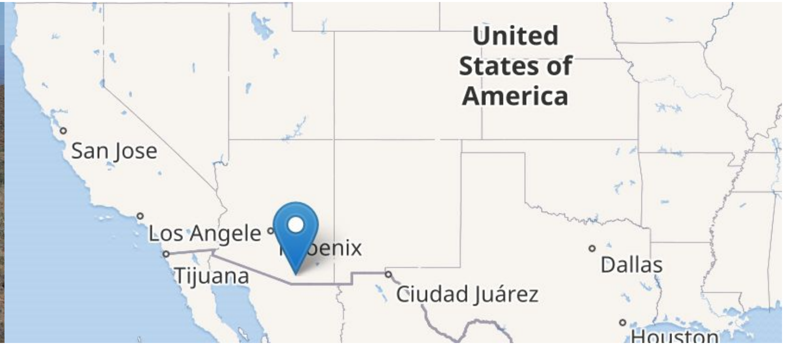
VERITAS Collaboration: B2 1811+31

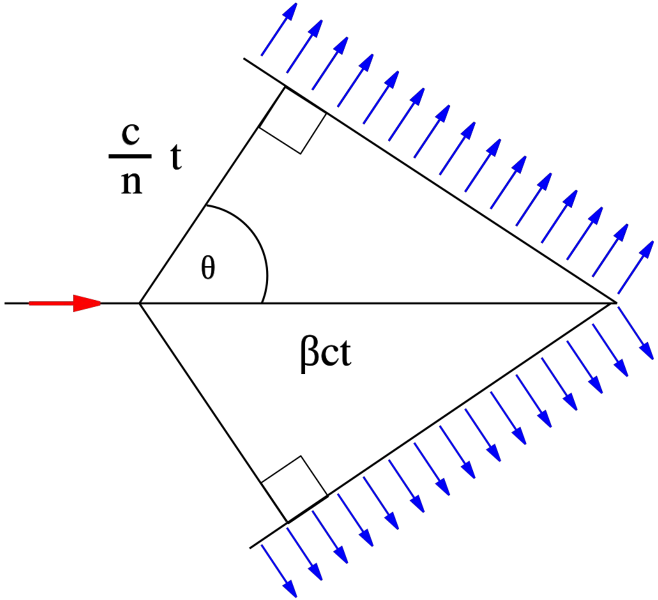
Presenter: Rafael Diaz Brenes
On behalf of the B2 1811+31 Flare working group:
Eileen Meyer, Reshmi Mukherjee, Colin Adams, Ste O'Brien, Pablo Drake, Cecilia Martinez Rodriguez, Cameron Hahn, Markos Georganopoulos

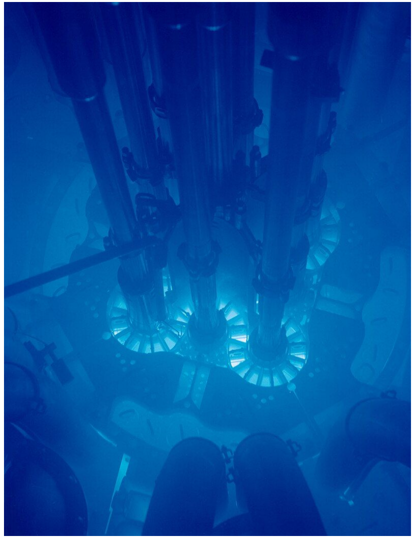
VERITAS Observatory

- Ground based gamma ray observatory
- Imaging Air Cherenkov Telescope
  - Detects optically wavelength cherenkov radiation from particle showers
- Energy Range: 50 GeV - 50 TeV



