The Venus Transit: a Historical Retrospective

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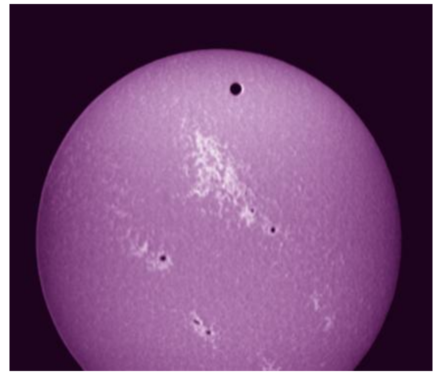

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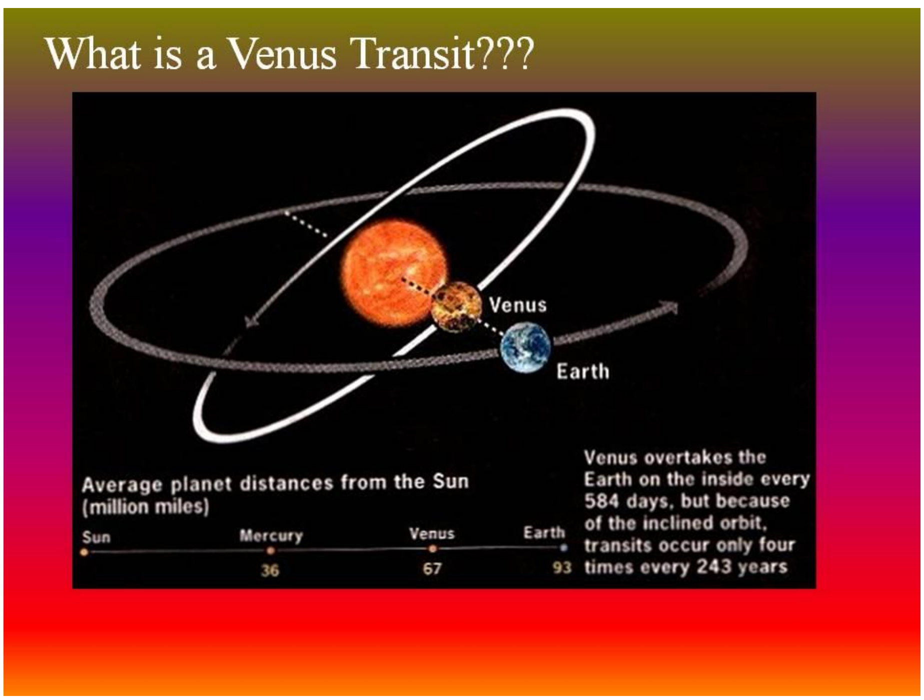
The Venus Transit: A Historical Retrospective

1) What is a 'Venus Transit"?

Introduction:

Last June, 2012, for only the 7th time in recorded history, a rare celestial event was witnessed by millions around the world. This was the transit of the planet Venus across the face of the Sun.
It is only visible from the Earth every few hundred years.
Today, we are going to take a historical retrospective look at the Venus Transit.

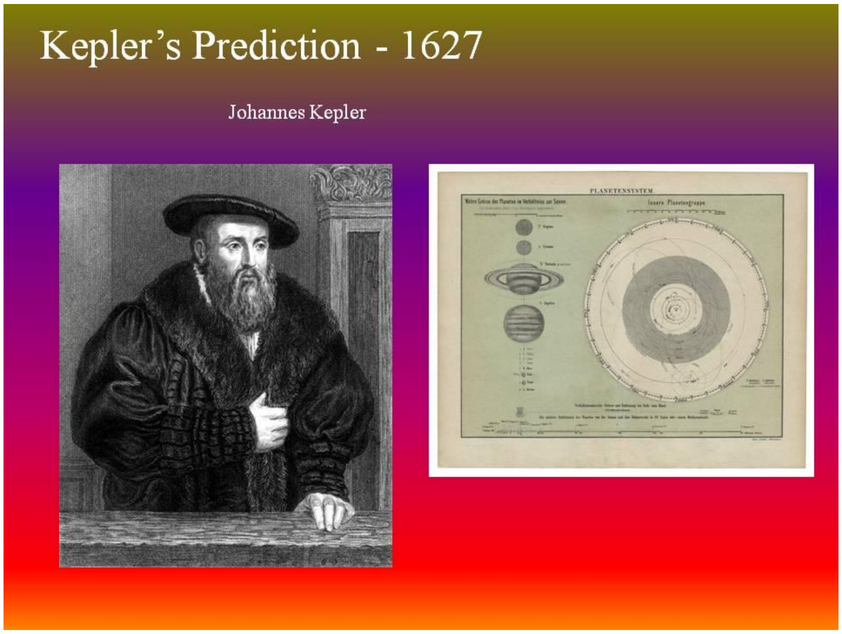
So, briefly, what is a Venus Transit? Basically the planet passes between the Earth and the Sun.
This occurs in a cycle of 2 every eights, then a gap of 105 years, followed by a pair of 8 year transits, followed by another gap of 121 years till the next 8 year pair.
Transits always occur either in June or December.
If you missed the June 2012 event, the next transit will not occur until December 2117.



A: Kepler's Prediction – 1627:

Johannes Kepler (December 27, 1571 – November 15, 1630) was a German mathematician, astronomer and astrologer. He is most famous for his laws of planetary motion.
In particular, Kepler's third law, (The square of the orbital period of a planet is directly proportional to the cube of the semi-major axis of its orbit), tells us the relationship between the distance of planets from the Sun, and their orbital periods. Using observational data and his third law, Kepler laid out a definitive model of the solar system based on what he called the 'astronomical unit' or the distance of the Earth to the Sun. Kepler gave the AU a value of '1' for his calculations. So Kepler was able to calculate that with the Earth being 1 AU from the Sun,that Venus was .7AU, and Jupiter was 5.2 AU, or Saturn was 9.5 AU. He could also calculate the AU distance between each planet; Jupiter is 4.2 AU from Earth. But Kepler did not know what the true value of '1 AU' equaled in terms of miles.

When Johannes Kepler published his last major work, the *Rudolphine Tables* of planetary motion in 1627, they permitted him to make detailed and fairly accurate predictions of the future positions and interesting alignments of the planets. Much to his surprise, he discovered that both Mercury and Venus would transit the Sun's disk in late 1631.



While Kepler could pinpoint the date of the transits, because of uncertainty in the exact time of the transit, he was not able to forecast from what part of the world the events would be visible. So he urged future observers to keep watch the entire day of the event. Kepler did not live long enough to attempt the observations, he died in November 1630.
But French astronomer Pierre Gassendi heeded Kepler’s prediction and succeeded in becoming the first to witness a transit of Mercury. Gassendi also tried to observe the transit of Venus, but it was not visible from his location.

B: 1st Transit Observation – Jeremiah Horrocks 1639

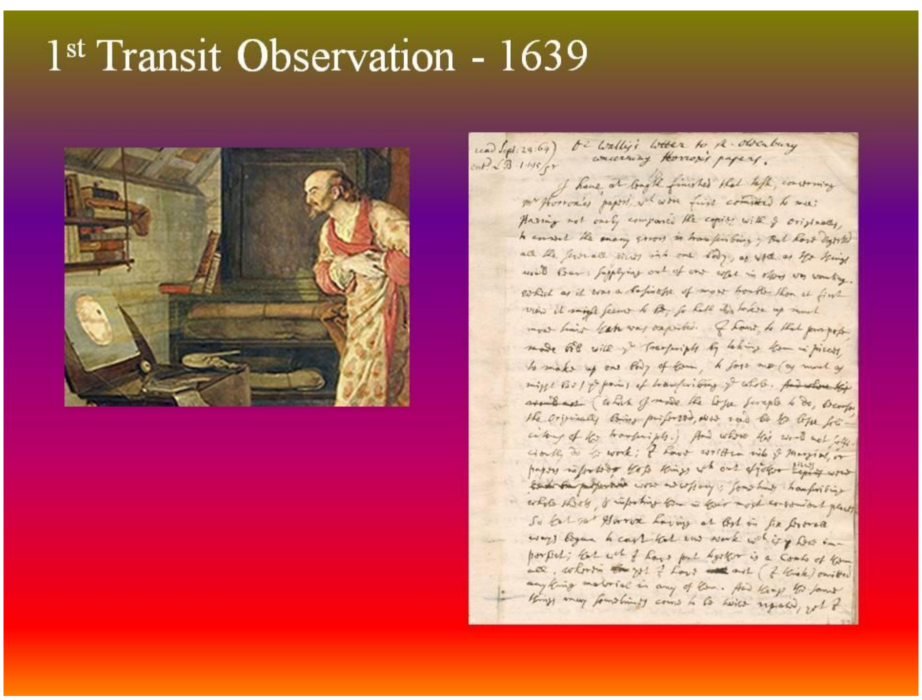
In Kepler's original predictions, the next Venus transit would not occur until the following century. But in 1637, a young 20 year-old British amateur astronomer and minister named Jeremiah Horrocks realized that Kepler had made a mistake. Kepler had calculated the visibility of a Venus Transit using the center of the Earth as the starting point. Horrocks began the huge task of recalculating the predictions based from the Earth’s surface, and completed them late in October 1639. Horrocks discovered that another transit would occur within the next month! On December 4^{th} mid-afternoon.

He only had time to notify a couple of fellow astronomers, only one of which, William Crabtree, attempted an observation on the date, and successfully observed the transit.

As it was Horrocks nearly missed the transit himself, as being the local minister, he was called away to attend a church mass early that afternoon. Upon his return home at 3:15pm, he discovered the transit already in progress! He quickly recorded an observation and sketch of the transit before the sun set about a half-hour later. Horrocks fast thinking allowed him to gather enough data to calculate Venus’ apparent diameter to within one arcminute.

Horrocks friend William Crabtree was clouded out for the start of the transit, but the clouds lifted in time for him to also make a transit observation before sunset. After exchanging letters, that info helped to collaborate Horrick's own observation.

It was a good thing that the two of them exchanged their data, as before Horrocks could write up an official report of the transit, he fell ill and died suddenly. None of his records survived.
A few years later, Crabtree died fighting in the English Civil War. Crabtree's letters & records from Horrock didn't nearly survive the war either.Fortunately, enough were saved by his brother and came into the hands of German astronomer Johannes Hevelius who published them, that we even know of Horrocks and Crabtree's historic 1st observation of a Venus Transit!



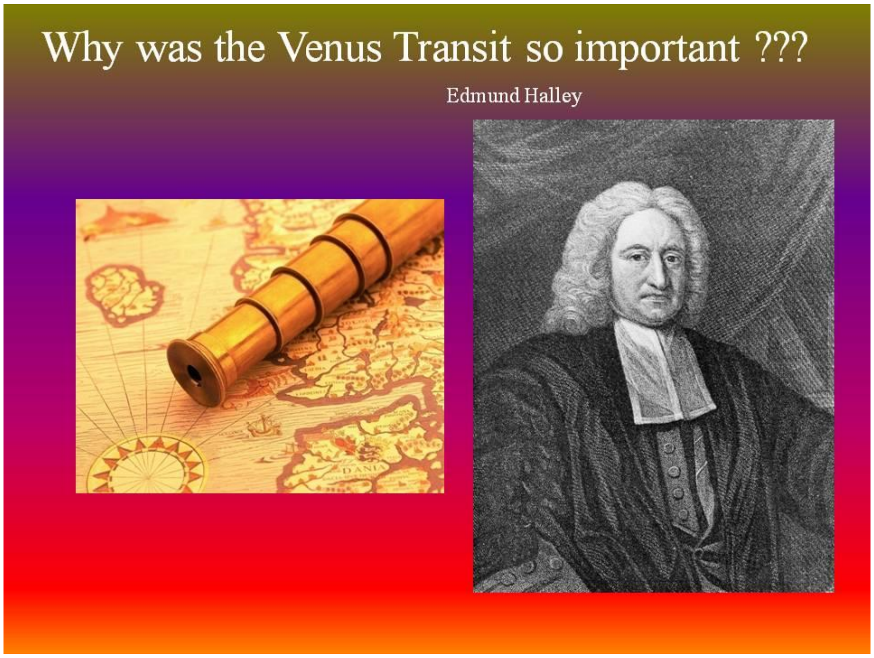
2) Why was it so Important?

A: Edmund Halley's call to action in 1716

Nearly forty years after Jeremiah Horrocks, Edmond Halley observed the 1677 transit of Mercury from the island of St Helena in the South Atlantic. Halley realized that the careful timing of transits could be used to determine the Astronomical Unit (or AU), the distance of Earth from the Sun. The technique relied on observations made from the far corners of the globe. Using these observations, astronomers could use simple principles of triangulation to calculate the distance to the Sun, and from that calculate the distance to the other planets. The effect of parallax on the remote observers would allow them to derive the absolute distance scale of the entire solar system. Once the AU was known, per Kepler's third law, all the other planet's distances from the Sun could be determined, along with their actual size and mass. This was the key to determining the true scale of our solar system.

From his own experience, Halley knew that Venus transits were better suited to this goal than were Mercury transits because Venus is closer to Earth and consequently exhibits a larger parallax.
The more spread out the observers, the bigger the difference in parallax would be, allowing for more accurate calculations. Near the end of his life, in 1716, Halley laid down a challenge to future astronomers to organize major expeditions to the ends of Earth in order to observe the transits of 1761 and 1769.

I recommend it therefore again and again to those curious astronomers who (when I am dead) will have an opportunity of observing these things, that they remember my admonition… that having ascertained with more exactness the magnitudes of the planetary orbits, it may redound to their immortal fame and glory".

