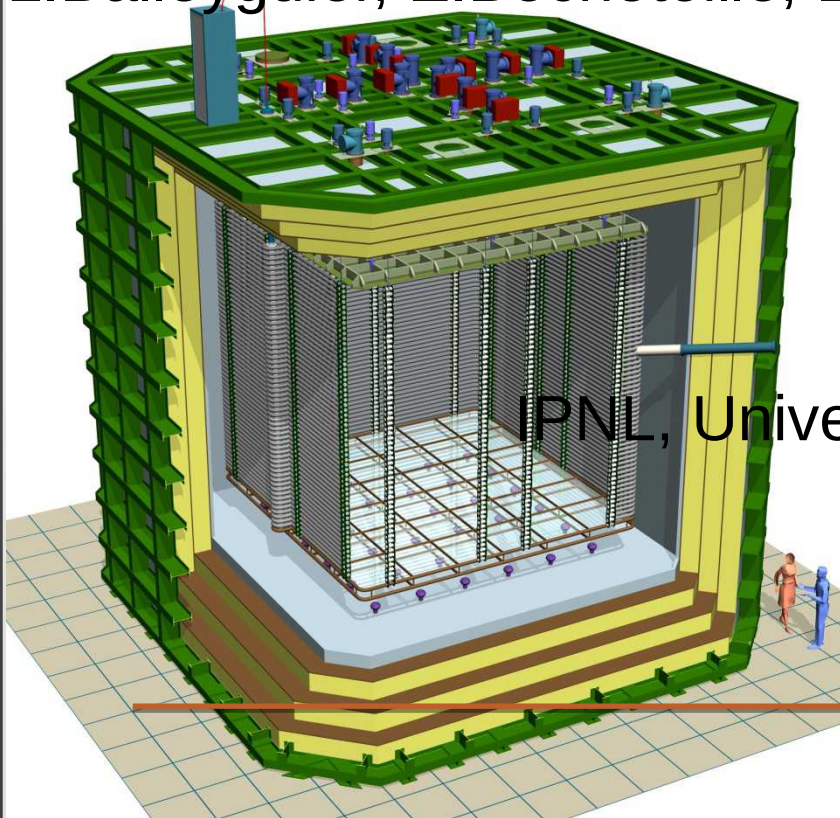


# WA105 global DAQ architecture

D.Autiero, D.Caiulo, S.Galymov, J.Marteau, E.Pennacchio

L.Balleyguier, E.Bechetoille, B.Carlus, C.Girerd, H.Mathez, D.Pugnère



IPNL, Université de Lyon, CNRS-IN2P3, UMR 5822

DUNE DAQ WG

October 5, 2015

# WA105 @CERN : R/O features

- **F/E-inside** : ASIC in the cold → feedthrough (power supply / signal)
- **F/E-outside** : **μTCA** (charge/PM) + **White Rabbit** (time/CLK/trigger)
  - ✓ μTCA crate on the cryostat :
    - ✓ direct coupling to the feedthrough to receive signals from the ASICs
    - ✓ do not power the ASICs in the cold
  - ✓ 12 slots for charge R/O (10/12 occupied : ~ 16 % contingency)
  - ✓ **Single MCH + WR slave board**
    - ✓ Time/CLK/trigger distribution to the backplane
    - ✓ 1 x 10 Gbe uplink
- **B/E** : **FPGA** processing boards inside standard PC :
  - ✓ 1 PC for 6 μTCA crates (6/8 occupied : ~ 25 % contingency)
  - ✓ **OpenCL** framework for developers

# WA105 data flow

- Local storage system specifications (starting point for discussion) : 1 day of beam data storage w/o zero suppression (upper limit constraint)
- Basic assumptions : beam duty cycle ~50 %, particules extraction rate ~ 100Hz, ~1 cosmic track to be acquired per beam trigger
- Charge R/O data flow :  
100Hz events = 100 Mbits/s/AMC => 10 Gbits/s/crate => 120 Gbits/s (15 GB/s) total
- Requirements :  $3600 \times 24 \times 50 \% \times 15 = 650$  TB per day
- Adding PMT data + contingency : requires a **PetaByte** local storage system
- Requires fast links from online DAQ to storage AND from offline computing farm to storage : simultaneous R/W access. Compression algorithms (factor 1/10 for the Huffman) not accounted for.

