Variability of Active Galaxy Nuclei at Very High Energy with H.E.S.S

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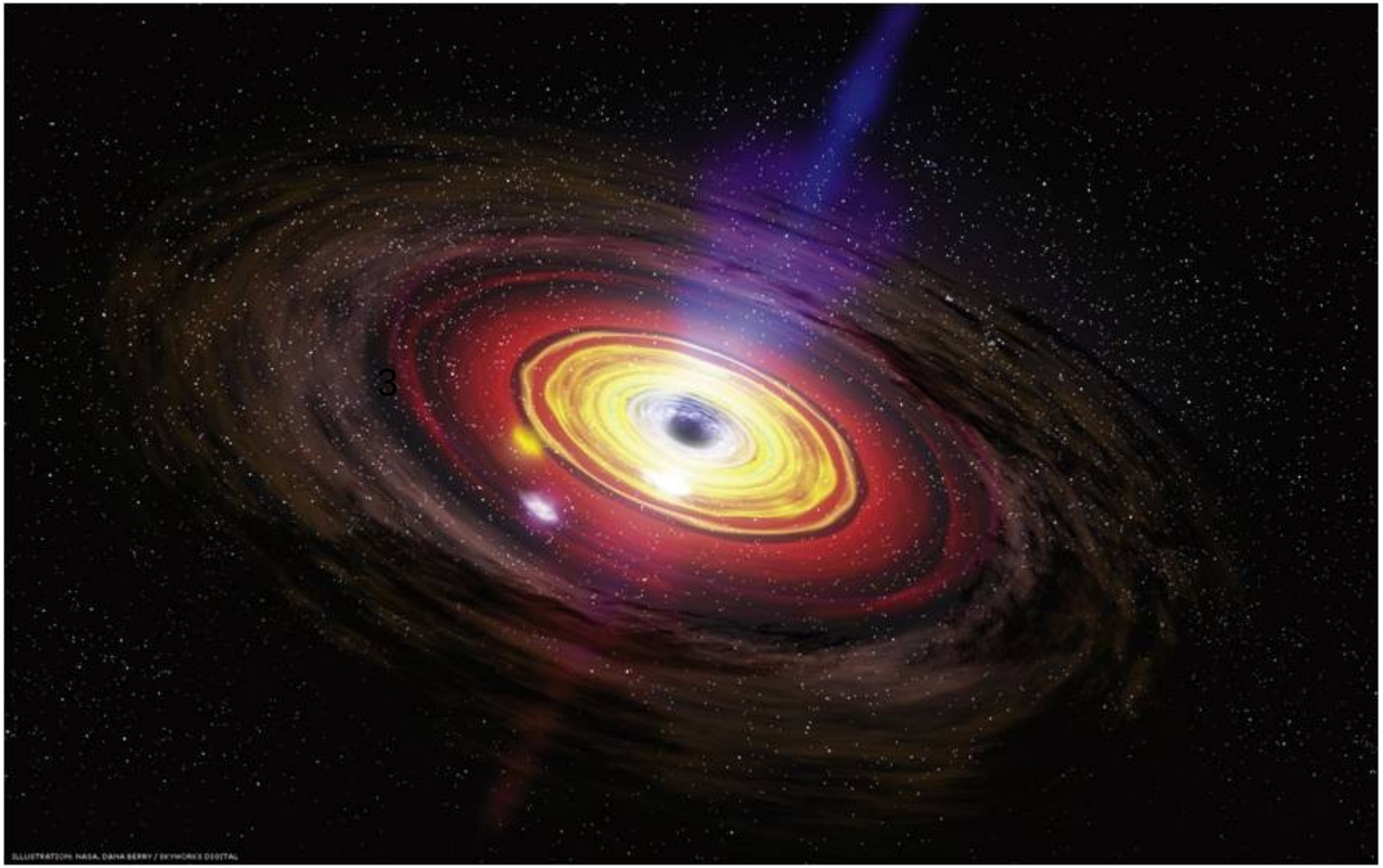
Some important ideas

In a random order, some points addressed in this talk :

High and Very High Energy photons
Ultra-relativistic acceleration
Interactions responsible of the emissions
Travel of the particles
Reception of the signal
Extension of the analysis software

