Indirect search of dark matter in the Sun with the ANTARES data 2007-2008

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Marseille
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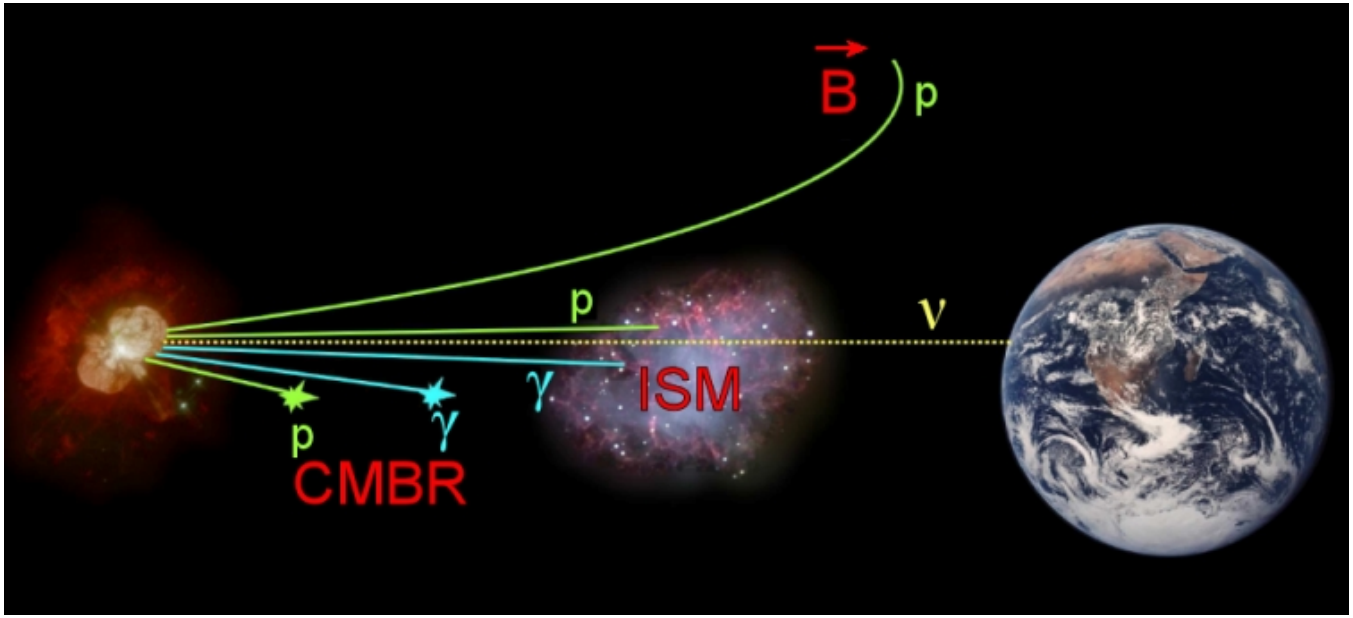
Neutrino Astronomy



Low cross-section messenger -> Barely any interaction with ISM
(ability to observe very distant objects)

No Electrical charge -> No deviation by the Galactic magnetic fields

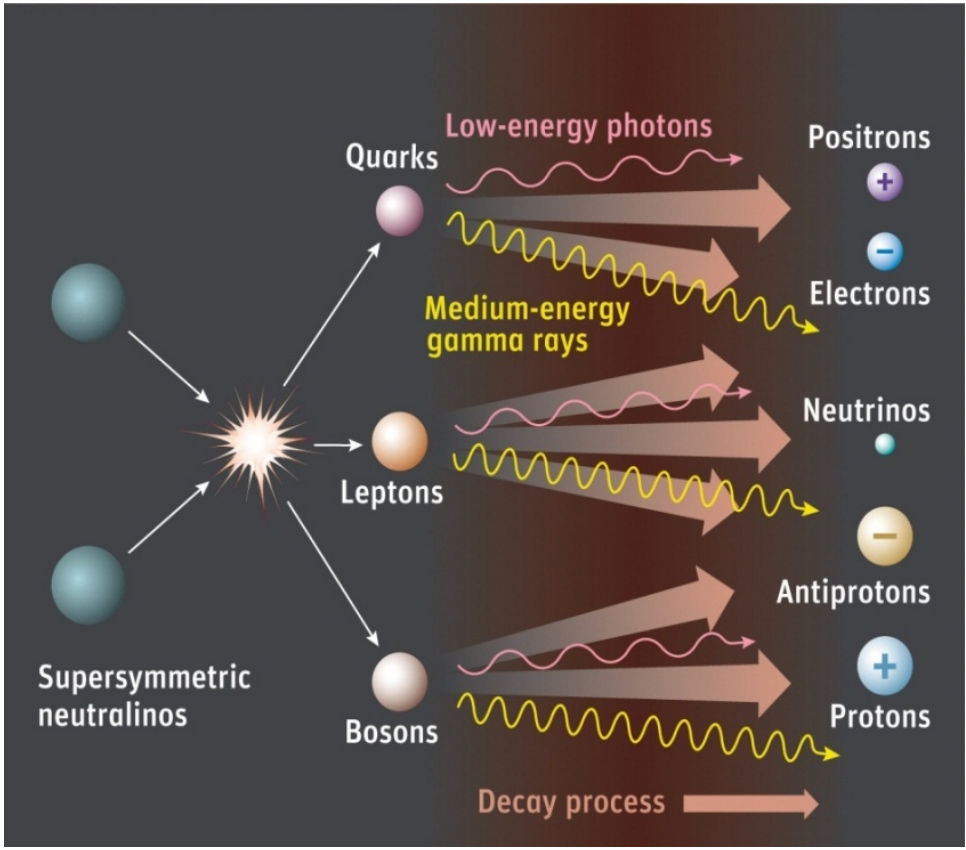
Ability to observe the inner working of astrophysical objects

Drawback: Large detector volume is needed!

