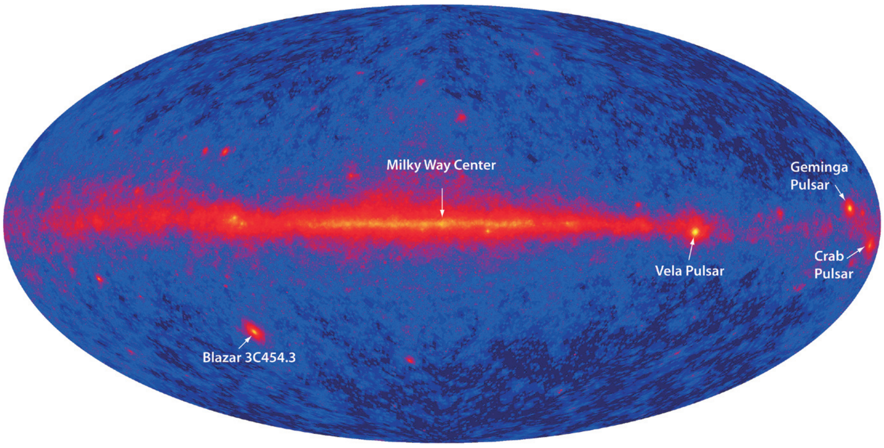
A New Window on the Universe has Opened

First Light for Fermi Gamma Ray Space Telescope

On August 26 2008, first light results of the Gamma-Ray Large Area Space Telescope (GLAST,[1]) were announced jointly by NASA and the US department of energy . At the same time GLAST changed its name to *Fermi* Gamma Ray Space Telescope.



Fermi Gamma-ray Space Telescope "first light" all-sky gamma-ray map

Fermi GRST is a high-energy gamma-ray observatory, designed to explore some of the most energetic phenomena in the Universe and enhance our knowledge of fundamental physics, astronomy, and cosmology. Fermi is expected to discover thousands of new sources of different classes, thus tackling many unresolved questions of modern physics.

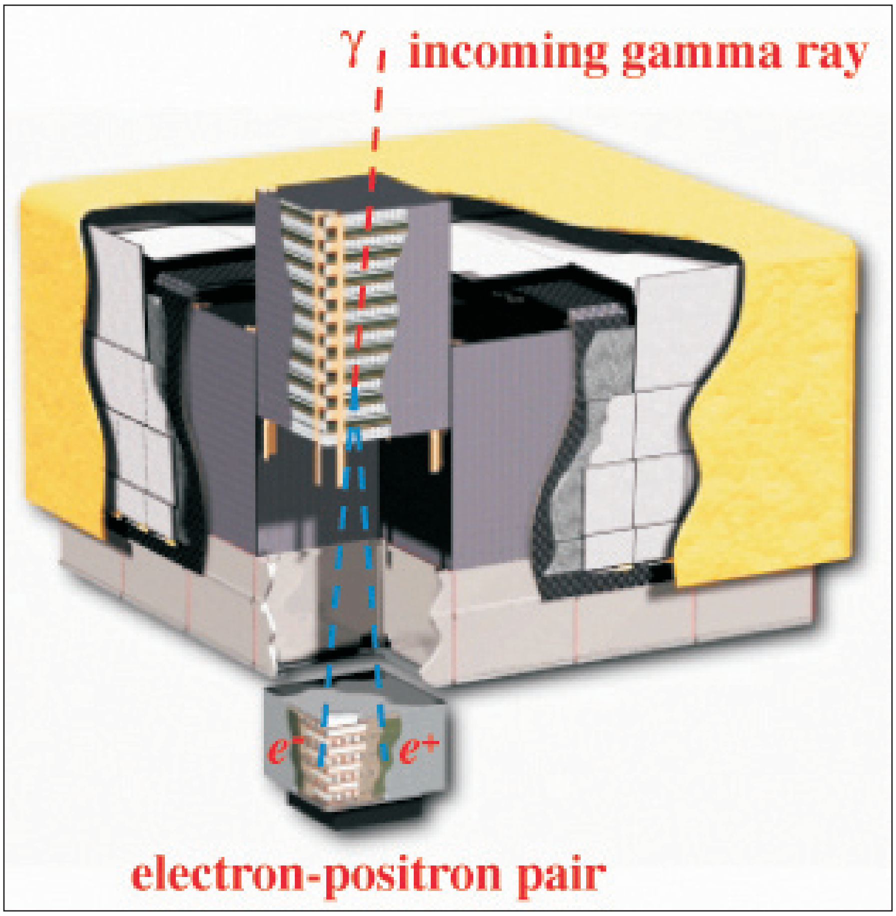
The observatory has been built in an international collaboration of astro- and particle physicists

