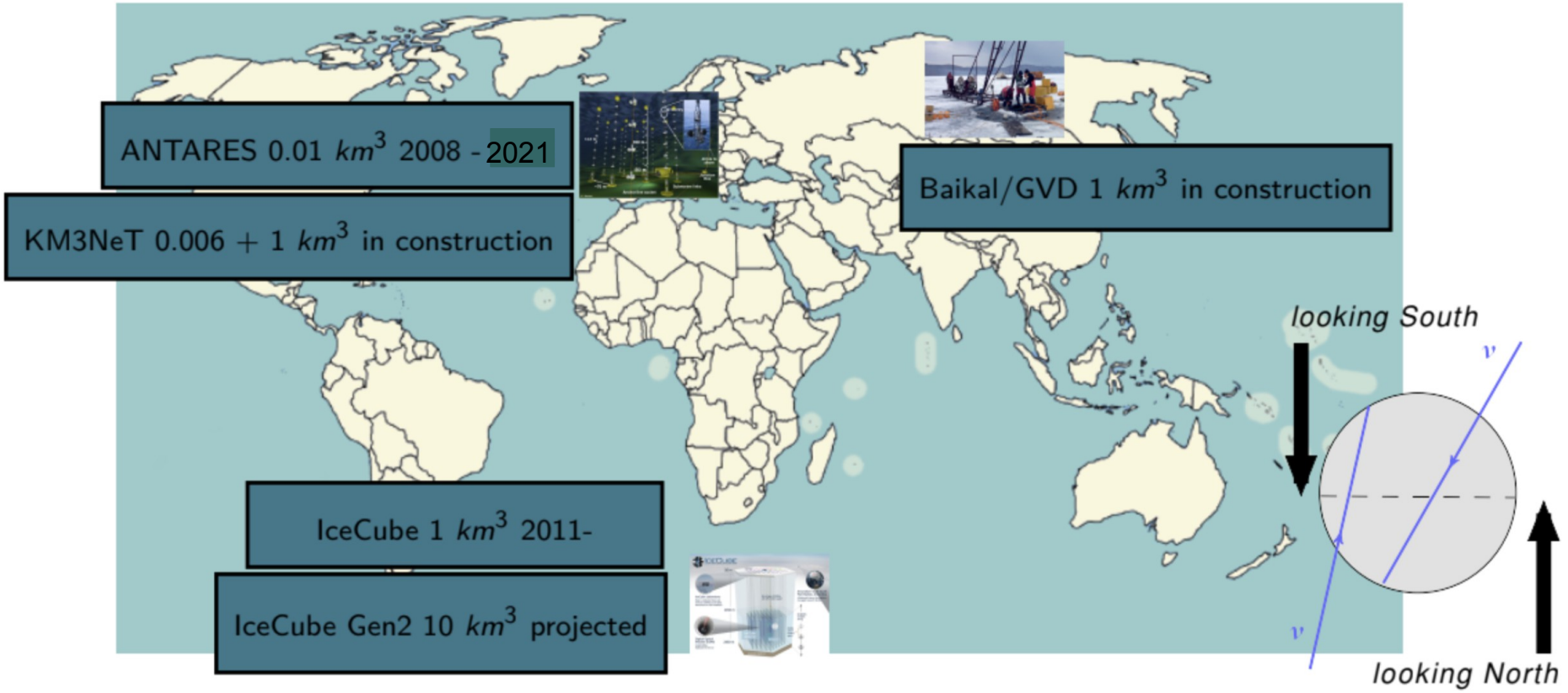
XVII Multidark Consolider Workshop

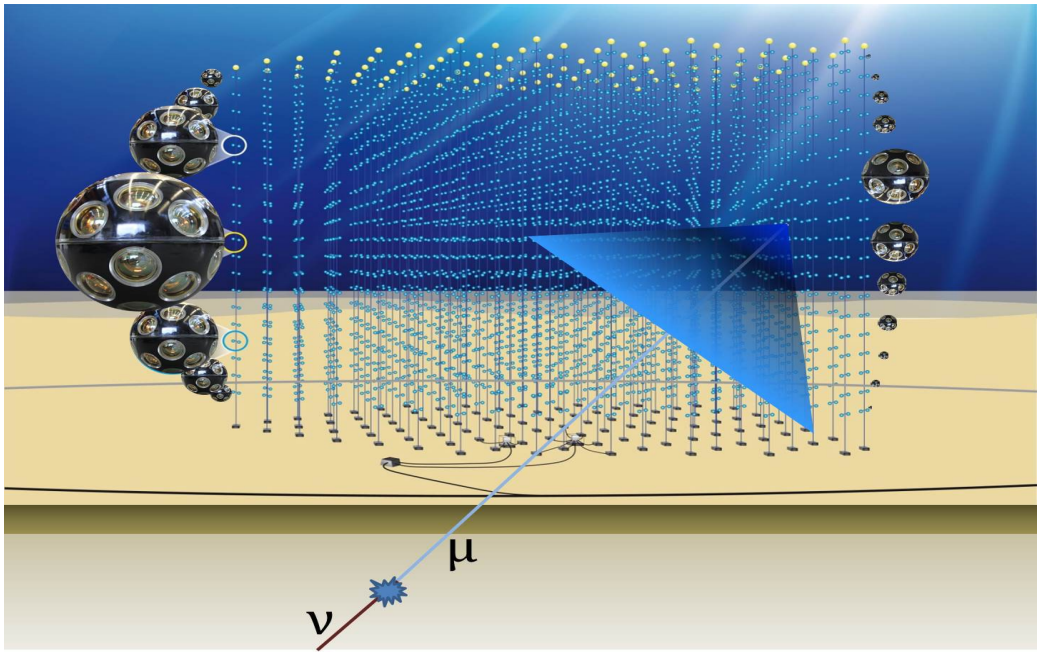
Indirect search for Dark Matter in the Sun with ANTARES

