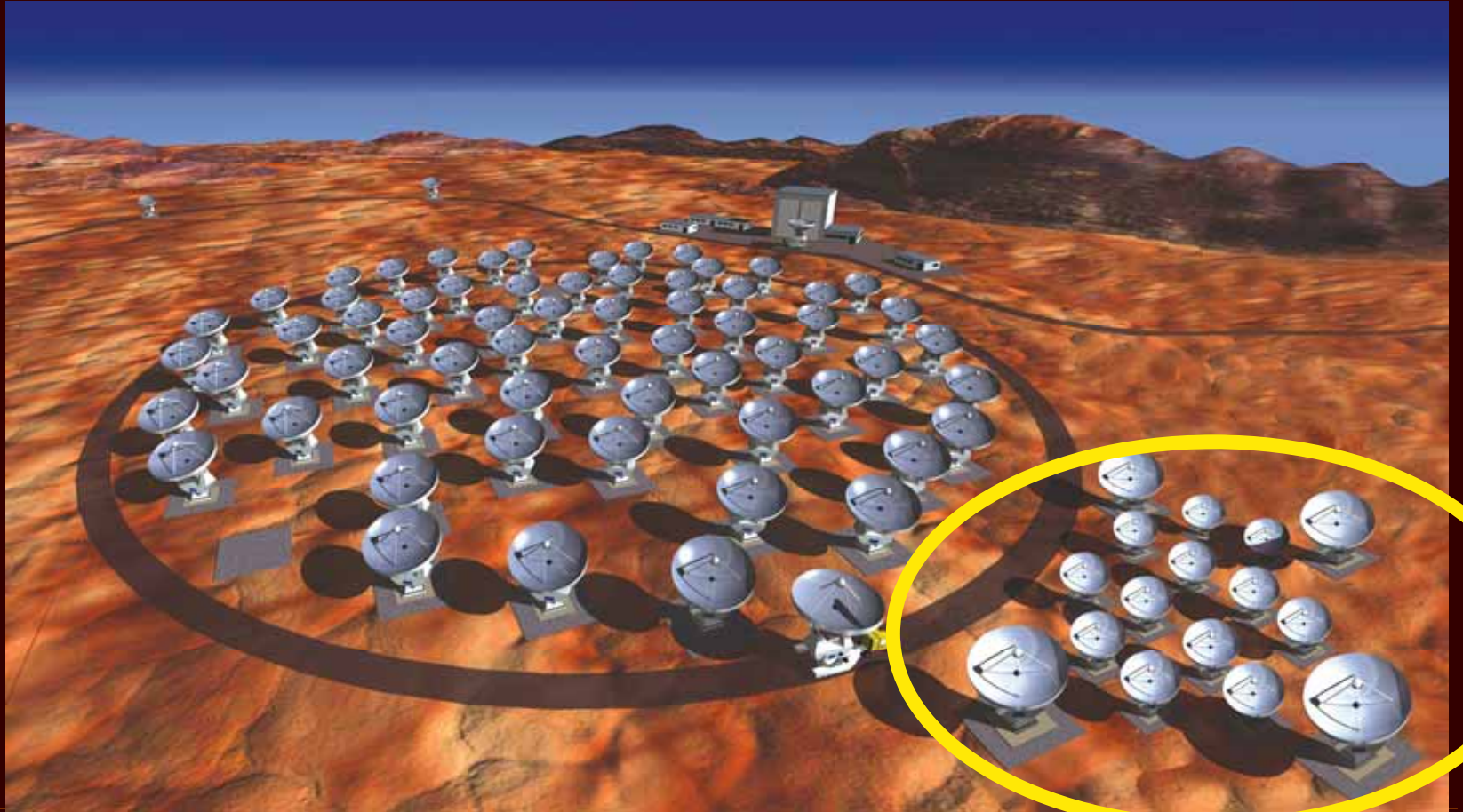


ALMA相関器 (欧米の動向、日本案)

国立天文台 ALMA推進室

井口 聖

ALMA



ALMA

□ Antenna

- 64 elements 12m
+ ACA (4 elements 12m + 12 elements 7m)

□ Receiver

- Frequency Band: Band 1 ~ 10 (43 ~ 950 GHz)

□ Correlator

- 1 antenna: 4Gsps 3bit 8IF = 96Gbps
 - 80 antennas: Total Data Rate ~ 8Tbps
-

ALMA Correlator (eBLC)

ALMA Correlator Specification

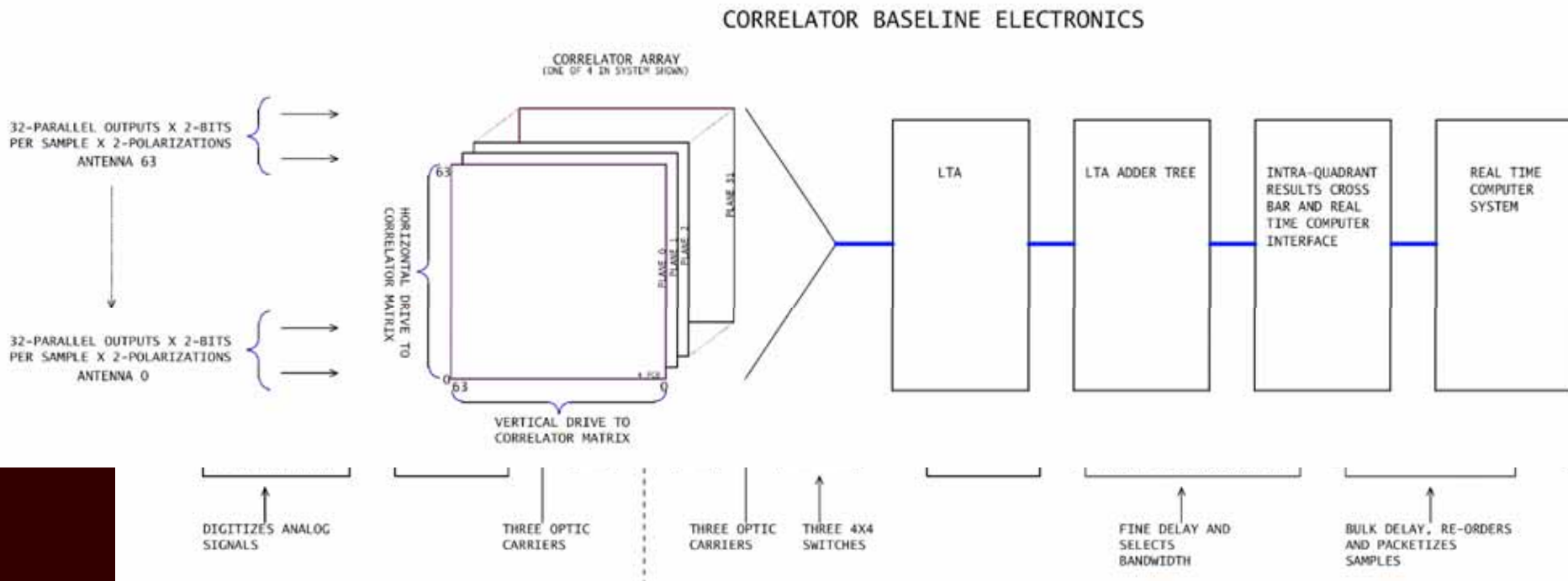
Item	Specification
Number of antennas	64
Number of baseband channel inputs per antenna	8
Input sample format	3 bit, 8 level at 4 GSample/s per baseband channel
Correlation sample format	2 bit, 4 level and 4 bit, 16 level; Nyquist and twice Nyquist
Maximum baseline delay range	30 km
Hardware cross-correlators per baseline*	32,768 leads + 32,768 lags
Hardware autocorrelators per antenna*	32,768
Typical performance in digital hybrid modes	8192 spectral points provided for each pair of baseband inputs**
Product pairs possible for polarization	HH, VV, HV, VH (for orthogonal H and V)