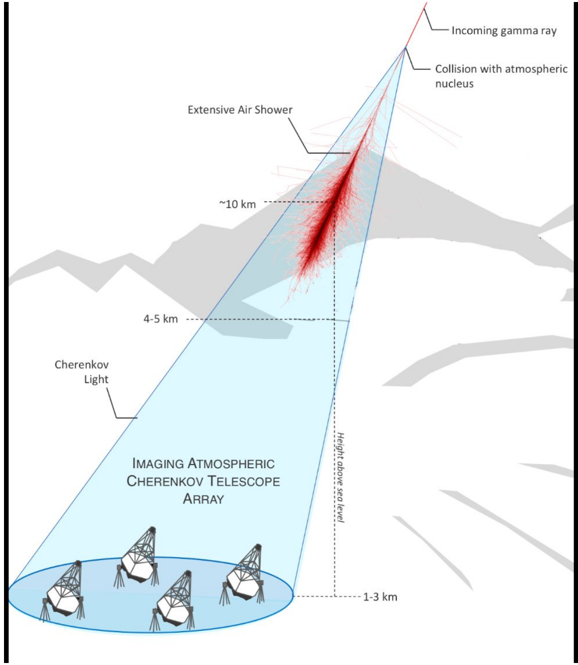
Cherenkov Radiation

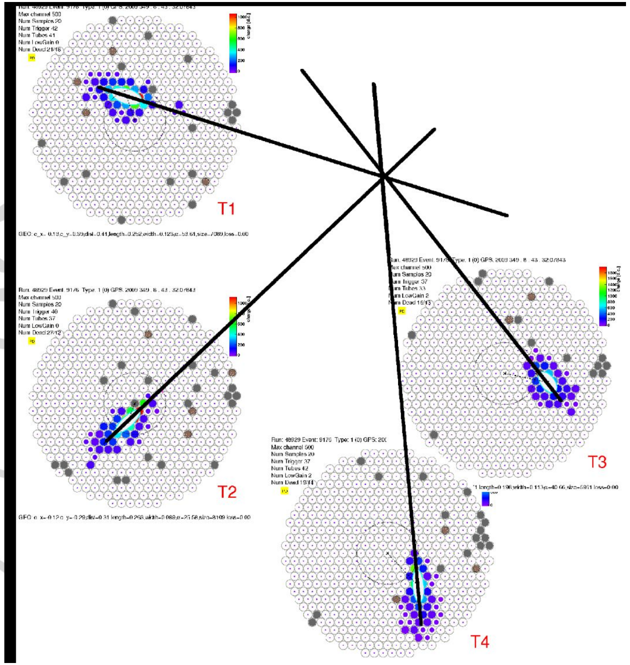




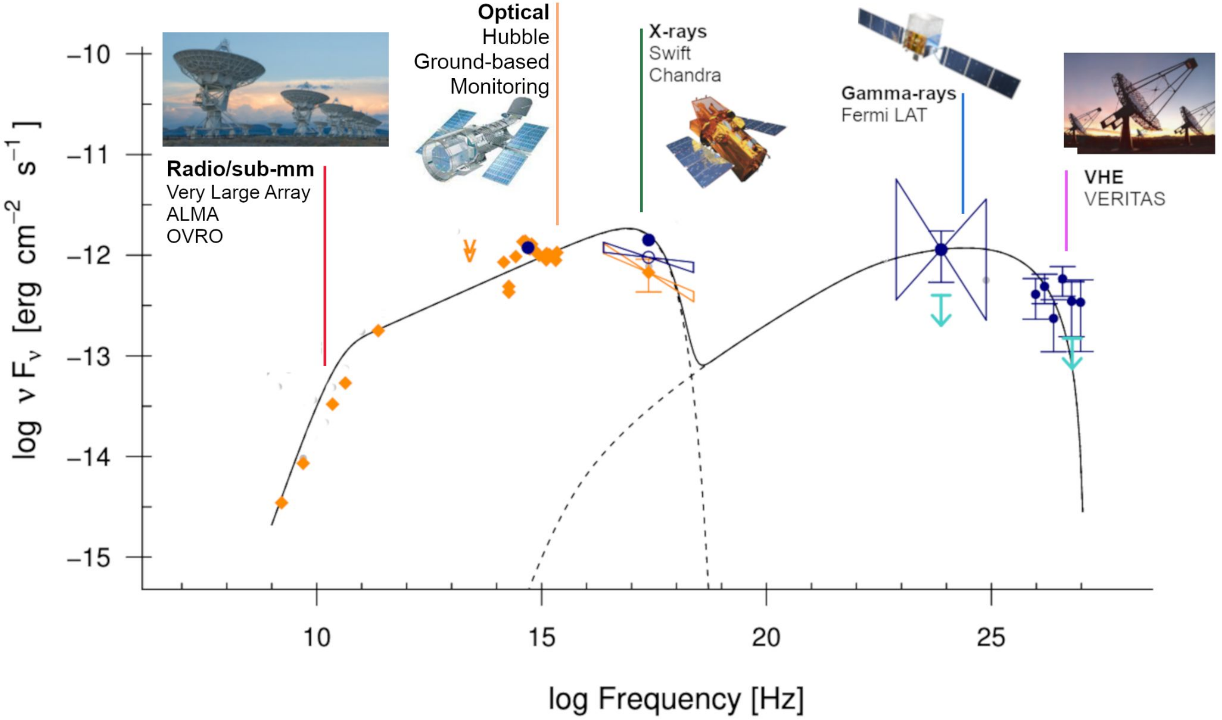
Idaho National Laboratory
Advanced Test Reactor

