Six of the 36 ASKAP dishes (photo by Maxim Voronkov, CASS)

The Australian SKA Pathfinder

Dr. B. S. Koribalski

CSIRO, Australia Telescope National Facility

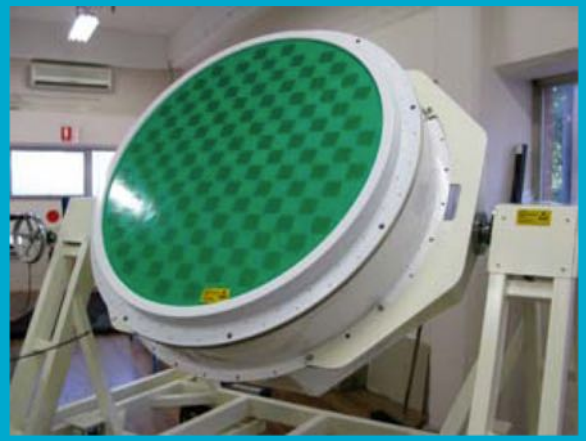
Six of the 36 ASKAP dishes (photo by Maxim Voronkov, CASS)

The Australian SKA Pathfinder

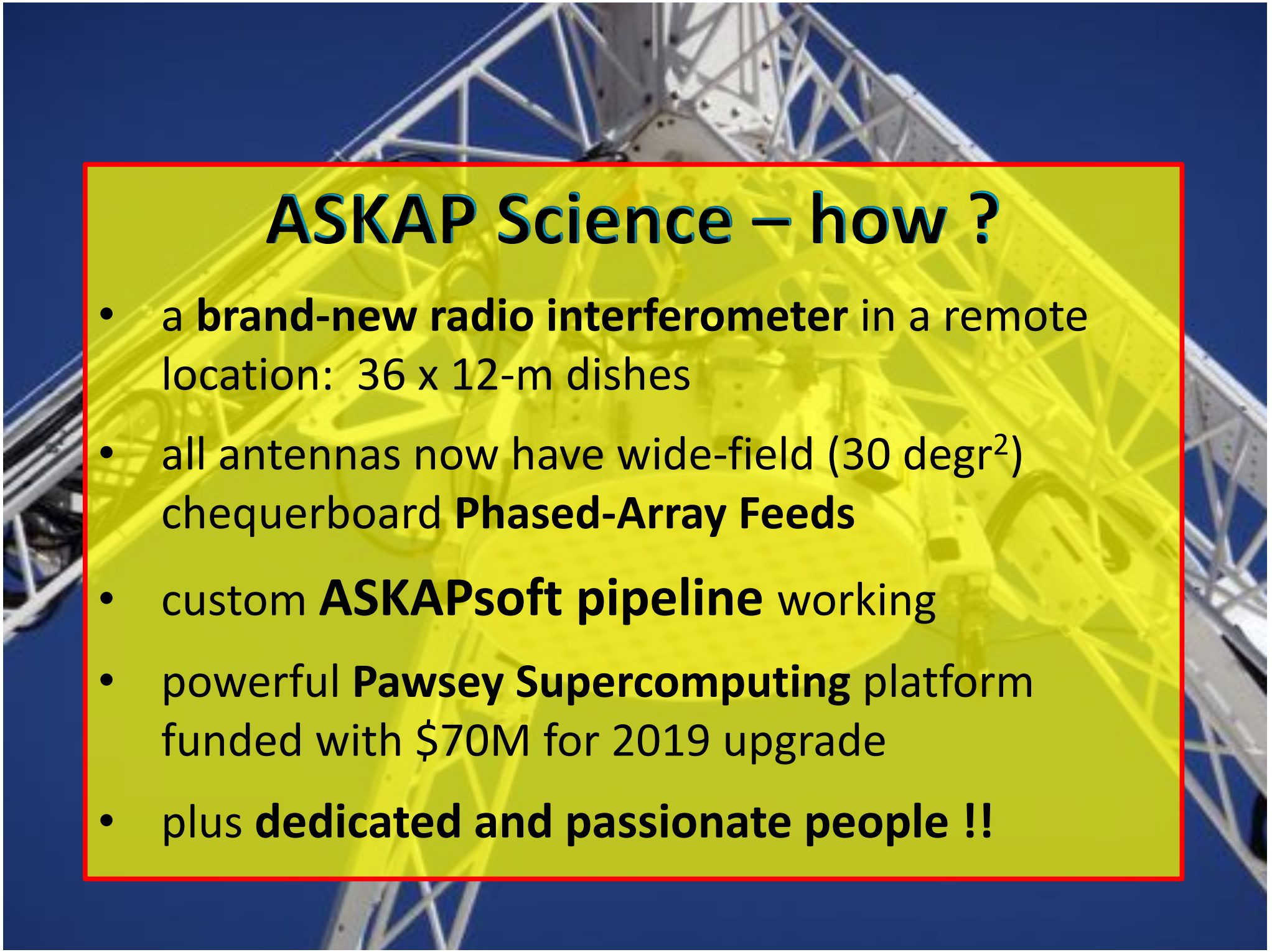
- **ASKAP**: 36 ×12-m dishes forming a **6-km diameter** radio telescope, frequency coverage = 0.7 – 1.8 GHz; resolution 10 – 30 arcsec, 4 km/s
- wide-field **Phased-Array Feeds (PAFs)** deliver FOV = 30 sq degr
- ASKAP's **data rate** is expected to be **72 Tbit/s** (once fully operational), data output **~500 PB/yr**; most raw data will be stored only temporarily; data products (images/cubes/catalogs) in **CASDA**

Six of the 36 ASKAP dishes (photo by Maxim Voronkov, CASS)

First generation Phased Array Feed (PAF)

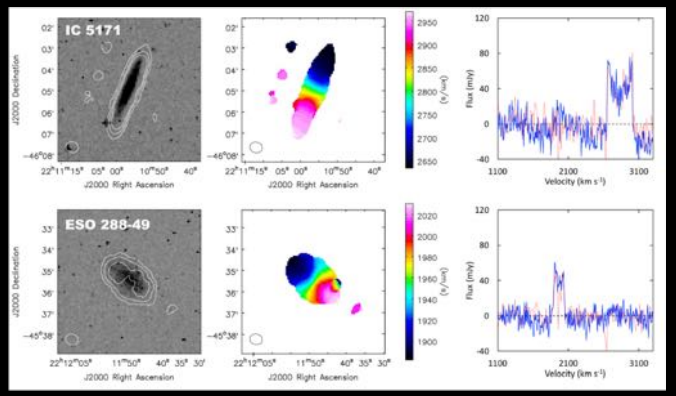


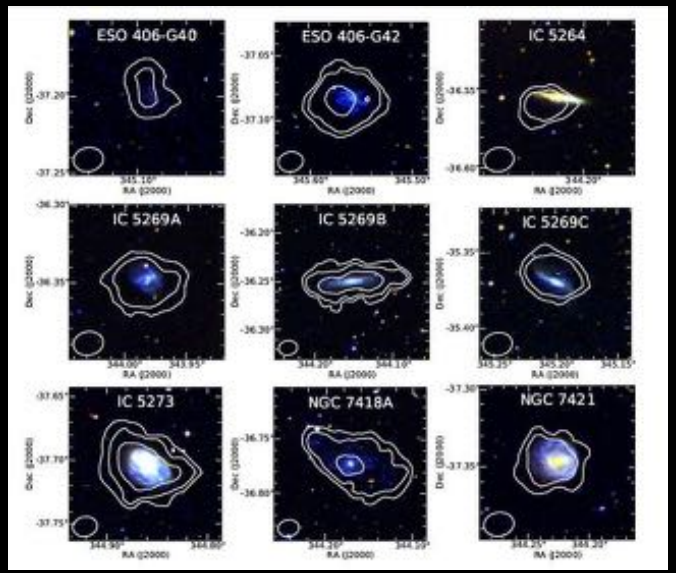
ASKAP - Mk II PAFs now installed on all 36 antennas

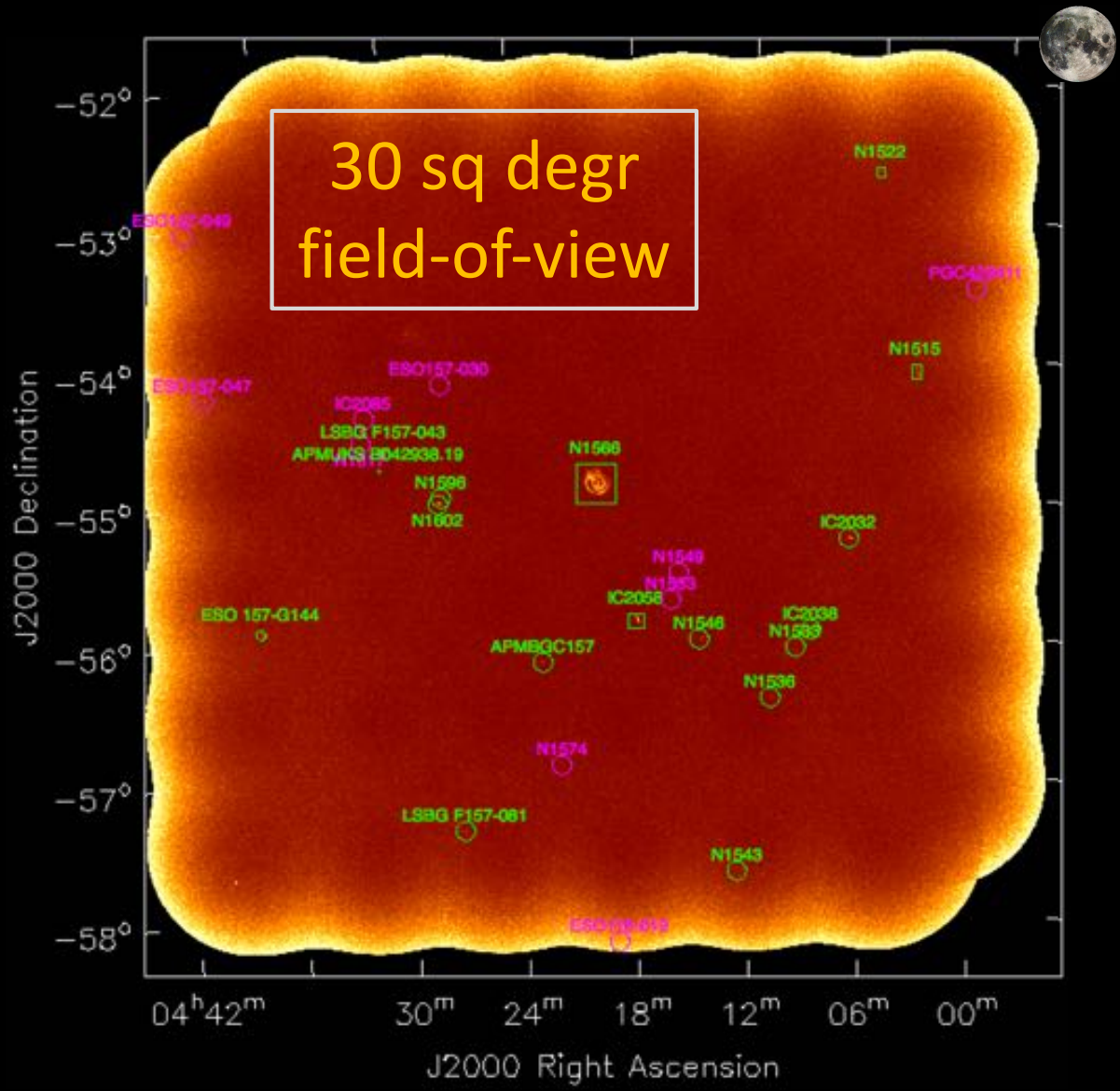


ASKAP Science – how ?

