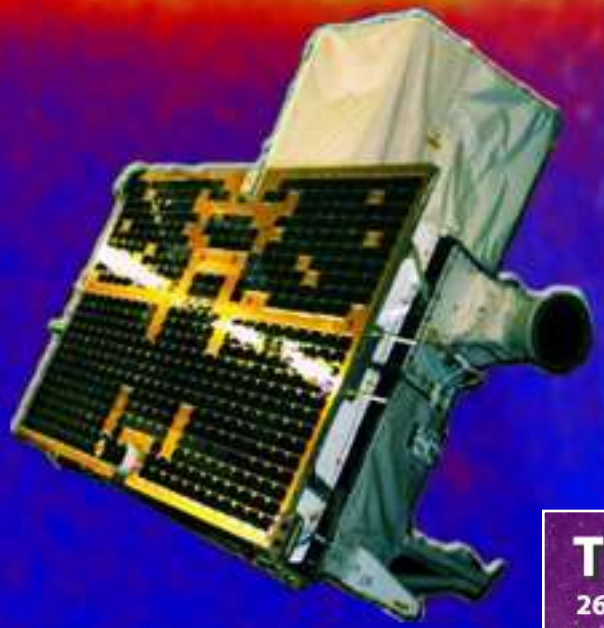
asdc
ASI Science Data Center

AGILE Highlights

Carlotta Pittori, ASDC & OAR
on behalf of the AGILE Collaboration



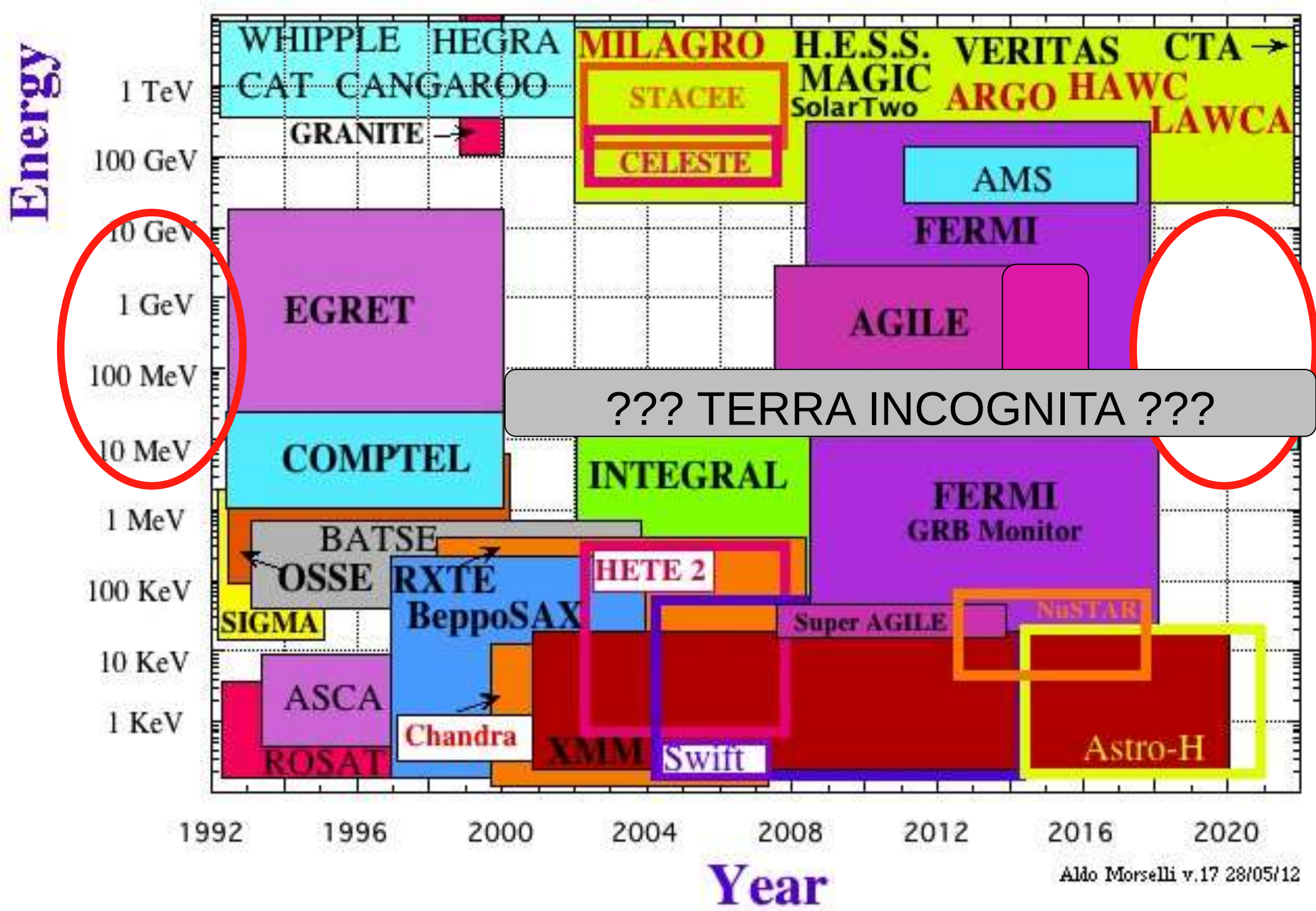
The Future of Research on Cosmic Gamma Rays
26 - 29 August 2015
La Palma -Canary Islands

The AGILE Payload: the most compact instrument for HE astrophysics

Payload: ~100 kg, ~ 60 cm^3

- **GRID gamma-ray imager (30 MeV - 30 GeV)(Pair conversion SI-Tracker)**
- **SuperAGILE hard X-ray imager (18 - 60 keV)**
- **MCAL Minicalorimeter (0.3 - 100 MeV)**

ASI Mission with INFN, INAF e CIFS participation


Energy
1 TeV
100 GeV
10 GeV
1 GeV
100 MeV
10 MeV
1 MeV
100 KeV
10 KeV
1 KeV
WHIPPLE
HEGRA
CAT
CANGAROO
GRANITE
MILAGRO
STACEE
CELESTE
H.E.S.S.
MAGIC
SolarTwo
VERITAS
ARGO
HAWC
CTA
LAWCA
AMS
FERMI
EGRET
AGILE
??? TERRA INCOGNITA ???
COMPTEL
INTEGRAL
FERMI
GRB Monitor
BATSE
OSSE
RXTE
BeppoSAX
HETE 2
SIGMA
Super AGILE
NuSTAR
ASCA
Chandra
XMM
Swift
Astro-H
ROSAT
1992
1996
2000
2004
2008
2012
2016
2020
Year
Aldo Morselli v.17 28/05/12


agile
Astro-rivelatore Gamma a Immagini LEggero
April 23, 2007: Launch!
INDIA
Baseline Equatorial orbit: 550 Km, < 3º inclination
Orbital decay estimate after 8 years:
Height < 400 Km on June 2017 (worst case)


TZP
FUCINO
Malindi
(Kenya)
ASI Science Data
Center

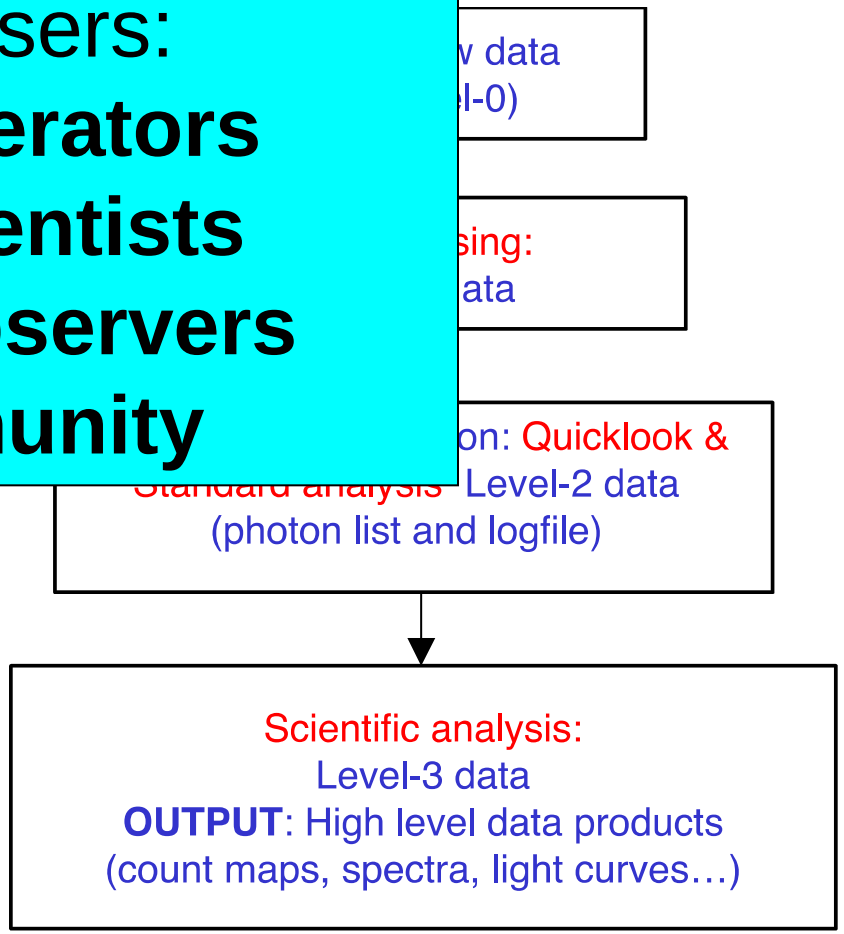
- The ADC, based at ASDC, is in charge of all the scientific oriented activities related to the analysis and archiving of AGILE data:

From scientific

- ✓ Preprocess
- ✓ Quick-Look
- ✓ Standard a (photon list)
- ✓ Scientific analysis (source detection, diffuse gamma-ray background)
- ✓ Archiving and distributing all scientific AGILE data

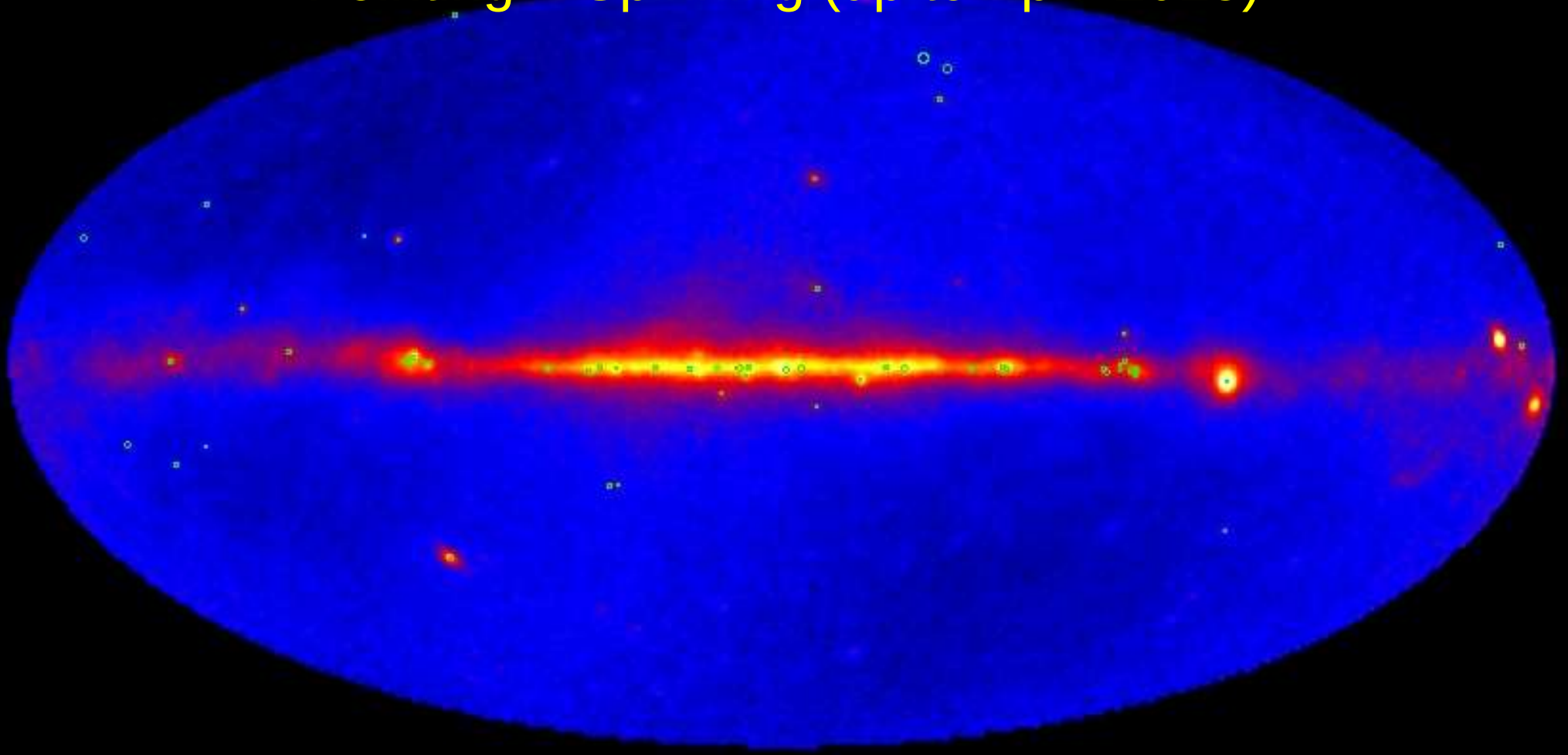
Different kinds of users:

- **Internal ADC operators**
- **AGILE Team scientists**
- **AGILE Guest Observers**
- **Scientific Community**



AGILE Total Intensity Map (E > 100 MeV)

Pointing + Spinning (up to April 2015)



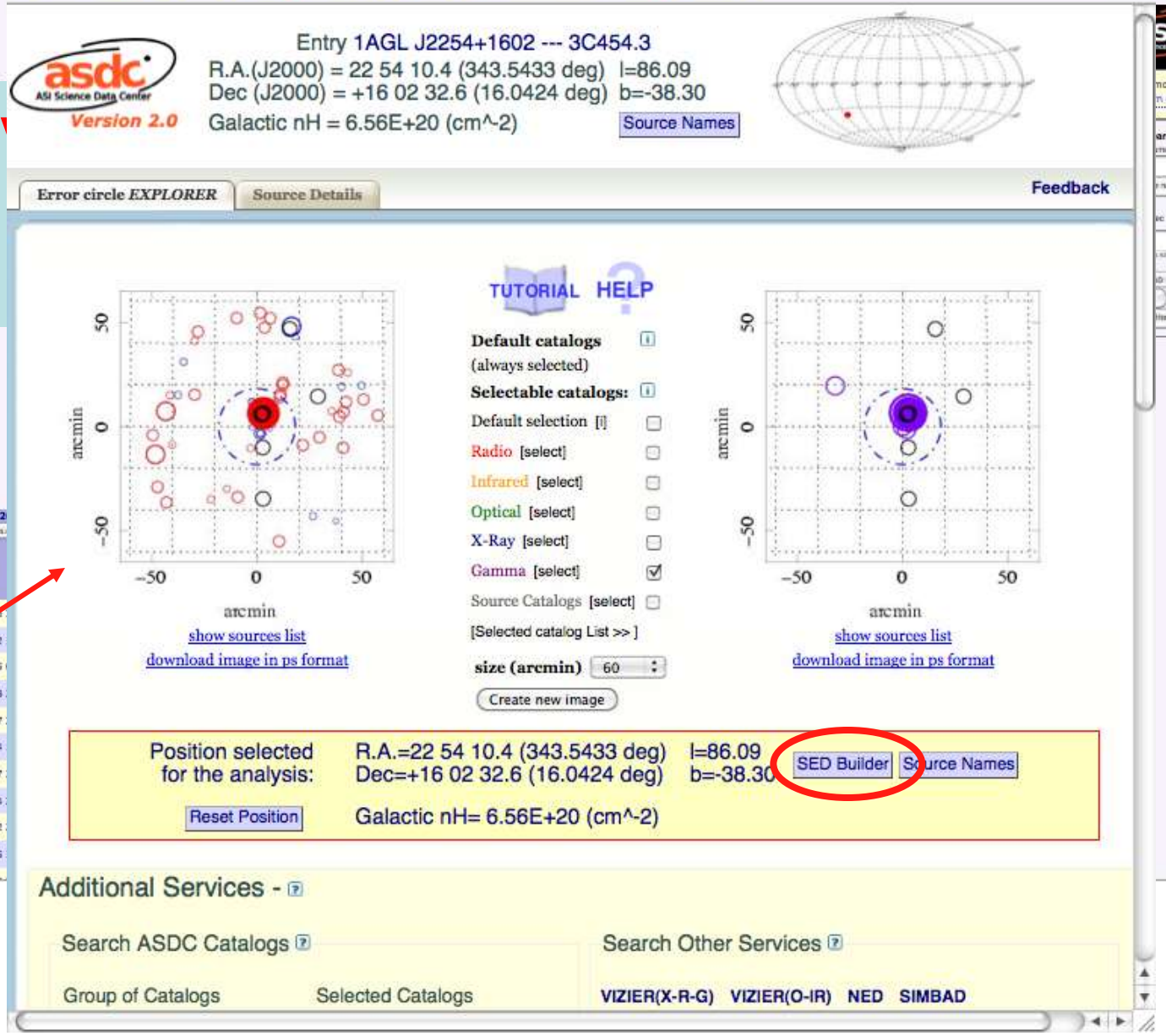
(green circles: AGILE sources, first year of operations)

"The First AGILE-GRID Catalog of High Confidence Gamma-Ray Sources", C. Pittori et al., A&A 506, 2009 and

"An updated list of AGILE bright γ-ray sources and their variability in pointing mode", F. Verrecchia et al., A&A 558, 2013

