



# LOFAR and SKA

## ICT developments in Radio Astronomy

Michiel van Haarlem – Head NL-SKA Office

on behalf of Ronald Halfwerk, Walter Jansen (ASTRON)



# International LOFAR Telescope

LV614 (Latvia)  
Commissioned: 16-8-2019

LOw Frequency ARray (LOFAR)



Image © Ventspils University of Applied Sciences, Latvia

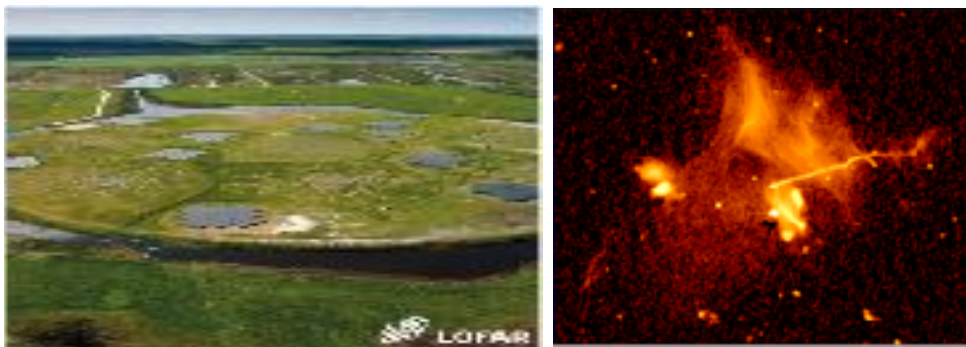
The International LOFAR telescope is the world's most powerful very-low-frequency and long-baseline radio interferometer until at least 2030.



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# LOFAR 2.0: Extra functionaliteit, nieuwe hardware



- Hogere efficiency, betere calibratie, simultaan inzet LBA en HBA antennes
- CDR: Q2 2021
- Roll-out voltooid: 2022 (Nederlandse stations)
- Fase-1:
  - Vervanging van stations electronica
    - Subracks (RCU, RSP, TBB)
    - Clock distributie
  - Monitoring and control software
  - LBA calibration pipeline

- Key:
- ✓ Samenwerking met industriële partners tijdens R&D fase
  - ✓ Sterke(re) positie in roll-out fase (aanbesteding)



39x NL LOFAR Cabinet  
14x International ILT-container



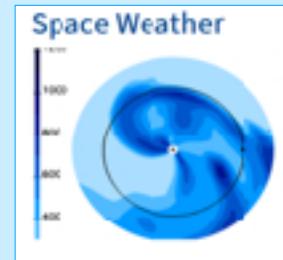
UniBoard2 FPGA Processing Platform

- Data throughput: 3 Tera bit per second (Tbps)
- Processing capability: 5 Tera MAC/s



