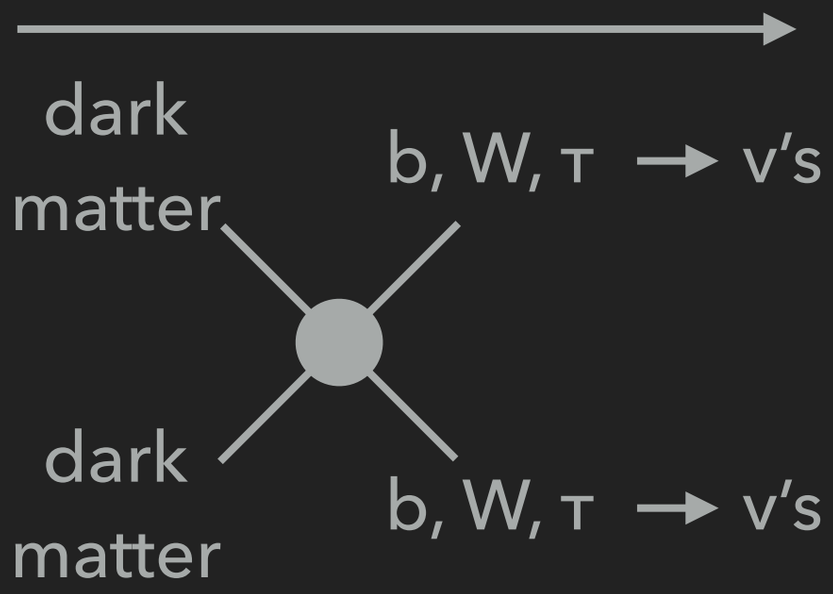
MORTEN MEDICI
ON BEHALF OF THE ICECUBE COLLABORATION

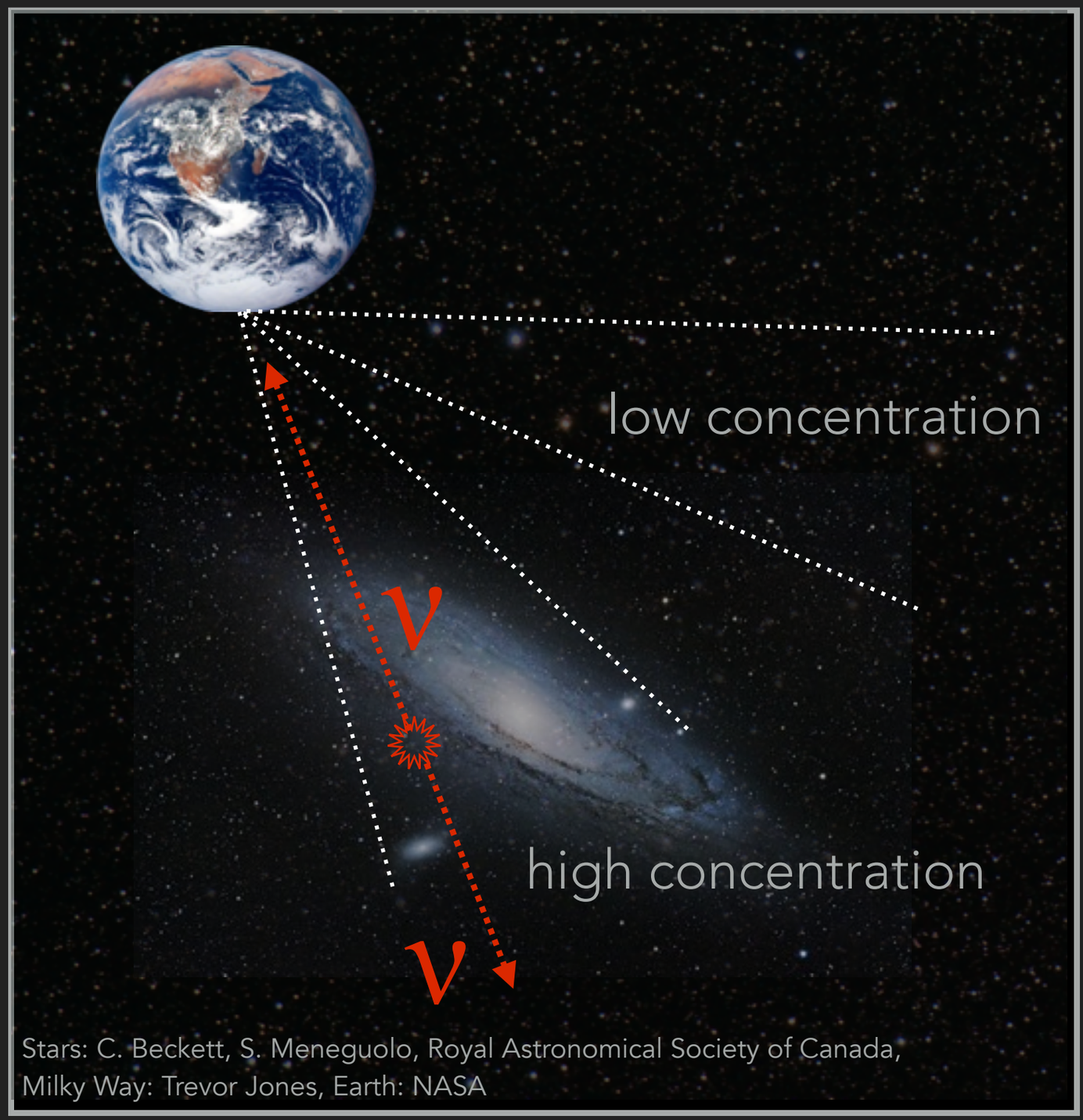
INDIRECT DARK MATTER SEARCHES IN ICECUBE

