Neutrinos from Neutralino Dark Matter
Expected fluxes and searches

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Outline

- Supersymmetric framework – MSSM
- Neutrino-induced muons from neutralino annihilation in the Earth / Sun
  - Expected fluxes
  - Comparison with experiments

The MSSM – parameters

μ - Higgsino mass parameter

M_2 - Gaugino mass parameter

m_A - mass of CP-odd Higgs boson

$\tan\beta$ - ratio of Higgs vacuum expectation values

m_0 - scalar mass parameter

A_b - trilinear coupling, bottom sector

A_t - trilinear coupling, top sector

Parameter / *Unit*	μ *GeV*	M_2 *GeV*	$\tan\beta$ *1*	m_A *GeV*	m_0 *GeV*	A_b/m_0 *1*	A_t/m_0 *1*
Min	-50000	-50000	1	0	100	-3	-3
Max	+50000	+50000	60	10000	30000	3	3

The MSSM – general

- The Neutralino – χ

$$\tilde{\chi}_1^0 = N_{11}\tilde{B} + N_{12}\tilde{W}^3 + N_{13}\tilde{H}_1^0 + N_{14}\tilde{H}_2^0$$

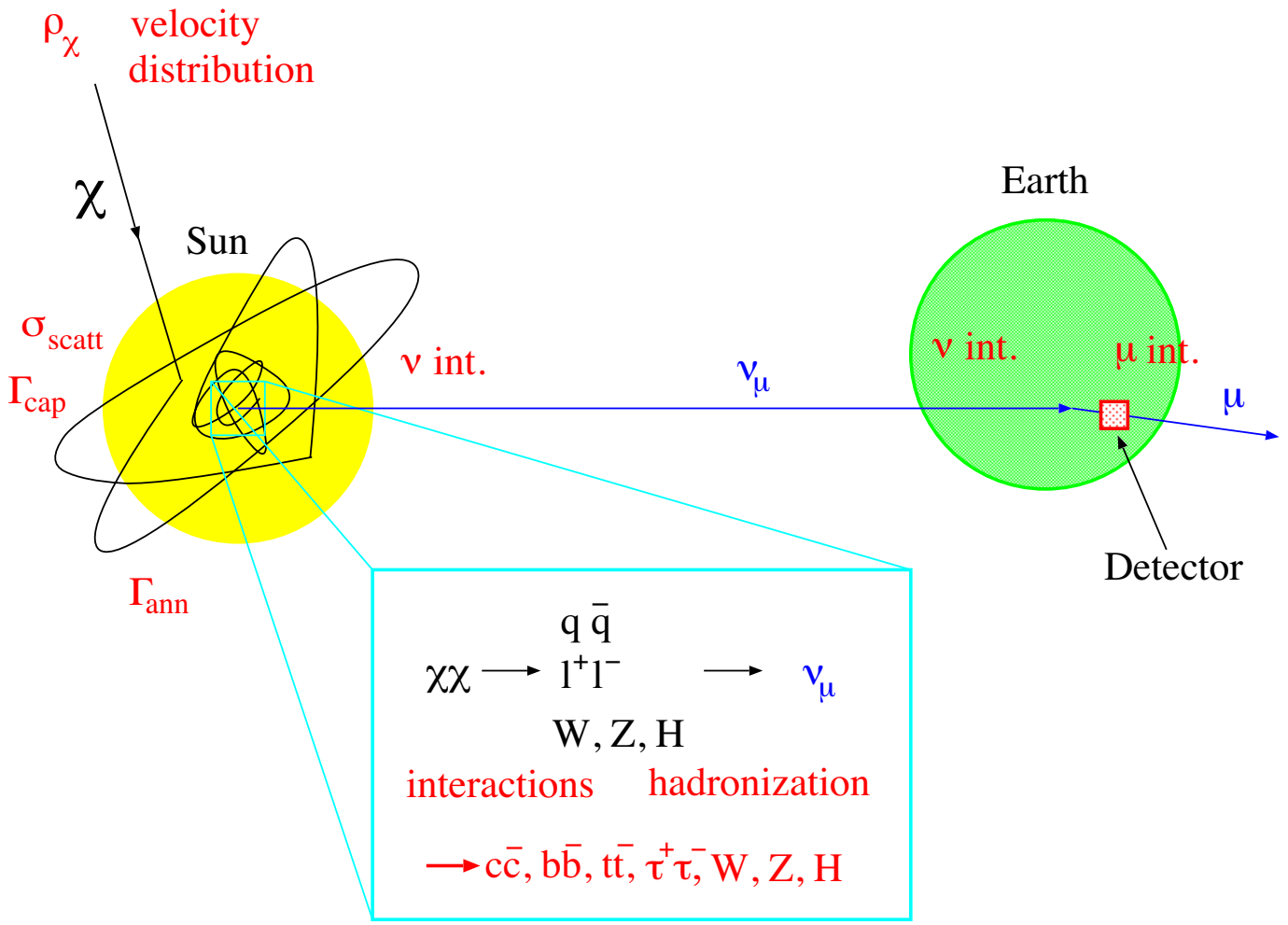
- Gaugino fraction

$$Z_g = |N_{11}|^2 + |N_{12}|^2$$

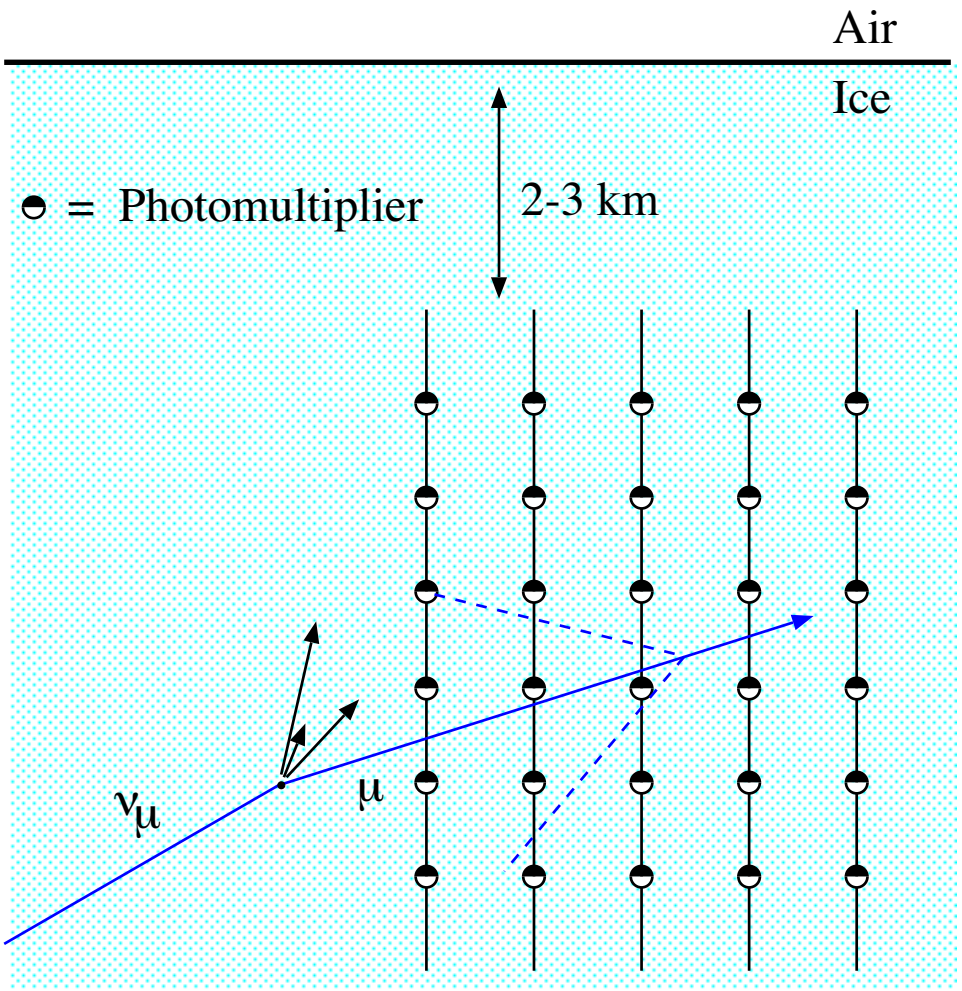
Calculation done with

1. Select MSSM parameters
2. Calculate masses, etc
3. Check accelerator constraints
4. Calculate relic density
5. $0.025 < \Omega_\chi h^2 < 1$?
6. Calculate fluxes, rates,...

Neutralino capture and annihilation



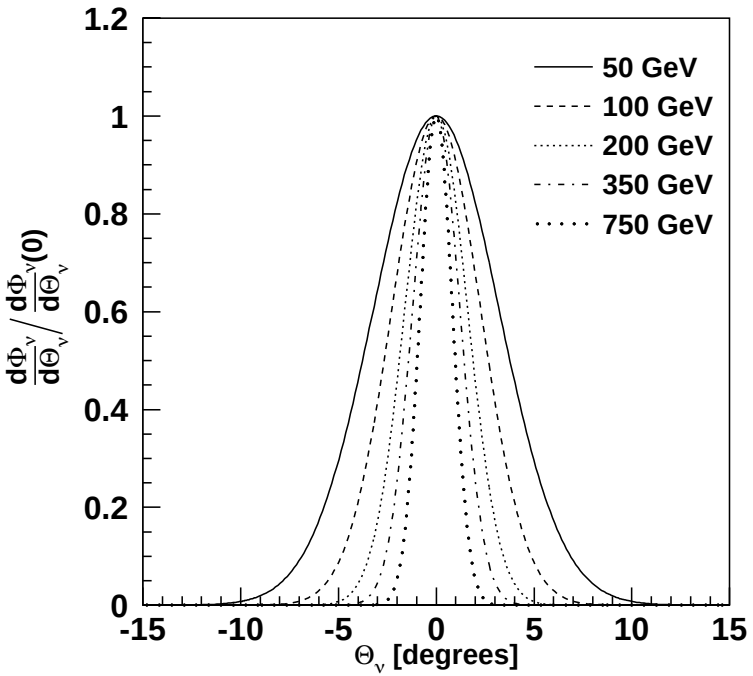
Neutrino telescopes – how do they work?



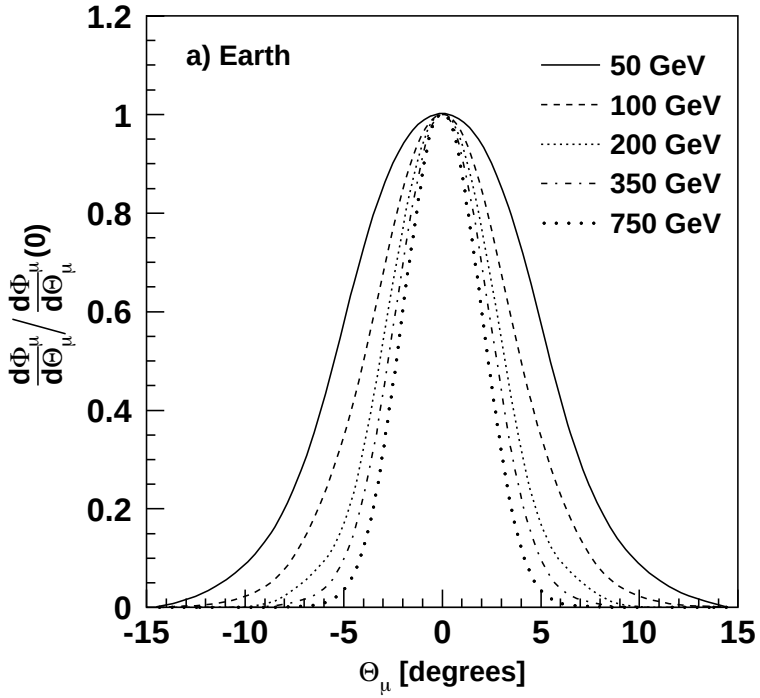
- The neutrino interacts with a nucleus in the ice and creates a muon.
- The muon emits *Cherenkov radiation*.
- The radiation is recorded by photomultipliers and the muon track can be reconstructed.