I – Active Galaxy Nuclei



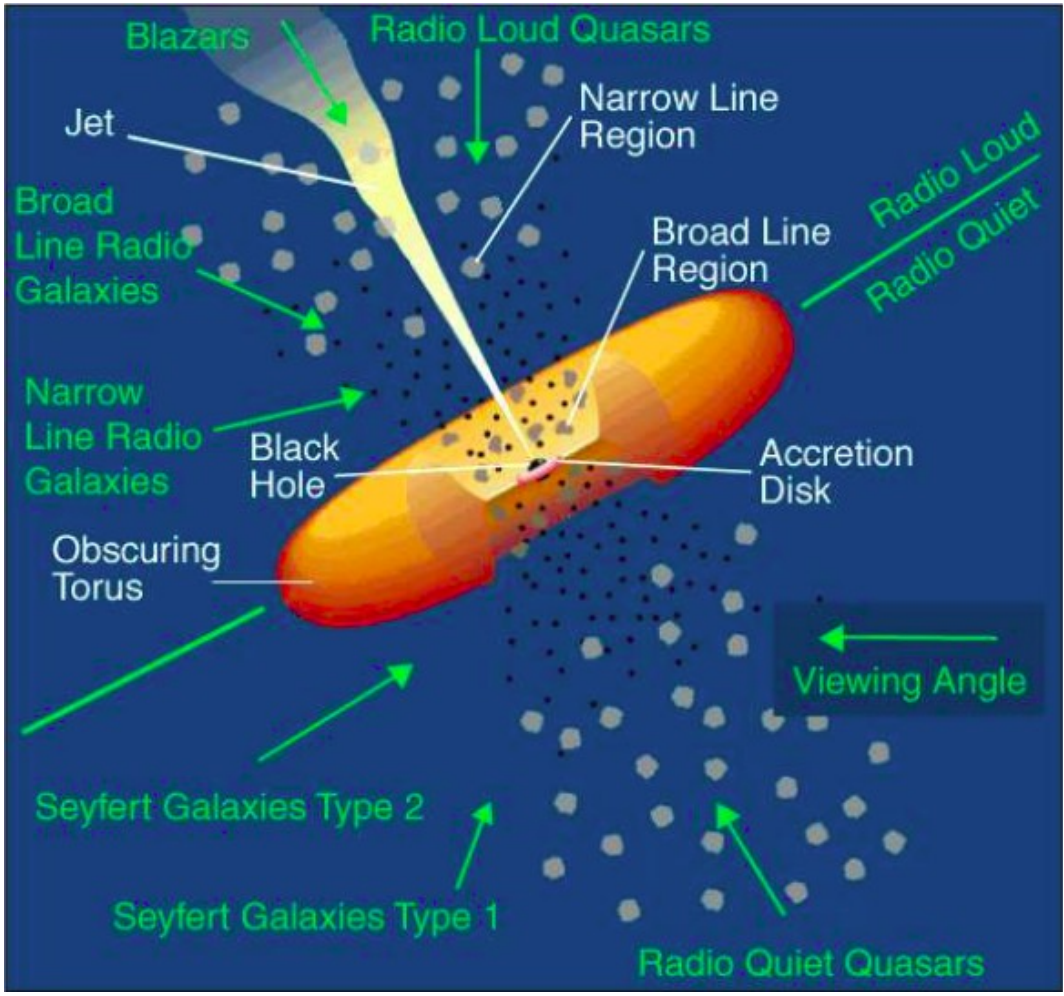
I – Active Galaxy Nuclei

Usual source of light in galaxies :
Stars, dust and gas

Active galaxy nuclei :
Strong additional source at the center of some galaxies

A sub-category of AGN emits at high and very high energy

Very High Energy > 100GeV



Urry & Padovani 1995

I – Active Galaxy Nuclei

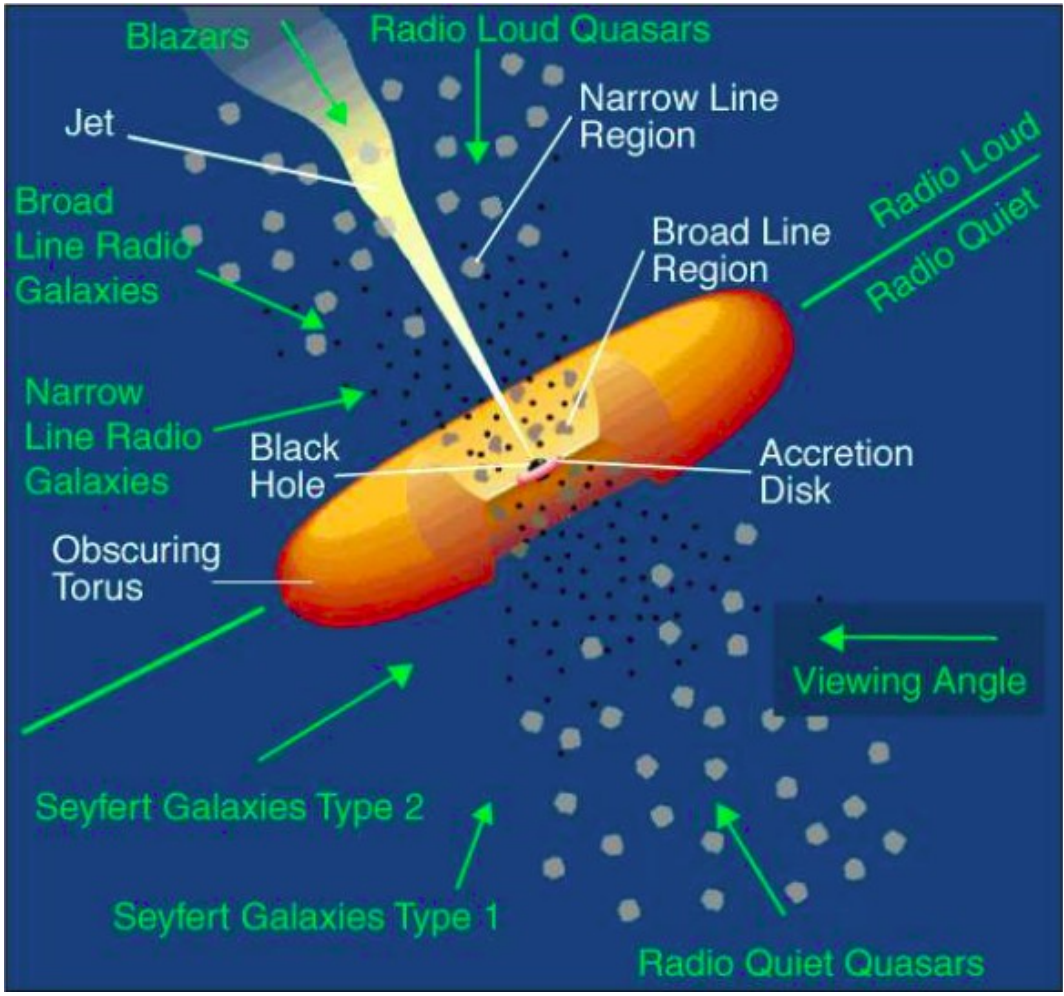
- Super-massive black hole :
$M>10^6$ solar masses

