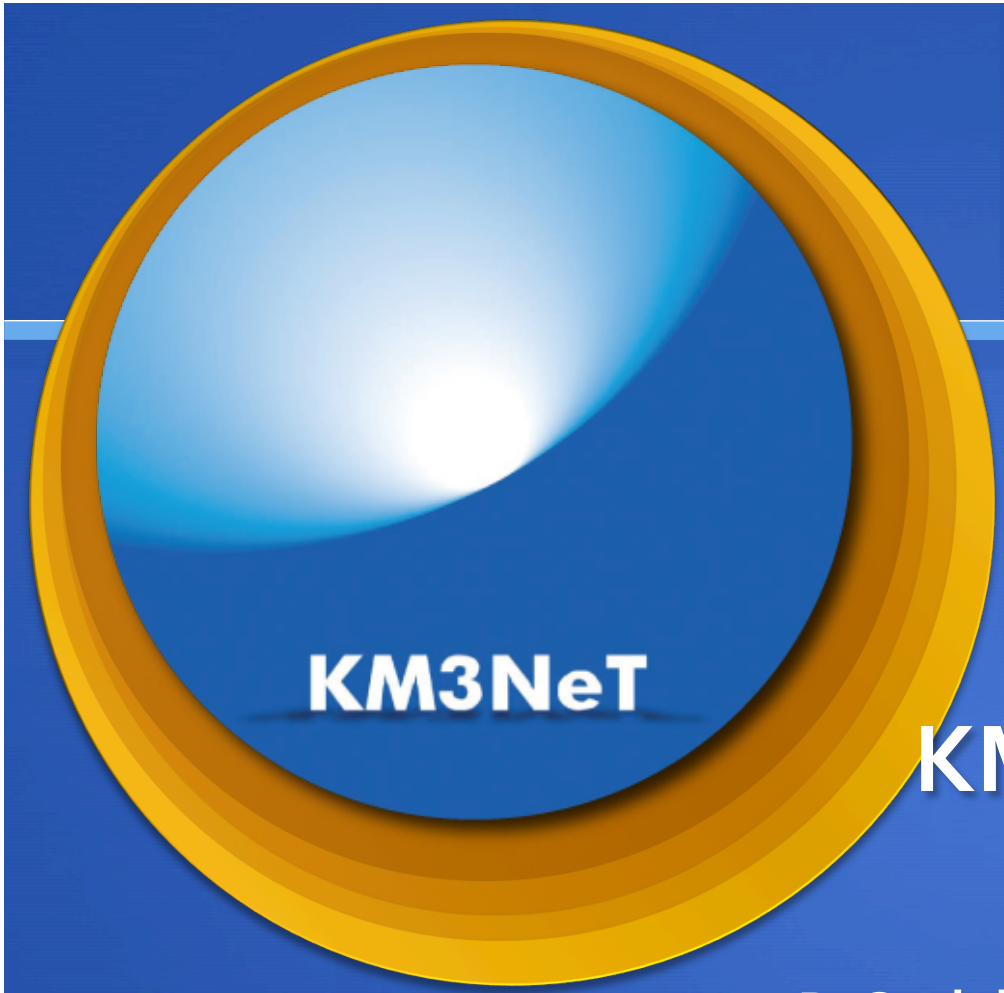


KM3NeT and diffuse flux: preliminary results

R. Coniglione – INFN Laboratori Nazionali del Sud

KM3NeT physics goal

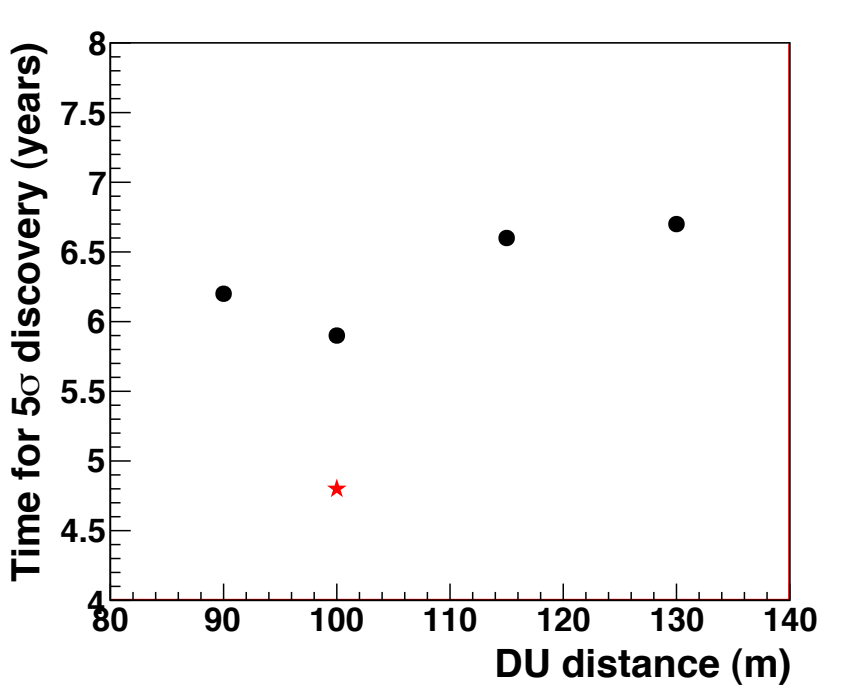
The main physics goal of the KM3NeT detector is "neutrino astronomy".

