

IceCube : Een nieuw venster op het Universum

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VRIJE
UNIVERSITEIT
BRUSSEL

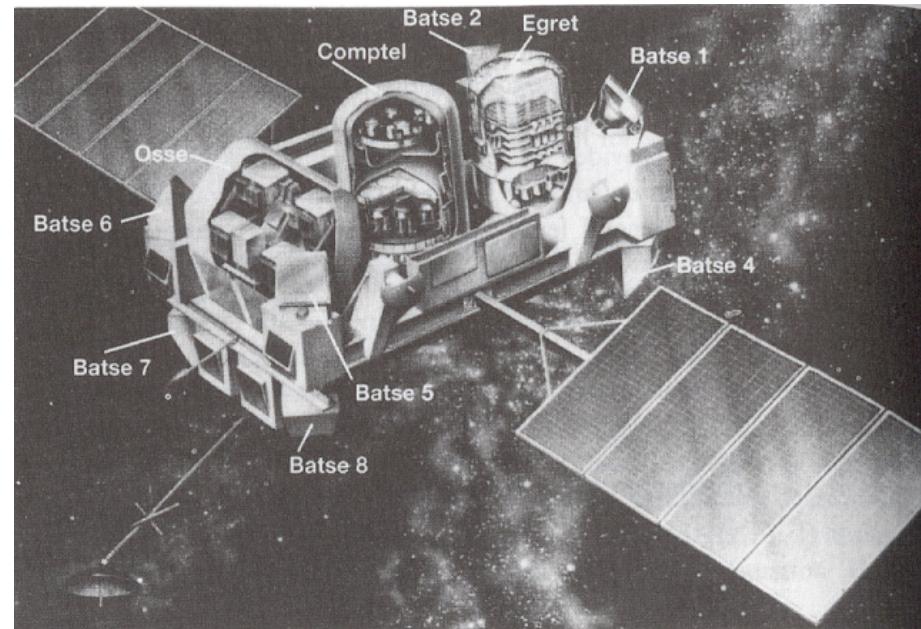
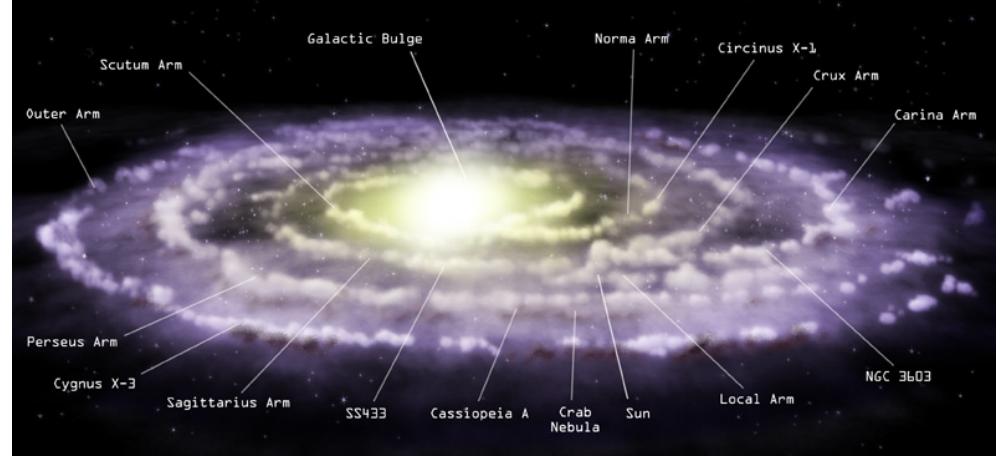
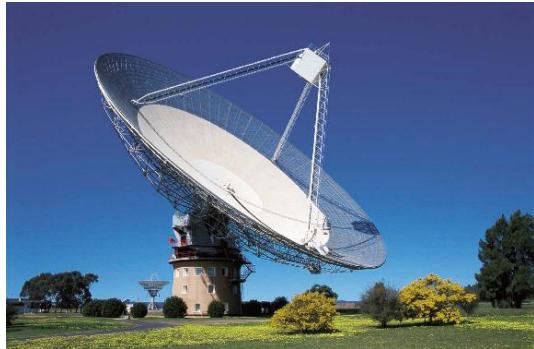


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Overzicht

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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.

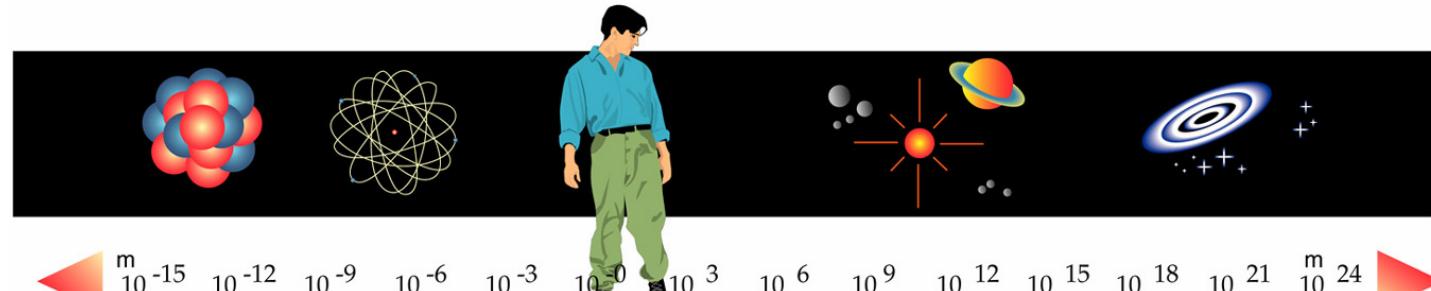


Particle physics looks at matter in its smallest dimensions.

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



Astrophysics looks at matter in its largest dimensions.



10^{-15}

10^{-12}

10^{-9}

10^{-6}

10^{-3}

10^{-0}

10^{+0}

10^{+3}

10^{+6}

10^{+9}

10^{+12}

10^{+15}

10^{+18}

10^{+21}

10^{+24}

m

Microscopes
Microscopes

Jumelles
Binoculars

Telescopes optiques & radio
Optical & radio telescopes

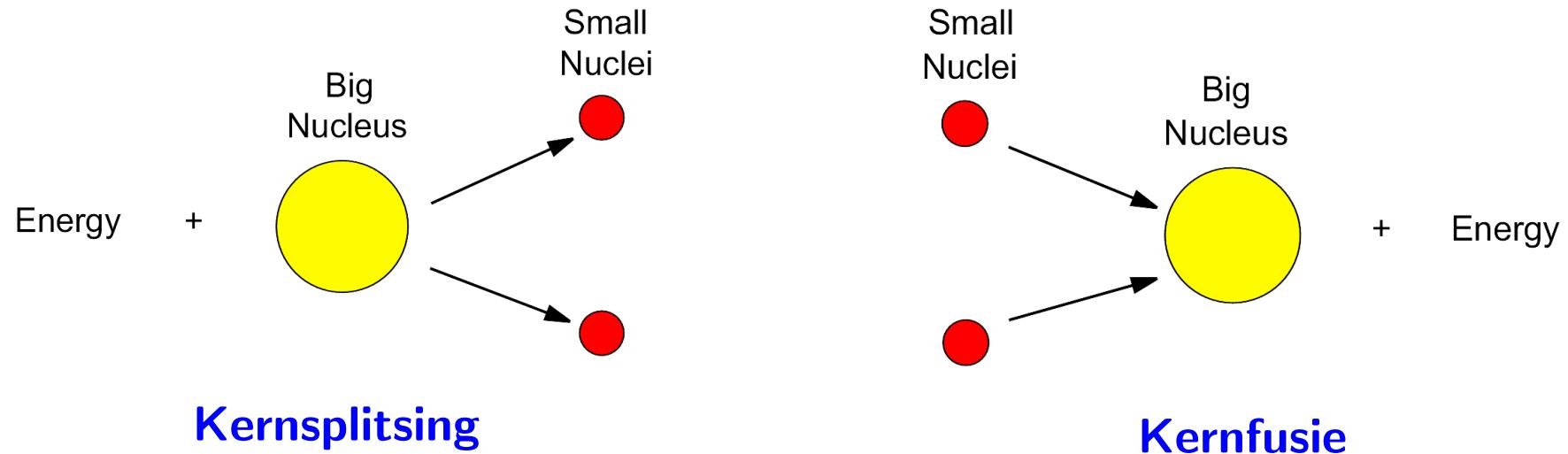
Accélérateurs
et détecteurs
Accelerators
and detectors