TAUP 2017, SUDBURY

INDIRECT DETECTION WITH NEUTRINOS

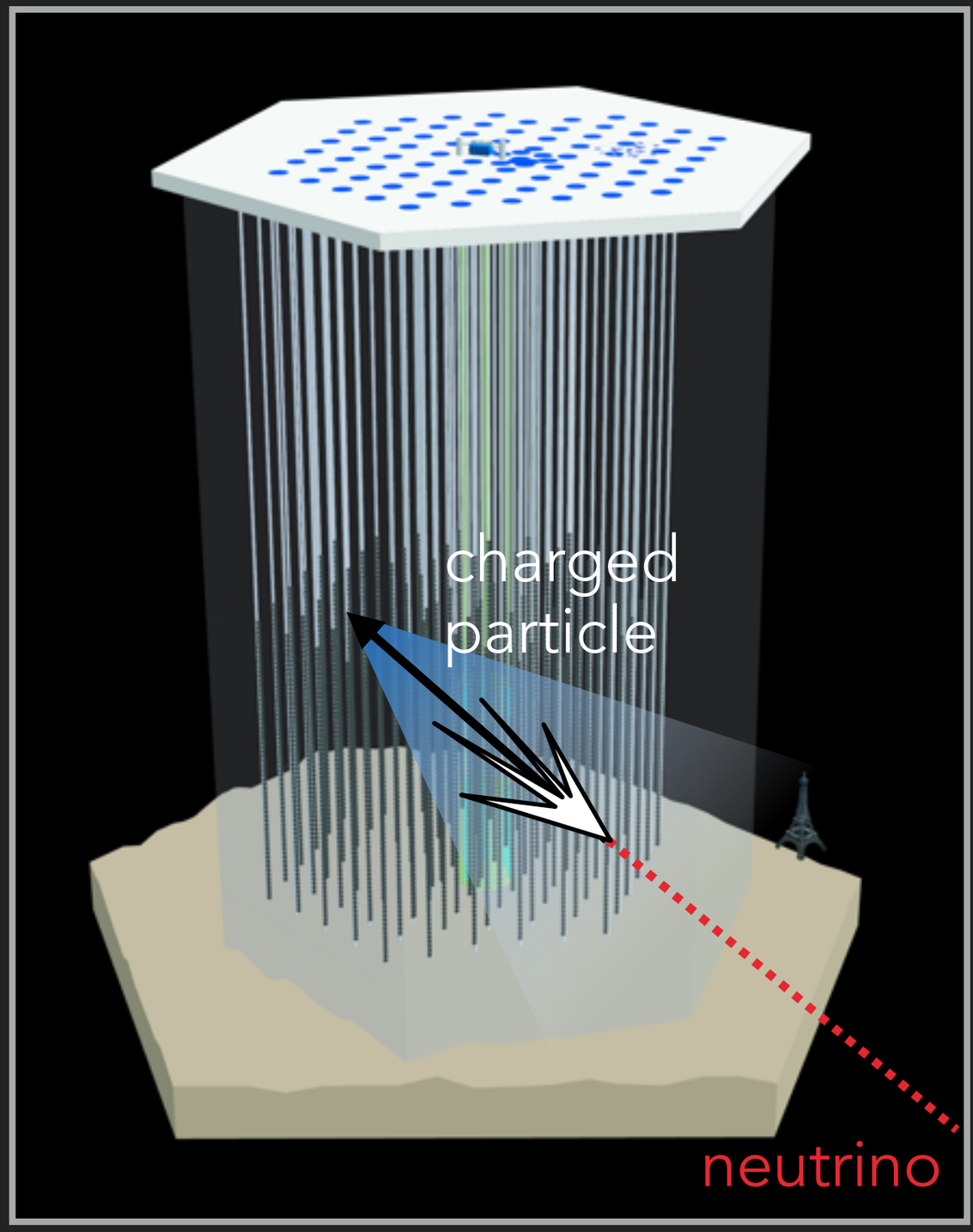
Indirect





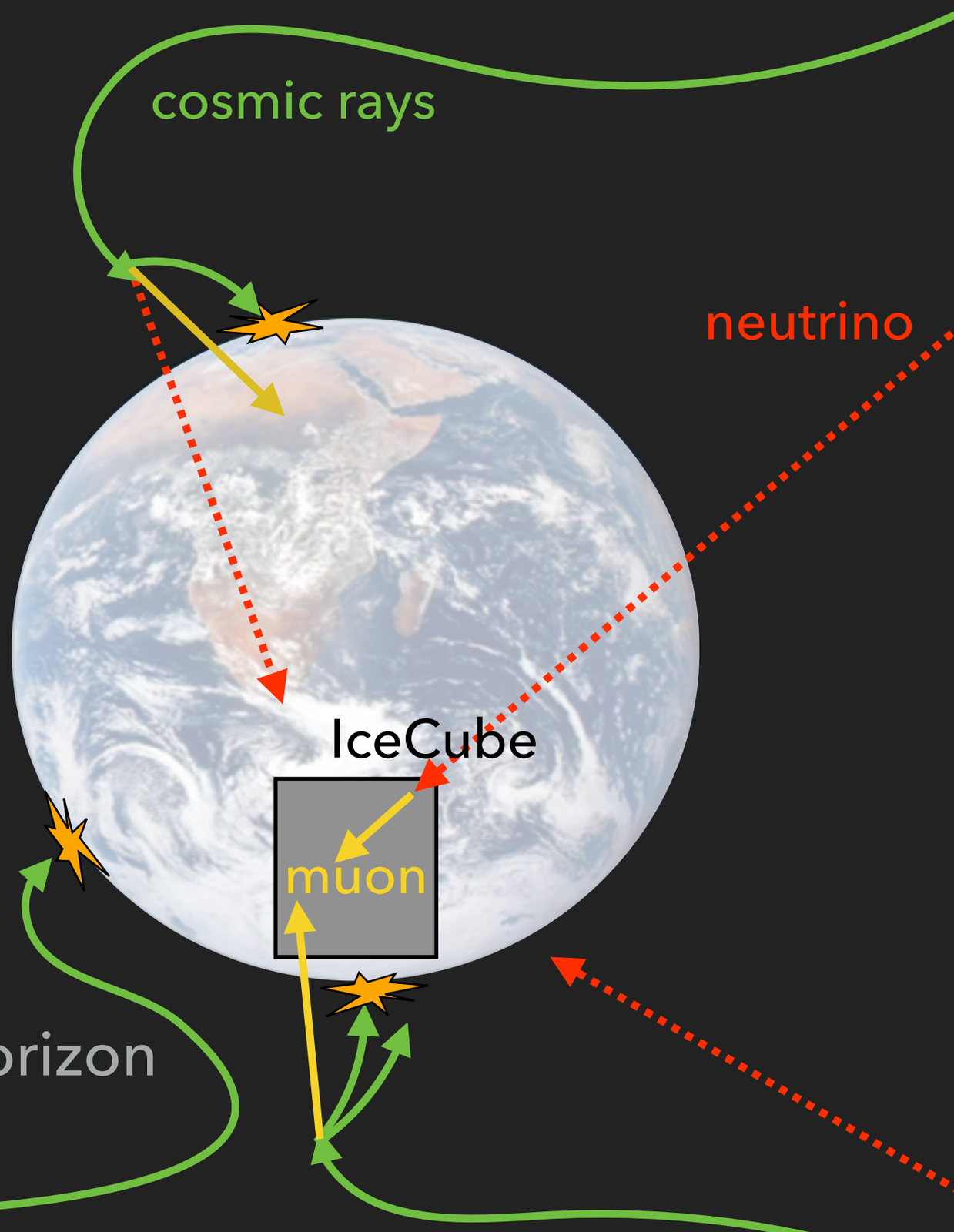
NEUTRINO PHYSICS WITH ICECUBE

- 1 km^3 instrumented ice below the South Pole (finished 2010)
- 5160 light sensors for detecting Cherenkov radiation
- Measuring neutrino-initiated events
- Energies down to 10s GeV
- Stable operation and reliable hardware (> 99% livetime)



