

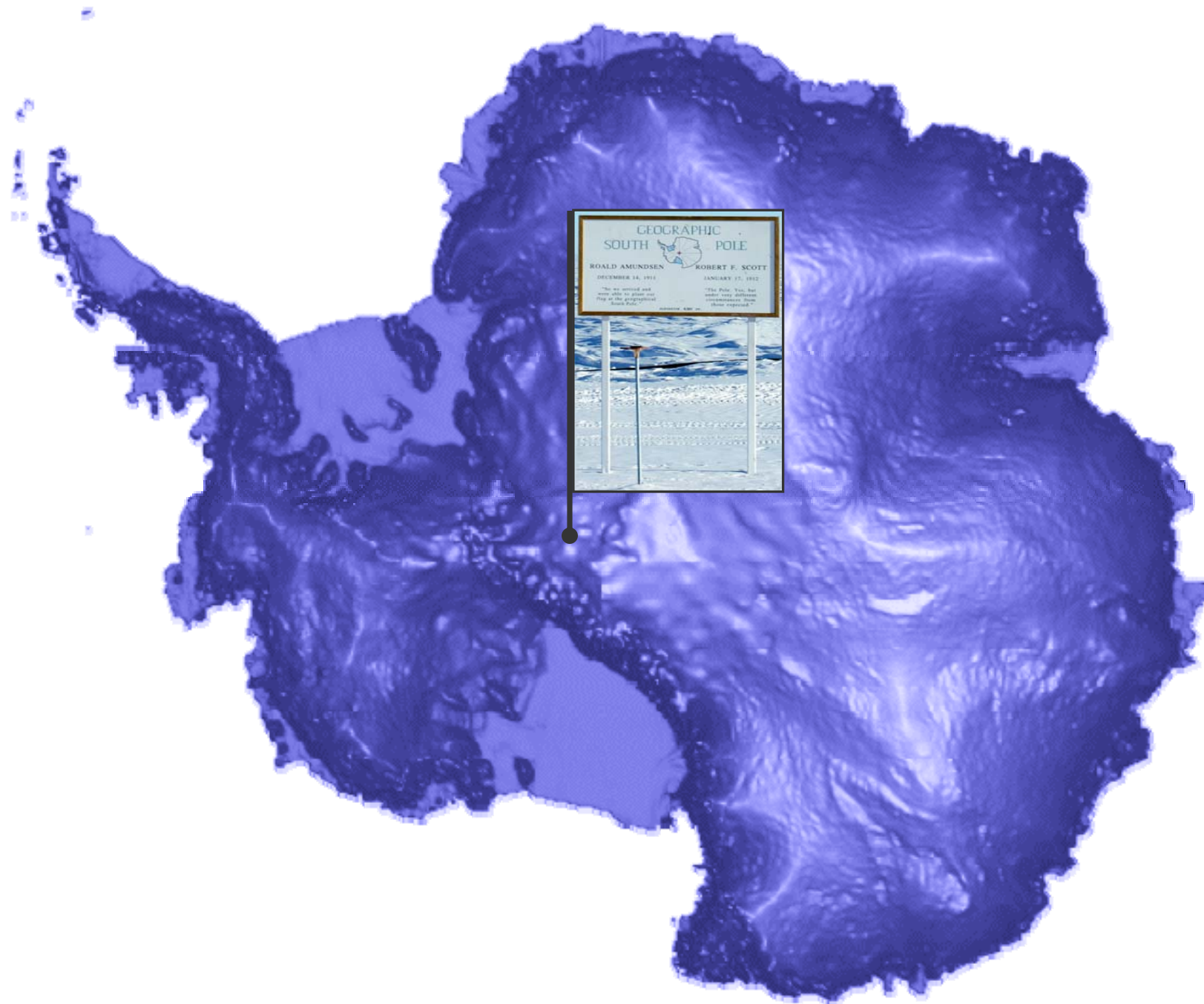
Neutrinojagd am Südpol



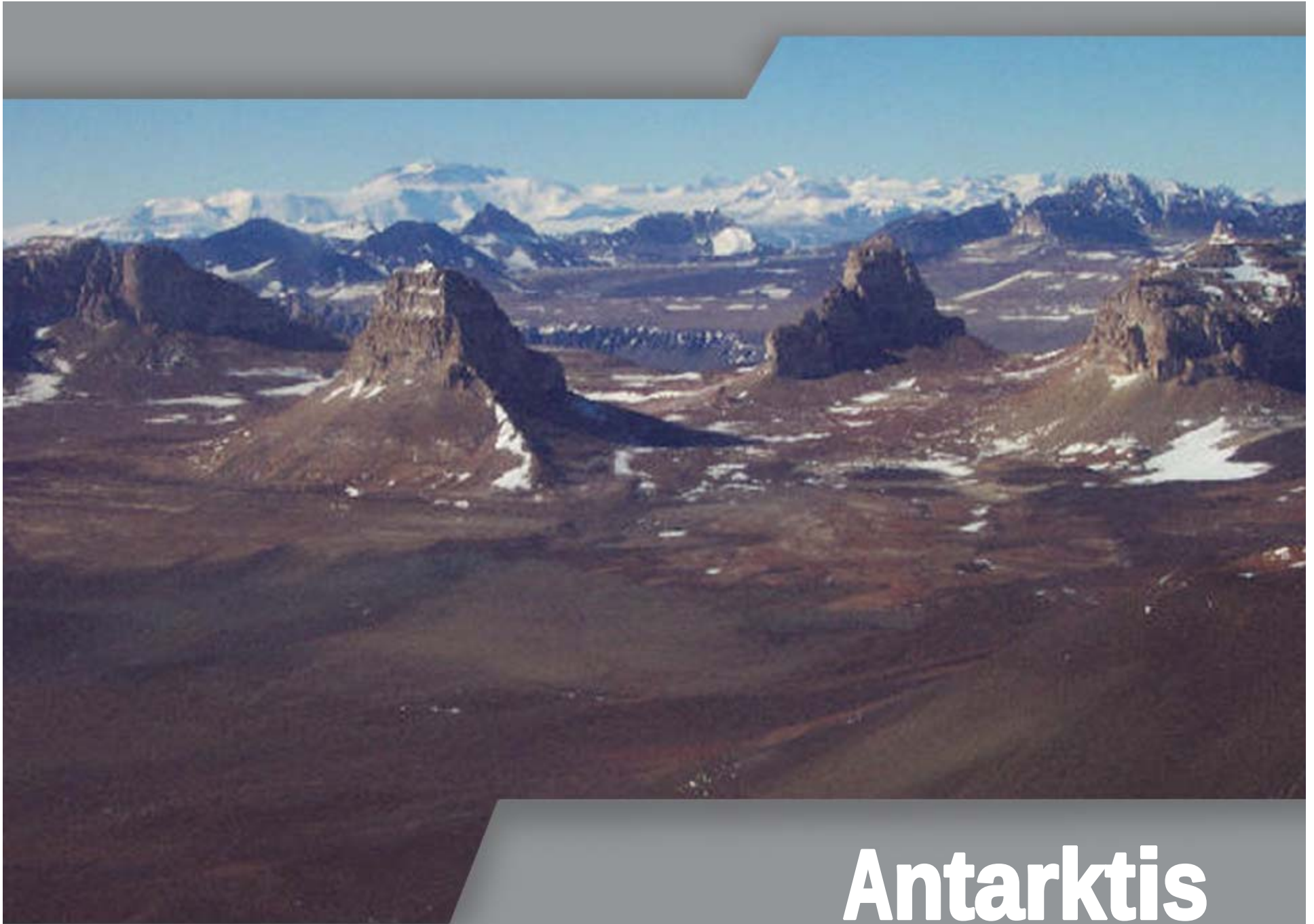
Marek Kowalski

Humboldt-Universität





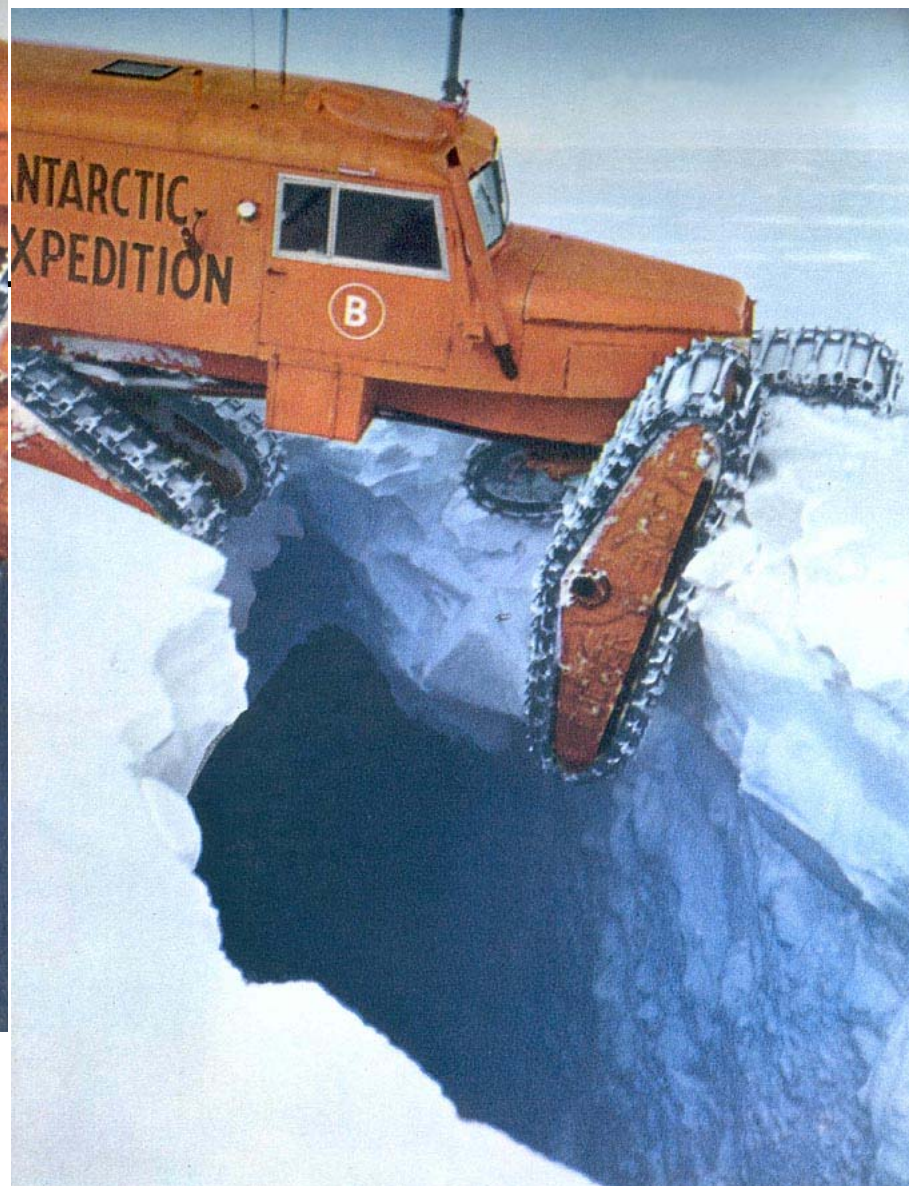
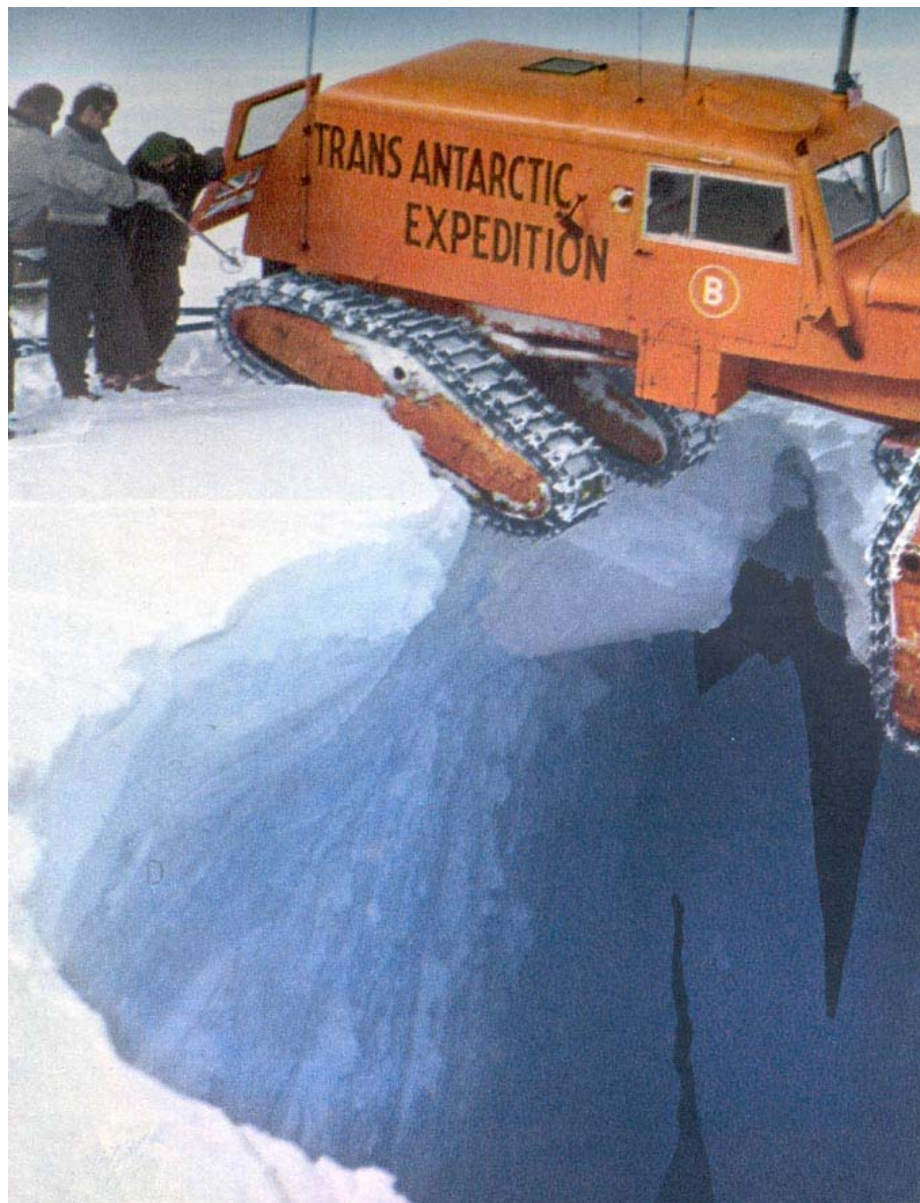




Antarktis









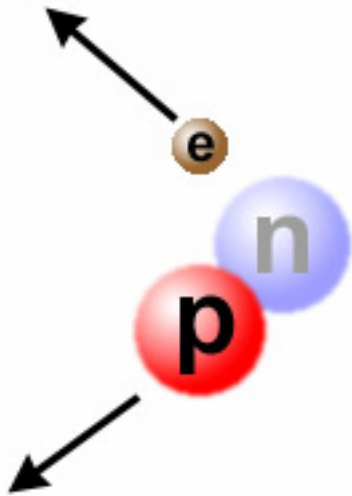


