KM3NET AND SENSITIVITY TO NEUTRINO POINT-LIKE SOURCES

P. Sapienza for the KM3NeT collaboration

KM3NeT

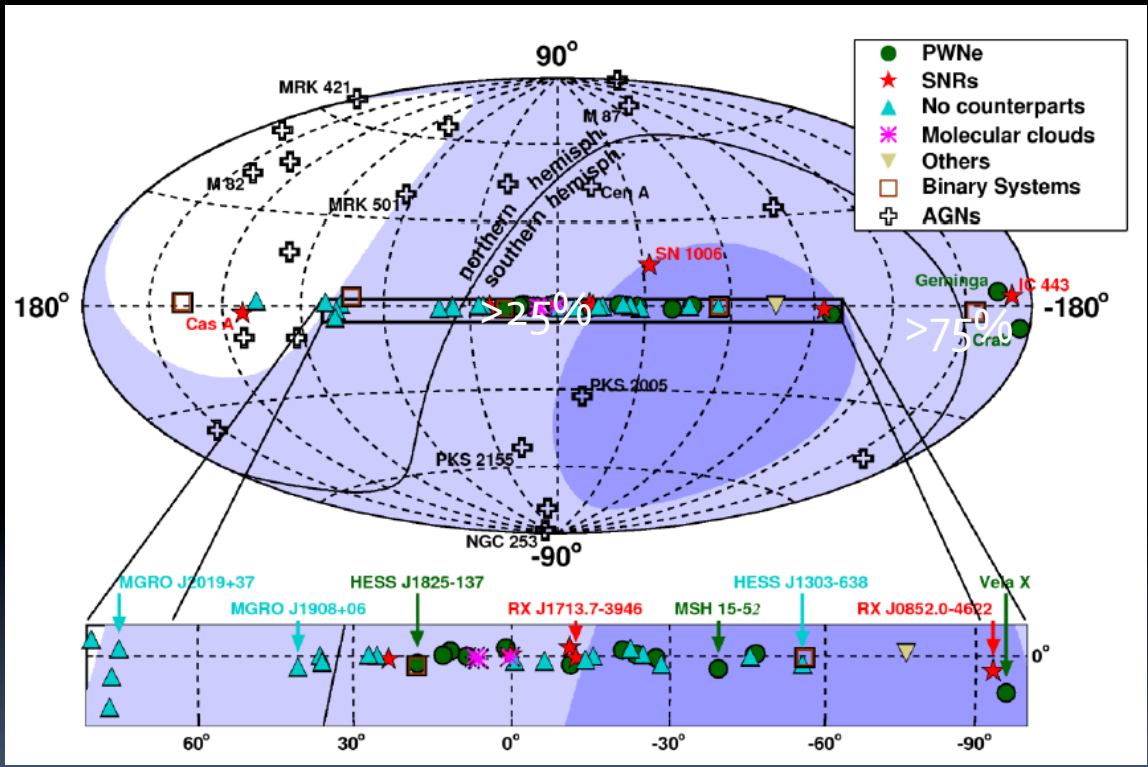
- Objective: build and operate a deep-sea infrastructure hosting a km3-scale high energy neutrino (E > 100 GeV) telescope in the Mediterranean Sea
- Full telescope instrumented volume about 5 km^3
  - Optical Cherenkov detection tecnique
  - optical properties of sea water allow excellent angular resolution
- Envisaged budget about 220 M€
- KM3NeT will allow to investigate the southern neutrino sky (not visible from the South Pole) with a sensitivity substantially larger than the IceCube sensitivity

The KM3NeT consortium

- KM3NeT consortium consists of 40 European institutes, including those in Antares, Nemo and Nestor, from 10 countries (Cyprus, France, Germany, Greece, Ireland, Italy, The Netherlands, Rumania, Spain, U.K)
- KM3NeT is included in the ESFRI and ASPERA roadmaps
- KM3NeT FP6- Design Study (2006-2009)
  - Conceptual Design Report
  - Technical Design Report (TDR)
  - See: km3net.org/public
- KM3NeT FP7-Preparatory Phase (2008-2012)
  - Scientific and technical aspects have been reviewed
  - Last in-situ validations on their way
  - Implementation of the first phase of KM3NeT in preparation

