Calorimeter Design for SoLID Project

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Jefferson Lab

OUTLINE

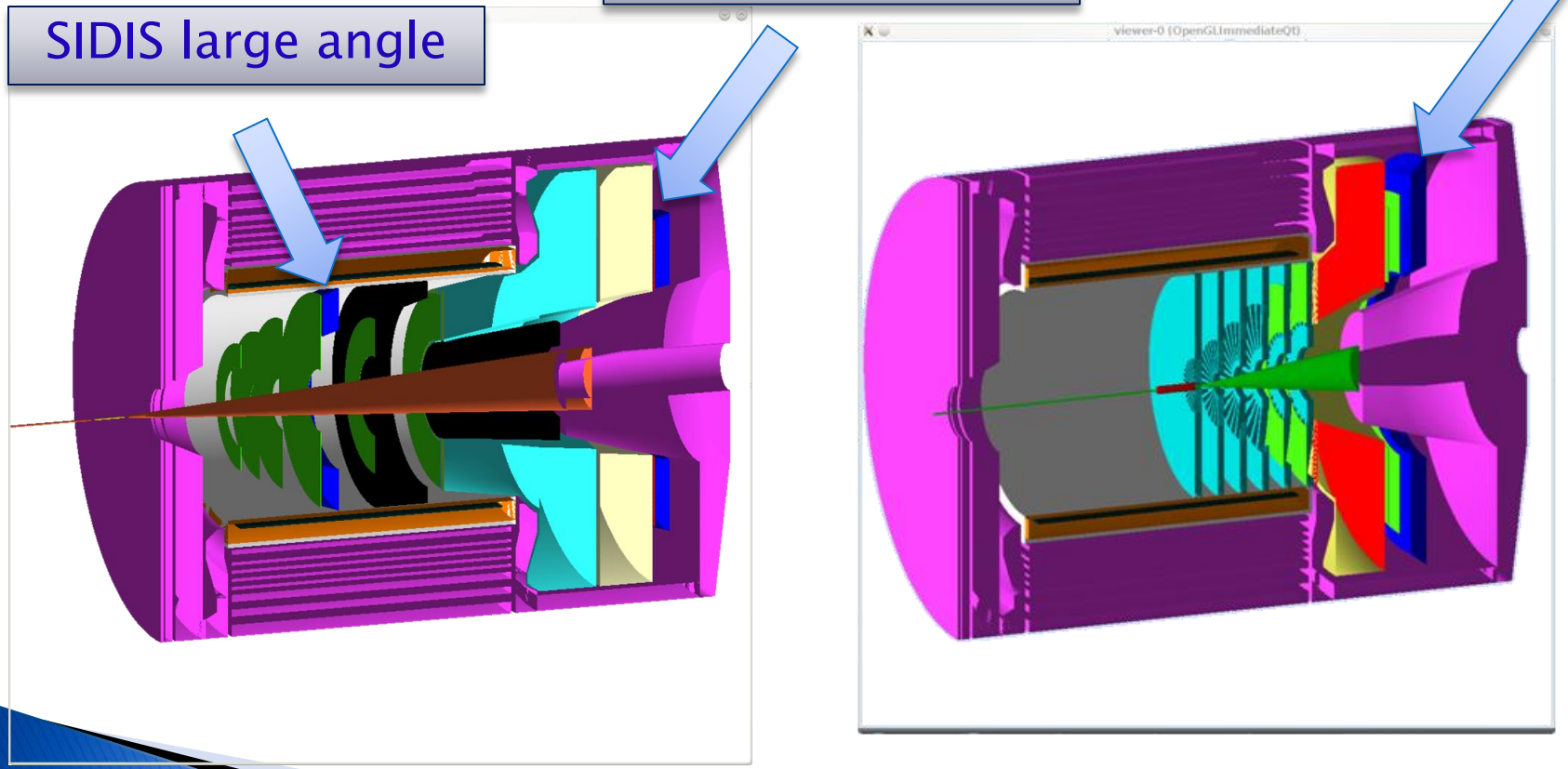
- Requirement
- Design Progress
  - Shashlyk calorimeter
  - Preshower/shower separation
  - Clear fiber connector
- Budget Estimation
- Conclusion