L'oeil nu.
Naked eye

THE TWO FRONTIERS OF PHYSICS LES DEUX FRONTIERES DE LA PHYSIQUE

CERN AC - Z11 - V11/5/98

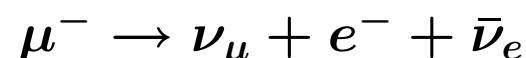
Kernfusie laat sterren stralen



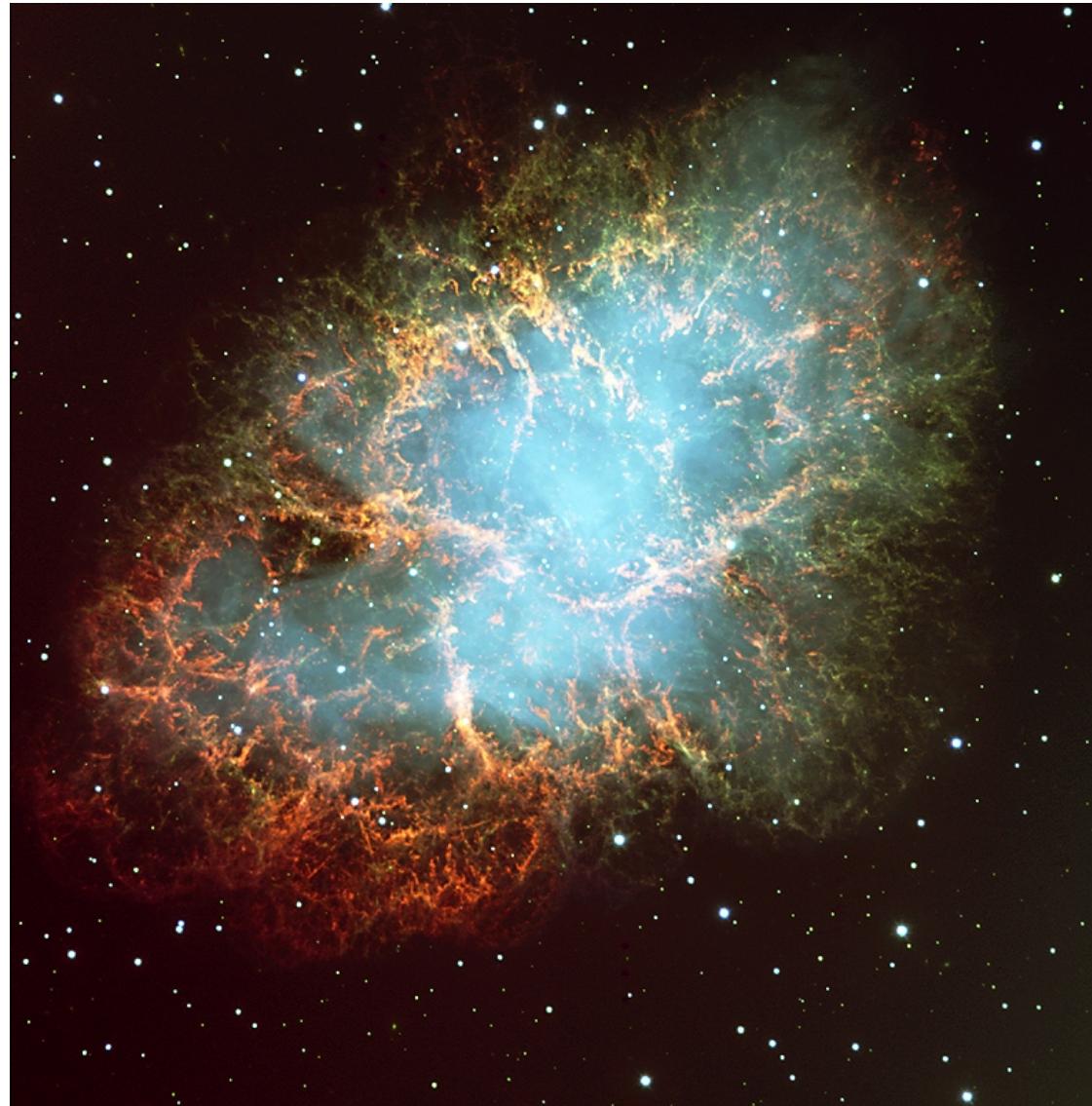
Zwakke kracht produceert neutrinos

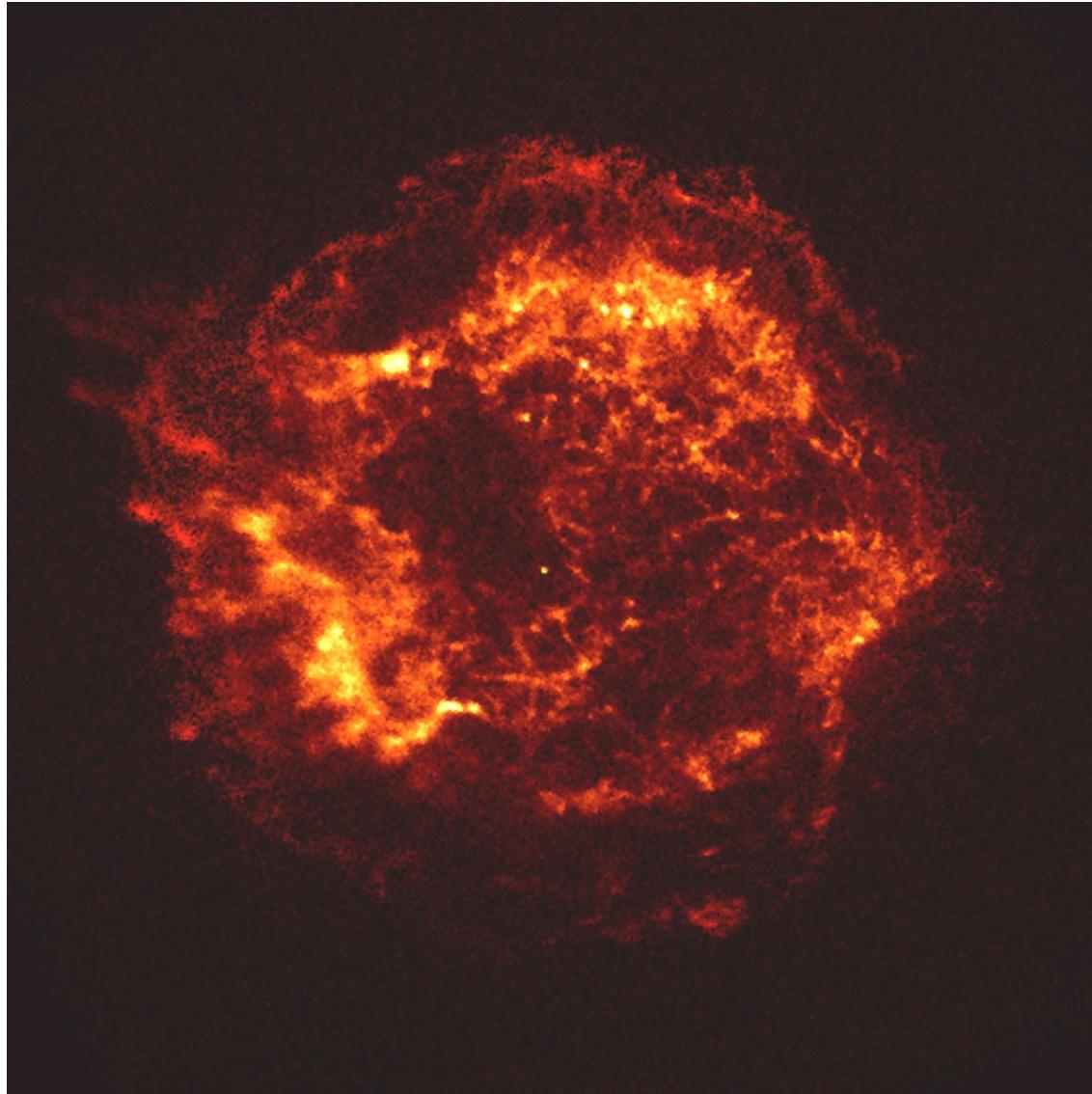
(Supernovae, AGN, GRBs)

