

The ROACH Digital Back End



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Atacama Large Millimeter/submillimeter Array

Expanded Very Large Array

Robert C. Byrd Green Bank Telescope

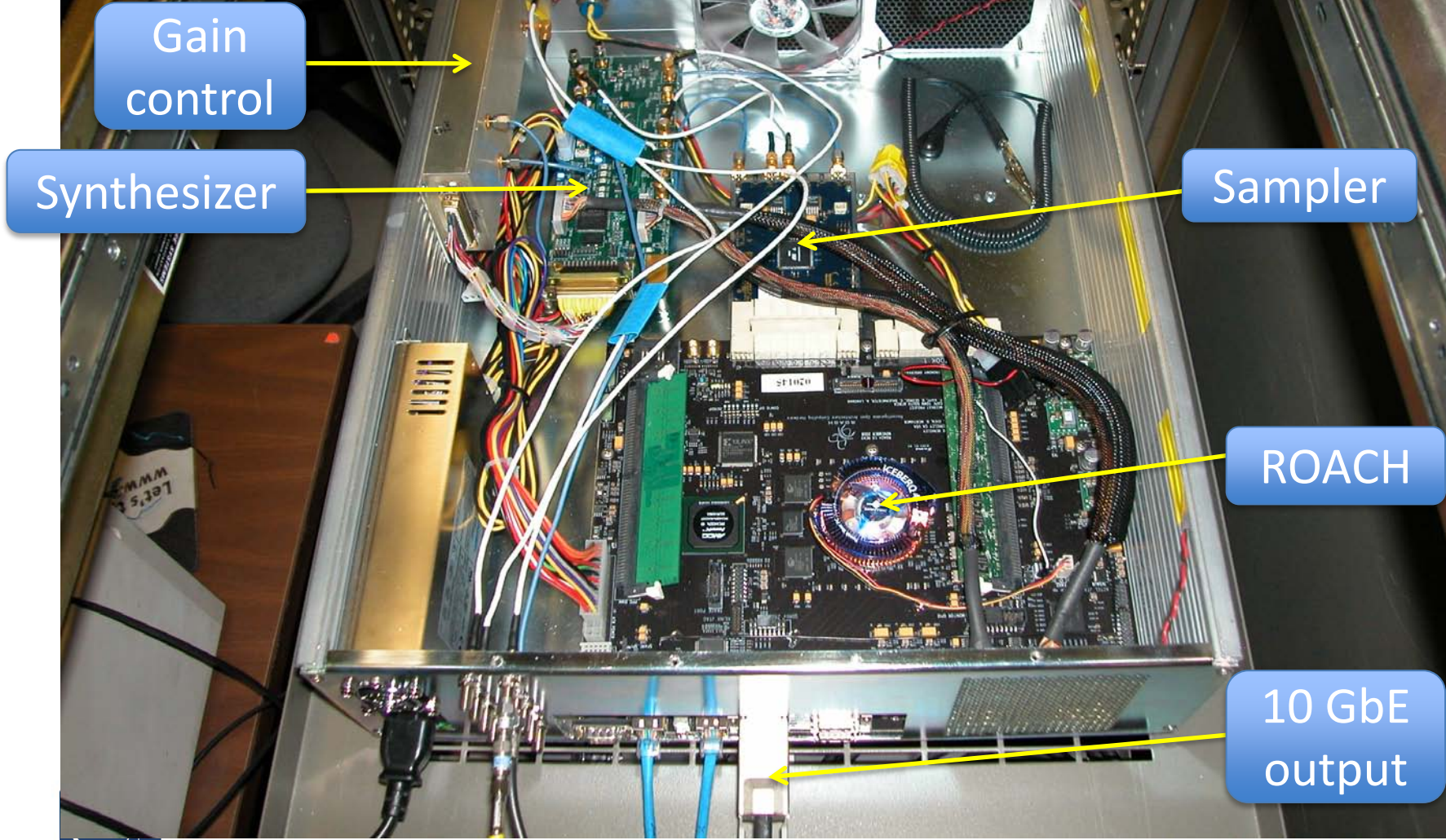
Very Long Baseline Array



The RDBE

- A complete digital back end in one 3U box
 - 2x 512-1024 MHz anti-aliasing filters (in NRAO units only)
 - 2x 0-31 dB selectable attenuation
 - 2x 1024 Msps 8-bit samplers
 - ROACH-I board
 - Virtex 5 FPGA (SX95)
 - PowerPC (PPC) CPU
- A big development effort
 - CASPER, KAT project of South Africa & NRAO developed ROACH
 - NRAO & Haystack developed firmware and chassis
 - Product available commercially through Digicom
- Price: \$15000 + FPGA (~\$3000) = 10600€ + ~2100€
 - Does not include anti-aliasing filters





RDBE Interfaces

- Input
 - Data: 2 independent channels
 - 512-1024 MHz IF passband (Nyquist zone 2)
 - Nyquist zone 1 to 5 sampling is possible with appropriate filter
 - -22 to +9 dBm input power
 - Clocks: 1 PPS & 5 MHz
- Output
 - Data: 10 GbE via CX4 connector
 - Mark5B or VDIF format encapsulated in UDP
 - Clocks: 1 PPS, 1024 MHz & 10-100 Hz noise cal.
- Monitor and control
 - VSI-S interface over 100 MbE

Primary function:

Tuning, filtering & formatting

- Polyphase FilterBank (PFB) personality
 - Each 512 MHz input is divided into 32 MHz sub-bands
 - 15 of the 16 sub-bands are usable
 - Arbitrary selection of any 16 sub-bands from the 2 inputs
 - 2-bit sampled and Mark5B formatted (2048 Mbps fixed data rate)
 - Currently LSB-only
