Fermi mission and AGN studies

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On behalf of the
Fermi Large Area Telescope collaboration

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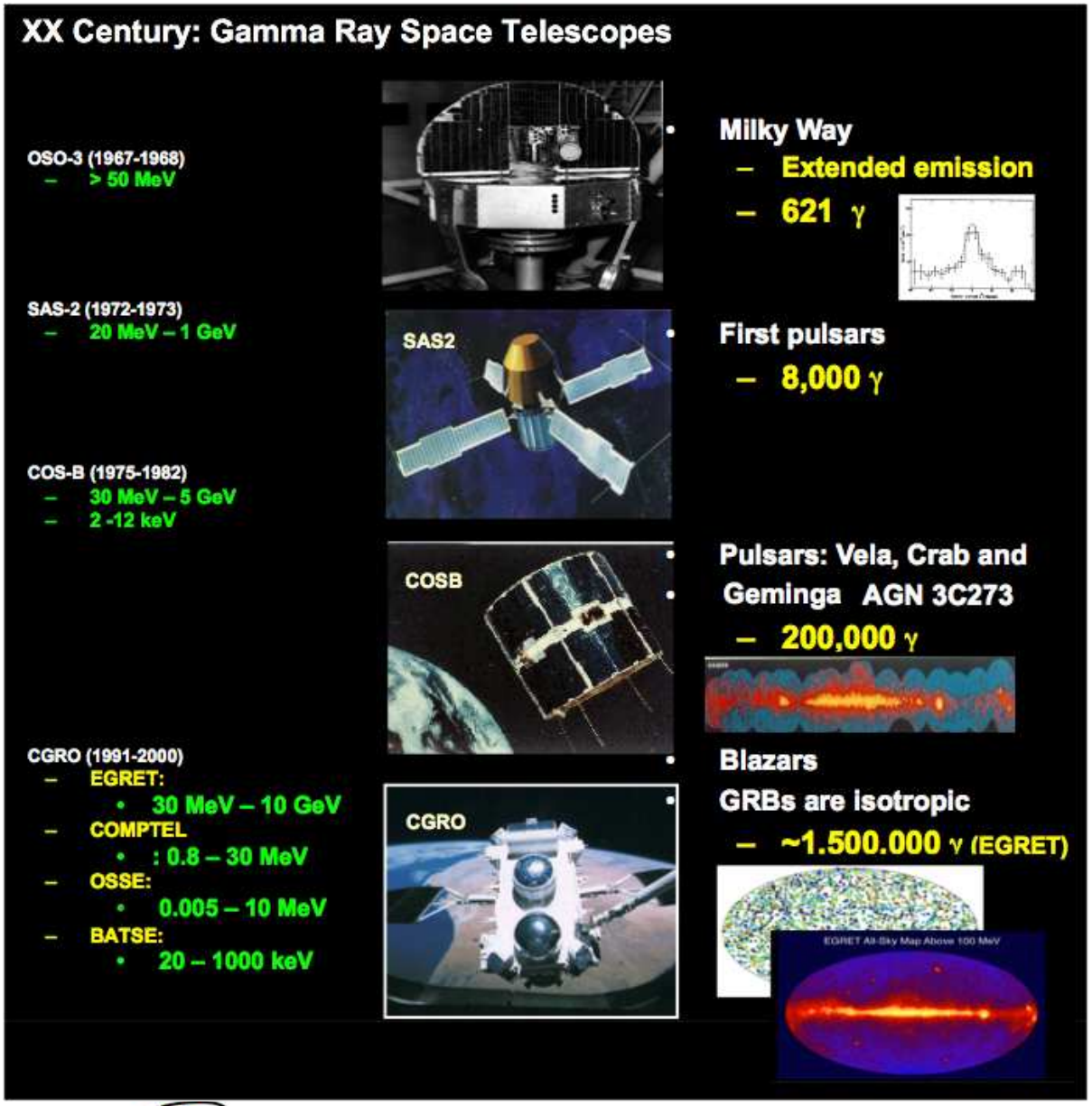
Italian Space Agency

INAF
ISTITUTO NAZIONALE DI ASTROFISICA
NATIONAL INSTITUTE FOR ASTROPHYSICS

Past gamma-ray space telescopes

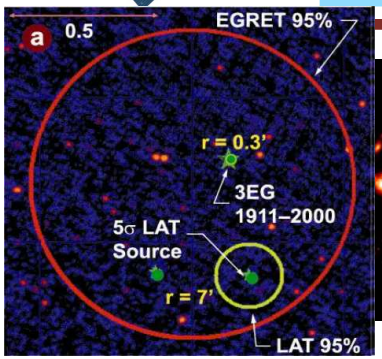


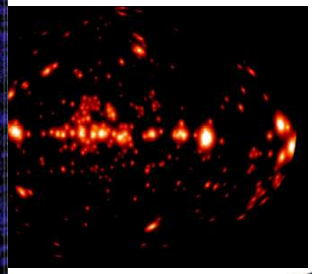
Why to study gamma-rays from space?

Gamma-rays carry a wealth of information:

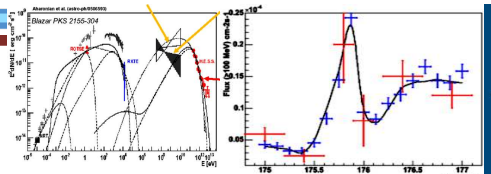
1. Gamma-rays do not interact much at their source: they offer a direct view into Nature's largest accelerators.
2. Similarly, the Universe is mainly transparent to gamma-rays: can probe cosmological volumes. Any opacity is energy-dependent (light interacts with light).
3. Conversely, gamma-rays readily interact in detectors, with a clear signature and are easy to detect (compared with neutrinos , and GW).
4. Gamma-rays are neutral unlike charged cosmic rays: no complications due to magnetic fields. Point directly back to sources, imaging and astronomy is easy.
5. Gamma-rays are produced by interactions of high-energy particles, not in thermal equilibrium implying tracing of the most violent and energetic processes in the Universe.

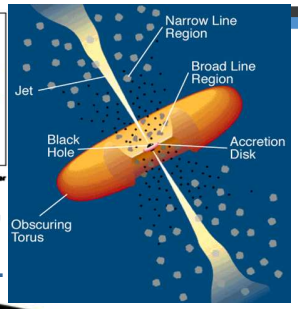
High energy gamma-ray sky above 100 MeV



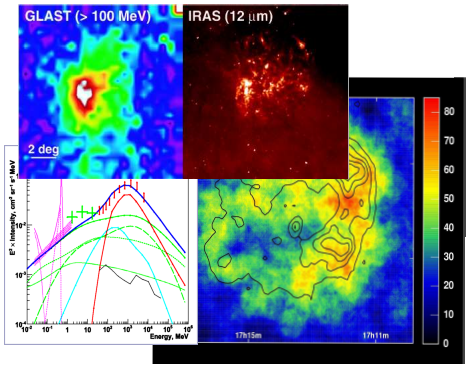


Unidentified sources

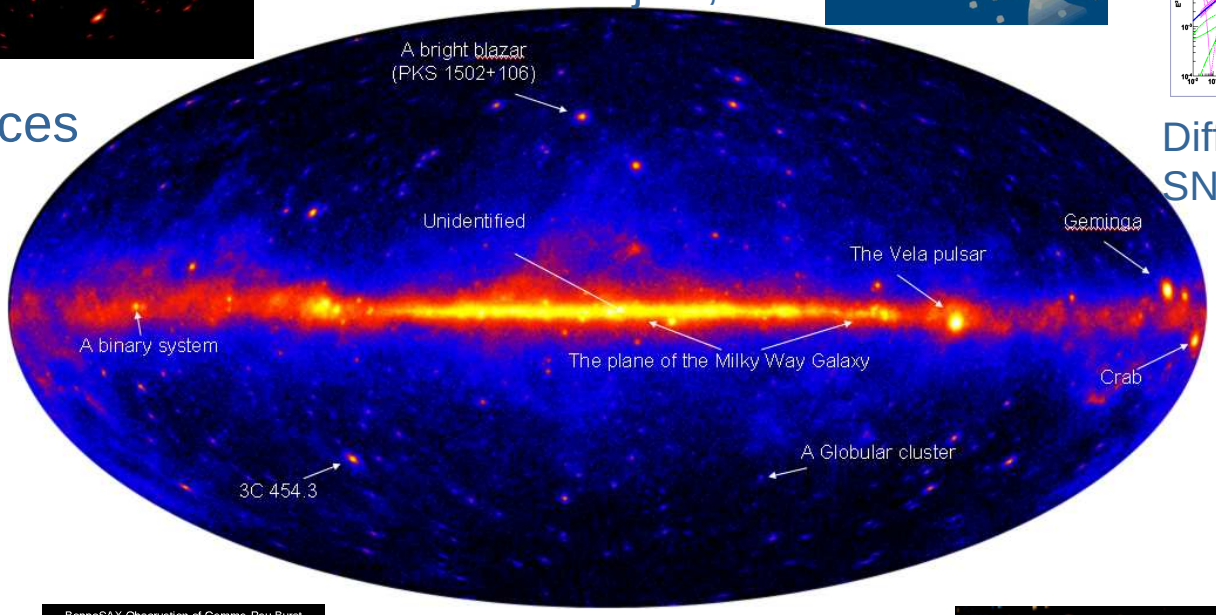


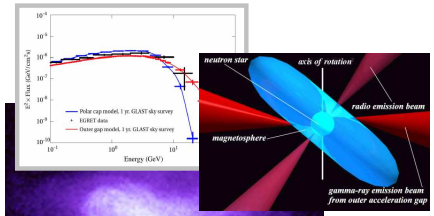


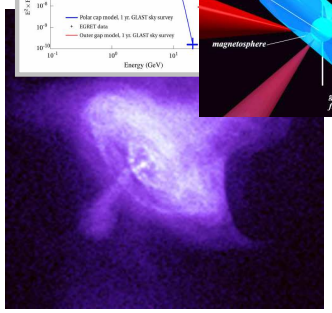
Active Galactic Nuclei, relativistic jets, EBL



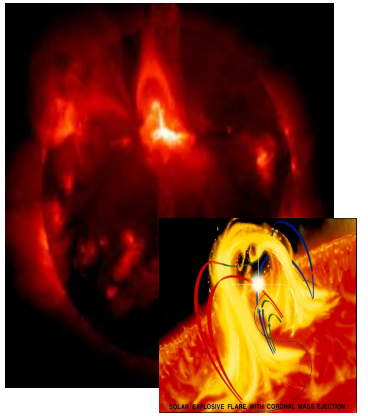
Diffuse, Molecolar Clouds, SNR, Cosmic ray accelerat.



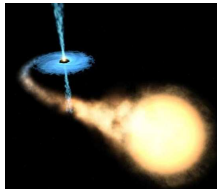




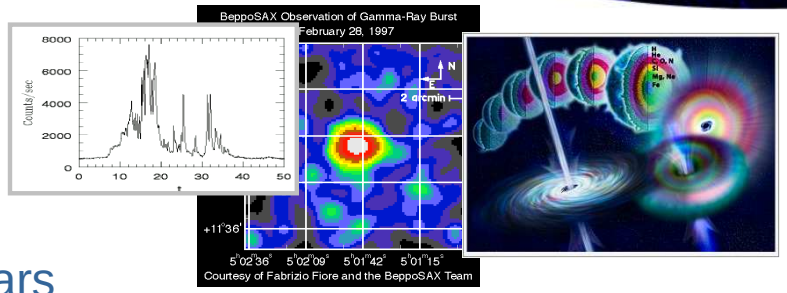
Pulsars



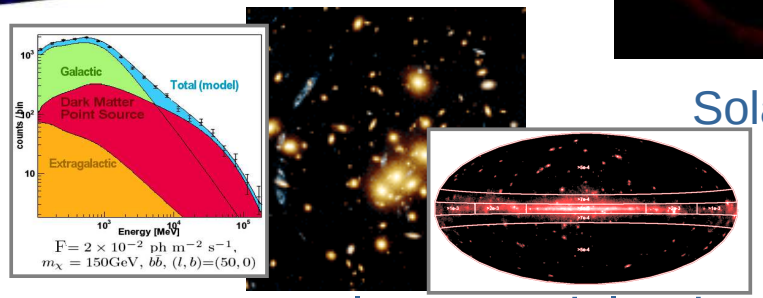
Solar flares



Microquasars



Gamma Ray Bursts



Dark matter, cosmology, particle physics

0.01 GeV | 0.1 GeV | 1 GeV | 10 GeV | 100 GeV | 1 TeV

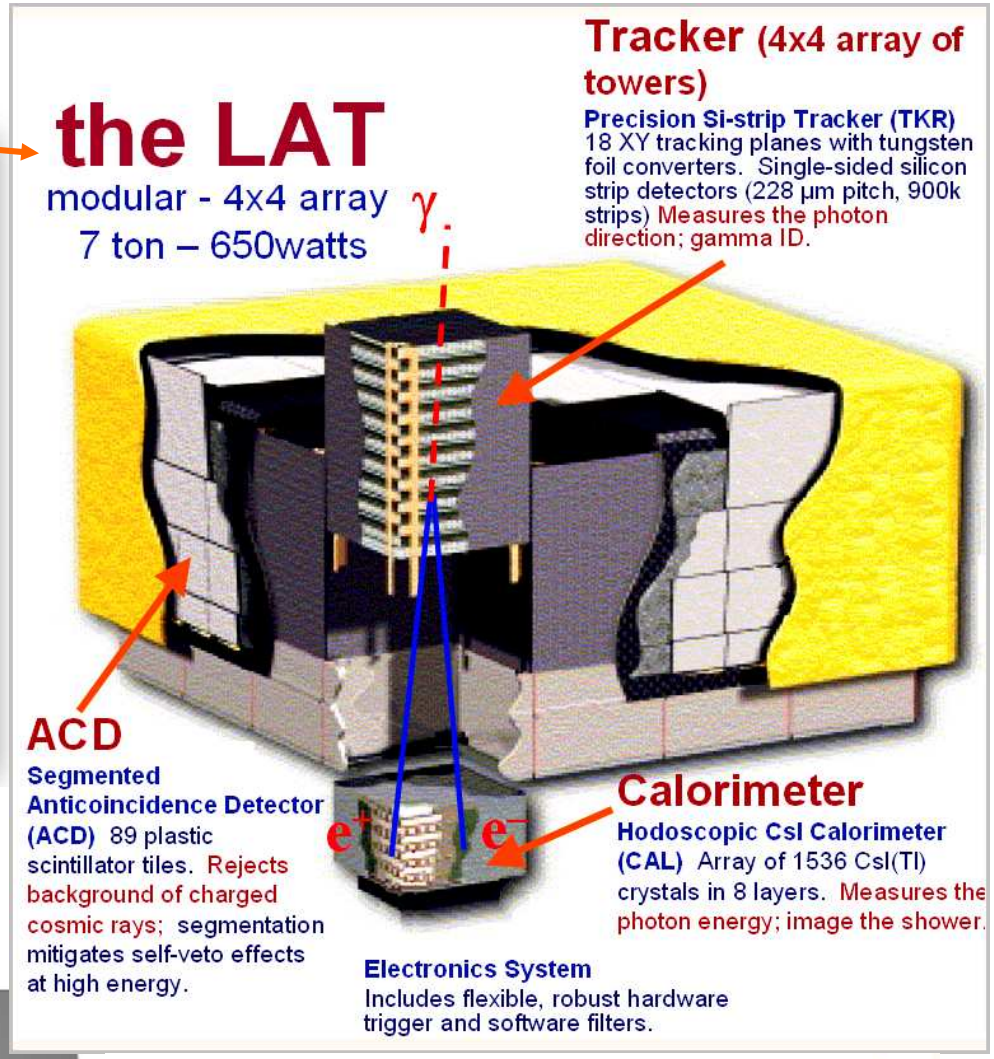
Fermi Gamma-ray Space Telescope

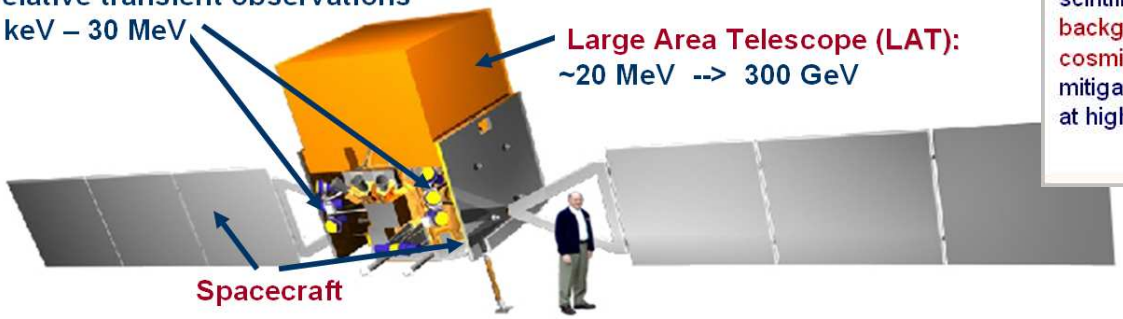
Fermi (formerly GLAST): two Instruments

The Large Area Telescope (LAT)
20 MeV - 300 GeV
>2.5 sr FoV

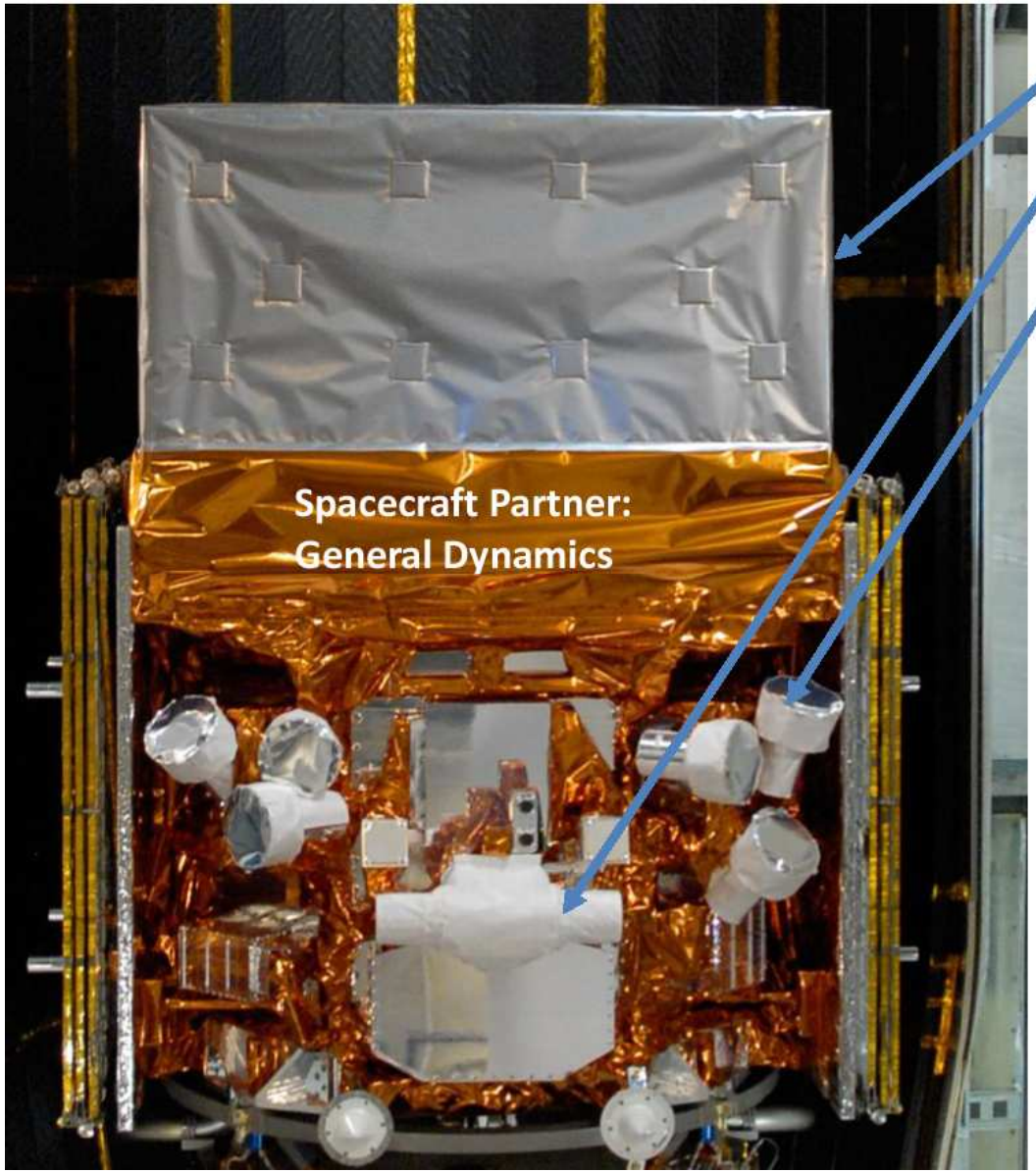
The Burst Monitor (GBM)
8 keV – 40 MeV
9.5 sr FoV

The systems work together to identify and measure the flux of celestial gamma rays with energy between about 20 MeV and above 300 GeV.





Fermi Gamma-ray Space Telescope



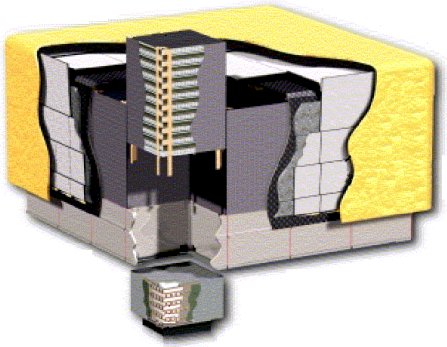
Large Area Telescope (LAT)
20 MeV - >300 GeV

Gamma-ray Burst Monitor (GBM)
NaI and BGO Detectors
8 keV - 40 MeV

KEY FEATURES

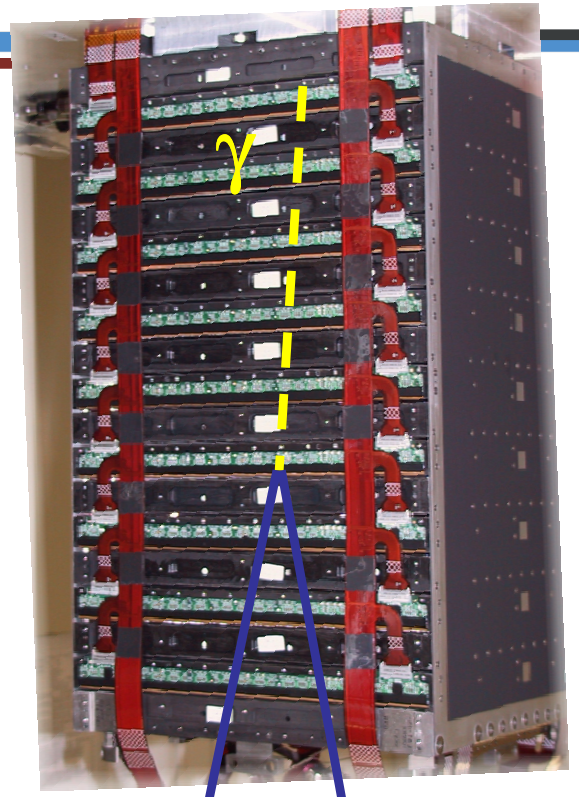
- **Huge field of view**
  - –LAT: 20% of the sky at any instant; in sky survey mode, expose all parts of sky for ~30 minutes every 3 hours. GBM: whole unocculted sky at any time.
- Huge energy range, including largely unexplored band 10 GeV - 100 GeV. **Total of >7 energy decades!**
- Large leap in all key capabilities. Great discovery potential.