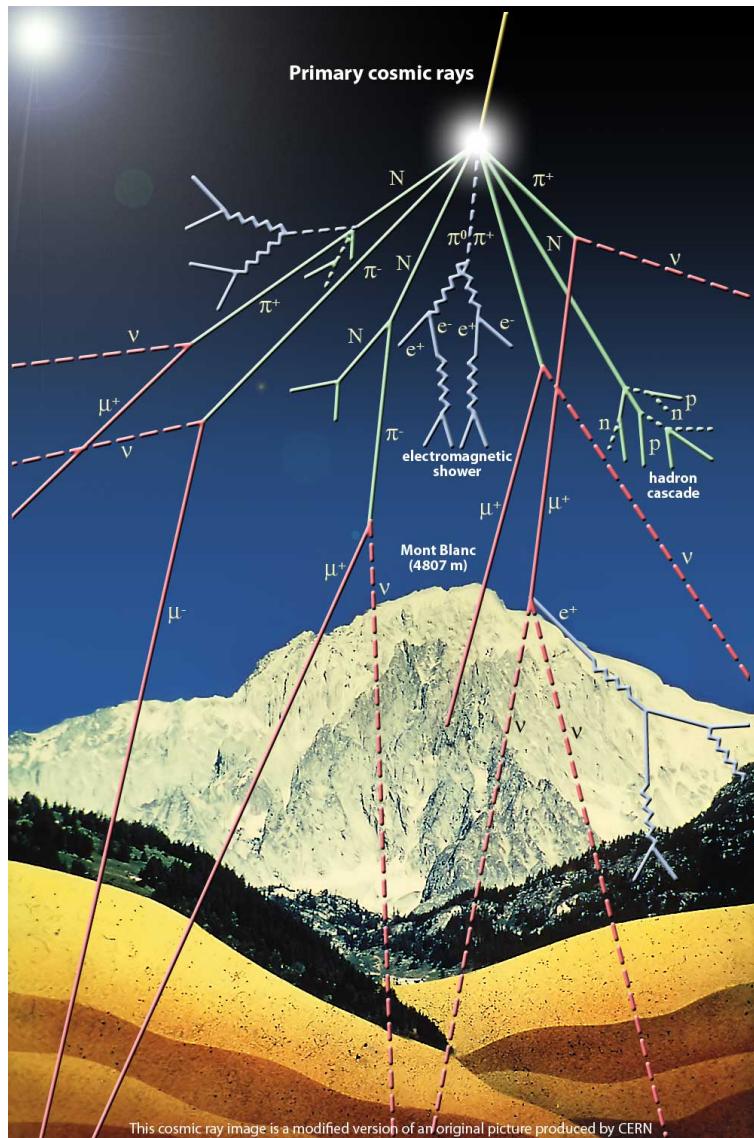
- Ontstaan van neutronen sterren



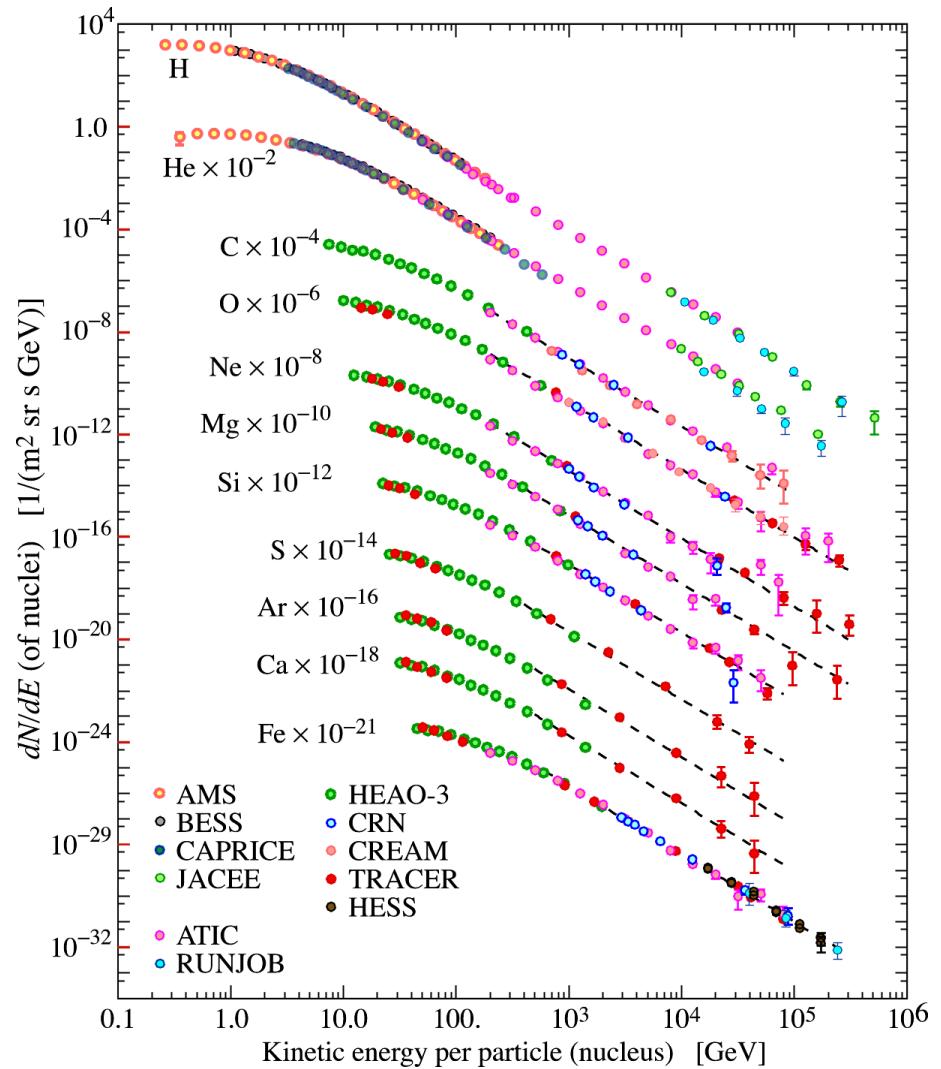
Het onzichtbare heelal



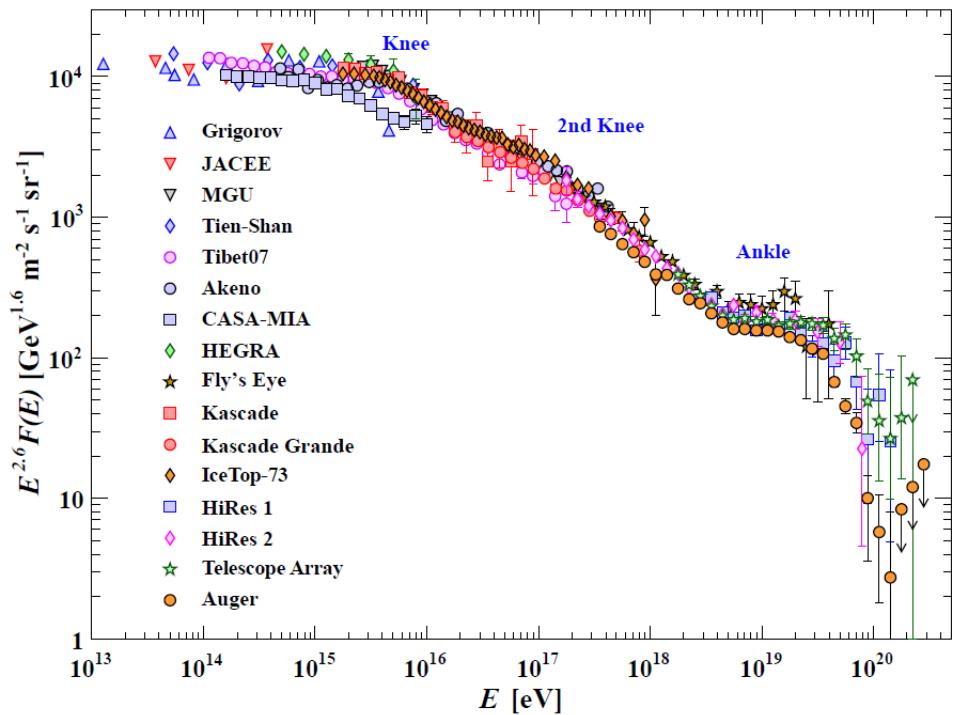




Spectrum van kosmische straling



$E^{2.6}$ 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

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

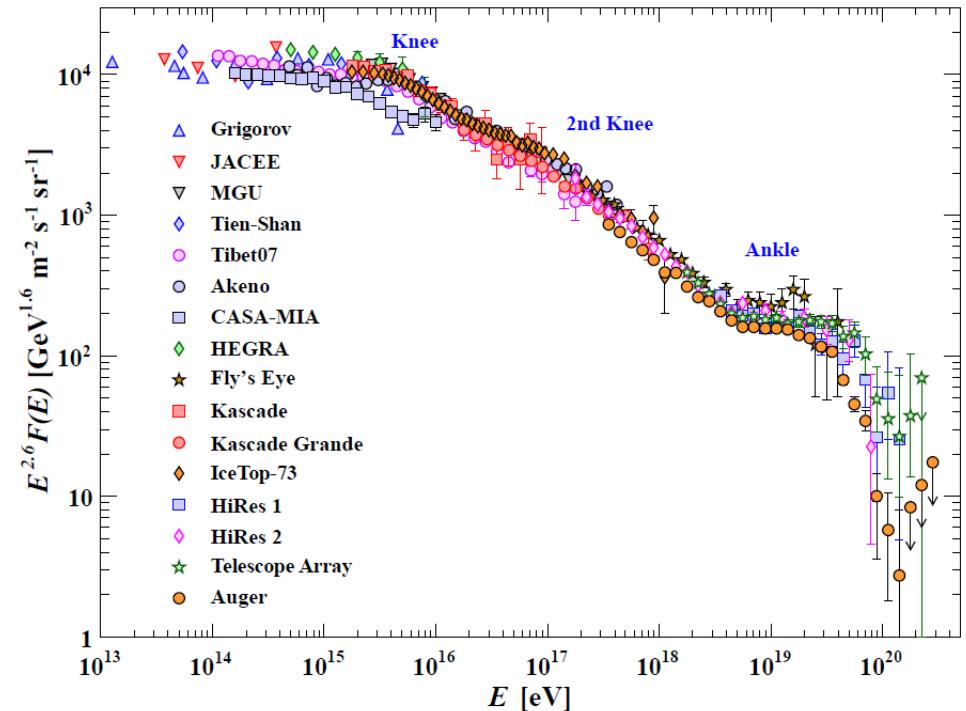
$$\text{Typisch : } B \approx \mu\text{G} \quad R \approx 3 \cdot 10^{16} \text{ m}$$

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

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

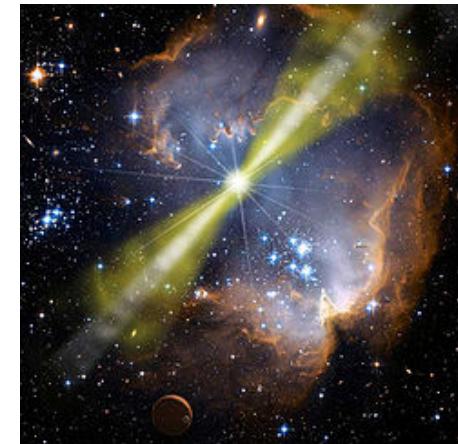
$$* E > 10^{19} \text{ eV} \rightarrow r > R_{melkweg}$$

\Rightarrow Extra-galactische oorsprong

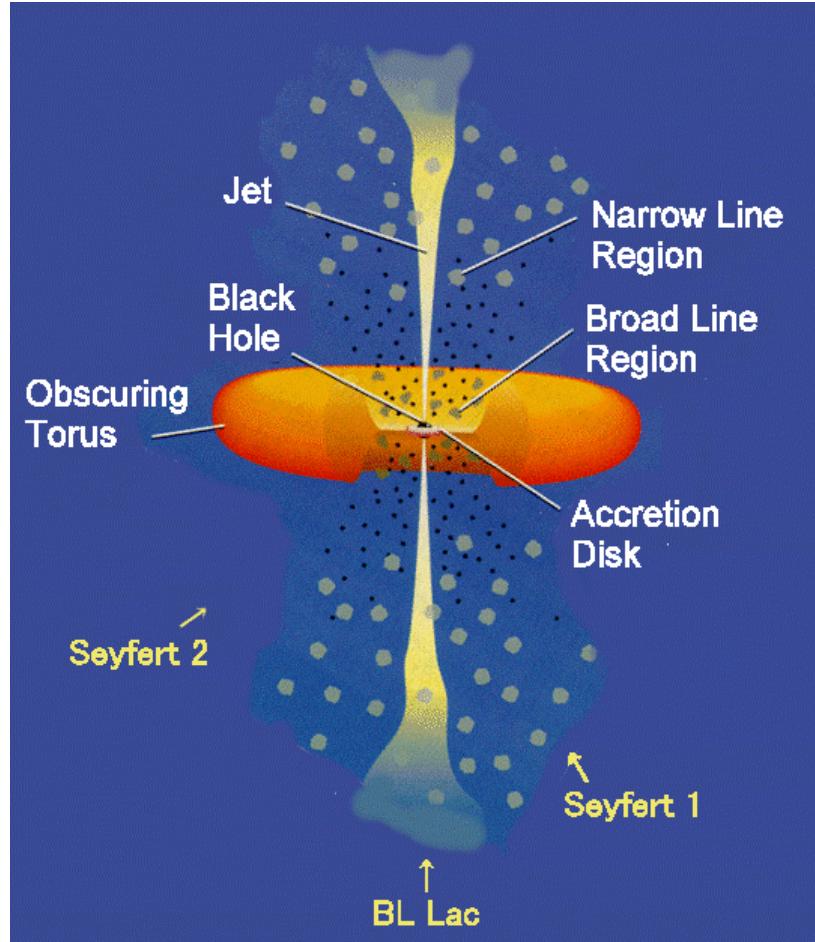


Wat veroorzaakt de 'enkel' ?

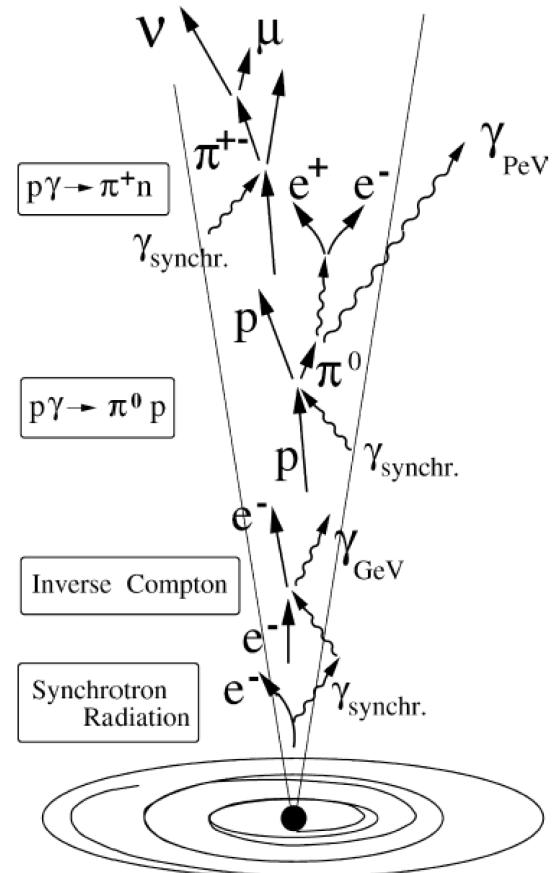
Nog veel krachtiger explosies
(AGN and GRBs)

