ASKAP early science and pilot surveys

An update on current activity and future plans

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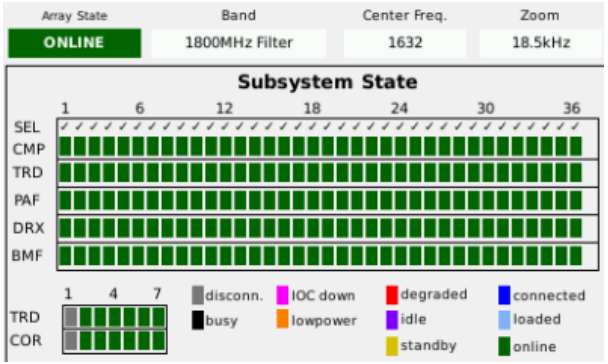
Australian SKA Pathfinder (ASKAP)

- Located within the Murchison Radio-astronomy Observatory
- Prime focus phased array feeds
  - 36 beams, 30 square degree FoV
- 36 antennas, 12m diameter
  - 3-axis mount to track offset beams
- 288 MHz bandwidth
  - 700 to 1800 MHz tuning range
- 15552 channels
  - 18.5 to 1.1 kHz resolution

Telescope commissioning



- Synchronisation of all electronics last week
- 28 out of 36 antennas fully integrated
  - Planning to complete all measurements this month
  - Gearbox replacement on two antennas this week

- ASKAP opened in October 2012
  - *Expect major design revisions to follow from field experience*
  - *Allow sufficient time to test prototypes under real conditions*

- Many long-term improvements possible during operations:
  - Clean-up of alarm system, reliability improvements, beamforming research, imaging software and pipeline improvements, split frequency modes, etc.

ASKAP science goal summary

- *Understanding galaxies, their environments and their evolution through large scale radio continuum and spectral line surveys*
  - EMU: Continuum survey, millions of new starburst and AGN detections
  - WALLABY: Neutral Hydrogen survey, studying local group dynamics

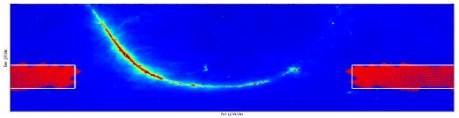
- Polarisation and cosmic magnetism
- HI absorption, stacking, galactic HI
- Transients and variable sources

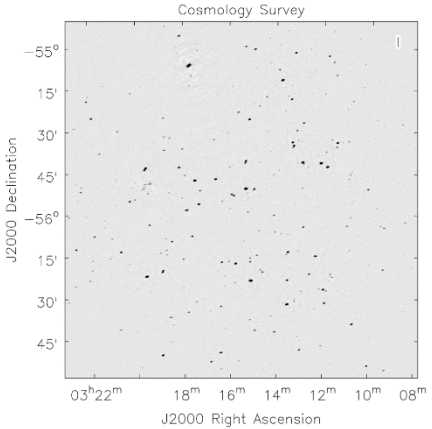
- Explore the unknown by opening new parameter space

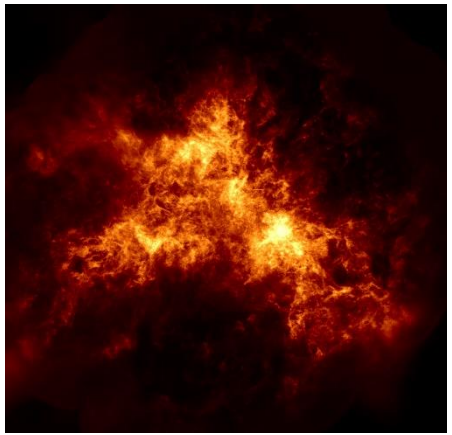
- Pioneer the emerging field of fast transient detection and localisation

