Search for neutrinos from the Galactic Plane with ANTARES

Journée des doctorants
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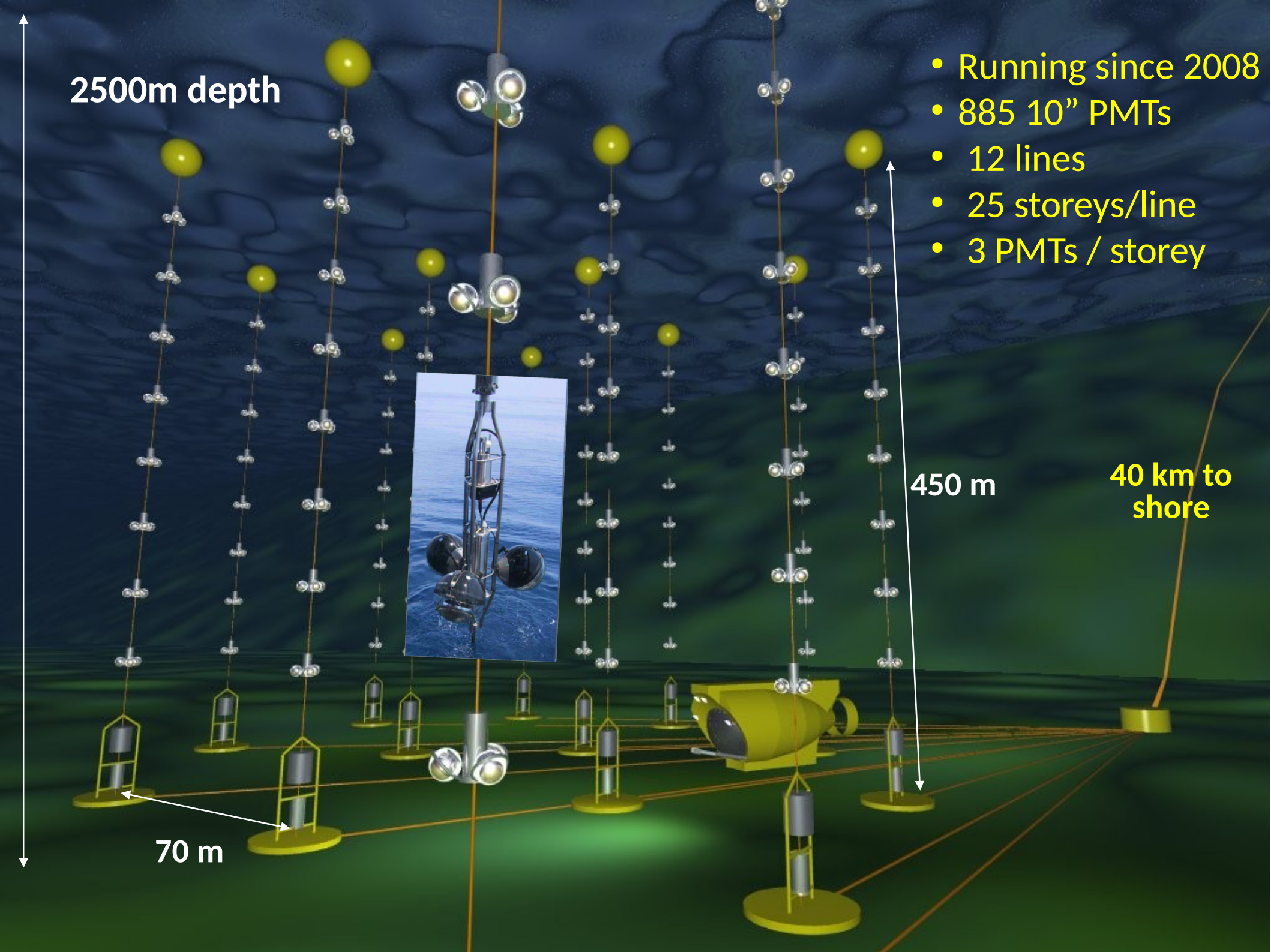
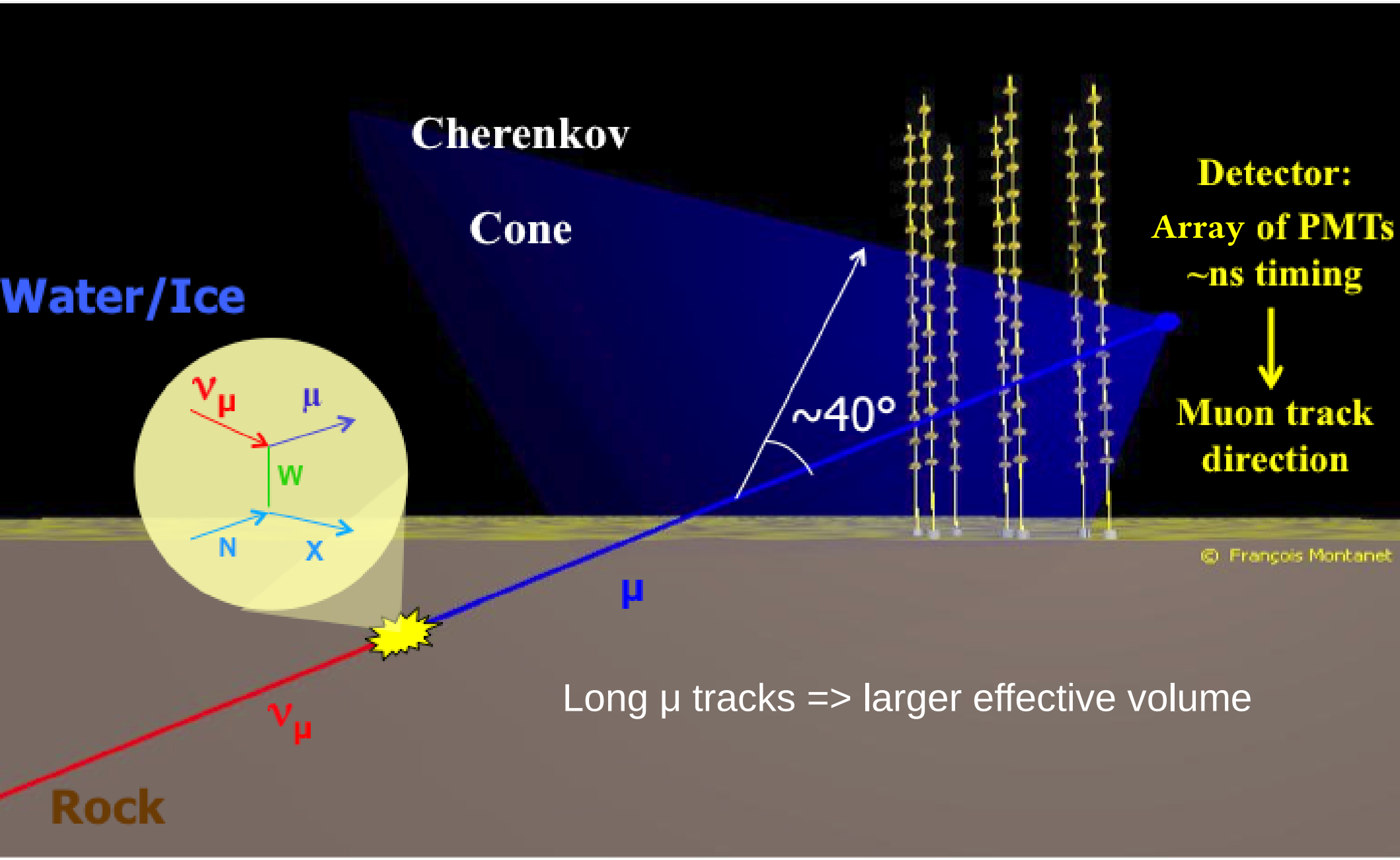
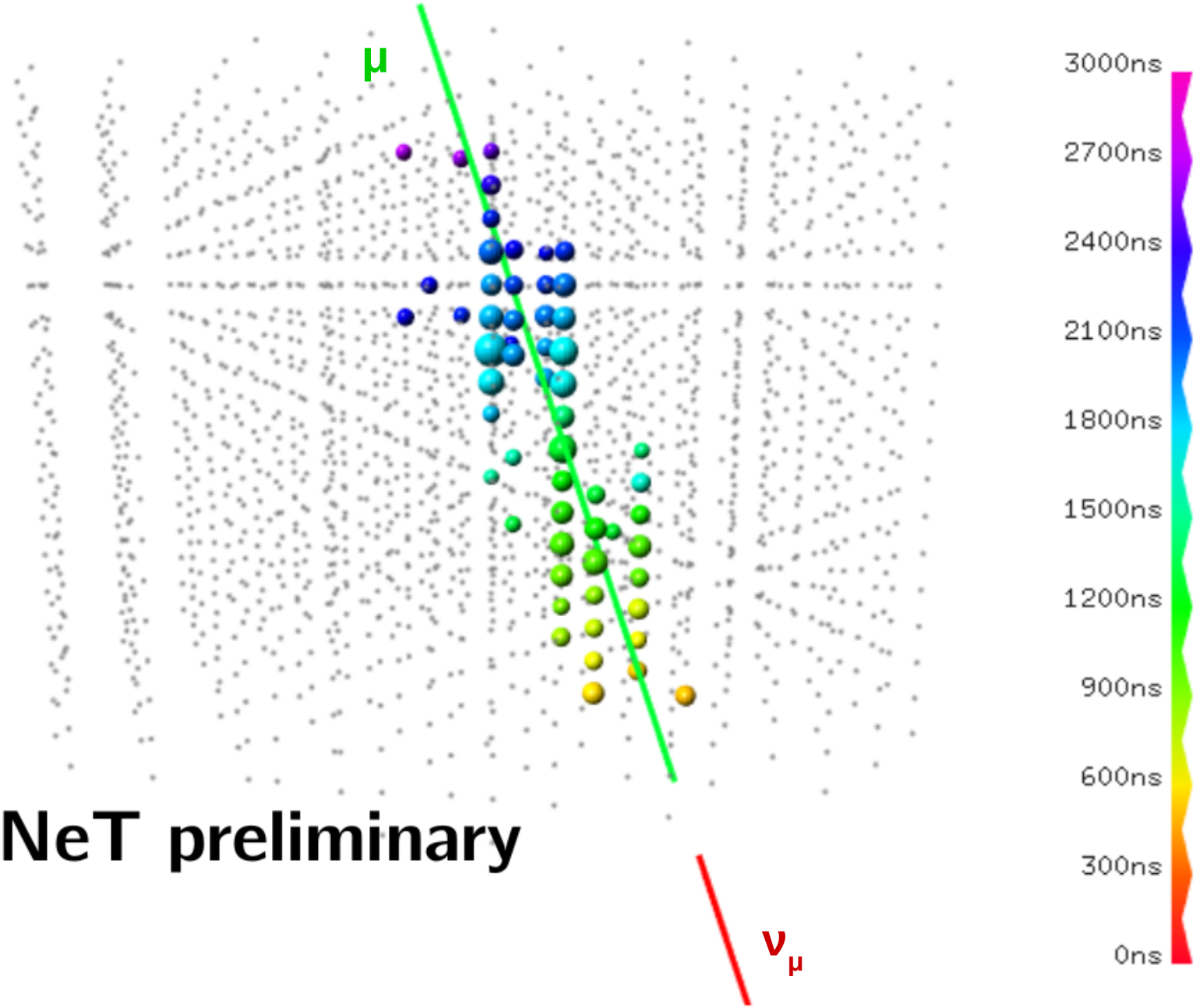

