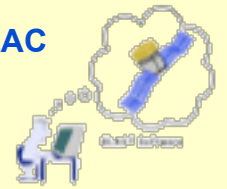


Fermi LAT

Data Preservation 2 May 26, 2009 SLAC



Fermi Large Area Telescope:

Long Term Public Analysis

Richard Dubois

richard@slac.stanford.edu

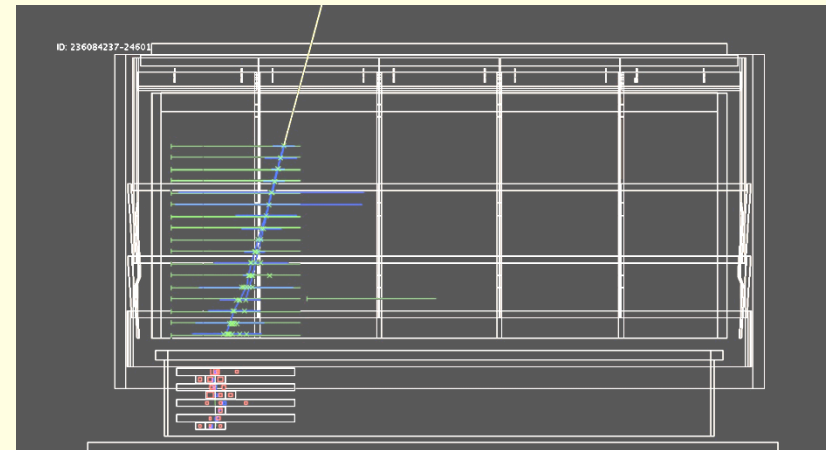
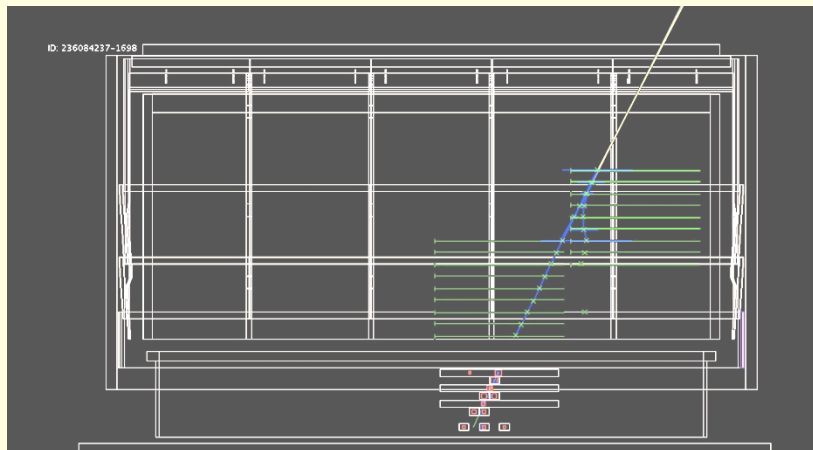
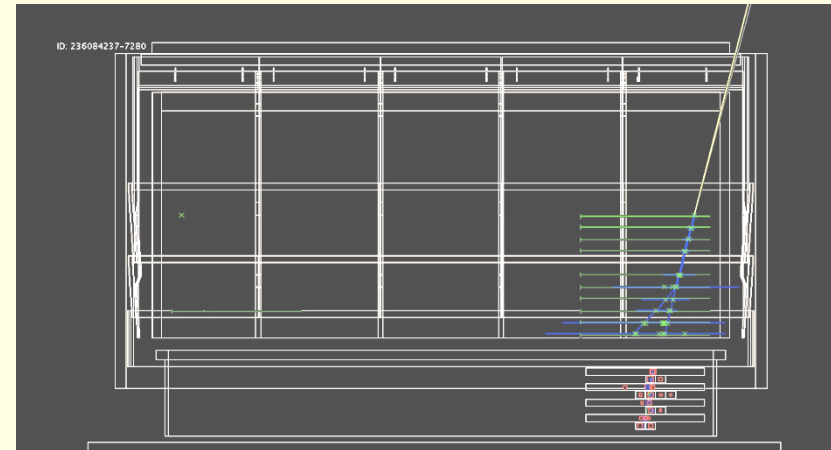
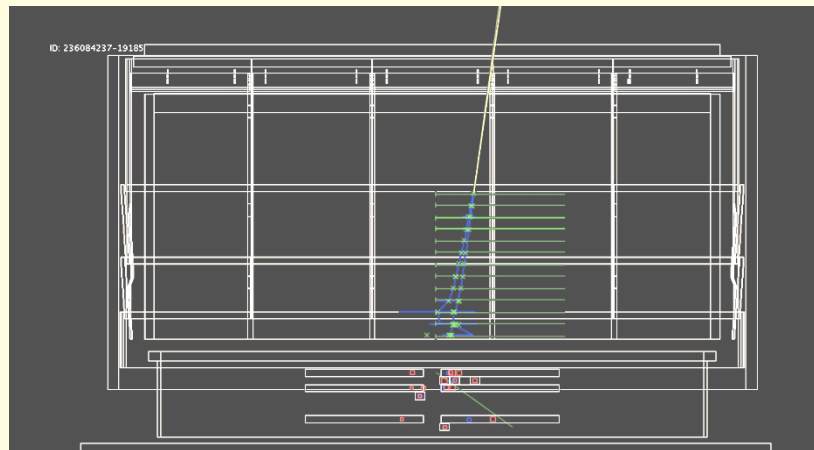


