

VLBI Requirements & Mid.CSP FSA

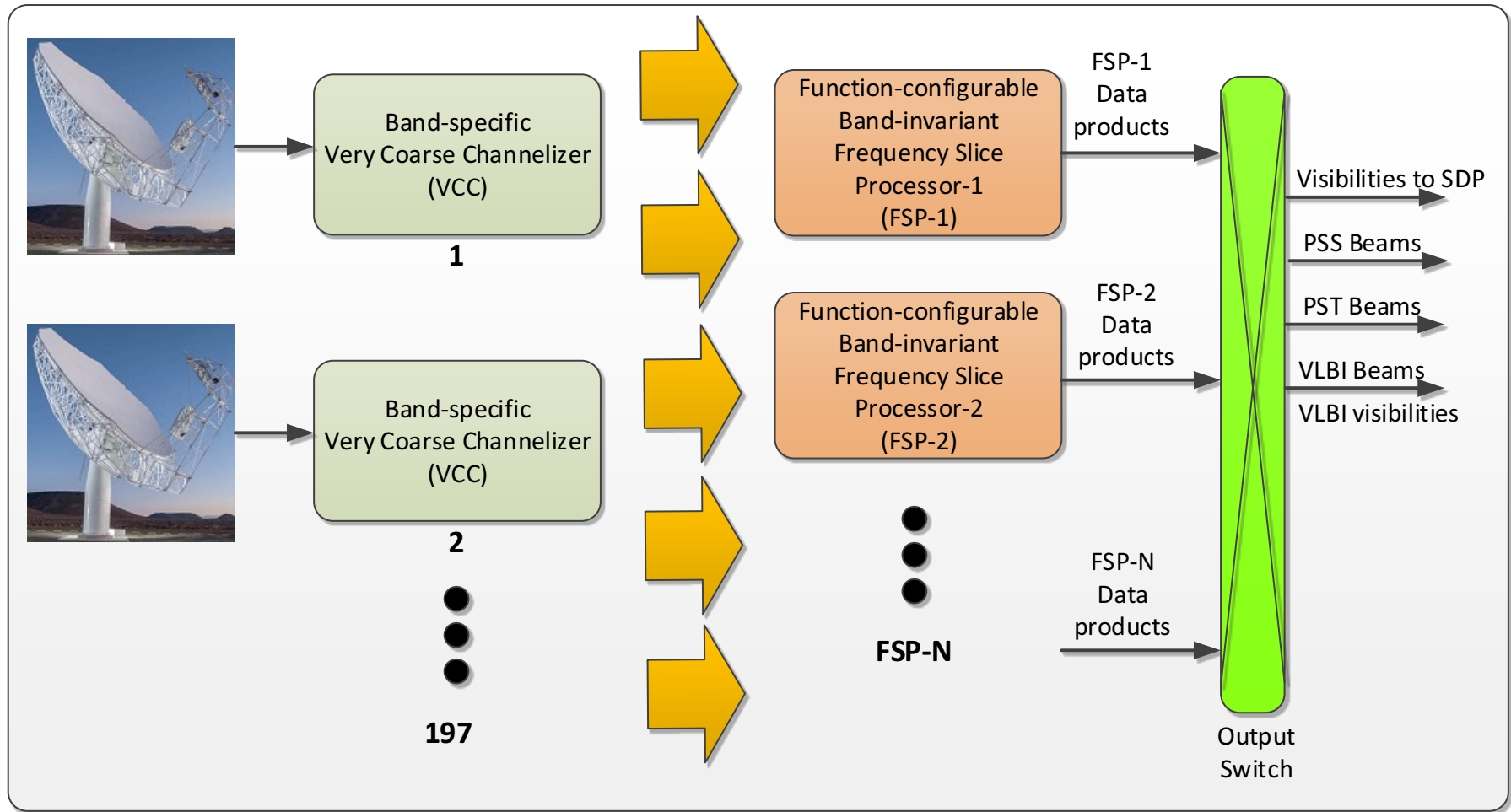
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Mid.CBF: Frequency Slice Architecture