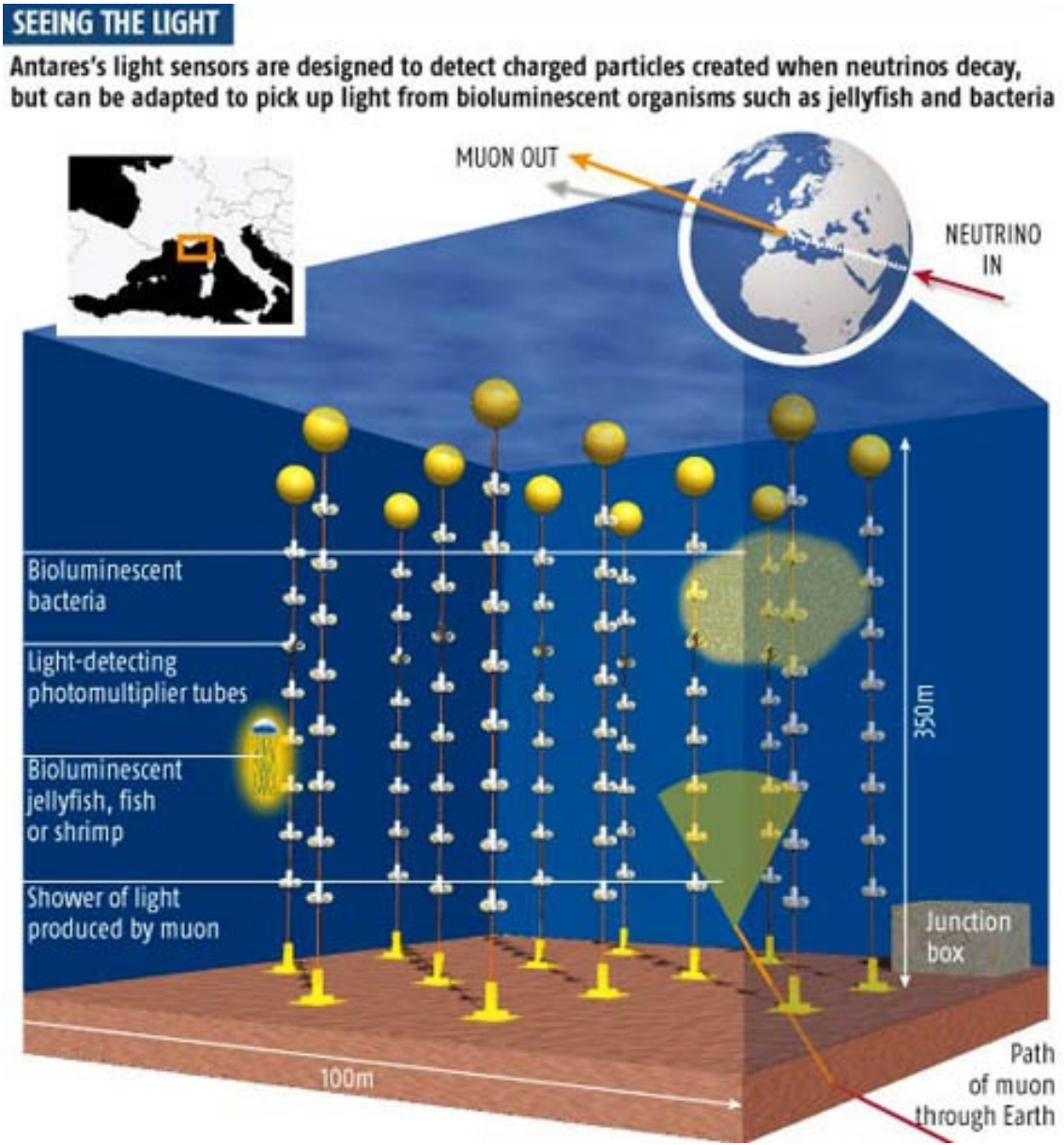
Dark Matter with neutrinos

1.If DM is a LSP or a LKP -> Auto-annihilation is possible -> ν is almost always an outcome of the annihilation

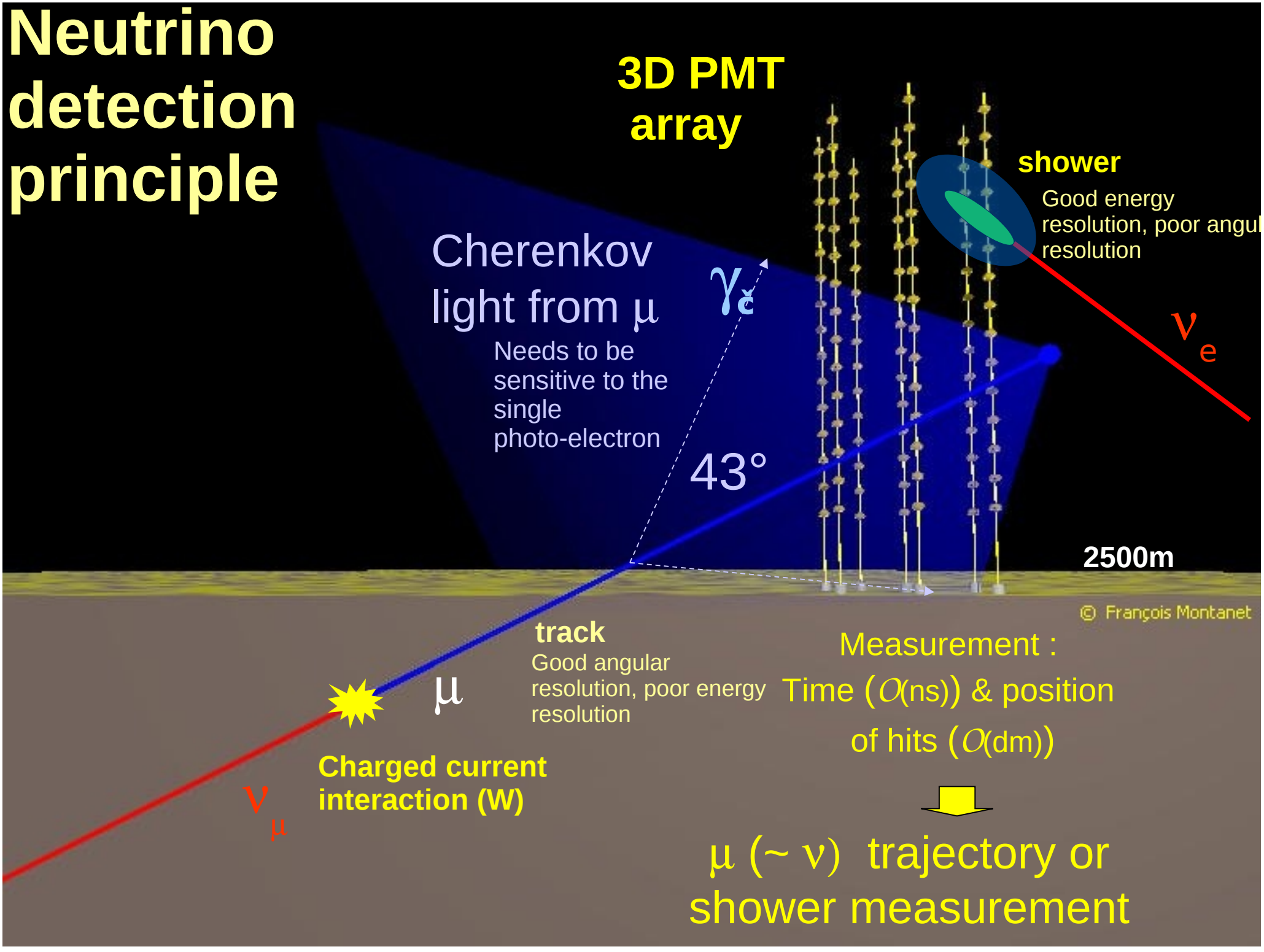
2.If we assume a local density -> accumulation inside the Sun is possible -> A neutrino flux coming from DM annihilation can be detected in the Sun's direction at earth



ANTARES

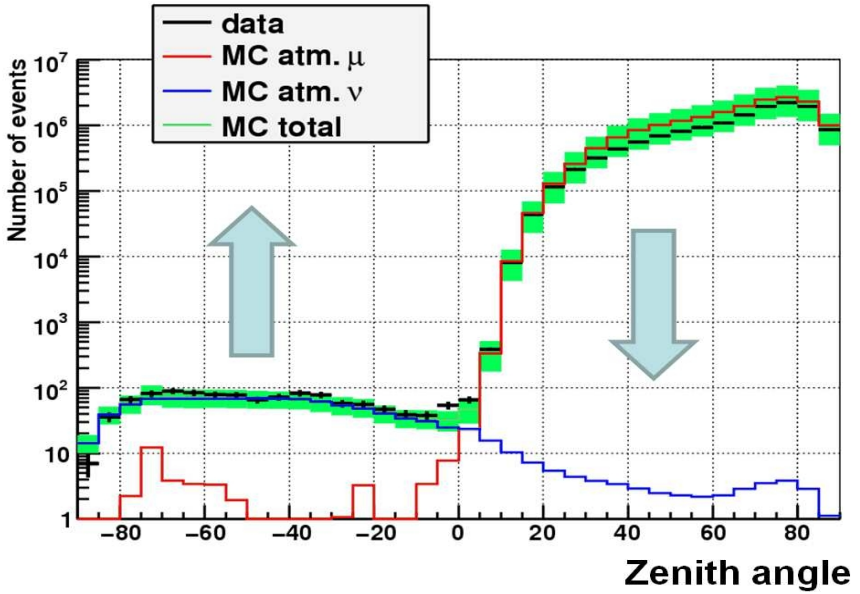


- One of the only few Cherenkov neutrino telescopes in the world (Antares, Baikal, IceCube)
- 40Km offshore, ~2500m deep, 12 lines, 25 floors per line, with 3 OMs per floor. Totaling a sum of 900 OMs