Launch: 11 June 2008
565 km circular orbit

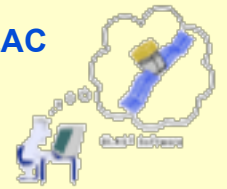




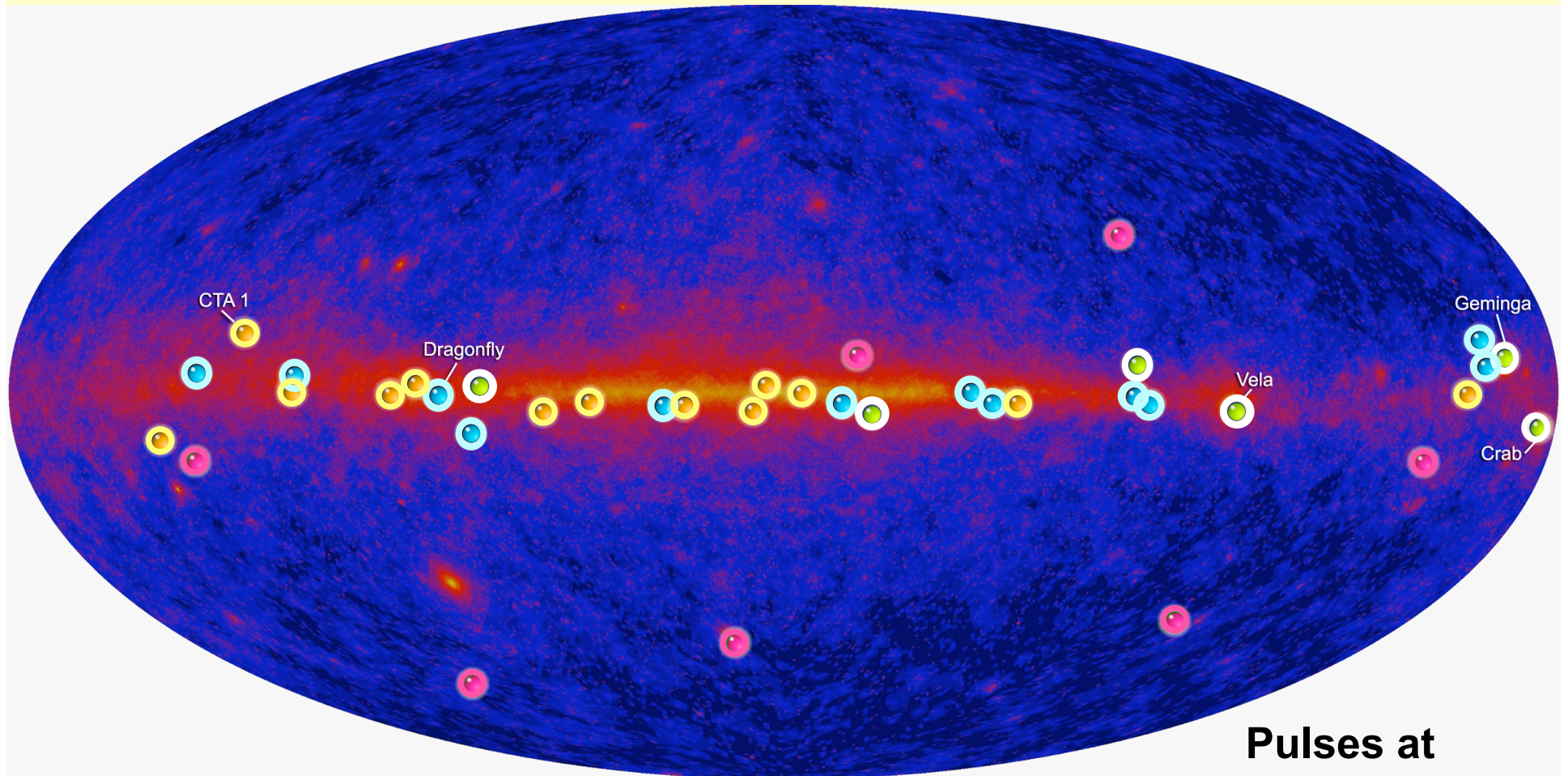
In Orbit: Single Events in the LAT



The green crosses show the detected positions of the charged particles, the blue lines show the reconstructed track trajectories, and the yellow line shows the candidate gamma-ray estimated direction. The red crosses show the detected energy depositions in the calorimeter.



