Koeling voor SKA (ASTRON)

Johan Pragt (ASTRON)

Competence Group Manager Mechanical R&D

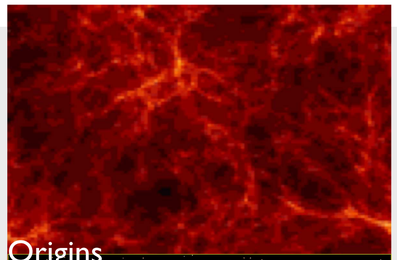
Iov Michiel van Haarlem (ASTRON)

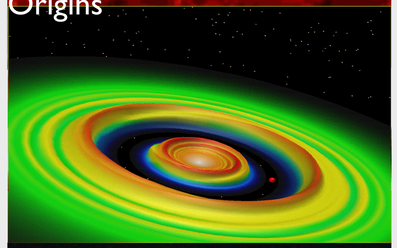
ILO

15 mei 2019 Mikrocentrum

We study the ‘big’ science questions of astronomy and physics…

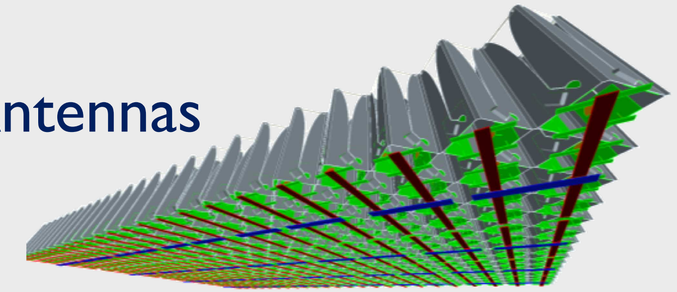
ASTRON



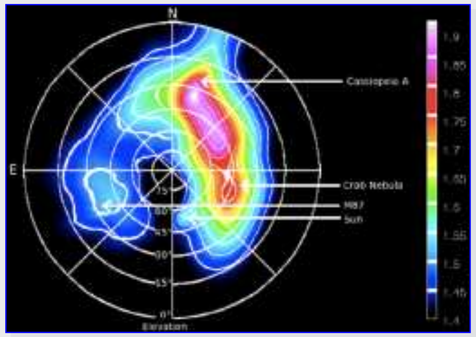


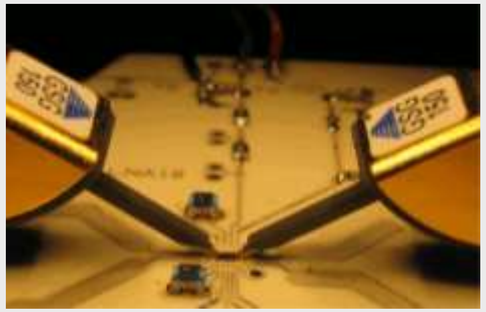
…and work on the large challenges in technology

Antennas

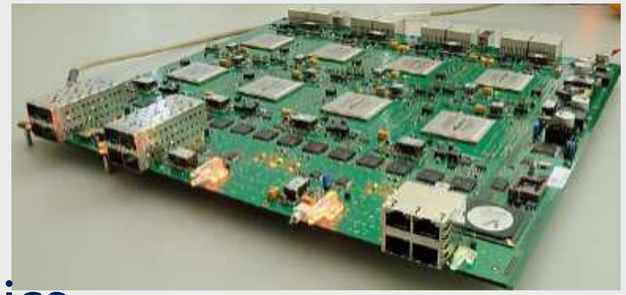


ICT, AO





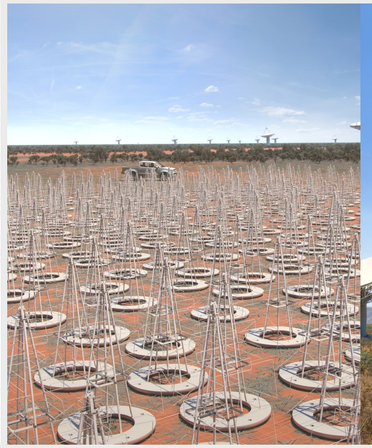
HPC, Edge Comp.
Chips

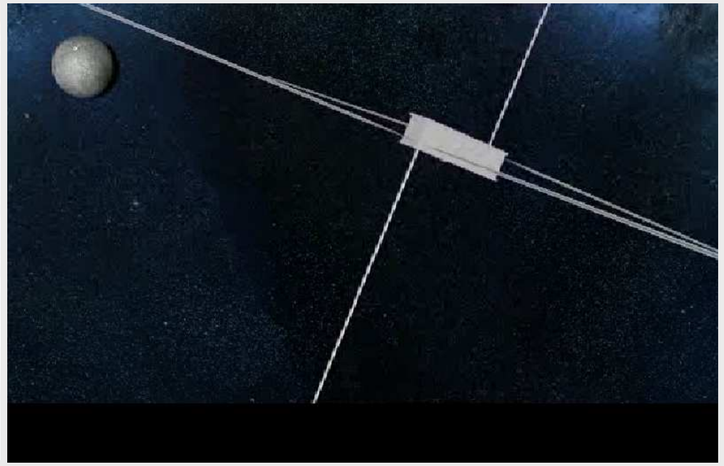


Electronics

Mission: to make discoveries in radio astronomy happen

ASTRON

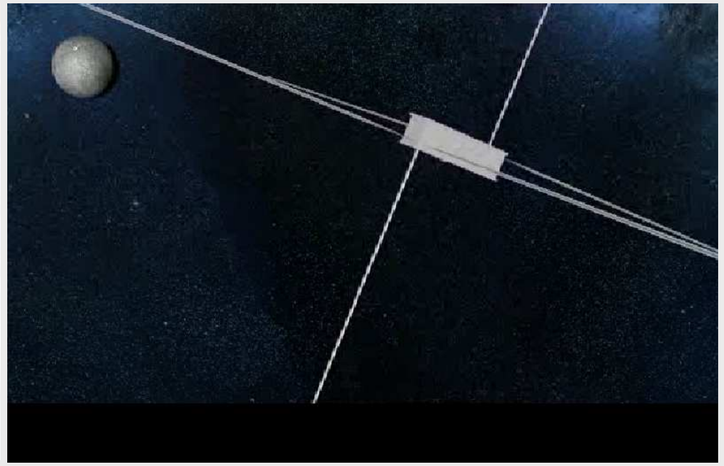




Present

Future

Mission: to make discoveries in radio astronomy happen



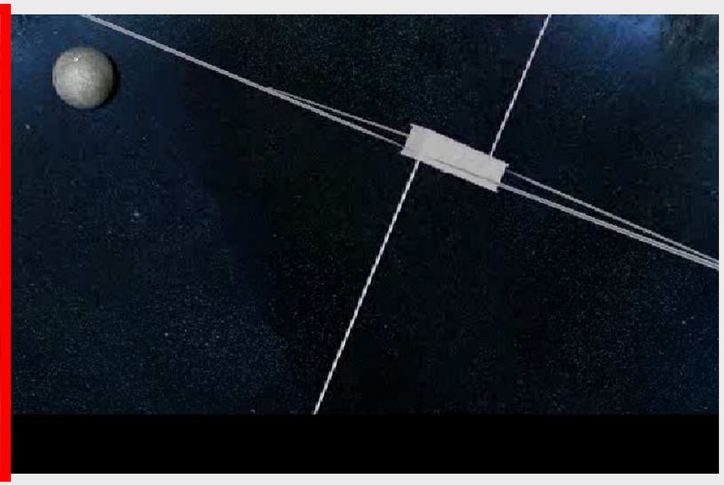
Present

Future

Westerbork

Since 1969
14 Dishes
Typical wavelength 1.4 GHz
Dish diameter 25 meter
Baseline 3.4 km
Classical Telescoop, receiver in focus

