LOFAR OPERATIONAL CHALLENGES

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LOFAR & WSRT/APERTIF

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ASTRON

LOFAR

OUTLINE

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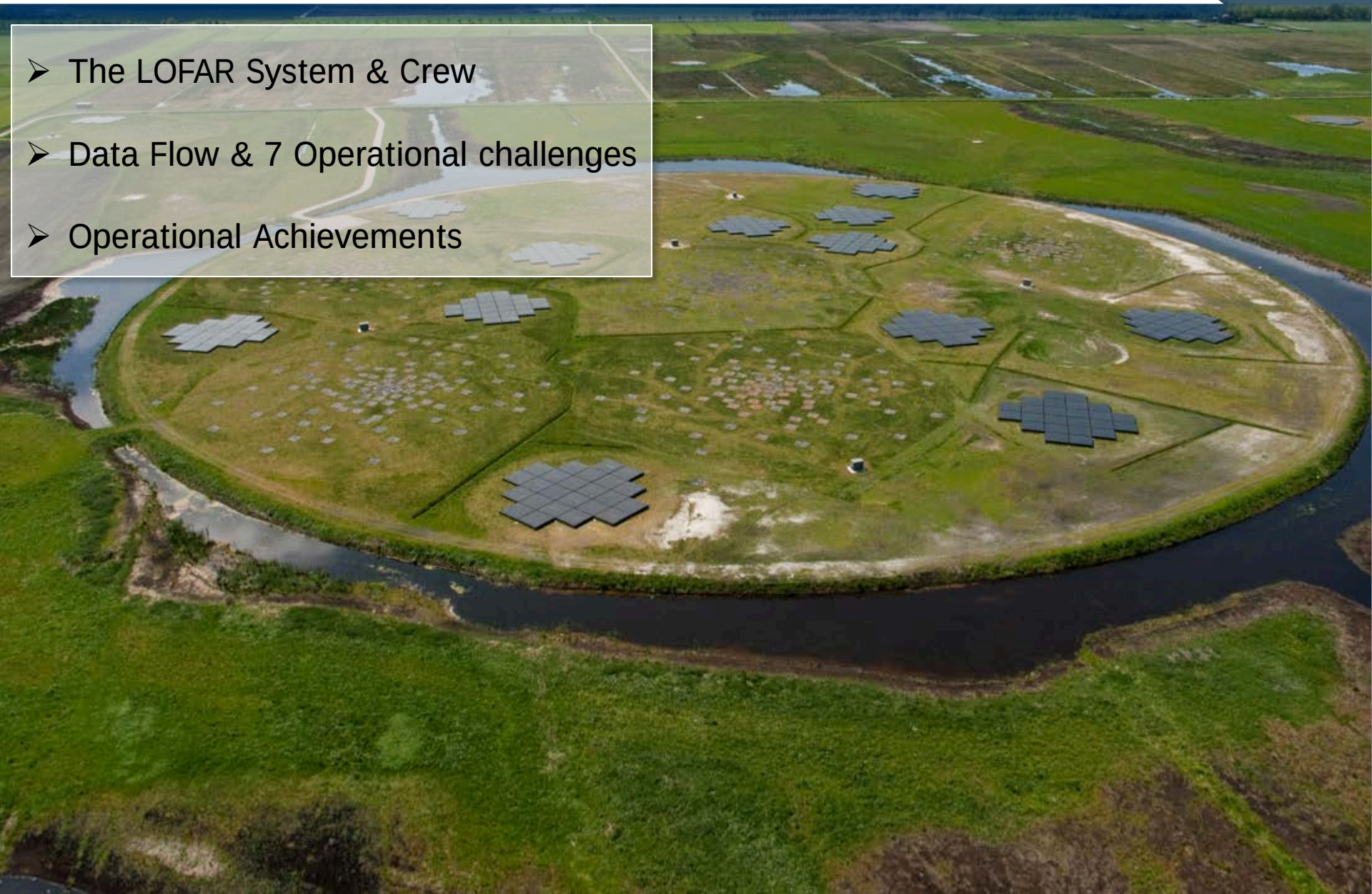

- The LOFAR System & Crew
- Data Flow & 7 Operational challenges
- Operational Achievements

THE LOW FREQUENCY ARRAY – KEY FACTS

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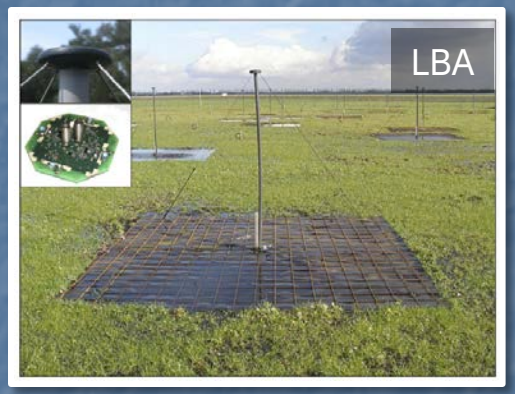
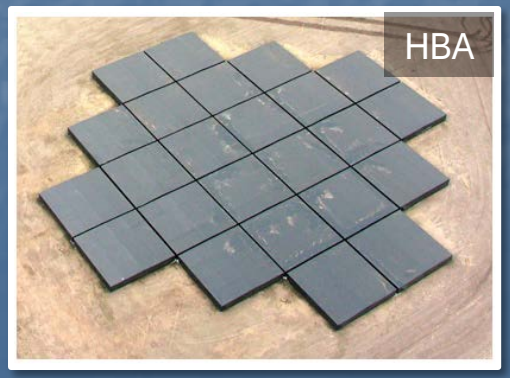




