ATLAS Global Trigger System

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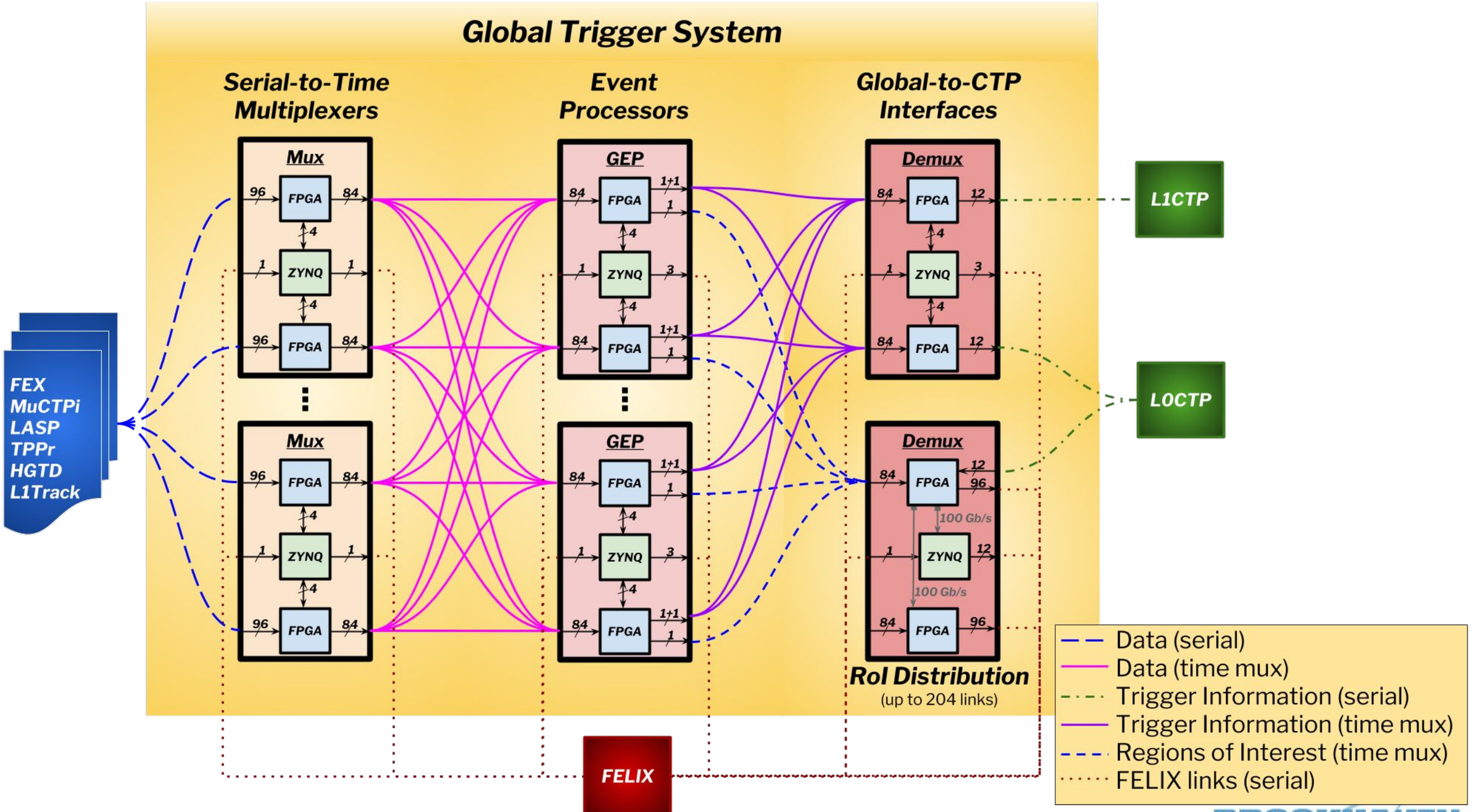
May 11, 2017