- a **brand-new radio interferometer** in a remote location: 36 x 12-m dishes
- all antennas now have wide-field (30 degr^2) chequerboard **Phased-Array Feeds**
- custom **ASKAPsoft pipeline** working
- powerful **Pawsey Supercomputing** platform funded with $70M for 2019 upgrade
- plus **dedicated and passionate people !!**



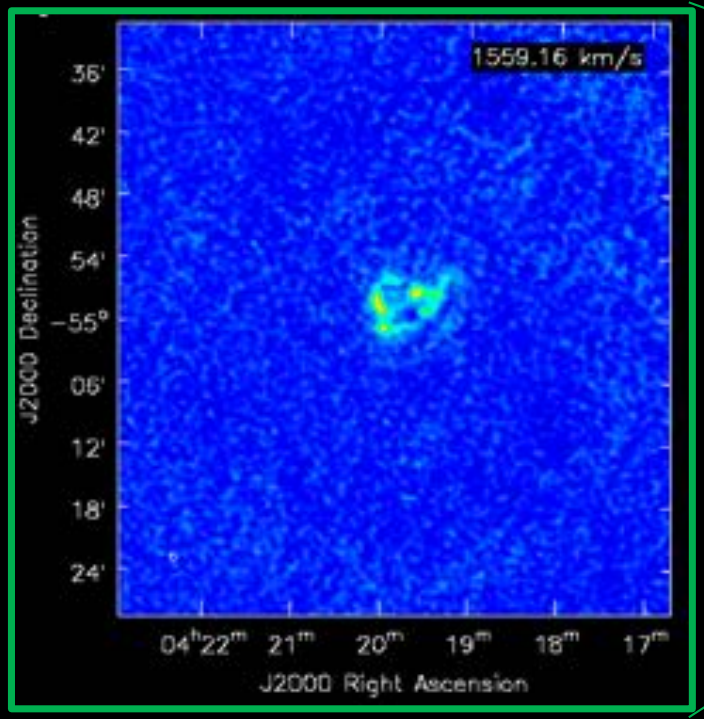




WALLABY Early Science - papers

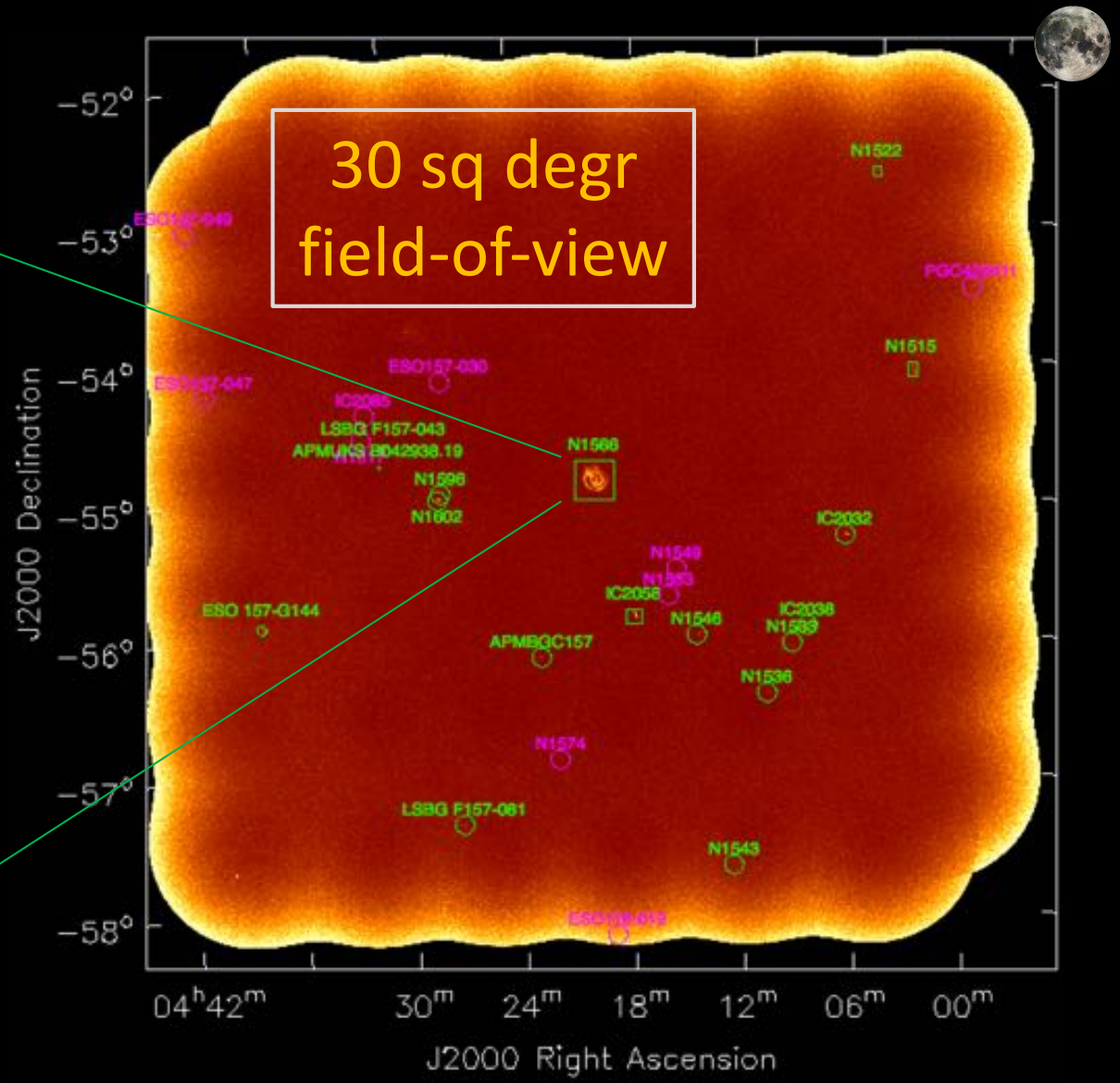
Serra et al. (2015), Lee-Waddell et al.,
Kleiner et al., Reynolds et al., Rhee et al.,
Elagali et al., Koribalski et al. (2018, in prep.)

Spiral galaxy NGC1566



Each observation

- 36 beams x 630 baselines
- 30 sq degrees FOV
- 16384 channels
- 30 arcsec, 4 km/s resolution



WALLABY Early Science - papers

Serra et al. (2015), Lee-Waddell et al., Kleiner et al., Reynolds et al., Rhee et al., Elagali et al., Koribalski et al. (2018, in prep.)

Part 1: ASKAP Pathfinder for SKA

Part 2: wide-field Phased Array Feeds

Part 3: Industry collaborations

WALLABY

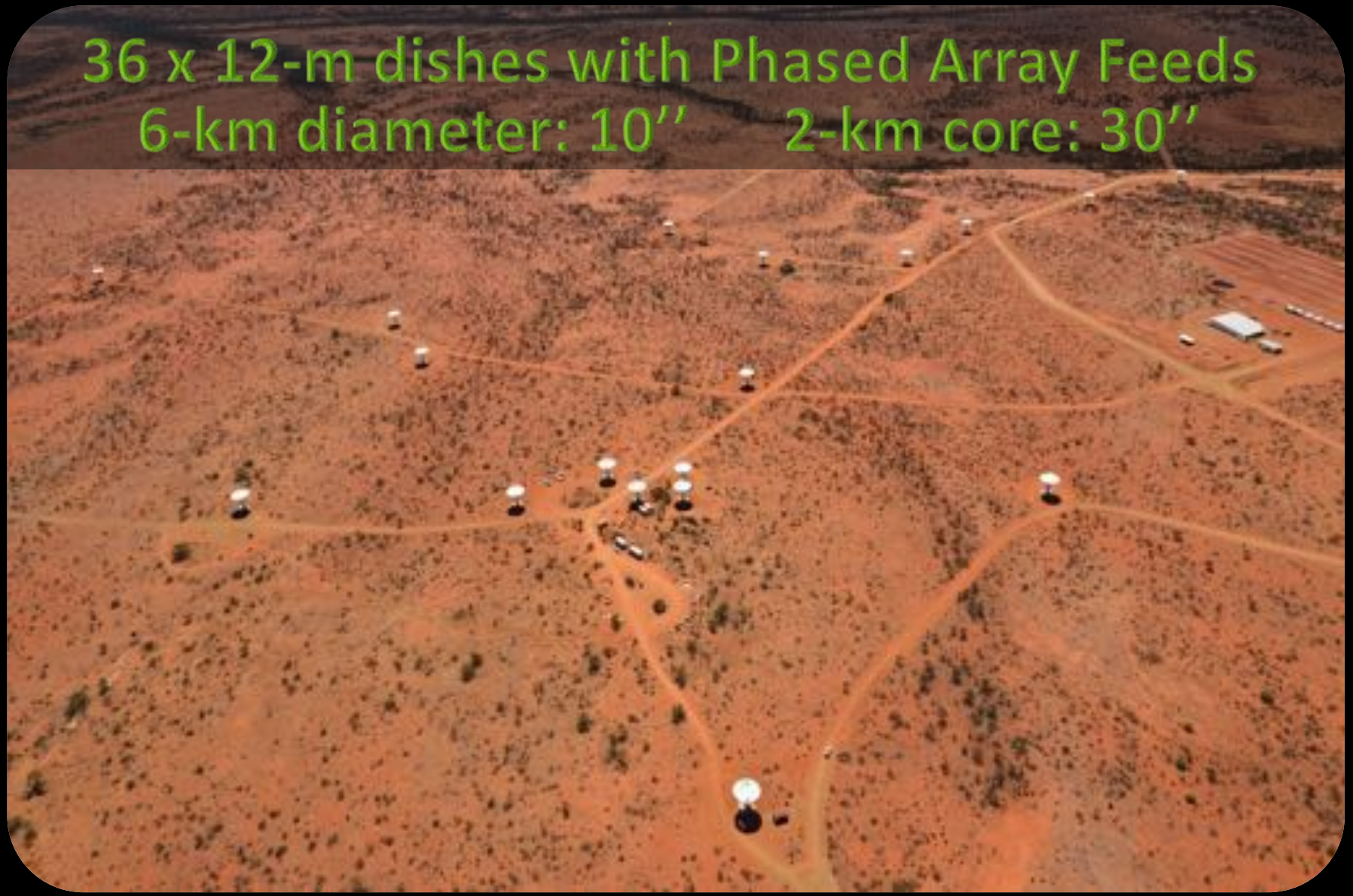
ASKAP HI All Sky Survey

~600 000 galaxies

Hydrogen in and between Galaxies

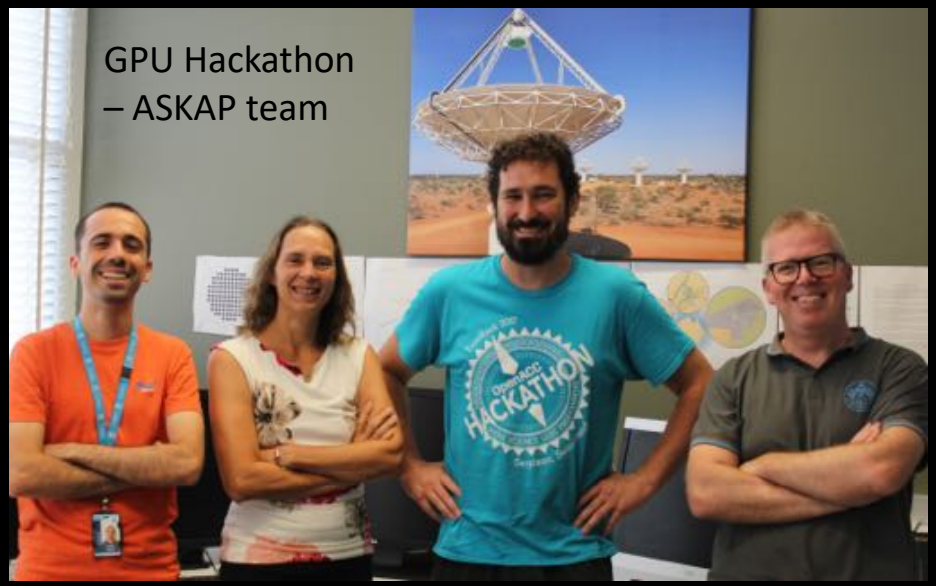
3D Visualisation of gas and stars in galaxies via Splotch (with Claudio Gheller, Tim Dykes, et al.)