Calorimeters for SoLID experiments

PVDIS forward angle

SIDIS forward angle

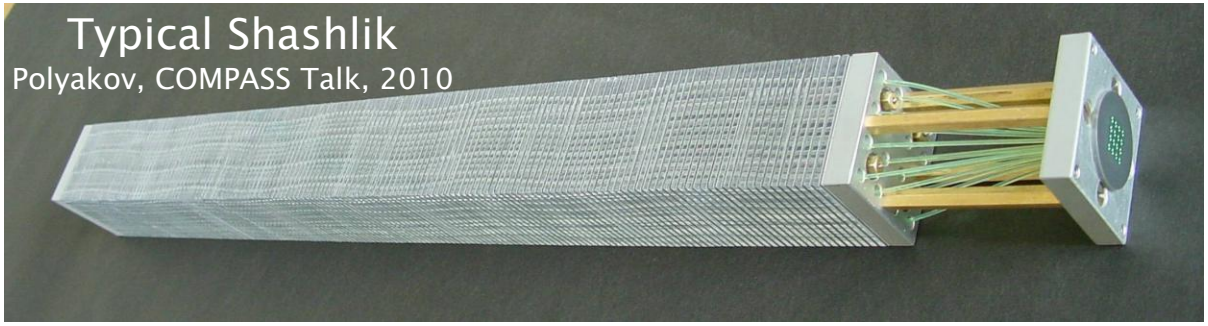
SIDIS large angle



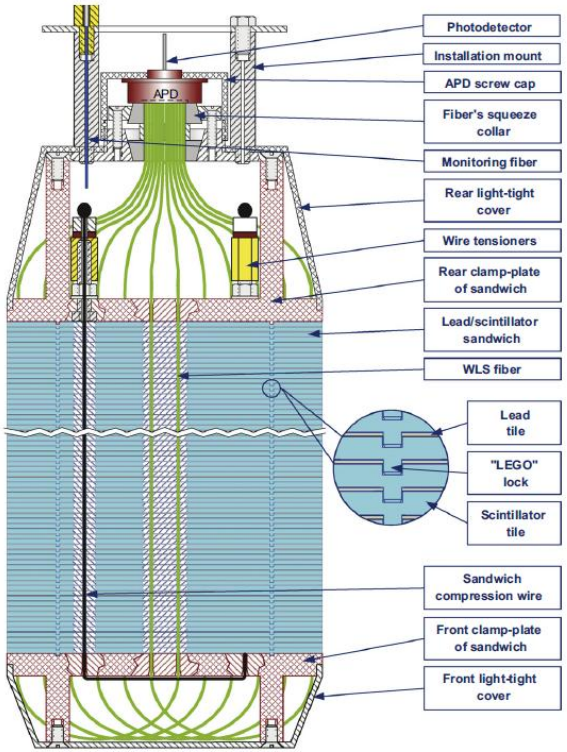
Requirement

- Electron-hadron separation
  - 100:1 pion rejection in electron sample
  - Energy resolution: $\sigma(E)/E \sim 6\%/\sqrt{E}$
- Provide shower Position
  - σ ~1cm, for tracking initial seed / suppress background
- Time response
  - σ <~ few hundreds ps
  - provide trigger/identify beam bunch (TOF PID)
- Radiation resistant
  - PVDIS forward angle
    - EM <=2k GeV/cm^2/s + pion (GeV/cm^2/s), total ~<60 krad/year
  - SIDIS forward angle
    - EM <=5k GeV/cm^2/s + pion , total, total ~<100 krad/year
  - SIDIS large angle
    - EM <=20k GeV/cm^2/s + pion, total, total ~<400 krad/year

Best option: Shashlyk calorimeter



KOPIO



- Shashlyk calorimeter
  - Lead-scintillator sampling calorimeter
  - Fiber collects and reads out light
- Satisfy the SoLID requirement
  - Good energy resolution (tunable)
  - Radiation hardness ~ 500kRad
- Easier to collect and read out the light
- Well developed technology, many experiments