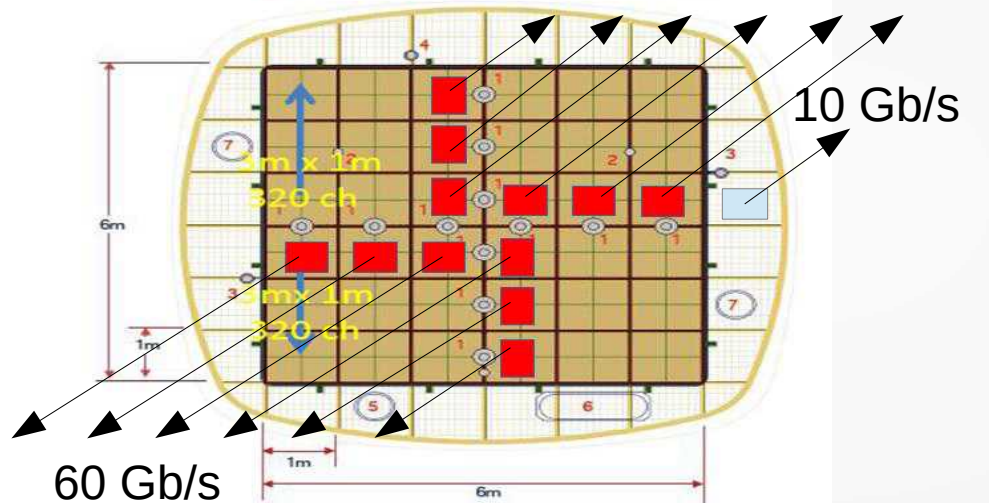
# WA105 $\mu$ TCA-DAQ architecture

2 x 40 Gb/s

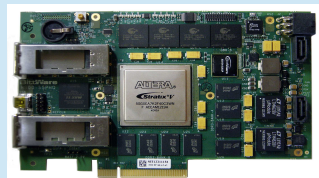
E.B.1



View from anode with signal (1), suspension (2), HV(3), PMT(4), manhole (5), detail insertion (6), clean room IN/OUT (7) nozzles