The First AGILE-GRID Catalog of High Confidence Gamma-Ray Sources

ASDC interacti
catalogs
webpages



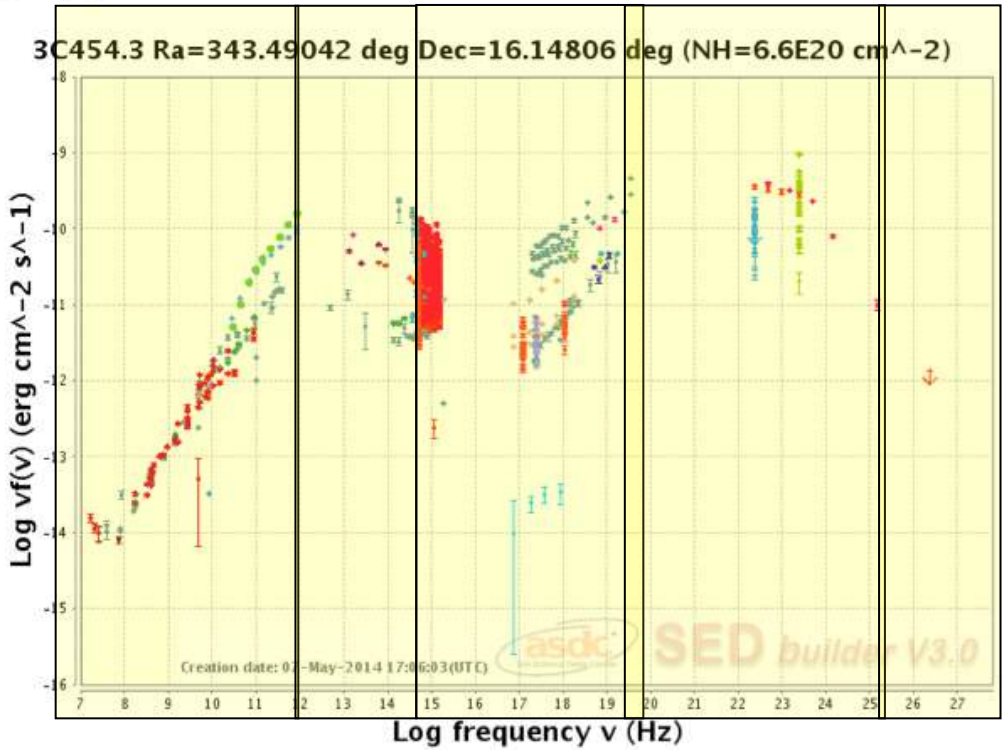
ASDC Data Explorer Tool

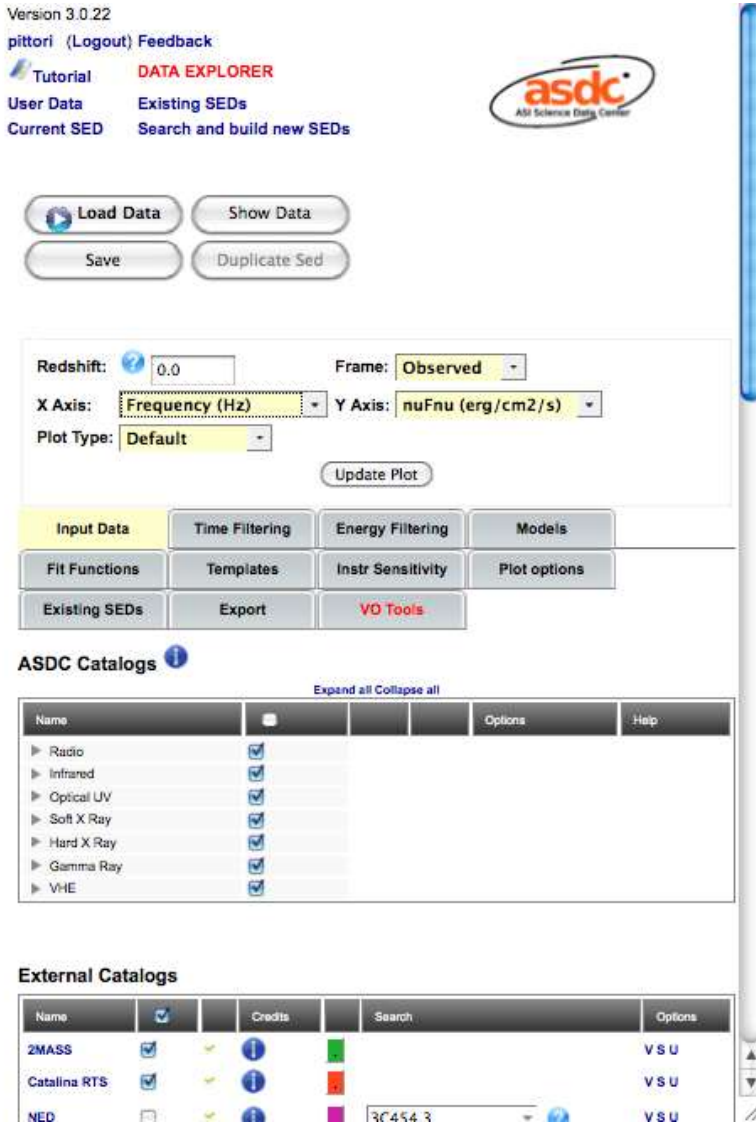
The new ASDC SED Builder

VO tools and TIME domain

SED(t) builder V3.0 Swift Radiotelescopes and Planck AGILE and Fermi TeV/CTA

A tool to build and handle Spectral Energy Distributions, time-resolved SEDs and multi-frequency light-curves





NEW AGILE CATALOGS:

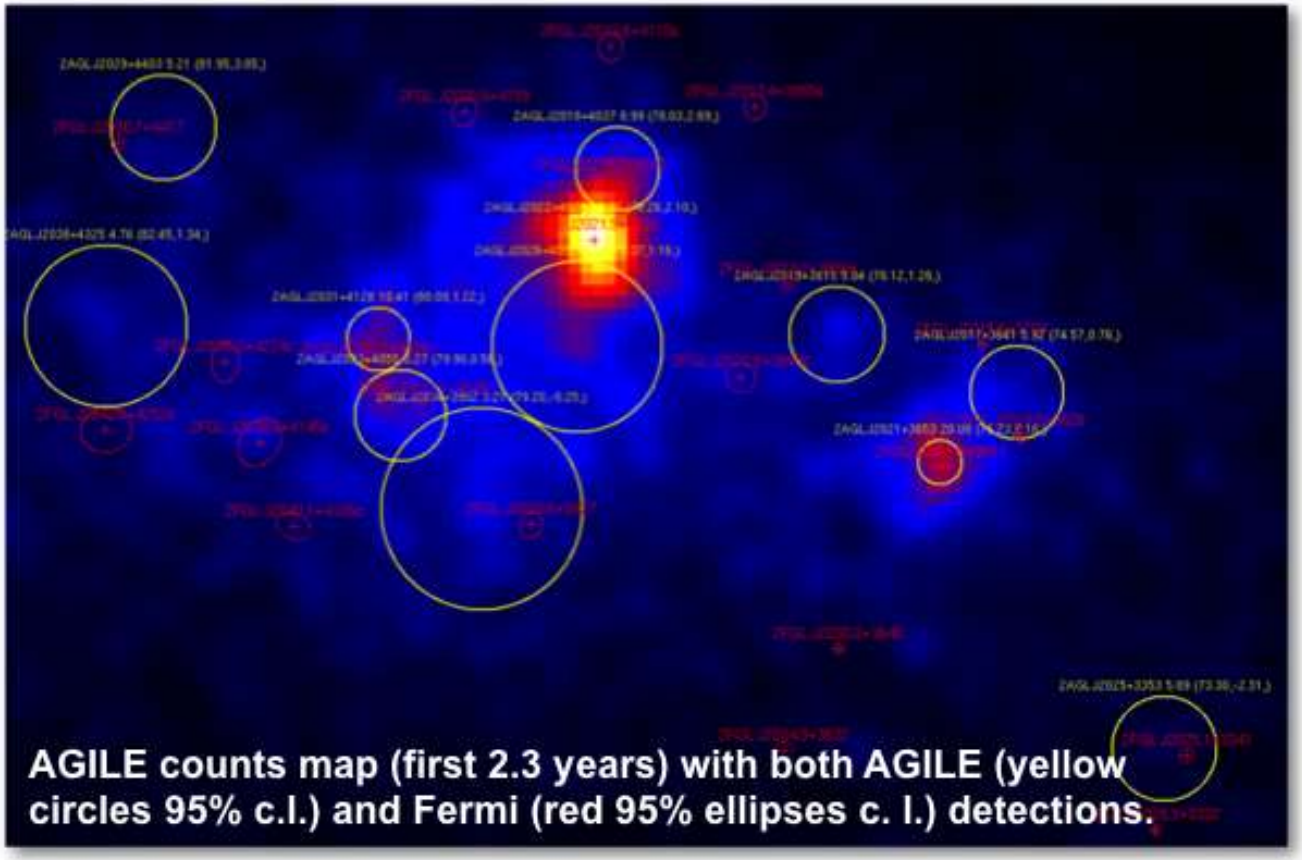
- **The second AGILE Catalog: 2AGL final validation *in progress*** (Bulgarelli et al.,*)*

New AGILE-GRID source catalog over the whole period of AGILE **pointed observations** (first 2.3 years), with improved event filter and updated calibrations.

More than 350 sources, >180 on the galactic plane only

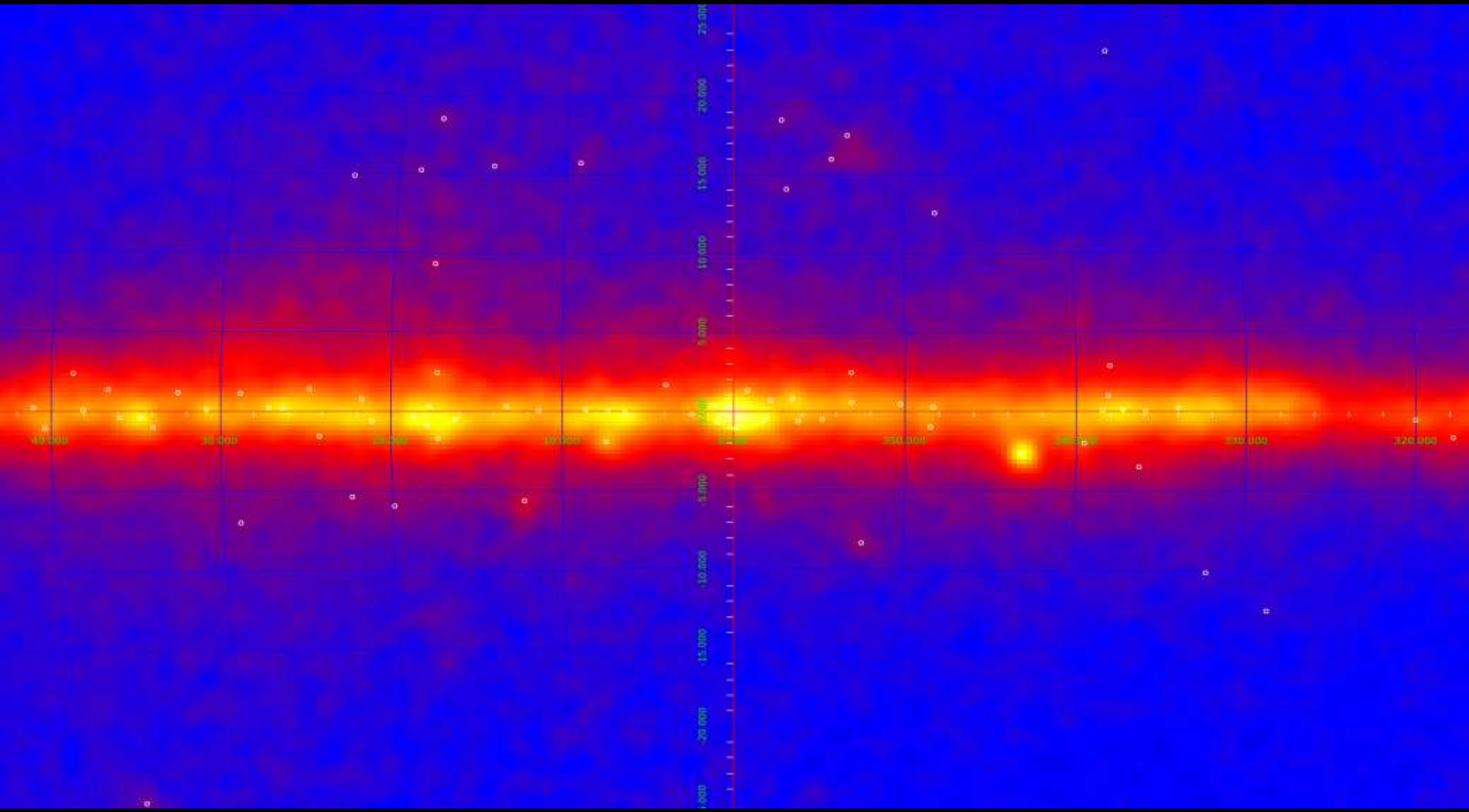
The Cygnus region →

Galactic Center region: very complicate data analysis, ***in progress*** (Fioretti et al.).



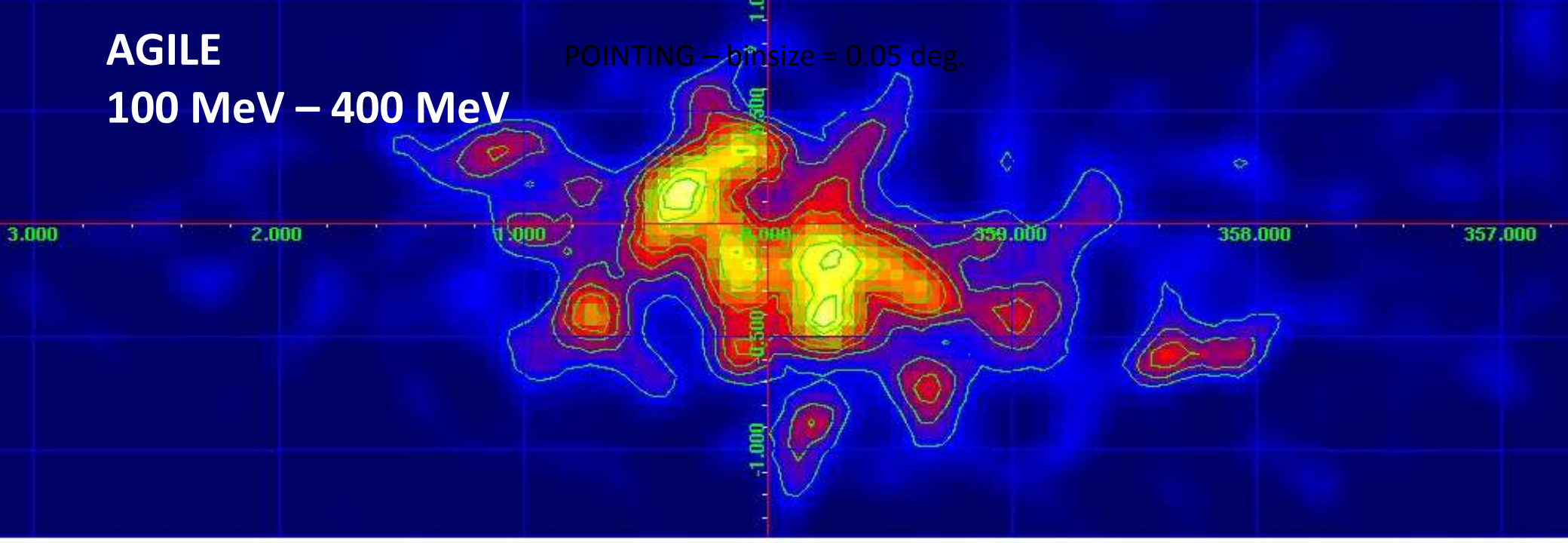
AGILE counts map (first 2.3 years) with both AGILE (yellow circles 95% c.l.) and Fermi (red 95% ellipses c. l.) detections.

The inner Galaxy seen by AGILE (E > 100 MeV)

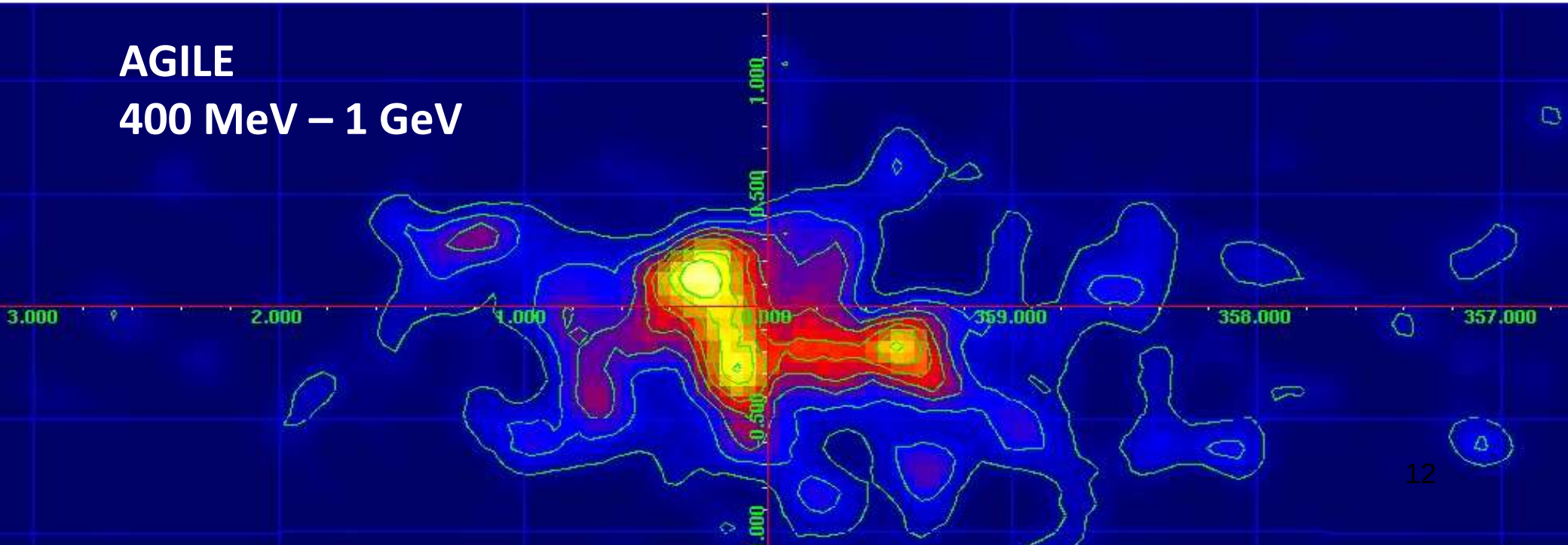


AGILE
100 MeV – 400 MeV

POINTING – binsize = 0.05 deg.

