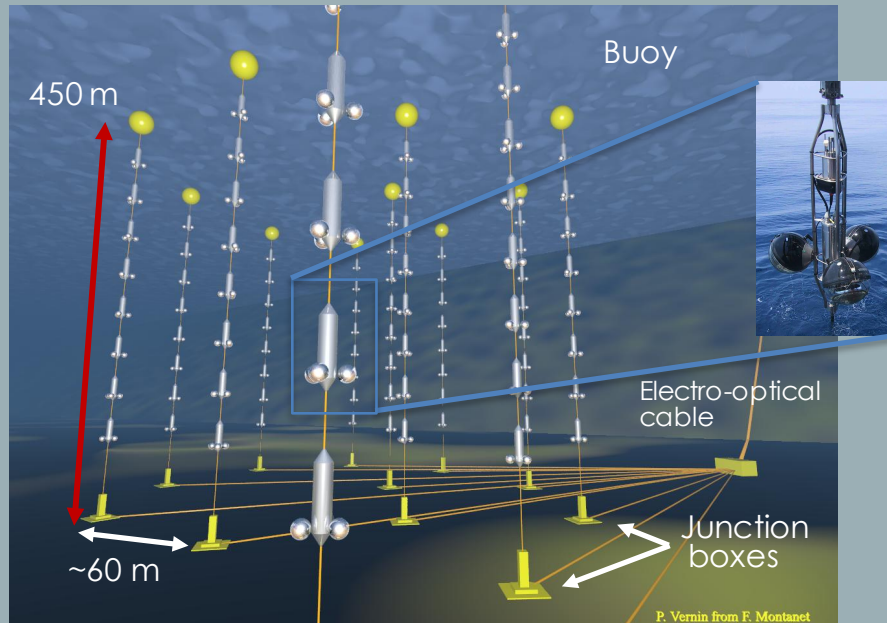


ANTARES-IceCube combined search for neutrino point-sources in the Southern Hemisphere

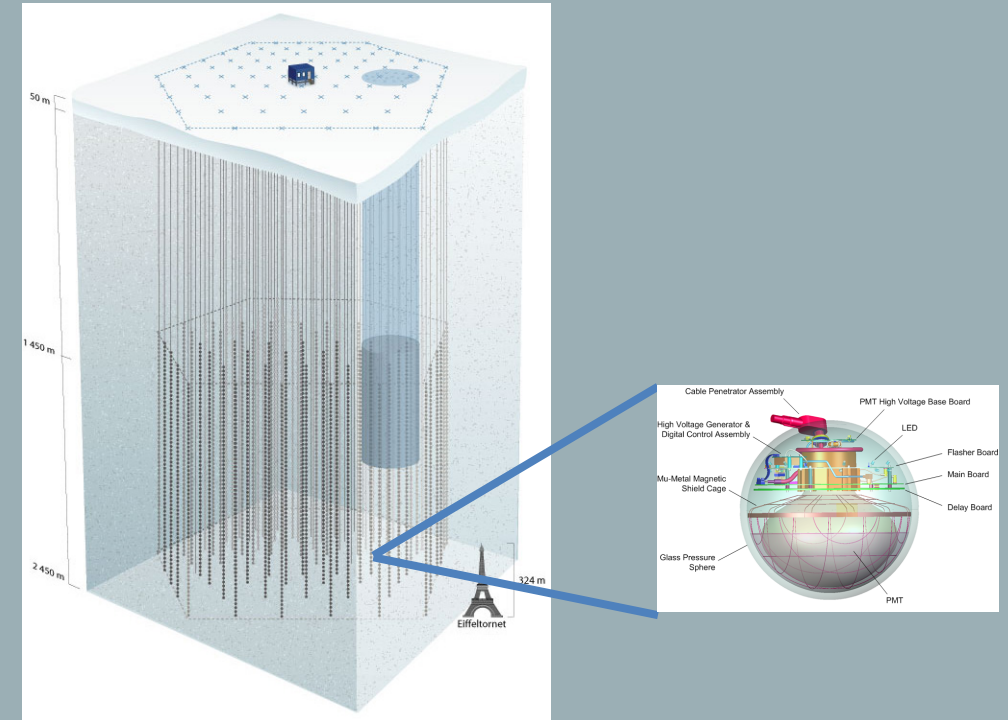
The ANTARES and IceCube detectors



- ~2500 m deep in the Mediterranean Sea
- 12 lines, 25 storeys, 885 PMTs

Complementarity for the Southern sky:

- Size
- Geographical location
- Atmospheric muon background



- Largest neutrino telescope (1 km^3)
- ~2500 m deep in Antarctica
- 86 strings with 60 DOMs
- 17 m between DOMs, 125 m between strings

Data samples

Sample	Livetime (days)	Events
tracks	2415	5807
showers	2415	102

ANTARES
9 years

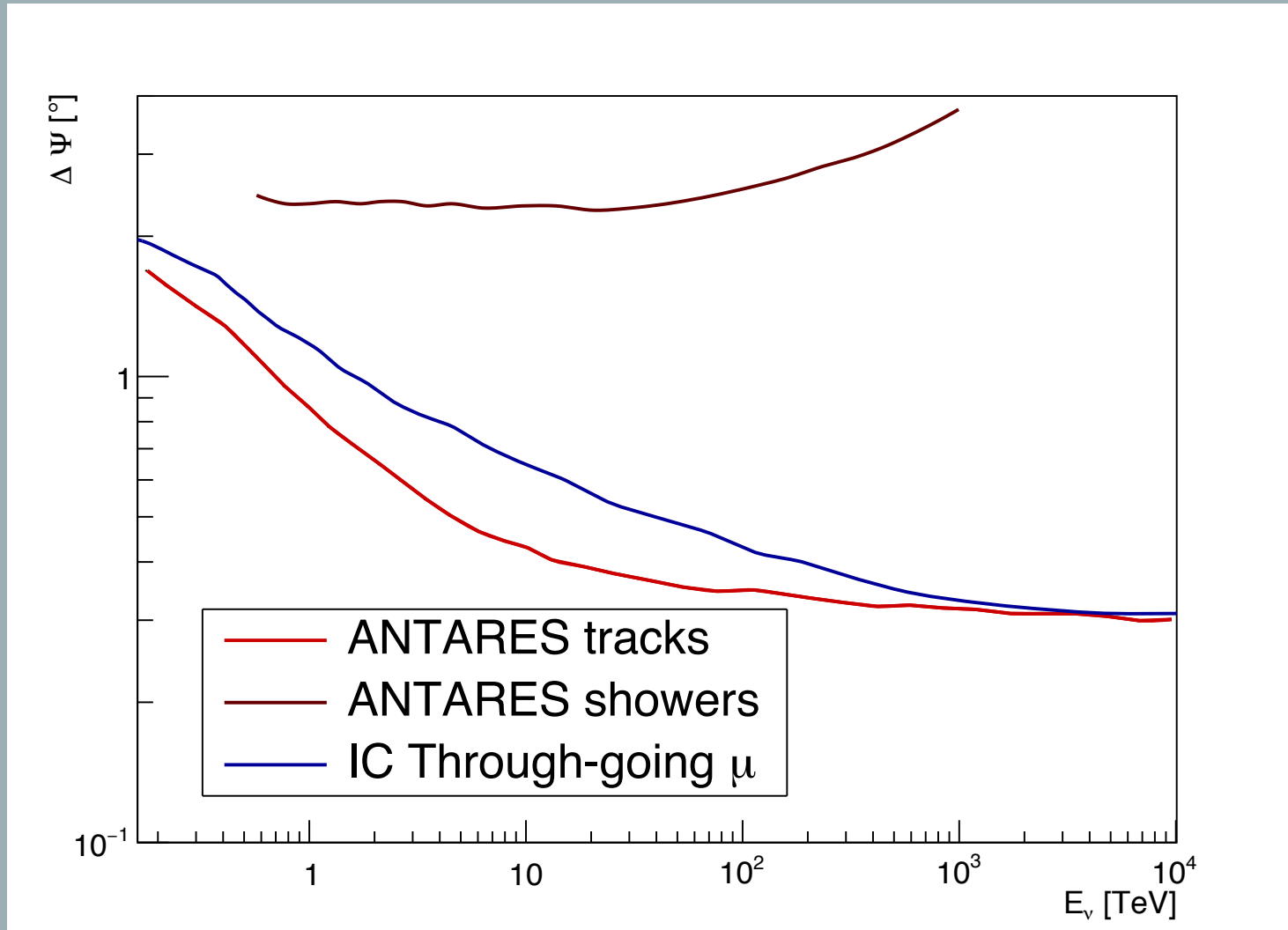
Sample	Livetime (days)	Events
IC40	376	22779
IC59	348	64257
IC79	316	44771
IC86	333	74931
2012-2015	1058	119231