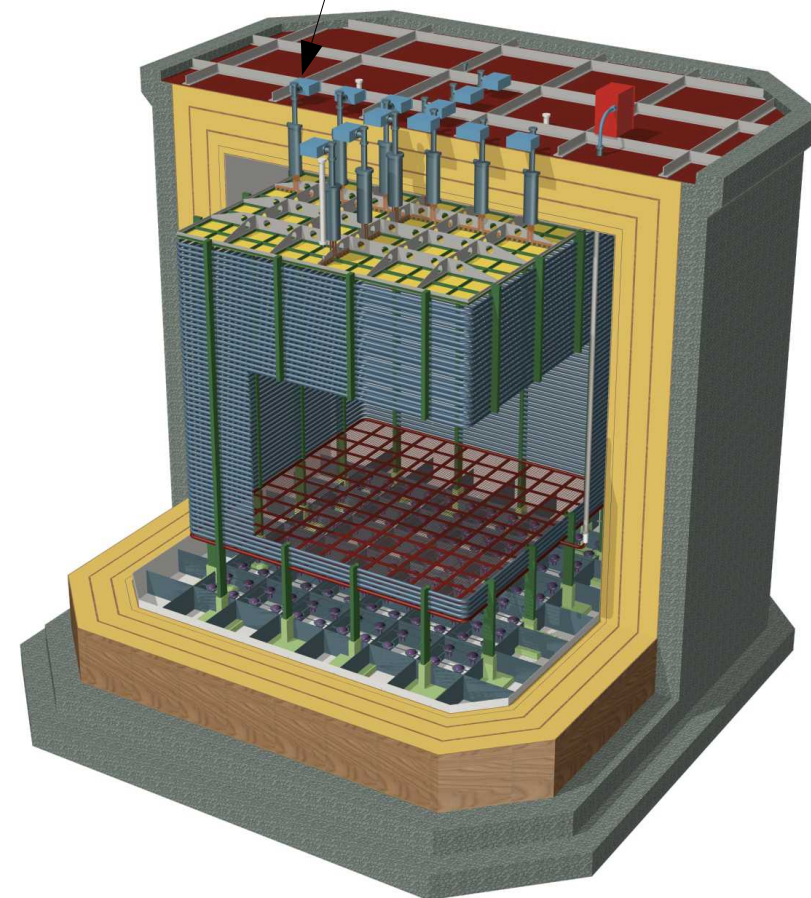


$\mu$ TCA.1 option

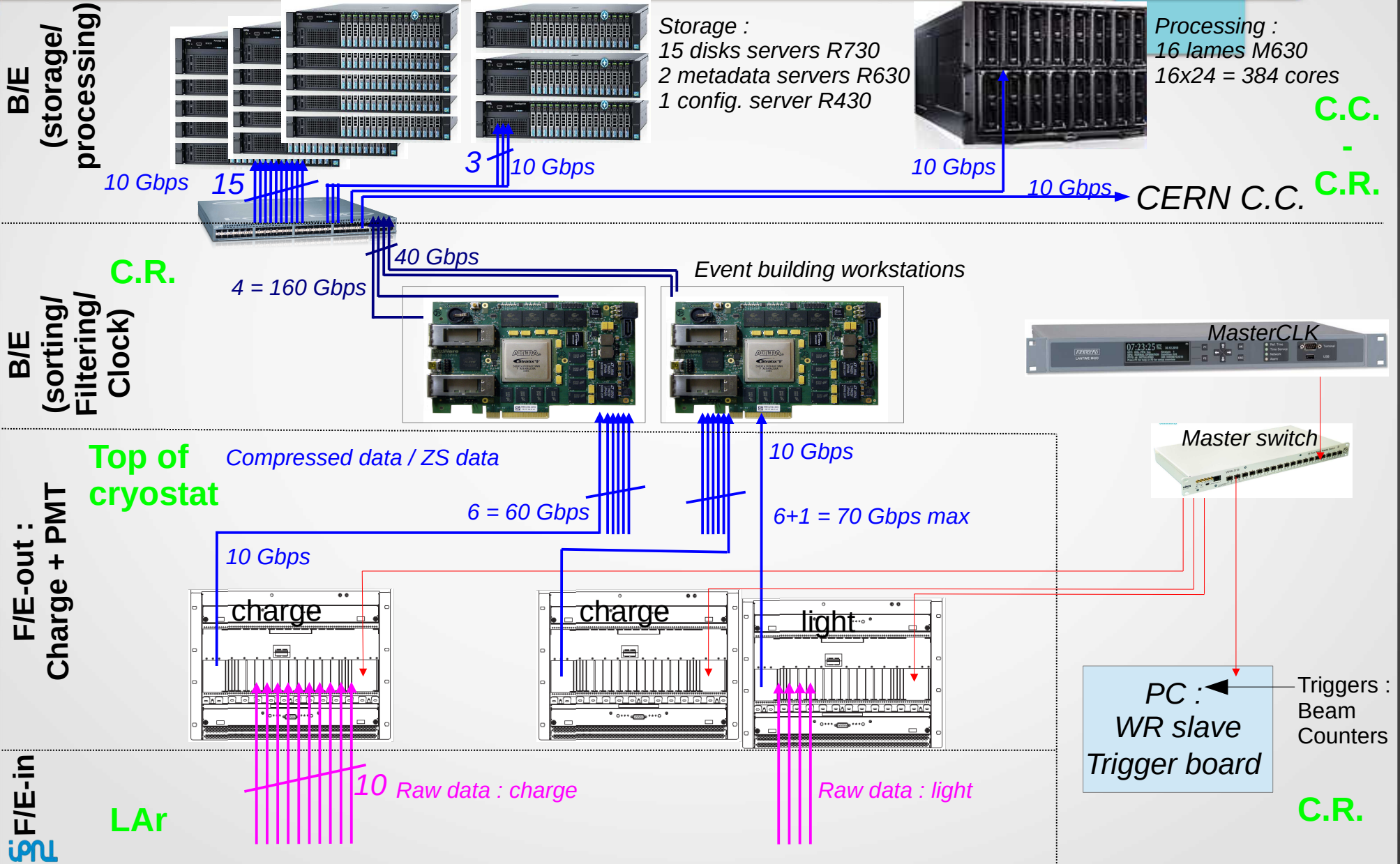


E.B.2

2 x 40 Gb/s



# WA105 data network



# WA105 power estimate

ITEM	CONSUMPTION	# of UNITS	TOTAL (kW)
• F/E-inside	• 20W / 640 ch.	12	0.24
• F/E- $\mu$ TCA crate	• 0.6kW max.	12	7.2
<b>TOTAL F/E</b>			<b>7.44 kW</b>
• B/E card + PC	• 0.5 kW max.	2	1.0
• Switch (10/40 GbE)	• 0.35 kW max.	1	0.35
• WR switch	• 0.3 kW typ.	1	0.3
• B/E storage	• 0.7 max./0.35 meas.	15	5.25
• B/E configuration	• 0.4 kW max.	3	1.2
• B/E online proc.	• 3 kW max.	1	3.0
<b>TOTAL B/E</b>			<b>11.1 kW</b>

To be adapted to DUNE scheme

Scalable for DUNE by a factor 20  
 $\rightarrow 20 \times 7.44 \approx \mathbf{150 \text{ kW for F/E}}$

– network architecture and computing facility will be very different in DUNE : no trigger from beam, lower data rate (WA105 = 100Hz), no cosmics, larger scale detector –

# WA105 B/E board

## Bittware S5-PCIe-HQ processing card : S5PHQ-

- FPGA

Altera® Stratix® V GX/GS FPGA

20 full-duplex, high-performance, multi-gigabit SerDes transceivers @ up to 14.1 GHz

Up to 952,000 logic elements (LEs) available

Up to 62 Mb of embedded memory

1.4 Gbps LVDS performance

Up to 3,926 18×18 variable-precision multipliers

Embedded HardCopy Blocks

- Memory

Two banks of up to 8 GBytes DDR3 SDRAM (x64)

Four banks of up to 18 MBytes QDRII+ (x18)

