Multiwavelength Studies of Active Galactic Nuclei

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African School of Fundamental Physics & Applications

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African School of Fundamental Physics and Applications

Outline

- Biography
- Active Galactic Nuclei - AGN
- What distinguishes AGN from each other
- Blazars
- Blazar emission models and challenges
- Cherenkov telescope array and multiwavelength campaigns
- Conclusion

Eli Bio

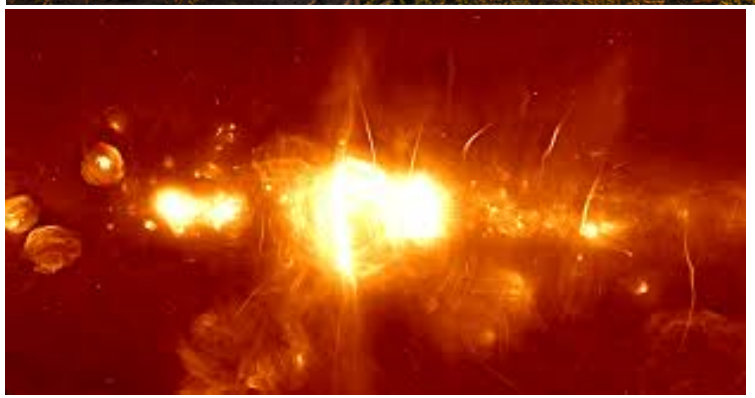
Education || Employment || Research

BSc - University of Namibia: 2001 - 2004

BSc(Hons), MSc, Phd - UCT: 2010 - 2017

South African Astronomical Observatory

SKA-South Africa (SARAO) - MeerKaT



African Institute for Mathematical Sciences

A research group of the AIMS African Institute for Mathematical Sciences

Institute of Cosmology & Gravitation

ICG Portsmouth

Employment

- Senior Lecturer - UNAM: Sep 2019 - present
- Intern - IAU-OAD: 2013 - 2015
- Commercial Analyst - NamPower: 2005 - 2009

University of Namibia - Main Campus

IAU Office of Astronomy for Development

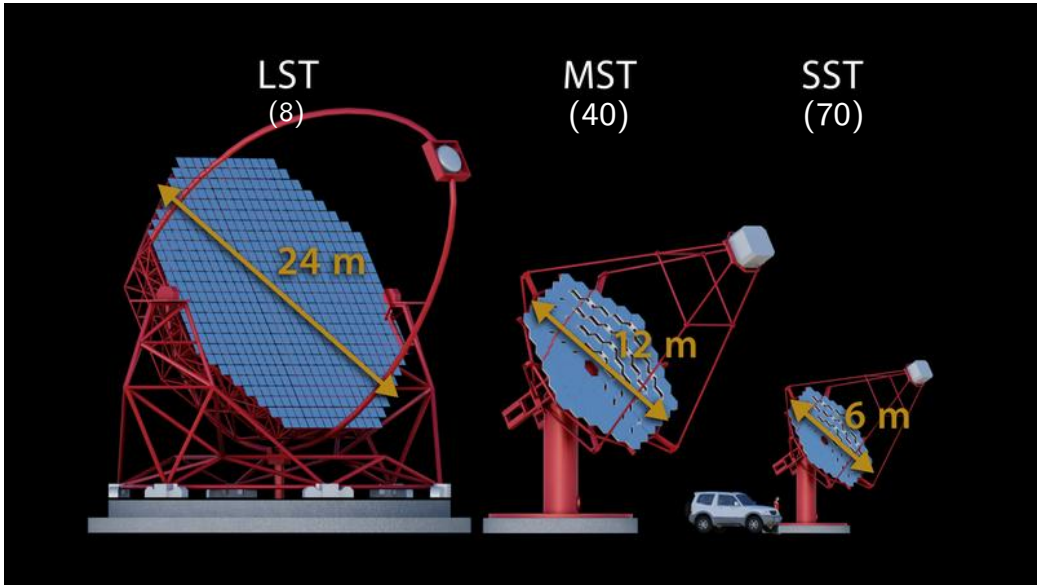
Namibia Power Corporation - NamPower

Research

- SALT redshift measurements of blazars for CTA
- Africa Data Science Intensive Program - 2020
  - ML, AI, Big Data, Data Science

SALT-CTA redshift program

Cherenkov Telescope Array



Sutherland observatory

The Africa Data Science Intensive (DSI) program is a hands-on skills training data science course based on solving real-world problems.