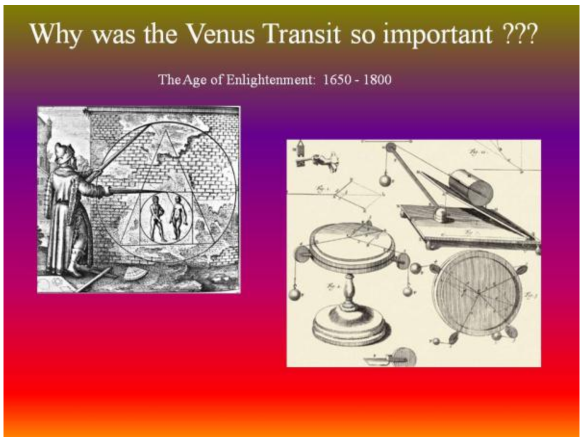


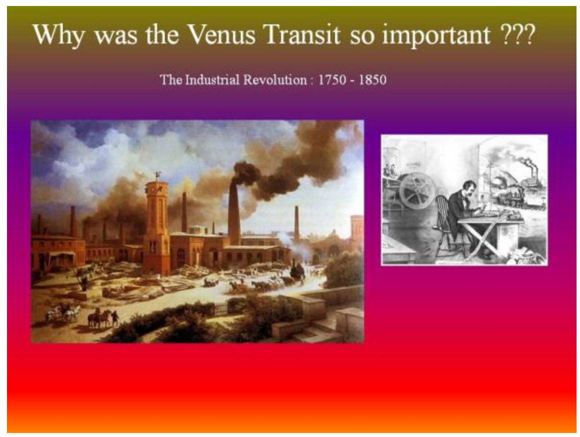
B: The Age of Reason (Enlightenment) and the start of the Industrial Revolution

During this time period there were several significant historical world-wide changes taking place.

The **Age of Enlightenment** (or simply the **Enlightenment** or **Age of Reason**) was a cultural movement of intellectuals in 18th century Europe and the American colonies. Its purpose was to reform society using reason and advance knowledge through science. It promoted science and intellectual thought and opposed superstition and intolerance.

The **Industrial Revolution** was a period from 1750 to 1850 where changes in agriculture, manufacturing, transportation, and technology had a profound effect on the social, economic and cultural conditions of the times. It began in England, thenspread throughout Western Europe, North America, and the rest of the world. The Industrial Revolution impacted almost every aspect of daily life in some way.





Together, the 'Enlightenment' and the 'Industrial Revolution' is sometimes referred to as the 'Age of Wonder', when modern science and its new machinery changed the world.

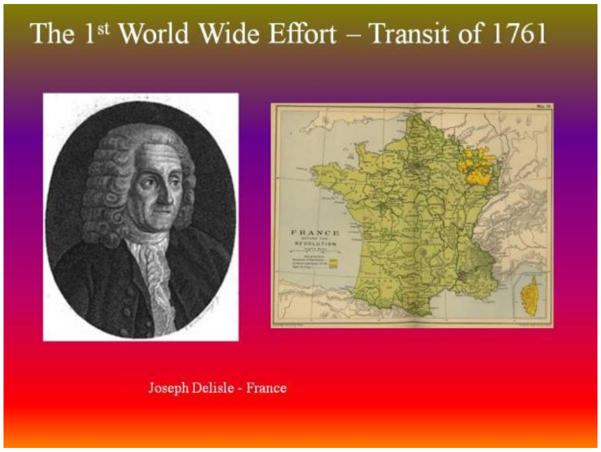
Both of these movements lead to the rise of new nation-states and the re-birth of the old world states with a keen interest in the international prestige of competing in the new sciences and technologies being created.

3) The First World Wide effort – the Transit of 1761.

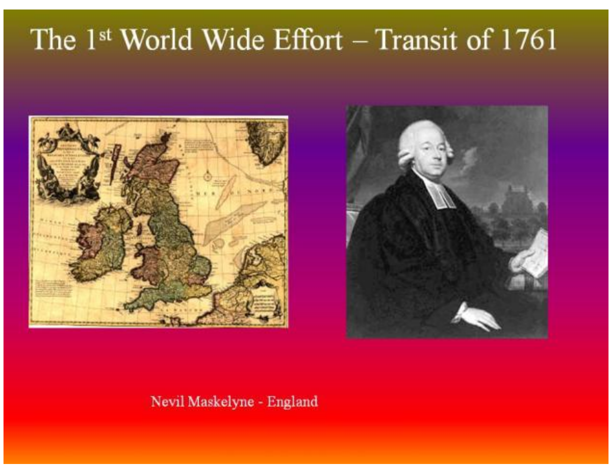
Halley's challenge was the 'shot heard round the world', and launched a world-wide quest for what was considered one of the most important scientific questions of the time – the scale of the solar system! Astronomers from around the world took note of Halley's words, and when the time came in 1761 & 1769, their remembrance prompted multiple global expeditions to dangerous and exotic locations around the word, involving many of the leading explorers and scientists of the day.
For 18th century astronomers, one of their most important task of their time was determining the AU.

A: Countries and Astronomers involved

Eight European nations sent out expeditions of the top astronomers of the day, among which were the following:



Joseph Delisle: Astronomer – France (Paris) Delisle was the organizational 'brains' behind the world-wide planning for the 1761 transit. He refined Halley's initial plans and determined where around the globe would be the best locations to positions observers, along with what data they needed to gather and what type of equipment they should use. Delisle then communicated this information to the astronomical & scientific societies and observatories of all the world powers. He would become the overall leader of the 1st international scientific endeavor in history!What makes this even more astounding was that all this international scientific cooperation occurred during the height of the 'Seven Years War' (what we call the French & Indian War), where all the major world powers were actively engaged against each other in open hostility. Because of the scope of this war, some historians actually consider it to be the first real world war.

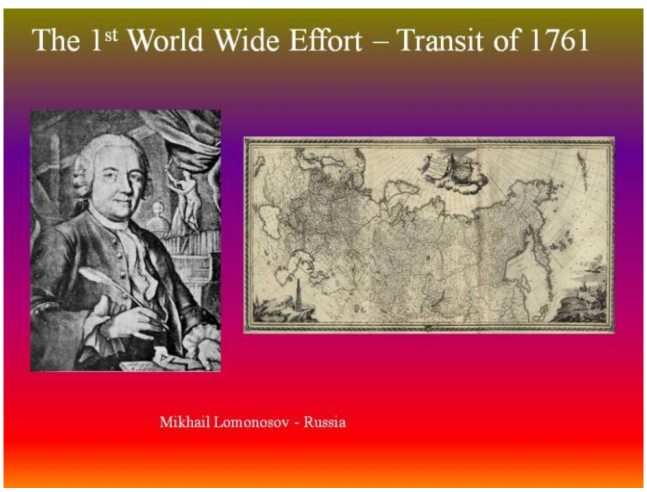


Nevil Maskelyne: Astronomer – England (St Helena) The Royal Society selected upcoming astronomer Nevil Maskelyne to travel to the British held island of St Helena in the Atlantic.
During his voyage, he tested his new method for calculating longitude at sea, based on lunar observations. Nevil hoped to not only succeed in observing the Venus Transit, but to also win the highly coveted Longitude Prize, a princely sum of cash from the King of England to whoever discovered a simple and practical method for the precise determination a ships location at sea.

Charles Mason and Jeremiah Dixon: Astronomer/Surveyors – England (South Africa – cape)
Mason & Dixon were charted by the Royal Society to travel to Sumatra (today known as Indonesia) to observe the transit. They had barely made it out of port when their ship was attacked by a French warship and heavily damaged, with a number of sailors killed in the sea-battle. The pair survived the battle, but were quite shaken up by it and tried to back out of the trip. But they agreed to continue on, after receiving sternly worded reprimand concerning the impact of their quitting would have on the rest of their career. After the ship was repaired, they once again set out on the long voyage. Upon stopping in for supplies at Cape Town South Africa, the ship's captain realized that there wasn't enough time to make it to Indonesia, so Mason & Dixon got permission from the Dutch running Cape Town to setup there. That ended up being a good thing, as they were the only expedition to successfully observe the transit from the Southern Hemisphere.

Jean Chappe: Astronomer – France (Siberia) French astronomer invited by the Russian Imperial Academy to help contribute by observing the transit from Siberia. Chappe travelled 4000 miles overland by carriage, cart, and sleds, having to ford icy rivers and sinking up to their axles on mud roads, or buried in snow drifts. After six months on the road, and suffering equipment damage from travelling over what passed as roads, He finally arrived at the location in Siberia with a little over three weeks left before the transit to prepare his observatory. But his troubles weren't over yet, as the locals accused him of being a magician and the threats to murder him or destroy his telescopes were such that he was forced to live in his observatory with a 24 hour guard.

Guillaume Le Gentil: Astronomer – France (Indian Ocean, at sea) The French sent Le Gentil to Puducherry India for his transit station. To give him plenty of time to make the journey over the war torn seas, he left for India over a year in advance. The ship arrived early to its port of call on the island of Mauritius off of Africa to resupply for the final leg of the journey. Unfortunately, Le Gentil came down with dysentery which delayed him. Once he recovered and the ship was able to sail, they hit the monsoon season, which blew the ship off course, and hit a period of calm winds with little to no travel progress. With time running out, as they were finally approaching their destination on the Indian coast, they learned that it had just fallen to British forces.
The ship captain had no choice but to turn around.



Mikhail Lomonosov: Astronomer – Russia (St Petersburg)a brilliant Russian astronomer who had a reputation of violence and was feared by his associates, having once stabbed a fellow Imperial Academy member in a drunken brawl.

B: What happened on Transit Day

Nevil Maskelyne: Astronomer – England (St Helena) Nevil had arrived two months before the day of transit, so he had his observatory well ordered and ready to go. The transit was already under way when the sun rose over the island. After a few initial observations, clouds quickly covered over the sun. But the overcast gradually cleared allowing Nevil to begin observing. As he prepared to time the final events, the clouds began rolling back in. But, Nevil was really thrown off by the trembling edges of Venus's limb. He couldn't precisely determine when the planet's edge actually met the sun's limb. Between that and the thickening clouds, Nevil was unable to take any timings of the exit.

Charles Mason and Jeremiah Dixon: Astronomer/Surveyors – England (South Africa – cape)
The preceding days had been overcast, and that weather continued thru-out the transit day. Because of their location, Mason & Dixon would not see the start of the transit, as the sun was below the horizon, but once it rose, they managed to periodically glimpse views of the transit thru sucker holes. Finally with just minutes before the start of when Venus would begin exiting the sun, the sky cleared and they were able to time third and fourth contact.
Shortly after Venus left the sun, clouds covered it back up.

Joseph Delisle: Astronomer – France (Paris) Along with a number of other French astronomers, Delisle was able to observe the entire transit from his Paris observatory in sunny skies. But now feeling his eighty years of age and going blind, left most of the observing up to his assistants, and even turned over much of the cataloging of the worldwide observations and calculations to his trusted protégé Joseph Lalande. A few years later he retired from astronomy to focus on religion and on the daughter of the Sultan of Constantinople.

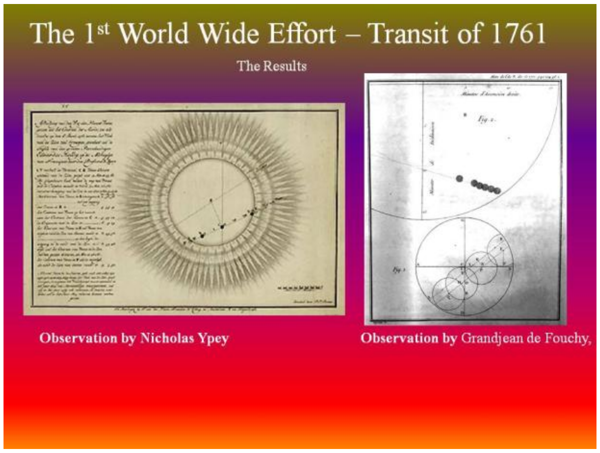
Jean Chappe: Astronomer – France (Siberia)the evening before the transit, low clouds and a thick fog had rolled that lasted thru the night and in the day of the transit, only clearing just prior to the start time. Having been up all the night before from being stressed out by the fog, Chappe hurriedly prepared his equipment, but because of a final lingering cloud missed the initial 1st contact. But he was able to accurately time second contact and the remainder of the transit.

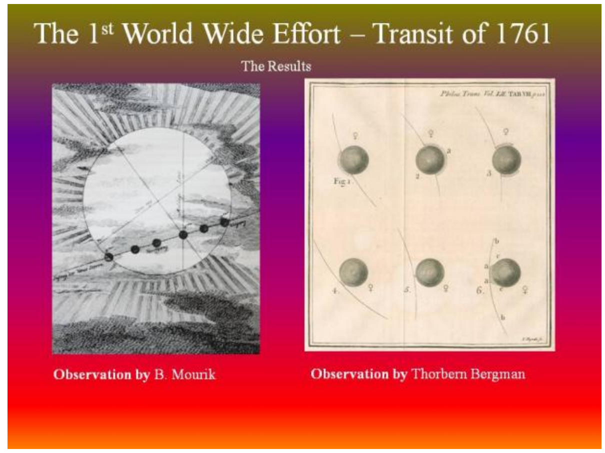
Guillaume Le Gentil: Astronomer – France (Indian Ocean, at sea) Le Gentil had a beautiful clear view of the transit at sea with calm weather allowing him to time the whole event.
But, he was unable to precisely determine his longitude location at sea, which made his observations useless.