The Pulsing Sky

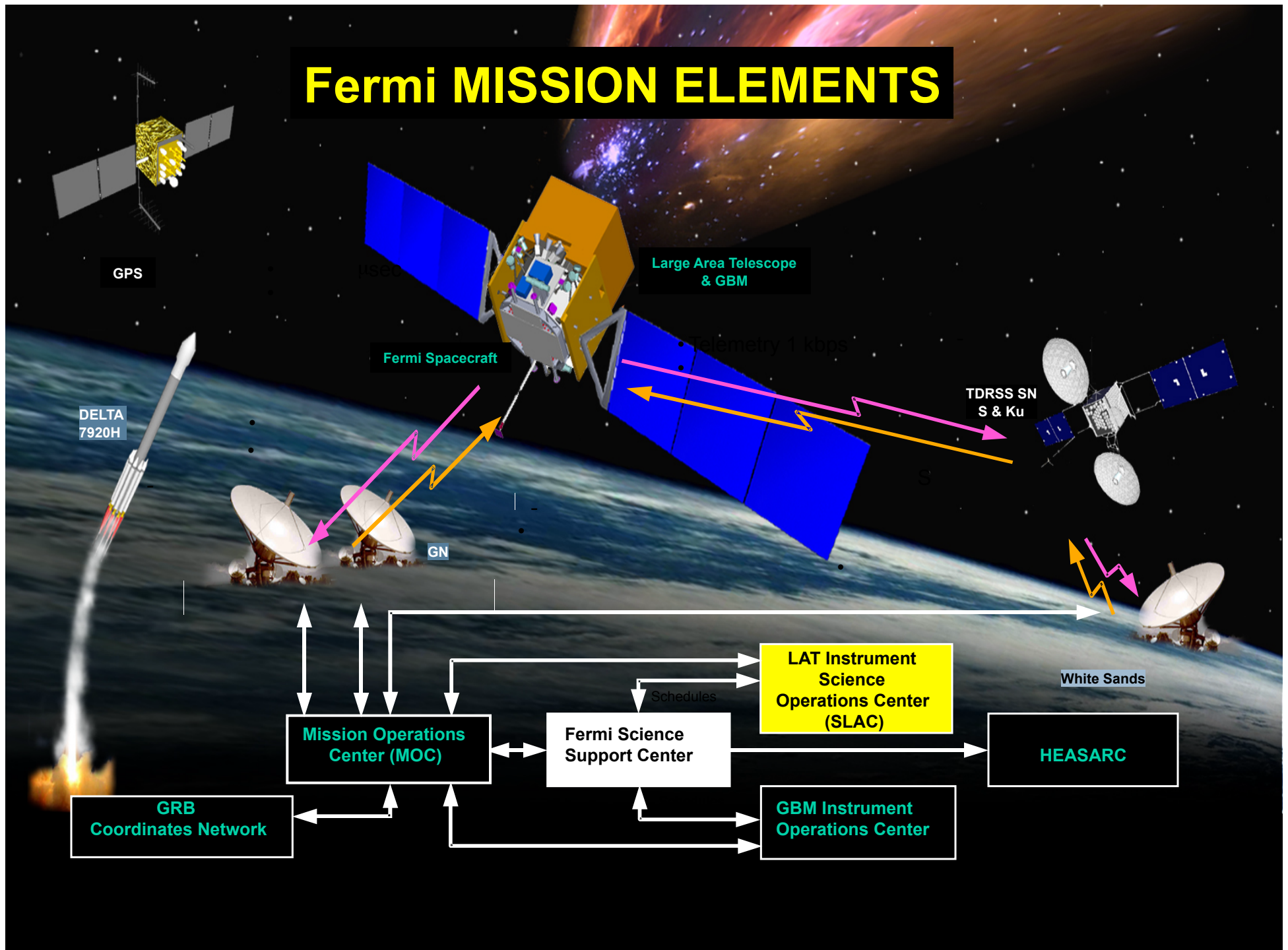


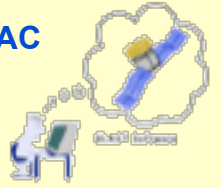
Fermi Pulsar Detections

- New pulsars discovered in a blind search
- Millisecond radio pulsars
- Young radio pulsars
- Confirmed pulsars seen by Compton Observatory EGRET instrument

**Pulses at
1/10th true rate**

Fermi MISSION ELEMENTS

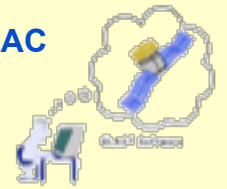




Data Processing Flow

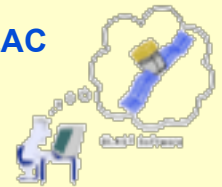
- **Downlink from Goddard Space Flight Center (FASTCopy) ~8/day**
 - **15 GB total daily**
- **Half-pipe**
 - **Automatic response to downlink**
 - **Decode & repackage incoming data**
 - **Trigger Level 1 Processing**
- **Level 1 Processing**
 - **Full event reconstruction: factor ~x50 expansion on raw data! 750 GB/day**
 - **Monitoring plots for Instrument Science Operations Ctr**
 - **Transfer science summary files to Goddard Science Support Ctr - 200 MB/day**
 - **Trigger ASP**
- **ASP (Automated Science Processing)**
 - **GRB and Flare detection**
 - **Spectral analysis**
- **RSP (Routine Science Processing)**
 - **Automated Science Group processing**

