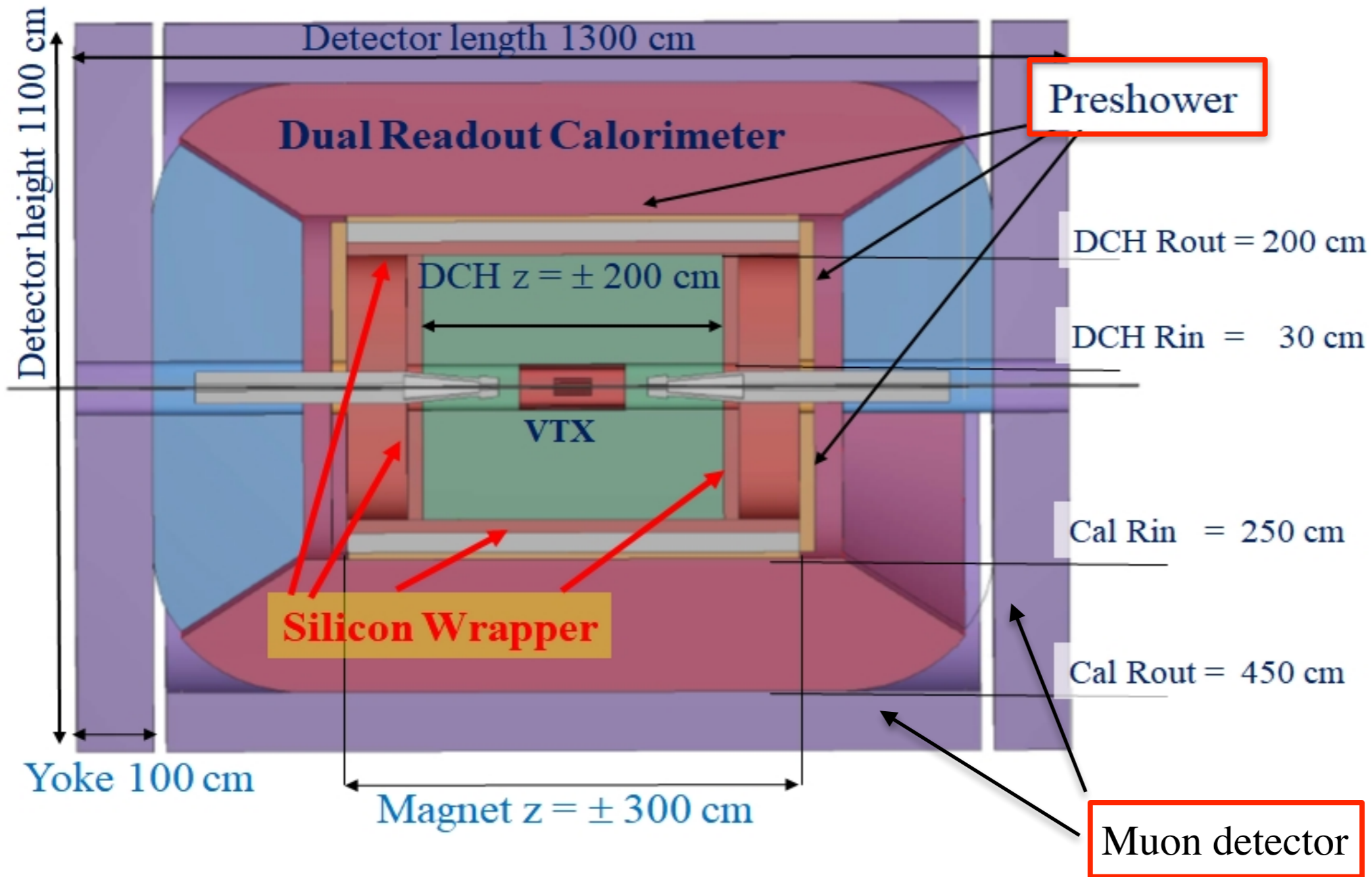


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TDAQ requests of μ RWELL-based IDEA subdetectors

