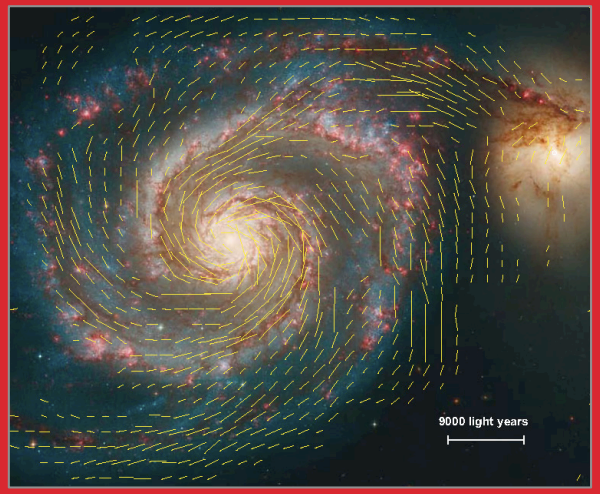
The Polarisation Sky Survey of the Universe's Magnetism

Bryan Gaensler

Sydney Institute for Astronomy



Beck et al. / Hubble Heritage

CSIRO / Swinburne

THE UNIVERSITY OF SYDNEY

ASKAP POSSUM

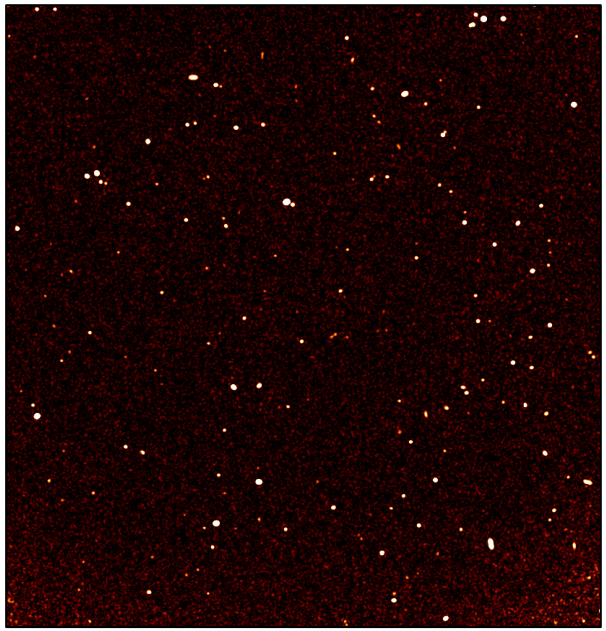
- ***Polarisation Sky Survey of the Universe's Magnetism***
  - PIs Bryan Gaensler, Tom Landecker, Russ Taylor
  - 67 scientists from 15 countries

- All-sky ($\delta < +30^{o}$) ASKAP survey of polarised continuum, over 1130-1430 MHz to 10 μJy rms at 10" resolution
  - Rotation Measures (RMs) for ~3 million sources (~100 RMs/deg^2) + diffuse polarisation (w. single dish)

- Four science goals:
  - magneto-ionic properties of ISM & its components
  - structure & geometry of large-scale B of Milky Way
  - magnetic properties of galaxies, clusters & IGM
  - evolution of magnetic fields with cosmic time

http://www.askap.org/possum

CSIRO / Swinburne



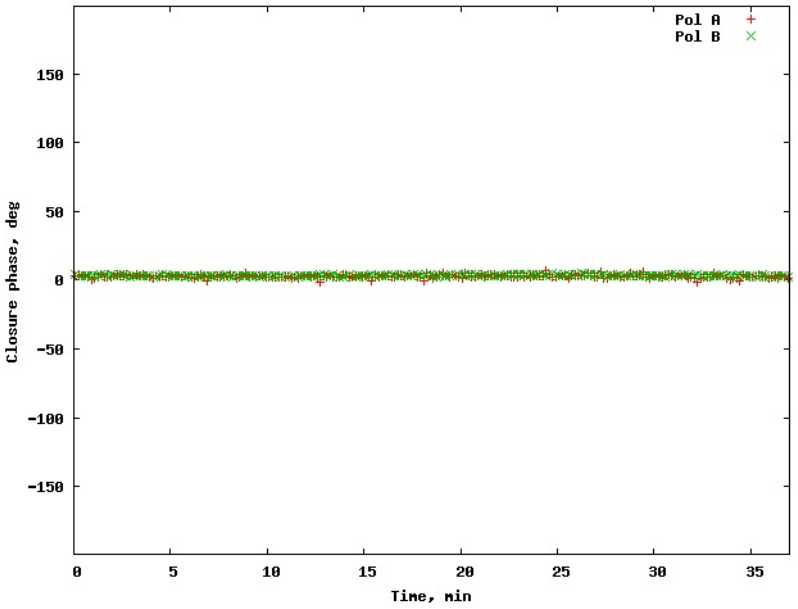
CSIRO

ASKAP Status & Timeline

- All 36 antennas assembled
- PAFs on 3 antennas
- Mark II PAF fixes high system temperature
- Funding in hand for
  - all antennas
  - 6 Mark I PAFs
  - 12 Mark II PAFs

Steve Barrker (CSIRO)

- **Aug 2012:** Phase closure for three PAFs
- End 2012: PAFs on 6 antennas (BETA)
- Apr 2013: Primary BETA capability
- Early 2013: Mark II PAFs installed
- Late 2013: ASKAP-12 operations
- Late 2014? Full ASKAP operations



