Atmospheric Neutrinos in ATLAS

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first proposed by François Vanucci
JK Lindner 2007
Wen Argüelles Kheirandish Murase 2023
Gosh Mukhopadhyay Mukhopadhyaya 2024

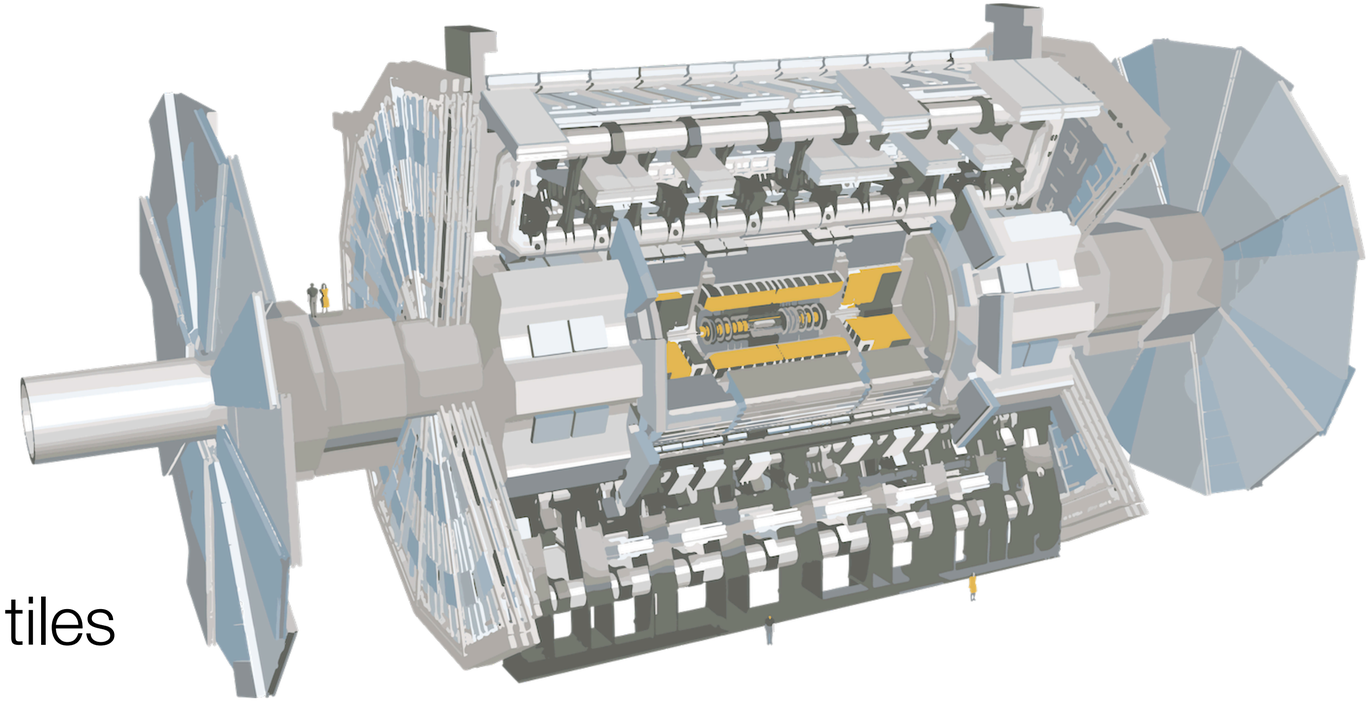
CERN

Neutrino PLATFORM

QUANTUM TECHNOLOGY INITIATIVE

JOHANNES GUTENBERG UNIVERSITÄT MAINZ

