Sensitivity of the KM3NeT detector to a neutrino flux from the Fermi Bubbles

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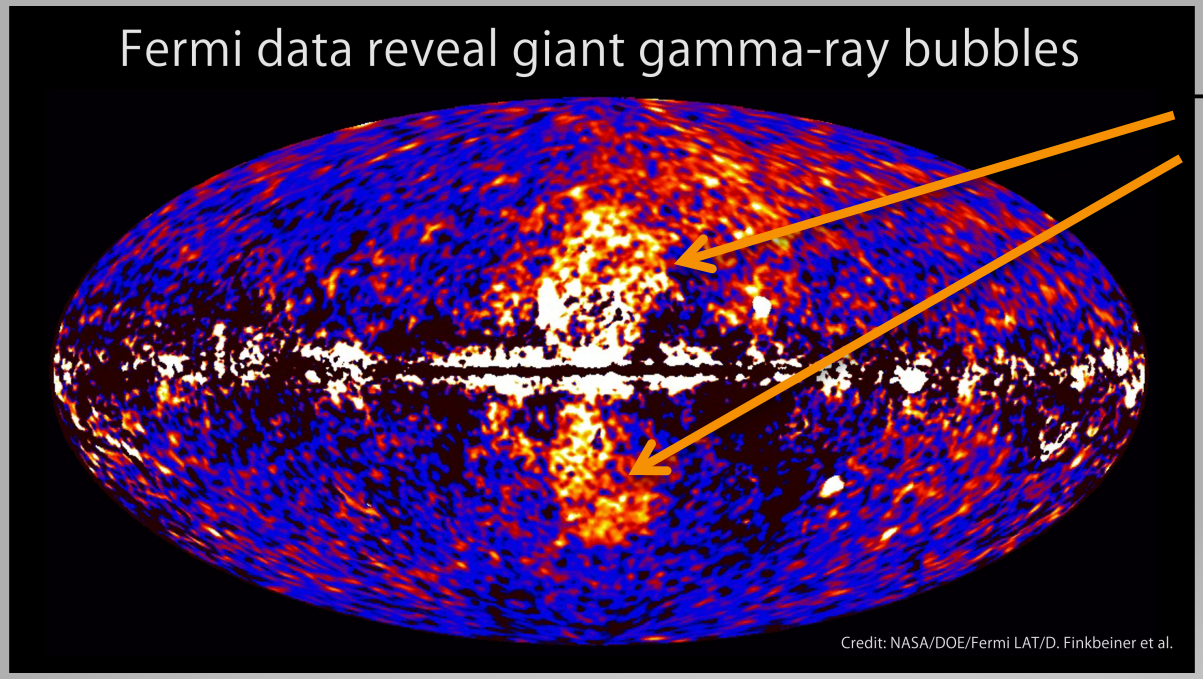
Presented on behalf of R. Coniglione

The Fermi Bubbles observations

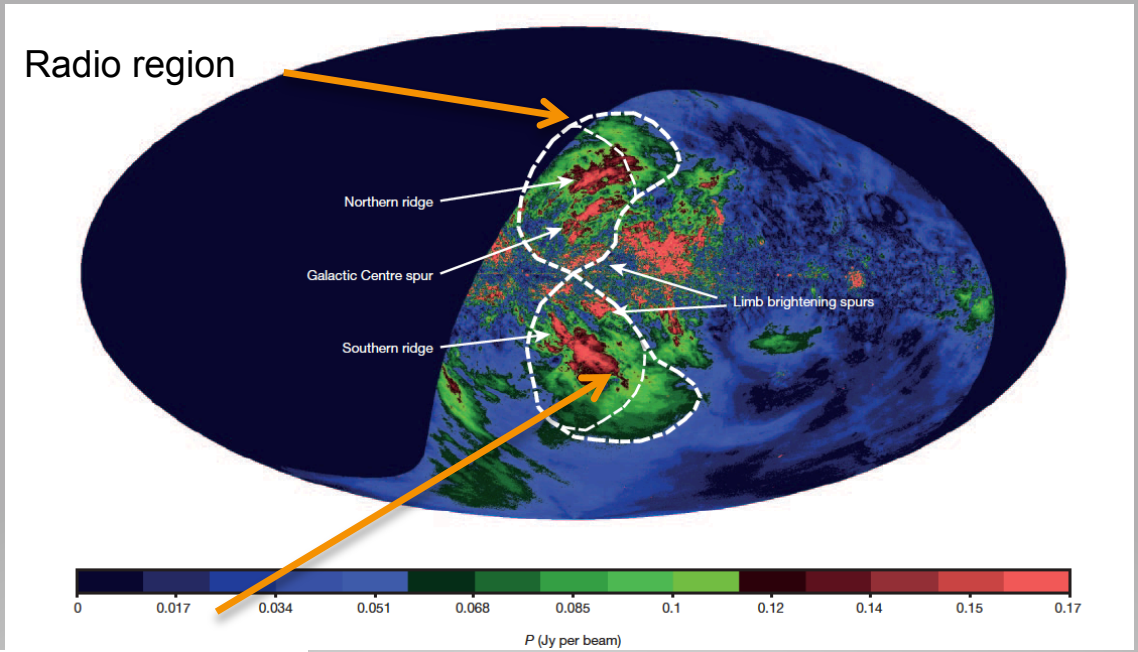
- High energy γ-rays from two well defined in shape large bubbles in the Milk Way has been observed by Fermi LAT (Meng and Su 2010)