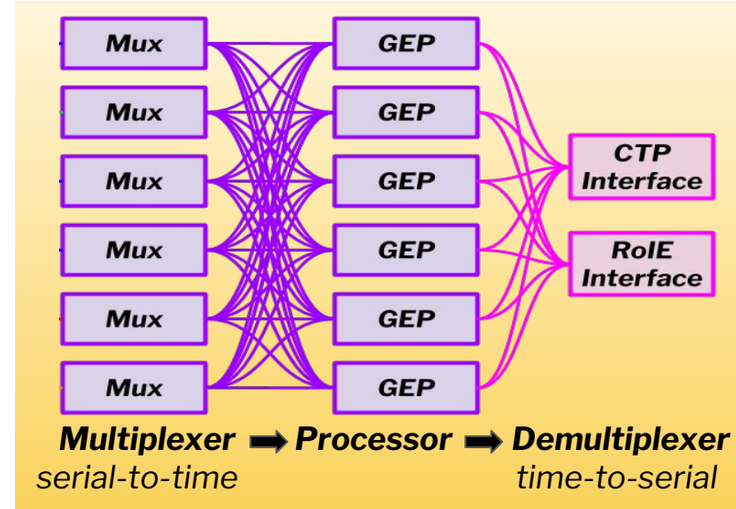
BROOKHAVEN
NATIONAL LABORATORY

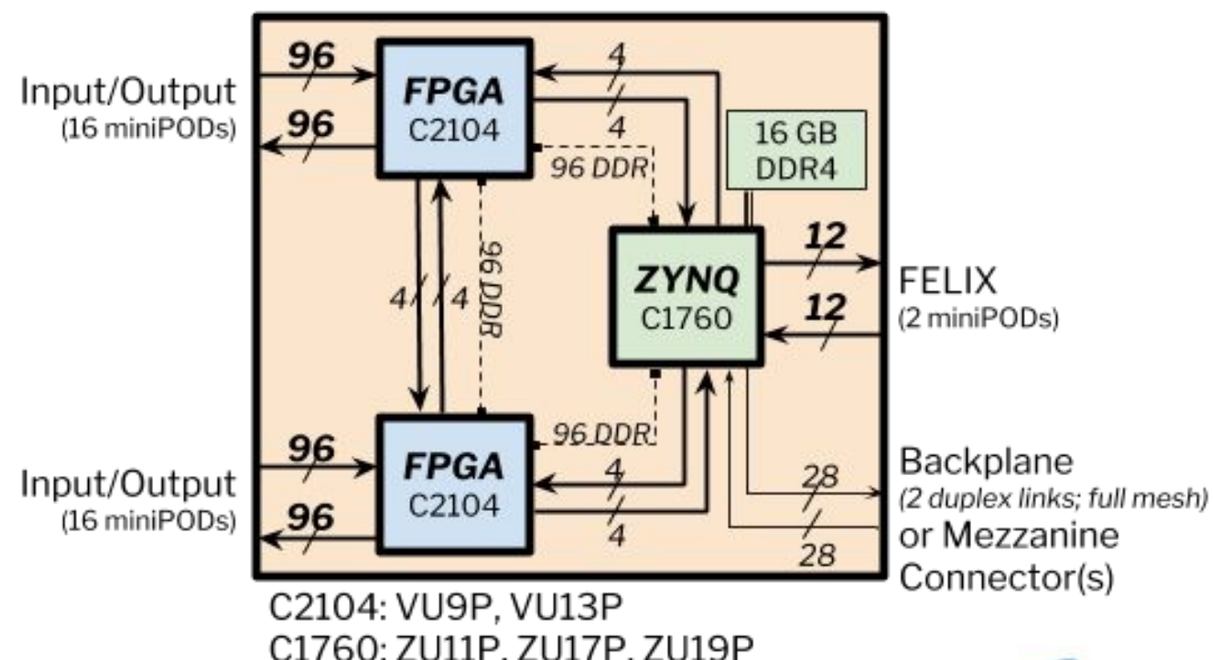

Global Trigger System
Serial-to-Time Multiplexers
Event Processors
Global-to-CTP Interfaces
Mux
GEP
Demux
FPGA
ZYNQ
96
84
1
4
1+1
3
12
100 Gb/s
FEX
MuCTPi
LASP
TPPr
HGTD
L1Track
L1CTP
L0CTP
Rol Distribution
(up to 204 links)
FELIX
Data (serial)
Data (time mux)
Trigger Information (serial)
Trigger Information (time mux)
Regions of Interest (time mux)
FELIX links (serial)

Global Common Module (GCM)

- ***Common hardware platform***
  - **one ATCA module design for Global Trigger System**
  - **different functionality implemented through firmware**
  - minimize costs & long-term maintenance

- ***Baseline proposal:***
  - two Xilinx Ultrascale+ FPGA
  - **204 inputs & 204 outputs**
    - **link speeds up to 25.78125 Gb/s**
    - 5.2 Tb/s throughput
  - additional features:
    - one Xilinx ZYNQ Ultrascale+ MPSoC
    - inter-FPGA: 4 MGT @ 25.78125 Gb/s
    - inter-FPGA: 96 DDR → 100 Gb/s with low latency
    - 16 GB DDR4 RAM for long-latency buffering
    - 28 MGT links for full-mesh backplane or mezzanine(s)





Architecture based on *today's* technology.
Does not preclude post-TDR developments!