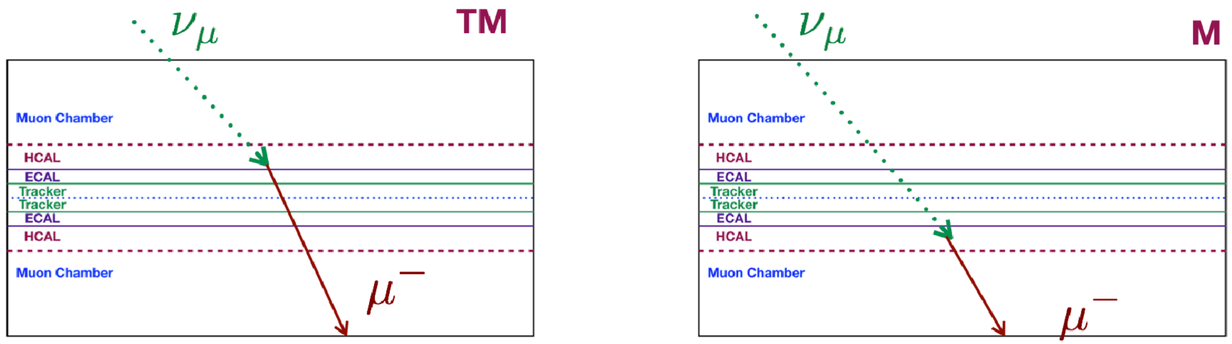
Basic Idea



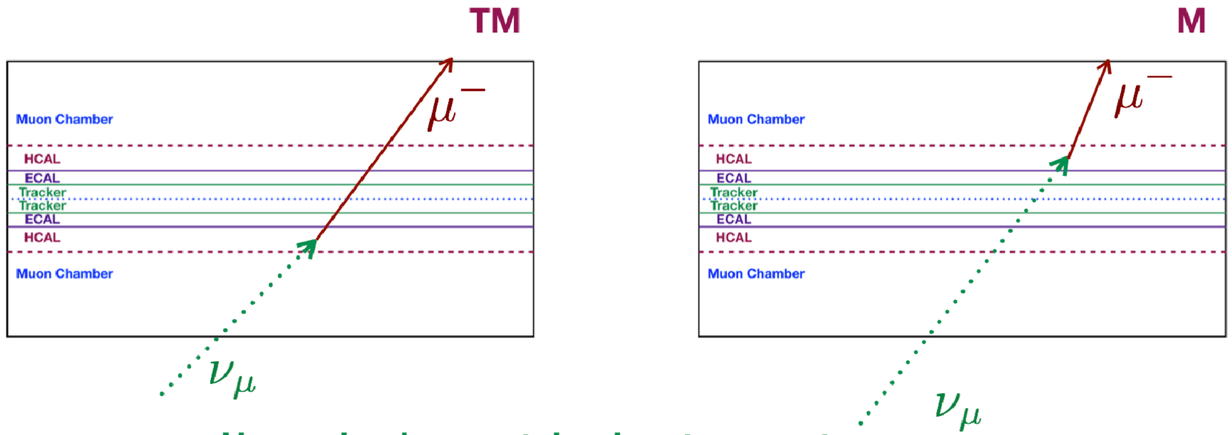
ATLAS has

- a 2.9 kt hadronic calorimeter
  made of steel + plastic scintillator tiles
  ➠ a decently sized neutrino target
- an excellent muon system
- a large geometric cross-section
  (~46 x 25 m^2) for upward-going muons

