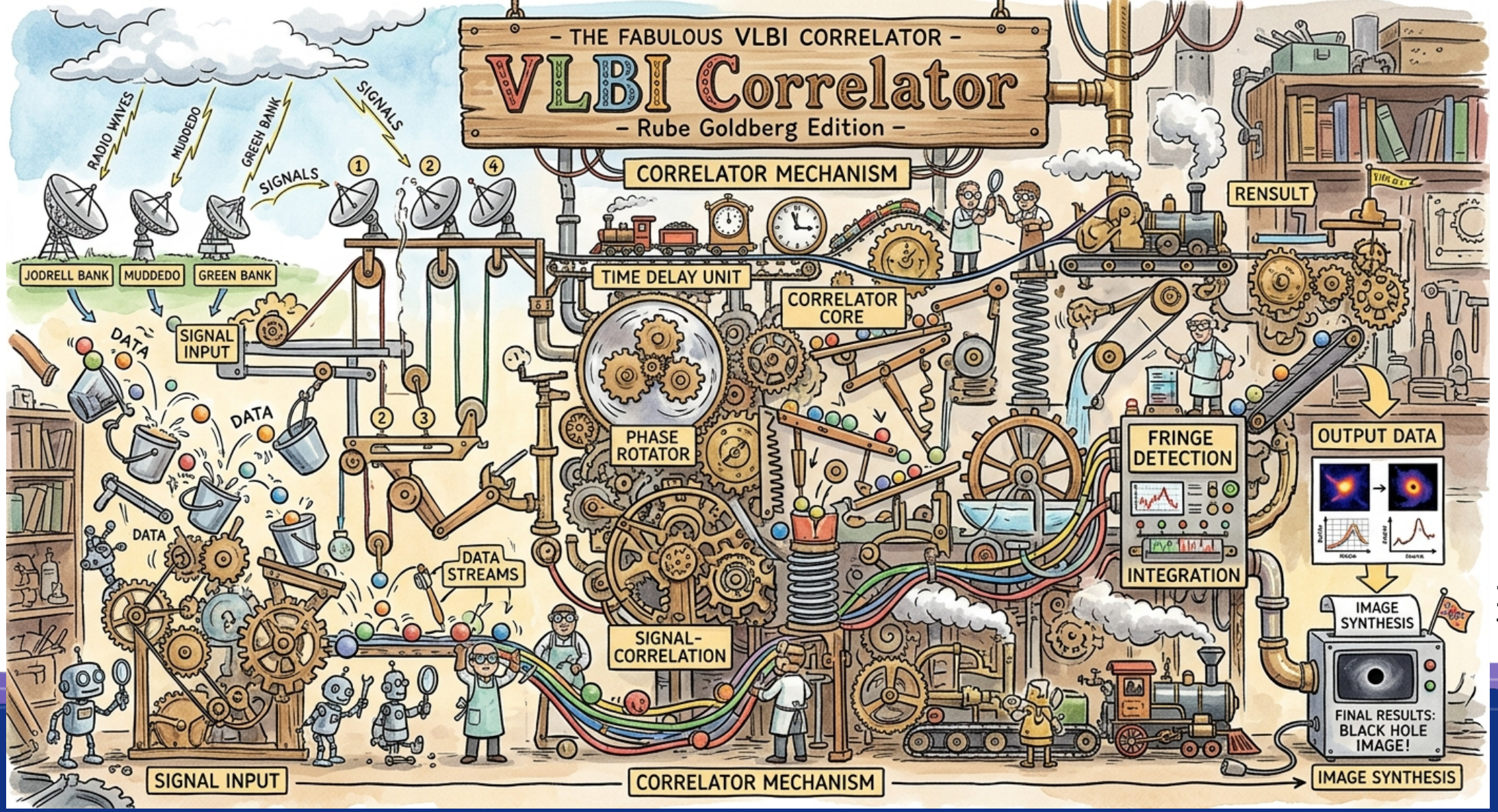


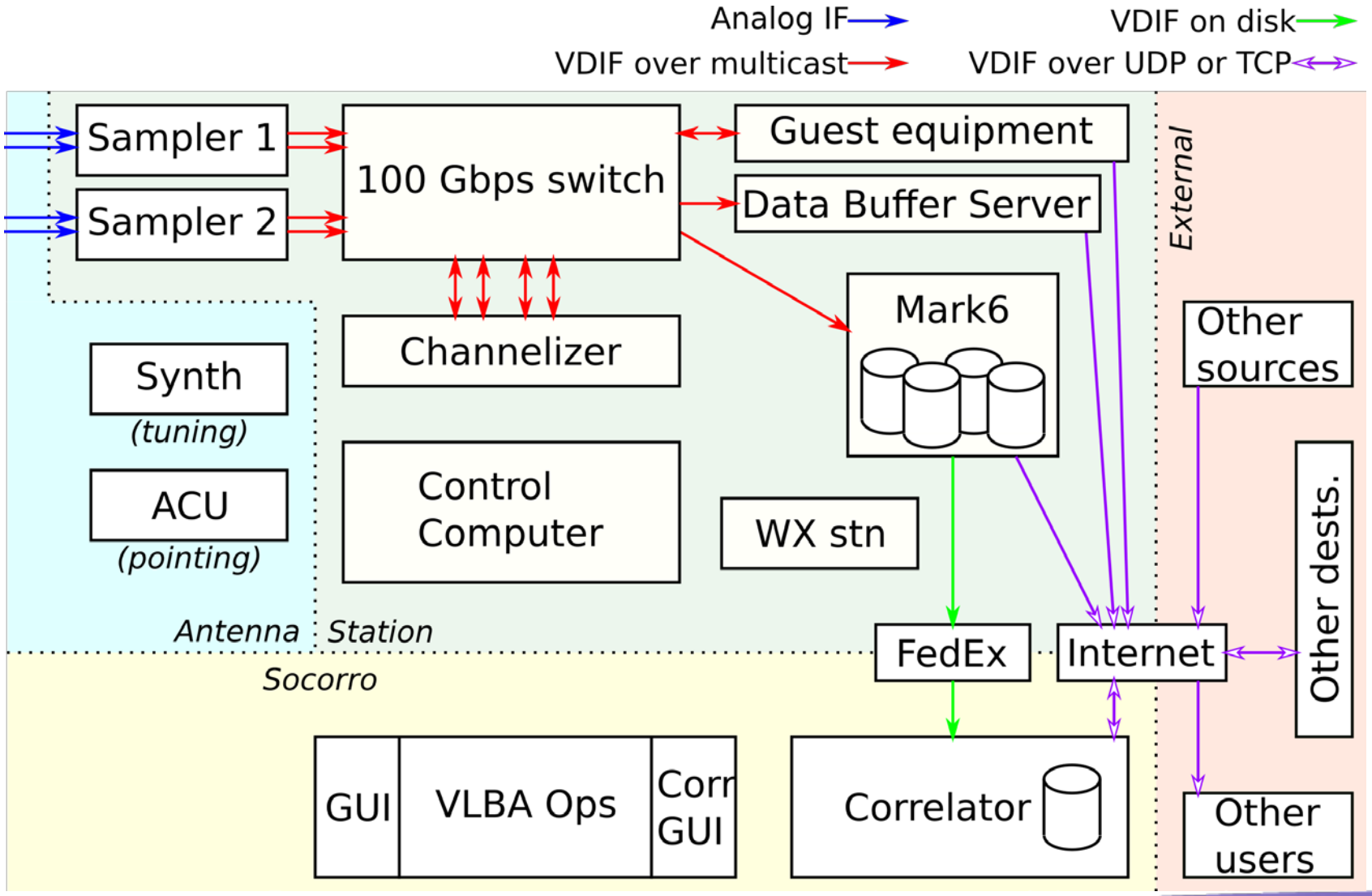

AI Image

# VLBA Update EVN TOG Walter Brisken

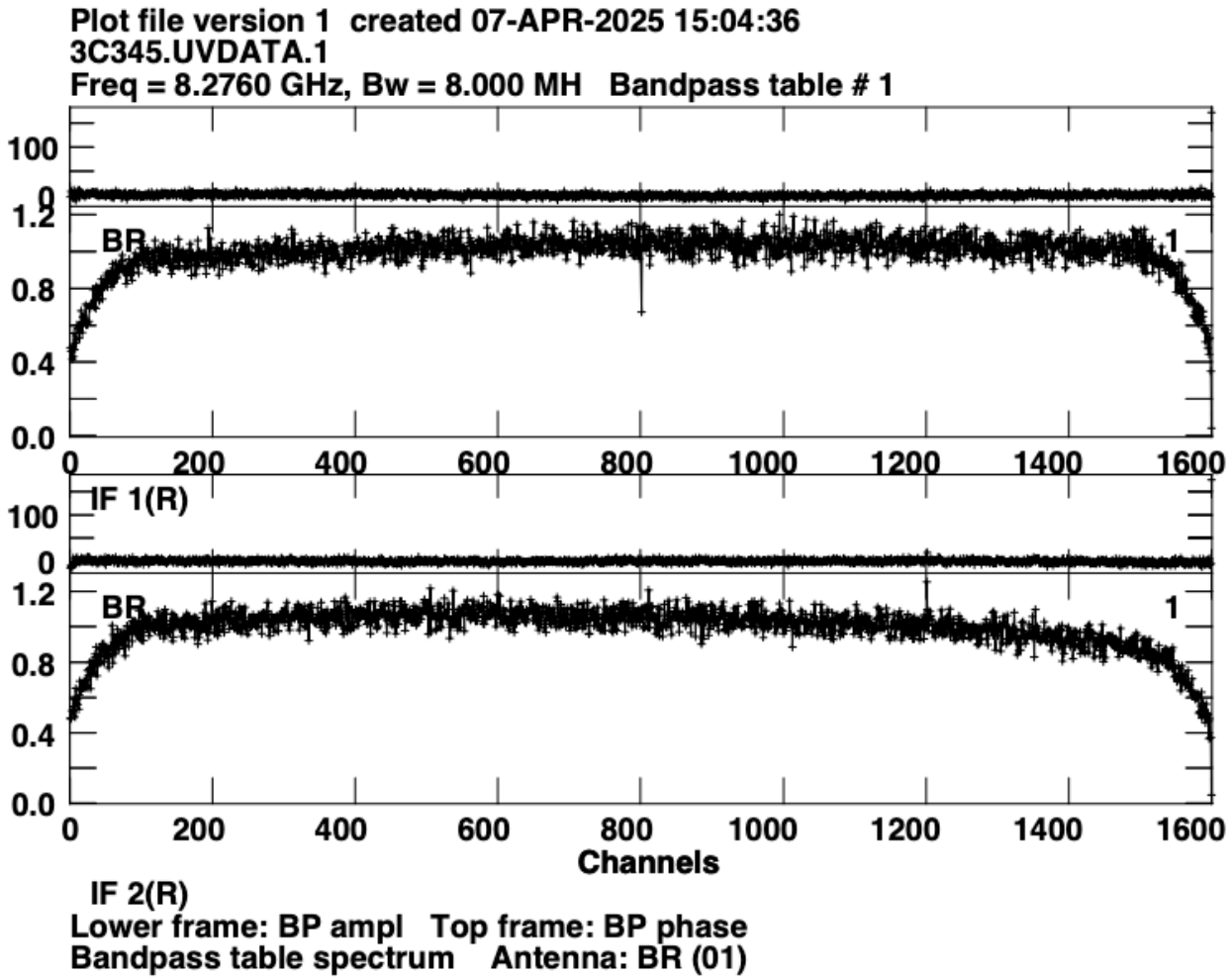
# VNDA architecture

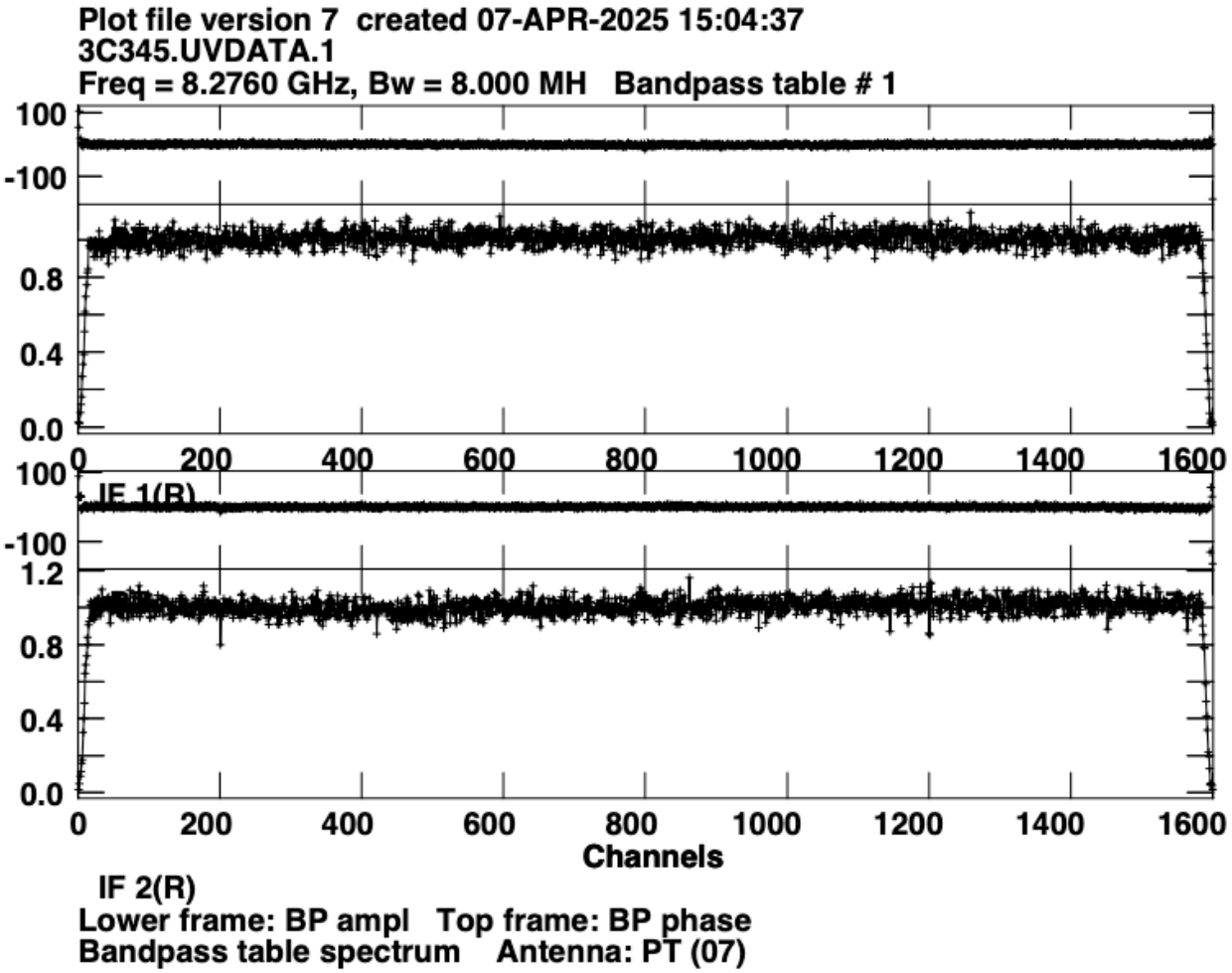
- A 100 Gbps Ethernet switch forms a hub
- Producer (sampler) modules stream VDIF into switch using multicast UDP
  - Digitized at 14 bits per sample
  - Sampler module is not configurable
  - Time-tags are applied here
- Consumer (channelizer) module digitally filters these streams
  - Create $2^n$ MHz channels
  - Requantize to 2, 4 or 8 bits per sample
  - Multicast channelized VDIF streams back into switch
- Other equipment can attach to switch (VNDA Guest Equipment)
  - Mark6 recorder for local recording
  - Data Buffer Server for store-and-forward operations; support real-time VLBI
  - Guest equipment for customized user-supplied processing

