Swedish Astroparticle Physics

Joakim Edsjö

edsjo@physto.se

Partikeldagarna, Uppsala

March 6, 2001

Astroparticle Physics groups

- **KTH:** GLAST, CAPRICE, PAMELA, ...
- **SU:** Amanda/IceCube, Supernova Cosmology Project/SNAP, GLAST, dark matter theory, gravitational lensing, GRBs, ...
- **UU:** Amanda/IceCube
- **Kalmar:** Amanda/IceCube, GLAST
- ...

CAPRICE

Cosmic AntiProton Ring Imaging Cherenkov Experiment

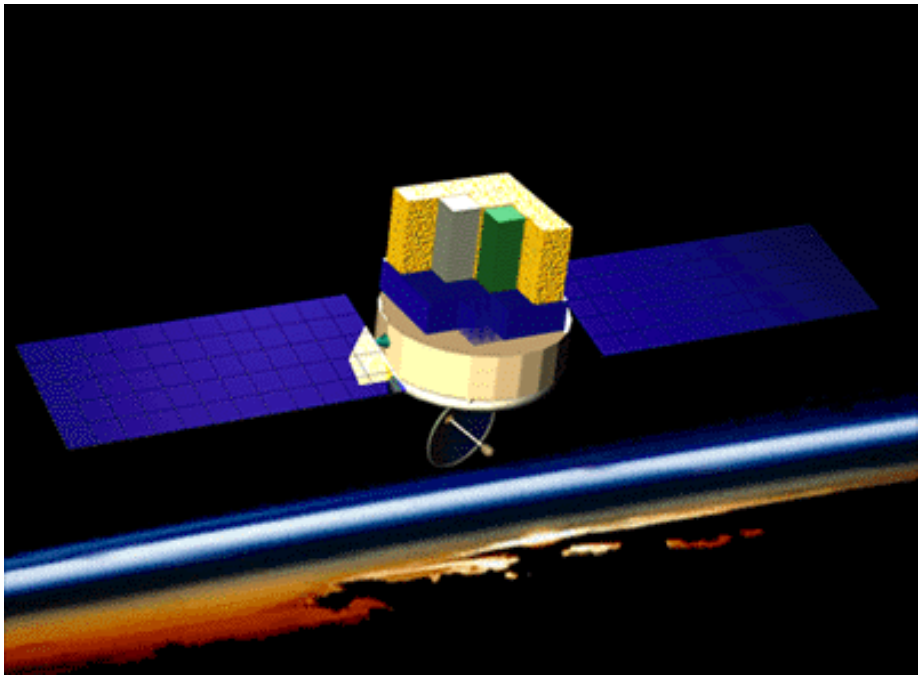
Goals

- Measure antiprotons, electrons and positrons at 5 – 50 GeV.
- These fluxes give information on cosmic ray sources, propagation of cosmic rays and possibly on dark matter

Joakim Edsjö, edsjo@physto.se

GLAST

The Gamma Ray Large Area Space Telescope



Science goals

- AGNs, pulsars, SNRs
- Unidentified sources and diffuse emission
- High energy behaviour of GRBs
- Dark matter

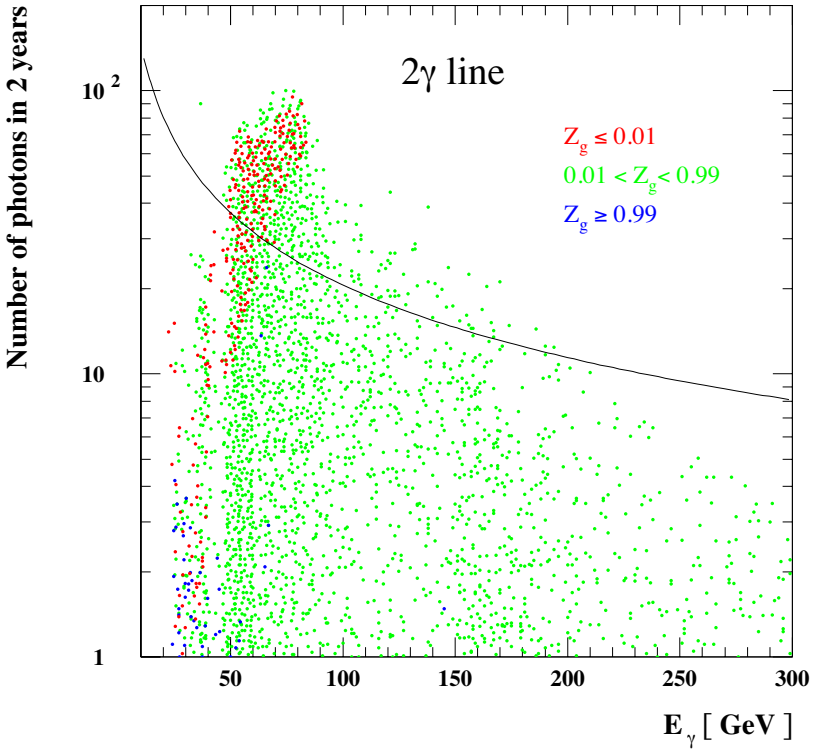
Launch: ~ 2005

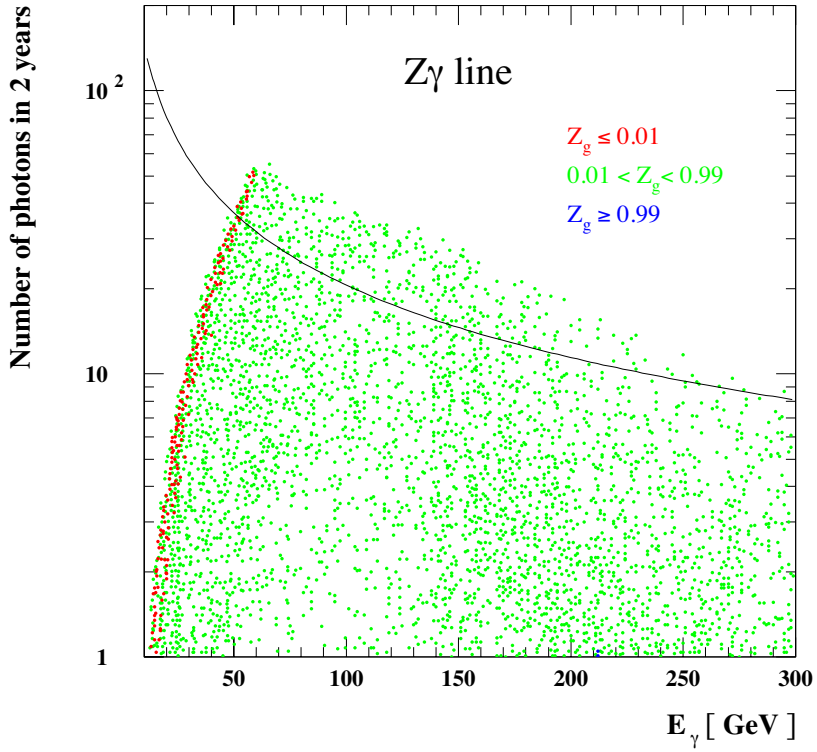
E_γ = 100 MeV – 300 GeV

Joakim Edsjö, edsjo@physto.se

GLAST The Gamma Ray Large Area Space Telescope

γ rays from dark matter annihilations: $\chi\chi \rightarrow \gamma\gamma, Z\gamma$

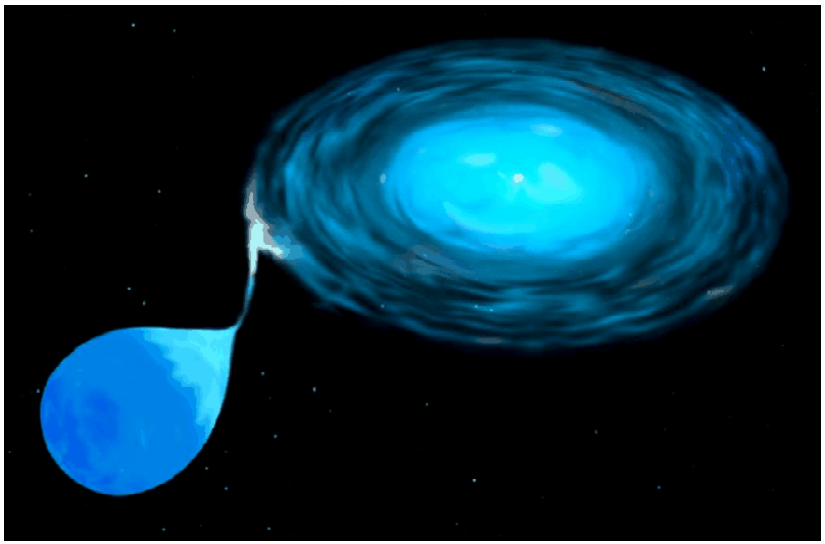




Joakim Edsjö, edsjo@physto.se
P. Ullio and L. Bergström

Supernovae IA as standard candles

- Supernovae IA are formed when a white dwarf in a double star system gets so heavy that it starts burning coal.
- It then explodes, always in roughly the same way and with the same luminosity.



Supernovae IA

How can they tell us about the geometry of the Universe?