Mikhail Lomonosov: Astronomer – Russia (St Petersburg) Lomonosov was able to observe the full transit and obtain timings from his home observatory in St Petersburg. During second and third contacts, he observed a faint hazy arc of light around Venus, and was the only astronomer to realize the implications. Lomonosov was credited with the discovery of Venus having an atmosphere, and he concluded that Venus must have life on it, like the Earth.
But a review of his records and recent observations from both the 2004 and 2012 transits have cast doubt that he really did see Venus's atmosphere. It looks to be based mostly on the widespread belief at that time that all worlds must have an atmosphere, even our Moon**.**

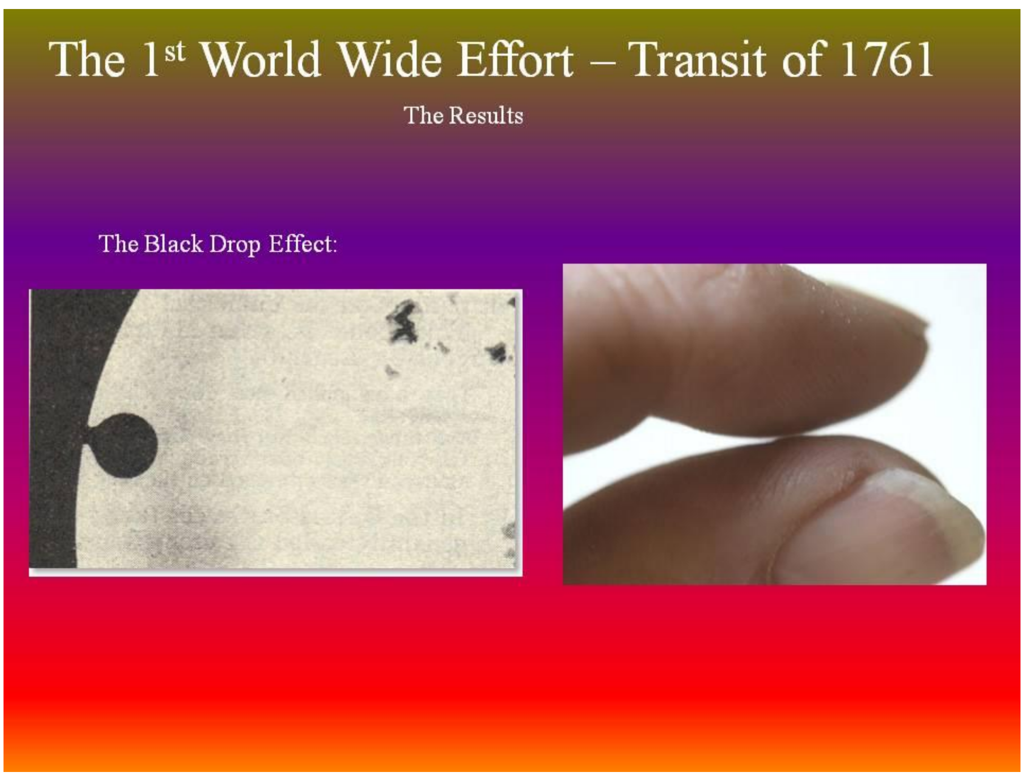
C: The Results

The 1761 transit was observed in part or whole from nearly 70 locations scattered around the globe. Once all the observations were finally compiled and analyzed, the timings were so far off from one another that the calculated AU varied by nearly 25%, and fell between 77,850,000 - 96,160,000 miles. Woefully inaccurate!!! The overall goal was deemed a failure.





This lack of accuracy in timings was the result of the '**Black Drop effect'**.
The black drop effect is an optical phenomenon visible during a transit of either Mercury or Venus across the Sun. During the transit, a small black "teardrop" appears to connect the planet's disk to the limb of the Sun, making it impossible to accurately time the exact moment of contact.



4) The Second Try – the Transit of 1769.

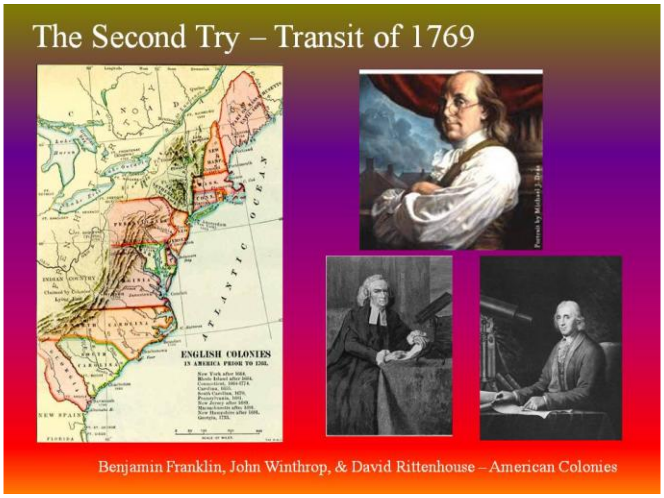
While the 1761 transit was a flop, the astronomers of the day knew they had a second chance coming up eight years later. They were determined this time to succeed, using bigger and better telescopes and timing clocks.

A: Countries and Astronomers involved

Now eleven European nations sent out expeditions of the top astronomers of the day to over 77 global locations. These included over 150 astronomers and their assistants, among which were the following:

Nevil Maskelyne: Astronomer Royal – England (Greenwich Observatory) Now as the head of British astronomy, Nevil took over the world-wide organizational effort that Delisle had done for the 1761 transit, sending out letters to other nations encouraging them to participate, writing transit equipment and observing instructions, and proposing expeditions to various locations around the world. All this, along with his duties as the King's Astronomer required him to stay in England and observe the transit from Greenwich. His appointment as Astronomer Royal also made Nevil the head of the 'Board of Longitude' and in charge of awarding the Longitude Prize, which put him at odds with his own longitude method contending with the other major seeker of the prize, clockmaker John Harrison. (the prize eventually went to John Harrison, but that is another story).
A great book about the fight for the prize is 'Longitude', by Dava Sobel.

James Cook: Sea Captain& Explorer (along with Charles Green : Astronomer, and Joseph Banks: Botanist) – England (Tahiti) Chosen by the Royal Navy to lead the South Seas expedition, James Cook was already known as a skilled marine surveyor, cartographer and astronomer. Along with the Royal Society astronomer Charles Green, who was in charge of the transit observation, and Joseph Banks, a wealthy gentleman botanist, Captain Cook set sailwith a crew of 94, and after nearly a year sailing on board his ship, the 'Endeavour', arrived at the island of Tahiti just in time to establish peaceful relations with the natives and setup for the transit.



John Winthrop and David Rittenhouse: Astronomers, and Benjamin Franklin – (American Colonies)the beginning of the1769 transit would also be visible from the 13 American colonies, until sunset. The American colonists were determined to be a part of the world-wide effort, particularly members of the American Philosophical Society (or APS), founded in Philadelphia by Benjamin Franklin for 'Promoting Useful Knowledge'. Chief among the APS was self-taught astronomer & instrument maker David Rittenhouse from the town of Norriton, located about 20 miles west of the city. Rittenhouse became the chief local organizer of the transit, in calculating and selecting the best observing locations and taking care of all advanced preparations. From his work, the APS chose two main observing stations, one from the Philadelphia statehouse, and another from Rittenhouse's' farm. Benjamin Franklin, at the time staying in London as the unofficial ambassador of the American colonies and a leadership member of the British Royal Society, also encouraged his friend and astronomer John Winthrop in Cambridge to organize a group to observe the transit.
Thru his London connections, Franklin was able to obtain new transit telescopes and timing clocks for both colonial groups.

Guillaume Le Gentil: Astronomer – France (India) Rather than head home after the Indian Ocean debacle, Le Gentil decided to stay in the region to prepare for the next transit in 8 years time. He decided that the city of Manila, Philippines, had the region's most perfect weather, and would make for a great transit site, and arrived there in 1766, well in advance, and setup an observatory. Then in late 1767, he was ordered to pull up stakes and again go to India, which was now back in French hands, for the transit. He arrived there almost a year before the 1769 transit date, and once again established an observatory.

Jean Chappe: Astronomer – France (Baja Mexico) Having successfully observed the first transit and published his three volume account of his travels in Siberia, Chappe was now assigned to travel under the Spanish to their territory in Baja Mexico, where the entire transit would be visible with the Sun high in the sky. The King of Spain, concerned that the French had ulterior motives, greatly restricted the size and movements of the transit part and ordered the accompanying Spanish astronomers to keep a close eye on Chappe. The party endured a stormy 2 month sea crossing on a small ship, and then once in Mexico had to travel 800 miles by horse to the western coast, where they boarded another ship for another 500 mile stormy voyage along the Baja coast. With time running out and only two weeks left before the transit, they abandon their original destination and made landfall by the small church mission community of San Jose del Cabo. A location that would prove to be fatal.

B: What happened on Transit Day

Nevil Maskelyne: Astronomer Royal – England (Greenwich Observatory) along with seven other astronomers at the Royal Greenwich Observatory, Nevil was able to time the start of the Transit. But the large discrepancy (53 seconds) between the seven observers made the results nearly useless. Nevil went on to lead the Royal Society's efforts in the cataloging of the worldwide observations and parallax calculations.

James Cook: Sea Captain & Explorer – England (Tahiti) after overcoming issues with the native inhabitants of the island, including their stealing and disassembling of their astronomical quadrant, without which they would not be able to calculate their exact position which would make their observation useless, Captain Cook and astronomer Charles Green successfully observed the entire transit. They distinctly noted the atmosphere around Venus, and once again all team members had difficulty with their timings, due to the Black Drop effect. They were able to get their quadrant instrument back from the natives and repaired it and were able to determine their exact coordinates. On the way back home, they explored the eastern coast of Australia where they collected numerous new botanical specimens and ended up running aground on the Great Barrier Reef.
After making emergency repairs, they limped into port at Jakarta where Cook lost quite a few of his crew to malaria, including astronomer Charles Green. Finally after being away for almost three years, Captain Cook and the Endeavour arrived back in London, where Cook presented Charles Greens transit notes to the Royal Society.

John Winthrop and David Rittenhouse: Astronomers, and Benjamin Franklin – (American Colonies)
Franklin's new transit equipment arrived barely in time, giving the colonialist only a few days to practice using them. The day of the transit arrived with clear skies, and the observers anxiously awaited the mid-afternoon appearance of Venus. Rittenhouse became so excited during the wait that he passed-out right before the start, missing the timing of 1st contact! After recovering, he went on to accurately record 2nd contact and continued to make observations until sunset.
Winthrop's group in Cambridge MA successfully observed the transit from start to sunset.
And in London, Franklin joined other members of the Royal Society in observing the transit, but the sky in their location was partly obscured by all the smoke coming up from the city!

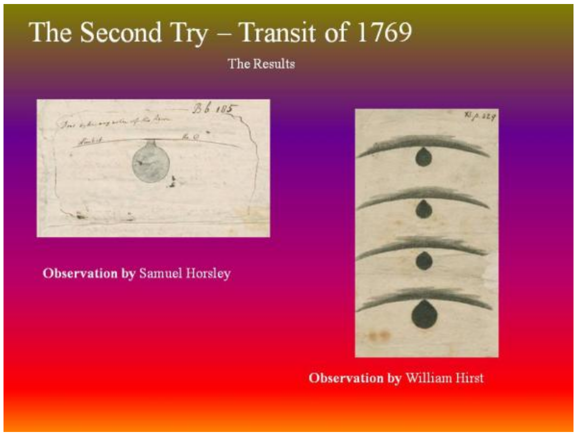
Guillaume Le Gentil: Astronomer – France (India) Le Gentil was probably the most prepared of all expeditions. He had an established observatory, all of its instruments in perfect working condition, and its location precisely calculated. But as fate would have it, shortly before the time of the transit, due to an early start of the monsoon season, the weather changed and he was clouded-out for the entire event! (he later learned that Manila had clear skies that day).
Because of bad weather, Le Gentel had missed timing both the 1761 & 1769 transits!
If the man could be any unluckier, during the trip home to France, he once again came down with dysentery, was almost shipped wrecked, and upon finally arrived home, discovered that he had been declared dead by his family and his estate sold off!!!

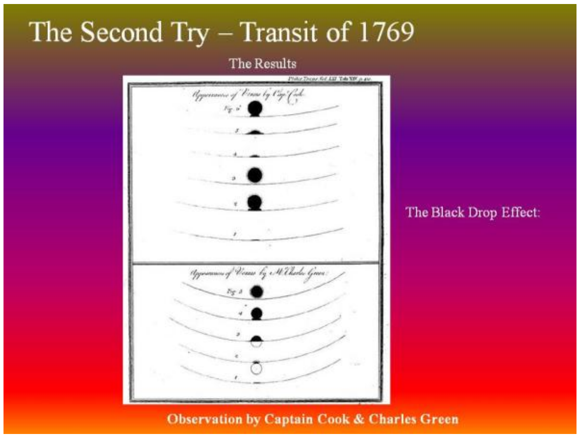
Jean Chappe: Astronomer – France (Baja Mexico) with just two weeks till the transit, Chappe converted a mission barn into a temporary observatory and prepared his telescopes and timing clocks. The transit began right at noon in a beautifully clear blue sky, and Chappe and his team were able to successfully observe and time the entire event, start to finish. Chappe couldn't believe how lucky he was, with all the trouble he had in getting to the observing location. Unfortunately for him, his luck didn't hold, as typhus was raging thru over half the local population, and eight days after his successful observation of the transit, Chappe fell sick. Over the course of a week, he forced himself out of his sickbed to complete the additional needed celestial observations of a lunar eclipse to fix his exact position coordinates so that his transit observation would not be useless. In the end, only two members of the French party survived to carry Chappe's crucial observations back to Europe. Jean Chappe, the only astronomer to successfully observe and time both the 1761 & 1769 Venus Transits in their entirety, was buried in an unmarked grave.

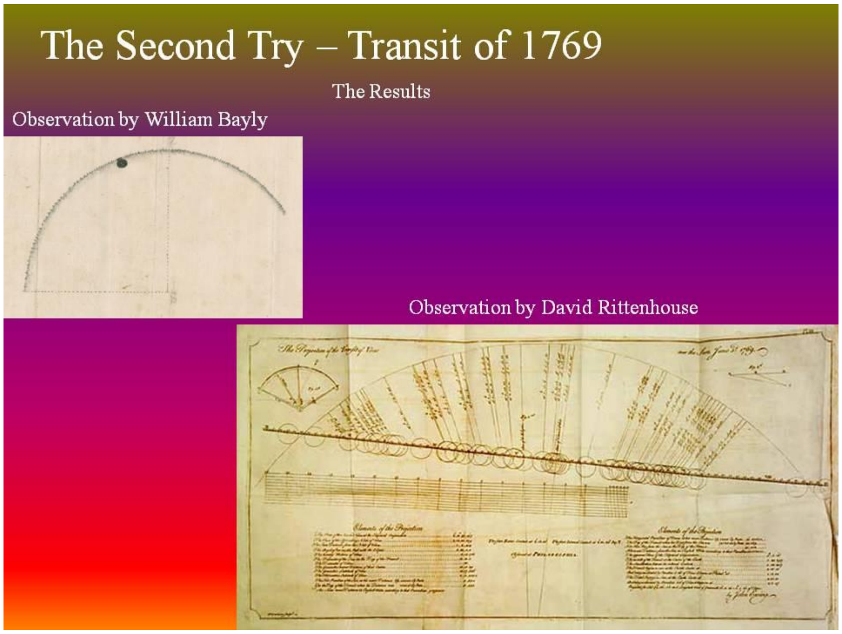
In the end, four astronomers had given their lives during overseas expeditions to observe the 1769 Transit of Venus! Charles Green, Jean Chappe, Salvador de Medina – Spanish Astronomer accompanying Chappe in Baja, and a Russian astronomer named Ochtenski on a small island in the Barents Sea.

