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Multiwavelength Study of *Fermi*-LAT blazars Variability and Radiation Production Mechanisms

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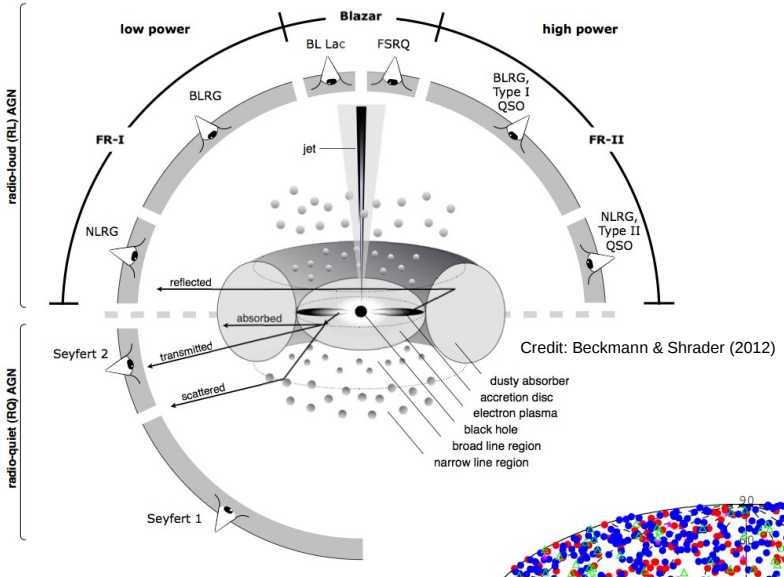
Quasars constitute a subclass of radio-loud active galactic nuclei (AGNs) that release a tremendous amount of non-thermal radiation through a pair of twin jets. When one of these jets is aligned with the direction of the Earth, the object is then called a blazar. A consistent monitoring of these sources can help to unveil physical mechanisms at the origin of the radiation production that spread throughout the whole electromagnetic spectrum, from radio waves to gamma rays. The goal of this paper is to report some current works being undertaken in terms of both spectral studies and time domain analyses of bright blazars which are observed with the *Fermi* Gamma-Ray Space Telescope and by South Africa based optical telescopes. We will discuss possible scenarios of radiation production and absorption, as well as possible constraints on the size of the gamma-ray emitting region, as given by the study of the variability of blazars 3C 454.3 and NVSS J141922-083830.

The Unified model of Active Galactic Nuclei (AGNs)

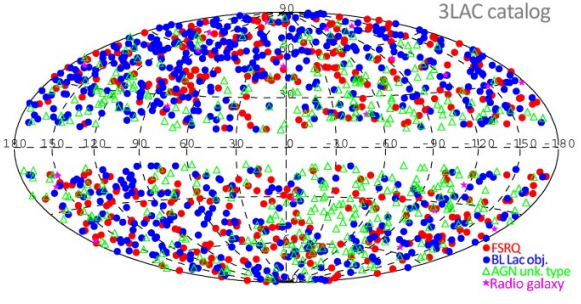


Credit: Beckmann & Shrader (2012)

The Third LAT AGN Catalog (3LAC)

E > 100 MeV (4 years of data)

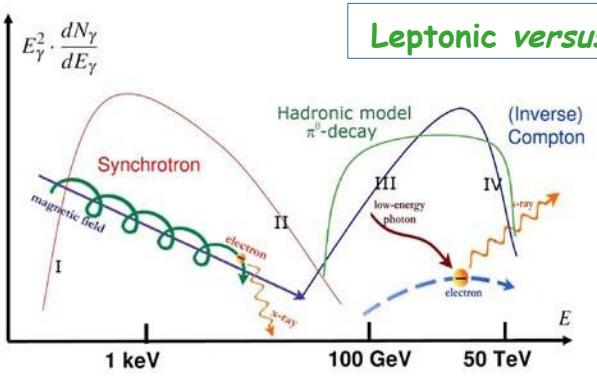
1591 blazars and other AGNs located at high Galactic latitudes (|b|>10deg)



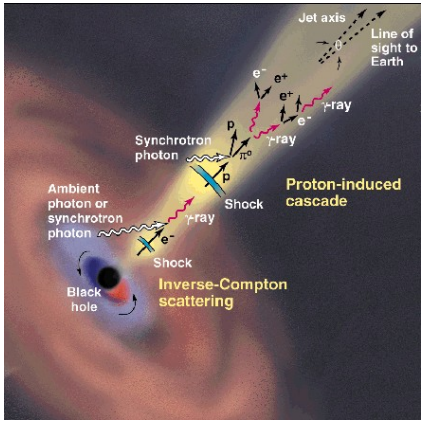
M. Ackermann et al, ApJ 810 14 (2015)

