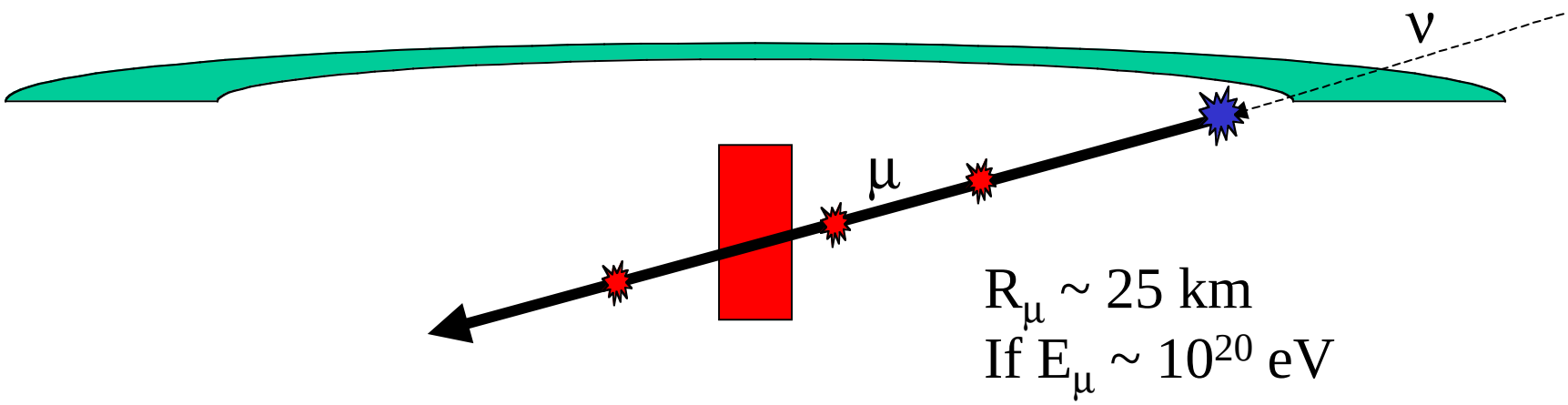
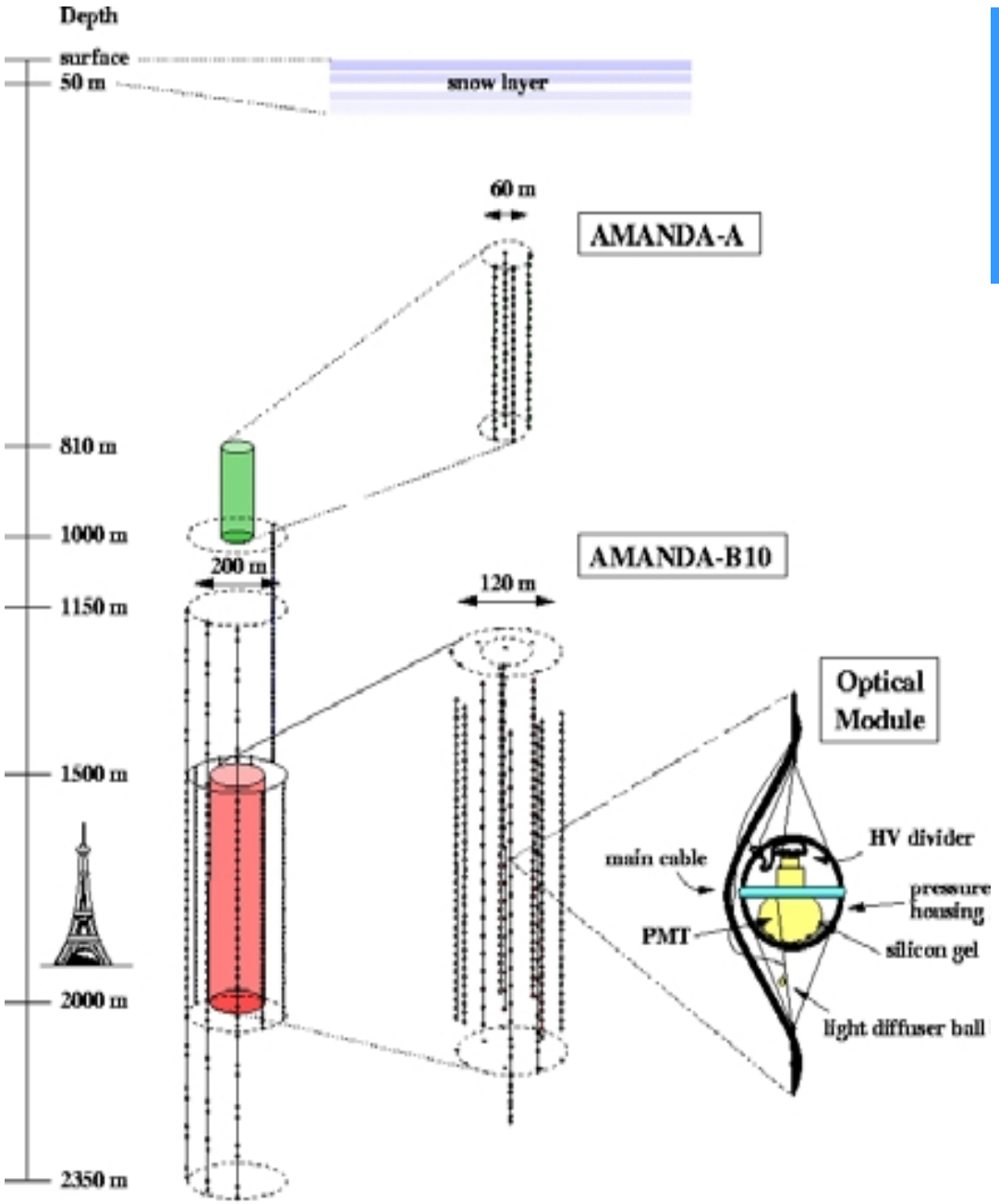
EeV ν_μ Detection in AMANDA