Overview of the Large Area Telescope (LAT)



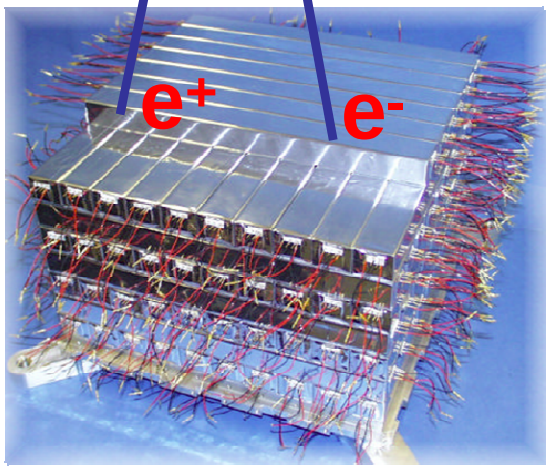
Anti-Coincidence (ACD):

- Segmented (89 tiles + 8 ribbons)
- Self-veto @ high energy limited
- **0.9997 detection efficiency**



Tracker/Converter (TKR):

- Si-strip detectors
- ~80 m^2 of silicon (total)
- W conversion foils
- **1.5 X0 on-axis**
- 18XY planes
- **~10^6 digital elx chans**
- Highly granular
- High precision tracking
- Average plane PHA



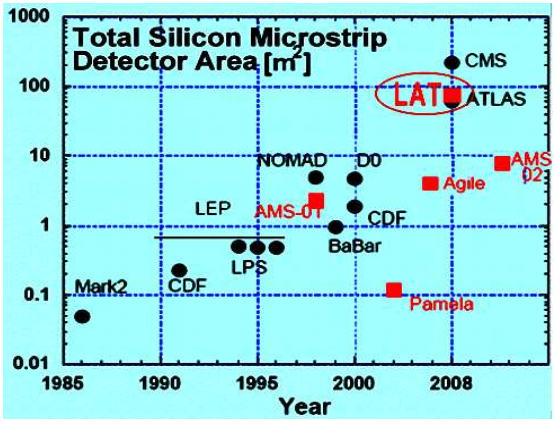
Calorimeter (CAL):

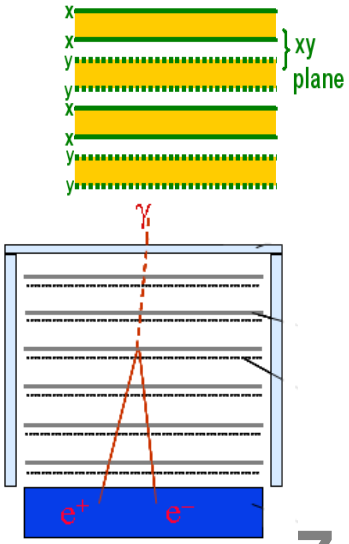
- 1536 CsI(Tl) crystals
- **8.6 X0 on-axis**
- large elx dynamic range (2MeV-60GeV per xtal)
- **Hodoscopic (8x12)**
- Shower profile recon
- leakage correction
- EM vs HAD separation

LAT Construction: an International Effort

TRACKER details:

- 16 tower modules: 37×37cm^2 active cross section/layer
- 83 m^2 of Si
- 11500 Single Strip Detectors, ~ 1M channels, strip-pitch: 228μm
- 18 *xy* layers per tower 19 "tray" structures, 12 with 3% X_0 W on top, 4 with 18% X_0 W on bottom, 3 with no converter foils. Every tray is rotated by 90° with the previous one: W foils followed by. *x,y* plane of detectors, 2mm gap between *x* and *y* oriented detect.
- Trays stack and align at their corners
- Electronics on sides of trays: minimize gap between towers





Large Area Telescope: Experimental Technique

Instrument must measure the direction, energy, and arrival time of high energy photons (from approximately 20 MeV to greater than 300 GeV):

- photon interactions with matter in Fermi LAT
  energy range dominated by pair conversion:
  - ➡ determine photon direction
  - ➡ clear signature for background rejection
- limitations on angular resolution (PSF)
  - low E: multiple scattering => many thin layers
  - high E: hit precision & lever arm

Energy loss mechanisms:

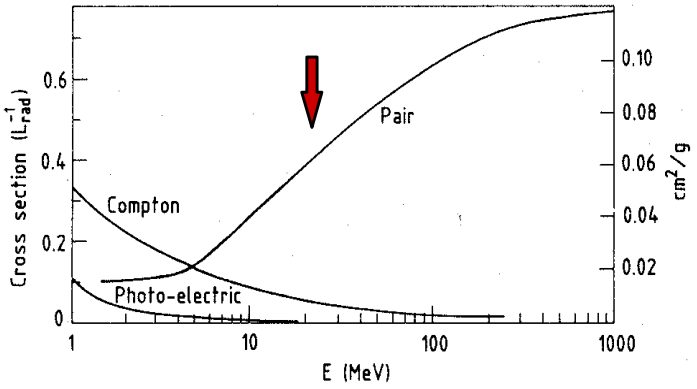
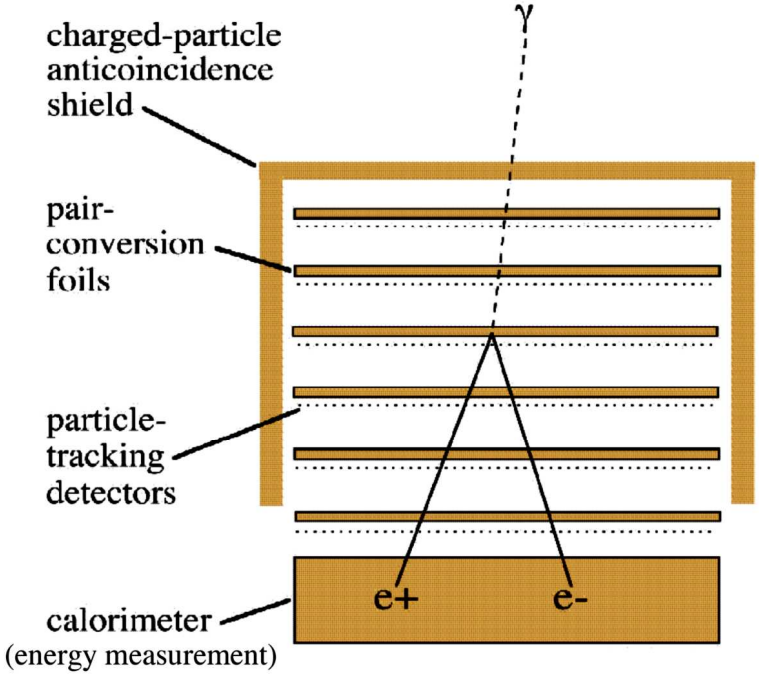
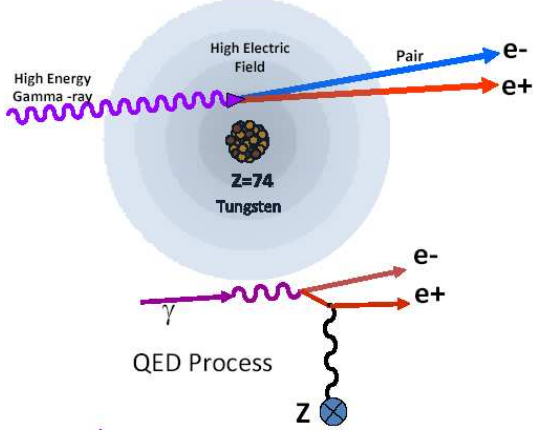


Fig. 2: Photon cross-section σ in lead as a function of photon energy. The intensity of photons can be expressed as $I = I_0 \exp(-\sigma x)$, where x is the path length in radiation lengths. (Review of Particle Properties, April 1980 edition).

Elements of a pair-conversion telescope

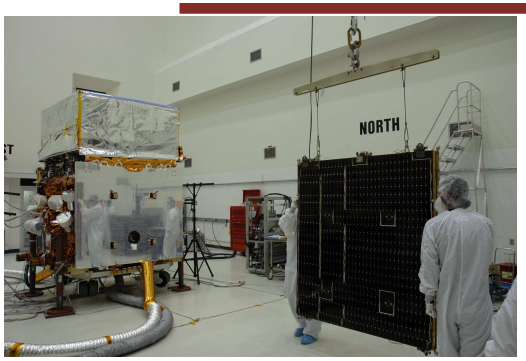


- photons materialize into matter-antimatter pairs:
  $E_\gamma \rightarrow m_{e^+}c^2 + m_{e^-}c^2$
- electron and positron carry information about the direction, energy and polarization of the γ-ray



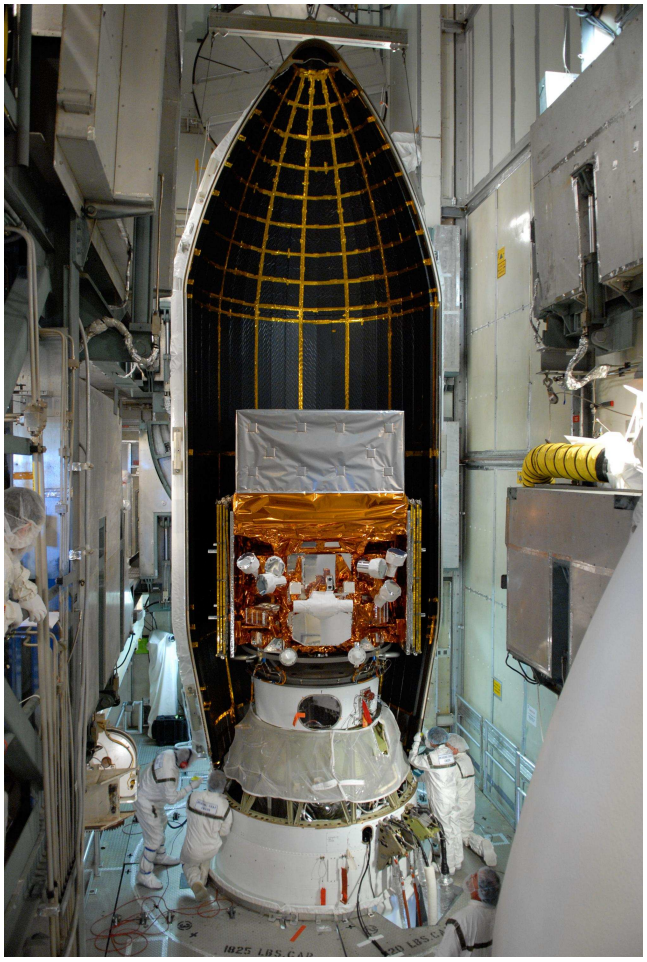
- instrument must detect gamma-rays with high efficiency and reject the much higher flux (x ~10^4) of background cosmic-rays, etc.;
- energy resolution requires calorimeter of sufficient depth to measure buildup of the EM shower. Segmentation in tiles useful.

Fermi Launch



Launch: 2008, June 11
5 year mission life

(goal: 10 years)

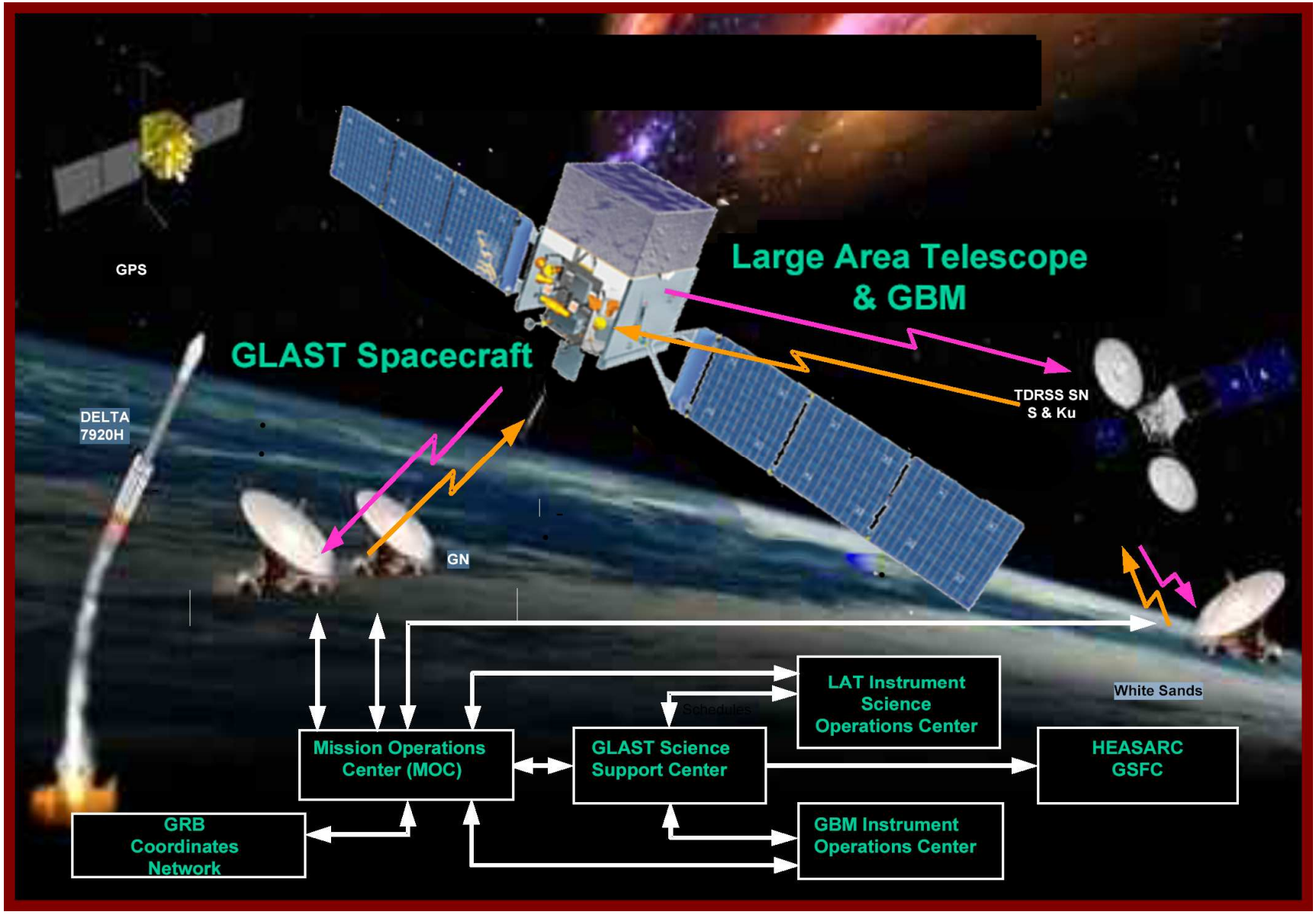


Fermi Launch

Launch from Cape Canaveral Air Station
11-June-2008
at 12:05PM EDT

Circular orbit, 565 km altitude (96 min period), 25.6 deg inclination.

Fermi Mission Elements



The Fermi LAT Collaboration

US Team Instituitions	
SU	Stanford University, Physics Department, GLAST group
SU-HEPL	Hansen Experimental Physics Laboratory
SU-SLAC	Stanford Linear Accelerator Center (SLAC), Kavli Institute for Particle Astrophysics and Cosmology
GSFC	NASA Goddard Space Flight Center, Astrophysics Science Division
NRL	U. S. Naval Research Laboratory, High Energy Space Environment (HESE) branch
OSU	Ohio State University, Physics Department
UCSC	University of California at Santa Cruz, Physics Department
SSU	Sonoma State University, Physics & Astronomy Department, GLAST group, Education and Public Outreach
UW	University of Washington
Denver	University of Denver
Purdue	Purdue University - Calumet

Italian Team Institutions	
ASI	Italian Space Agency
INAF-IASF	Istituto di Astrofisica Spaziale e Fisica Cosmica, Milano, CNR
INFN-Bari	INFN Sezione di Bari
Bari	Università e Politecnico di Bari
Perugia	INFN and University of Perugia
Pisa	INFN and University of Pisa
Rome	INFN and University of Rome 2 (Tor Vergata)
Trieste	INFN and University of Trieste
Udine	INFN and University of Udine

French Team Institutions	
CEA/DAPNIA	Service d'Astrophysique, DAPNIA, CEA Saclay
CESR/CNRS/UPS	Centre d'Étude Spatiale des Rayonnements, Toulouse
IN2P3/LLR	Laboratoire Leprince-Ringuet de l'École Polytechnique
IN2P3/CENBG	Centre d'Études Nucléaires de Bordeaux Gradignan
IN2P3/LPTA	Laboratoire de Physique Théorique et Astroparticules Montpellier

Japanese Team Institutions	
Tokyo Tech	Tokyo Institute of Technology
ISAS	Institute for Space and Astronautical Science
Hiroshima	Hiroshima University

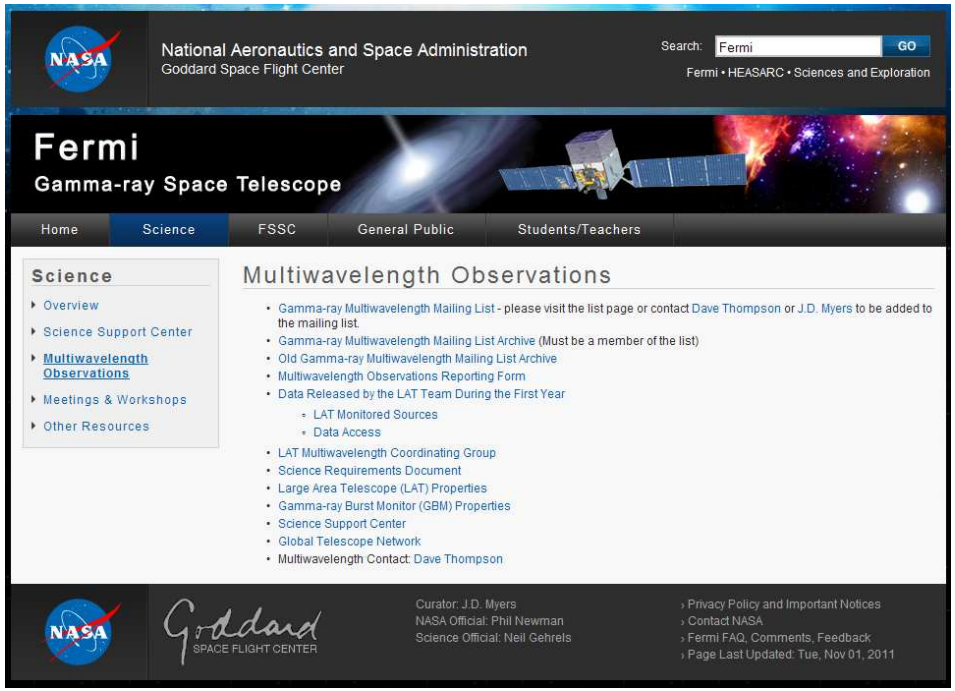
Swedish Team Institutions	
KTH	Royal Institute of Technology
Stockholm	Stockholms Universitet

- ❑ Cooperation between US NASA and DOE, with key contributions from Institutions and Government Agencies in France, Italy, Japan, and Sweden.
- ❑ LAT instrument construction and instrument data processing managed by the SLAC National Acceleration Laboratory.
- ❑ Goddard GSFC Fermi Science Support Center (FSSC) runs the guest investigator program, creates and maintains the mission time line, provides analysis tools for the scientific community, and archives and serves the Fermi data.

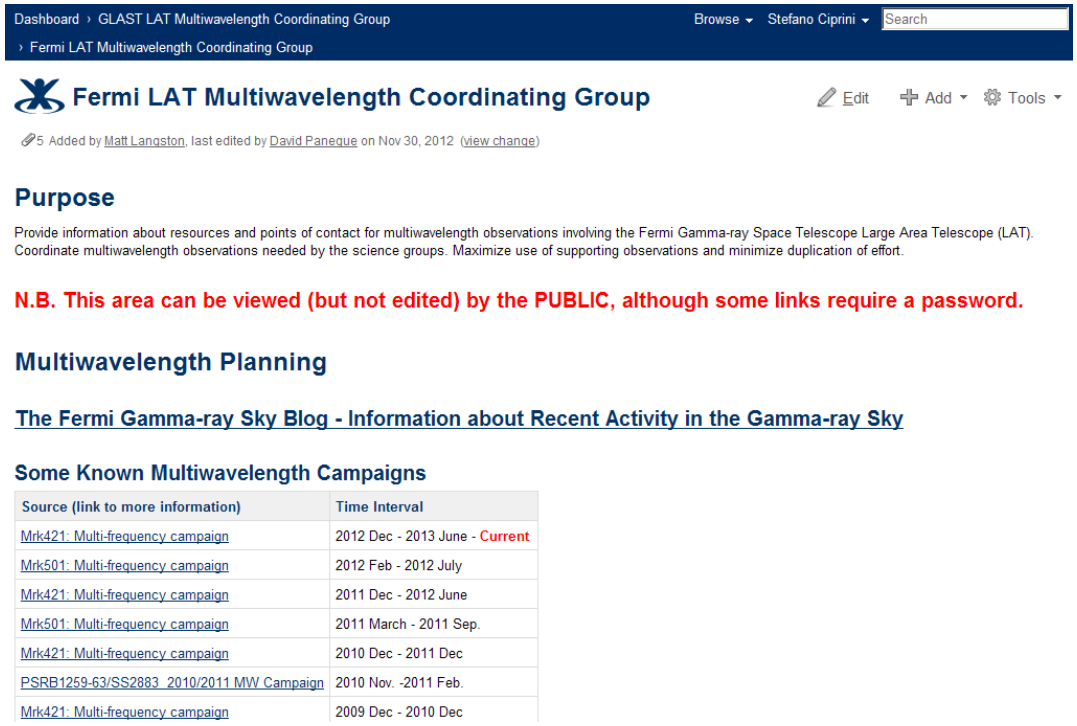
Currently the LAT scientific collaboration includes more than 400 scientists and students at more than 90 universities and laboratories in 12 countries.

Fermi LAT - TeV Telescopes Agreements

- ❑ TeV telescopes observe with high timing and spatial resolution at the higher energies.
- ❑ Fermi LAT provide information before, during, and after the times of TeV observations.
- ❑ The GeV - TeV communities work together with longer-wavelength observers to build a more complete picture.
- ❑ The key to making this approach work is communication. The Fermi LAT team has agreements with the four major TeV telescopes operational now.



http://fermi.gsfc.nasa.gov/science/multi/



https://confluence.slac.stanford.edu/x/YQw

Spacecraft/instrument status at about L + 4 year

Event statistics (at April 2012)

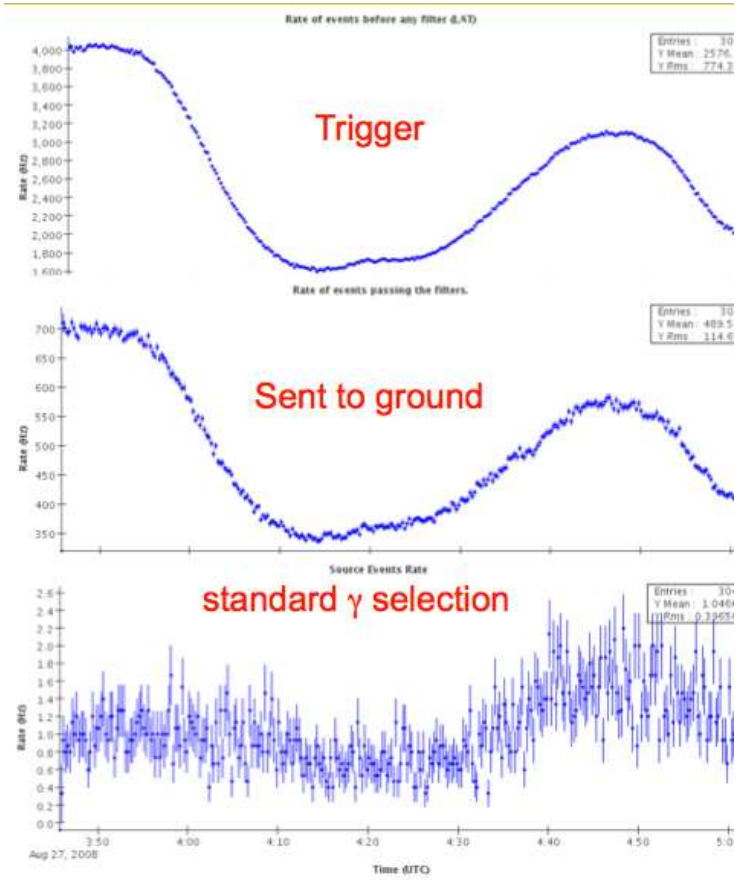
- Over 230 billion triggers in orbit
- 45 billion events down-linked to ground
- 680 million gamma-ray candidates made public

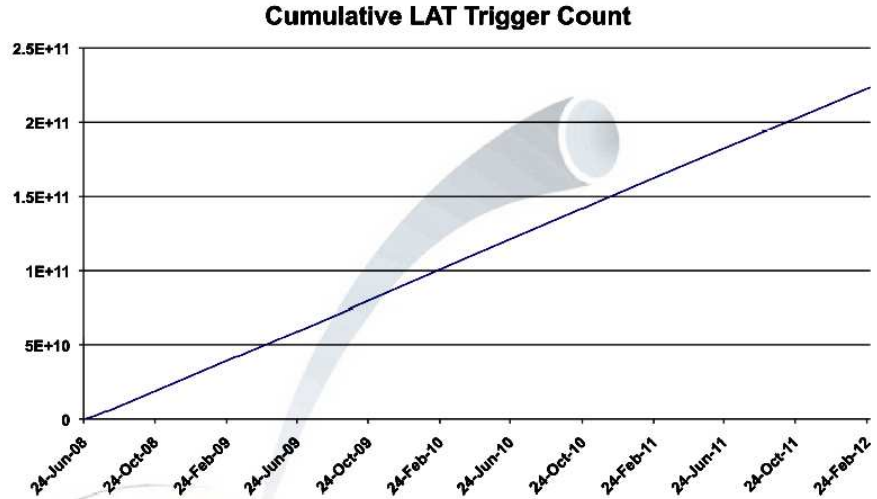
All subsystem working properly, no performance degradation

- 0.06% of the TKR strips masked (out of 884,736)
- One readout on one CAL crystal (out of 1536) failed, using redundant

More than 99% up-time collecting science data (out of the South Atlantic Anomaly)

- Including detector calibrations/hardware issues





- Average input rate at detectors: ~2500Hz
- Downlink rate (sent to ground): ~450Hz
- Gamma-ray event rates (after event selection):~Hz
- Large fraction of the events sent to ground are background.