≈ 50° above and below the Galactic centre and ≈ 40° in longitude.

The Fermi Bubbles observations: the counterparts

- X-ray, microwaves and very recently radio emissions also observed

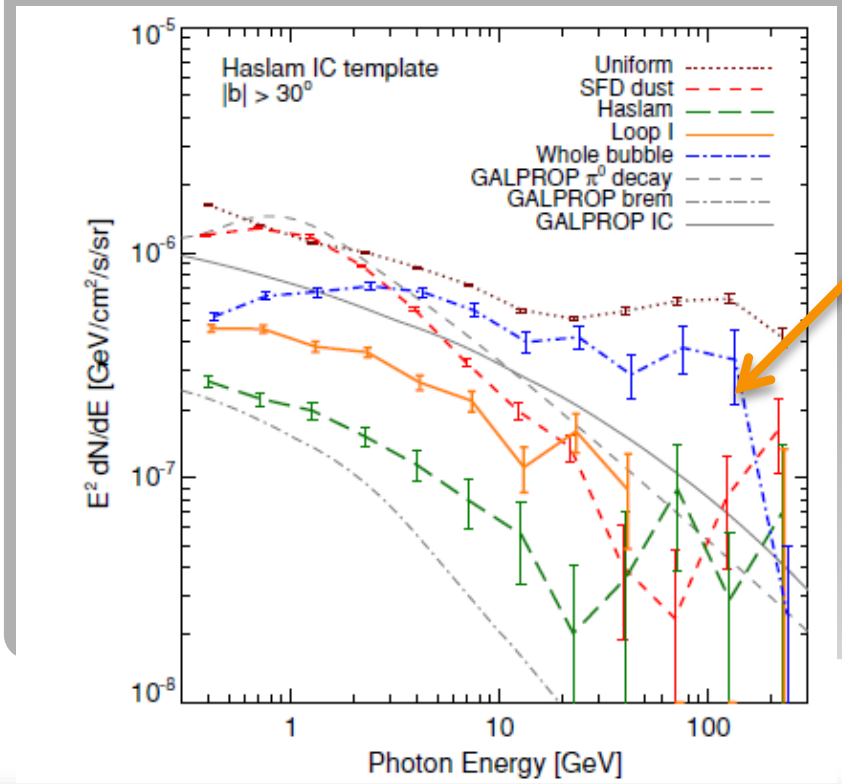


High energy γ-emission region

Carretti et al., Nature Jan 2013

The high energy γ-ray spectrum

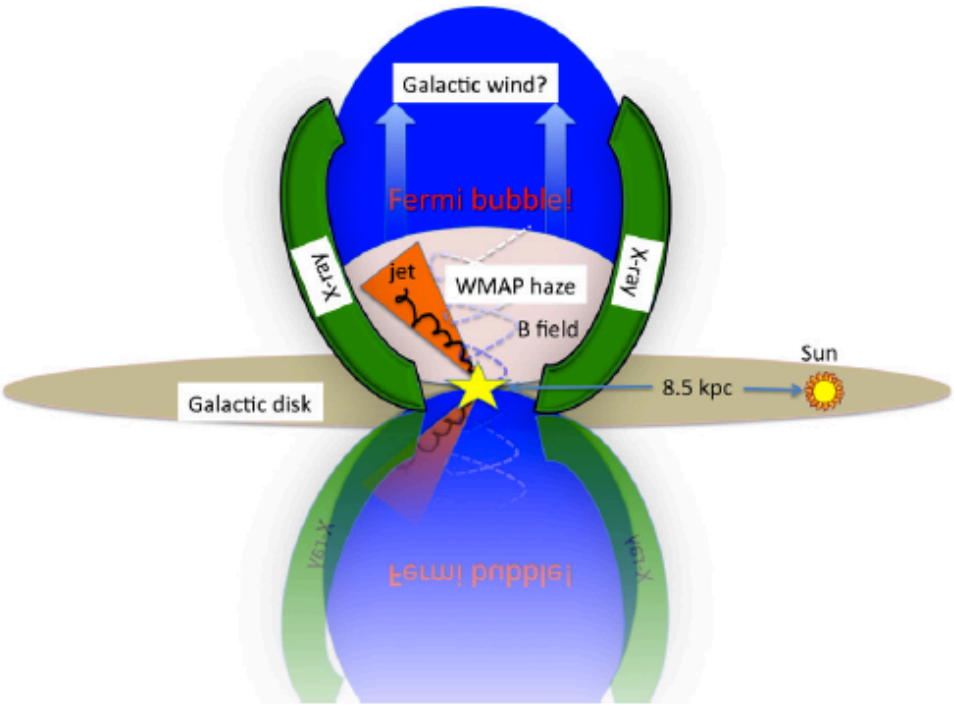
- Analysis based on a complex map processing depending on Galactic emission modelling
  - First analysis of Meng Su et al. (Astrophys. J. 2010)
  - Confirmed by the Fermi collaboration on a larger set of data … bubble spectrum measured up to 500 GeV (Preliminary spectrum showed at ICRC2013 -- not yet published -- with a cutoff above 100 GeV … very low statistics in the cutoff region)



The γ spectrum is flat in E^2 dN/dE and of high intensity (several 10^{-7} GeV cm^{-2} s^{-1} sr^{-1})

No evidence of spacial variation both in the spectrum shape and in the intensity

A cartoon picture



In *Meng Su et al.* the bubbles are explained as due to relativistic CR electrons that produce γ through IC process