Mid.CBF: VLBI beam channels

- No beam channels wider than 256 MHz
 - Maximum “pure” bandwidth per channel= 200 MHz
 - Some signal out to 224 MHz
 - $256/2^n$ MHz? $224/2^n$ MHz?
 - Down to ~10 MHz?
 - How many beam channels are required within one 200 MHz Frequency Slice?
- Overlap between adjacent beam channels
- Prefer SPEAD heaps to SDP, then SDP combines, formats, & gets to recorders
 - Otherwise more restricted in data groupings
 - Note SaDT ICD has CSP-SDP VLBI section
 - Plan had been 4 x 100 Gbps links from CSP to VLBI
- Any limit on output paths to VLBI equipment?

Mid.CBF: VLBI beams & bandwidth

- 2 beams @ 5 GHz/beam, 4 beams @ 2.5 GHz/beam, ..., (potentially) 52 beams @ 200 MHz/beam
- Up to 10 subarrays

Mid.CBF: VLBI tuning limitations

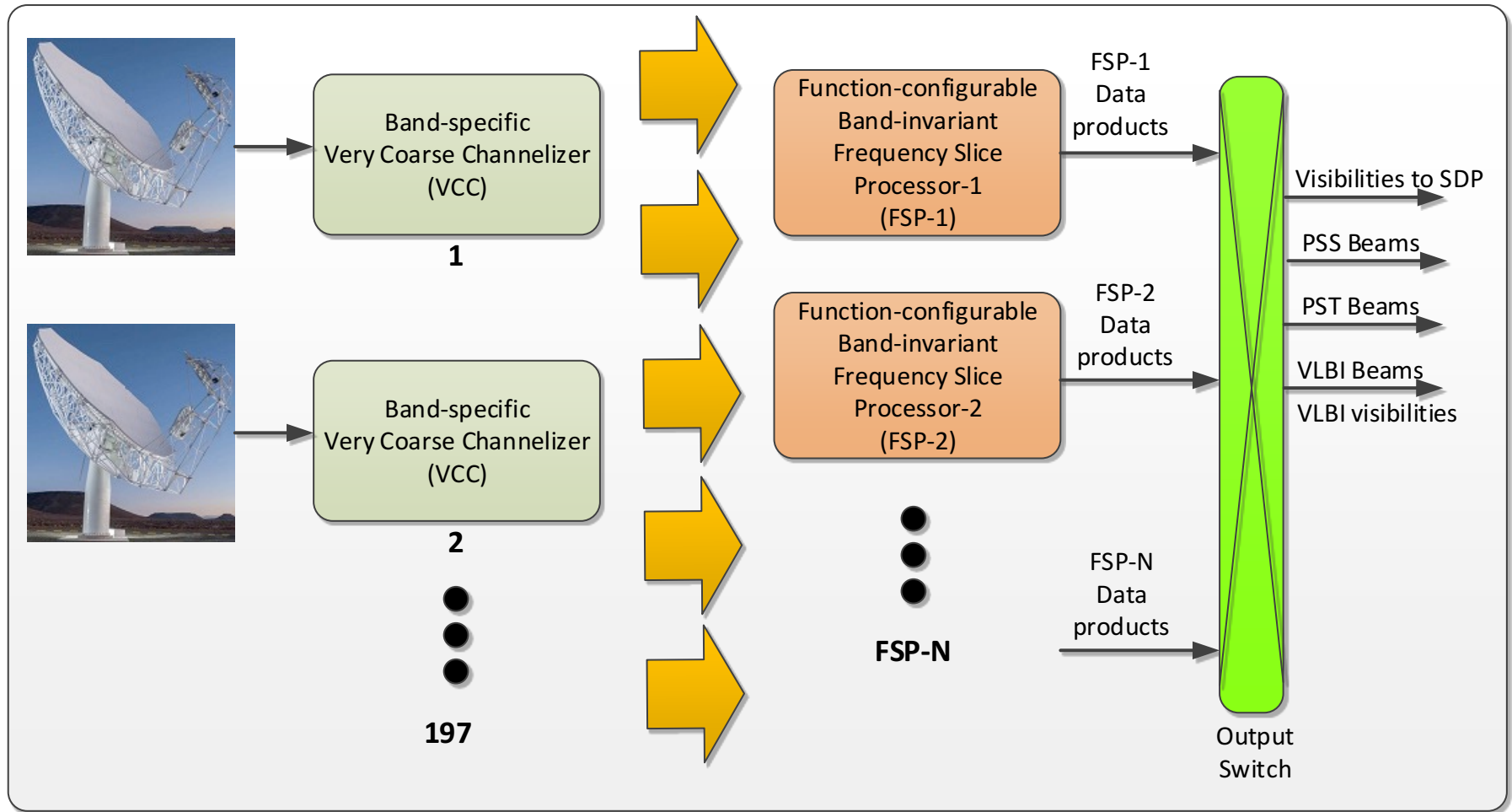
- Tuning limitations
 - Wideband is fully tunable, for all bands
 - Frequency Slices are set, 200 MHz “chunks”
 - No VLBI beam channels can cross FS boundaries
 - Beam channels fully tunable within 200 MHz Frequency Slices