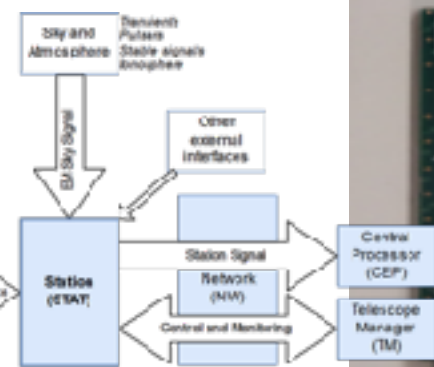
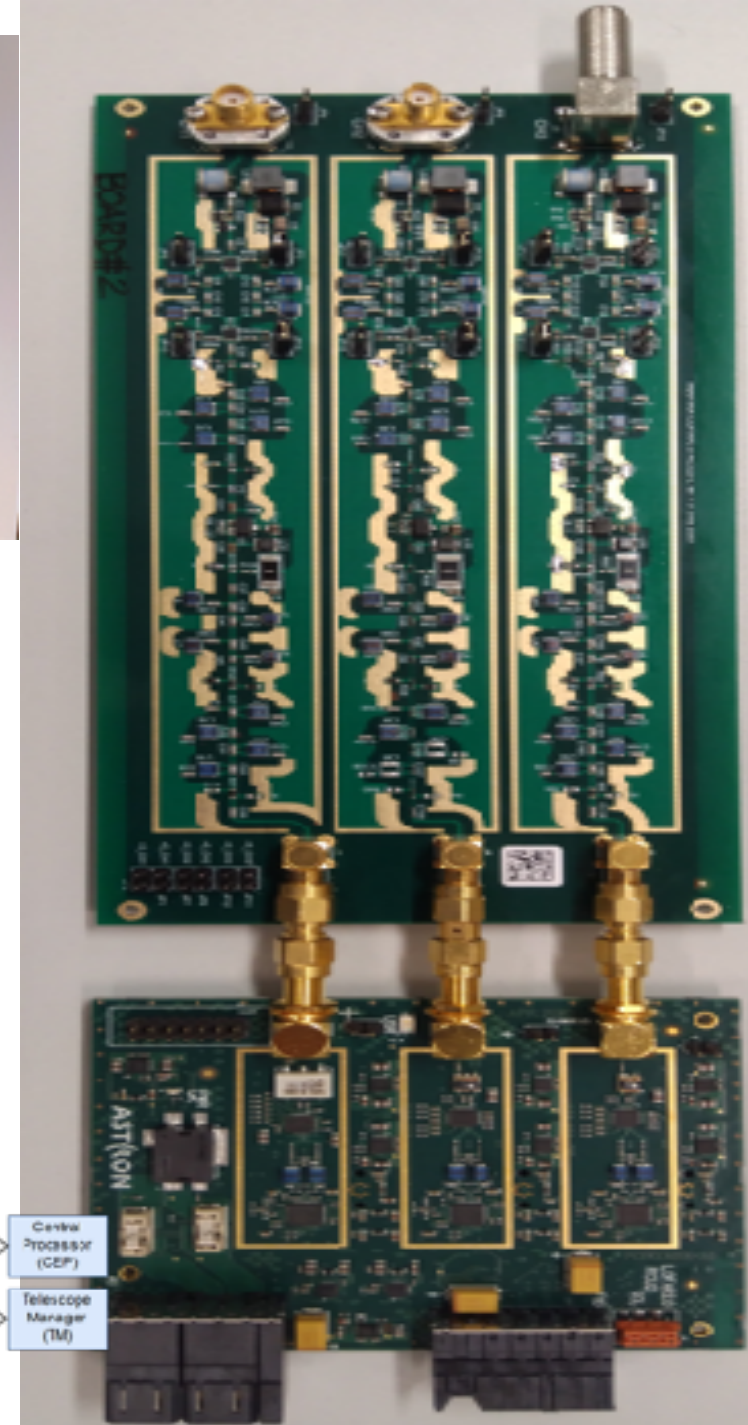
