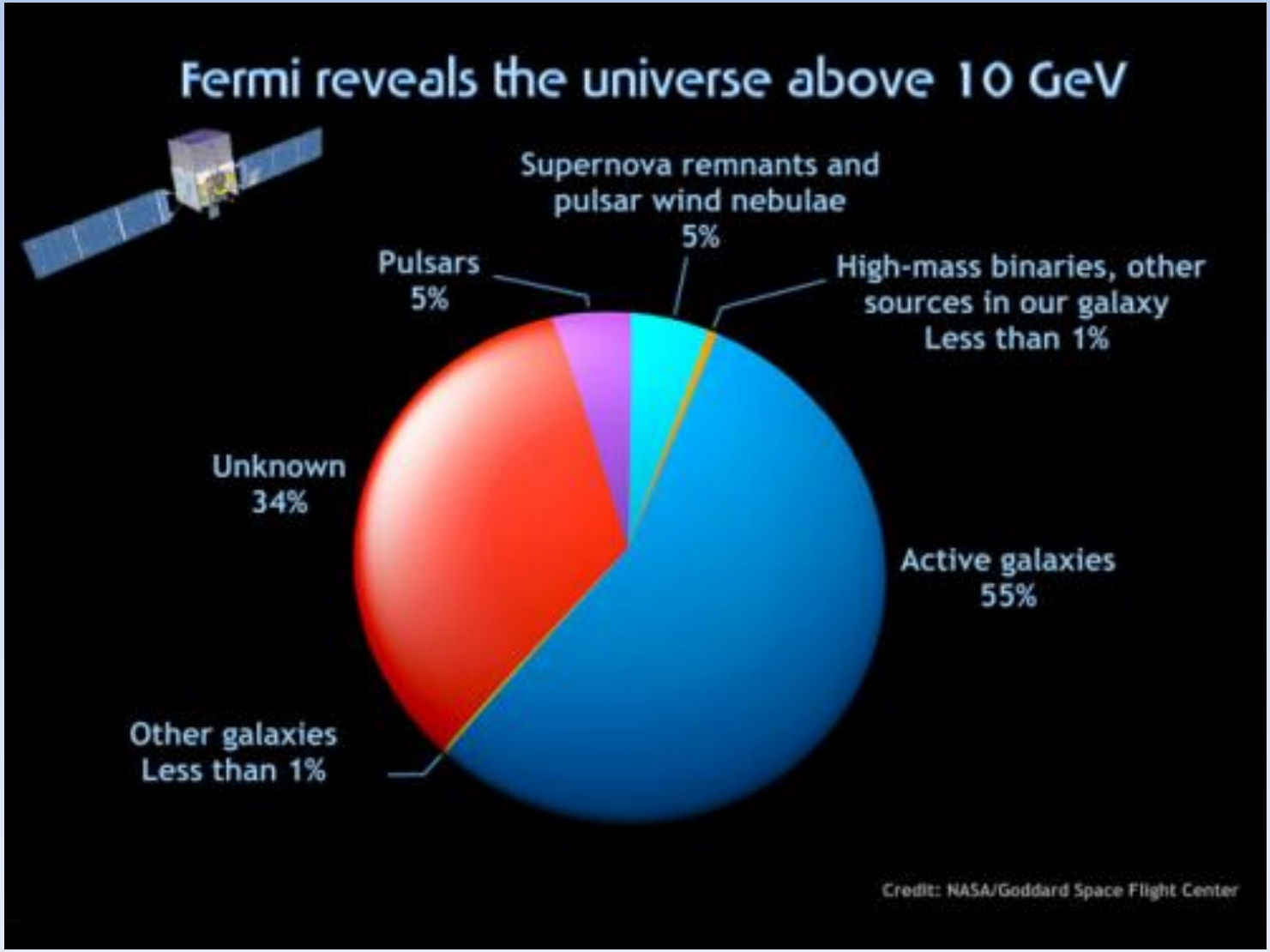
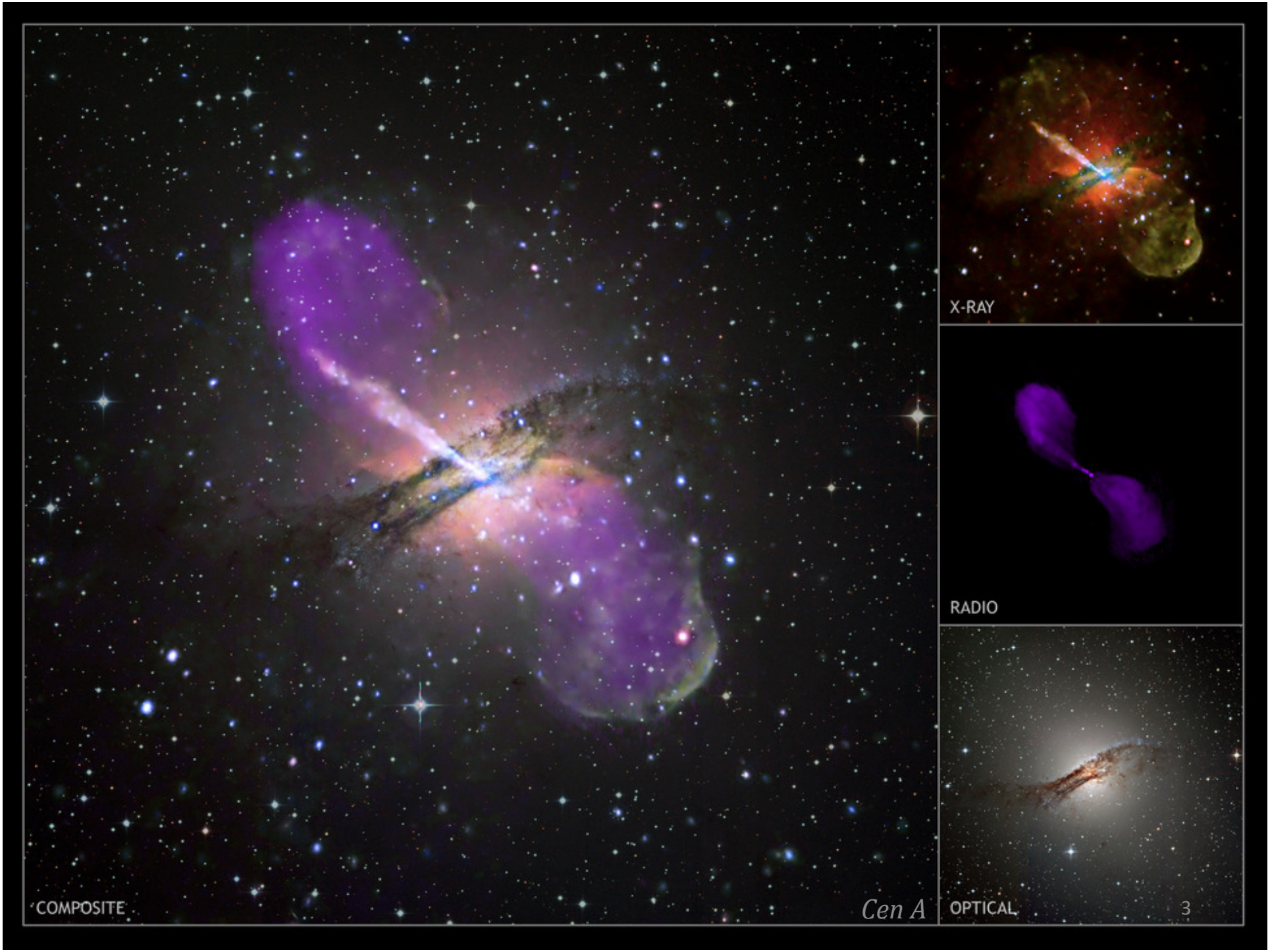
Studying emission mechanisms of AGN