* 62.5 MHz correlators (125 MHz clock rate), divide by 32 to get number of equivalent 2 GHz correlators

** Resulting in 8192, 4096 or 2048 spectral points across the baseband spectrum, depending on polarization mode

ALMA Correlator (eBLC)

Block Diagram (STARRENA UNIT)



ALMA Correlator (eBLC)

□ Organization Structure

■ NRAO/ESO

□ Correlation Part (NRAO)

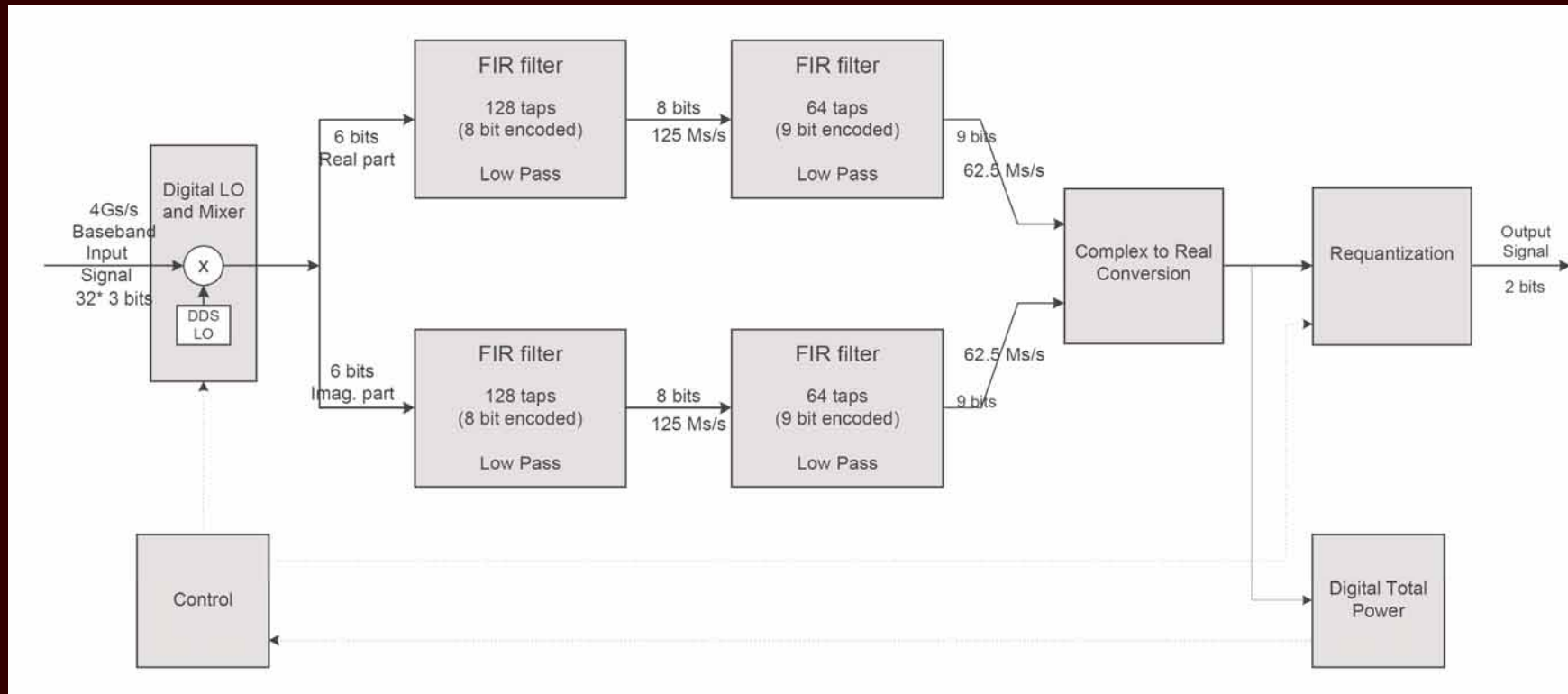
□ Digital Filter (ESO)

- Leader: Allan Baudry (France)

- Designer: B. Quertier (France),
G. Comoretto (Italy), A. Gunst & A. Bos
(ASTRON)

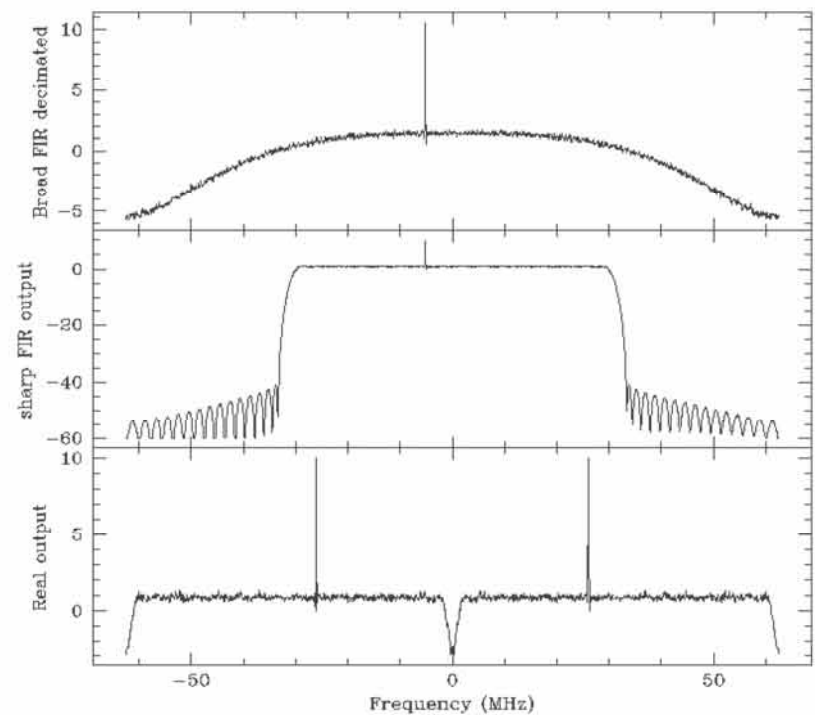
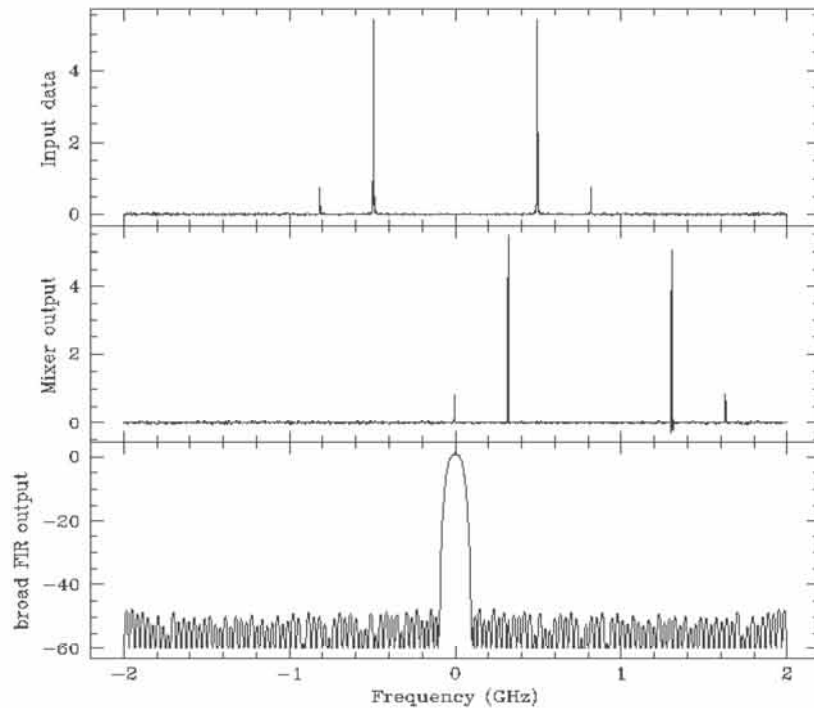
ALMA Correlator (eBLC) 2-stage DF

