RPC Option for Muon Detector

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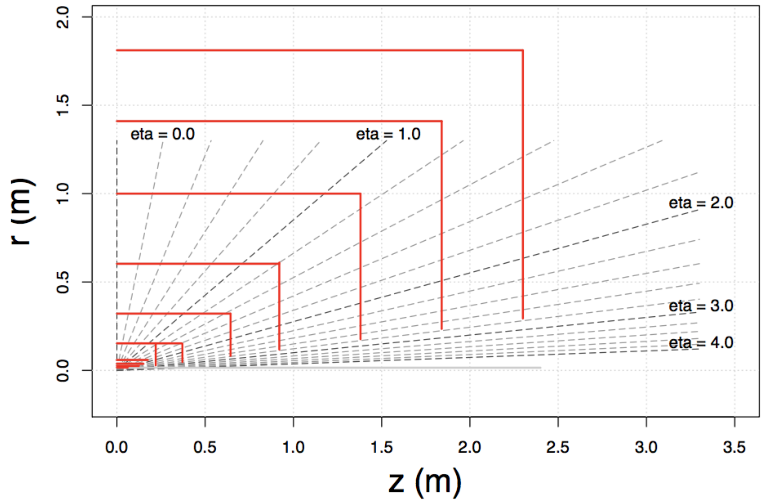
CEPC Detector Overview

