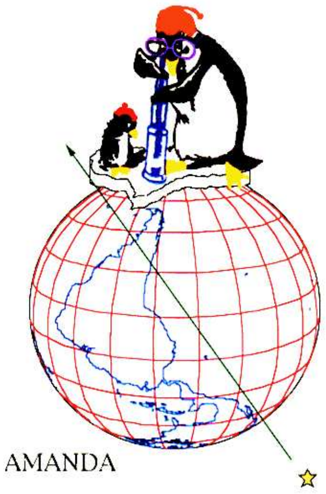
Dark Matter Searches with the AMANDA Neutrino Telescope



Daan Hubert
Interuniversity Institute for High Energies - VUB

Overview

- Modern cosmology
- SUSY to the rescue
- AMANDA-II neutrino telescope
- Conclusion

Measurements in Cosmology

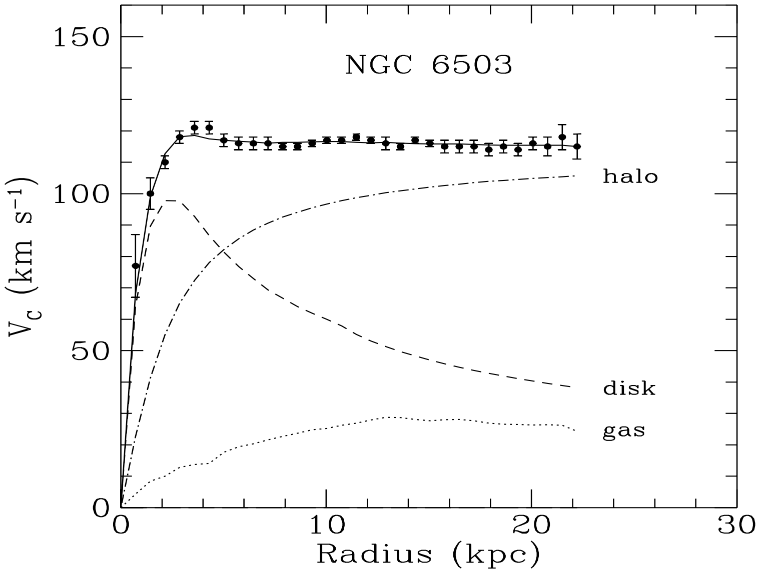


Figure 1: Rotation curve

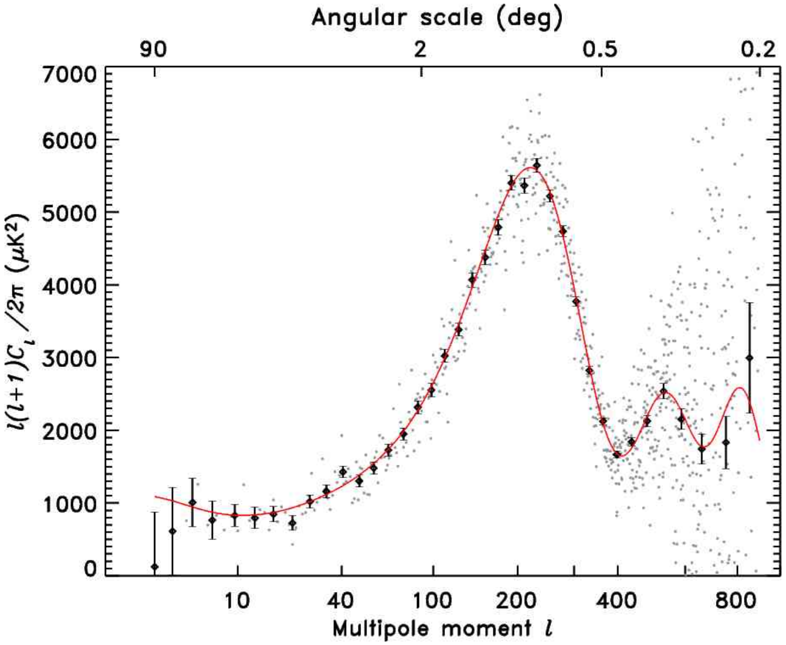


Figure 2: WMAP results

Our view of the modern flat universe: the Dark Force rulez

1. Matter content: $\Omega_{matter} \simeq 0.27$
   - baryonic (stars, gas, dust...): $\Omega_b \simeq 0.05$
   - dark matter (see below): $\Omega_{dm} \simeq 0.23$
2. Energy content: $\Omega_{de} \simeq 0.73$
   - unknown nature: contact your local cosmologist for his opinion

Dark matter candidates

- **Baryonic**
  - MACHOs: possibly not needed anymore
- **Non-baryonic**
  - HDM
    - neutrinos: do not predict observed LSS
    - . . .
  - CDM
    - axions: to be discovered
    - neutralinos: to be discovered hopefully by me
    - . . .