Signal predominantly from horizon
Atm. background closer to zenith

S. Barwick, UCLA workshop
November, 2000

AMANDA-II
Feb. 00



AMANDA as of 2000
Eiffel Tower as comparison
(true scaling)

zoomed in on
AMANDA-A (top)
AMANDA-B10 (bottom)

zoomed in on one
optical module (OM)

Features

- Am-II/B Sensitivity: $V_{eff}\Omega \sim 10\ km^3sr$
- 2 years of livetime on tape
- Calibration possible using *in-situ* N_2 laser
  - Equivalent to 80 TeV cascade
- Background rejection straightforward
  - Total energy and “energy flow” variables

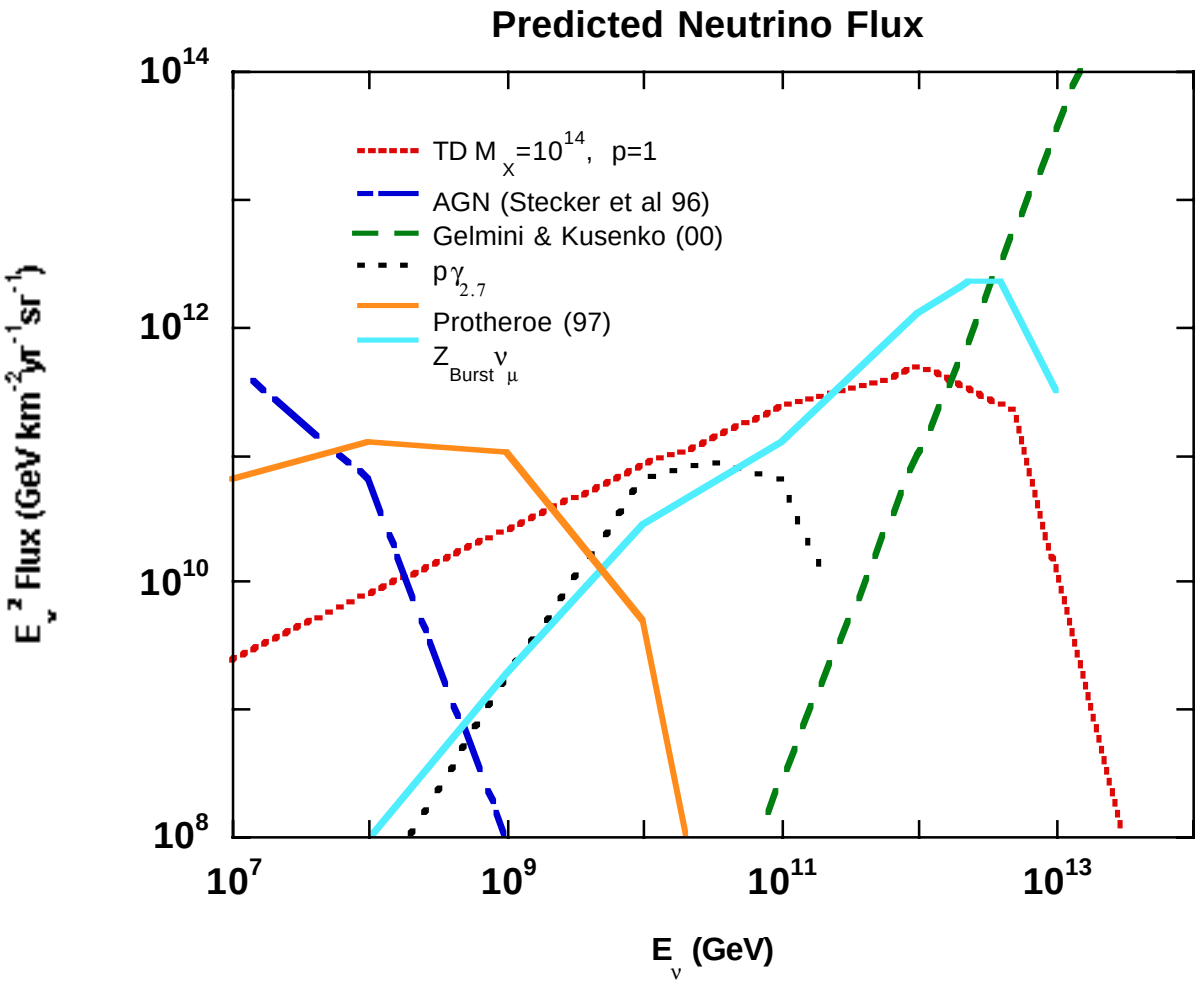
EeV Science Goals

- GZK from $p+\gamma_{CMB}$
  - Detection would confirm mechanism
  - Evolution gives factor 10 uncertainty in flux
  - Non-detection can be used to constrain neutrino cross section at EeV energies in lab frame.
- Supermassive Black Hole/ AGN models
  - Compared to searches at 1-100 TeV, probes a complementary set of models
  - Salamon and Stecker (‘95), Protheroe(‘97), Mannheim(‘95), Halzen and Zas(‘97)
- Exotic sources - physics of the early Universe
  - Topological defects, Heavy Boson decay, Z-burst

