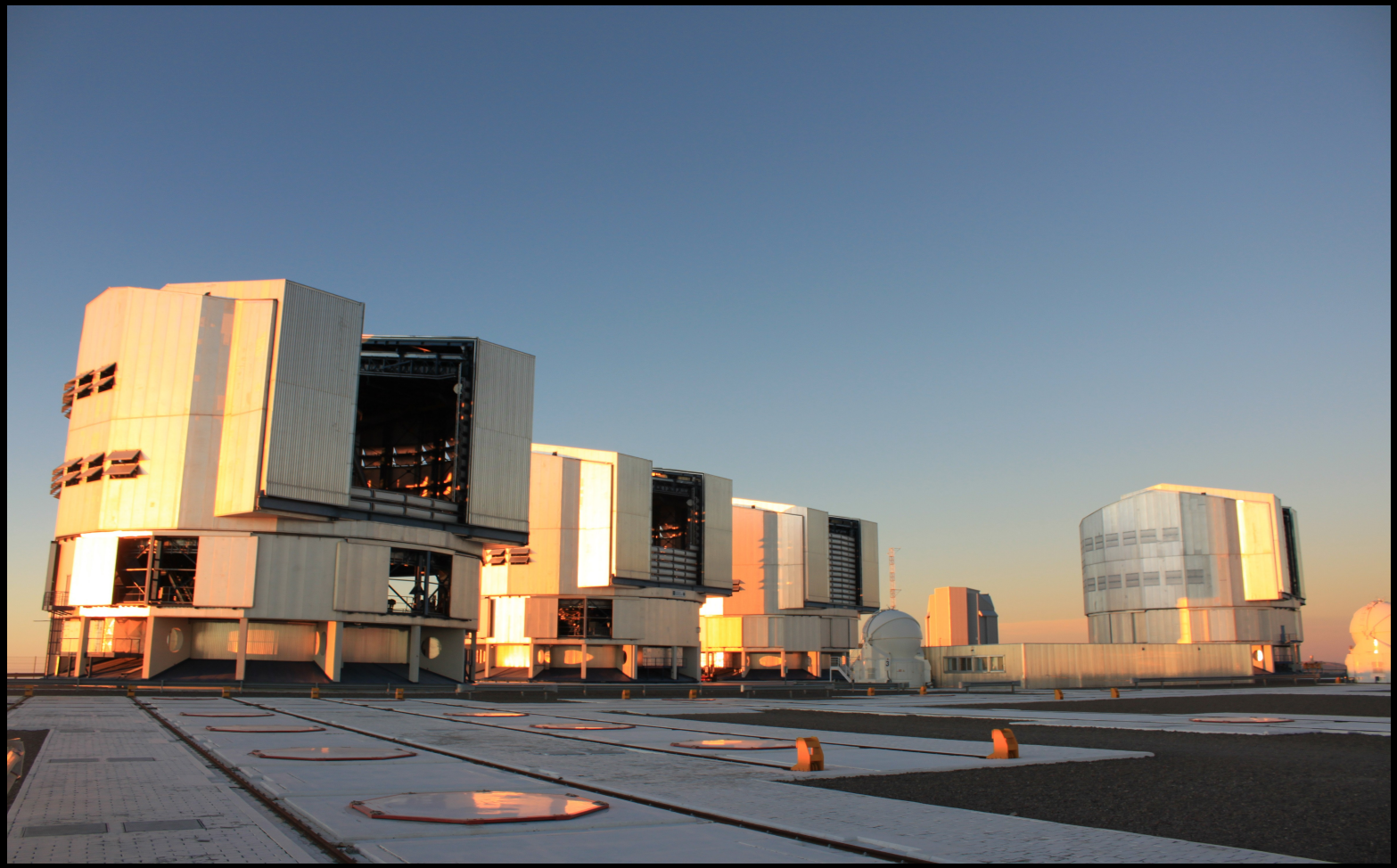
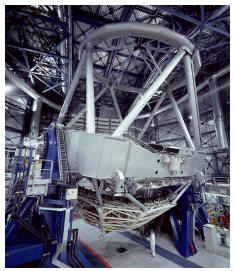
Astronomische Technieken
Hovo Cursus 2010

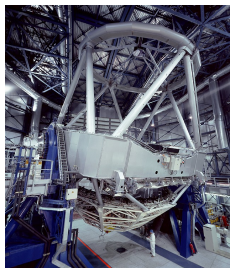


Prof.dr. Paul Groot (RU)
Dr. Gijs Nelemans (RU)

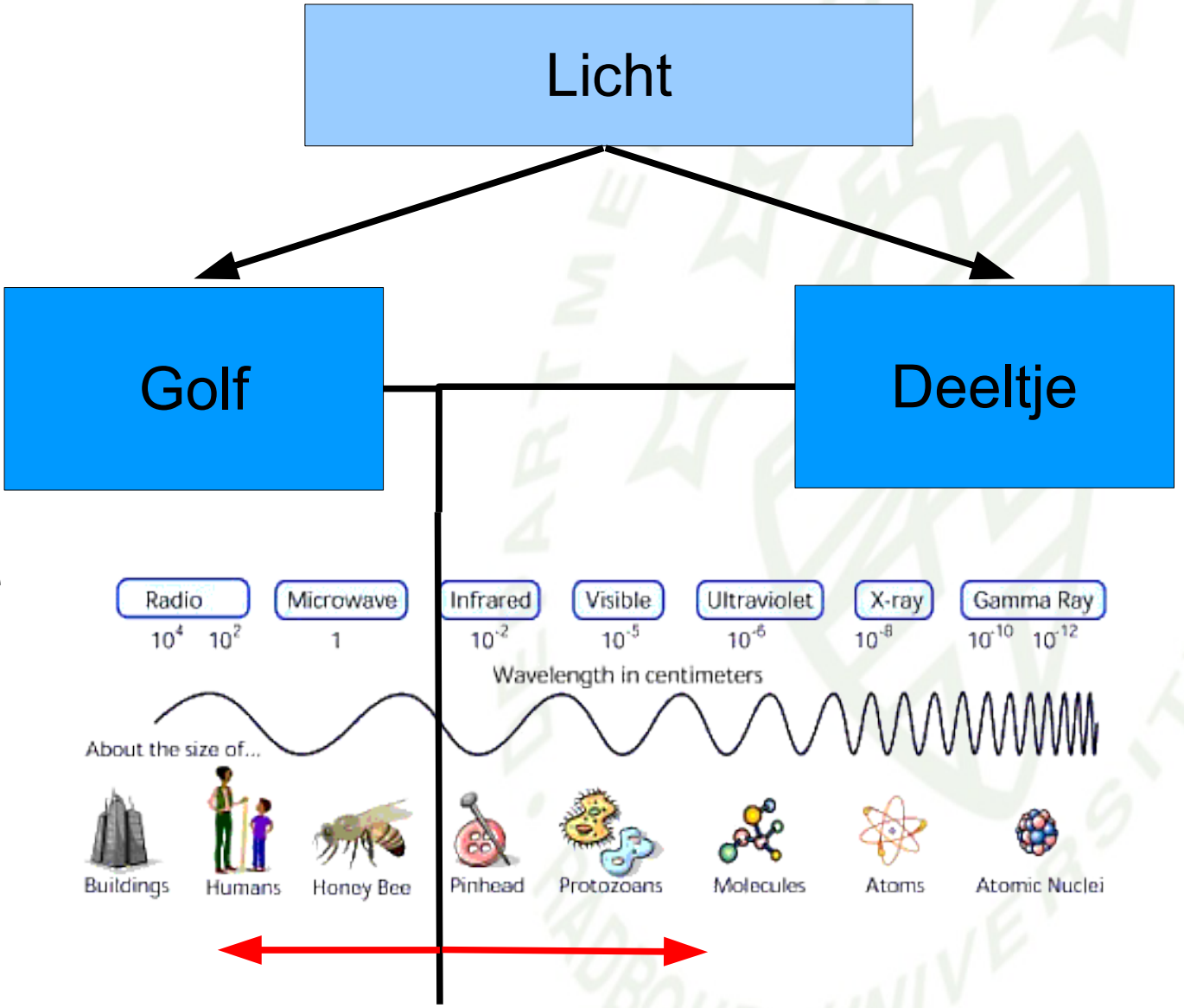


Opbouw van de cursus

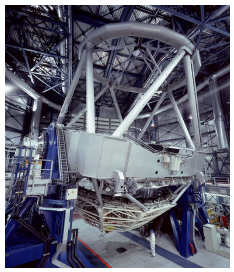
15/3:	- Berichten uit de ruimte - Ontvangers op Aarde	 Paul Groot
22/3:	- Telescopen en detectoren - De perfecte waarneming	 Gijs Nelemans
12/4:	- Telescopen in de ruimte - De invloed van de atmosfeer	 Gijs Nelemans
19/4:	- Radio telescopen - Interferometrie: meer met minder	 Paul Groot
26/4:	- Excursie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



