

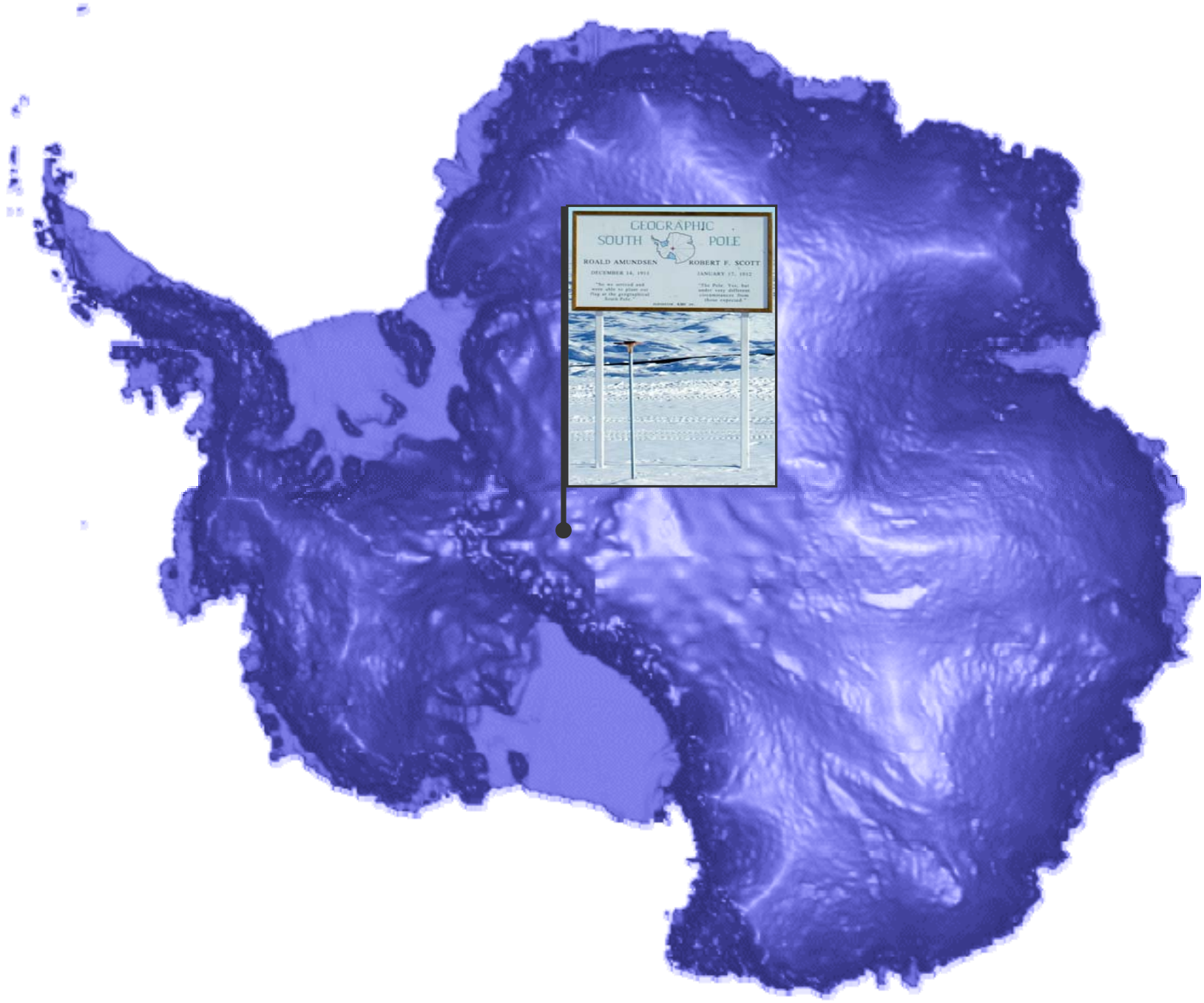
Neutrinojagd am Südpol

An aerial photograph of a research station in Antarctica. The station consists of several buildings and structures clustered together on a flat, snow-covered landscape. Long, straight tracks are visible in the snow, leading from the station towards the horizon. The sky is a clear, pale blue, and the overall scene is desolate and remote.

Marek Kowalski

Humboldt-Universität





GEOGRAPHIC SOUTH POLE

ROALD AMUNDSEN ROBERT F. SCOTT

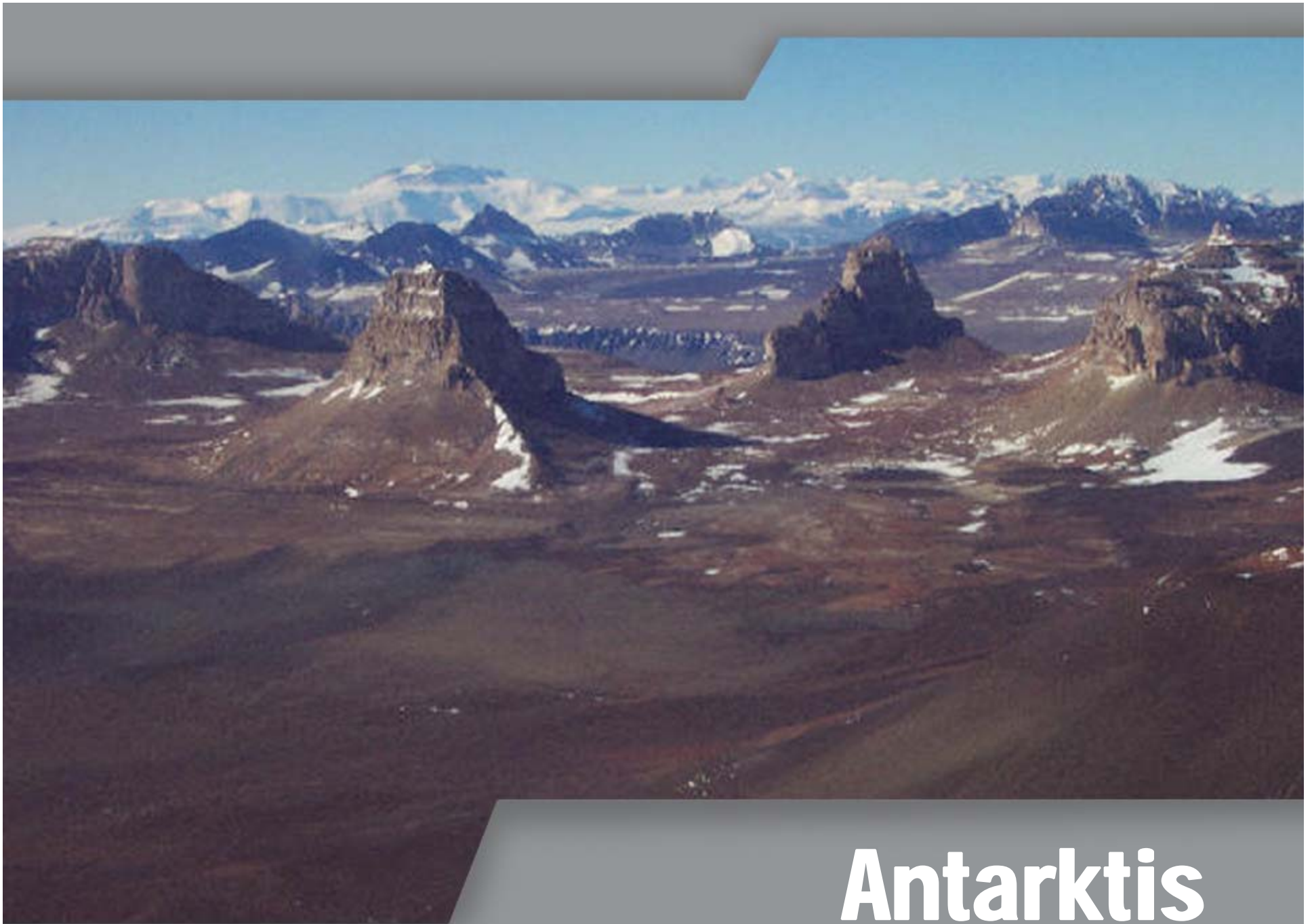
DECEMBER 14, 1911 JANUARY 17, 1912

"We are arrived and were able to plant our flag at the geographical South Pole."

"The Pole, Yes, but under very different circumstances from those expected."



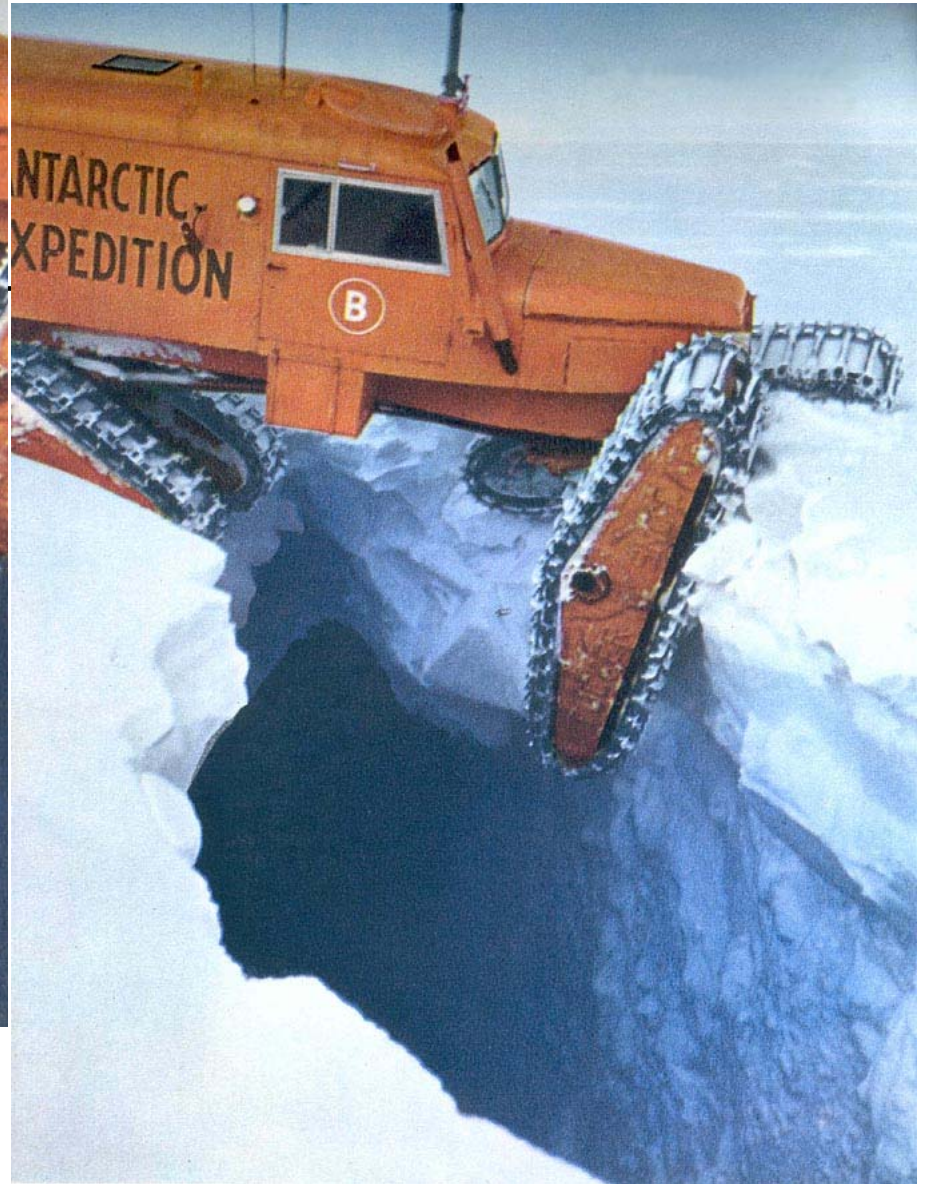
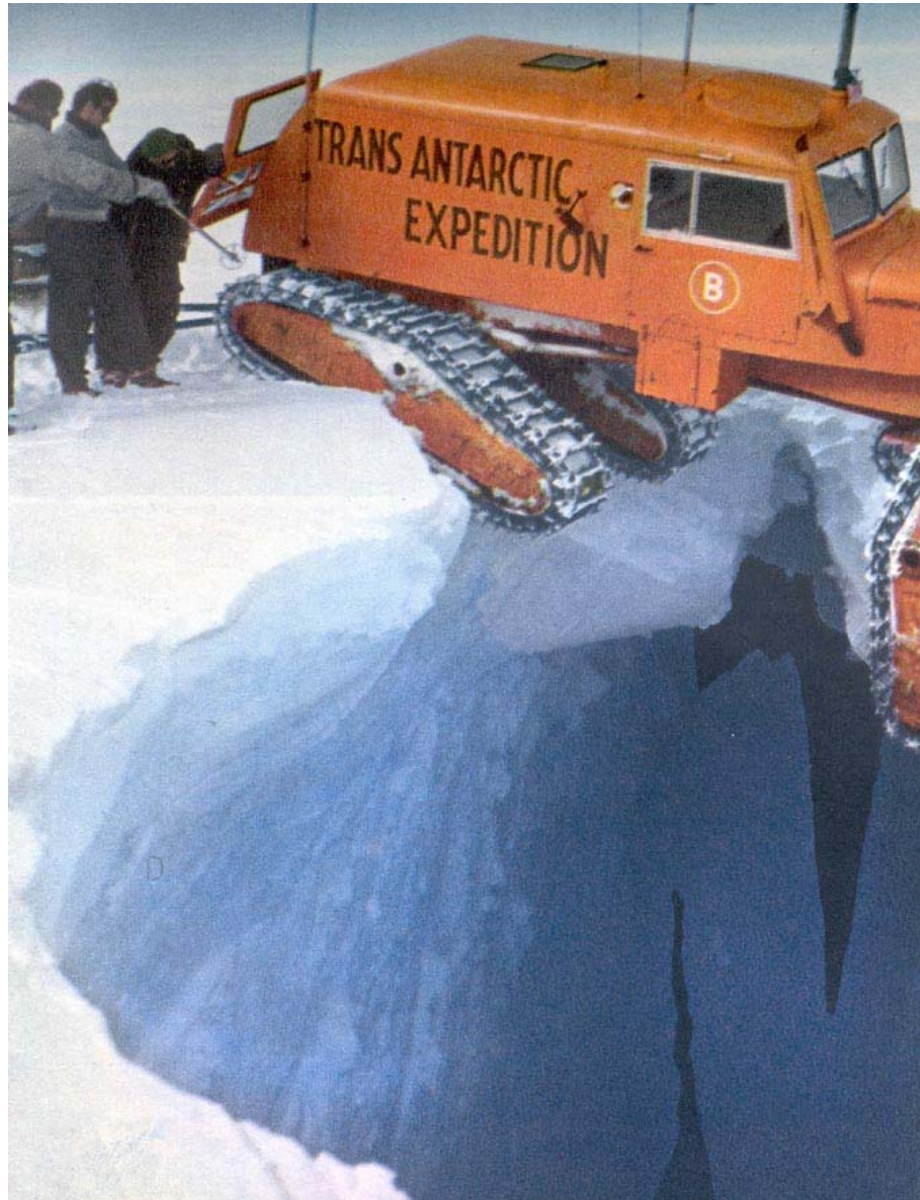