- Array of 50 dipole antenna stations distributed across EU
- 10-250 MHz
- Low band antenna (LBA; 4896 dipole pairs, 96 LBA per station, Area ~ 75200 m^2; 10-90 MHz)
- High Band Antenna (HBA; 47616 dipole pairs, 48/96 tiles per station in NL/EU, Area ~ 57000 m^2; 110-250 MHz)
- Several observing modes (imaging, BF, BF+IM, TBB)
- 96 MHz bandwidth (multi-beam option)

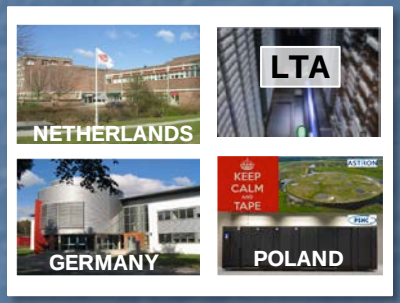
THE LOFAR SYSTEM: DATA FLOW

stations: data collection

COBALT: correlation

CEP4 compute cluster

processing



ingest into Long-term archive (3 sites: NL, D, PL)

- Transport, processing and storage of large amounts of data :
  - Data flow from all antennas combined: 1.7 Tbyte/s
  - To COBALT from station after beamforming: 28 Gbyte/s
  - Correlator output to disk: between 2-10 Gbyte/s
  - Data storage challenges: ~ 80 TB/h
- LOFAR: important technological pathfinder for SKA

THE LOFAR TASK FORCE & COORDINATION

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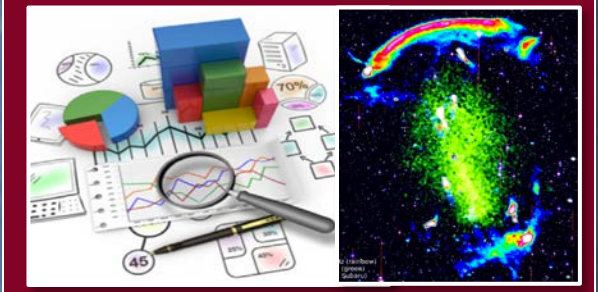
O&M

Operations & maintenance

- Hardware maintenance
- System monitoring

SOS

Science Operations & Support



- Link to community
- Data quality assurance
- Commissioning & research

SDOS

Software Development & Operational Support

- Software development
- Maintenance of software and compute clusters

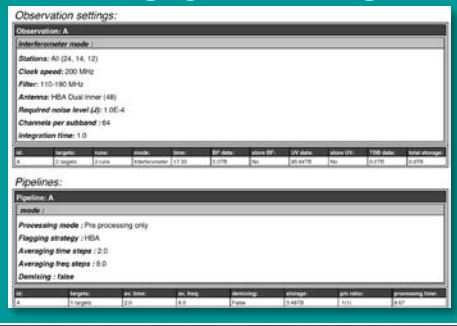
I: HARDWARE HEALTH

- Hardware maintenance
- Wet and corrosive environment
- Challenging to maintain a distributed system
- Monitoring software returns info on element status -> disabling -> maintenance -> re-enabling
- Design of a maintainable/accessible system is important
- Automation hardware status data management

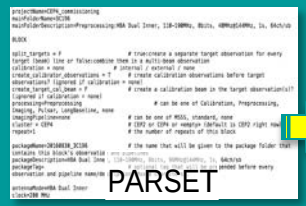
II: OBSERVING/PROCESSING SPECIFICATION

USERS

NORTHSTAR SUBMISSION TOOL – BASIC DETAILS



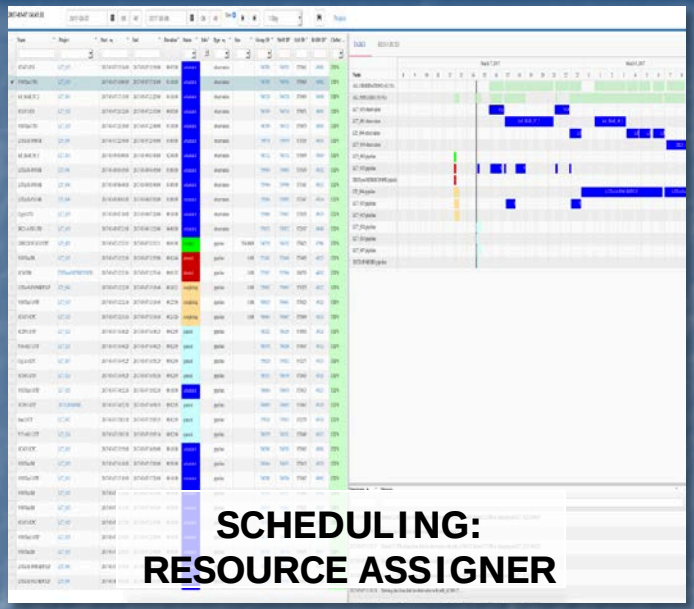
PARSETS GENERATION & MOM



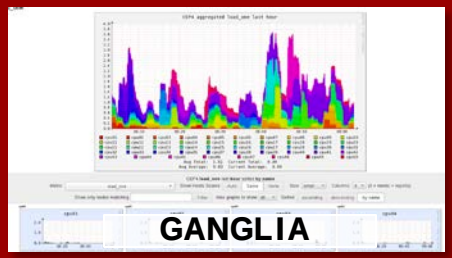
SEMESTER SCHEDULE

- Specification process reflects instrument complexity
- Roughly 1/3 time investment by SOS
- Essential to rely on automatic tools – new specification tool in progress
- Next generation specification tools under development (2018)

