

IceCube : Neutrino's vangen op Antarctica

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UNIVERSITEIT
BRUSSEL

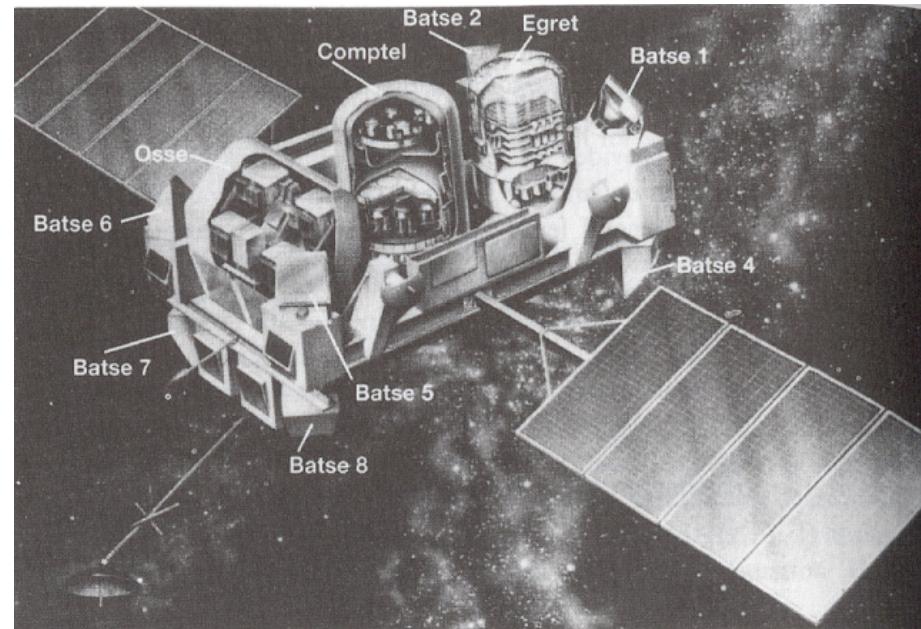
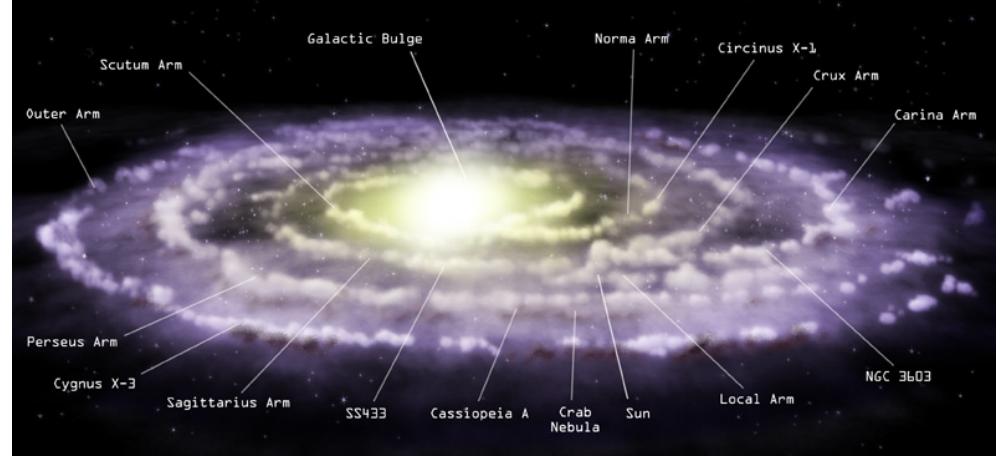
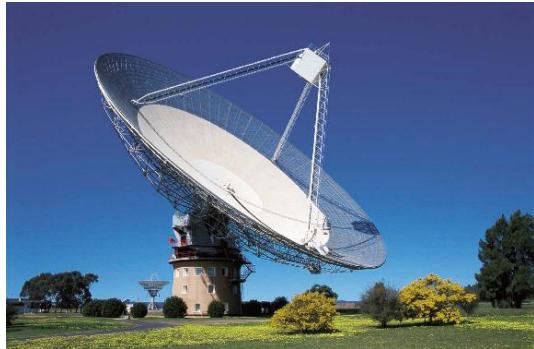


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Overzicht

Het zichtbare heelal	1
Het onzichtbare heelal	3
Jacht op kosmische neutrinos	15
De IceCube Neutrino Telescoop	16
Neutrinos van kosmische gammaflitsen	29
The Muppets on Ice	30
Vooruitzichten	36

Electromagnetische straling



Het zichtbare heelal

- Waar komt deze materie vandaan ?



- Waarom zo "klonterig" verdeeld ?

Onderlinge interacties

Mechanica (zwaartekracht)

- Wat laat de sterren stralen ?

Nucleaire processen

Deeltjes fysica

- Emissie en absorptie lijnen ?

Atoom structuur

Quantum fysica

- Observatie verschoven spectraallijnen

Uitdijend Heelal

Kosmologisch model

Het onzichtbare heelal

La physique des particules étudie la matière dans ses dimensions les plus petites.

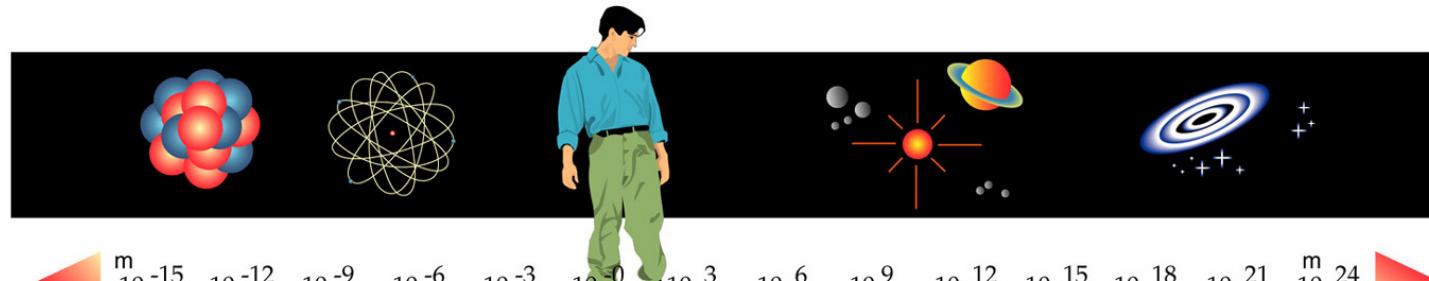


Particle physics looks at matter in its smallest dimensions.

L'astrophysique étudie la matière dans ses dimensions les plus grandes.



Astrophysics looks at matter in its largest dimensions.



Microscopes
Microscopes

Jumelles
Binoculars

Telescopes optiques & radio
Optical & radio telescopes

Accélérateurs
et détecteurs
Accelerators
and detectors

L'oeil nu.
Naked eye

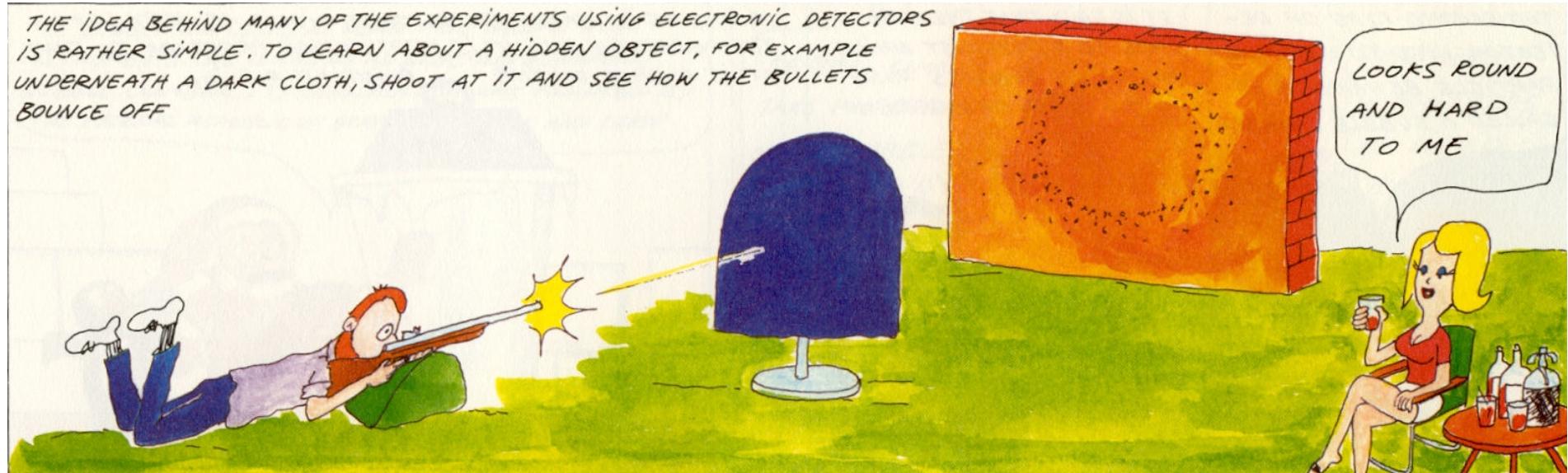
THE TWO FRONTIERS OF PHYSICS LES DEUX FRONTIERES DE LA PHYSIQUE

CERN AC - Z11 - V11/5/98

Het onzichtbare heelal

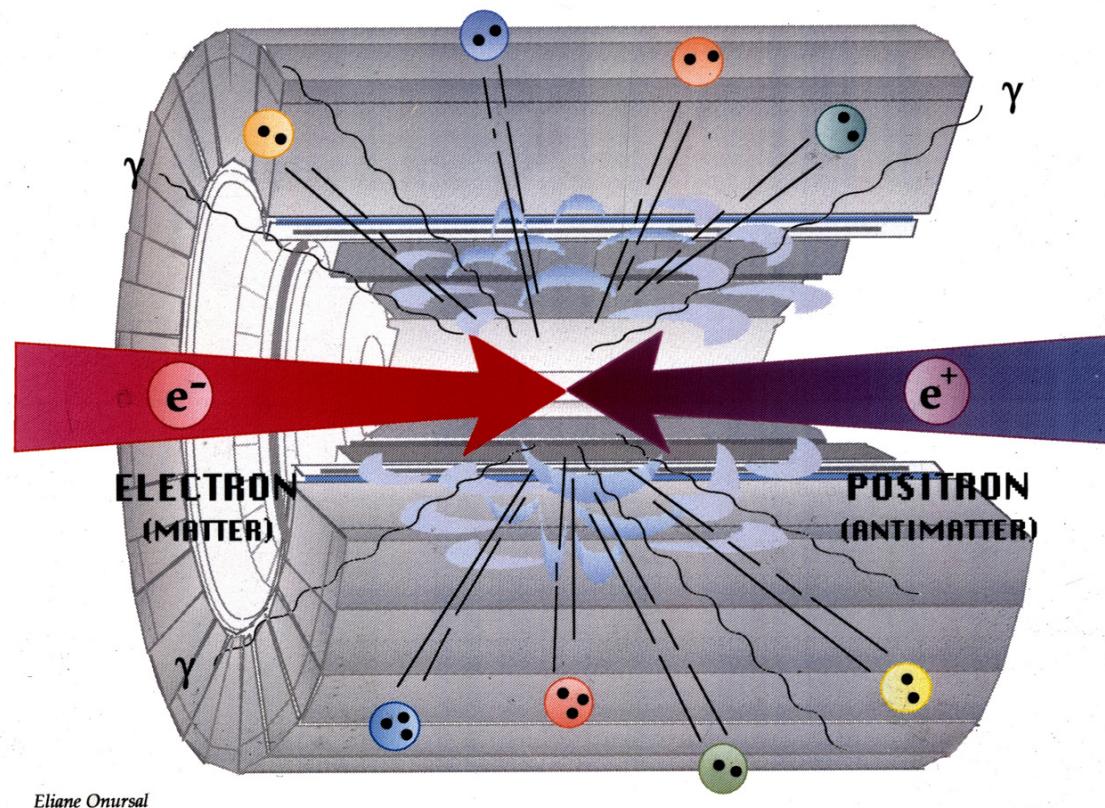
Onderzoek naar de structuur van materie

THE IDEA BEHIND MANY OF THE EXPERIMENTS USING ELECTRONIC DETECTORS IS RATHER SIMPLE. TO LEARN ABOUT A HIDDEN OBJECT, FOR EXAMPLE UNDERNEATH A DARK CLOTH, SHOOT AT IT AND SEE HOW THE BULLETS BOUNCE OFF



