NCC, Status and Trigger Capability

- Detector layout
- Event size
- Readout of stripixel sensors
- <u>Readout of calorimeter towers</u>
- <u>L1 trigger capability</u>

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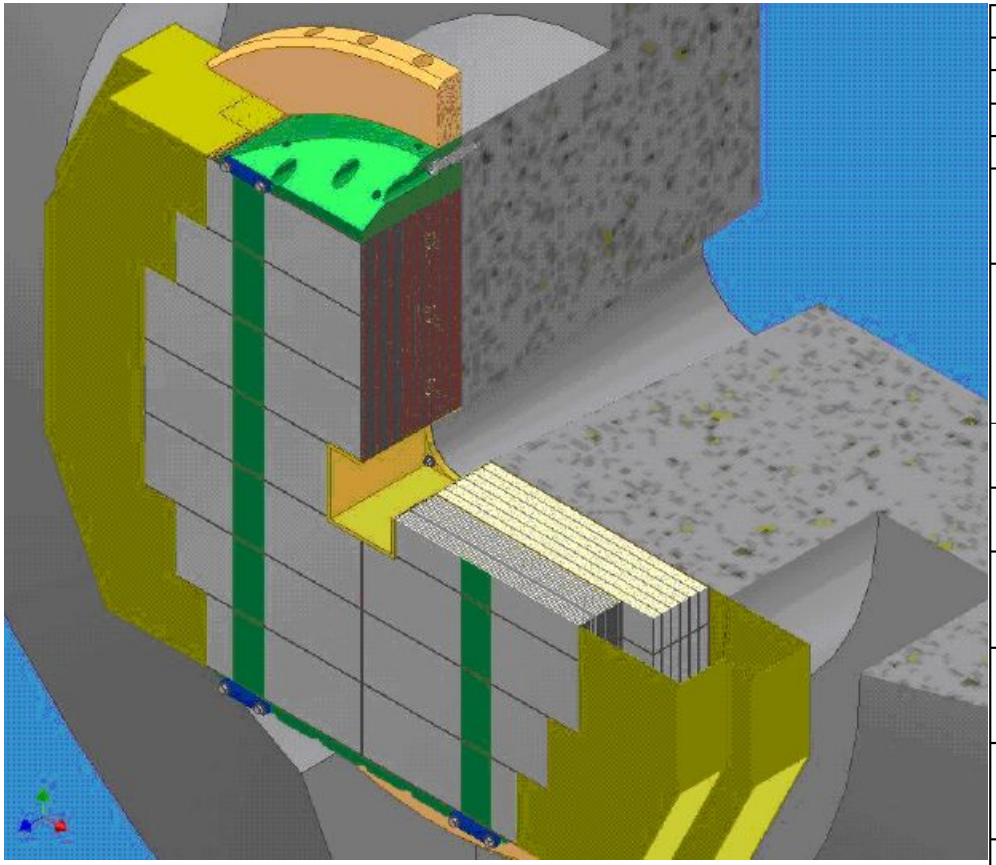
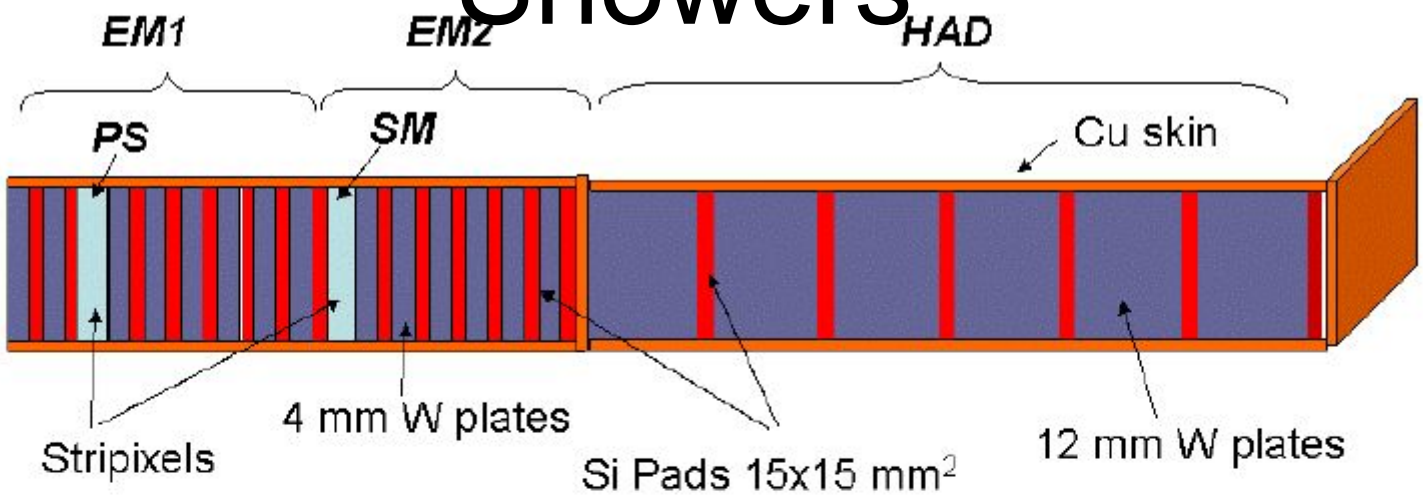
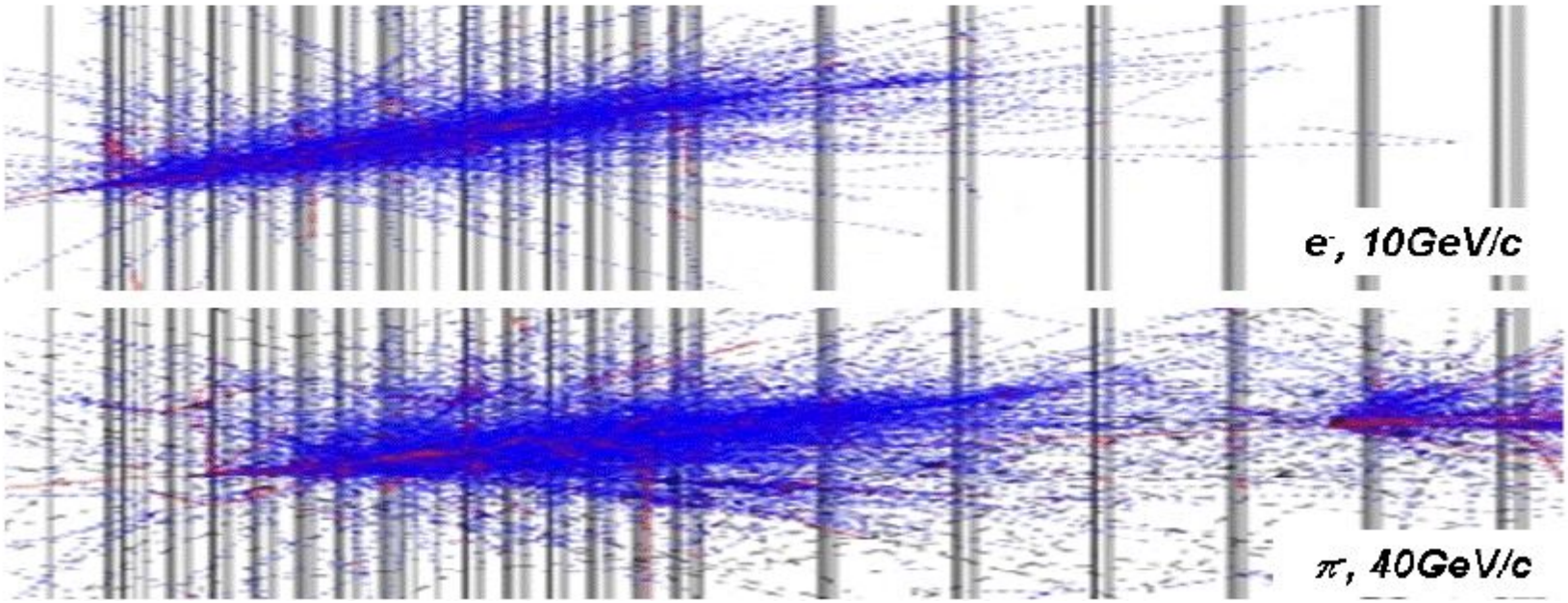
NCC