Particle Shower Detection in Visible Light

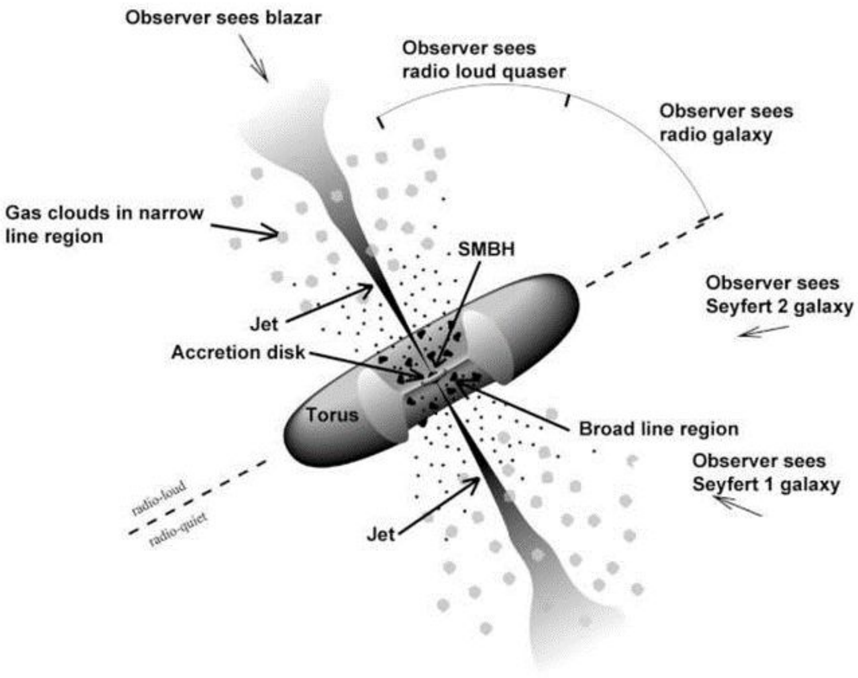




Multiwavelength SED



AGN Unified Model



Blazars

- BL Lac (Bl Lacertae Object):
    - Low Power radio galaxies that directly point towards the observer.
    - No thermal features in spectrum.
- OVV*:
    - Optically Violent Variable Quasars
    - Powerful Radio Galaxies with stronger broad emission lines
- Extremely variable