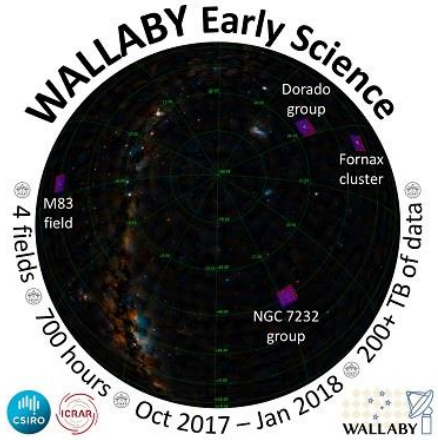
Highlights from early science

- WALLABY ES papers I & II
  - NGC 7232 data on CASDA soon
- Continuum cosmology survey
  - Data on CASDA now
- Small Magellanic Cloud in HI
  - Improved sensitivity and resolution
- 20 new Fast Radio Bursts
  - Localisation efforts underway





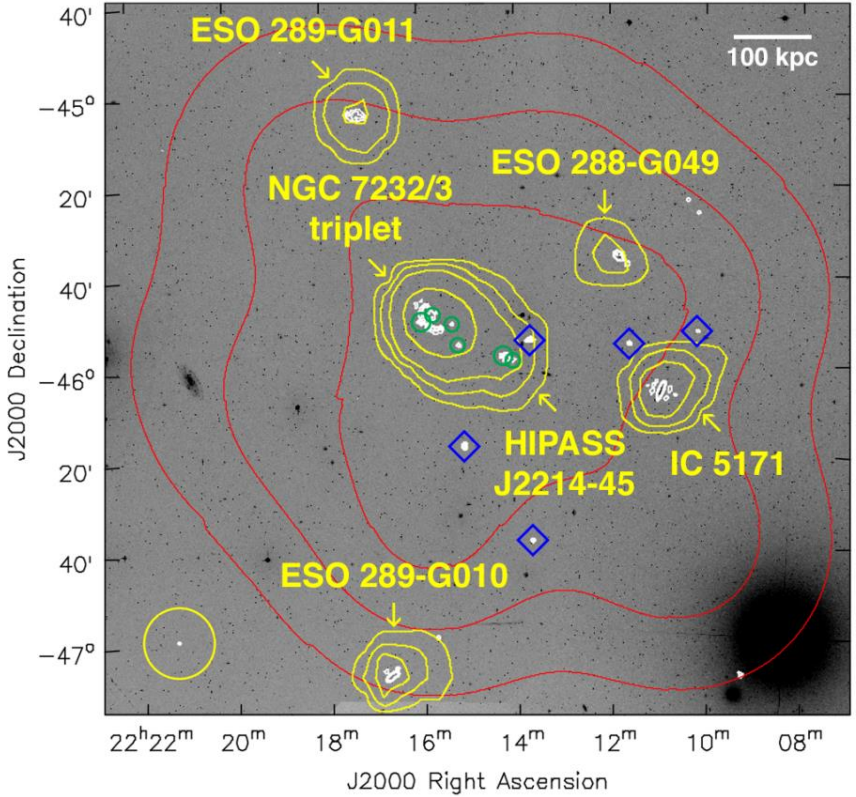




WALLABY Early Science

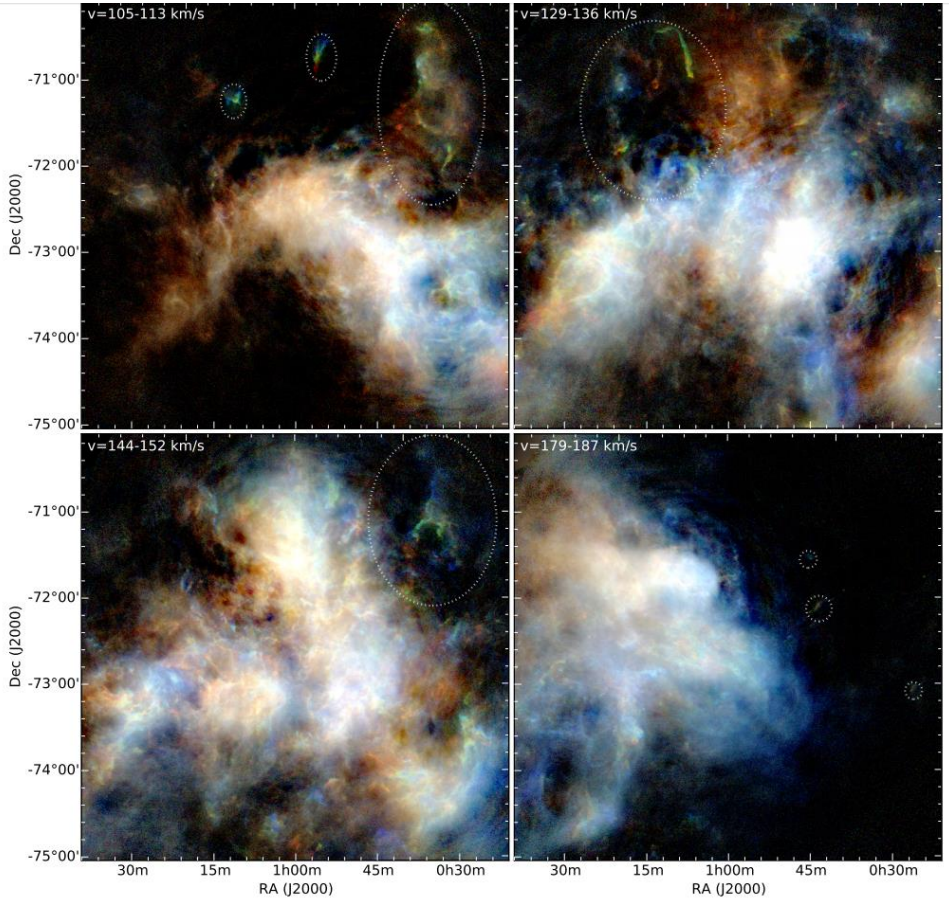
- Lee-Waddell et al. 2019
- 12 antenna array

- Region around NGC 7232
  - Yellow = HIPASS
  - White = ASKAP
  - Background = DSS
  - Blue triangles = new detections with stellar counterparts



Small Magellanic Cloud