128 MBytes of Flash memory for booting FPGA

- PCIe Interface

x8 Gen1, Gen2, Gen3 direct to FPGA

- Debug Utility Header

RS-232 port to Stratix V

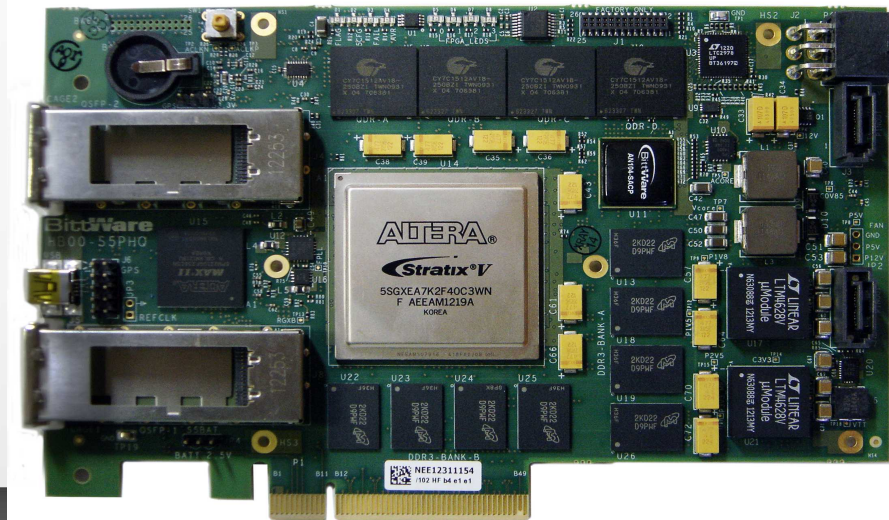
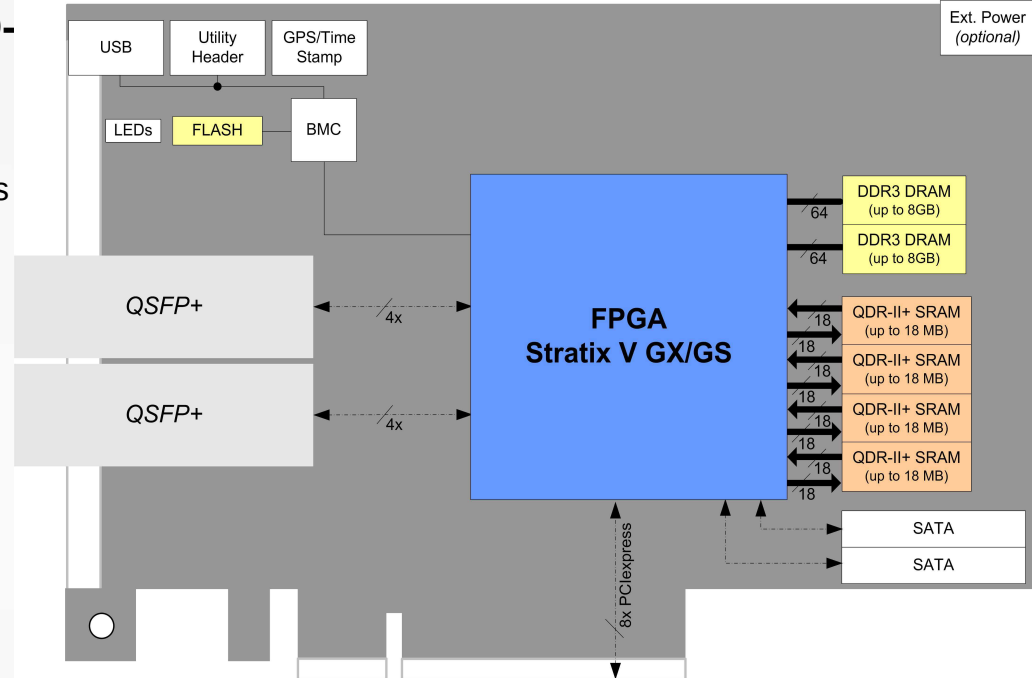
JTAG debug interface to Stratix V