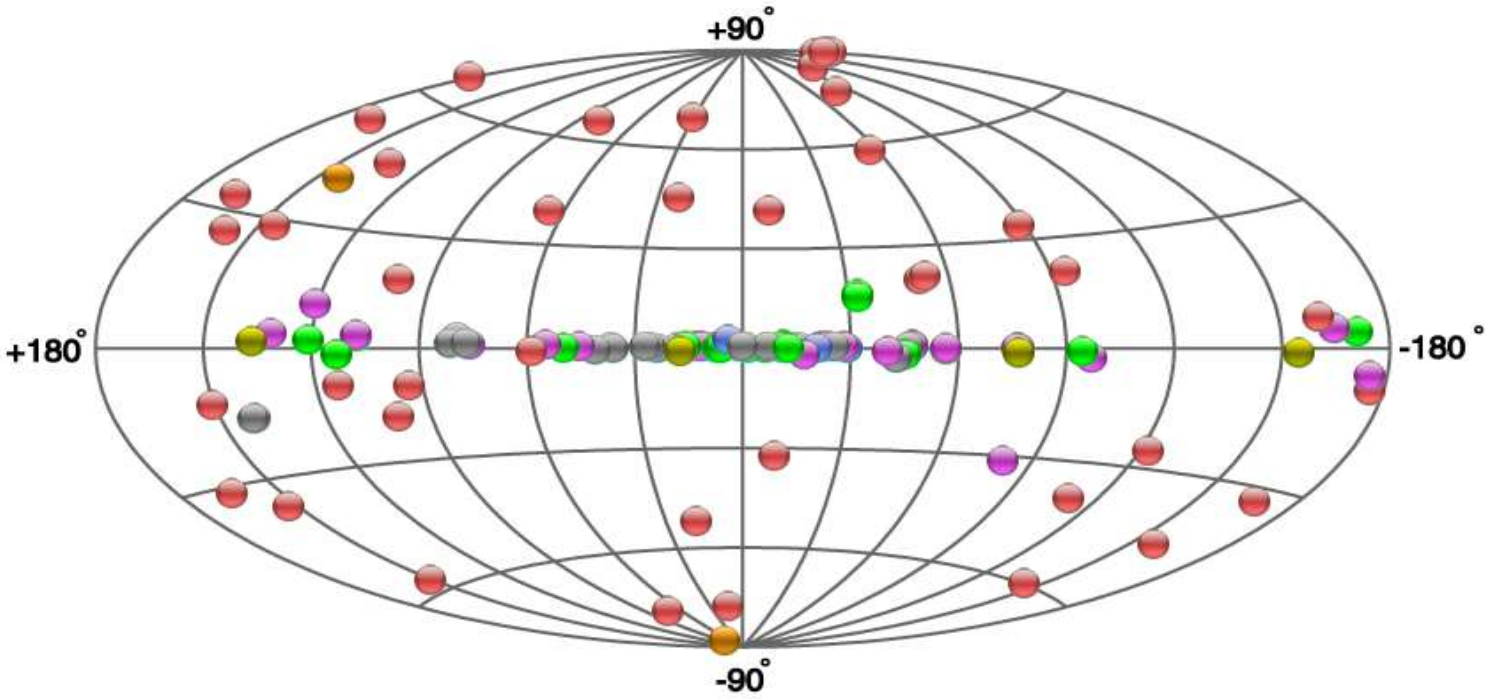


AGILE
400 MeV – 1 GeV



Search for GeV counterparts of TeV sources with AGILE in pointing mode

INPUT: **147** Tev source positions taken from the **TeVCat** Web based catalog (http://tevact.uchicago.edu)



Source Types

28	PWN
5	Binary XRB PSR Gamma BIN
59	HBL IBL FRI FSRQ LBL AGN (unknown type)
21	Shell SNR/Molec. Cloud Composite SNR
2	Starburst
28	DARK UNID Other
4	uQuasar Star Forming Region Globular Cluster Cat. Var. Massive Star Cluster BIN BL Lac (class unclear) WR

A. Rappoldi, F. Lucarelli, C. Pittori et al., 2015
(to be published in A&A)

Results: known and new sources

In total, **52** TeV sources show a significant *count excess* in the AGILE data covering the pointed observation period, corresponding to 35% of the original sample

Among them, **26** have a spatial association with already known AGILE sources from 1AGL/1AGLR catalogs (within 95% C.L. *error radius*): 15 galactic, 6 extra-galactic, 5 unassociated

The other **26** detections represent new AGILE sources (with respect to the reference catalogs): 15 galactic, 7 extra-galactic, 4 unidentified

(New sources will be also included in the 2AGL catalog)

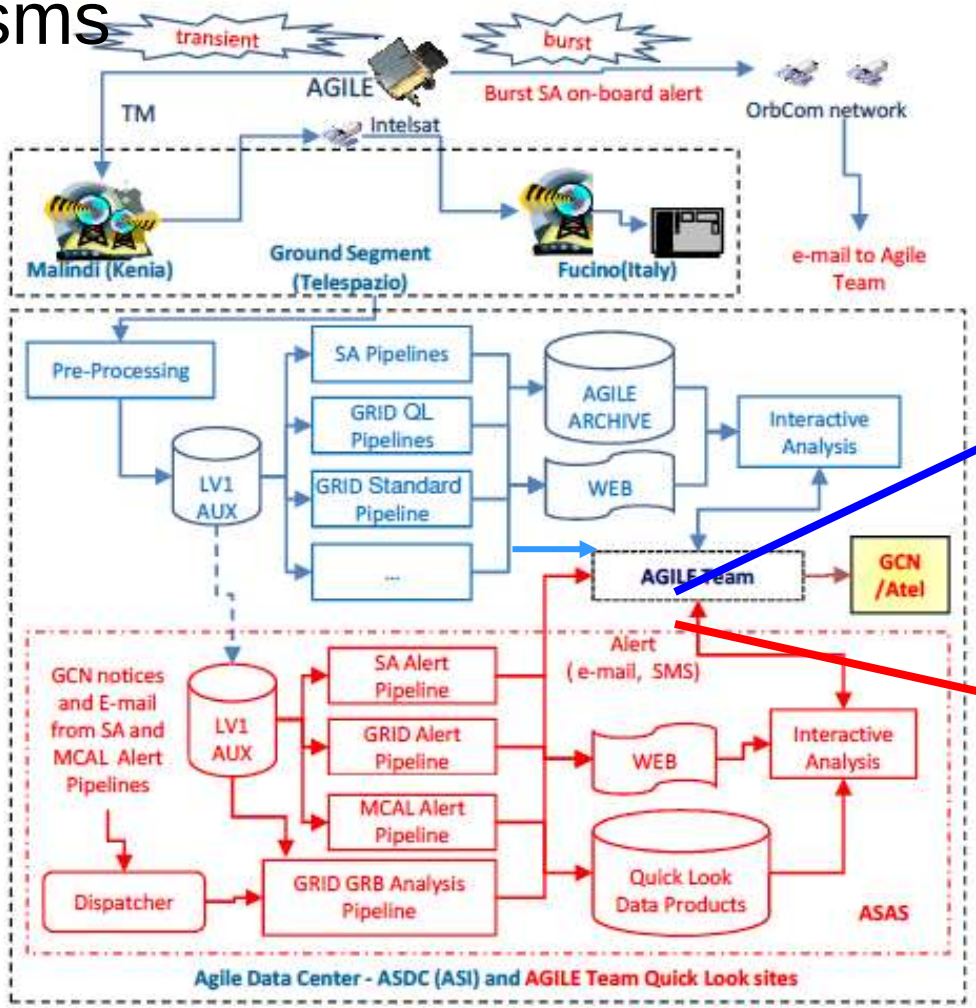
Variable sources and transients: the AGILE Science Alert System

- The system is distributed among the ADC @ ASDC and the AGILE Team Institutes (Trifoglio, Bulgarelli, Gianotti et al.)
- Automatic Alerts to the AGILE Team are generated within **T_0 + 45 min (SA) and T_0 + 100 min (GRID)**
- GRID A t-by-contact l
- Refine ed every day (dai

ATel #2761 (Lucarelli et al. 2010) led to the discovery of:
MWC 656, the first Be/BH binary
Casares et al., Nature 505, 2014

- **126 ATel** (48 in pointing + 78 in spinning) and **44 GCN** published up to June, 2015: **recently** several transient sources and new record gamma-ray flare from **3C 279** (**but no new** Crab flares or Cyg X-3, Cyg X-1 flares yet…)

Selected **alerts** sent via email, sms



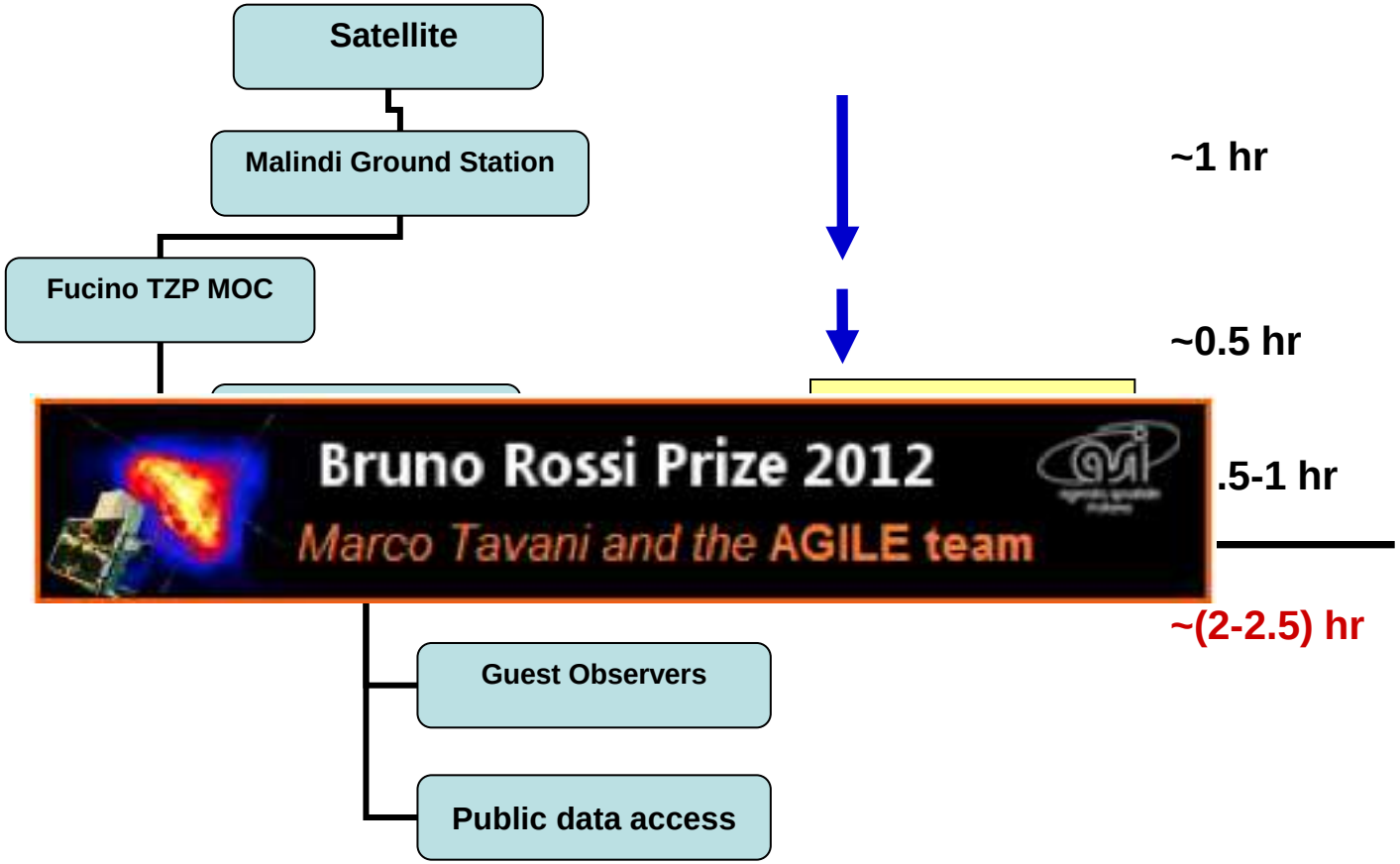
(Figure adapted from M. Trifoglio et al.)

Daily reports on a 48h time scale (sent twice a day) FAST

Contact-by-contact alerts on a 48h time scale (sent every ~100 min) VERY FAST

+ App for mobile devices!

AGILE: “very fast” Ground Segment (with contained costs)



Record for a gamma-ray mission!

Main galactic AGILE discoveries above 100 MeV

- **Carina region: γ-ray detection of the colliding wind massive binary system η-Car with AGILE**

  Tavani et al., ApJ, 698, L142, 2009 (arXiv:0904.2736)

- **Detection of Gamma-Ray Emission from the Vela Pulsar Wind Nebula with AGILE**

  Pellizzoni et al., Science 327, 2010

- **Cygnus region microquasars:**
  - **AGILE observations of Cygnus X-1 gamma-ray flares**

    Sabatini et al., ApJ 2010, Del Monte et al., A&A 2010

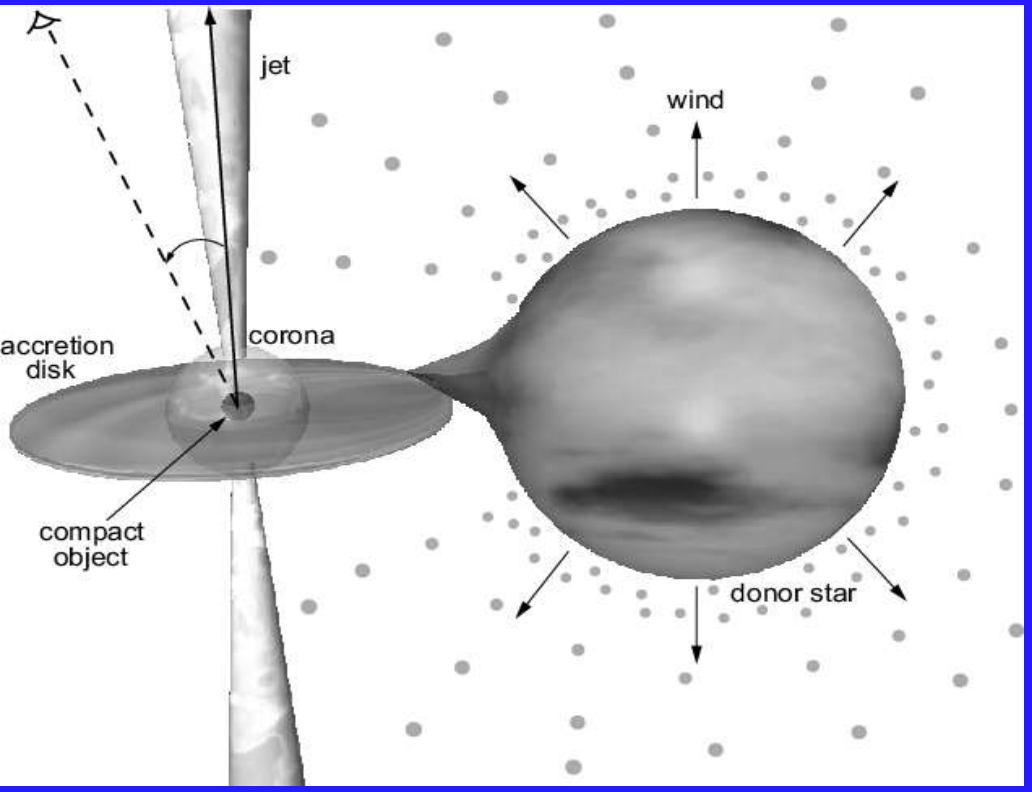
  - **AGILE detects several gamma-ray flares from Cygnus X-3, and also weak persistent emission above 100 MeV**

    Tavani et al., Nature 462, 620, 2009 (arXiv:0910.5344)

- **Neutral pion emission from accelerated protons in the SNR W44**

  Giuliani et al., ApJ, 742, 2011

Microquasars



Open questions (pre-AGILE):

- **Can jet formation accelerate relativistic particles?**
- **Can the jet emit γ-rays above 100 MeV?**

The discovery of the γ-ray activity from Cygnus X-3 is the proof of extreme particle acceleration in microquasars.

