TeV Gamma Ray Survey of the Northern Hemisphere with Milagro

Gus Sinnis/LANL

for

The Milagro Collaboration

The 28th ICRC
Tsukuba, Japan August 6, 2003

The Milagro Collaboration

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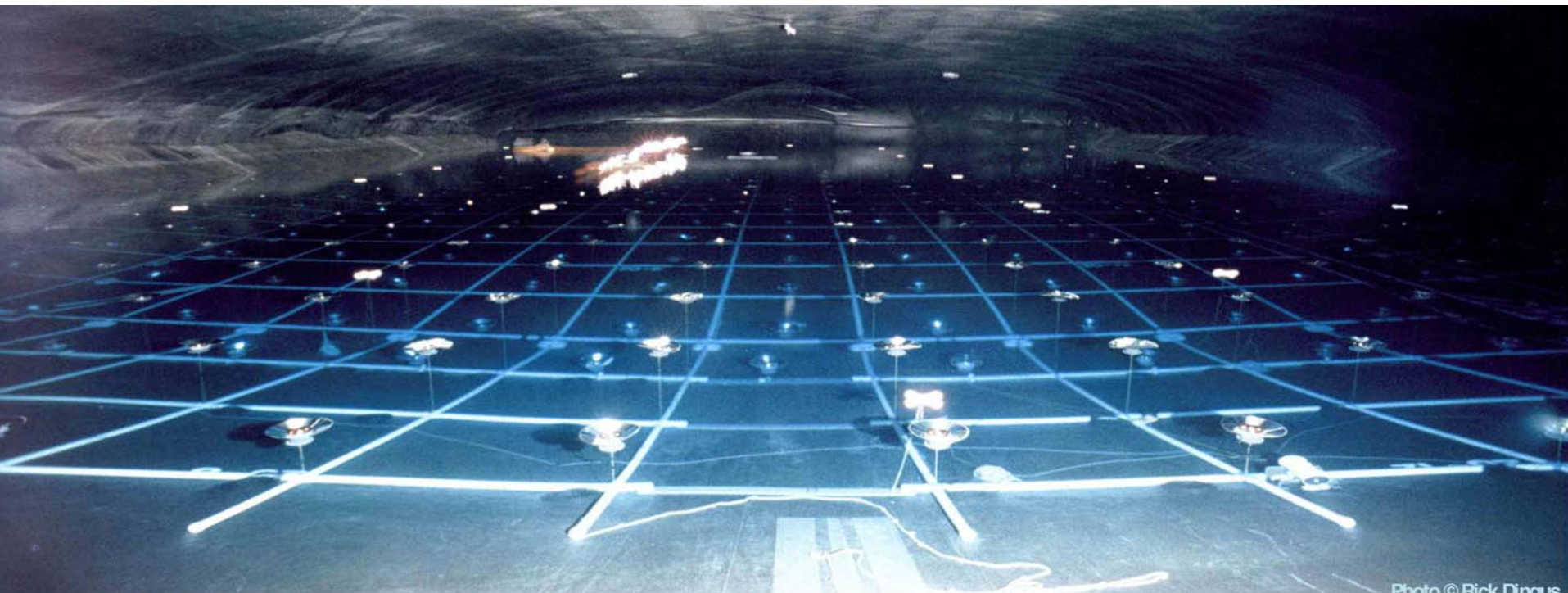
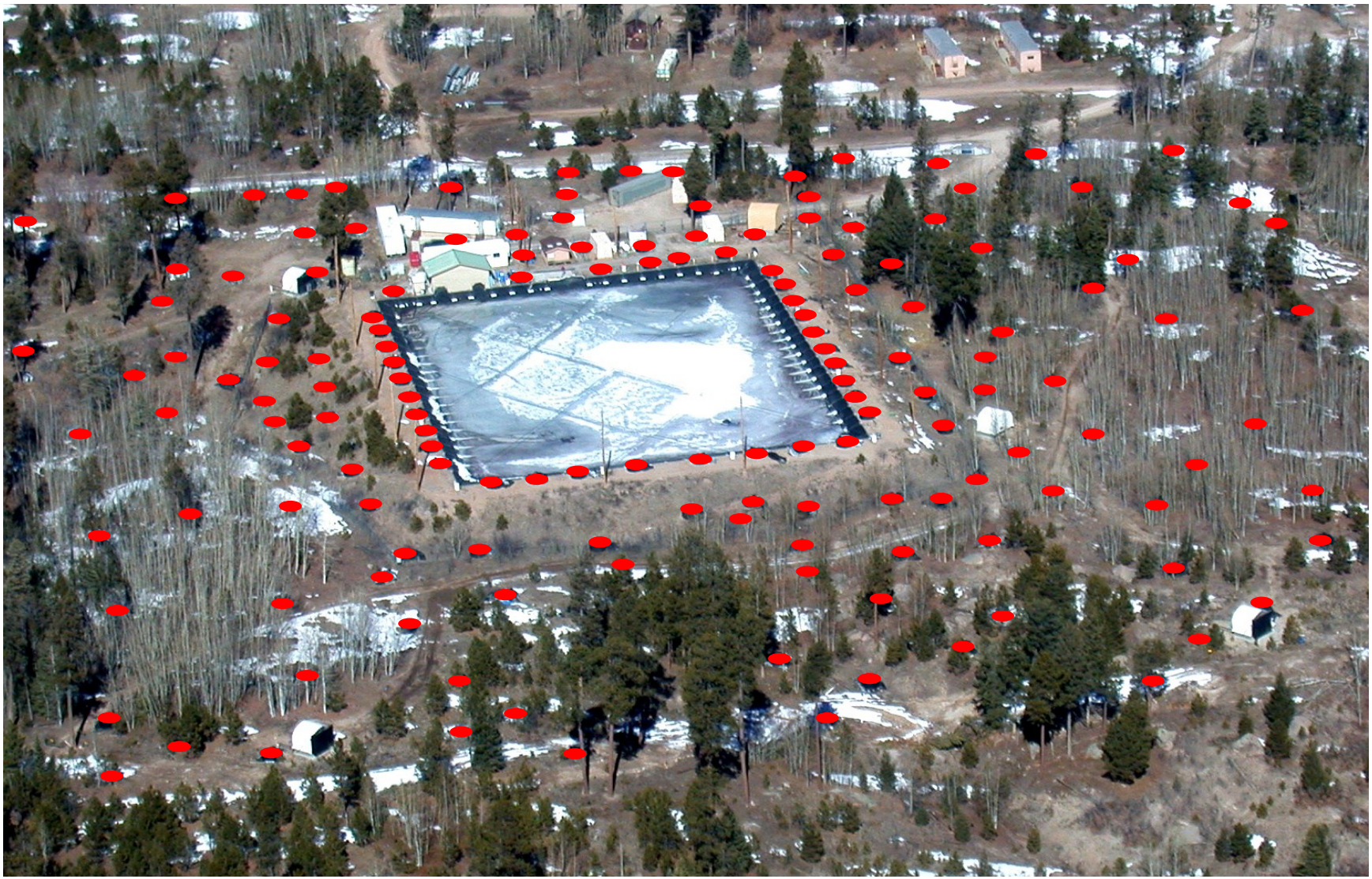
The Milagro Detector

