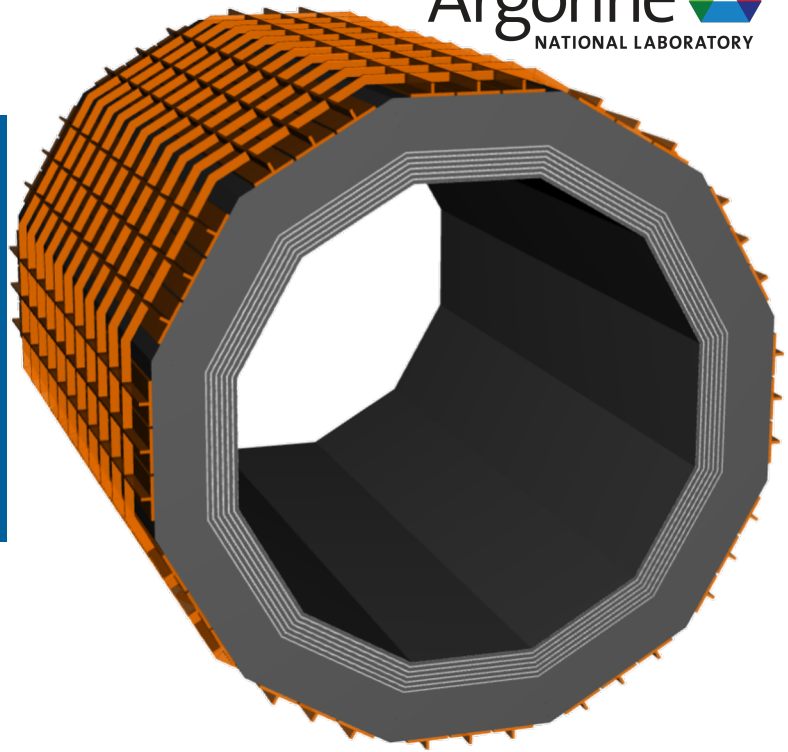
Barrel EM Calorimeter Si Tracking Layers: Calo WG consensus for 9 layers