2-stage DF



ALMA Correlator (eBLC) 2-stage DF

- Digital Down Converter, Digital Filter response (simulation)



ALMA Correlator (eBLC) 2-stage DF

□ Digital Filter

■ Altera FPGA

□ 1S25 (2 DFs) 8192 chips:1.24M\$

■ Altera FPGA Hardcopy

□ 1S25 (2 DFs) 8192 chips:0.65M\$

□ HardCopy 0.16M\$

□ **SUM** **0.81M\$**

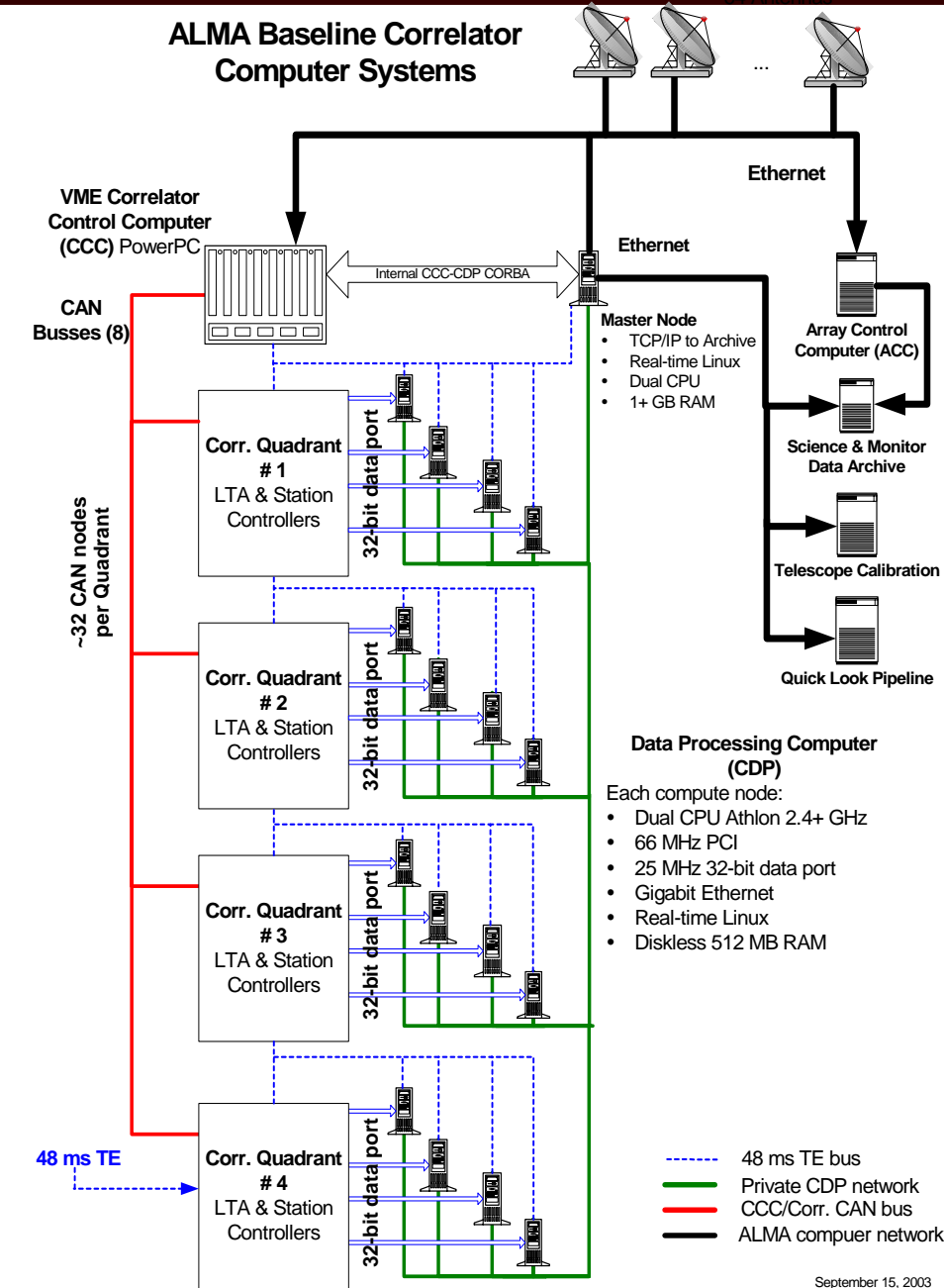
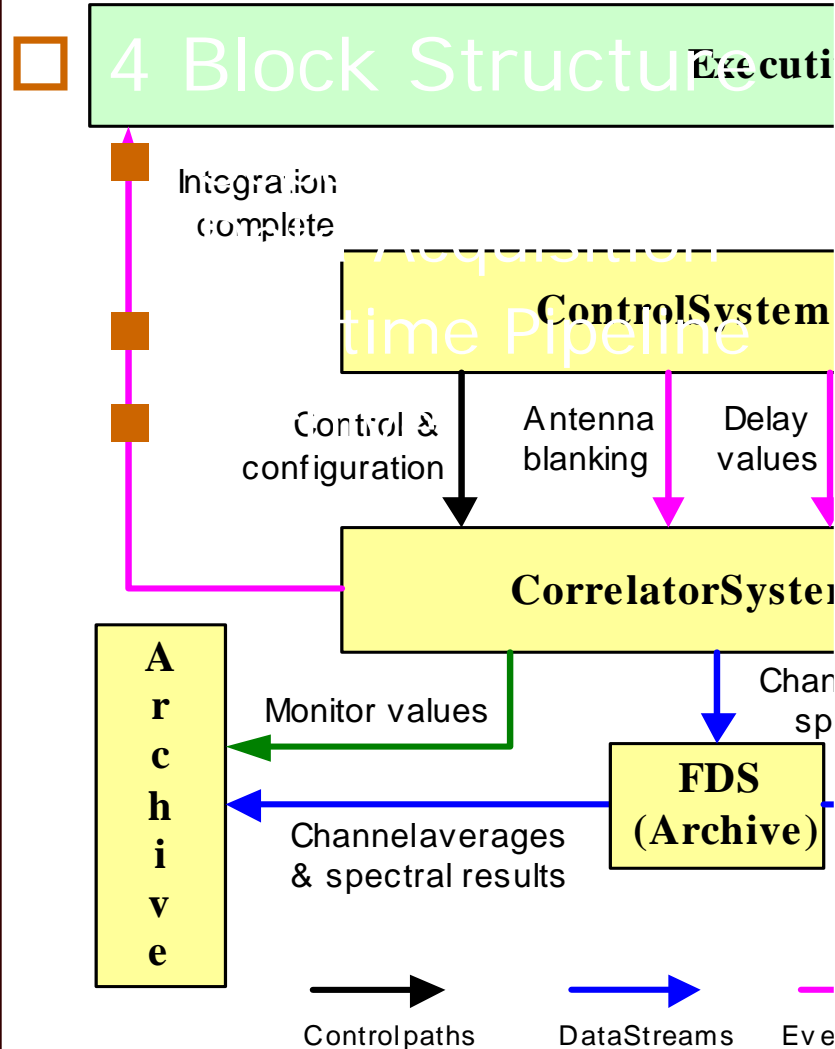
■ Next, Altera FPGA HardCopy