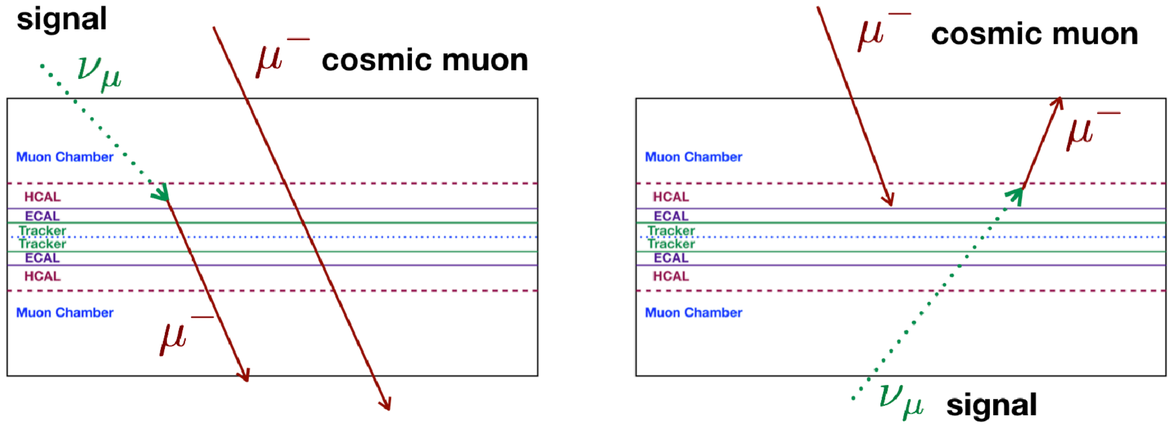
ν_μ Event Signatures

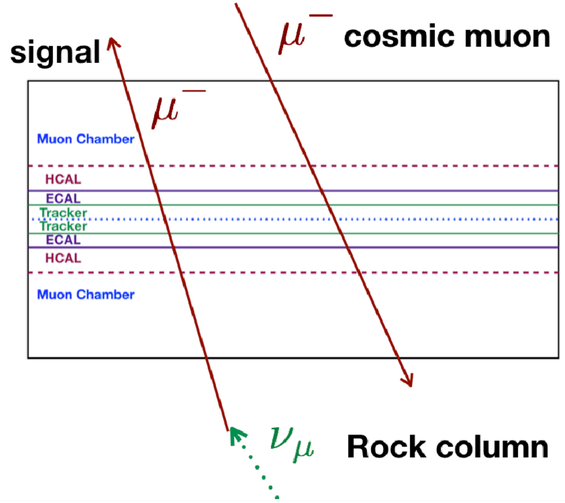


Downward going contained vertex events



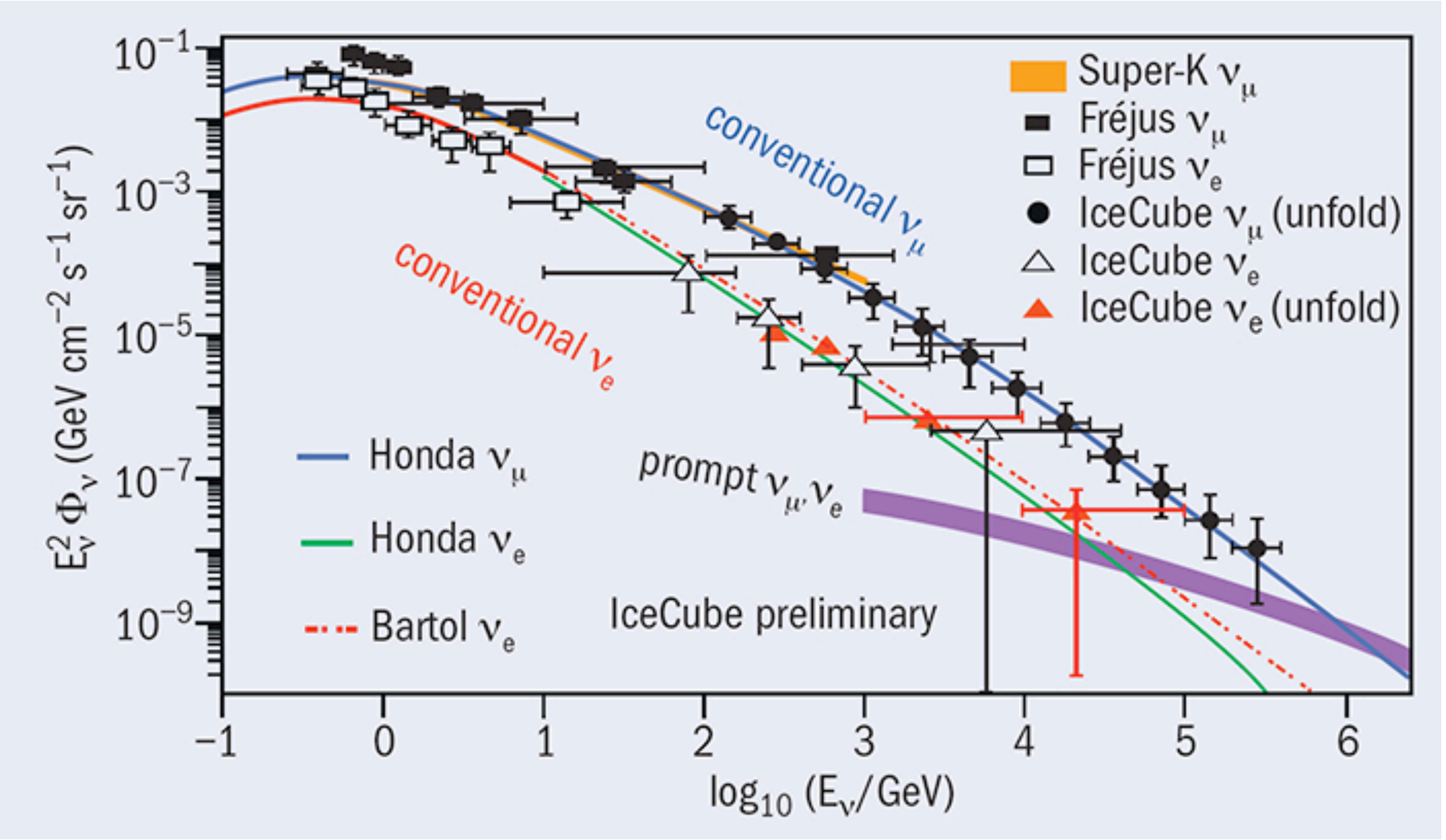
Upward going contained vertex events



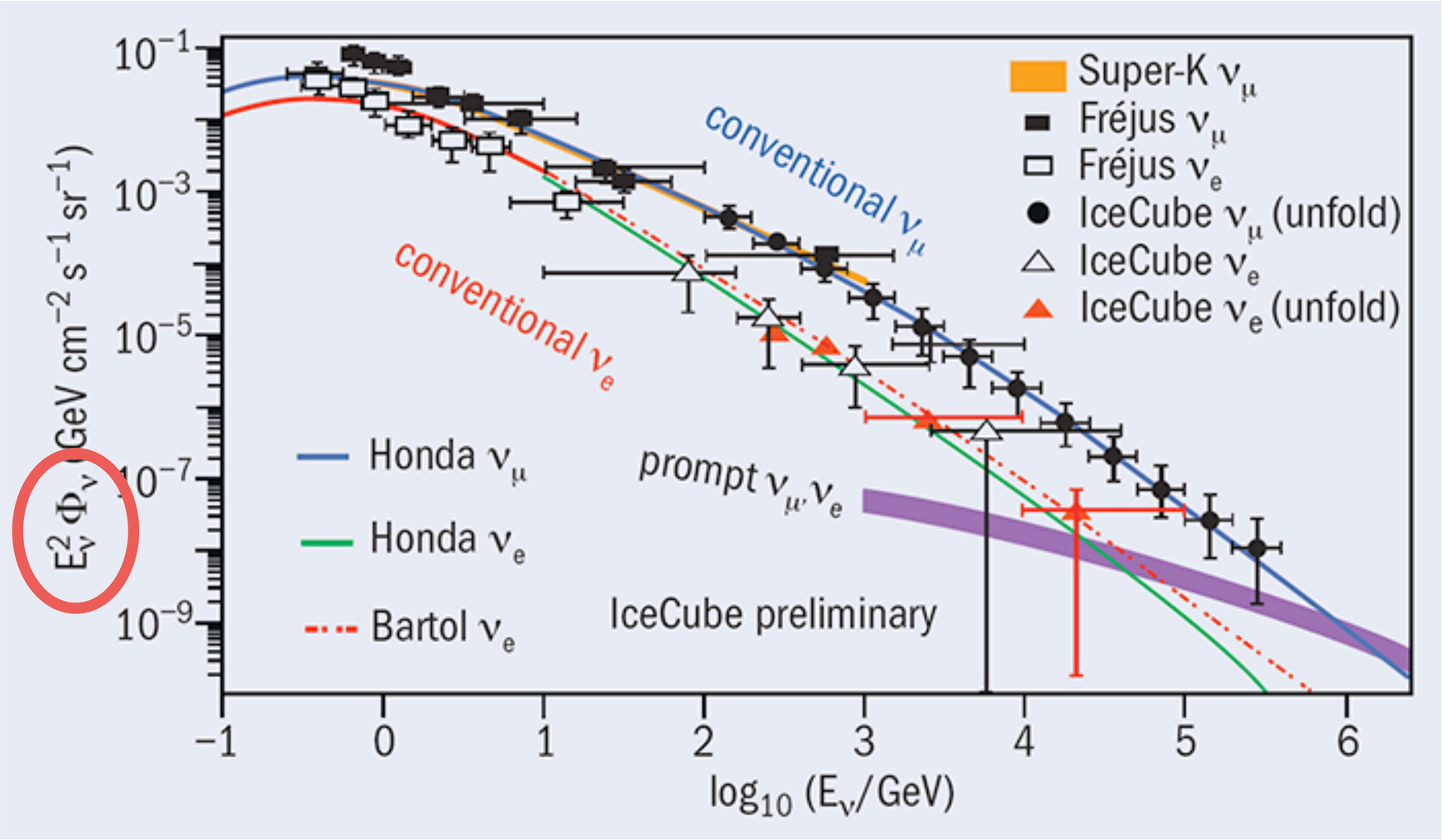


ν_e or ν_τ could also leave a shower-like signal in the HCAL (but neglected in the literature so far)

Atmospheric Neutrino Spectrum