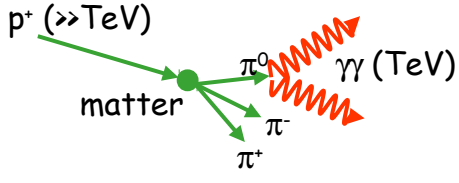
Challenges of the high energy production mechanisms in the blazar jets

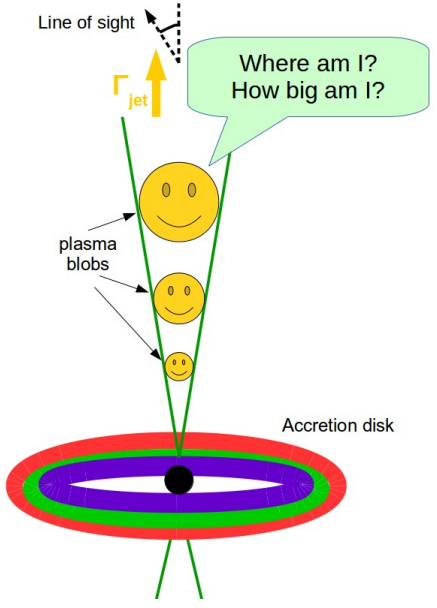
Leptonic *versus* hadronic acceleration



Adapted from Angelis et al, Rivista del Nuovo Cimento, 2008, 31: 187-246







Leptonic *versus* hadronic discrimination of the high energy production mechanisms in the blazar jets

Britto, Razzaque and Lott
on behalf of the Fermi-LAT Collaboration (2015)
arXiv:1502.07624

Investigations using:

- **Light-curves:**
  - Correlation or non-correlation of optical *versus* gamma rays
  - Fast variability

- **Broadband SED:**
  - Fitting of the HE bump
  - Polarisation in the X-ray and gamma-ray domain

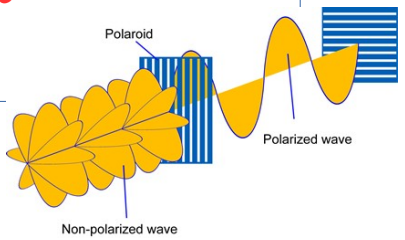
- **Neutrinos detections**
  - PG 1553+113 **(Vianello et al, ATEL 9008, 2016)**

Point to leptonic scenarios under certain conditions

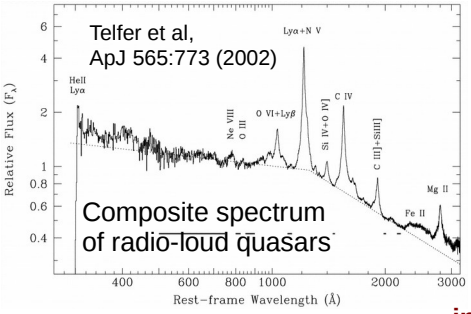
In some cases…

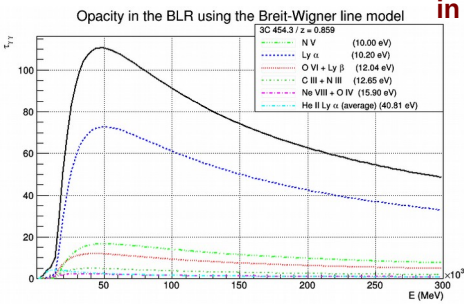
Maybe in the near future…?