Actieve Melkwegkernen (AGN)**Kosmische Gamma Flitsen (GRBs)**

Algemeen beeld

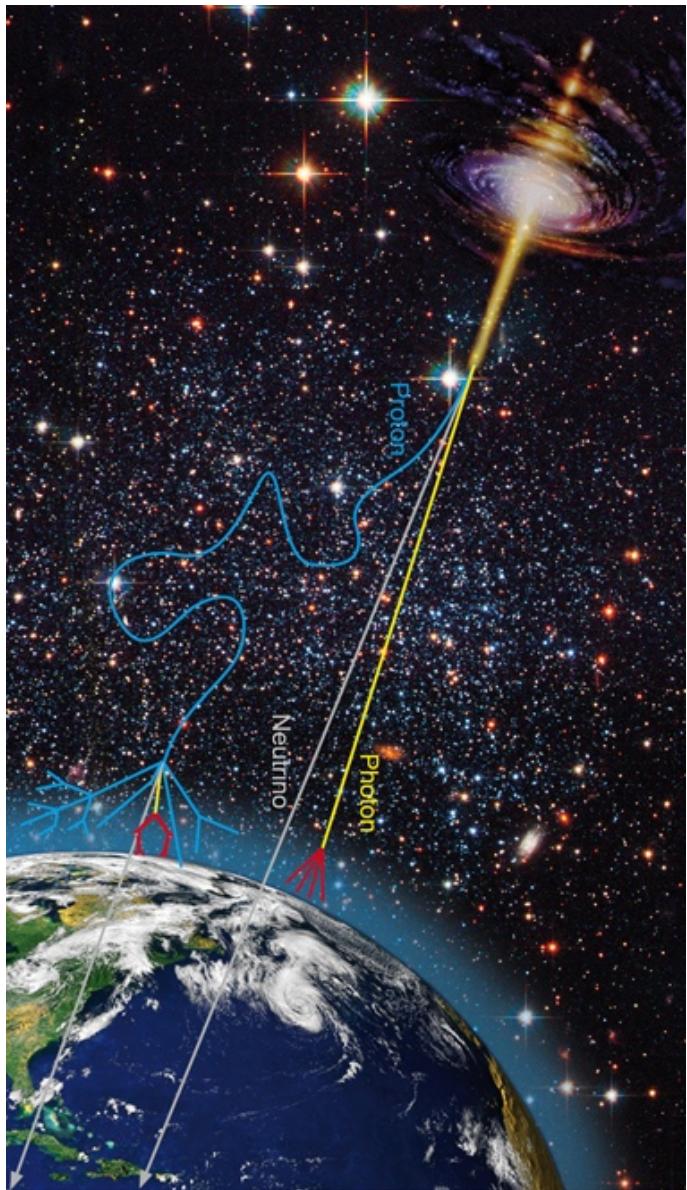


Fysische processen



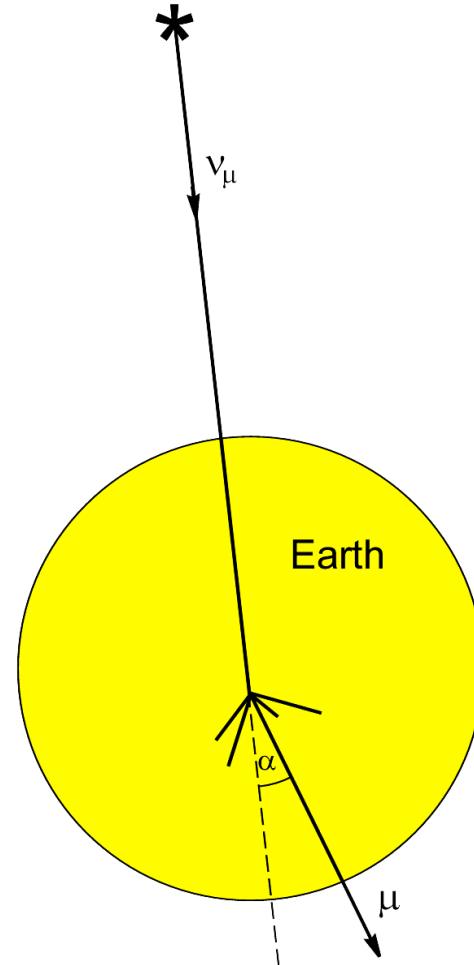
Versnelling in schokgolven

Hoog-energetische fotonen en neutrinos

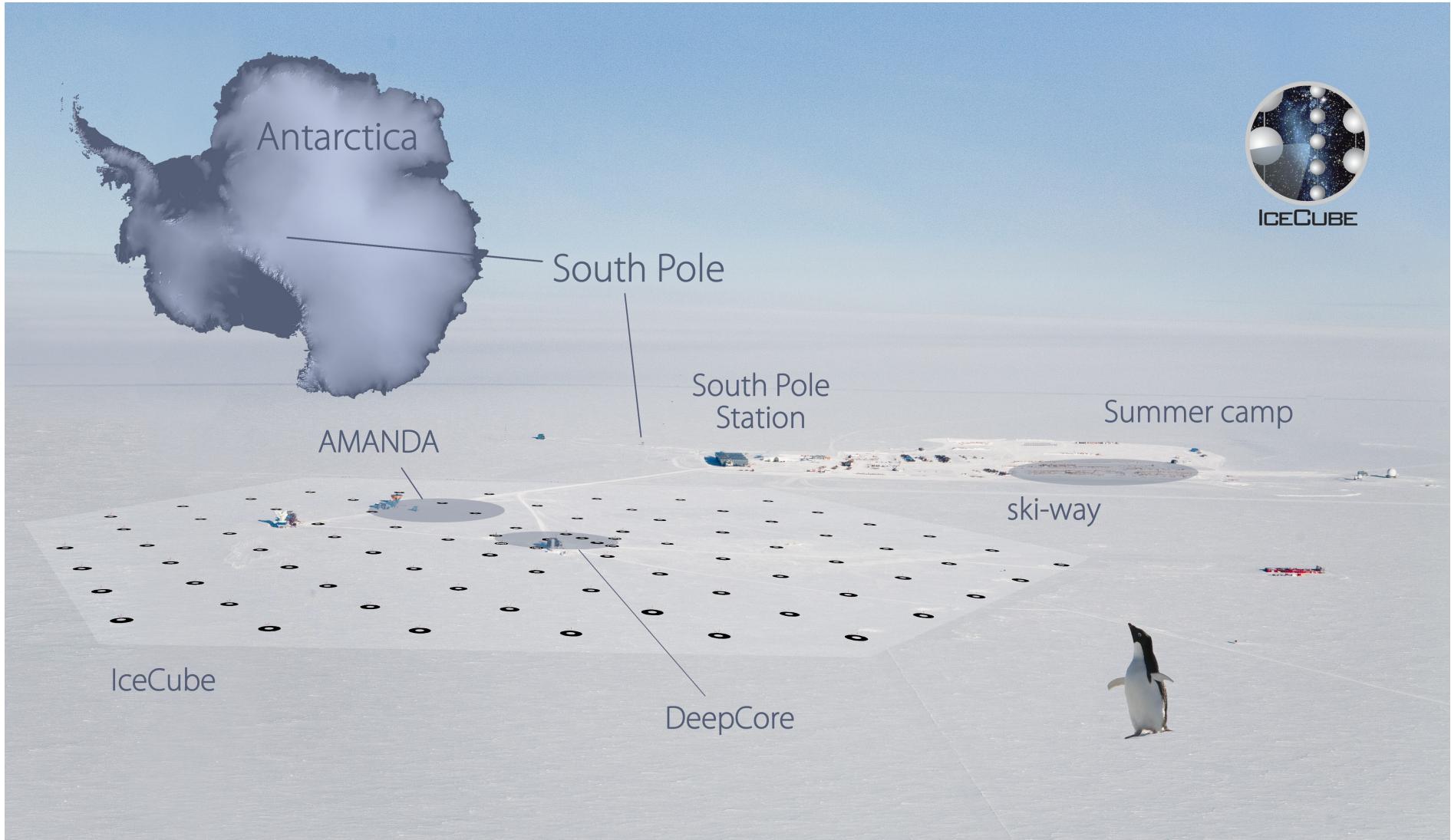


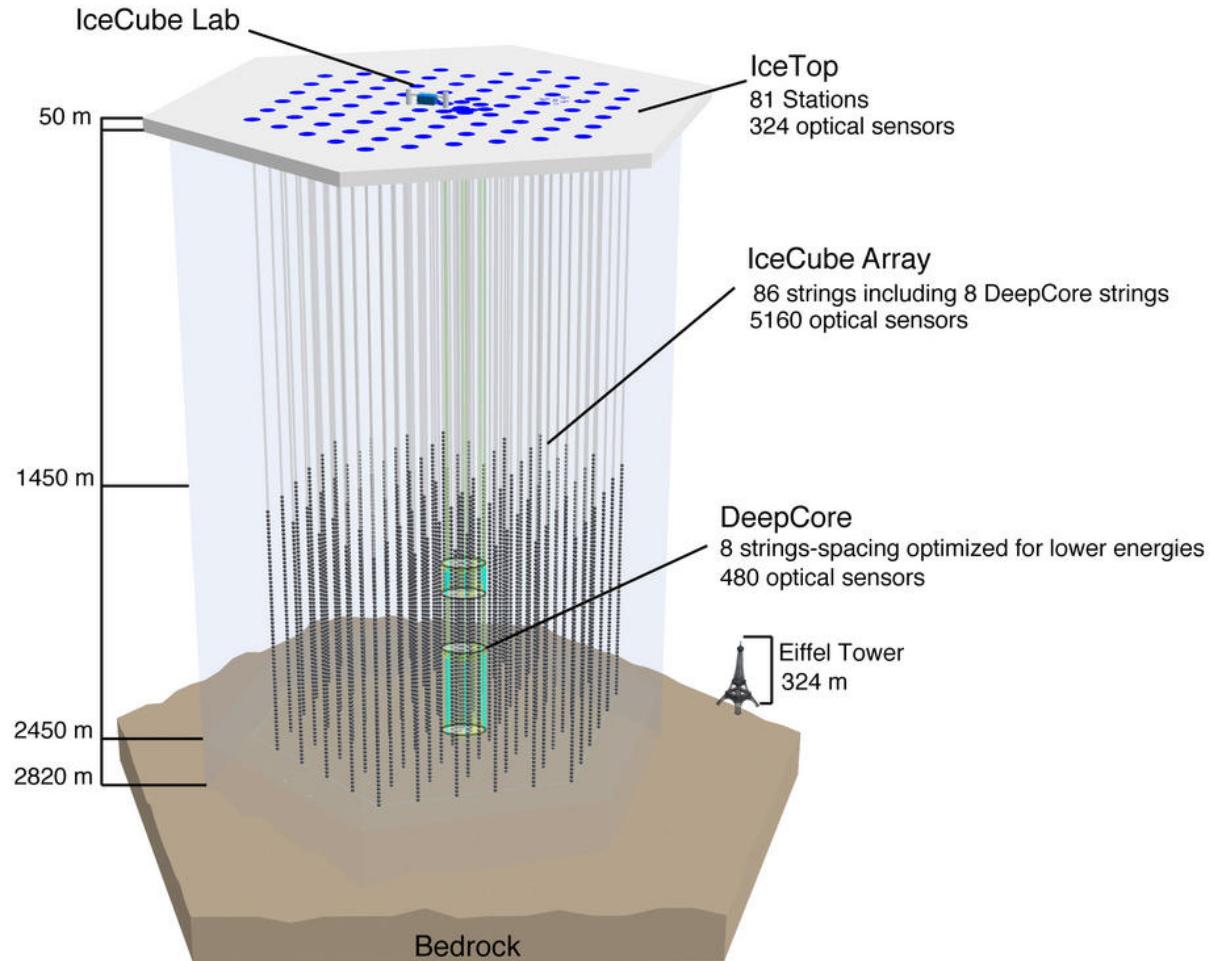
Neutrino detectie mechanisme