Atmospheric Neutrino Spectrum



Energy Threshold

- low energy threshold is crucial due to the steeply falling flux
- in JK Lindner 2007, a ν_μ energy threshold of 1.5 GeV has been used
  (probably a somewhat optimistic estimate)
- Gosh Mukhopadhyay Mukhopadhyaya 2024 use 3 GeV instead
  (minimum energy required for a muon to cross the HCAL and leave a signal in the muon system)
- reality is probably somewhere in between
  - Higher threshold for contained events (which have to be able to leave the HCAL
  - Lower threshold for through-going muons (which only interact with the muon system)

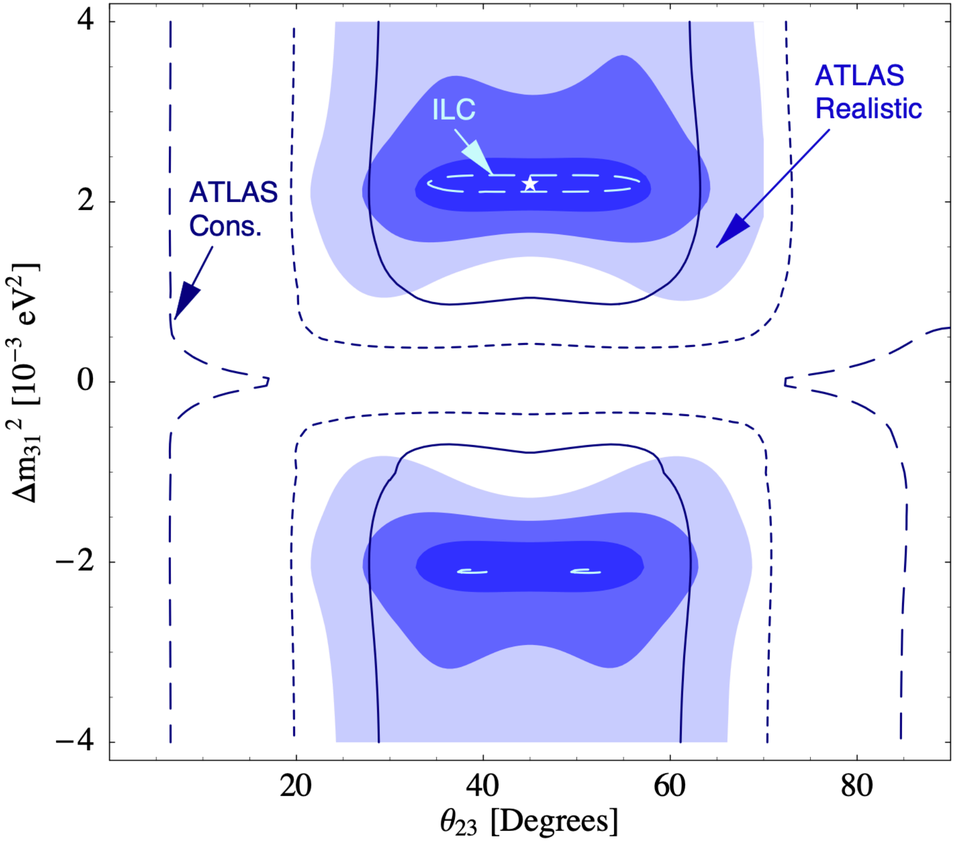
Event Rates

- JK Lindner 2007:
  160 contained ν_μ events / 100 days of running
  360 upward-going ν_μ events / 100 days of running
- Gosh Mukhopadhyay Mukhopadhyaya 2024:
  contained events per ~1,400 days of running