GCM Cost Estimate

Description	Manufacture	Part Number	Distributor	Unit Cost	QTY	Cost
PCB Fabrication	TTM		TTM	$ 1,927.01	1	$ 1,927.01
PCB Assembly	AA Tech.		AA Tech.	$ 1,275.00	1	$ 1,275.00
DC/DC CONVERTER 3.3V 5V 400W	GE	PIM400KZ	Digi-Key	$ 72.05	1	$ 72.05
CONVERTER DC/DC 12V 33A OUT	GE	QBVW033A0B41Z	Digi-Key	$ 67.40	1	$ 67.40
DC/DC CONVERTER DUAL 0.6-5.3V	Linear	LTM4630AEV#PBF	Digi-Key	$ 59.26	12	$ 711.12
ADVTCA ATCA PLNG IEA DIE CST HDL Front Panel	Schroff	21596324	Digi-Key	$ 43.22	1	$ 43.22
CONN MALE 34POS R/A GOLD ATCA ZONE 1 CONNECTOR	TE Connectivity	1766500-1	Digi-Key	$ 27.64	1	$ 27.64
CONN RCPT 80POS 8ROW RT ANG HM-Z ATCA ZONE 2	TE Connectivity	2065657-1	Digi-Key	$ 24.53	4	$ 98.12
IC CLK BUFFER PLL 64QFN	Silicon Labs	SI5345A-B-GM	Digi-Key	$ 23.49	1	$ 23.49
IC SUPERVISOR/SEQUENCER 48-TQFP	ADI	ADM1066ASUZ	Digi-Key	$ 17.12	2	$ 34.24
IC CLK BUFFER 2:16 800MHZ 48VQFN	TI	CDCLVD1216RGZT	Digi-Key	$ 13.48	5	$ 67.40
NOR Flash Serial-SPI 1.8V 2Gbit 2G x 1bit/1G x 2bit/0.5G x 4bit	Micron	MT25QU02GCBB8E12-0SIT	Arrow/Avnet	$ 14.34	4	$ 57.36
288 Position MiniDIMM DDR4 SDRAM Socket Surface Mount	Molex	1511050001	Digi-Key	$ 33.41	1	$ 33.41
Mini-DIMM w/ECC VLP 16GB 2400MT/s	Innodisk	M4M0-AGS1YCSJ	Innodisk	$ 185.00	1	$ 185.00
IC ADC 24BIT DELTA SIG 38-QFN	Linear	LTC2499IUHF#PBF	Digi-Key	$ 8.52	2	$ 17.04
CAP TANT POLY 470UF 6.3V 2917	Kemet	T530X477M006ATE004	Digi-Key	$ 7.97	10	$ 79.70
Aluminum Organic Polymer Capacitors 470uF 2.5volt SP-Cap	Panasonic Electr	EEF-GX0E471R	Mouser	$ 2.19	20	$ 43.80
SMT Chip Resistor/Ceramic Capacitor/jumpers		Misc (Resistor, Capacitor)	Digi-Key	$ 0.05	500	$ 25.00
Vertex Ultrascale+ FPGA	Xilinx	XCZU11EG-1FFVC1760EES9820	Avnet	$ 1,734.10	1	$ 1,734.10
BOARD SUBTOTAL						**$ 6,522.10**
MiniPODs socket	FCI	55714-002LF	Mouser	$ 9.87	28	$ 276.36
MiniPOD Transmitter	Avago	AFBR-814FH1Z	Avnet	$ 201.25	14	$ 2,817.50
MiniPOD Receiver	Avago	AFBR-824FH1Z	Avnet	$ 117.65	14	$ 1,647.10
Vertex Ultrascale+ FPGA	Xilinx	XCVU5P-1FLVB2104ES9830	Avnet	$ 6,352.71	2	$ 12,705.42
B2104 Multiplexer						**$ 23,968.48**
MiniPODs socket	FCI	55714-002LF	Mouser	$ 9.87	28	$ 276.36
MiniPOD Transmitter	Avago	AFBR-814FH1Z	Avnet	$ 201.25	14	$ 2,817.50
MiniPOD Receiver	Avago	AFBR-824FH1Z	Avnet	$ 117.65	14	$ 1,647.10
Vertex Ultrascale+ FPGA	Xilinx	XCVU13P-1FHGB2104ES9830	Avnet	$ 17,305.07	2	$ 34,610.14
B2104 Event Processor						**$ 45,873.20**
MiniPODs socket	FCI	55714-002LF	Mouser	$ 9.87	28	$ 276.36
MiniPOD Transmitter	Avago	AFBR-814FH1Z	Avnet	$ 201.25	14	$ 2,817.50
MiniPOD Receiver	Avago	AFBR-824FH1Z	Avnet	$ 117.65	14	$ 1,647.10
Vertex Ultrascale+ FPGA	Xilinx	XCVU5P-1FLVC2104ES9830	Avnet	$ 6,411.46	2	$ 12,822.92
C2104 Multiplexer (small)						**$ 24,085.98**
MiniPODs socket	FCI	55714-002LF	Mouser	$ 9.87	34	$ 335.58
MiniPOD Transmitter	Avago	AFBR-814FH1Z	Avnet	$ 201.25	14	$ 2,817.50
MiniPOD Receiver	Avago	AFBR-824FH1Z	Avnet	$ 117.65	14	$ 1,647.10
Vertex Ultrascale+ FPGA	Xilinx	XCVU13P-1FHGC2104ES9830	Avnet	$ 17,305.07	2	$ 34,610.14
C2104 Event Processor (small)						**$ 45,932.42**
MiniPODs socket	FCI	55714-002LF	Mouser	$ 9.87	34	$ 335.58
MiniPOD Transmitter	Avago	AFBR-814FH1Z	Avnet	$ 201.25	17	$ 3,421.25
MiniPOD Receiver	Avago	AFBR-824FH1Z	Avnet	$ 117.65	17	$ 2,000.05
Vertex Ultrascale+ FPGA	Xilinx	XCVU9P-1FLGC2104ES9830	Avnet	$ 12,622.03	2	$ 25,244.06
C2104 Multiplexer (large)						**$ 37,523.04**
MiniPODs socket	FCI	55714-002LF	Mouser	$ 9.87	34	$ 335.58
MiniPOD Transmitter	Avago	AFBR-814FH1Z	Avnet	$ 201.25	17	$ 3,421.25
MiniPOD Receiver	Avago	AFBR-824FH1Z	Avnet	$ 117.65	17	$ 2,000.05
Vertex Ultrascale+ FPGA	Xilinx	XCVU13P-1FHGC2104ES9830	Avnet	$ 17,465.21	2	$ 34,930.42
C2104 Event Processor (large)						**$ 47,209.40**

Module Type	USD	CHF
B2104 Mux	23968.48	23968.48
B2104 GEP	45873.20	45873.20
C2104 Mux (small)	24085.98	24085.98
C2104 GEP (small)	45932.42	45932.42
C2104 Mux (large)	37523.04	37523.04
C2104 GEP (large)	47209.40	47209.40

1 USD = 1 CHF
close of business 24/4/17

Basis of Estimate (cost)
quotes for miniPODs & FPGAs
otherwise, gFEX module costs (similar complexity)

