

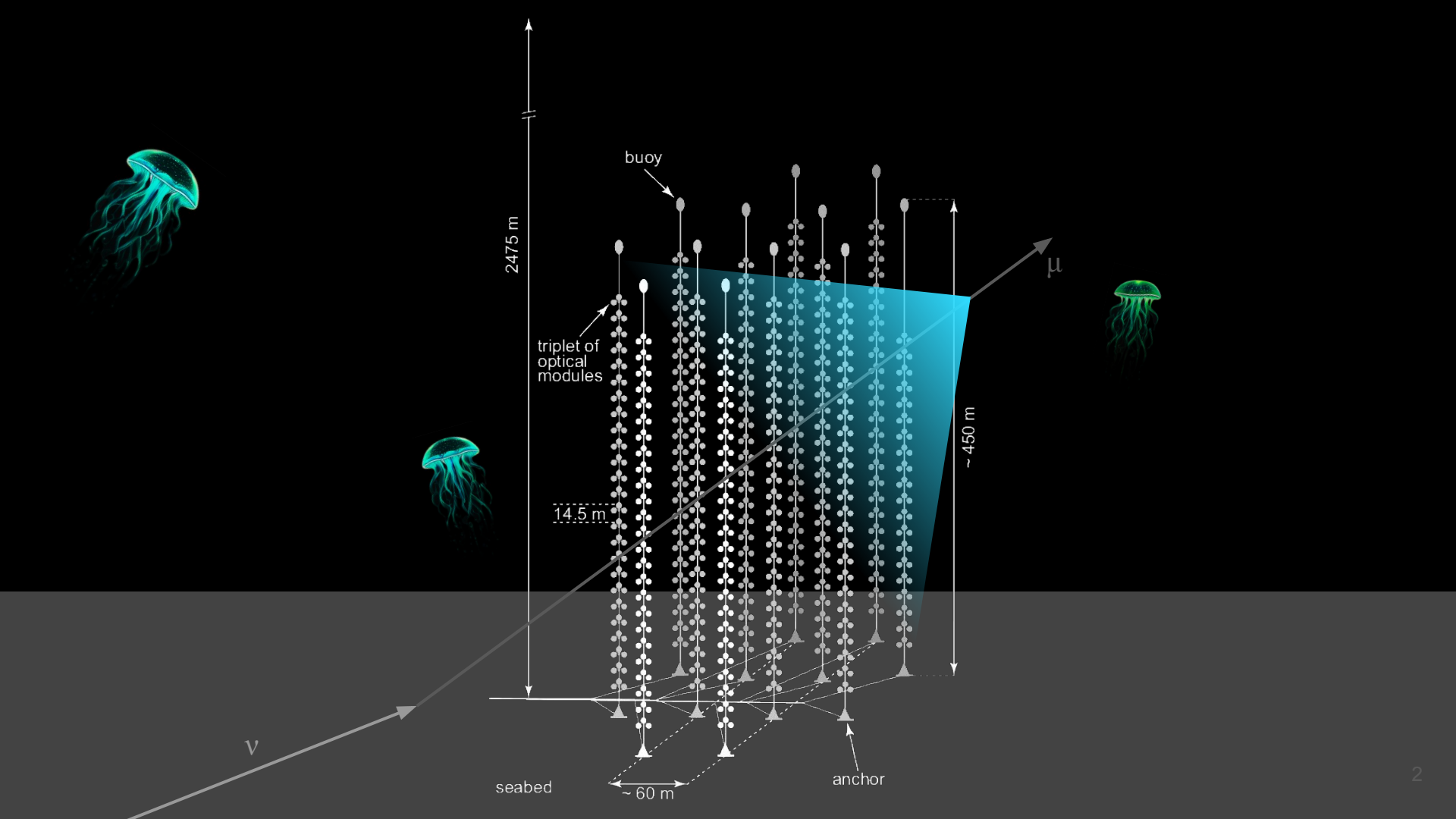


IRN Neutrino Meeting — 10/10/2024

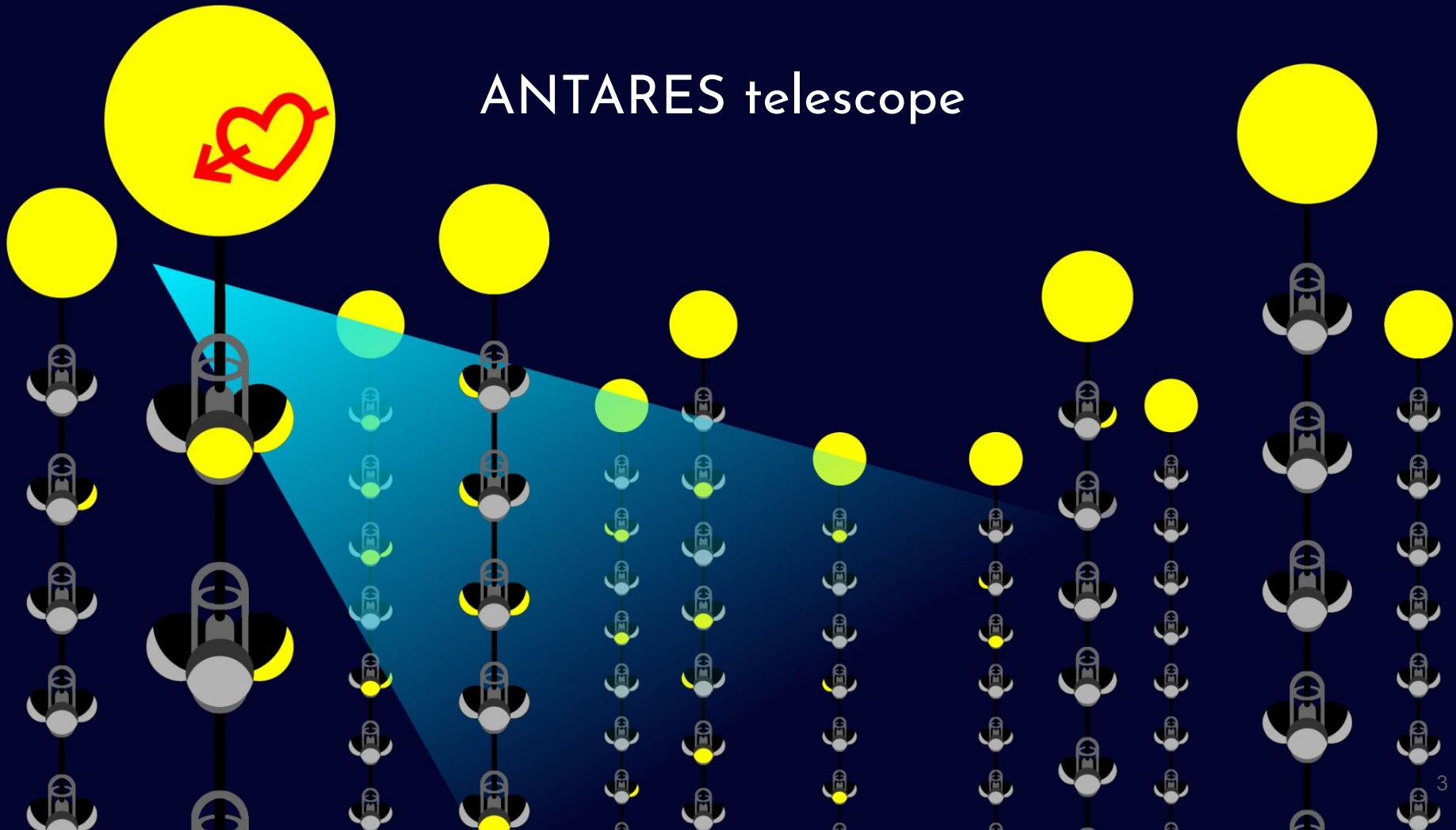
# Search for high-energy Galactic neutrinos: An ANTARES legacy