A Continuous All Sky TeV Gamma Ray Monitor

Energy Threshold: 100 GeV
Median Energy: ~3 TeV
Trigger Rate: 1.7 kHz



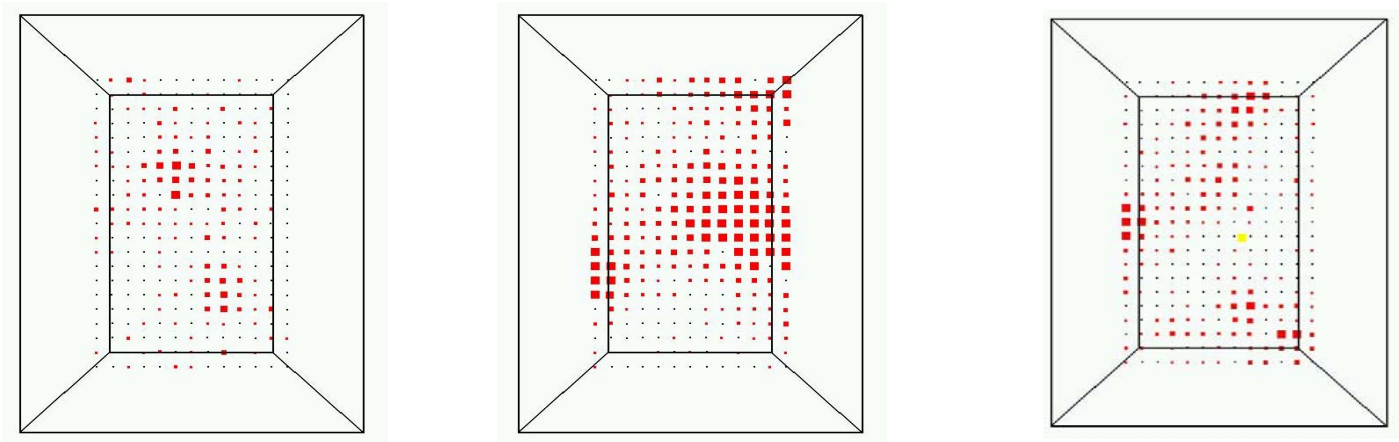
Milagro with Outriggers



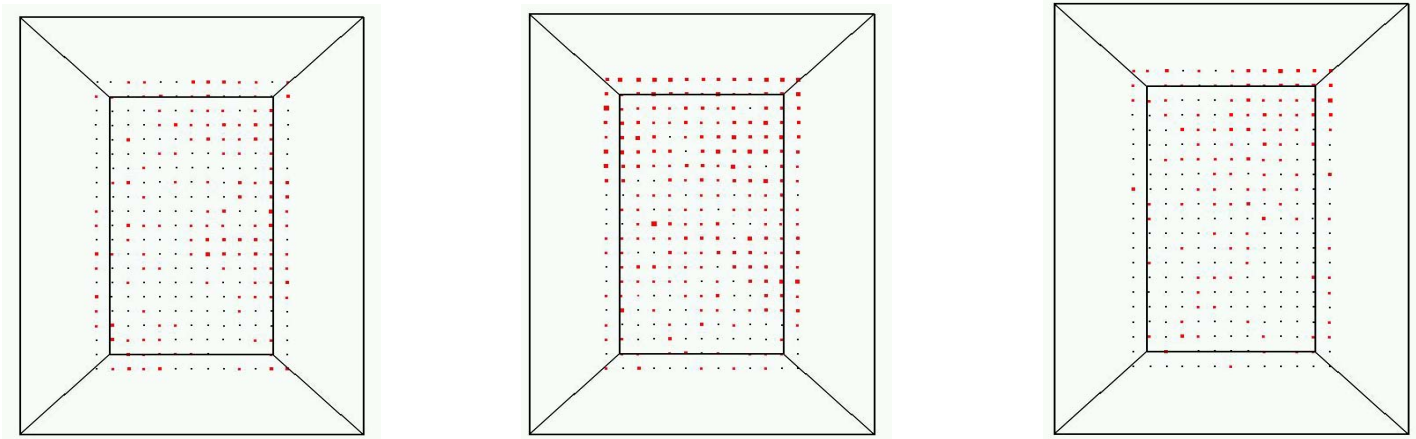
Background Rejection in Milagro

- Hadronic cosmic ray showers contain penetrating particles
  - Muons and hadrons
- Deposit energy deep in Milagro – use bottom layer

Protons



Gammas



Background Rejection: *C*

Search for large pulses in small number of tubes

$$C = \frac{NBottom(>2Pes)}{PE_{Max}(Bottom)}$$

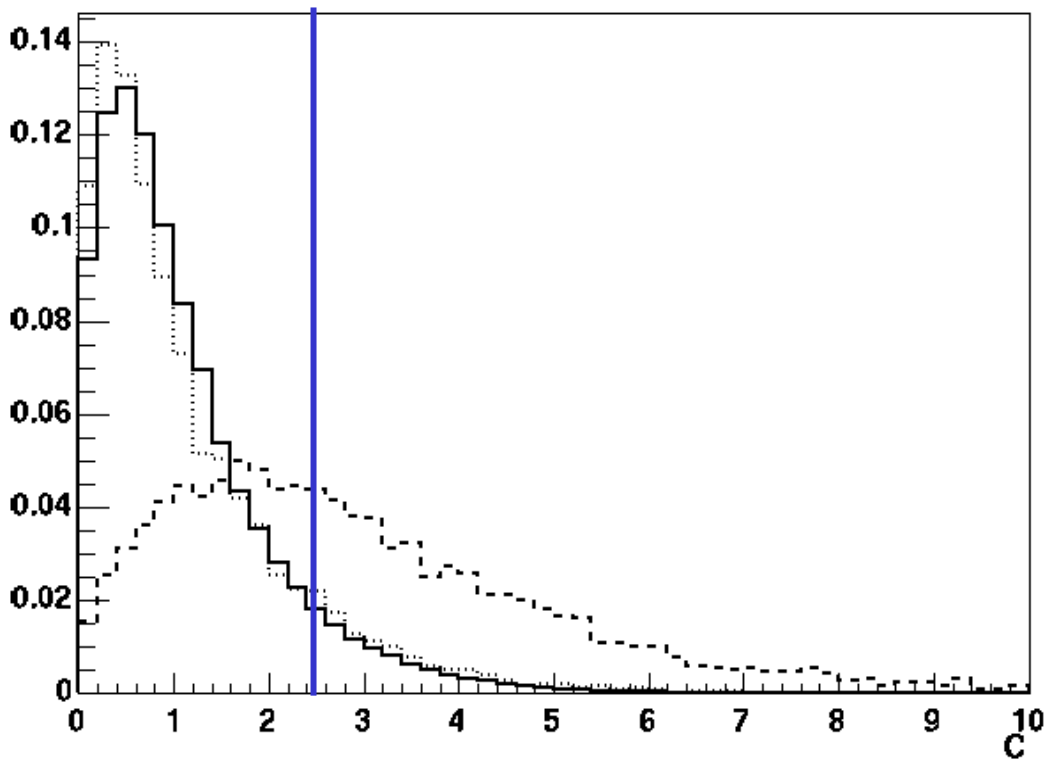
Demand C > 2.5

Retain:

53% of Gammas

11% of Protons/Data

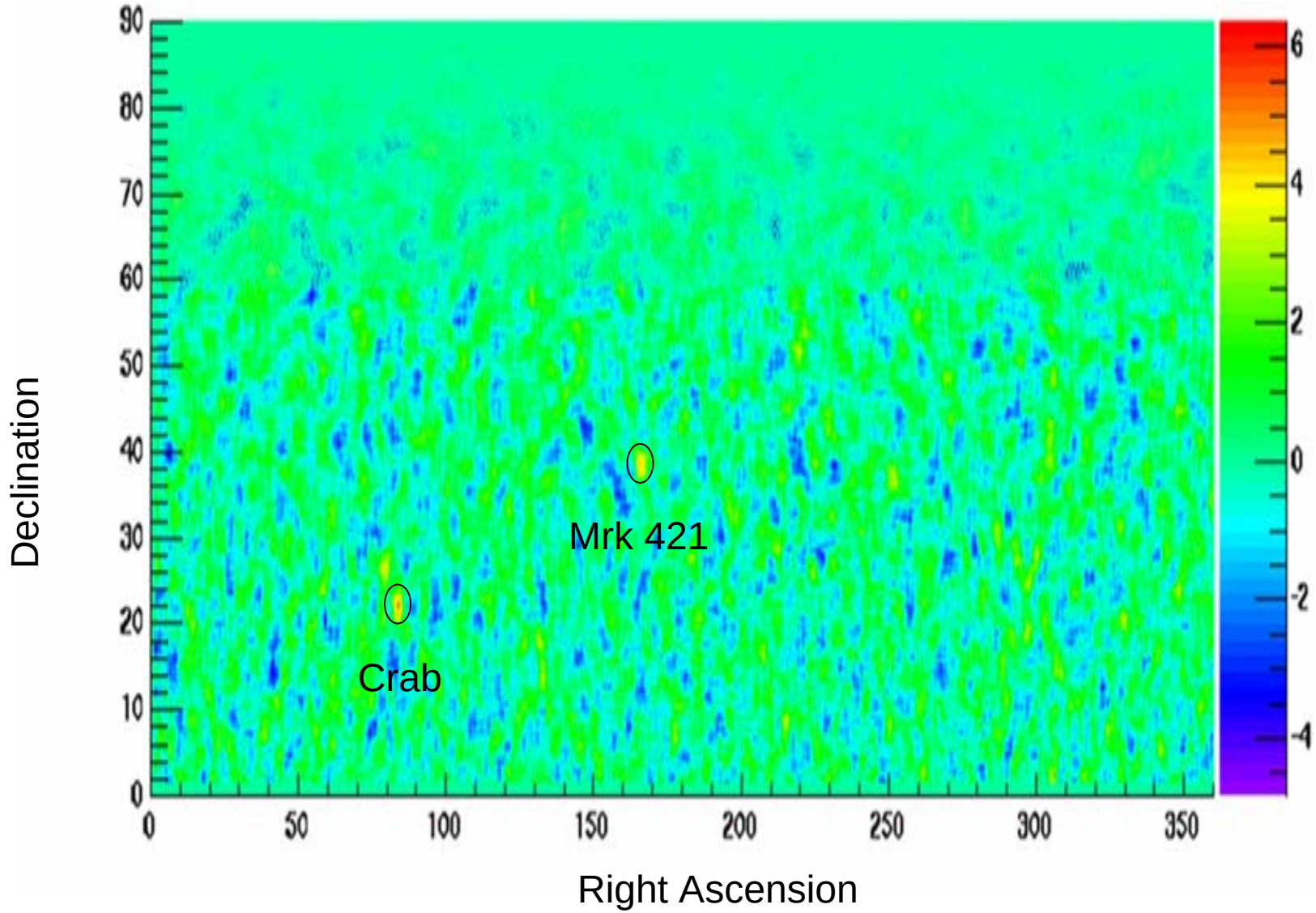
Q = 1.7



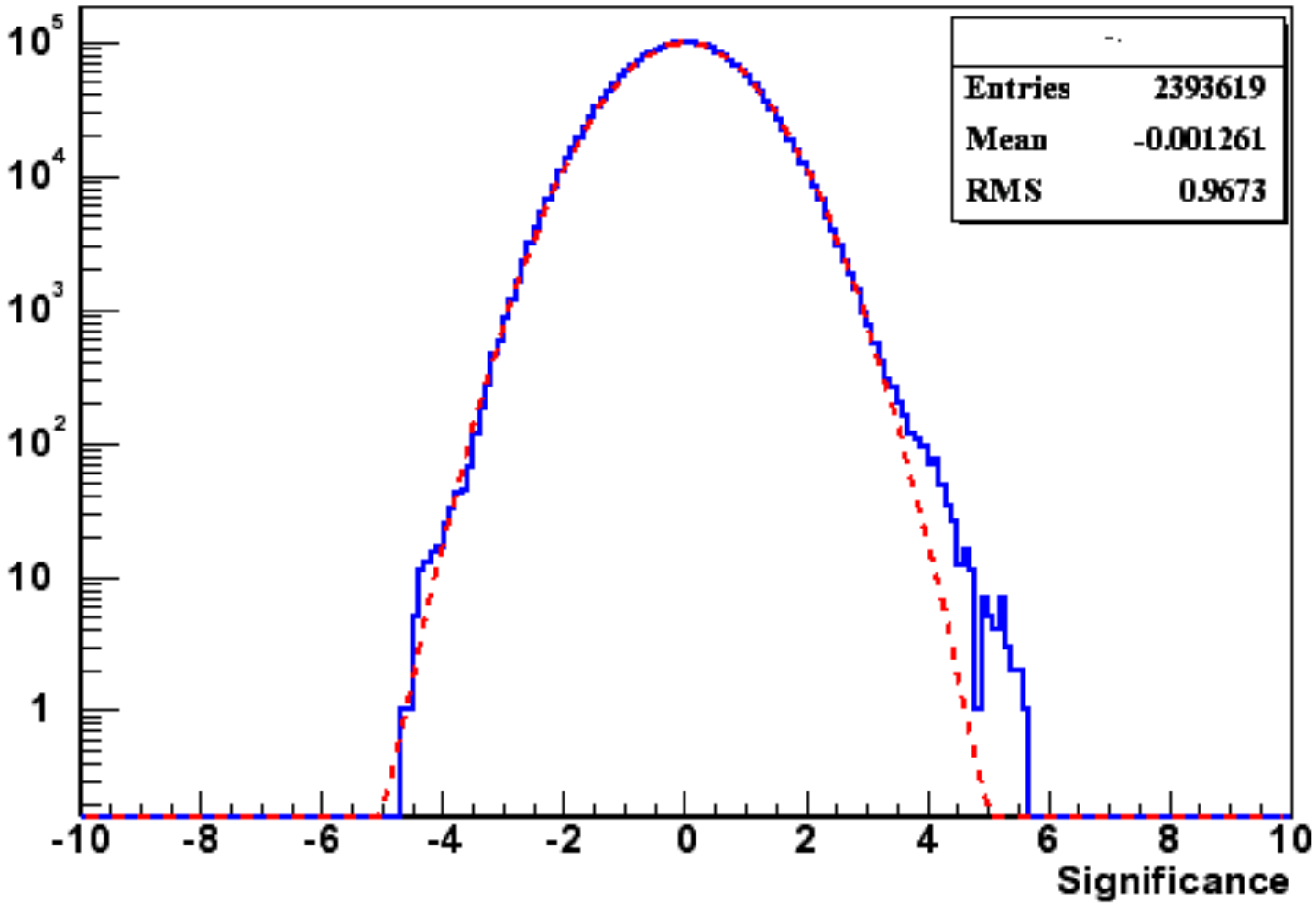
Survey Strategy

- Timescales examined
  - 1 week, 2 week, 4 week, … DC (~128 week)
- Two intervals/timescale
  - Shifted by ½ of timescale
- Angular resolution ~0.75 degrees
  - Use binsize of 3 degrees
- Apply compactness cut (C>2.5) to data
- Oversample sky
  - Bin centers on an 0.1 degree grid (in RA and DEC)
- Survey duration
  - Dec 15, 2000 – June 3, 2003

