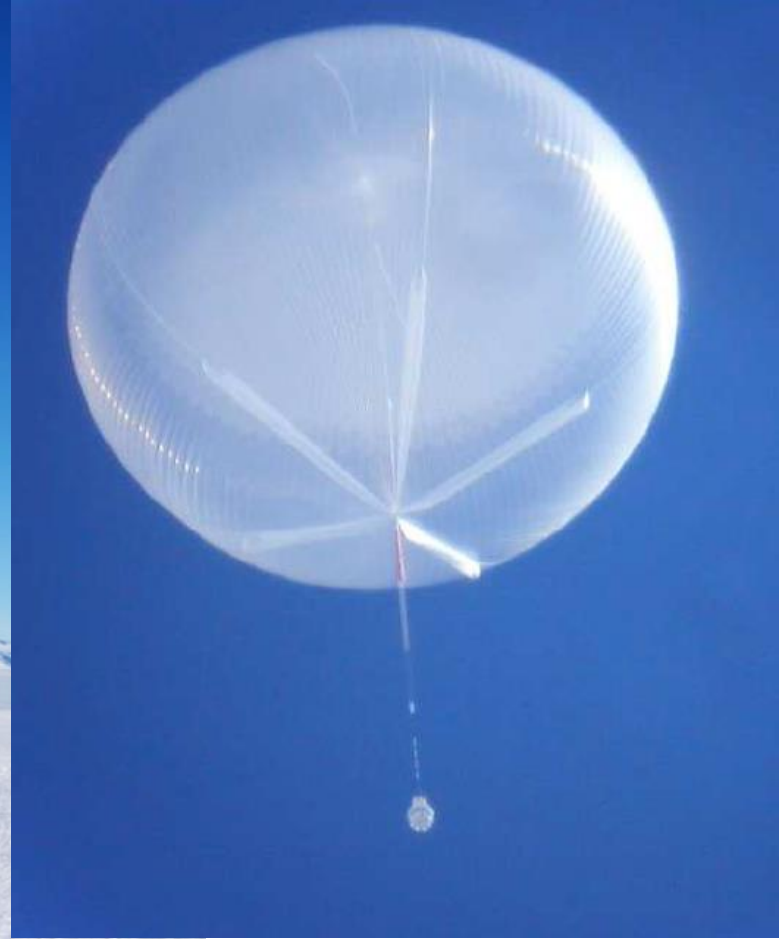




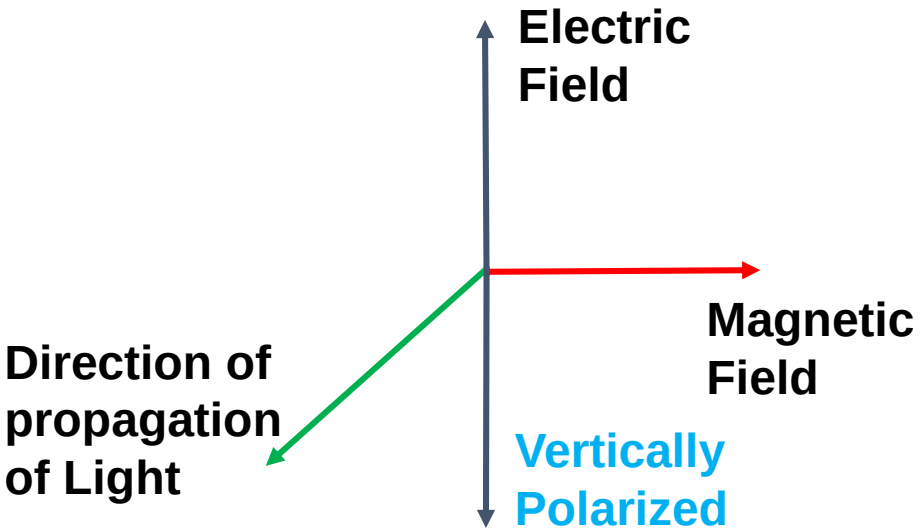
An Overview of ANITA Hardware

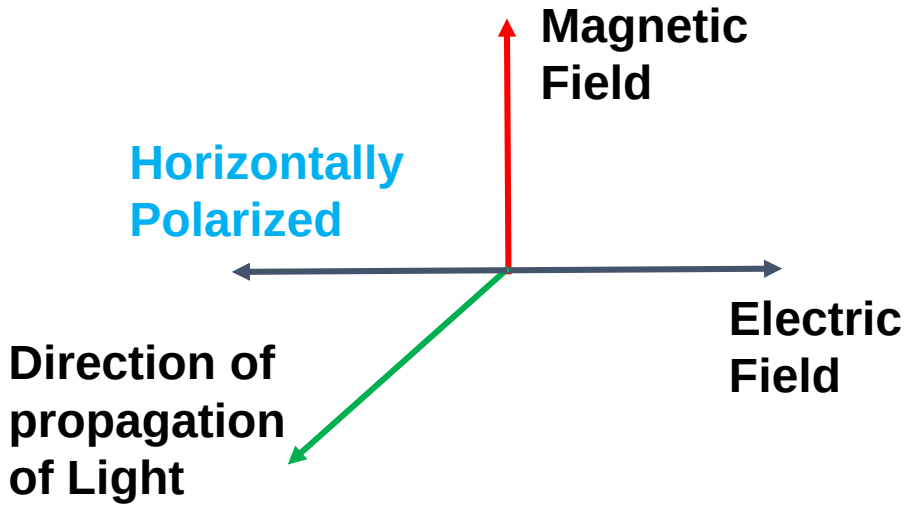
Oindree Banerjee

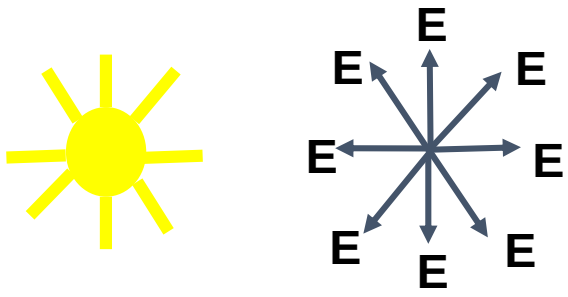
References

- PhD thesis of Abigail Vieregg
- PhD thesis of Matt Mottram
- Connolly group members