WBS 1.4 Global Trigger System

1.4.1 Common Module

- 1.4.1.1 Core Design
- 1.4.1.2 Frame Firmware

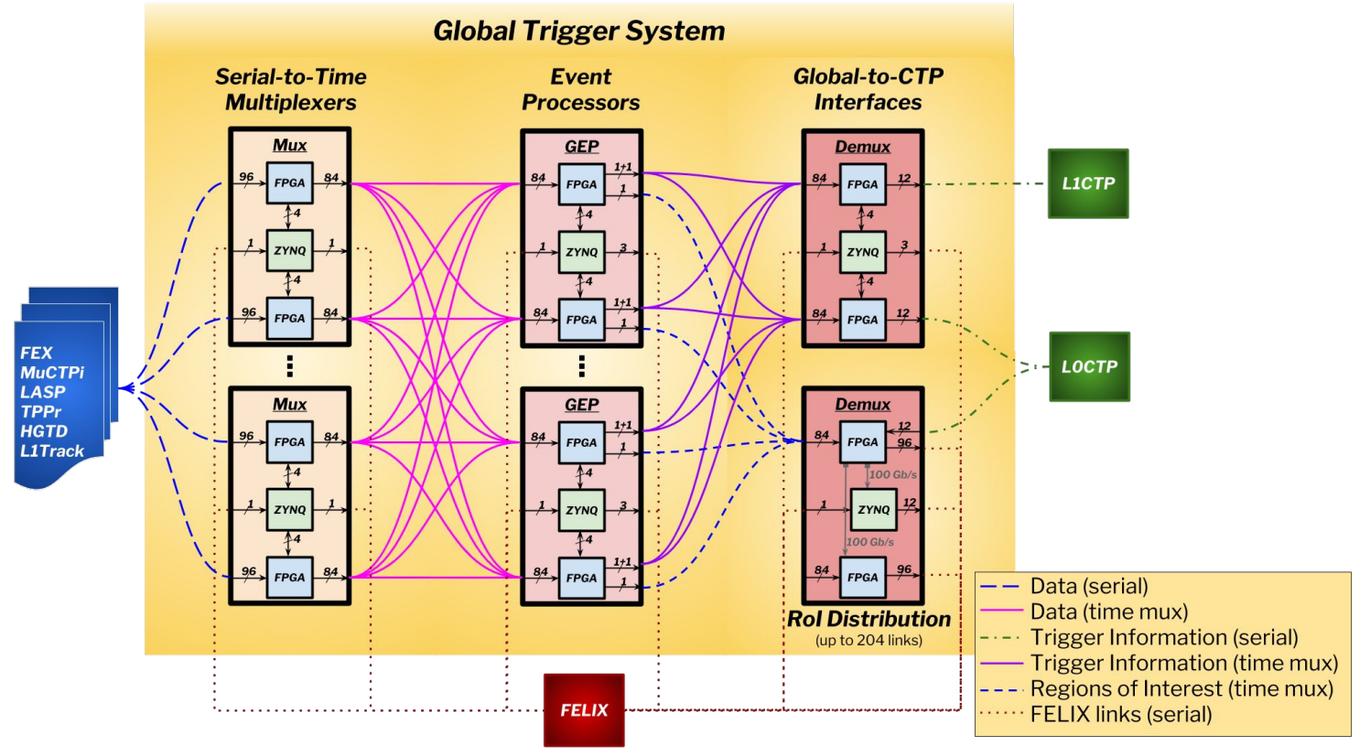
1.4.2 Interfaces

- 1.4.2.1 Multiplexer
- 1.4.2.2 Event Processor
- 1.4.2.3 CTP Interface
- 1.4.2.4 ROI Interface
- 1.4.2.5 FELIX Interface

1.4.3 Trigger Signatures

- 1.4.3.1 Calorimeter
- 1.4.3.2 Tracking
- 1.4.3.3 Muon
- 1.4.3.4 EGamma
- 1.4.3.5 Tau
- 1.4.3.6 Jet
- 1.4.3.7 MissingET
- 1.4.3.8 B-Physics
- 1.4.3.9 Heavy Ion/Forward

Trigger Signature scope similar to that in HLT.



1.4.4 Integration

- 1.4.4.1 Fiber Optic Plant
- 1.4.4.2 Demonstrator
- 1.4.4.3 ZYNQ Processor
- 1.4.4.4 Online Software
- 1.4.4.5 System Integration
- 1.4.4.6 Installation & Commissioning