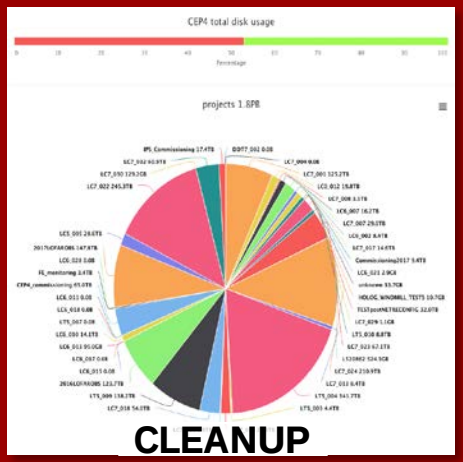
III – RESOURCE MANAGEMENT



CEP4 - PROCESSING

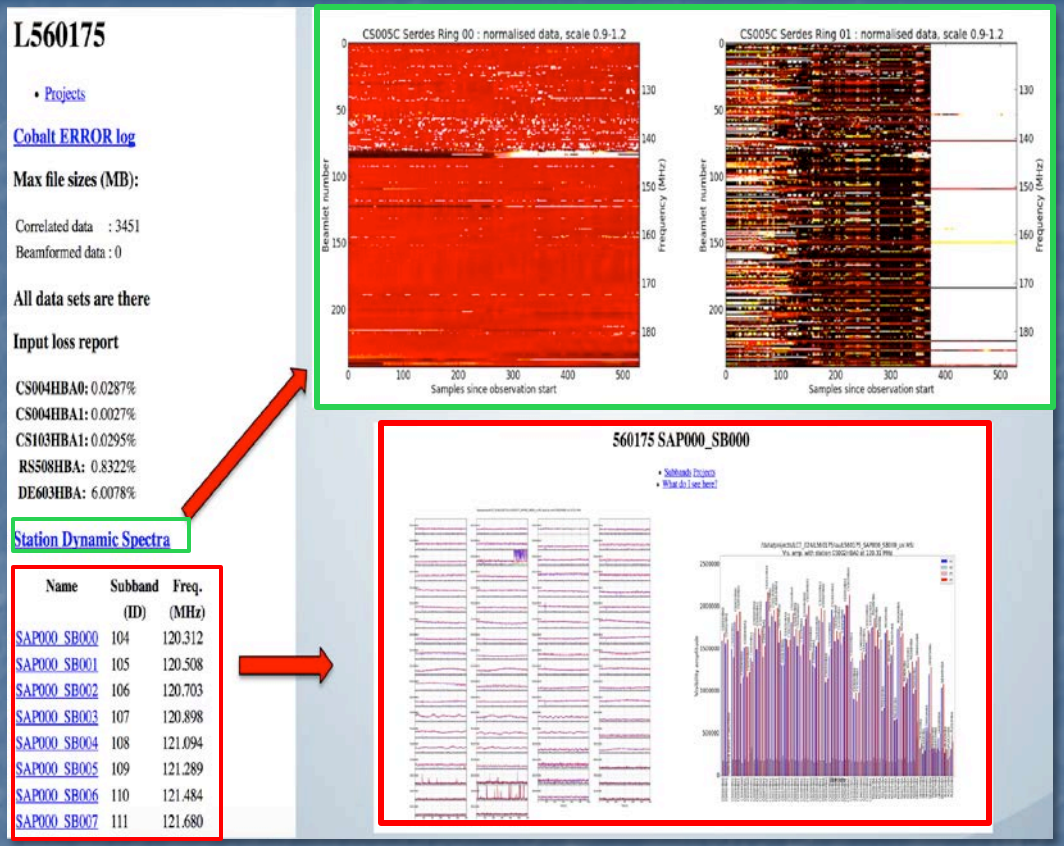


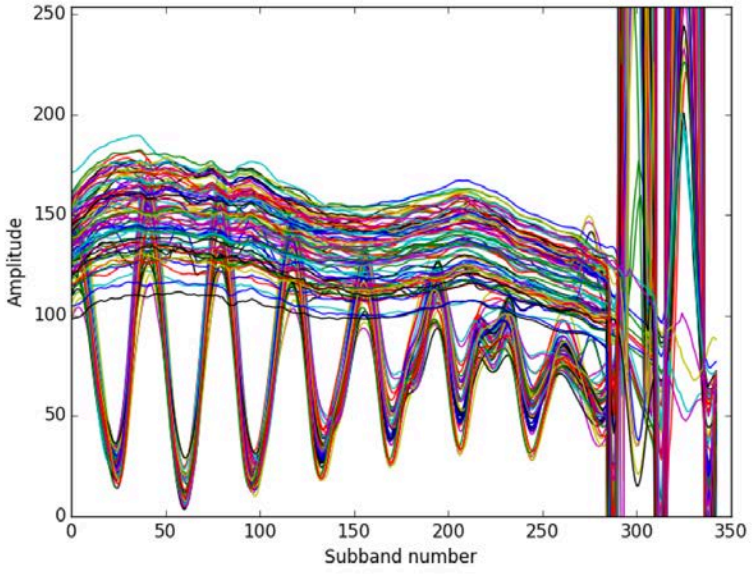
- CPU/network/memory/ SLURM/…

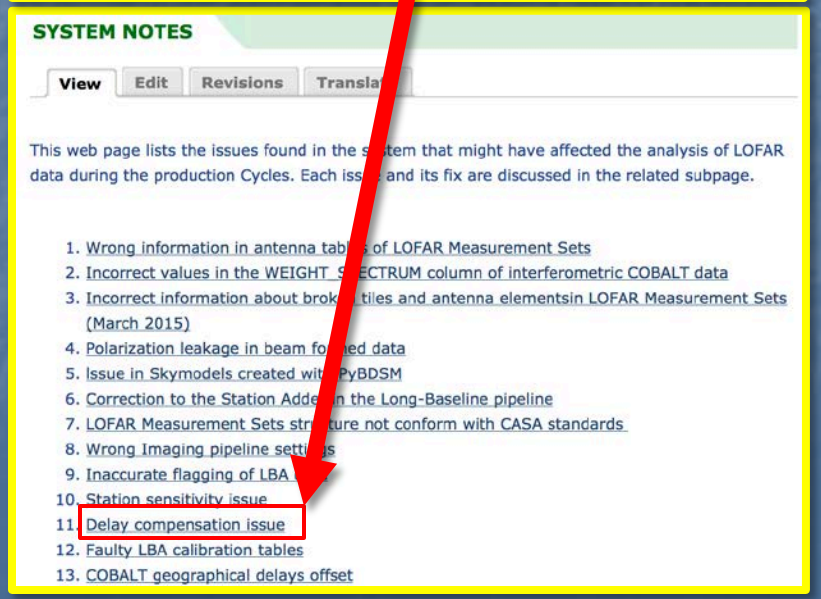


- Keeping steady data flow – per Cycle: 3.5 PB products + 20 PB raw data
- Scheduling on available resources
- Pipeline queue handled automatically: SLURM
- Data cleanup after ingest
- Manual ingest after data quality assessment

