GLAST IDS Proposal

C. Dermer (NRL)

- Formulation Phase (A/B)

  Quantify models relevent to GLAST science

- Implementation Phase (C/D)

  Develop software to confront GLAST data
  (alone or as part of multiwavelength campaigns)

  Software must accomodate spectral and temporal
  variability

  Hire postdoctoral associate; work closely with
  Norris, Digel, and GLAST software team

- Operations Phase (E)

  Confront models with data

  Identify new avenues of research

  Develop new software tools

- Graduate student
- E/PO effort

Scientific Consultants

M. Böttcher (Rice U.)

- Chandra Fellow
- GBH, Blazar, GRB Expert
- X-ray Simulation Tools (XSPEC, XSTAR, MARX)

S. Sturner (NASA/GSFC)

- Spectral Deconvolution of SPI on Integral
- GEANT-based MC simulator on INTEGRAL
- SNR, Pulsar Expert

J. Chiang (JILA)

- Developed Maximum-Likelihood Program for EGRET, Epoch-folding software
- Developed software to construct AGN luminosity function
- Spectral and Temporal Analysis of λλλ Seyfert data
- GRB, AGN, pulsar Expert

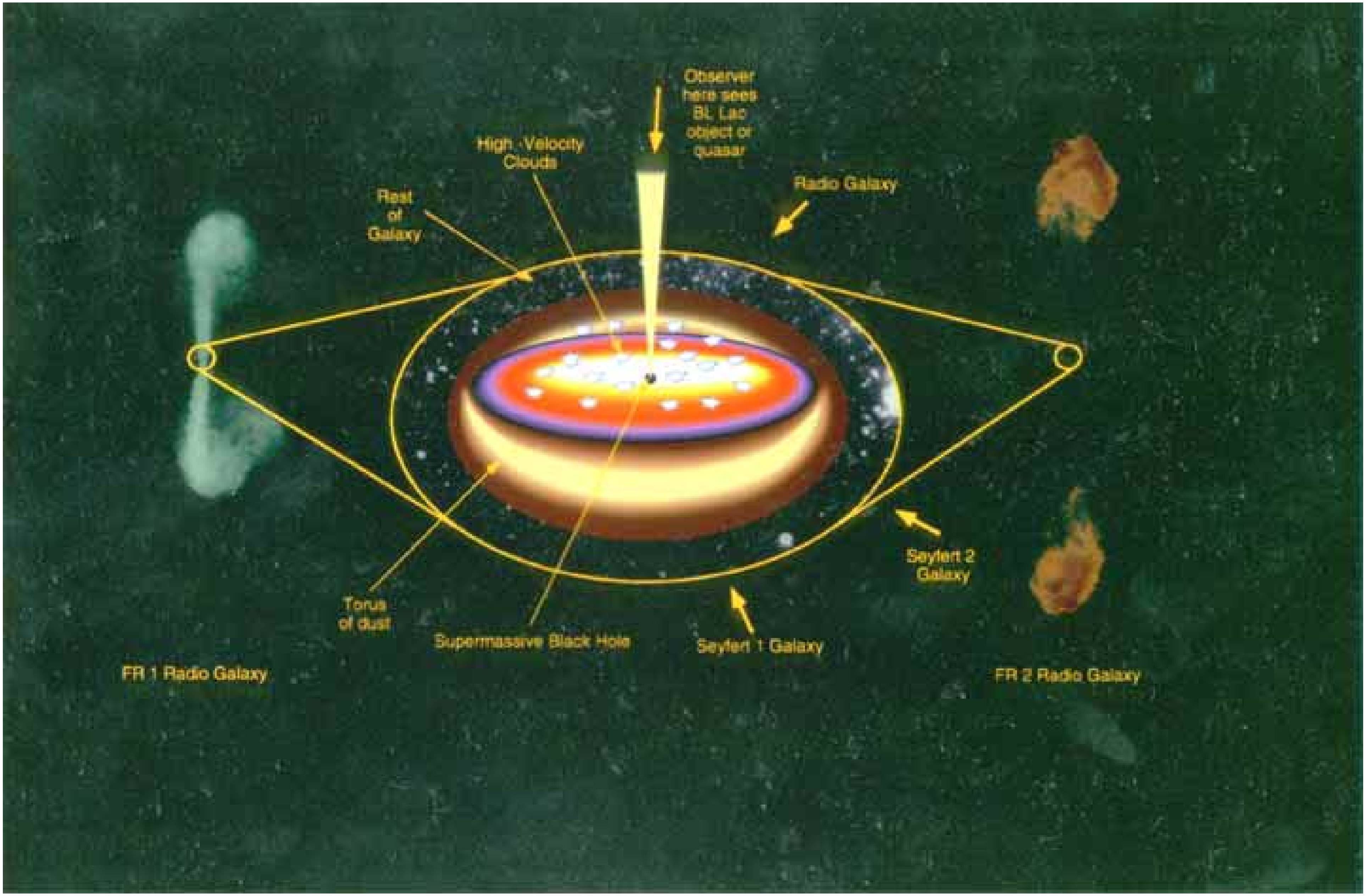
Theory and Modeling Focus

- Blazars and AGNs
  - Beaming tests $\gamma\gamma$, Elliot-Shapiro, $\lambda\lambda\lambda$
  - Statistics and Population Studies / γ-ray Background
  - Spectral Models / Misaligned Sources
- Gamma-Ray Bursts
  - High Energy Emission from Blast Wave Model
    - SSC, Hadronic-induced Cascade
  - $\gamma\gamma$ Attenuation (at source, due to IIRF)
  - Internal Shells vs. External Shock
- Supernova Remnants and Cosmic Ray Origin
  - Multiwavelength spectral models
  - Spectral index maps
  - Particle acceleration
- Unidentified Sources
  - Pulsars / plerions / galactic jet sources
  - Isolated accreting black holes

