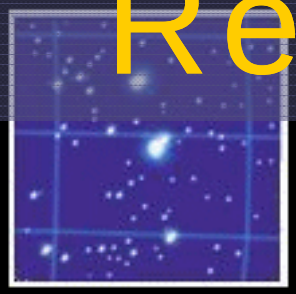
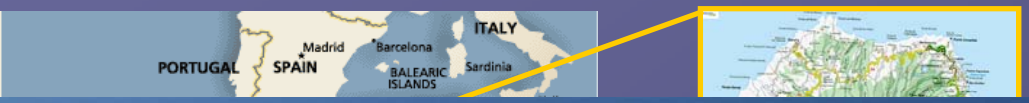
Results from MAGIC



M.Teshima
MPI für Physik, München
(Werner-Heisenberg-Institut)

MAGIC Telescope



New technologies to lower the threshold energy

17m diameter world largest cherenkov tel.
0.1° High resolution camera
Hemispherical PMT with enhanced QE
Analogue signal fiber transmission
2GS/sec Ultra Fast FADCs

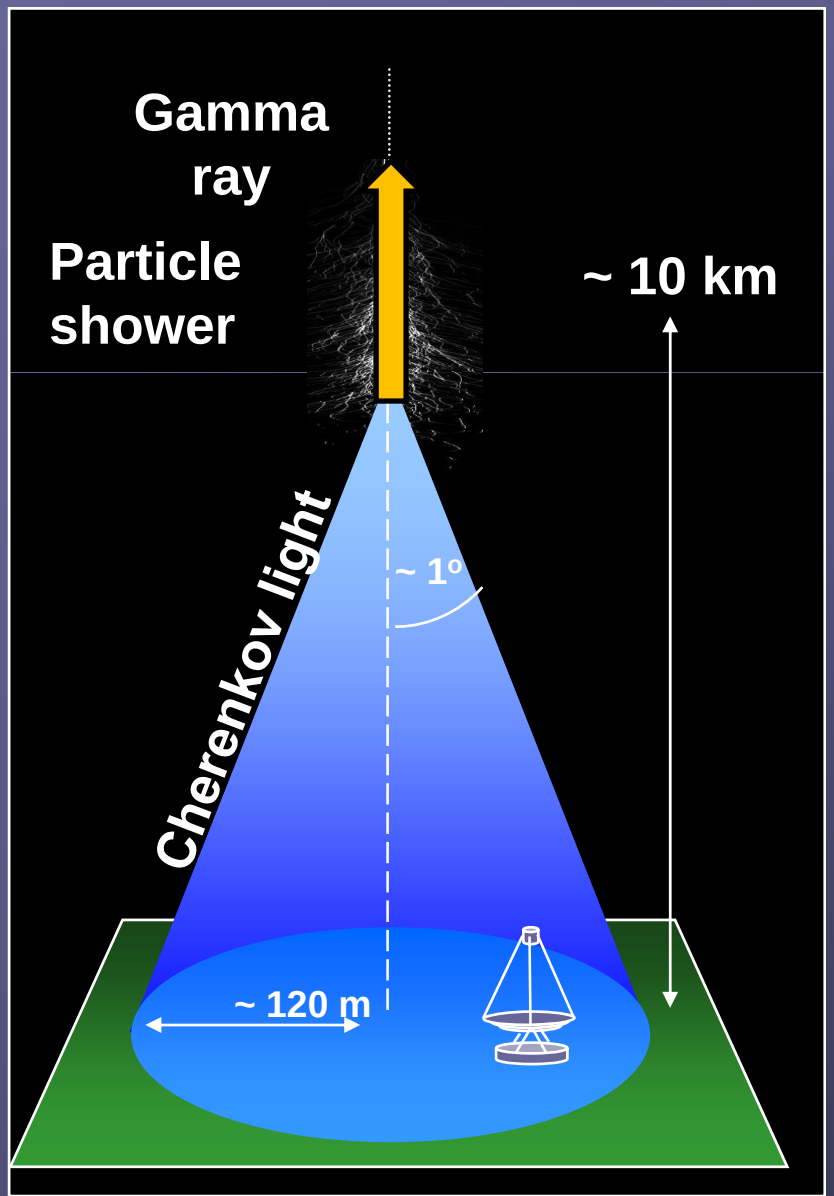
Current MAGIC-I Performance

Fast rotation for GRB < 40secs
Trigger threshold ~50GeV ➔ 25GeV
Sensitivity ~1.6% of Crab (50hrs)
Angular resolution ~0.1 degrees
Energy Resolution 20-30%

MAGIC-II is under construction and will be completed in summer (September 18, 19)

Improve sensitivity by a factor of three
Effectively lower the threshold energy
(upgrade with HPD 55%QE photodetectors)

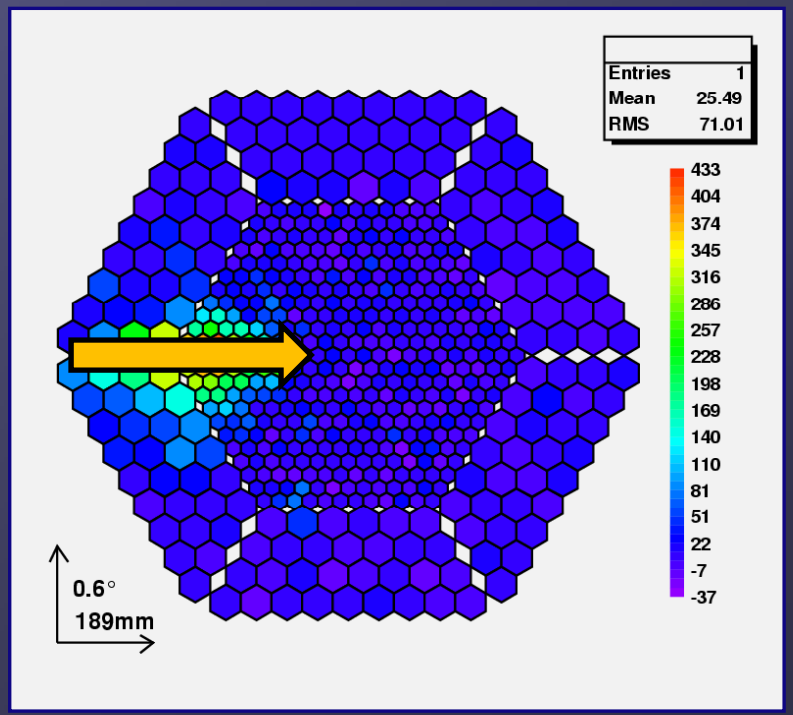
Atmospheric Imaging Cherenkov Telescope



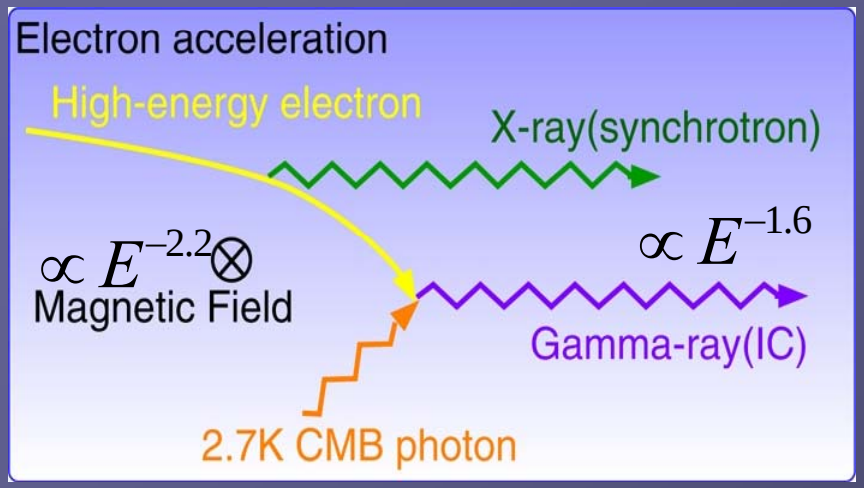
Observe Cherenkov light from gamma ray showers

