MWA RLFD EOR Real-Time System

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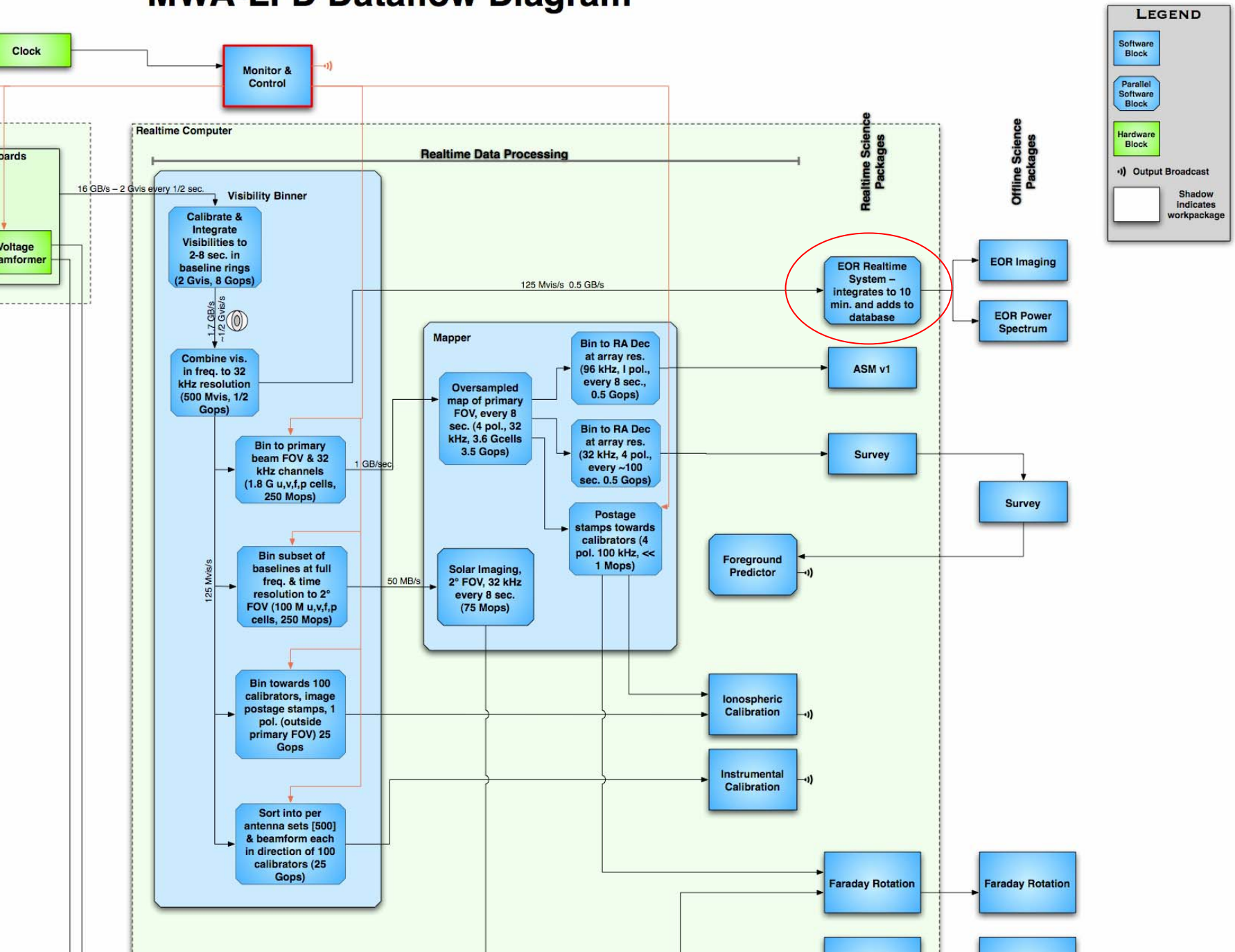
QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

MWA-LFD Dataflow Diagram



Function of EOR Real-Time System is to produce a database for EOR science applications

• It is necessary to integrate over time to make volume manageable and affordable

• This requires accurate correction for instrumental response and ionospheric distortions *which cannot be undone*

• Information on properties and quality of data (metadata) must also be stored

Going in:

- Visibilities at 125 Mvis/sec (0.5 GB/sec)
- Ionospheric phase screen on sky
- Complex antenna beam models
- Monitor and control data
- Other data on environmental conditions, system health, etc.