- Accretion disk of in-falling matter :
thermal emission + X-rays

- Large torus

And in less than 10% cases

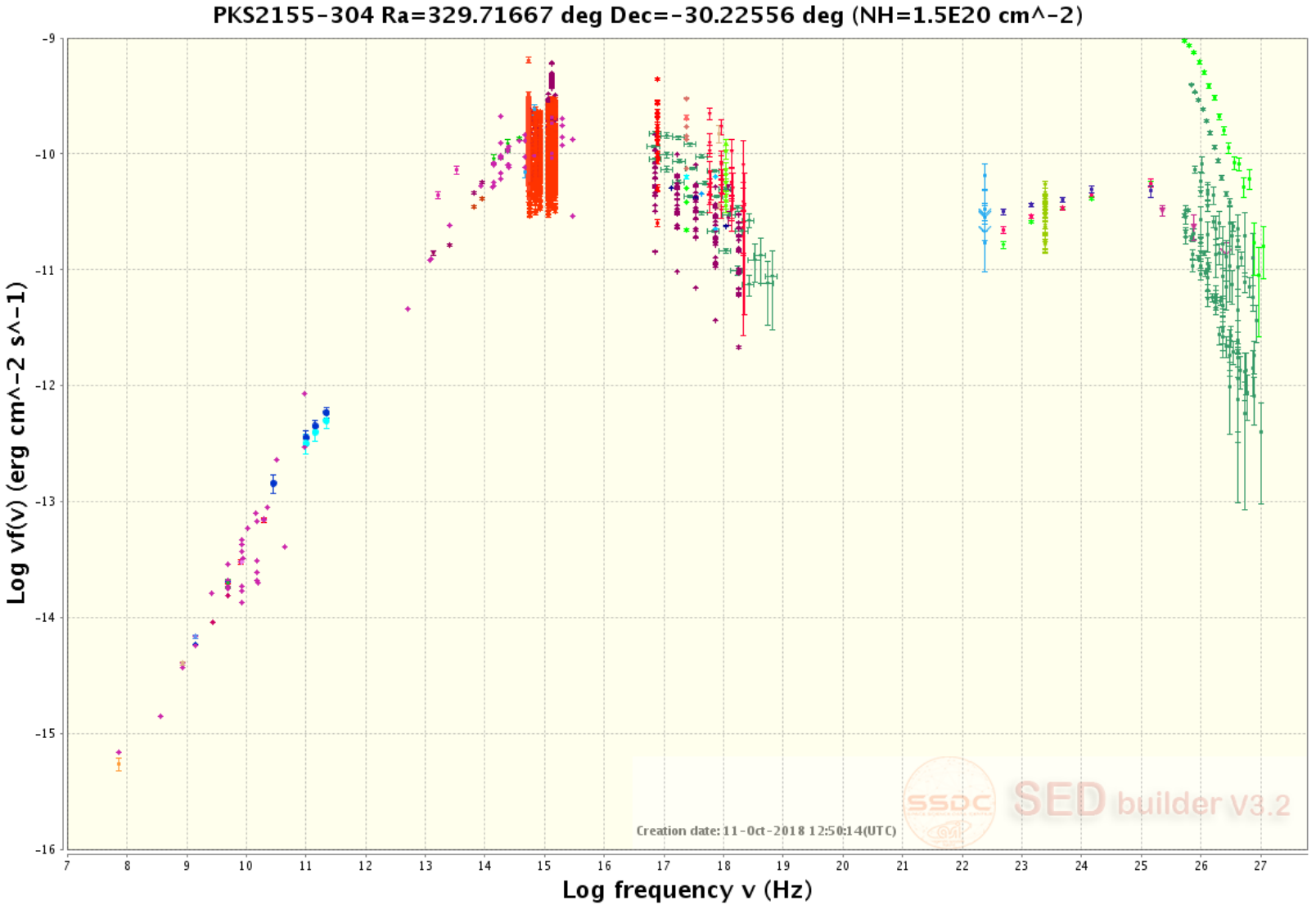
- Relativistic jets :
Radio to X-ray + HE to VHE



Urry & Padovani 1995

I – Active Galaxy Nuclei

Typical jet spectrum : 2 bumps



I – Active Galaxy Nuclei

Emission processes :

- Lower energy component :
  Synchrotron emission from HE electron in a magnetic field

- Higher energy component :

  2 main categories of model

  - leptonic models

    Lower energy photons from an internal or external field are boosted by inverse Compton

  - lepto-hadronic models

    High energy protons or nuclei are present in the jet

    Produce additional messengers

I – Active Galaxy Nuclei

Hadronic emission processes :

- Interactions between proton and low energy photons
  - Bethe Heitler → e^+ e^- pairs
  - Pion production dominant for ultra relativist protons
- Neutral pions decay
- Synchrotron :
  - protons
  - charged pions
  - muons from charged pion decay
  - electrons from Bethe-Heitler and muon decay
- Other hadronic transformation with heavier nuclei

II – ToO program and analysis

Extra-galactic Target of Opportunity program mission :

Monitor multi-wavelength chains for interesting flaring activity of extragalactic sources and potentially issue H.E.S.S. ToO observations