The γ-ray detection of Cygnus X-3: brief story of a discovery

- December 2, 2009:

  The AGILE-*GRID* detects 4 γ-ray flares from C

  ("*Extreme particle acceleration in the microquasar Cygnus X-3*", Tava

  - γ-ray flaring-fluxes greater than 1 order of magnitude with
  - coincident with **prominent minima** of the hard X-ray flux
  - a few days before major radio flares

- December 11, 2009:

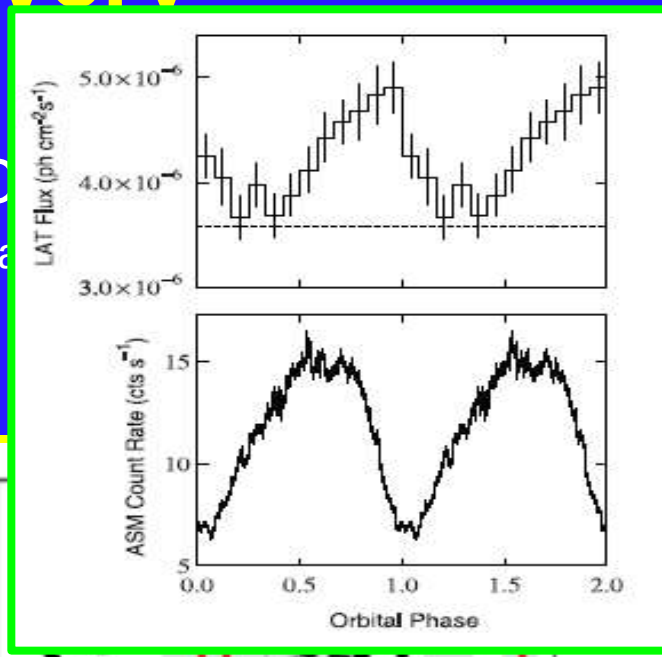
  Fermi-LAT confirms AGILE det

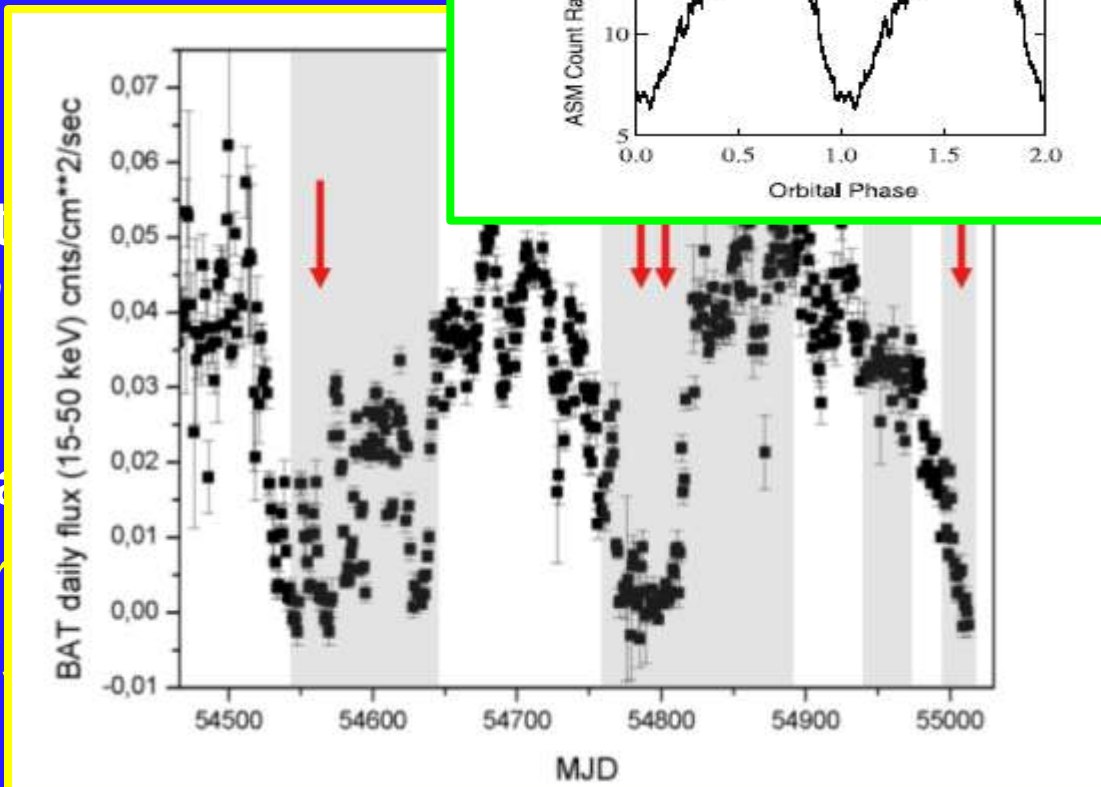
  ("*Modulated High-Energy Gamma-Ray Emission*

  - γ-ray detection of the **orbital period** microquasar

In 9 days a long-lasting mystery ha

Cygnus X-3 is able to acceler energies and to emit γ-ray





Major gamma-ray flares in special transitional states in preparation of radio flares!

• Gamma-ray flares tend to occur in the **rare** low-flux/pre-flare radio states.

• For all gamma-ray flaring episodes, the radio and hard-X-ray fluxes are low or very low, while the soft X-ray flux is large

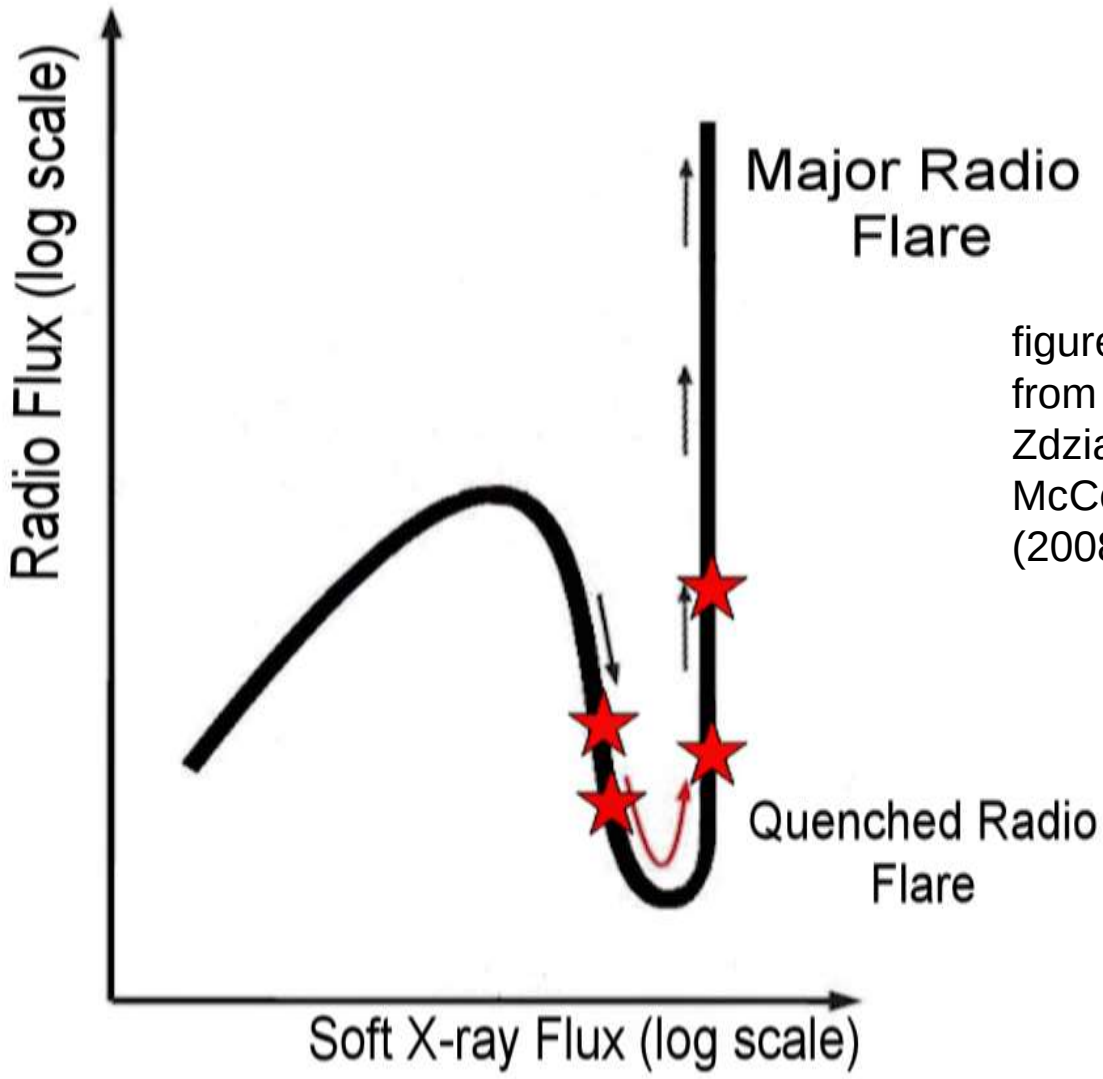
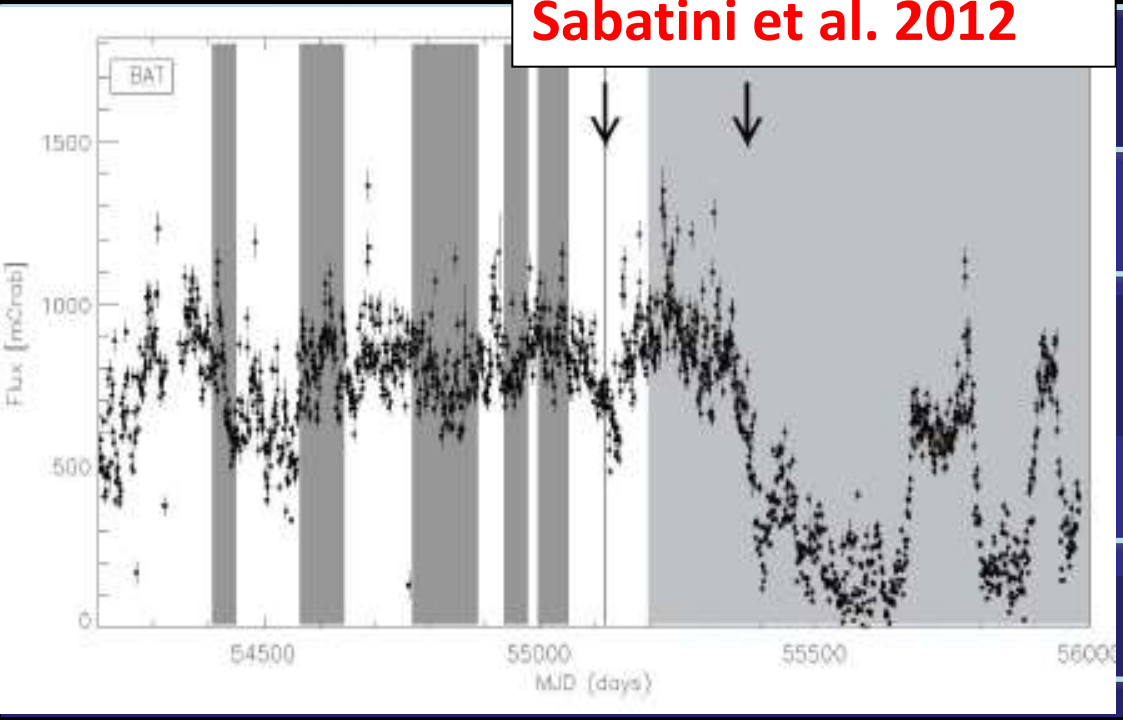


figure adapted from Szostek Zdziarski & McCollough (2008)

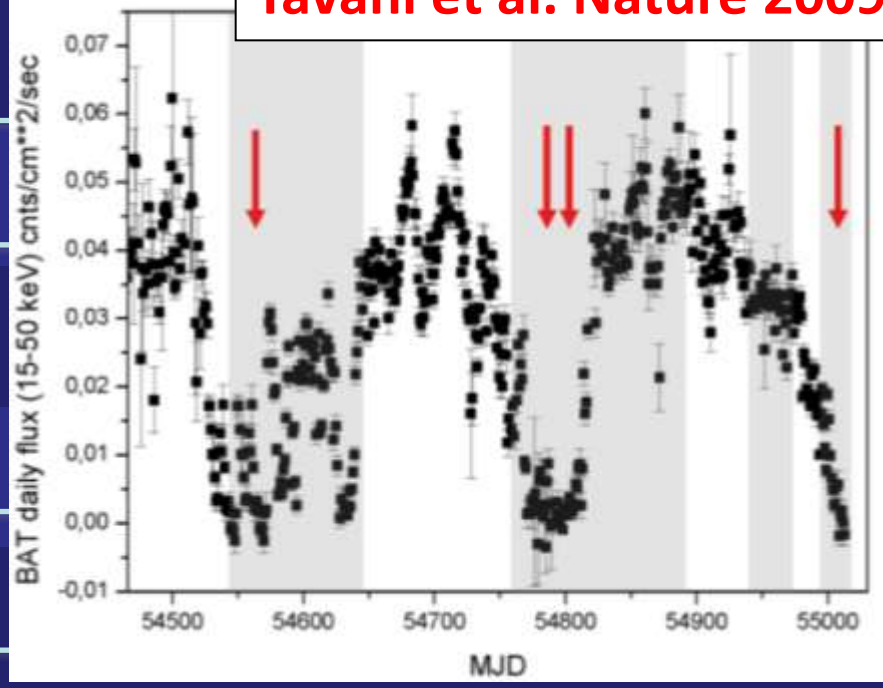
Cygnus X-1

Sabatini et al. 2012



Cygnus X-3

Tavani et al. Nature 2009



SPORADIC

2 AGILE detected episodes:

- **Hard state**
- **Hard-to-soft transition**

REPETITIVE PATTERN !!

- **bright soft X-ray states (soft-to-hard state transitions)**
- **state preceeding strong radio flares.**

	Cygnus X-1	Cygnus X-3
Compact Object	4-15 $M_\odot$ BH	1.4 $M_\odot$ NS or 10 $M_\odot$ BH
Companion	O9.7 Supergiant, L ~ 10^{39} erg/s	Wolf Rayet, L ~ 10^{39} erg/s
Companion wind	~ 10^{-6} $M_\odot$/yr, v ~ 2000 km/s	~ 10^{-5} $M_\odot$/yr, v ~ 1000 km/s
Period	5.6 days, orb. r. ~ 3.4 x 10^{12} cm	4.8 h, orb. r. ~ 3 x 10^{11} cm
Inclination Angle	30?	< 14

Cygnus X-3 is unique in orbital separation, luminosity of the companion star and inclination -> different behaviour can be expected in the two systems

Slide from S. Sabatini, RICAP-13

First evidence of proton acceleration in the Supernova Remnant W44 with AGILE

A. Giuliani et al., ApJ 742, 2011

SNR W44

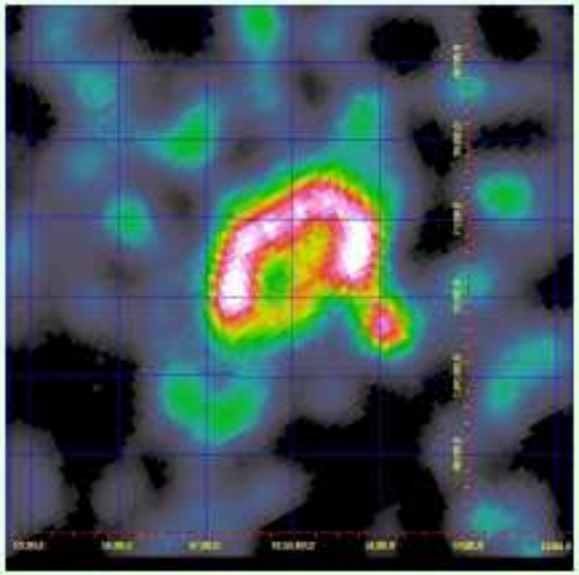


Fig 1 : SNR W44 as seen by AGILE for energies greater than 400 MeV

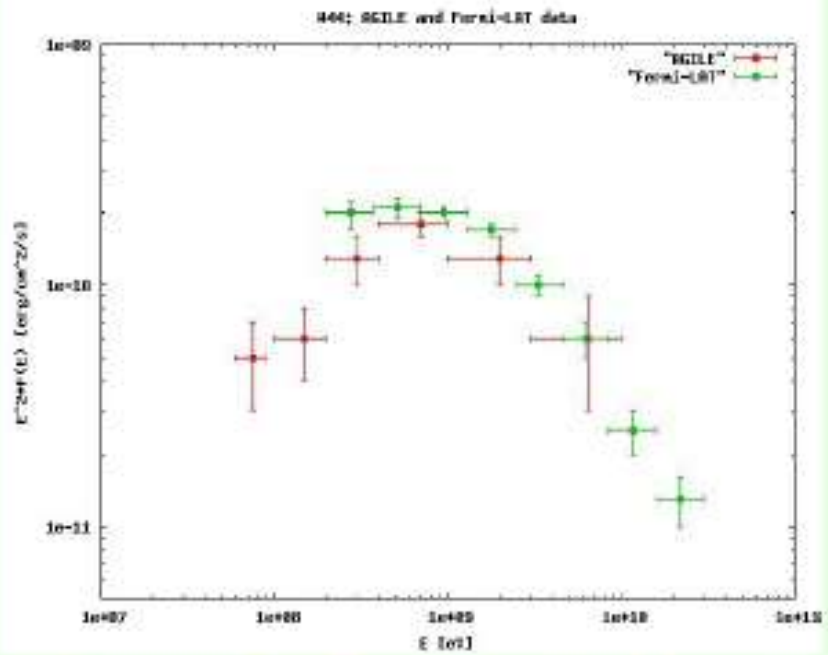
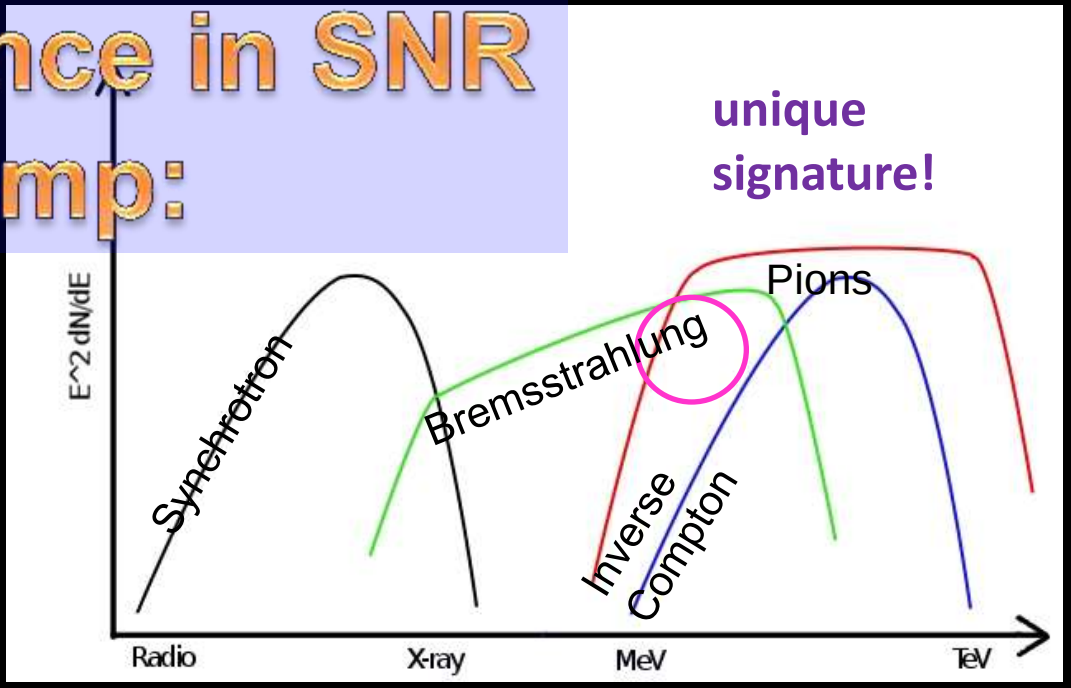