Angular Spread of WIMP signal – Earth

Neutrinos



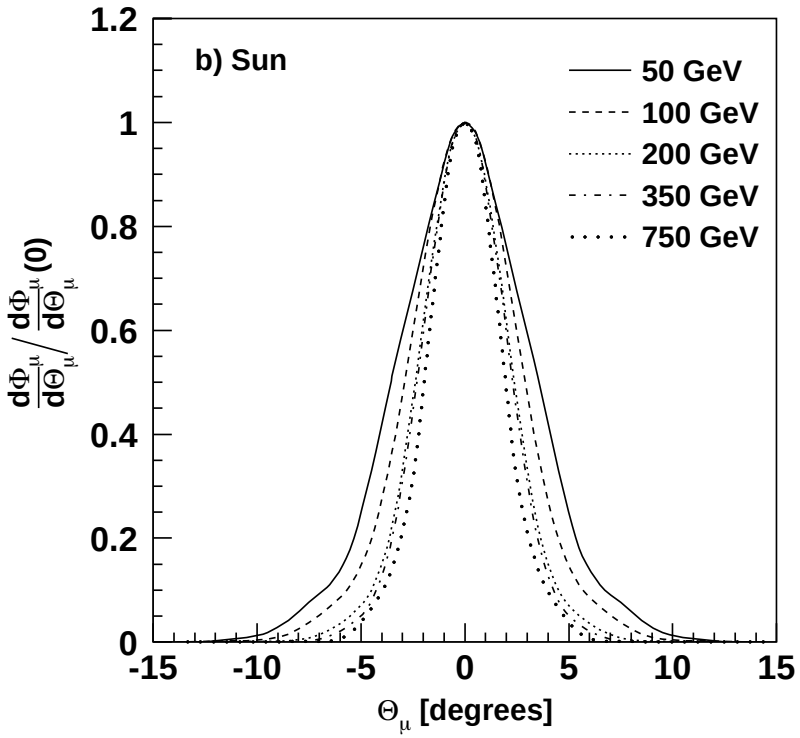
Neutrino-induced muons



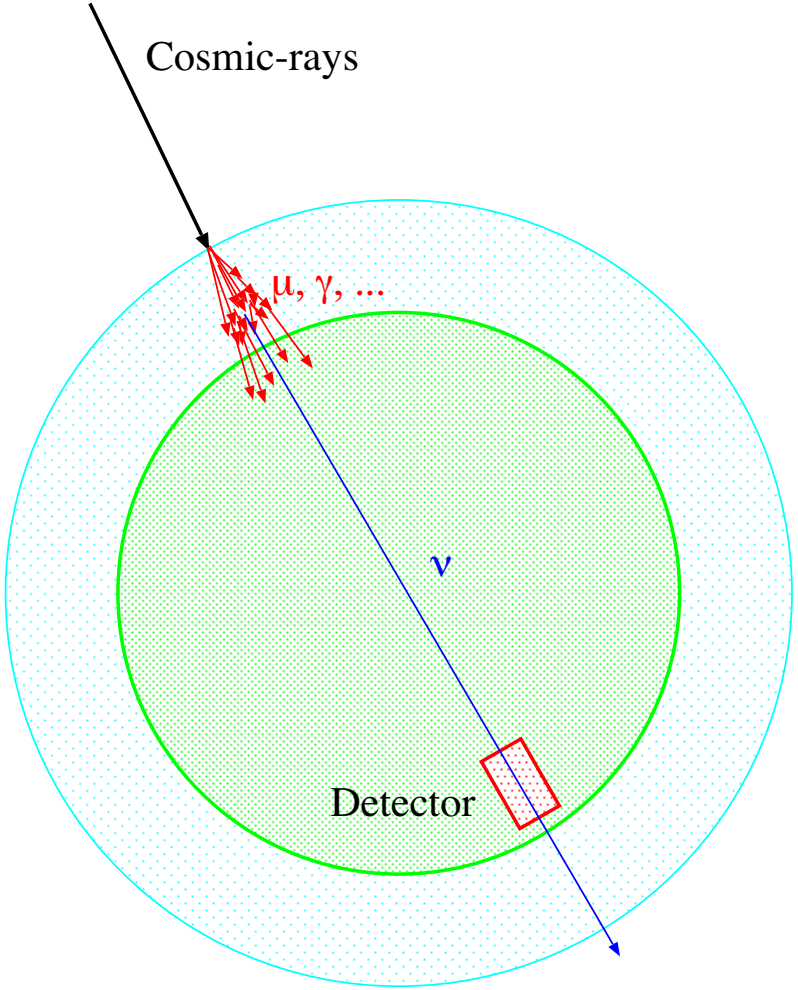
Angular Spread of WIMP signal – Sun

Neutrino-induced muons

The angular spread decreases with increasing WIMP mass, making it easier to discriminate against the background of atmospheric neutrinos.