Mission: to make discoveries in radio astronomy happen



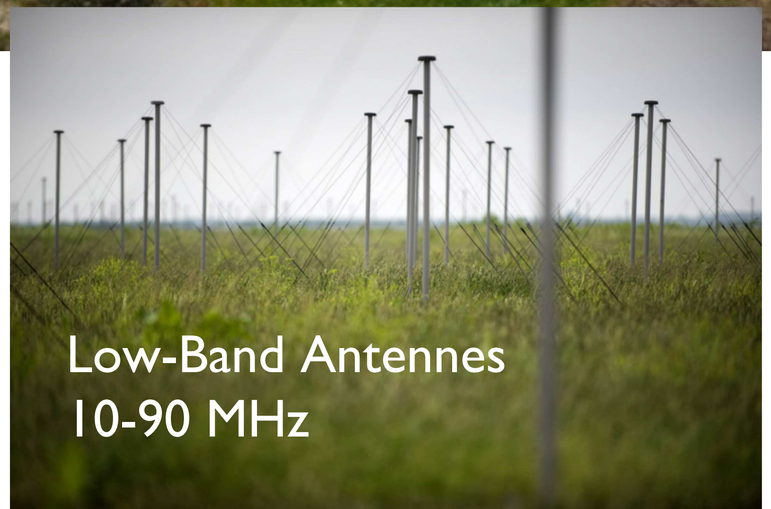
Present

Future

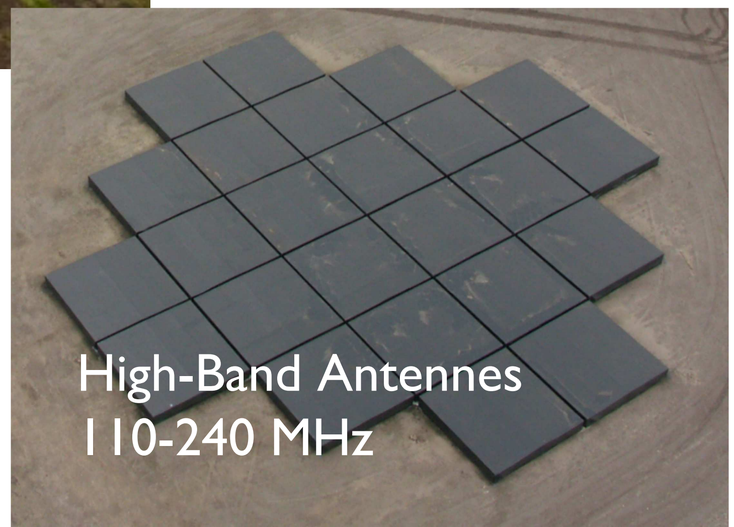
LOFAR

ASTRON

Since 2010
50 LOFAR fields in Europe and growing
Total 5000 Low Band antennas
Total 40.000 High Band antennas
Since 2010
Phased Array type of telescope



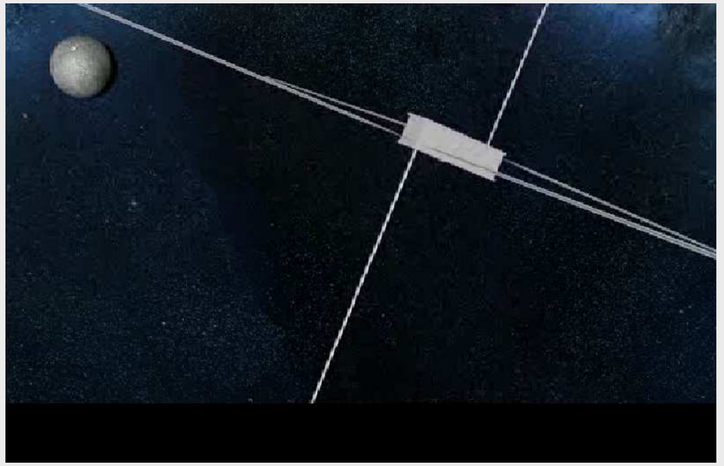
Low-Band Antennes
10-90 MHz



High-Band Antennes
110-240 MHz


Onsala
Irbene
Birr
Dutch stations
Chilbolton
Norderstedt
Bałdy
Potsdam
Borówiec
Jülich
Effelsberg
Tautenburg
Łazy
Nançay
Unterweilenbach
Medicina

