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126Gev Higgs in Next-to-Minimal-UED

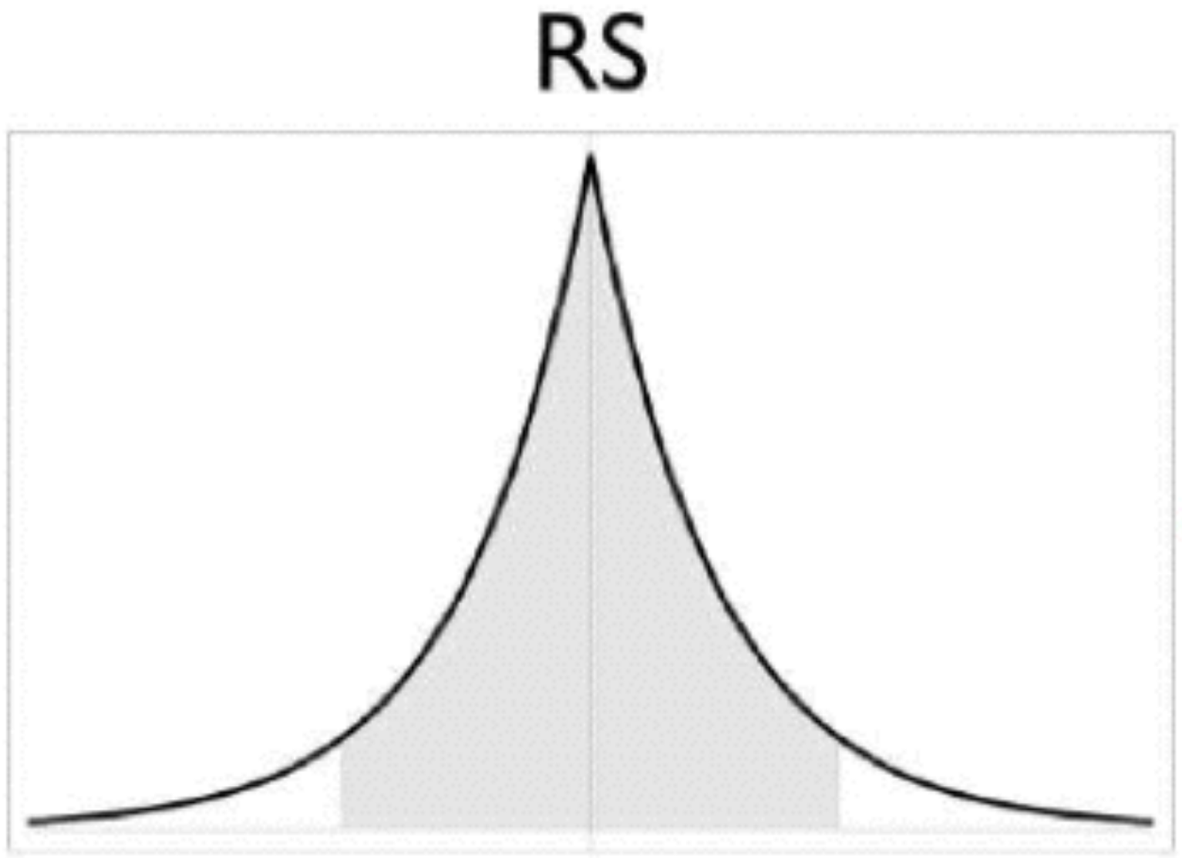
s.park (SKKu)

PASCOS, Taipei
Nov 21, 2013

Flacke, SCP, Kong arXiv:1309.7077 to appear in PLB

UED as an effective theory of RS

Csaki, Heinonen, Hubisz, SCP, Shu (2011)



IR UV IR

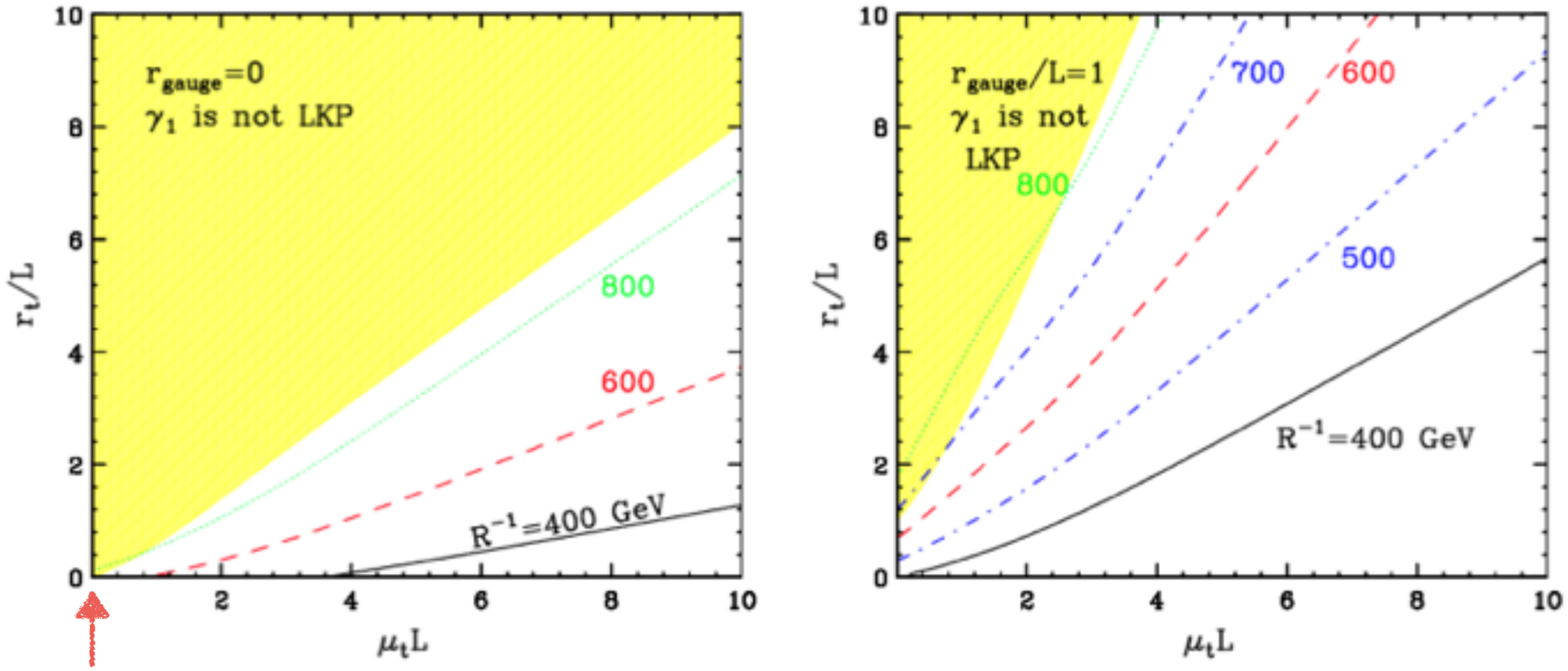
-KK Dark matter with KK-parity
-Big hierarchy with warping
-Rich phenomenology~ bosonic SUSY
-Still UED is an attractive model for the LHC!