SIGNAL AND BACKGROUND

- **Background at trigger level**
  - Atm. muons: 10^{11}/year
  - Atm. neutrinos: 10^{5}/year
- **for Dark matter searches**
  - Sun: +/- 23° above horizon
  - Galactic center: 29° above horizon



ICECUBE EVENTS

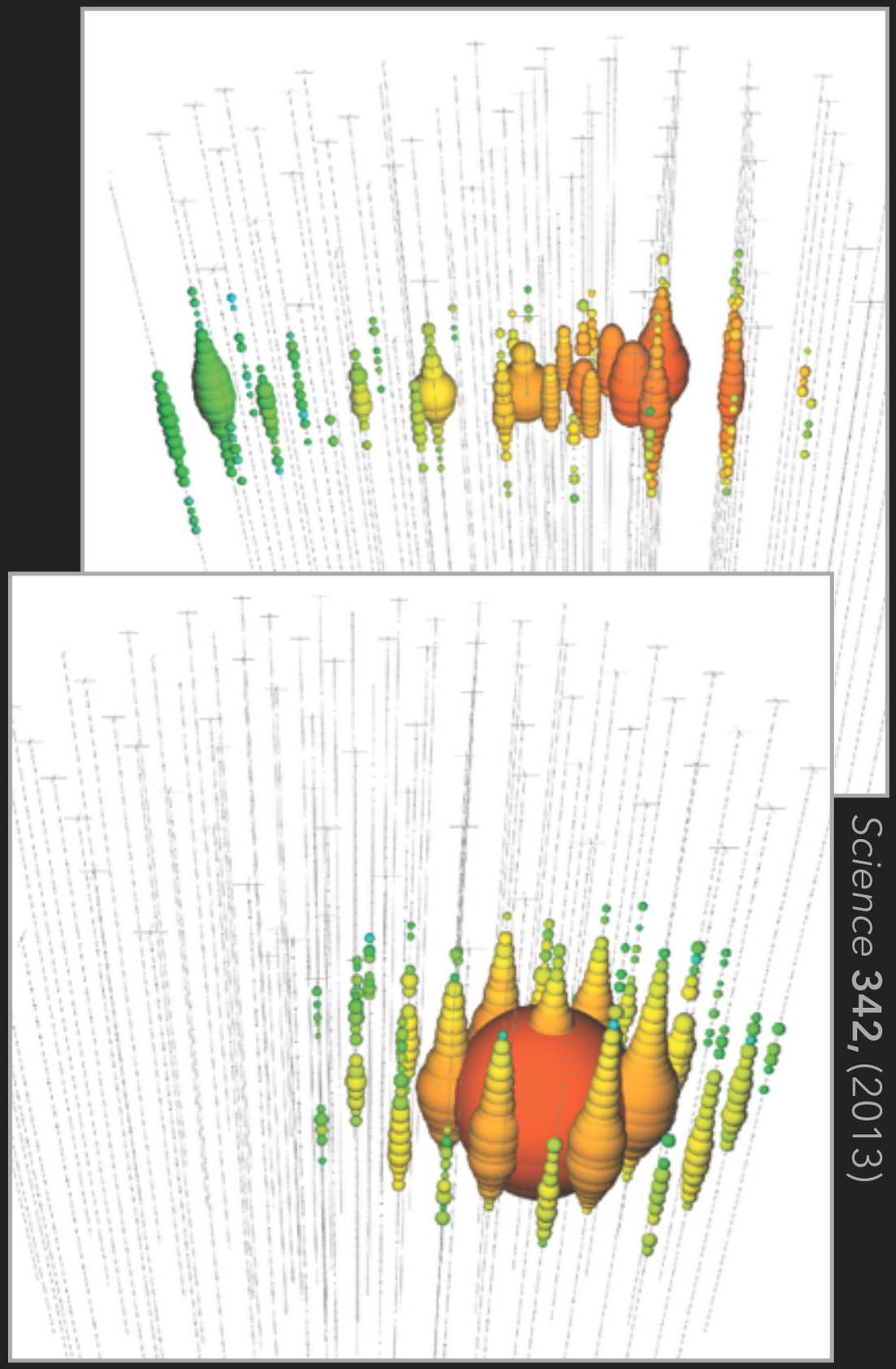
- Two topologies:
  - **Tracks** (best pointing)
  - **Cascades** (contain all energy)

- Reconstructing the neutrino:

  Charge, time, geometry

  ↓

  Direction, energy, position



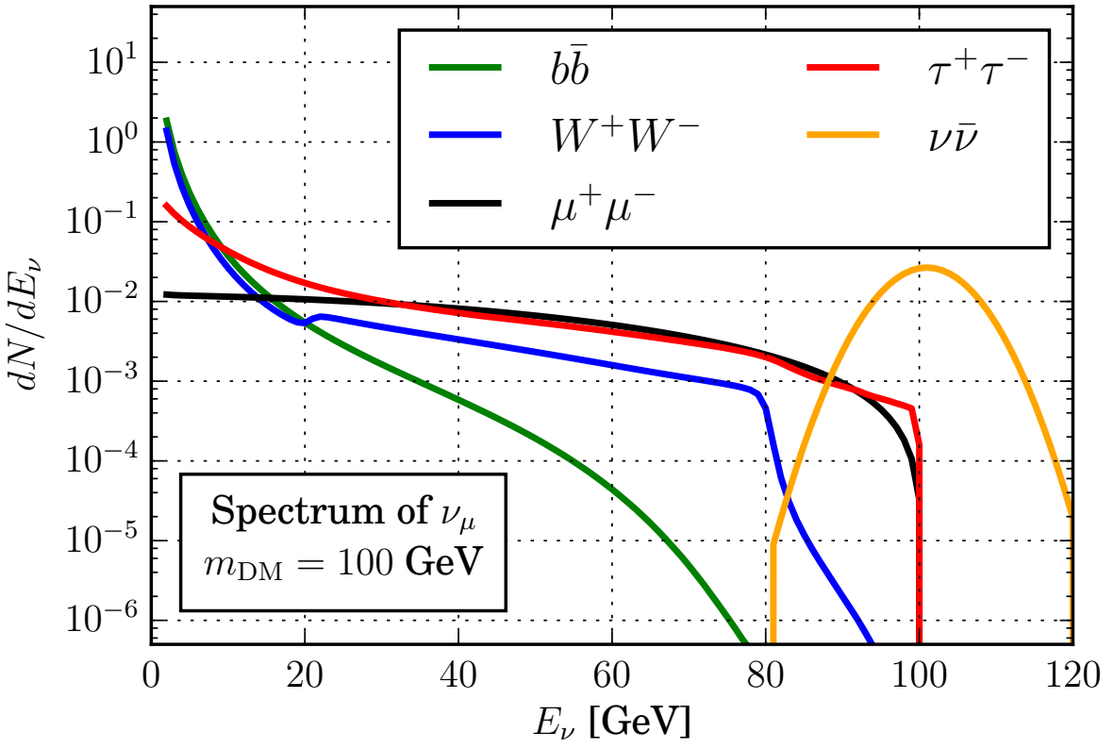
Science **342,** (2013)