Parameter		Value	Comment
Distance from collision vertex		41 cm	
Radial coverage		50 cm	
Geometrical depth		$\sim$ 19 cm	
Absorber		W	42 X_0 or 1.6 L_{abs}
Readout		Si pads (15x15 mm^2) and pixilated strips (0.5x0.5 mm pixels grouped into 60 mm long strips)	
Calorimeter		EM1 and EM2 (14 sampling cells: 4mm W + 2.5 mm readout) longitudinally structured into two identical non-projective sections. HAD (6 sampling cells: 12 mm W + 2.5 mm readout)	
Preshower detector (PS)		StriPixel layer downstream of the first two EM sampling cells	
Shower max detector (SM)		StriPixel layer downstream of the first 9 EM sampling cells	
Sensors		calorimeter	3320 (14 x 160 + 6 x 180)
		PS and SM detectors	320 (2 x 160)
Channel count		calorimeter	8000
		PS and SM detectors	81920 (672 SVX4 chips)
Multiple scattering in NCC combined with Fe magnet pole		133 MeV	To compare with 106 MeV in the existing configuration with Cu NoseCone
Expected EM energy resolution		$23\%/\sqrt{E}$	
Expected jet energy resolution		$45\%/\sqrt{E}$	
Two showers resolved at	in calorimeter	3 cm	
	in preshower	2 mm	
	in shower max.	4 mm	