- New Classes of Sources
    - Cen A, Radio Galaxies
    - ms Pulsars (PSR J018+4232)
    - Cen X-3
    - Evaporating Black Holes
    - WIMP / Dark Matter Annihilation
    - Nonthermal Galaxy Cluster Halo Emission

Software Tools

- XSPEC-type Analyses Including Time Variability
- Transient Emission near sensitivity threshold
- Variability Analyses
- Theoretical Templates


Observer here sees BL Lac object or quasar
High -Velocity Clouds
Rest of Galaxy
Radio Galaxy
Torus of dust
Supermassive Black Hole
Seyfert 1 Galaxy
Seyfert 2 Galaxy
FR 1 Radio Galaxy
FR 2 Radio Galaxy

TESTS FOR BEAMING IN BLAZARS II.

- **Gamma-Ray Transparency**
  - **$\gamma - \gamma$ Pair Production Interactions in a Stationary Source in the Cosmological Ref. Frame Attenuates γ-ray Photons**

Pair Production Optical Depth: $\tau_{\gamma\gamma}(\varepsilon_1) = R \int_{2/\varepsilon_1}^{\infty} d\varepsilon\, \sigma_{\gamma\gamma}(s)\, n_{ph}(\varepsilon)$

  - **If $\tau_{\gamma\gamma} >> 1$ Then Beaming is Required** ✓

Source	$\tau_{\gamma\gamma}$ (E = 1 MeV)
3C 273	1.1 → 3-10
3C 279	7.2×10^{-2}
3C 454.3	13
CTA 102	13
PKS 0528+134	250

TESTS FOR BEAMING IN BLAZARS I.

- **Luminosity and Mass Estimates**
  - **Minimum Mass Derived From Luminosity, Assuming Eddington-Limited Accretion**
  - **Maximum Mass Inferred From Emission Size Scale**

$$R = c\,\Delta t/(1+z) > R_S \propto M$$

  - **If Min Mass > Max Mass, Then Beaming is Required**

Source	Min M_8	Max M_8
3C 273	1.5	220
3C 279	4.7	1.9×10^4
3C 454.3	14	560
CTA 102	25	890
PKS 0528+134	70	85

New Test for Beaming in Blazars

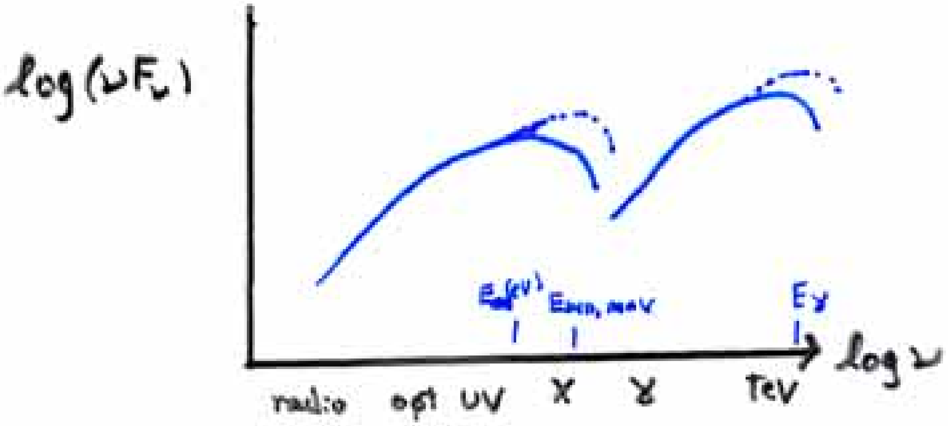
Catanese (1997)
Dermer (1998)

Doppler factor $\mathcal{D} = [\Gamma(1-\beta\mu)]^{-1}$

$$\left[E_{obs}(eV)\cdot \mathcal{D}\cdot(\Delta t(day))^2\right]^{-1/3} \lesssim B(Gauss) \lesssim \left[\frac{2\mathcal{D}\, E_{syn,max}}{E_\gamma^2(TeV)}\right]^2$$

- **Variability timescale due to synchrotron cooling**
  ⇒ lower limit on B

- **Maximum synchrotron energy and TeV gamma-ray energy**
  ⇒ upper limit on B



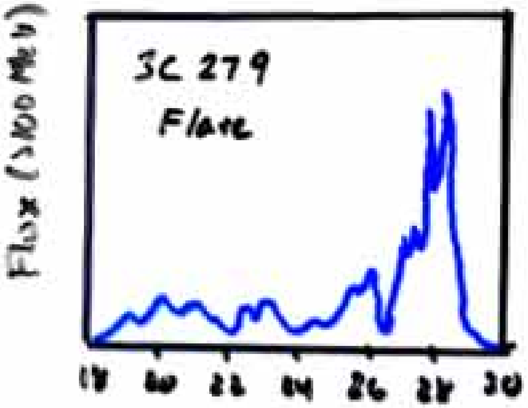
Correlate $\mathcal{D}$ with different source types

