The cosmological evolution of blazars and the cosmic gamma-ray background in the Fermi era

Yoshiyuki INOUE (Kyoto, JSPS fellow DC1)

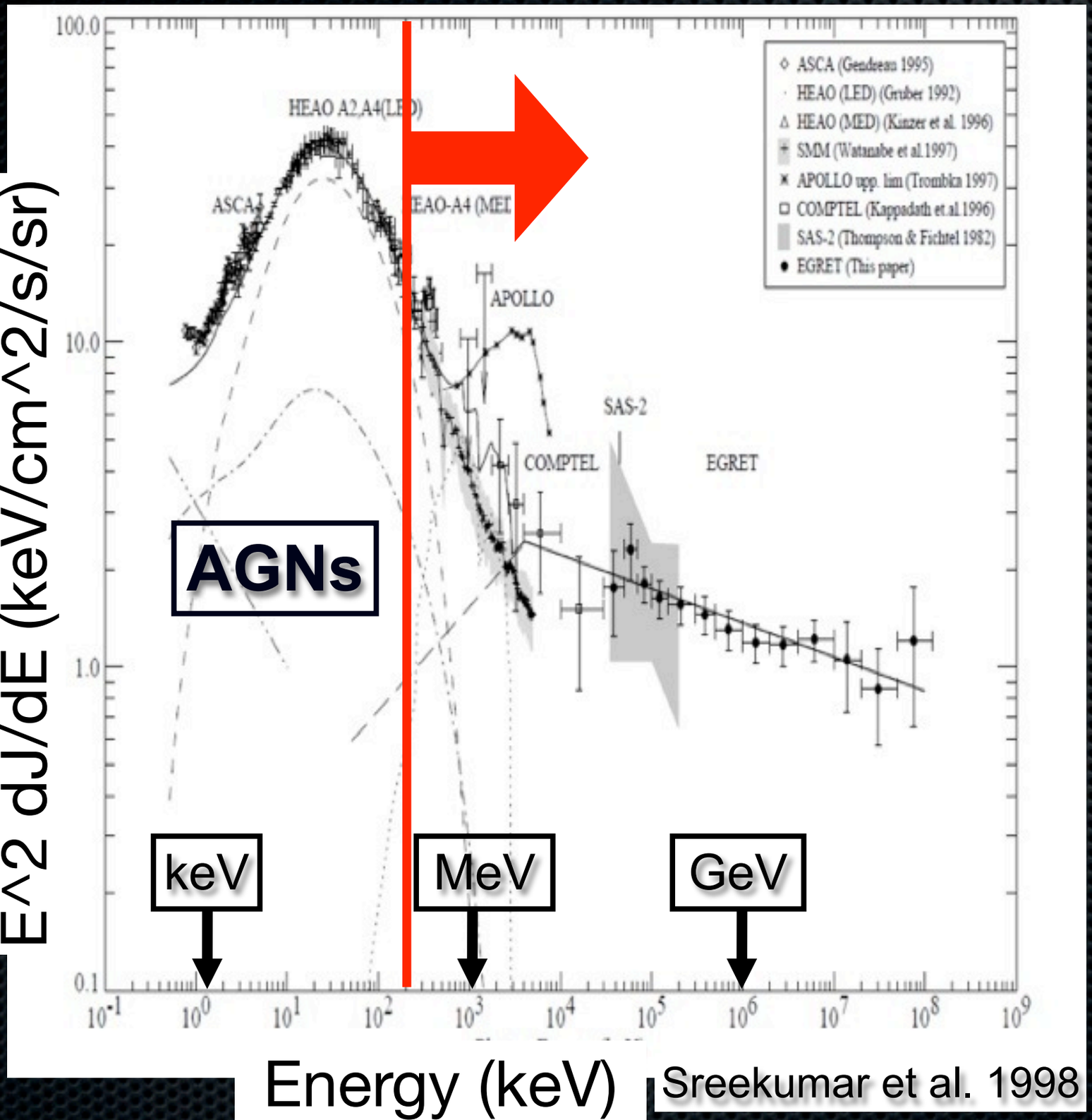
Collabolators：Tomonori Totani, Susumu Inoue (Kyoto),

Masakazu. A. R. Kobayashi (NAO),

Jun Kataoka (Waseda), Rie Sato (JAXA)

Fermi Symposium

What's the origin of the cosmic gamma-ray background?



Sreekumar et al. 1998

1. MeV Background

AGNs (Rogers & Field '91; Field & Rogers '93; Stecker, Salamon, & Done '01; YI, Totani, & Ueda'08)

Supernovae (Clayton & Ward '75; Zdziarski '96; Watanabe+'99)

MeV Dark Matter annihilation (Ahn & Komatsu '06, Rasera+'06; Lawson & Zhitnitsky '07)

MeV Blazars (Ajello+'09)