Antarktis











Die neue Südpol-Station

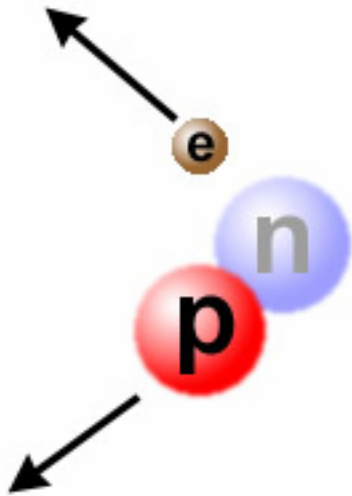




1 km

IceCube

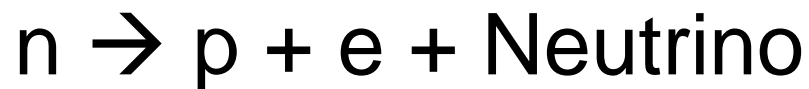
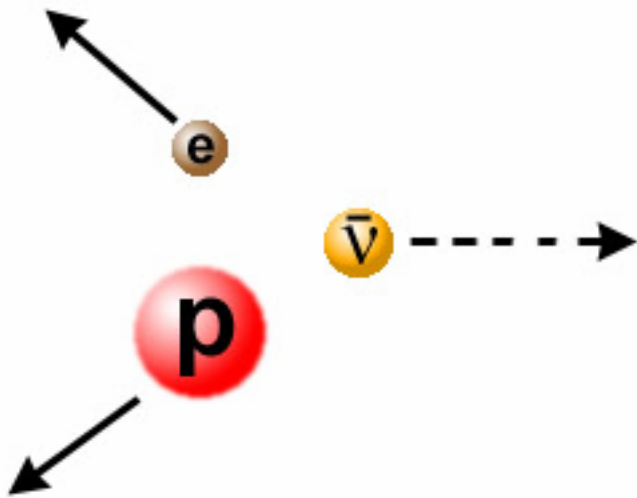
Woraus besteht die Welt?



- Neutronen
- Protonen
- Elektronen

Umwandlung durch nuklearen Reaktionen möglich.

Fast, denn eine Kleinigkeit fehlt...



**...man braucht
noch ein Neutrino!**

**Aber das Neutrino
wechselwirkt nur
schwach, daher nicht
zu sehen.**

Wolfgang Pauli:

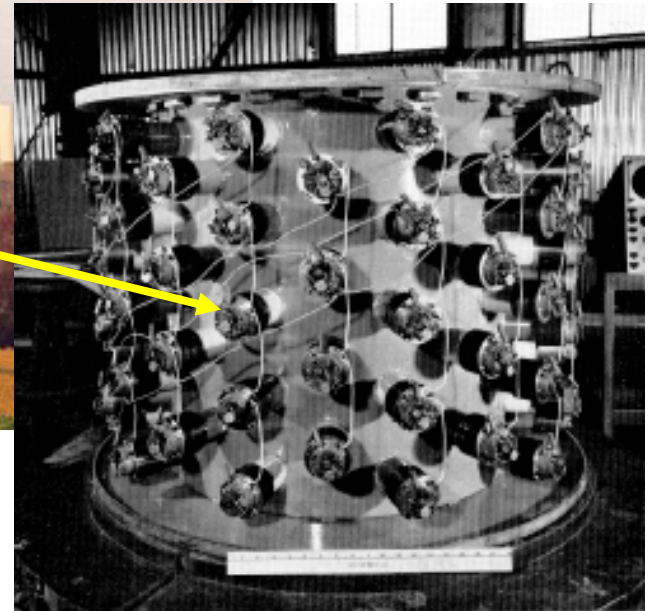
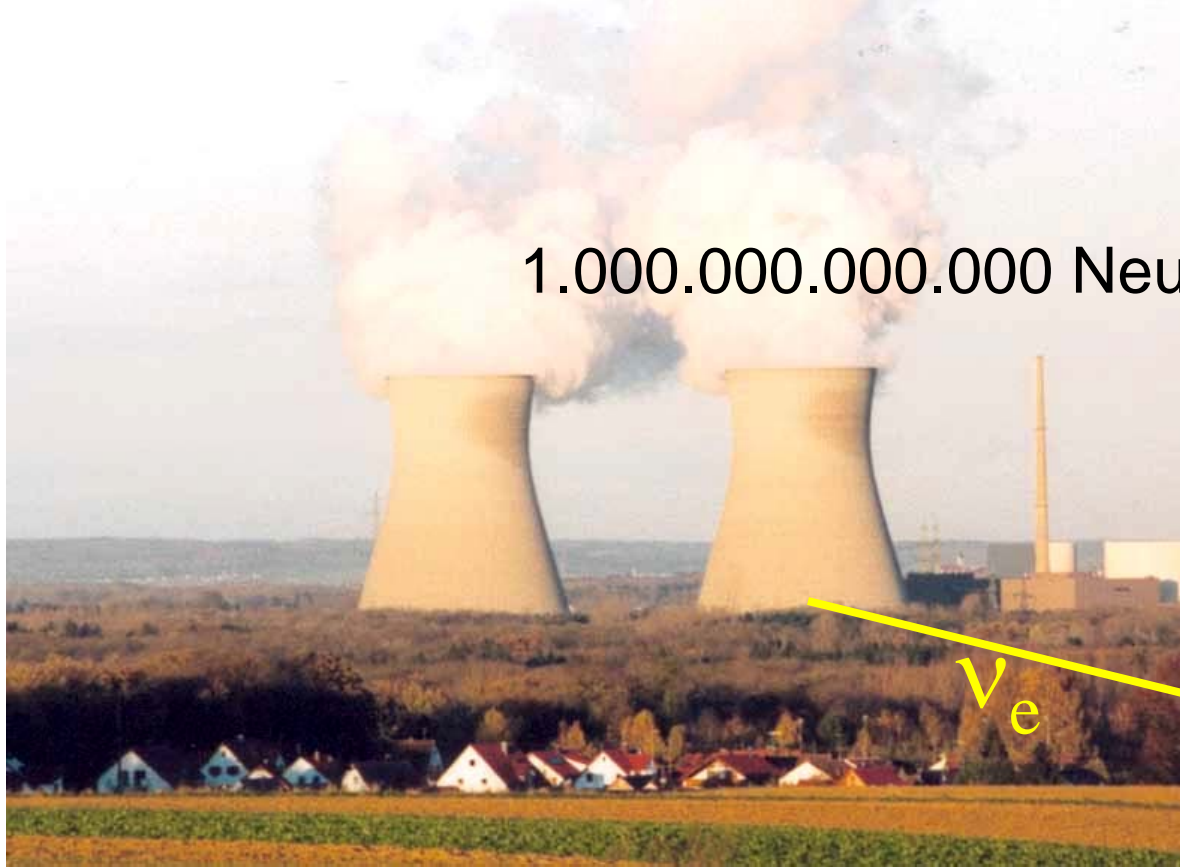
„Um den Energiesatz zu retten, bin ich einem verzweifelten Ausweg verfallen.“

Pauli postulierte die Existenz des Neutrinos



Erster Nachweis von Neutrinos

1.000.000.000.000 Neutrinos / cm² / s



erster Nachweis von Neutrinos
im Experiment von F. Reines (1956)

