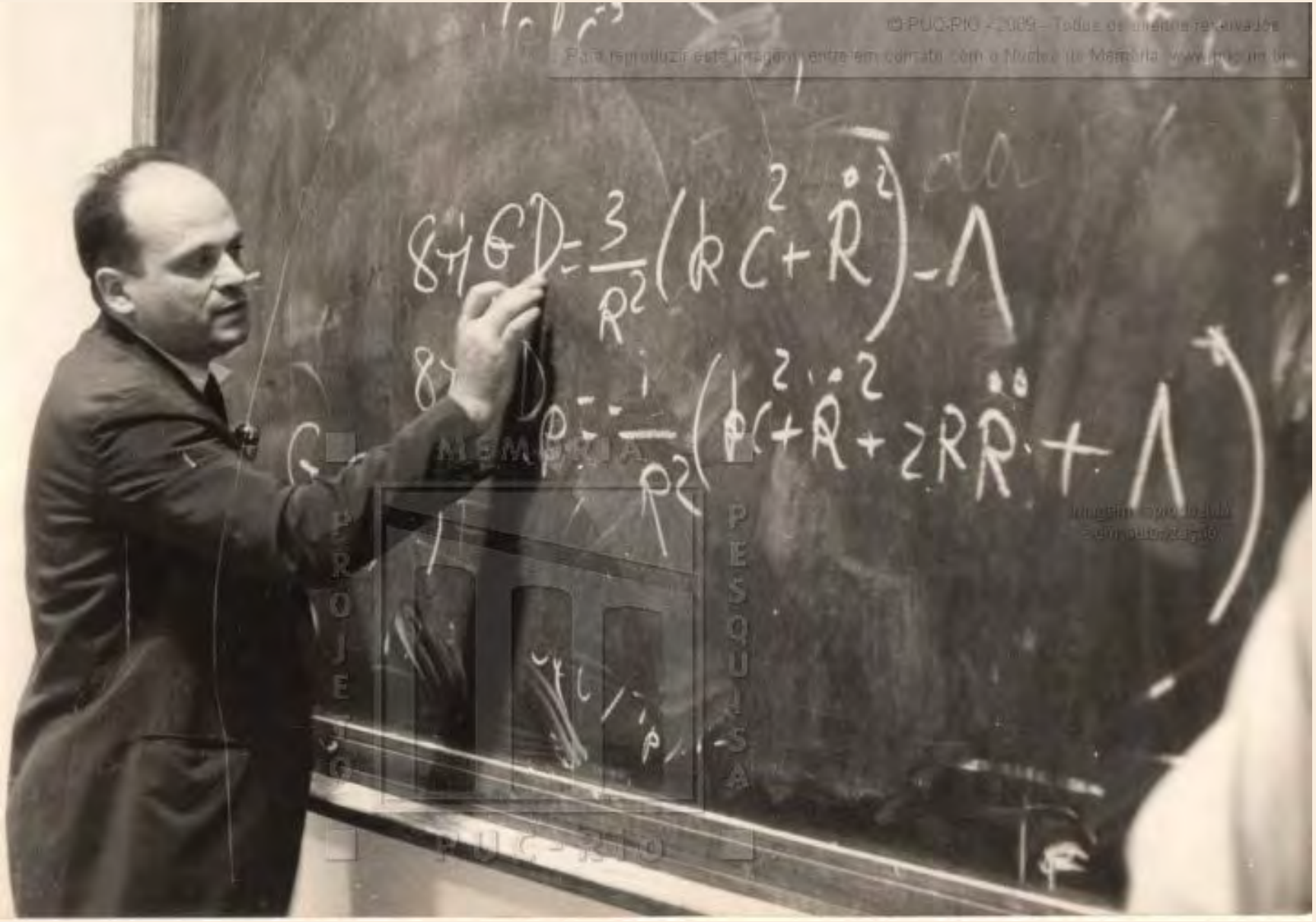
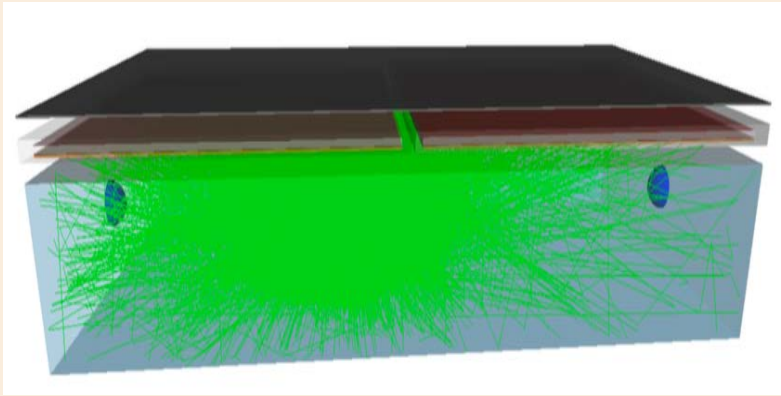


Michele Doro
University and INFN Padova
michele.doro@pd.infn.it

4th LATTES meeting
May 2017, Rio de Janeiro



Science case with LATTES

Disclaimers

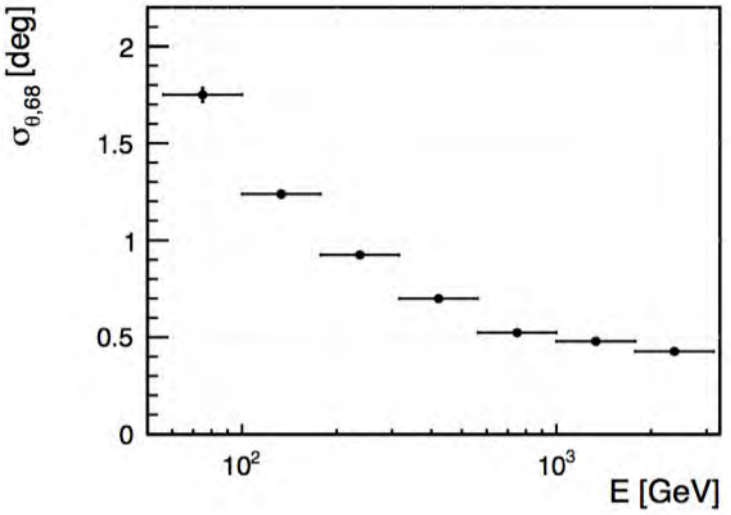
1. Apologies for not being able to come in person… I wish you a fruitful meeting
2. This talk may sound naive or not impartial or too qualitative, I apologize for that
3. Making a serious science case without the full perfomance of an instrument is not possible, take this as a starter for discussion
4. I know of an effort for the definition of the science case for a southern-hemisphere array, and I appreciate this effort: I believe science should be discussed firstly and the outcome shall shape whatever instrument

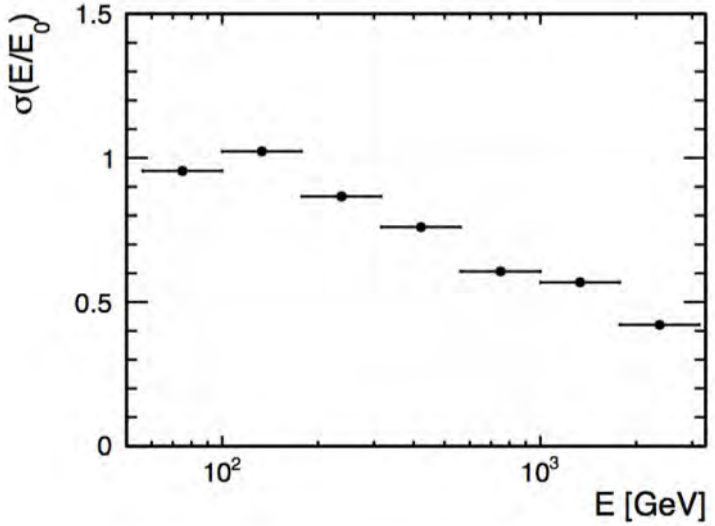
LATTES Facts

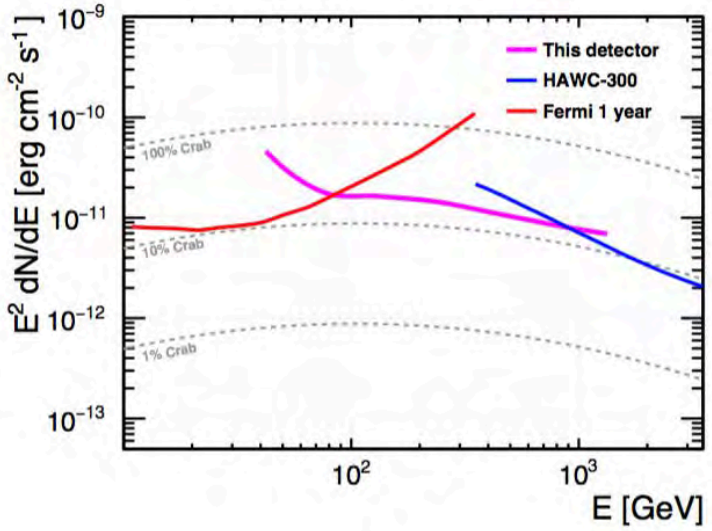
Updates needed!