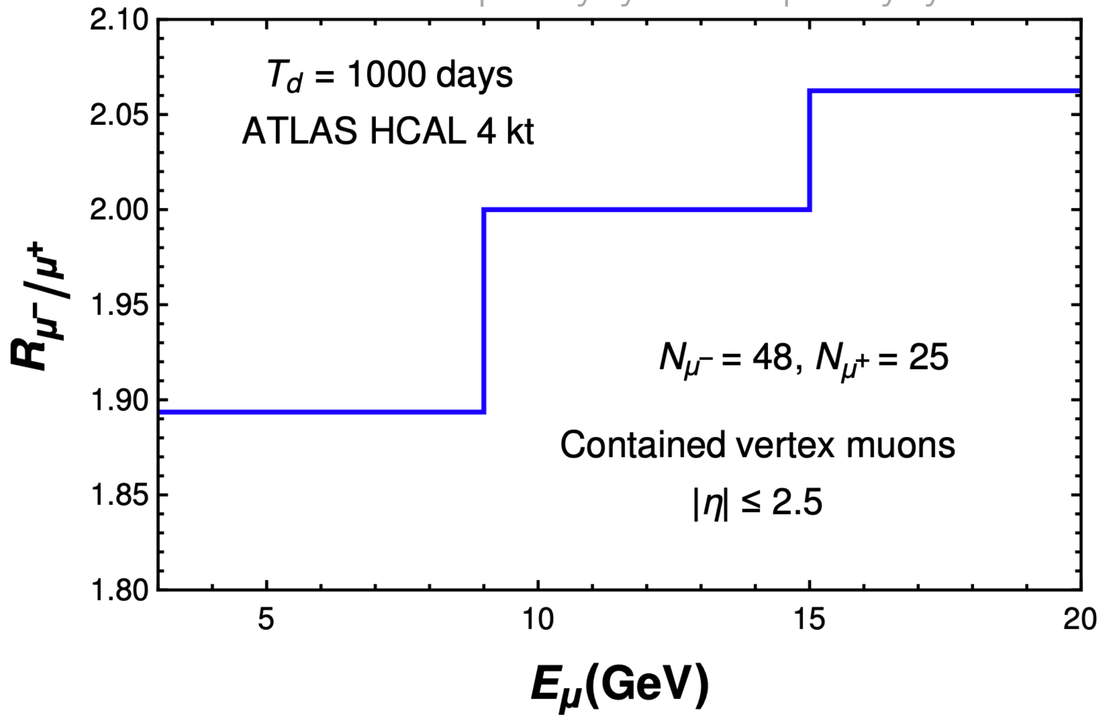
Energy	N_{μ^-}	N_{μ^+}	N_{μ^-}/N_{μ^+}	Category
$3 \leq E_\mu \leq 10$ GeV	33	17	1.82	Only TM
$5 \leq E_\mu \leq 10$ GeV	14	7	2.0	Only TM
$E_\mu > 10$ GeV	30	15	2.0	TM & M
$E_\mu > 20$ GeV	15	7	2.14	TM & M
Total: $E_\mu \geq 3$ GeV	63	32	1.97	