Australian SKA Pathfinder



ASKAP: step by step

ASKAP: step by step



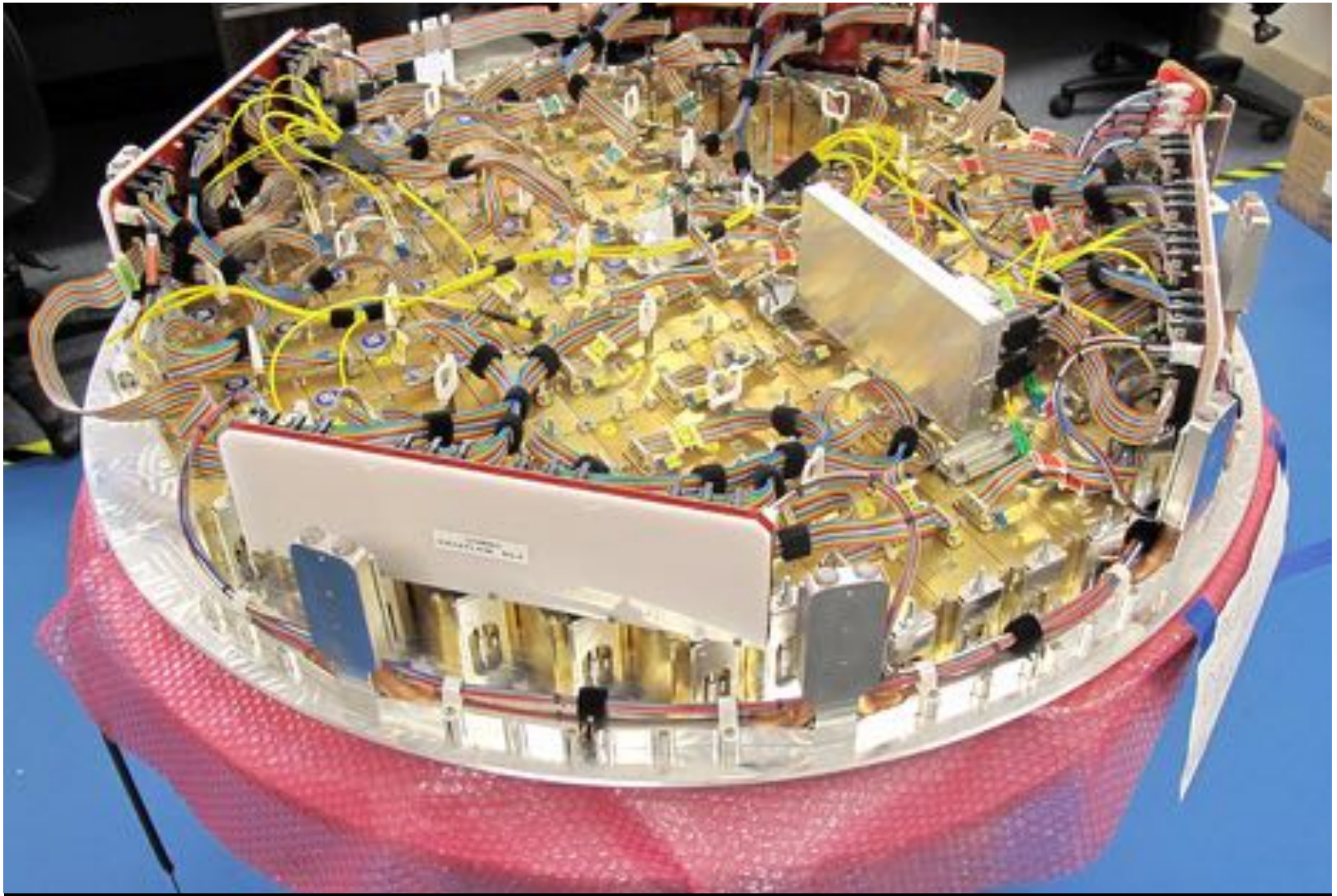
ASKAP: step by step

Currently observing with ASKAP-18; full ASKAP-36 ready early 2019

Our neighbours: MWA and SKA-Low

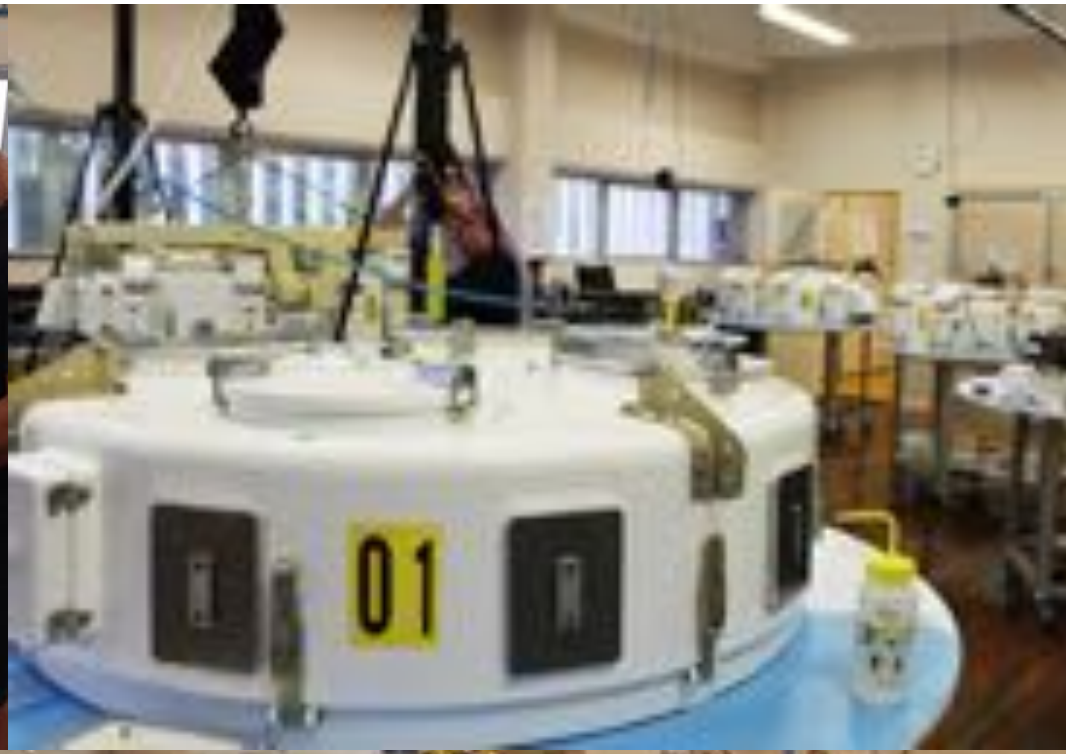
ASKAP: step by step

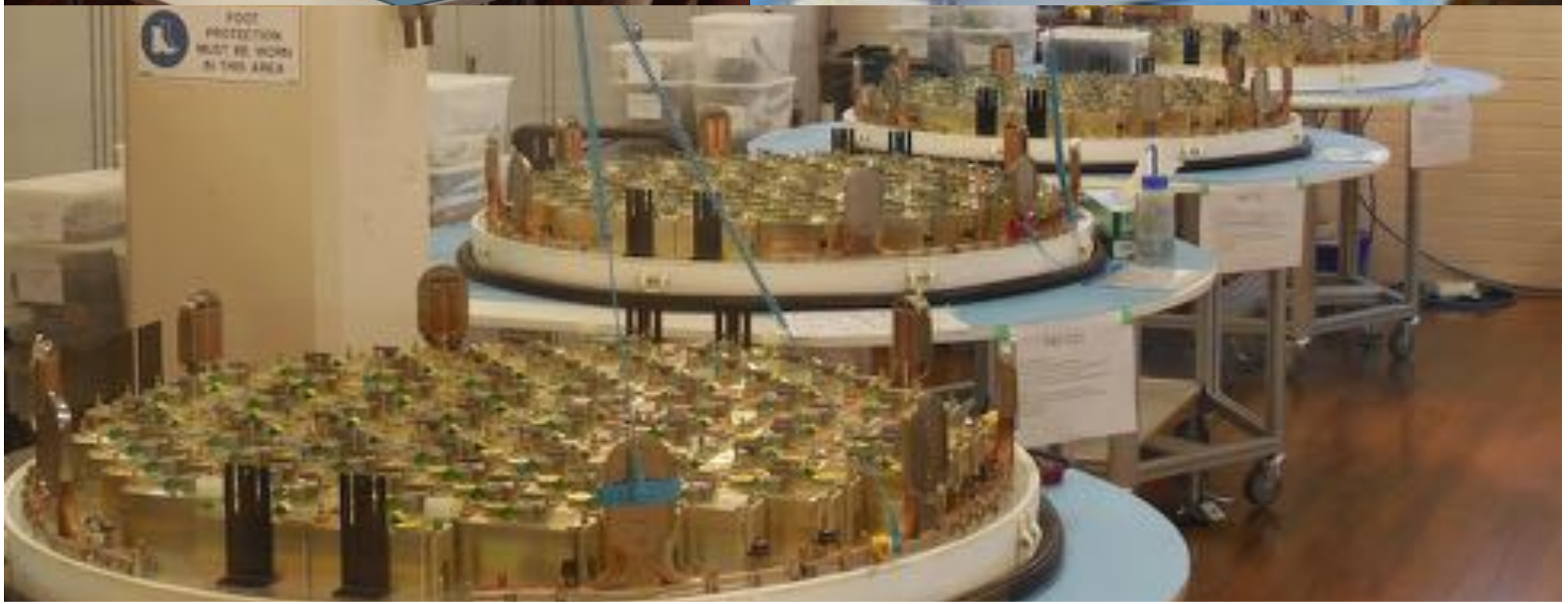
ASKAP - Mk II PAFs now installed on all 36 antennas

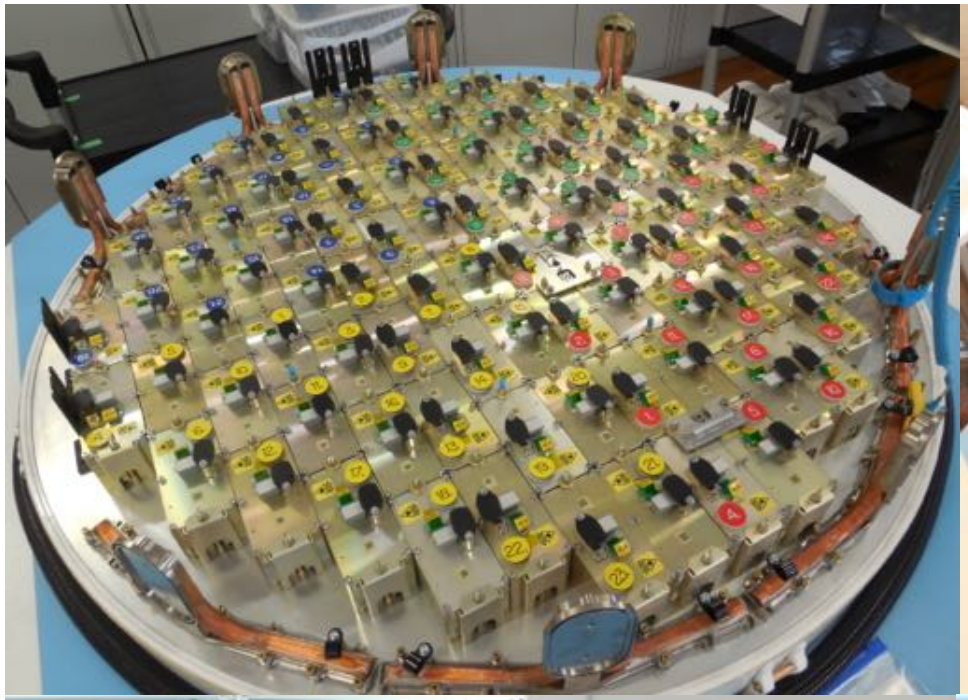


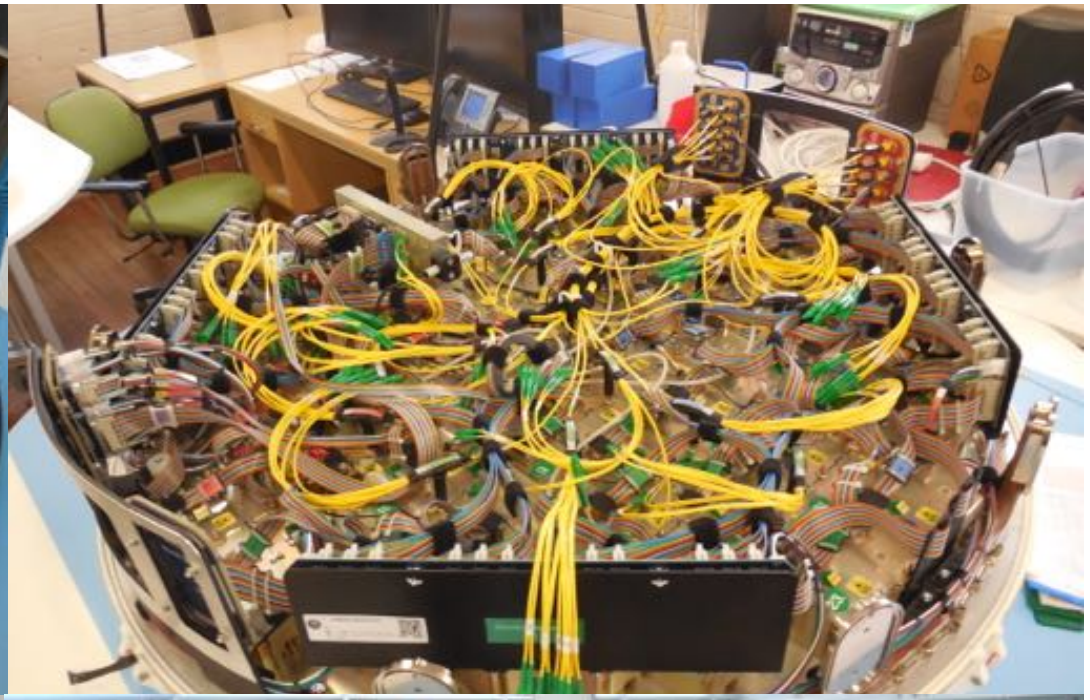
ASKAP Mk II Phased Array Feed (PAF) assembly