+ annual bulk reprocessing
+ simulations
- **Final science analyses**



Principal Computing Resources

- **SLAC compute farm (Fermi allocation)**
 - 1200 CPUs in batch farm running LSF (+ peak loads of >2000)
 - 600TB disk = 100 TB NFS + 500 TB xroot – 32 TB Raid 10 Sun thumpers
 - 350 TB tapes in silo (HPSS)
 - Making transition to higher density tapes
 - Storage model strategy is to keep latest versions of data on disk; all else on tape.
- **Lyon compute farm (CCIN2P3, France)**
 - 400 CPUs in batch farm running BQS
 - few TB disk allocated for all Fermi uses (transfer generated files to SLAC)
 - seamlessly used by pipeline from SLAC
- **Plans for using an Italian center (Bologna or Padova)**



Data Storage and Catalog

Show: MC beam test obsolete

Update

Folders

- ASP
- Data
 - Flight
 - LEOScience
 - Level1
 - LCI
 - LPA
 - ACDPEDSANALYZER
 - ACDPLOTS
 - CAL
 - CALGAINSANALYZER
 - CALHIST
 - CALHISTALARM
 - CALPEDSANALYZER
 - CALTREND
 - COMPAREDFM
 - DIGI
 - DIGIHIST
 - DIGIHISTALARM
 - DIGITREND
 - DIGITRENDALARM
 - FASTMONERROR
 - FASTMONHIST

Folder /Data/Flight/Level1/LPA

Output from Level 1 processing of on-orbit data [Edit description](#)

Name	Type	Files	Events	Size	Created (UTC)	Links
RECON	Group	1931	3,803,647,787	52.7 TB	25-Jun-2008 16:43:00	Files
CAL	Group	1954	3,790,237,100	13.3 TB	25-Jun-2008 16:35:11	Files
SVAC	Group	1953	3,848,209,867	9.0 TB	25-Jun-2008 16:29:03	Files
DIGI	Group	1954	3,855,037,479	8.0 TB	25-Jun-2008 15:22:31	Files
FASTMONTUPLE	Group	1954	0	3.7 TB	25-Jun-2008 15:34:54	Files
MERIT	Group	1954	3,852,358,312	2.9 TB	25-Jun-2008 16:25:29	Files
GCR	Group	1954	3,852,208,291	92.6 GB	25-Jun-2008 16:32:57	Files
FASTMONTREND	Group	1954	0	58.9 GB	25-Jun-2008 15:57:51	Files
LS1	Group	1954	69,293,586	50.7 GB	25-Jun-2008 16:29:02	Files
DIGITREND	Group	1954	0	45.8 GB	25-Jun-2008 15:25:58	Files
MAGIC7HP	Group	1732	0	37.2 GB	08-Jul-2008 18:20:31	Files
CALHIST	Group	1954	0	26.4 GB	25-Jun-2008 15:32:55	Files
TKRANALYSIS	Group	1953	0	23.8 GB	25-Jun-2008 16:40:49	Files
RECONTREND	Group	1954	0	23.7 GB	25-Jun-2008 16:39:44	Files
RECONHIST	Group	1953	0	16.4 GB	25-Jun-2008 16:42:37	Files
LS3	Group	1954	0	14.7 GB	25-Jun-2008 16:29:02	Files
MAGIC7	Group	250	0	7.4 GB	25-Jun-2008 15:13:53	Files

- Data resides in xroot (some NFS, and some, temporarily, in AFS)
- Catalogue gives file location and user-supplied metadata



Accessing the Data

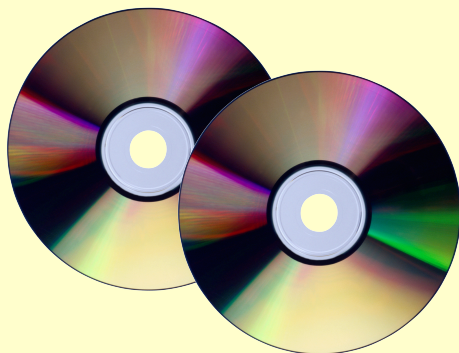
Root

Fits

Raw, Recon

Mini-summary
All events

Micro-summary
Photon list



Access via web: use pipeline/parallel batch

Apply arbitrary cuts on mini – get mini; raw, recon out

Analysis of details, event displays

+ Line mode interface

Access via web: use pipeline/parallel batch

Optimized for direction, energy, time cuts

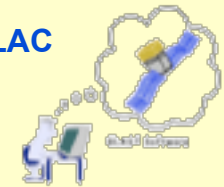
Apply cuts on micro– get micro; (To Come: raw, recon, mini out)