IV - DATA QUALITY ASSESSMENT



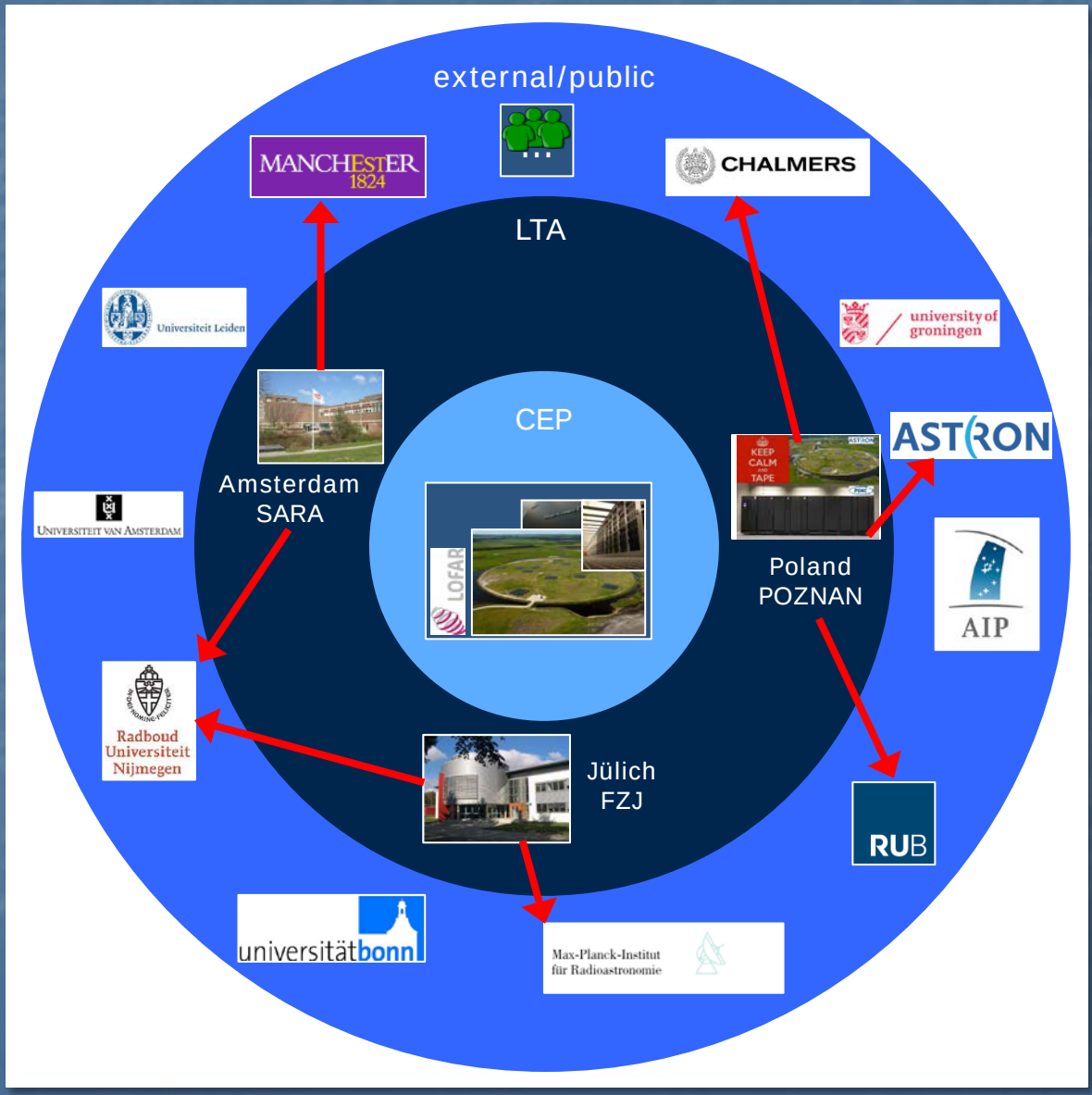




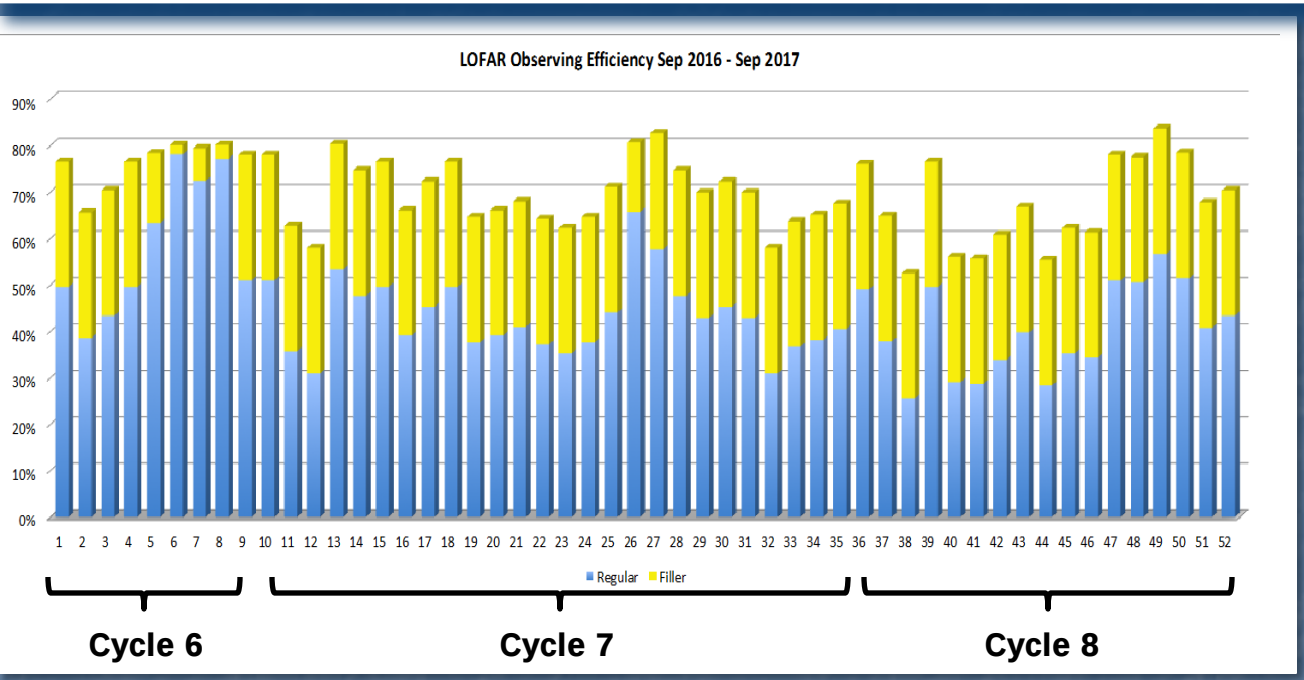
- Inspection plots: > 6000 generated per observation
- Visual inspection - time intensive exercise
- Next generation inspection plots based on AI intelligence being worked on (2018)

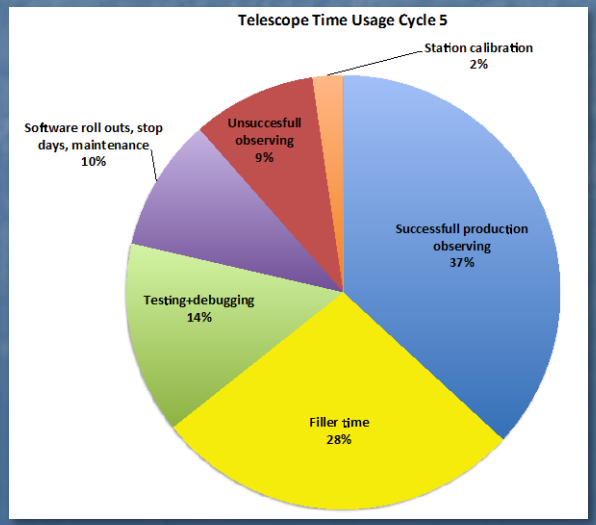
V - DATA SHARING

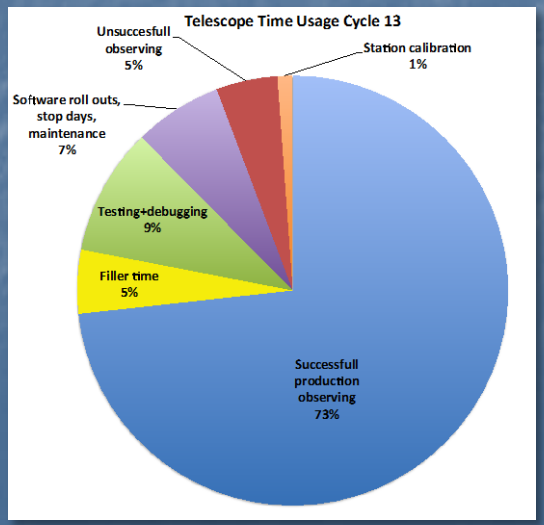
- Scientific exploitation -> data retrieval to external clusters
  - Download limited by instability and shared resources
  - LOFAR software distribution -> support needed