2500m depth
• Running since 2008
• 885 10” PMTs
• 12 lines
• 25 storeys/line
• 3 PMTs / storey
450 m
40 km to shore
70 m

Detection principle

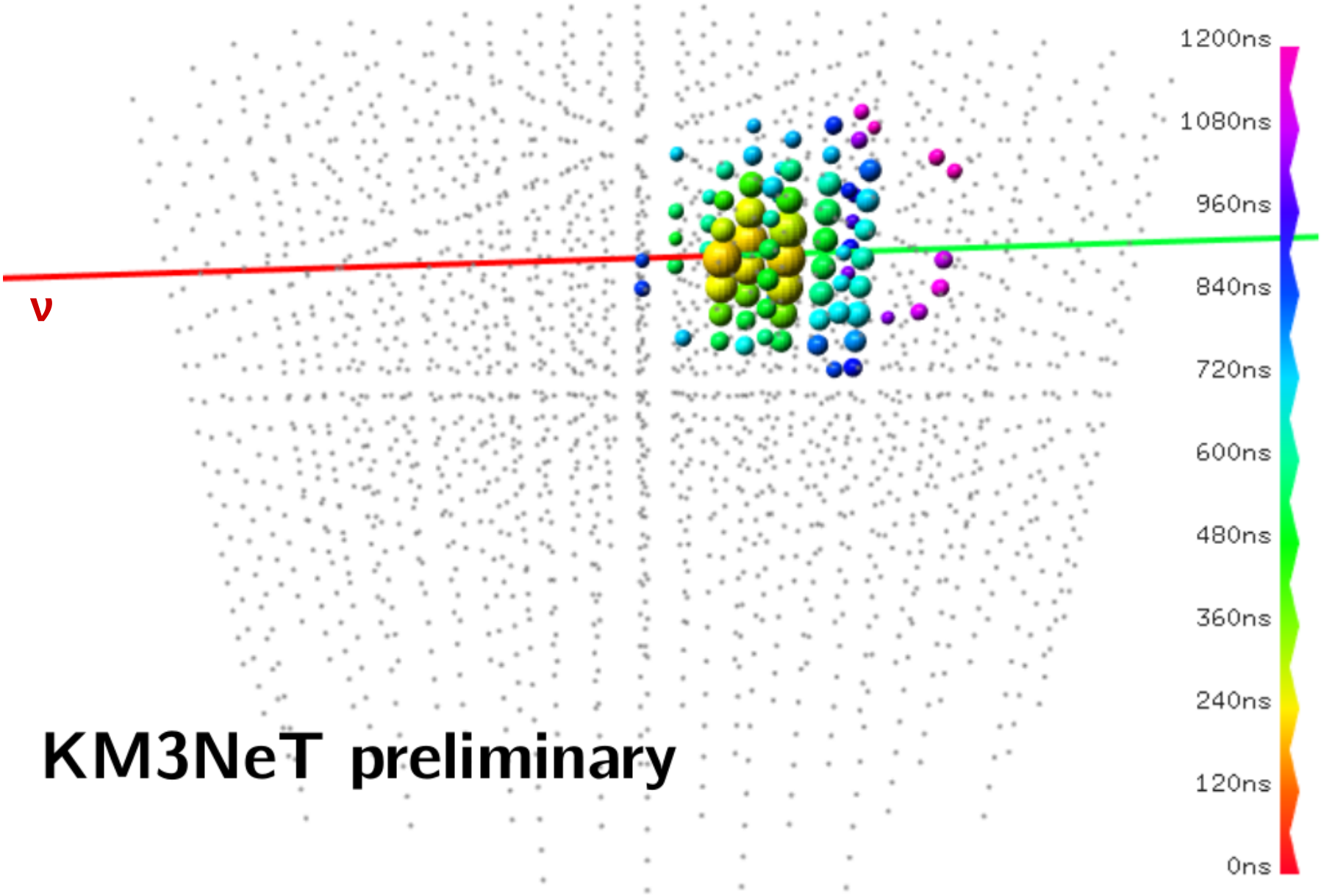


Long μ tracks => larger effective volume

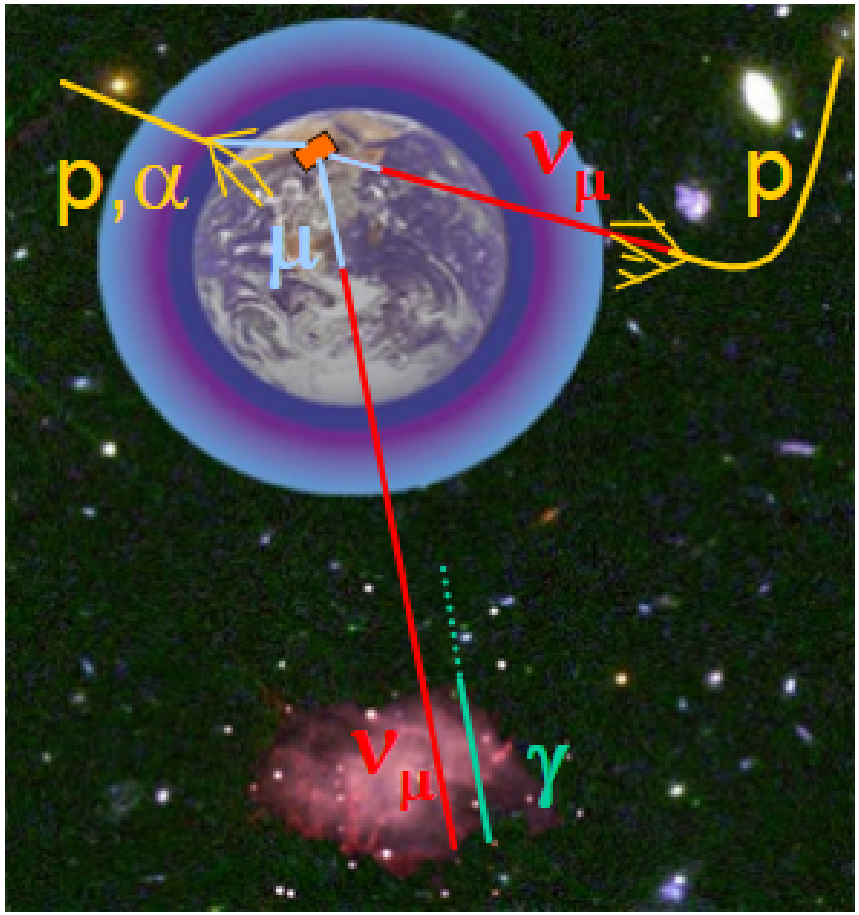
Track


μ
3000ns
2700ns
2400ns
2100ns
1800ns
1500ns
1200ns
900ns
600ns
300ns
0ns
KM3NeT preliminary
ν μ