C: The Results

Of the many 18th century scientific expeditions that were mounted to observe the 1769 Venus transit, all of the results, while better, were once again disappointing. The accurate parallax timings needed were still not possible due to the mysterious "black drop" effect in which the edge of Venus's disk appeared to deform and cling to the limb of the Sun.The final calculated values fell anywhere between 92 – 97 million miles, with the average being somewhere around 95 million. So, all of the attempts during the 18th century's transits of Venus to establish a truly precise value for the Astronomical Unit, (AU), the fundamental measuring stick of the Solar System, were deemed failures.
Astronomers would now have to wait 105 years for another try.





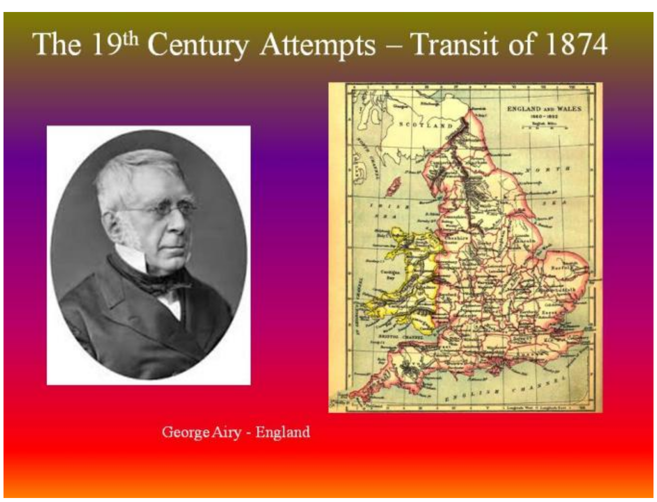


5) The 19th Century attempts – 1874 Transit

Disappointed by the results of the previous century, a new generation of 19th century astronomers, equipped with even better telescopes and new observing tools were determined to take up Halley's challenge and achieve the quest of determining the Astronomical Unit. The new astronomical tools included better refractors, new method of using silver-glass mirrors, clock-drive mounts, and the solar Heliostat. Getting around the world had also become much easier with the steamship having replaced sail. Where it use to take several months to cross the Atlantic, now it could be done in as little as eight days! Additionally, most of the major countries of the world had developed extensive railroad systems, making travel into their interior regions easy. With the invention of the telegraph and its lines weaved across the continents and oceans, planning and reporting activities could be communicated in a matter of hours throughout the world. This even allowed for accurate time signals to be transmitted from central locations, allowing the determination of a sites longitude to be much more precise. Finally, Photography had been invented and already used by 1845 to capture images of the Sun, and a new technique of capturing multiple images, called a 'Revolver Camera' has just been invented. This was the forerunner to the motion picture camera.

A: Countries and Astronomers involved

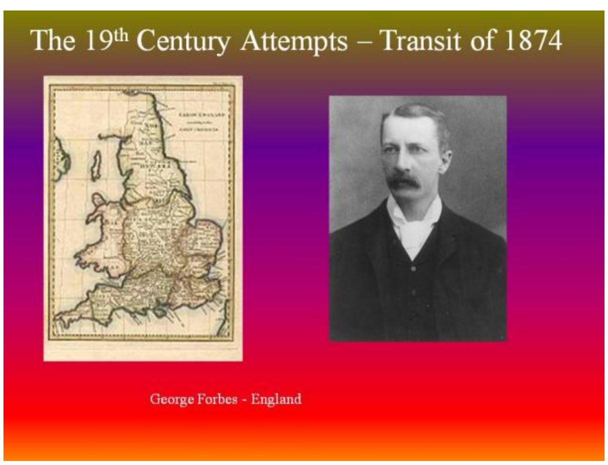
Once the transit visibility map had been calculated, it was obvious that only a few established observatories in the southern hemisphere would be able to observe the transit in its entirety – the observatories at Cape Town South Africa, Chennai India, and Adelaide, Melbourne, and Sydney in Australia. So another major overseas observing campaign was mounted by many nations to over 80 destinations for the Venus transits of 1874. These included the new counties of Germany, Italy, Mexico, Brazil, and the United States. During this transit season, there were no major ongoing wars and only a few areas of the world were considered unstable and not suitable for travel.



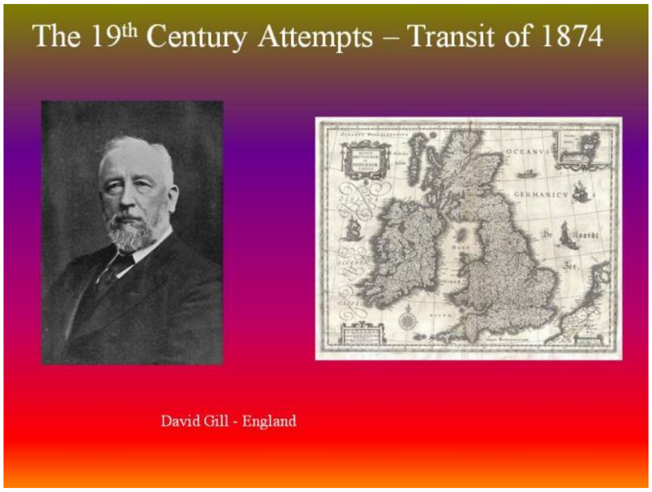
George Airy: Astronomer Royal – England (Greenwich Observatory) Once again, as the head of British astronomy, Airy took over the world-wide organizational effort that Nevil Maskelyne and Joseph Delisle had done for the 18th century transits, sending out letters to other nations encouraging them to participate, writing transit equipment and observing instructions, and proposing expeditions to various locations around the world. Airy was a strong advocate for transit planning, stating that finding the value of the AU is the 'noblest problem in astronomy'.

Prior to becoming the Astronomer Royal, as a relatively young astronomer, Airy was appointed head of the Cambridge Observatory where he published many scientific research papers.
Once installed at Greenwich Observatory, he proceeded to organize it into the world's leading observatory in positional astronomy. Airy was noted for his gruff personality and over the years made many critics, especially around the fiasco of his failure to use the predictive calculations of Cambridge Astronomer John Adams to search for the planet Neptune, letting that prize fall to the French.
For the 1874 Venus Transit, Airy chose 5 locations to send the British astronomers: Egypt, the Hawaiian Islands, Rodriguez Island in the western Indian Ocean, New Zealand, and Kergulelen Island in the far southern Indian Ocean.

Rev Stephen Perry: Astronomer – England (Kerguelen Island – Southern Indian Ocean)
The British split into three teams on the island, as far apart as they could get. The main team was lead by Perry, who was the director of Stonyhurst Observatory, and had led the 1870 total solar eclipse expedition. Perry had a 6" refractor as their primary instrument, several 4" refractors, and transit instruments and an equatorially mounted telescopic solar camera. The secondary teams each had a 4" refractor.



George Forbes: Astronomer – England (Kona – Big Island, Hawaii – Pacific Ocean) an astronomer from Cambridge who had written a book for the transit, Forbes was assigned to man the post on the Big Island of Hawaii. Forbes picked a location at Kona and had a pier built on the beach for the observatory. Part of Forbes duties was to restore the monument to Captain Cook located near where he was killed. (In a dispute with the Hawaiian natives back in 1779, Captain Cook was killed, 'cooked' and eaten by the locals).



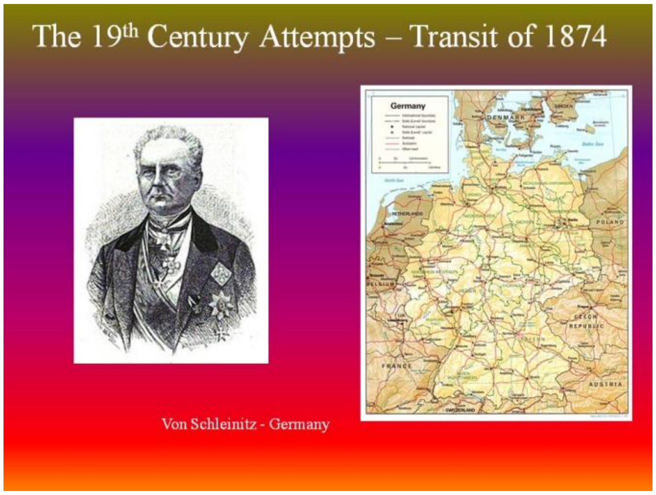
David Gill: Astronomer – England (Mauritius – Indian Ocean)
This was a private expedition funded by Lord Lindsay and was the most completely equipped. They sailed on private 3-masted yacht, named the 'Venus' to the island arriving well in advance to setup their fully equipped transit observatory, including both visual transit refractors and solar photography equipment.

The United States Transit Commission: acquired a large fund from congress and the use of ships and assistance from the US Navy. The Americans decided to send major transit observing parties to Vladivostok Russia, Peking China, Nagasaki Japan, Kerguelen Island, Tasmania, and New Zealand.

Asaph Hall: Astronomer – USA (Vladivostok, Russia) (noted for discovering the moons of Mars in 1877) Hall, located on the coast by the Sea of Japan where he had to build his observing site over a mile from where they were staying. This made for travelling during the frigid winter weather quite uncomfortable for Hall and his team.

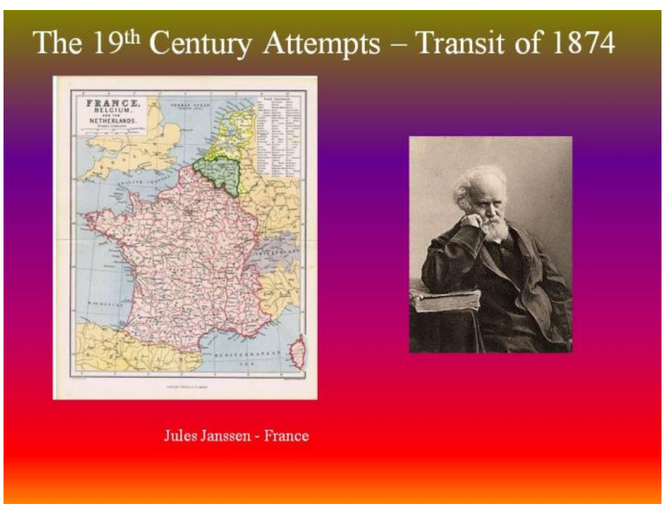
Comdr G.P. Ryan: USA-Navy – USA (Kerguelen Island – Southern Indian Ocean)
The Americans setup camp just across the bay from the British, close enough to signal one another. They brought with them a 5" Alvan Clark refractor, transit instruments, and a solar camera that utilized a heliostat.

The German Transit Commission: Sent observing parties to Kerguelen Island, Mauritius Island, Auckland Islands, New Zealand, and China.

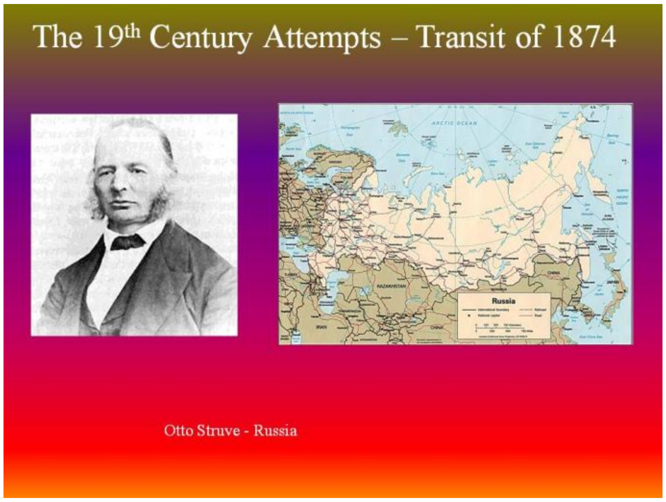


Von Schleinitz: Astronomer – Germany (Kerguelen Island – Southern Indian Ocean)
The German team setup camp on the far northern cost of the island in the flattest area they could find, which happened to be right in the middle of an old whaler's cemetery.

The French Transit Commission: sent astronomers to Peking China, Yokohama Japan, Saigon, and Campbell Island in the South Pacific.



Jules Janssen: Astronomer – France (Yokohama, Japan) the inventor of the Jansen **'**Revolver Camera', which consisted of a rotating disk with slots in it, which projected a small window onto the photographic plate that advanced as the individual exposures were taken. This allowed 48 images to be taken in a little under 2 seconds. Even though Janssen was handicapped in his youth and was unable to walk, he was a prominent French astronomer known for his numerous solar eclipse observations. In order to observe a total eclipse in Algeria in December 1870, he rode a hot air balloon out of the city of Paris while it was under siege by the Prussians. During the trip over to Japan, his team had to ride out a typhoon off of Hong Kong. Upon arriving in Yokohama, Janssen moved his main group of observers with the Revolver Camera to Nagasaki, and sent a small detachment of visual observers to Kobe to increase his chances of clear weather.



The Russian Transit Commission: lead by Otto Struve, Sent observing parties to 32 separate locations, Stretching across the entire Russian Empire.