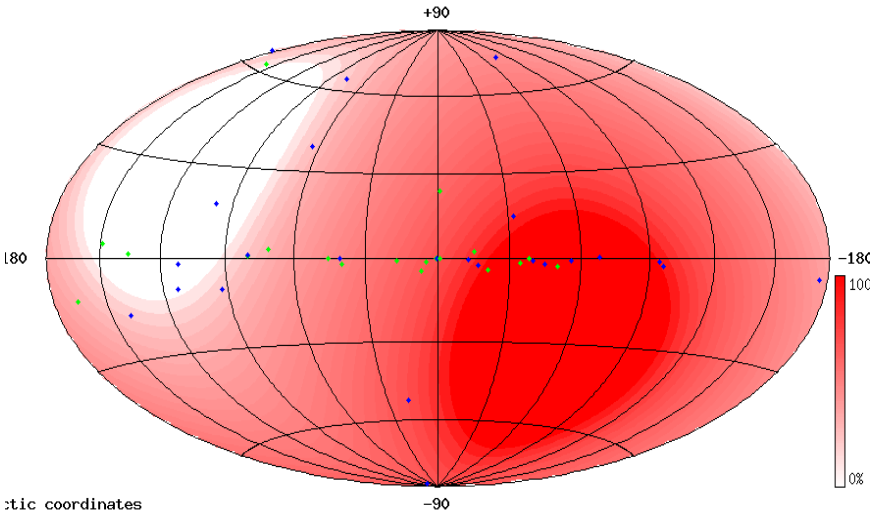

Neutrino detection principle
3D PMT array
shower
Good energy resolution, poor angular resolution
Cherenkov light from μ
Needs to be sensitive to the single photo-electron
γč
43°
νe
2500m
© François Montanet
track
Good angular resolution, poor energy resolution
μ
Charged current interaction (W)
νμ
Measurement :
Time (O(ns)) & position of hits (O(dm))
μ (~ ν) trajectory or shower measurement

Status

Running since 2007 (5 lines), 12 lines (full detector) since May 2008.



Angular resolution : ~ 1.5°
for E~1 TeV(Dark Matter region)
Effective area for neutrinos :
10^-3 m² @ 1 TeV



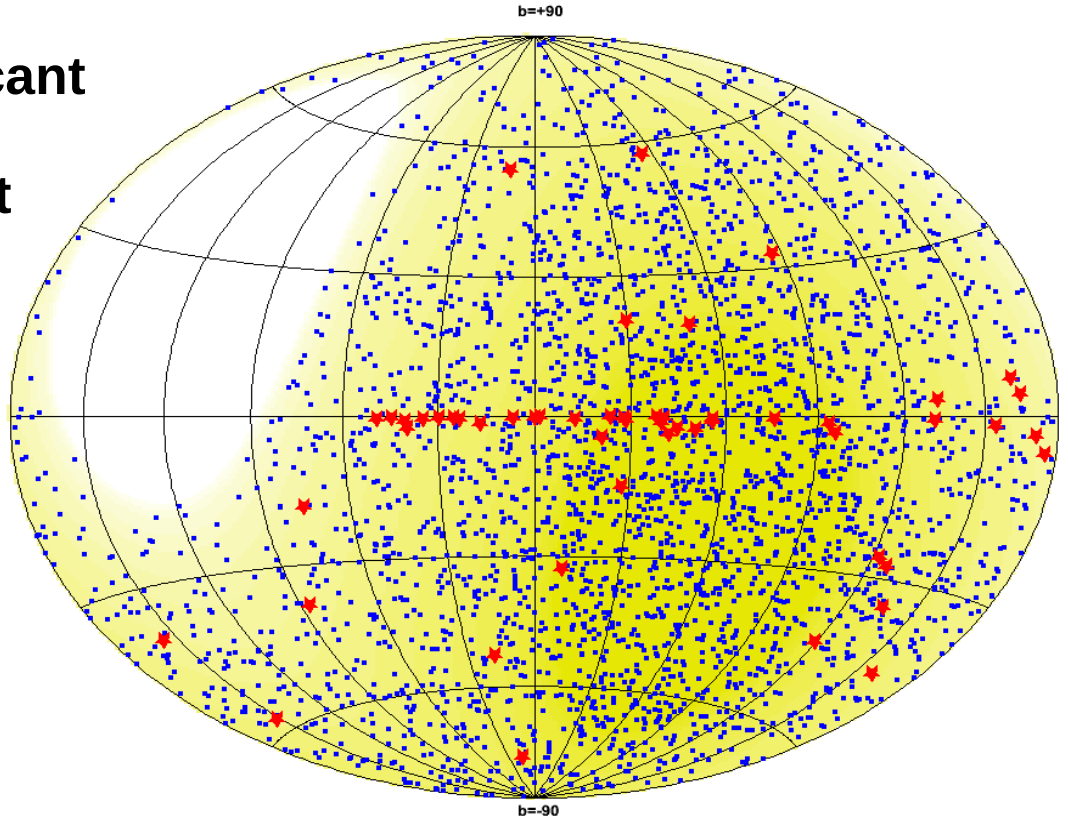
ANTARES @ 42.5° N =>
coverage 3.5π sr

See the GC 2/3 of the time.

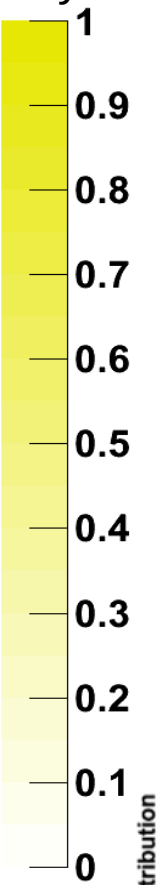
ANTARES point source searches

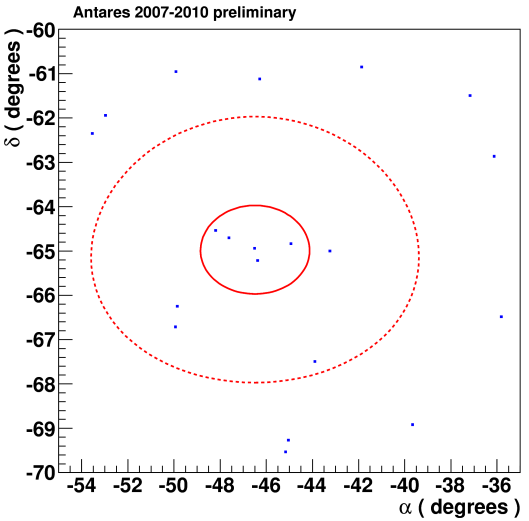
Antares 2007-2010, preliminary

No significant excess (largest is 2.2 σ)