Muon Backgrounds

- At E> 10^{15} eV, Atm. ν are negligible
- Atm. charm production (c -> μ)
  - Significant theoretical uncertainty, but becomes dominant at $E_\mu \sim 10^{16}$ eV
- Atm. multi-muon events may mimic higher energy events
- The latter two backgrounds are angular dependent

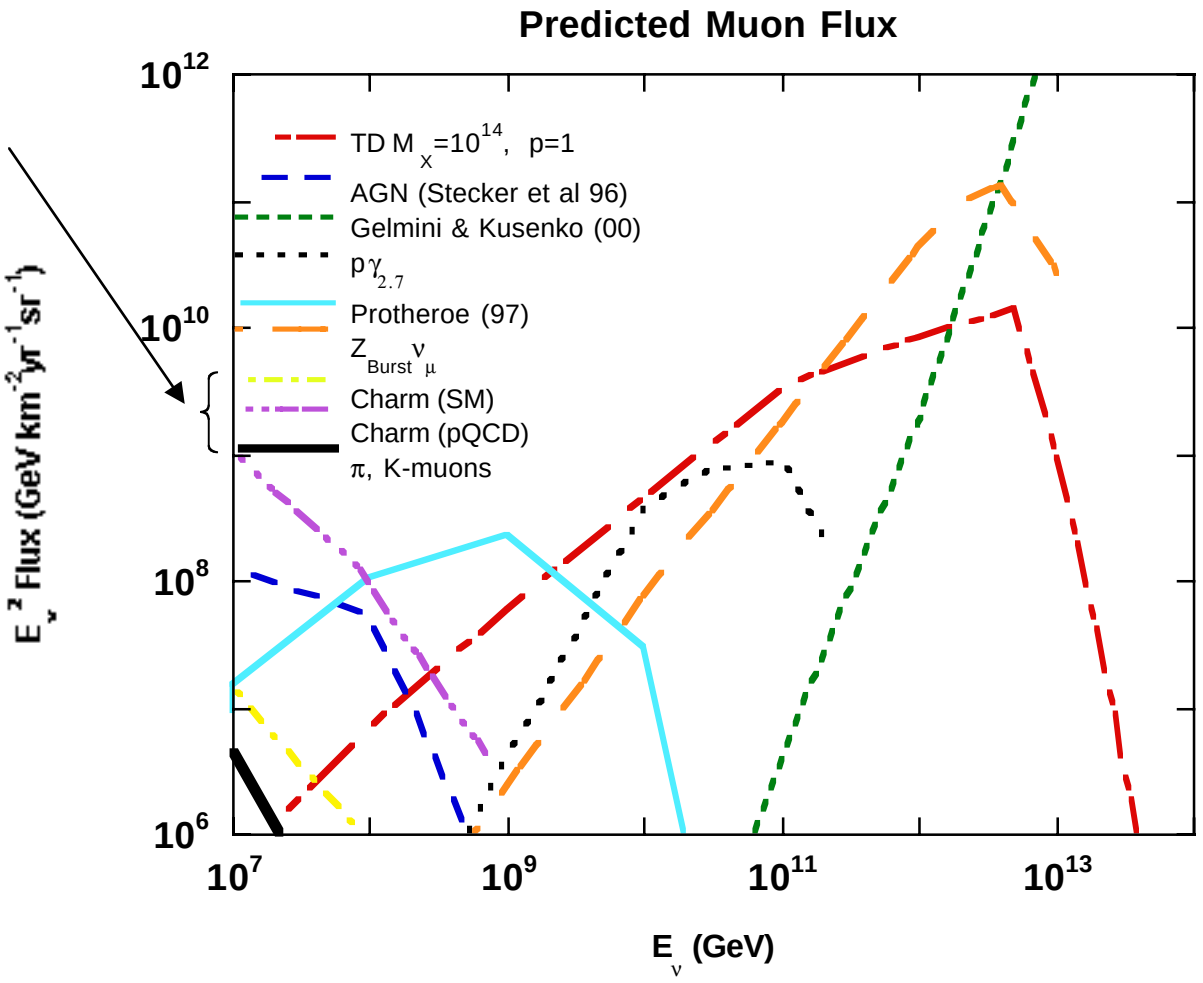
