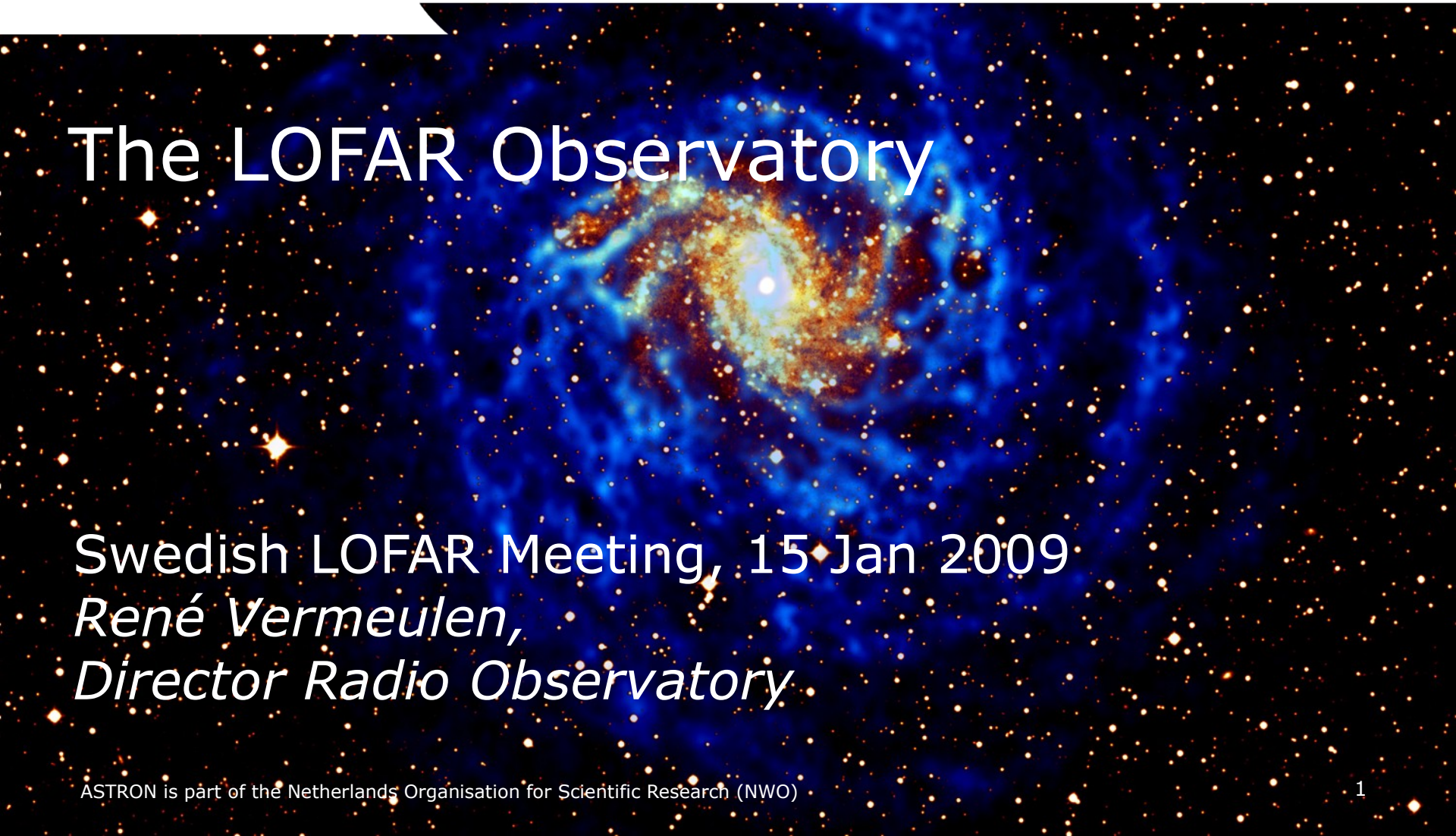
ASTRON

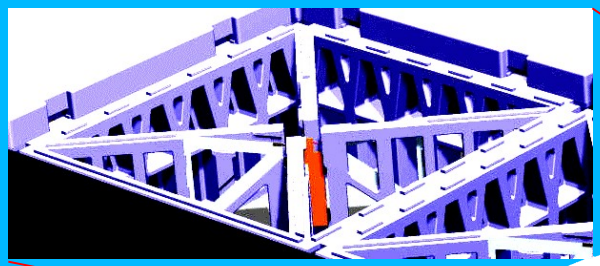
Netherlands Institute for Radio Astronomy

