XIX International Workshop
on Neutrino Telescopes

18-26 February 2021
Online

Atmospheric electron and muon neutrinos energy spectrum with the ANTARES neutrino telescope

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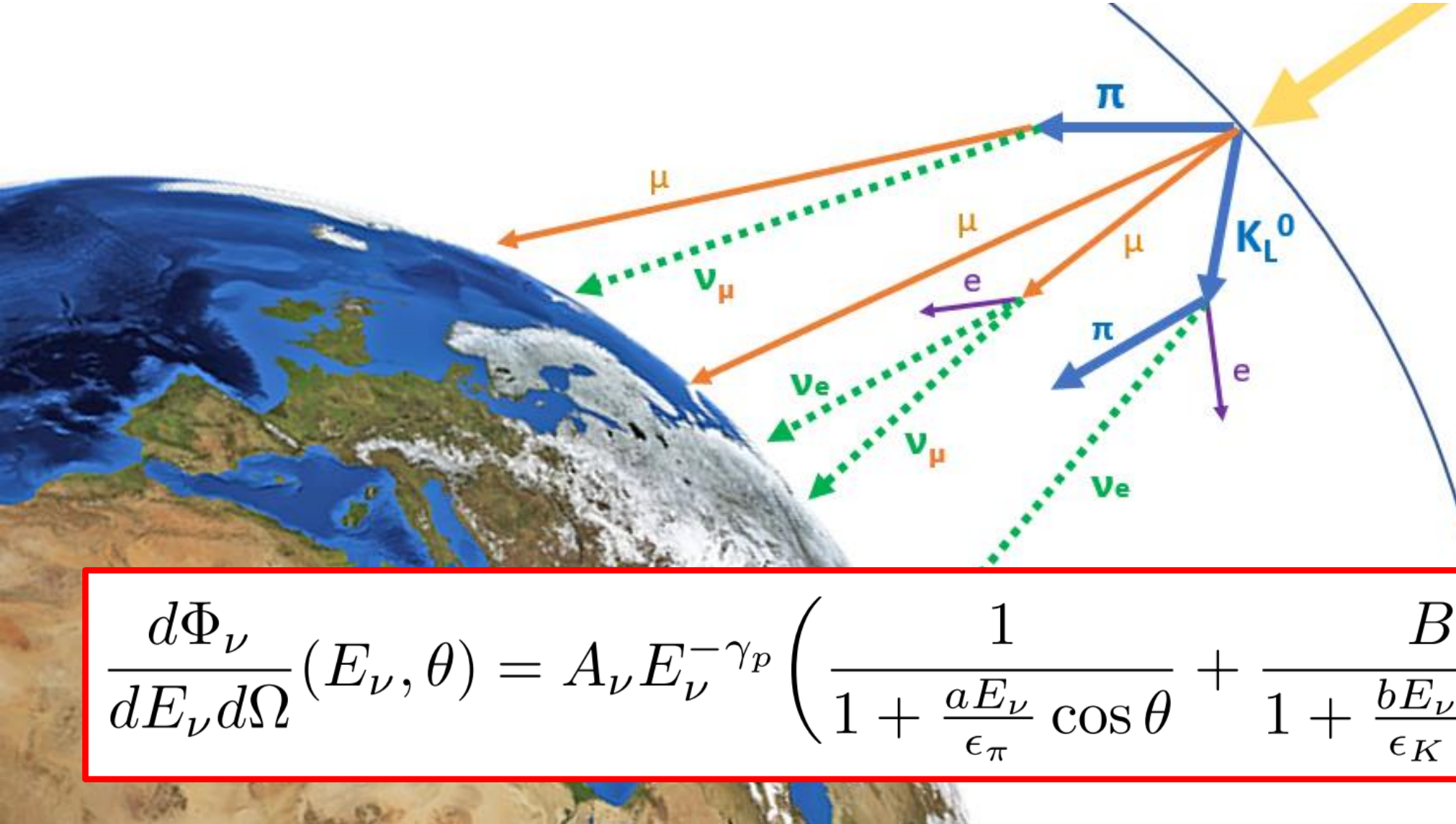
Atmospheric neutrinos