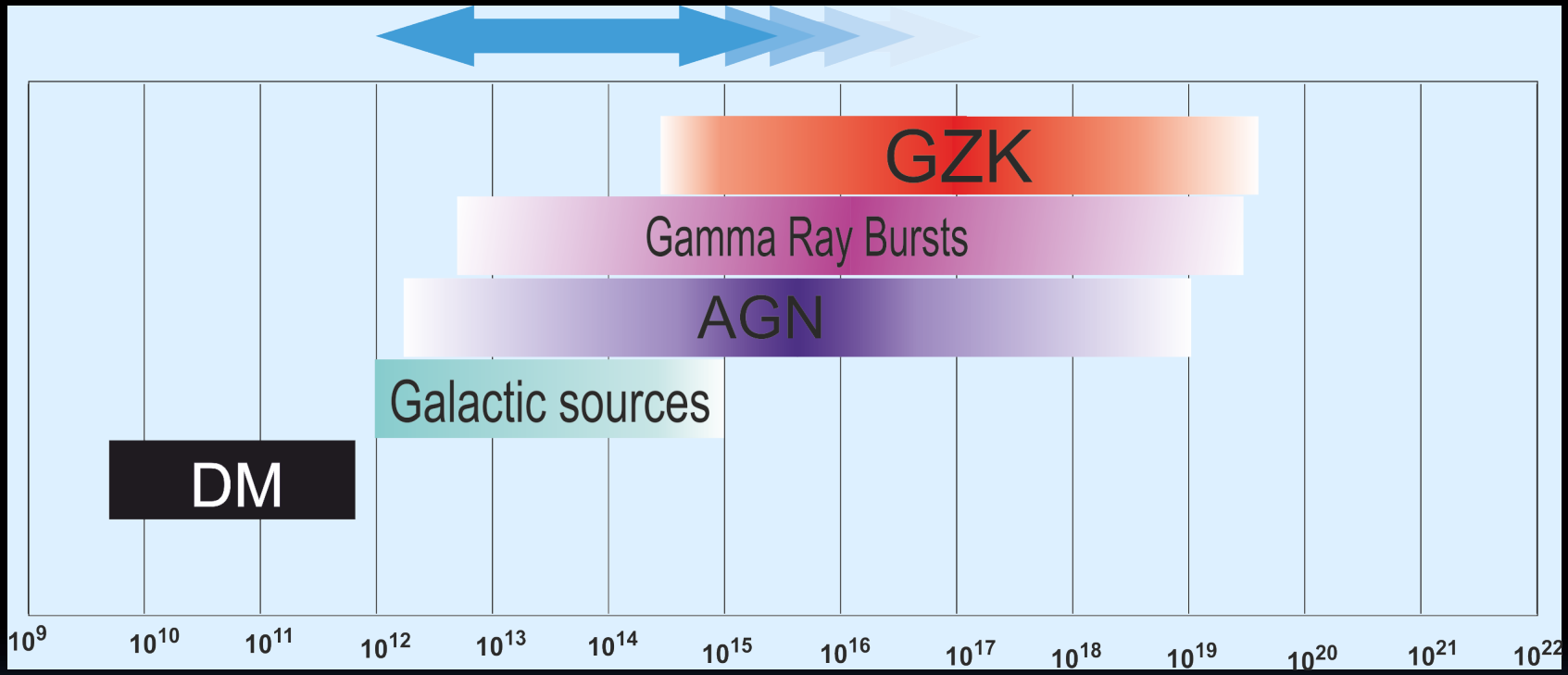
Sky view of a Mediterranean Sea telescope (up-going neutrinos)

From Mediterranean 24h per day visibility up to $\delta \sim -50°$



➢ KM3NeT coverage of most of the sky including the Galactic Centre

Neutrinos from cosmos



In addition the measurement and study of atmospheric neutrinos can provide very interesting pieces of information on neutrino phyiscs => Mass Hierarchy (E_ν up to tens of GeV) .....