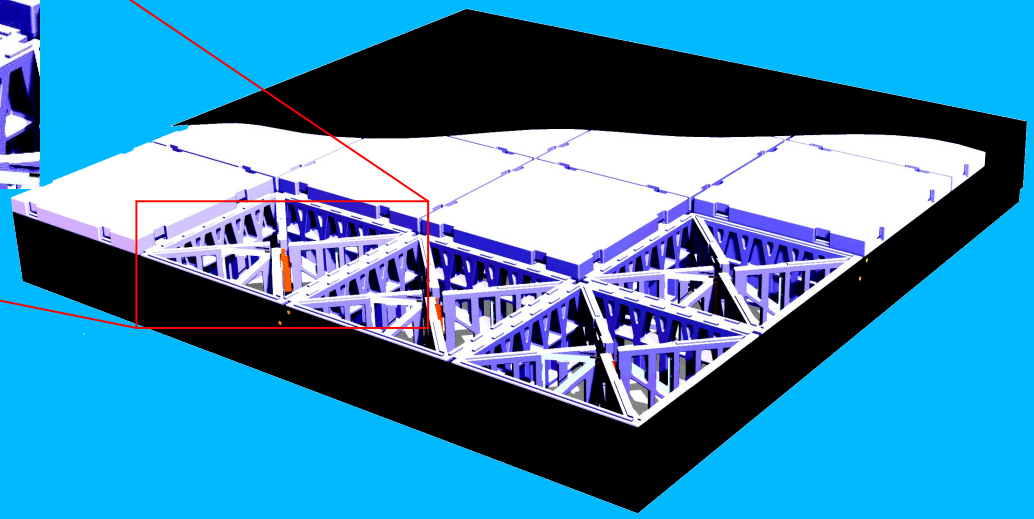


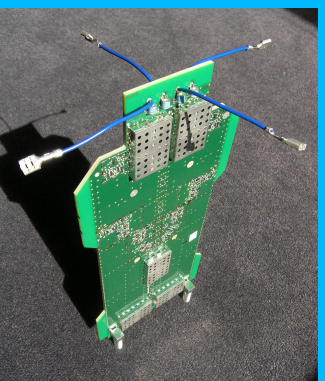
The LOFAR Observatory

Swedish LOFAR Meeting, 15 Jan 2009

René Vermeulen,
Director Radio Observatory







LOFAR characteristics

ASTRON

- Stations: electronically steered phased arrays of antennas
  - No moving parts
  - All-sky monitoring, transient buffer boards
  - Rapid electronic direction switching
  - Multiple simultaneous beams on sky
- Remotely operated from ASTRON Dwingeloo
- Aperture synthesis imaging, Tied Array, Transient Buffers
- 3 Gbit/s per station via fibre to BlueGene supercomputer
- Data model allows distributed archiving and post-processing

LOFAR on a European scale

ASTRON

LOFAR basics

ASTRON

Frequency ranges :	LBA 30 - 80 MHz	HBA 115 - 240 MHz	
	Isolated dipoles	Tiles of 4x4 dipoles	
18+ NL Core Stations	96 dipoles	2x24 dipoles	~2 km
18+ NL Remote Stations	96 dipoles	48 dipoles	~100 km
8+ International Stations	96 dipoles	96 dipoles	>1000 km

Sensitivity (after 4 h, 4 MHz bandwidth)

- @ 50 MHz ~ 3 mJy
- @ 150 MHz ~ 0.15 mJy

Up to 8 simultaneous 4MHz beams possible

LOFAR-NL

LOFAR

E-LOFAR: our ambitions for expanded capabilities in the next decade

LOFAR: In the beginning...

ASTRON

- Original science concepts:
  - George Miley & others in NL university community
  - Low-frequency radio surveys: under-explored terrain
- Original technology concepts:
  - Jaap Bregman & others at ASTRON
  - Phased arrays: great promise for the future
- NL subsidies/consortium: multi-disciplinary sensor network
  - Development of applications & operations left to communities
  - Geophysics, atmospherics, climatology, agriculture, ...
  - Astrophysics / radio telecope is dominant application
- International interest and collaboration growing rapidly
  - National LOFAR Astronomy Consortium in each country
  - International LOFAR Astronomy Consortium being formed

LOFAR as a radio telescope

ASTRON

- Applications driving the design, called “key science projects” (KSP)
  - The epoch of re-ionisation
  - Extragalactic surveys
  - Transients and pulsars
  - Cosmic rays, particle astrophysics
  - Cosmic magnetism
  - Solar science, space weather
- For each KSP area, a team of astronomers is involved with ASTRON in realising the required technical capabilities
  - Will be recognised by means of privileged access to observing time
- Capabilities allow very wide range of projects that fall: centrally / periferally / not at all, within the general areas envisaged by: one / several overlapping, of the KSP teams