An old friend comes to our rescue... SUSY!

1. SuperSymmetry (1970s)
   - solves the hierarchy problem
   - $particle \longleftrightarrow \widetilde{sparticle}$
   - broken at low energies $\Rightarrow$ unseen SUSY particles are much heavier than SM companions ($\sim$ TeV-scale)
2. MSSM: minimal supersymmetric standard model
   - 2 Higgs doublets for up and downlike quarks
   - conserved R parity $\Rightarrow$ lightest SUSY particle (LSP) stable
   - mixing of $\widetilde{B}, \widetilde{W_3}, \widetilde{H_1^0}, \widetilde{H_2^0}$ = neutralino χ = LSP
3. Neutralino χ: stable, heavy, only weakly interacting (aka WIMP)

How to detect neutralinos indirectly in 3 steps

Step 1 Capture of neutralinos from our Galactic halo (by e.g. Sun, Earth)

- slow χ's most easily captured
- capture more or less unsensitive to clumpy DM halo

Step 2 Annihilation into SM particles

- dominant annihilation channel depends on mixture details of χ

$$\chi\chi \longrightarrow \left\{ \begin{array}{l} \ell\bar{\ell},\ q\bar{q},\ W^+W^-,\ Z^0Z^0,\ Z^0\gamma,\ \gamma\gamma, \\ gg,\ H^+H^-,\ W^\pm H^\mp,\ \ldots \end{array} \right.$$

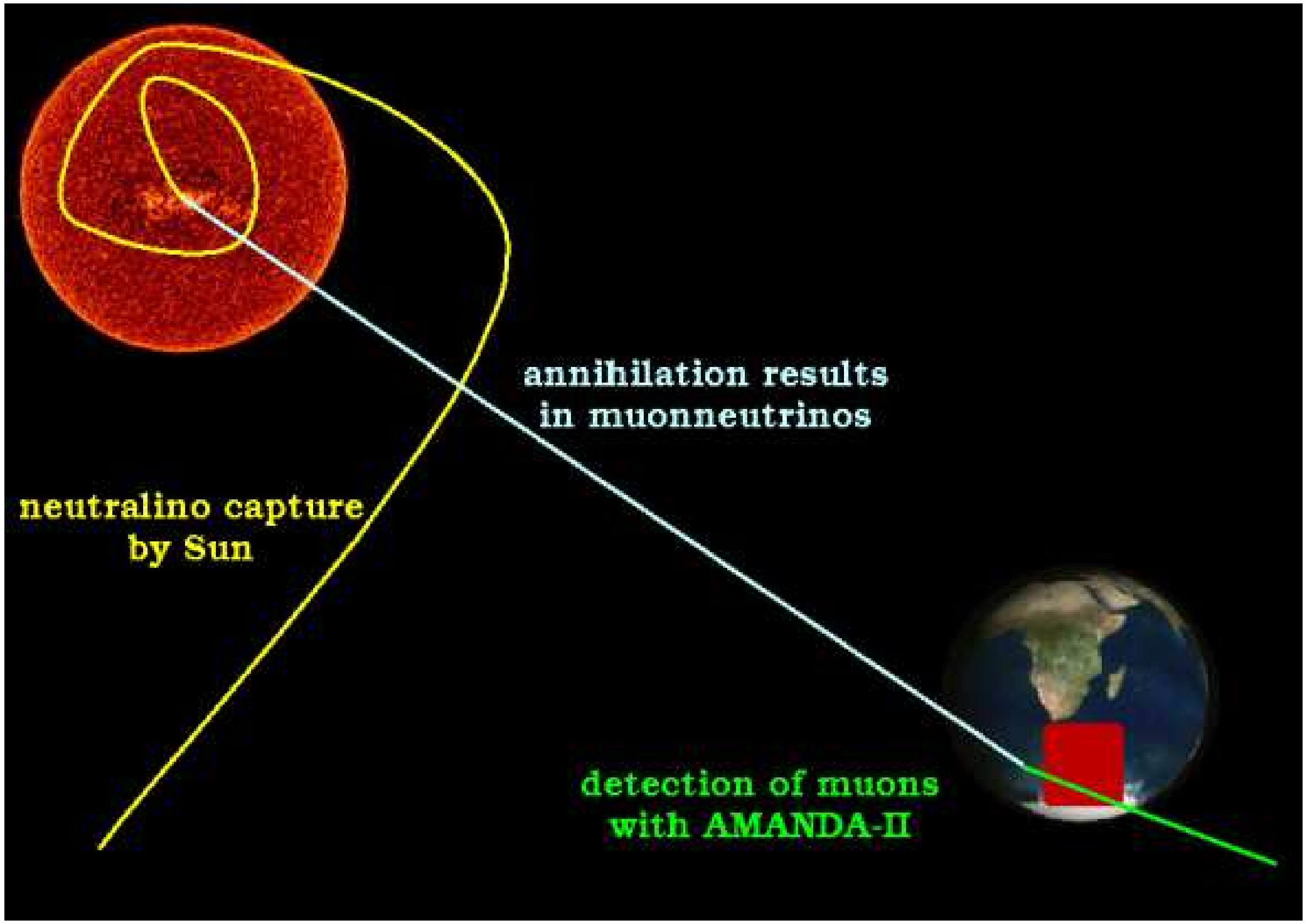
- secundary SM particles: ν_μ, $\overline{\nu}_\mu$