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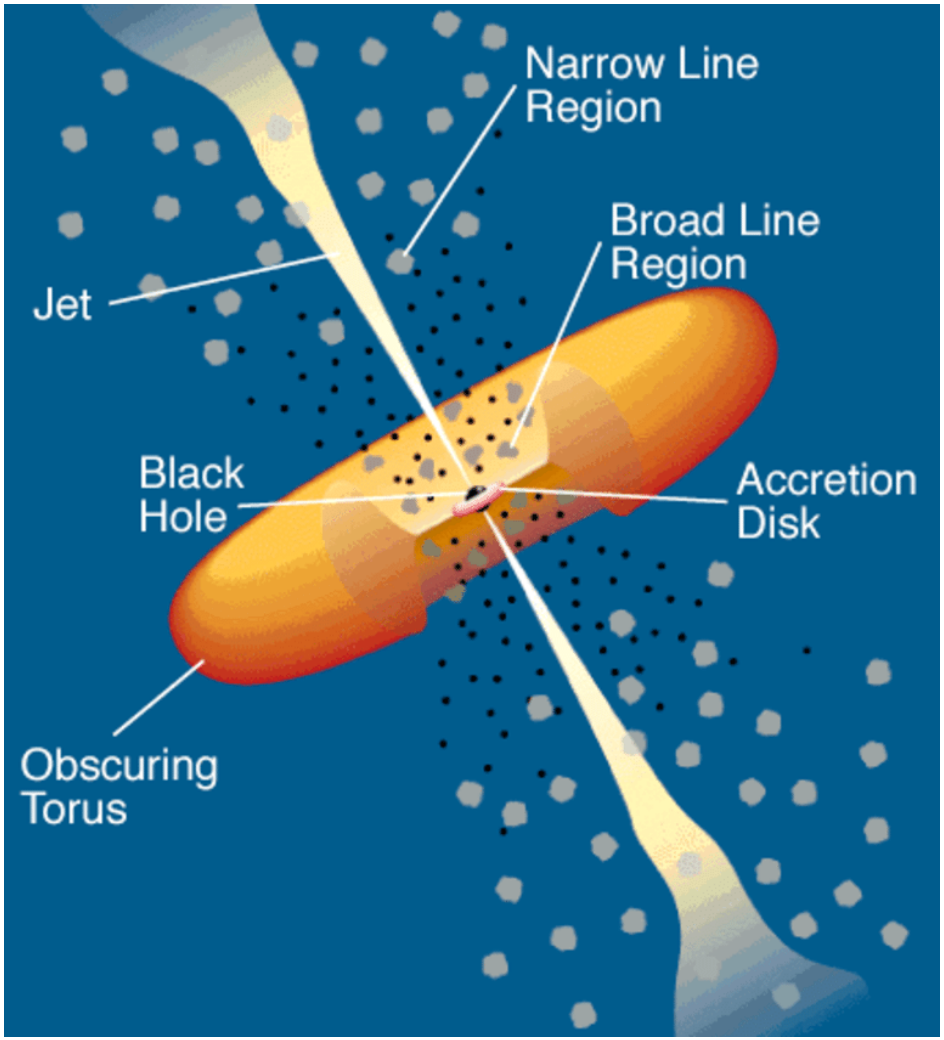
Active Galactic Nuclei - AGNs