Diffuse ν-flux survey



Downgoing ν-induced μ flux

$$F_\mu = F_\nu * P_{\nu\mu}(E_{th} > 10^7 \text{ GeV}, \cos(\theta))$$

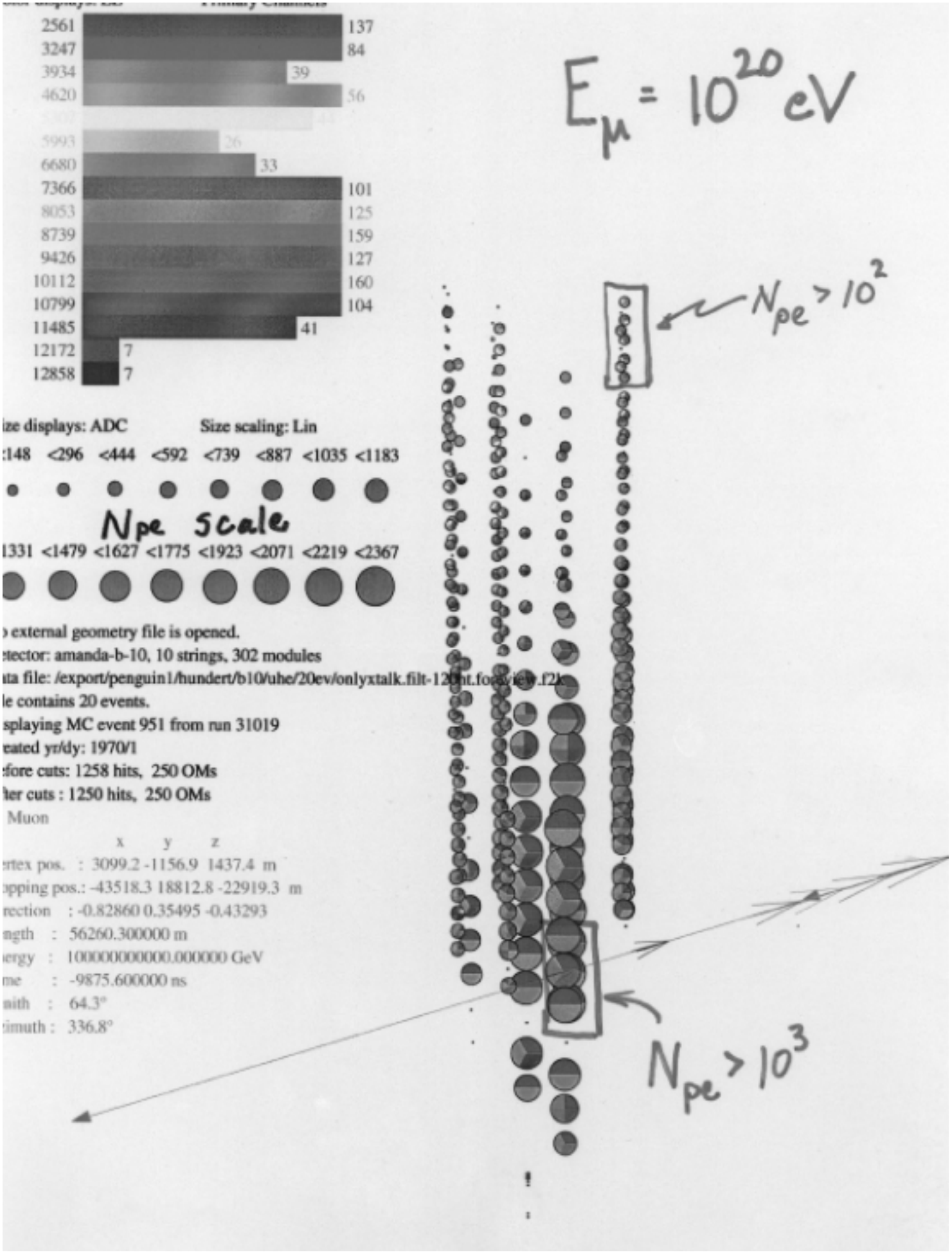
atm μ background



Energy Resolution

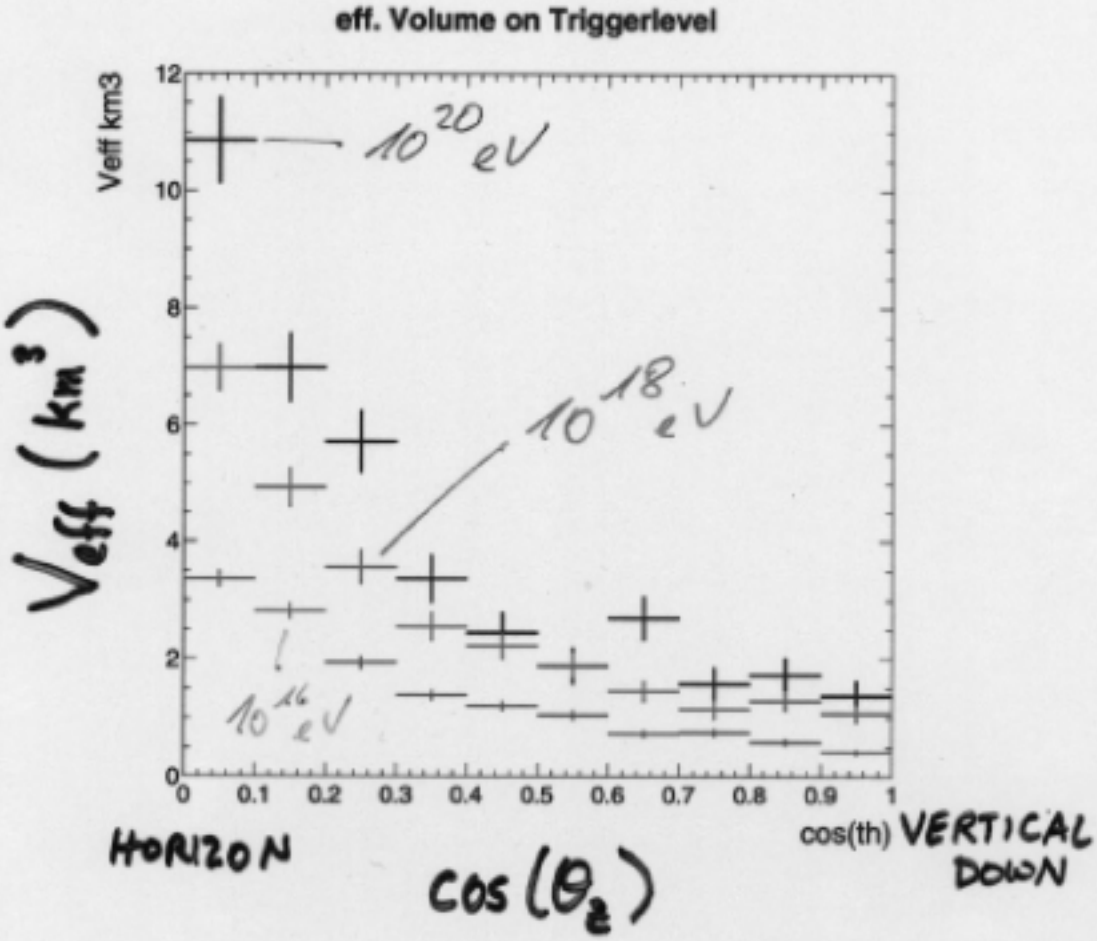
- Catastrophic dE/dx within 400m provides $E_\mu > E_{min}$ threshold.