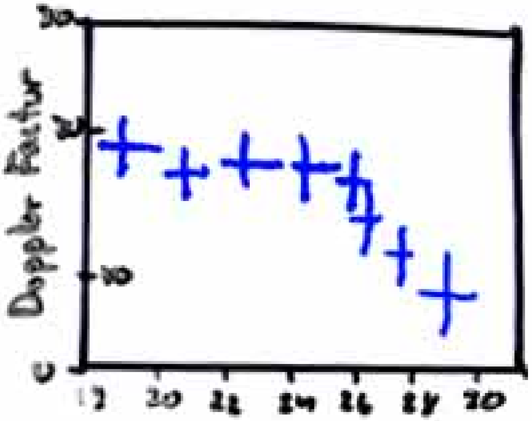
Measure $\mathcal{D}$(t)

Probe closer to the central engine; therefore expect larger values of $\mathcal{D}$ than inferred from radio observations

Chart variation of Doppler Factor with GLAST

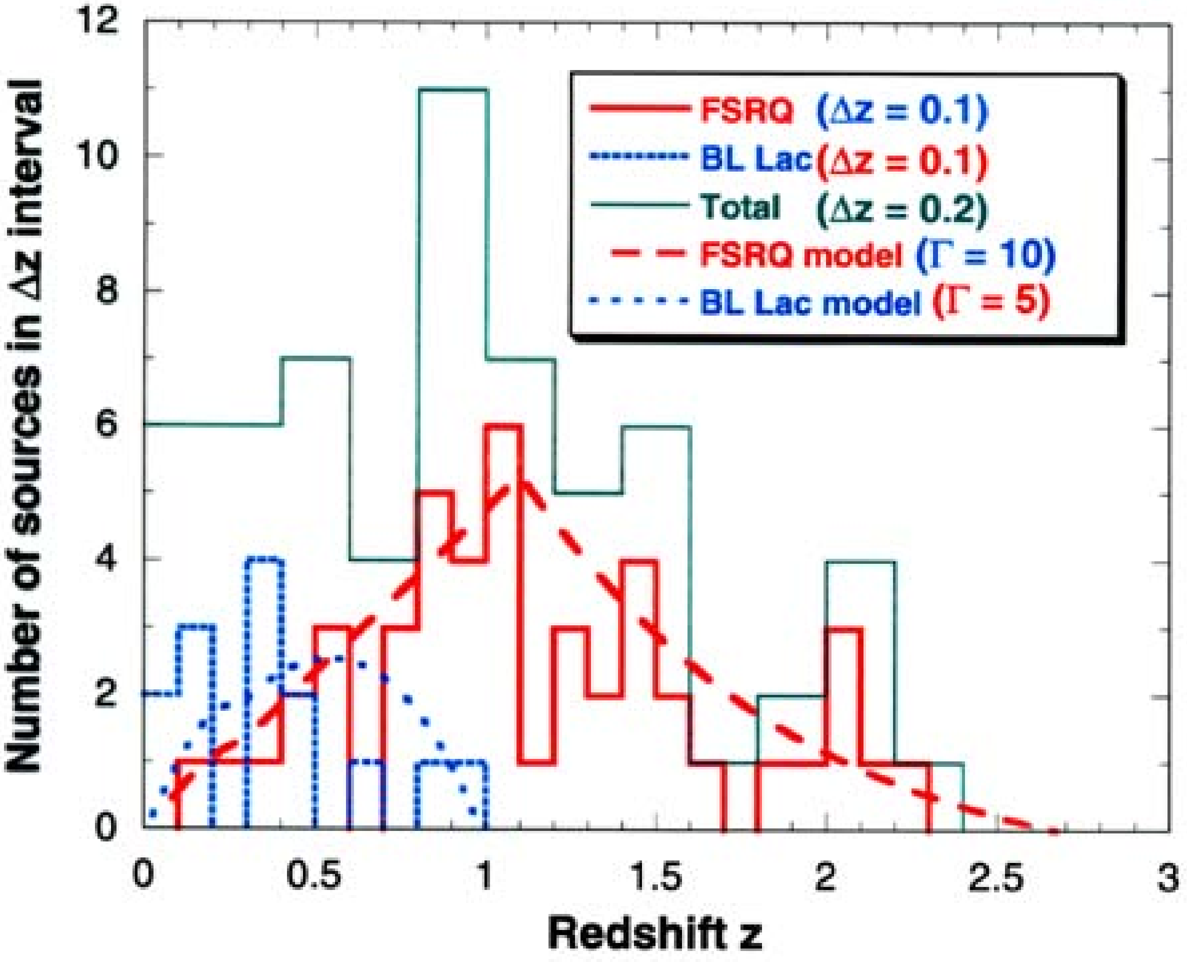
Test Accelerating/Decelerating Jet Models

