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TDAQ requests of μRWELL-based IDEA subdetectors

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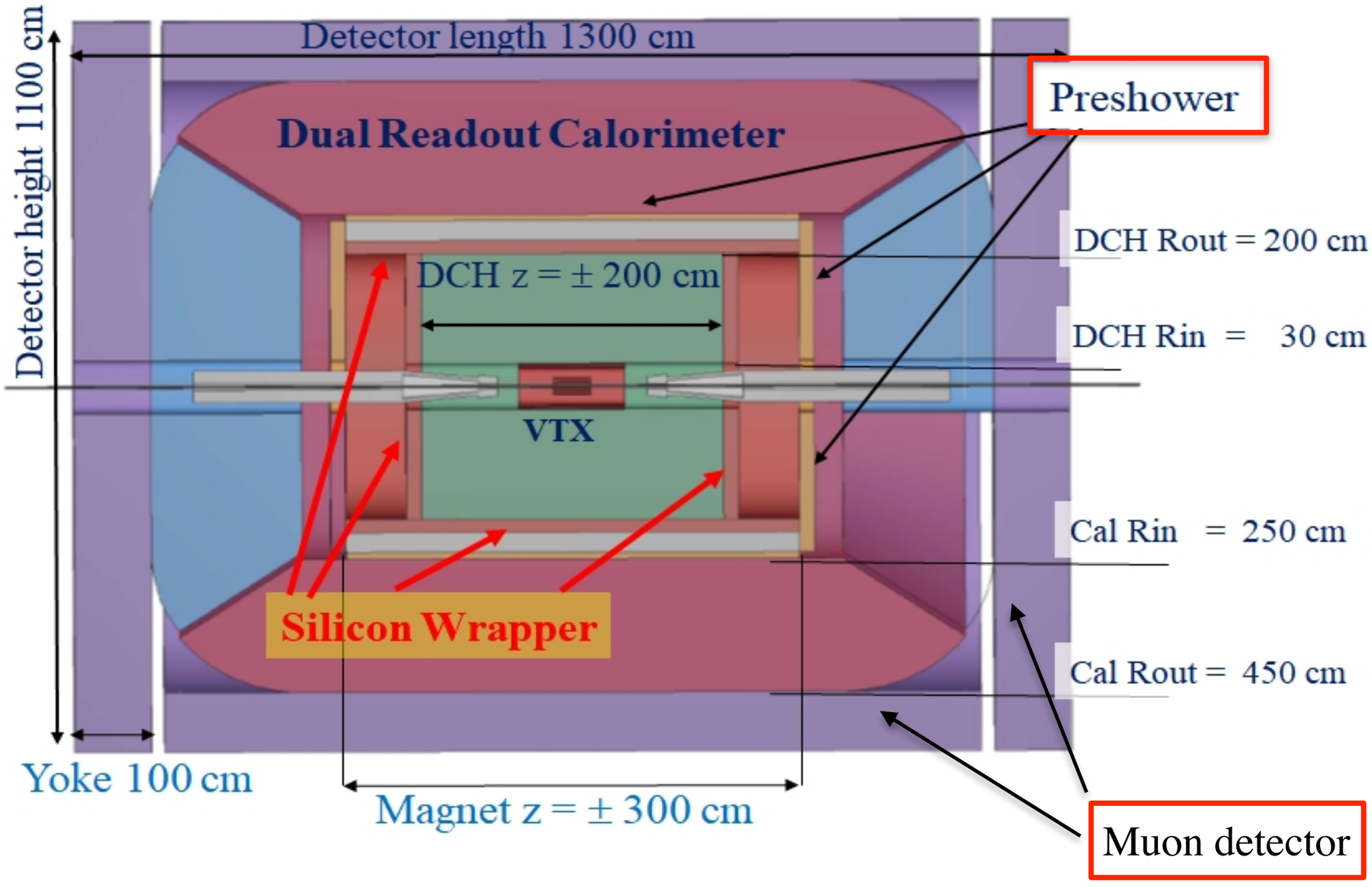
IDEA detector layout



Preshower and the muon detection system are designed with the μRWELL technology

IDEA Muon detector dimensions

Barrel

Layer	R [mm]	Length [mm]	Thickness [mm]	int. length	pixel size [mm]	area [cm²]	# 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

50x50 cm² strips 50 cm pitch 1.5 mm

Endcap

Disk	R_{in} [mm]	R_{out} [mm]	z [mm]	Thickness [mm]	int. length	pixel size [mm]	area [cm²]	# 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

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 μRWELL for IDEA with a basic μRWELL 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 μRWELL prototypes with the TIGER, a custom-made ASIC developed for BESIII CGEM-IT at BEPCII (IHEP). μRWELLs have a similar output signal to GEMs, therefore the TIGER should be able to read also a μRWELL 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

Electronics is by far the dominant cost

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

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

Muon detector datasize

Running conditions

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

Muon detector

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

Muon detector datasize

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 (track) x 3 (stations) x 2 (XY) x 5 (strips) x 64 bit/strip +193 + 272 = **2385 bits**
- Considering a rate of 3.3 KHz of Z-> $\mu^+\mu^-$ events:
  - 2385 x 3300 x 2 (μ tracks)= ~16 Mbits/s = **2 MBytes/s**
- From experience with the TIGER chips:
  - Expect an electronic noise of ~5 KHz
    - 1 (strip) x 64 bit/strip + 193 + 272 = 529 bits
    - 529 x 5 KHz = ~2.6 Mbit/s = **~0.3 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 cm^2

strips 50 cm

pitch 0.4 mm

IDEA's Preshower detector would have in total:

Barrel 77x2 m^2 (154 m^2 total)

Barrel 384000x2 channels

Endcaps 37x2 m^2 (74 m^2 total)

Endcaps 185000x2 channels

Preshower detector datasize

Running conditions

- **91 GeV** c.m. energy
- **100 KHz** Z decays
  - Mean charged multiplicity **~20**
- **30 KHz** γγ -> hadrons
  - Mean charged multiplicity **~10**

Preshower detector

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

Preshower detector datasize

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 (track) x 2 (XY) x 5 (strips) x 64 bit/strip +193 + 272 = **1105 bits**

- Considering a rate of 100 KHz (Z^0 events) x 20 charged particles:
  - 1105 x 2 x 10^6 (events) = ~2 Gbits/s = **250 MBytes/s**
- Considering a rate of 30 KHz (γγ events) x 10 charged particles:
  - 1105 x 3 x 10^5 (events) = ~300 Mbits/s = **40 MBytes/s**

- From experience with the TIGER chips:
  - Expect an electronic noise of ~5 KHz
    - 1 (strip) x 64 bit/strip + 193 + 272 = 529 bits
    - 529 x 5 KHz = ~2.6 Mbit/s = **~0.3 Mbytes/s**

- We estimate the preshower data size to be **300 Mbytes/s**

Summary

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**