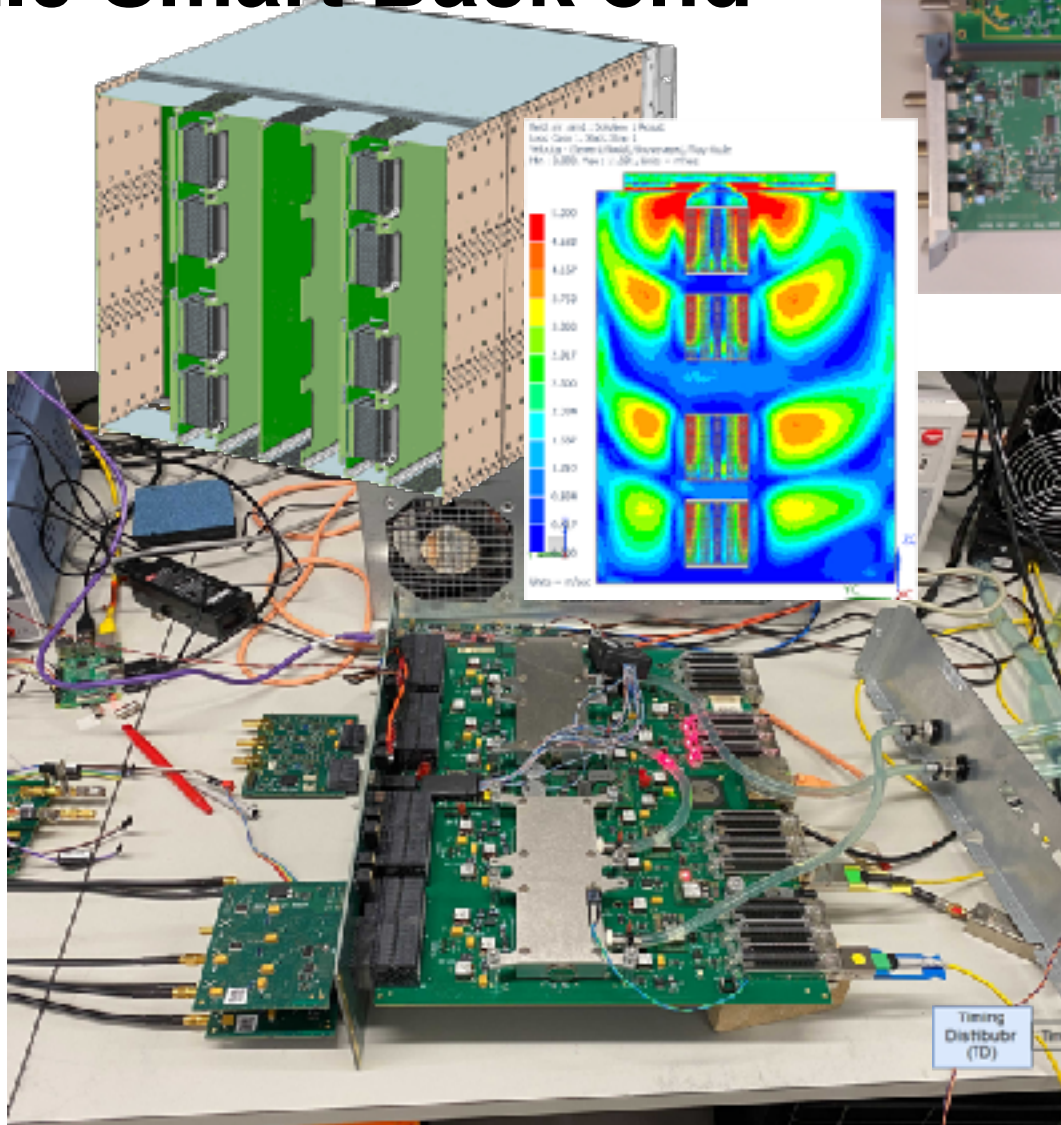
Low-noise amplifier High Band Antenna:  
LOFAR nu: 50.688 stuks