Flexible Design of Shashlyk Detectors

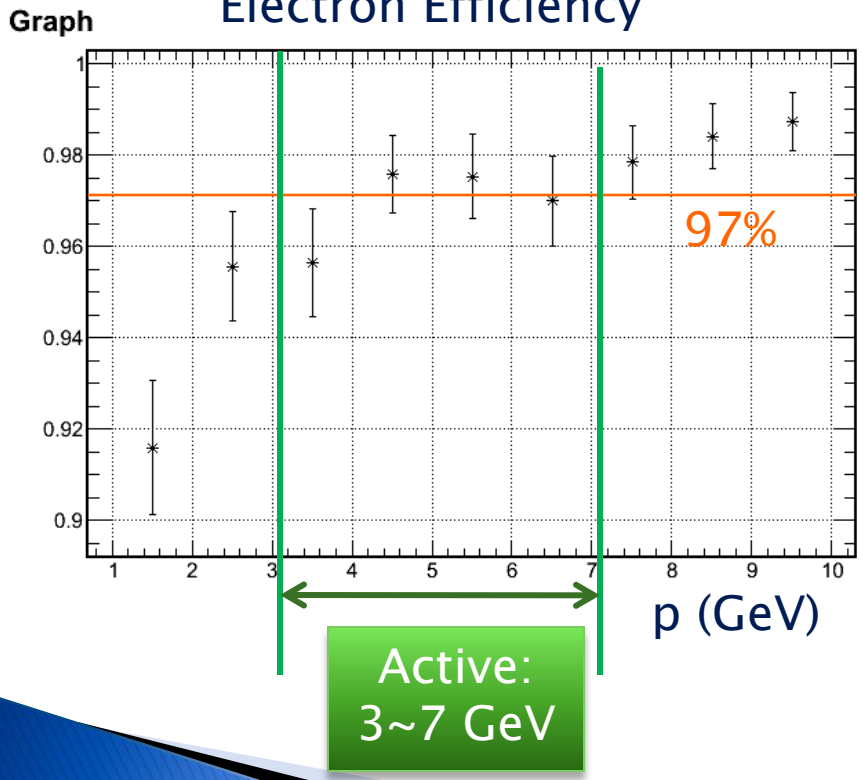
- Flexible design to customize for exp. needs
- Experience collaborations contacted
  - IHEP@Protvino (design & production), INR@Trozik (design), Uniplast (production)
  - 200 module/month mass production (~1500 needed)

Experiment	COMPASS	PANDA	KIPIO
Pb Thick/ Layer (mm)	0.8	0.3	0.28
Sci Thick/ Layer (mm)	1.5	1.5	1.5
Energy Res. a/sqrt(E)	6.5%	~3%	~3%
Rad. Length, X_0 (mm)	17.5	34	35
Total Rad. Length (X_0)	22.5	20	16
Moliere radius (mm)	36	59	60
Typical Detecting Energy	10^1~10^2GeV?	<10GeV	<1GeV
Trans. Size (cm)	~4x4	11x11	11x11
Active depth(cm)	400	680	555

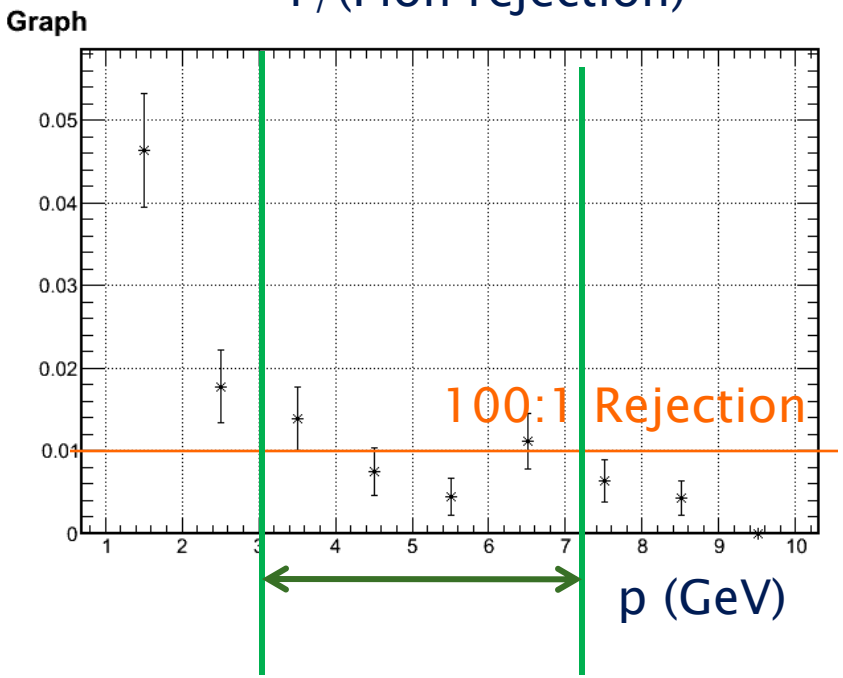
Tuning for SoLID/Lead-Sci Ratio

- Dedicated Geant4 MC developed
- Reach 100:1 pion rejection w/ Pb thick =0.6mm/Layer

