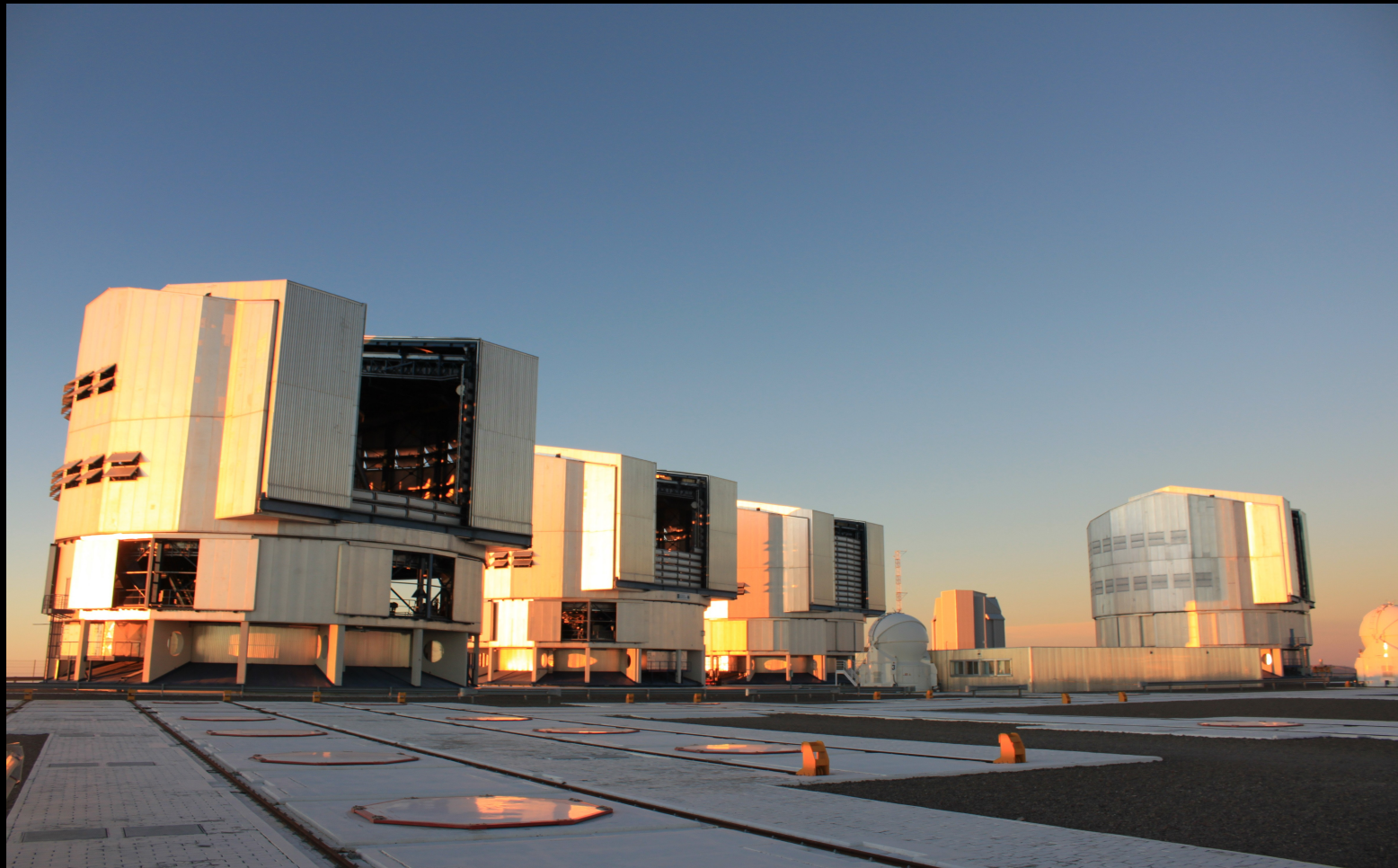


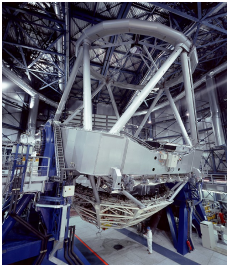
Astronomische Technieken

Hovo Cursus 2010



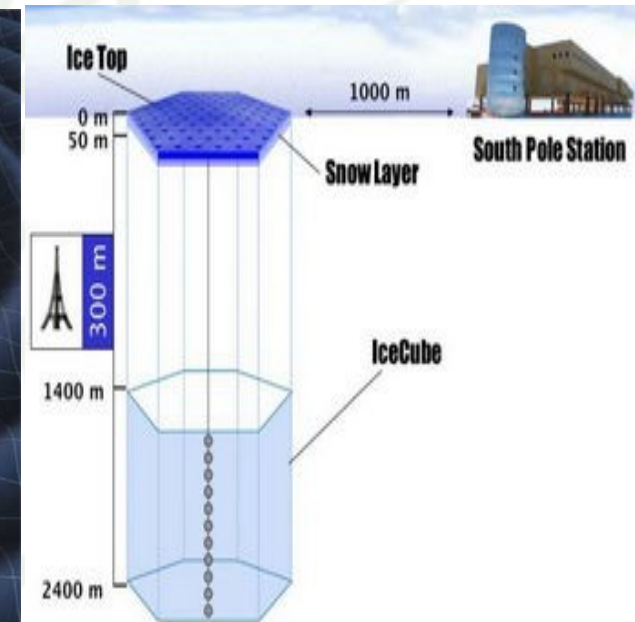
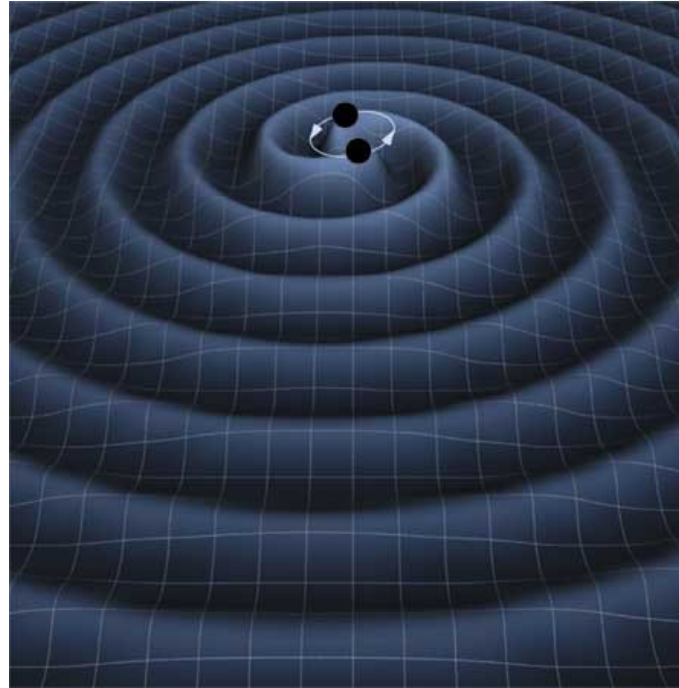
Prof.dr. Paul Groot (RU)
Dr. Gijs Nelemans (RU)

Opbouw van de cursus

- 
- 15/3: - Berichten uit de ruimte
- Ontvangers op Aarde Paul Groot
 - 22/3: - Telescopen en detectoren
- De perfecte waarneming Gijs Nelemans
 - 12/4: - Telescopen in de ruimte
- De invloed van de atmosfeer Gijs Nelemans
 - 19/4: - Radio telescopen
- Interferometrie: meer met minder Paul Groot
 - 26/4: - Excursie naar sterrenwacht RU
- Instrumentontwikkeling Afdeling Sterrenkunde Beide
 - 3/5: - Fotonen voorbij: neutrino's, gravitatiegolven
- Telescopen van de toekomst Paul Groot