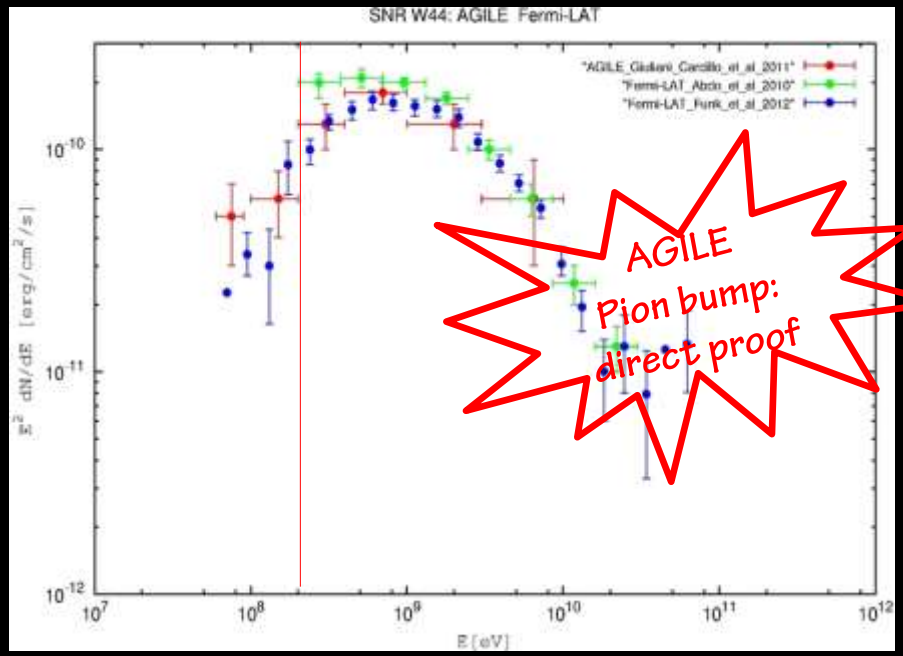
Fig 3 :combined AGILE (red) and Fermi/LAT (green) spectra energy distribution (SED) for SNR W44. AGILE points are in the range 50 MeV- 10 GeV divided in six energy intervals. Fermi/LAT data span the energy range 0,2-30GeV (from Abdo et al, 2010)

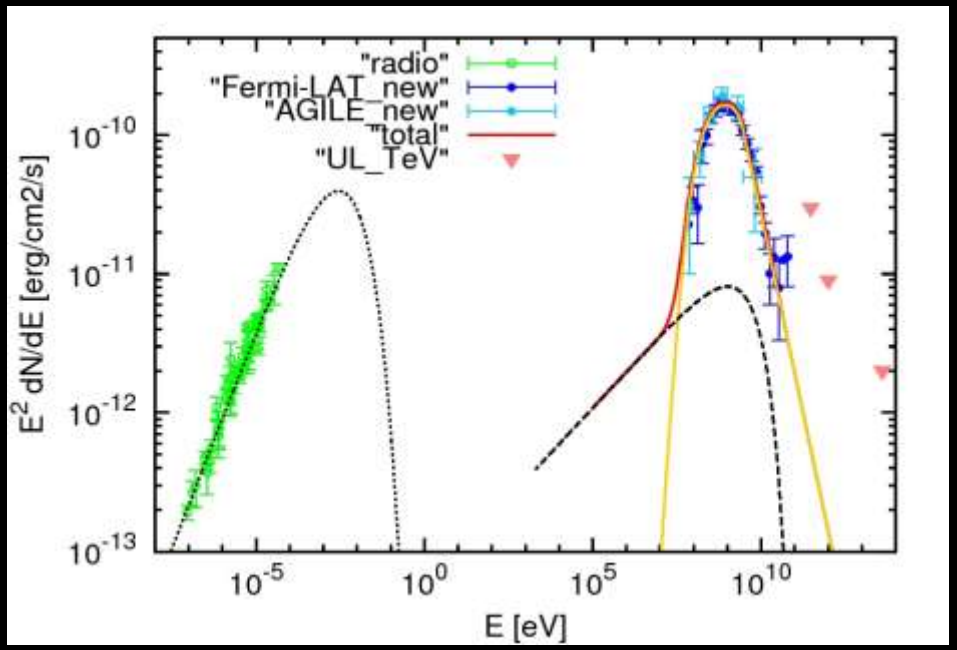
Acceleration evidence in SNR
The Pion bump:

unique signature!

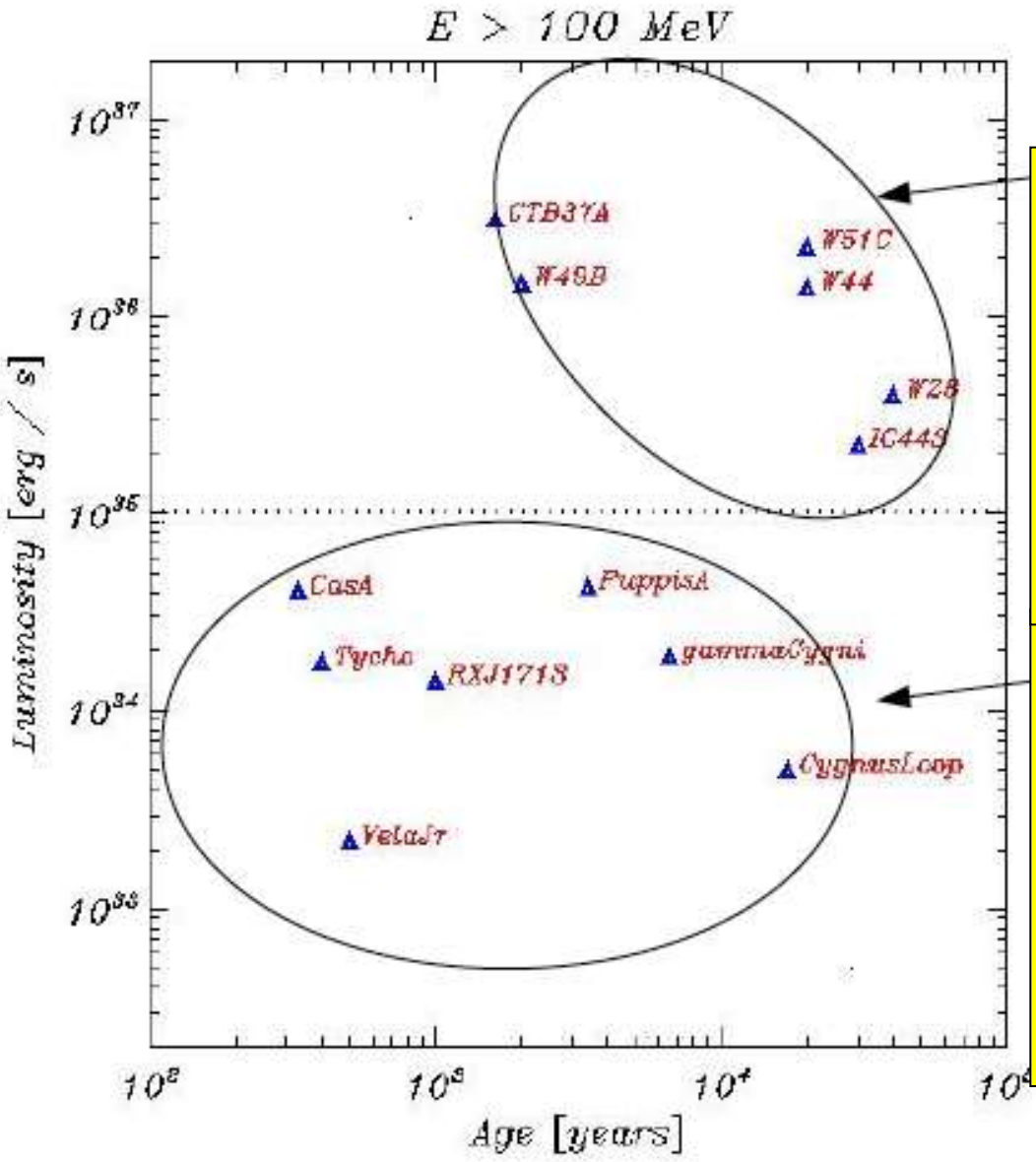


Cardillo et al., A&A 565, 2014





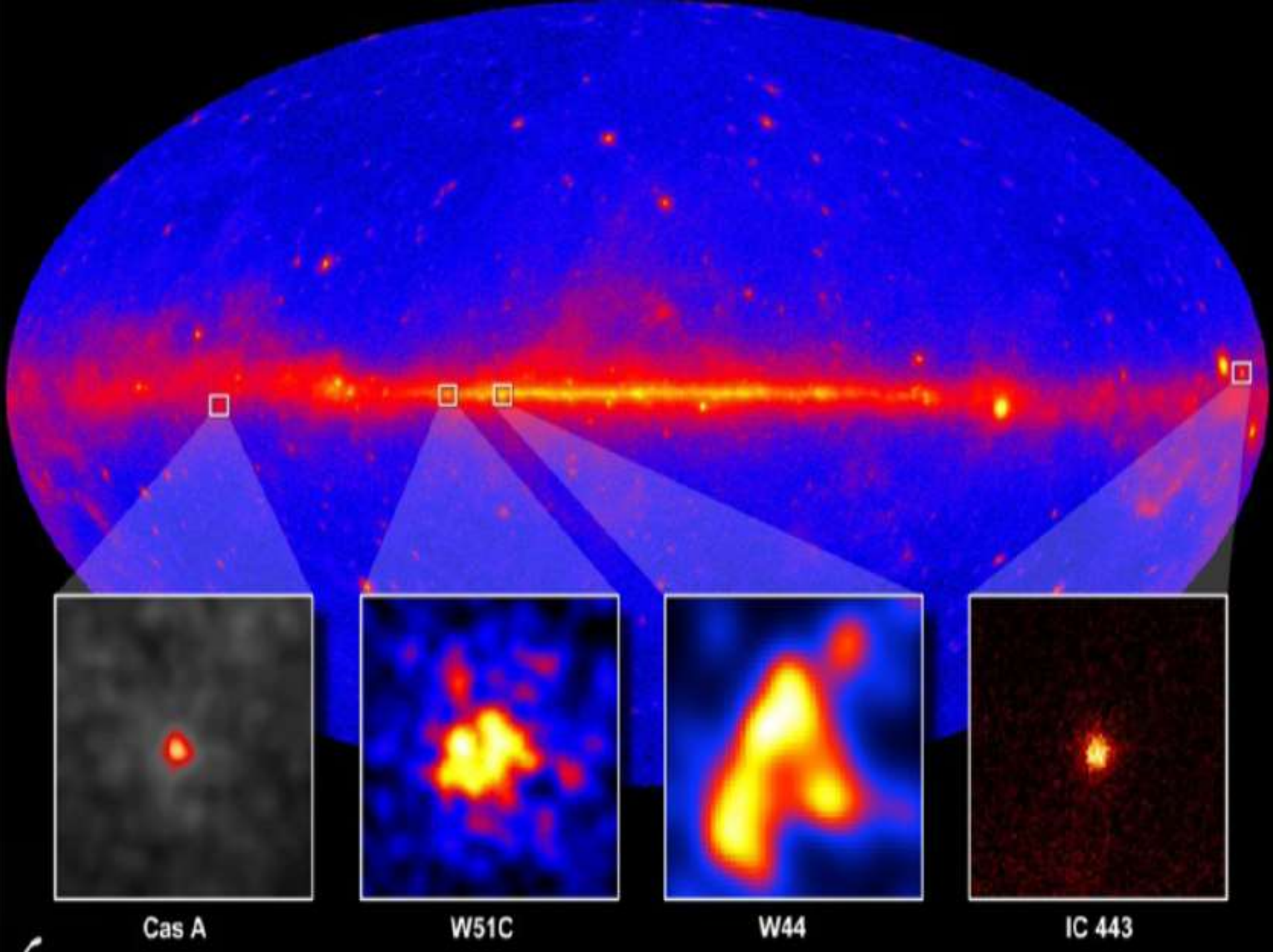
Two classes of γ-ray SNR



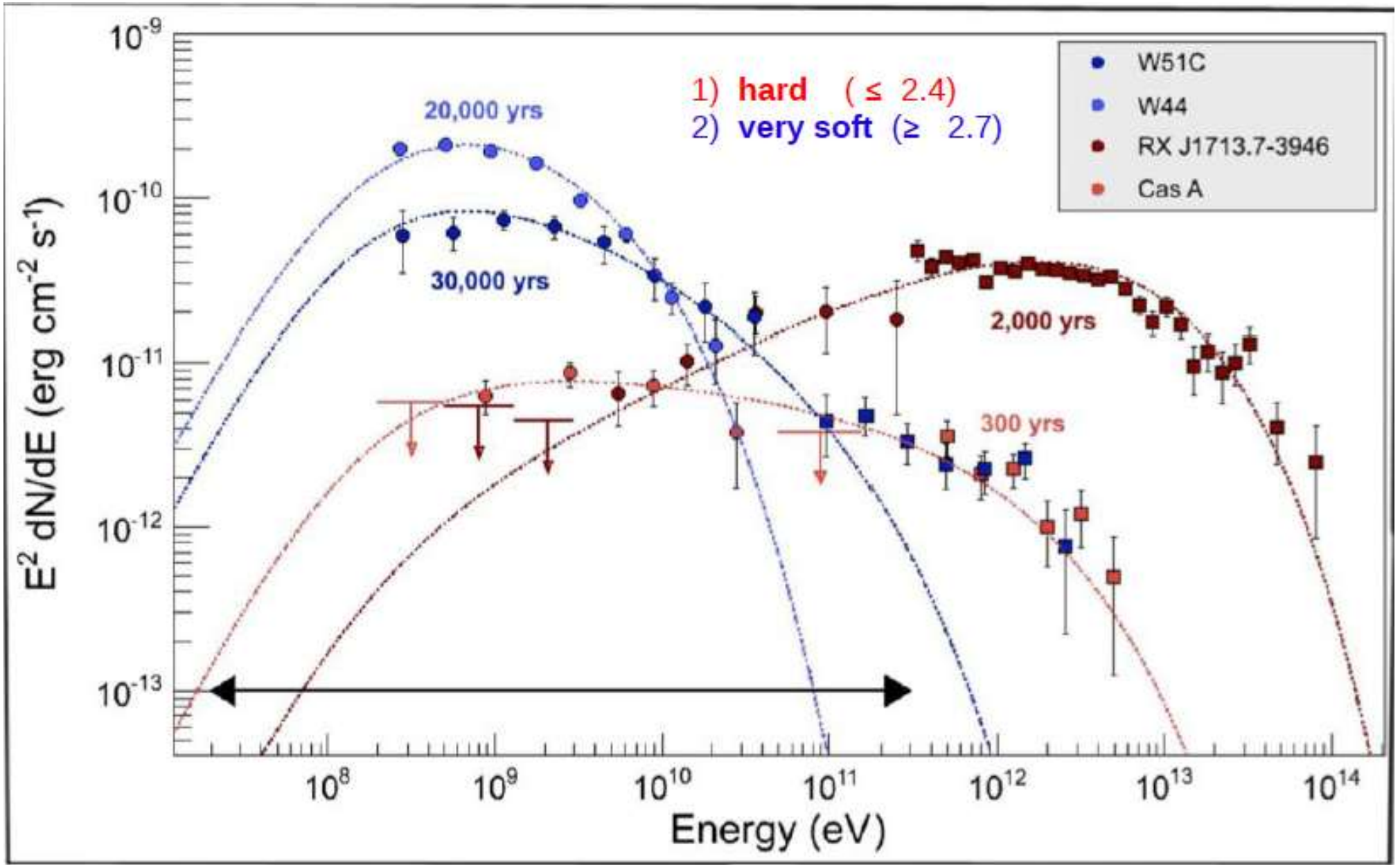
Class 2

Middle-aged SNRs (10^3 - 10^4 yrs): mixed morphology objects, interacting with giant molecular clouds, with γ-ray morphology that correlates better with M.C. than with the radio shell

Young SNRs (10^2 - 10^3 yrs): shell-like objects, expanding in a relatively low density medium, with γ-ray morphology typically well correlated with the radio and X shells


Cas A
W51C
W44
IC 443

At 100 MeV middle-aged SNRs are brighter: AGILE SNRs on average older than TeV or Fermi SNRs



UNEXPECTED DISCOVERY FROM THE γ-RAY SKY:

AGILE DISCOVERY OF THE CRAB NEBULA VARIABILITY IN γ-RAYS

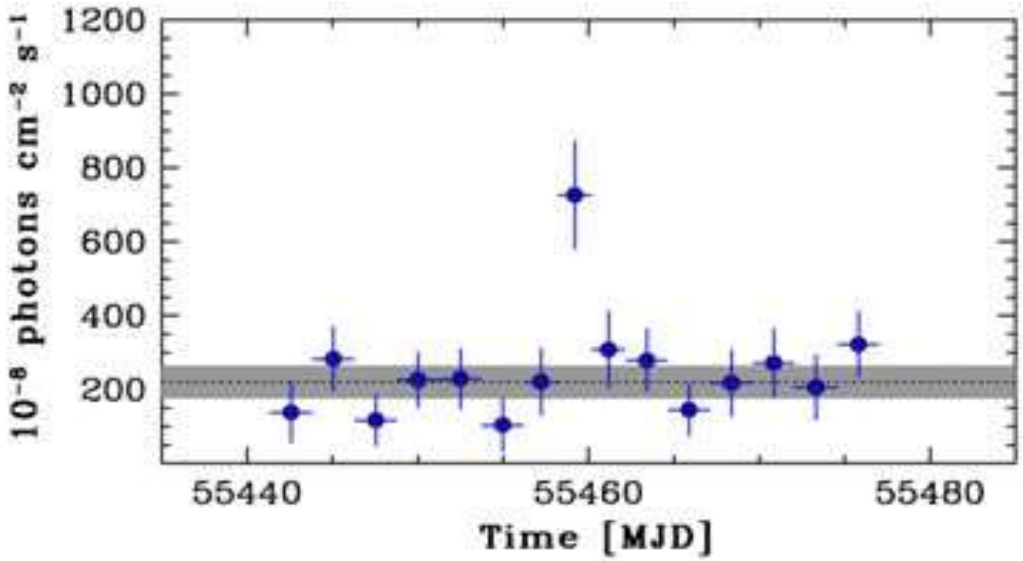
Tavani et al., Science, 331, 736 (2011)