Through-going
tracks

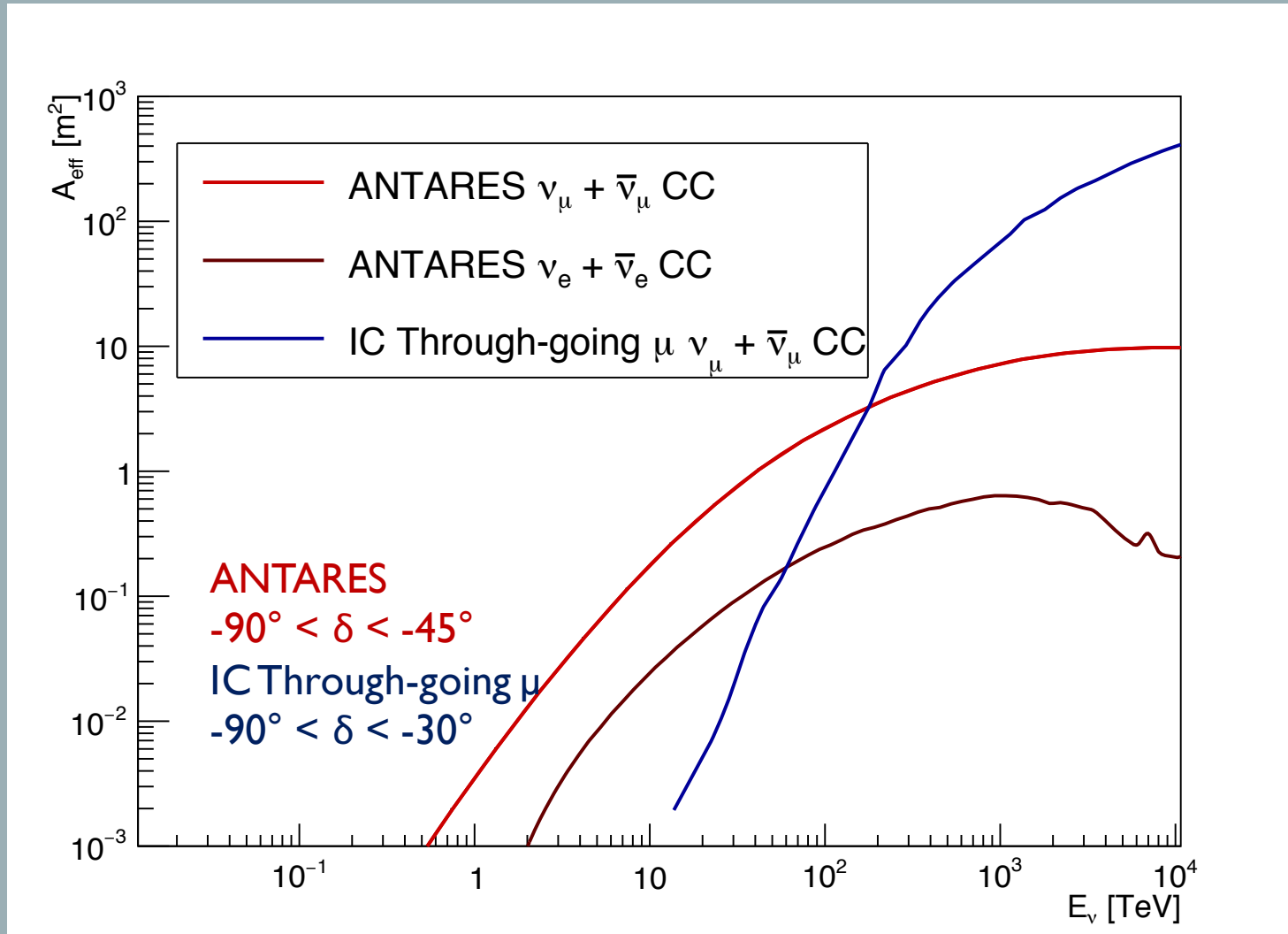
IceCube
7 years

All these samples have been used for point-source analyses in their respective collaborations