2. GeV Background

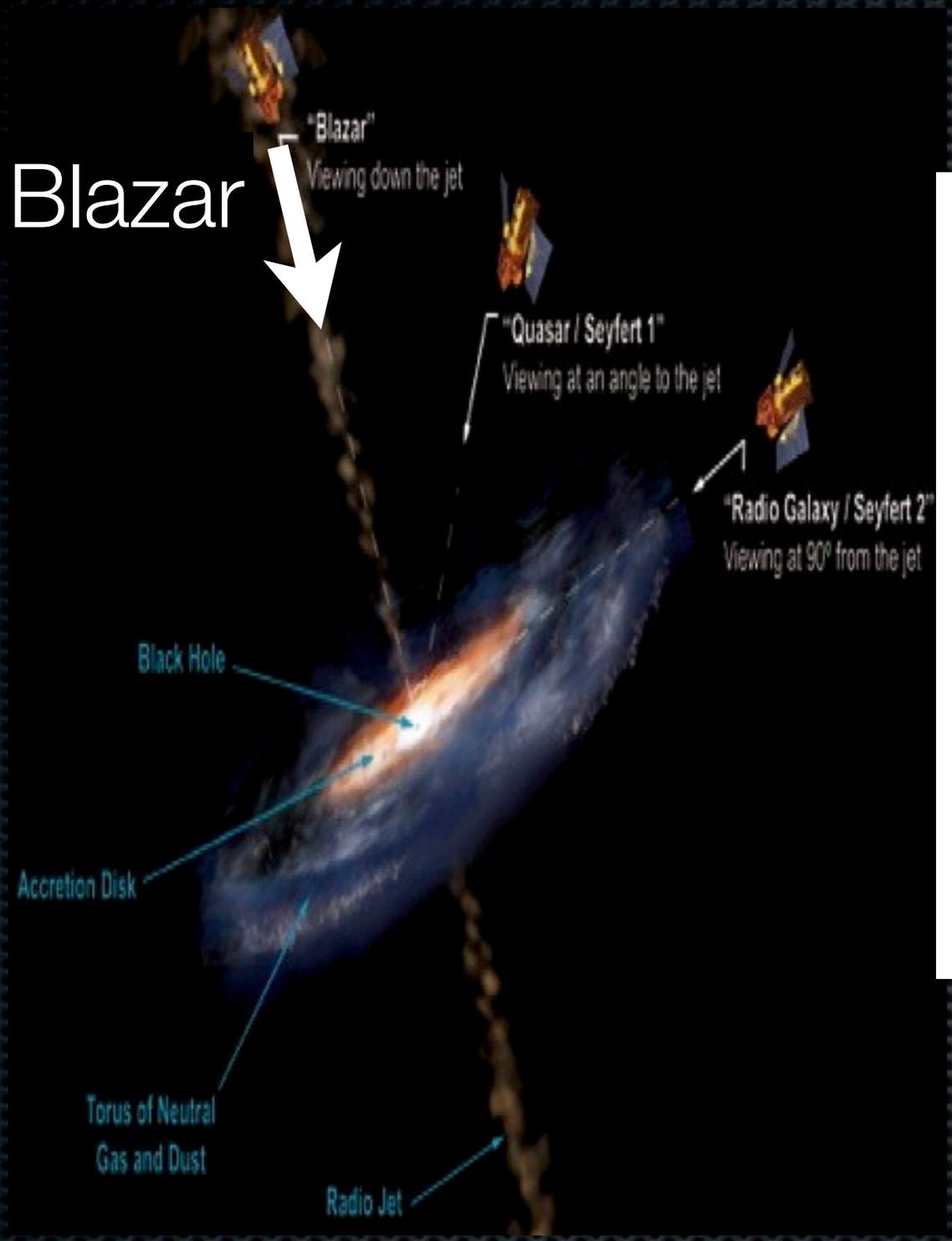
Blazars (Stecker & Salamon '96; Chiang & Mukherjee '98; Mücke & Pohl 00; Narumoto & Totani '06; Dermer '07; YI & Totani '09)

Galaxy Cluster Merger (Loeb & Waxman '00; Totani & Kitayama '00)

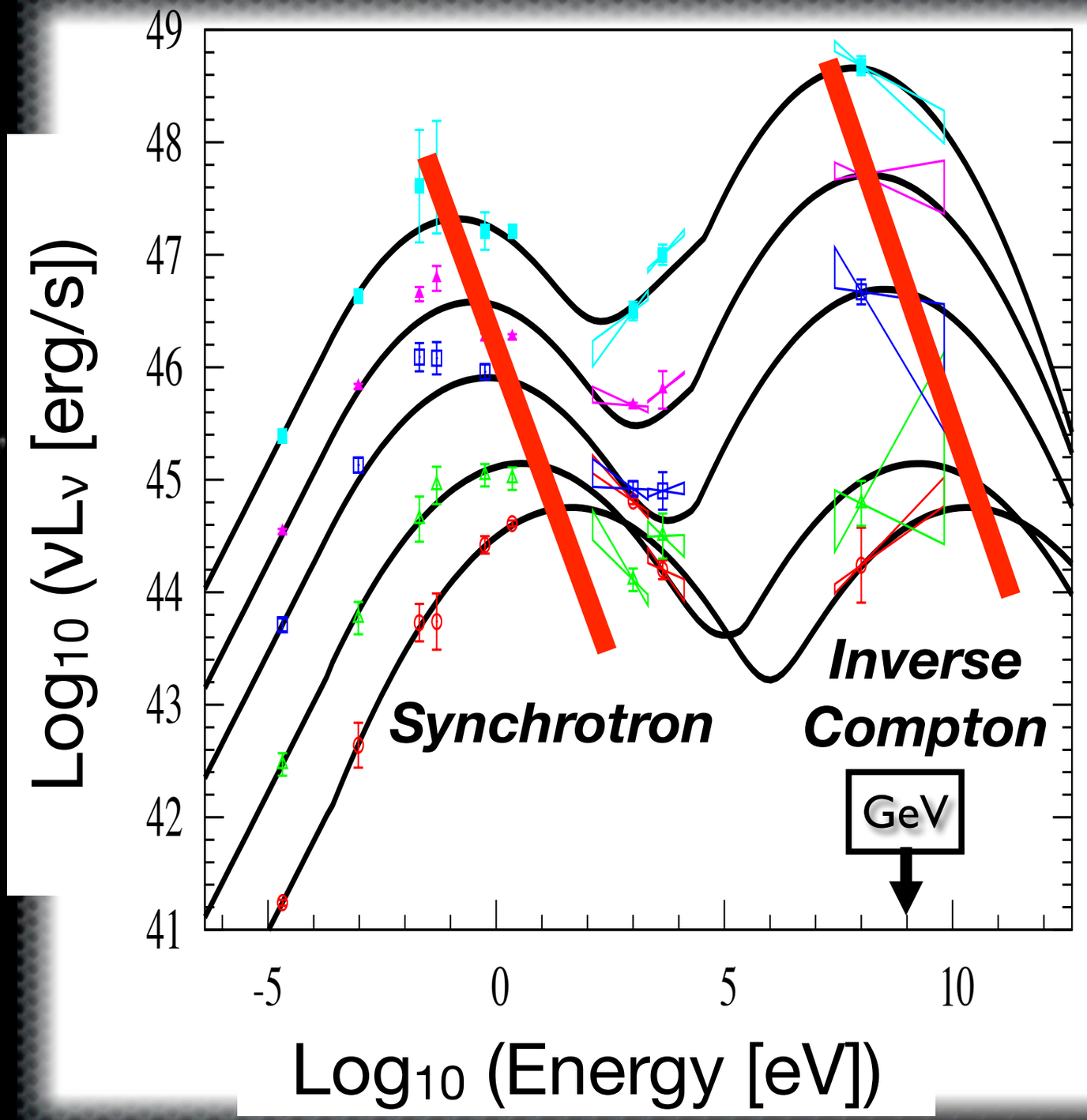
GeV Dark Matter annihilation (e.g. Oda et al. '05)

What is BLAZAR?

