

Big Science Industriemiddag Woerden October 16th 2013

ASTRON

Netherlands Institute for Radio Astronomy

SKA & DOME Users platform

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*Credits: Albert-Jan Boonstra, Program manager ASTRON-DOME project

ASTRON is part of the Netherlands Organisation for Scientific Research (NWO)

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By studying the Big Questions of Physics...

We face Major Challenges of Technology!

Origins

Fundamental Physics

Discovery


Antennas

Chips


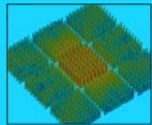
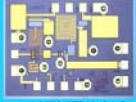
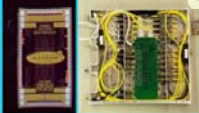


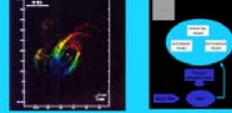
Electronics

ICT

Next generation radio telescopes: ASTRON technologies




End-to-end design capability

<p>Antennas broad-band, low-noise</p>  <p>EMBRACE Vivaldi array</p>	<p>Antenna simulation</p>  <p>in-house developed package CAESAR</p>	<p>Low noise amplifier (LNA)</p>  <p>mHEMT LNA (70 nm OMMIC)</p>	<p>Beam-formers</p>  <p>electronic (left), opto-electronic (right)</p>
<p>Fast digital signal processing boards</p>  <p>UniBoard 4Tops</p>	<p>High-performance super computing</p>  <p>BleuGene, GPU clusters,...</p>	<p>Scientific computing image processing and calibration</p>  <p>imaging (left), modeling (right)</p>	

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Mapping op de HTSM Roadmaps

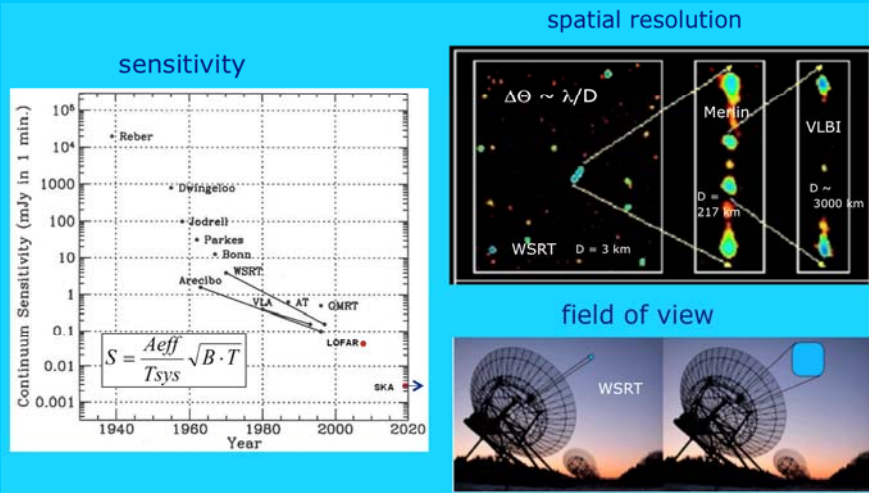
(SKA on the National Roadmap for Large-Scale Research Facilities 2013)



HTSM Roadmap	Category	SKA link
Advanced Instrumentation	<ul style="list-style-type: none"> - Information Infrastructure and high-speed/high-volume data handling - Customised Micro-electronics and Nano-photonics: multidisciplinary micro-electronics and nano-photonics - ICT Infrastructures & data mgt tools: high speed, huge volume, real time "streaming" data processing 	<ul style="list-style-type: none"> - throughout SDP, CSP, LFAA station processing - SaDT - LFAA station processing SDP, DOME
Embedded Systems	<ul style="list-style-type: none"> - Model based system design techniques - System architecting and system design - Techniques for system implementation - Model-driven design and tooling 	<ul style="list-style-type: none"> - LFAA UniBoard2 design; also potential platform for CSP; also link with OpenCL-FPGA programming R&D within DOME - LFAA station processing, SDP accelerator R&D; DOME/IBM exabounds tool - SDP system/software design, parallelism, accelerators - SDP design, parametric models, requirement analysis
High Tech Materials	<ul style="list-style-type: none"> - Bio based materials 	<ul style="list-style-type: none"> - MFAA parts
ICT	<ul style="list-style-type: none"> - Computer architecture, algorithms, performance modelling - Database technology, storage technology, computer architecture - Signal processing, machine learning 	<ul style="list-style-type: none"> - SDP, CSP and LFAA designs - SDP storage and data delivery - SDP processing algorithm optimisation

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Why bigger radio telescopes?



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LOFAR

Low Frequency Array

Worlds largest radio telescope !