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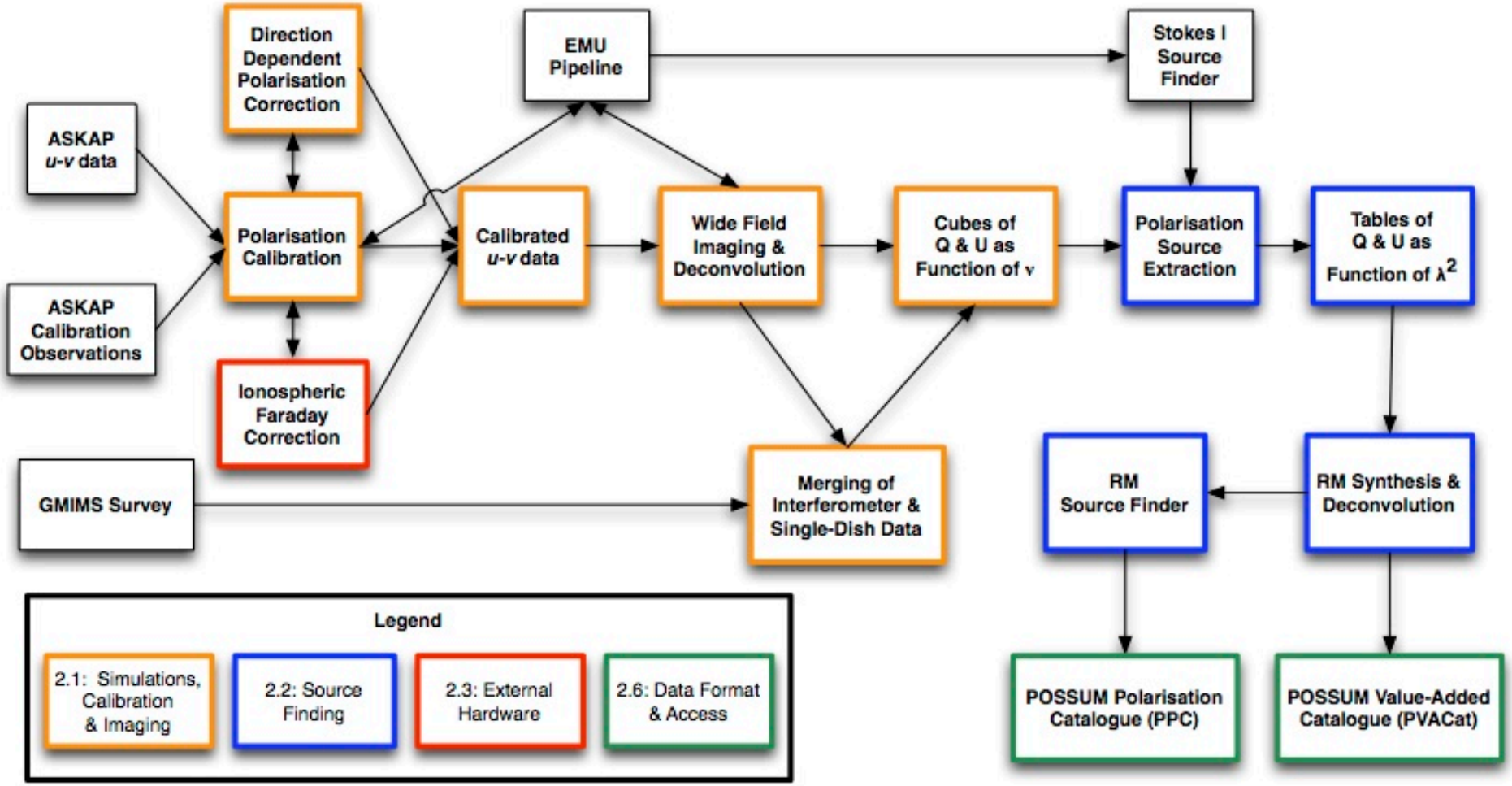
POSSUM Pipeline