γ_p : Primary spectral index

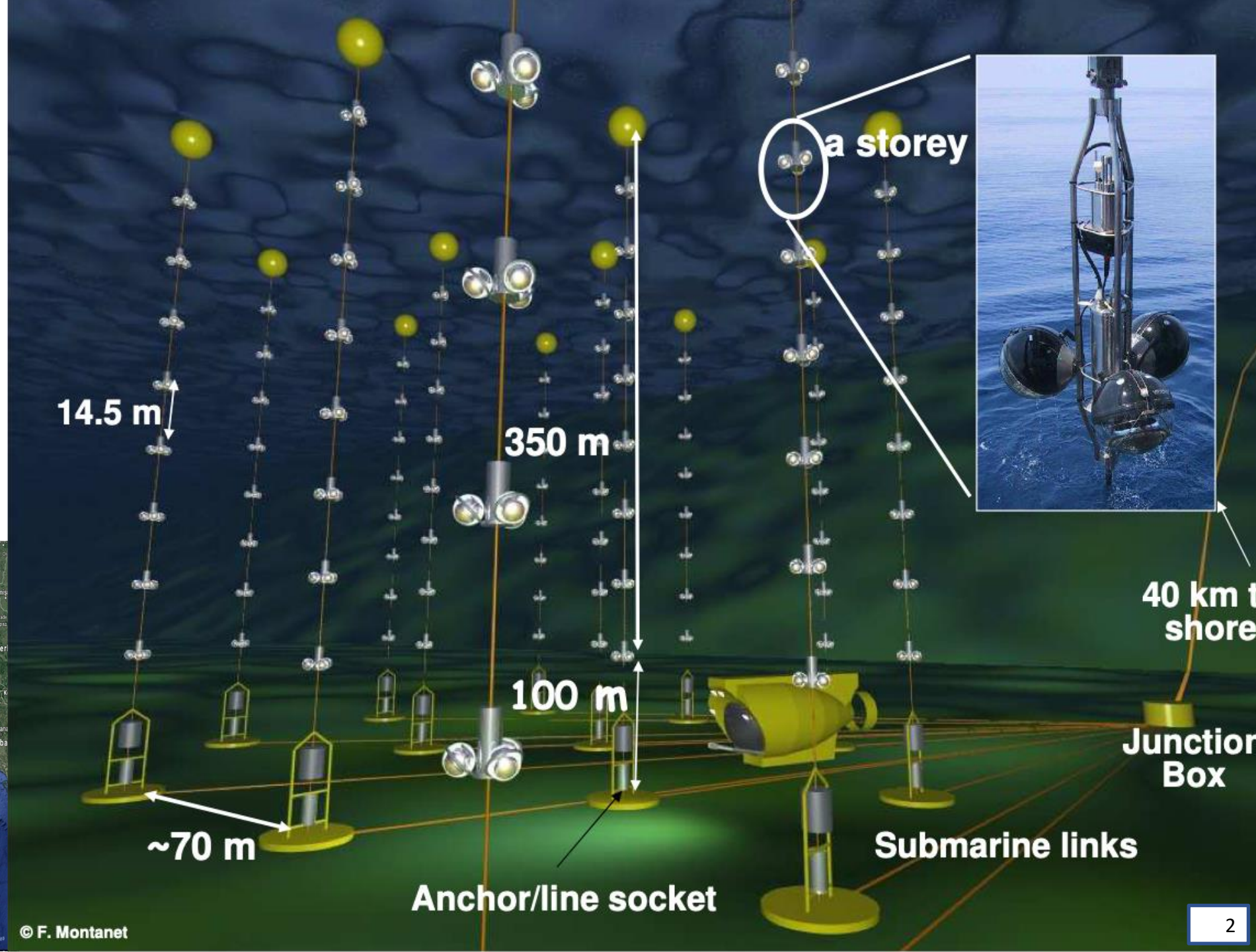
B: Balance factor (kaon-pion ratio ralated)

a , b: neutrino production efficiency from pion and kaon decays

$$\frac{d\Phi_\nu}{dE_\nu d\Omega}(E_\nu,\theta) = A_\nu E_\nu^{-\gamma_p}\left(\frac{1}{1+\frac{aE_\nu}{\epsilon_\pi}\cos\theta}+\frac{B}{1+\frac{bE_\nu}{\epsilon_K}\cos\theta}\right)$$