SED Sequence



http://www.nasa.gov/



(Fossati+'97,'98; Kubo+'98; Donato +'01, but see also Padovani+'07)

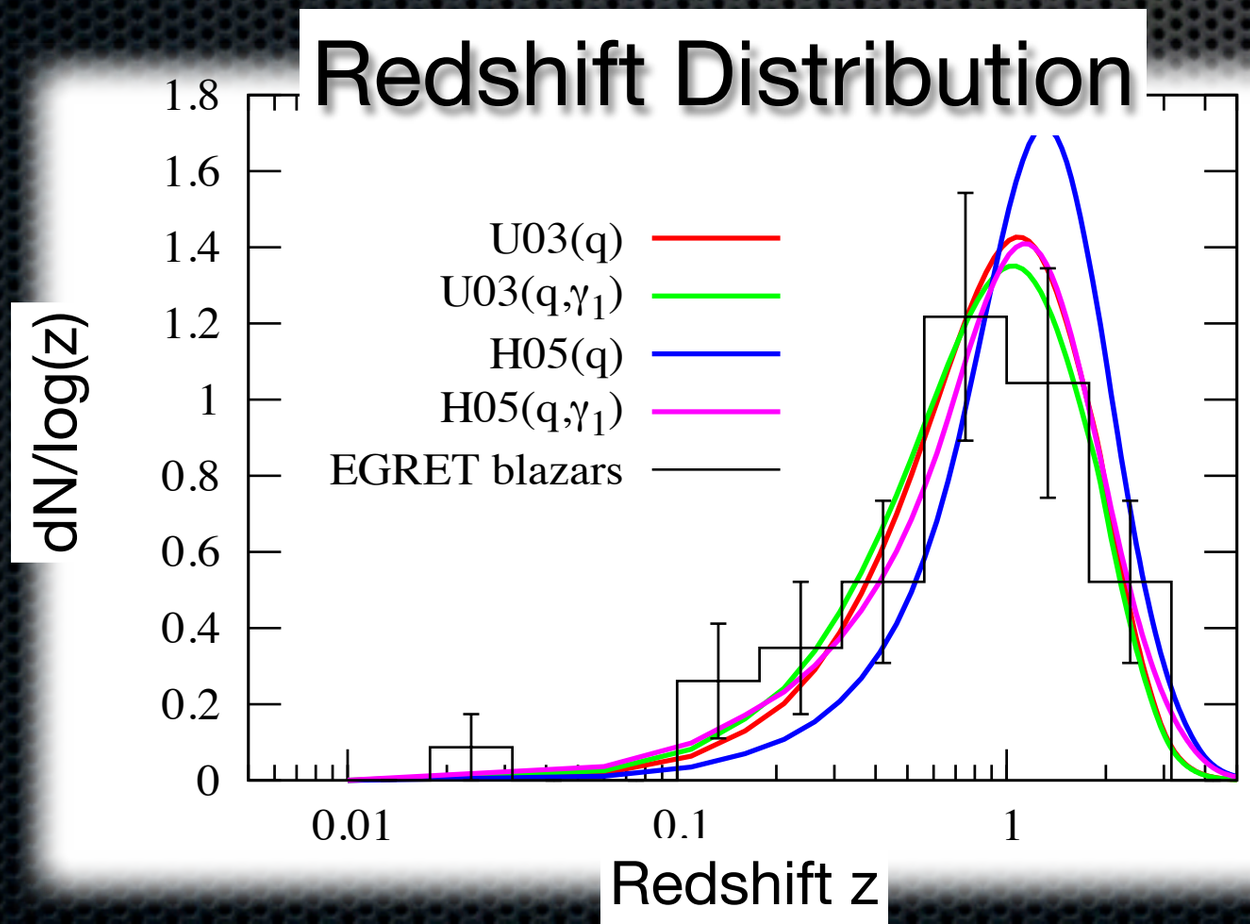
Blazar Gamma-ray Luminosity Function

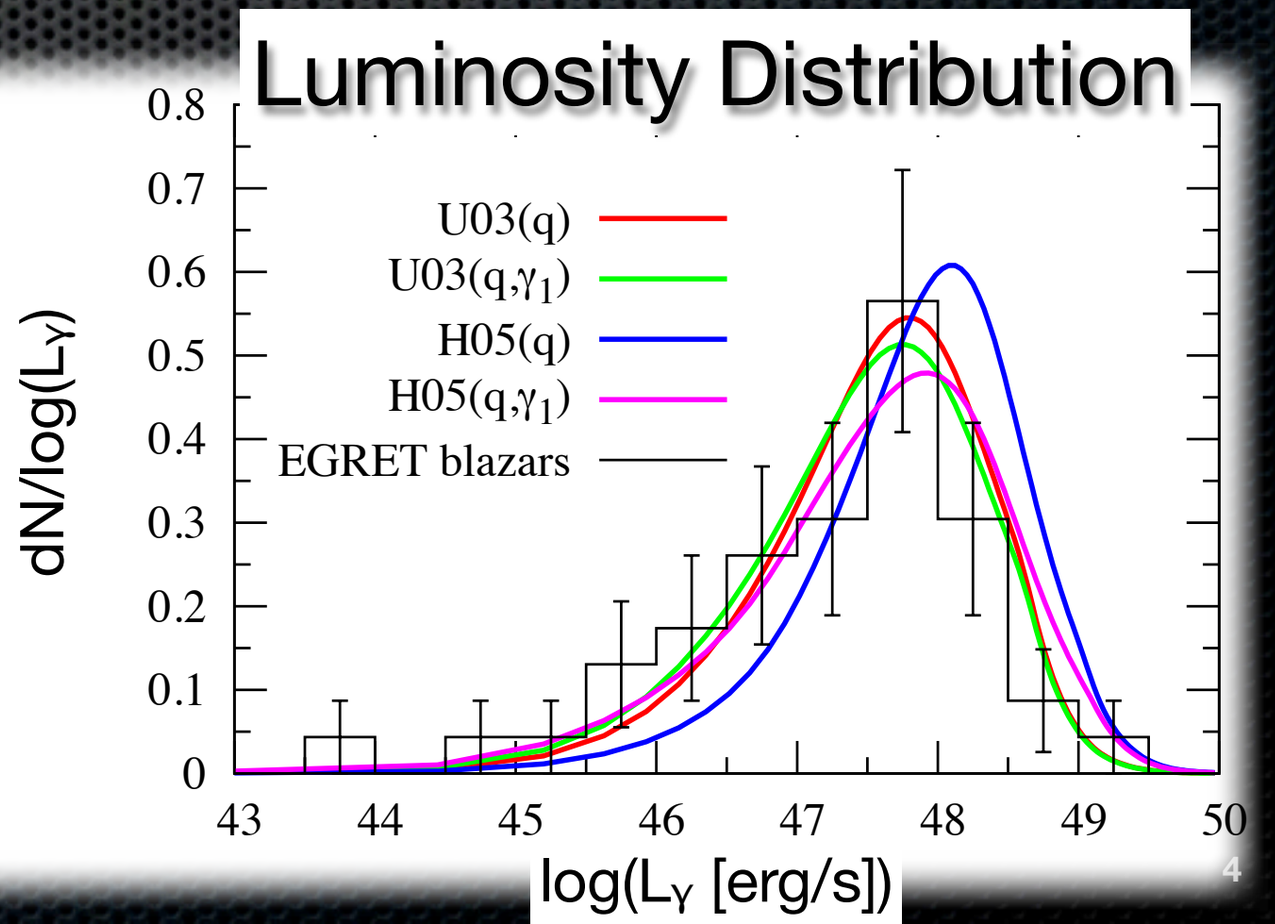
(YI & Totani '09)

