From Space To Your Laptop In 8 hours!

Science Data Processing And Monitoring For The Fermi Large Area Telescope

Anders W. Borgland

Science Operations Group
Fermi LAT Instrument Science Operations Center

SLAC NATIONAL ACCELERATOR LABORATORY

Overview

- Why gamma-rays …. in space?
- The Fermi Mission
- Constraints
- Fermi LAT science data processing
- Fermi LAT science data monitoring
- Lessons learned
- The PR page

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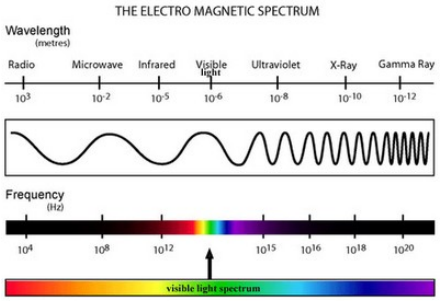
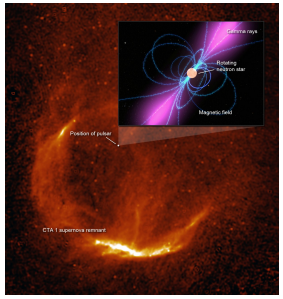
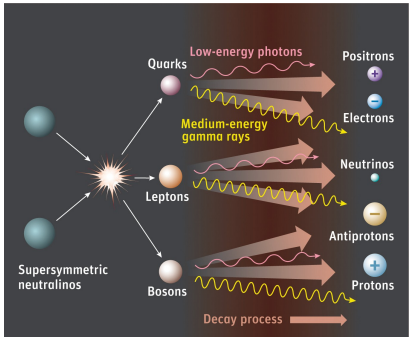
Going forward by looking back … (in a mirror)

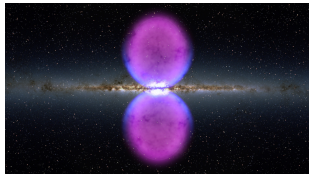
Why Gamma-Rays …. In Space?

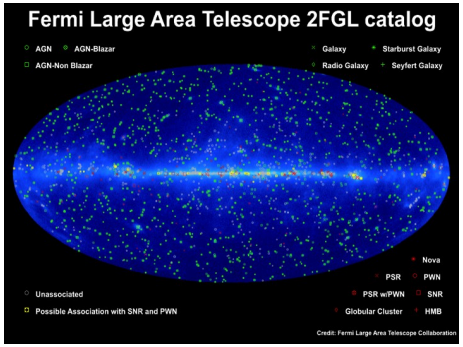
- The most violent phenomena in the Universe produce gamma-rays:
  - Non-thermal production
  - Particle acceleration
- Gamma-rays can be produced by multiple mechanisms:
  - Hadronic: Hadrons → Pi0 → Gamma-rays
  - Leptonic: Bremsstrahlung, Inverse Compton, Synchrotron emission, …..
- Gamma-rays:
  - Advantages:
    - Photon energy related to the original energy
    - Identify the original production mechanism
    - Point straight back to the production sources
  - Disadvantage:
    - Can't penetrate the Earth atmosphere
- Earth based Atmospheric Cherenkov Telescopes:
  - Use the Earth atmosphere as the detector
  - Difficult to go below ~100 GeV





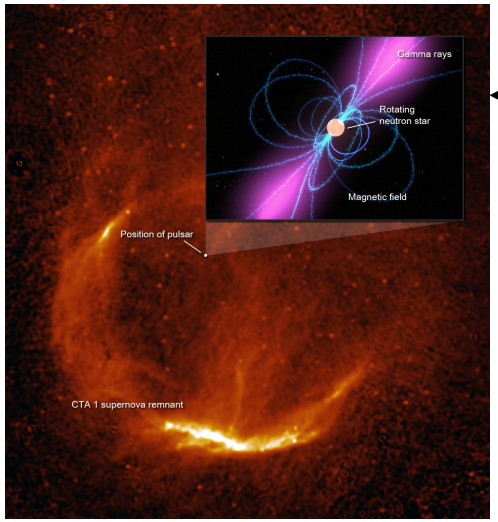






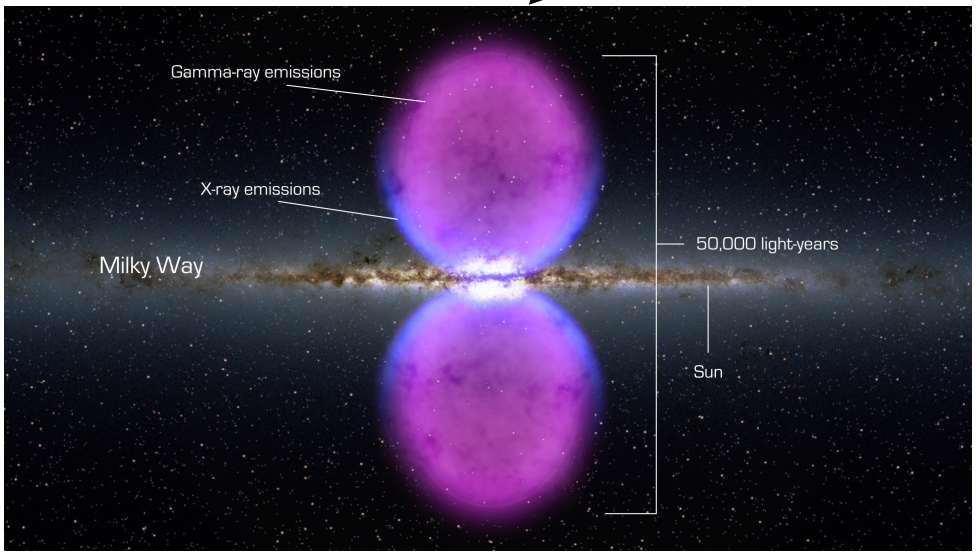
Spaceborne gamma-ray experiments are filling a critical energy gap!

Why Gamma-Rays .. In Space? Fermi Results*

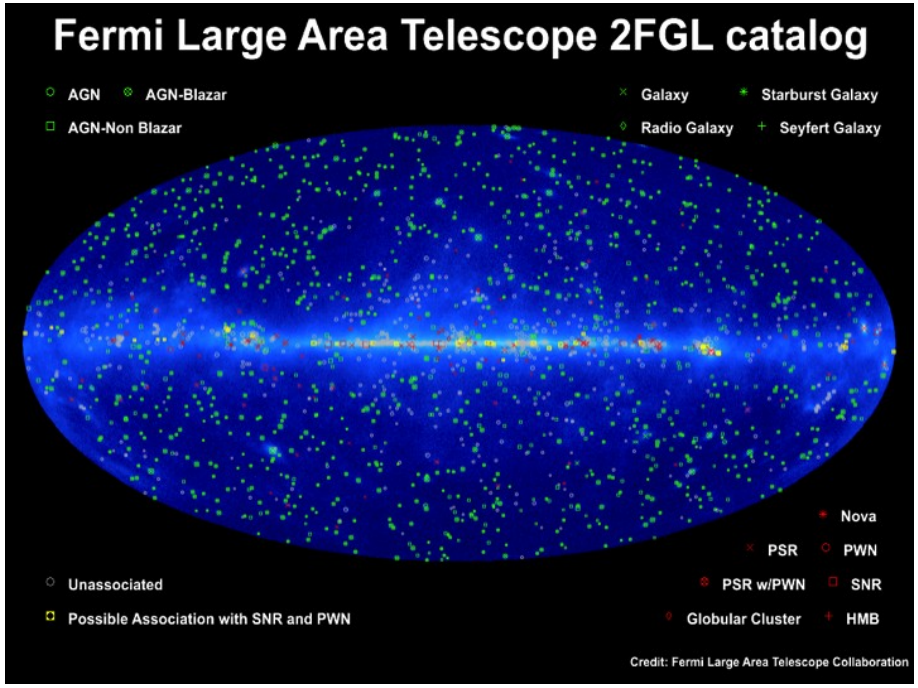


Gamma-ray-only pulsar (within supernova remnant CTA 1)

Giant gamma-ray bubbles (Finkbeiner, analysis using public data)



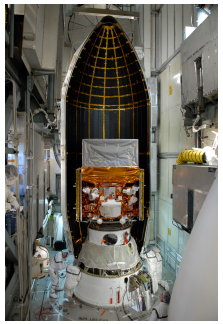
The Catalog



(*) Our most famous result is actually with e+/e- but that's a different story ...

The Fermi Mission

- Two separate instruments covering the energy range from 8 keV to >300 GeV:
  - Large Area Telescope (LAT)
  - Gamma-Ray Burst Monitor (GBM)
- LAT:
  - Unprecedented view of the gamma-ray sky:
    - 30x improvement in sensitivity!
  - Covering largely unexplored 10-100 GeV domain
  - Broad science program
- GBM:
  - Sees all of the un-occulted sky
  - Hard x-rays and soft gamma-rays:
    - Overlaps with LAT energy range
- 5 year design lifespan:
  - Goal is 10 years (no consumables)
- Launched:
  - 09:05 PDT June 11, 2008
- Fermi:
  - Was originally called GLAST
- Fermi LAT photon data are publicly available!



The Fermi LAT Collaboration

- France
  - CNRS/IN2P3, CEA/Saclay
- Italy
  - INFN, ASI, INAF
- Japan
  - Hiroshima University
  - ISAS/JAXA
  - RIKEN
  - Tokyo Institute of Technology
- Sweden
  - Royal Institute of Technology (KTH)
  - Stockholm University
- United States
  - Stanford University (SLAC and HEPL/Physics)
  - University of California, Santa Cruz - Santa Cruz Institute for Particle Physics
  - Goddard Space Flight Center
  - Naval Research Laboratory
  - Sonoma State University
  - The Ohio State University
  - University of Washington

PI: Peter Michelson
(Stanford)

~400 Scientific Members (including 96 Affiliated Scientists, plus 68 Postdocs and 105 Students)

Cooperation between NASA and DOE, with key international contributions from France, Italy, Japan and Sweden.

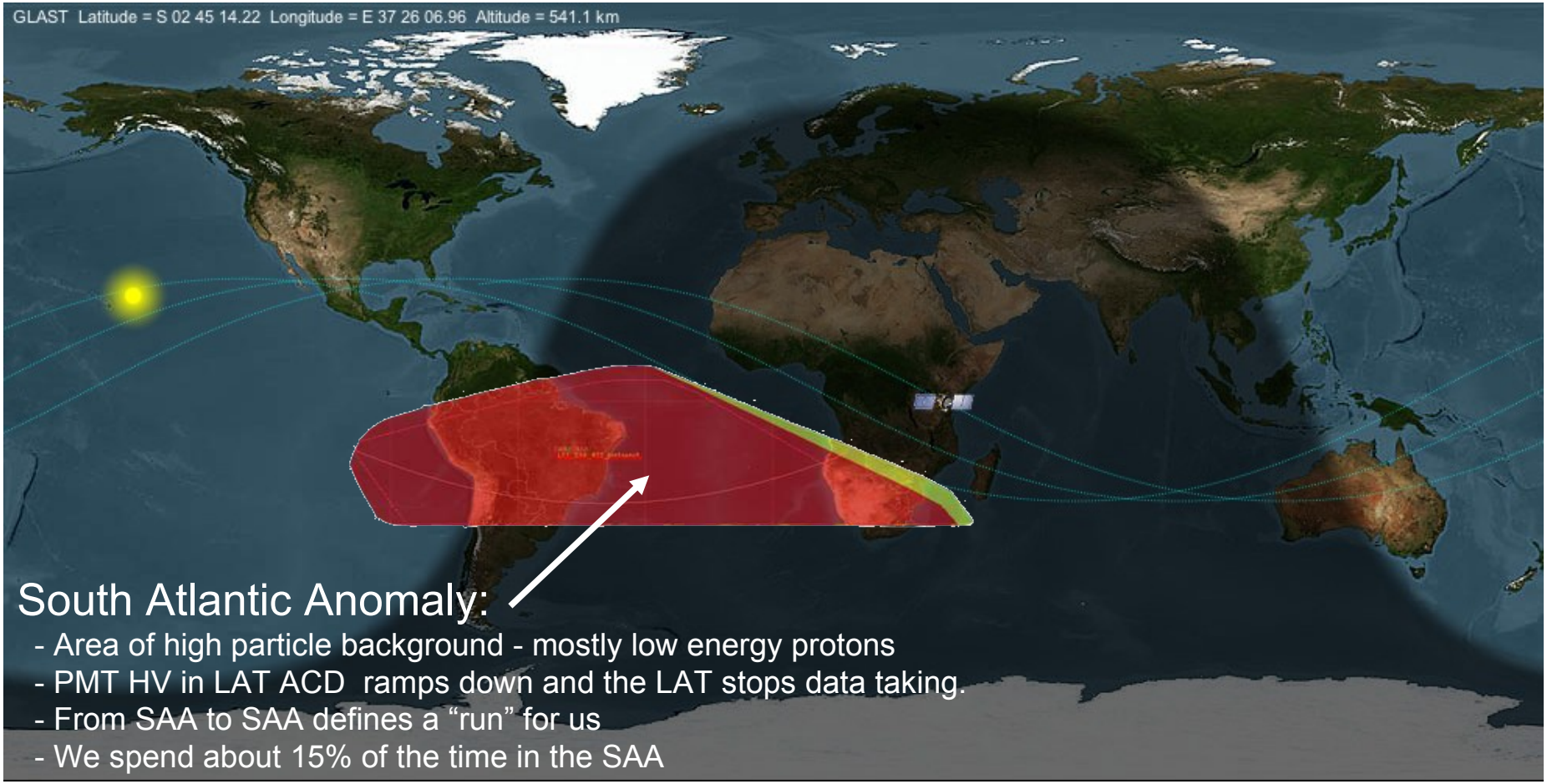
Project managed at SLAC.

Fermi LAT Instrument Science Operations Center (ISOC): Situated at SLAC

GBM: Separate instrument with a separate collaboration and separate data stream/processing. Not covered here.

Fermi In Space

- Circular orbit with a 94 minute period
- Altitude: 565 km
- Inclination: 25.5 degrees



Fermi Gamma-Ray Space Telecope

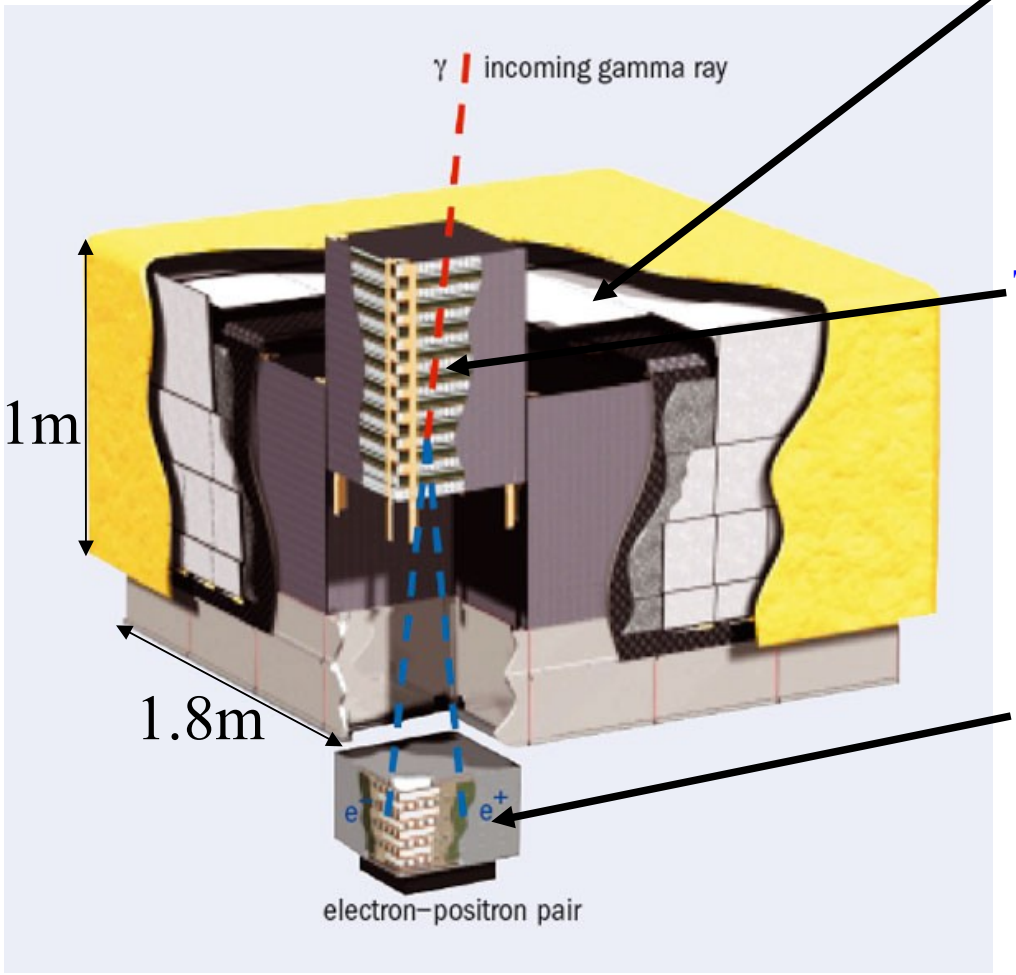
Large Area Telescope

- **Energy range:**
  - 20 MeV to >300 GeV
- **Huge field of view:**
  - 20% of the sky at any time
  - Covers the whole sky every 3h
- **Rocking:**
  - Space craft rocks +/- 50 deg about the zenith direction every orbit

Gamma-ray Burst Monitor

- **Energy range:**
  - 8 keV to ~25 MeV
  - NaI (x12) and BGO (x2)
- **Field-of-View:**
  - The whole un-occulted sky

Large Area Telescope: Detector Details



Anti-Coincidence Detector (ACD):

- 89 scintillating tiles + 8 ribbons
- Efficiency for MIPs: >0.9997
- 4% of a Radiation Lenght

Tracker (TKR):

- 18 bi-layers of silicon strip detectors
- 16 tungsten converter foils:
  - 12x3%Rad.L. + 4x18%Rad.L.
- 228 μm pitch
- 80 m^2 of Silicon
- 800k channels

Calorimeter (CAL):

