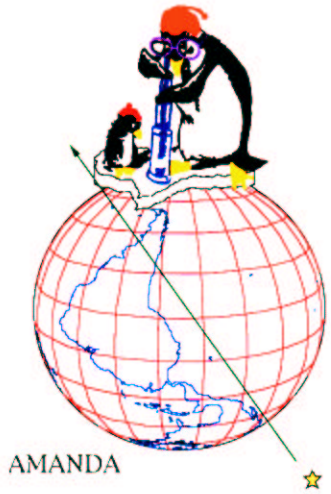
# Dark Mater Searches with the AMANDA Neutrino Telescope




Daan Hubert
Interuniversity Institute for High Energies - VUB

# Overview

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

# Measurements in Cosmology

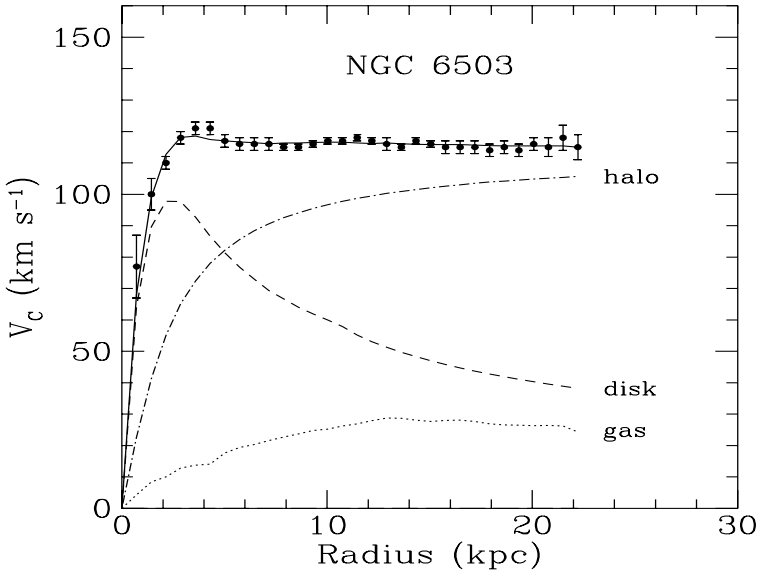



Figure 1: Rotation curve

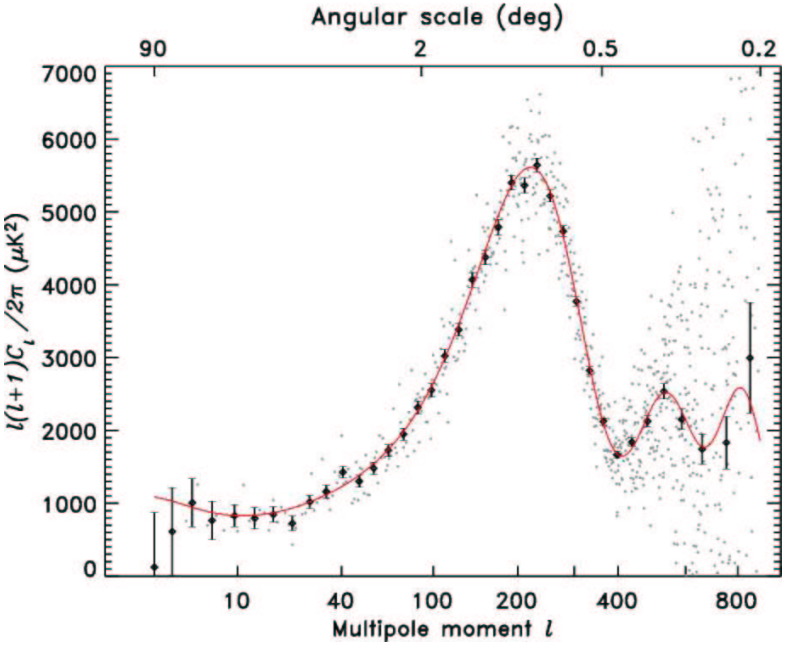



Figure 2: WMAP results

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

1. Matter content: $\Omega_m{}^{ater} \simeq 0.27$
   - 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 $\chi$ = LSP

3. Neutralino $\chi$: 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 $\chi$'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 $\chi$