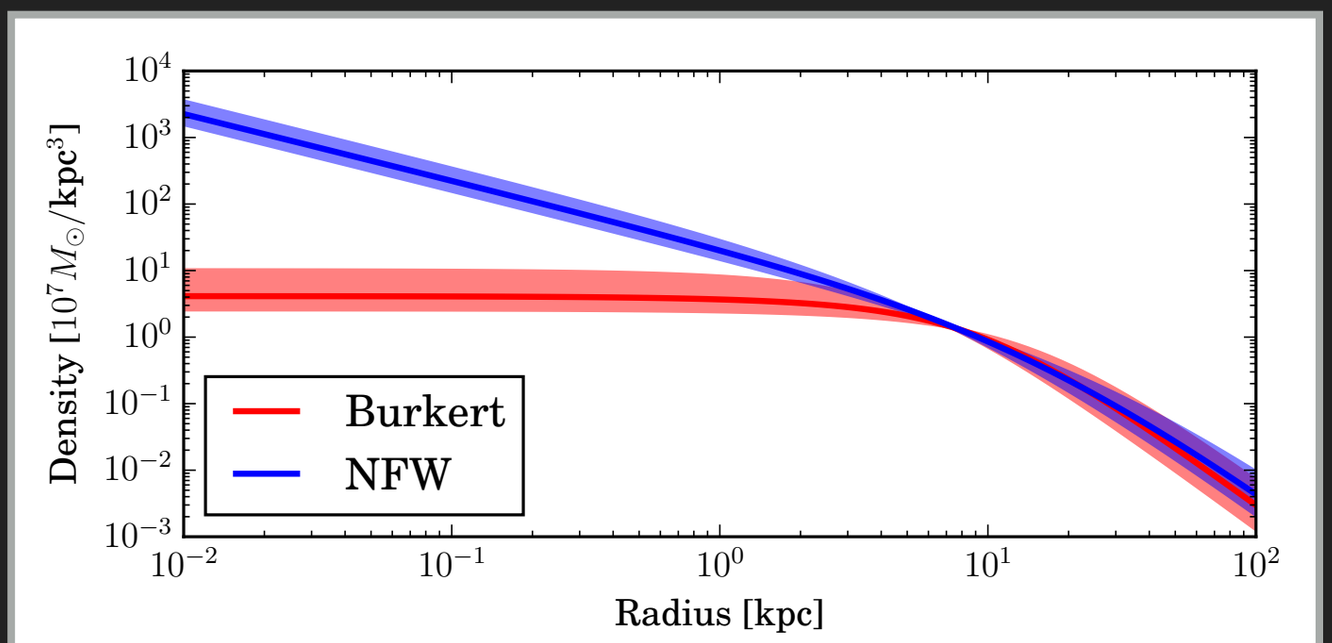
GALACTIC HALO

TARGETED SIGNAL FROM GALACTIC HALO

- Spectrum model dependent
- Signal sensitive to assumed halo profile

$$\Phi = \frac{\langle \sigma_A v \rangle}{4\pi \cdot 2m_{\mathrm{DM}}^2} \frac{dN}{dE}(E_\nu) \int_{\mathrm{los}} \rho^2_{\mathrm{halo}}(\Psi)$$





ANALYSIS TECHNIQUE

- Likelihood approach with a mixture of:
  - **Signal**: Modelled from simulated neutrino events weighted to correspond to dark matter annihilation
  - **Background**: Estimated from exp. data
- Signal contamination in background is subtracted
- Same approach used across all presented galactic halo analyses

LATEST UPDATE ON ANALYSES

- Three different event selections in IceCube are covering dark matter masses from **10 GeV to 1000 TeV**
  - **Muon tracks** (DM masses: 10-1000 GeV)
    Dedicated low energy reconstruction & events (3 years of data)
    Submitted [arXiv:1705.08103]
  - **Muon tracks** (DM masses: 0.3-1000 TeV)
    Using sample for point source searches (4 years with an overlapping 3 years)
    Includes energy (relevant above DM mass of 10 TeV)
  - **Contained cascades** (DM masses: 3-300 TeV)
    Using sample for neutrino spectrum unfolding (2 years of data)
    Includes energy, exploiting good energy resolution
- **No excess** above the expected background