ANTARES

- *Running since 2007*
- *885 10” PMTs*
- *12 lines*
- *25/storeys/line*
- *3 PMTs/storey*
- *0.05 km³ instr. Vol.*



Analysis strategy

STARTING CONDITIONS

- General and simple criteria to have a reliable sample of events (run selection, geometrical condition, well reconstructed events)

PRESELECTION

- Reject the majority of atmospheric CR muons

FINAL SELECTION

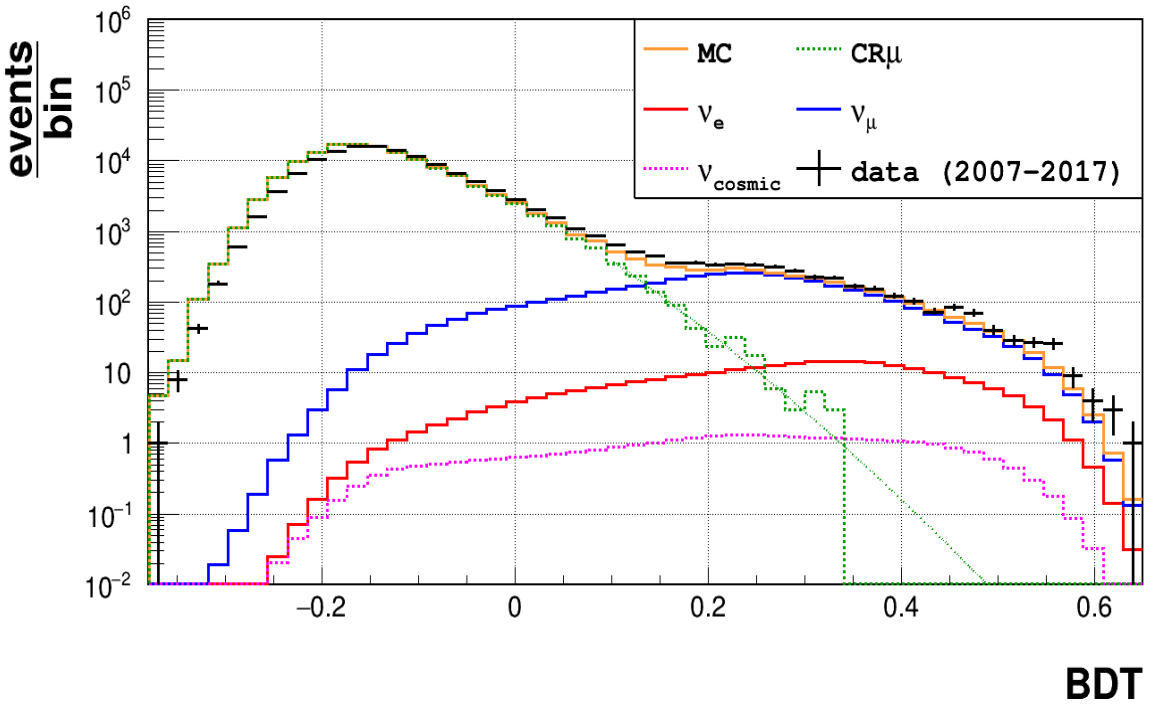
- Rejection almost all the atmospheric CR muons
- Use of multivariate tecnique: BDT (Boosted Decision Tree)