Chiara Poirè,
On behalf of the ANTARES collaboration

Neutrino telescopes around the world



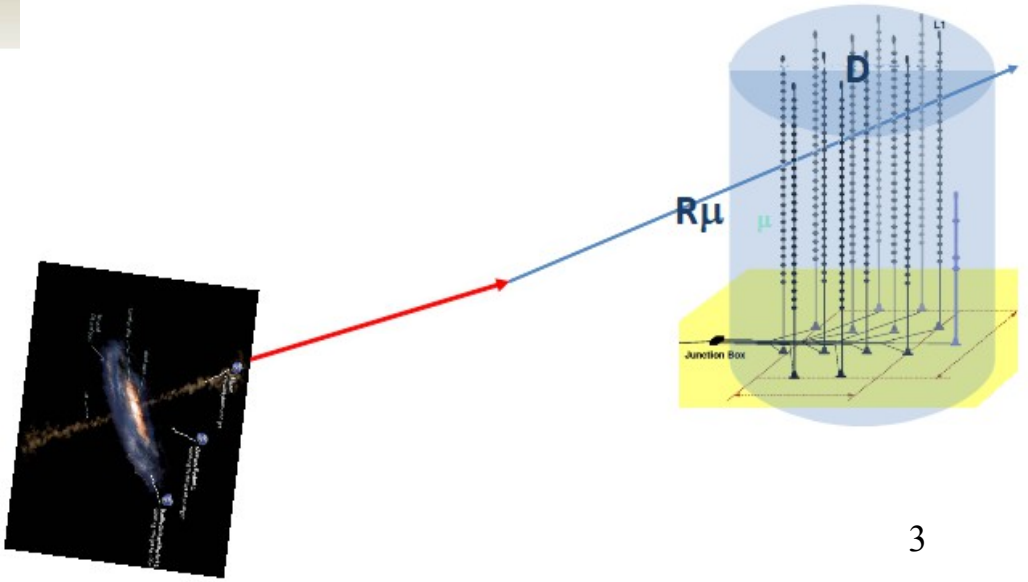
Neutrino telescopes: detection principle



- Large volume
- Transparent medium (Ice or water)
  → Cherenkov effect
- Large depth

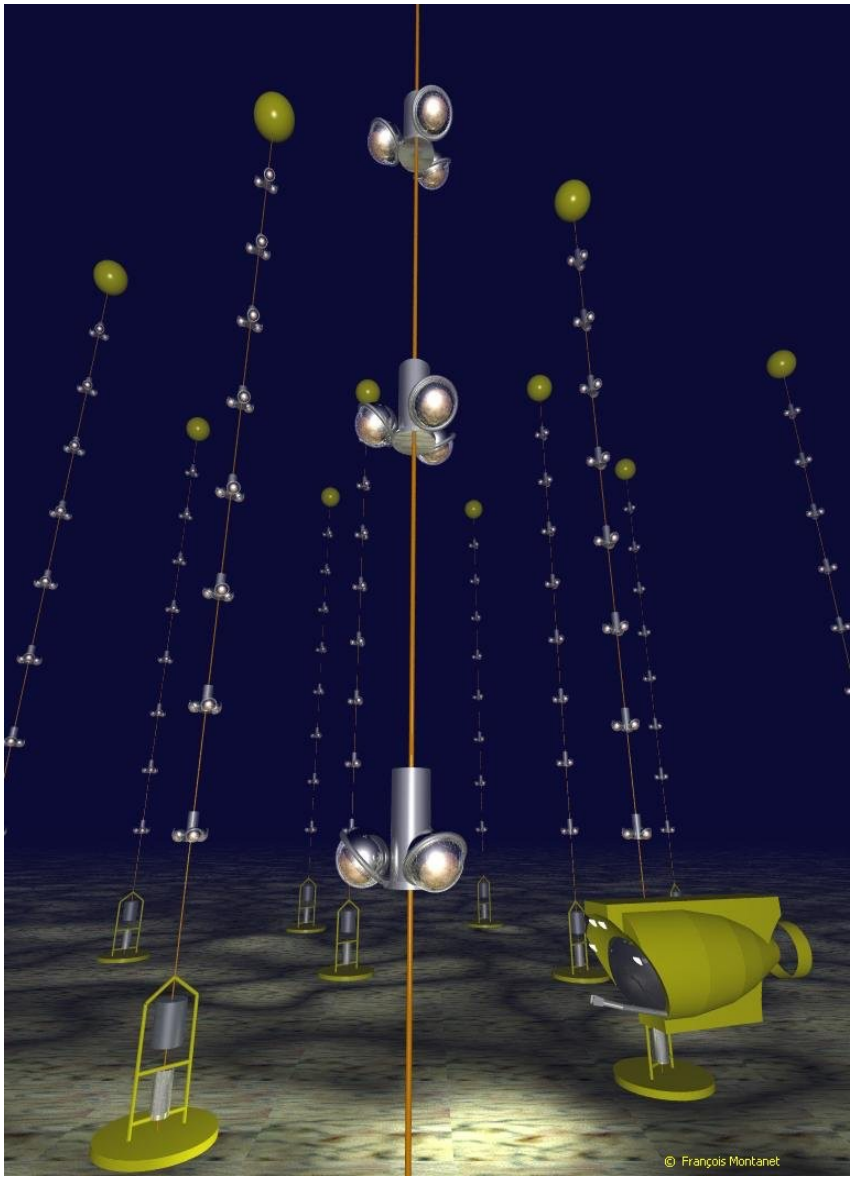
Water vs Ice:

- Noise of ^{40}K
- Larger scattering length → better angular resolution



ANTARES

- Toulon, France
- Data taking: 2007 → 2021
- 2500 m depth



- 12 lines
- 25 storeys/line
- 3 PMT/storey
  (~ 900 PMTs)

KM3NeT

ARCA

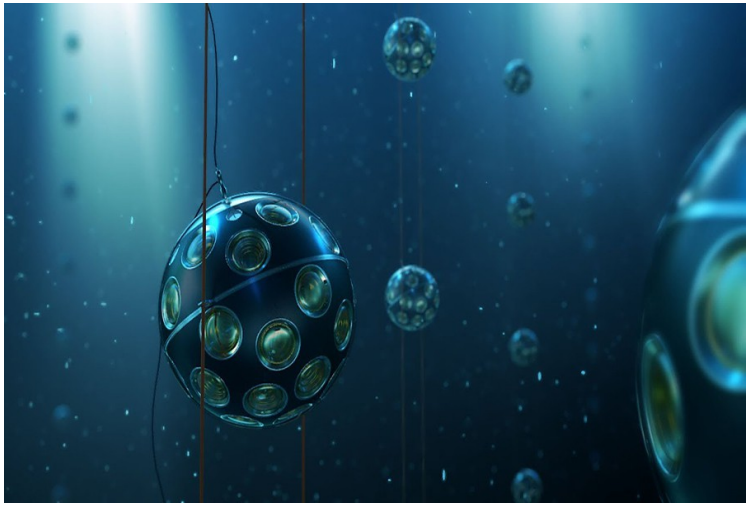
→ 2 blocks to catch low fluxes of astrophysical ν