Physics Case and Main objectives

- Main physics goals
- Origin of Cosmic Rays and Astrophisical ν sources
  - Galactic Candidate n Sources (SNRs, Fermi Bubbles, microquasar,…)
  - Extragalactic Candidate n Sources (AGN, GRB, …)
  - Telescope optimisation→ "point sources" energy range 1 TeV-1 PeV
- Implementation requirements
  - Construction time ≤5 years
  - Operation over at least 10 years without "major maintenance"
- Cabled platform for deep-sea research (marine sciences)

Technical Challenges and Telescope Design

- Technical design

  Objective: Build, deploy and operate a km3-scale 3D-array of photosensors connected to shore (power, slow control, data)

  @ 2500 – 5200 m depth undersea

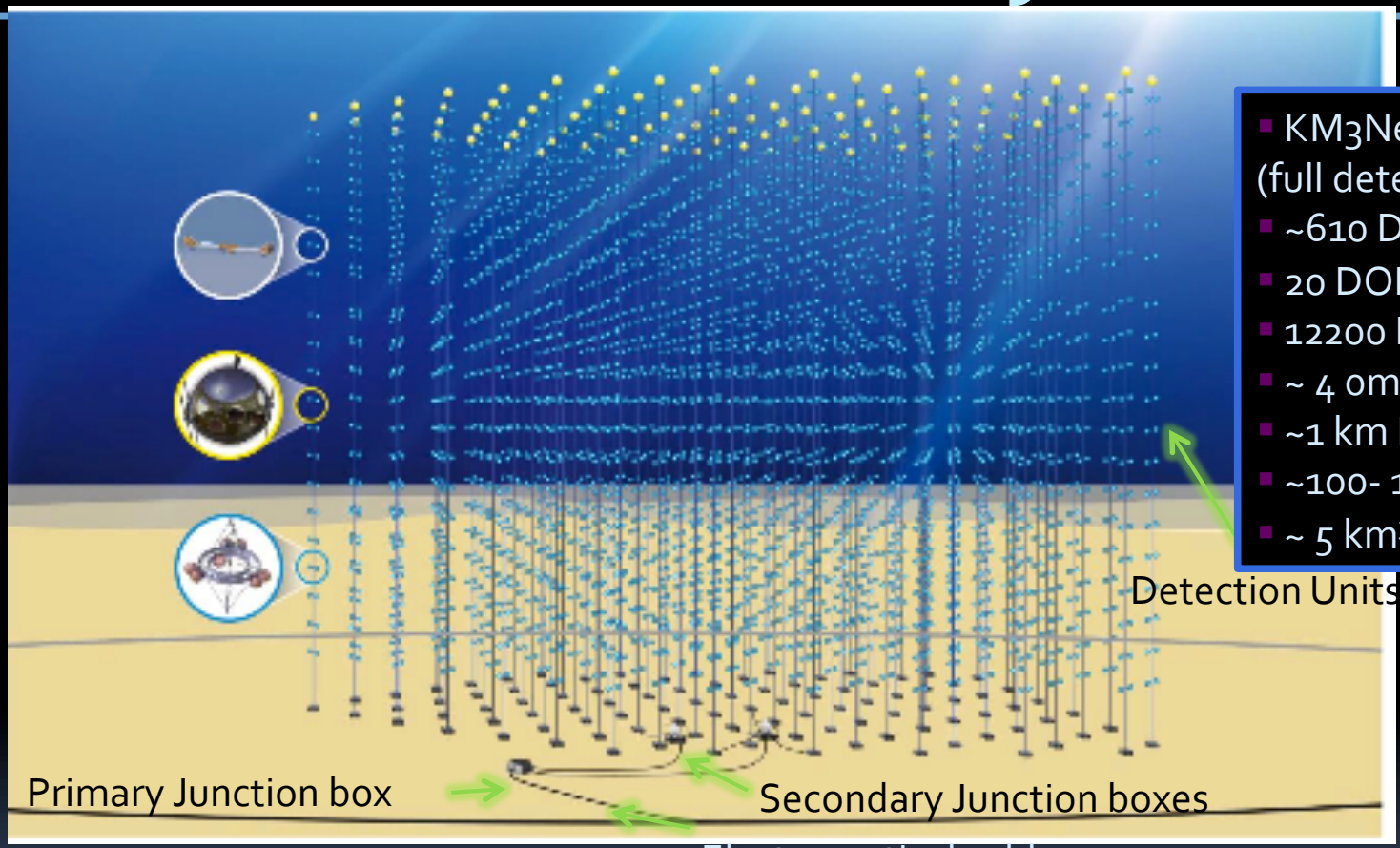
  - Optical modules (OM)
  - Mechanical structures (DU)
  - Data transmission, information technology and electronics
  - Deep-sea infrastructure
  - Deployment
  - Calibration