UPSHOT

Flacke, SCP, Kong arXiv:1309.7077 to appear in PLB

In NMUED, 1/R~O(100)GeV is still okay with H_{126}

** bulk mass makes KK-fermion heavier, BLT makes gauge boson lighter



1/R>700 GeV in MUED

$$S_{NMUED} = S_{MUED} + \int d^4x \int_{-L}^{L} dy \left\{ -M_t \xi_{L/R} \overline{\Psi}_3 \Psi_3 \right.$$
$$\left. + [\delta(y-L) + \delta(y+L)] \left[r_g \mathcal{L}_{MUED} + (r_t - r_g) i \overline{\Psi}_{3,L/R} \not{D} \Psi_{3,L/R} \right] \right\}$$

126Gev Higgs and PeV scale DM

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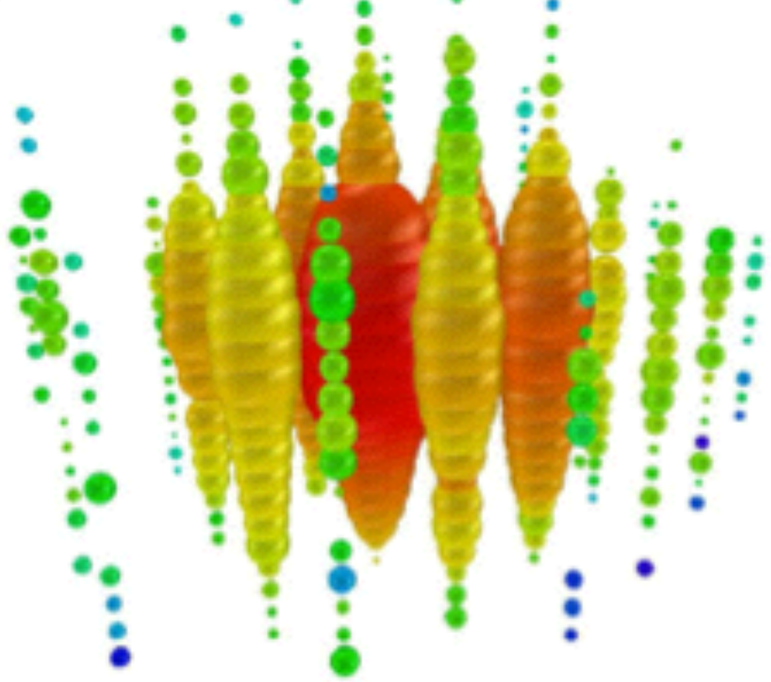
work with K. Kohri (KEK), C. Rott (IceCube, SKKU)

NEW!

Two PeV neutrinos observed by IceCube in 615.9 days

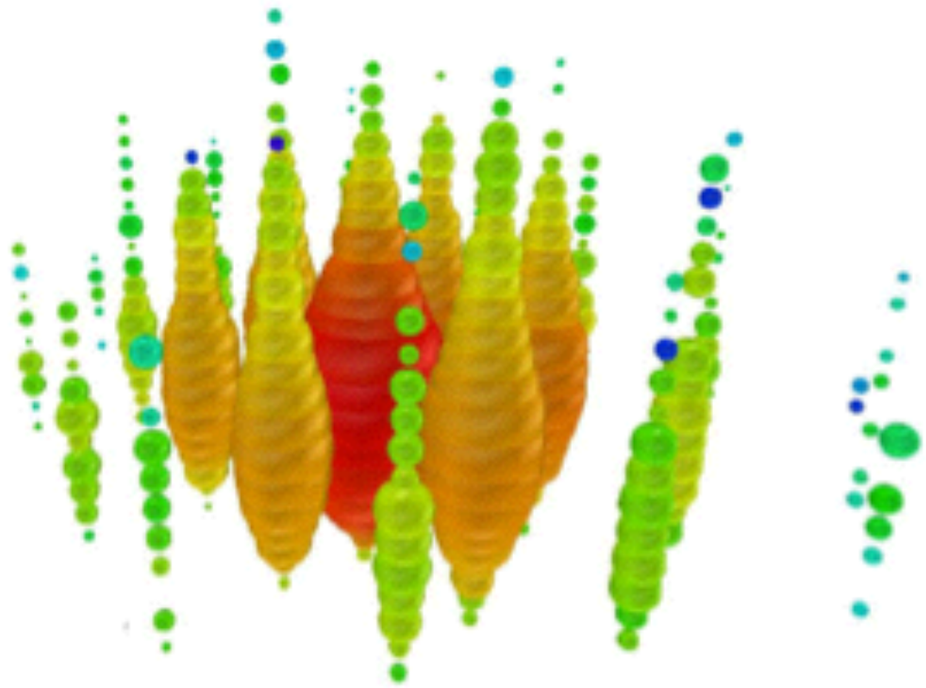
[Aartsen et. al. (IceCube) Phys.Rev.Lett. 111 (2013) 021103]

(a) "Bert"



$1.04 \pm 0.16\text{PeV}$

(b) "Ernie"