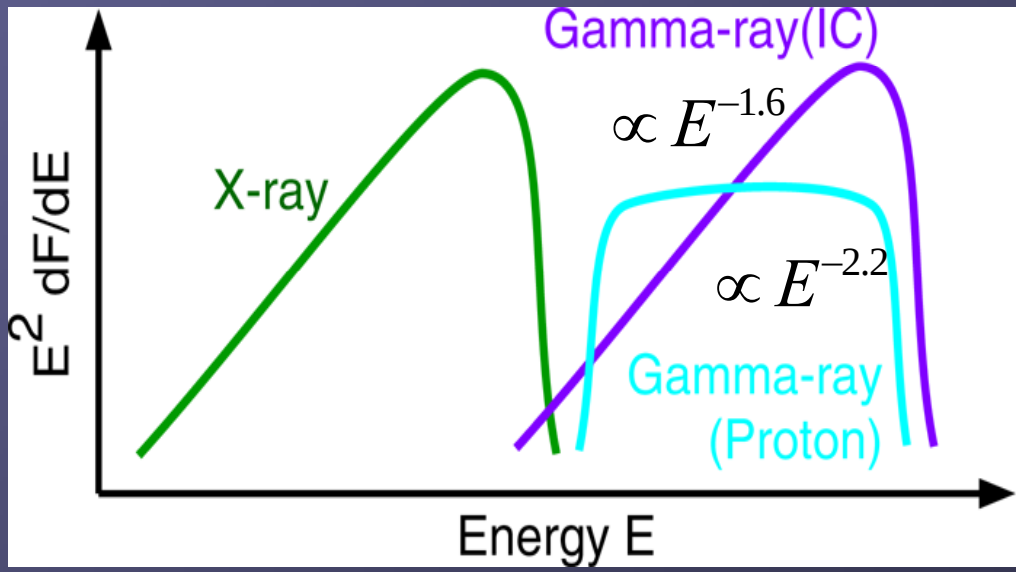
Effective area ~ $10^5 m^2$

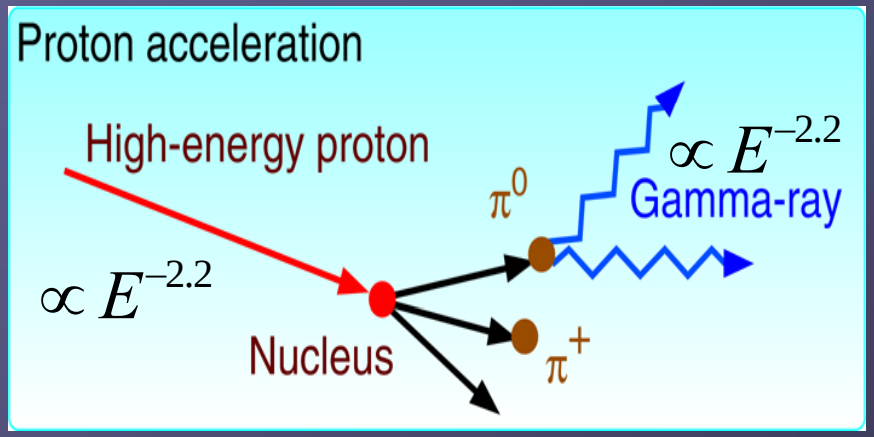
~50photons/m^2 at 1TeV



Gamma-Ray Emission Processes(1) Astrophysical process



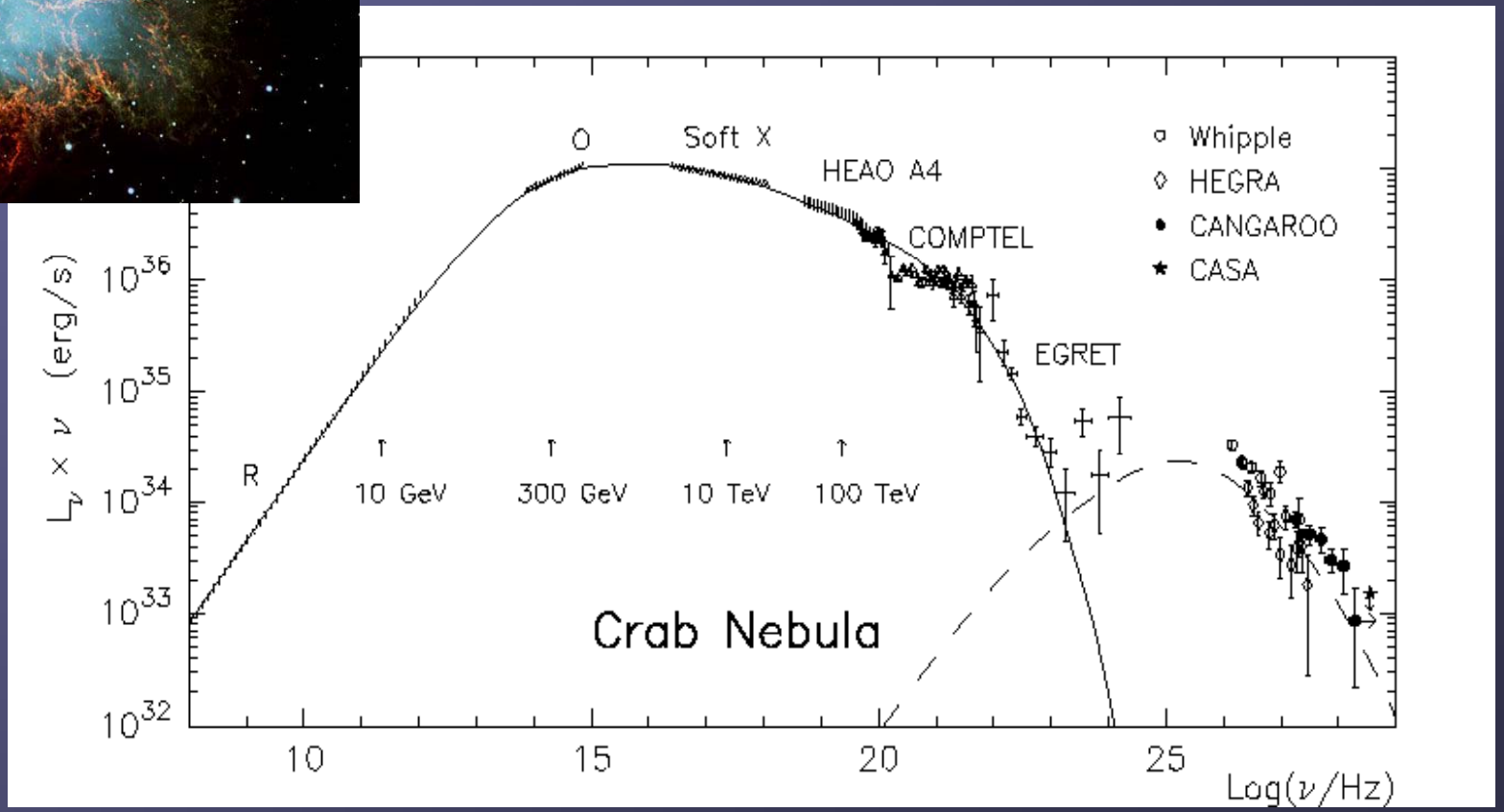




$$\left(\frac{dE}{dt}\right)_{\mathrm{I.C.}} = \frac{4}{3}\sigma_{\mathrm{T}} c \gamma_{\mathrm{max}}^{2} \mathrm{U}_{\mathrm{photon}}$$

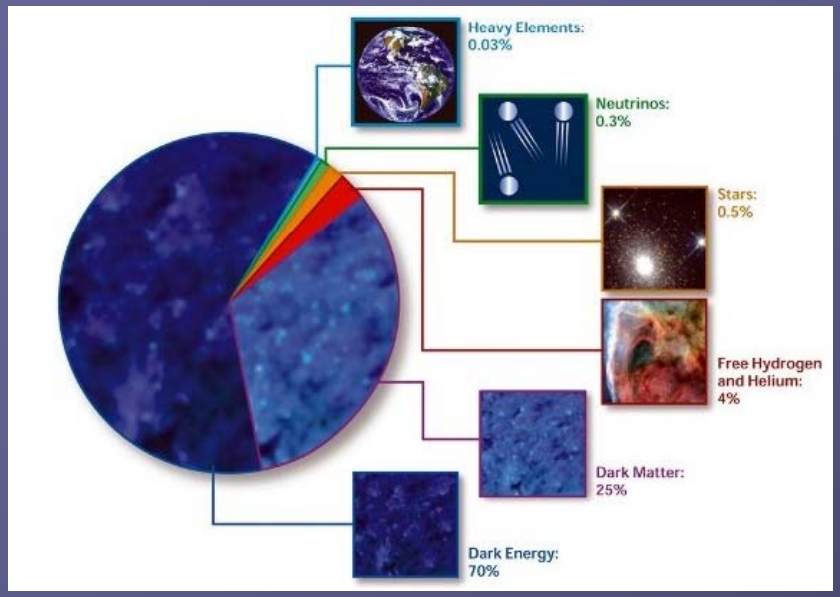
$$\left(\frac{dE}{dt}\right)_{\mathrm{Sync}} = \frac{4}{3}\sigma_{\mathrm{T}} c \gamma_{\mathrm{max}}^{2} \frac{B^2}{2}$$

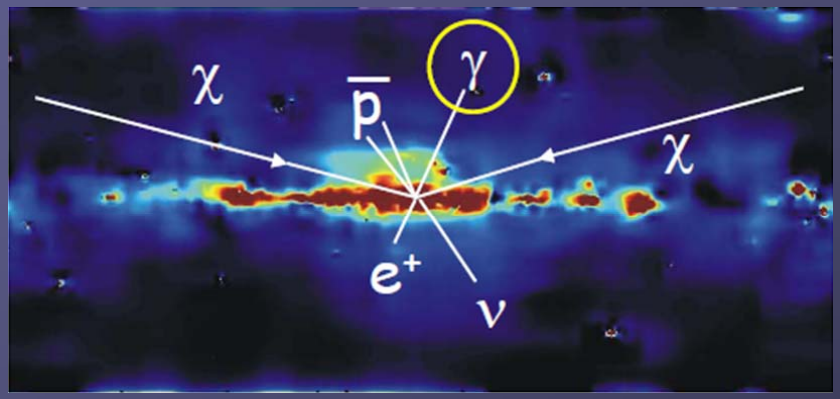
Crab Nebula
Synchrotron and IC

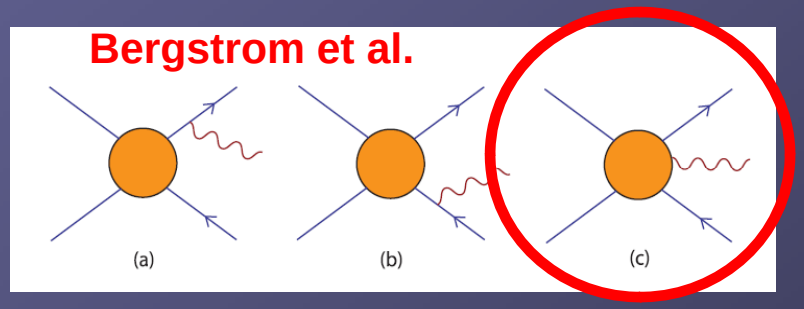


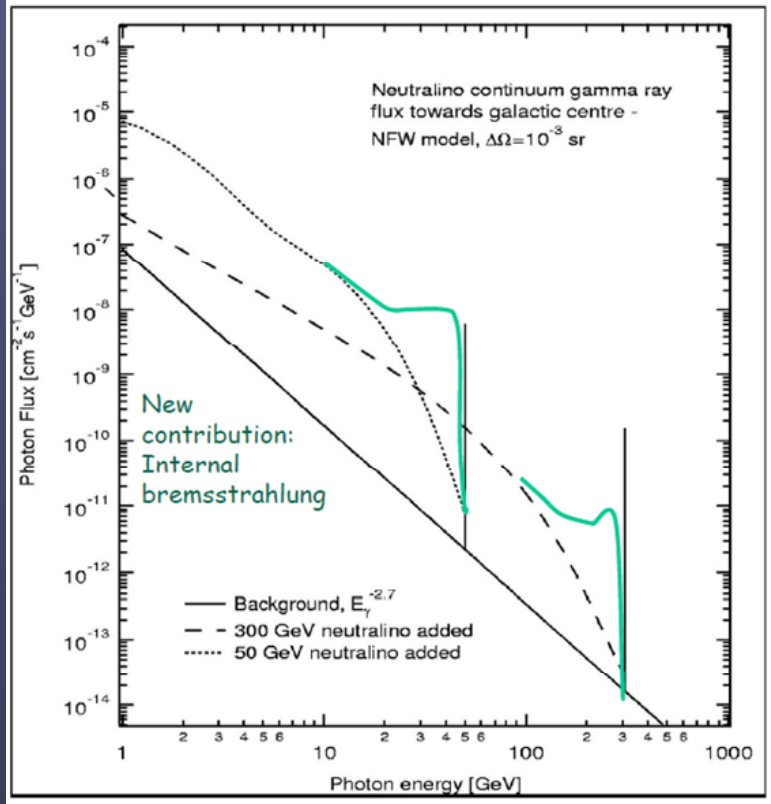
Gamma ray emission processes (2)
Exotic processes (DM, Mini-BHs)

Dark Matter Annihilations



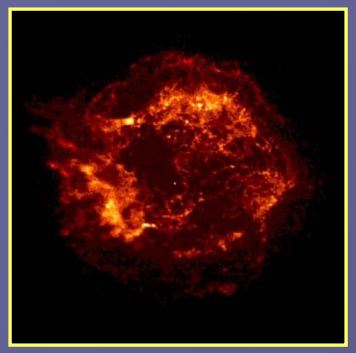






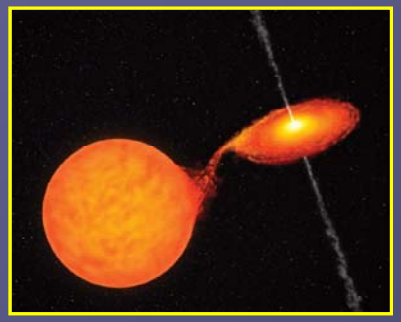
L.B., P.Ullio & J. Buckley 1998 T. Bringmann, L.B., J. Edsjö, 2007