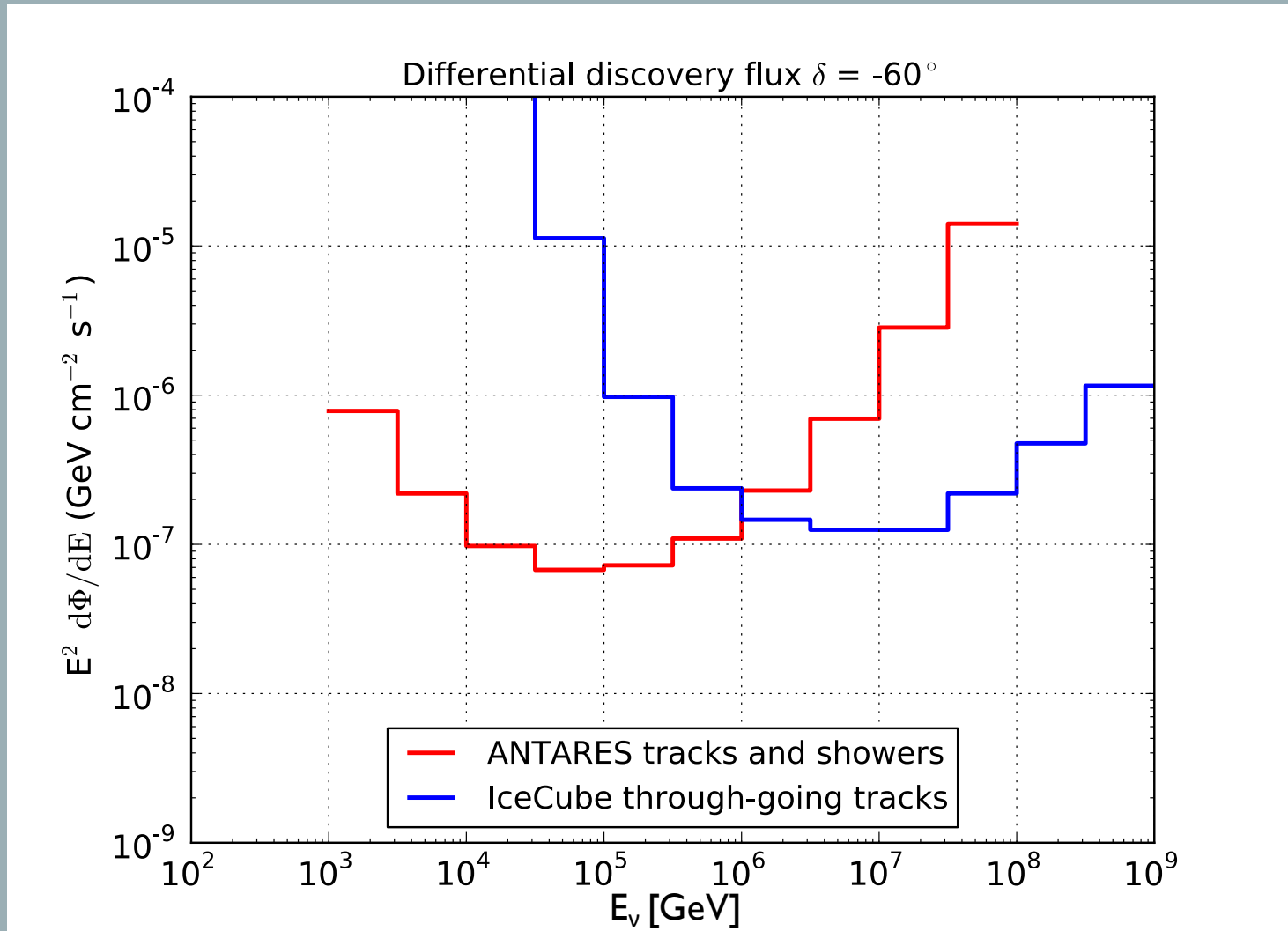
Data samples: Median Angular Resolution