Quantity	*Fermi*-LAT	IACTs	EAS
Energy range	20 MeV–200 GeV	100 GeV–50 TeV	400 GeV–100 TeV
Energy res.	5-10%	15-20%	~ 50%
Duty Cycle	80%	15%	> 90%
FoV	$4\pi/5$	5 deg × 5 deg	$4\pi/6$
PSF	0.1 deg	0.07 deg	0.5 deg
Sensitivity	1% Crab (1 GeV)	1% Crab (0.5 TeV)	0.5 Crab (5 TeV)

arXiv:1607.03051v1

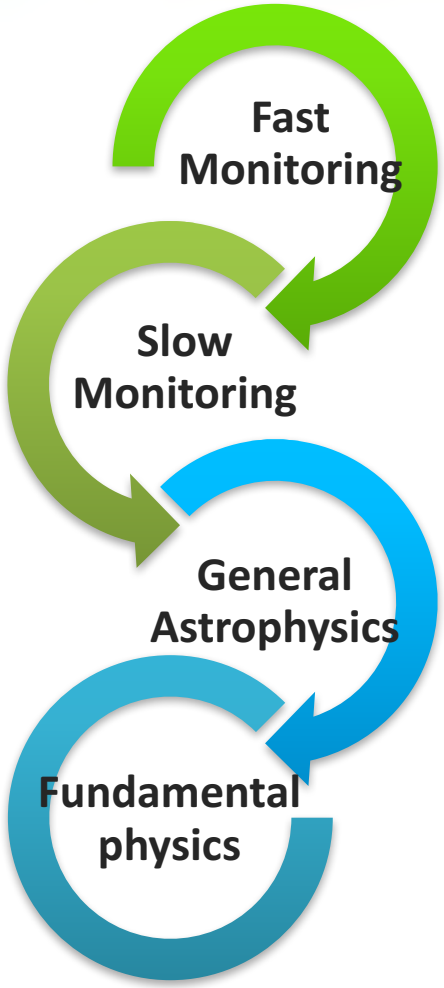






- LATTES cards
  - Wide FOV
  - Large duty cycle
  - Energy range 100 GeV – 100 TeV?
- And, although the final design is not fully simulated
  - The angular resolution is acceptable for a lot of science case
  - The energy resolution is instead a strong drawback for precise science

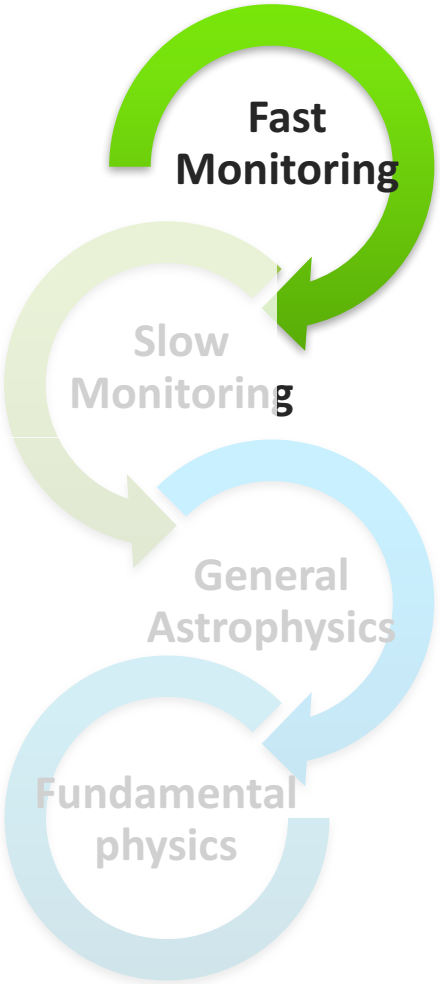
What can LATTES do?



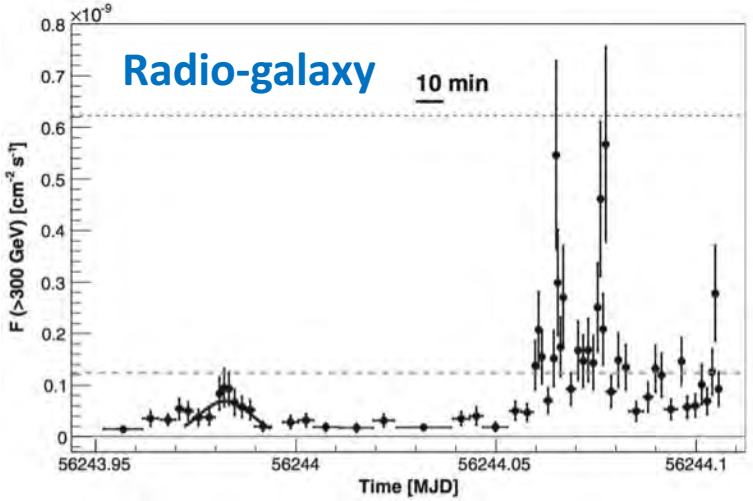
- Physics case can be classified in (my opinion):
  - **Fast Monitoring: Serendipituos flare hunting + trigger of other observatories.**
  - **Slow Monitoring : Long baseline on several TeV sources.**
  - **General Astrophysics: high energy TeV tail + sinergy with IACT + wide-FOV observation**
  - **Fundamental physics: exotic physics, the unknown**

- In the following, I will briefly discuss these cases, in a rather naive way. It is clear that all science cases should suffer a ***stress-test*** *against performance.* This has only started for LATTES.