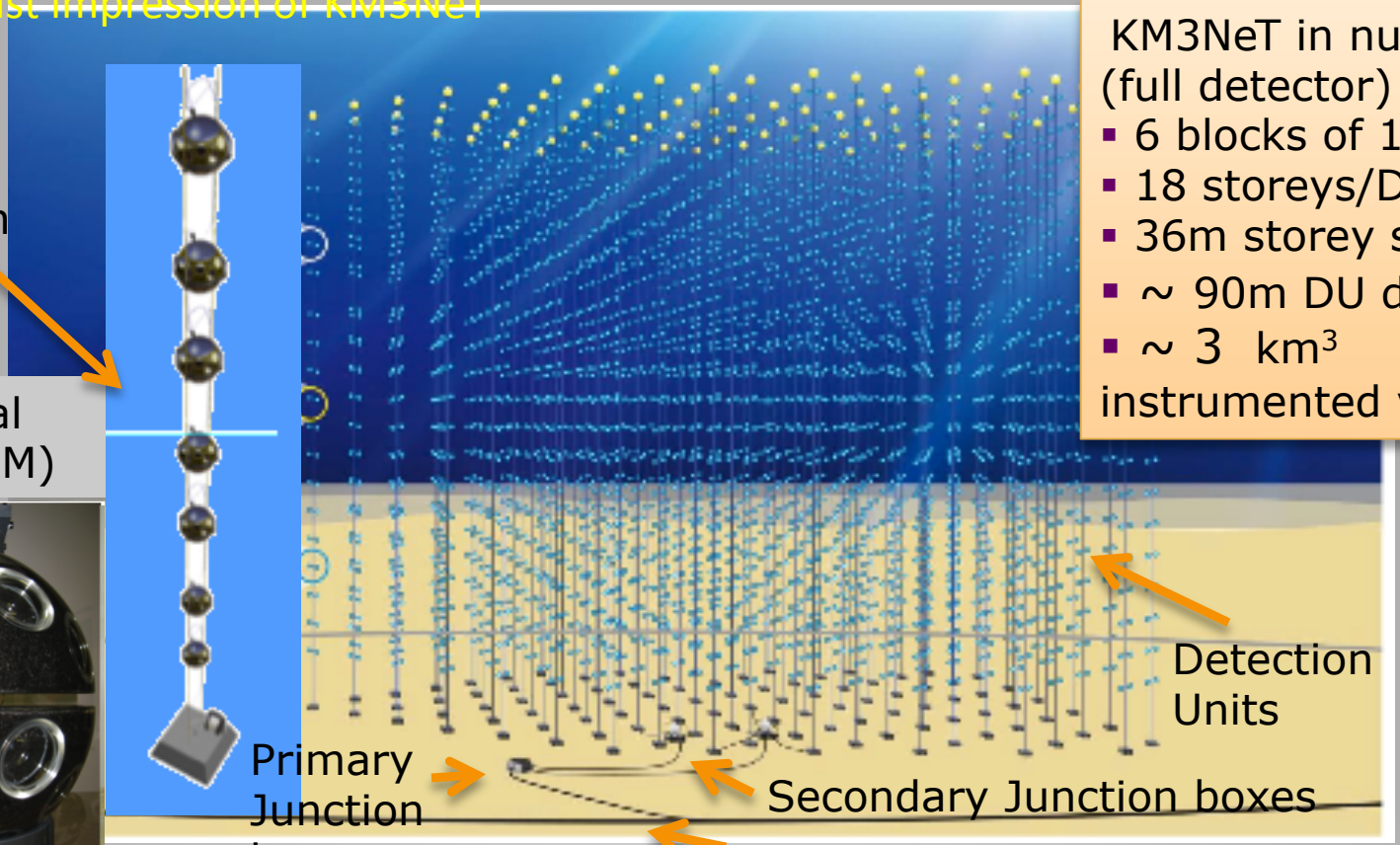
In *Crocker et Aharonian (2010)* gammas are originated by a CR population associated with long time scale star formation in the GC (~10^{10} years), interacting with the ambient matter and producing high energy gamma through $\pi 0$ decay.

OPEN QUESTIONS

- ✓ What mechanism produces the high energy γ-rays?
- ✓ Are also high energy neutrinos produced?

KM3NeT detector layout

Artist impression of KM3NeT



KM3NeT in numbers (full detector)

- 6 blocks of 115 DUs
- 18 storeys/DU
- 36m storey spacing
- ~ 90m DU distance
- ~ 3 km^3

instrumented volume

The Optical Module (OM)

31 3" PMT inside a glass sphere

KM3NeT detector -> talk by U. Katz

The sensitivity analysis

Monte Carlo Simulations

- neutrinos from bubbles and their interactions
- atmospheric neutrinos (Bartol flux) and their interactions
- atmospheric muons (Mupage parameterisation)
- Light simulation (optical water properties)
- Hit generation (PMT simulation)
- ^{40}K Background and electronics
- Track reconstruction

