

# Point source/GRB report

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## ★ Point Sources

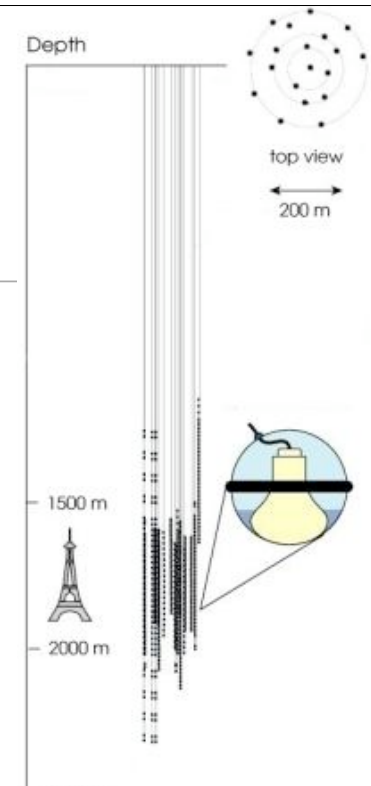
- Positive signal: the Moon
- 22 strings results
- 40 strings readiness for unblinding and reach

## ★ GRBs

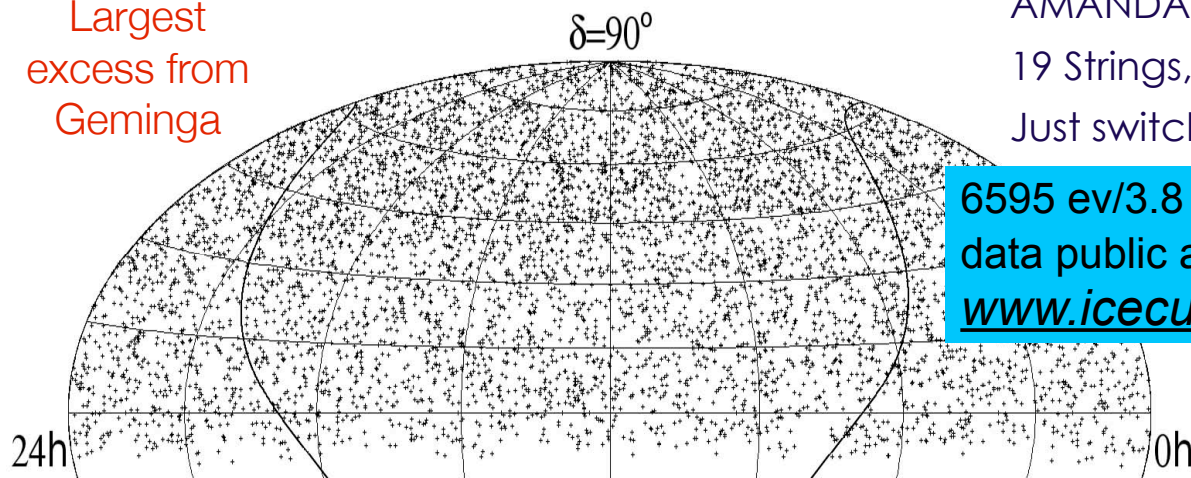
## ★ Status of ToO programs

Scientific Advisory Committee  
Madison, May 20, 2009

# Goodbye AMANDA



Largest  
excess from  
Geminga

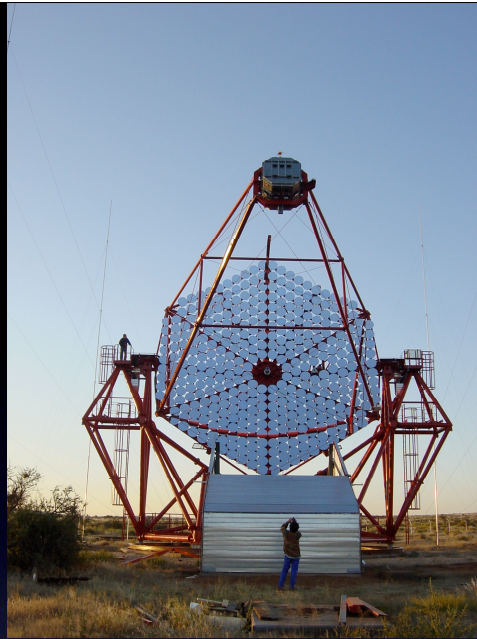


AMANDA (1996-2009), completed in 2000  
19 Strings, 677 Modules, 8 inch PMTs  
Just switched off

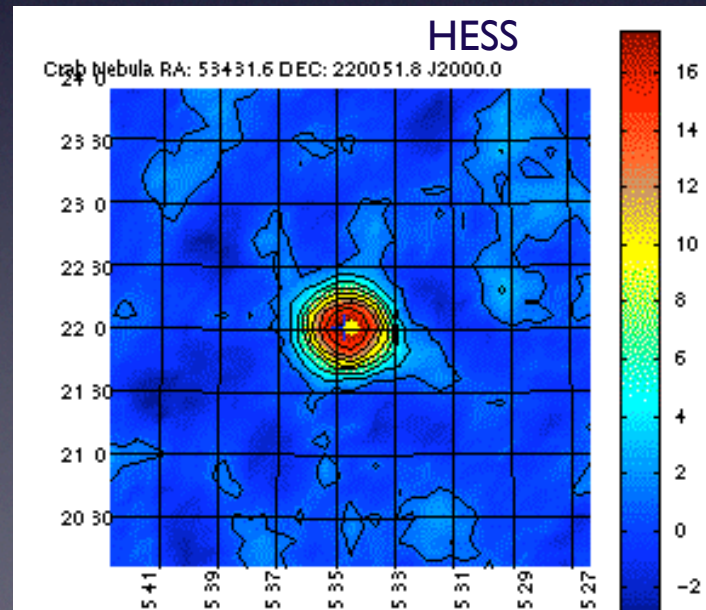
6595 ev/3.8 yr  
data public at [http://  
www.icecube.wisc.edu/science/data](http://www.icecube.wisc.edu/science/data)