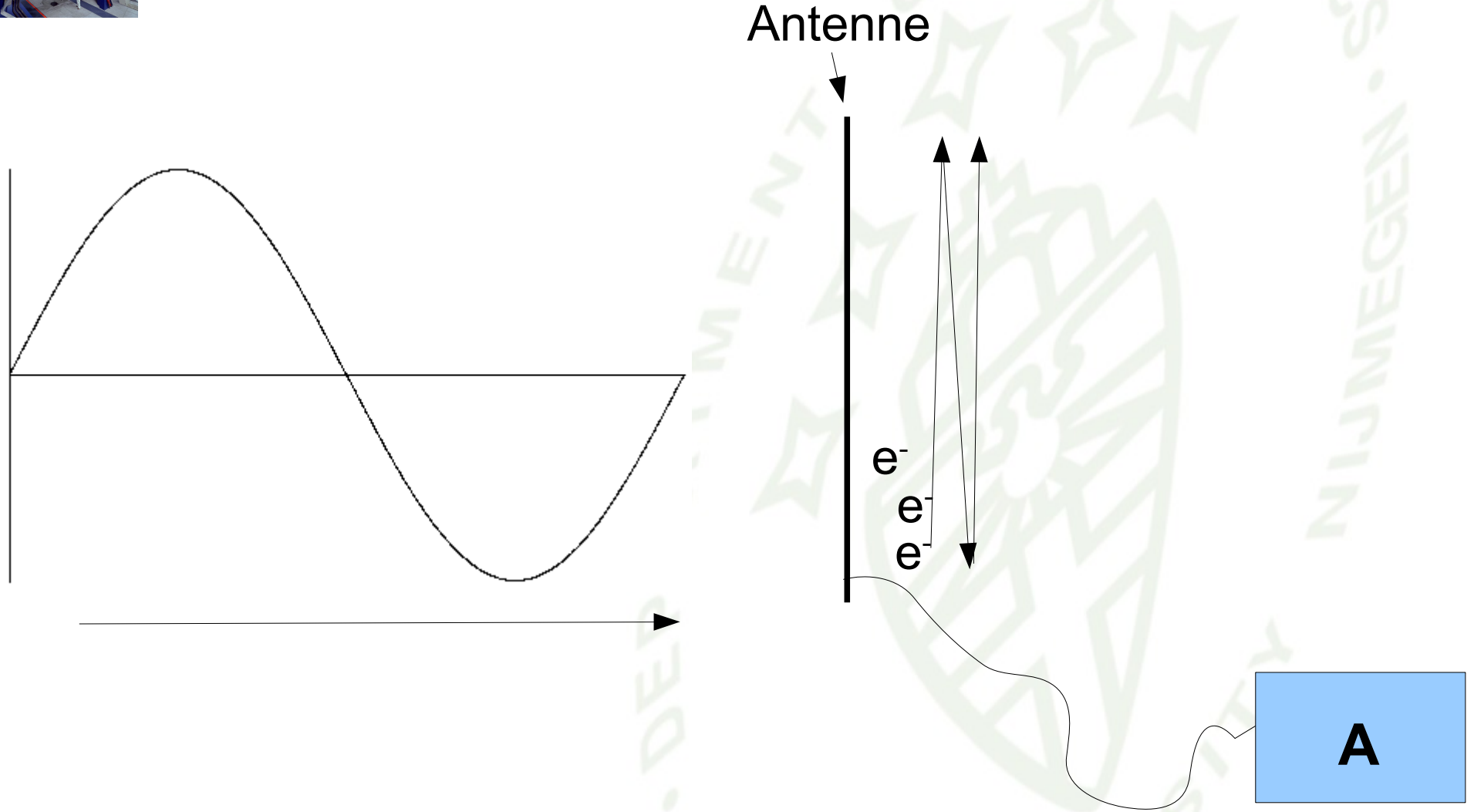
Golfkarakter licht

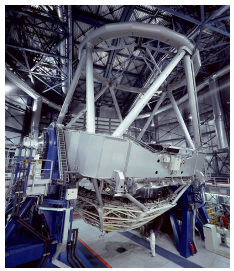


Detectie



Detectie radio straling

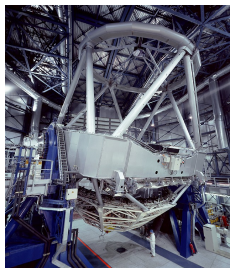




Radio sterrenkunde

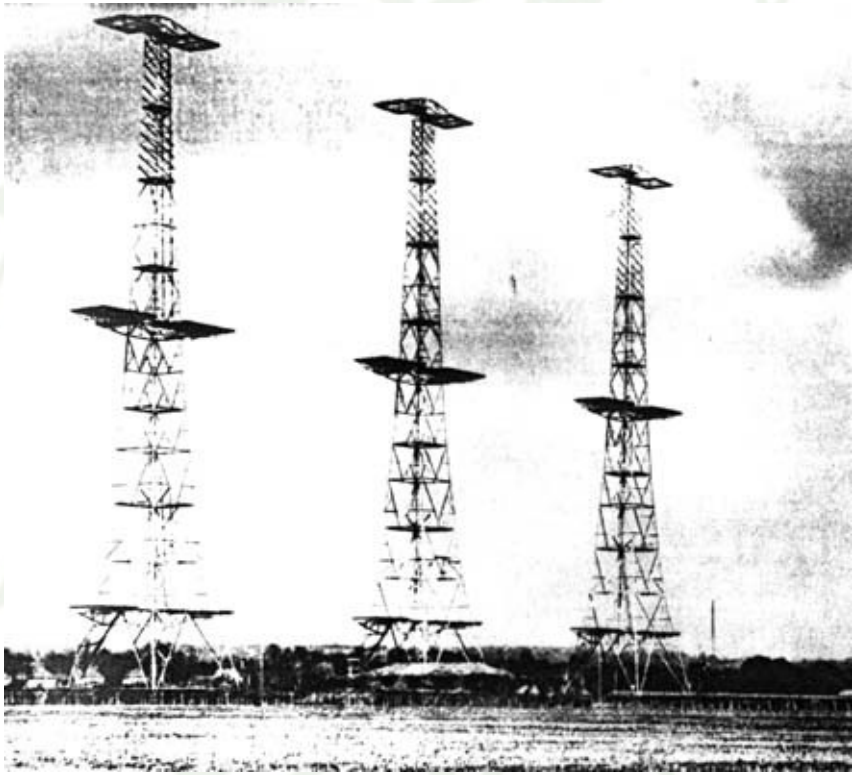
Karl Jansky

1930-1933, VS
Frequentie van 20 MHz



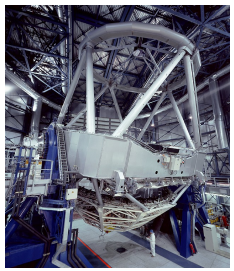
Radar ontwikkelingen

Geluidspiegel

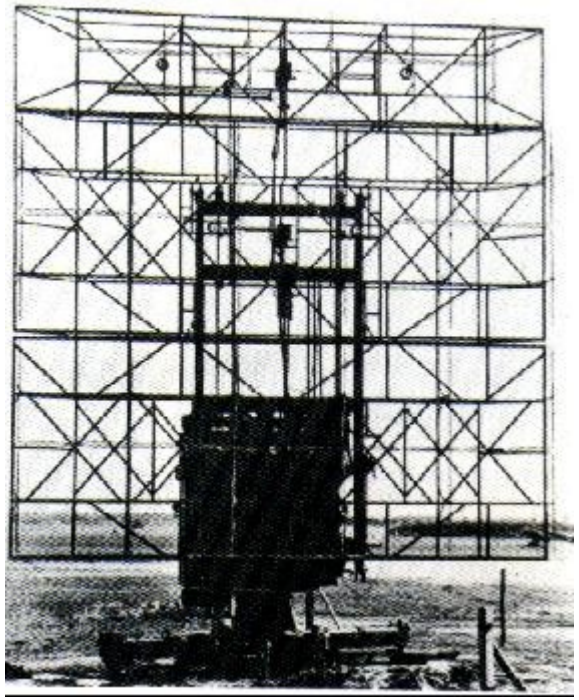


'Chain Home' systeem

Aan de vooravond van de 2e Wereld Oorlog in Engeland



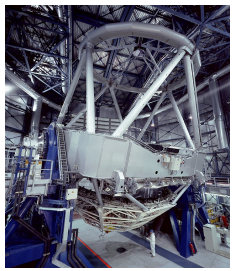
Radar ontwikkelingen



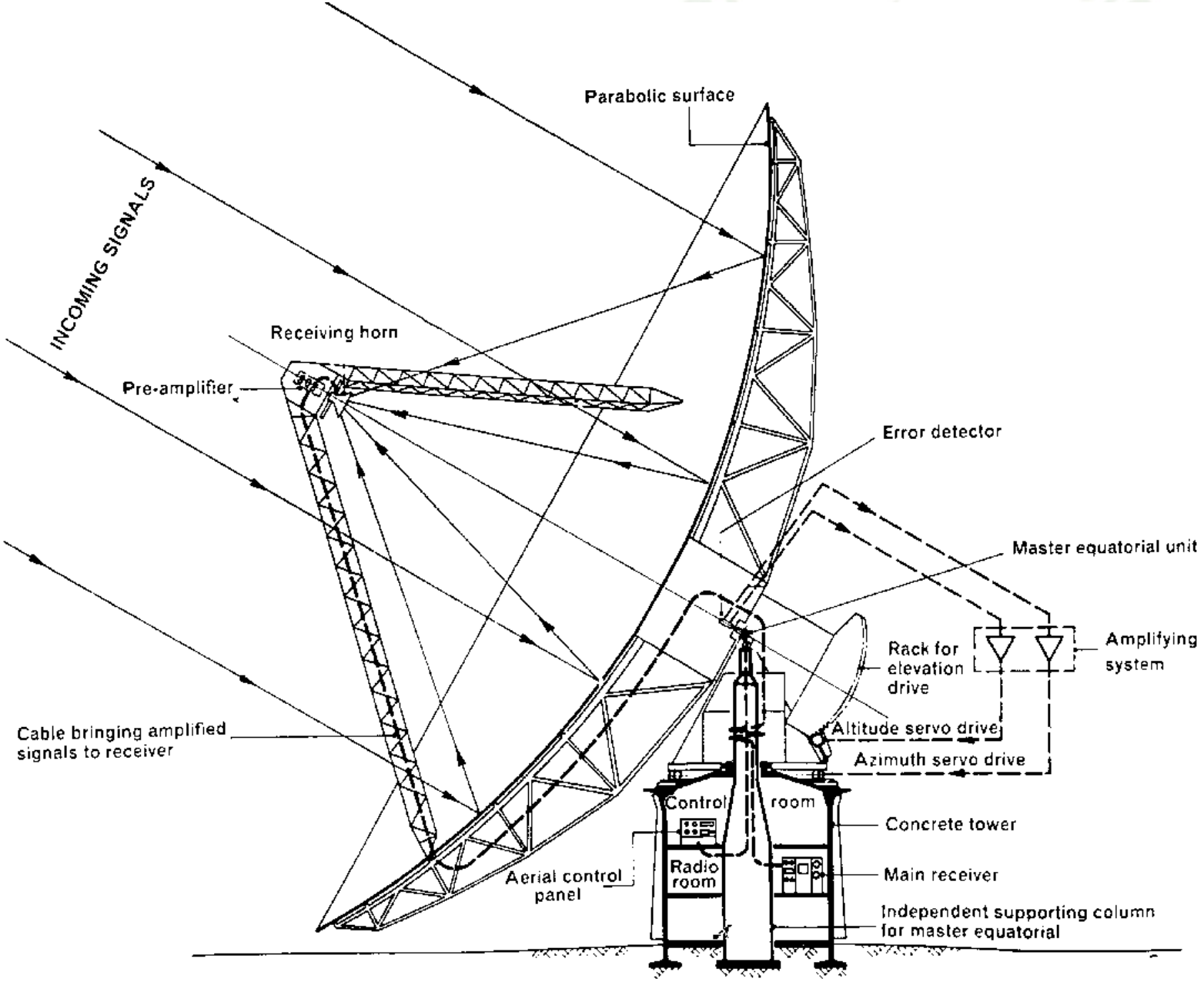
Freya

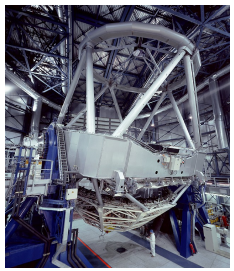
Wurzburg

Aan de vooravond van de 2e Wereld Oorlog in Duitsland



Radio schotel





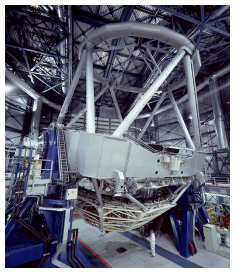
Tijdens de Oorlog

Jan Oort (rechts)

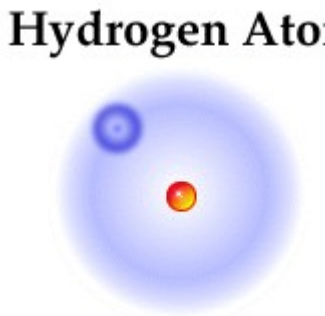
en

Henk van der Hulst (links)

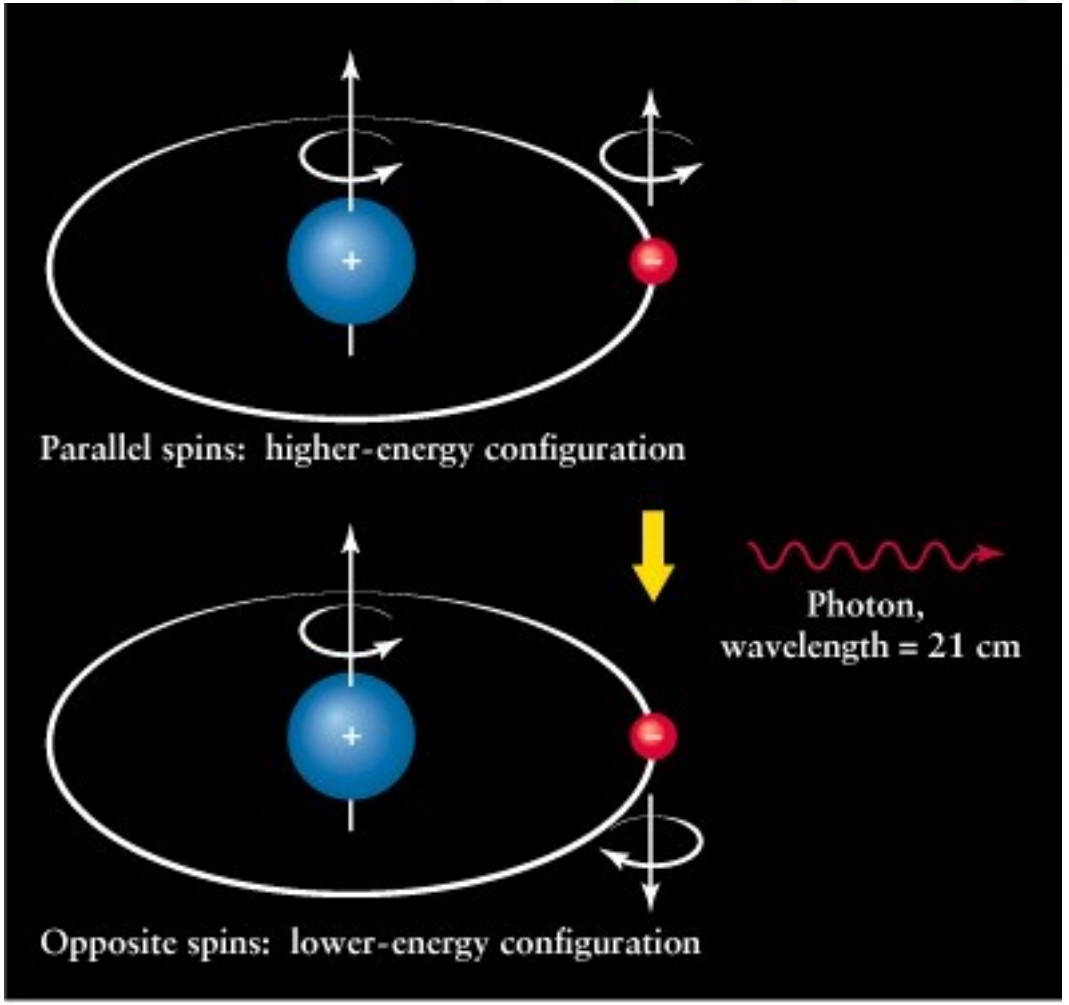
'Zeg, Henk, zou jij eens...'



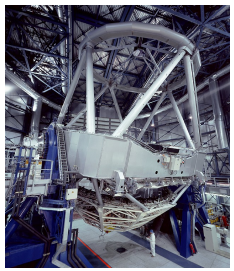
21-centimeter lijn



Kans van 10^{-13} s^{-1} !!



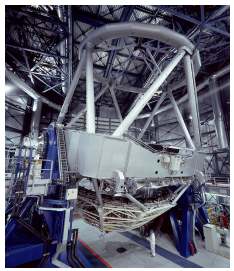
b



Radio Kootwijk

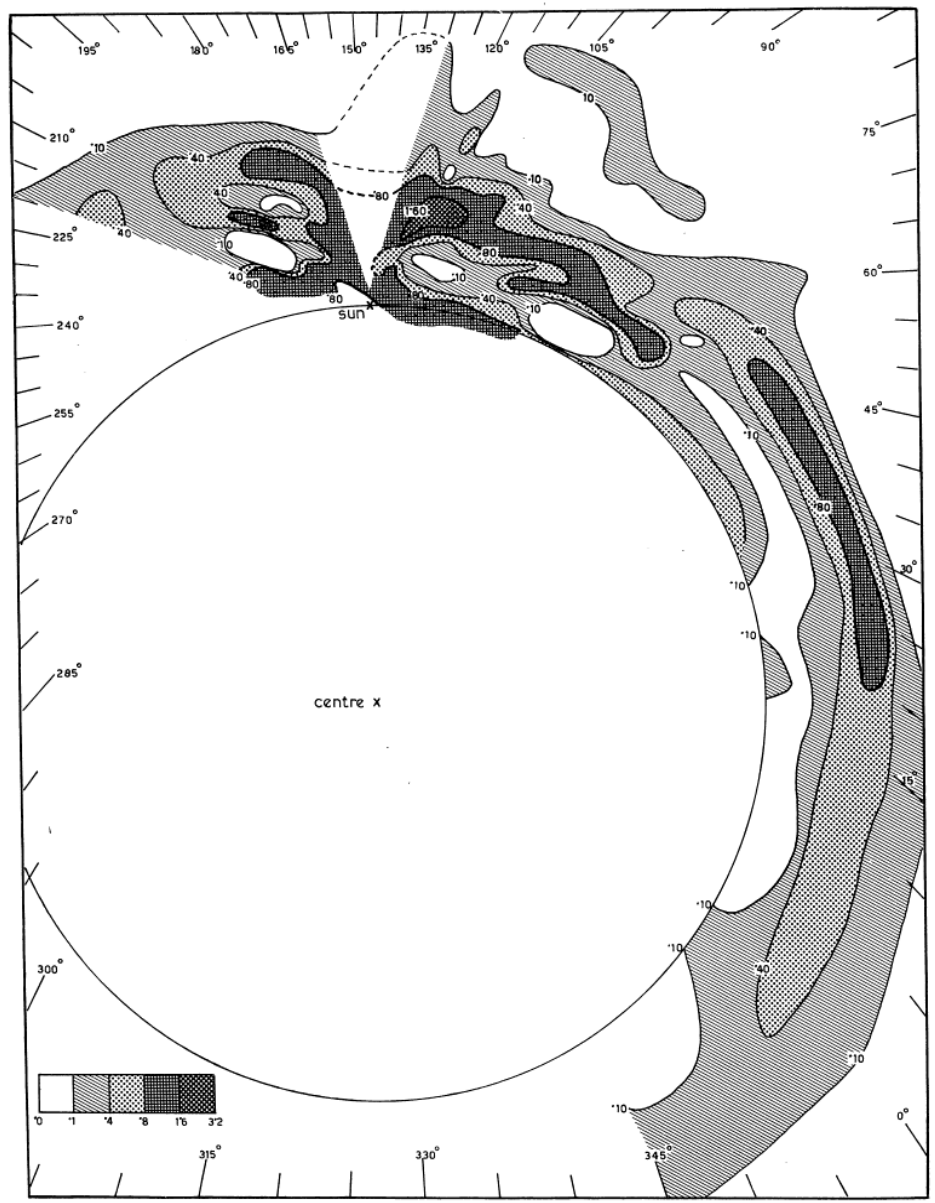
Geconfisceerde Wurzburger Riese is basis van de Nederlandse sterrenkunde in periode na 1945.