Neutrinoquellen

Der Big Bang

$$\rho_\nu = 330 / \text{cm}^3$$

$$E_\nu = 0.0004 \text{ eV}$$

$$(1 \text{ MeV} = 1.6 \times 10^{-13} \text{ Joules})$$

SN1987

$$E_\nu \sim \text{MeV}$$

Die Sonne

$$\Phi_{\nu_e}^{\text{Erde}} = 6 \times 10^{10} \nu / \text{cm}^2 \text{s}$$

$$E_\nu \sim 0.1 - 20 \text{ MeV}$$

Atmosphäre

$$\Phi_\nu \sim 1 \nu / \text{cm}^2 \text{s}$$

$$E_\nu \sim 0.1 - 100 \text{ GeV}$$

Jeder Mensch

$$\Phi_\nu = 340 \times 10^6 \nu / \text{day}$$



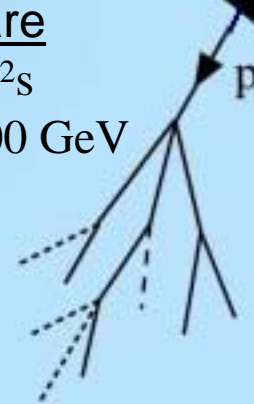
Nuklear-Reaktor

$$E_\nu \sim \text{MeV}$$



Radioaktivität aus der Erde

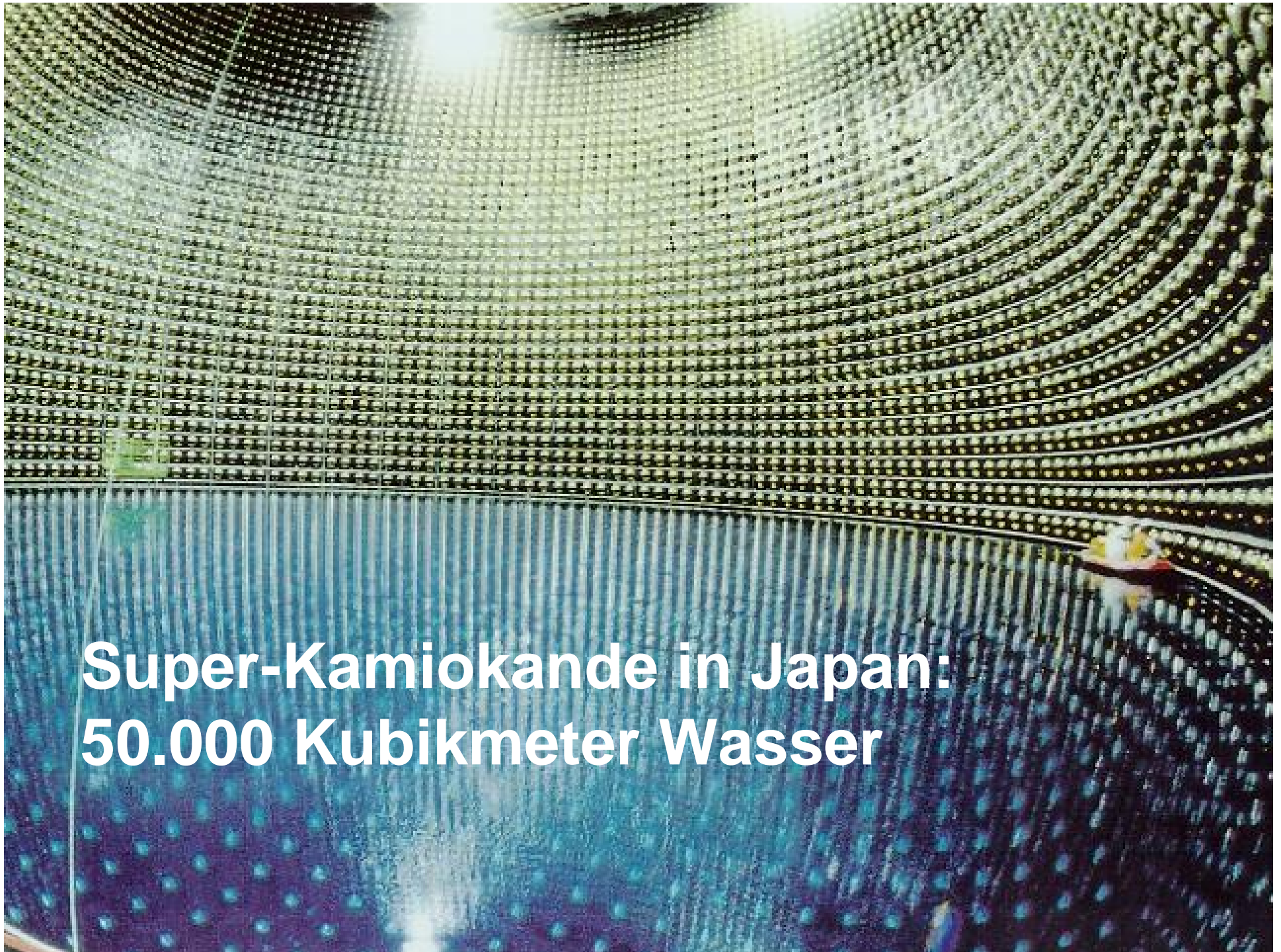
$$\Phi_\nu \sim 6 \times 10^6 \nu / \text{cm}^2 \text{s}$$



Beschleuniger

$$E_\nu \sim 0.3 - 30 \text{ GeV}$$

**Neutrino-Detektoren:
je größer, desto besser**



**Super-Kamiokande in Japan:
50.000 Kubikmeter Wasser**

Unsere Sonne, gesehen mit Neutrinos

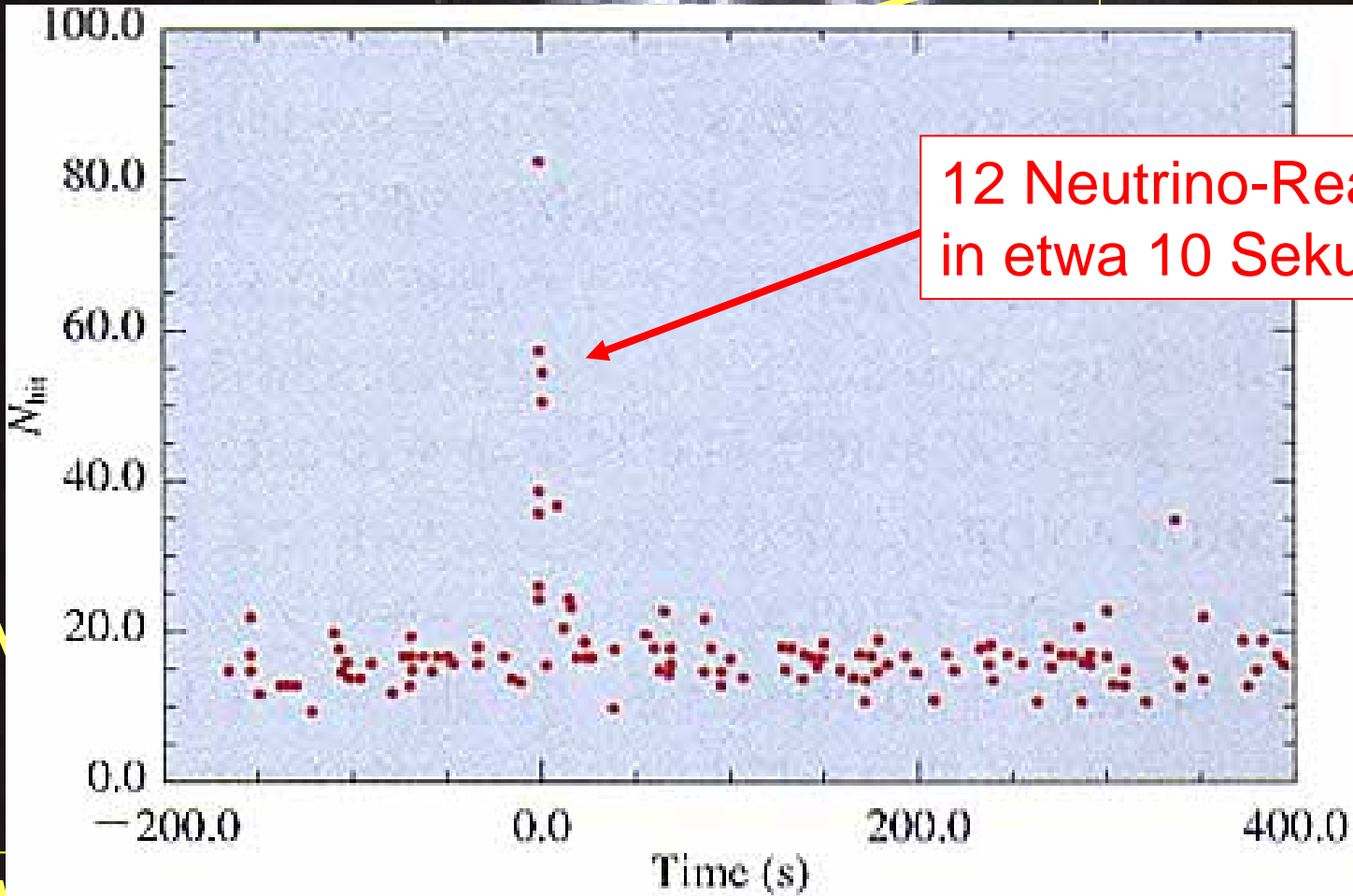


Supernova 1987A in der Großen Magellanschen Wolke



23.2.1987

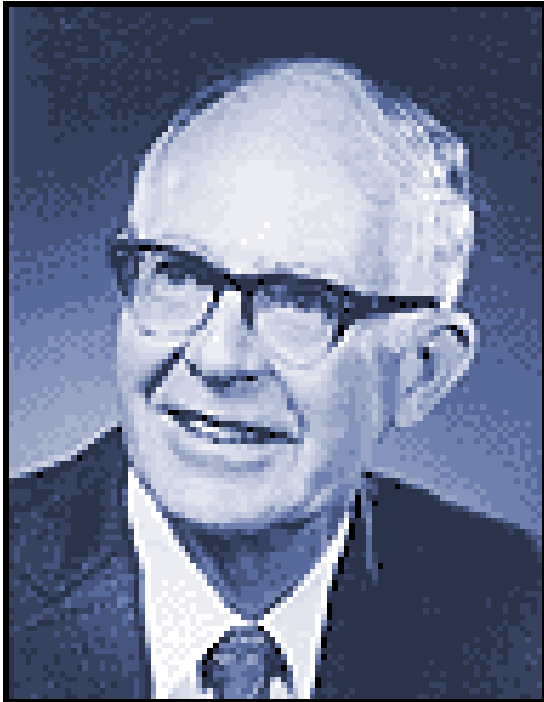
Sonne



12 Neutrino-Reaktionen
in etwa 10 Sekunden

**Magellanische
Wolken**

Nobelpreise 2002: 2x für Neutrinoastronomie



Raymond Davis jr.