How to detect neutralinos indirectly in 3 steps (cont'd)

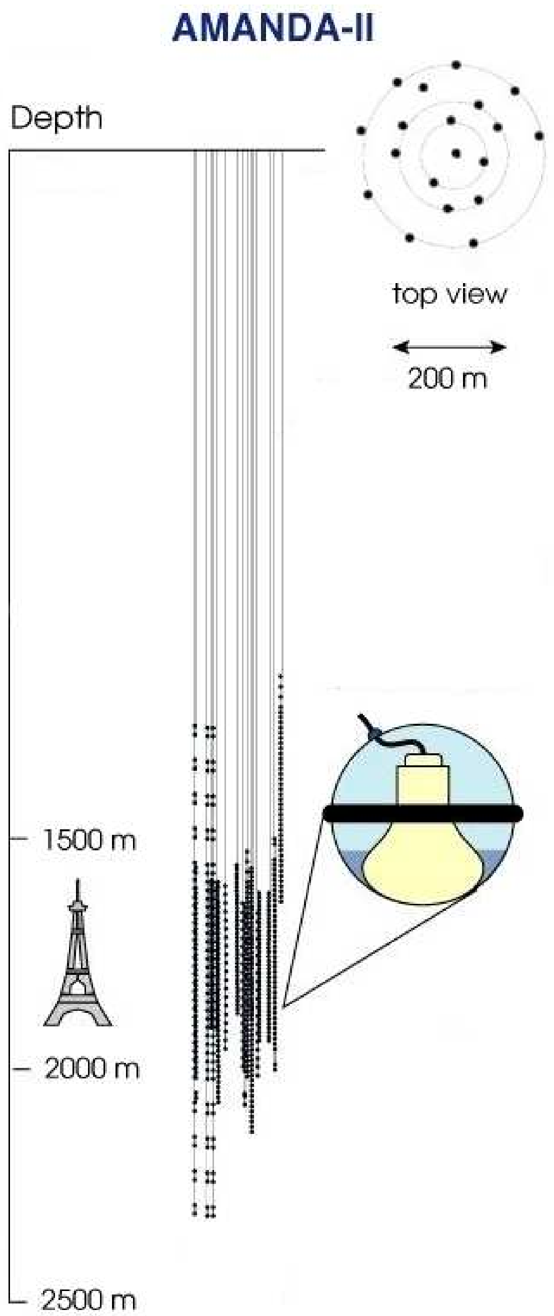
Step 3 Detection!