2012 NASA Senior Review

Fermi planned as a 10-year mission with a 5-year prime phase

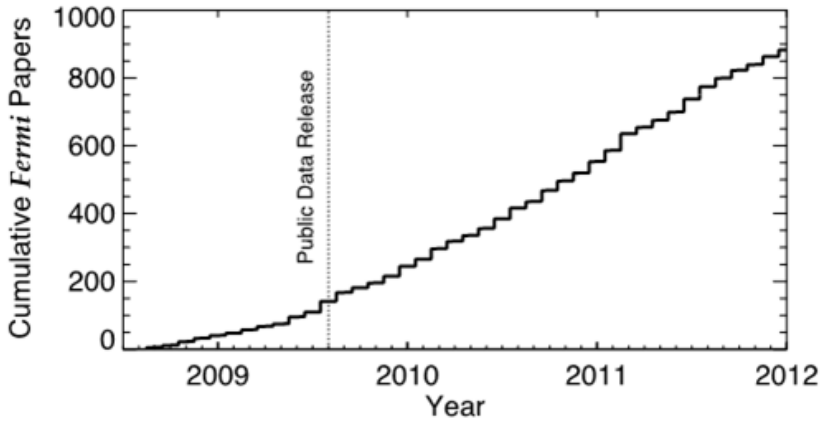
- Prime phase ending in August 2013.
- NASA considers Mission extensions through Senior Review process every two years
- All operating missions in (or about to begin) their extended phase participate.
- Senior Review committee evaluates the anticipated science productivity of each mission over the next four years, focusing on the next two years.

The first Fermi SR just finished

- http://science.nasa.gov/astrophysics/2012-senior-review/

"The Senior Review Committee recommends funding at the desired level of augmentation to provide for full operations through FY14. We recommend an extension through 2016 (1) with a review in 2014."

(1)2016 is the horizon as far as the 2012 SR, so this is not the same as recommending that the mission ends at that point.



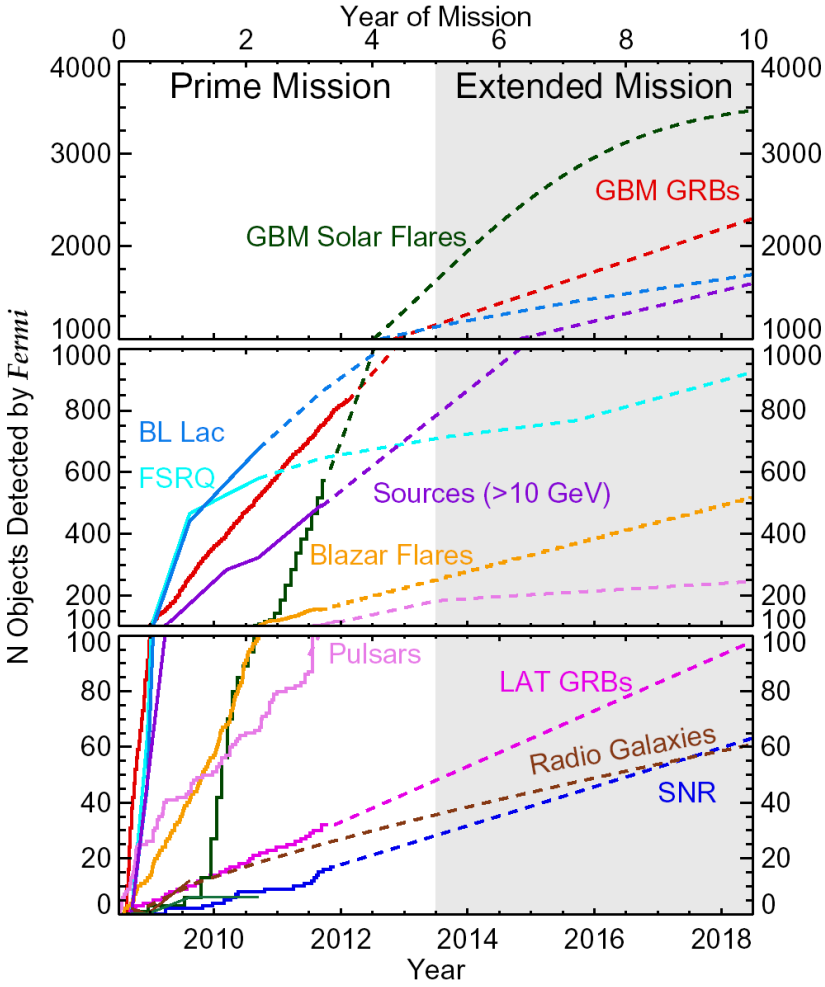


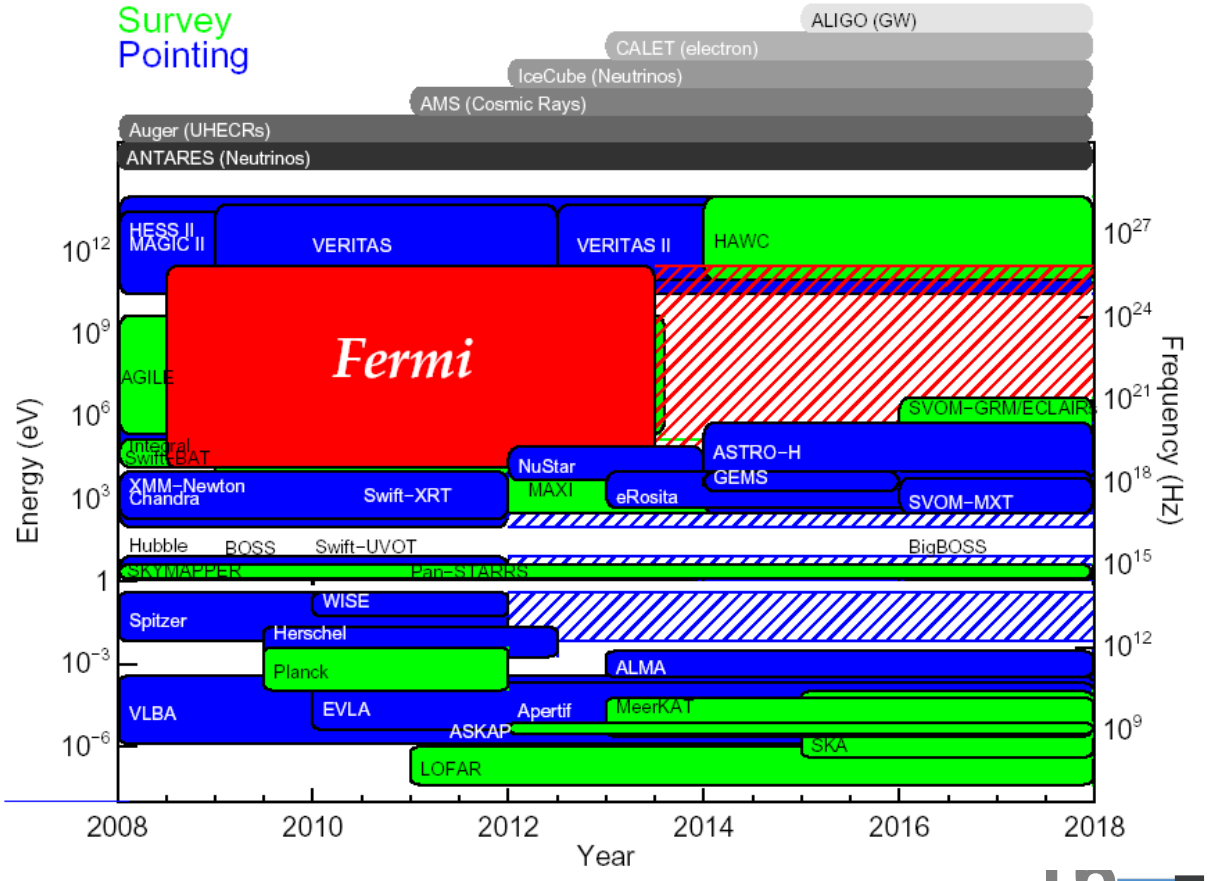
Figure 2: *Fermi* has increased the number of known γ-ray-emitting objects by nearly an order of magnitude compared to previous experiments, and has added several new source classes not previously known in this energy range. The numbers of objects in source classes as a function of time (*solid lines*) are continuing to increase, and predictions with additional exposure (*dashed lines*) demonstrate the varying detection rates.

Path forward for the extended Fermi mission

(i) Continue doing what we've been doing:
- deeper exposure;
- more statistics;
- increasing fraction of pointed (target of opportunity and planned) observations.

(ii) Improve on what we've been doing in the prime phase and maximize the scientific reach of the observatory:
- better understanding of the instrument (reduce systematic uncertainties);
- better calibrations;
- event reconstruction improvements (better PSF, larger energy range);
- event selection improvements (larger e ective area, less background);
- analysis improvements (e.g., LLE);
- operational improvements (new instrument configurations);
- external inputs (e.g., pulsar timing solutions, inputs to the DGE
- modeling…);

- Fermi covers a huge swath of the EM spectrum
  - Crucial and unique spectral coverage
- Complement the large number of upcoming new survey instruments from VHE to radio wavebands
  - At the dawn of time domain astrophysics

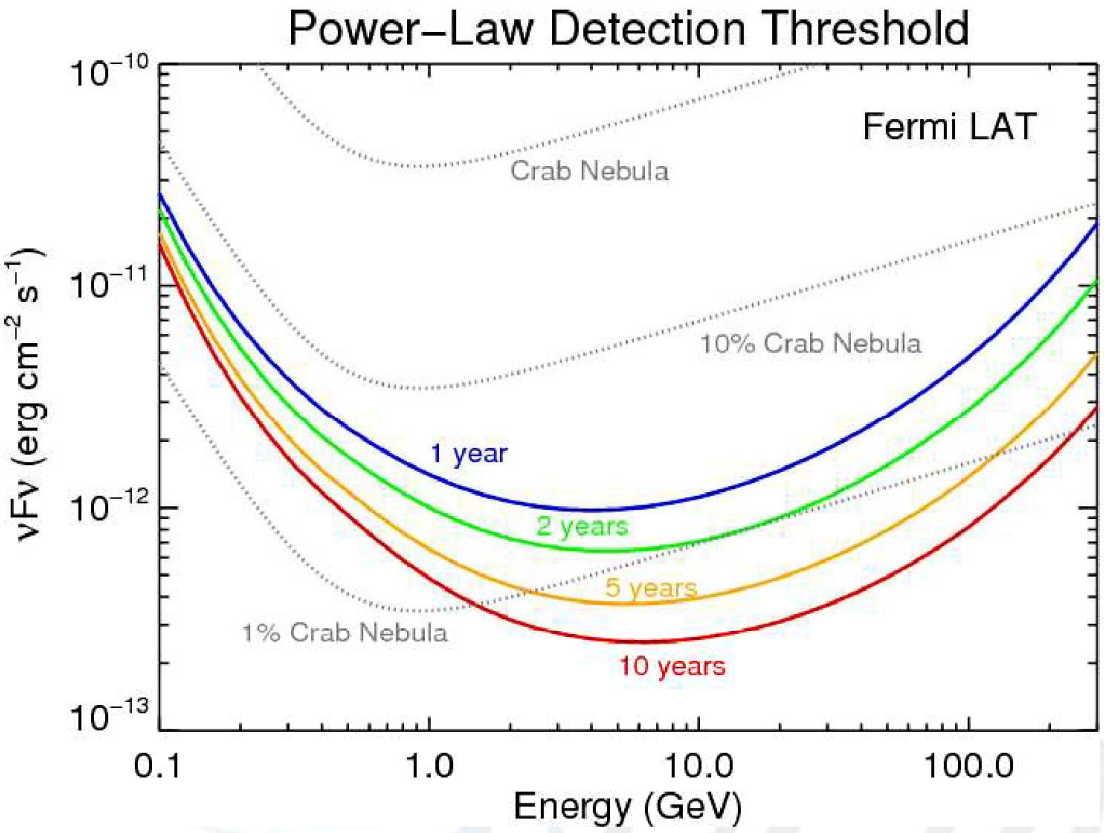


Source detection threshold

—Low energy

Bkg. dominated

$\propto \sqrt{t}$



—High energy

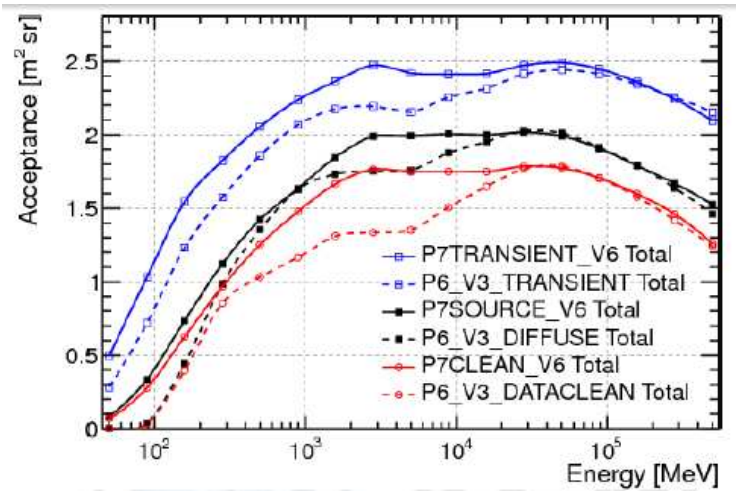
Photon counting

nearly $\propto t$

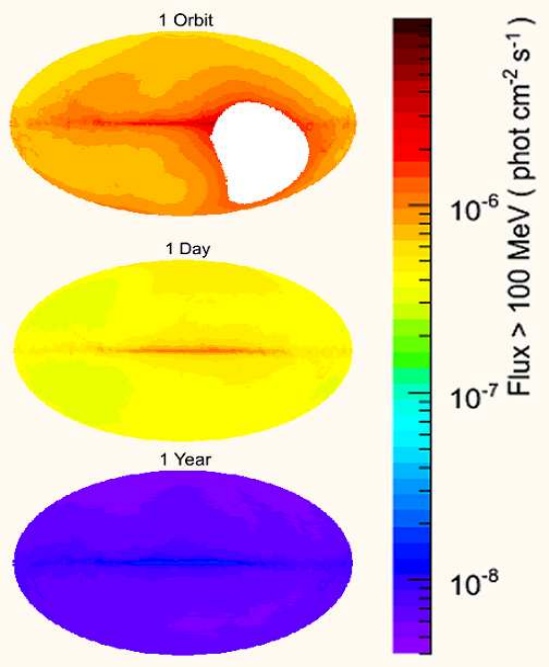
Envelope of the minimum detectable power-law spectra over the full band, varying the spectral index (i.e, not a differential sensitivity plot).
(accounts for uncertainties in the background and source density, P7SOURCE V6 IRFs, bkg. and exposure weighted over |b| > 10)
—Low energy is Bkg. dominated (proportional to sqrt(time))
—High energy is Photon counting statistics dominated (linearly with time)

Some ideas and next improvements

- Continuous effort by the LAT collaboration to make public the advances in the understanding of the detector
- First new event classification since launch (Pass 7 data) released in Aug.2011
  - Greater and more uniform acceptance
  - Significant enhancement at low energy (below about 100 MeV)
- End-to-end reworking of the event reconstruction, analysis and classification (Pass 8 data) ongoing
  - Larger effective area, better bkg rejection, extended energy range
- Extending observations to higher energies for cosmic ray electrons
- Tracker reconstruction using event-by-event errors as opposed to an average PSF parametrization
  - project covariant error ellipse into the sky and aim at improving the angular resolution by using all the available information
- Calorimeter event reconstruction
  - it has some imaging capability at the level of about 1deg above 10 GeV, substantial increase of effective area at high energy
- Applying the standard likelihood analysis below about 100 MeV proved to be more challenging than anticipated (steeply falling effective area and poor energy resolution)
- LAT Low Energy (LLE) analysis can fill the gap between the GBM and the LAT (30–100 MeV) for short transients (e.g., GRBs and solar flares).
  Use a loose event selection and statistically subtract the background (not an event-by-event analysis).

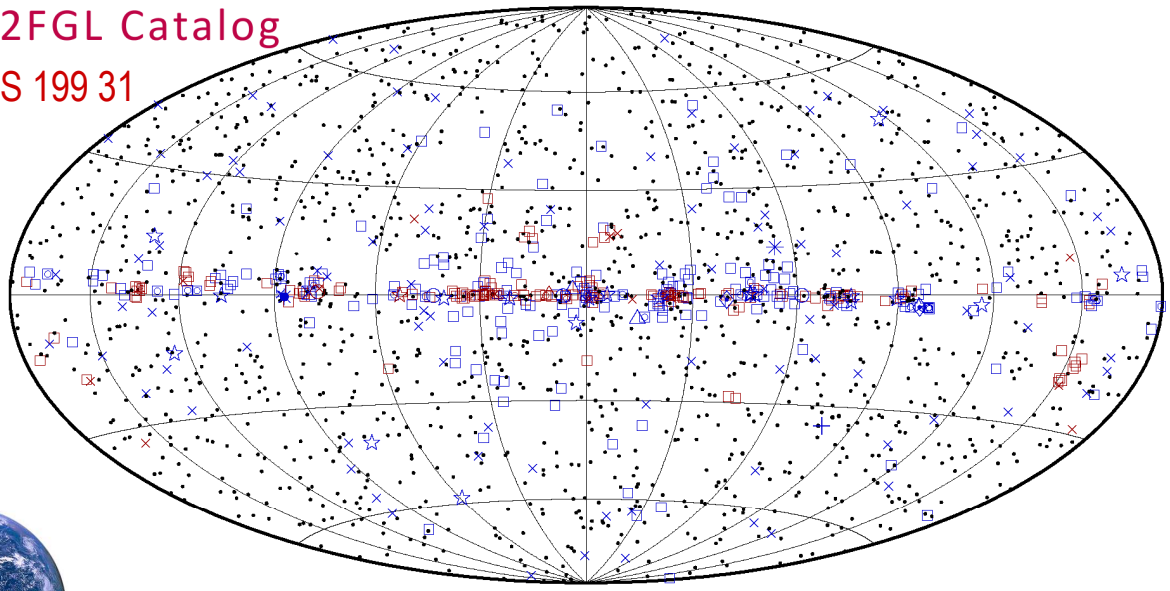


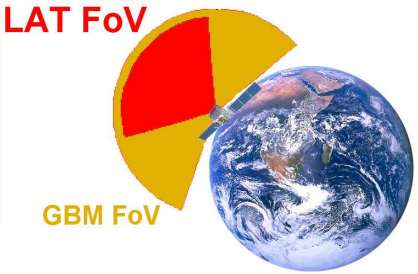
Fermi LAT as an all-sky survey and time monitor



2FGL Catalog

Nolan et al. 2012 ApJS 199 31





□ No association	⧈ Possible association with SNR or PWN	
× AGN	☆ Pulsar	△ Globular cluster
✳ Starburst Gal	⟐ PWN	⊠ HMB
+ Galaxy	○ SNR	✷ Nova

- LAT has a wide field of view >20% of the sky (>2.5 sr) → Excellent to "catch" gamma-ray GRBs, AGN/blazars flares, galactic transients, and to monitor variable bright gamma-ray sources.
- In survey mode, the LAT observes the entire sky every 2 orbits (~3 hours). Each point on the sky receives ~30 minutes exposure during this time.
- LAT is an all-sky hunter and surveyor for high-energy transients and flares, and all-sky monitor for variability of the restless and violent high-energy sky, producing (mostly) daily/weekly-sampled light curves for dozens of bright GeV gamma-ray sources.
- In some cases, like Crab nebula or blazar 3C 454.3, we obtained 3h/6h-bin light curves, while for about 70-80% of the other, weaker, sources, 1- or 3-month time intervals have significant maximum likelihood detections in each light curve bin.
- Multiwavelength observations limited only by the ability to coordinate other observations.

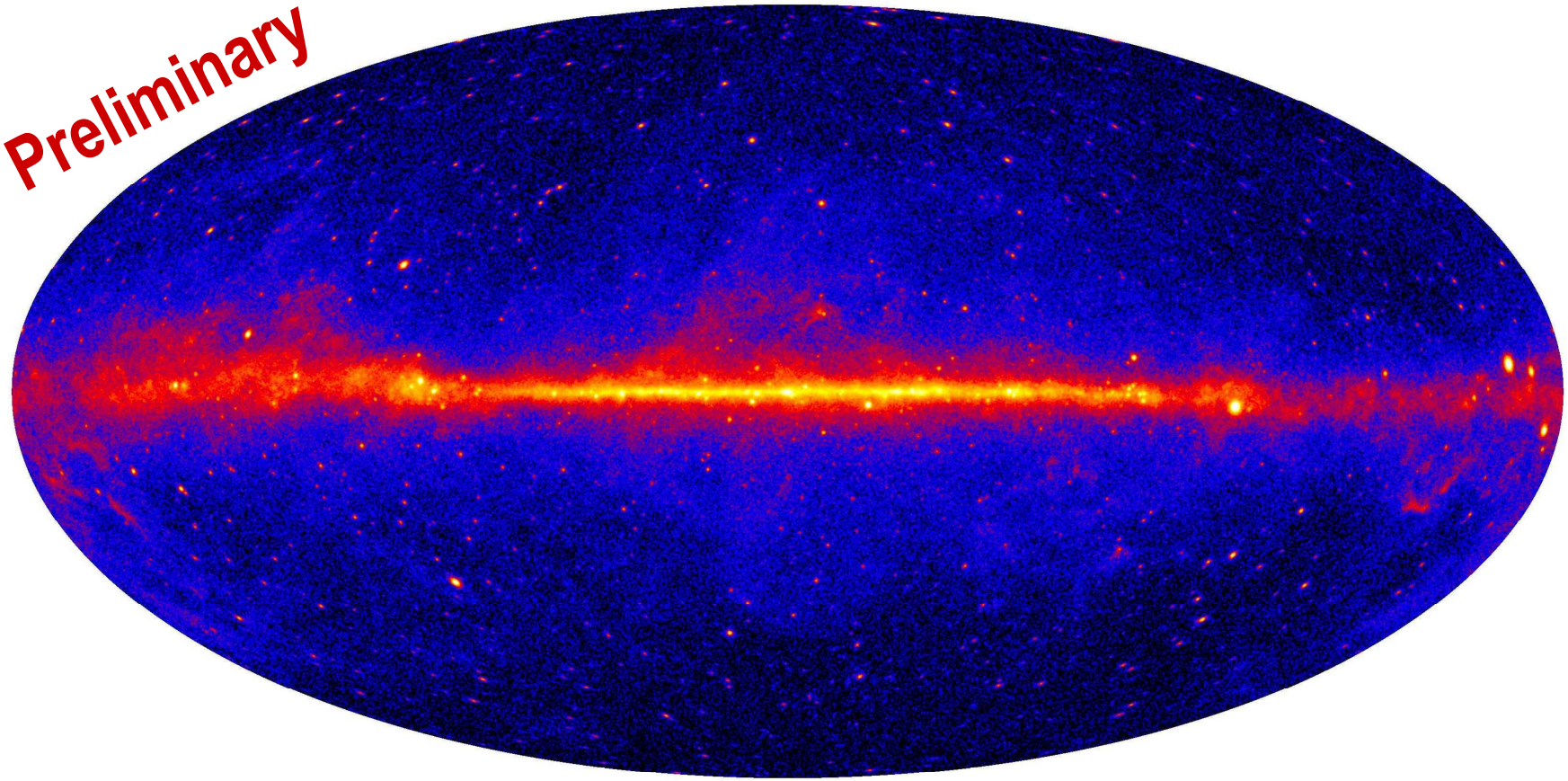
4-years gamma-ray sky at E>1 GeV

Fermi LAT space observatory is operating smoothly

– instruments and spacecraft operate as designed, no degradation in science performance since launch