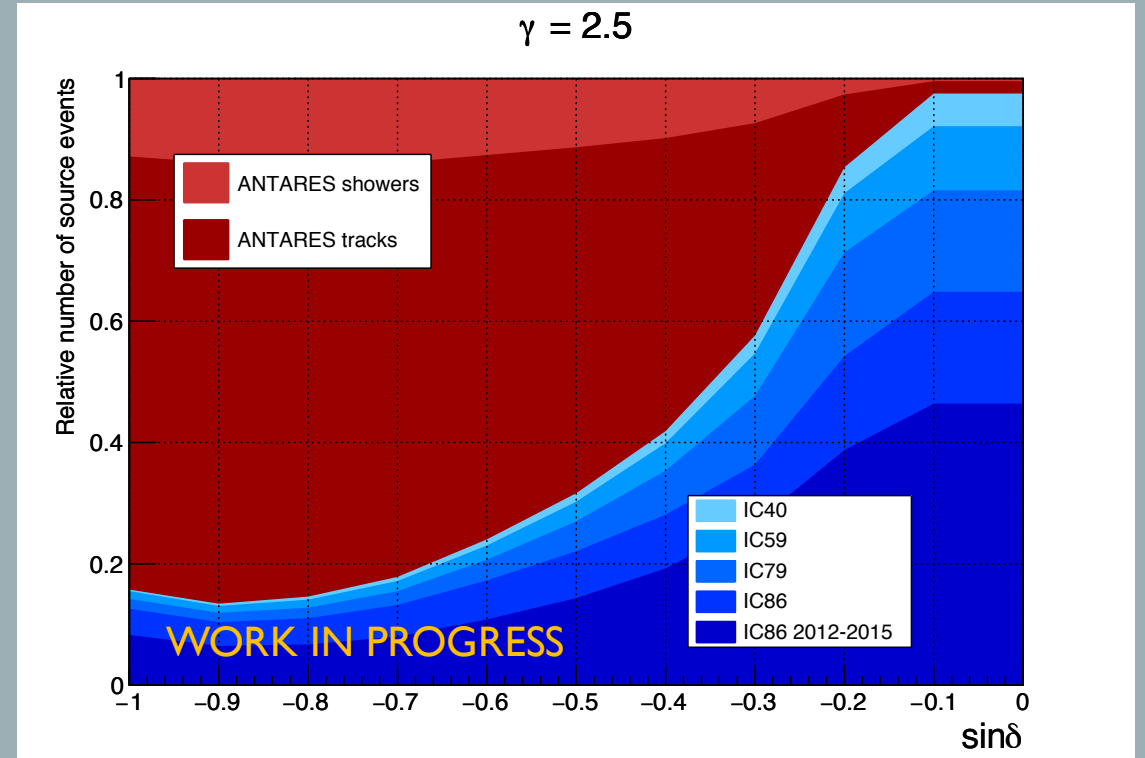
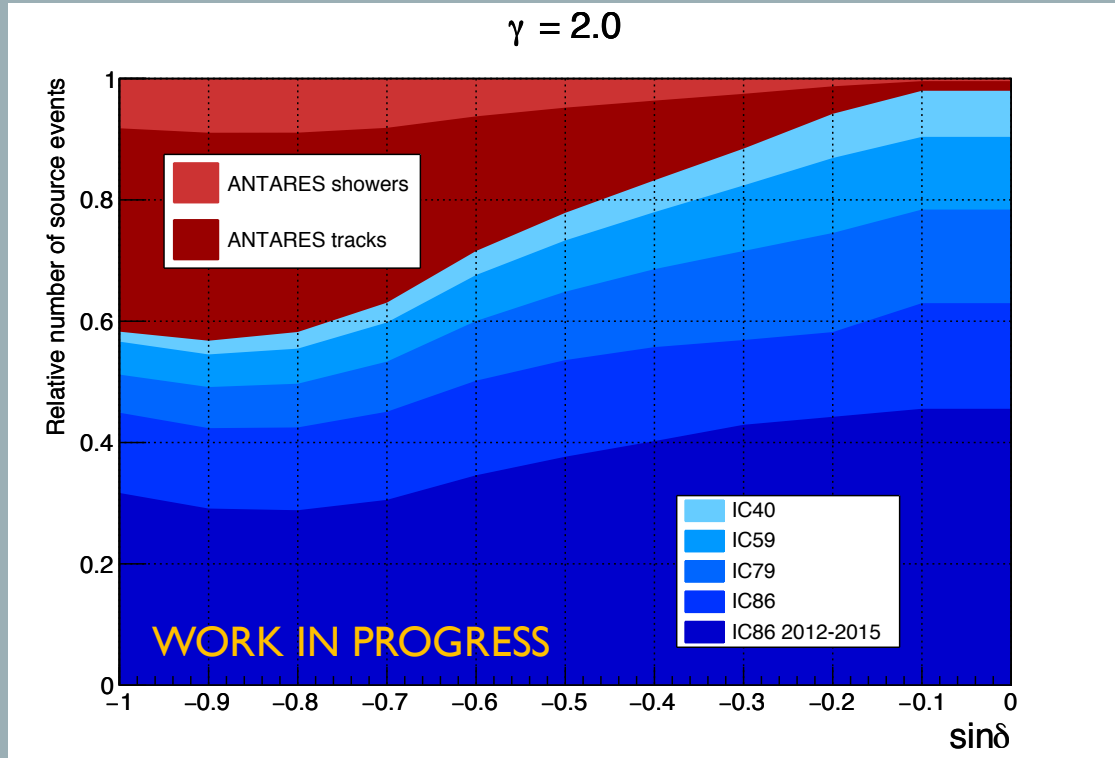
Data samples: Effective area