Théophile Cartraud, APC

on behalf of the ANTARES collaboration

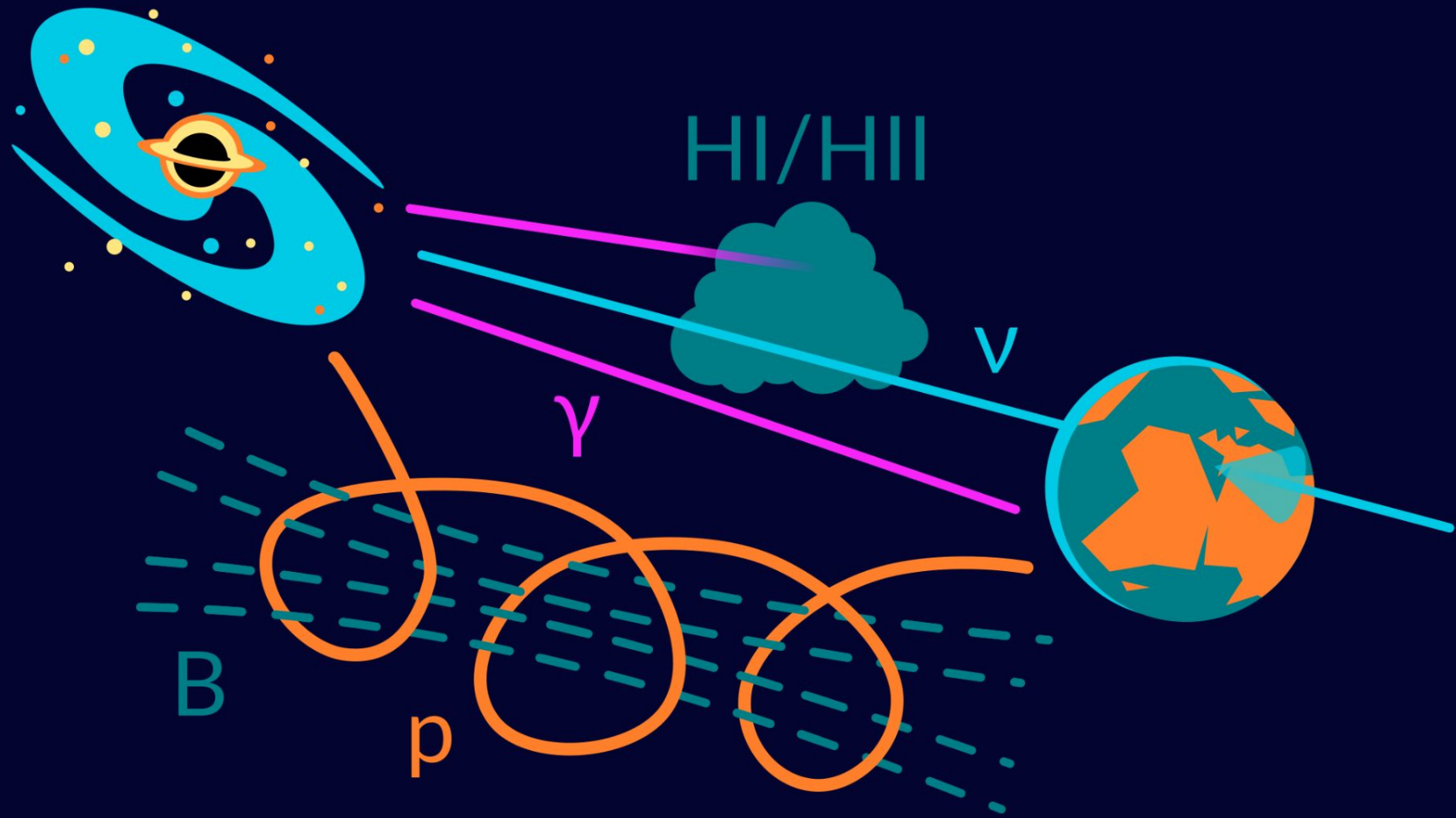


# ANTARES telescope



# ANTARES telescope

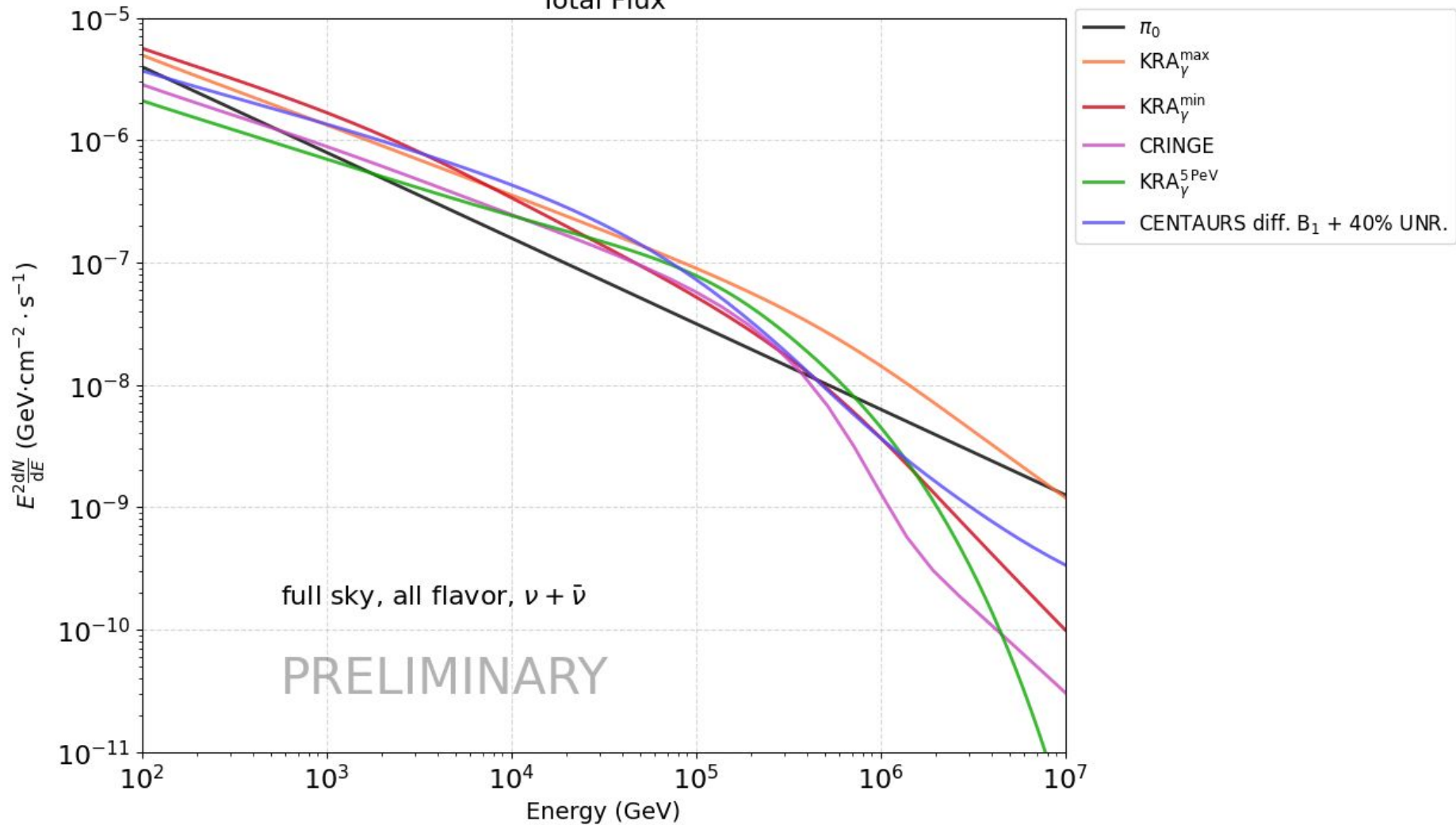
- 2007-2022.
- location: Mediterranean Sea, 40 km off-shore Toulon, France
- depth: 2475 m.
- 12 lines of 350m made of 25 triplets of optical modules.
- track and shower event topologies.