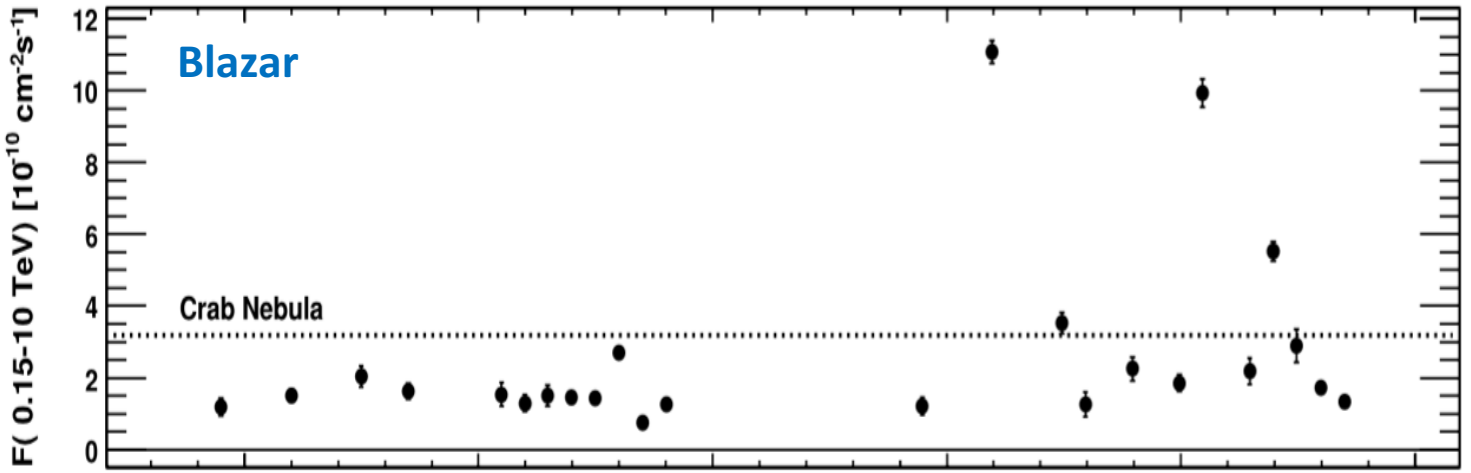
1/ Fast monitoring



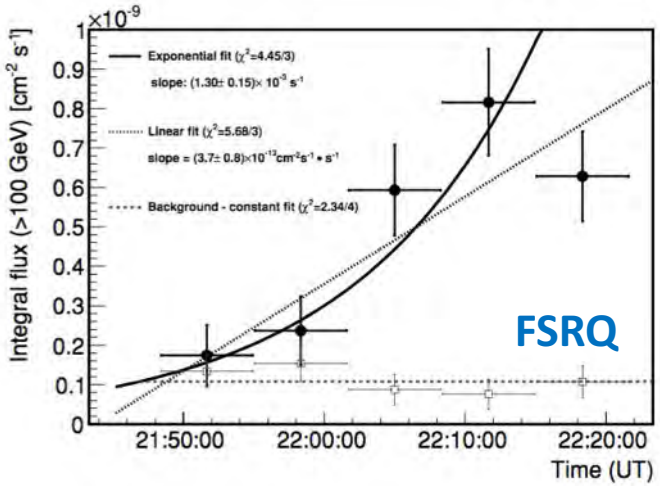
TeV variability



IC310. Doubling time 4.8 min



Mrk501 2005. Flux doubling time ~2min

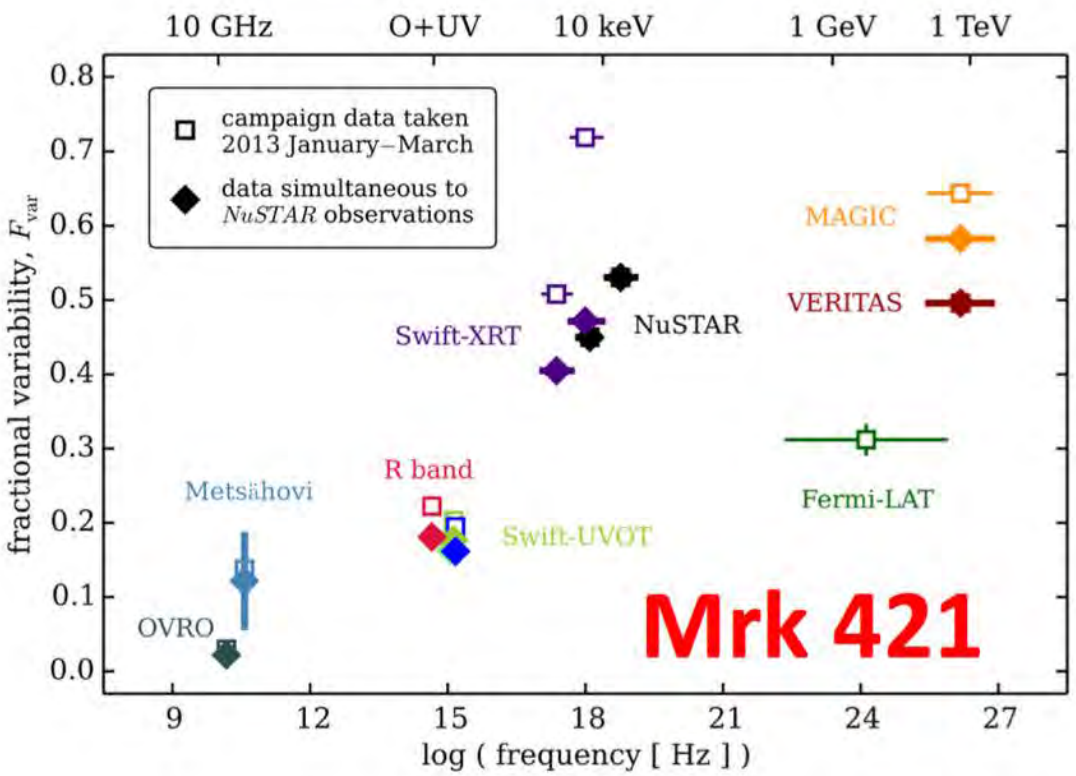


PKS1222. Doubling time 10 min

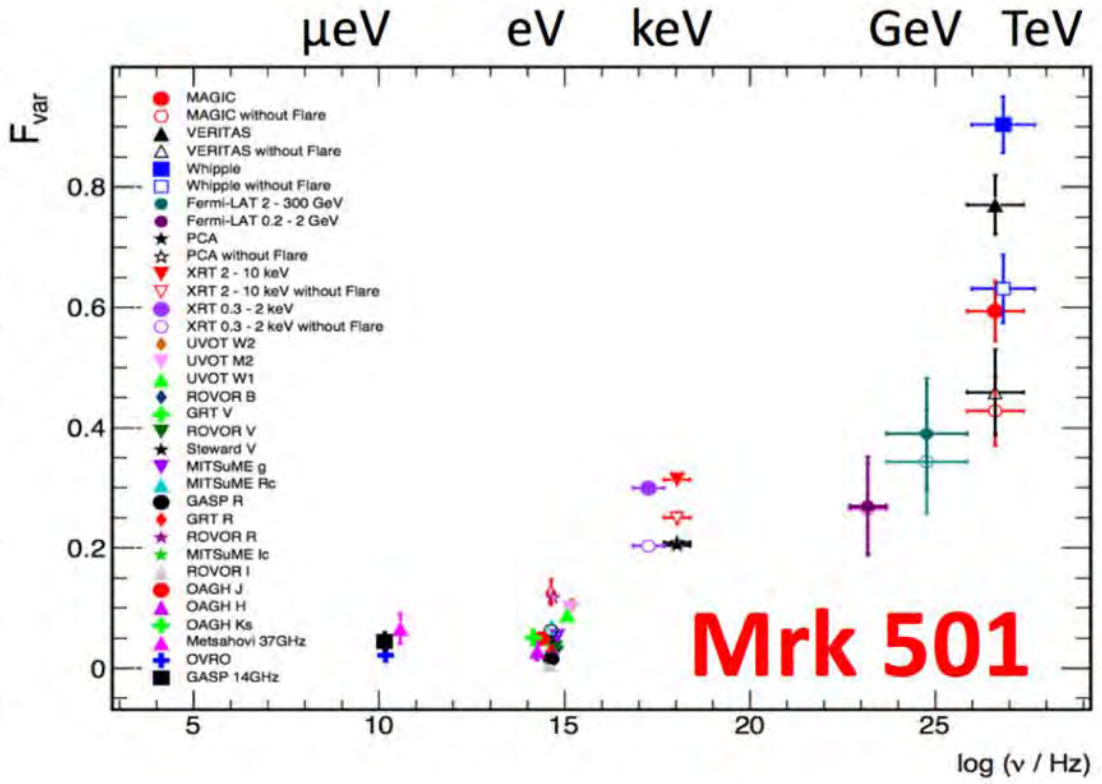
- All kind of sources have shown TeV extremely fast variability Radio-galaxy, Blazars and FSRQ.
- Or flux variation can last longer: days, weeks
- Both obviously carry **relevant information** on acceleration mechanisms and acceleration regions

e.g. Fractional variability: a global picture of dynamics

Balokovic et al., 2016 *ApJ* 819, 156

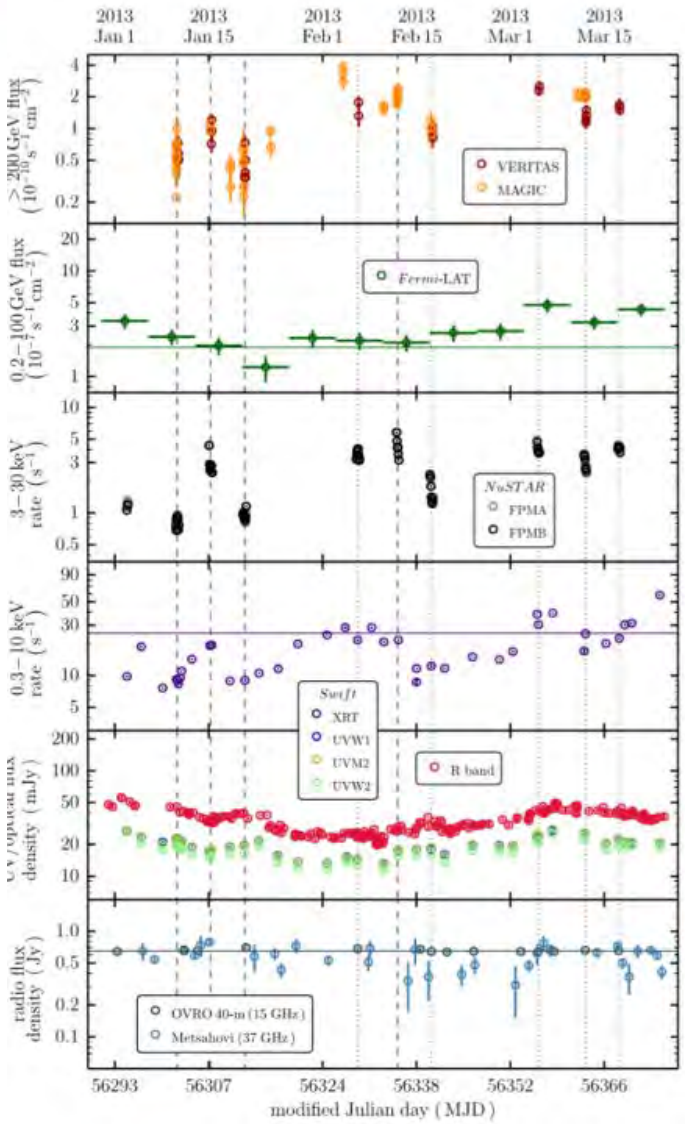


Ahnen et al. Submitted to A&A



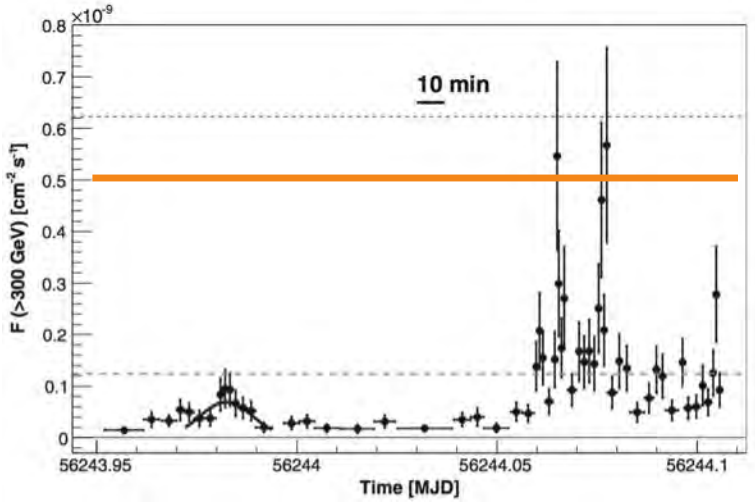
- Fractional variability requires large coverage, but guarantees connection between wavelengths and carry information on particle populations, acceleration efficiency…
- (need enough sensitivity to reach small enough time bins though)