# VLBA New Digital Architecture (VNDA)



# Bandpass Results



# VNDA status

- Two stations have prototype VNDA systems deployed
  - On the sky tests completed; data quality looks very good
- Passed final design review
- Equipment for deployment has been ordered
  - AI datacenters caused huge delays and cost increases
  - Delivery expected in 1-2 months
- Deployment at all 10 sites by end of CY2026
- Commissioning complete by Mar 2027
  - Available to users soon thereafter!

# VNDA: Notes for Global VLBI Users

- We will require vex2 files for configuration of VNDA (Sched 12.2 supports this)
- VNDA produces complex-valued VDIF in 8032 byte frames
- Expected data rate increase to 8 Gbps in some modes, including >2 bits per sample
- Maximum baseband channel width to 512 MHz
- VDIF Extended Data Header
  - Currently VNDA is using EDH 0x00 – containing nothing
  - Will develop a new EDH

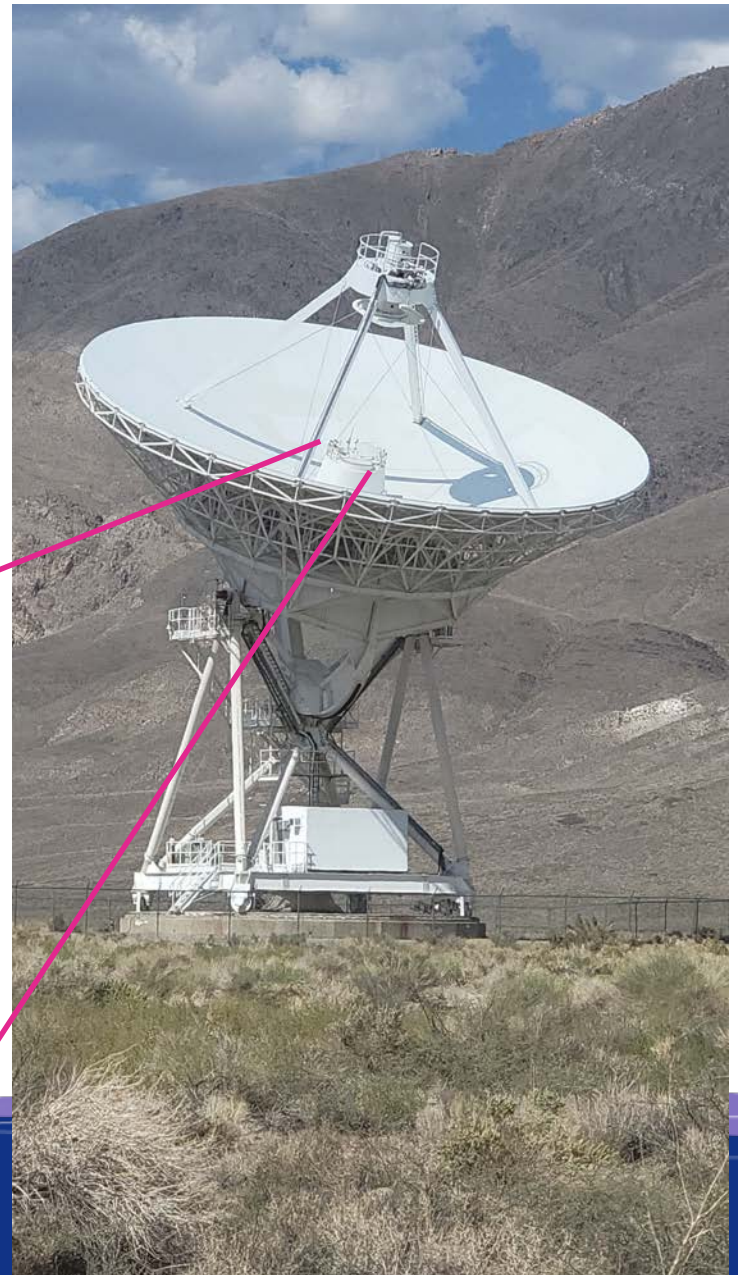
# Proposed VDIF EDV 5 for VNDA

| Byte # | 3 | | | | | | | | 2 | | | | | | | | 1 | | | | | | | | 0 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bit # | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Word 0 | $I_1$ | $L_1$ | Seconds from reference epoch$_{30}$ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Word 1 | $U_2$ | | | Epoch$_6$ | | | | | Data frame number in second$_{24}$ | | | | | | | | | | | | | | | | | | | | | | | |
| Word 2 | Ver$_3$ | | | | $\log_2(n_{\text{chan}})_5$ | | | | Data frame length (units of 8 bytes)$_{24}$ | | | | | | | | | | | | | | | | | | | | | | | |
| Word 3 | $C_1$ | Bits/samp-1$_5$ | | | | | | | Thread Id$_{10}$ | | | | | | | | Station Id$_{16}$ | | | | | | | | | | | | | | | |
| Word 4 | EDV=5$_8$ | | | | | | | | Sample Rate$_{24}$ | | | | | | | | | | | | | | | | | | | | | | | |
| Word 5 | Sync word = 0xACABFEED$_{32}$ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Word 6 | Sky Frequency$_{32}$ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Word 7 | Unassigned$_{20}$ | | | | | | | | | | | | | | | | | | | | Src IF$_4$ | | | | Src Dev$_4$ | | | | | SB$_1$ | Pol$_3$ | |

- Input welcome on how to structure this or we should collaborate for wider
- Sample rate and sky frequency in units of 1 kHz
- 20 bits currently unassigned

# X/Ka Wideband Receiver

- Install 8-38 GHz receiver at every VLBA site
- Prototype showed suitable performance at OV VLBA site
- Motivation
  - Access to larger portion of spectrum
  - Simultaneous multi-frequency observing
    - 3 infinitely flexible IF pairs
  - Update the "plumbing" for wider bandwidth