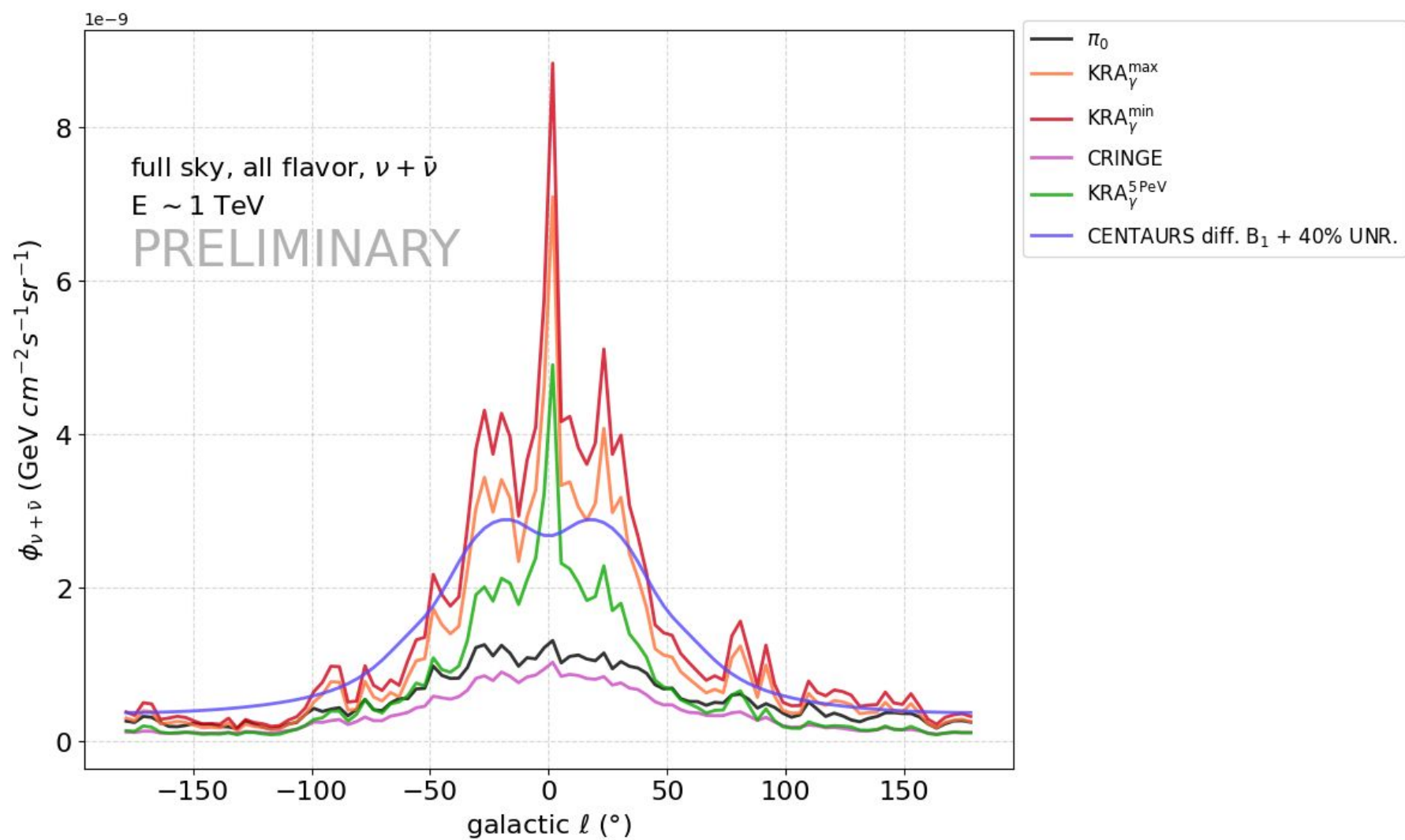


# List of models

- Galprop Fermi-LAT  $\pi_0$
- KRA $\gamma$  5 PeV
- KRA $\gamma$  max
- KRA $\gamma$  min
- CRINGE (fiducial diffuse + unresolved contribution)
- CENTAURS (diff. B1 + 40% unresolved contribution) [V. Vecchiotti et al. JCAP09 (2023)027]
- Galactic Ridge:
  - $||l| < 30^\circ, |b| < 2^\circ$
  - $\gamma = -2.45, \Phi(1 \text{ GeV}) = 7.6 \times 10^{-5} \text{ GeV}^{-1} \text{ cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1}$

## Total Flux







# Data selection

- Full ANTARES lifetime (15 years), both track and shower channels.
- Same as the most recent ANTARES diffuse flux analysis - [[A. Albert et al JCAP08\(2024\)038](#)]
- High purity: low muon contamination.
- Excellent pointing.
- 3392 track-like events.
- 187+219 shower-like events.

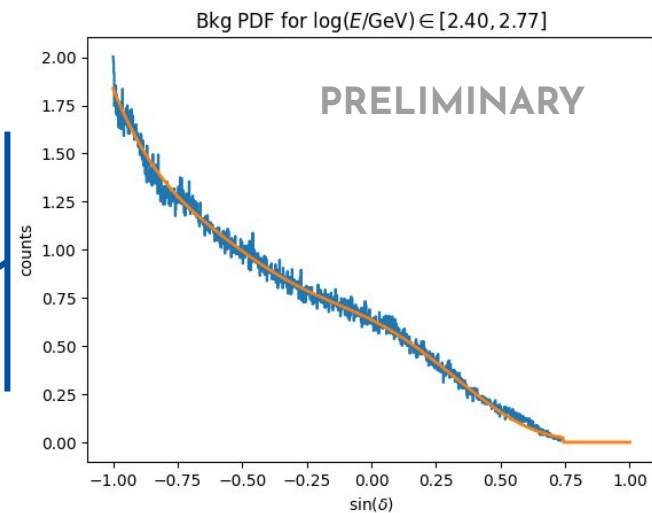
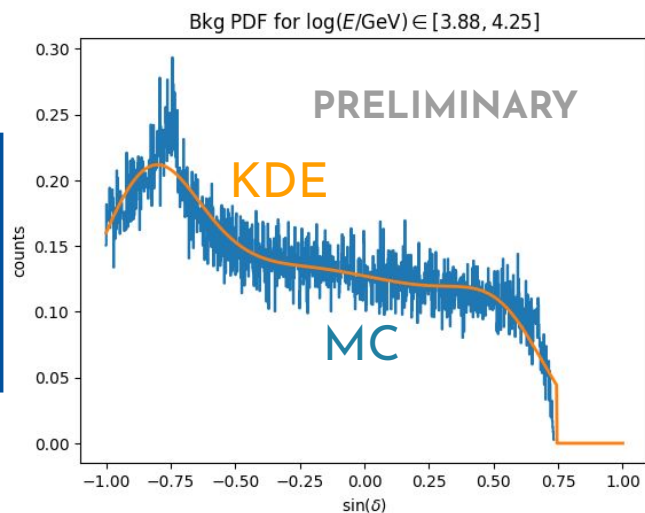
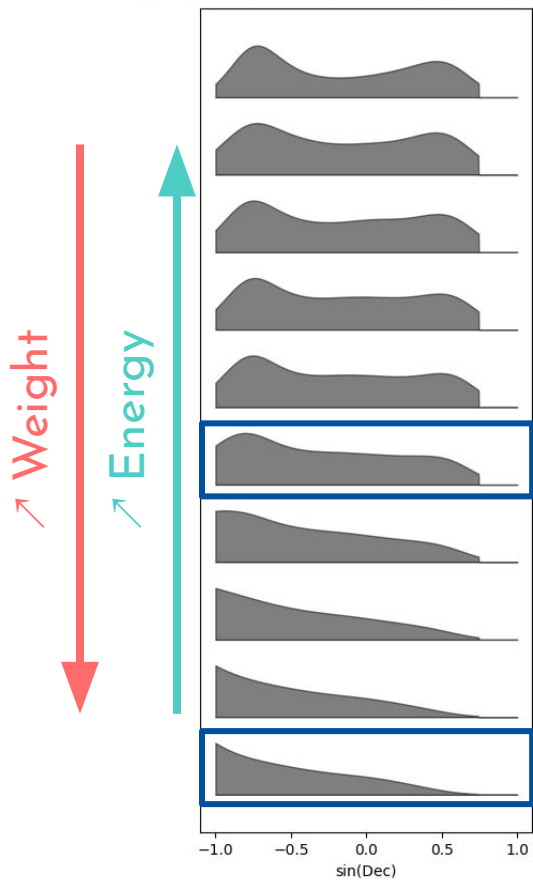
# Likelihood framework