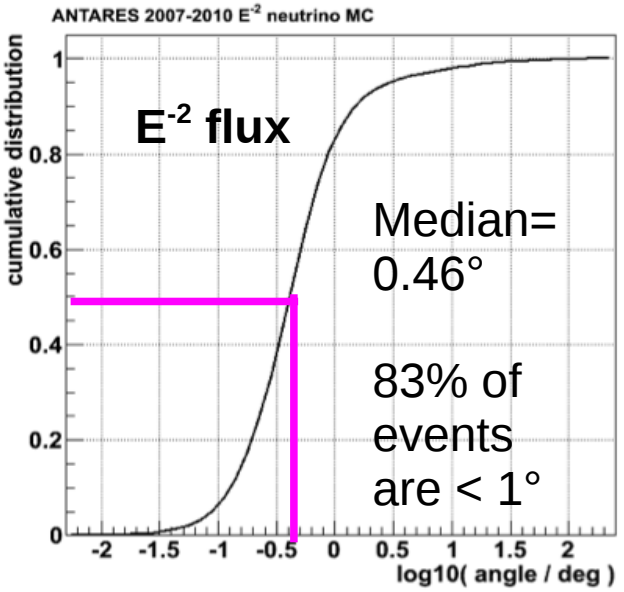


visibility





Angular resolution
Angle between true neutrino direction and reconstructed track for selected muons:



Up-going selected tacks

List of sources

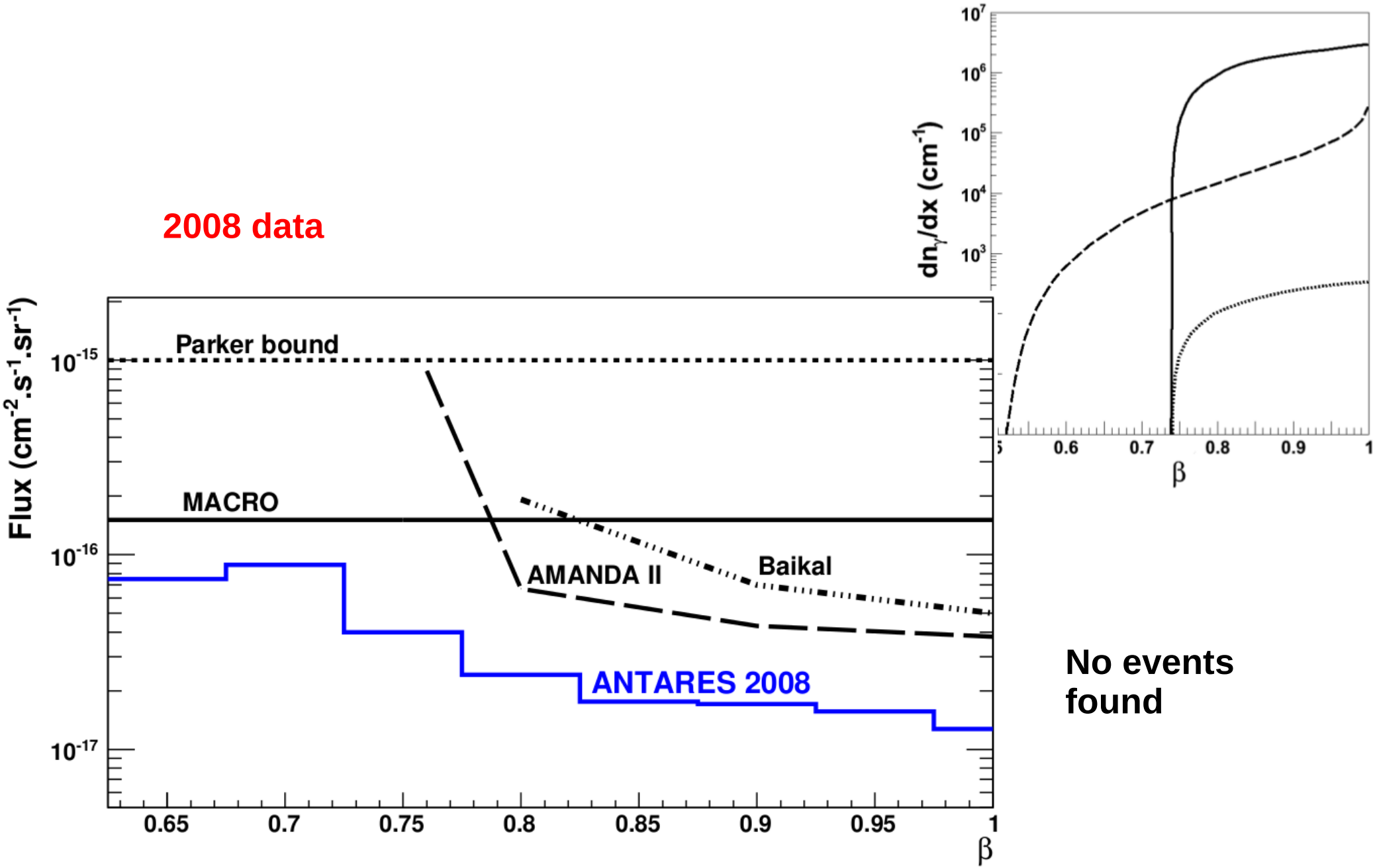
2007-2010 data

813 days

3058 events (reconstructed as up-going)
Contamination by~ 15% atmospheric muons

Magnetic Monopoles

2008 data



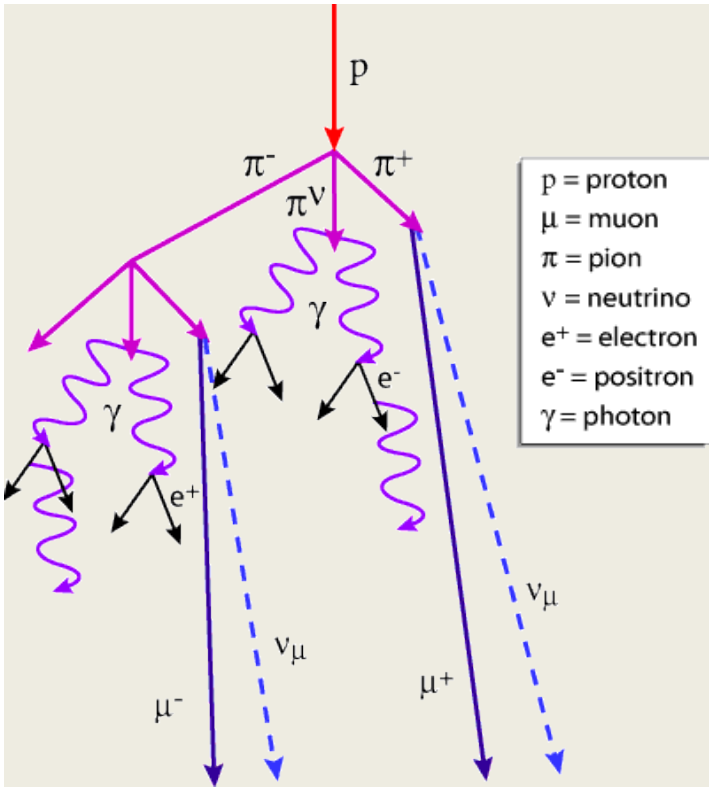
No events found

DM in the Sun

Background:

Two sources of background:

- Mis-reconstructed down-going muons
- Up-going atmospheric neutrinos



From cosmic rays interacting with the atmosphere on the southern-hemisphere side of the earth