Die neue Südpol-Station





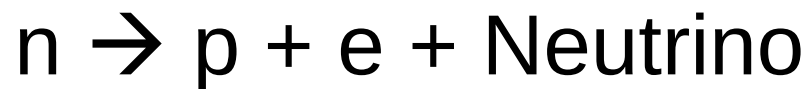
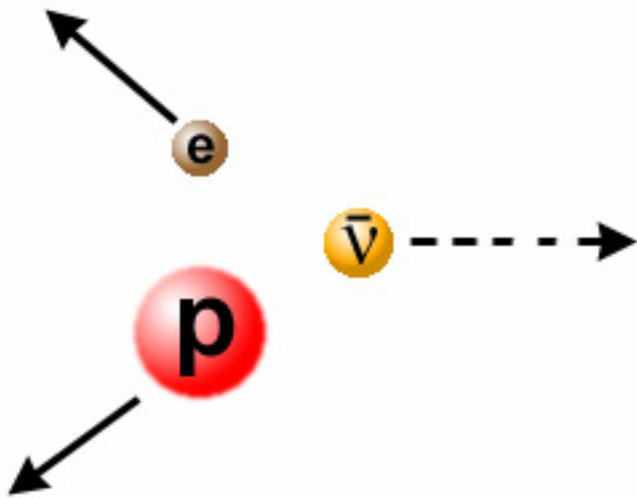
Woraus besteht die Welt?



- 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:

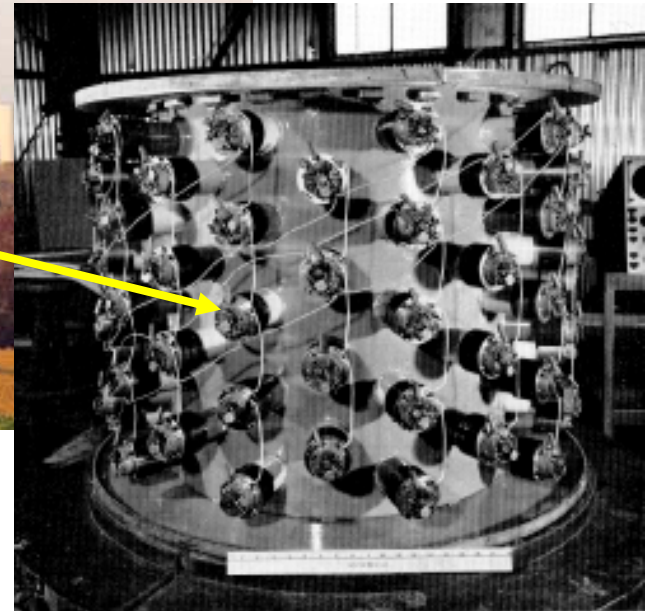
„Um den Energiesatz zu retten, bin ich einem verzweifelten Ausweg verfallen.“