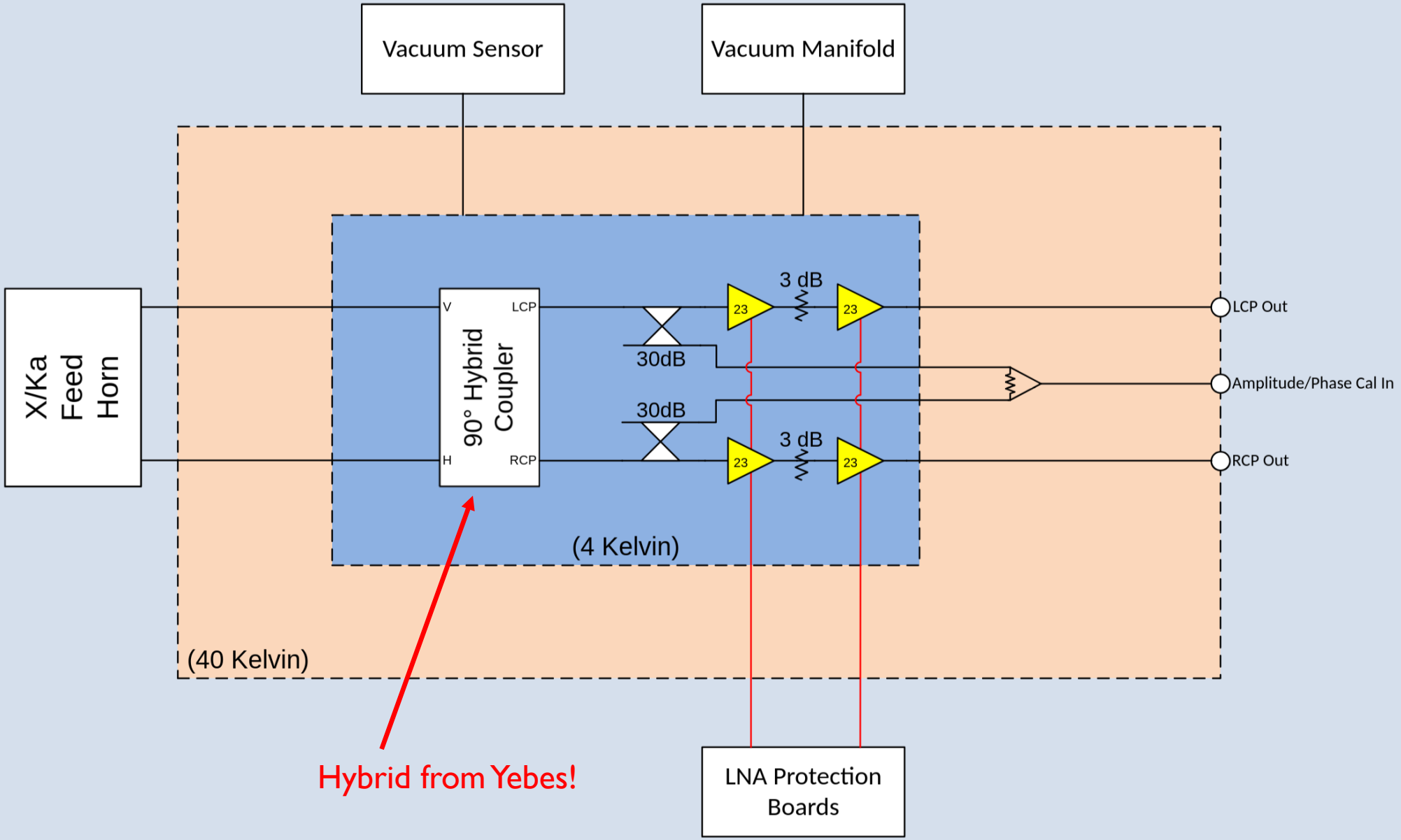
# Wideband receiver

- 1 year into a 3-4 year project
  - PDR targeting February
- Engineer new components based on JPL prototype
  - Wide-band feed
  - Receiver
  - Downconverter
- Integrate new pulse cal system