Electron Efficiency

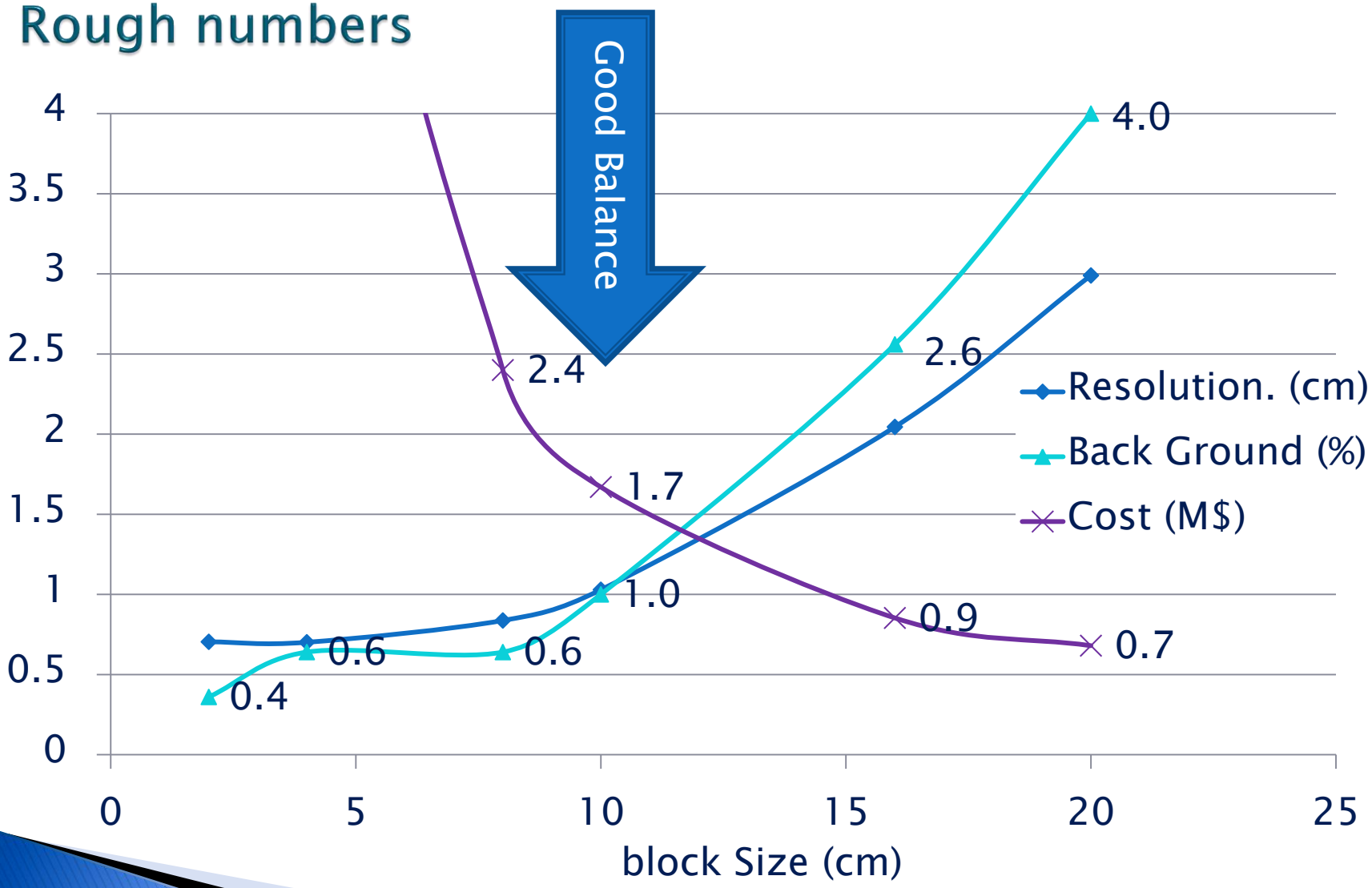


1/(Pion rejection)