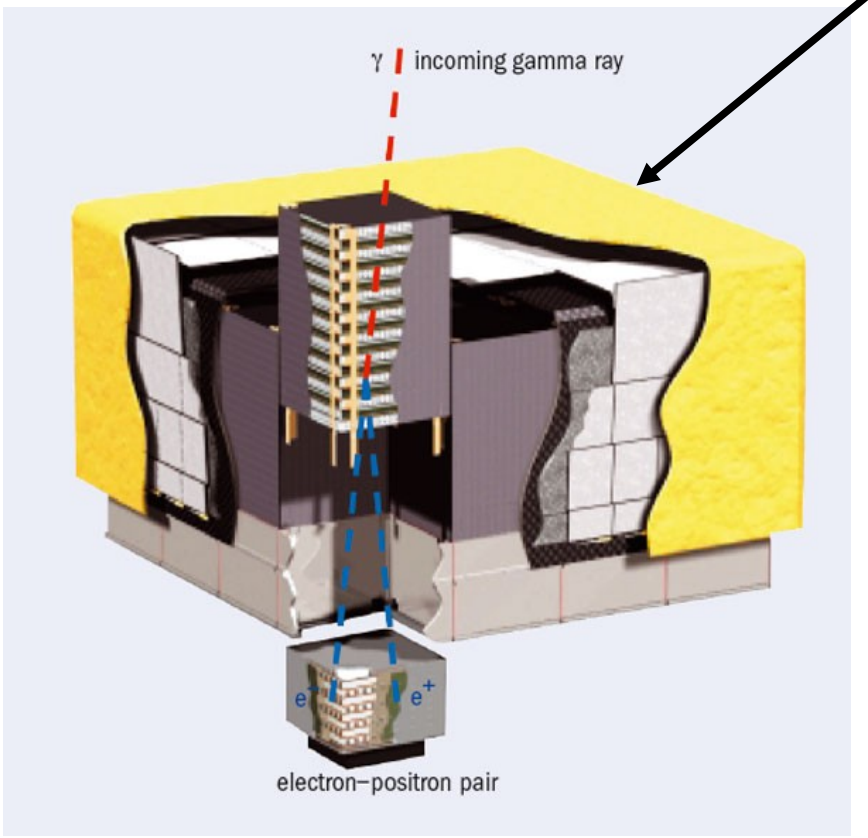
- 8 layers x 12 CsI xtals
- 8.5 radiation lenghts

Weight: 3000 kg
Power consumption: 650 W

"It uses less power than a toaster and we talk to it over a telephone line."
(Bill Atwood)

Large Area Telescope

16 identical towers (TKR+CAL) covered by the Anti-Coincidence Detector (to reject charged particles)



Pair-producing telescope:

- Incoming photon goes through the ACD without leaving a signal, then interacts in the tungsten layers in the silicon tracker, producing an electron-positron pair

Photon:

- Direction given by the e+e- in the TKR
- Energy is measured in the calorimeter

Hardware trigger: 2.5 kHz
Software filters: 500 Hz downlinked
Photon rates: Few Hz

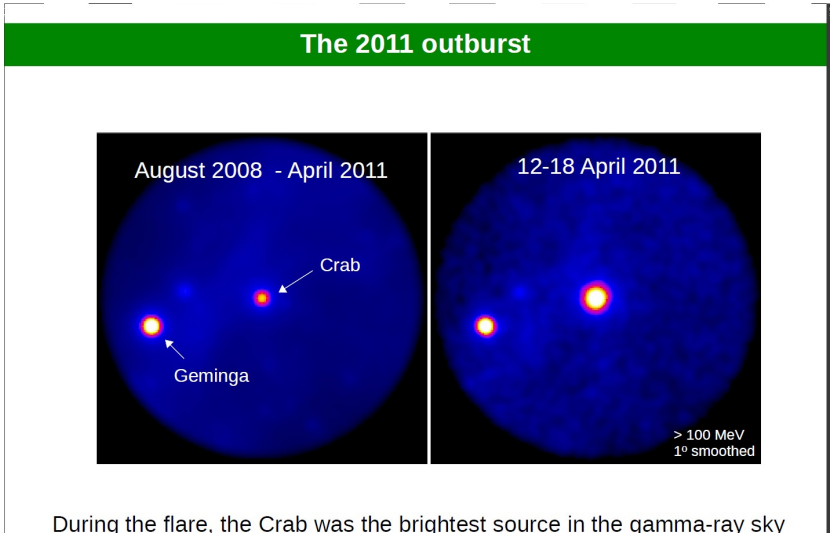
Final information used for science analysis:

- Photon direction in the sky
- Photon energy
- Photon arrival time
- Instrument livetime
- Instrument Response Functions

All the photon data fits on a laptop!

Constraints

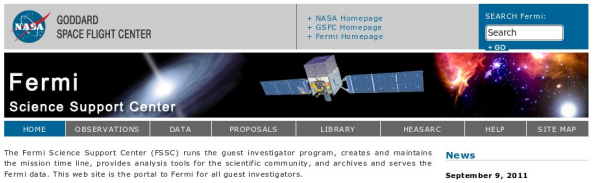
- **Multi-wavelength campaigns:**
  - **To fully understand an astrophysical object you have to study it in all wavelengths, not just gamma-rays**
  - **Need to alert and cooperate with other observatories**
- **Gamma-ray sky:**
  - **Dynamic on very short time scales:**
    - **From seconds to hours to days**
  - **Fermi LAT sends out one ATEL/week**
  - **Flaring Crab:**



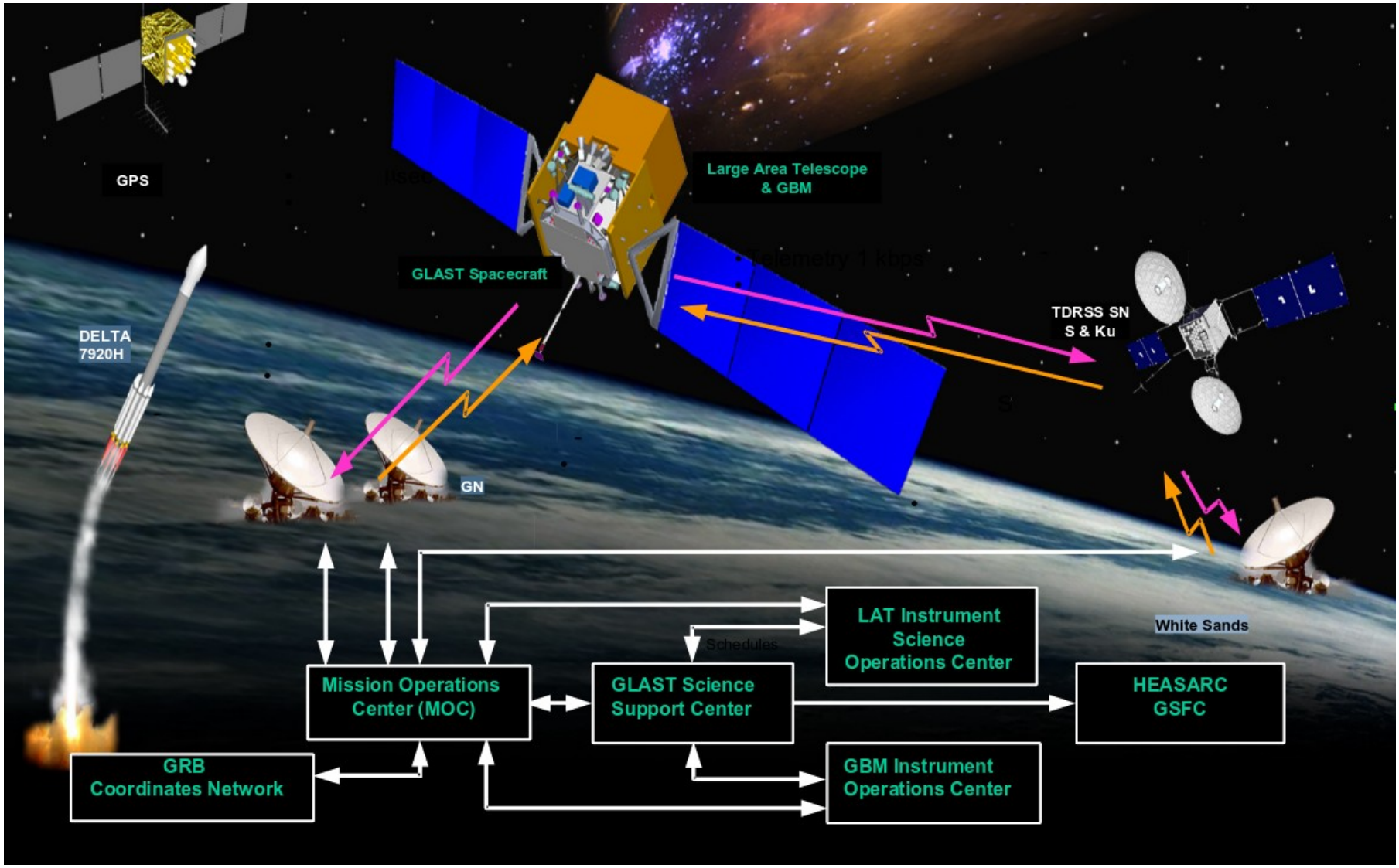
Rolf Buehler, KIPAC

"I feel the need … the need for speed!"

- **Fermi LAT photon data:**
  - **Public!**
    - **Anybody can download it from the Fermi Science Support Center**
  - **Formal latency requirements:**
    - **We take pride in beating that**
  - **There is an element of "serving the gamma-ray community":**
    - **Not just the Fermi LAT Collaboration**
- **Additional motivation:**
  - **The gamma-ray community has a say in whether the Fermi mission gets extended beyond 5 years :-)**
- **Bottom line:**
  - **We have to get the data out as quickly as possible!**

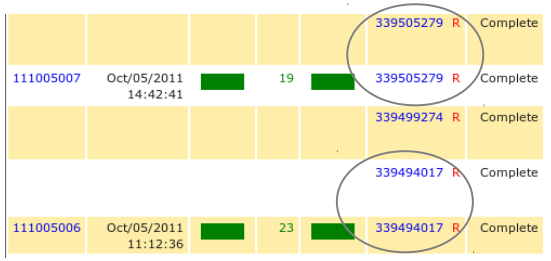


Fermi Mission Elements



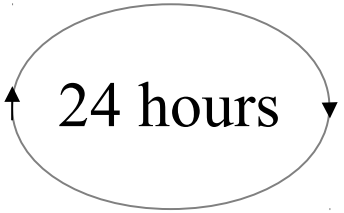
Data Arrival

- Data are stored on the Space craft Solid State Recorder (SSR):
  - Downlinked every 3 hours
  - Equivalent to a continous 1.6 Mb/s link (15 GB/day)
- Runs:
  - Fermi LAT data taking are done in runs:
    - From SAA to SAA i.e. ~90 minutes
  - Also the basic data processing unit
- Downlink:
  - No 1-1 mapping to runs
  - Typically contains:
    - End of a run from previous downlink
    - A complete run
    - Start of a new run
- In addition:
  - We may receive downlinks out of order



Dtaa Airravl

- **Missing data:**
  - Data may be lost in the transmission to ground
  - Redump it:
    - SSR only holds 24h of data (wraps around)

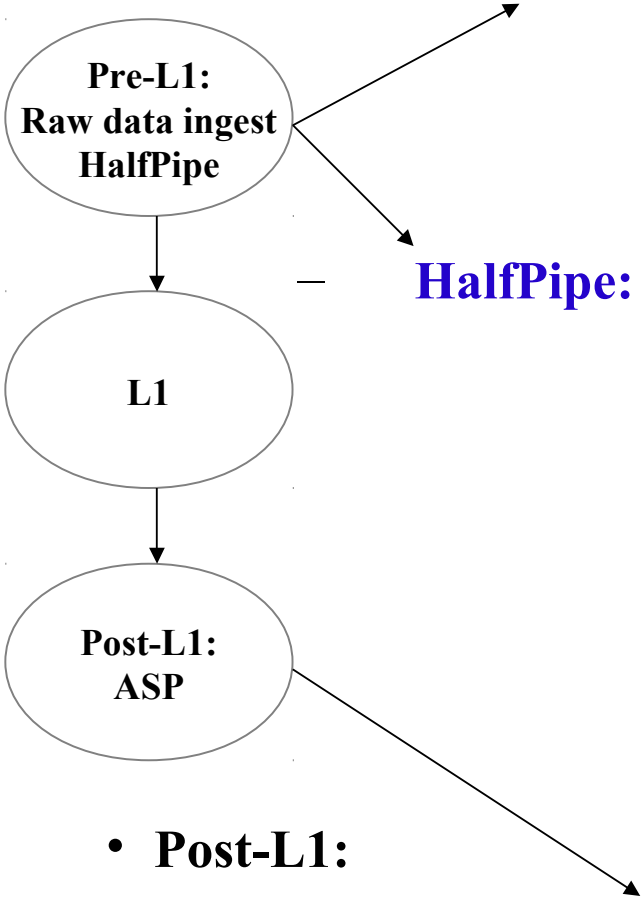


- **So:**
  - We may receive bits of missing data from previous runs
- **Conclusion:**
  - We will receive data in random order
  - L1 data processing system must be able to deal with this in a natural way
- **In addition:**
  - We must ship out whatever processed data we have as soon as we can:
    - We can not wait until a run is complete

Random data arrival and speedy processing is the normal operating mode!

Pre-L1 & Post-L1

- There are many elements to what happens to the data at SLAC
- Pre-L1:
  - Raw data storage:
    - Raw data (L0) arriving at SLAC is stored:
      - » CCSDS packets in files (xrootd)
      - » Duplicate data removed
  - HalfPipe:
    - Merge the two event streams from the instrument into a single ordered stream
    - Prepare data for L1 processing:
      - » Provide "chunks" of contiguous data to L1
      - » Makes it easier for L1 to deal with missing data



- Post-L1:
  - Automatic Science Processing:
    - Higher level science analysis

Reconstruction Steps

Raw Data

↓

Digitization

- Translates from electronics space (cable controllers) to physical space (layers)
- ROOT format

↓

Reconstruction

- Apply calibration constants
- Run reconstruction (tracks, clusters, etc)
- Particle (Photon) identification

↓

Photon data

- FITS format

} **L1**

Reconstruction Steps And Data Sizes

Raw Data

↓

Digitization

- Translates from electronics space (cable controllers) to physical space (layers)
- ROOT format

↓

Reconstruction

- Apply calibration constants
- Run reconstruction (tracks, clusters, etc)
- Particle (Photon) identification

↓

Photon data

- FITS format

} **L1**

We get 15 GB/day downlinked from the space craft:

- Custom compression

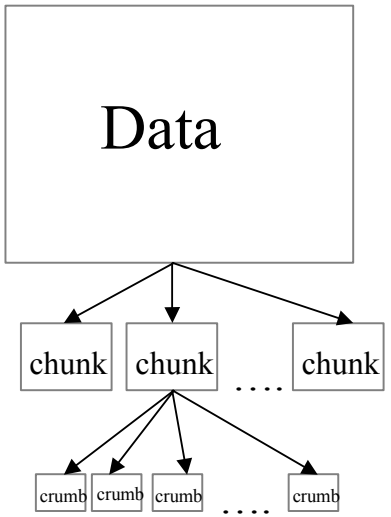
L1 writes 750 GB/day to disk

Photon data sent to the Fermi Science Support Center:

- 13 MB/day for basic photon data and pointing information
- 200 MB/day with extended summary photon data

(Embarassingly) Parallel Processing

- **Reconstruction runs at ~5 Hz:**
  - **Must do things in parallel:**
    - **Downlink rate is ~500 Hz**
- **Two-fold split:**
  - **"Chunks" from the HalfPipe:**
    - **100k events**
    - **Digitized in one job**
  - **Split each digitized chunk into "crumbs":**
    - **3k events/crumb**
    - **Run (slow) recon on (small) crumbs**
- **CPU usage:**
  - **We have 800 cores which we use for each delivery:**
    - **Available in the general batch queues when we don't use them**
  - **Equivalent DC level of 125 cores:**
    - **15-20k batch jobs/day (processing + DQM)**

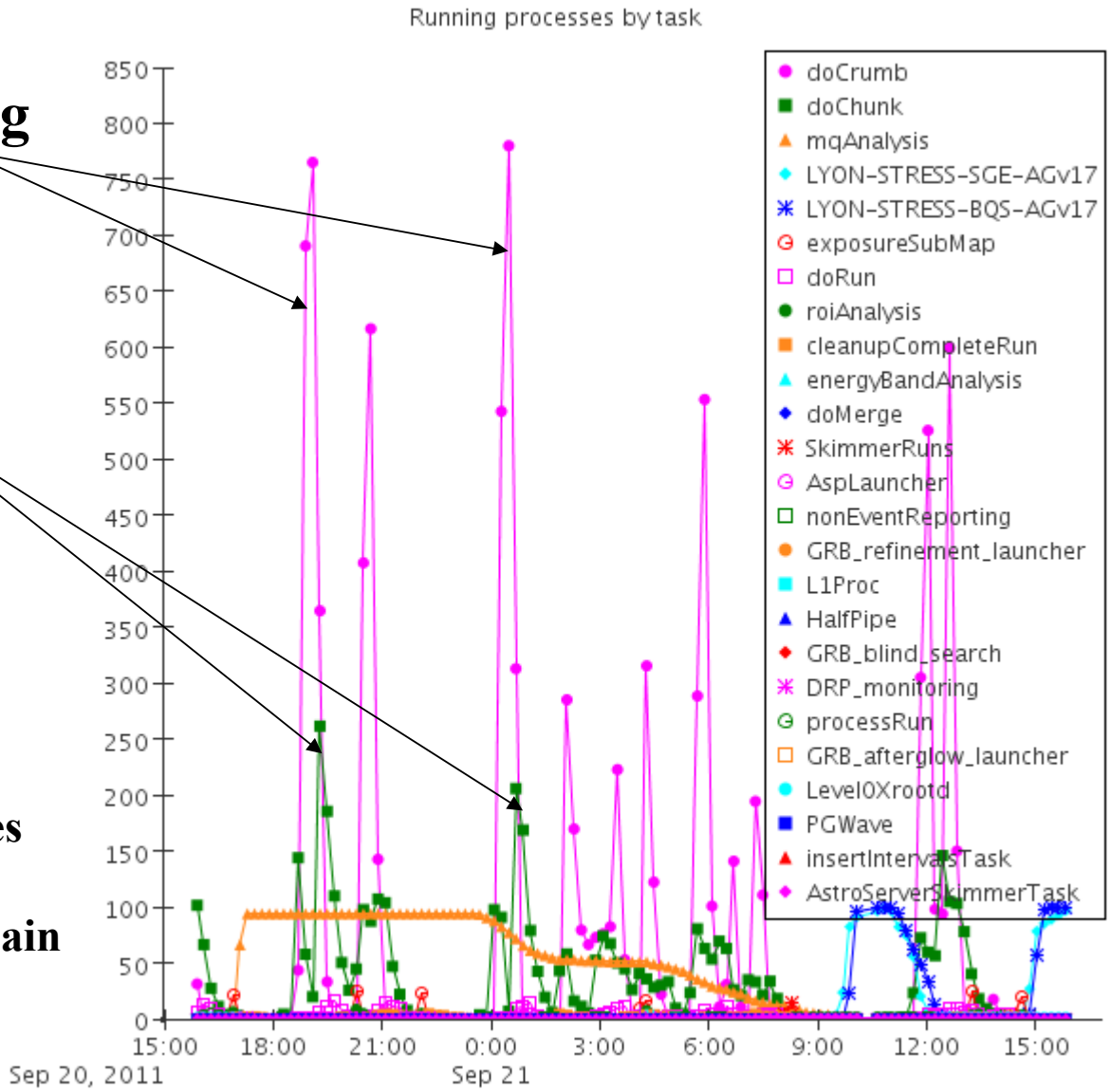


L1 CPU Usage

Recon processing
(“crumbs”)

Digitization
(“chunks”)

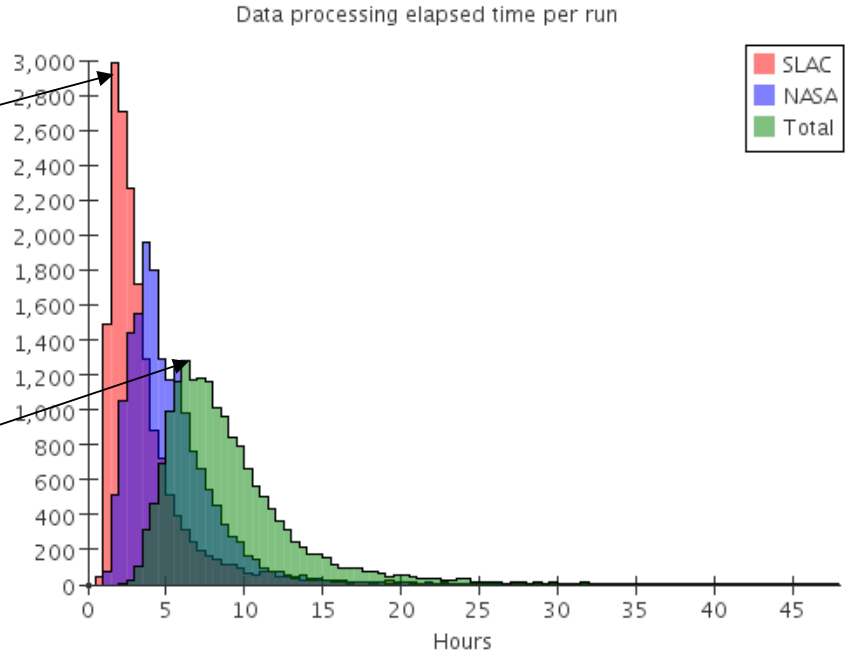
Fermi suspends user jobs on these 800 cores when we need them. And resumes them again when we're done.