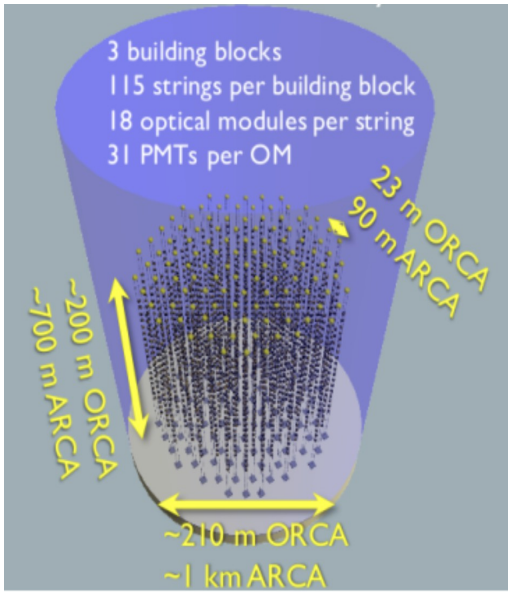
→ Capo Passero, Sicily (Italy)

ORCA

→ 1 block for oscillations and mass ordering with atmospheric ν

→ Toulon, France





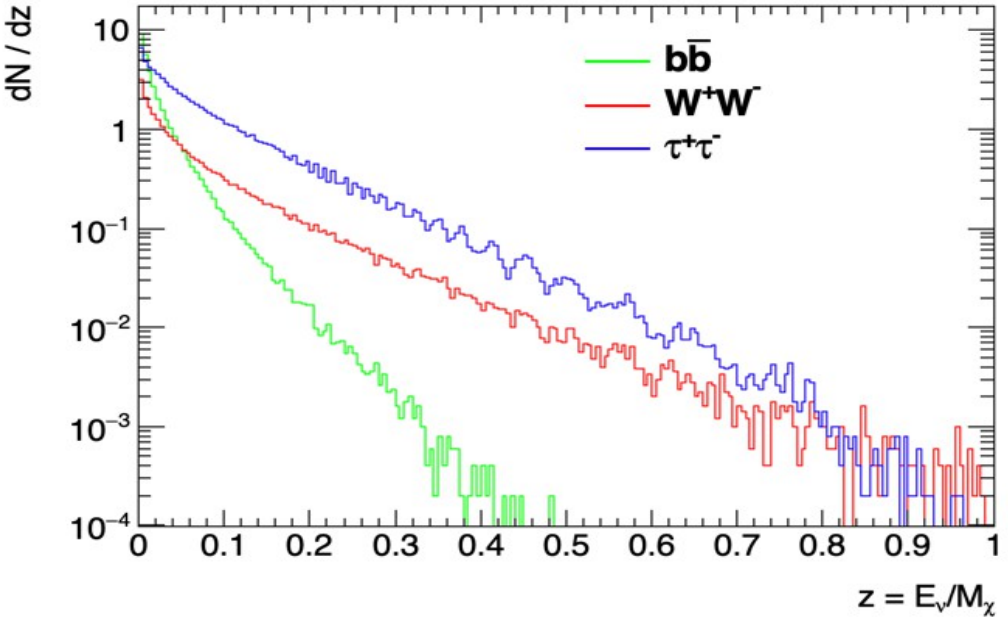
! Both suitable for dark-matter searches

DM in the Sun

- Sensitive to DM-nucleon scattering cross-section, spin-dependent and spin-independent
- Differential neutrino flux is related with the annihilation rate $\frac{d\Phi}{dE_\nu} = \frac{\Gamma}{4\pi d^2}\frac{dN_\nu}{dE_\nu}$
- In equilibrium between capture and annihilation $\Gamma = C/2$ with C capture rate
- Very clean: if signal $\rightarrow$ direct interpretation (astrophysical background well known)

Sun Input

Neutrino signal from WIMP annihilations



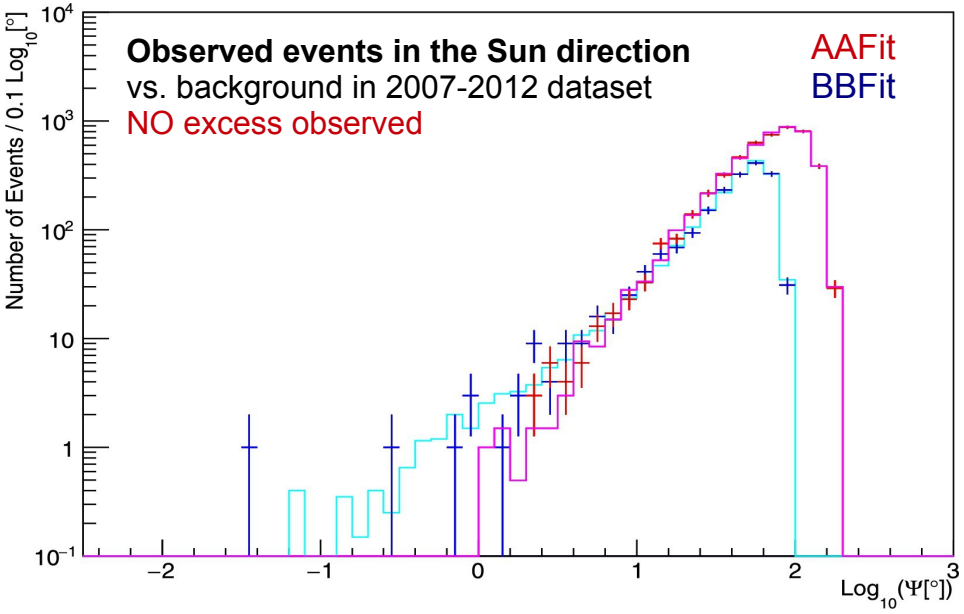
- WIMPSIM package (Blennow, Edsjö, Ohlsson, 03/2008) used to generate events in the Sun in a model independent way
- Annihilations into b quarks (soft spectrum) and τ leptons, W^+W^-/Z^+Z^- bosons (hard spectrum) used as benchmarks
- Take into account ν interactions in the Sun medium, regeneration of ν_τ in the Sun and ν oscillations