Uncertainties and opportunities



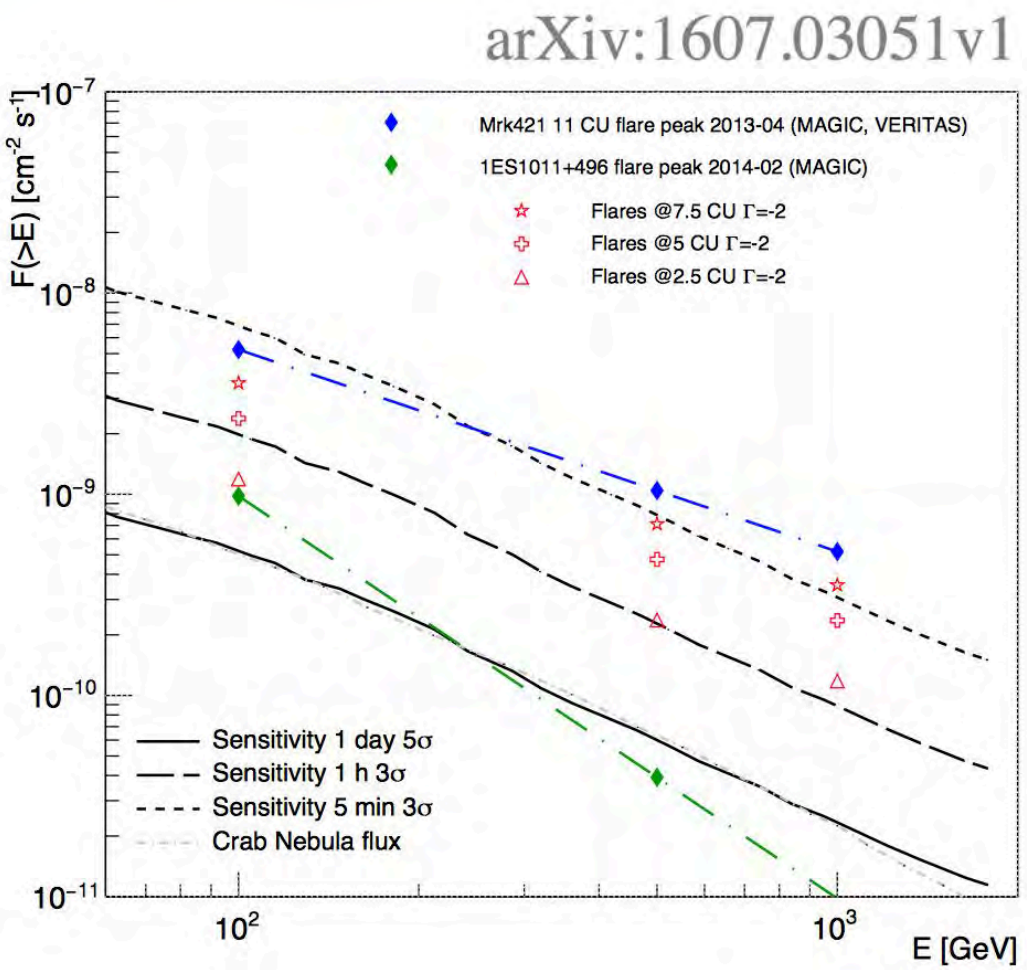
- We are trying to decipher if, how, how much and why lightcurves among different wavelength are connected
- Not clear picture so far, not even a clear HE-VHE connection (e.g. Crab)
- This imply we cannot create a valid statistical sample of flare intensities and durations at the TeV or above.

- It is however clear that **LATTES can become a TeV flare hunter to trigger CTA**



ALERT CTA!

Performance of LATTES (core) for flares

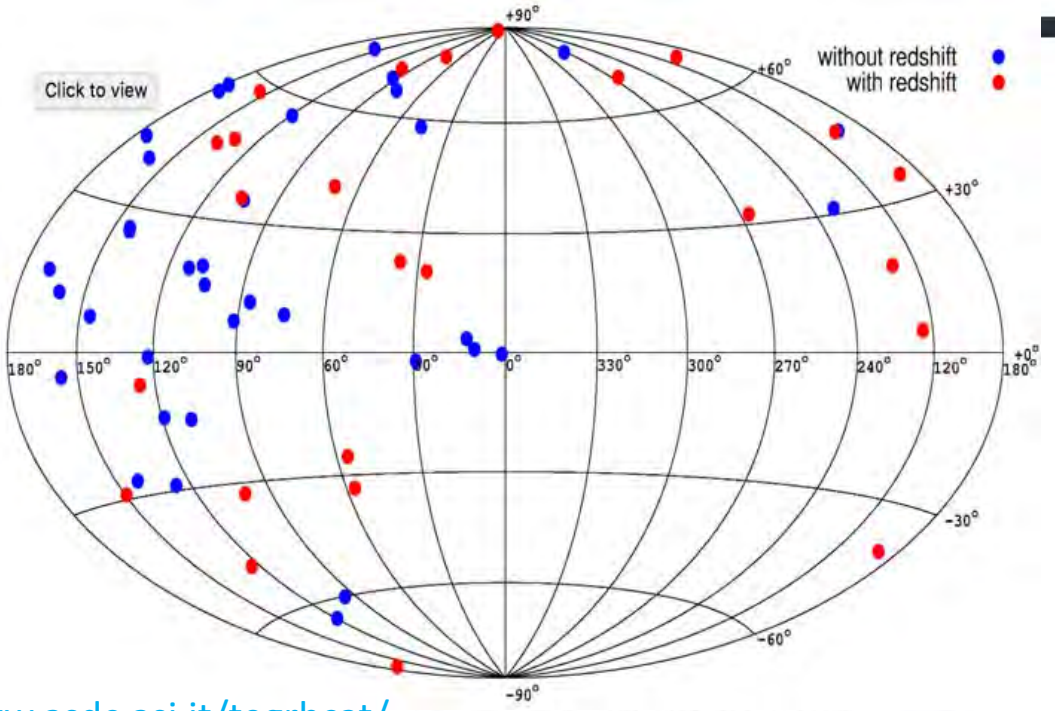


- Using LATTES core sensitivity (low-energy) we have computed prospects for real and benchmark flares:
  - Mrk 421 2013-14 (11 CU)
  - 1ES 1011+496 2014
  - 2.5, 5., 7.5 CU flares
- It is clear that very fast flare (5min@3s) can be detected only if extremely bright
- However, 2.5 CU flare can be detected if longer than 1hour
- How many of them? Not enough statistics

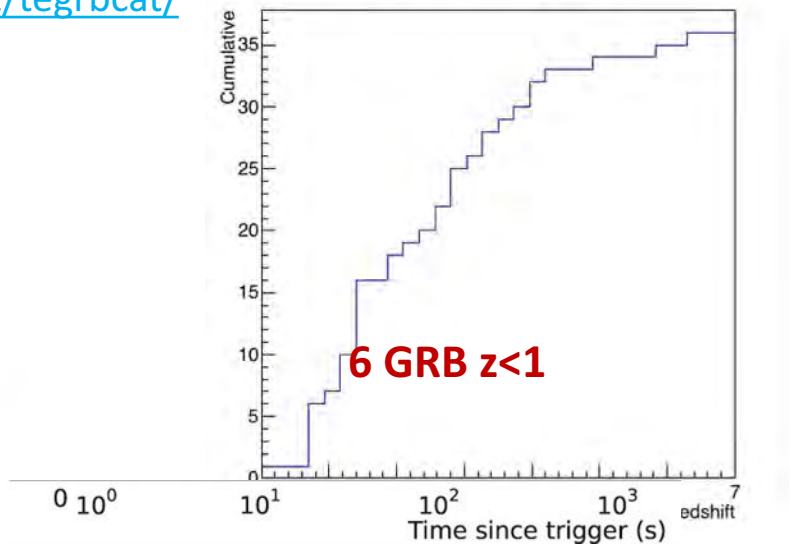
Gamma Ray Bursts

- **MAGIC** observed >**89 GRBs at the TeV:** No significant hints at any target ☹
- However, pointing and follow-up strategy is never optimal for small-FOV instrument:
  - How many to follow-up?
  - For how long to follow-up
- All in all, how many expected to emit at TeV?

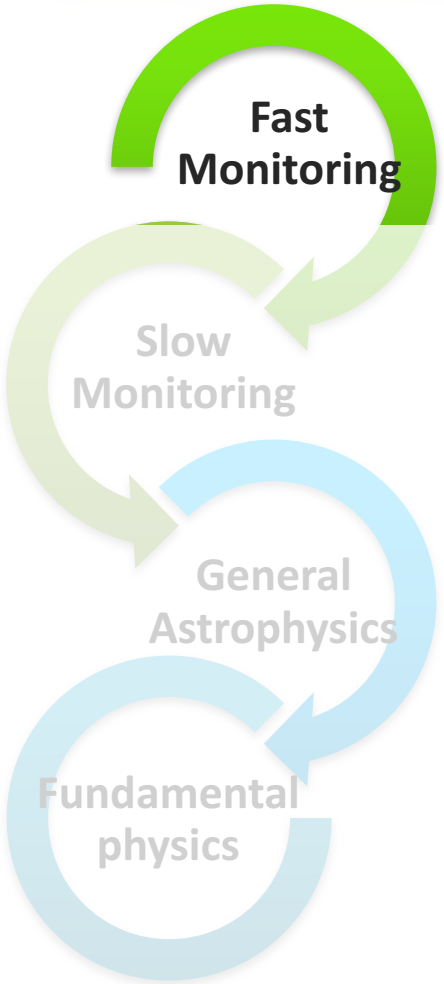
- Obvious core program for LATTES, whose eyes can always be there