#14


01

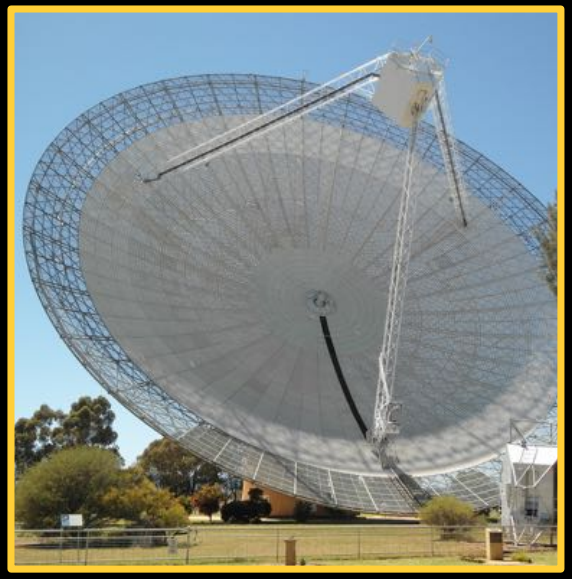

FOOT
PROTECTION
MUST BE WORN
IN THIS AREA





INNOVATION COMPOSITES

PUZZLE PRECISION

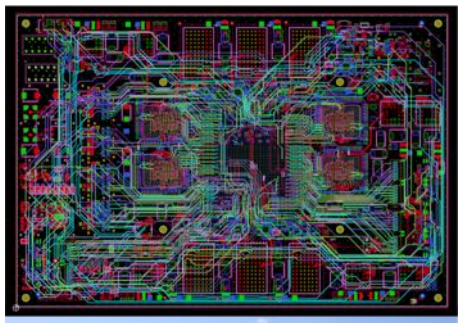


Parkes 64-m dish
with 21-cm multibeam receiver

New
19-beam receiver for FAST

Now Rocket PAF testing

CASS's role in SKA1-Low pre-construction



- **Leading** Australian Infrastructure consortium
  - ➢ Engineering work by Aurecon
- **Leading** correlator and beamformer for SKA1-Low
  - ➢ with ASTRON and AUT
- Australian lead for Assembly, Integration and Verification
- Imaging and calibration in Science Data Processor
- Contribute to Signal and Data Transport, Telescope Manager
- Recently invited to join Low Frequency Aperture Array on behalf of MWA
- Many other Australian organisations also working on SKA1-Low, including ICRAR (Curtin and UWA), AARNet, Swinburne, industry partners

SKA SQUARE KILOMETRE ARRAY CSP
CENTRAL SIGNAL PROCESSOR

SKA SQUARE KILOMETRE ARRAY SDP
SCIENCE DATA PROCESSOR

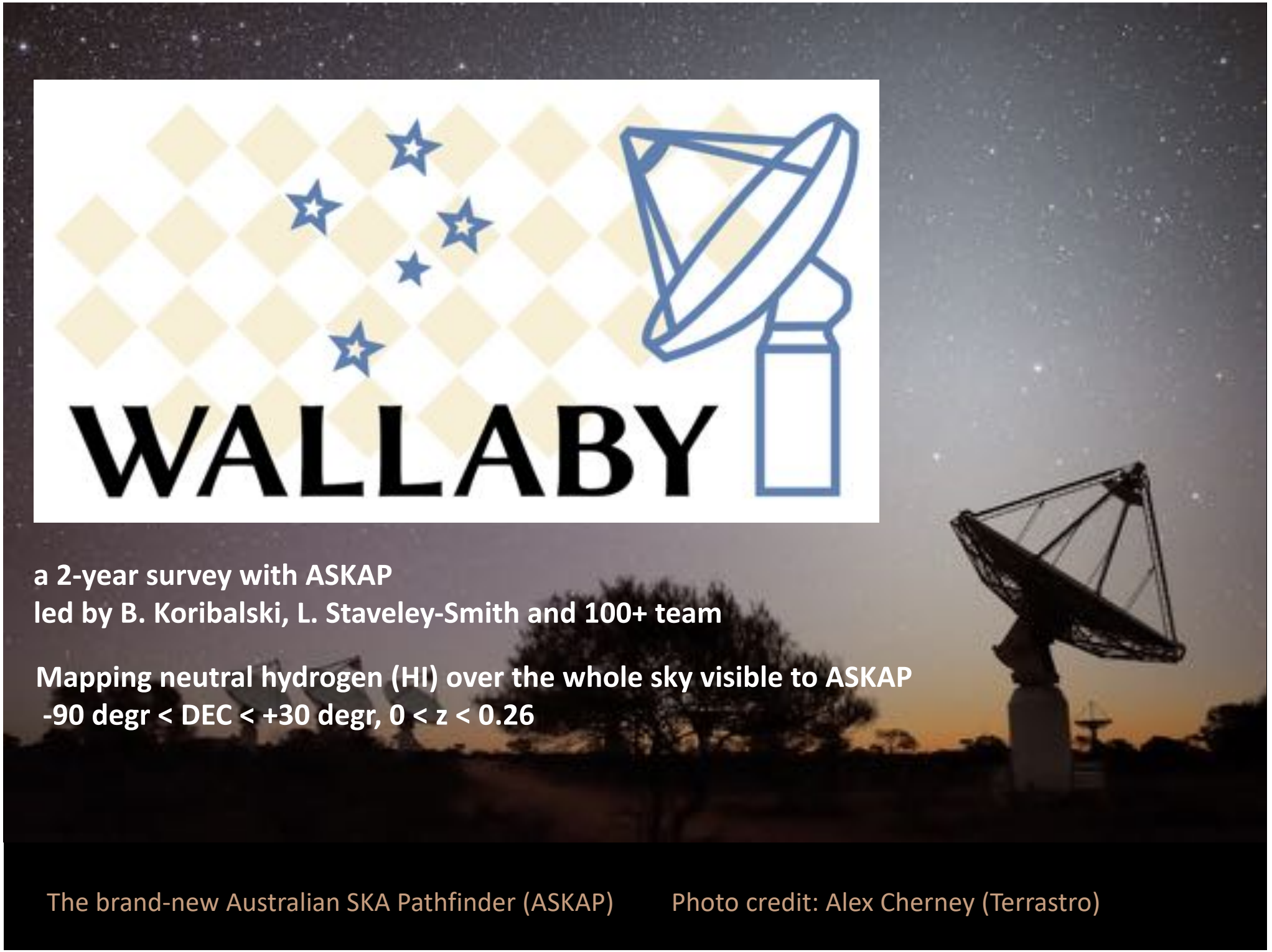
SKA SQUARE KILOMETRE ARRAY
ASSEMBLY, INTEGRATION & VERIFICATION

SKA SQUARE KILOMETRE ARRAY
LOW-FREQUENCY APERTURE ARRAY

SKA SQUARE KILOMETRE ARRAY
SIGNAL AND DATA TRANSPORT

Australian SKA Consortium Roles in Pre-Construction (until end of 2018)

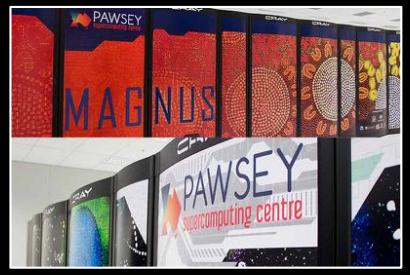
Consortium	Australian partners
Assembly Integration and Verification	**CSIRO**
Central Signal Processor	**CSIRO**, ICRAR, Swinburne University of Technology, CISCO Australia
Dish	**CSIRO (consortium lead),** RPC technologies
Infrastructure Australia	Aurecon, **CSIRO (consortium lead),** Horizon Power, Radio Quiet Zone (RQZ) Solutions Rider Levett Bucknall
Low Frequency Aperture Array	ICRAR
Science Data Processor	ICRAR, **CSIRO**, iVEC
Signal and Data Transport	AARNet, **CSIRO**, UWA
Telescope Manager	**CSIRO**


WALLABY
a 2-year survey with ASKAP
led by B. Koribalski, L. Staveley-Smith and 100+ team
Mapping neutral hydrogen (HI) over the whole sky visible to ASKAP
-90 degr < DEC < +30 degr, 0 < z < 0.26
The brand-new Australian SKA Pathfinder (ASKAP)
Photo credit: Alex Cherney (Terrastro)

Our science goals for ASKAP Early Science

Study the evolution of galaxies, their transformation and star formation as a function of environment.

PAWSEY supercomputing centre



U. Varetto et al.

C Gheller et al.

SKA
SQUARE KILOMETRE ARRAY

A SKA P

WALLABY

PIs
Bärbel Koribalski
and
Lister Staveley-Smith

short & long visits
secondments
sabbaticals
Students & postdocs
xxxx

CSIRO

ASTRON

PRACE

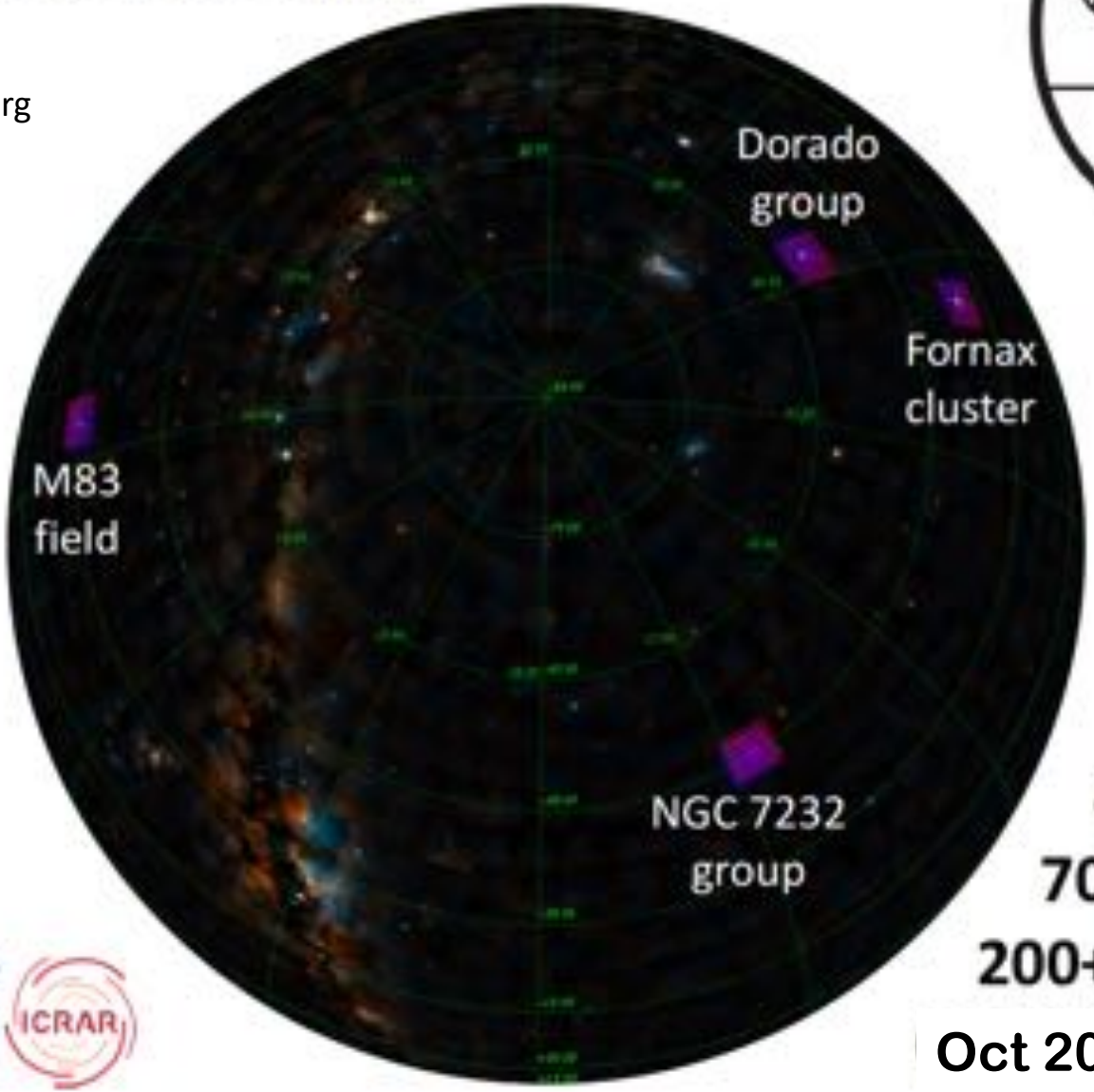
PUZZLE PRECISION

INNOVATION
COMPOSITES

WALLABY Early Science

(PIs: Koribalski & Staveley-Smith)