- Digital Down-Converter (DDC) personality
 - Produces 8 fully tunable (in 15625 Hz steps) sub-bands
 - Except: no band can cross 128 or 384 MHz boundary
 - Sub-band bandwidth selectable from 128 MHz down to ~125 kHz by 2
 - Eventual support for mixed sub-band bandwidth
 - 64 MHz most difficult and might require separate personality
 - Currently Mark5B format is produced; ultimately VDIF will be

The 8 Gbps RDBE variant

- A variant of the standard RDBE hardware
 - 4x 512 MHz IF supported
 - 2x iADC boards employed to do this
 - Output on 2x 10GbE ports in VDIF format
- Uses stripped-down firmware
 - FPGA does no channelization, just level setting and formatting
 - Formats full IF bandwidth so no tuning configuration required
- You can make your own RDBE variant if you like!

Gain control

- Analog “external” gain control
 - Performed using 0-31 dB step attenuator module
 - Feedback for setting based on sample capture statistics within PPC
 - Desire to keep this attenuator fixed during an experiment
 - Different signal paths could lead to delay or bandpass change
- Digital “internal” gain control
 - Independently selectable on each sub-band
 - In 2-bit case equivalent to setting the quantizer thresholds
 - New scheme in DDC personality uses captured state counts to iteratively set the gain; will be ported to PFB
 - Desire to adjust this during an experiment
 - Compensate for sky brightness changes
 - Changes to be done only on 1 second ticks
 - Geodesy and astronomy make different use of this capability