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

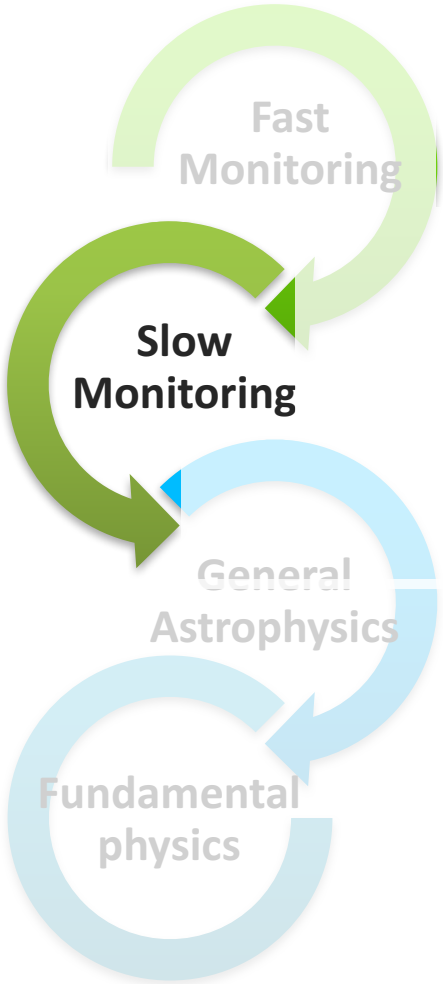


What are the flaring sources



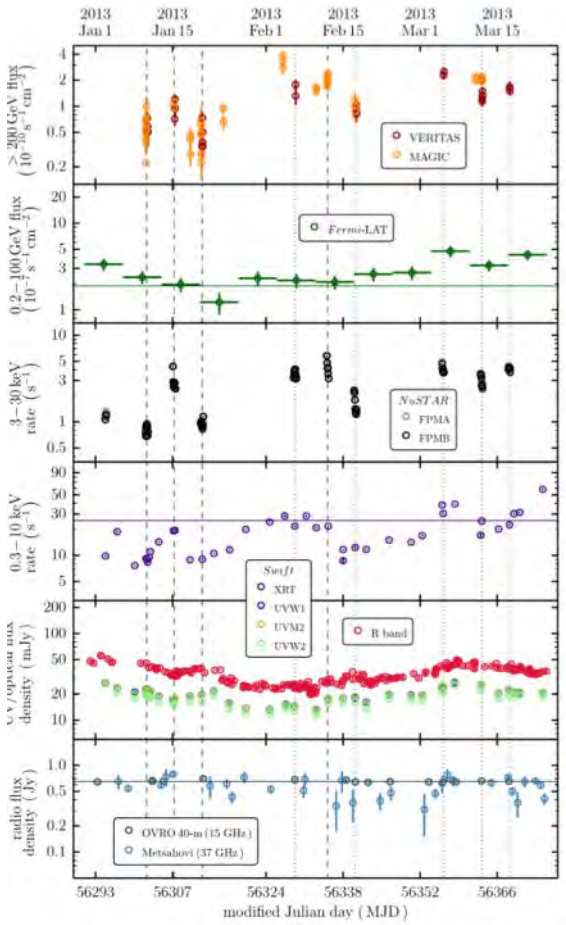
- There are several TeV gamma-ray sources in the sky that may appear above threshold (and later on disappear or go to undetected flux levels). We have seen
  - Active galaxies
  - Gamma-ray bursts
- But also:
  - Micro-quasars / binaries at TeV?
  - Fast Radio Bursts?
  - Primordial Black hole Evaporation?
  - Unknown flares?
- Large space for serendipity here

2/ Slow monitoring

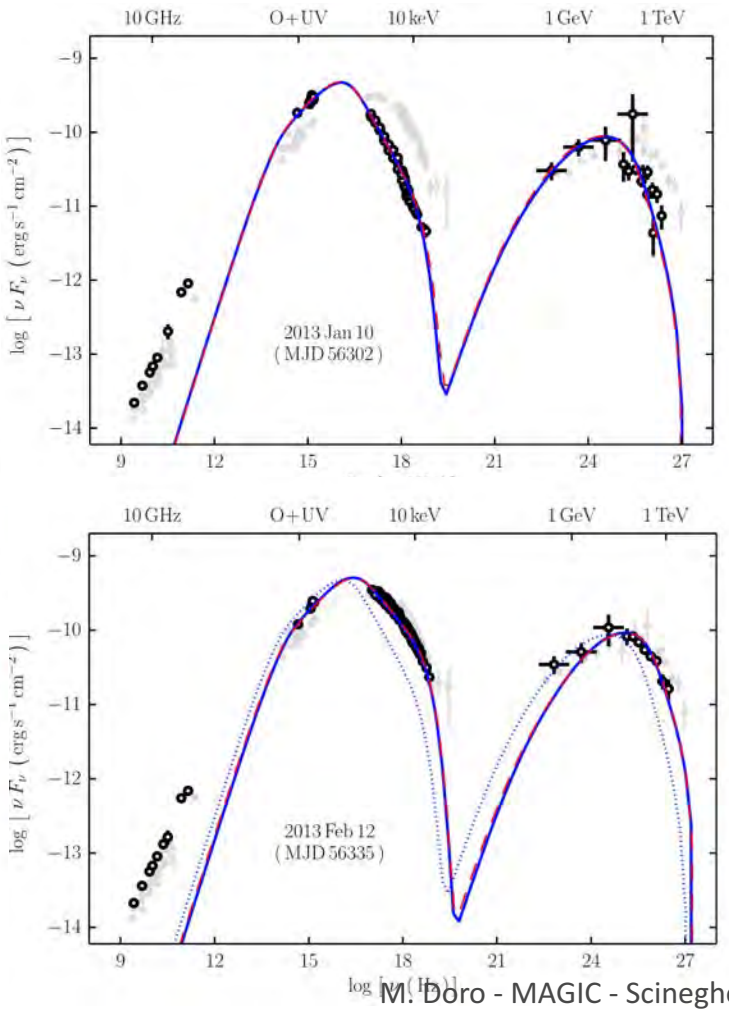


Large projects: Multi-wavelength/multi-year

- The importance of multi-w campaign has become utter



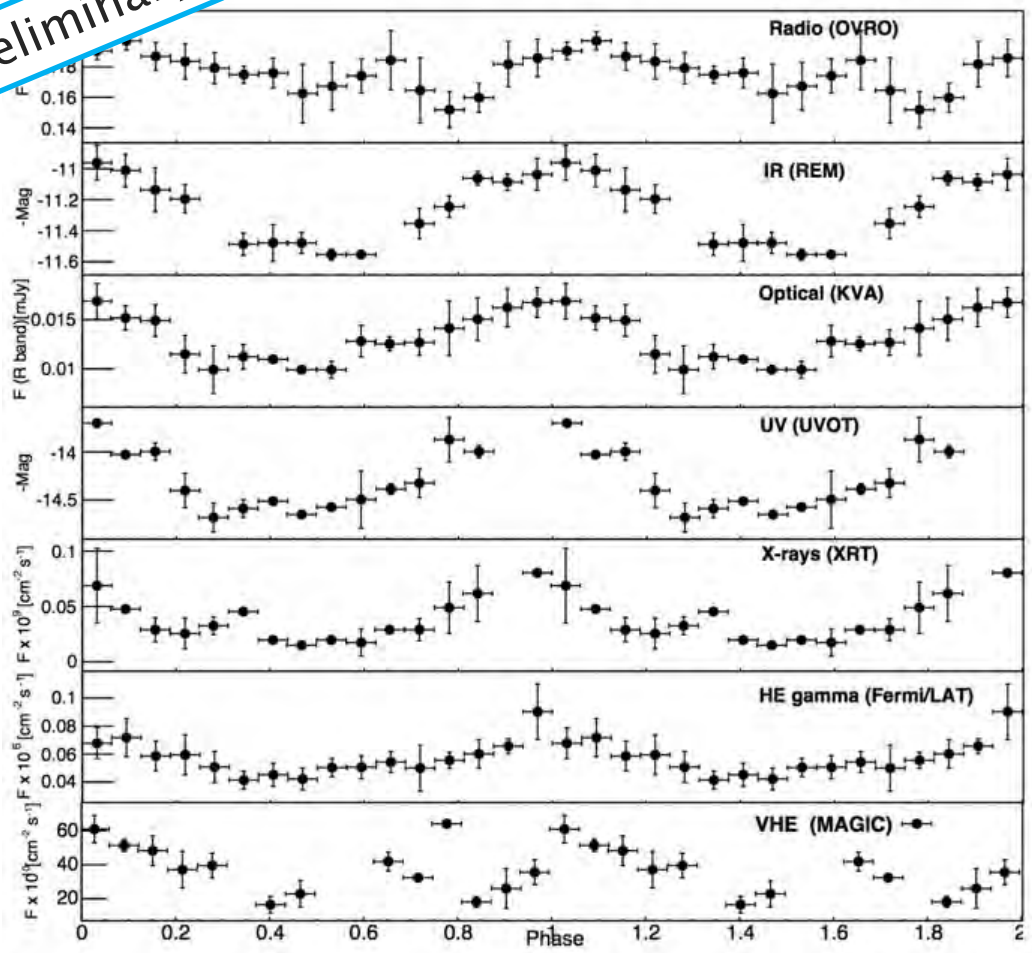
Astrophys.J. 819 (2016) 156



- ← Mrk421 Swift-UVOT, Swift-XRT, NuSTAR, Fermi-LAT, MAGIC, and VERITAS [MAGIC+ 2016 Apj 819]
- Flares cause not only increased flux, but also (correlated) peak-shifts.
  - A different (than baseline) electron population swept-up?
  - Same population received boost?
- It is clear that dense monitoring is utterly important