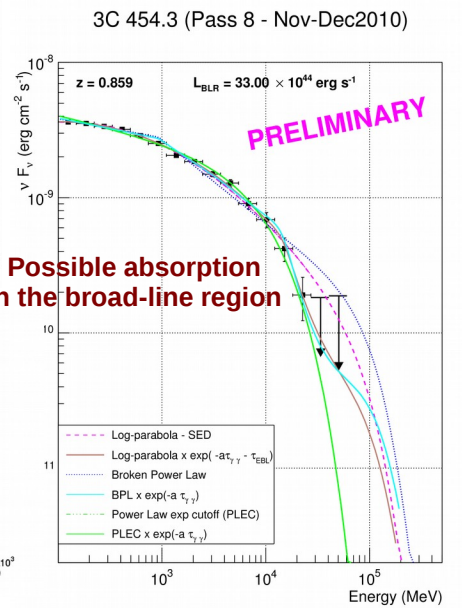
We need to narrow time coincidences…



The case of 3C 454.3

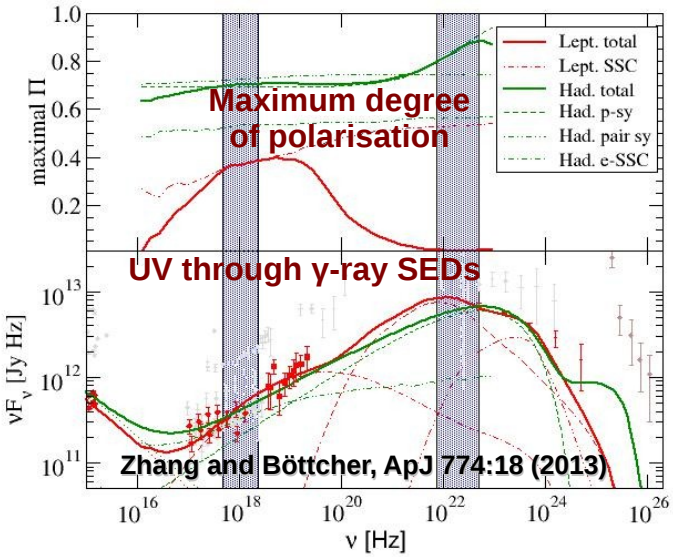






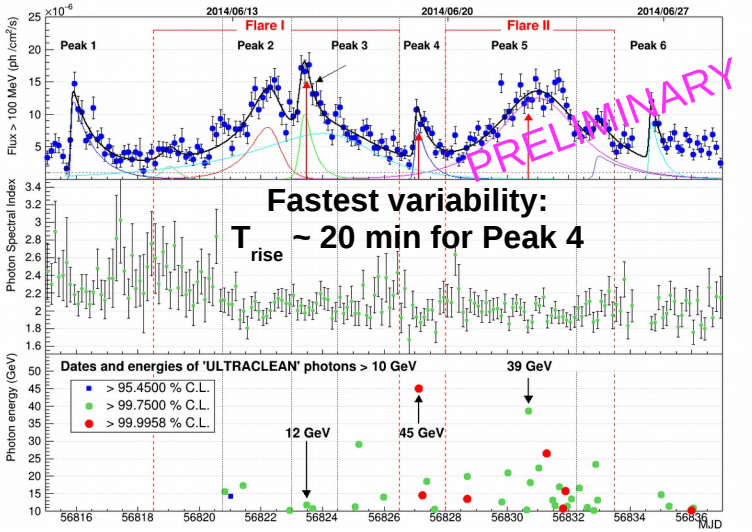
Possible absorption in the broad-line region

Leptonic and hadronic modeling of FSRQ 3C 279



Fermi-LAT Observations of the 2014 May-July Outburst from 3C 454.3

Britto, Bottacini, Lott, Razzaque and Buson
(submitted to ApJ)
arXiv:**1511.02280**



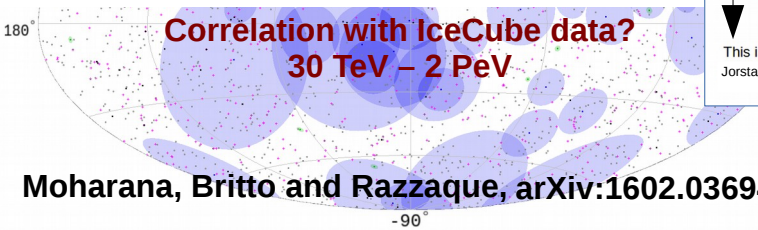
Fastest variability:
T_{rise} ~ 20 min for Peak 4

Constraint on the distance R of the gamma-ray emitting region

- Rapid variability suggest gamma rays emitted from compact region(s)
- Gamma-ray emitting region at: $R \approx \delta^2 c t_v/(1+z)$
- Doppler factor δ constrained by opacity of blob to HE photons, considering spectral shape from X-ray (Swift-XRT) to gamma rays (Fermi-LAT)

- Peak 3: we find $\delta \geq 19 \rightarrow R \geq 1.6 \times 10^{16}$ cm $\rightarrow \Gamma_{jet} \gtrsim 10$ (12 GeV)
- Peak 4: we find $\delta \geq 29 \rightarrow R \geq 1.0 \times 10^{16}$ cm $\rightarrow \Gamma_{jet} \gtrsim 16$ (45 GeV)
- Peak 5: we find $\delta \geq 14 \rightarrow R \geq 1.4 \times 10^{17}$ cm $\rightarrow \Gamma_{jet} \gtrsim 7$ (39 GeV)

This is compatible with the previously estimated value of Γ_{jet} from Jorstad et al, AJ, 130:1418 (2005) and Sikora et al, ApJ, 675:71 (2008).