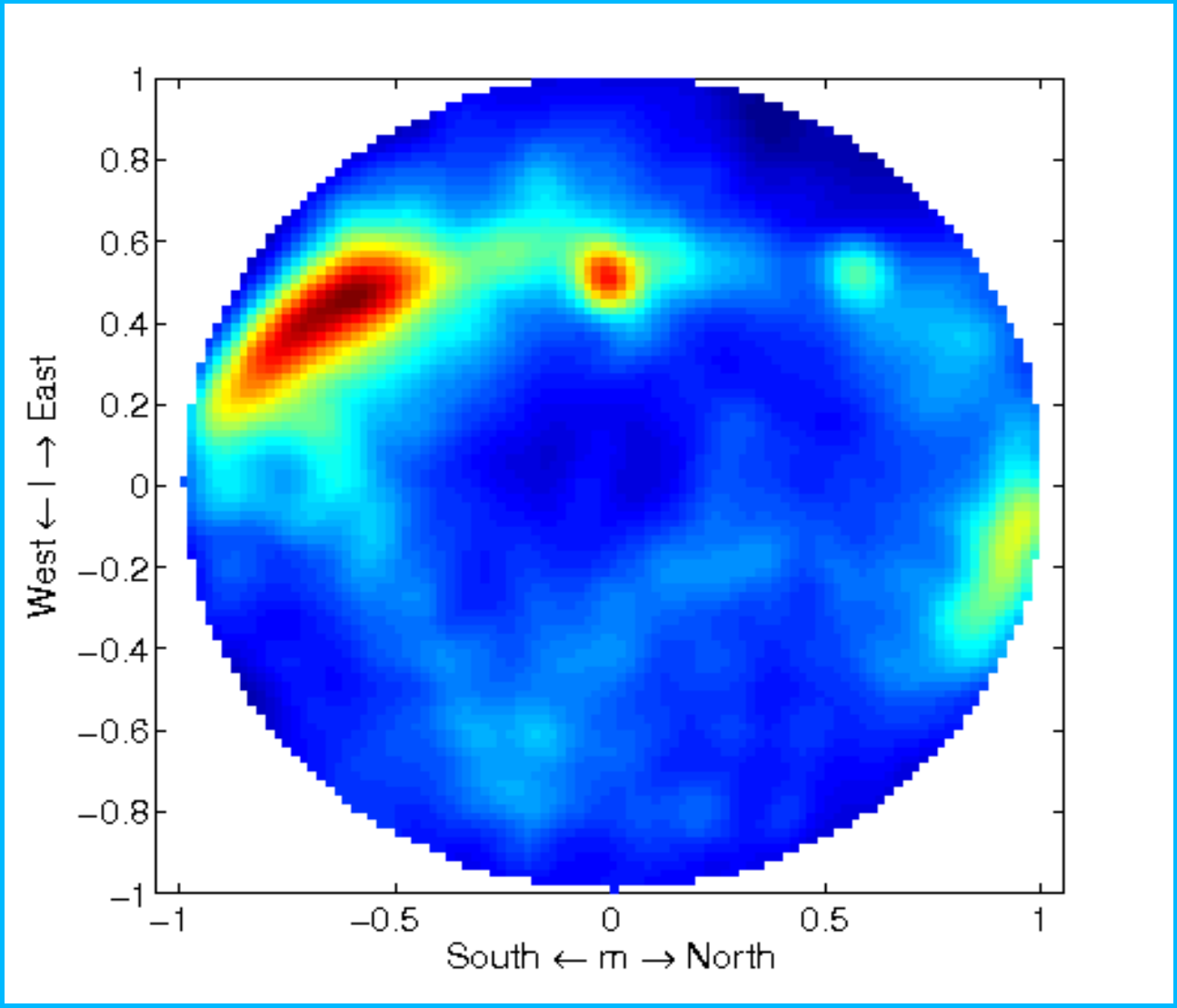
Wide range of astrophysical applications
A sample:

ASTRON

- The Sun and space weather
- Planets, exo-planets and SETI
- Single and multiple stellar transient/variable radio sources
- Pulsar science
- GRBs
- Galactic structure, ISM, SNR, starforming regions, magnetic properties
- Nearby Galaxies: structure, magnetic fields, dynamics
- Formation of (massive) galaxies and clusters
- Star formation in galaxies at high redshift
- Evolution of AGN activity / young and old radio galaxies
- Variable/transient extragalactic radio sources
- Properties of clusters and halos, large-scale magnetic structures
- Cosmic rays, particle astrophysics
- The Epoch-of-Reionisation
- Serendipitous discoveries
- YOUR TOPIC HERE