Mission: to make discoveries in radio astronomy happen



Present

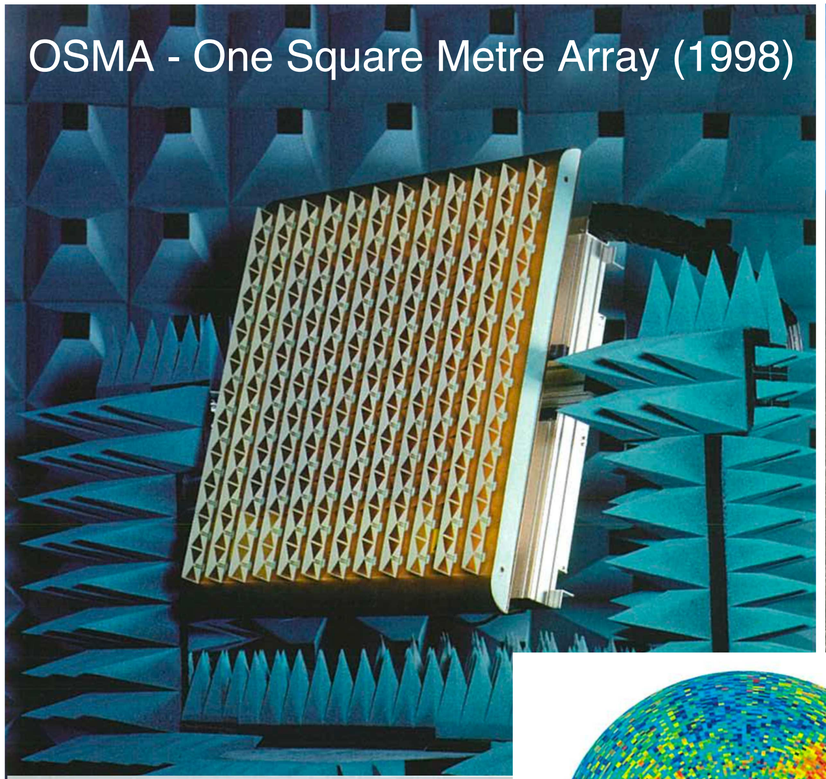
Future

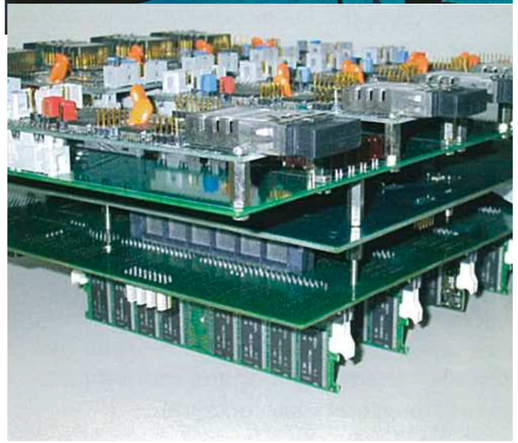

SKA– Key Science Drivers:
The history of the Universe
Cosmic Dawn
(First Stars and Galaxies)
Testing General Relativity
(Strong Regime, Gravitational Waves)
Galaxy Evolution
(Normal Galaxies z~2-3)
Cradle of Life
(Planets, Molecules, SETI)
Cosmology
(Dark Matter, Large Scale Structure)
Cosmic Magnetism
(Origin, Evolution)
Exploration of the Unknown

SKA design sinds jaren 90

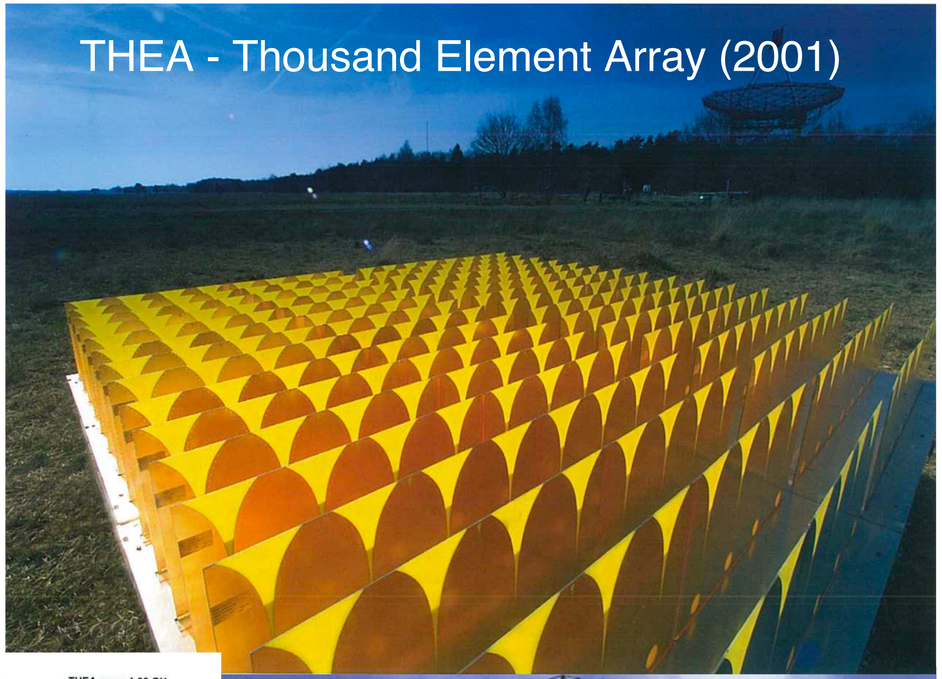
ASTRON

OSMA - One Square Metre Array (1998)





THEA - Thousand Element Array (2001)



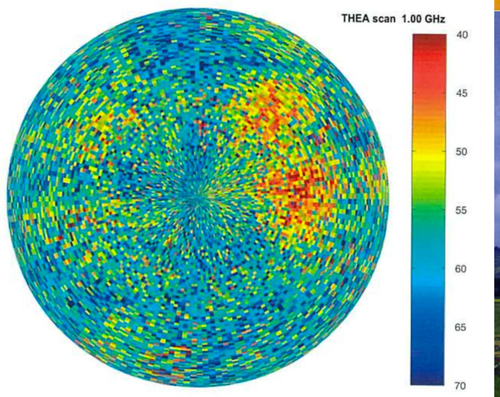
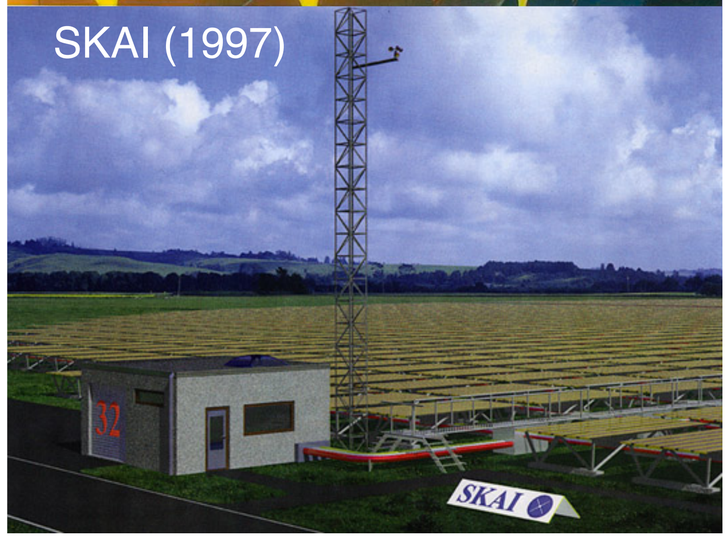