Independent from gravitational waves and neutrino ToO programs

Most used channel : Fermi-LAT high energy

Surveillance of optical, X-rays, other VHE

Trigger on average once per month

II – ToO program and analysis

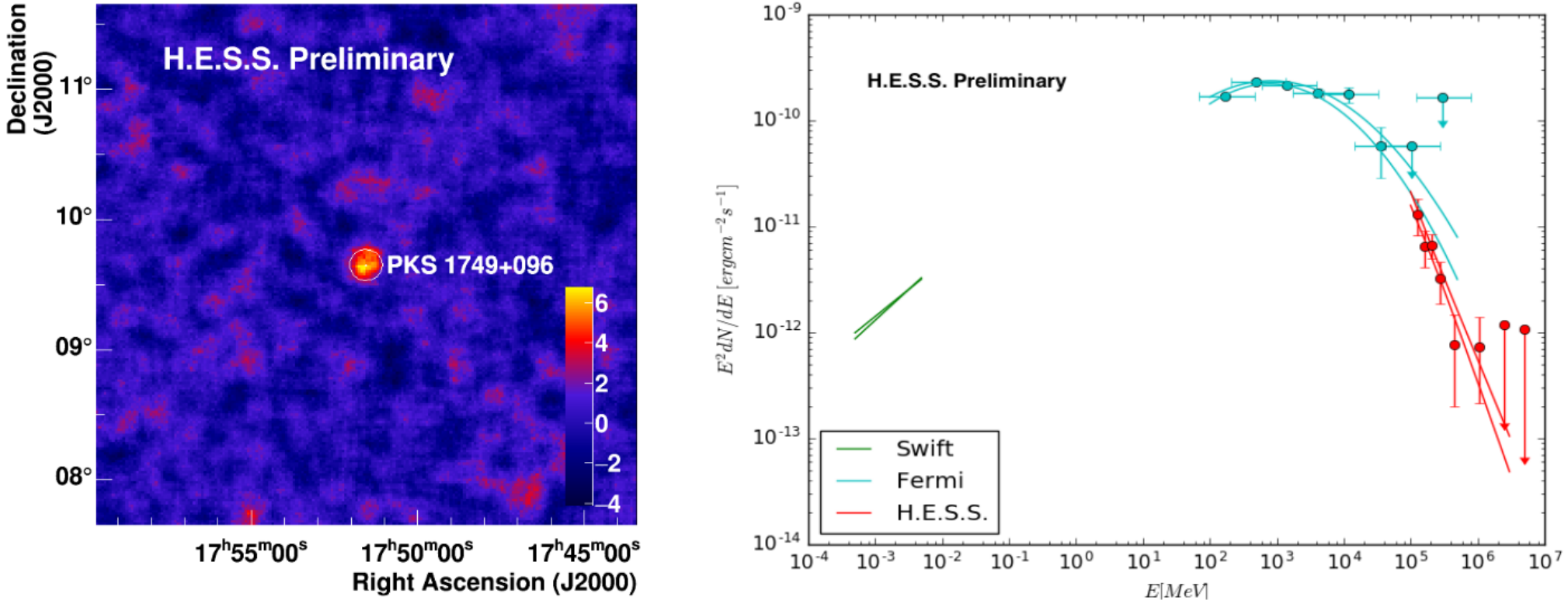


Figure 1: Left: Significance map of PKS 1749+096 obtained from H.E.S.S. observations in July 2016. Right: Multi-wavelength spectral energy distribution of PKS 1749+096 derived from contemporaneous Swift-XRT, Fermi-LAT and H.E.S.S. observations.

F. Schüssler, M. Seglar-Arroyo et al. for the H.E.S.S. collaboration
Proc. ICRC 2017 (Busan, South Korea))

II – ToO program and analysis

Data analysis, studied 2 sources observed during ToOs :

- 3C 279 was active a lot during the year, it is a well known source with a typical blazar behavior

  I analyzed the January and June flare of this year

- PKS 2022-077 was observed twice in 2017

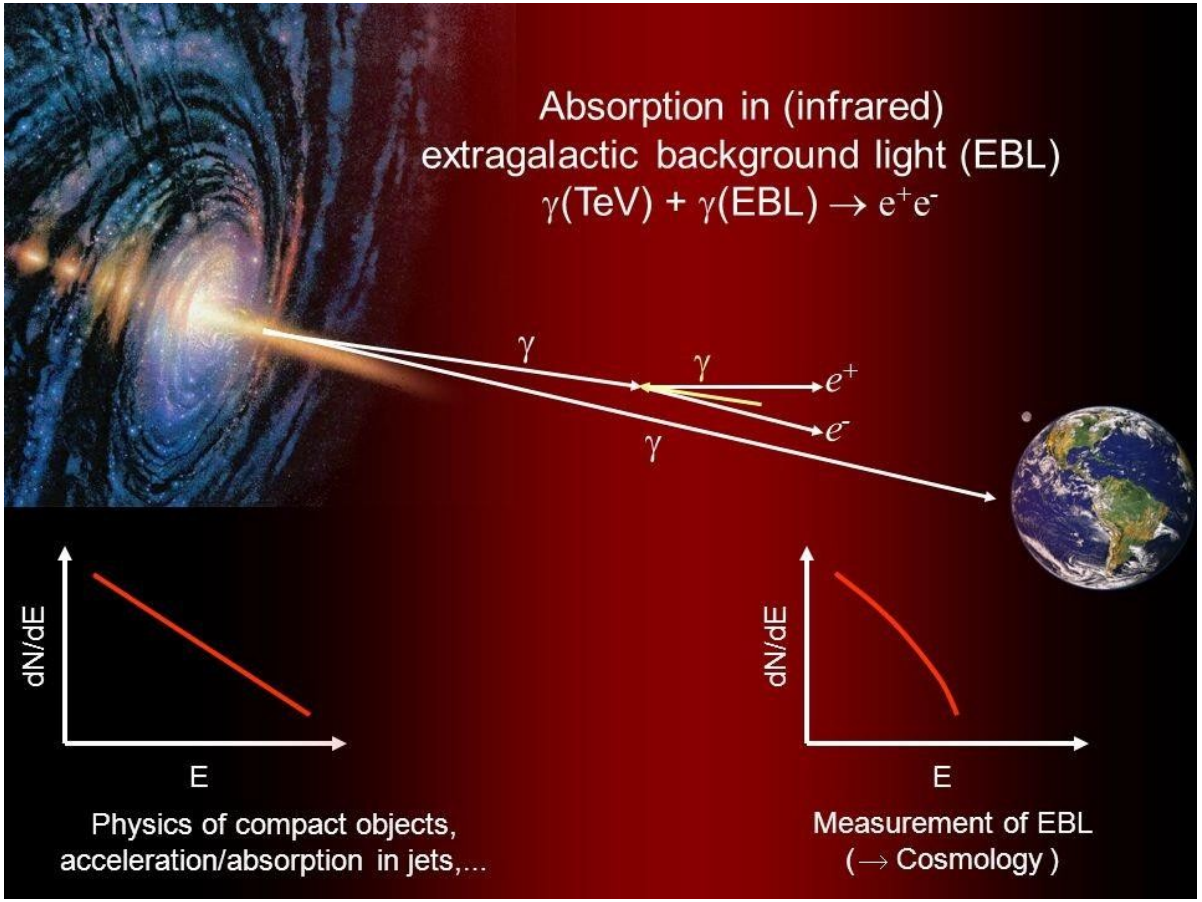
  The high redshift (z=1.388) make it an interesting but hard to see source due to EBL absorption