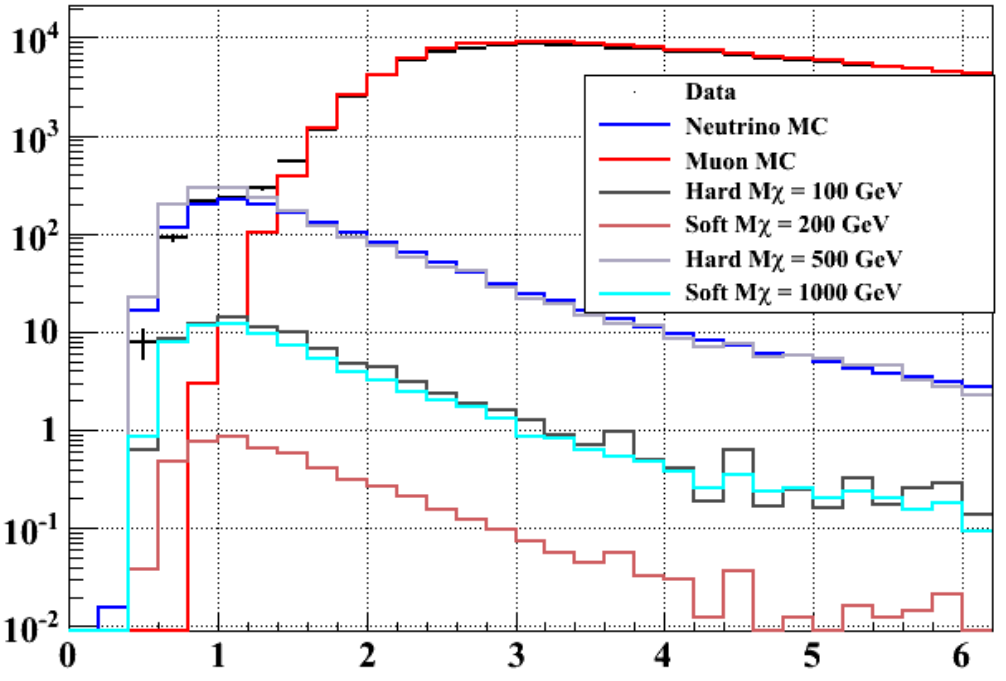
Additional hits coming from several sources along the trajectory of the muon

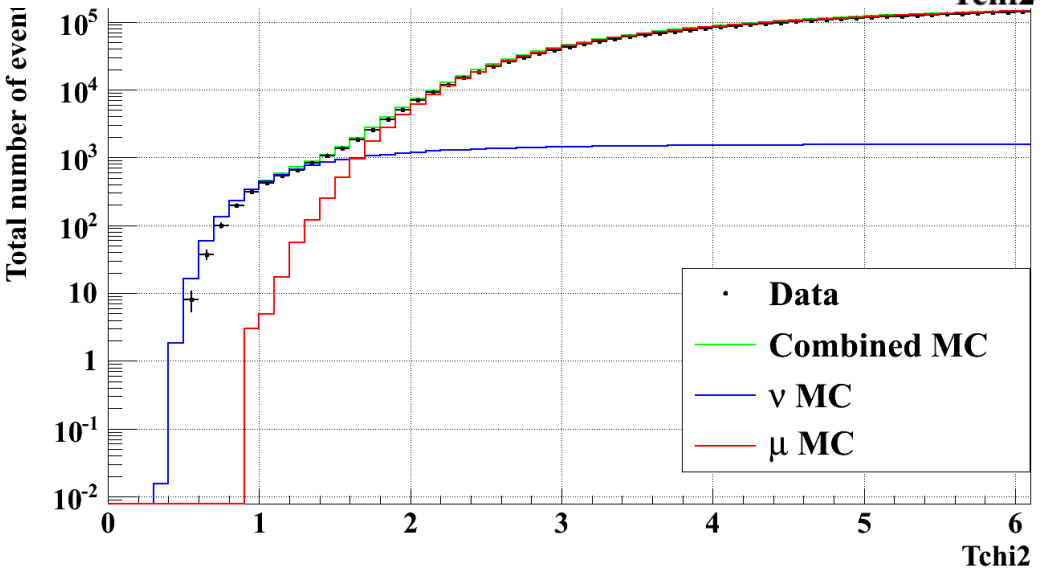
DM in the Sun

Data MC comparison:

Preliminary set of cuts on the data are taken, such as selection of:

- Up-going events
- Events that are more track-like than shower-like
- Events that has a solution for Zenith-Azimuth (minimum # of hits in the detector)

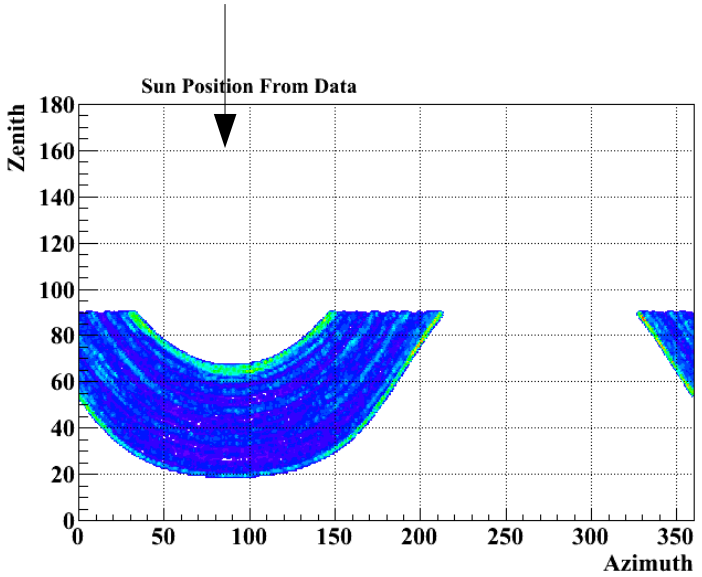




DM in the Sun

Strategy:

1) Find the Sun when below the horizon



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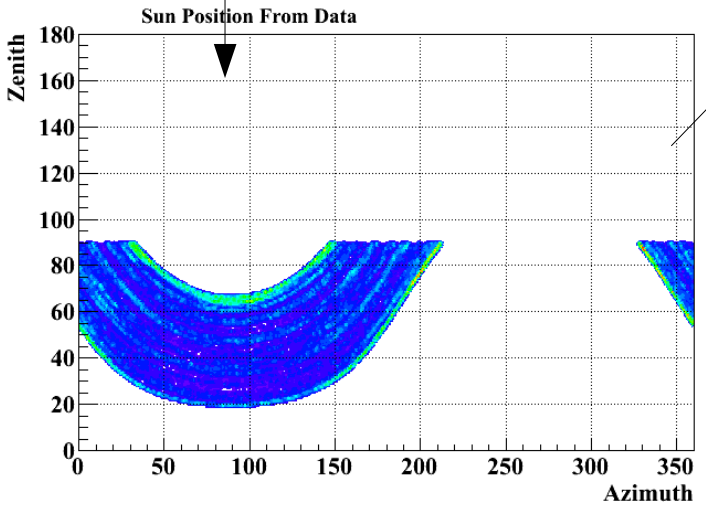
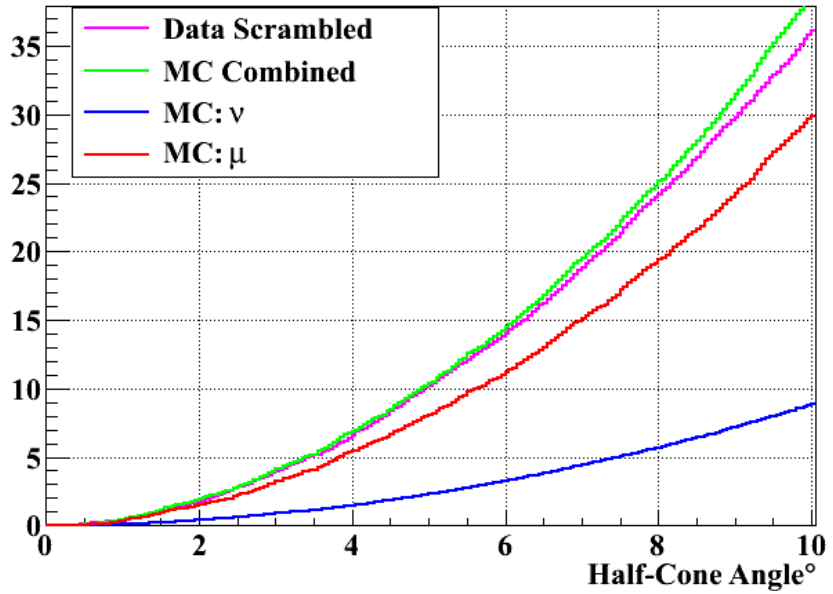