Fermi confirmation:

Abdo et al., Science, 331, 739 (2011)

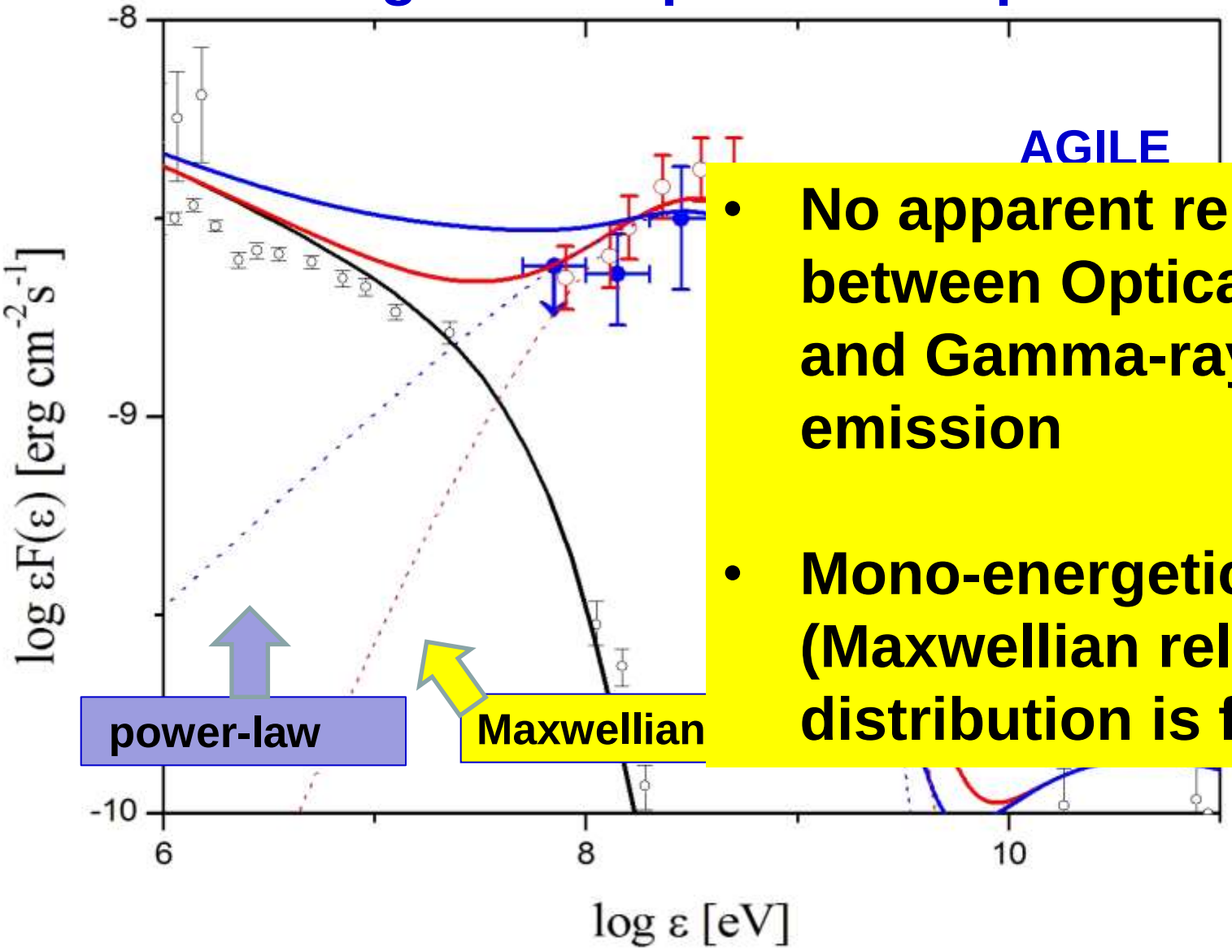
The variable Crab Nebula!

FIRST PUBLIC ANNOUNCEMENT
Sept. 22, 2010: AGILE issues the Astronomer's Telegram n. 2855



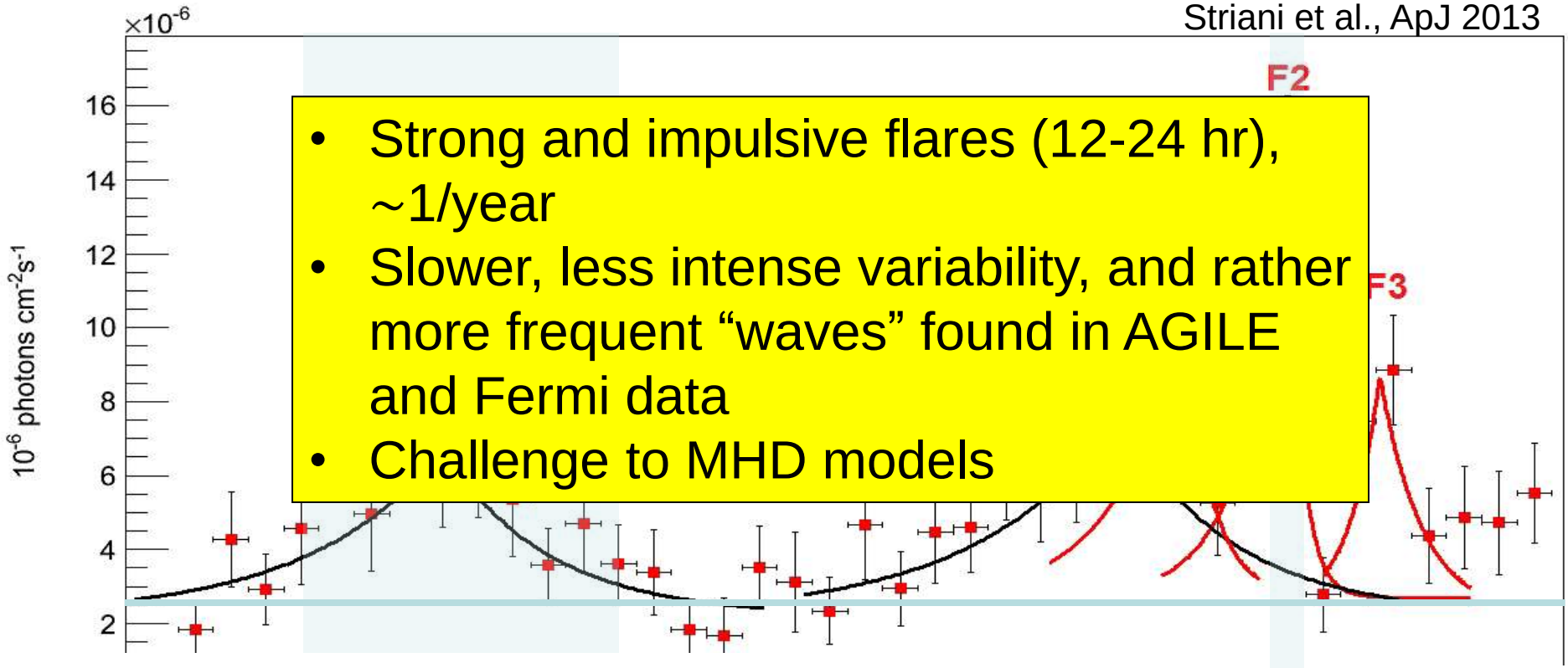
Science Express **(6 January 2011)**

Modelling of the April 2011 super-flare

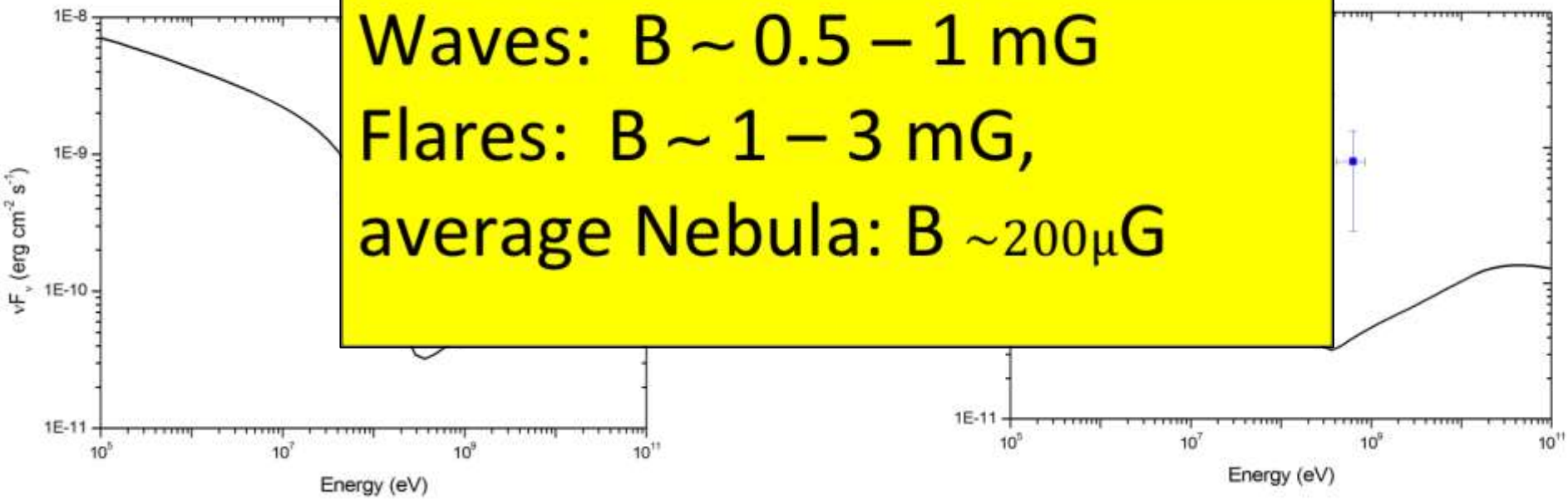


- **No apparent relation between Optical, X-ray and Gamma-ray flaring emission**
- **Mono-energetic (Maxwellian relativistic) distribution is favored**

Striani et al., ApJ 2013



- Strong and impulsive flares (12-24 hr), ~1/year
- Slower, less intense variability, and rather more frequent “waves” found in AGILE and Fermi data
- Challenge to MHD models



Waves: B ~ 0.5 – 1 mG

Flares: B ~ 1 – 3 mG,

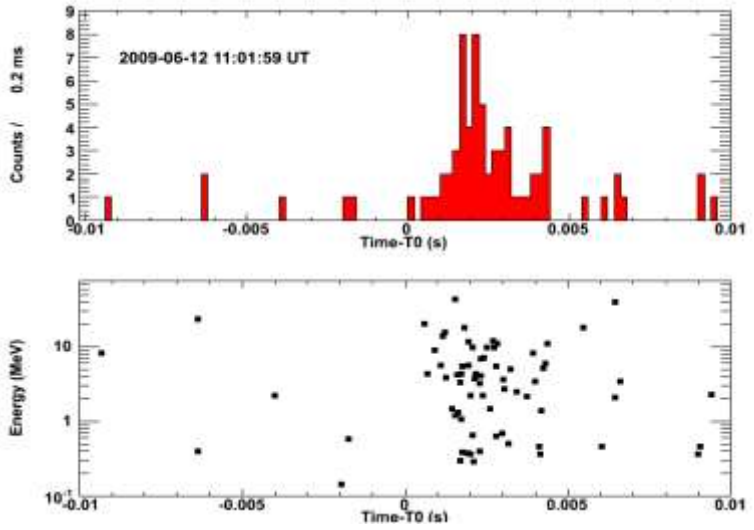
average Nebula: B ~200μG

AGILE:
SURPRISES FROM THE EARTH ATHMOSPHERE

AGILE contributions to TGF science

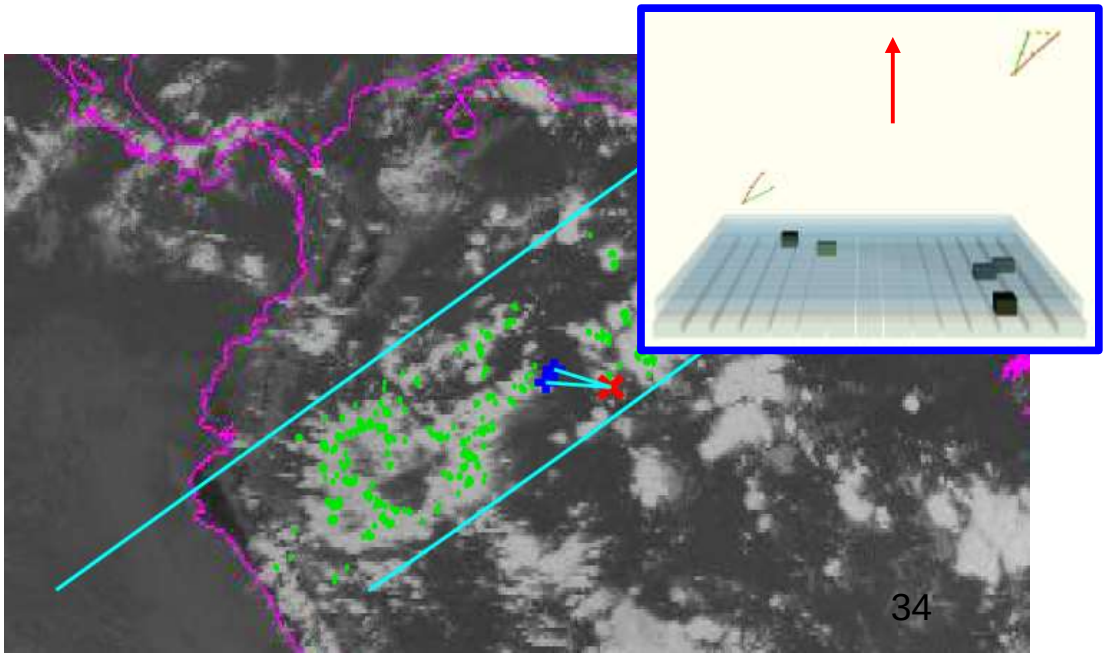
- TGF energy range extends at least to 40 MeV, doubling the previous range set by RHESSI:

Marisaldi et al., J. Geophys.Res. 115 (2010)



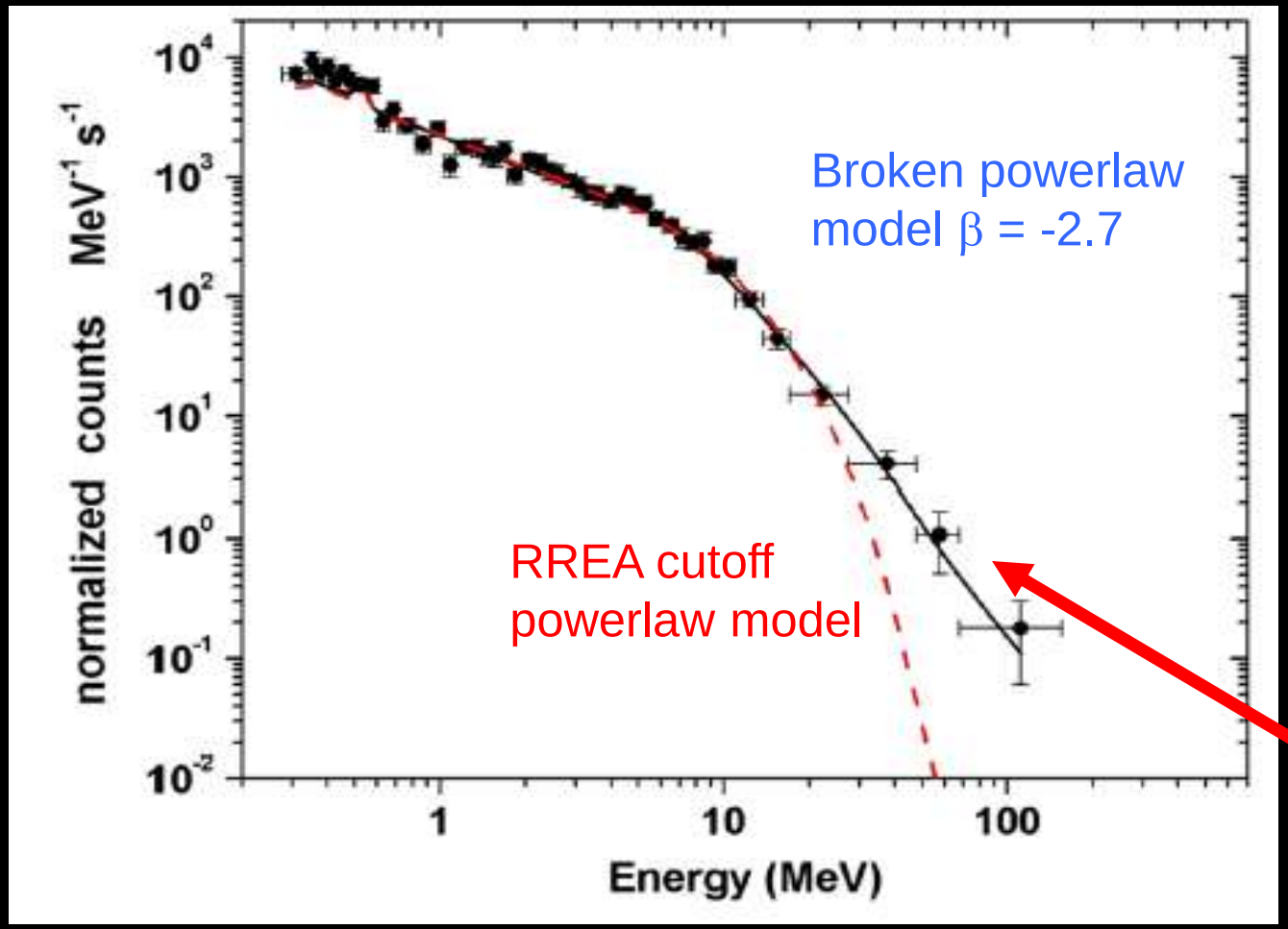
- TGFs can be localized from space directly in gamma-rays by the AGILE silicon tracker:

Marisaldi et al., Phys. Rev. Lett. 105 (2010)