  z=1.388 → light travel time = 9.113 Gyr

  Farthest VHE source detected: S3 0218+35 at z = 0.954

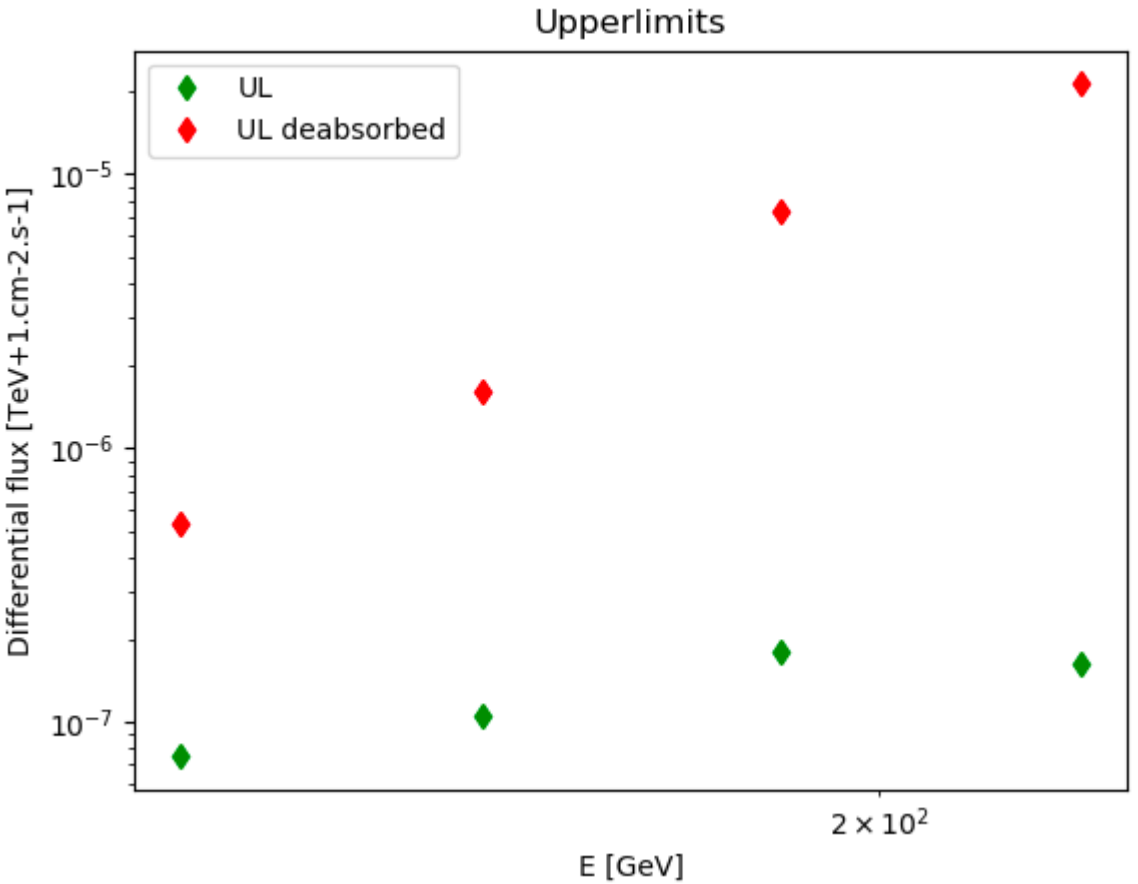
() – Extragalactic Background Light

EBL is all the radiated energy produced during the formation and evolution of galaxies in the universe and partly absorbed/re-emitted by dust