Polarization of Light







Unpolarized sunlight

Vertically Polarizing sunglasses

Vertically Polarized sunlight

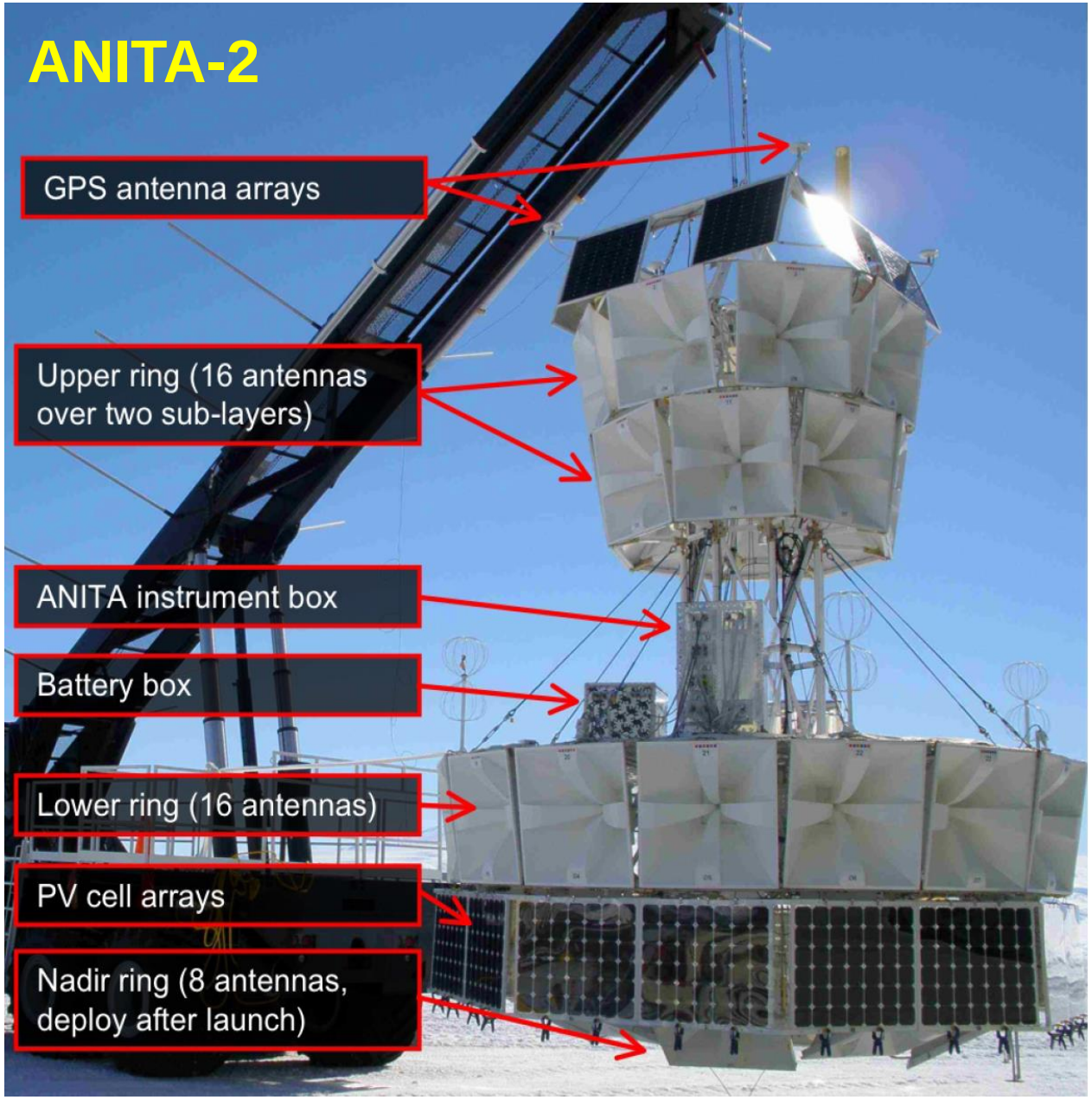
Quick Features

✓ Antennas

- 48 (8+8+16+16) highly directional horn antennas
- 48 x 2 = 96 channels of RF signal
- Upper 2 layer antennas evenly spaced, 45˚ apart
- Upper 2 layers offset by 22.5° for uniform coverage
- 3rd layer antennas spaced 22.5°
- Lowest layer antennas spaced 45˚ apart
- Downward cant angle of 10° below horizontal

✓ Frame, Temperature control

- Aluminum frame of beams and hollow tubes
- Painted white to reflect sunlight, regulate temperature
- Teflon-coated silver tape lined radiator plate on instrument box