AMANDA-II 7 yr  
arXiv:0809.1646

Looking  
for point-  
sources



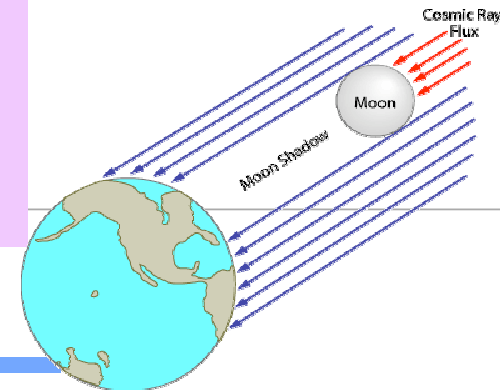
Checking the PSF with a Standard candle





# First Moon shadow in a neutrino telescope

Preliminary

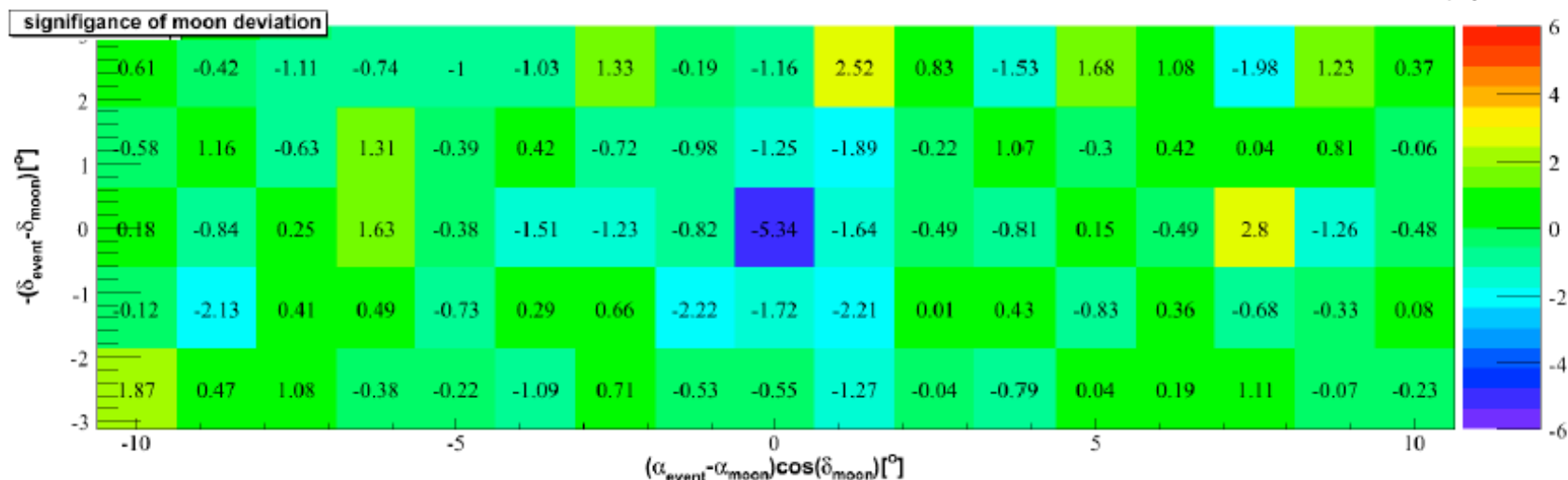
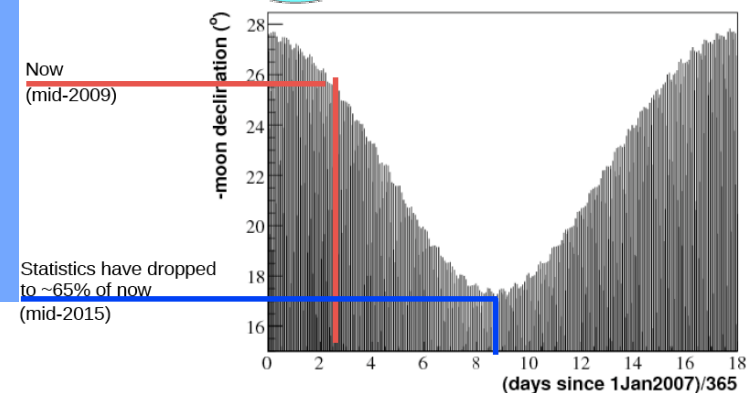


8 months of IC40 data, 9M muons,  
13 cycles

0.7° radius bins around Moon position

Check of absolute positioning and coordinate  
transformations

(L. Gladstone's talk at APS)



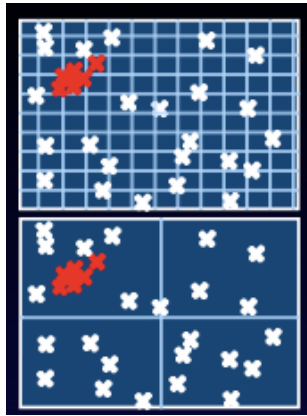


# Test of hypothesis and relevant discriminating variables

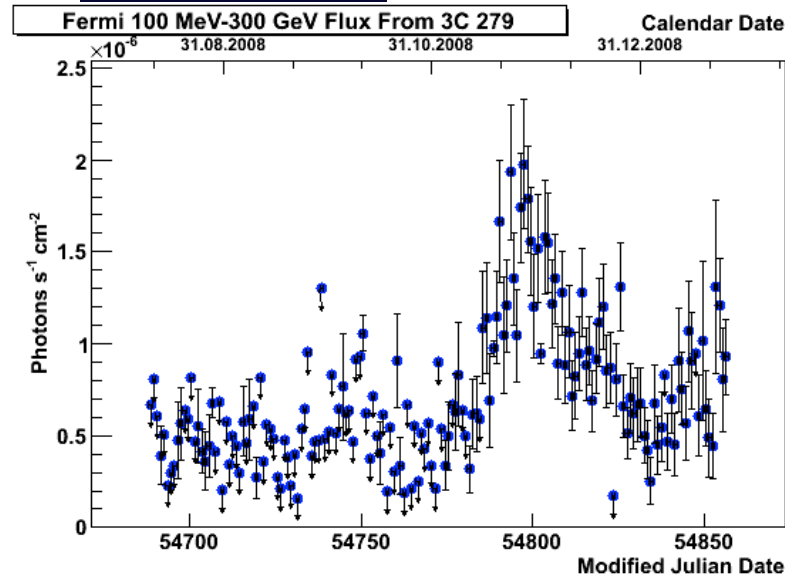
binned methods not optimal



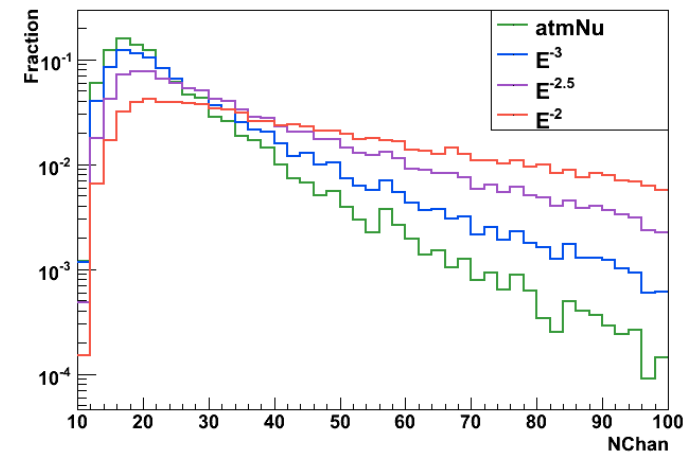
LH ratio methods exploit the power of all variables characterizing signal against background



Energy distribution

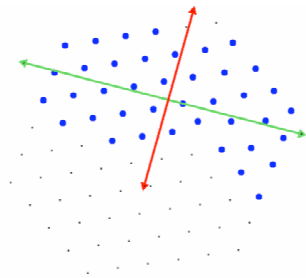
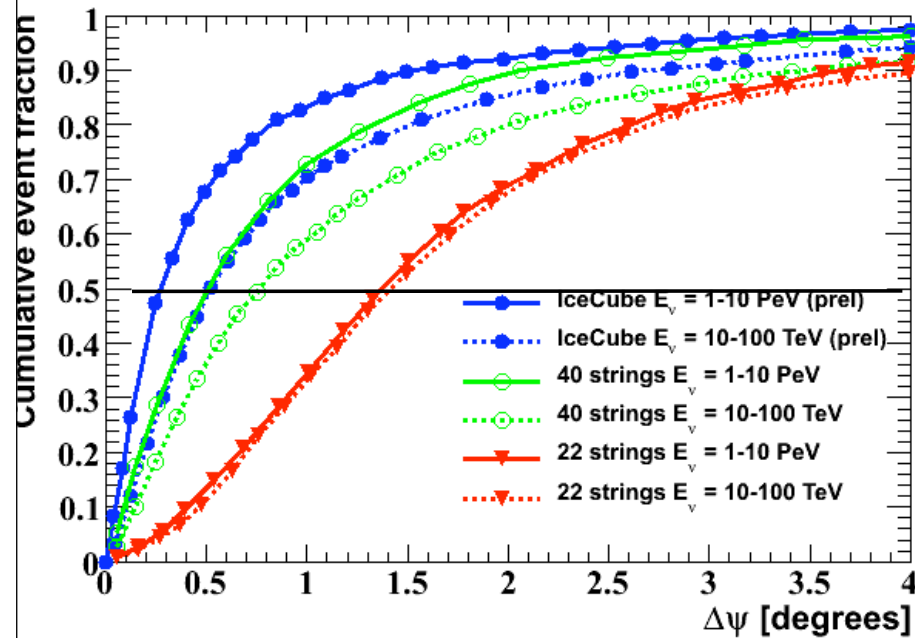