Dr. Karsten Berger

Fermi School, June 2013

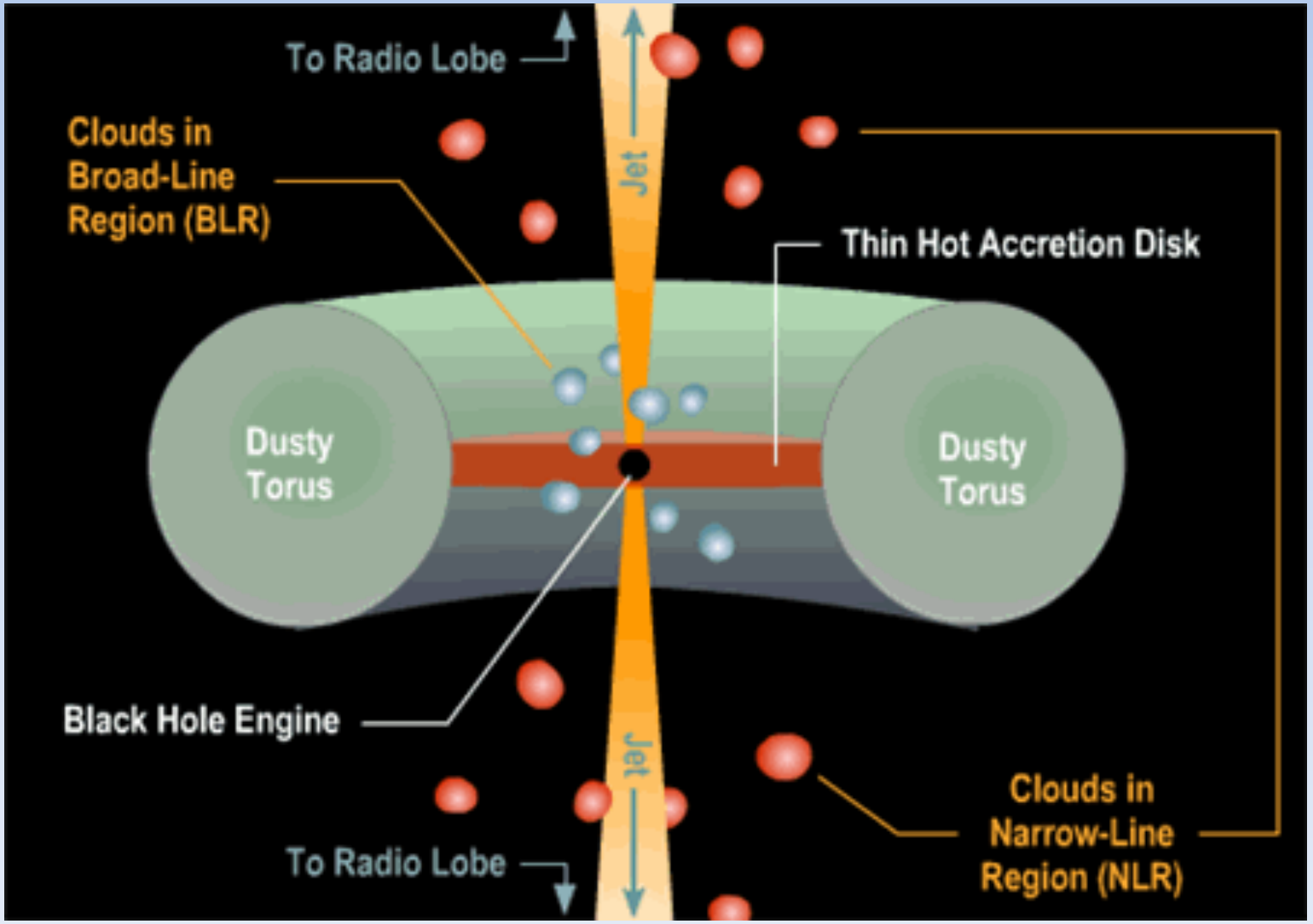
Motivation


Fermi reveals the universe above 10 GeV
Supernova remnants and pulsar wind nebulae 5%
Pulsars 5%