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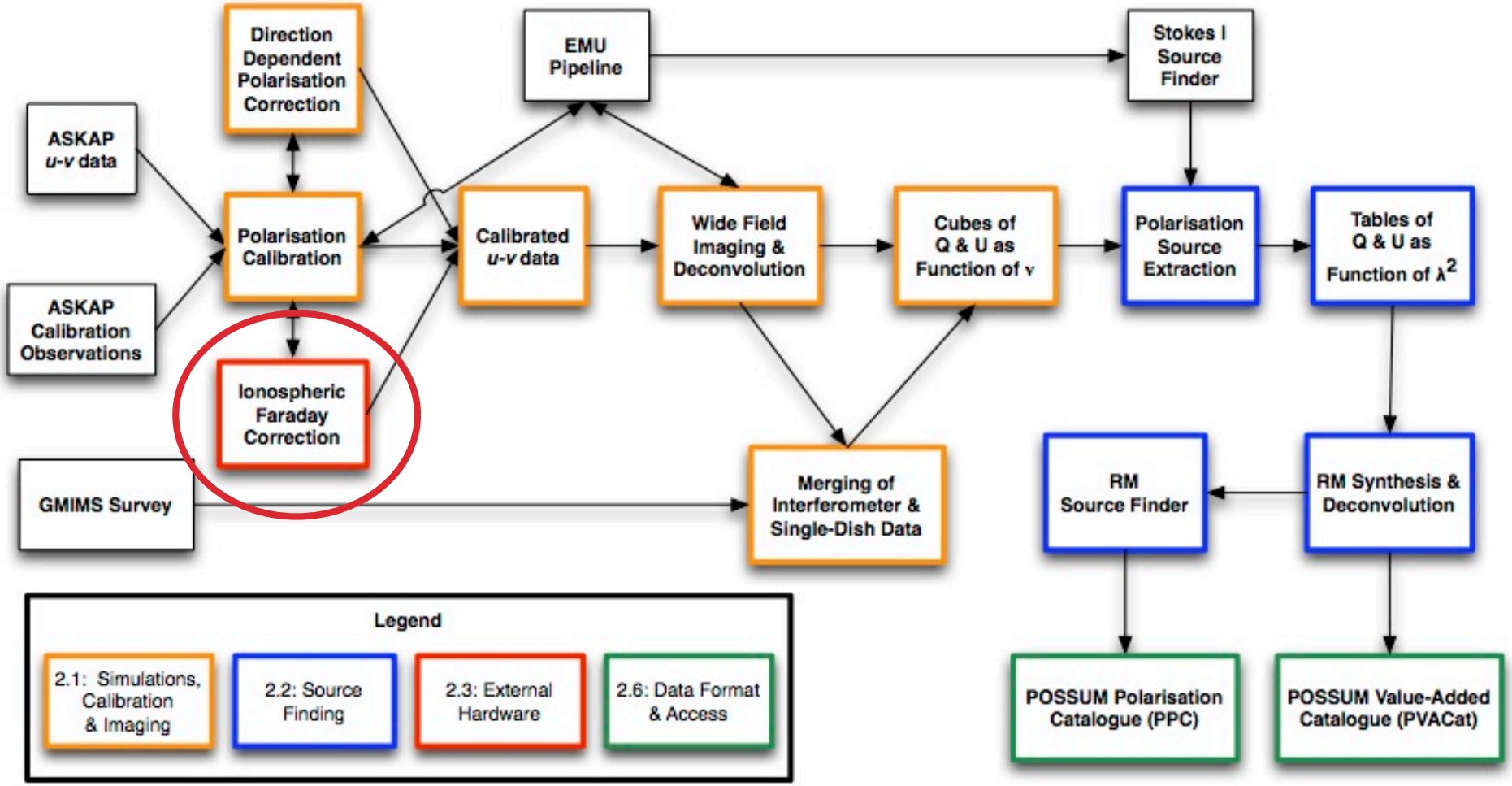
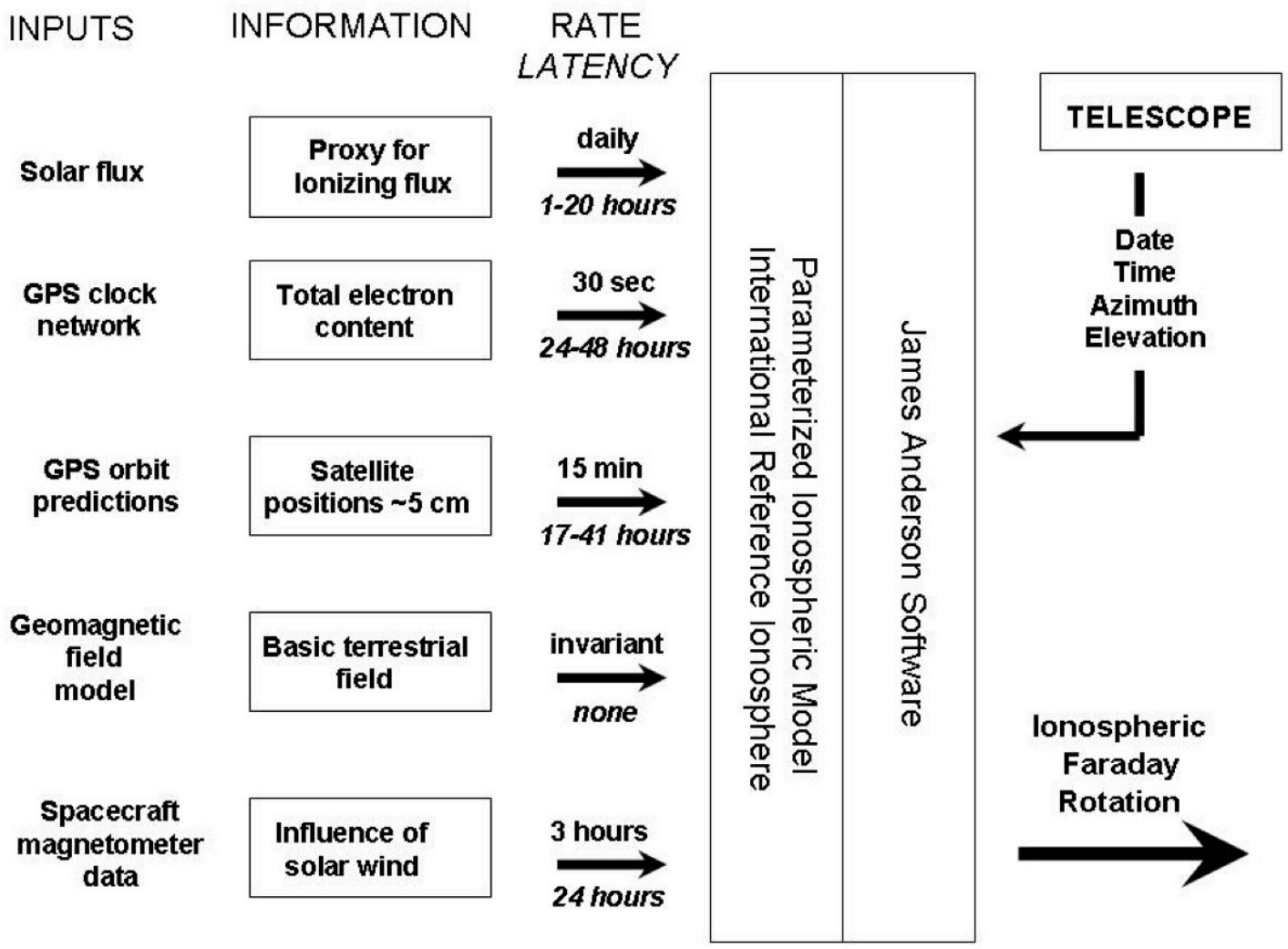


Ionospheric Faraday Rotation



James Anderson

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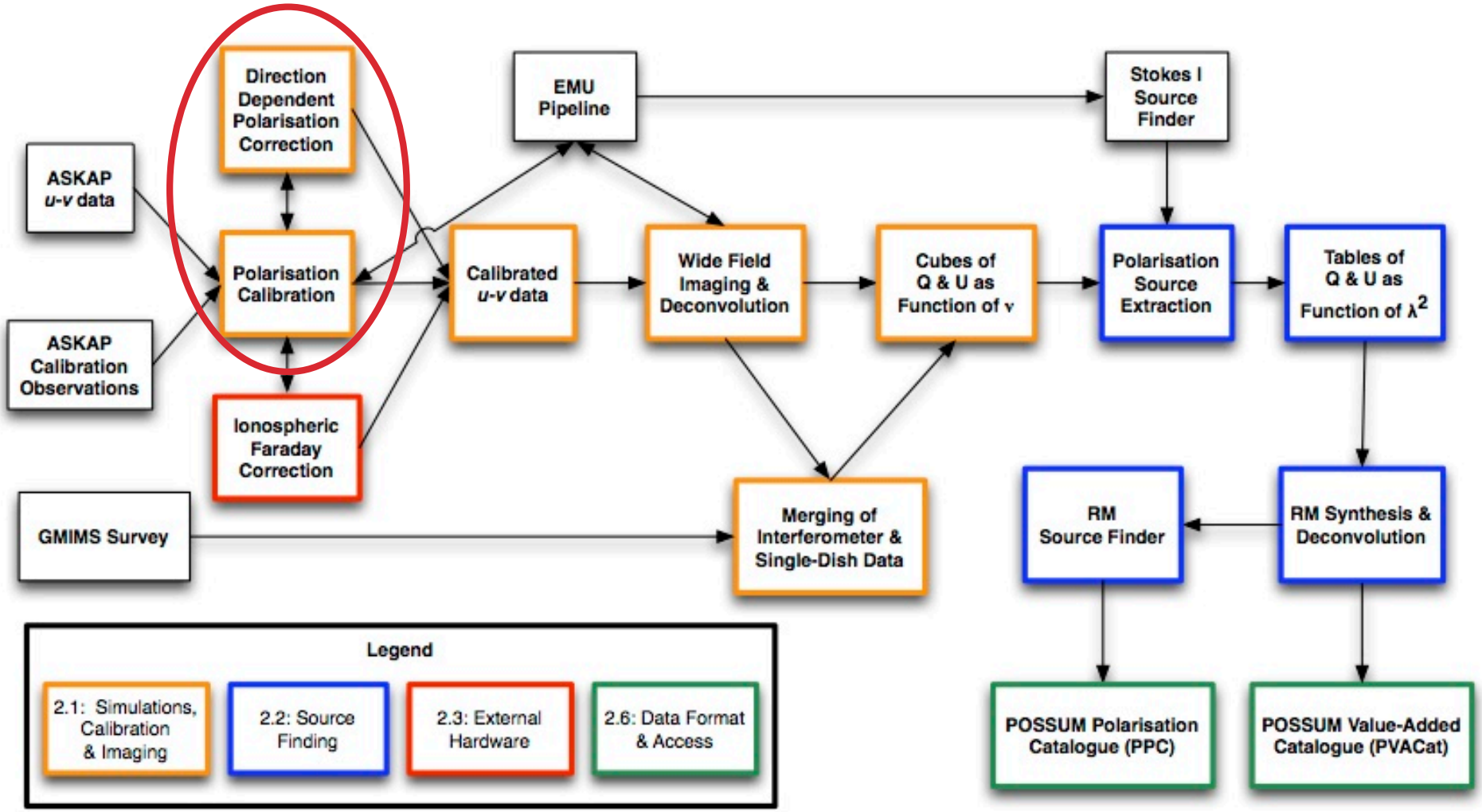
POSSUM Pipeline