Cosmic Event



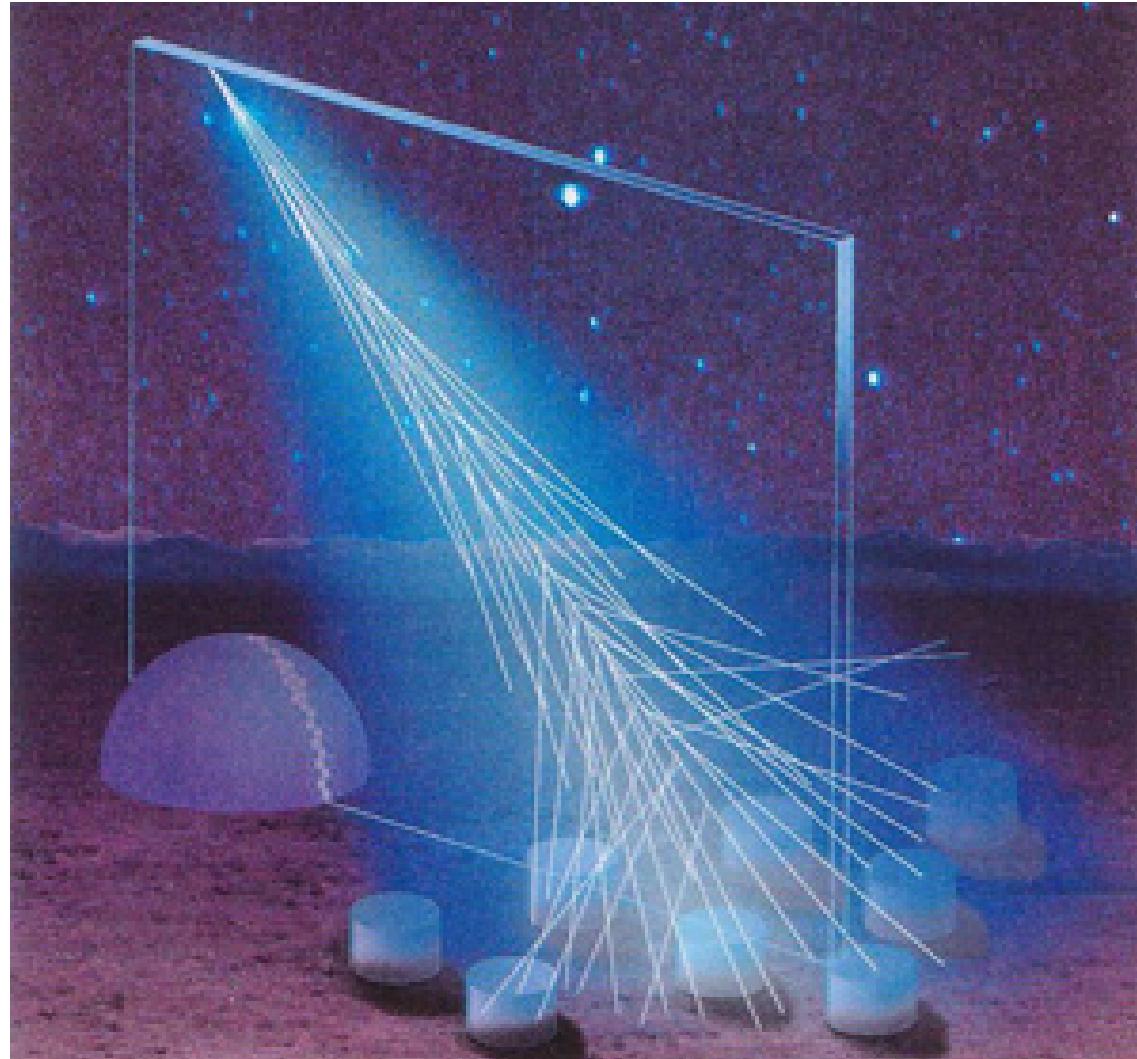


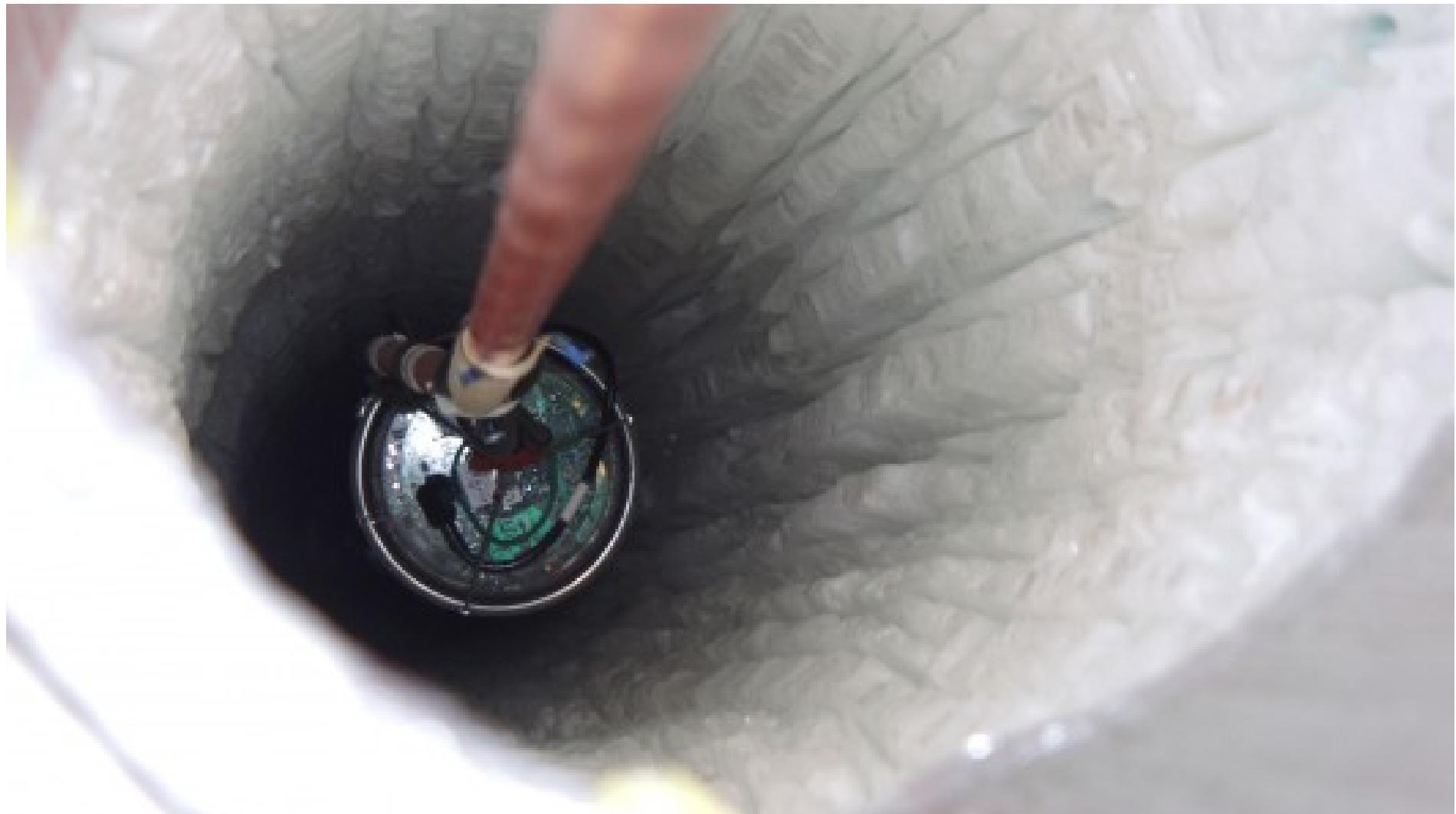




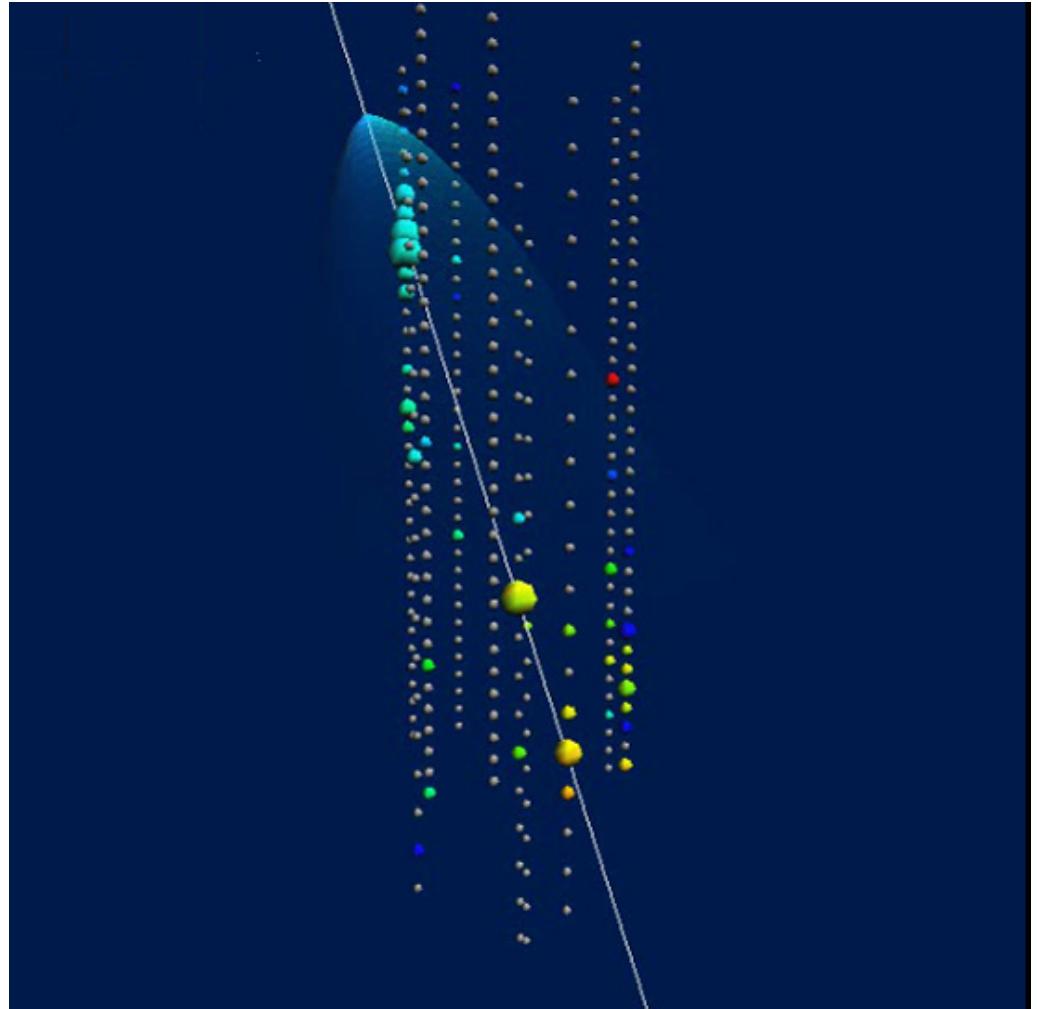
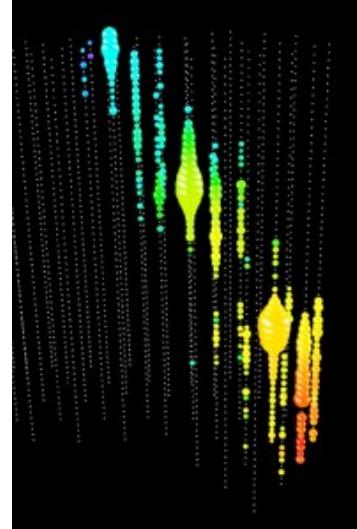


IceTop detectie principe

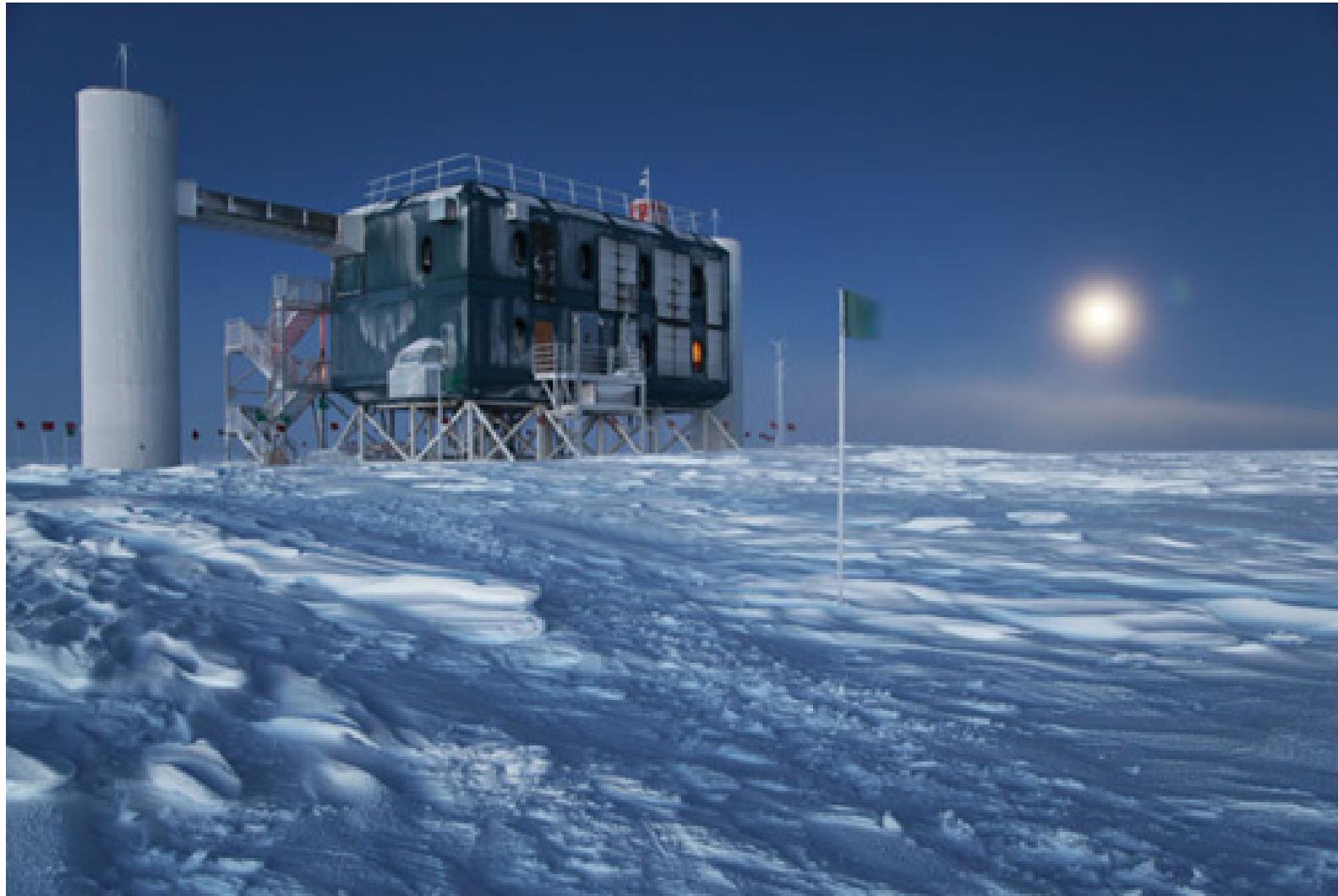




InIce detectie principe

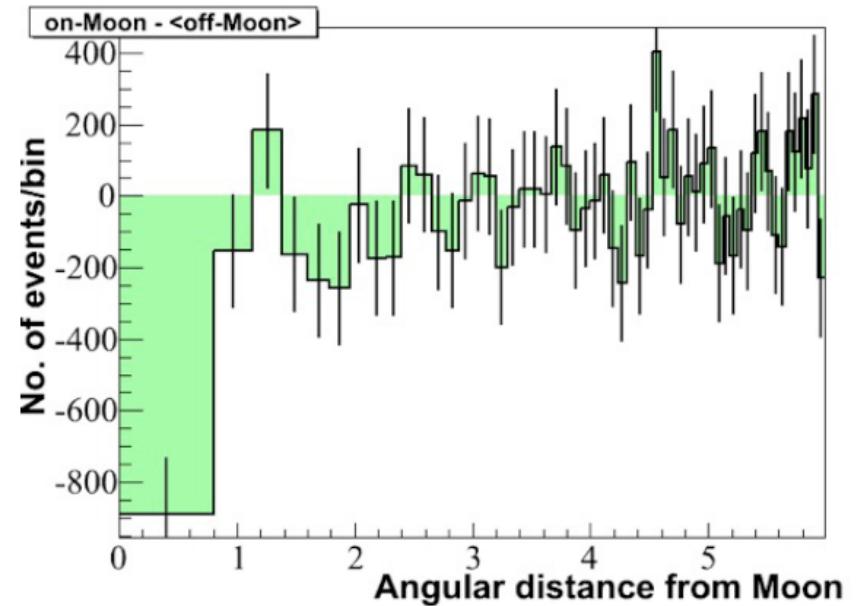
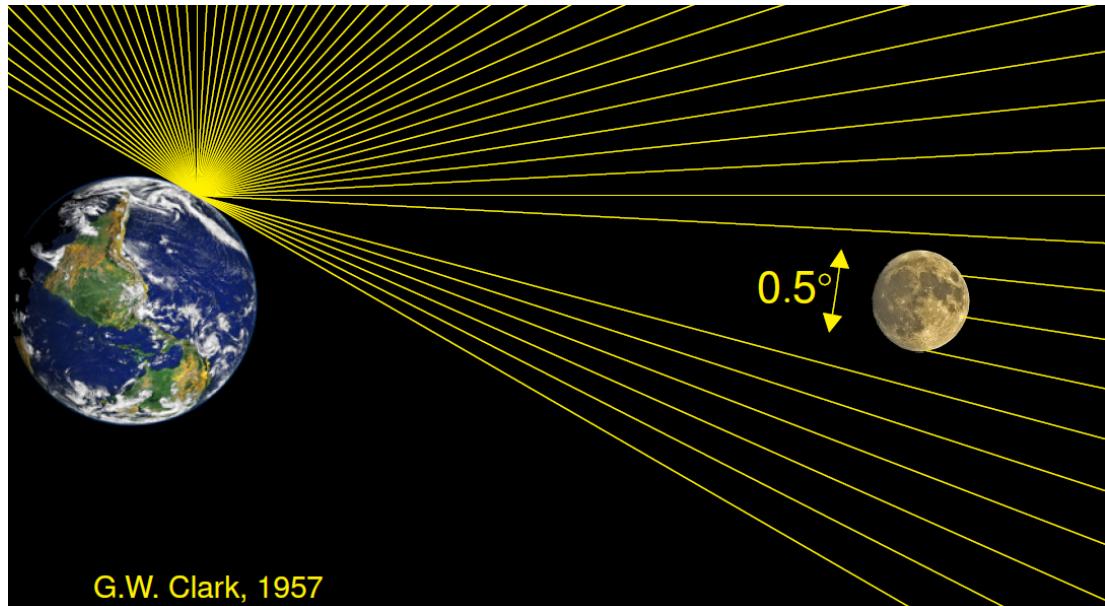