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

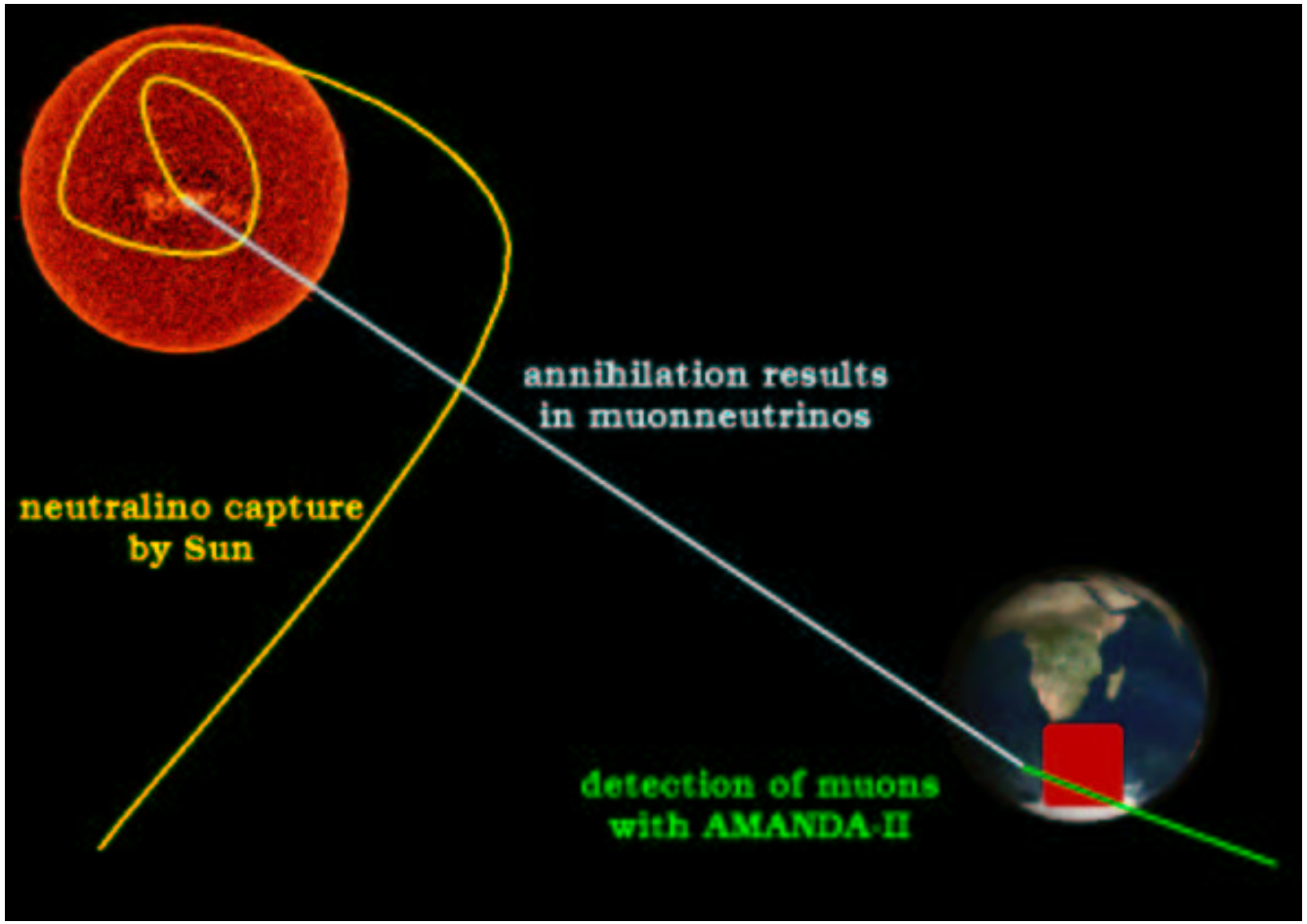
- secundary SM particles: $\nu_\mu,\ \bar{\nu}_\mu$

