

PhD presentation at the Biennale 2026

Subject: “Research of high-energy neutrinos in the Milky Way”

Start : 1st February

Direction : Antoine Kouchner

Supervision : Sonia El Hedri, Mathieu Lamoureux

Plan :

I) Introduction

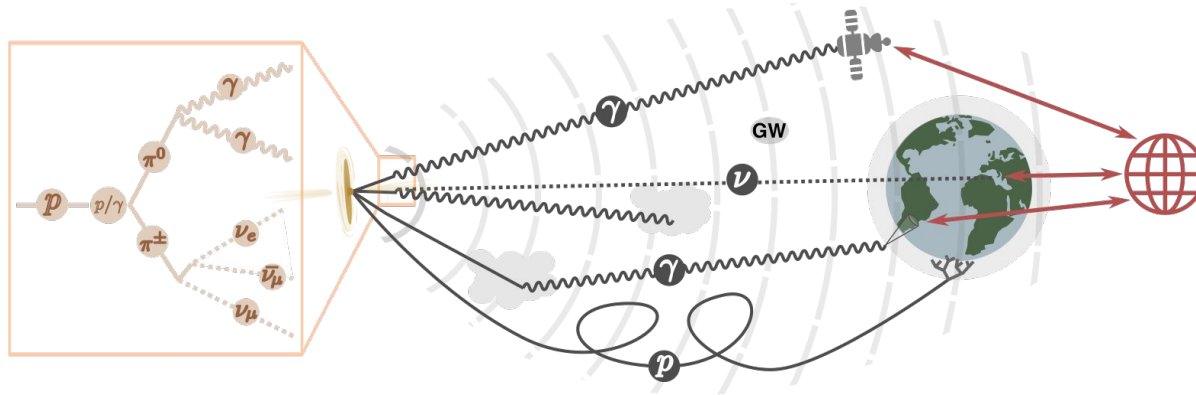
II) State of the art and analysis method

III) Starting track project

I - Research of high-energy neutrinos in the Milky Way

- **Context** : Observation and analysis of the diffuse neutrino flux from the galactic plane

Questions : propagation of cosmic rays, their sources and their contribution to this flux



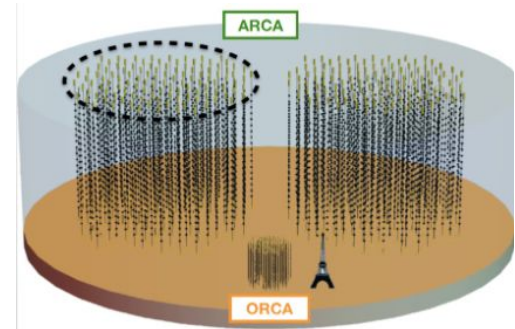
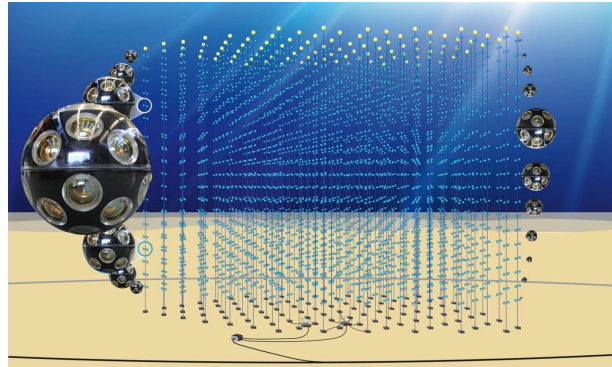
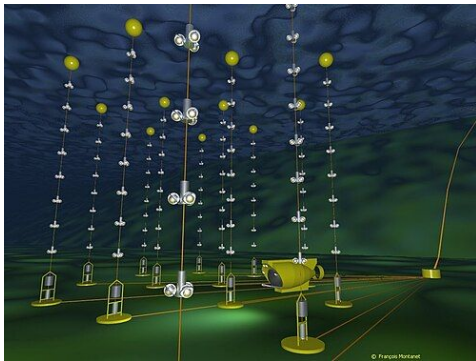
- **Discovery**: by IceCube (cf. [\[1\]](#))

Goal of my PhD : Improve our understanding and constrain on this flux, continuing the work of Théophile C. and Julien A. [\[2\]](#)

How : New analysis methods and the combination of data from ANTARES and KM3NeT (and possibly IceCube).