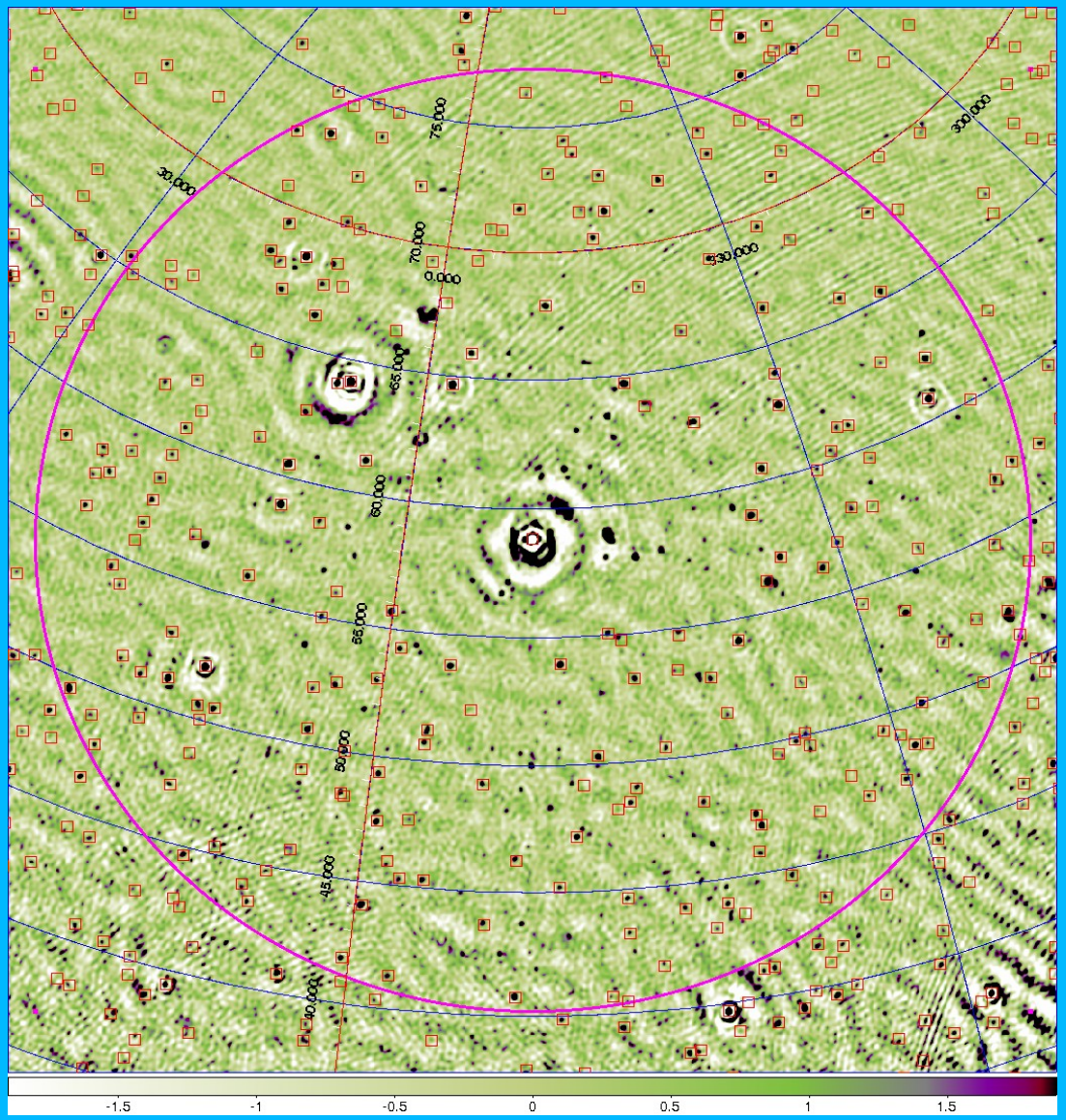
Test: Single Station All-Sky image

The Effelsberg sky at 14h on 29 October 2007



Test: Deep Image with HBA

ASTRON



Test: Confusion-limited image at 50 MHz

16 dipoles (only ~70 baselines)

3 x 24h

38 - 59 MHz (B=6 MHz)

~ 800 sources !