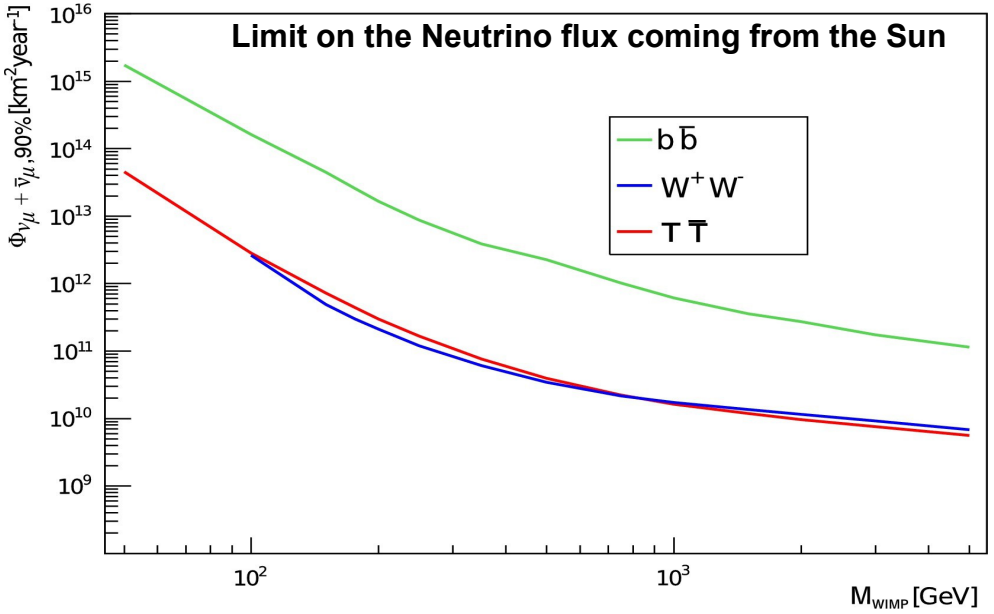
Search for DM towards the Sun: strategy and results

Maximization of the Likelihood function based on Signal and Background PDF:

$$\mathcal{L}(\mathrm{n_s}) = e^{-(n_s+N_{\mathrm{bg}})} \prod_{i=1}^{N_{tot}} \left(n_s S(\psi_i, N_{hit,i}, \beta_i) + N_{\mathrm{bg}} B(\psi_i, N_{hit,i}, \beta_i) \right)$$

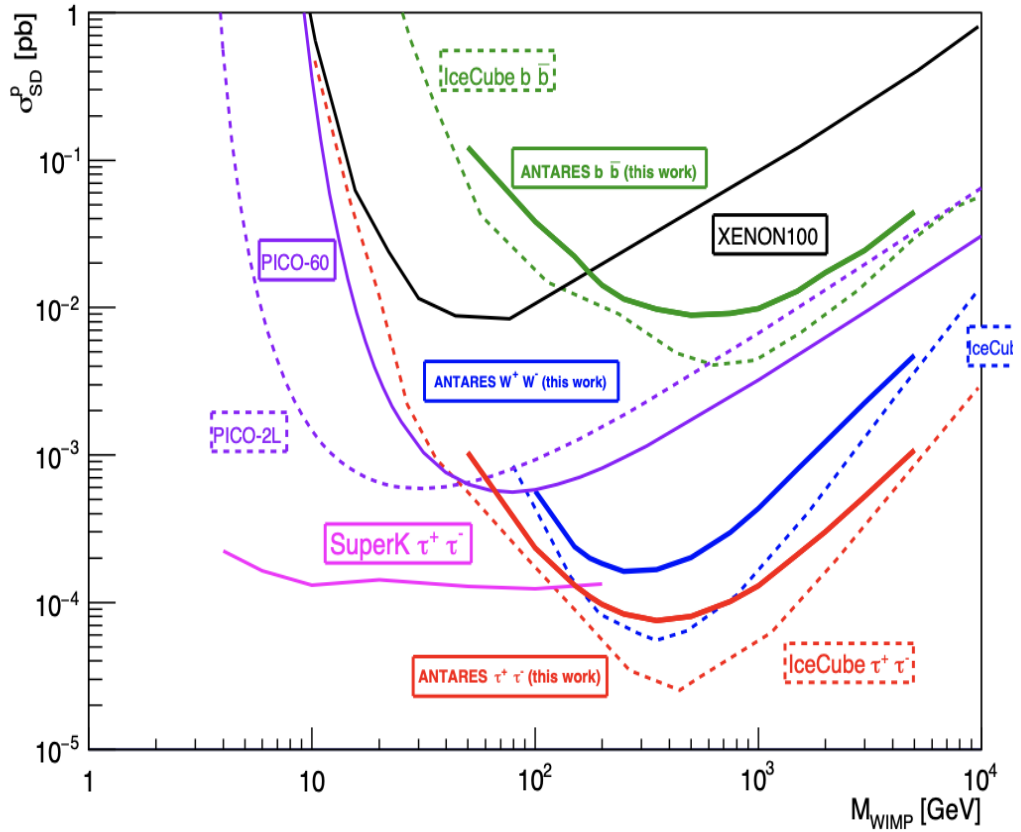
- Signal PDF determined from MC sim, is based on WIMPSim spectra
- Background PDF is determined from real data sample with scrambling



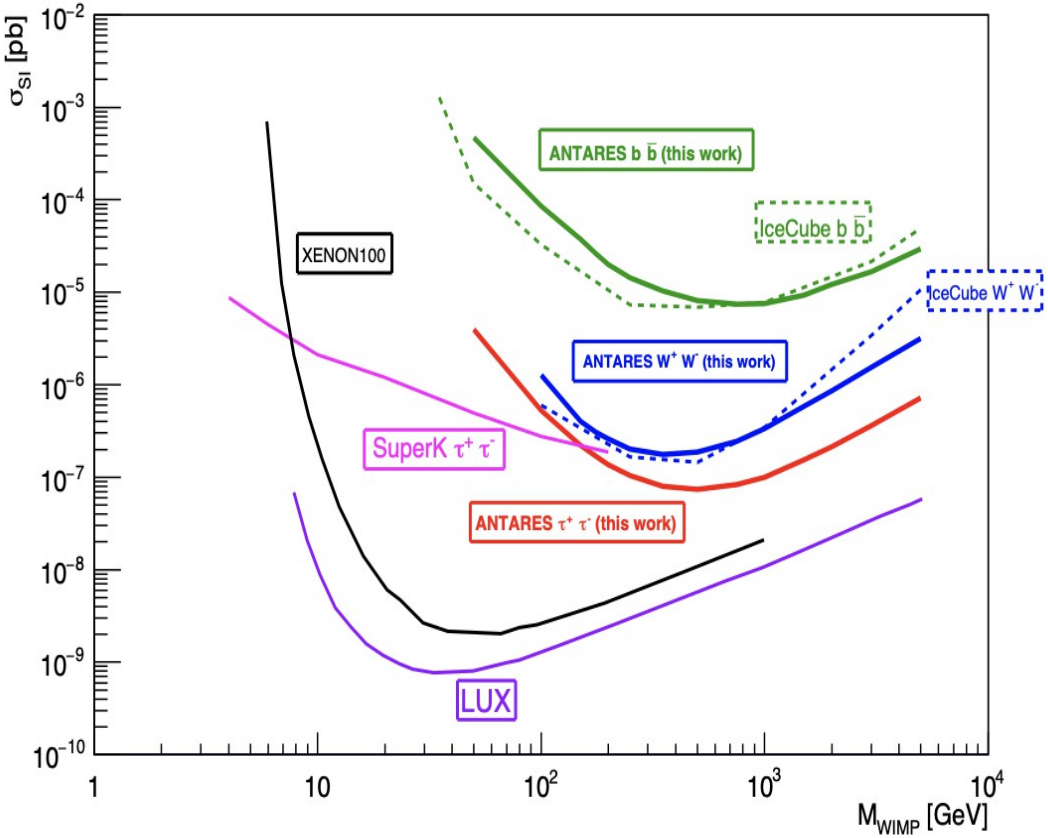


N_hit = number of hits used for track reco
Beta = angular error estimate for reco track
N_tot = tot. Number of reco events
n_s = number of signal
N_bg = number of background