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

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

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

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

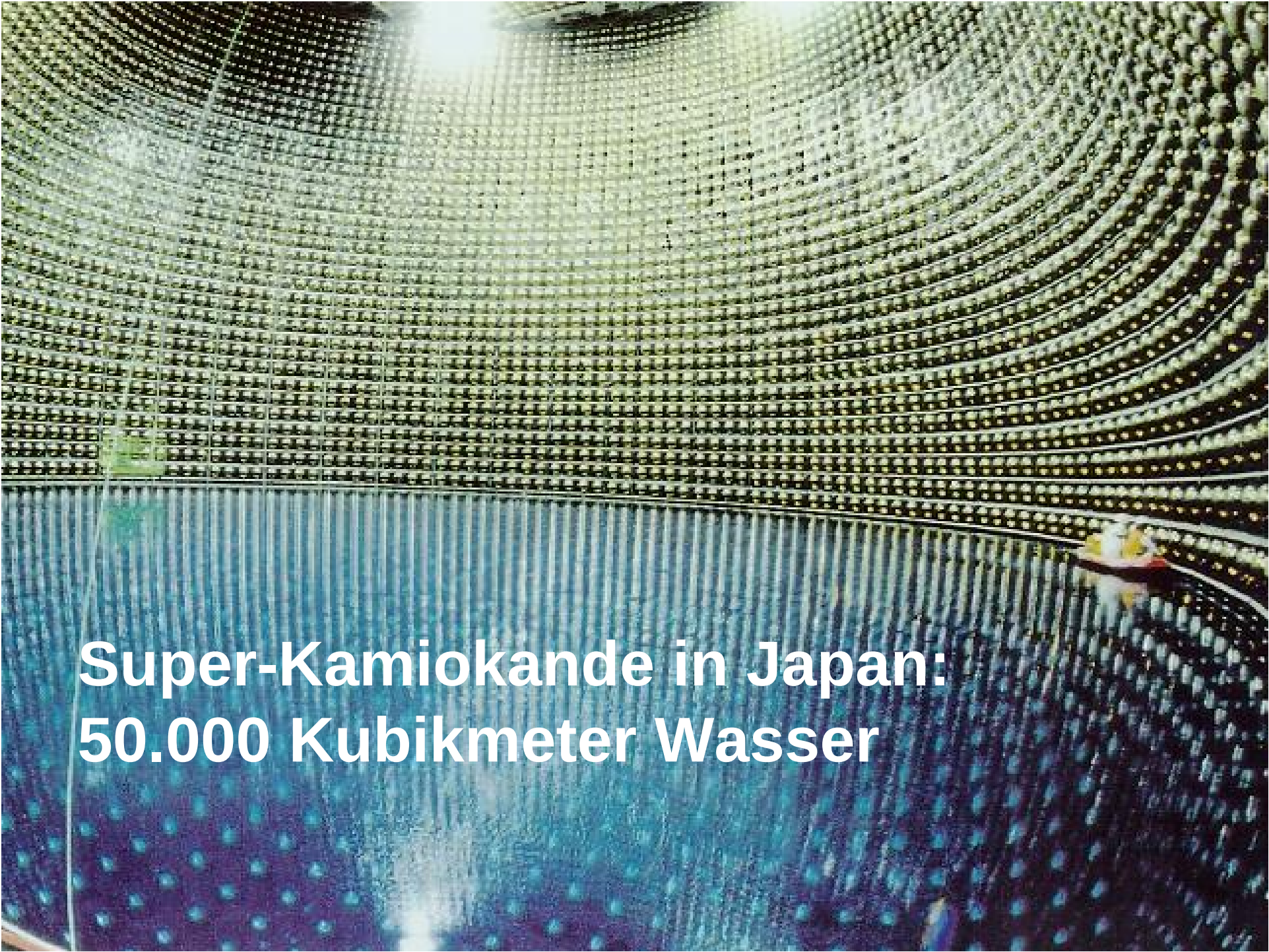
$$E_\nu \sim 0.3 - 30 \text{ GeV}$$





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



The image shows the interior of the Super-Kamiokande detector, a large cylindrical tank filled with water. The walls of the tank are lined with thousands of photomultiplier tubes (PMTs) arranged in a grid pattern, designed to detect light flashes from neutrino interactions. The water is clear and blue, and the overall structure is massive and circular. A small boat or platform is visible on the right side of the tank.

Super-Kamiokande in Japan: 50.000 Kubikmeter Wasser

Unsere Sonne, gesehen mit Neutrinos

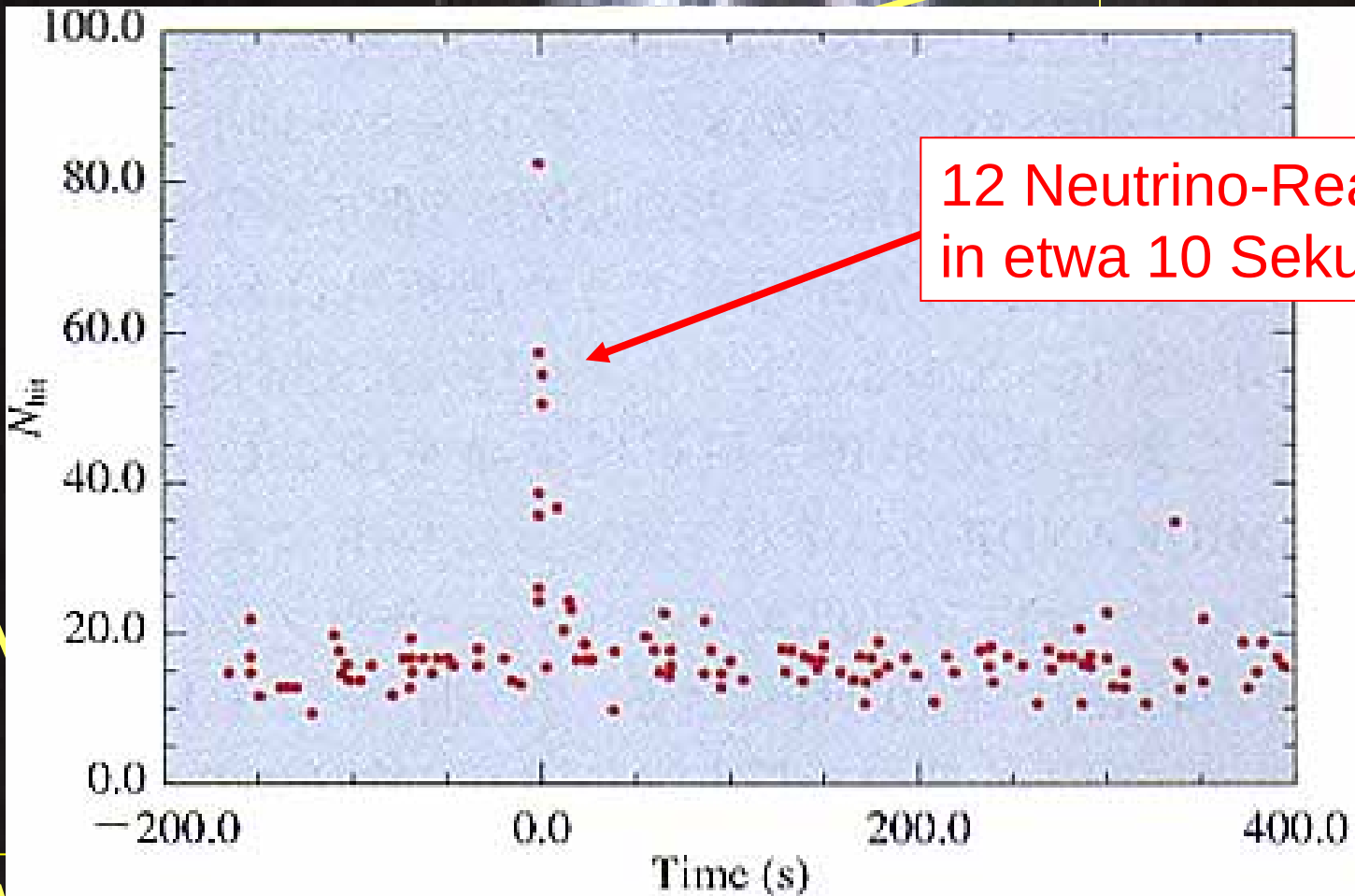


Supernova 1987A in der Großen Magellanschen Wolke



23.2.1987

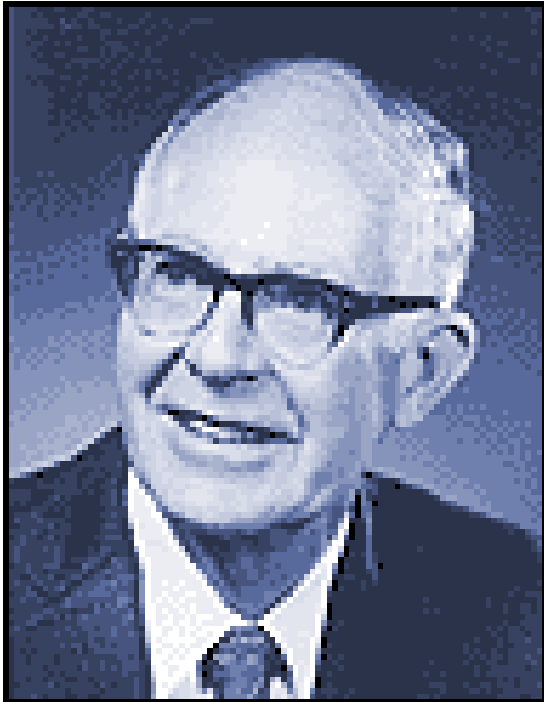
Sonne



12 Neutrino-Reaktionen
in etwa 10 Sekunden

**Magellan'sche
Wolken**

Nobelpreise 2002: 2x für Neutrinoastronomie



Raymond Davis jr.