- McClure-Griffiths et. al. 2018
- Highest ever resolution and sensitivity image of the SMC
  - Observational evidence for strong atomic hydrogen outflows
- New features observed
  - comet-shaped head-tail clouds
  - enormous looping HI filaments
  - compact high-velocity clouds
- The whole SMC fits in one field!

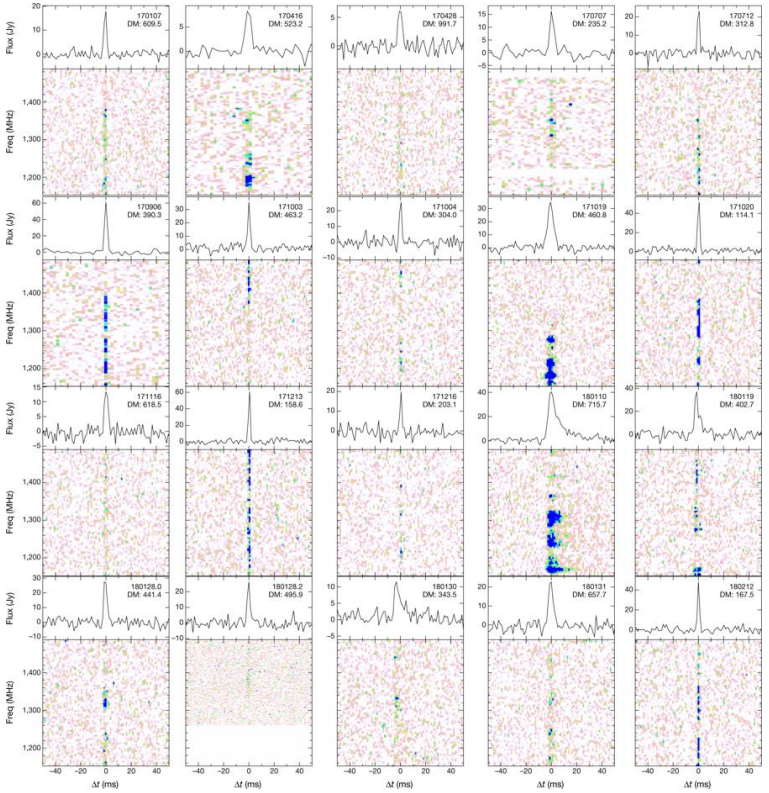


20 new Fast Radio Bursts

- Shannon et. al. 2018
- Fast filter-bank download and fly's eye

- Dispersion – brightness relation
  - FRBs have cosmological origin

- Next step is localisation
  - Using triggered voltage capture
  - Can run in commensal mode
  - Goal is to identify FRB host galaxies