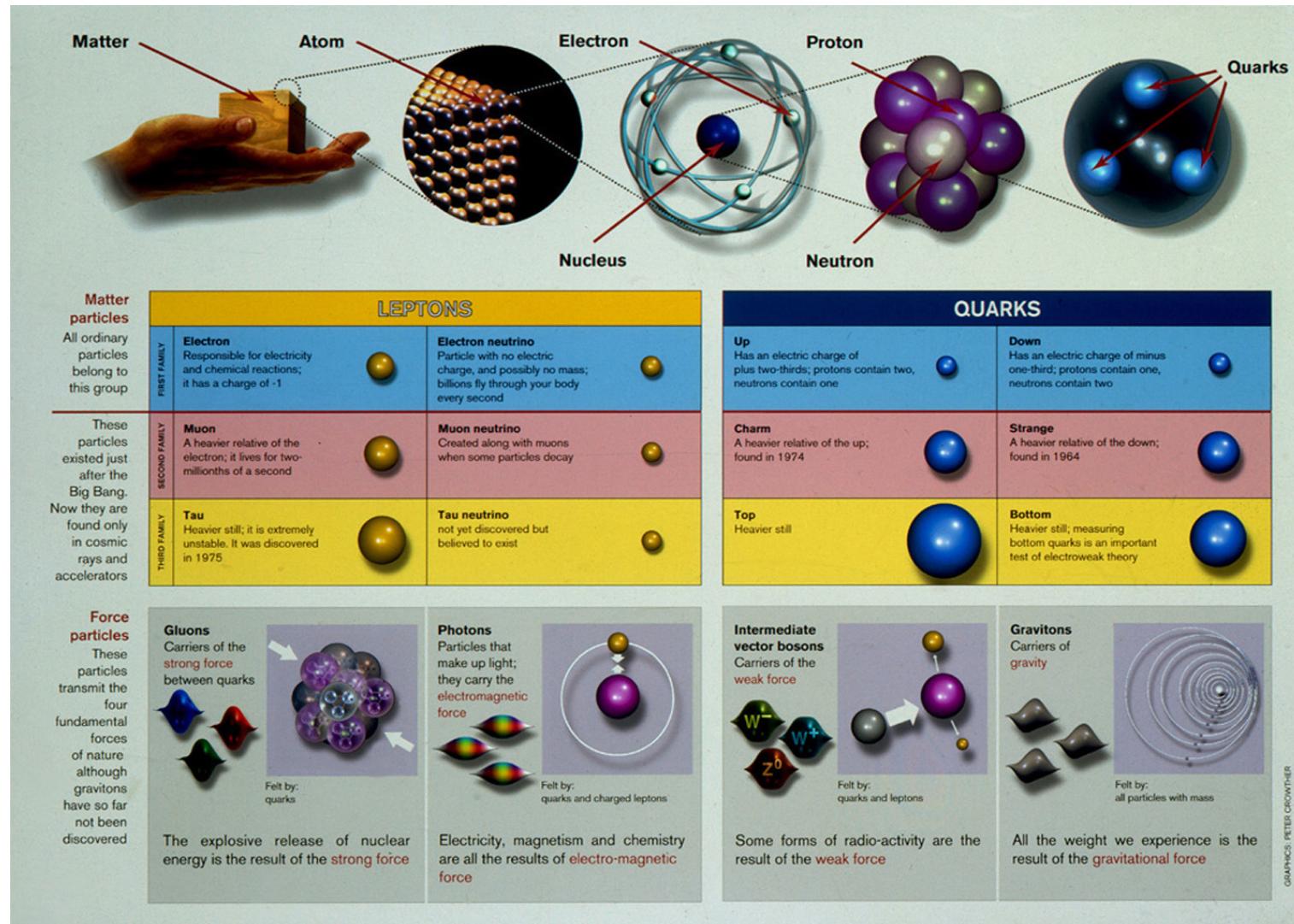
Het onzichtbare heelal

Speurtocht naar nieuwe deeltjes



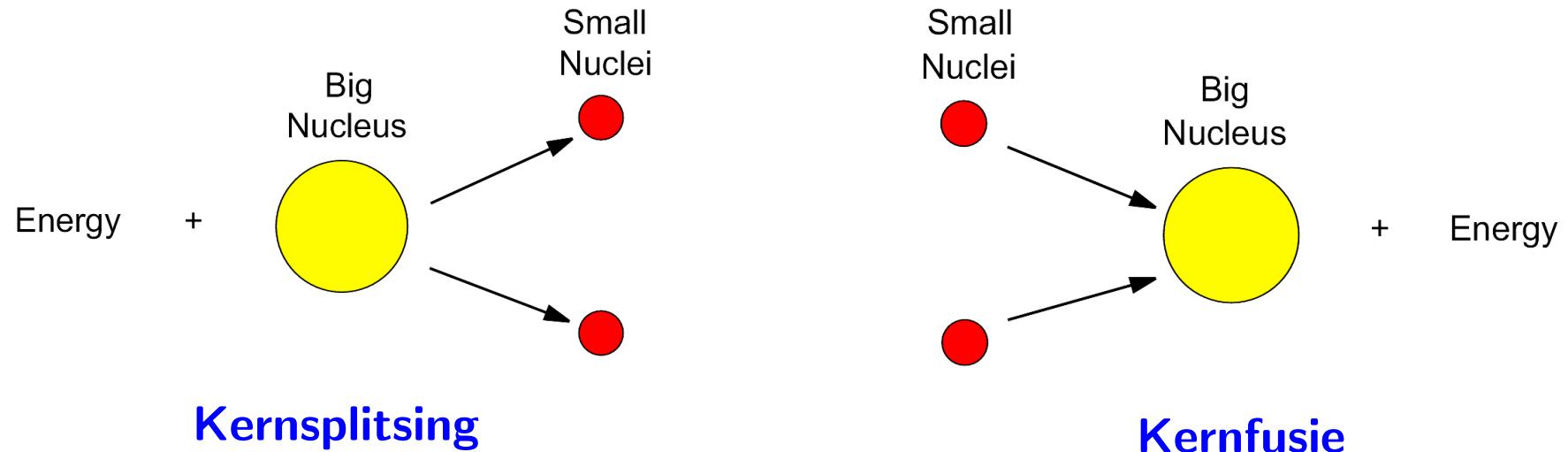
Deeltjes productie via Energie – Massa conversie ($E_{rust} = mc^2$)