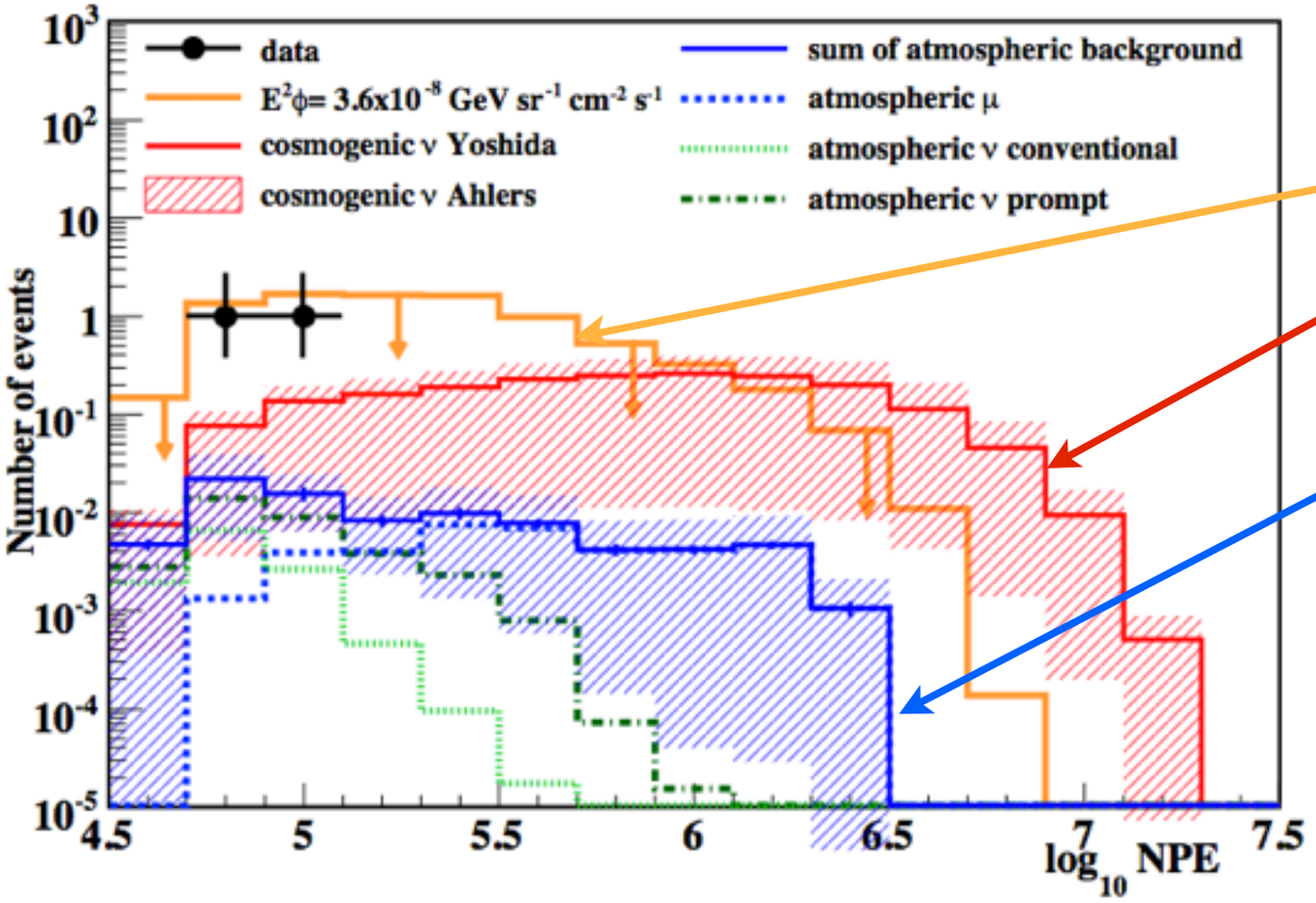


$1.14 \pm 0.17\text{PeV}$

~consistent with fully contained simulated particle showers induced by neutral-current $\nu_{e,\mu,\tau}$ or charged-current ν_e interactions within the IceCube detector.

The observational result looks odd ..

**Expected: $0.082 \pm 0.0024^{+0.041}_{-0.057}$



~E^{-2} ??

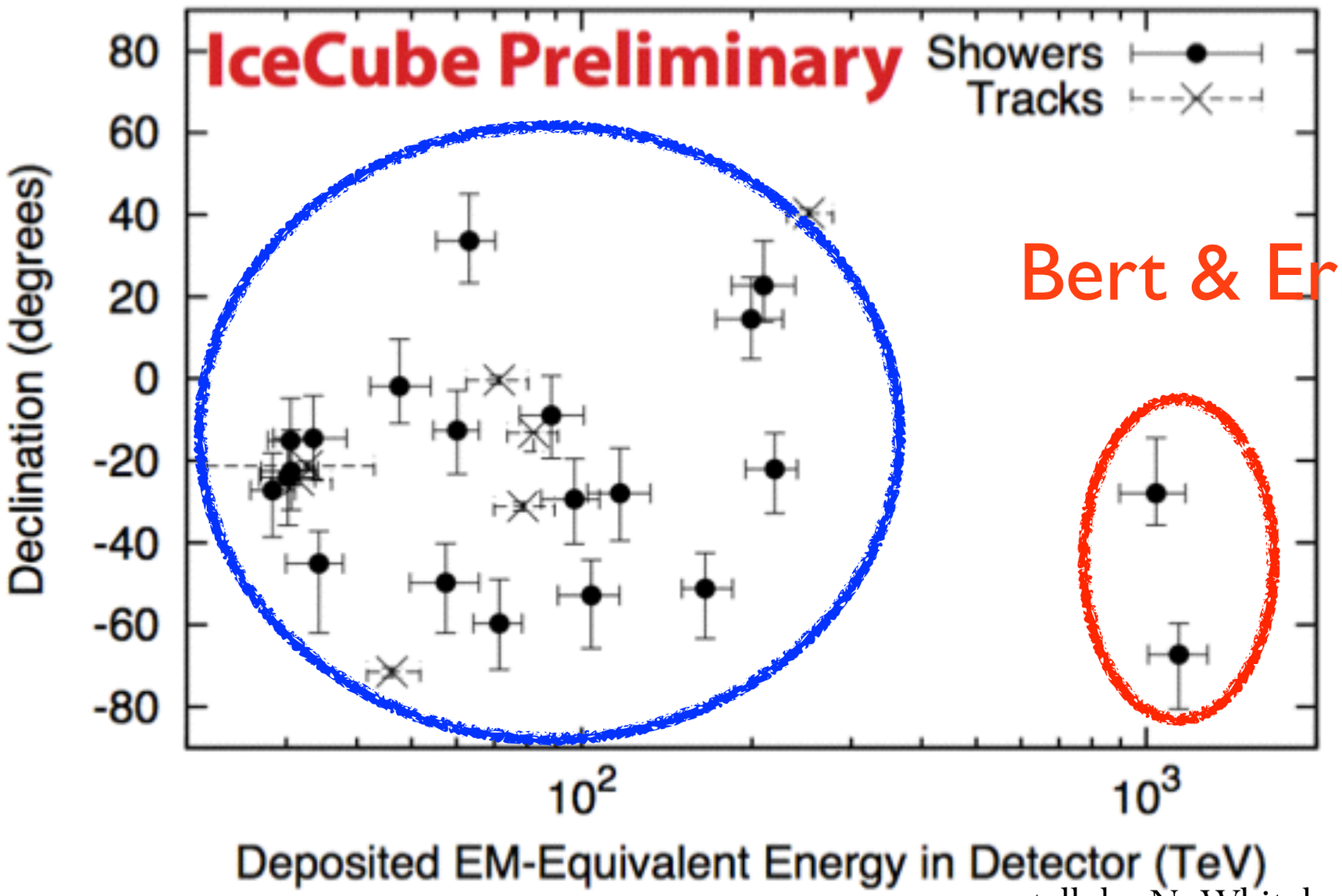
-Too low in energy for GZK

-Too high in energy for atmospheric nu.

upshot:

These events cannot be understood by known sources!

In addition,
26 more neutrinos observed in 1Tev-250Tev window,
(cf) background is 10.6+-4.5