Auxiliary functions

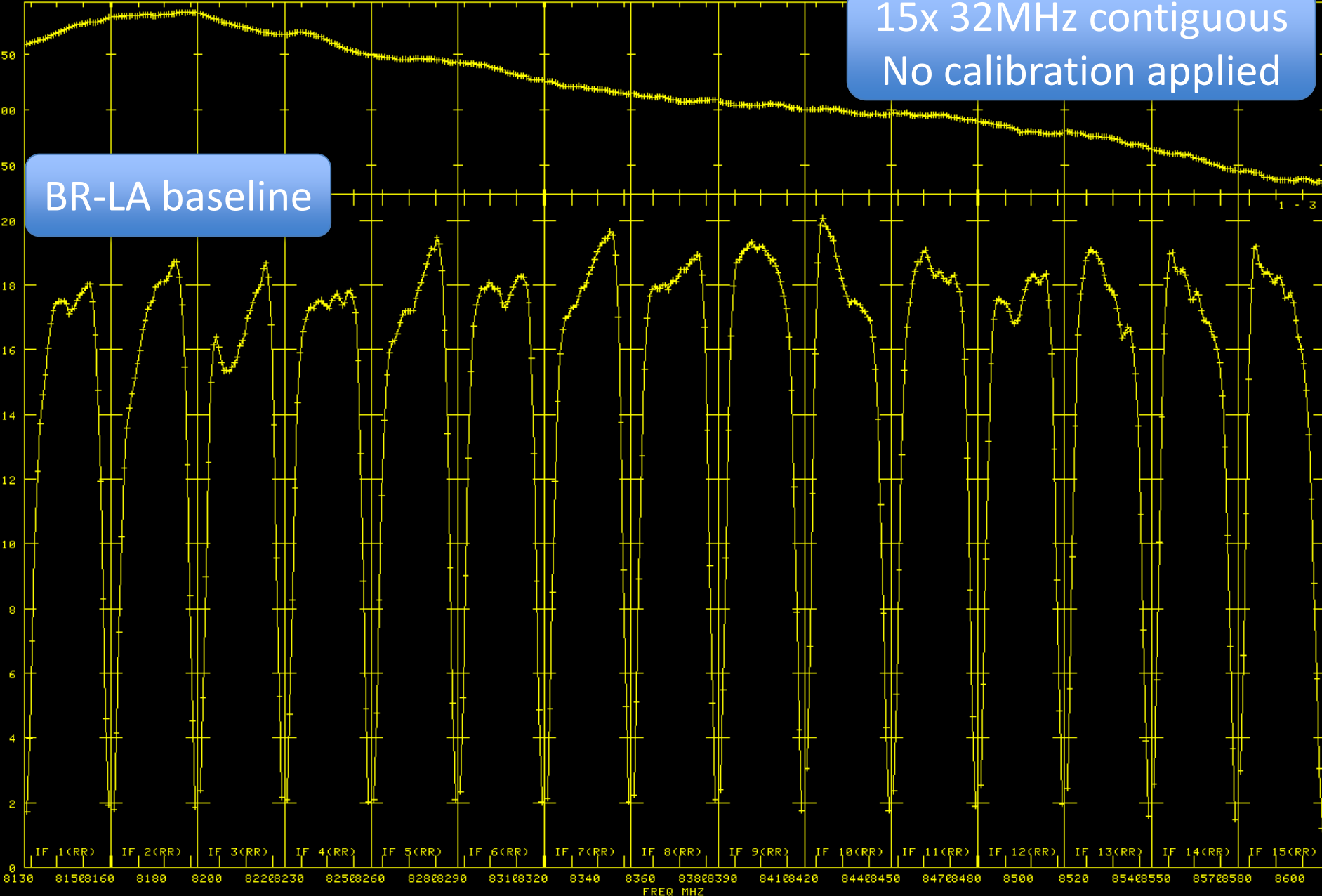
- Switched power detection
 - Continuous switched noise power is used for amplitude calibration
 - 10 to 100 Hz switching rate supported
 - FPGA will accumulate integrated power into “on” and “off” bins
 - Separately for each sub-band
 - Dumped to PPC once per second
 - Being integrated into PFB personality now; DDC soon
- Pulse cal tone extraction (under consideration)
 - Useful for real-time diagnostics
 - Data for calibration likely to be derived at correlators
 - Concept not yet chosen
 - Possible to extract 1 or 2 tones completely within FPGA
 - Possible to extract many tones with a joint FPGA/software approach