Shower


ν
1200ns
1080ns
960ns
840ns
720ns
600ns
480ns
360ns
240ns
120ns
0ns
KM3NeT preliminary

Background



Two types of physical background

- Atmospheric muons
  - ➔ Selection of up-going events
- Atmospheric neutrinos
  - ➔ Unavoidable background

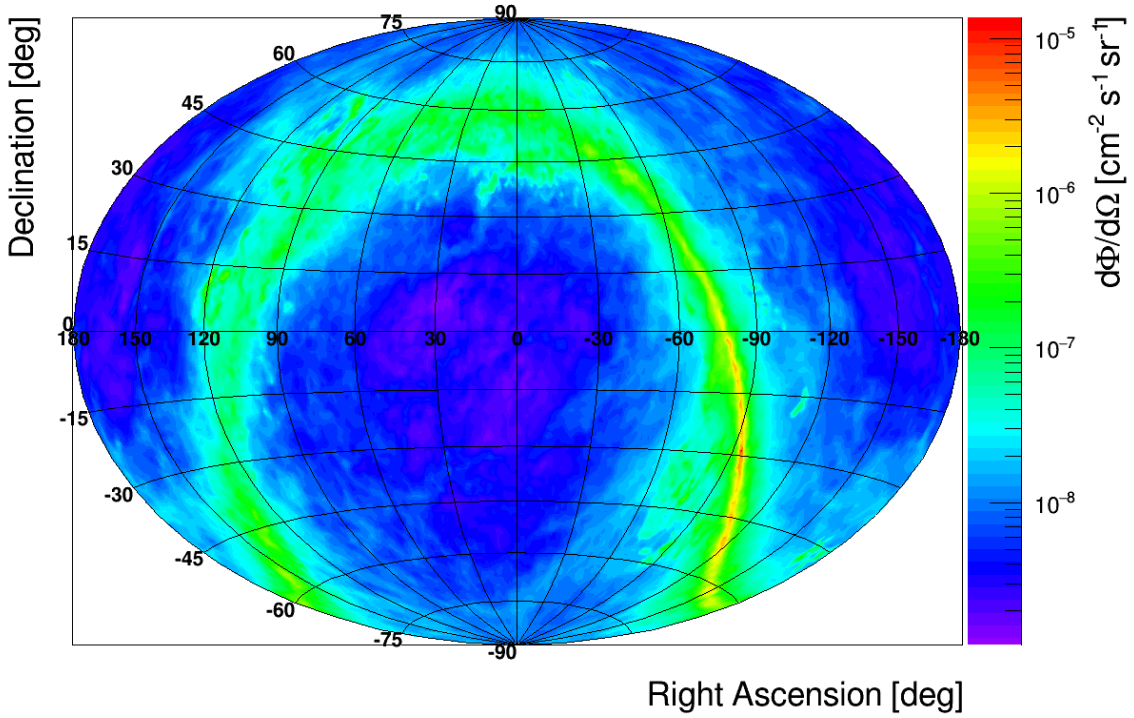
Galactic Plane analysis

Testing the **KRAγ** model:

- Phenomenological model of **Cosmic Ray diffusion** in the Galaxy
  - ➔ interaction with the medium
    - ➔ ν production

- Designed to reproduce Fermi-LAT γ-ray data and local cosmic ray observables

- Predicts the ν energy and spatial distribution on the sky:



Search Method

- Data from 2007 to 2015: tracks + **showers**
- **How likely** our data contain some **signal** with the **KRAγ** characteristics?

