Muon Detector Status

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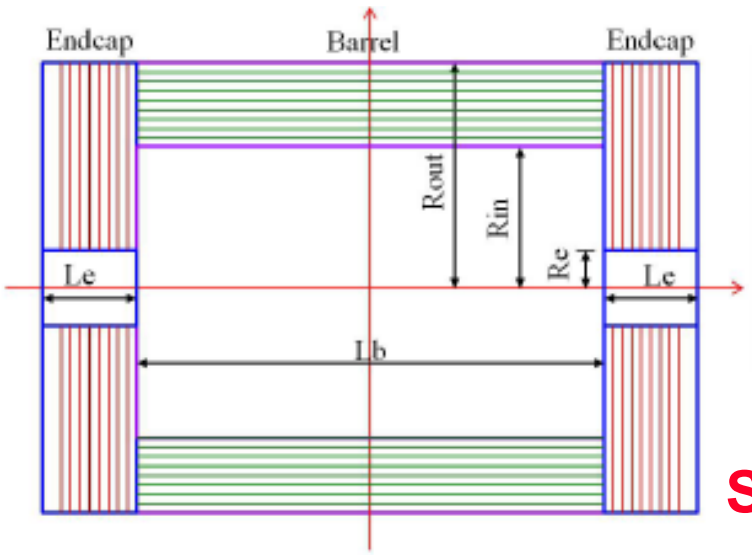
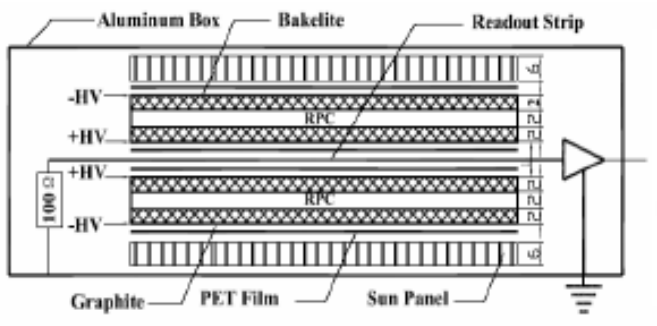
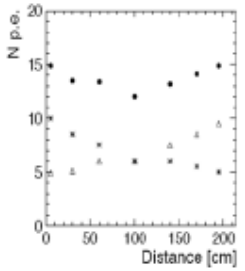
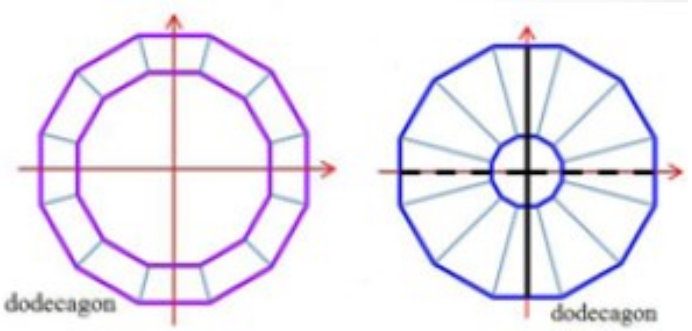
Muon System Overview









Structure:

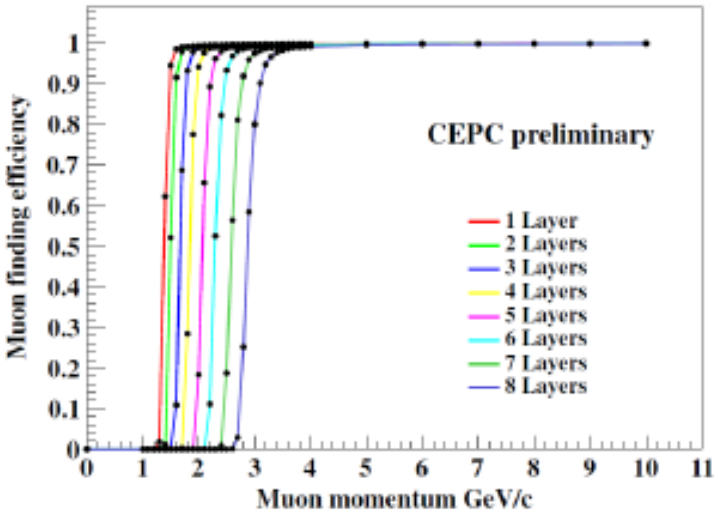
- Between magnet iron yoke, outside HCAL
- Cylindrical barrel & two endcap system
- Solid angle coverage: 0.98 * 4π