Mid.CBF: VLBI visibilities

- Current plan: FSP produces 2 beams & 6+6b correlation
- Could instead produce 1 beam & 9+9b correlation
- Which is preferred?

Mid.CBF Frequency Slice Architecture & VLBI

Mid.CBF Frequency Slice Architecture



Mid.CBF Frequency Slice Processors

- *Frequency Slice*= 200 MHz oversampled → 224 MHz
 - *NOT* tunable – but wideband is
- 26+1 *Frequency Slice Processors* (FSPs) to handle 5 GHz of Band 5 (+ redundancy)
- Each FSP performs **one** function on **one** Frequency Slice for **all** subarrays
 - Correlation: wideband or zoom window (up to 16k channels)
 - PSS/PST beamforming (192 PSS beams, 16 PST beams)
 - **VLBI**: corr'n + beamforming

Mid.CBF: VLBI FSPs

- Can assign any or all FSPs to VLBI, *without affecting the others*
 - N.b. 200 MHz VLBI slices need not be adjacent
- **Each VLBI FSP produces:**
 - ~1k visibility channels covering 200 MHz (~220 kHz/channel)
 - 2 VLBI beams on the same 200 MHz frequency slice
 - ...for up to 10 subarrays
- **Each beam can be split into (up to) 2-4 (TBC) VLBI beam channels**
 - Each channel is {1, 2, 4, 8, ..., 128, 256} MHz
 - Re-quantized to {2, 4, 8, 16} bits
 - Possibly more beam channels per beam if fewer subarrays
- **More FSPs → more BW and/or more beams and/or more subarrays**
 - Allows 5 GHz for 2 beams, 2.5 GHz for 4 beams, etc.

ECP 170017 Example 5

Full Band 5 continuum bandwidth, other sub-arrays full continuum + zoom windows

Subarray	Band	Continuum Imag BW (MHz)	# Zoom Windows	# PSS Beams	PST BW (MHz)	# PST Beams	VLBI BW (MHz)	# VLBI Beams
1	5	5000.0						
2	1	700.0	22					
3	2	810.0	21					
4	3	1400.0	19					
5	4	2380.0	14					