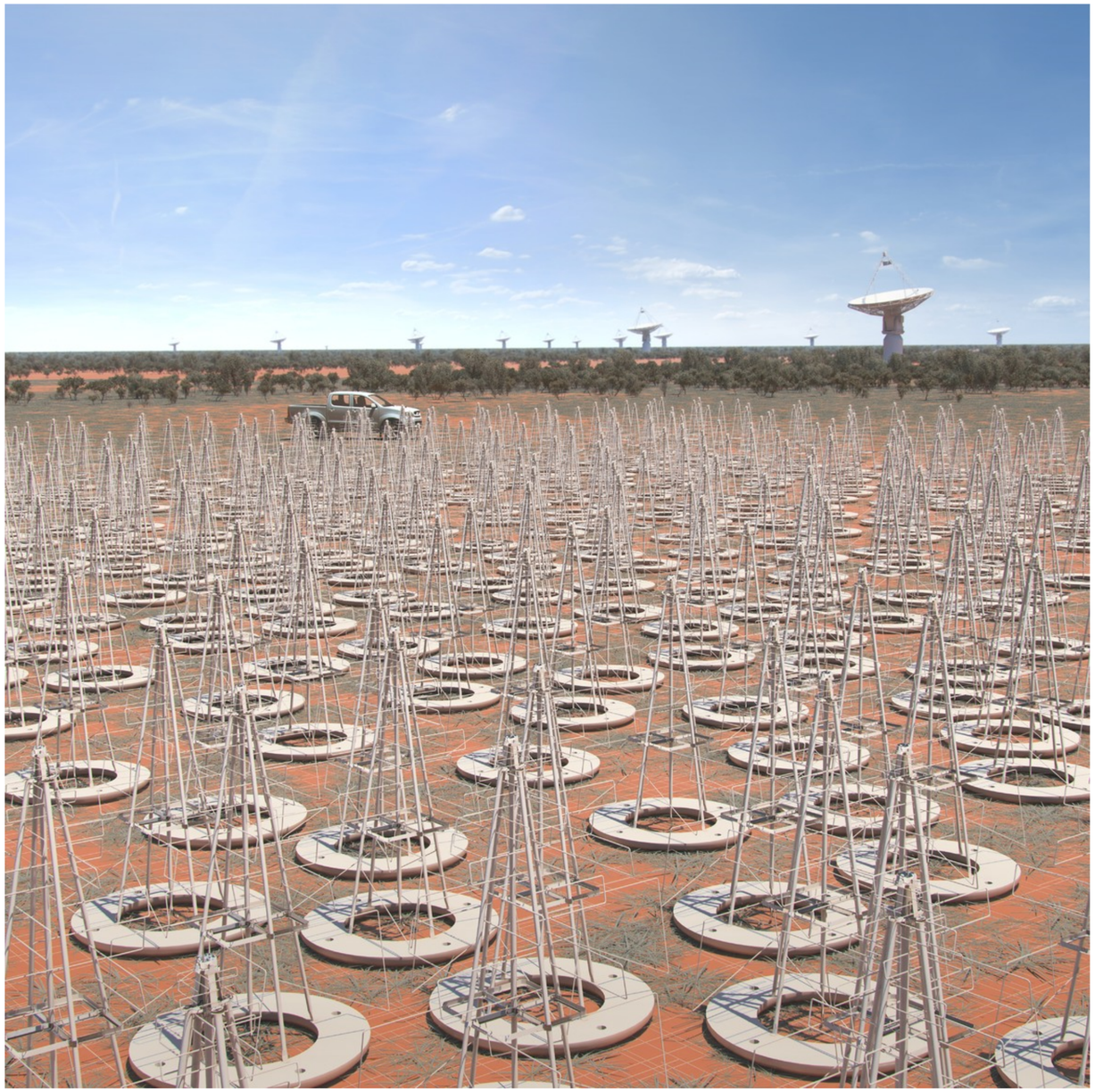
Figure 2.6 A plot of an all night full sky survey. The integrated signal power at 1GHz has been measured in all directions and is plotted in projection, with North at the top. The two areas of higher intensities are in the direction of the Dwingeloo telescope, east of THEA, and in the direction of the main building, north-east of THEA.

SKAI (1997)



LOFAR (2010)

SKA1 in Australië en Zuid Afrika



SKA1-Low in Australië

SKA1 LOW - the SKA's low-frequency instrument

The Square Kilometre Array (SKA) will be the world's largest radio telescope, revolutionising our understanding of the Universe. The SKA will be built in two phases - SKA1 and SKA2 - starting in 2018, with SKA1 representing a fraction of the full SKA. SKA1 will include two instruments - SKA1 MID and SKA1 LOW - observing the Universe at different frequencies.

Location: Australia

Frequency range:
50 MHz to **350 MHz**

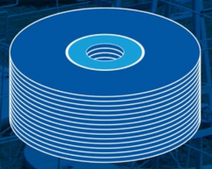
~130,000 antennas spread between **500 stations**

Total collecting area:
0.4km²

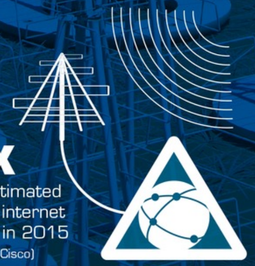
Maximum distance between stations:
65km

SKA1 LOW

Total raw data output:
157 terabytes per second
4.9 zettabytes per year



Enough to fill up
35,000 DVDs
every second



5x the estimated global internet traffic in 2015
(source: Cisco)

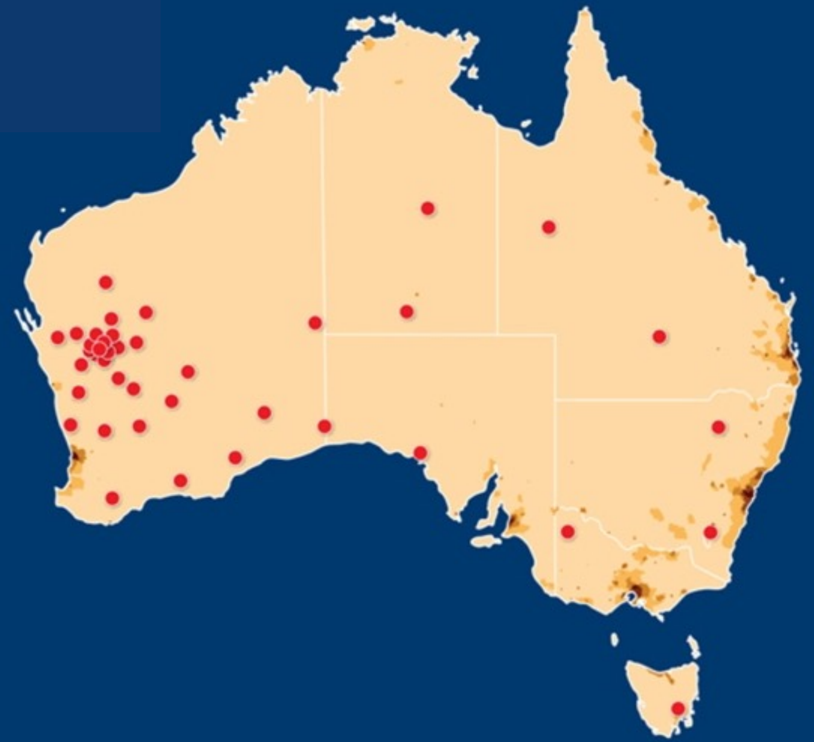
Compared to LOFAR Netherlands, the current best similar instrument in the world

25% better resolution
8x more sensitive
135x the survey speed

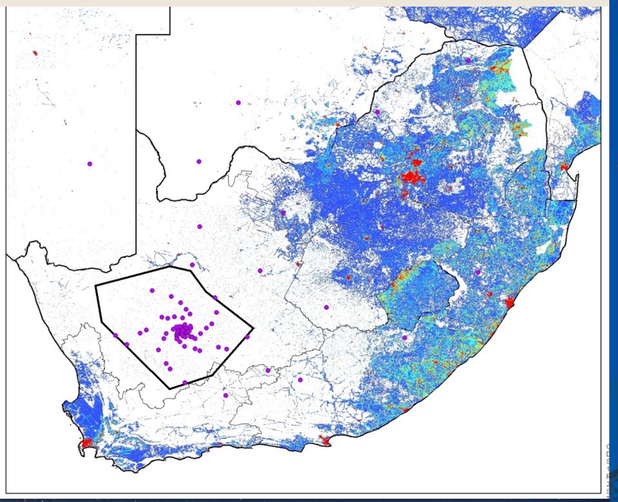
www.skatelescope.org | Square Kilometre Array | @SKA_telescope | YouTube The