2) Estimate the # of events around the Sun



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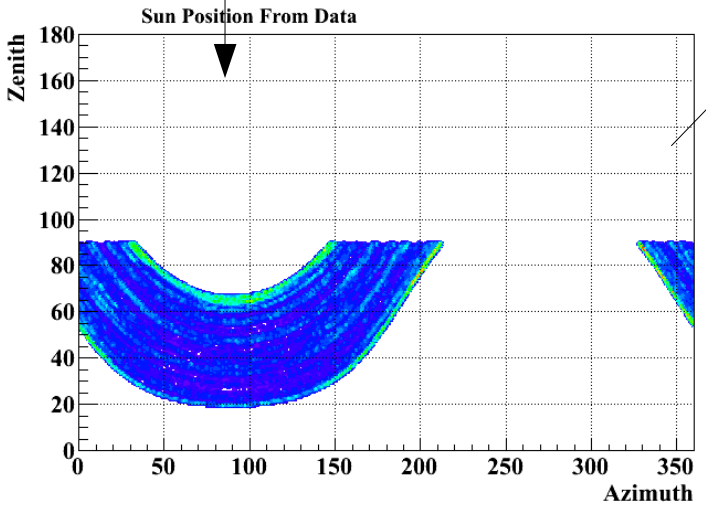

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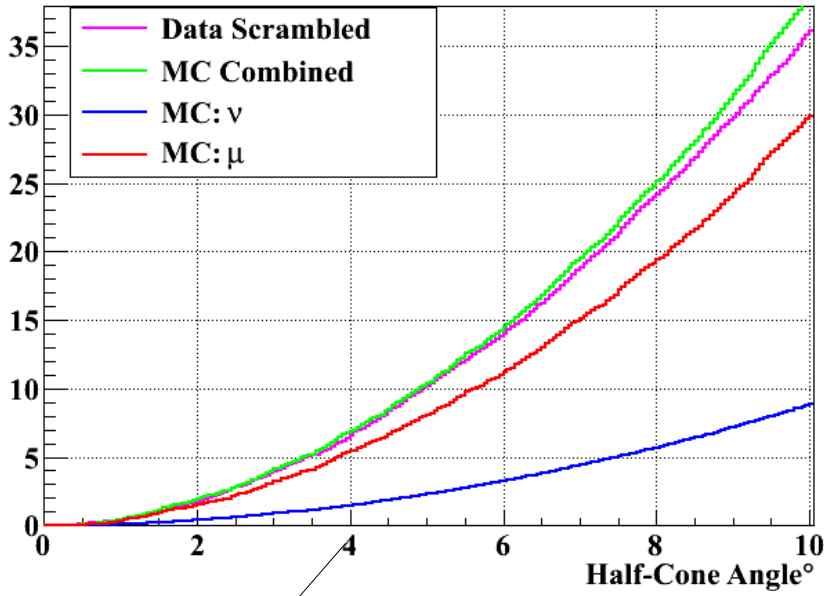
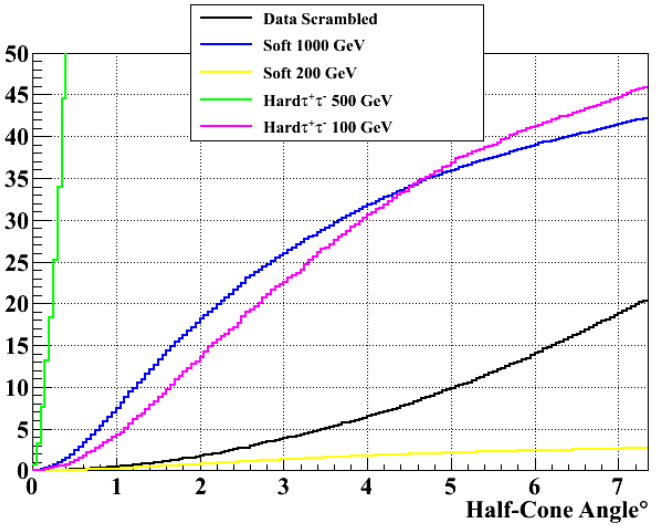


3) Estimate the # of DM events from the Sun



DM in the Sun

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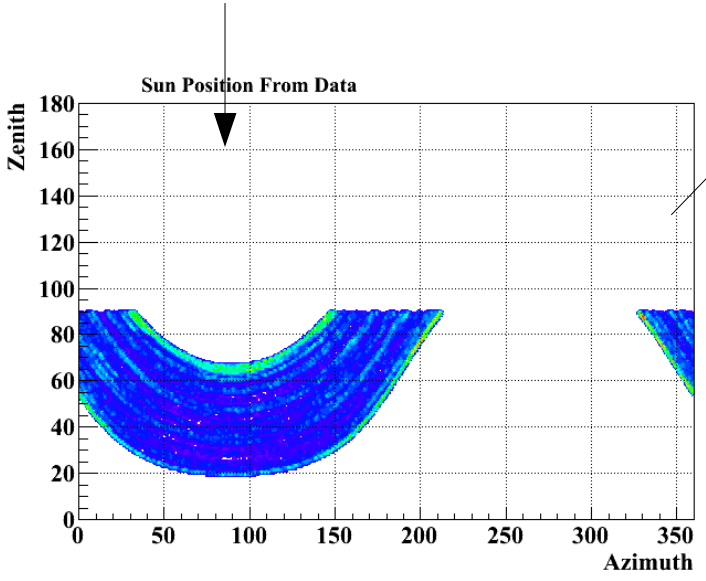

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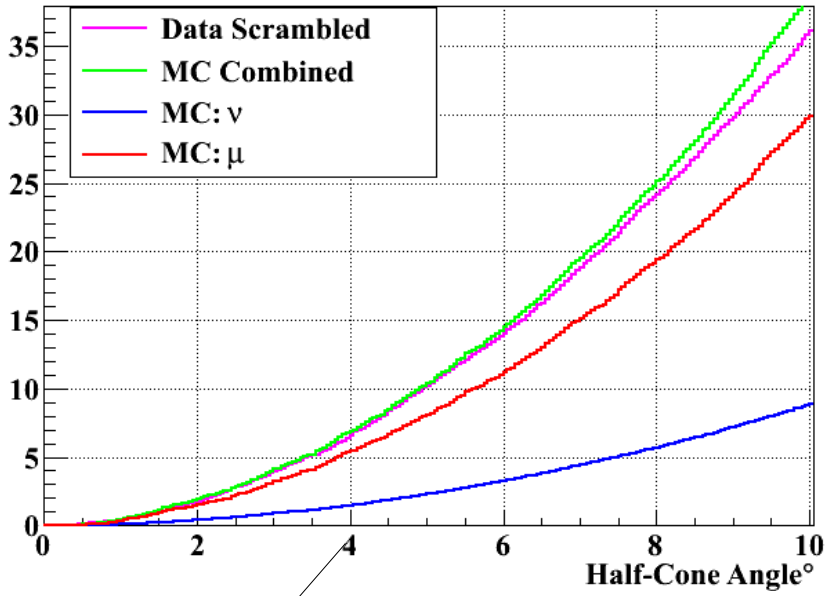