High-mass binaries, other sources in our galaxy Less than 1%
Unknown 34%
Active galaxies 55%
Other galaxies Less than 1%
Credit: NASA/Goddard Space Flight Center



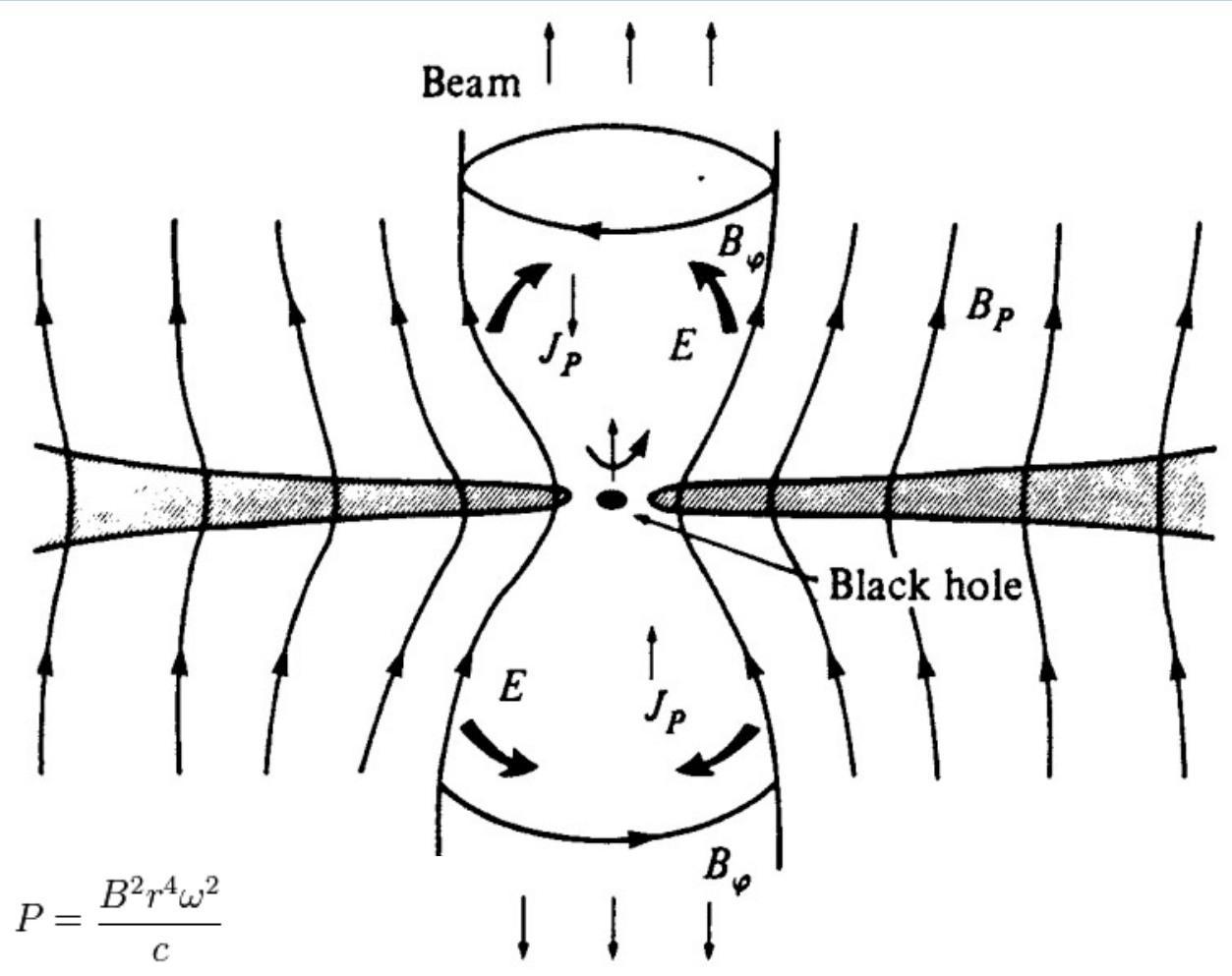
Cen A

What is an AGN made of?