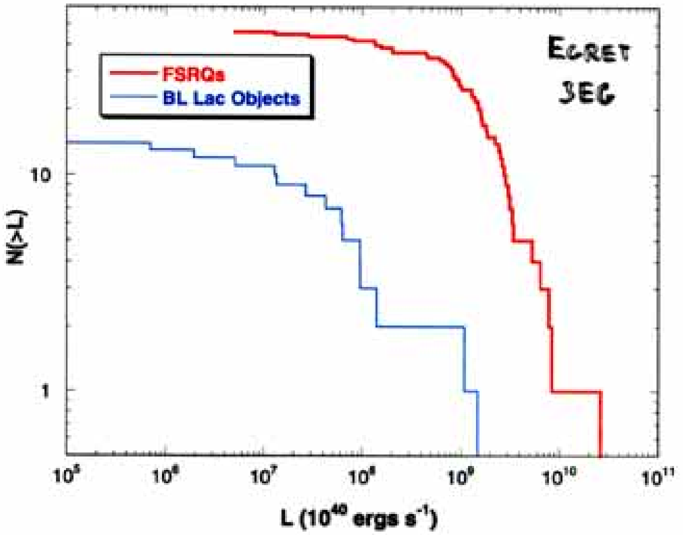




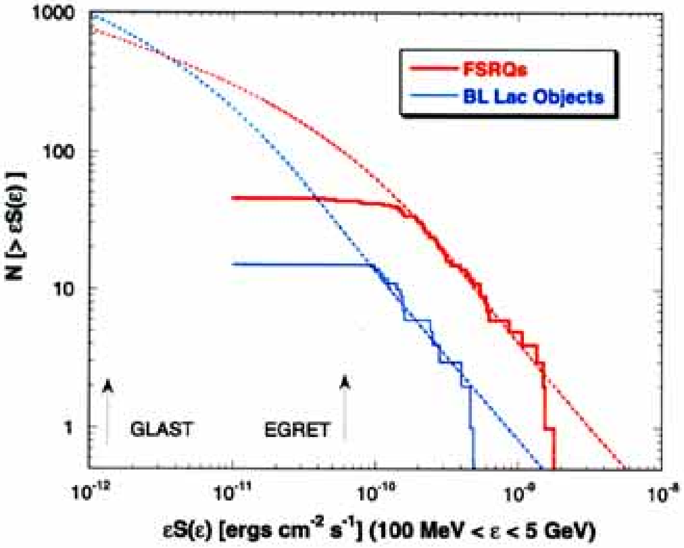
Statistics of Blazars

(with S. Davis)