- Moving large amount of data: impractical
  - Exploiting processing resources at the LTA (2018)



VI: OBSERVING EFFICIENCY







- LOFAR: instrument on the move – introducing new functionality -> instability
- Larger and more uniform efficiency requires automation, robustness, and flexibility
- Lesson learned: good foundations are essential
- Efficiency project is the answer (starts now)

VII: CONTINUITY & CAREERS IN SOS

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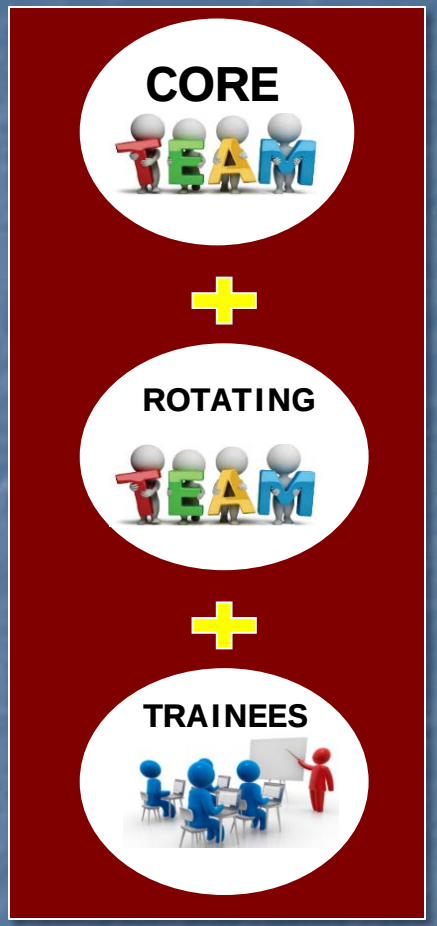
- Complex system demands expertise & continuity
- Expertise needs career perspectives