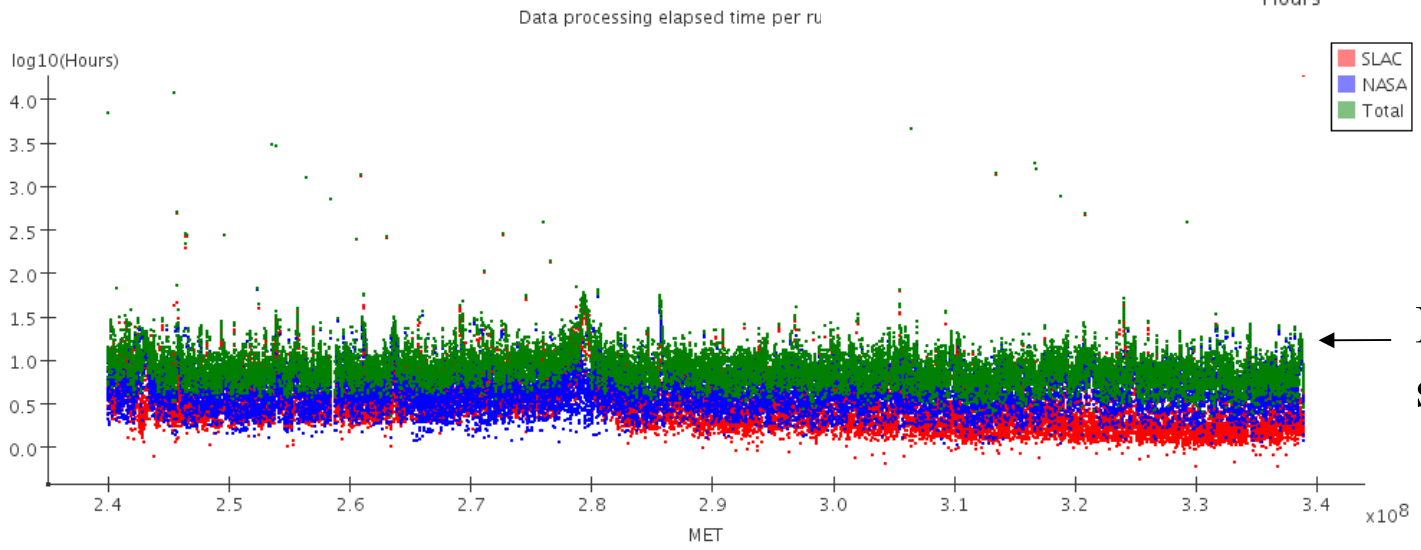


L1 Processing Time

Processing time at SLAC: ~1-2h

Total time from we take the data until we export the photon data: ~8h





Processing times since we launched

I/O Load

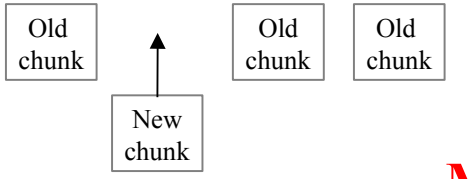
- I/O load:
  - Each chunk/crumb has a slightly different size so jobs don't finish at the same time and we spread the I/O load:
    - Originally we used AFS buffers for intermediate storage
    - Now use xrootd directly
  - All files stored locally on batch host and copied over when the job is finished
- At the end we merge:
  - Crumbs into chunks
  - Chunks into run level file
  - Lots of I/O ….
- To reduce the risk of I/O overload:
  - Throttle the number of runs we process at the same time
  - We can increase the throttle in case of backlog

When we Get Additional Data For A Run

- We process and export the part of the run we have:
  - We merge up everything we have for the run
  - We keep the chunks until the run is complete
- When we get additional data for a run:
  - Only process the new data!

Deliveries/Runs processing status

Delivery		FASTCopy		HalfPipe	Runs			L1Proc			
Id	Time (UTC)	Proc	Logs	Proc	Id - Start MET	Status	Intent	DI	Proc	Status	Logs
111005010	Oct/05/2011 20:07:41		13		339522489 R	InProgress	nomSciOps_diagEna			Running	679



  - Chunks are contigous so new chunks slot in between the old ones
  - Merge up everything we have for the run:
    - Old and new pieces
  - Repeat every time we get a new piece of a run
- This means:
  - We do redundant run level merging:
    - Even more I/O …..
  - Can only process one new delivery for a given run at the time:
    - Run locking

The Advantage

- **Advantage:**
  - **Simplifies the design of L1**
  - **Chunk files have intelligent names so a simple 'ls' sorts them in the correct order for merging:**
    - **No need to do any advanced book keeping**
- **Deliberate decision:**
  - **Move a lot of the intelligence out of L1 and into preparing the data for L1:**
    - **Raw data ingest and the HalfPipe**
    - **Online group also had more database experience**
- **Design of L1 has worked:**
  - **Very robust and flexible**
- **As we have gained experience with the system:**
  - **Have added some additional intelligence into L1**

Catching The Things That Should Never Happen

- At each step of the processing:
  - Make sure nothing goes wrong
- At the end:
  - "Trust but verify!"
- "Verify":
  - Monitoring module that scans the final data for the impossible:
    - Events out-of-order?
    - Time goes backwards?
    - Livetime < 0?
    - Data gaps where there should be none?
    - …..
- And yes:
  - It has caught some 'impossible' things

Problems? Transient? Retry!

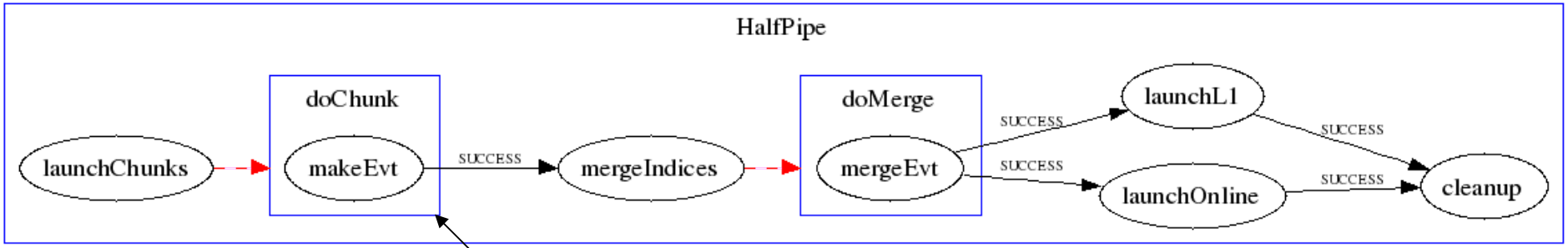
- L1 operates in an open SLAC computing environment:
  - Uses the general batch queues
  - Disks are on servers that may host other people's stuff
- Sensitive to problems outside our control:
  - In particular server overloads:
    - "This file ain't here". Even though it is.
      - » Computers lie all the time
  - Annoying! Requires shifter intervention to roll it back
- Automatic retry:
  - If something fails we automatically retry a configurable number of times:
    - Usually 2 or 3 times
  - Made a huge difference
- Shifters can now concentrate on more complicated failures:
  - Total failure rate is very low (~0.01%)

L1 vs. The Pipeline

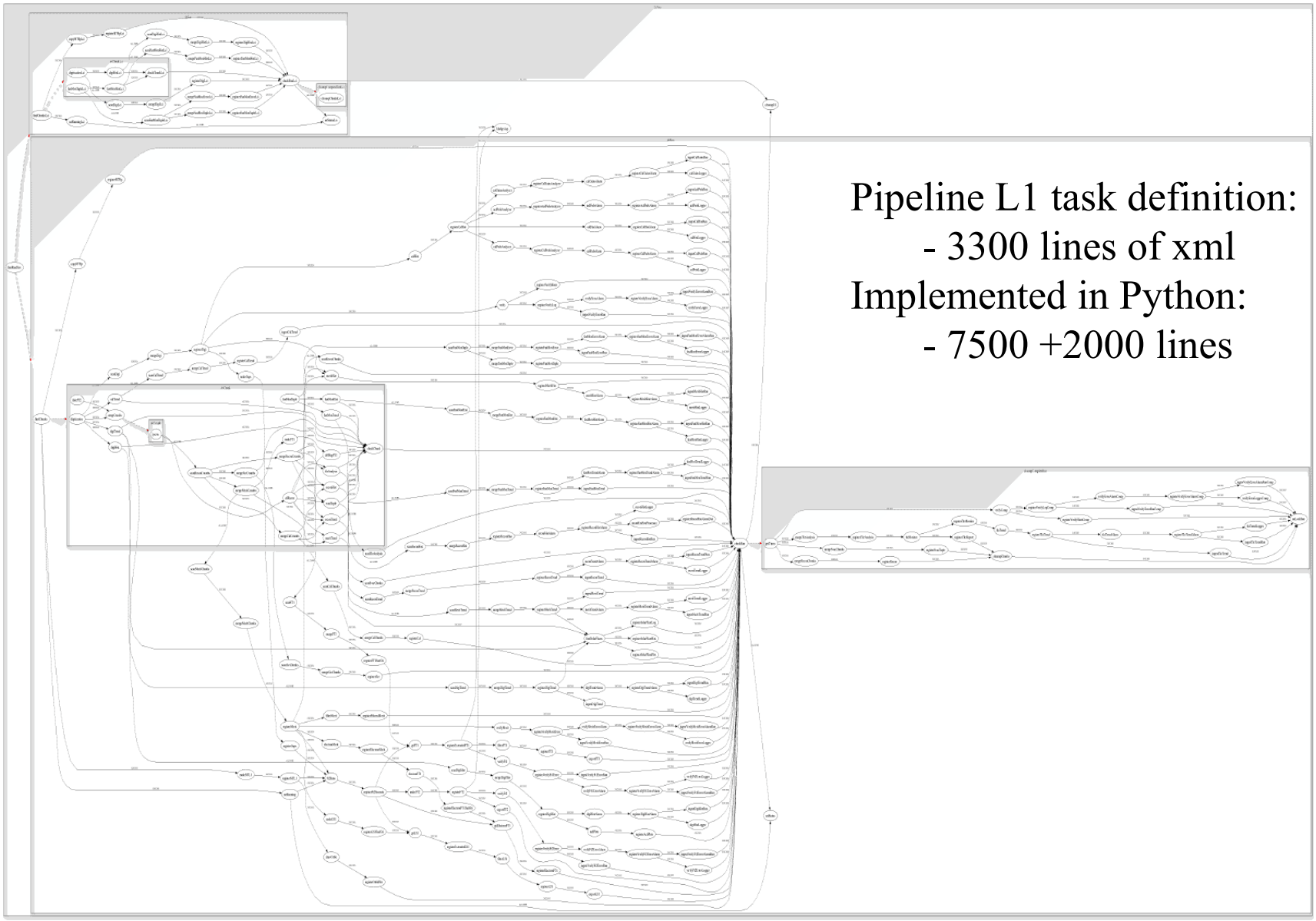
- **L1:**
  - All the scripts that deal with the logic of Fermi LAT data processing
  - Runs on top of the Pipeline
- **Pipeline:**
  - Work-flow engine provided by the Fermi/SCA Data Handling group
  - Deals with running and keeping track of thousands of batch jobs
  - Generic tool:
    - Originally developed for Fermi LAT
    - Now also used by EXO and SuperCDMS
  - Not limited to data processing:
    - MC production
    - Anything where you need to run a large number of batch jobs (at SLAC or offsite)

The Pipeline

- A tool to run a graph of processes:
  - Well suited for massively parallel tasks
- Pros:
  - Takes care of splitting data and bringing it back together
  - Knows about dependencies:
    - If you have to roll back a failed job it knows which other jobs will have to be rolled back
- Cons:
  - Need to explicitly specify dependencies:
    - User provided xml



L1 Task Definition



Pipeline L1 task definition:
- 3300 lines of xml

Implemented in Python:
- 7500 +2000 lines

The Pipeline Under The Hood

- Database driven system:
  - Oracle:
    - Two Niagara-class 64-thread servers
    - Primary/secondary redundant configuration
  - Java stored procedures for query intensive tasks
- Implemented in java:
  - Apache Tomcat web servers
  - Web pages written in Java Server Pages (JSP)
- Email:
  - Asynchronous persistent messaging from batch hosts to the pipeline server:
    - Email at start and stop of each batch job
  - A majority of non-spam email at SLAC is now from the pipeline:
    - Dedicated email server

Data Processing Page

Fermi LAT Data Processing

Summarizes the overall processing status

Start refreshing page every 300 secs Start Refreshing

User: borgland . (Switch|Logout) | Version 0.2.3 | Jira

Prod | Dev

Summary | Delivery | Run Selection

Time Interval (UTC) : Sep/27/2011 06:31:00-Sep/28/2011 18:31:00

Hide Deliveries/Runs processing status

Deliveries/Runs processing status

Delivery		FASTCopy		HalfPipe	Runs			L1Proc					GRB Search
Id	Time (UTC)	Proc	Logs	Proc	Id - Start MET	Status	Intent	DI	Proc	Status	Logs	Data Mon	Proc
110928009	Sep/28/2011 16:26:13		19		338909701 R	InProgress	nomSciOps_diagEna			Running	88 3808	Di | Re | Me | Cal	
					338904018 R	Complete	nomSciOps_diagEna			Running	2 1 3893	Di | Re | Me | Cal	
					338898465 R	Complete	nomSciOps_diagEna			Complete	4235	FM | Di | Re | Me | Cal	
110928008	Sep/28/2011 12:41:42		15		338898465 R	Complete	nomSciOps_diagEna			Complete	4235		
110928007	Sep/28/2011 11:20:35		15		338892522 R	Complete	nomSciOps_diagEna			Complete	4235	FM | Di | Re | Me | Cal	
110928006	Sep/28/2011 09:49:22		17		338886550 R	Complete	nomSciOps_diagEna			Complete	4235	FM | Di | Re | Me | Cal	
					338880574 R	Complete	nomSciOps_diagEna			Complete	1 4234	FM | Di | Re | Me | Cal	
110928005	Sep/28/2011 07:36:45		17		338880574 R	Complete	nomSciOps_diagEna			Complete	1 4234		
					338874589 R	Complete	nomSciOps_diagEna			Complete	4235	FM | Di | Re | Me | Cal	
110928004	Sep/28/2011 06:12:33		17		338874589 R	Complete	nomSciOps_diagEna			Complete	4235		
					338868584 R	Complete	nomSciOps_diagEna			Complete	8 5 4222	FM | Di | Re | Me | Cal	
110928003	Sep/28/2011 04:47:49		19		338868584 R	Complete	nomSciOps_diagEna			Complete	8 5 4222		
					338865482	Complete	nadirOps			Complete	216 167 60 3792	FM | Di | Re | Me | Cal	
					338863382	Complete	nadirOps			Complete	3318 121 22 774		

GRB Alerts

Trigger Time		GRB		Processing		Data
UTC	MET	Name	Notice	Prompt	Afterglow	
Sep/28/2011 17:29:47	338923787	GRB110928729	FERMI			
Sep/28/2011 13:37:28	338909848	GRB110928568	FERMI			338909701
Sep/28/2011 13:26:11	338909171	GRB110928560	FERMI			338904018
Sep/28/2011 12:29:02	338905742	GRB110928520	FERMI			338904018
Sep/28/2011 04:19:53	338876393	GRB110928180	FERMI			338874589
Sep/28/2011 01:51:33	338867493	GRB110928077	SWIFT			338865482
Sep/27/2011 14:01:01	338824861	GRB110927584	FERMI			338823799
Sep/27/2011 10:52:36	338813556	GRB110927453	FERMI			338812521
Sep/27/2011 07:43:49	338802229	GRB110927322	FERMI			338800591

ASP Sky Monitor Process

Processing (UTC)	PGWave	DRP	Data	Data Start (UTC)	Frequency
Sep/28/2011 06:57:30			Pgwave Drp	Sep/28/2011 06:00:00	six_hours
Sep/28/2011 03:42:01			Pgwave Drp	Sep/28/2011 00:00:00	six_hours
Sep/27/2011 21:49:30			Pgwave Drp	Sep/27/2011 18:00:00	six_hours
Sep/27/2011 17:24:51			Pgwave Drp	Sep/27/2011 00:00:00	daily
Sep/27/2011 15:20:05			Pgwave Drp	Sep/27/2011 12:00:00	six_hours
Sep/27/2011 13:44:03			Pgwave Drp	Sep/27/2011 06:00:00	six_hours
Sep/27/2011 09:48:18			Pgwave Drp	Sep/27/2011 00:00:00	six_hours