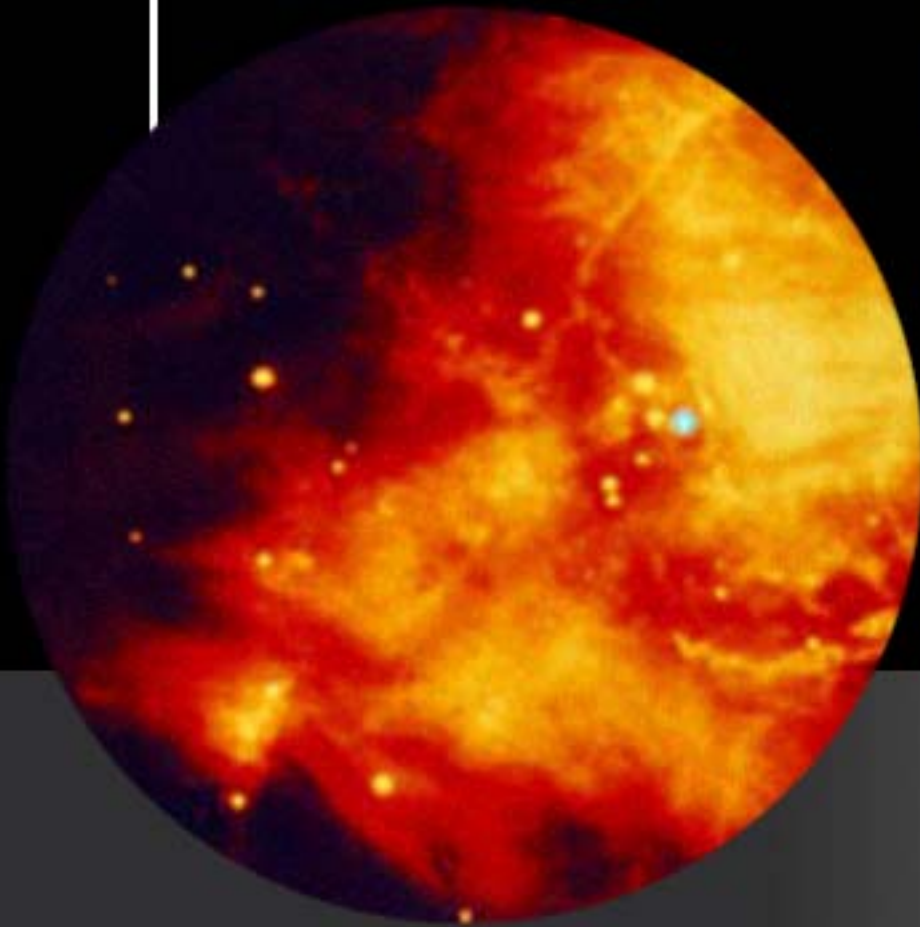


Masatoshi Koshihara

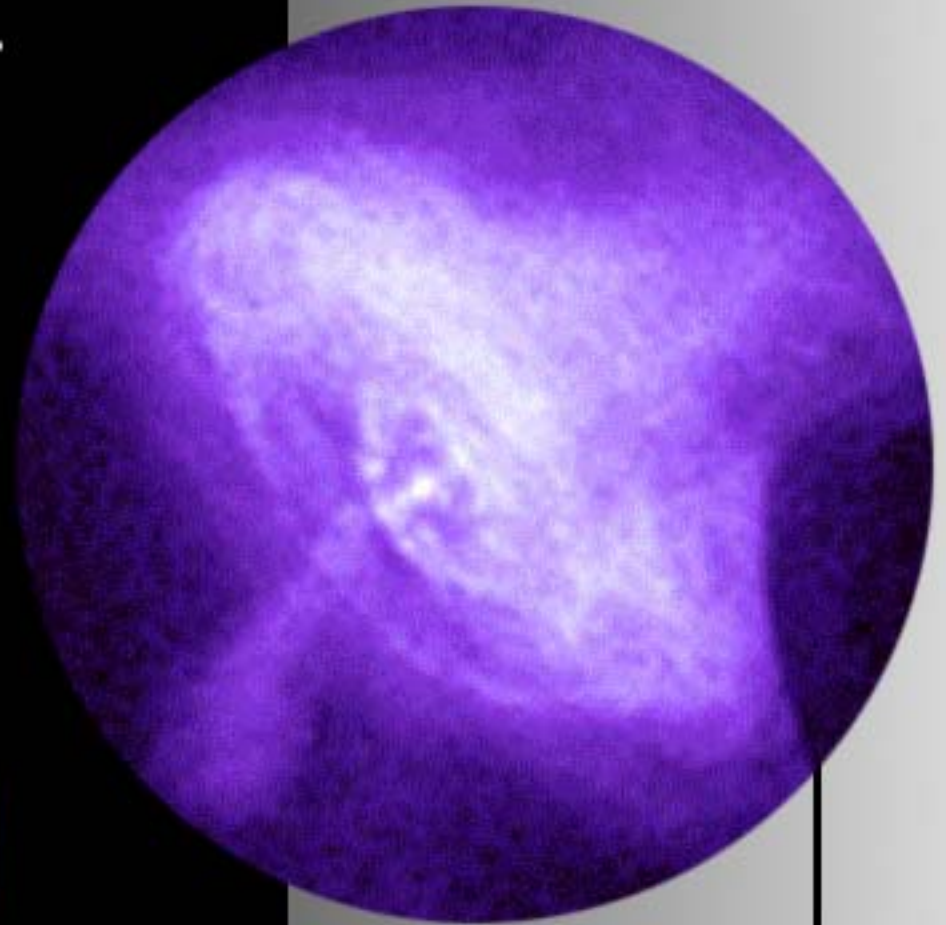
The background is a solid dark grey or black. There are two horizontal bars of a lighter grey color. The top bar is positioned in the upper third of the image and has rounded corners on its left side. The bottom bar is positioned in the lower third of the image and has rounded corners on its right side. The text is centered between these two bars.

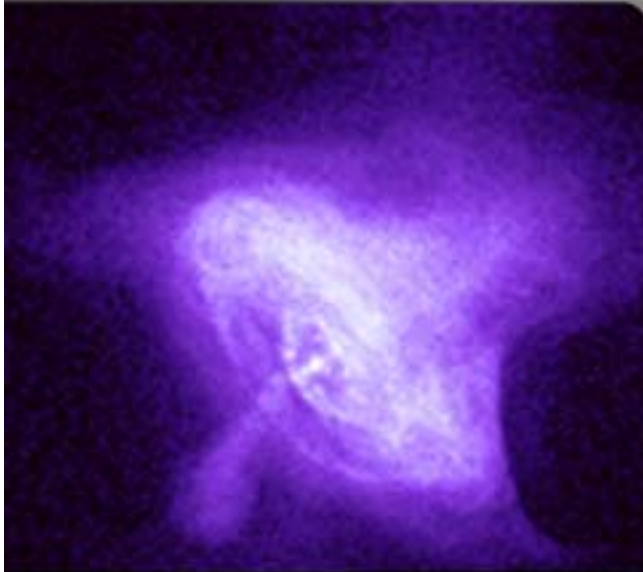
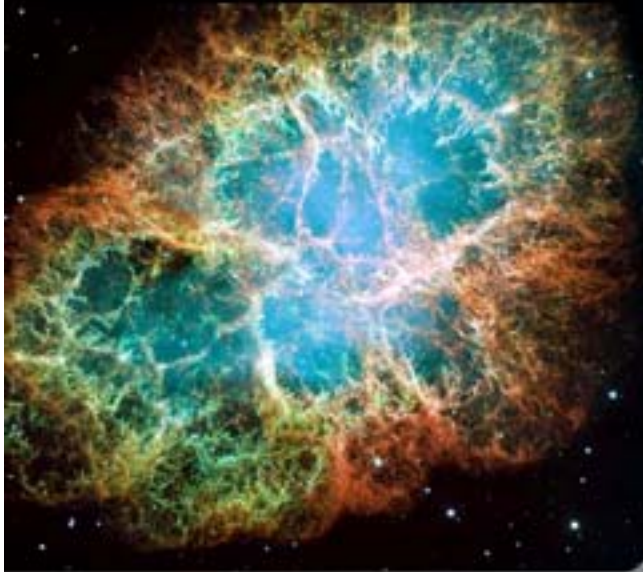
Neutrinoastronomie: ein neues Fenster zum Universum

**Infrarot-
strahlung**

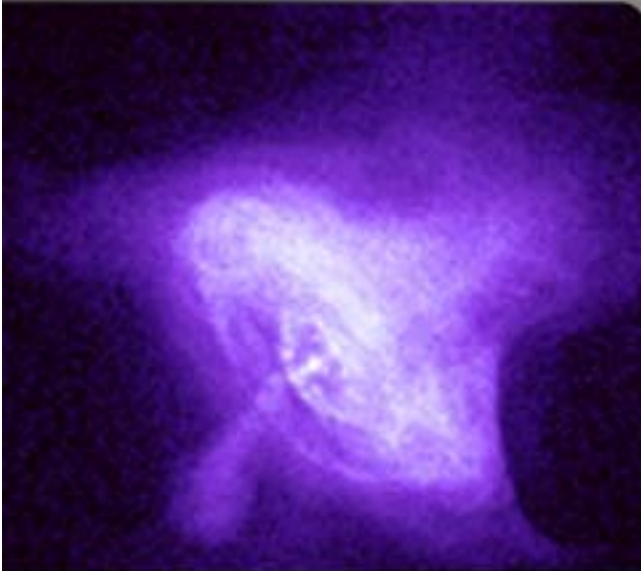
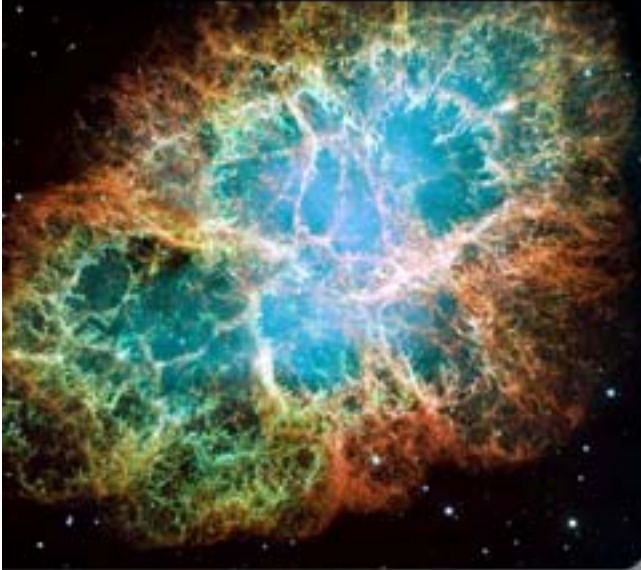


**Röntgen-
strahlung**





Neutrinos?

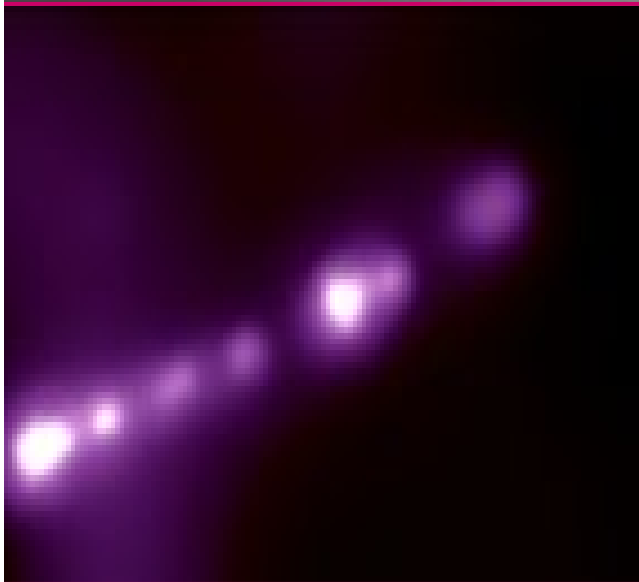
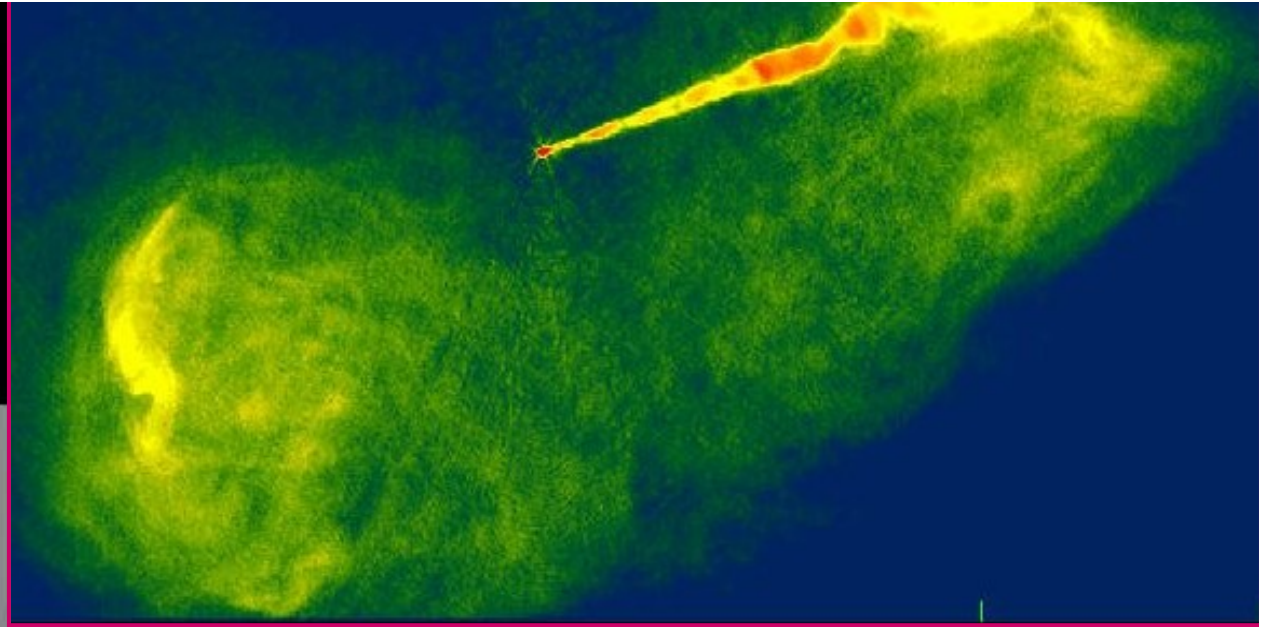
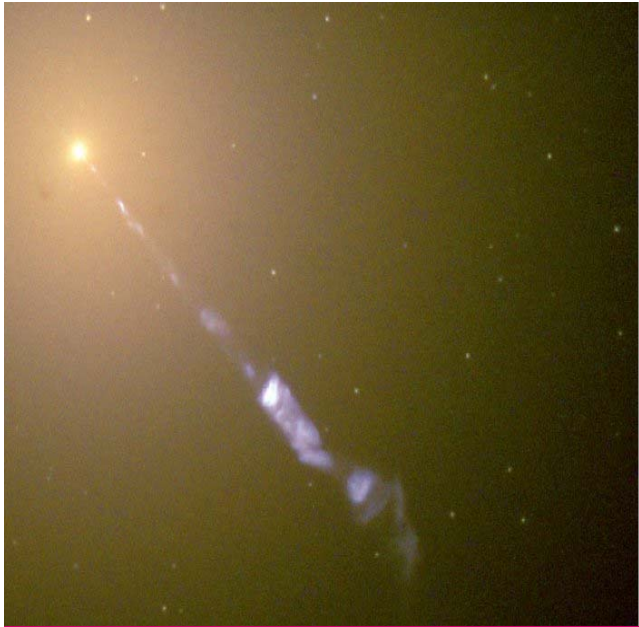