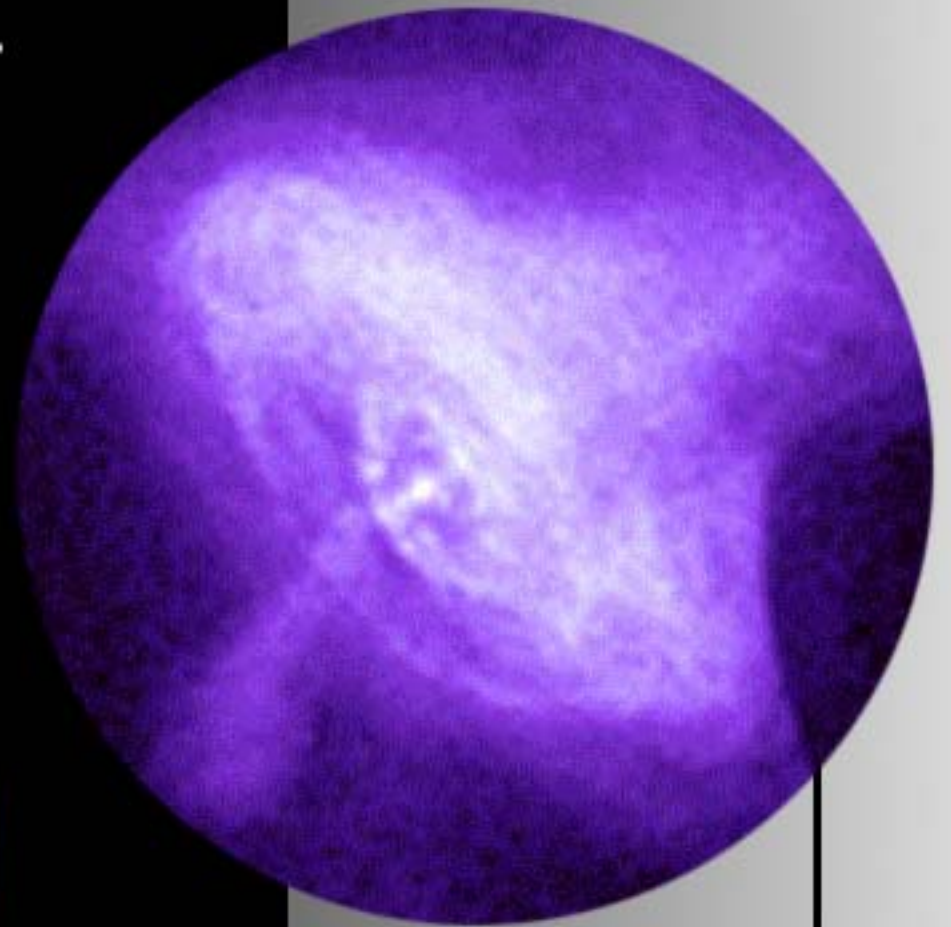
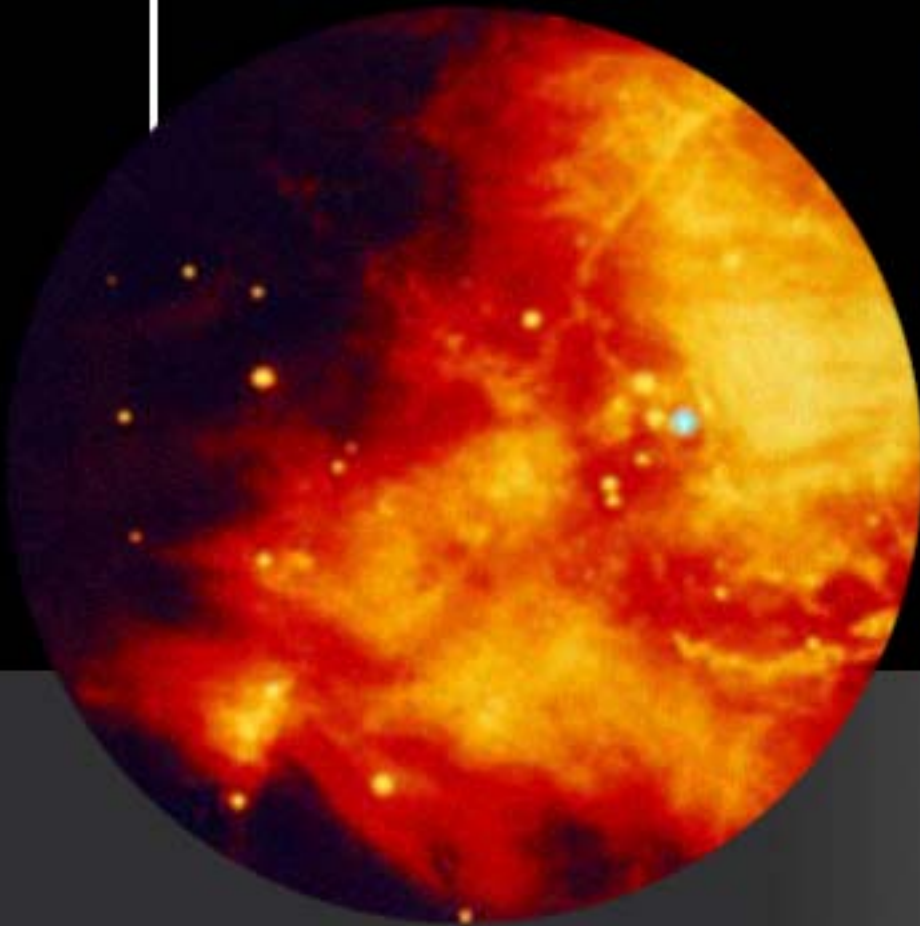
Masatoshi Koshihara



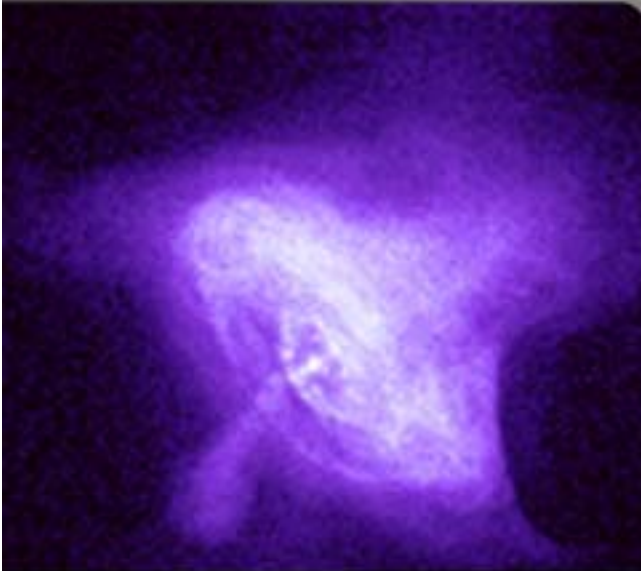
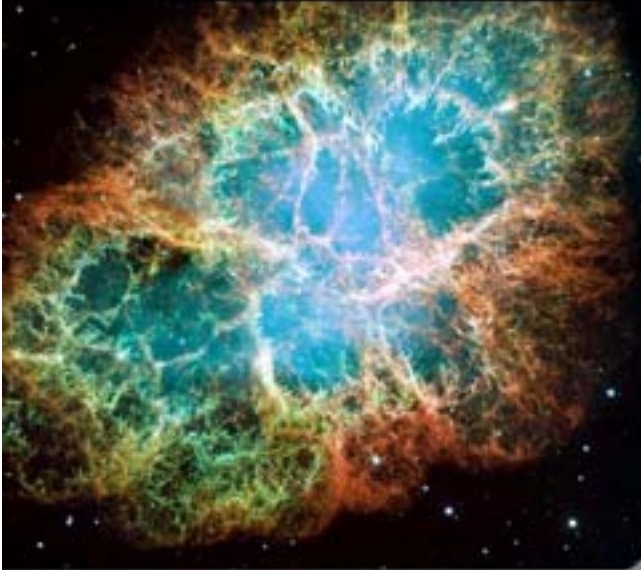
**Neutrinoastronomie:
ein neues Fenster zum Universum**



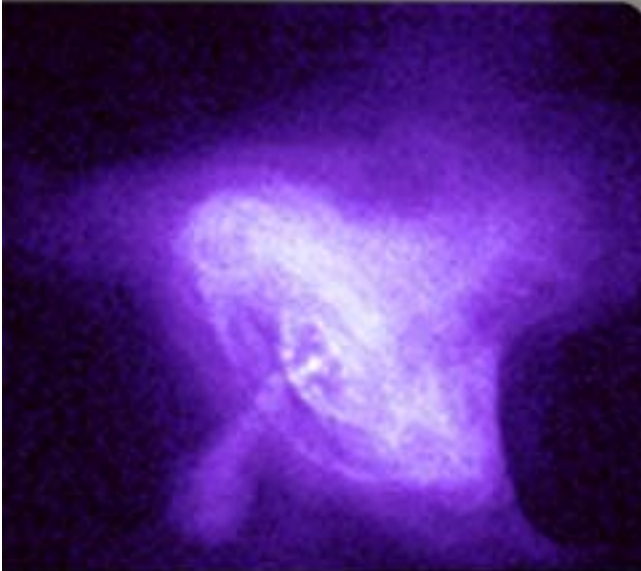
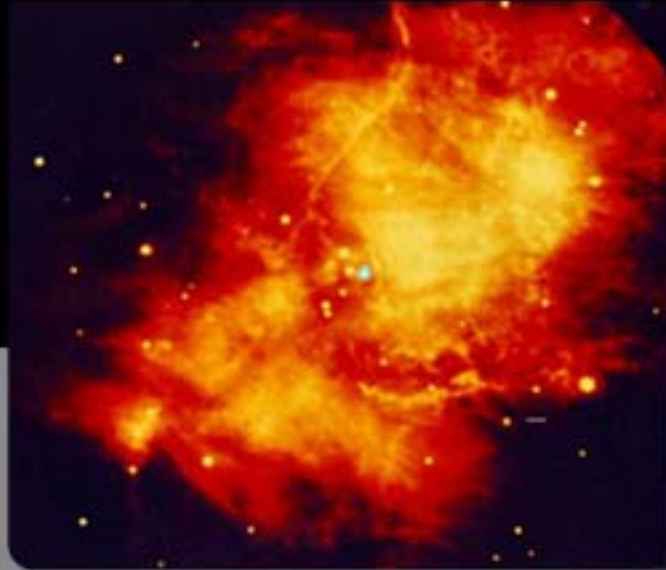
**Infrarot-
strahlung**



**Röntgen-
strahlung**



Neutrinos?

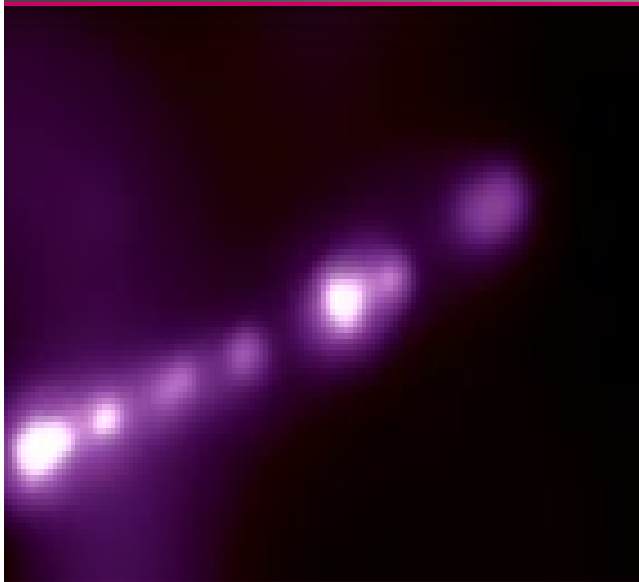
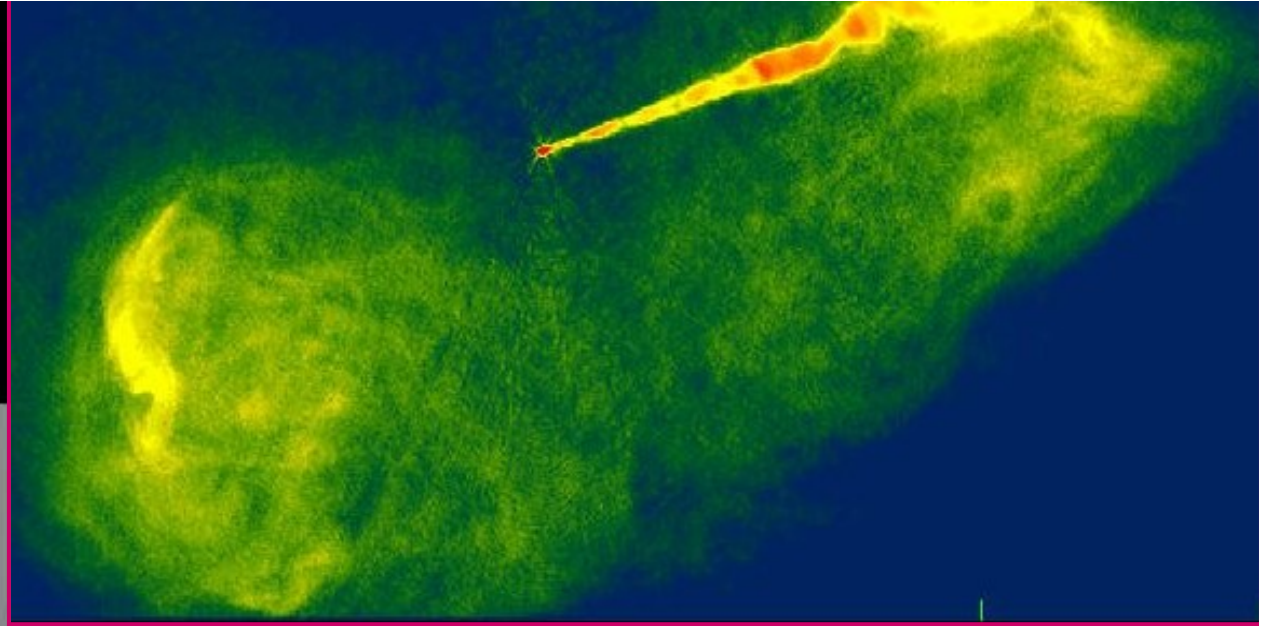
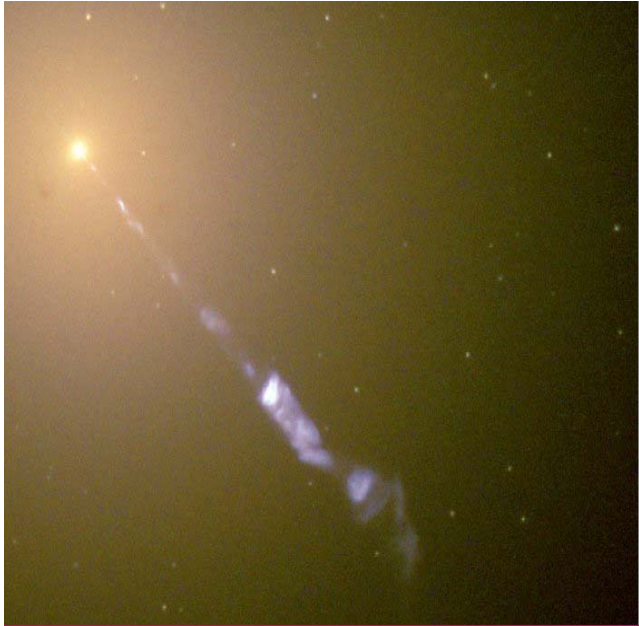


Neutrinos:
Ist dies die Quelle der
kosmischen Strahlung?