- Events are very “bright”

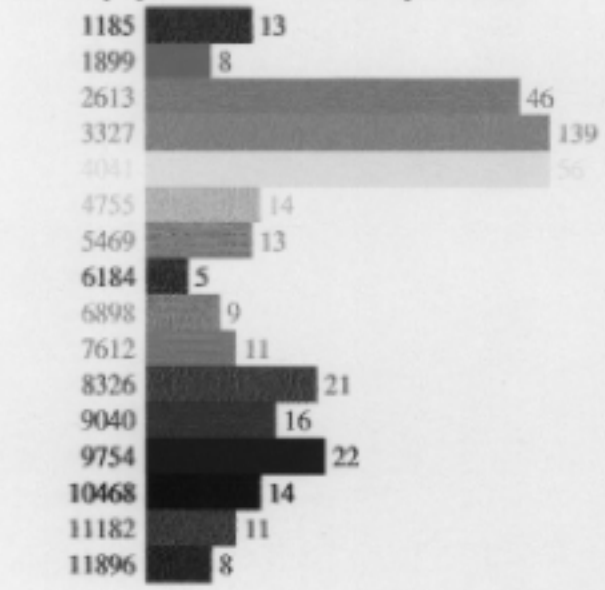

2561 137
3247 84
3934 39
4620 56
5993 26
6680 33
7366 101
8053 125
8739 159
9426 127
10112 160
10799 104
11485 41
12172 7
12858 7
ize displays: ADC
Size scaling: Lin
:148 <296 <444 <592 <739 <887 <1035 <1183
Npe scale
1331 <1479 <1627 <1775 <1923 <2071 <2219 <2367
) external geometry file is opened.
etector: amanda-b-10, 10 strings, 302 modules
ta file: /export/penguin1/hundert/b10/uhe/20ev/onlyxtalk.filt-120it.fo
le contains 20 events.
splaying MC event 951 from run 31019
eated yr/dy: 1970/1
efore cuts: 1258 hits, 250 OMs
her cuts : 1250 hits, 250 OMs
Muon
x y z
rtex pos. : 3099.2 -1156.9 1437.4 m
opping pos.: -43518.3 18812.8 -22919.3 m
rection : -0.82860 0.35495 -0.43293
ngth : 56260.300000 m
ergy : 100000000000.000000 GeV
me : -9875.600000 ns
nith : 64.3°
imuth : 336.8°
$E_\mu = 10^{20}$ eV
$N_{pe} > 10^2$
$N_{pe} > 10^3$

Effective Volumes

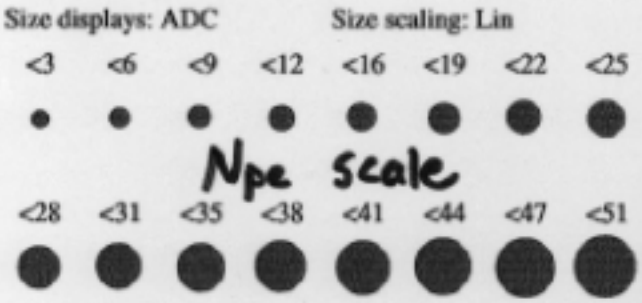
Triggerlevel:



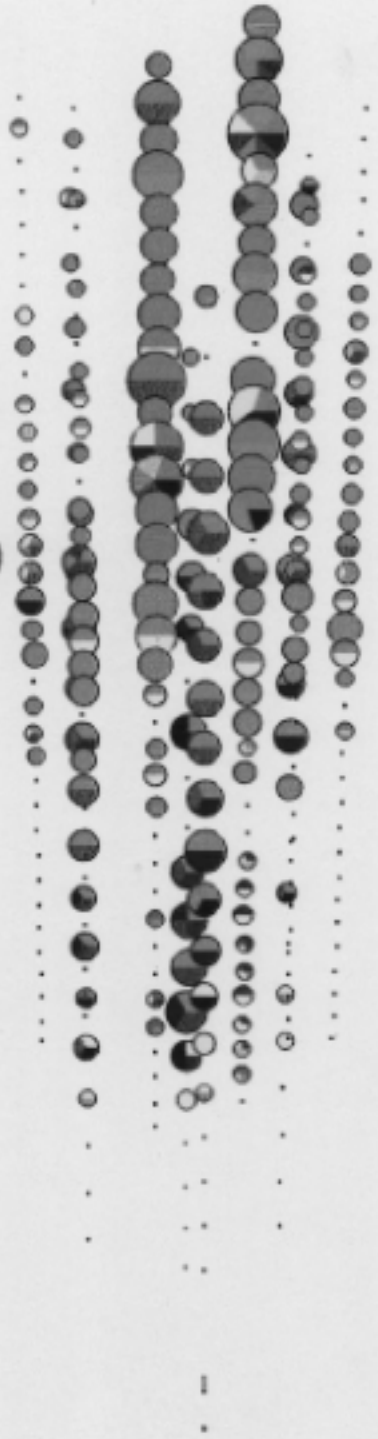
High Multiplicity (>=120 hits): $V_{eff} \cdot \Omega = 25\ km^3 sr$ for $E_\mu = 10^{20}_6 eV$