ANTARES: Limits on Spin-(in)dependent cross section



Spin-dependent

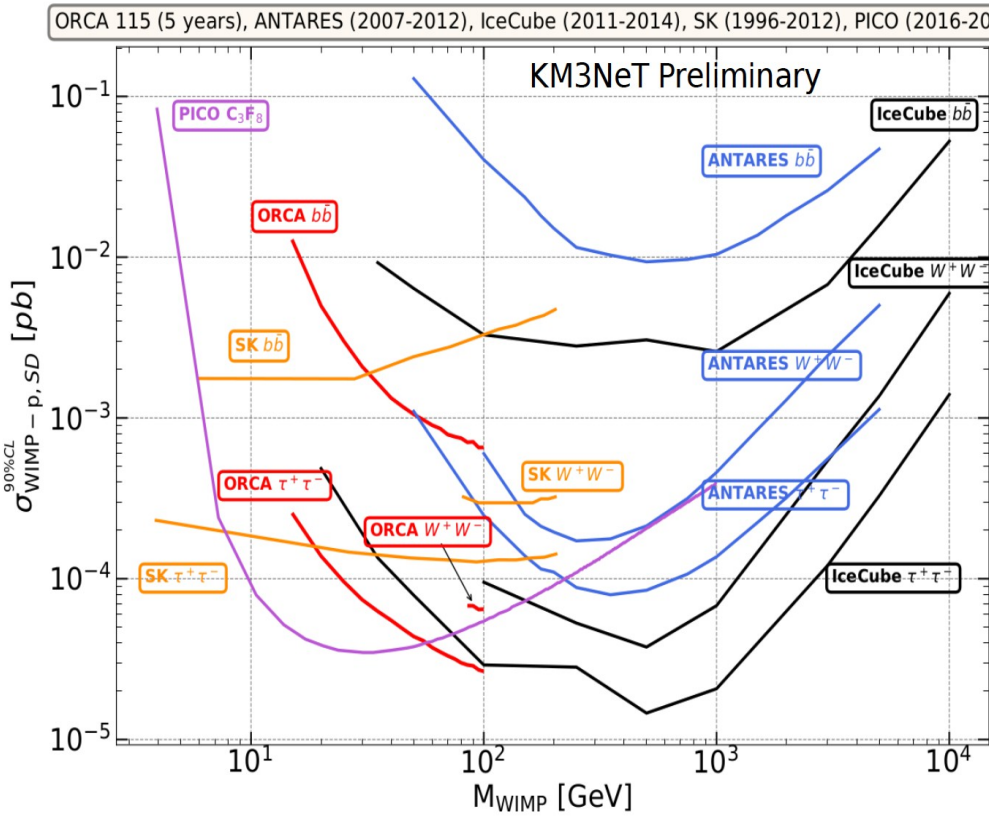


Spin-Independent

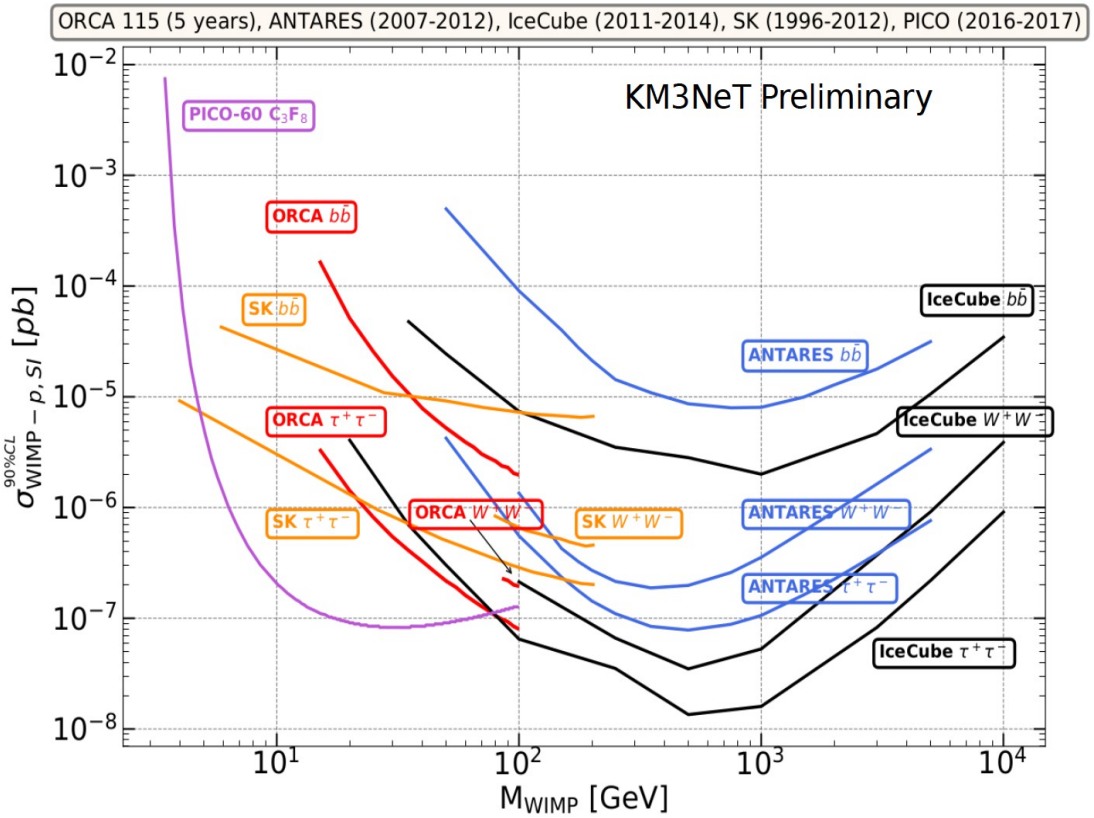
https://arxiv.org/pdf/1603.02228.pdf

Searches towards the Sun: ANTARES results and KM3NeT-ORCA: sensitivities

WIMP-proton scattering cross-section. Red lines are 5 years of ORCA simulated data.