- Supernovae IA are standard candles with an intrinsic luminosity B. Measure how bright they appear to be, b, and determine the luminosity distance, d,

$$b = \frac{B}{4\pi d_L^{\,2}} \qquad \Leftrightarrow \qquad d_L = \sqrt{\frac{B}{4\pi b}}$$

- This relation can be expressed in terms of the redshift, z,

$$d_L = \frac{1}{H_0}\left(z + f(\Omega_{matter}, \Omega_\Lambda) z^2 + \ldots\right)$$

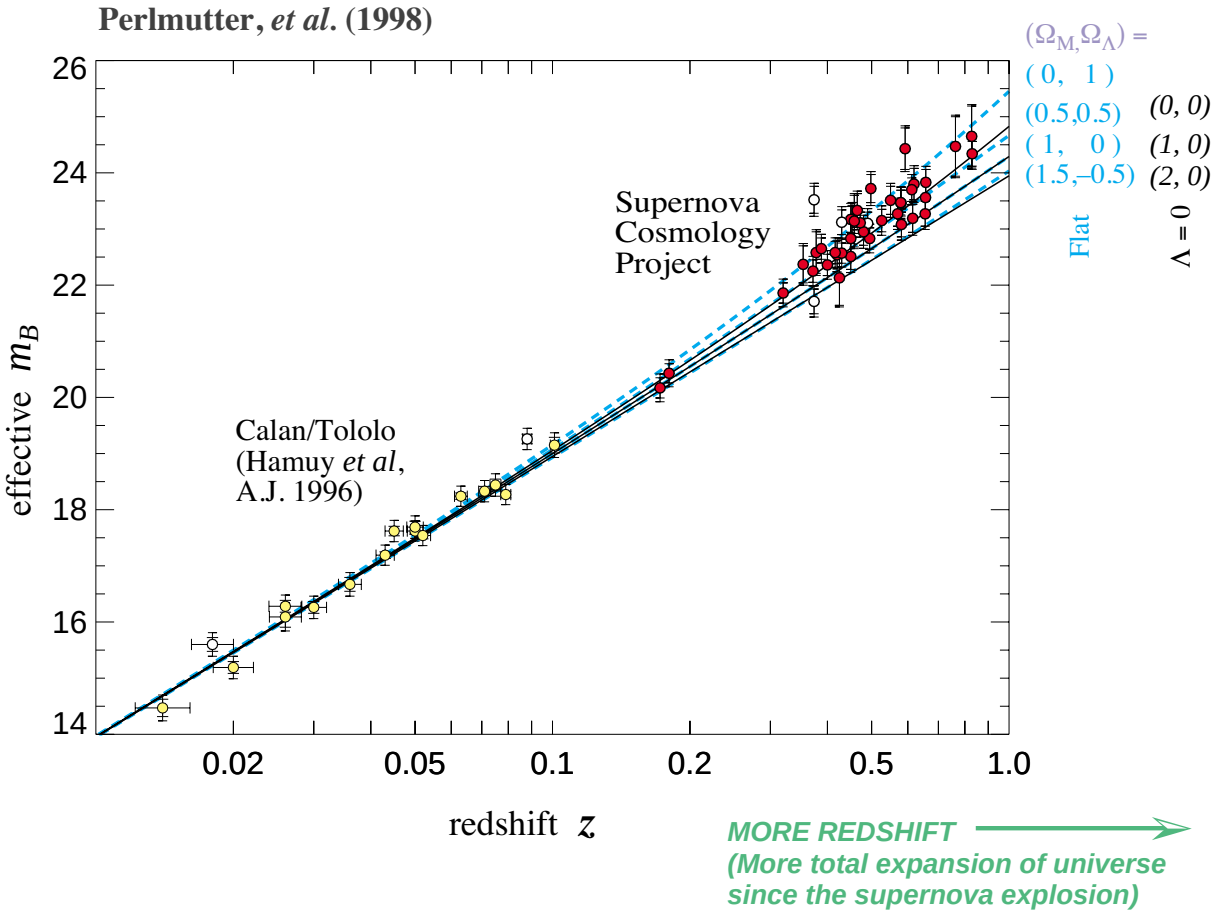
Measure the deviation from a linear relationship and we learn about Ω_{matter} and Ω_Λ.

Supernova Cosmology Project

Measure brightness of supernovae Ia as a function of redshift.

⇩

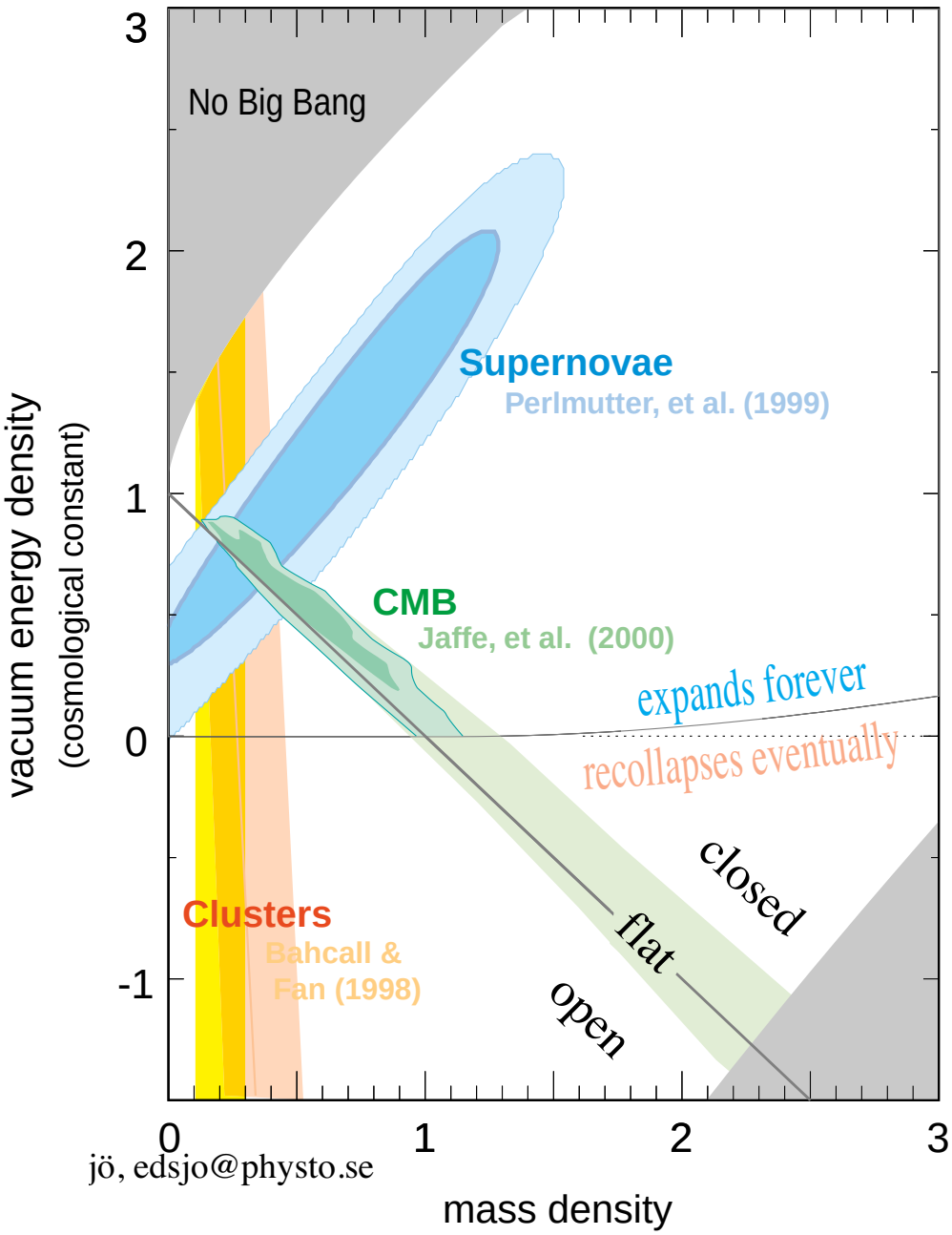
The geometry of the Universe.