□ 1S60 in review

ALMA Correlator (eBLC)

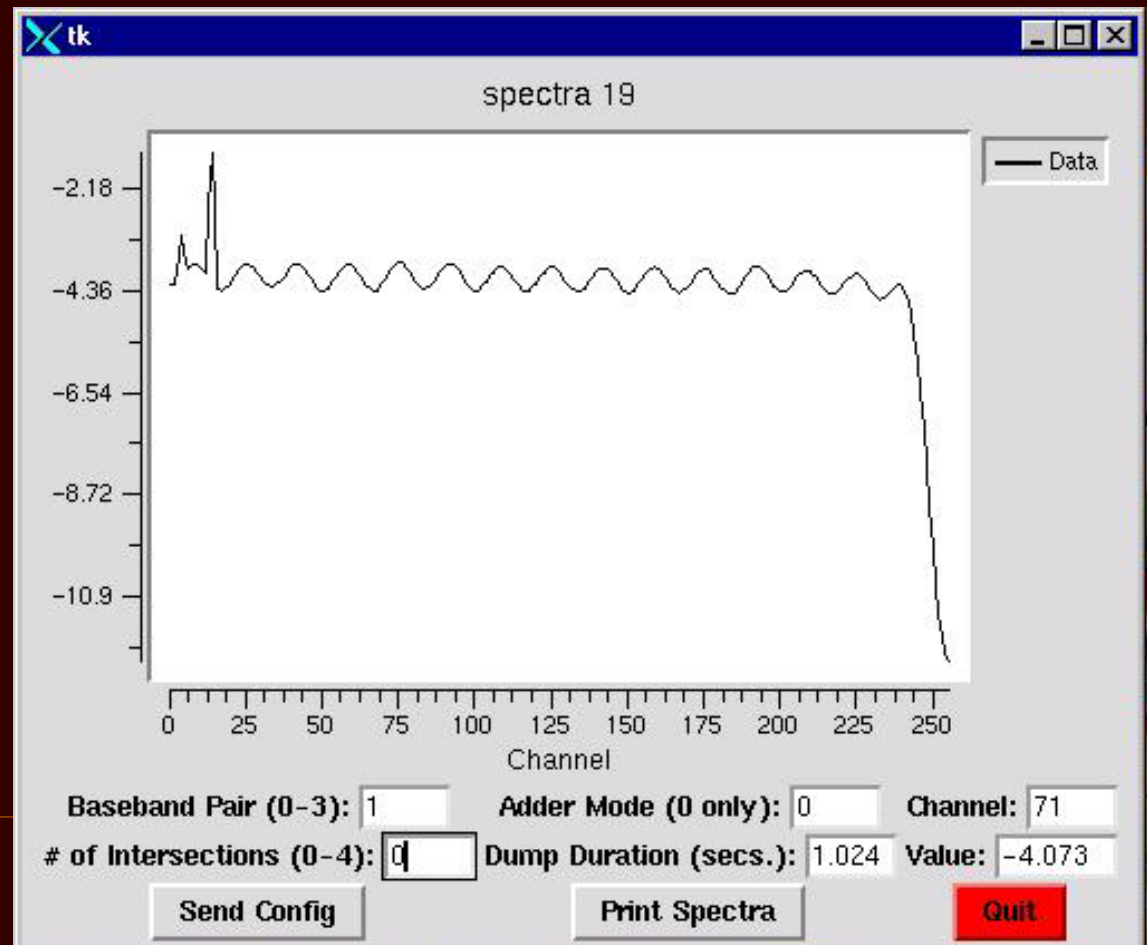
- 64 ant. Correlator
 - 64 ant.: 2016 baselines:
8IF: 2-GHz BW dual polarization:
2bit correlation:
32 frequency resolution points
 - Present Cost Estimation
 - 12M US\$
 - Future: down in price
-

ALMA Correlator



ALMA Correlator (eBLC) Software

Realtime Monitor Demonstration



ALMA Correlator (eBLC)

□ First Quadrant Production

ID	Task Name	2004				2005				2006			
		Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3
151	First Quadrant Correlator												
152	Interfaces w/other IPTs												
165	LAB Upfit for Correlator Assembly Area												
169	Rack, Bins, & Cables - First Quadrant												
182	Text Fixtures (Advanced)												
186	Assemble, Populate, & Test 1st Quadrant												
198	Integrated Testing												
203	Software Development												
205	Shipping of First Quadrant Correlator												

ACA Correlator (Japanese)

□ Requirement

- We need the high sensitivity due to 7m ant.

Item	Specifications	Remarks
Number of antennas	16	
Number of max. cross-correlations	120	
Bandwidth per baseband	2 GHz	
Number of baseband input per antenna	8	Input format 3bit, 4Gbps
Correlation functions	cross + auto	
180-degree phase switching	yes	
Image band rejection (90-degree switching)	yes	
delay compensation	30 km	
Highest frequency resolution	3.8 kHz	Without a reduction of the total bandwidth
Correlation: Number of bits	4 bits	3bit + sign
Maximum number of frequency channels per baseband pair per baseline	8192 channels	
Minimum integration time	1 msec (auto) 16 msec (cross)	
Number of Sub-array	2	Supports single-dish mode and ACA interferometry simultaneously
Polarimetry	yes	HH,VV,HV,VH(for orthogonal H and V)*
VLBI phase-up mode	yes	