Spin-dependent

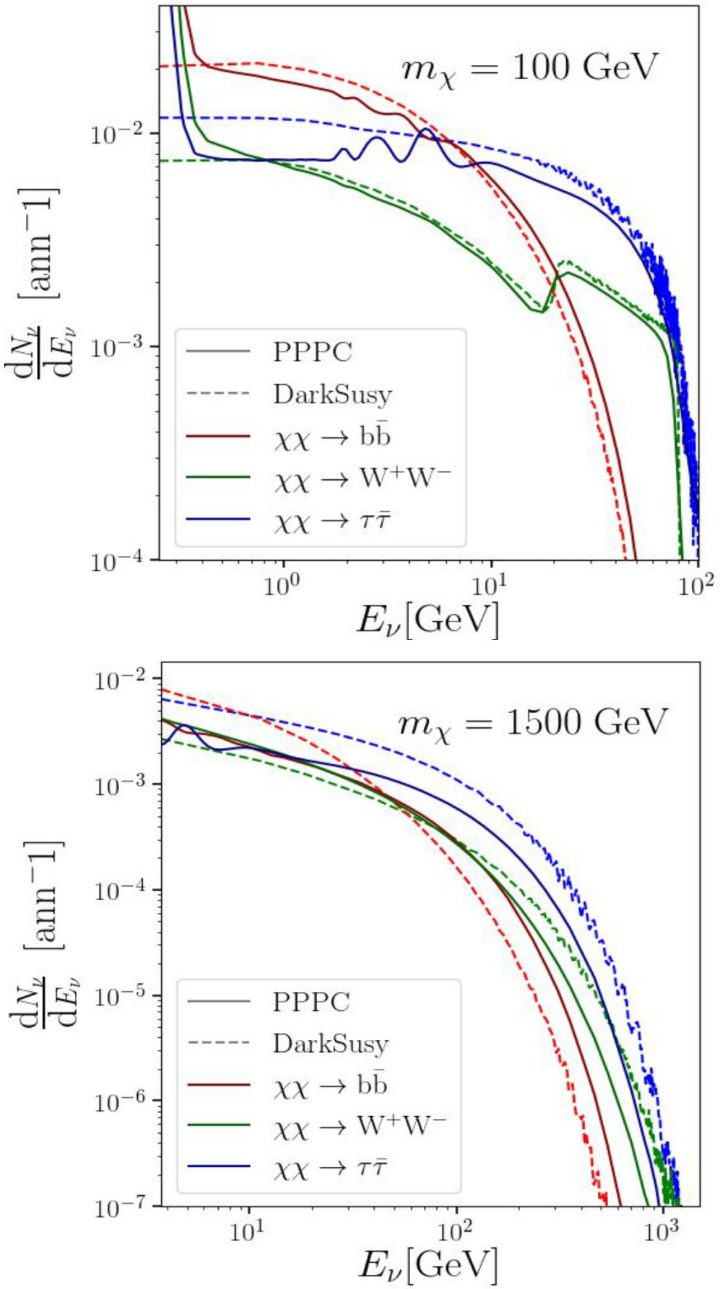


Spin-Independent

For more details about KM3NeT see C. Pieterse presentation

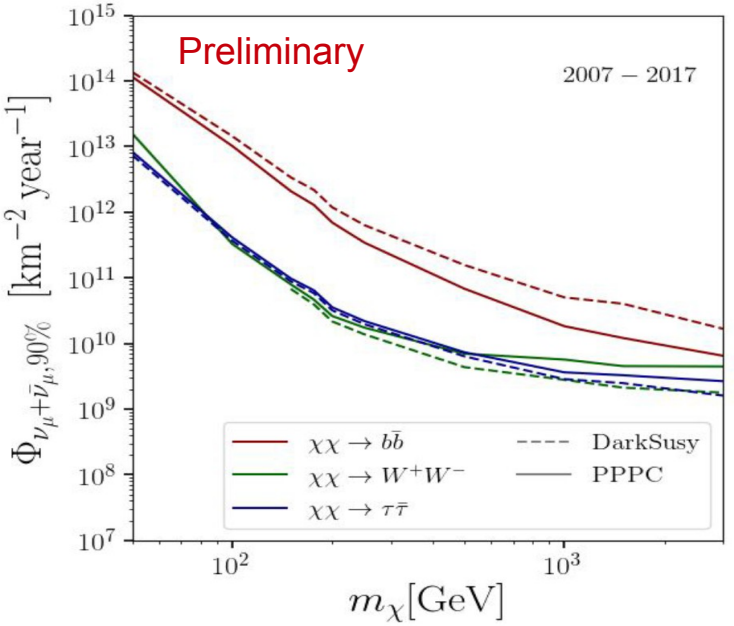
Updates Sun analysis ANTARES 2007 - 2017