Neutrino Event NChan Distributions

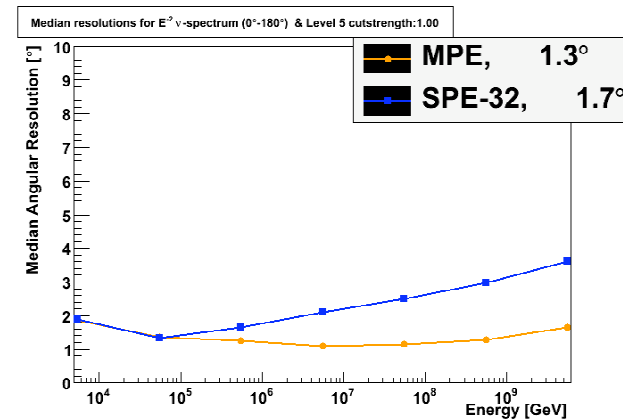


Time dependence

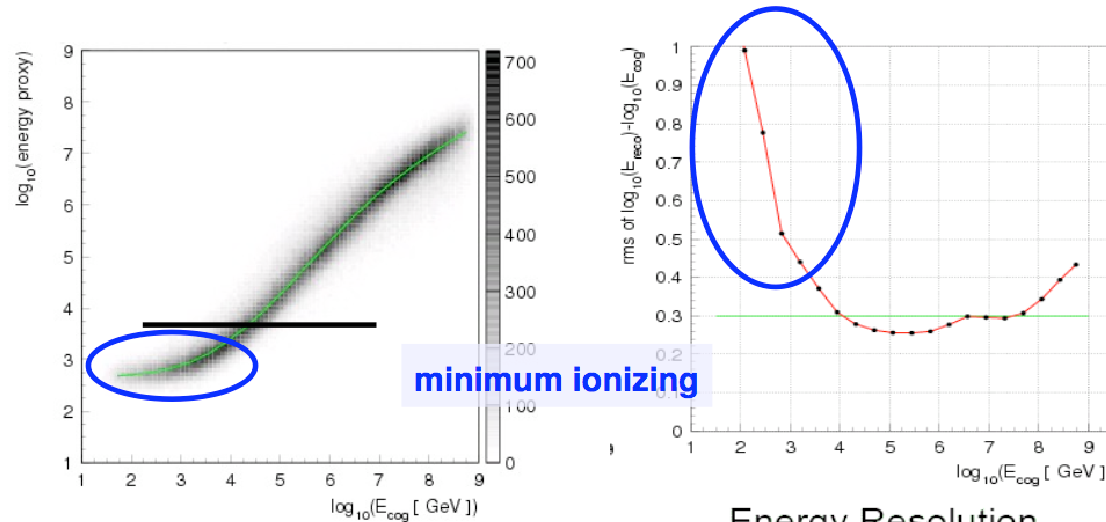
# The PSF of the growing detector



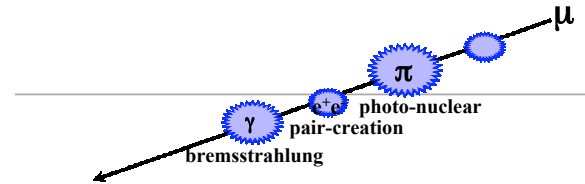
Improved track reconstruction respect to IC22 using multiple pulse times.



# Getting to know charge and energy variables better

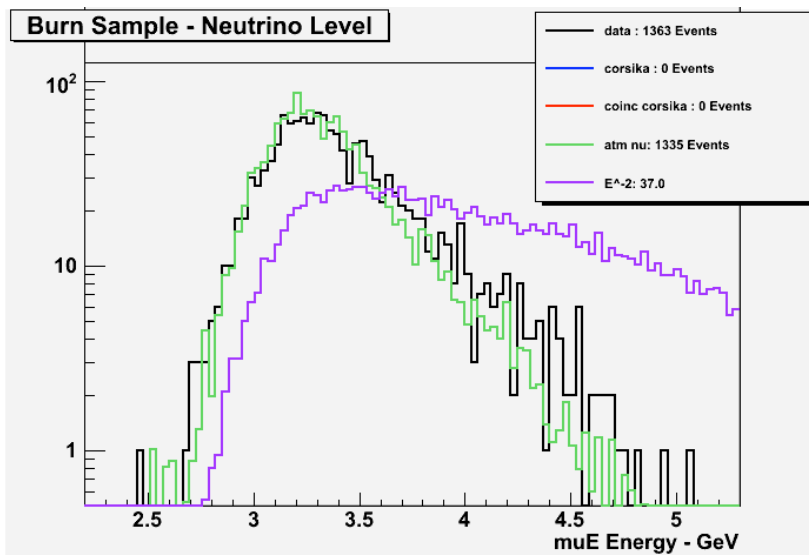


Source: D. Chirkin, UW

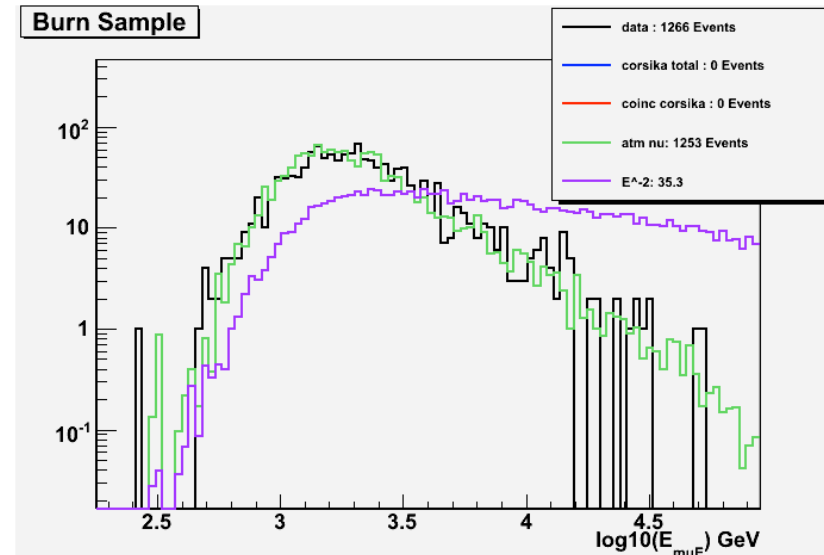


Found a problem in pulse first level reconstruction of FADC charge => solution use only ATWD. It works!  
 Now testing a the new project extracting pulses

before correction



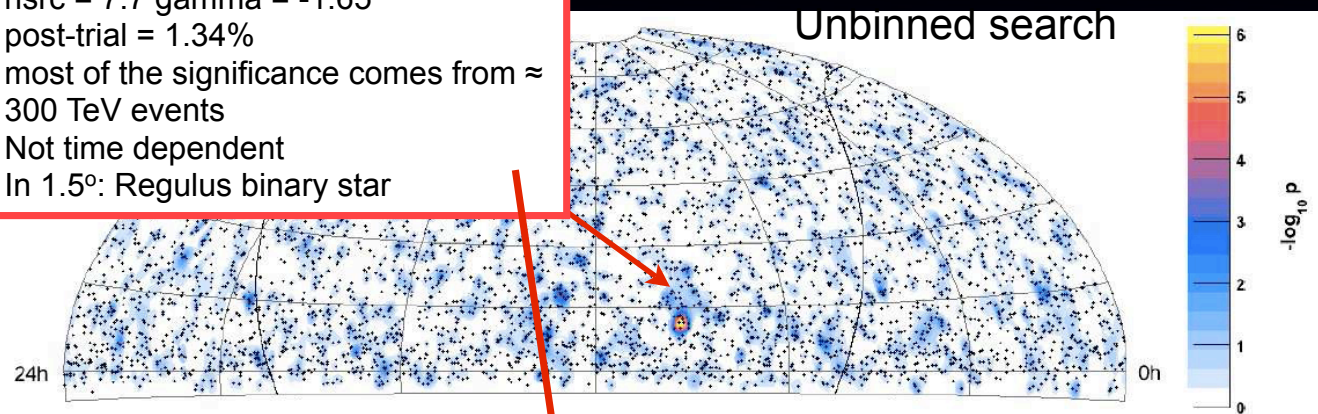
after correction





# Unblinded IceCube Sky Maps (22 strings)

nsr = 7.7 gamma = -1.65  
 post-trial = 1.34%  
 most of the significance comes from  $\approx$  300 TeV events  
 Not time dependent  
 In  $1.5^\circ$ : Regulus binary star