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TIFF (LZW) decompressor
are needed to see this picture.

Coming out:

- Visibility database
- Meta-database
- Database of data statistics

Relationship to Science Specifications

• Bandwidth, channel width set by specs

• Binning must allow hemisphere for complete foreground subtraction

• Size of grid must accommodate angular resolution spec

• Longer integration times are not directly driven by science but are desirable/necessary to reduce cost, complexity. However, significant risk is that instrumental and ionospheric calibration cannot be redone.

Data Volume - the Numbers

Two-year observing plan calls for 1250 + 625 + 625 = 2500 hours of observing (of which we expect 40% to be “good”). Without integration this requires 0.5 GB/s * 2500* 3600s = 4500 Tbytes of storage.

Integrating to ten minutes resolution reduces requirement to (16GB/s / 4) * 2500* 3600s / 600 = 60 TBytes of storage.

Current Design is Very Conceptual

Much discussion of real-time calibration algorithms under way - eg., uv plane vs image plane. Much to be learned from CMB experience.

VLA 74 MHz ionospheric calibration system provides an existence proof (brute force):

- Divide sky into facets over which antenna complex beam pattern and ionospheric screen can be approximated as constant
- Image all facets simultaneously, applying correction for each facet
- Knit facets together into calibrated image of sky
- FFT back to uv plane? (perhaps not necessary)

Current Design is Very Conceptual (con.)

Uv plane version

- Convolving with window function in uv plane will isolate each isoplanactic patch
- Calibration corrections can then be applied in uv plane
- Populate uv grid and accumulate/average for integration time
- Need to understand noise properties after convolution

Is there in fact an algorithm in the uv plane that is computationally more efficient? Miguel says there is - the rest of us are getting our head around it

EOR science collaboration is studying this.

The measured visibility data on baseline (i,j) have been folded through the two tile beam patterns

Tile amplitudes

$$\Delta I_{\mathrm{IFIB}}(i,j,u,v,\Delta f) = \int\int B(i,\theta_x,\theta_y,\Delta f)B(j,\theta_x,\theta_y,\Delta f) \tag{9}$$

$$(\Delta I_{\mathrm{EOR}}(\theta_x,\theta_y,\Delta f) + \Delta I_{\mathrm{FG}}(\theta_x,\theta_y,\Delta f)) \tag{10}$$

$$e^{-i2\pi(u\theta_x+v\theta_y+\phi(|\vec{u}|,\theta_x,\theta_y,f,t)+\chi(i,\theta_x,\theta_y,\Delta f)-\chi(j,\theta_x,\theta_y,\Delta f)}d\theta_x d\theta_y \tag{11}$$

Ionosphere

Tile phases

If the tiles are identical, we can express this in terms of an array weighting function

$$\Delta I_{\mathrm{IFIW}}(u,v,\Delta f) = \Delta I_{\mathrm{IFI}} *_{uv} W(u,v,\Delta f) \tag{12}$$

Visibility is sampled once per convolution element, so correction is simply multiplication by a complex field

Generalizing this to non-identical tiles

The Rest of Colin's Questions

• What are the challenges and risks - schedule, cost, technical?
Difficult to evaluate quantitatively without algorithms in place in more detail. *EOR team is moving into high gear!!*

• Skills needed for development and implementation? Algorithm development for large datasets (CMB experience should continue to be be drawn upon). Close communication with receiver/correlator groups. Scientist need to guide the design and development of the system. Then we need good real-time programmers.

• Dependence on other subsystems? Visibility binner, antenna gain calibration system, ionosphere calibration system. Need to work closely with database query person/team.

• Interface definitions? Should be reasonably straightforward once we settle on the algorithms.