Comparison PPPC vs. WIMPSim

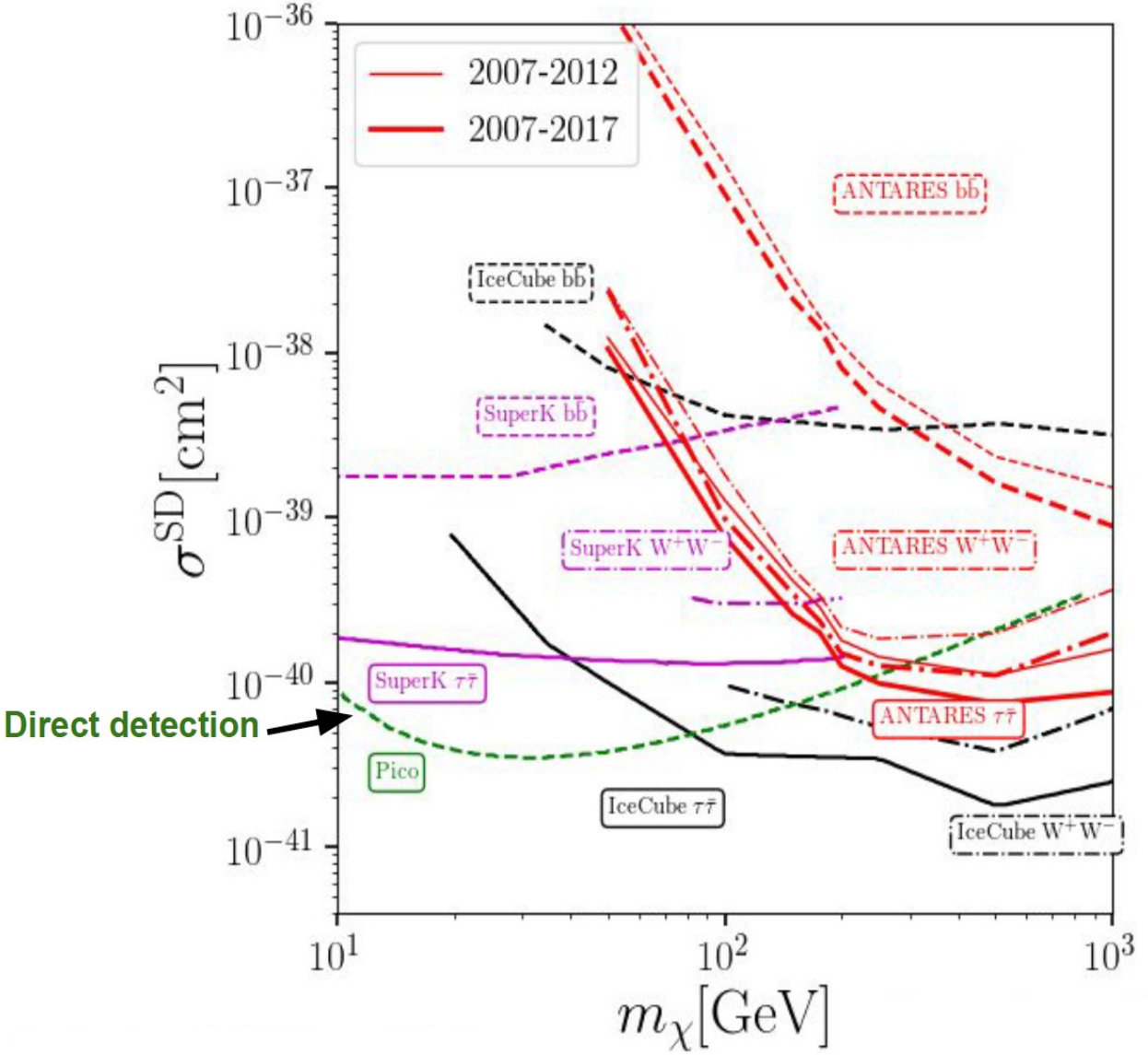


Sensitivity 2007 – 2017

$$\Phi_{\nu+\bar{\nu},90\%} = \frac{\bar{\mu}_{90\%}}{Acc(m_\chi)}$$

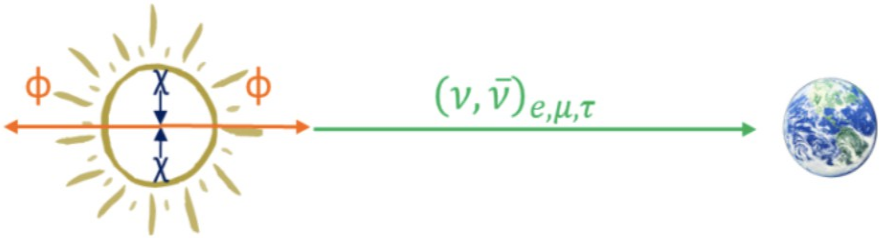


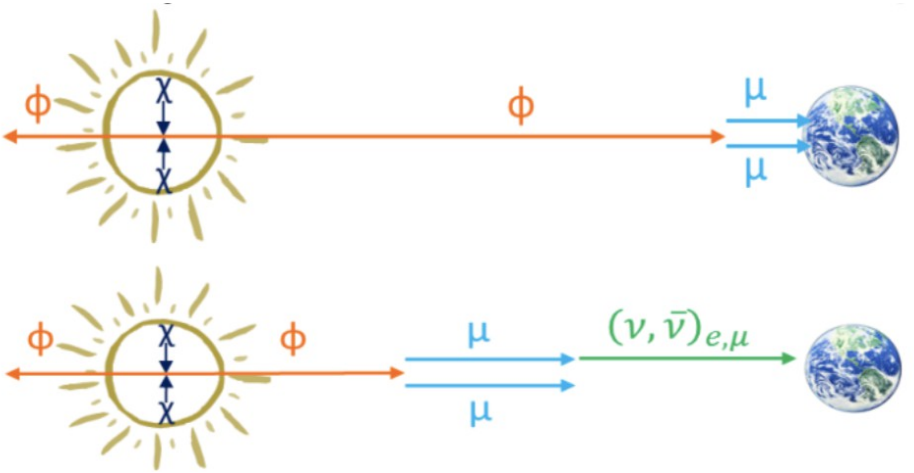
Updates Sun analysis ANTARES 2007 – 2017: Sensitivity



Search for DM secluded in the Sun

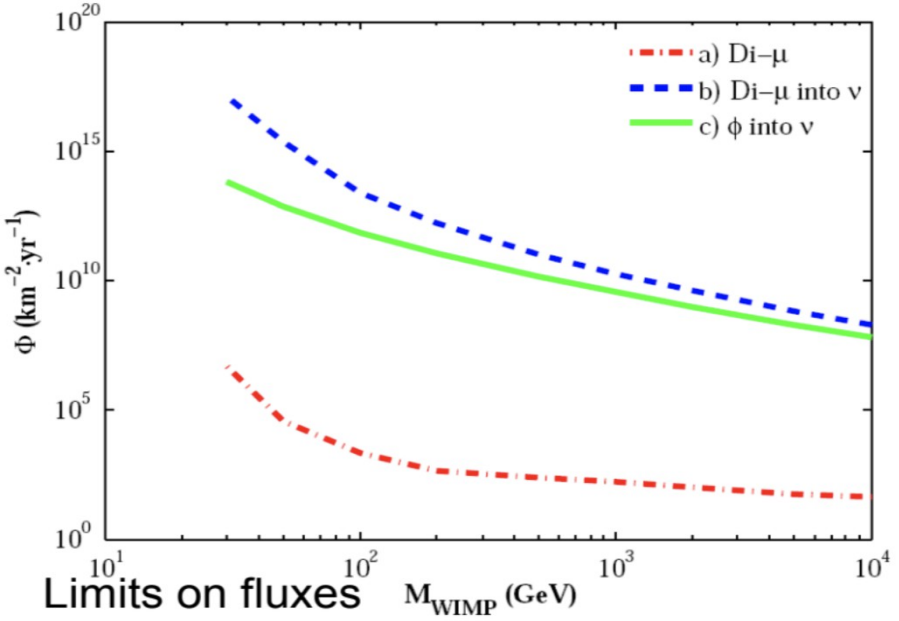
Analysis and results in JCAP 05 (2016) 016, arXiv:1602.07000