Builds on the experience gained with ANTARES, NEMO and NESTOR

Design rationale:

Cost-effective
Reliable
Producible
Easy to deploy

KM3NeT lay-out



- KM3NeT in numbers (full detector)
- ~610 DU
- 20 DOM/DU
- 12200 DOM
- ~ 40m DOM spacing
- ~1 km DU height
- ~100- 180 m DU distance
- ~ 5 km^3 volume

Detection Units

Optical Module (OM) = pressure resistant/tight sphere cointaining photo-multpliers
Detection Unit (DU) = mechanical structure holding OMs, enviromental sensors, electronics,… *DU is the building element of the telescope*
Construction in several blocks => Multi-site option

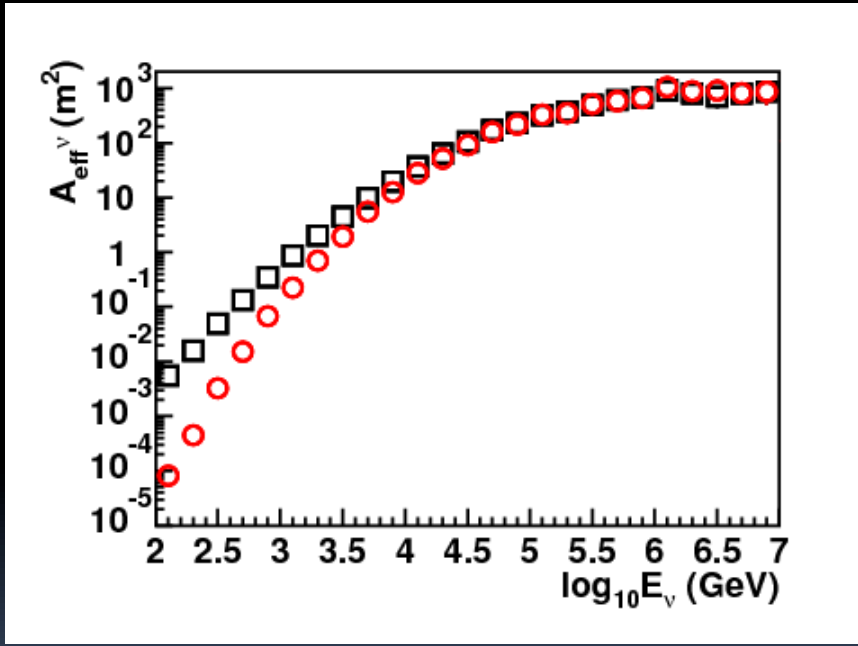
The Digital Optical Module

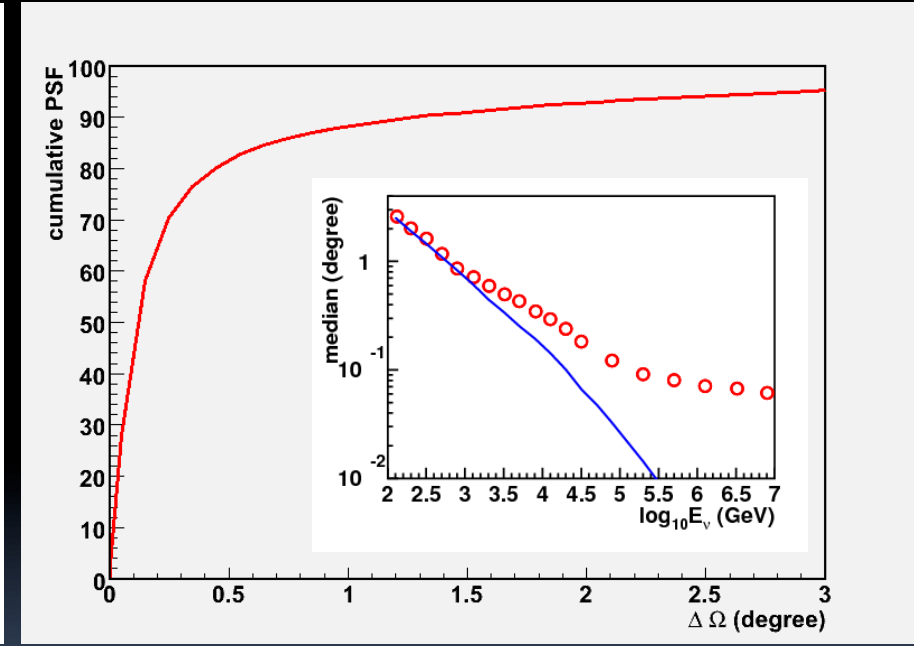
- Multi-PMT DOM
  - 31 PMTs (3" diameter)
  - Almost uniform coverage
  - Photon counting
  - All electronics inside
  - Concentrator ring
  - All identical units
  - First prototype built and under validation