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

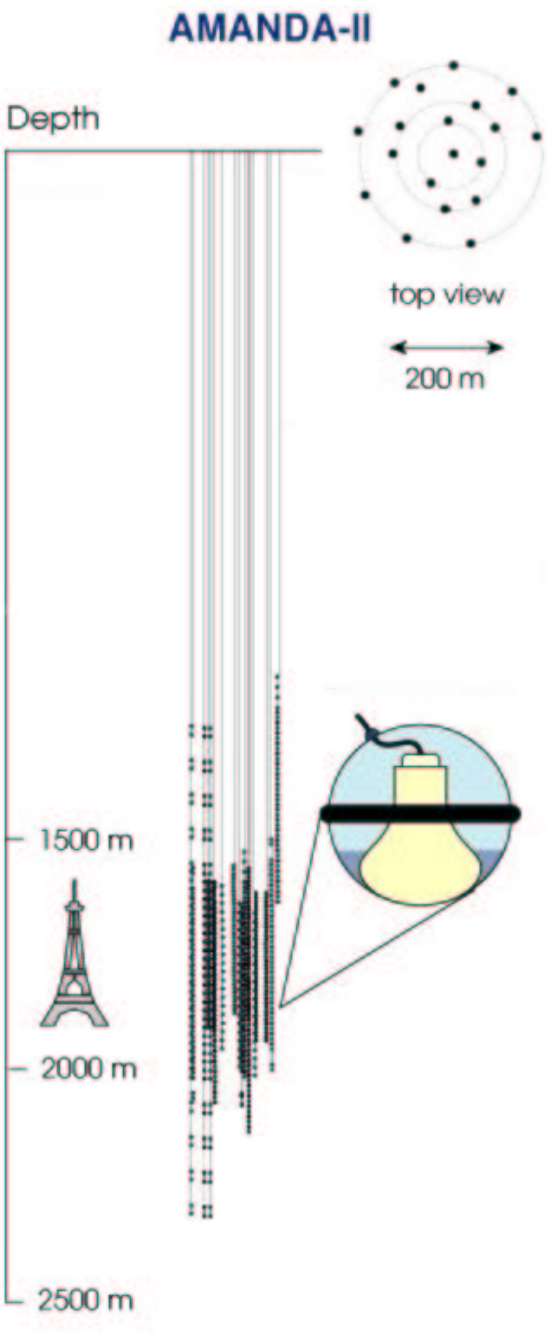
**Step 3** Detection!

- use your favourite high energy neutrino detector

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

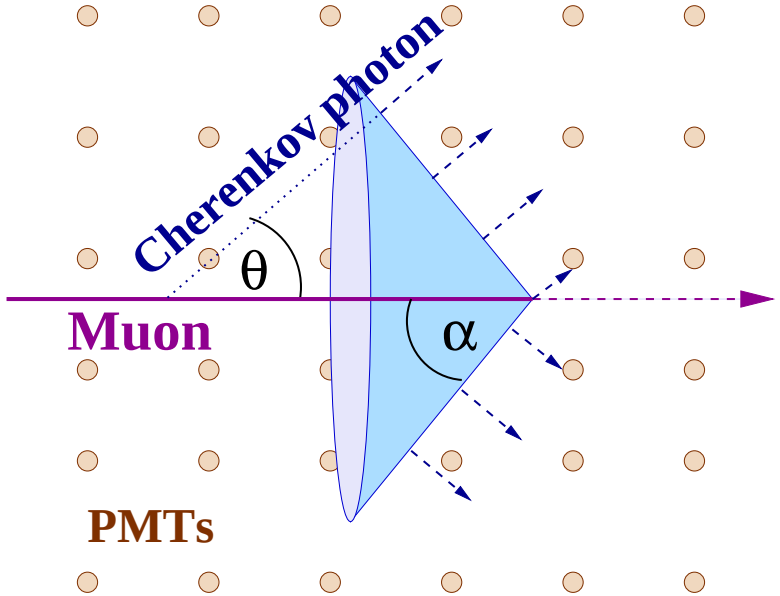


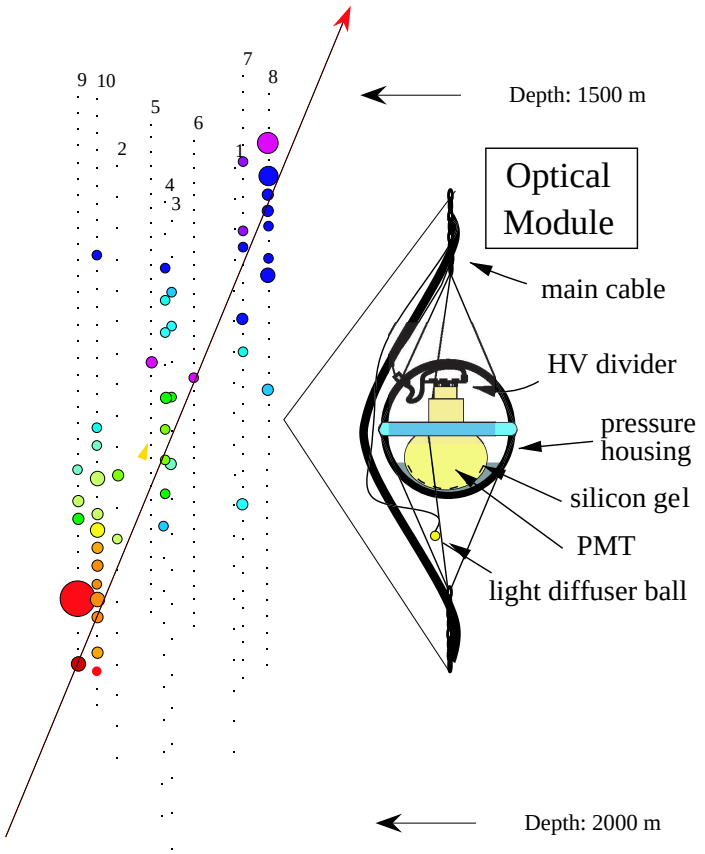
# Introducing AMANDA-II...