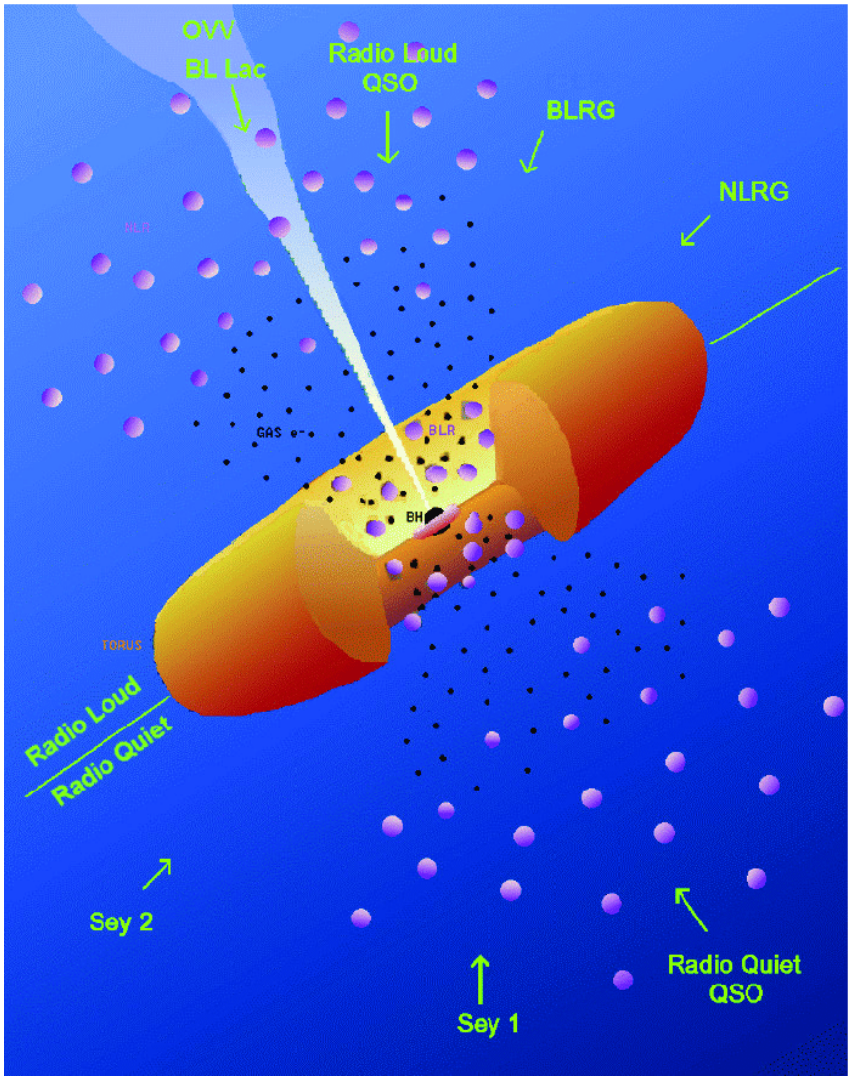


Credit: C.M. Urry & P. Padovani

From observational features, luminous AGNs appear to fall into 3 categories:

- Seyferts
  - Seyfert I (narrow & broad lines)
  - Seyfert II (narrow lines)
- Quasars
  - QSOs
  - BL Lacs
  - OVVs
- Radio Galaxies
  - FR-I (edge-darkened)
  - FR-II (edge-brightened)