- QSFP+ Cages

2 QSFP+ cages on front panel connected directly to FPGA via 8 SerDes (no external PHY)

Each supports 40 GigE or four 10 GigE interfaces

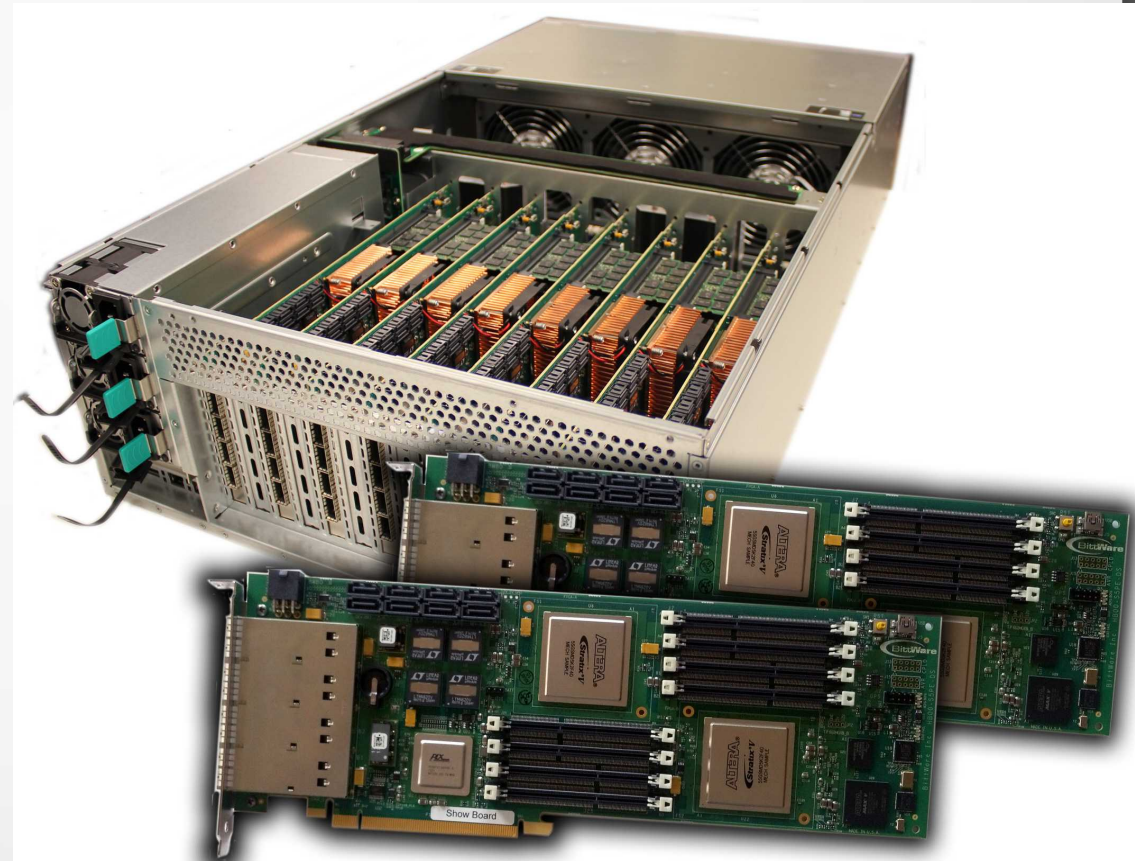
Can be optionally adapted for use as SFP+