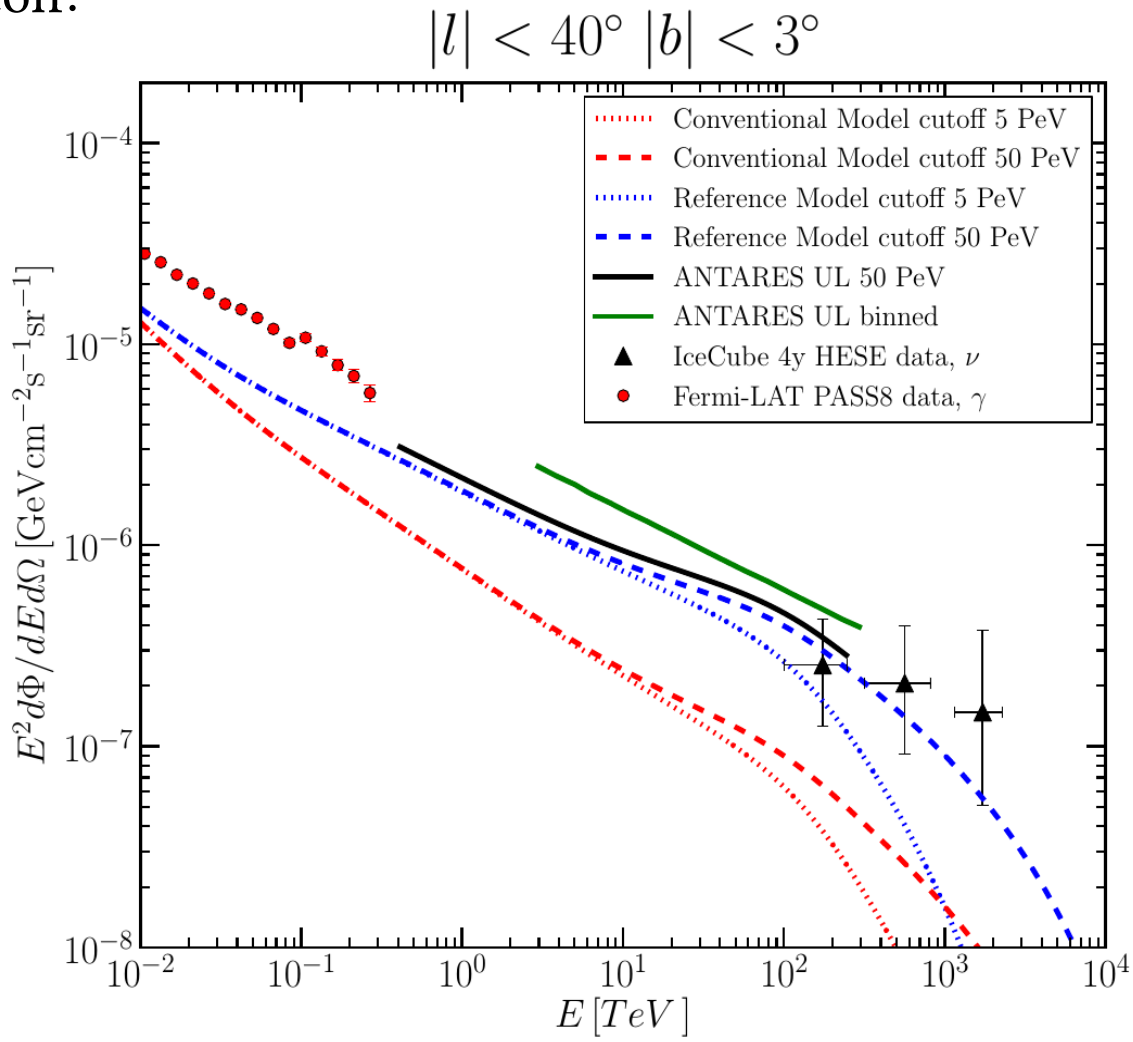
$$L_{sig+bg} = \prod_{evts} \left[n_{sig} \cdot pdf_{sig}(\alpha, \delta, E) + n_{bg} \cdot pdf_{bg}(z, \delta, E) \right]$$

- **Weight** this **against** the likelihood to have only **background**: **likelihood ratio**
- **Fit** the **number of signal** events by maximising the likelihood ratio

Results

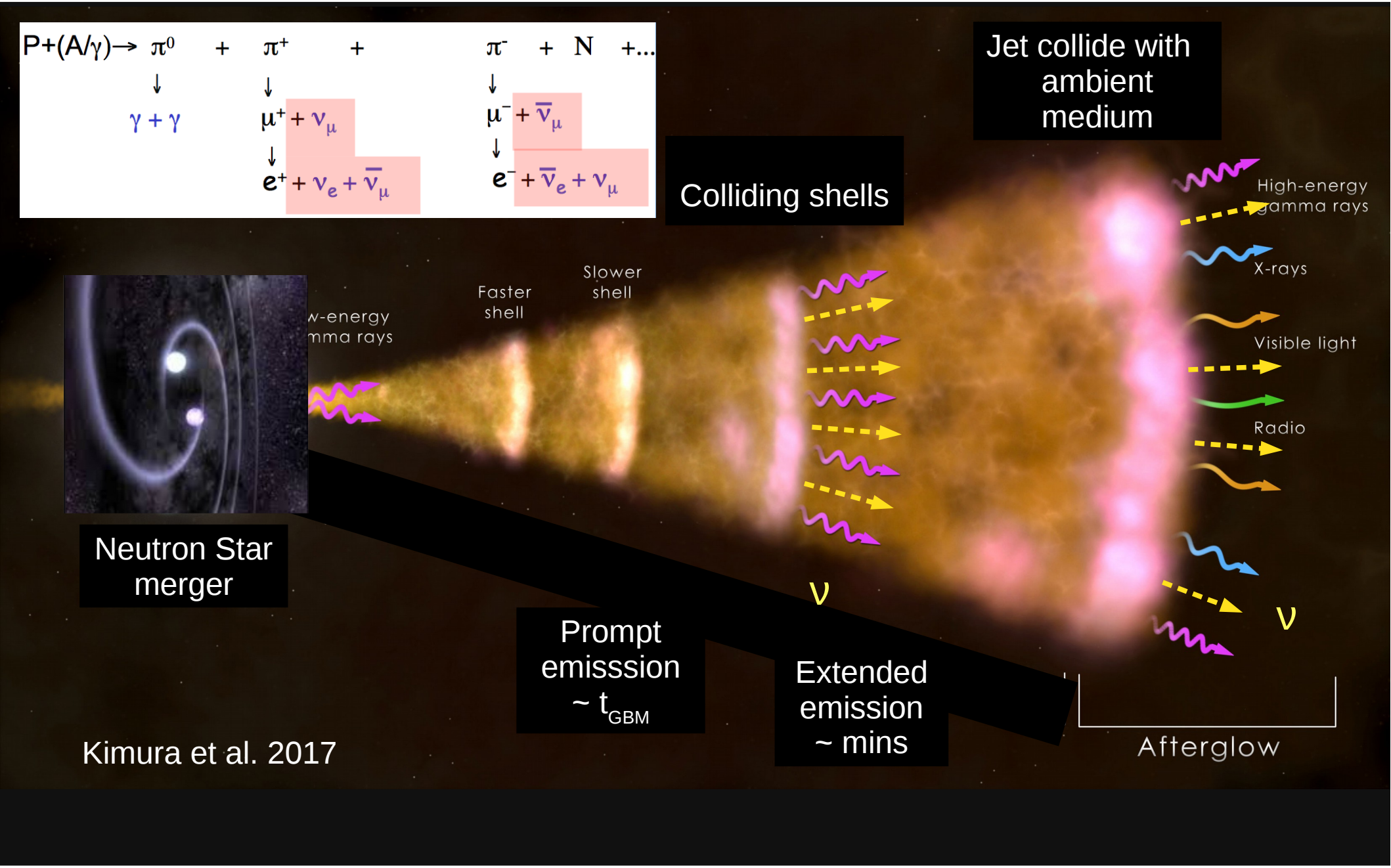
For the model with the 50 PeV cutoff:

- **13.7 signal** events expected
  ➔ **20% showers**
- **0.0 fitted tracks**
- **2.6 fitted showers**
- **UL** (90% CL) = **$1.2 \times \Phi_{KRA\gamma}$**
- To come: combination with IceCube



GWHEN

Short time-scale emissions



Long time-scale emissions

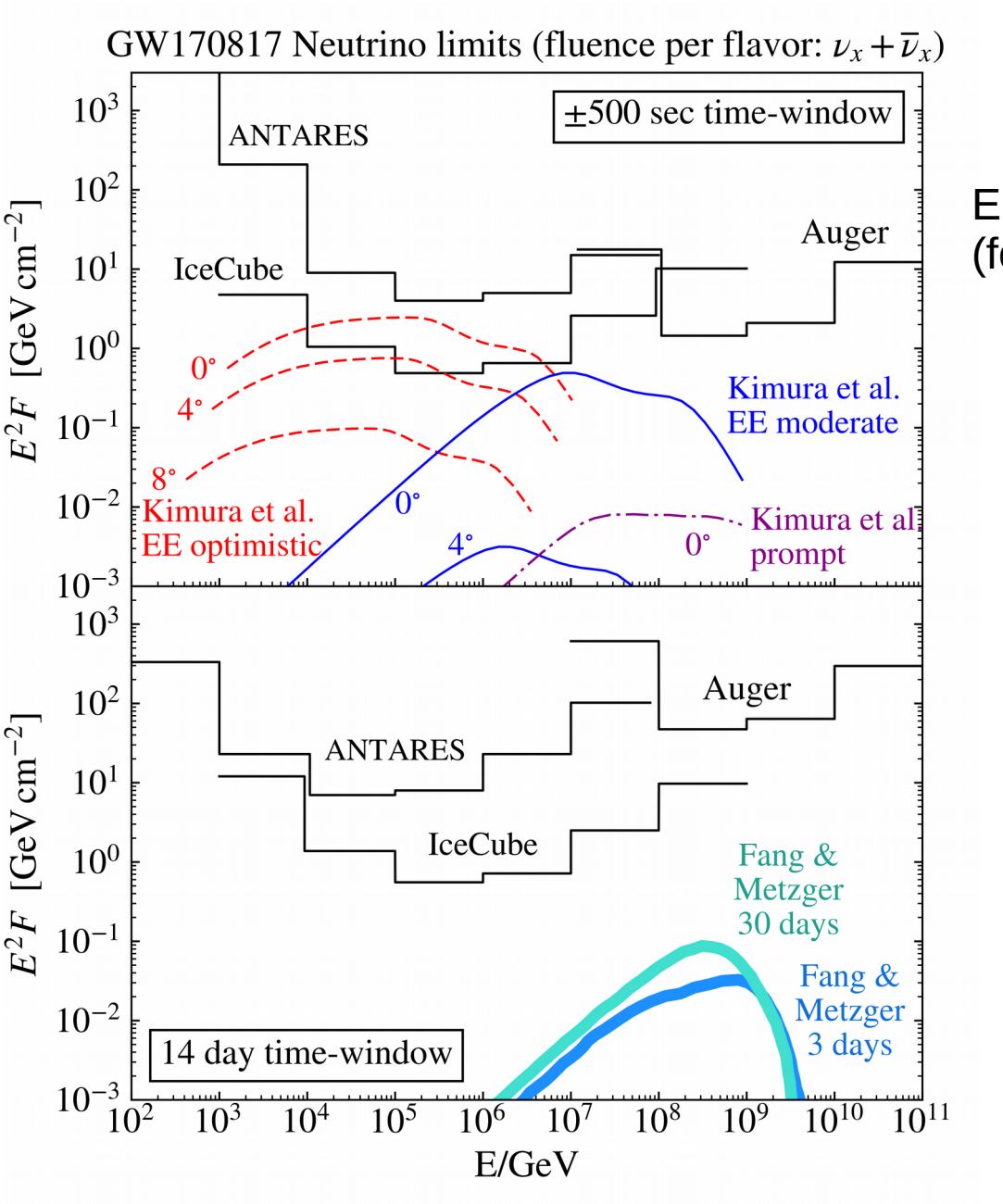
- NS-NS merger may result in **millisecond magnetar remnant** that can power a relativistic wind and UHECR acceleration
- UHECR + thick ejecta ⟶ **high energy ν** production lasting for days

"We propose that **high energy neutrinos**, with a characteristic light curve peaking days after the merger, **could provide a** comparatively "clean" **way to verify the presence of a long-lived magnetar.**" Fang & Metzger 2017

Search Method

- Look for neutrinos at the position of the event
- **Online** and **offline** follow-up
- Time windows: **± 500 seconds** and **+14 days**
- The merger was not in ANTARES field of view:
  - ➔ First **downgoing** search with ANTARES
  - ➔ First use of **showers** in GW follow-up

Results



EE: Extended emission (few minutes)

Conclusion

- No ν counterpart at the location of the event
  - ➔ Consistent with expectations from GRB observed off-axis or low luminosity GRB
  - ➔ Our limits constrain the EE optimistic scenario + on-axis viewing angle hypothesis
- A source location below the ANTARES and/or IceCube horizon would lead to a factor ~ 10 increase in sensitivity
- With more events, stacking analyses would permit to put better limits
- Neutrino detection would reduce the position uncertainty to 1 deg^2

Thank you for your attention !