Data Processing Page

Fermi LAT Data Processing

Start refreshing page every 300 secs Start Refreshing

User: borgland . (Switch|Logout) | Version 0.2.3 | Jira

Prod | Dev

Summary | Delivery | Run Selection

L1

Time Interval (UTC) : Sep/27/2011 06:31:00-Sep/28/2011 18:31:00

Hide Deliveries/Runs processing status

Additional science processing: GRB and ASP

Deliveries/Runs processing status

Delivery		FASTCopy		HalfPipe	Runs			L1Proc					GRB Search
Id	Time (UTC)	Proc	Logs	Proc	Id - Start MET	Status	Intent	DI	Proc	Status	Logs	Data Mon	Proc
110928009	Sep/28/2011 16:26:13		19		338909701 R	InProgress	nomSciOps_diagEna			Running	88 3808	Di | Re | Me | Cal	
					338904018 R	Complete	nomSciOps_diagEna			Running	2 1 3893	Di | Re | Me | Cal	
					338898465 R	Complete	nomSciOps_diagEna			Complete	4235	FM | Di | Re | Me | Cal	
110928008	Sep/28/2011 12:41:42		15		338898465 R	Complete	nomSciOps_diagEna			Complete	4235		
110928007	Sep/28/2011 11:20:35		15		338892522 R	Complete	nomSciOps_diagEna			Complete	4235	FM | Di | Re | Me | Cal	
110928006	Sep/28/2011 09:49:22		17		338886550 R	Complete	nomSciOps_diagEna			Complete	4235	FM | Di | Re | Me | Cal	
					338880574 R	Complete	nomSciOps_diagEna			Complete	1 4234	FM | Di | Re | Me | Cal	
110928005	Sep/28/2011 07:36:45		17		338880574 R	Complete	nomSciOps_diagEna			Complete	1 4234		
					338874589 R	Complete	nomSciOps_diagEna			Complete	4235	FM | Di | Re | Me | Cal	
110928004	Sep/28/2011 06:12:33		17		338874589 R	Complete	nomSciOps_diagEna			Complete	4235		
					338868584 R	Complete	nomSciOps_diagEna			Complete	8 5 4222	FM | Di | Re | Me | Cal	
110928003	Sep/28/2011 04:47:49		19		338868584 R	Complete	nomSciOps_diagEna			Complete	8 5 4222		
					338865482	Complete	nadirOps			Complete	216 167 60 3792	FM | Di | Re | Me | Cal	
					338863382	Complete	nadirOps			Complete	3318 121 22 774		

GRB Alerts

Trigger Time		GRB		Processing		Data
UTC	MET	Name	Notice	Prompt	Afterglow	
Sep/28/2011 17:29:47	338923787	GRB110928729	FERMI			
Sep/28/2011 13:37:28	338909848	GRB110928568	FERMI			338909701
Sep/28/2011 13:26:11	338909171	GRB110928560	FERMI			338904018
Sep/28/2011 12:29:02	338905742	GRB110928520	FERMI			338904018
Sep/28/2011 04:19:53	338876393	GRB110928180	FERMI			338874589
Sep/28/2011 01:51:33	338867493	GRB110928077	SWIFT			338865482
Sep/27/2011 14:01:01	338824861	GRB110927584	FERMI			338823799
Sep/27/2011 10:52:36	338813556	GRB110927453	FERMI			338812521
Sep/27/2011 07:43:49	338802229	GRB110927322	FERMI			338800591

ASP Sky Monitor Process

Processing (UTC)	PGWave	DRP	Data	Data Start (UTC)	Frequency
Sep/28/2011 06:57:30			Pgwave Drp	Sep/28/2011 06:00:00	six_hours
Sep/28/2011 03:42:01			Pgwave Drp	Sep/28/2011 00:00:00	six_hours
Sep/27/2011 21:49:30			Pgwave Drp	Sep/27/2011 18:00:00	six_hours
Sep/27/2011 17:24:51			Pgwave Drp	Sep/27/2011 00:00:00	daily
Sep/27/2011 15:20:05			Pgwave Drp	Sep/27/2011 12:00:00	six_hours
Sep/27/2011 13:44:03			Pgwave Drp	Sep/27/2011 06:00:00	six_hours
Sep/27/2011 09:48:18			Pgwave Drp	Sep/27/2011 00:00:00	six_hours

Deliveries

Runs, DQM quality, data completeness, intent, processing status, DQM alarms

Drilling Down

Fermi LAT Data Processing

Click on L1Proc to drill down to the processing of that run

Start refreshing page every 300 secs Start Refreshing

User: borgland . (Switch|Logout) | Version 0.2.3 | Jira

Prod | Dev

Summary | Delivery | Run Selection

Time Interval (UTC) : Sep/28/2011 06:31:00-Sep/28/2011 18:31:00

Hide Deliveries/Runs processing status

Deliveries/Runs processing status

Delivery		FASTCopy		HalfPipe	Runs				L1Proc				GRB Search
Id	Time (UTC)	Proc	Logs	Proc	Id - Start MET	Status	Intent	DI	Proc	Status	Logs	Data Mon	Proc
110928009	Sep/28/2011 16:26:13		19		338909701 R	InProgress	nomSciOps_diagEna			Running	88 3808	Di | Re | Me | Cal	
					338904018 R	Complete	nomSciOps_diagEna			Running	2 1 3893	Di | Re | Me | Cal	
					338898465 R	Complete	nomSciOps_diagEna			Complete	4235	FM | Di | Re | Me | Cal	
110928008	Sep/28/2011 12:41:42		15		338898465 R	Complete	nomSciOps_diagEna			Complete	4235		
110928007	Sep/28/2011 11:20:35		15		338892522 R	Complete	nomSciOps_diagEna			Complete	4235	FM | Di | Re | Me | Cal	
110928006	Sep/28/2011 09:49:22		17		338886550 R	Complete	nomSciOps_diagEna			Complete	4235	FM | Di | Re | Me | Cal	
					338880574 R	Complete	nomSciOps_diagEna			Complete	1 4234	FM | Di | Re | Me | Cal	
110928005	Sep/28/2011 07:36:45		17		338880574 R	Complete	nomSciOps_diagEna			Complete	1 4234		
					338874589 R	Complete	nomSciOps_diagEna			Complete	4235	FM | Di | Re | Me | Cal	
110928004	Sep/28/2011 06:12:33		17		338874589 R	Complete	nomSciOps_diagEna			Complete	4235		
					338868584 R	Complete	nomSciOps_diagEna			Complete	8 5 4222	FM | Di | Re | Me | Cal	
110928003	Sep/28/2011 04:47:49		19		338868584 R	Complete	nomSciOps_diagEna			Complete	8 5 4222		
					338865482	Complete	nadirOps			Complete	216 167 60 3792	FM | Di | Re | Me | Cal	
					338863382	Complete	nadirOps			Complete	3318 121 22 774		

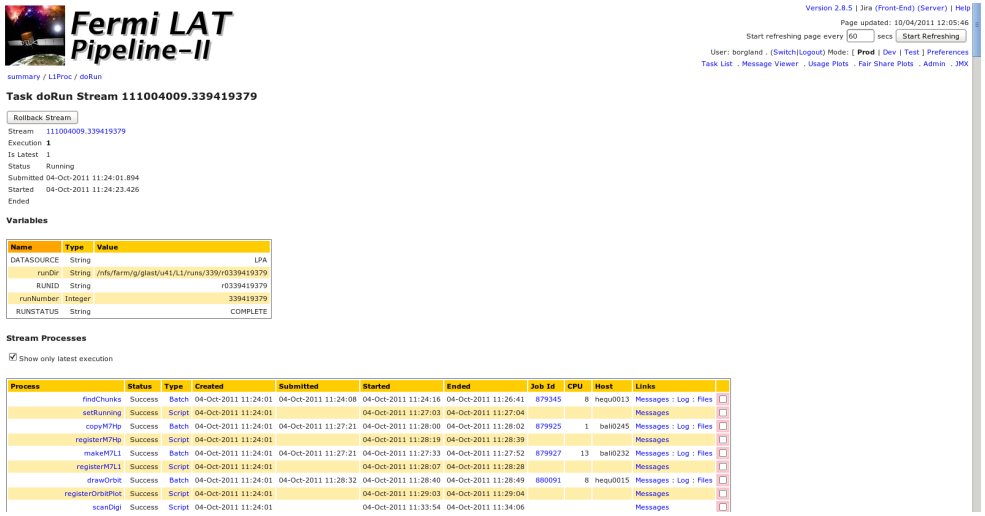
GRB Alerts

Trigger Time		GRB		Processing		Data
UTC	MET	Name	Notice	Prompt	Afterglow	
Sep/28/2011 17:29:47	338923787	GRB110928729	FERMI			
Sep/28/2011 13:37:28	338909848	GRB110928568	FERMI			338909701
Sep/28/2011 13:26:11	338909171	GRB110928560	FERMI			338904018
Sep/28/2011 12:29:02	338905742	GRB110928520	FERMI			338904018
Sep/28/2011 04:19:53	338876393	GRB110928180	FERMI			338874589
Sep/28/2011 01:51:33	338867493	GRB110928077	SWIFT			338865482
Sep/27/2011 14:01:01	338824861	GRB110927584	FERMI			338823799
Sep/27/2011 10:52:36	338813556	GRB110927453	FERMI			338812521
Sep/27/2011 07:43:49	338802229	GRB110927322	FERMI			338800591

ASP Sky Monitor Process

Processing (UTC)	PGWave	DRP	Data	Data Start (UTC)	Frequency
Sep/28/2011 06:57:30			Pgwave Drp	Sep/28/2011 06:00:00	six_hours
Sep/28/2011 03:42:01			Pgwave Drp	Sep/28/2011 00:00:00	six_hours
Sep/27/2011 21:49:30			Pgwave Drp	Sep/27/2011 18:00:00	six_hours
Sep/27/2011 17:24:51			Pgwave Drp	Sep/27/2011 00:00:00	daily
Sep/27/2011 15:20:05			Pgwave Drp	Sep/27/2011 12:00:00	six_hours
Sep/27/2011 13:44:03			Pgwave Drp	Sep/27/2011 06:00:00	six_hours
Sep/27/2011 09:48:18			Pgwave Drp	Sep/27/2011 00:00:00	six_hours

All Processes For This Run In This Delivery



Substreams

taskname	Stream	Status	Created	Started	Ended
doChunk	4203049	Success	04-Oct-2011 11:26:58	04-Oct-2011 11:27:22	04-Oct-2011 11:33:43
	6436087	Running	04-Oct-2011 11:26:59	04-Oct-2011 11:27:33	
	7019041	Running	04-Oct-2011 11:26:56	04-Oct-2011 11:27:11	
	7572646	Running	04-Oct-2011 11:26:56	04-Oct-2011 11:27:11	
	8094499	Running	04-Oct-2011 11:26:56	04-Oct-2011 11:27:11	
	8576441	Running	04-Oct-2011 11:26:57	04-Oct-2011 11:27:22	
	9014008	Running	04-Oct-2011 11:26:55	04-Oct-2011 11:27:10	
	9408314	Success	04-Oct-2011 11:26:44	04-Oct-2011 11:27:10	04-Oct-2011 12:02:09
	9764351	Success	04-Oct-2011 11:26:58	04-Oct-2011 11:27:22	04-Oct-2011 12:02:33
	10083517	Running	04-Oct-2011 11:26:58	04-Oct-2011 11:27:22	
	10741133	Running	04-Oct-2011 11:26:59	04-Oct-2011 11:27:34	
	11318887	Running	04-Oct-2011 11:26:59	04-Oct-2011 11:27:34	
	11827916	Running	04-Oct-2011 11:26:57	04-Oct-2011 11:27:22	
	12279276	Running	04-Oct-2011 11:26:59	04-Oct-2011 11:27:22	
	12689179	Running	04-Oct-2011 11:26:57	04-Oct-2011 11:27:22	

Select all . Deselect all . Toggle selection Rollback Selected SubStreams

All Substreams

Task	Process											Total
doRun	findChunks	0	0	0	0	0	1	0	0	0	0	1
	setRunning	0	0	0	0	0	1	0	0	0	0	1
	copyM7Hp	0	0	0	0	0	1	0	0	0	0	1
	registerM7Hp	0	0	0	0	0	1	0	0	0	0	1
	makeM7L1	0	0	0	0	0	1	0	0	0	0	1
	registerM7L1	0	0	0	0	0	1	0	0	0	0	1
	drawOrbit	0	0	0	0	0	1	0	0	0	0	1
	registerOrbitPlot	0	0	0	0	0	1	0	0	0	0	1

All the data chunks

Click to drill down

Tells you whether jobs are Running, Failed etc

All Processes For One Specific Chunk Of Data

Fermi LAT Pipeline-II

Version 2.8.5 | Jira (Front-End) (Server) | Help
Page updated: 10/04/2011 12:06:58
Start refreshing page every 60 secs [Start Refreshing]
User: borgland . (Switch|Logout) Mode: [**Prod** | Dev | Test] Preferences
Task List . Message Viewer . Usage Plots . Fair Share Plots . Admin . JMX

summary / L1Proc / doRun / doChunk

Task doChunk Stream 111004009.339419379.4203049

[Rollback Stream]

Stream 111004009.339419379.4203049
Execution **1**
Is Latest 1
Status Success
Submitted 04-Oct-2011 11:26:58.152
Started 04-Oct-2011 11:27:22.986
Ended 04-Oct-2011 11:33:43.212

Variables

Name	Type	Value
CHUNK_ID	String	e00000000000004203049
tStart	Integer	339421333
tStop	Integer	339421335

Stream Processes

☑ Show only latest execution

Process	Status	Type	Created	Submitted	Started	Ended	Job Id	CPU	Host	Links
digitization	Success	Batch	04-Oct-2011 11:26:58	04-Oct-2011 11:27:07	04-Oct-2011 11:27:14	04-Oct-2011 11:27:30	879788	7	hequ0011	Messages : Log : Files
checkChunk	Success	Batch	04-Oct-2011 11:26:58	04-Oct-2011 11:33:31	04-Oct-2011 11:33:37	04-Oct-2011 11:33:38	880565	0	fell0140	Messages : Log : Files
fastMonTuple	Success	Batch	04-Oct-2011 11:26:58	04-Oct-2011 11:27:08	04-Oct-2011 11:27:38	04-Oct-2011 11:28:05	879791	9	hequ0016	Messages : Log : Files
fastMonHist	Success	Batch	04-Oct-2011 11:26:58	04-Oct-2011 11:28:08	04-Oct-2011 11:28:12	04-Oct-2011 11:28:28	880085	5	hequ0014	Messages : Log : Files
fastMonTrend	Success	Batch	04-Oct-2011 11:26:58	04-Oct-2011 11:28:09	04-Oct-2011 11:28:12	04-Oct-2011 11:28:27	880086	7	hequ0013	Messages : Log : Files
digiHist	Success	Batch	04-Oct-2011 11:26:58	04-Oct-2011 11:27:45	04-Oct-2011 11:27:56	04-Oct-2011 11:28:11	879935	8	fell0142	Messages : Log : Files
digiTrend	Success	Batch	04-Oct-2011 11:26:58	04-Oct-2011 11:27:45	04-Oct-2011 11:28:01	04-Oct-2011 11:29:08	879936	53	fell0182	Messages : Log : Files
calTrend	Success	Batch	04-Oct-2011 11:26:58	04-Oct-2011 11:27:45	04-Oct-2011 11:28:03	04-Oct-2011 11:28:57	879937	45	boer0009	Messages : Log : Files
setupCrumbs	Success	Batch	04-Oct-2011 11:26:58	04-Oct-2011 11:27:56	04-Oct-2011 11:28:01	04-Oct-2011 11:28:12	879978	5	bali0246	Messages : Log : Files
scanReconCrumbs	Success	Script	04-Oct-2011 11:26:58		04-Oct-2011 11:30:22	04-Oct-2011 11:30:22				Messages
allRecon	Success	Script	04-Oct-2011 11:26:58		04-Oct-2011 11:30:22	04-Oct-2011 11:30:22				Messages

Can get to log file of digitization job

Log File For Digitization (Batch) Job

Fermi LAT Pipeline-II

Task doChunk Process digitization Stream 111004009.339419379.4203049

Log file: /nfs/farm/g/glast/u41/L1/logs/PROD/L1Proc/2.12/doRun/doChunk/digitization/111xxxxxx/004xxx/009/339xxxxxx/419xxx/379/004xxxxxx/203xxx/049/logFile.txt (download)

```
ARCHNAME=linux
CHUNK_ID=e00000000000004203049
CLASSPATH=/u/gl/glast/bsub/org-glast-jobcontrol-1.10.jar
CMTPATH=/afs/slac/g/glast/ground/releases/volume13/L1Proc/2.12:/afs/slac.stanford.edu/g/glast/ground/releases/volume11/GlastRelease-v17r35p23:/afs/slac.stanford.edu/g/glast/ground/GLAST_EXT/rhel4_gcc34opt
DATASOURCE=LPA
DOWNLINK_ID=111004009
DOWNLINK_RAWDIR=/nfs/farm/g/glast/u28/stage/111004009
EDITOR=/usr/bin/emacs
EVENTSTOSKIP=
GROUP=gl
G_BROKEN_FILENAMES=1
HOME=/u/gl/glastraw
HOST=glastlnx04
HOSTNAME=hequ0011
HOSTTYPE=LINUX
JOBCONTROL_LOGFILE=/nfs/farm/g/glast/u41/L1/logs/PROD/L1Proc/2.12/doRun/doChunk/digitization/111xxxxxx/004xxx/009/339xxxxxx/419xxx/379/004xxxxxx/203xxx/049/logFile.txt
JOBCONTROL_SUBMIT_COMMAND=/usr/local/bin/bsub -o logFile.txt -J digitization -q glastdataq -sp 75 -R "select[rhel40 || rhel50] rusage[scratch=1]" bash pipeline_wrapper
KDEDIR=/usr
```