Scientific Objectives

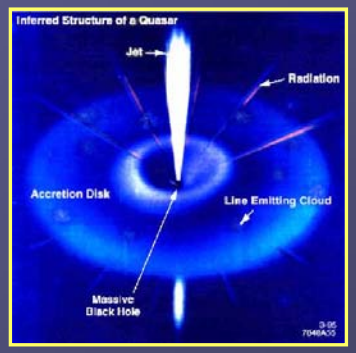


SNRs

Pulsars and PWNe



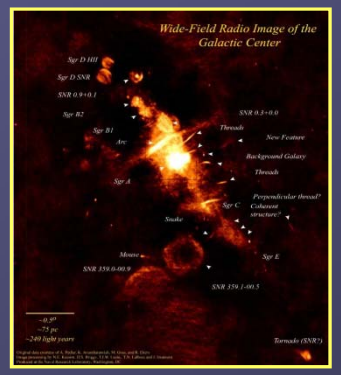
Micro quasars X-ray binaries



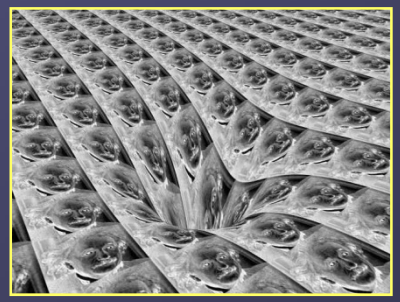
AGNs

GRBs

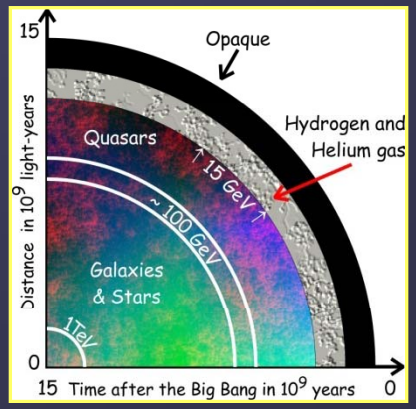
Origin of cosmic rays



Dark matter

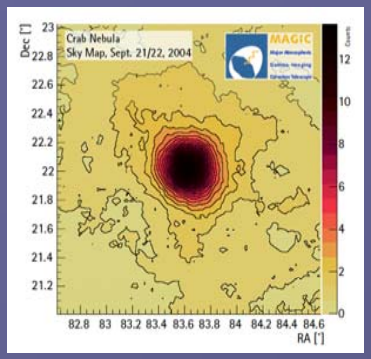


Space-time & relativity

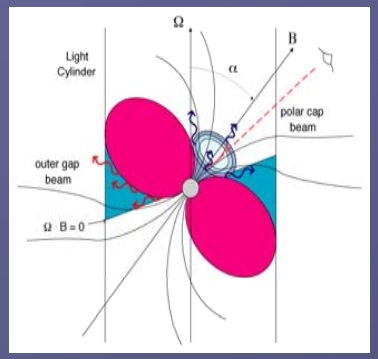


Cosmology

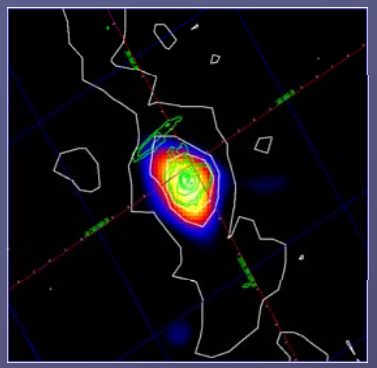
Galactic sources



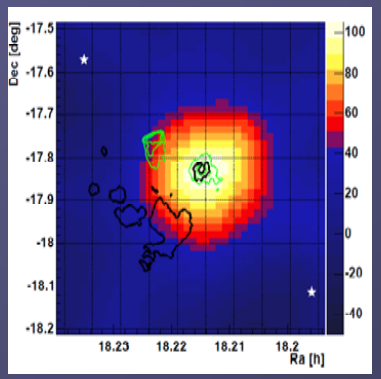
Crab Nebula



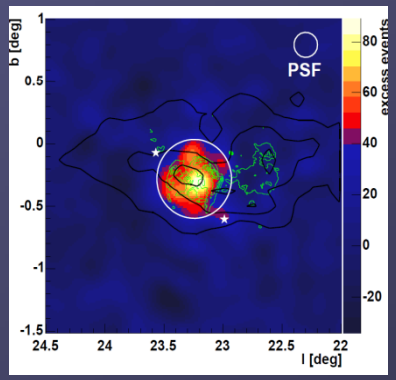
Crab Pulsar Discovery



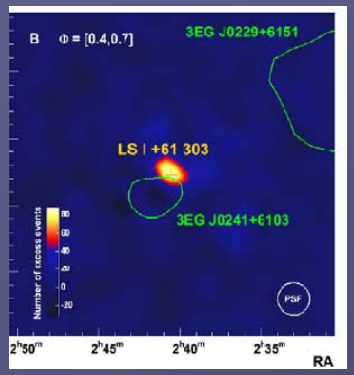
Galactic Center



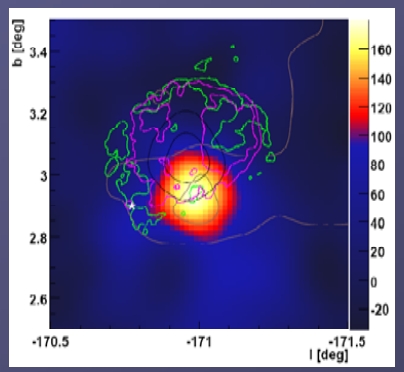
HESS J1813 PWN?



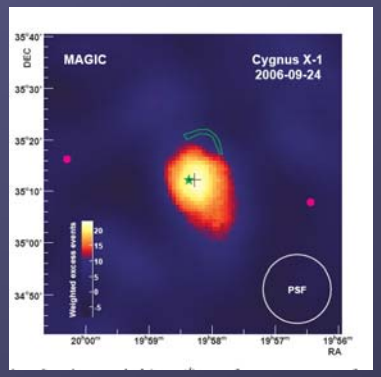
HESS J1834 ^{13}CO cloud



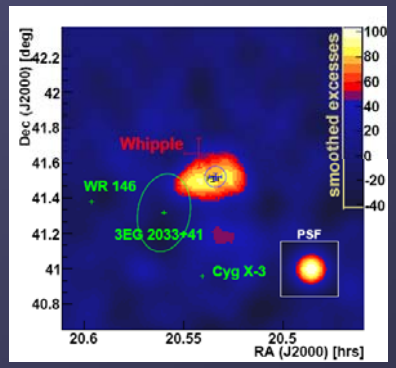
LSI+61 303 Discovery



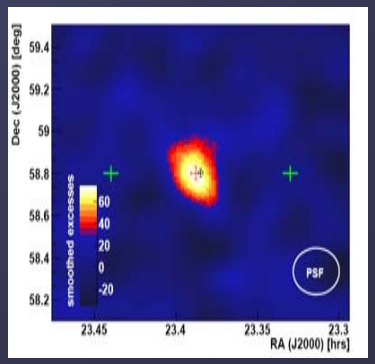
IC443 discovery



Cyg X-1 discovery



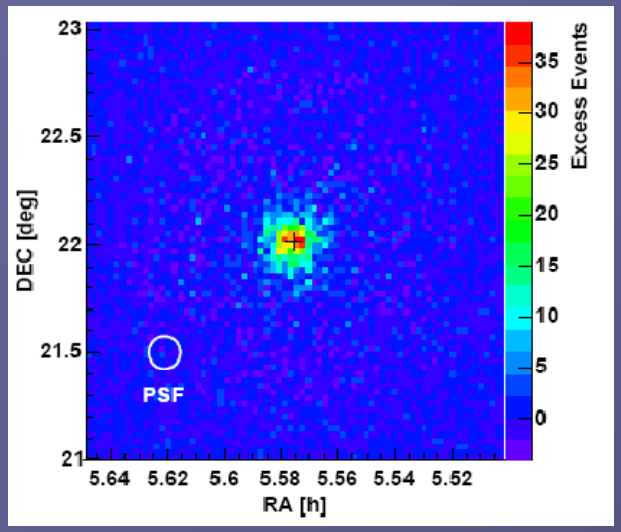
HEGRA Un-ID TeV2032

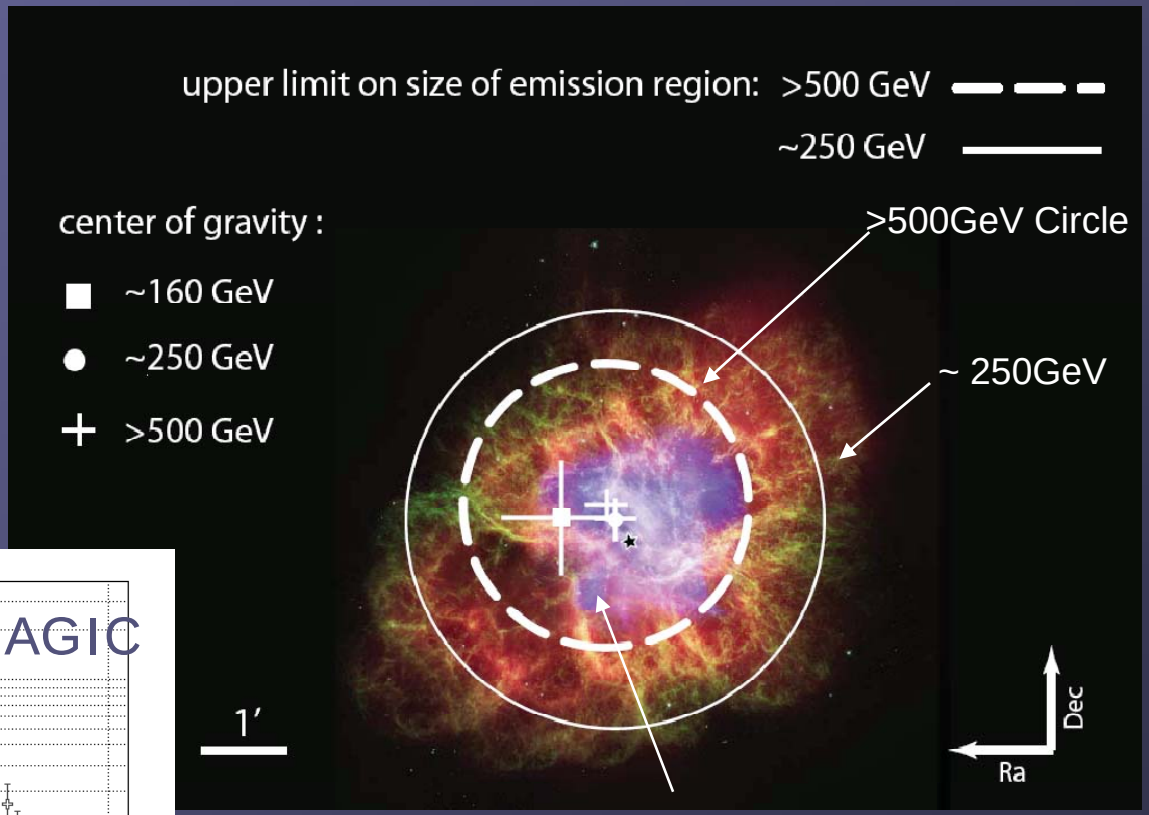


Cas-A

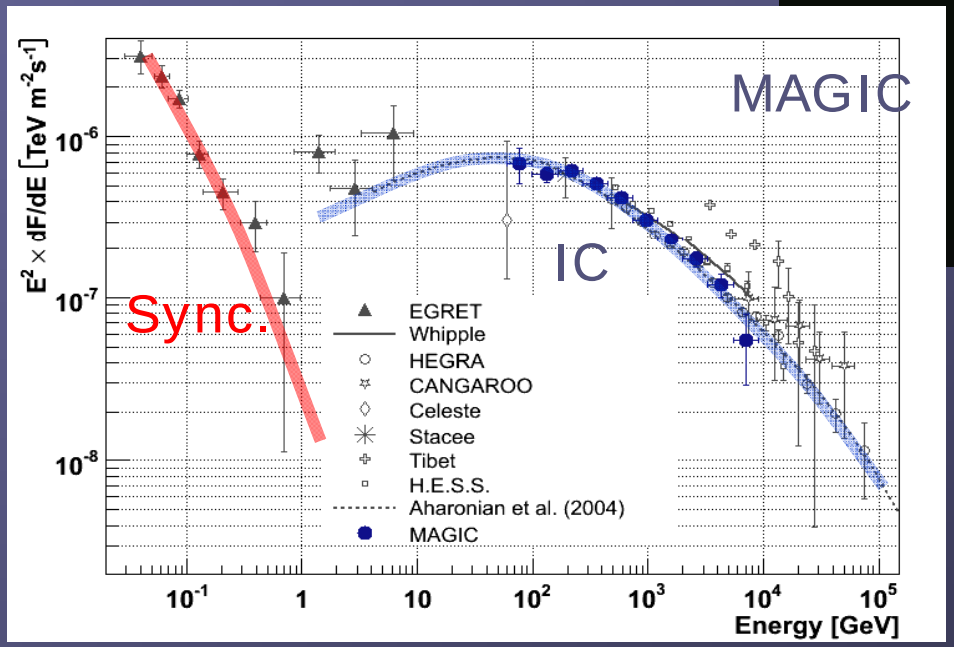
MAGIC Crab Nebula (PWN)