+ Line mode interface

FSSC Data Server:
Access via web

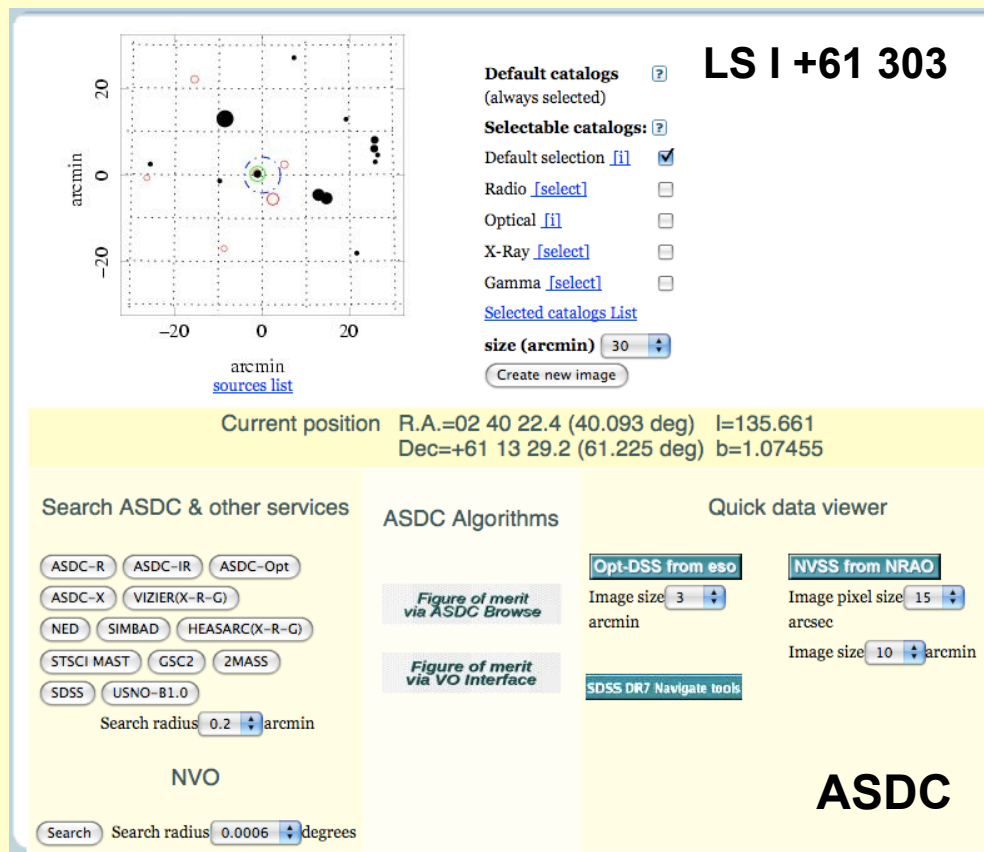
Optimized for direction, energy, time cuts

Apply cuts on micro– get micro



Astro Culture on Facilities

- telescopes are facilities for general use
 - driven by user groups with scheduled observations
 - not the property of the instrument teams
 - community organises multi-wavelength campaigns



LSI +61 303

Default catalogs (always selected) [?](#)

Selectable catalogs: [?](#)

Default selection [f11](#)

Radio [\[select\]](#)

Optical [f11](#)

X-Ray [\[select\]](#)

Gamma [\[select\]](#)