FSP Mode

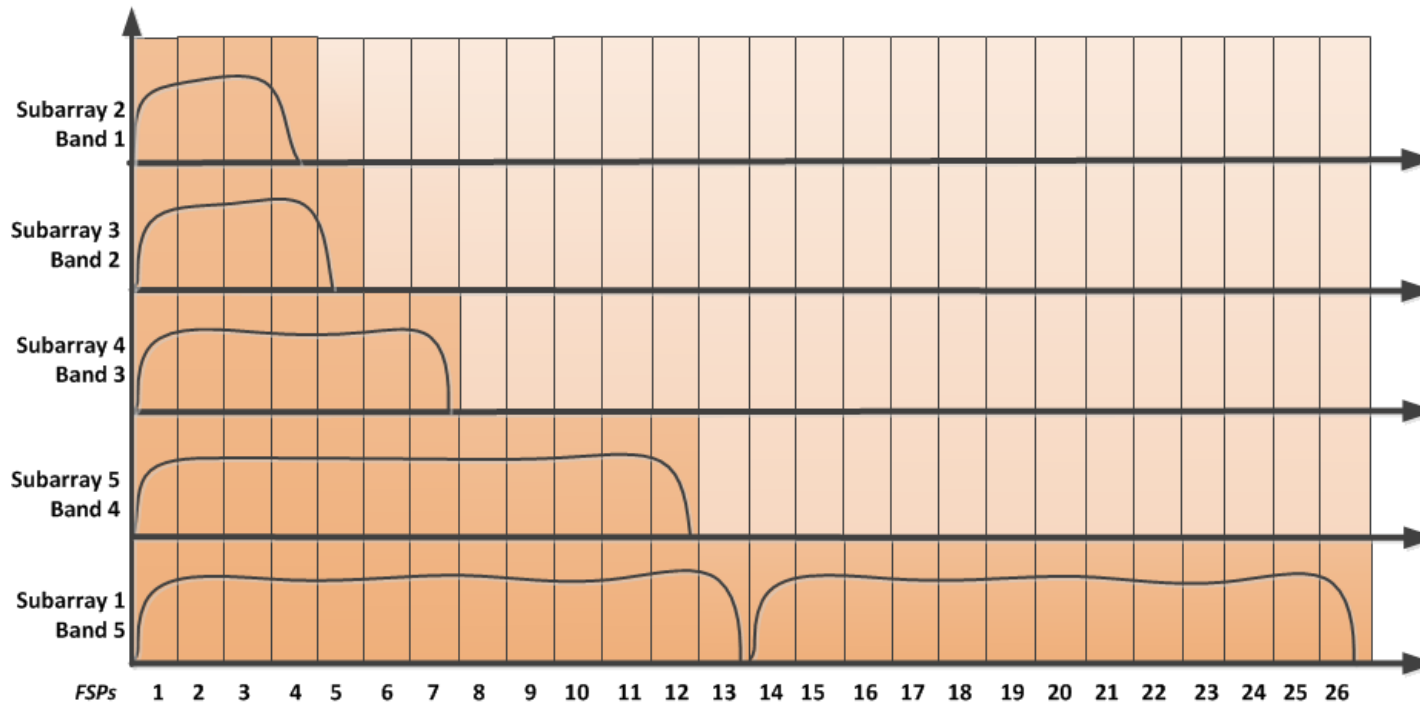
IMAGING mode – FSP producing visibilities for a Frequency Slice (200MHz)

IMAGING mode – FSP producing visibilities for a Zoom Window (<200MHz)

PST Beamforming

PSS Beamforming

VLBI Beamforming



Bandwidth is shown to illustrate how many FSPs are needed to correlate full band.
Any frequency slice can be processed on any FSP.

Example: Wideband VLBI

- **Band 2:** 810 MHz $\rightarrow 810/200 = 5$ FSPs to cover full BW
 - Each set of 5 FSPs produces 2 VLBI beams
 - 4 VLBI beams requires 10 FSPs
 - 25 FSPs could produce 10 VLBI beams
 - Or, use FSPs for commensality: wideband continuum, zoom windows, PSS, PST, ...
- **Band 5:** 2 x 2.5 GHz $\rightarrow 2 * 2500/200 = 26$ FSPs to cover full BW
 - 26 FSPs allocated to VLBI
 - \rightarrow 2 x 5 GHz VLBI beams or 4 x 2.5 GHz VLBI beams
(for up to 10 subarrays...each of which could be doing different tunings/bands)