- Unbinned extended likelihood framework
- Flux ratio  $r$
- number of events  $\mu$

$$\mathcal{L}_{H_1}(r, \boldsymbol{\mu}_b) = \sum_{i=1}^m \left\{ \sum_{j=1}^{n_i} \log [r\mu_{\text{model}}^i s_j^i + \mu_b^i b_j^i] - r\mu_{\text{model}}^i - \mu_b^i \right\}$$

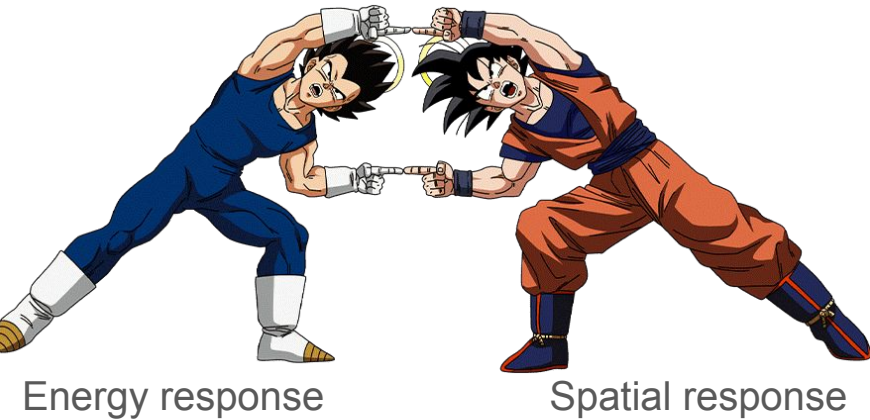
$$\mathcal{L}_{H_0}(\boldsymbol{\mu}_b) = \sum_{i=1}^m \left\{ \sum_{j=1}^{n_i} \log [\mu_b^i b_j^i] - \mu_b^i \right\}$$

# Background PDFs



# Background PDFs

- spatial shape vary highly energy
- cumulated spatial shape dominated by low energy events



$$s_j^i = f_s^i(\alpha_j^i, \delta_j^i) \cdot g_s^i(E_j^i)$$

$$b_j^i = f_b^i(\delta_j^i) \cdot g_b^i(E_j^i)$$



$$s_j^i = f_s^i(\alpha_j^i, \delta_j^i, E_j^i)$$

$$b_j^i = f_b^i(\delta_j^i, E_j^i)$$



# PDFs: Cooking recipe

- data  $\rightarrow$  MC [more statistics]

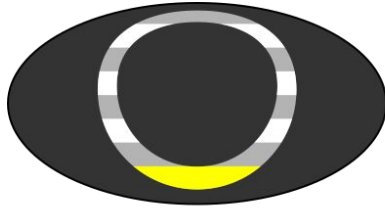


# PDFs: Cooking recipe

- data  $\rightarrow$  MC
- Resampling [even more statistics]