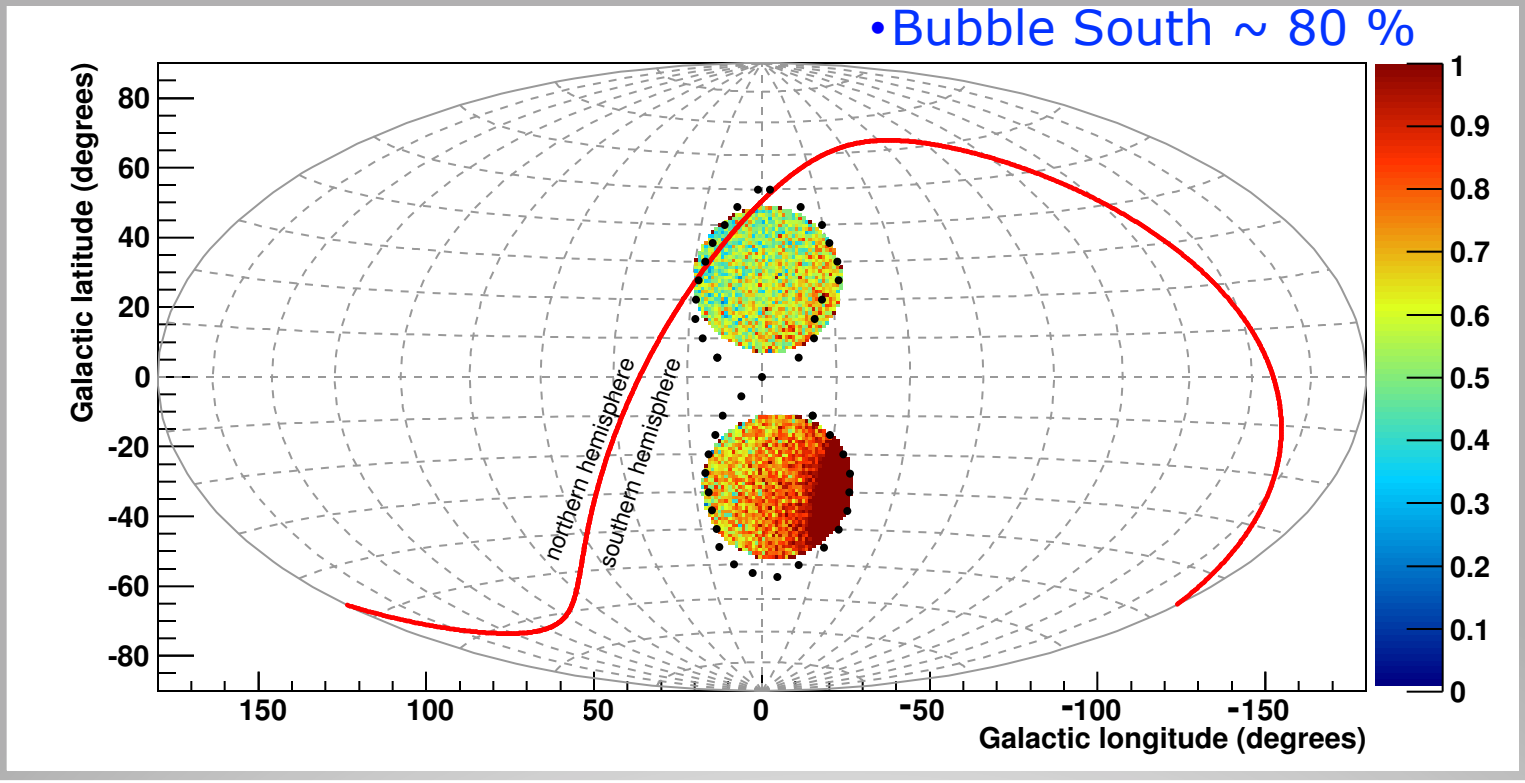
Discovery flux calculation

- Minimization of Discovery Potential (MDP)
- Cuts related to the reconstruction quality and number of hits (related to the muon energy)

Details on: A.M. Martinez et al. (KM3NeT collaboration), Astropart. Physics 42 (2013) 7

The generation region

- Up-going tracks selected
- Visibility for a detector located in the Mediterranean sea
  - Bubble North ~ 58%
  - Bubble South ~ 80 %



The neutrino spectrum

If the mechanism is fully hadronic and the source transparent to γ-rays the expected neutrino flux can be estimated from the measured γ-ray spectrum. (F.L.Villante and F.Vissani, Phys.~Rev.~D 78 (2008) 103007)

From measured γ

$E_\gamma^2 \, d\Phi/dE_\gamma \approx 4 \times 10^{-7}$ GeV cm^{-2} s^{-1} sr^{-1}