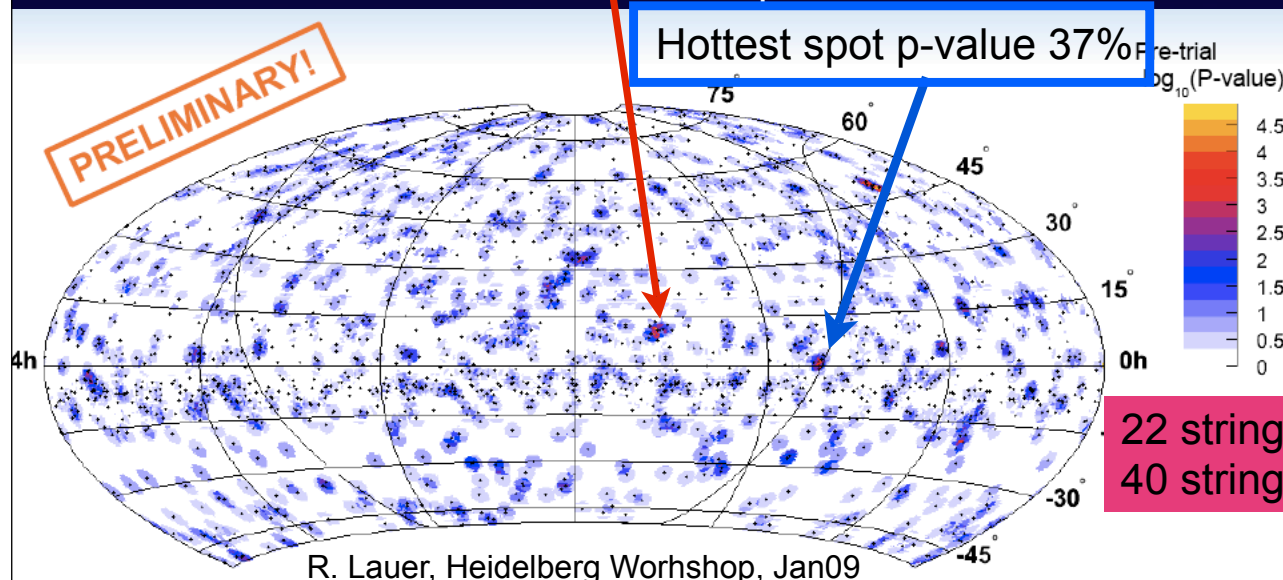
Neutrino Flux needed  
 for this significance  
 ( $\text{TeV}^{-1} \text{ cm}^{-2} \text{ s}^{-1}$ )

$$E^{-2} \quad 2.2 \times 10^{-11}$$

$$E^{-1.65} \quad 3.6 \times 10^{-12}$$

5114 events/276 days

Binned search extends FoV to Southern hemisphere and  
 35% less sensitive in Northern hemisphere

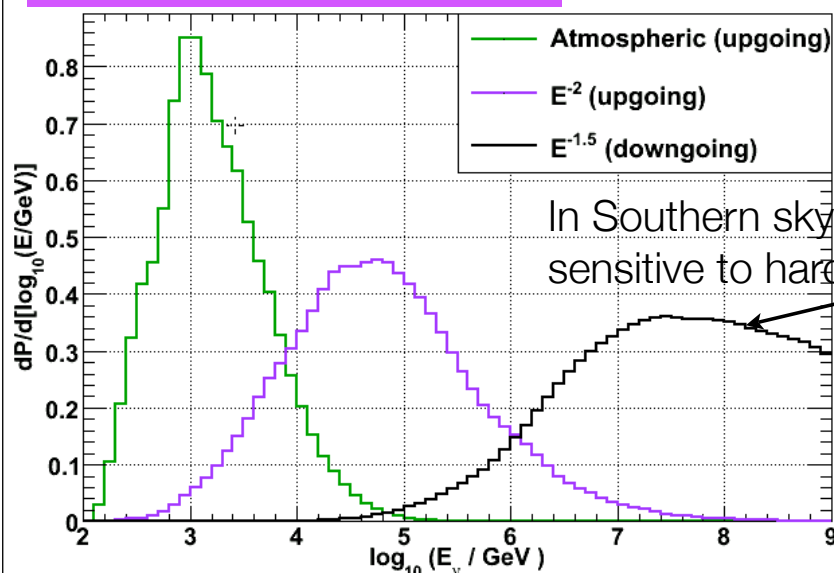


Hot Spot triggered  
 observations with  
 VERITAS and future  
 with H.E.S.S.

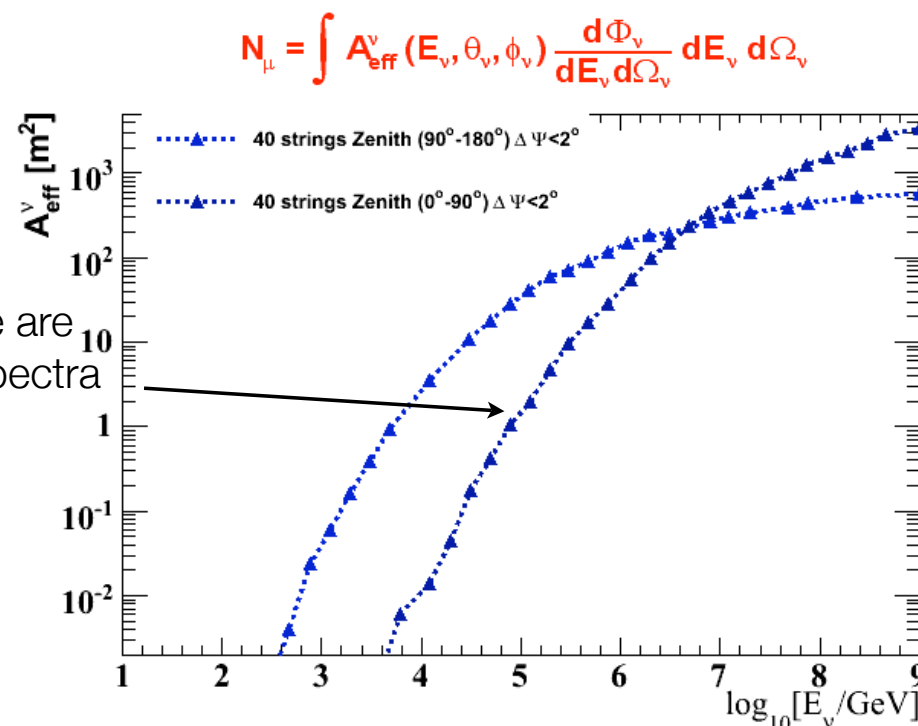
22 strings: paper ready for submission  
 40 strings at ICRC2009