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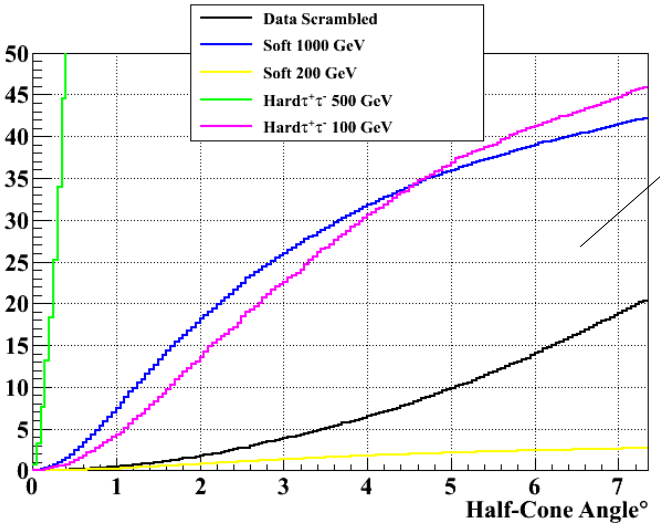
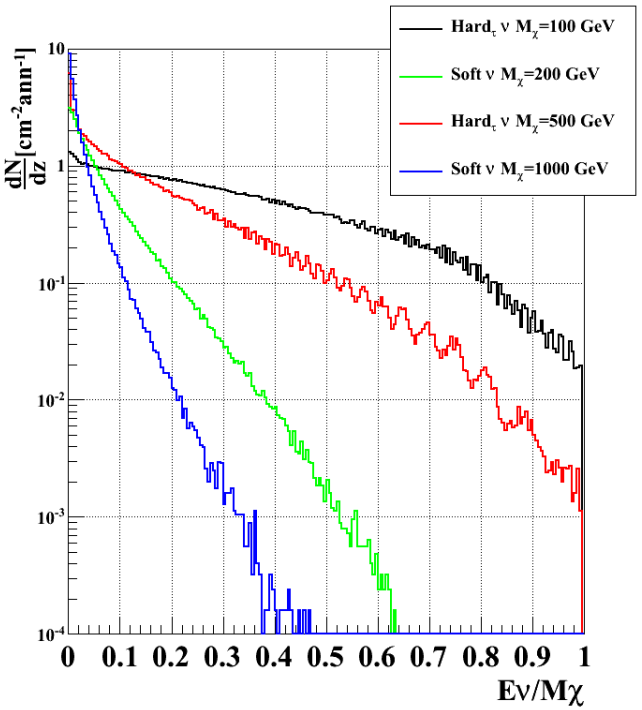


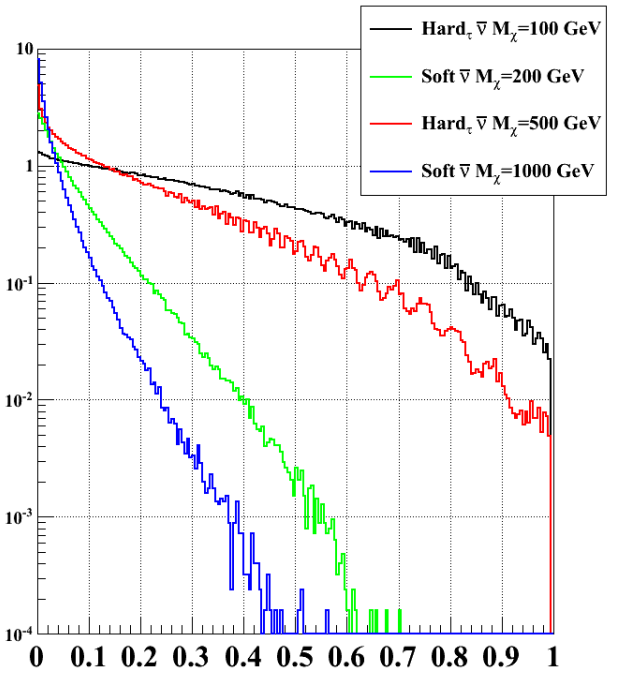
4) Optimize cuts and check if we have anything

DM in the Sun

Estimation of the number of DM events:

The flux is needed → **WIMPSIM :**





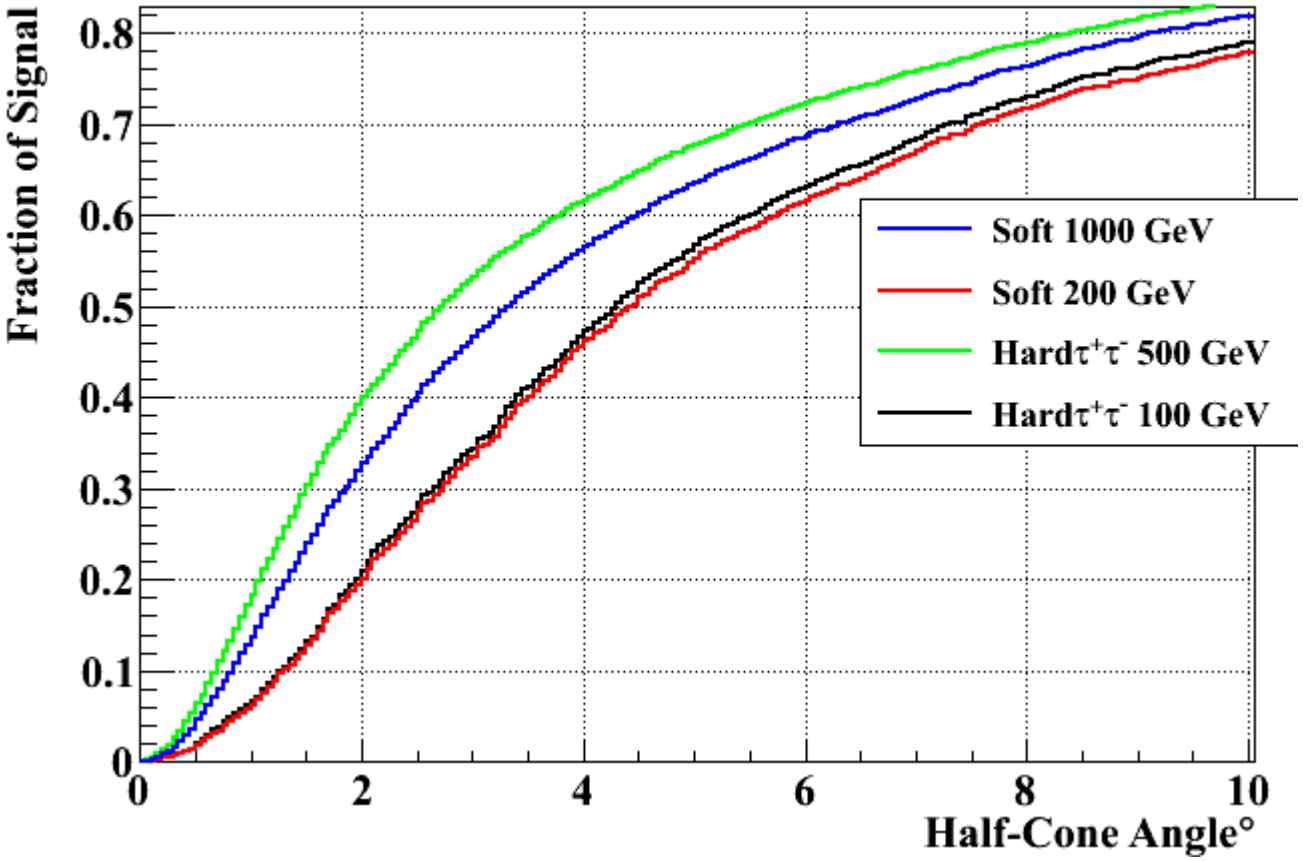
1. Assume Equilibrium inside the Sun
2. Annihilate Neutralinos via different channels: W+W- , b+b-, τ+τ-, etc
3. Take the produced (anti)neutrinos and propagate them inside the Sun
4. Apply oscillation, tau regeneration, etc...
5. Propagate to the Earth
6. Repeat for different Neutralino Mass