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For the
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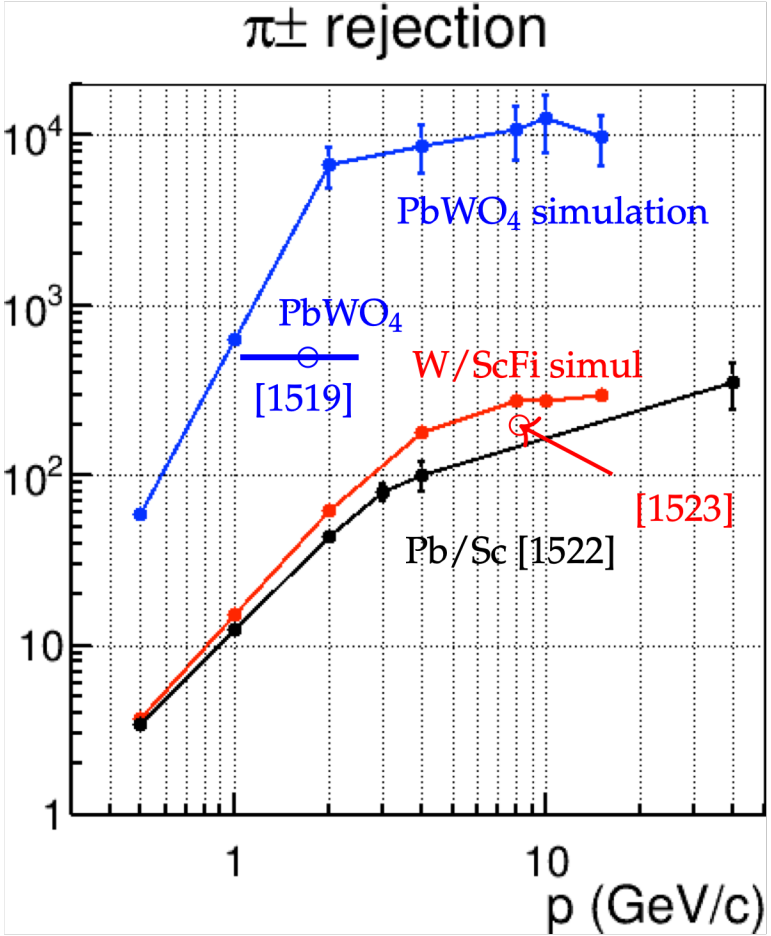
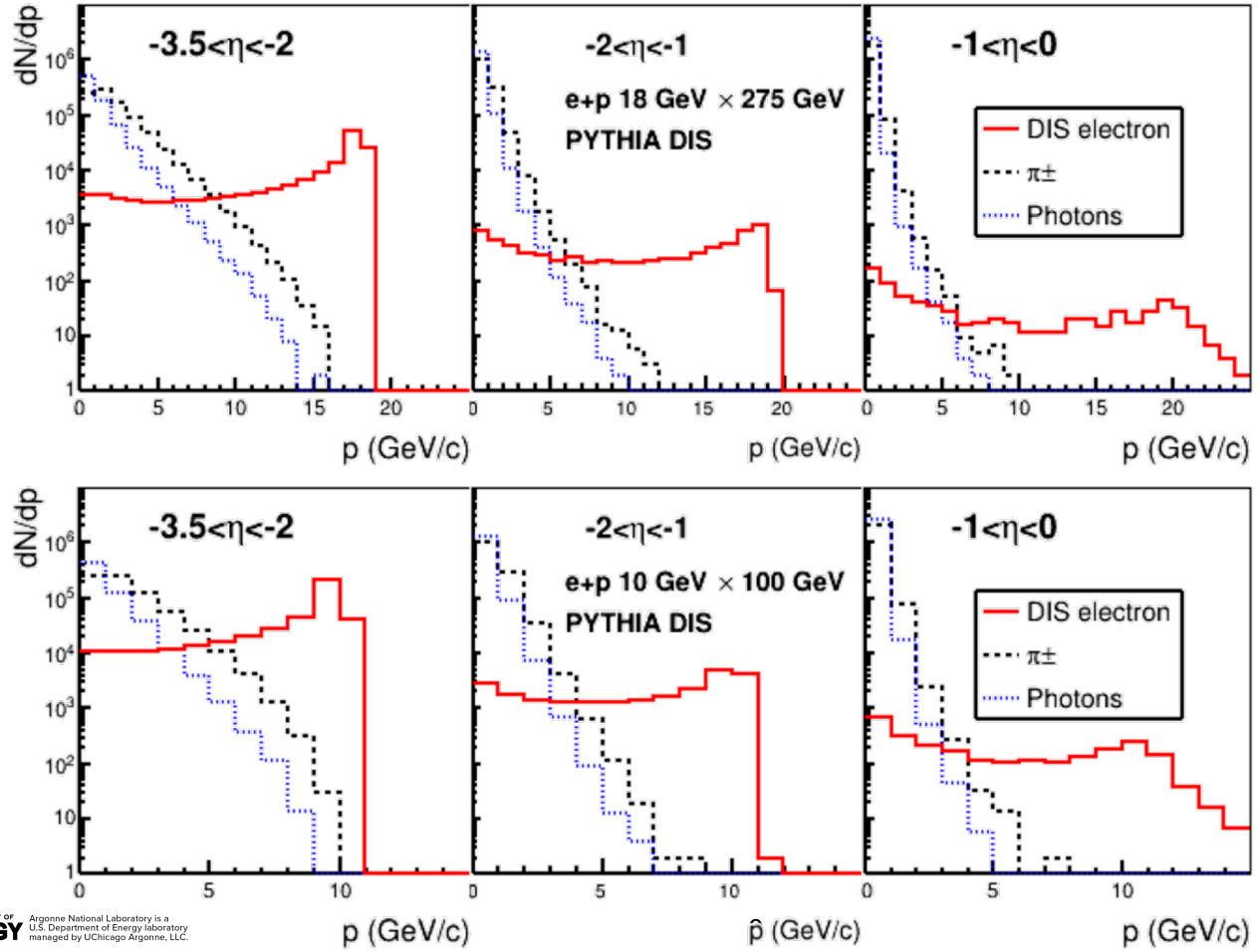
Basic Considerations