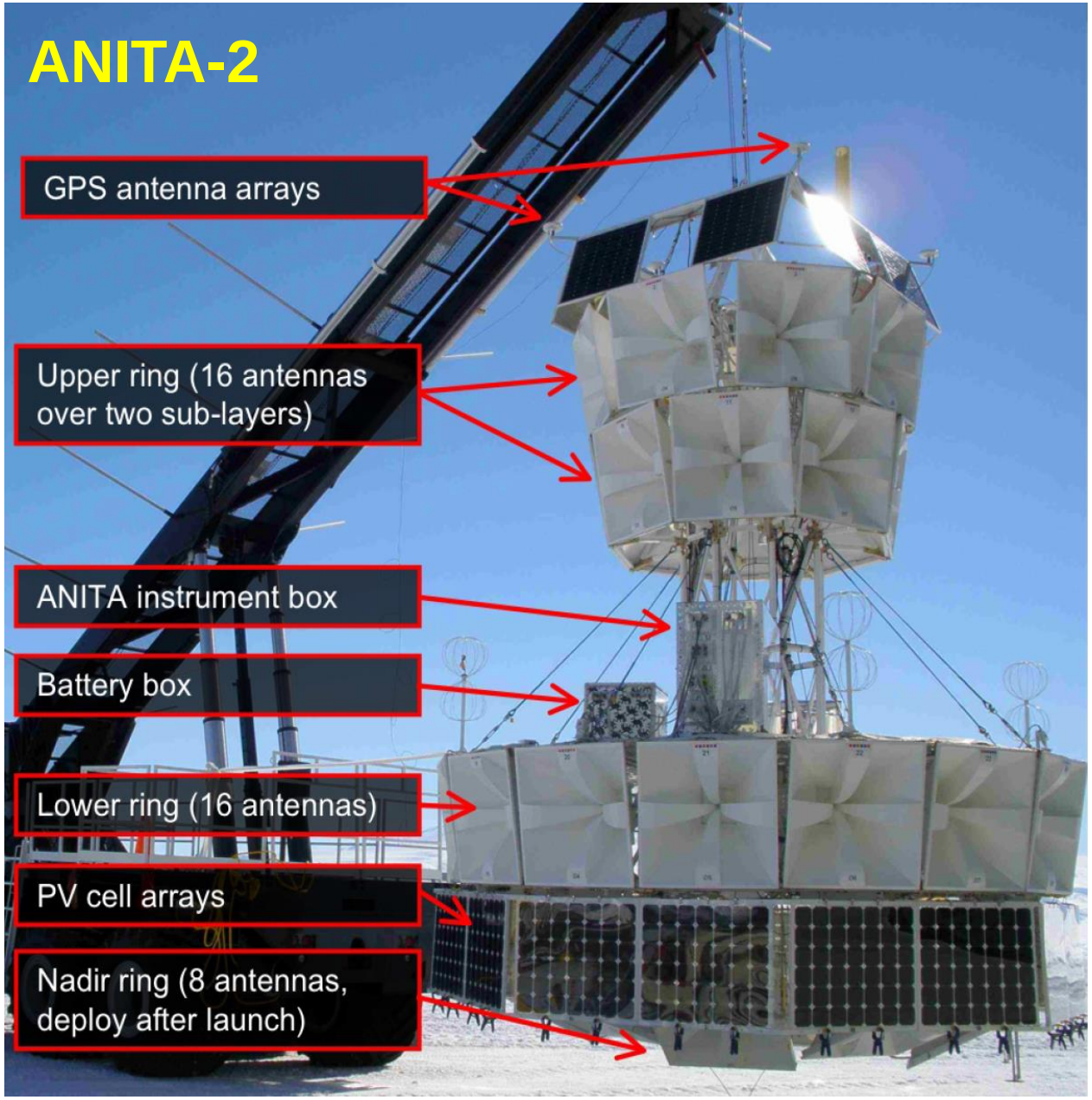
Quick Features

✓ Power

- ❖ Omnidirectional photovoltaic array below lowest layer of antennas
- ❖ 8 panel output fed into charge controller charging 12 V lead-acid battery farm
- ❖ Battery farm provides steady 24 V to power distribution box (PDB)
- ❖ PDB powers CPU, cPCI, iRFCM** receivers
- ❖ 24 V converted to 12 V, -12 V, etc. by DC/DC converters
- ❖ Parallel relays in PDB to switch power from ground during flight

✓ Global Positioning System

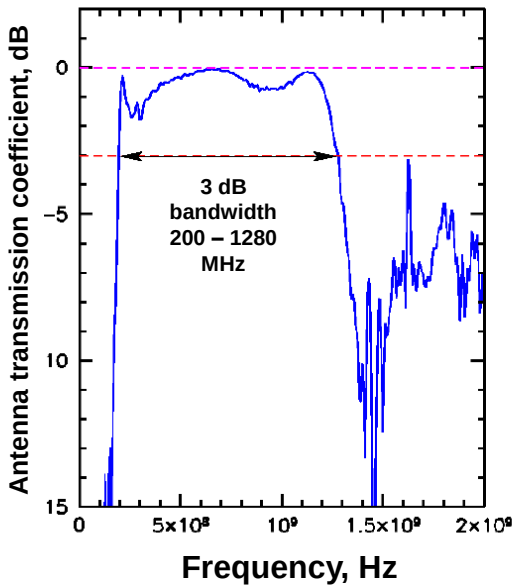
- ❖ 3 GPSs (2 ADU5 and 1 G12) give location, orientation, time
- ❖ Sun-sensor suite and GPS on SIP* are backups



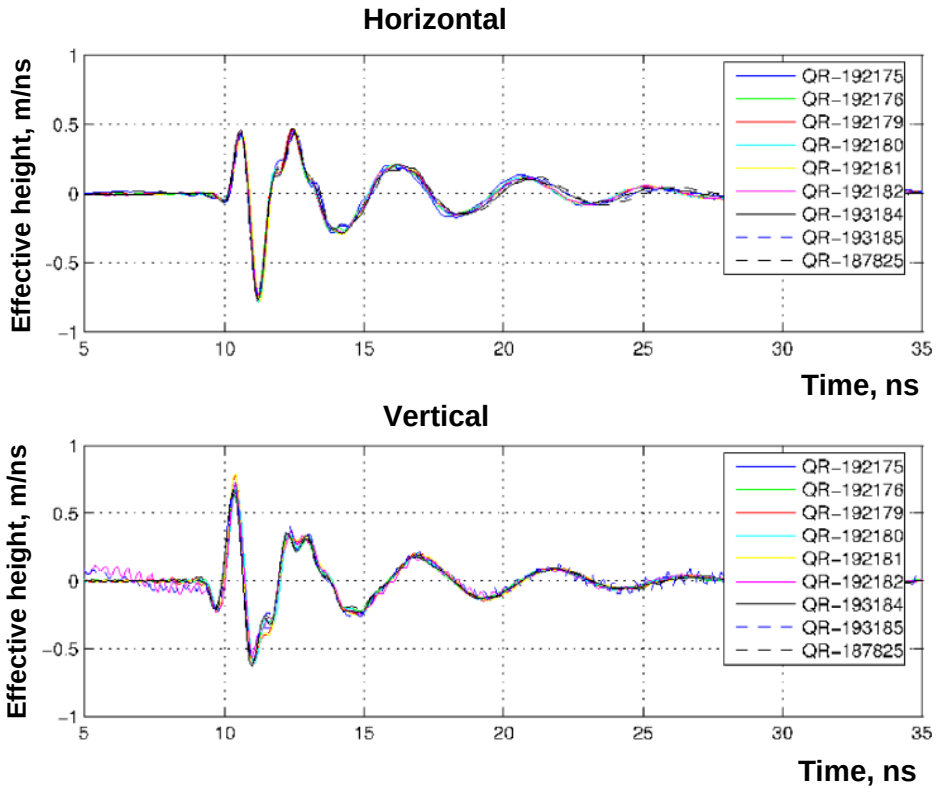
** internal Radio Frequency Conditioning Module
* Science Instrument Package