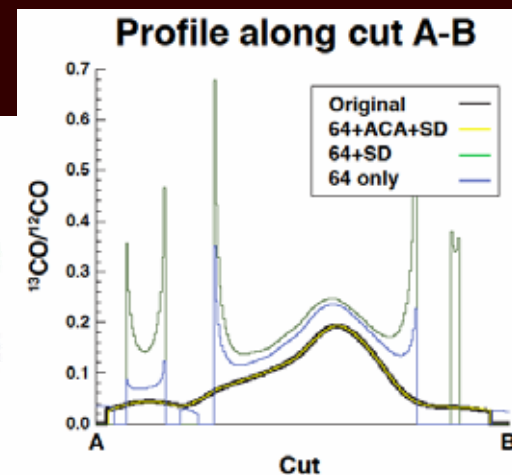
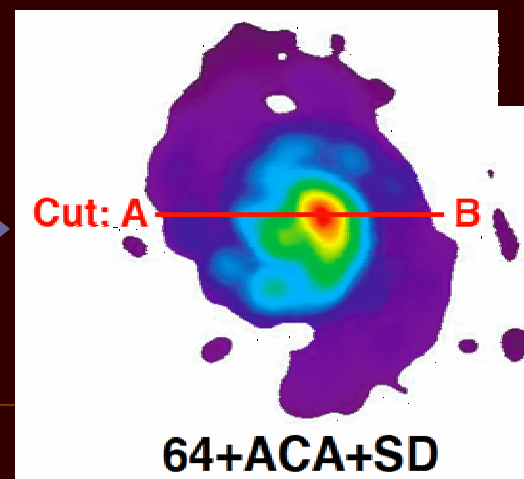
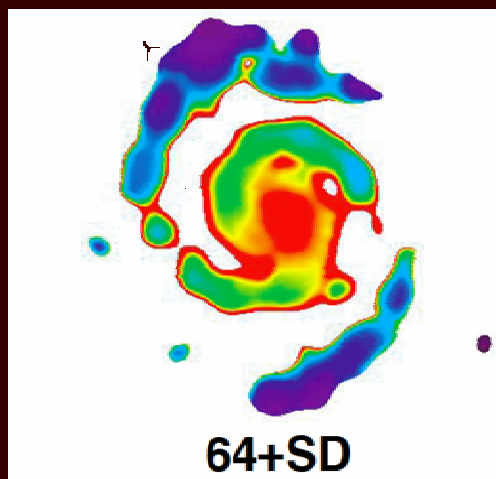
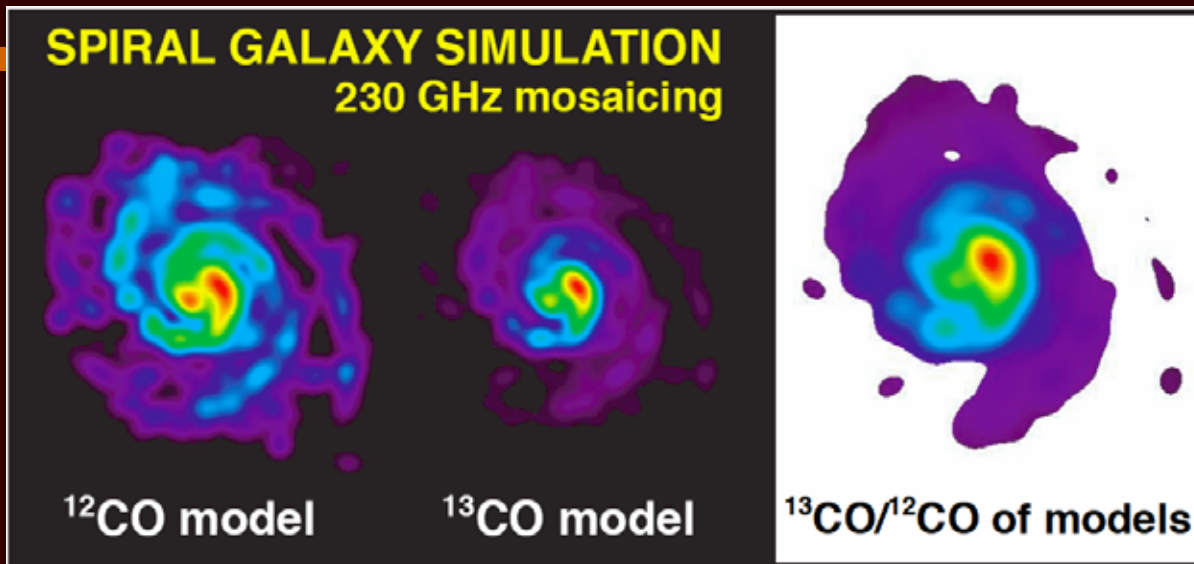
ACA Correlator (Japanese)

□ Specifications

	Type	Num. Ant	Corr. Bit	CH
eBLC	DHXF	64	2 bits	4096
ACA	FX	16	4 bits	8192

Image Fidelity Improved by ACA (1)

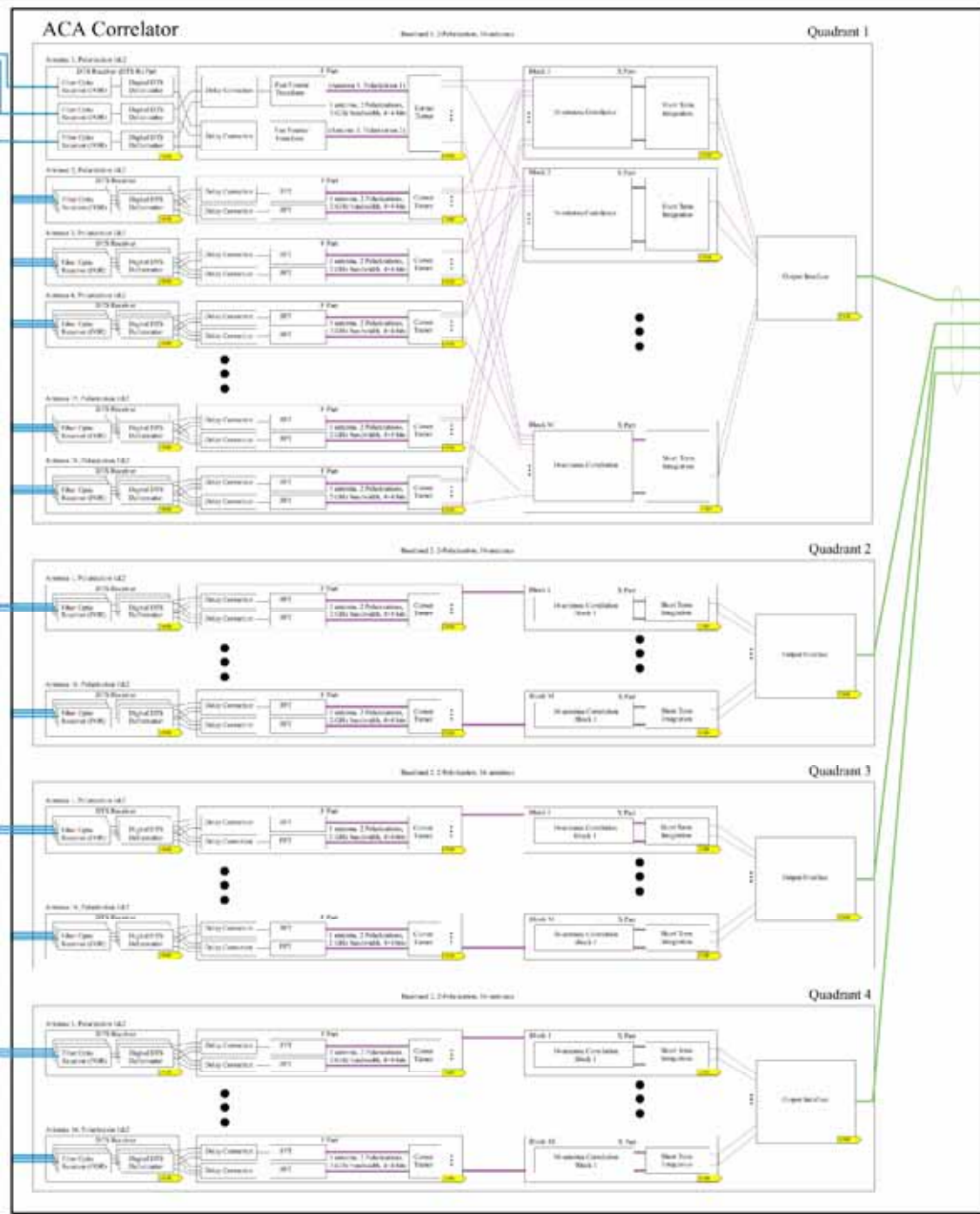
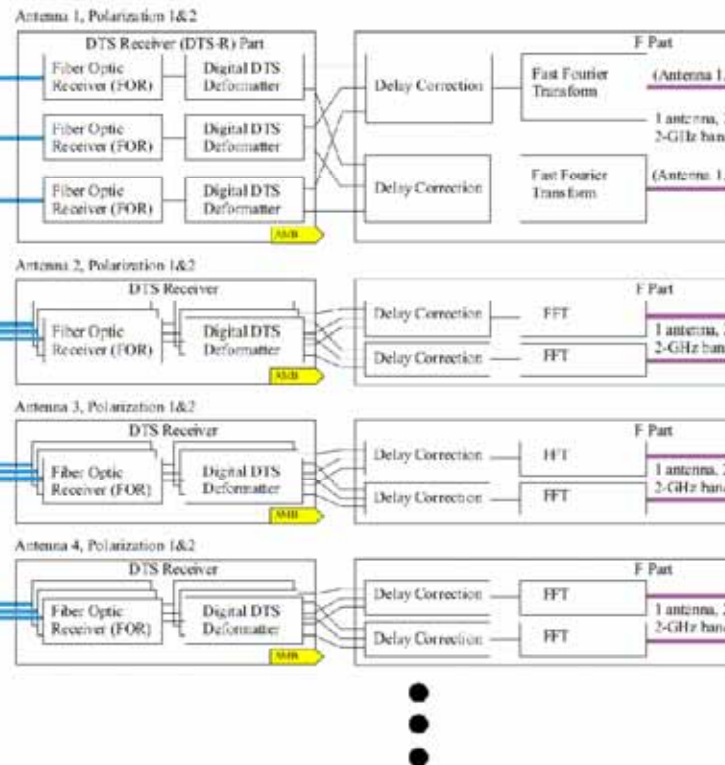
Simulation (Tatematsu, Tsutsumi et al.)