LOFAR - WAN characteristics

- Unidirectional data transport
- No data routing
- 216 Gbps to Groningen (6 DVDs/s)

LOFAR Correlator/Supercomputer and storage:

- Uses 1 (14 TFlops) of 3 racks
- Total capacity: 20 TFlop en 2 PByte

LOFAR - arms

- 16 stations
- 3 Gbps per station
- Distance to LOFAR core < 120 km

LOFAR - Core

- 24 stations
- 3 - 6 Gbps per station
- Intra core distance < 5 km

LOFAR - international

- 8 stations
- 3 Gbps per station
- Distance to LOFAR core ~ 1000 km

DIT IS INDUSTRIËLE PRODUCTIE!

> 81.000 dipole antennas
in phased array configuration

SKA – Square Kilometer Array

SKA array and receptor technologies
 South Africa / Australia dual site

ASTRON

250 Dense Aperture Arrays
 SA (AIP/phase 2)
 3-Core Central Region
 2500 Dishes
 SA (phase 1/2)
 Wide Band Single Pixel Feeds
 Recessed Array
 Aus (AIP) SA (phase 2)
 250 Sparse Aperture Arrays
 Artists' Renditions from Swinburne Astronomy Productions

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2013 Preliminary Design Review/System Requirements Review
 2014
 2015 Critical Design Review
 2016 Go/No Go Decision for Construction of SKA1
 2017 Construction Proposal brought to SKA Board
 2018 Start of SKA1 Construction
 2020 SKA1 early science
 2023 SKA1 completed

SKA facts

ASTRON

- The SKA central computer will have the processing power of about **1 billion PCs**.
- The SKA will use enough **optical fibre** to wrap twice around the Earth!
- The dishes of the SKA will produce **10 times the global internet traffic**.
- The aperture arrays in the SKA could produce more than **100 times the global internet traffic**.
- The SKA will generate enough raw data to **fill 15 million 64 GB iPods every day!**
- The SKA super computer will perform **10¹⁸ operations** per second
- The SKA will be so sensitive that it will be able to detect an **airport radar on a planet 50 light years away**.
- The SKA will contain thousands of antennas with a combined collecting area of about **one square kilometre**, distributed over >1000 km area

- **Start construction: 2017**
- **Full science: 2023**

Source: SKA Office, www.skatelescope.org

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SKA: Uitdaging qua Rekenkracht en reductie van energieconsumptie van (super)computers - Research in technologieontwikkeling:

The DOME project (overall figures)



The DOME Project

- Program for 5 years fundamental research, 2012-2017
- Collaboration between ASTRON, IBM-NL, and IBM-ZRL (Switzerland)
- Three main research areas, seven research streams to meet the SKA signal processing challenges

Budget €32.9

- 5M+15M Province of Drenthe and EL&I REP "Zuiderzeelijn gelden"

Headcount growing to 25 researchers

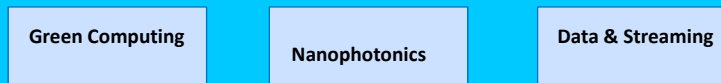
- Over the project period: 15 PhD/PostDoc
- Involved ASTRON/IBM: 21 senior staff



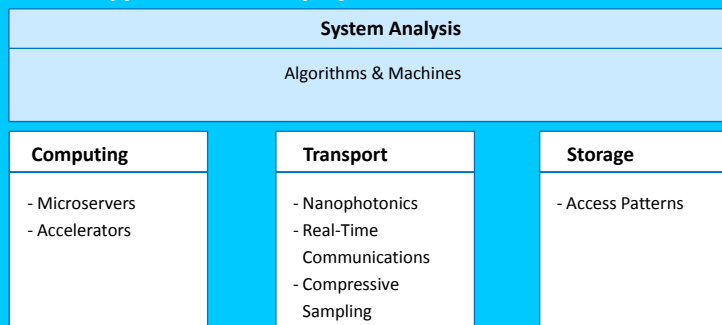
DOME Themes vs. workstreams



Research Streams...



...are mapped to research projects:

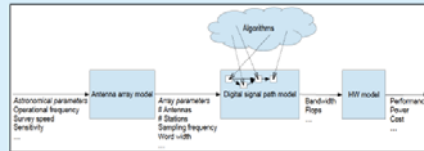


DOMÉ
 Themes vs. workstreams



Algorithms & Machines (P1)

- LOFAR / Meerkat retrospective analysis
- Establish baseline of SKA central design/scientific computing
 - Optimizing algorithms & hardware
 - Incorporate scaling rules of basic SP functions
- Recommendations on architecture / critical design review of SKA
- SKA: energy and I/O limited



DOMÉ
 Themes vs. workstreams



Storage (P2)

- Workloads: data access patterns
- Data formats
- Model storage architecture & workloads
- Optimize architecture: TCO, Reliability & Performance
 Tiering strategy, Access Patterns



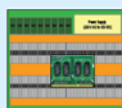
Nano Photonics (P3)

- Digital optical interconnect technology (UniBoard based)
- Analog optical interconnection technology for photonic phased array receivers
- Analog optical signal processing technology for photonic arrays



Microservers (P4)

- Take features from a full-sized server
- Remove what you don't need
- Integrate most of what you do need onto the CPU
- Pack as densely as possible (within thermal limit)
- Until you've reached exactly the performance you need



Accelerators (P5)

- Comparing different existing accelerators
- Mapping algorithms onto accelerators
- For example mapping correlator functionality on GPU based systems



DOME Users Platform: de verbinding met het MKB (SME)



Goal

- Strengthen SME's
- Prepare companies for a role in SKA development
(early collaborative research is advantage when the tendering process will start around 2016 and beyond)
- Prepare SME's for a role in hosting, servicing and application development for next generation data-centres

DOME and NWO are jointly intending to sponsor a **call** late 2013/early 2014 for proposals supported by the HTSM ICT Roadmap Team on the topic of using ICT innovations to drive progress in astronomy. This will directly connect industry via the DOME User Platform with research carried out at universities and the DOME Exascale Center.....