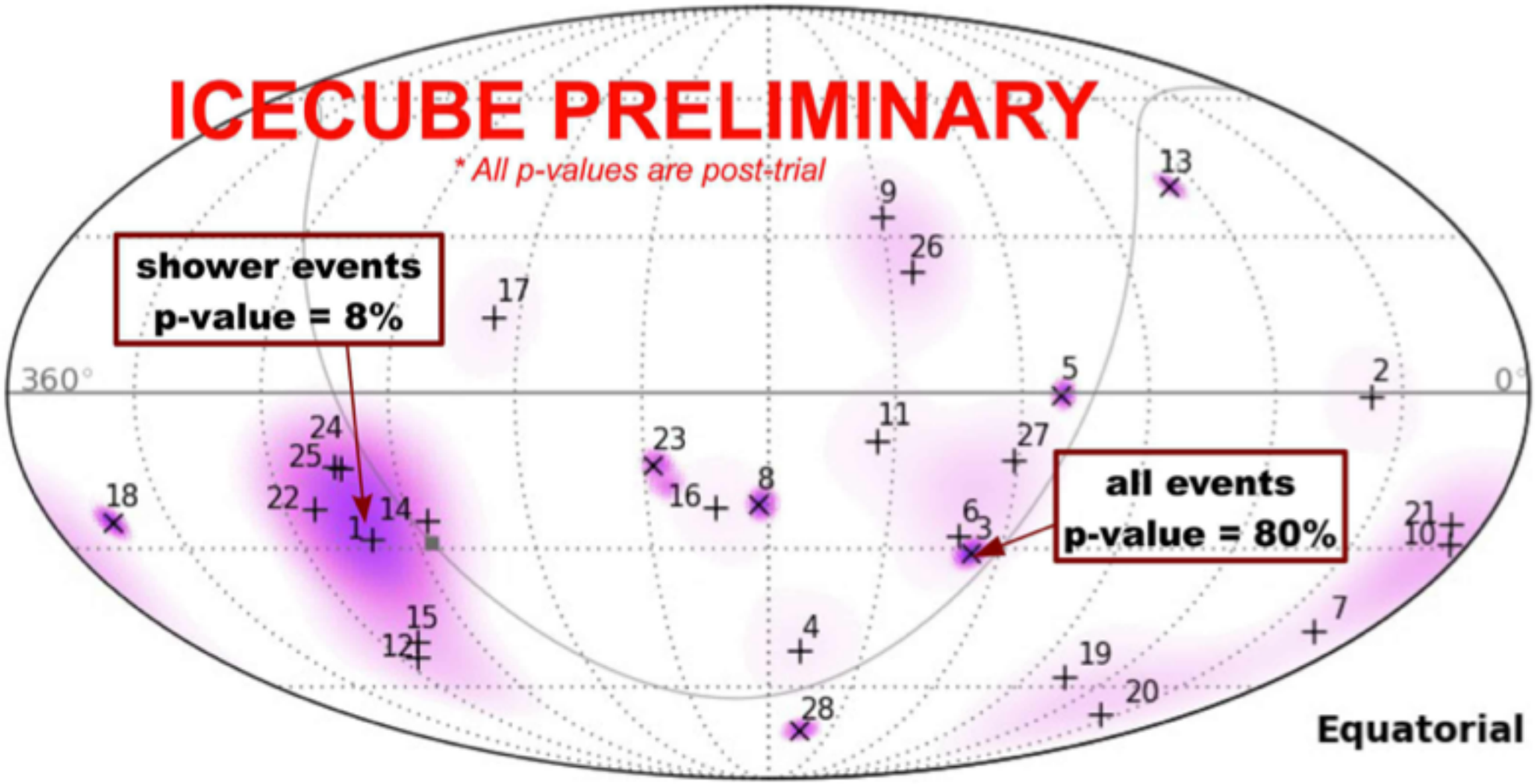
'northern sky (upgoing)'

Bert & Ernie

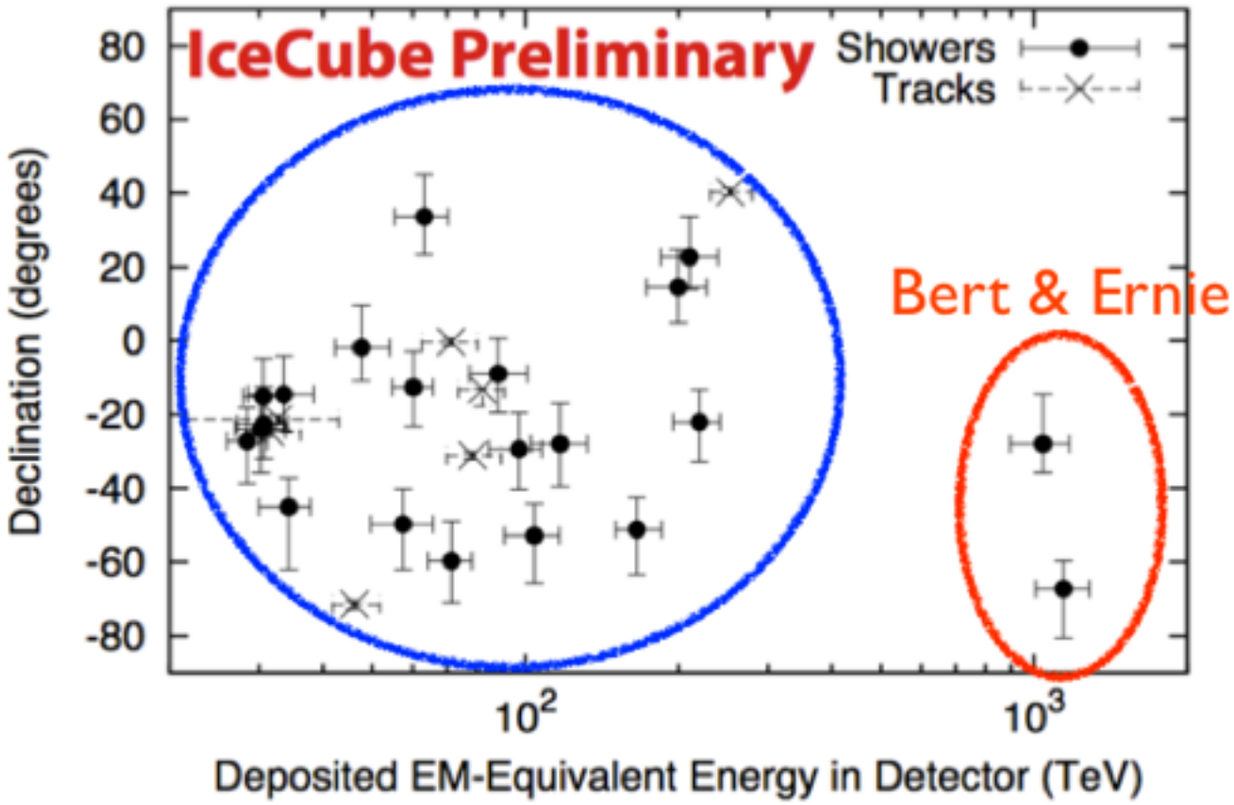
'southern sky(downgoing)'