https://wallaby-survey.org



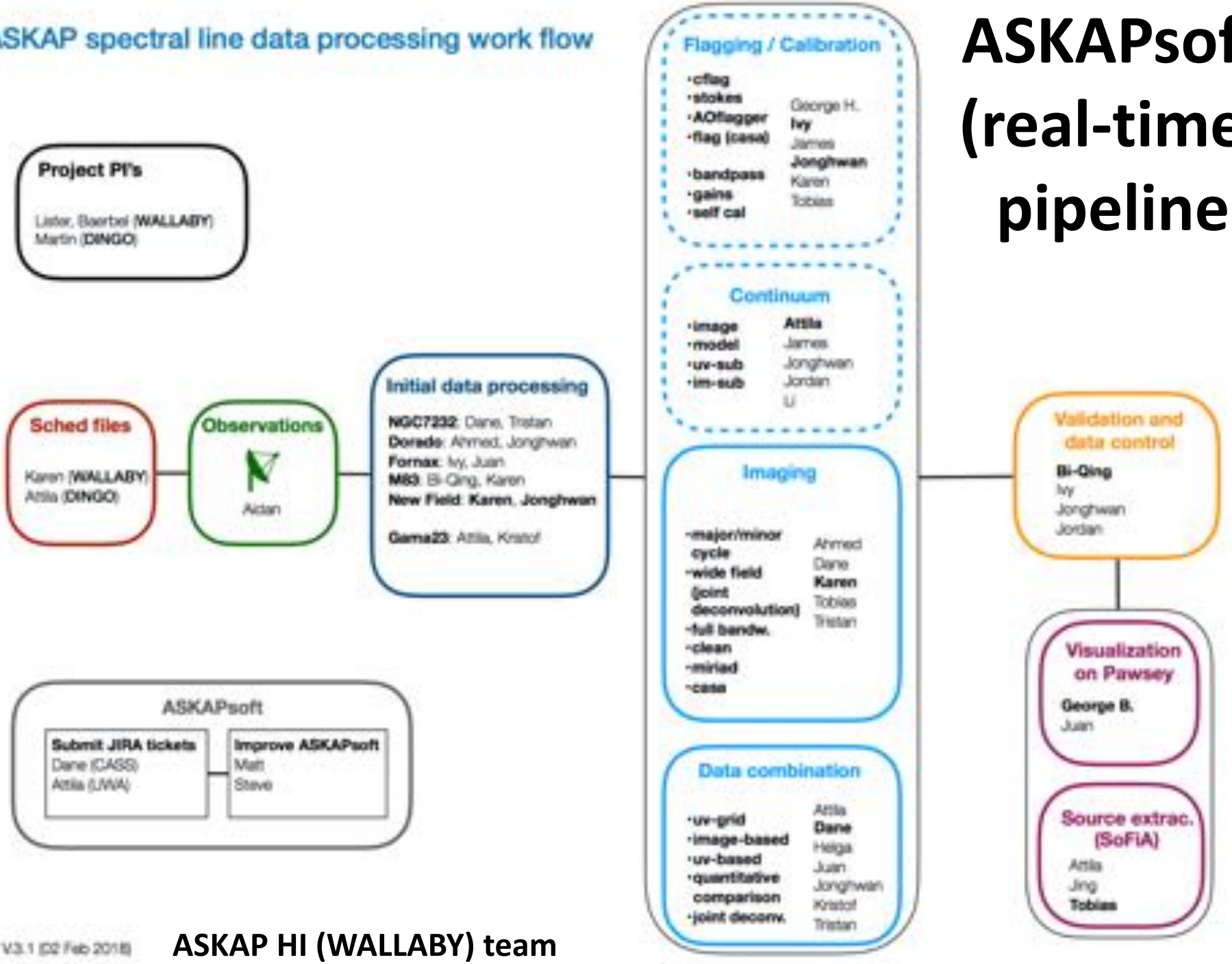
ASKAP
CSIRO

4 fields
700+ hours
200+ TB of data

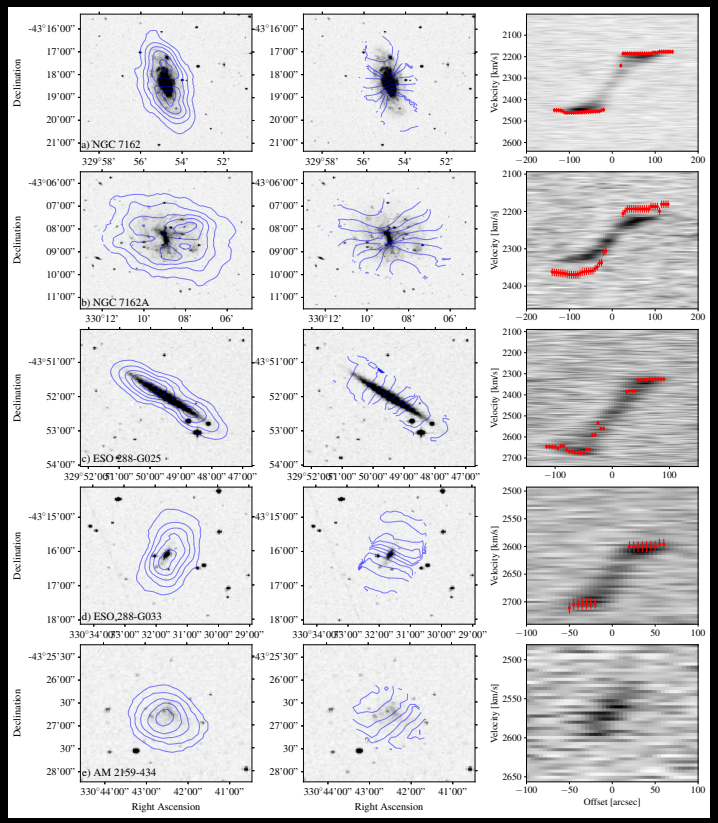
Oct 2016 – Jan 2018

CSIRO WALLABY ICRAR

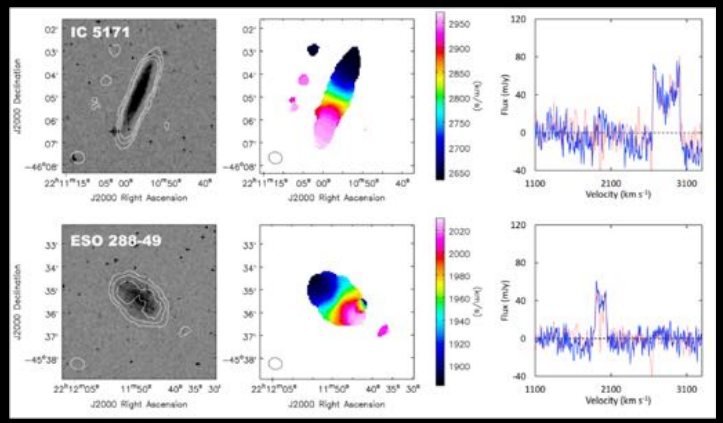
ASKAPsoft (real-time) pipeline



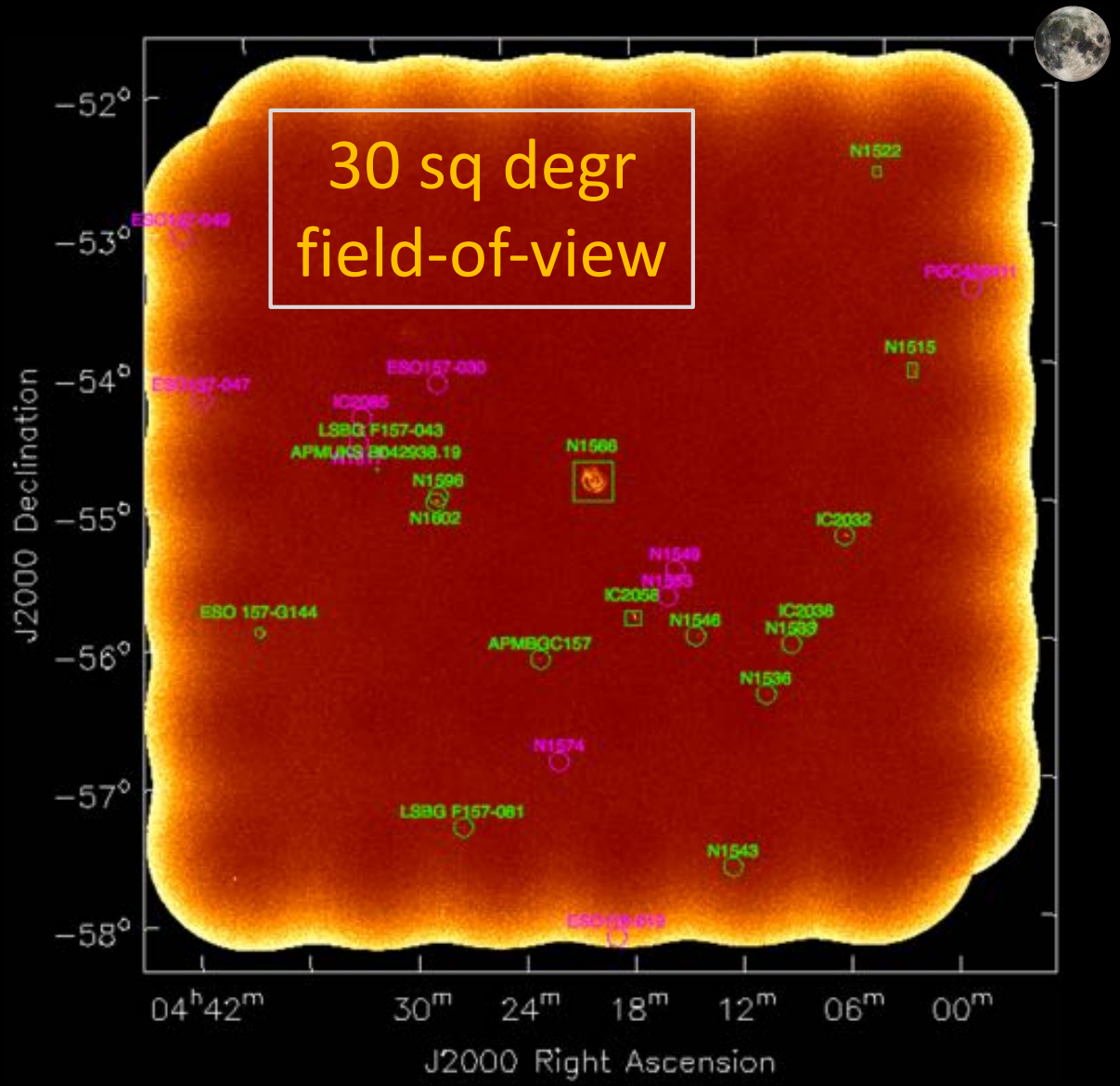
ASKAP HI (WALLABY) team



Reynolds et al. (2018)



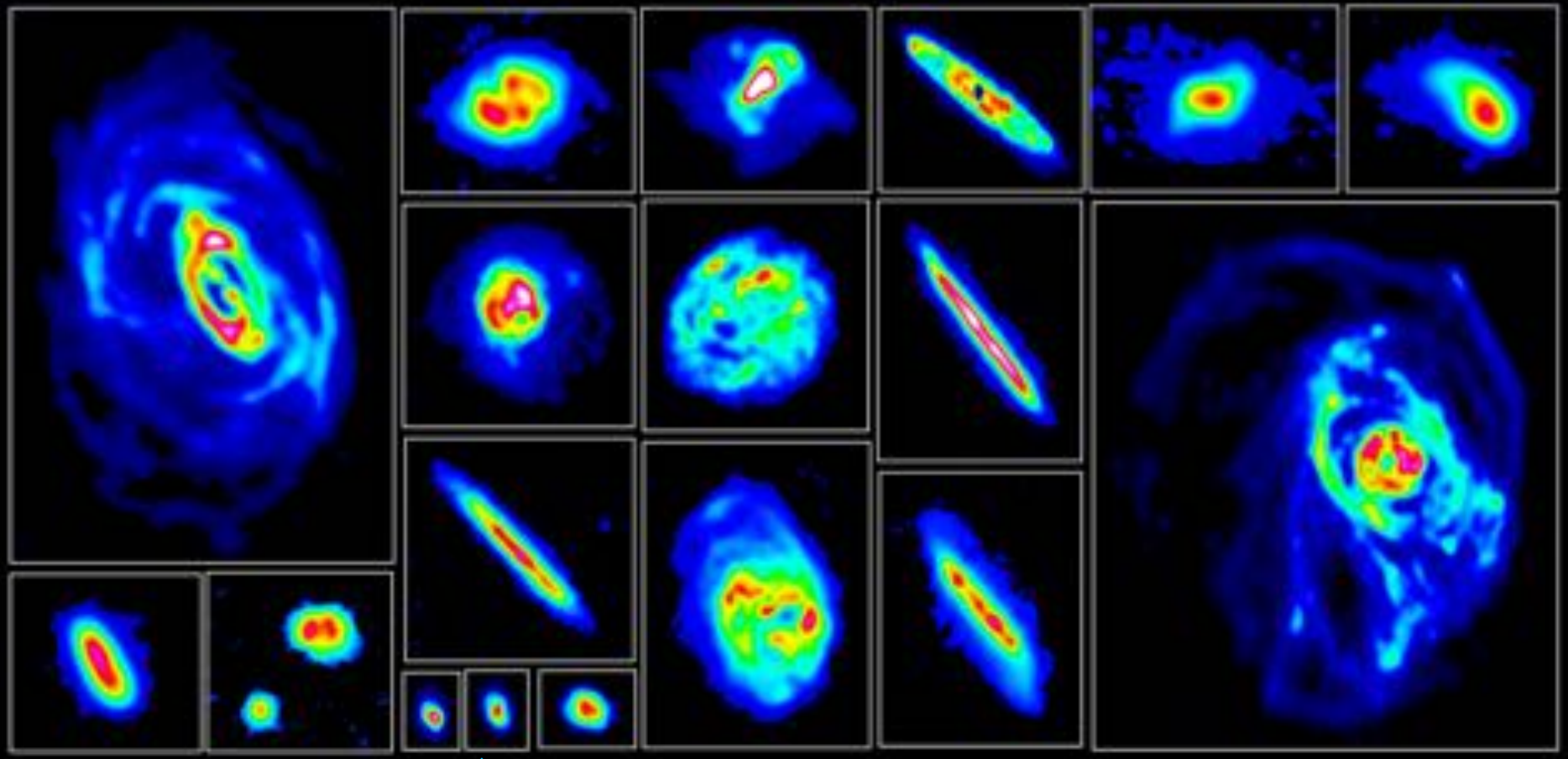
Lee-Waddell et al. (2018)



WALLABY Early Science - papers

Rhee et al., Elagali et al., Kleiner et al.,
Koribalski et al. (2018, in prep.)