- Very large field of view mainly in the southern sky
- Large visibility of the Galactic plane and Galactic center
- Good angular resolution for ν_μ events

Detector geometry optimized for detection of neutrinos from Galactic sources

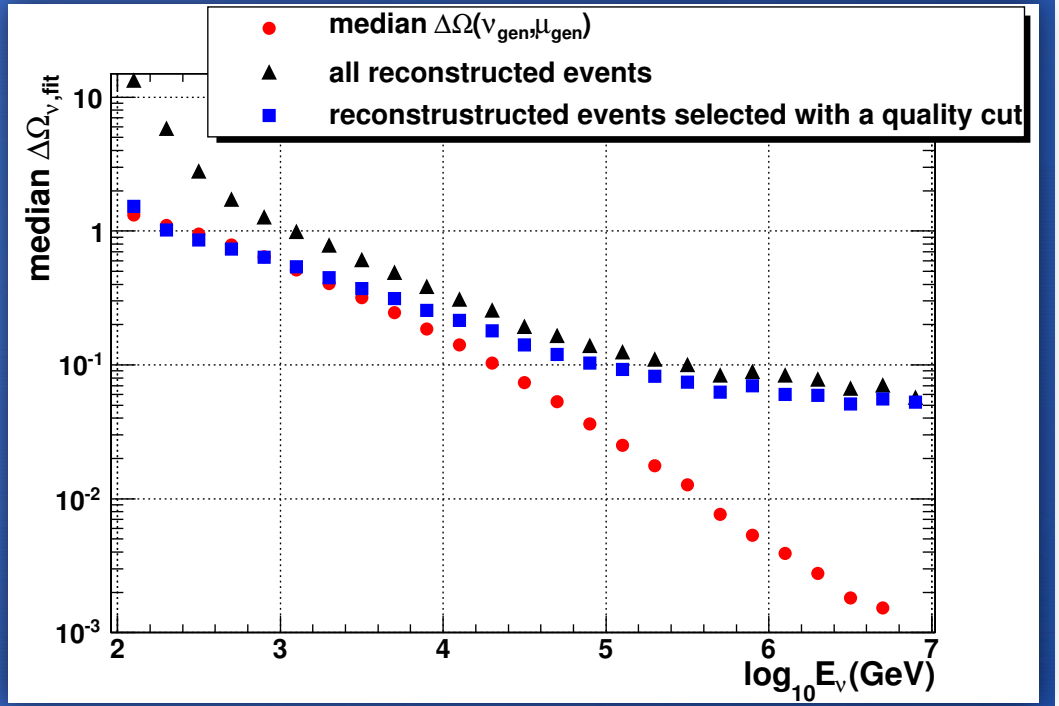
- TDR detector optimized for E^{-2} spectrum (180 m distance between DUs). Detector volume about 6 km^3
- New reference detector optimized for Galactic sources with spectrum with a cutoff in the TeV region (90 m distance between DUs). Detector volume of about 3 km^3

- Detector optimization for RXJ1713



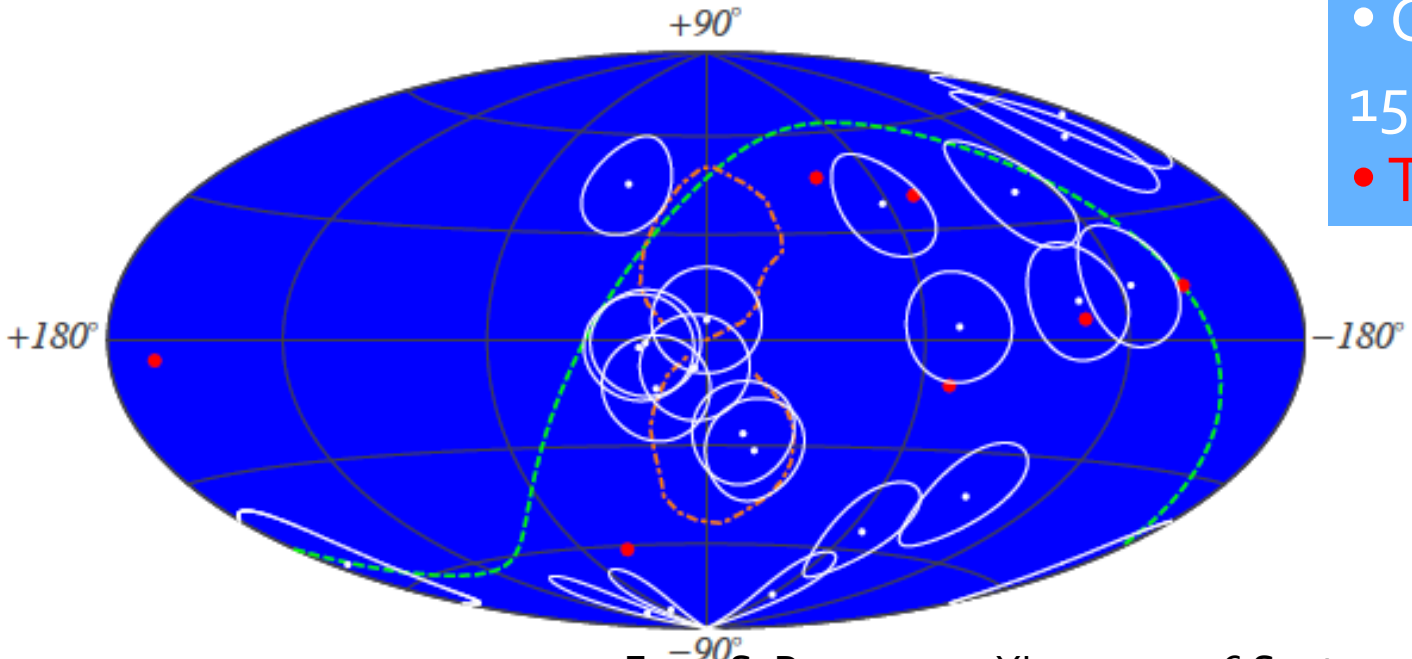
Best DU distance around 90-100m

- Detector resolution



Resolution below 3 TeV limited only by intrinsic $\theta_{\nu-\mu}$ angle

Neutrino astronomy enforced by the discovery of IceCube high energy events. Where do they come from?



From S. Razzaque arXiv:1309.2756 Sept 2013

- Cascade events with 15° of uncertainty
- Track events

28 detected events:
- 21 cascades
- 7 tracks

Better resolution expected in KM3NeT detector for cascade events.