Zie film 'Spiral Galaxy' van Maarten Roos Serote.



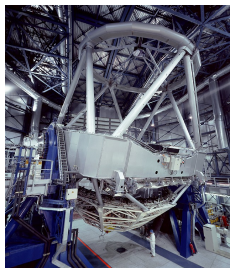
Structuur van de Melkweg

FIGURE 15



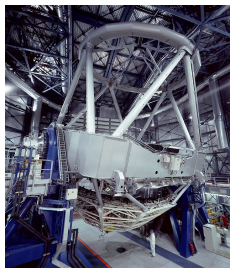
Contour map of hydrogen density in the galactic plane. Scale 1 cm = 1 kps

Spiraal structuur Melkweg

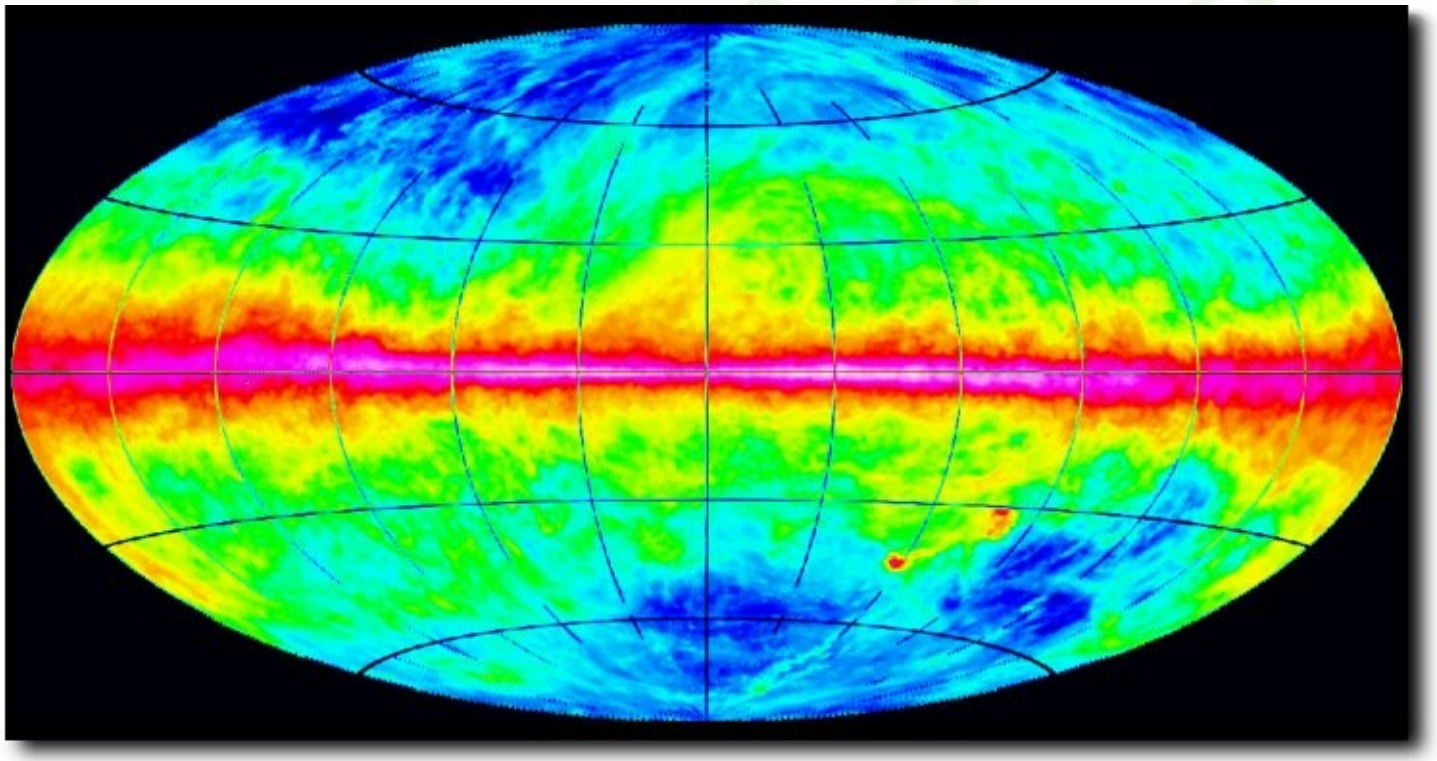


Dwingeloo 25m telescoop

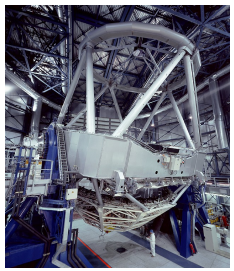
Geopend in 1956



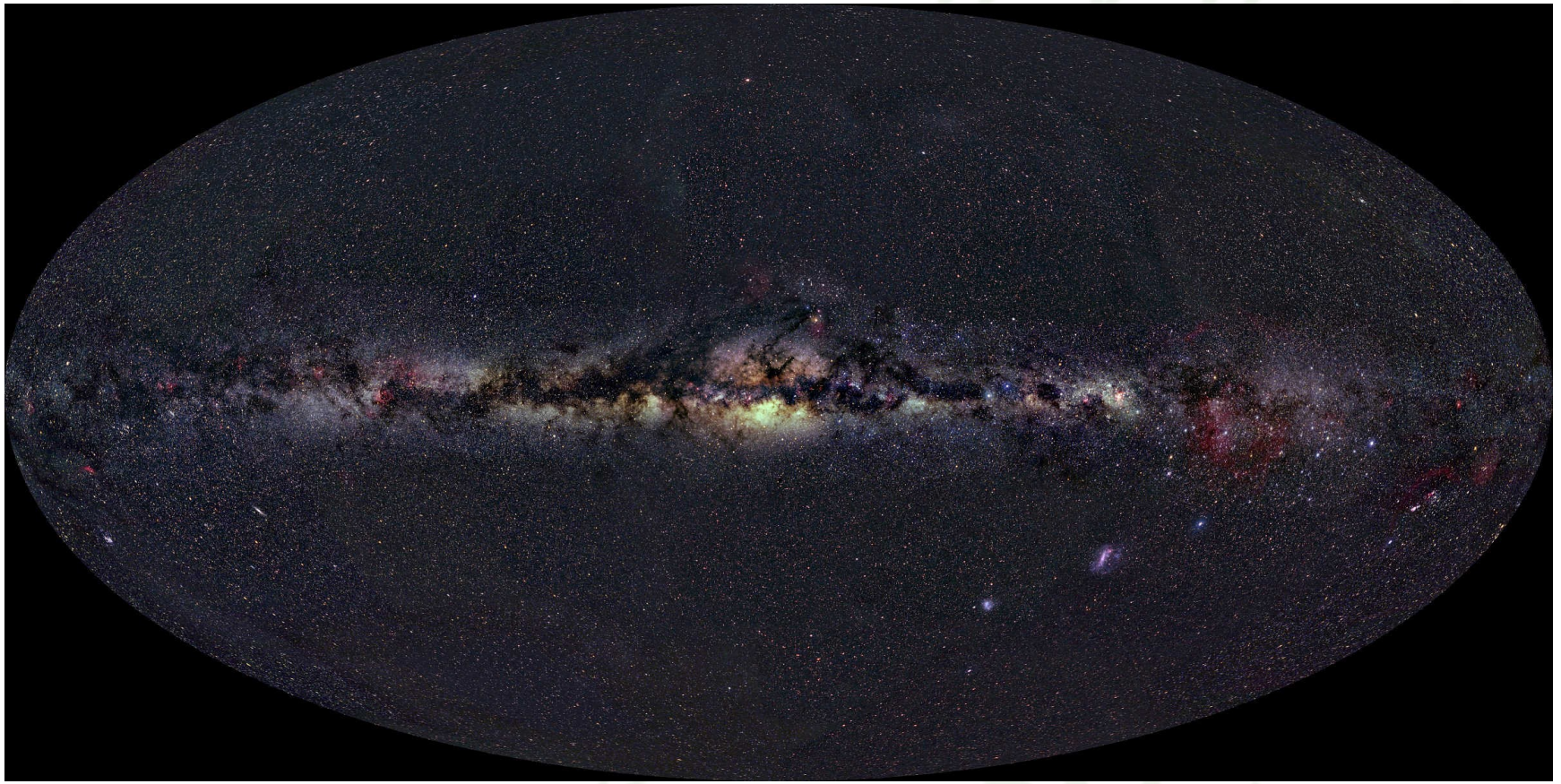
Structuur van de Melkweg



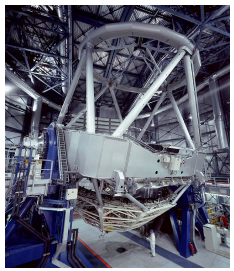
Kaart van de Melkweg in de 21 centimeter lijn
(Leiden/Dwingeloo/Argentina)