TGF Cumulative spectrum

In 2011: 110 TGFs 1806 photons 142 γ E> 10 MeV 26 γ E> 20 MeV

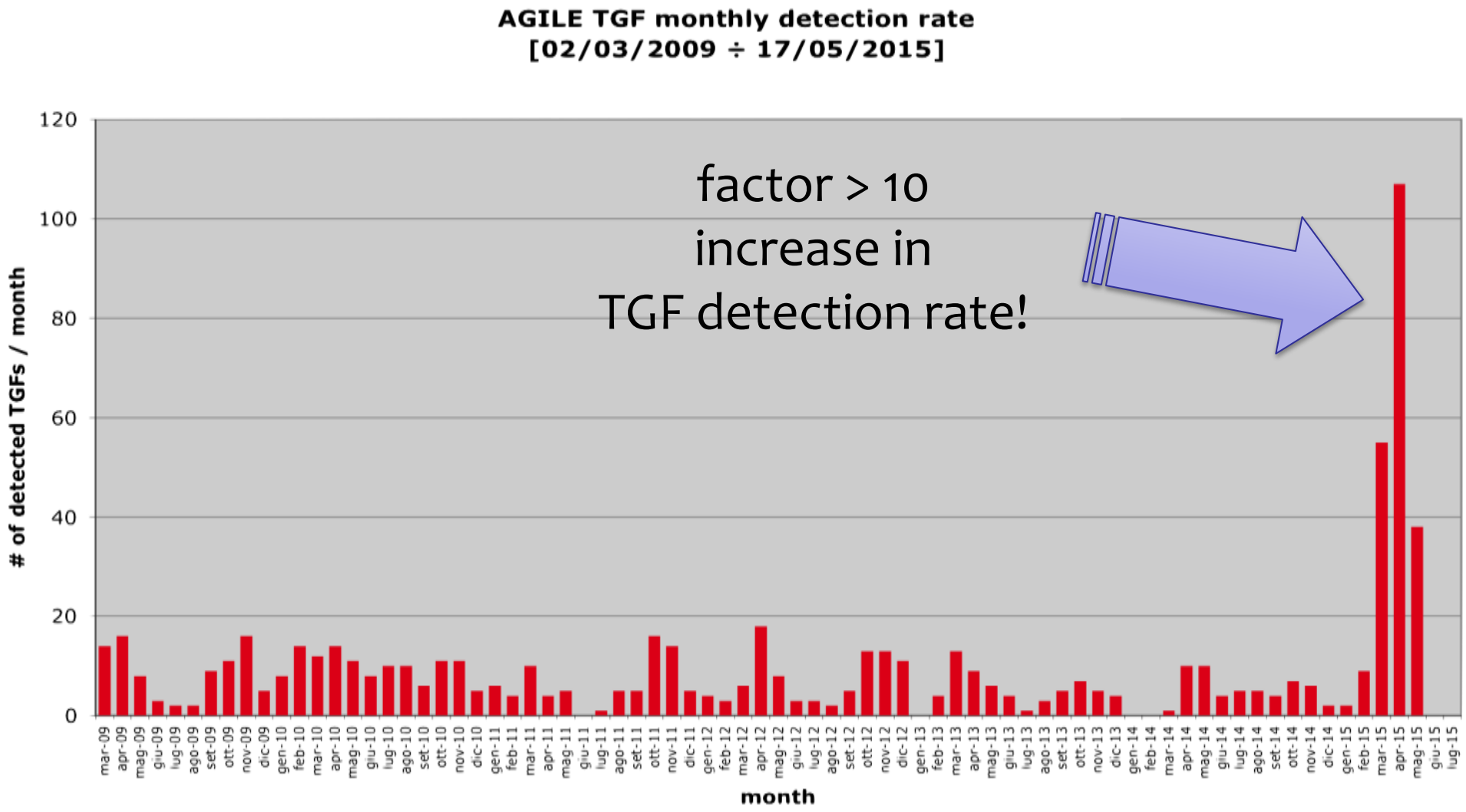


Significant detection of γ >40 MeV!! Uneplained by standard RREA model: challenge for emission models

AGILE-MCAL crucial spectral contribution up to 100 MeV!!

Tavani et al., Phys. Rev. Letters 106, 018501 (2011)

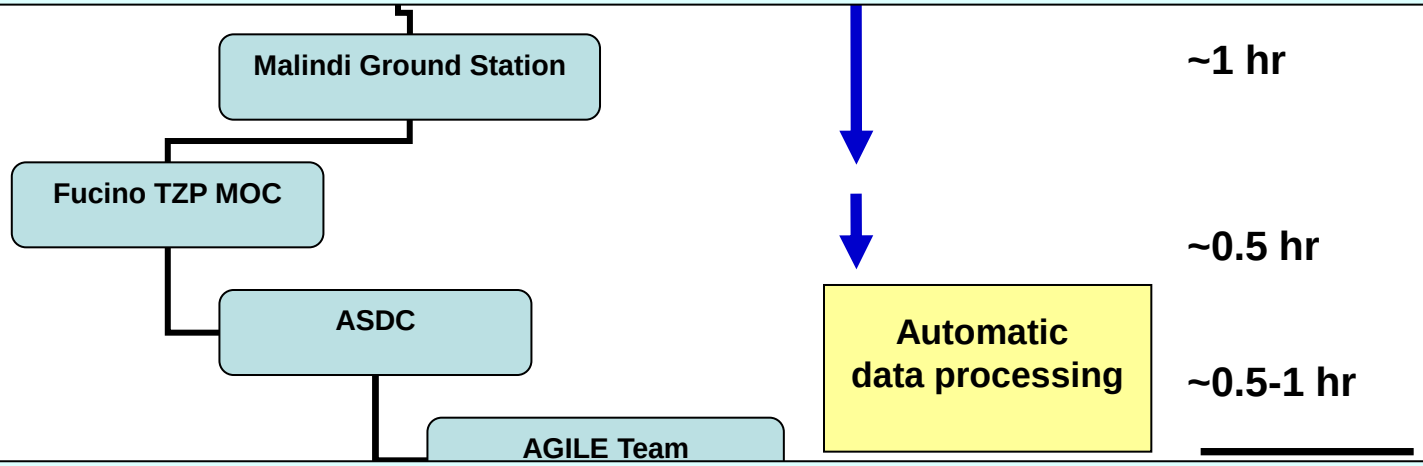
Recent change on the on-board configuration to reduce MCAL dead time: submillisecond timescales



AGILE and the Earth

- much improved detection capability for TGFs (rate > 10 times larger than before)
- detection of repeated TGFs from the same thunderstorm
- meteorology of TGFs
- impacts of TGFs
- gamma-ray mapping of the Earth

FUTURE: A NEW Real Time Pipeline to Link Meteorological Information and TGFs Detected by AGILE



Extend also to Terrestrial data the ASDC expertise on web based interactive tools and cross-correlations among different DBs and archives

AGILE: 8th year in orbit

• **Pointing observation** mode up to October 18, 2009 and **spinning observation mode** since October 2009.

• **Very good scientific performance, especially at ~ 100 MeV**

• **40000 orbits around the Earth** completed on January 19, 2015

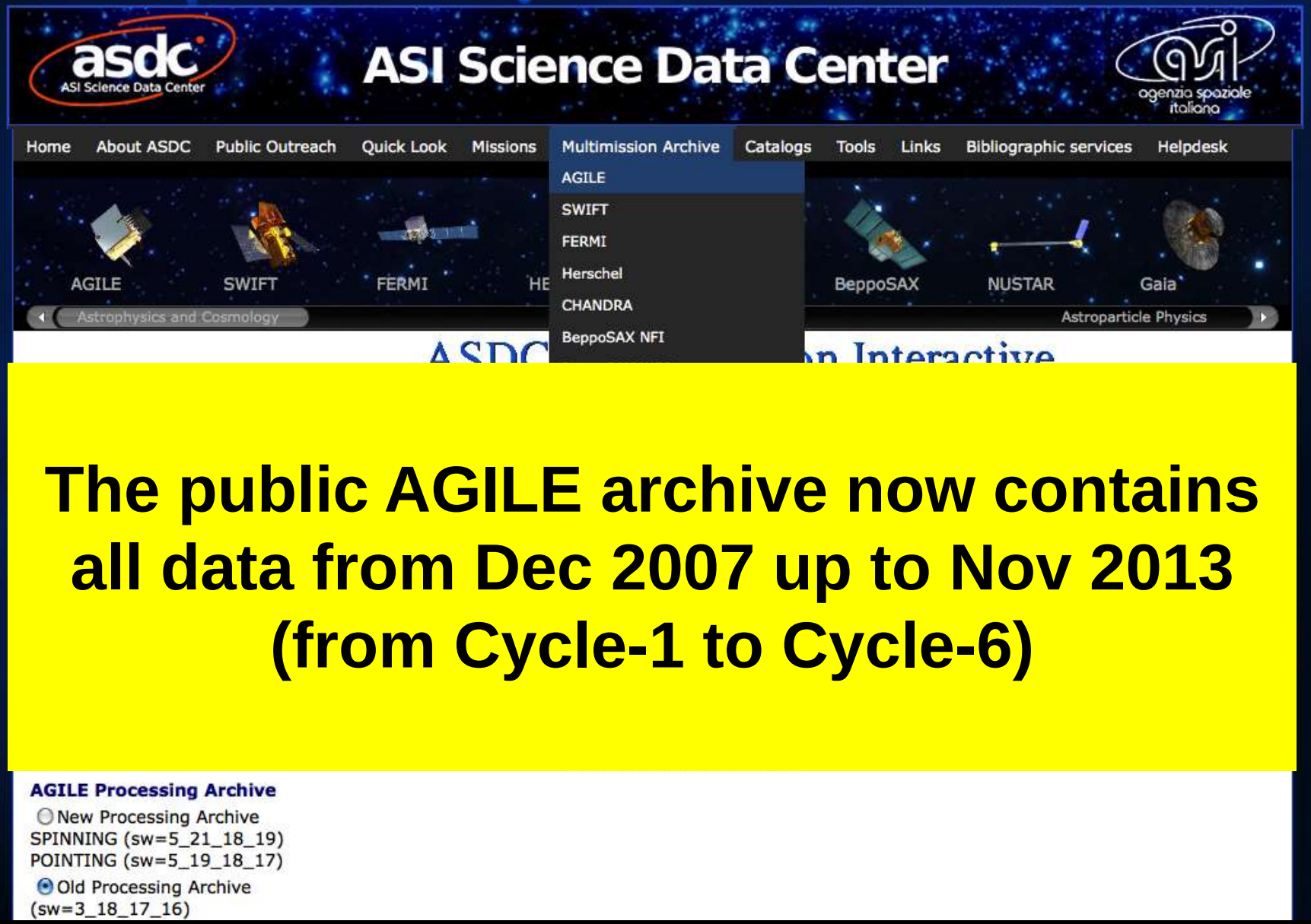
• **All AGILE functions are NOMINAL. Mission operations funded by ASI at least till 2016, March.**

• **Guest Observer Program open to the scientific community**

4 ASI Announcements of Opportunity from Cycle-1 to Cycle-4: completed (Dec. 1, 2007– Nov 30, 2011).

Cycle-5, 6 and 7: completed (Dec.1, 2001 – Dec. 31 2014).

Cycle-8 on-going data taking


asdc
ASI Science Data Center
ASI Science Data Center
agenzia spaziale italiana
Home
About ASDC
Public Outreach
Quick Look
Missions
Multimission Archive
Catalogs
Tools
Links
Bibliographic services
Helpdesk
AGILE
SWIFT
FERMI
Herschel
CHANDRA
BeppoSAX NFI
AGILE
SWIFT
FERMI
BeppoSAX
NUSTAR
Gaia
Astrophysics and Cosmology
Astroparticle Physics
The public AGILE archive now contains all data from Dec 2007 up to Nov 2013 (from Cycle-1 to Cycle-6)
AGILE Processing Archive
New Processing Archive
SPINNING (sw=5_21_18_19)
POINTING (sw=5_19_18_17)
Old Processing Archive
(sw=3_18_17_16)

NEW AGILE Data Publication Policy

The AGILE Mission Board suggested in 2015 to **eliminate the one year proprietary period**.

Data will be published as soon as they will be processed and validated, **about 4 times a year.**

Next delivery on September 2015: new public data up to June 2015


asdc
ASI Science Data Center
ASI Science Data Center
agenzia spaziale italiana
Home
About ASDC
Public Outreach
Quick Look
Missions
Multimission Archive
Bibliographic services
Helpdesk
AGILE
SWIFT
FERMI
NUSTAR
Gaia
Astrophysics and Cosmology
Astroparticle Physics
Working prototype
(password restricted access)
Mission
active Archive
Mission Selected
AGILE-LV3
AGILE-LV3 Tutorial
Enter source name or coordinates:
PKS 1510-089
RA, DEC
L, B
Lon, Lat
(e.g. CYGX-1 or 19 58 21.7, +35 12 05.8 or 299.590333, 35.201611 or 71.334960, 3.066917)
NEW TOOL: web interface for official interactive on-line ML analysis on AGILE data archive under validation!
Durat
1, 2,
Submit

On-line science ready ML results (no need to install any software)

1) **Source detection**: significance, average gamma-ray flux (or flux upper limit) (Max

2) **Source light curve** in few minutes (depends on # of chosen timebins):

AGILE Legacy Archive and on-line tools to optimize science and discovery potential in the years to come

AG_Multi4 1.4 - Wed

Input

Psf	/data/agile/agil
Raeff	/data/agile/agil
Edp	/data/agile/agil

Gal Mode	Iso Mode
1	1

Map	Name
1	/data/agile/agile

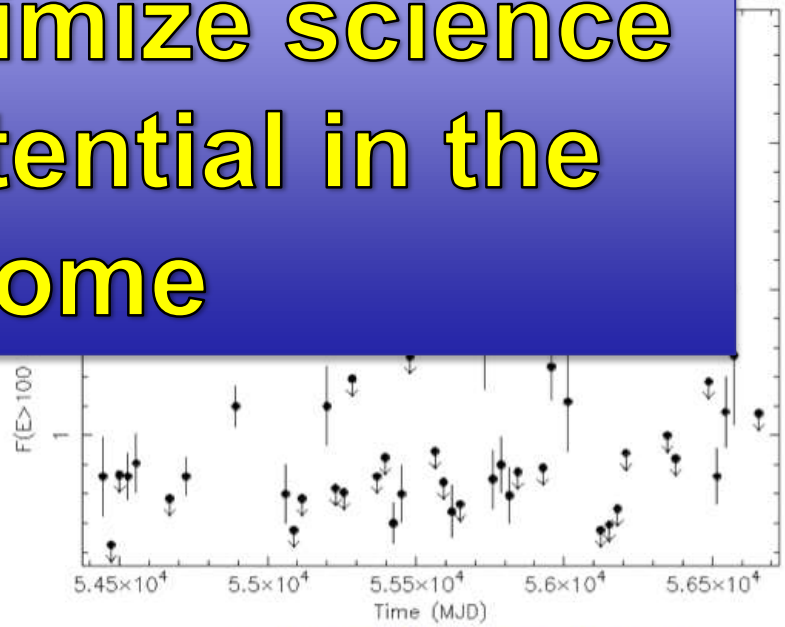
Map	Counts	Date st
1	5933	2011-06-06 12:00:00 2011-07-04 12:00:00 100.50000 0.60 337.5, 41.8103 90 0.25 4 90

Source	Flux	Index	L	B	sqrt(minTS)	FixFlag
1AGLRJ1513-0906-ORIG	1e-06	2.1	351.373	40.091	2	1

Output

DiffName	Coeff	Err	+Err	-Err
Galactic	0.7	0	0	0
Isotropic	13.8561	0.888729	0.902918	-0.874694

SrcName	sqrt(TS)	L	B	Radius	Exp	Counts	Err	Flux	Err	Flux UL	Index	Err
1AGLRJ1513-0906-ORIG	4.89402	351.373	40.091	0	2.26688e+07	41.3843	11.6043	1.82561e-06	5.11906e-07	2.95956e-06	2.1	0



DOWNLOAD: 1AGLRJ1513-0906-ORIG_28dd-timebin_input_for_SED.dat

Total number of GOOD bins in the lightcurve: 45/69

Download GRID ML results

ASDC SED Builder access:
(click below to include SED data points)

Add data to SED

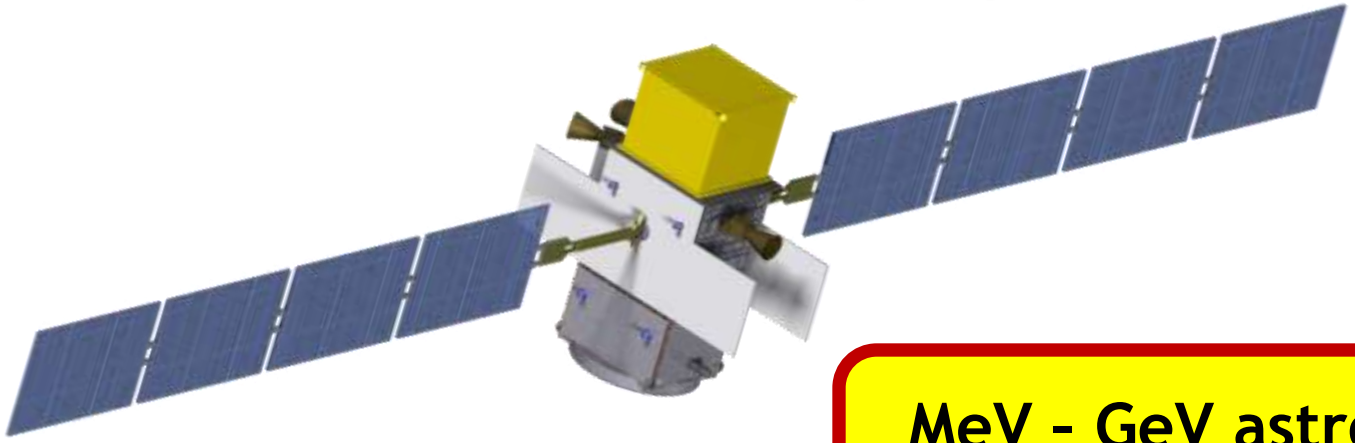
The future…

- **Community should focus and «coalesce» into future projects**

MeV - GeV astrophysics:
OPENS A NEW
OBSERVATION WINDOW

- **MeV-GeV astrophysics: the ASTROGAM project**
- **Next chance: ESA M5**
- **Open to discussion and collaboration**

The next gamma-ray MeV-GeV mission: the ASTROGAM project



MeV - GeV astrophysics
MeV - GeV community

Proposed for the ESA M4 call; currently under study for enhancement and reconfiguration for the ESA M5 call. ASTROGAM is **focused on gamma-ray astrophysics in the range 0.3-100 MeV** with excellent capability also at GeV energies.