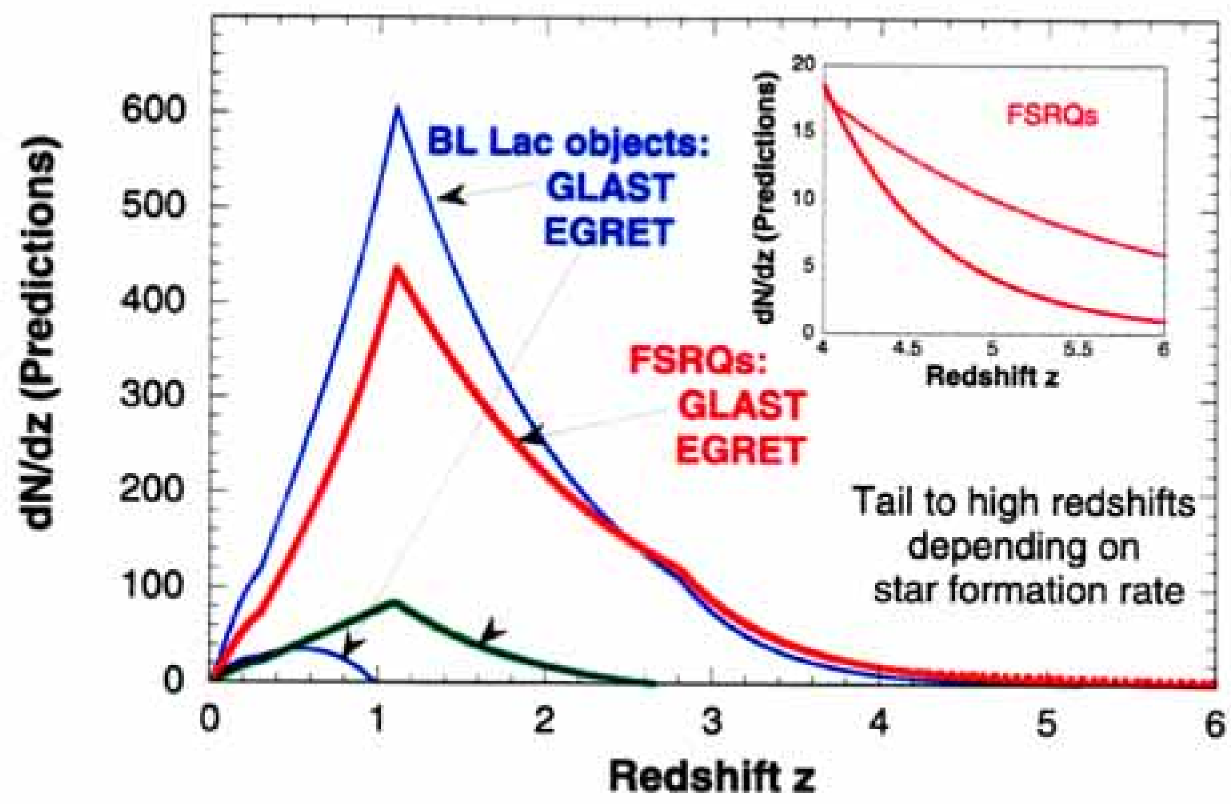


Size Distribution of γ-Ray Blazars

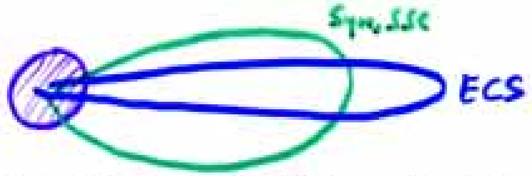


Flowering of BL Lac Objects with GLAST
Targets for TeV Observations