- 'Core team' – permanent – balance: 2/3 support – 1/3 science research
- 'Rotating' component – temporary – balance: 50%-50%
- Trainees (1-2 per year; share built up knowledge)



SKA
SQUARE KILOMETRE ARRAY

TRAINEESHIP IN SCIENCE OPERATIONS

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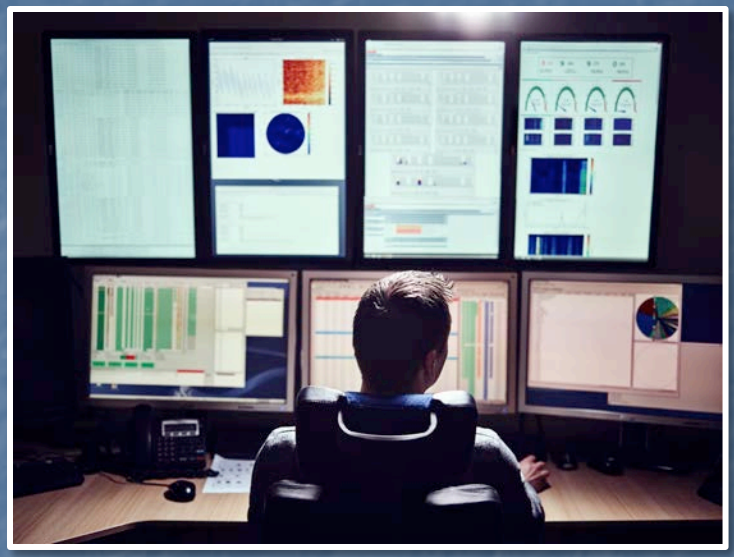
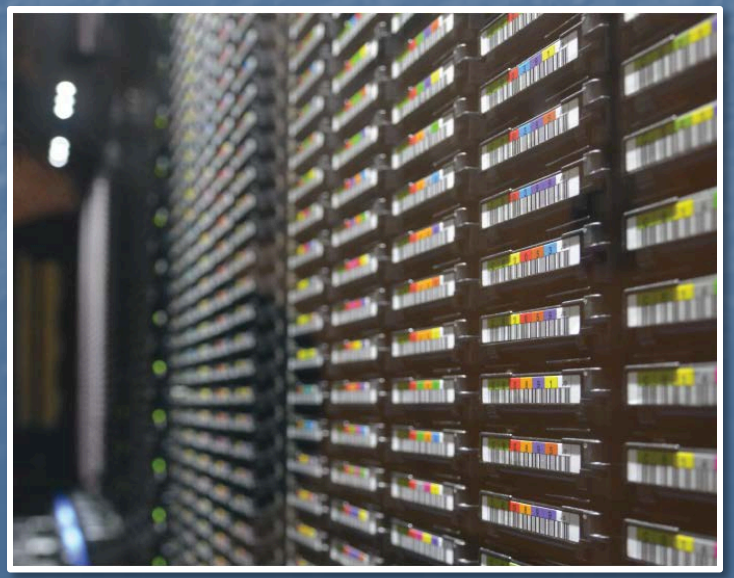
- Share knowledge & experience in operating a massive aperture array
- 12 weeks
- Full immersion into the system
- Direct involvement in operations
- **Contact: pizzo@astron.nl**





