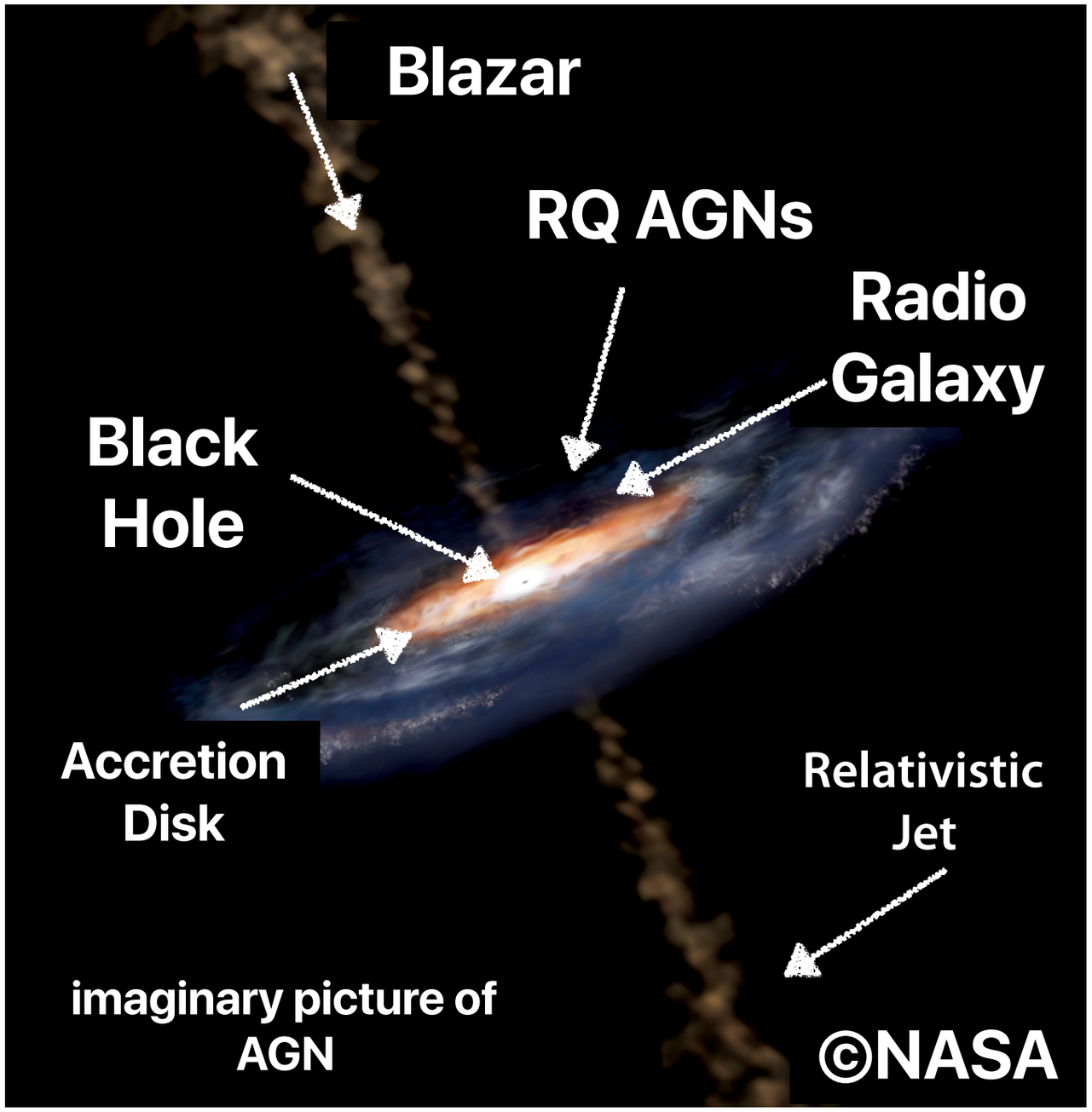
活動銀河中心核からの MeVガンマ線放射

Yoshiyuki Inoue (RIKEN)

MeVガンマ線研究会 @ 東大本郷, 2019-09-27

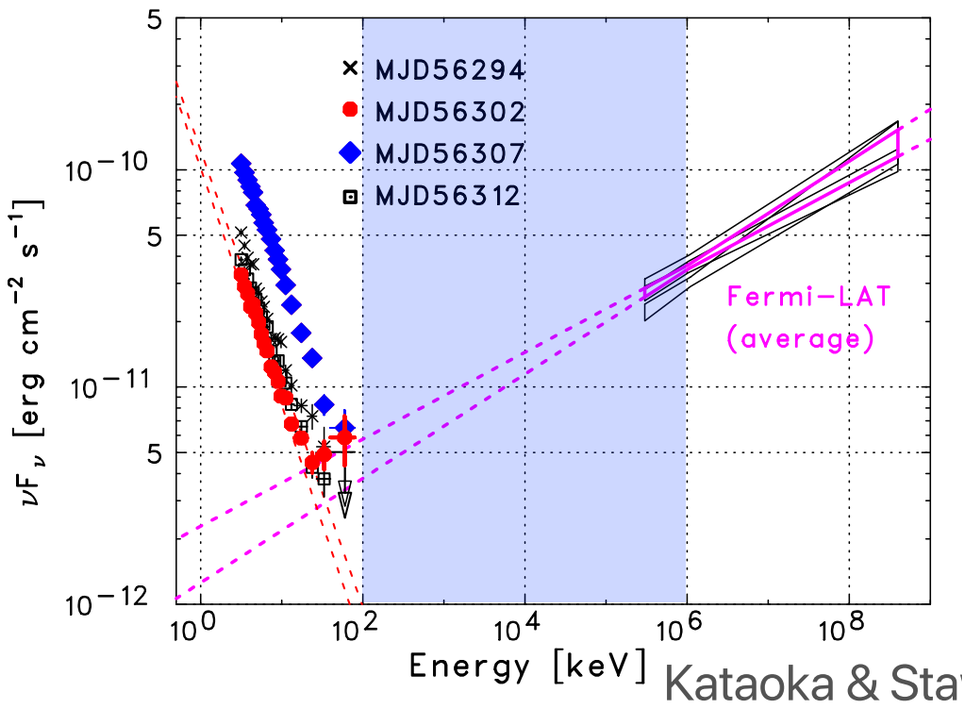
Active Galactic Nuclei (AGNs)



- >10^6 solar mass @ galactic center
  - Correlate with various physical parameters of host galaxies
- Gas accretion
  - brighter than host galaxies (AGNs)
- Hot Coronae
- Relativistic jets