DATA '97

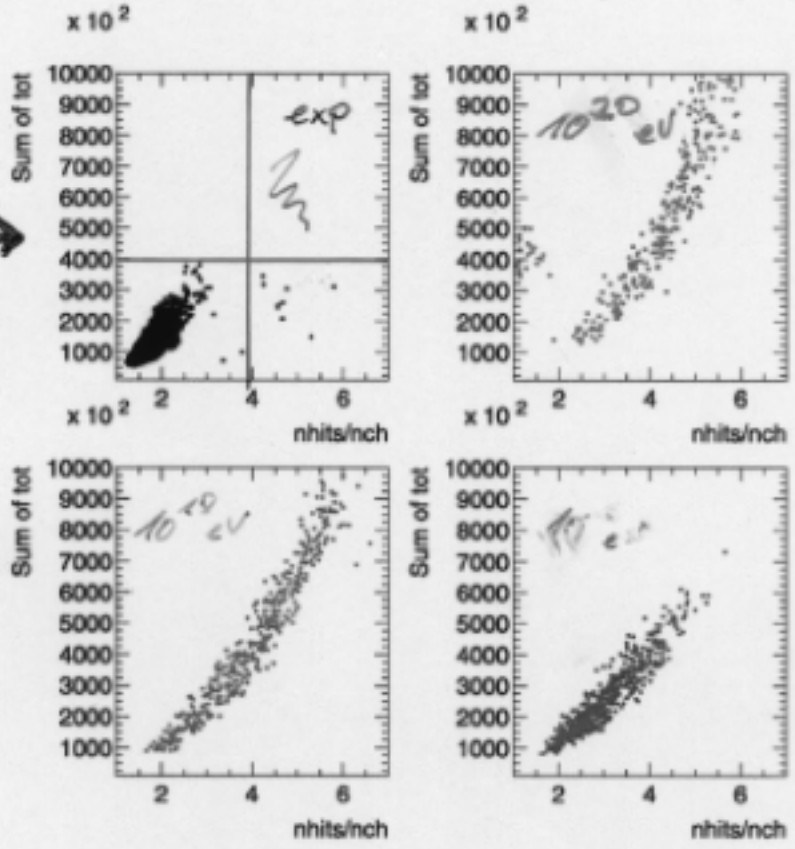


No external geometry file is opened.
Detector: amanda-b-10, 10 strings, 302 modules
Data file: standard input
Displaying data event 3671705 from run 0
Recorded yr/dy: 1997/98
30935.2887064 seconds past midnight.
Before cuts: 578 hits, 244 OMs
After cuts : 406 hits, 182 OMs



BACKGROUND REJECTION

DATA →



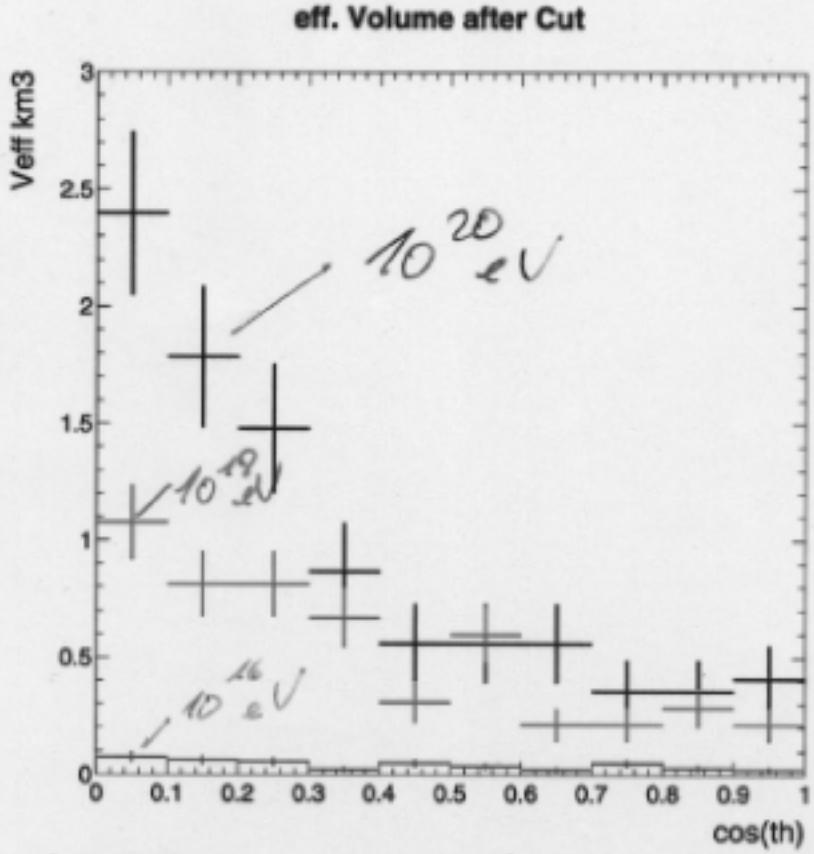
$E_\mu = 10^{20}$ eV

$E_\mu = 10^{18}$ eV

$E_\mu = 10^{16}$ eV

$\sum_{\text{all hits}} \text{tot}$ vs. $\frac{\text{nhits}}{\text{nch}}$

Cut sumtot>4000 and nhits/nch>4:



V_{eff} (km^3)

HORIZON

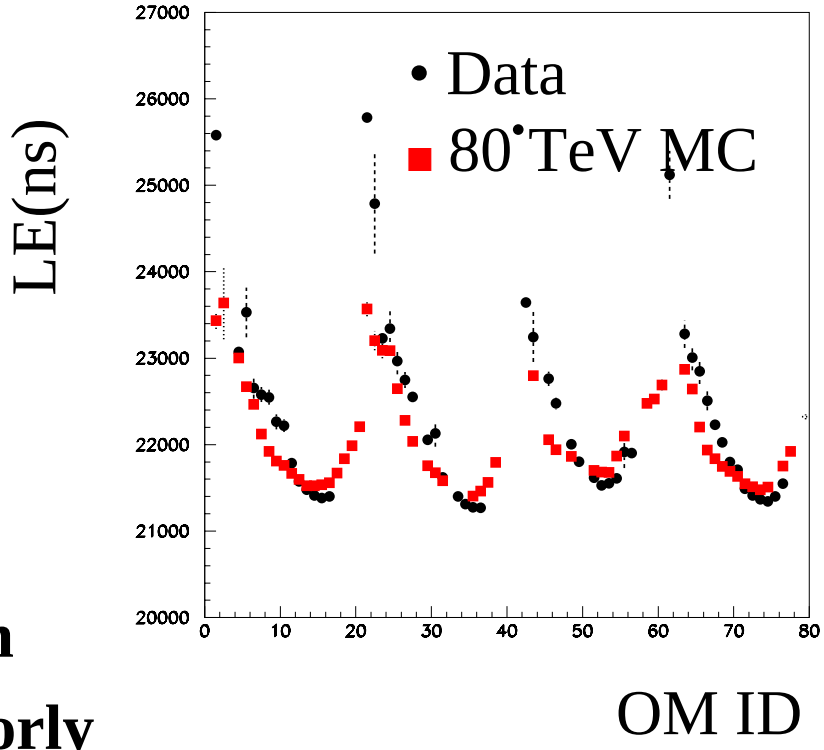
$\cos(\theta)$

VERTICAL DOWN

- $V_{eff}\Omega \simeq 6\ km^3\ sr$ for $E_\mu = 10^{20}$ eV

Calibration: N_2 laser ($\sim 10^{12}$ γ/pulse)

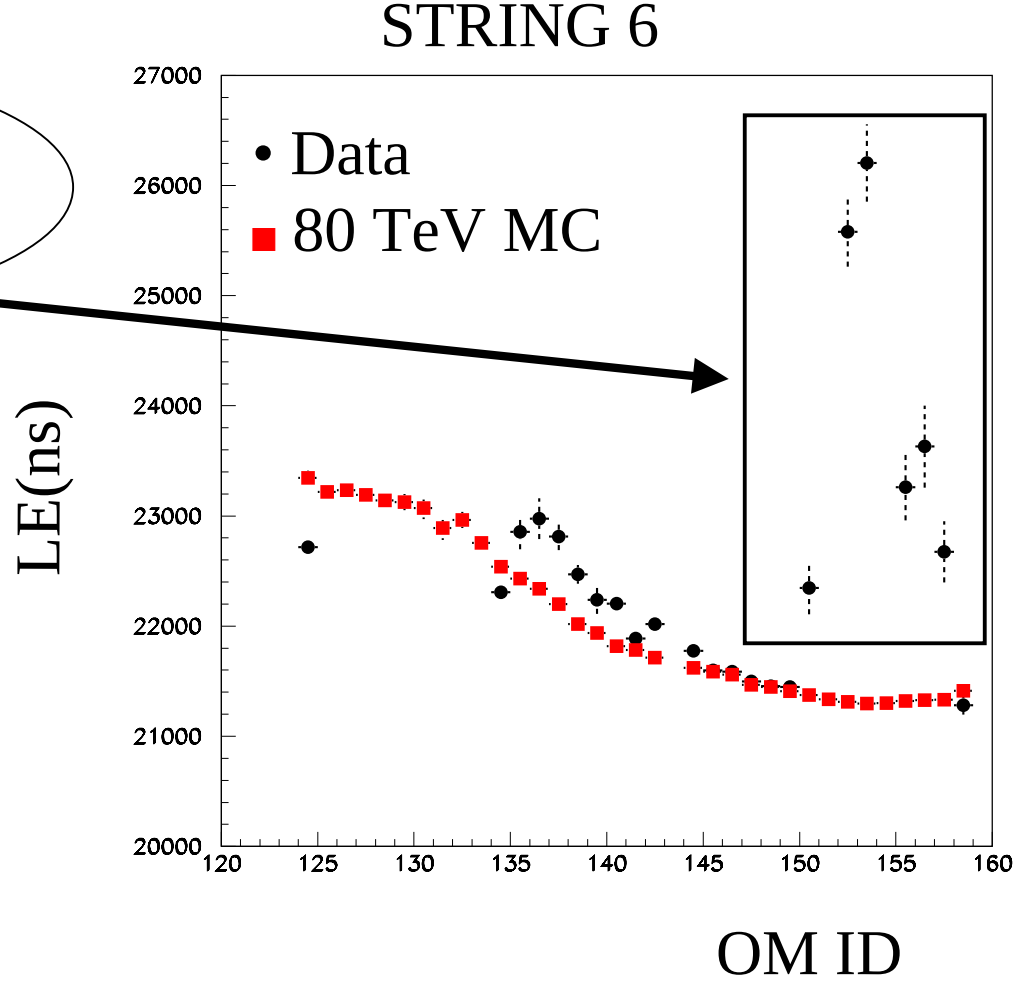
- $E_{casc} \sim$ 100 TeV
  - LE vs distance
  - Npe vs distance