Basic assumptions for blazar GLF construction

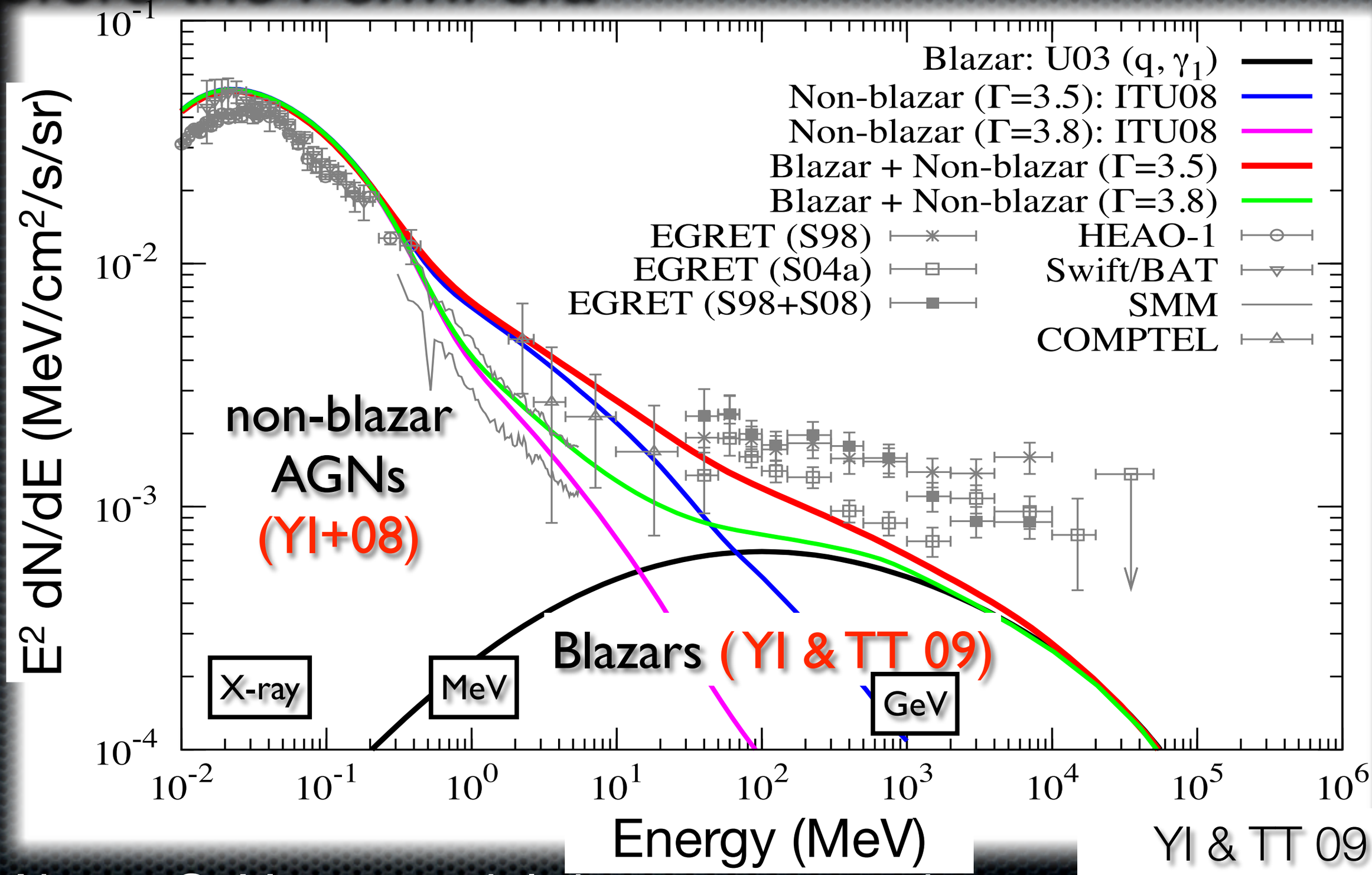
- Blazar SED sequence.
- AGN X-ray Luminosity Function (Ueda+'03:hereafter U03).
  Assuming "$L_{jet,\,bol} \propto L_{disk,\,X}$ ".

Constraining GLFs from EGRET data.