Simulations

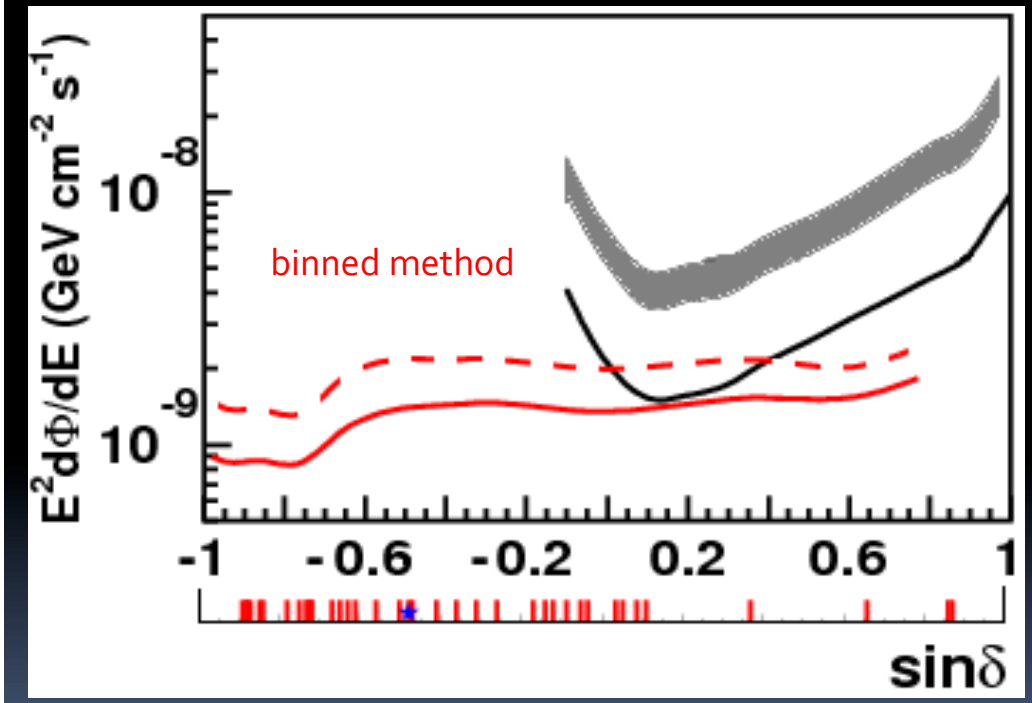
- Antares code modified for km3 scale detectors with multi-PMTs
- Trigger and reconstruction adapted to multi-PMT optical modules
- For point-like sources algorithm exploiting the knowledge of the source position has been developed

KM3NeT effective area and angular resolution - point-like E^{-2} spectrum -





KM3NeT Sensitivity & Discovery potential E^{-2} spectrum



KM3NeT sensitivity 90%CL

KM3NeT discovery 5s 50%

IceCube sensitivity 90%CL

IceCube discovery 5s 50% 2.5÷3.5 above sensitivity flux. (extrapolation from IceCube 40 string configuration)

| Observed Galactic TeV-g sources (SNR, unidentified, microquazars)
F. Aharonian et al. Rep. Prog. Phys. (2008)
Abdo et al., MILAGRO, Astrophys. J. 658 L33-L36 (2007)