# DUNE B/E board

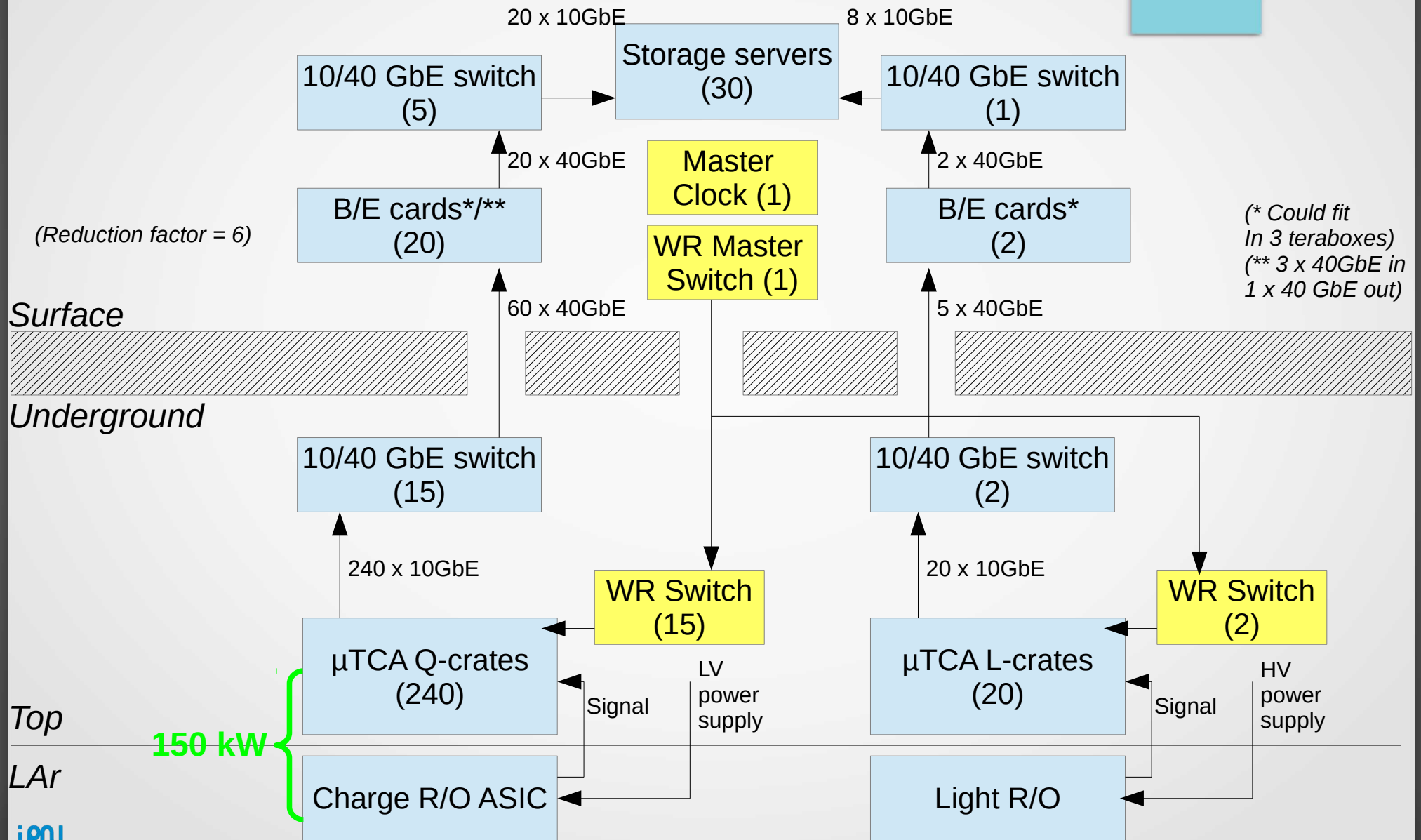
## Terabox

- 24 TeraFLOPS processing: 16x Altera Arria 10 or Stratix V FPGAs  
Up to 18 million logic elements (Arria 10 GX)  
Up to 62,000 multipliers (Stratix V GS)  
Dual card wrt WA105 cards  
New FPGA-board with Stratix X available by the time of DUNE
- 1.28 Terabits/sec I/O
- 128x 10GigE, 32x 40GigE, 32x 100 GigE,  
or 32x QDR Infiniband
- 6.5 Terabits/sec memory bandwidth  
Up to 64 banks DDR3-1600 (512 GBytes)  
DDR4, QDR-IV, QDRII+, and RLDRAM3 memory options
- 4U or 5U Rackmount PCIe system  
(server, industrial, or expansion)  
Dual socket Intel Ivy Bridge with up to 12 cores  
Up to 768 GBytes of system memory  
8 Gen3 x16 PCIe slots
- Complete software support  
Windows and Linux 64 drivers, interface libraries, and  
hardware management  
FPGA development kit for Arria 10 and Stratix V