Supernova Cosmology Project

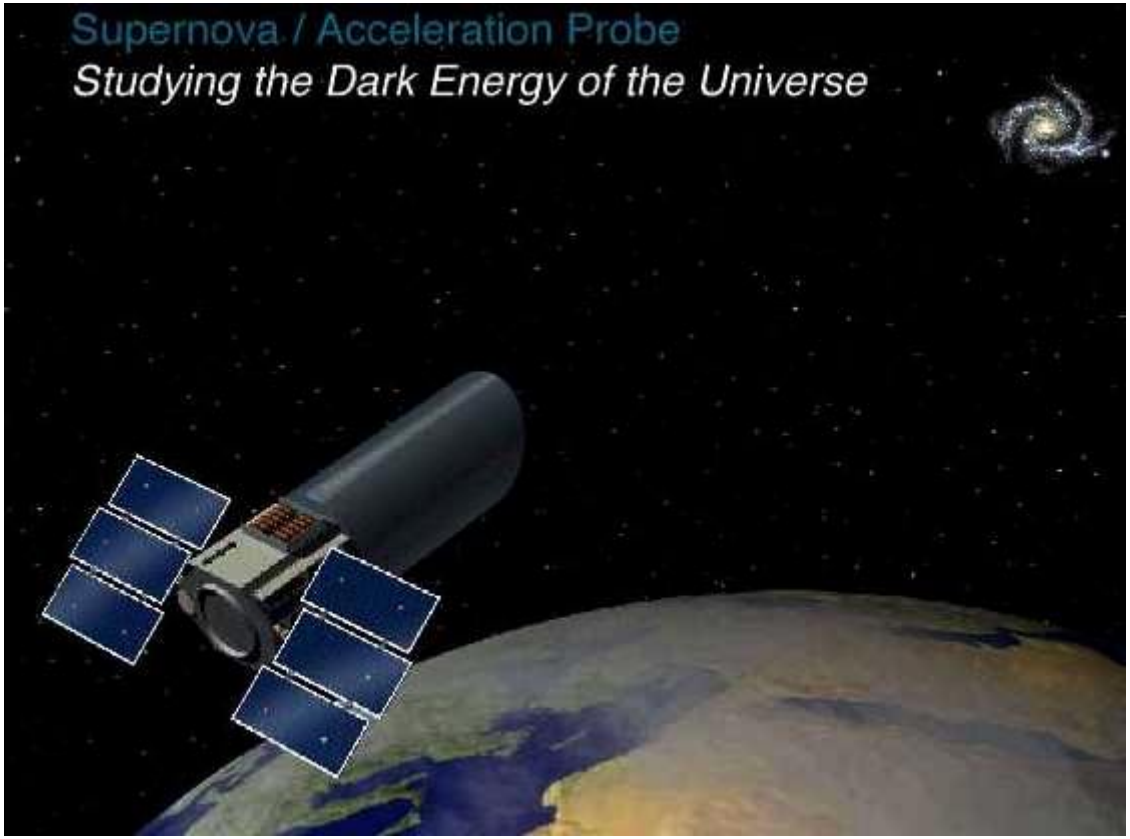
Current constraints on

- Ω_m – dark matter density
- Ω_Λ – cosmological constant



jö, edsjo@physto.se

SNAP

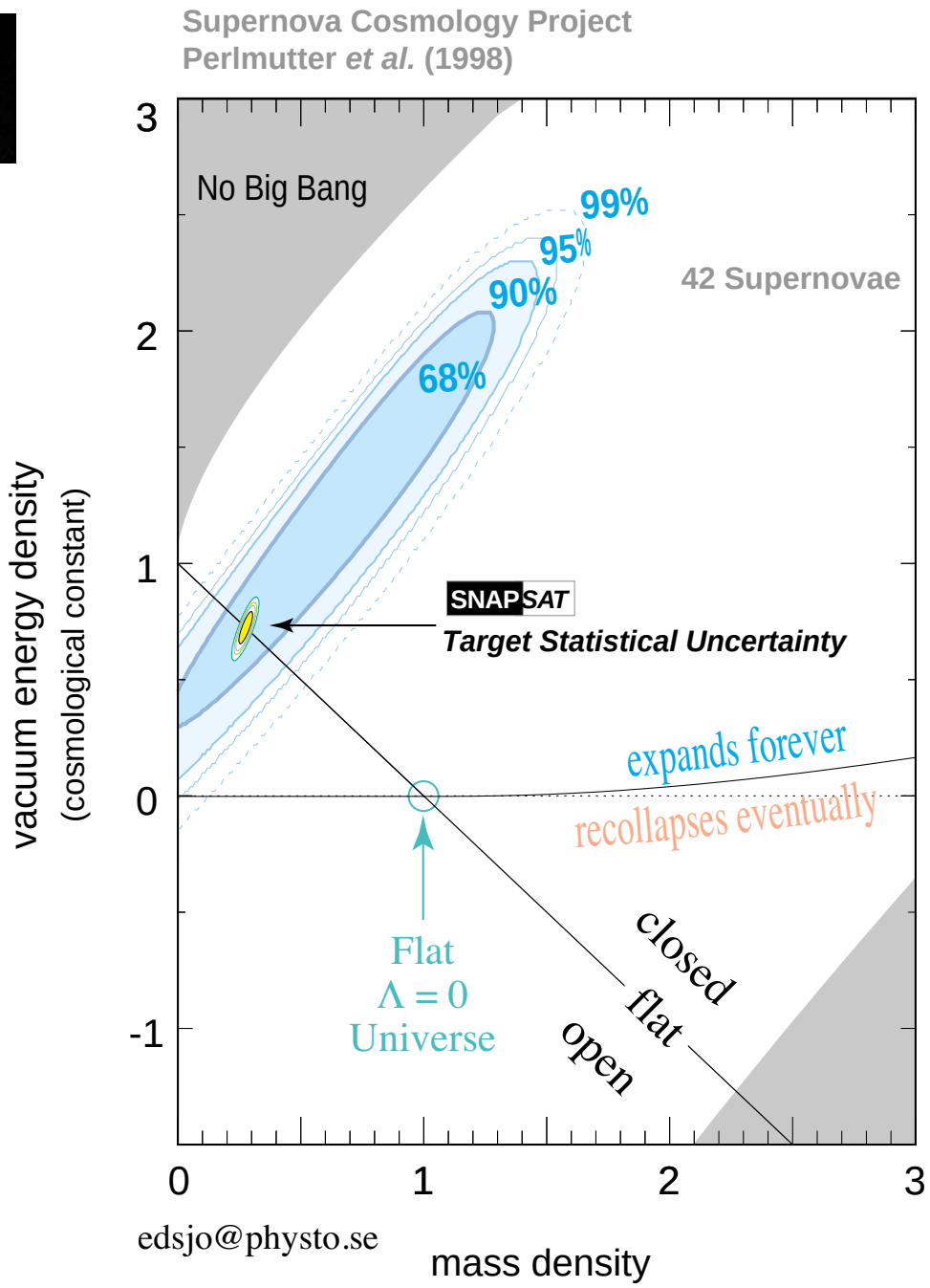


Science goals

- Measure ~ 2000 supernovae Ia / year out to z~1.7
- Determine the geometry of the Universe to high precision.

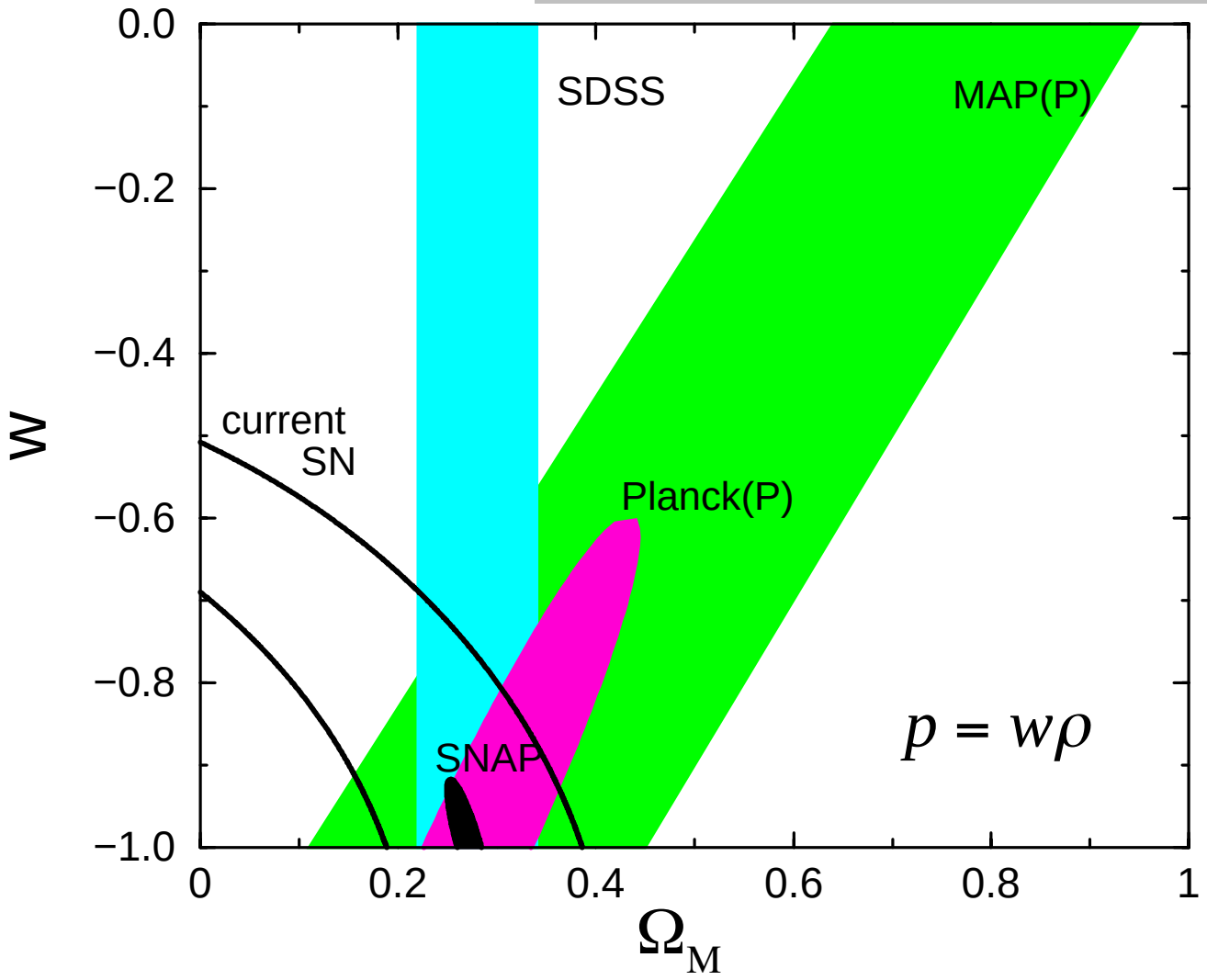
Launch: ~ 2008 (if approved)