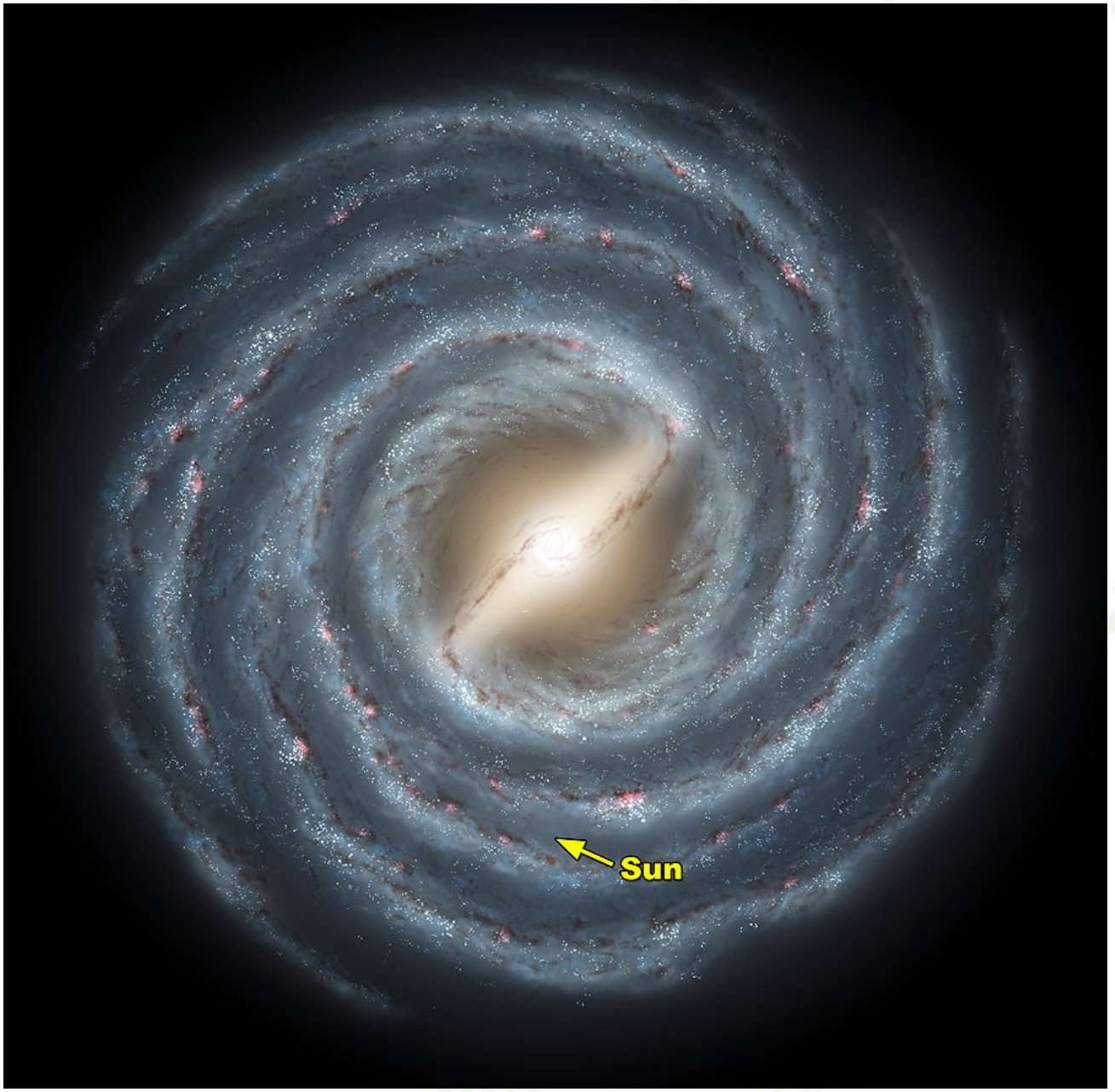
Structuur van de Melkweg

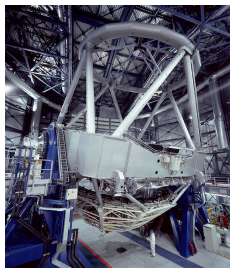


Optisch: stof verhindert zicht op de Melkweg

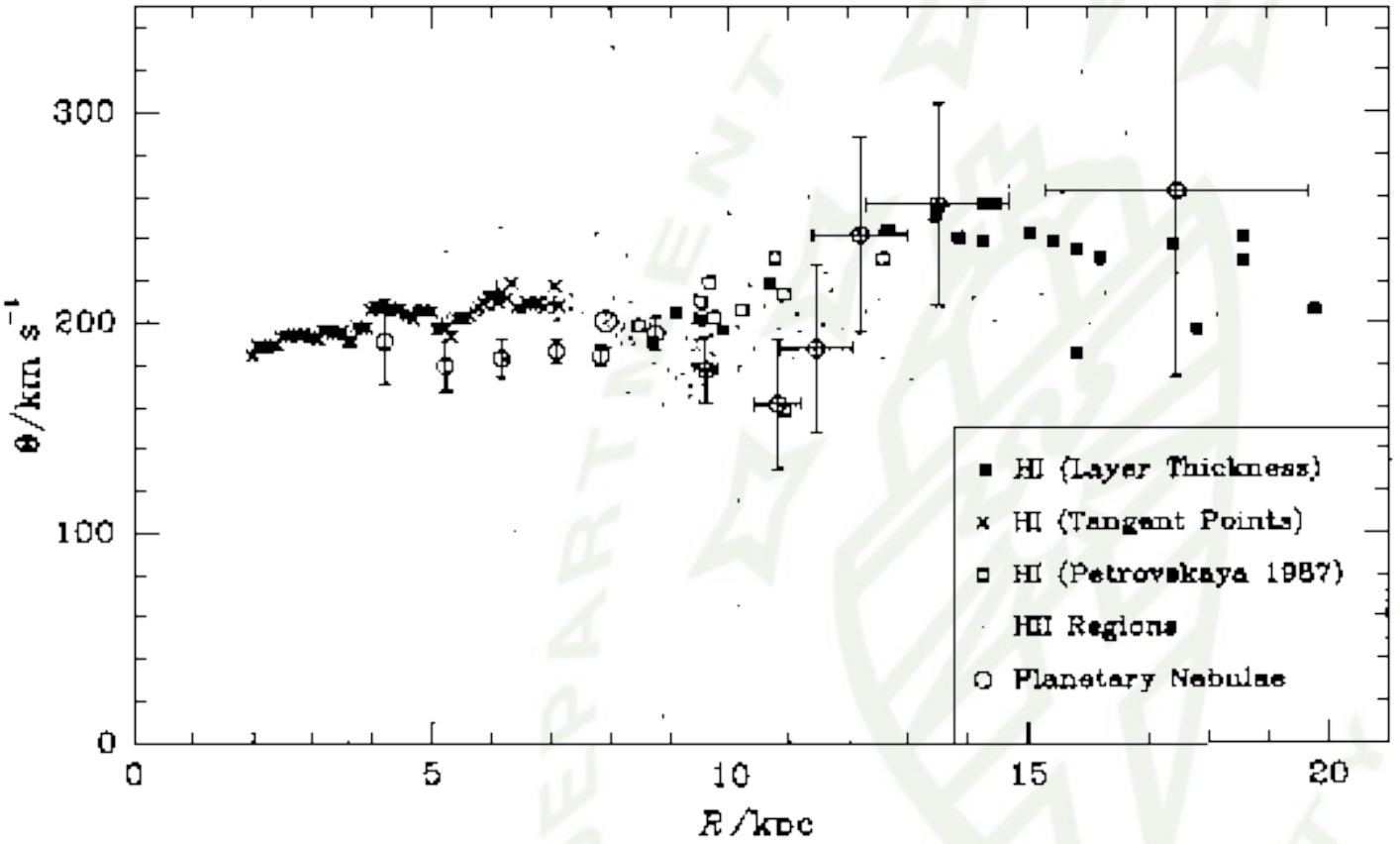


Structuur van de Melkweg

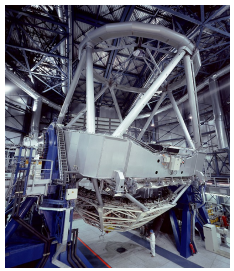




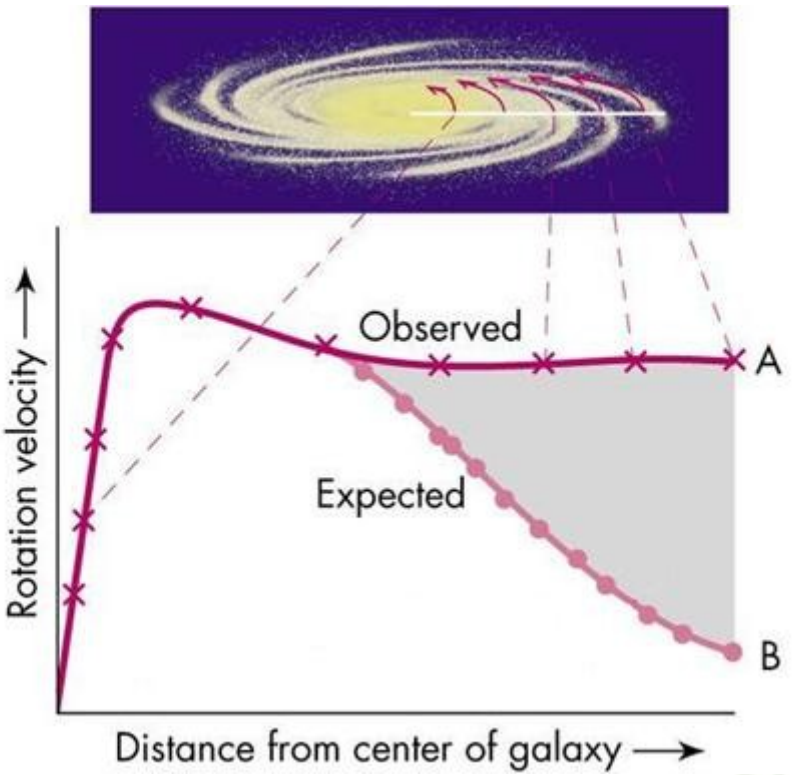
Rotatiecurve van de Melkweg

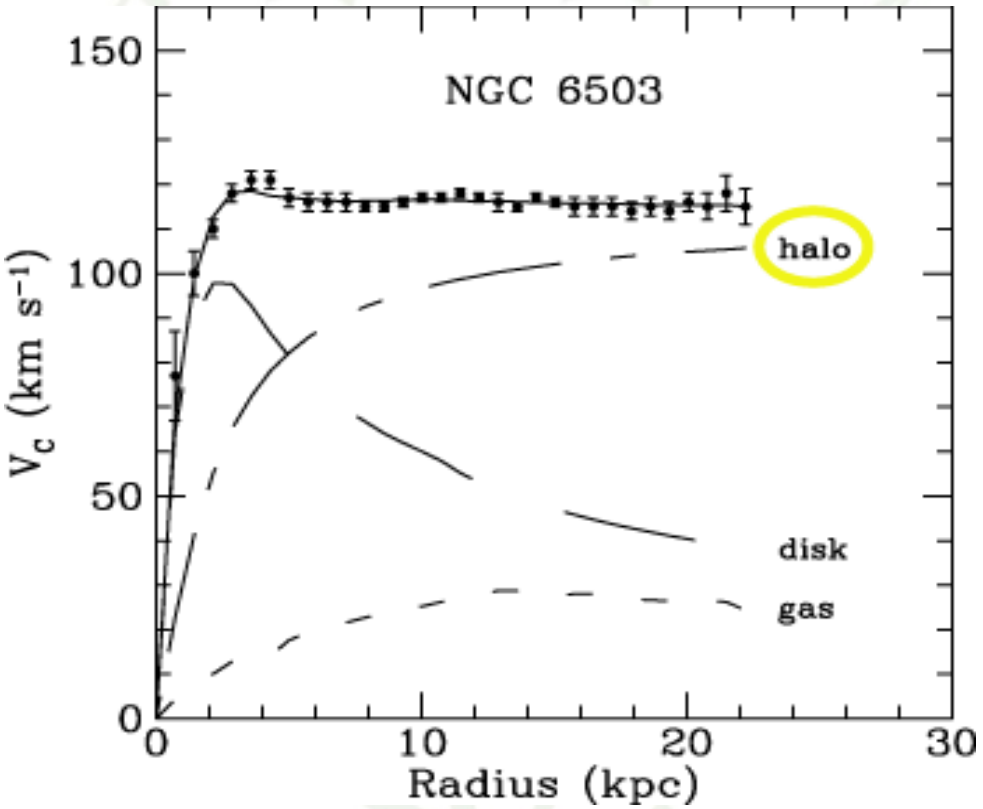


Comparison of the rotation curves calculated by all the methods discussed (assuming $R_0 = 7.9$ kpc and $\Theta_0 = 200$ km s^{-1}).

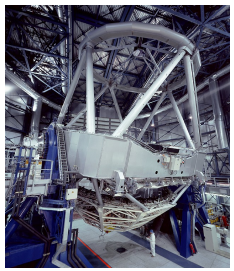


Rotatiecurve van de Melkweg





Ontdekking van donkere materie halos



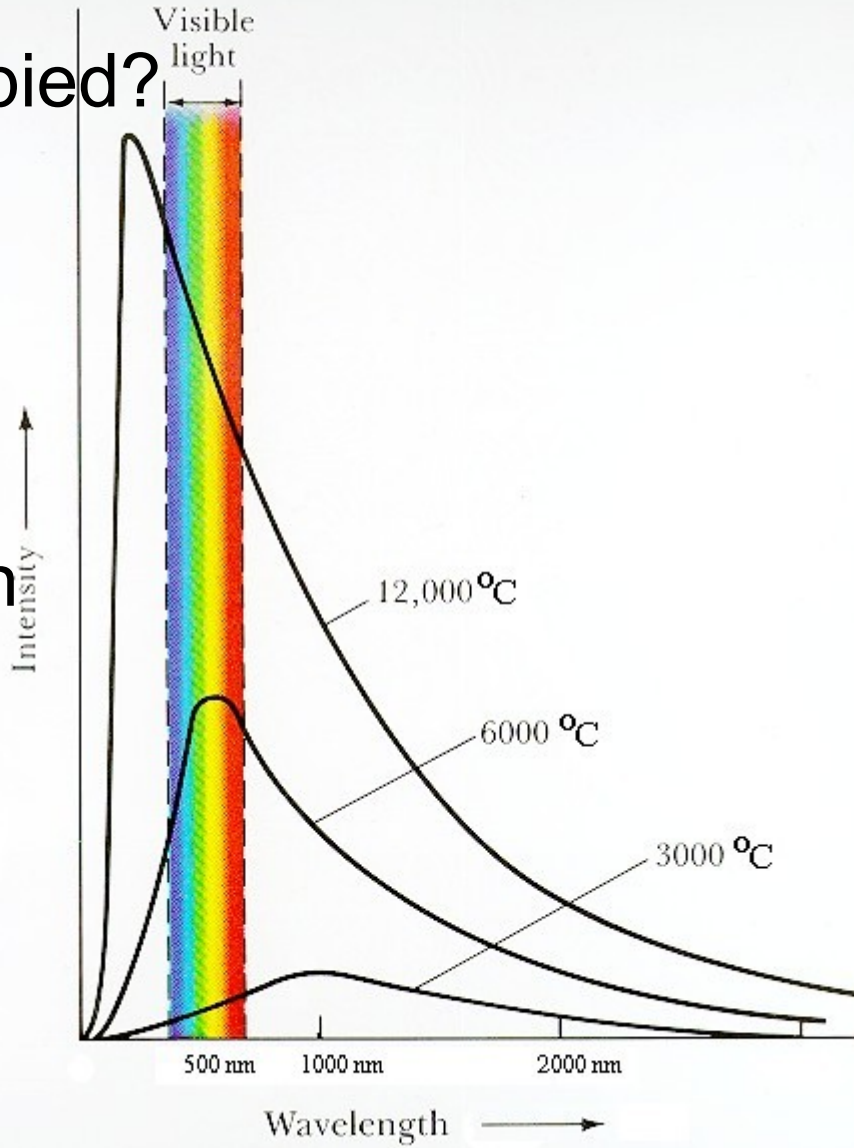
Niet-thermische emissie

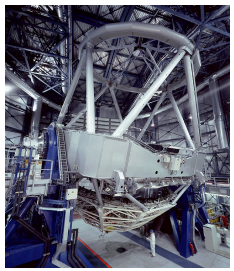
Wanneer straalt iets in het radio gebied?