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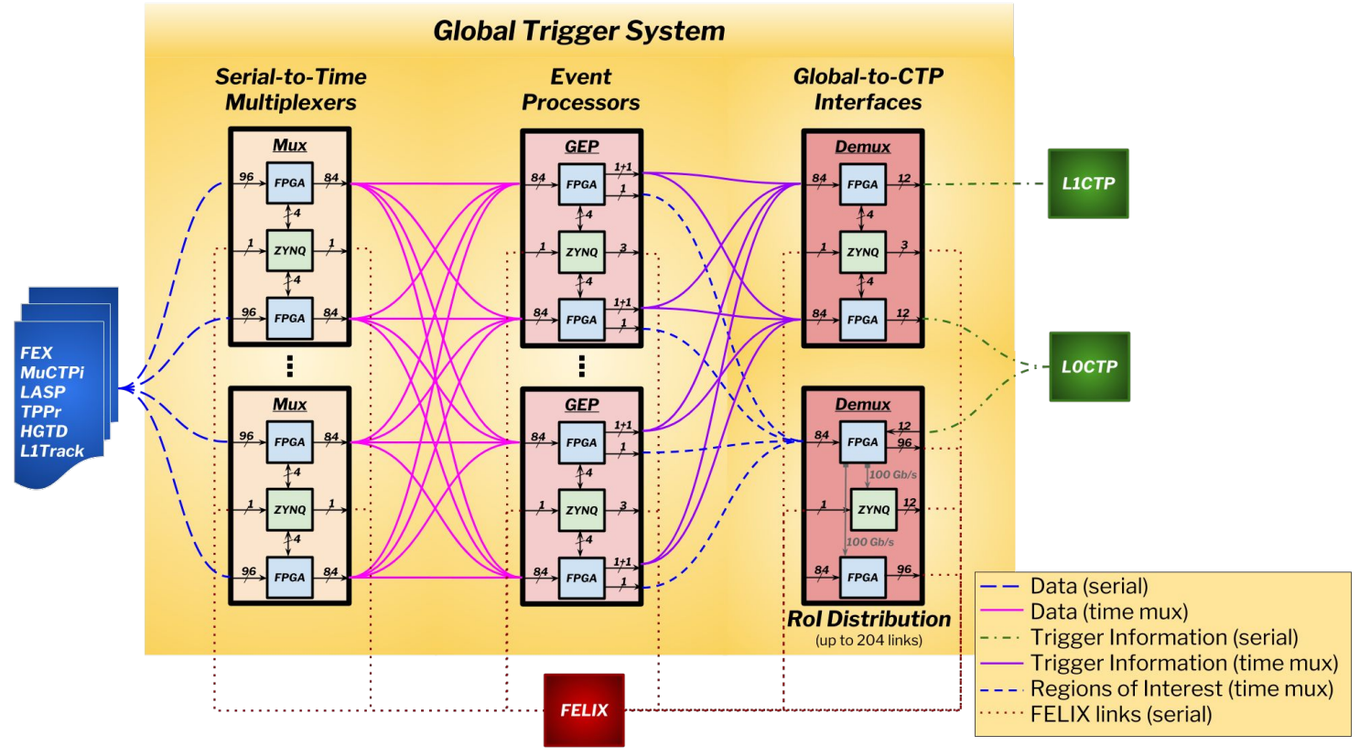

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- 1.4.4.5 System Integration
- 1.4.4.6 Installation & Commissioning