Het onzichtbare heelal



Interacties via uitwisseling van "boodschapper" deeltjes

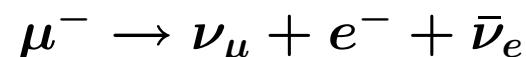
Kernfusie laat sterren stralen

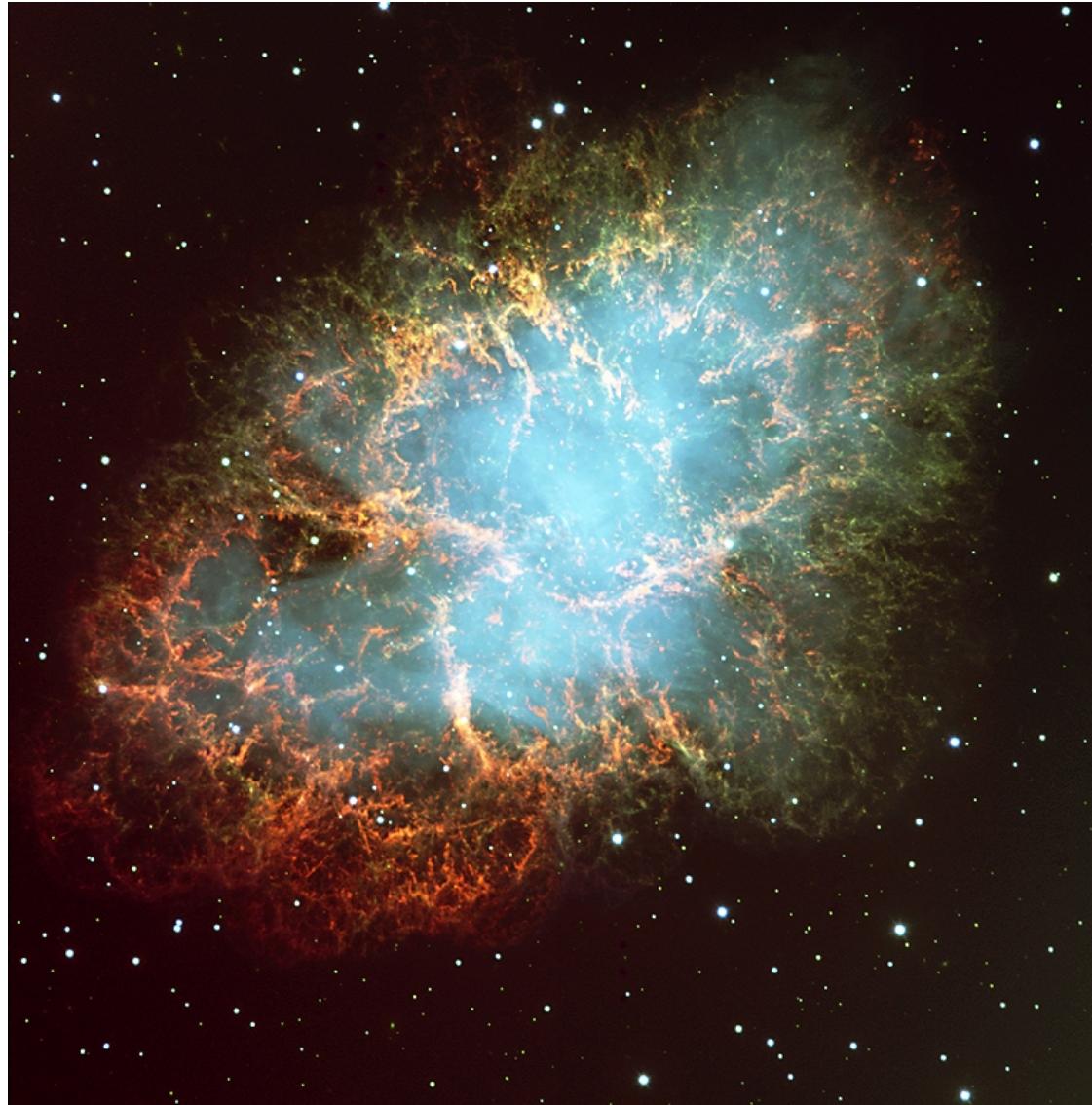


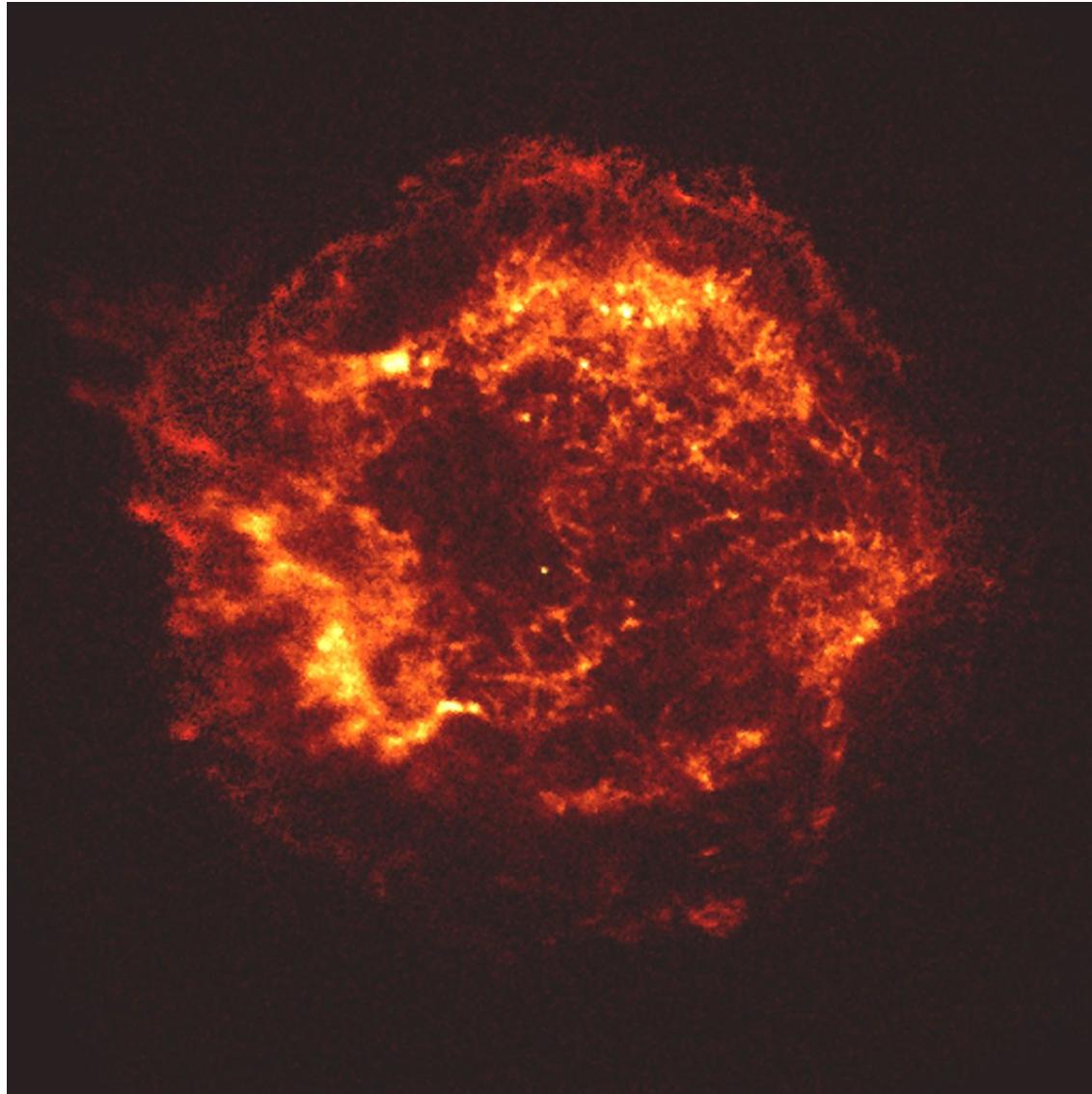
Zwakke kracht produceert neutrinos

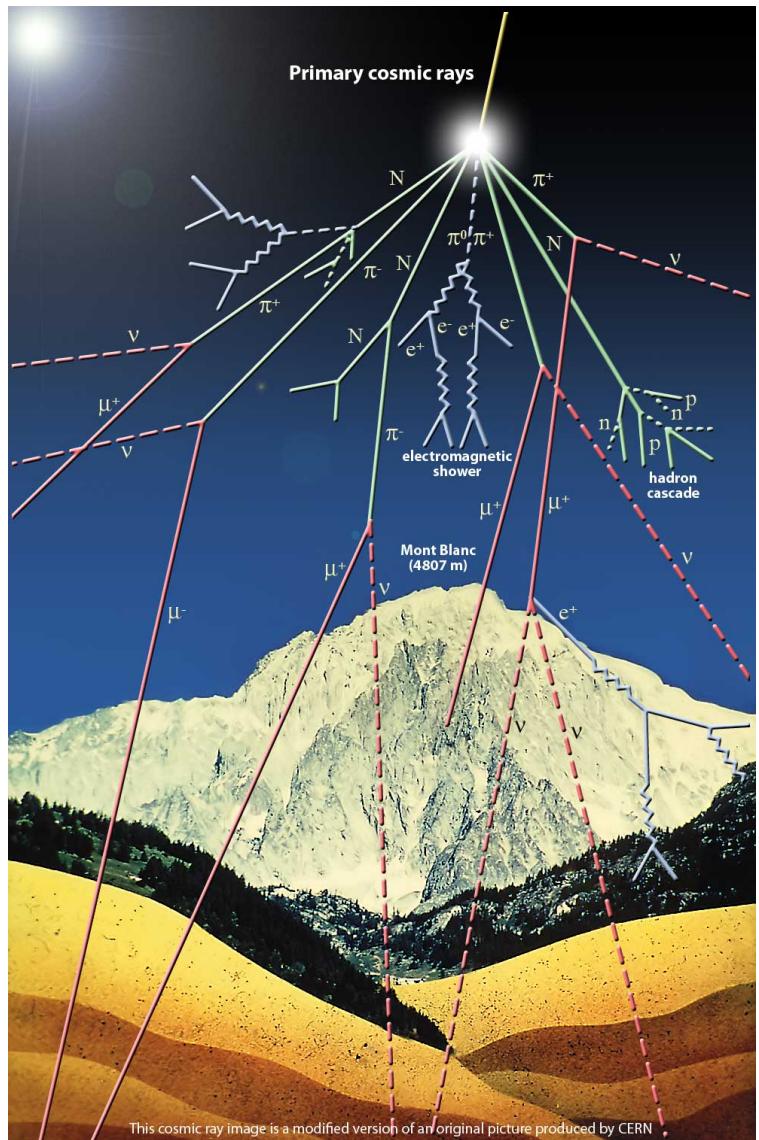
(Supernovae, AGN, GRBs)

- Ontstaan van neutronen sterren

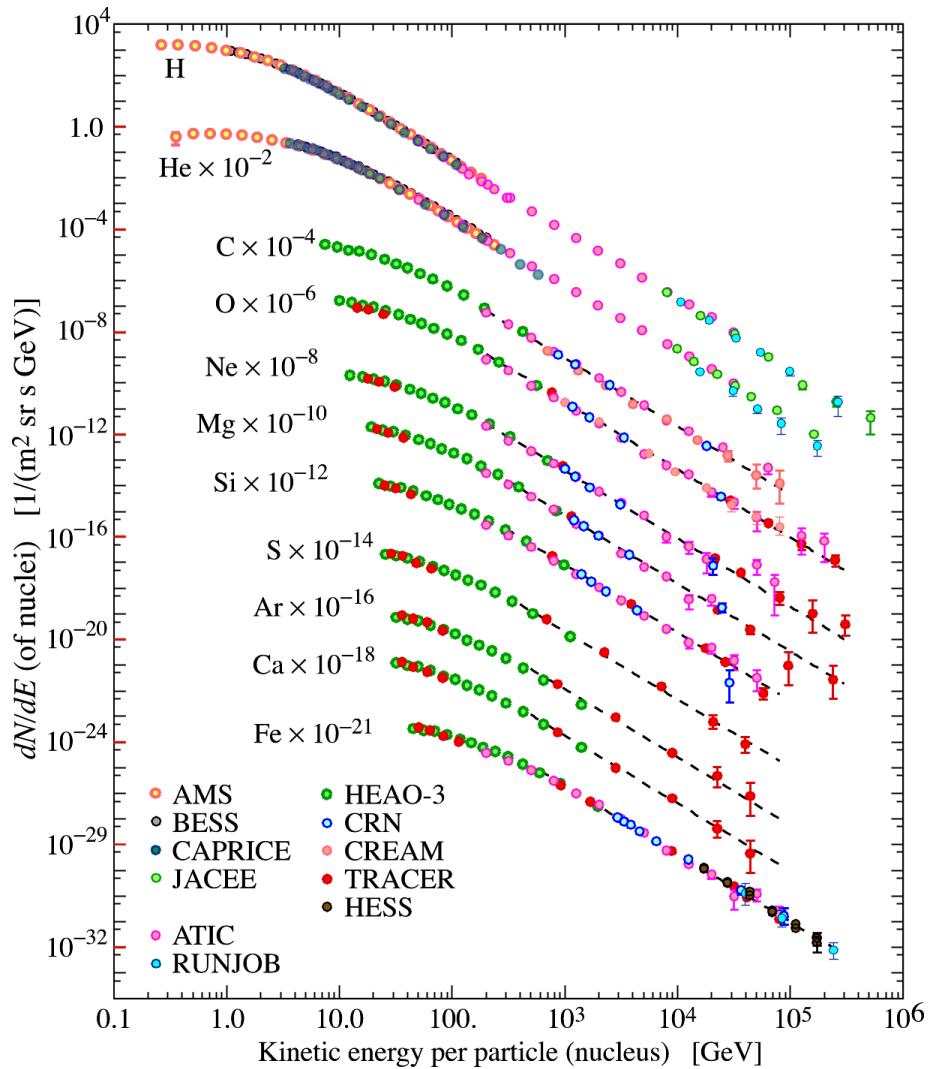




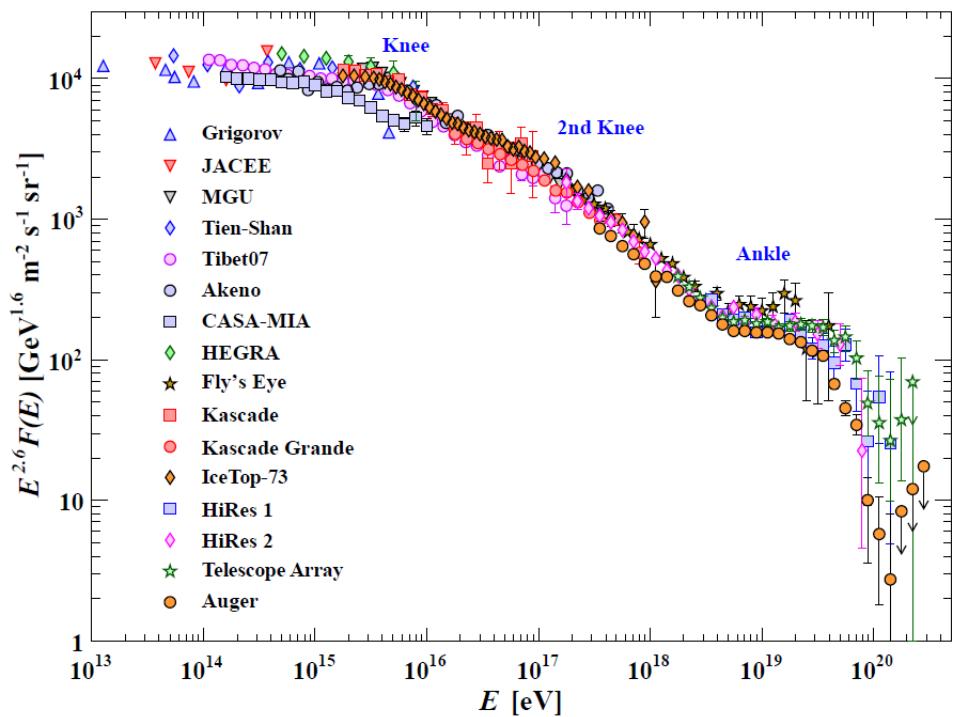




Spectrum van kosmische straling



$E^{2.6}$ geschaalde flux



- Spectraal structuur (knie, enkel)
Energetische limieten van kosmische versnellers ?
- Wat zijn dit voor versnellers ?
Heftige explosieve fenomenen
 - Supernova's
 - Gammaflitsen
 - Zwarte gaten

- Supernova schokgolven

Bewegende lading in mag. veld

$$\text{Gyroradius } r = \frac{p}{ZeB} \quad (\vec{p} \perp \vec{B})$$

$$\rightarrow \left(\frac{p}{1 \text{ eV}} \right) = 0.03 \cdot Z \left(\frac{B}{1 \mu\text{G}} \right) \left(\frac{r}{1 \text{ m}} \right)$$

- Versneller van afmeting R

$r > R \rightarrow \text{deeltje ontsnapt} \rightarrow E_{max}$

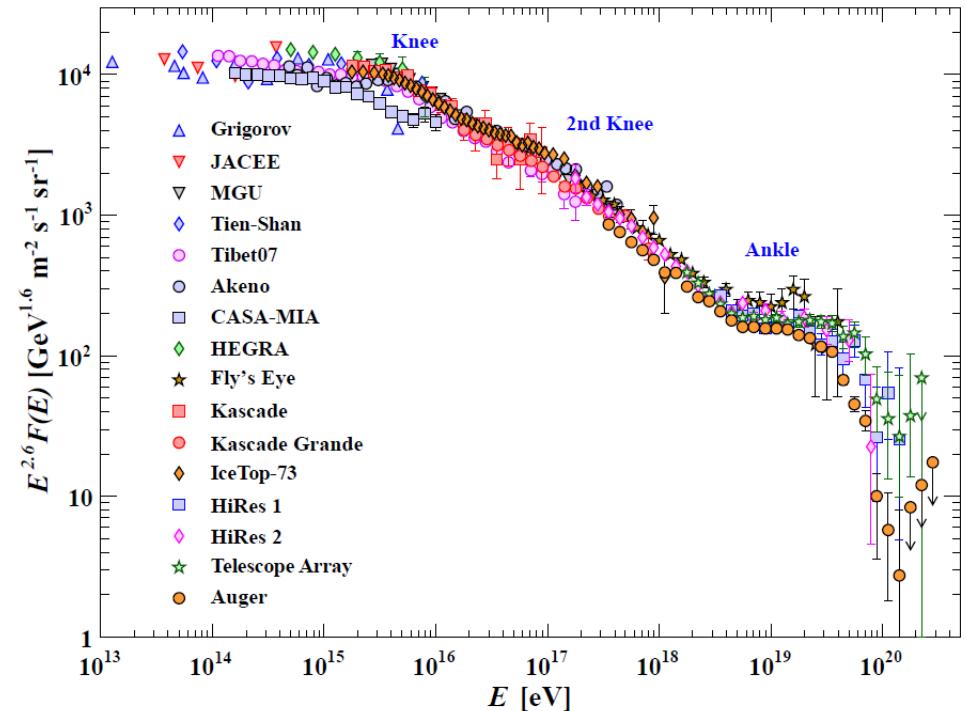
Typisch : $B \approx \mu\text{G}$ $R \approx 3 \cdot 10^{16} \text{ m}$

→ Protonen : $E_{max} \approx 10^{15} \text{ eV}$

* Bij bepaalde $r \rightarrow E_Z = ZE_{proton}$

* $E > 10^{19} \text{ eV} \rightarrow r > R_{melkweg}$

⇒ Extra-galactische oorsprong



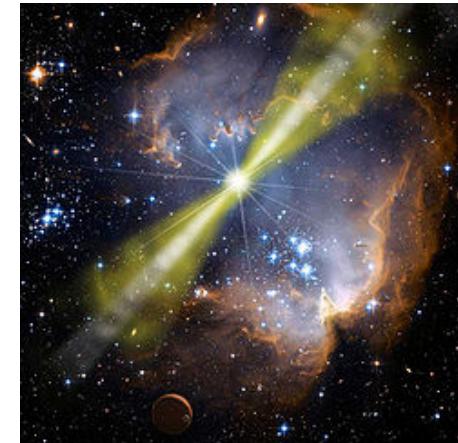
Wat veroorzaakt de 'enkel' ?