[Selected catalogs List](#)

size (arcmin)

Current position R.A.=02 40 22.4 (40.093 deg) l=135.661
Dec=+61 13 29.2 (61.225 deg) b=1.07455

Search ASDC & other services

ASDC-R ASDC-IR ASDC-Opt

ASDC-X VIZIER(X-R-G)

NED SIMBAD HEASARC(X-R-G)

STSCI MAST GSC2 2MASS

SDSS USNO-B1.0

Search radius arcmin

NVO

Search radius degrees

ASDC Algorithms

[Figure of merit via ASDC Browse](#)

[Figure of merit via VO Interface](#)

[SDSS DR7 Navigate tools](#)

Quick data viewer

[Opt-DSS from eso](#)

Image size
arcmin

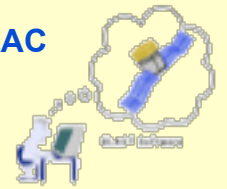
[NVSS from NRAO](#)

Image pixel size
arcsec

Image size arcmin


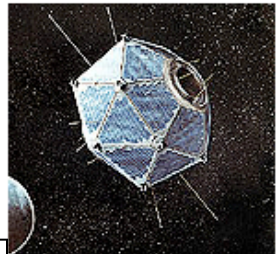
ASDC

TeV telescopes are the exception so far: more like HEP experiments

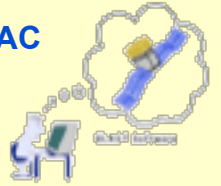


NASA Archives

NASA's HEASARC: Observatories

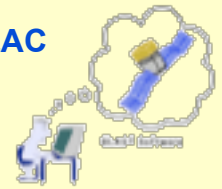
ACTIVE MISSIONS	PAST MISSIONS	UPCOMING MISSIONS	COMPARISON OF MISSION CAPABILITIES																									
<p>ACTIVE MISSIONS</p> <ul style="list-style-type: none"> AGILE Chandra Fermi (formerly GLAST) INTEGRAL Rossi XTE Suzaku Swift XMM-Newton <p>PAST MISSIONS</p> <table border="1"> <tr><td>ANS</td><td>ARIEL V</td></tr> <tr><td>ASCA</td><td>BBXRT</td></tr> <tr><td>BeppoSAX</td><td>CGRO</td></tr> <tr><td>COPERNICUS</td><td>COS-B</td></tr> <tr><td>DXS</td><td>EINSTEIN</td></tr> <tr><td>EUVE</td><td>EXOSAT</td></tr> <tr><td>GINGA</td><td>GRANAT</td></tr> <tr><td>HAKUCHO</td><td>HEAO-1</td></tr> <tr><td>HEAO-3</td><td>HETE-2</td></tr> <tr><td>OSO-7</td><td>OSO-8</td></tr> <tr><td>ROSAT</td><td>SAS-2</td></tr> <tr><td>SAS-3</td><td>TENMA</td></tr> <tr><td>UHURU</td><td>VELA 5B</td></tr> </table>	ANS	ARIEL V	ASCA	BBXRT	BeppoSAX	CGRO	COPERNICUS	COS-B	DXS	EINSTEIN	EUVE	EXOSAT	GINGA	GRANAT	HAKUCHO	HEAO-1	HEAO-3	HETE-2	OSO-7	OSO-8	ROSAT	SAS-2	SAS-3	TENMA	UHURU	VELA 5B	<p>High Energy Astrophysics Observatories</p> <p>These Web pages describe all the high energy astronomy observatories, or "missions," ever launched. The links to the left are dedicated to the most notable past and present X-ray and gamma-ray astronomy missions. The pages include</p> <ul style="list-style-type: none"> a mission overview, technical information on the instrumentation, a bibliography and a gallery of images. <p>They also contain a description of the available data if they are present in the HEASARC archive. Information on other satellites carrying either an X-ray or a gamma-ray telescope is available on the All Missions pages.</p> <div style="border: 1px solid gray; padding: 5px;"> <p>Upcoming Missions</p> <ul style="list-style-type: none"> ASTROSAT MAXI <p>Other Resources</p> <ul style="list-style-type: none"> All Missions (info & images) All Missions by Time All Missions by Energy Comparison of Mission Capabilities Future Missions Images, Spectra, and Light Curves </div>	<p>Latest News</p> <ul style="list-style-type: none"> GLAST  <p>launched June 11, 2008</p> <ul style="list-style-type: none"> GLAST renamed to Fermi Gamma-ray Space Telescope (Aug 26, 2008) <p>More News</p> <p>Spacecraft Image of the Week</p>  <p>Vela 5B DoD/AEC mission May 1969 - June 1979</p>
ANS	ARIEL V																											
ASCA	BBXRT																											
BeppoSAX	CGRO																											
COPERNICUS	COS-B																											
DXS	EINSTEIN																											
EUVE	EXOSAT																											
GINGA	GRANAT																											
HAKUCHO	HEAO-1																											
HEAO-3	HETE-2																											
OSO-7	OSO-8																											
ROSAT	SAS-2																											
SAS-3	TENMA																											
UHURU	VELA 5B																											