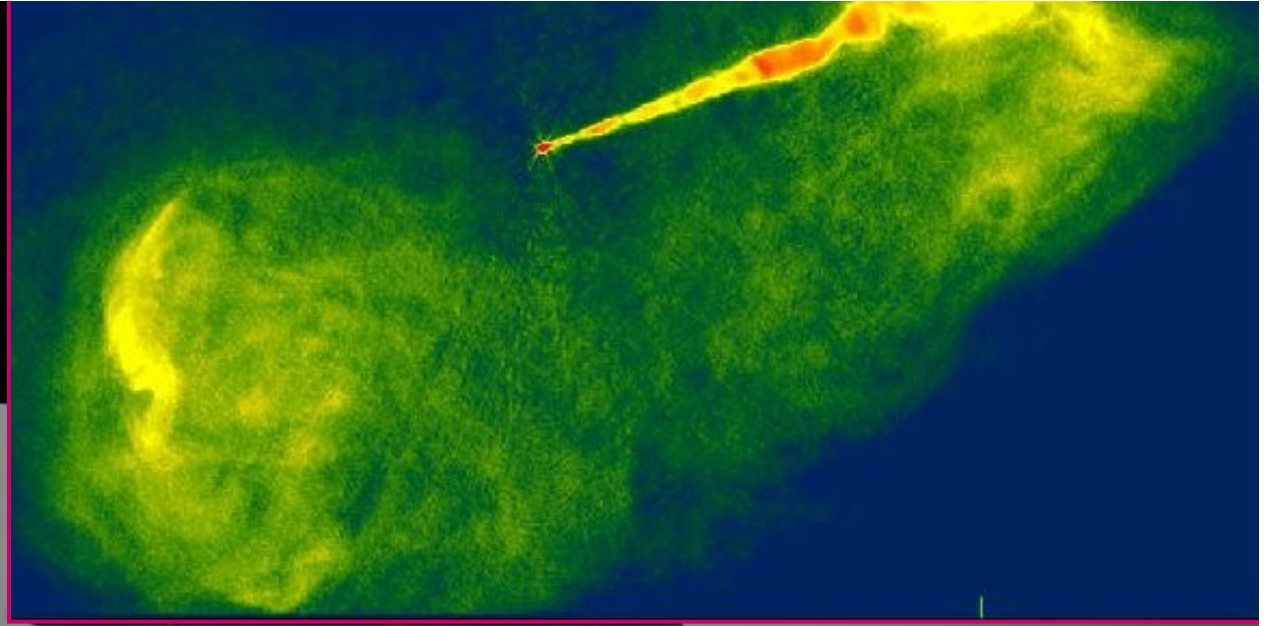
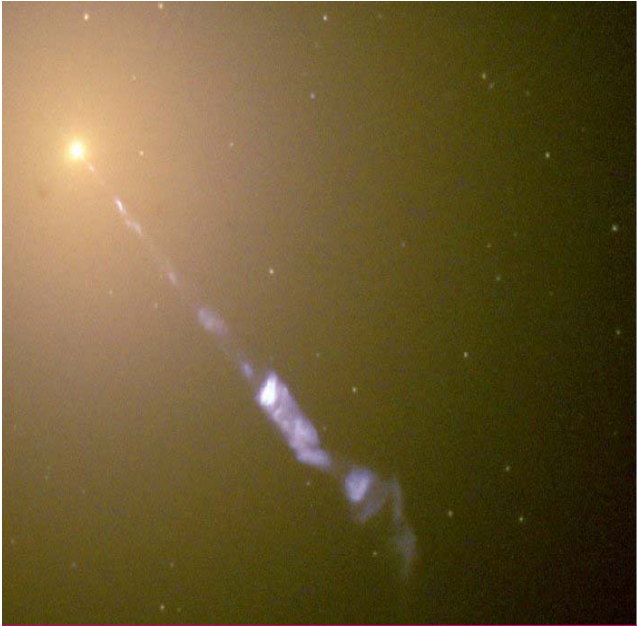
Die Aktive Galaxie M87: Im Zentrum ist ein
supermassives Schwarzes Loch
ca. 100.000.000 Sonnen



M87



Neutrinos?



Neutrinos:

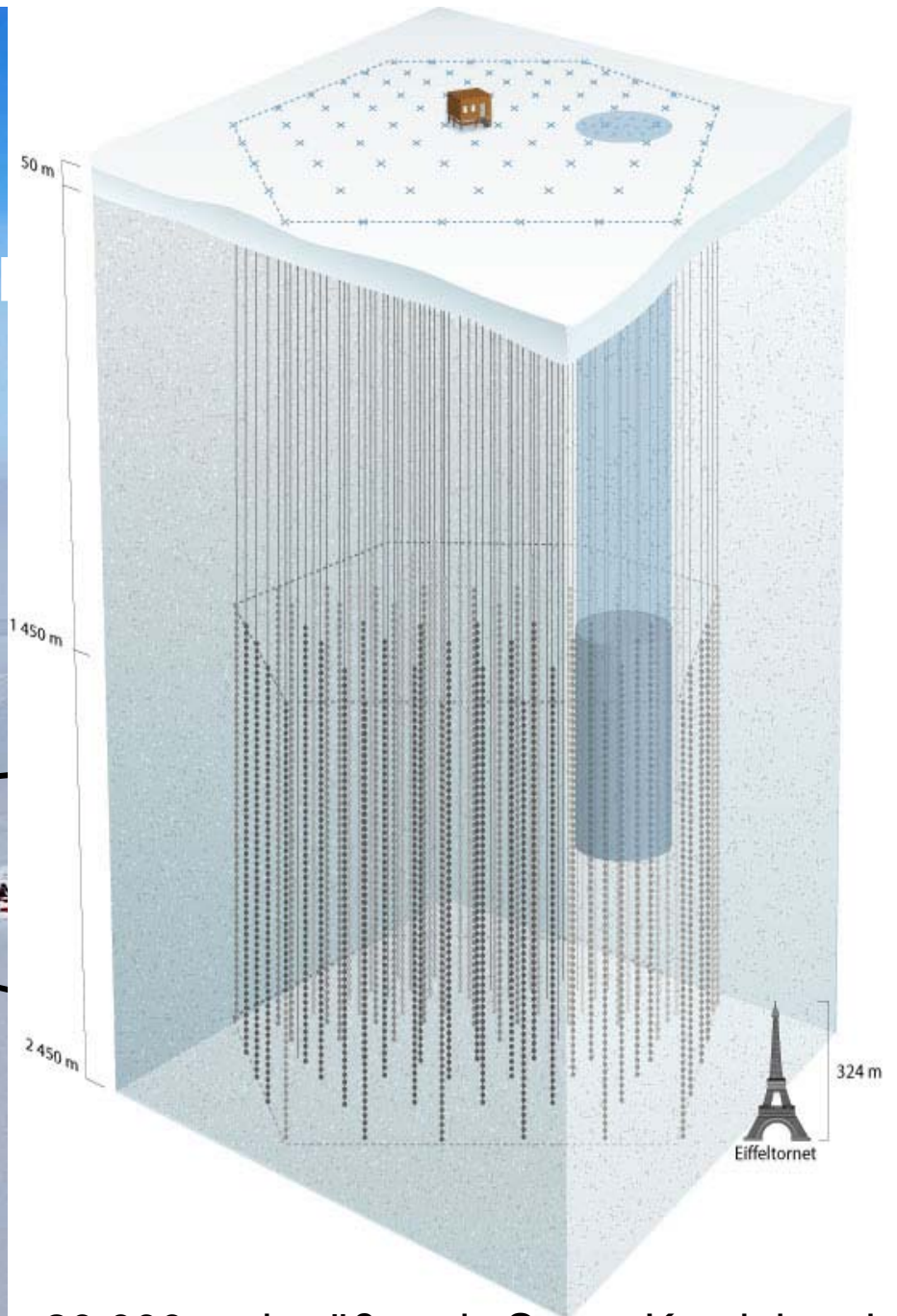
- Werden Protonen beschleunigt ?
- Was sind die Mechanismen ?
- Sind es die Teilchen die ständig aus dem Weltall auf die Erdatmosphäre auftreffen ?