Fotonen voorbij

- Gravitatiegolven
- Neutrino's
- Kosmische straling



Kosmische straling



Jaren '30:
Victor Hess vindt
in ballonvlucht
de kosmische straling

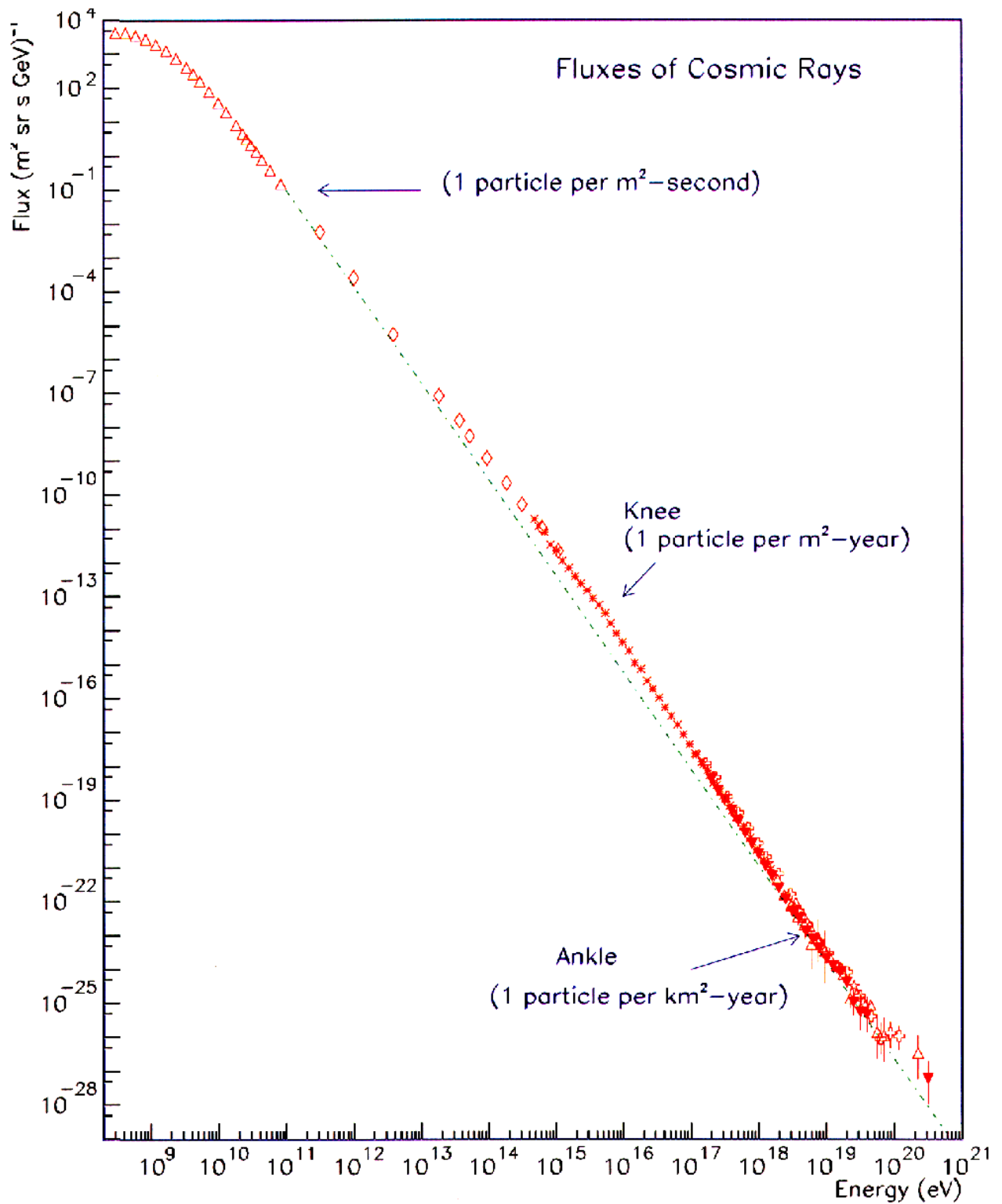


Kosmische straling

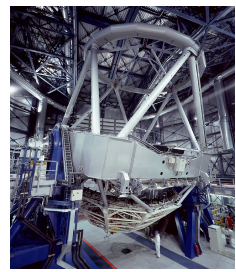


Spectrum

Spectrum zoals
op Aarde ontvangen



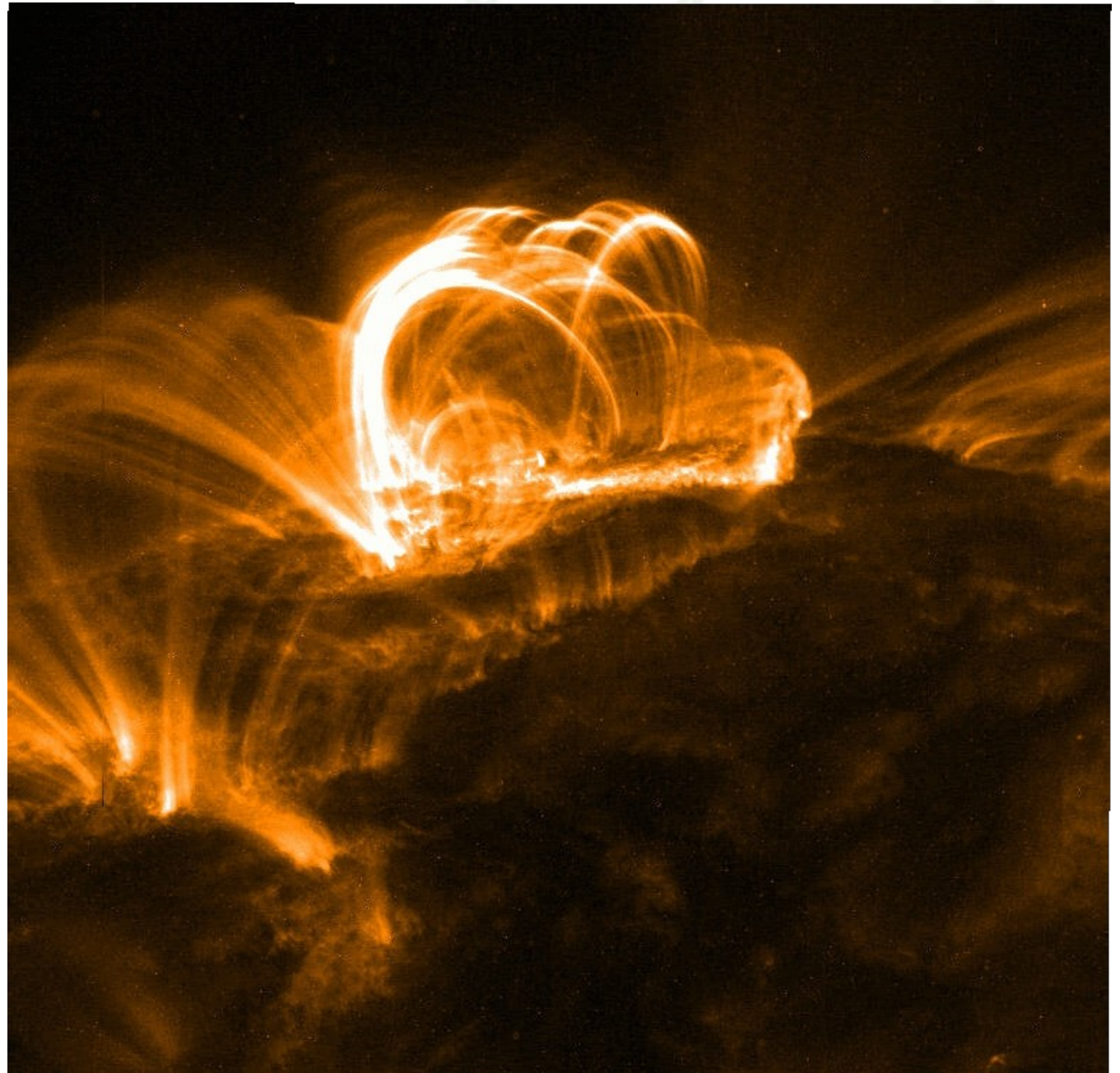
Bronnen van kosmische straling



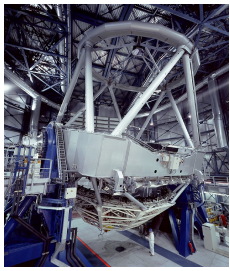
Lage energieën:

$<10^{12}$ eV

De Zon



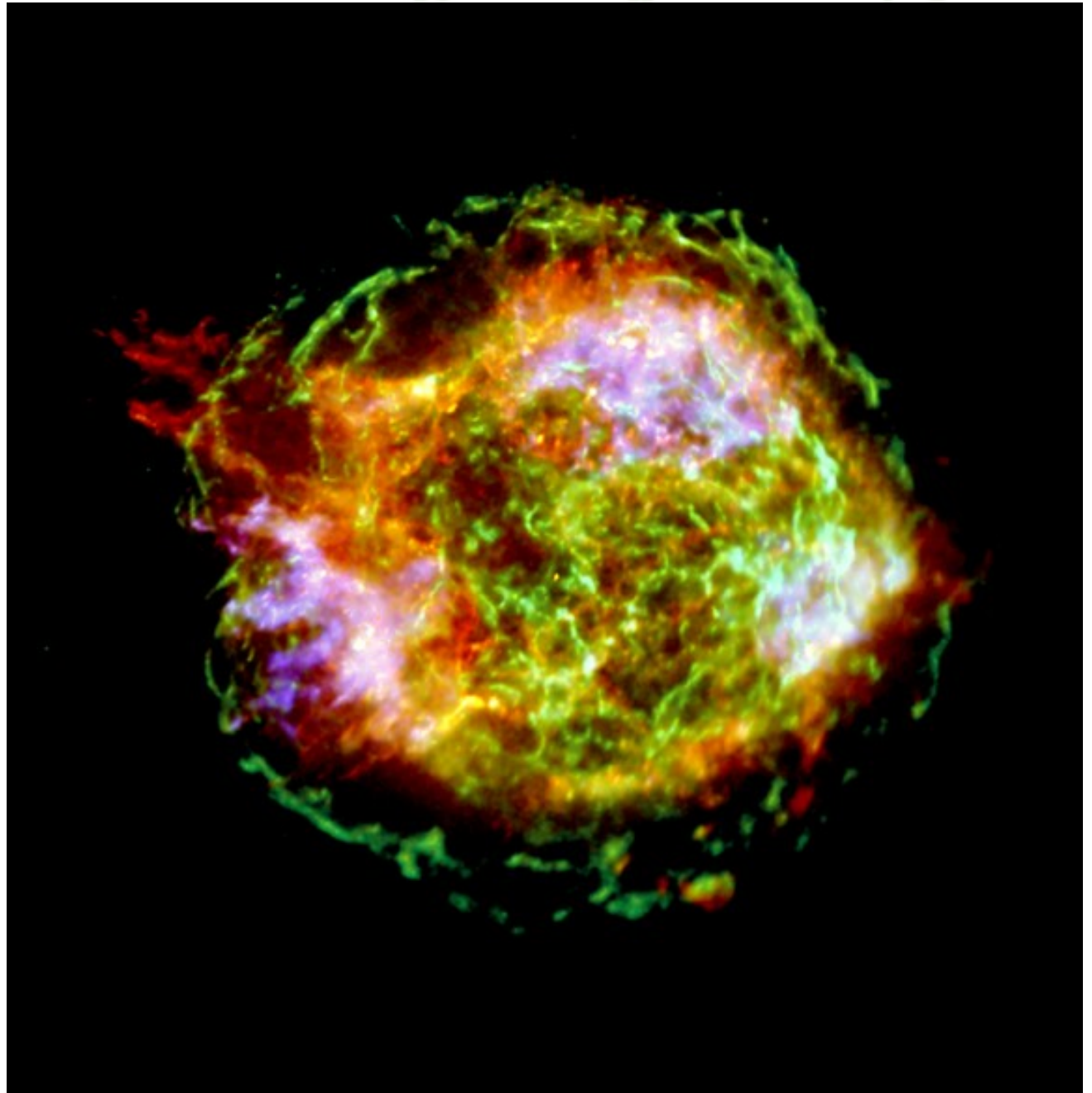
Bronnen van kosmische straling



Middel energieën:

$<10^{16-18}$ eV

*Supernova
restanten*

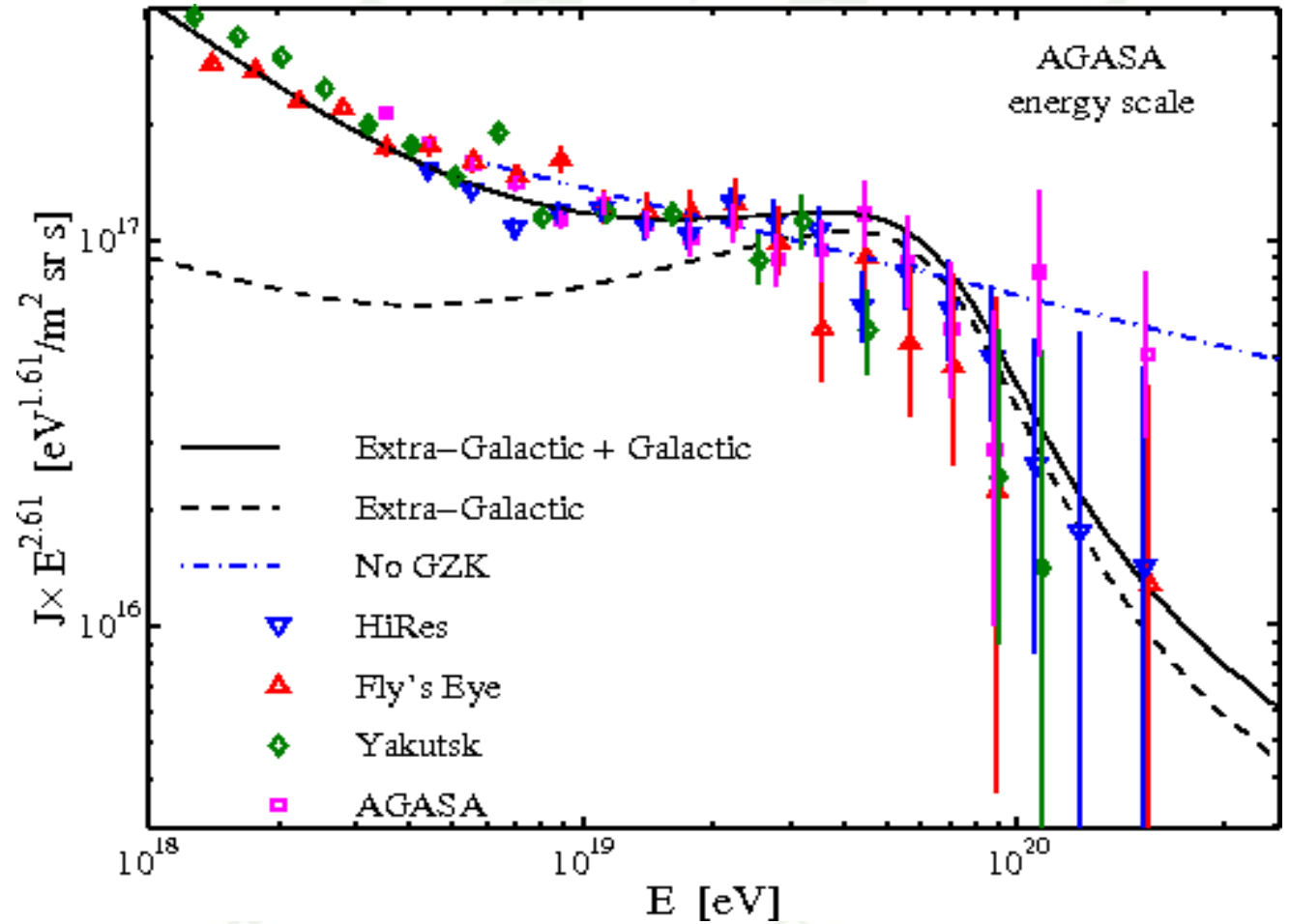


Bronnen van kosmische straling

Hoogste energieën:

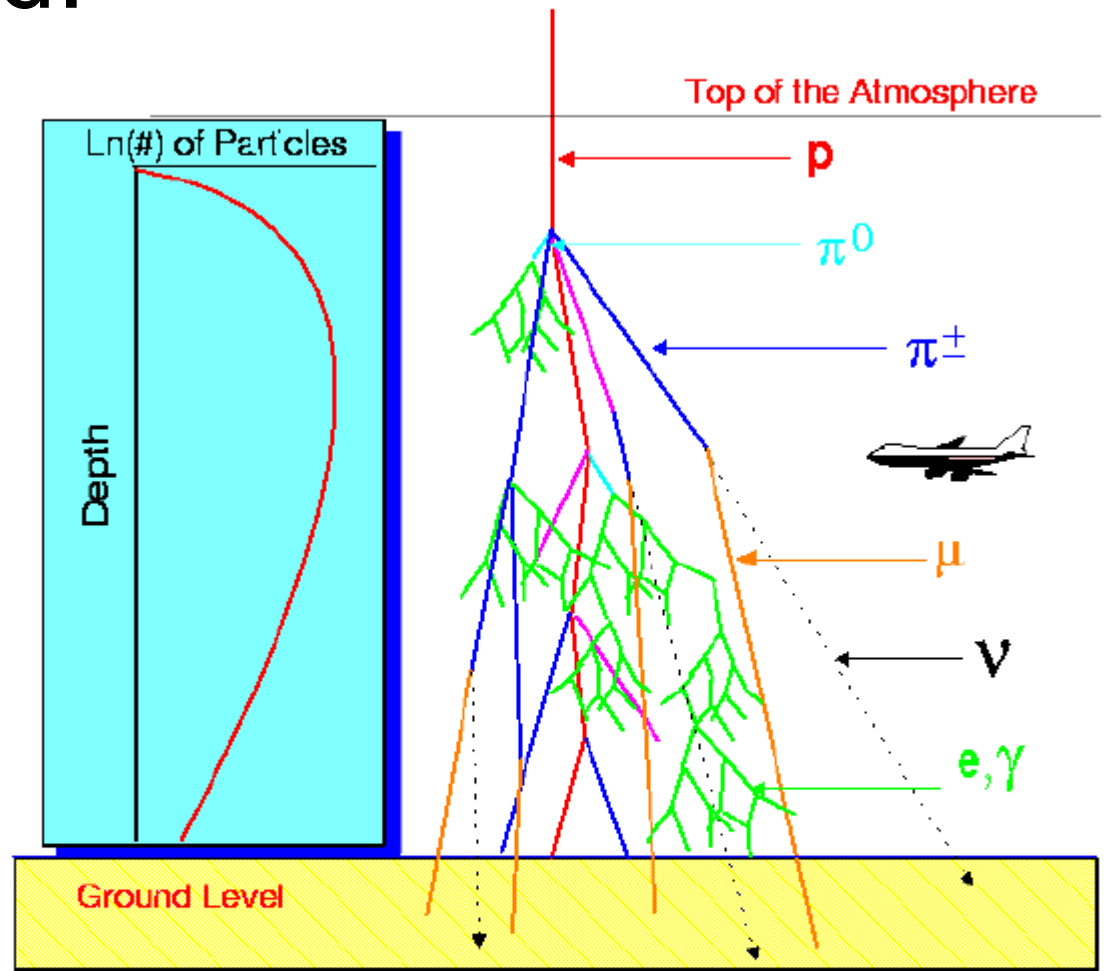
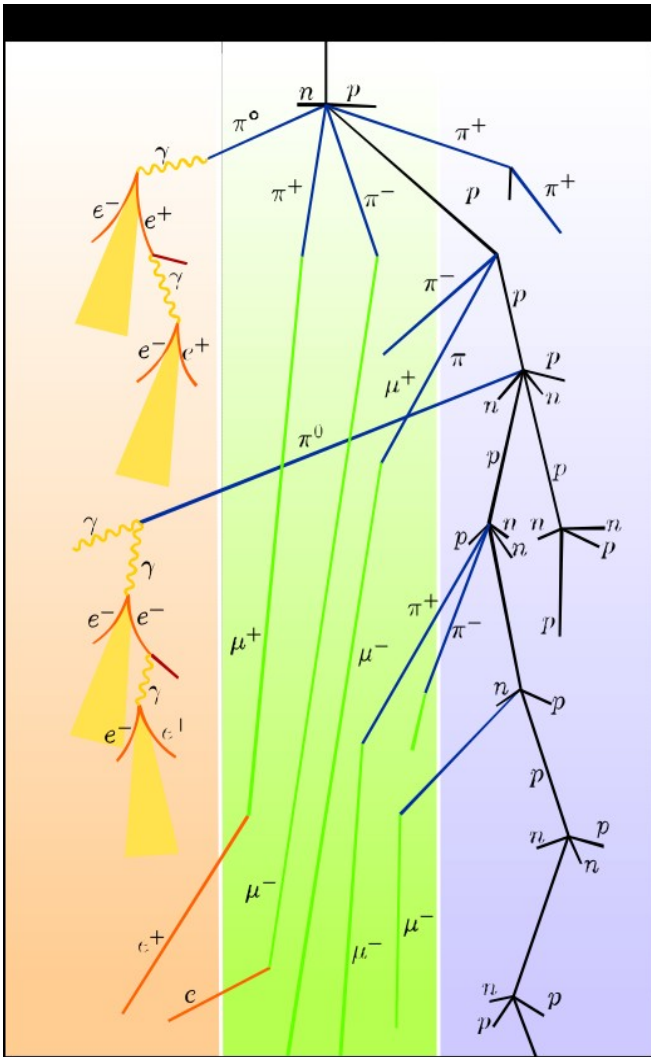
$>10^{18}$ eV

?? Zwarte gaten?



Moeilijkheid:

Ze zijn zo zeldzaam!