Applicatie:  
Space weather = 24/7



Vraagt **2x zoveel** electronica !  
(en bekabeling)

# Station 2.0 Smart Back end



# SKA Phase 1

3 sites (Australia, South Africa, UK)

2 telescopes (Low & Mid)

1 Observatory

Construction 2021-2027/2028

Science commissioning from 2024

## SKA1-Low

512 x 256 low frequency dipoles

50-350 MHz

65 km baselines

(11" at 110 MHz)

Murchison, Western Australia



## SKA1-Mid

133 x 15m + 64 x 13.5m MeerKAT

0.35 - 15 GHz

150 km baselines

(0.22" at 1.7 GHz; 34 mas at 15 GHz)

Karoo, South Africa



# SKA1 construction participation



## 1. Central Signal Processor, CSP-LOW

- Correlator / beamformer
- Firmware (FPGA), Testing, Integration, SE & PM
- NL Tier 1 Lead

## 2. Science Data Handling & Processing, SDH&P

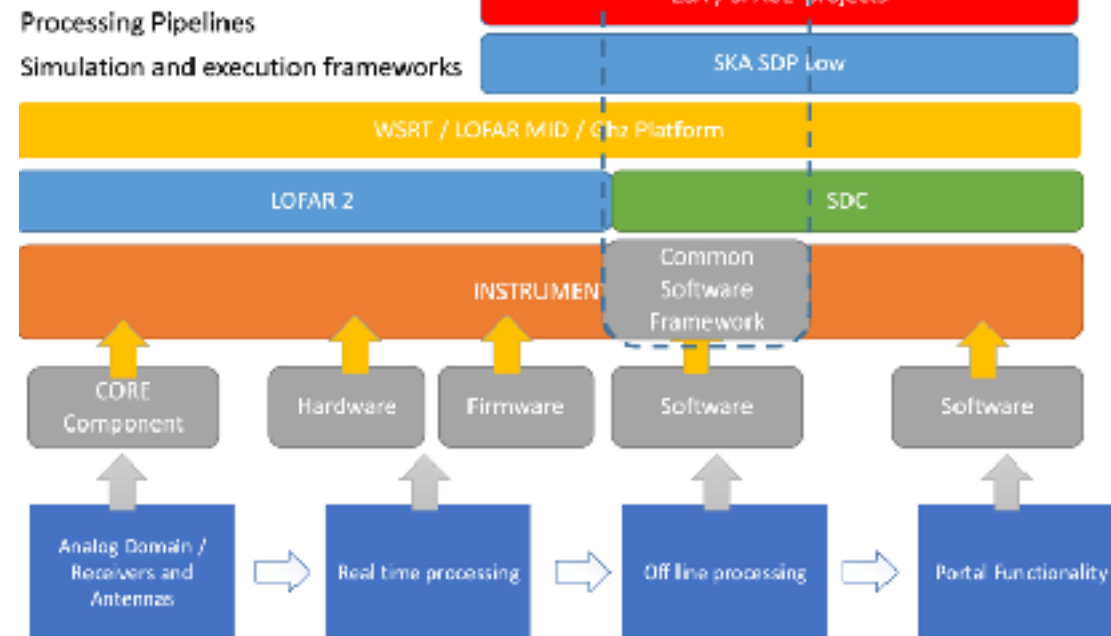
- Maximise synergy with LOFAR & Science Data Centre
- SAFe (Scaled Agile Framework) approach
- Team active during bridging already
- ASTRON + 3 NL Companies

## 3. SKA Low Field Node, PaSD

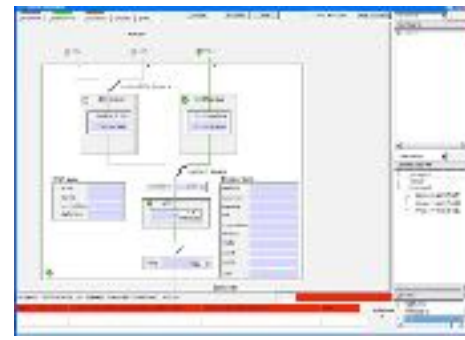
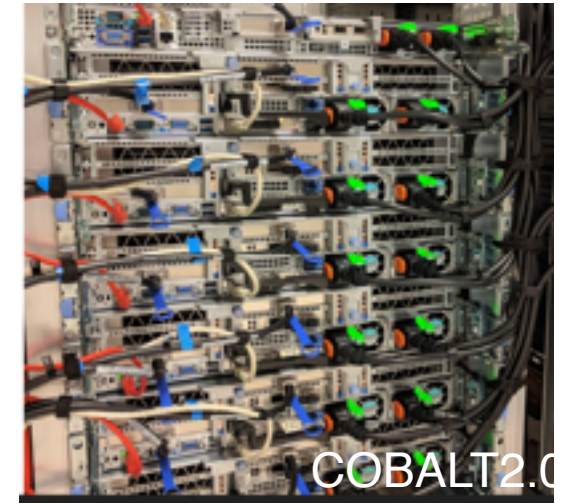
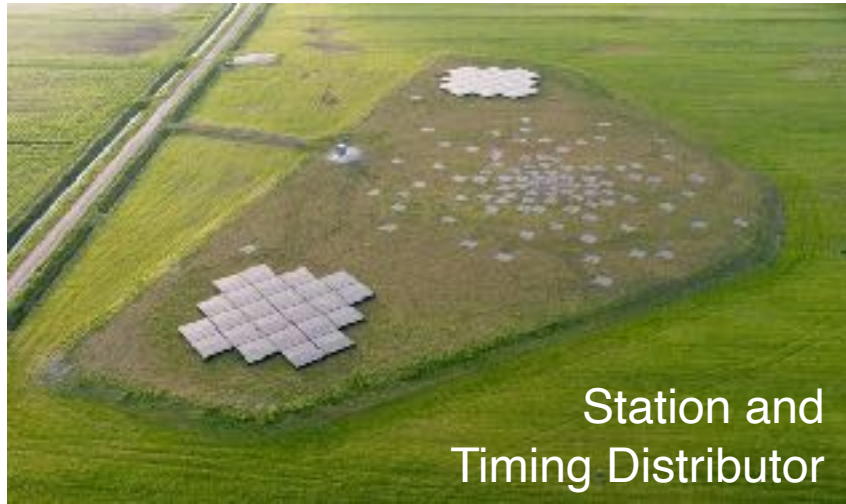
- RFoF transporting data from 130k antennas
- Design not yet complete
- Likely to lead to tender for laser+electronics in 2022