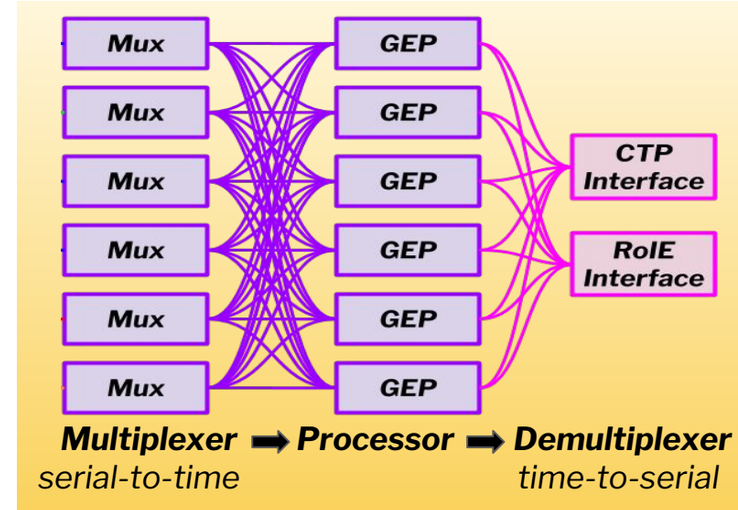
DOE
NSF

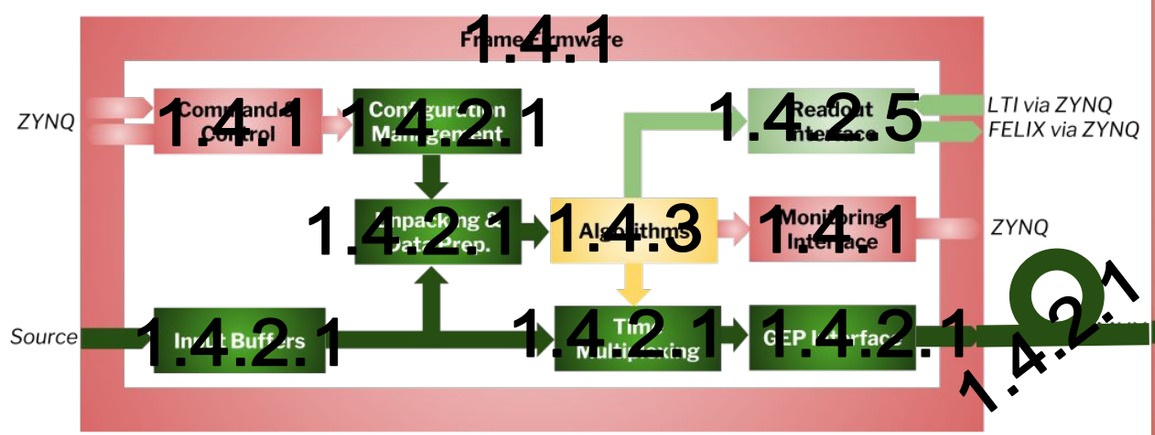
Multiplexer → Event Processor

WBS Items

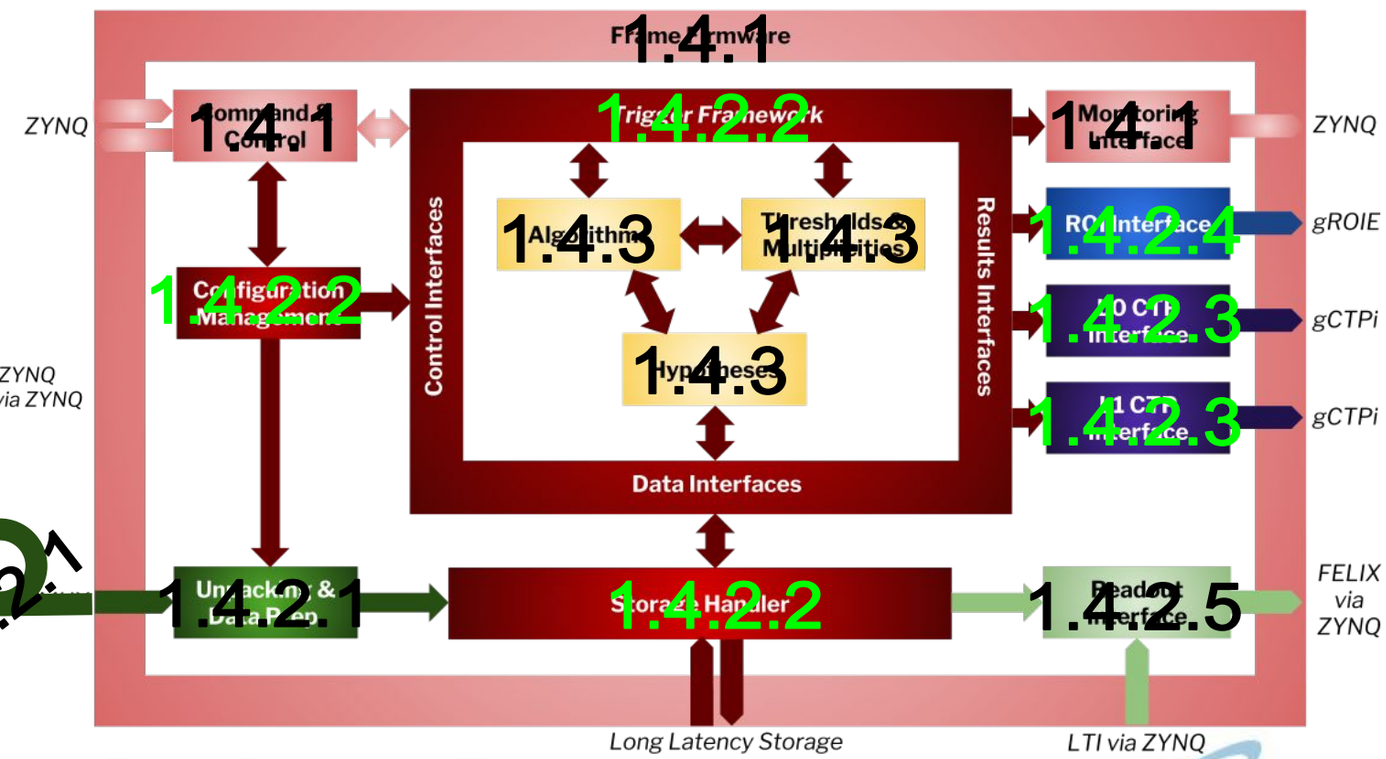
- *1.4.1 Common Module*
- *1.4.2 Interfaces*
  - 1.4.2.1 Multiplexer
  - 1.4.2.2 Event Processor
  - 1.4.2.3 CTP Interface
  - 1.4.2.4 ROI Interface
  - 1.4.2.5 FELIX Interface
- *1.4.3 Trigger Signatures*

Each functional board incorporates significant contributions from multiple WBS items.





Multiplexer Firmware



Event Processor Firmware

WBS 1.4.2 Interfaces

1.4.2.1 Multiplexer

- 1.4.2.1.1 Serial-to-Time Multiplexer
- 1.4.2.1.2 Mux & GEP/Unpacking & Data Org.
- 1.4.2.1.3 Protocols
- 1.4.2.1.4 Mux Integration