Active Galactic Nuclei - AGNs



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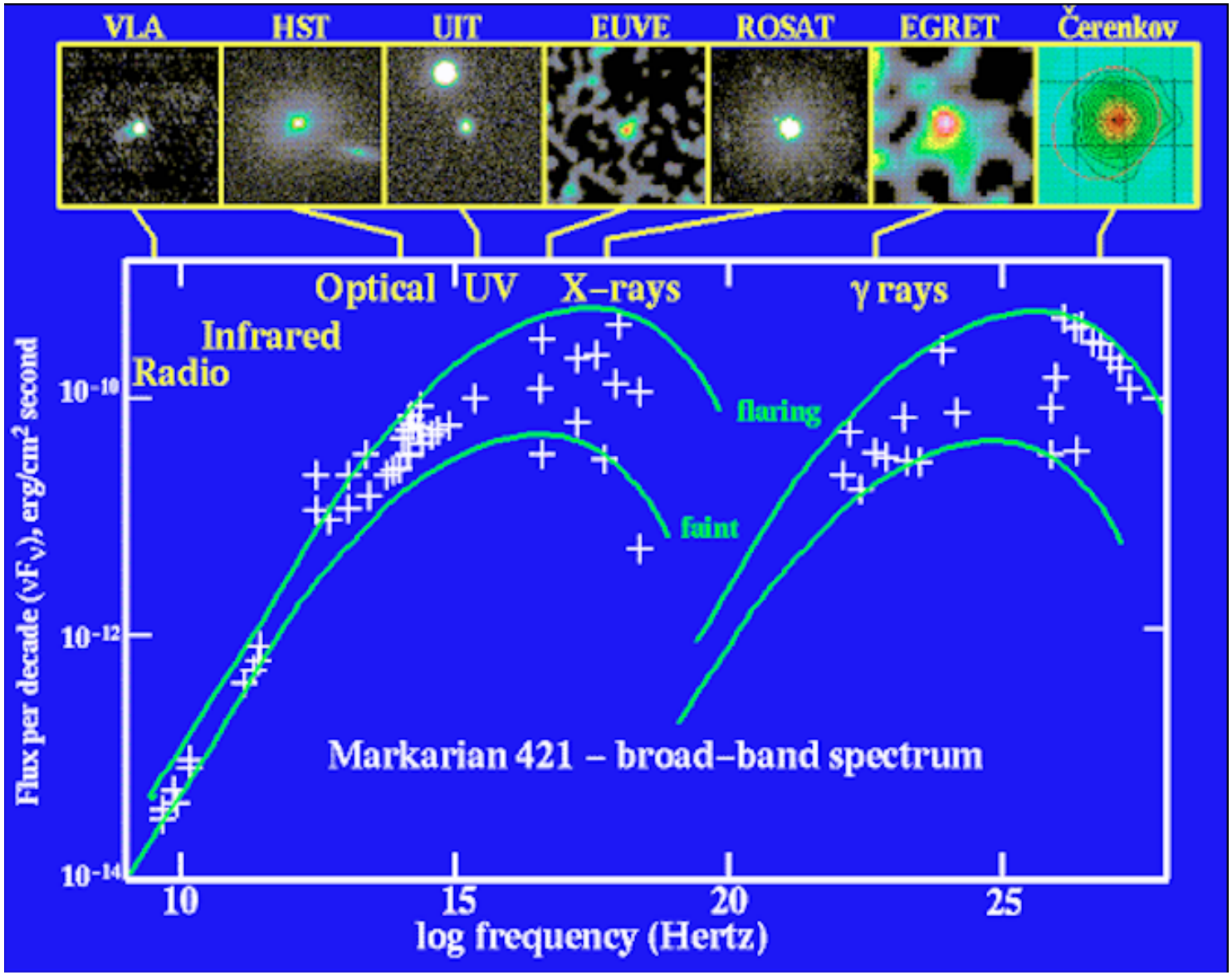
Multiwavelength AGN observations