In addition to the above major countries, Mexico sent an expedition to Yokohama, the Italians sent one to India, and the Dutch sent one to Reunion Island

B: What happened on Transit Day

George Airy: Astronomer Royal – England (Greenwich Observatory) As the Astronomer Royal, Airy had to stay behind at Greenwich and await the reports to come in.

Rev Stephen Perry: Astronomer – England (Kerguelen Island – Southern Indian Ocean)
The main British team was clouded out at the start of the transit, but was able to make goodvisual timings using the 6" refractorof third & fourth contact at the end. The clouds ruined all attempts at photography. The first 'secondary' team had good weather at the start, but was clouded out at the end, but the other secondary team, had clear weather the entire transit and had good timings of both the beginning and end of the transit. So Perry's plan of splitting the team paid off.

George Forbes: Astronomer – England (Kona – Big Island, Hawaii – Pacific Ocean) only the first two hours of the transit was visible from the Hawaiian Islands. The skies were clear at Honolulu, but on the Big Island where Forbes had setup, scattered clouds had blocked Forbes from accurately timing the first & second contact points, rendering his transit observations of little use. In addition, because of operator error in loading the plates, none of his photographic images came out. For all his troubles, Forbes almost drowned a few weeks prior to the transit, trying to save another man caught in heavy surf.

David Gill: Astronomer – England (Mauritius – Indian Ocean) Clouds blocked the initial phase of the transit, Gill was able to successfully observe egress, taking 271 photographic images and visual timings with a 6" refractor.

Asaph Hall: Astronomer – USA (Vladivostok, Russia) Hall, located on the coast by the Sea of Japan had clear skies and was able to take accurate timings of 1st and 2nd ingress contacts and third contact prior to sunset.

Comdr G.P. Ryan: USA-Navy – USA (Kerguelen Island – Southern Indian Ocean)
Being located near the primary British team on the island, the Americans suffered the same fate, clouded out except for the very end.

Von Schleinitz: Astronomer – Germany (Kerguelen Island – Southern Indian Ocean)
The German team enjoyed clear weather for the entire transit, and obtained photographic and visual contact timings of both beginning and end of the transit.

Jules Janssen: Astronomer – France (Yokohama, Japan) Janssen's team experienced perfect weather at both the main location in Nagasaki and the alternate site in Kobe, and were able to make full visual and photographic observations of both ingress and egress contacts.
Using a new spectrograph, the French team also observed Venus silhouetted against the solar chromosphere. After the transit was over Janssen was able to telegraph Paris later that day with his team's success.

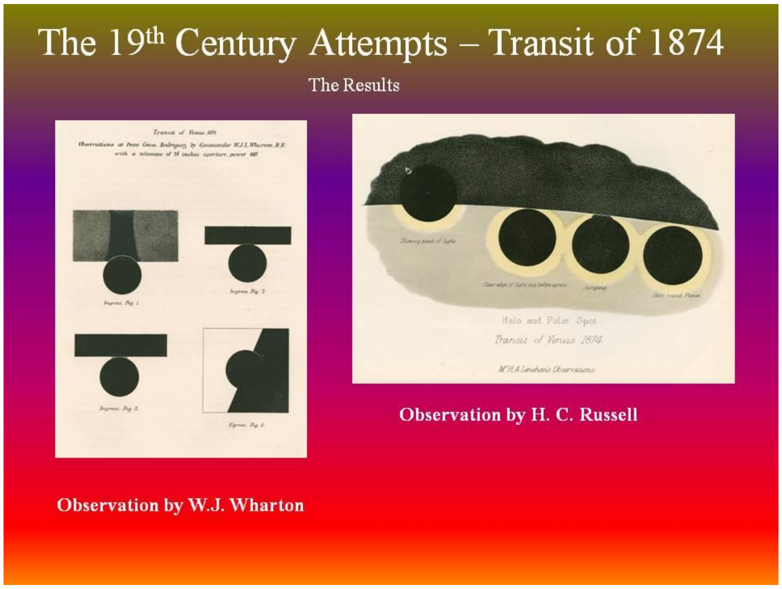
The Russian Transit Commission: lead by Otto Struve, the Russians, with their 32 observing locations, had mixed results. Only 13 stations reported any kind of observation, 10 were completely clouded out, and the rest never reported at all.

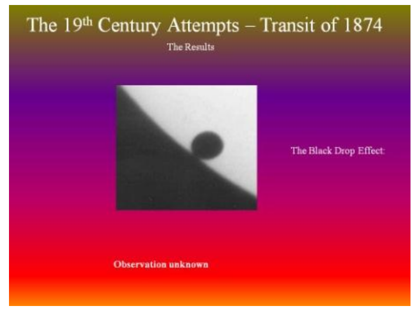
Most of the transit expeditions sent to New Zealand were clouded out.
But the Americans at Queenstown had better weather and managed to take 59 images of first and second contact. The British were able to take a few photographs at their locations in Christchurch and Burnham. Across the Pacific, the Germans made successful observations on Auckland Island, and the French were able to capture over 100 photographic images on Campbell Island.
In Australia, the Americans were clouded out at Hobart, but the British at the Sydney Observatory were able to take 560 photographic images using their version of the Janssen Revolver camera. Astronomer Henry Russell was also able to use the observatory's 11.5" refractor to make color drawings of the entire event. India also enjoyed clear skies where the Italian team was successfully able to take visual timings of all four contacts, and also used a spectroscope to observe Venus against the chromosphere. The British team in India, using their revolver camera, was able to take 420 images and full visual timings of all four contacts.

C: The Results

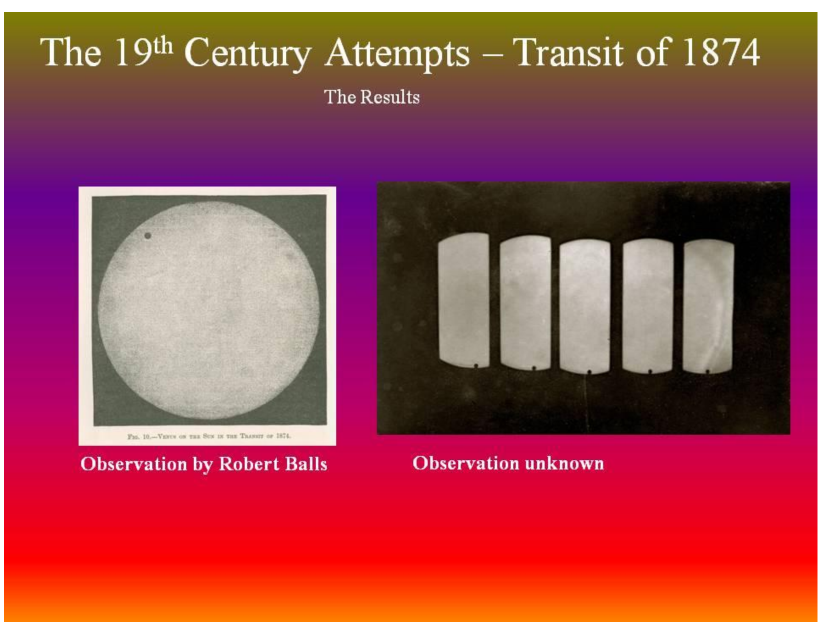
The 1874 Venus Transit was successfully observed from numerous world-wide locations by both the new and old world powers, employing both the traditional visual observation utilizing 3 – 6" refractors, along with various photographic equipment, including the new Janssen Revolver camera. Within hours of their observations, preliminary reports began to come in over the telegraph to all the world's astronomical societies. Still it would take several months for the more remote island observations to make it back to civilization. Then began the calculations of adjusting the multitude of visual timings to common formats and the processing and careful measurements of all the photographic images captured.

Soon it became apparent that the curse of the 18th century had struck again!
The Black Drop effect once again allowed errors to creep into the individual astronomers visual observations. Even worse, almost all of the photographic images suffered from fuzziness, even when magnified, and led to guesswork when trying to bisect the limb using a micrometer. Not even the motion picture Revolver cameras were able to capture enough steady single images to be conclusive. Astronomer Royal George Airy was so disappointed with the British photographic observations, that he didn't even bother to publish any of them!





As the various astronomical transit commissions from across the globe began publishing their calculated AU results in late 1875, the numbers were all over the place, depending on who did the calculations and what observations they used, with the average being somewhere around 92 million miles. In the end, there was just too much data from too many observing stations. So much, that no one ever attempted to use all of the visual timings, micrometer measurements, and photographs rolled into one definitive calculation. Once again, the attempt to use a transit of Venus to establish a truly precise value for the Astronomical Unit, (AU), was deemed a failure.
The Astronomers of the 19th century would have one more change in eight years to get it right.



6) The 19th Century's Last Try – 1882 Transit - Photography will save the day.

Now with the unexpected poor results of the 1874 transit behind them, a number of professional astronomers and countries around the world began to lose interest in using the Venus Transit as a method to calculate the AU. Several competing alternate methods were being advocated as replacements. That of French astronomer Leon Foucault in developing equipment to accurately measure the speed of light, which in turn using that to accurately calculate the distance to Jupiter's Moons during their eclipses, which could then be used to calculate the AU. Or the method put forward by British astronomer David Gill in using the planet Mar's changing position among background stars during a close opposition to calculate the solar parallax.

But, with the start of the 1882 transit being visible from most of Europe, and the entire event visible from the Eastern half of North American, public interest ran very high. This was fed by numerous magazine and newspaper articles, and even composer John Philip Sousa wrote an orchestral piece titled – 'Transit of Venus March'. Anyone with a telescope or even a smoked piece of glass was determined to catch a view of the transit. Everyone, Adults and children were encouraged to try and view a 'once in a lifetime' event.

A: Countries and Astronomers involved

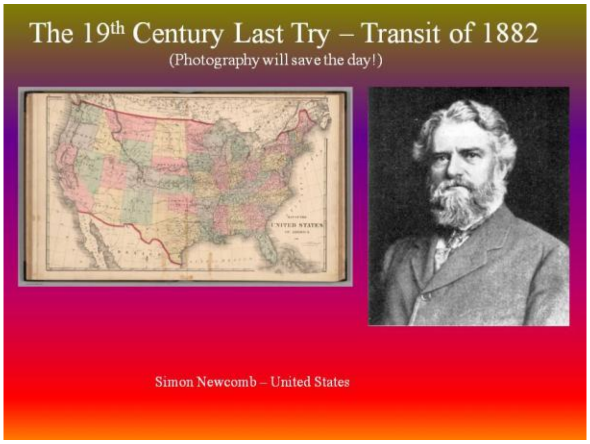
This surge in public interest served to spur the professionals into taking advantage of the last Venus Transit in their lifetimes to make one more effort in determining the AU from a transit.
Most of the national 1874 transit committees were still in existence, and the professional astronomers had been honing their skills by observing the 1878 & 1881 transits of Mercury, along with a number of solar eclipses prior to 1882. Due to the failure of photography during the 1874 transit, a number of countries, including England and Germany decided to abandon photography and revert back to visual timings. Russia decided to not participate at all. But recognizing that 1882 was their last chance, a total of 45 overseas transit expeditions were organized to the areas of the Caribbean, South Africa, Australia, New Zealand, and South Georgia Island.

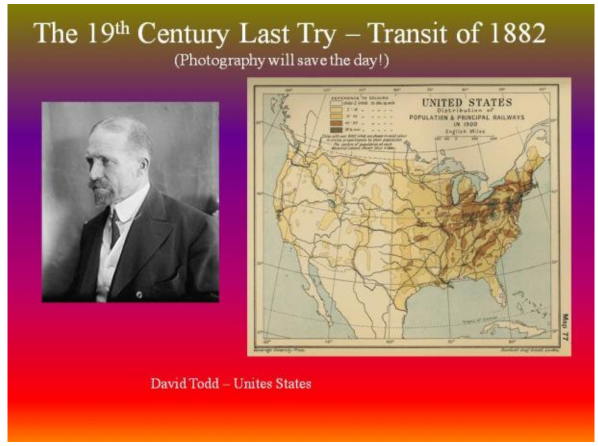
George Airy: Astronomer Royal – England (Greenwich Observatory) Once again, as the head of British astronomy, Airy continued his world-wide organizational efforts, but he focused on visual methods. Airy stated that the British , "due to the apparent general failure of the photographic principle, they were unwilling to spend further time on it'. While the British mounted a number of overseas expeditions to Bermuda, Jamaica, New Zealand, Australia, and several islands in the Indian Ocean, many British astronomers planned on staying in England at the major observatories where the initial contact events would be visible.

Rev Stephen Perry: Astronomer – England (small island off the coast of Madagascar) Father Perry once again led one of the two British Indian Ocean expeditions. He picked a tiny island off the southwestern coast of the main island of Madagascar.

The United States Transit Commission: with the 1882 transit falling all across the east coast thru the mid-west, a number of the world's best known astronomers could easily plan on viewing the transit from among some of the foremost major observatories of the day. In fact the US would host a number of foreign transit expeditions including those from France and Germany. The Americans planned to go full-out in using photography for the transit, using the latest state-of-the-art dry plate technique, along with the older style wet plates.

The Americans decided to send major transit observing parties to San Antonio, Texas, Cedar Keys, Florida, Fort Selden, New Mexico Territory, San Francisco, Santa Barbara, and the future site of Lick Observatory on Mt Hamilton, in California. They also sent overseas expeditions to South Africa and New Zealand.





Simon Newcomb: Astronomer – USA (Cape Town, South Africa) The head of the US Naval Observatory's transit planning. While Simon was one of the professionals who no longer believed that using a Venus Transit was the best way of calculating the AU, he still would lead an overseas American expedition to Cape Town, South Africa.

David Todd: Astronomer – USA (Mt Hamilton, Ca) Todd was a young upcoming astronomer employed at the Naval Observatory by Newcomb as an observer and to help with calculating the results of the 1874 Venus Transit. While there, he assisted Asaph Hall in discovering the moons of Mars in 1877. Todd left the Naval Observatory in 1881 to head-up the small observatory at Amherst College. He was selected by Richard Floyd, president trustee of the Lick Observatory project to come to the site of the proposed observatory on Mt Hamilton, CA to operate a special horizontal photoheliograph built specifically to photograph the Venus Transit of 1882.