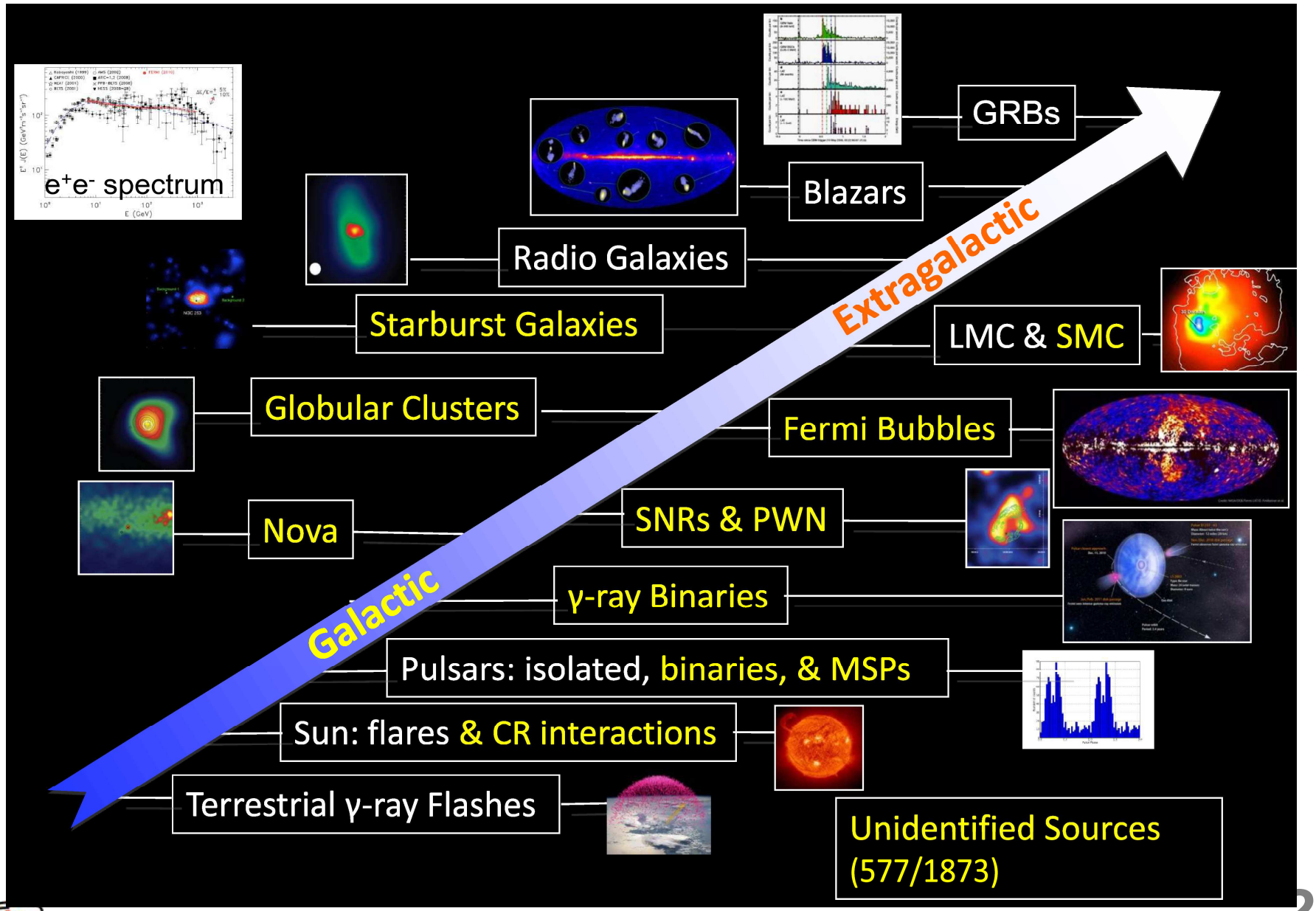
- 4-year sky map, >1 GeV, front converting (best psf) (4.52M events)

(E > 1 GeV, 4 Years)



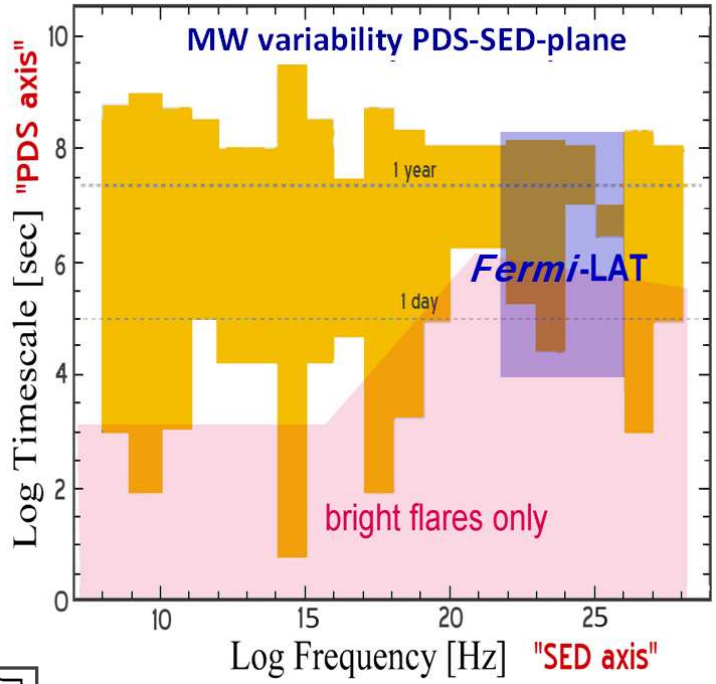
Aitoff projection of the Sky in Galactic Coordinates

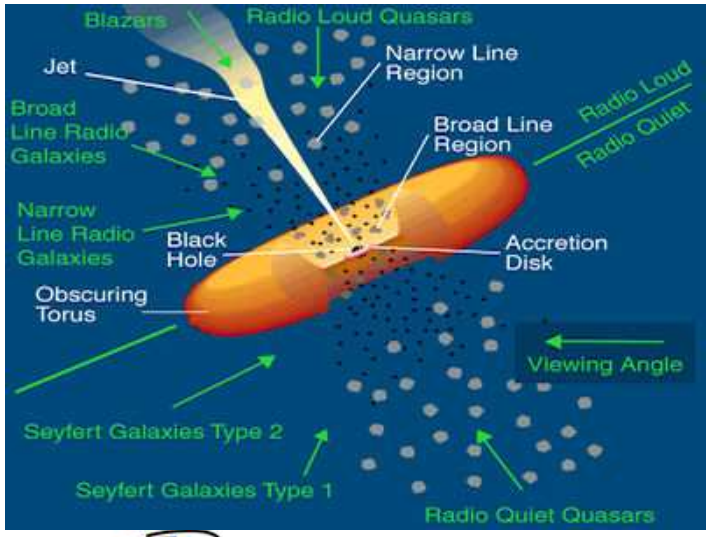
Fermi Highlights and Discoveries Highligh coveries

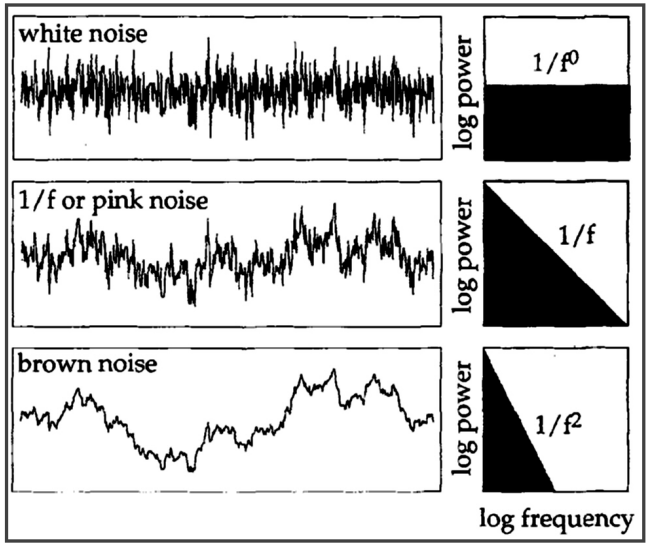


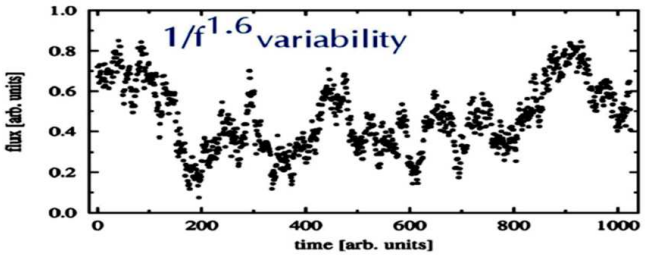
Multifrequency variability of blazars

- → Variability: the “range of change” .
  → Time series: sequence of observations.
  Variability → Time series analysis
- Blazars: irregular/aperiodic variability, at all the frequencies
  → also seen in GeV-energy gamma-ray emisson
  (observed by CGRO-Egret, Agile and Fermi missions).
- Irregular blazar variability is boring (no correlation, no memory, full random behavior…) or is interesting (the power of unexpected, emergence of complexity, modulations, characteristic timescales, long-term memory…) instead?
- Observed flux temporal variability (radio, optical, X-ray bands) of blazar-like AGNs shows $1/f^{\alpha}$ power spectrum decline in a wide range of frequencies f=1/t. Power/scaling law index α generally is placed between about 1 and 3. → Between flickering (pink-noise) to shot-noise (red/brown/Brownian/relaxation noise).









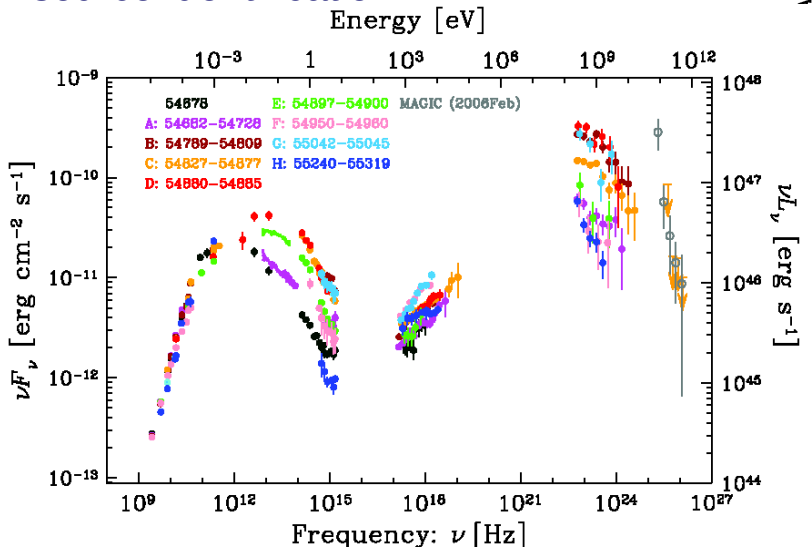
Variability of gamma-ray blazars with Fermi LAT

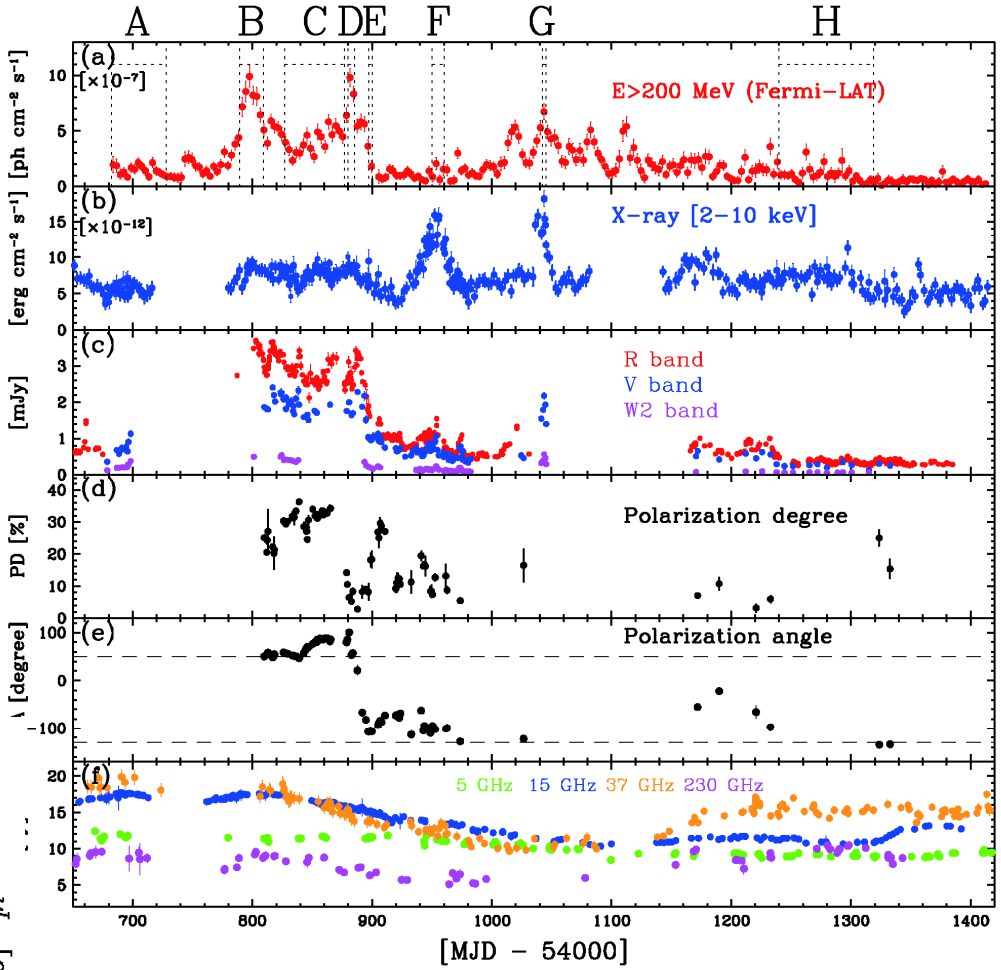
Gamma-ray band variability studies with Fermi only:

- Catch flaring sources (and so to find weak sources)
- Study variability on timescales of hours to years
- Measure spectral variations
- Daily continuous light curves (although most sources need longer integrations to be detected).
- Shortest time scale?: Down to a few hours but depends on definition, (Shortest significant, with some amplitude e.g. factor 2, flare rise or decay time).

Multiwavelength multi-mission variability studies:

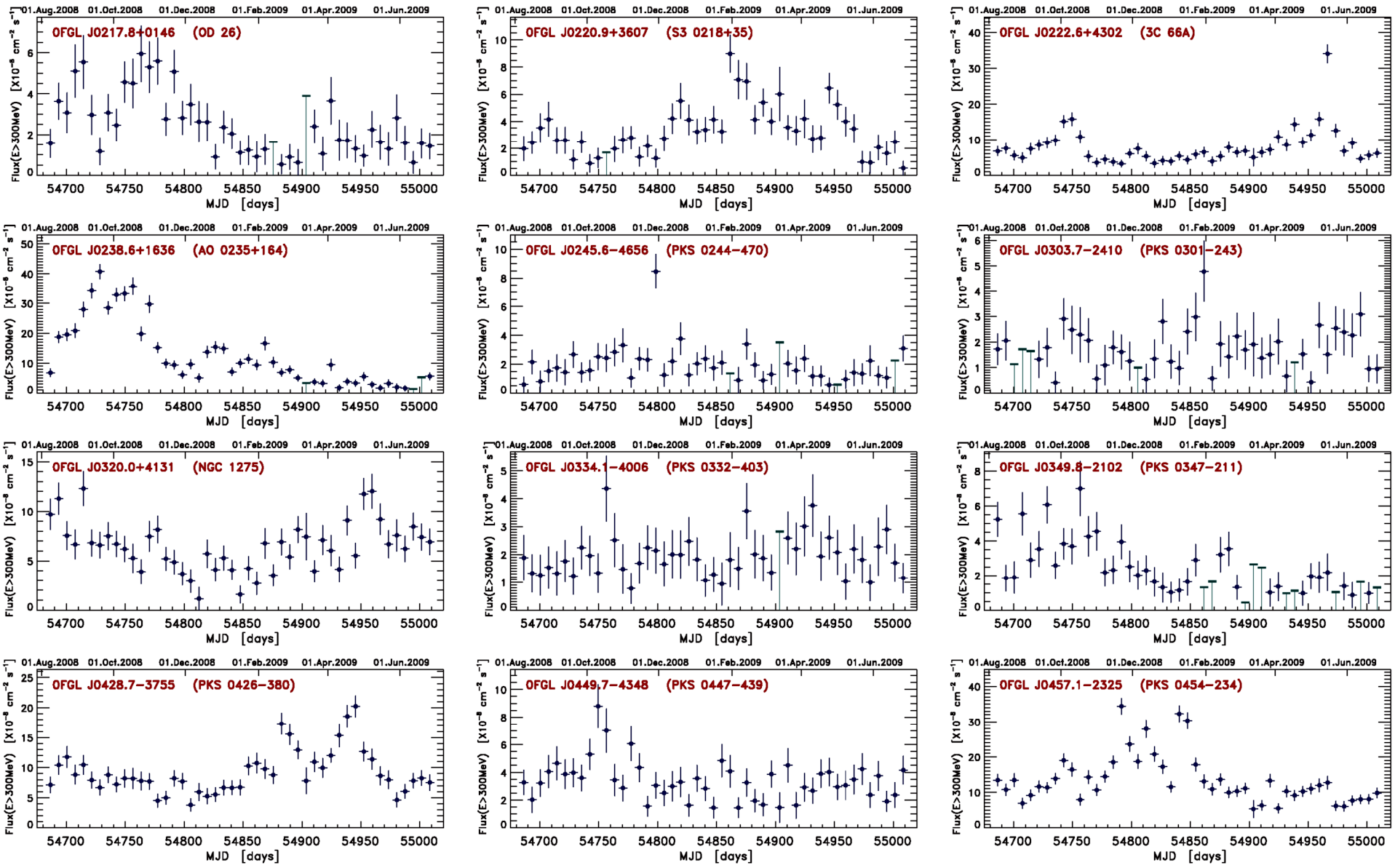
- Correlation amplitudes and time lags
- Wavelength dependent flare shapes
- Follow correlations with time
- Differences between objects and source classes
- Also help for source identification





Hayashida et al. 2012 ApJ 754 114

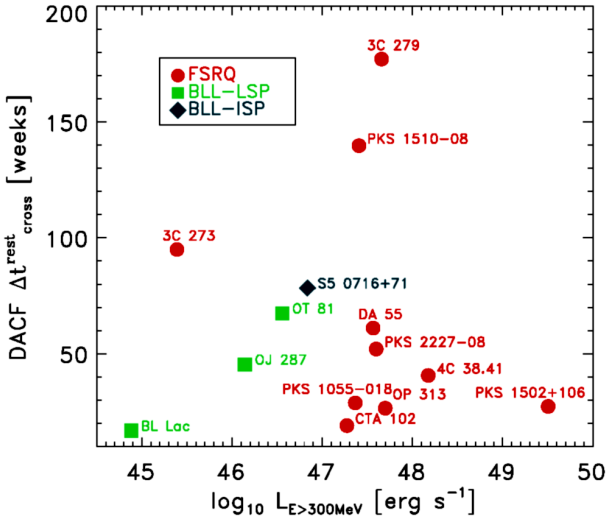
Examples: weekly bins, first 11 months of survey

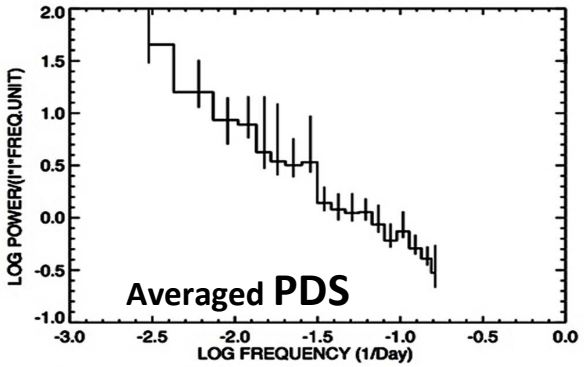


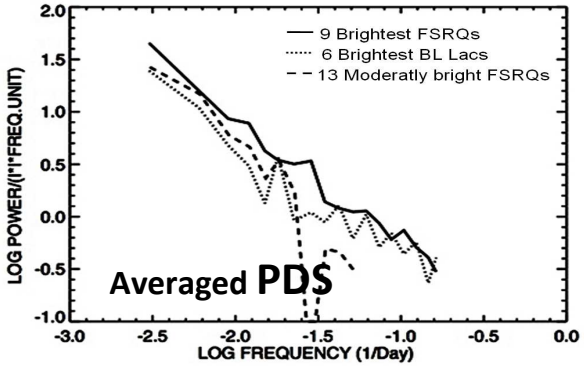
Abdo et al. 2010 ApJ 722 520

Gamma-ray variability of bright Fermi-detected blazars

- A first systematic look and characterization of gamma-ray blazar variability through a homogeneous sample of GeV gamma-ray light curves of AGN.
- 2/3 of sources are variable. (This fraction is increasing with time)
- High states < 1/4 of observation time
- Relative variance is larger for FSRQs than for BL Lacs. Maybe also LSPs relative to HSPs (but selection effects.)
- DACF timescales ~ 4 to > 10 weeks
- Averaged PDS slope ~ 1.5 (halfway between flickering and Brownian noise variability)
- No evidence for a persistent characteristic time scale or periodicity
- Flare profiles: symmetric (on average)
- Modest variations in spectral index
- Variability amplitude of low synchrotron frequency peaked (LSP) blazars tends to be generally larger than for the intermediate/high synchrotron frequency peaked (ISP/HSP) blazars.
- Different autocorrelation patterns, zero lag peak amplitudes, temporal slopes implying different variability modes for different gamma-ray blazars (more flicker-dominated or more shot-noise dominated). For example very Brownian variability (more power is observed on long term time scales / lower frequencies) for blazars like 3C 434.3, and AO 0235+164).







Abdo et al. 2010 ApJ 722 520

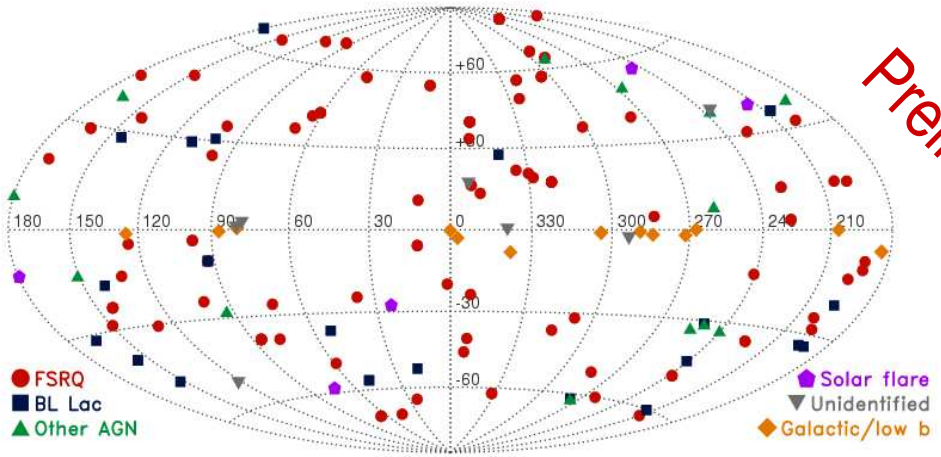
LAT source monitoring and Flare Advocate service

A twofold service:

- **Flare Advocate (FA)**: look for flares, transients, sources above 1E-6 ph/cm2/s; ATels, internal emails to science groups, ToO requests for MW observations, MW campaings, source friendship, papers on flares.
- **Gamma-ray Sky Watcher (GSW) side**: outlook to daily and 6h interval all sky maps and ASP data; daily confluence report; weekly summary in the public Fermi sky blog; new sources detected (with respect to Catalogs), validation of ASP pgwave sources through gtlike run for detection and localization.

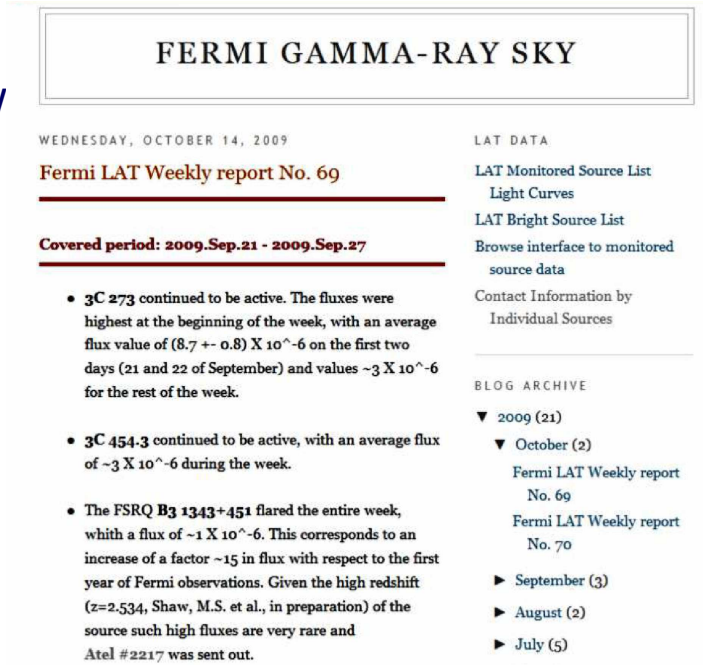
❑ Astronomer's Telegrams: 203 ATels published in period Jul. 24, 2008 – Aug. 28, 2012 (4.1 years).

http://www-glast.stanford.edu/cgi-bin/pub_rapid



Preliminary

http://www.asdc.asi.it/feratel/



FERMI GAMMA-RAY SKY

WEDNESDAY, OCTOBER 14, 2009

Fermi LAT Weekly report No. 69

Covered period: 2009.Sep.21 - 2009.Sep.27

- **3C 273** continued to be active. The fluxes were highest at the beginning of the week, with an average flux value of (8.7 +- 0.8) X 10^-6 on the first two days (21 and 22 of September) and values ~3 X 10^-6 for the rest of the week.
- **3C 454.3** continued to be active, with an average flux of ~3 X 10^-6 during the week.
- The FSRQ **B3 1343+451** flared the entire week, whith a flux of ~1 X 10^-6. This corresponds to an increase of a factor ~15 in flux with respect to the first year of Fermi observations. Given the high redshift (z=2.534, Shaw, M.S. et al., in preparation) of the source such high fluxes are very rare and Atel #2217 was sent out.