Neutrinos and muons from the Earth's atmosphere



Cosmic rays + Earth's atmosphere

⇓

Muons and neutrinos

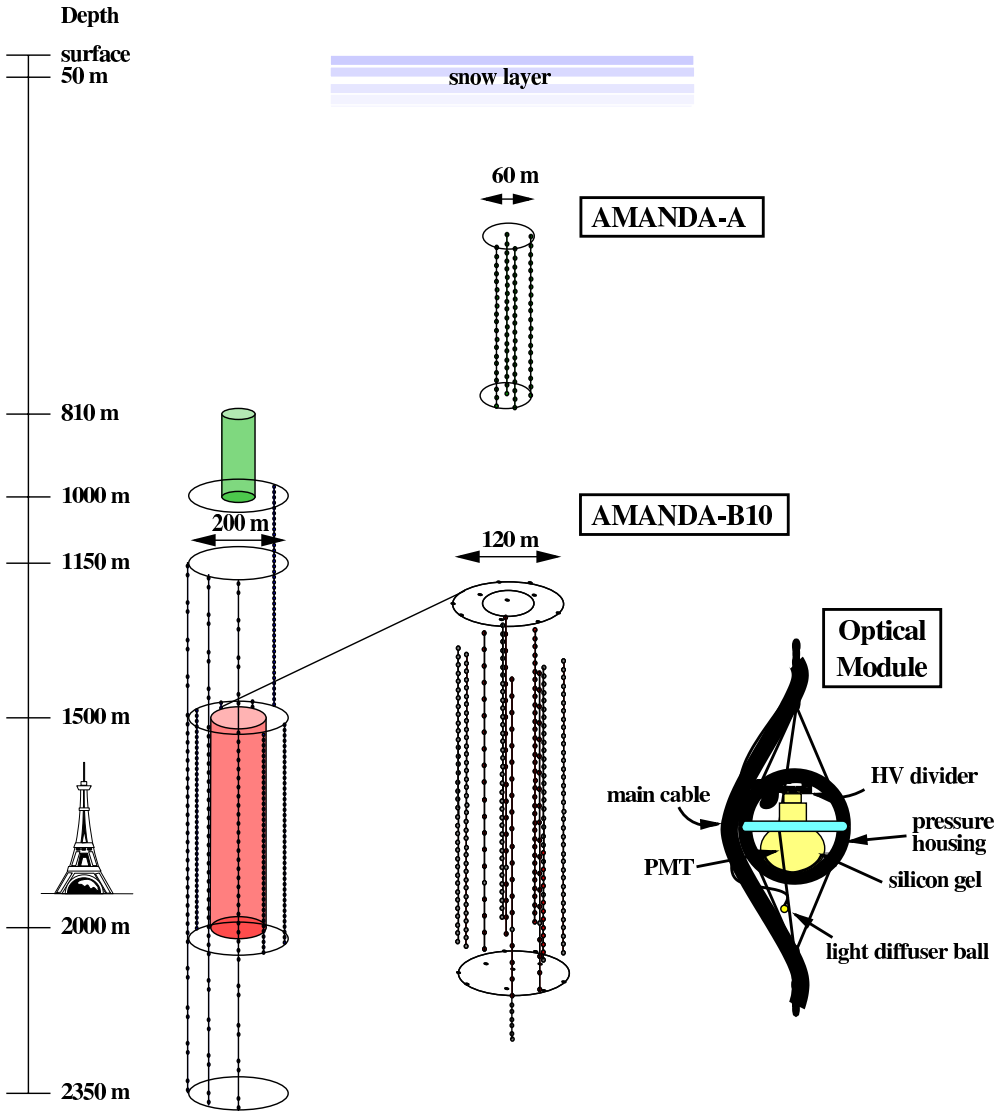
⇒ Use the Earth as a **filter** by looking for upgoing muons.

⇒ Only atmospheric neutrinos remain as a background.