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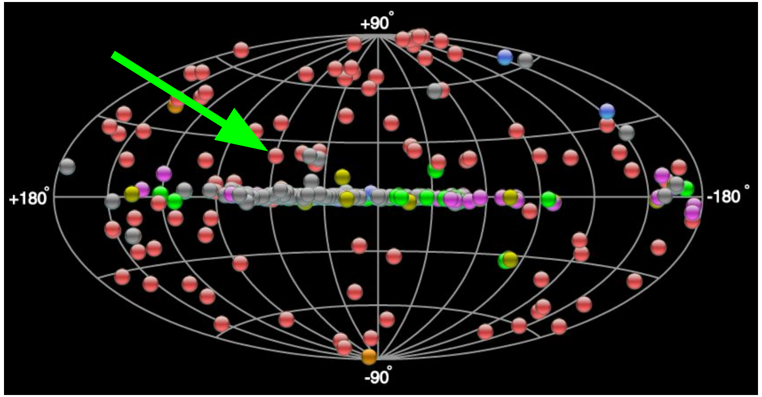
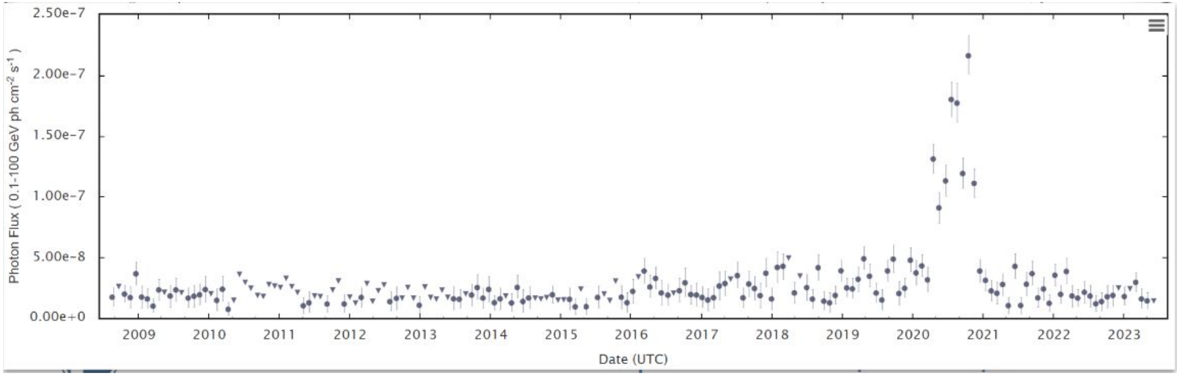
- BL Lac
  - Intermediate Energy Peaked BL Lac Object
- Highly variable AGN
- Z = 0.117



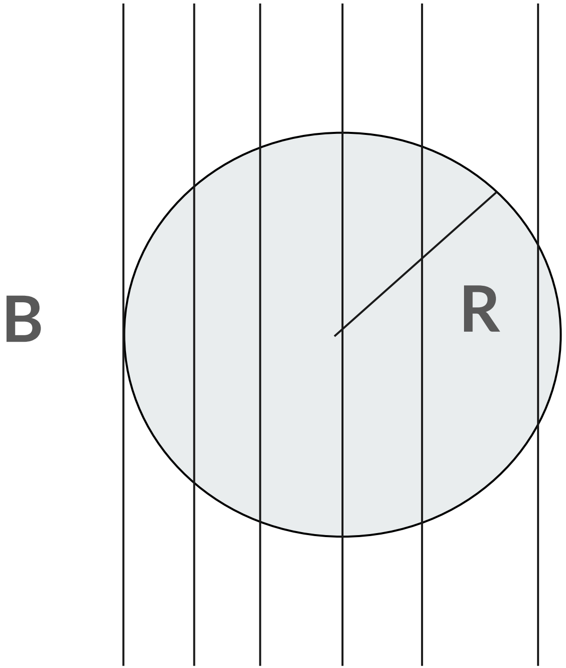
Flare Up

Fermi-LAT detected gamma ray flare up October 1st, 2020:

- Fermi LAT analysis conducted using Bayesian Blocks (**Colin Adams,Pablo Drake et al. 2023, Cameron Hahn)**:
  - 1 month bining for quiescent state
  - Half month and 2 day bining for flaring state:
- Fermi LAT + VERITAS Flare (**Ceci Martinez Rodriguez)**:
  - Intrinsic flux given by log parabola with TeV scaling for both quiescent and flare states.