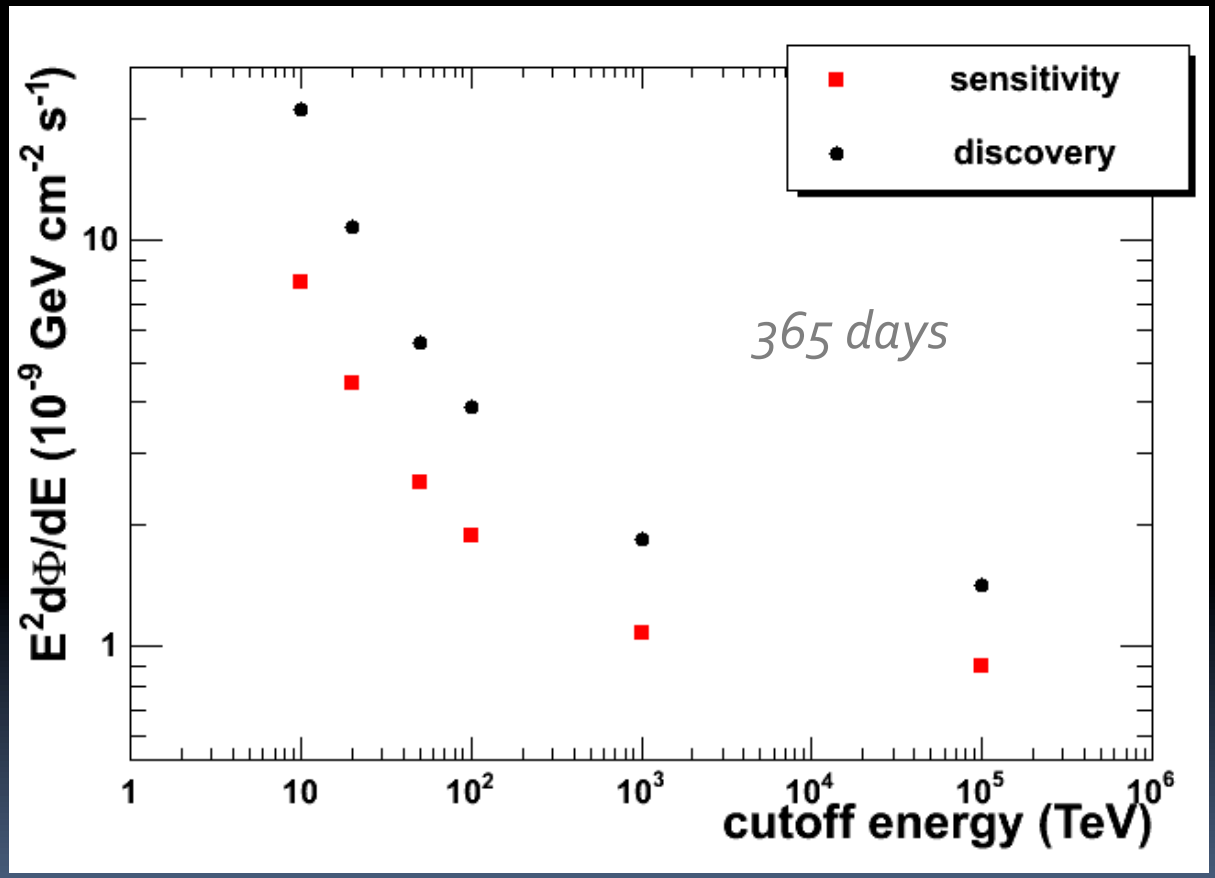
★ Galactic Centre

Galactic Candidate ν Sources

Detection of high energy neutrino galactic sources is one the main KM3NeT objective

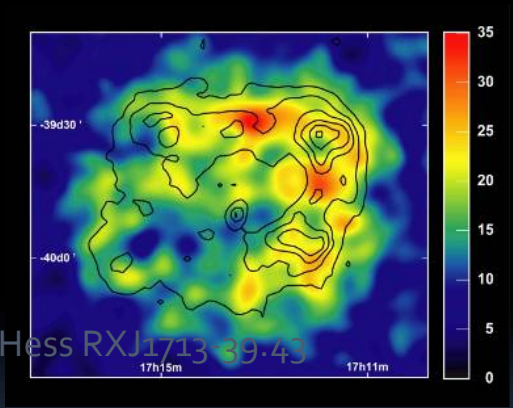
- Almost full coverage of galactic plane
- Robust prediction of flux from γ TeV observation in the hypothesis of hadronic emission
- Cut-off in proton energy at PeV expected => optimization needed

Sensitivity and 5σ discovery vs Energy Cut-off (E^{-2} spectrum)