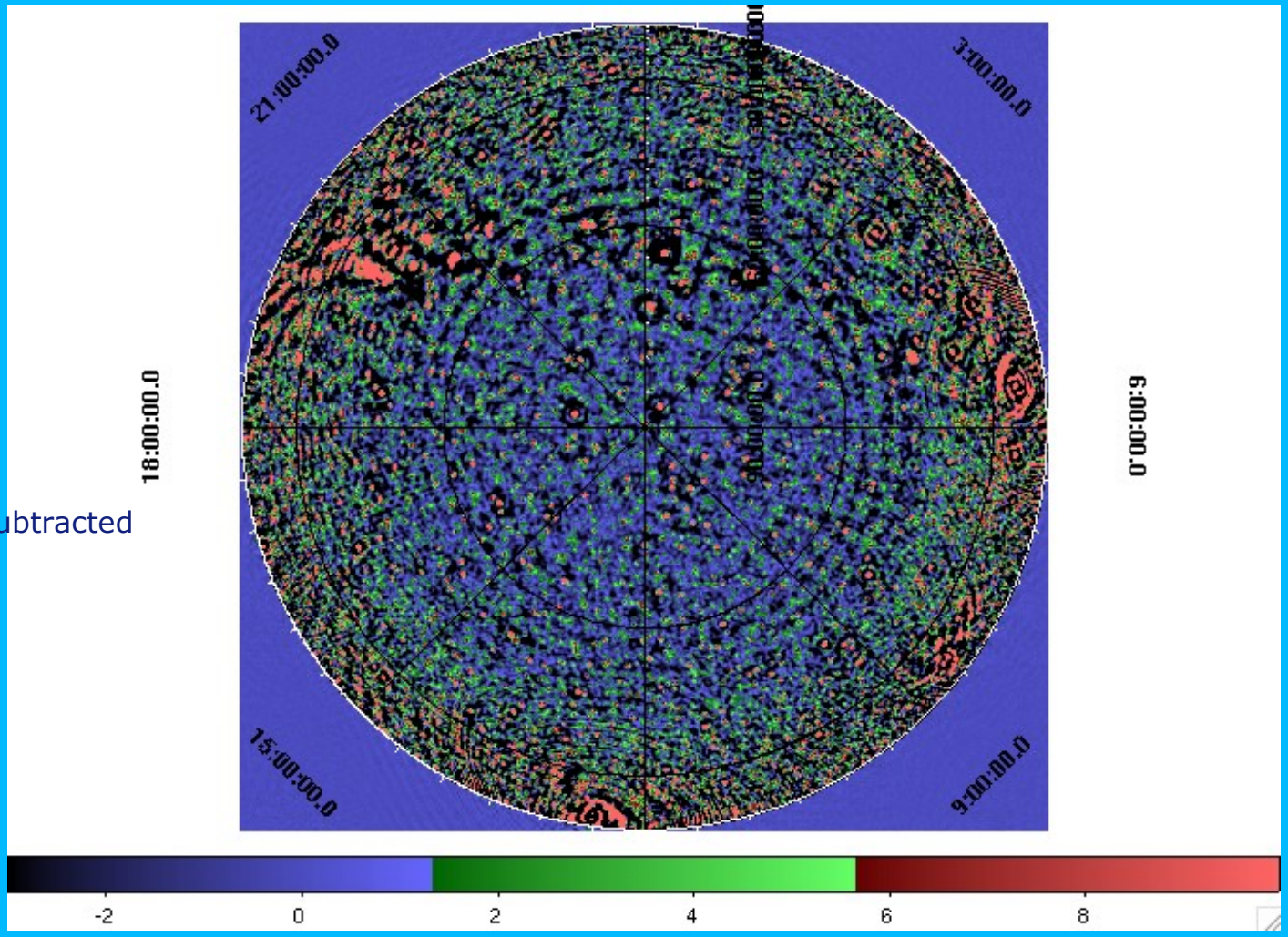
PSF ~ 0.5°

noise ~ 0.5 - 1 Jy

CasA/CygA (~20,000 Jy) subtracted

- dipole beam corrected
- no deconvolution

Sarod Yatawatta



Test: Imaging Sun-Taurus conjunction

~12h syntheses

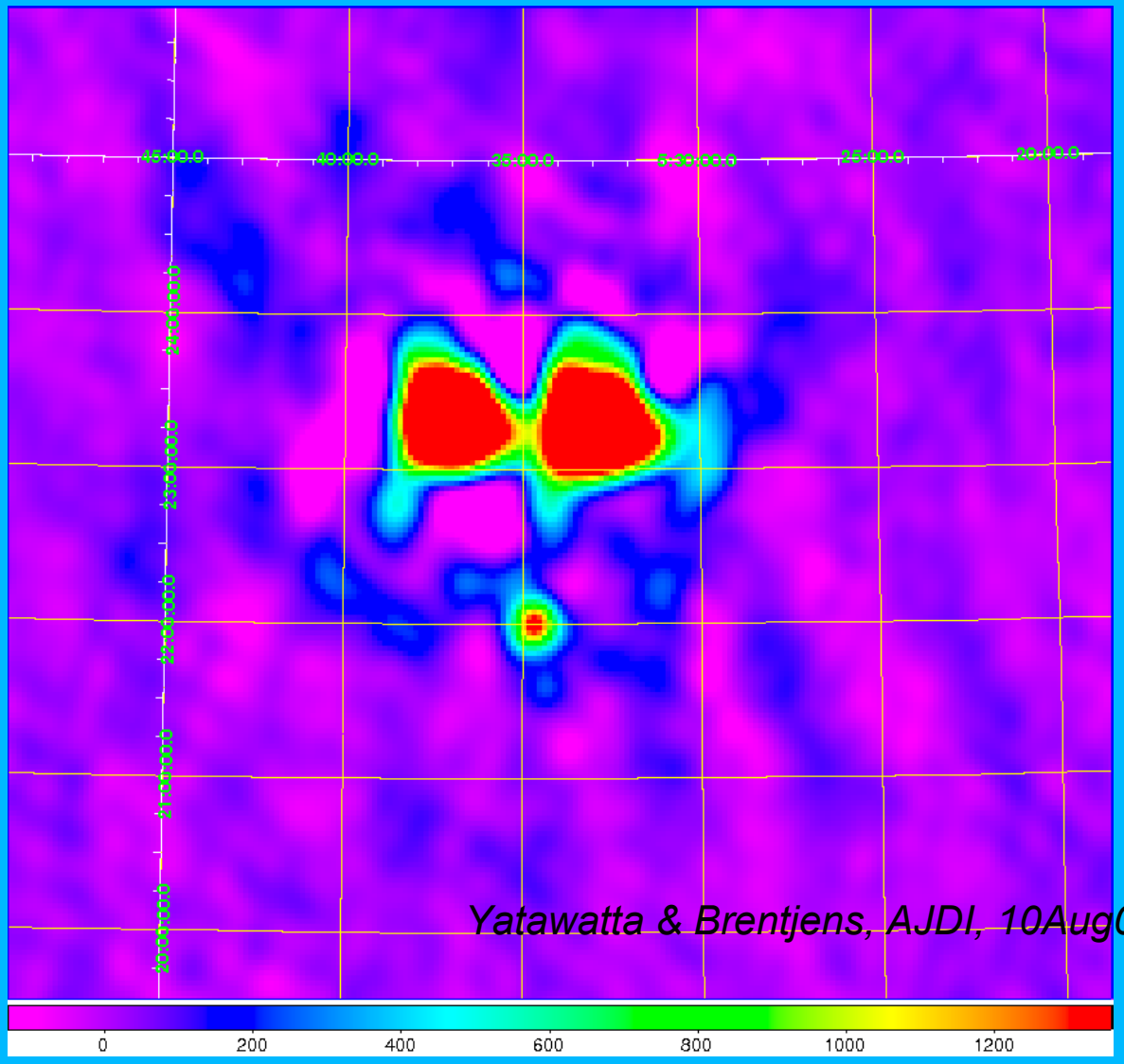
on 14+15 Jun 2008

~ 150 MHz

~ 10’ PSF

Sun moves,

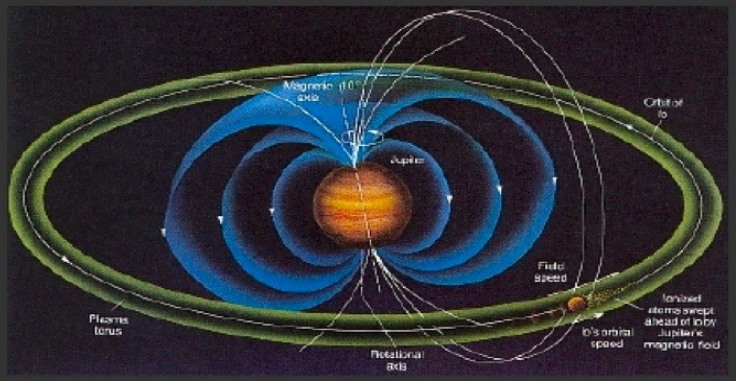
Taurus stays put



Yatawatta & Brentjens, AJDI, 10Aug08

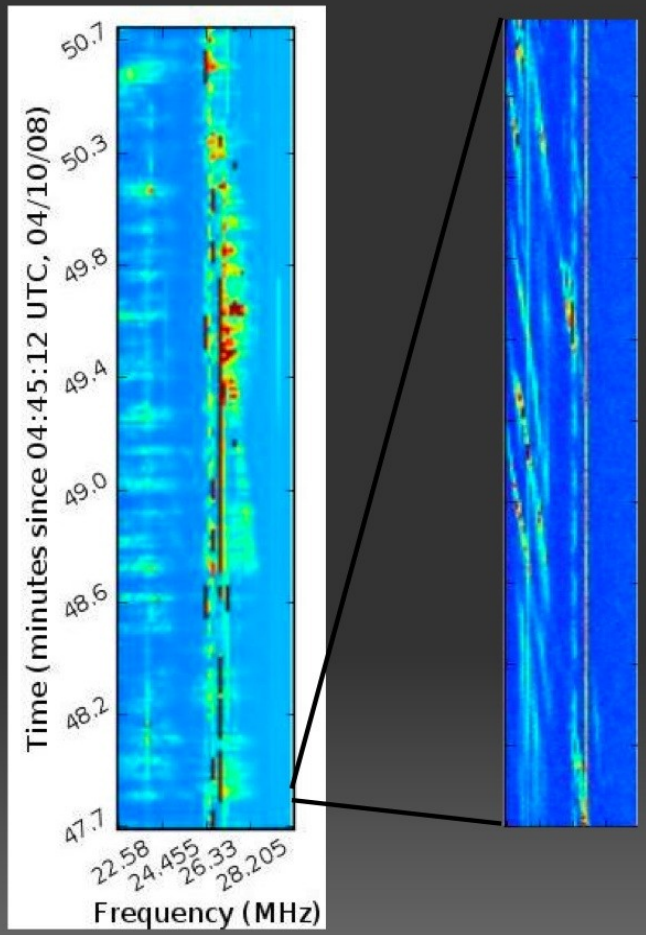
Test: Jupiter dynamic spectrum

ASTRON

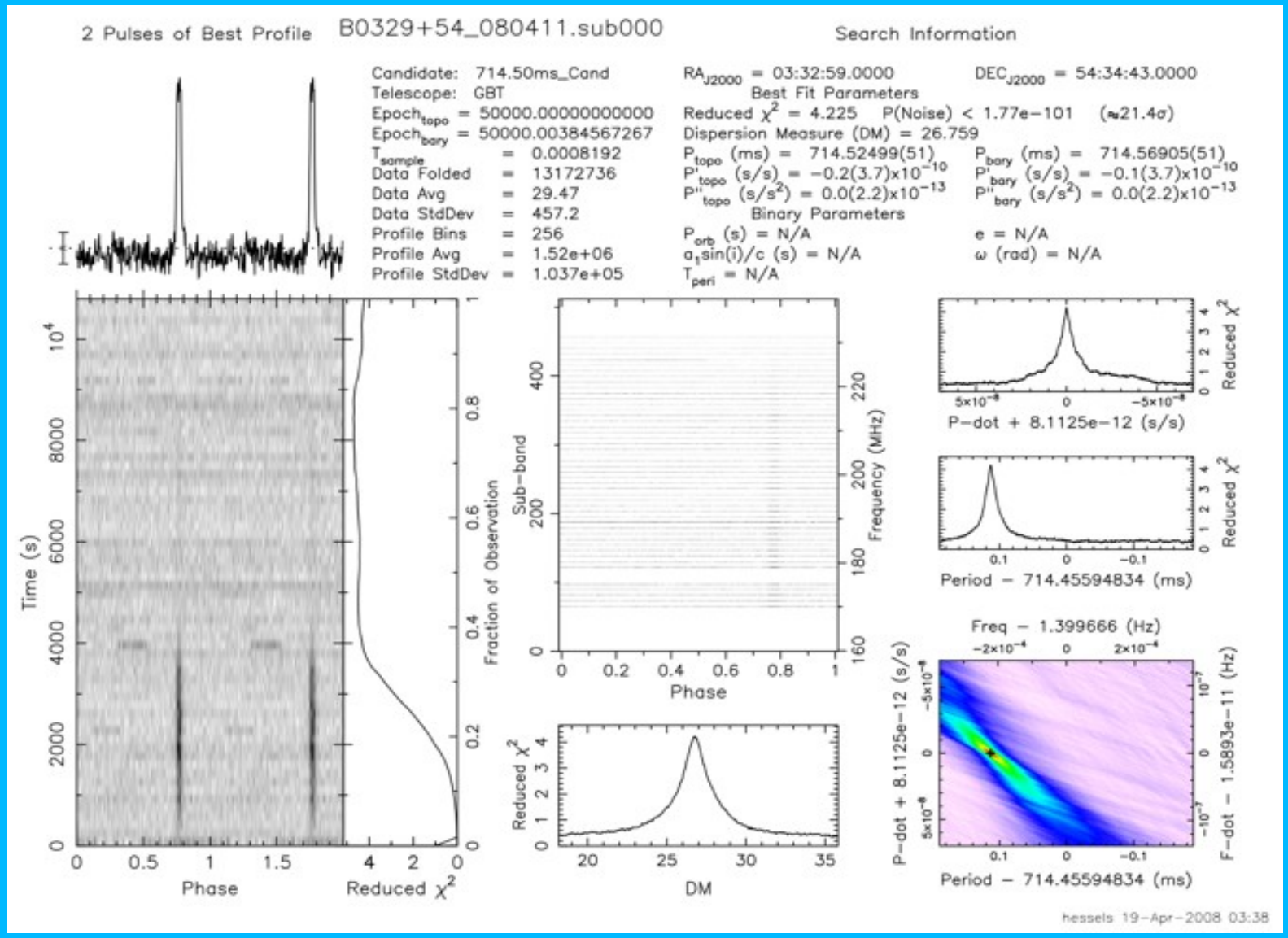


Jupiter/Io magnetosphere radiates cyclotron maser

To Earth and CS1



Test: Pulsar Detection



LOFAR: a broad common-user Observatory

ASTRON

- LOFAR scope has gone from “project” to “observatory”
- Observatory aims at maximal, long-term overall scientific output
  - Integrated operations via ASTRON/Radio Observatory
  - National consortia participate: International Astronomy Consortium
- Many individual user groups
  - Each focusing on maximal yield in their specific research topic(s)
  - In individual collaborations that fit specific science and style
- Substantial contributions are rewarded with privileged access
  - Development, commissioning of common, integrated infrastructure
  - Participation in integrated operations
- Rapidly growing Open Skies portion