ν_μ the best probe for neutrino astronomy

The discovered flux

- **IceCube discovered a flux of high energy neutrinos (from ~ 10 TeV to few PeV)**

contained events analysis - full sky

$\nu_e + \nu_\mu + \nu_\tau$

IceCube detector	Detector Size (km^3)	Obs. Time (year)	$\Phi_{observed}$ ($GeV^{-1}\ s^{-1}\ sr^{-1}\ cm^{-2}$)	Cutoff energy	σ
IC79+86	≈ 1	1.8	$3.6\ 10^{-8}$	≈2 PeV ?	4.1

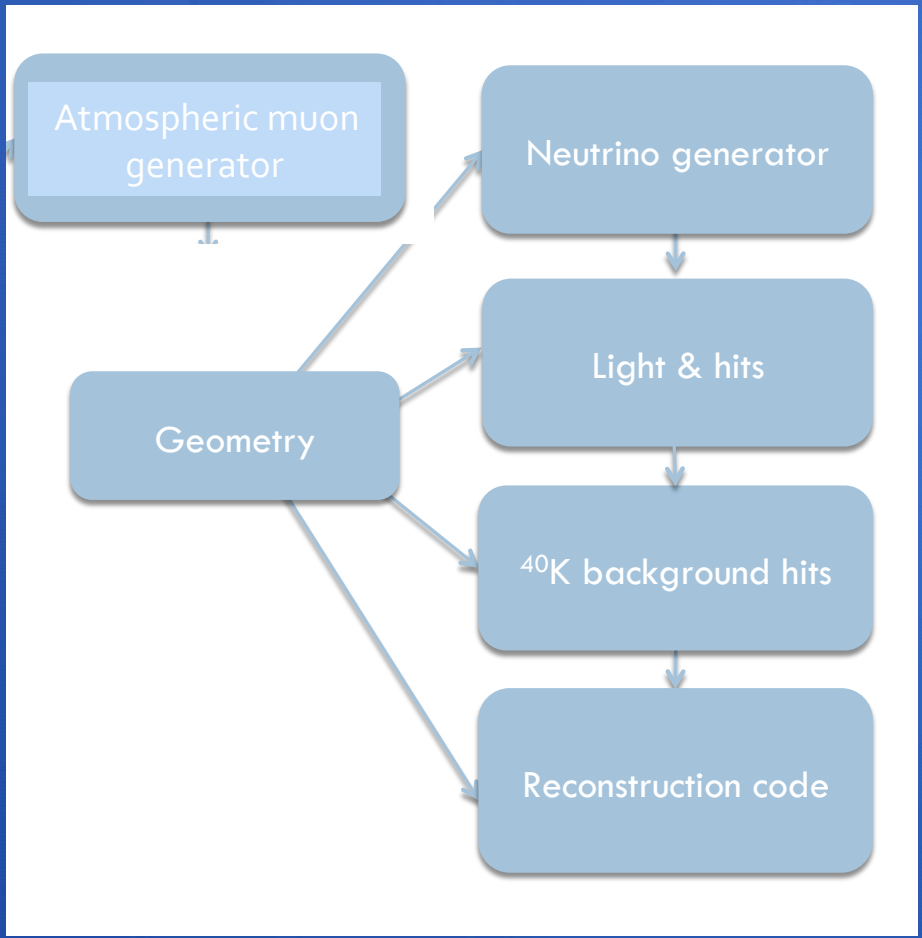
$\nu_e : \nu_\mu : \nu_\tau = 1:1:1 \rightarrow \Phi_{\nu\mu} \approx 1.2\ 10^{-8}\ GeV^{-1}\ sr^{-1}\ cm^{-2}\ s^{-1}$

Is this flux visible with the "traditional" diffuse flux analysis (up-going tracks)?

Warning !!!! KM3NeT not optimized for this flux

The simulations chain

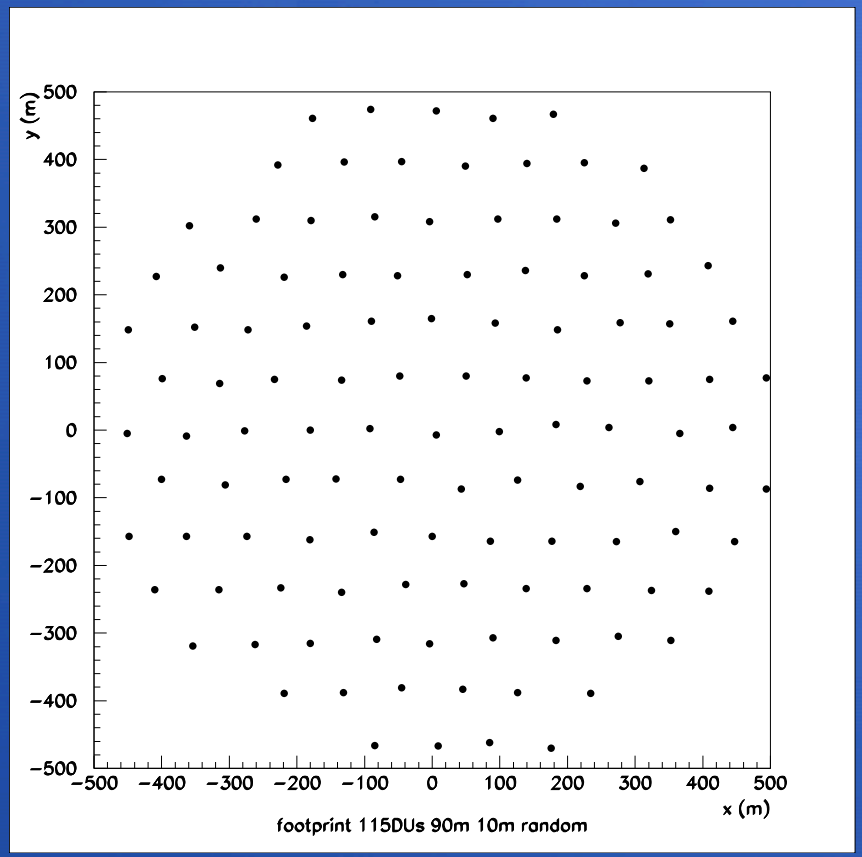
- **ANTARES code modified for KM3NeT**



- Neutrino generator ➔ GENHEN
- Atmospheric muons generator ➔ MUPAGE
- Light & hits ➔ KM3
- Reconstruction code ➔ hit selection + reconstruction based on PDF