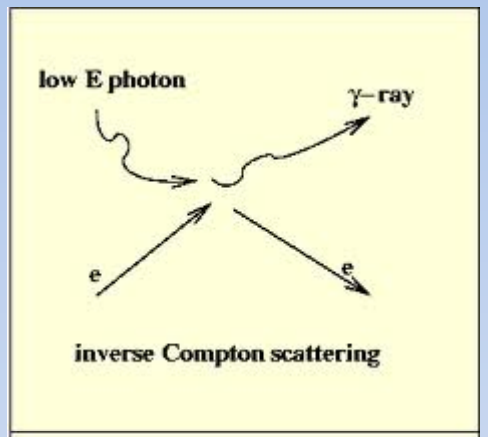
Blandford-Znajek process

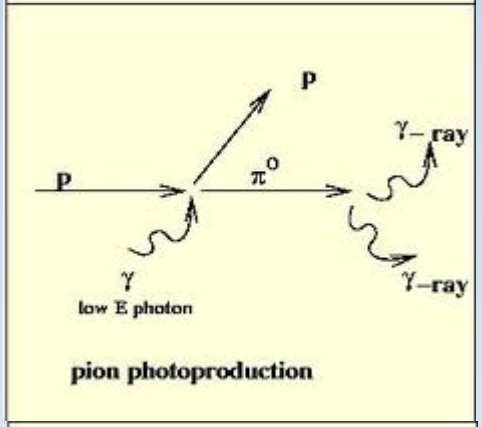
- Remember: black holes don‘t have hairs!!!

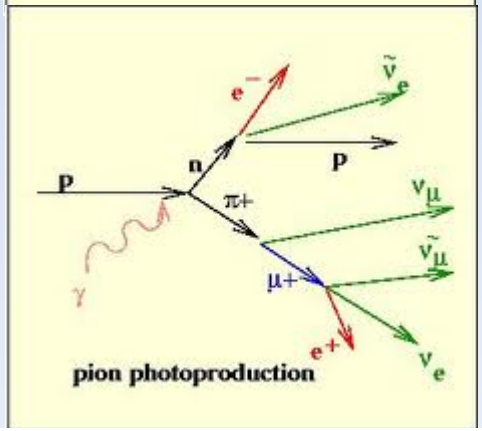


Which particles dominate in the jet?

- For simplicity: usually only leptons are considered in the models
- Should include protons, and thus also Muons, Pions…
- Synchrotron radio from e+/e-, μ+/μ-
- Inverse compton, external compton
- Pion decay…
- The exact jet composition is still under study