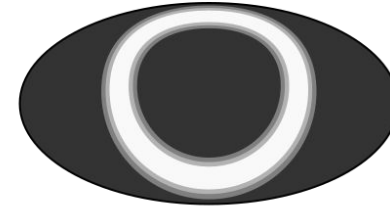


True coordinates

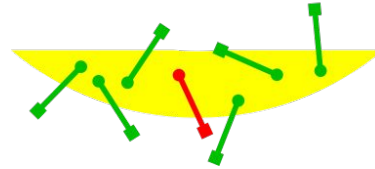


Template

Reconstructed coordinates



Signal PDF



MC event

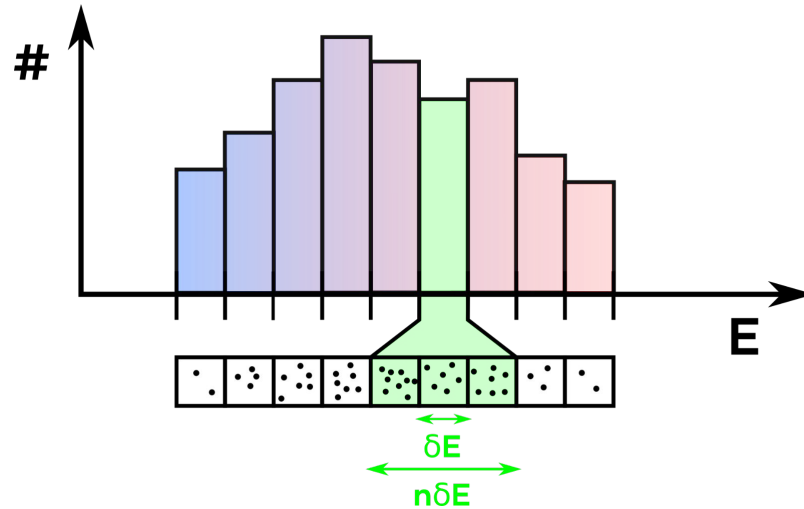
Resampled events

—● True position

—■ Reconstructed position

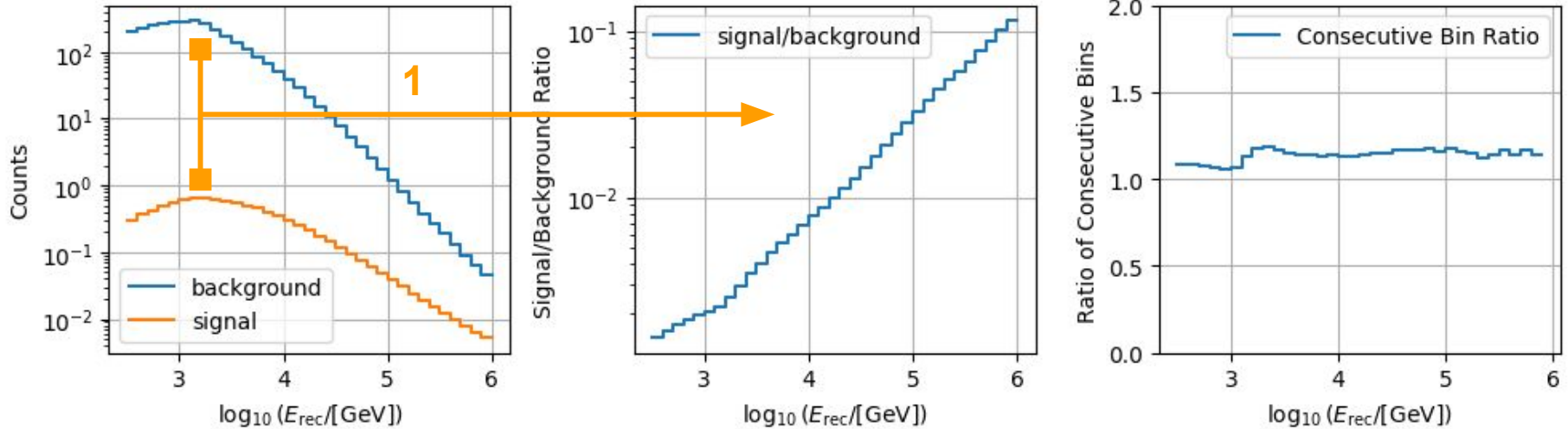
# PDFs: Cooking recipe

- data  $\rightarrow$  MC
- Resampling
- Overlapping bins in energy [smoother bins]



# Overlapped bins

- 1) Define the **signal/background ratio**: significant quantity in the likelihood function.