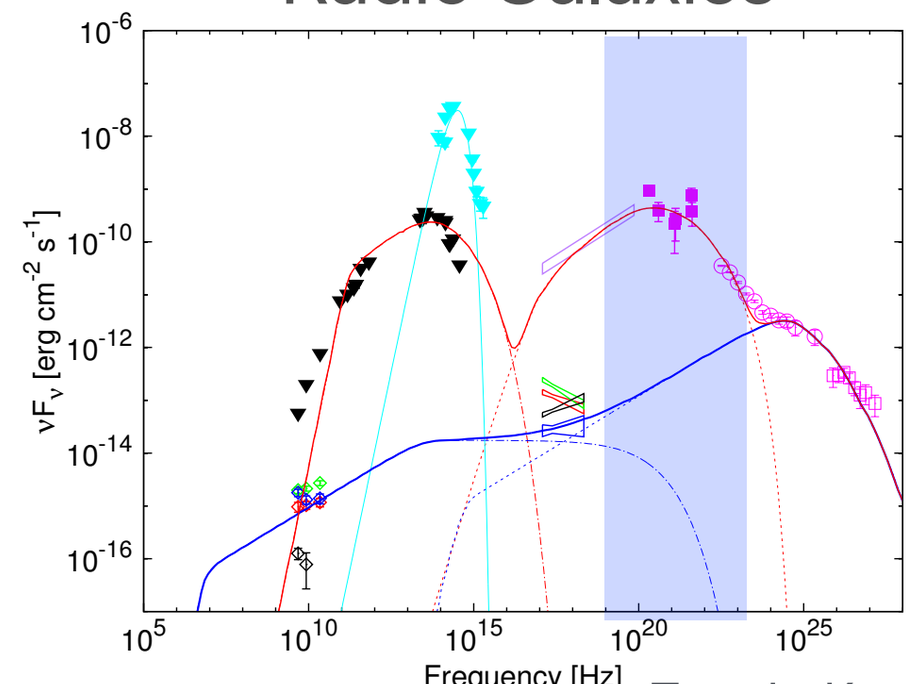
MeV AGNs

BL Lacs



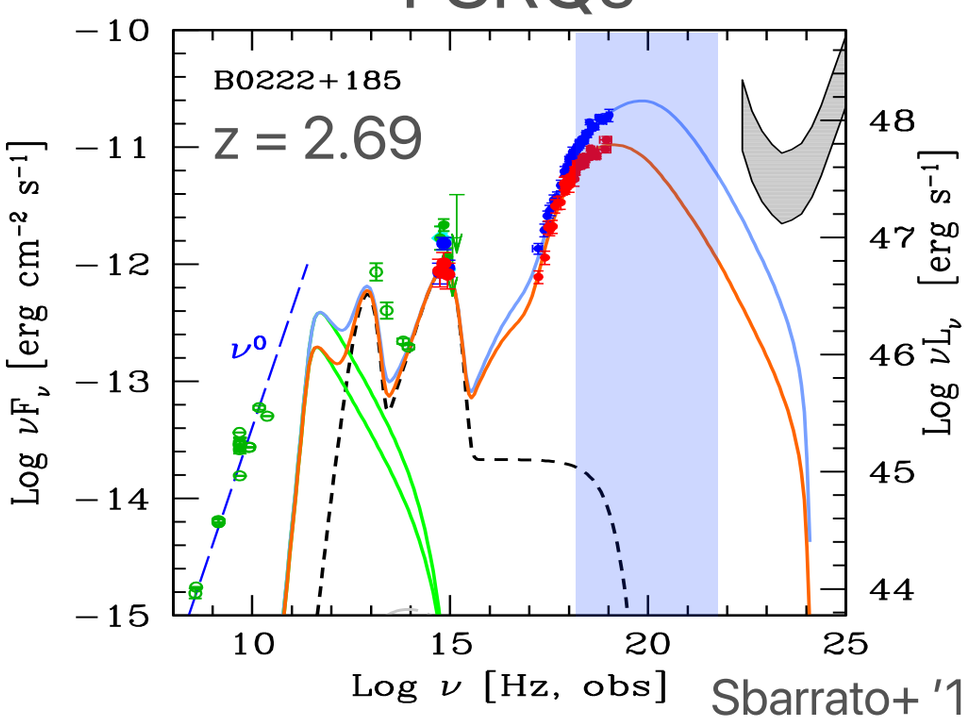
Kataoka & Stawarz '16

Radio Galaxies



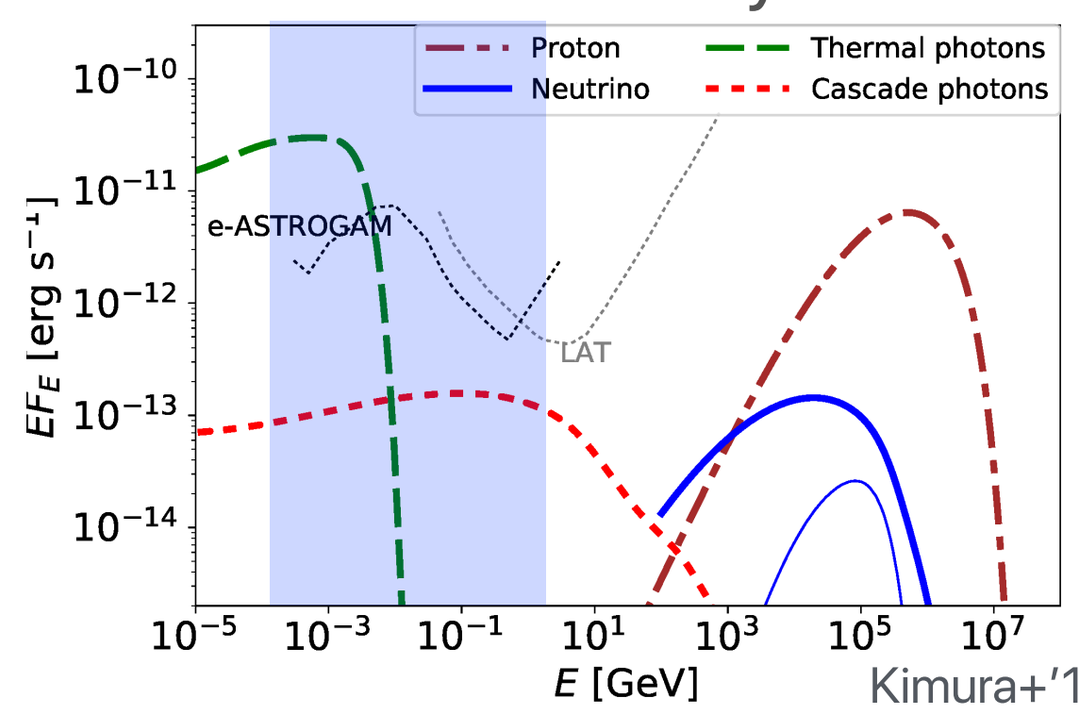
Tanada, Kataoka, YI'19

FSRQs



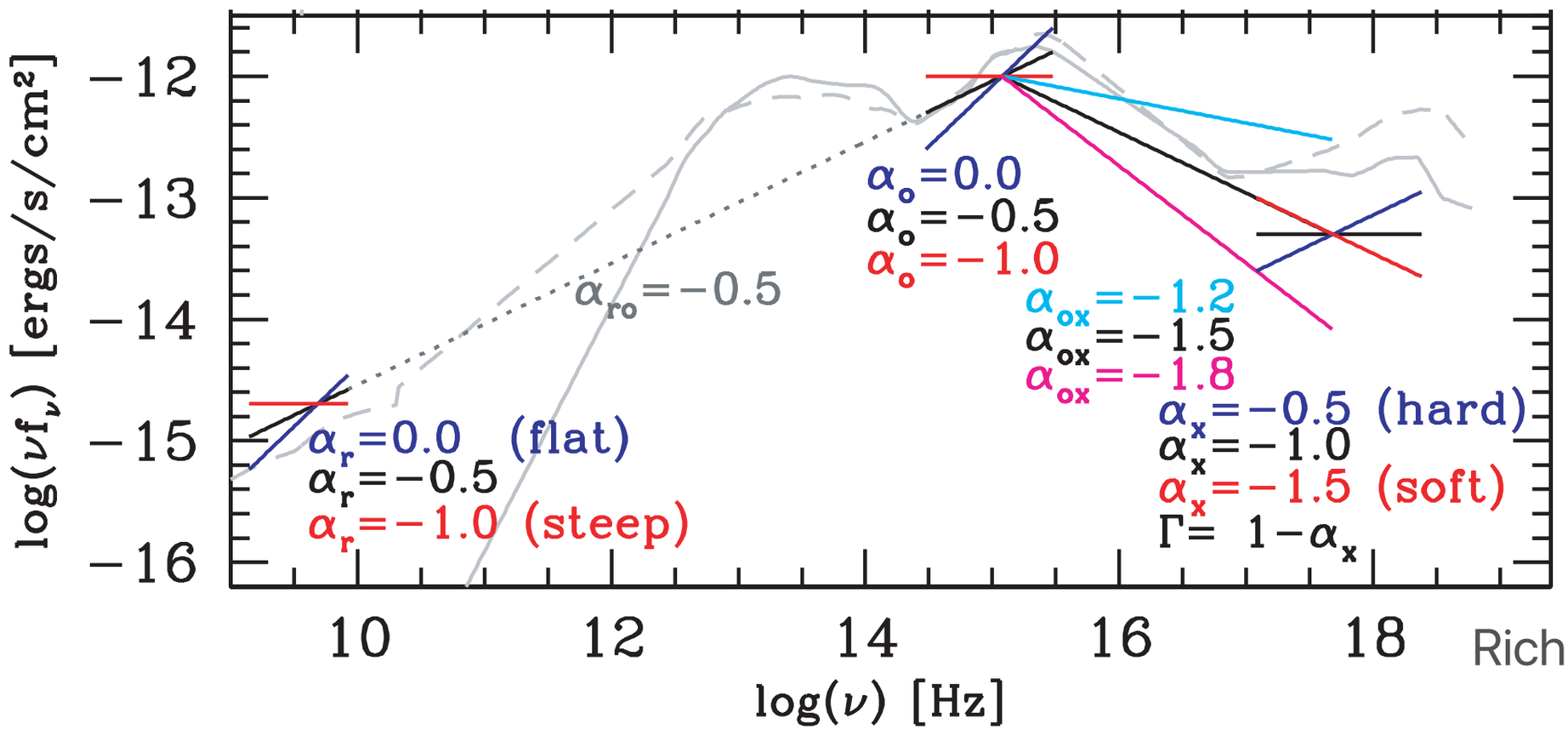
Sbarrato+ '16

Low-luminosity AGNs