Extensive Air Showers

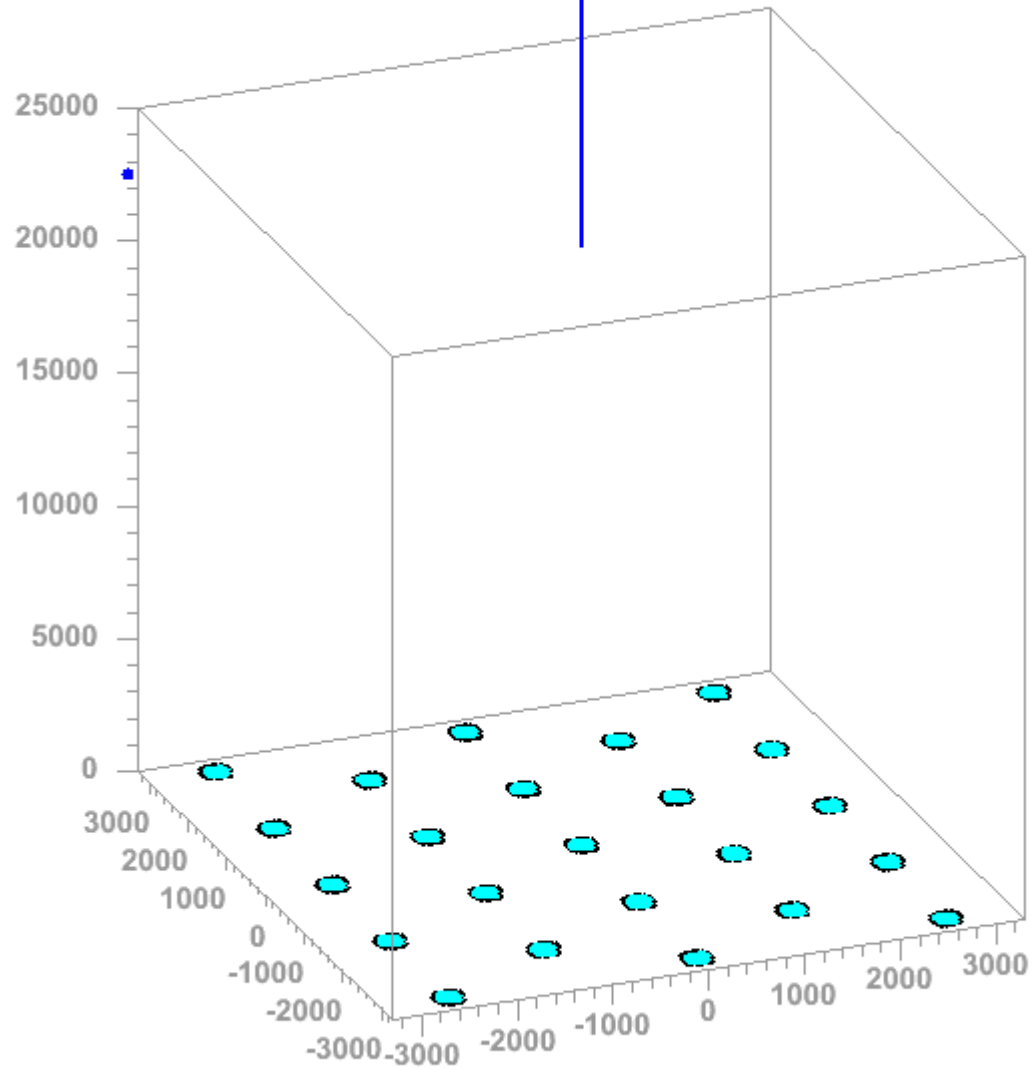
Deeltjesregen

hadrons muons electrs neutrs

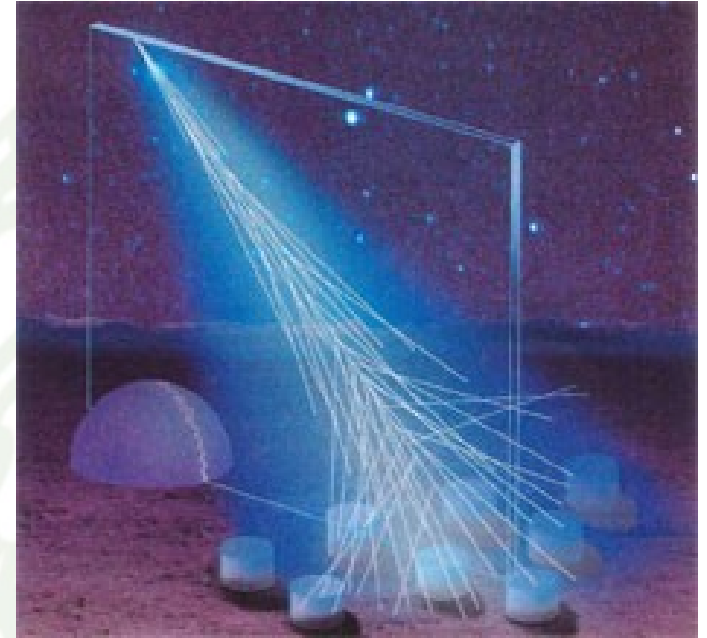
$0.00 \cdot 10^{-6}$ sec

Proton 10^{15} eV

$h^{1st} = 22489$ m



Pierre Auger Observatory

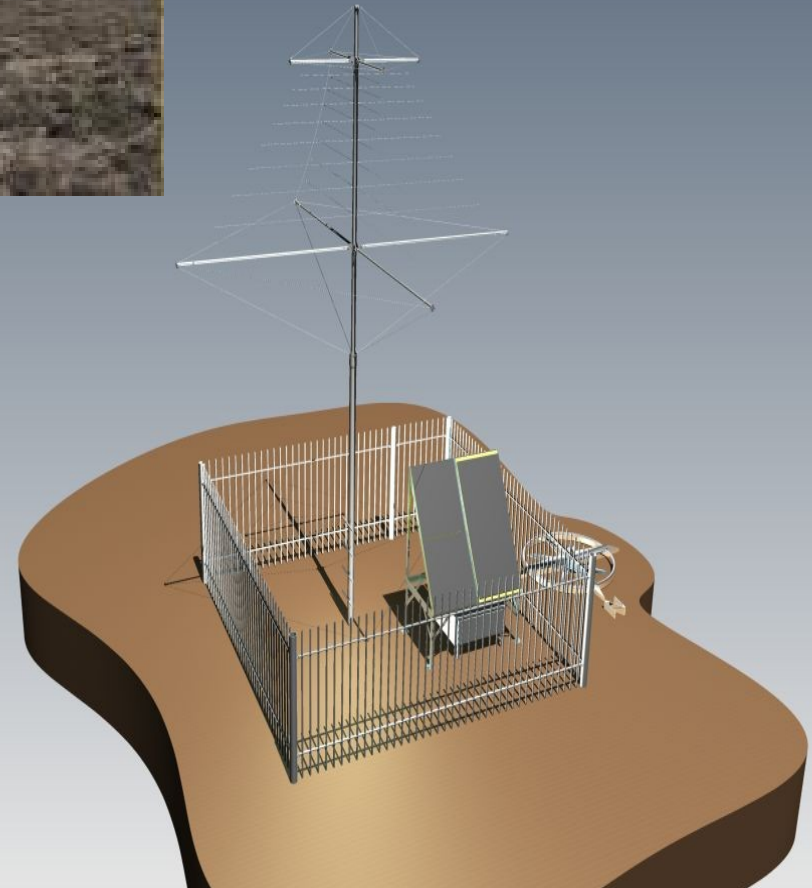


Oppervlak: 3000 km², zo groot als provincie Utrecht

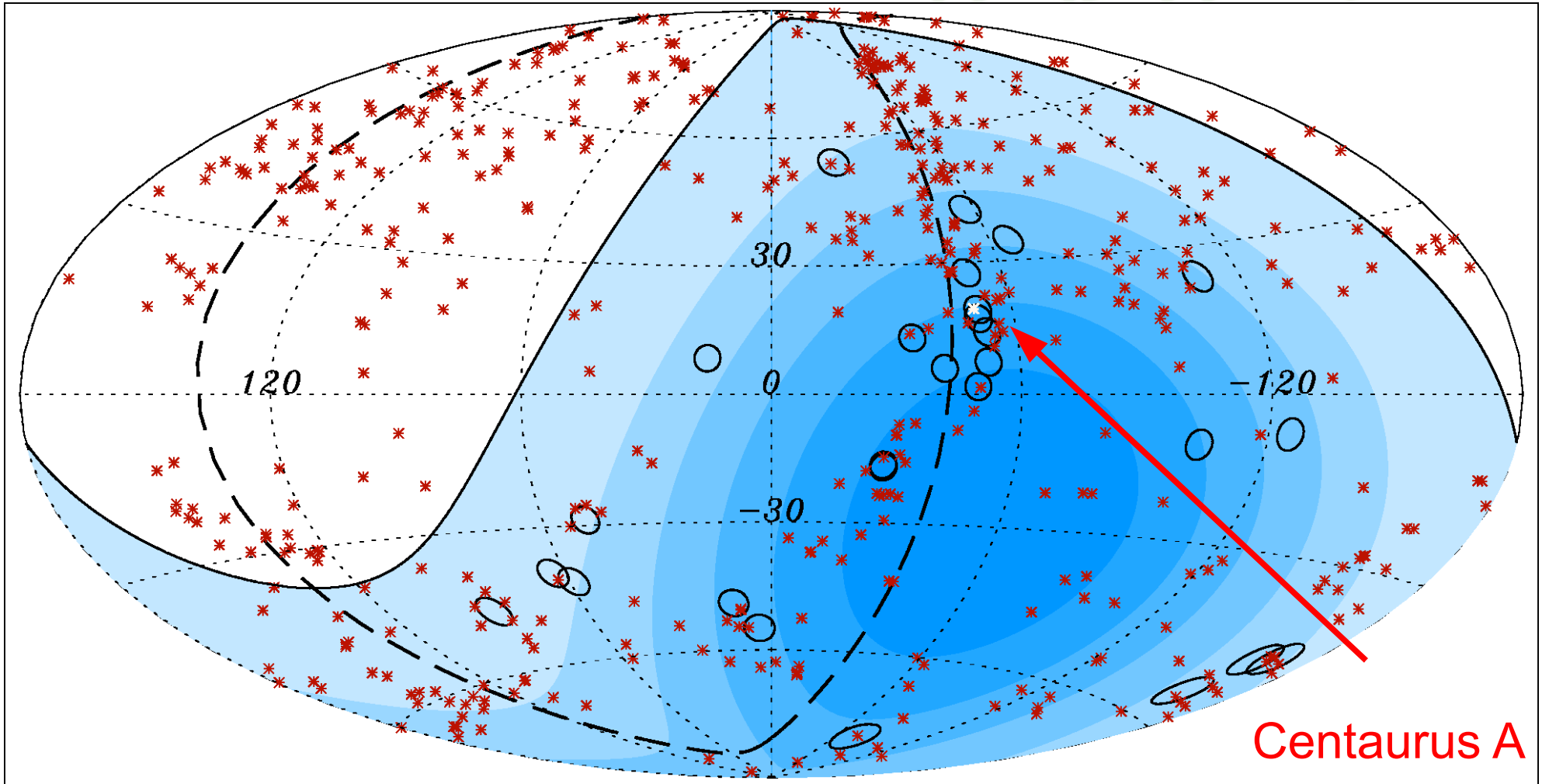
Pierre Auger Observatory



Inclusief 'onze'
radio-antennes



Geladen deeltjes astronomie



Blauw: hemel zichtbaar boven Auger
Cirkels: aankomst kosmische straling

rood: Active galactic Nuclei
gestippeld: supergalactisch vlak

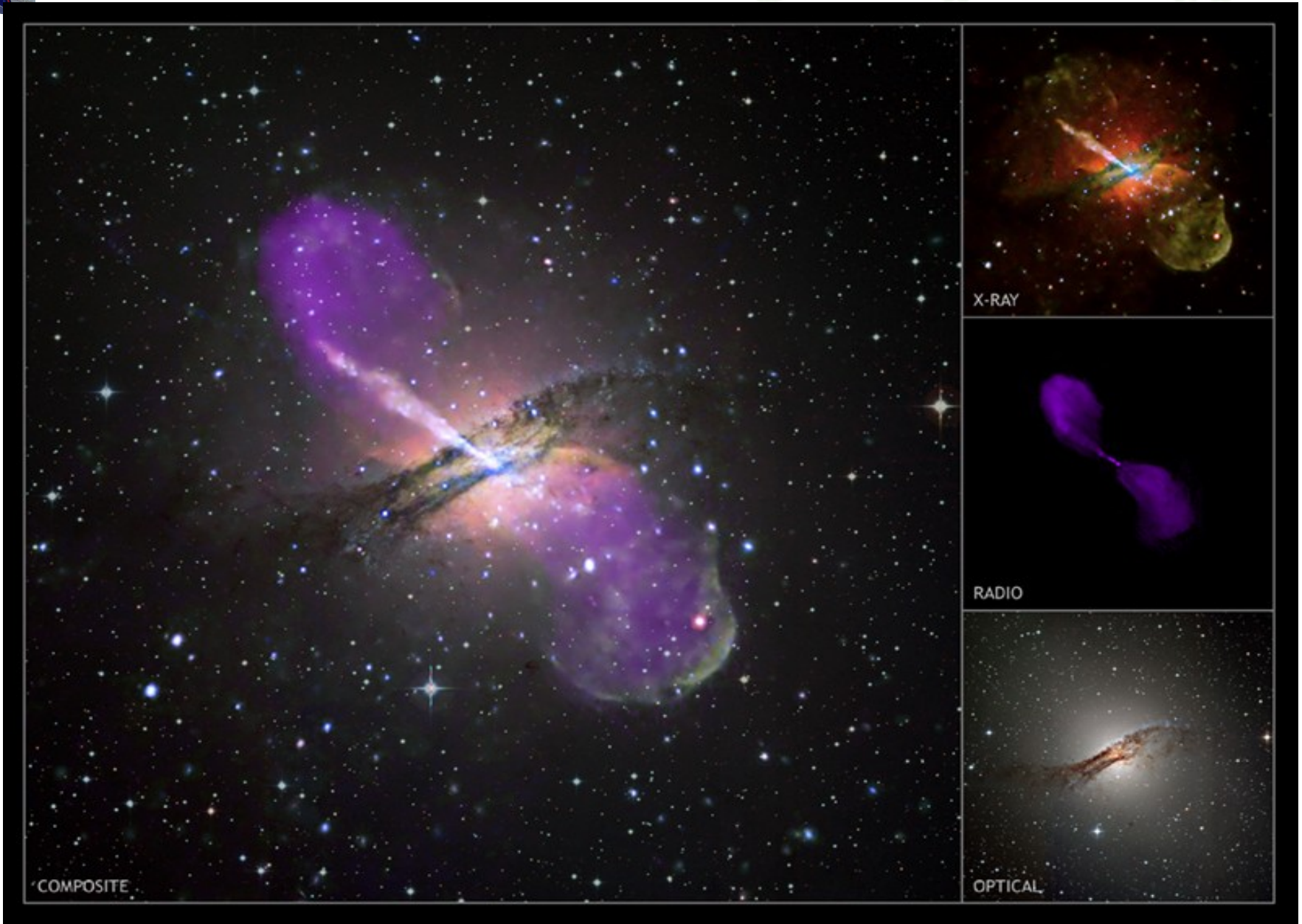
Centaurus A



Meeste nabije actieve melkwegstelsel: 4 Mpc afstand (15 miljoen lichtjaar)