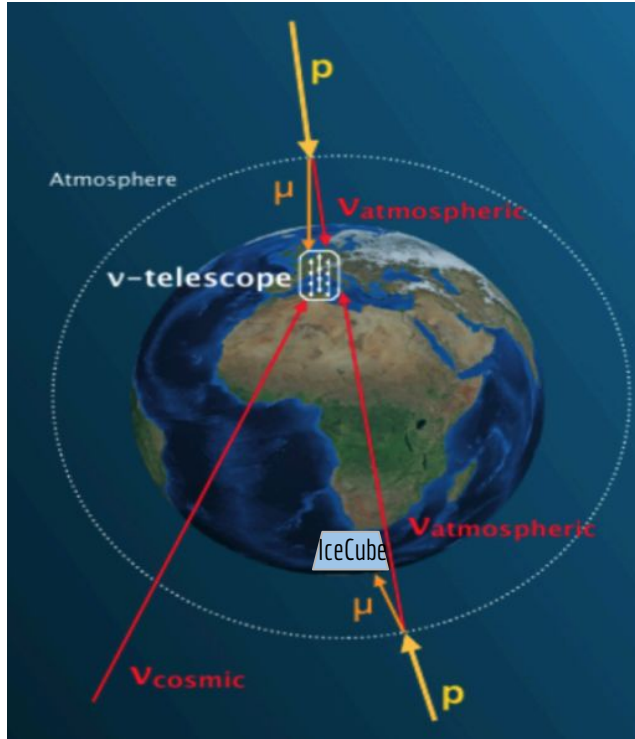
I - KM3NeT and ANTARES detectors

- **Context:** KM3NeT Collaboration (Cherenkov telescopes in the Mediterranean Sea)
Two detectors : ARCA (TeV-PeV) and ORCA (GeV-TeV) -> Complete configuration 2029-2032
- Bigger ($\sim 10x$) and better sensitivity than ANTARES \rightarrow more expected events



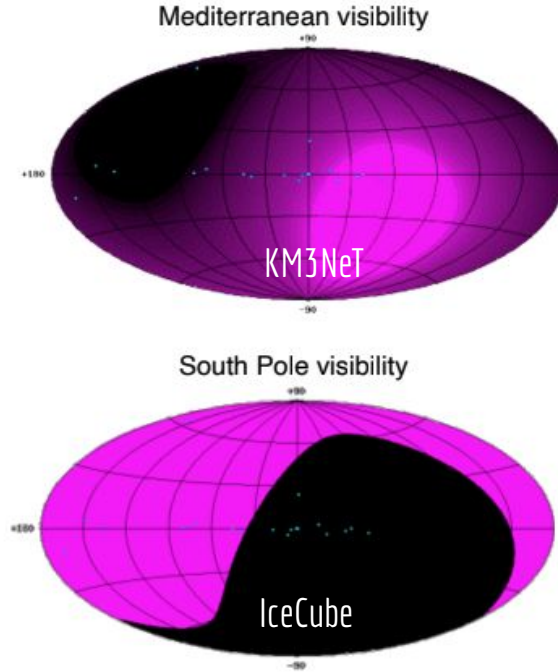
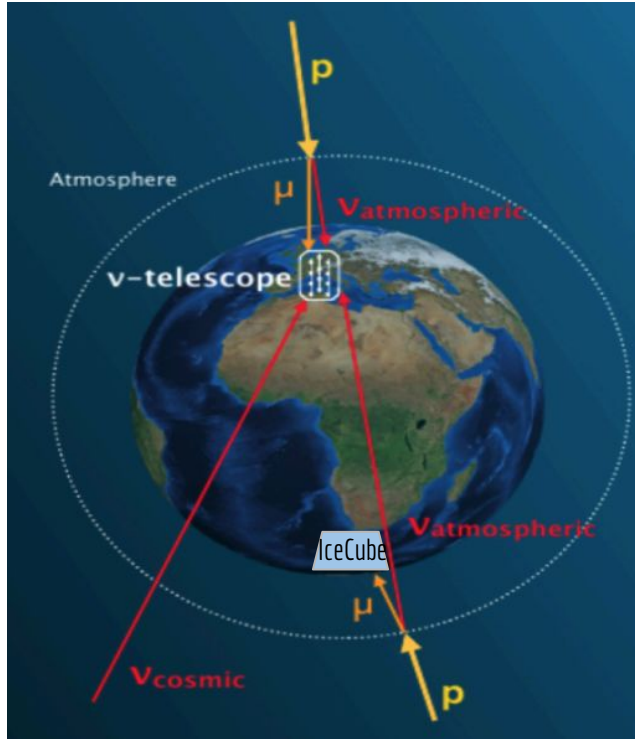
I - Up and down-going events

- What are the events observed by the detector ?