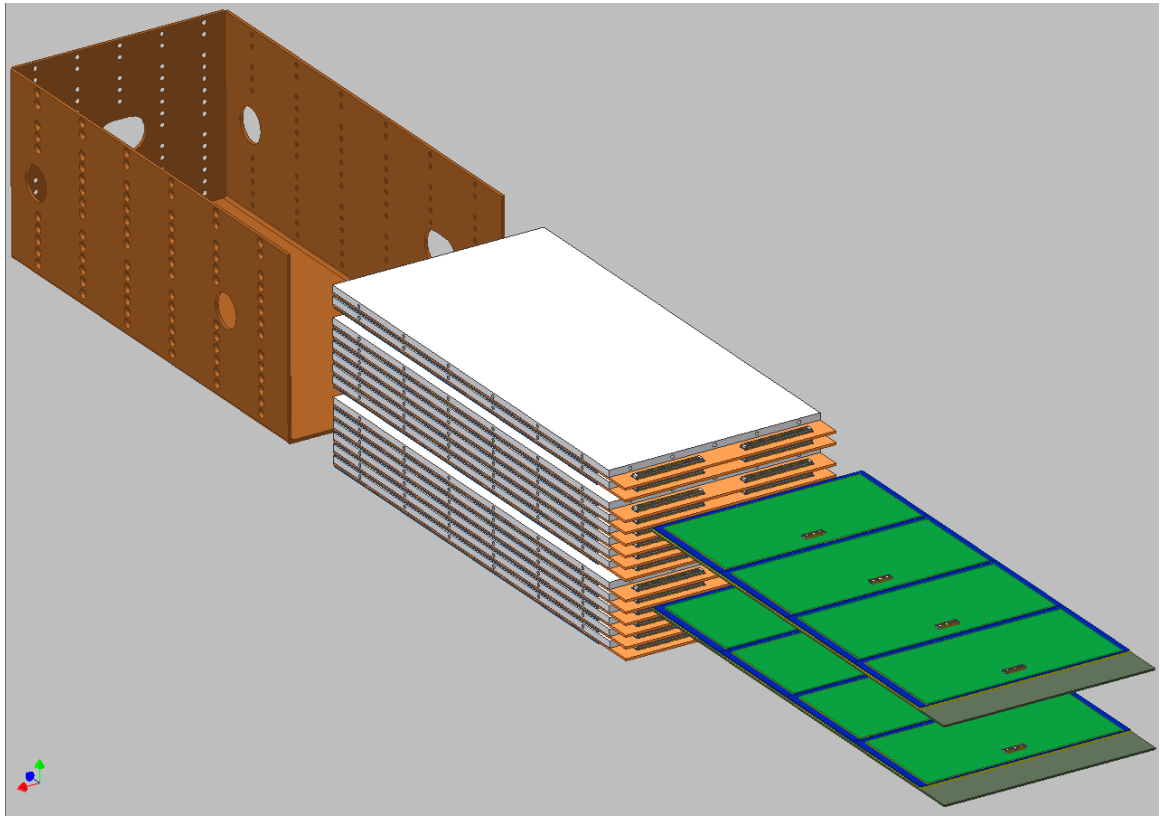
Showers

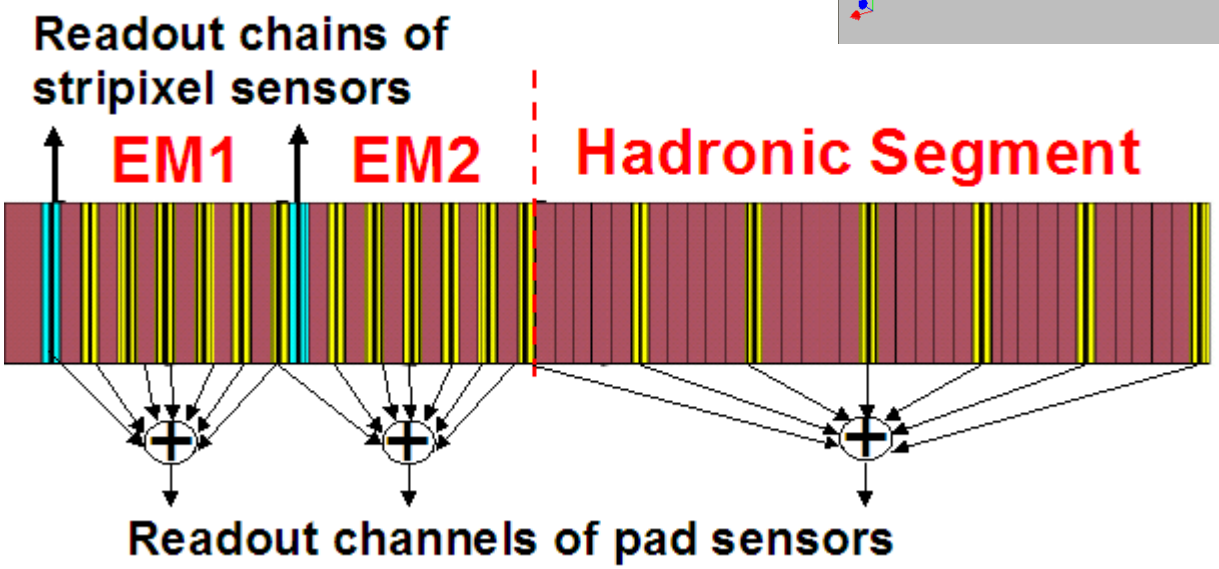




Shown in the bottom panel are electromagnetic and hadronic showers due to a 10 GeV/c electron and 40 GeV/c charged pion