Antennas

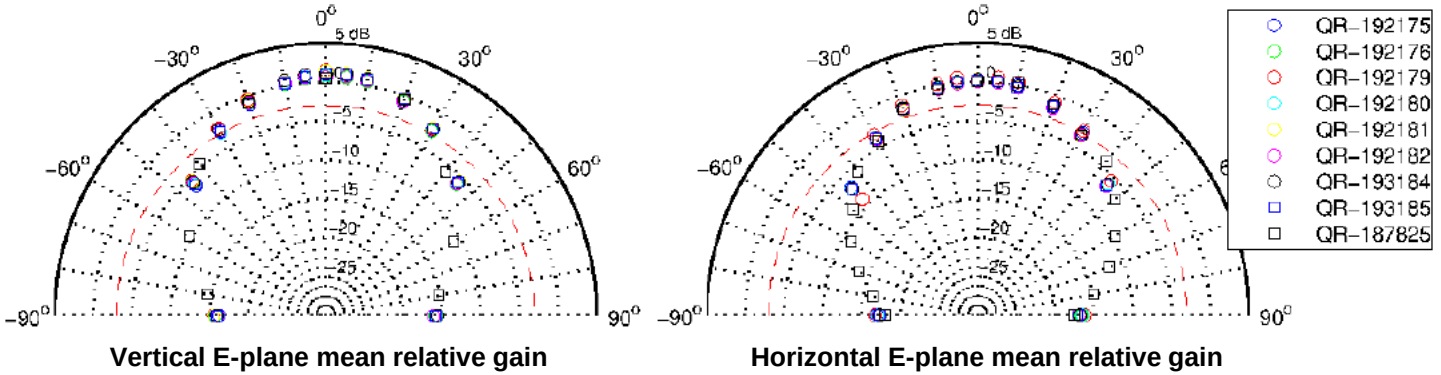
- ✓ **Frequency range, polarization and geometry**
  - ❖ 200 – 1200 MHz
  - ❖ Vertically (VPOL) and horizontally (HPOL) polarized light
  - ❖ Face of each antenna ~ 0.8 m across
- ✓ **Gain, Beam Pattern**
  - ❖ On-axis gain of ~ 10 dBi (decibel w.r.t. isotropic)
  - ❖ 3 dB point averaged over in-band frequencies is ~ 30°
  - ❖ Beam pattern wide at low Hz, narrow at high Hz