- use your favourite high energy neutrino detector

How to detect neutralinos indirectly in 3 steps (cont'd)

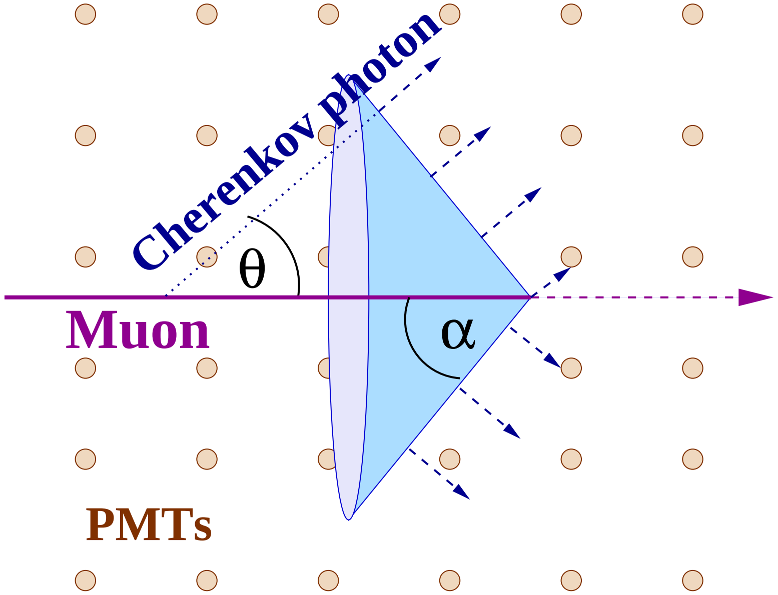


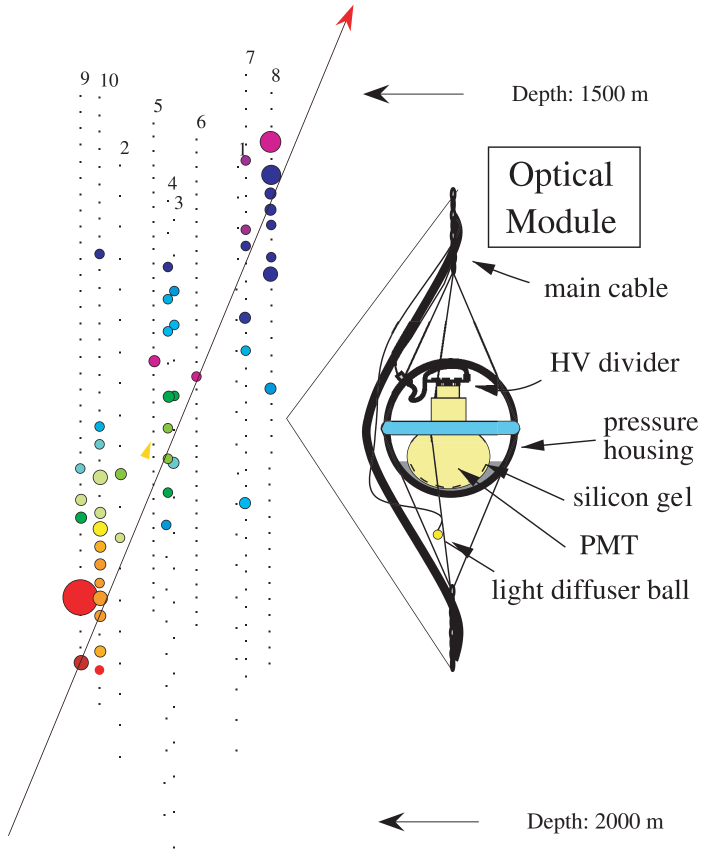
Introducing AMANDA-II...



- AMANDA-II and IceCube
  - AMANDA-II: 677 modules on 19 strings
  - IceCube: 4800 modules on 80 strings (1 km^3), construction starts next year!
- Backgrounds
  - 80 atmospheric μ per second
  - a few atmospheric ν per day
- Signal
  - (if we are lucky) a few χ per year