SNAP projected sensitivity



edsjo@physto.se

Sensitivity to quintessence



SNOC
SuperNova Observation Calculator

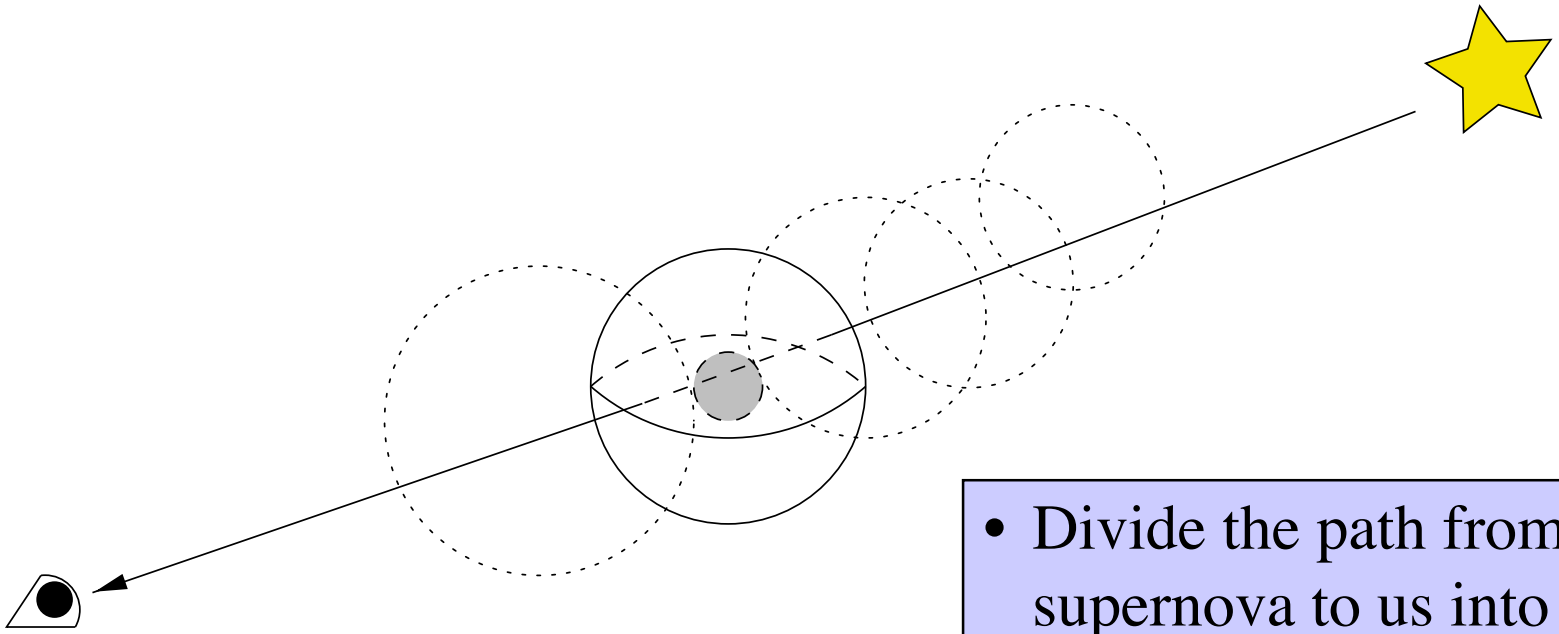
SNOC is a set of programs to calculate the effects of

- gravitational lensing
- dust
- …

on e.g. supernova measurements.

Joakim Edsjö, edsjo@physto.se

SNOC – Gravitational lensing



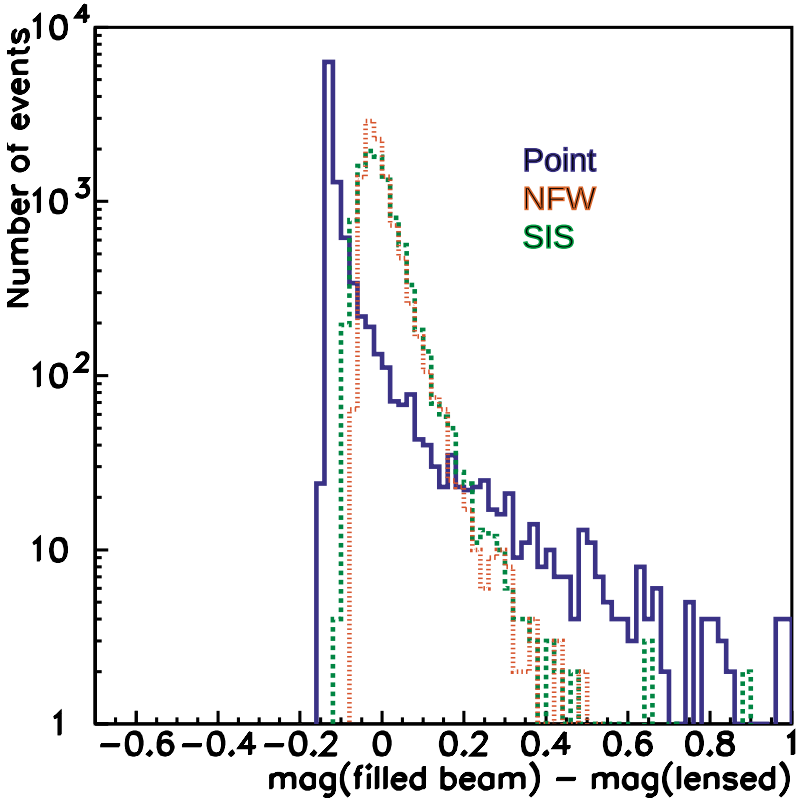
- Divide the path from the supernova to us into cells.
- Distribute mass in the cells.
- Follow the light rays with Monte Carlo methods.