The simulated detector

Footprint of a detector block of 115 DU



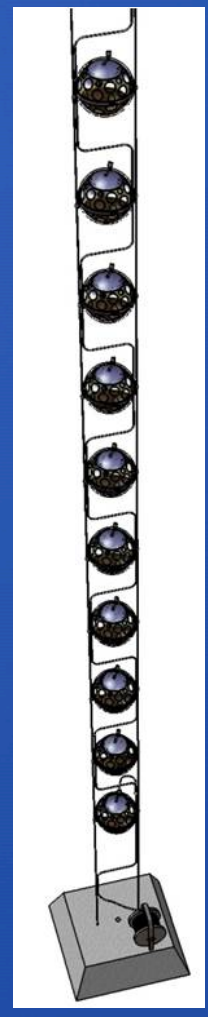
Each block:

- 115 detection Units
- ≈ 90 m distance between strings
- 18 floors per DU
- 1 DOM with 31 3" PMTs per floor (12 PMTs up-looking and 19 down-looking
- 36 m distance between floors

- Volume of a single block ≈ 0.5 km^3
- Full detector of 6 blocks (≈ 3 km^3)

Digital Optical Module

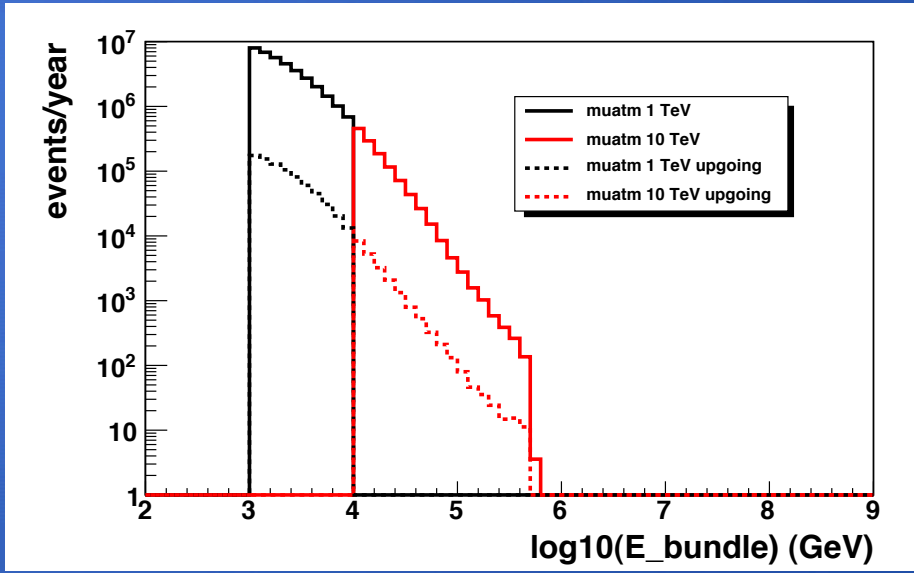
Detection Unit



The event production

- CC interaction of ν_μ and anti-ν_μ in the energy range $10^2 - 10^8$ GeV and θ_{zenith} 0°-180° (full sky)
- Atmospheric neutrino background
  - Conventional Bartol flux
- Two samples of μ_{atm}
  - >1 TeV → 1.4 10^7 events → live time 1.0 day
  - >10 TeV → 7.5 10^6 events → live time 25.6 days

μ_{atm} at generation level and at reconstruction level

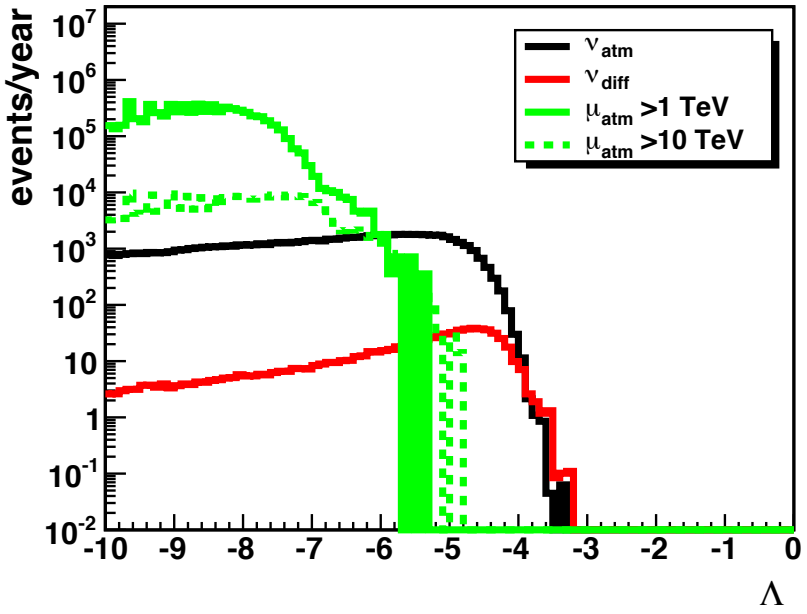


Diffuse flux: up-going events

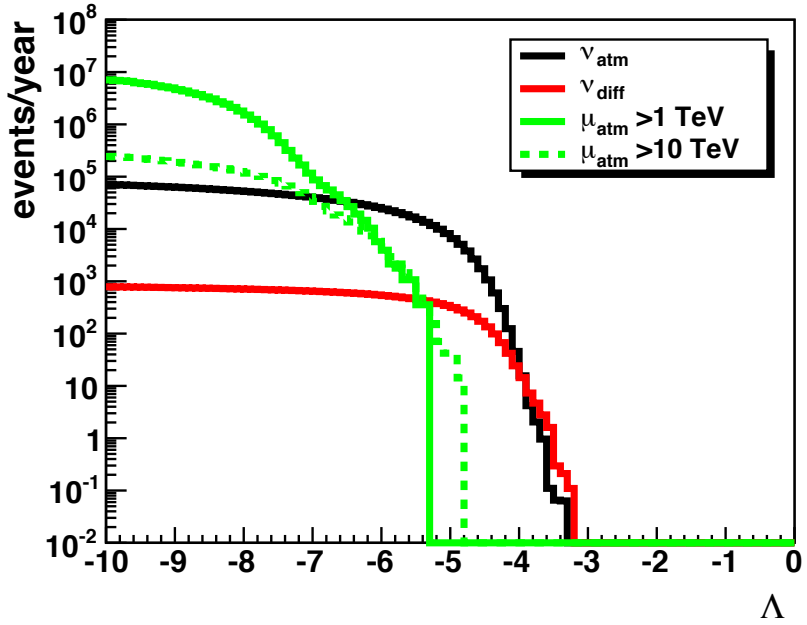
Sensitivity and Discovery fluxes estimated minimizing MRF and MDP with cuts on Λ (reconstruction quality parameter) and N_{hit} (number of hit → muon energy estimator)