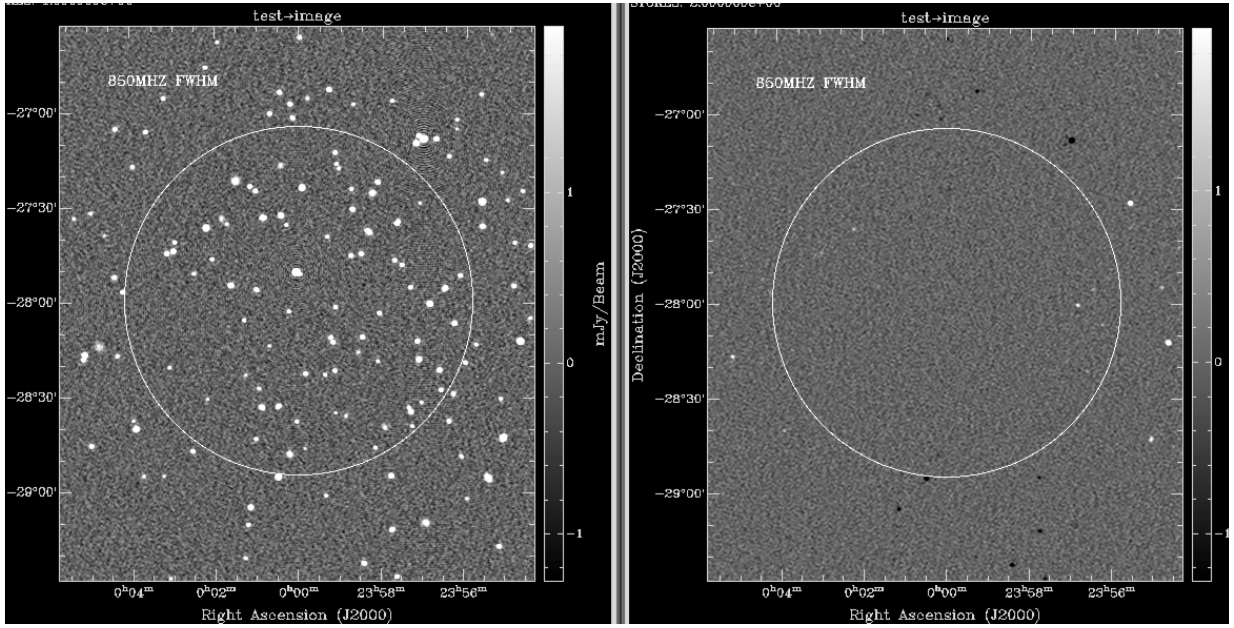


Simulating the ASKAP Primary Beam

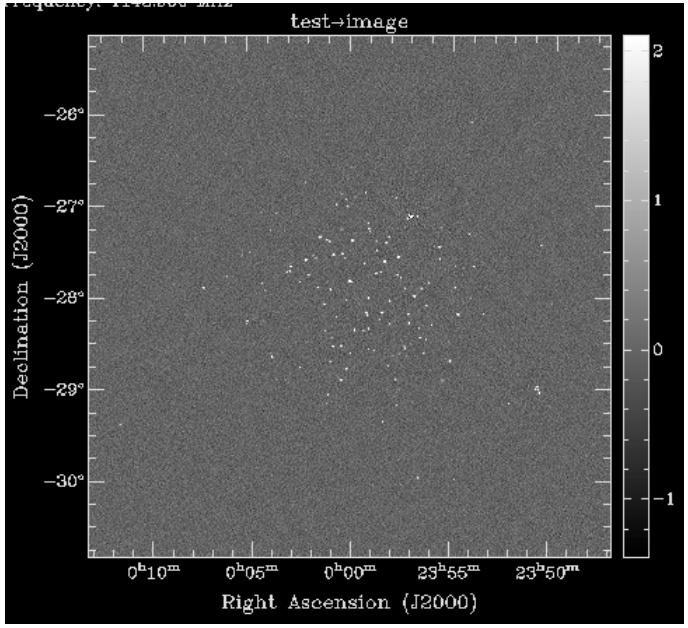
- MeqTrees simulation of individual focal-plane array beam (Willis & Smirnov)
  - voltage beams over 850-1430 MHz provided by Rong-Yu Qiao (CSIRO ICT)
  - can simulate response in *XX*, *YY*, *XY*, *YX* to sky model of unpolarised sources

    → Q,U,V response varies wildly as function of position/freq, but values quite low

    → beam-forming weighting schemes can minimise polarisation leakage



Stokes *I* and *Q* at 850 MHz (Tony Willis)