1.4.2.2 Event Processor

- 1.4.2.2.1 Trigger Framework
- 1.4.2.2.2 GEP Integration

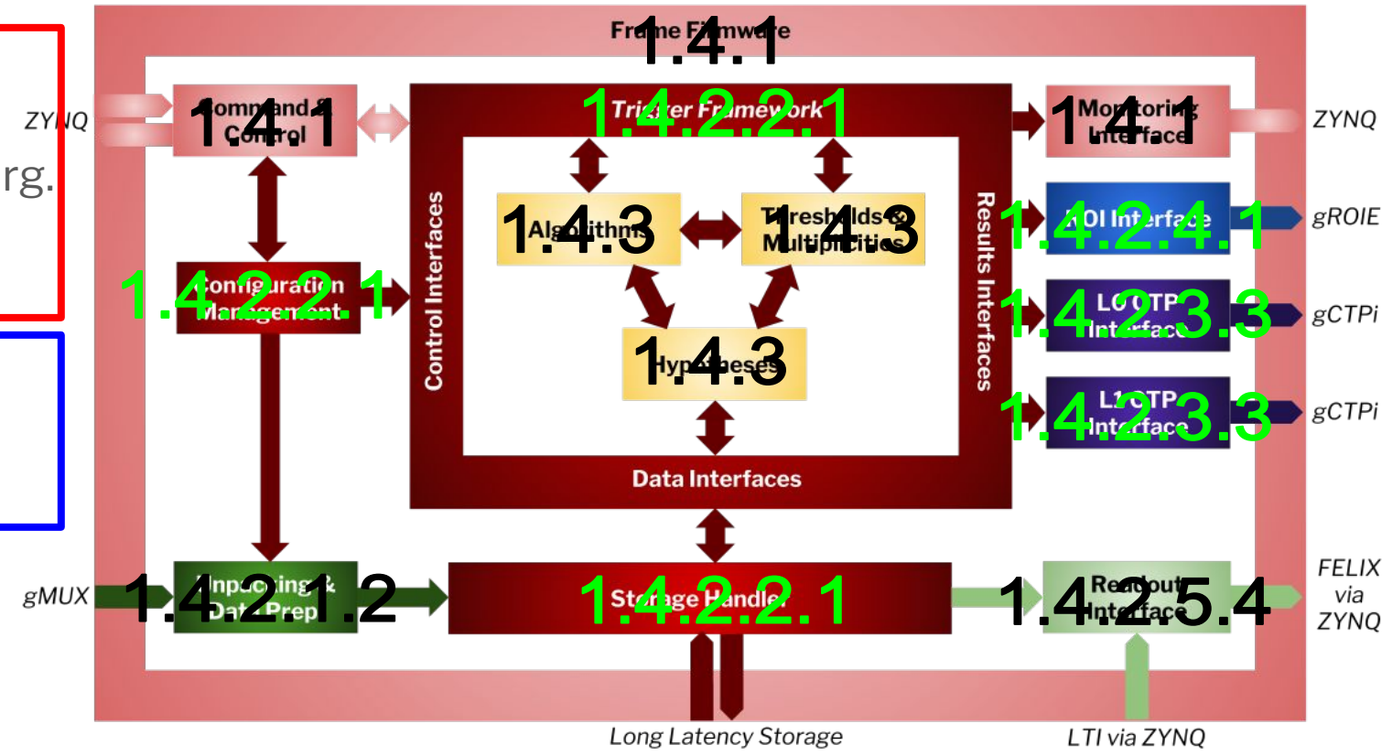
1.4.2.3 CTP Interface

- 1.4.2.3.1 GEP/CTP Interface
- 1.4.2.3.2 Time-to-Serial Demultiplexer
- 1.4.2.3.3 gCTPi & gROIE/Trigger Items
- 1.4.2.3.4 gCTPi Integration

1.4.2.4 RoI Interface

- 1.4.2.4.1 GEP/ROI Interface
- 1.4.2.4.2 Time-to-Serial Demultiplexer
- 1.4.2.4.3 RoI-to-R3 Mapping
- 1.4.2.4.4 R3 Transmission
- 1.4.2.4.5 gROIE Integration

Event Processor Firmware (Conceptual Diagram)



DOE

NSF

1.4.2.5 FELIX Interface

- 1.4.2.5.1 Communications
- 1.4.2.5.2 Data Transmission
- 1.4.2.5.3 Mux/Readout
- 1.4.2.5.4 GEP/Readout
- 1.4.2.5.5 gCTPi/Readout
- 1.4.2.5.6 gROIE/Readout

Core Costs

US CORE: 2375 kCHF

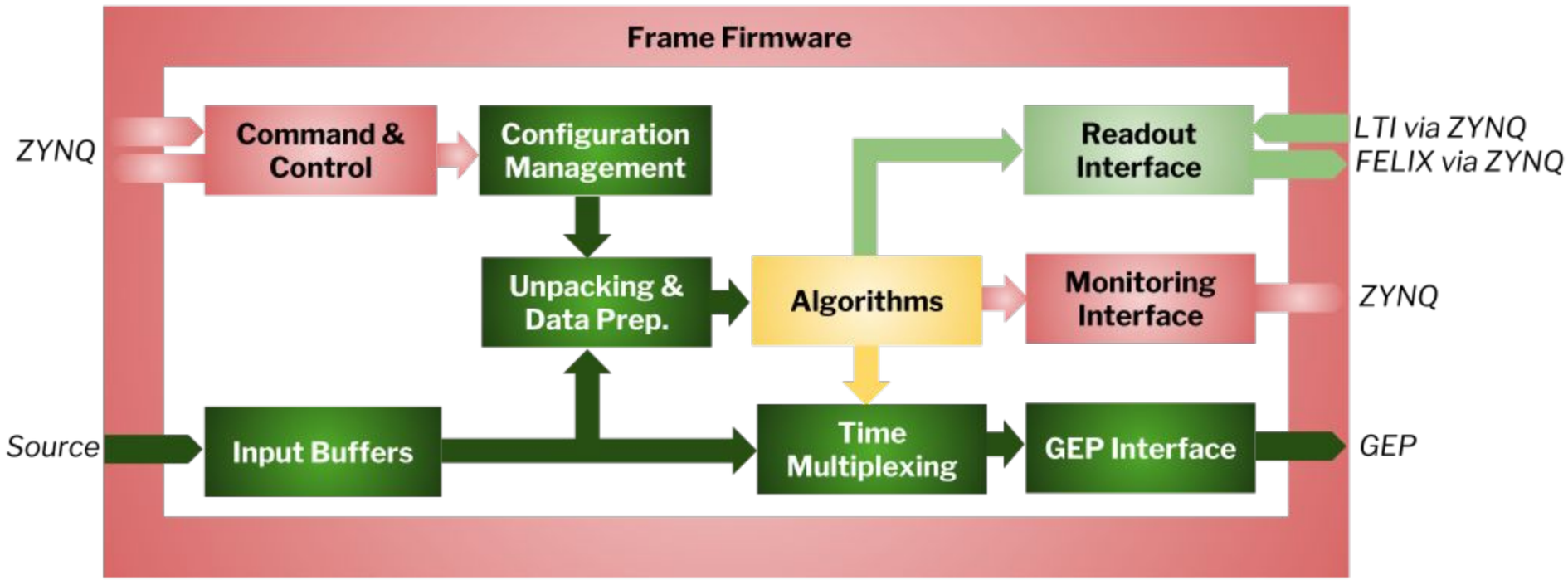
Data Source	Small FPGA — No HGTD		Large FPGA — No HGTD		Large FPGA — With HGTD	
	Mux	GEP	Mux	GEP	Mux	GEP
GCM in USA15	27	24	25	24	33	24
Shelves	4		4		5	
Fiber Plant	250		250		250	
CORE (MCHF)	2.07		2.39		2.71	
GCM on Surface	7	7	7	7	7	7
GCM Spares	3	3	3	3	3	3
Shelves	2		2		2	
ADD (MCHF)	0.74		0.88		0.88	
TOTAL (MCHF)	2.81		3.27		3.59	

Addition of HGTD (end-cap) increases cost by 780 kCHF.