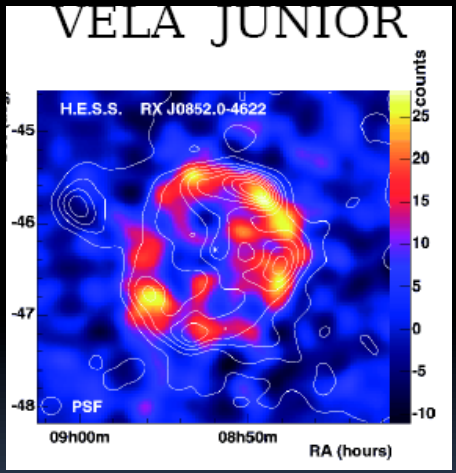


Galactic Candidate ν Sources: SNRs

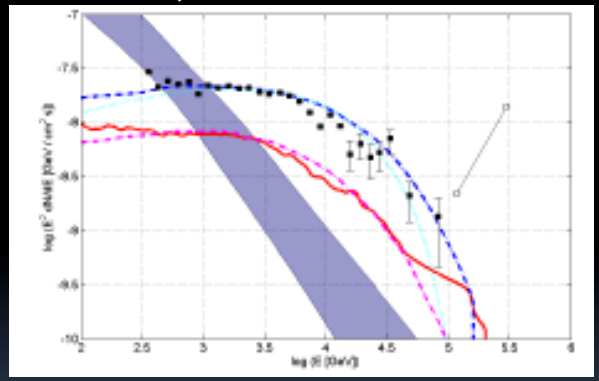
Origin of Cosmic Rays => SNR paradigm, hints from VHE g but no conclusive evidence about CR acceleration RXJ1713-39.43 and Vela JR best candidates



Hess RXJ1713-39.43



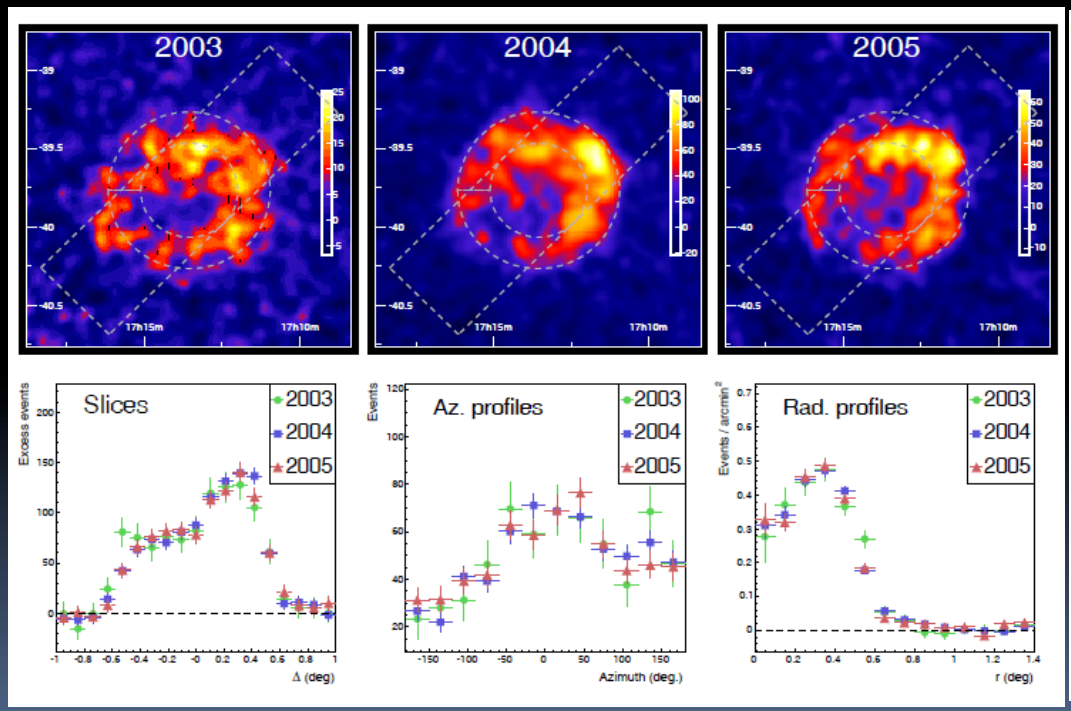
RXJ1713-39.43
IF hadronic mechanisms =>n spectrum can be calculated from VHE g spectrum (solid red line Vissani)