De IceCube Neutrino Telescoop



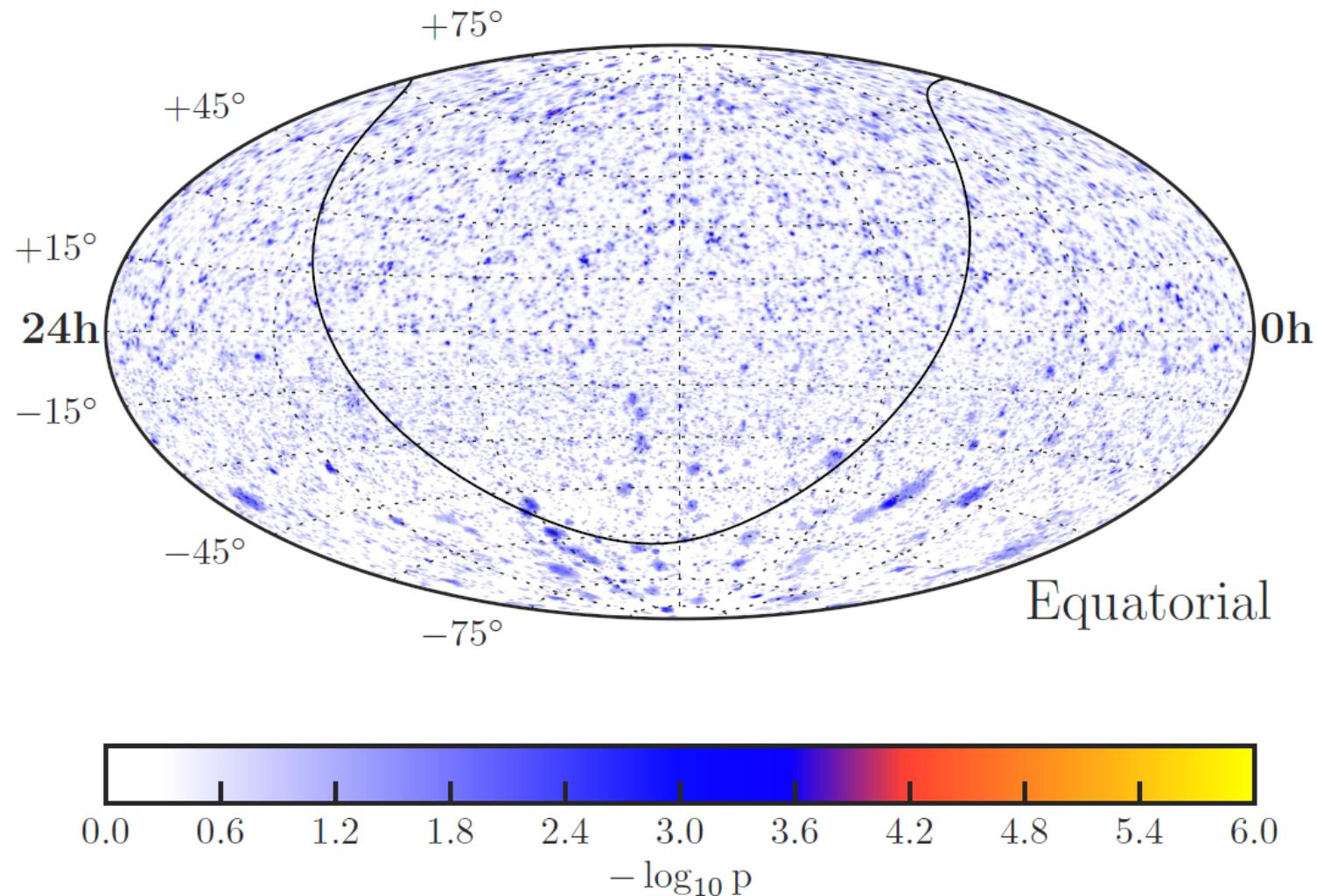
Muonen van atmosferische interacties

De schaduw van de Maan



Hoekresolutie : $\sim 0.8^\circ$

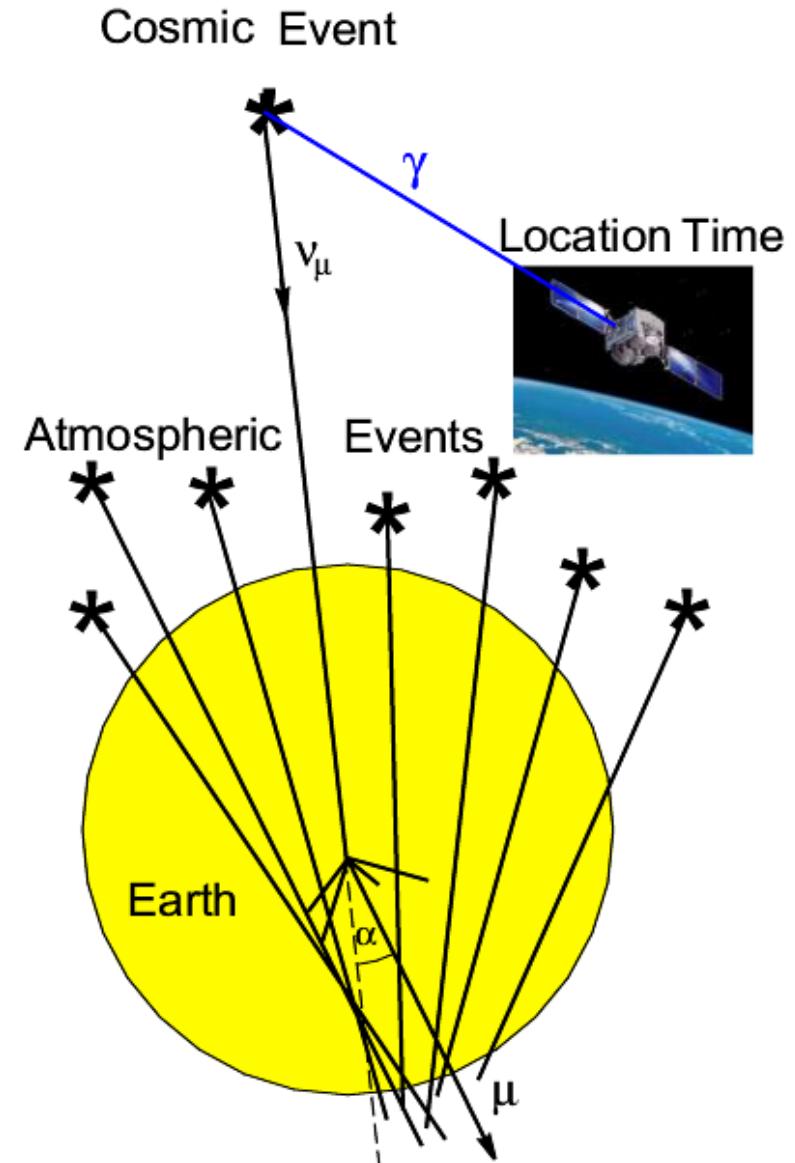
De IceCube hemelkaart (7 jaar data, $\sim 700'000$ events)



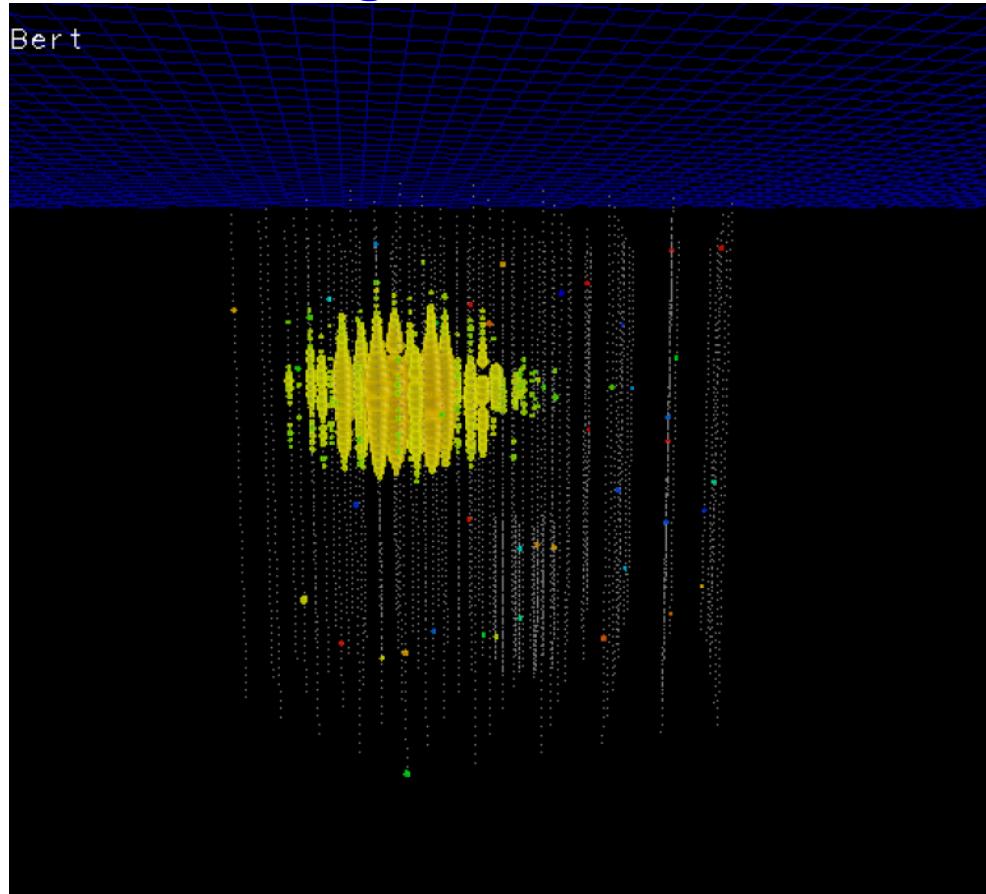
- Signalen zijn atm. achtergrond ν
Niet te onderscheiden van kosm. ν

Kijk naar kortstondige explosies

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



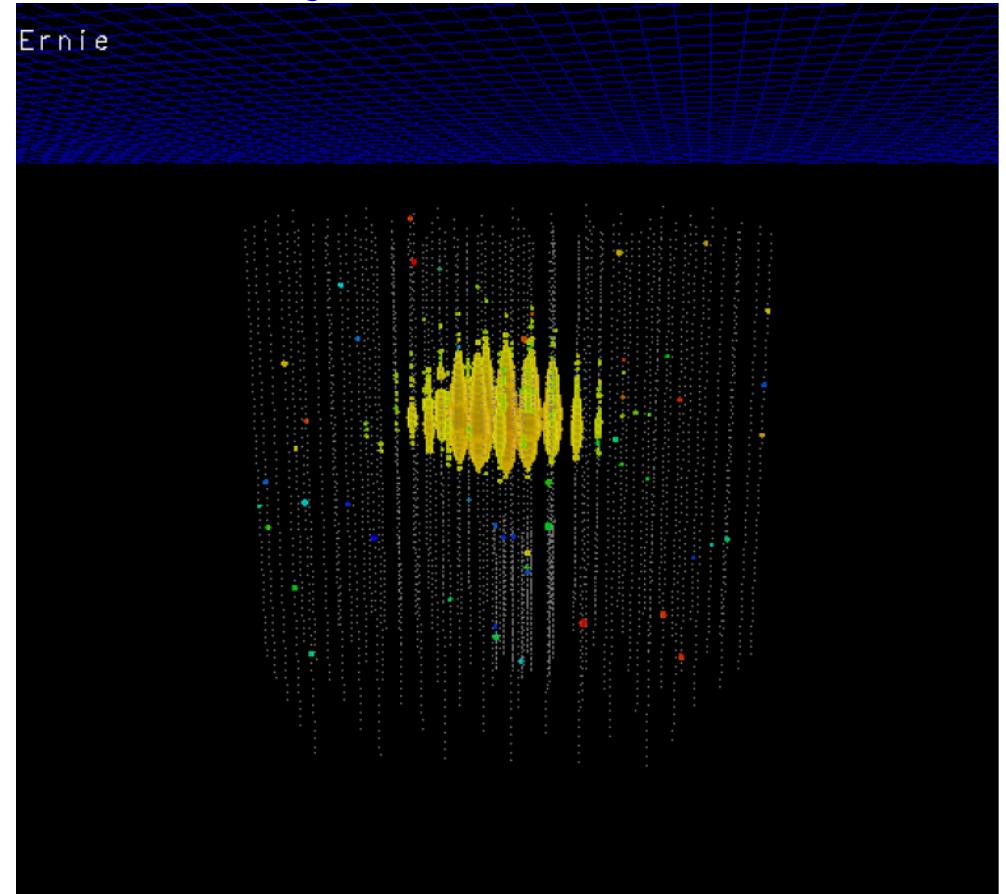
Tue 09-aug-2011 07:23:18 UTC



$1.04 \pm 0.16 \text{ PeV}$

Atmosferische ν achtergrond ?