Hydrogen in Galaxies



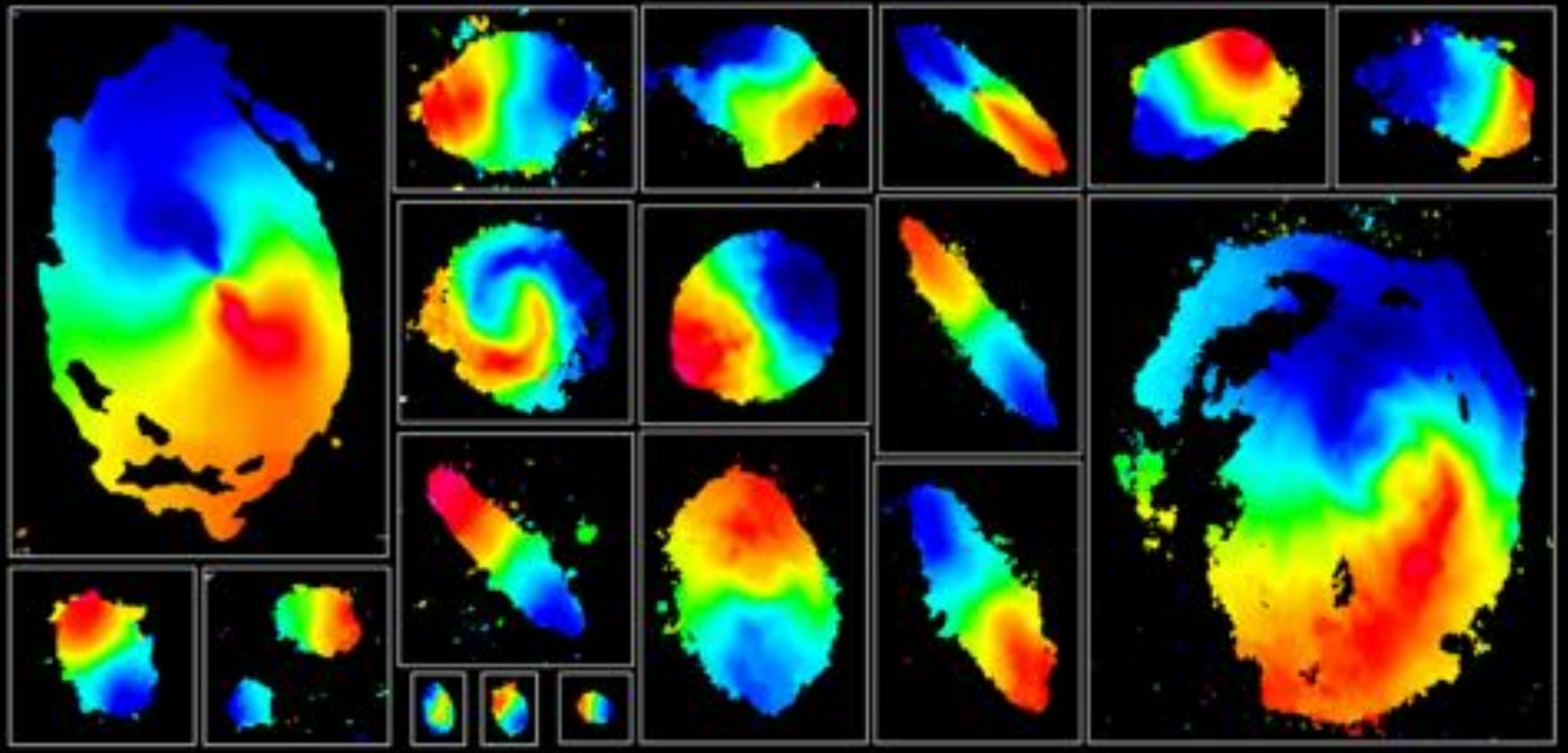
The Local Volume HI Survey (LVHIS) • Kamphuis et al. 2018

CSIRO's Australia Telescope Compact Array

SKA

SQUARE KILOMETRE ARRAY

Hydrogen in Galaxies



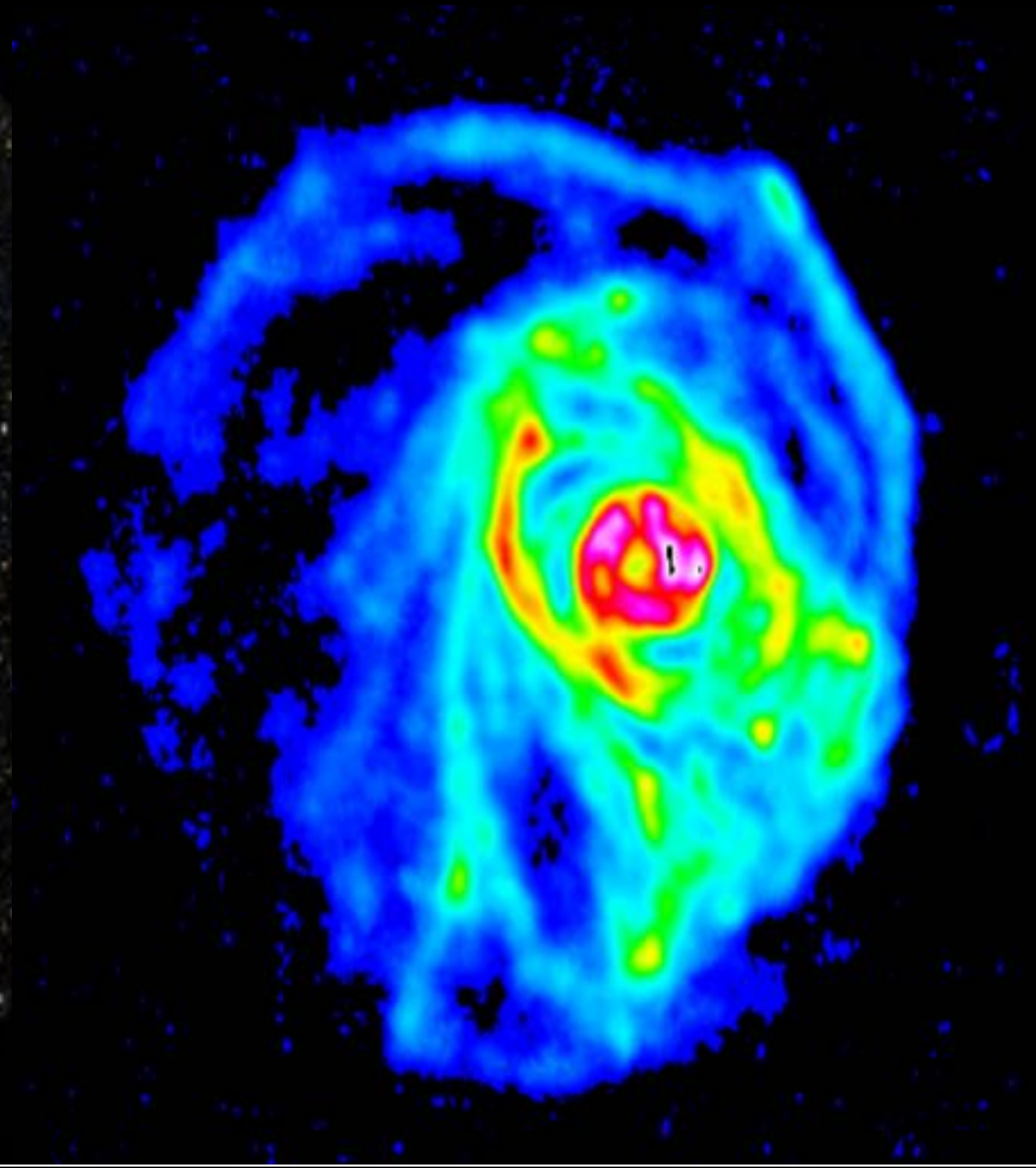
The Local Volume HI Survey (LVHS) • Koribalski et al. 2018

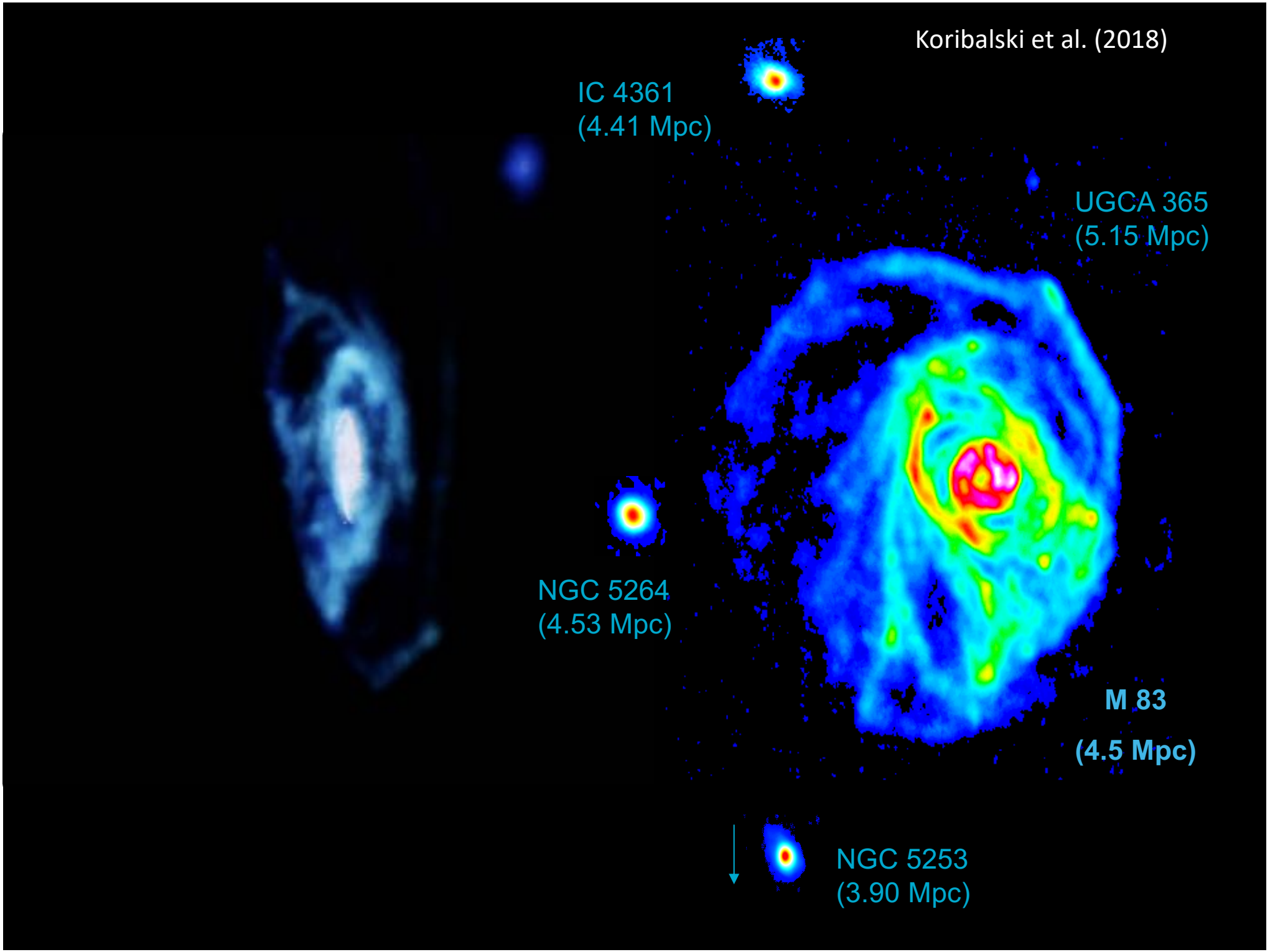
CSIRO's Australia Telescope Compact Array

SKA
SQUARE KILOMETRE ARRAY

The spiral galaxy M83

GALEX NUV+FUV (Thilker et al. 05) | ATCA HI mosaic (Koribalski et al. 2018)




Koribalski et al. (2018)
IC 4361
(4.41 Mpc)
UGCA 365
(5.15 Mpc)
NGC 5264
(4.53 Mpc)
M 83
(4.5 Mpc)
NGC 5253
(3.90 Mpc)

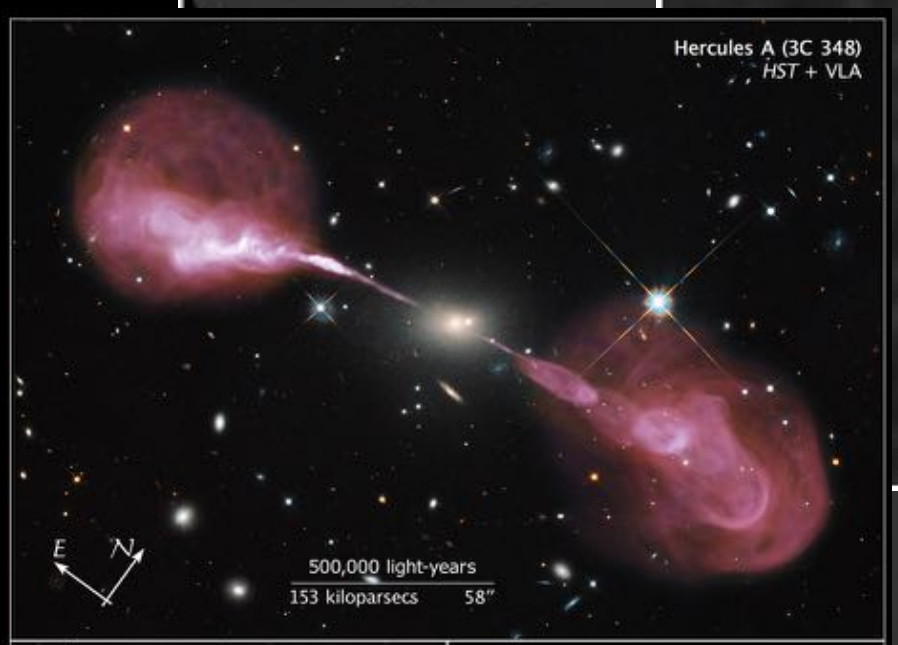
HI disks are large, extending well beyond the stellar disks of galaxies.