Shire of Murchison:

- 50,000 km² Size of the Netherlands
- 0 gazetted towns
- 29 sheep/cattle stations
- 110 population



SKA1-Mid in Zuid Afrika



SKA1 MID - the SKA's mid-frequency instrument

The Square Kilometre Array (SKA) will be the world's largest radio telescope, revolutionising our understanding of the Universe. The SKA will be built in two phases - SKA1 and SKA2 - starting in 2018, with SKA1 representing a fraction of the full SKA. SKA1 will include two instruments - SKA1 MID and SKA1 LOW - observing the Universe at different frequencies.

Location: South Africa

Frequency range: **350 MHz** to **14 GHz**

~200 dishes (including 64 MeerKAT dishes)

Total collecting area: **33,000m²**

or **126 tennis courts**

Maximum distance between dishes: **150km**

SKA1 MID

Total raw data output:

2 terabytes per second

62 exabytes per year

x340,000

Enough to fill **340,000** average laptops with content **every day**

Compared to the JVLA, the current best similar instrument in the world:

4x the resolution

5x more sensitive

60x the survey speed

www.skatelescope.org Square Kilometre Array @SKA_telescope YouTube The

MeerKAT een SKA precursor

N. Maddox (ASTRON)

Image courtesy of SARAO/SKA-SA

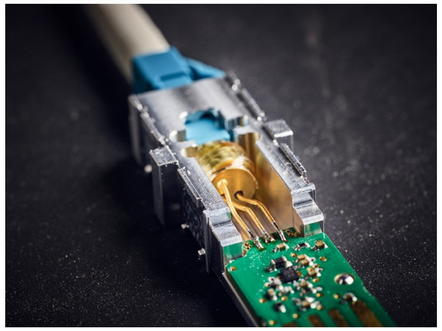
Image courtesy of SARAO/SKA-SA

en… onderdeel van SKA1-Mid in ZA

SKA Consortia

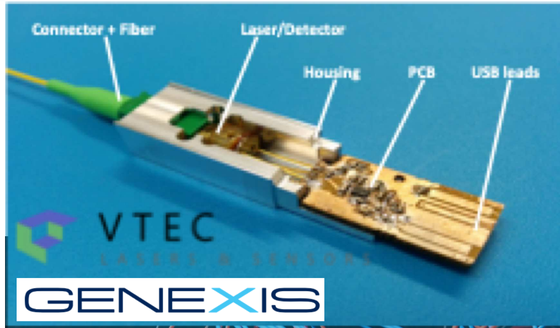
Bijdrage Nederland

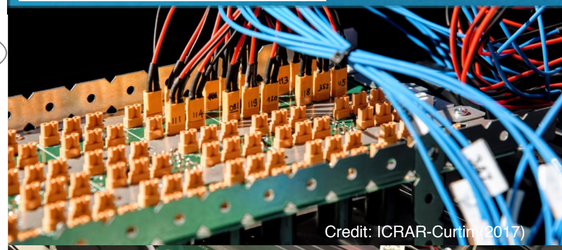
- ASTRON investeert in SKA sinds 1994
- Ontwerp van SKA-Low antennestations
- Correlator + Beamformer
- Signal Data Processing
- Timing & VLBI (JIVE)
- Wide Band Single Pixel Feed support
- Universiteiten Amsterdam, Groningen, Leiden, Nijmegen

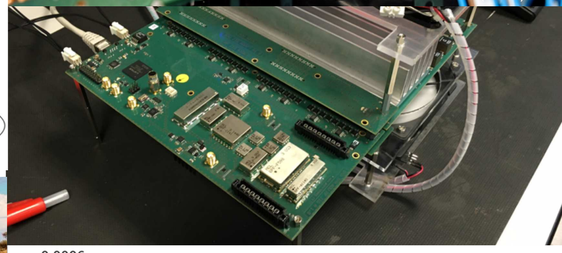


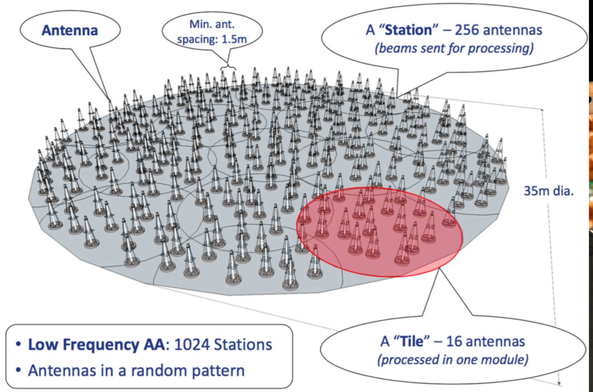
Low Frequency Aperture Arrays

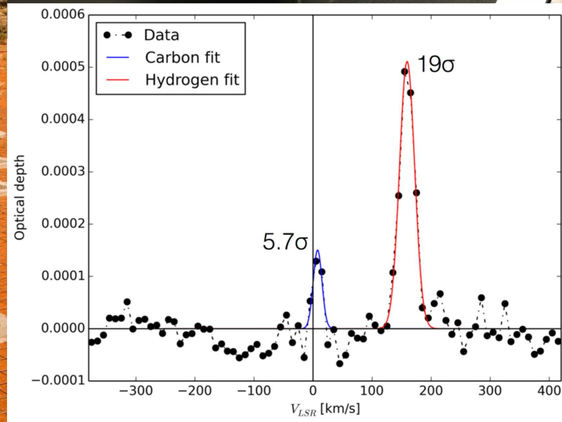
- Consortium Lead: ASTRON (Nederland)
- Partners: Australië, China, Italië, Malta, Verenigd Koninkrijk
- ASTRON: management, system engineering, RFoF, AAVS1
- CDR november 2018
- AAVS1 - eerste teststation
  - data komt direct naar ASTRON





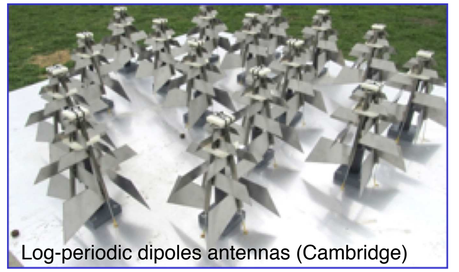


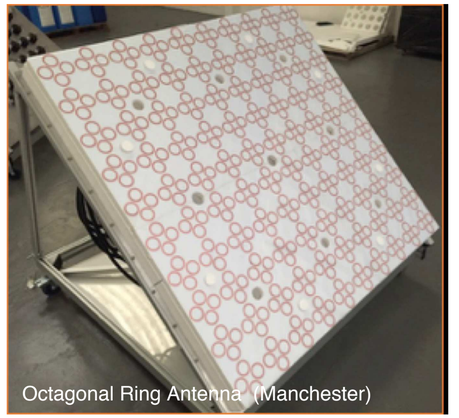




- Mid Frequency Aperture Arrays (AIP)