LOFAR observing resource allocation

ASTRON

- Scarce/distinct resources to be allocated:
  - Telescope time, i.e. opportunity to determine setup/configuration
  - Data storage capacity and throughput
  - (Post)processing capacity and throughput
  - Access privileges to data / archive access, for specific science purposes, piggyback use
- 3-tiered allocation mechanism with pre-arranged fractions to various communities and "rights holders"
  - Operators (rewards sustained operational involvement)
  - Contributors (rewards building of common infrastructure)
    - Major shares initially, allowing some large, well-focused projects
  - Open Skies (fosters broad user base)
    - Limited, shared-risks commissioning opportunities for first call
    - Fraction grows rapidly in later years

Programme Committee assessment for all

ASTRON

Single, independent Programme Committee

- Composed of independent international experts
- Uniform assessment of all projects (new & progress reports)
  - Scientific merit
  - Technical feasibility
  - Project plan: timelines, people, data analysis resources
  - Scope, focus, demarcation
    - Cannot "reserve" technique, sky area, "umbrella science",...
    - Piggy-back & archive use allowed/encouraged
  - Suitability for privileged ("large programme") support

National Consortia can sponsor projects

ASTRON

- Rights accumulated by National Consortia:
  - Contributions of all adhering members added
- National Consortia then distribute their acquired rights:
  - To any/all of their favourite (large) projects
- Scientists are free to set up projects and collaborations for maximal efficiency:
  - Propose per project, with relevant group of collaborators
  - Seek collaborations for greater observing efficiency
  - Obtain (multiple) national sponsorships
  - Or use Open Time

LOFAR commissioning phase

ASTRON

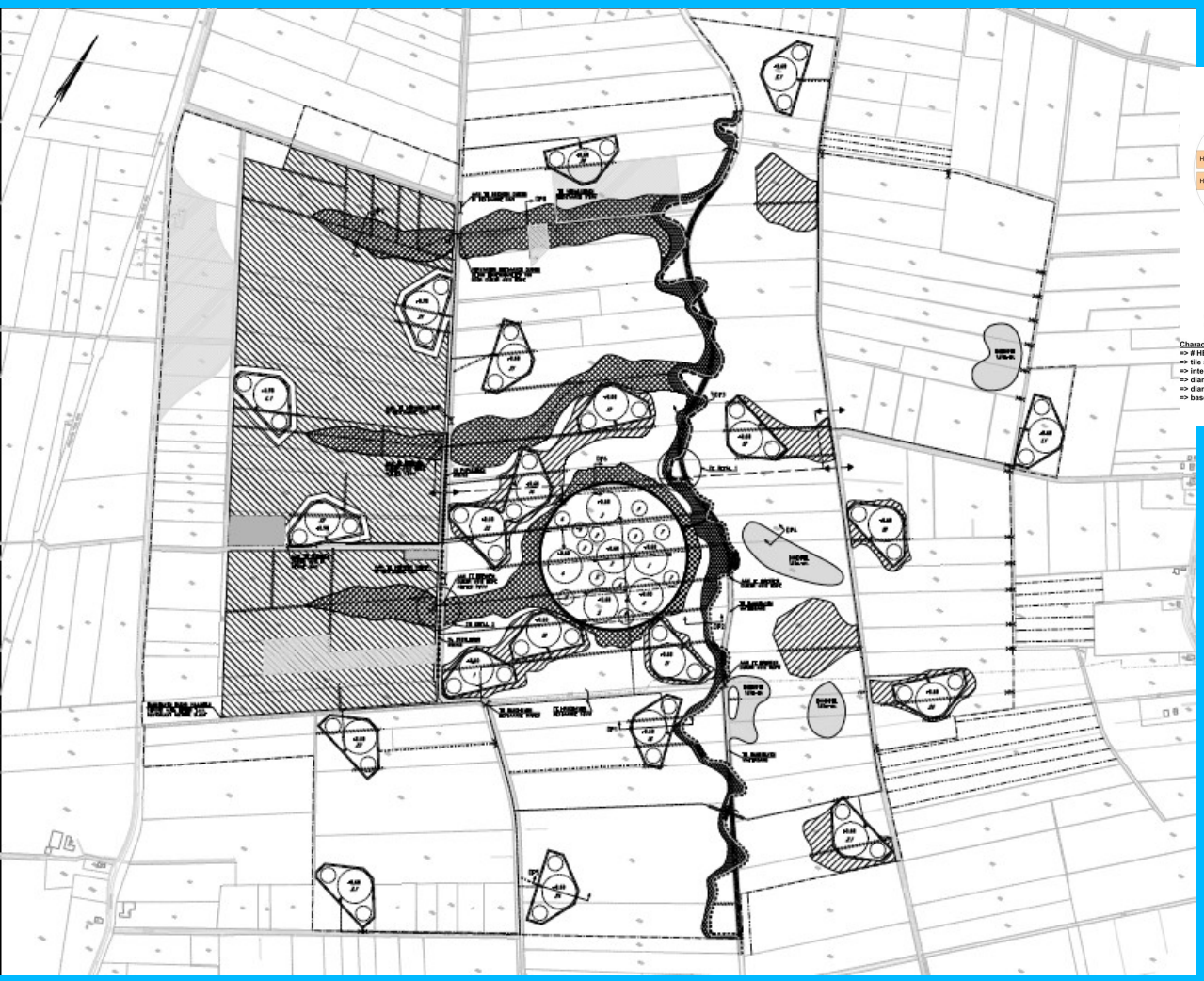
Commissioning phase requires intensive partnerships, coordination