Example: Periodicity of 1553 – very long-term monitoring

preliminary



Da Vela+ Proc. Gamma2016

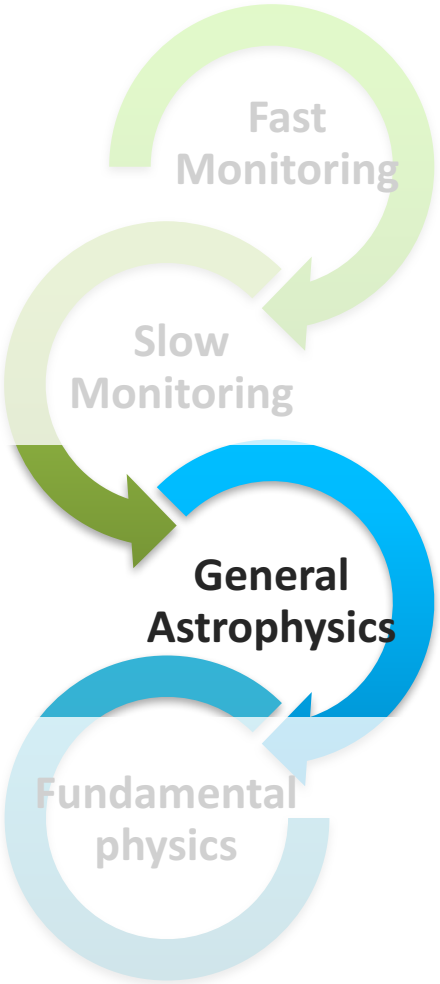
- **PG 1553+113** is the first gamma-ray blazar with a compelling evidence of **quasi-periodic modulation** (2y) in the correlated gamma-ray and optical light curves.
- Can be interpreted as **periodic changes in jet geometry or feeding processes**
  - The presence of a secondary black-hole in a sub-parsec orbit respect to the primary SMBH
  - Different mechanisms as jet precession, internal jet rotation, or helical jet motion may be invoked.
- Of course, minimum time bin depends on sensitivity, however, one could find more of this targets with LATTES

Monitoring

- It is again obvious that long-term monitoring can carry more information than snapshots
- They will also drive the way CTA will design its observational program
- Targets:
  - Extragalactic for sure
  - Galactic?
  - Surely serendipity expected
- Of course, all this is true provided enough sensitivity in the sub-TeV range is reached.