The German Transit Commission: In addition to home teams, they sent overseas observing parties to Argentina and the United States.

The French Transit Commission: in addition to planning observations at the major national observatories in Paris and elsewhere, they sent astronomers to Mexico, Chile, Haiti , and North Africa.

Jules Janssen: Astronomer – France (French Algeria) This time around, Janssen took his Revolver camera to French Algerian territory in Northern Africa.

In addition to the above major countries, Mexico, Brazil, and Argentina also planned transit activities at their major national observatories, and New Zealand and Australia planned to observe third and fourth contacts from their home observatories.

B: What happened on Transit Day

On the cold winter day of the transit, December 6th, 1882, schools along the Eastern US closed. Some rang their bells or fire alarms to signal the start of the transit. Amateurs and college observatories setup telescopes in all the large cities and some drew sizable crowds that the local police had to come to keep order in the long lines of people waiting to look thru the telescope. Even the brokers on Wall Street took a break to look thru a telescope setup near the stock exchange. (a few telescope owners made quite a killing, charging 10 cents a view). Some of the upcoming astronomers who helped out with the public effort included E.E. Barnard at Vanderbilt University, John Rees at Columbia University, and Maria Mitchell at Vassar College. Locally, Samuel Langley at Allegheny Observatory in Pittsburgh enjoyed a view of the transit thru scattered clouds. Unfortunately, across Europe, where hundreds of astronomers scattered among the Old World's major observatories were unable to see the event due to the winter weather.

George Airy: Astronomer Royal – England (Greenwich Observatory) Airy, along with all the British astronomers who stayed home in hopes of observing the transit, were clouded, rained, or snowed out at Cambridge, Oxford, Greenwich, and elsewhere. But the British overseas teams had good success in timings at their locations in the Caribbean and New Zealand and Indian Ocean.

Rev Stephen Perry: Astronomer – England (small island off the coast of Madagascar) Perry's pick of the small island off of Madagascar in the Western Indian Ocean proved to be good, as he was able to successfully observe ingress.

The United States Transit Commission: had numerous successfully timings and photographs of the entire transit start-to-finish, from across the states, with some of the best timings made by George Davidson at Fort Selden, in the New Mexico Territory. The overseas expedition to Auckland New Zealand led by Edwin Smith, successfully timed egress and obtained 74 photographs.

Simon Newcomb: Astronomer – USA (Cape Town, South Africa) Newcomb had setup about 40 miles out of Cape Town in a girl's school, where he had some of the best views of the Sun that he had ever seen, and made successful visual timings and photographs.

David Todd: Astronomer – USA (Mt Hamilton, Ca) As the sun rose that morning, the transit was already in progress in a perfectly cloudless sky. Todd worked the horizontal photoheliograph, while Lick Observatory trustee Richard Floyd visually observed with a 12" refractor. Todd acquired 147 plate images of the transit thru third and forth contacts. His photographs at the time were considered to have been the sharpest obtained anywhere of all the 1874 and 1882 transit expeditions, and are the best set of photographs that have survived from the 19th century transits. In later years, Todd became a prolific solar eclipse observer, going on 13 overseas expeditions across the globe.

The German Transit Commission: while the Sun was low at the start of the transit, the German home teams, had clear skies and made successful observations, including those of Herman Vogel at the Potsdam Observatory.

The French Transit Commission: the French teams that stayed in-country were also clouded out or rained on in Paris and Bordeaux, but some observers were able to make visual timings and photographs thru breaks in the clouds. All of the overseas teams were able to successfully observe the entire transit, including those in Port-au-Prince, Haiti, and Santiago, Chile.

Jules Janssen: Astronomer – France (French Algeria) Janssen was once again able to successfully observe and capture multiple photographic images of the start of the transit.

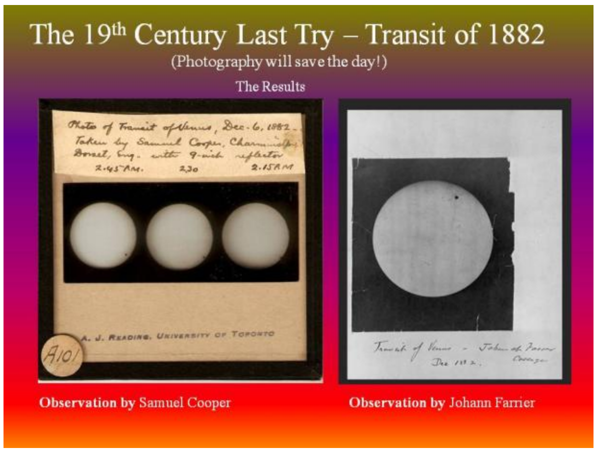
In addition to the above major countries, the start of the transit was observed throughout Italy and as far east as the Athens Observatory in Greece. The entire transit was also successfully observed by astronomers from the observatories in Central and South America, including the Brazilian emperor himself. The transit parties in New Zealand were successful in observing egress, but Australia had mixed results as Sydney and Brisbane were clouded out, but Melbourne and Hobart had clear skies.

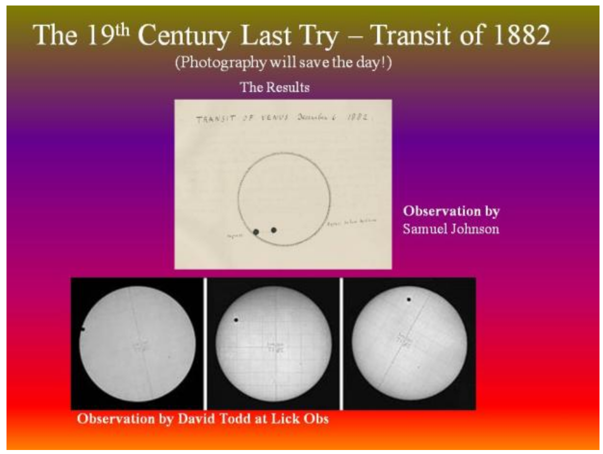
C: The Results

Again, the "black drop" limited the precision of the observations and the determination of the Sun's distance, even with using photography!The black drop effect was long thought to be due to Venus' thick atmosphere, and it was held to be the first real evidence that Venus had an atmosphere. Modern analyses showed that the "black drop" is really an optical effect caused by the smearing of the image of Venus by turbulence in the Earth's atmosphere or imperfections in the telescopes used in the observation. The final calculated values fell across a wide range, with the average again being somewhere around 92 million miles. (very close).

Once again, the overall astronomical goal was deemed a failure.

Astronomers came to the conclusion that obtaining the AU from a Venus Transit, even using photography, would never be as precise as they wanted. Because of this, even fewer AU calculated results for 1882 were published than for the 1874 transit.





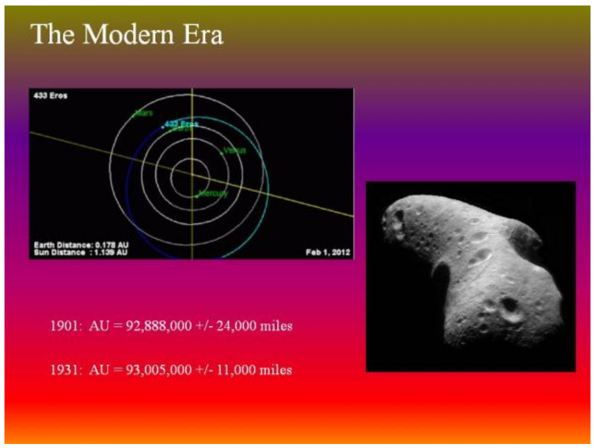
But for the first time, a Venus Transit was observed by millions of common people, and inspired many to a lifelong interest in astronomy, including a five-year-old Henry Russell from Long Island, who went on to become the leading American astrophysicist of the early 20th century.

So, in a way, the 1882 Venus Transit was a success, as it led to a higher level of public involvement in astronomy and funding of professional observatories across the US.

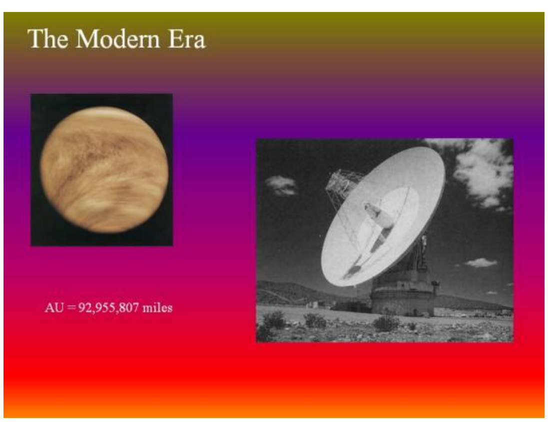
7) The Modern Era

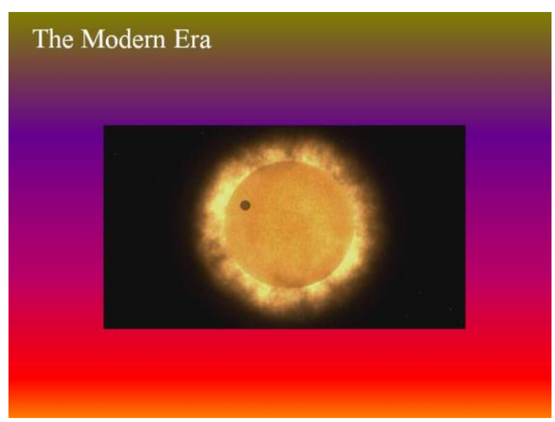
A: Now it's just for fun: The AU has been calculated by other means.

Over the decades, since the last Venus Transit in 1882, better methods of calculating the AU were worked-out, including using the stellar parallax observations of close approach asteroids.
In 1901, the asteroid Eros came within 30 million miles of Earth, and after careful visual micrometer and photographic measurements by several dozen professional observatories from around the world, the AU was calculated to equal 92,888,000 +/- 24,000 miles.
Then in 1931, Eros again made a close approach of only 26 million miles to Earth, and once again was widely observed, with almost 3,000 images taken.
Based on these observations, the Au was then calculated to equal 93,005,000 +/- 11,000 miles.



Finally, in 1958, engineers from MIT bounced radar signals off of the planet Venus.
Then in 1961, astronomer Rich Goldstein from Caltech was able to accurately time the radar bounces between Venus and Earth, and using the known value for the speed of light, was able to precisely calculate the distance between the two planets, and from that definitely calculate the value of the Astronomical Unit. Today, we know that one AU is equal to 92,955,807 miles, which is Earths average distance from the Sun.



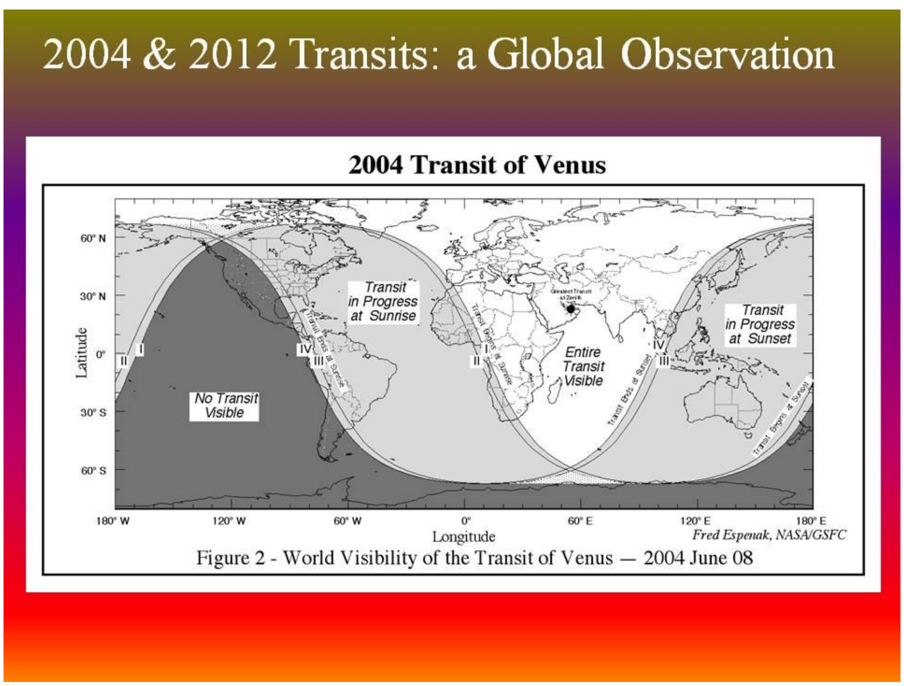


With the distance to the Sun and planets now measured extremely accurately using radar, the 21st century's round of transits lost much of its scientific importance. Still, it is a remarkably rare event which was worth observing in its own right.

B: the 2004 and 2012 Transits: a Global Observation.

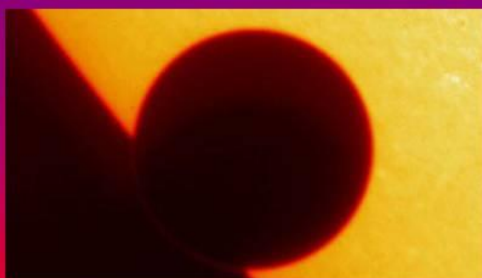
Over the last 25 years we've seen great advances in affordable amateur astronomy solar equipment. From 1000 Oaks optical glass WL filters, to Baader solar film, to Lumicon Prominence filters, to Daystar T-Scanner Ha filters, to Coronado PST & Cak dedicated solar telescopes, to the new line from Lunt.