Kimura+'19

Radio-quiet AGNs

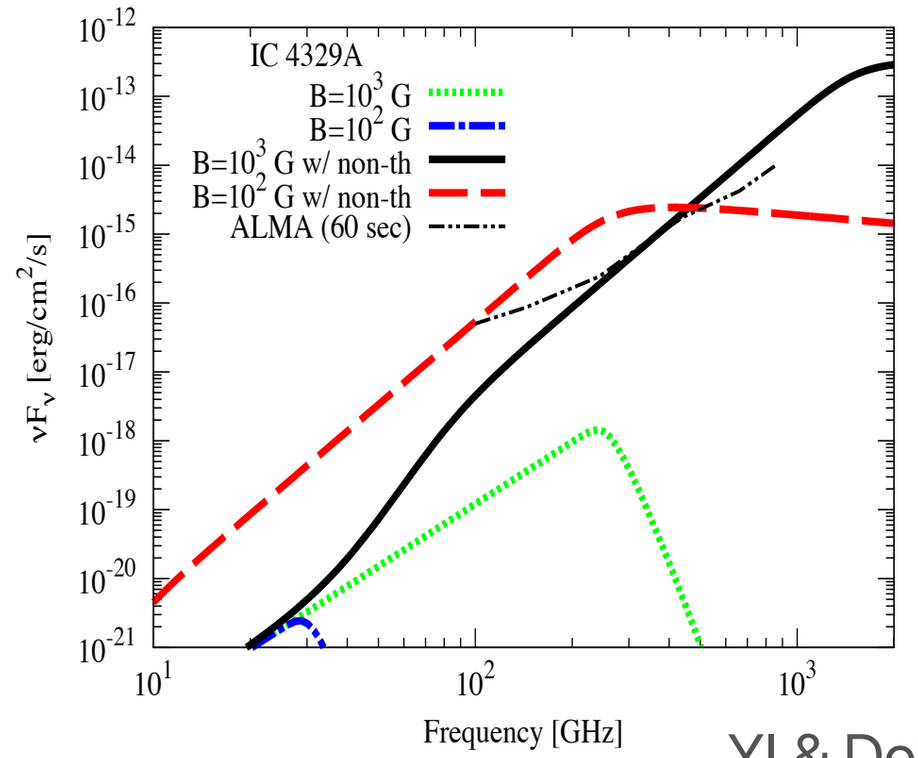


Richards+'06

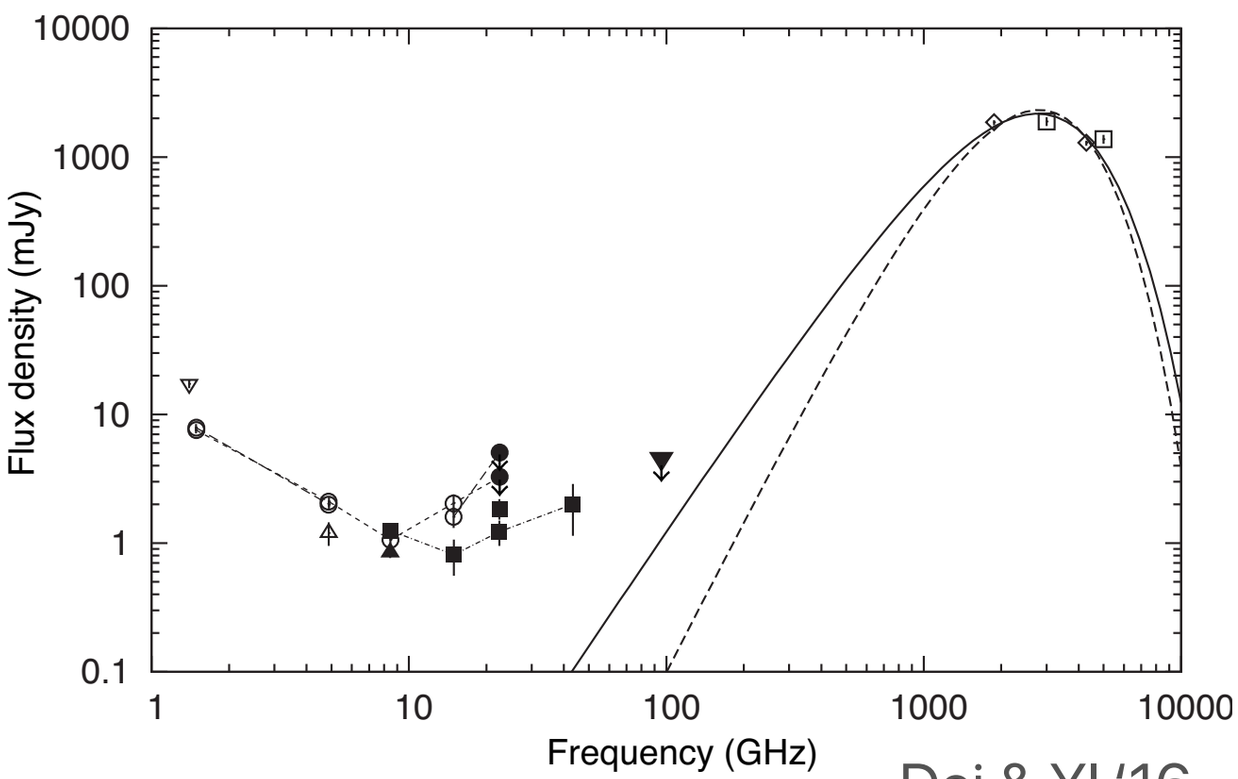
- cm-radio: jet, galactic CRs
- **mm-radio : ?**
- IR : dust (>~0.1 pc)
- opt: accretion disk (<~0.1 pc)
- X-ray: disk corona (~10 r_s)
- **Gamma-ray : ?**

Millimeter Excess?

