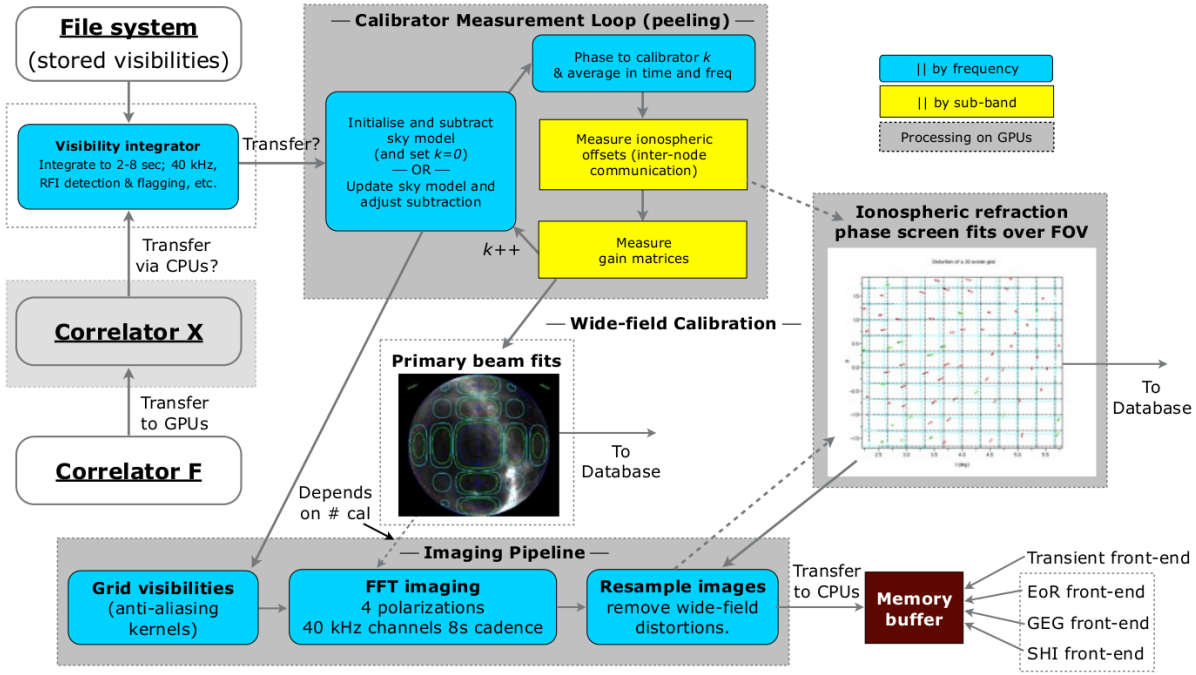
PROCESSING (FUTURE) MWA DATA WITH THE (FUTURE) RTS

Bart Pindor
University of Melbourne

INTRODUCTION

- The MWA Real-Time System (RTS) was originally designed to be an integrated part of the instrument, generating dirty images from stream of correlated visibilities.
- The ability to store visibilities has allowed collaboration members to use/develop a range of imaging/calibration software:
  - CASA (NRAO)
  - WSCLEAN written by Andre Offringa
  - FHD (Fast Holographic Deconvolution) written by Ian Sullivan
  - RTS
- Should the development of an expanded MWA include an expanded RTS and what would it look like?