Correlation with IceCube data?
30 TeV – 2 PeV

Moharana, Britto and Razzaque, arXiv:1602.03694

- Since the launch of *Fermi* in 2008, we observed and characterised a lot of properties of AGNs;
- A lot still need to be understood;
- We need multiwavelength observations and new windows (X-ray and γ-ray polarisation, neutrinos, etc.).

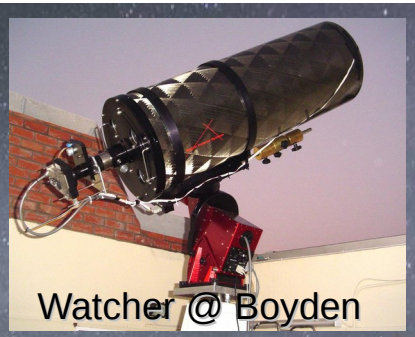
Multiwavelength projects using Southern Africa-based telescopes

We use *Fermi*-LAT, SALT and other SA-based telescopes for the monitoring of transient sources of the Southern sky, including potentially flaring AGNs, such as NVSS J141922-083830. This project is conducted in collaboration with M. Böttcher, D. A. H. Buckley, S. Chandra, P. J. Meintjes, S. Razzaque, K. P. Singh, B. van Soelen, et al.

From all **3LAC** sources (|b| > 10 deg) that are:

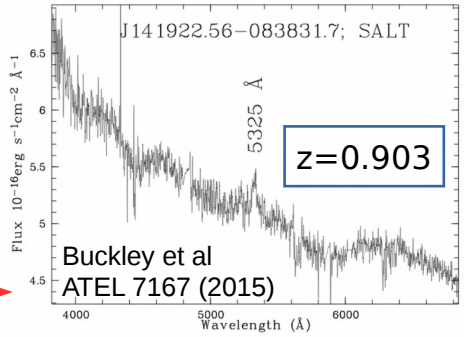
- **variable**,
- belonging to the **BL Lac or FSRQ or BCU** classes,
- **observable by the SALT telescope** in South Africa (-75 < Dec < +10),

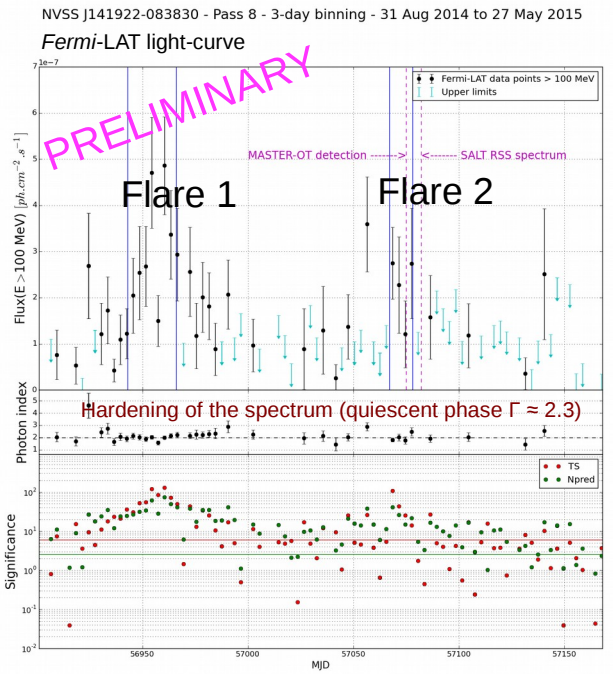
we have **~280 target sources**, and ~50 % of them (~140) with mag V < 19.



Blazar candidate of unkown type (BCU) NVSS J141922-083830

Russia-based MASTER-Kislovodsk optical telescope system detected a flare from blazar NVSS J141922-083830, at a magnitude 14.6 (unfiltered) on 21 Feb 2015 (Lipunov et al, ATEL 7133). We are undertaking multiwavelength study of this blazar. We identified it as a flat spectrum radio quasar (FSRQ). The SED of the source is well modeled by a leptonic scenario producing high energy radiation during Flare 2 (***Buckley et al, in preparation***).





Good potential in South Africa for contributing to this blazar quest!

Thanks to the *PNHE* and the *University of the Free State* for their support to attend this conference!