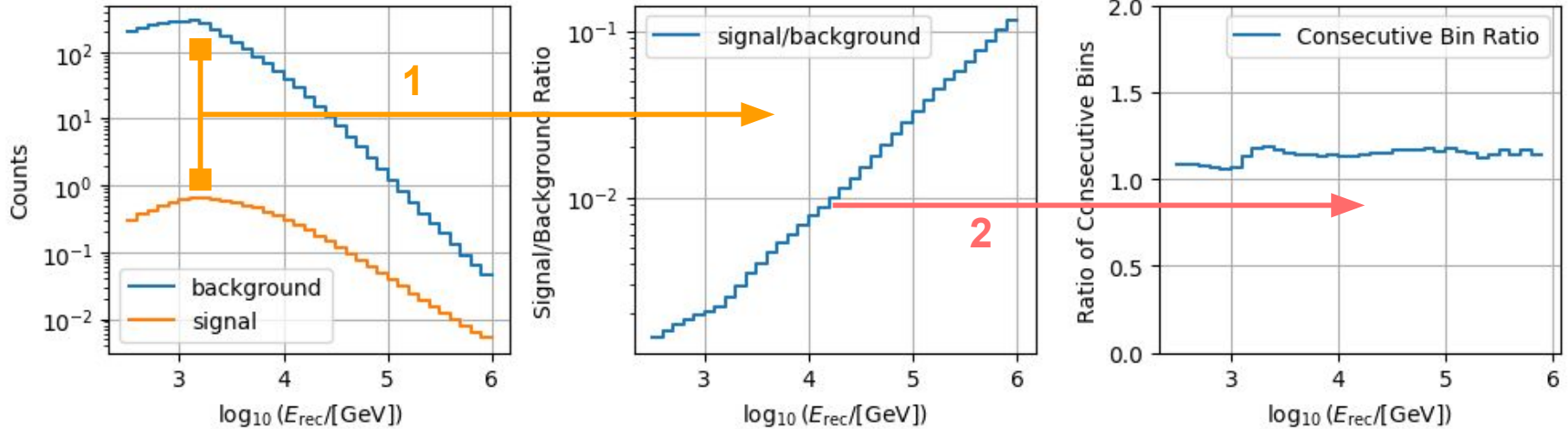


KRAy max, track channel



# Overlapped bins

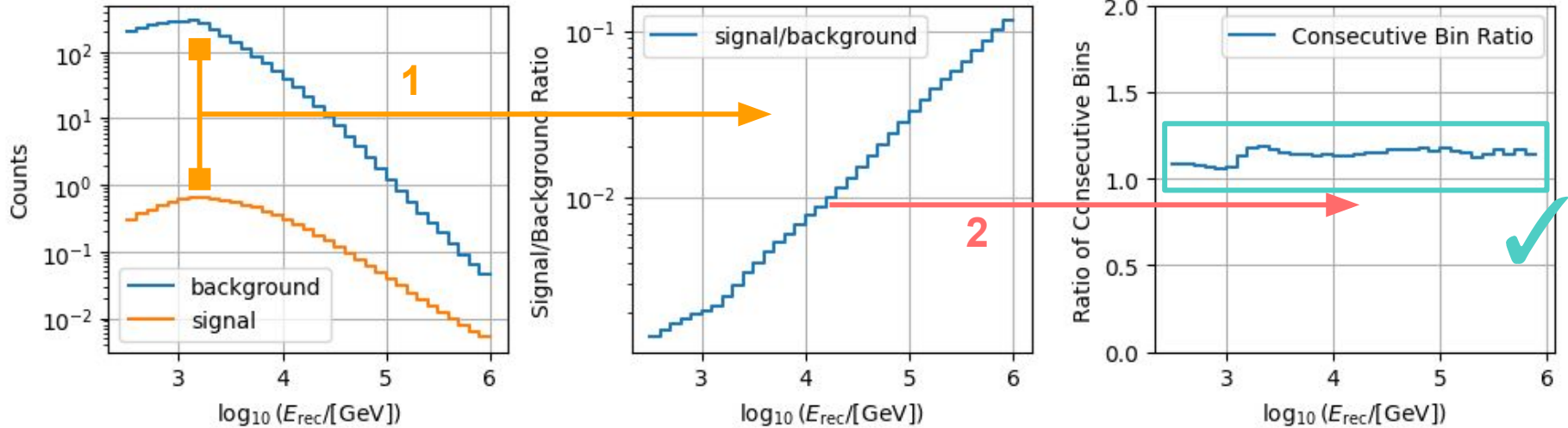
- 1) Define the **signal/background ratio**: significant quantity in the likelihood function.
- 2) Take the **derivative**.



KRAy max, track channel

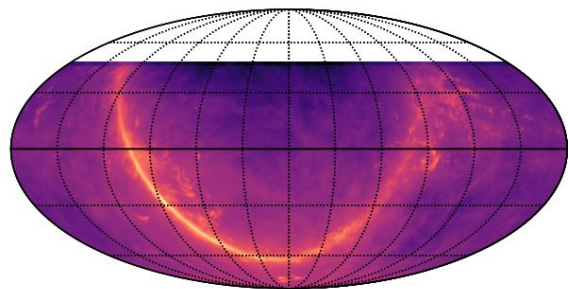
# Overlapped bins

- 1) Define the **signal/background ratio**: significant quantity in the likelihood function.
- 2) Take the **derivative**.

