Carl,

This is as far as I've gotten. I decided not to interweave the descriptions of the portrait images with the rest of the text. When I finally sat down to do it, it didn't seem to fit in. As I've indicated below, we can either include these descriptions (and whatever basic diffraction or imaging physics we can pull out of them) in the text in one contiguous piece or relegate them entirely to the figure captions.

Let me know if you want me to continue a bit further ... it's obviously not completed ... or if you want to take over from here and them submit a second draft back to me or both. As an example, if we keep the portrait description in the text, then I can be working on this while you fill in the history.

It was good seeing you and Annie again, and thanks for a most entertaining evening. Kisses to Sammie and Alex.

Ciao,
Carolyn

On February 14, 1990, in a final parting salute to its place of birth, the Voyager 1 spacecraft directed its cameras to take one last historic array of planetary images. Sitting high above the ecliptic plane, eight and a half years beyond its last planetary encounter, and XX astronomical units from the Sun, Voyager intercepted and executed a set of Earthly instructions to acquire 60 individual exposures of Venus, the Earth, Mars, Juptier, Saturn, Uranus, Neptune, the Sun and the vast nothingness in between. This deceptivly simple sequence of commands, the last of 67000 images taken by both Voyager 1 and its sister craft, Voyager 2, in their epic journeys across the solar system, capped an unprecedented decade of discovery, characterized by a broadening scientific vision of what lay beyond the neighborhood of earth.

The Voyagers had been launched in the summer of 1977. One by one, over the course of 12 years, the planetary systems of Jupiter, Saturn, Uranus, and Neptune were laid bare under their watchful gazes. Ironically, the very culture which had constructed and launched the Voyagers was, during this time, becoming increasing mired in political myopia and economic uncertainty, and began showing signs of retreat from its once grand plan of planetary exploration and eventual human colonization. While the Voyagers sped past the giant planets of the outer solar system, political, economic and social changes occuring back here on Earth were making it increasing unlikely that a space-faring vehicle with a scope and mission as broad as Voyager's would ever again make it from the drawing board to the launch pad.

The portrait of the Sun's family of planets taken in the winter of 1990 was composed to capture and convey the magnitude of the Voyagers' journeys. Its purpose was to place before us an interplanetary perspective, won by millenia of evolution in human thought and self-awareness and the toils of those who had dreamed and worked towards reaching the planets. It was to be a perspective of our small and ever-shrinking place in the ever-widening view of one of our most distant and distinguished emissaries. [[Is this too romantic?]]

The portrait concept was originally conceived in 1981, when it was feared that Saturn would be the last planet paid visit by Voyager. By this time, both Voyagers had flown through the planetary systems of Jupiter (in March and September of 1979) and Saturn (in November 1980 and August 1981). In reaching these two largest and closest planets of the outer solar system, Voyager had accomplished its primary mission, but it was as such a reduced version of a much grander scheme proposed in the late 1960's. [[The history of the Grand Tour concept and the evolution of MJS. Proceed with political events during this time, up to and including 1981 when (I think) Reagan proposed setting the Voyagers adrift.]]

A picture taken of the Earth by either Voyager spacecraft in 1981 would not be terribly remarkable in its scientific merit or visual detail. The two Voyagers carry identical imaging systems, consisting each of two cameras of differing focal lengths and fields of view backed by a selenium-sulfur vidicon detector -- much less sensitive than the charged couple devices (CCDs) flown on interplanetary spacecraft today. The camera with the higher resolving power -- a

reflecting `narrow angle' telescope with a 1.5 meter focal length and a Ø.4 degree field of view -- was designed to image bright planetary objects from a distance of a few tens of thousands of radii and closer, but not for resolving the Earth from a distance of 1.5 billion km. Nonetheless, Voyager imaging team scientists felt strongly that a photo containing even an unresolved image of Earth and, if possible, one or more of the other planets, would be useful in illustrating the remarkable distances traveled by the Voyagers and the Earth's place within the solar system.

A proposal was developed by imaging team scientists to use Voyager 1, on its way out of the solar system after its encounter with Saturn in November 198Ø, to acquire an image of Earth which, if properly timed, might also contain Jupiter and Saturn within its wide angle camera's field of view. Voyager 2 had already been earmarked for rendezvous with Uranus and Neptune later on in the decade, and its cameras and other remote sensing instruments boresighted with the cameras could not be jeapardized by pointing as close to the sun, ~ 6 degrees, as the Earth image necessitated.