Searches for neutrinos from WIMPs

- IMB
- Macro
- Baksan
- Kamiokande, Super-Kamiokande
- Amanda, ICE^3
- Antares

The Amanda detector

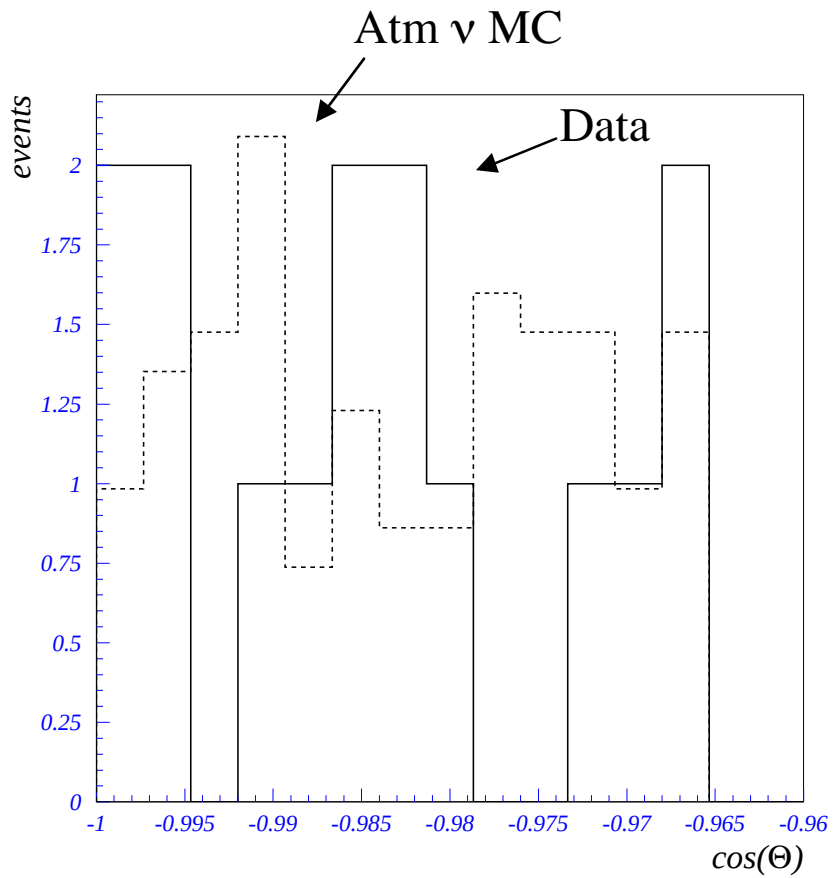


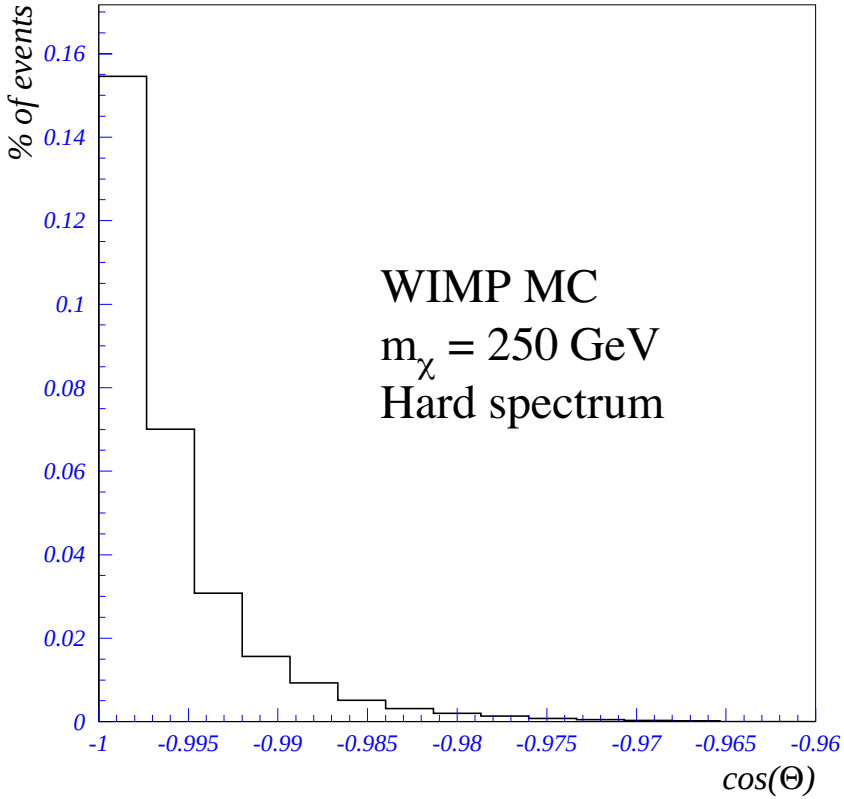
AMANDA as of 2000
Eiffel Tower as comparison
(true scaling)

zoomed in on
AMANDA-A (top)
AMANDA-B10 (bottom)

zoomed in on one
optical module (OM)

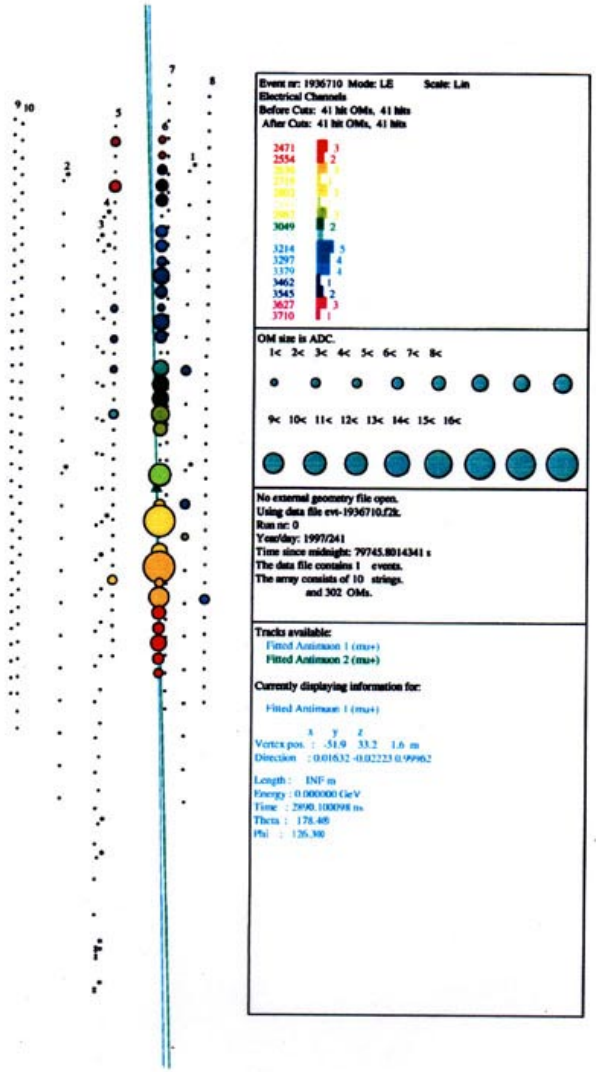
Event distributions
Amanda B10, 1997 years data





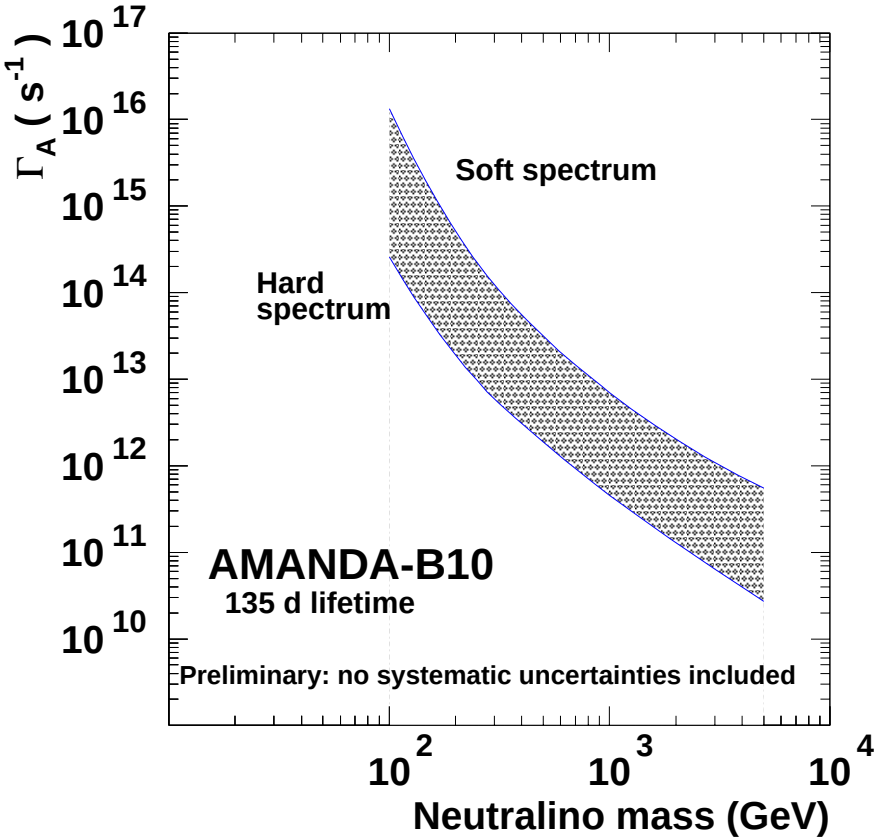
AMANDA ν-candidate

- Early photons are red, late photons are blue. More photons are larger circles.
- Bottom of array is towards center of the Earth.
- The muon is clearly traveling in the upward direction.