Joakim Edsjö, edsjo@physto.se

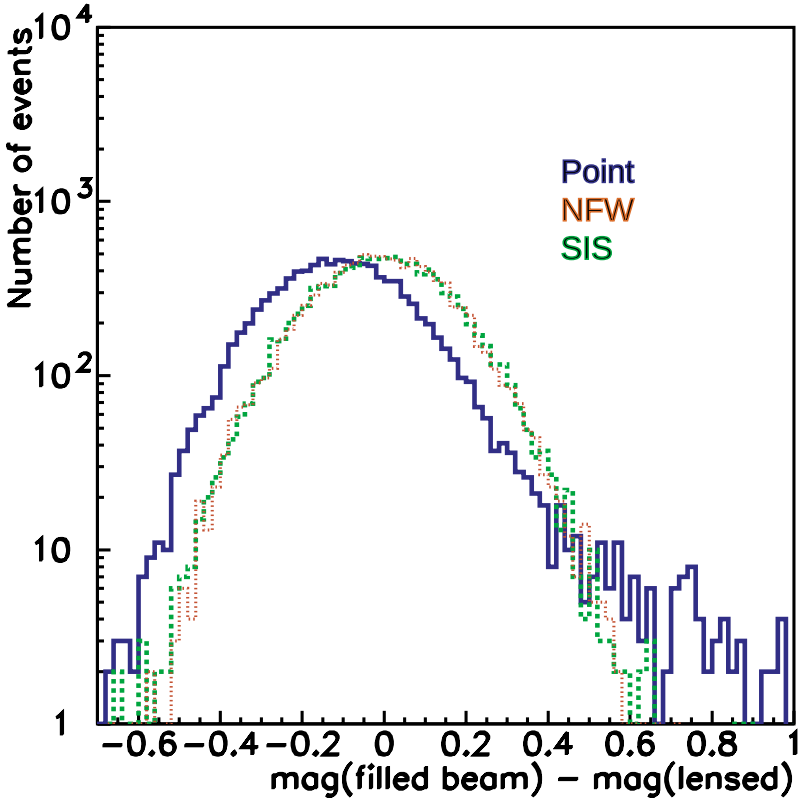
SNOC – Sensitivity to halo profiles

Demagnification from gravitational lensing

a) without intrinsic dispersion

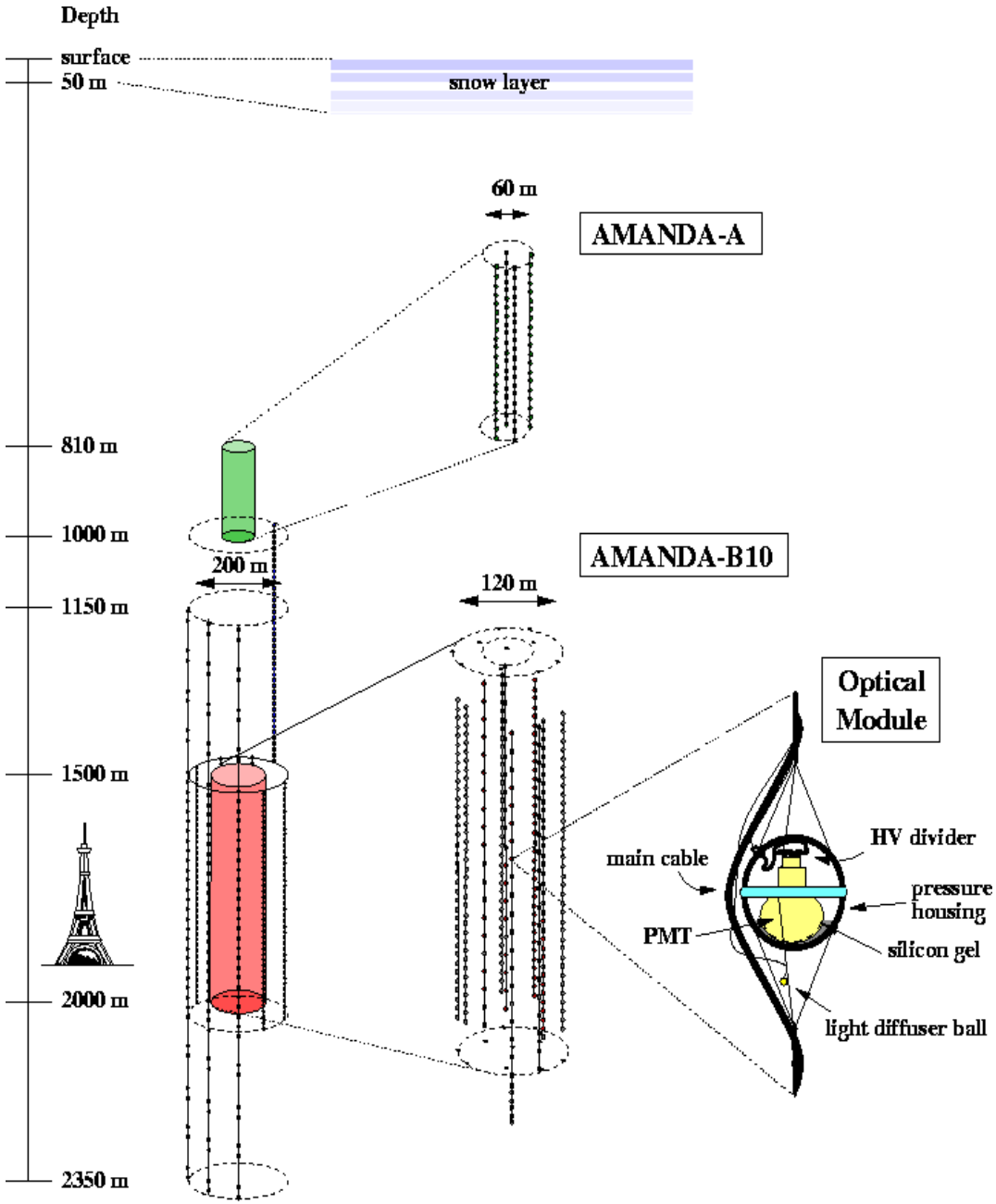


b) with intrinsic dispersion



Joakim Edsjö, edsjo@physto.se

AMANDA-II
Feb. 00



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

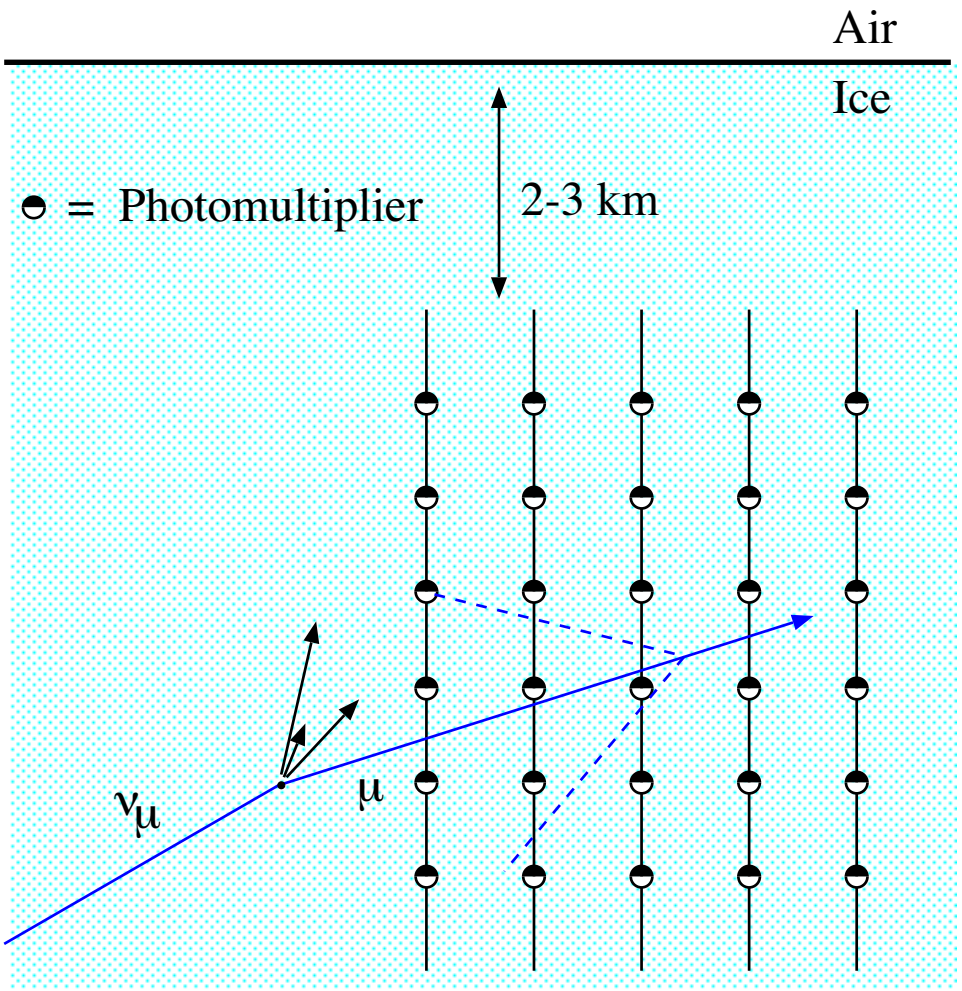
zoomed in on
AMANDA-A (top)
AMANDA-B10 (bottom)

zoomed in on one
optical module (OM)

- 19 strings
- 680 PMTs

AMANDA

Neutrino telescopes – how do they work?

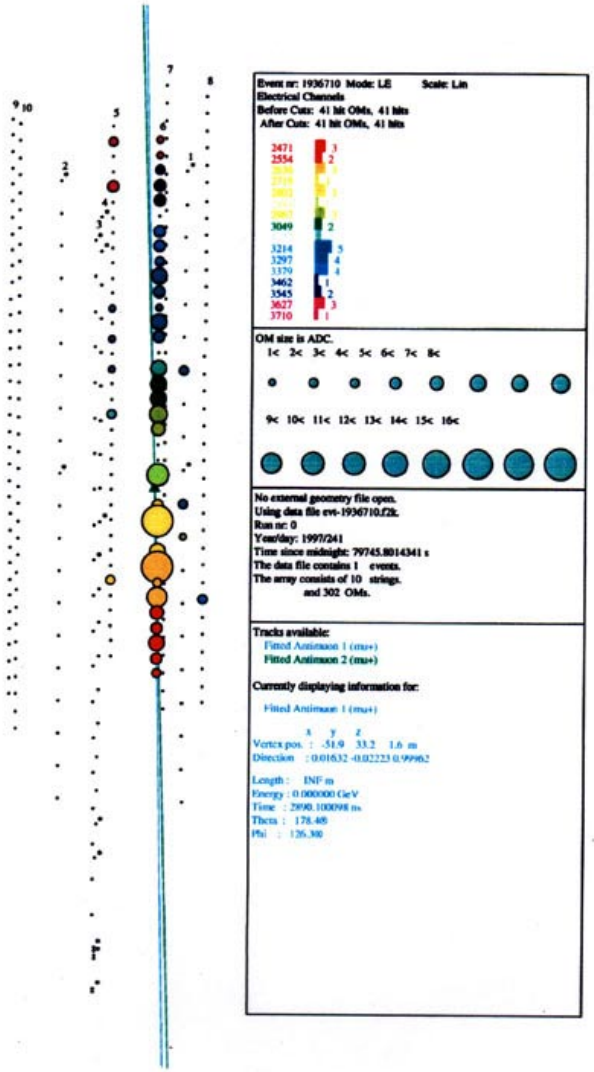


- The neutrino interacts with a nucleus in the ice and creates a muon.
- The muon emits *Cherenkov radiation*.
- The radiation is recorded by photomultipliers and the muon track can be reconstructed.

AMANDA

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.