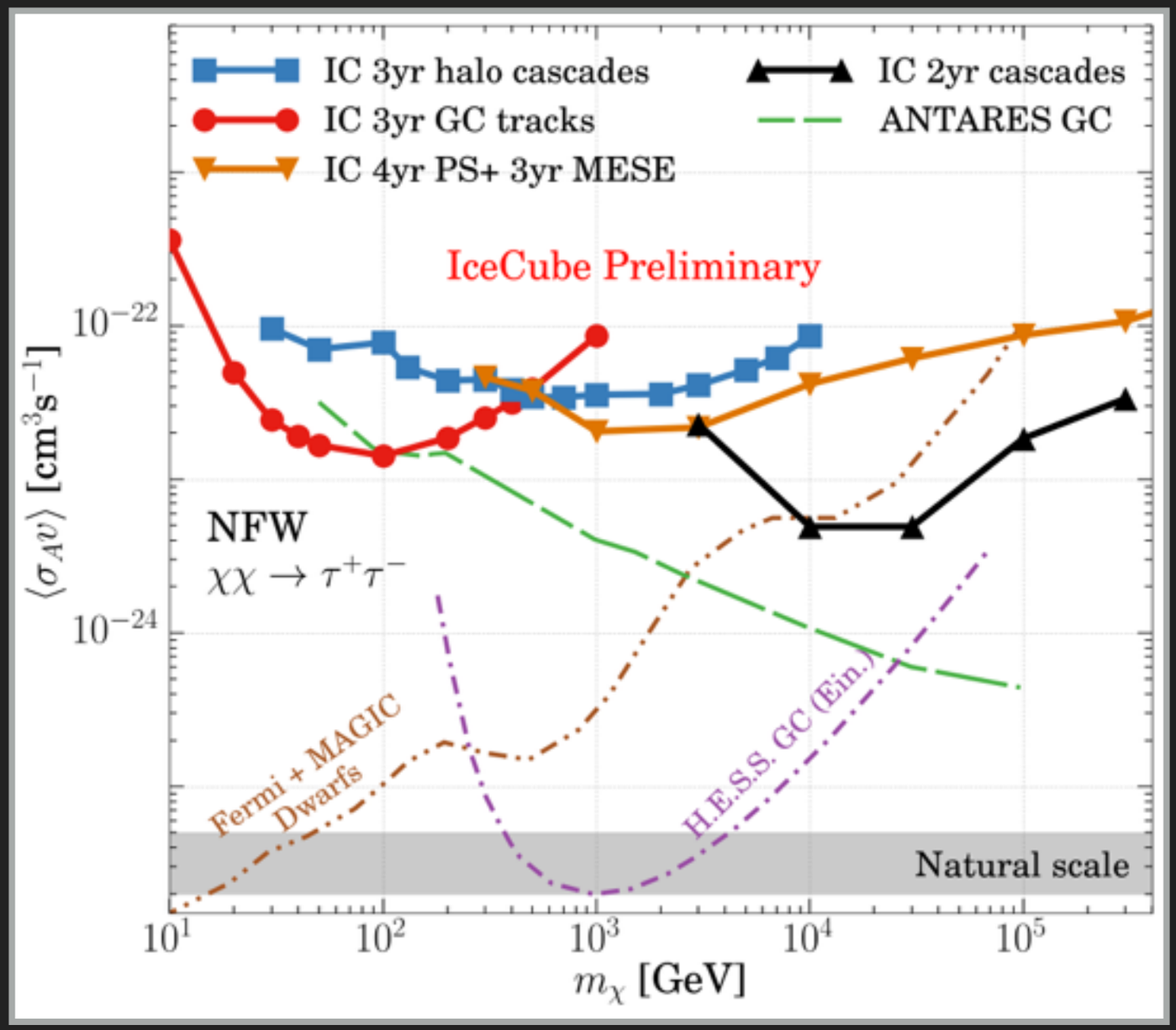
IC 3yr GC tracks

IC 4yr PS+3yr MESE

IC 2yr cascades

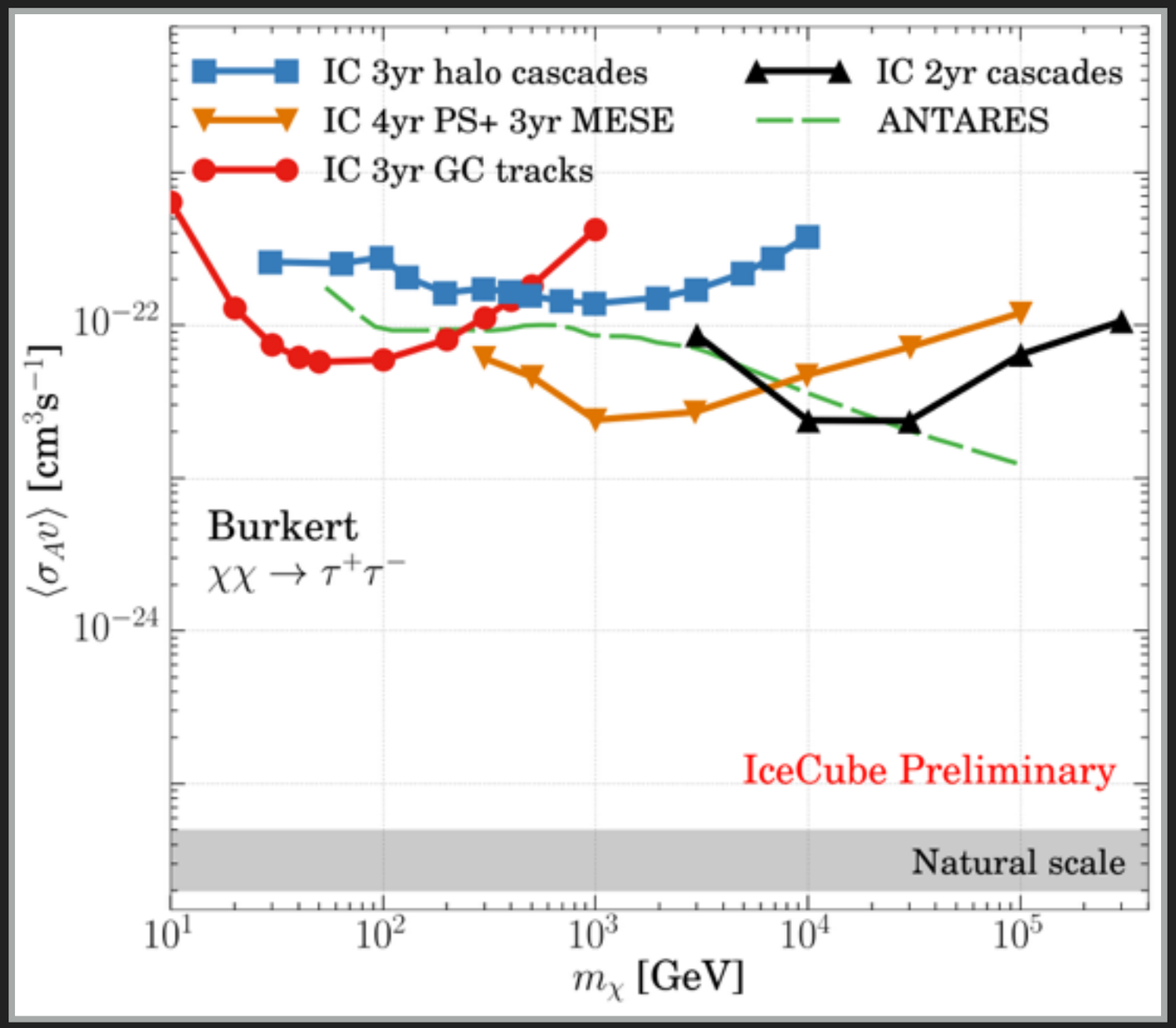
RESULTING LIMITS: GALACTIC HALO WIMPS

- Assuming NFW dark matter halo profile



CONSERVATIVE HALO PROFILE

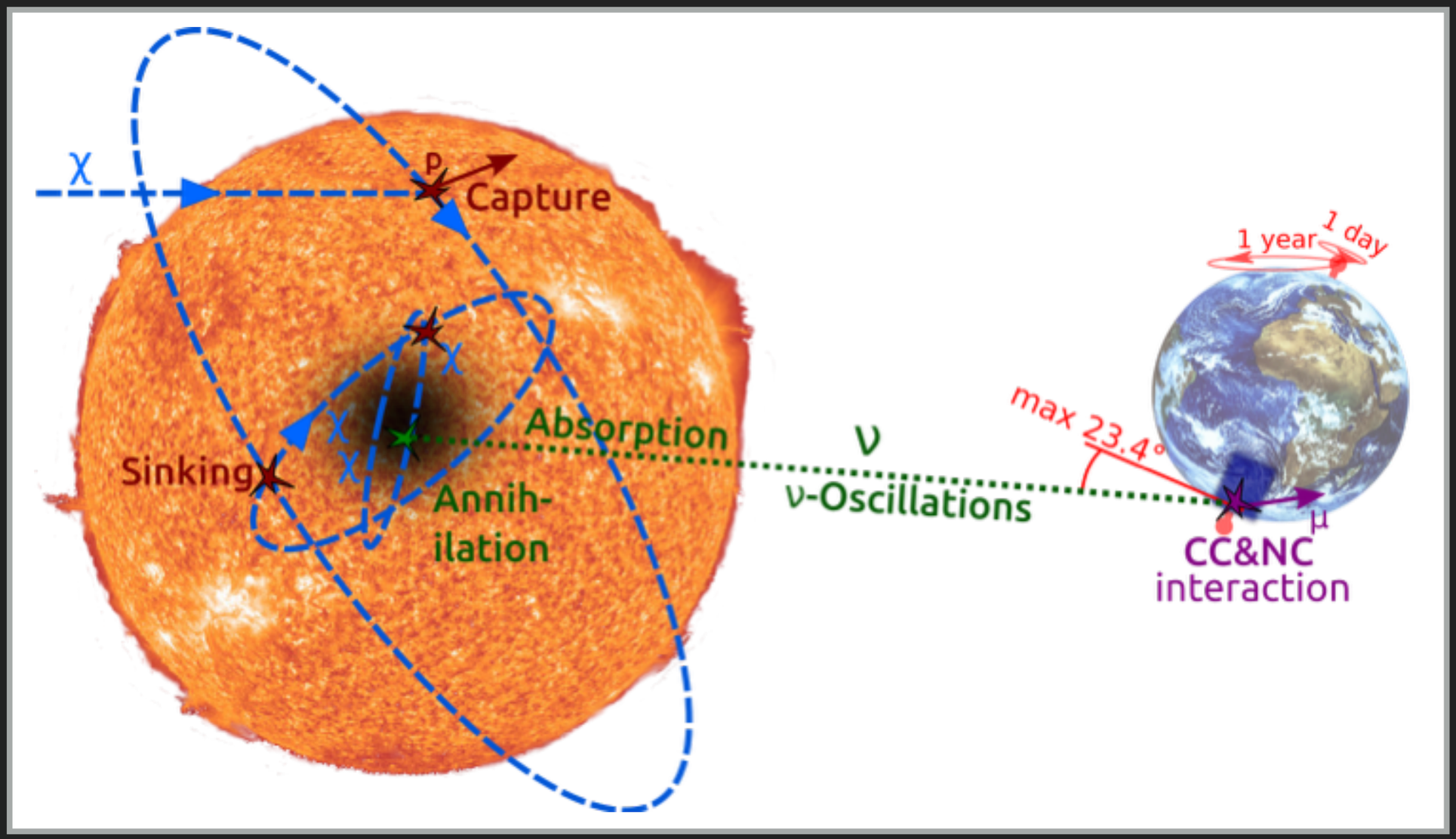
- Assuming Burkert dark matter halo profile



SOLAR SEARCH

TARGETED SIGNAL FROM THE SUN