<http://heasarc.gsfc.nasa.gov/>



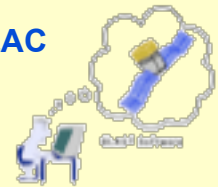
High Level Analysis

- **Output of a telescope (for “event” data) is:**
 - **Location on sky, time, energy, quality**
 - **Very simple output tuple!**
 - **Implemented in Root and FITS**
 - **Where instrument and celestial analysis overlap**
 - **Public data makes sense in astrophysics**
 - **NEED data from multiple missions to understand celestial sources**
- **NASA mandates that all its space missions use FITS as a data format**
 - **In use for 25+ years**
 - **Format fully documented and files self documenting**
 - **File headers are an integral part of the format**
 - **Interface library supplied for popular languages**
 - **And that the data be made public**
 - **Fermi negotiated one year hiatus on doing this. Expires Aug 11. Then all existing & ongoing data goes public**
 - **Funds a Science Support Center to interface to the public**
 - **Instrument teams not asked to do this**
 - **10+ FTEs for Fermi (LAT+GBM)**
 - **Charter is to support the Fermi data “forever”**



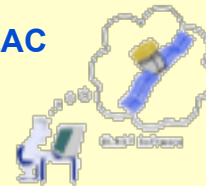
More NASA Mandates

- **NASA-funded missions required to create a Project Data Management Plan prior to launch to cover the life of the mission**
 - **Specify data format details**
 - **Down to tuple column names**
 - **Under configuration control**
 - **Responsibilities across the Mission ground elements**
- **For high energy astrophysics, NASA further mandates their OGIP standards**
 - **FTOOLS are a notable example**
 - **Utilities do almost any manipulation you can think of**
 - **Adhere to the IRAF parameter file interface**
 - **Instrument-team developed tools must be shared with public**



Is FITS All Rosy?

- **Well, no.**
- **The analysis model is atomic operations with files used as the messengers**
 - **Linked together with scripts (called pipelines)**
 - **Designed for interactive use**
 - **Not made for (parallel) batch processing**
 - **Very easy to step on the parameters files**
 - **No structures/objects in the files**
 - **Images or tables**
- **OTOH, FITS headers are nice**
 - **Intrinsic to the files**
 - **all tools respect the header**
 - **Carries processing history etc etc**



Summary

- **Fermi is an amalgam of HEP (Root) and Astro (FITS)**
- **NASA worries about public data and long term analysis capability**
 - **We are riding their coat-tails**
 - **We have no plan for the Root data and assume at end of mission that it more or less dies**
 - **A price is paid in terms of functionality**
- **Our data goes public in August**
 - **We'll see how well we did in weaving our data into the multi-wavelength world**