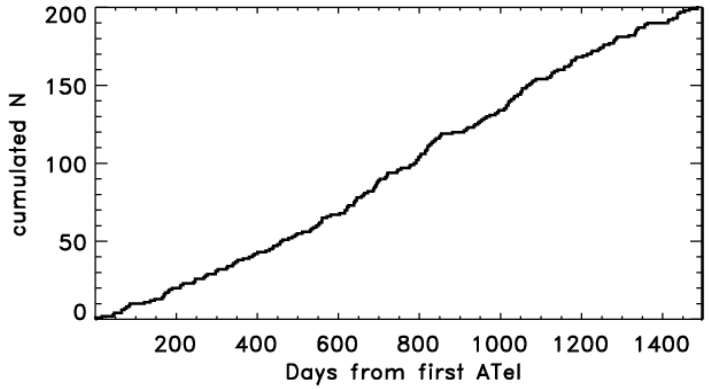
LAT DATA

LAT Monitored Source List
Light Curves
LAT Bright Source List
Browse interface to monitored source data
Contact Information by Individual Sources

BLOG ARCHIVE

▼ 2009 (21)
▼ October (2)
Fermi LAT Weekly report No. 69
Fermi LAT Weekly report No. 70
► September (3)
► August (2)
► July (5)

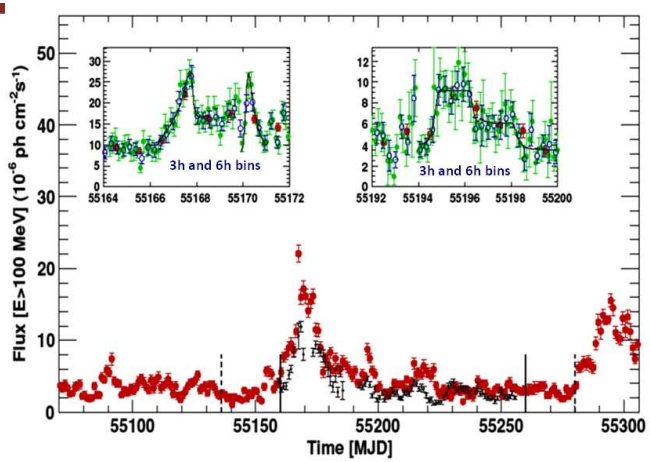
http://fermisky.blogspot.com



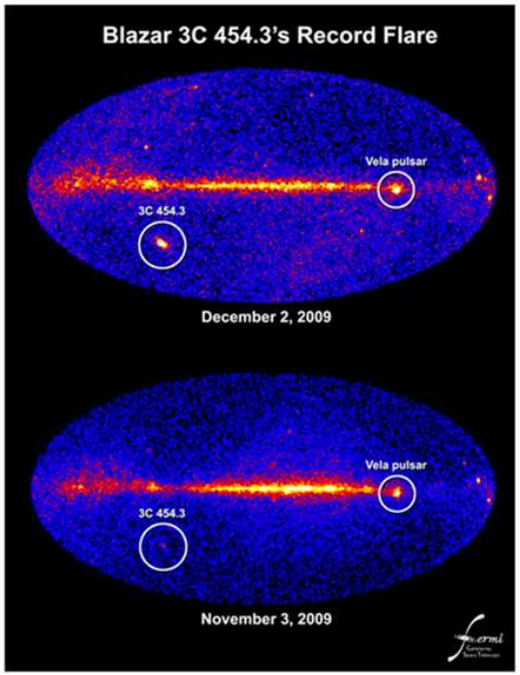
Ciprini et al. 2012 AIP Conf. Ser. 1505 697

Fermi LAT AGNs

- Fermi has discovered hundreds of new sources, proving that blazars dominate the extragalactic sky (detailed population studies, detailed spectral and variability temporal studies possible):
  - BL Lac objects (x~20 with respect to EGRET), many are HSPs
  - Flat Spectrum Radio Quasars (x~5 wrt EGRET)
  - majority of TeV AGNs.
- Important spectral properties (correlation of photon index with blazar class, spectral breaks, relative constancy of photon index with flux, but there are exceptions: 3C 454.3, Mkn 501, etc.)
- Variability time scales were observed ranging from sub-day to several months.
- Many multifrequency studies heve been triggered by Fermi observations, providing time-resolved SEDs and interband (radio, optical, X-ray, TeV) temporal correlation.
- The emission of gamma-rays from the lobes of Cen A has been discovered.
- Many new non-blazars sources have been detected (Radio galaxies, NRLSy1, NGC 1275, etc.).
- Gamma-ray flares from gravitationally lensed blazars discovered.
- Constraints on EBL opacity have been obtained.
- A lot of novel features and correlations to digest, but ultimately a better understanding of gamma-ray emitting AGNs is emerging.
- The cause of the gamma-ray spectral break is still a mystery, although several causes have been proposed.
- Large variability events might be thought to be initiated by sporadic accretion events with clues as to how AGN engine works.



Ackermann et al. 2010 ApJ 721 1383

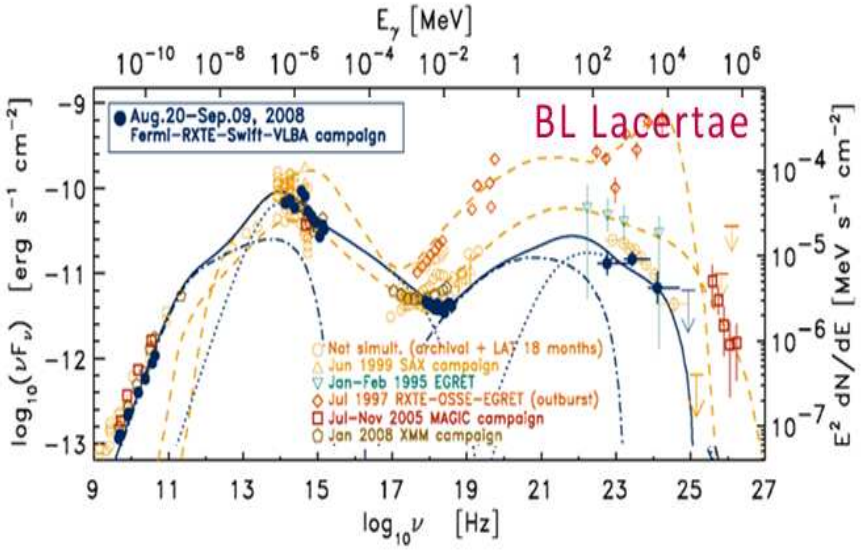


Fermi LAT AGNs

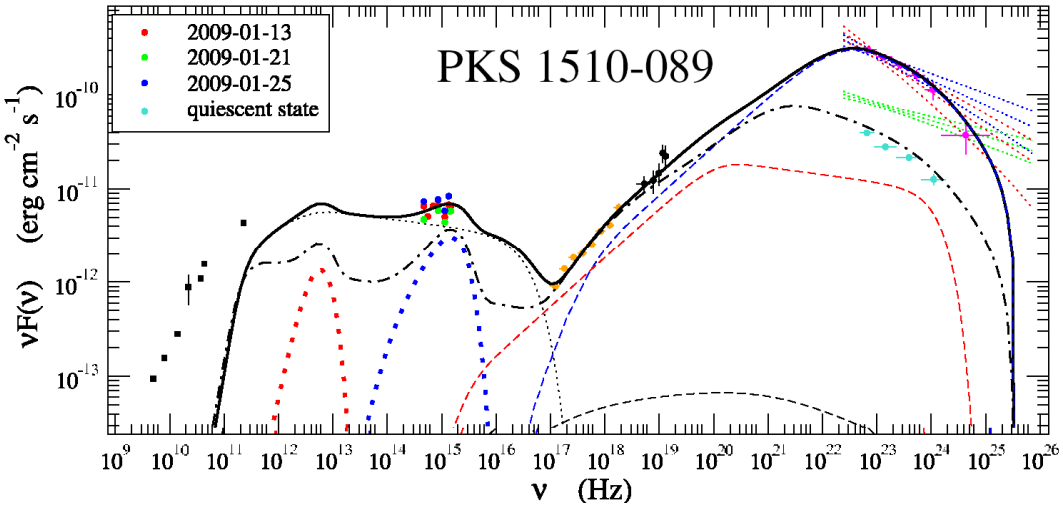
- First Fermi obsrvations provided some evidence, independent of redshift, that there is an anti-correlation between Compton dominance and the peak value for blazars a key component of the “blazar sequence”.

On the other hand new high-power and high synchrotron peaked blazars are discovered.

- It is certainly is possible in the future that high gamma-ray luminous and flat sources will be found as more redshifts are available (potential selection effect involving sources with unknown redshifts).
- Some cases with Evidence for large distances gamma-ray emission regions from BH.
- Gamma-ray flares appear to be correlated with 43 GHz VLBI flux of the core, while gamma-ray vs cm radio flux light curves finds strong correlations and results consistent with cospatial emission regions on parsec scales.
- The location of the gamma-ray emitting region in the jet is still ambiguous, although gamma-ray variability may be the key to resolving this issue.
- Fermi and multi-wavelength observations and simultanous radio-to-gamma-ray SEDs are forcing us to look for models beyond the standard one-zone leptonic models.

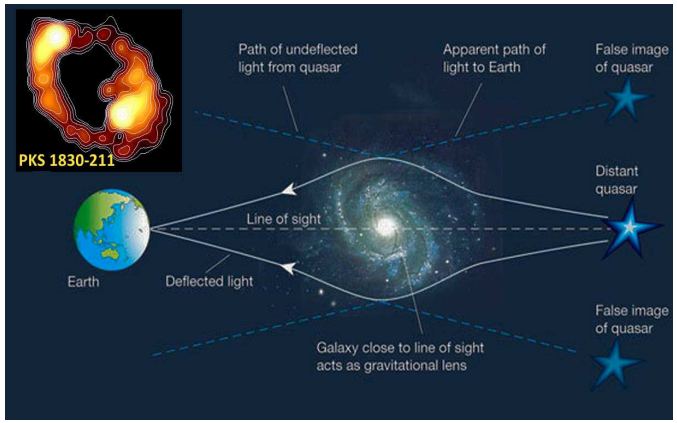


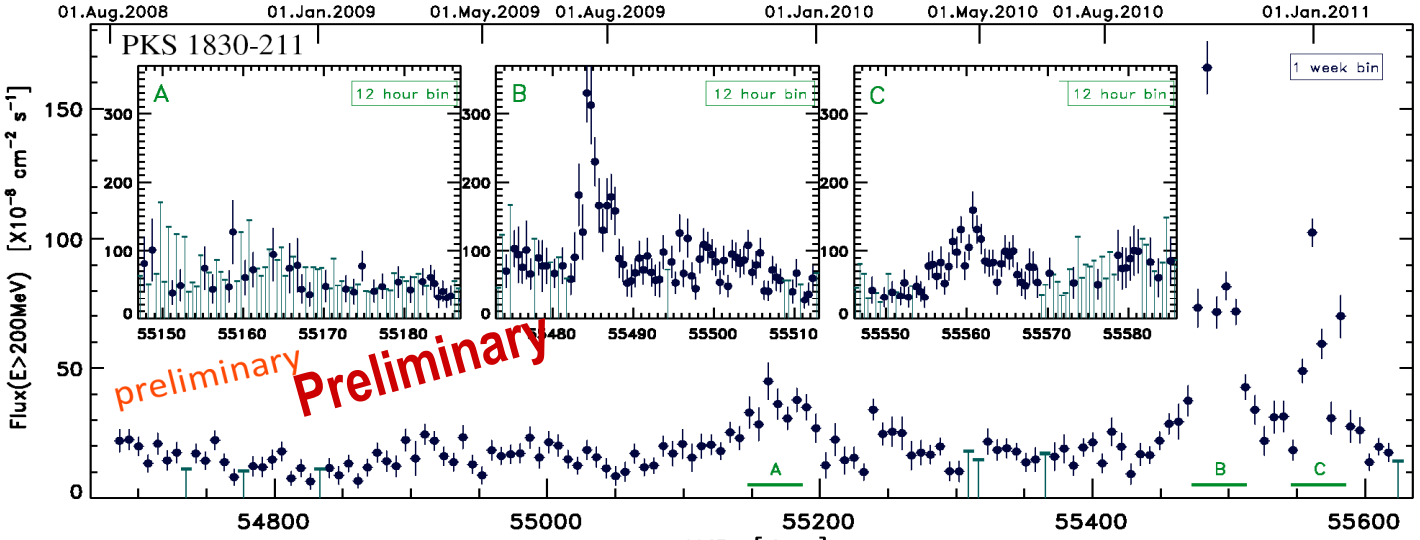
Abdo et al. 2011 ApJ 730 101



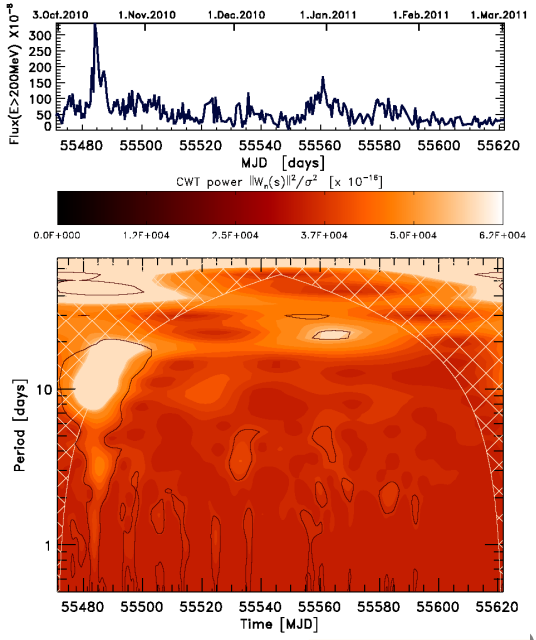
Abdo et al. 2010 ApJ 721 1425

Gravitationally lensed blazar: PKS 1830-211





- Intense gamma-ray outburst from the blazar PKS 1830-211 (z =2.507) in October 2010, followed by high activity and other flares. Variability analysis still ongoing.
- A gravitationally lensed, highly dust-absorbed and reddened (by our Galaxy) flat spectrum radio quasar, peaked at MeV energy band.
- Analysis of 3-year Fermi LAT observations and simultaneous Swift observations (ToO during the LAT outburst) between Oct. 15 and 24, 2010.
- Swift-UVOT: only upper limits. Swift-XRT: no sign of a simultaneous X-ray flare. 0.3-10 KeV flux rather stable → Uncorrelated daily flux (but low count rate).
- No evident sign of echo gamma-ray flares caused by the lens.
- External-Compton (where seeds photons are from dusty torus) can fit the collected SED data. X-rays data are very similar to what was seen by Chandra in 2005 while gamma-rays are flaring → X-rays can origin from a different region or radiation mechanism.

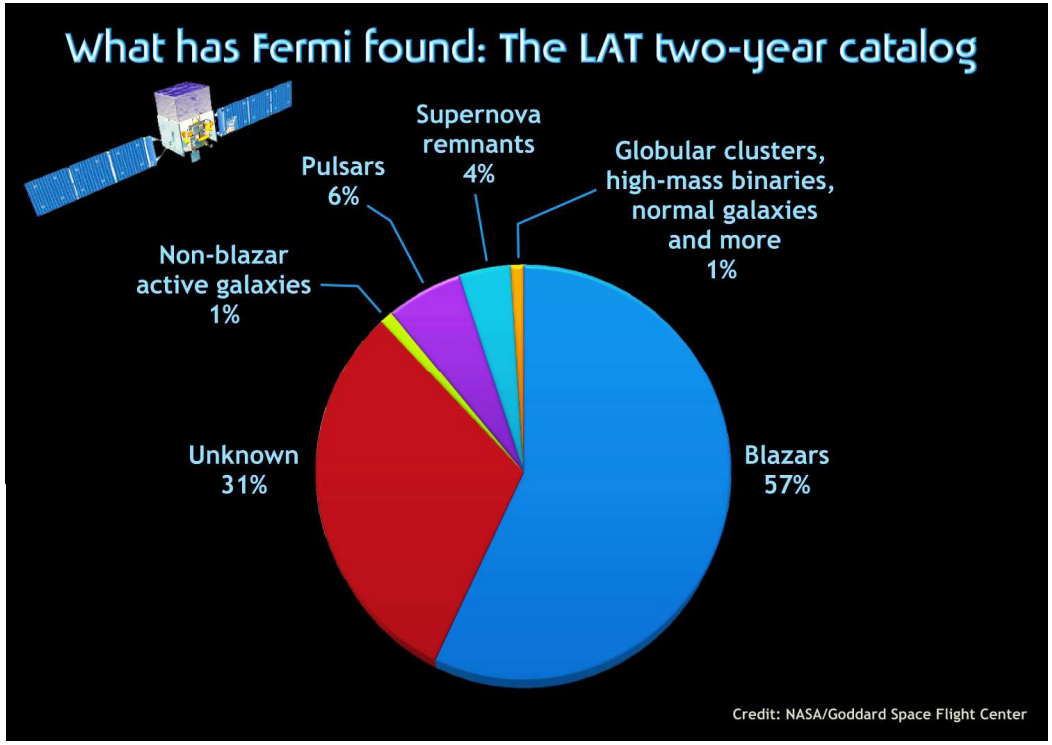


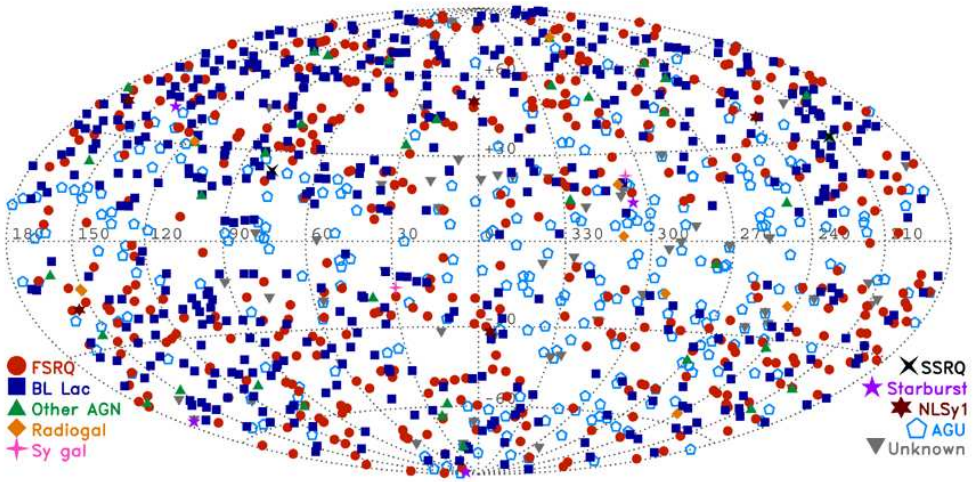
Preliminary

Second Fermi-LAT Catalog: "Fermi is a blazars telescope!"

Fermi is a blazar telescope!

The Second Fermi LAT Catalog:
- 1,298 identified or associated sources
- 575 unassociated sources



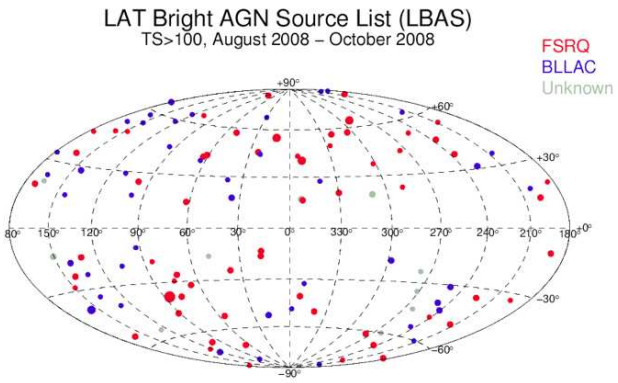


Fermi AGN cumulative master list of published LAT AGN-associated sources (preliminary)

www.asdc.asi.it/fermi2fgl

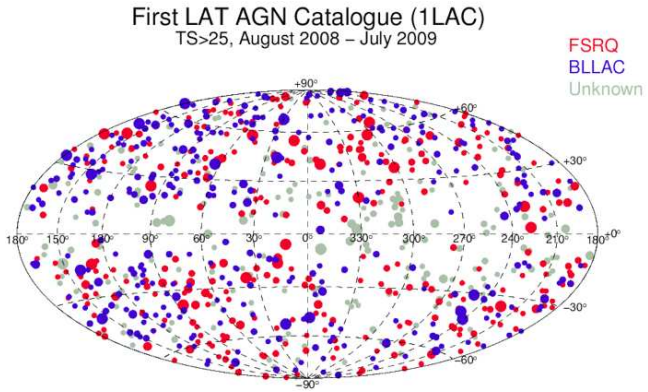
Fermi AGN Catalogs

www.asdc.asi.it/fermibls



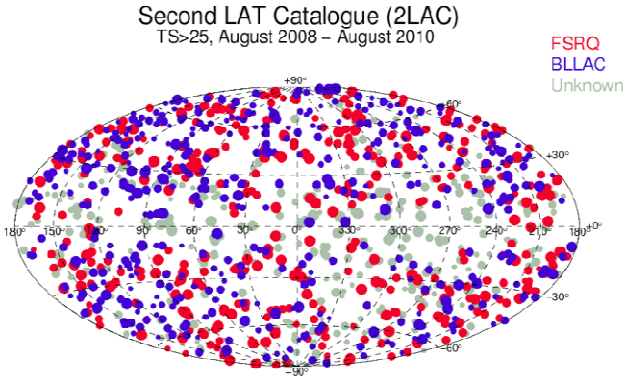
LBAS-high latitude:
58 FSRQs
42 BL Lacs
6 AGNs

www.asdc.asi.it/fermi1lac



1LAC-clean sample:
248 FSRQs
275 BL Lacs
50 Blazars with unknown type
26 AGNs

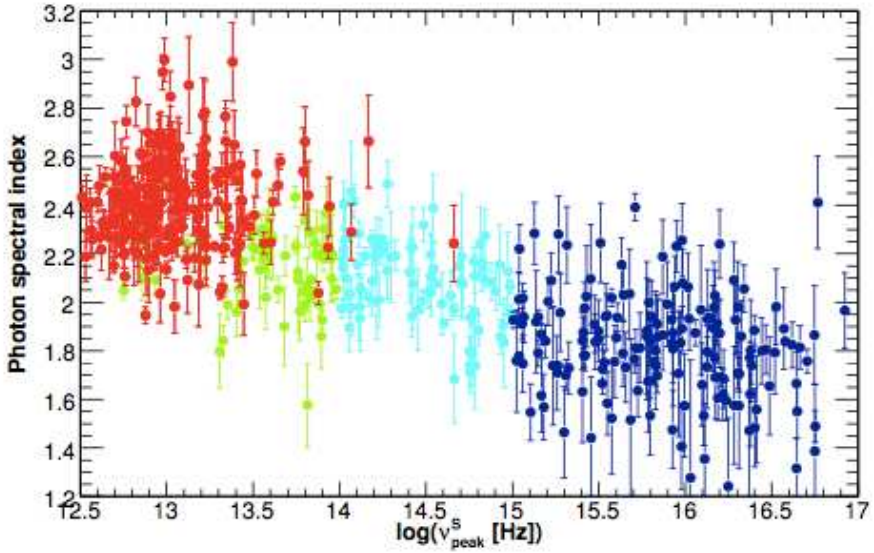
www.asdc.asi.it/fermi2lac



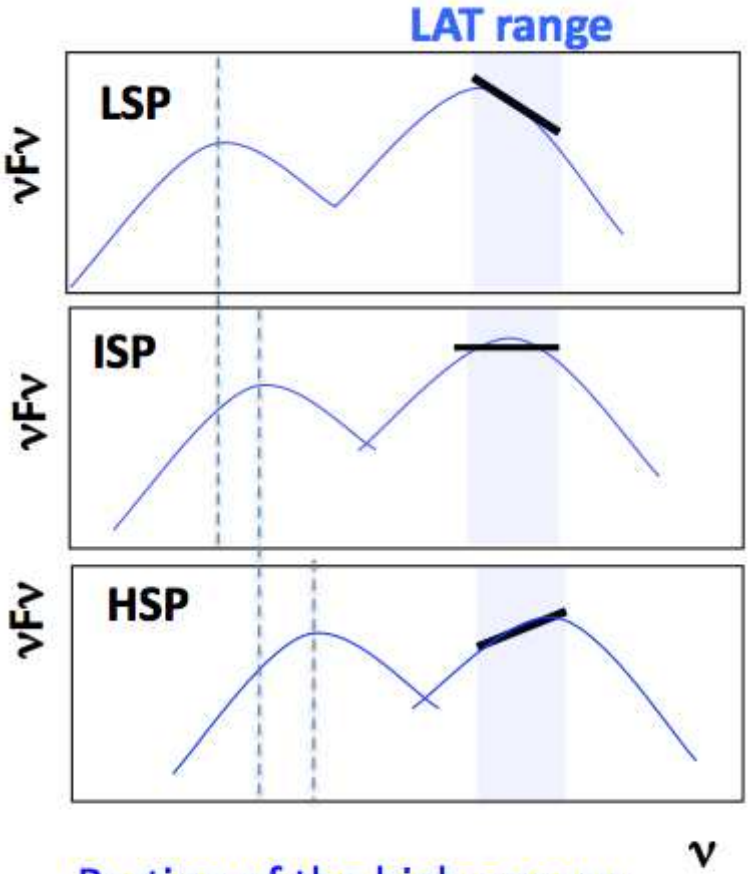
2LAC-clean sample:
310 FSRQs
395 BL Lacs
156 Blazars with unknown type
24 AGNs