Fermi will detect high-energy gamma rays from a wealth of cosmic sources including supermassive black holes in Active Galactic Nuclei, Supernova Remnants, neutron stars, galactic and solar system sources, and Gamma-Ray Bursts (GRBs). The physics of the particle acceleration mechanisms believed to be operational in these objects was first proposed by Enrico Fermi, who is now honored with the new name of the telescope. Apart from investigating the most extreme places in the Universe, Fermi will shed light on many fundamental physics questions, one example being the nature of the ubiquitous dark matter (DM). DM particles could decay or annihilate into gamma-rays, giving rise to possibly unambiguous signatures in gamma-ray spectra. These signatures could be used to infer or constrain DM particle properties.

The authors:

Felix Ryde is 38 and received his PhD in astronomy from Stockholm University in 2000. After postdoc stays at Stanford University and Rice University, Houston, he returned to Stockholm where he was appointed docent in astronomy in 2005. He is currently researcher at KTH, Stockholm His main research area is high energy astrophysics, especially Gamma-ray bursts. He is a full member of the Fermi-Lat collaboration since 2008.

Jan Conrad, 35 earned his PhD in high energy physics from Uppsala University in 2003 where he worked with the neutrino telescopes AMANDA/IceCube. After spending 2 years at the european particle physics laboratory at CERN he returned to Sweden as research associate first at KTH and from 2007 at Stockholm University. He is currently the project leader for the Swedish participation in Fermi and the co-leader of the Fermi working group on Dark Matter and New Physics. He is full member for the Fermi-LAT collaboration since 2007.