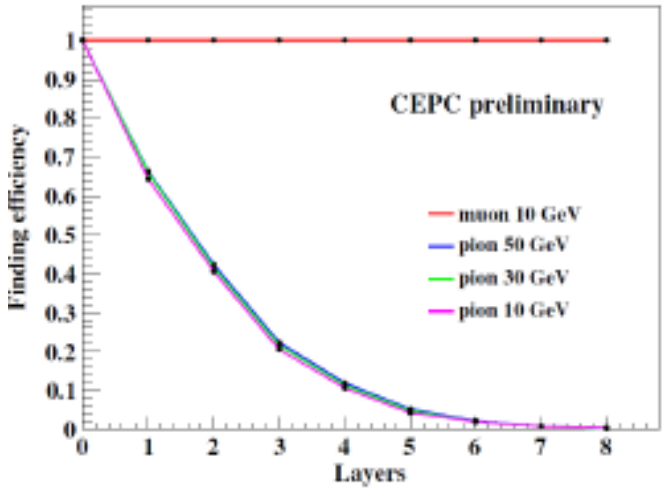
Technology:

- Bakelite/glass RPC, Scintillator strip
- New technology/design welcome

Baseline Design (pre-CDR)

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 (~4 cm per layer)
Total thickness of iron	6 – 10λ (λ = 16.77 cm)	8 (136 cm) (8/8/12/12/16/16/20/20/24)
Solid angle coverage	0.94 – 0.98×4π	0.98
Position resolution [cm]	$\sigma_{r\phi}$: 1.5 – 2.5	2
	σ_z: 1 – 2	1.5
Average strip width [cm]	Wstrip: 2 – 4	3
Detection efficiency	92% – 98%	95%
Reconstruction efficiency (E_μ > 6 GeV)	92% – 96%	94%
$P(\pi \to \mu)$@30GeV	0.5% – 3%	< 1%
Rate capability [Hz/cm²]	50 – 100	~60
Technology	RPC	RPC (super module, 1 layer readout, 2 layers of RPC)
	Scintillating strip	
	Other	
Total area [m²]	Barrel	~4450
	Endcap	~4150
	Total	~8660
Total channels	Barrel	26500
	Endcap	29000
	Total	~ 5.55×10^4 (3 cm strip width, 1-D readout, 2 ends for barrel, 1 end for end-cap)





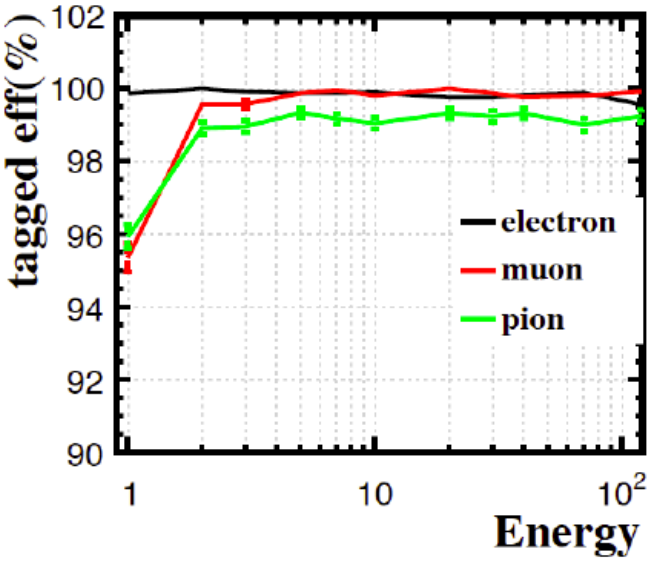
Signal efficiency > 95% for muon pT > 4 GeV with 8 layers