Electromagnetic Brick





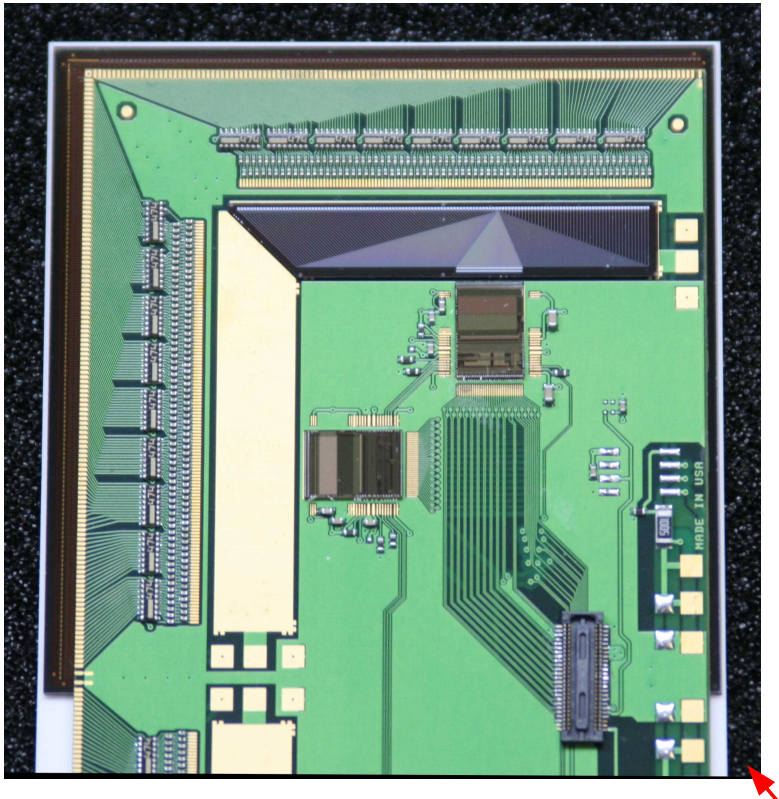
Data Sizes

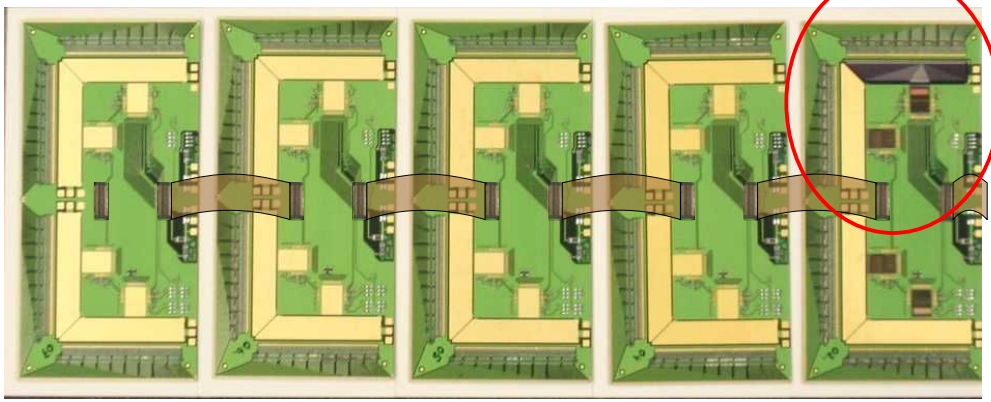
Assumed occupancy = 10%

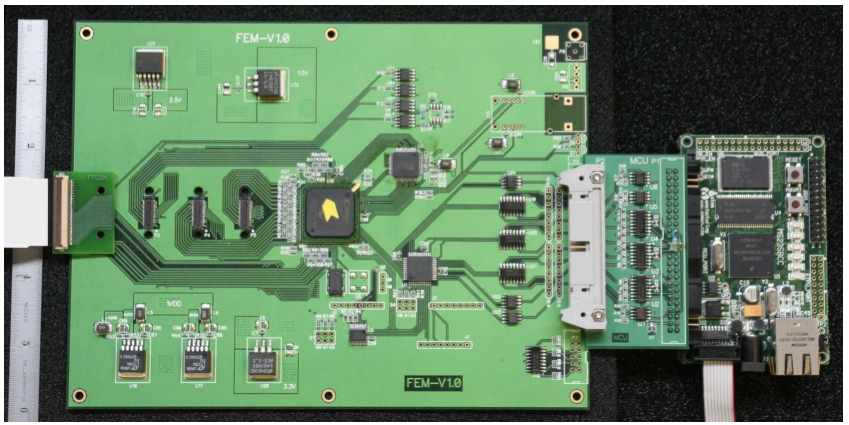
Stripixel sensors	
Number of channels	81920
Raw event size	1311 KB
Zero suppressed	131 KB
ZS+compressed	44 KB