RTS STATE OF PLAY

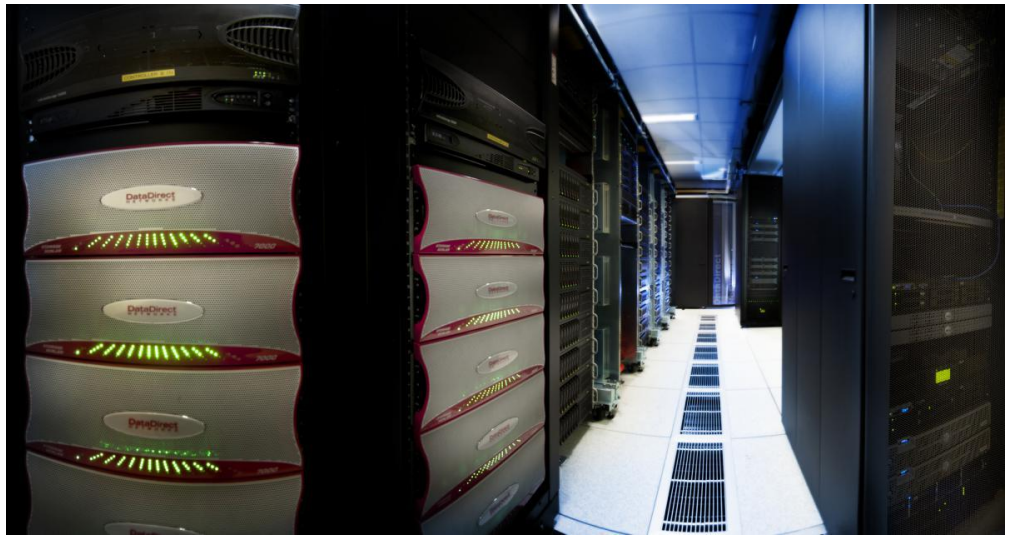


- RTS runs in ~ real time across 24 GPU enabled nodes when peeling ~ 300 sources (0.5s 160kHz outputs)
  - 300K CPU hours to process 1000 hrs of data
  - ~1M hours for 256T with current BW
    - ~10% of Fornax@IVEC for a year
- Current users:
  - EOR: CHIPS, UWPS
  - Emil Lenc: Polarization
  - GLEAM: Pietro Procopio

NEXT GEN DEVELOPMENT WISHLIST

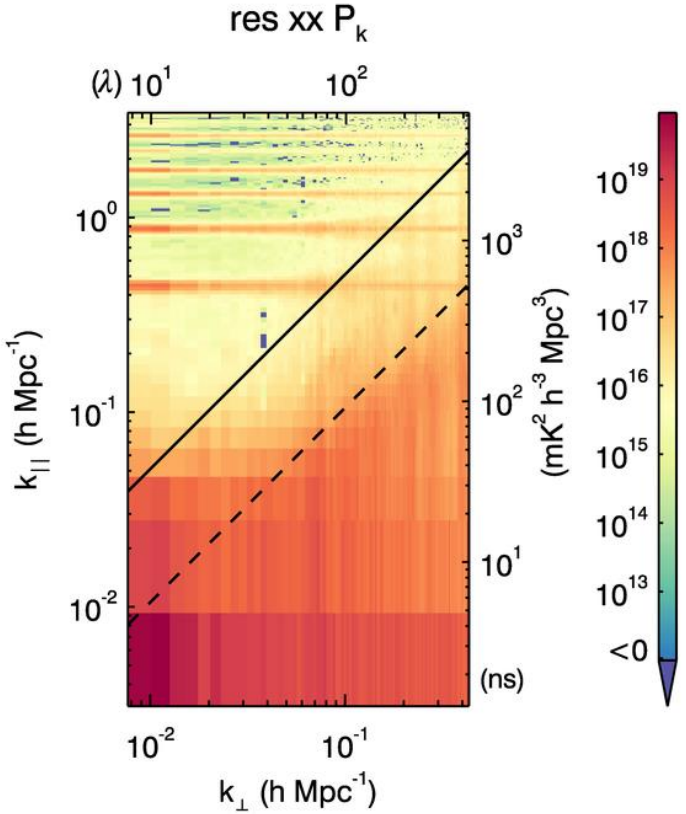
- RTS already has numerous attractive features:
  - Full polarization
  - Parallelized over frequency
  - Uses GPU acceleration
  - We have full control of software
- To get the most out of an extended MWA we might want:
  - Improved Workflows
  - Ionospheric Correction
  - Additional Deconvolution Ability
  - Refine Calibration
  - Refactoring/Optimization/Publication