Neutrinos:
Ist dies die Quelle der
kosmischen Strahlung?

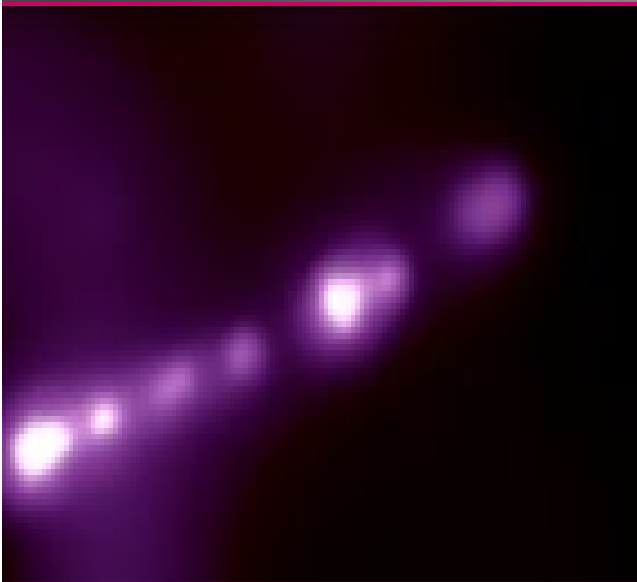
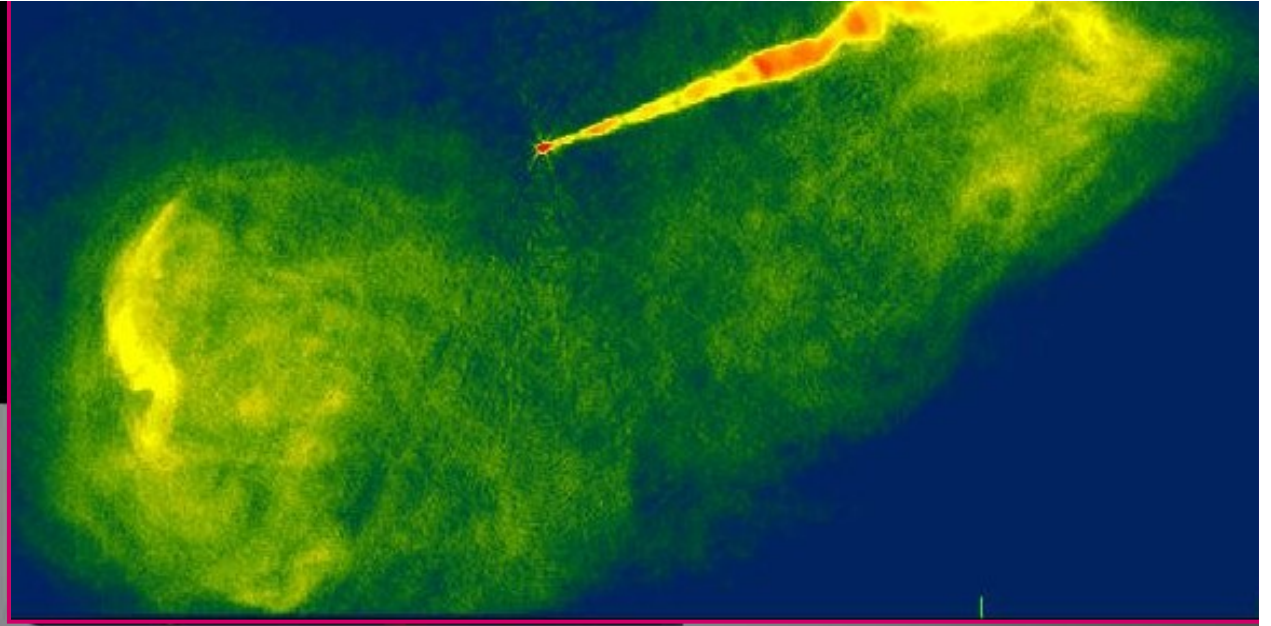
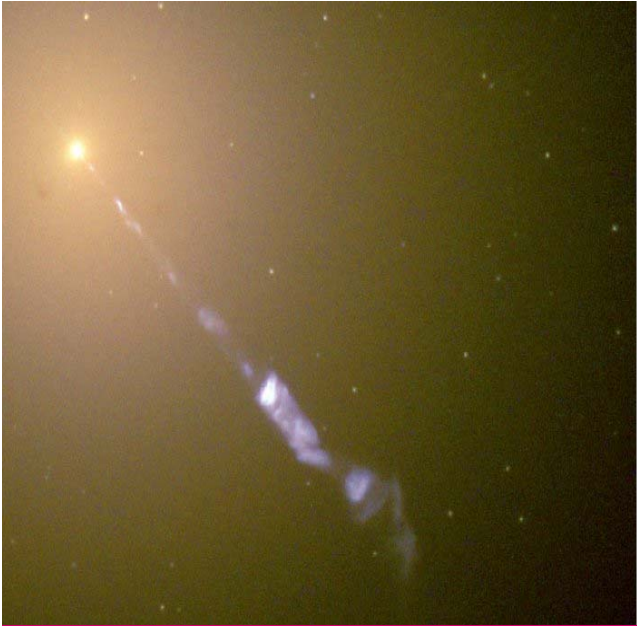
Die Aktive Galaxie M87: Im Zentrum ist ein
supermassives Schwarzes Loch
ca. 100.000.000 Sonnen



M87



Neutrinos?



Neutrinos:

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



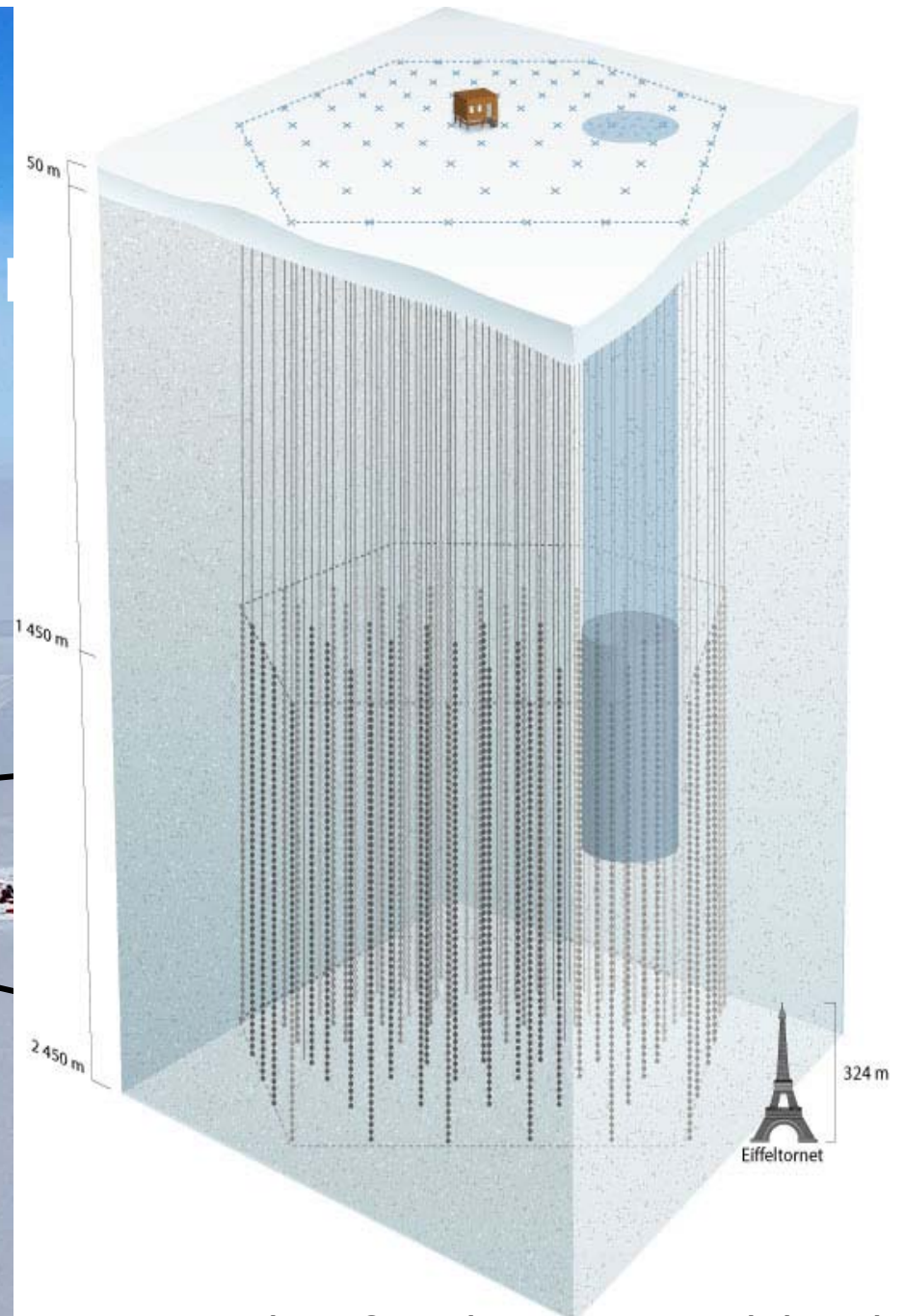
**Neutrino-Detektoren:
je größer, desto besser**