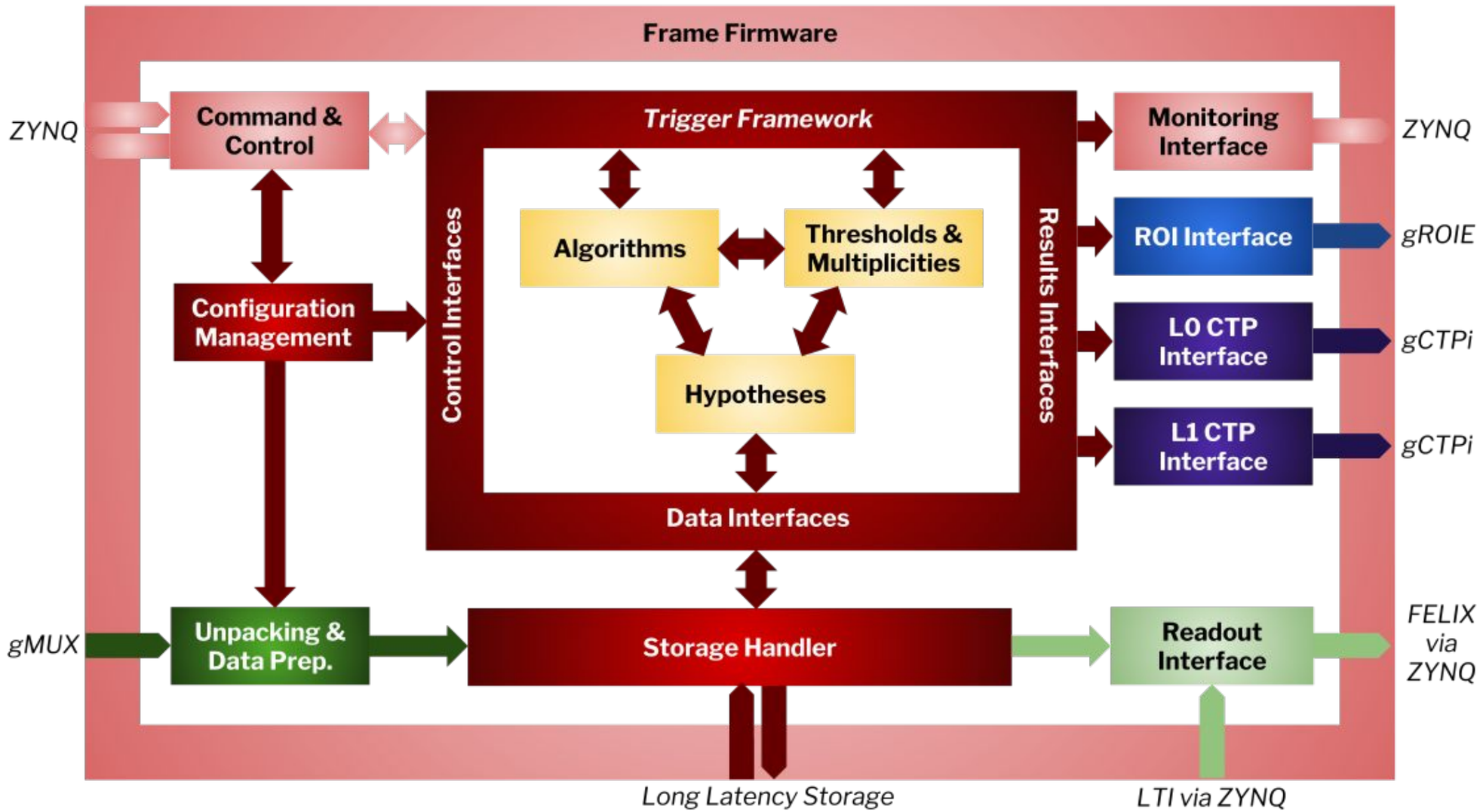
Al Ross, New Yorker
June 22, 1992

Questions?

Multiplexer (Conceptual Diagram)



Event Processor Firmware (Conceptual Diagram)



Multiplexers (48 GEP but excludes HGTD)

Data Source	Link Speed (Gb/s)	Expected Fibers	Fibers/Mux (small)	Mux (small)	Fibers/Mux (large)	Mux (large)
eFEX	11.2	384	72	9	96	7
jFEX	11.2	224				
gFEX	11.2	16				
MuCTPi	12.8	16	16	1	16	1
LASP	25.8	1412	48	30	48	30
TPPr	11.2	352	72	5	96	4
L1Track	9.6	280?	72	4	96	3
TOTAL			**2760**	**49**	**2800**	**45**

Multiplexers (48 GEP and includes HGTD)

Data Source	Link Speed (Gb/s)	Expected Fibers	Fibers/Mux (small)	Mux (small)	Fibers/Mux (large)	Mux (large)
eFEX	11.2	384	72	9	96	7
jFEX	11.2	224				
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MuCTPi	12.8	16	16	1	16	1
LASP	25.8	1412	48	30	48	30
TPPr	11.2	352	72	5	96	4
L1Track	9.6	280?	72	4	96	3
HGTD-EC	25.8	780	48	17	48	17
TOTAL			**3576**	**66**	**3616**	**62**

Maximum possible number of Mux is 70!