# 40 strings events for point-source analysis

In Northern sky we are sensitive to  $E^{-2}$  spectra



In Southern sky we are sensitive to hard spectra



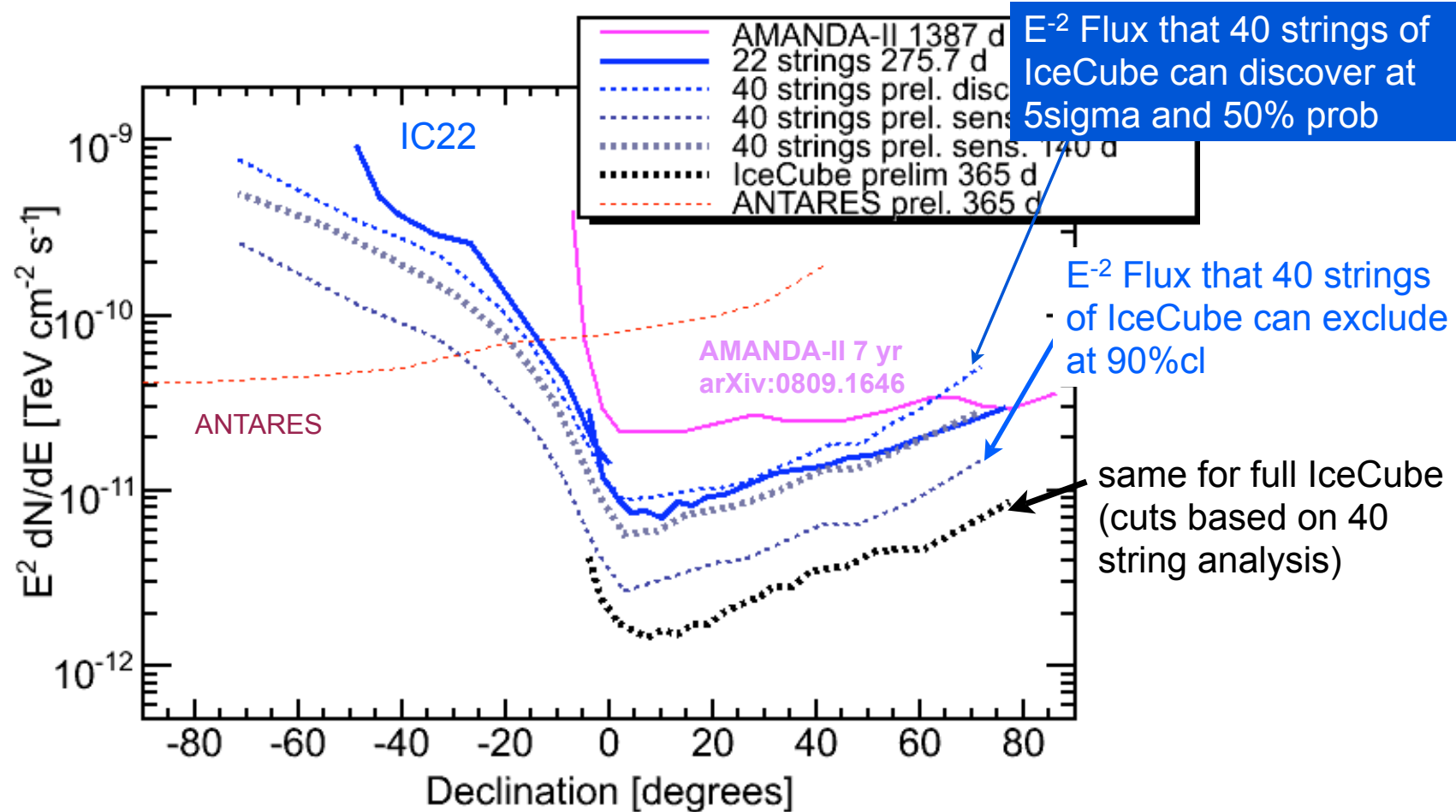
**Filter level:** 23Hz, 35% reconstructed as upgoing still dominated by misreconstructed atmospheric muon background

**Cut level:**

**Downgoing events : 70 ev/day** (mainly atm muons) after tight E-related variable zenith dependent cuts

**Upgoing events:** atmospheric neutrino background + 5% contamination of muons  
**35 ev/day**

# What fluxes accessible by experiments?



In IC22 about a factor of 2 better than AMANDA 7 yrs

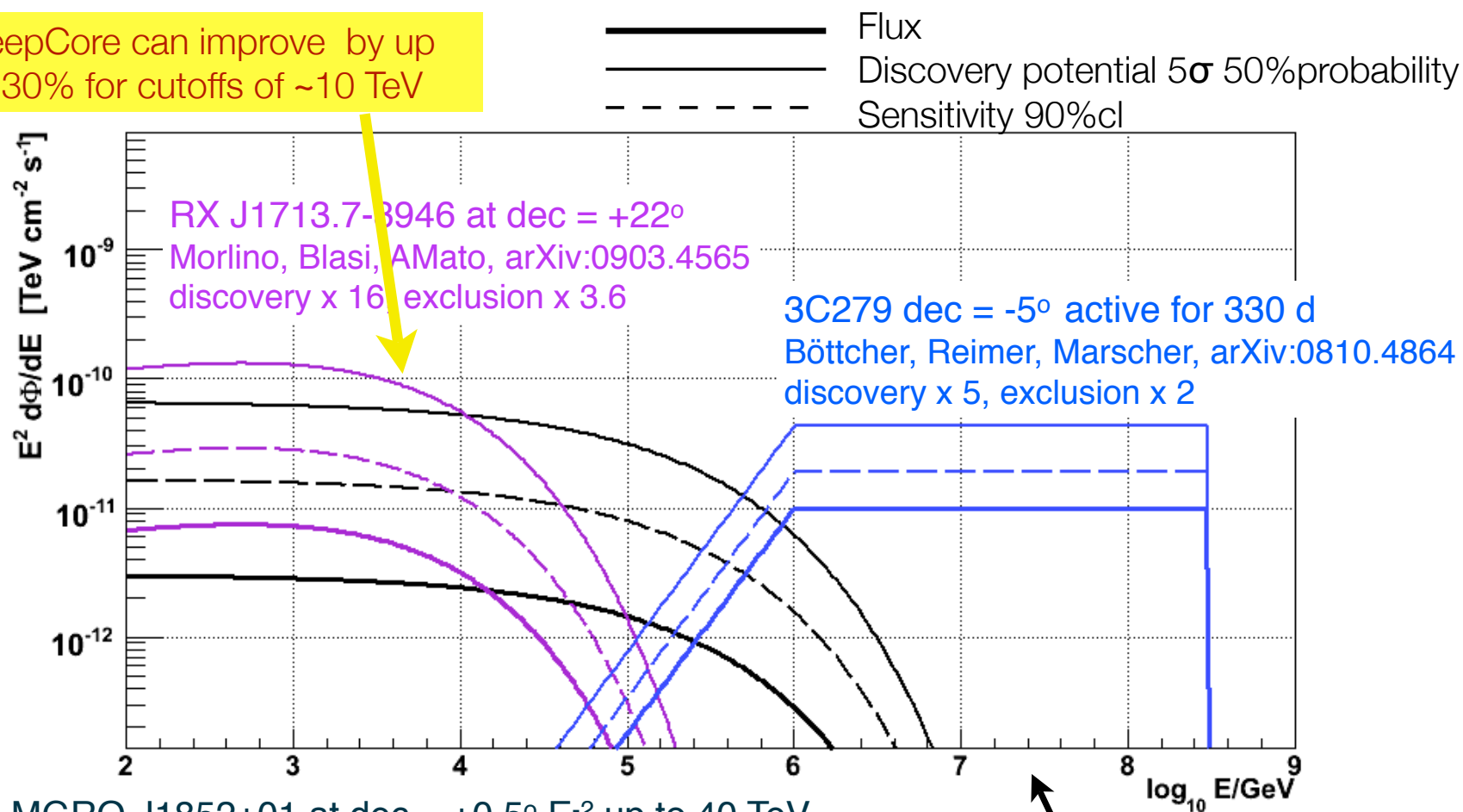
IC40 factor of 2 better than IC22: 35 upgoing events/day and 69 downgoing events/day