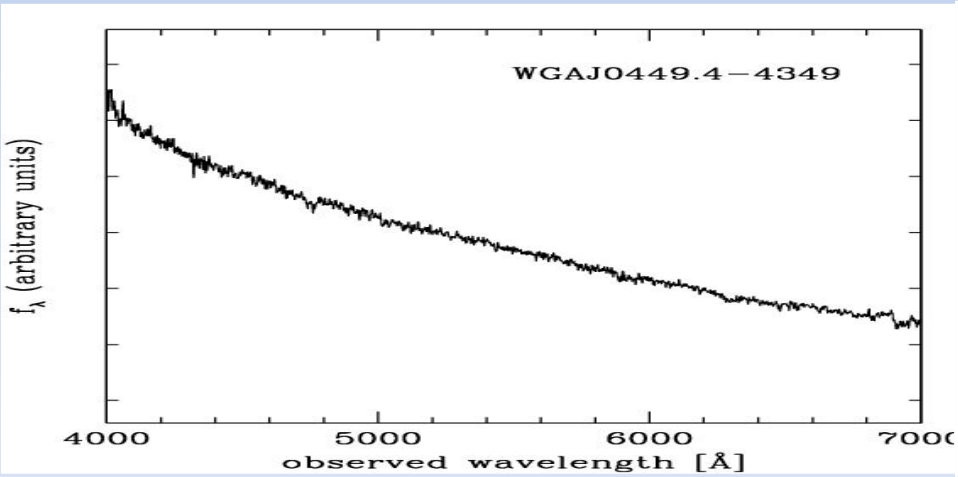




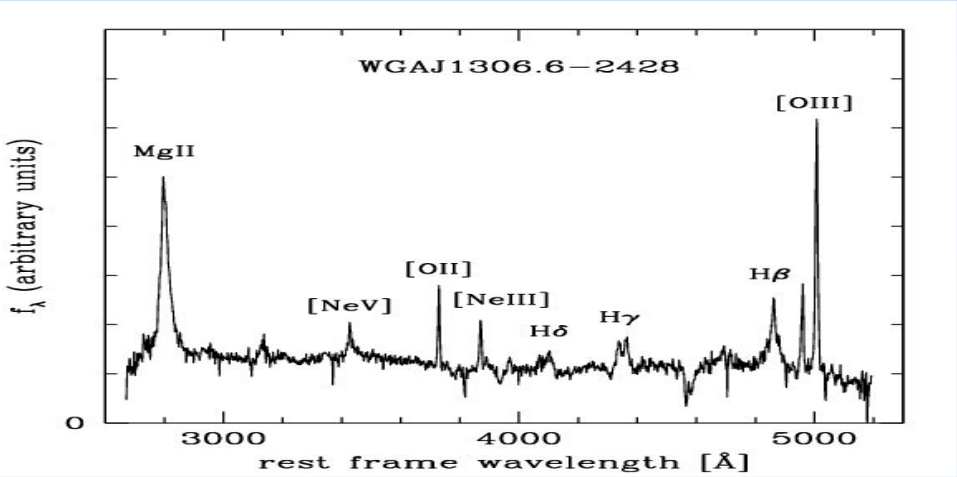


Two Blazar classes

BL Lac object



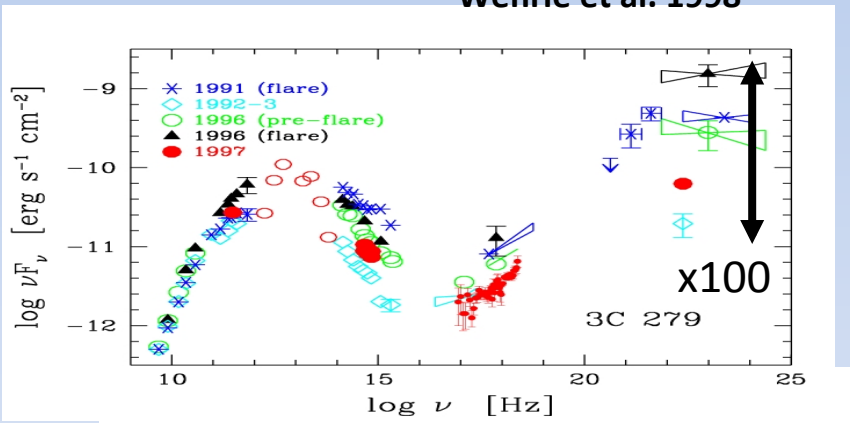
Flat spectrum radio quasar

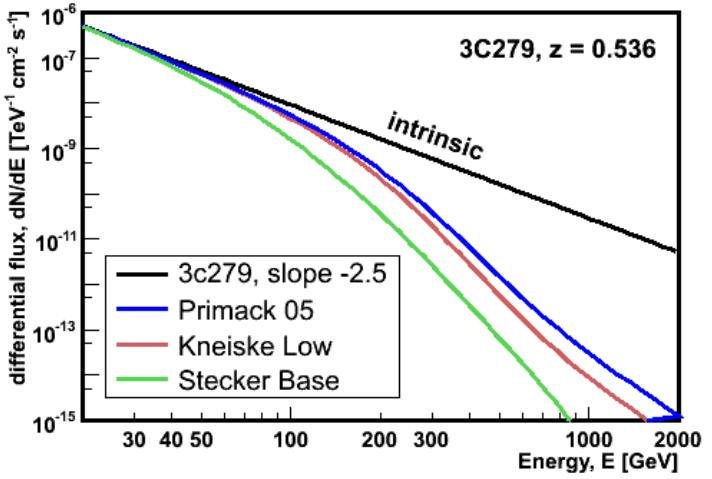


3C279 (z = 0.536)