Gamma Ray Signals from Crab ~ 0.4Hz





Position of Pulsar

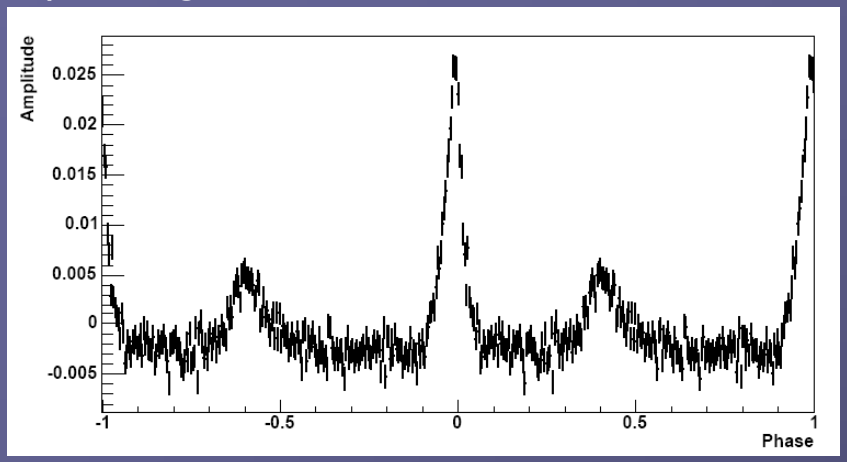


IC peak is estimated to be

IC_peak = 77 ± 35 GeV

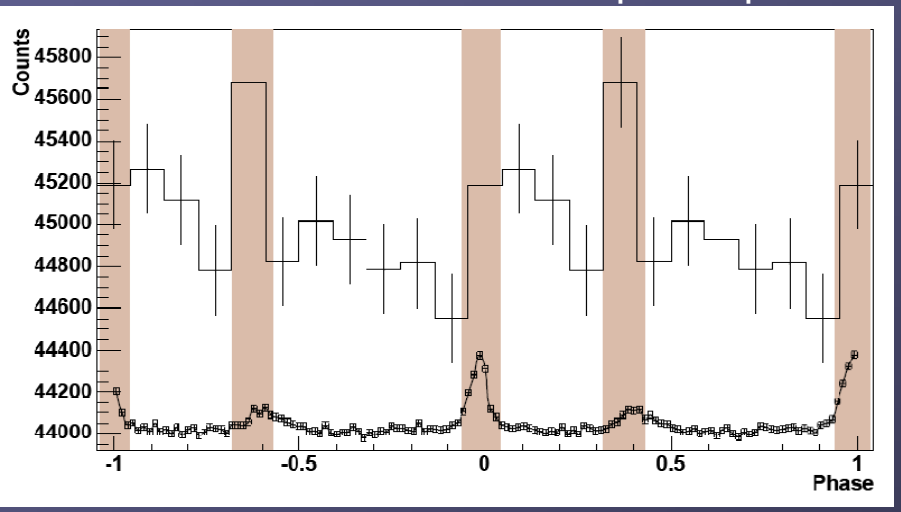
Observation of Crab Pulsar

Optical light curve of Crab Pulsar observed by MAGIC

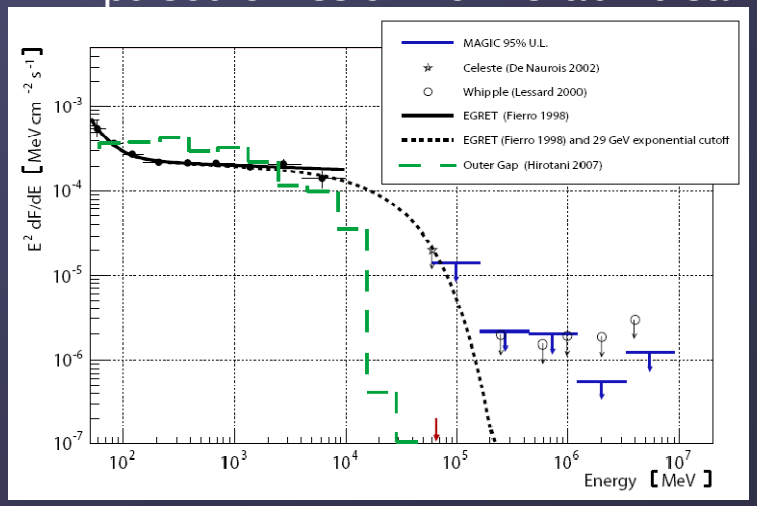


Central pixel readout optical light intensity (not Cherenkov light)

Distribution of shower events in pulsar phase at ~65GeV

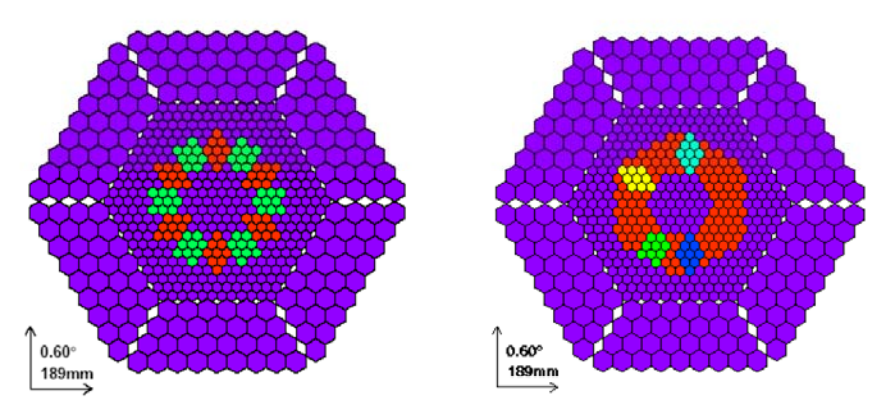


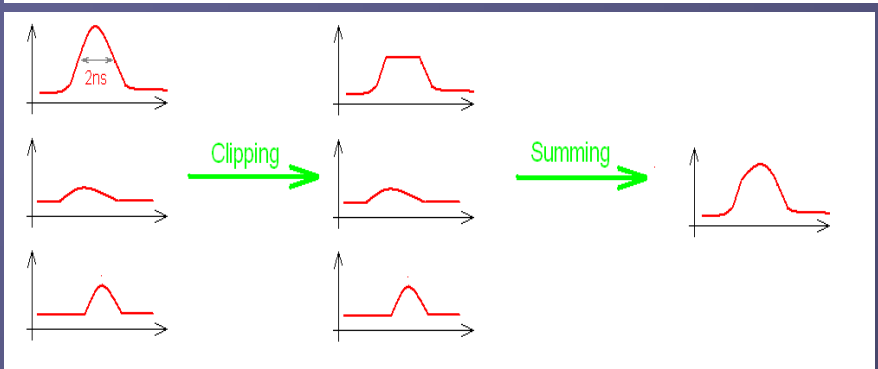
95% Upper Limit for H.E. Gamma ray pulsed emission from Crab Pulsar

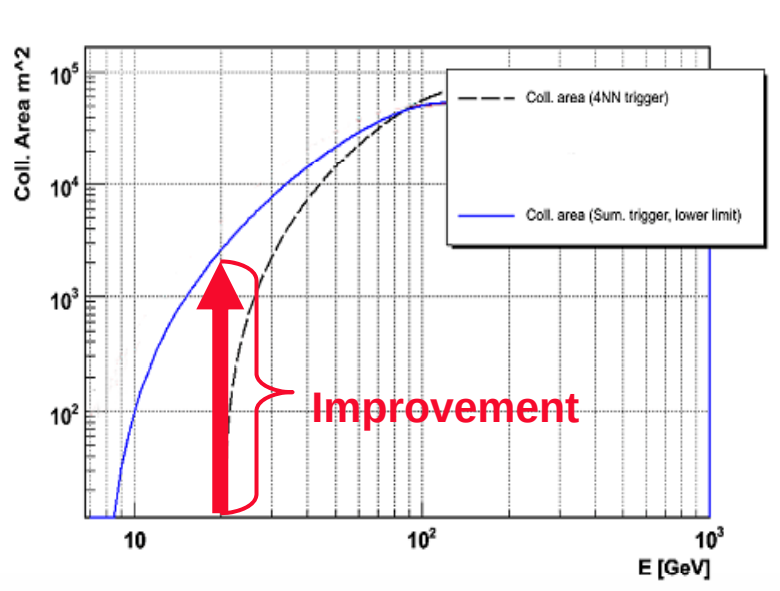


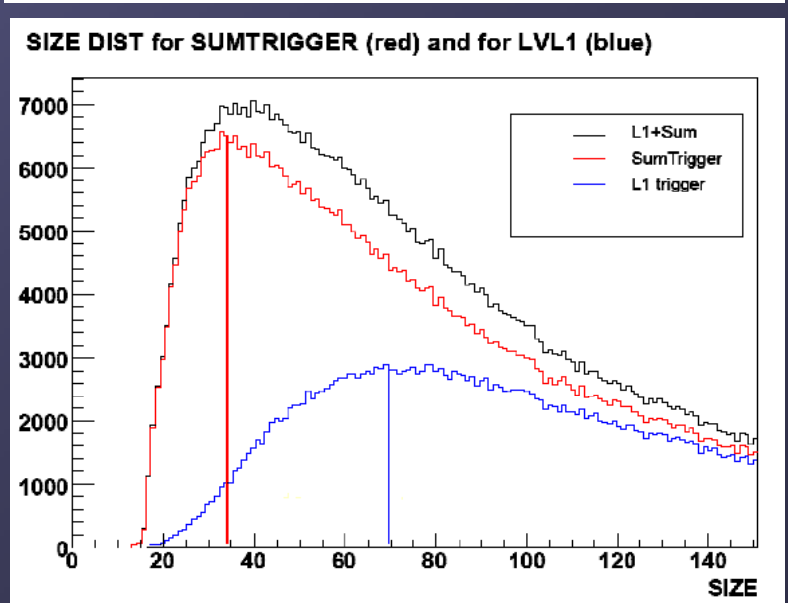
Sum Trigger (~25GeV)

analogue sum pattern trigger after clipping signal









Sum Trigger (25GeV Eth)

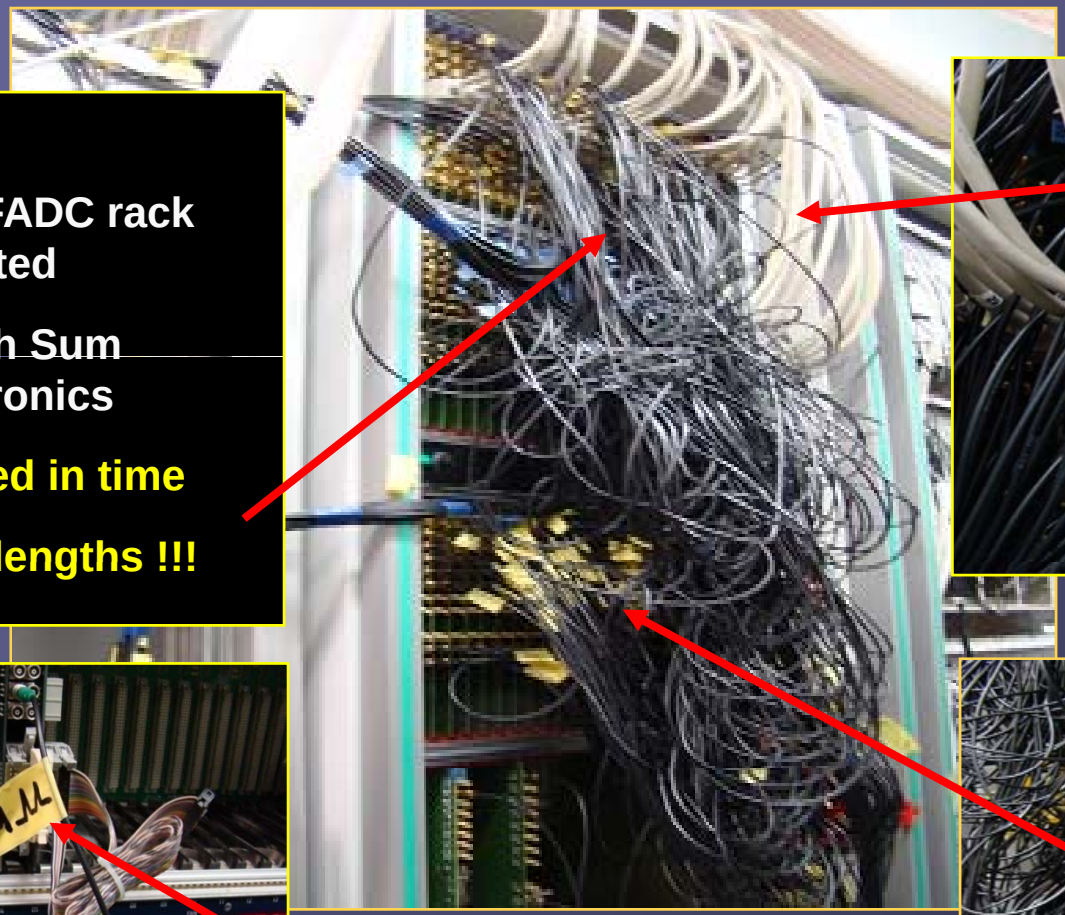
T. Schweizer, N. Otte, M. Shayduk, M. Rissi, et al.

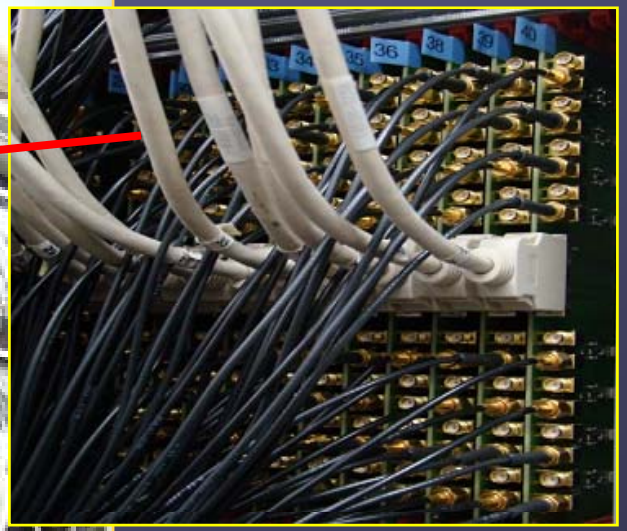
One Siegen FADC rack was unmounted

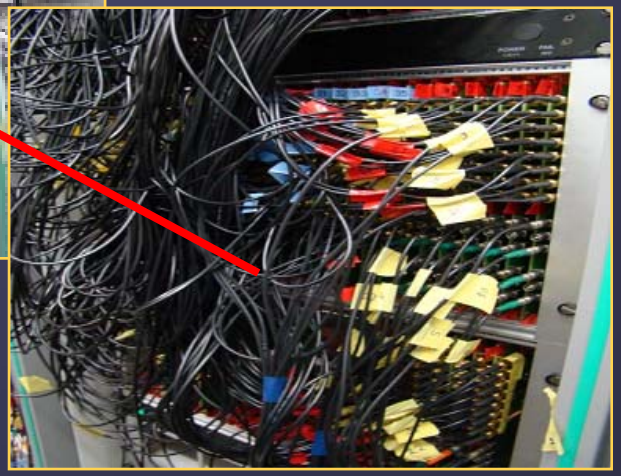
and filled with Sum Trigger electronics

Flatfielded in time

by cable lengths !!!