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

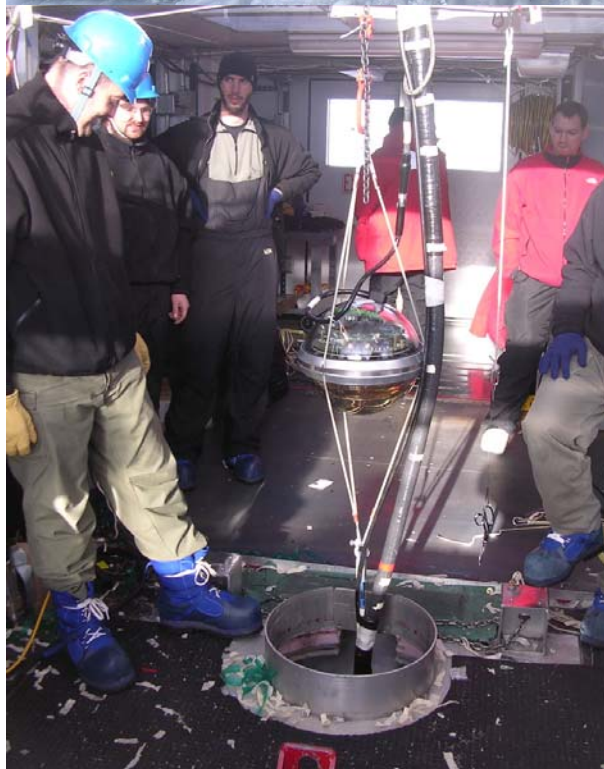
3-4 Tage / 2 km



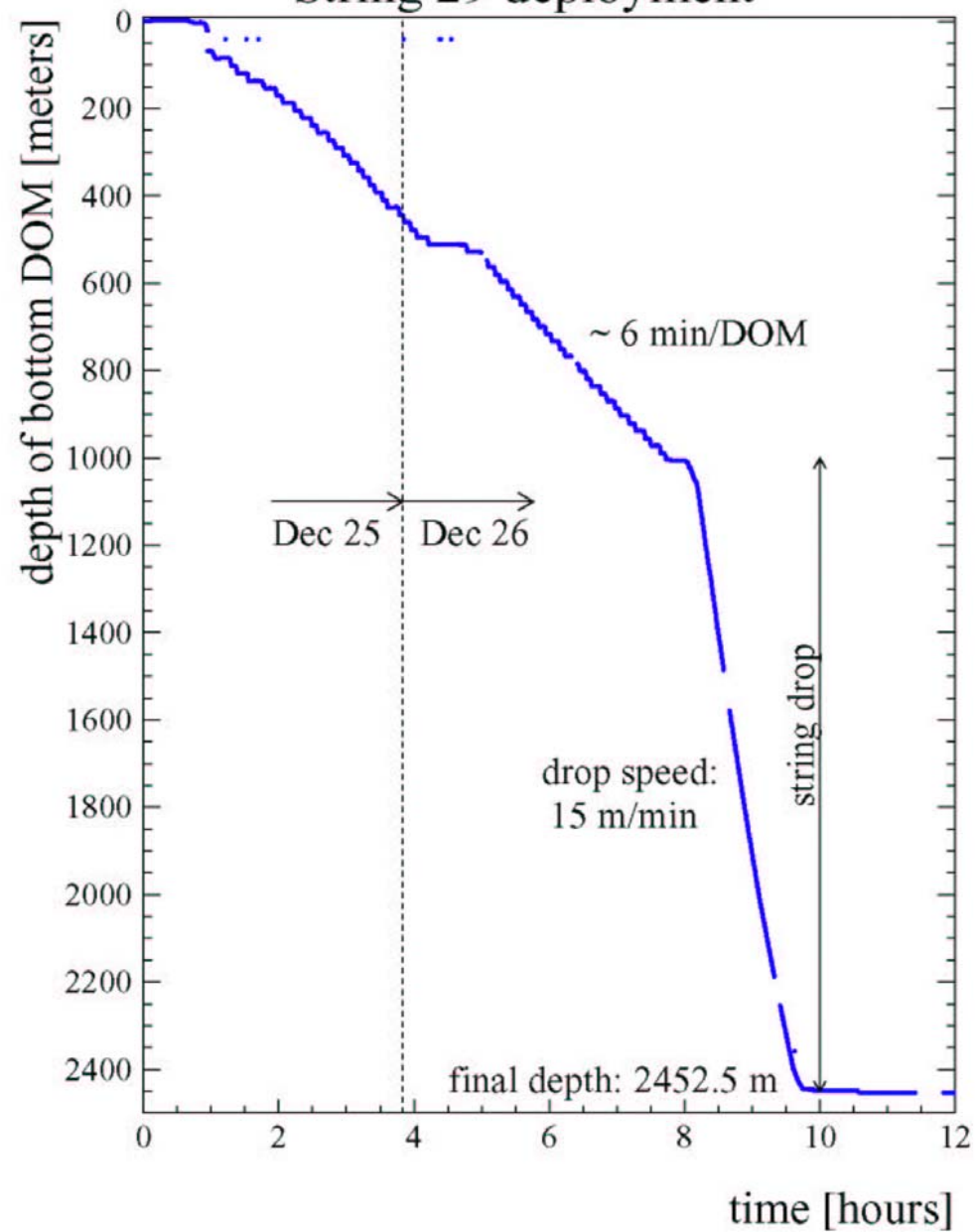
60 cm Loch



String cable 2500 m Weight ~6 tons



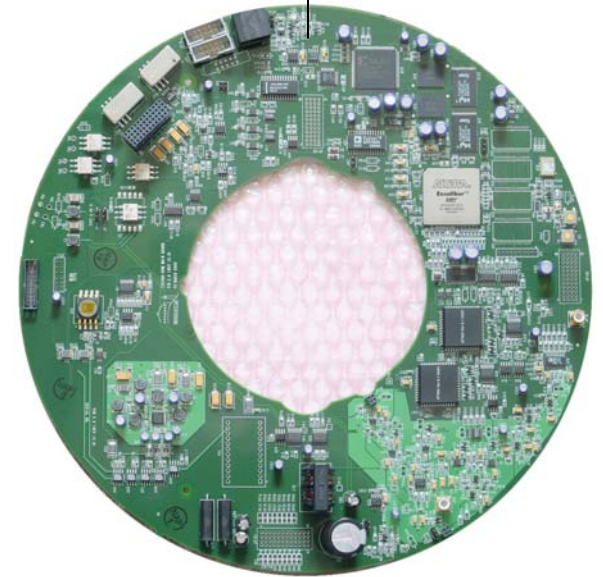
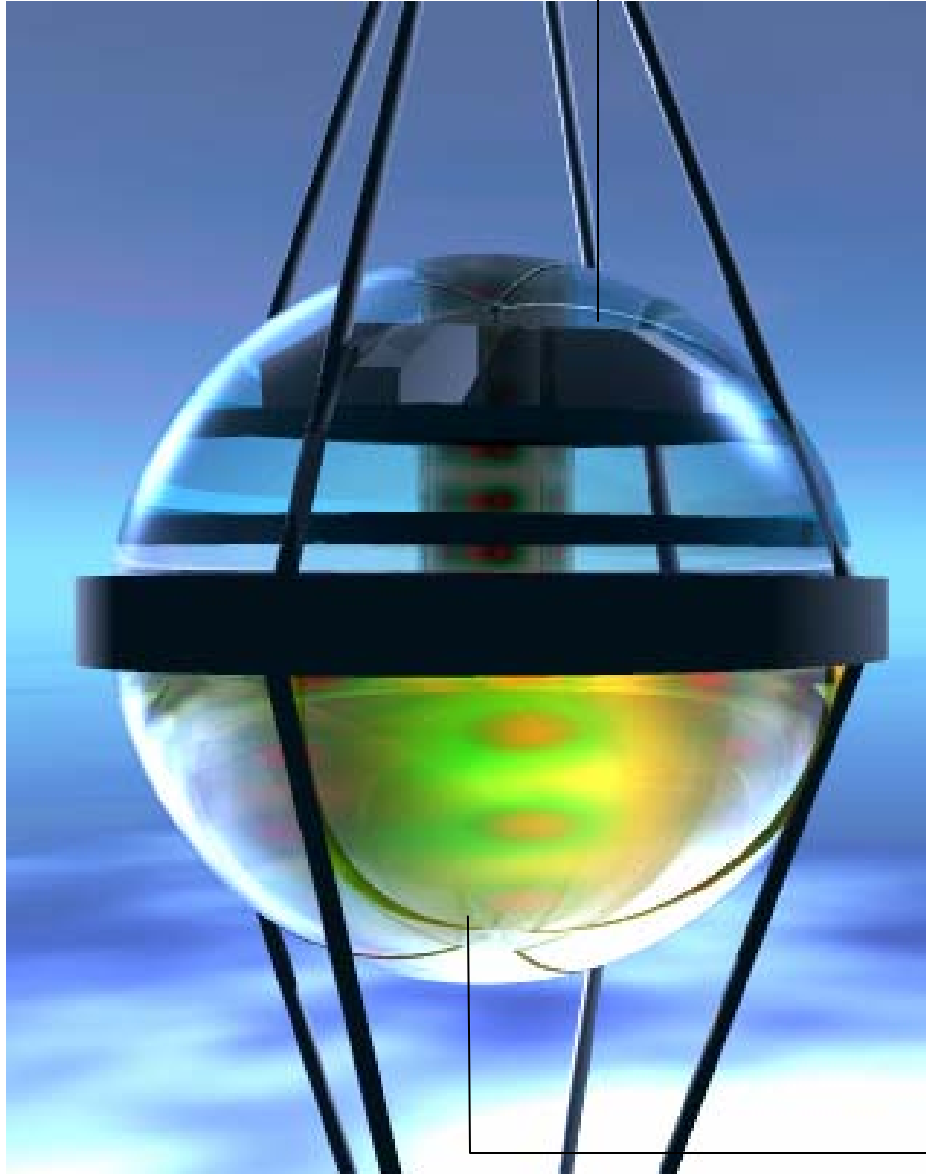
String 29 deployment