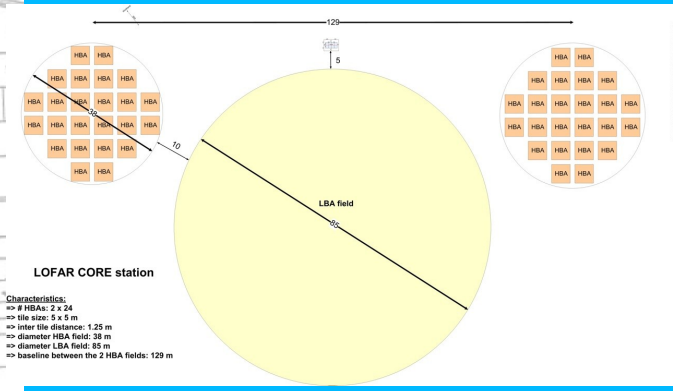
- With users and user groups (YOU!)
  - Technical design/development issues: the TWG
  - Software development: the LAD
  - Users Committee will be set up

- With national consortia (the Internationalisation Working Group)
  - Handle management/policy issues as they arise
  - Prepare appropriate consortium for operational phase

Rollout: Building the core area

ASTRON





The Superterp

Living on the edge ?

Roll out “the Information Super Highway”

Fighting the mud

Flattening of RS307

Status of station work and hardware

ASTRON

- Superterp needs to settle, dry for a few months.
- Remote fields (RS302, RS503, RS307) being prepared
  - Fields were very wet in Oct/Nov
  - Then dryer weather set in, but also colder, everything frozen now
  - antenna installation starts as soon as thawed/dried
- Effelsberg LBA in place
- Unterweilenbach, Tautenburg, Potsdam work in progress
- Hardware delivery issues largely solved
  - Hardware stockpiled/warehoused in Emmen for rapid rollout later
  - TBB delivery still delayed
- Rollout procedures are getting tested
  - Practical experience with field preparations
  - Cabinet electronic preparation in warehouse

LOFAR Rollout timeline

ASTRON

- Winter 2009: Limited test observing with first hardware
- Spring 2009: First processing software pipelines delivered
- Summer 2009: Intensive commissioning observing
- End of 2009: aiming for 36+8 stations in the field
- 2010: Ramp-up of science operations

Commissioning in 2009

ASTRON

- LOFAR observing resources will be limited in 2009:
  - Gradual increase of available hardware & software
  - Operational control tools also still in delivery/commissioning
  - Simultaneous debugging of many components
  - Still on high part of maintenance "bathtub curve"
- Scheduling and priorities set by observatory
  - Based on rollout & commissioning needs
  - Changes on short timescale
  - No guarantees for any time
- But there will be exciting opportunities !
  - The many technical needs MUST predominate
  - Some results will show-case LOFAR capabilities
  - Some resultant data will be useful for early science
  - Some tweaks or modest add-on observing may help this along

Astronomical commissioning observing plan

ASTRON

- Requirements for general, common LOFAR capabilities coordinated via LAD
  - A million-source-shallow-survey (MSSS)
    - to obtain initial Global Sky Model
    - for imaging pipeline and calibration purposes
  - Tied Array commissioning
  - Long baseline issues
  - Polarisation calibration
  - Etc.

  New participants with time/manpower very welcome

  LOFAR data processing workshop n February (M. Wise)
- Your own science projects: technical tests / pilot runs
- Bright ideas for novel initial science based on short observations of uncertain quality

The first call for LOFAR proposals

ASTRON

First call for proposals will be circulated soon,

deadline in spring 2009

- Validation/consolidation of commissioning period
- Very limited opportunities for Open Time in 2009
  - All on shared-risks basis
  - Either making novel use of ongoing commissioning observing
  - Or small new, stand-alone, or pilot observing projects
- If applicable, plans for 2009 to be described w.r.t. preparations for projects in 2010 and later
  - No long-term allocations made yet
  - But allows iteration: equitable balance between all interests
  - Specific science can start to be tackled by specific groups
  - Range of planned science becomes known

First call for proposals

ASTRON

- PC will provide scientific assessments, give feedback on longer term plans:
  - Oversubscriptions
  - Appropriateness, scope, focus
    - Overlaps, different groups allowed to use same data
    - Timeline, processing & analysis resources required
    - Growing Open Skies share to be defined
- All groups can then tune and focus their projects without losing any observing opportunities
  - Scoping out parameter space for 2010+
- Actual “full-scale science” proposals will be due later

Collaborations and interactions

ASTRON

- Overall science output from the LOFAR Observatory will benefit from:
  - breadth of the user community
  - healthy competition
  - Focused research carried out by dedicated research groups

- YOU:
  - Should set up your project scope and collaborations in the way you think best suits your science interests, your style of work, and the finite amount of your time and of telescope time
    - Within a large conglomerate or with a small group or on your own
    - A grand-design programme or a very focused project
    - Requesting observing time or data access rights

- LOFAR SCIENCE WILL BE EXCITING AND MULTI-FACETED !!

ASTRON's 2007 Christmas card