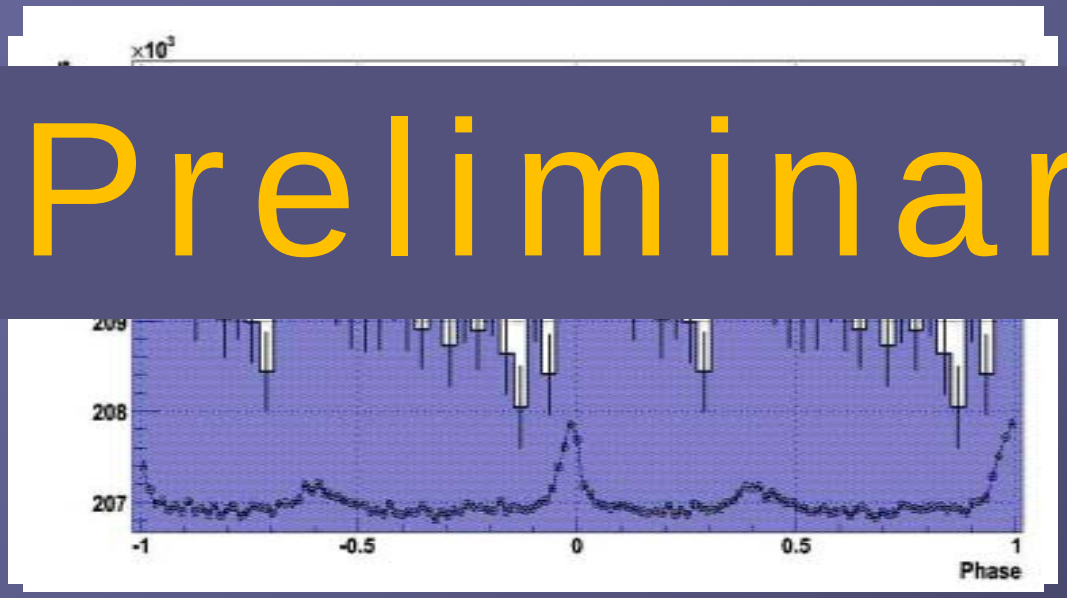


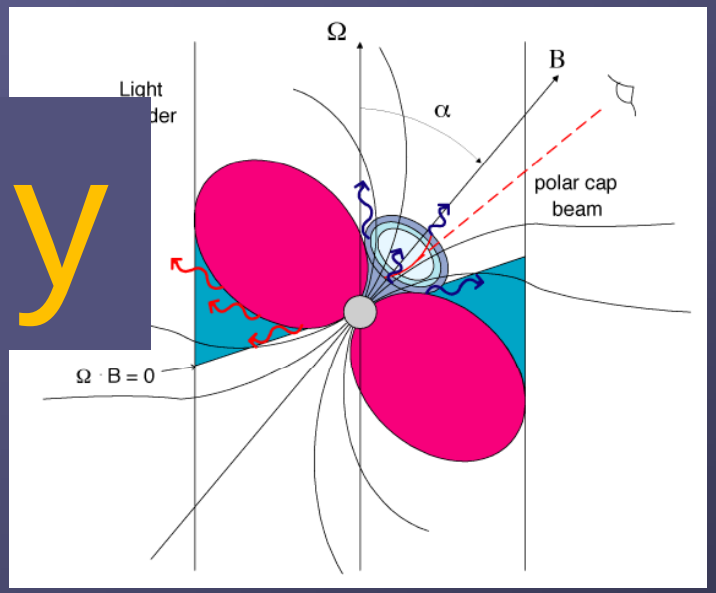


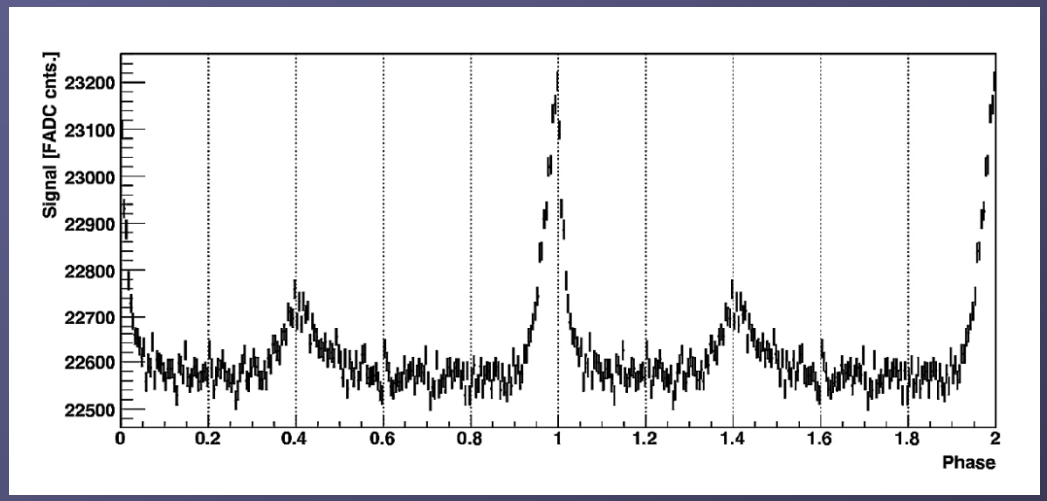
Riccardos patchboard

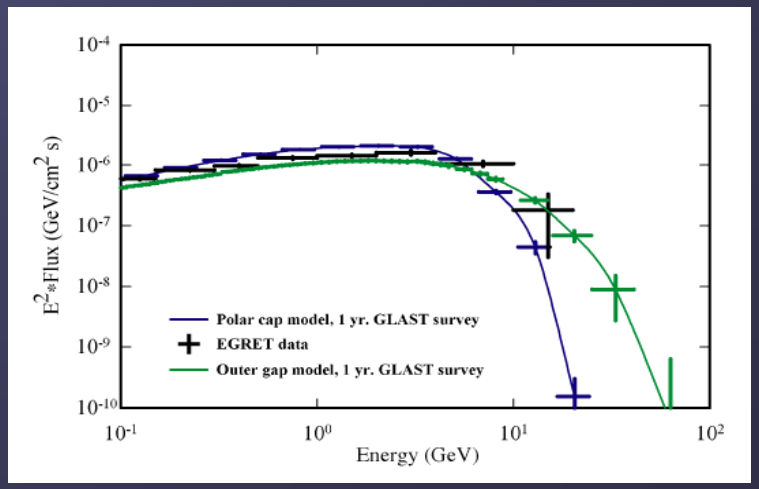
Detection of Crab Pulsar after 20 years long effort