Nog veel krachtiger explosies
(AGN and GRBs)

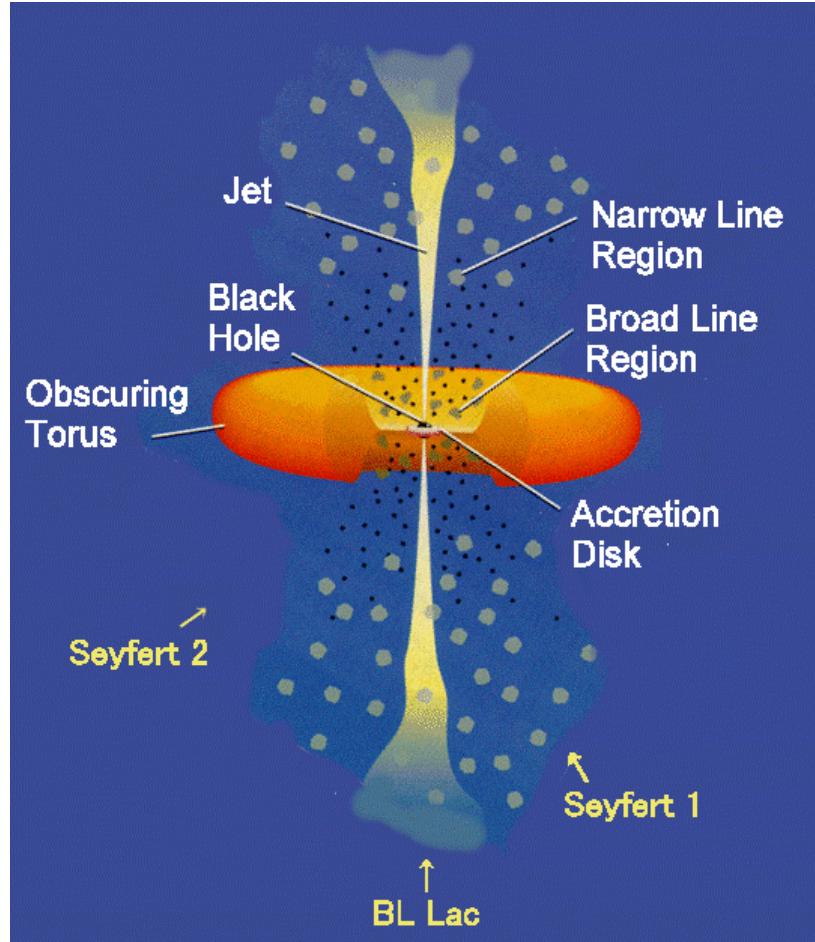
Actieve Melkwegkernen (AGN)



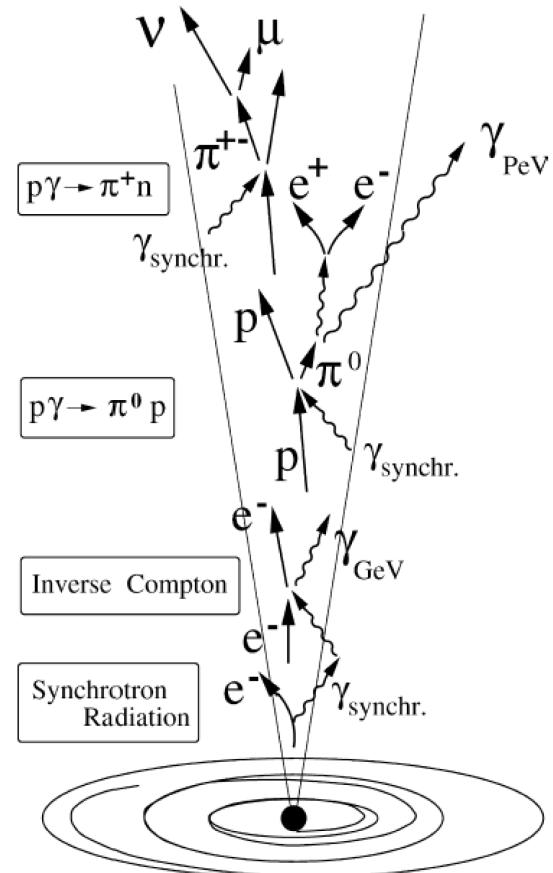
Kosmische Gamma Flitsen (GRBs)