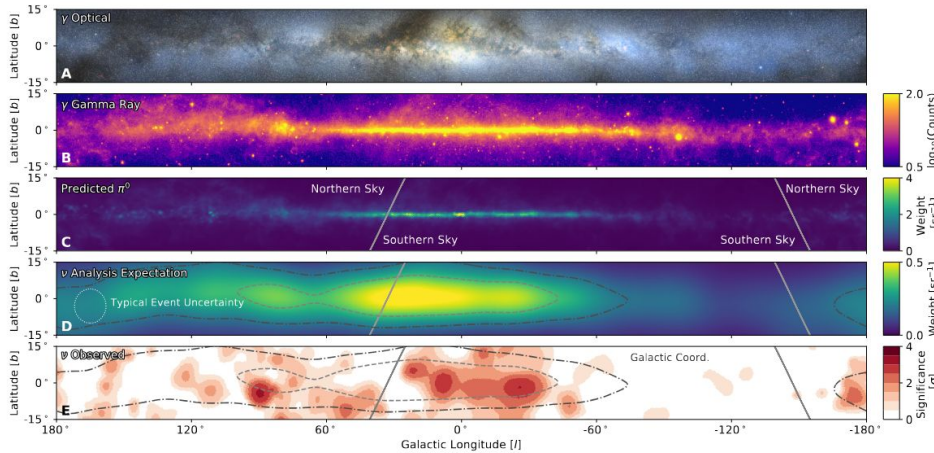


I - Up and down-going events

- What are the events observed by the detector ?



II - State of the art



IceCube observation of high-energy neutrinos from the Galactic plane ($>4\sigma$) [3]

Model	\hat{r}	\widehat{T}_S	p-value	90% upper limit	Sensitivity
π^0	2.7 (9.5 evts)	0.2	0.22 (0.78 σ)	9.4 (32.5 evts)	5.7 (19.8 evts)
KRA_γ^{\max}	0.3 (6.0 evts)	0.6	0.11 (1.21 σ)	1.2 (20.6 evts)	0.6 (9.5 evts)
KRA_γ^{\min}	0.4 (6.2 evts)	0.4	0.15 (1.04 σ)	1.4 (22.3 evts)	0.8 (12.2 evts)
CRINGE	0.6 (7.5 evts)	0.2	0.22 (0.78 σ)	2.1 (24.5 evts)	1.3 (15.1 evts)
$KRA_\gamma^{5\text{PeV}}$	0.5 (6.3 evts)	0.7	0.10 (1.28 σ)	1.4 (18.9 evts)	0.7 (9.8 evts)
DiffUSE	0.6 (8.2 evts)	0.2	0.23 (0.73 σ)	2.1 (27.7 evts)	1.3 (17.1 evts)

Constraints on the models (spatial and energetic neutrino distributions) using the complete ANTARES dataset

- KM3NeT better angular resolution than IceCube (up to 0.1° à 100 TeV for tracks)



II - Analysis method

- **Principle** : Test of models based on cosmic rays transport -> likelihood fit of background and signal of diffuse neutrinos



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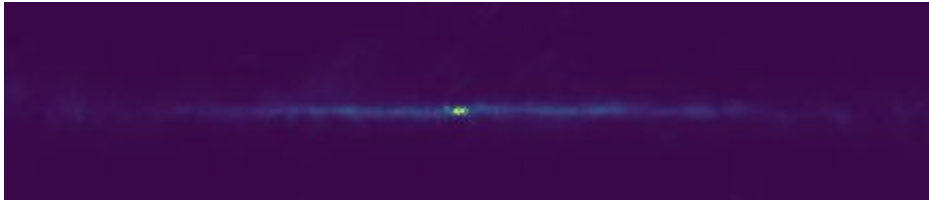
$$\Phi_{\text{model}} \xrightarrow{MC} \begin{cases} PDF = PSF \star E_{\text{resp}} \star \Phi_{\text{model}} \\ N_{\text{det}} = A_{\text{eff}} \star \Phi_{\text{model}} \end{cases}$$