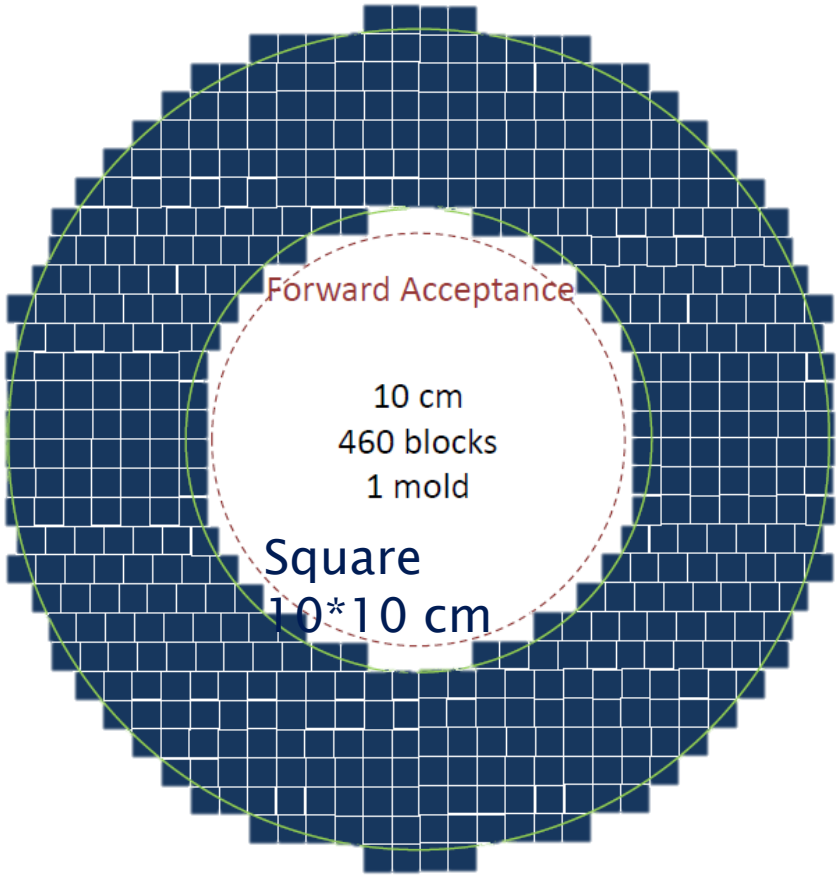
Tuning for SoLID/Lateral Size

Rough numbers



Layout map

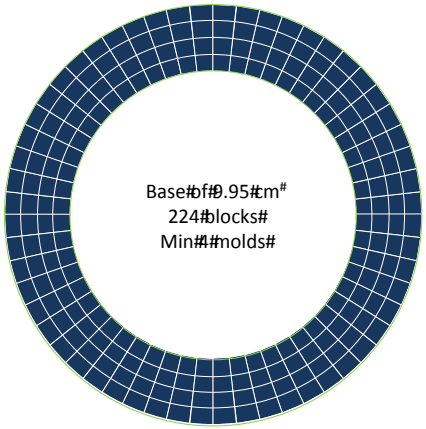
Preferred



Square 10*10 cm

Also studied

Hexagon



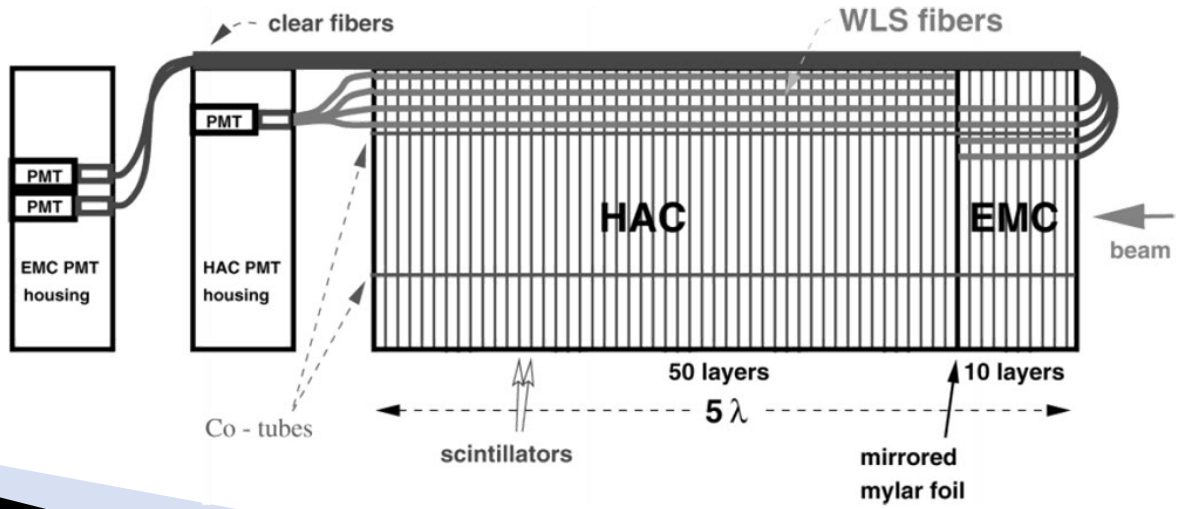
Ring Sector

Preshower/shower

- Preshower-shower separation for better electrion ID
- Options
  - Curve fiber from front, example (ZEUS) below
  - Run fiber through shower part within light-protected tube
  - Run preshower fiber (separately) to outside magnetic field