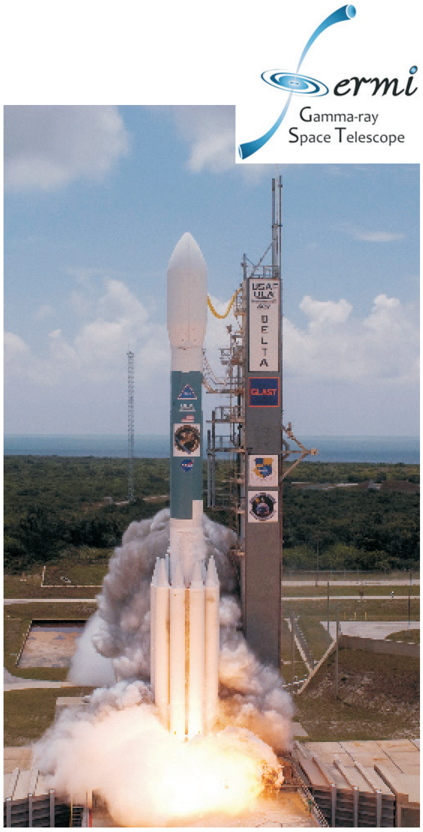


Fig 1: Schematic diagram of the LAT

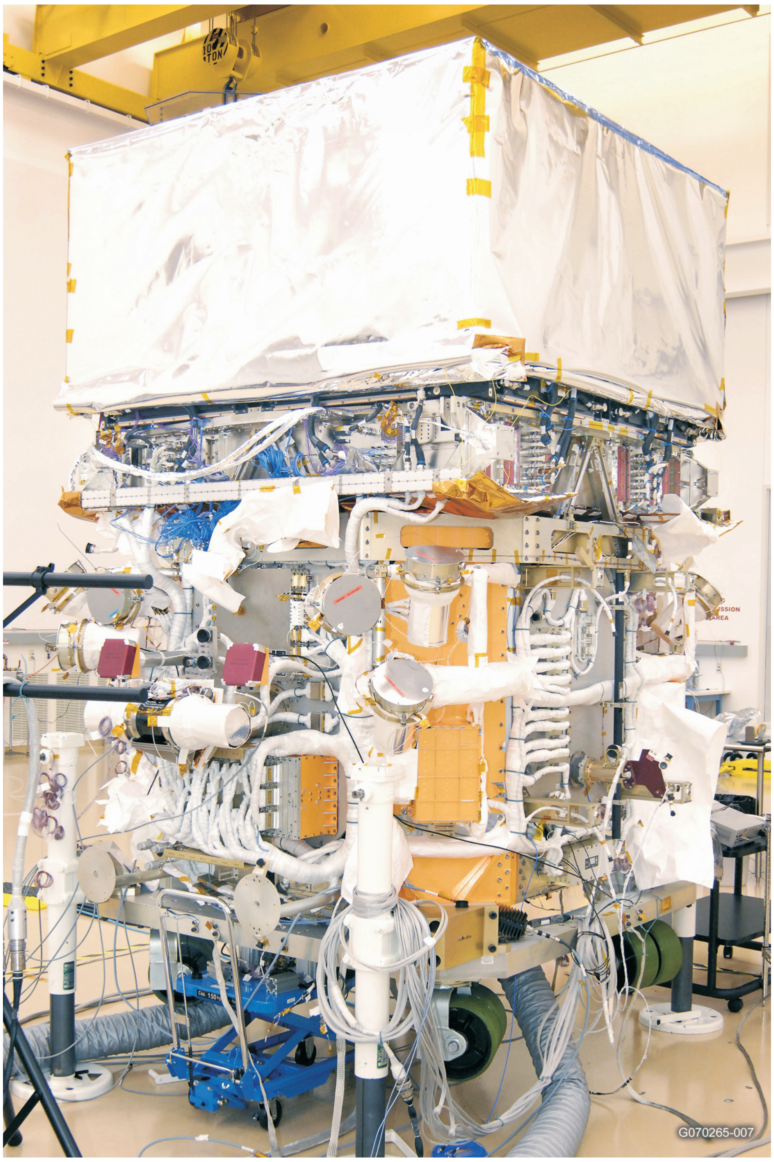
The Large Area Telescope (LAT, [2]) is the main instrument on-board *Fermi* detecting gamma-rays between 20 MeV and 300 GeV. Along with the secondary GLAST Burst Monitor (GBM, [3]), an instrument primarily dedicated to the detection of GRBs between 8 keV and 30 MeV, the instruments of Fermi cover an energy range of 7 decades in total. The aspect ratio of the LAT allows for a large field of view, observing 20 % of the whole visible sky at any instance. The GBM provides complete sky coverage for GRB detection.

To reach its goals the Large Area Telescope had to be designed to yield a large field of view and excellent angular and energy resolution. The detector technology has to be reliable under conditions in space with moderate power consumption and no consumables in order to reach the envisaged livetime of 5 to 10 years.

The LAT (see figure 1 for an illustration) is a pair-conversion telescope which consists of an array of 4 x 4 towers each consisting of a precision converter/tracker and a calorimeter. Each tracker module has 18 x,y tracking planes consisting of single sided silicon strip detectors (400 um thick with a 228 um pitch) interleaved with a high Z converter material (tungsten). The tracker has an active surface of 70 m2 and 900000 digital channels.