Antenna response as function of frequency

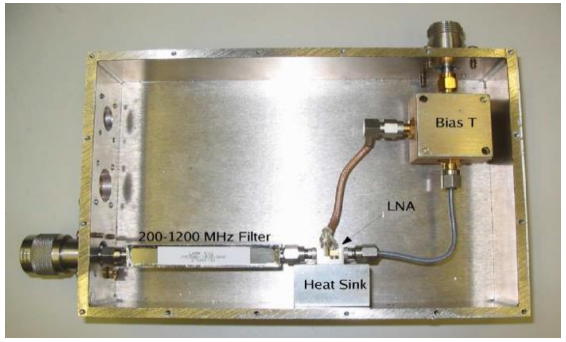


Antenna impulse response

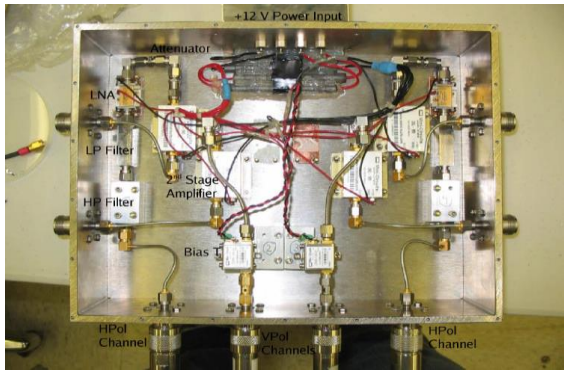


Antenna beam pattern

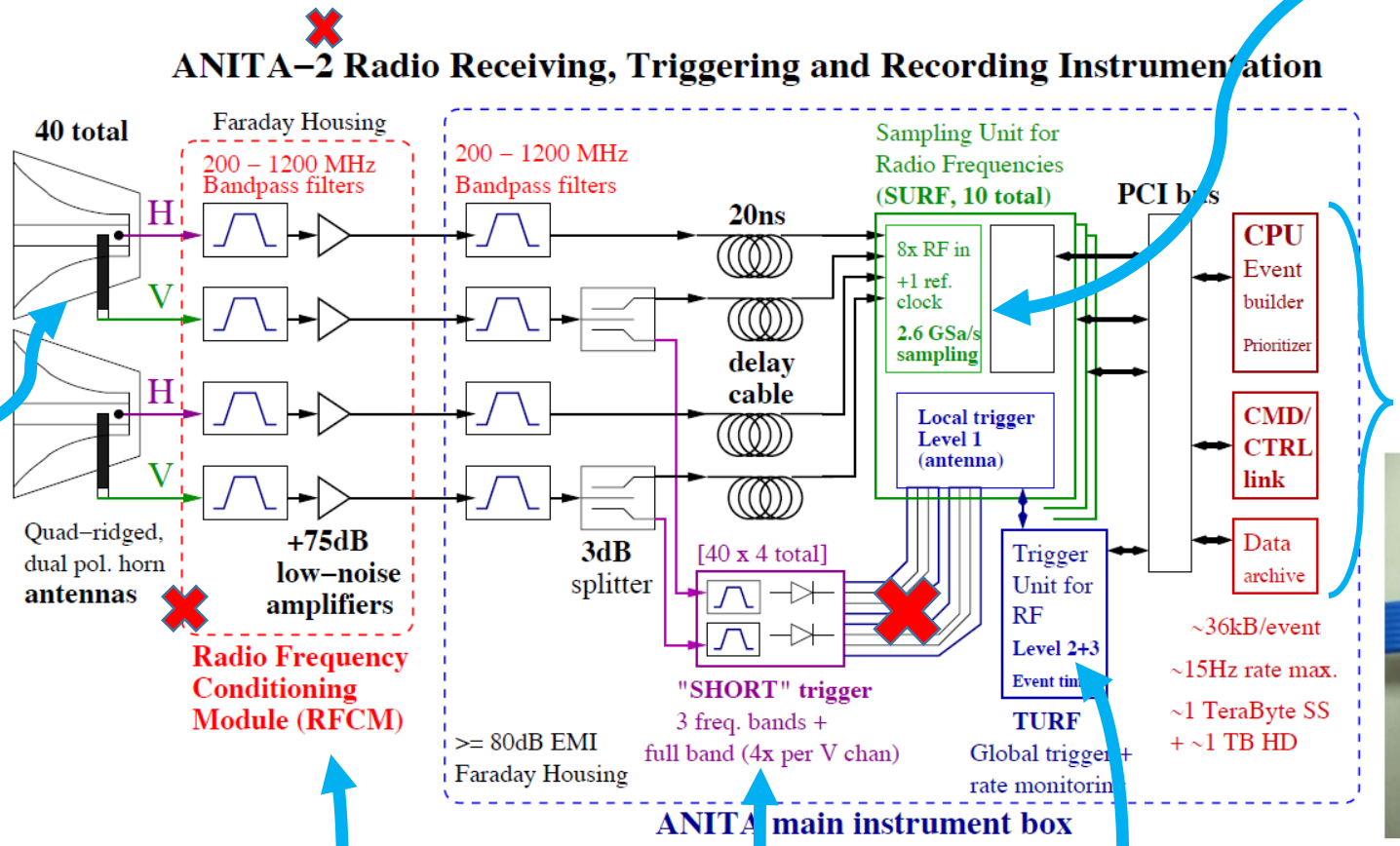
RF Signal Chain from Antennas, through signal path, trigger logic and readout



AMPA sits directly on output of antenna, does 1st stage of amplification of +35 dB for VPOL and HPOL



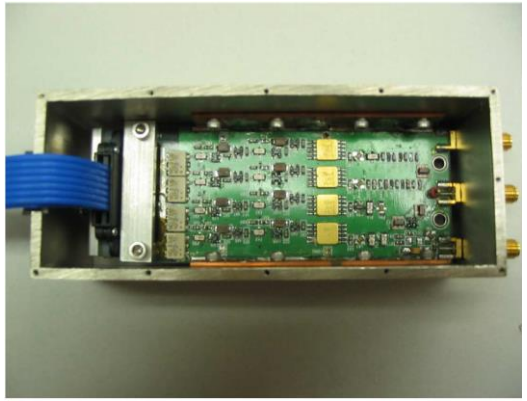
iRFCM (for ANITA-3 inside main instrument box) houses 200 – 1200 MHz band-pass filters, +40 dB low-noise amplifiers



TURF responsible for L2, L3 and global triggers

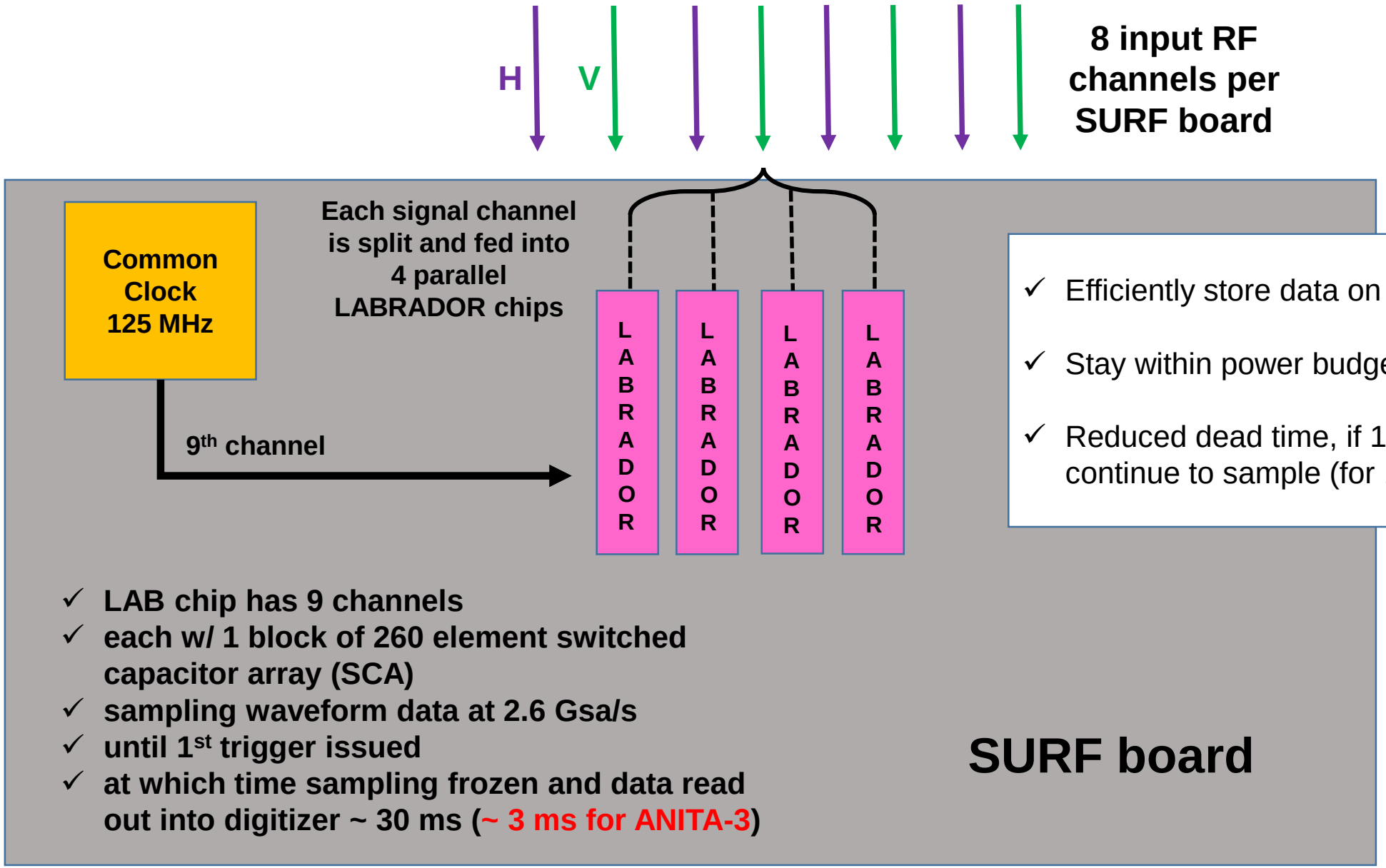
SURF samples waveform data with LABRADOR chips and does L1 triggering with discriminator