## 4. Assembly Integration & Verification for SKA-LOW (t.b.d.)

## Common Software Framework



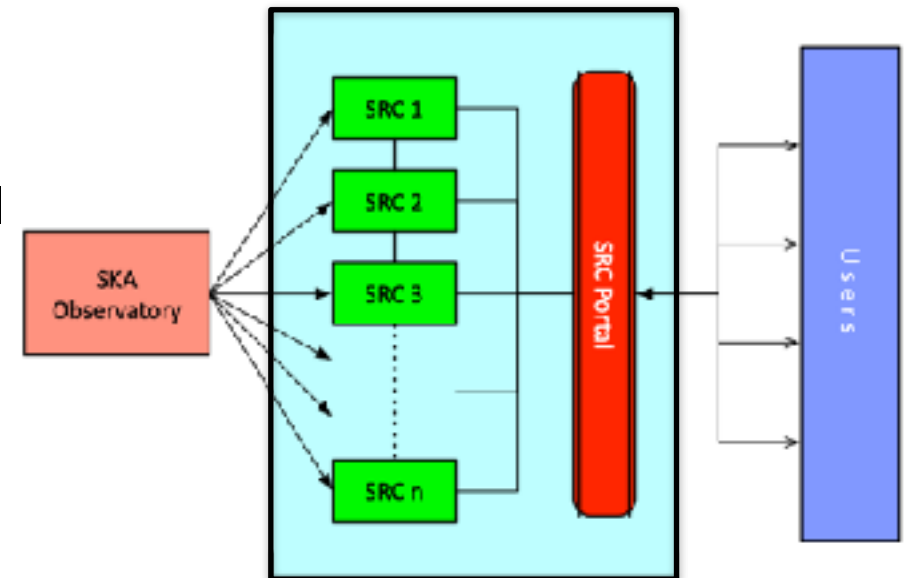
# LOFAR – the *Software Telescope*



Telescope Manager and Operator screens

# SKA Regional Centres

- ~700 PB/year of Observatory Data Products produced in Cape Town & Perth
- SKA Observatory Data will be exported to a network of ~10-15 Regional Centres
- SRCs will host the SKA Science Archive
- Users will only be able to access SKA data in the SRCs
- Further processing, Science Analysis and Interpretation will take place in the SRCs
- Details of data location & movement hidden from users
- NL SRC will be part of ASTRON's Science Data Centre serving both LOFAR and SKA
- Development & preparation funded by NL Roadmap (2021-2025)