-talk by N. Whitehorn at IPA2013

Skymap: No Significant Clustering ~not from a local source



Closer look at the DATA



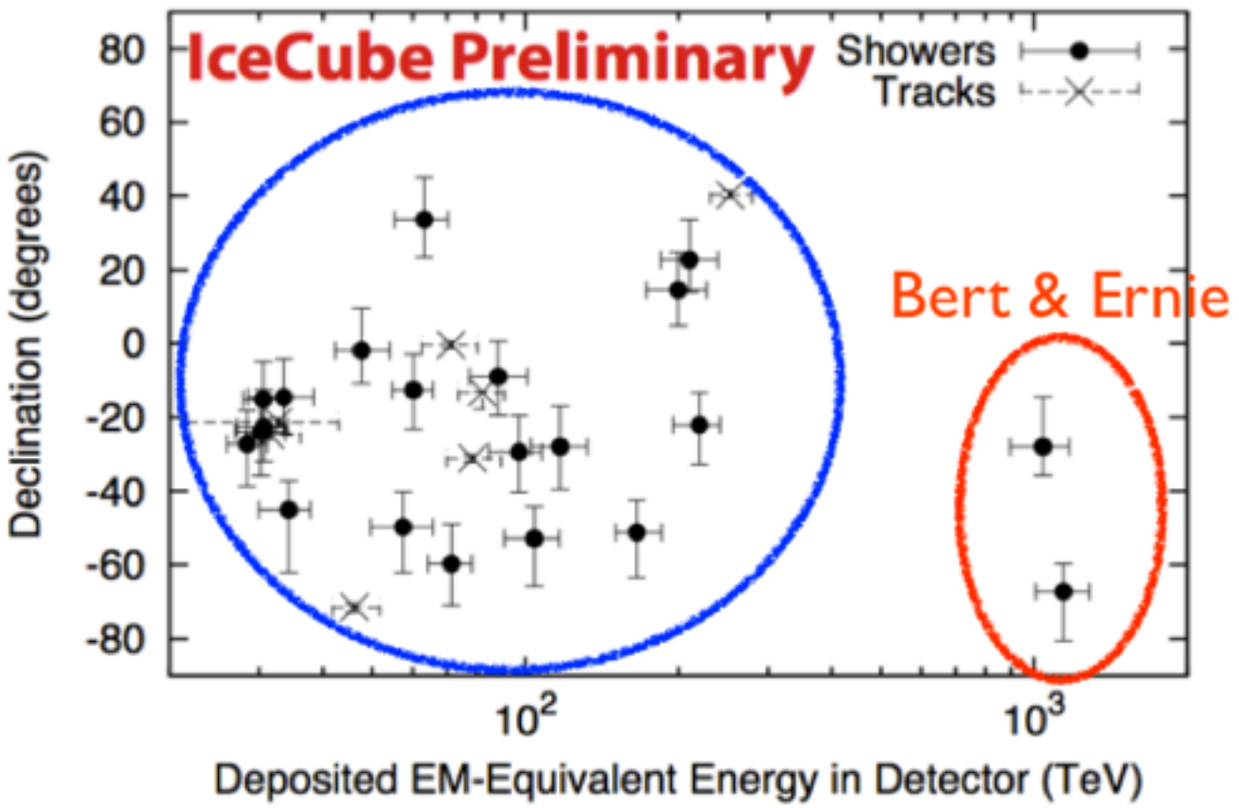
Properties of observed neutrinos

- "Continuous" in 1-250 TeV
- "Peak" at ~1 PeV
- Consistent with isotropic distribution
- 1:1:1 neutrino flavor

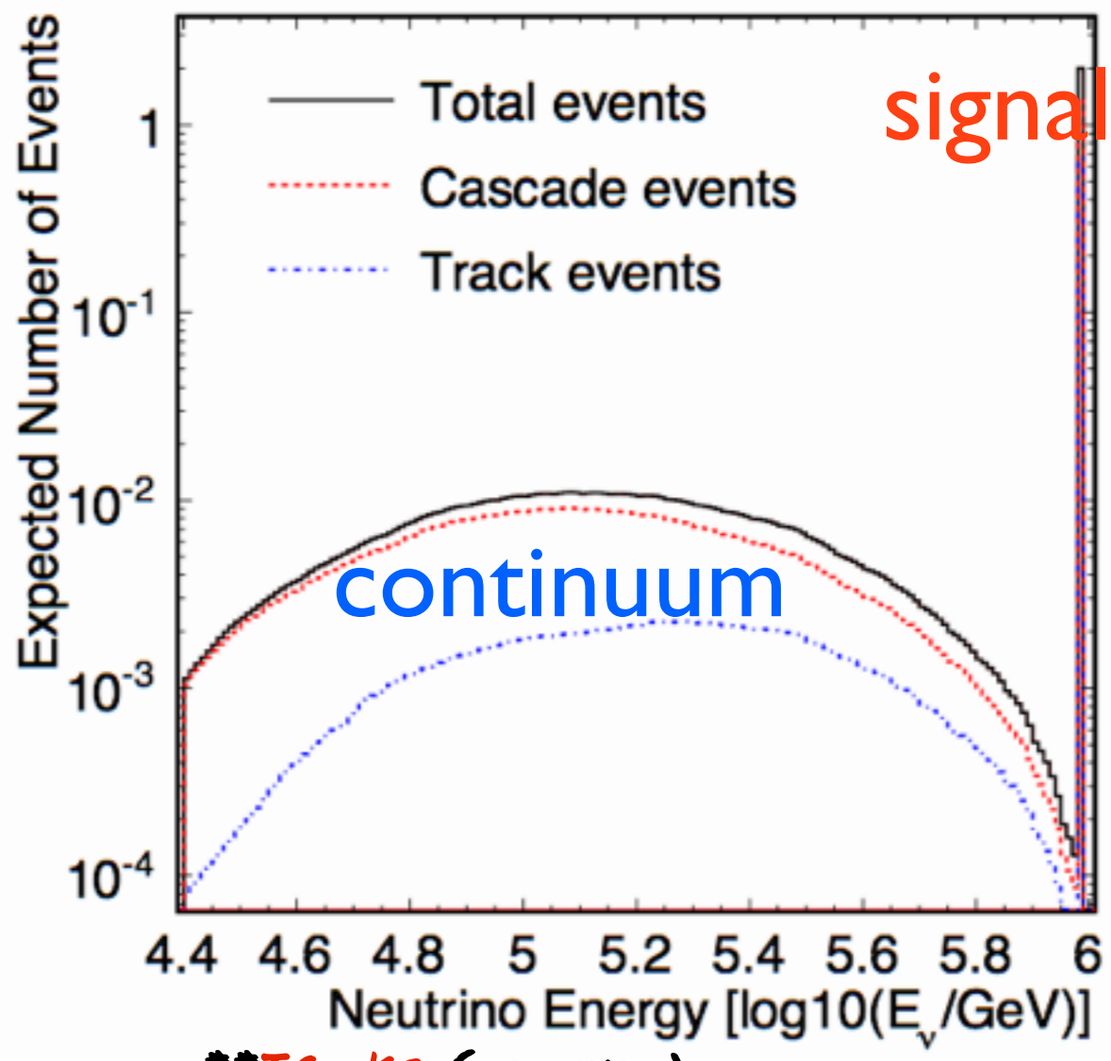
$$P(\nu_e \leftrightarrow \nu_e) = 0.56\,,$$
$$P(\nu_e \leftrightarrow \nu_\mu) = P(\nu_e \leftrightarrow \nu_\tau) = 0.22\,,$$
$$P(\nu_\mu \leftrightarrow \nu_\mu) = P(\nu_\mu \leftrightarrow \nu_\tau) = P(\nu_\tau \leftrightarrow \nu_\tau) = 0.39\,.$$

understandable since after a long enough propagation, neutrino flavor info. would disappear

The "continuum+peak" may imply particle DM!



$\chi \to \nu_L + X(\nu + \cdots)$



**Tracks (nu_mu)

**Cascades (nu_e+nu_tau)

Annihilation

[Feldman, Kusenko, Matsumoto, Yanagida]

$$\Gamma_{Events} \sim V L_{MW} n_N \sigma_N \times \left(\frac{\rho_{\rm DM}}{m_{\rm DM}}\right)^2 \langle \sigma_A v \rangle$$

with

$$\sigma_N \sim 9 \times 10^{-34} {\rm cm}^2 \quad M_{\rm DM} \sim 1 \text{ PeV}$$

$$n_N \simeq n_{\rm Ice} \simeq 5 \times 10^{23} / {\rm cm}^3$$

$$\rho_{\rm DM} \simeq 0.4 {\rm GeV}/{\rm cm}^3,$$

$$v \sim 10^{-3},$$

$$L_{\rm MW} \simeq 10 {\rm kpc}$$

$$V \simeq 1 {\rm km}^3$$

$$\sigma_A \leq 4\pi/(m_{\rm DM}^2 v^2)$$

$$\Gamma \lesssim 1 \text{ per few hundred years}$$

(essentially impossible to explain IceCube data)

Decay

[Kohri, SCP, Rott (2013)]

$$\Gamma_{\rm Events} \sim V L_{\rm MW} n_N \sigma_N \frac{\rho_{\rm DM}}{m_{\rm DM}} \Gamma_{\rm DM}$$