- If a AGN corona is magnetized, synchrotron radiation is expected
  (Di Matteo+'97; YI & Doi '14, Raginski & Laor '16)



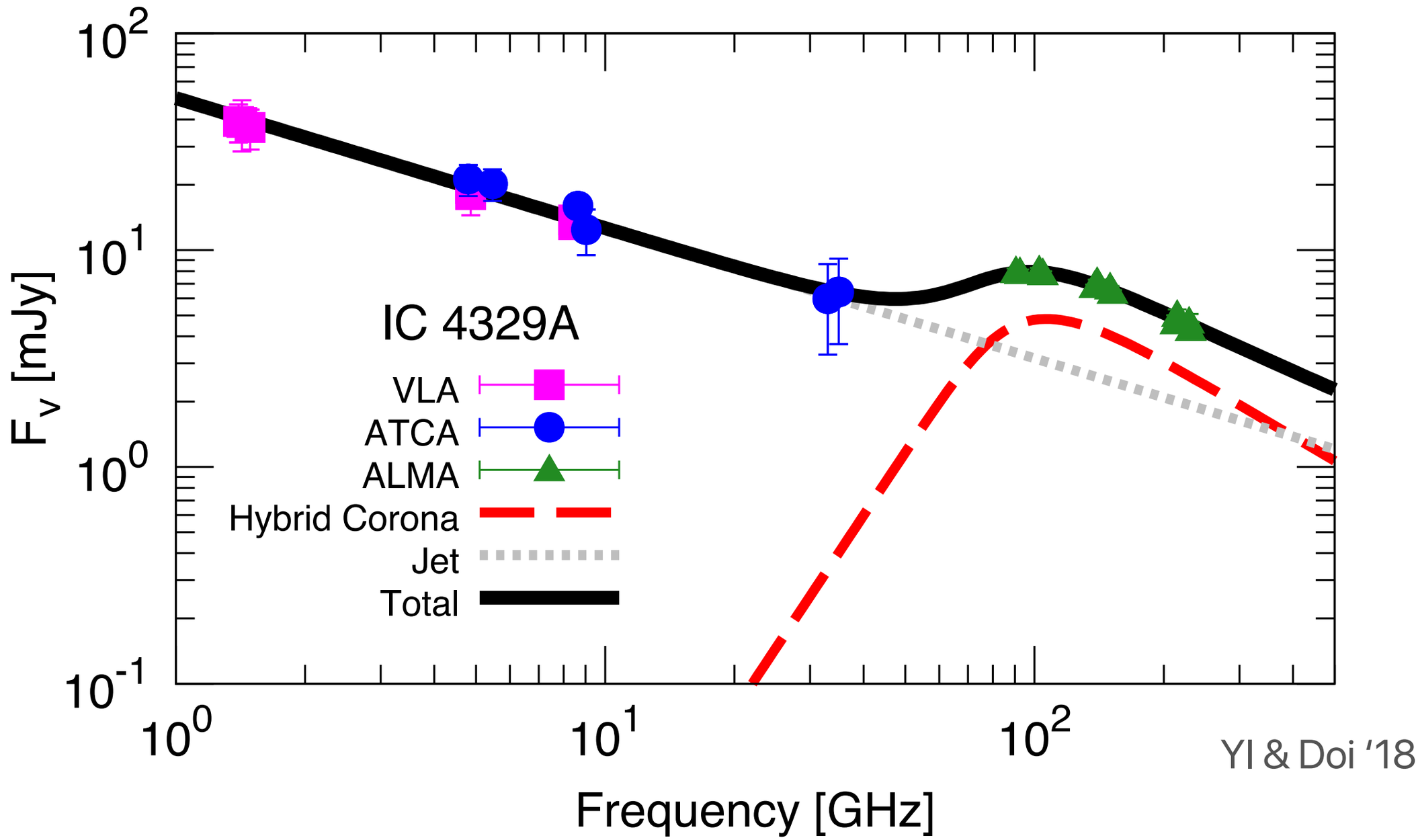
YI & Doi '14



Doi & YI '16

- Possible mm excess
  (e.g., Antonucci & Barvainis'88; Barvainis+'96; Doi & Inoue '16; Behar+'18)
- Contamination of extended components
- Lack of multi-frequency observations.