- Koud (Thermisch), T<100 K

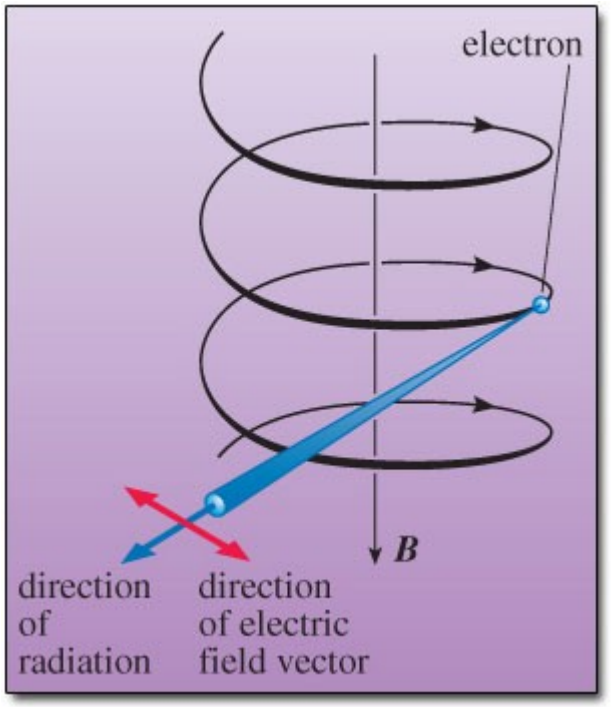
- Lijn emissie, bv. 21 cm overgang

- *Synchroton straling*: niet-thermisch

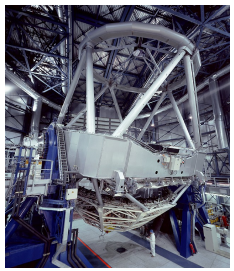




Synchroton straling

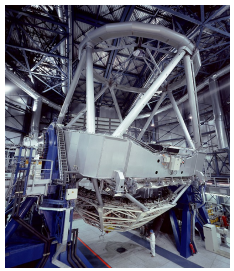


Radio straling als electronen met relativistische snelheden in magneetveld bewegen

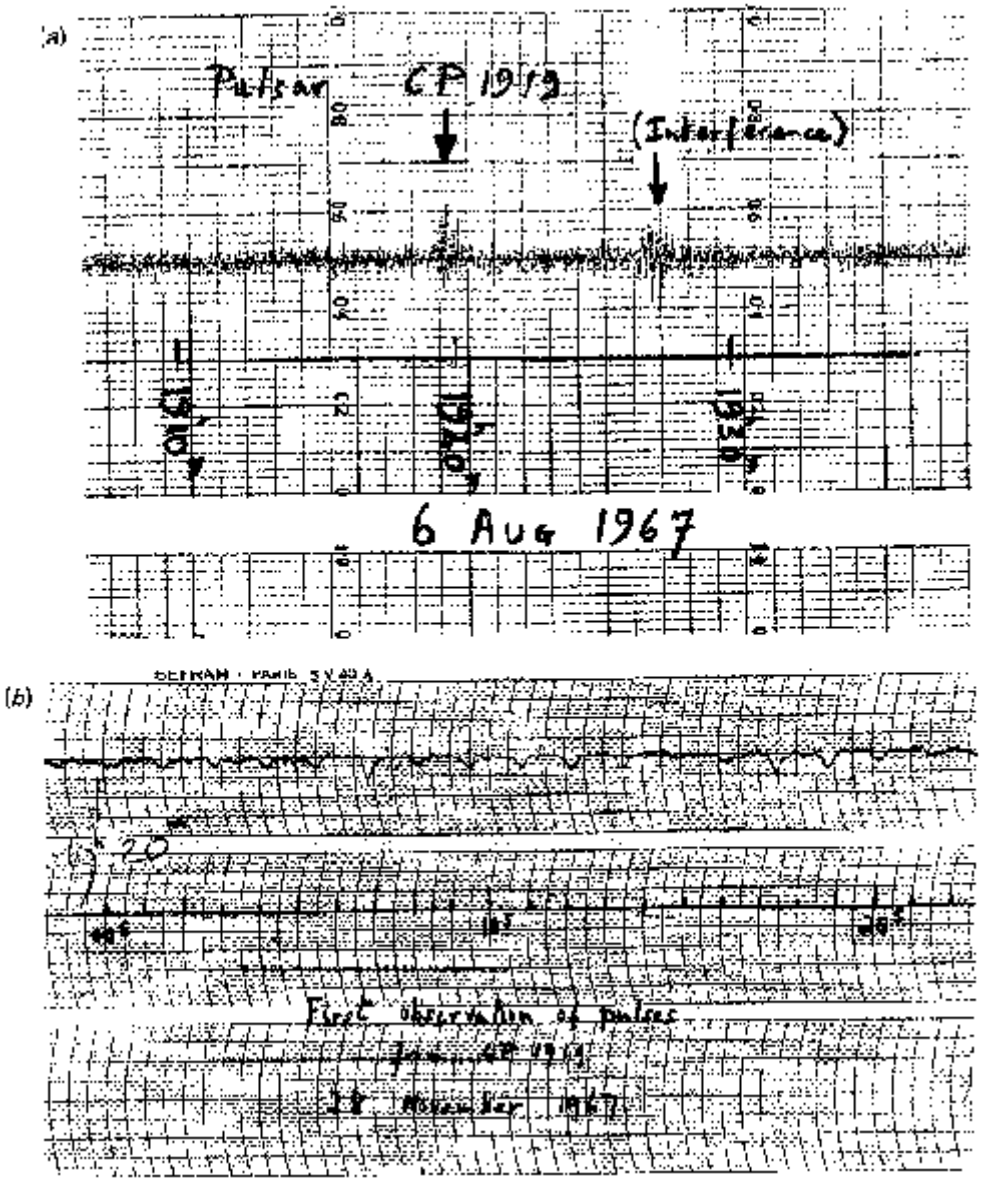


Waslijn detectoren

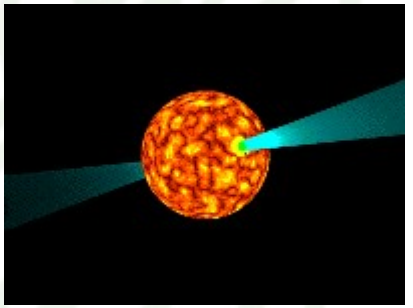
Begin jaren 60 in Cambridge, UK

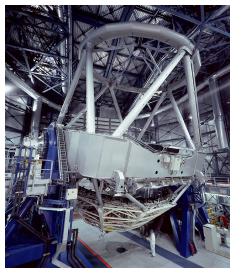


Waslijn detectoren

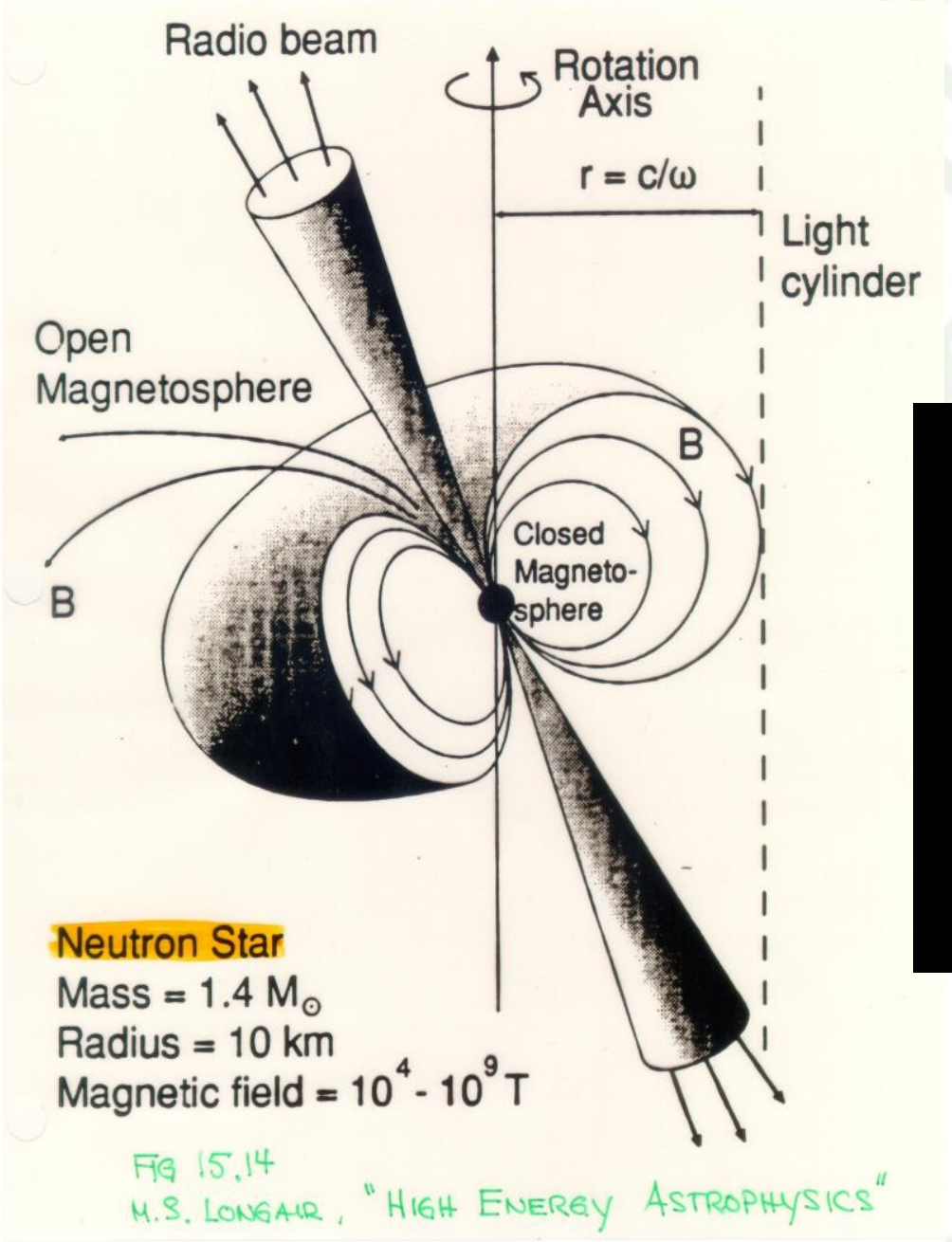


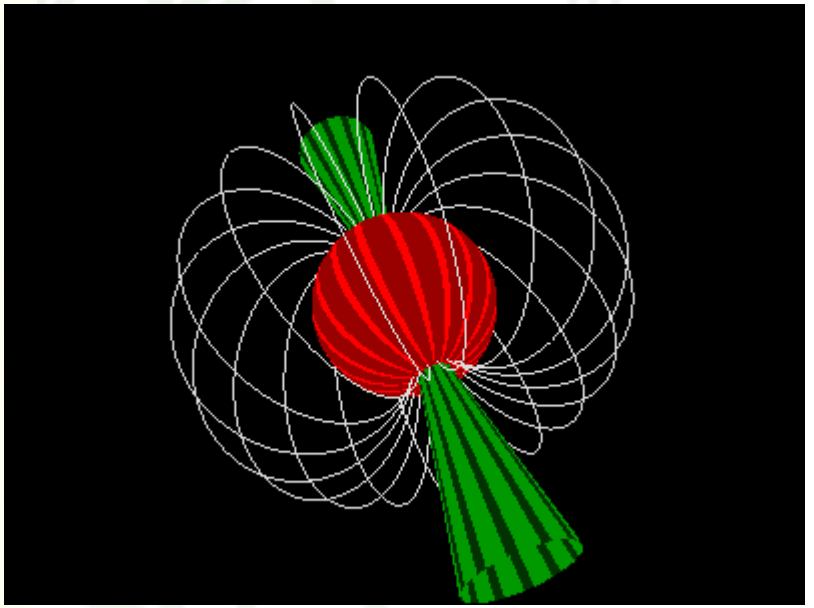
Ontdekking van de pulsar: een extreem stabiele klok in de ruimte