Optischer Sensor beginnt die 2500 m Talfahrt

Digitale Ausleseelektronik



Photonvervielfacher Röhre

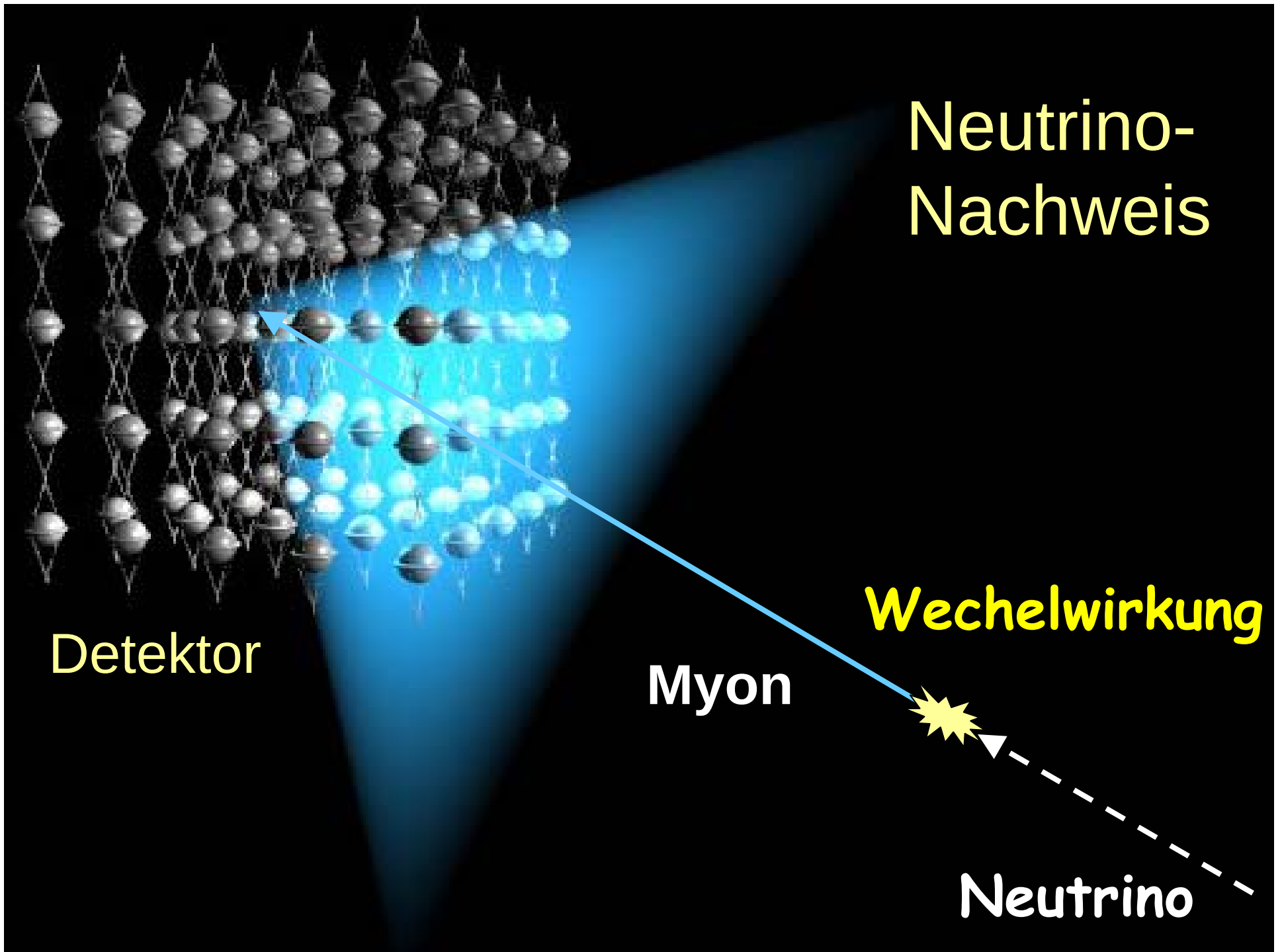
Neutrino- Nachweis

Detektor

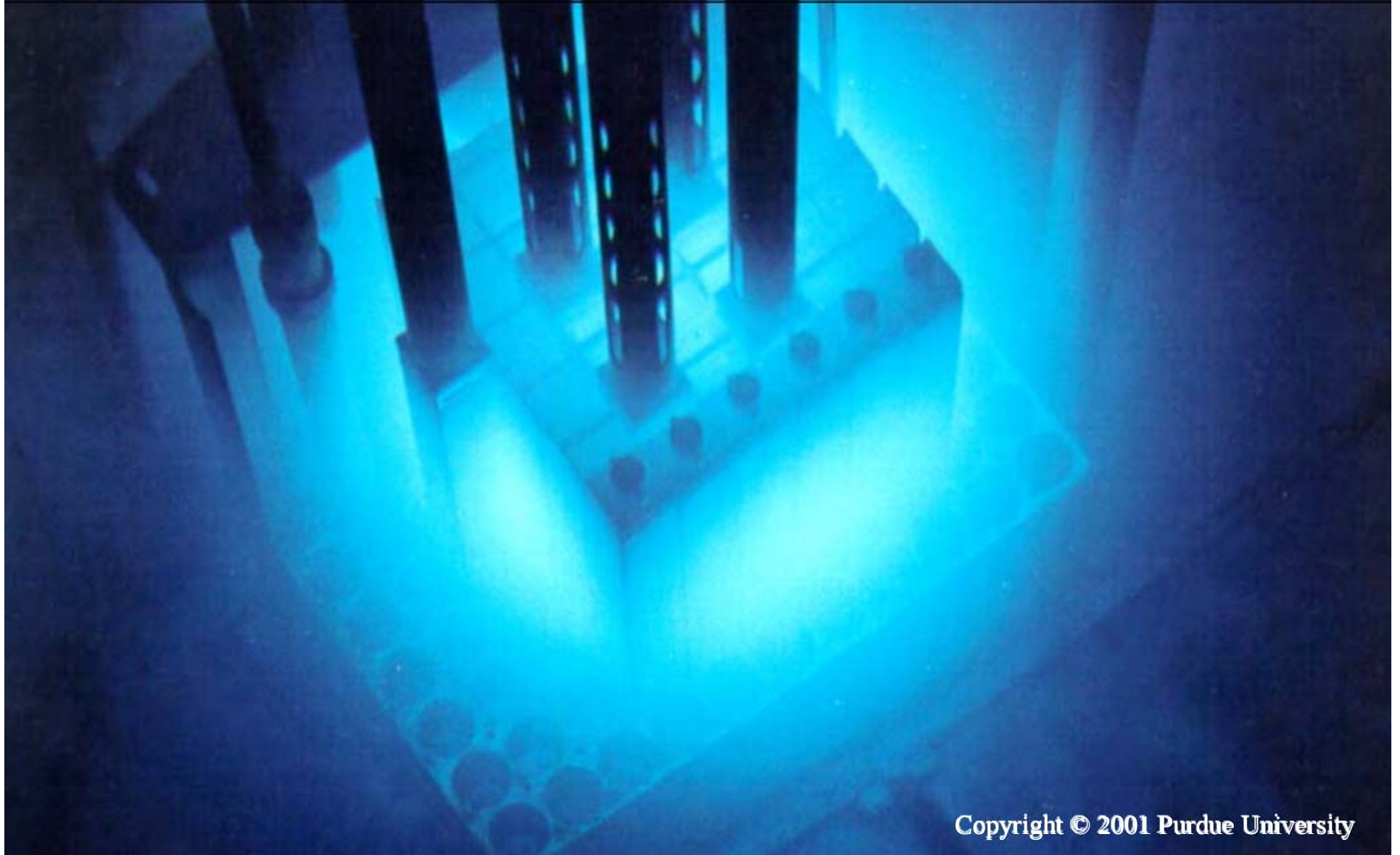
Myon

Wechselwirkung

Neutrino

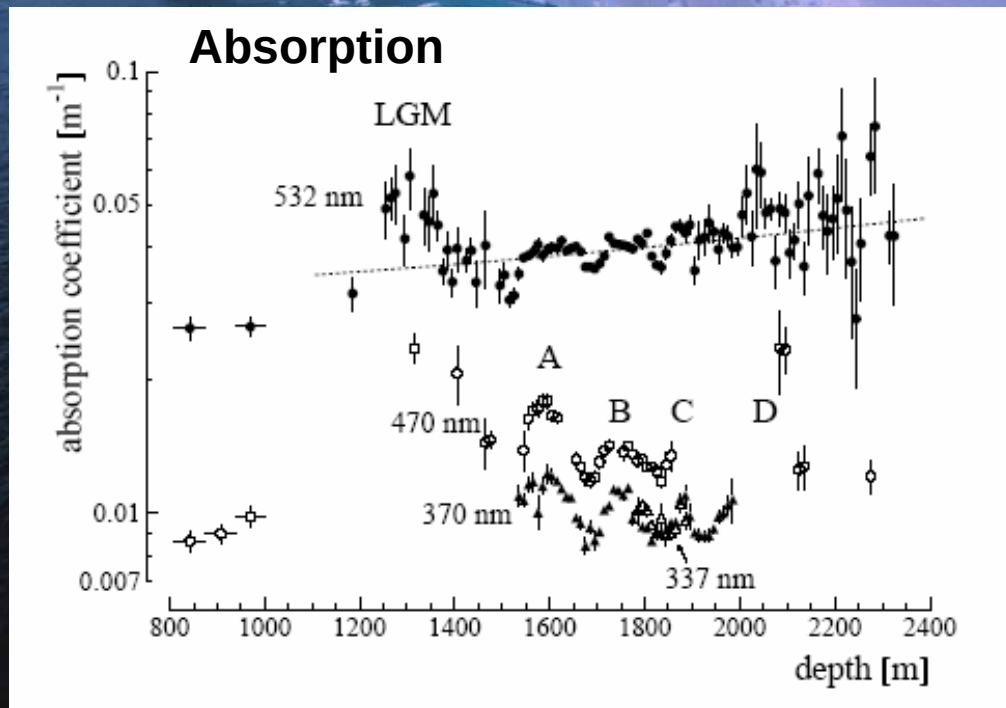


Freigesetzte Elektronen in einem Nuklearreaktor produzieren Cherenkov-Licht



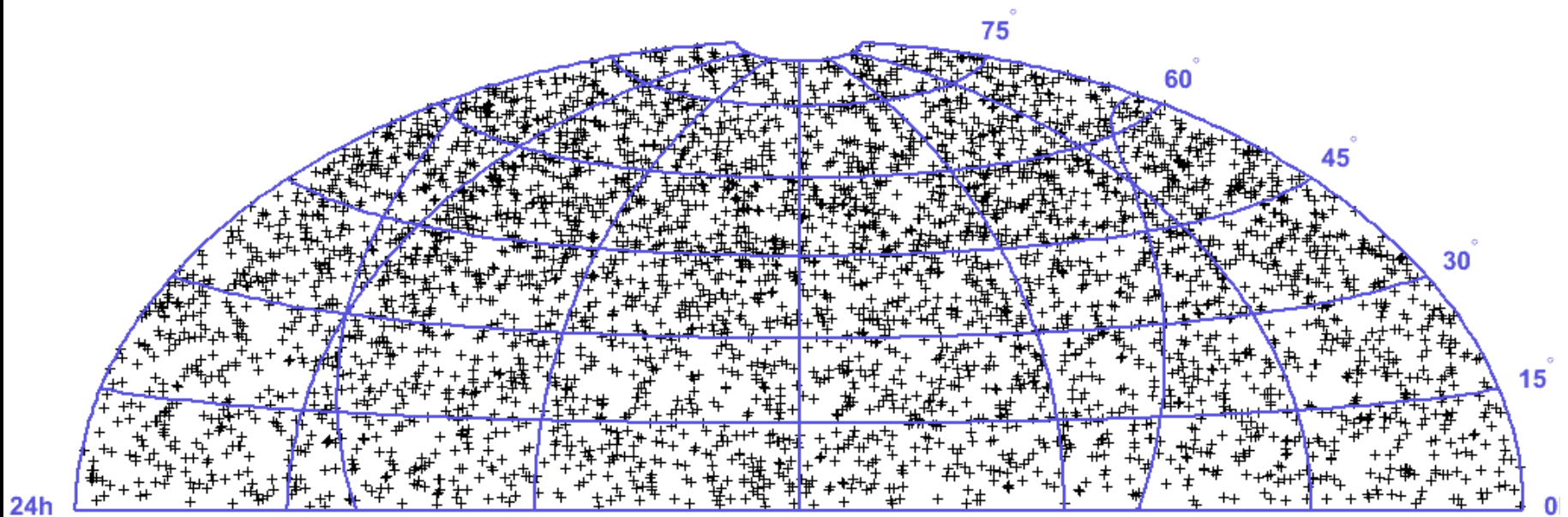