ASTROGAM History and heritage

heritage	M1/M2 (2007)	M3 (2010)	S1 (2012)
CLAIRE, NCT	GRI	DUAL	
COMPTEL	GRIPS I	CAPSITT, GRIPS II	
FERMI / AGILE			Gamma-Light

AstroMeV

M4

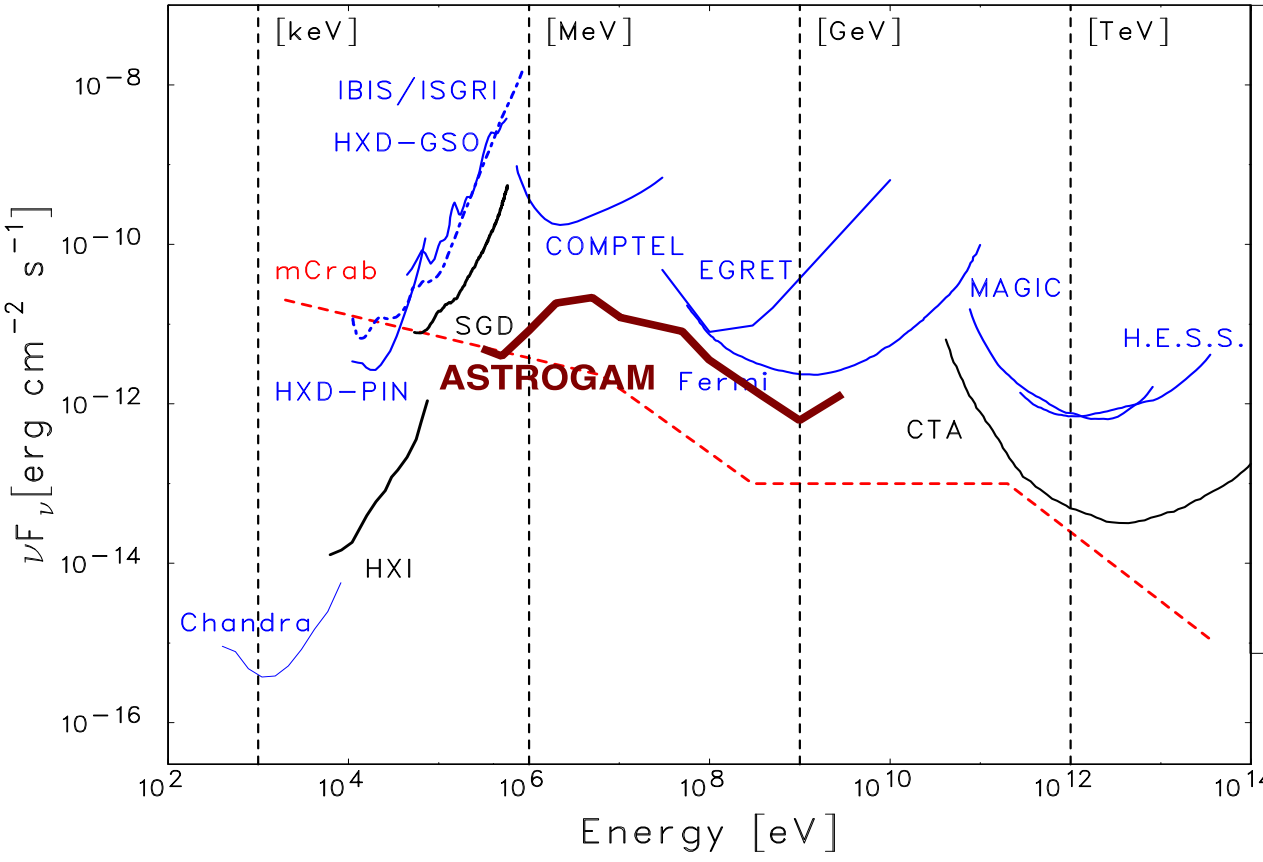
ASTROGAM

MeV - GeV astrophysics

- **A new window for Galactic, extragalactic & fundamental science.**

- **Broad band (0.3 MeV – 3 GeV), focused on the mostly unexplored energy range (0.3- 100 MeV). Continuum & line detection.**

ASTROGAM Sensitivity



Adapted from Takahashi et al. (2013)

- **ASTRO-H/SGD**: S(3σ) for 100 ks exposure of an isolated point source
- **COMPTEL** and **EGRET**: sensitivities accumulated during the whole duration of the CGRO mission (9 years)
- **Fermi/LAT**: 5σ sensitivity for a high Galactic latitude source and after 1 year observation in survey mode
- **ASTROGAM** – 3σ/5σ sensitivity for a 1-year effective exposure of a high Galactic latitude source (M4 configuration)

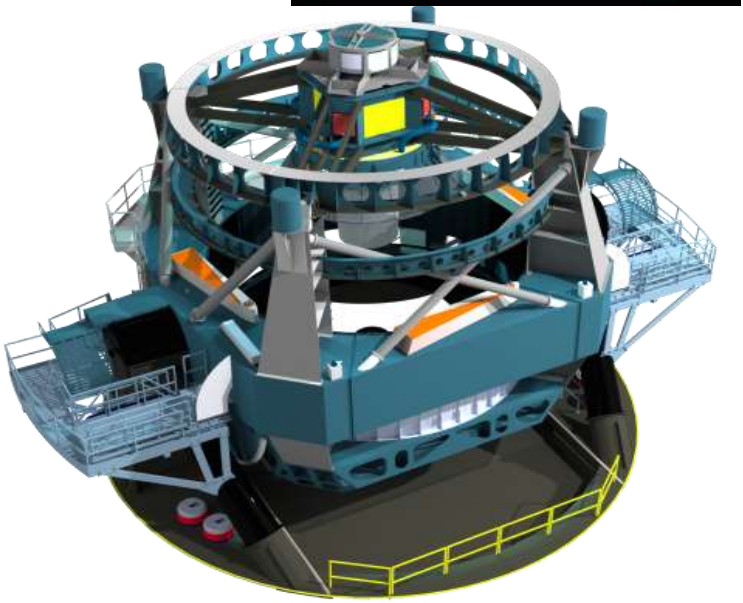
ASTROGAM will gain a factor 10−30 in line sensitivity compared to INTEGRAL/SPI

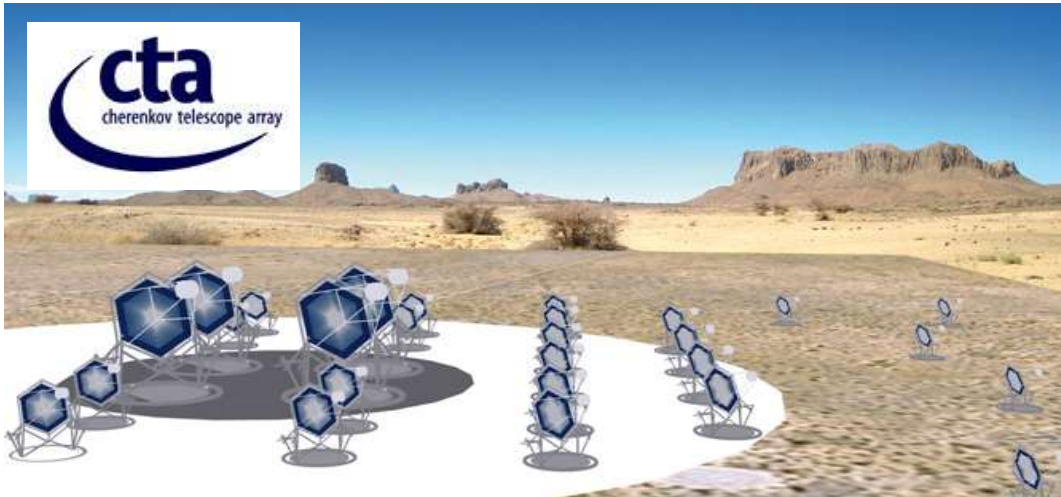
E (keV)	FWHM (keV)	Gamma-ray line origin	SPI sensitivity (ph cm^{-2} s^{-1})	ASTROGAM (ph cm^{-2} s^{-1})
847	35	^{56}Co line from thermonuclear SN	2.3 ´ 10^{-4}	8.7 ´ 10^{-6}
1157	15	^{44}Ti line from core-collapse SN remnants	9.6 ´ 10^{-5}	8.4 ´ 10^{-6}
1275	20	^{22}Na line from classical novae of the ONe type	1.1 ´ 10^{-4}	1.1 ´ 10^{-5}
2223	20	Neutron capture line from accreting neutron stars	1.1 ´ 10^{-4}	1.2 ´ 10^{-5}

ASTROGAM

Time domain astronomy

- A wide-field γ-ray observatory operating at the same time as facilities like LSST and SKA will give a more coherent picture of the transient sky.
- CTA science related to variable sources will need a coverage of the γ-ray sky at lower energies to trigger Target-of-Opportunity observations.



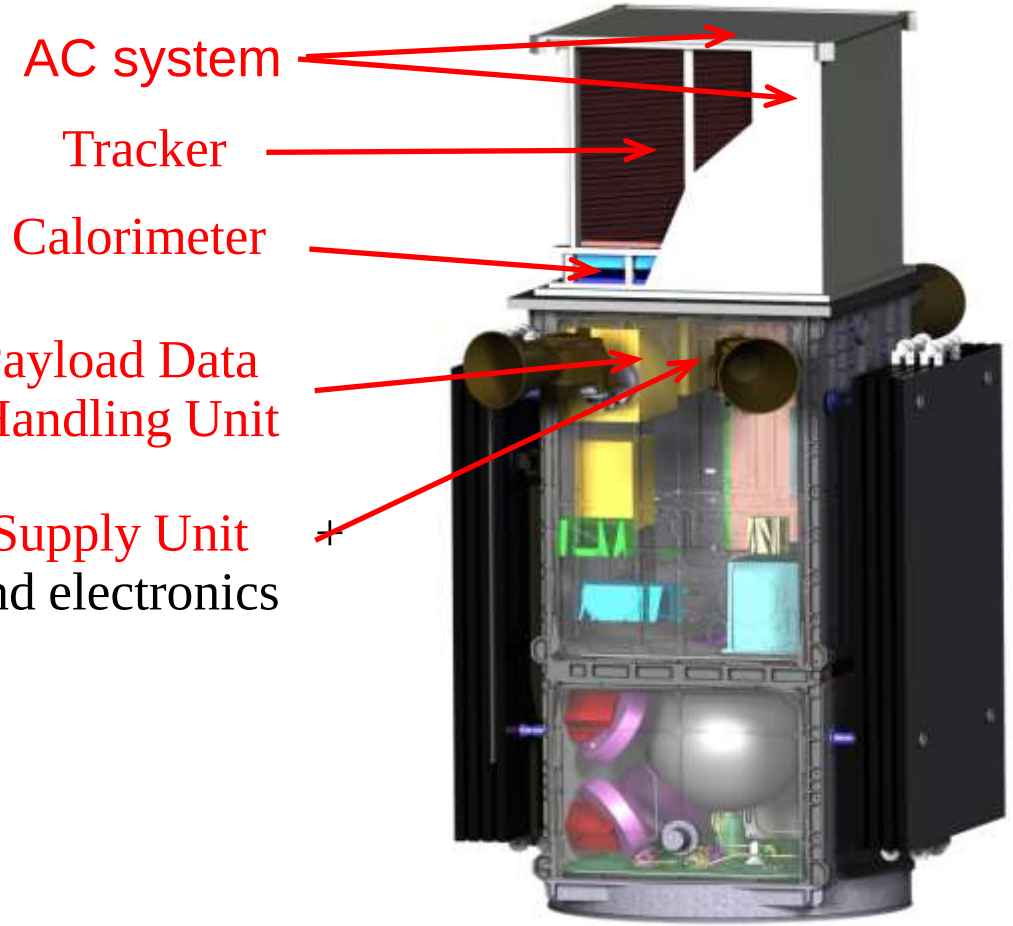


- **For what will ASTROGAM be remembered ?**
  - **Origin of the elements & CR feedback in star formation**
  - **Central region of the Galaxy, the BH activity, origin of antimatter**
  - **Resolving the mystery of the extragalactic gamma-ray background in the MeV range**
  - **DM searches in regimes not accessible by current accelerators or other indirect searches**

- **ASTROGAM will change our view of the nearby and distant Universe !**

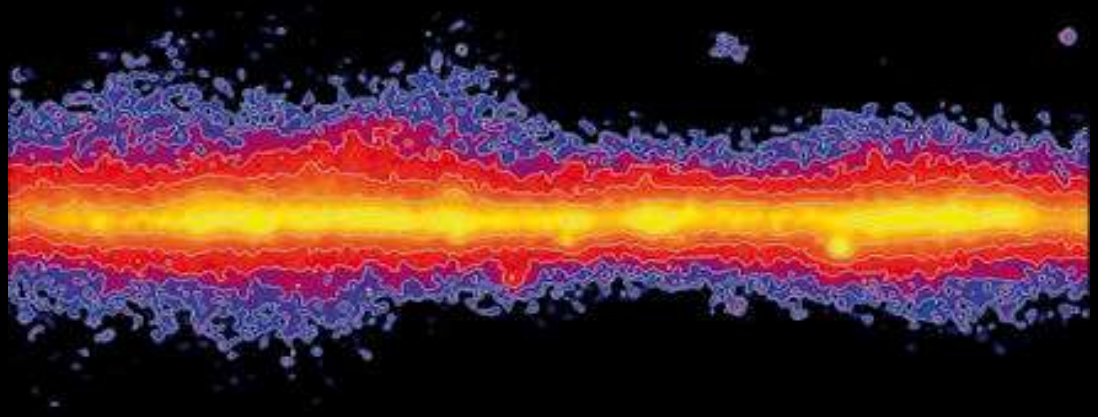
Payload and satellite

- **ESA guidelines for the M4 Call ⇒ ASTROGAM payload designed to be 300 kg (total satellite mass 860 kg).**



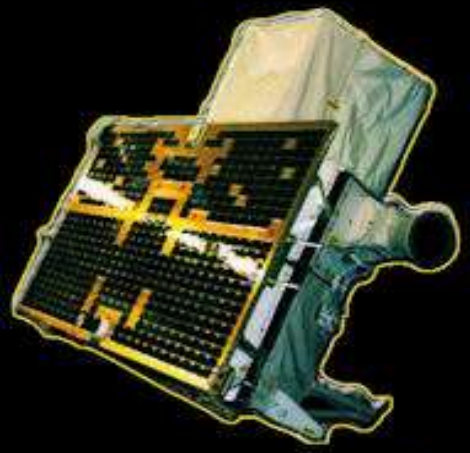
- Steerable solar panels
- Microsecond timing through a GPS unit.
- Possibility of fast communication to the ground through TDRSS.

13th **AGILE** Science Workshop



AGILE: 8 AND COUNTING

All presentations available on-line from:
http://www.asdc.asi.it13thagilemeeting/



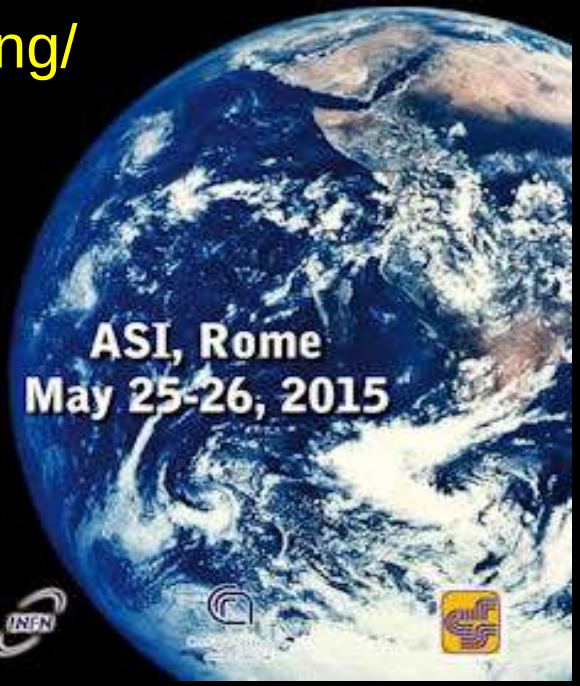


Table 3: **AGILE Scientific Performance**

Gamma-ray Imaging Detector (GRID)		
Energy Range	30 MeV – 50 GeV	
Field of view	~ 3 sr	
Sensitivity at 100 MeV (ph cm^{-2} s^{-1} MeV^{-1})	6×10^{-9}	(5σ in 10^6 s)
Sensitivity at 1 GeV (ph cm^{-2} s^{-1} MeV^{-1})	4×10^{-11}	(5σ in 10^6 s)
Angular Resolution at 1 GeV	36 arcmin	(68% cont. radius)
Source Location Accuracy	$\sim$5–20 arcmin	S/N$\sim$10
Energy Resolution	$\Delta E/E \sim 1$	at 300 MeV
Absolute Time Resolution	$\sim 1\,\mu$s	
Deadtime	$\sim 200\,\mu$s	
Hard X–ray Imaging Detector (Super-AGILE)		
Energy Range	10 – 40 keV	
Field of view	107° ×68°	FW at Zero Sens.
Sensitivity (at 15 keV)	$\sim$5 mCrab	(5σ in 1 day)
Angular Resolution (pixel size)	~ 6 arcmin	
Source Location Accuracy	$\sim$2-3 arcmin	S/N$\sim$10
Energy Resolution	$\Delta E < 4$ keV	
Absolute Time Resolution	$\sim 4\,\mu$s	
Deadtime (for each of the 16 readout units)	$\sim 4\,\mu$s	
Mini-Calorimeter		
Energy Range	0.3 – 200 MeV	
Energy Resolution	~ 1 MeV	above 1 MeV
Absolute Time Resolution	$\sim 3\,\mu$s	
Deadtime (for each of the 30 CsI bars)	$\sim 20\,\mu$s	