IC80 ~ factor of 4-5 better than IC22



# Sensitivity and Discovery potential to specific flux models in 40 strings of IceCube

DeepCore can improve by up to 30% for cutoffs of ~10 TeV



3 Pevatrons can be stacked: full IceCube can discover them in about 5 yrs

HE extension can help by > 30%

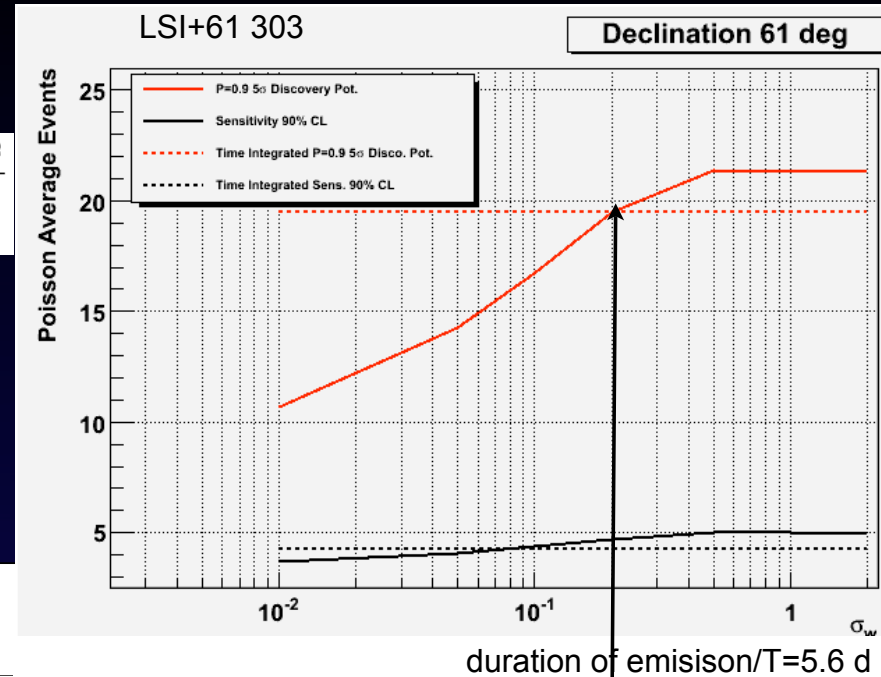
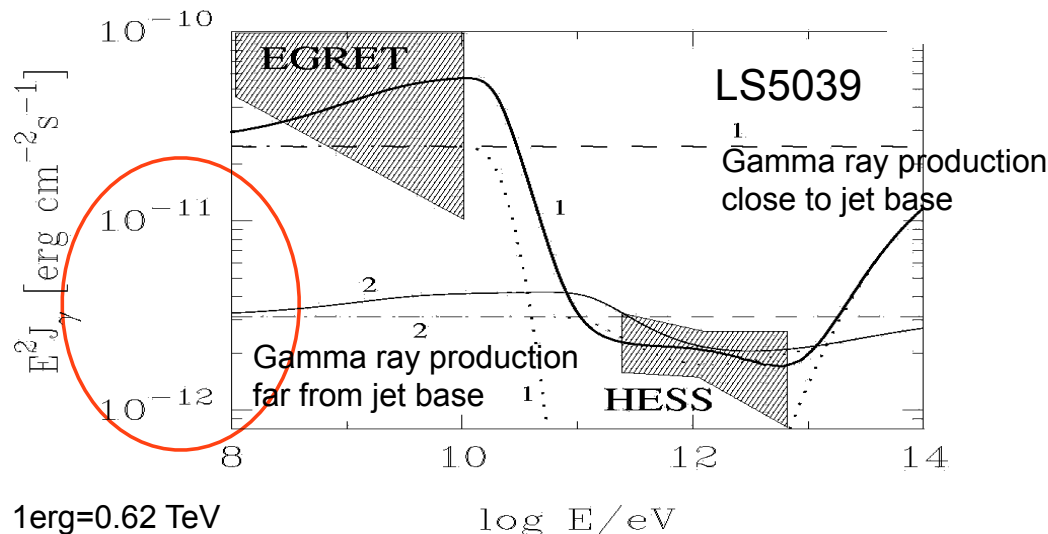
# IC22 periodical search for MQSO

Assume T from spectroscopic information  
and fit phase and duration of emission/T

$$S_i = \frac{1}{2\pi\sigma^2} e^{-\frac{|\vec{x}_i - \vec{x}_s|^2}{2\sigma^2}} \cdot P(N_{ch}|\gamma) \cdot \frac{1}{\sqrt{2\pi}\sigma_w} e^{-\frac{(\phi_i - \phi_o)^2}{2\sigma_w^2}}$$

space                  energy                  time

Aharonian, Anchordoqui, Khangulyan, TM, astro-ph/0508658

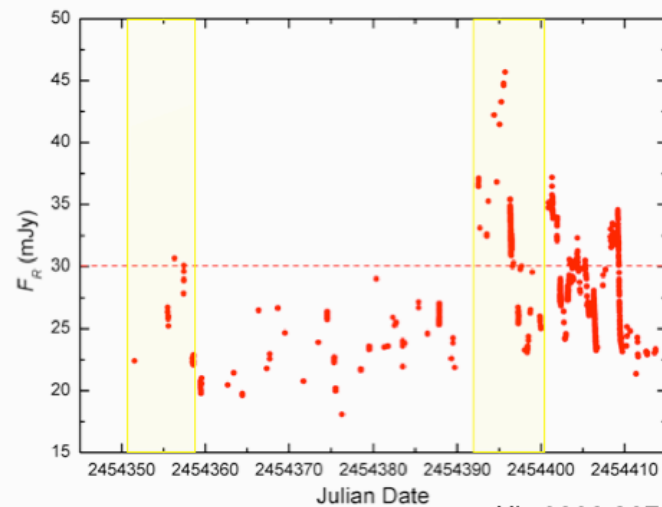
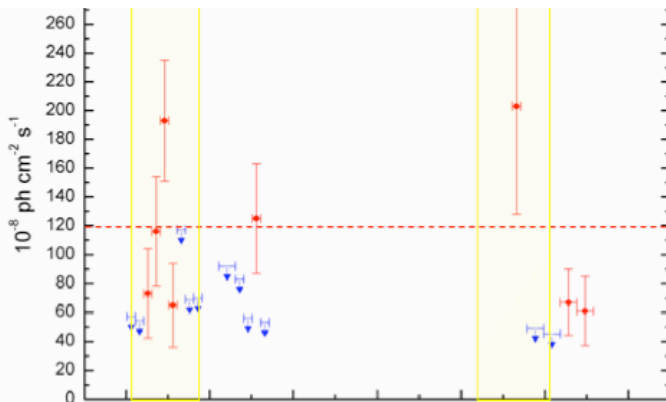


More sensitive than time  
independent search for  
durations <20% of period  
No significant probability that  
the emission is periodical from  
7 mqso  
Upper limits:  
 $\sim 1.5 \times 10^{-11} \text{ TeV}^{-1} \text{ cm}^{-2} \text{ s}^{-1}$

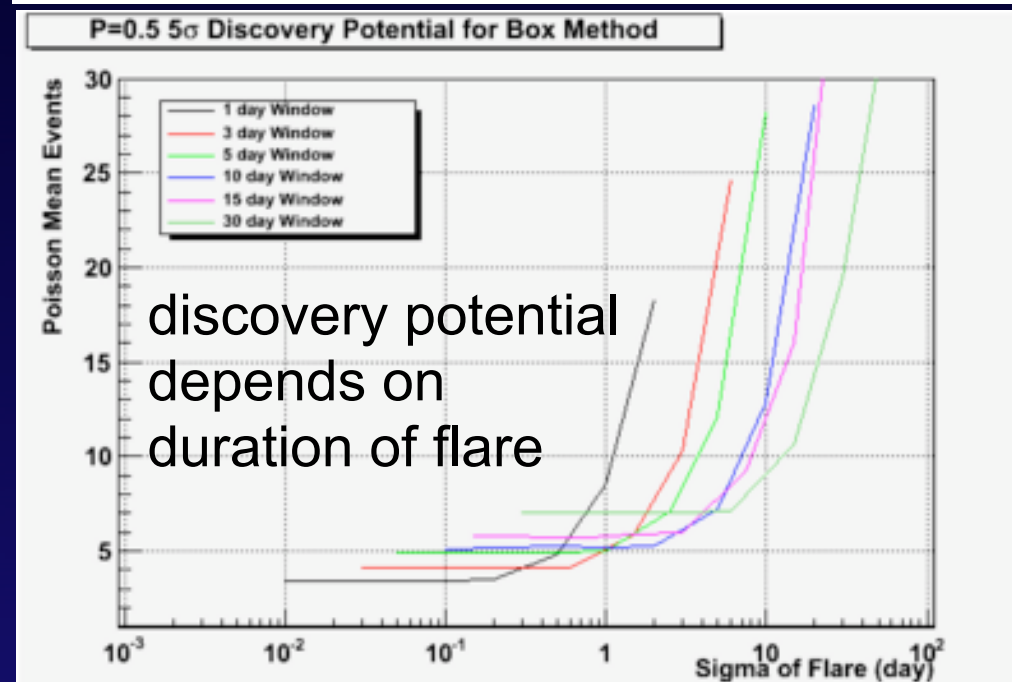
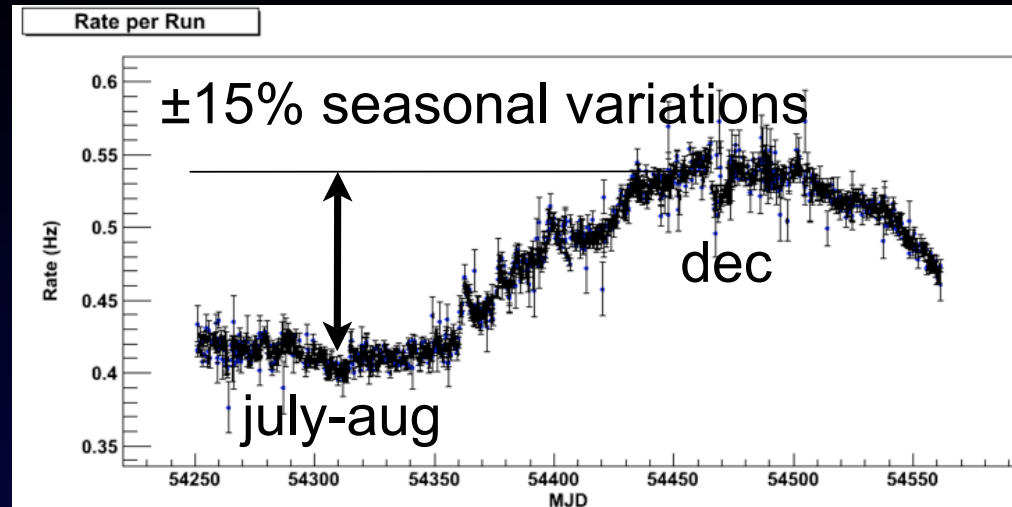
# Search for flares in Jun 2007-Apr 2008