Preliminary

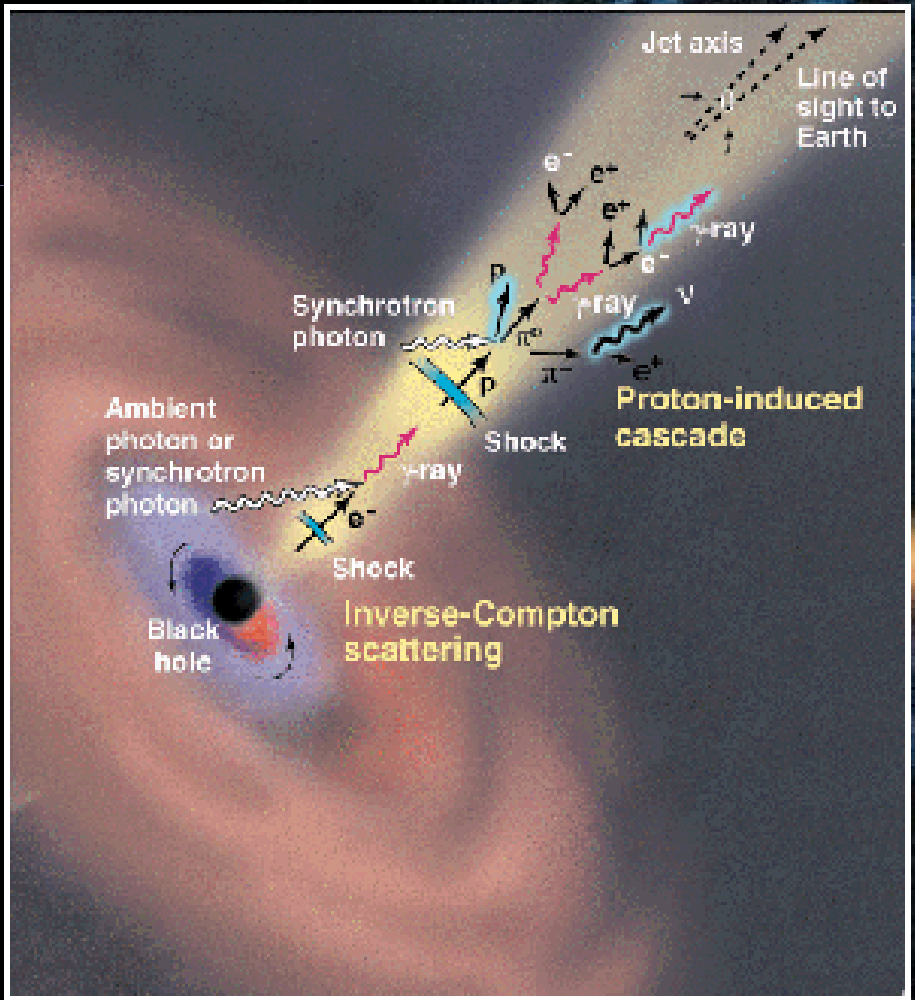




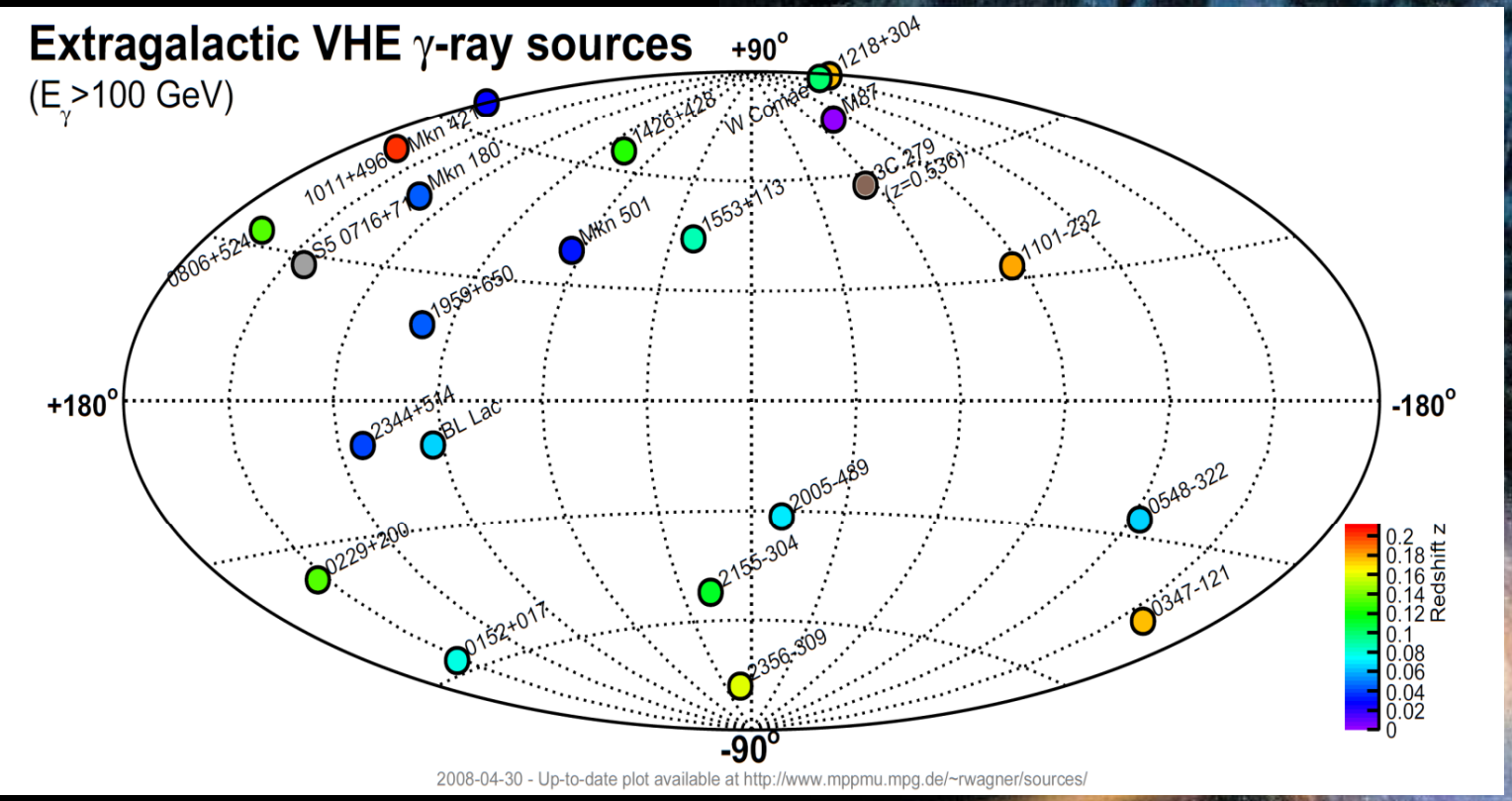


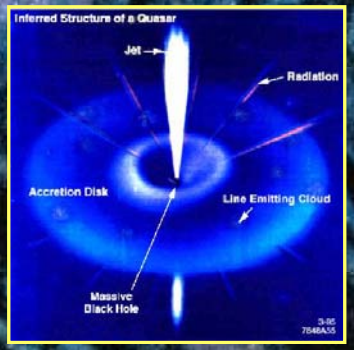


Extragalactic sources



Extragalactic sources AGNs



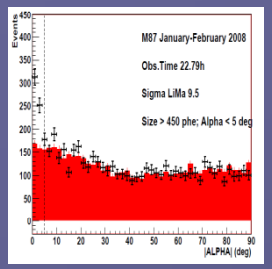


AGNs

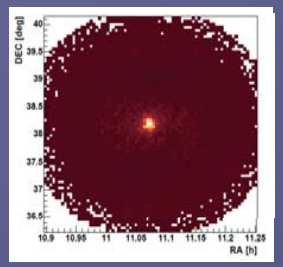
23 sources (1 x FR-I, 18 x HBL, 3 x LBL, 1 x FSRQ)

~700 sources with CTA

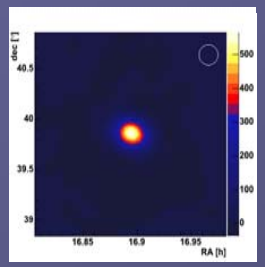
MAGIC Highlights in extra-galactic source observation (13)



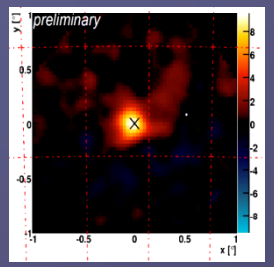
M87
(z=0.0041)



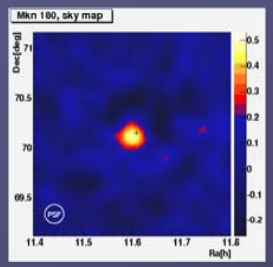
Mrk421
(z=0.031)



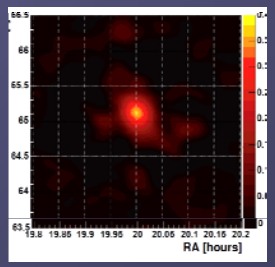
Mrk501
(z=0.034)
Very fast flare



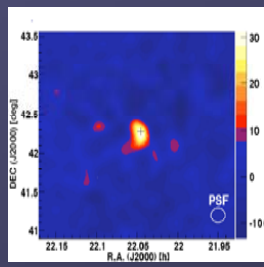
1ES2344
(z=0.044)



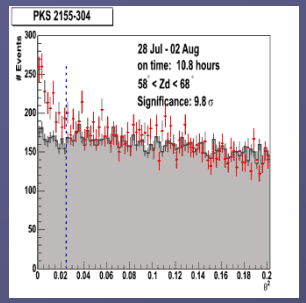
Mrk180
(z=0.045)
Discovery



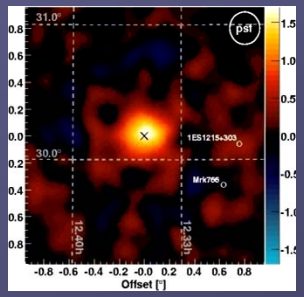
1ES1959
(z=0.047)



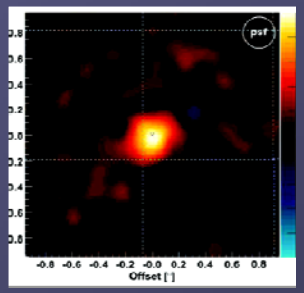
BL-Lac
(z=0.069)
Discovery



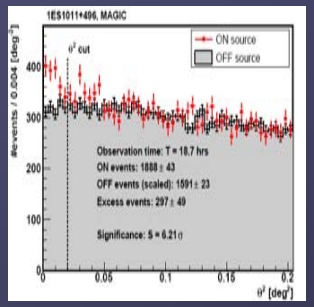
PKS2155
(z=0.116)