Up-going tracks – NO cut applied

Lambda distributions



Cumulative distribution

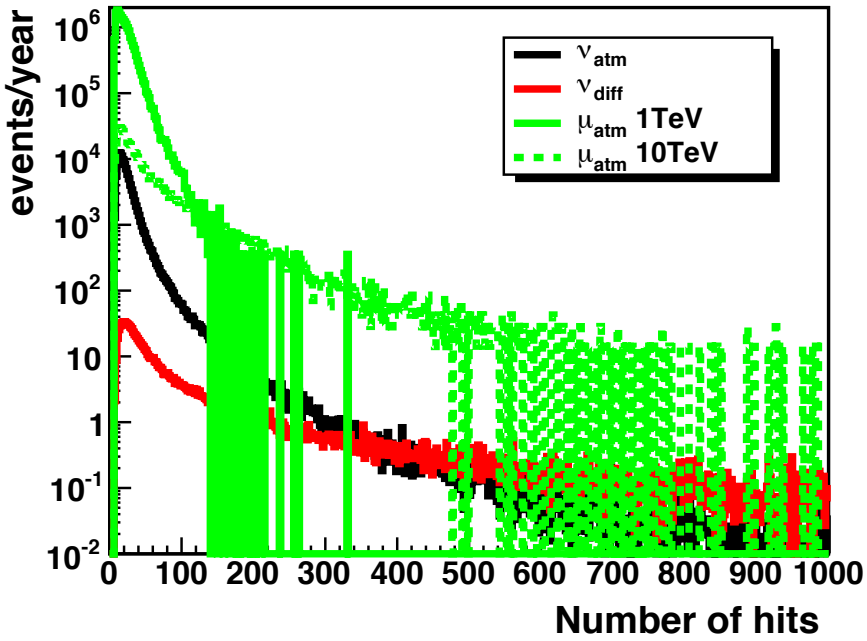


Diffuse flux: up-going events

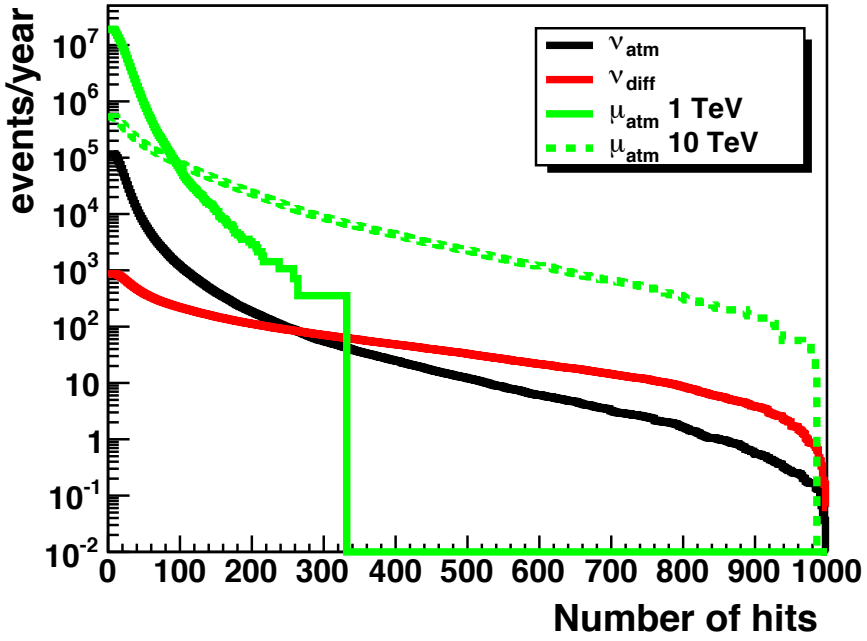
Sensitivity and Discovery fluxes estimated minimizing MRF and MDP with cuts on Λ (reconstruction quality parameter) and N_{hit} (number of hit → muon energy estimator)

Up-going tracks – NO cut applied

N_{hit} distributions



Cumulative distribution



Preliminary results

Sensitivity (90% C.L.) and discovery flux (5σ 50% prob.) for one year of full KM3NeT detector (6 blocks)

Spectrum	Λ	N_{hit}	Φ_{sens}	Φ_{disc}	ν_{atm}	$* \nu_{diff}$	μ_{atm}
E^{-2}	-4.5	498	$4.4\ 10^{-9}$	$1.3\ 10^{-8}$	35.1	11.5	0
E^{-2} exp(-E/2PeV)	-4.5	489	$7.0\ 10^{-9}$	$2.1\ 10^{-8}$	36.2	11.7	0

Flux in $GeV^{-1}\ sr^{-1}\ cm^{-2}\ s^{-1}$

* the number of ν_{diff} is normalized to the sensitivity flux

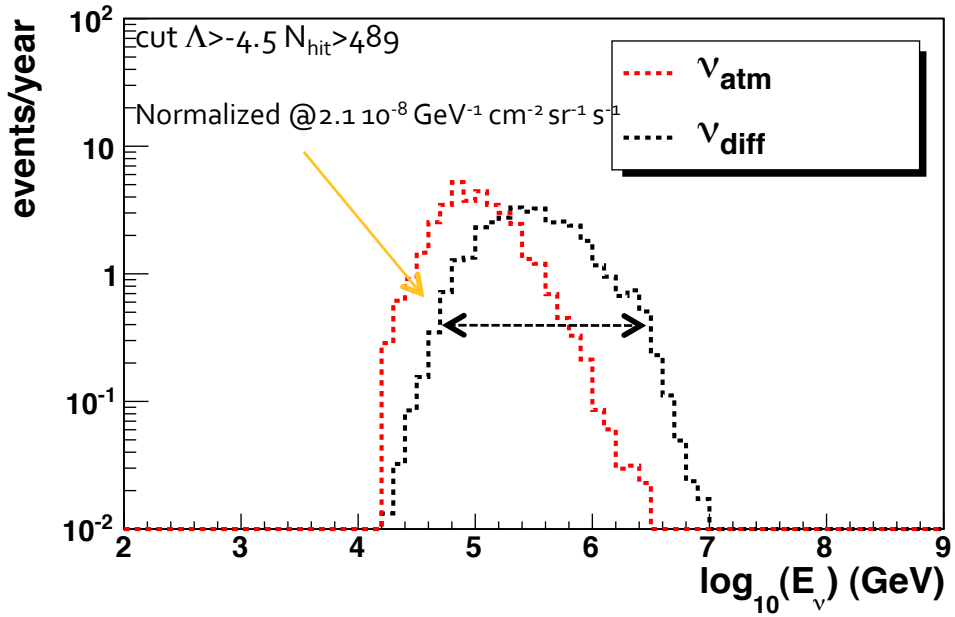
NO prompt component considered in the ν_{atm} spectrum