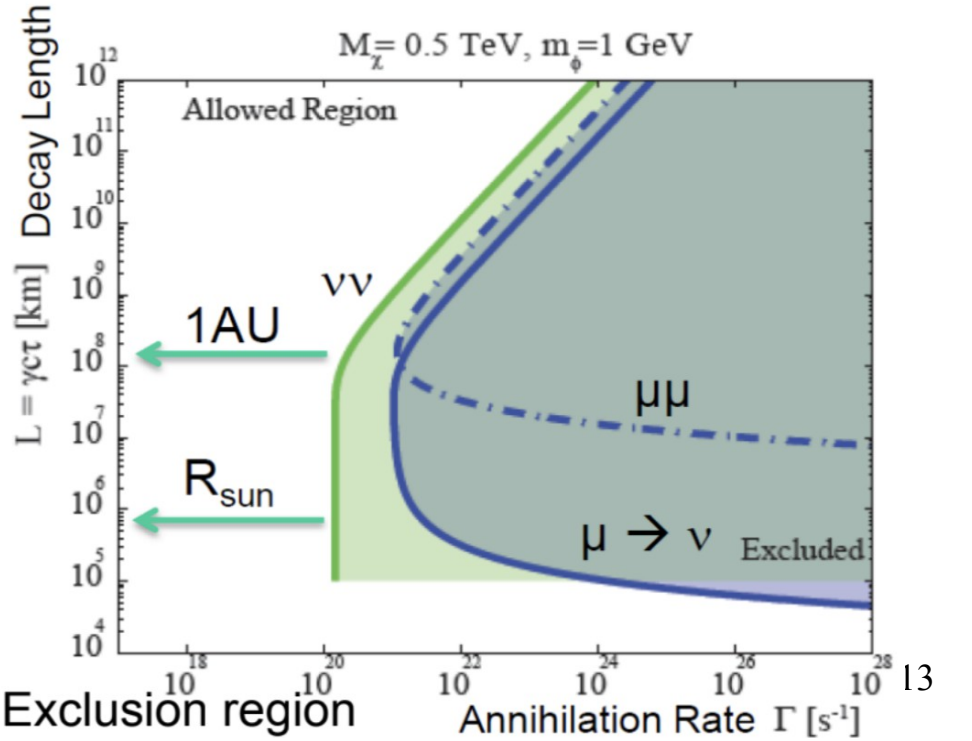


Testing models from:

- Meade et al., JHEP06(2010)29
- Bell and Petraki, JCAP04(2011)003

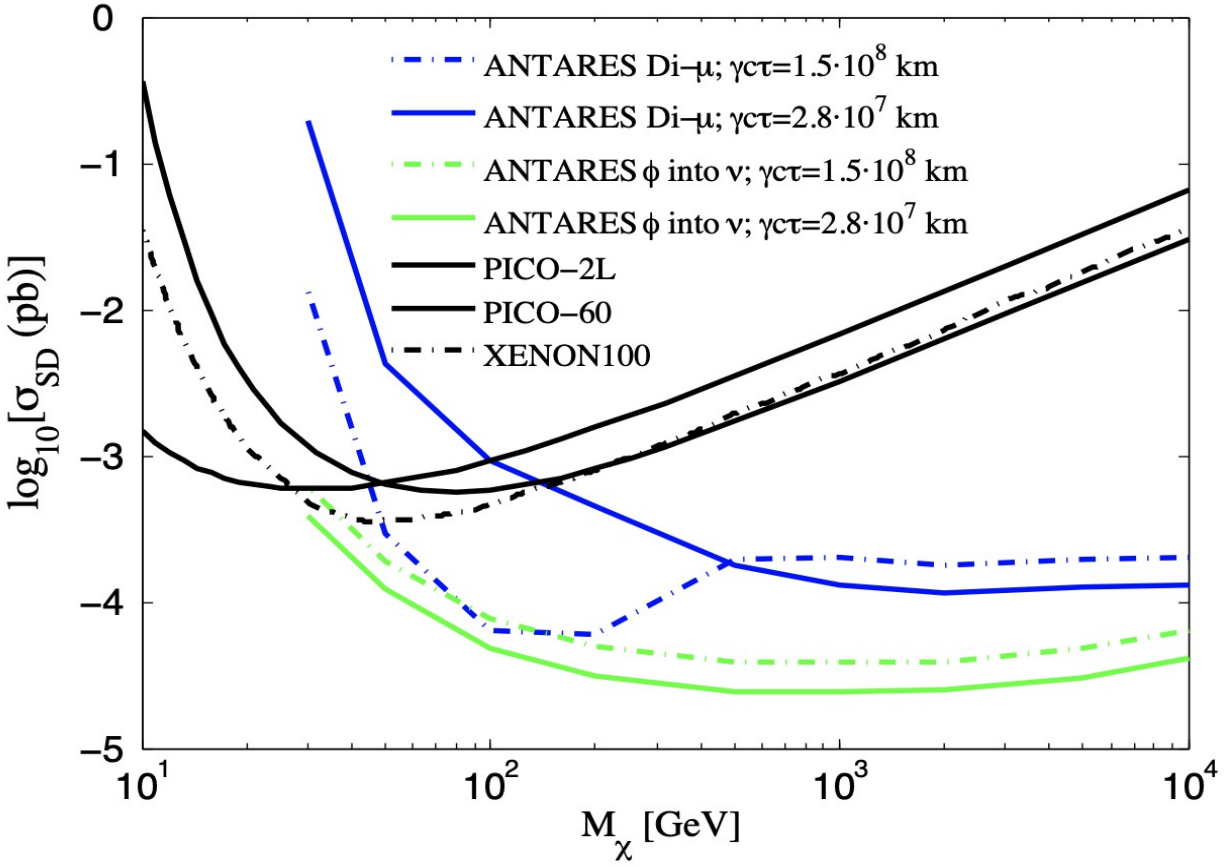


Limits on fluxes



Exclusion region

ANTARES: secluded DM in the Sun



First constrains to these models from neutrino telescopes

Restrictive limits for Spin Dependent proton-WIMP cross-section in secluded models for sufficiently long-live but unstable mediators

arXiv:1602.07000

Conclusions

→ Indirect search for Dark Matter is a major goal for neutrino telescopes

→ ANTARES limits for WIMP masses 50GeV – 100 TeV

→ Important complementarity to direct detection experiments (Sun) and gamma searches (Galactic Centre / Halo) (see also Gozzini presentation)

ANTARES Analysis under progress:

→ Full ANTARES data set (end of ANTARES data taking 2021)
→ ANTARES latest data set (still blind)

KM3NeT is future
→ Competitive KM3NeT sensitivities
(see C. Pieterse presentation)