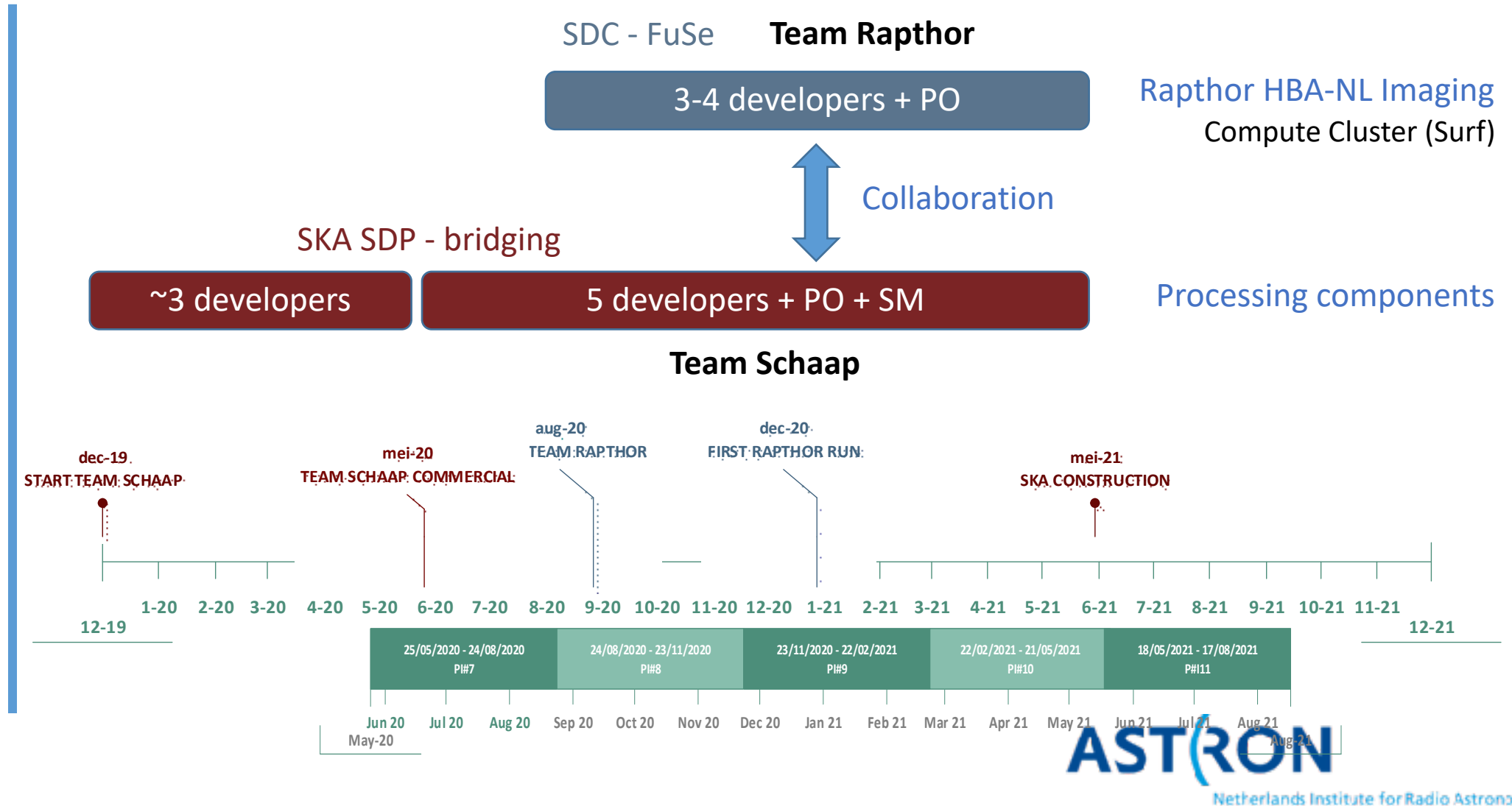




# Achtergrond

- Moderne wetenschappelijke instrumenten (bv. radiotelescopen) leveren veel data (> PB/dag) die complexe bewerking moeten ondergaan
- Real-time en off-line verwerking van data is flinke opgave
- Software is vaak sluitpost in planning & begroting
  - Vaak eind van de keten, upgrades & doorontwikkeling mogelijk
- Instituten hebben (soms) moeite om hooggeschoold personeel aan te trekken en te behouden
- Samenwerking met bedrijven biedt mogelijkheden
  - Toegang tot ervaren ontwikkelaars
  - Flexibeler
  - Ook aantrekkelijk voor bedrijven (?)
- Uitdagingen
  - Balans tussen subject matter experts & vaardige ontwikkelaars
  - Behoud van kennis, verlies door verloop