Aanmelden nieuwsbrief:
info@dome-exascale.nl

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DOME Users Platform & Facility Sharing



Users Platform

- Knowledge created will be made available to SME's
- Identify and test new technologies for market applications

Support valorization by several means

- Facility sharing (at ASTRON, later at Kennis Campus Assen)
- Expert meetings, training sessions
- Access to ASTRON laboratory facilities for start-ups
- Regulated access to Dome technology demonstrators




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DOME Users Platform & Facility Sharing



- Expose: Immersion Course**
 - Open (developers, integrators)
 - Keynote by ASTRON/IBM expert
 - Knowledge transfer to SMEs
- Connect: Building Business**
 - Semi-open (solution looking for a problem)
 - Technology-push brainstorming
 - Check if/where applicable to SMEs
- Try-out: Technology Challenge (Users Platform)**
 - Closed (problem looking for a solution)
 - Problem analysis, modelling sessions
 - Probe solution space, identify follow-ups

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DOME Toegang tot het **Users Platform**:




Users Platform

- Knowledge created will be made available to SME's
- Identify and test new technologies for market applications

Deelname: www.dome-exascale.nl

- Kost niets (no entrance fee)
- Maar ook geen subsidie
- JDA: Joint Development Agreement
 - Bilateraal DOME v.s. specifieke MKB
 - Alleen JDA indien mutual benefits geïdentificeerd
- *Er is budget voor prototypes ed. Dus ruimte voor outsourcingcontracten.*

Aanmelden nieuwsbrief:
info@dome-exascale.nl



SKA on the National Roadmap for Large-Scale Research Facilities 2013



... Seeking funding for the SKA pre-construction phase (2013-2017)

- SKA NL consortium:
 - ASTRON
 - Sterrenkundig Instituut Anton Pannekoek, Universiteit van Amsterdam
 - Kapteyn Instituut, Rijksuniversiteit Groningen
 - Sterrewacht Leiden, Universiteit Leiden
 - Afdeling Sterrenkunde, Radboud Universiteit Nijmegen, Faculteit NWI
- Periode: 2014 – 2018
- Aangevraagd: 13M€ waarvan 2M€ investment & machines



SKA on the National Roadmap for Large-Scale Research Facilities 2013



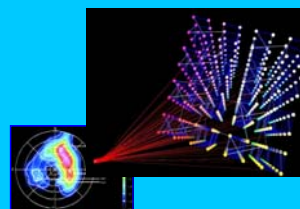
Waar gaat NL SKA Consortium op inzetten:

- Netherlands will lead two work package consortia:
 - Low Frequency Aperture Arrays (led by ASTRON) (Ph-I)
 - Science Data Processing system (Ph-I)
- Development of the Mid Frequency Aperture Arrays (Ph-II)

	SKA1-low
Country	Australia
New antennas	250,000 antennas
Precursor incorporated	none
Type of SKA antenna	Log-periodic dipole
Frequency coverage	50 - 650 MHz
Bandwidth	250 MHz
Maximum Baseline	50 km
Sensitivity Improvement (LOFAR ¹)	16 x LOFAR
Survey Speed Improvement ¹	520 x LOFAR
Progression to SKA2 ²	yes (more antennas and longer maximum baselines)



Artist's impression of a Low-Band SKA Sparse Aperture Array Station



Artist's impression of a Science Data Processing system of peta flop/s scale.

SKA on the

National Roadmap for Large-Scale Research Facilities 2013

ASTRON

- Netherlands will lead two work package consortia:
 - Designing the Low Frequency Aperture Arrays (Ph-I)
 - Development of the Mid Frequency Aperture Arrays (Ph-II)
- Major contributions to work package consortia:
 - Science Data Processing system
 - Synchronisation and Data Transport (via DOME project)
- **Announcement: SKA NL Industry day @ ASTRON:**
- **12 december 2013 (datum: provisional)**

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ASTRON
Netherlands Institute for Radio Astronomy

Creating Synergy!

Science SME

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The graphic features a dark blue background with a glowing blue arc at the top. Below the arc, the text 'Creating Synergy!' is written in yellow. Two white arrows point from the words 'Science' and 'SME' towards each other, meeting at a yellow double-headed arrow pointing upwards. In the bottom right corner, there is an image of a globe with several coins resting on it.