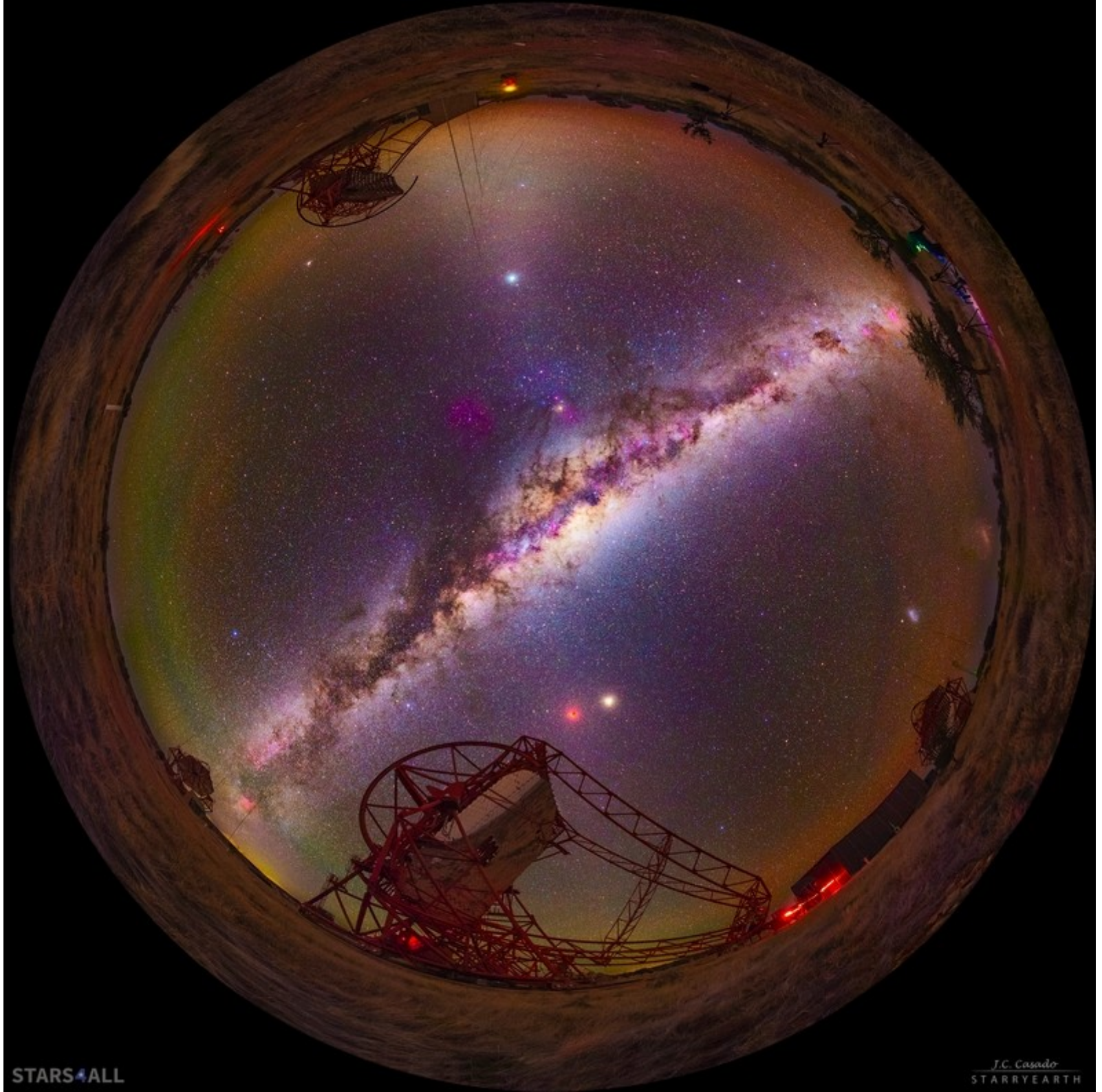


II – ToO program and analysis

ToO on PKS 2022-077 in 2016, no detection



C. Romoli, M. Zacharias et al. for the H.E.S.S. collaboration
Proc. ICRC 2017 (Busan, South Korea) (for data)


STARS4ALL
J.C. Casado
STARRYEARTH

III – Software development

Adaptative Light Curve :

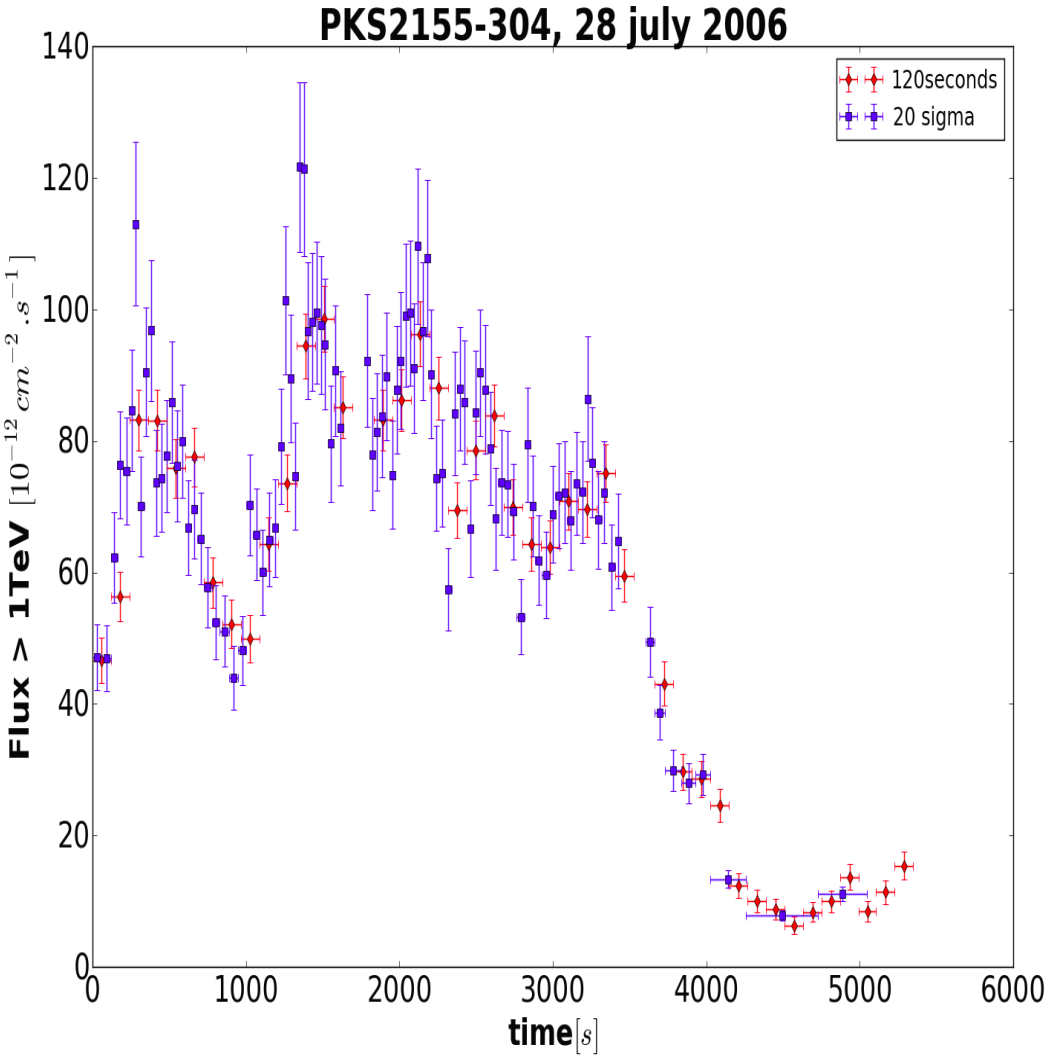
Automatically adapt the binning to the significance of the signal

Better precision when signal permit it

Allow to see faster variability

Implemented in H.E.S.S analysis software

Also in gammapy for CTA



III – Software development

Interval selection :