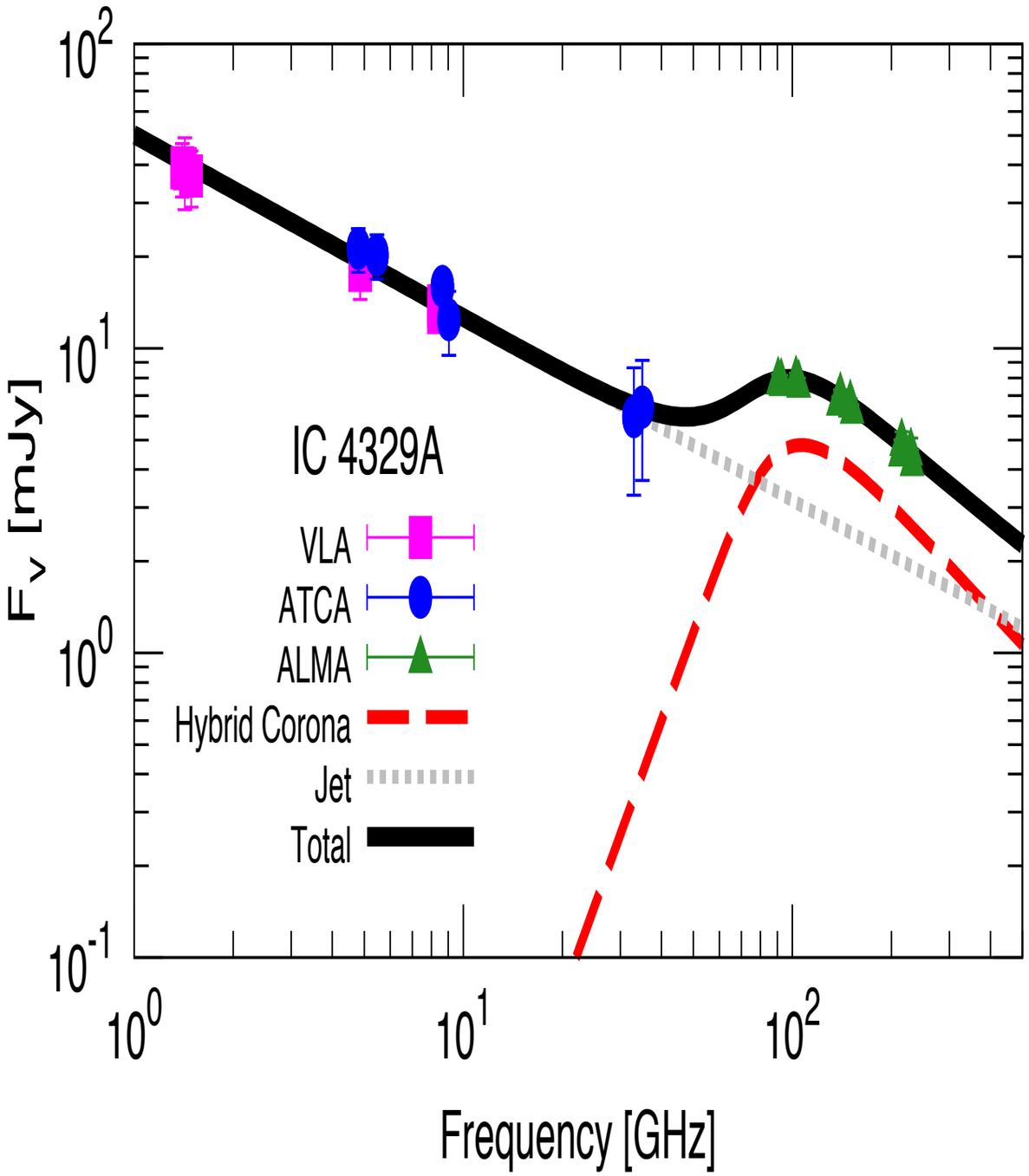
cm-mm spectrum of IC 4329A Core



YI & Doi '18

- Clear mm excess from cm spectrum

Coronal parameters

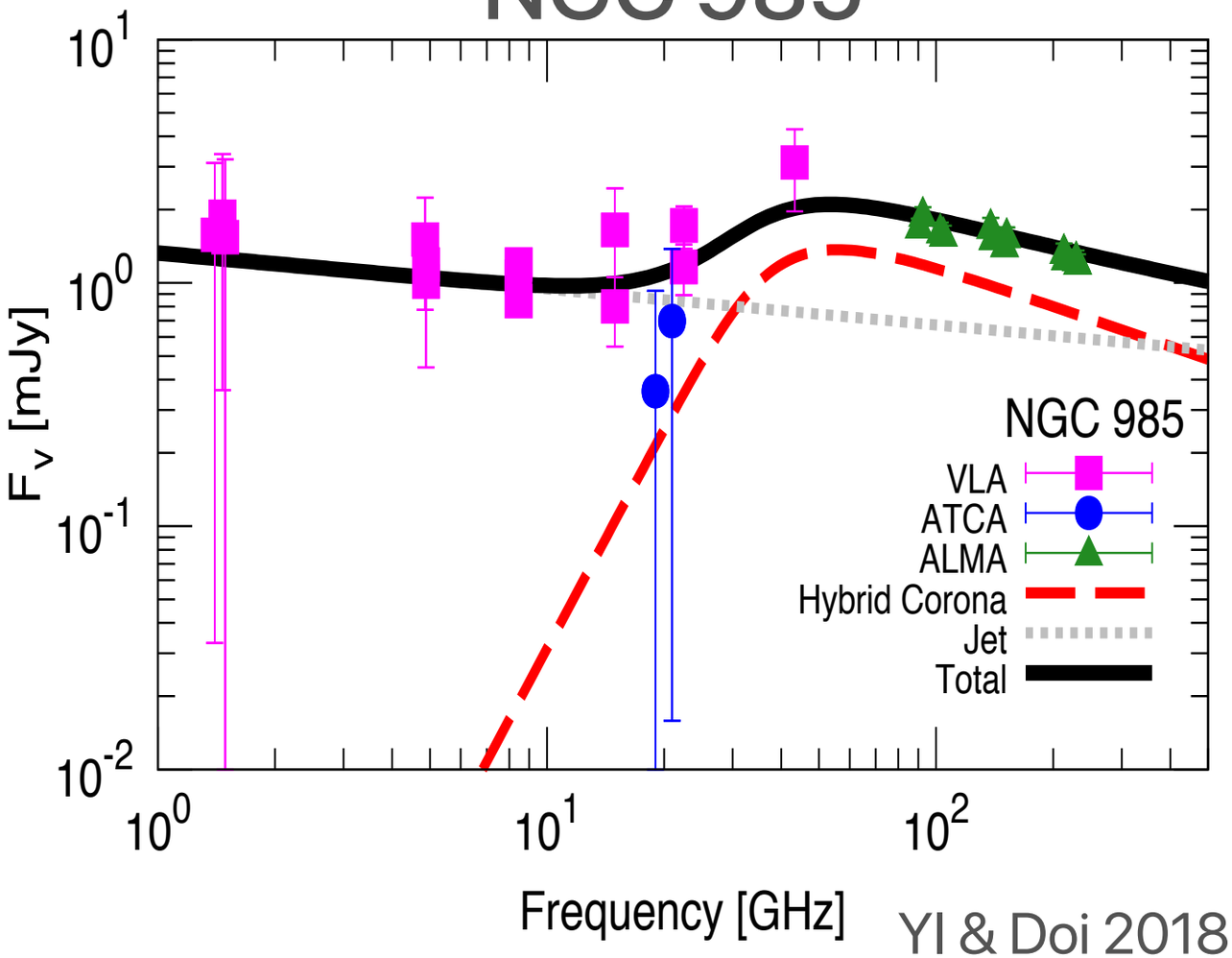


- Hybrid corona model (YI & Doi '14)
- Non-thermal electron fraction : $\eta = 0.03$ (fixed)
- Non-thermal spectral index $p = 2.9$
- Size: 40 r_s
- B-field strength : 10 G