Example: Spectral Line VLBI

- Band 2: 0.95-1.76 GHz
- VLBI: 4 beams
 - 810 MHz continuum: 10 FSPs, 2-bits
 - ...4 x 256 MHz + 1 x 16 MHz beam channels/beam
 - + 2 MHz (420 km/s) local HI, 8-bits
 - ...done in appropriate FSPs as separate beam channel
 - ...1 x 2 MHz beam channel/beam
 - + 16 MHz (3400 km/s) redshifted HI, 16-bits
 - ...done in appropriate FSPs as separate beam channel
 - ...1 x 16 MHz beam channel/beam
- Zoom windows for high spectral res'n visibilities on local & redshifted HI → 2 more FSPs

Example: Subarray VLBI

- 6 subarrays to cover 6 bands (Bands 1-4, 5a, 5b)
- Full BW in each Band
 - 26 FSPs allocated to VLBI, to cover Band 5
 - 2 beams in Bands 5a, 5b; 4 beams in Bands 1-4
 - ~220 kHz visibility data channelization
 - no zoom windows, PSS, PST
- 2.5 GHz max BW
 - 13 FSPs allocated to VLBI
 - 2 beams in Bands 3-5; 4 beams in Bands 1-2
 - Full wideband channelization for all Bands: 13 FSPs
 - ...with zoom windows in Bands 1-3
 - (one zoom window in Band 4)
- Could use more subarrays to cover more of Band 5b

VLBI Mid.CSP L2 requirements

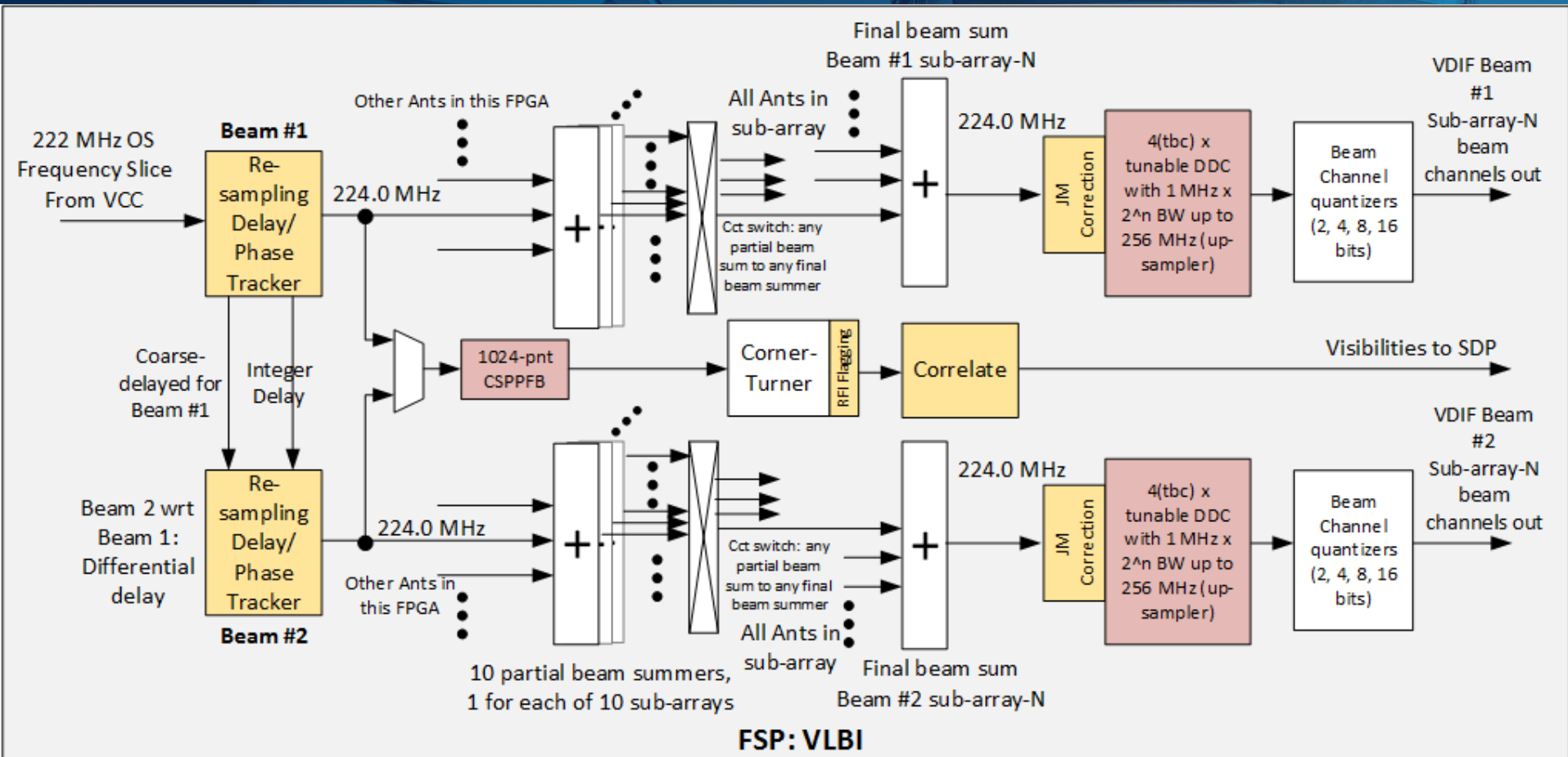
- phase response across 100% of the channelized bandwidth varying by no more than 0.05 radians (TBC)
- amplitude response with a variation across the central 80% of the channelized bandwidth of no more than 0.1 dB (TBC).
- spectral confusion response of no more than -30 dB (TBC) in amplitude and 0.01 radians (TBC) in phase across the central 80% of the channelized bandwidth.
- amplitude response that is monotonically decreasing from the edge of the central 80% to the channel edge.
- amplitude response of -15 dB +/- 2 dB (TBC) at the channel edge.
 - Do not comply for -15 dB. The band edge attenuation varies from -7.6 dB to about -11 dBs.