OPERATIONAL ACHIEVEMENTS

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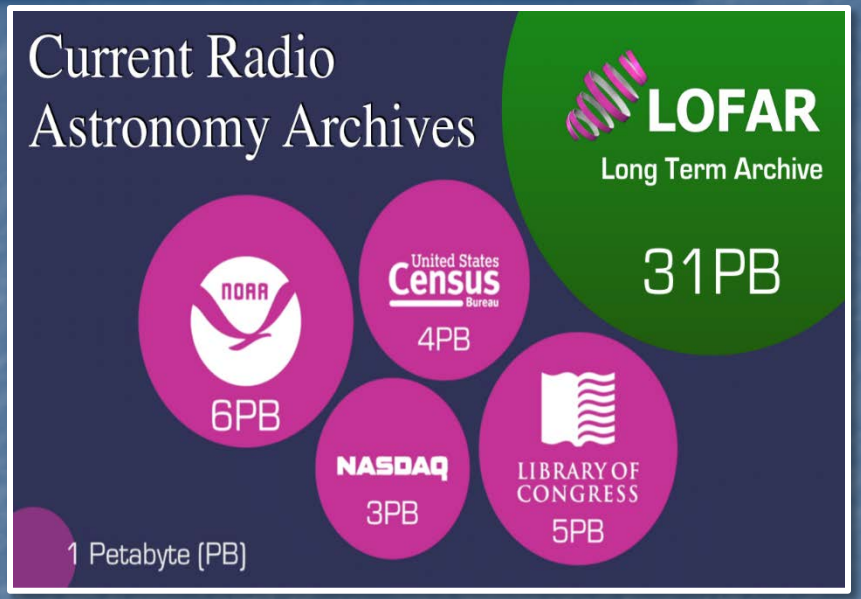
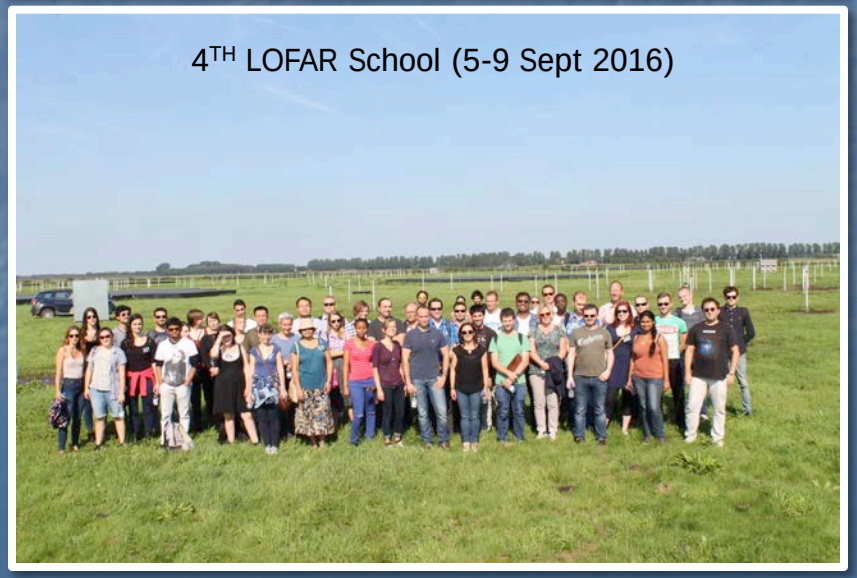
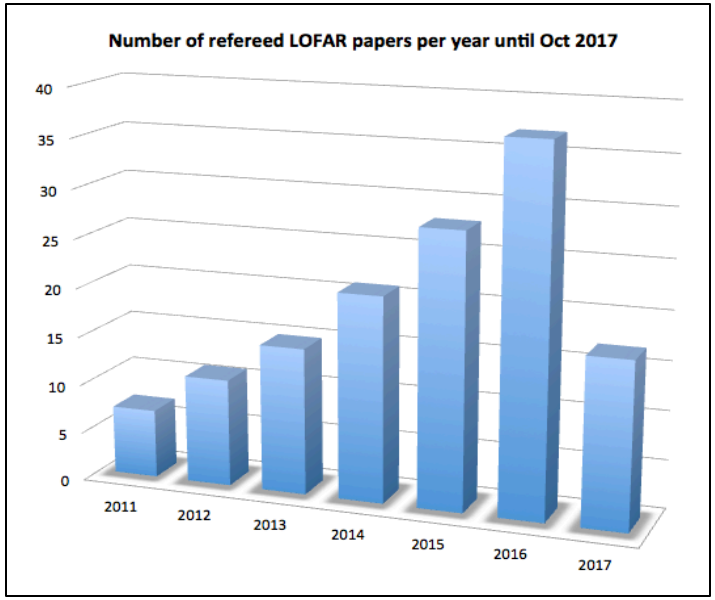
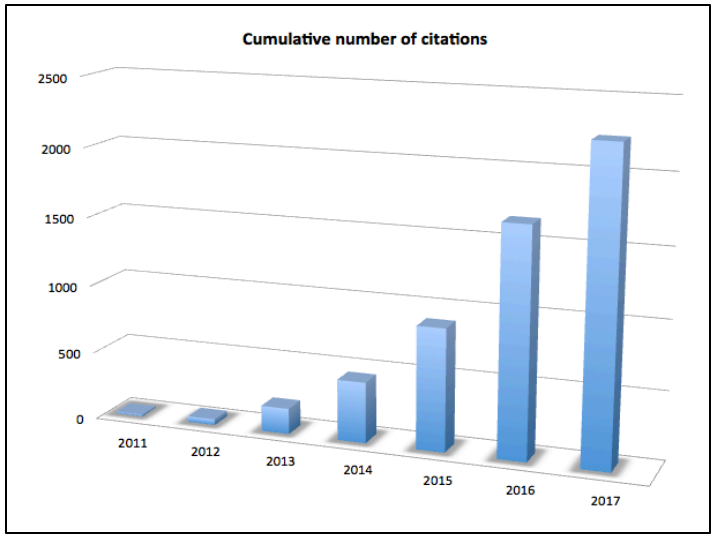
- 8 operational Cycles completed: 15000+ hours observed
- LTA: 31 PB - Largest astronomical data collection to date.
- Community growing in size: 550+ users
  - LOFAR Schools (200+ participants)
  - 60 Busy Weeks