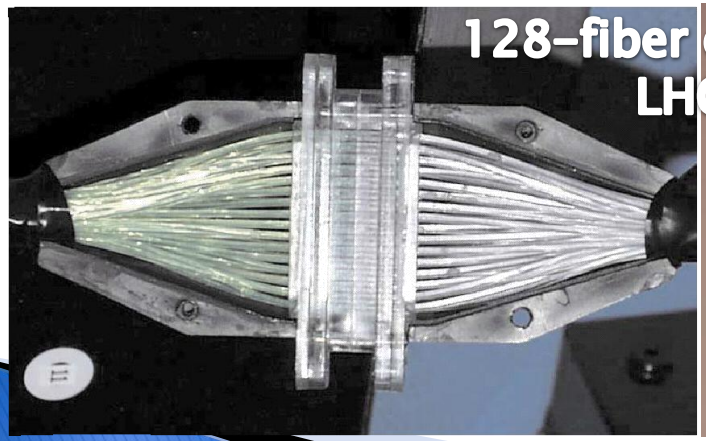
ZEUS forward Cal.

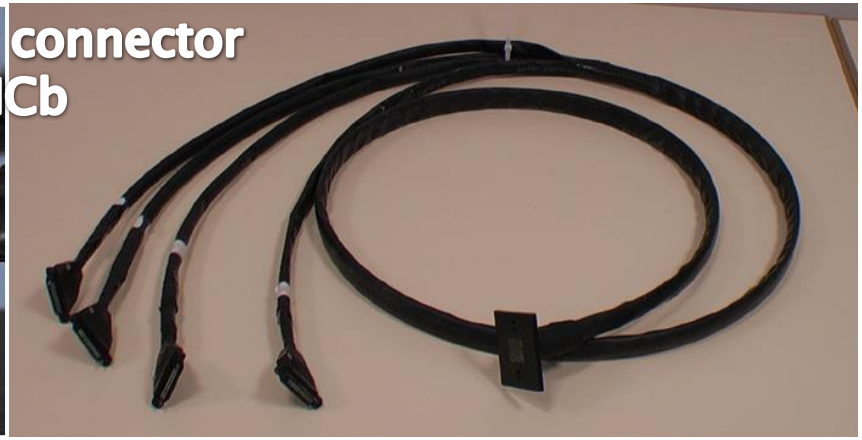
Bamberger, NIM, 2000



Photon Readout Options

- Large angle calorimeter
  - Prefer transporting photons to outside magnetic field
  - No field/PMT read out/easy to maintain
- Forward calorimeter
  A. In field readout (<~100G), PMT with mu-metal shielding
  B. Transport photons to outside end cap
  - Options still under study.
- Fiber connectors and clear fiber
  - Clear fiber are cheaper, w/ longer attenuation length





Budget (preliminary)

Experiment	Angle(degree)	Radius(cm)	Area(m^2)	Number of modules	Module cost (M$)	Fiber Extension (M$)	PMT+ support (M$)	Total cost
PVDIS (forward angle)	22-35	110-258	~10	1000? ~Baffle design	1.5	0	0.6	2.1
SIDIS (forward angle)	9-15	107-202	11	948				
SIDIS (large angle)	17-24	82-141	5	460	0.8	0.3(?)	0.3	1.4

- +Support structure: 0.2M$ (?)
- 10x10cm Shashlyk module costs about $1~1.5K each
- PVDIS : factor 0.5 reduction due to only covers ~half of azimuthal angle, which depends on baffle design.
- PVDIS and SIDIS forward angle calorimeter will rearrange modules

Summary

- Shashlik calorimeter is the best option
  - Good energy resolution/Radiation resistant/Concentrated photon output/Matured production
- Tuning the design for SoLID
  - Tuning Pb-Sci ratio/Preshower-shower thickness/lateral size and shape/layout
- Exploring new features
  - Preshower/shower splitting/clear fiber extensions