WIMP mass simulated [GeV]: 50, 80.3, 100, 150, 200, 350, 500, 750, 1000

DM in the Sun

Optimization:

Average Neutrino energy for b+b- channel is around 33% and 50% for τ+τ- (W+W-)



Kinematics and reconstruction algorithm contributions to the angular resolution are both energy dependent:

- Higher WIMP mass -> better angular resolution
- Higher average neutrino energy -> better angular resolution

Sensitivity to WIMPS with large masses is better

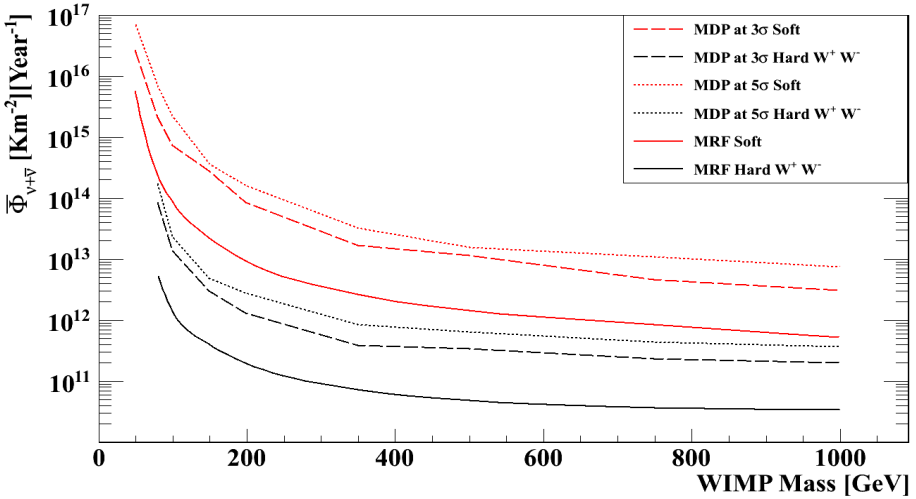
Sensitivity to hard fluxes is better than soft fluxes

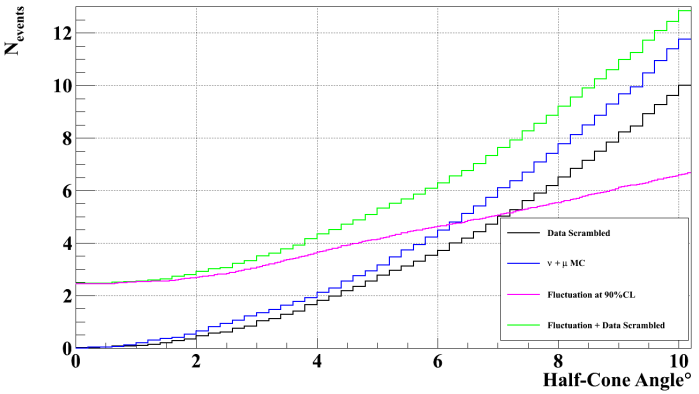
DM in the Sun

Results:

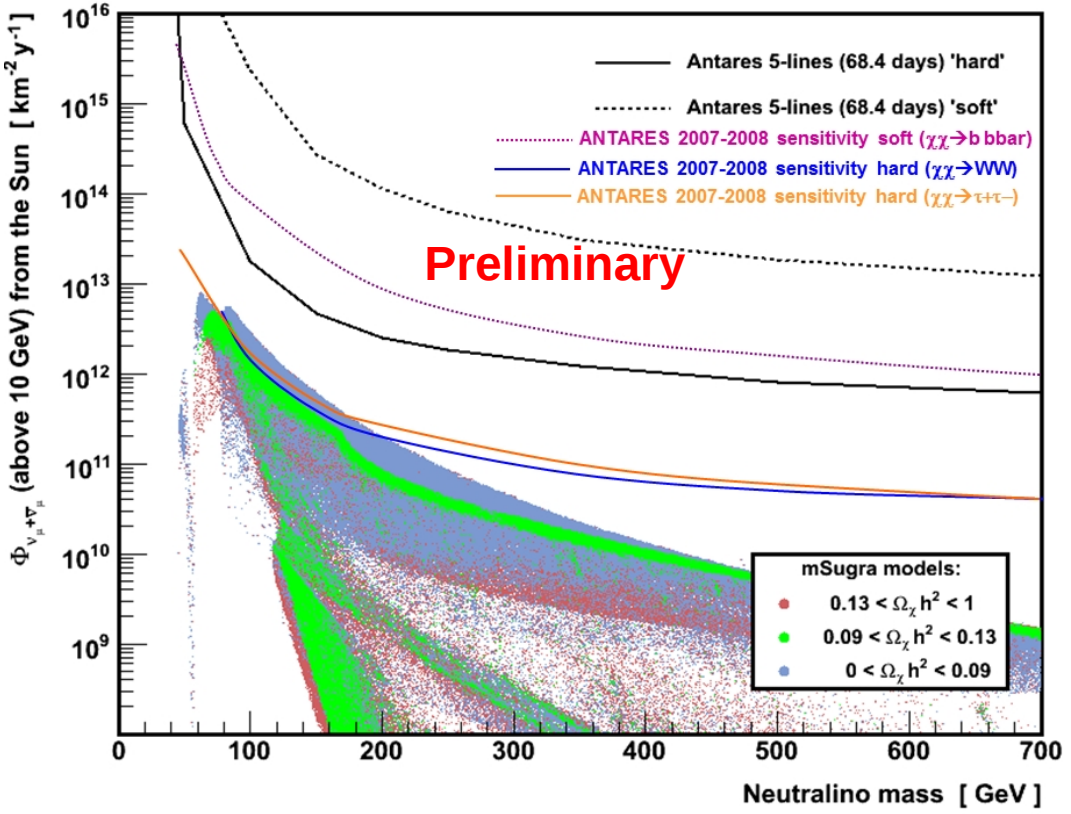
2007-2008 data -> 280 days of livetime -> ~1400 Neutrino candidates.

Two cuts optimization strategies were considered: Best flux sensitivities and for discovery.





Neutrino threshold energy > 10GeV



Conclusions

- Analysis of the 2007-2008 data has been presented
- Full results are expected soon
- Other methods including Neural Networks show improvements of ~20%
- Current sensitivities is starting to explore the SUSY domain
- Analysis the Sun of 2007 to 2010 data is underway
- Other DM analysis as Galactic Halo, Galactic Center, and Dwarf Galaxies are starting
- Stay tuned to the next presentation by G. Lambard on comparison with theoretical models and other experiments

3000 Neutrinos candidates already collected up to date