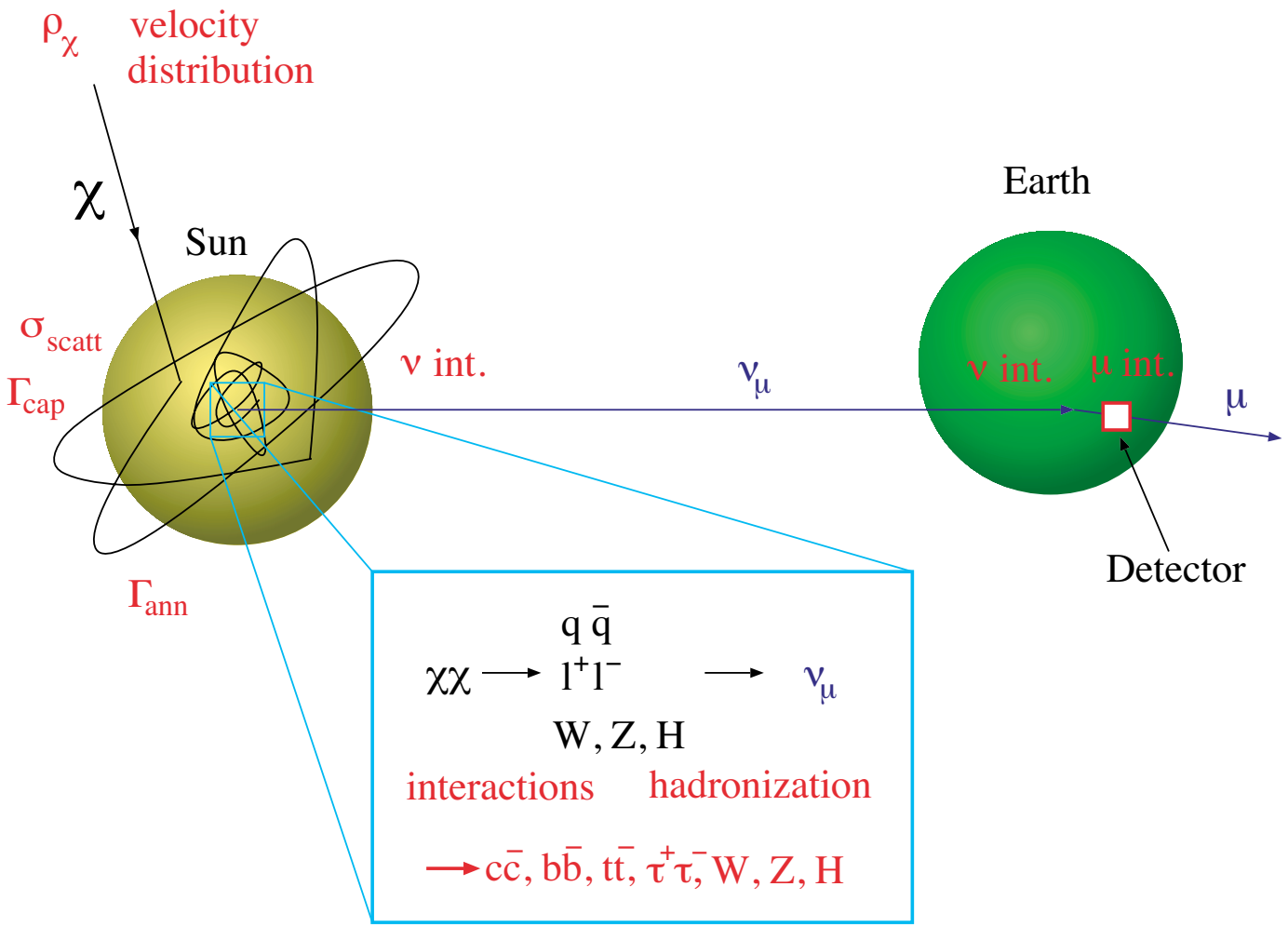


AMANDA

Amanda science goals

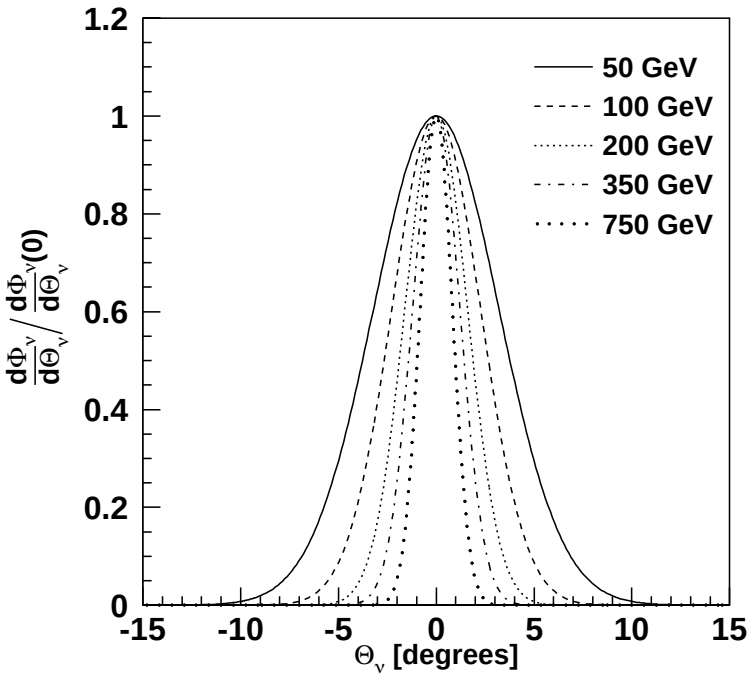
- Neutrinos from GRBs
- Point sources, AGNs
- Diffuse fluxes
- Supernova monitor
- Neutrinos from dark matter annihilations
- The unexpected...