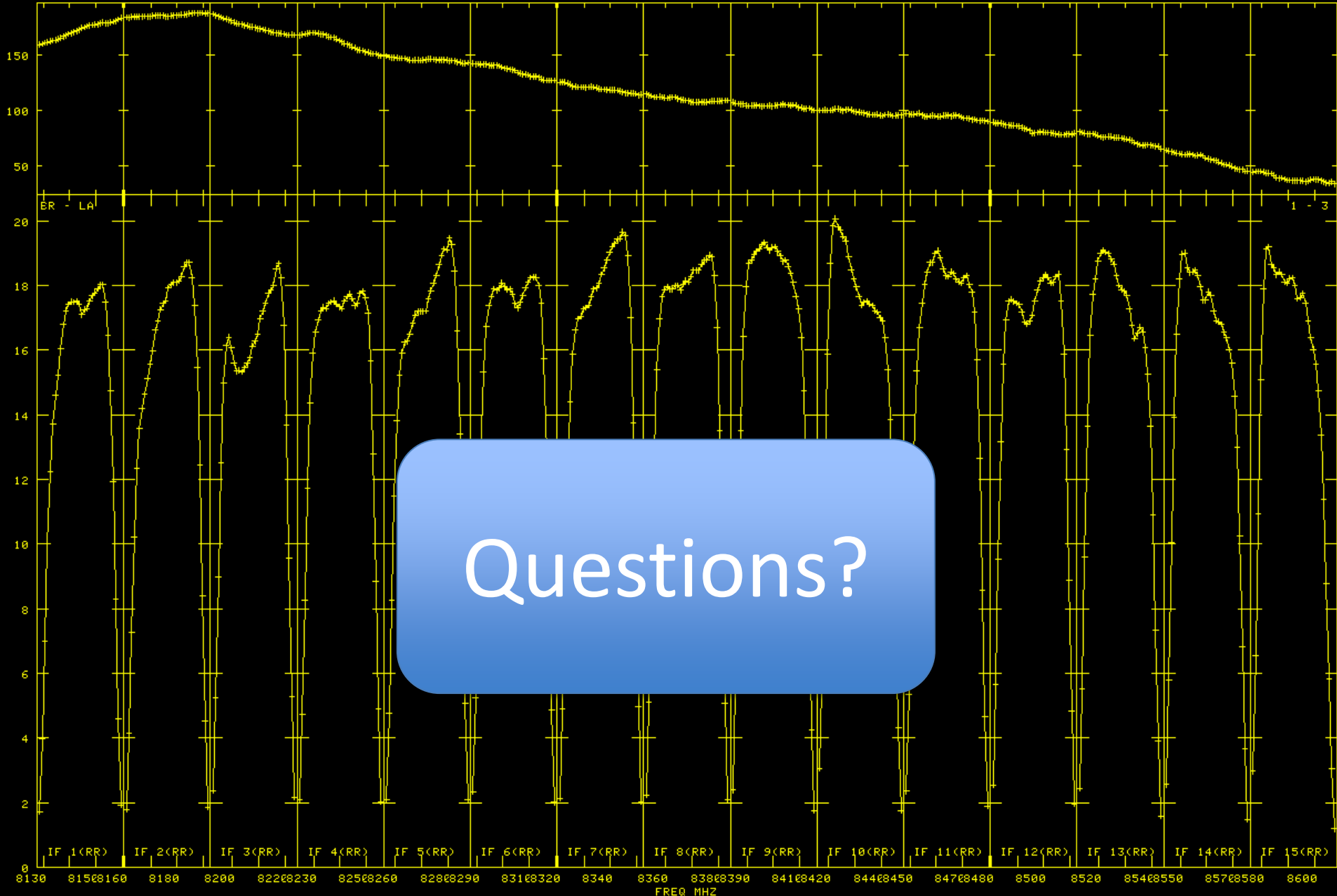
Deployment status within NRAO

- 7 antennas outfitted with RDBE + Mark5C
 - BR, HN, LA, MK(x2), PT(x2), SC & GBT(not yet tested)
 - Remaining 4 to be completed by mid May
- Full installation will consist of 2 RDBEs per site
 - Initially recording will be done via 10GbE switch with one Mark5C
- First early science observation made on Mar 19
- Ten station science to begin this summer

15x 32MHz contiguous
No calibration applied

BR-LA baseline





Questions?