Algemeen beeld

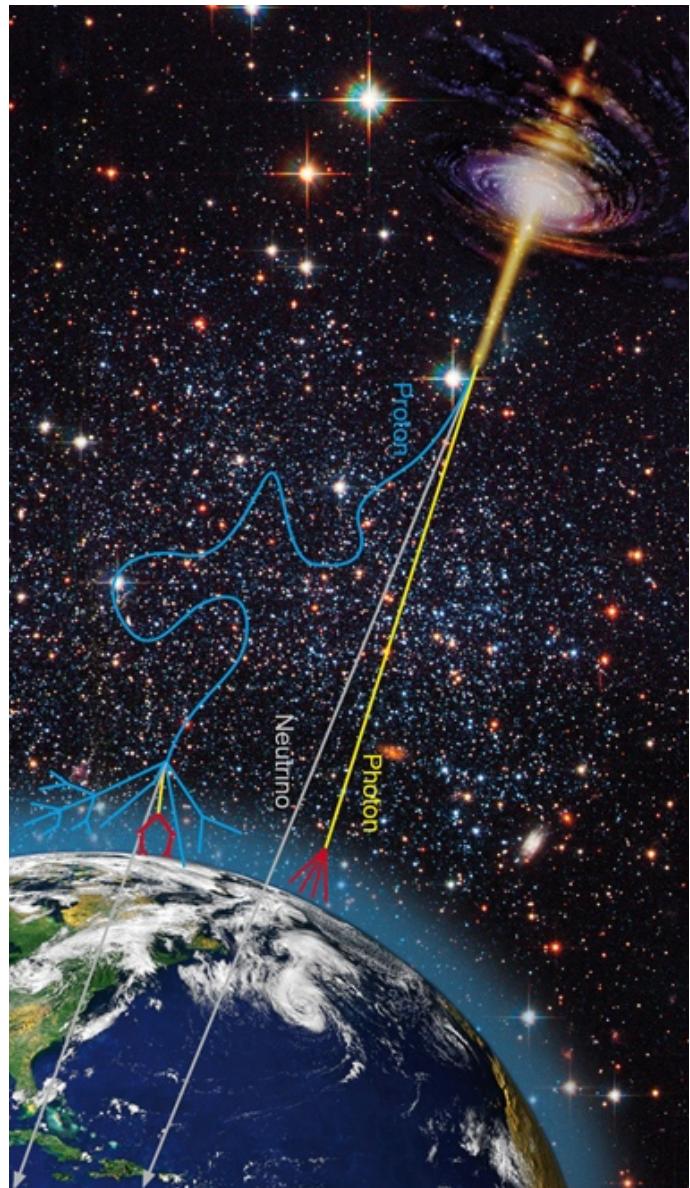


Fysische processen



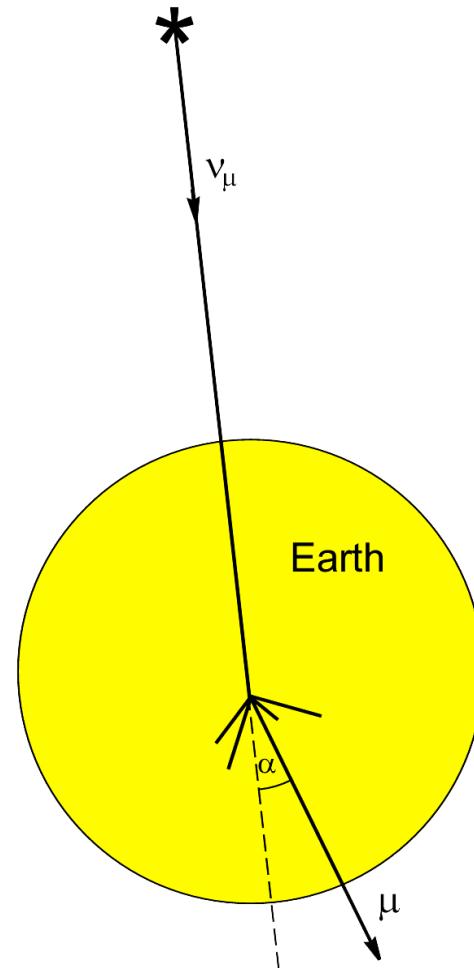
Versnelling in schokgolven

Hoog-energetische fotonen en neutrinos



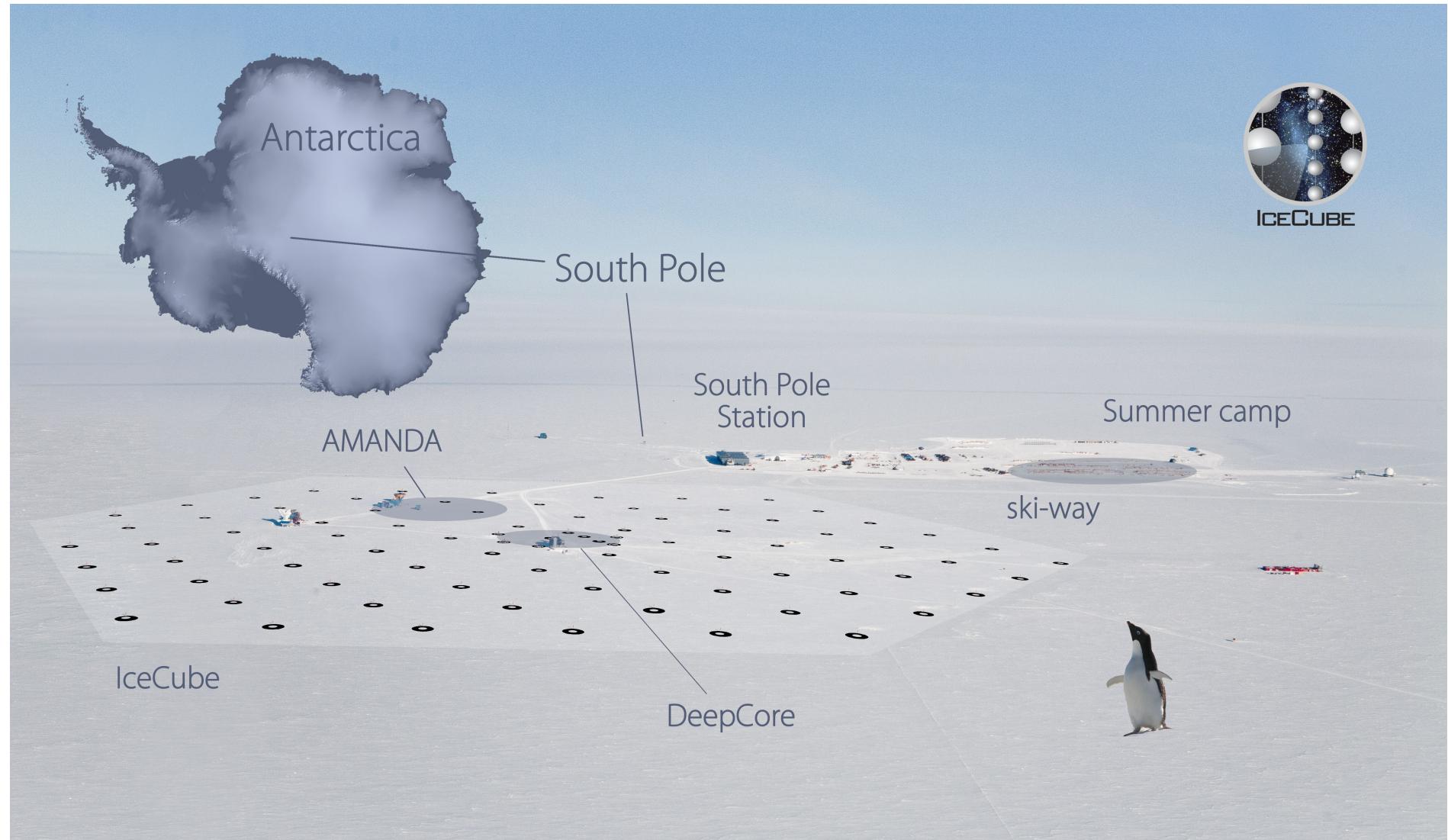
Neutrino detectie mechanisme

Cosmic Event





De IceCube Neutrino Telescoop





De IceCube Neutrino Telescoop



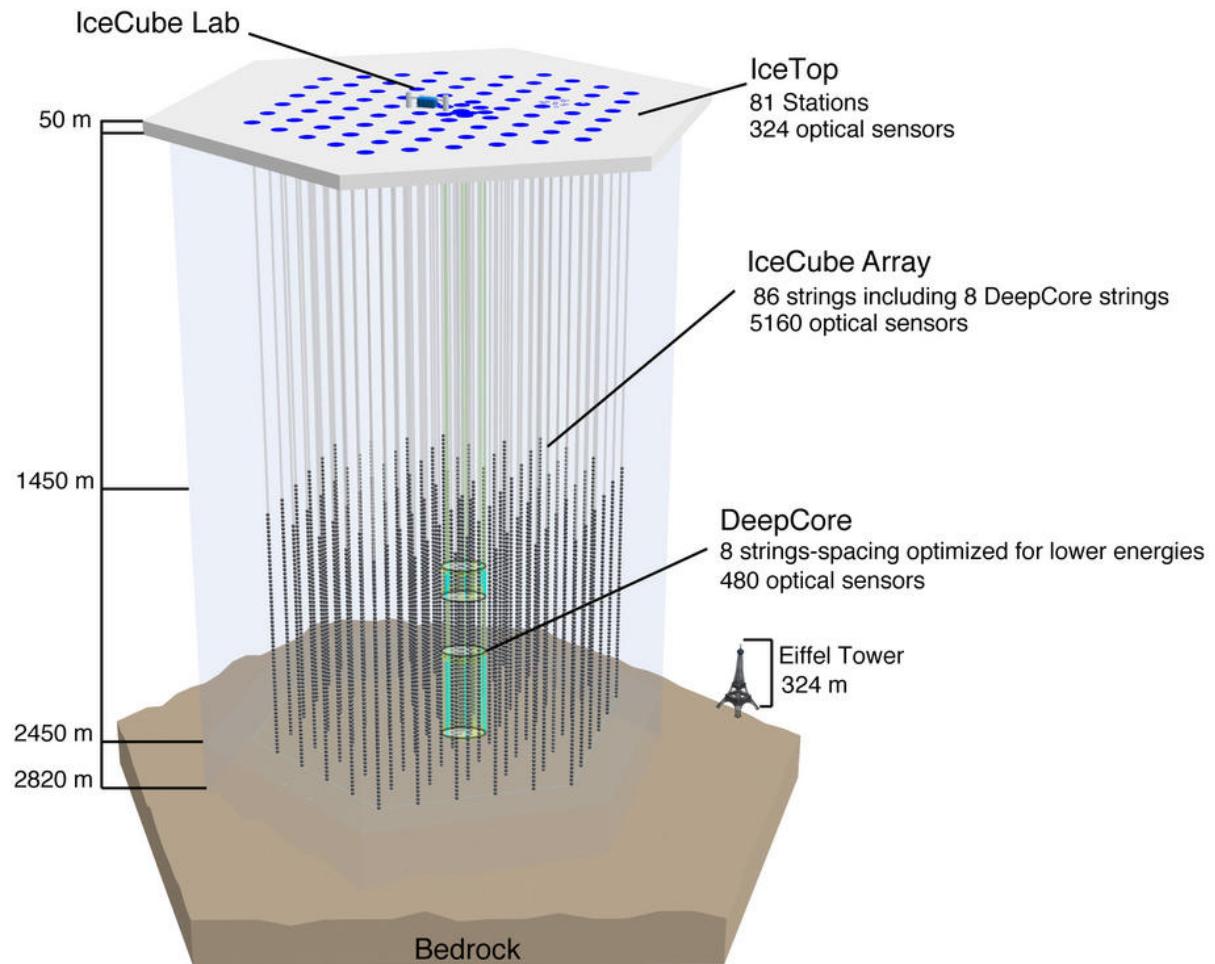
De IceCube Neutrino Telescoop



De IceCube Neutrino Telescoop

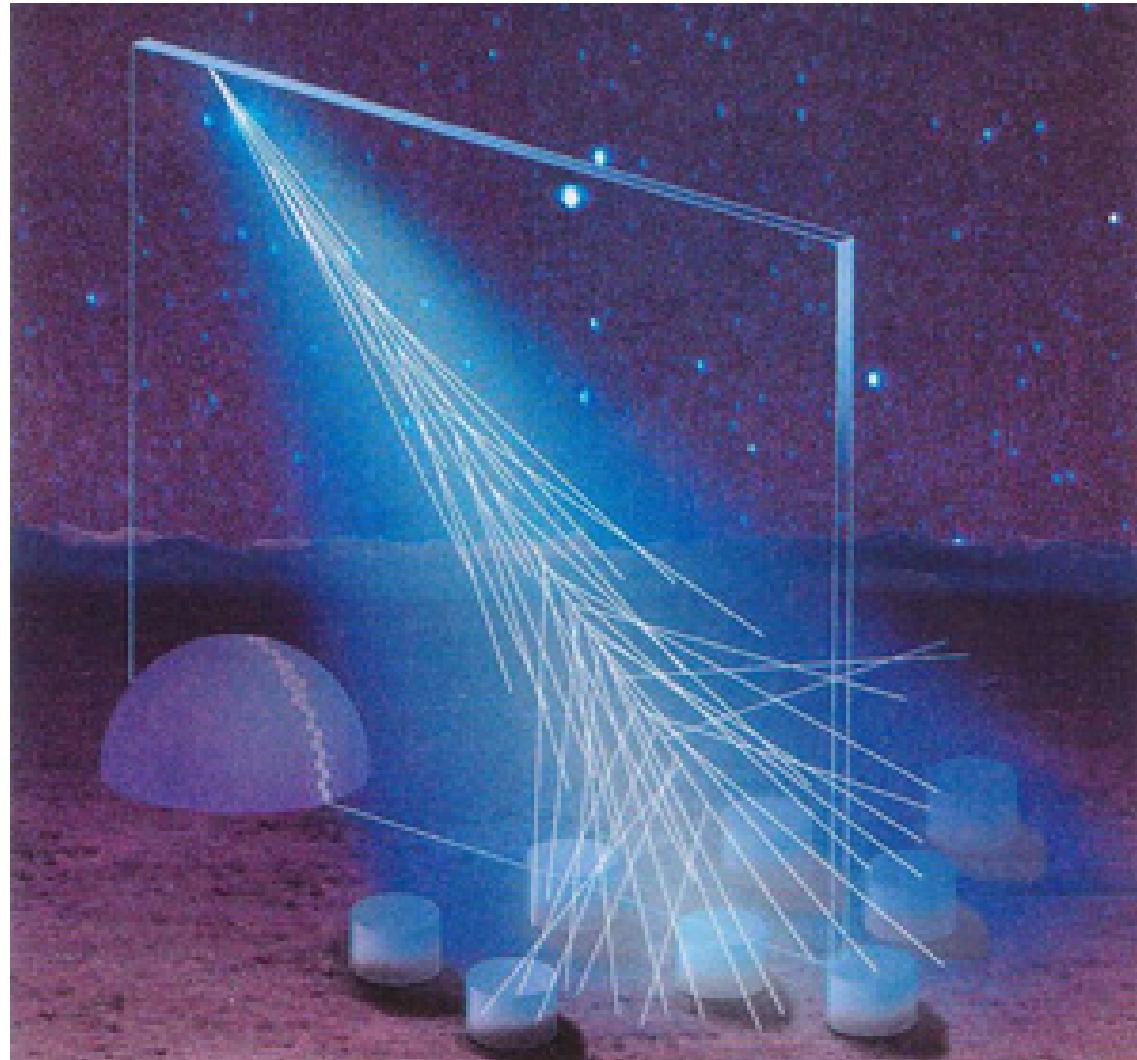


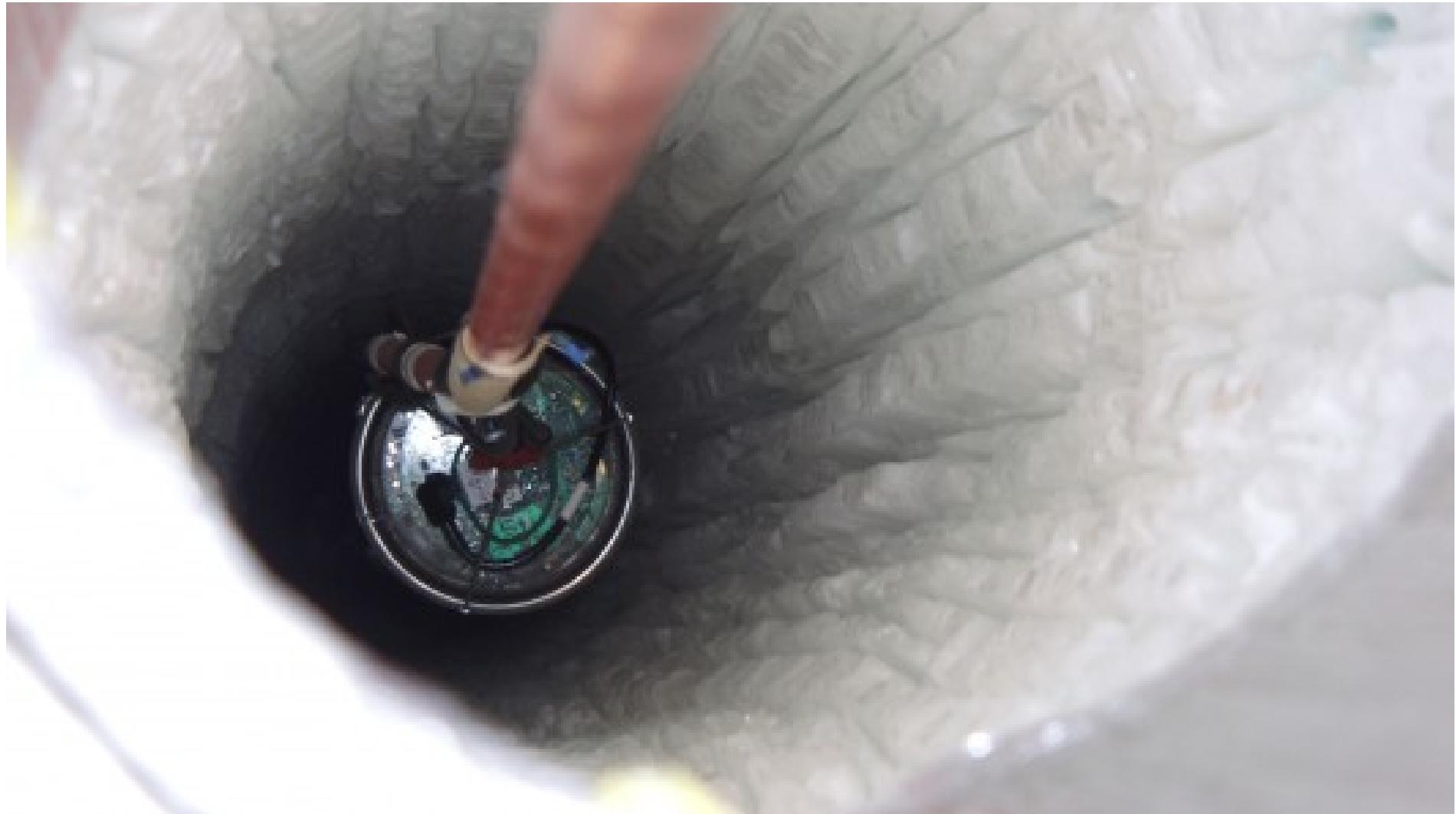
De IceCube Neutrino Telescoop



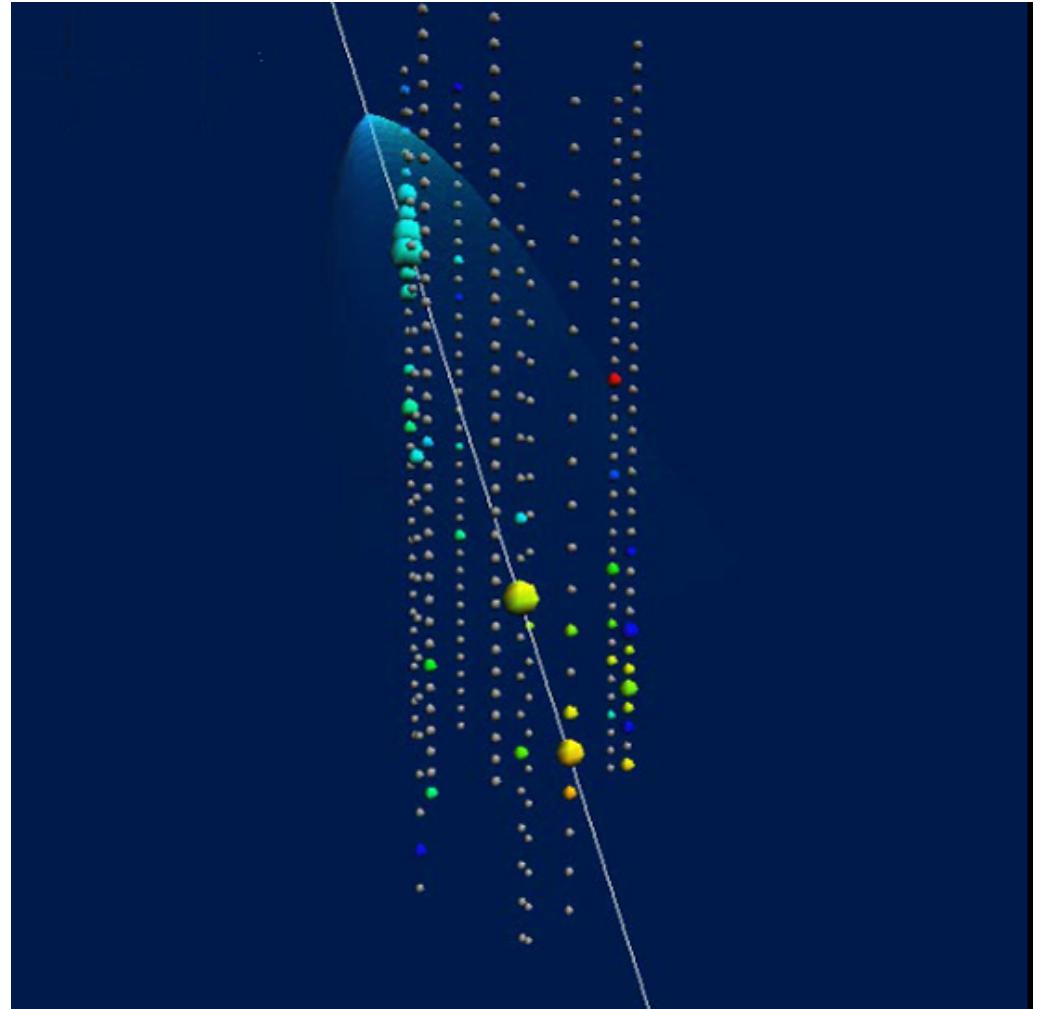
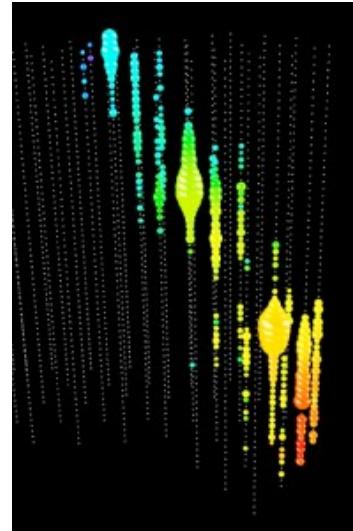