One Zone Model (Graff and Markos et al. 2008)



Constant **B** field

Diffusion Loss Equation

(1)

$$\frac{\partial n(\gamma,t)}{\partial t} + \frac{\partial}{\partial \gamma}[\dot{\gamma} n(\gamma,t)] + \frac{n(\gamma,t)}{t_{\rm esc}} = q(\gamma,t).$$

(2)

$$\dot{\gamma} = \dot{\gamma}_s + \dot{\gamma}_{\rm IC}, \quad \dot{\gamma}_s = \frac{4\sigma_{\rm T}}{3mc}\gamma^2 U_B,$$

$$\dot{\gamma}_{\rm IC} = \frac{4\sigma_{\rm T}}{3mc}\gamma^2 \int_{\epsilon_{\rm min}}^{\min[\epsilon_{\rm max},3/(4\gamma)]} U(\epsilon,t)d\epsilon,$$

Diffusion Loss Equation

(3)

$$\frac{n_{j,i+1} - n_{j,i}}{\Delta t} = -\frac{\dot{\gamma}_{j+1,i+1} n_{j+1,i+1} - \dot{\gamma}_{j,i+1} n_{j,i+1}}{\Delta \gamma} + q_{j,i+1} - \frac{n_{j,i+1}}{t_{\rm esc}}.$$

Diffusion Loss Equation

(4)

$$n_{j,i+1} = a n_{j,i} - b n_{j+1,i+1} + c q_{j,i+1},$$

$$a = \frac{\Delta\gamma}{\Delta\gamma + \Delta t\, \Delta\gamma / t_{\mathrm{esc}} - \Delta t\, \dot{\gamma}_{j,i+1}},$$

$$b = a \frac{\Delta t}{\Delta\gamma} \dot{\gamma}_{j+1,i+1}, \quad c = a\Delta t.$$

Diffusion Loss Equation

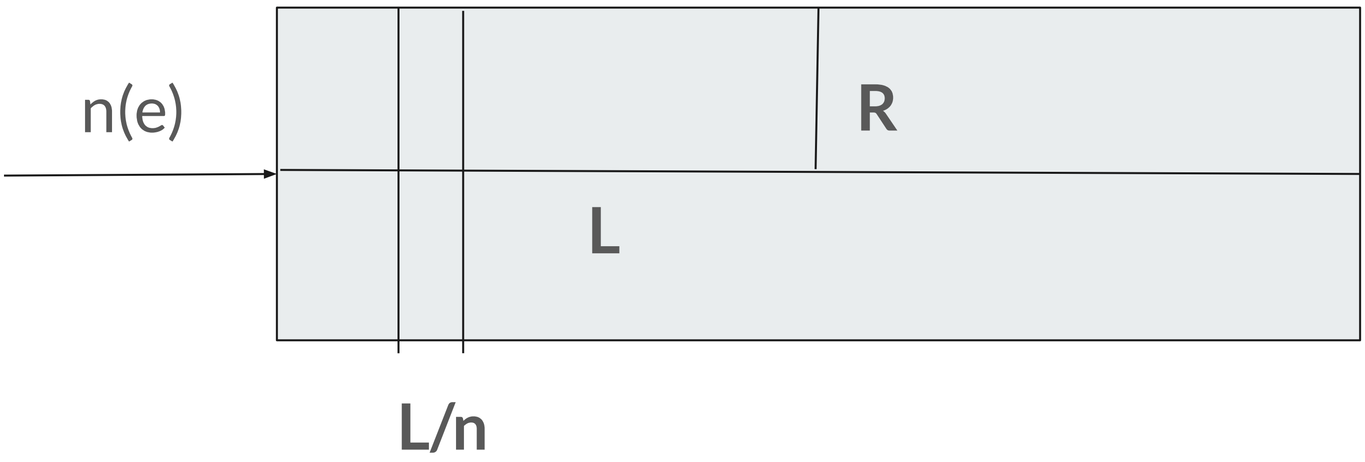
(5)