Data samples: Differential Discovery Flux



Data samples: Relative Contribution



Relative fraction of signal events for different energy source spectra $\frac{dN}{dE} \propto E^{-\gamma}$

Search method: Likelihood

- Unbinned likelihood method:

$$L(n_S, \gamma) = \prod_j \prod_{i \in j} \left[\frac{n_S^j}{N^j} S_i^j(\Delta\Psi, \sigma, E, \gamma) + \left(1 - \frac{n_S^j}{N^j}\right) B_i^j(\delta, \sigma, E) \right]$$

J : sample
 i : event in sample J

n_S : number of signal events
 γ : spectral index

Signal PDF S_i^j depends on:

$\Delta\Psi$: angular distance from source
 σ : angular error estimate
 E : energy
 γ : spectral index

Background PDF B_i^j depends on:

δ : declination
 σ : angular error estimate
 E : energy

- Source hypothesis: unbroken $E^{-\gamma}$ energy spectrum
- Same PDFs as those used in the respective latest point-source analyses
- Test statistics: likelihood ratio of null hypothesis $L(n_S = 0)$ and best fit $L(\hat{n}_S, \hat{\gamma})$:

$$TS = -2 \log \frac{L(n_S = 0)}{L(\hat{n}_S, \hat{\gamma})}$$

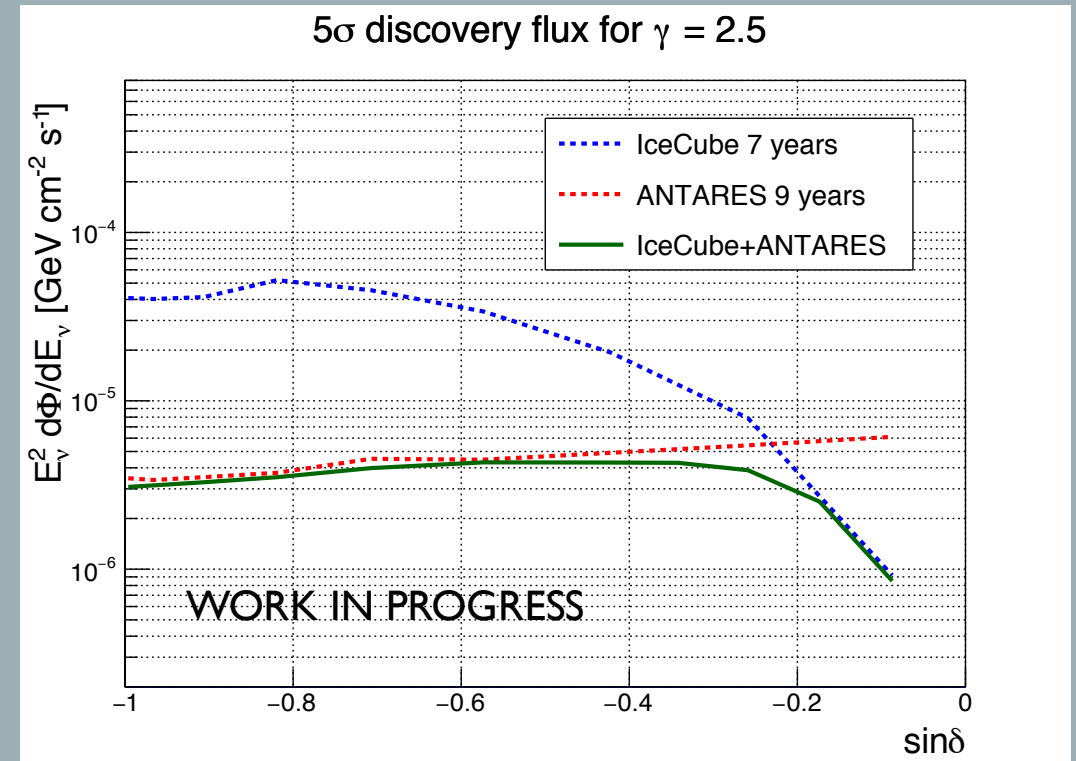
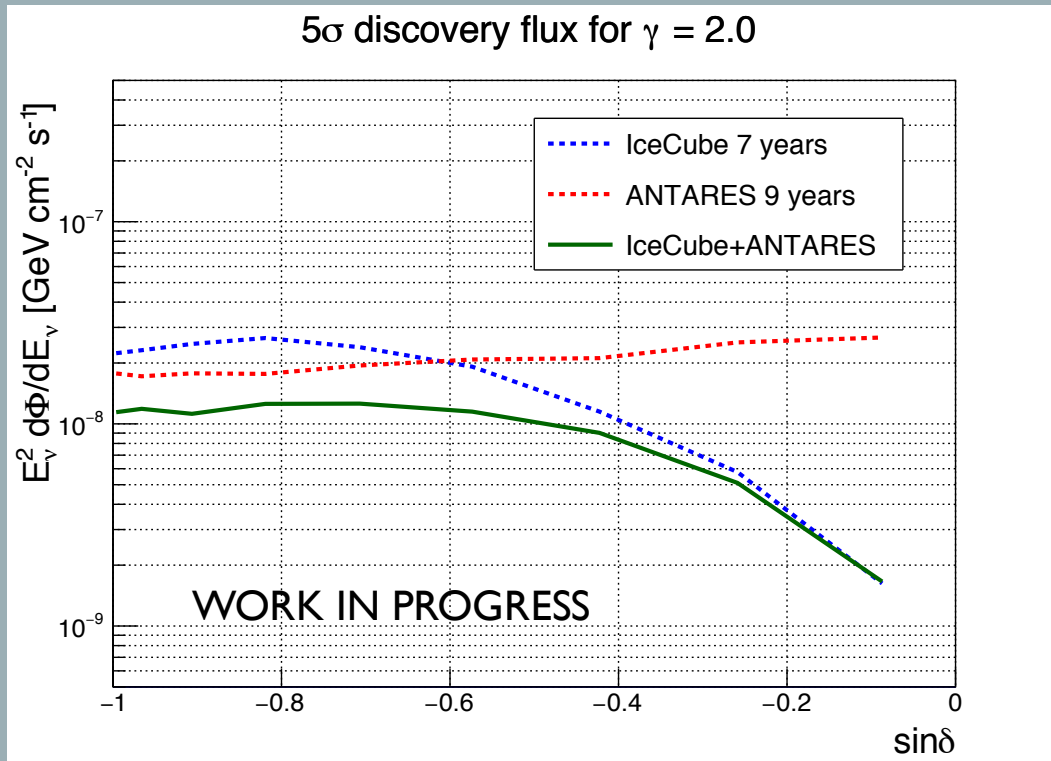
Search method: Strategies (1/2)