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Das Eis in 2 km Tiefe ist sehr transparent

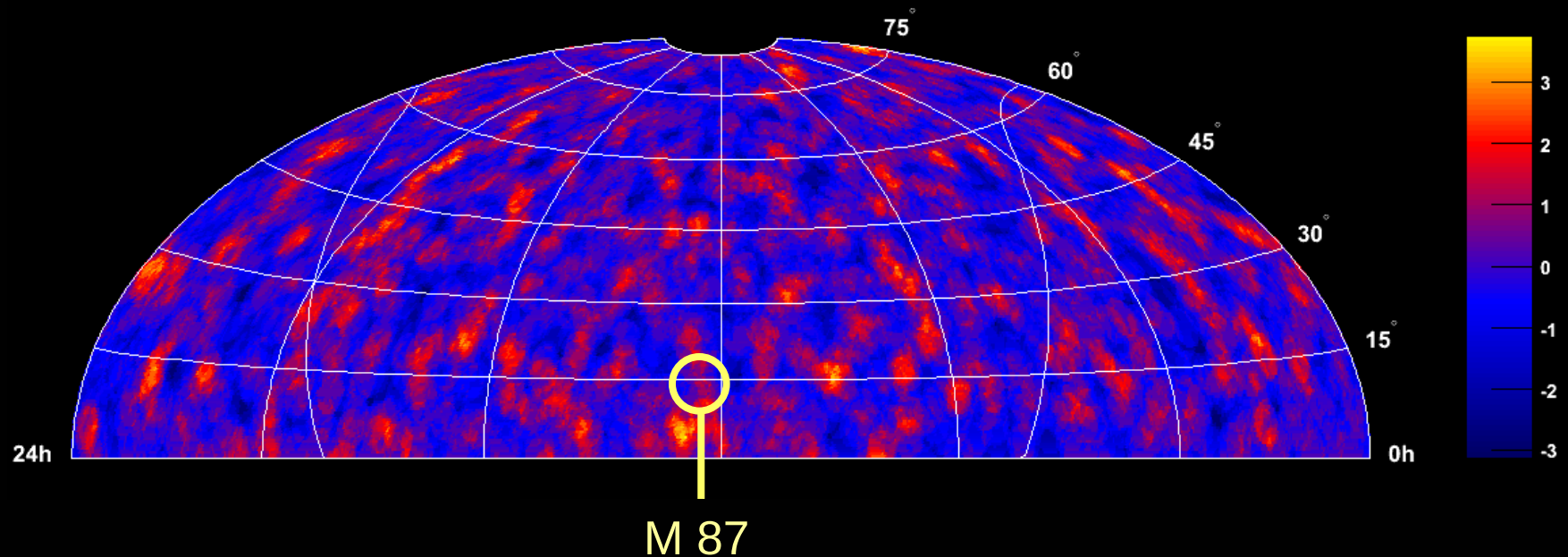




Neutrinos von AMANDA (2000-2004)



Statistische Auswertung der AMANDA Neutrinos



Noch kein kein Anzeichen für eine Neutrinoquelle gefunden!

Der IceCube Detektor

2005: 1

2006: 8

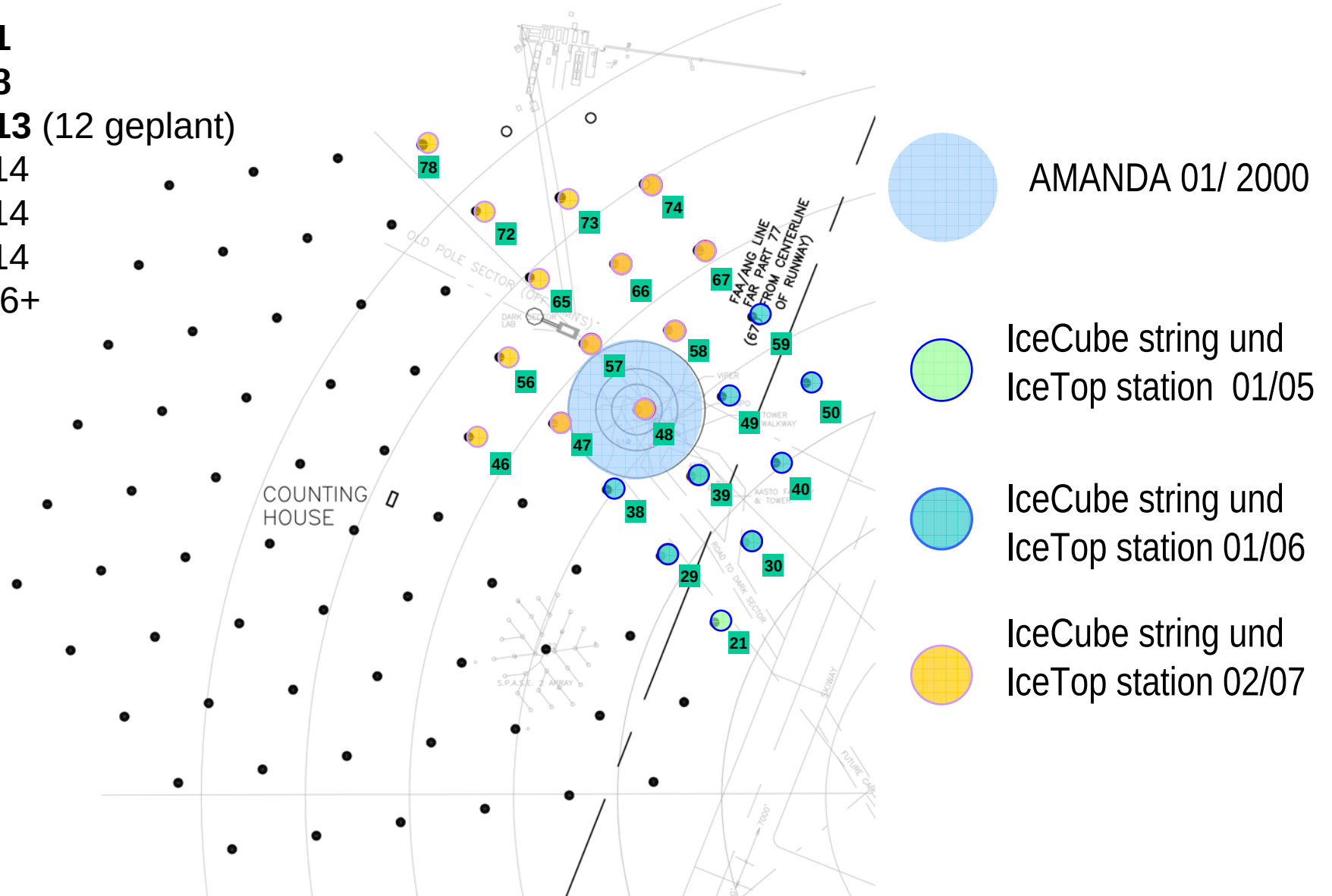
2007: 13 (12 geplant)

2008: 14

2009: 14

2010: 14

2011: 6+



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



Gute Nacht!