Flight computer and data storage devices



ANITA-3 SHORT lets full band signal to pass through tunnel diode that acts as square law detector tracking power

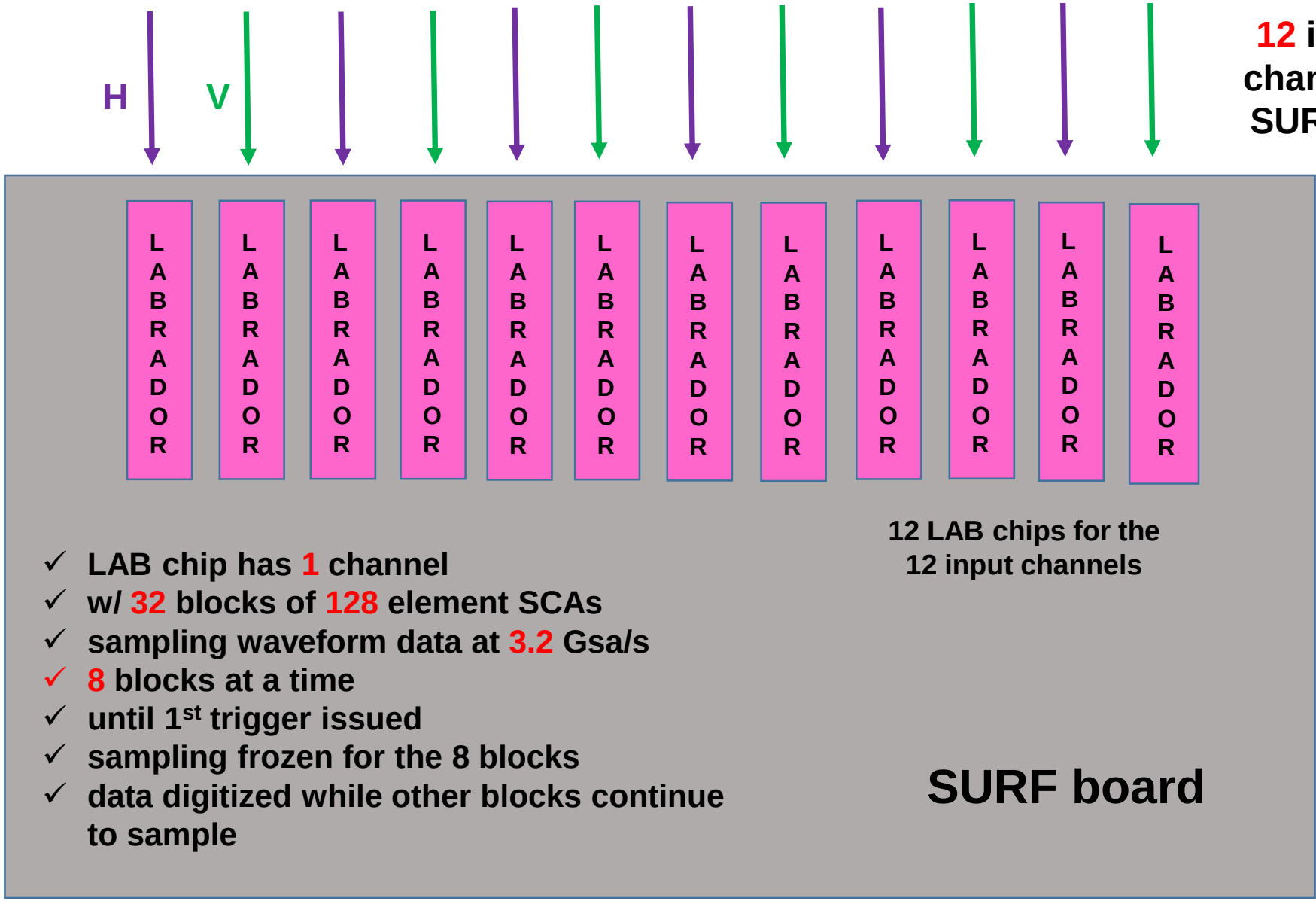
LABRADOR for ANITA-2 and ANITA-3



- ✓ Efficiently store data on board
- ✓ Stay within power budget of ~ 1 kW
- ✓ Reduced dead time, if 1 chip digitizing, other 3 continue to sample (for 1st trigger)