Unfolding

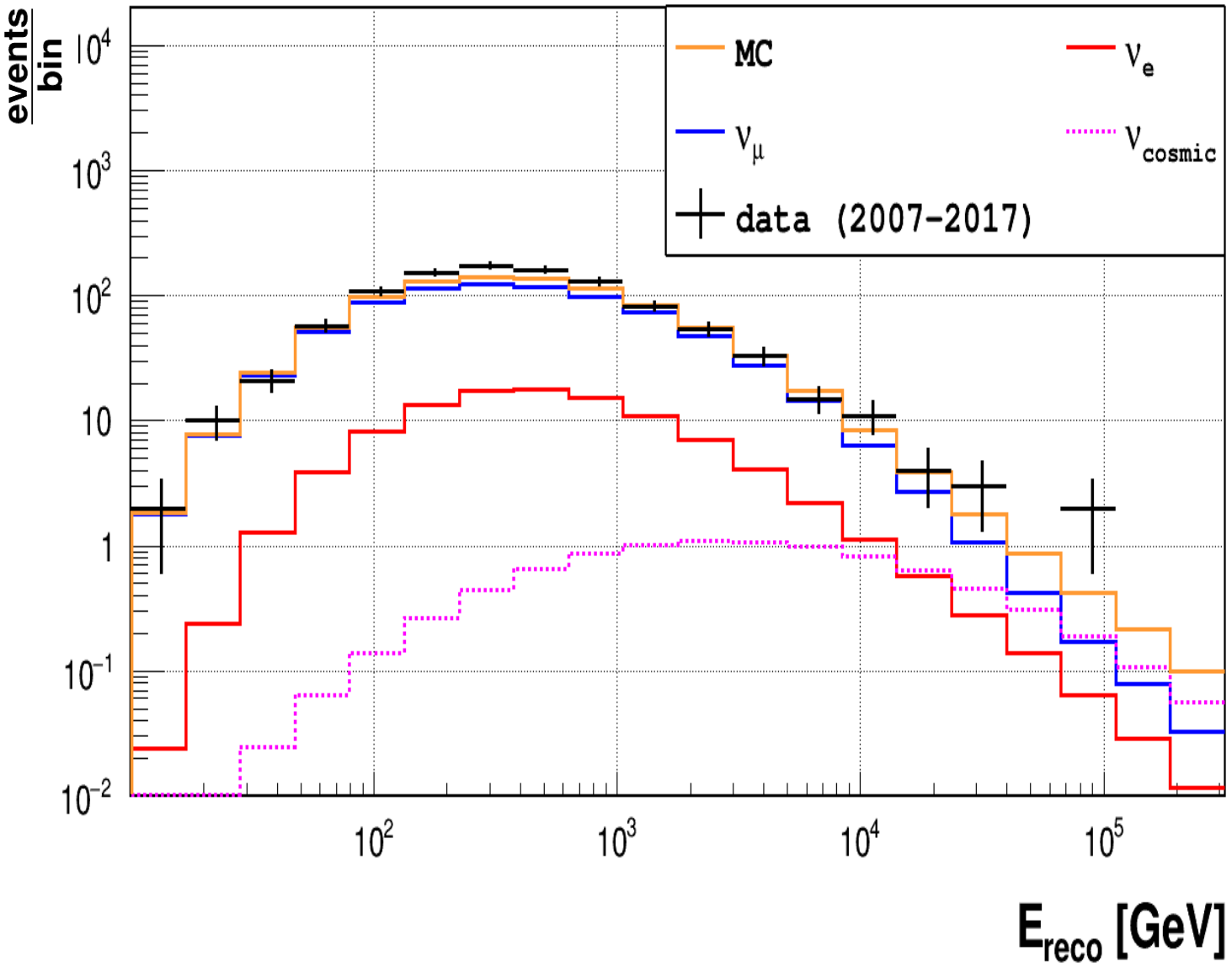
- Unfolding strategy: from the reconstructed energy distribution to the true neutrino energy distribution
- Unfold both ν_e and ν_μ fluxes

- Data: 2007 - 2017
- **SIGNAL**: Atmospheric ν_e and ν_μ
- **BACKGROUND**: Cosmic ray muons