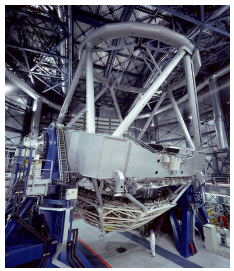




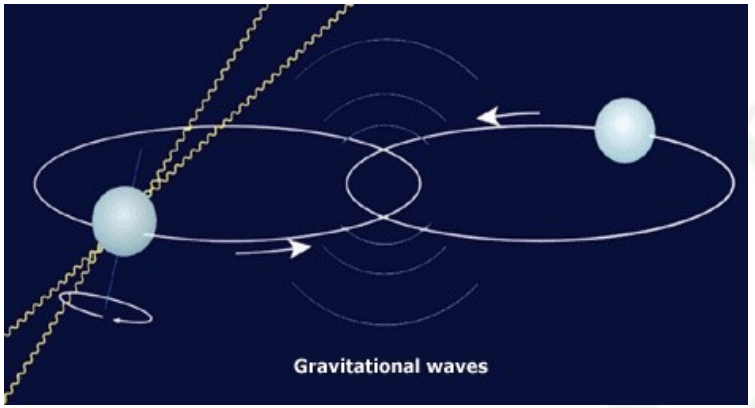
Pulsar: roterende neutronenster



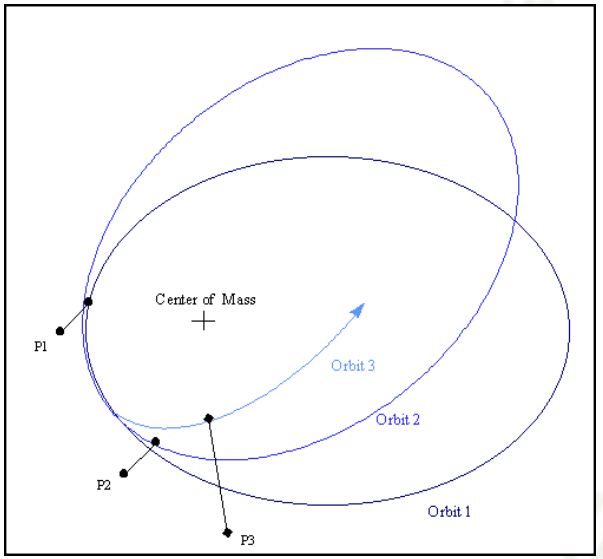


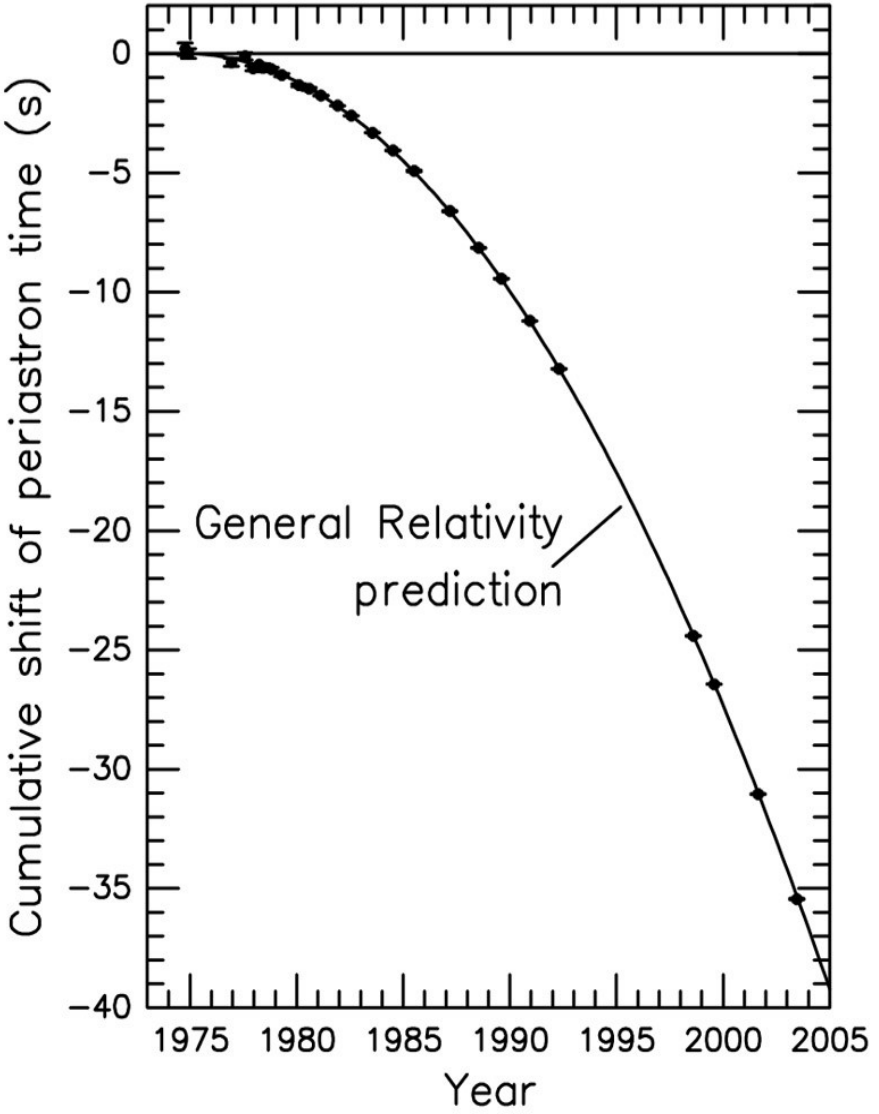


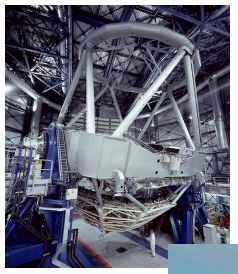
Binary Pulsar: PSR1913+16



Joe Taylor &
Russell Hulse

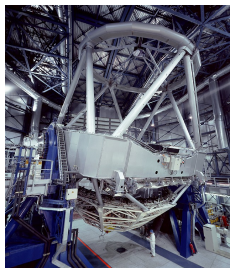






Hoe groot kun je ze maken?

Effelsberg
100m
telescoop



Interferometrie

Prestatie van telescoop hangt af van:

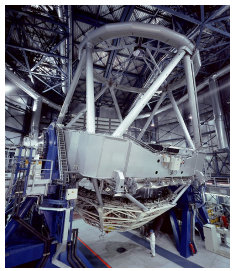
- Doorsnede: hoe groter hoe scherper het beeld

$$\sin\theta = 1.22\frac{\lambda}{D}$$

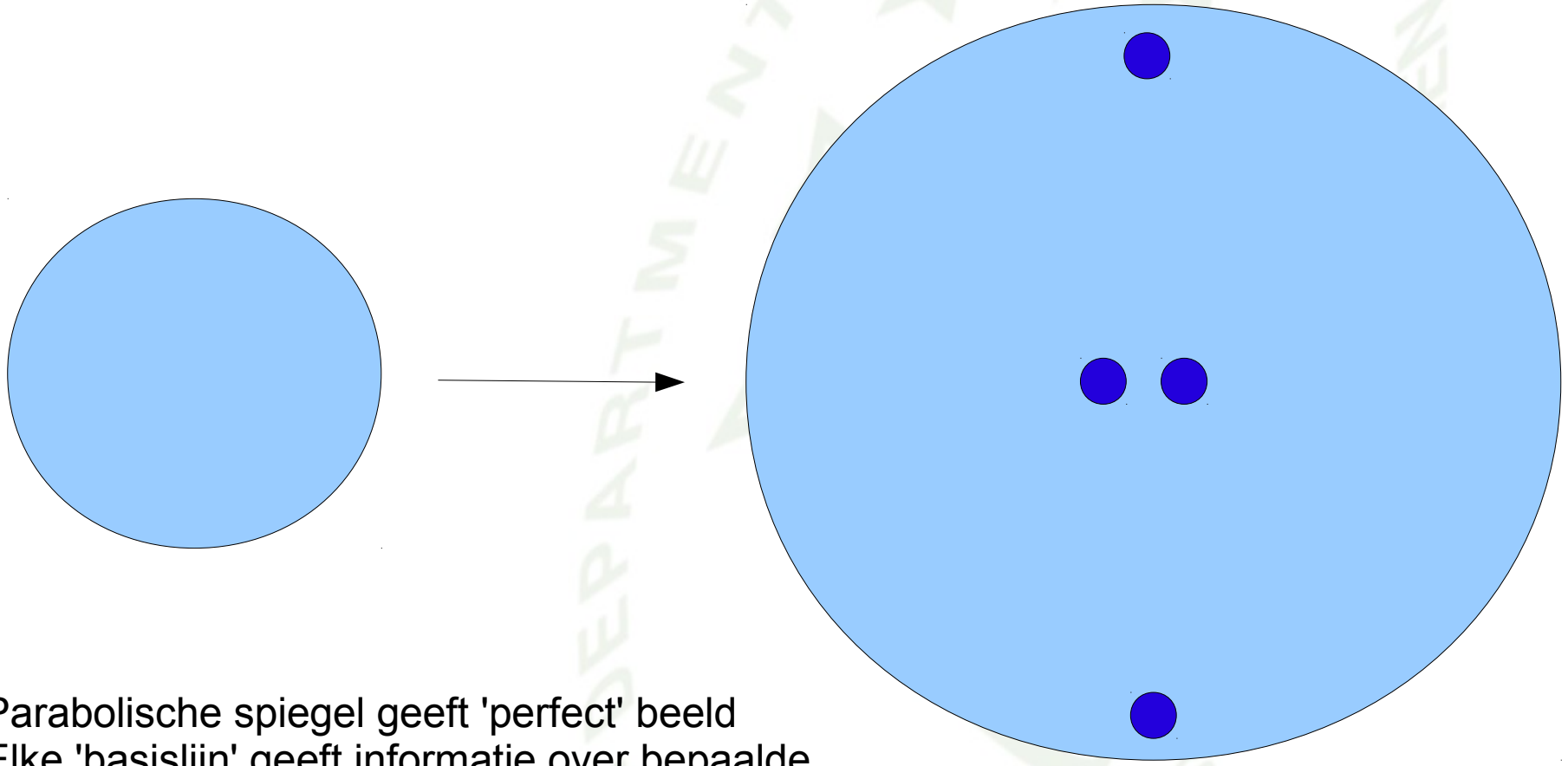
- Oppervlak: hoe groter hoe gevoeliger

$$Opp. \propto D^2$$

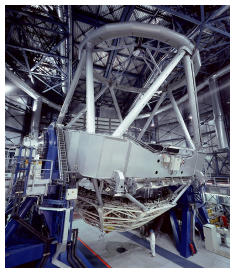
- Licht komt aan in fase



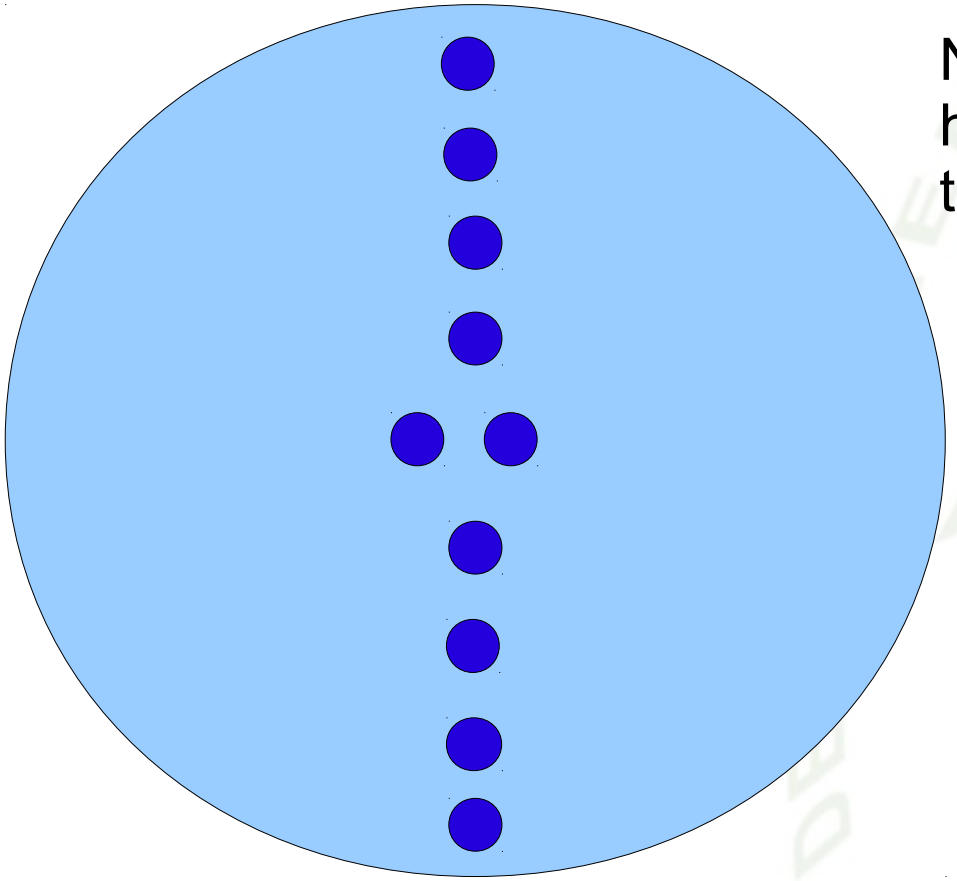
Interferometrie



Parabolische spiegel geeft 'perfect' beeld
Elke 'basislijn' geeft informatie over bepaalde
Schaalgrootte in het beeld.

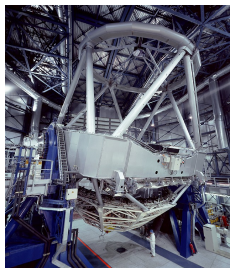


Interferometrie

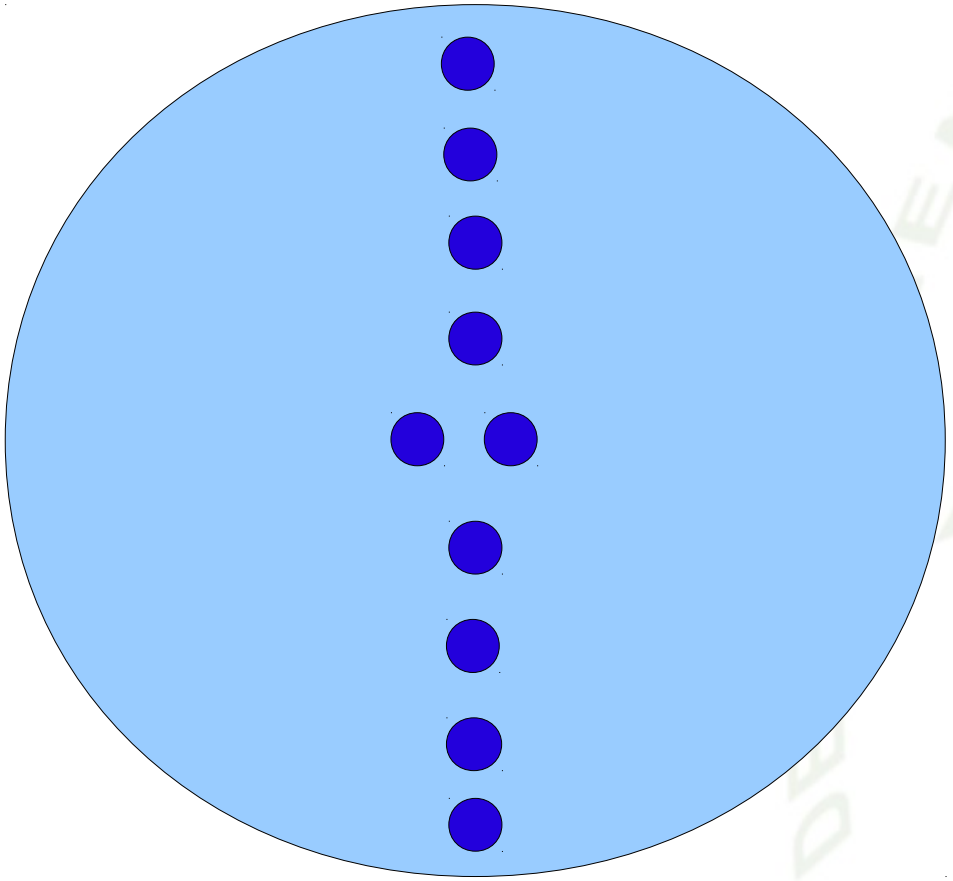


Nieuwe reeks met telescopen heeft wel de resolutie van een grote telescoop maar niet de gevoeligheid

Maar...



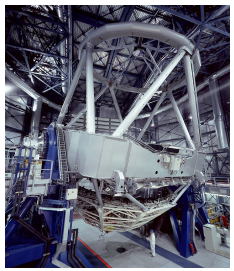
Interferometrie



Door opstelling op lijn, maar resolutie in 1 richting!

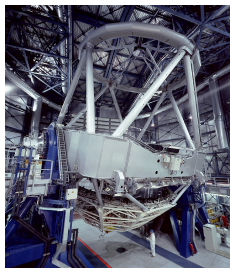
Niet alle richtingen.

Oplossing: telescoop draaien!