**Neutrino-Detektoren:
je größer, desto besser**

IceCube: ein Kubikkilometer großer Neutrinodetektor



IceCube: ein Kubikkilometer großer Neutrinodetektor



20.000 mal größer als Super-Kamiokande

IceCube: ein Kubikkilometer großer Neutrinodetektor



Heiß-Wasser Bohrer

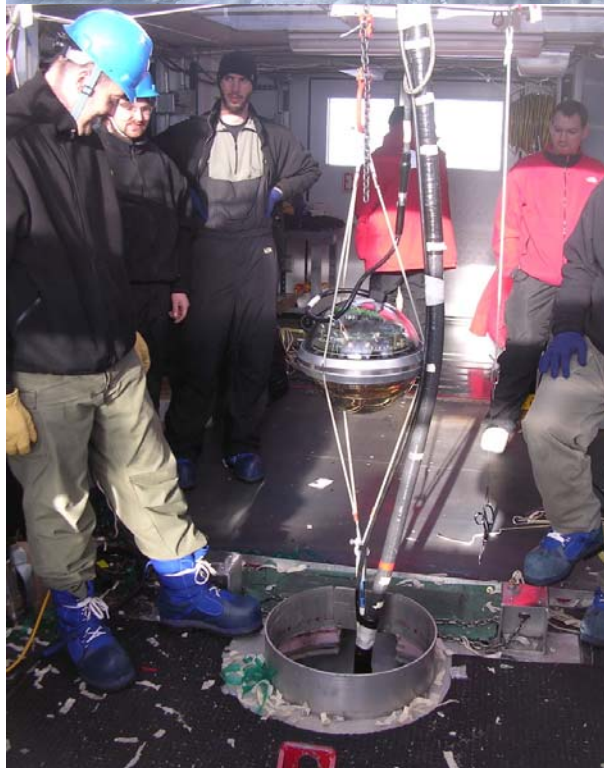
2 MW Leistung
3-4 Tage / 2 km



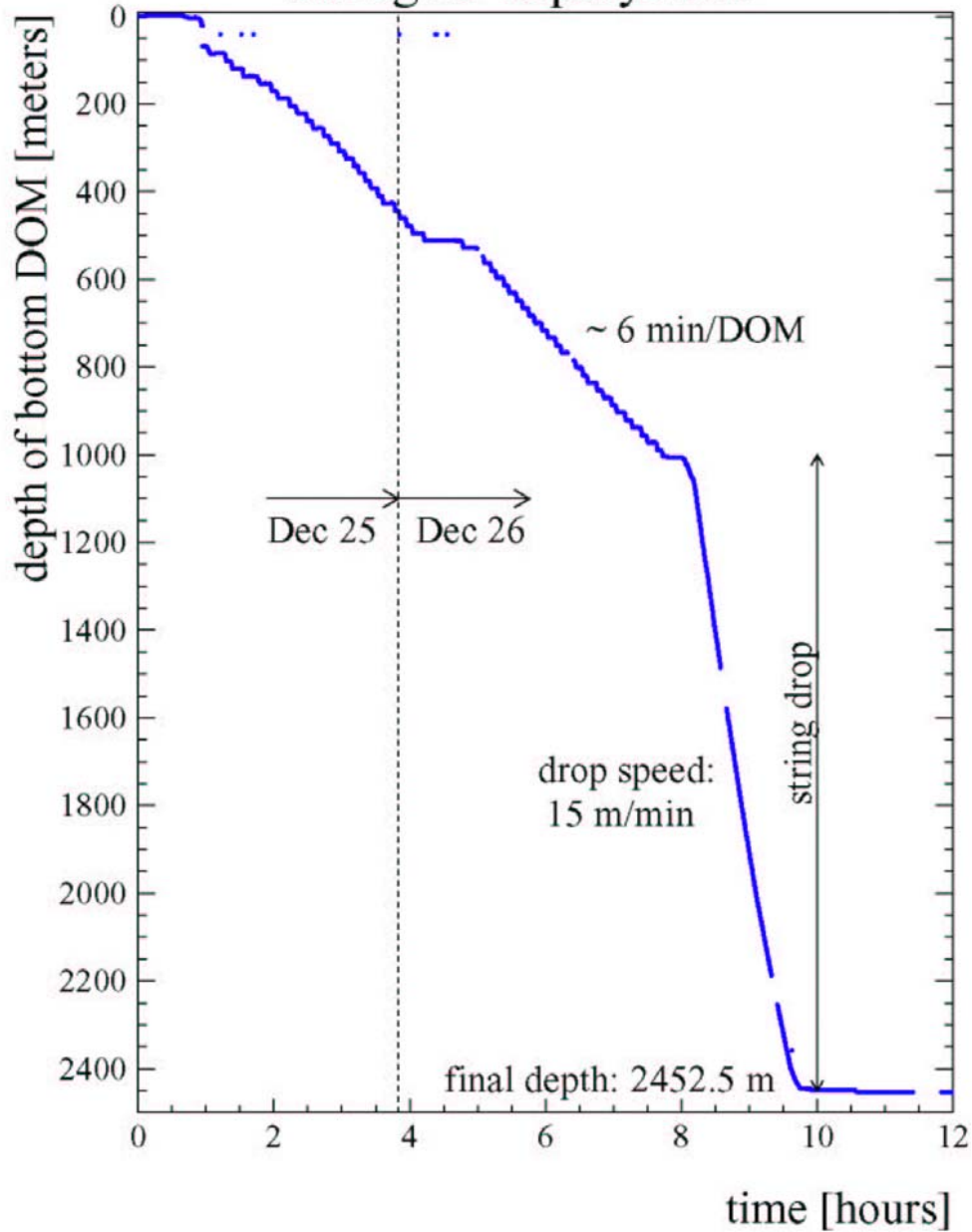
60 cm Loch



String cable 2500 m Weight ~6 tons



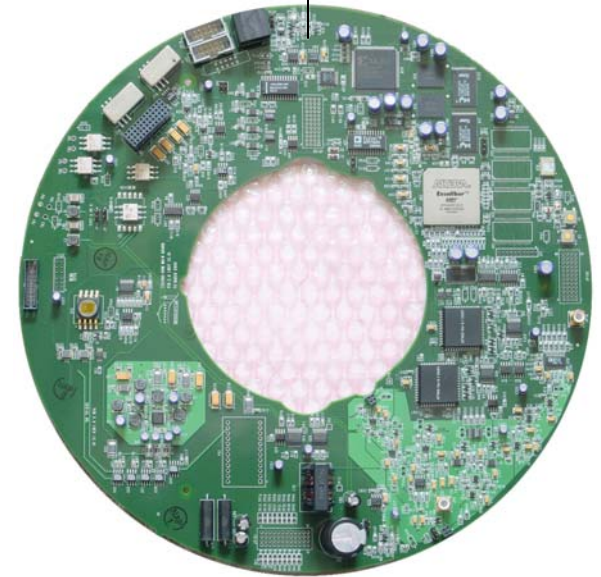
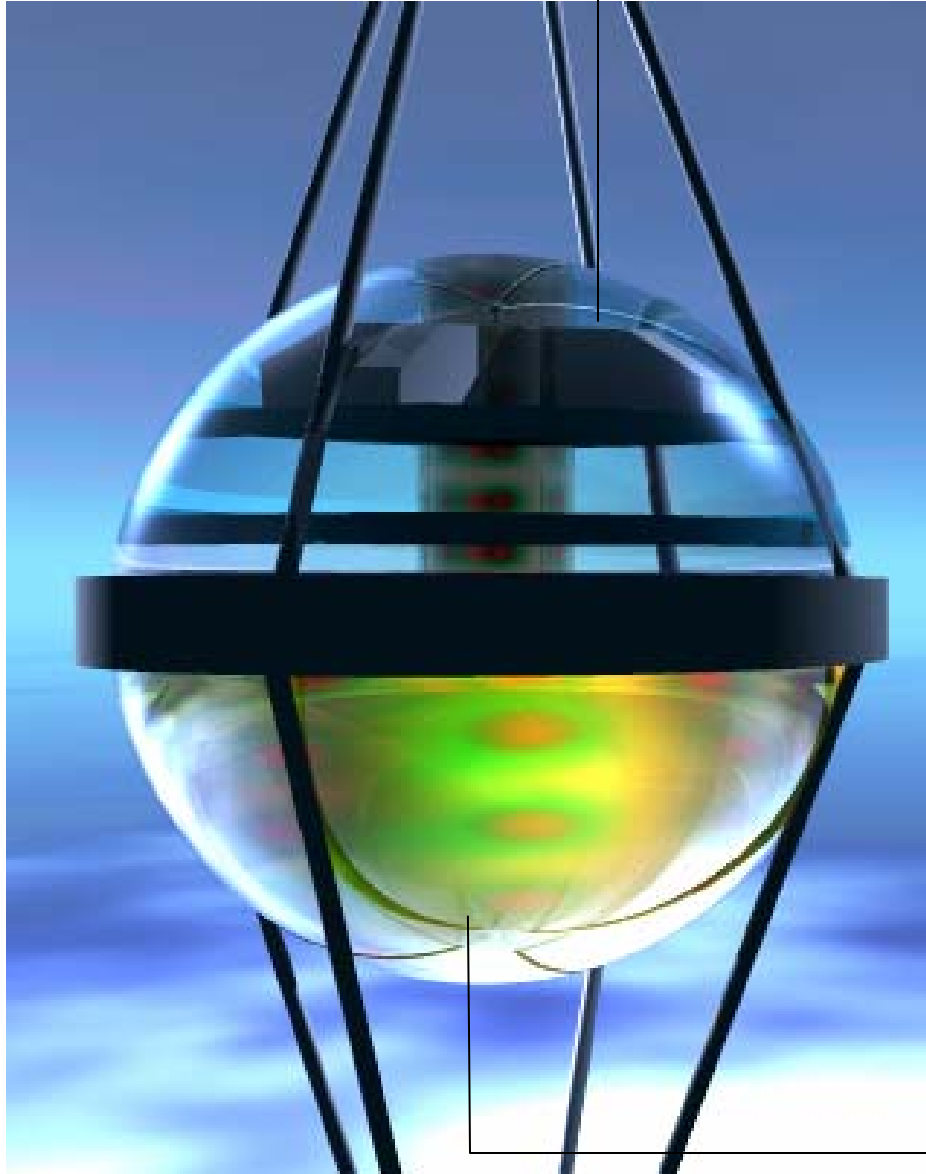
String 29 deployment