$\sigma_N \sim 9 \times 10^{-34} {\rm cm}^2$

$M_{\rm DM} \sim 2$ PeV

$n_N \simeq n_{\rm Ice} \simeq 5 \times 10^{23} / {\rm cm}^3$

$\rho_{\rm DM} \simeq 0.4 {\rm GeV}/{\rm cm}^3,$

$v \sim 10^{-3},$

$V \simeq 1 {\rm km}^3$

$L_{\rm MW} \simeq 10 {\rm kpc}$

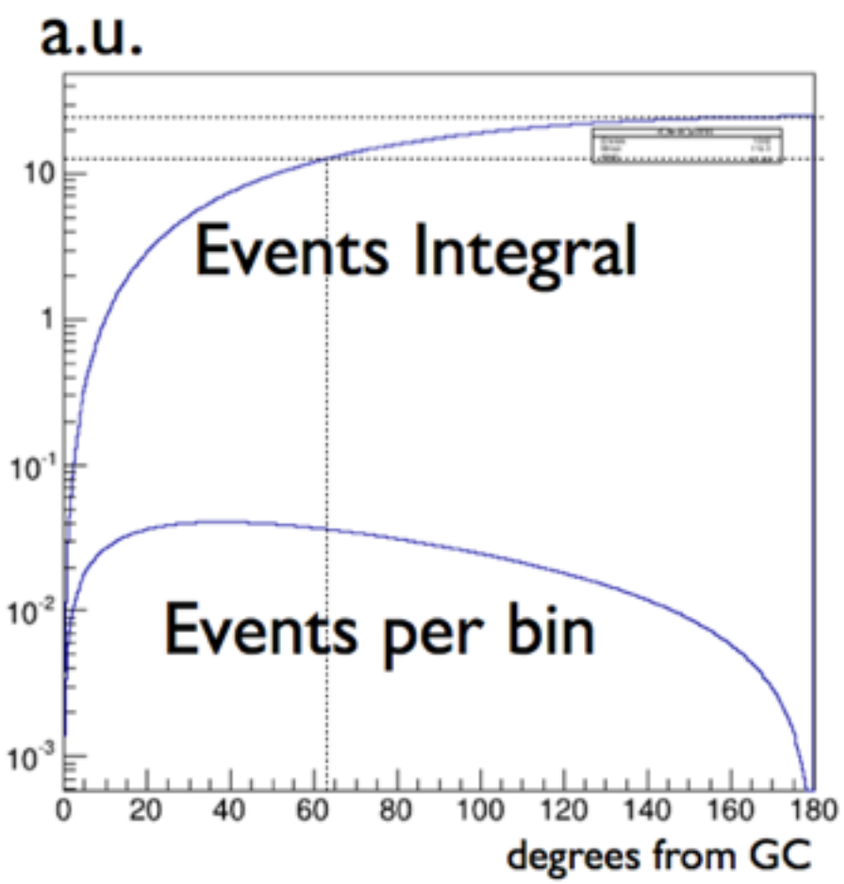
$$\tau_{\rm DM} \simeq 1.9 N_\nu \times 10^{28} {\rm sec}$$

Directional information

[Kohri, SCP, Rott (2013)]

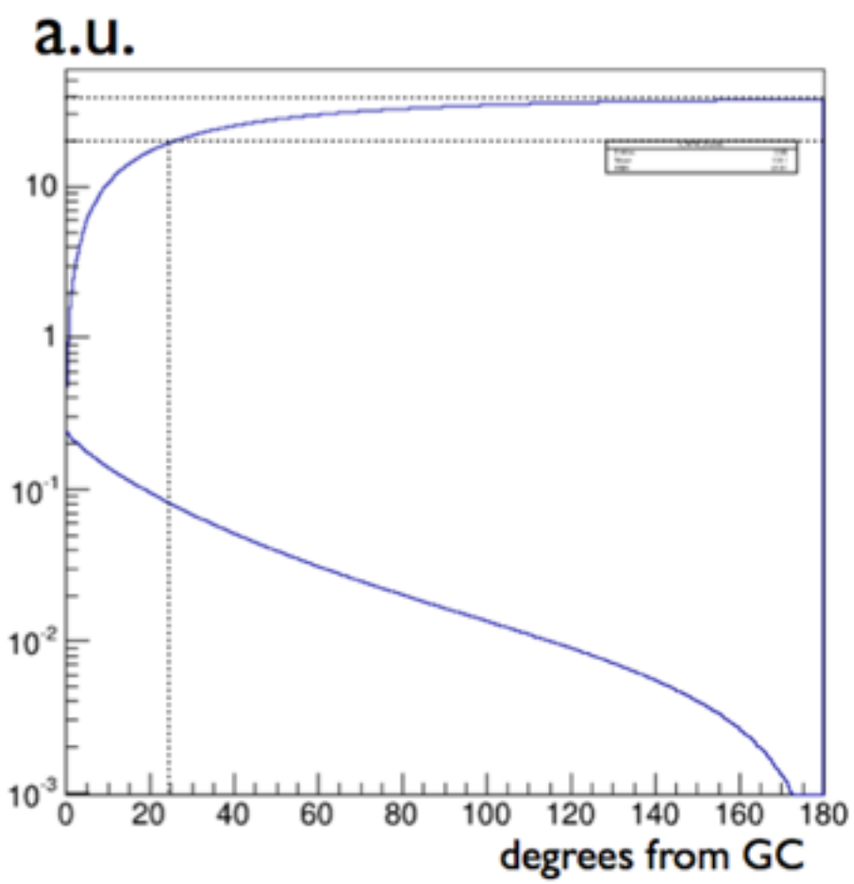
NFW Profile

Decay



50% of events within 65°

Annihilation



50% of events within 25°

Ann vs Decay

[Kohri, SCP, Rott (2013)]

Annihilating $\chi\chi \to \nu_L + X(\to \nu + \cdots)$

-less than one event/100 years with PeV DMs

-centered (50% within 25°)