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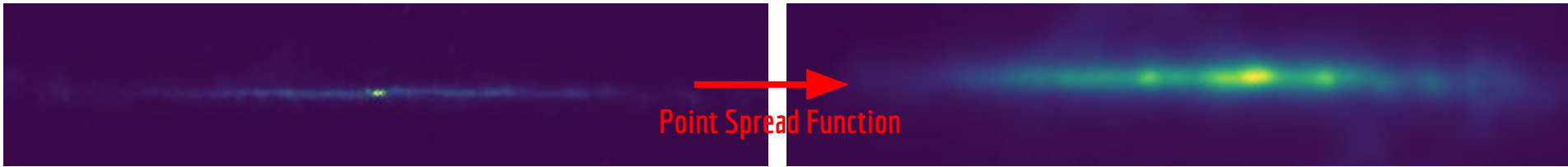
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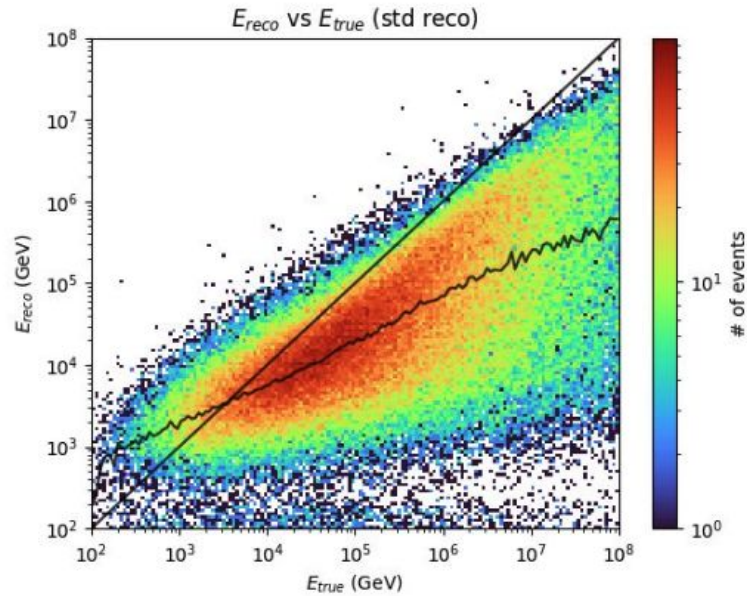
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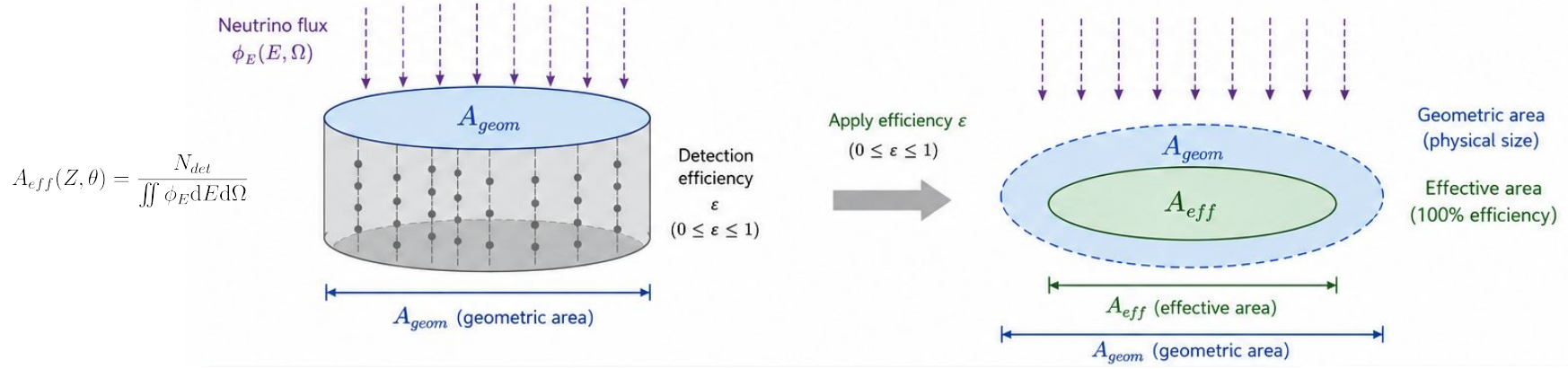