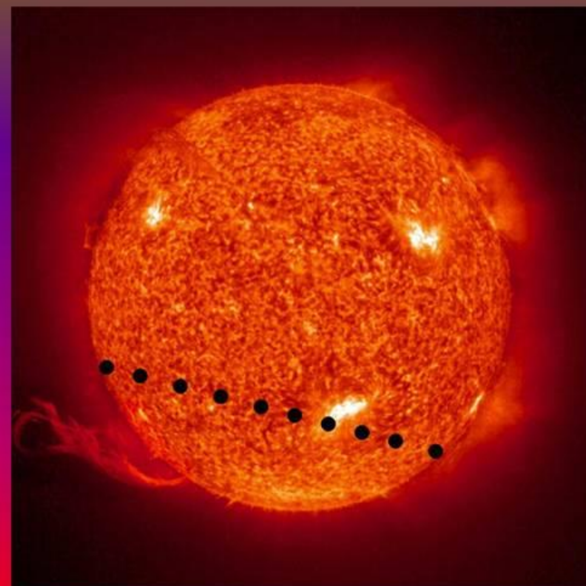
There were also the corresponding advances in imaging equipment, from CCD cameras to digital SLR's, to video and webcams that gave amateurs easy-to-use tools in capturing images of the transit.Today's amateurs heading into the Venus Transits had available to them equipment that the professional astronomers over a 100 years ago couldn't even begin to dream of.



In 2004, millions of people across the globe observed some portion of the transit.
Here in the US, the June 8th 2004 transit started in the early morning hours before sunrise, and was close to being over when the Sun finally rose on the East Coast around 7:00am. We had less than 45 minutes of transit, but still we were able to observe the egress – third & forth contact.

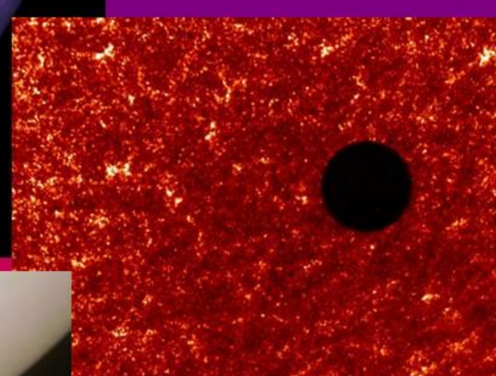
2004 & 2012 Transits: a Global Observation





NASA - 2004

2004 & 2012 Transits: a Global Observation

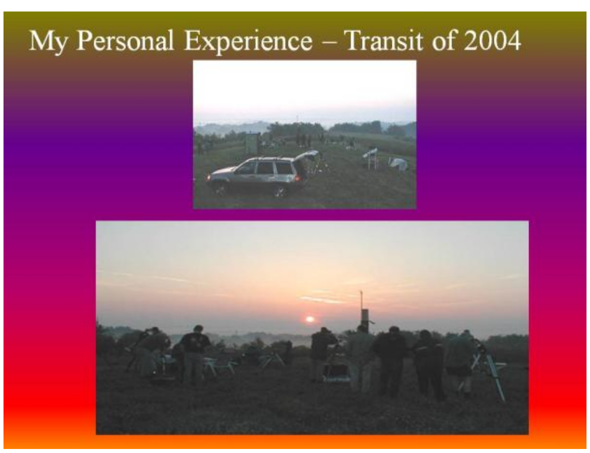


NASA - 2004

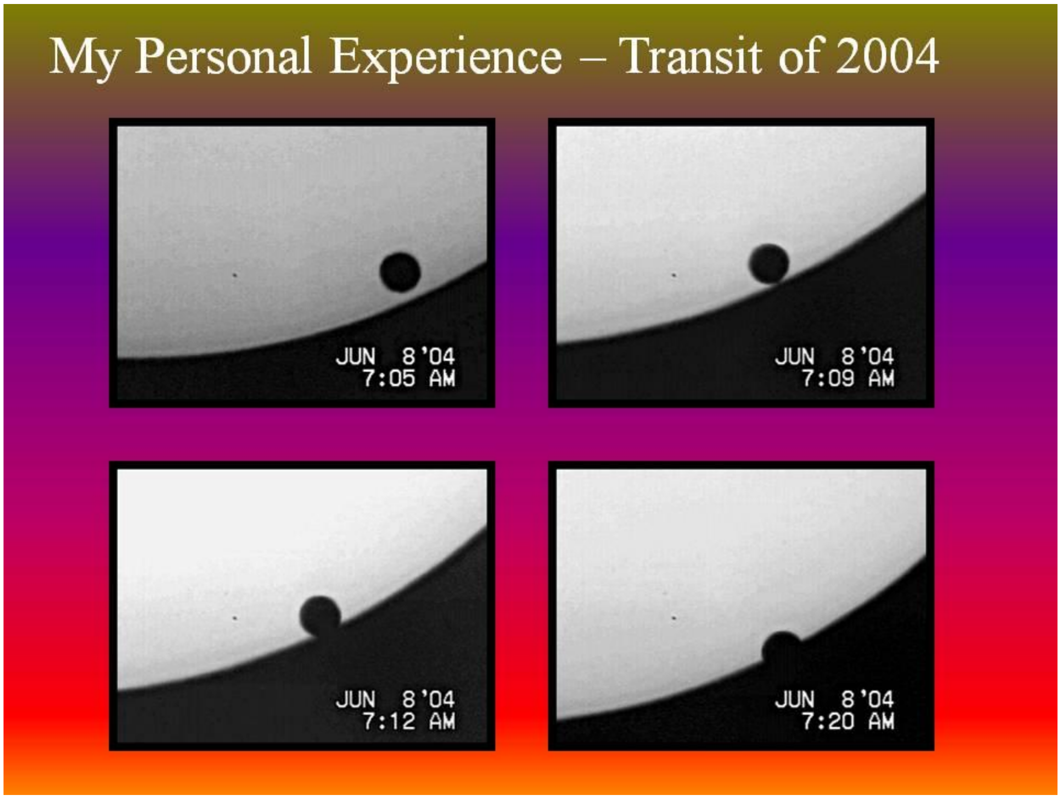
C: **My personal experience.**

2004: *Tuesday, June 8th, 2004:*
Equipment used: 8" Celestron Ultima SCT (f10).
Lumicon 1.5 A H-alpha solar filter
AstroVid StellaCam EX, 1/2" CCD with 600 line resolution.

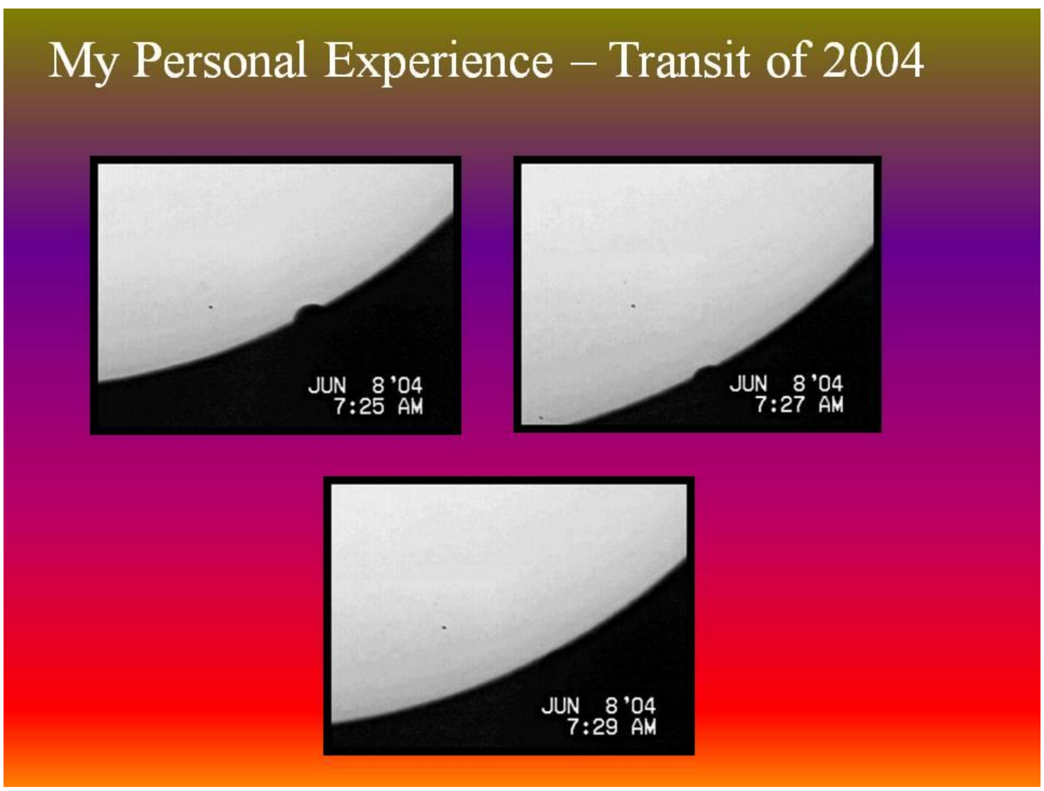
On the early morning hours of June 8th, 2004, about 50 amateurs and public set up their solar telescopes at a local Pittsburgh area observatory to witness a rare transit of Venus.
There was some concern, as the morning haze was thick on our eastern horizon, but right at 7:00am, the Sun broke out of the cloudbank it was hiding in. A big wave of excitement rolled over those gathered as they trained their telescopes on the Sun, followed by various exclamations as to how big Venus looked silhouetted against the disk of the Sun!



The joy of seeing the transit was quickly overshadowed by the realization of how close it was to the time for Venus to exit the Sun. Using my solar and video equipment, I quickly gave a 'live' video presentation for the group.I was able to videotape the 3rd & 4th contact, and had beautiful views on the TV screens where more than one person could watch at a time.

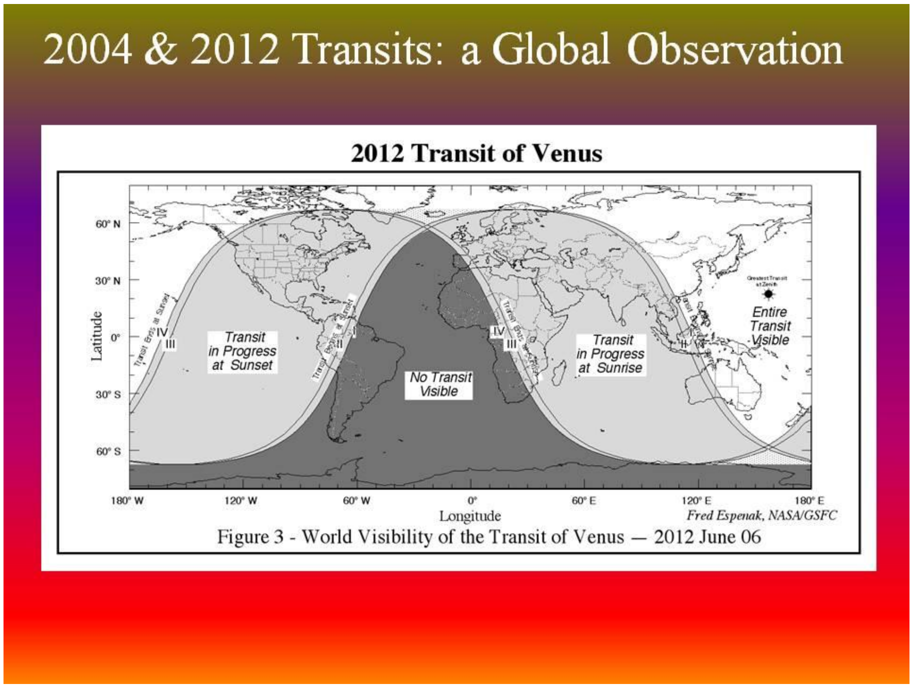


Within a half-hour, it was all over! But, we had witnessed an amazing event!
After about an hour of walking around congratulating one another, and replaying the videotape multiple times, I packed up and went home.



D: the 2004 and 2012 Transits: a Global Observation…. Cont.

The 2012 Venus Transit was observed by an estimated 1 billion people with over half the world being able ‘to directly observe some part of the transit, and the rest having access to online viewing over the internet.



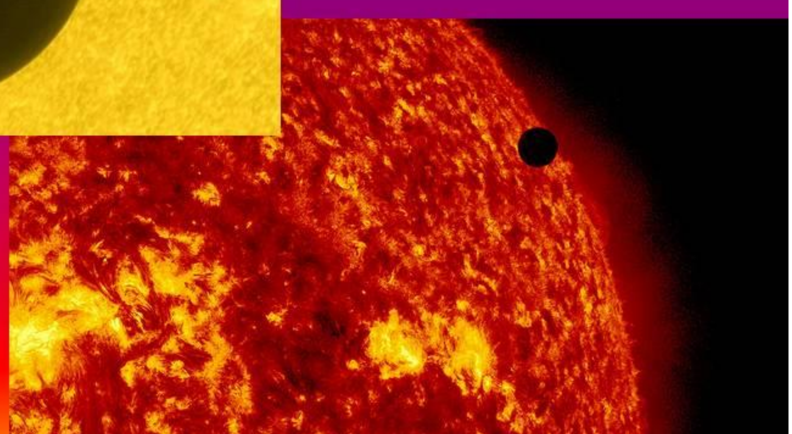
For example, NASA ran a HD live video stream for the entire 6-hour 40 minute event using White-Light, H-alpha, and Calcium-K solar telescopes from the 13,800 ft summit of Mauna Kea Observatory in Hawaii. The broadcast included live interviews of solar and planetary astronomers from various agencies. The feed was even briefly carried over the major nightly broadcast news programs. The national science academies of numerous other countries, such as India, Australia, and Great Britain, also broadcast portions of the transit. Over 20,000 amateur astronomers worldwide participated by sending images.

Once again, here on the East Coast, we were only able to observe the initial stages of the transit, with Ingress – first & second contact starting a few minutes past 6:00pm and lasting till sunset at close to 8:30pm. So even though we never got to see a transit in its entirety, those of us on the East coast did get to see the most exciting portions – ingress & egress, spanning two transits.

2004 & 2012 Transits: a Global Observation

NASA - 2012

2004 & 2012 Transits: a Global Observation



NASA - 2012

E: My personal experience….Cont.