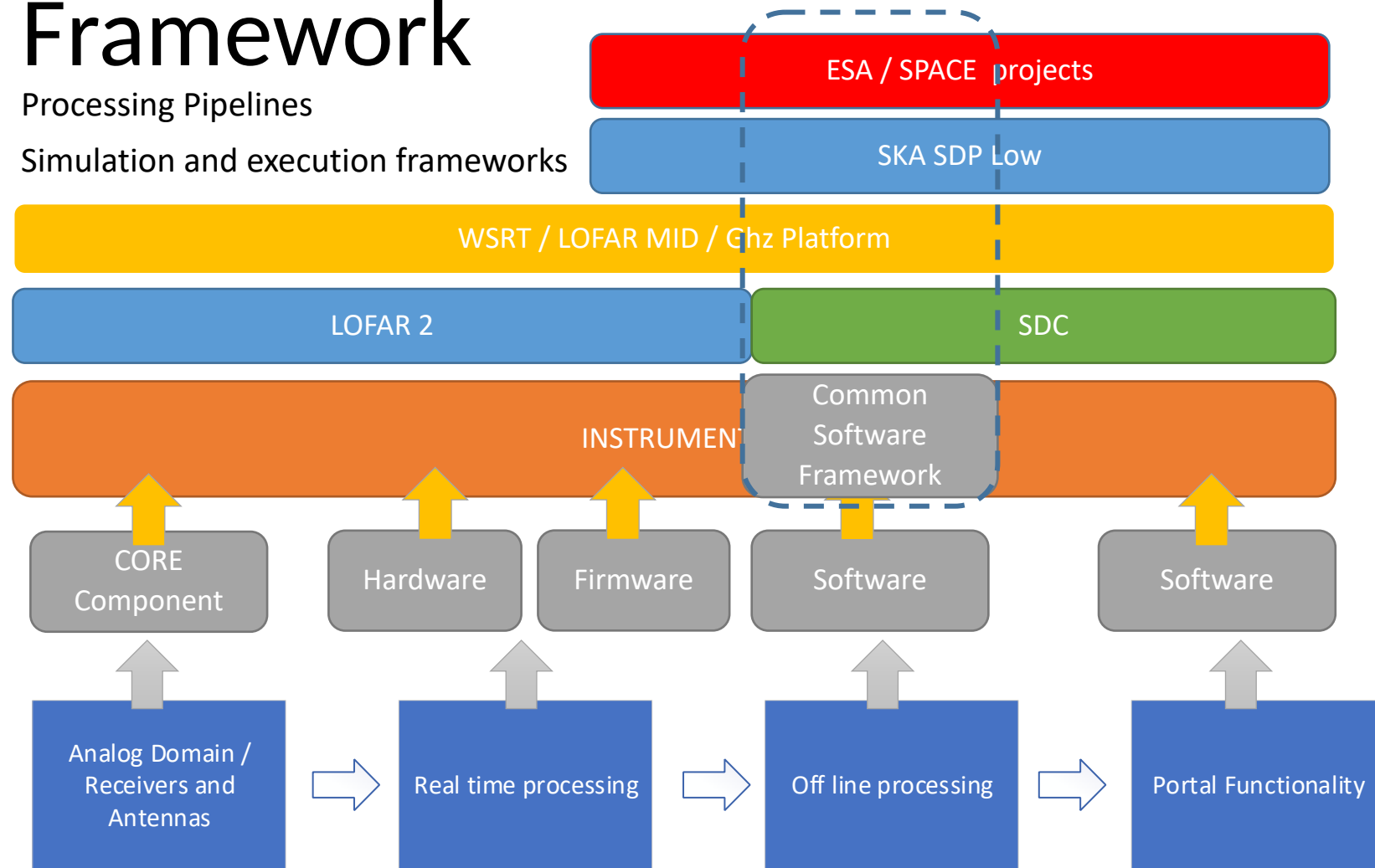
# Developing Continuum Imaging pipelines