ACA Correlator

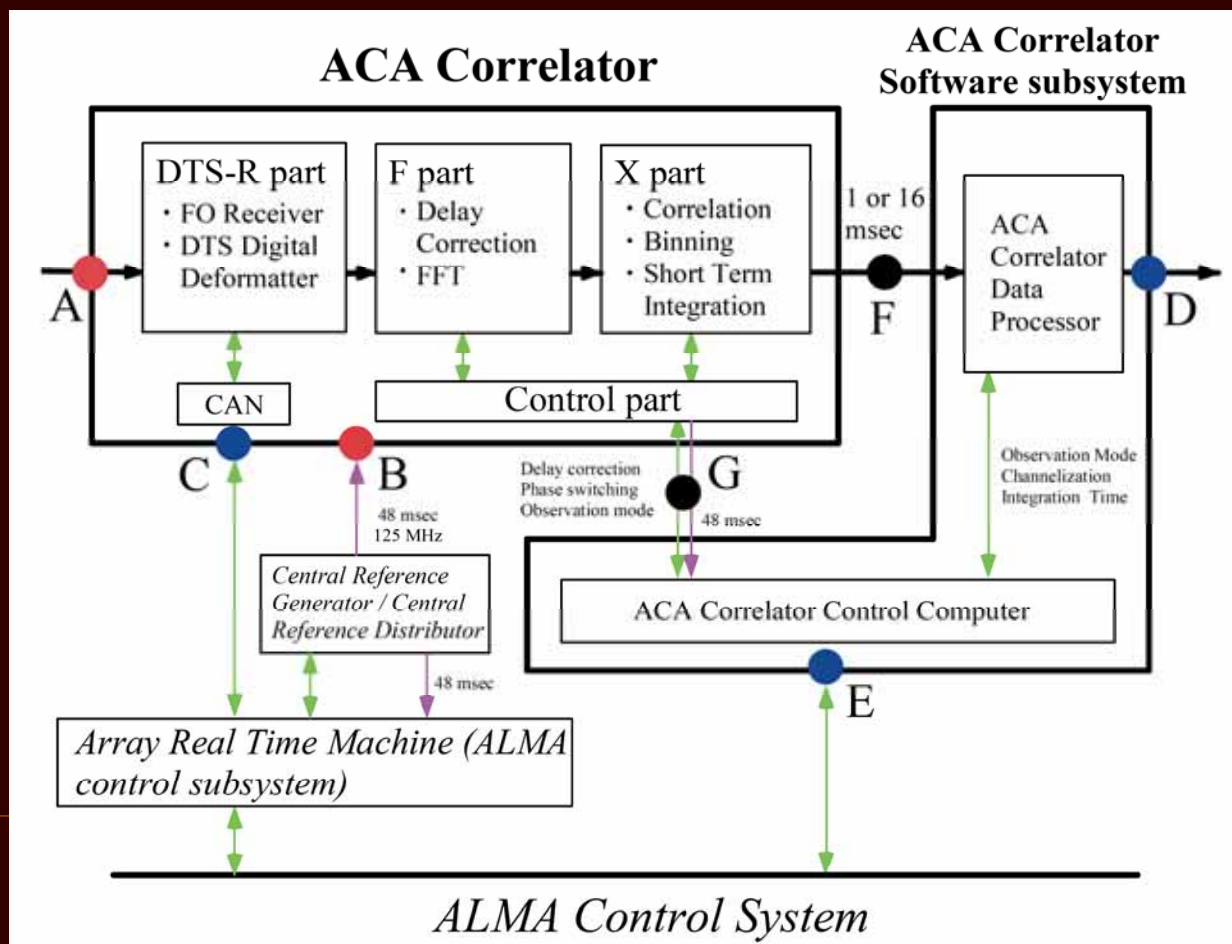
ACA Correlator

ACA Correlator



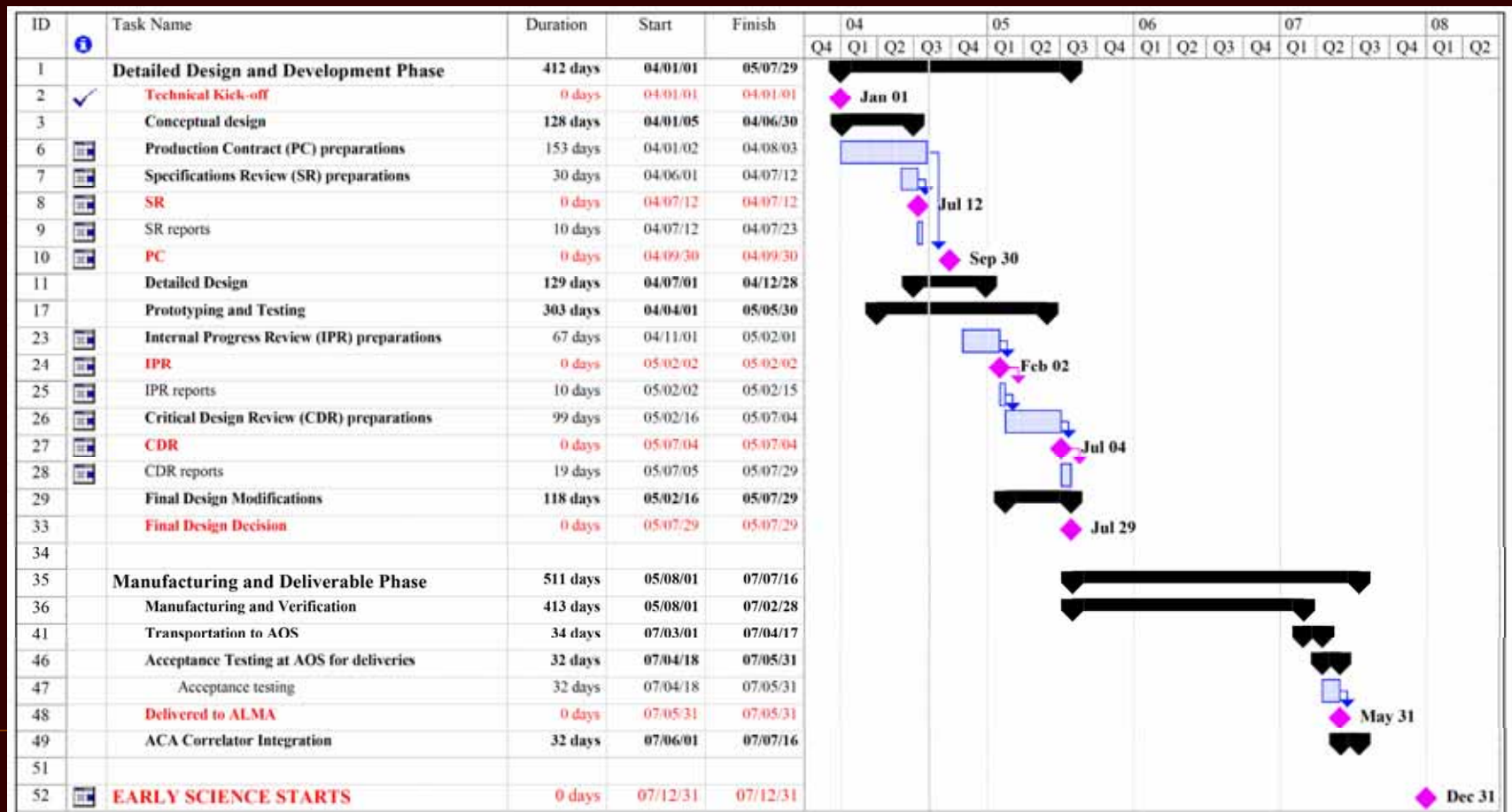
ACA Correlator (Japanese)

ACA Correlator ICD



ACA Correlator (Japanese)

ACA Correlator Production



ACA Correlator (Japanese)

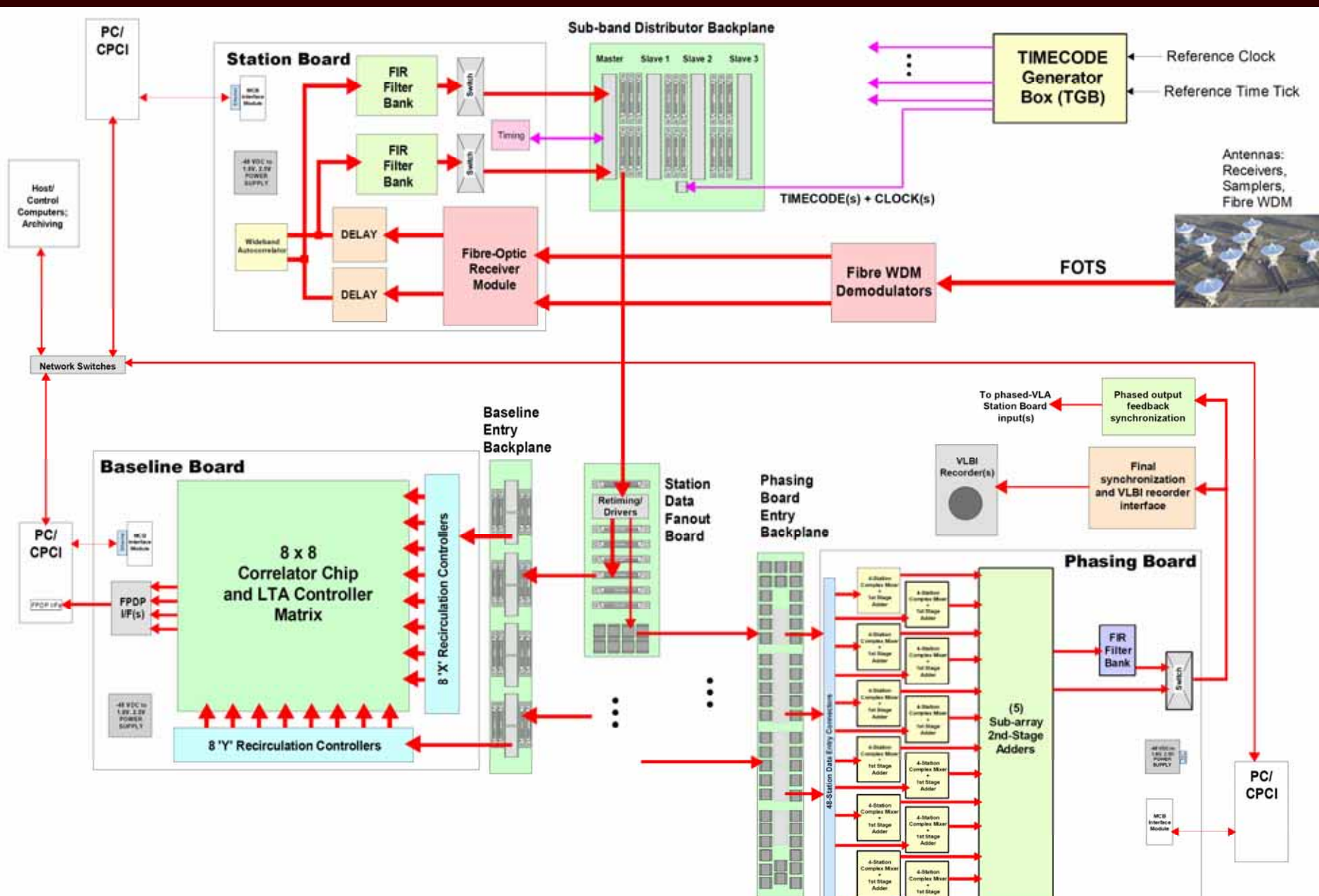
□ Present Status

- Bid Briefing (8/6)
 - Bid opening (end of Sep.)
 - Cost performance = eBLC
 - Details
 - Oct. after contract
-

E-VLA

- Exanded VLA project
 - WIDAR: E-VLA Correlator





SKA

□ SKA

Antenna	Elements	Effective Area	Upper Frequency	Tsys	A/Tsys	Year Finished
DSN 70m	1 x 70 m	2,607	8 GHz	18	145	1965
GBT	1 x 100 m	5,700	100 GHz	20	285	2000
VLA	27 x 25 m	8,978	43 GHz	32	280	1982
Arecibo	1 x 305 m	23,750	8 GHz	25	950	1970
ALMA	64 x 12 m	4,608	800 GHz	50	92	2011
ATA	350 x 6 m	6,703	11 GHz	35	192	2005
DSN Prototype	100 x 12m	7,200	38 GHz	20@8GHz 40@32GHz	360 180	2007
DSN Goal	3600 x 12m	259,200	38 GHz	18@8GHz 36@32GHz	14,400 7,200	2012
SKA	4550 x 12m	327,600	22 GHz	18	20,000	2016