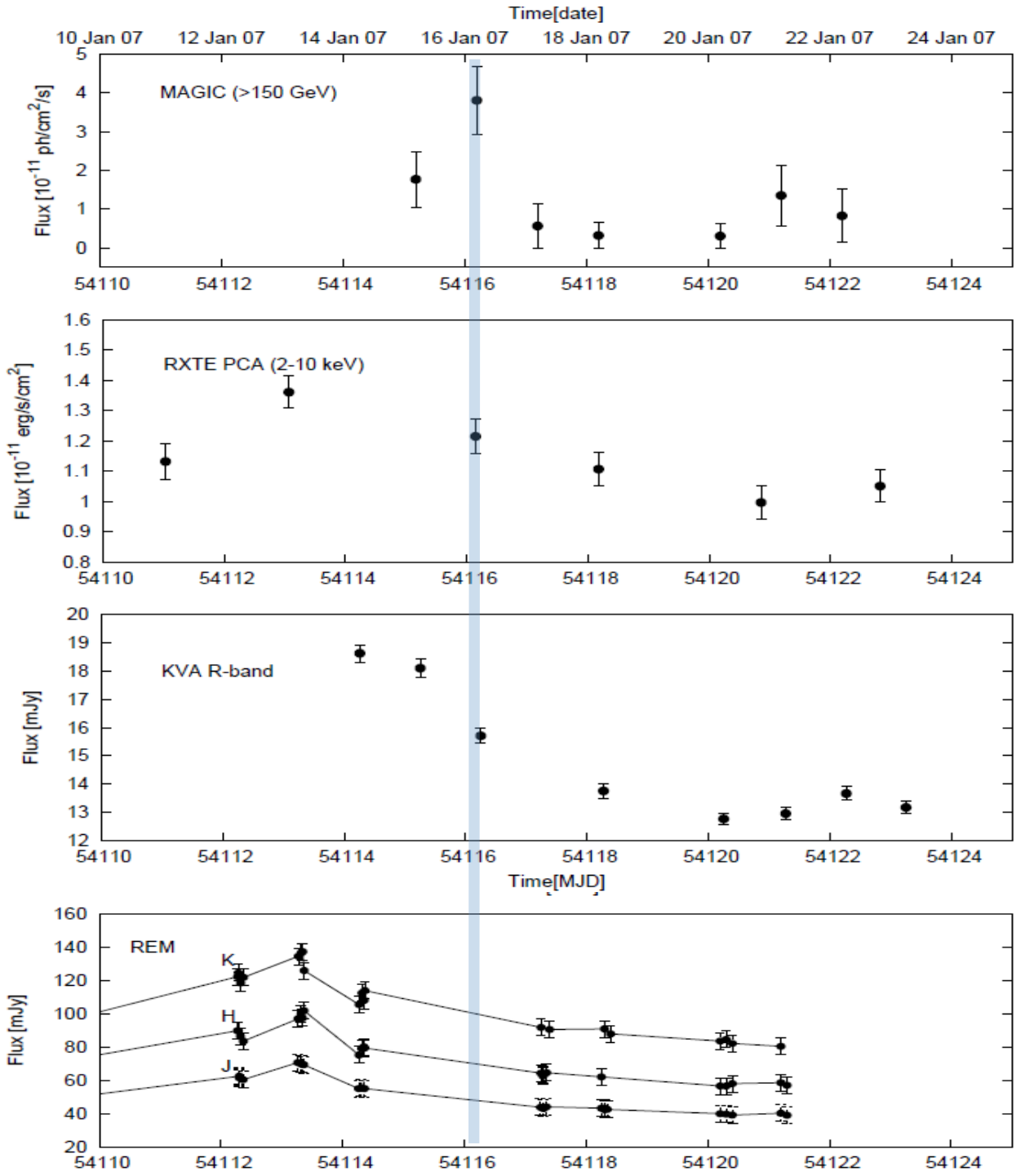
- Flat spectrum radio quasar (FSRQ)
- Brightest AGN detected by EGRET (but see Fermi)
- Very strong flares in 1991 and 1996
- low states in 1992 and 1997
- ➢ Variable on a scale of ~100
- ➢ Apparent luminosity ~ 10^{48} erg/s
- ➢ Fast time variation ΔT ~ 6hr in 1996
- Strong absorption in very-high-energy (VHE): E_γ > 100 GeV:
- VHE discovery by MAGIC in 2006
- Second flare in 2007