Wide field Stokes *I* at 1150 MHz

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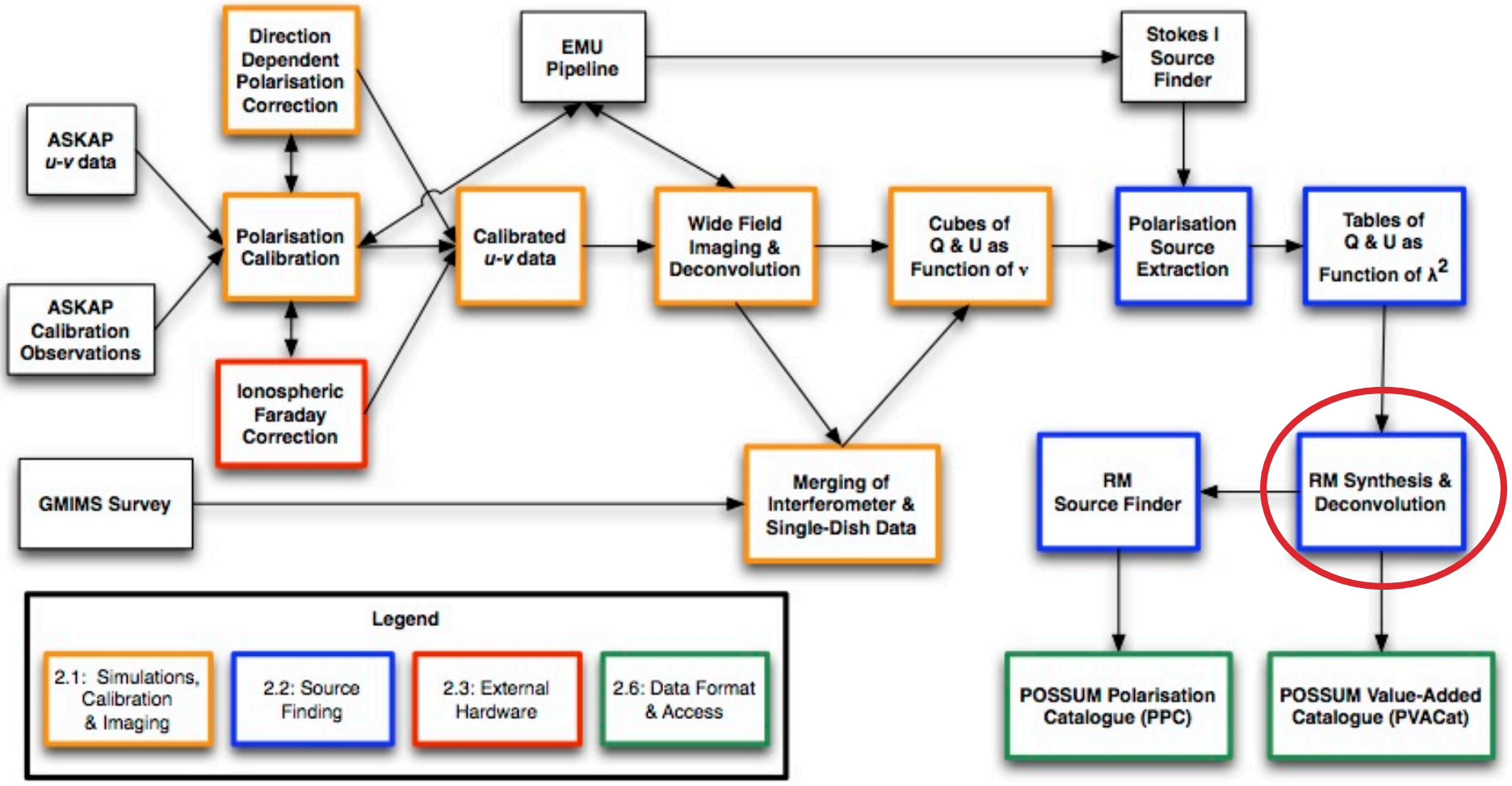
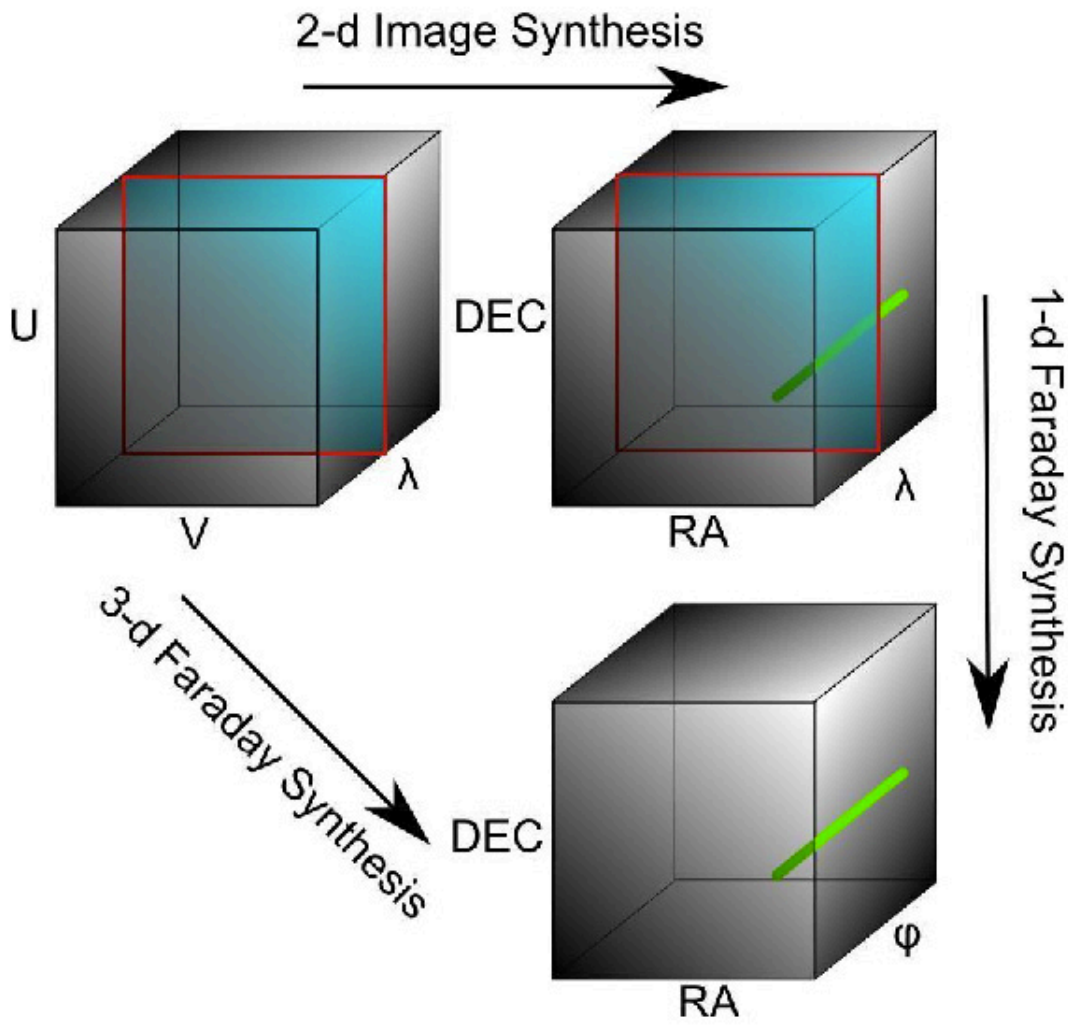