$$L_s(\epsilon_s, t) = 1.85 \frac{\sqrt{2} q^3 B}{h} \int_{\gamma_{\min}}^{\gamma_{\max}} z^{1/3} e^{-z} n(\gamma, t) d\gamma,$$

$$z = (2/3)^{1/2} \epsilon_s / B_\star \gamma^2,$$

$$B_* = \frac{B}{B_{crit}}, B_{crit} = (m^2{}_e c^3)/(e\hbar)$$

Multizone Model

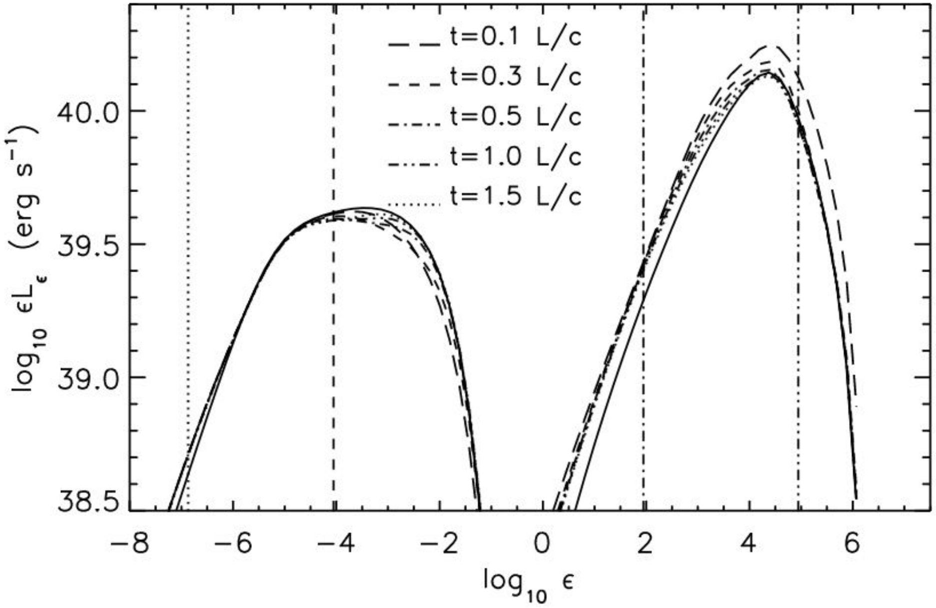


MWL SED Picture

One Zone Model Fitting for steady low state and high states (**Eileen Meyer, Markos Georganopoulos, Rafael Diaz Brenes**):

- Require two components for quiescent state:
  - IR/optical/UV from "slow sheath" or "decelerated flow" - 1000x larger, lower density, lower B field
  - X-rays from base of jet
- High state consistent with single component, i.e. a flare of the "fast spine" (note size, escape time)
- Parameters are degenerate