There are 10 total SURF boards for the 40x2 = 80 total RF signal channels

LABRADOR for ANITA-4

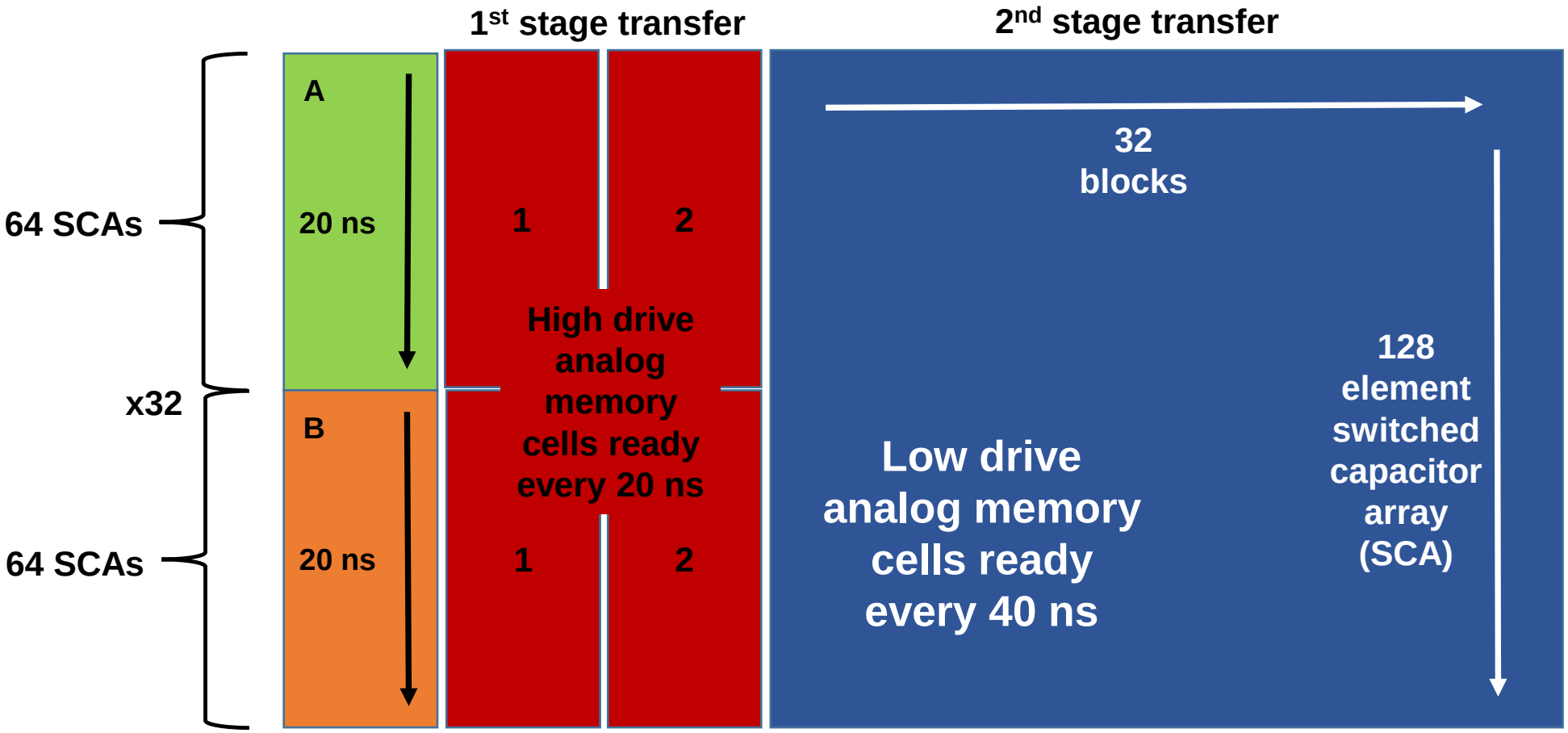


12 input RF channels per SURF board

- ✓ LAB chip has 1 channel
- ✓ w/ 32 blocks of 128 element SCAs
- ✓ sampling waveform data at 3.2 Gsa/s
- ✓ 8 blocks at a time
- ✓ until 1st trigger issued
- ✓ sampling frozen for the 8 blocks
- ✓ data digitized while other blocks continue to sample

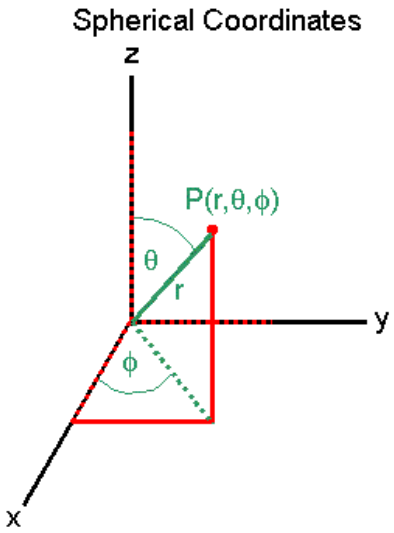
There are 8 total SURF boards for the 48x2 = 96 total RF signal channels

LAB-4 2-stage transfer for low power consumption

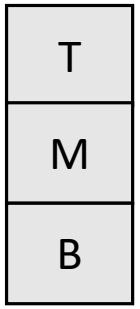


- ✓ Data written in analog form to these memory cells in a “zigzag” manner
- ✓ First the red cells fill up, then the blue ones
- ✓ When trigger issued, the 8 blocks stop writing, and start read out into digitizer