Bubbles solid angle ≈ 0.7 sr

To expected neutrino

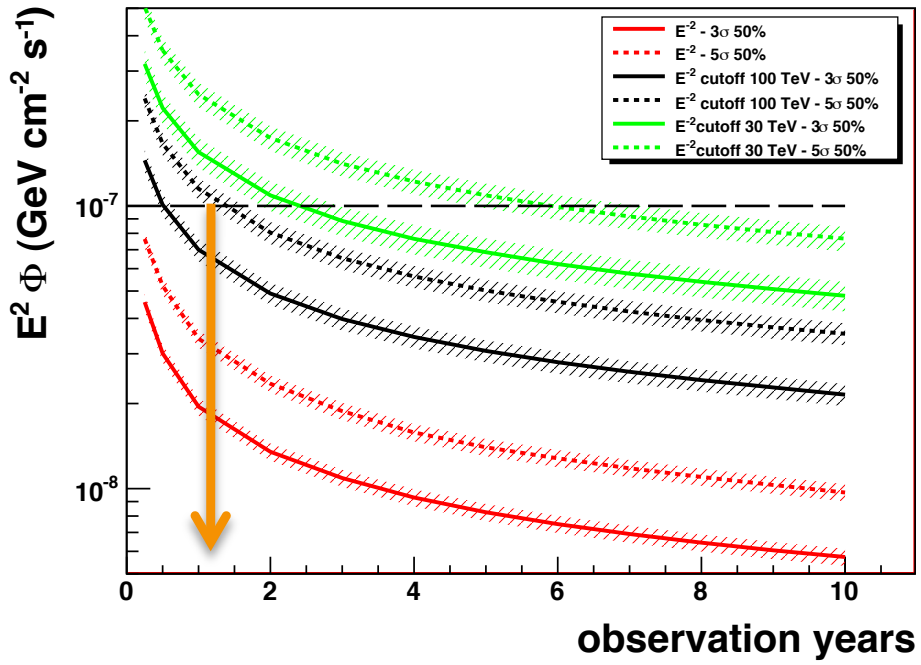
$E_\nu^2 \, d\Phi/dE_\nu \approx 10^{-7}$ GeV cm^{-2} s^{-1}

Neutrino spectra with cutoff at 100 TeV and 30 TeV also considered

Is this flux observable with the KM3NeT detector?

The results

Discovery potential at 3σ and 5σ (50% discovery probability) as a function of the observation years



Detector with:

- 12320 OMs
- 180m distance between DUs
- ≈ 6 km^3

Cutoff 30 TeV

Cutoff 100 TeV

No Cutoff

Results depend on the assumed spectrum

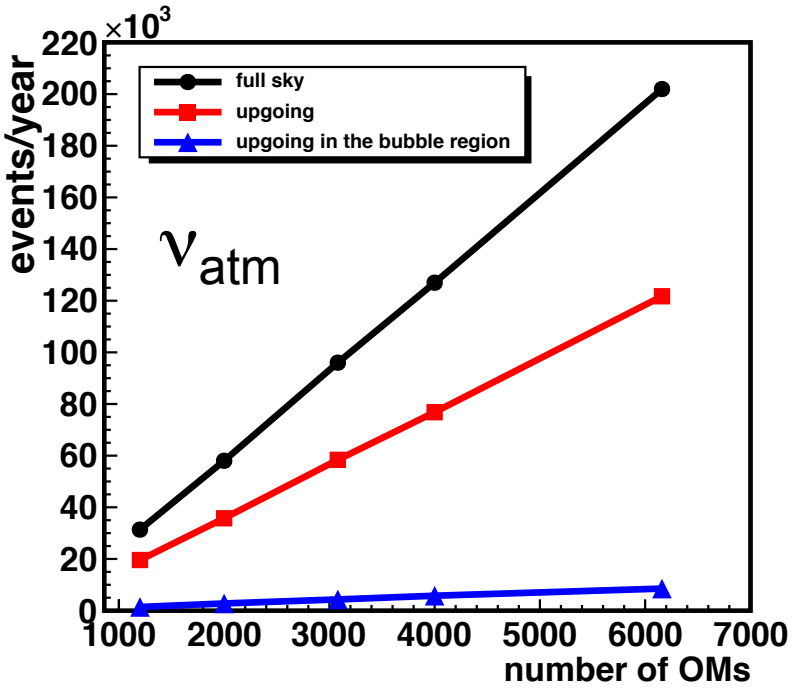
About 1.5 year to discover the Fermi Bubbles for a 100 TeV cutoff spectrum