YI & Doi 2018

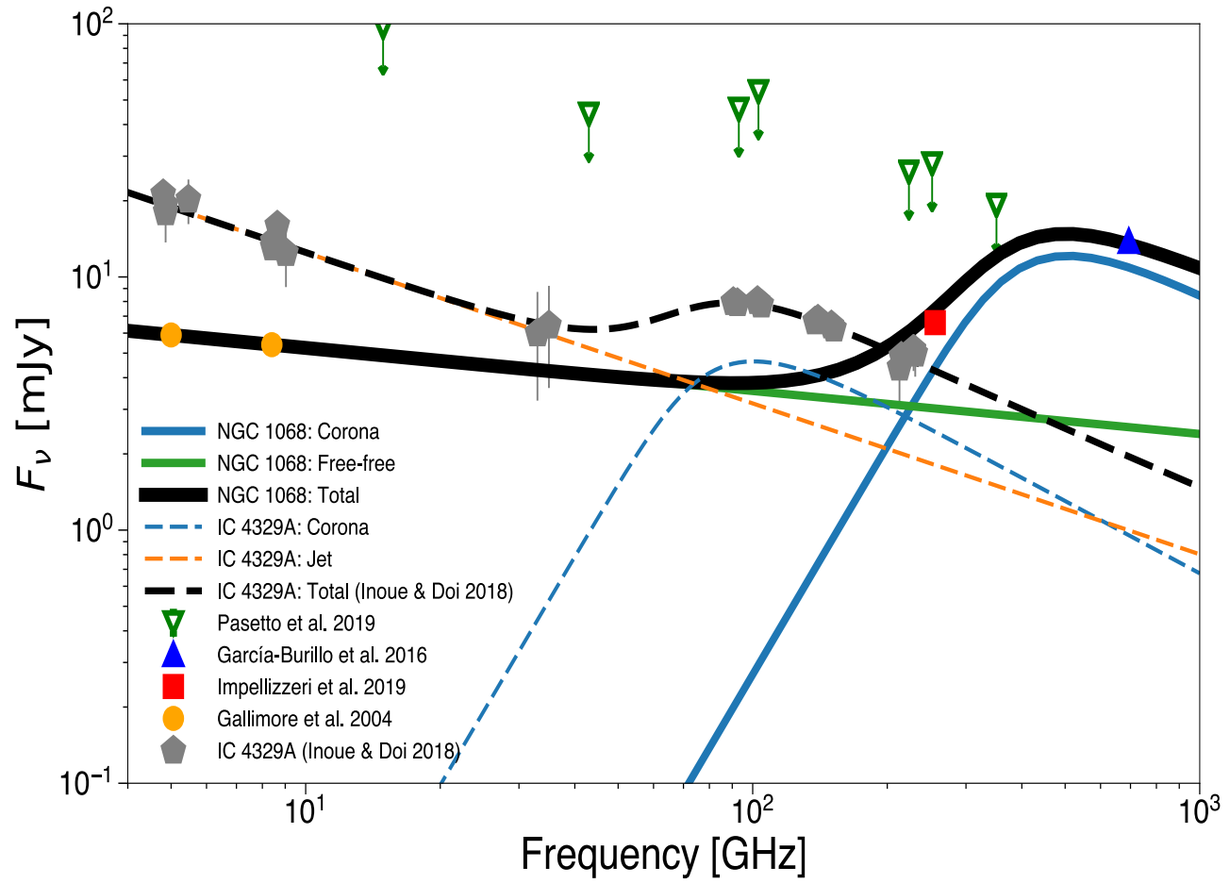
Other RQ AGNs

NGC 985



YI & Doi 2018

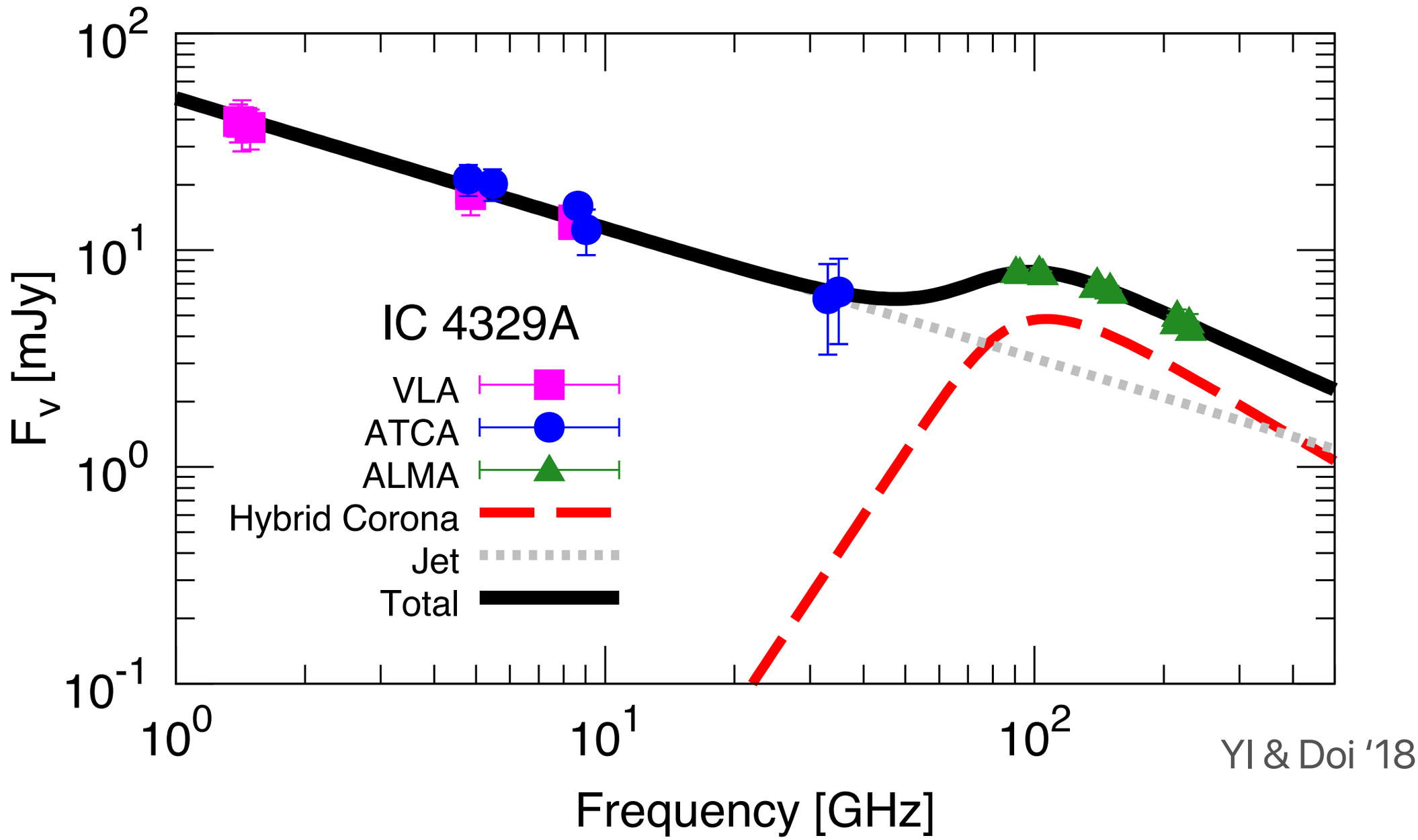
NGC 1068



YI+'19

- NGC 985 is detected. NGC1068 is also marginally detected.
- 9 more RQ AGNs are observed in the ALMA cycle-6.

cm-mm spectrum of IC 4329A Core

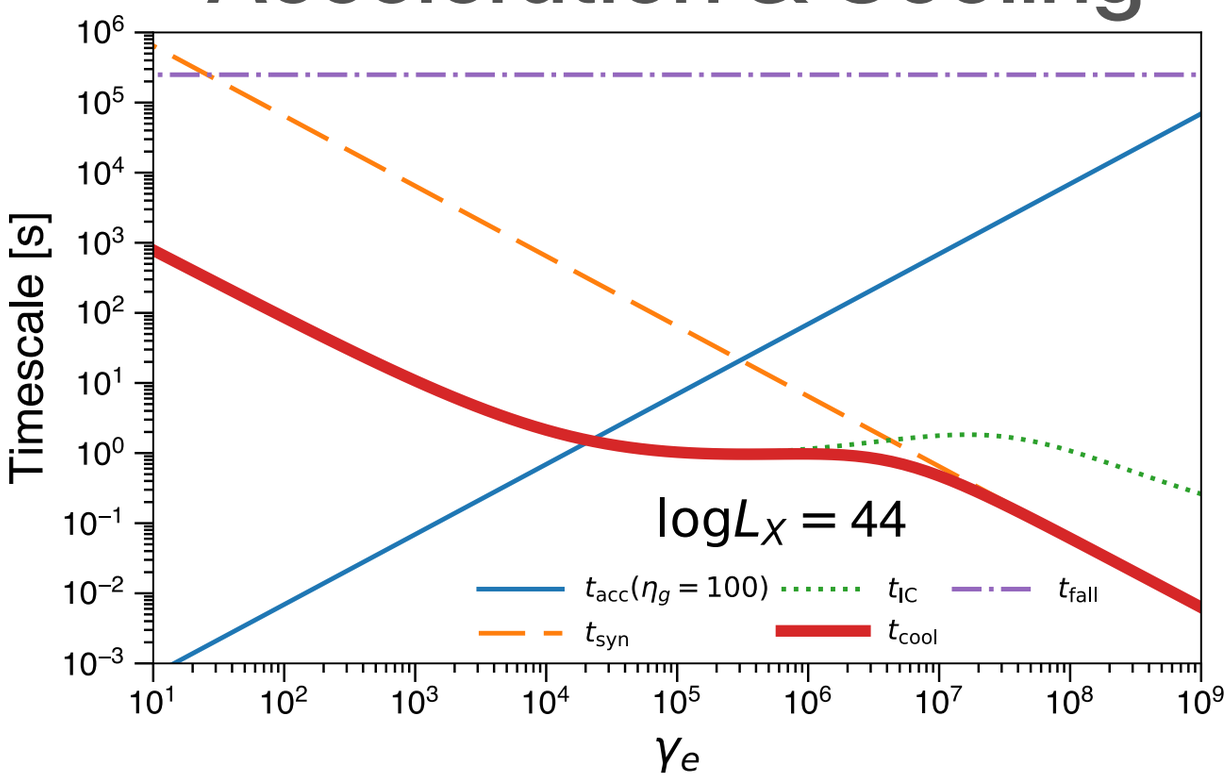


YI & Doi '18

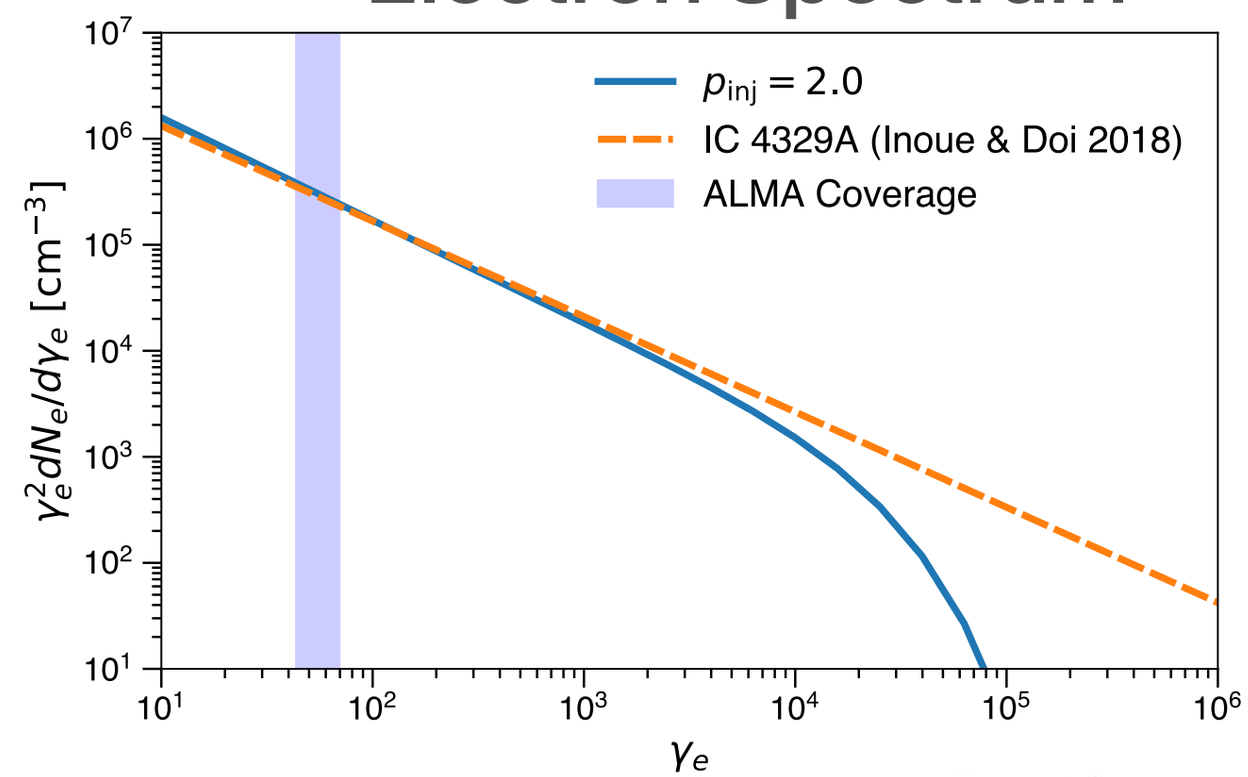
- Non-thermal electrons should exist in the coronae