Pad sensors	
Number of channels	8000
Raw event size	16 KB
Zero suppressed	1.6 KB

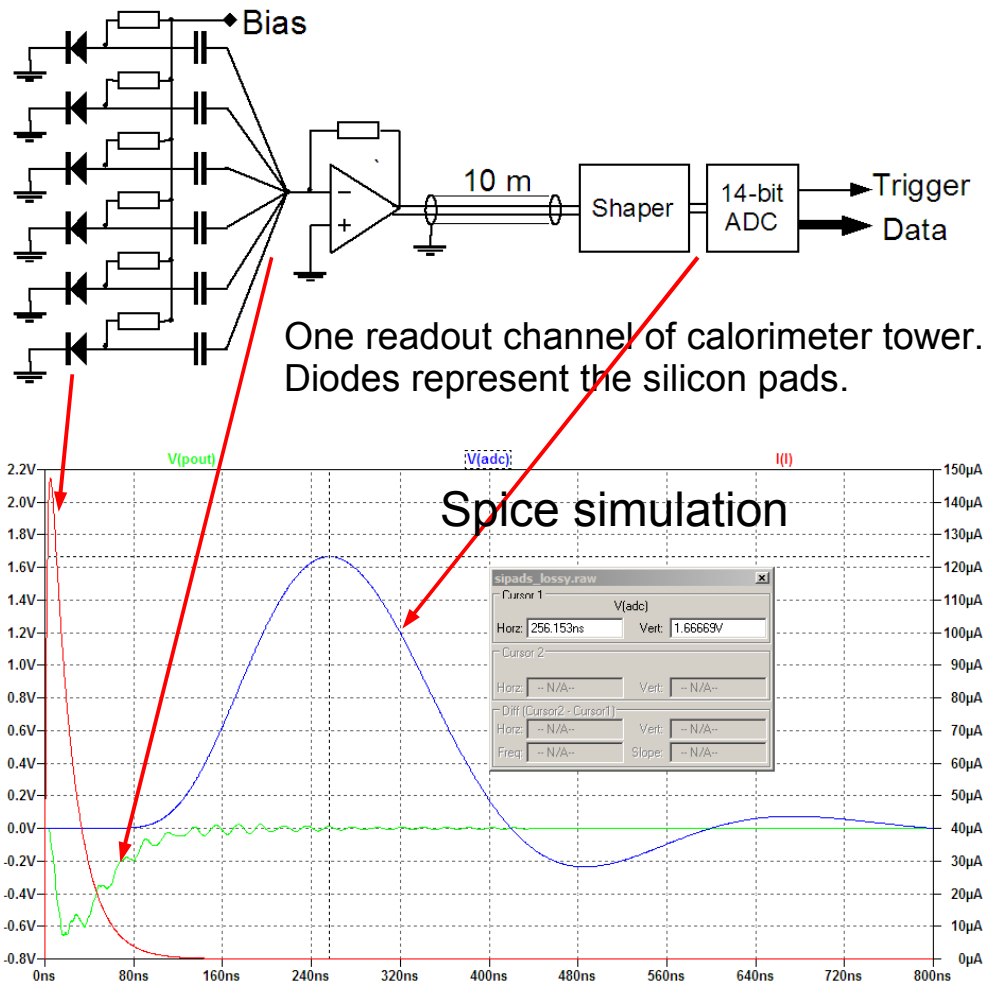
Readout of Stripixel Sensors







Readout of Pad Sensors



ADC clock 25 MHz,
Digitization time = Shaping time + ADC latency
= 400ns + 8*40ns = 720 ns

Trigger Primitives

- Shower: 4x4 tower overlapping trigger tiles, fully contain high pT electromagnetic showers

- Jet: 8x8 tower overlapping tiles, good match the the width of a jet of hadrons

- Segment energy: Used to separate electromagnetic from hadronic showers. If HAD/(EM1 + EM2) < 1 then shower is electromagnetic.

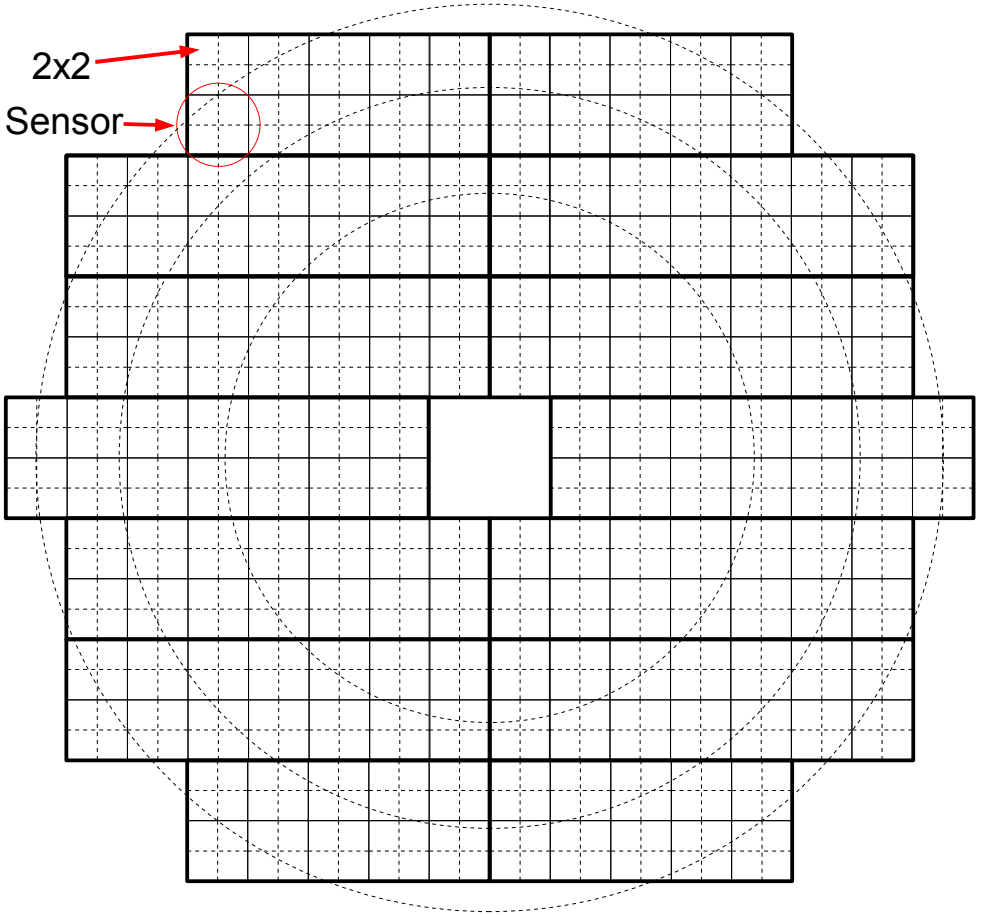
Bit Count

Global parameters			
Bunch Crossing Period	100	ns	1.0E-7
2x2 Word Legth	8	bit	
Max Serial Bitrate	2.5	Gbit/s	2.5E+9
Max Parallel Clock	80	MHz	8.0E+7
Occupancy	10%		

Channel Counts	EM1	EM2	Hadron	Total
Number of layers	7	7	6	
Number of sensor stacks	160	160	180	500
Number of towers	2560	2560	2880	8000
Number of ADCs	40	40	45	125
Number of 8x8	40	40	45	125
Number of 4x4	160	160	180	500
Number of 2x2	640	640	720	2000
Number of overlapping 4x4	640	640	720	2000