Wehrle et al. 1998



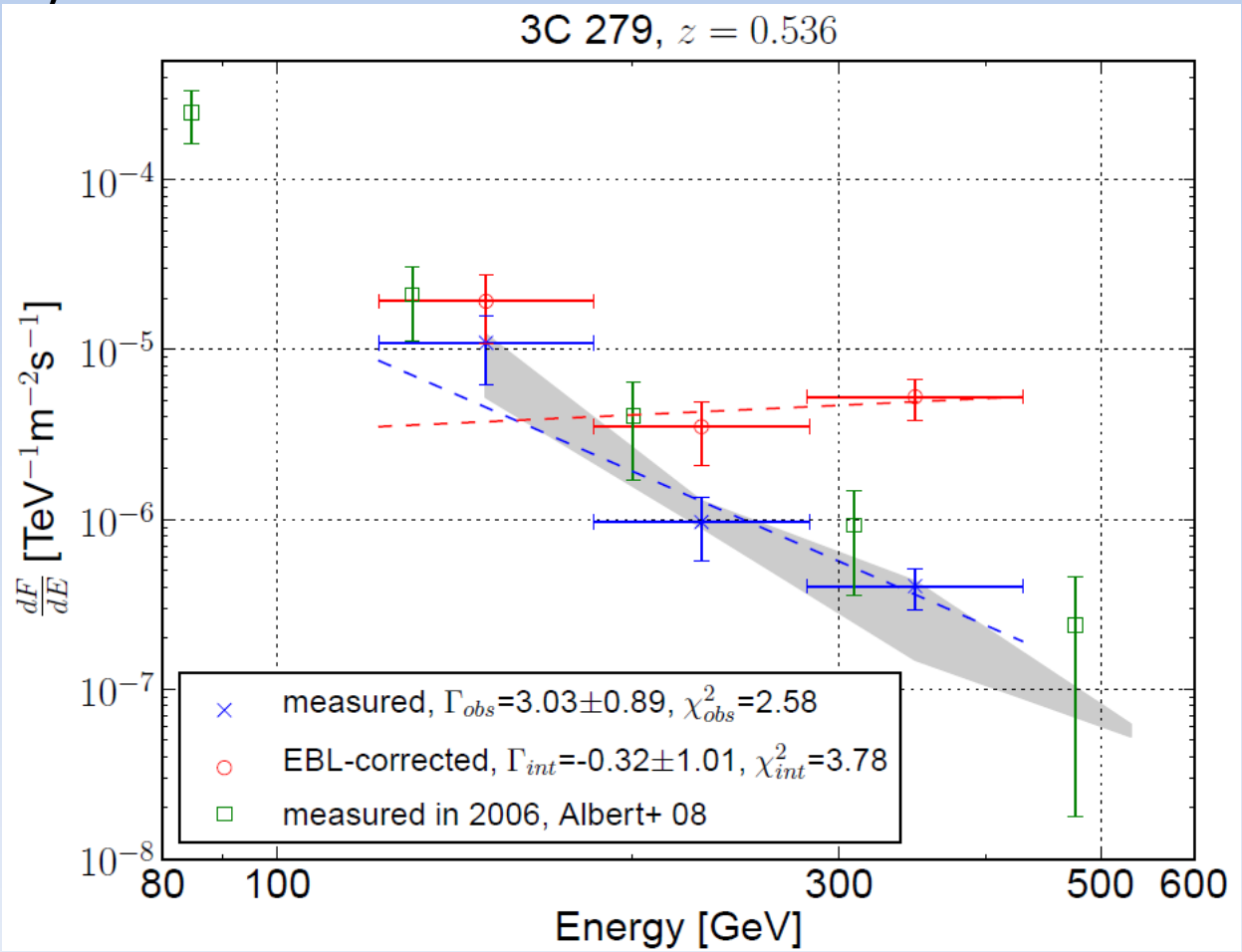


Light curve 2007: Again no direct correlation, but delayed emission. Different emission regions?

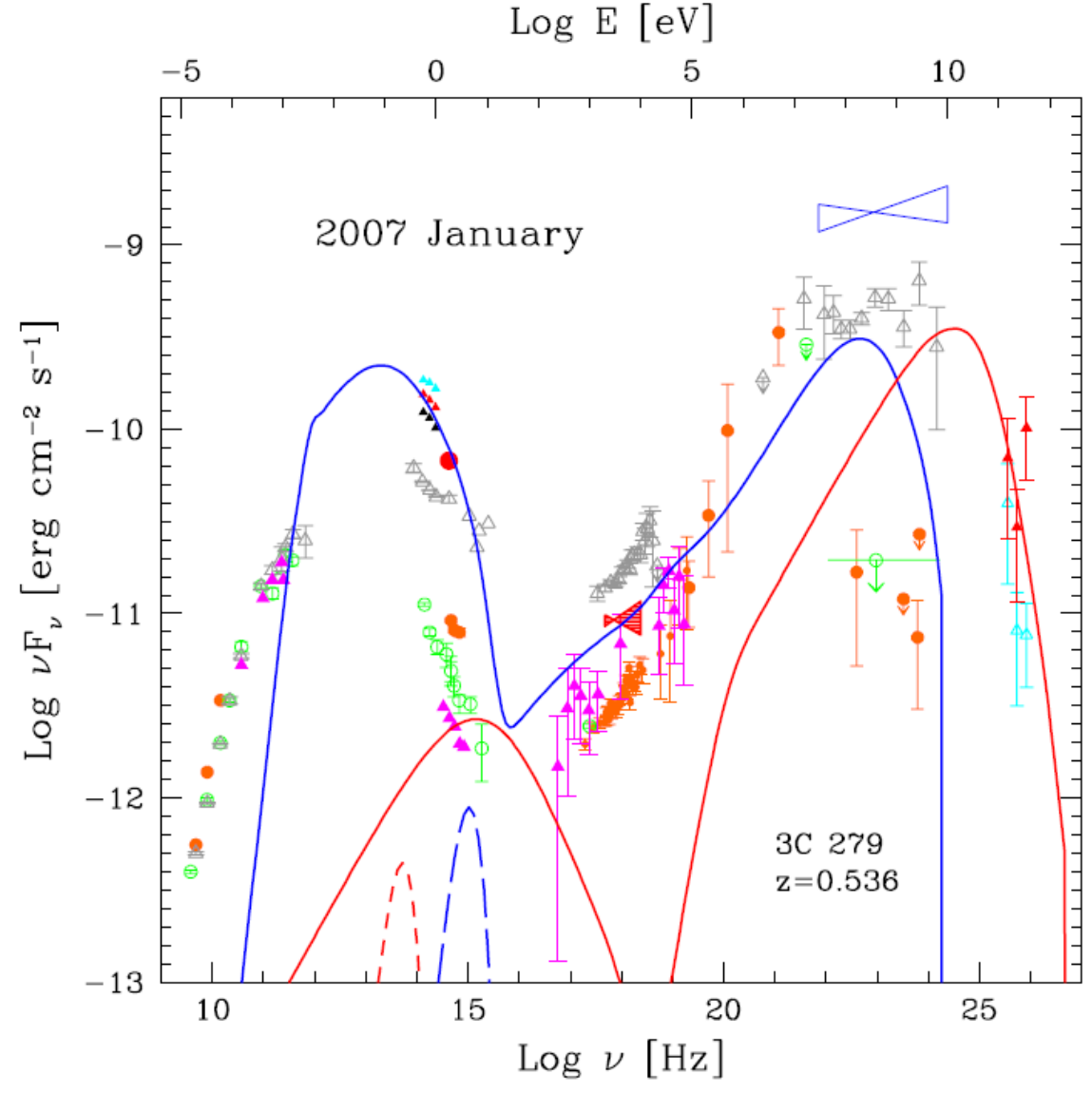


Spectrum 2007

Very hard spectrum confirmed, photon index consistent with 2006 observations within errors (grey band corresponds to varying cut efficiencies)