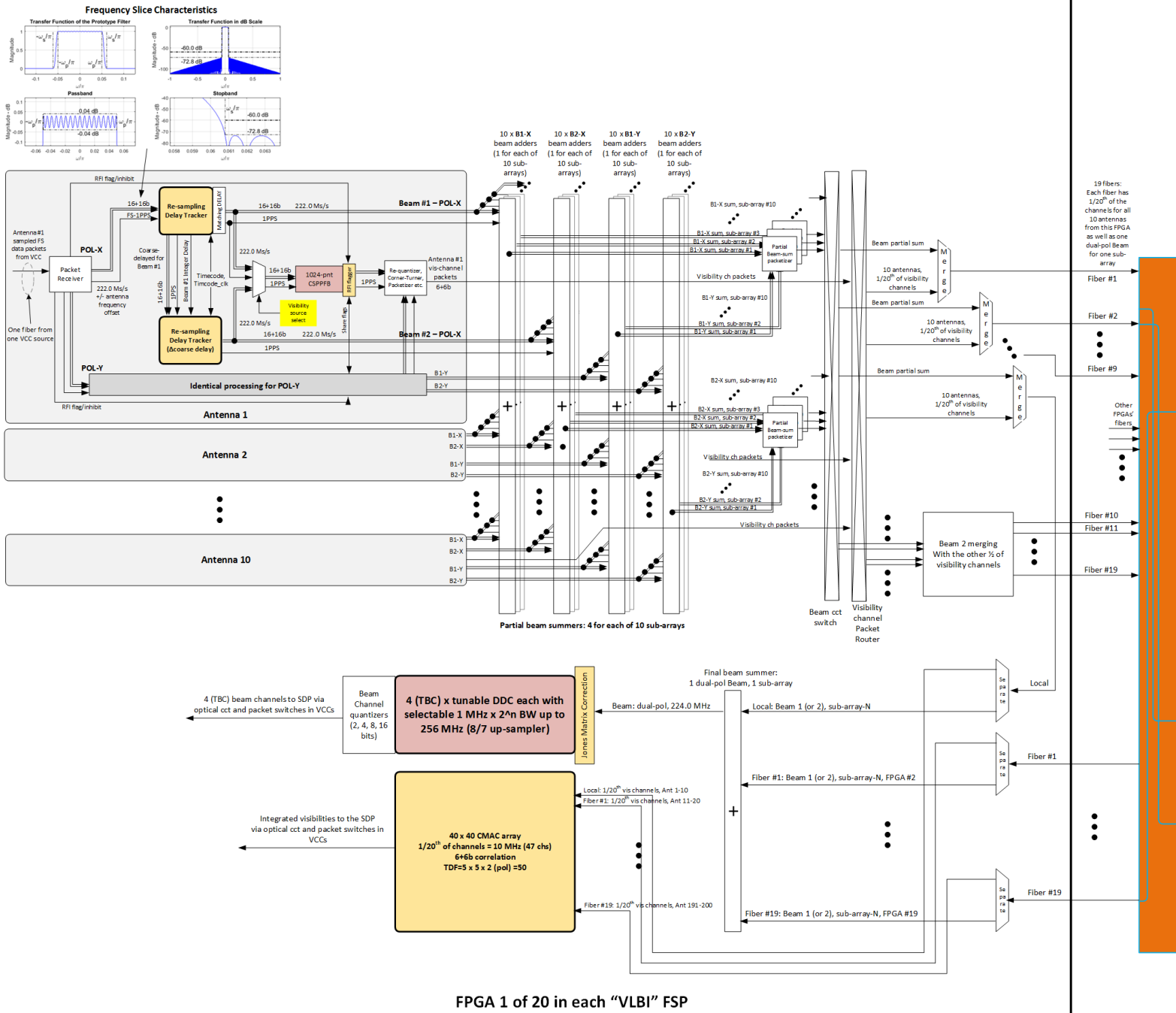
VLBI Mid.CSP L2 requirements

- amplitude response that is monotonically decreasing from the channel edge to 10% away from the edge
- stop-band attenuation response of -60 dB or better anywhere greater than 10% away from the channel edge
- leaked spectral power is suppressed by more than 60 dB for the central 80%