Backup slides

High energy neutrino production

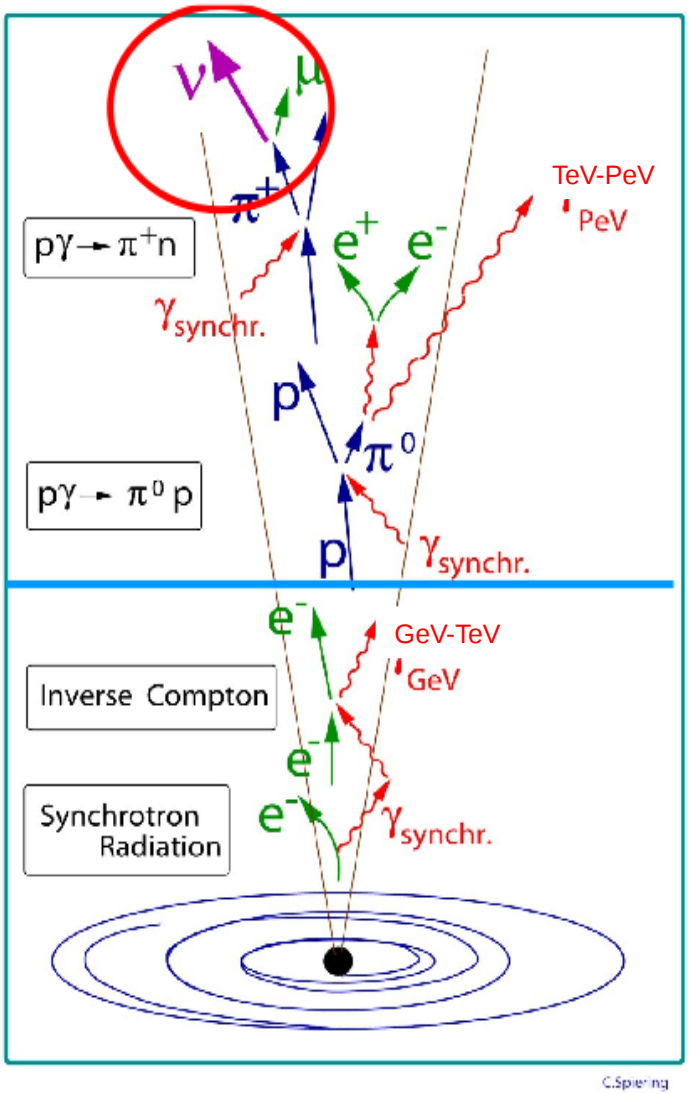
- Hadronic interaction, e.g.: relativistic jets:
- Production during acceleration or propagation

$$P+(A/\gamma) \rightarrow \pi^0 + \pi^+ + \pi^- + N + \ldots$$

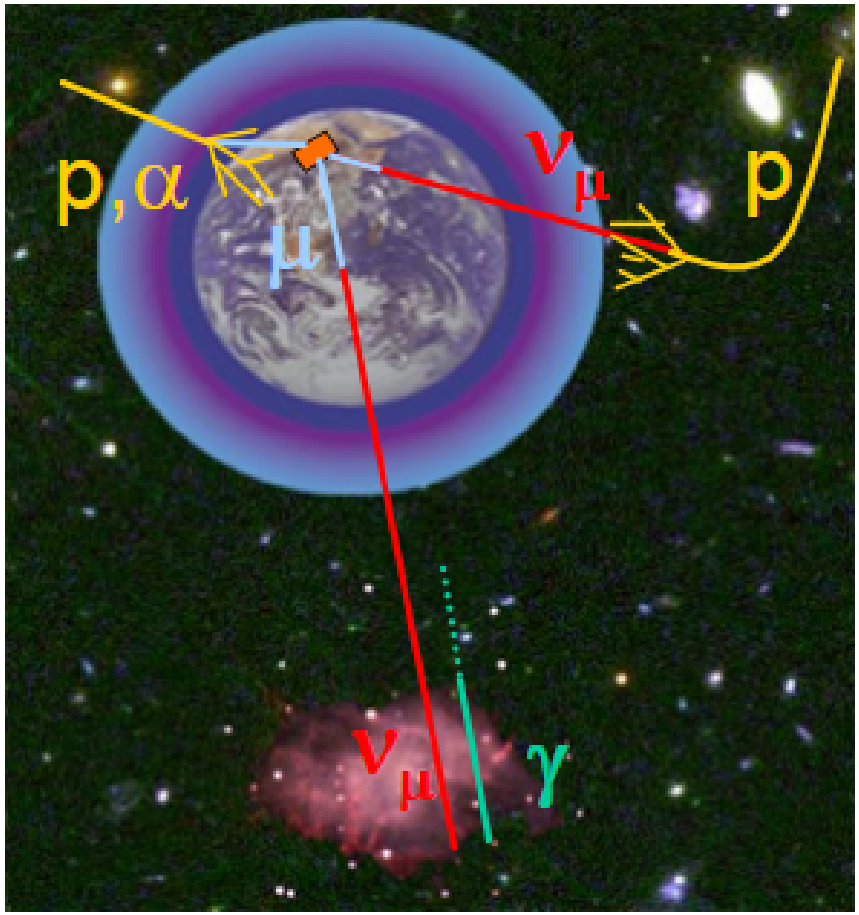
$$\pi^0 \rightarrow \gamma + \gamma$$

$$\pi^+ \rightarrow \mu^+ + \nu_\mu \rightarrow e^+ + \nu_e + \bar{\nu}_\mu$$

$$\pi^- \rightarrow \mu^- + \bar{\nu}_\mu \rightarrow e^- + \bar{\nu}_e + \nu_\mu$$