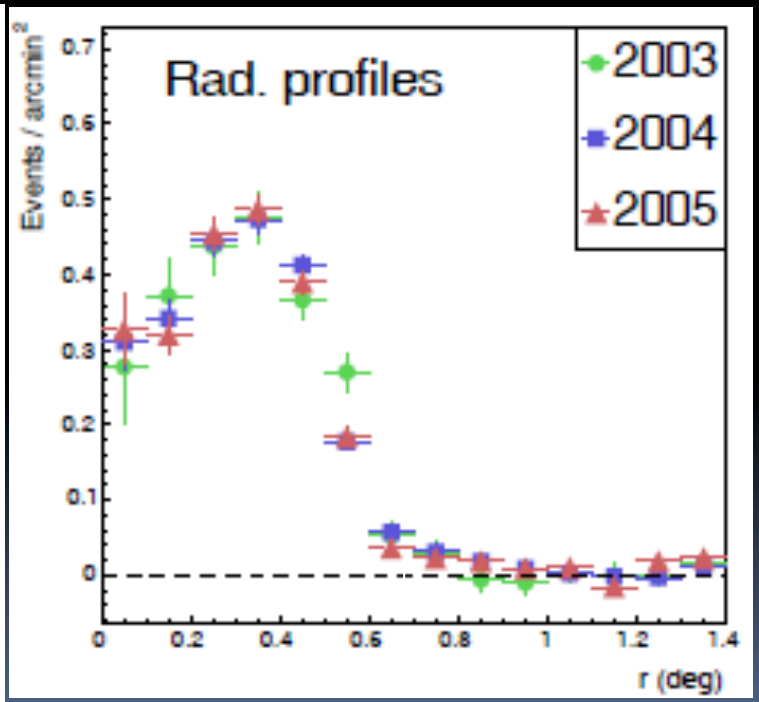


RXJ1713

- H.E.S.S. observations

F. Aharonian et al. Astronomy and Astrophys 2008





RXJ1713-39.46 Simulation

- Flat disk with 0.6° radius -> conservative
- Energy Spectrum and Flux from Kelner et al.

$$\Phi(E) = 1.68 \times 10^{-14} \left[\frac{E}{TeV}\right]^{-1.72} e^{-\sqrt{\frac{E}{2.1TeV}}} GeV^{-1} s^{-1} cm^{-2}$$

- Binned Analysis
- Reconstruction based on Likelihood without Energy Dependence

RXJ1713 – Preliminary results

RXJ1713	DU Distance [m]	years for discover [y]	signal	bkg
3σ ext. 0.6°	100	2.3±0.2	8.0	5.1
5σ ext. 0.6°	100	6.1±0.2	28.2	23.5
3σ ext. 0.6°	130	2.7±0.2	9.5	7.2
5σ ext. 0.6°	130	7.4±0.4	21.3	12.3

- Preliminary results indicate an improvent in the flux for discovery with unbinned analysis
- Including morphology from gamma TeV emission expected detection time reduced
- Detection time decrease with decreasing DU distance

KM3NeT funding

- In total 40 MEuro already available in Italy, France, the Netherlands and Romania
- Start-up construction in Italy and France

- A MoU is under definition between the international parterns

Implementation of the first phase of KM3NeT

- Detection Units will be deployed at the KM3NeT sites near Capo Passero and Toulon

- Due to tight time constraints of the Italian funding, first Detection Units (number t.b.d.) at the Capo Passero site will be built with the technology developed by the Nemo collaboration (towers with 10" PMTs)

Other topics

- Estimate sensitivity for indirect search of Dark Matter from Galactic Center
- Neutrino detection from Fermi Bubbles

  arXiv:1208.1226v1
- ORCA: a feasiblity study to investigate the possibility to use the KM3NeT in a smaller and more densily instrumented volume to measure the neutrino mass hierachy using atmosperic neutrinos at 5-30 GeV energy

Conclusions

- KM3NeT has good perspectives for detection of high energy neutrino from galactic sources
- The implementation of the first phase of KM3NeT has started with construction at the sites near Capo Passero (PON funds) and Toulon

THE END