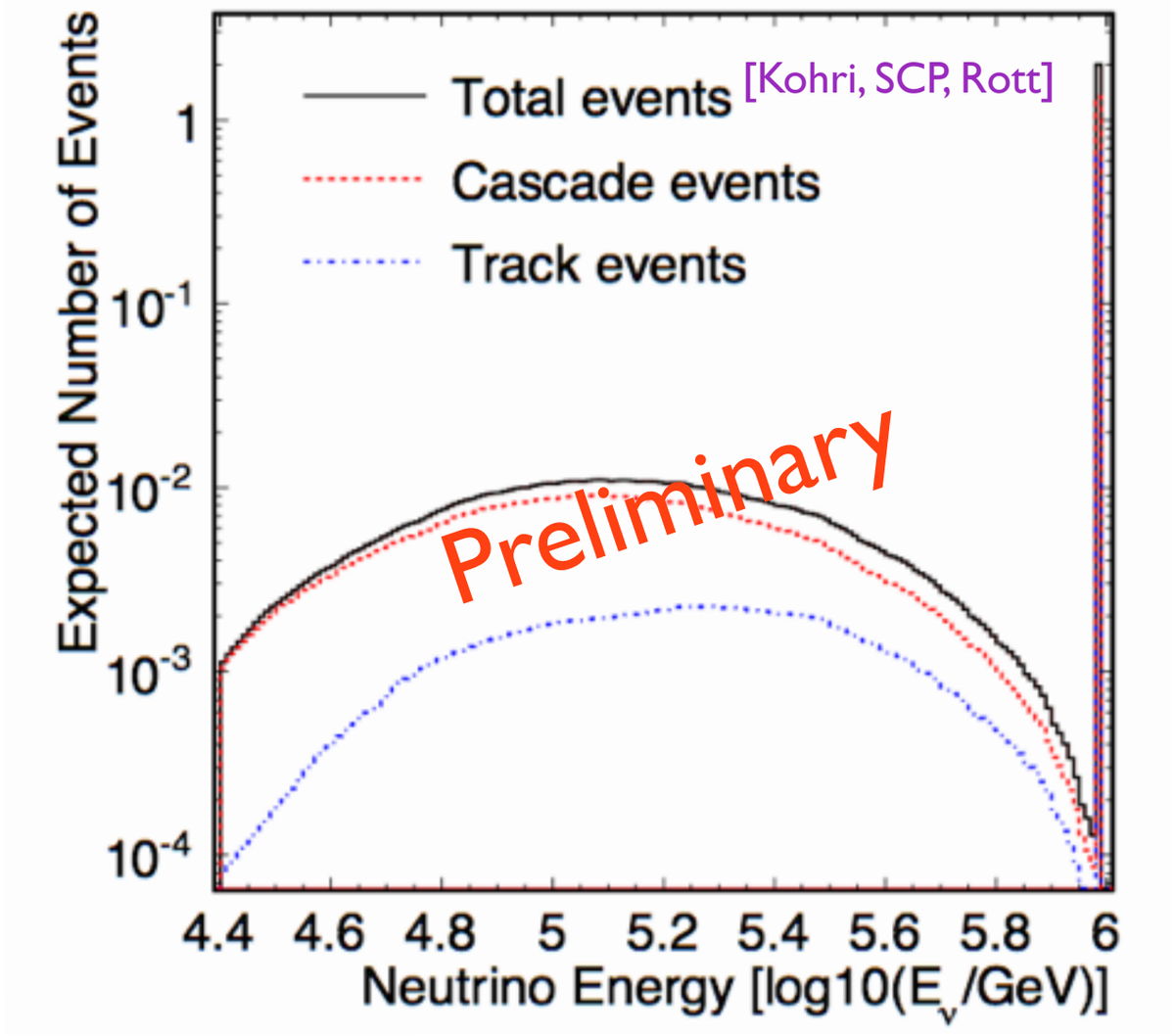
Decaying (preferred)

$\tau_\chi \sim 10^{28-29}\mathrm{sec}$ would fit the "peak"

-broadly distributed (50% within 65°)

A simple case

We consider a simple decay $\chi \to \nu_L + H$ and found it can fit the observation pretty well!