Optischer Sensor beginnt die 2500 m Talfahrt

Digitale Ausselelektronik



Photonvervielfacher Röhre

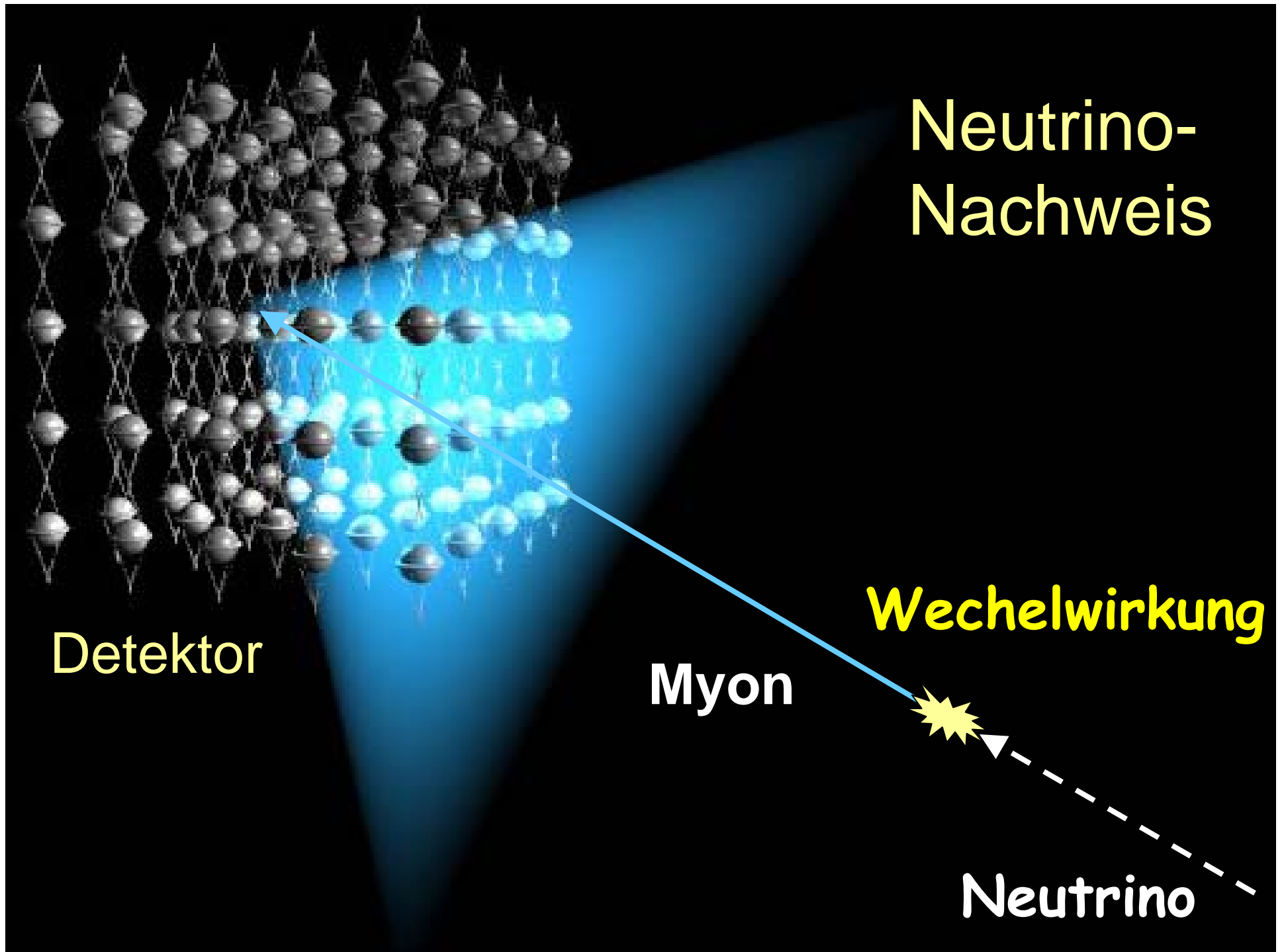
Neutrino- Nachweis

Wechselwirkung

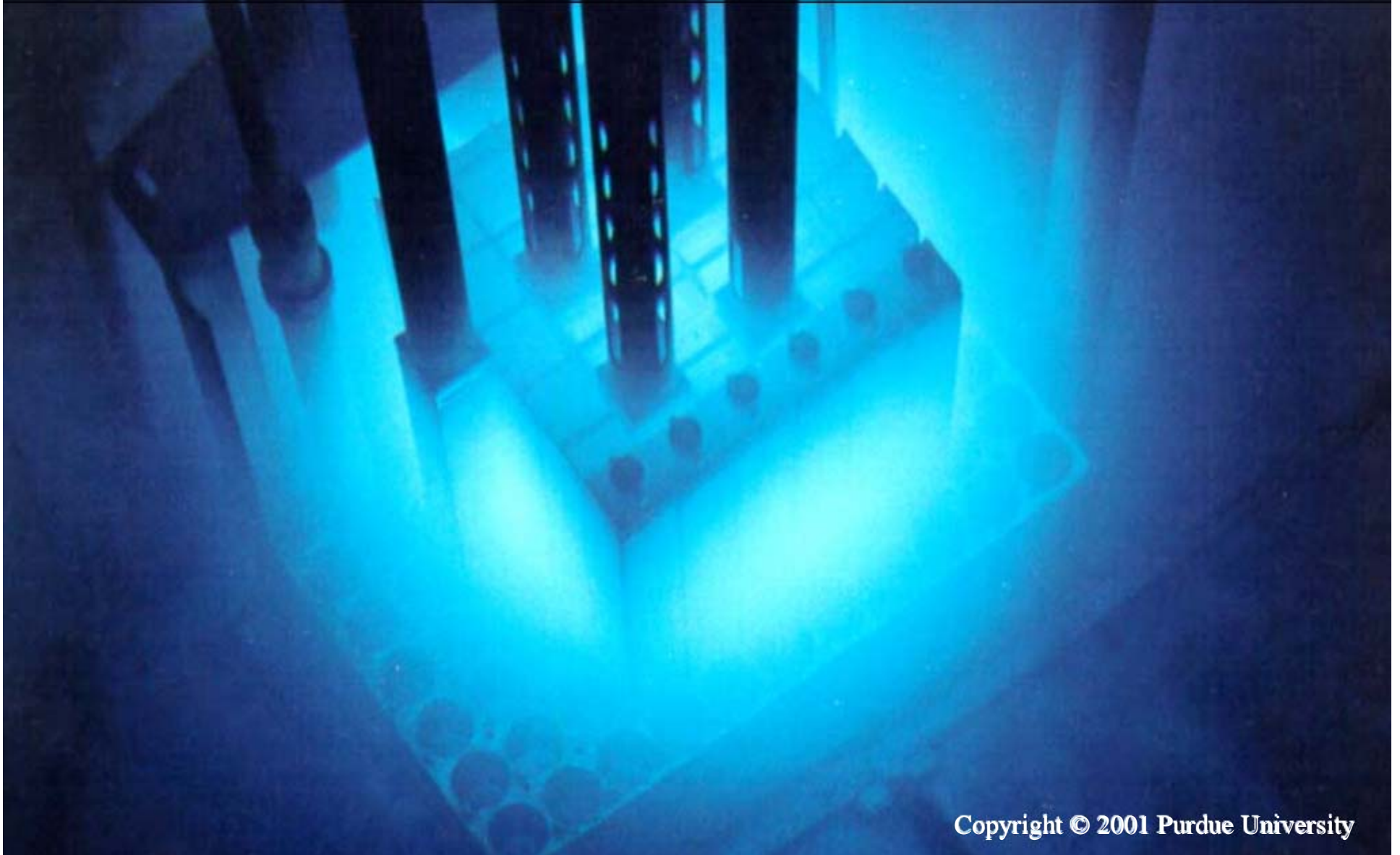
Myon

Neutrino

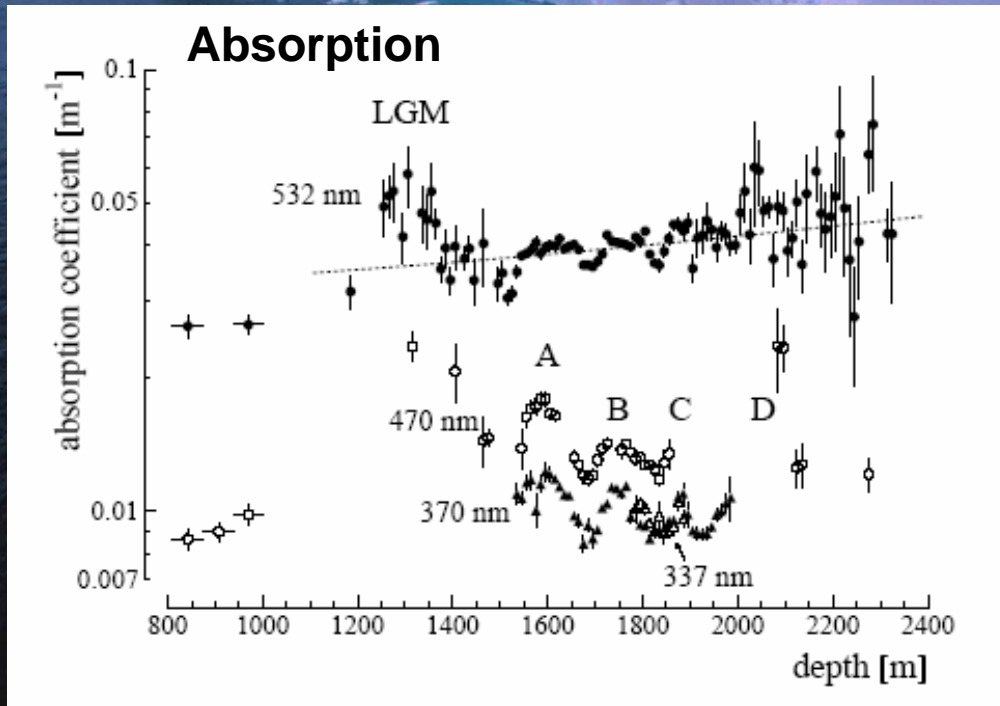
Detektor

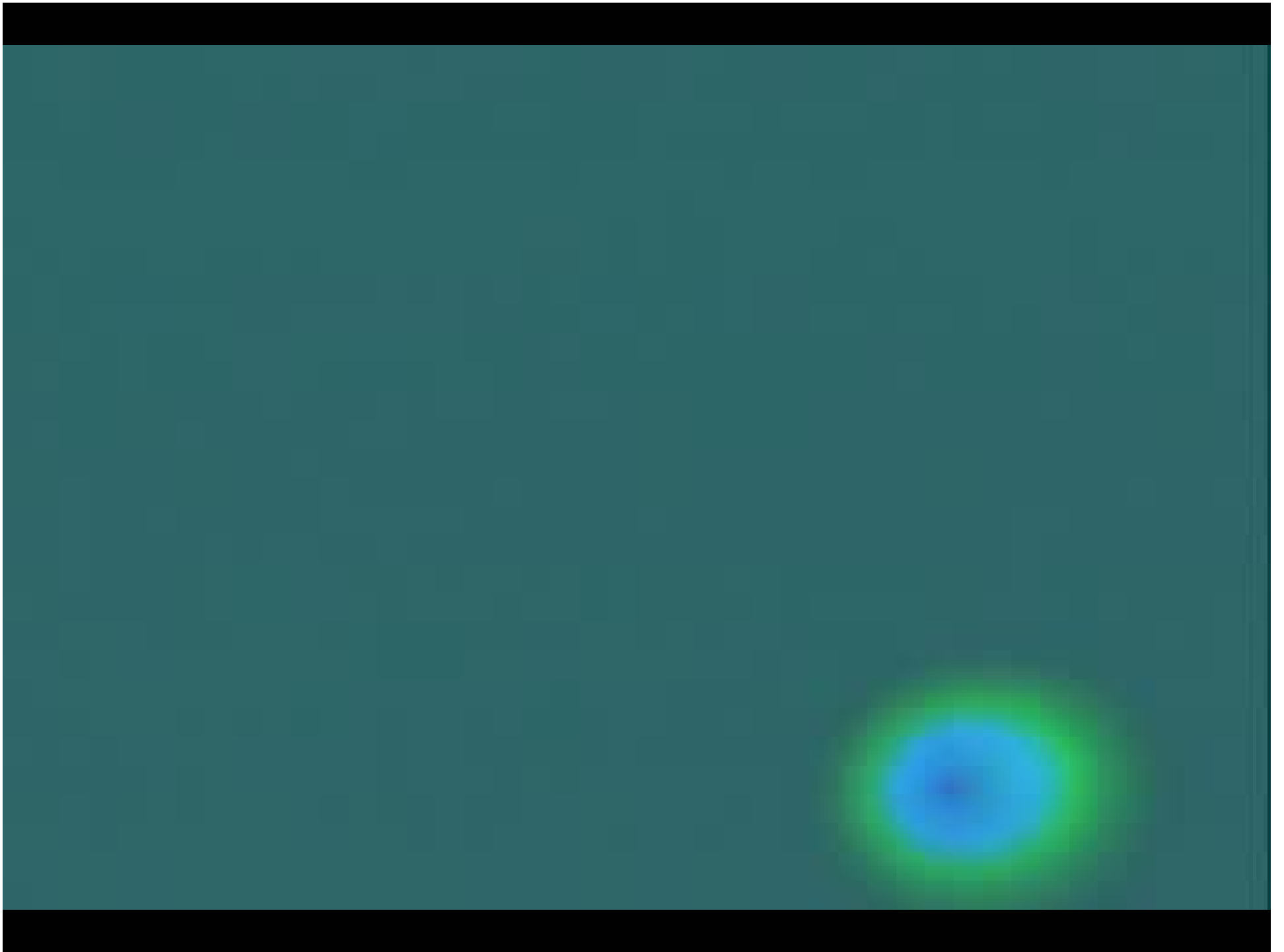


Freigesetzte Elektronen in einem Nuklearreaktor produzieren Cherenkov-Licht

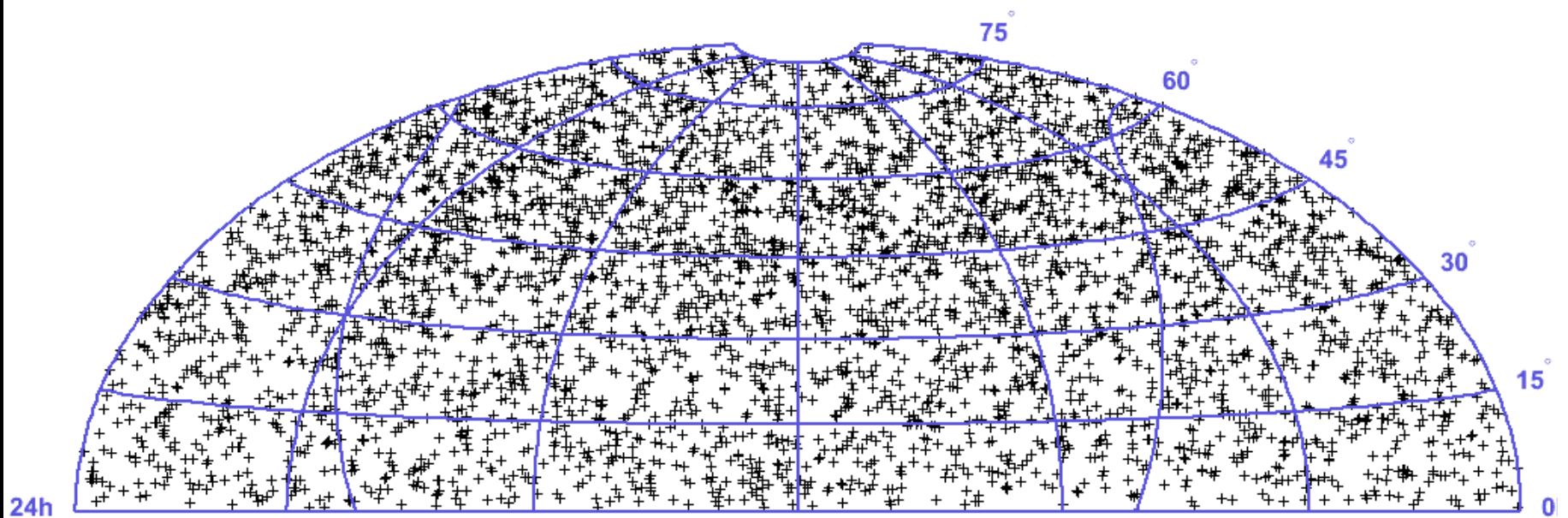


Das Eis in 2 km Tiefe ist sehr transparent

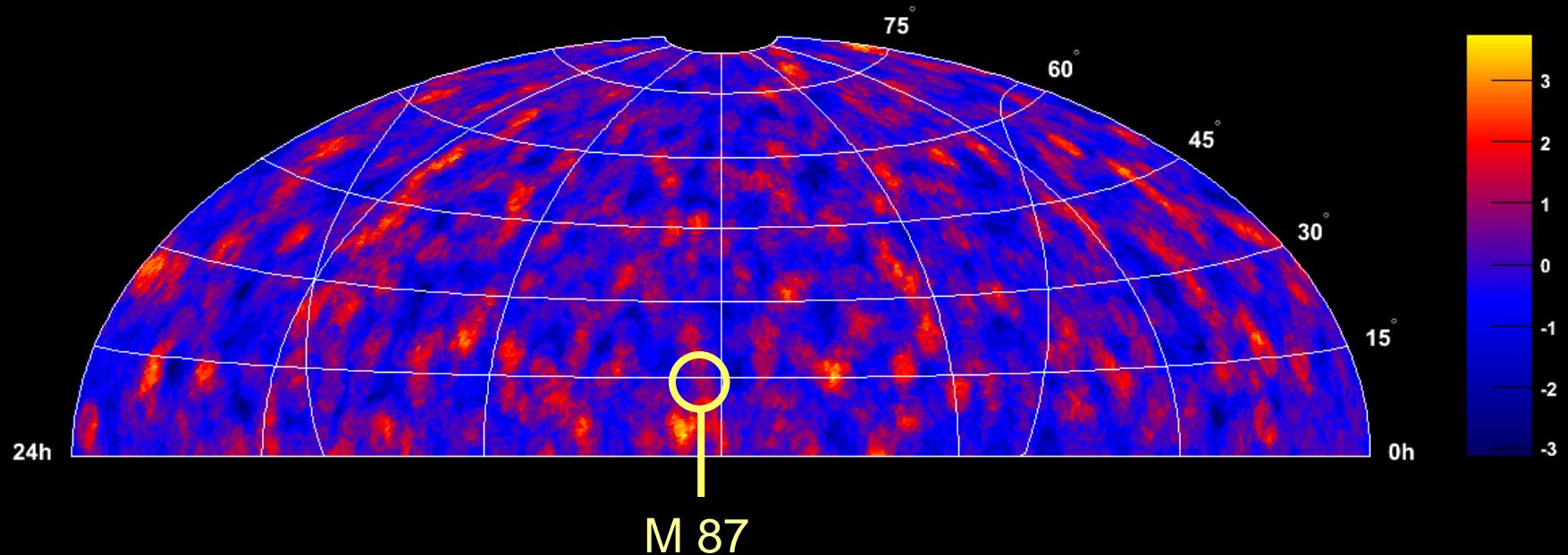




Neutrinos von AMANDA (2000-2004)