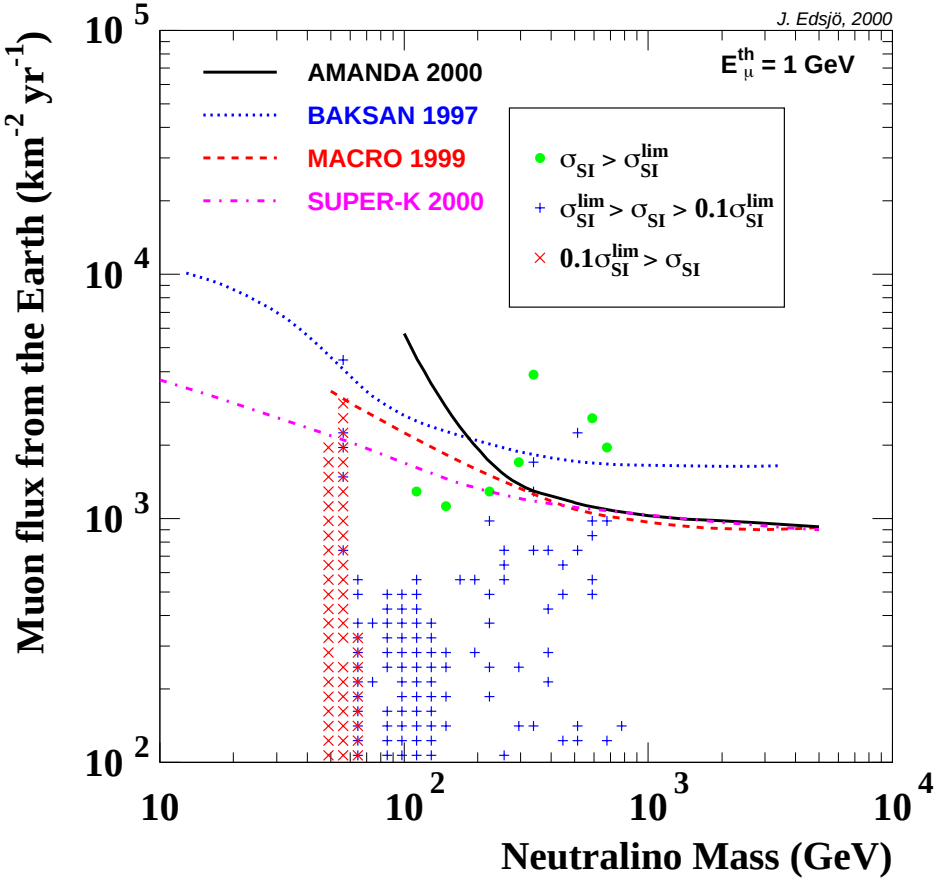
Limits: Annihilation rate

- Derived limits on the annihilation rate in the center of the Earth.
- **Preliminary:** systematic uncertainties are not included.



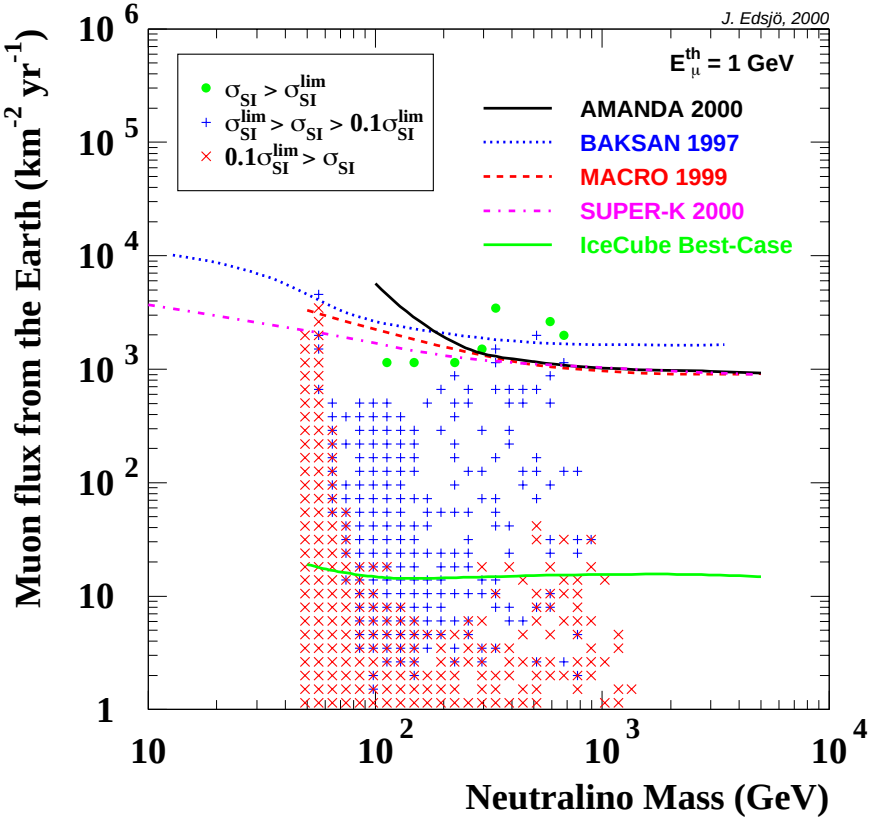
Limits: μ flux from the Earth

- AMANDA limits comparable to MACRO, Baksan and Super-Kamiokande.
- **Preliminary:** systematic uncertainties are not included.