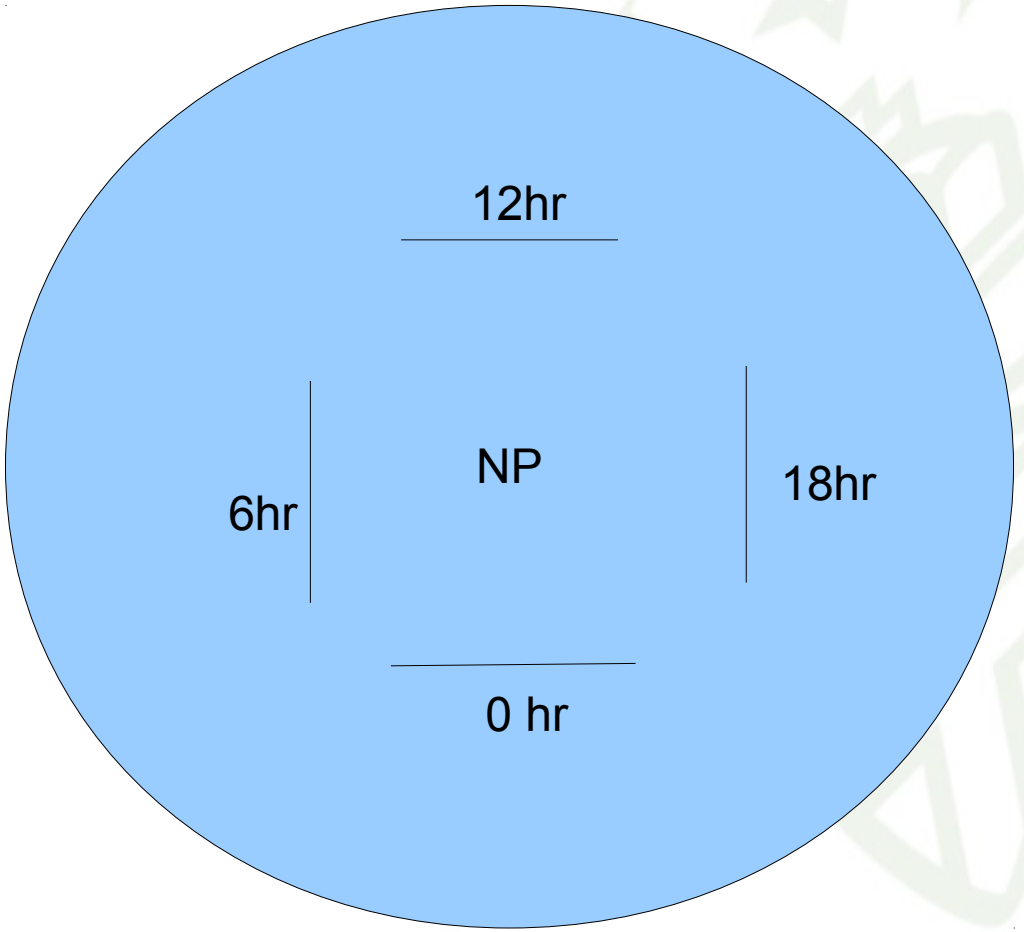
Interferometrie

Uuuuhhhhhh: draaien?

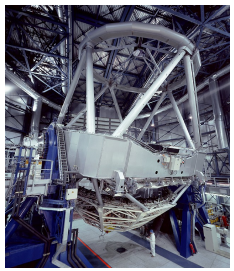


Interferometrie

De Aarde helpt!

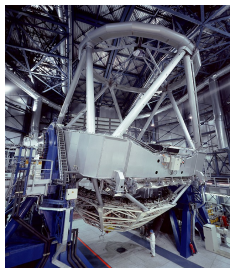


Na 12 hr meten hebben we alle hoeken gehad!

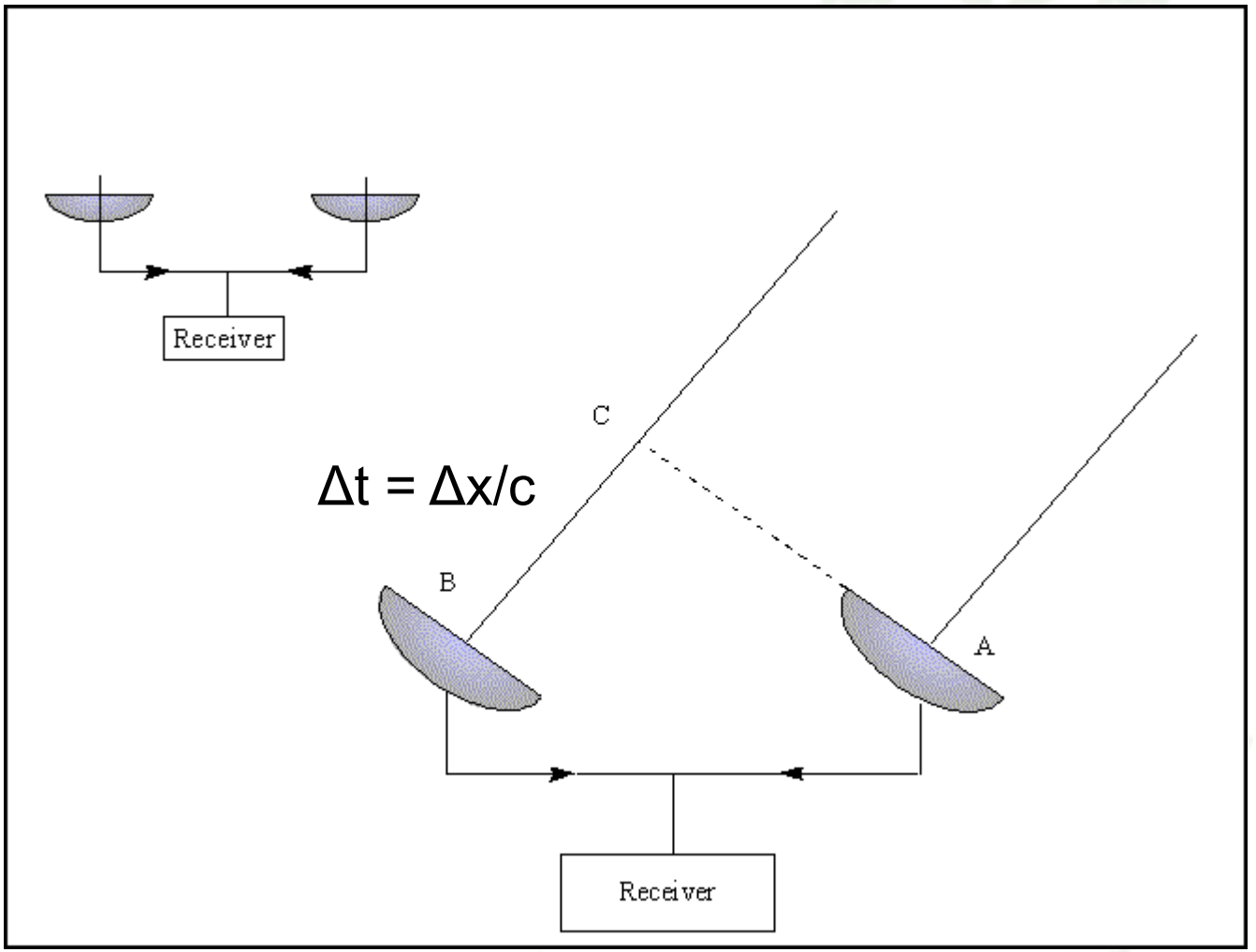


Interferometrie

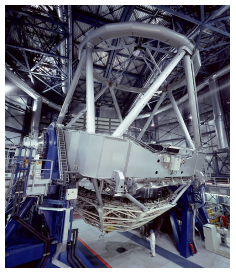
En voor de VLA (New Mexico)?



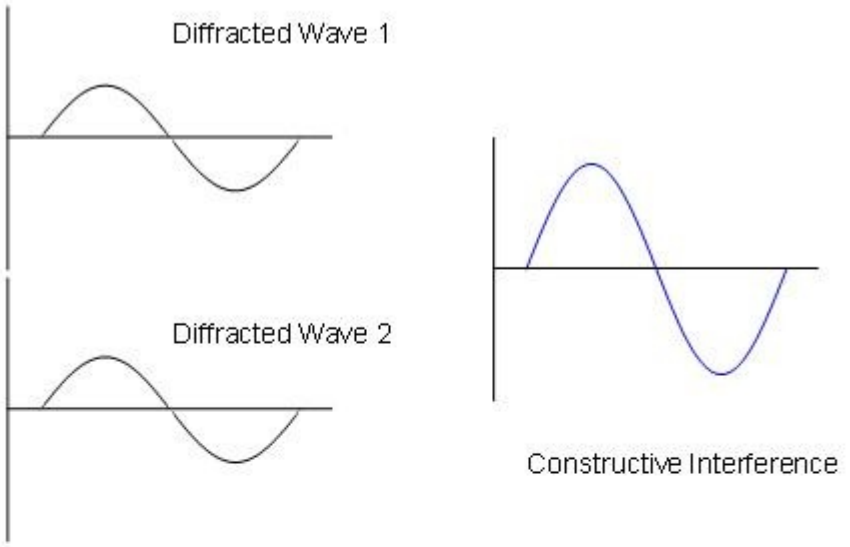
Tijdsvertraging

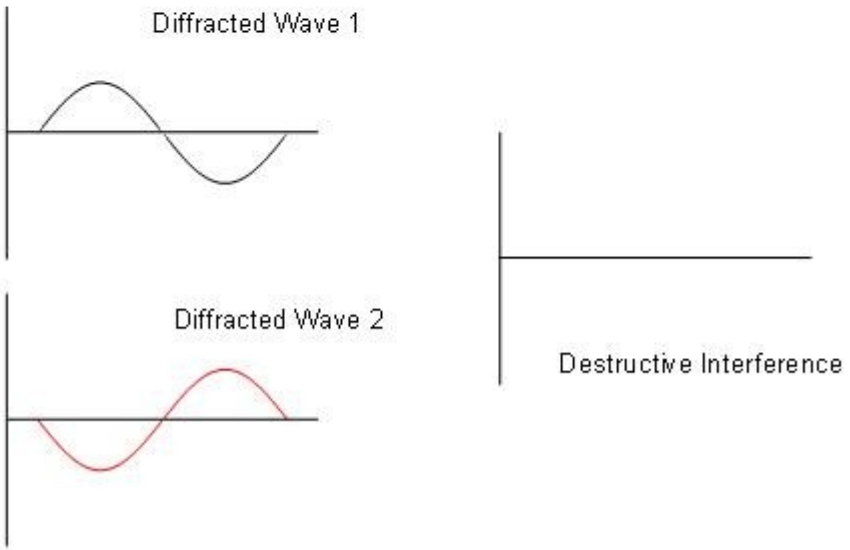


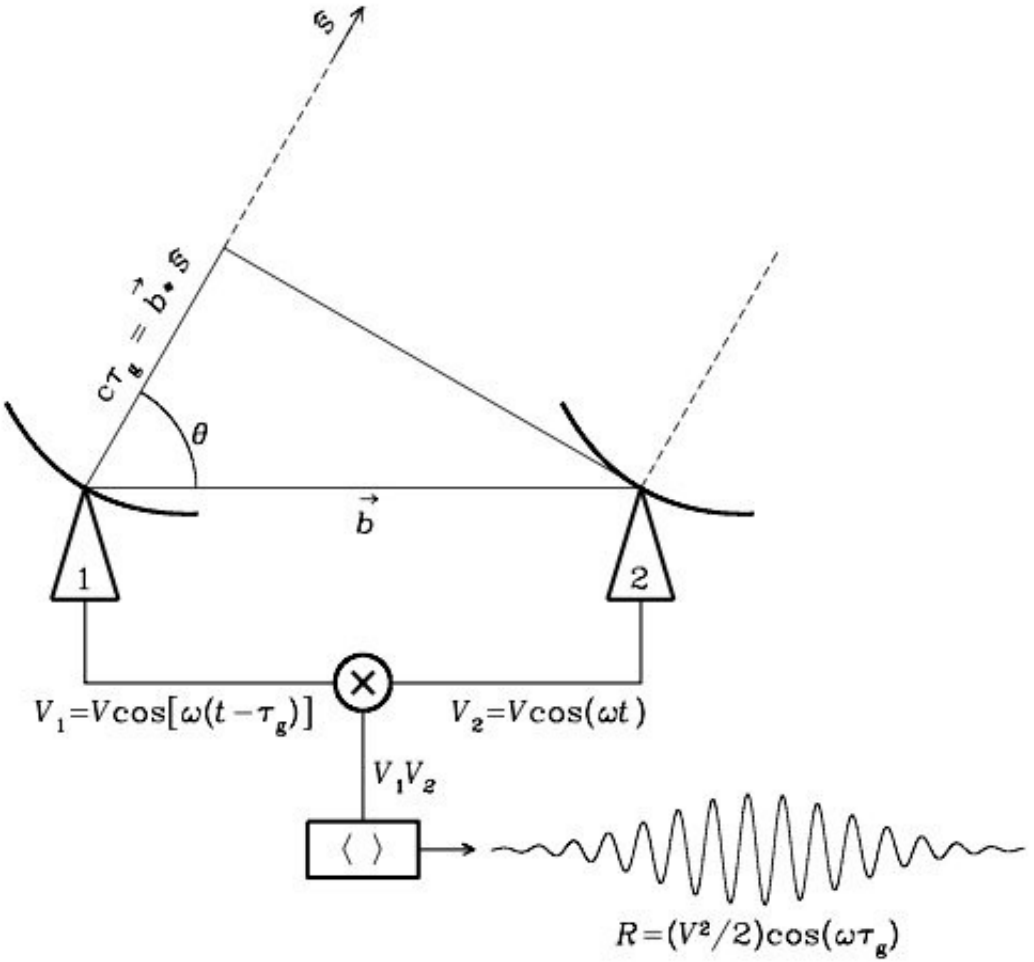
Dit is nodig om golven 'in fase' te detecteren