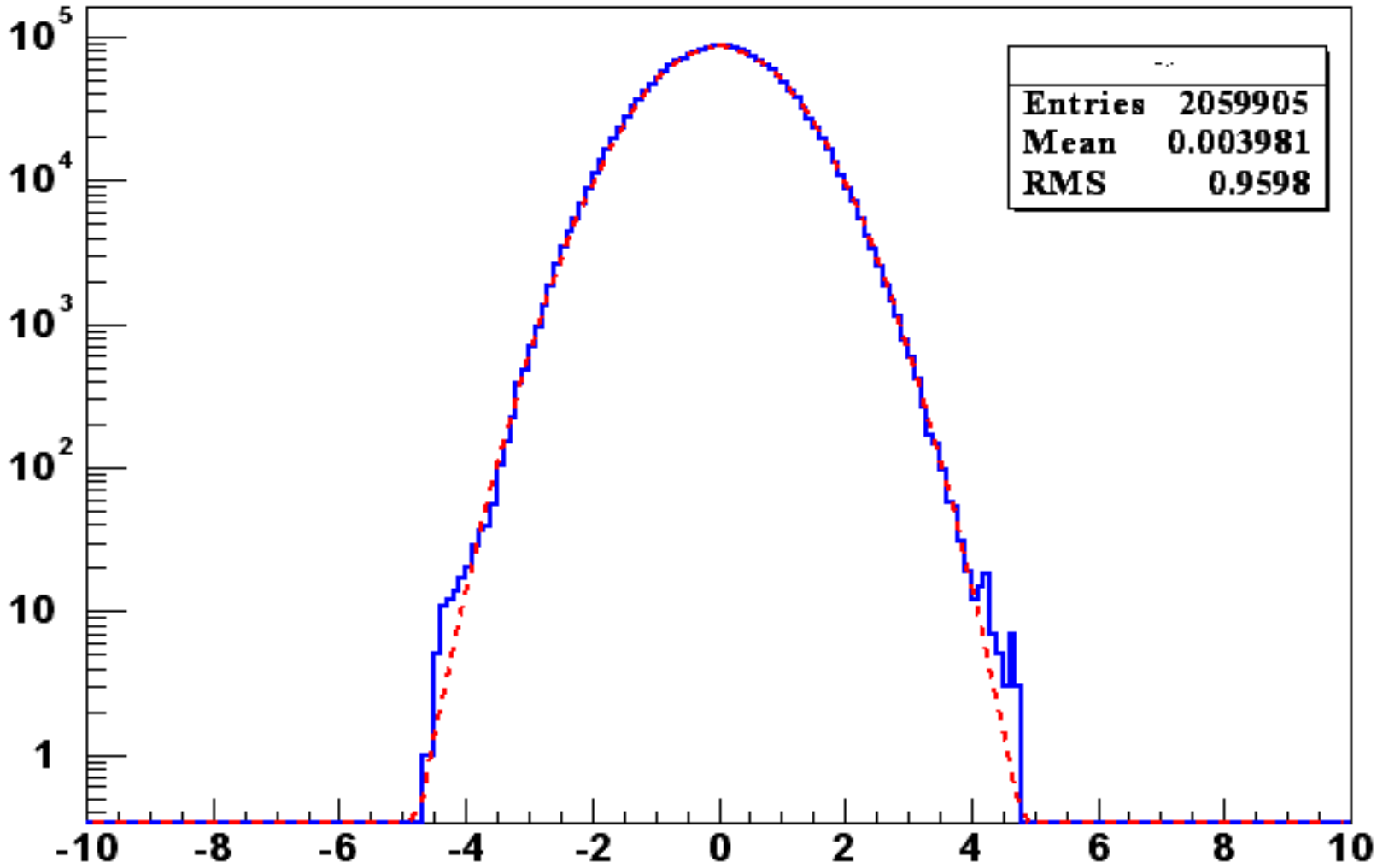
D.C. Map of Northern Hemisphere



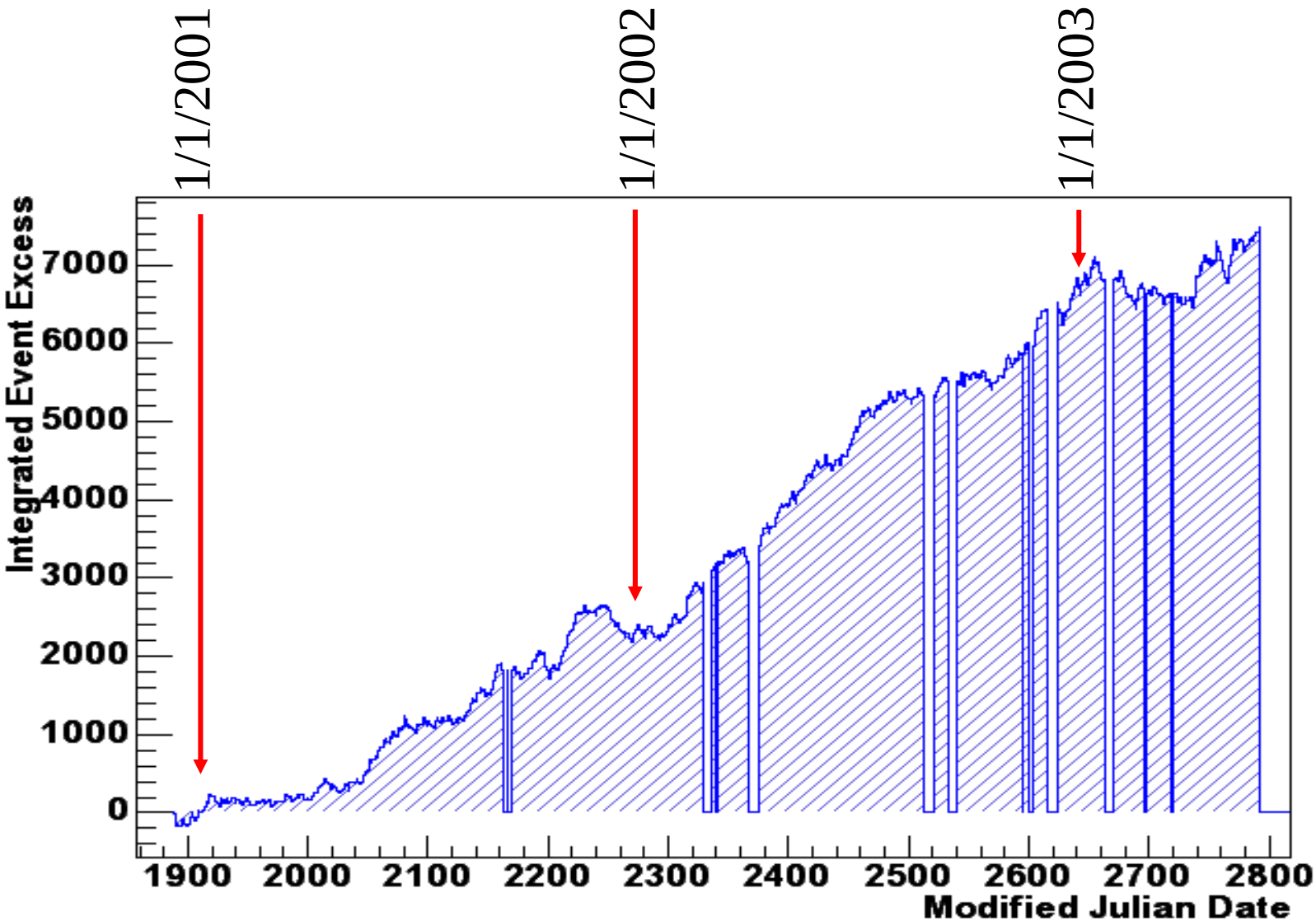
Distribution of Excesses: D.C. Survey



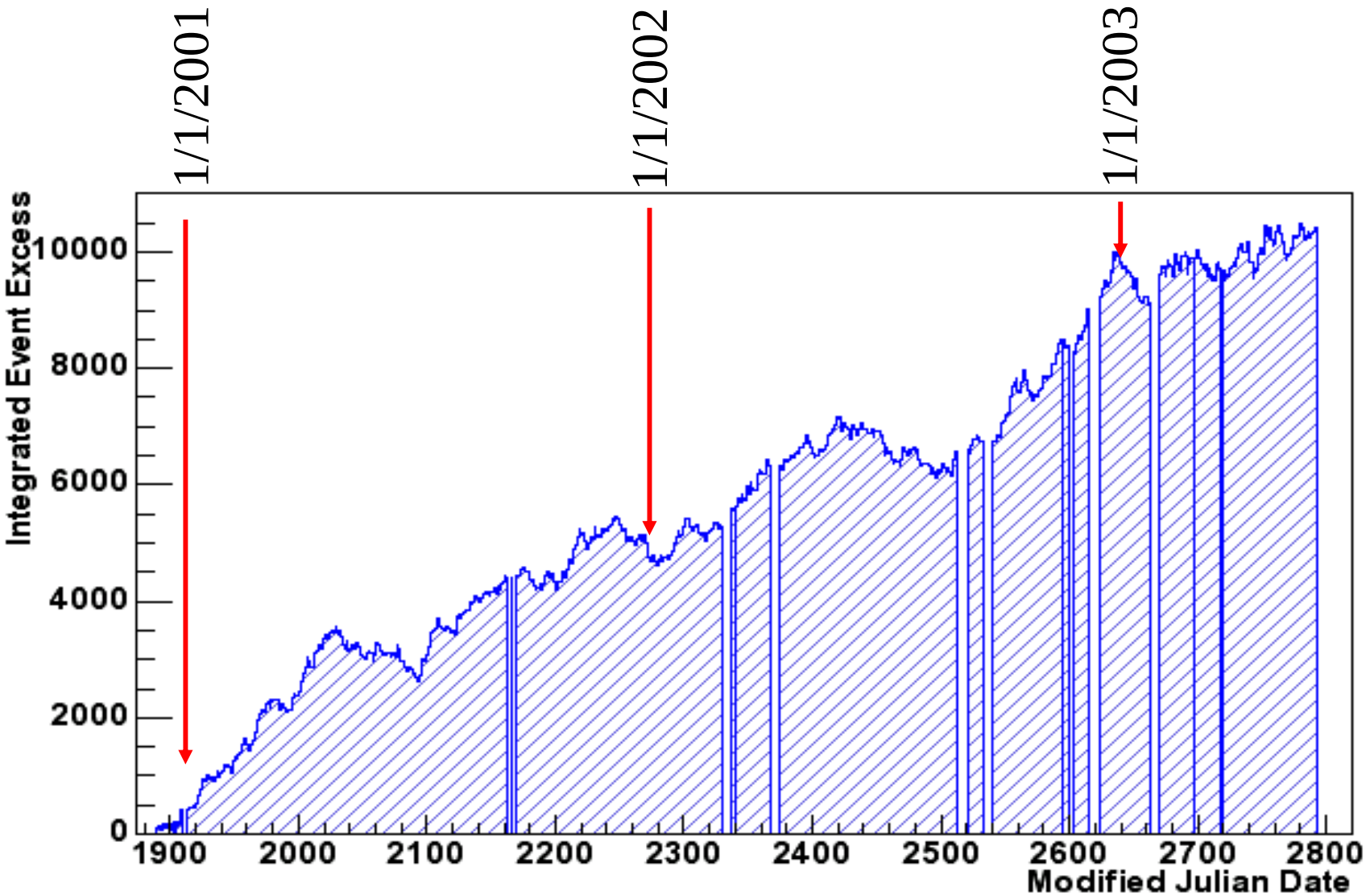
Distribution of Excesses: Crab and Mrk421 Removed