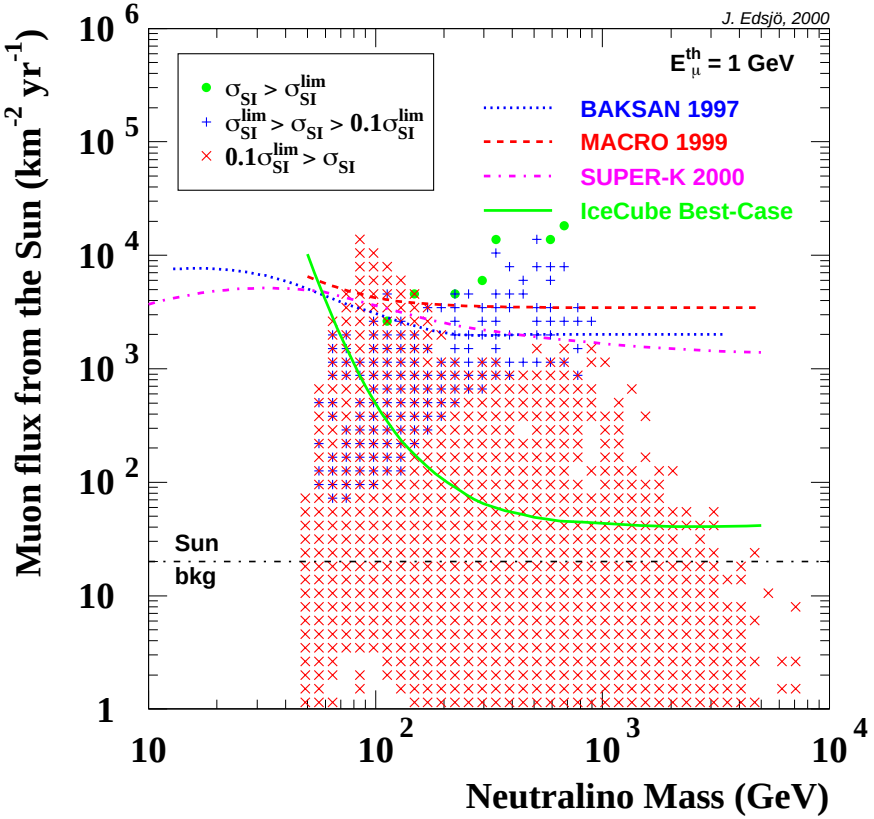


Predicted fluxes and searches

Earth

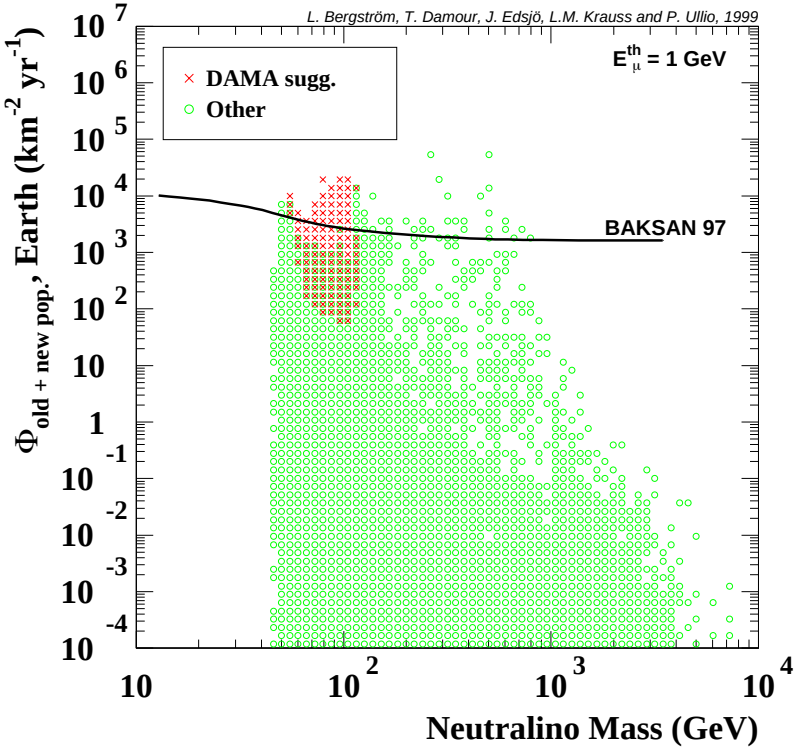


Sun



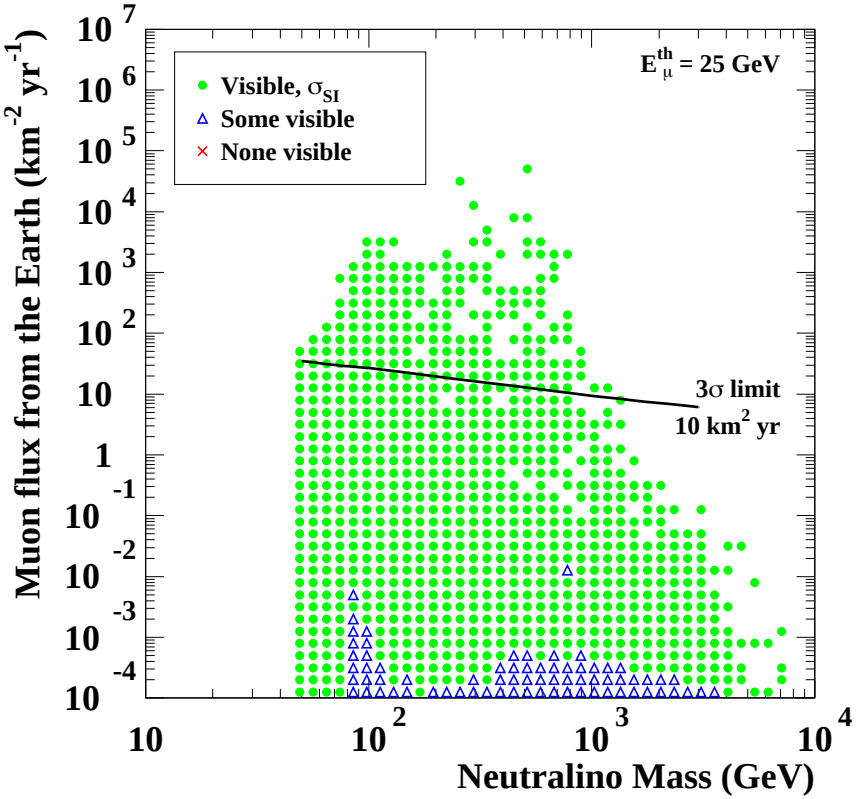
DAMA claim and neutrino telescopes

- DAMA has claimed a direct detection signal.
- If interpreted as WIMPs, it can be searched for with neutrino telescopes.