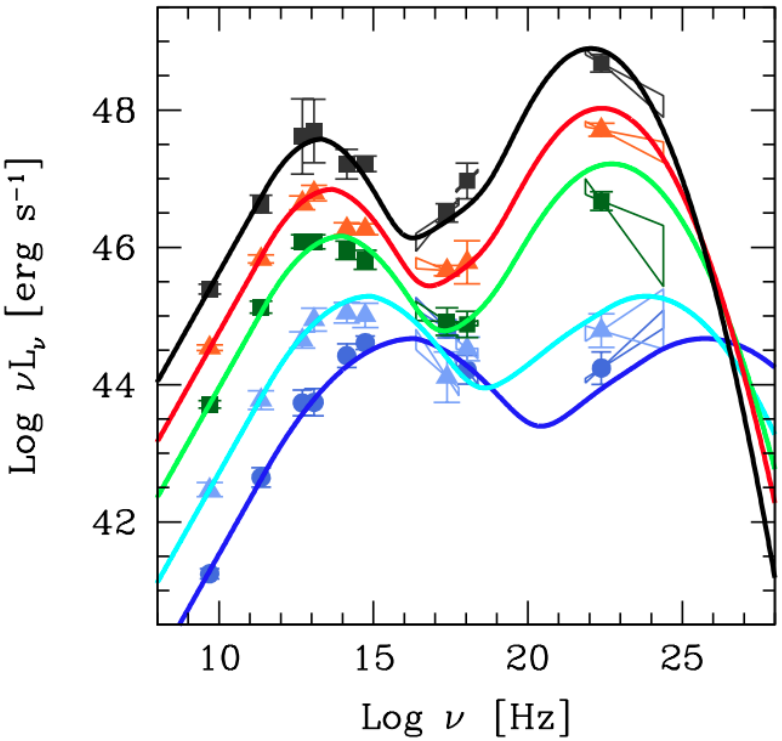
Blazar studies

- Over 200 VHE sources (both galactic and extra-galactic) have been detected in the last decade by ground-based Atmospheric Imaging Cherenkov Telescopes:
  - H.E.S.S. (SH)
  - MAGIC (NH)
  - VERITAS (NH)
- AGN make up 40% of the 200+ sources
- 3/4 of the 40% AGN fraction are high-frequency peaked BL Lacs (the rest are FSRQs, LBLs, IBLs and UHBLs)
- VHE observations of active galaxies represent a unique tool to probe the physics of extreme environments, including
  - accretion physics
  - jet formation
  - interaction of the black-hole magnetosphere with the accretion disk corona
  - relativistic interaction processes, etc.

Blazar subdivision

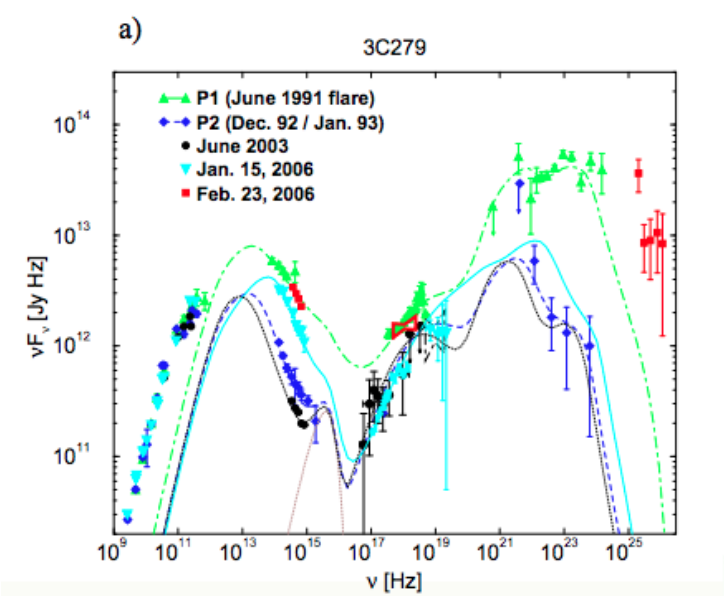
- Blazar SEDs are dominated by non-thermal emission and consist of two distinct, broad components
  - a low-energy component from radio through UV or X-rays, and
  - a high-energy component from from X-rays to gamma-rays.
- Blazars are sub-divided into several types, determined by the location of the peak of the low-energy (synchrotron) SED component, ν_s:
  - Low-synchrotron-peaked (LSP) have $\nu_s \leq 10^{14}$Hz, i.e. infrared
    - FSRQs
    - Low-frequency peaked BL Lacs (LBLs)
  - Intermediate-synchrotron-peaked (ISP) have $10^{14}\text{Hz} < \nu_s \leq 10^{15}\text{Hz}$, i.e. optical - UV
    - LBLs
    - Intermediate BL Lacs (IBLs)
  - High-synchrotron-peaked (HSP) have $\nu_s > 10^{15}$Hz, i.e. X-rays
    - almost all high-frequency peaked BL Lacs (HBLs)