Graff and Markos et al. 2008



MWL SED Picture

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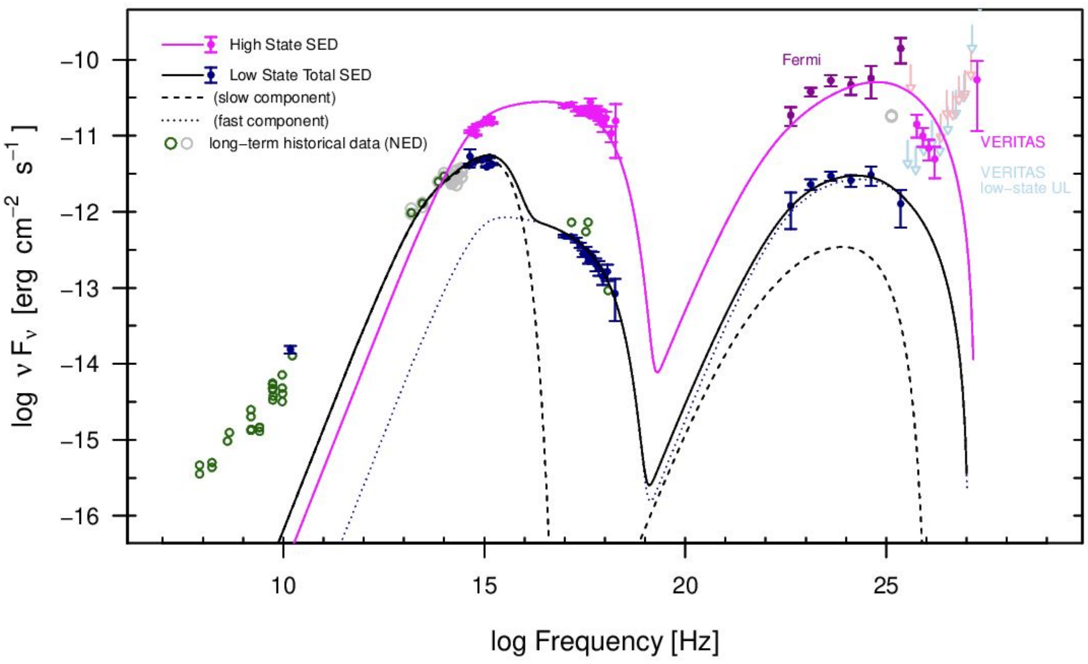
- Many parameters are degenerate

[preliminary]



SSC and ICC Models

Parameter	low-state slow	low-state fast	flare state
Bulk Γ	15	25	45
Dop. factor (δ)	30	48	68
EED exponent	2	2.75	2.1
γ_min	4.E+03	4.E+03	4.E+03
γ_max	5.E+04	2.E+05	2.E+05
com. Luminosity [erg/s]	2.0E+41	7.0E+38	1.8E+39
B field [G]	0.01	0.2	0.2
radius [cm]	1.0E+17	1.5E+14	6.0E+14
t_escape [R/c units]	1	40	60

[preliminary]

Future Work

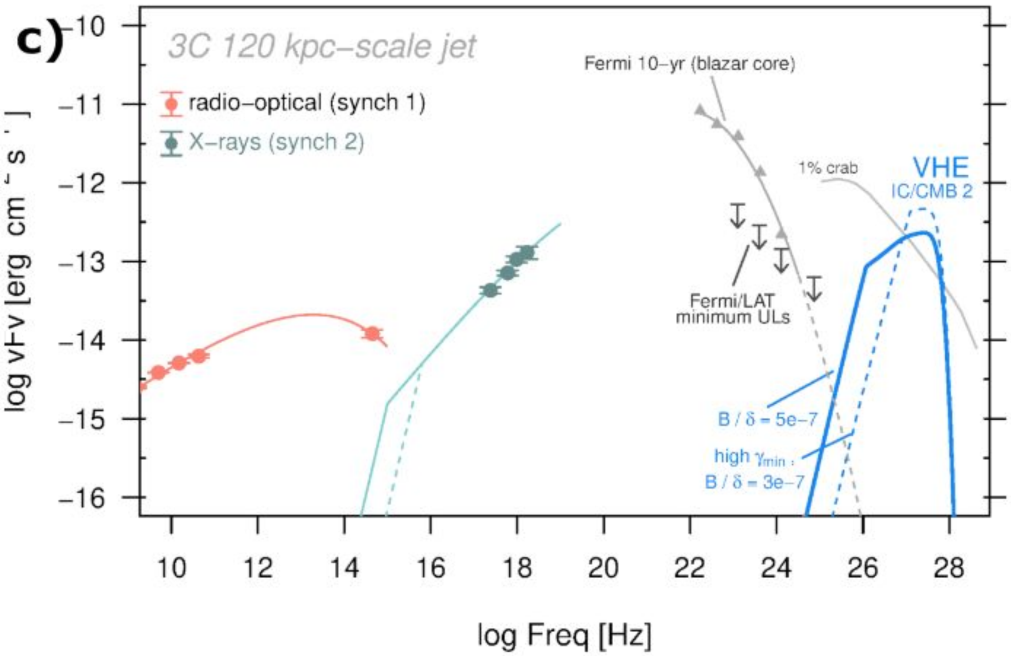
- Obtain IR/Optical/UV components from “decelerated flow”
- X-rays from the base of jet
- Improve parameter degeneracy by creating a minimizer of the One Zone Model
  - Perhaps apply a multi zone model?
- Better parametrization for MWL SED