IceTop detectie principe



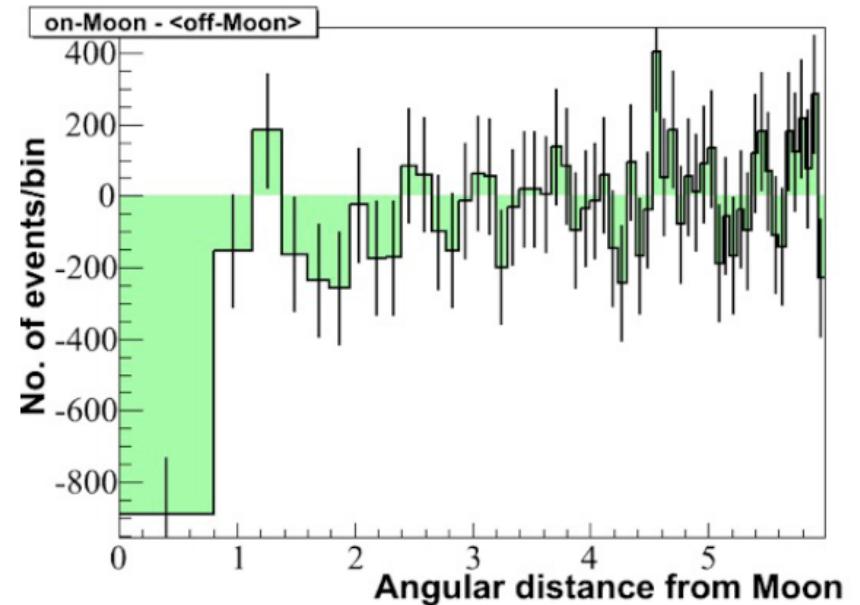
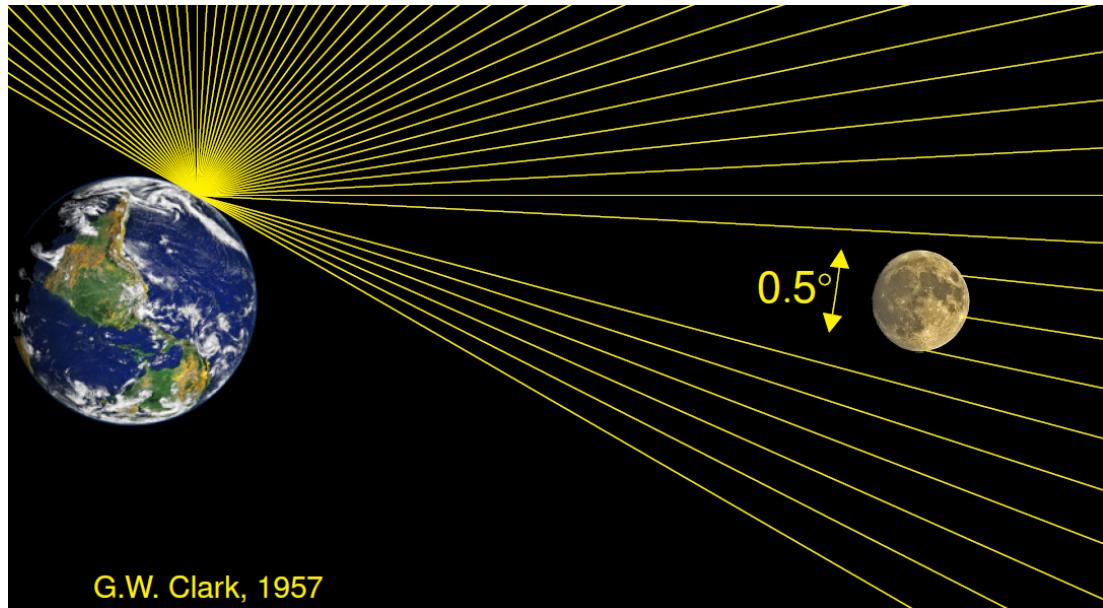


InIce detectie principe



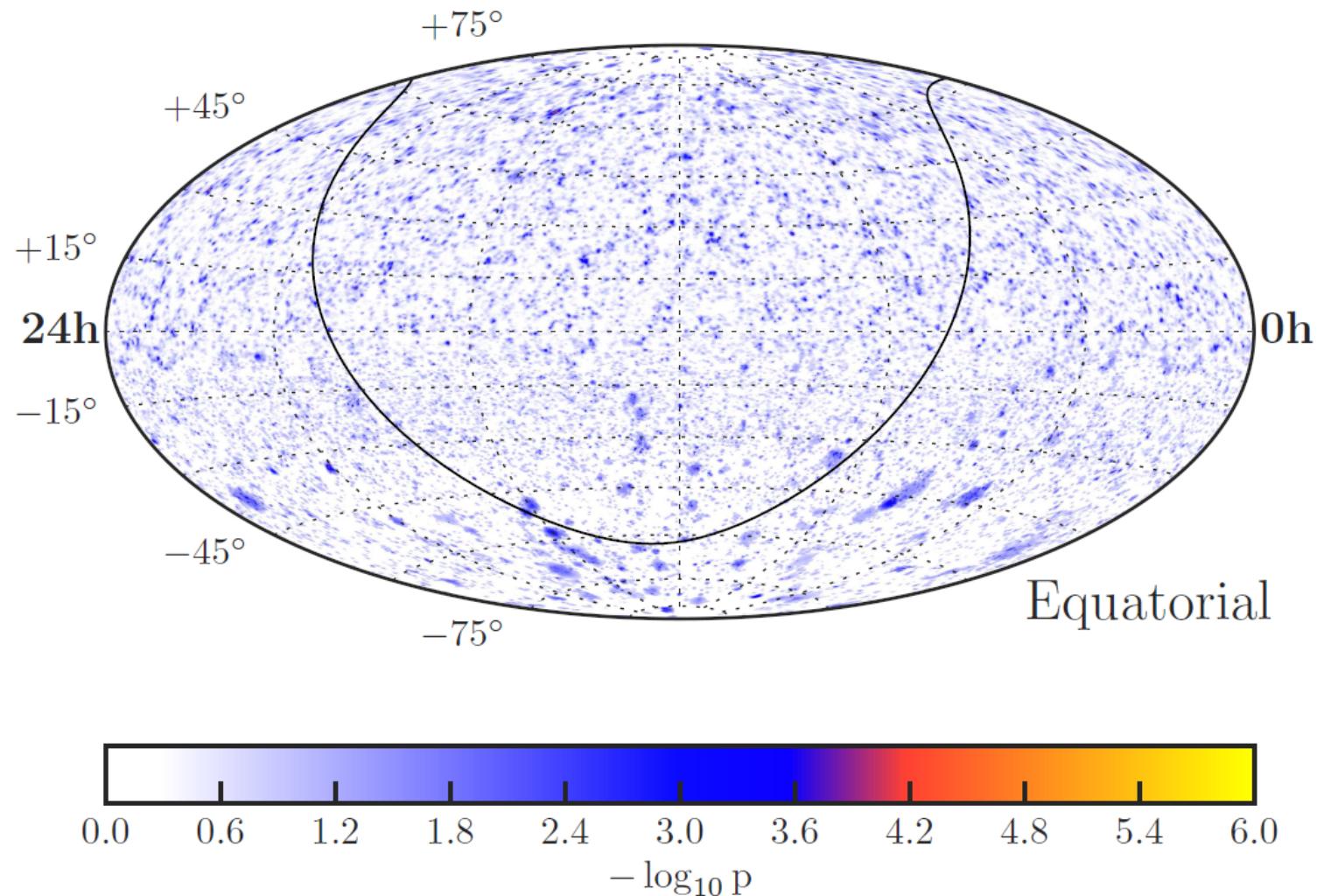
Muonen van atmosferische interacties

De schaduw van de Maan



Hoekresolutie : $\sim 0.8^\circ$

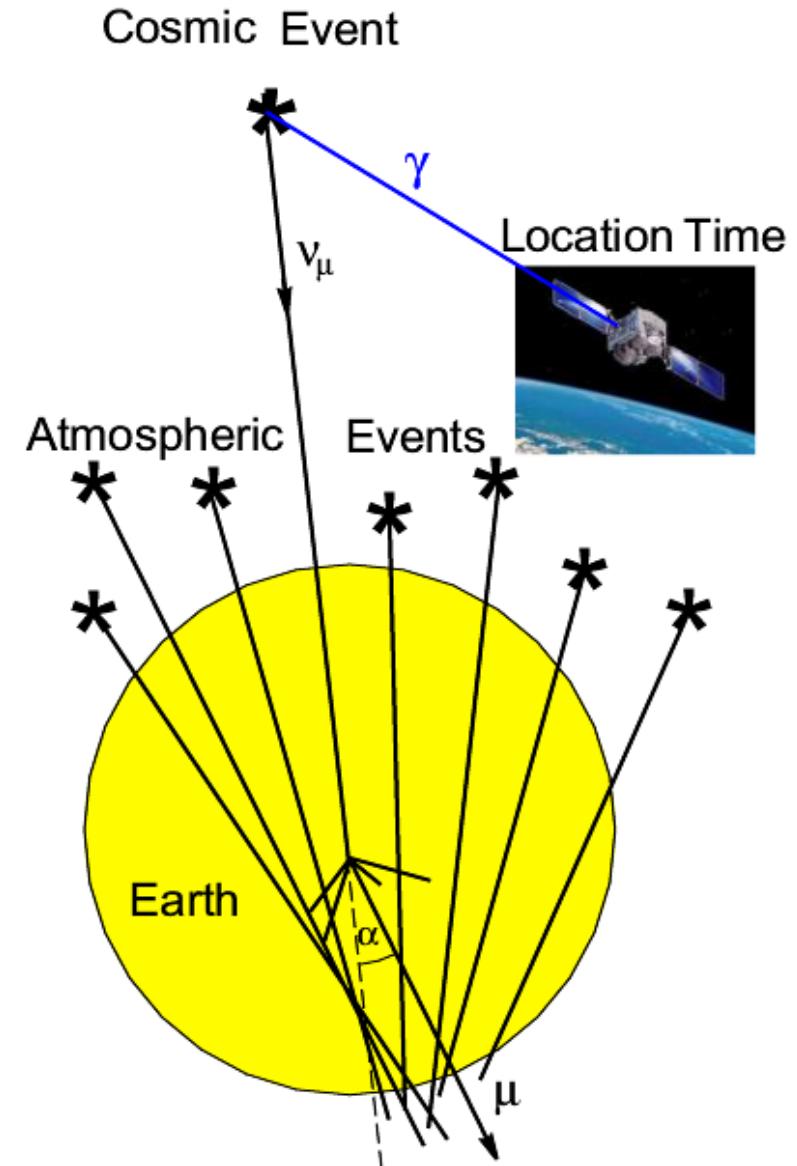
De IceCube hemelkaart (7 jaar data, $\sim 700'000$ events)



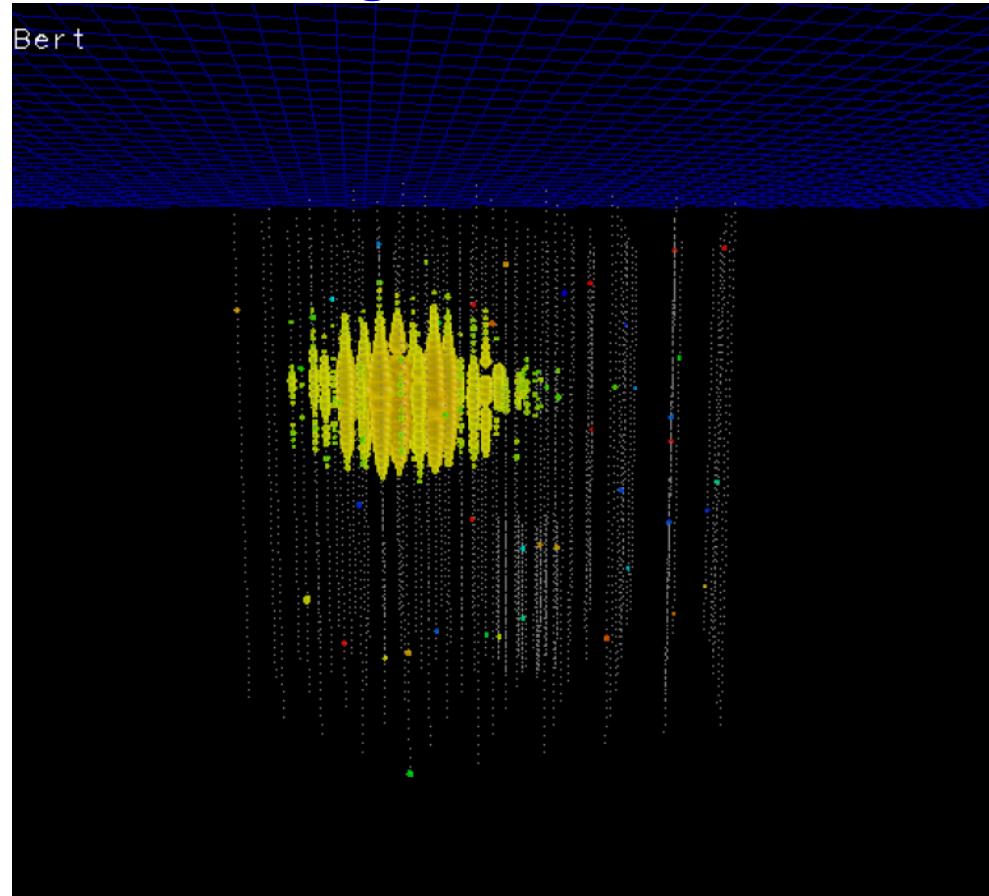
- Signalen zijn atm. achtergrond ν
Niet te onderscheiden van kosm. ν