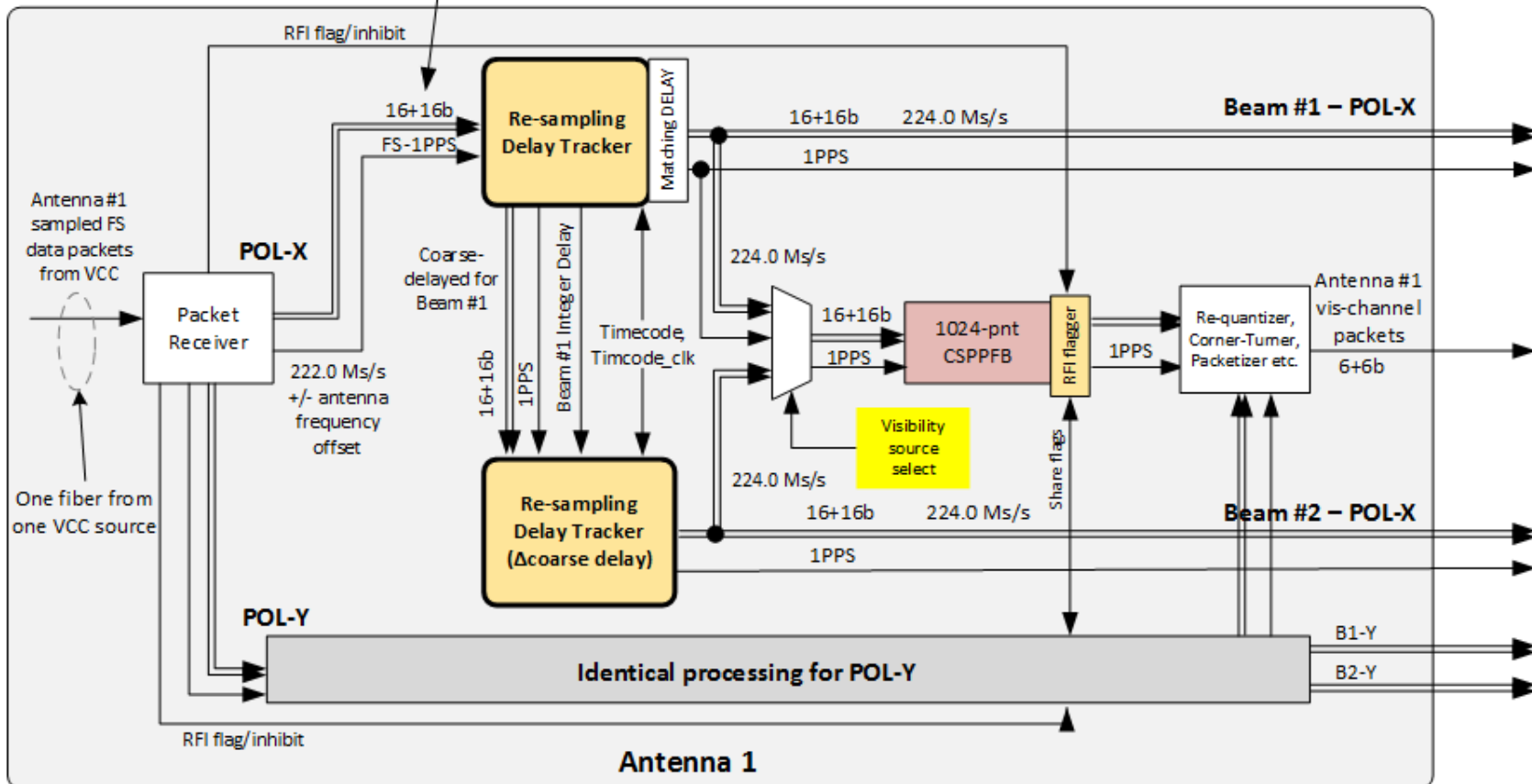
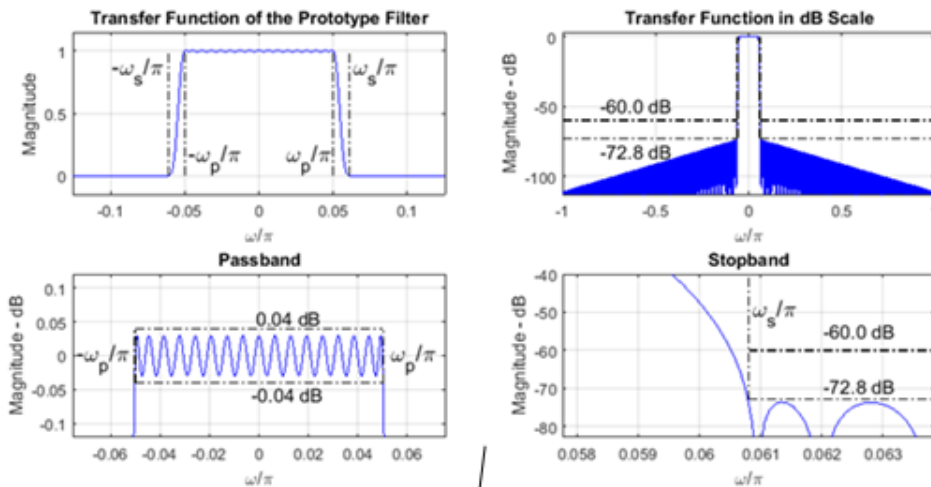
Backup slides: details

Overview – FSP-VLBI





Frequency Slice Characteristics



Questions and Discussion?

Thank you.