- 2LAC clean sample include 286 more sources than the 1LAC clean sample, i.e. 48% increase
- BL Lac outnumbers the FSRQ ➔Fermi-LAT detection limits
- Smaller error ellipse due to longer integration results in a fewer multiple associations with respect to 1LAC
- The fraction of unknown type objs has increased dramatically ➔due to improved association procedure

SED Classification



Ackermann et al. 2011 ApJ 743 171

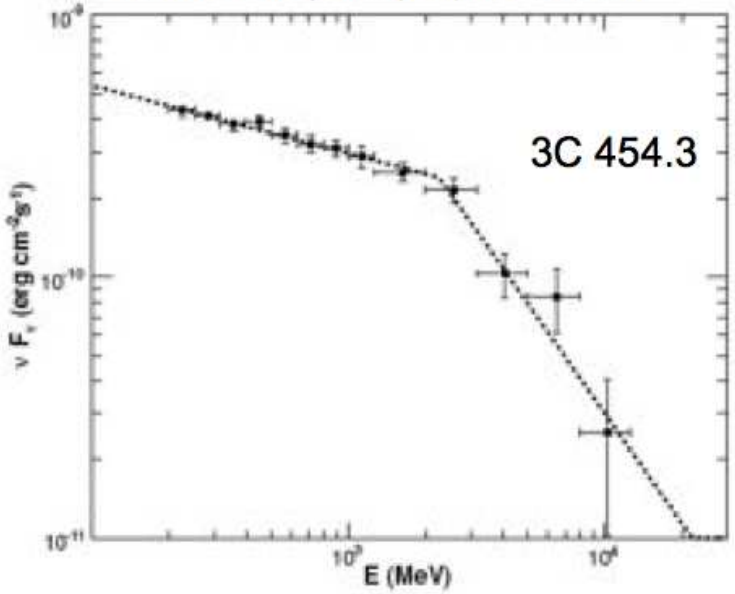


- FSRQ: $\langle \log \nu^{S}_{peak} \rangle = 13.02 + 0.35$
- BL Lac: spread the whole parameters space from LSP to HSP
- Results consistent with Abdo et al 2010 (ApJ 715, 429) and Giommi et al 2011 (A&A,541,160)

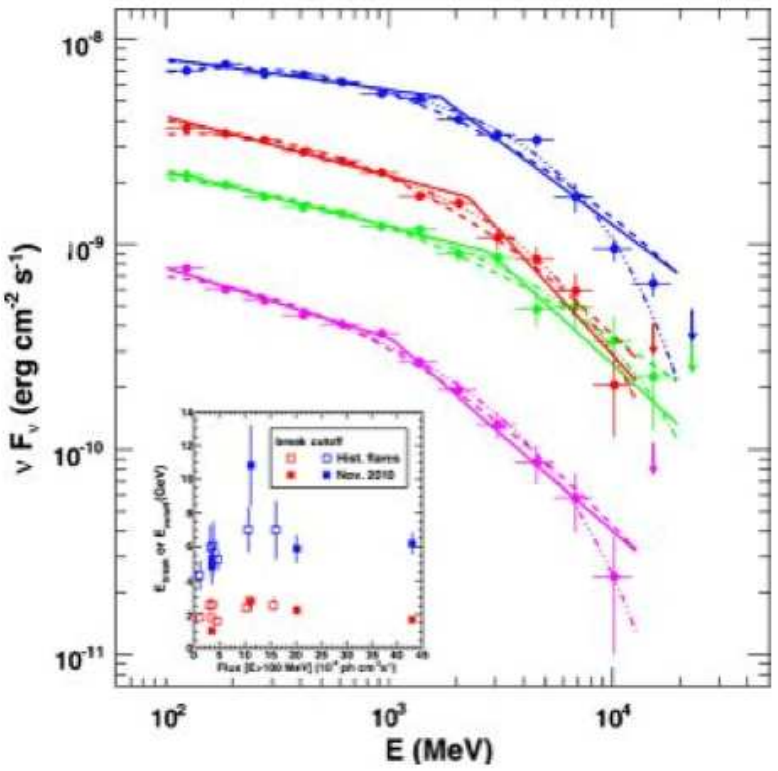
Portion of the high-energy bump covered by LAT depends on the blazar SED classification

Features of Fermi-LAT AGN spectra

Abdo et al. (2009), ApJ, 699, 817



Abdo et al. (2011), ApJ, 733, L26

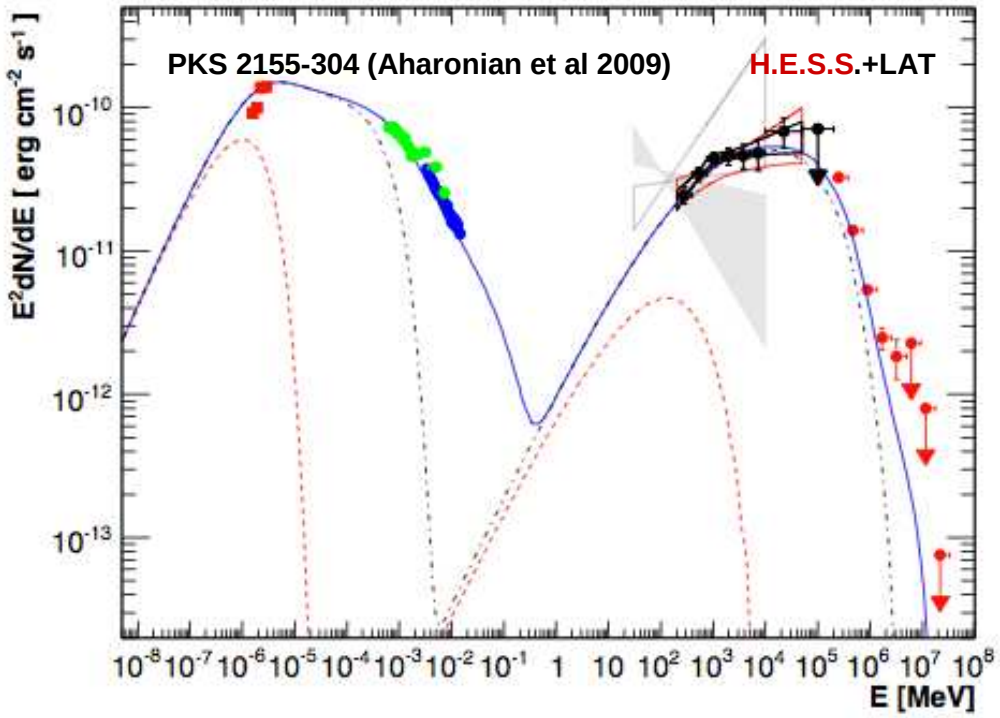


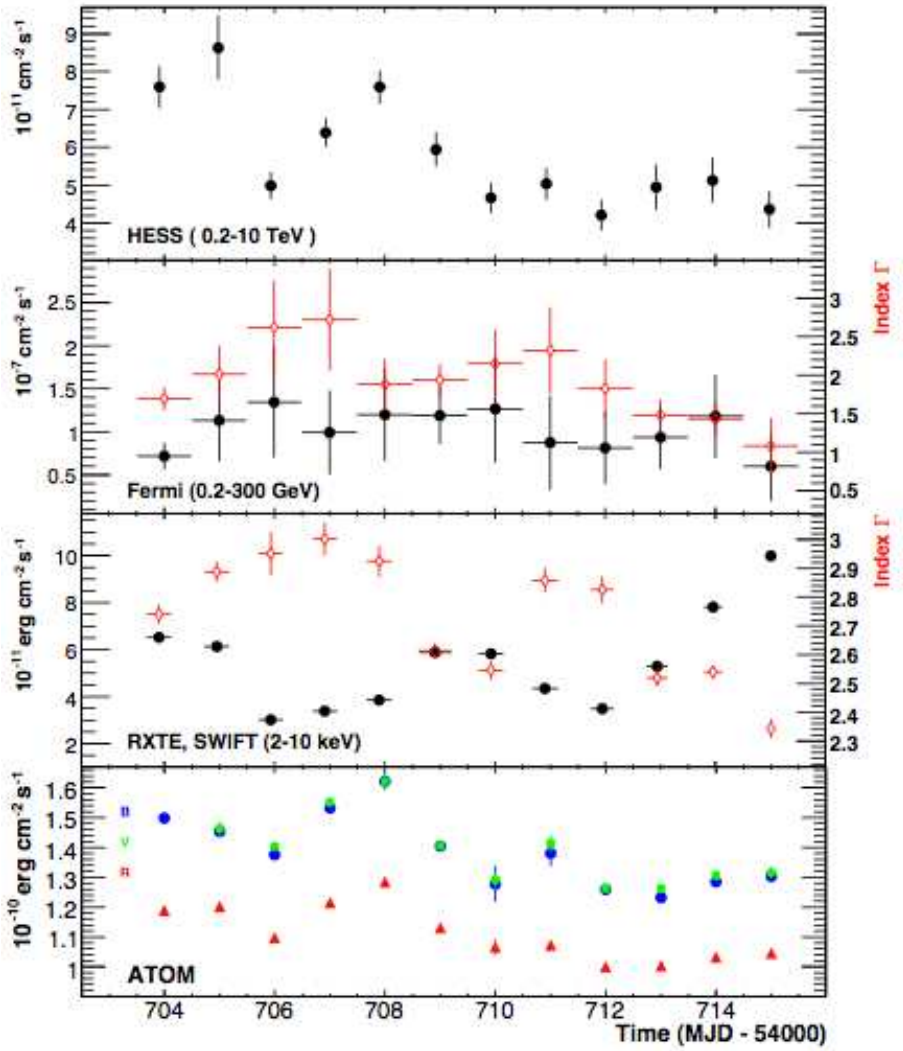
❒Spectral breaks at ~ a few GeV have been found in the γ-ray spectra of many LSP FSRQs and BL Lacs, most prominently in the extremely bright 3C454.3.

- γγ attenuation from He II line photons (Poutanen et al. 2010)
- intrinsic electron spectral breaks (Abdo et al 2009, ApJ 699, 817)

GeV-TeV Connection:

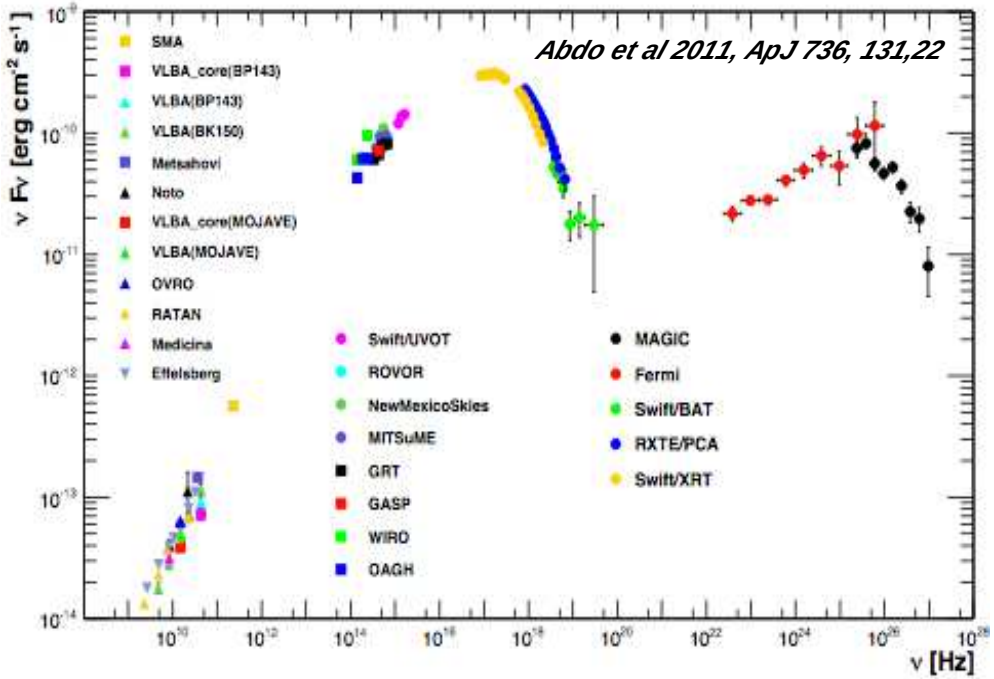
case of PKS 2155-304





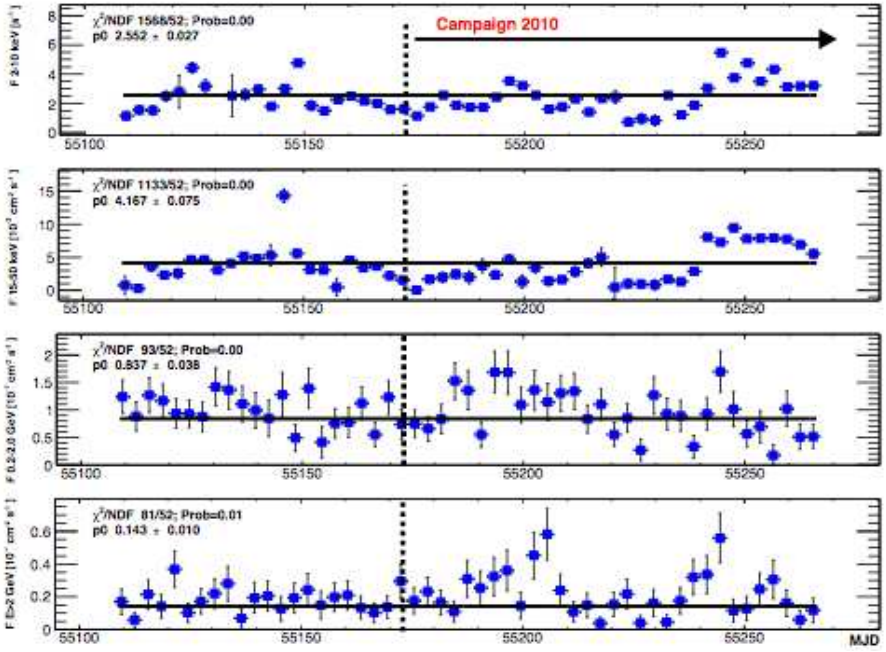
- One of few cases with SED modeled with 1-zone SSC
- Indication of a correlation between Optical and VHE
- Anticorrelation between X-ray fluxes and Fermi-LAT spectral indices

GeV-TeV Connection:
case of MKN 421



Extensive multi-wavelenght campaing on MKN 421

- **SED emerging from this is the most complete and accurate representation of the low/quiescent state of Mrk421.**
- **Two scenarios are proposed:**
  Hardonic and Leptonic

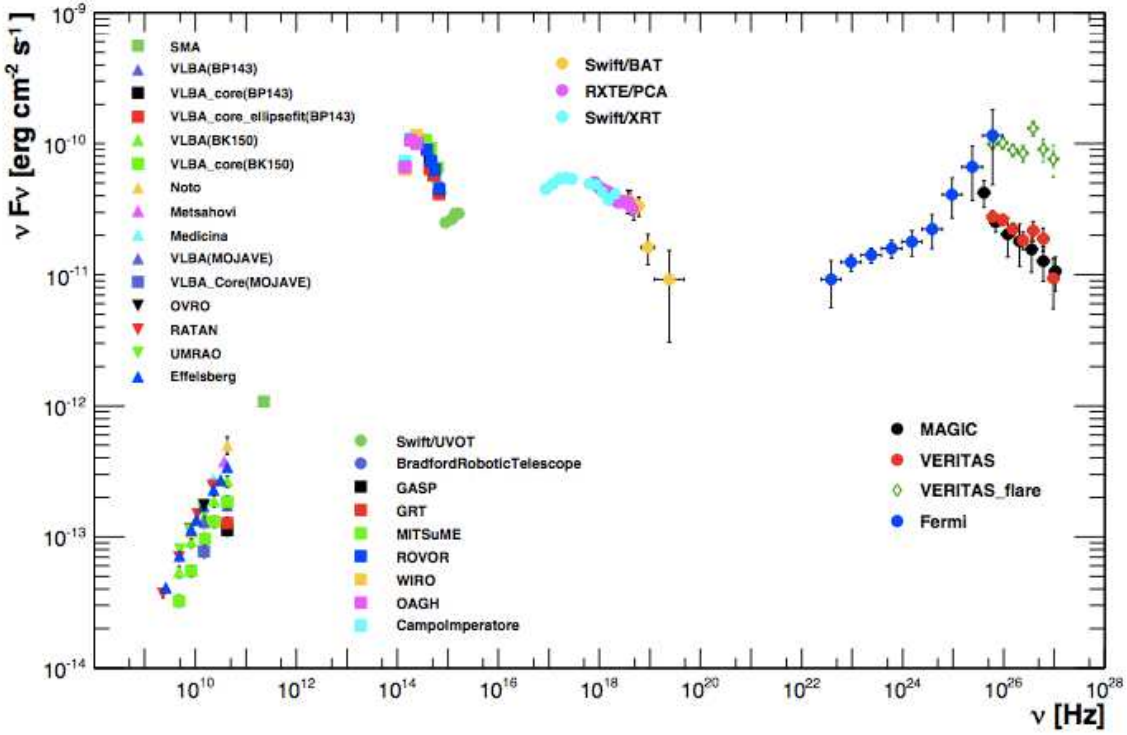


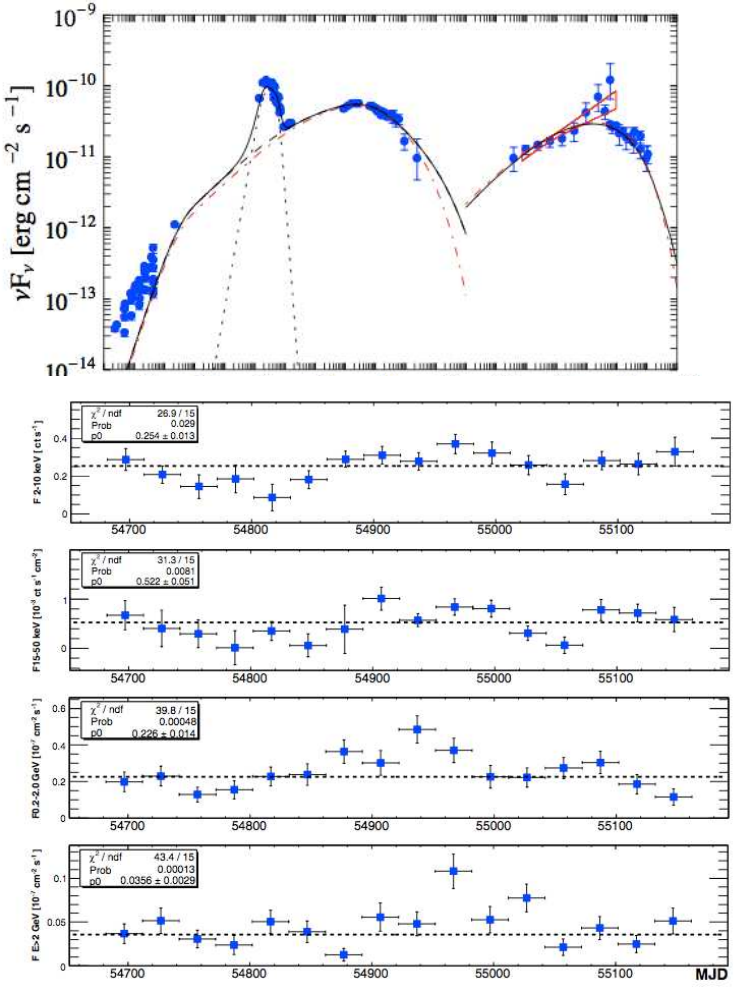
Multi-frequency light curves (X-ray:RXTE/ASM, Soft-Gamma:Swift-BAT, Gamma-ray:Fermi-LAT)

- **No indication of a correlated activity between X-ray and Gamma-ray**

GeV-TeV Connection:

case of MKN 501





❒**Modeled with 1-zone SSC in the low phase**

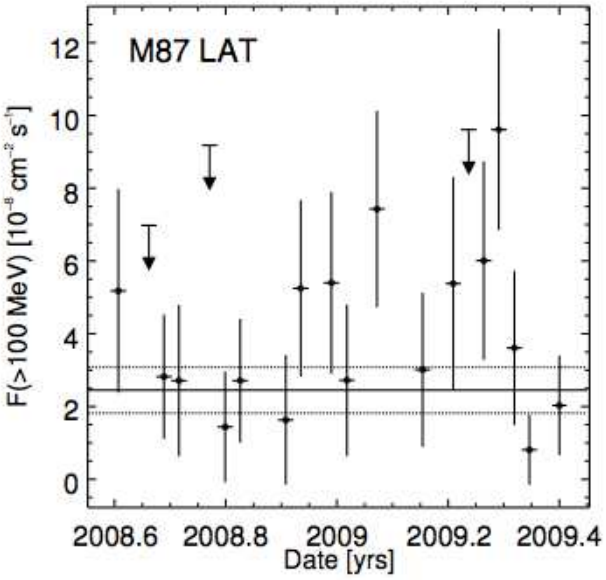
❒**The epoch of enhanced gamma-ray activity may be more difficult to explain with a single SSC**

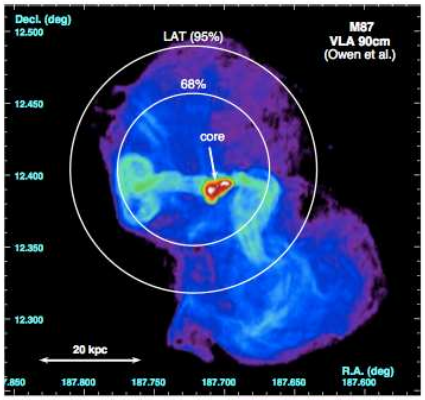
Multi-frequency light curves (X-ray:RXTE/ASM, Soft-Gamma:Swift-BAT, Gamma-ray:Fermi-LAT)

Abdo et al. 2011 ApJ 727 129

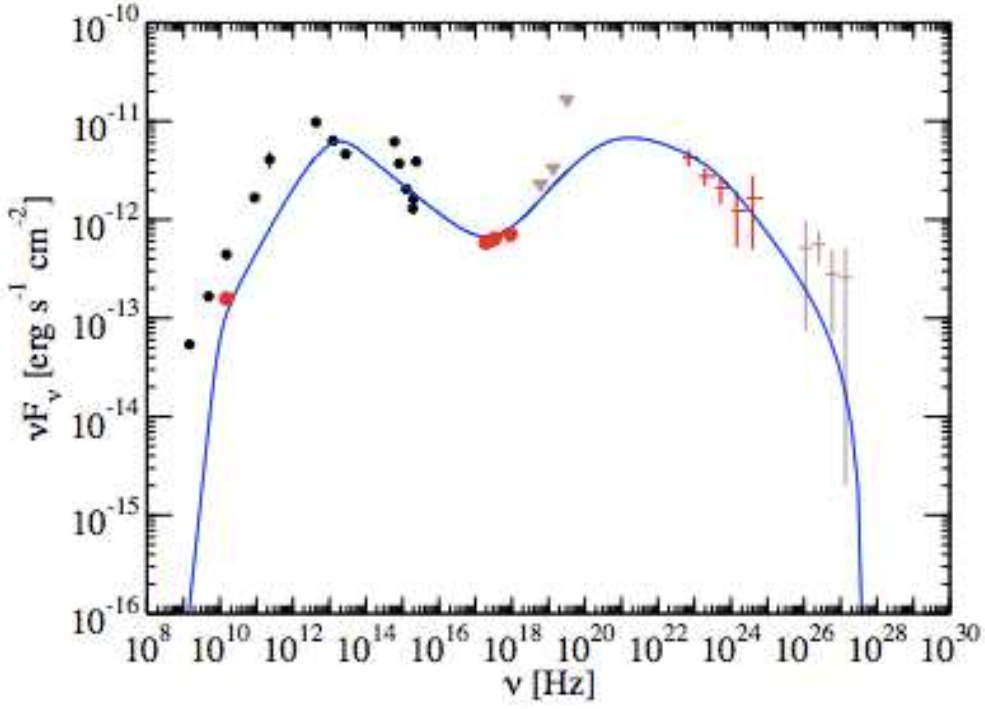
GeV-TeV Connection:

case of radio galaxy M87





- Single SSC with a viewing angle > 10 deg
- Bulk lorenz factor ~ 3
- Such SSC model also reproduce well the broad band SED of Per A and Cen A

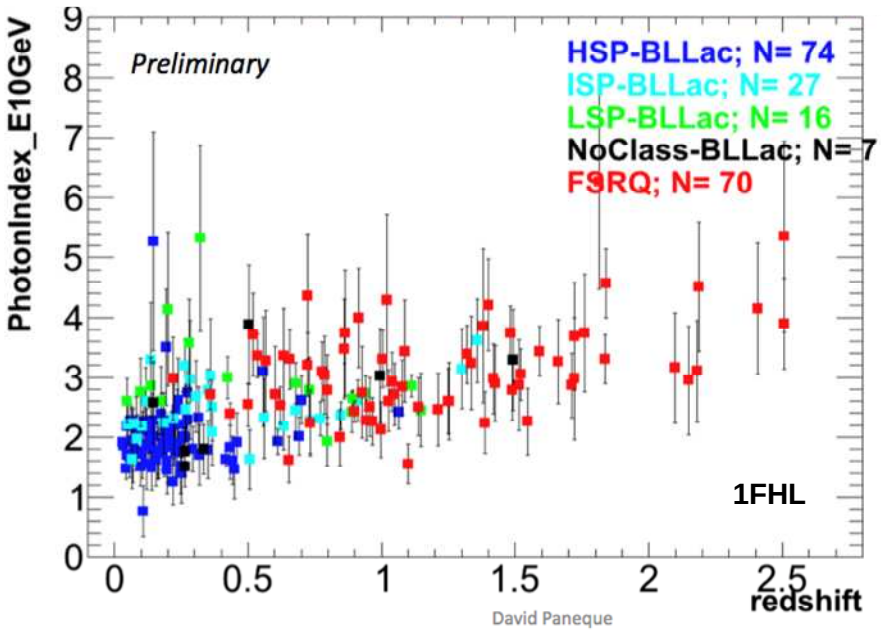


No significant variability in the MeV/GeV regime

Gamma-ray emission appears to be correlated to the compact radio core.