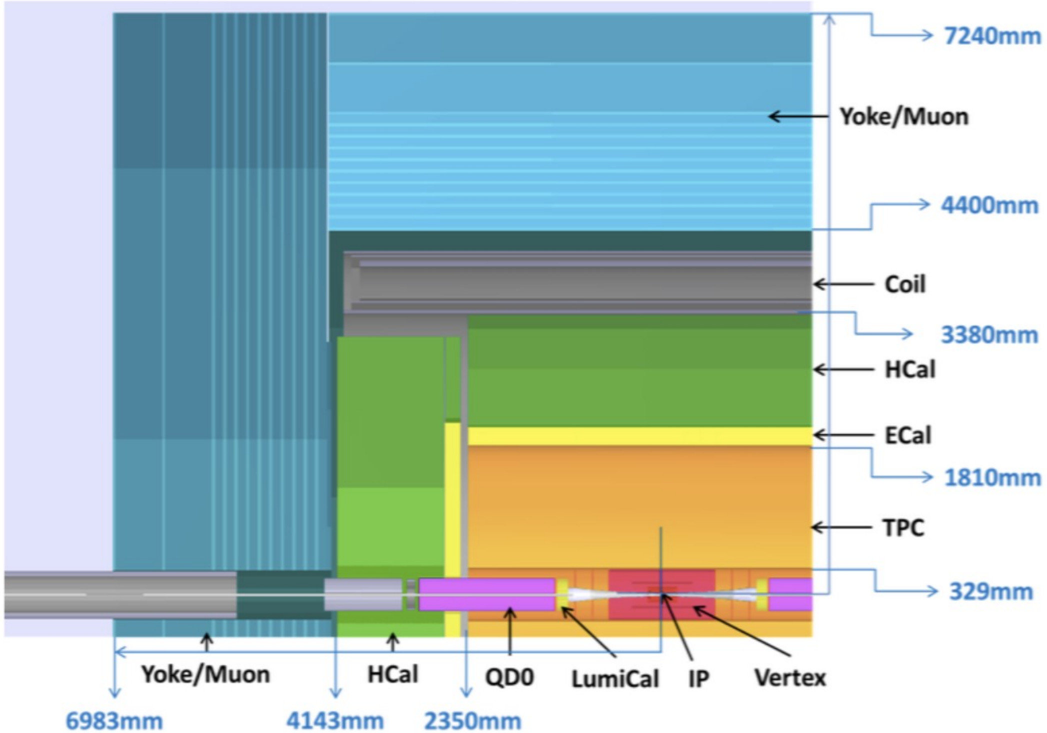
Baseline: ILD-like

- TPC tracking + Imaging calorimetry (ECAL+HCAL)
- PFA-oriented

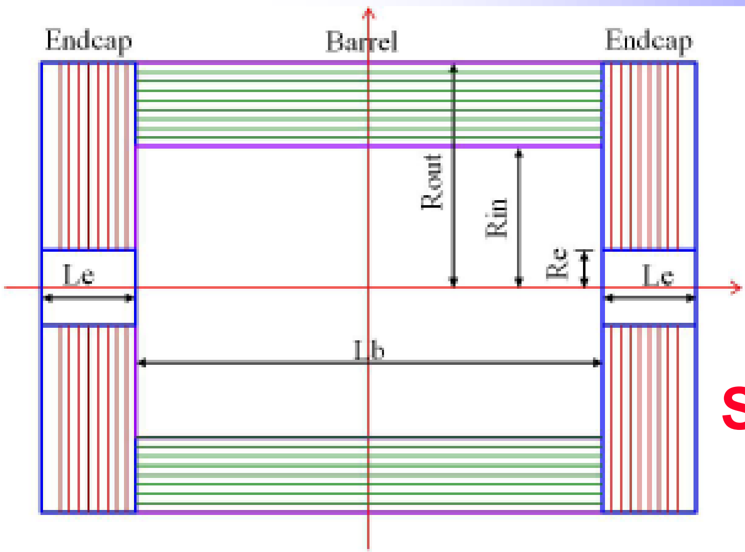
Alternatives

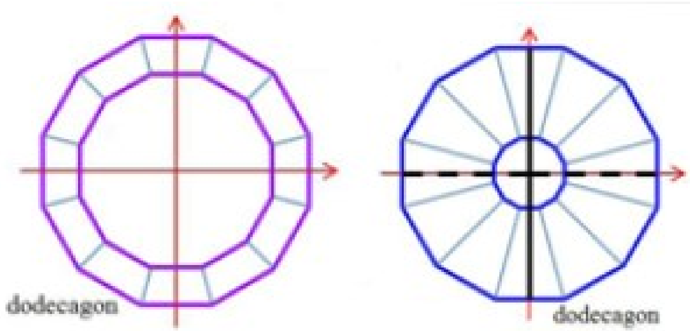
- Low-field concept
- Full-silicon concept

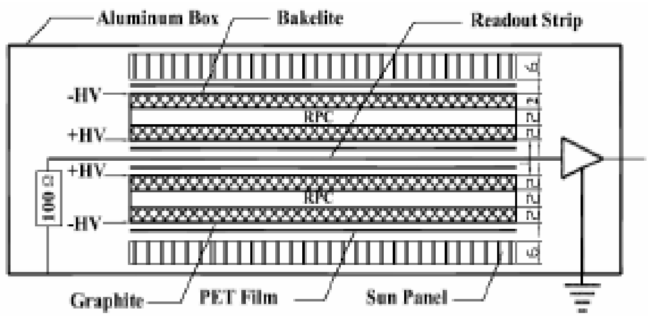




Muon Detector Overview







Structure:

- **Between magnet iron yoke, outside HCAL**
- **Cylindrical barrel & two endcap system**
- **Solid angle coverage: 0.98 * 4π**

Technology:

- **Bakelite/glass RPC as baseline**
- **Many other options considered**
  - ***μ*RWell**
  - **Micromegas, GEM**
  - **MDT, Scintillator Strip**