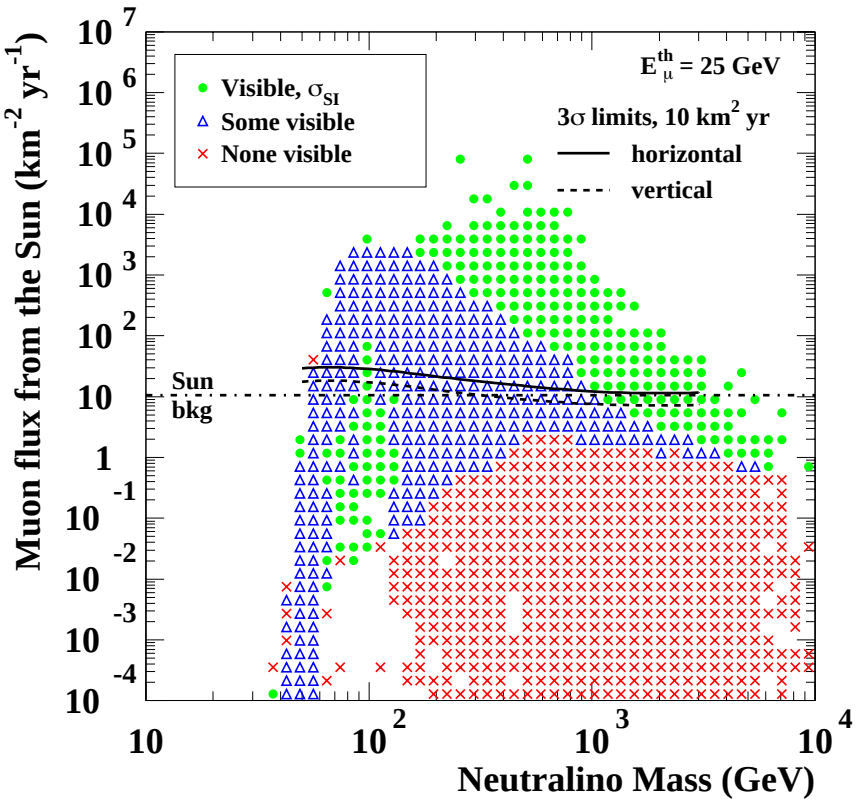


Flux from Earth/Sun and future GENIUS/CRESST limits

Earth

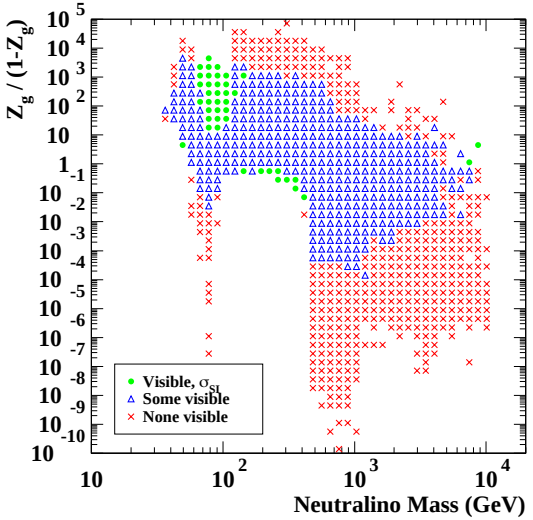


Sun

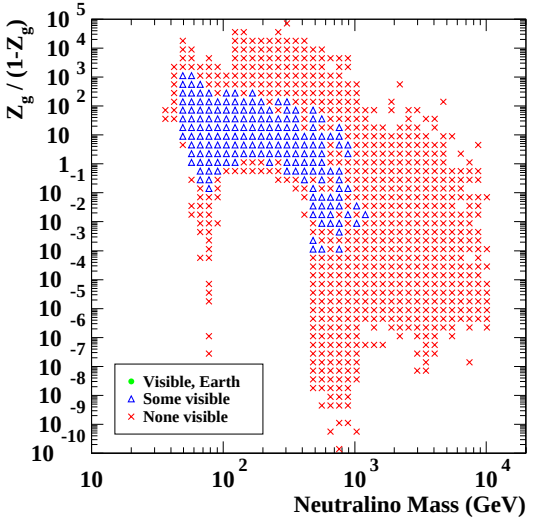


MSSM parameter space
Future probed regions

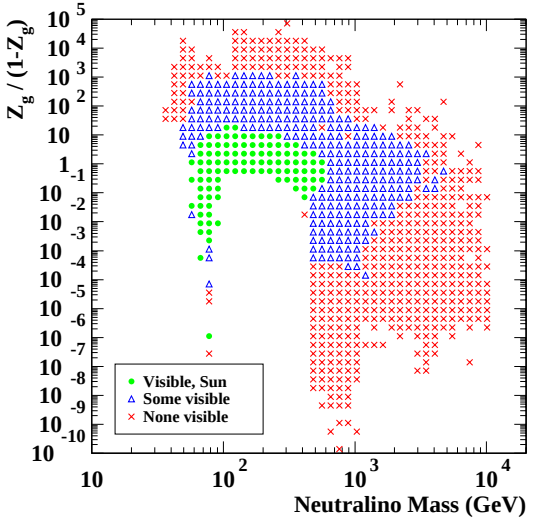
Direct detection Genius/Cresst



Earth, km^3



Sun, km^3



Conclusions

- The neutrino-induced muon fluxes from neutralino annihilations in the Earth and the Sun can be large and detectable.
- Current neutrino telescopes are probing the MSSM parameter space.
- Complementarity with direct searches, especially for the Sun.
- Future, bigger telescopes are under construction.