Kijk naar kortstondige explosies

Specifieke plaats en tijd (satelliet)
→ nagenoeg geen achtergrond
* IIHE movie



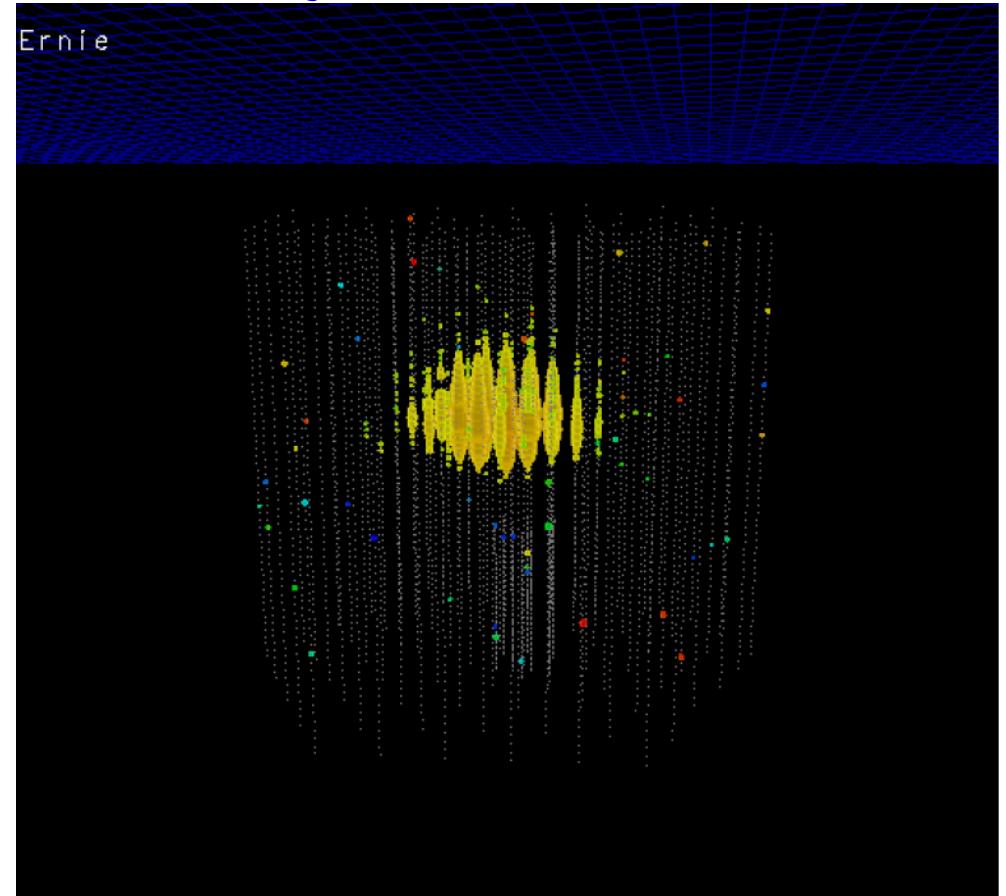
Tue 09-aug-2011 07:23:18 UTC



1.04 ± 0.16 PeV

Atmosferische ν achtergrond ?

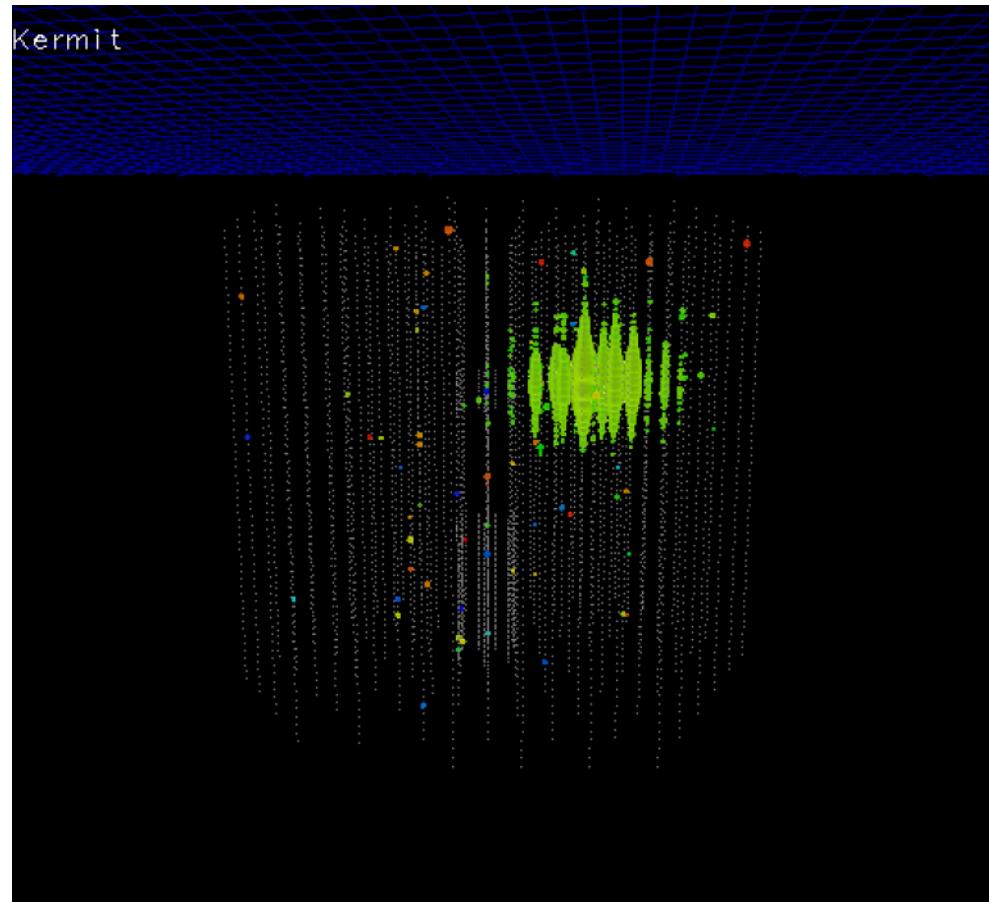
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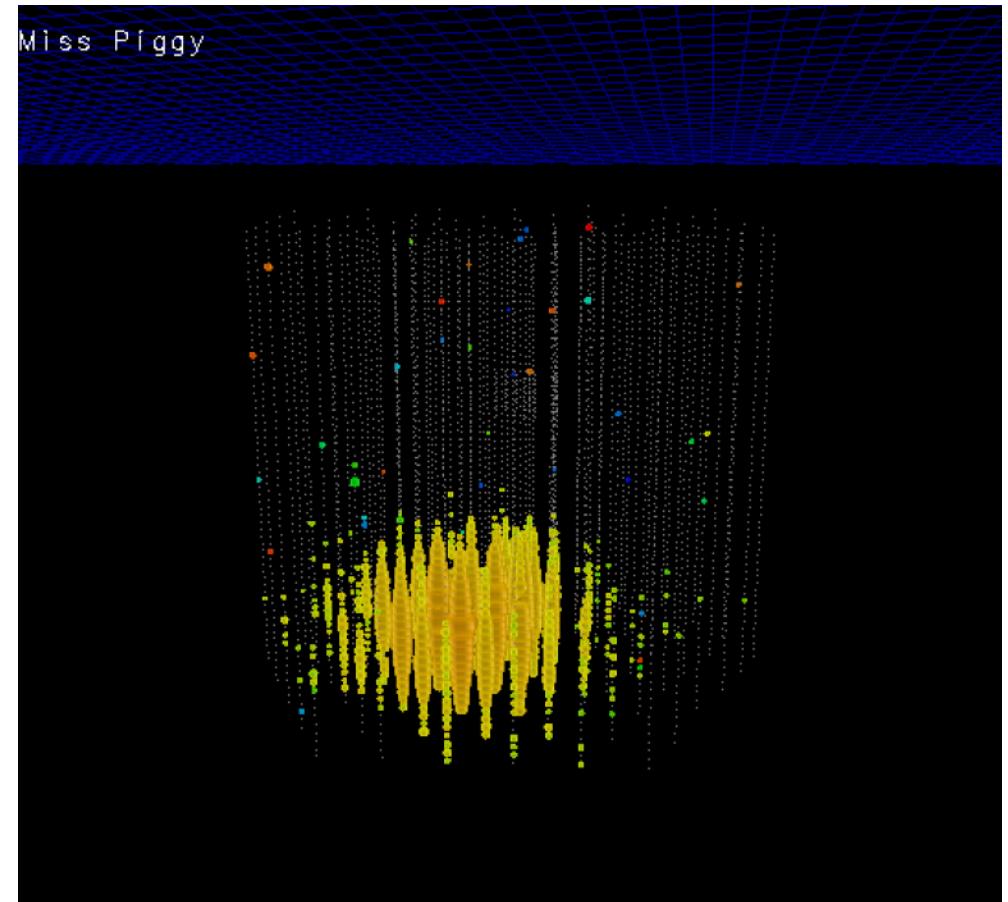
1.14 ± 0.17 PeV

Slechts ca. 0.3% kans op achtergrond

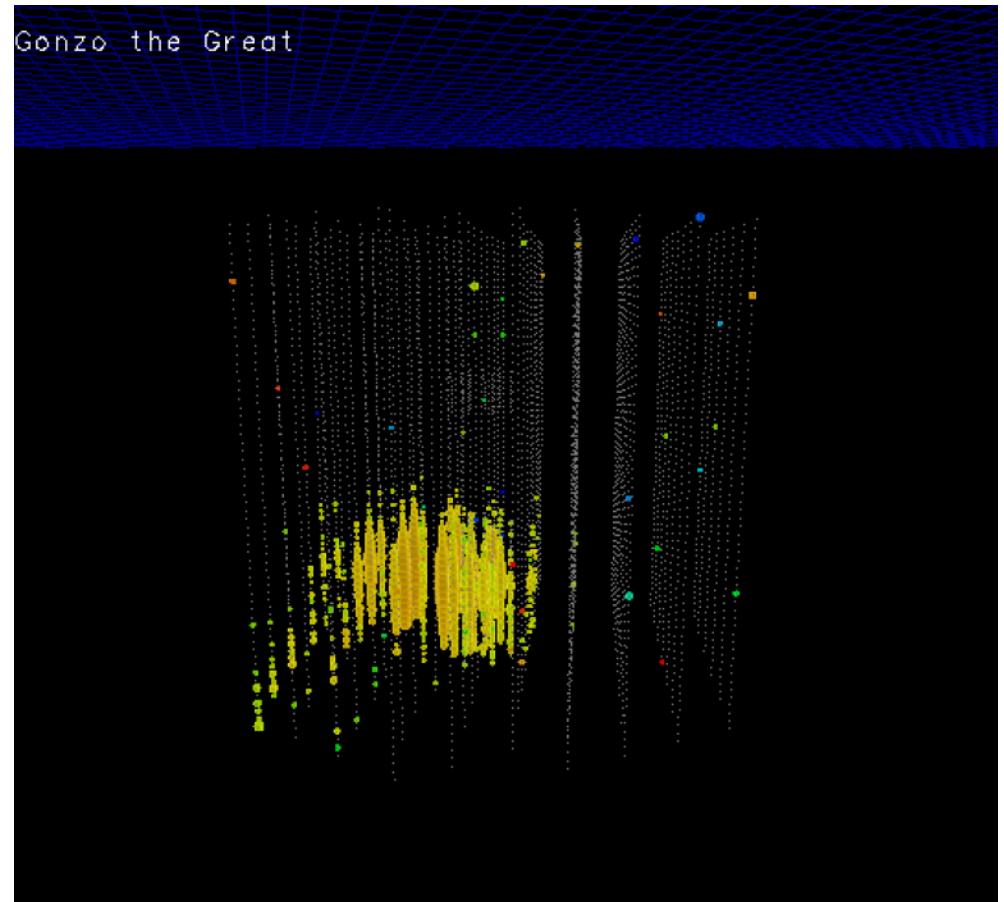
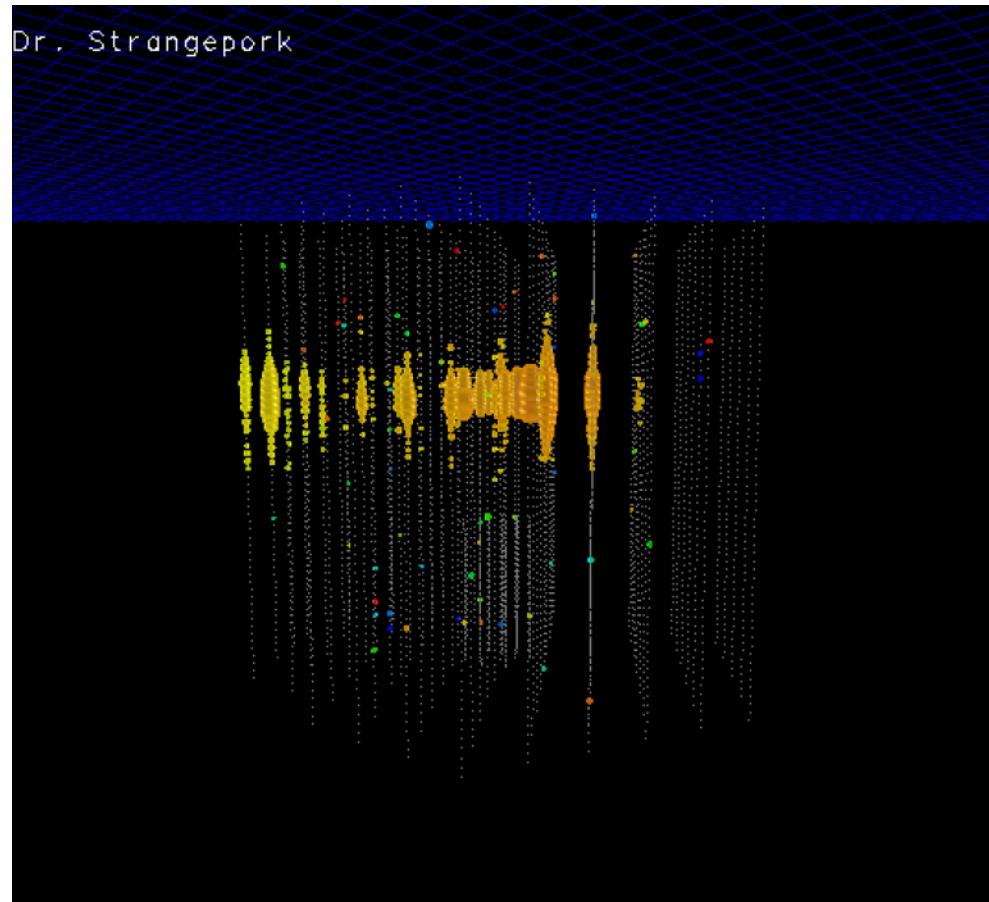
Kermit