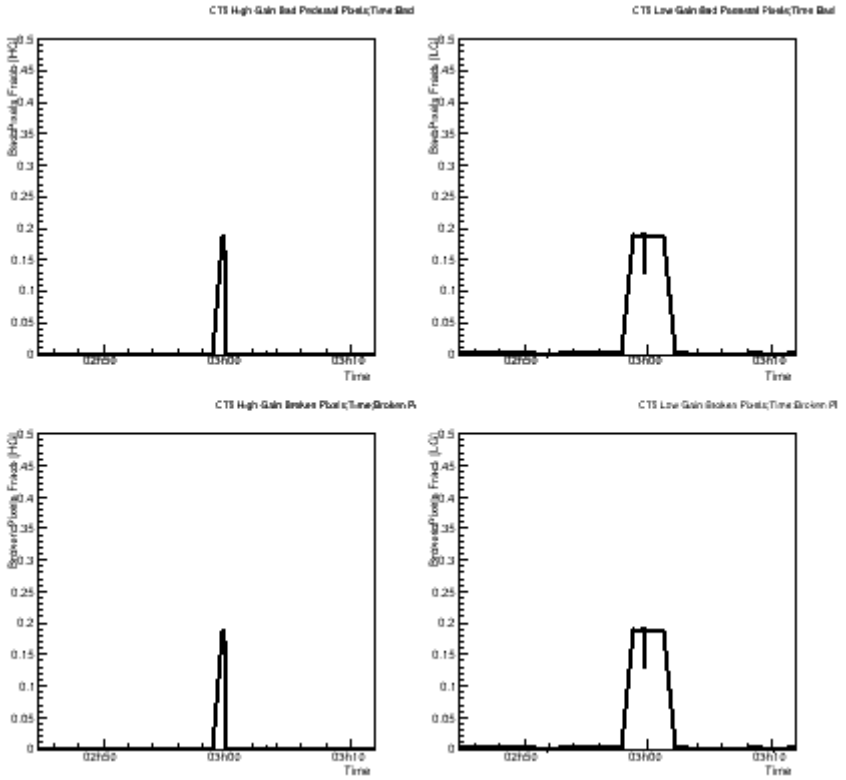
Some observation can be lost if part of it is of bad quality
→ Loss on efficiency

Worse for time sensitive observations like ToOs

Idea : Filter all event in the problematic time window

Example use : 4 X 28min taken during 3C 279 flare
Problem in the camera for 3 minutes
Lose ¼ of observation time?

III – Software development



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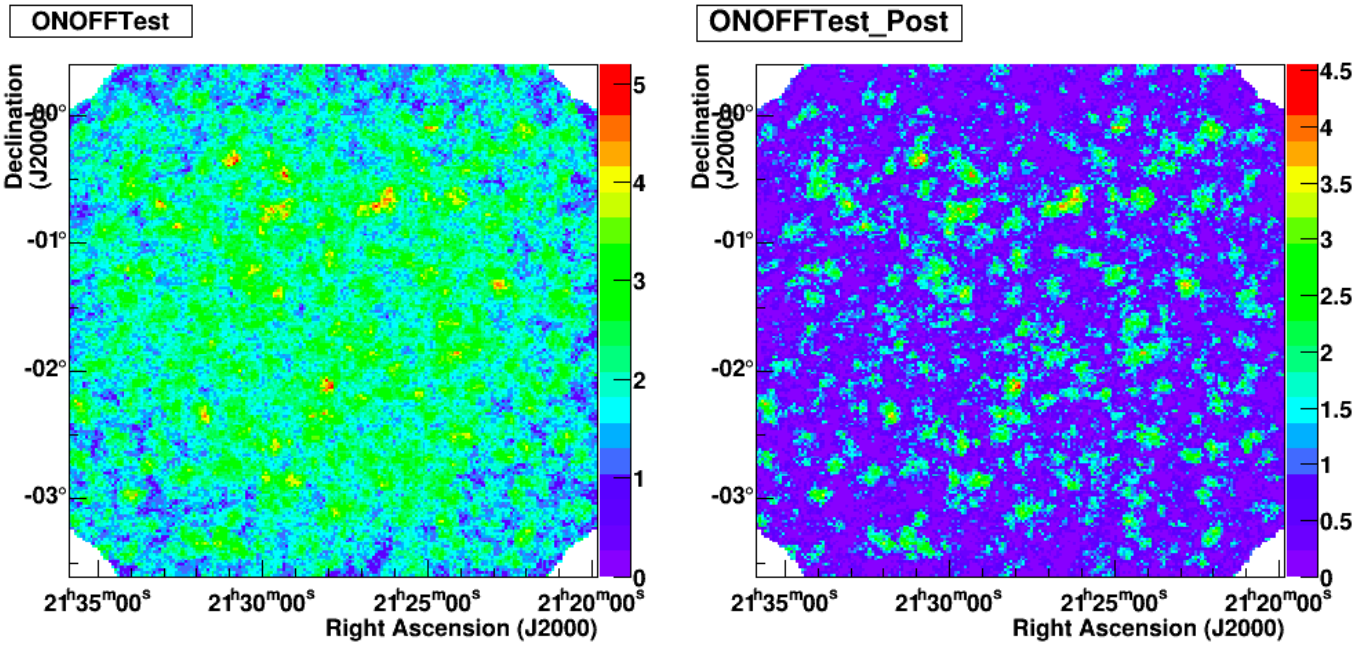
IV – Continuous surveillance

Extra Galactic Round Up :

Monthly analysis of all extra galactic data

2 Goals :

- Check if sources were active or variable
- Search for transients in the field of view



IV – Continuous surveillance

Real Time Analysis :

Allows to have a quick estimation of the source signal

Need to study RTA reliability for internal use
→ Comparison significance RTA / Significance offline

Need to study RTA / offline flux correlation for external communication
→ Useful to initiate Multi-Wavelength observations