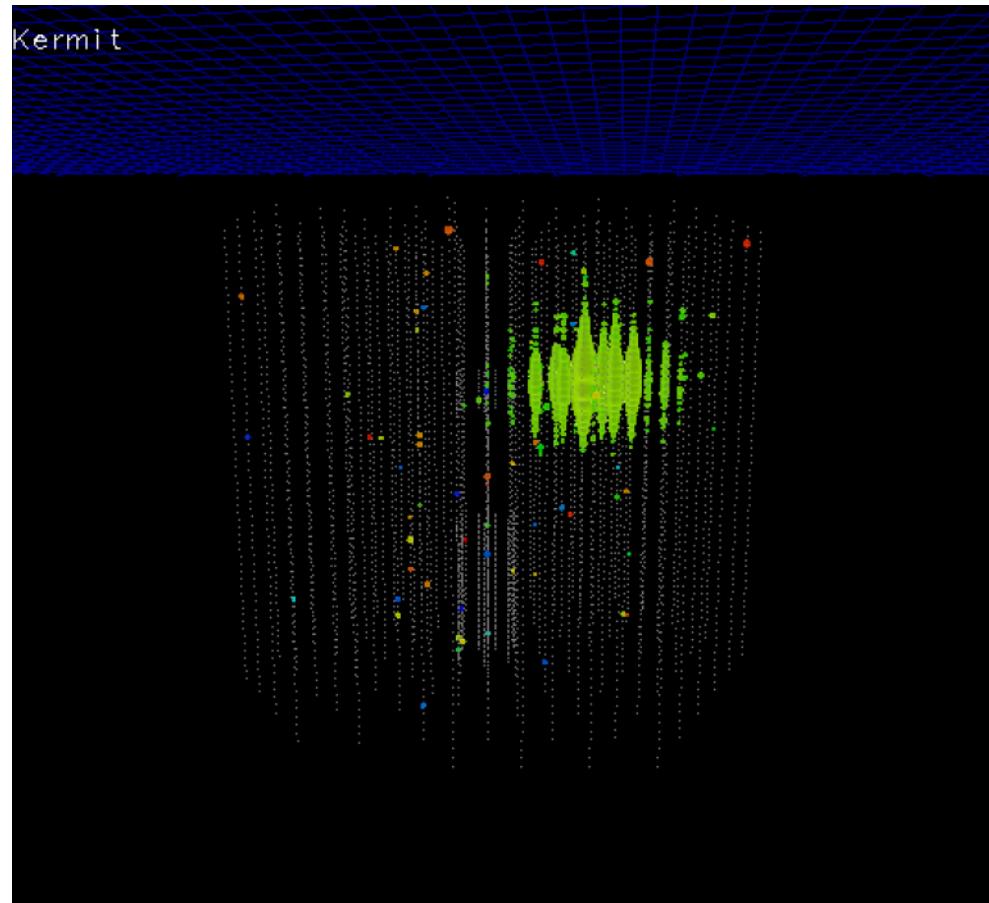
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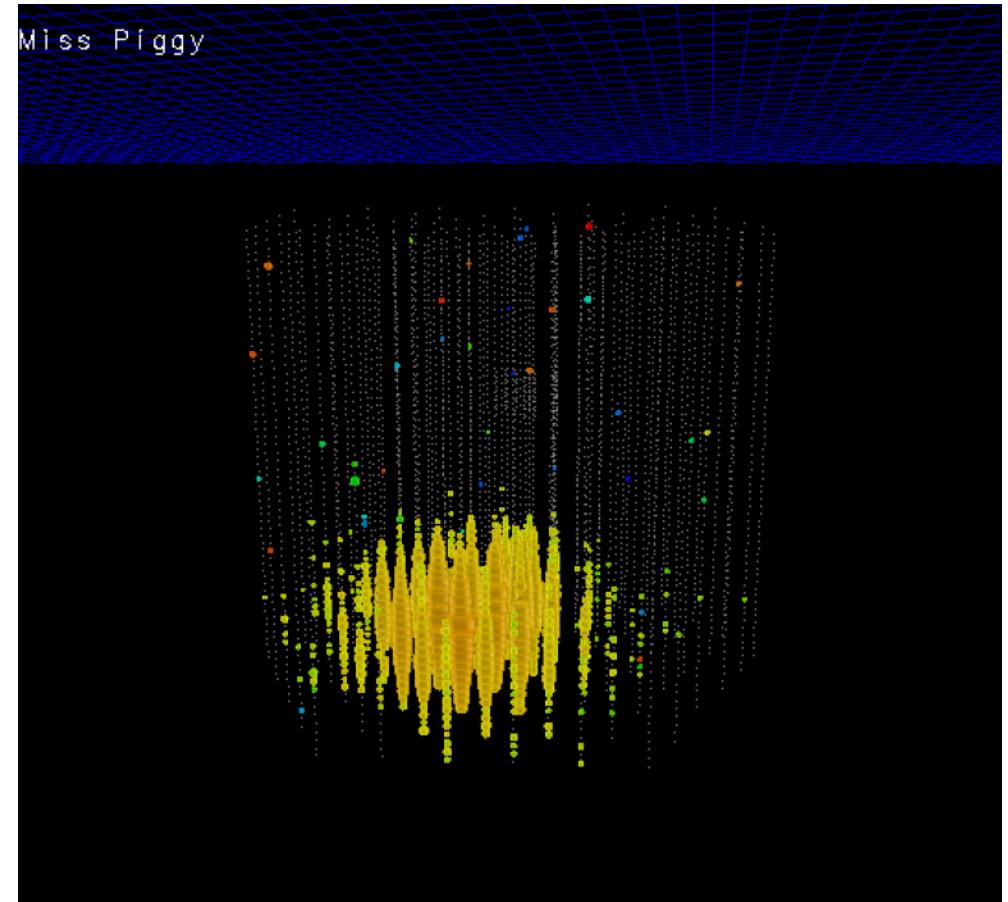
$1.14 \pm 0.17 \text{ PeV}$

Slechts ca. 0.3% kans op achtergrond

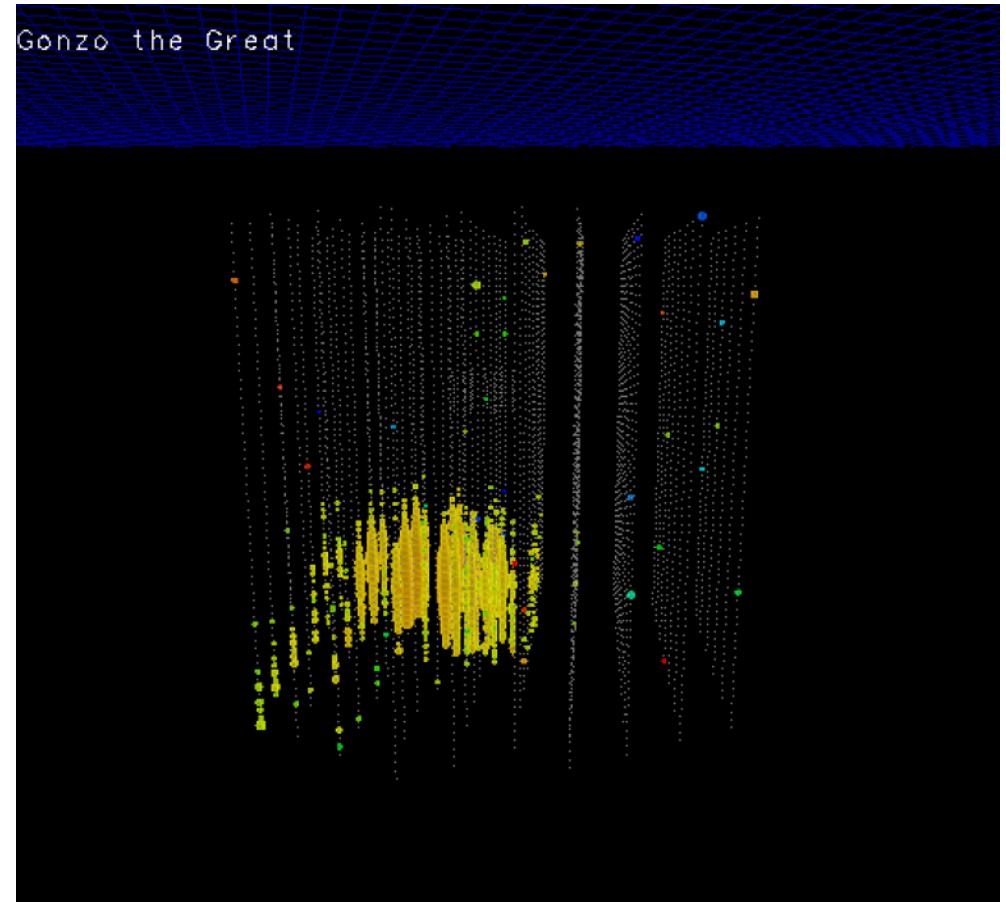
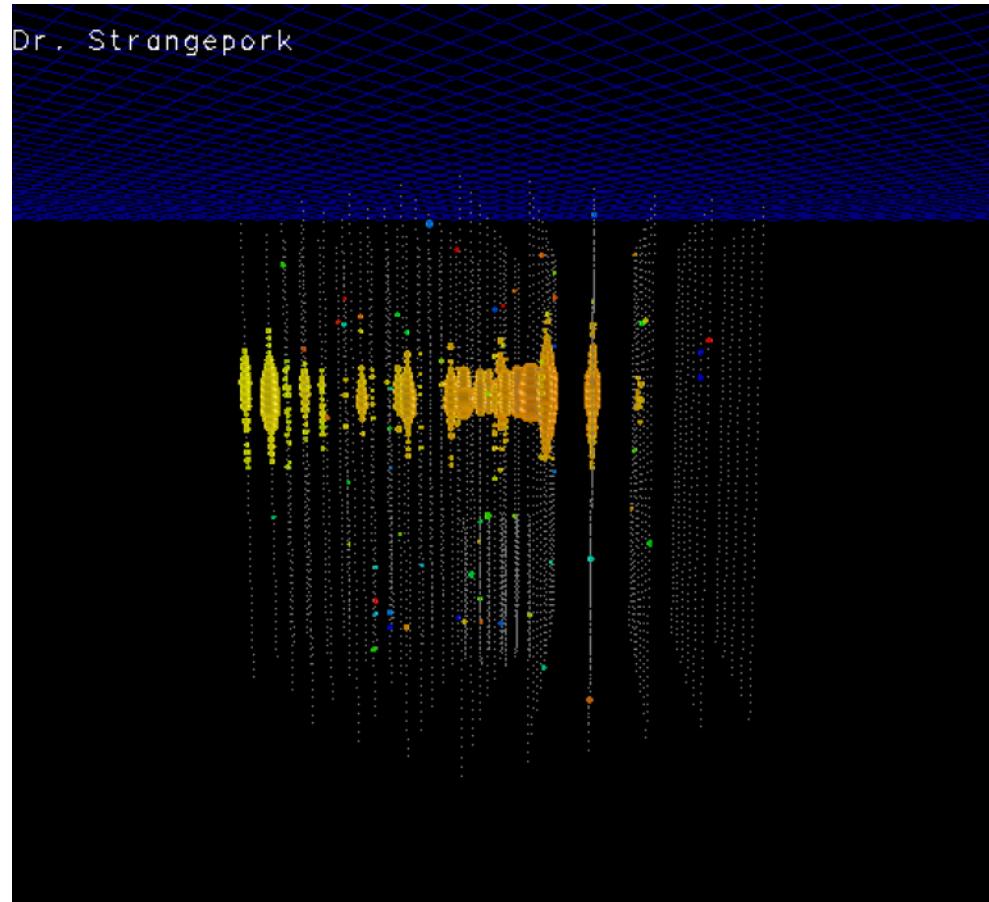
Kermit