Physics with Atmospheric Neutrinos in ATLAS

JK Lindner 2007



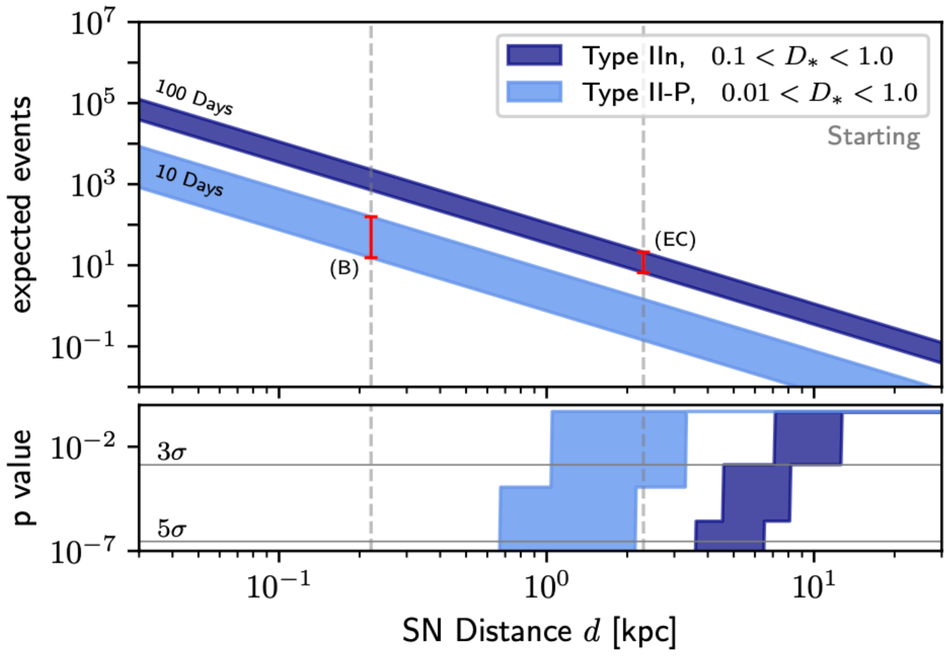
Gosh Mukhopadhyay Mukhopadhyaya 2024



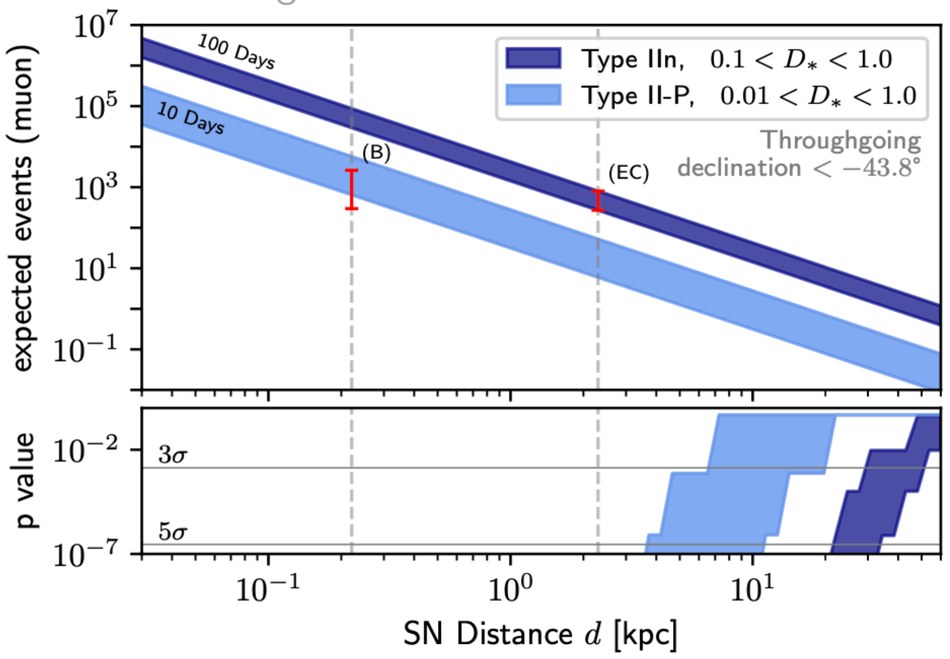
Supernova Neutrinos in ATLAS

- besides the well-known O(10 MeV) flux, core-collapse supernovae are expected to yield high-energy (≥ 100 GeV) neutrinos from cosmic rays accelerated by the outflowing matter

Wen Argüelles Kheirandish Murase 2023



(a) starting events



(b) throughgoing events

What about CMS?

- less massive calorimeter ➠ fewer contained events
- a lot of material between muon chambers ➠ higher threshold

Naïve expectation is therefore worse performance than ATLAS

… but never underestimate the ingenuity of the CMS collaboration