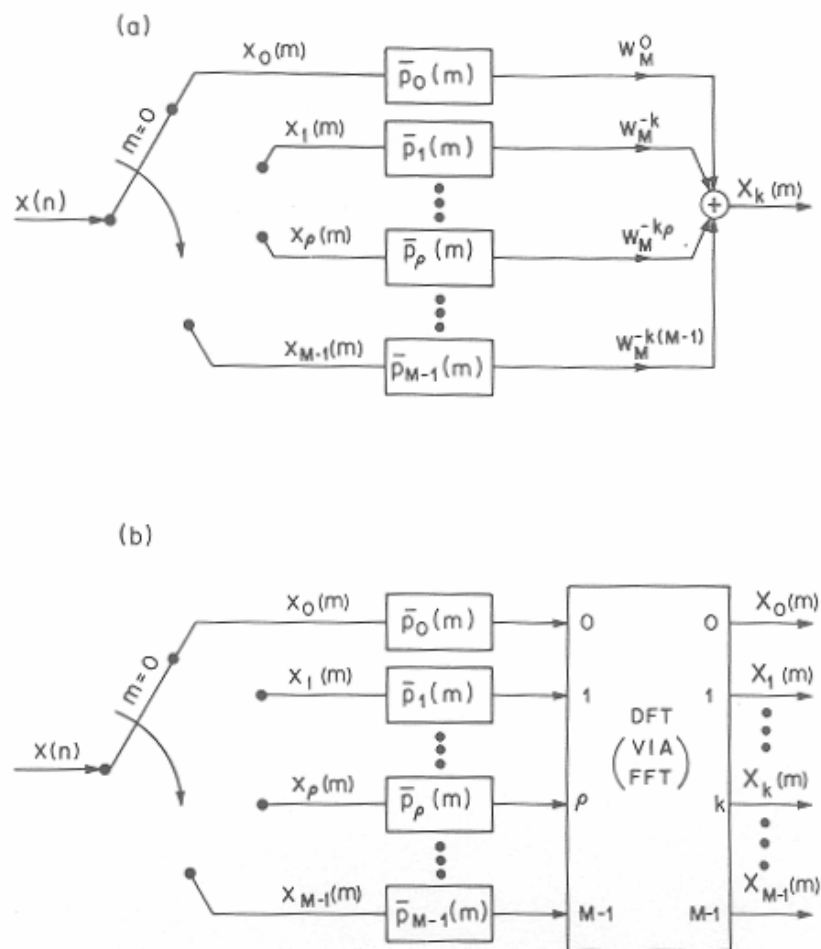
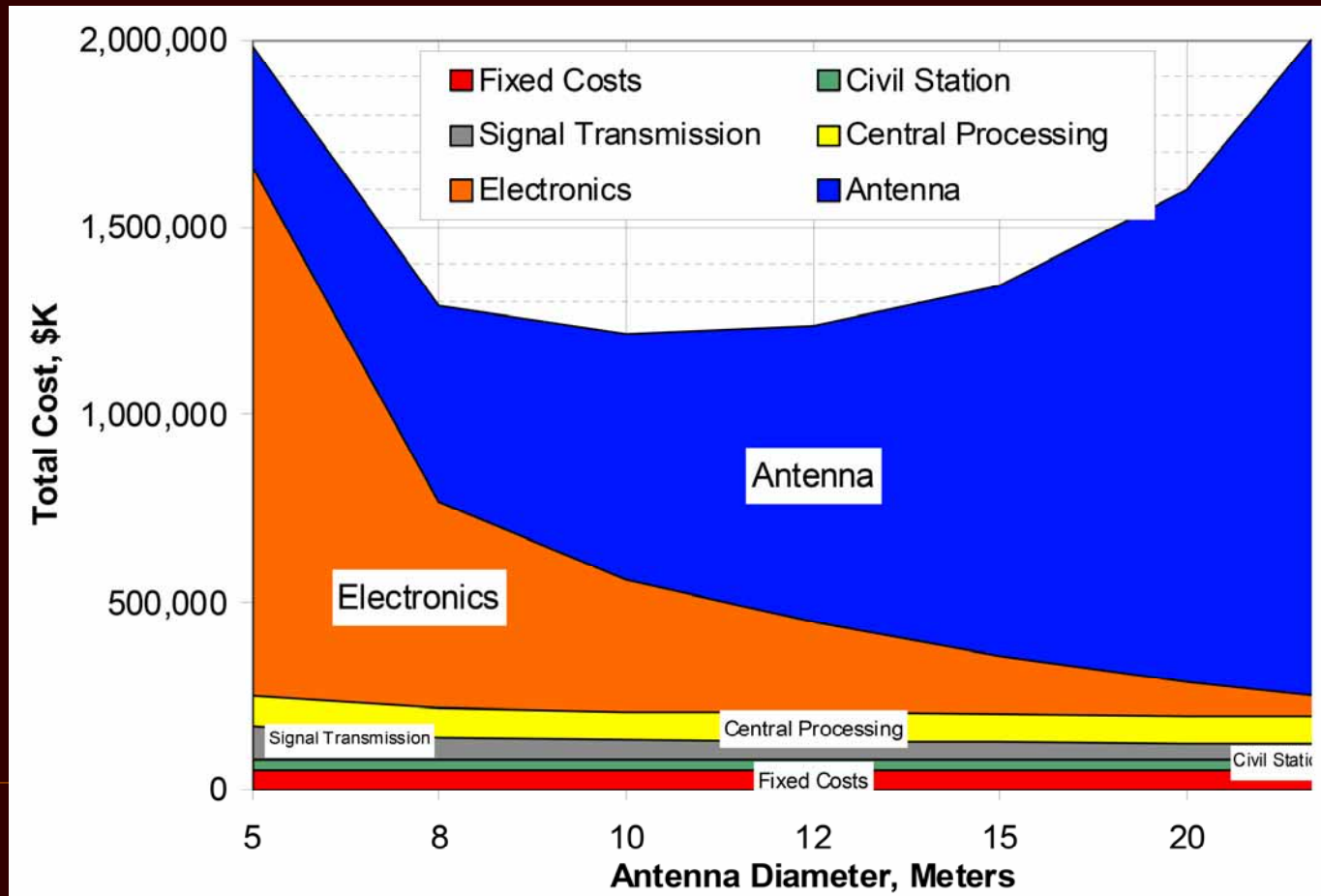


Figure 7.11 (a) Polyphase structure for the k th channel of a DFT filter bank analyzer; (b) the total polyphase DFT filter bank structure with an FFT modulator.

SKA

Cost estimation for Big Project



Big Project Correlator

□ ALMA

- 2 GHz BW X 8 IFs X 3 bits X 64 antennas
 - eBLC (including Digital Filter)
- 2 GHz BW X 8 IFs X 3 bits X 16 antennas
 - ACA Correlator (FX type)

□ SKA

- 4550 antennas
 - Polyphase FX (Australia)

□ Future