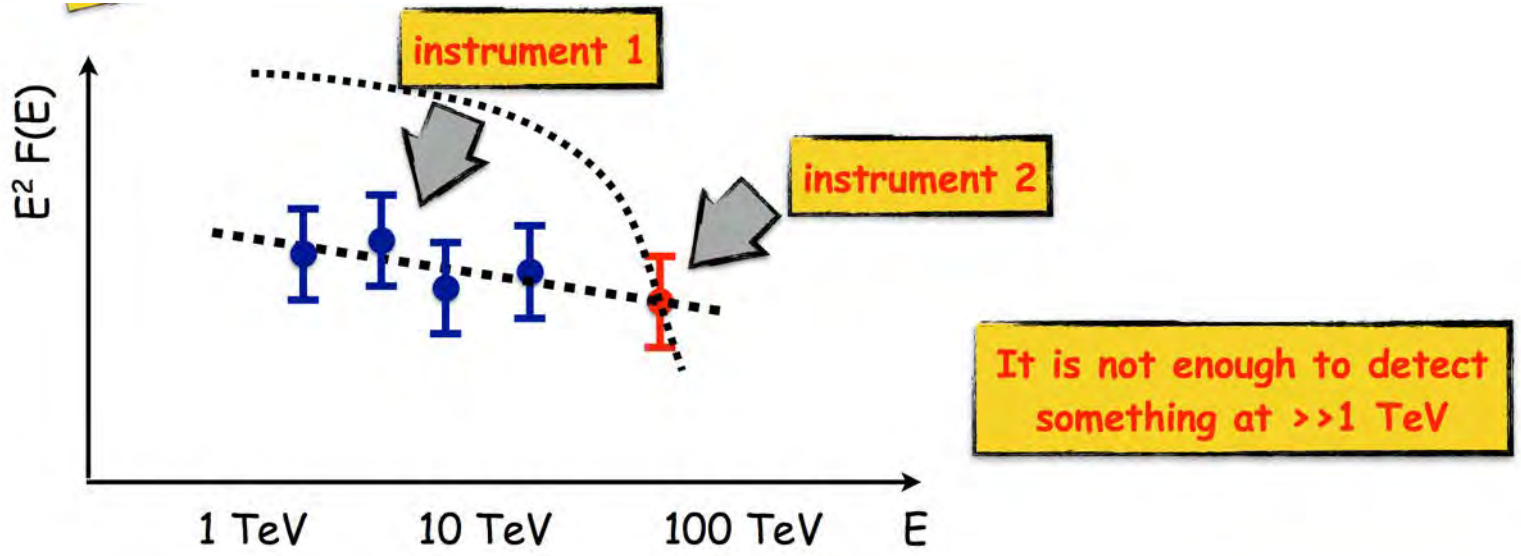
- Prospects to be computed

3/ General Astro



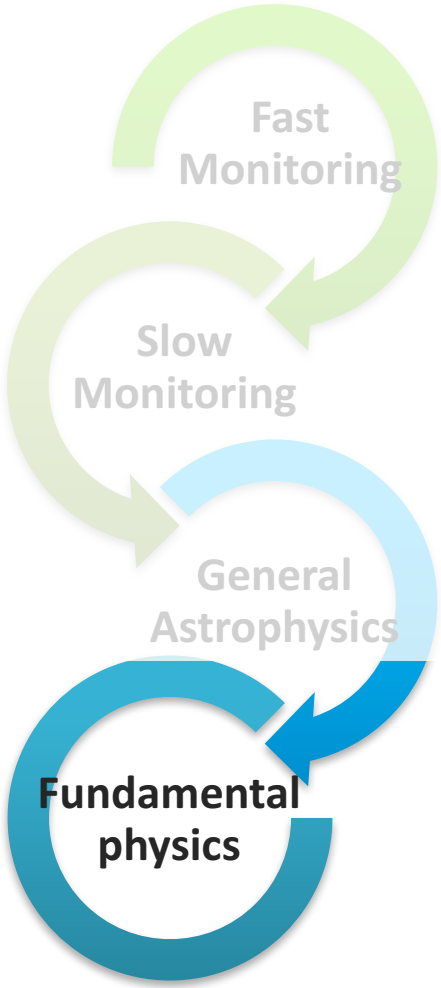
The sea of things to see

One thing at least: provide high energy tail

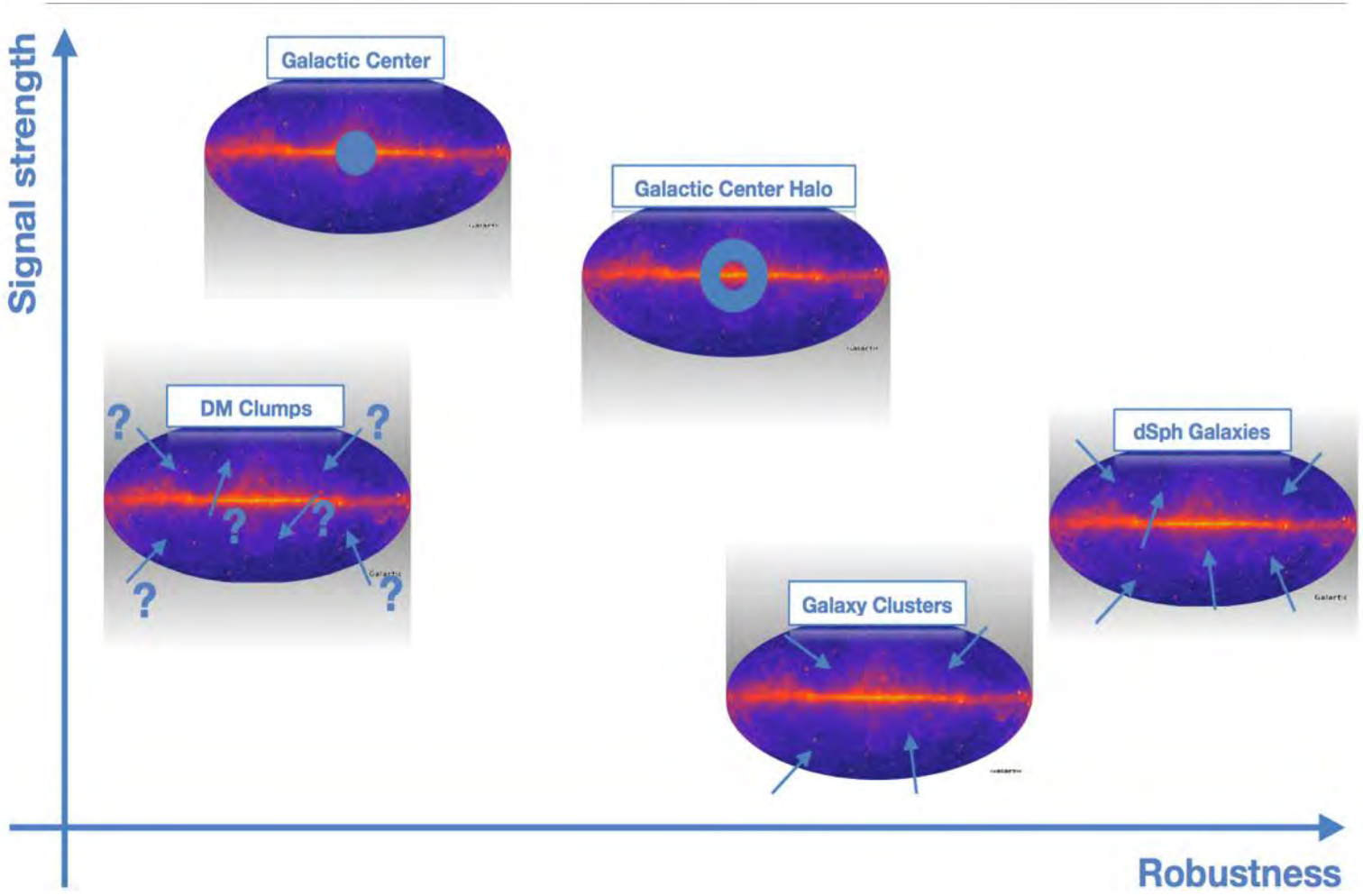


- We have seen with current IACTs how “short” is the 2 orders of magnitude range in energy we achieve
- CTA will solve this issue by going from few tens of GeV to hundreds TeVs
- However, at the highest end, statistics will always be an issue, good to have a 2nd instrument
- Science-wise: Hadronic model hopefully probed by sinergy IACT+EAS detectors

4/Unknown


Fast
Monitoring
Slow
Monitoring
General
Astrophysics
Fundamental
physics

Dark Matter

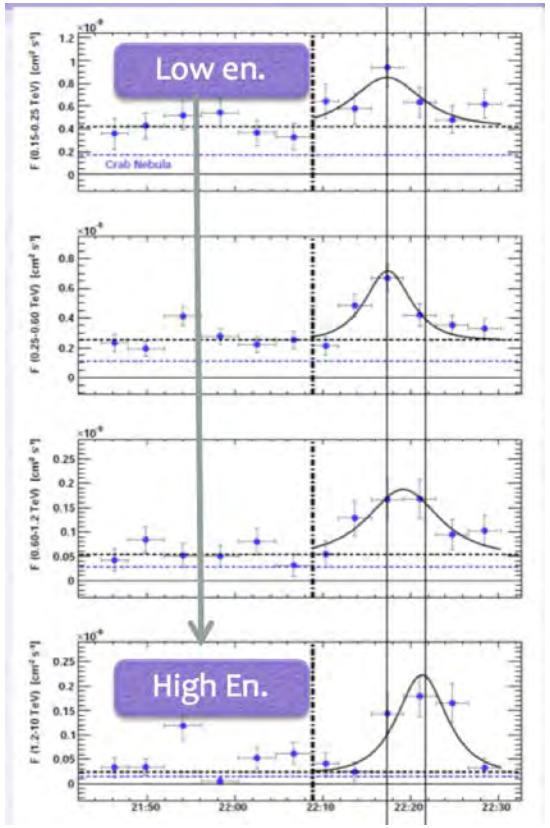


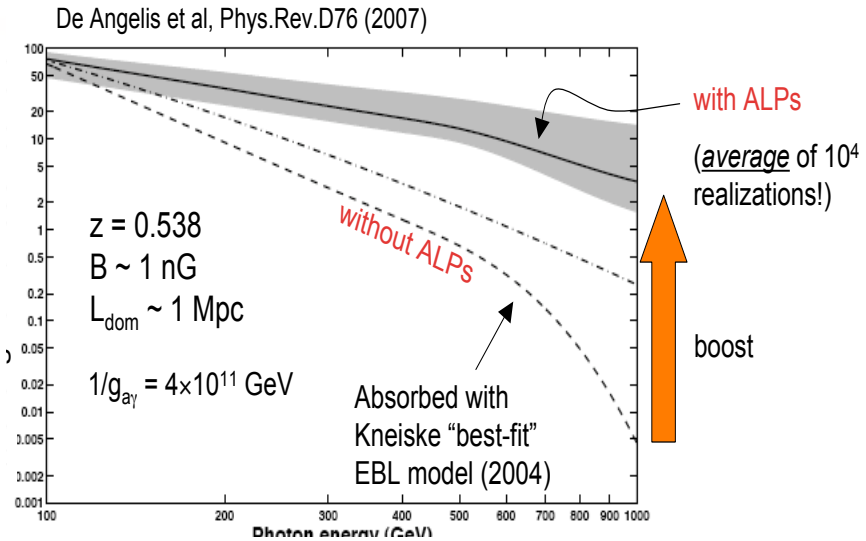
- Several hot-spots in the sky
- Some are too extended for IACT (e.g. clusters)
- DM targets are steady, good to integrate over them for many years
- Dark clumps (only DM, no gas or stars): only wide-FOV can detect them at TeV if exist: good for CTA
- Contributions also to DM anisotropies in the sky

❖ ***DM anisotropies***

+ In principle possible with LATTES although challenging

LIV and ALP – signatures in spectra and time





- Besides dark matter, there are two active research fields now:
  - LIV from AGNs (or GRBs)
  - ALP from AGNs
- **LIV**: arrival time delay from g-ray flare versus g-ray energy should disperse
- **ALP**: spectral changes: photon recovery and/or spectral wiggles

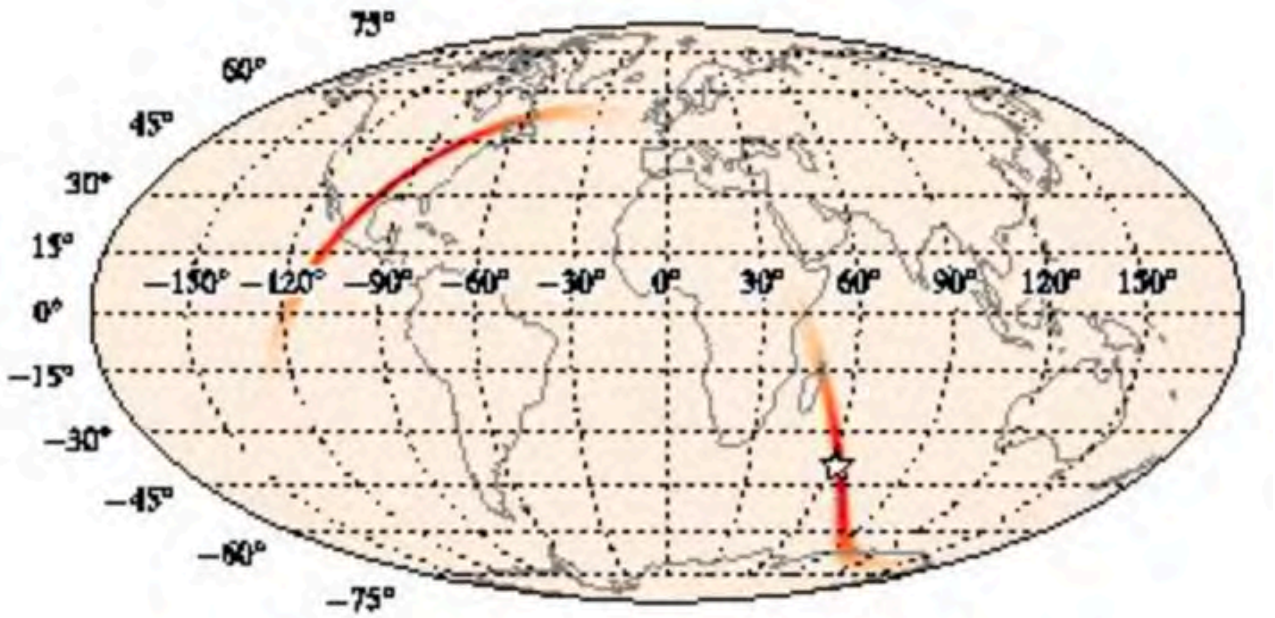
- LATTES would suffer from poor energy resolution…

Rare Events

See also MD, Ricap 2016

- Magnetic monopoles or Quark matter.
  - Maybe they can provide peculiar signature in the calorimeter?
- Primordial black hole evaporation.
  - Formed in the early Universe, because of the Hawing radiation, those with a specific mass could be evaporating today: Brief bursts of gamma rays (similar to short GRBs)
- Dedicated pipelines needed

Gravitational Waves



- An instrument in the S-hemisphere can address the large uncertainty in the GW position due to large FOV
- Good again for CTA too