7 flares from Cyg X-1 and 6 blazars:  
3-5 events needed for discovery for  
flare search windows 5-10 days.

S5 0716+71 AGILE arXiv:0808.3673



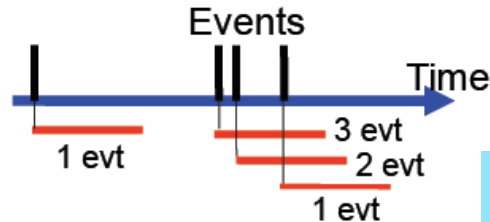
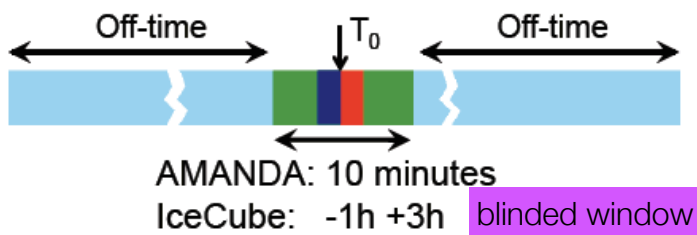
arXiv:0808.3673v1





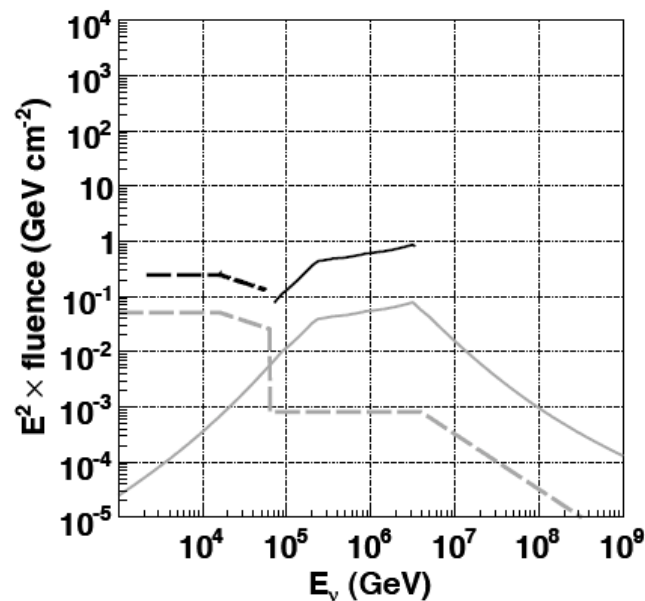
# GRB analysis in 22 strings

■ On Time    ■ Extended Window  
■ Precursor    ■ Off-time

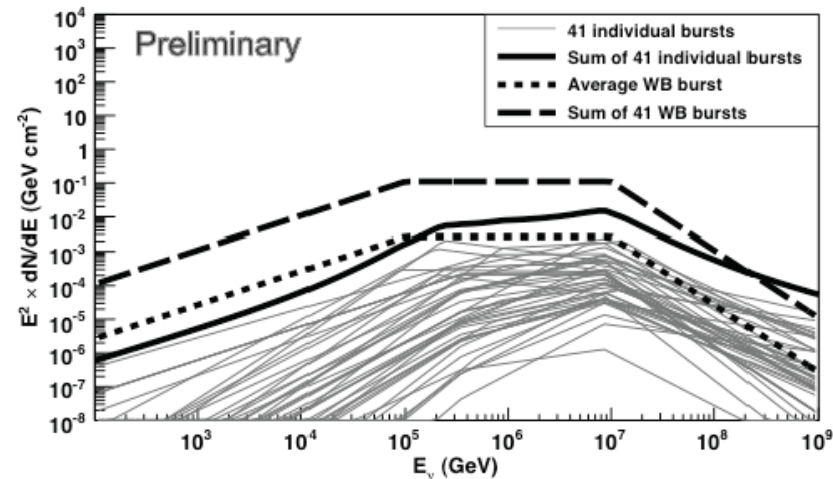


Individual and average neutrino  
 fluxes for 4 GRBs during 22  
 string operation  
 (05/31/2007-04/05/2008)  
 0.033 prompt muon events  
 expected (1.5 in 40 strings that  
 extends FoV to Southern sky)

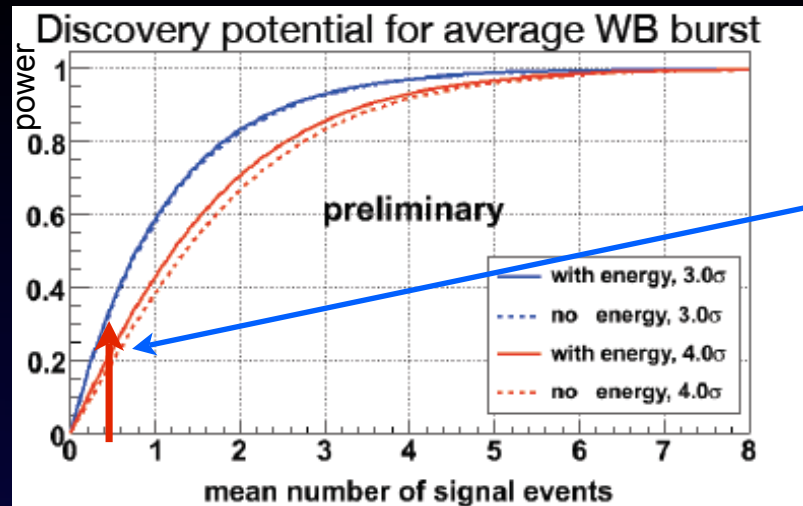
## Triggered Search



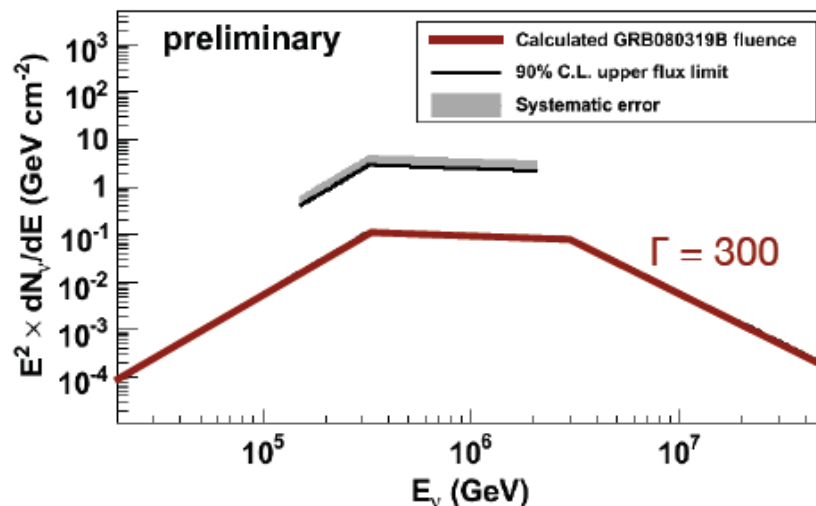
## Rolling Search



# Naked eye GRB



Expected events from prompt emission (Waxman & Bahcall, 1999)  $\approx 0.5$  ev in IC22 30% probability of 3 sigma discovery