Generation of High Energy Electrons in Coronae

Acceleration & Cooling



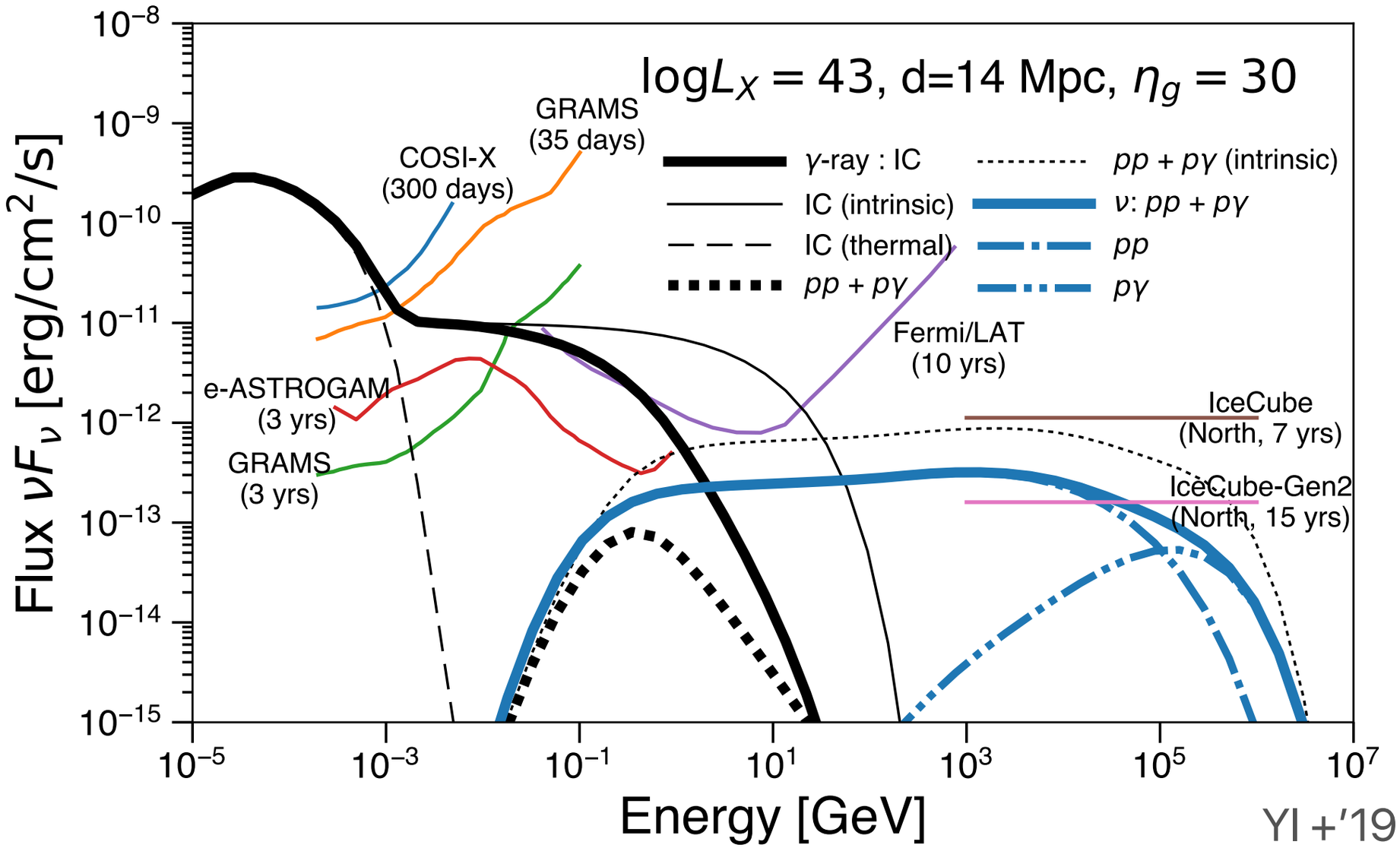
Electron Spectrum



YI + '19

- 1st-order Fermi acceleration can produce the observed electrons with an injection index of 2
- Other mechanisms may be difficult.