  - Rohde and Schwarz COTS comb generator
  - 1-44 GHz
  - 5 MHz spacing
- Move samplers to antenna
  - Improved signal fidelity
  - Access to 1 GHz wide IFs

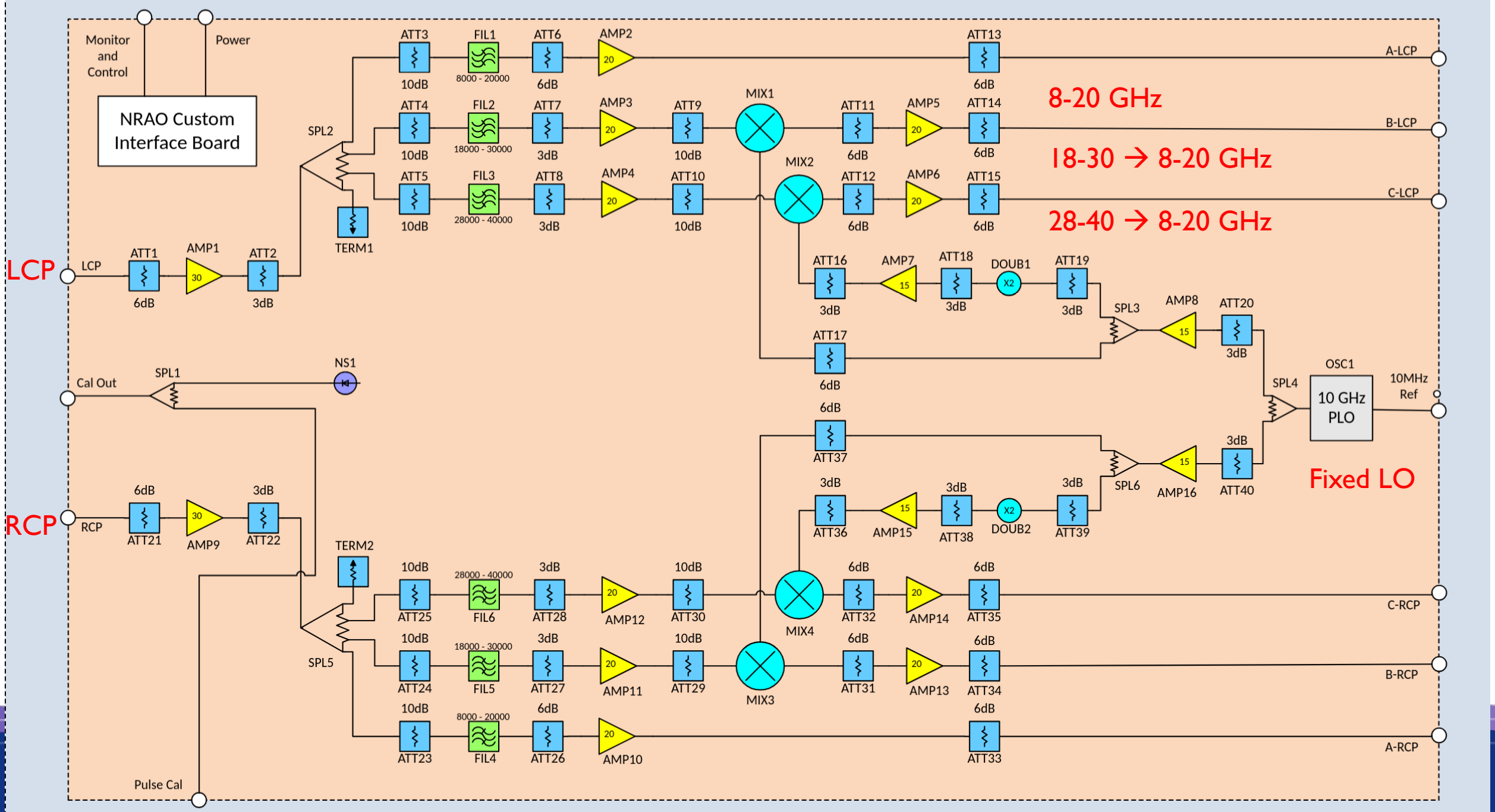
# X/Ka Wideband Receiver: User visible changes