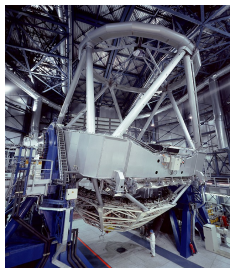


Interferentie



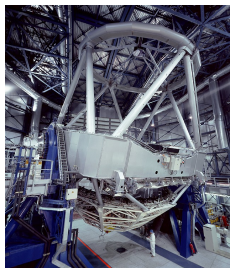




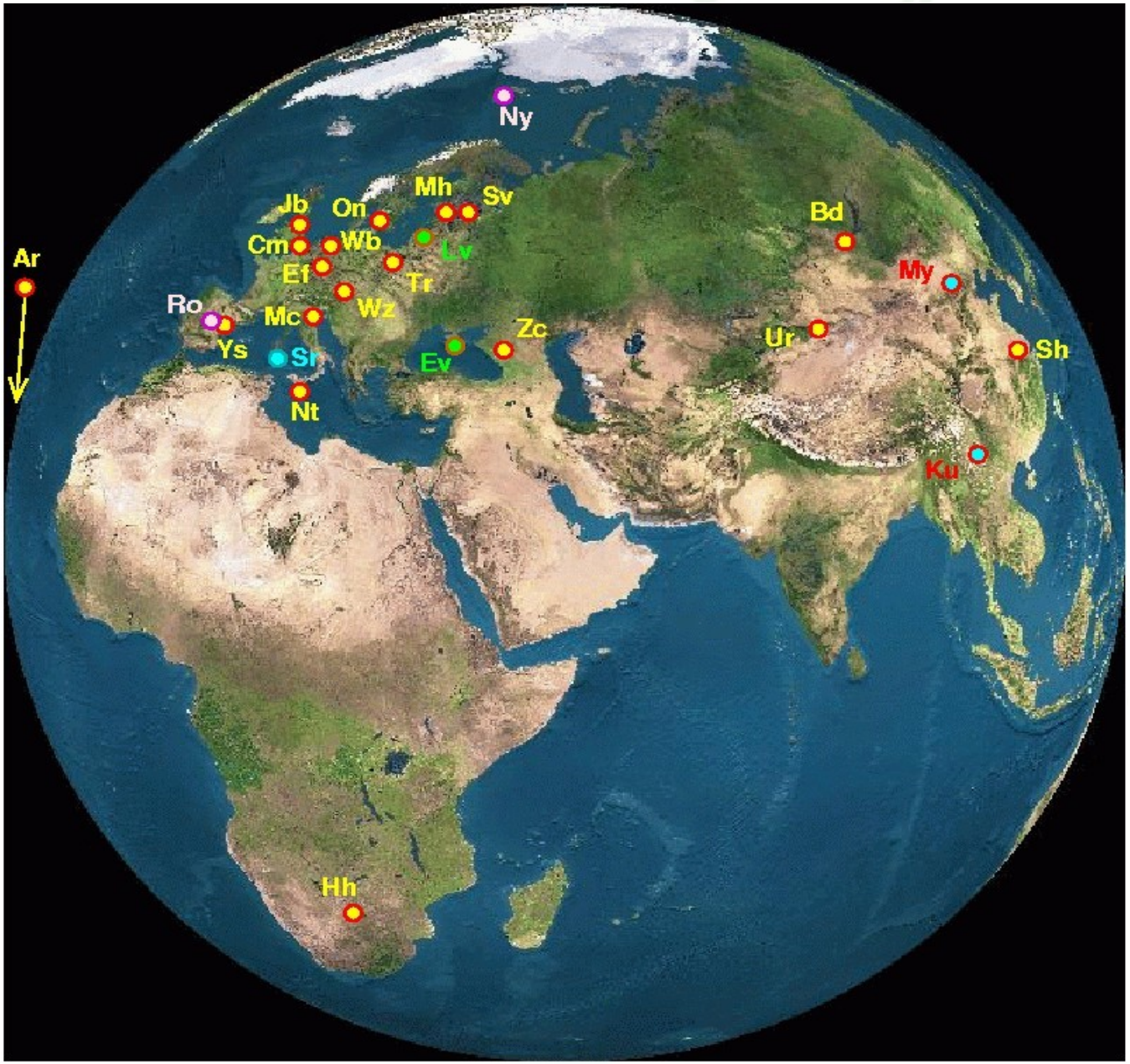


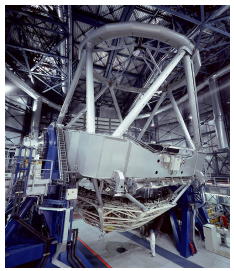
Radio interferometers

Veel hogere resolutie dan 'single-dish' telescopen

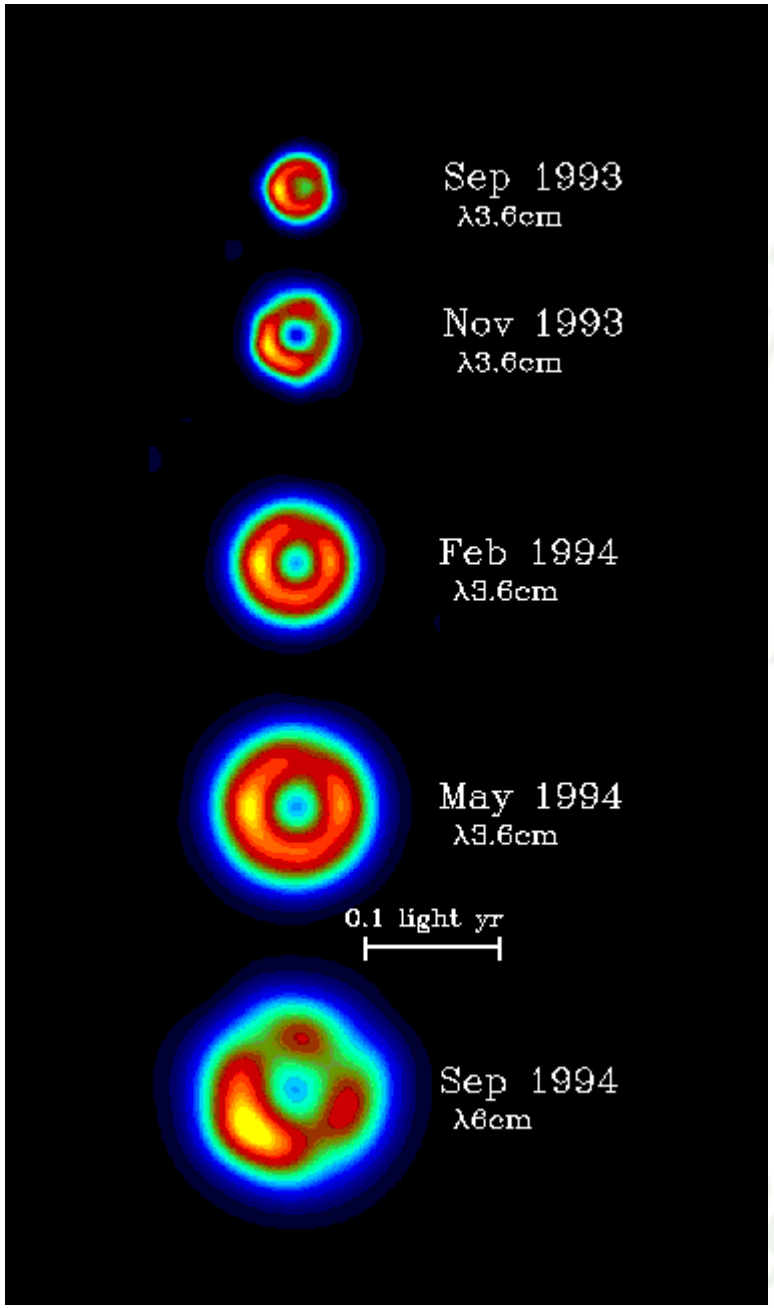


Very Long Base Line Interferometry



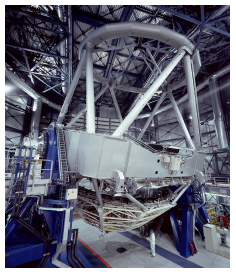


VLBI: SN93J in M81

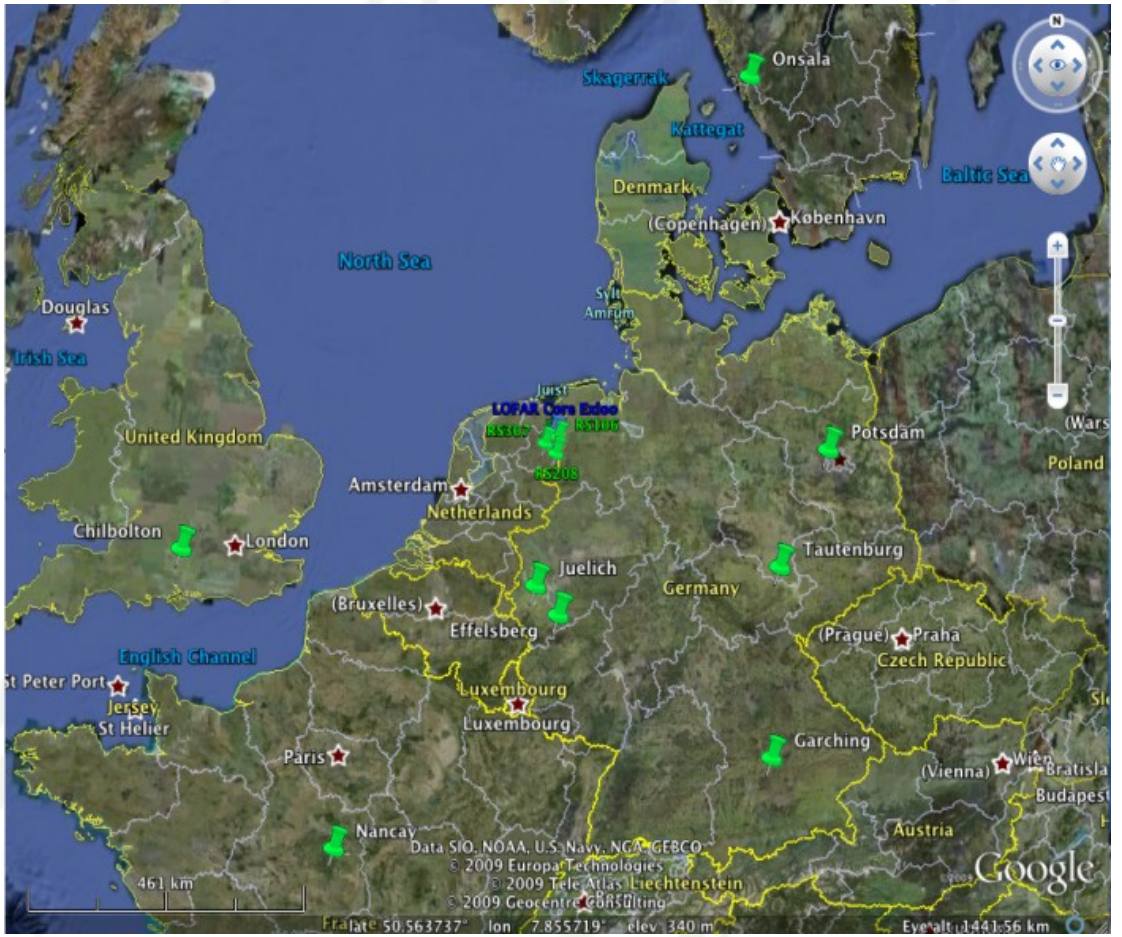


Extreem hoge resolutie behaald
Met VLBI technieken.

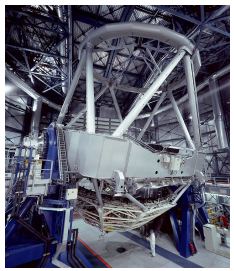
Expansie van de supernova schil
Op afstand van 11 miljoen lichtjaar



Interferometrie zonder schotels: LOFAR

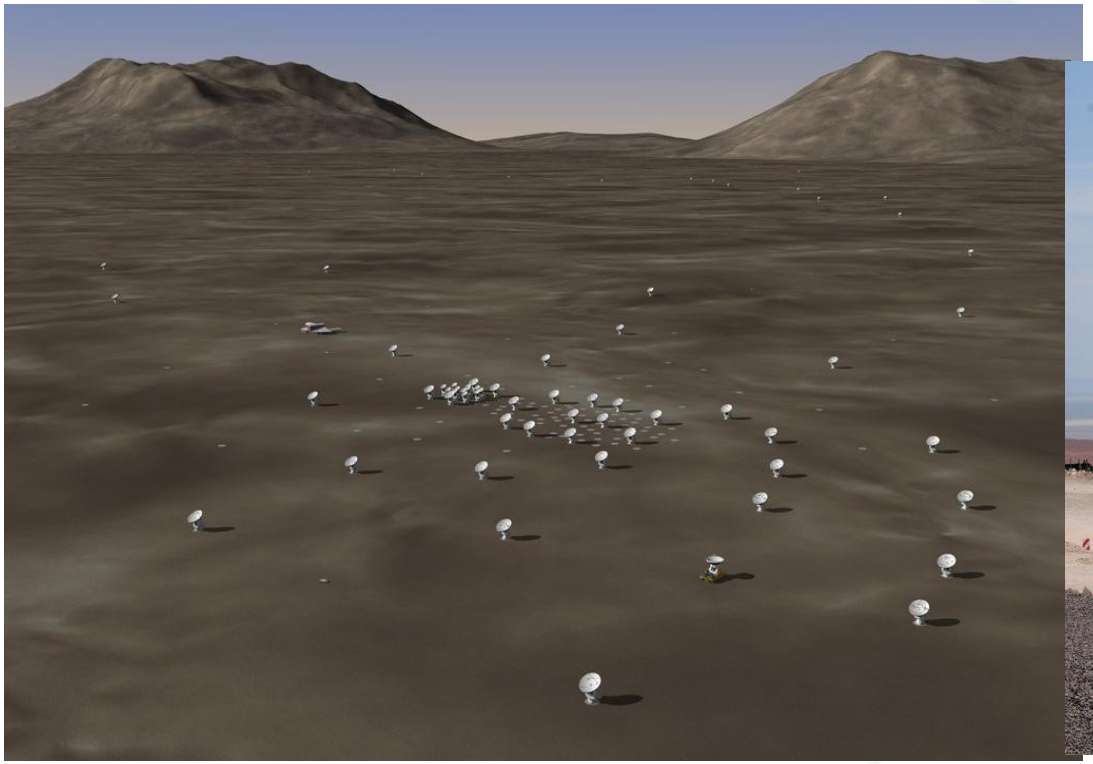


Website: www.lofar.org

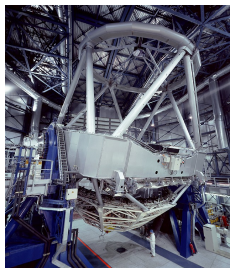


Interferometrie op kortere golven

Atacama Large Millimeter Array (ALMA): EU, US, Japan project in Chili



www.almaobservatory.org



Interferometrie op kortere golven

Very Large Telescope Interferometer op Paranal, ESO, Chili