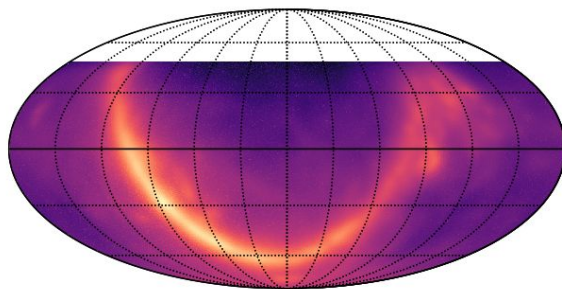


KRAy max, track channel

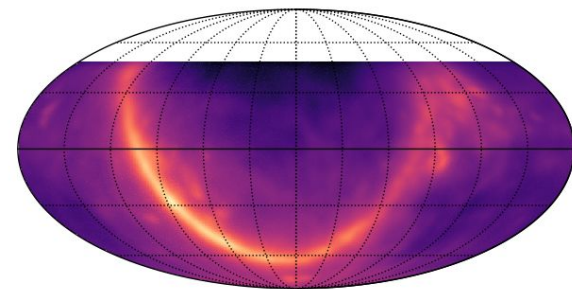
# Signal PDFs



track

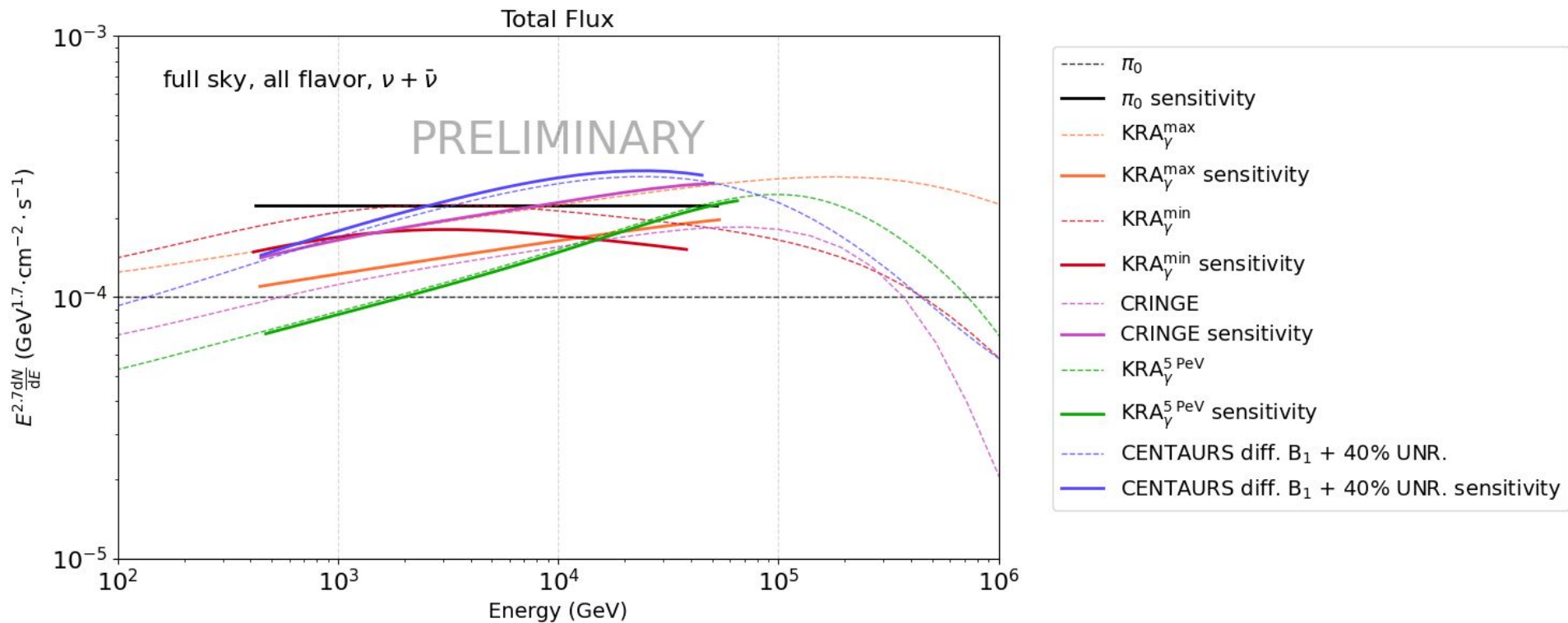


shower low

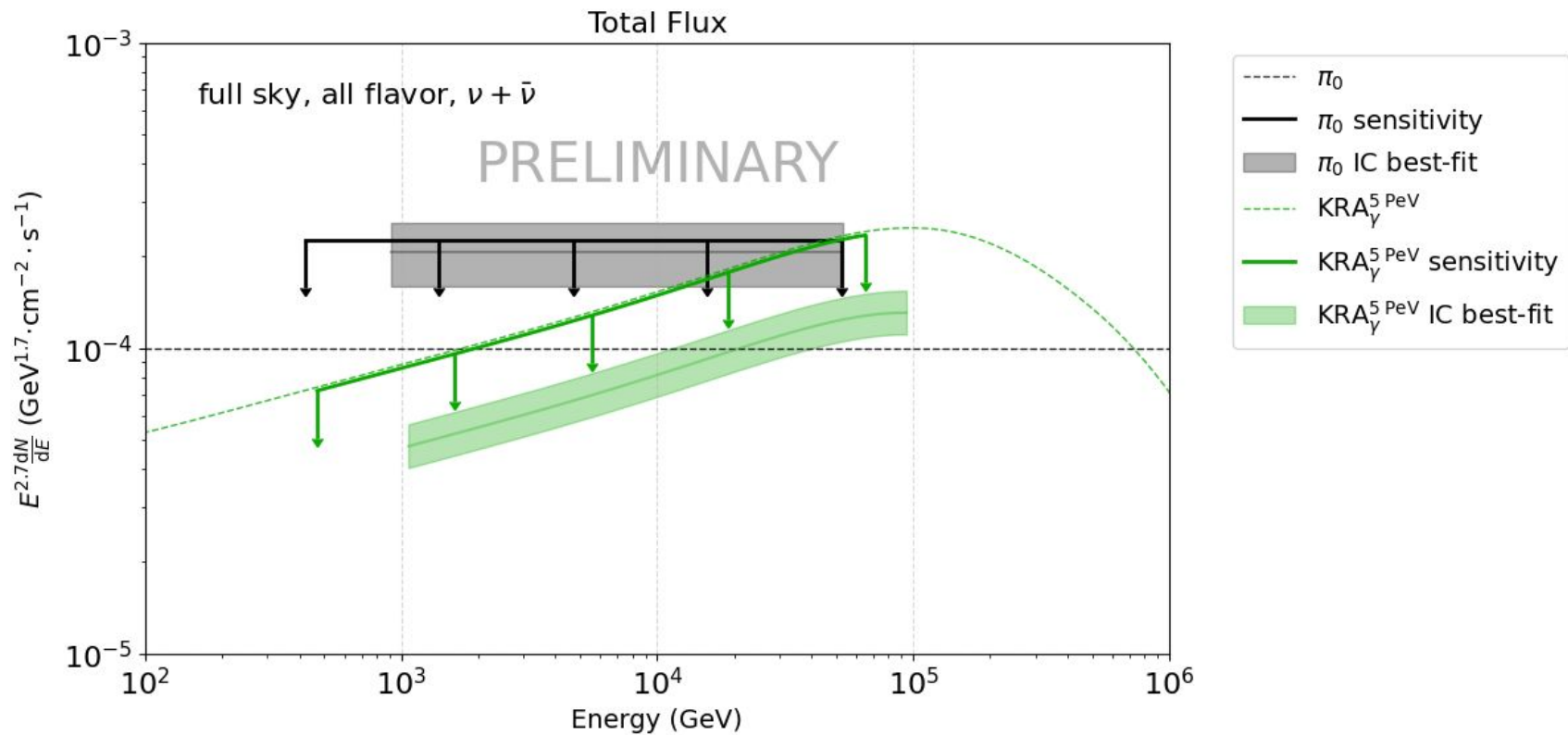


shower high

# Sensitivity for every model tested



# Comparison with IC



# Conclusion

- Convolution of template/IRF  $\Rightarrow$  Spatial-energy correlation preserved.
  - Many models tested: Central hardening vs unresolved contribution.
  - Potential to constraint KRA $\gamma$  max/min models.
  - Lower range of energy than IceCube.
- 
- Internal unblinding  $\Rightarrow$  Paper coming soon 🕒
  - Combination with IceCube/KM3NeT will be promising !



Thanks to all of you !

Feel free to contact me at [cartraud@apc.in2p3.fr](mailto:cartraud@apc.in2p3.fr)