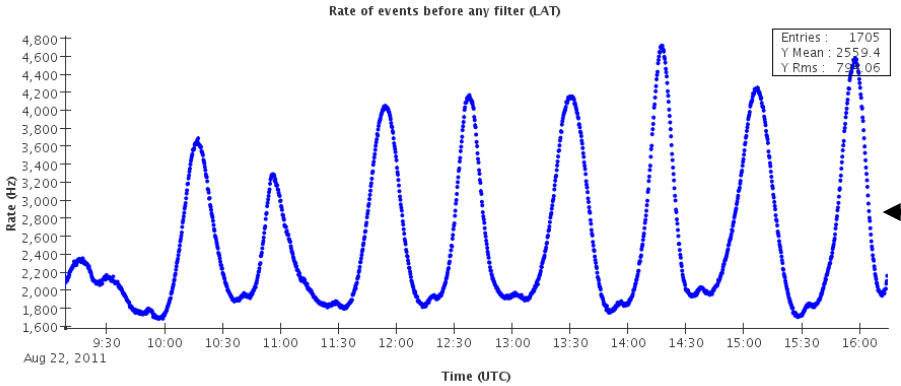
```
------------------------------------------------------------
Sender: LSF System <lsf@hequ0011>
Subject: Job 879788: <digitization> Done

Job <digitization> was submitted from host <glastlnx04> by user <glastraw>.
Job was executed on host(s) <hequ0011>, in queue <glastdataq>, as user <glastraw>.
</u/gl/glastraw> was used as the home directory.
</nfs/farm/g/glast/u41/L1/logs/PROD/L1Proc/2.12/doRun/doChunk/digitization/111xxxxxx/004xxx/009/339xxxxxx/419xxx/379/004xxxxxx/203xxx/049> was used as the working directory.
Started at Tue Oct  4 11:27:14 2011
Results reported at Tue Oct  4 11:27:30 2011

Your job looked like:

------------------------------------------------------------
# LSBATCH: User input
bash pipeline_wrapper
------------------------------------------------------------

Successfully completed.

Resource usage summary:

    CPU time   :      6.91 sec.
    Max Memory :         2 MB
    Max Swap   :        23 MB

    Max Processes  :         1
    Max Threads    :         1

The output (if any) is above this job summary.
```

Science* Data Quality Monitoring

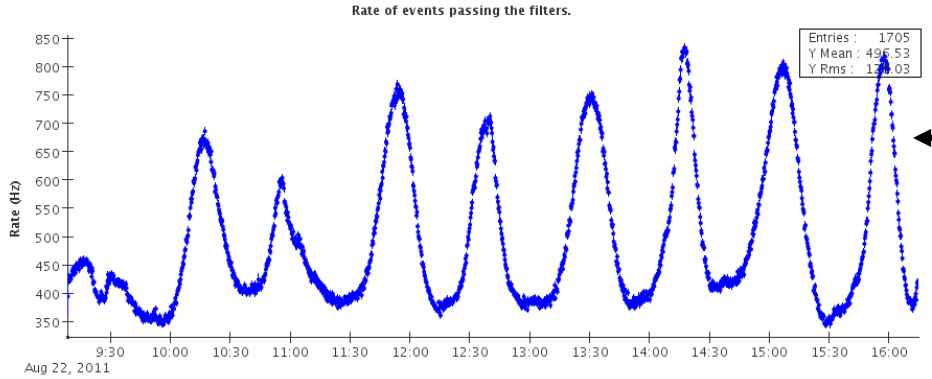
- **Fermi LAT:**
  - **A particle physics detector**
  - **In space**
- **Fair to say:**
  - **We were mostly (ex)particle physicists in the DQM group**
  - **Not much experience with spaceborne missions**
- **DQM:**
  - **The way we approached monitoring reflects this duality:**
    - **We knew the detector and what detector quantities to monitor**
    - **But not the (space) environment**
- **We needed a flexible system that we could improve as we learned more after launch!**

(*) There is also Telemetry trending. Not covered here.

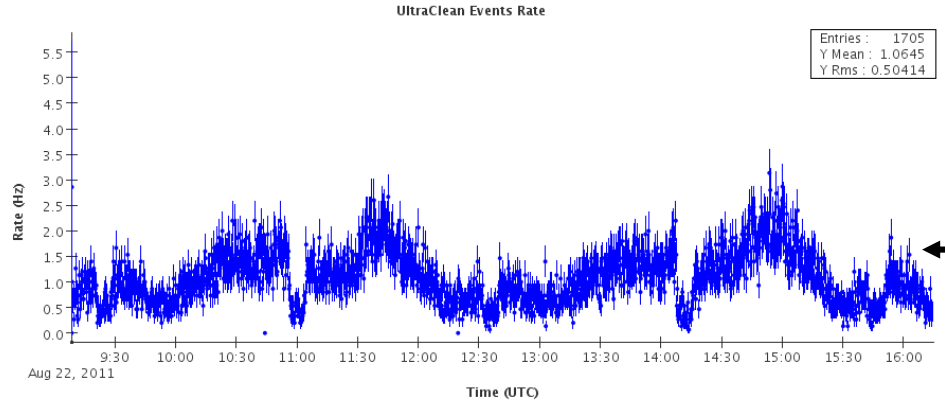
2500:1



Trigger rate:
2.5 kHz



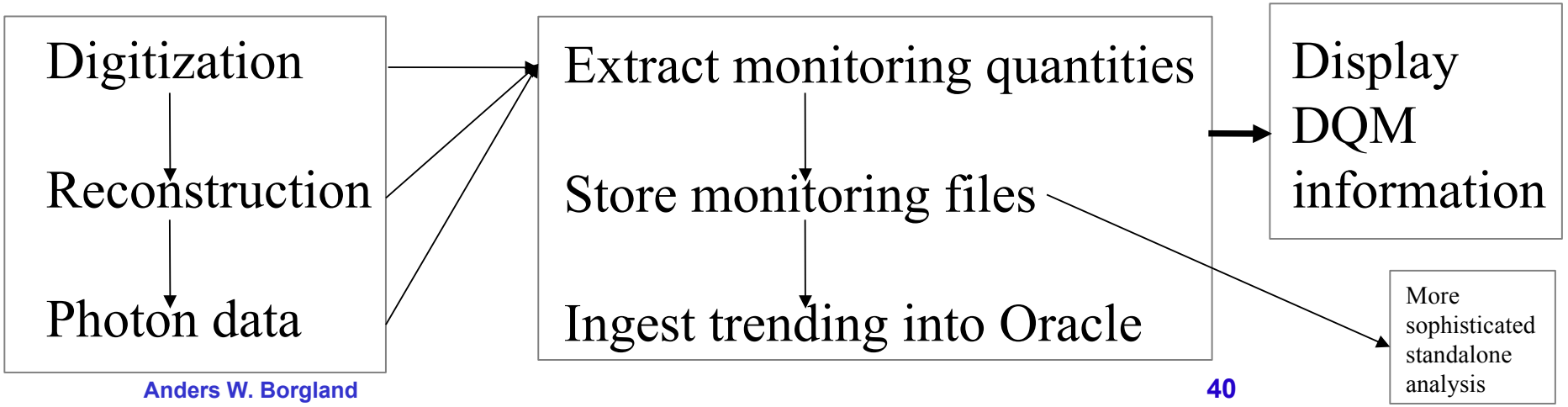
Downlink rate:
500 Hz



UltraClean photon rate:
1 Hz

Data Quality Monitoring: Basic Ideas

- **Main idea:**
  - **Monitoring follows the processing steps:**
    - **Digitization -> Reconstruction –> Photons**
- **Production vs display:**
  - **Separate production of DQM products from displaying them**
  - **We make and store files with monitoring quantities:**
    - **Root files with histograms**
    - **Ntuples with trending information**
  - **Ingest trending information into an Oracle database**



Most Files Are …. Monitoring Files!

Fermi LAT Data Processing

User: borgland . (Switch|Logout) | Version 0.2.3 | Jira
Prod | Dev
Summary | Delivery | **Run** Selection

Time Interval (UTC) : Sep/26/2011 08:06:45-Sep/27/2011 20:06:45

Details for Run 338776531

Latest Delivery 110927005

Run Summary

SCID	RunID	Intent	Type	Analysis	Status	Datagrams	Num of Events	Datagram Start	Datagram End	Event Begin	Event End	Moot Key
77	338776531	nomSciOps_diagEna	LPA		Complete	16527	1999468	2011-09-27 00:35:32.8971	2011-09-27 01:48:34.085972	2011-09-27 00:35:32.661239	2011-09-27 01:48:34.085314	2691

Run Quality

	ACQ Status	Status	Quality	Burst Advocate	L1Proc Status
R	Complete	Waiting review	Good		Complete

Run Data Sets

First Processing

Create Date (UTC)	Name	Type	Format	No. Events	Filesize	Links	Up To Date
27-Sep-2011 17:50:45	r0338776531	RECON	root	1,999,468	27.0 GB	Data Cat|Dnld	✓
27-Sep-2011 17:33:12	r0338776531	TKRTRENDALARM	xml	0	3.3 kB	Data Cat|Dnld	✓
27-Sep-2011 17:32:37	r0338776531	TKRTREND	root	0	61.2 kB	Data Cat|Dnld	✓
27-Sep-2011 17:32:02	r0338776531	TKRREPORT	tar	0	780.0 kB	Data Cat|Dnld	✓
27-Sep-2011 17:32:02	r0338776531	TKRMONITOR	root	0	2.5 MB	Data Cat|Dnld	✓
27-Sep-2011 17:16:18	r0338776531	TKRANALYSIS	root	0	12.8 MB	Data Cat|Dnld	✓
27-Sep-2011 17:12:02	r0338776531	SVAC	root	1,999,468	5.0 GB	Data Cat|Dnld	✓
27-Sep-2011 17:11:03	r0338776531	VERIFYERRORALARM	xml	0	6.9 kB	Data Cat|Dnld	✓
27-Sep-2011 17:10:17	r0338776531	VERIFYHISTO	root	0	5.7 kB	Data Cat|Dnld	✓
27-Sep-2011 17:10:17	r0338776531	VERIFYLOG	xml	0	216 B	Data Cat|Dnld	✓
27-Sep-2011 17:03:32	r0338776531	FASTMONHISTALARM	xml	0	188.1 kB	Data Cat|Dnld	✓
27-Sep-2011 17:02:56	r0338776531	FASTMONHIST	root	0	1.4 MB	Data Cat|Dnld	✓
27-Sep-2011 16:38:24	r0338776531	CALPEDSALARM	xml	0	20.4 kB	Data Cat|Dnld	✓
27-Sep-2011 16:38:24	r0338776531	CALGAINSALARM	xml	0	10.1 kB	Data Cat|Dnld	✓
27-Sep-2011 16:38:12	r0338776531	ACDPEDSALARM	xml	0	10.9 kB	Data Cat|Dnld	✓
27-Sep-2011 16:37:49	r0338776531	CALPEDSANALYZER	root	0	827.3 kB	Data Cat|Dnld	✓
27-Sep-2011 16:37:48	r0338776531	CALGAINSANALYZER	root	0	275.0 kB	Data Cat|Dnld	✓
27-Sep-2011 16:37:36	r0338776531	ACDPEDSANALYZER	root	0	30.0 kB	Data Cat|Dnld	✓
27-Sep-2011 16:37:25	r0338776531	CALHISTALARM	xml	0	1.6 kB	Data Cat|Dnld	✓
27-Sep-2011 16:36:50	r0338776531	CALHIST	root	0	13.8 MB	Data Cat|Dnld	✓
27-Sep-2011 16:35:04	r0338776531	RECONHISTALARMDIST	root	0	7.4 kB	Data Cat|Dnld	✓
27-Sep-2011 16:34:02	r0338776531	RECONHISTALARM	xml	0	2.1 MB	Data Cat|Dnld	✓
27-Sep-2011 16:33:22	r0338776531	RECONHIST	root	0	9.5 MB	Data Cat|Dnld	✓
27-Sep-2011 16:24:43	r0338776531	LS1	fit	58,788	9.8 MB	Data Cat|Dnld	✓
27-Sep-2011 16:23:24	r0338776531	EXTENDEDLS1	fit	292,851	48.6 MB	Data Cat|Dnld	✓
27-Sep-2011 16:22:33	r0338776531	LS1BADGTI	fit	0	48.6 MB	Data Cat|Dnld	✓
27-Sep-2011 16:21:25	r0338776531	FILTEREDMERIT	root	292,851	249.7 MB	Data Cat|Dnld|Skim|Wired	✓
27-Sep-2011 16:18:23	r0338776531	RECONTRENDALARM	xml	0	2.0 kB	Data Cat|Dnld	✓
27-Sep-2011 16:15:52	r0338776531	RECONTREND	root	0	12.0 MB	Data Cat|Dnld	✓
27-Sep-2011 16:15:52	r0338776531	MERITHISTALARM	xml	0	204 B	Data Cat|Dnld	✓
27-Sep-2011 16:15:04	r0338776531	MERITHIST	root	0	301.6 kB	Data Cat|Dnld	✓
27-Sep-2011 16:11:53	r0338776531	CAL	root	1,999,468	6.7 GB	Data Cat|Dnld	✓
27-Sep-2011 16:10:23	r0338776531	VERIFYFT2ERRORALARM	xml	0	830 B	Data Cat|Dnld	✓
27-Sep-2011 16:09:50	r0338776531	VERIFYFT1ERRORALARM	xml	0	824 B	Data Cat|Dnld	✓
27-Sep-2011 16:09:11	r0338776531	FASTMONTRENDALARM	xml	0	1.9 kB	Data Cat|Dnld	✓
27-Sep-2011 16:08:48	r0338776531	ELECTRONFT1	fit	0	374.1 kB	Data Cat|Dnld	✓
27-Sep-2011 16:08:48	r0338776531	VERIFYFT1ERROR	xml	0	187 B	Data Cat|Dnld	✓
27-Sep-2011 16:08:47	r0338776531	FT1	fit	8,735	829.7 kB	Data Cat|Dnld	✓
27-Sep-2011 16:08:46	r0338776531	VERIFYFT2ERROR	xml	0	184 B	Data Cat|Dnld	✓
27-Sep-2011 16:08:46	r0338776531	FASTMONTREND	root	0	30.1 MB	Data Cat|Dnld	✓
27-Sep-2011 16:08:14	r0338776531	ELECTRONFT1BADGTI	fit	0	374.1 kB	Data Cat|Dnld	✓
27-Sep-2011 16:08:14	r0338776531	EXTENDEDFT1	fit	292,851	26.3 MB	Data Cat|Dnld	✓
27-Sep-2011 16:08:13	r0338776531	FT2	fit	0	36.6 kB	Data Cat|Dnld	✓
27-Sep-2011 16:07:29	r0338776531	FT2SECONDS	fit	0	610.3 kB	Data Cat|Dnld	✓
27-Sep-2011 16:04:59	r0338776531	VERIFYMERITERRORALARM	xml	0	828 B	Data Cat|Dnld	✓
27-Sep-2011 16:04:44	r0338776531	ELECTRONMERIT	root	0	4.3 MB	Data Cat|Dnld	✓
27-Sep-2011 16:04:23	r0338776531	SOLARFLAREPLOT	png	0	38.0 kB	Data Cat|Dnld	✓
27-Sep-2011 16:04:23	r0338776531	SOLARFLARELOG	xml	0	231 B	Data Cat|Dnld	✓
27-Sep-2011 16:04:23	r0338776531	SOLARFLAREHIST	root	0	22.8 kB	Data Cat|Dnld	✓
27-Sep-2011 16:04:23	r0338776531	FT1BADGTI	fit	0	26.3 MB	Data Cat|Dnld	✓
27-Sep-2011 16:04:09	r0338776531	MERITTRENDALARM	xml	0	8.8 kB	Data Cat|Dnld	✓
27-Sep-2011 16:04:09	r0338776531	VERIFYMERITERROR	xml	0	188 B	Data Cat|Dnld	✓
27-Sep-2011 16:03:25	r0338776531	MERITTREND	root	0	429.5 kB	Data Cat|Dnld	✓
27-Sep-2011 16:00:51	r0338776531	MERIT	root	1,999,468	1.7 GB	Data Cat|Dnld|Skim|Wired	✓
27-Sep-2011 15:59:01	r0338776531	GCR	root	1,999,468	49.8 MB	Data Cat|Dnld	✓
27-Sep-2011 15:55:14	r0338776531	DIGITRENDALARM	xml	0	22.0 kB	Data Cat|Dnld	✓
27-Sep-2011 15:54:29	r0338776531	DIGIHISTALARM	xml	0	132.2 kB	Data Cat|Dnld	✓
27-Sep-2011 15:54:01	r0338776531	ACDPLOTS	tar	0	420.0 kB	Data Cat|Dnld	✓
27-Sep-2011 15:53:28	r0338776531	CALTREND	root	0	3.1 MB	Data Cat|Dnld	✓
27-Sep-2011 15:53:28	r0338776531	DIGITREND	root	0	23.5 MB	Data Cat|Dnld	✓
27-Sep-2011 15:53:27	r0338776531	DIGIHIST	root	0	2.5 MB	Data Cat|Dnld	✓
27-Sep-2011 15:53:10	r0338776531	FASTMONERRORALARM	xml	0	8.1 kB	Data Cat|Dnld	✓
27-Sep-2011 15:51:55	r0338776531	FASTMONTUPLE	root	0	1.9 GB	Data Cat|Dnld	✓
27-Sep-2011 15:49:55	r0338776531	FASTMONERROR	xml	0	895.7 kB	Data Cat|Dnld	✓
27-Sep-2011 15:36:53	r0338776531	DIGIGAP	txt	0	0 B	Data Cat|Dnld	✓
27-Sep-2011 15:28:58	r0338776531	DIGI	root	1,999,468	4.4 GB	Data Cat|Dnld	✓
27-Sep-2011 15:09:54	r0338776531	ORBITPLOT	png	0	27.2 kB	Data Cat|Dnld	✓
27-Sep-2011 15:07:53	r0338776531	MAGIC7HP	txt	0	27.1 MB	Data Cat|Dnld	✓
27-Sep-2011 15:07:30	r0338776531	MAGIC7L1	txt	0	3.9 MB	Data Cat|Dnld	✓

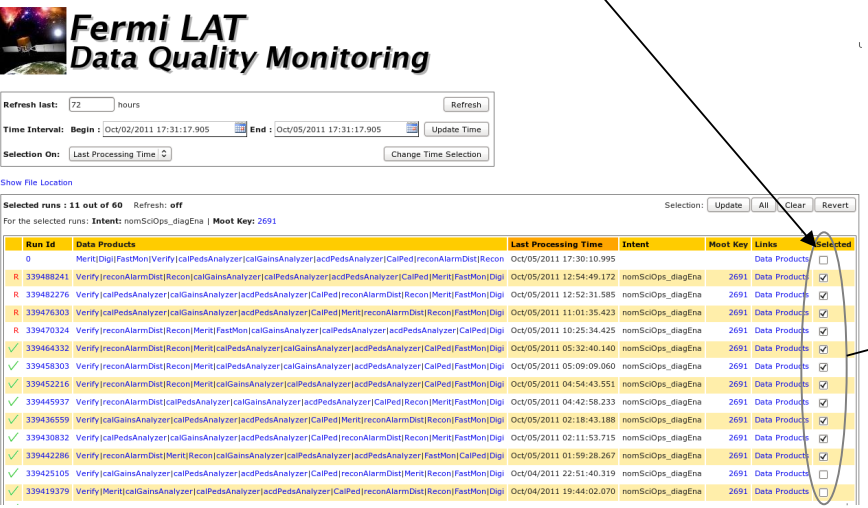
Runs page:
- **Info**
- **Files**

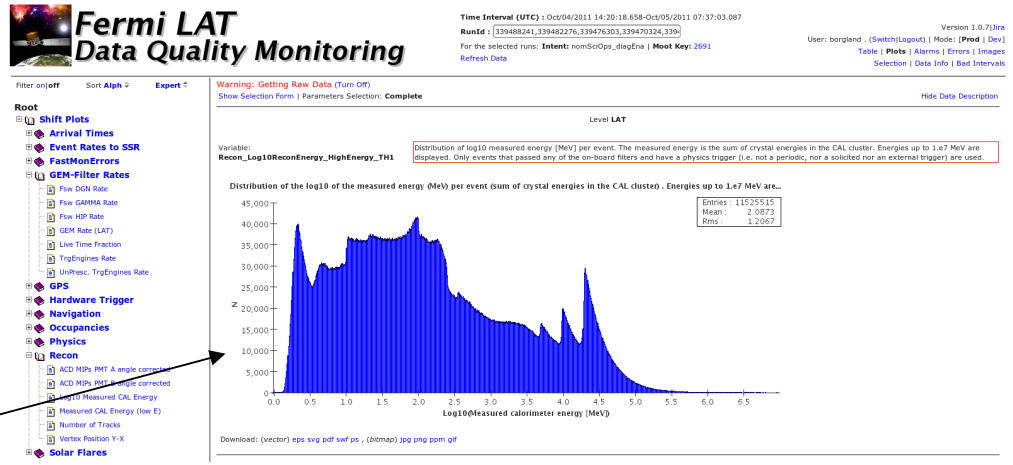
Run Bound.