Energy spectra

Minimization cut applied

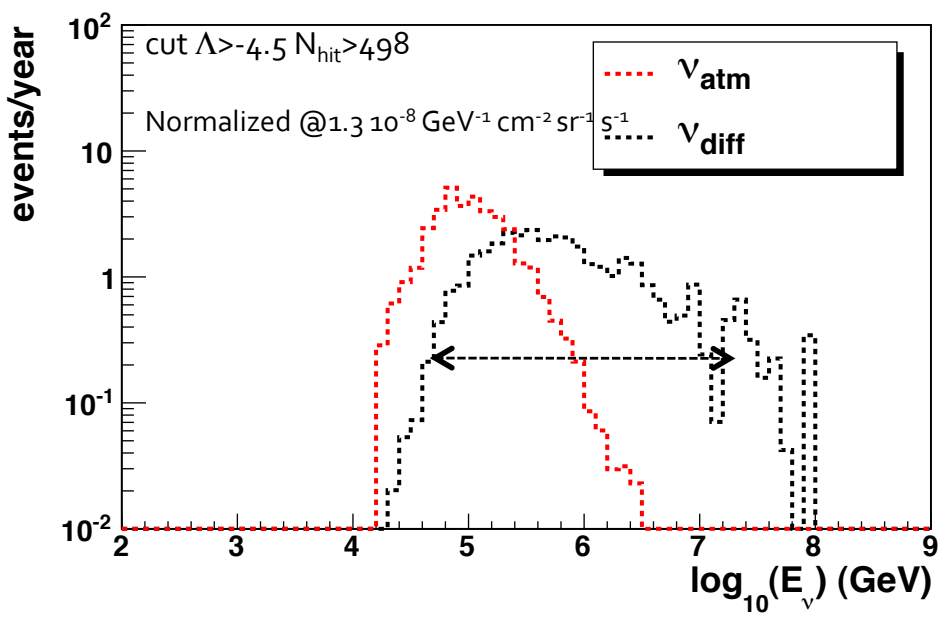
Energy range ≈40 TeV- 3PeV

E^{-2} exp(-E/2PeV) spectrum



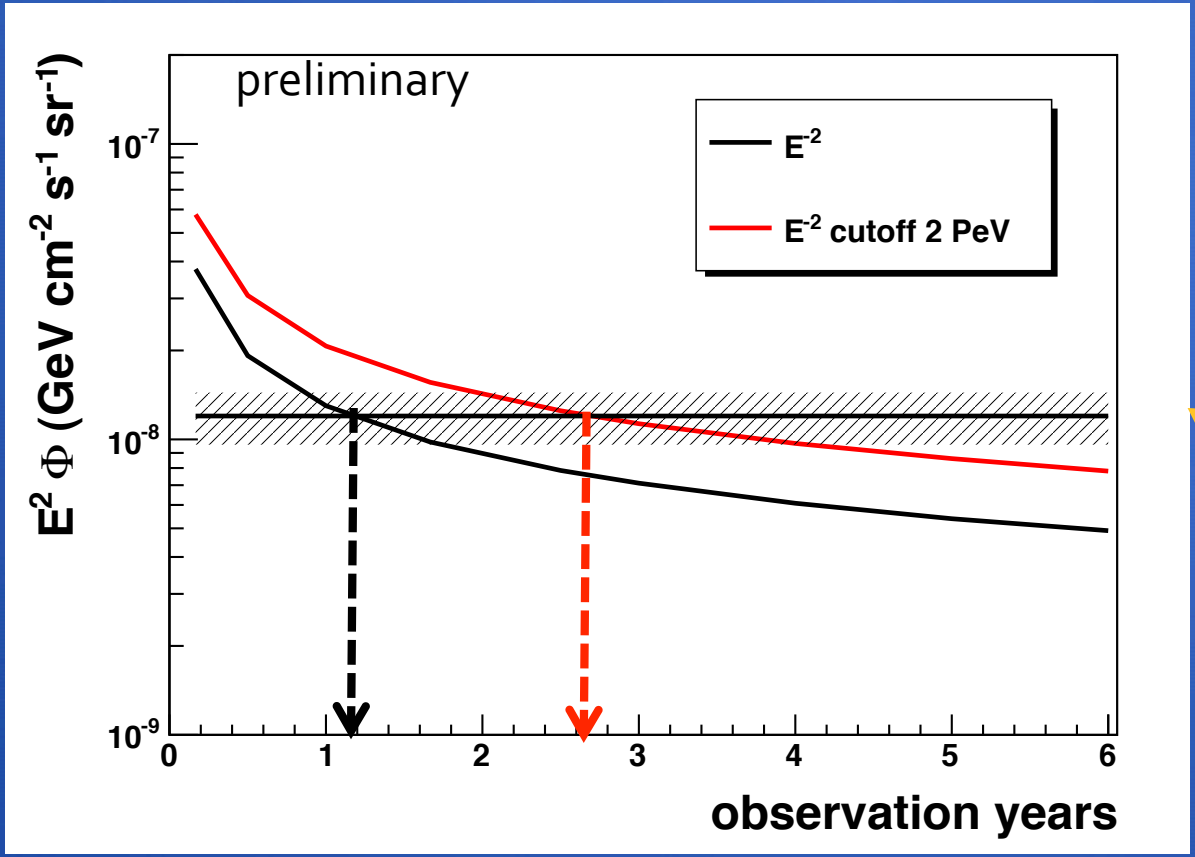
Energy range ≈40 TeV-10 PeV

E^{-2} spectrum



Discovery flux

Discovery flux at 5σ 50% probability for the full KM3NeT detector

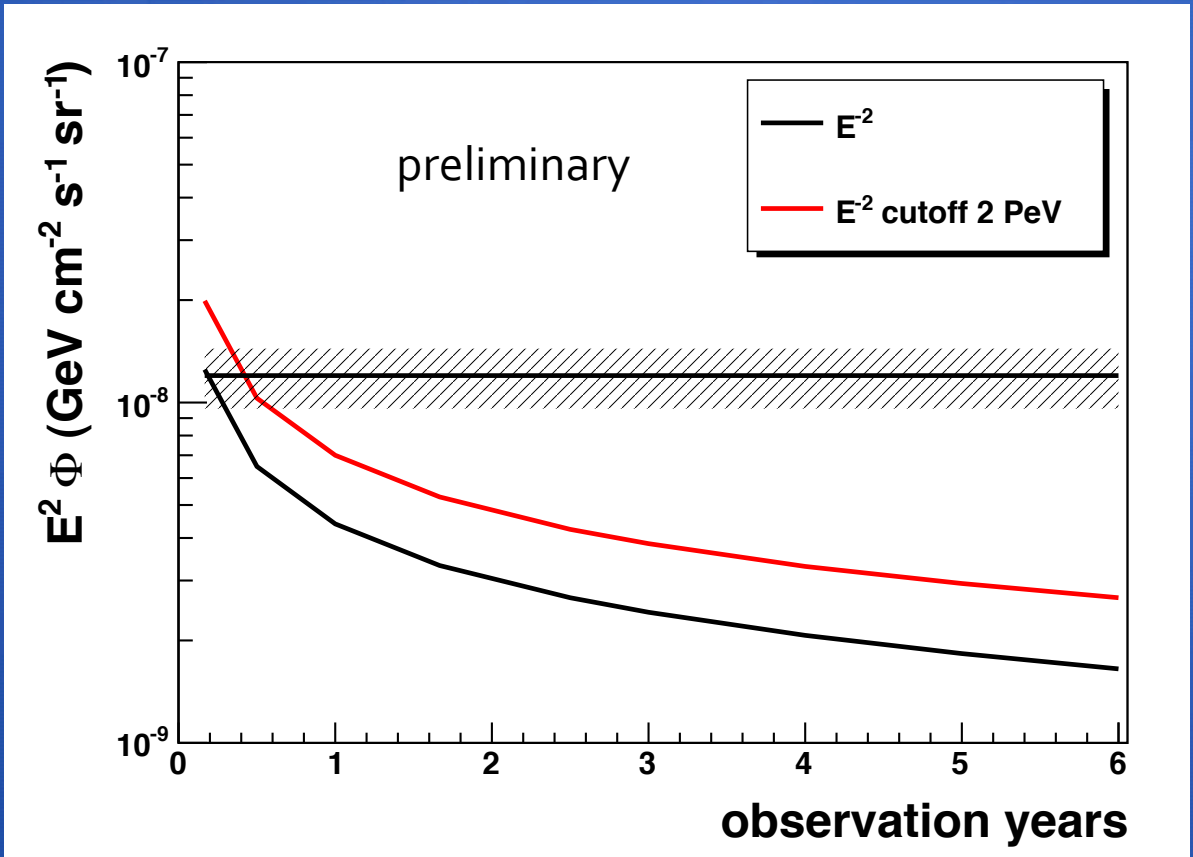


- E^{-2} spectrum