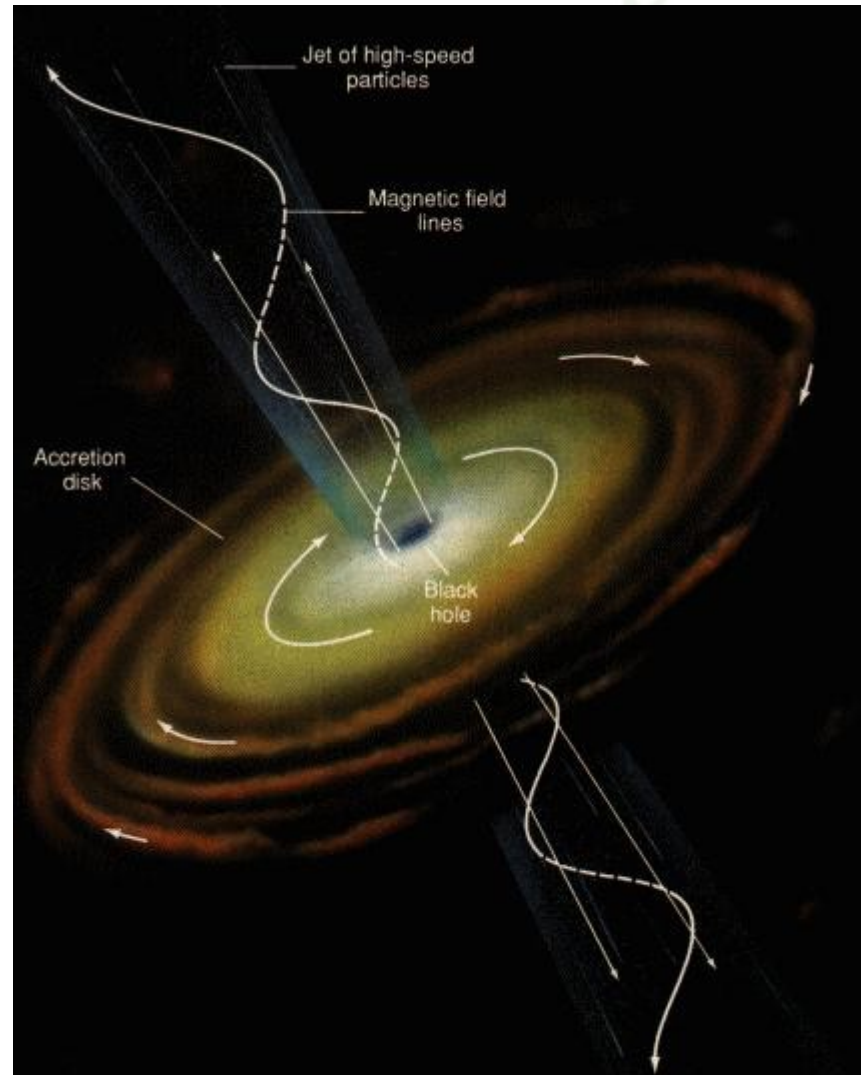
Centaurus A

ASTROPHYSICS



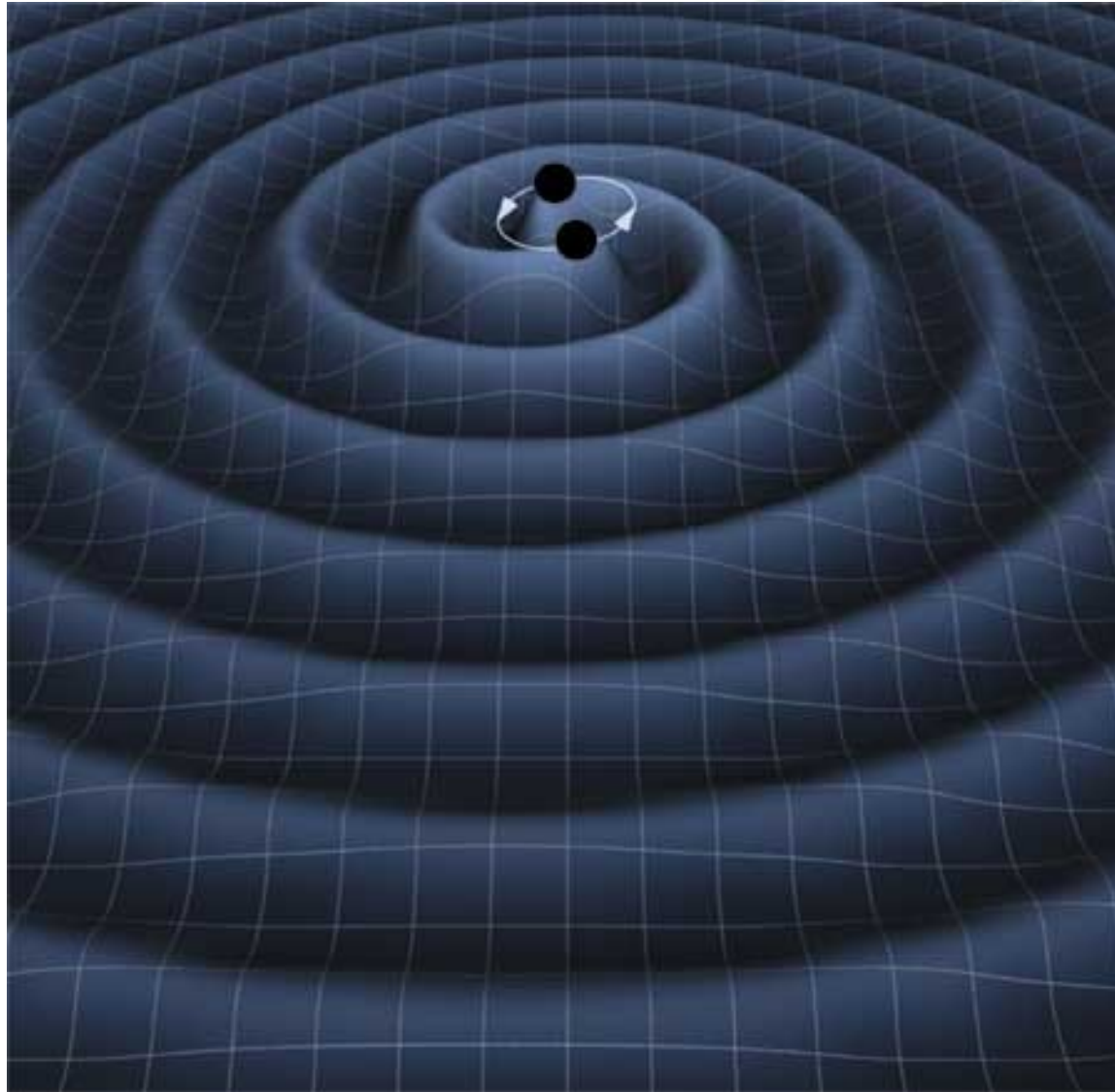
UNIVERSITY

Kern van Centaurus A



Zwart gat van > 100 miljoen Zonsmassas

Zwaartekrachtsgolven

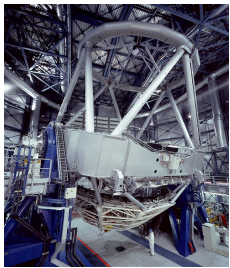
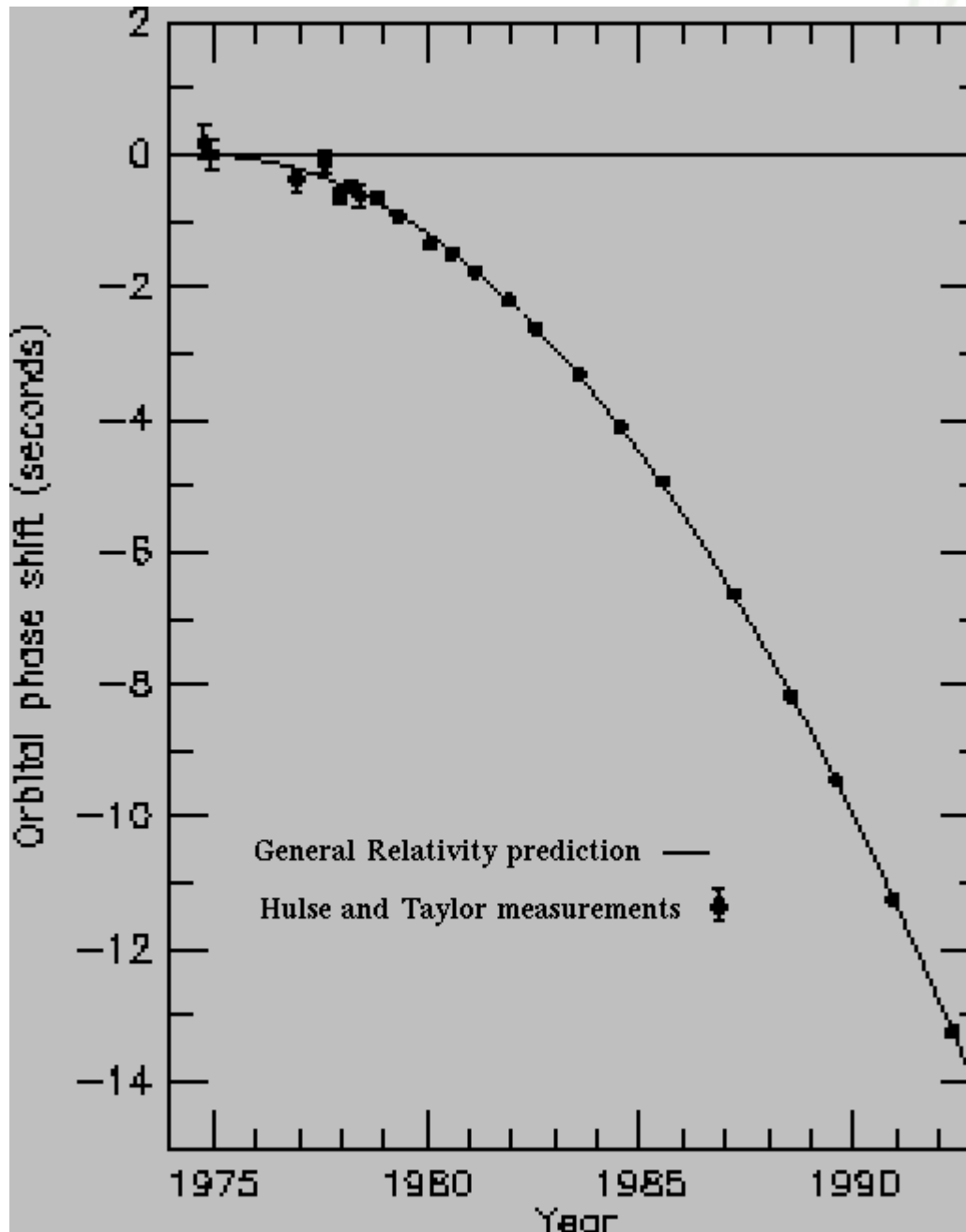


Worden opgewekt door versnelde massas

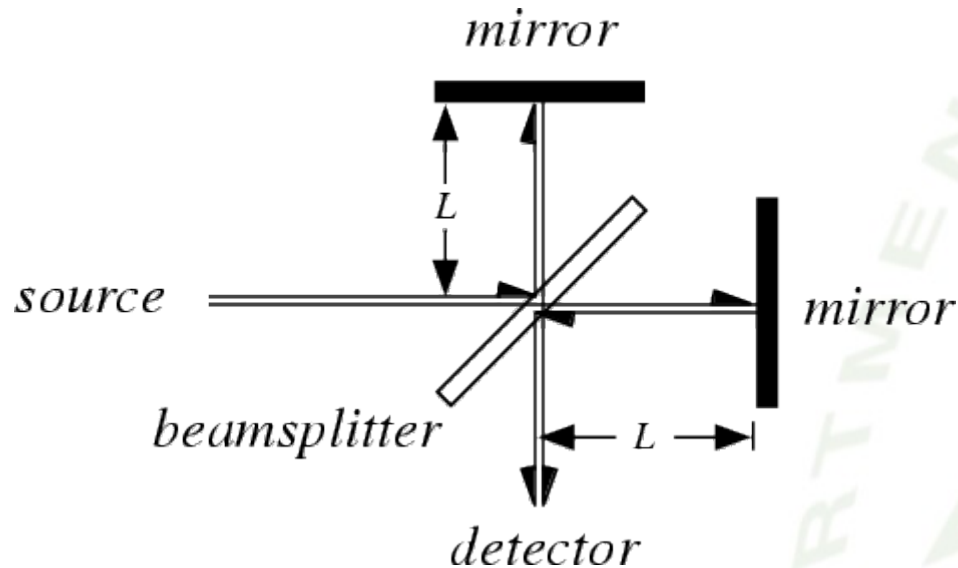
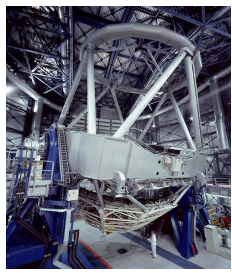
Indirect aangetoond



Hulse-Taylor pulsar
PSR1913+16



Direct nog niet gedetecteerd



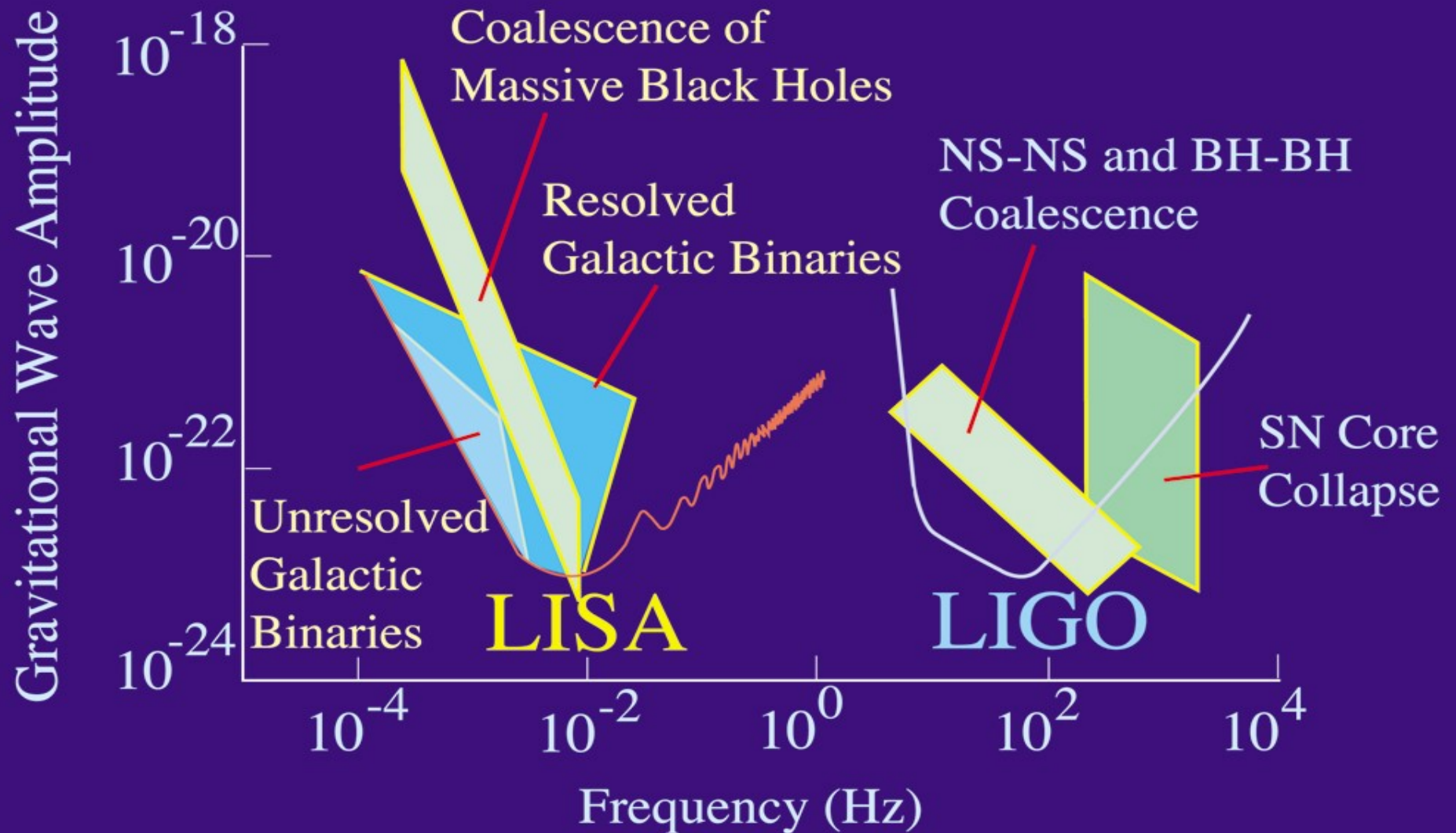
Methode is bekend:
Michelson-Morley interferometer

Vervormingen van de ruimte

Moeilijkheid: nauwkeurigheid en achtergrond

Verandering in weglengte: 10^{-22} x lengte arm!