WORKFLOWS



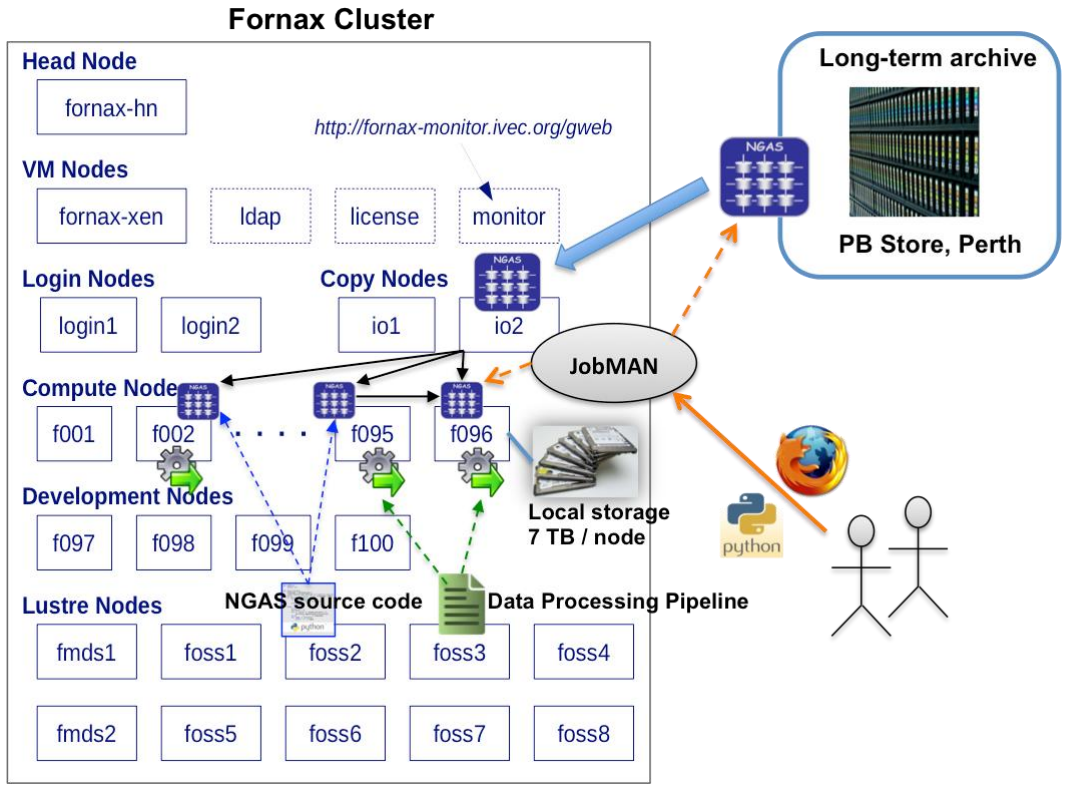
- Current software chain between correlator and science products:
  - NGAS
  - MWA_TOOLS
  - Cotter
  - PBS
  - RTS
    - 120+ parameters
  - Bespoke QA
  - CHIPS/IDL
  - Sourcefinding, ??

WORKFLOWS



- Current software chain between correlator and science products:
  - NGAS
  - MWA_TOOLS
  - Cotter
  - PBS
  - RTS
    - 120+ parameters
  - Bespoke QA
  - CHIPS/IDL
  - Sourcefinding, ??