Ice fishing for neutrinos

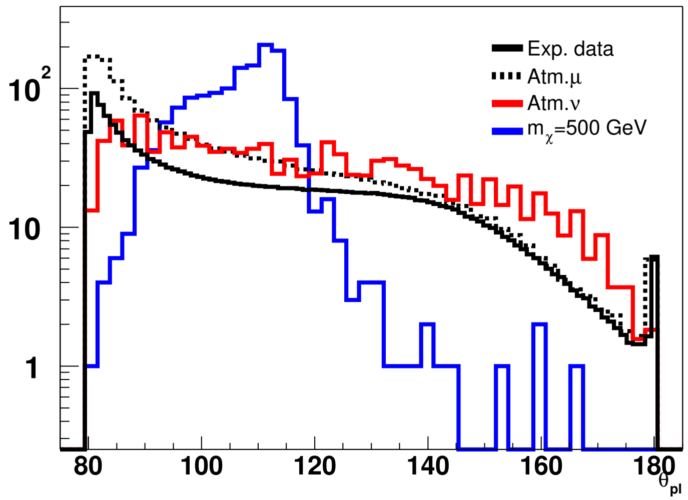




Background rejection

1. **Downgoing atm. μ**: remove events with bad resolution (short track length, much scattered photons, ...), select on zenith angle

2. **Upgoing atm. ν_μ**: remove as much as possible with quality cuts



AMANDA results

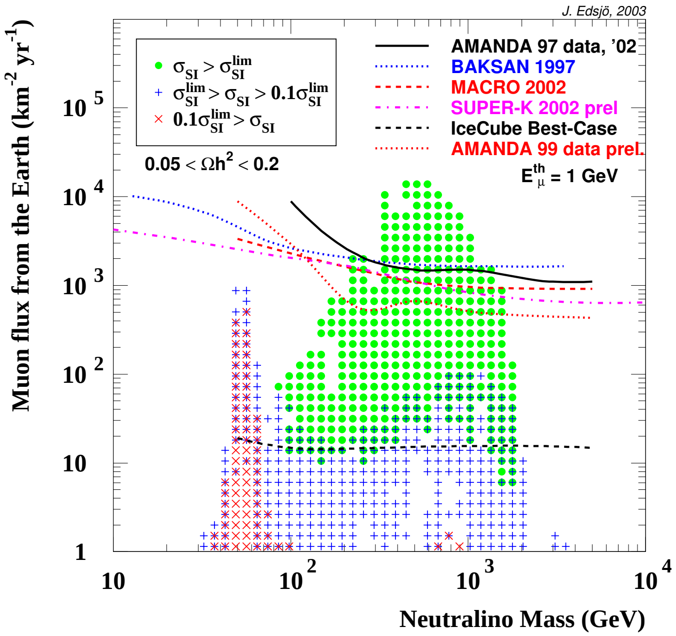


Figure 3: Limit for Earth (preliminary)

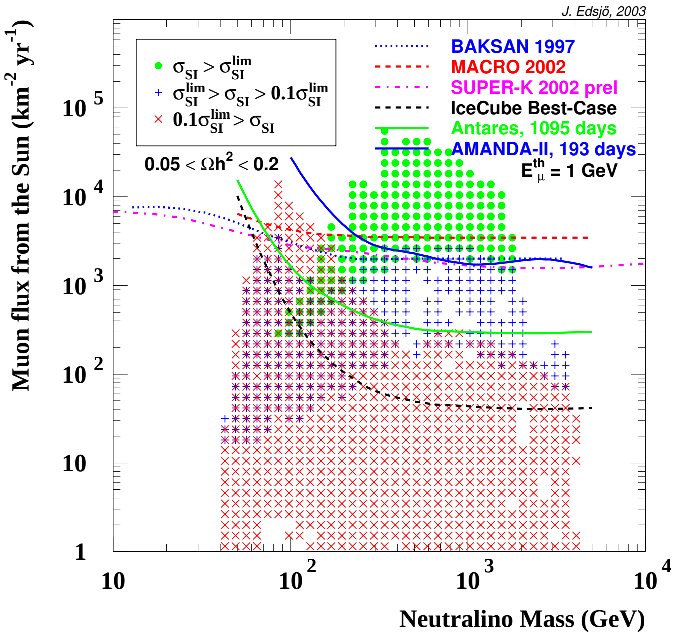


Figure 4: Sensitivity for Sun (preliminary)

Conclusion: Liaisons Intéressantes

- Connection between cosmology and high energy particle physics is becoming stronger and stronger
- AMANDA-II (and its successor IceCube) are sensitive enough to rule out a lot of SUSY parameter space - detection possible
- To be continued