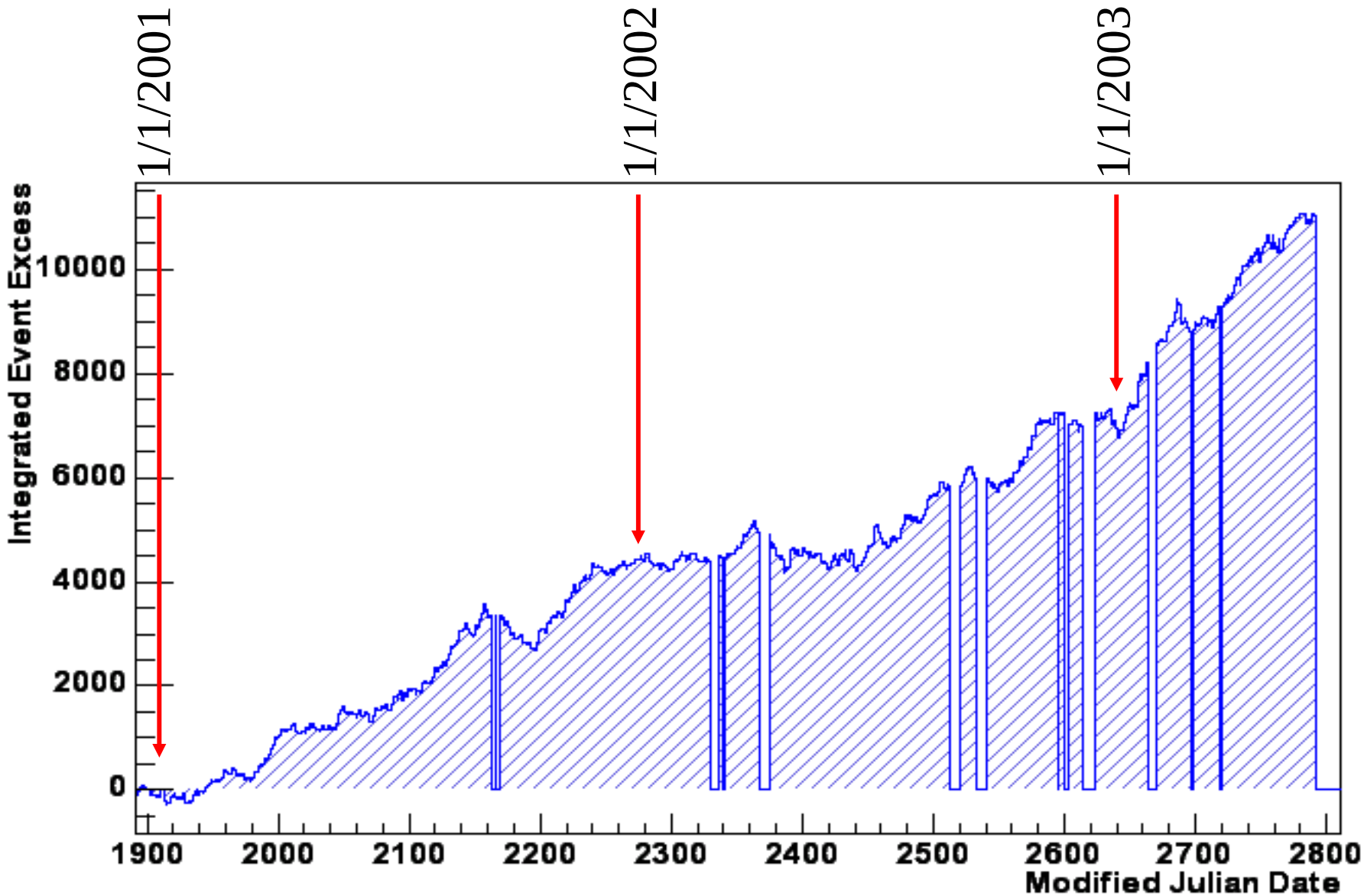
Crab Nebula: Excess vs. Time



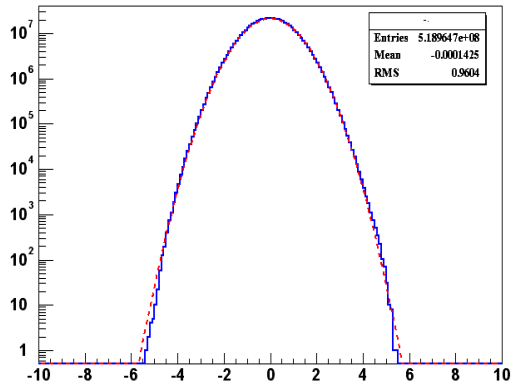
Mrk421: Excess vs. Time



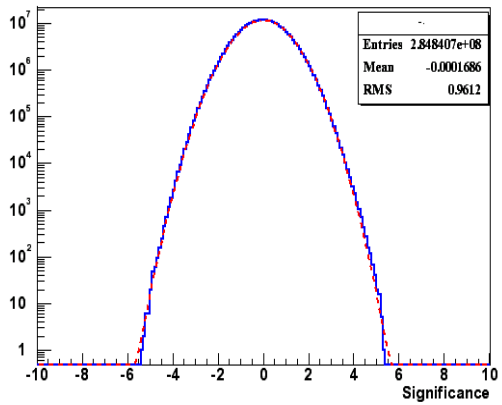
“Hotspot”: Excess vs. Time



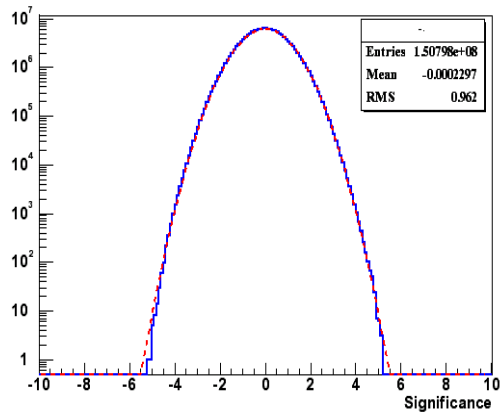
Shorter Duration Results



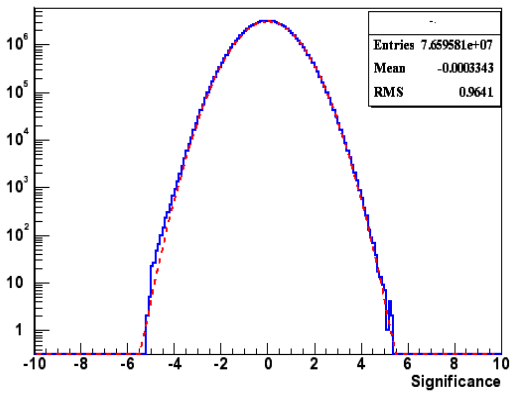
1 week



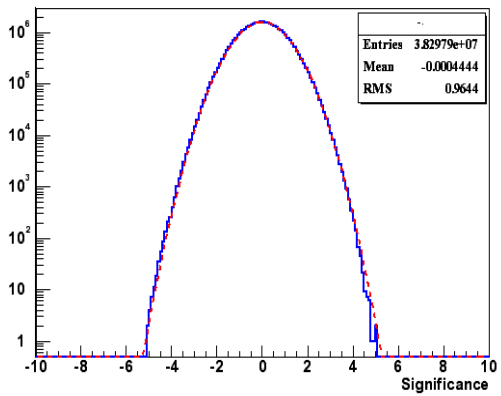
2 weeks