Background



Two types of physical background

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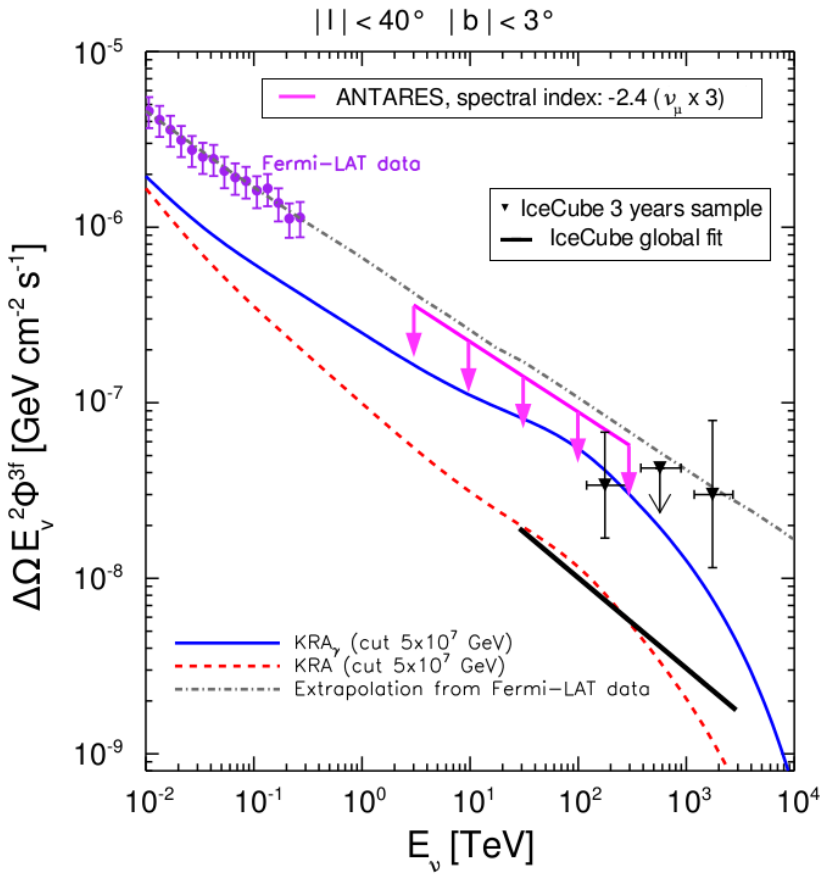
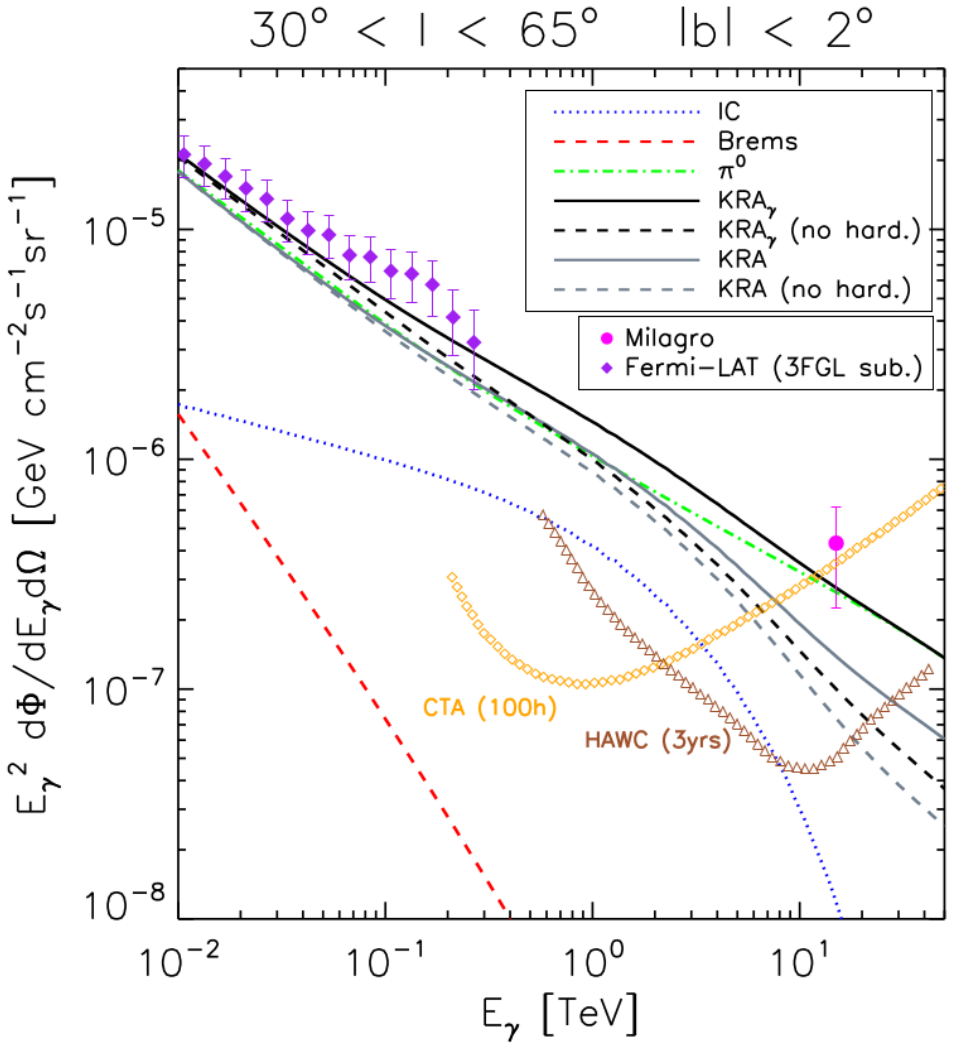
Other background

- β decay of ^{40}K
- Bioluminescence

KRAγ model


|l| < 40° |b| < 3°
ANTARES, spectral index: -2.4 (ν_μ x 3)
Fermi-LAT data
IceCube 3 years sample
IceCube global fit
KRA_γ (cut 5x10^7 GeV)
KRA (cut 5x10^7 GeV)
Extrapolation from Fermi-LAT data
ΔΩ E_ν^2 Φ^3f [GeV cm^-2 s^-1]
E_ν [TeV]


30° < l < 65° |b| < 2°
IC
Brems
π^0
KRA_γ
KRA_γ (no hard.)
KRA
KRA (no hard.)
Milagro
Fermi-LAT (3FGL sub.)
CTA (100h)
HAWC (3yrs)
E_γ^2 dΦ/dE_γdΩ [GeV cm^-2 s^-1 sr^-1]
E_γ [TeV]