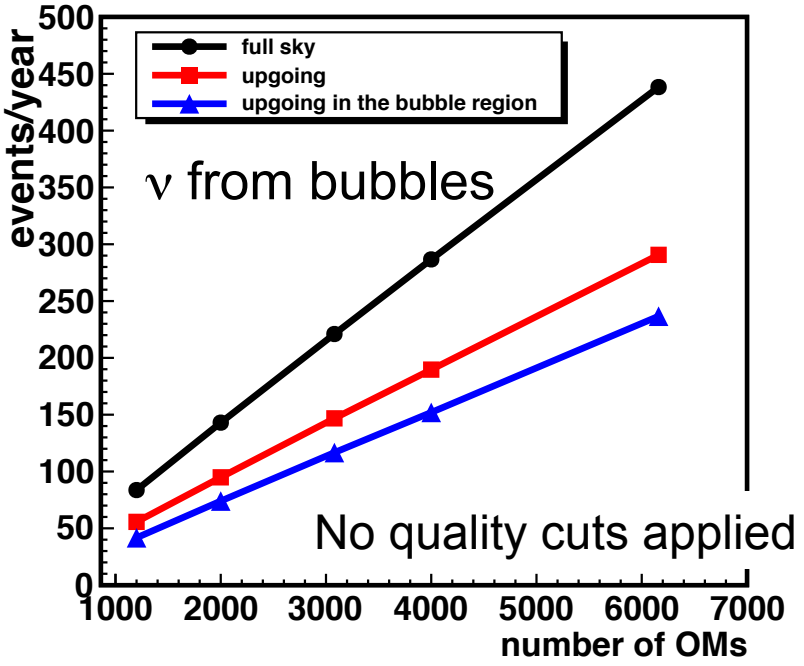
Detail on A. M. Martinez et al. KM3NeT collaboration, Astropart. Physics 42 (2013) 7-14

....as a function of detector size

Neutrino telescopes have modular design; science capabilities increase continuously with size.