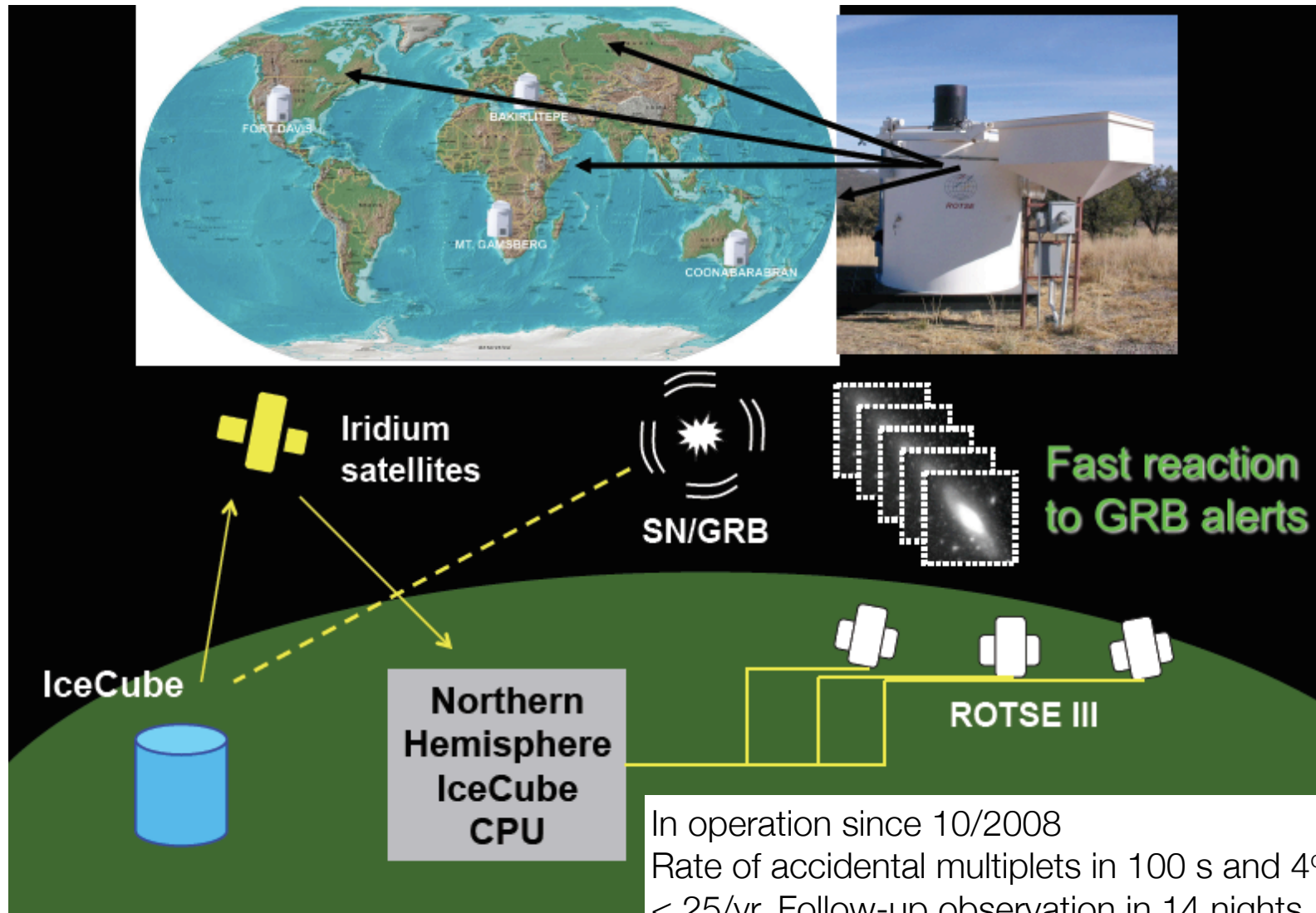
Expect 0.1 events in 9 strings (1 event in 80 strings ) for the naked-eye GRB 080319B  
arXiv:0902.0131

IceCube HE extension may improve by 40% the sensitivity for  $>\text{PeV}$

Scenario for 110 strings: 2 additional rings of 12 strings, 48 DOMs/string

Effective area  $2.2 \text{ km}^2 > \text{PeV}$

# Optical follow up with ROTSE-III



Other ToO with MAGIC

In operation since 10/2008  
Rate of accidental multiplets in 100 s and  $4^\circ$   
< 25/yr. Follow-up observation in 14 nights  
14 alerts are being analyzed



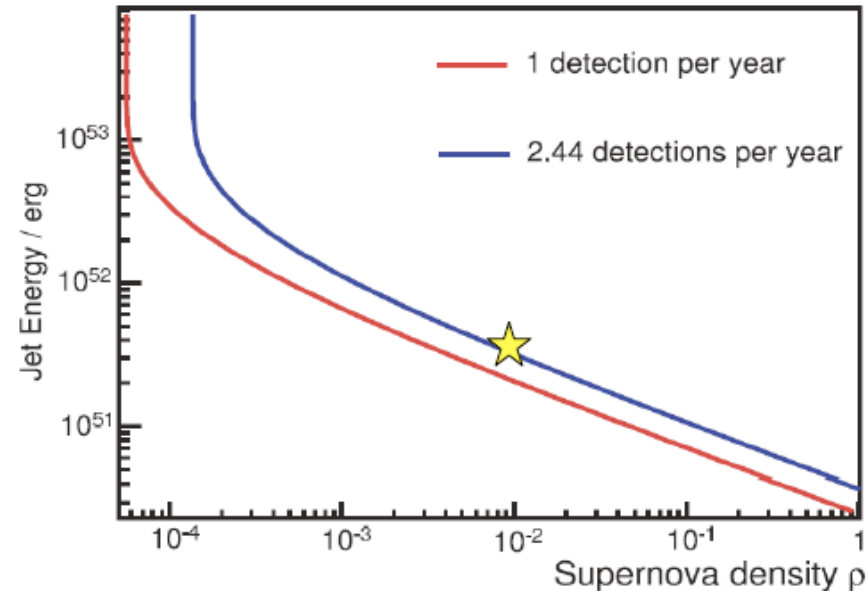
# Astrophysical limits to SN models

- If no SN is detected 40 strings limit the rate of neutrino-producing SNe is smaller than  $\rho = 3 \cdot 10^{-6} \text{ Mpc}^{-3} \text{ yr}^{-1}$  (90%cl)

- A neutrino doublet in coincidence with a SN @ 20 Mpc in 10 s corresponds to  $3.5\sigma$
- A coincidence in 300 s with a GRB corresponds to  $4.4\sigma$

★ Model prediction of Ando and Beacom

SN core collapse accompanied by a jet of energy  $3 \times 10^{51} \text{ erg}$



# Summary

some of the hot spot events

Main pointing capability verification: we see the Moon shadow with  $5\sigma$

22 strings point-source analysis shows a hot spot at the level of 1%. 40 string analysis ready

Astrophysics neutrino discovery at  $5\sigma$  could require 5yrs of IceCube if predictions are based on gamma observations, but already now exclusion limits severely constrain CR acceleration models from SNRs and extragalactic sources

GRBs: 1 yr of full IceCube in coincidence with Fermi ( $2\pi\text{sr}$ ) leads to observation of WB flux at  $5\sigma$