Final selection BDT



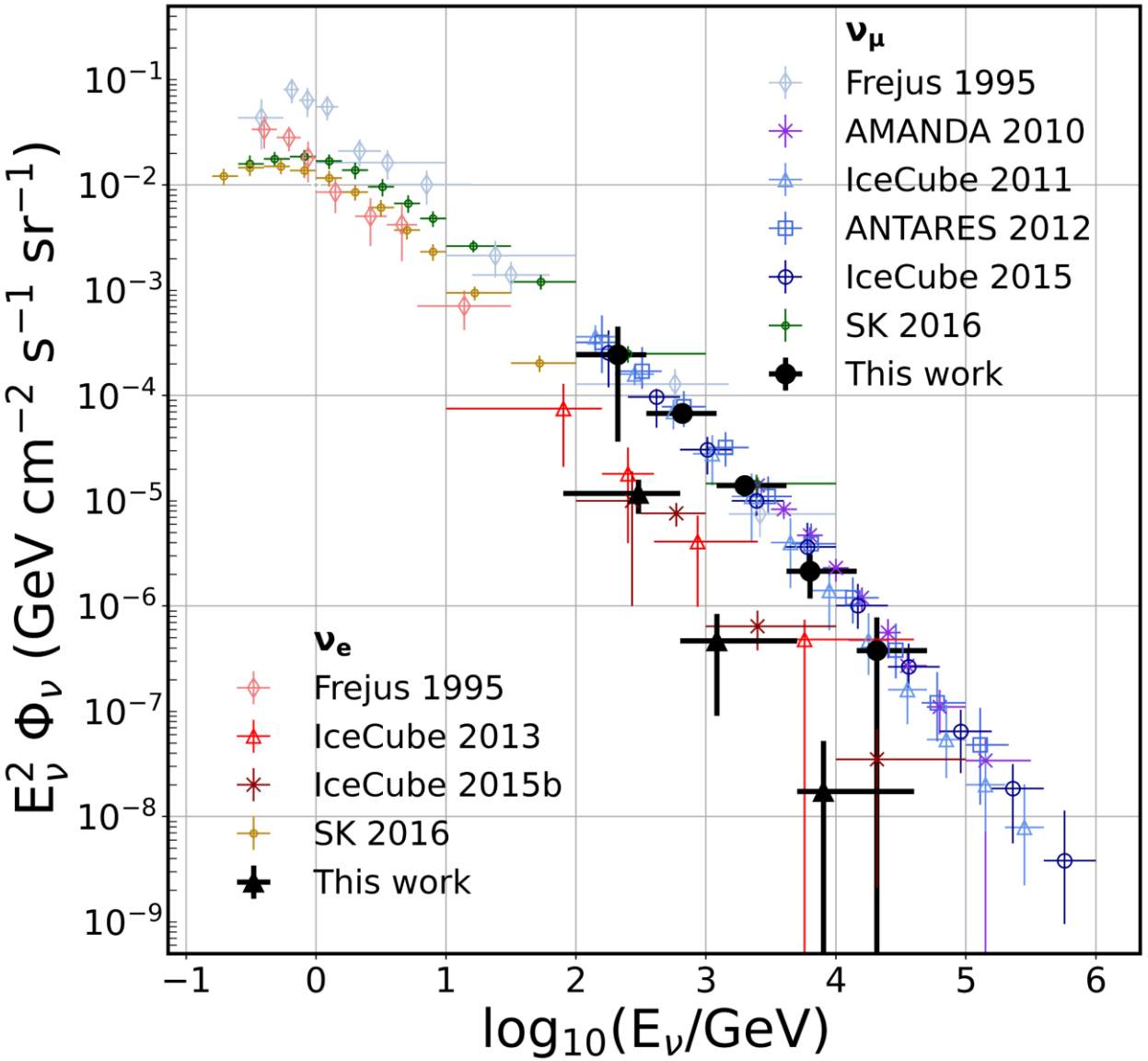
Final sample and unfolding



	Preselection $+ \Lambda > -5.7$	$+\text{BDT} > 0.33$
CRμ	136700	~3
Atmospheric ν_e CC	242	96
Atmospheric ν_e NC	22	9
Atmospheric ν_μ CC	3780	620
Atmospheric ν_μ NC	400	180
Cosmic ν	30.4	9.2
MC sum	141200	917
Data	133676	1016