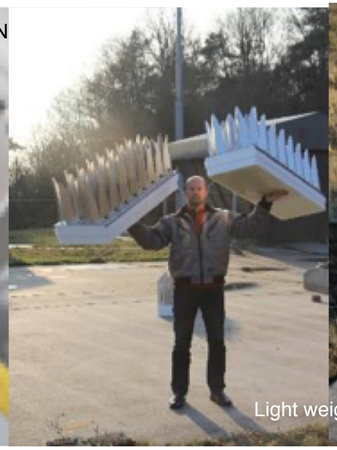
- Consortium Lead: ASTRON (Wim van Cappellen)
- Main Partners: Cambridge, Manchester, Oxford, SKA-SA, KLAASA (CETC-38), Malta, Bordeaux, Paris/Nançay, IT Portugal
- MFAA System Requirements Review (SRR) passed (2016)
- Important Focus: lower power consumption, reduce cost
- Developed plans for MFAA demonstrator
- AIP consortia awaiting SKA Development Programme


Log-periodic dipoles antennas (Cambridge)


Octagonal Ring Antenna (Manchester)


Environmental Prototypes SA (2017)

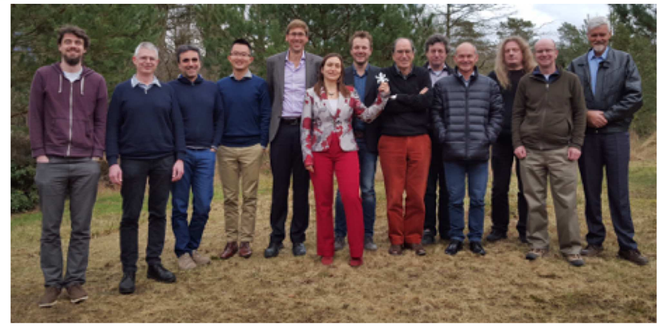

Low Cost Vivaldi antenna with LNA (ASTRON

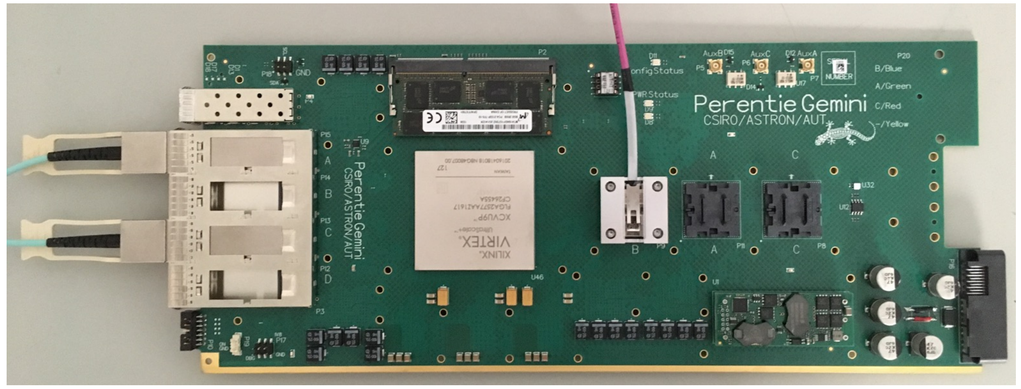


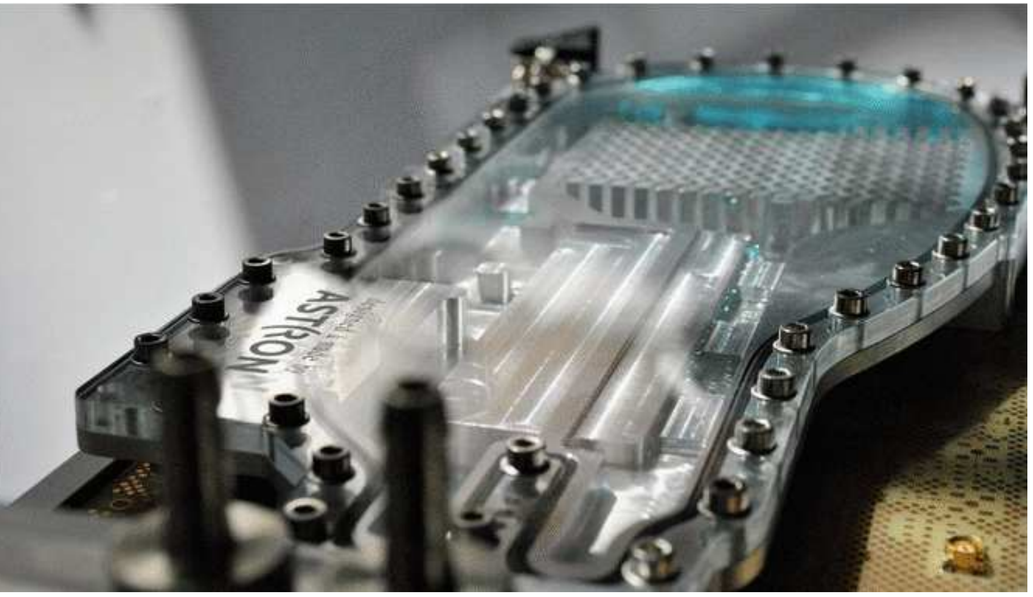

Light weight antenna design (ASTRON)