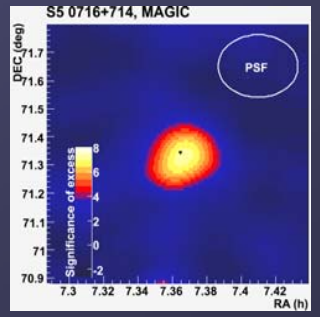
1ES1218
(z= 0.18)
Discovery



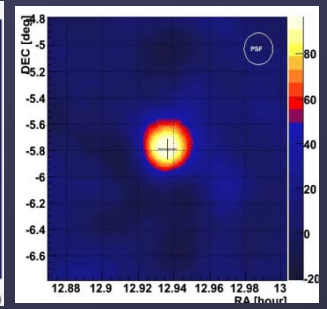
PG 1553
(Z>0.25)
Discovery



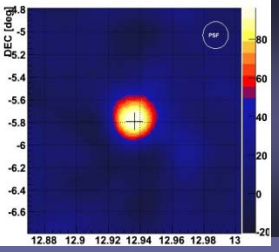
1ES1011
(Z=0.212)
Discovery



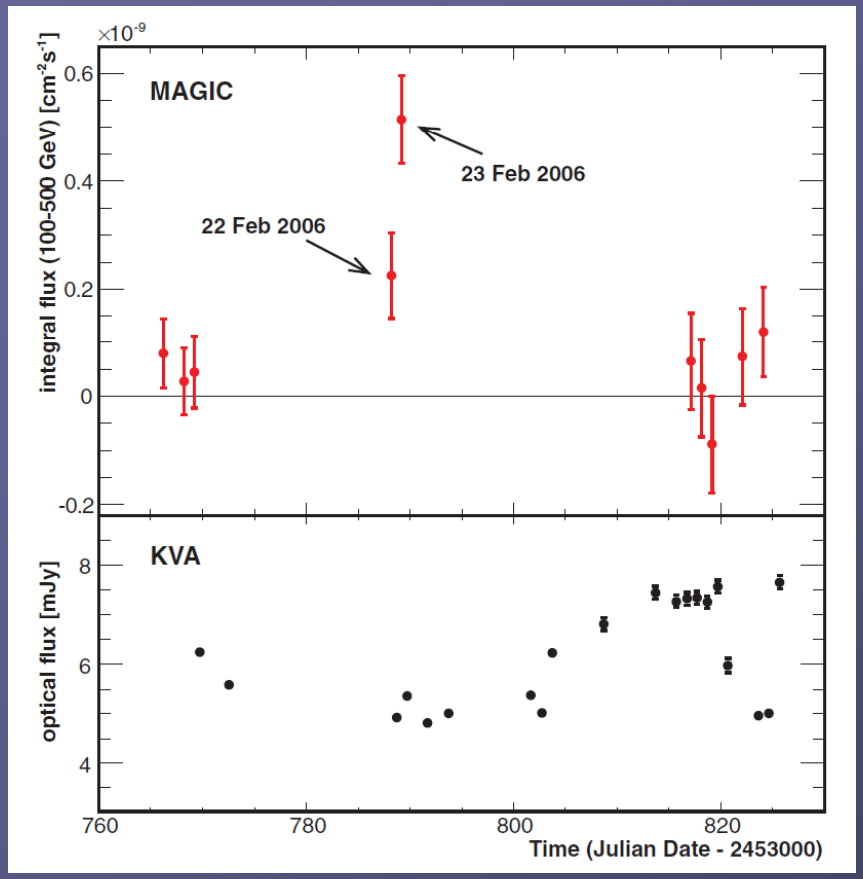
S5 0716
(z = 0.31)
Discovery

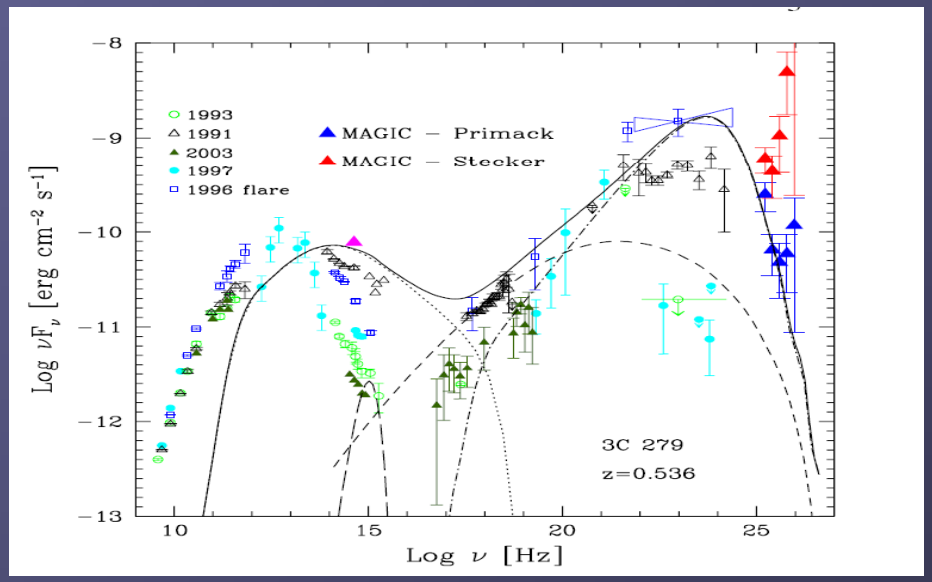


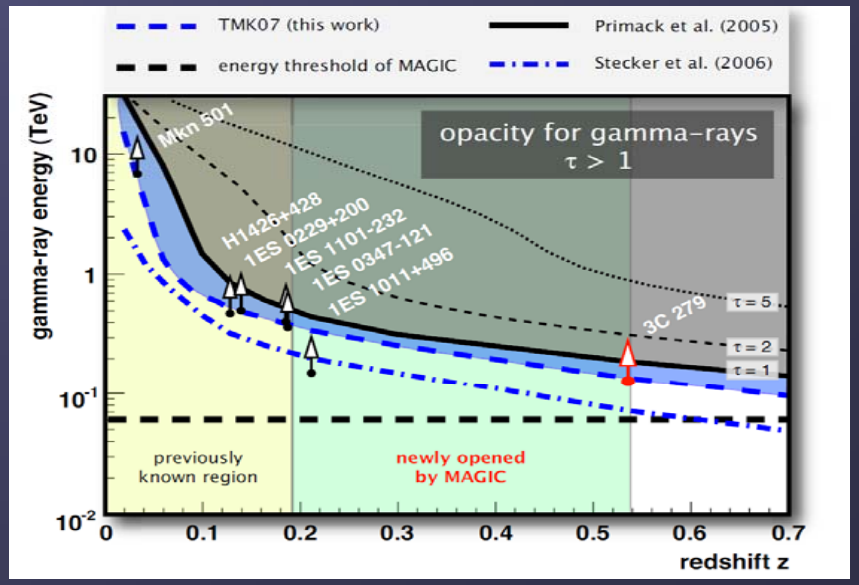
3C279
(z = 0.536)
Discovery



FSRQ 3C279 (z=0.536)
Most distant 100GeV AGN

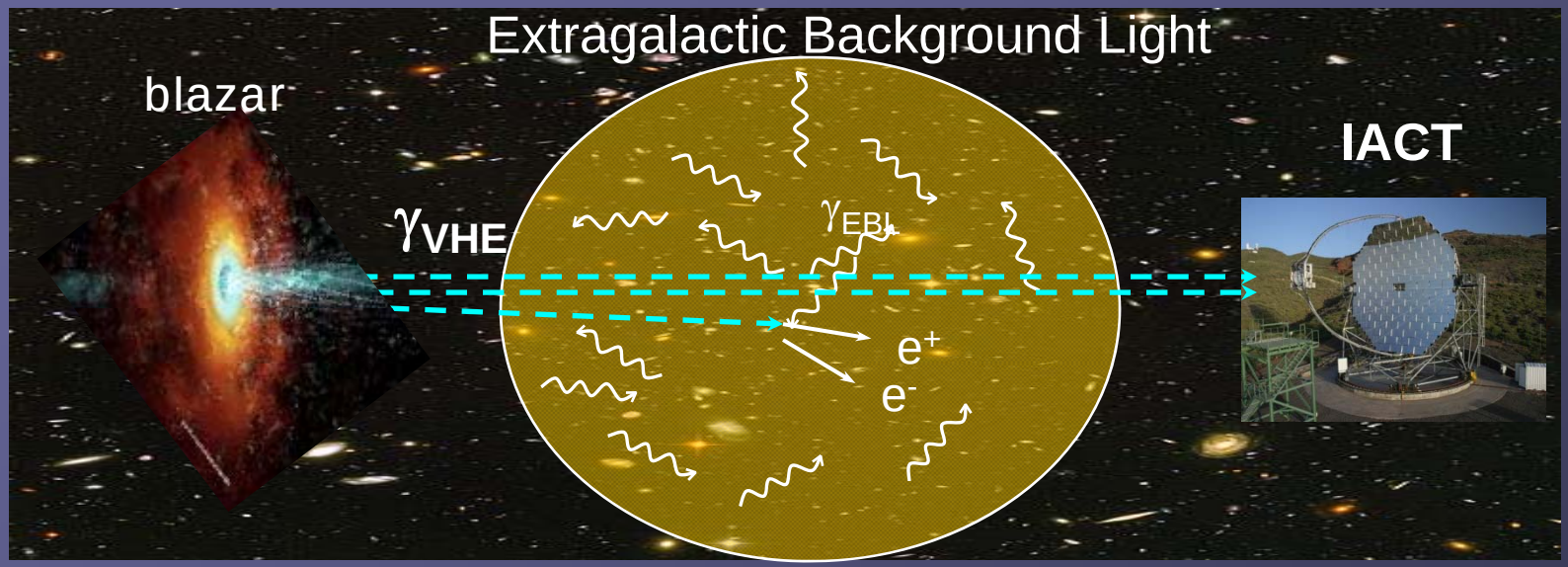


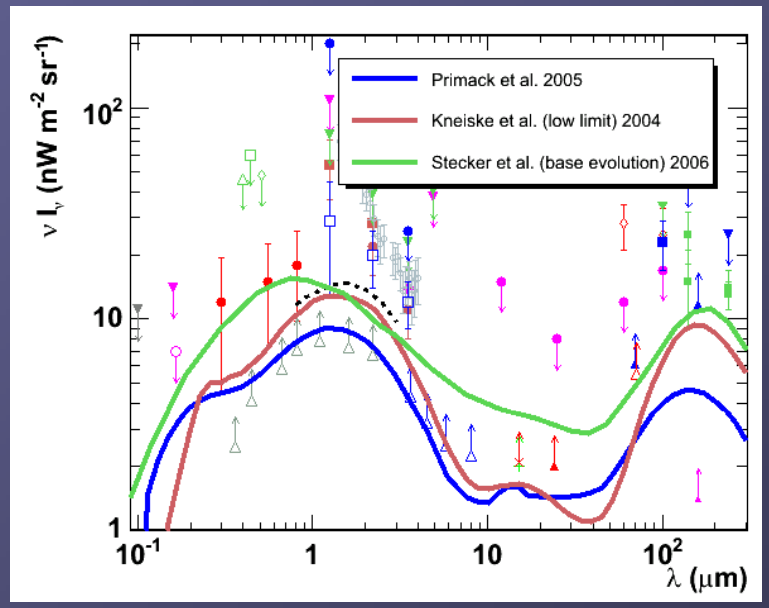


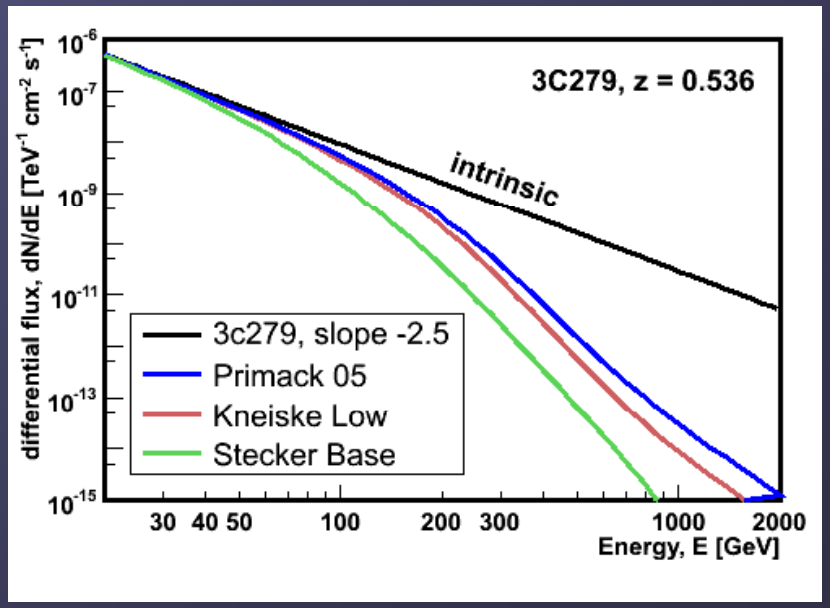


The source was active in optical but
the correlation is not clear,
but good correlation with X-ray intensity
(A.Marscher et al. 2008)