II - Analysis method



Energy response/resolution

II - Analysis method



Effective area

II - Analysis method

- **Principle** : Test of models based on cosmic rays transport -> likelihood fit of background and signal of diffuse neutrinos

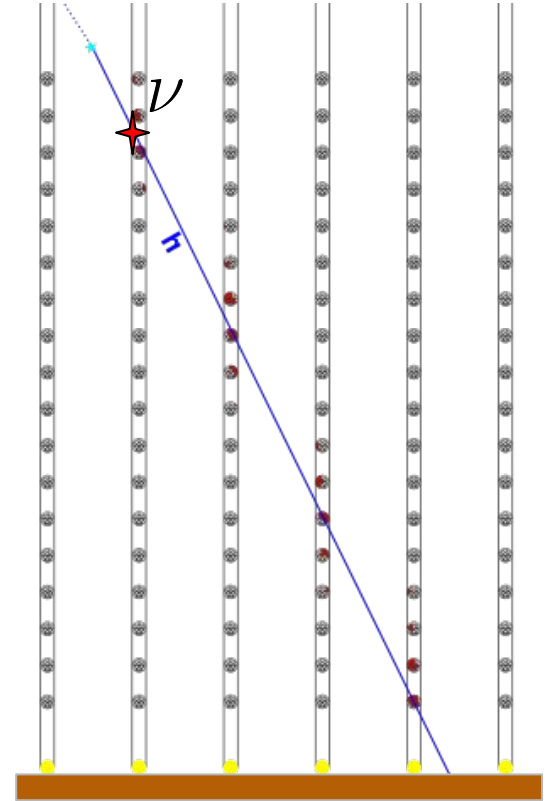
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- A **easily automatable procedure**
- Apply this new method to the KM3NeT detector and combine the data. Combination with IceCube under discussion
- Add models + fit parameters other than model normalisation (e.g. point source contributions)



III - Project on *starting tracks*

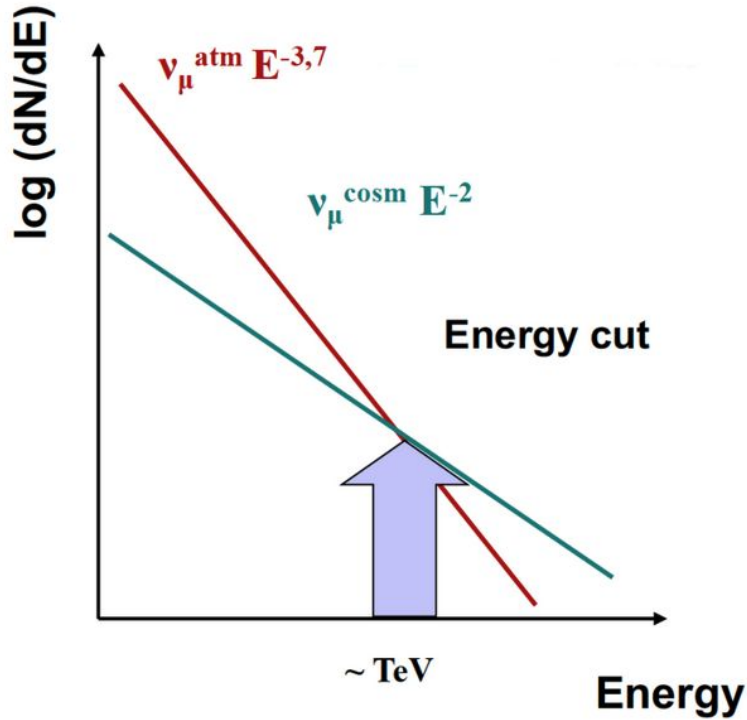
- **Advantages:** reduced atmospheric muon background, very good estimation of neutrino energy, down-going events are preserved
- **Context:** a project with researchers from Abu Dhabi, 2nd year. This project is part of my service task of the collaboration



Thank you for your attention !

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Back up



	TRACK *	CASCADE *
ANTARES	0.3°	3°
KM3NET	0.1°	1.5°
ICECUBE	0.3°	$7^{\circ} - 8^{\circ}$