IV – Continuous surveillance

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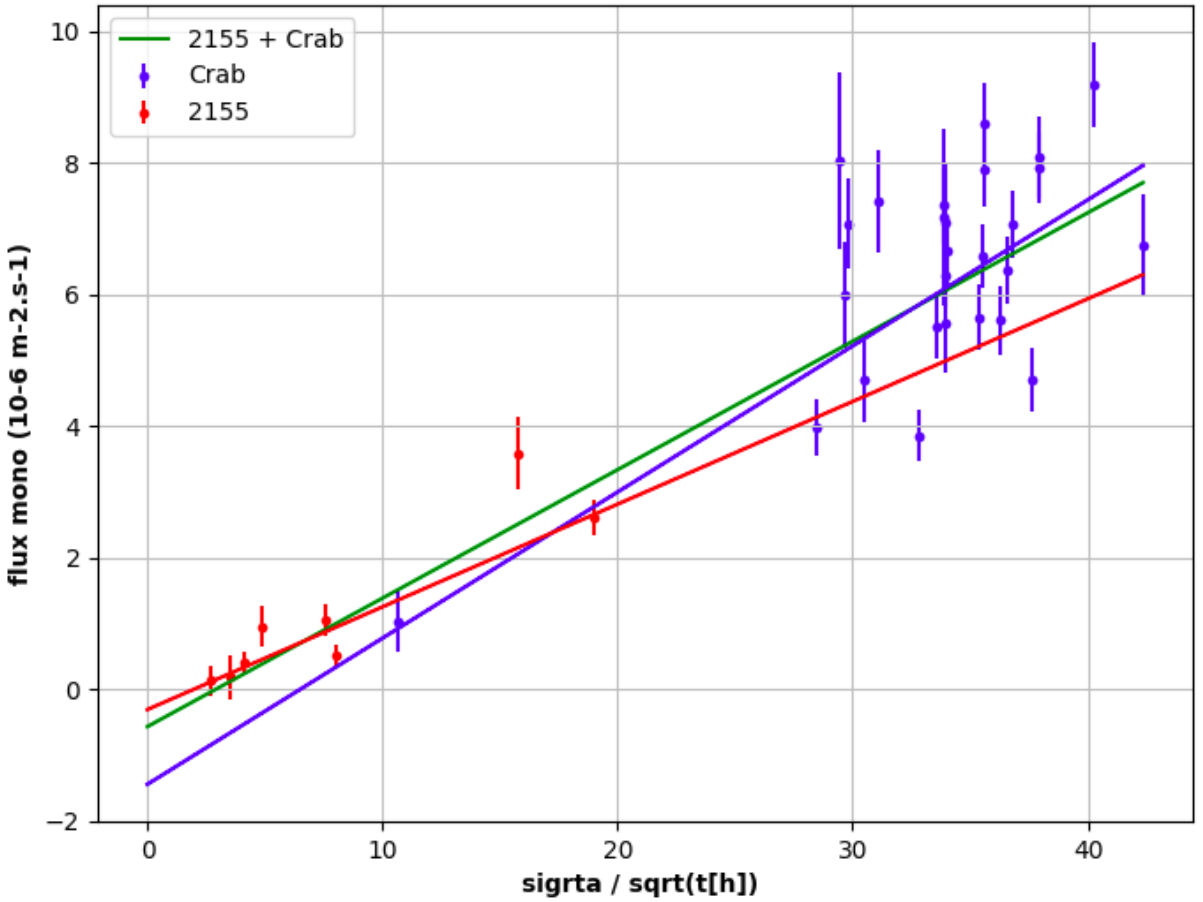
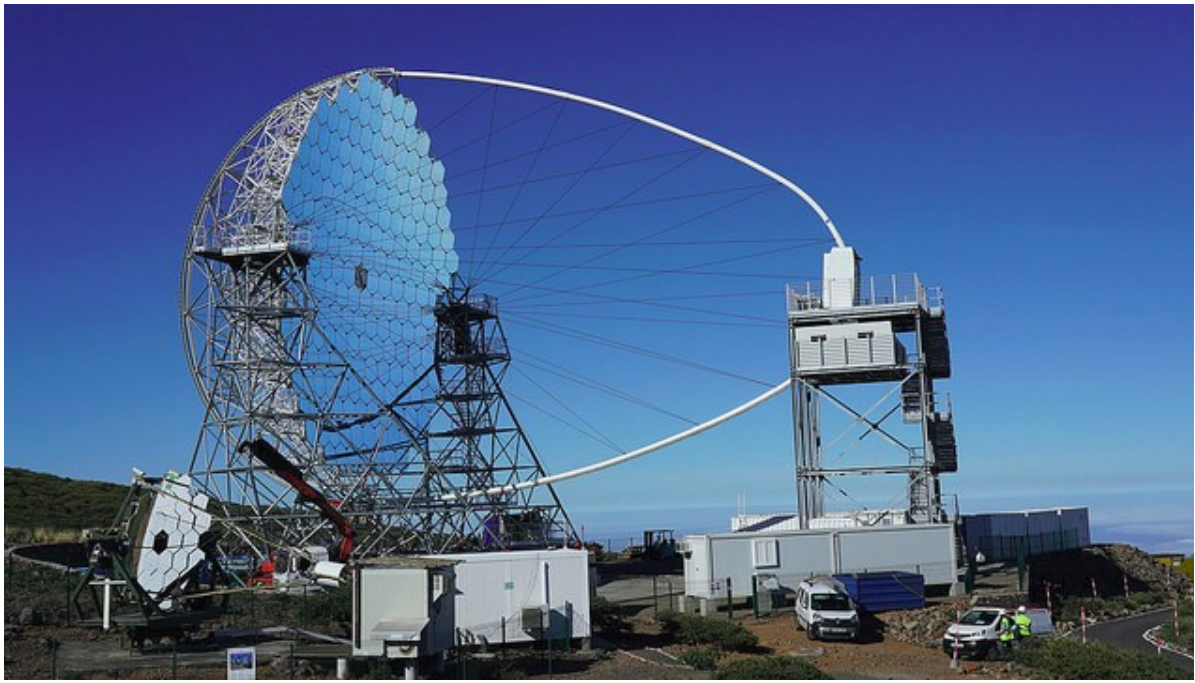


Conclusion



The newly installed LST-1 , Credit: Iván Jiménez (IAC)

- CTA : Increased sensibility → Better understanding of variability
- New era of Multi-Messenger astrophysics
  - TXS 0506+056 first neutrino associated with a flaring blazar
  - LIGO/VIRGO gravitational waves