- Accumulation of WIMP in the sun, assumed to be in equilibrium with the annihilation rate

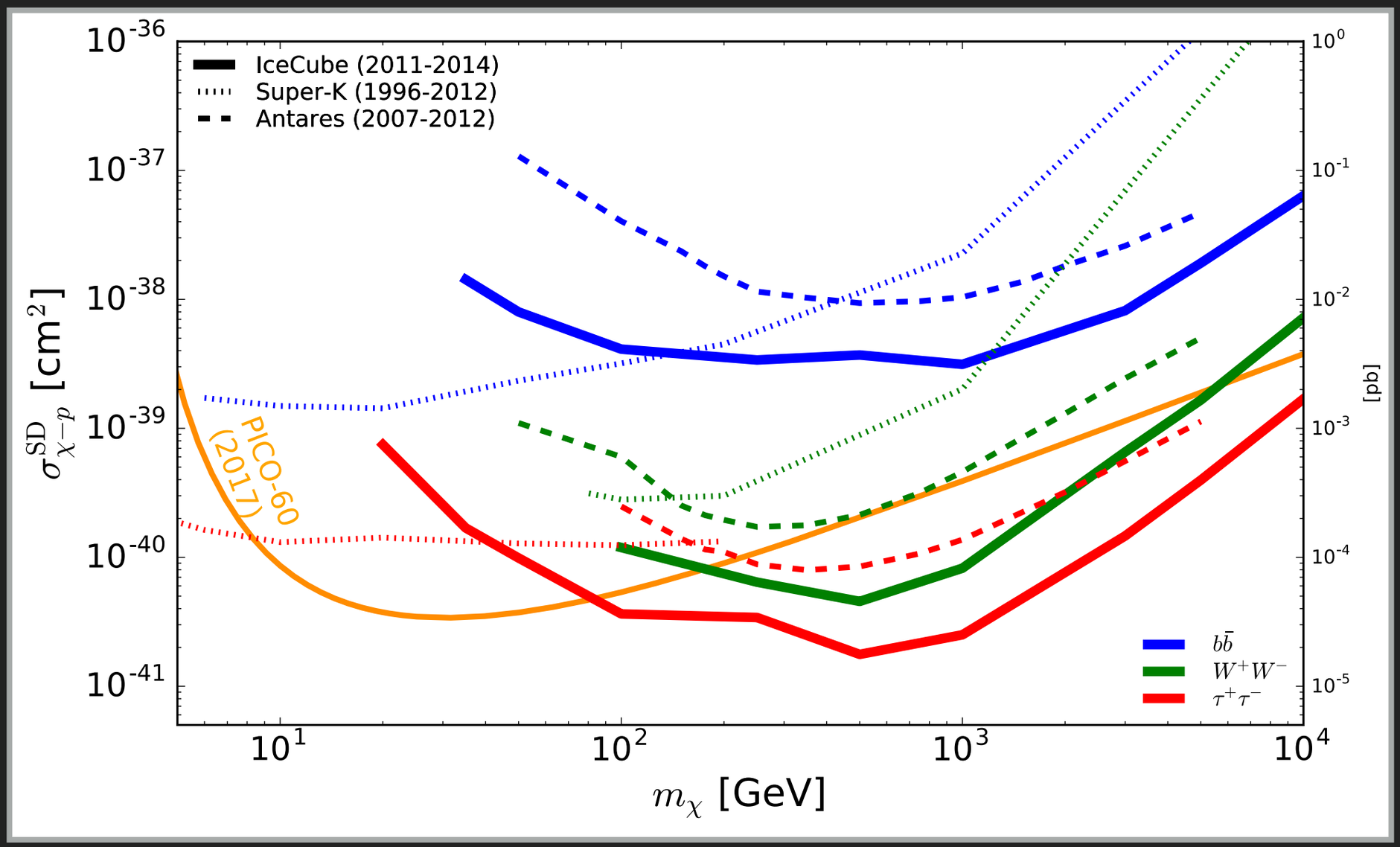


SOLAR WIMP STUDIES

- New results using the finished IceCube with 86 strings
- Results published:
  EPJC **77** 146 (2017) **[arXiv:1612.05949]**
- 3 years of data: 532 days of livetime
- Two independent analyses focusing on high and low dark matter mass
- **No excess** above the expected background