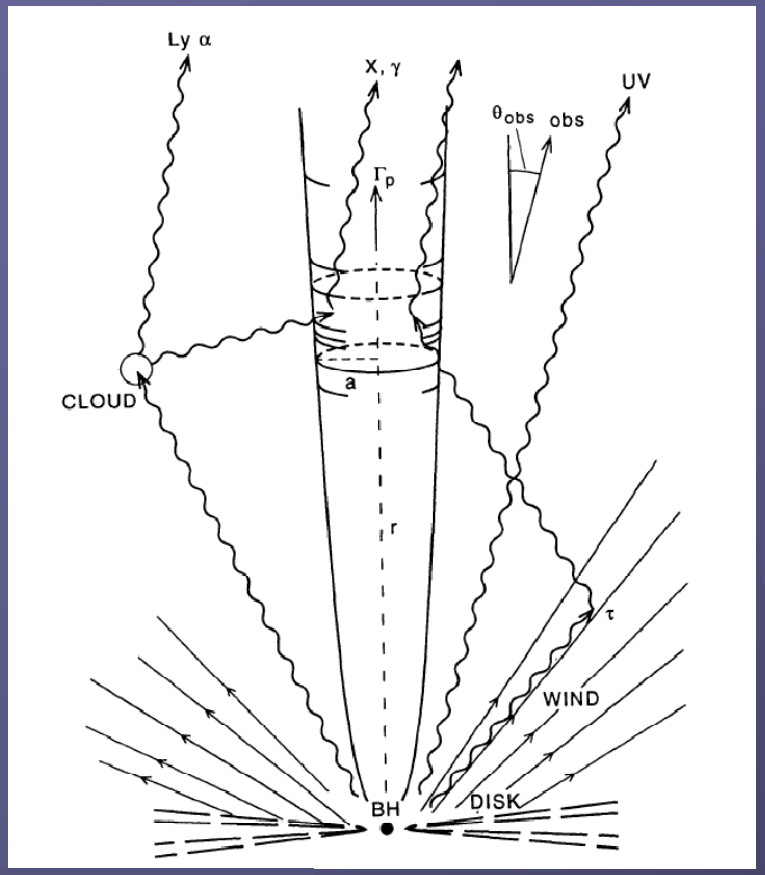
EBL Absorption





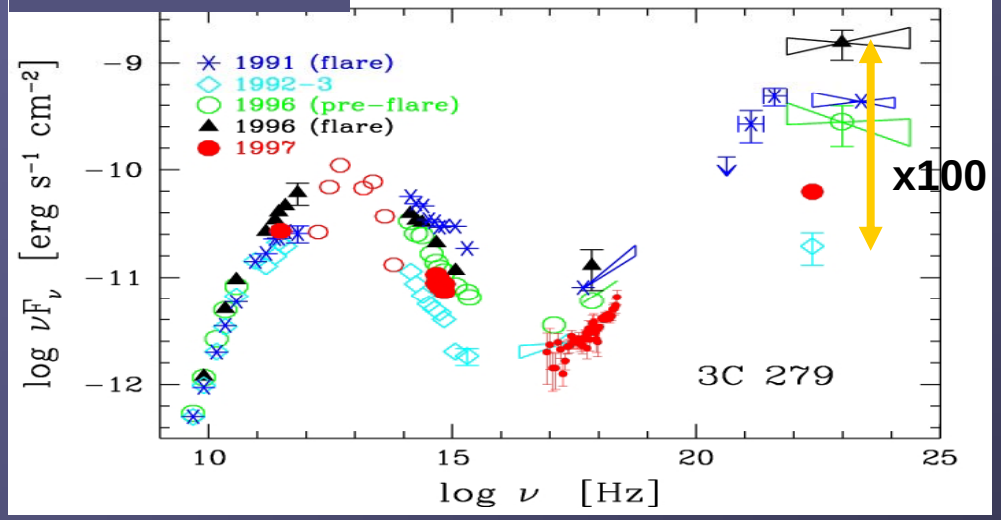


EC / Hadronic

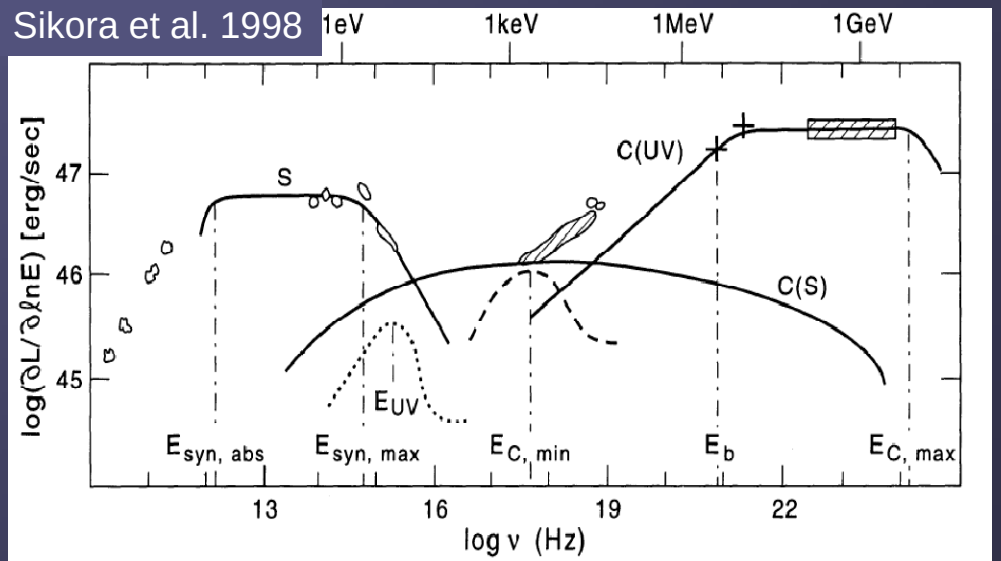


Sikora et al. 1998

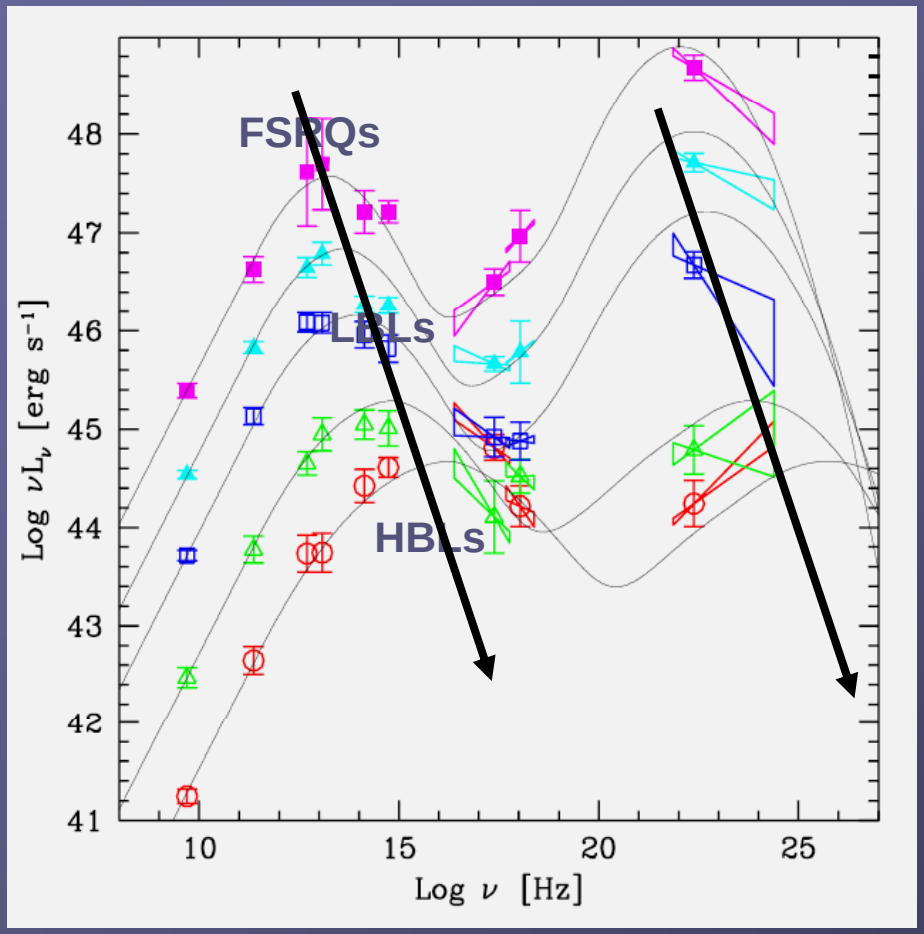
Wehrle et al. 1998



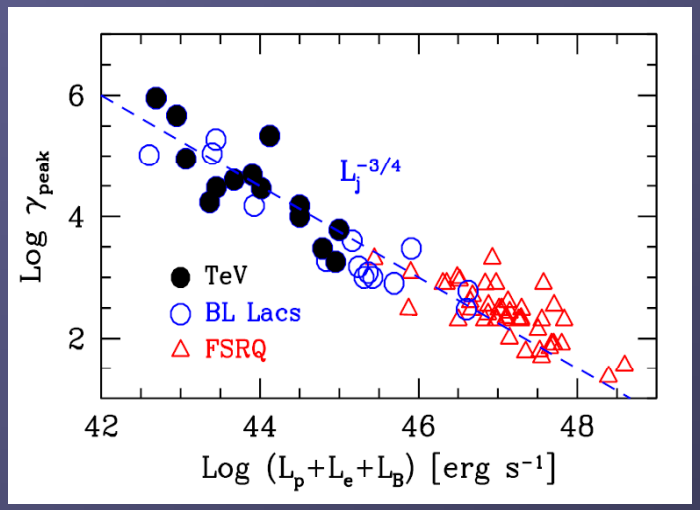
Sikora et al. 1998



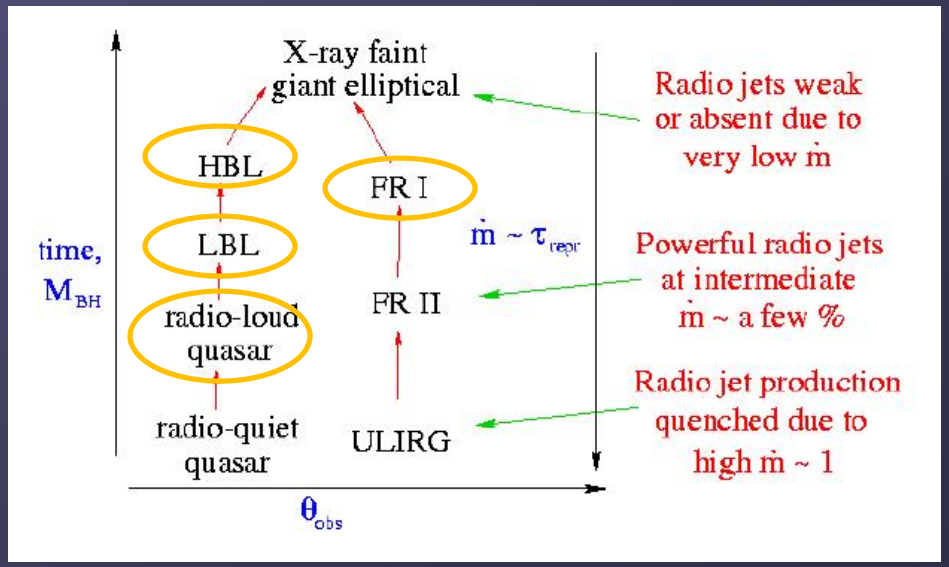
Blazar's Sequence



Fosatti et al. 1998

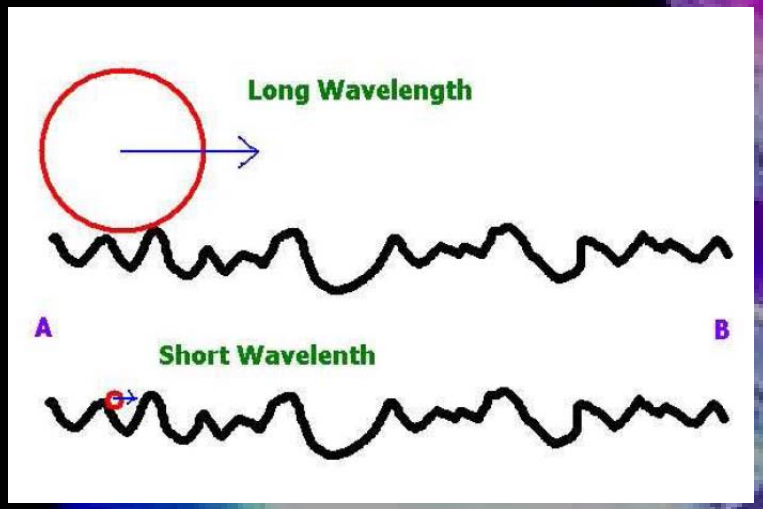


Celotti & Ghisellini 2007



Probe Quantum Gravity

with long flying HE gamma rays



$$E_{Pl} = \sqrt{\frac{\hbar c^5}{G}} \approx 1.22 \times 10^{19} GeV$$

If Gravity is a Quantum theory,
at a very short distance it may show a very complex "foamy" structure due to quantum fluctuation.

Use gamma ray beam from AGNs/GRBs
to study the space-time structure

Energy 1000GeV ~ $10^{-16} E_{Pl}$
Distance 100~1000Mpc ($10^{16\text{-}17}$sec)

Visible time delay ~ 1 - 10 sec

Linear deviation:

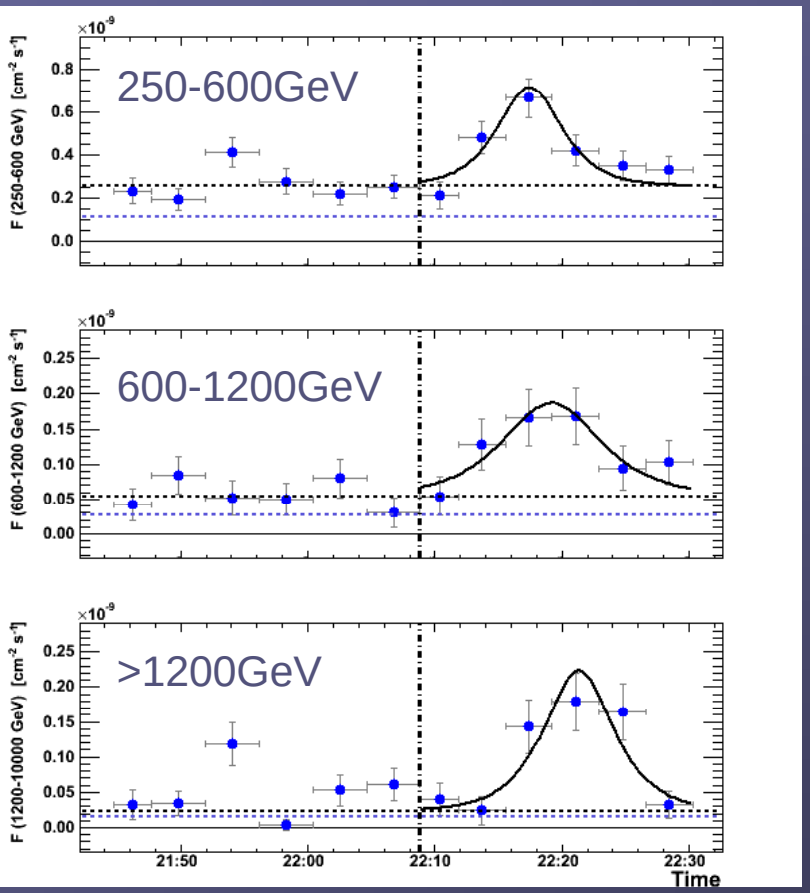
$$\xi_1 < 0; \quad v = c(1 - \frac{E}{M_{QG1}}); \quad n(E) = 1 + \frac{E}{M_{QG1}}$$

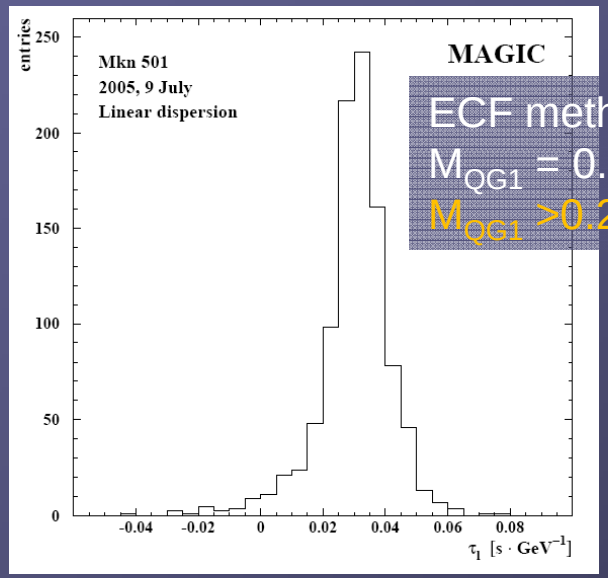
Quadratic deviation:

$$\xi_1 = 0; \quad \xi_2 < 0; \quad v = c(1 - \frac{E^2}{M_{QG2}^2}); \quad n(E) = 1 + \frac{E^2}{M_{QG2}^2}$$

Probing Q.G., Mrk501 very fast flare MAGIC + CERN Th. Group (J. Ellis et al.)

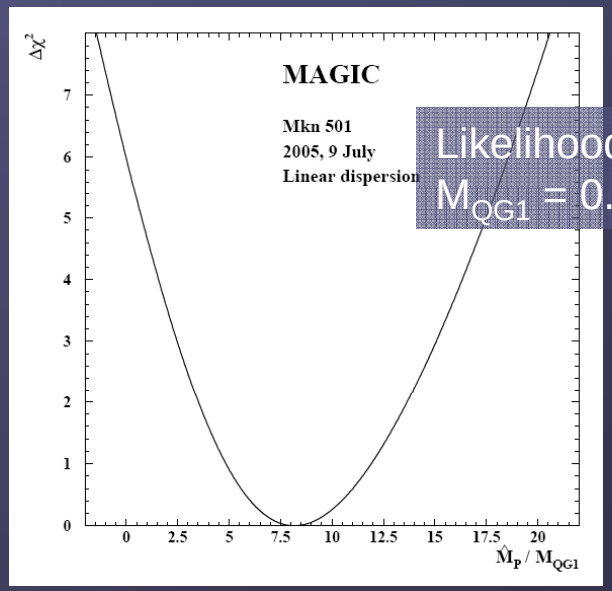
Mrk501 flare
09. July.2005





Energy Cost Function

ECF method
M_{QG1} = 0.47(+0.31-0.13)x10^{18}GeV
M_{QG1} >0.26 x 10^{18}GeV



Likelihood method

Likelihood method
M_{QG1} = 0.30(+0.24-0.10)x10^{18}GeV

New HE AGNs

- FR-1 M87, AGN with a misaligned jet
  - A lot of theoretical discussion on fast variation is on-going
- FSRQ 3c279 z=0.56
  - EBL study
    - Good news; Universe is relatively transparent for gammas
    - Galaxy counts explain the major part of EBL➔ bad news not many room for Pop-III stars (giant stars in the early epoch)
- FSRQ, LBL(Bl Lacertae, W Comae, S50716)
  - Leptonics mdoels, SSC, SSC+EC
  - Synchrotron Proton Blazars?

Summary

- Preliminary: Pulsed gamma ray emission from Crab Pulsar was discovered by MAGIC at 25GeV
  - Gamma ray emissions occur at far place from neutron star
  - 25GeV ➔ 60GeV (dramatic change P1/P2 ratio)
- The most distant 100GeV Quasar 3C279 was discovered by MAGIC
  - EBL – very close to the lower limit obtained by the HST and Spitzer galaxy counts
  - No big contribution from the extra component s like Pop-III stars
- MAGIC-II
  - Completed this summer
  - the start of the scientific operation (Stereo observation) is expected at the end of this year
  - The upgrade with advanced photo-detector HPD(>50% QE) in 2009