- Two categories:
  - Histograms:
    - Cover an entire run
  - Trending information:
    - Trend quantities every 15 seconds:
      - » Corresponds to about 1 degree
    - Pedestals:
      - » Every 5 minutes
    - Run quantities:
      - » Once per run
- Run bound:
  - We produce monitoring files on a per run basis:
    - Histograms cover one run
    - Trending files are ingested once per run

Run Bound. Not.

Select multiple runs

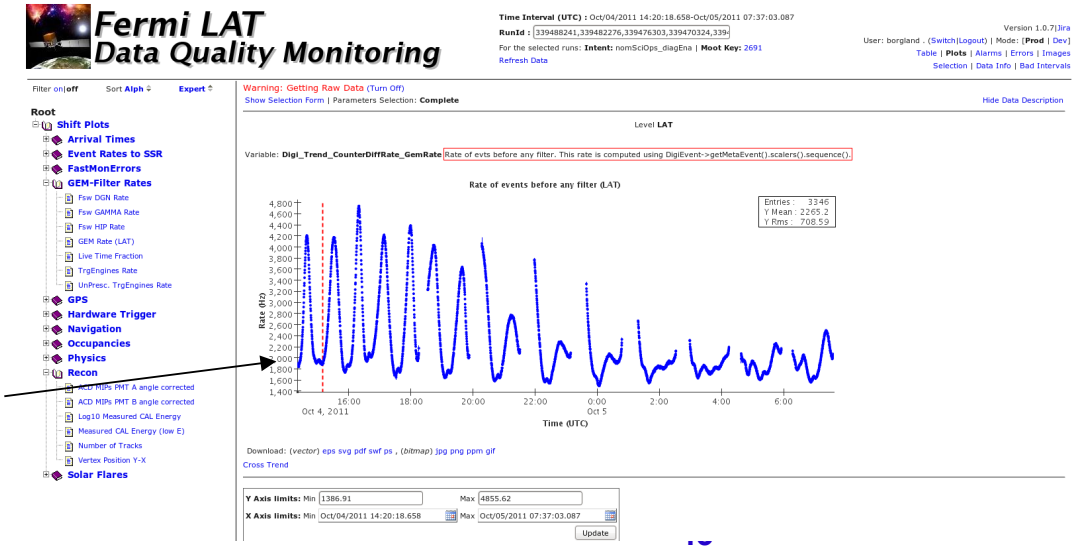




Histograms are merged

(automatically fetched from files accessed through the Fermi Data Catalog)

Trend any time period from 15s to 3+ years:



DQM Start Page

Quick Links | Data Processing | Data Access | Data Monitoring | Science | Shifts | Mission Planning | Contact Info | Change Control | Software Tools | Developer

Fermi LAT Data Quality Monitoring

Version 1.0.7|Jira
User: borgland . (Switch|Logout) | Mode: [**Prod** | Dev]
Table | Plots | Alarms | Errors | Images
Selection | Data Info | Bad Intervals

Refresh last: 72 hours Refresh

Time Interval: **Begin :** Sep/25/2011 17:35:39.453 **End :** Sep/28/2011 17:35:39.453 Update Time

Selection On: Run Start Time Change Time Selection

Show File Location

Time selection for runs list

Arbitrary time selection

Selected runs : 1 out of 48 Refresh: **on** Selection: Update All Clear Revert

For the selected runs: **Intent:** nomSciOps_diagEna | **Moot Key:** 2691

	Run Id	Data Products	Run Start Time	Intent	Moot Key	Links	Selected
R	338909701	acdPedsAnalyzer|calGainsAnalyzer|CalPed|calPedsAnalyzer|Digi|Verify	Sep/28/2011 13:35:02.651	nomSciOps_diagEna	2691	Data Products	☐
R	338904018	Digi|Verify	Sep/28/2011 12:00:19.658	nomSciOps_diagEna	2691	Data Products	☐
R	338898465	acdPedsAnalyzer|calGainsAnalyzer|CalPed|calPedsAnalyzer|Digi|FastMon|Merit|Recon|reconAlarmDist|Verify	Sep/28/2011 10:27:46.647	nomSciOps_diagEna	2691	Data Products	☐
R	338892522	acdPedsAnalyzer|calGainsAnalyzer|CalPed|calPedsAnalyzer|Digi|FastMon|Merit|Recon|reconAlarmDist|Verify	Sep/28/2011 08:48:43.649	nomSciOps_diagEna	2691	Data Products	☐
R	338886550	acdPedsAnalyzer|calGainsAnalyzer|CalPed|calPedsAnalyzer|Digi|FastMon|Merit|Recon|reconAlarmDist|Verify	Sep/28/2011 07:09:11.648	nomSciOps_diagEna	2691	Data Products	☐
R	338880574	acdPedsAnalyzer|calGainsAnalyzer|CalPed|calPedsAnalyzer|Digi|FastMon|Merit|Recon|reconAlarmDist|Verify	Sep/28/2011 05:29:35.651	nomSciOps_diagEna	2691	Data Products	☐
R	338874589	acdPedsAnalyzer|calGainsAnalyzer|CalPed|calPedsAnalyzer|Digi|FastMon|Merit|Recon|reconAlarmDist|Verify	Sep/28/2011 03:49:50.670	nomSciOps_diagEna	2691	Data Products	☐
R	338868584	acdPedsAnalyzer|calGainsAnalyzer|CalPed|calPedsAnalyzer|Digi|FastMon|Merit|Recon|reconAlarmDist|Verify	Sep/28/2011 02:09:45.648	nomSciOps_diagEna	2691	Data Products	☐
✗	338865482	acdPedsAnalyzer|calGainsAnalyzer|CalPed|calPedsAnalyzer|Digi|FastMon|Merit|Recon|reconAlarmDist|Verify	Sep/28/2011 01:18:03.656	nadirOps	2695	Data Products	☐
✗	338863382	acdPedsAnalyzer|calGainsAnalyzer|CalPed|calPedsAnalyzer|Digi|FastMon|Merit|Recon|reconAlarmDist|Verify	Sep/28/2011 00:43:03.654	nadirOps	2695	Data Products	☐
✗	338862511	acdPedsAnalyzer|calGainsAnalyzer|CalPed|calPedsAnalyzer|Digi|FastMon|Merit|Recon|reconAlarmDist|Verify	Sep/28/2011 00:28:32.656	nadirOps	2695	Data Products	☐
✗	338859362	acdPedsAnalyzer|calGainsAnalyzer|CalPed|calPedsAnalyzer|Digi|FastMon|Merit|Recon|reconAlarmDist|Verify	Sep/27/2011 23:36:03.651	nadirOps	2695	Data Products	☐
✗	338857262	acdPedsAnalyzer|calGainsAnalyzer|CalPed|calPedsAnalyzer|Digi|FastMon|Merit|Recon|reconAlarmDist|Verify	Sep/27/2011 23:01:03.654	nadirOps	2695	Data Products	☐
✗	338856385	acdPedsAnalyzer|calGainsAnalyzer|CalPed|calPedsAnalyzer|Digi|FastMon|Merit|Recon|reconAlarmDist|Verify	Sep/27/2011 22:46:26.655	nadirOps	2695	Data Products	☐
✗	338853242	acdPedsAnalyzer|calGainsAnalyzer|CalPed|calPedsAnalyzer|Digi|FastMon|Merit|Recon|reconAlarmDist|Verify	Sep/27/2011 21:54:03.654	nadirOps	2695	Data Products	☐
✗	338852046	acdPedsAnalyzer|calGainsAnalyzer|CalPed|calPedsAnalyzer|Digi|FastMon|Merit|Recon|reconAlarmDist|Verify	Sep/27/2011 21:34:07.654	nadirOps	2695	Data Products	☐
R	338846728	acdPedsAnalyzer|calGainsAnalyzer|CalPed|calPedsAnalyzer|Digi|FastMon|Merit|Recon|reconAlarmDist|Verify	Sep/27/2011 20:05:29.658	nomSciOps_diagEna	2691	Data Products	☐
✓	338840979	acdPedsAnalyzer|calGainsAnalyzer|CalPed|calPedsAnalyzer|Digi|FastMon|Merit|Recon|reconAlarmDist|Verify	Sep/27/2011 18:29:40.648	nomSciOps_diagEna	2691	Data Products	☐
✓	338835252	acdPedsAnalyzer|calGainsAnalyzer|CalPed|calPedsAnalyzer|Digi|FastMon|Merit|Recon|reconAlarmDist|Verify	Sep/27/2011 16:54:13.649	nomSciOps_diagEna	2691	Data Products	☐

List of runs

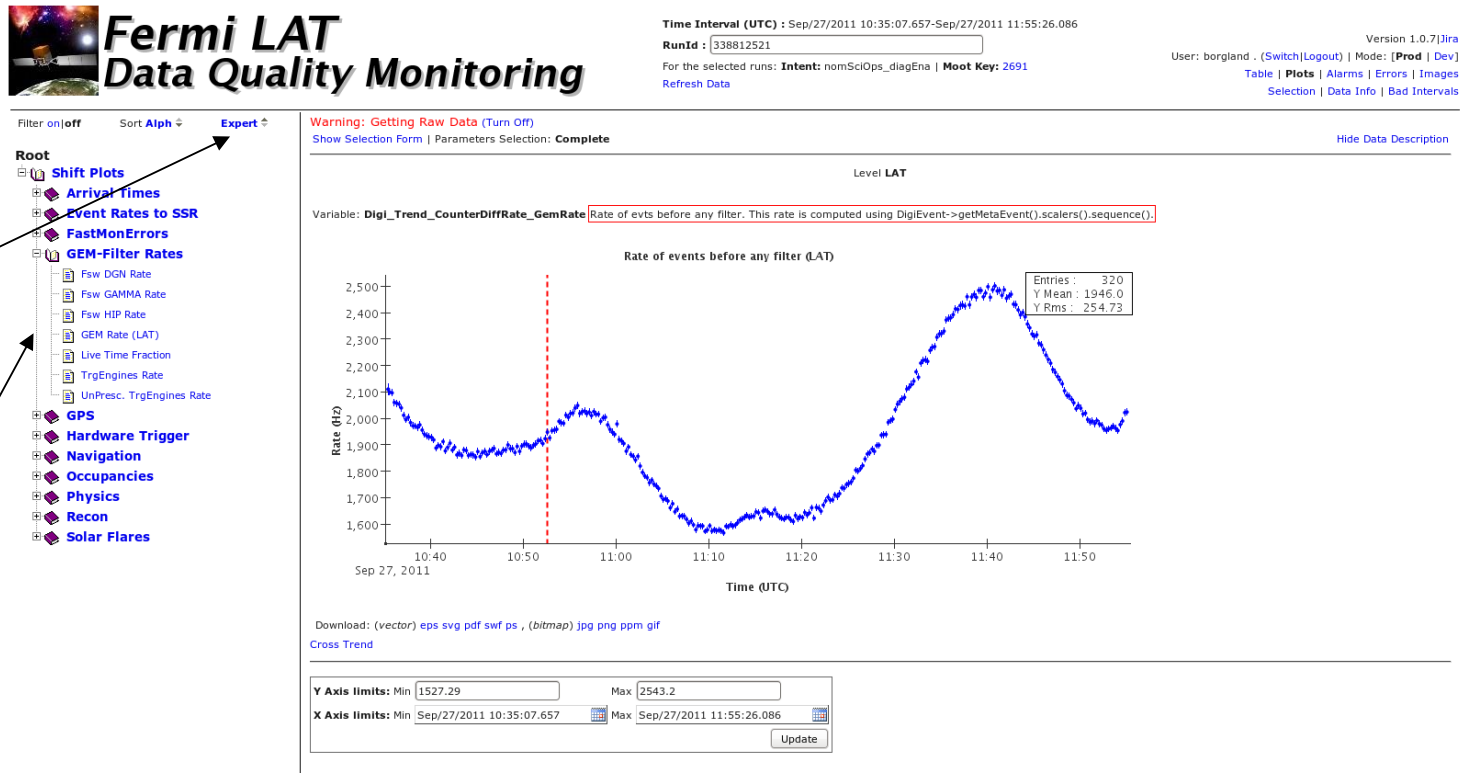
Can select multiple runs

Trees Of Folders With Plots

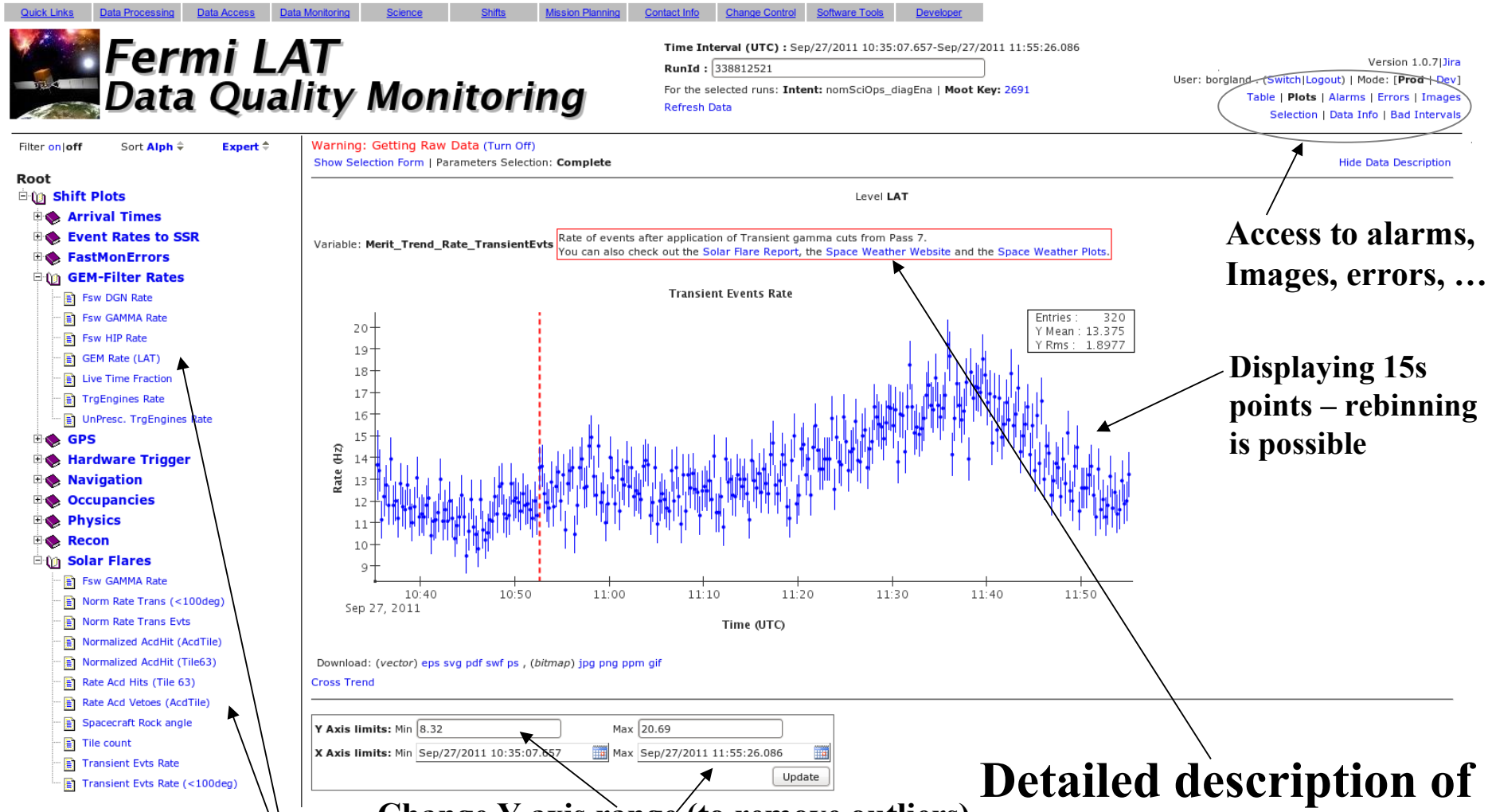
- **Multiple expandable trees with folders of plots:**
  - **Example:**
    - **Shifter Tree containing all the shifter plots**
    - **Expert Tree with all the plots**
  - **Easy to toggle between them**

Toggle to get the Expert Tree

Shifter Tree



Plot Folders And Detailed Plot Description



Access to alarms, Images, errors, …

Displaying 15s points – rebinning is possible

Detailed description of the plot (including web links for external info)

Change Y axis range (to remove outliers) and shrink time period (to zoom)

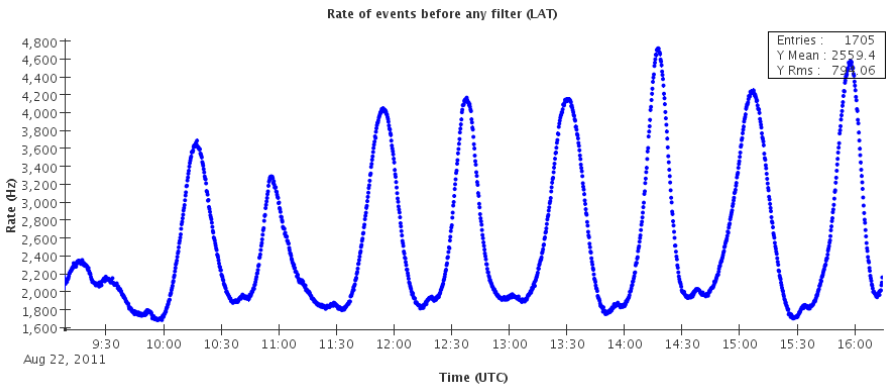
Expandable folders with plots

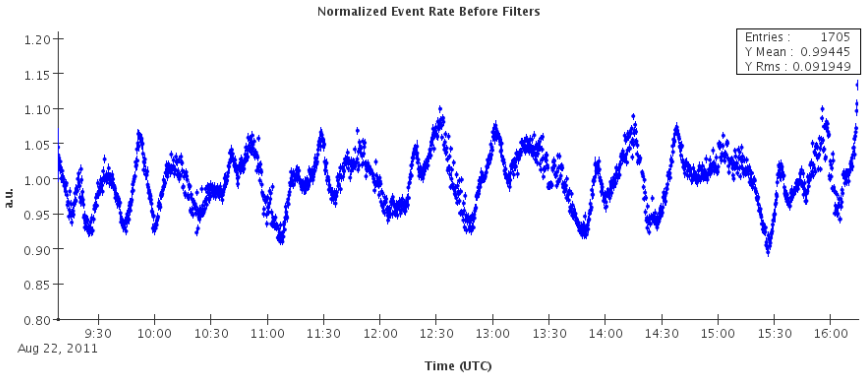
800k Channels To Monitor

- **Fermi LAT:**
  - **800k electronic channels**
  - **16 identical TKR+CAL towers:**
    - **Lots of redundancy**
    - **Great! …. except it makes it more difficult to catch local problems:**
      - » **A dead section in one TKR may not significantly affect the overall trigger rate**
- **Currently monitoring over 20k different quantities:**
  - **100k quantities if you count the multiple ways we monitor CAL pedestals**
  - **Note:**
    - **We never routinely look at all this information**
    - **When you have a problem you never know what you need, but you need it right now!**
- **Can't depend only on a human shifter to catch problems in all of this!**

Surprise!