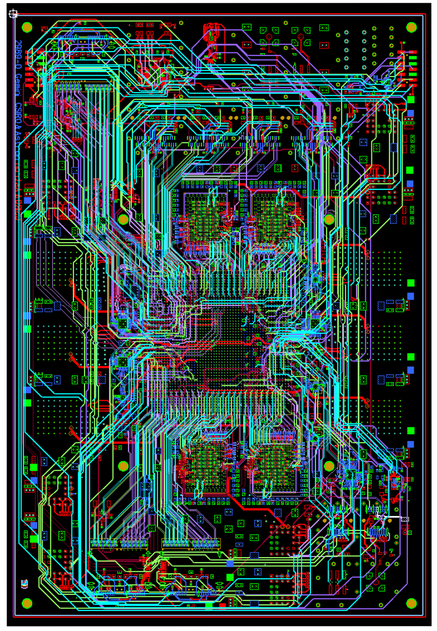
CSP Low - Central Signal Processing

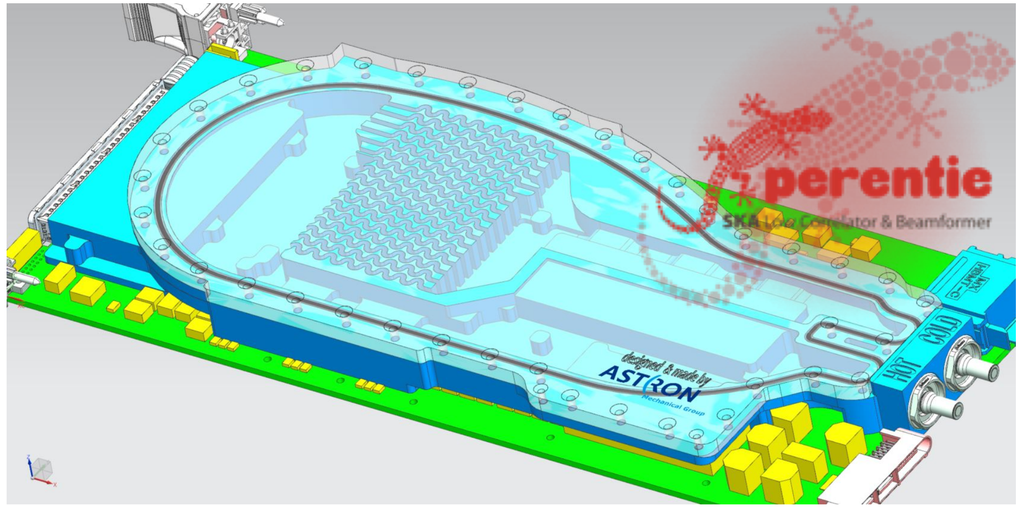
- ASTRON, i.s.m. Australië en Nieuw Zeeland ontwerpen SKA_Low correlator en beam-former
- ASTRON PCB en Firmware ontwerp; System Engineering
- CDR eind 2018 succesvol afgesloten
- Prototyping/voorbereiden op productie











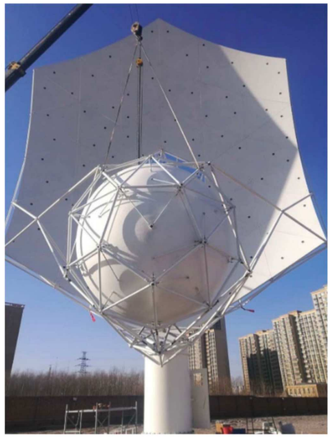
MAJOR Electronics b.v.

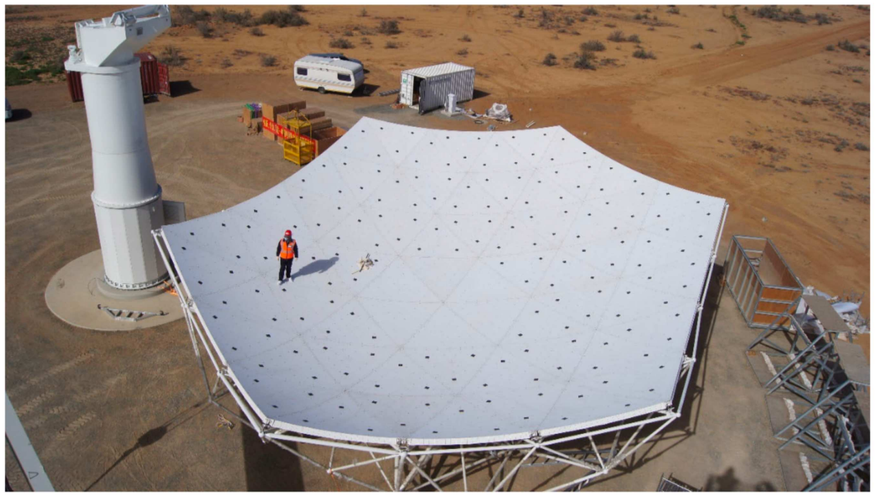
NEWAYS

Dish - telescopes & receivers

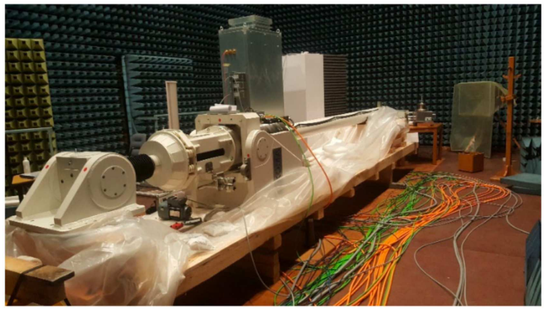
Band 1	0.350 – 1.050 GHz
Band 2	0.95 – 1.76 GHz
Band 3	1.65 – 3.05 GHz
Band 4	2.80 – 5.18 GHz
Band 5	4.6 – 13.8 GHz
Band 5a	4.6 - 6.8 GHz
Band 5b	8.4-13.7 GHz

SKA P China





SKA P – MPI
Karoo SA



Elevation drive RFI verification

Dish Consortia CDR status

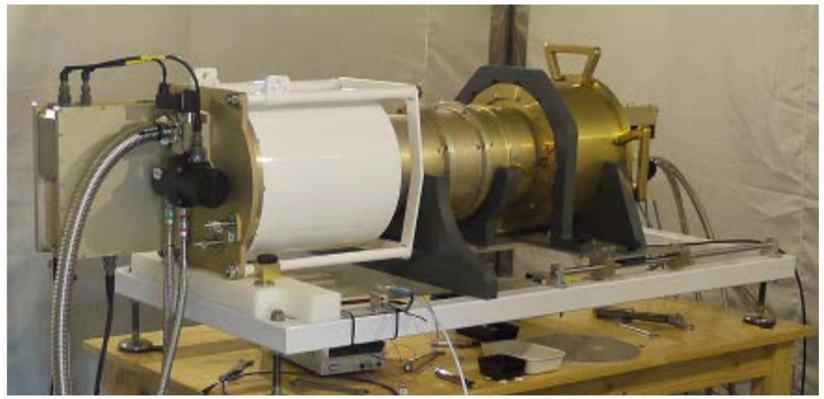
- Band 1 CDR Complete
- Band 2 CDR Complete
- LMC Complete
- Band 5 DDR Scheduled Mar 2019

Dish Consortium status:

Band 1 CDR complete
Band 2 CDR complete
Band 5 DDR complete
Band 3 en 4 working towards CDR