  ➔ discovery in about 1 years
- E^{-2} with cutoff@2 PeV
  ➔ discovery in about 2.5 years

IceCube discovered flux + 20% of indetermination

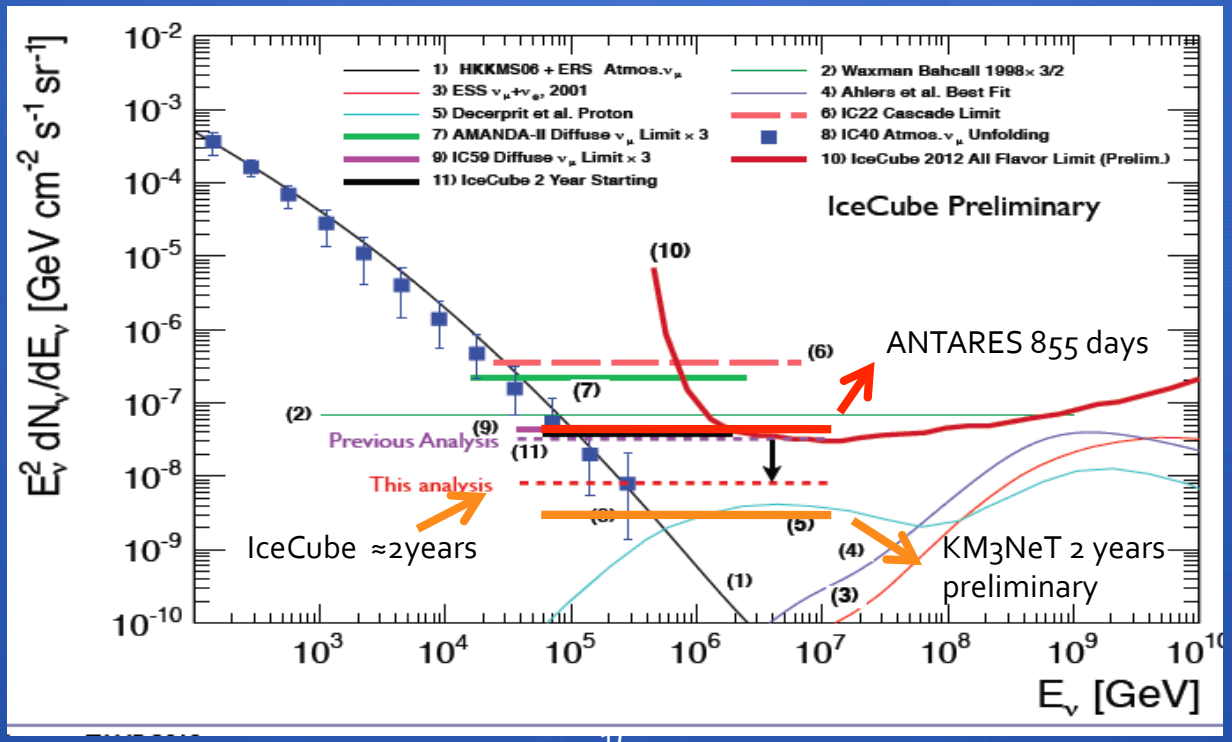
Sensitivity flux

Sensitivity flux at 90% C.L. for the full KM3NeT detector



Slide from Waever TAUP2013 – ν_μ diffuse flux search with the full IceCube detector - analysis on up-going tracks - Data not yet unblinded