RESULTING LIMITS: SOLAR WIMP STUDIES

- Very competitive bounds on the spin-dependent nucleon-dark matter interaction cross-section



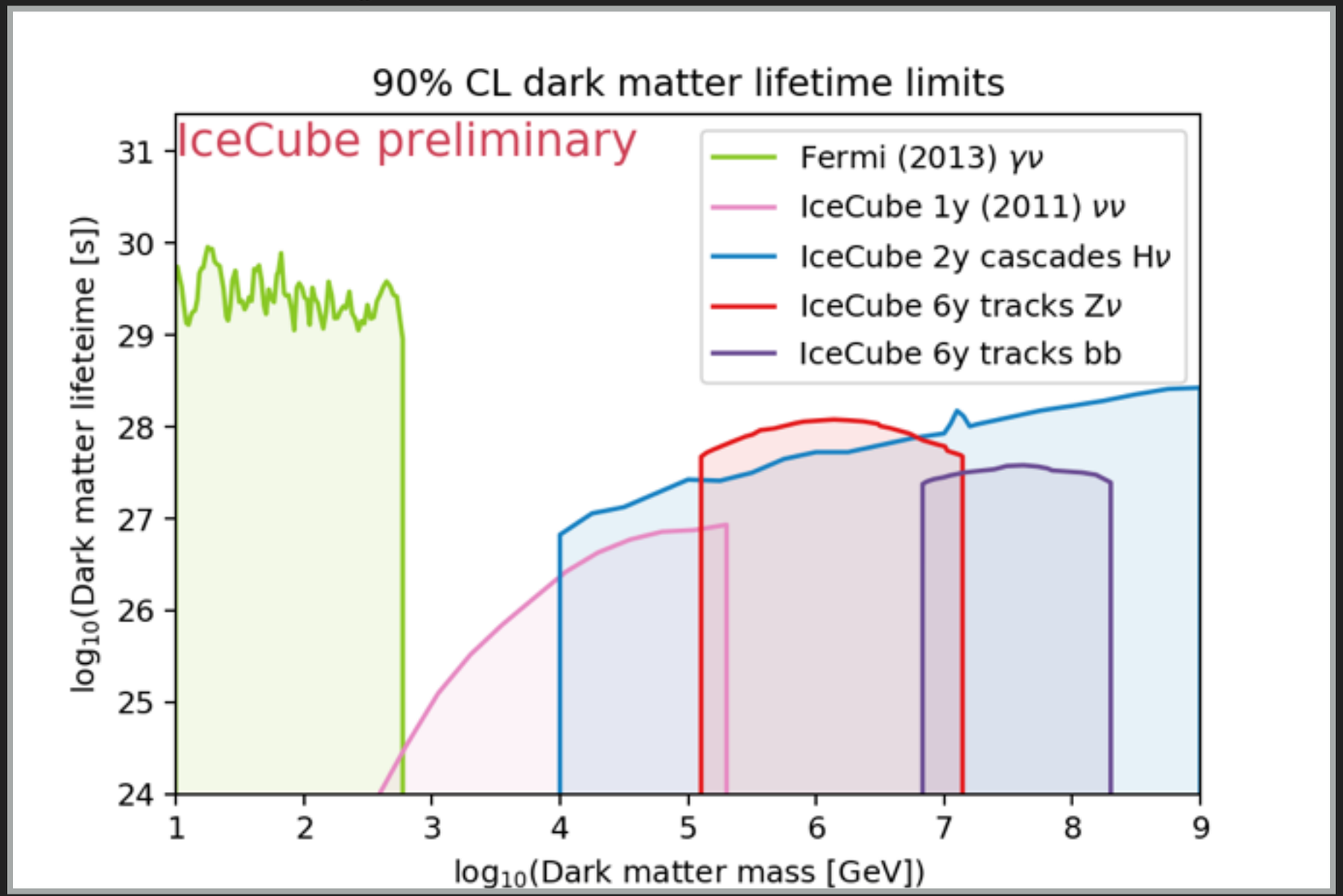
DECAYING DARK MATTER

DECAYING DARK MATTER STUDIES

- Dark matter signal: **Galactic halo** and **isotropic extragalactic** component
- Background: Simulated atmospheric muons/neutrinos and astrophysical neutrinos
- Analysis fit: Dark matter **mass**/**lifetime**, isotropic astrophysical **flux**/**index** (single power law)
- **Two independent analyses** using event selections designed for unfolding the neutrino spectrum:
  - 1) Using dataset with 6 years of northern hemisphere **tracks**
  - 2) Using dataset with 2 years of full sky **contained cascades**
- Focusing on the Hv- or Zv-channel which has a significant peak in energy from the neutrino line spectrum
- **No excess** above the expected background

EXPERIMENTAL LIMITS ON DECAYING DARK MATTER

- Adding limits on dark matter lifetime for dark matter masses above 10 TeV for high mass dark matter



SUMMARY

- No observation of a neutrino signal in IceCube compatible with dark matter annihilation or decay
- More sensitive analyses and longer reach in dark matter masses provides very competitive limits on the annihilation cross section
- IceCube is less sensitive to the exact distribution of dark matter in the galactic halo.
- First limits from IceCube on the search for dark matter decay extending to higher dark masses than probed before