Physical Model and TeV Detection: 3c 120

- Detect TeV emissions at Kpc scales from central engine Evidence for SC origin of extended hard X-ray emissions at Kpc
    - A synchrotron origin for the X-ray emission in kpc-scale jets can only be positively confirmed through a detection of the 'VHE echo' of this component
    - IC/CMB spectrum peak > 10 TeV (aiming for 5σ)

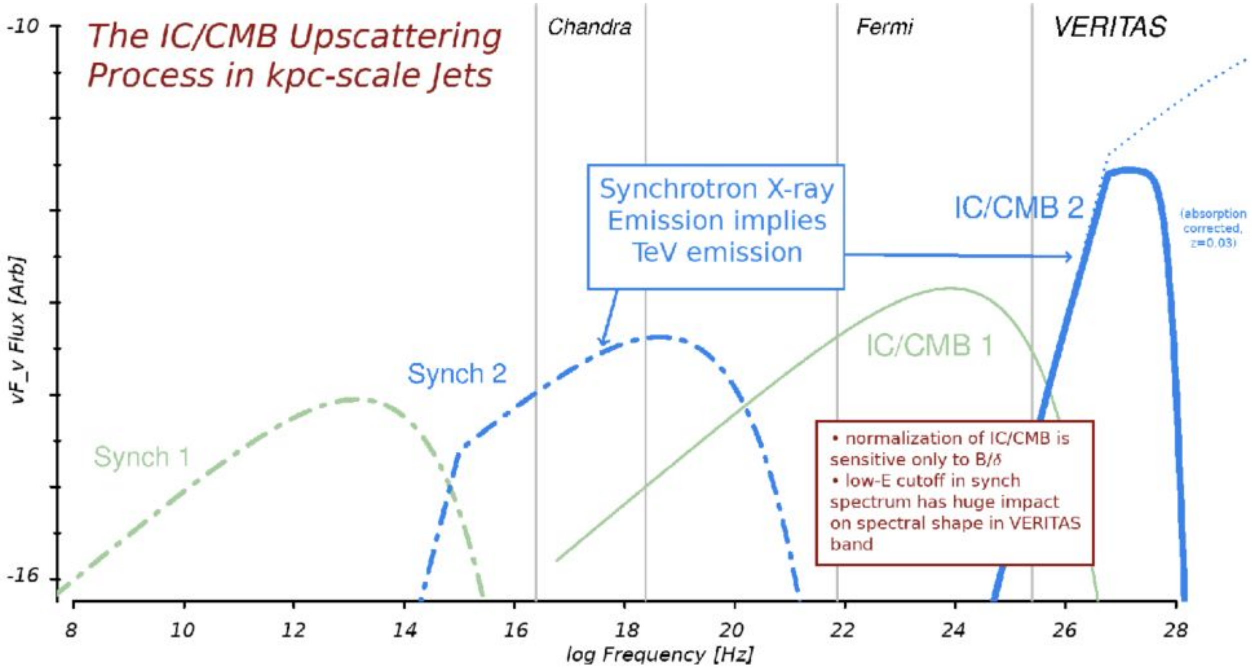
Expected TeV Detection: 3c 120

- Detection of a VHE component would clearly confirm that the strong, hard-spectrum X-ray emission has synchrotron origin.



et al. Meyer 2022/2023

Expected TeV Detection: 3c 120



et al. Meyer 2022/2023