Each calorimeter module consists of 96 CsI(Tl) crystals of size 2.7 cm x 2.0 cm x 2.6 cm. The crystals are arranged in 8 layes of 12 crystals each forming a hodoscopic (x,y) array. The total depth of the calorimeter is 8.6 radiation lengths (10.1 for the whole instrument). The dimensions of the crystals are comparable to the CsI radiation length (1.86 cm) and Moliere radius for electromagnetic showers (3.8 cm). Thus, the segmentation allows for spatial imaging of the shower profile and accurate reconstruction of the shower direction which makes the high energy reach of the LAT possible and improves the background rejection.

The tracker is surrounded by an anticoincidence detector (ACD), which



Fermi during the last preparations at Goddard Space Flight Center. Photo: NASA

consists of 89 plastic scintillator tiles of different sizes read out by wavelength shifting fibers coupled to photomultiplier tubes. The ACD is used to reject charged cosmic rays thus is required to have a large efficiency of charged particle detection. The segmentation is optimized to reduce the effect of backsplash (secondaries produced in the interaction of high energy photons with the heavy calorimeter which give signal in the ACD) , which was reducing the efficiency of EGRET by at least a factor of 2 at energies above 10 GeV .

The optimisation of the Fermi LAT design has been performed using extensive state of the art Monte Carlo simulations. Calibration of the *Fermi* LAT is performed by a combination of on-orbit and ground cosmic ray data and beam tests.

Swedish groups which are involved in the Fermi Telescope are the Kungliga Tekniska Högskolan , University of Stockholm and Kalmar University. The original design of the calorimeter was proposed by scientists from KTH [2]. Due to a grant by the Wallenberg foundation, Sweden was able to contribute with the complete set of CsI(Tl) crystals for the calorimeter. The crystals were tested for radiation hardness in Sweden. In 2006, Swedish scientists participated in a large calibration beam test which was performed at the European accelerator laboratory CERN.

The Swedish Fermi consortium currently consists of about 10 scientistists. Swedish groups are leading the effort of Fermi to look for the Dark Matter with Fermi and actively participate in the effort to understand the enigmatic Gamma-ray Bursts (GRBs).

Fermi was launched by NASA Wednesday June 11 from the Cape Canaveral Air Station in Florida (CERN courier reference). The first 60 days of data taking constituted the commissioning phase, which went smoothly without any significant problems greatly thanks to the thorough preparatory work undertaken by the Fermi LAT and GBM collaborations. On August 11, 2008 Fermi entered the phase of nominal science operations, surveying the complete gamma-ray sky every 3 hours.

The onboard LAT all-sky image (see fig 3), which was published on August 26, 2008, was created using only 95 hours of “first light” observations, corresponding to a whole year of EGRET observations. It shows gas and dust in the plane of the Milky Way emitting gamma rays due to collisions with cosmic rays. Other clearly visible sources include Crab, Geminga and Vela pulsars in our own Galaxy as well as the blazar 3C454.3 an extragalactic active galaxy currently being in a flaring state and therefore particularly bright. The GBM, detected 31 GRBs in its first month of operation.

Fermi is expected to take data for at least 5 years with a goal of 10 years. For sour understanding of the high energy Universe will grow tremendously, but even more exciting could be the unexpected. Historically opening new observational windows has often yielded completely unanticipated discoveries. Stay tuned!