Neutralino capture and annihilation

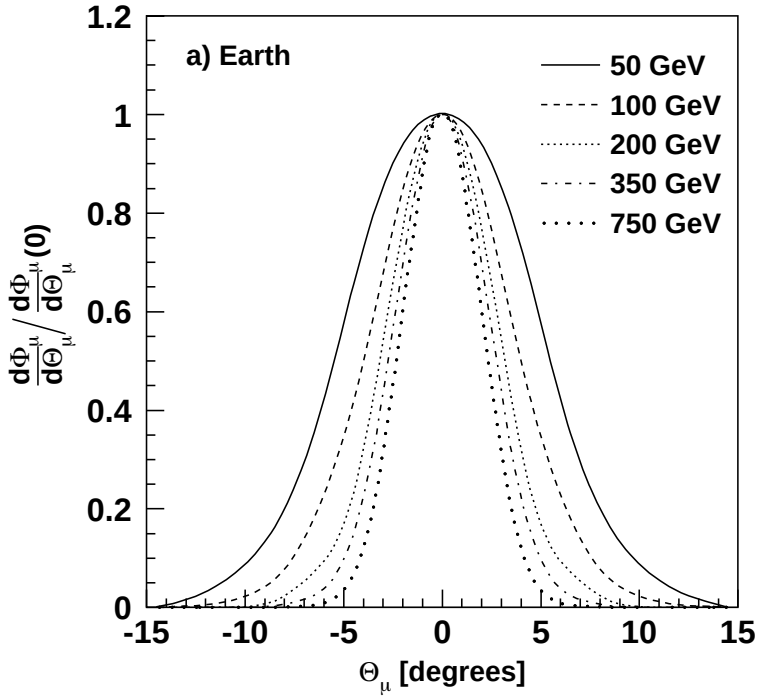


Angular Spread of WIMP signal – Earth

Neutrinos



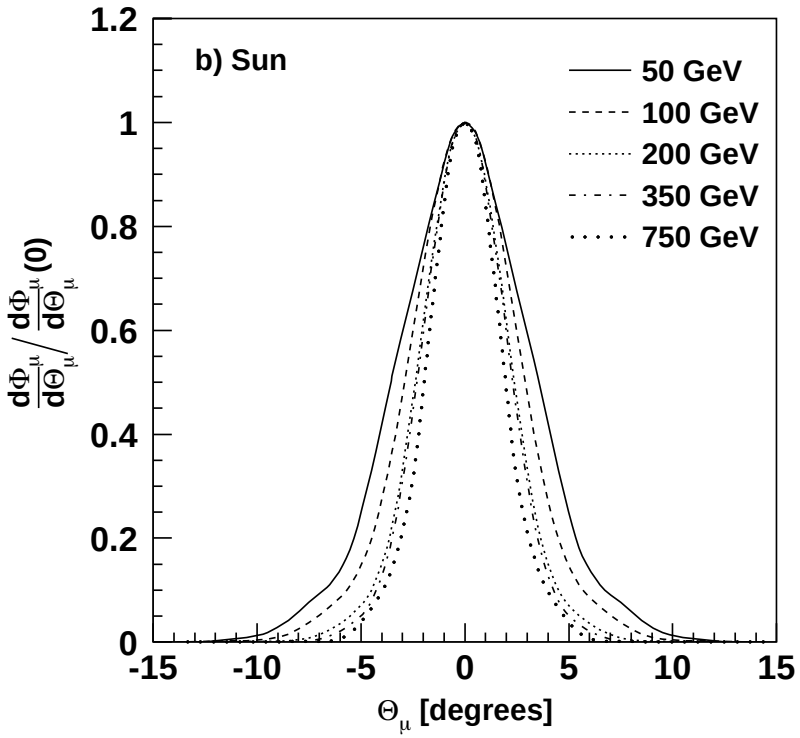
Neutrino-induced muons



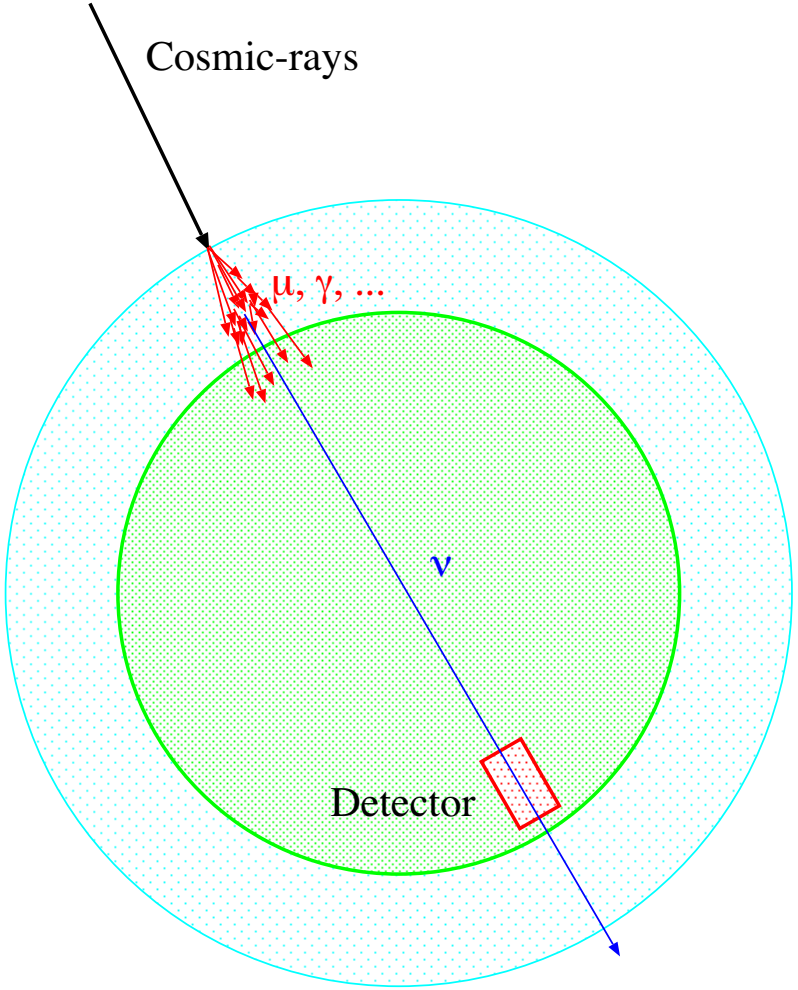
Angular Spread of WIMP signal – Sun

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

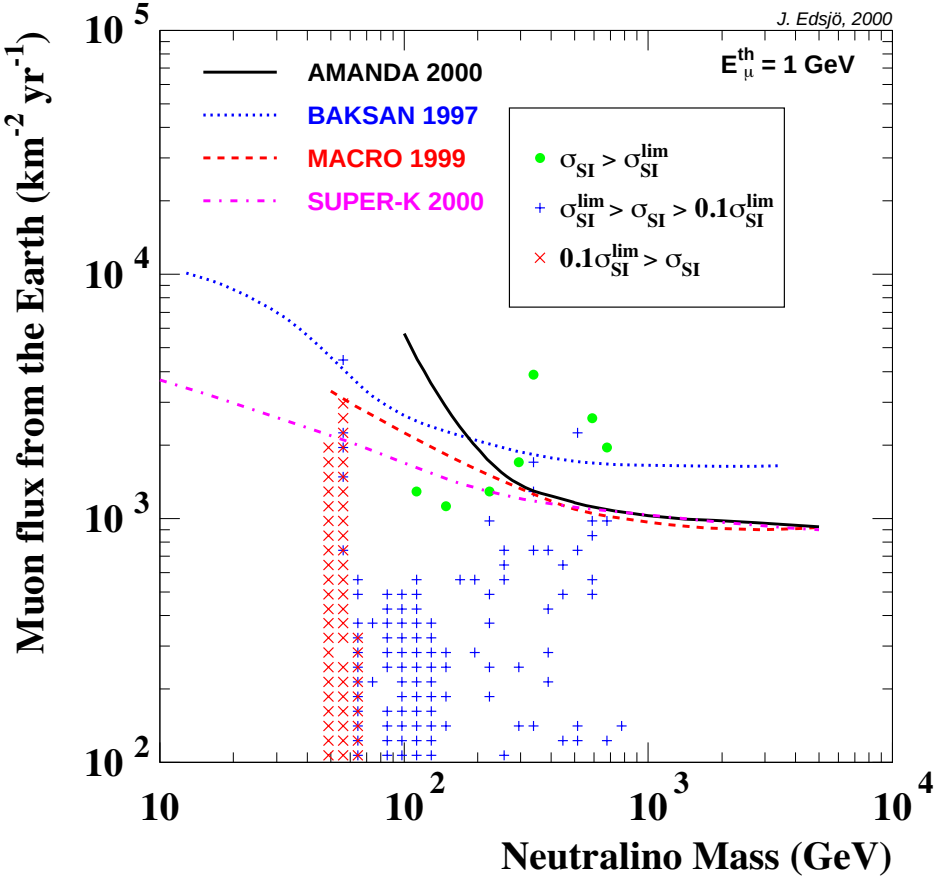
⇒ Use the Earth as a **filter** by looking for upgoing muons.

⇒ Only atmospheric neutrinos remain as a background.