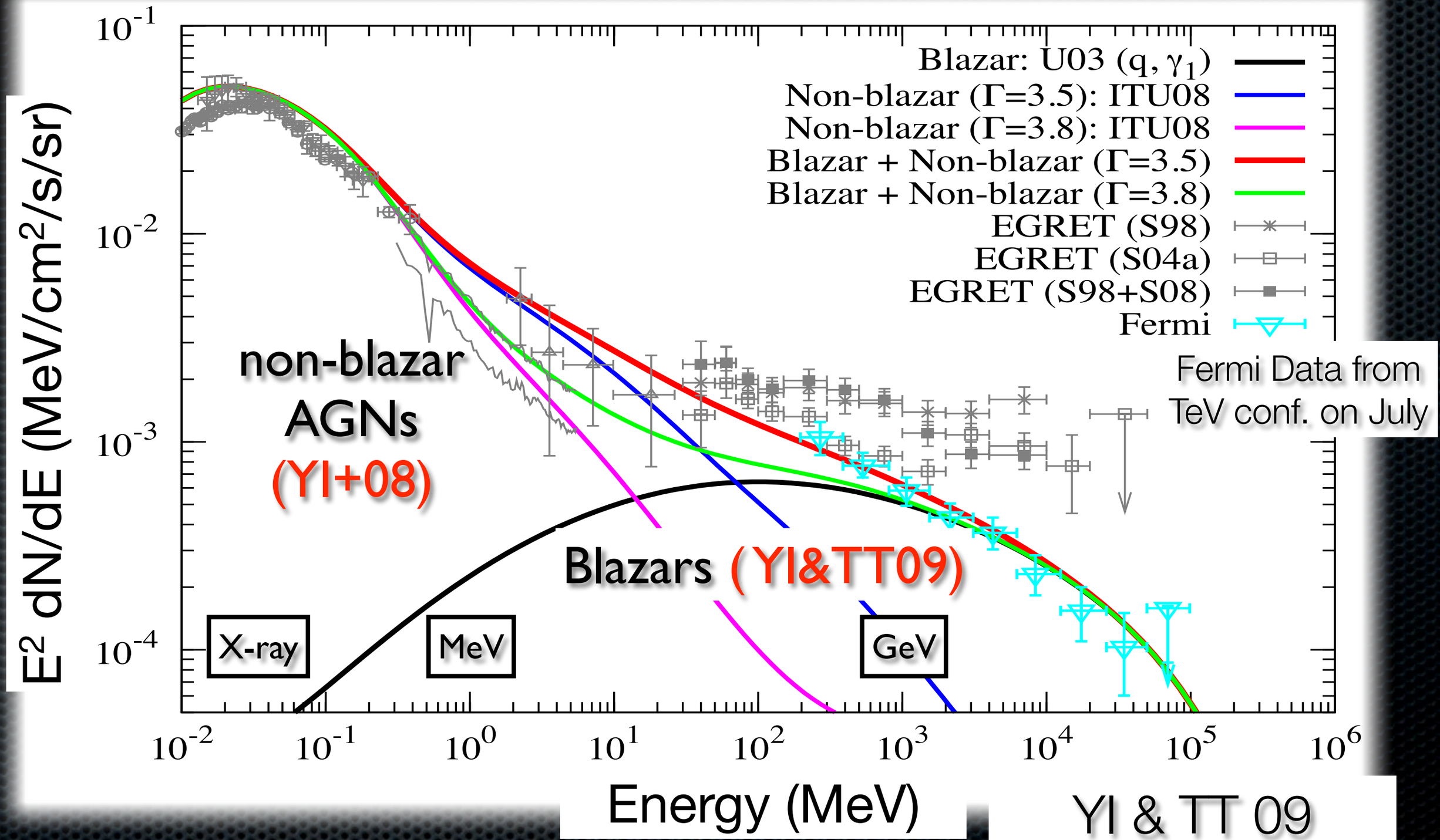
Cosmic X-ray and Gamma-ray Background before the Fermi era



YI & TT 09
arXiv:0810.3580

Above GeV, our model does not reproduce observational data.

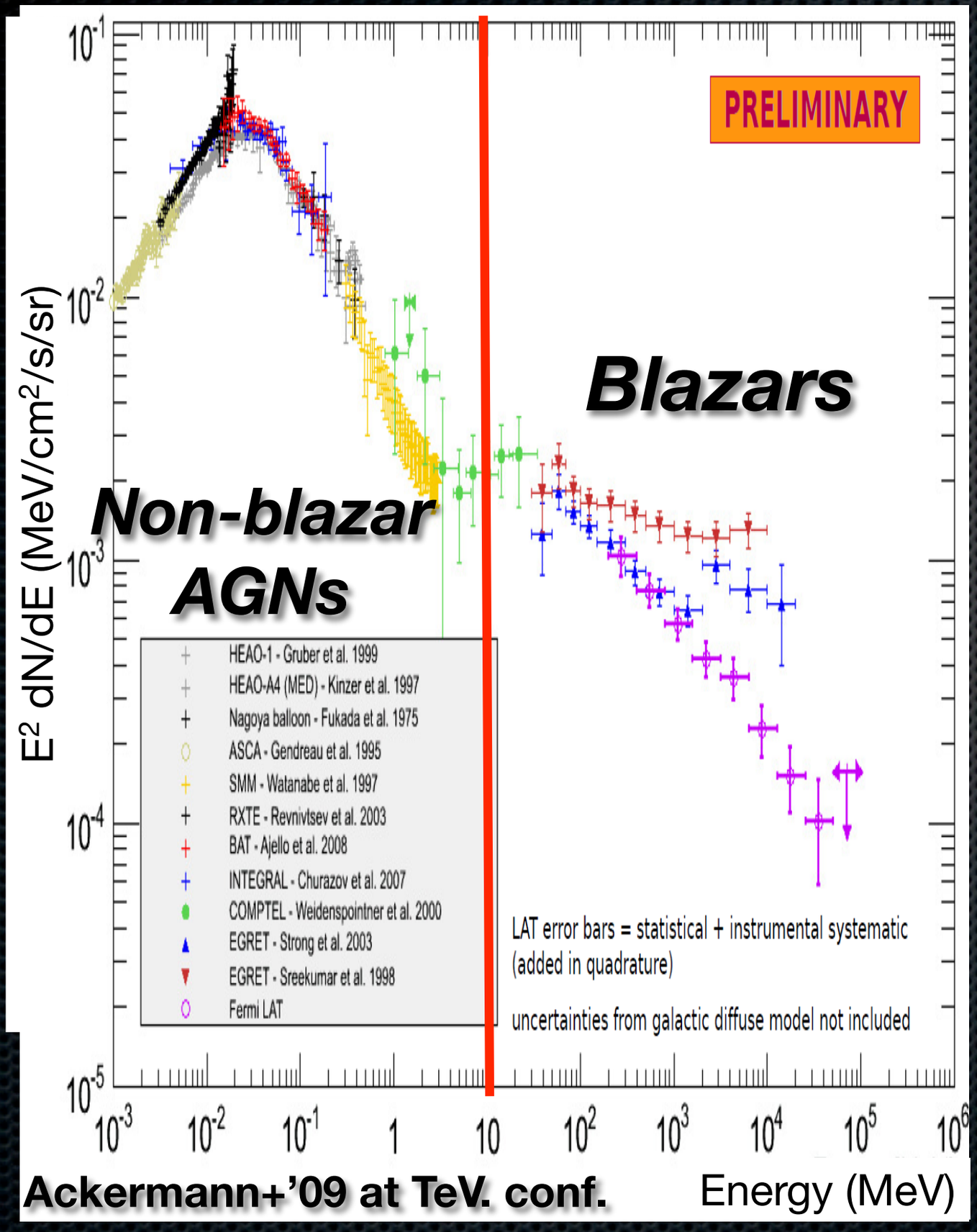
Cosmic X-ray and Gamma-ray Background in the Fermi era



Our prediction matched very well with the Fermi data.