Experimenten op grond en in ruimte



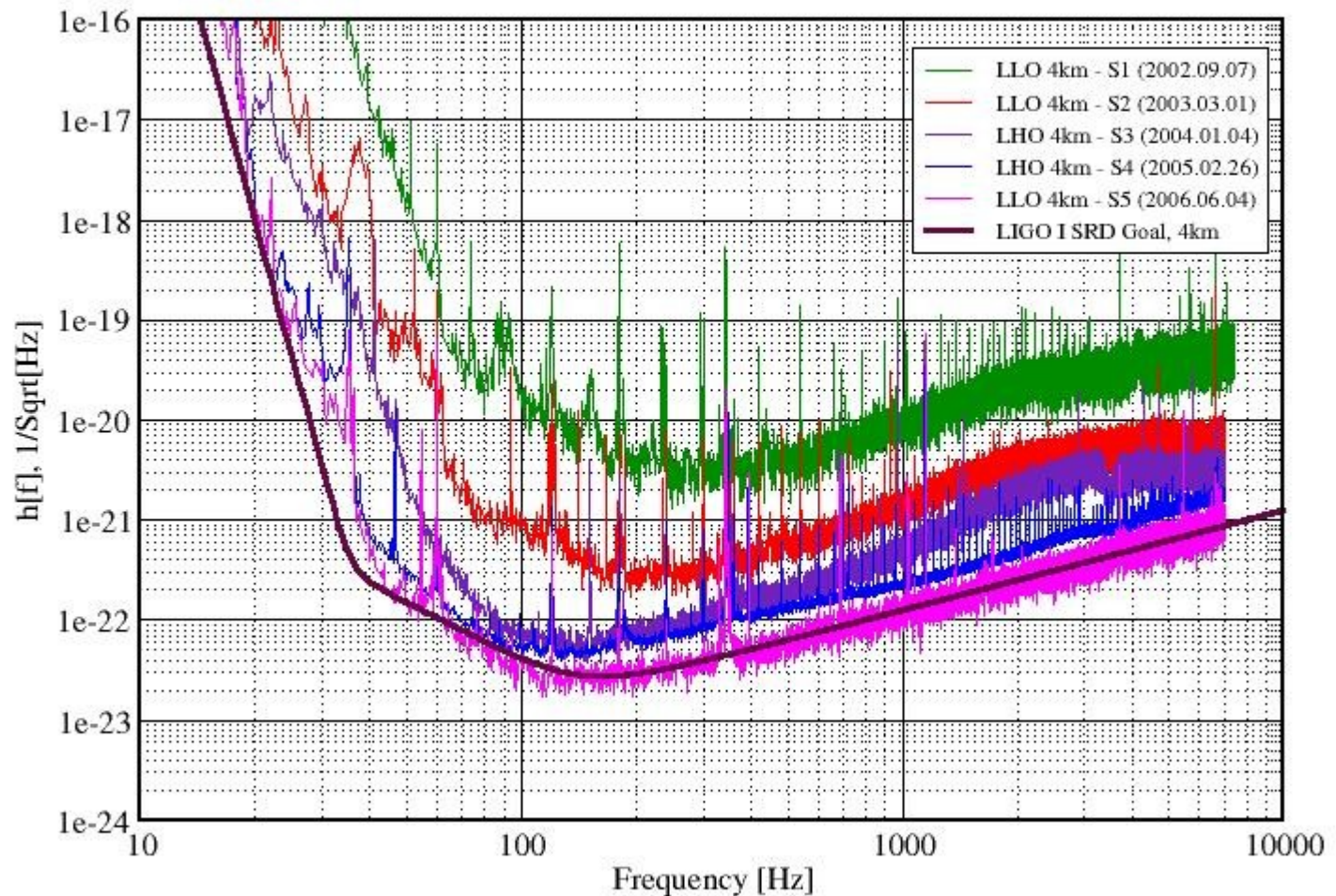
Experimenten op grond: LIGO & VIRGO



Vacuum laser
4 km lang in l

Best Strain Sensitivities for the LIGO Interferometers

Comparisons among S1 - S5 Runs LIGO-G060009-02-Z



Probleem: geen stationaire, bekende bronnen!

Experimenten in ruimte: LISA



LISA
Laser Interferometer Space Antenna

Gravity is talking. LISA will listen.

Supermassive Black Hole Binaries
Compact Object Captures
Galactic White Dwarf Binaries
Cosmic Strings and Phase Transitions

Black hole binary at $z=15$, $10^6 M_{\odot}$, two hours before merger. Numerical waveform plus instrument noise and WD background (L. Baker)

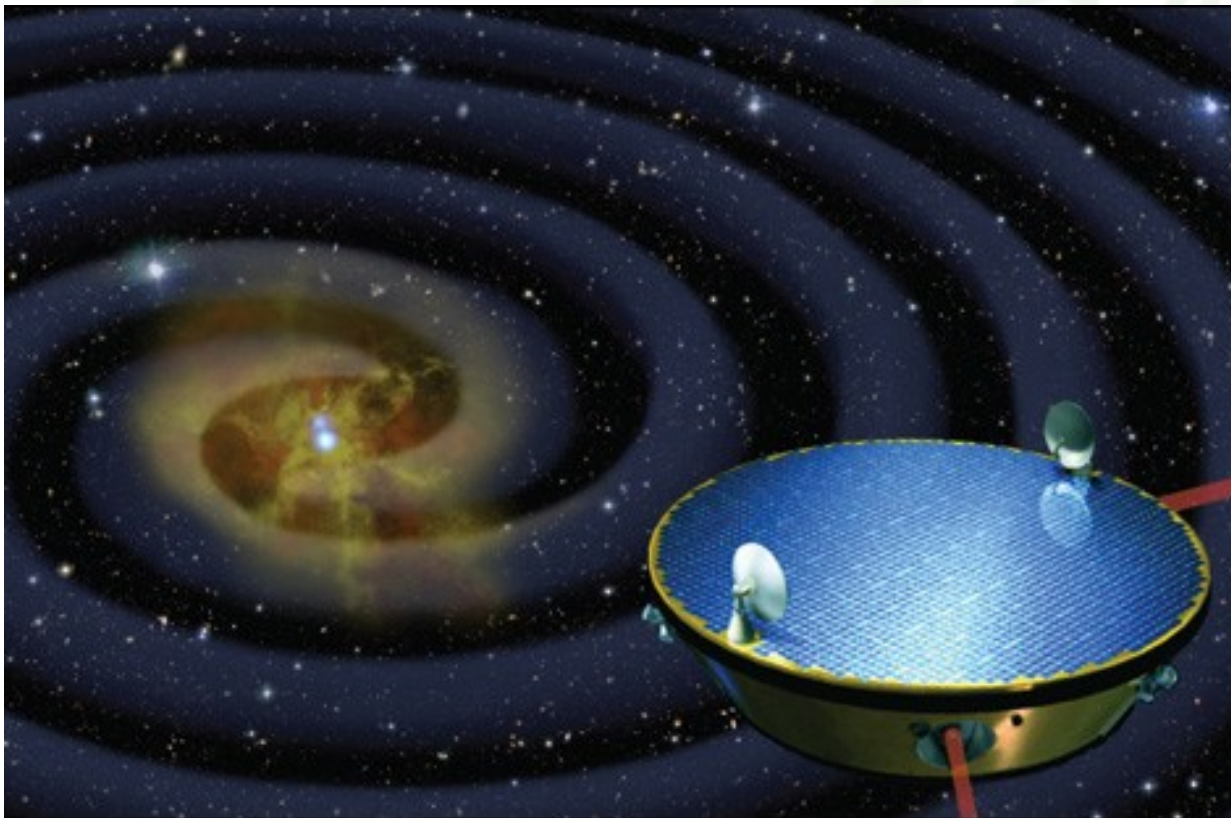
NASA ESA

Background: COINADs (Babak et al. 2007), MCG 6-23-6 (NASA/CXC/STScI, Artist's Rendering)

Both: design by S. Bhagwat, D. Leviton, S. Finnerty, B. Schumaker, and M. Willmann

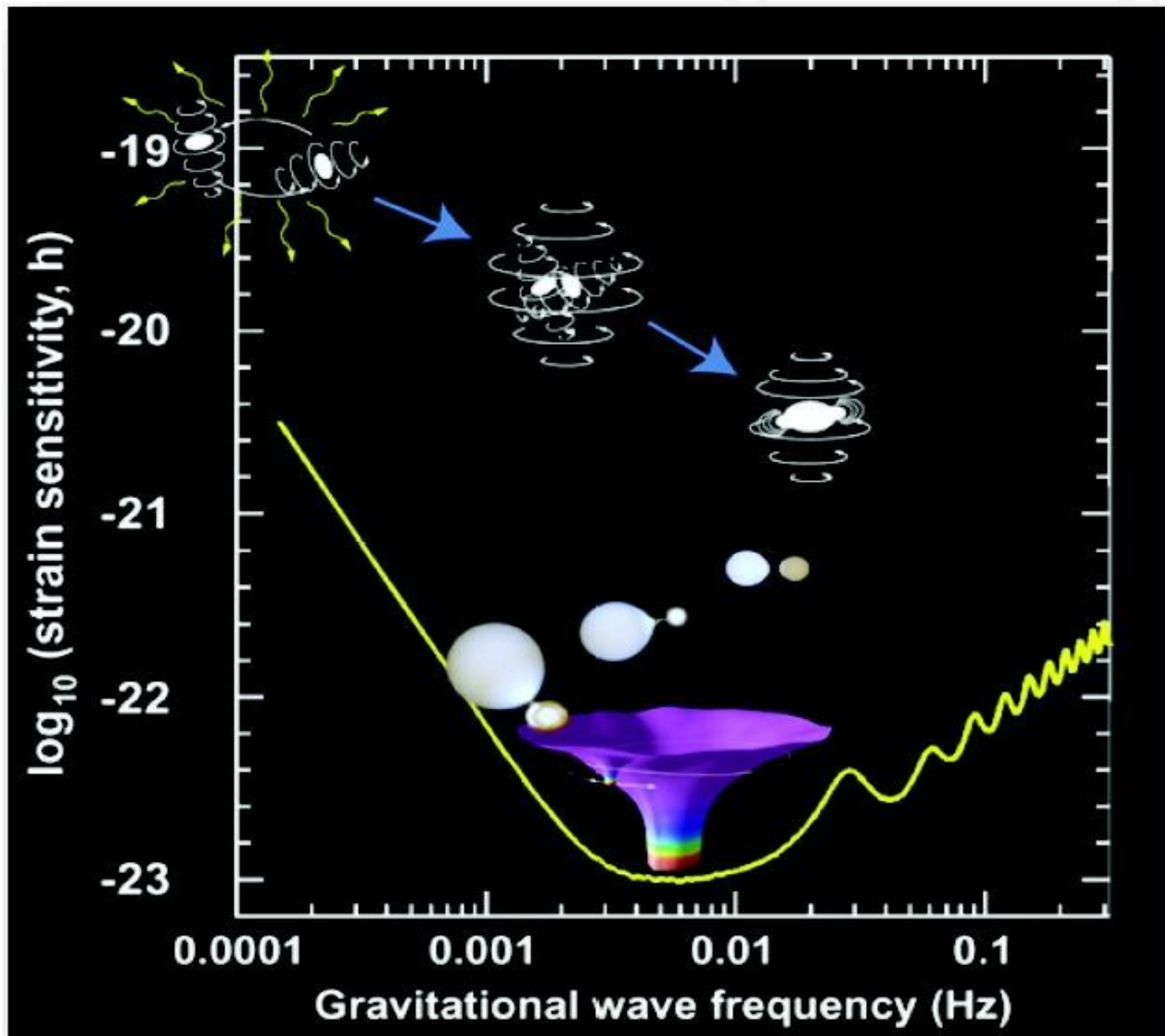
Experimenten in ruimte: LISA

LISA: Elke arm is 5 miljoen kilometer
In baan rond Zon, achter de Aarde aan
Lancering: 2020+