Redshift Distribution of γ-Ray Blazars



Spectral Model



Beaming Cones { → Sync, SSC $\propto D^{3+\alpha}$
→ ECS $\propto D^{4+2\alpha}$

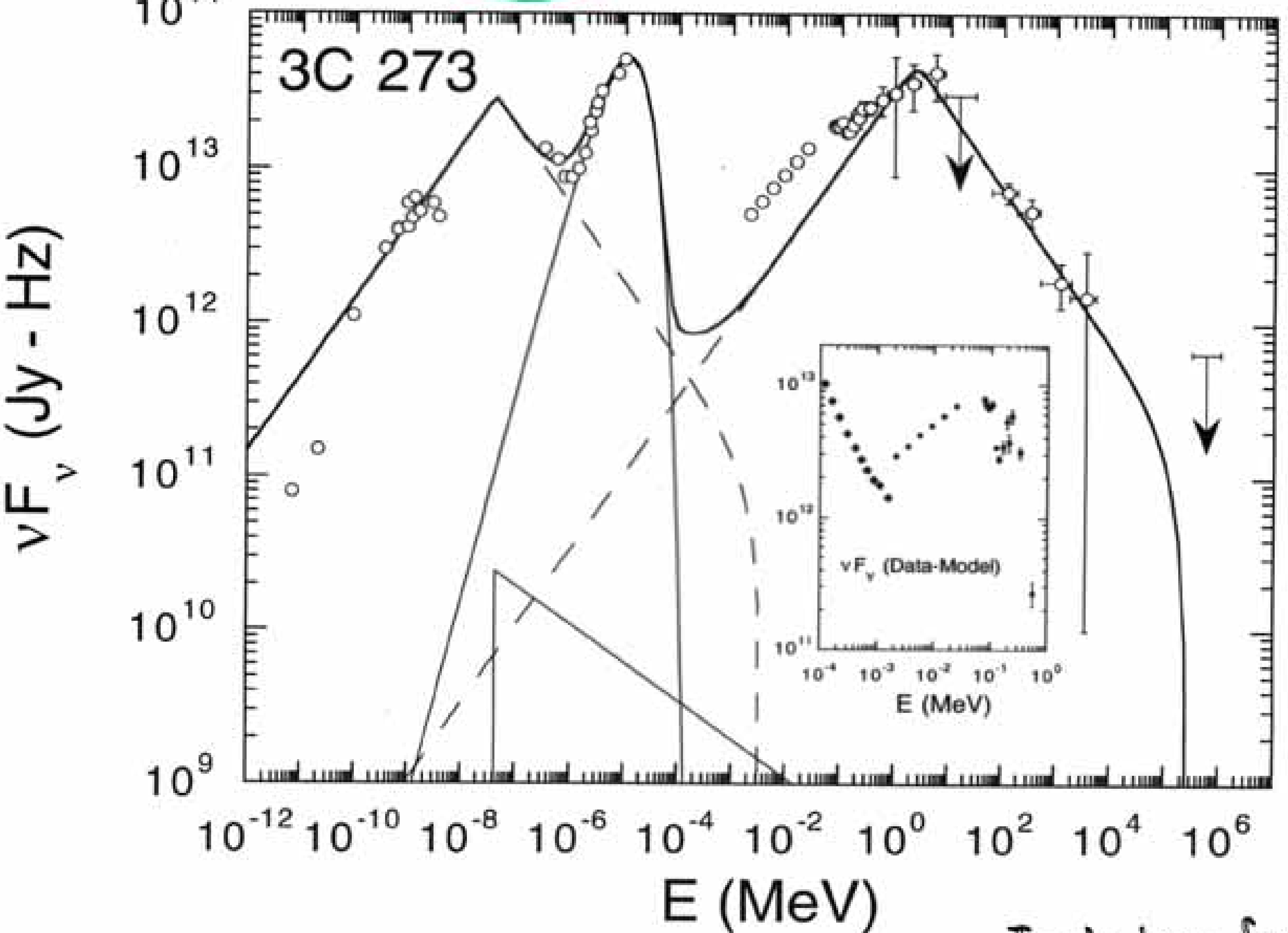
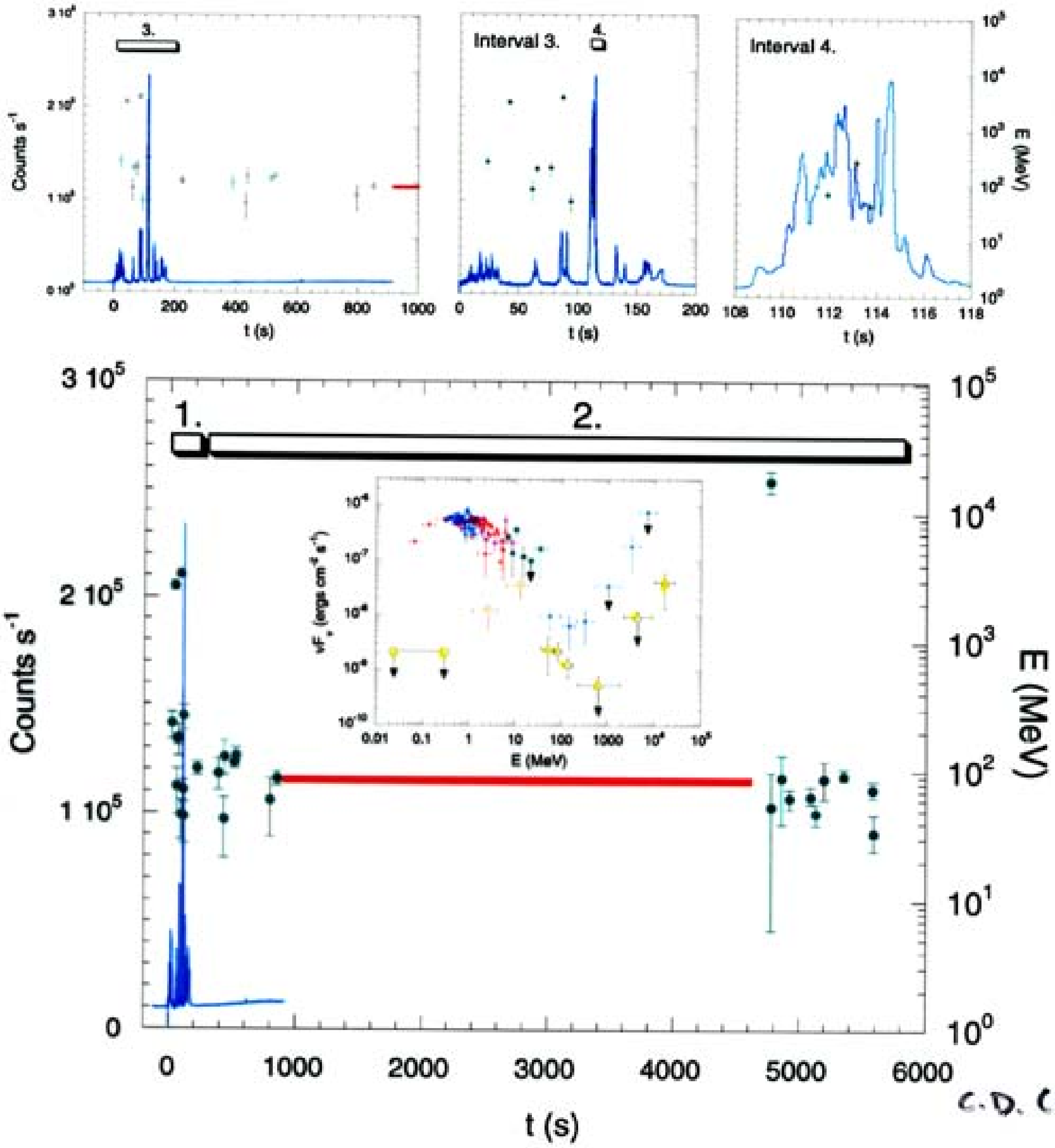