Bitrate requirements				
Number of bits per trigger	5120	5120	5760	16000
Bitrate [Gb/s]	51.2	51.2	57.6	160

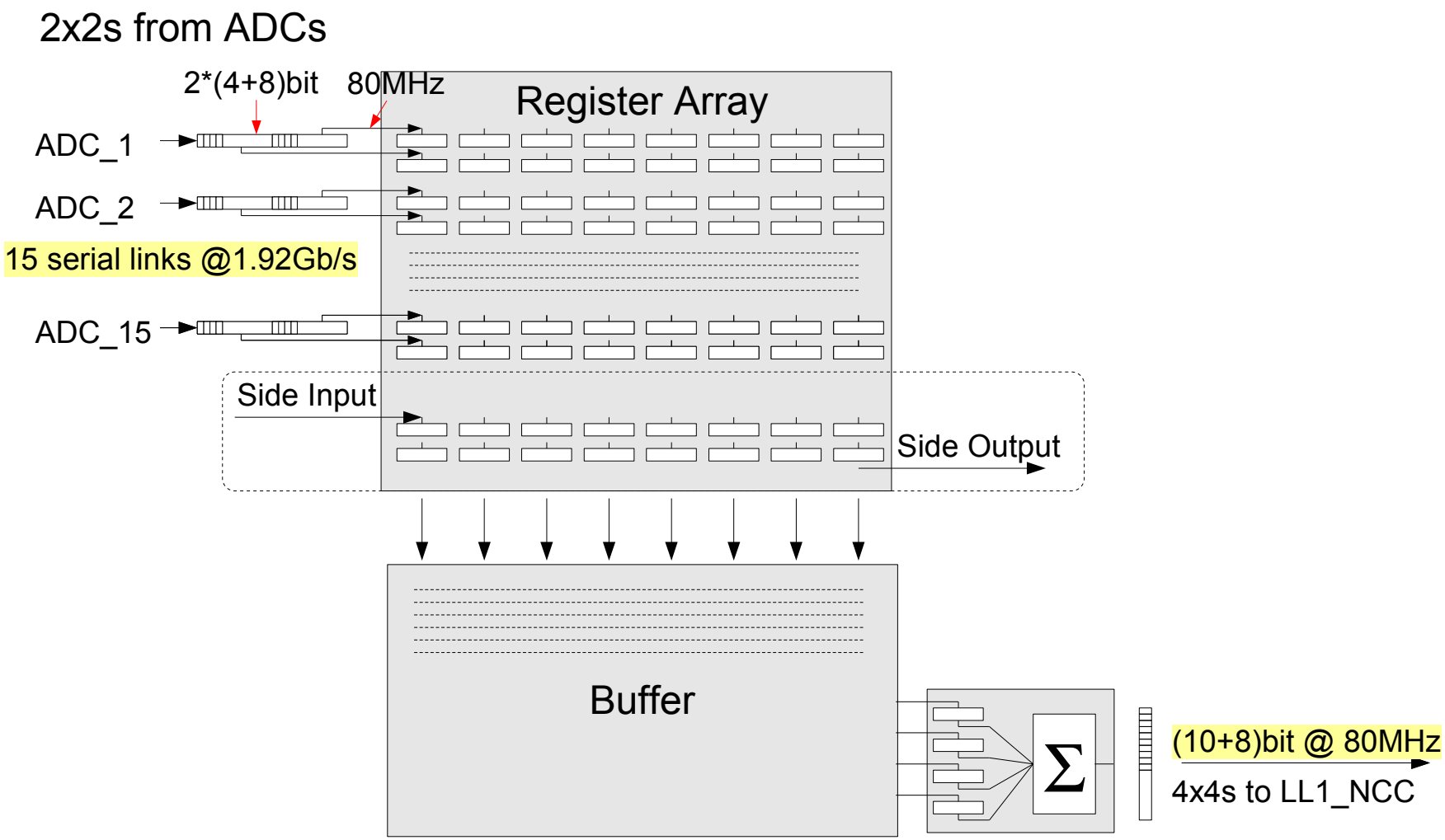
Deserializer	
Address+data length	12
Number of bits per trigger	192
Min input link bitrate [Gb/s]	1.92
Number of parallel bits	16