- Dual-band & tri-band observing
  - Critical for CRF as S/X becoming challenging due to RFI
  - Beneficial for NASA for navigation at Ka-band
  - Beneficial for CRF due to better quasar behavior
  - X/K/Ka tri-band observing likely to be a heavily used mode
- Access to new spectral lines
- Access to high frequency continuum band that is minimally weather affected
  - Less affected than K- or Q-band by atmospheric absorption
- Q- and W-band to be routed through new converters
  - Allow 1 GHz IFs for greater tuning flexibility and wider bandwidth
- Improved noise performance in Ku-band
- Increased redshift coverage of 22.2 GHz water line
- Options for Frequency Phase Transfer calibration

# X-Ka Cold Front End

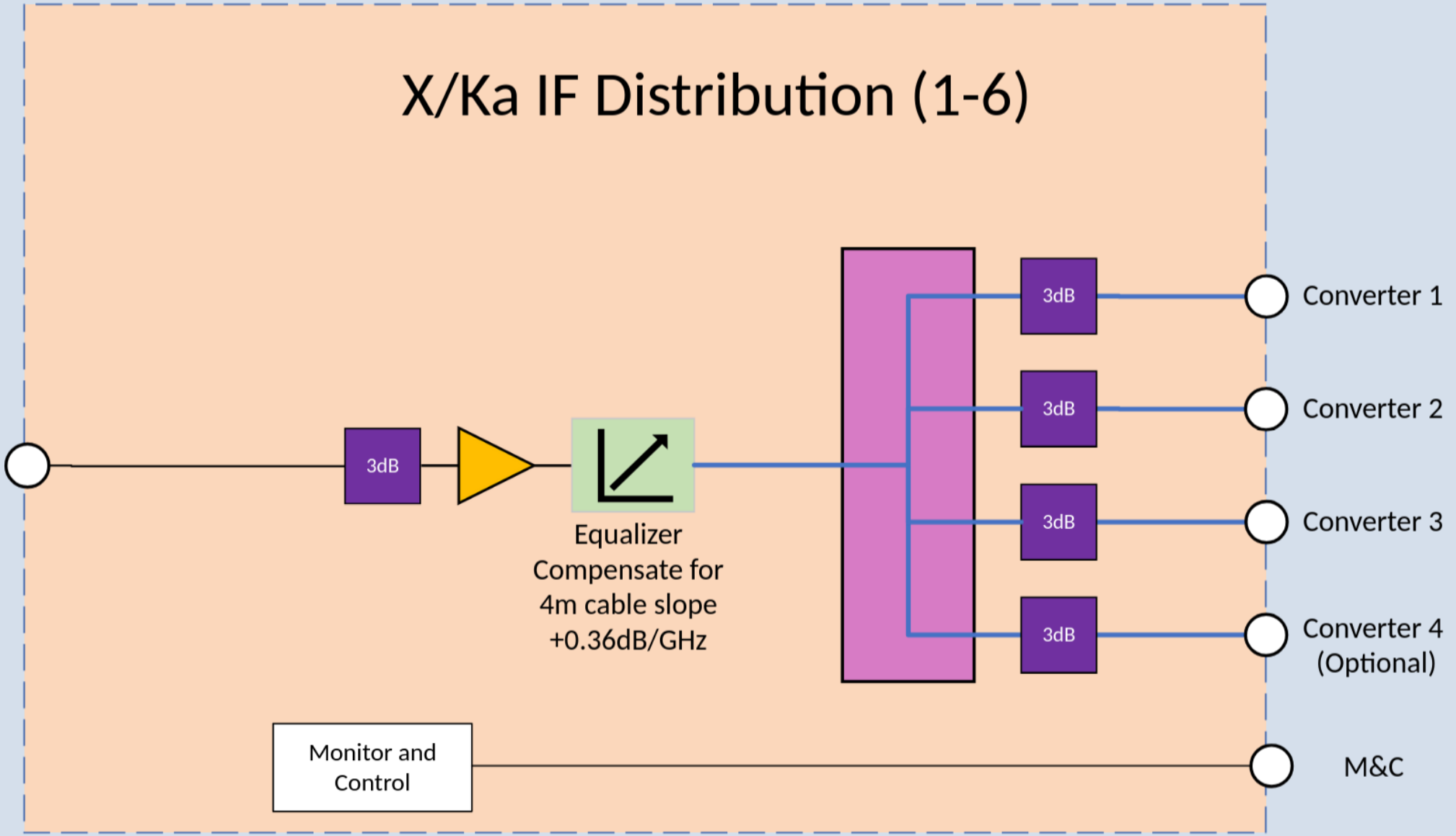


# X-Ka Warm Front End

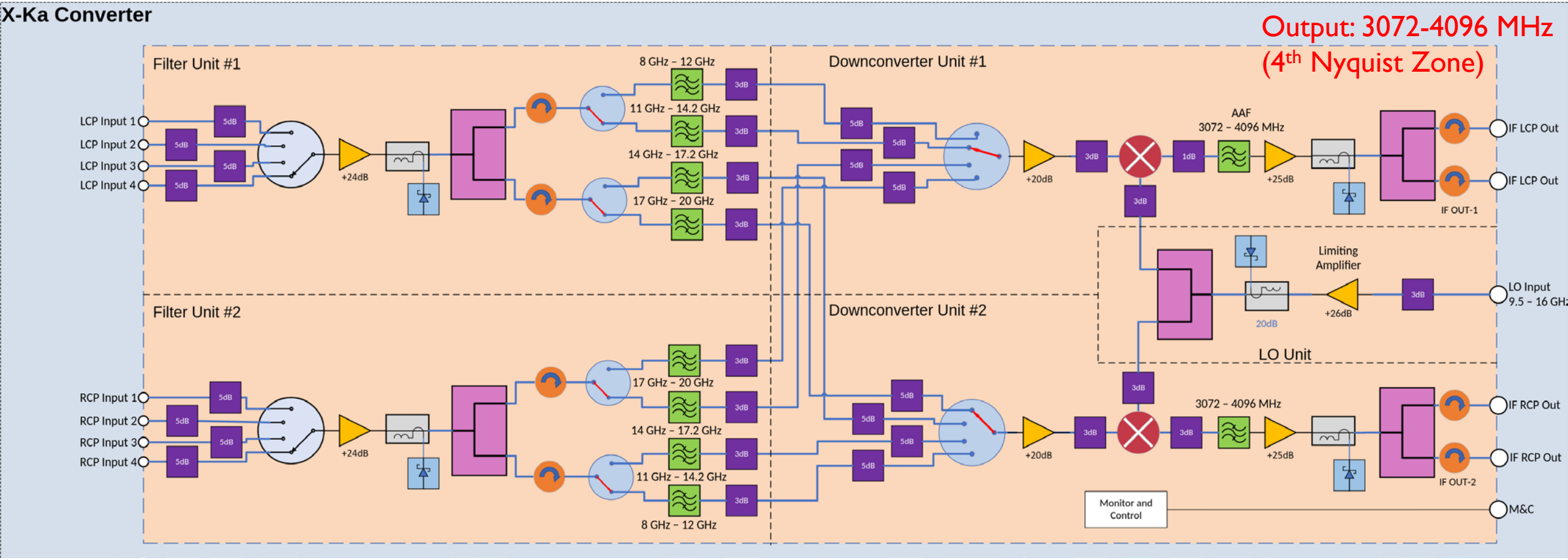


# X-Ka IF Distribution

6 identical modules



3 identical modules
Could add 4th for another IF pair



# X/Ka receiver: Notes for Global VLBI users

- No expected changes to VDIF data
- Two separate receivers can operate in 8-9 GHz range
  - Gain and Tcal values could vary
- Focus change with frequency
  - Requires a compromise focus position, further complicating gain tables
- Option for frequency-phase transfer calibration in the 8-40 GHz range
  - Three IF polarization pairs anywhere in the receiver frequency range
- Data rates to 12+ Gbps
  - Unclear how recording will occur
  - Option to write to multiple Mark6 modules simultaneously

# Other user-visible ongoing efforts

- Wide-band fiber to each VLBA antenna
  - For near-real-time and real-time capabilities
  - Desire to get out of disk shipment business
  - Proceeding as funds and time allow
- E-transfer expansion
  - Currently e-transfer has approx. 1.9 PB capacity
  - Increase to approx. 7 PB in coming months
- GNSS receivers
  - Hopefully improved / more reliable timing model
- Full VLBI capabilities in CASA for data reduction
  - Many thanks to folks at JIVE for pulling a lot of weight here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