2012: *Tuesday, June 5th, 2012:*

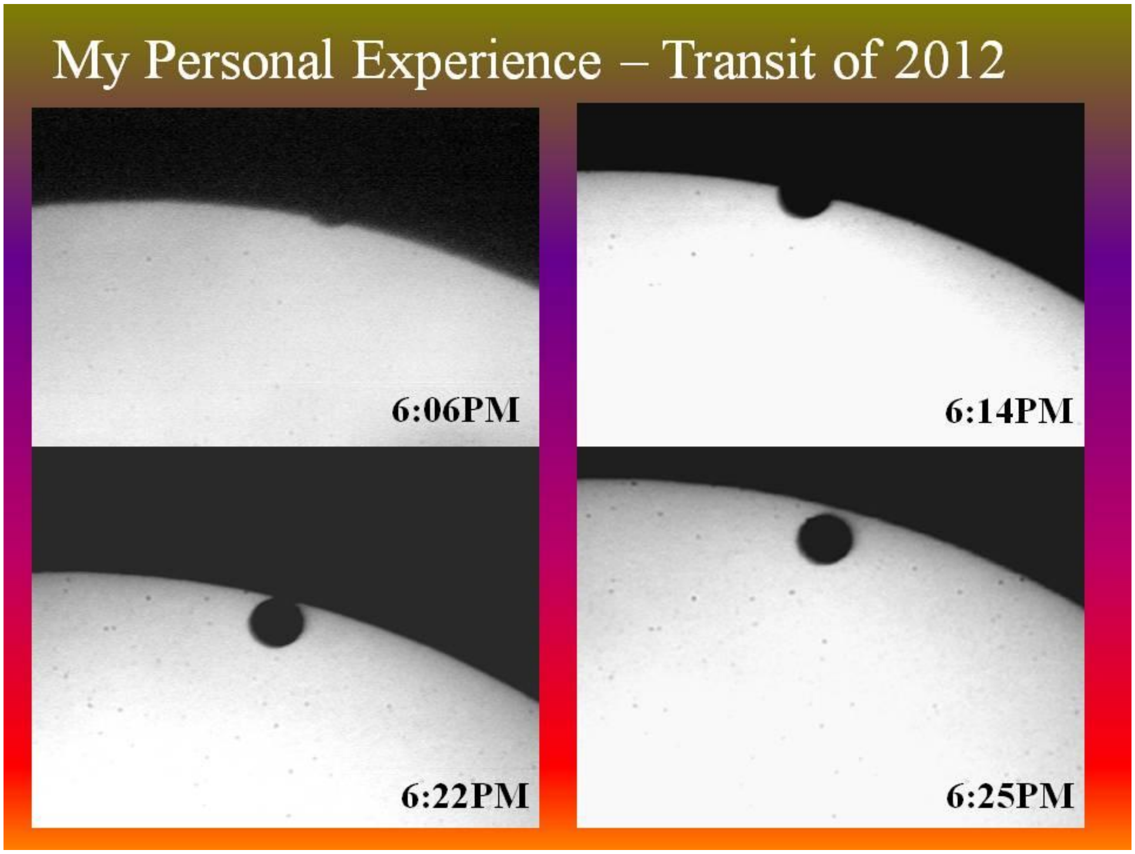
Equipment used: 8" Celestron Ultima SCT (f10). Daystar T-Scanner .6A H-alpha solar filter & StellaCam-3 1/2" CCD videocamera and a 40mm Coronado PST Cak with a Sony Super HAD B&W CCTV 1/3" CCD videocamera.

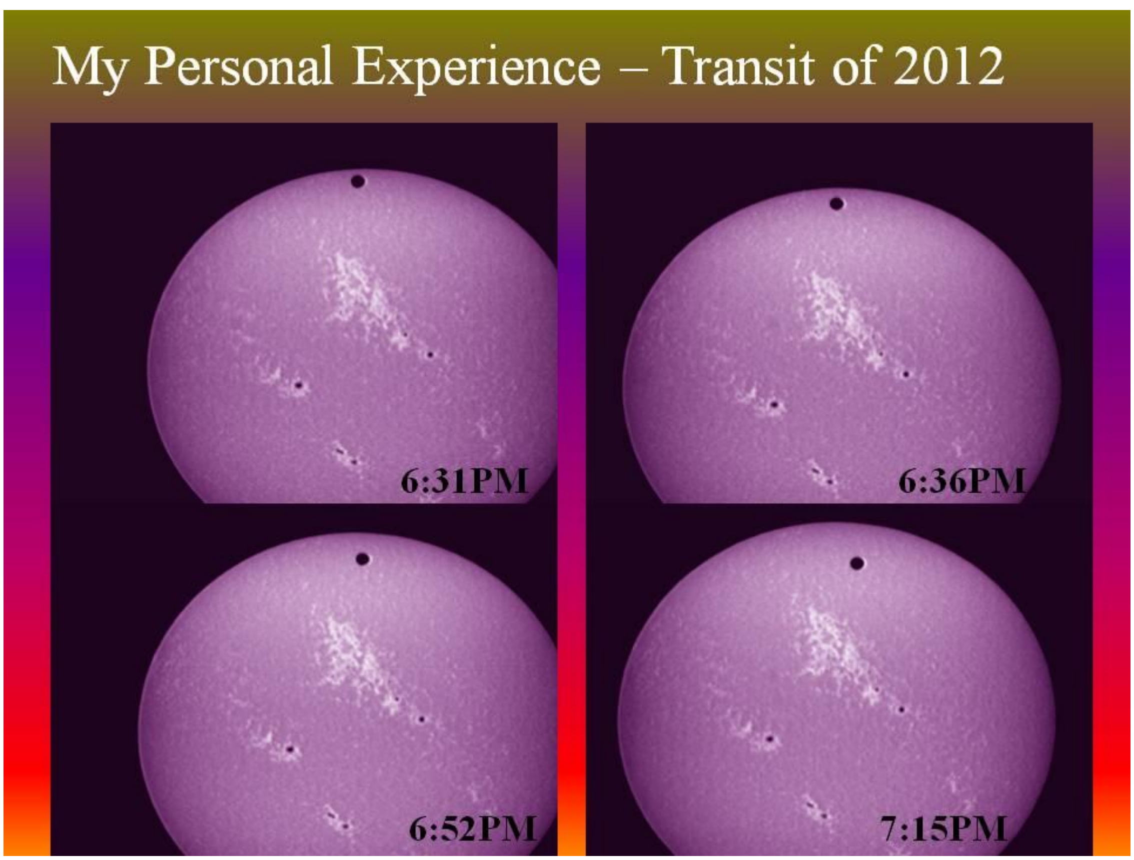
The day of the transit, a large cloudy weather pattern rotating in from the north-east had settled over the western PA region. The local Kiski club Transit party was soon cancelled, and I spent the early afternoon frantically looking for a break in the clouds within driving distance.
Both of my alternate observing sites were engulfed in the cloud cover. I was about ready to give-up and begin unloading my car, when Gary, the organizer of the club Transit party called me.
He had just gotten off the phone with Denny, another Kiski member, who noticed on the satellite images that a thin band of shoreline around Lake Erie was in the clear. It was a 'Reverse Lake Effect'! As the clouds traveled over the lake, they evaporated, but then reformed shortly after hitting land. Denny had passed that info on to Gary, who called me with a great location the he knew was right on the lake shore. As soon as I hung up the phone with Gary, I realized that if I didn't leave 'now', I would not have enough time to make the drive. So I sent out a quick email to the club and jumped in my car and drove like a nut up I-79. I arrived at the North East Marina at 5:10pm to find mostly clear blue skies along the shore with a bit of a breeze coming in off Lake Erie.
After picking out a spot in the grassy 'boat parking area', I proceeded to setup.

Had everything ready to go by 5:50 (except focusing the cameras) when the only grouping of clouds in the sky decided to 'park' right over-top the Sun.Finally, they thinned out enough for me to get the C8 on the Sun and the StellaCam-3 camera focused.
I Realized at that point I had missed 1st contact by less than two minutes.

Right about then a group of visitors stopped in, so between answering questions, starting up the camcorder to record the C8 StellaCam video feed,and getting the PST Ha scope pointed at the Sun on a separate tripod, I didn't get the PST Cak focused and video-capturing until after 2nd contact.

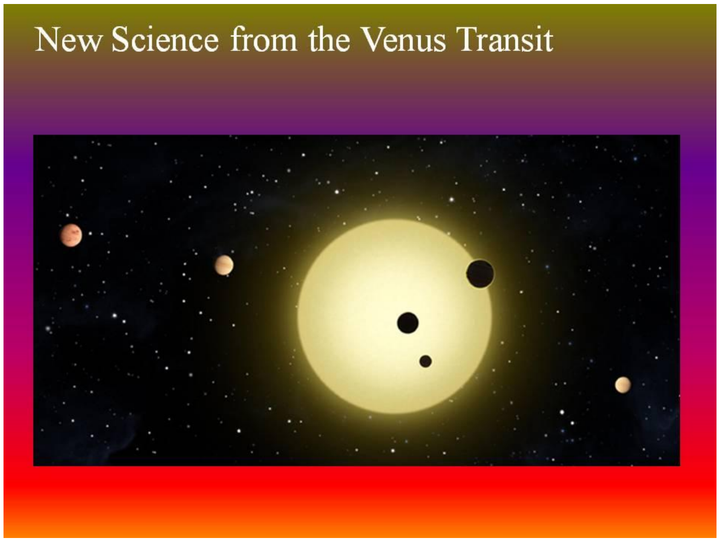
At that point the sky had completely cleared off, and the breeze had died down. A perfect late afternoon! Was able to following the transit until the Sun reached the tree line, around 8:25pm.
On the drive home, was treated to a beautiful sunset over the lake.
I was fortunate enough to once again witness an amazing celestial event!!!


My Personal Experience – Transit of 2012
6:06PM
6:14PM
6:22PM
6:25PM

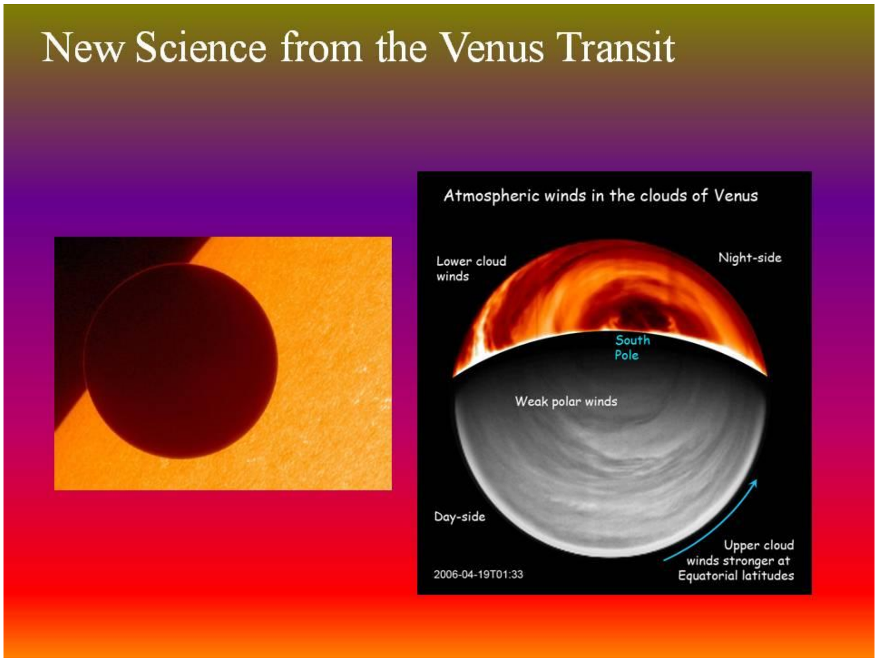

My Personal Experience – Transit of 2012
6:31PM
6:36PM
6:52PM
7:15PM

F: New Science from the Transit

A number of years back, scientist realized that like Venus, plants in other solar systems would also transit their own suns.From our perspective, Venus only blocks about .1% of our Sun during a transit. A similar planet orbiting another star would be much too far for us to visually observe, but sensitive instruments could be designed that could detect the miniscule drop in brightness of that distant star. This concept was proven in 1999 when a gas giant sized planet was detected transiting a G class star HD20948. Since then more than 230 exo-planets have been detected by using the transit method. Using data from the recent Venus transits, scientists are fine-tuning their detection software used by the Kepler Space Telescope, and hope to be able to detect Venus sized exo-planets sometime in the next 3 years.



Additionally, ground based observations of the small sliver of Venus's atmosphere visible during 2nd & 4th contacts, along with data from NASA's SDO & ESA's Venus Express orbiter was successfully used to refine wind models of Venus's upper atmospheric mesosphere layer.
So, in a way, even after 252 years, the Transits of Venus continue to be scientifically important. Hopefully, they still will be 104 years from now, when we enter the next Venus Transit 'season'.



8) Conclusion – What Next – December 10th 2117.

It's been a year gone by now since the June 2012 Venus Transit.
The worldwide excitement of that day has started to fade, and with the realization that another transit season will not occur this century, it's become a little bittersweet thinking about the observations of 2004 & 2012. But reading about the early astronomers involved with the Venus Transits over the centuries, and learning their adventures and stories still gives me inspiration, and leaves me with a feeling that I, as an amateur astronomer 350 years after Jeremiah Horrock's 1st brief observation, was able to stand on the shoulders of giants, and successfully observe and understand what they struggled and sacrificed to obtain.

I hope that 100 years from now, future amateur astronomers will look back to our time and our observations for a similar inspiration, and they keep the tradition alive of observing the Venus Transit!

Who knows what wonder observing tools that they will have available:
X-Ray glasses with zoom lens.
Or if it's cloudy, just get in their "George Jetson" flying car with the family and head for orbit.

Credits:

"Chasing Venus – The Race to Measure the Heavens" by Andrea Wulf
"Transit of Venus – 1631 to the Present" by Nick Lomb
"The Transit of Venus"by William Sheehan and John Westfall
"The Suns Heartbeat" by Bob Berman
"The Astronomical Scrapbook" by Joseph Ashbrook
"A short History of Nearly Everything" by Bill Bryson
"Sky & Telescope" magazine – January 2012, June 2012, October 2012
"Astronomy" magazine – June 2012
"Astronomy Technology Today" magazine – March-April 2012
"Reflector" magazine – September 2012
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