- **Pleasant surprise:**
  - Within an orbit we may have x2 variations in rates etc
  - But we can take that out using geomagnetic information
- **Normalized quantities:**
  - Works very well!
    - 5-30% level!
  - But only for normal operations! Not for TOO, nadirObs, …
- **Example:**
  - Normalized trigger rate





Alarms

- **Alarms:**
  - We put alarms on nearly every single quantity we have
  - Automatically tells us if there is a hot TKR strip, noisy CAL channel, photon rates are too high/low etc
- **Run specific:**
  - Alarms run once a run
  - But they look at individual (15s) trending points!
- **Many different alarm algorithms:**
  - Allowed range, spikes and holes, …...
    - Normalized quantities makes using ranges quite easy
- **Ingested:**
  - Number of alarms ingested into Oracle and can be trended
- **Success!**
  - Alarms have caught every problem we have had so far!

List Of Alarms For A Run

Alarms for run 335809468

Mode	Type	Error	Warning	Undefined	Clean
acdPedsAnalyzer	Hist	0	1	0	14
calGainsAnalyzer	Hist	12	0	0	6
CalPed	Hist	0	0	0	2
calPedsAnalyzer	Hist	0	1	0	32
Digi	Trend	8	7	0	15
Digi	Hist	67	24	67	87
FastMon	Hist	67	22	115	135
FastMon	Trend	1	1	0	1
fastMonError	Trend	0	0	0	26
Merit	Hist	0	0	0	0
Merit	Trend	10	1	0	3
Recon	Hist	2	4	4	3469
Recon	Trend	1	1	0	1
TkrMon	Trend	0	0	0	5
verifyFt1ErrorAlarm	Hist	0	0	0	2
verifyFt2Error	Trend	0	0	0	2
verifyLog	Trend	0	0	0	22
verifyMeritErrorAlarm	Hist	0	0	0	2

Alarm categories:

- **Error**
- **Warning**
- **Undefined i.e. not enough statistics**
- **Clean i.e. OK**

ERROR Status

Severity	Mode	Type	Variable Name	Algorithm	Value	Limits	Details
5	FastMon	Hist	AcdGemROI_Tower_TH1	y_values	357277 +- 1195	[133801.08 | 152915.52 | --- | 305831.04 | 324945.48]	View
5	FastMon	Hist	CalHiTrigger_Tower_TH1	y_values	0 +- 0	[0.035 | 0.04 | --- | 0.08 | 0.085]	View
5	FastMon	Hist	CalLoTrigger_Tower_TH1	y_values	0 +- 0	[0.945 | 1.08 | --- | 2.16 | 2.295]	View
5	FastMon	Hist	CalX_NHit_TH1_Tower_0	low_high_ratio	37.3 +- 0.1	[8.0 | 11.0 | --- | 16.5 | 20.0]	View
5	FastMon	Hist	CalX_NHit_TH1_Tower_0	x_rms	8.59	[13.0 | 18.0 | --- | 26.0 | 32.0]	
5	FastMon	Hist	CalX_NHit_TH1_Tower_0	x_average	5.30	[6.0 | 9.0 | --- | 18.0 | 22.0]	
5	FastMon	Hist	CalX_NHit_TH1_Tower_1	low_high_ratio	33.7 +- 0.1	[6.0 | 9.0 | --- | 13.5 | 18.0]	View

Details About Alarms

ERROR Status

Alarm limits

Severity	Mode	Type	Variable Name	Algorithm	Value	Limits	Details
5	FastMon	Hist	AcdGemROI_Tower_TH1	y_values	357277 +- 1195	[133801.08 | 152915.52 | --- | 305831.04 | 324945.48]	View
5	FastMon	Hist	CalHiTrigger_Tower_TH1	y_values	0 +- 0	[0.035 | 0.04 | --- | 0.08 | 0.085]	View
5	FastMon	Hist	CalLoTrigger_Tower_TH1	y_values	0 +- 0	[0.945 | 1.08 | --- | 2.16 | 2.295]	View
5	FastMon	Hist	CalX_NHit_TH1_Tower_0	low_high_ratio	37.3 +- 0.1	[8.0 | 11.0 | --- | 16.5 | 20.0]	View

Detailed Description

Make sure all the y values are within limits.

The algorithm loops over the contents of each bins and checks that all the values are within the limits.

Valid parameters:

- `normalize`: if this parameter is set, then all the limits are scaled to (read: multiplied by) the number of entries in the histogram.
- `exclude`: a list of indexes of the branch array to be excluded.
- `only`: the list of indexes the alarm has to run on.
- `num_sigma`: multiplicative factor for the error bars.

Output value:

The value of the bin/point which is "more" out of the limits.

Output details:

- `num_warning_entries`: number of bins/poins causing a warning.
- `num_error_entries`: number of bins/poins causing an error.
- `warning_entries`: detailed list of bins/poins causing a warning.
- `error_entries`: detailed list of bins/poins causing an error.

Member Function Documentation

def alg__y_values.alg__y_values.run (*self*)

Actual algorithm implementation ("virtual" function to be overridden by the derived classes).

Parameters:
self The class instance.

Reimplemented from pAlarmBaseAlgorithm.pAlarmBaseAlgorithm.

Member Data Documentation

string alg__y_values.alg__y_values.OUTPUT_LABEL = 'The worst y-value' [static]

A brief string representing what the output value actually represents.

Reimplemented from pAlarmBaseAlgorithm.pAlarmBaseAlgorithm.

list alg__y_values.alg__y_values.SUPPORTED_PARAMETERS = ['normalize', 'exclude', 'only', 'num_sigma'] [static]

The list of (optional) parameters supported by a given algorithm.

Reimplemented from pAlarmBaseAlgorithm.pAlarmBaseAlgorithm.

list alg__y_values.alg__y_values.SUPPORTED_TYPES = ['TH1F', 'TH1D', 'TProfile'] [static]

The list of ROOT object types which are supported by a given algorithm.

Reimplemented from pAlarmBaseAlgorithm.pAlarmBaseAlgorithm.

The documentation for this class was generated from the following file:

- alg__y_values.py

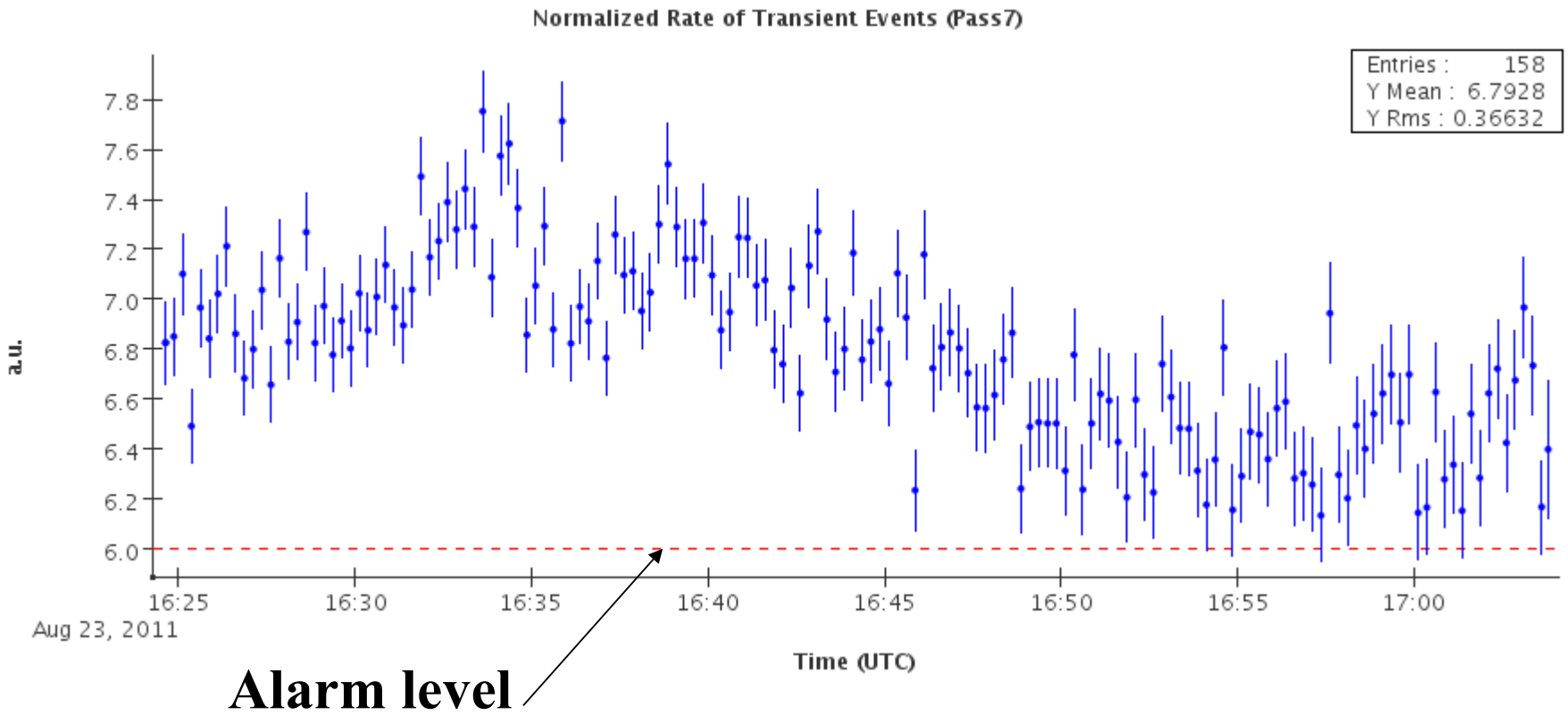
All Classes Namespaces Functions Variables

Details for alarm AcdGemROI_Tower_TH1

Name	Value
warning_entries	Tower number = 0, y-value = 314598 +- 1122 Tower number = 9, y-value = 142352 +- 755 Tower number = 10, y-value = 144970 +- 761
num_warning_entries	3
output_bin	Tower number = 15, y-value = 357277 +- 1195, badness = 3.63
error_entries	Tower number = 5, y-value = 131347 +- 725 Tower number = 6, y-value = 132668 +- 728 Tower number = 12, y-value = 342454 +- 1170 Tower number = 15, y-value = 357277 +- 1195
num_error_entries	4

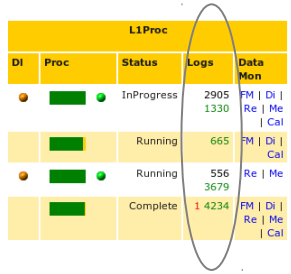
Links To Plot That Triggered The Alarm

5	Merit	Trend	OutF_NormRateTransientEvts	values	7.75 +- 0.32	[0.2 | 0.5 | --- | 4.0 | 6.0]	View
5	Merit	Trend	Rate_TransientEvts	values	160.5 +- 6.5	[0.5 | 1.0 | --- | 75.0 | 150.0]	View
5	FastMon	Trend	Mean_FastMon_CalTowerCount	values	1.21 +- 0.03	[2.0 | 2.5 | --- | 4.0 | 5.0]	View
5	Digi	Trend	Mean_CalXHit_MHit_TowerCalLayer	values	0.0263 +- 0.0041	[0.05 | 0.1 | --- | 0.7 | 0.9]	View
5	Digi	Trend	Mean_Cal_NHit	values	6.60 +- 0.34	[15.0 | 25.0 | --- | 60.0 | 80.0]	View



Check Your Email!

- **Alarms2Email:**
  - **For each category of monitoring an email summary is sent out if there are Warnings or Errors**
- **In addition:**
  - **Links from the Data Processing Page to all alarms**
  - **For each run:**
    - **Detailed page with all alarms for that run**



Run and Delivery

Type of Monitoring application

Errors and warnings

Images

Quick Links | Data Processing | Data Access | Data Monitoring | Science | Shifts | Mission Planning | Contact Info | Change Control | Software Tools | Developer

Fermi LAT Data Quality Monitoring

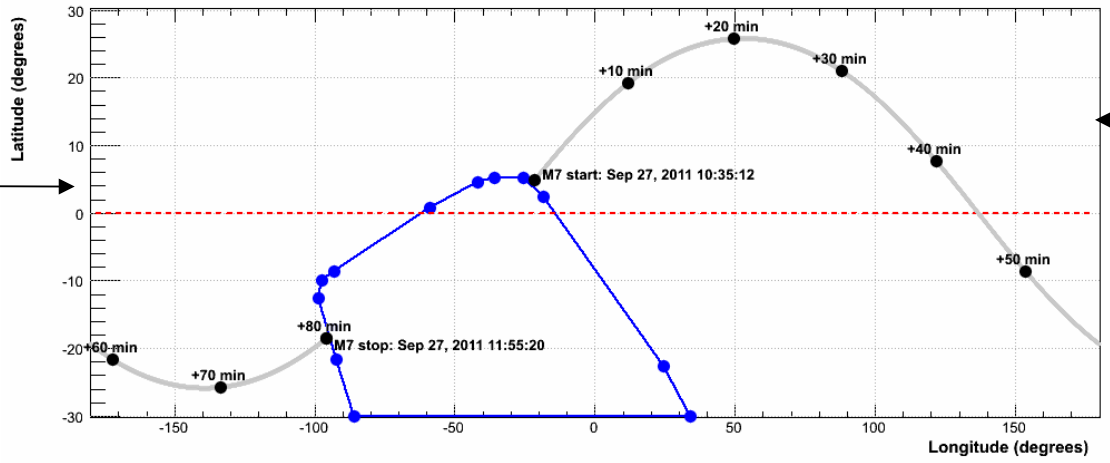
Time Interval (UTC) : Sep/27/2011 10:35:07.657-Sep/27/2011 11:55:26.086
RunId : 338812521
For the selected runs: **Intent:** nomSciOps_diagEna | **Moot Key:** 2691
Refresh Data

Version 1.0.7|Jira
User: borgland . (Switch|Logout) | Mode: [**Prod** | Dev]
Table | Plots | Alarms | Errors | **Images**
Selection | Data Info | Bad Intervals

Plots for run 338812521

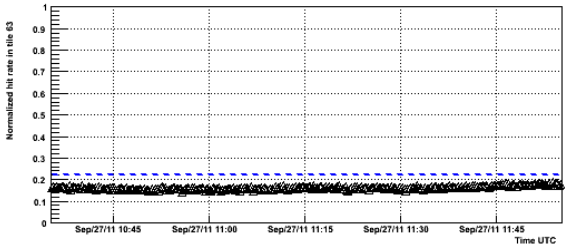
Orbit Plot

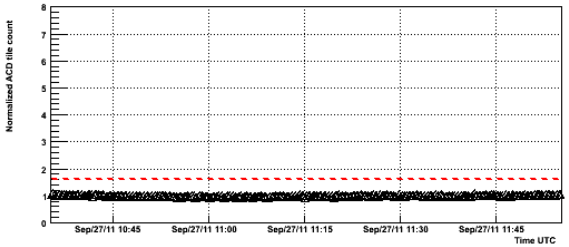
Useful for the shifter to know the actual orbit



Can attach images to each run

Solar Flare Plots





DQM As A Framework

- DQM is not only a monitoring application:
  - It's a framework!
- Can hook additional (monitoring) applications into DQM:
  - Plug-and-Monitor
- The TKR subsystem (tkrMon) took advantage of this:
  - Produces monitoring files on a per run basis
- For anything that needs more than a single run (like efficiencies):
  - Merging of run level files is done after-the-fact and outside of DQM
  - Even in this case it's a real time saver

It's All GOOD

- We make the photon data public as soon as it's processed:
  - Before the DQM shifter has looked at the data
- The Data Quality Flag is preset to GOOD for all runs:
  - DQM flag is part of the public data:
    - » Fermi Science Analysis software only uses GOOD data
  - If the shifter later finds a quality problem we change the flag and re-export the run:
    - » Data may already have been downloaded by the public
- How can we get away with this?
  - We have had no significant problems with the Fermi LAT detector affecting the data quality
- Recent Solar Flares have changed this:
  - Many runs have periods that are "BAD"
  - Difficult balancing act between speed, convenience and data quality control

Oracle Database

- We decided to put the trending information into an Oracle database:
  - Each quantity may have up to 2 additional associated numbers used for rebinning purposes
- Currently:
  - 140k numbers / 15 seconds
  - 89k numbers / 5 minutes
  - 11k numbers / run
- Stored in Oracle:
  - 1.2 TB total
  - Growth rate: 0.6 GB/day
    - Includes periodic purging of large arrays (every 50 days)
    - But remember that we still have the files with all the trending points

You Gotta Tune

- It's a beast:
  - There is a reason there are so many Oracle consultants
  - We learned a few lessons ….
- Tuning/optimization is everything:
  - It's the difference between "it will take longer than the age of the Universe to finish your query" and "done in a fraction of a second"
- Dynamic:
  - An Oracle database is dynamic:
    - A query was quick yesterday
    - Today it just hangs
  - Answer:
    - Oracle has decided to auto-optimize itself
    - Sometimes it gets it spectacularly wrong!
  - Solution:
    - Manual tuning/re-optimization

There Are A Few Things We Don't Understand

- The same page can either load in a blink of an eye or take 10 minutes:
  - Don't understand why it's sometimes very slow
  - Can't predict when it will be slow
  - We're living with this “feature”
- Plotting data:
  - Plot 4 weeks worth of data:
    - May hang and time out
  - Plot week 4:
    - Quick
  - Plot week 3+4:
    - Quick
  - Plot week 2+3+4
    - Quick
  - Plot 4 weeks worth of data:
    - Quick
    - ??????