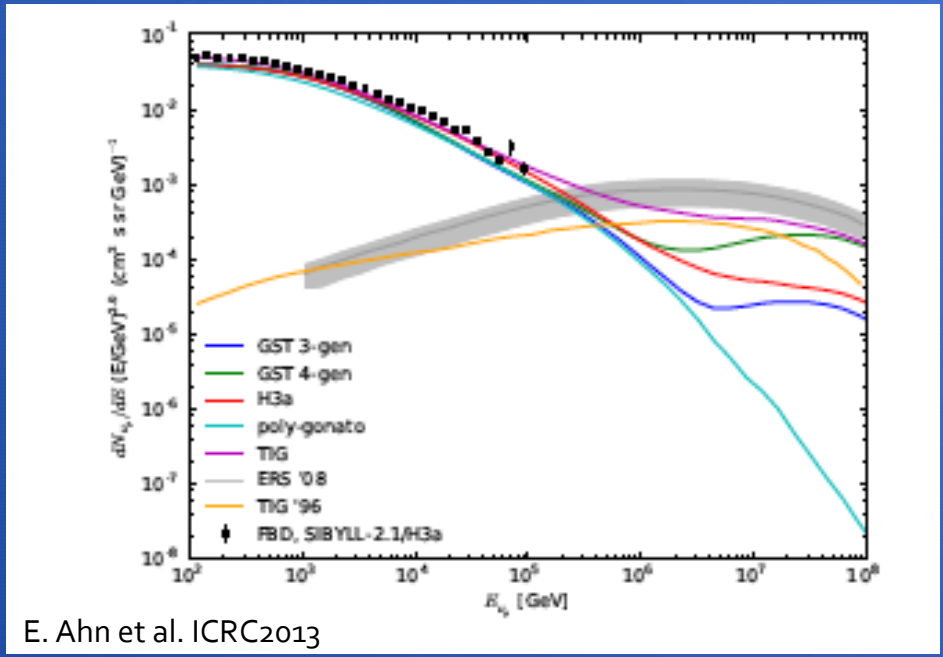
sensitivity



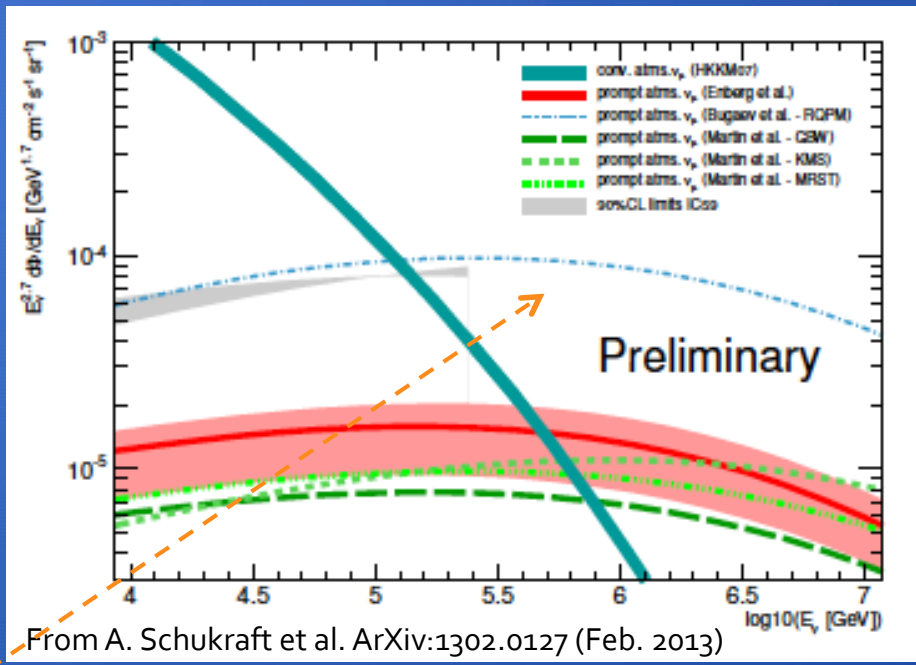
ν_{atm} flux

Dependence on the ν_{atm} flux to be explored

For energies >$10^{5.5}$ GeV the prompt component is dominant.



E. Ahn et al. ICRC2013



From A. Schukraft et al. ArXiv:1302.0127 (Feb. 2013)

First preliminary test with the RQPM prompt component ➔ difference of about a factor 2

Summary

- First preliminary results show that KM3NeT will discover a $1.2\ 10^{-8}\ E^{-2}$ diffuse flux in about **1 year** and a $1.2\ 10^{-8}\ E^{-2}$ flux with a cutoff at 2 PeV in about **2.5 years**
- Results depend on the assumed ν_{atm} flux model ..... Caution in the comparisons between different experiments

The next

- Studies of the dependence on the ν_{atm} spectrum assumed
- Energy reconstruction algorithms to be implemented and tested
- Try to explore few degrees above the horizon -> good μ_{atm} statistics needed

A lot of work to do…

- Cascade reconstruction
- Full sky search
  - Remove down-going μ to remove ν_{atm} and μ_{atm} backgrounds
    ν_{atm} suppression vetoing the accompaning muons (Schonert et al. PRD79 (2009))
    - ✓ at E_ν = 10Te V 70% of ν_{atm} accompanied by a muon but only at vertical angles θ_{zenith}>45 ➔ Corsika simulations needed
    - ✓ At E_ν > 30-100 Te V all accompanied by a muon ➔ Corsika simulations needed
  - Veto strategies
    - Exploiting the DOM up-looking behaviour
    - External strings and upper floors ….
    - Pseudo-vertex (Luigi Fusco talk)…