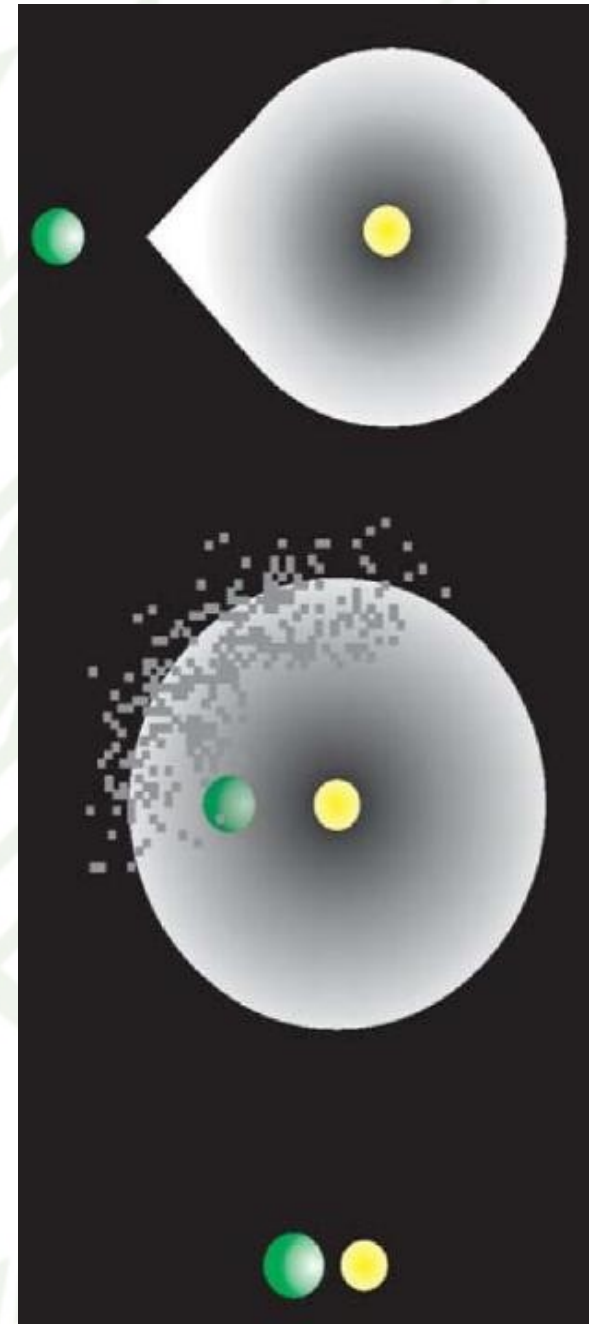
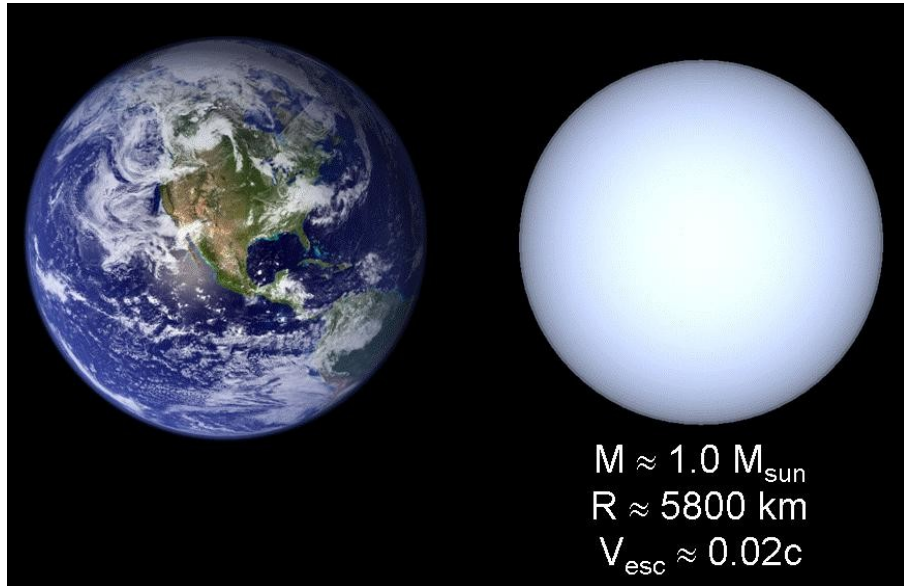
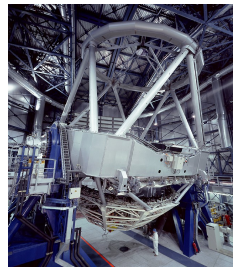


Verschuiving: 10^{-13} m

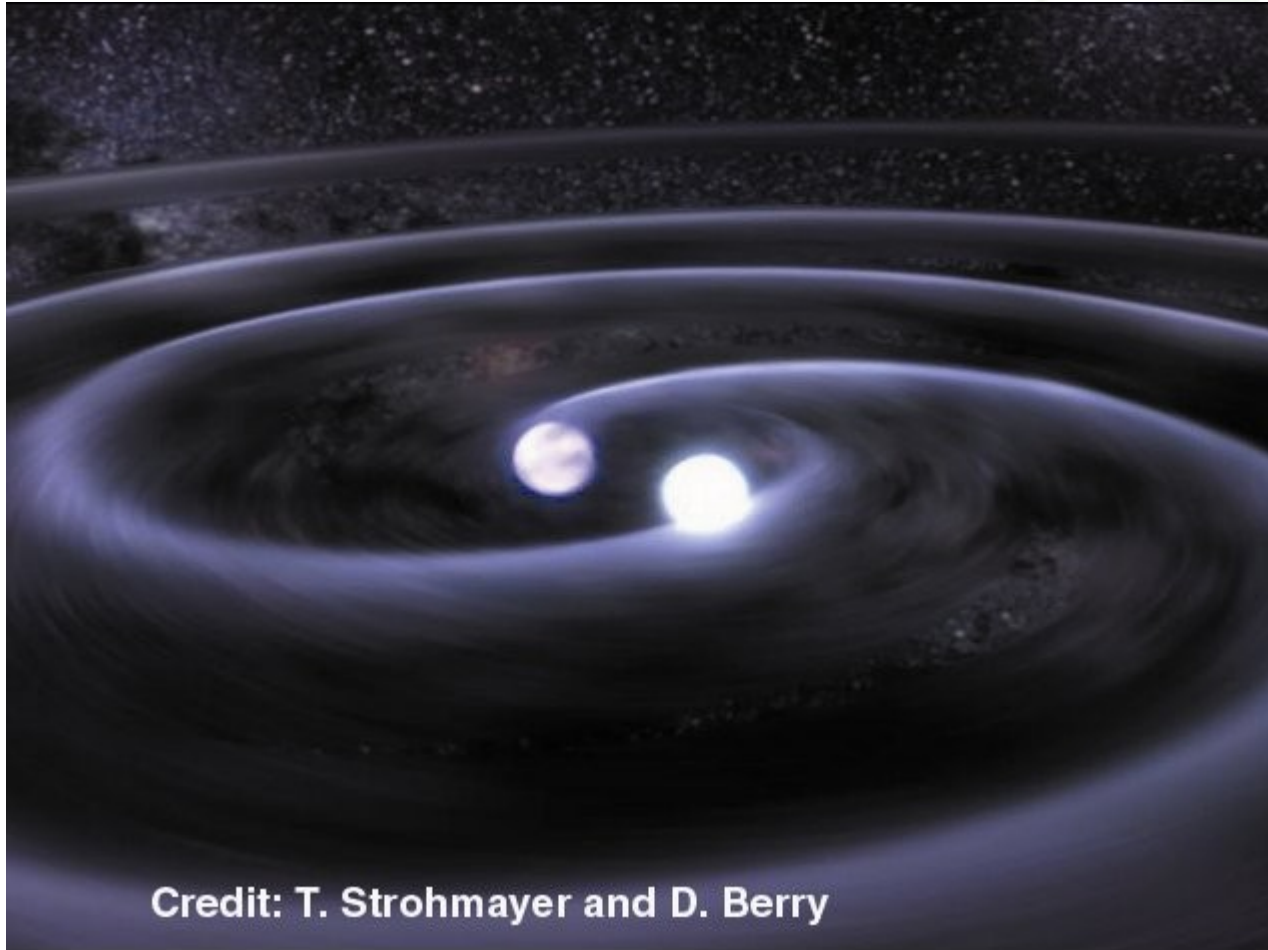
LISA bronnen: ja!



Dubbele witte dwergen



Dubbele witte dwergen

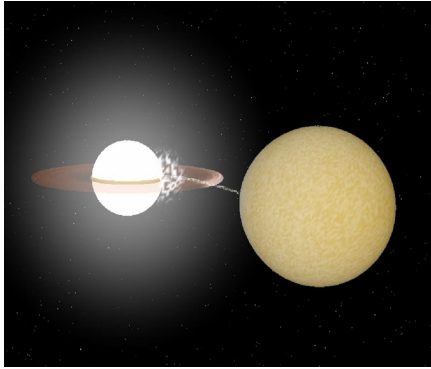


Zwaartekrachtsgolven!