Fig. 12

High-Energy Emission / $\gamma\gamma$ Cutoffs

Implications for Statistics

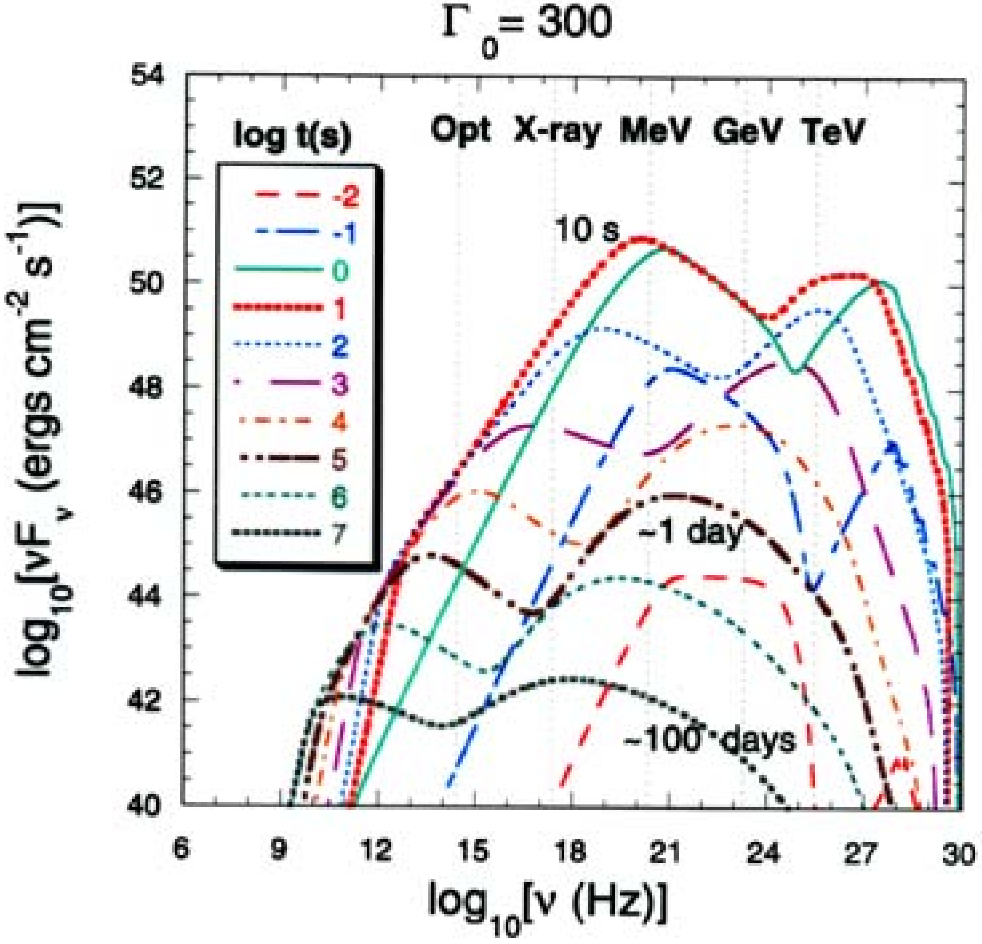
Gamma-Ray Bursts



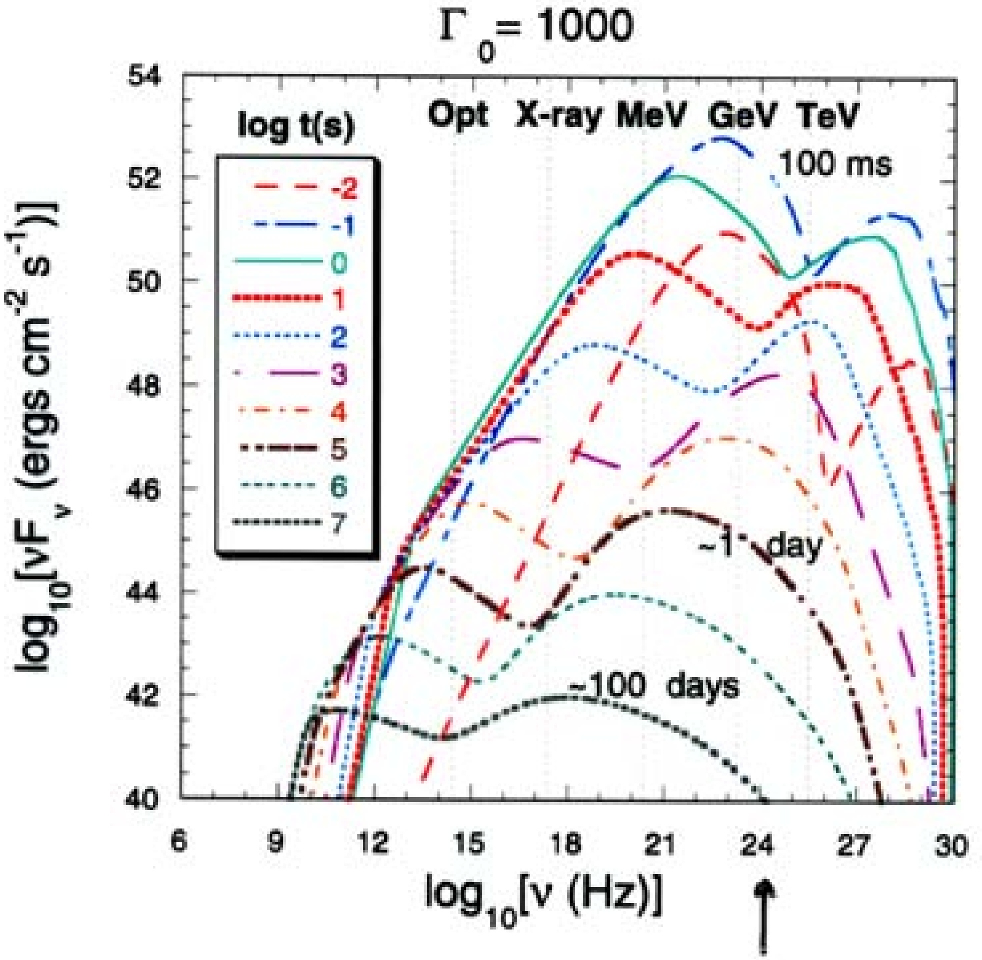
C.D. (1999)

GRB 940217 (Hurley et al. 1994)