YI & TT 09
arXiv:0810.3580

Non-blazar AGNs vs. Blazars



Ackermann+'09 at TeV. conf.

<~10 MeV:

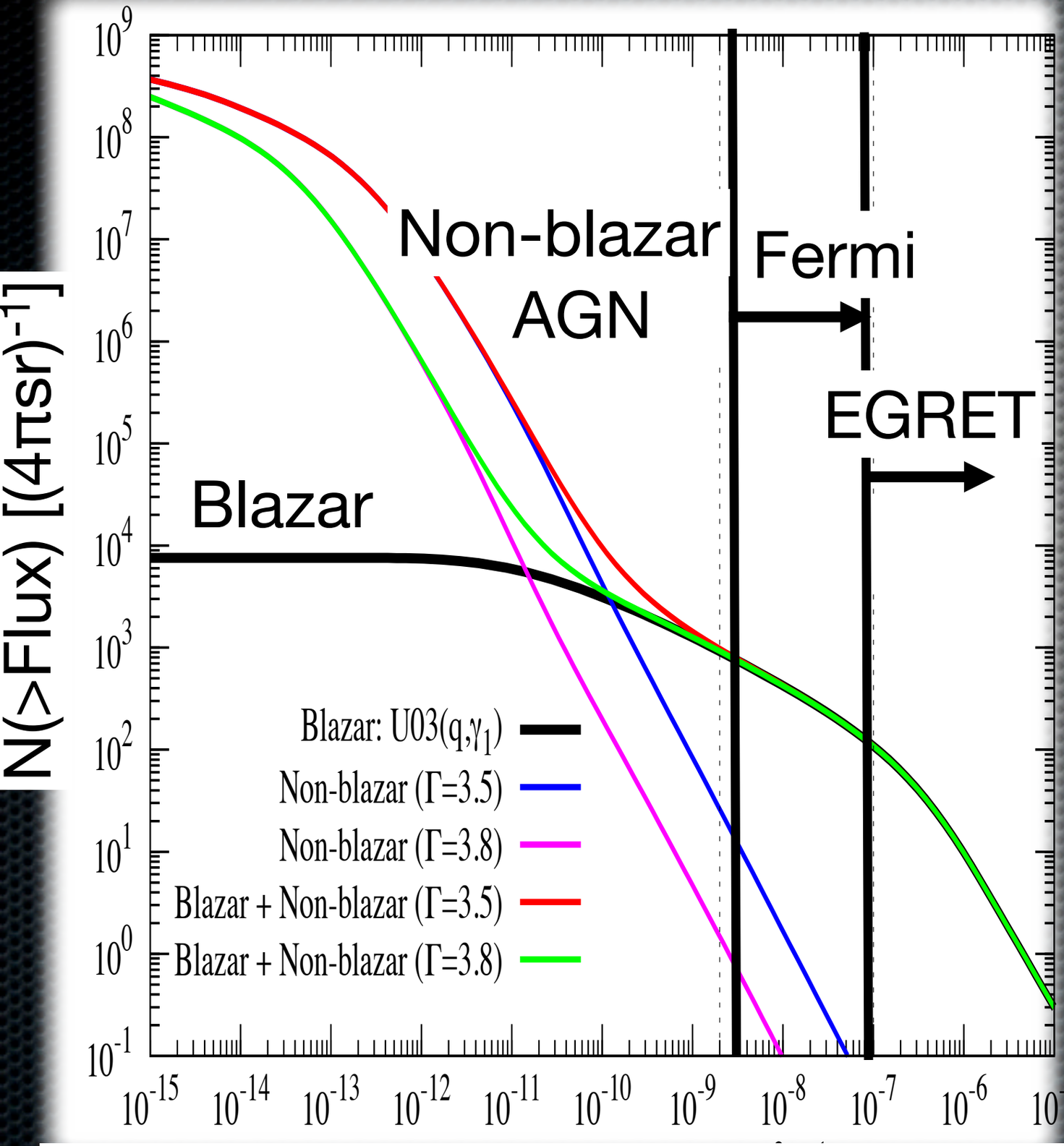
- smooth connection to CXB
- likely to be non-blazar AGNs

>~10 MeV:

- distinct SED from CXB
- likely to be blazars

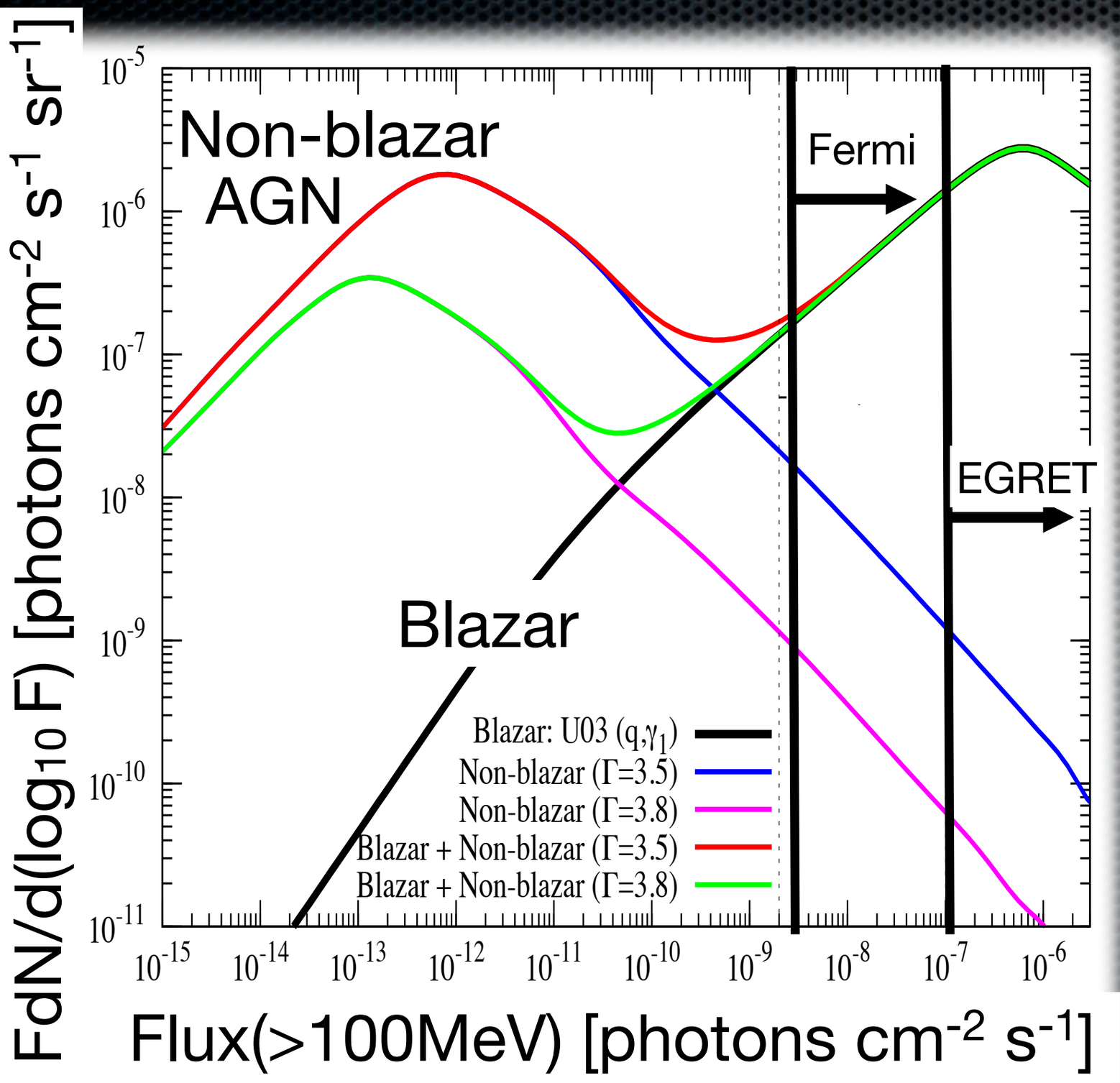
- MeV-blazar contribution at <~10 MeV? (Ajello+09)
  - fine-tuning required for SED
  - distinct blazar population required between MeV and GeV.

Expected Number of Fermi AGNs



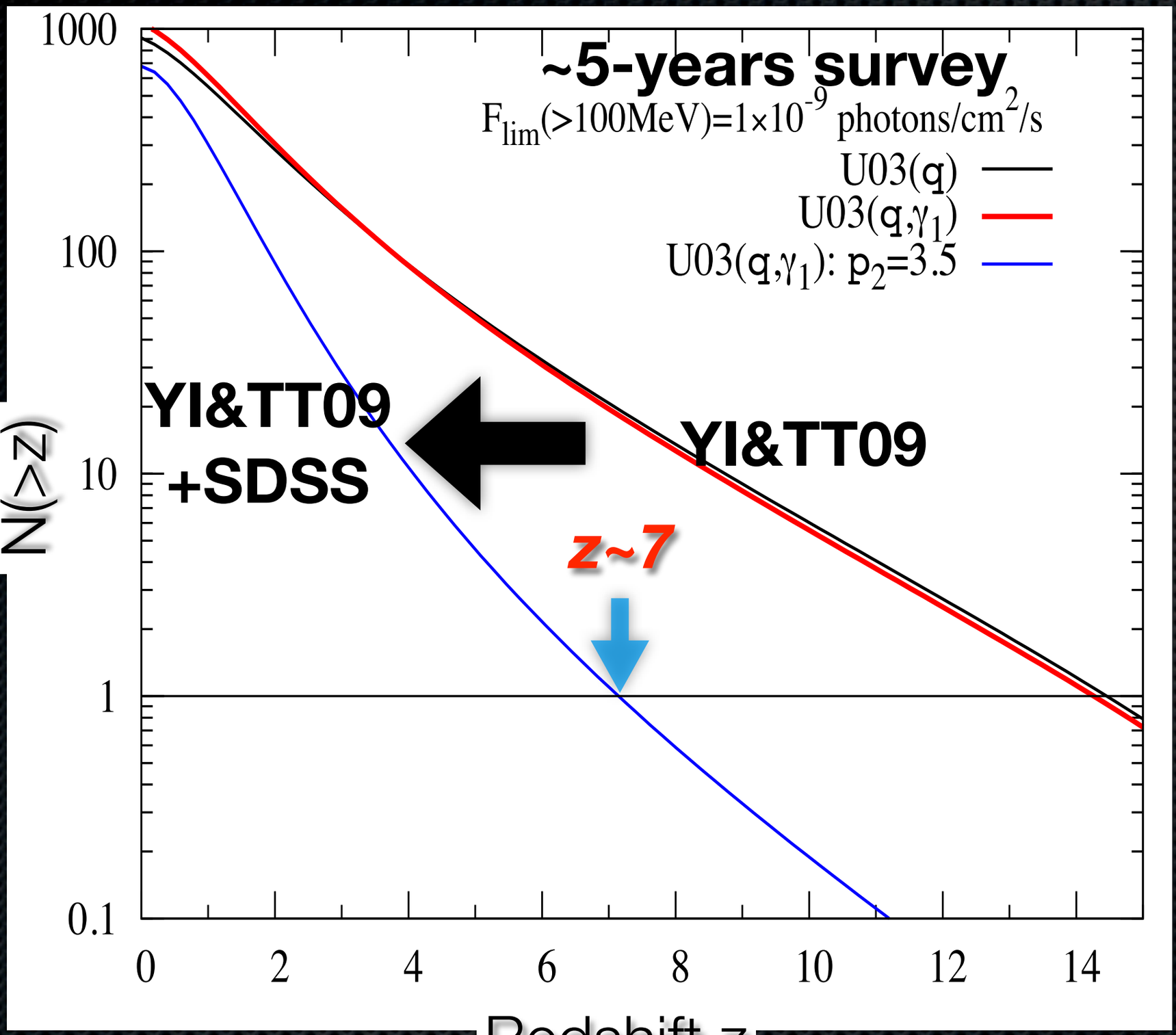
- One-year survey
  - ~800 blazars
  - 1~10 non-blazar AGNs
- Five-year survey
  - ~1200 blazars
  - 4~50 non-blazar AGNs
- Nonthermal gamma-ray flux from NGC 4151, the brightest Seyfert AGN
  - Flux(>100 MeV): ~1e-8 γ/cm/s
  - Photon Index: ~3.5

Will Fermi resolve the cosmic gamma-ray background?