Sequence of events in 2019

- Major control system feature releases complete
  - Fringe tracking per beam, frequency zoom modes
- Final array release with 36 antennas
- Publication of specifications and performance metrics
- Request for detailed pilot survey strategies
- Full-scale test observations to inform survey strategies
- Rapid ASKAP Continuum Survey (RACS)
- Commencement of pilot survey observations
- Transition to full survey operations over time

ASKAP pilot survey plan

- ASKAP was designed to be a survey telescope, however:
  - Surveys are usually done by mature, well-understood instruments
  - ASKAP's operational model is new to the Southern radio community
  - 5-year observing plans need to be tested and verified in advance

- Pilot surveys will assess proposed modes and strategies
  - Need to focus on technical validation before science
  - Limited time allocation of 100 hours per team for pilot surveys
  - Community involvement in data processing is critical to success
  - Service observing model shifts traditional responsibilities

  - https://confluence.csiro.au/display/askapsst/Pilot+Surveys

Rapid ASKAP Continuum Survey

- ASKAP's most advanced feature is its wide field of view
  - Excellent UV coverage makes snapshot imaging viable
- Can achieve NVSS sensitivity with 10-minute observations
  - With 30 square degree FoV, can survey the entire sky in a week
  - Survey science teams all have much deeper imaging in mind

- Rapid survey mode will be run as an observatory project
  - Should provide a greatly improved Southern sky model
  - Repeated rapid surveys will study the dynamic universe

Community engagement with commissioning

- ASKAP's large science teams make communication challenging
  - Need feedback from experts, but without inundating developers
- The ASKAP commissioning team (ACES)
  - Formed from operations, engineering and experts in each science field
  - First priority is the telescope itself - solving issues that cross team boundaries
  - Help determine engineering priorities for bug fixes and future development
  - Provide a single point of contact to large science teams
    - Work closely with operators to develop processing strategies

- Centralised data processing requires tight resource control
  - Sharing disk space, CPU time, etc. has been a real challenge

Image processing strategy

- The original ASKAP plan called for automated, real-time processing
  - Projected to be the only way to achieve 100% duty cycle
  - Relies upon real-time calibration using a sky model
  - Assumes that processing parameters are known in advance
  - Completely isolates astronomers from calibration and imaging
  - Assumes data are perfect *(simulations do not adequately test software!)*

- Experience with early science prompted a shift in priorities
  - Real-time processing is extremely restrictive
    - Makes parameter tuning and fault investigation nearly impossible
  - Lack of framework meant pipeline scripts arose out of necessity
    - Should have designed a flexible batch processing scheme from the start
  - *High duty cycle is useless if the image quality is poor!*

CSIRO ASKAP Science Data Archive

- ASKAP will produce roughly 5 PB of *images* per year
  - These, and associated catalogues, will be stored online
- The CSIRO ASKAP Science Data Archive (CASDA):
  - Stores quality-controlled data from each scheduling block
  - Stores value-added products created by external science teams
  - Has a Virtual Observatory interface to facilitate access
  - Is intended to be the primary interface to the telescope

- NGC7232 and Cosmology data now available
- https://data.csiro.au

Summary

- ASKAP will be fully operational this year
  - Many lessons learnt during commissioning
  - Only the beginning, many improvements possible

- Early science observations demonstrate exciting potential
- Full-scale pilot surveys commencing in the next few months

- Precursor communities are the SKA regional centre prototype
  - Building on experience helps reduce risk

Thank you