Number of reconstructed events as a function of the number of OM

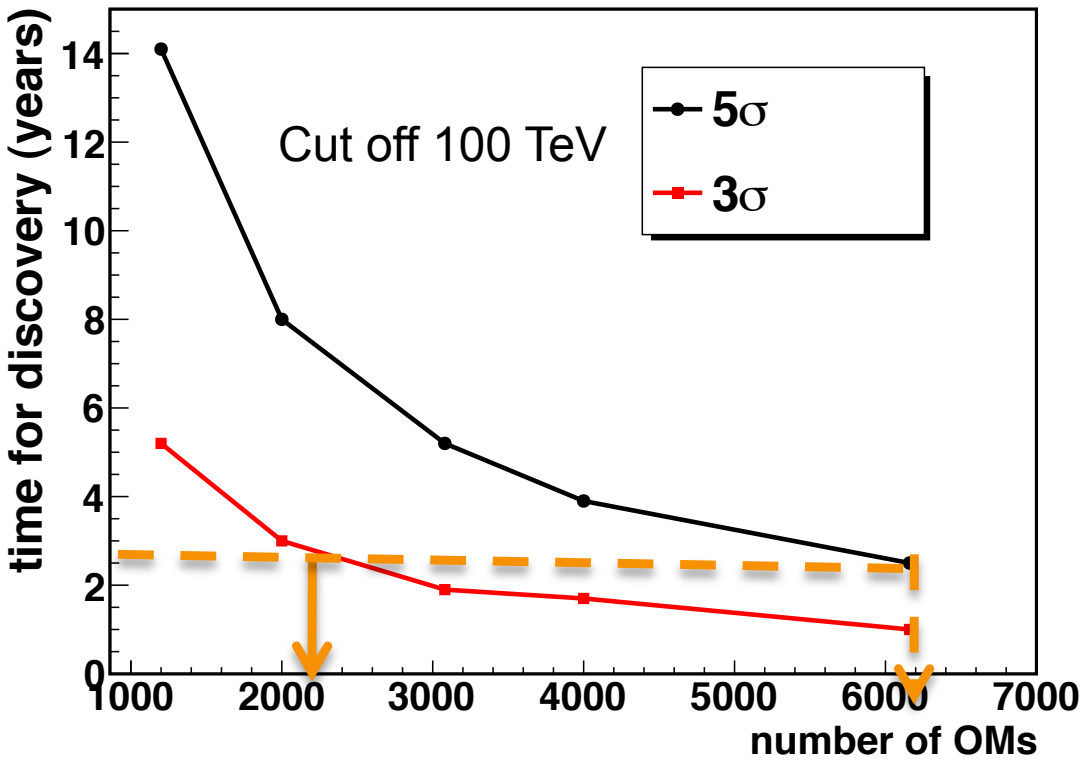




Linear increase of the number of reconstructed events

....as a function of detector size

Time for discovery as a function of number of OM



Discovery (5σ) for a detector with ≈ 6000 OMs in about 2.5 years

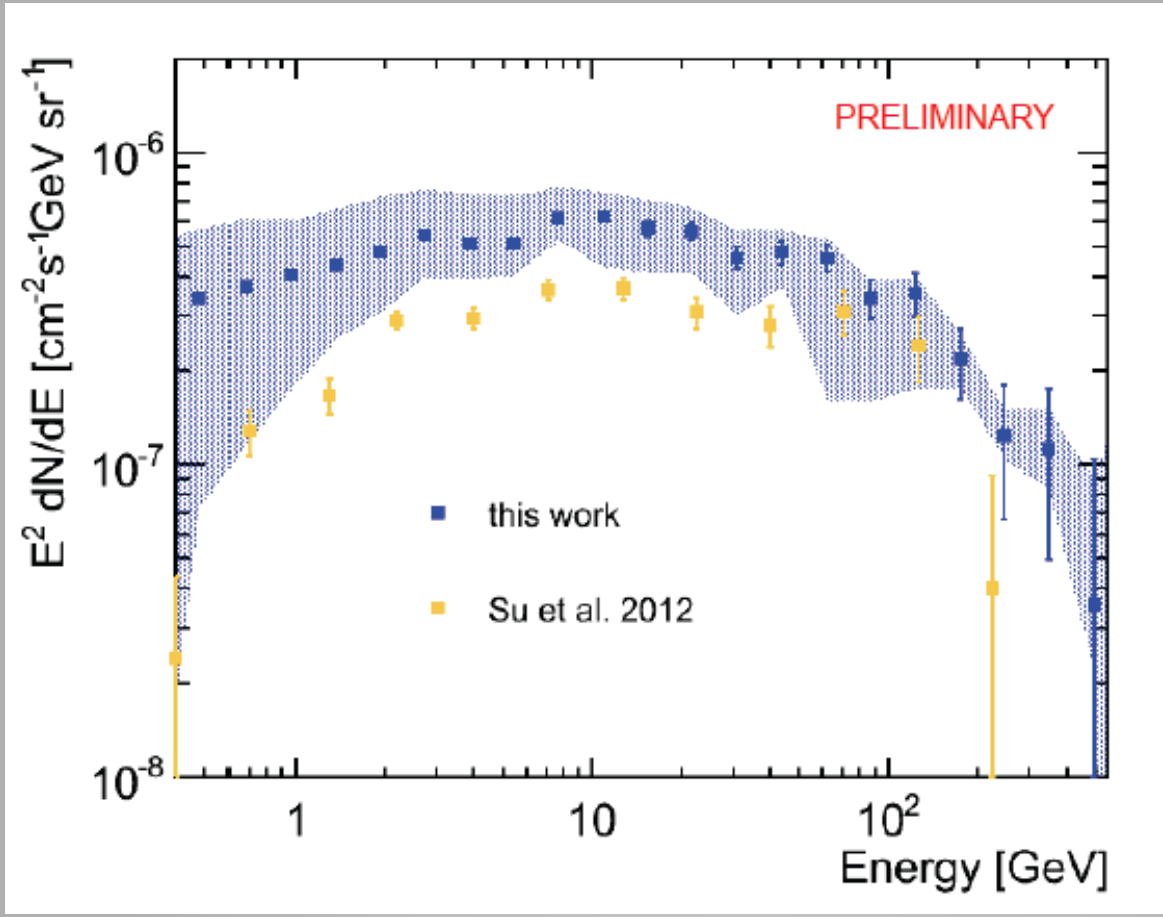
Evidence 3σ in 2.5 years for a detector with ≈ 2000 OMs

Conclusions

- Fermi bubbles are a promising source for the KM3NeT detector

- Assuming a E^{-2} neutrino spectrum with cutoff@100 TeV
  - Discovery (5σ) in 1.5 years for the full KM3NeT detector
  - Evidence (3σ) in about 2.5 years in the first stage of construction (about 15% of the complete detector)

SPARES


PRELIMINARY
E^2 dN/dE [$cm^{-2}s^{-1}GeV\ sr^{-1}$]
10^{-6}
10^{-7}
10^{-8}
this work
Su et al. 2012
1
10
10^2
Energy [GeV]