# Common Software Framework

Processing Pipelines

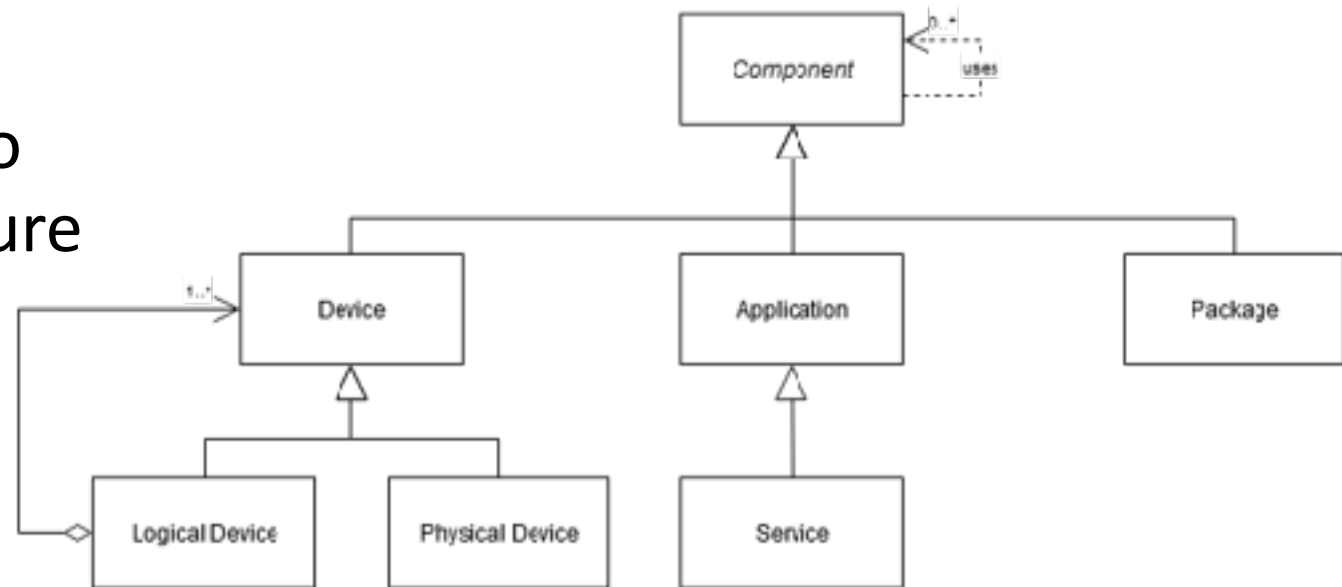
Simulation and execution frameworks



# Collaboration with LOFAR (or SDC)

## Team Monitoring & Control

- 4 persons for software development, part of a larger team
- Open source framework Tango
- Python and C++ skills needed
- Transform current software into hierarchical component structure



# Future Opportunities

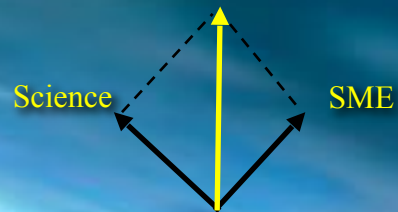
- Development of Correlators/Beamformers based on GPU & programmable switches
- Cryogenically cooled Phased Array Feeds – operating at cm wavelengths
- Low cost aperture arrays – also at cm wavelengths (few hundred MHz - 1.5 GHz)
- SDC/SRC related technologies (pipelines, w/ accelerator technologies, HPC/HTC, storage, networking)



# ASTRON

Netherlands Institute for Radio Astronomy

Creating Synergy



From the edge of the universe to the market place

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ASTROTEC HOLDING



# The Square Kilometre Array

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