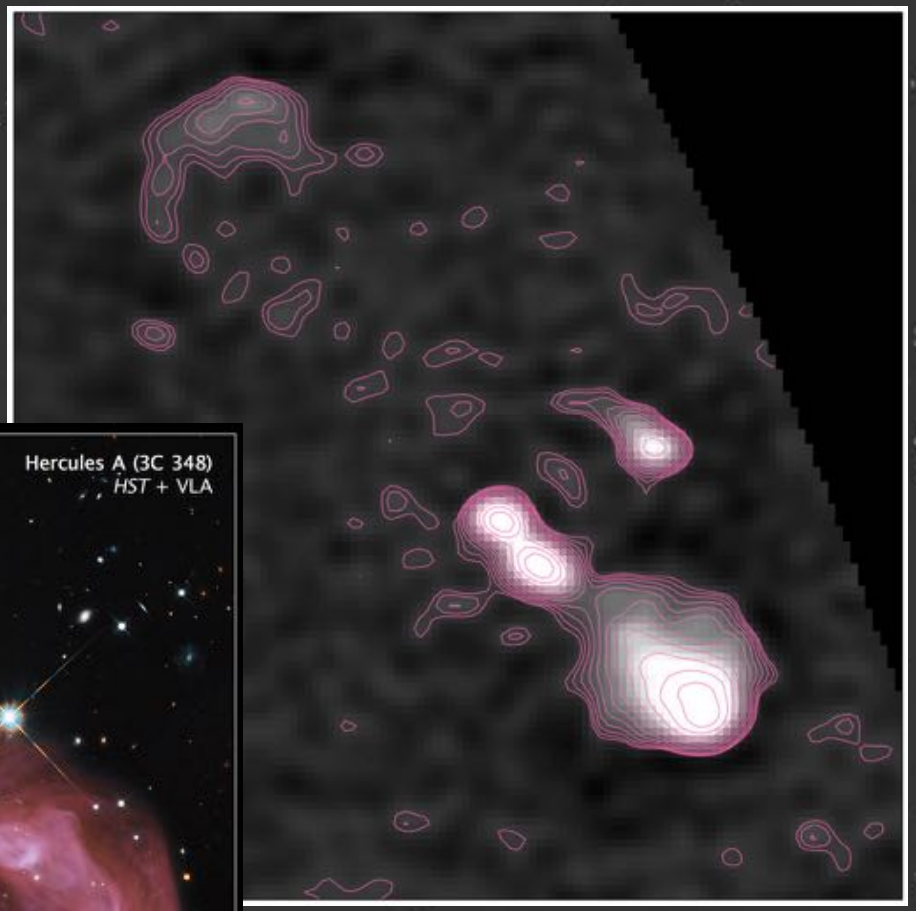
HI disk dynamics allow us to measure dark matter mass & distribution.

HI is an excellent tracer for SF in the outer disk.

The spiral galaxy M83

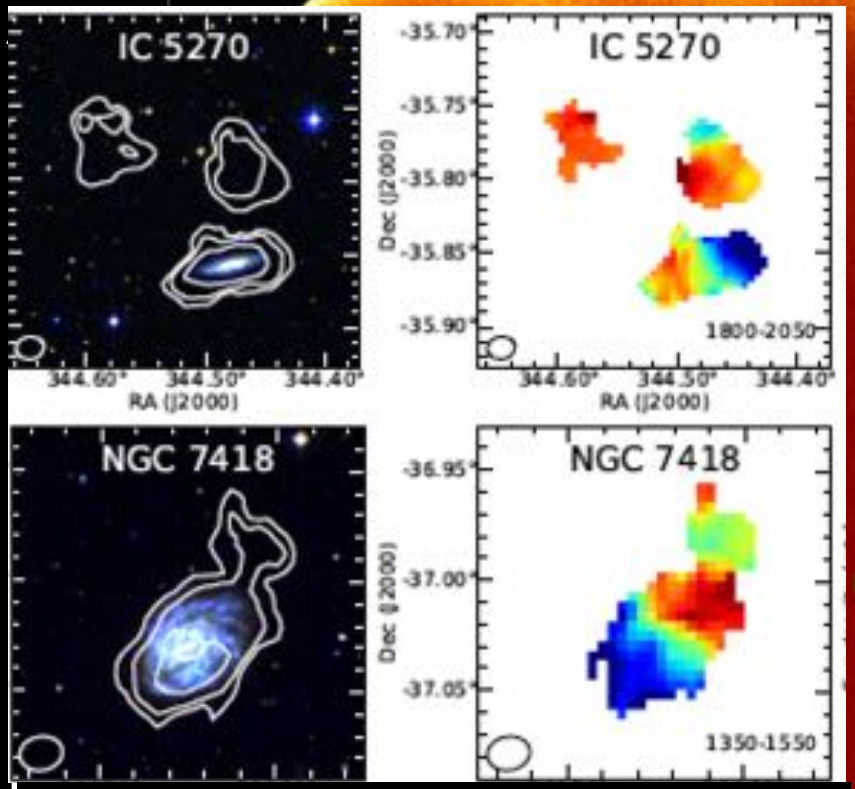
(HI+UV+optical color-composite image by Angel Lopez-Sanchez)



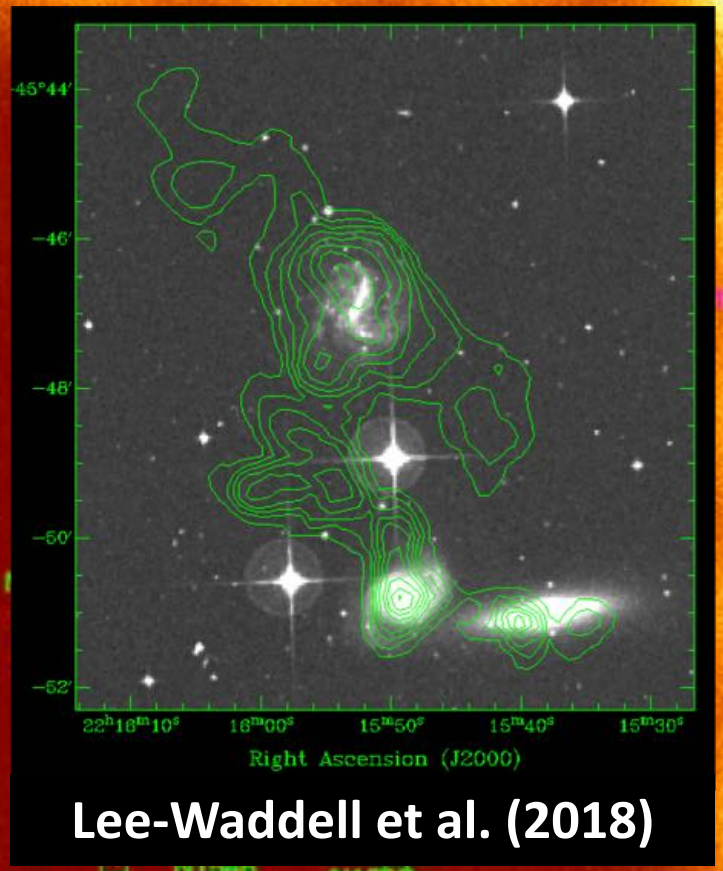


Thanks to Ian Heywood and the ASKAP/WALLABY team

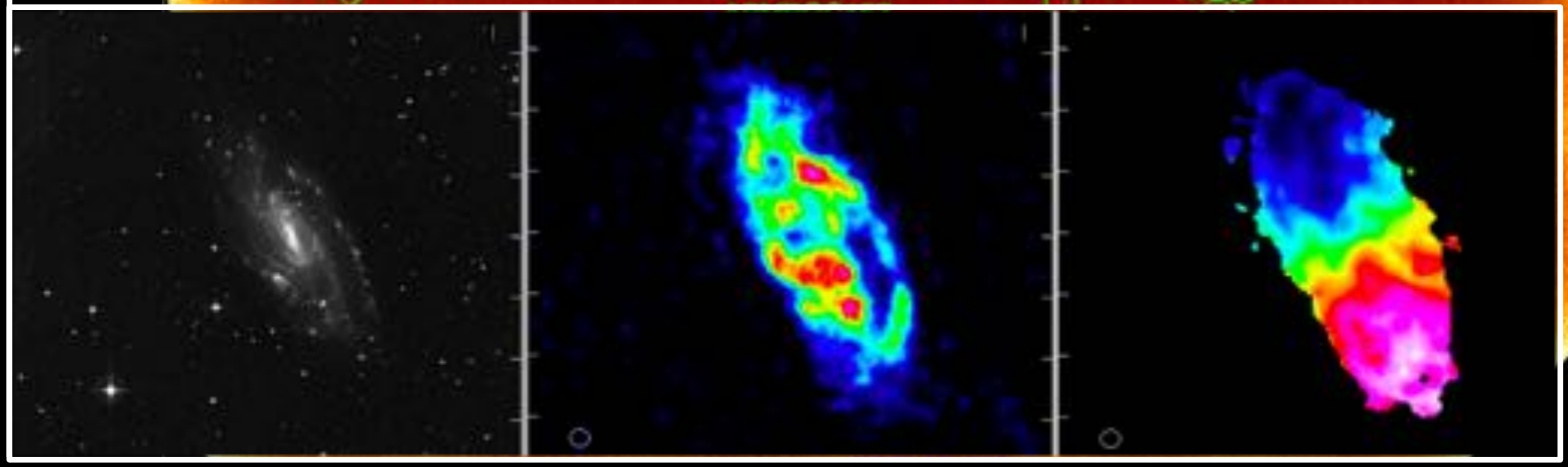
Heywood et al. (2016)



Serra, Koribalski et al. (2015)