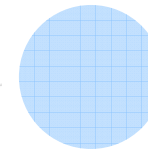
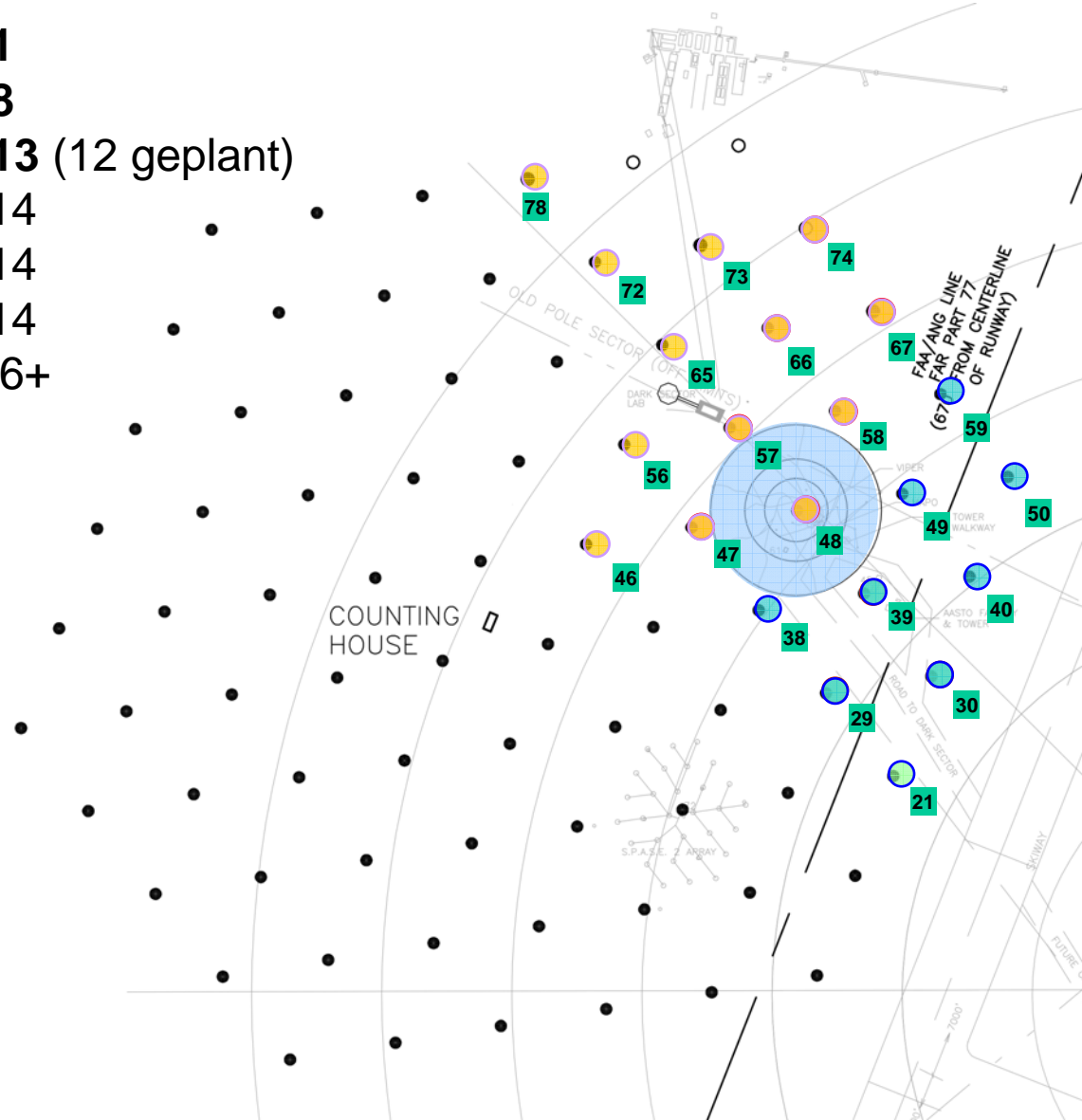
Statistische Auswertung der AMANDA Neutrinos



Noch kein kein Anzeichen für eine Neutrinoquelle gefunden!

Der IceCube Detektor

2005: 1
2006: 8
2007: 13 (12 geplant)
2008: 14
2009: 14
2010: 14
2011: 6+



AMANDA 01/ 2000



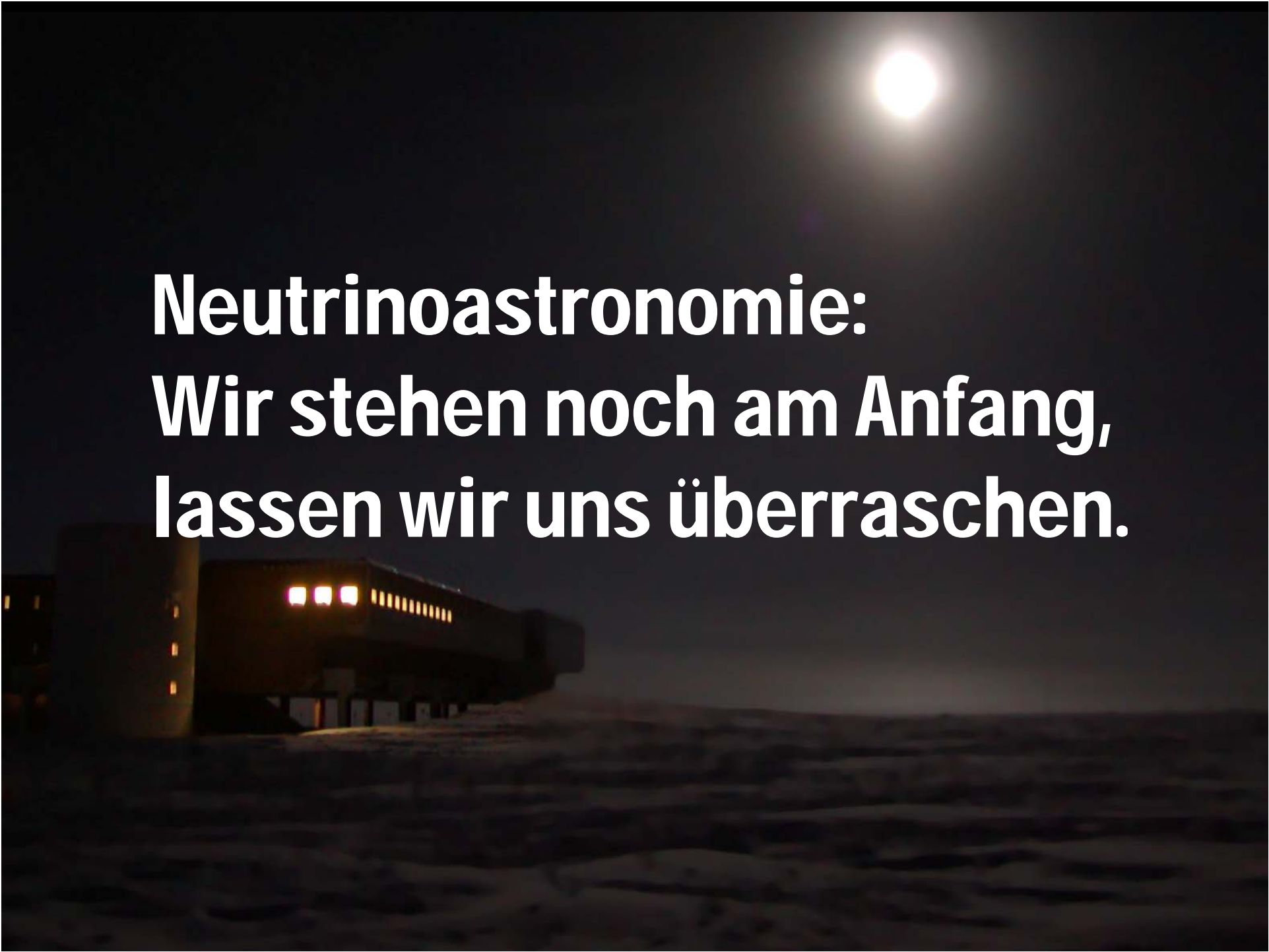
IceCube string und
IceTop station 01/05



IceCube string und
IceTop station 01/06



IceCube string und
IceTop station 02/07



**Neutrinoastronomie:
Wir stehen noch am Anfang,
lassen wir uns überraschen.**

Gute Nacht!