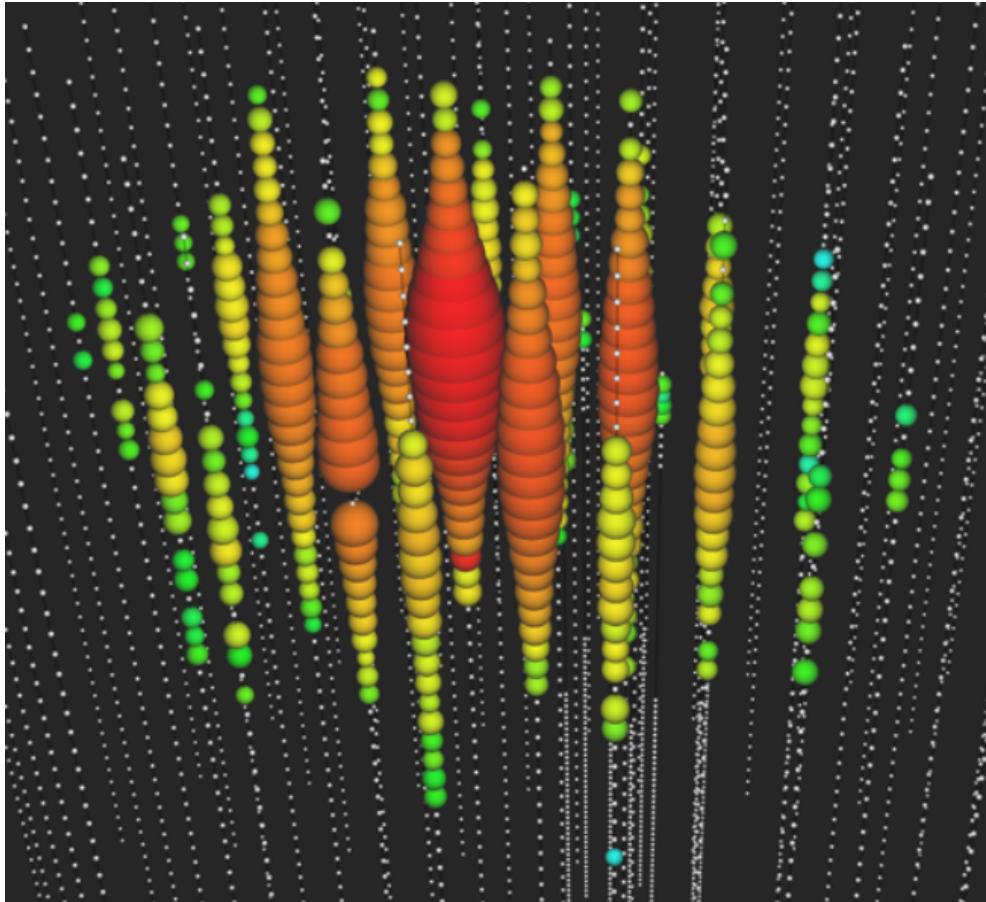
Miss Piggy



Ook enkele μ spoor signaturen



Onze huidige kampioen

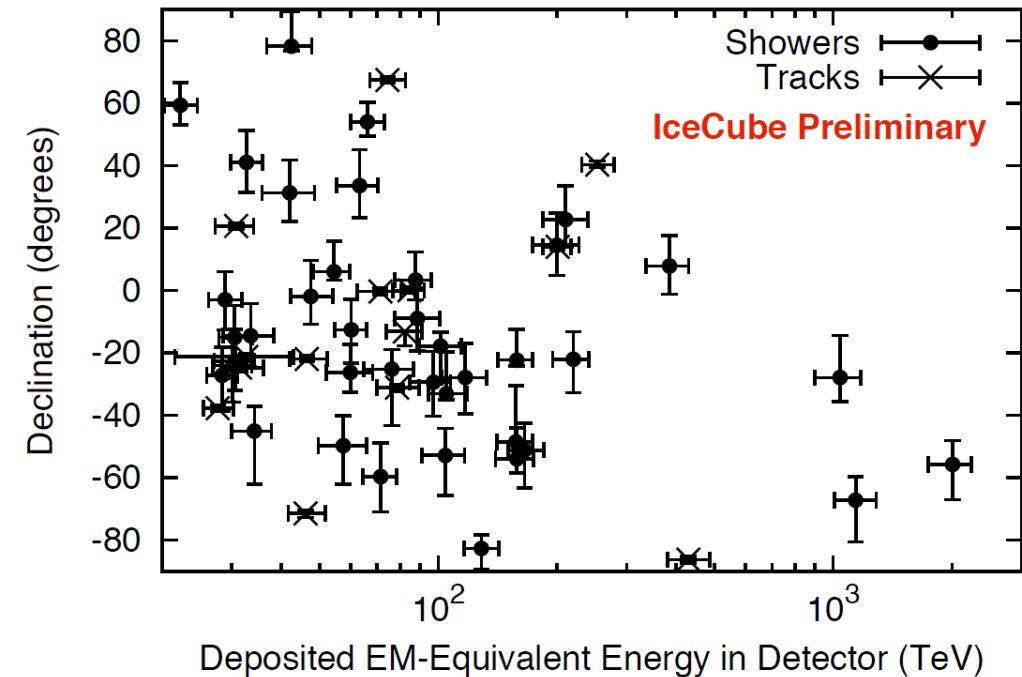
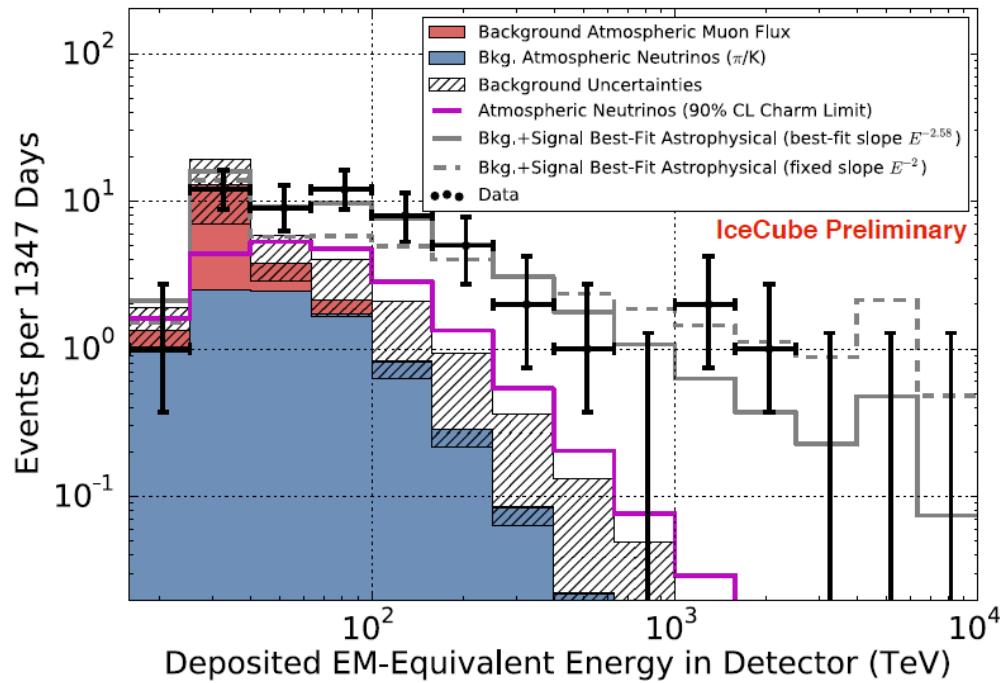


2.00 ± 0.25 PeV



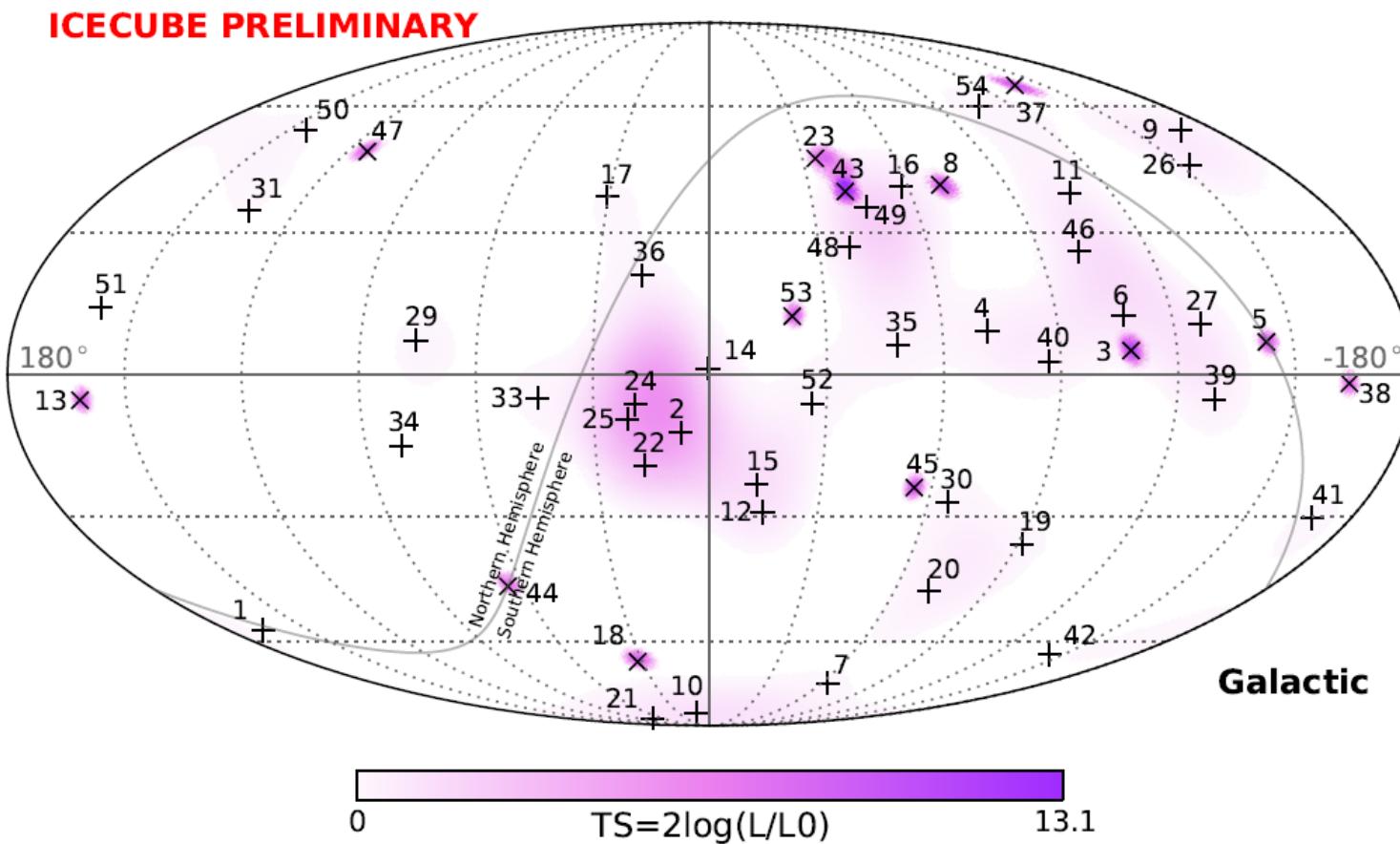
Big Bird

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 het IIHE :**

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 !