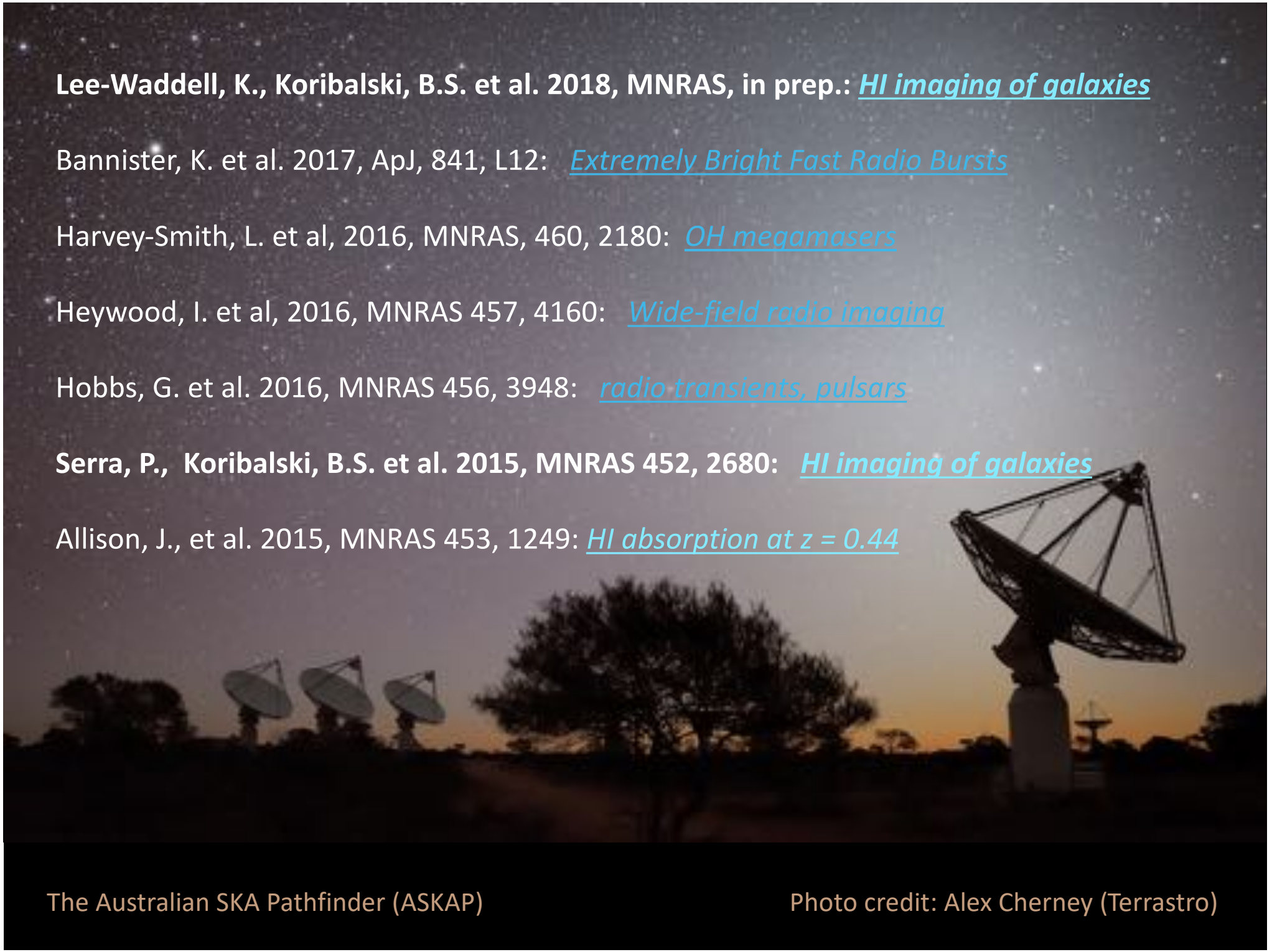


Lee-Waddell et al. (2018)



Kleiner, Koribalski + WALLABY team members (2018)

Rhee et al., Elagali et al. (2018)

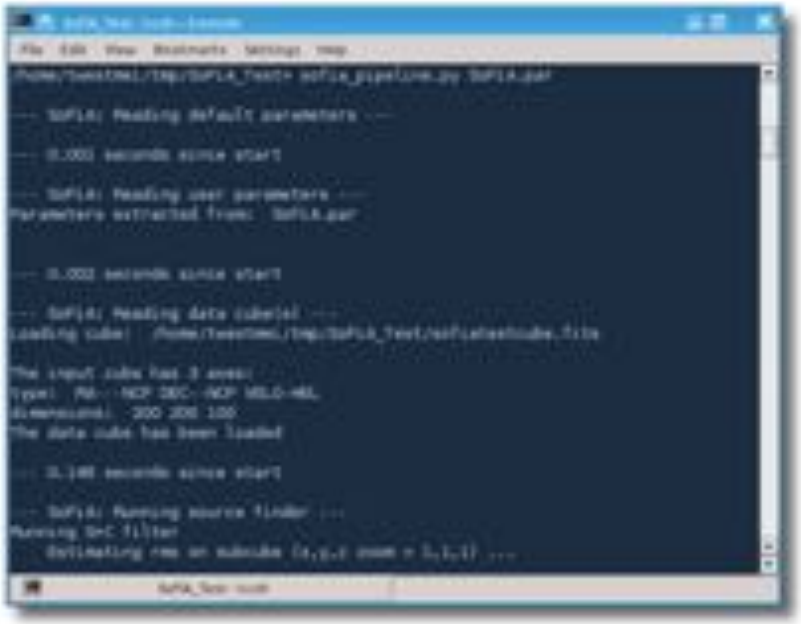

Lee-Waddell, K., Koribalski, B.S. et al. 2018, MNRAS, in prep.: *HI imaging of galaxies*
Bannister, K. et al. 2017, ApJ, 841, L12: *Extremely Bright Fast Radio Bursts*
Harvey-Smith, L. et al, 2016, MNRAS, 460, 2180: *OH megamasers*
Heywood, I. et al, 2016, MNRAS 457, 4160: *Wide-field radio imaging*
Hobbs, G. et al. 2016, MNRAS 456, 3948: *radio transients, pulsars*
Serra, P., Koribalski, B.S. et al. 2015, MNRAS 452, 2680: *HI imaging of galaxies*
Allison, J., et al. 2015, MNRAS 453, 1249: *HI absorption at z = 0.44*
The Australian SKA Pathfinder (ASKAP)
Photo credit: Alex Cherney (Terrastro)

Source Finding Application (SoFiA)

Serra, Westmeier, Giese, et al, 2015, MNRAS, 448, 1922

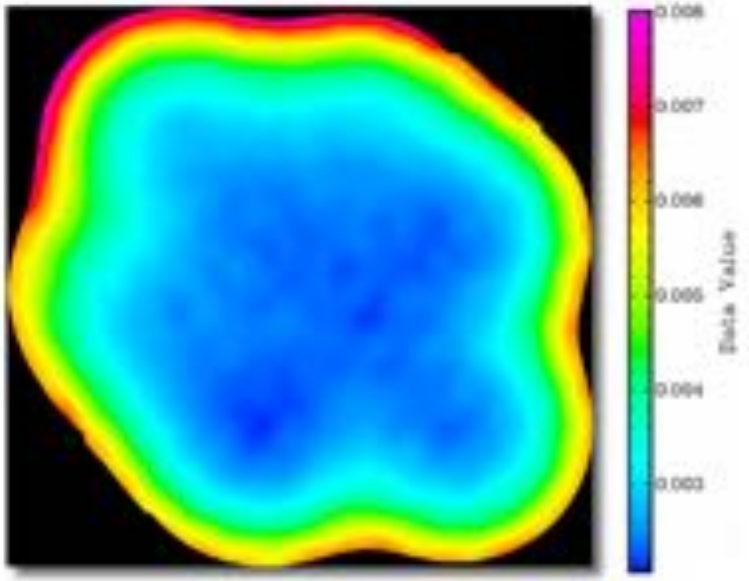
SoFiA
Source Finding Application

- Stand-alone HI source finding pipeline
- Developed by international team led by Tobias Westmeier
- Two interfaces:
  - Command line
  - Graphical user interface
- Available on GitHub:
  - https://github.com/SoFiA-Admin/SoFiA

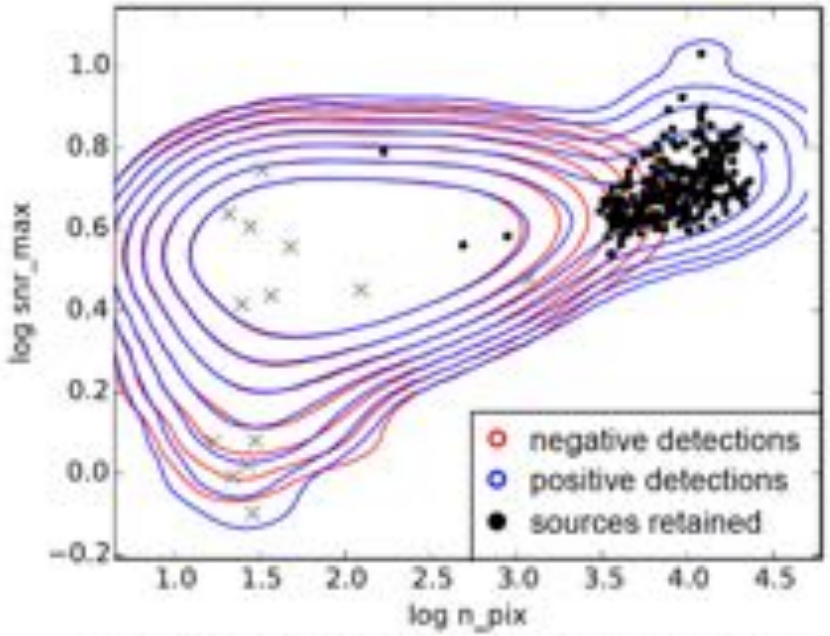


Major features of SoFiA

- Accepts **2-D** and **3-D** data
- Measurement and correction of **noise** variation
- Selection of different **source finding** algorithms:
  - Smooth + Clip finder
  - CNHI finder
  - 2D–1D wavelet filter
  - Threshold finder
- Fully automated **reliability** estimation
- **Mask** optimisation
- Busy Function fitting
- Large selection of **output** products and formats



Local noise measurement on ASKAP data



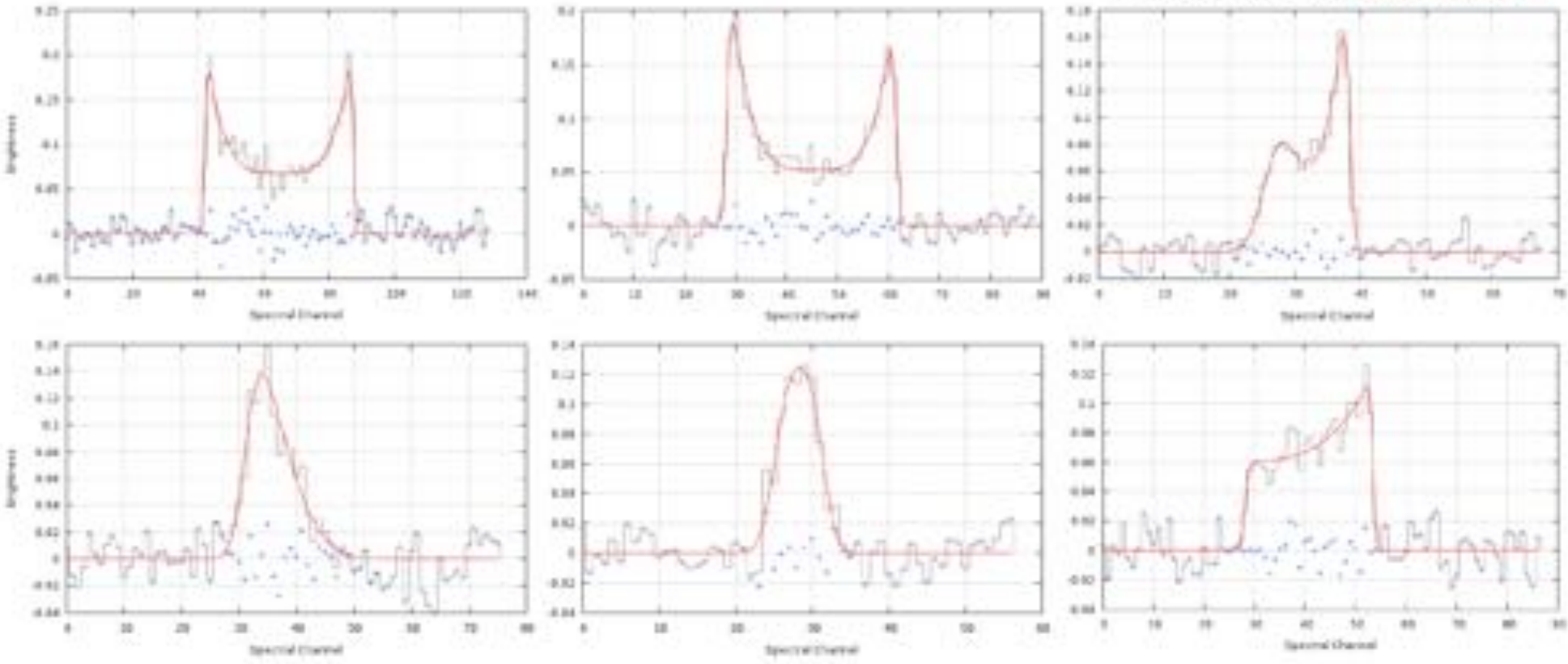
Reliability estimation from negative sources

The Busy Function

Westmeier, Jurek, Obreschkow, et al., 2014, MNRAS, 438, 1176

- Analytic function for fitting global HI profiles of galaxies
- Product of two **error functions** and one **polynomial**:
  - $B_1(x) = \frac{a}{4} \times (\mathrm{erf}[b_1\{w + x - x_\mathrm{e}\}] + 1) \times (\mathrm{erf}[b_2\{w - x + x_\mathrm{e}\}] + 1) \times \left(c\,|x - x_\mathrm{p}|^n + 1\right)$
- Versatile: symmetric or asymmetric, single-component or double-horn profiles
- Purpose: Accurate and robust parameterisation of galaxies

HIPASS profiles with Busy Function fit



INNOVATION COMPOSITES

PUZZLE PRECISION

JP Kneib: science and computing

C. Gheller, M. di Lorenzo: computing, 3D visualization

K. Schawinski et al.: science, GalaxyZoo

Our host today: computer science

Bernstein/Boehlen: stream processing

SKA MOU: data processing, etc.

A SKA P

PIs
Bärbel Koribalski
and
Lister Staveley-Smith

D. Pfenninger: science

P. Hurley: computing Bluebild/ DOME

Swiss Industries

WALLABY

Thank you !