External Shock Model



Clean Fireball

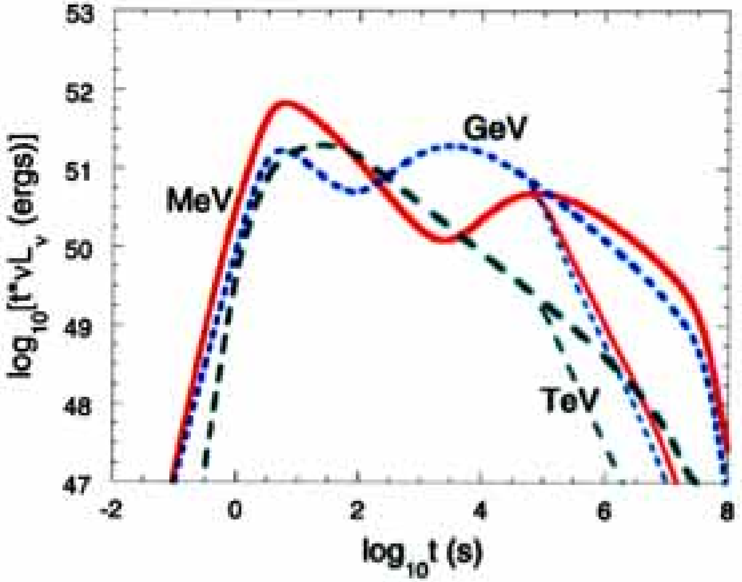


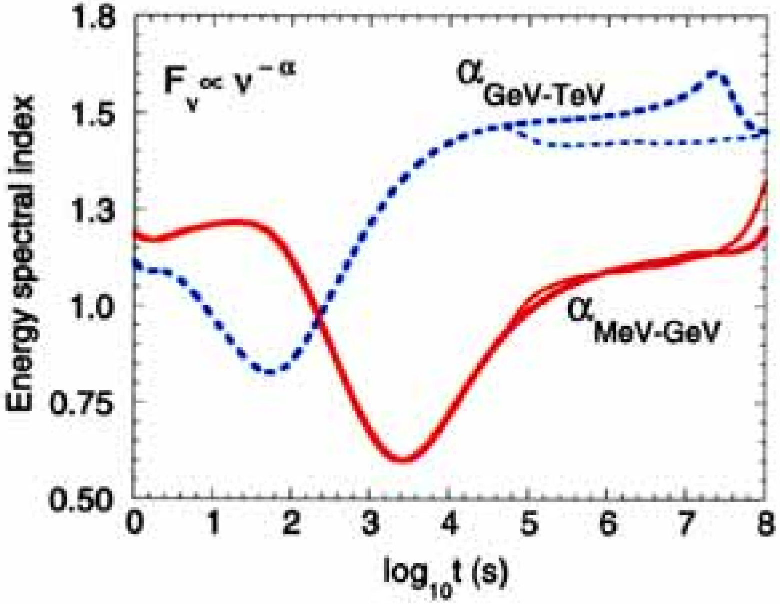
↑ 1 GeV

Brief, very luminous

< 0.1 s for prompt phase

$\Gamma_0 = 300$





Test of External Shock Model

soft-hard-soft evolution

GRBs and the Origin of the Cosmic Rays

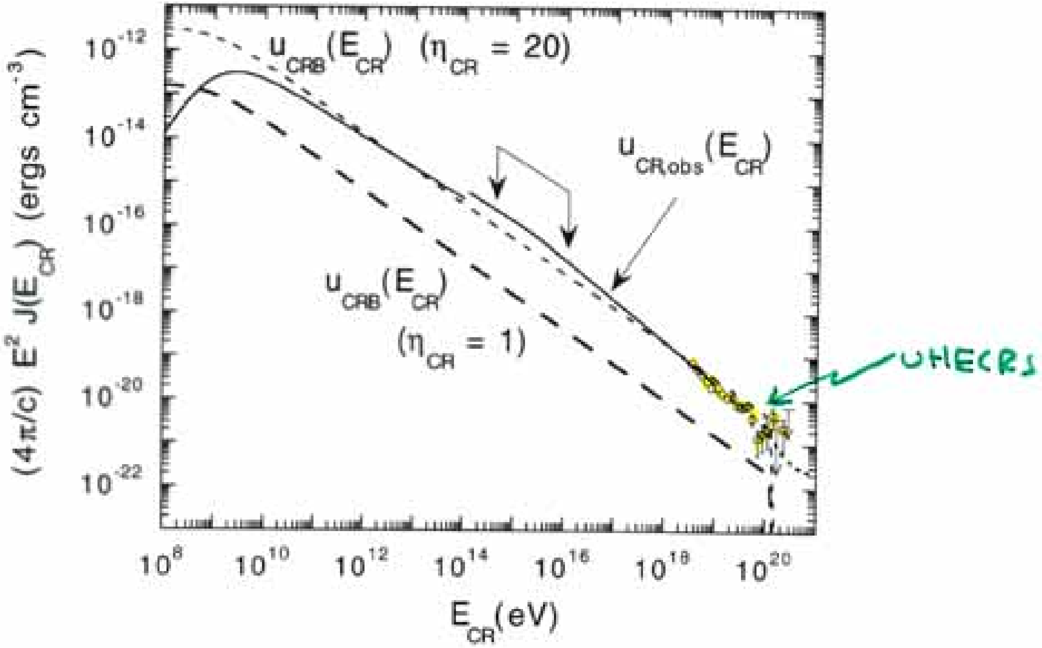


Fig. 9.— Comparison of the observed cosmic ray energy density with the predicted energy densities of cosmic rays that originate from fireball transients (FTs) and GRBs. The two solid curves show extrapolated fits to the observed (Simpson 1983; Fowler et al. 2000) cosmic ray proton spectrum, and the data points are UHECR observations (Takeda et al. 1998). The thick dashed curve shows the predicted time-averaged cosmic ray spectrum for an L^* galaxy such as the Milky Way if a large fraction of the energy from FTs is channeled into a nonthermal particle spectrum with $p = 2.2$. The thick dotted curve shows the predicted UHECR flux if a large fraction of FT emissivity in the local universe emerges in the form of UHECRs. The thin short-dashed curve shows that an enhancement in the local emissivity by a factor of ~ 20, for example by temporal stochastic processes, underestimation of the FT emissivity, overestimation of γ-ray production efficiency from GRBs or the preferred location of the Solar system near star-forming regions, could explain the origin of cosmic rays through production by FTs. The fit to the UHECR spectrum is described in the text.