Summary

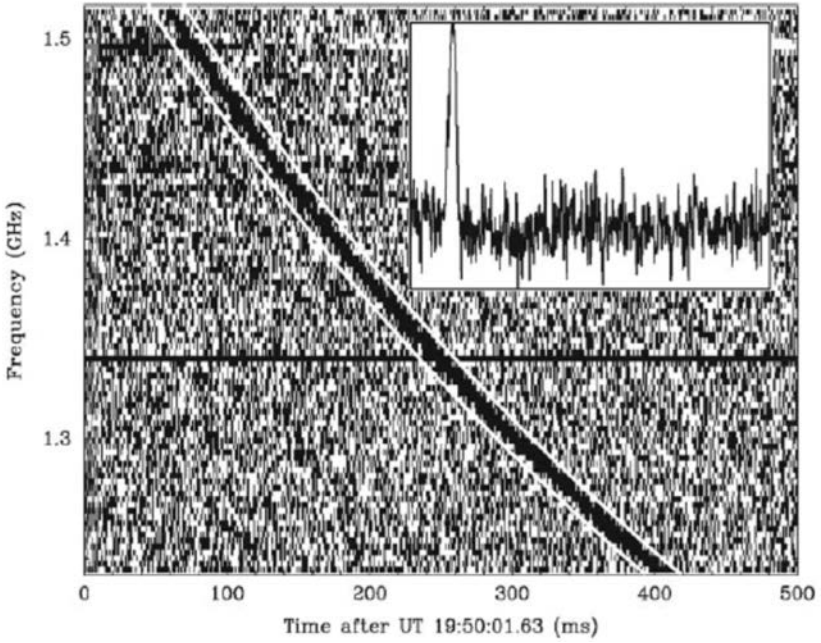
- Science with LATTES is wide, specially if in sinergy with other g-ray installations: CTA, maybe space telescopes too
- Main strenghts:
  - Fast variability
  - Slow variability/monitoring/long baseline
  - High energy multi-TeV tail for acceleration processes
  - Possible contributions to unknowns
- Science should be tested against performance, or better: performance should be determined by science

THANKS

Backup

N5: Fast Radio Bursts (FRBs)

- In 2007 (*analyzing archival data*!) Lorimer discovered a radio burst at 1 GHz with
  - Duration below 1ms
  - Time dispersion
- ..now a catalog of **17 FRBs** is public online
- The **dispersion measurement** provide clues to **distance**: they are likely **extragalactic**
- Association/Nature:
  - FRBs are seen to repeat from the same target! Cannot be a destroying event
  - No clear counterparts at other wl
  - Small size (stellar BH)

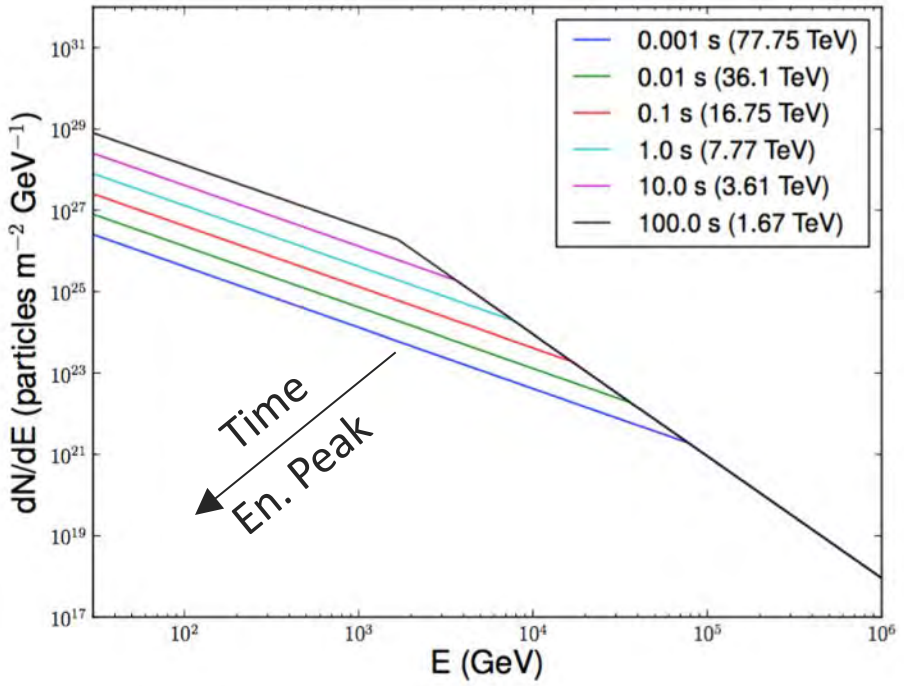


VHE emission if FRBs are associated to magnetar-like sources.
→ serendipitous events in the FOV?

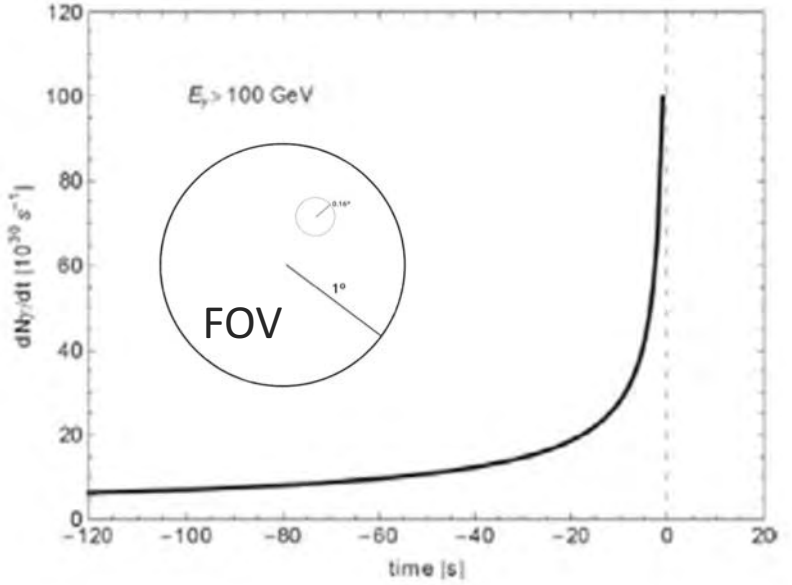
Murase 2016

N4: Evaporating PBH

- Formed in the early Universe, because of the Hawing radiation, those with a specific mass could be evaporating today
  - Brief bursts of gamma rays (similar to short GRBs)



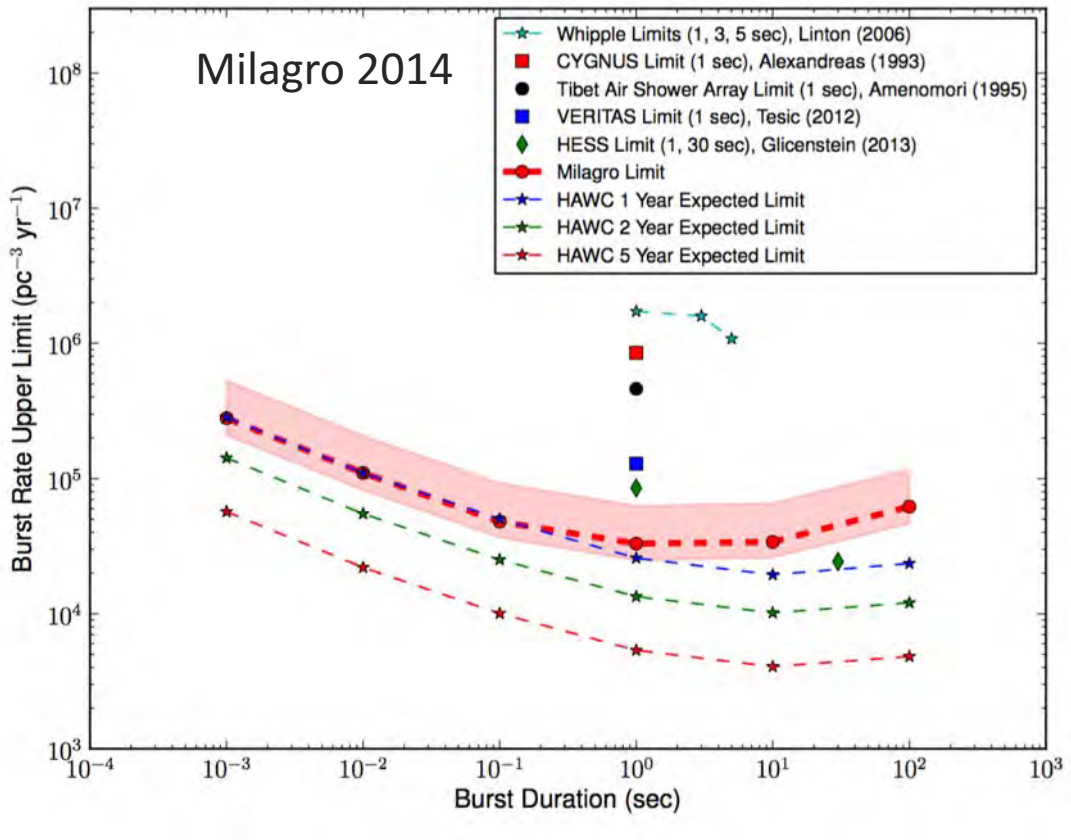
- ← Gamma-ray spectrum for various PBH remaining lifetimes ranging from 0.001 s to 100 s.
- → Short Bursting signal anywhere in the FOV



V. B. Petkov et al., Astronomy Letters, vol. 34, pp. 509–514, Aug. 2008; Abdo et al. Astroparticle Physics, Volume 64, p. 4-12. 2015

MacGibbon, PRD44, 991.

- A dedicated search for short burst anywhere in the FOV can provide a serendipity detection
- Upper limits are given in PBH density explotion rate (pc^3y^{-1})



- Currently most sensitivite searches ($\sim 10^5 pc^3y^{-1}$) are performed with Milagro and HAWC
- **We should investigate LATTES performance**