Trigger Logic: what changed from ANITA-2 to ANITA-3

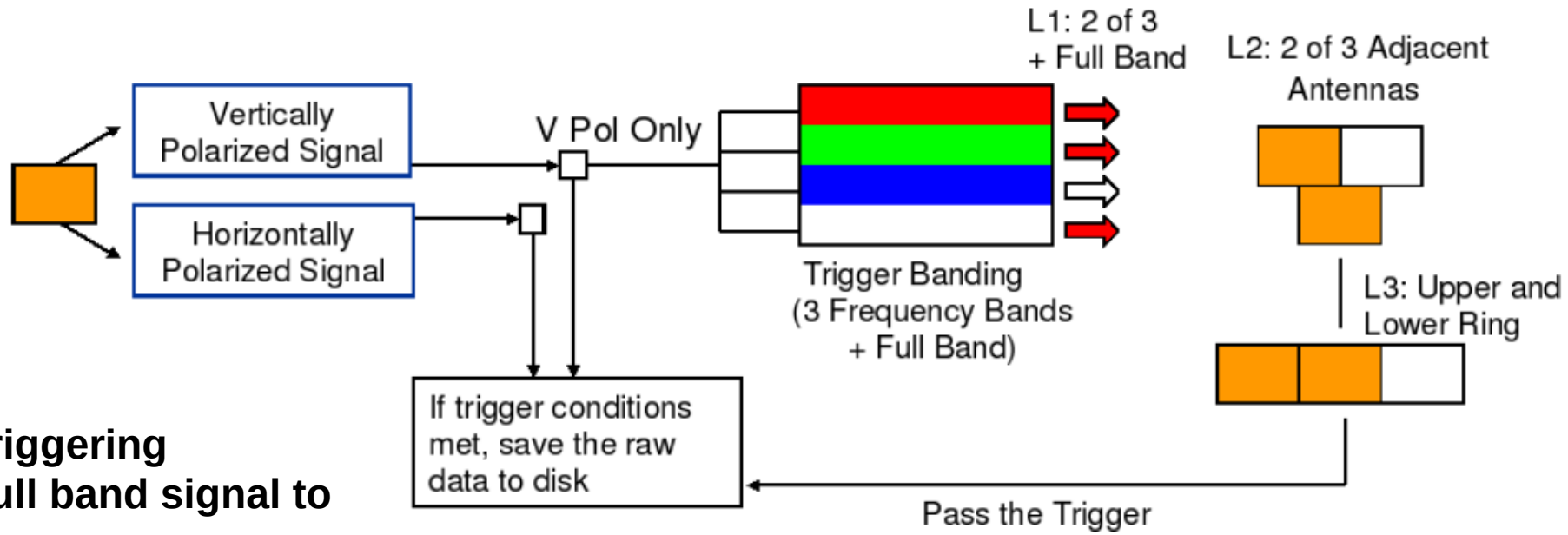


Phi-sector: antennas that are spatially in a column at around the same angle phi in 3D spherical coordinates



ANITA-3 L1: if top antenna signal > threshold, then check middle and bottom signals in previous 8 ns, or bottom in previous 12 ns, if middle signal > threshold, check bottom in previous 4 ns.

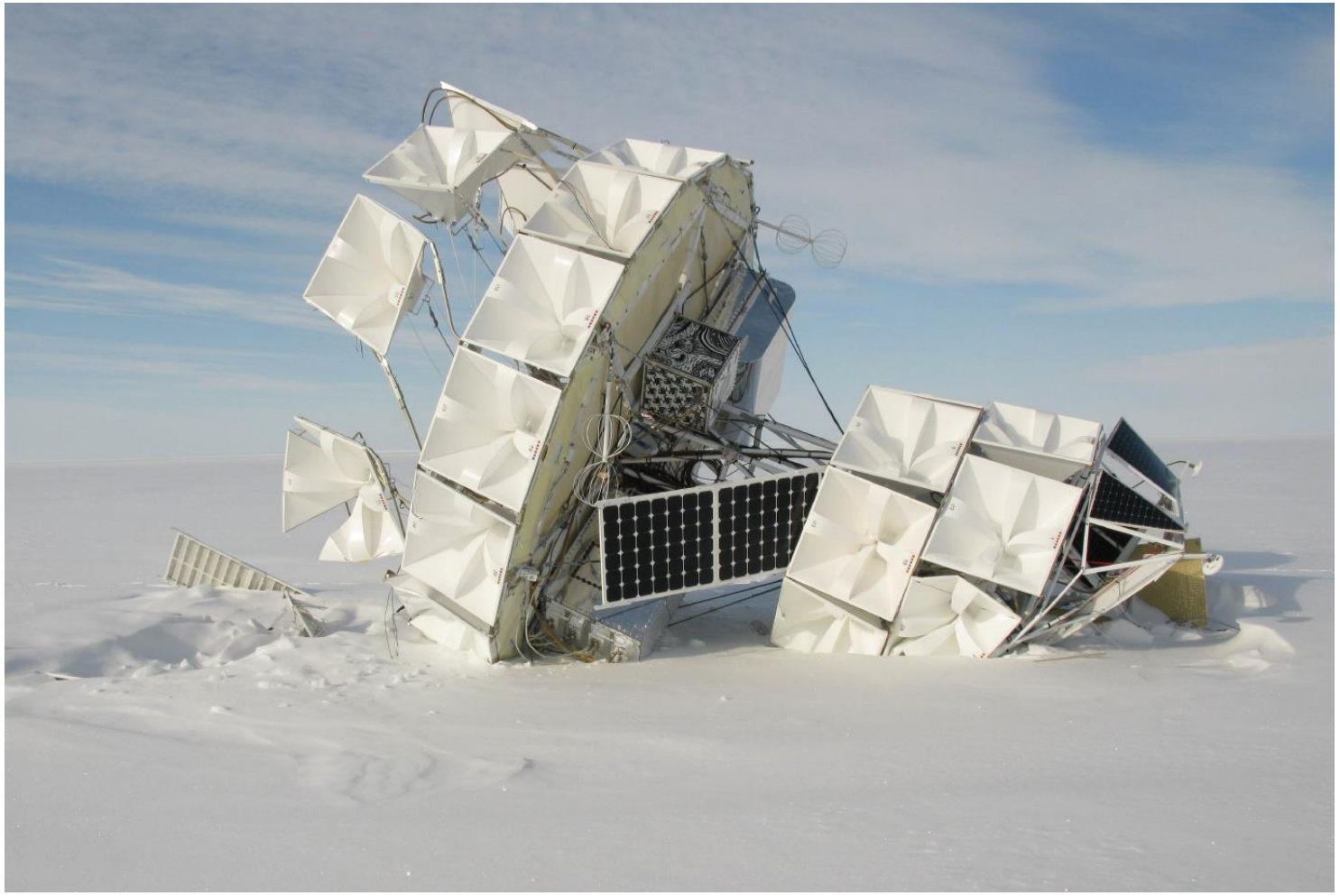
ANITA-3 L2 = L1



ANITA-3

- ✓ **More selective triggering**
- ✓ **SHORTS allow full band signal to pass**
- ✓ **which gives us better SNR, better sensitivity**

ANITA-3 L3: Just like L1 but for adjacent phi sectors



Thank you for your attention. Any questions?

Antenna Fun Facts

- ✓ Turns radio waves (Hz) to electric power (dB)
- ✓ Flaring metal waveguide shaped like a horn
- ✓ Catches radio signals coming from specific directions only
- ✓ Radio waves go into waveguide and are more concentrated in some areas than others.. Leading to a gain.