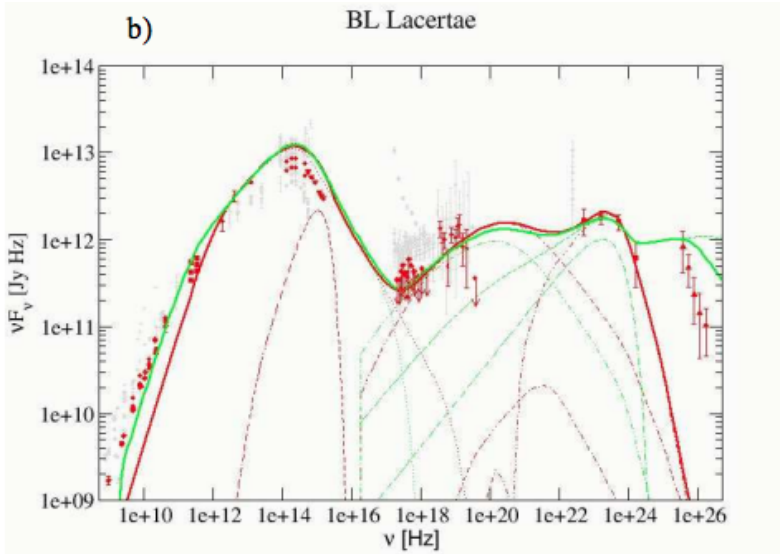
Traditional blazar sequence

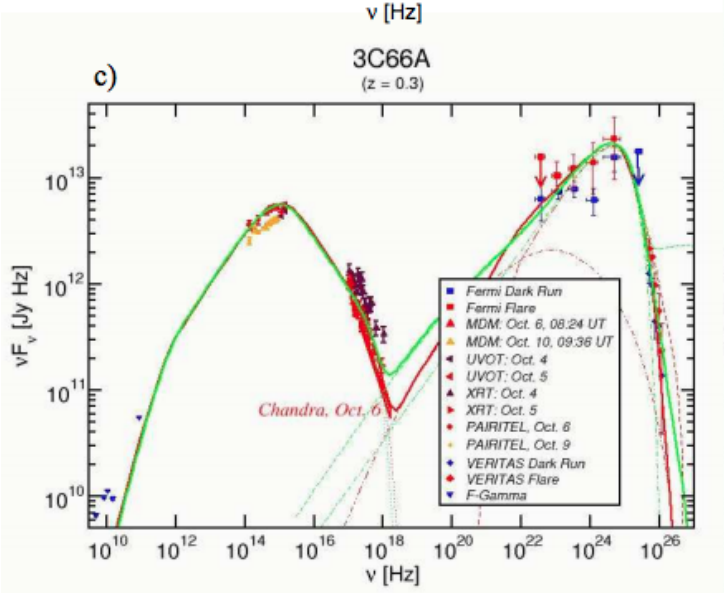


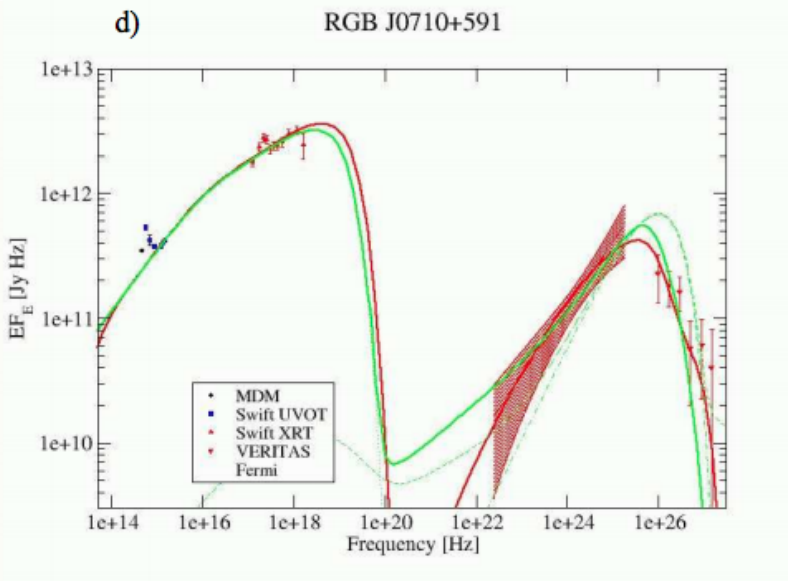
- Overall decreasing bolometric luminosity as well as decreasing gamma-ray dominance along the sequence FSRQ $\rightarrow$ LBL $\rightarrow$ HBL.
- FSRQs are expected to have strong gamma-ray dominance, while HBLs are expected to be synchrotron dominated.

Contradictions with the sequence









Blazar emission models

- The low-frequency emission from blazars is generally accepted to be synchrotron emission from relativistic electrons in the jet
- For the origin of the high-energy (X-ray through gamm-ray) emission, two fundamentally different approaches have been proposed:

Leptonic model

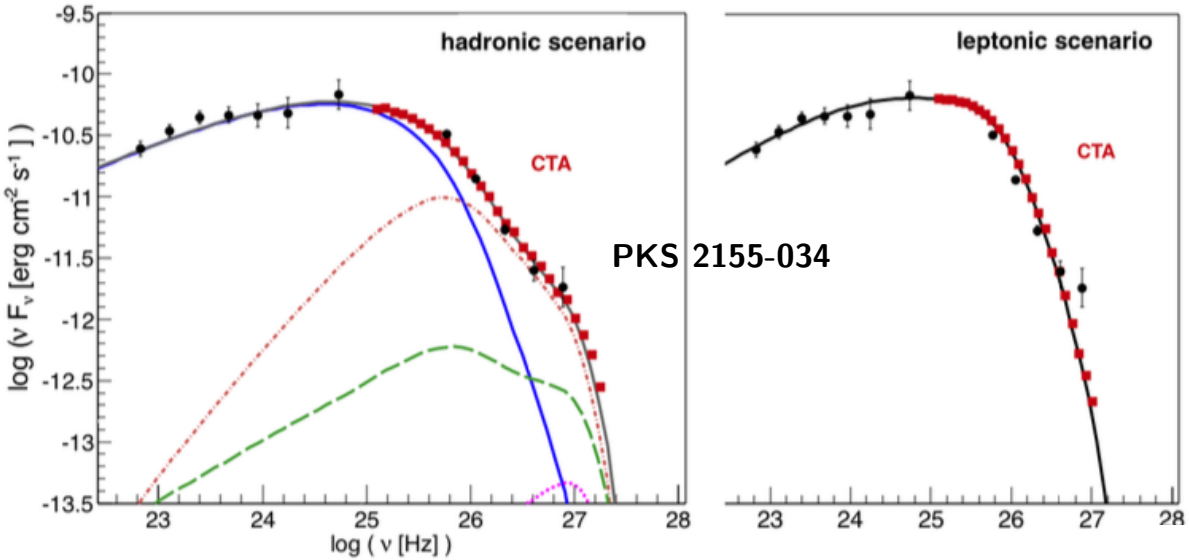
- radiative output throughout the EM spectrum assumed to be dominated by leptons (electrons and possibly positrons)
- high-energy emission explained by Compton scattering of low-energy photons by the same electrons producing the synchrotron emission

Leptonic model

- low-frequency emission is still dominated by synchrotron emission from primary electrons
- high-energy emission is dominated by proton-synchrotron emission, π^0 decay photons, synchrotron, and Compton emission from secondary decay products of charged pions, and the output from pair cascades initiated by these high-energy emissions.