Faraday Synthesis



Bell & Ensslin (2012)

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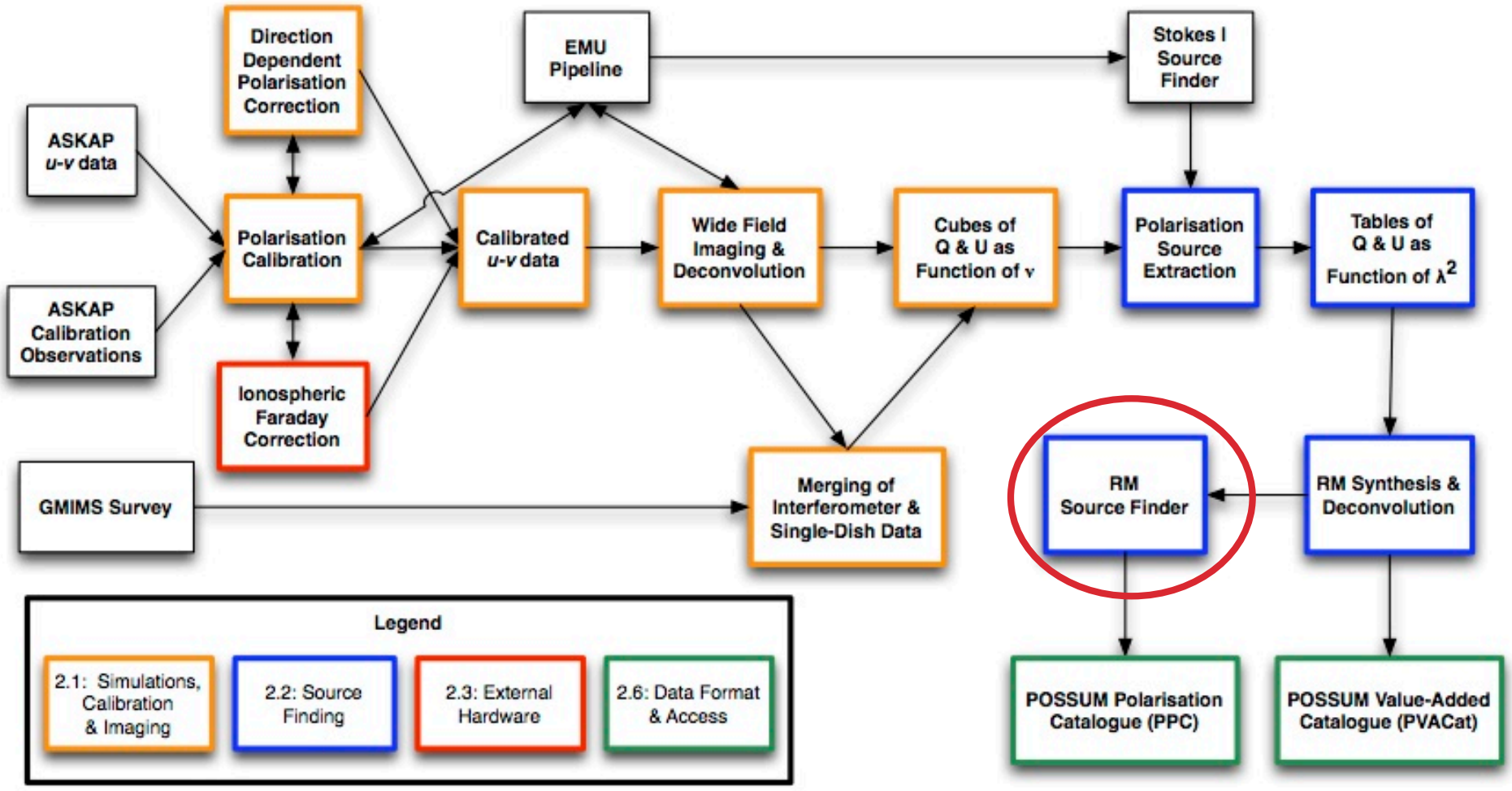
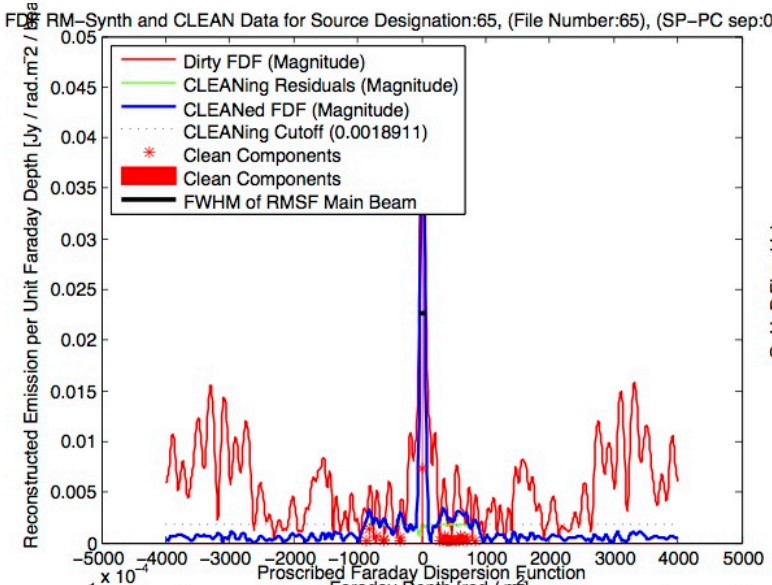
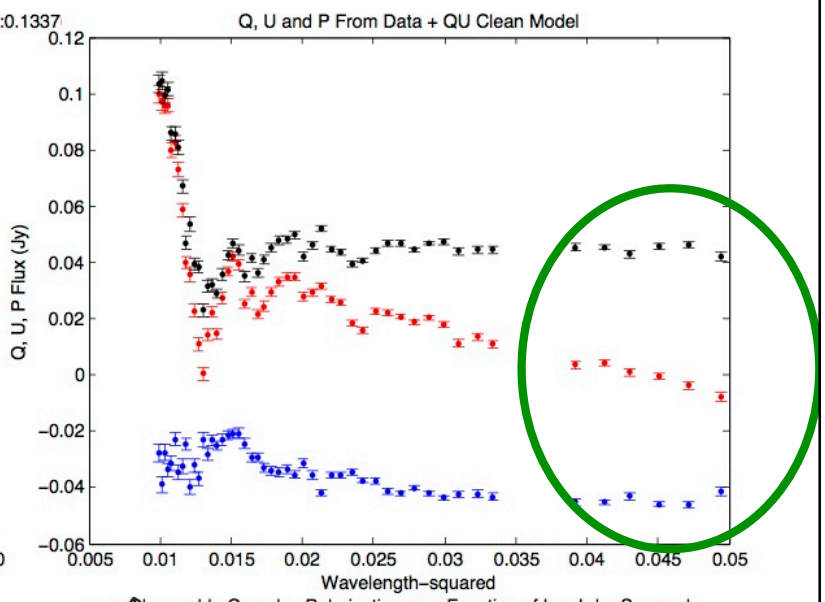