- Five year survey will resolve
  - ~99% of the background flux from blazars (>100 MeV).
  - ~0.01% of the background flux from non-blazar AGNs (>100 MeV).

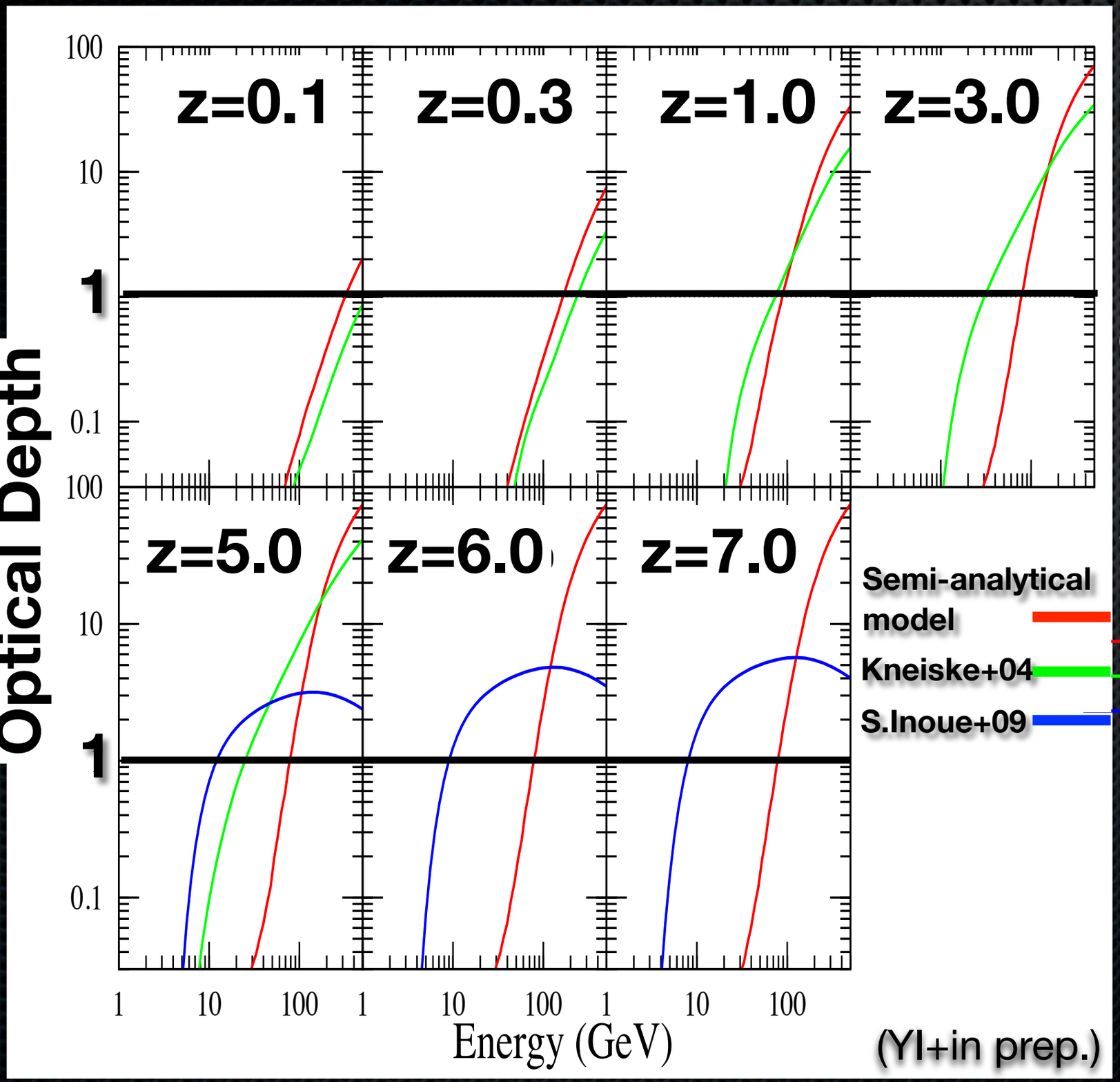
Fermi blazar @ z~7



- Predictions for z~7 blazar detectability
  - based on IT09
  - improved at high-z based on SDSS quasar LF upto z~6.

~1 blazar @ z~7 with ~5-year Fermi survey (YI+in prep.).

Probing high-z universe through GeV gamma-ray attenuation



- $\gamma_{(>GeV)}+\gamma_{UV}\rightarrow e^{+}+e^{-}$.

GeV flux attenuated by high-z UV background (Oh '01, Gilmore+09, S.Inoue+09).

- information of early star/galaxy formation may be obtained.
  - Red model: consistent with z<5 data (e.g. galaxy LF)
  - Blue model: consistent with z>5 data (e.g. reionization data)

Summary 1

- New blazar GLF (Y. Inoue & Totani ’09, arXiv:0810.3580)
  - Blazar SED sequence incorporated
  - Non-trivial prediction for the cosmic gamma-ray background

- Our prediction matched very well with the Fermi data.
  - AGNs are the primary sources as the origin of cosmic X-ray/Gamma-ray background.

Summary 2

- Fermi will find
  - ~800 blazars and 1~10 non-blazar AGNs in 1-year survey,
  - ~1200 blazars and 4~50 non-blazar AGNs in 5-year survey.

- Fermi will resolve
  - ~99% of the gamma-ray background from blazars (>100 MeV),
  - ~0.01 % of the gamma-ray background from non-blazar AGNs (>100 MeV).

- ~1 blazar @ z~7 may be found by Fermi.
  - A new key to understanding the high-z cosmic evolution.