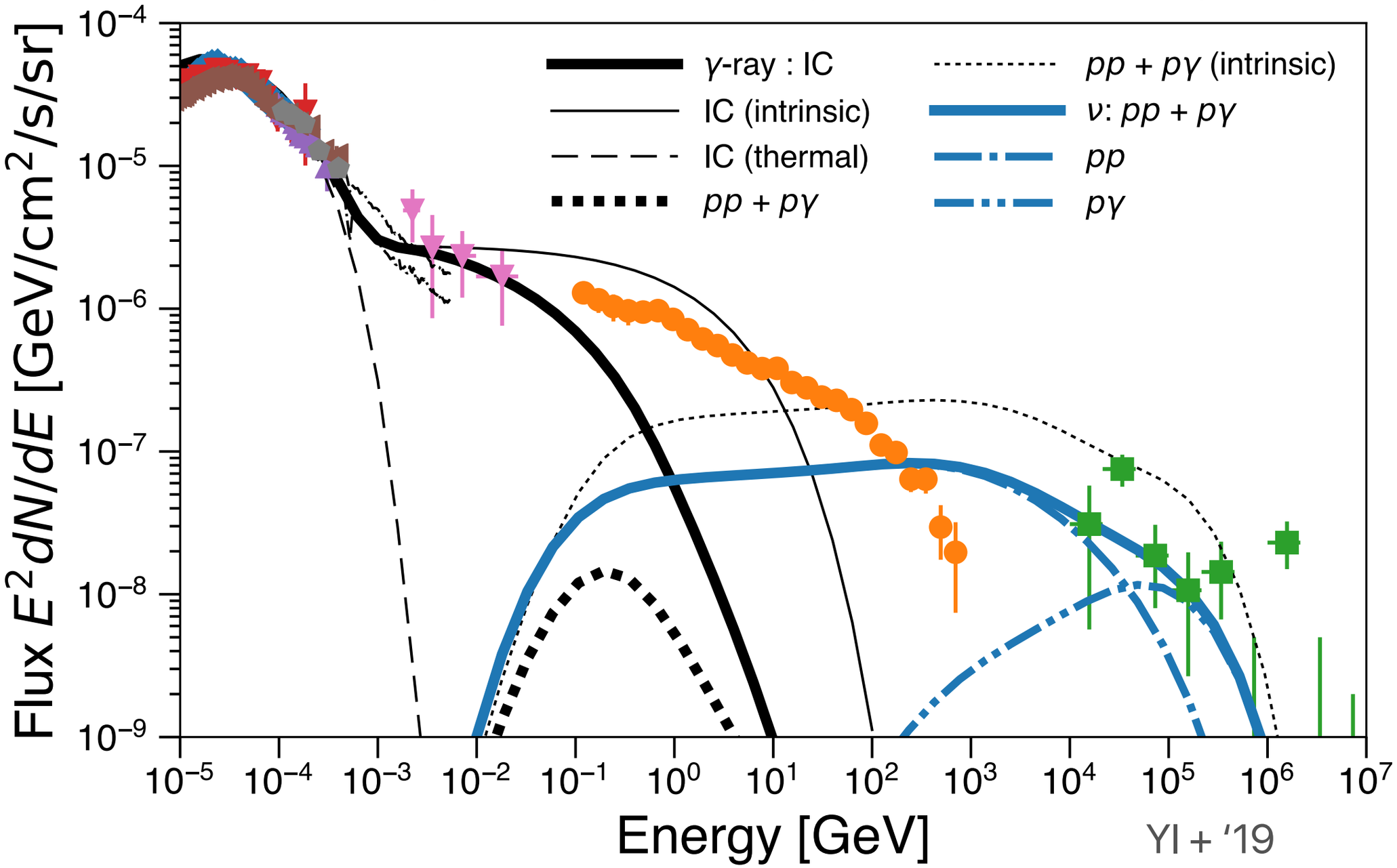
High energy emission from AGN coronae



YI +'19

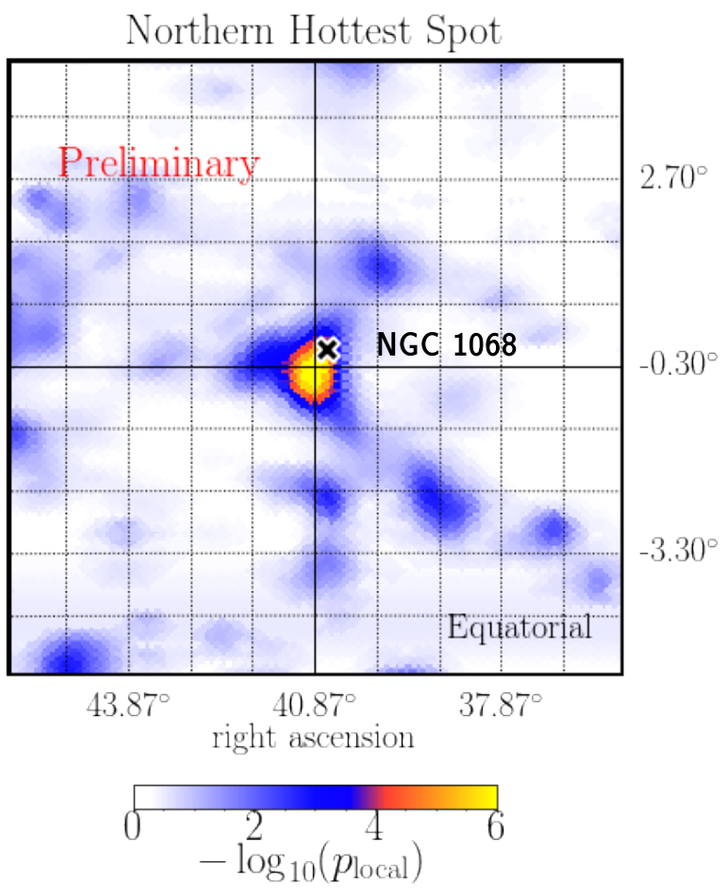
- MeV emission is expected, but no GeV emission due to pair creation
- Protons would also be simultaneously accelerated.
  - generation of neutrinos (see also e.g., Begelman+'90;Stecker+'92;Kalashev+'15;Murase+'19)

Cosmic High Energy Background

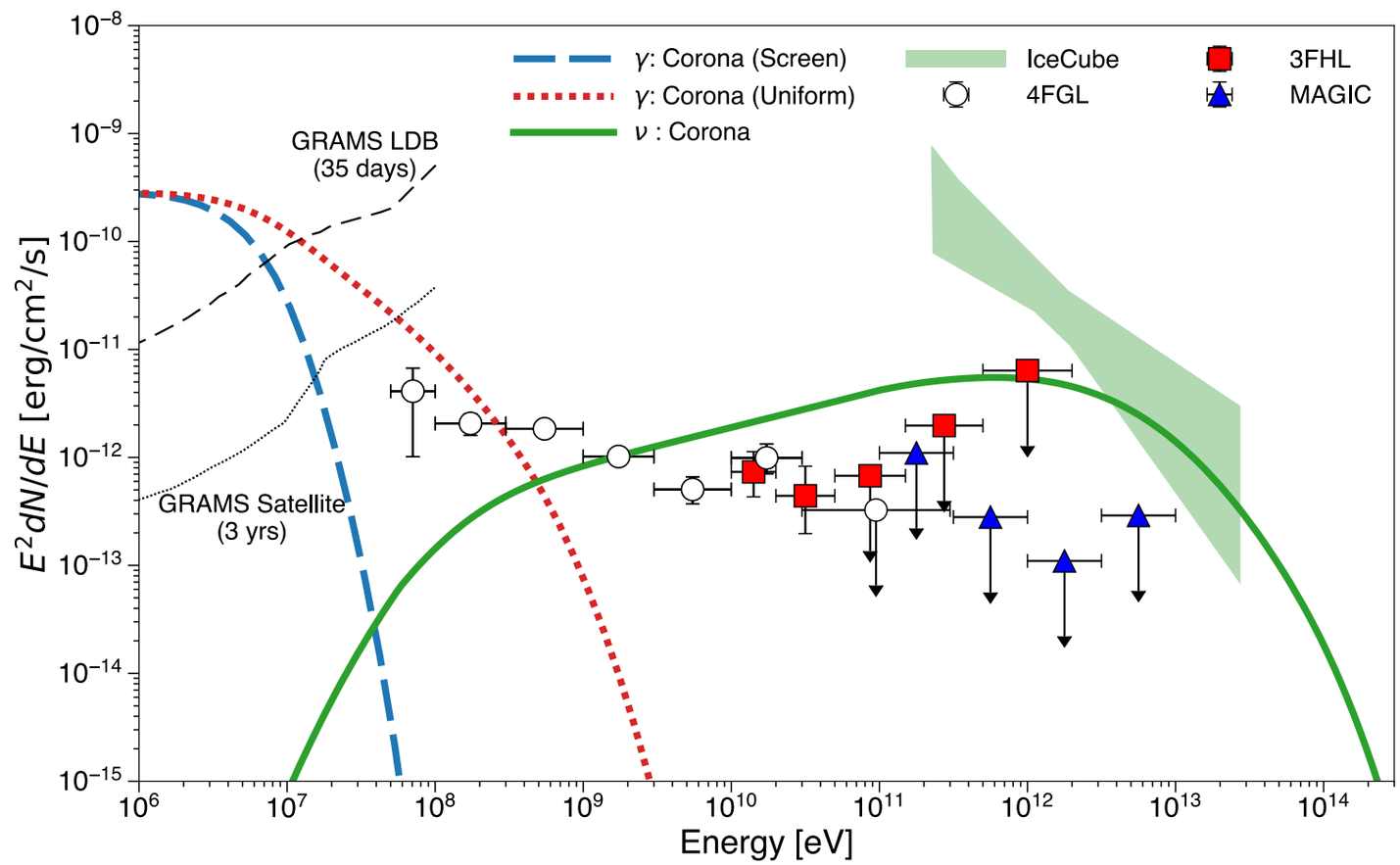


- RQ AGNs can explain X-ray, MeV gamma-ray, & TeV neutrino background.
  - But, if both protons and electrons carry ~5% of the shock energy and gyrofactor is 30.

IceCube Hottest Spot



IceCube 2019 (ICRC)



YI +'19b

- Type-2 Seyfert NGC 1068 is reported at 2.9-σ.
- Corona can be a neutrino production site above several TeV.

Summary

- MeV emission is expected from various AGN populations.
- non-thermal electrons exist in coronae
  - MeV emission is expected also from radio-quiet AGNs
- Radio-quiet AGNs may be responsible for cosmic X-ray, MeV gamma-ray, and TeV neutrino background fluxes.
- NGC 1068, type-2 Seyfert, is the hottest spot in the IceCube data.
  - MeV is a key for testing the model.