CTA and other coordinated MWL efforts

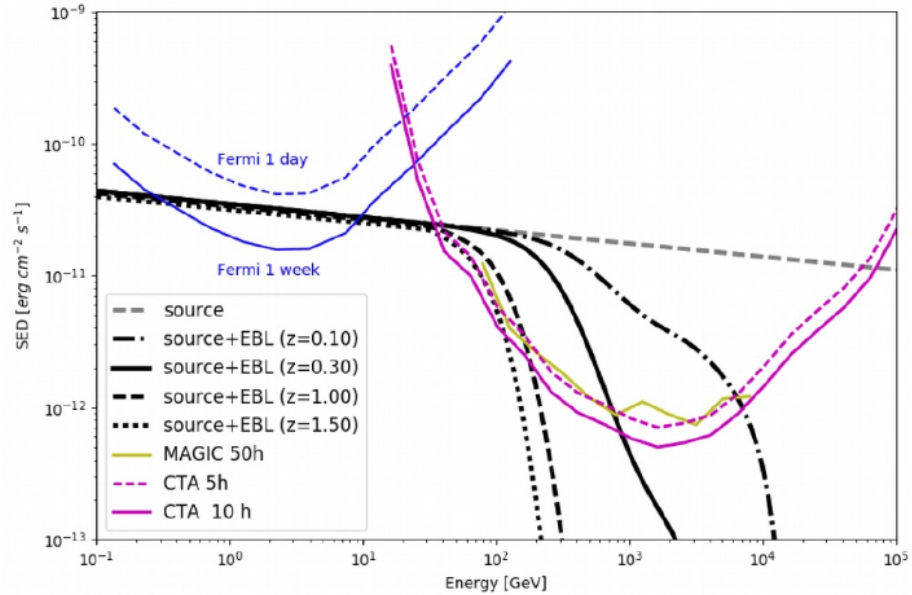
https://doi.org/10.1142/10986

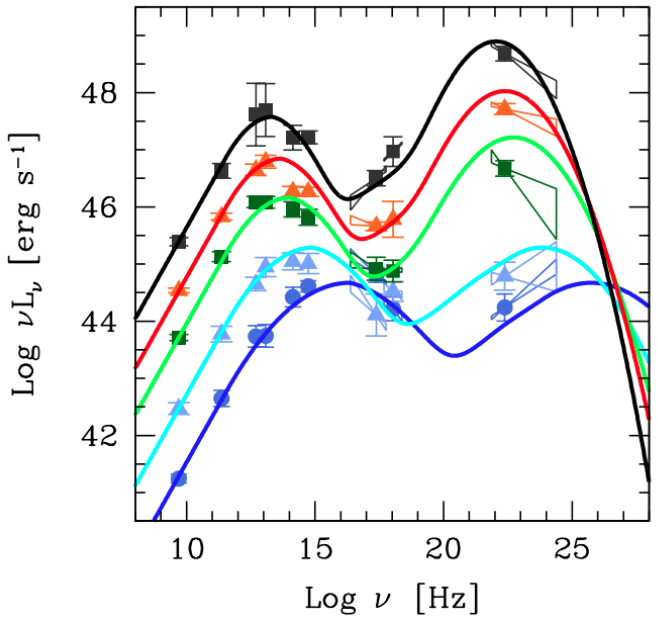


Needed:

- Hiqh-quality spectra: CTA
- Redshifts: e.g. SALT

https://arxiv.org/abs/1702.02571





Conclusions

- A lot is yet to be understood about AGN
- High-quality spectra obtained with CTA at various redshifts will be key to fully understanding the emission mechanisms of blazars **https://www.cta-observatory.org/science/cta-performance/**.