Infrastructure

- Java based tools:
  - Servers and backend
  - Web frontend developed in JSP (Java Server Pages):
    - And limited use of JavaScript
- Web Tools deployed in Apache Tomcat Servers:
  - 10 production server hosting >50 applications:
    - Not just DQM
  - Servers very stable and reliable
- Libraries:
  - Reusability in mind from the start when developing code:
    - Packaged in experiment-independent common code
  - External libraries:
    - Sitemesh for common look-and-feel across web applications
    - Display tags (tables)

How Do You Interact With L1 and DQM?

- **Only one access point to DQM:**
  - **Your browser!**
- **Accessible from everywhere:**
  - **As long as you have a laptop, smart phone, ...**
- **Shifts:**
  - **Done remotely from people's home institutions**

- **Main interaction with L1:**
  - **Also through your browser**
  - **Data processing page shows the status**
  - **Shifter can roll back failed run etc using the browser:**
    - **It has been done using a smart phone**

Lessons Learned - I

- Fermi LAT data processing and monitoring have been a great success!
  - Ready on schedule – hit the ground running!
  - Enabling time critical Fermi science
- Resources:
  - It's easier to get resources for development than …. getting manpower for running it afterwards:
    - I said "easier", not "easy"
- And the (gold plated) kitchen sink:
  - When you don't know what to expect … prepare for everything:
    - Never paint yourself into a corner even if you never expect to end up there:
      - » Because you will!
    - "Impossible" is just a lack of imagination
  - "Over-engineered" is another word for "robust":
    - i.e. "I won't get paged in the middle of the night"

Lessons Learned - II

- Accept your own limitations:
  - You can never entirely predict how a complex system will behave in every situation:
    - Assume bad things will happen all the time and everywhere and build that into the system from the beginning!
  - "Belt and suspenders!"
  - "Trust but (run) Verify!"
- Flexibility:
  - Things will change with time!
    - In ways you couldn't predict!
  - The design must be open enough to be able to grow:
    - Deal with unforseen circumstances
  - Flexibility must be in the design from the beginning!
    - Don't try to add in flexibility after-the-fact

Lessons Learned - III

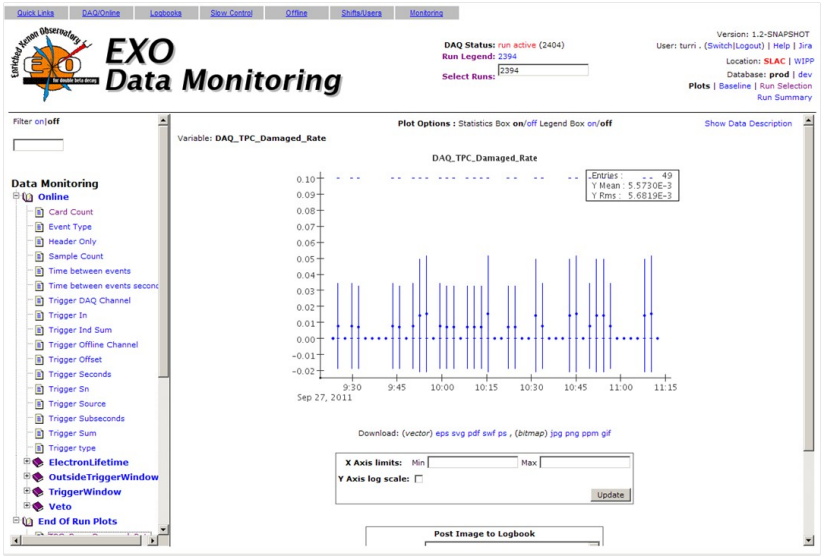
- **In the end:**
  - **No magic solution!**
- **Just:**
  - **Lots of work**
  - **Lots of testing***
  - **By lots of good people** having the necessary resources**
  - **Iterate ….**

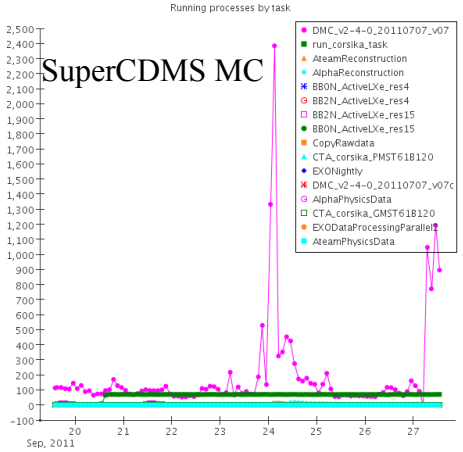
(*) Including two full scale data processing and monitoring excercises with the whole collaboration

(**) It should be obvious by now I hope that all of this was a real team effort with people from Fermi LAT ISOC, KIPAC, Pisa, …..

The PR Page

- These tools are available!
  - Both the pipeline and the DQM framework are tools that are available from the PPA Scientific Computing Applications (SCA) department
  - Examples:
    - Pipeline used by EXO and SuperCDMS
    - DQM used by EXO
      - » Easy to port
      - » Easy to use
      - » Very little manpower to operate

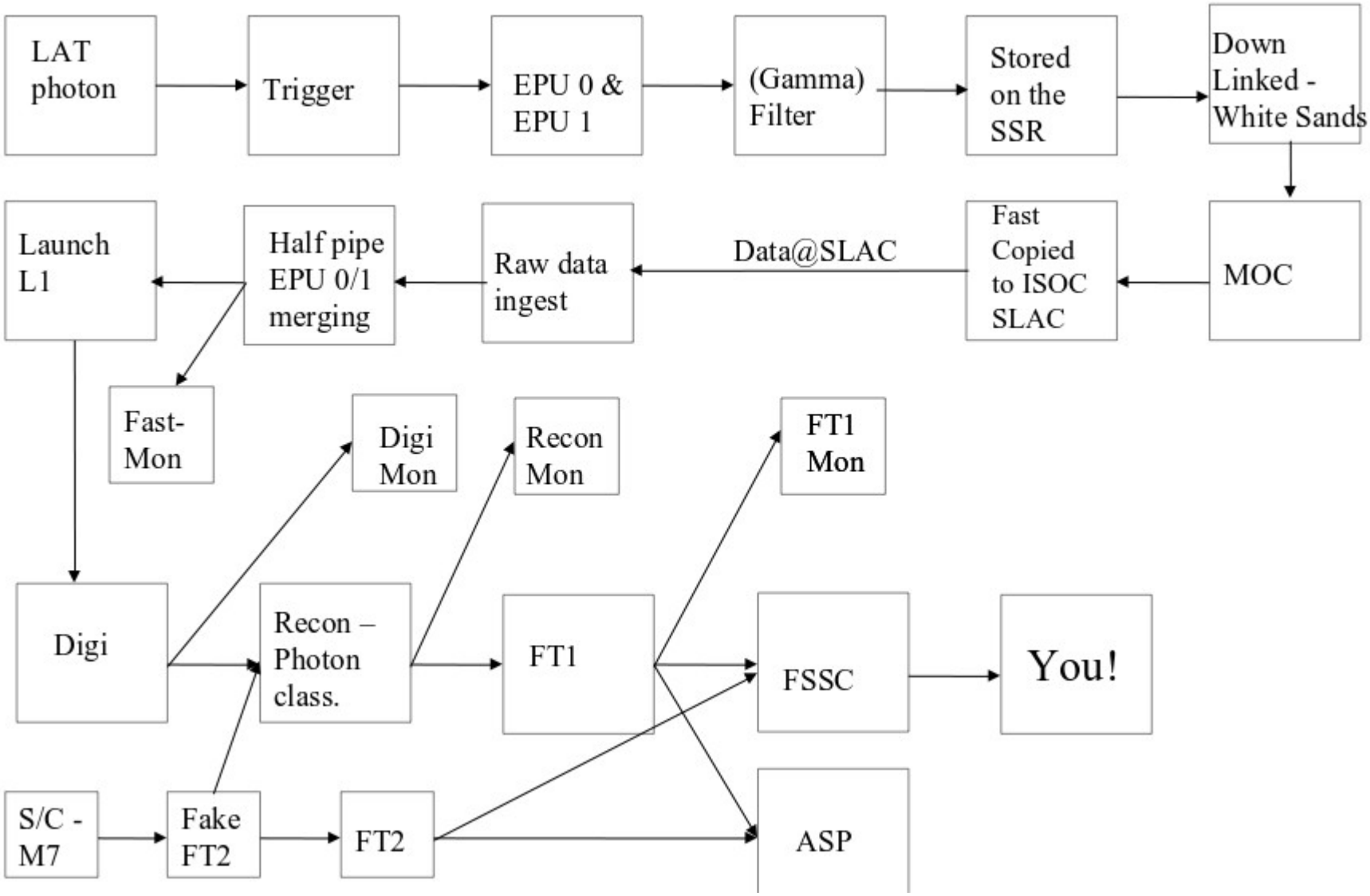




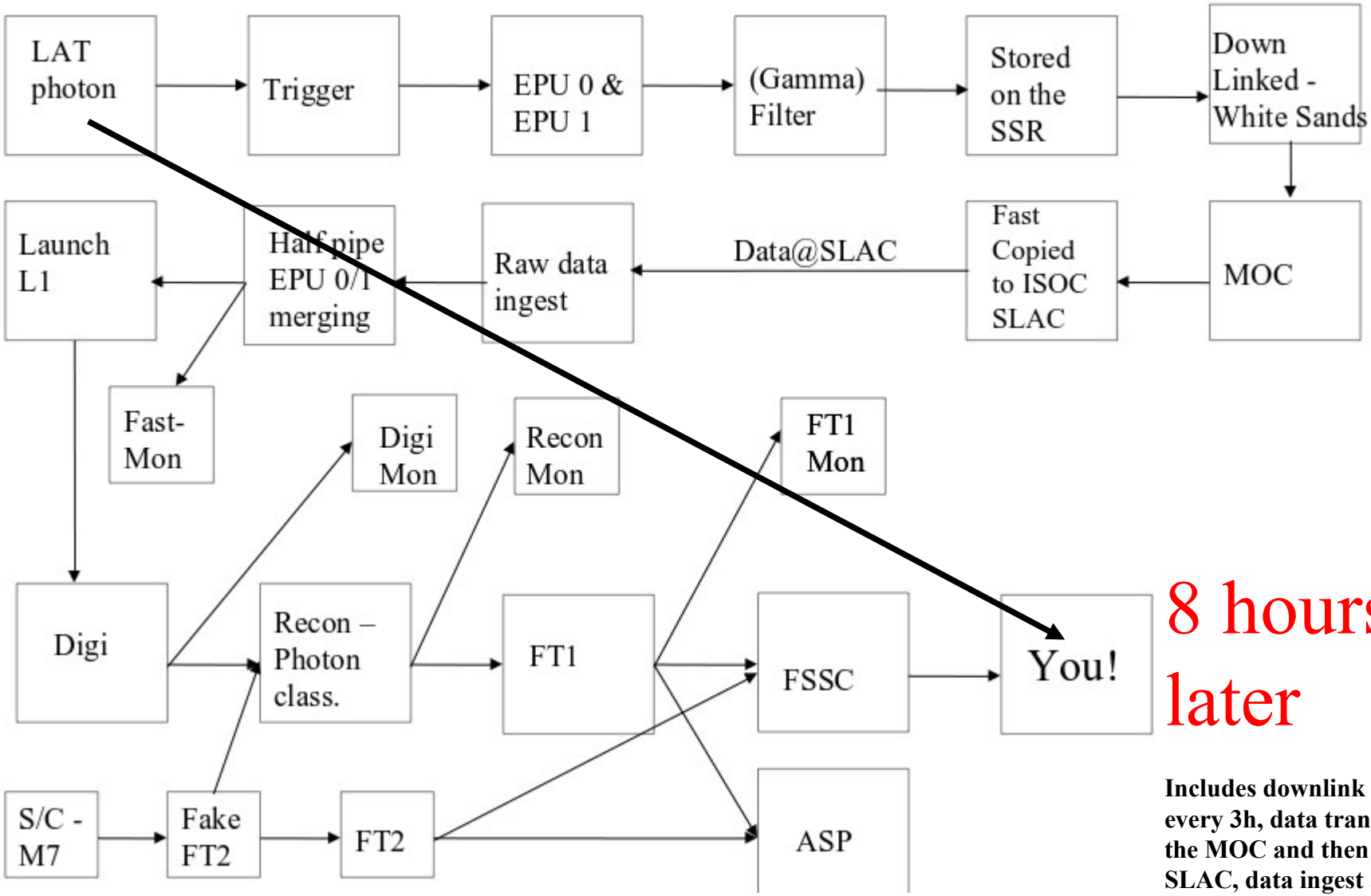
The End

Extra Slides

From Space To Your Laptop



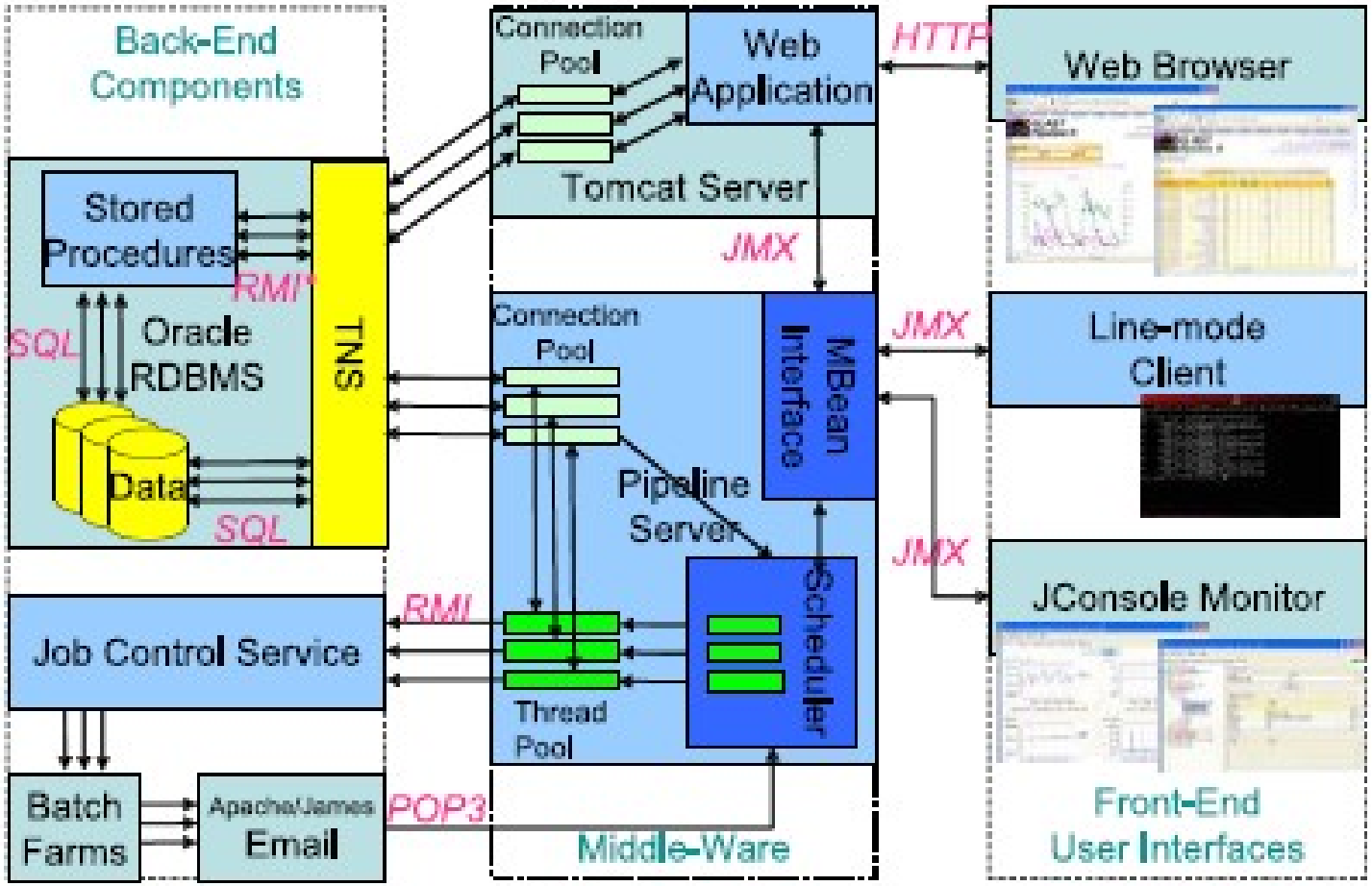
From Space To Your Laptop …. In 8h!



8 hours later

Includes downlink only every 3h, data transfer to the MOC and then to SLAC, data ingest at SLAC and L1 processing.

Pipeline Architecture



D. Flath

Future L1 Improvements

- **Priority processing:**
  - **All data are important**
  - **But some data are more important than other**
- **Example:**
  - **Gamma Ray Burst data**
- **Current situation:**
  - **If we receive multiple deliveries at the same time it's somewhat random which delivery gets processed first**
  - **Sometimes random picks the wrong one ….**

Future Improvement: Sparsified Data

- Even in the best of times it takes a long time to display 3 years worth of data:
  - No need for 15 second granularity:
    - Rebinning is not quicker since it needs to extract all the points and then rebin
- Make and ingest sparsified data:
  - Make one point per day and ingest it every day
  - Useful for long time periods
- Why didn't we think about that?
  - On the todo list ….

Plotter – Future Development

- Data is plotted using JAS Plotter:
  - Displayed in browser using AIDA tag libraries:
    - Histograms and trending plots
- Limitations:
  - Plots are static images
- Future development:
  - Google Web Toolkit:
    - Applications can be made more dynamic and interactive:
      - » Drag & Drop
      - » Asynchronous Data Exchange with the server