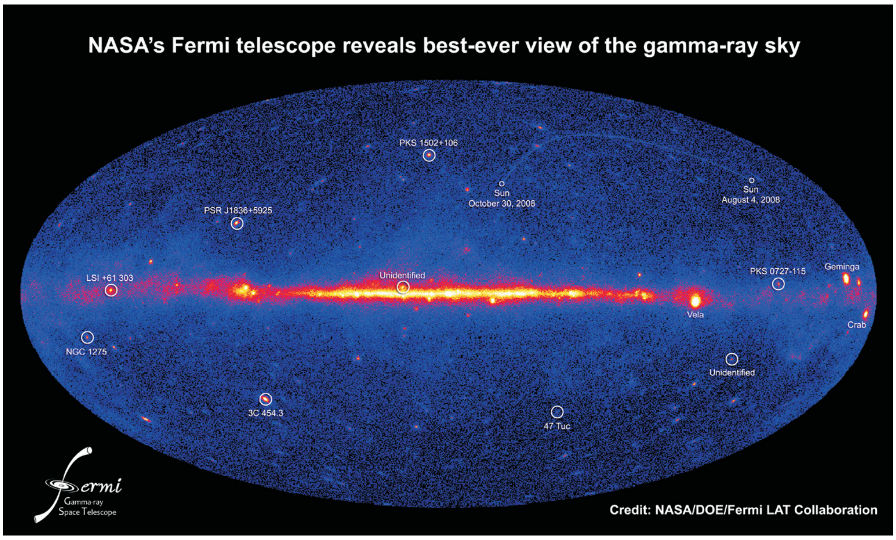
References:

[1] http://www.nasa.gov

[2] Nucl.Instrum.Meth.A376:271-274,1996

Three Months of Monitoring

Fermi's Best-Ever Look at the Gamma-Ray Sky03.11.09 A new map combining nearly three months of data from NASA's Fermi Gamma-ray Space Telescope is giving astronomers an unprecedented look at the high-energy cosmos. To Fermi's eyes, the universe is ablaze with gamma rays from sources within the solar system to galaxies billions of light-years away.



This view from NASA's Fermi Gamma-ray Space Telescope is the deepest and best-resolved portrait of the gamma-ray sky to date. The image shows how the sky appears at energies more than 150 million times greater than that of visible light. Among the signatures of bright pulsars and active galaxies is something familiar -- a faint path traced by the sun. Credit: NASA/DOE/Fermi LAT Collaboration

Swedish Institutes Participating in Fermi

Stockholm University is participating in Fermi with members of the Physics Department, Group for Cosmology, Particle Astrophysics and String Theory. The group concentrates on experimental and theoretical particle astrophysics as well as observational cosmology, the focus being on investigation of dark matter and dark energy. The group in theoretical astroparticle physics is internationally among the leading for predicting signals of dark matter annihilation in different detectors. Except for the Fermi satellite, members of the group of experimental astroparticle physics are involved in a design effort for a future ground based gamma-ray telescope (Cherenkov Telescope Array, CTA). The observational cosmology group concentrates on Supernova observations and gravitational lensing and is involved in a number of large collaborations such as the Supernova Cosmology Project and the Sloan Digital Sky Survey.

The Royal Institute of Technology (KTH) is participating with members of the Particle and astroparticle physics group. The department is also involved in the satellite experiment PAMELA (measuring charged cosmic rays) and the balloon experiment PogoLITE, intended to measure the polarization of low energy gamma-rays. The group also participates in the CERN experiment ATLAS.

The University of Kalmar is participating with members of the Physics department. Except for Fermi they are also involved in the AMANDA/IceCube project at the South Pole – an experiment looking for neutrinos of cosmic origin.

Who was Enrico Fermi

Enrico Fermi (1901-1954) was an Italian physicist who immigrated to the United States. He was the first to suggest a viable mechanism for astrophysical particle acceleration. This work is the foundation for our understanding of many types of sources to be studied by NASA's Fermi Gamma-ray Space Telescope.

Fermi is most noted for his work on the development of the first nuclear reactor and for his major contributions to the development of quantum theory, nuclear and particle physics, and statistical mechanics. He was awarded the Nobel Prize in Physics in 1938 for his work on induced radioactivity and is today regarded as one of the top scientists of the 20th century.

In addition to his direct connection to the science, Fermi holds special significance to the U.S. Department of Energy, the Italian Space Agency, and the Italian Particle Physics Agency.