- e-π separation goals
  - Alternative to $PbWO_4$ crystals
  - Lower cost than $PbWO_4$
  - Differentiate lower momentum particles
  - Si Tracking use the shape of the shower for discrimination.
- Overall electromagnetic resolution ($\gamma, e^{\pm}, \pi^0$)

- Barrel Hadron Calorimetry
  - Some optimization may help with hadron energy measurement.
  - Under consideration, not before proposal
  - Many parameters, e.g. Pb thickness, W vs Pb



THE ISSUE

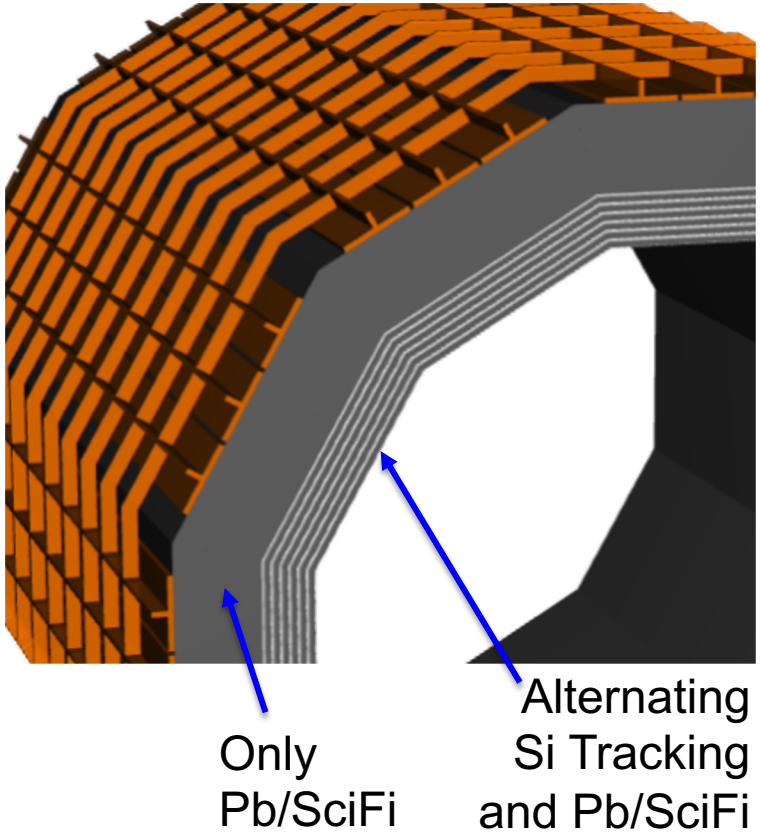


18x275 GeV

10x100 GeV

BECAL CONFIGURATION

- Alternating sections of Pb/SciFi and Si Tracking Calorimeter
- Si layers are
  - 0.155 cm of Si + 1 cm of air = 1.155 cm
- Pb/SciFi layers are
  - 13 layers of fibers
  - 13*1.22 mm = 1.586 cm layers of Pb/SciFi



Number of Layers

- First made E/p cut based on total energy in both Si Tracking and Pb/SciFi layers
- Apply recognition algorithm with goal to keep $e_{\text{eff}} \geq 95\%$

p (GeV)	Edep/p cut (9 + 9 layers)			ML			Combined	
	Cut	e Eff.	pion Rej.	e:pion Weighting	e Eff.	pion Rej.	e Eff.	pion Rej.
0.1	> 0.05	99.94%	1.05	1:10	95.55%	489.85	**95.49%**	**514**
0.2	> 0.06	99.87%	1.04	1:20	95.36%	590.72	**95.24%**	**614**
0.5	> 0.085	98.48%	3.45	1:30	96.47%	479.63	**95.00%**	**1655**
1	> 0.085	98.67%	4.72	1:80	97.18%	505.95	**95.89%**	**2388**
2	> 0.085	98.08%	6.72	1:100	98.42%	746.00	**96.53%**	**5013**
5	> 0.08	98.17%	8.27	1:40	96.77%	678.86	**95.01%**	**5613**