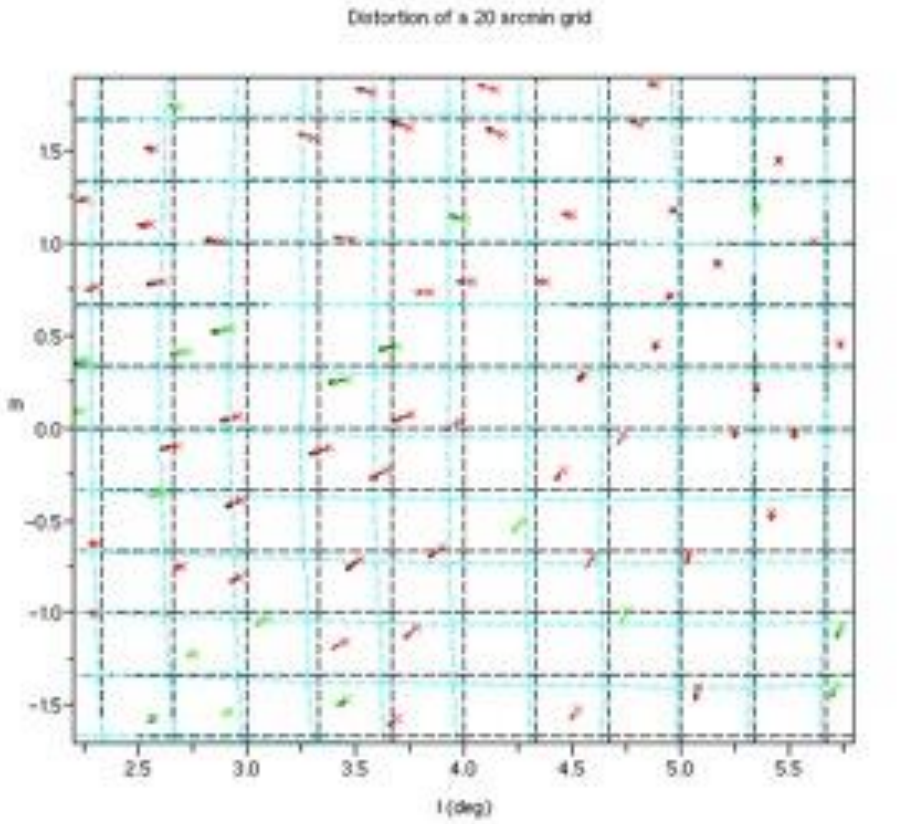
WORKFLOWS



Chen Wu

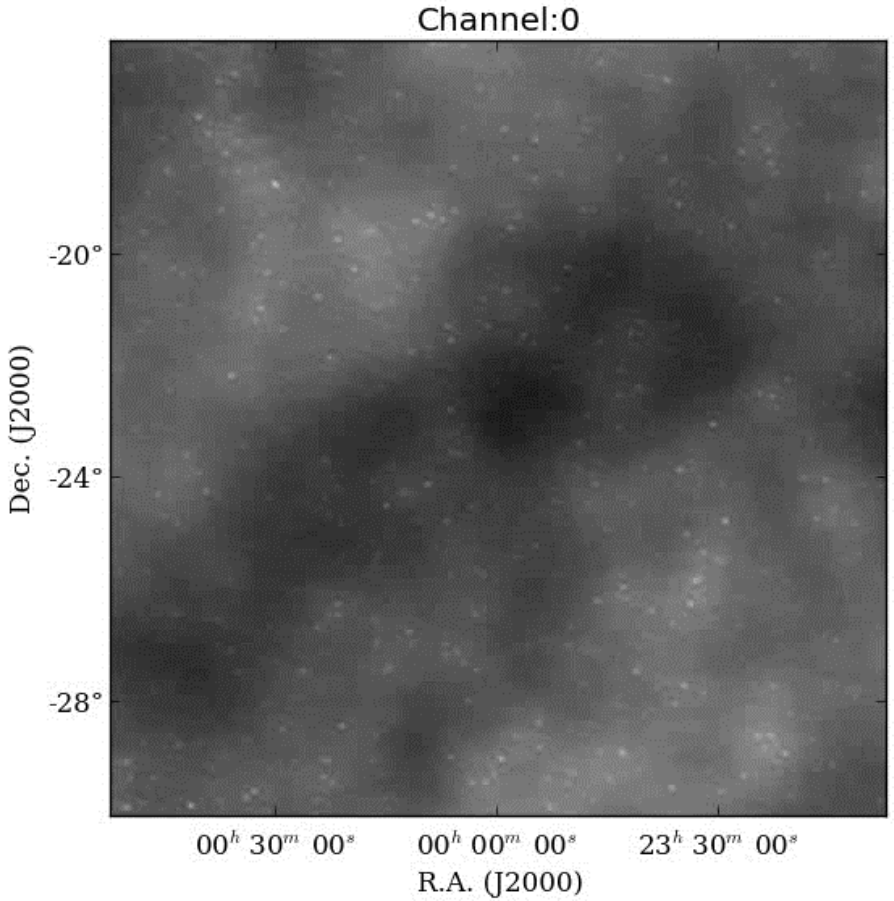
- Human overheads limit processing rate
- Learning curve has slowed adoption
- Best workflow efforts to date developed by Chen Wu et al.
  - Requires support and engagement from HPC facility
- Some separate software modules should be combined
  - RTS + CHIPS
    - Process visibilities while they are still on the GPUs