- **Unfolding:**
  - **Tunfold** 🕮**:** **https://arxiv.org/abs/1205.6201**
  - **Background subtraction procedure**
  - **Same unfolding strategy for ν_e and ν_μ**

Results



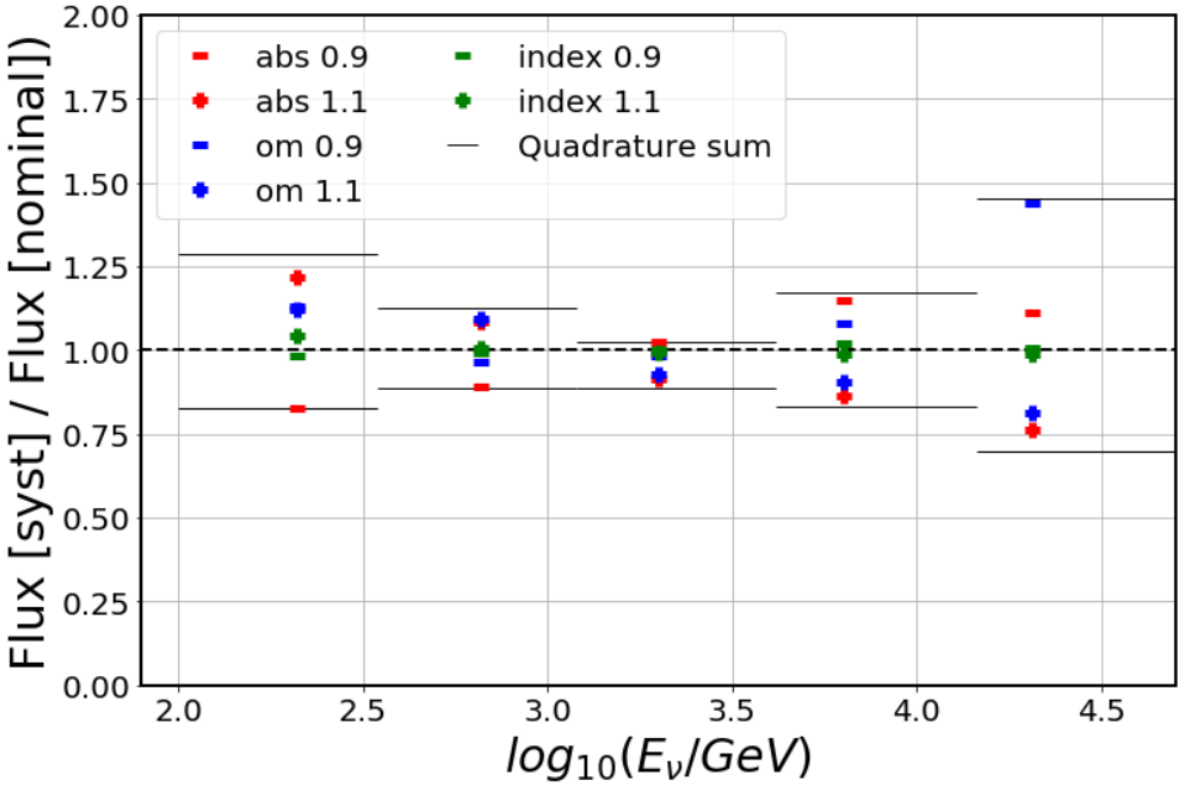
- **Paper 🕮: https://arxiv.org/pdf/2101.12170.pdf**
- **First atmopheric ν_e flux with the ANTARES neutrino telescope**
- **Indipendent data sample for the atmospheric ν_μ measurement respect to the previous ANTARES analysis (2012)**
- **Results in agreement with other experiment measurements**