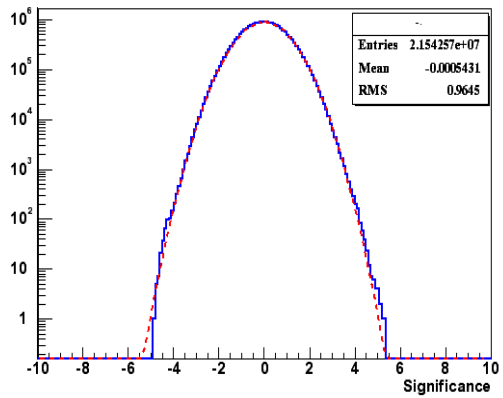
4 weeks



8 weeks

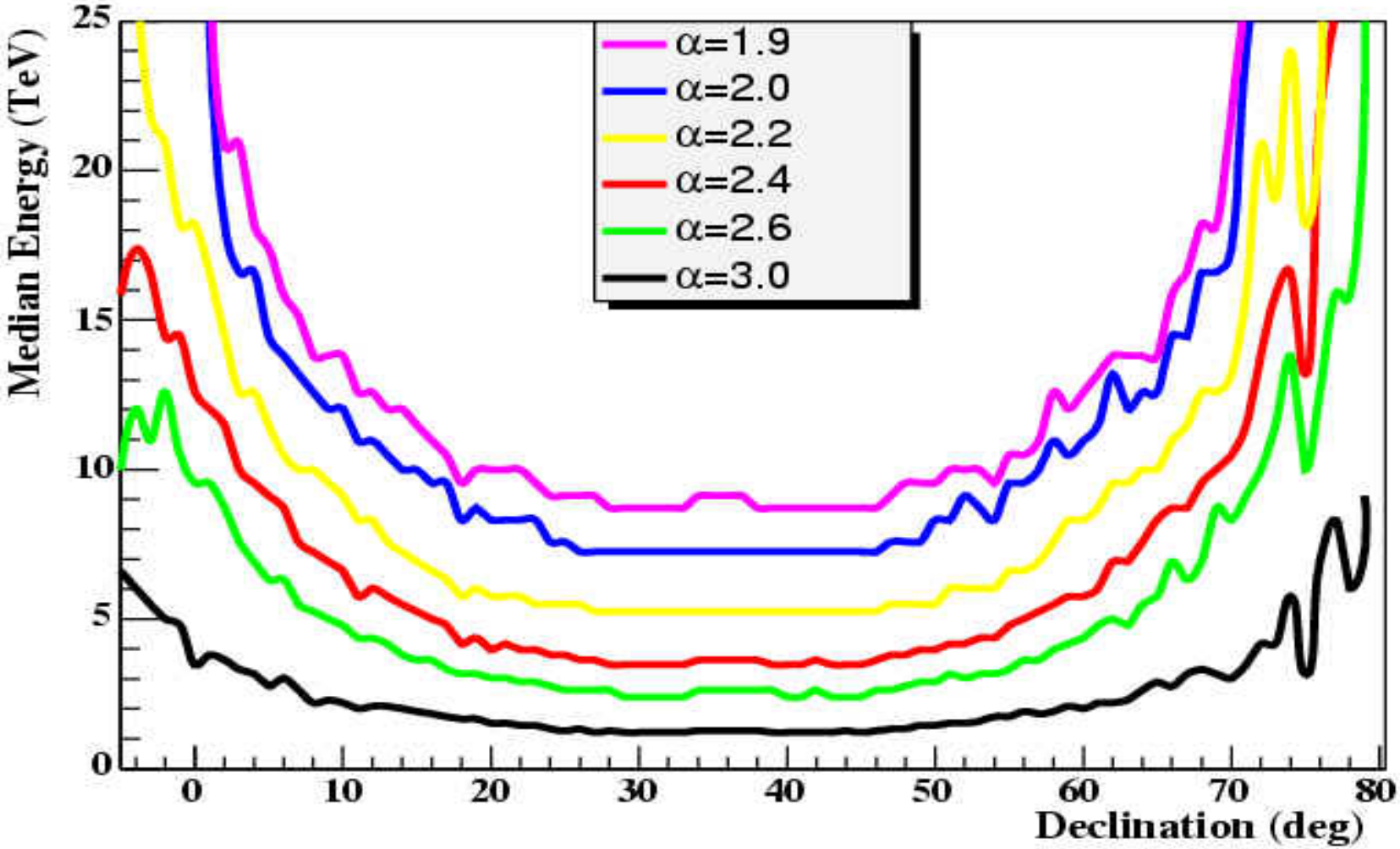


16 weeks

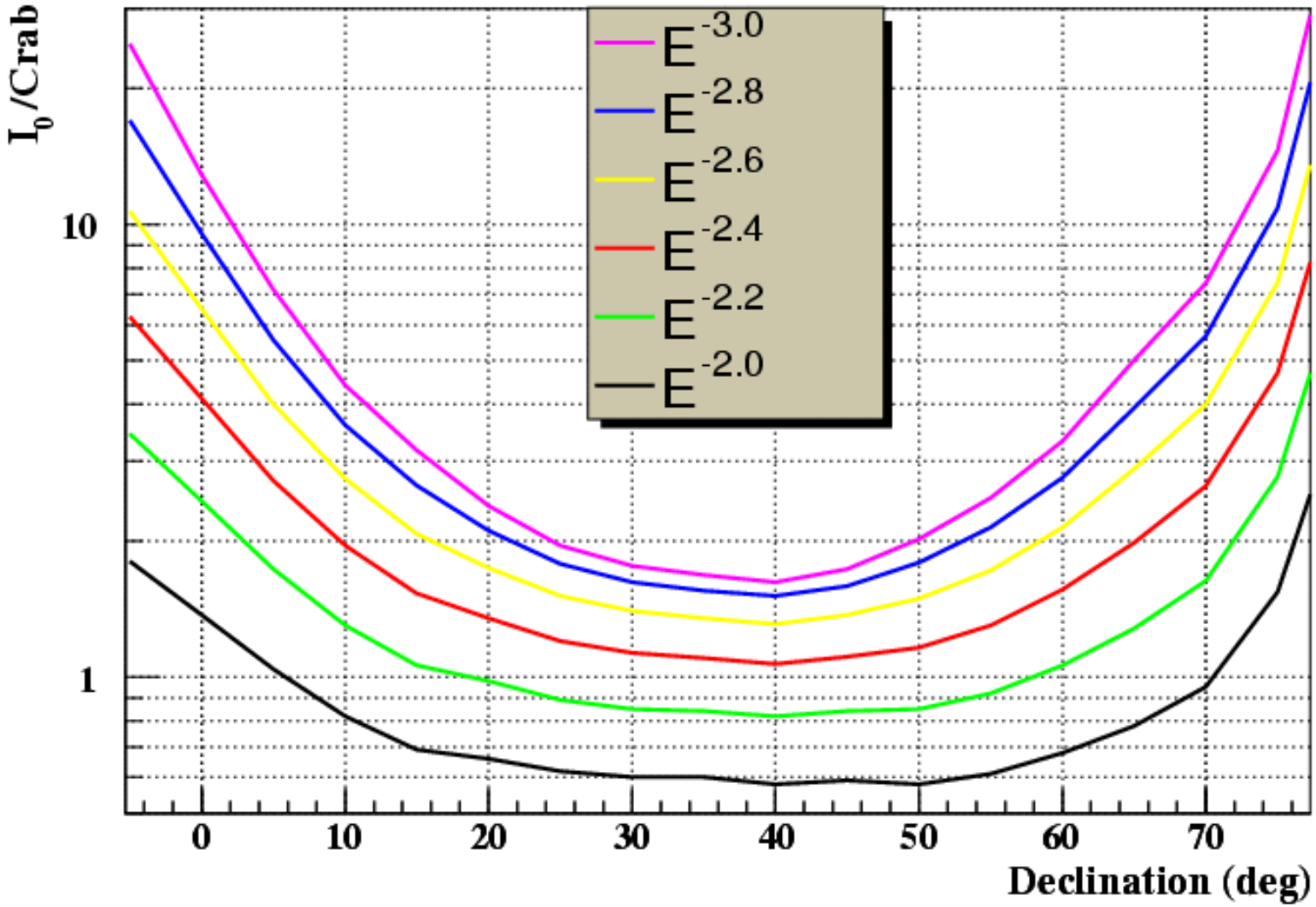


32 weeks

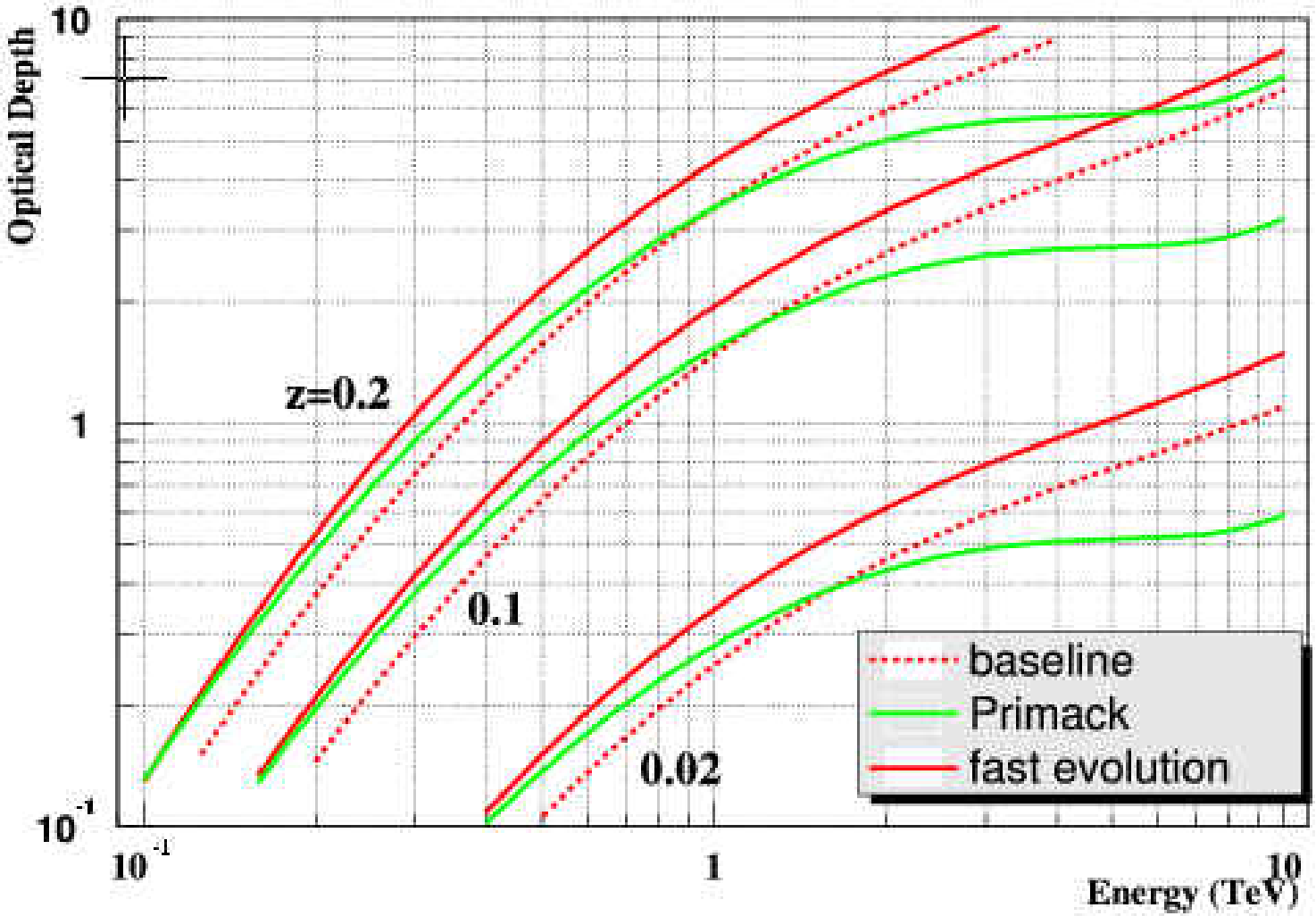
Median Energy vs. Declination



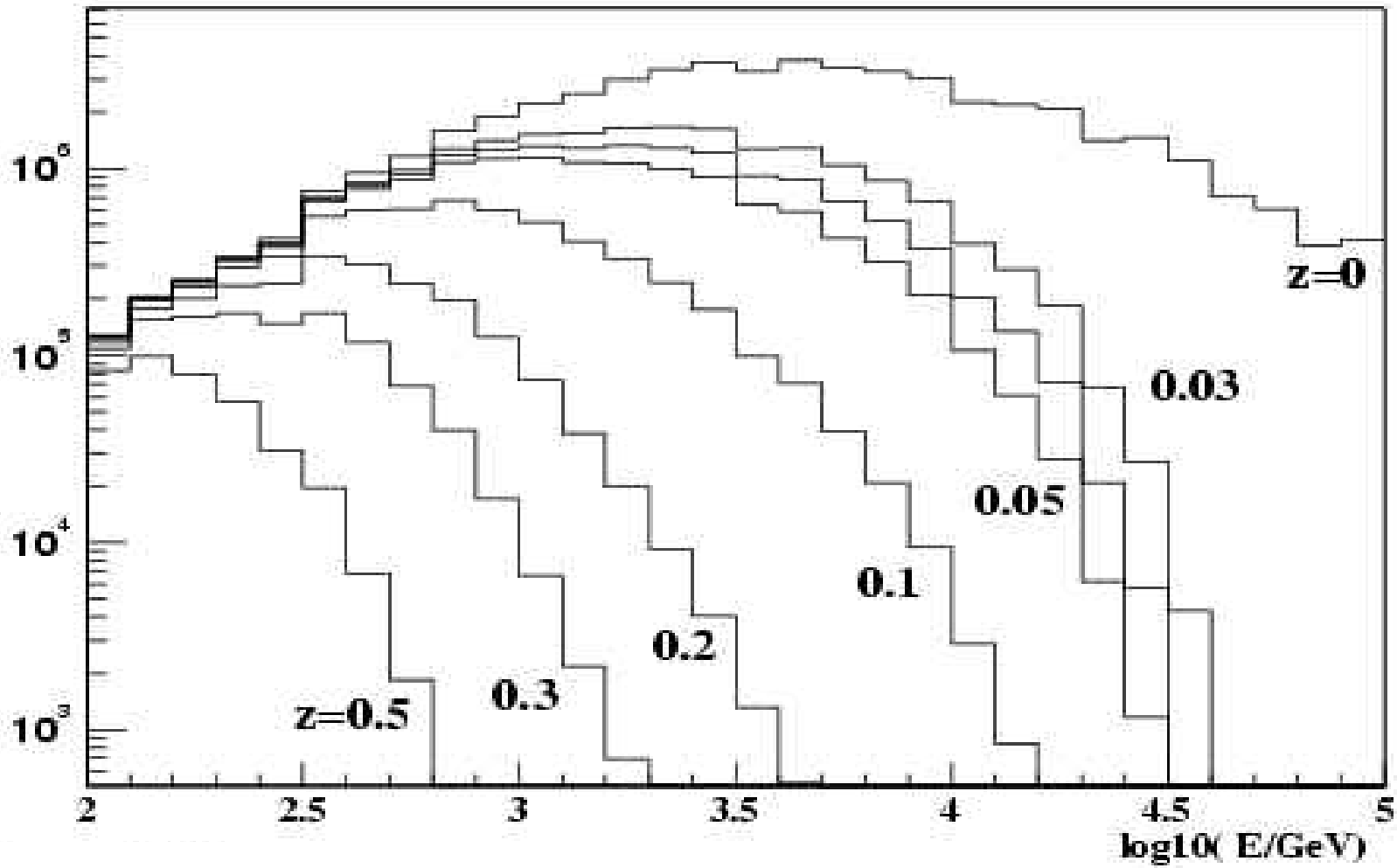
D.C. Upper Limits: Local Sources



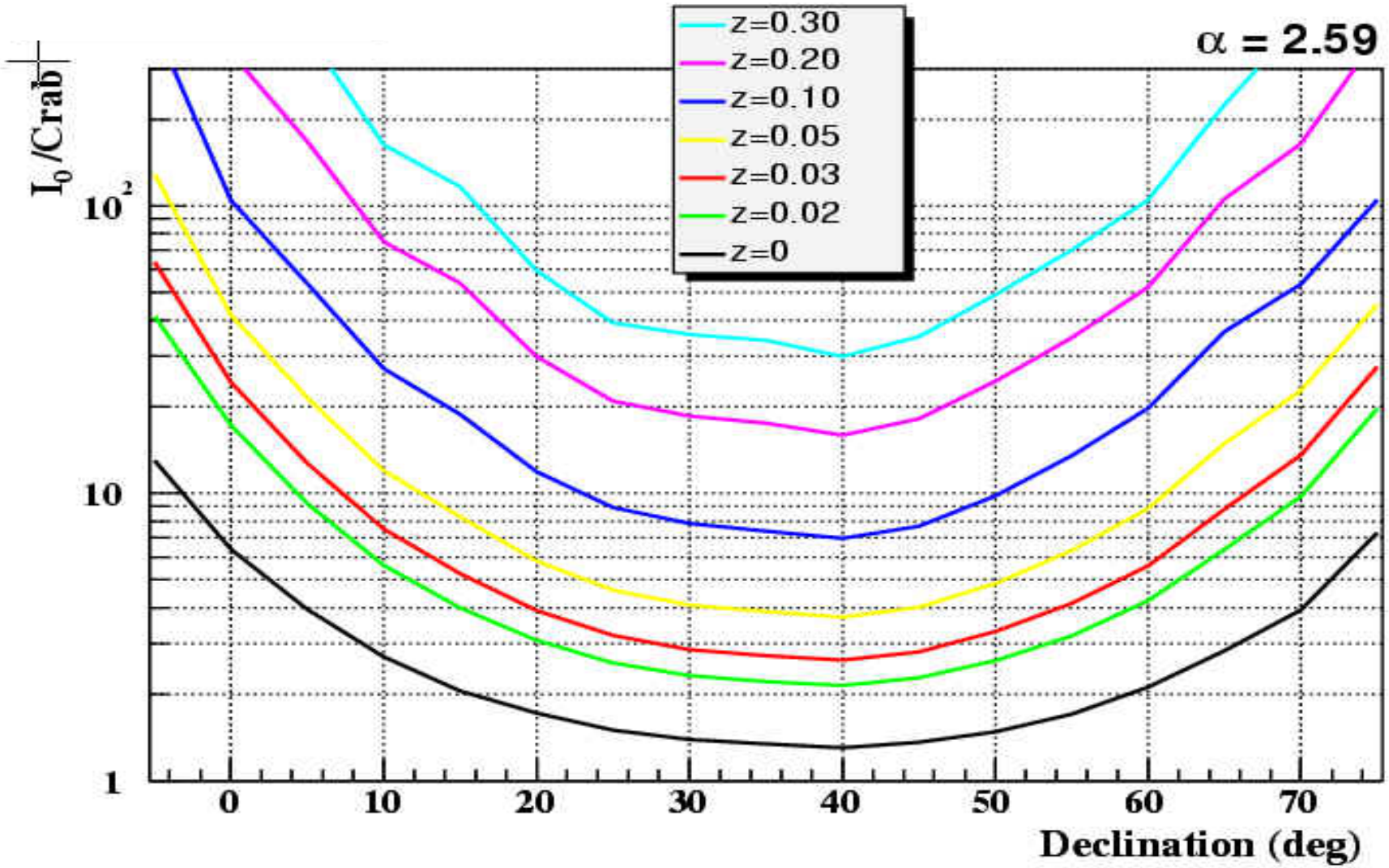
Upper Limits for Distant Sources: Effect of IR Absorption



IR Absorption: Effect on Milagro Response



D.C. Upper Limits: Distant Sources



Conclusions

- Crab Nebula and Mrk421 were brightest TeV gamma ray sources in northern hemisphere over past 2.4 years
- Previously reported hotspot still appears to be next brightest region of sky (RA 26.2 Dec 80.3 - 4.8 σ)
  - But excess is consistent with background fluctuations
  - Whipple upper limit (OG2.3 Vol. 5 p2579) <0.09 Crab
- D.C. Upper limits
  - <1.5 Crab for z=0, <3 Crab z=0.03, <8 Crab z=0.1, <30 Crab z=0.30
- No evidence for strong flaring from any northern hemisphere source on timescales > 1 week
  - Upper limits scale like ~1./SQRT(T) (~12% higher due to search inefficiencies)
- Outrigger detectors recently incorporated into the detector
  - Expect ~2x improvement in sensitivity