- Full Southern-sky search
 - Evaluate the whole Southern sky
 - Free parameters: $n_S, \gamma, \delta_S, \alpha_S$
 - Also for extended sources ($\sigma_S = 0.5^\circ, 1.0^\circ, 2.0^\circ$)
- Candidate list search
 - Evaluate the position of a pre-selected list of neutrino source candidates
 - 57 Southern sky candidates considered in the latest ANTARES point source analysis:
 - Galactic and extra-Galactic sources in TeVCat selected on the basis of flux*visibility criteria

Search method: Strategies (2/2)

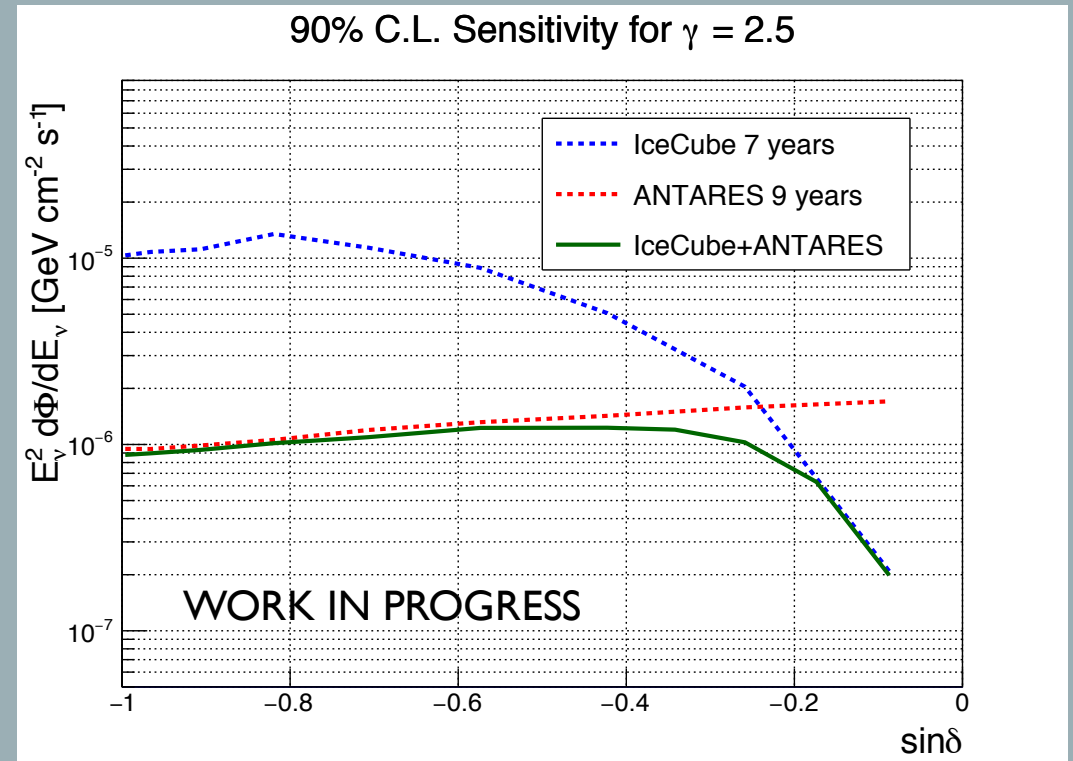
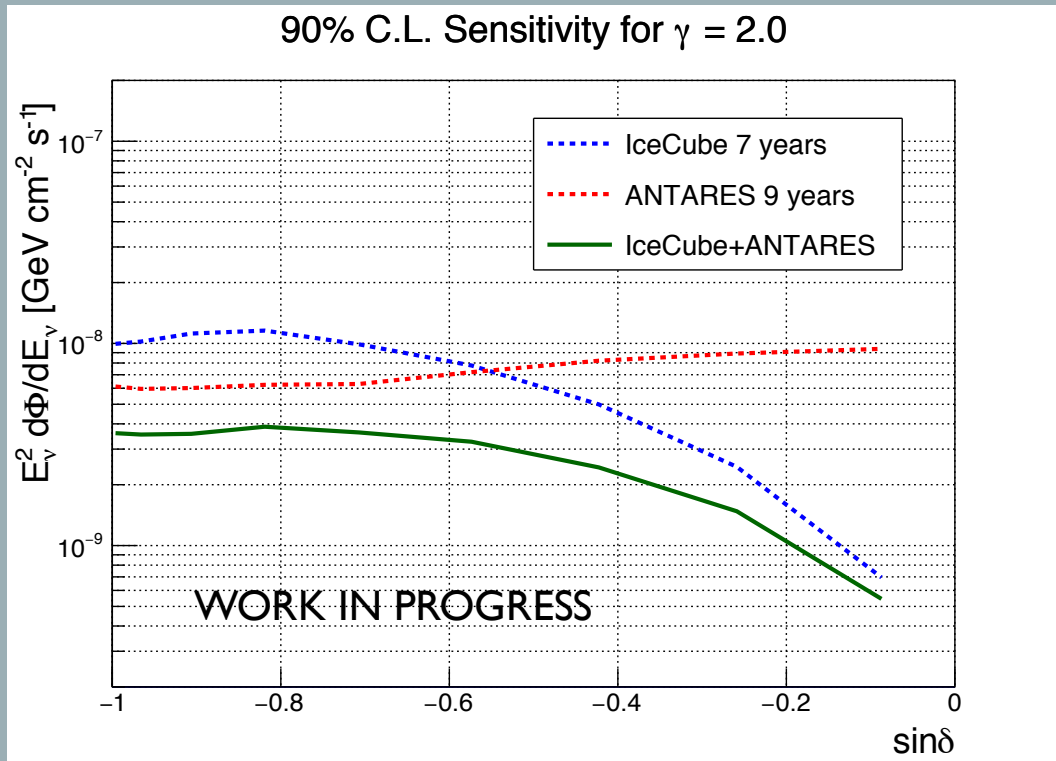
- Galactic Center region search
 - Full-sky search method applied to a restricted region around the GC (ellipse, 15° semi-axis in galactic latitude, 20° semi-axis in galactic longitude)
- Sagittarius A* location
 - Tested as an extended source by assuming a Gaussian emission profile of various widths [0.5° , 5.0°]
- RX J1713.7-3946 location
 - Tested as an extended source with disk emission profile of 0.6° radius

Results: Combined 5σ discovery flux



5 σ discovery flux for different energy source spectra

Results: Combined 90% C.L. sensitivity



90% C.L. sensitivity for different energy source spectra

Conclusions

- The complementarity of the ANTARES and IceCube detectors with respect to the Southern sky sources allows for a gain in sensitivity by combining the data of both experiments.
- The level of improvement varies depending on the source declination and assumed source spectra.
- A gain in sensitivity to E^{-2} point-sources close to the GC of almost a factor 2 is obtained.
- Work in progress, updates soon!