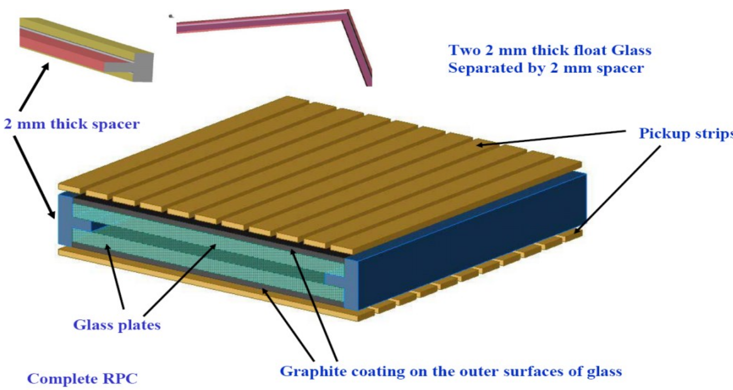
Baseline: RPC Option

Table 7.1: The baseline design parameters of the CEPC muon system

Parameter	Possible range	Baseline
Lb/2 [m]	3.6 – 5.6	4.0
Rin [m]	3.5 – 5.0	4.4
Rout [m]	5.5 – 7.2	7.0
Le [m]	2.0 – 3.0	2.6
Re [m]	0.6 – 1.0	0.8
Segmentation	8/10/12	12
Number of layers	6 – 10	8
Total thickness of iron	6 – 10λ ($\lambda = 16.77$ cm)	8λ (136 cm) (8/8/12/12/16/16/20/20/24) cm
Solid angle coverage	$(0.94 – 0.98) \times 4\pi$	0.98
Position resolution [cm]	$\sigma_{r\phi}$: 1.5 – 2.5	2
	σ_z : 1 – 2	1.5
Detection efficiency ($E_\mu > 5$ GeV)	92% – 99%	95%
Fake($\pi \to \mu$)@30GeV	0.5% – 3%	< 1%
Rate capability [Hz/cm^2]	50 – 100	∼60
Technology	RPC	RPC (super module, 1 layer readout, 2 layers of RPC)
	μRWell	
Total area [m^2]	Barrel	∼4450
	Endcap	∼4150
	Total	∼8660

Resistive Plate Chamber (RPC)

Parameters		Bakelite	Glass
Bulk resistivity [$\Omega \cdot$ cm]	Normal	$10^{10} \sim 10^{12}$	$> 10^{12}$
	Developing	$10^8 \sim 10^9$	
Max unit size (2 mm thick) [m]		1.2×2.4	1.0×1.2
Surface flatness [nm]		< 500	< 100
Density [g/cm^3]		1.36	2.4∼2.8
Min board thickness [mm]		1.0	0.2
Mechanical performance		Tough	Fragile
Rate capability [Hz/cm^2]	Streamer	100@92% [97]	
	Avalanche	10K	100@95% [98]
Noise rate [Hz/cm^2]	Streamer	< 0.8	0.05 [99]



- ✓ Low cost, easy construction
- ✓ Position resolution: 5-10 mm
- ✓ Time resolution: ~ 1 ns

