MWA Real-Time Subsystem

MWA post-correlation calibration & imaging sys.

Short-term picture
- C-code development / testing in Cambridge
- use simulated data now, and 32T data later

Long-term picture
- parallelized RTC implementation: 16 GB s\(^{-1}\) thru O(100) pipes
- construct dirty images every 8\(^s\), remove ionospheric distortion
- provide real-time calibration to other subsystems (B<1.5 km)

Greenhill: Harvard-Smithsonian CfA
RTS Manpower & Resources

• Group kept small, geographically proximate
• Overseen by Greenhill, reporting to Sault (RT System)
  – Daniel Mitchell (SAO): full-time
  – Randall Wayth (SAO): full-time
  – Shepherd Doeleman (Haystack): part-time
  – Miguel Morales (MIT): part-time
  – Justin Kasper (MIT): part-time
  – Bob Sault on-site with local MWA groups 10/06 - 01/07
  – Steve Ord (SAO): new start Jul. 1, part-time on RTS
  – Technical requirements TBD for (1-2) open slots
• Harvard IIC collaboration⇒200+core devel. cluster
RTS Development Priorities

(following 03/07 TAC review)

• Accelerated assembly of formal test harness
  – "right answer" for RTS design cannot be anticipated
    • nuts and bolts testing required; sooner the better
  – sky, ionosphere, and MWA configuration present "challenges"
    • extensive use of simulations for test & evaluation
  – obtain benchmarks; scale; assess performance; rework; repeat

• Drop standalone, individual exploratory codes
  – test-harness to run on desktops and IIC cluster; tight version ctl.
  – built from scratch; C code
  – maintain flexibility in light of uncertain RTC configuration

• Obtain realistic sims via MAPS: dipoles, ionosphere…
MWA Geography

RTS

SCIENCE PKGS
RTS Processing Flow

- Parallel-by-frequency processing steps; data sedentary w/in nodes
- Distribution of measurements (low-BW)
- Distribution of calibration (low-BW)

Ungridded visibilities | Gridded visibilities | Images

Peeled vis.
RTS Processing Flow

Ungridded visibilities  Gridded visibilities  Images

- Parallel-by-frequency processing steps; data sedentary w/in nodes
- Distribution of measurements (low-BW)
- Distribution of calibration (low-BW)
RTS v.0 Elements in Harness

Element

• Raw vis. integrator
• Cal Msrm't Loop
• Tile-beam solver
• Gridder
• Imager

TBD (examples)

• $\sigma^2$-weighting
• $\nu$-chan avg'g; polarized sky; tolerance testing
• full beam response; tolerance testing;
• kernel (w-corr; fully integrate beam response; optimal anti-alias)
RTS v.0 Elements to be Integrated

Element

- Source Detector
- Ionospheric solver:
- De-distorter:
- Simulations (ongoing)

TBD (examples)

- planning
- trial integration
- planning
- clean Stokes-I diffuse sky model; polarized sky model; translating turbulent ionosphere
Simple Sky Model: Pks + Haslam*

The RTS must handle this
Simple Tile Beam: 10%, 5° noise
CML Peel Demonstration

• **XX** polarization
• 140 MHz
• Compact sky only
• $10^3$ brightest sources
• LST=1.5\(^h\) Boolardy
• Flat sky projection
CML Peel Demonstration

- XX polarization
- 140 MHz
- Compact/diffuse sky
- $10^3$ brightest sources
- LST=1.5$^\text{h}$ Boolardy
- Flat sky projection
CML Peel Demonstration

• StokesQ polarization
• 140 MHz
• Compact sky only
• $10^3$ brightest sources
• LST=1.5$^h$ Boolardy
• Flat sky projection
CML Peel Demonstration

- StokesQ polarization
- 140 MHz
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Ionospheric Correction Demo.

- Chapman profile
- 2% turbulence
  - ~ 4x VLA night
  - ~ 2x VLA day
- 9th order poly.
- 361 sources
- 8°x8° field; 140 MHz

Fitted sources Sample for RMS est.
Ionospheric Correction Demo.

- Chapman profile
- 2% turbulence
  - ~ 4x VLA night
  - ~ 2x VLA day
- 9th order poly.
- 361 sources
- 8°x8° field; 140 MHz
- 30°x30° field will be a challenge.
  - Source Detector
  - >1000 sources req.
End-to-end Processing

- Sky to MAPS sim
- MAPS to RTS
- RTS to display
- Demo CML
- Demo Gridder
- Demo data path
  - Compact/diff. sky
  - $10^3$ brightest srcs
  - 20 sources peeled
  - XX @ 140 MHz
  - LST=6h Boolardy

36° square
Relevance to 32T

- **32T enables RTS** real-world testing & guides development
  - benchmarks inform scaling of computation to 512T
- **RTS enables 32T** data processing *off-site*
  - Assessment of dipole/tile performance
  - Construction of initial un/polarized sky survey
- **RTS testing transitions to site** with h/w transition to 512T
  - regulated by RTC/infrastructure development
CML Peel 32T Demonstration

- **XX** polarization
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CML Peel 32T Demonstration

- XX polarization
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- Flat sky projection
end
Analytic Tile Beam: no noise