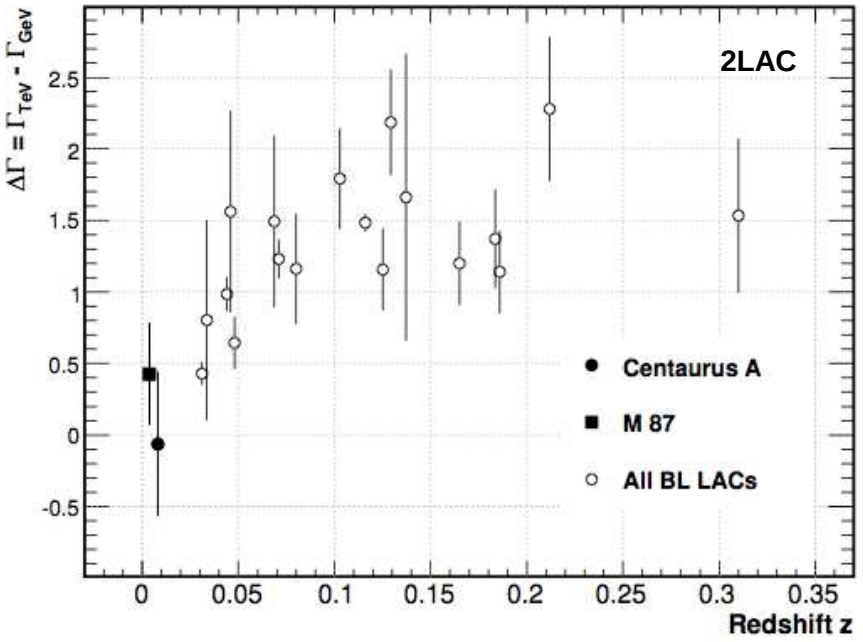
Abdo et al. 2009 ApJ 707 55

Extragalactic background light attenuation in Fermi-LAT data



❒Sources get softer with redshift ➔possibily due to attenuation on the EBL

❒Such trend is less clear with photon index from E>100MeV (see 2LAC paper)



Deficit of distant sources with small values of ΔΓ

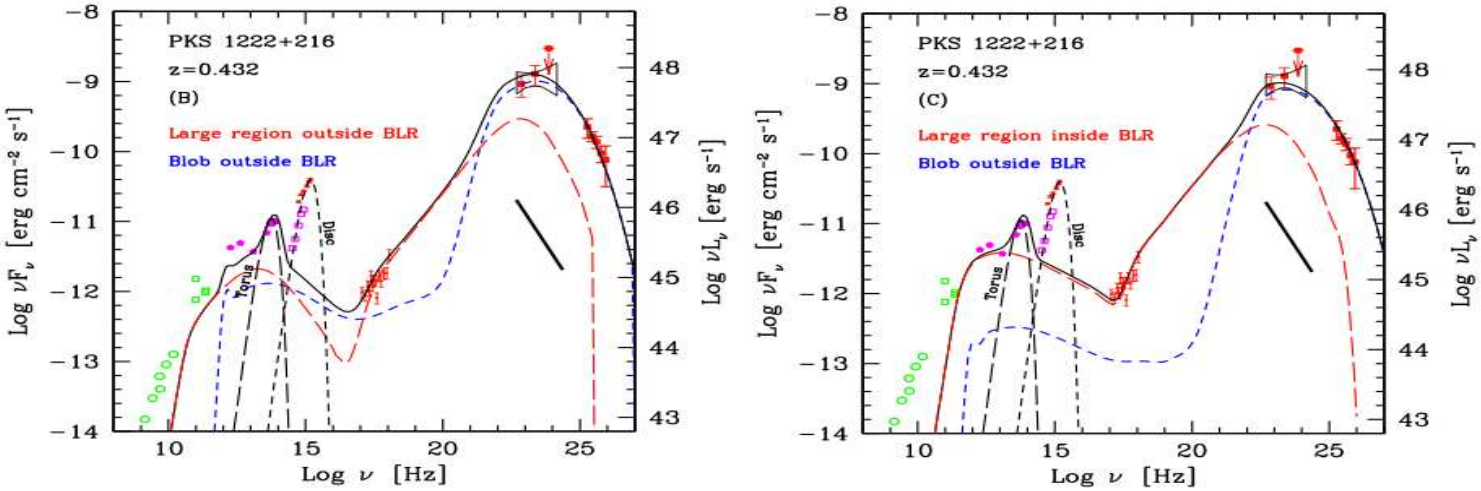
❒EBL: softening of the VHE spectrum dependent on z

Ackermann et al. 2011 ApJ 743 171

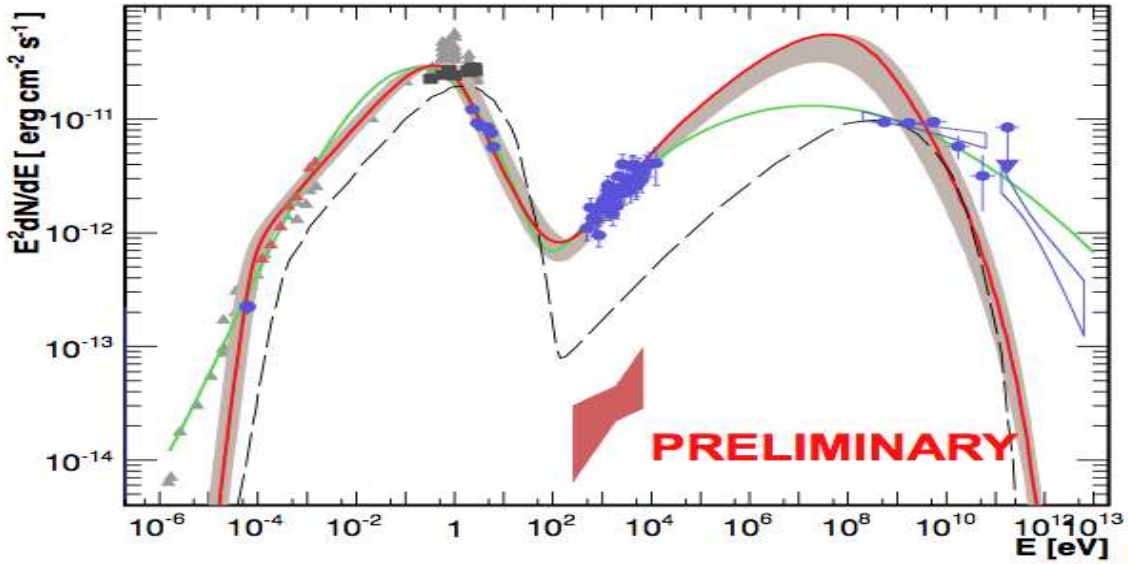
Challenging the one zone leptonic model

PKS 1222+216 (Tavecchio et al 2011)

➔Huge compton dominance

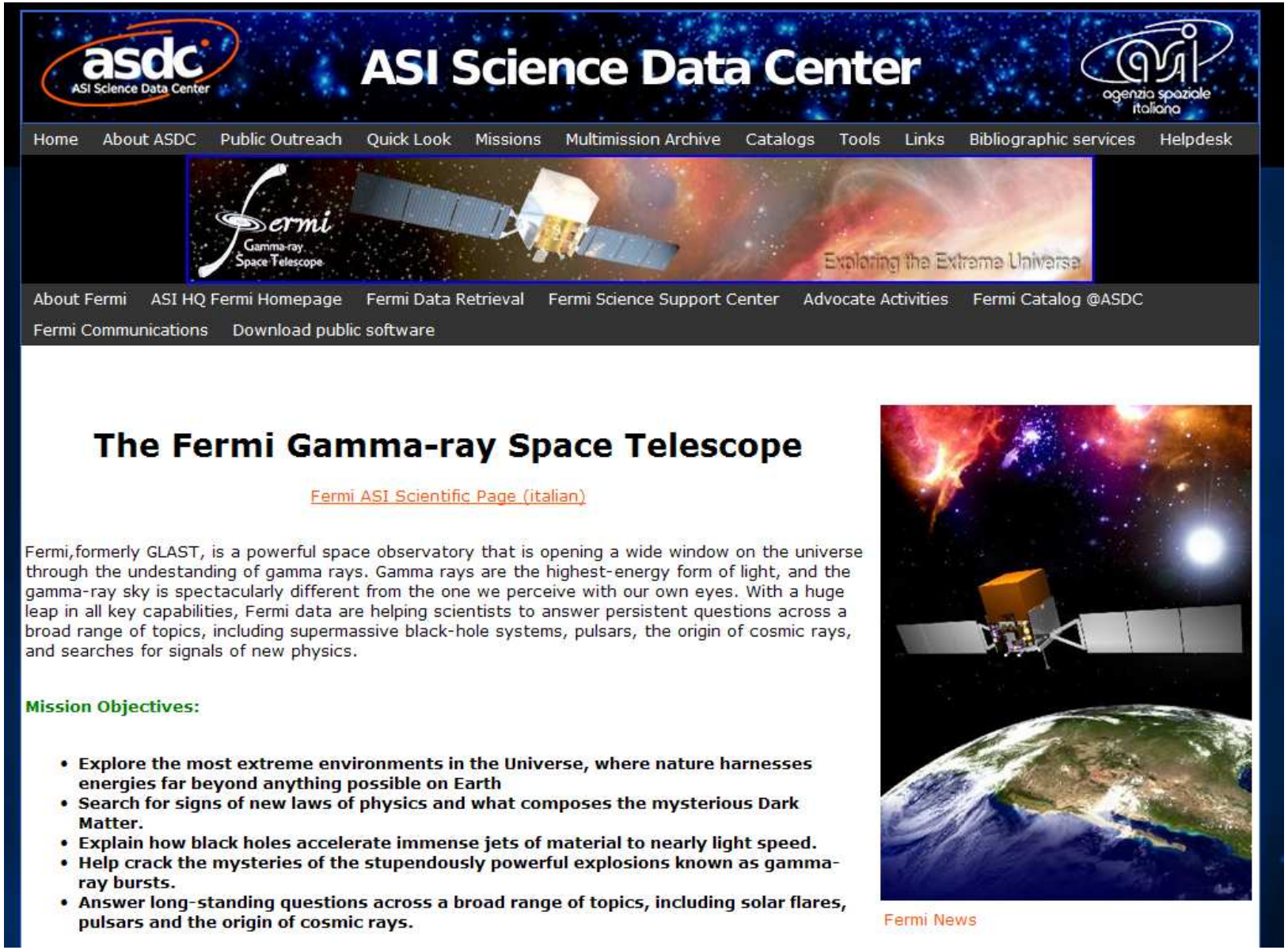


AP Librae - HESS & LAT (Abramowski et al in prer.)

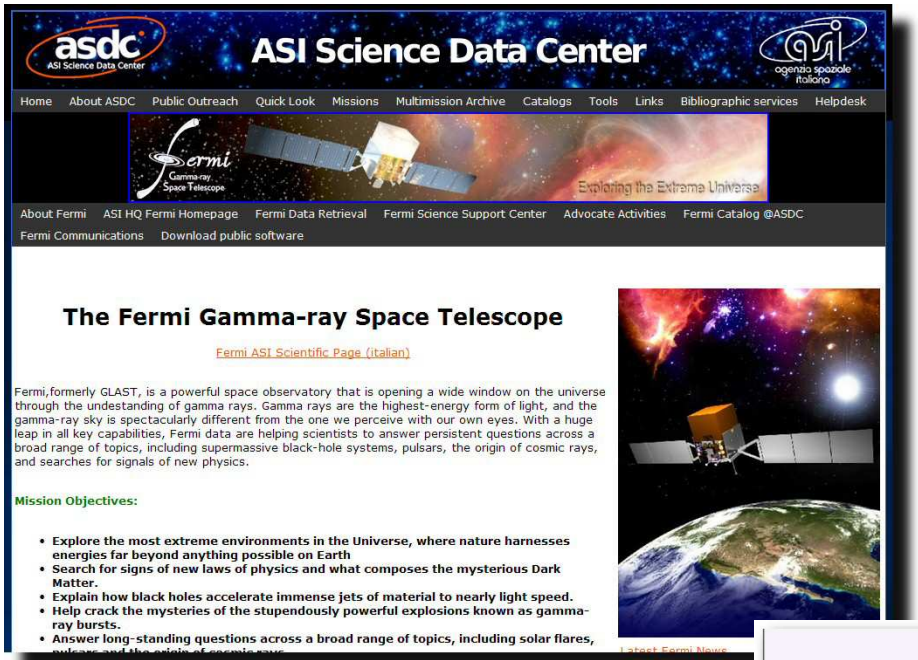


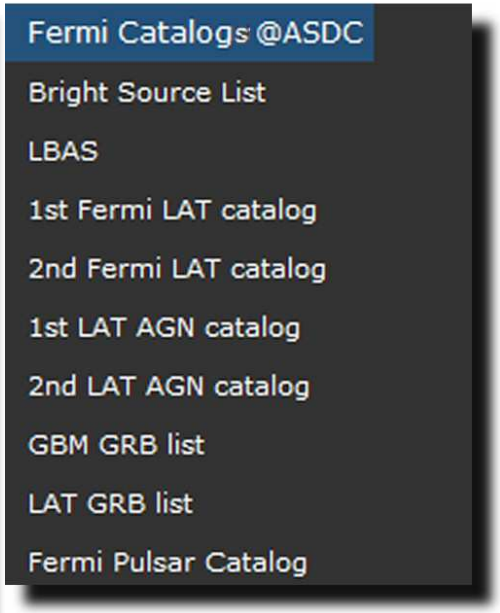
➔Extremely narrow sychrotron component and very large compton component

Update on Fermi tools/catalogs @ ASDC



New Fermi catalogs @ ASDC



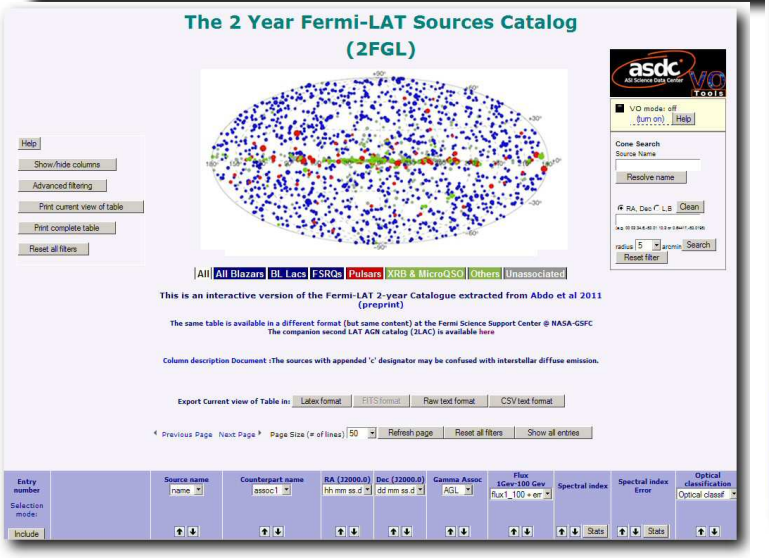


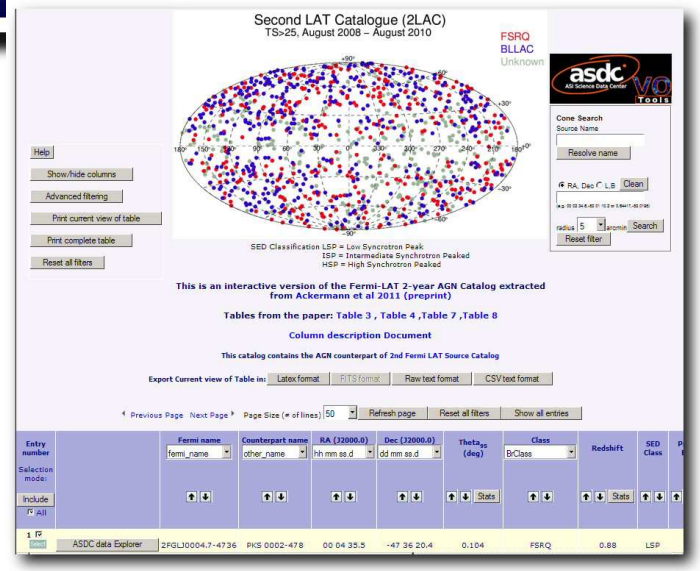
News:

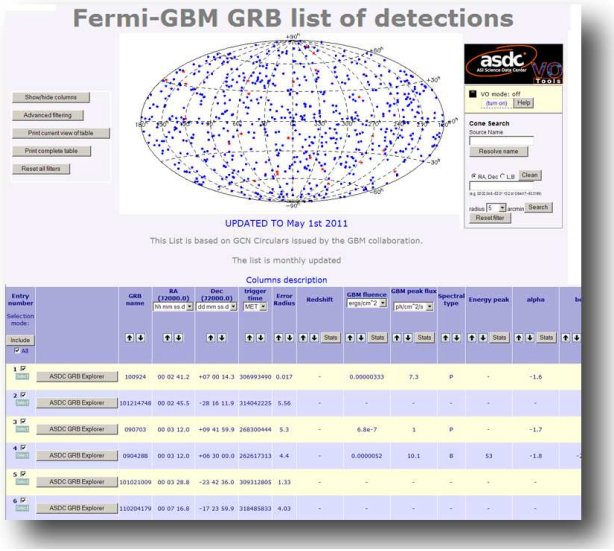
1) New GBM GRB catalog online

2) New FA ATel sources online

3) AGN ADB light curves (Benoit) lists (P6 online, P7 in construction) oline (LAT coll password).







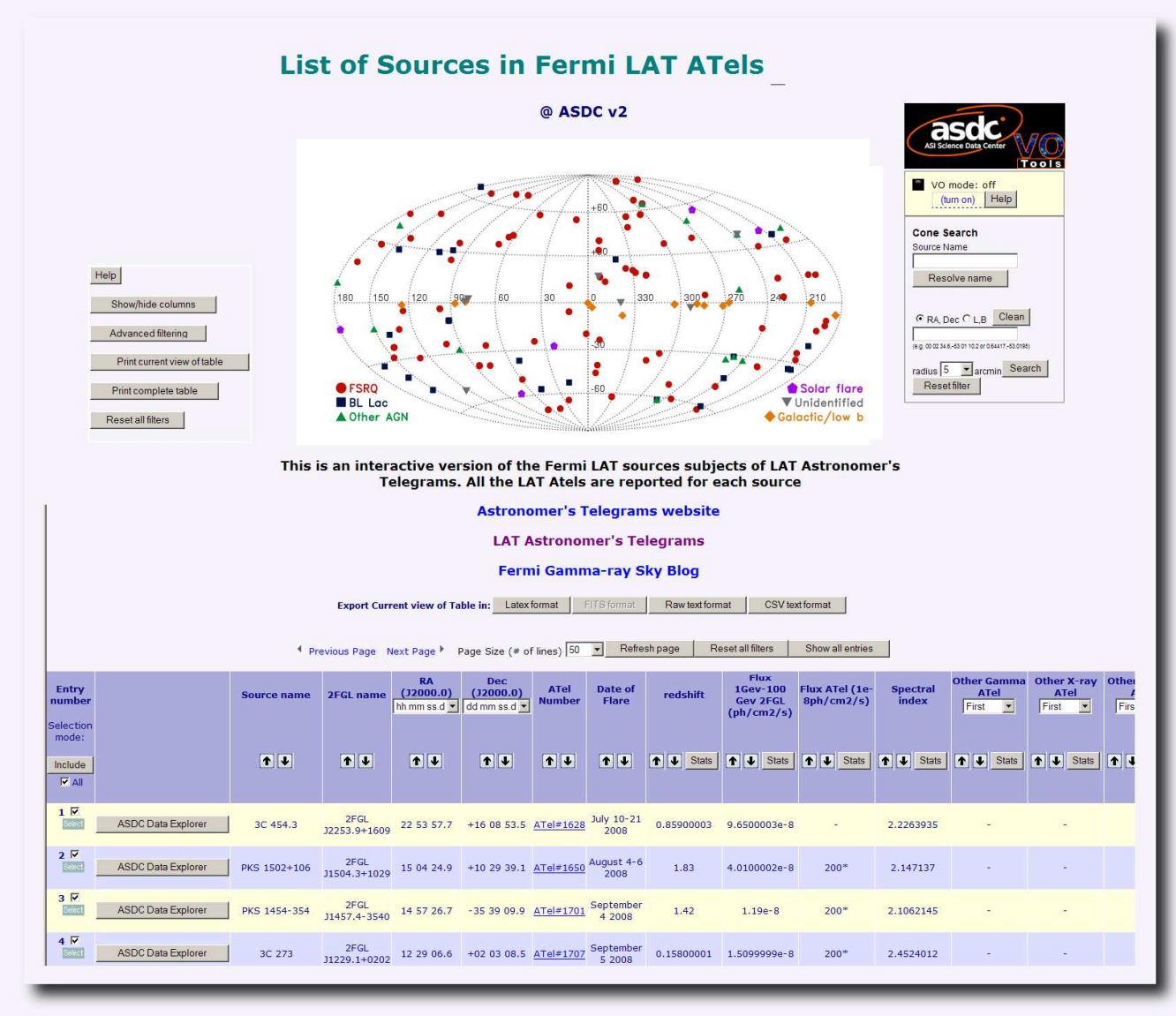
New list of sources subject of Fermi ATels

http://www.asdc.asi.it/feratel/

Incremental list with usual links to ASD sky position and data archives tools

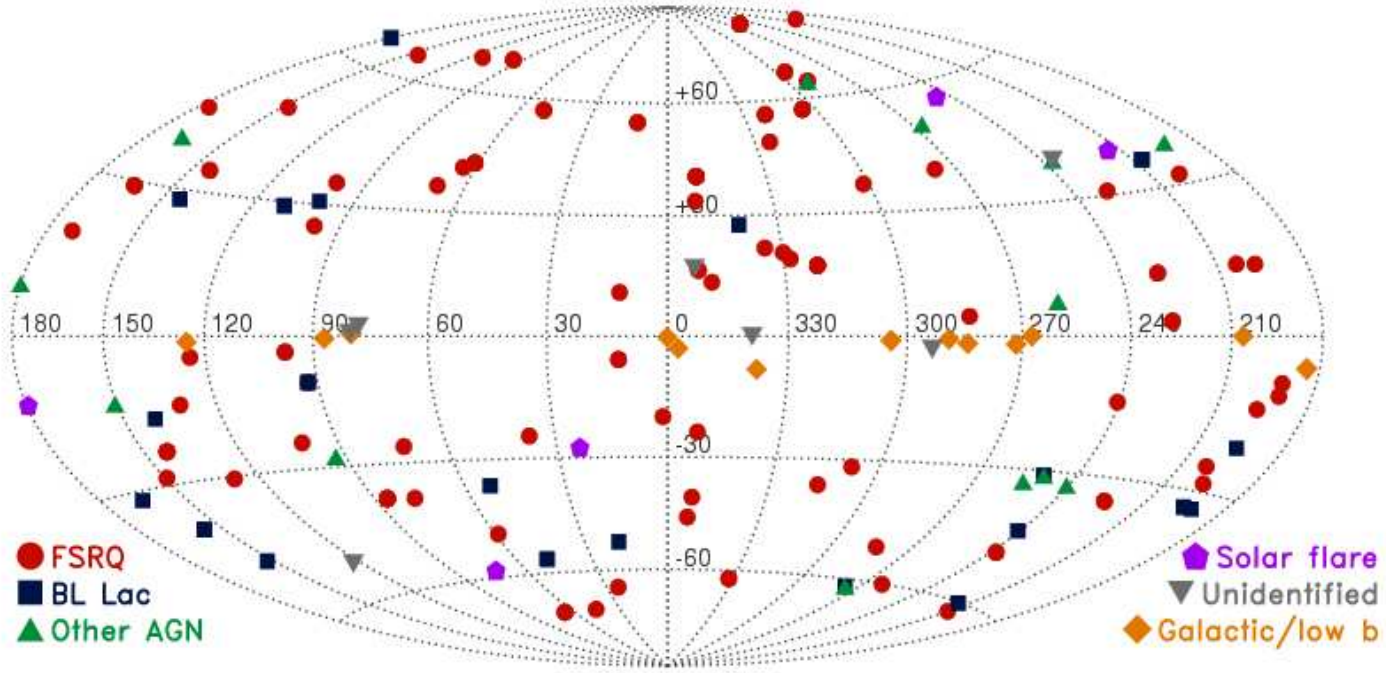
Columns

Source name
- 2FGL name
- RA/Dec
- Date reported for the flare
- redshift
- Flux 1Gev-100 Gev 2FGL (ph/cm2/s)
- Flux (E>100MeV) reported in ATel (1e-8ph/cm2/s)
- Photon Spectral index
- Other Gamma ATel
- First Second Third follow up X-ray ATel
- First Second Third follow up Optical ATel
- First Second Third follow up Radio ATel
- First Second Third follow up Friends of source