-peak by ν_L

-continuum by nu from Higgs decay

$$m_\chi = 2\mathrm{PeV}$$
$$\tau_\chi = 9.7 \times 10^{28}\mathrm{sec}$$

gives

$$N_\nu(\mathrm{PeV}) = 2.04$$

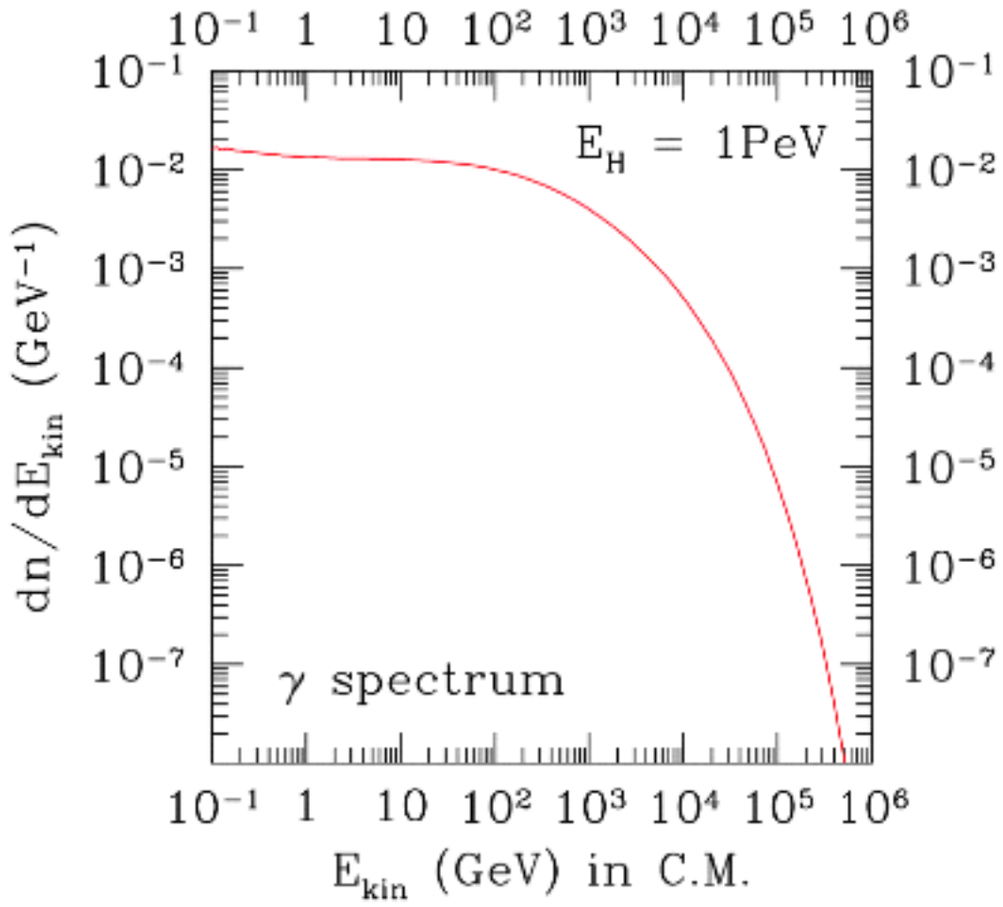
with continuum

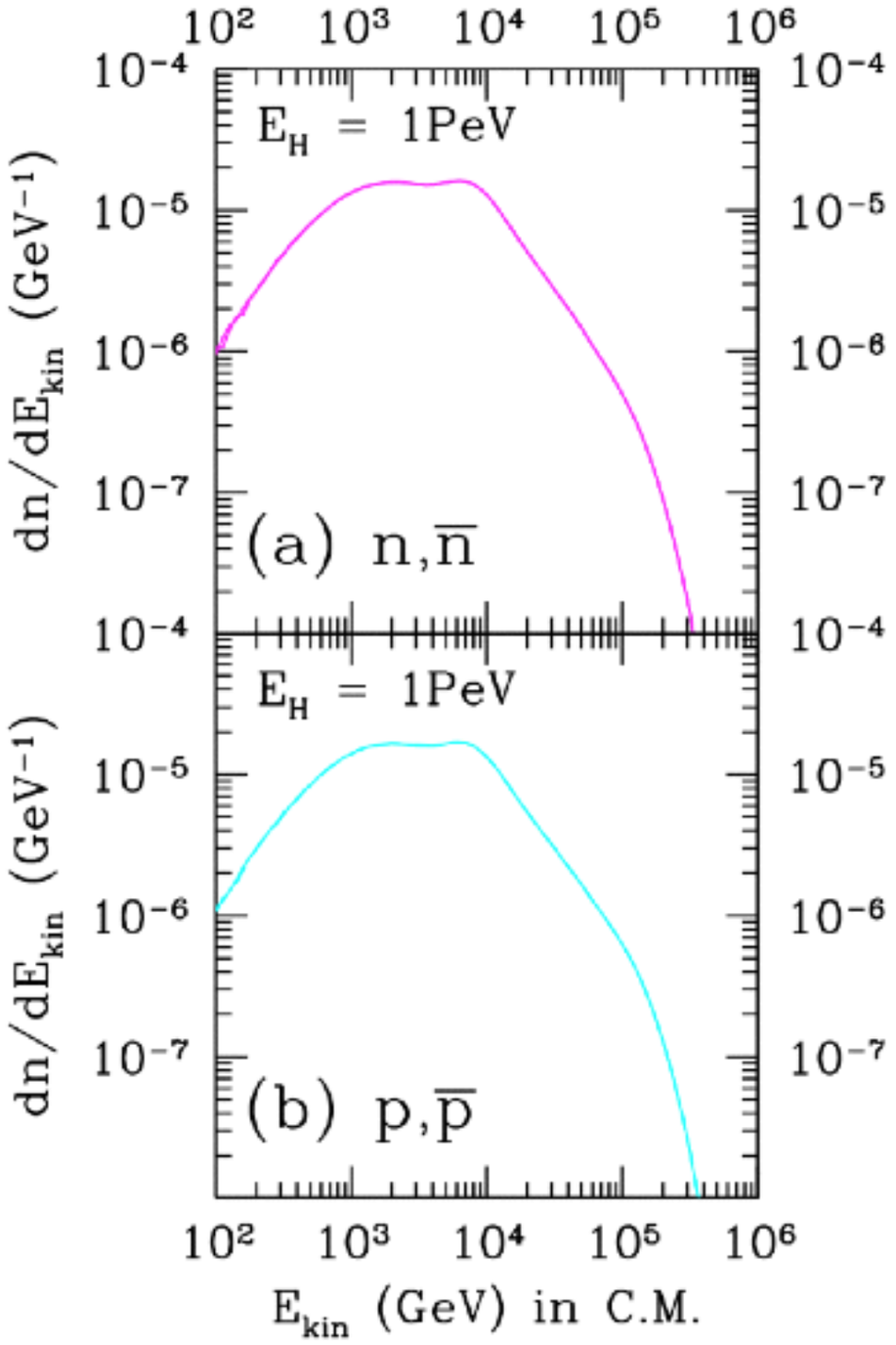
[Kohri, SCP, Rott (2013)]

**Tracks (muon neutrinos)

**Cascades (sum of electron and tau neutrino events)

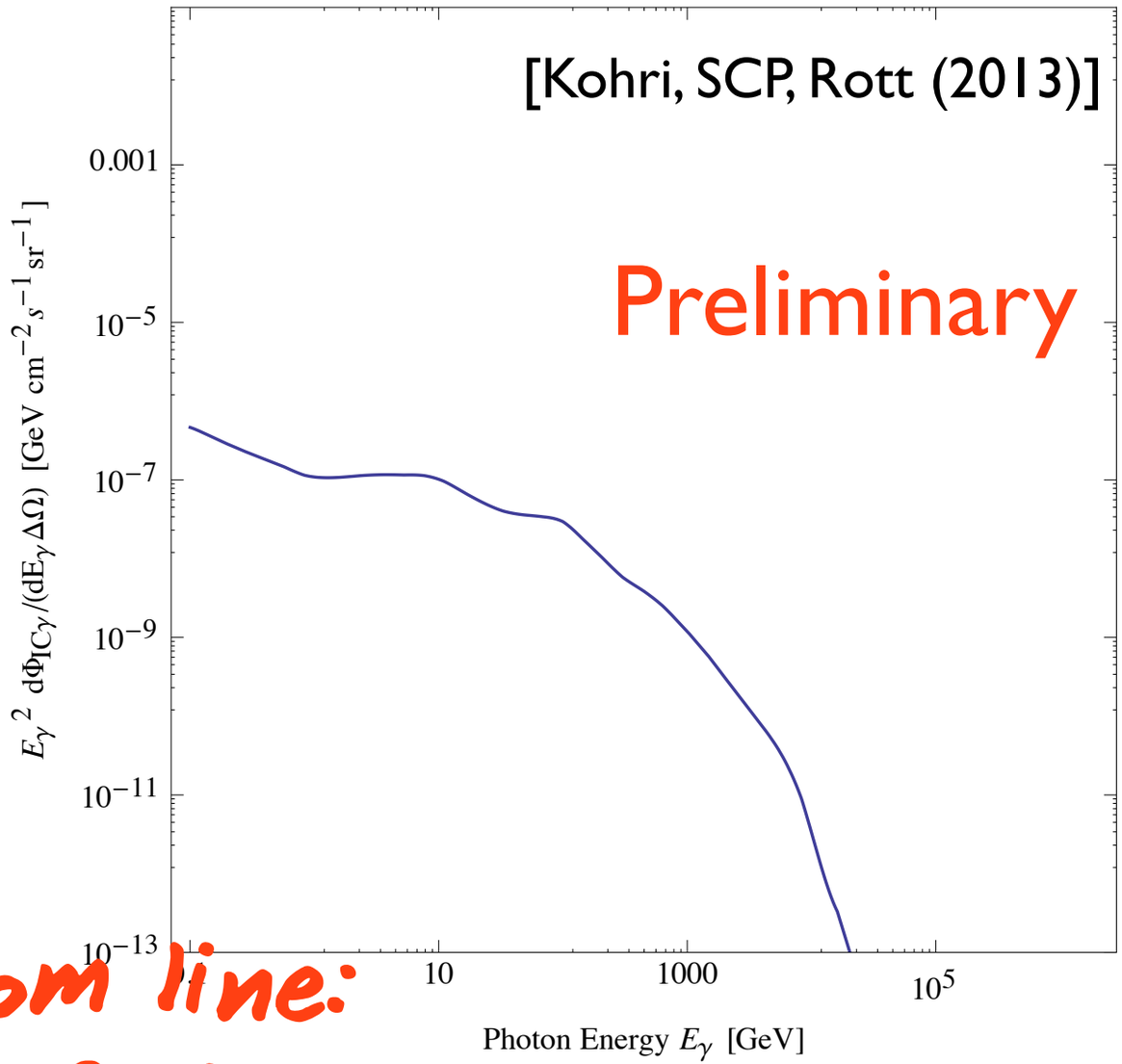
contributions to CR





*bottom line:
it looks safe in <TeV regime

gamma by ICS



*bottom line:
it looks safe in <TeV regime

Model building

$$\mathcal{L} = y\bar{\nu}Hn + \overline{(n^c, \chi)} \begin{pmatrix} M_n & \sigma \\ \sigma & M_\chi \end{pmatrix} \begin{pmatrix} n \\ \chi \end{pmatrix}$$

we can arrange

<u>seesaw mechanism + small mixing in n & DM</u>

such that DM can decay to neutrino + Higgs with a suppressed rate

$$\Gamma_{\chi \to \nu_L + H} = \frac{(y\epsilon)^2}{8\pi} M_-$$

$$\epsilon \approx -\frac{\sigma}{M_n - M_\chi} \ll 1$$

$$M_- \approx \frac{1}{2}(M_n + M_\chi) - \sqrt{\delta^2 + \sigma^2}, \delta = \frac{1}{2}(M_n - M_\chi)$$

Summary

- 1/R~O(100)Gev is fine in NMUED framework!
- Pev neutrinos at IceCube can be explained by a decaying DM model based on seesaw + small mixing.