Hadronic Segment

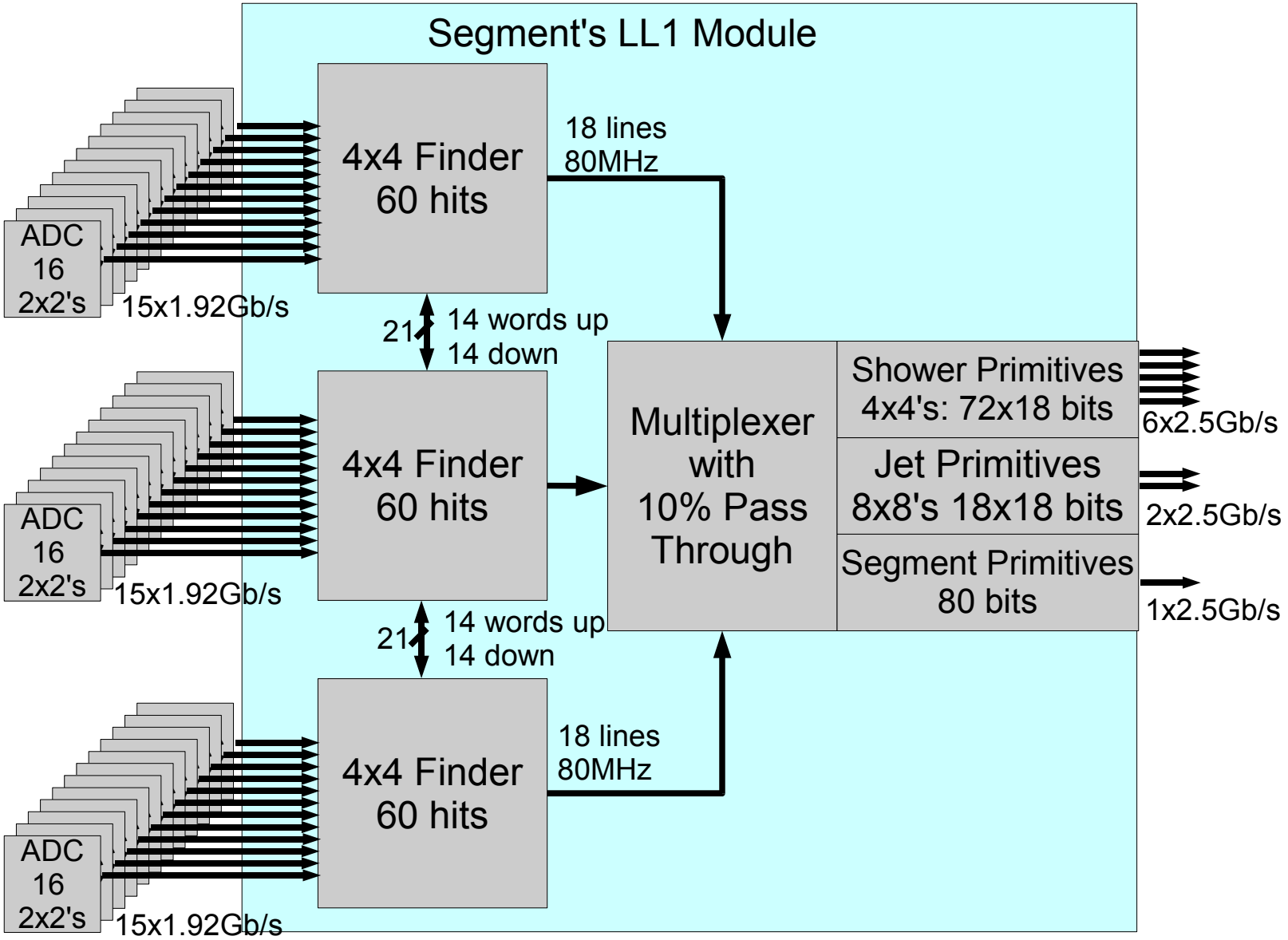
Algorithm for Overlapped 4x4s

ADC provides zero-suppressed data: 4bit address and 8bit data

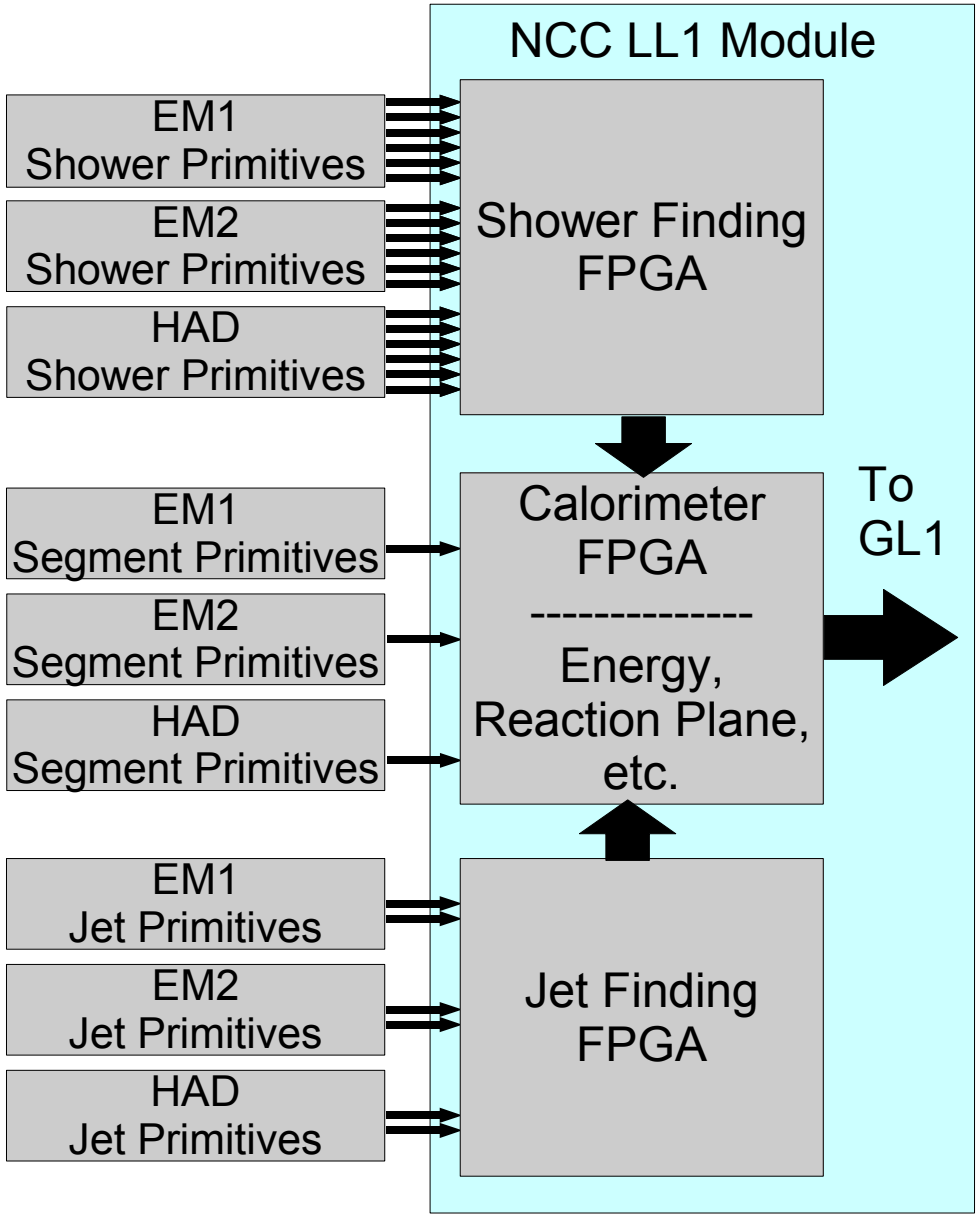


Processing time = 1+1/8 beam clocks.

Segment's LL1 Module

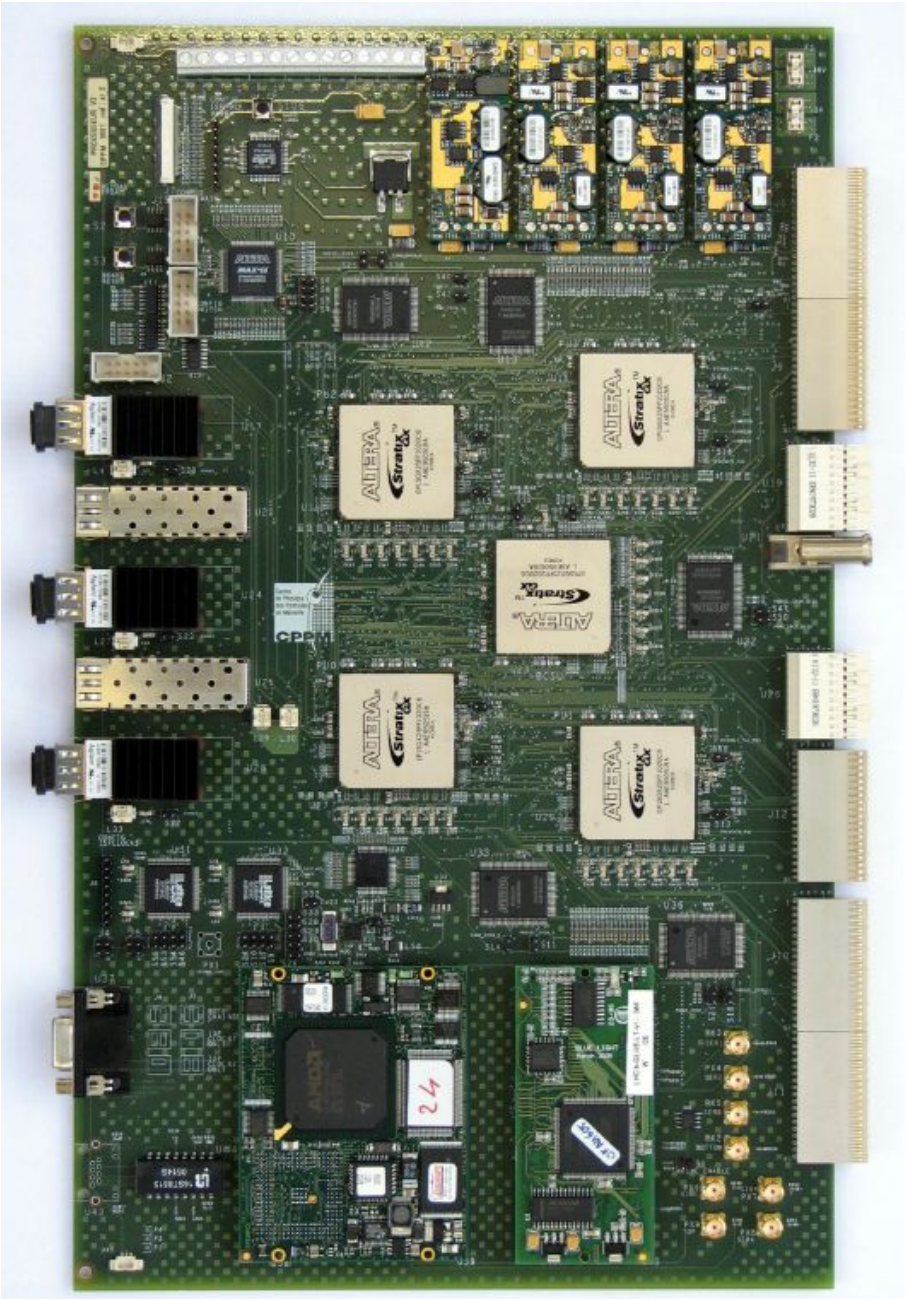


NCC LL1 Module



Is it Doable?

Example: LHCb L1 Trigger Processing Unit:



have all necessary functionality for segment LL1

- 9U board (366.7mm x 220mm)
- 18 layers
- 92 differential signals @1.6Gbps
- 5 StratixGX EP1SGX25FF1020-C6
- 1512 components
- Consumption < 60W

Summary

Digital signals from NCC calorimeter towers are available 8 beam clocks after interaction.

After 8+2=10 clocks after interaction we are able to get:

- Non-overlapping 2x2s
- Overlapping 4x4s
- Overlapping 8x8s
- Segment (EM1, EM2, HAD) energies