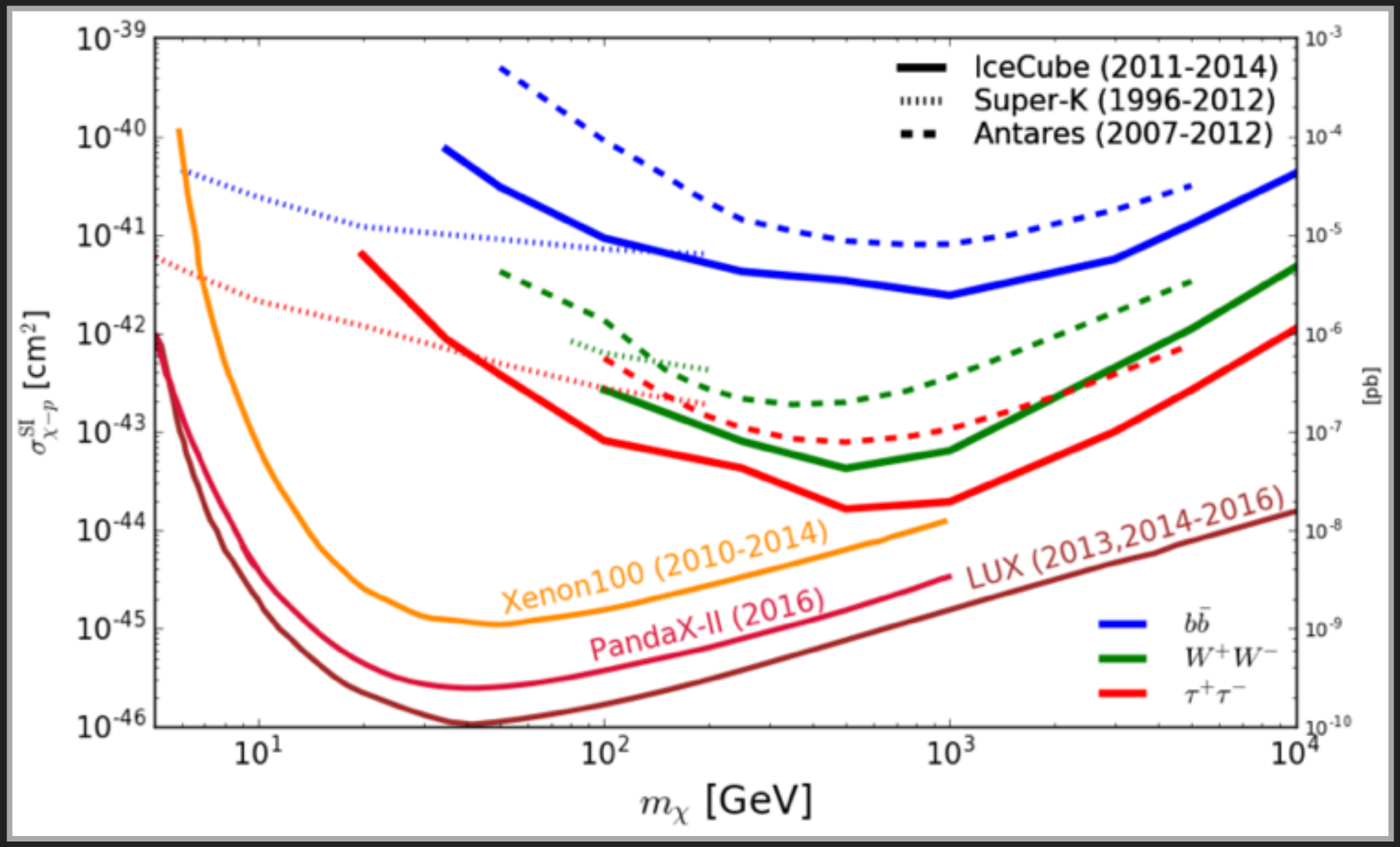
THANKS FOR YOUR ATTENTION!

IceCube

UNIVERSITY OF COPENHAGEN

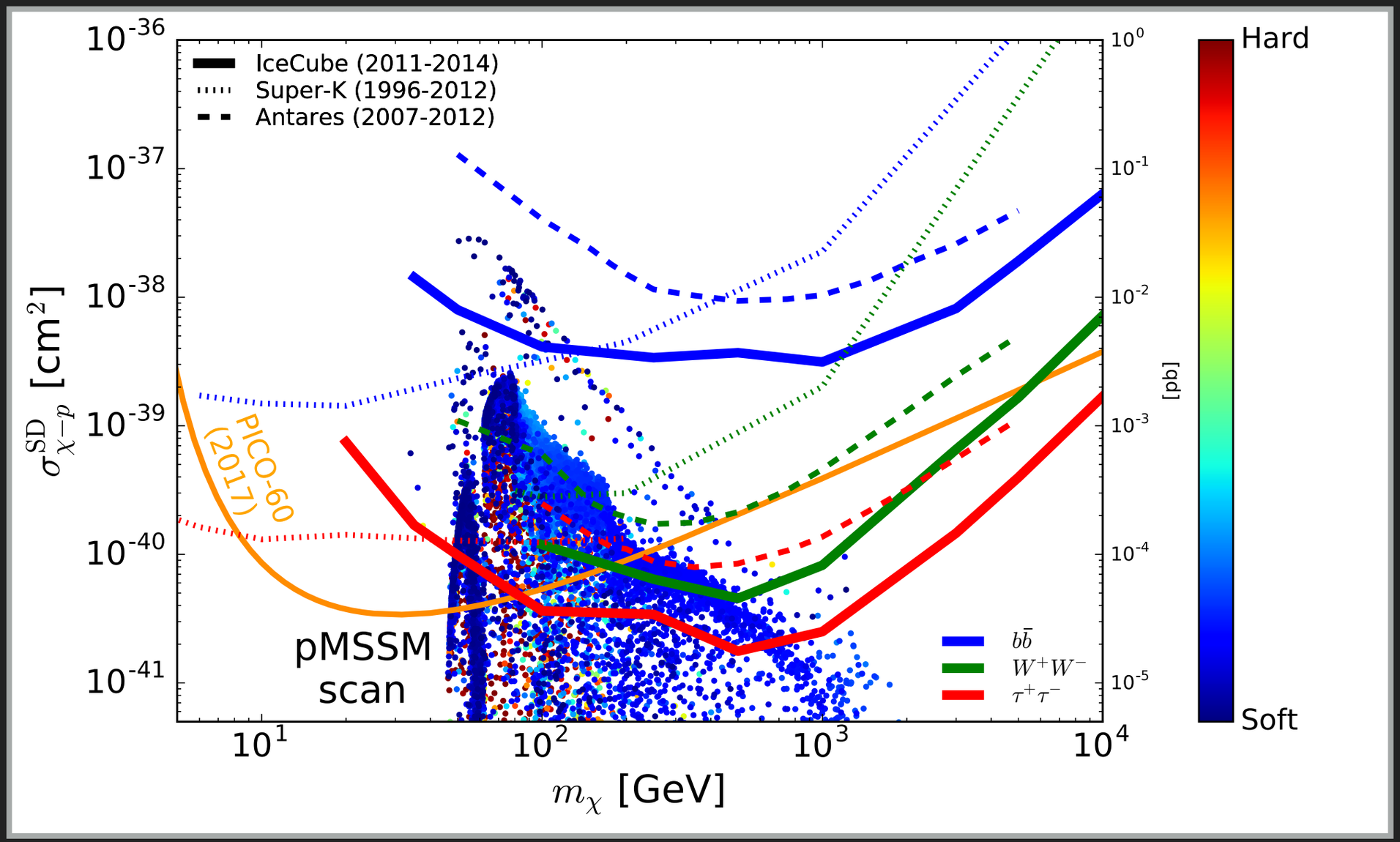
SOLAR WIMP STUDIES

- Spin-independent dm-nucleon cross section



SOLAR WIMP STUDIES

- pMSSM model scans, indicating the fraction of hard and soft final states



DECAYING DARK MATTER

- Significant excess of high energy neutrinos above backgrounds
- Used to look for decaying heavy dark matter