IONOSPHERIC CORRECTION



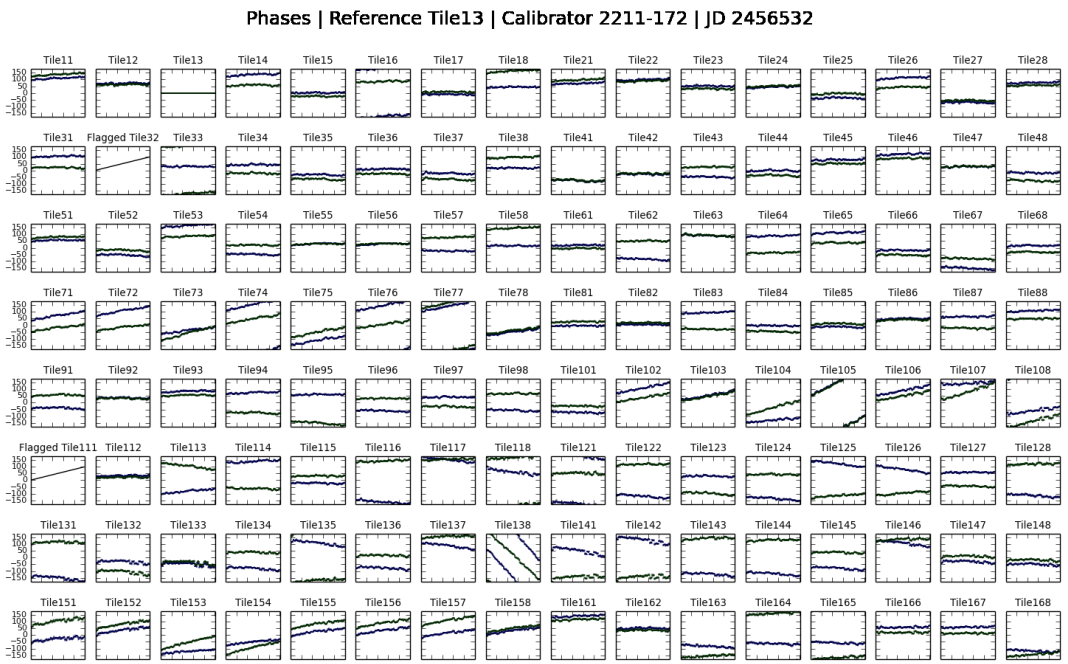
- RTS currently measures and corrects for ionospheric offsets of designated calibrators
  - These corrections can also be applied to weaker sources which peeled but not fit
- Code to apply corrections to the entire image exists but
  - Needs to be fully ported to GPUs
  - Needs to be tested
  - What are the science requirements?
- Also use RM maps (a la Lenc)?
- Ionospheric correction required to:
  - Get the most out of long baseline configuration?
  - Go to lower frequencies
  - Act as SKA precursor?