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IDEA detector layout



Preshower and the muon detection system are designed with the μ RWELL technology

IDEA Muon detector dimensions

Barrel

Layer	R [mm]	Length [mm]	Thickness [mm]	int. length	pixel size [mm]	area [cm ²]	# of channels
μRwell	4520	±4500	20		1.5×500	2.6M	341K
iron	4560	±4500	300	1.5			
μRwell	4880	±4500	20		1.5×500	2.8M	368K
iron	4920	±4500	300	1.5			
μRwell	5240	±5260	20		1.5×500	3.5M	462K

Endcap

Disk	R _{in} [mm]	R _{out} [mm]	z [mm]	Thickness [mm]	int. length	pixel size [mm]	area [cm ²]	# of channels
μRwell	454	5220	±4520	20		1.5×500	1.7M	227K
iron	454	5220	±4560	300	1.5			
μRwell	454	5220	±4880	20		1.5×500	1.7M	227K
iron	454	5220	±4920	300	1.5			
μRwell	454	5220	±5240	20		1.5×500	1.7M	227K

50x50 cm²
strips 50 cm
pitch 1.5 mm

IDEA's Muon detector would have in total:

Barrel 900x2 m² (1800 m² total)

Barrel 1200000x2 channels

Endcaps 500x2 m² (1000 m² total)

Endcaps 680000x2 channels

~ 4 M channels in total

Reducing strip pitch for the muon detector

R&D finalised to the construction of μ RWELL for IDEA with a basic μ RWELL module of 50x50 cm² with these characteristics:

- Pre-shower
 - **Strip pitch 0.4 mm, strip length 50 cm**
- Muon detector
 - **Strip pitch 1 mm, strip length 50 cm**
 - pitch reduced from 1.5 mm originally proposed, this would be possible only with a reduction of the electronics cost/channel

~ 6 M channels in total

We are proposing to equip a few μ RWELL prototypes with the TIGER, a custom-made ASIC developed for GEM readout. μ RWELLS have a similar output signal to GEMs, therefore the TIGER should be able to read also a μ RWELL detector. With a custom-made ASIC we could hope to reduce the front-end electronics cost to something like **1 euro/channel** (in comparison APV electronics has a typical cost of ~10-15 euro/channel)

Muon detector cost

	Cost [Meuro]	Engineers [years]	Technicians [years]	Operators [years]
Detectors	4,9	0,4	1,0	0,0
Installation	0,7	0,6	2,8	2,9
Electronics	12,3	0,3	1,5	0,0
HV/LV Systems	0,7	0,2	1,4	0,0
Gas System	0,3	0,2	1,3	0,0
TOTAL	18,9	1,7	7,9	2,9

Assumed 3 euro/channel

Assuming the following manpower costs:

Engineer	80 euro/hour
Technician	40 euro/hour
Operator	30 euro/hour

36 hours/week * 48 week/year = 1728 hours/year

	Cost [Meuro]
Detectors	4,9
Installation	0,7
Electronics	12,3
HV/LV Systems	0,7
Gas System	0,3
TOTAL	18,9

Electronics is by far the dominant cost



Assuming 300 MEuro as the cost of a FCC-ee or CEPC detector, the Muon detector would be ~ 7% of the total

Running conditions

- **91 GeV** c.m. energy
- **100 KHz** Z decays ($L \sim 2.5 \times 10^{36} \text{ cm}^{-2}\text{s}^{-1}$)
 - **3300 Hz** Z- $\rightarrow \mu^+\mu^-$ decays

Muon detector

- **3 stations**
- Cluster width ~ 5 strips
- 64 channels \rightarrow 1 TIGER
- 2 TIGER (128 channels) \rightarrow 1 Frontend board (FEB)
- 4 FEBs (512 channels) \rightarrow 1 GEMROC
- For each event a GEM ROC sends **one packet of data**