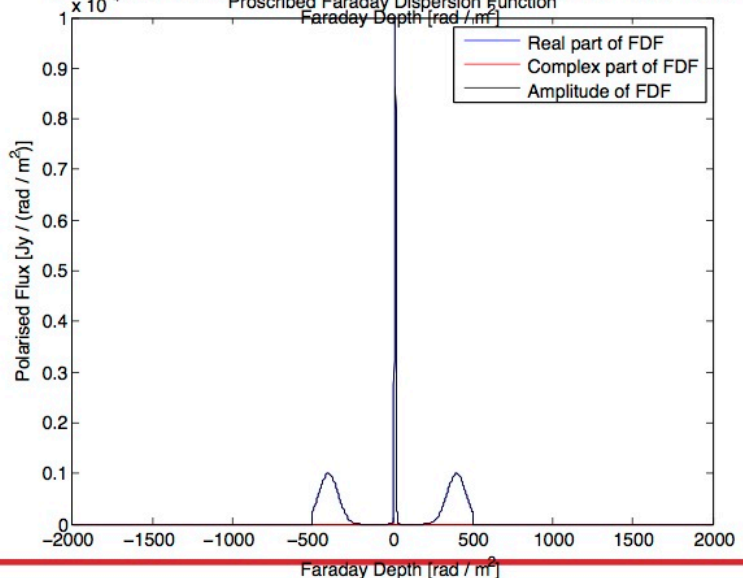
Complexity in Faraday Depth

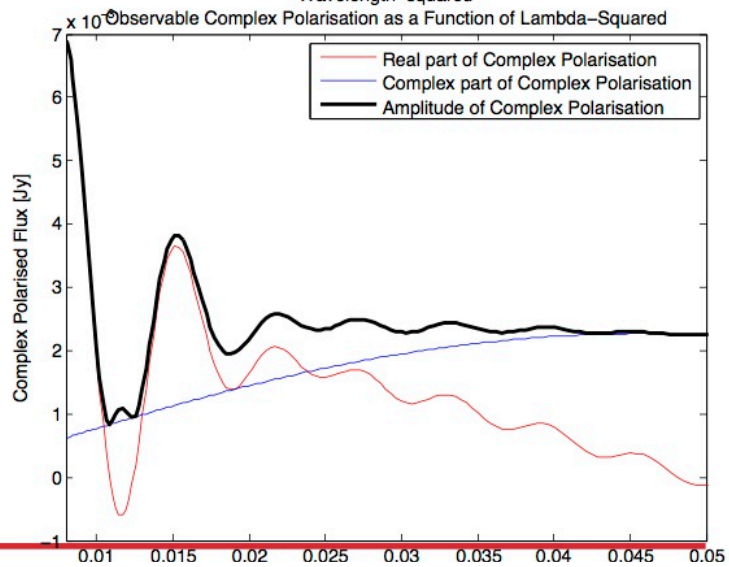
Data

Toy Model









Craig Anderson

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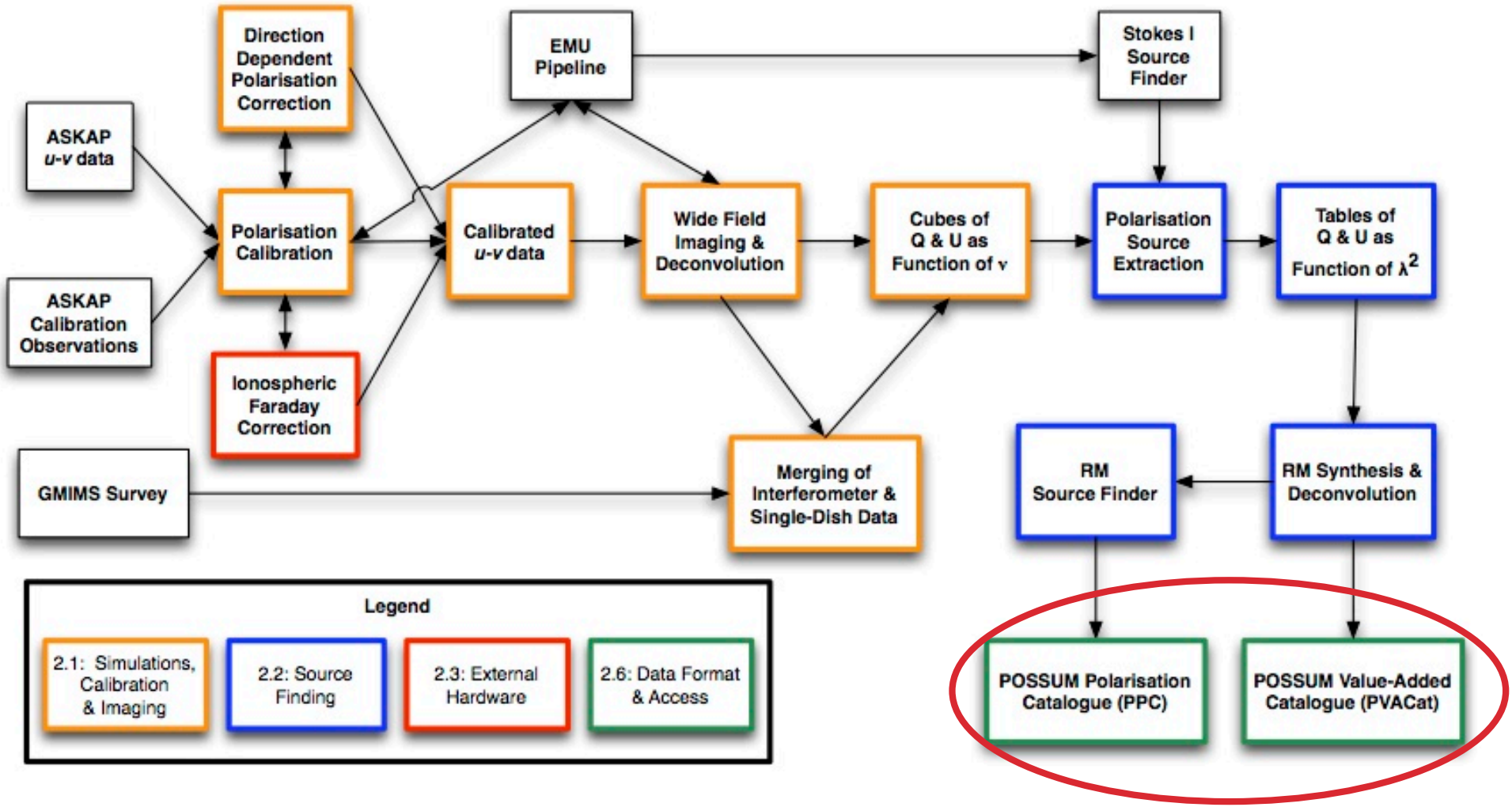
POSSUM Pipeline