Ongoing Studies

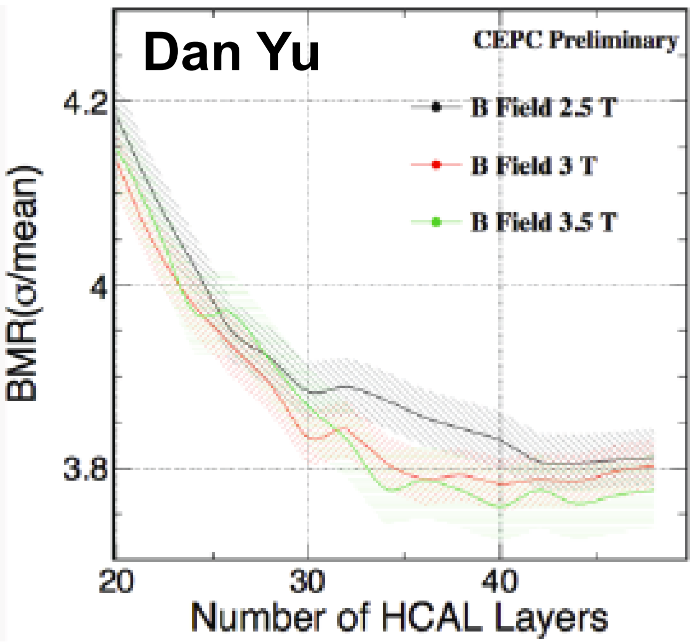
Muon system as an add-on

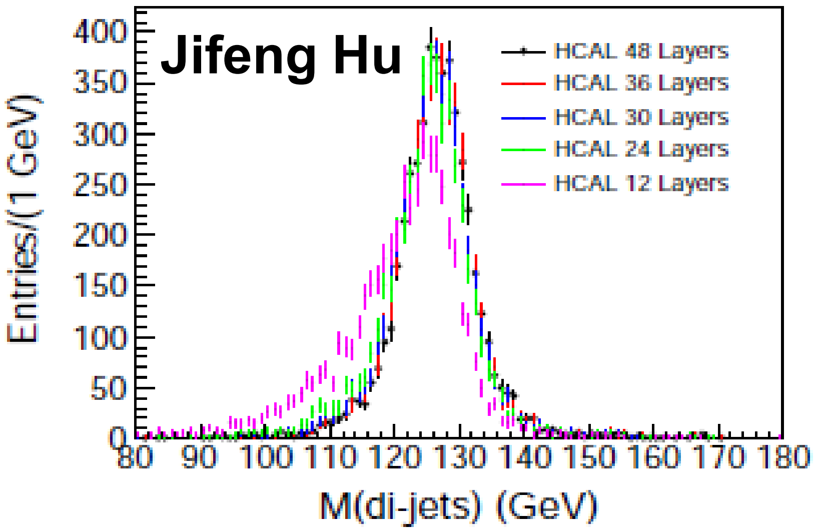
- Simulation study with built-in calorimeter / TCMT geometry, also integrated with yoke and magnet system
- Complementary to Calorimeter
  - Effect as a tail catcher / muon tracker (TCMT)
  - Simulation study suggest the level of improvement seems non significant, also depends on the energy deposited in the muon detector

Non-isolated muon efficiency

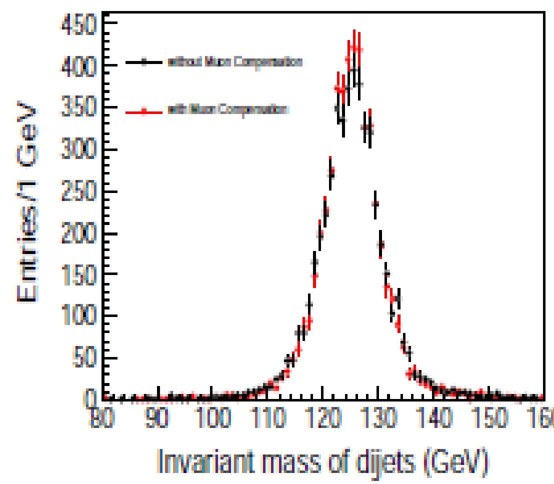
- Simulation study using LICH (PFA) muon ID algorithm
- Check muons inside jets
  - Preliminary study using ZH->bb simulation sample sees much lower efficiency than isolated case
  - Room for improvement: make PFA work in harsh environment?

Energy Compensation





Example: simulation study using ZH->vvgg sample



Jifeng Hu

HCAL outer layers unused
Optimized # of layer: 40

Mass resolution effect small
Energy compensation < 1GeV

Future R&D

- ✓ **Layout and geometry optimization using full simulation samples: detailed studies on the structure of the segments and modules. The geometry and dimensions need to be optimized together with the inner detectors, in particular the ECAL and the HCAL.**
- ✓ **Long-lived particles optimization: explore new physics scenario of long-lived particles and exotic decays.**
- ✓ **Gas detectors: study aging effects, improve long-term reliability and stability.**
- ✓ **All detectors: improve massive and large area production procedures and readout technologies.**