$\Delta \log E_\nu$	$\overline{\log E_\nu}$	N^{evt}	$E_\nu^2\Phi_\nu$	stat.	syst.
Atmospheric muon neutrinos					
2.00–2.54	2.32	232	2.4×10^{-4}	±80%	±30%
2.54–3.08	2.82	348	6.8×10^{-5}	±10%	±15%
3.08–3.62	3.30	203	1.4×10^{-5}	±15%	±15%
3.62–4.16	3.80	58	2.2×10^{-6}	±40%	±20%
4.16–4.70	4.31	13	3.8×10^{-7}	±100%	±40%
Atmospheric electron neutrinos					
1.9–2.8	2.48	113	1.2×10^{-5}	±30%	±20%
2.8–3.7	3.08	21.2	4.7×10^{-7}	±80%	±10%
3.7–4.6	3.9	1.4	1.7×10^{-8}	$^{+200\%}_{-100\%}$	±20%

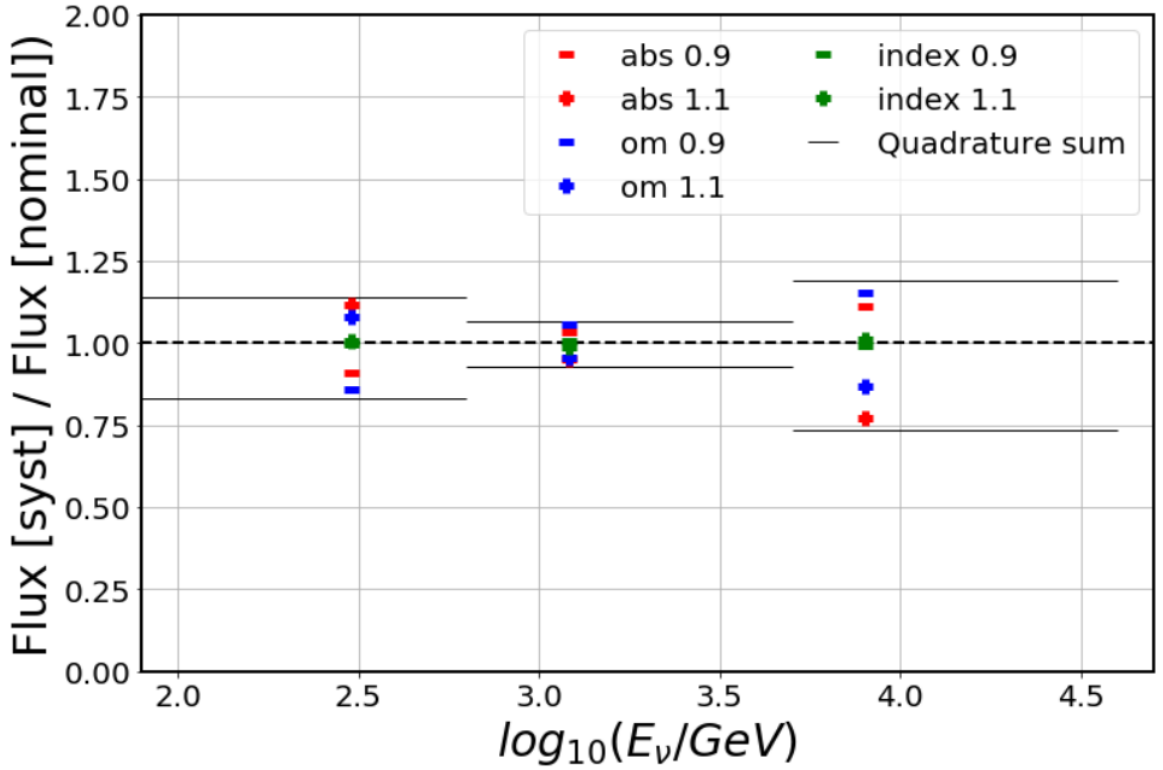
Thank you

Systematic uncertainties

ν_μ



ν_e



Event topologies