AMANDA

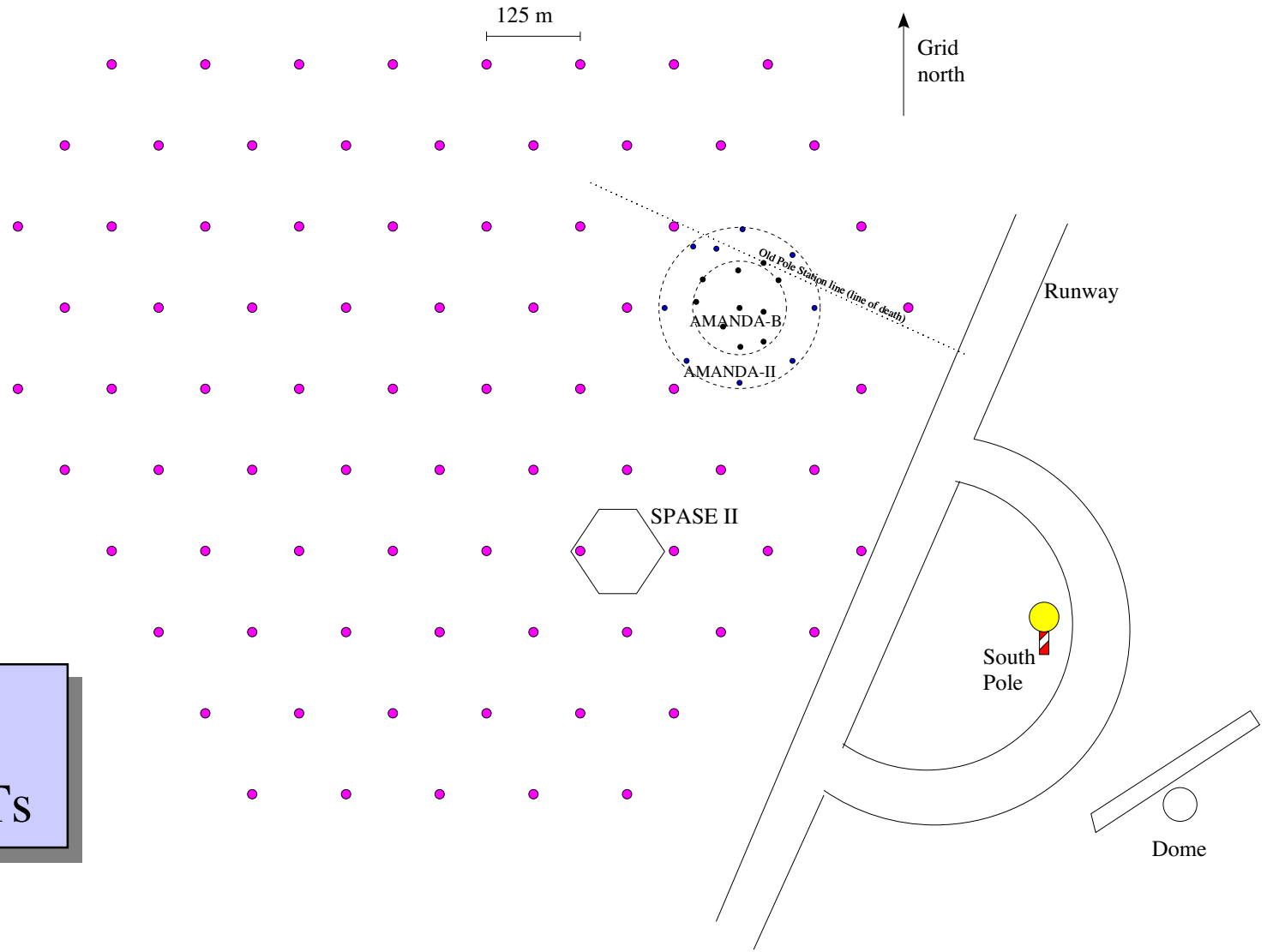
Limits: μ flux from the Earth

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



 Joakim Edsjö, edsjo@physto.se

ICECUBE preliminary geometry

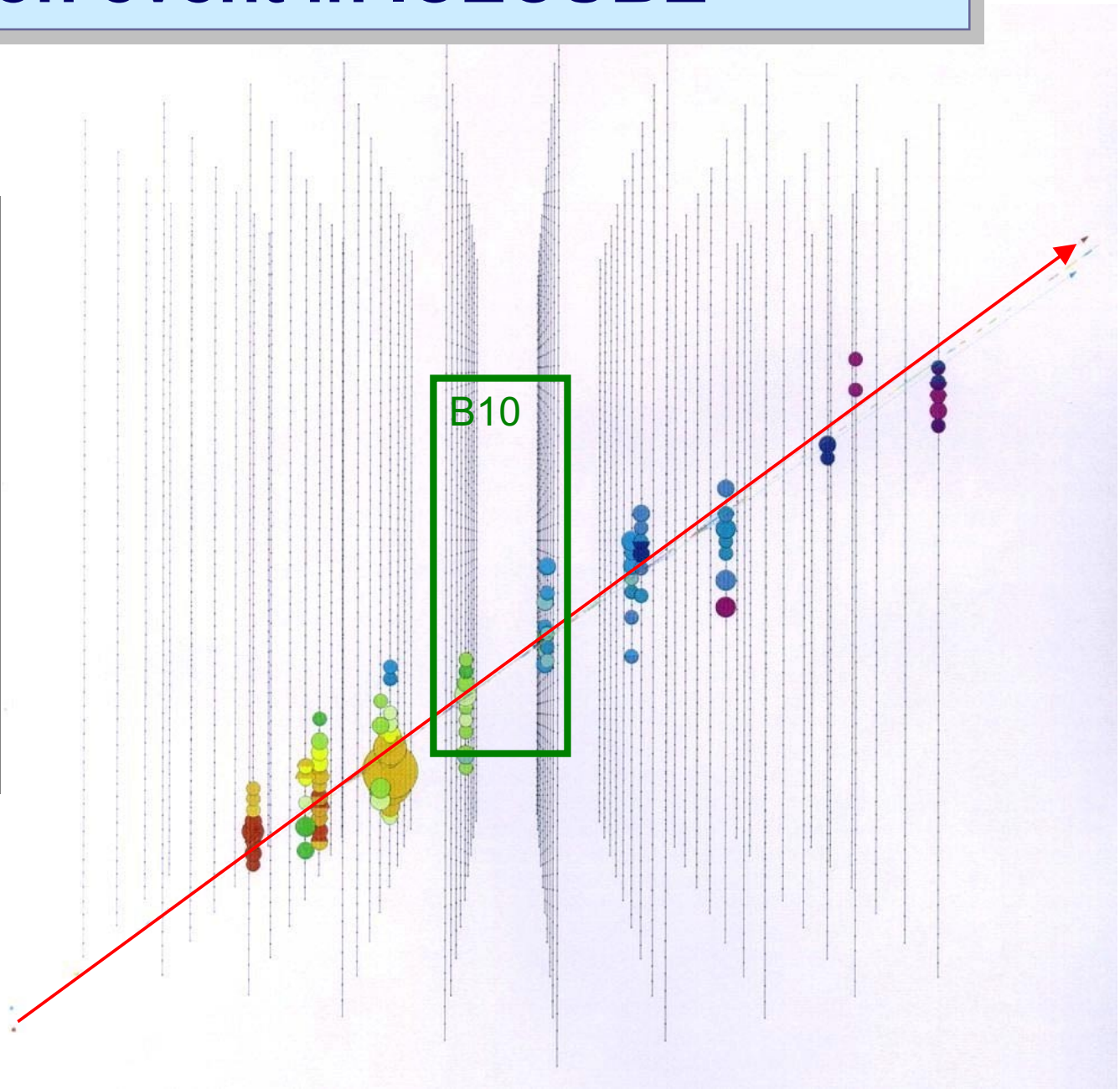


- 80 strings
- 4800 PMTs

Muon event in ICECUBE

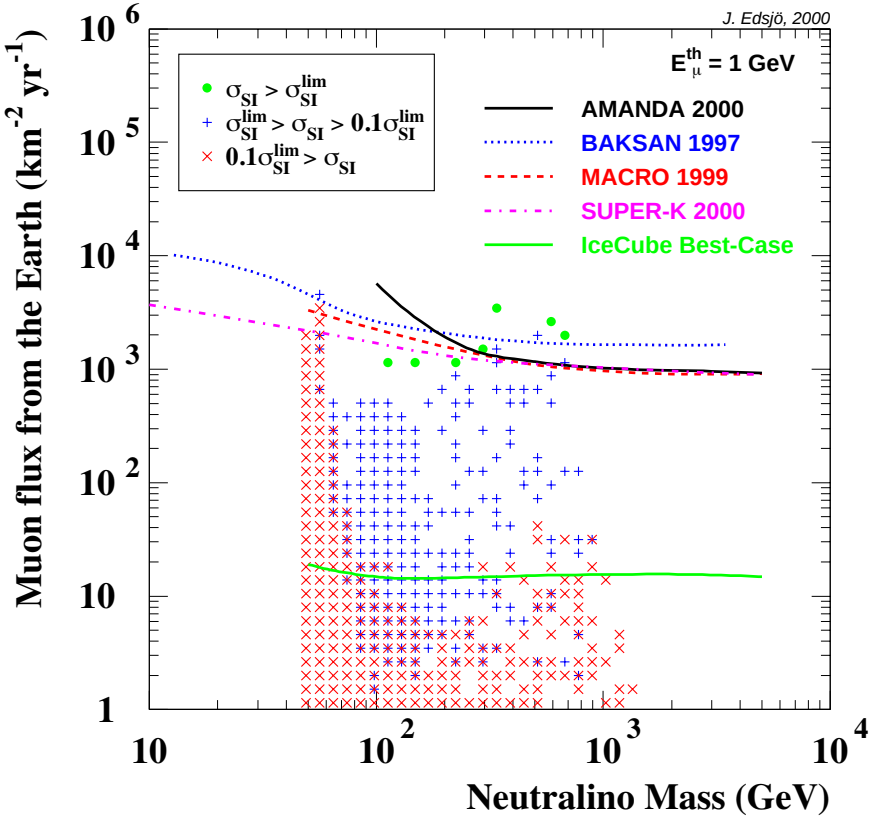
Amanda B10:
~ 300 PMTs
200 atm. ν´s
in 132 days

IceCube:
~ 5000 PMTs
250 atm. ν´s
per day

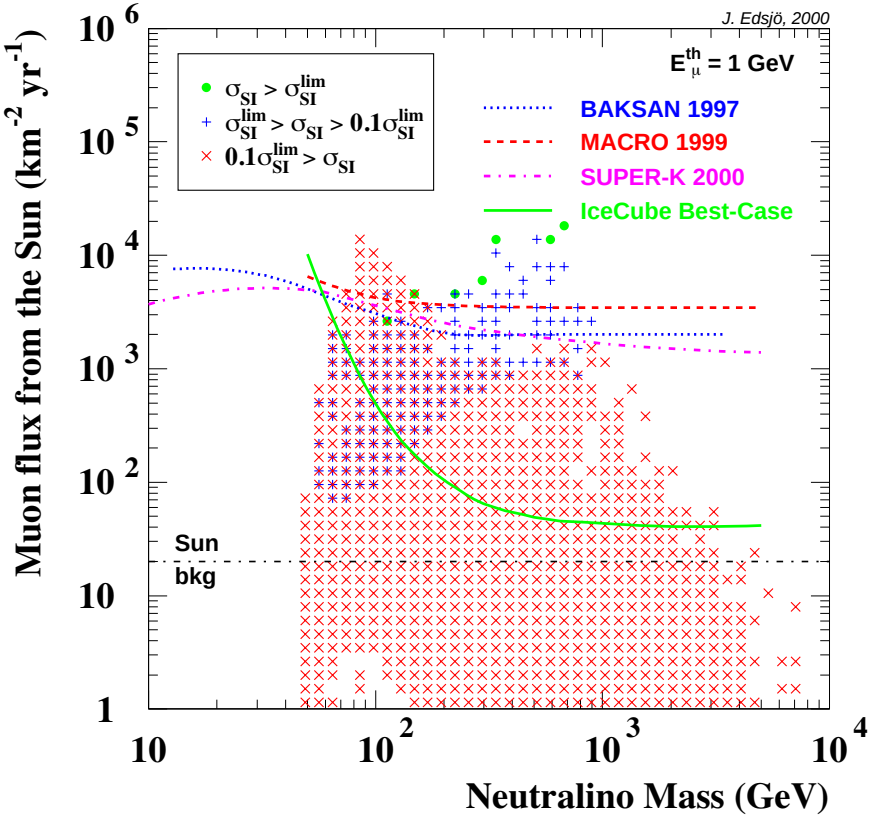


Predicted fluxes and searches

Earth



Sun



ICECUBE deployment schedule

Year	Number of deployed OM	Number of deployed strings	Total number of strings	Total number of OM
2002/2003	*180*	*3*	*3*	*180*
2003/2004	*360*	*6*	*9*	*540*
2004/2005	*960*	*16*	*25*	*1500*
2005/2006	*960*	*16*	*41*	*2460*
2006/2007	*960*	*16*	*57*	*3420*
2007/2008	*960*	*16*	*73*	*4380*
2008/2009	*420*	*7*	*80*	*4800*

Paolo Gondolo, Joakim Edsjö, Lars Bergström,
Piero Ullio and Edward A. Baltz

 Joakim Edsjö, edsjo@physto.se

Overview

DarkSUSY is a Fortran package for MSSM dark matter calculations. Calculable quantities include:

- Vertices
- Mass spectrum
- Accelerator bounds
- Relic density
- Scattering cross sections
- Rates in neutrino telescopes
- Fluxes from the halo: antiprotons, positrons, continuum gammas, gamma lines ($Z\gamma$ and $\gamma\gamma$) and neutrinos.

Download from http://www.physto.se/~edsjo/darksusy/