- 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 $\mu$ per second
  - a few atmospheric $\nu$ per day
- Signal
  - (if we are lucky) a few $\chi$ per year

# Ice fishing for neutrinos

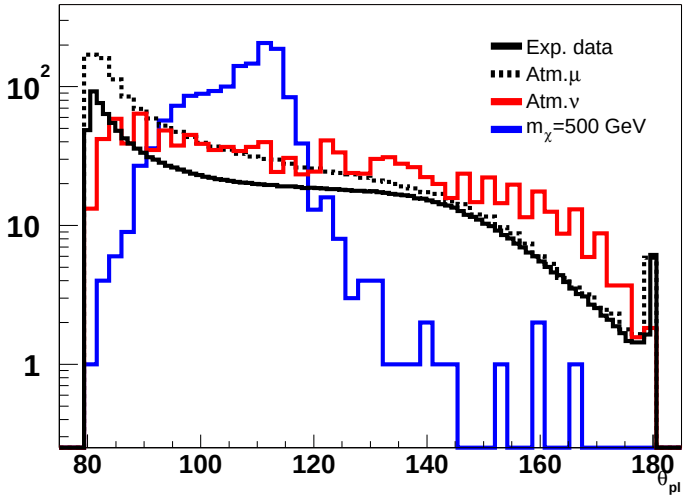


# Background rejection

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

2. **Upgoing atm.** $\nu_\mu$: remove as much as possible with quality cuts



# AMANDA results

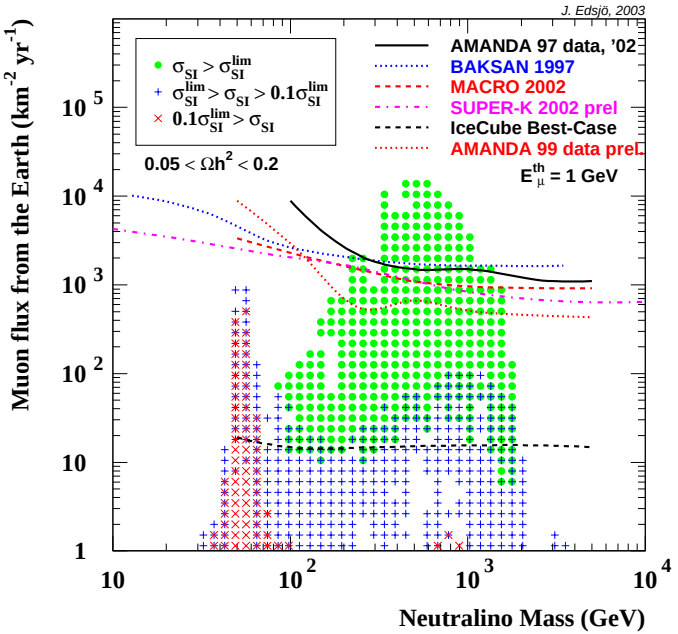



Figure 3: Limit for Earth (preliminary)

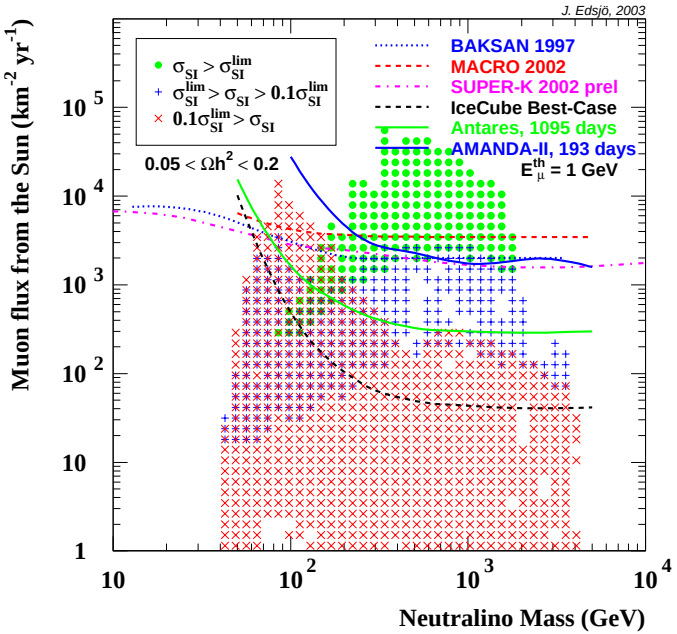



Figure 4: Sensitivity for Sun (preliminary)

# 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