- No B field/material between production and Calo

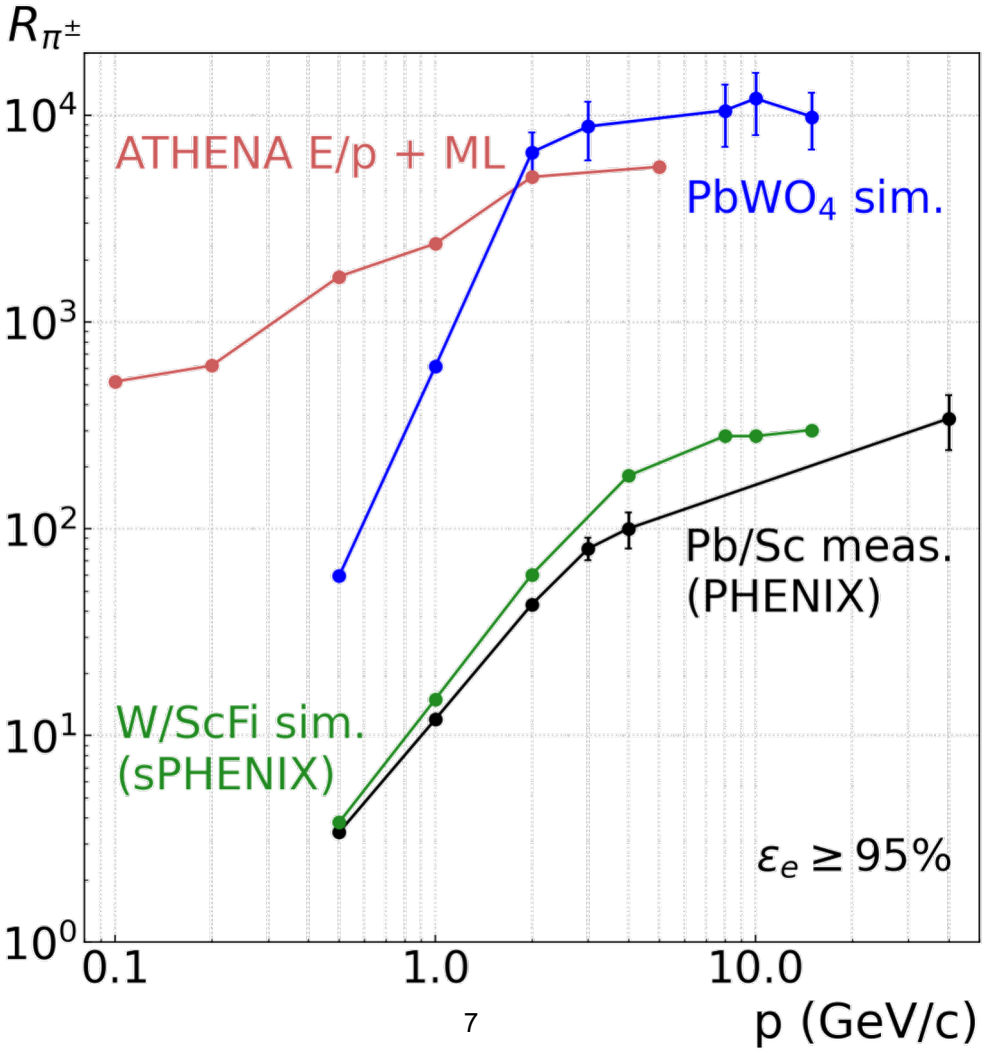
Number of Layers

- First made E/p cut based on total energy in both Si Tracking and Pb/SciFi layers
- Apply recognition algorithm with goal to keep $e_{\text{eff}} \geq 95\%$

p (GeV)	Pion Rejection Power (e Eff. >= 95%)		
	2 AstroPix layers	6 AstroPix Layers	9 AstroPix Layers
0.1	147	344	514
0.2	113	366	614
0.5	410	699	1655
1	983	1393	2388
2	1567	3135	5013
5	2098	4578	5613