DECONVOLUTION



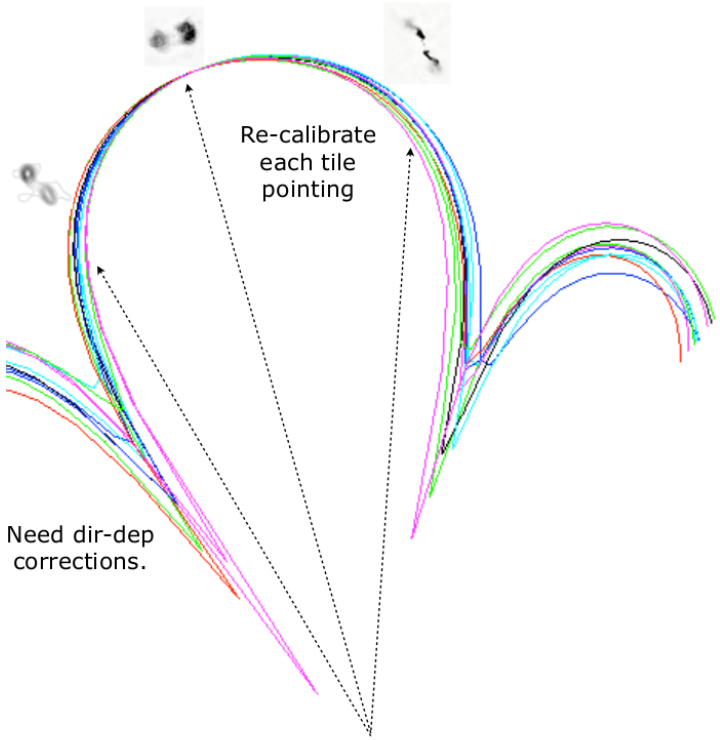
- RTS Calibrator Measurement Loop effectively deconvolves brightest sources and allows visibility space subtraction of hundreds more
  - Shapelets / Compound models for extended sources
- No native facility for CLEAN style deconvolution of arbitrary fields
  - What required uses/modes for this?
  - Multi-frequency multi-scale?
- Deconvolving the Galaxy requires the ability to generate model visibilities from a sky model
  - Bootstrap from MWA + Higher Freq. + Modelling of Extended Sources
  - Use of holographic mapping?

CALIBRATION



- Current RTS calibration occurs on imaging cadence which is meant to resolve ionospheric variations
- Consistency of calibrations across time/pointing suggests constrained parameter space
  - Categorize leading terms in variations
  - Calibrations across different timescales
  - Build calibration libraries
  - Calibration error budget in PS space
- Best use of redundant baselines
- Parallel calibration across wide BW

CALIBRATION



- Current RTS calibration occurs on imaging cadence which is meant to resolve ionospheric variations
- Consistency of calibrations across time/pointing suggests constrained parameter space
  - Categorize leading terms in variations
  - Calibrations across different timescales
  - Build calibration libraries
  - Calibration error budget in PS space
- Best use of redundant baselines
- Parallel calibration across wide BW

REFACTORING/OPTIMIZATION/PUBLICATION

- In 2008 the RTS was well-designed, neatly commented, highly optimized software
  - Then I joined the project
- Refactoring:
  - Rationalizing historical aspects of code structure would aid new development
- Optimization:
  - Complete profiling exercise for most common (EOR/GLEAM/Transients) usage cases
  - Known improvement in available algorithms:
    - Romein/LOFAR gridder 6-8X faster than MWA
    - Adoption of NVIDIA Performance Primitives (eg regridding)
- Publication:
  - Should elements of RTS be made public and would it be useful?

CONCLUSIONS

- Data reduction is already the rate-limiting step for existing PBs of MWA Data
- Plausible hardware expansions lead to a greater volume of data with greater sensitivity
- Further software investment leverages existing MWA data
- (When) Will we need a real time system?
- Will we need a new acronym:
  - FERTS: Future Extended RTS
  - CHIRTS: CHIPS + RTS
  - MITCHD: MWA Imager Towards Cosmic Hydrogen Detection