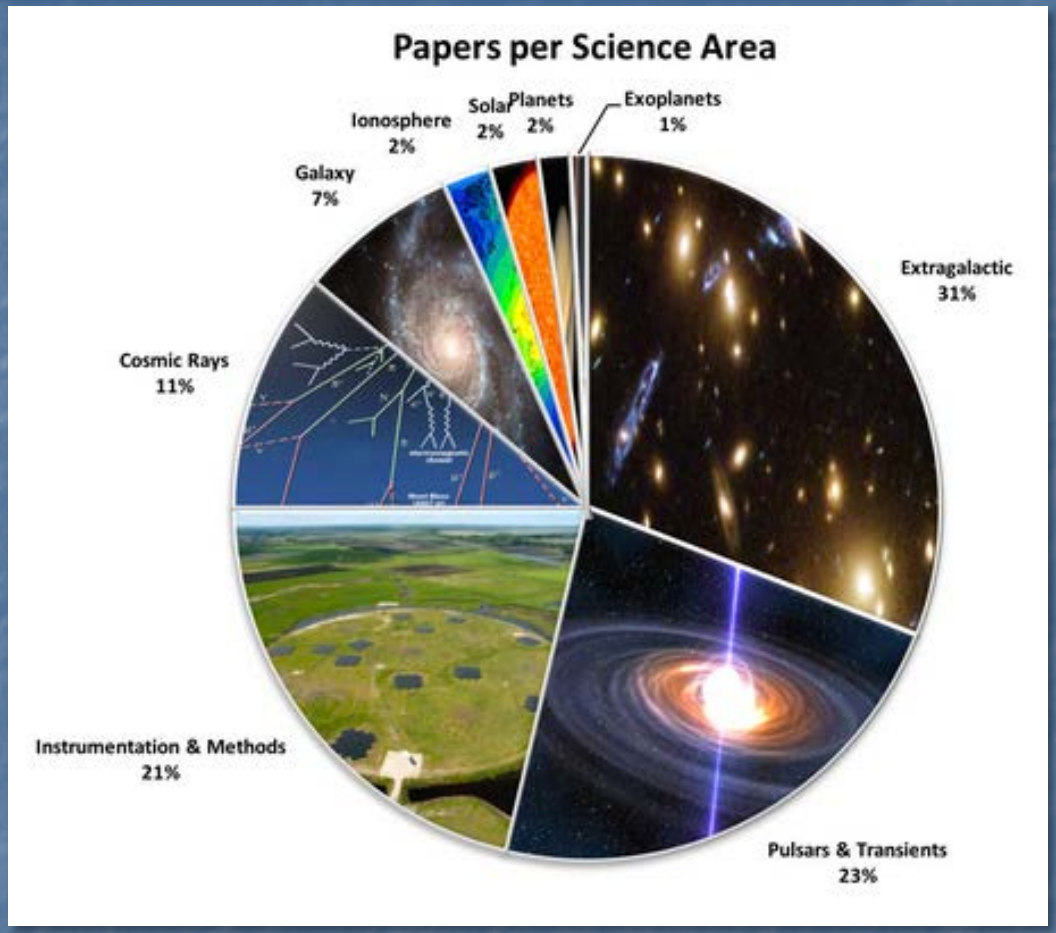




LOFAR Science Productivity

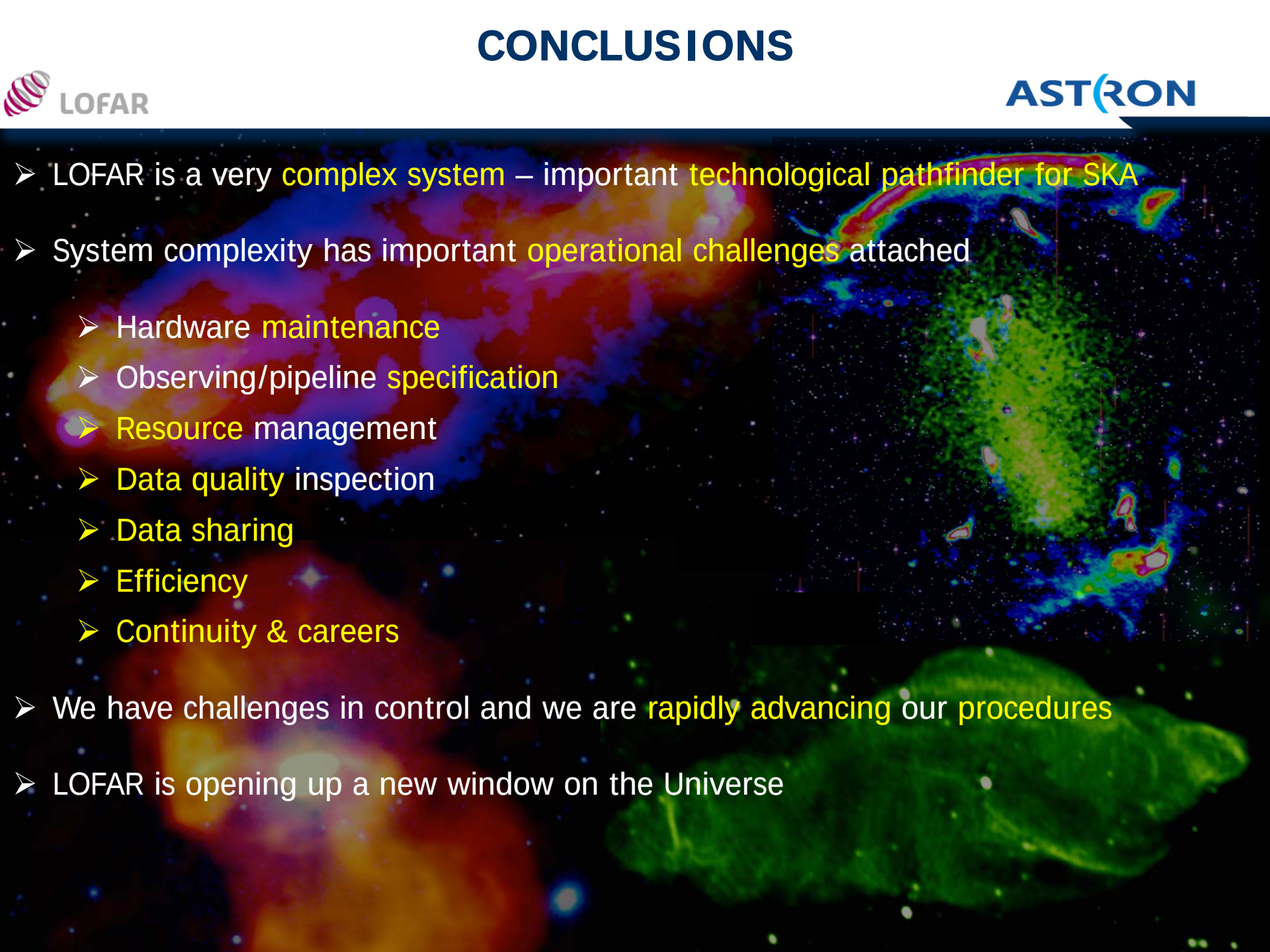






- 136 refereed papers
- 98 unique first authors
- 590 unique authors

CONCLUSIONS



- LOFAR is a very complex system – important technological pathfinder for SKA
- System complexity has important operational challenges attached
  - Hardware maintenance
  - Observing/pipeline specification
  - Resource management
  - Data quality inspection
  - Data sharing
  - Efficiency
  - Continuity & careers
- We have challenges in control and we are rapidly advancing our procedures
- LOFAR is opening up a new window on the Universe