New list of sources subject of Fermi ATels

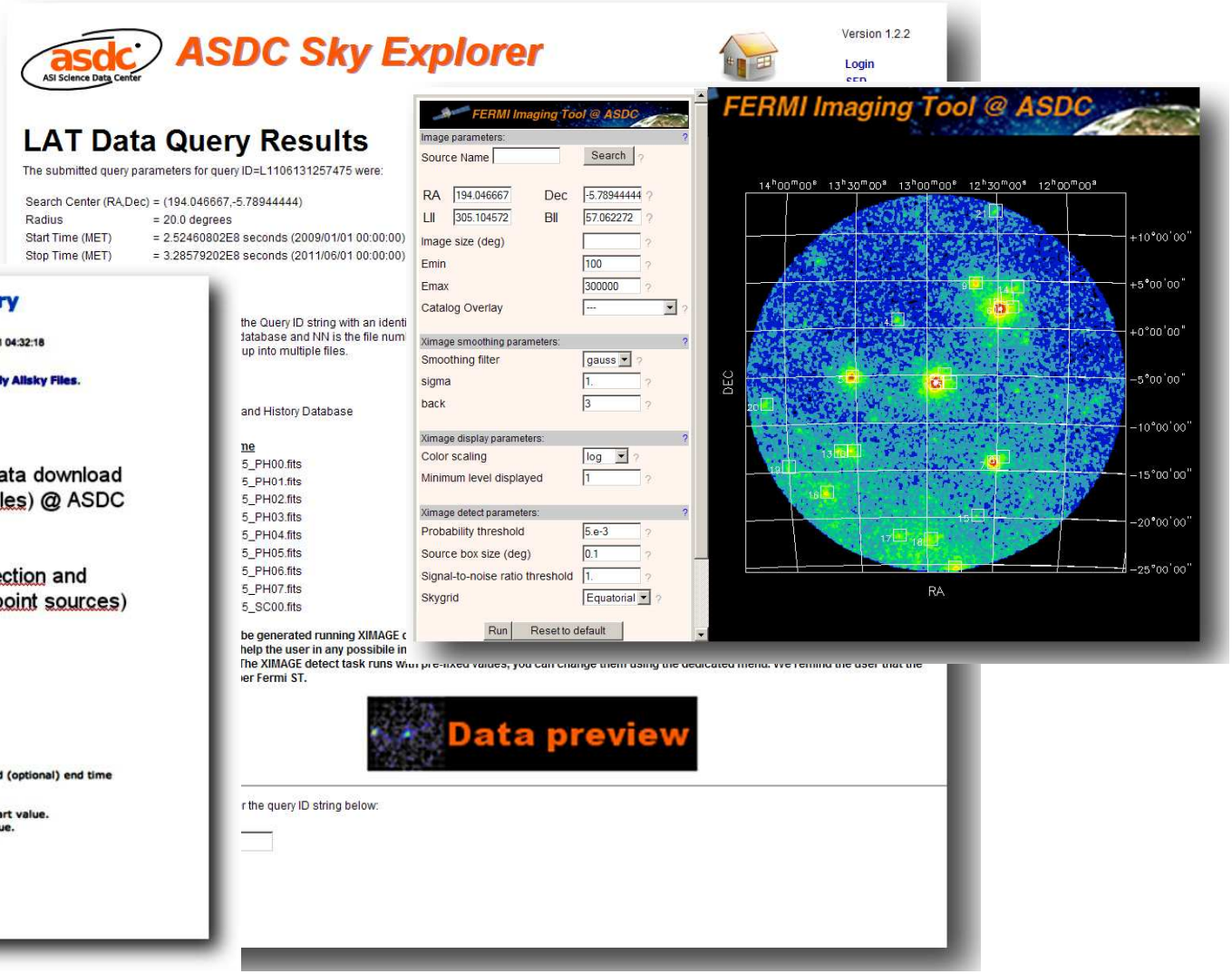
http://www.asdc.asi.it/feratel/



Entry number / Selection mode: Include / All		Source name	2FGL name	RA (J2000.0) hh mm ss.d	Dec (J2000.0) dd mm ss.d	ATel Number	Date of Flare	redshift	Flux 1Gev-100 Gev 2FGL (ph/cm2/s)	Flux ATel (1e-8ph/cm2/s)	Spectral index	Other Gamma ATel First	Other X-ray ATel First	Other Optical ATel First	Other AT First
1 Select	ASDC Data Explorer	3C 454.3	2FGL J2253.9+1609	22 53 57.7	+16 08 53.5	ATel#1628	July 10-21 2008	0.85900003	9.6500003e-8	-	2.2263935	-	-	-	-
2 Select	ASDC Data Explorer	PKS 1502+106	2FGL J1504.3+1029	15 04 24.9	+10 29 39.1	ATel#1650	August 4-6 2008	1.83	4.0100002e-8	200*	2.147137	-	-	-	-

Fermi LAT public data archive

- FT1 and FT2 public science FITS data. Now serving Pass-7 data.
- Data RoI retrieval and data preview (XImage) with MW source catalogs overlay.



Fermi gtlike Online Data Analysis (FODA) tool

From Fermi public FT1/FT2 data retrieval -> now there is the possibility to choose also a basic online data analysis, and/or calculation of highest energy photon.

- FODA is a wrap-up of Science Tools using python scripts and web user interfaces
- FODA allows to choose a 2 weeks time interval from the TSTART time at maximum. It also works only for sources with |b|>5 degrees.
- Highest energy photon will be extracted using the predicted PSF in function of energy *(http://www.slac.stanford.edu/exp/glast/groups/canda/lat_Performance.htm)*

FT1/FT2 data retrieval

LAT Data Query Results

The submitted query parameters for query ID=L1302051441179303 were:

Search Center (RA,Dec)	= (166.113542,38.208559)
Radius	= 20.0 degrees
Start Time (MET)	= 378518403 seconds (2012/12/30 00:00:00)
Stop Time (MET)	= 378691203 seconds (2013/01/01 00:00:00)
Minimum Energy	= 100 MeV
Maximum Energy	= 300000 MeV

The filenames of the result files consist of the Query ID string with an identifier appended to indicate which database the file came from. The identifiers are of the form: _DDNN where DD indicates the database and NN is the file number. The file number will generally be '00' unless the query resulted in a very large data return. In that case the data is broken up into multiple files.
The values of the database field are:

- PH - Photon Database
- SC - Spacecraft Pointing, Livetime, and History Database

File Name	Number of entries	Size (MB)	Status
L1302051441179303_PH00.fits	28672	2.6	Available
L1302051441179303_SC00.fits	4868	0.71	Available

Clicking on "data preview" an image will be generated running XIMAGE detect task on the Fermi count map, produced with standard ST in the queried time interval. It aims to provides a preview of the source field to help the user in any possibile improvement of the data query before to run the likelihood analysis. The map is interactive: move the cursor on image to explore it. WARNING The XIMAGE detect task runs with pre-fixed values, you can change them using the dedicated menu. We remind the user that the data analysis should be run with the proper Fermi ST.

Highest Energy Photon:

MKN421

Highest Energy Photon	Predicted PSF	distance
44823.7 MeV	0.202954340167 deg	0.0441396376193 deg

Gtlike FODA results

Posta in Arrivo: ASDC tools: Fermi Lat Archive : GTLIKE (25709 di 25721)

Contrassegna come: | Sposta | Copia | Questo messaggio a

Elimina | Rispondi | Inoltra | Reindirizza | Visualizza per Argomento | Intestazioni Messaggio | Salva con Nome | Stampa | Intestazioni

Data: Tue, 5 Feb 2013 14:57:01 +0100 [05/02/2013 14:57:01 CET]

Da: noreply@asdc.asi.it

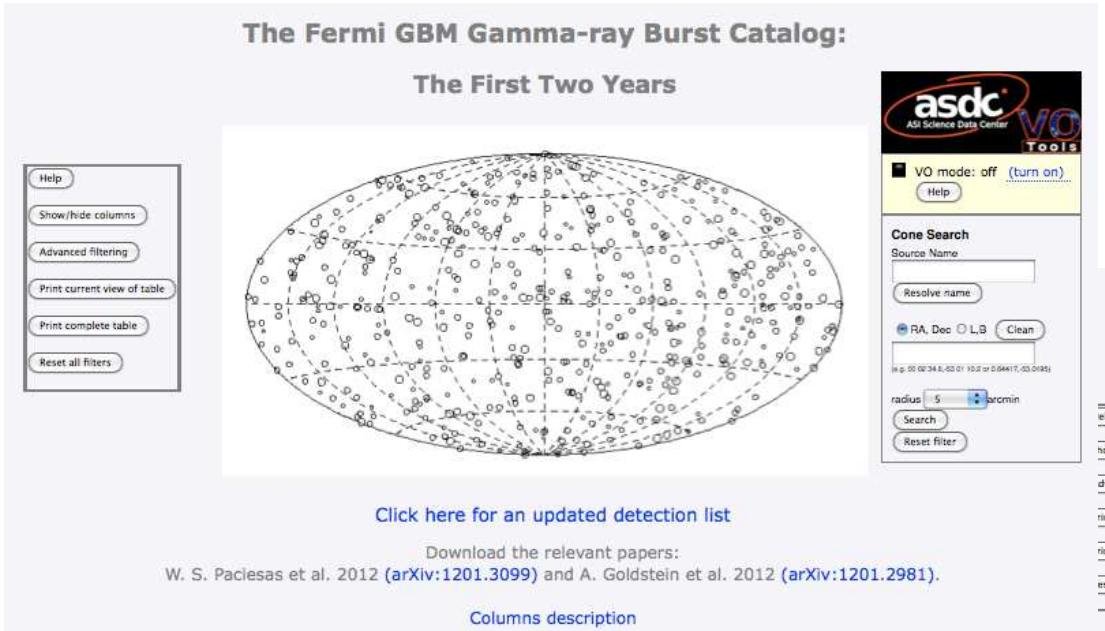
A: cutini@asdc.asi.it

Oggetto: ASDC tools: Fermi Lat Archive : GTLIKE

```
Your request is completed.
 Object Name:  MKN421
 Search Center (RA,Dec):  166.113542,38.208559
 Radius = 20.0 degrees
 Start Time (MET)= 3.78518403E8 seconds (30/12/2012 00:00:00)
 Stop Time (MET)= 3.78691203E8 seconds (01/01/2013 00:00:00)
 Minimum Energy = 100 MeV
 Maximum Energy = 300000 MeV
Click on the link below to download : http://tools.asdc.asi.it/fermi/results.jsp?id=L1302051441179303
GTLike Result :
MKN421 RA=166.113542 DEC= 38.208559 TS= 89.6019888863
 Time Interval (MJD) 56291.0000347 56293.0000347
 Flux 3.05595780901e-07 8.88180007279e-08
Spectral Index = 1.81976389735 0.167887899255
```

One email will post you results (after some <30min time).

Fermi GBM GRB catalogs @ ASDC



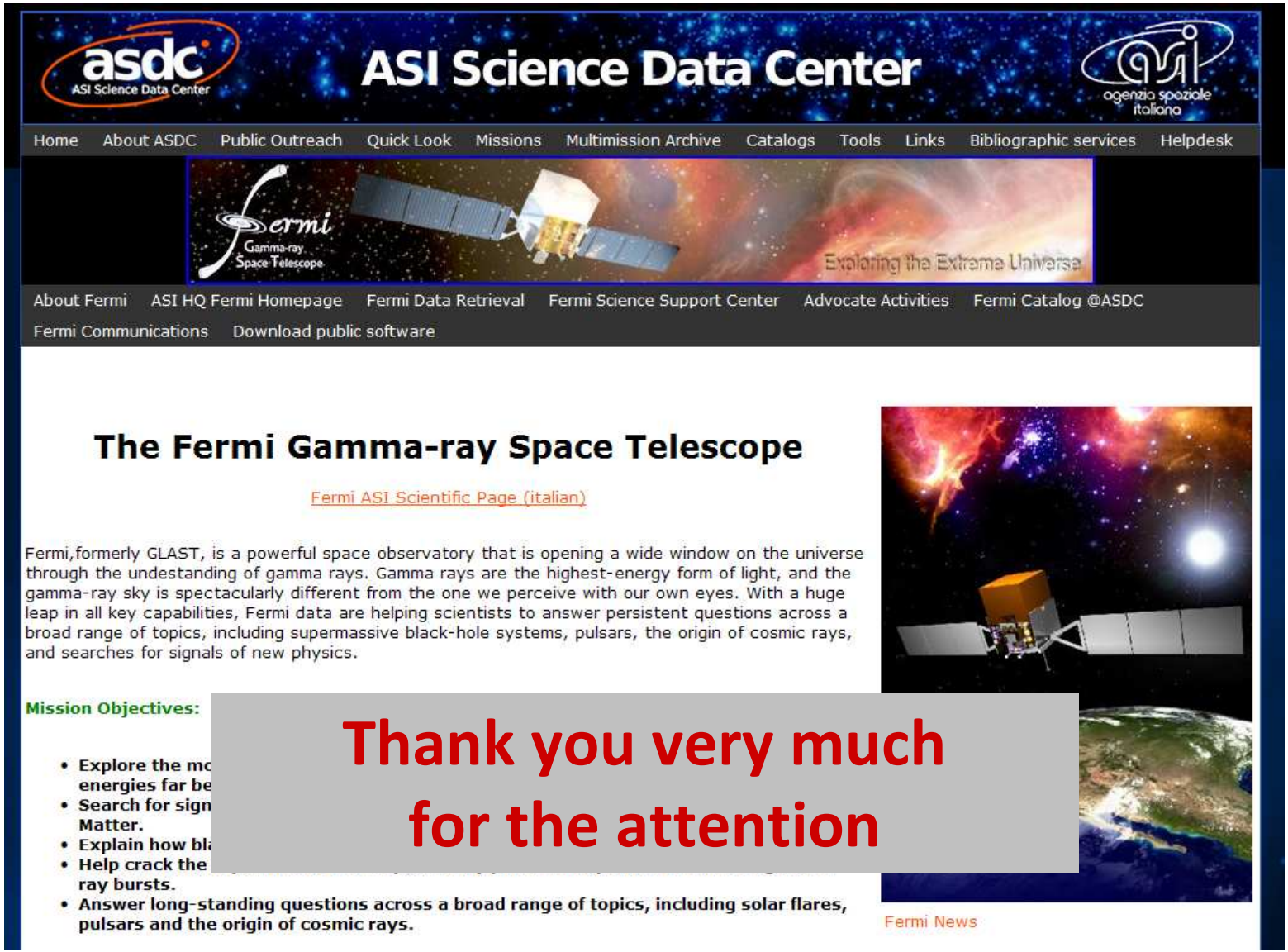
trigger time (MET)	Error Radius	Redshift	T50 (s)	T50 error	T90 (s)	T90 error	best fitting model peak flux	best fitting model fluence	Fluence (erg/cm^2)	Fluence e (erg/cm
268300444	5.25	-	3.072	0.92	8.96	1.86	Power Law Model	Power Law Model	8.46e-7	2.88e-8

- ❑Update of the 2Y Fermi GBM GRB catalog .
- ❑Update of GBM incremental list of detected GRBs

RA (J2000.0) hh mm ss.d	Dec (J2000.0) dd mm ss.d	trigger time (MET)	Error Radius	Redshift	GBM fluence ergs/cm^2	GBM peak flux ph/cm^2/s	Spectral type	Energy peak	alpha
00 02 41.2	+07 00 14.3	306993490	0.017	-	0.00000333	7.3	P	-	-1.6
00 02 45.5	-28 16 11.9	314042225	5.56	-	-	-	-	-	-

www.asdc.asi.it/gbmcatalog

…and soon available the solar flares catalog

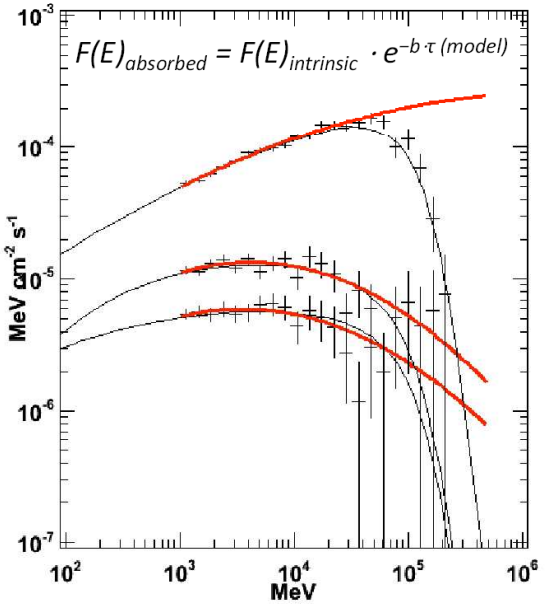


Thank you very much for the attention

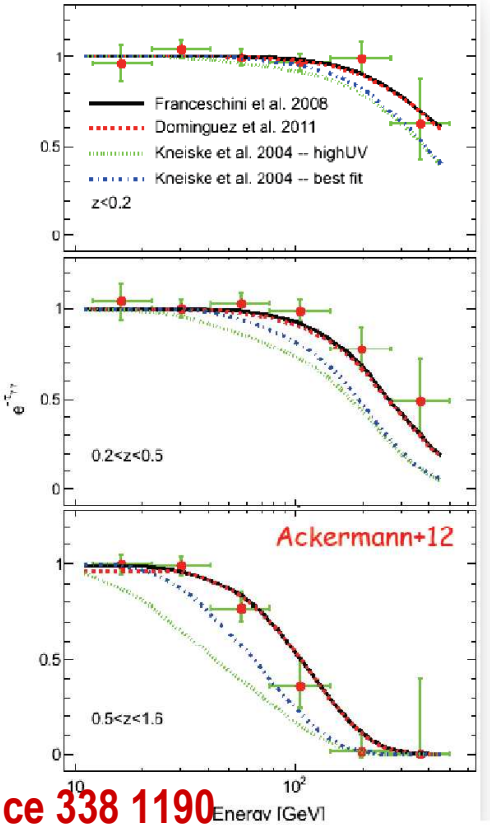
Backup slides

EBL with Fermi LAT AGNs

- AGN produce VERY high energy γ's
- γ's at high energy and large red-shift DON'T survive trip to Earth
- Pair Cascades off Extra-Galactic Background Light (EBL)
- History of Galaxy Formation determines EBL



Ajello et al., 4th Fermi Symp.

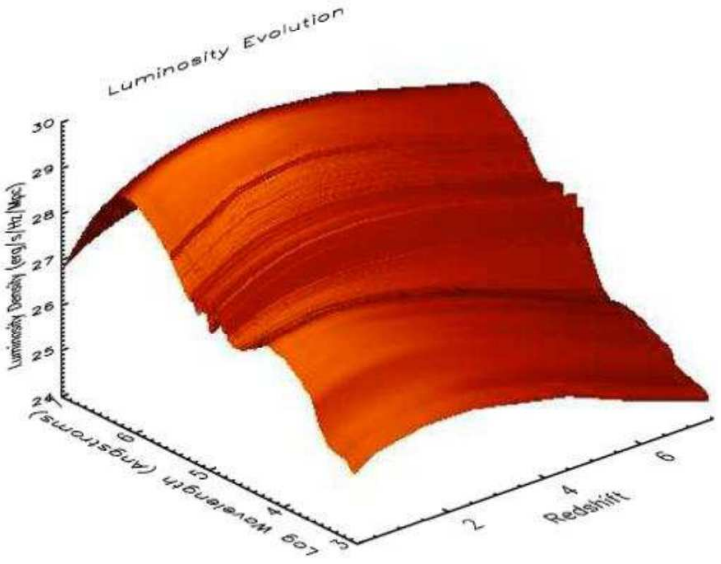


Ackermann 2012 Science 338 1190

Analysis

- 3 Bins in red-shift:
  0-0.2, .2 - .5, .5-1.6
- 50 Sources each bin
- Fit each to Intrinsic Spectra * Common Absorption

History of Galaxy Formation



Gilmore, Somerville, Primack and Dominguez (2012)

Blazar SEDs

Why do we understand stars so well but not blazars?

- Anisotropic emitters
- Highly variable on human type scales (as short as hours or minutes)
- Energy generation mechanism (involving black hole) not well understood
- No way to know if different AGN are the same age
- Fully ionized non-thermal plasma, composition cannot be determined from optical spectroscopy

Blazars also classified based on the position of their synchrotron peak (Second LAT AGN Catalog; Ackermann et al. 2011, ApJ, 743, 171).

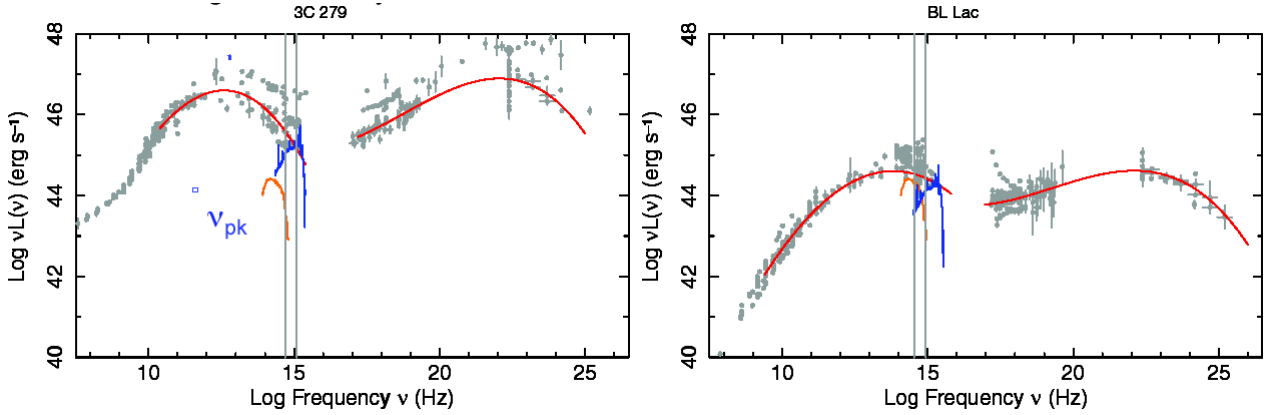
- 10^{15} Hz < ν_{pk}: *high synchrotron peaked (HSP)*
- 10^{14} Hz < ν_{pk} < 10^{15} Hz: *intermediate synchrotron peaked (ISP)*
- ν_{pk} < 10^{14} Hz: *low synchrotron peaked (LSP)*

❑Almost all FSRQs are LSPs.

❑About half of BL Lacs in 2LAC do not have a measured redshift. Could be due to nonthermal continuum overwhelming line emission, or

❑BL Lacs having intrinsically weaker lines.

Giommi et al. (2012), MNRAS, 420, 2899



Single zone SSC