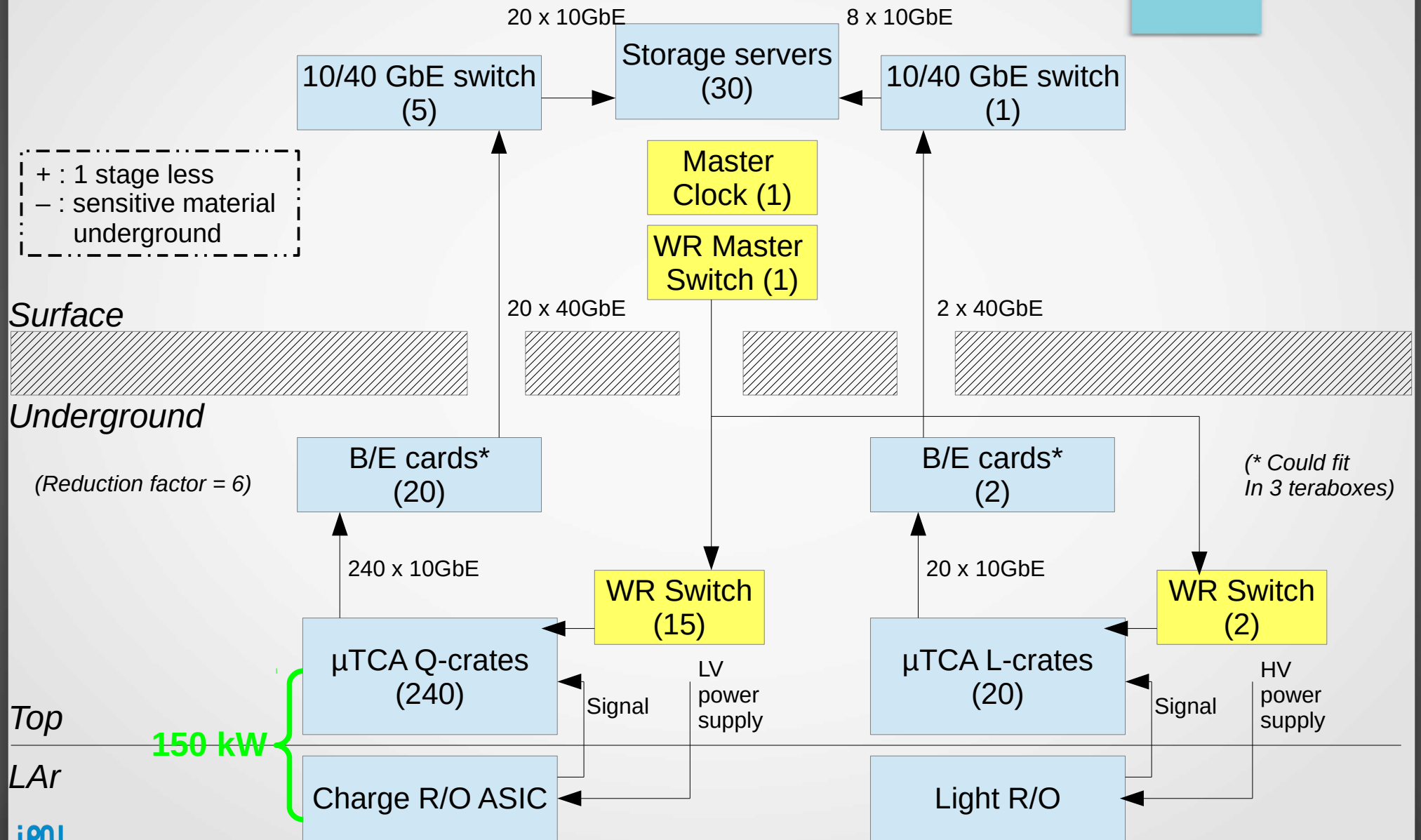




# DUNE proposed scheme - I



# DUNE proposed scheme - II



# Power estimate

ITEM	CONSUMPTION	# of UNITS		TOTAL (kW)	
<b>TOTAL F/E</b>				<b>150 kW</b>	
• B/E cards (terabox)	• 1.5 kW max.	3		4.5	
• Switch (10/40 GbE)	• 0.35 kW max.	23	6	8	2.1
• WR switch	• 0.3 kW typ.	18		5.4	
• B/E storage	• 0.7 max. / 0.35 meas.	30		10.5	
• B/E configuration	• 0.4 kW max.	6		2.4	
• B/E online proc.	• 3 kW max.	2		6.0	
<b>TOTAL B/E</b>				<b>36.8 (I)</b>	<b>30.9 (II)</b>

Underground.vs.surface :

- Scheme I :  $(150+17 \times 0.35+17 \times 0.3)$ .vs. $(4.5+6 \times 0.35+1 \times 0.3+18.9) = \mathbf{161}$ .vs. $\mathbf{25.8}$
- Scheme II :  $(150+4.5+17 \times 0.3)$ .vs. $(6 \times 0.35+1 \times 0.3+18.9) = \mathbf{159.6}$ .vs. $\mathbf{21.3}$

**In any case, most of the power, 160kW, goes underground for the F/E.**

# Comments

- Network architecture may be simplified with 100GbE standards which will be available for DUNE. The number of switches here is very conservative and will be reduced by a large factor. e.g. CISCO NEXUS series 7700 & 9500 chassis :

	Nexus 9504 Switch	Nexus 9508 Switch	Nexus 9516 Switch
- Form factor	7 RU	13 RU	21 RU
- Bandwidth per slot (Tbps)	3.84	3.84	3.84
- Bandwidth per system (Tbps)	15	30	60
- Max number of 10 GE ports	576	1152	2304
- Max number of 40 GE ports	144	288	576
- Max number of 100GE ports	32	64	128

- Position of the WR Master Switch may be moved underground if GPS timing is available there.
- Estimate of the F/E power is at the limit, very conservative as well.
- The online processing is still the most uncertain part.
- The total power consumption is estimated below 200kW for the double phase option, 80 % of which go underground.