This restriction did not apply to the Voyager 1 remote sensing instruments which, except for the ultraviolet spectrometer (UVS), would never be used again, and the UVS team voiced no concern about being sun-directed. A formal request to take a single image of the Earth, Jupiter and Saturn was made to the Voyager Project management at the Jet Propulsion Laboratory in the summer of 1981.

Though the Voyagers had been astonishing in their successes at Jupiter and Saturn, the Project was certainly not immune to the budgetary problems afflicting NASA and the rest of the country. Immediately after the Voyager 2 Saturn encounter, Voyager personnel staffing levels at JPL were scaled down for the long, relatively inactive cruise to Uranus. Resources which might have been used for spacecraft experiments during this time were woefully scarse. Moreover, without some promise of genuine scientific return, the Project would not agree to expend what limited resources were available on the portrait experiment. The request, deemed frivolous, was ultimately denied.

By 1985, circumstances had changed. On the political/economic front.... [[some background history here]].

However, in the scientific arena, two astronomical phenomena were fast becoming hot topics of discussion. In 1983, the Infrared Astronomical Satellite (IRAS) had discovered bands of fine dust centered on the ecliptic, XX degrees in thickness as seen from the Earth, and very likely confined to the asteroid belt (reference). Voyager imaging team scientists recognized that Voyager 1, now sitting 30 degrees above the ecliptic and 31 AU from the SUN, had an excellent and unique vantage point from which to image these bands and proposed that the Voyager 1 cameras be turned towards the asteroid belt to do just that. The scientific justification: to extract information on particle sizes and heliocentric distance on which IRAS data were ambiguous. Having clear scientific content, this proposal was being greeted favorably, if cautiously, by Project management.

While the arguments and design for a Voyager dustband image sequence were being developed, Comet Halley was nearing perihelion for the XXth time in recorded history. Voyager scientists saw an opportunity for stereoscopic analysis on the comet's tail by acquiring Earth-based images of the comet and an image taken simultaneously by the Voyager 1 spacecraft. If, perchance, the comet image could be taken when the Earth and other planets were in the same field, then the Earth portrait could hitch a ride on this more scientifically-justifiable experiment.

The observations of the asteroid dustbands and a combined protrait of Halley's Comet, the Earth, and Mars, were submitted to the Voyager Project as a single request with a double science objective in the summer of 1985. The request, again, was denied: preparations for the upcoming Voyager 2 encounter with Uranus in January 1986 made critical personnel unavailable to design and execute the rather tricky manuever and image design. By the time the Uranus encounter was over, the observation had been whittled down to a series of images of the dustbands alone, an observation that was successfully made in March, 1987. The Earth portrait was postponed again.

Voyager 1 continued its retreat out of the solar system, but Voyager 2 was now on its way to Neptune; . [[Historical events here. End on Neptune encounter in August 1989]]

Two more requests for the Earth portrait -- one in the summer of 1988, and another in early 1989 -- were again denied. When finally NASA in Washington, D.C. gave a full endorsement of the portrait image, which by mid 1989 had evolved to include a mosaic of all 9

planets (if possible) as well as an image of the Sun, the Voyager Project management could no longer refuse. The 60 images comprising the portrait of our solar system were taken in February of 1990.

[[Description of portrait images could start here, or could be completely relegated to the figure captions. Which should we do?]]

Its planetary reconnaissance duties completed by summer's end of 1989, Voyager 2 joined Voyager 1 in entering the final `interstellar' phase of its mission. The instruments designed to obtain in situ measurements of magnetic fields, plasma waves, and charged particles would now gather information about the nature of the Sun's magnetosphere beyond the orbit of Pluto and, if they lasted long enough for Voyager to cross the heliopause, about the interstellar medium as well. Models of the Sun's magnetic field predicted that the heliopause was probably located XXX AU from the Sun. [[check this]] Voyager X, traveling close to the apex of the sun's motion about the galaxy, would reach this distance by the year 2015; Voyager Z, in the year ZZZZ.

In 1992 and 1993, in a surprising and unanticipated discovery, the Voyagers detected plasma waves, generated by strong solar flares, being reflected off the heliopause. [[I don't know much about this observation. Is this all correct?]] Using simple triangulation and the times of the arrival of these waves at both spacecraft, Voyager scientists have placed the heliopause at XXX AU. [[to be continued]]