- Conclusions
  - **Details require ice variation**
  - **If $N_{pe}>10^3$, OMs behave poorly**
  - **X-talk can be removed with TOT cuts**

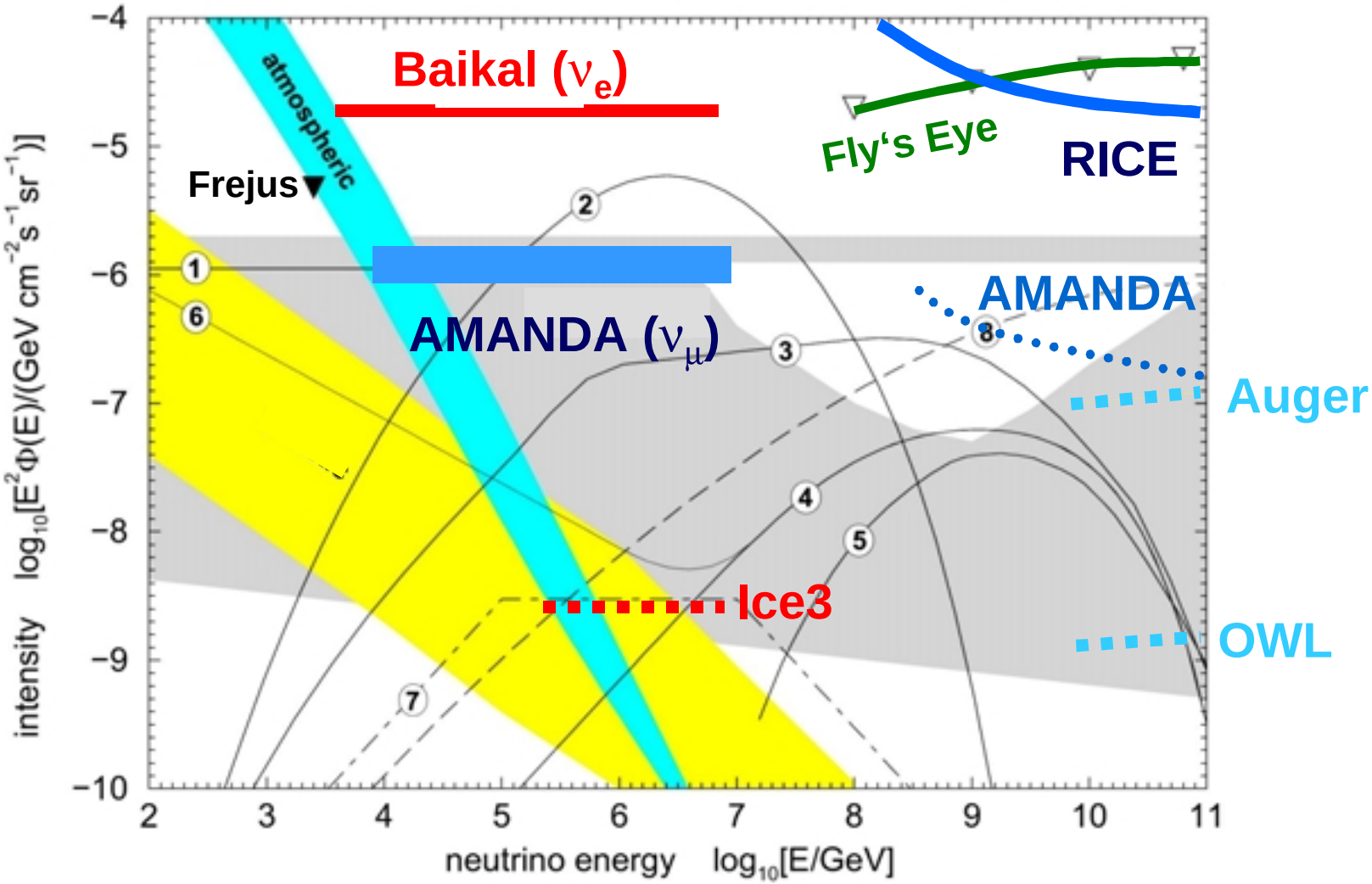
N_2 Laser Calibration

Lose timing info when $N_{pe}>10^3$



Adopted from Learned and Mannheim(2000)

Dotted curves are anticipated sensitivity



What's Next

- Develop energy flow and "PMT saturation" variables
- Tune analysis on 1/3 of '97 data
- Include nonlinear OM behavior in detector simulation (some loss of information at small distances); better AP description
- Begin AMANDA-II simulation