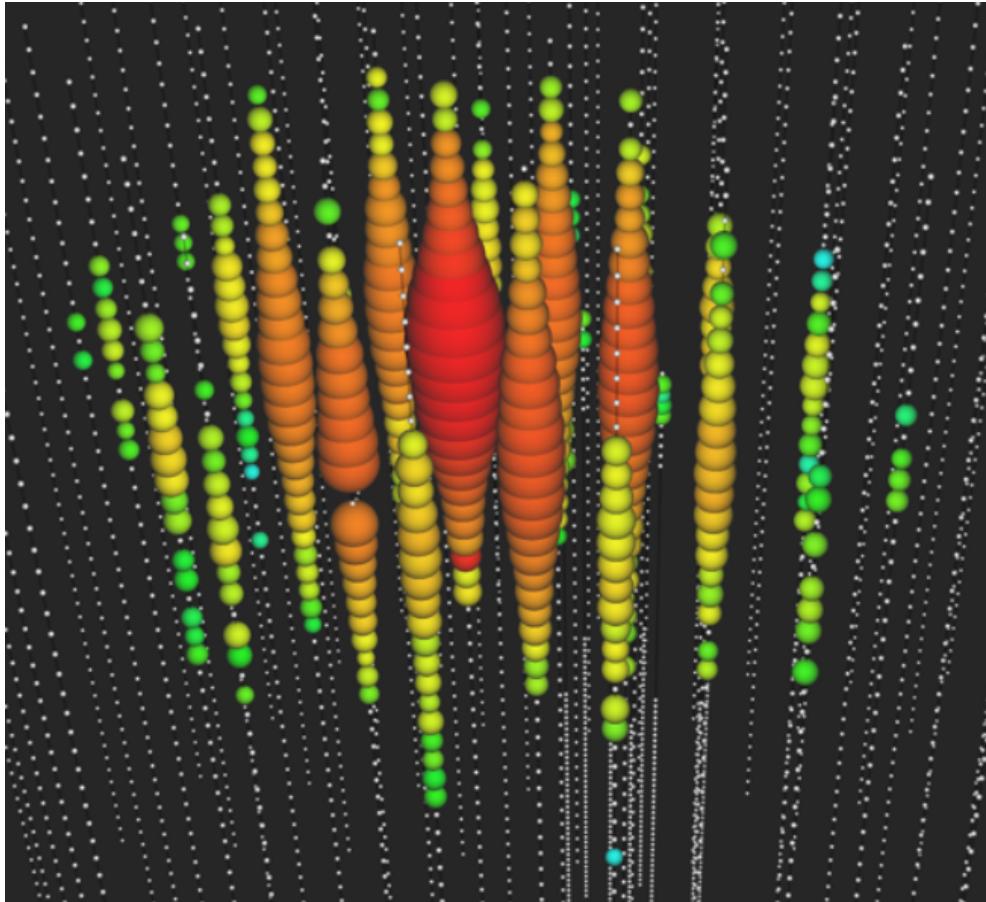
Miss Piggy



Ook enkele μ spoor signaturen



Onze huidige kampioen

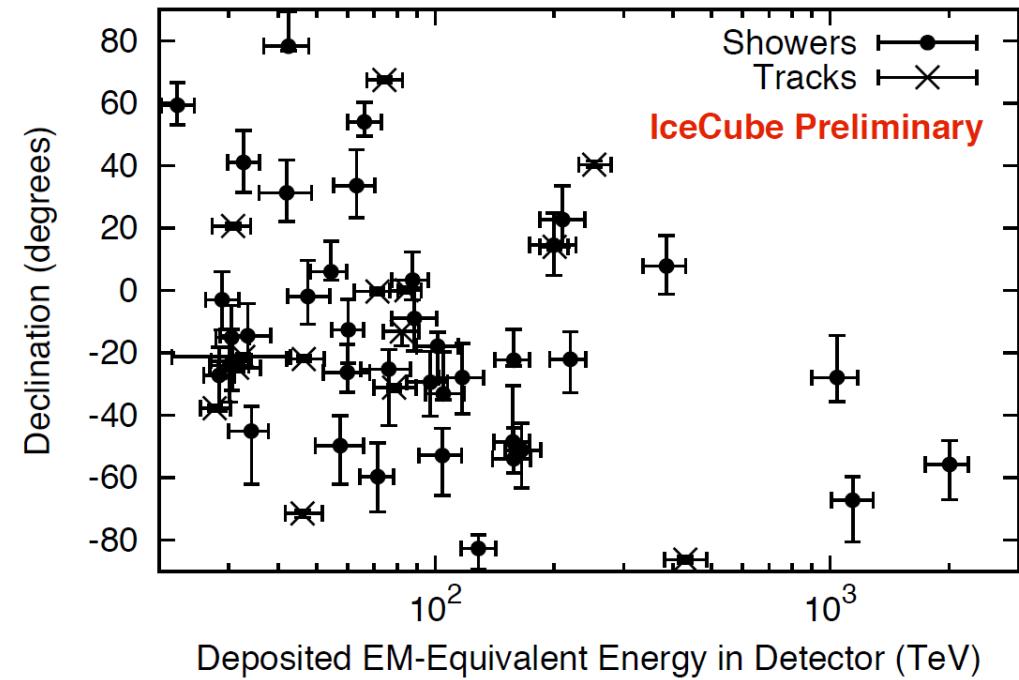
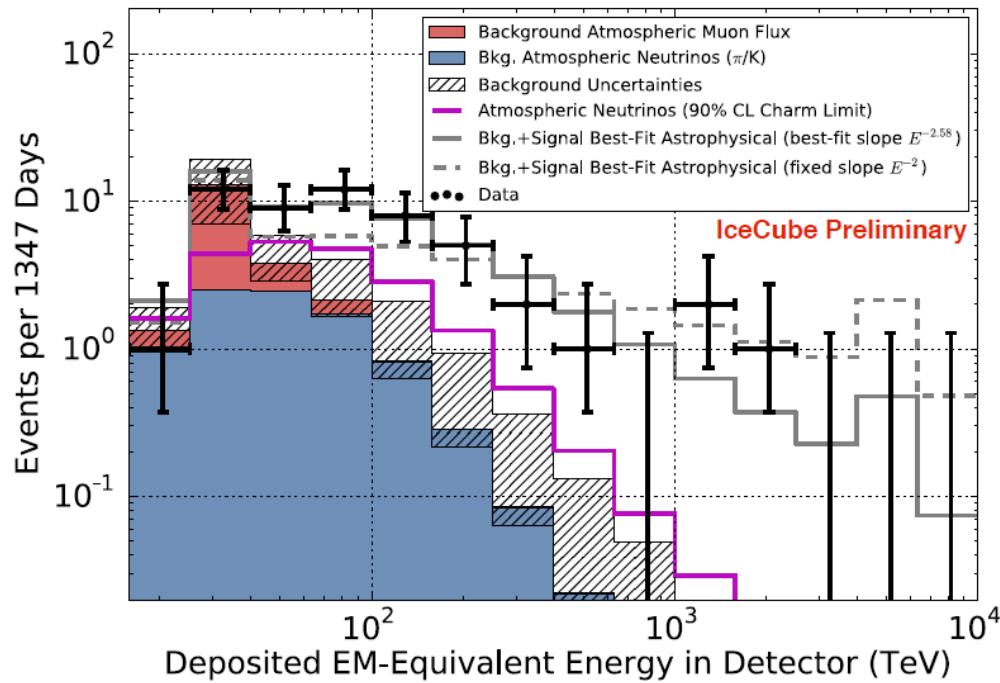


2.00 ± 0.25 PeV



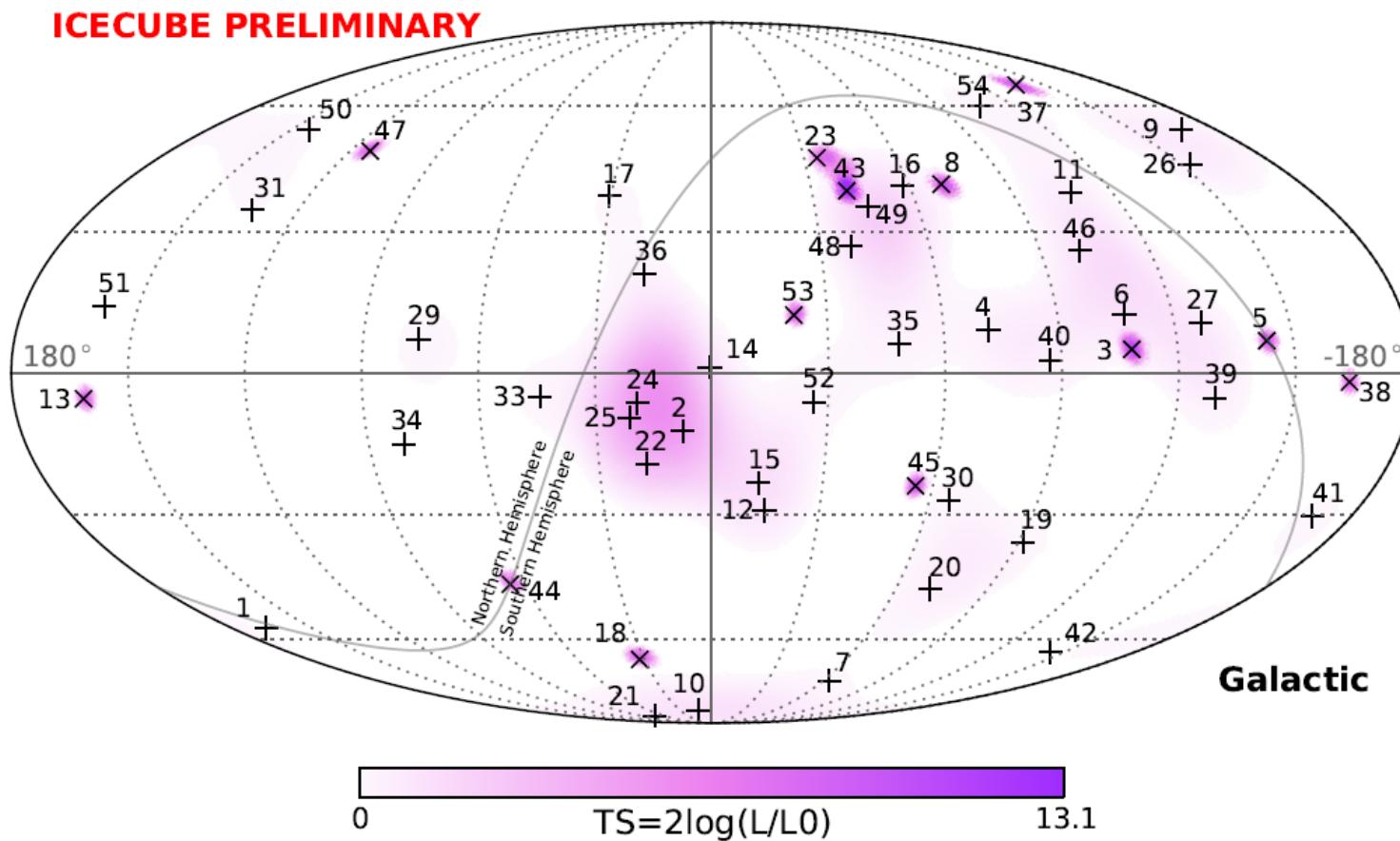
Big Bird

Energie distributie van de 54 events



Aanduiding voor kosmische hoog-energetische neutrino's

Herkomst van de 54 events



Geen bewijs voor puntbron(nen)

- **IceCube : 's Werelds grootste neutrino observatorium op de Zuidpool**

De volledige IceCube detector is sinds december 2010 in bedrijf

IceCube sensoren werken naar behoren (Maanschaduw, hemelkaart)

- **Zeer gedetailleerd onderzoek van de "neutrino hemel"**

Valt in tijd mooi samen met satelliet waarnemingen (Swift, Fermi)

→ Perfect voor GRB onderzoek

- **Wereldprimeur : Kosmische hoog-energetische neutrino's ontdekt**

De geboorte van Neutrino Astronomie

- **Onderzoek aan de VUB :**

Nieuwe methode voor detectie van GRB neutrino's

Onderzoek naar neutrino productie in zonnevlammen

Nieuw idee voor neutrino detectie van actieve melkwegkernen

Er breken zeer interessante tijden aan voor onze Astrodeeltjes Fysica !