PPC and PVACat

EMU Source Catalog	EVACat (EMU value added catalog)
Name, position (all with errors) Size, Peak flux, Integrated flux Spectral index & curvature Beam size Time of observation Local rms Postage stamp links to images	Cross-ID **(and components → source)** Redshift +? number of pixels > some threshold flux-weighted moments (e.g. SExtractor), maximum/minimum extent/orientation, total flux estimates

PPC	PVACat
• Automated, based on EMU • Fixed product *(perhaps 1 iteration)* • Early, easy, fast public access • Acceptable to ASKAP/CSIRO **ART:: "PPC should be the best we can do in real time on the EMU objects" (nothing more and nothing less)**	Evolving Everything we've put blood and sweat into, and which can't be done in real time.

Larry Rudnick

PPC and PVACat

PPC

Polarised fraction, angle, V
- **all** EMU sources

Catalogue of point-source RMs
(for simple RM spectra)

Polarisation (and Stokes I) SEDs
- all sources (?)

RM synthesis spectrum
- all EMU sources

Cubes of Q, U, RM, V around sources

RM spectrum annulus around EMU source (at own risk)

Noise map in I, Q, U, V (for every frequency channel?) for every EMU source (to be used as a weight map)

PVAC

Dominant & secondary RMs for all EMU sources (unresolved)

Offsets and organisation of discrete Q, U, RM components into groups/clusters corresponding to the same EMU source
+ opt. ID, redshift

RM , Q_0, U_0 images?

Catalogue of polarised sources that are not EMU sources

Cubes of Q, U, RM & zeroth moment RM & P for the whole sky (with and without single dish)

Gradient maps of (Q, U) over whole sky at 20'' resolution

RM statistics for defined classes

Larry Rudnick

POSSUM-12: "The RM Sky"

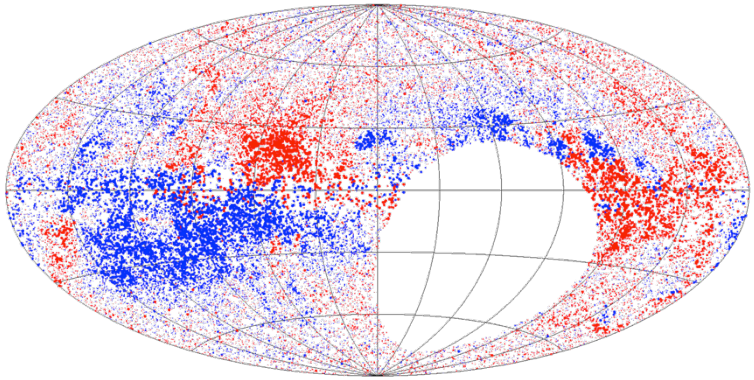
- Proposed survey: 2π sr to σ = 80 μJy, 800-1100 MHz (8 weeks of observing)
- EMU-12: 4 million sources above 0.4 mJy, ~10% with continuous SEDs
- POSSUM-12: ~400,000 polarised sources
  - 200,000 sources with full RM spectra from 300 frequency channels

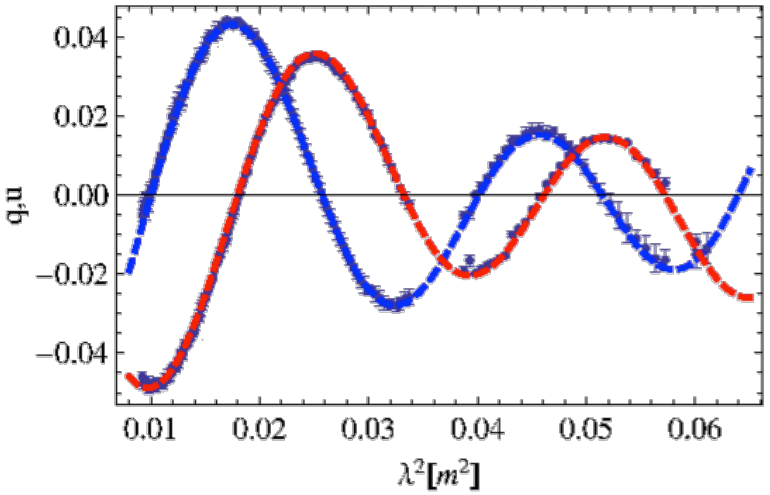
  → evolution of magnetic field with time to high redshift

  - diffuse polarised emission over whole sky, to be combined with single dish

  → relics, haloes, cosmic web;
  strong synergy with MWA programs

Taylor et al. (2009)





O'Sullivan et al. (2011)