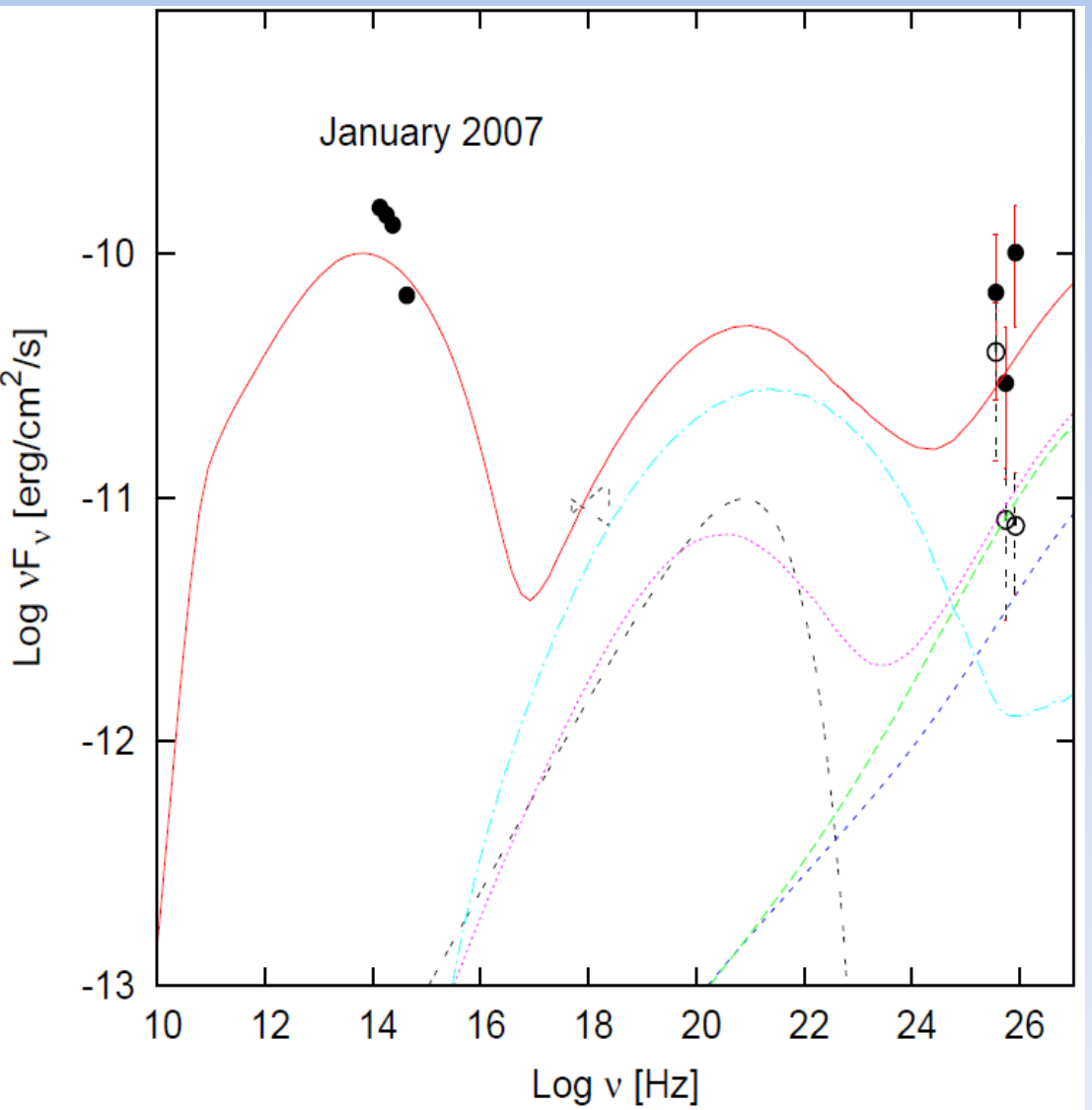


SED 2007: two zone SSC model



- Unfortunately no FERMI data yet
- Blue line: emission inside the BLR
- Red line: external compton emission outside the BLR
- Pro: acceptable fit to the data, VHE emission region outside of dense photon fields: no problems with absorption
- Con: twice the number of model parameters, more freedom

SED 2007: lepto-hadronic model



- Considers not only leptons but also protons in the jet
- Synchrotron emission from electrons/protons
- γ-rays from pion decay (p-p-collisions)
- Pro: can also reproduce the data
- Con: again large number of free parameters, many emission components

Model results

Model	γ_{min}	γ_b [10^3]	γ_{max} [10^5]	n_1	n_2	B [G]	K [10^4 cm^{-3}]	R [10^{16}cm]	δ	θ [deg]	τ_{BLR}	R_{BLR} [10^{17}cm]	R_{IR} [10^{18}cm]
2006 One-zone BLR	1	2.5	3.5	2	3.7	0.15	2	5	20	2.9	0.015	4	–
2006 One-zone IR	1	2	2	2	4	0.19	1	4.5	27	2	–	–	4
2007 Two-zone: Opt-X-ray zone	1	0.5	0.03	2	4.3	2.2	5.5	5	18	3.1	0.05	6	–
2007 Two-zone: VHE zone	45	20	5	2	4.3	0.1	0.01	10	18	3.1	–	–	2.5
2009 One-zone BLR	1	0.33	0.2	2	3.5	0.8	23	3	20	2.1	0.1	6	–

- Results are rather different depending on the model
- A general trend: hadronic models have lower B and higher doppler factors
- This leaves us the problem that we still cannot precisely determine the physical properties in the AGN, since several solutions are viable
- More observations are needed, especially short term variability can help