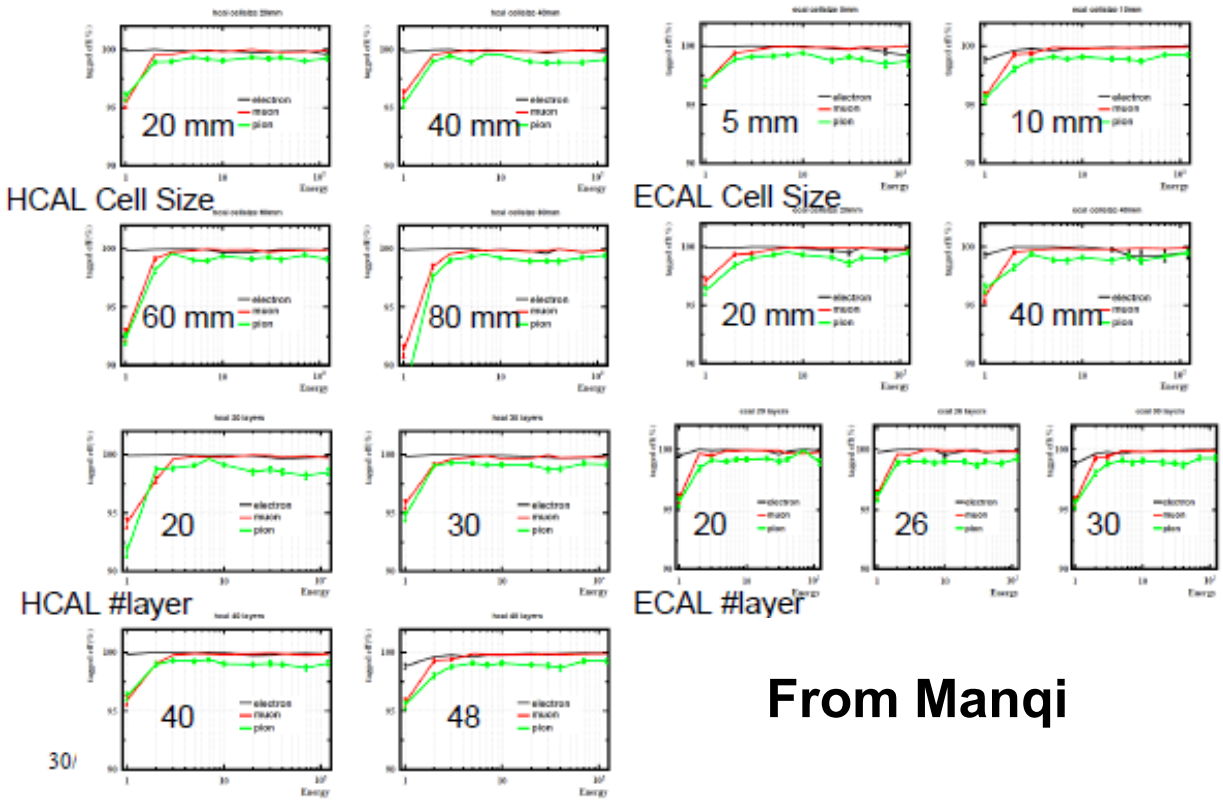
CDR Plan

Changing calorimeter parameters and study muon ID performance: near-term plan → mostly already done by Lepton ID and optimization group

- **Baseline configuration (ILD)**
- **Single particle sample with CEPC_v1**
- **Change cell size, inner radius of ECAL/HCAL**
- **Change number of Si layers , e.g. ECAL 30→20, HCAL 48 → 40, layer thickness etc.**
- **Efficiency/rejection power vs. various parameters**

Muon ID Performance: PFA & calorimeter alone





From Manqi

- PFA has done a terrific job in terms of Lepton ID
- No significant degradation for E > 2 GeV charged particles

CDR Plan

Muon system as an add-on: long-term plan

- Full simulation samples with built-in calorimeter / TCMT geometry, also integrated with yoke and magnet system
- Further layout optimization: N layers, thickness, cell size
- Complementary to Calorimeter
  - Effect as a tail catcher / muon tracker (TCMT)
    - JER with/wo TCMT
  - Exotics/new physics search study, e.g. long lived particles

Future Plan

Currently muon subgroup under calorimeter group

- Manpower in much need
  - New people/collaboration very welcome
- International / domestic collaboration opportunities abundant
  - Bakelite RPC, Scintillator strips
  - Electronics
  - New design/technology
- Detector technology
  - Bakelite/glass RPC: long-term reliability, readout system, resistivity and rate capability study
  - scintillator strips: extrusion production, performance study
- Detector electronics
  - Gas detector electronics: radiation hardness, spark-tolerant, ASIC electronics, bi-dimensional readout
  - SiPM readout electronics

Muon Detector Technology

Muon Chamber Technology	Deployment	Comments
Drift Tubes with field shaper electrodes	Barrel Tracking & Triggering Cell resol'n ($r\phi$) < 250 μm	CMS
MDT (Monitored Drift Tubes) 3 cm dia.	Barrel Tracking Tube resol'n ($r\theta$) ~ 150 μm resolution	ATLAS
Small Diameter MDT 1.5 cm dia.	Tracking in some special regions of barrel	ATLAS
Cathode Strip Chambers (CSC)	Endcaps Tracking & CMS Triggering ATLAS: η strip pitch 5.5 mm, ϕ strip pitch 13 - 21 mm	CMS and ATLAS ($2<\|\eta\|<2.7$)
Micromegas	Endcaps Tracking & Triggering Readout pitch ~ 0.4 mm	ATLAS Phase I Upgrade New Small Wheel
Thin Gap Chambers (TGC)	Endcaps Triggering & Tracking 2nd coordinate	ATLAS 1st and 2nd stations Endcap
Small-strip Thin Gap Chambers (sTGC)	Endcaps Triggering & Tracking Fast enough for BC tagging 95% τ < 25 ns; 3 mm strip-pitch	ATLAS Phase I Upgrade New Small Wheel
Resistive Plate Chambers (RPC)	Barrel and Endcaps Triggering Fast τ ~ 3ns ATLAS: η strip pitch ~ 30 mm, ϕ strip pitch ~ 30 mm	ATLAS and CMS
Low Resistivity RPC	Higher rate capability 10^{10} Ωcm	R&D
Multi-gap Resistive Plate Chamber	Very fast τ ~ 50 ps	ALICE and R&D
GEMs (3 layer)	Endcaps Rate ~ 10^5Hz/cm^2 Fast τ ~ 4-5 ns	CMS Phase I Test & Phase II

From F. E. Taylor