MEERKAT 64 dishes in operation in RSA

SKA1 133 dishes 2021-2026

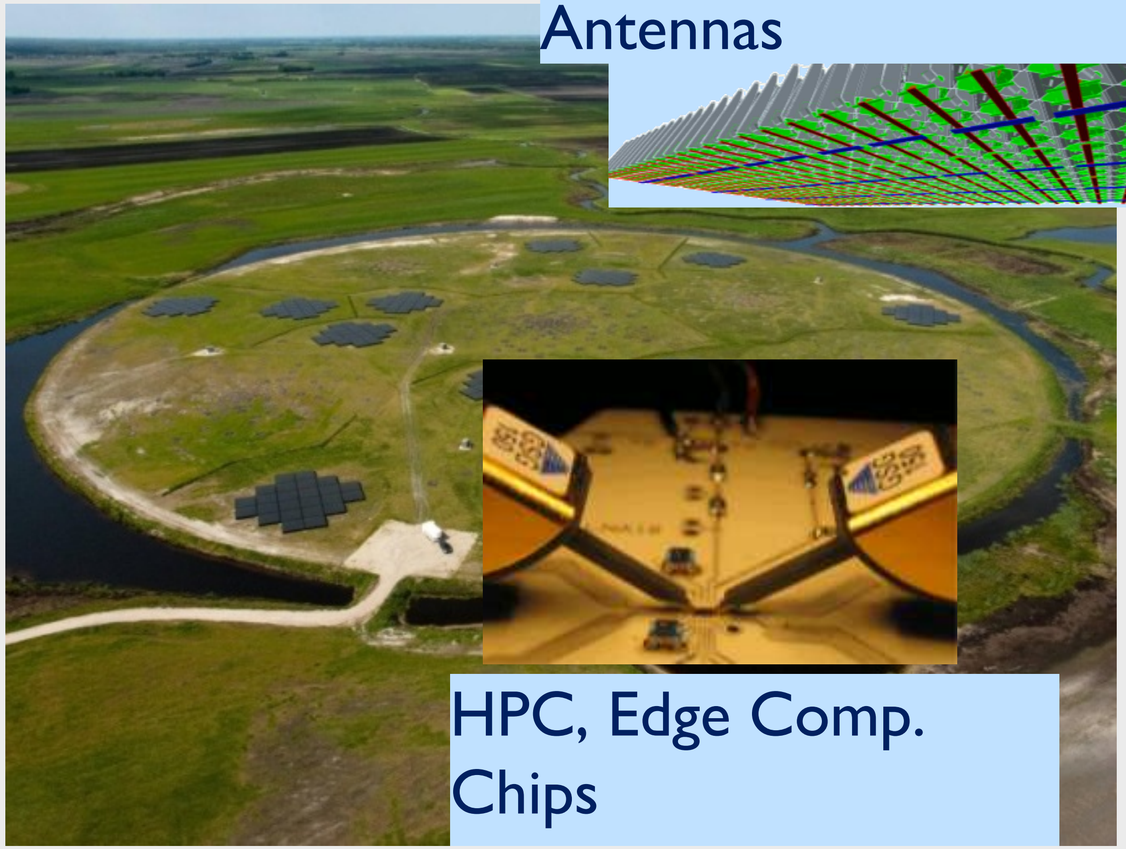


Netwerk van Science Data Centres

- (SKA) Science Data Centre in (Noord) Nederland
- Samenwerken met bedrijven, kennisinstellingen, HBO en Universiteit
- Samenwerken met andere projecten/domeinen op gebied van Big Data, High Performance Computing, Cloud Computing
- ASTRON leidt ontwikkeling van SKA Science Data Centres (o.a. H2020 Aeneas)
- Beginnen nu, met LOFAR, Westerbork en Zuid Afrika
- Vanaf 2021-2022 klaar voor SKA

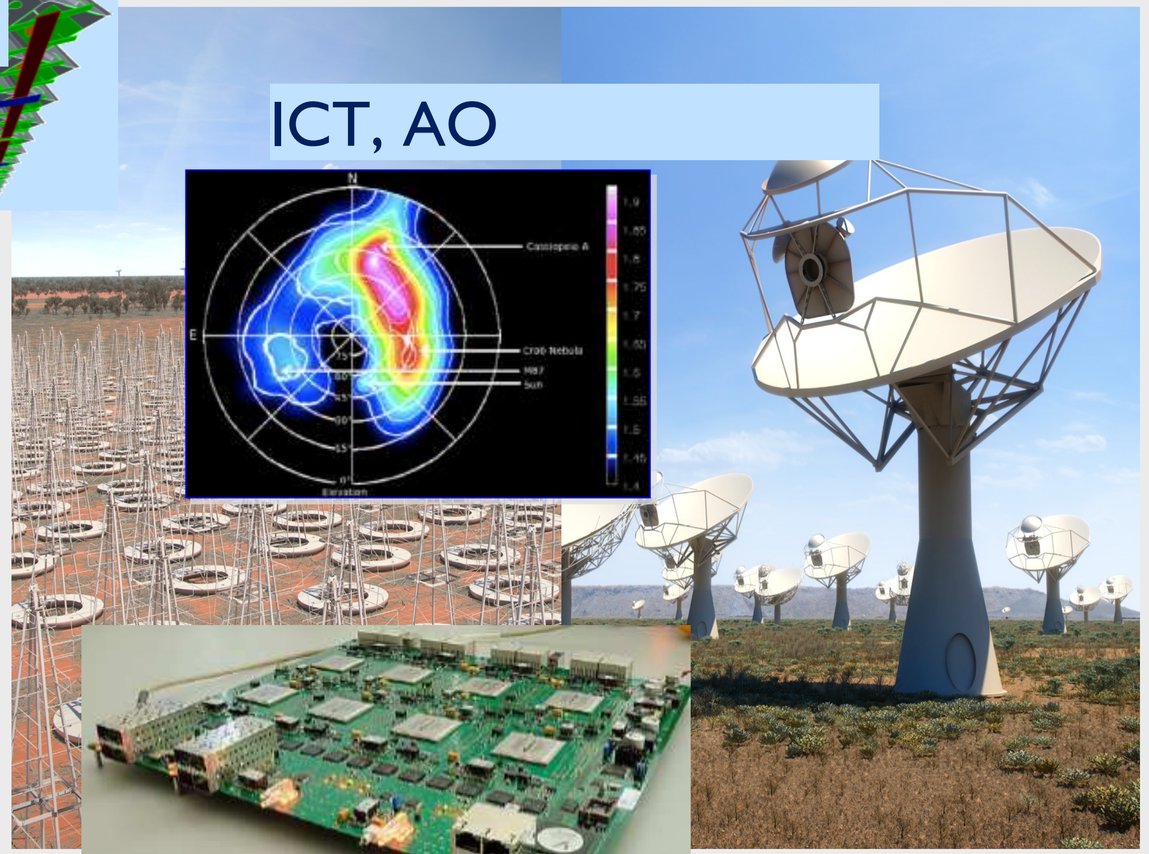
LOFAR is gebouwd door de Industrie
SKA wordt gebouwd door de Industrie

ASTRON



Antennas

HPC, Edge Comp.
Chips



ICT, AO

Electronics

SKA Thermische uitdagingen Industrie en ASTRON

- Uitdagend - Energiezuinig rekenen, Big Data, Complexe software
- Sluit goed aan bij maatschappelijke thema’s (Top Sectoren, Nationale Wetenschapsagenda; stimuleren studie wetenschap & techniek)

- Rol voor NL bedrijfsleven in constructie en operationele fase
- SKA is Game Changer op gebied van Big Data (Science Data Centre)
- Nederlands leiderschap op gebied van radiosterrenkunde

- Johan Pragt, Michiel van Haarlem ASTRON