Muon detector

- Each GEMROC packet contains:
 - 272 bits for IP and UDP protocols
 - 193 bits for header and trailer
 - 64 bits for each hit
- For a track traversing all 3 stations of the muon detector:
 - $1 \text{ (track)} \times 3 \text{ (stations)} \times 2 \text{ (XY)} \times 5 \text{ (strips)} \times 64 \text{ bit/strip} + 193 + 272 =$
2385 bits
 - Considering a rate of 3.3 KHz of $Z \rightarrow \mu^+\mu^-$ events:
 - $2385 \times 3300 \times 2 \text{ (}\mu \text{ tracks)} = \sim 16 \text{ Mbits/s} =$ **2 MBytes/s**
- From experience with the TIGER chips:
 - Expect an electronic noise of $\sim 5 \text{ KHz}$
 - $1 \text{ (strip)} \times 64 \text{ bit/strip} + 193 + 272 = 529 \text{ bits}$
 - $529 \times 5 \text{ KHz} = \sim 2.6 \text{ Mbit/s} =$ **$\sim 0.3 \text{ Mbytes/s}$**
- We estimate the muon detector data size to be **2.5 Mbytes/s**

IDEA Preshower detector dimensions

Barrel

R [mm]	Length [mm]	Thickness [mm]	pixel size [mm]	area [cm ²]	# of channels
2460	±2480	20	0.4×500	768K	384K

Endcap

R _{in} [mm]	R _{out} [mm]	z [mm]	Thickness [mm]	pixel size [mm]	area [cm ²]	# of channels
248	2440	±2460	20	0.4×500	370K	185K

50x50 cm²
strips 50 cm
pitch 0.4 mm

IDEA's Preshower detector would have in total:

Barrel 77x2 m² (154 m² total)

Barrel 384000x2 channels

Endcaps 37x2 m² (74 m² total)

Endcaps 185000x2 channels

Running conditions

- **91 GeV** c.m. energy
- **100 KHz** Z decays
 - Mean charged multiplicity **~20**
- **30 KHz** $\gamma\gamma \rightarrow$ hadrons
 - Mean charged multiplicity **~10**

Preshower detector

- **1 station**
- Cluster width **~5 strips**
- **64 channels** \rightarrow **1 TIGER**
- **2 TIGER** (128 channels) \rightarrow **1 Frontend board (FEB)**
- **4 FEBs** (512 channels) \rightarrow **1 GEMROC**
- For each event a GEM ROC sends **one packet of data**

Preshower detector

- Each GEMROC packet contains:
 - 272 bits for IP and UDP protocols
 - 193 bits for header and trailer
 - 64 bits for each hit
- For a track traversing the preshower detector:
 - $1 \text{ (track)} \times 2 \text{ (XY)} \times 5 \text{ (strips)} \times 64 \text{ bit/strip} + 193 + 272 = 1105 \text{ bits}$
- Considering a rate of 100 KHz (Z^0 events) x 20 charged particles:
 - $1105 \times 2 \times 10^6 \text{ (events)} = \sim 2 \text{ Gbits/s} = 250 \text{ MBytes/s}$
- Considering a rate of 30 KHz ($\gamma\gamma$ events) x 10 charged particles:
 - $1105 \times 3 \times 10^5 \text{ (events)} = \sim 300 \text{ Mbits/s} = 40 \text{ MBytes/s}$
- From experience with the TIGER chips:
 - Expect an electronic noise of $\sim 5 \text{ KHz}$
 - $1 \text{ (strip)} \times 64 \text{ bit/strip} + 193 + 272 = 529 \text{ bits}$
 - $529 \times 5 \text{ KHz} = \sim 2.6 \text{ Mbit/s} = \sim 0.3 \text{ Mbytes/s}$
- We estimate the preshower data size to be **300 Mbytes/s**

Estimated data sizes at the high lumi Z run

- **Preshower**
 - Number of channels: **~ 0.75 million**
 - Data size should be **300 MBytes/s**
 - Noise contribution negligible
- **Muon detector**
 - Number of channels: **~ 4 million** (could increase to **6.0 M**)
 - Data size should be **2.5 Mbytes/s**
 - Noise contribution **0.3 Mbytes/s**