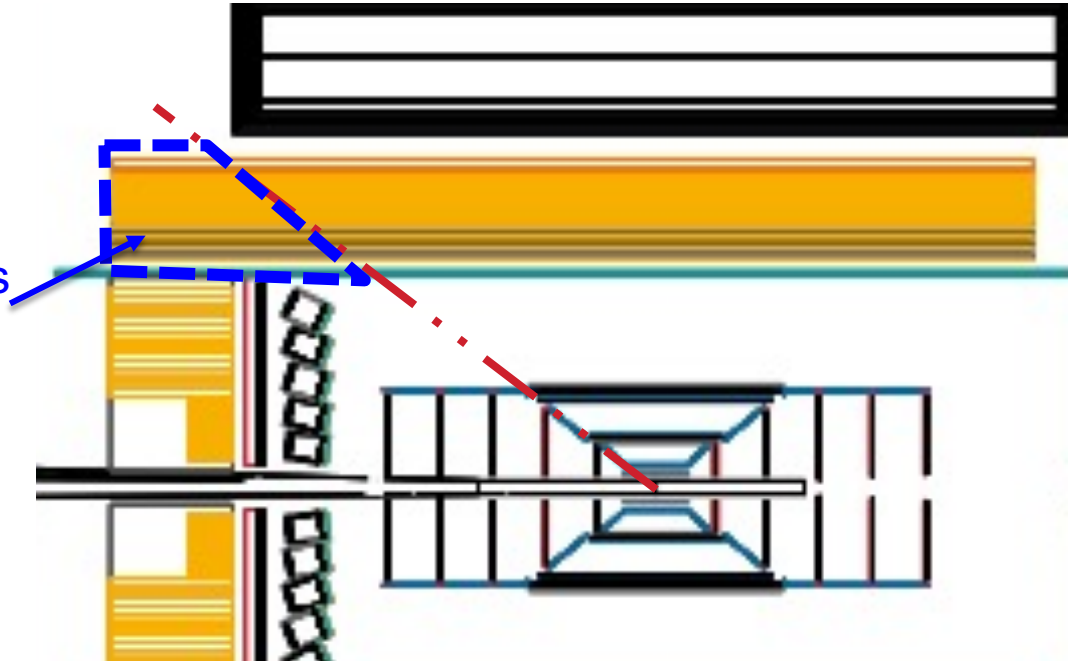
- No B field/material between production and Calo
- Q: Why not 12 layers? Even better?

SEPARATION WITH 9 LAYERS



Cost

- Remember ***Barrel*** ECal is covering much of the *electron endcap*



- Rough cost
  - fixed costs + $1.1M/layer
  - Cost directly scales with area
  - Radius is important to cost $1M/10 cm radial.

CAVEATS

- DD4HEP and GEANT4 does not reproduce low energy hadronic showers well
  - Known problem
- **GlueX** w/similar Pb/SciFi calo in barrel
  - All pattern recognition was done with real identified pions from ρ-decays in forward region.
  - In Barrel could use ω-decays—not done by GlueX.
  - Could not use GEANT4 MC for this.
  - Recommended that we try FLUKA.
- **KLOE** w/similar SciFi calo in barrel
  - Appears to have used FLUKA (based on web presentations that I've found)

Once hadronic shower is better understood,
The number of Si tracking layers may be able to be reduced

CONCLUSION:

- It was the consensus of the Calorimetry WG that the barrel ECal have 9 layers of Si tracking
- Will give performance similar to $PbWO_4$
- Known issues with simulations of low energy hadronic showers in GEANT4
- May be able to fall back to 6 layers
- More information from Chao and Maria's presentation at the Calo WG https://indico.bnl.gov/event/13531/contributions/55893/attachments/37653/62025/BECAL_pion_rejection_1011.pdf
- Some hadronic calorimetry might be achievable
  – Trade photon resolution.