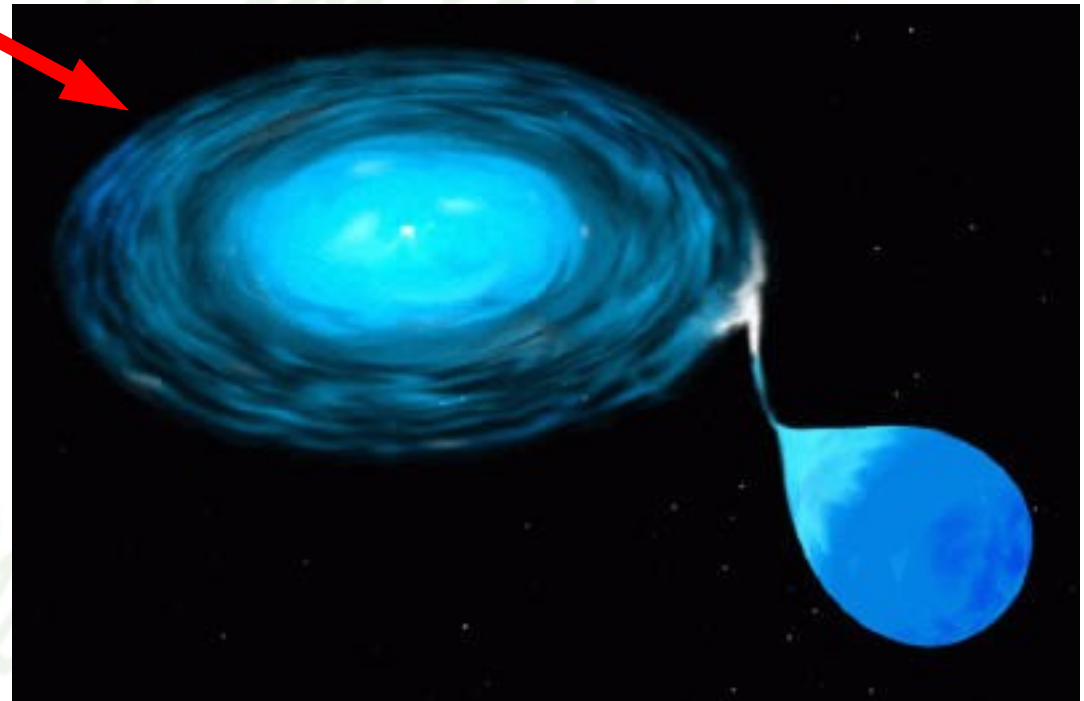
Credit: T. Strohmayer and D. Berry



Massa-overdragende systemen

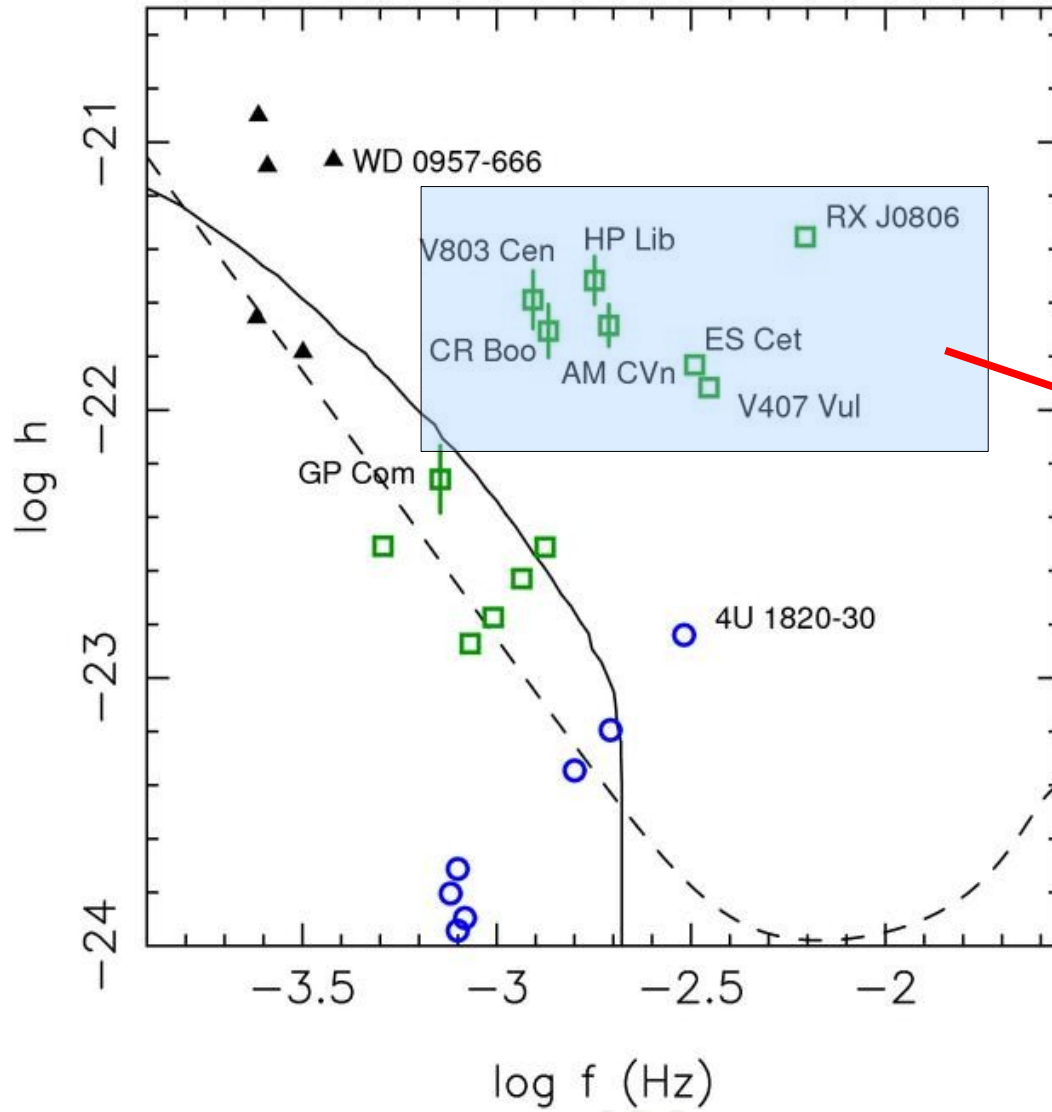


tijd

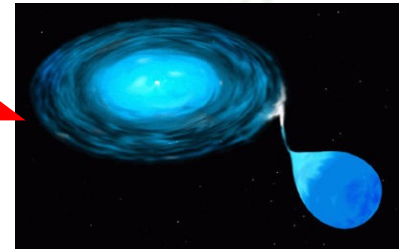


Zwaartekrachtsbronnen

- AM CVn systems
- UC X-ray binaries
- ▲ Double WD/sdB + WD



Galactic GWR plot © GN 2005



N04

RADBOUD UNIV

HM Cancri (RXJ0806+15)

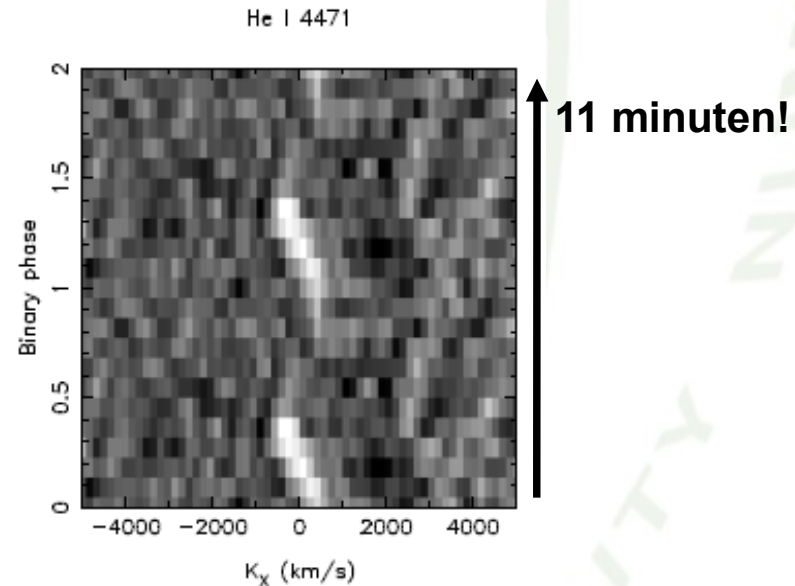


Vinden van baanperiode: een uitdaging!

HM Cancri (RXJ0806+15): de korst bekende baanperiode
Baan periode is slechts 5.4 minuten!

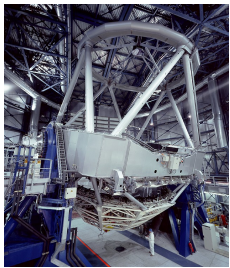


Op Schaal!!!!!!

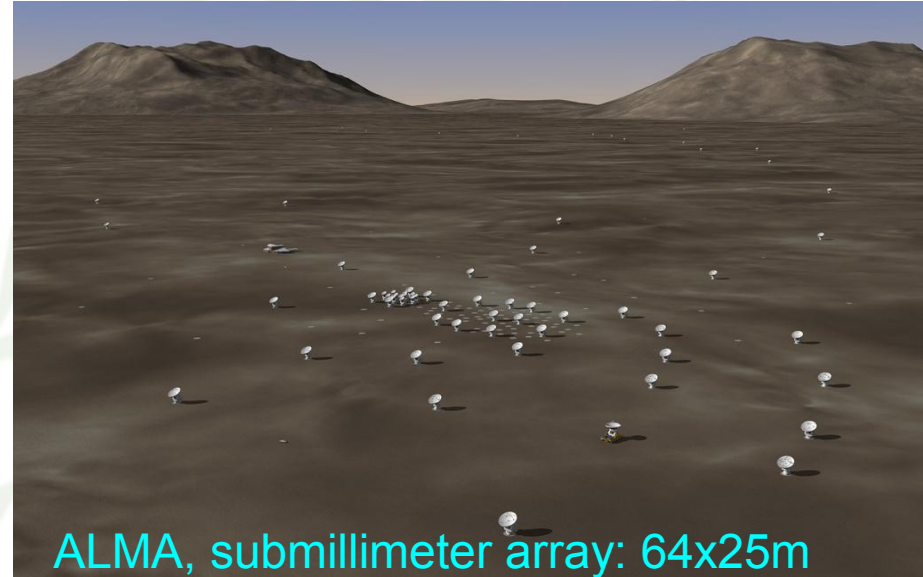
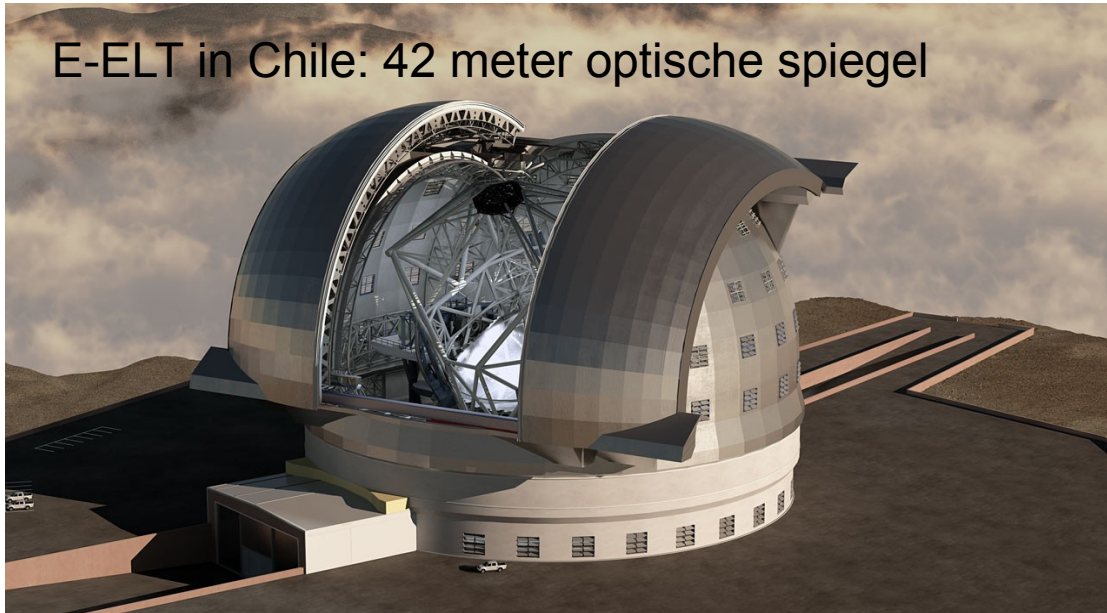


Eerste vondst van radiale snelheidsvariaties in dit systeem
Roelofs, Groot et al., 2010

De toekomst!

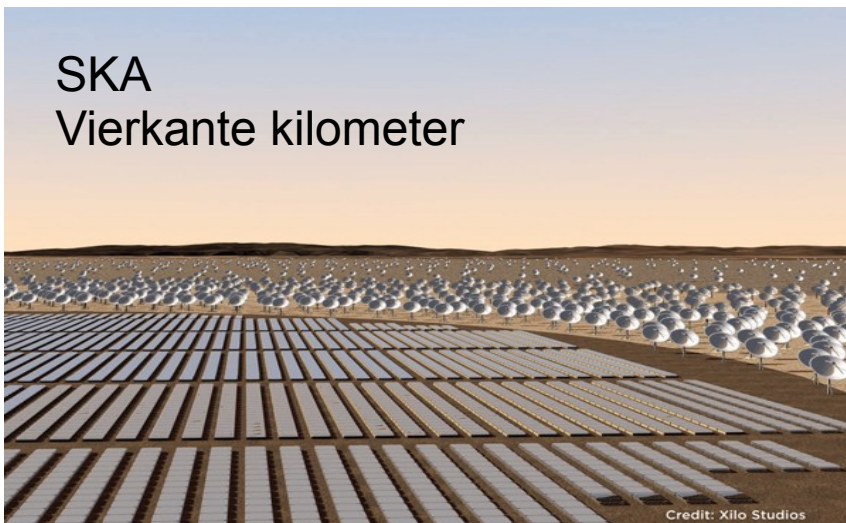


E-ELT in Chile: 42 meter optische spiegel

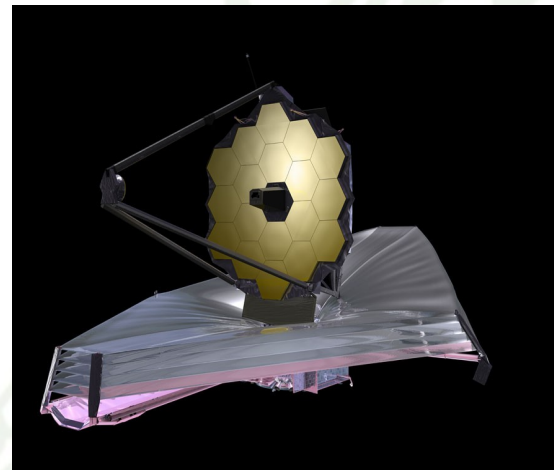


ALMA, submillimeter array: 64x25m

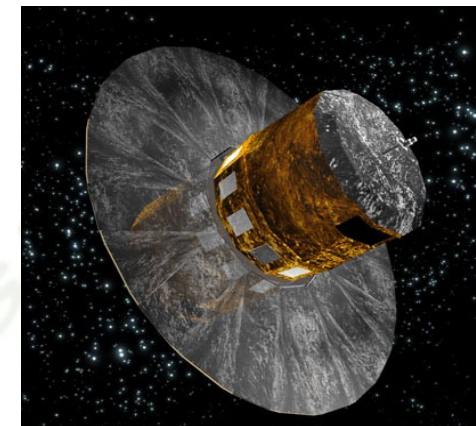
SKA
Vierkante kilometer



Credit: Xilo Studios



JWST: opvolger HST



Gaia,
astrometrie

Waarom?

- Groter: meer oppervlak, meer gevoeligheid
- Groter: hogere resolutie, meer scherpte
- Meer objecten: beter verband tussen alle objecten in het Heelal
- Tijdsvariabiliteit: grotendeels onontdekt
- Golflengte bereik: verschillende fysische processen



Hubble Ultradeep field in het infrarood