Introduction to Hall C electromagnetic calorimeters

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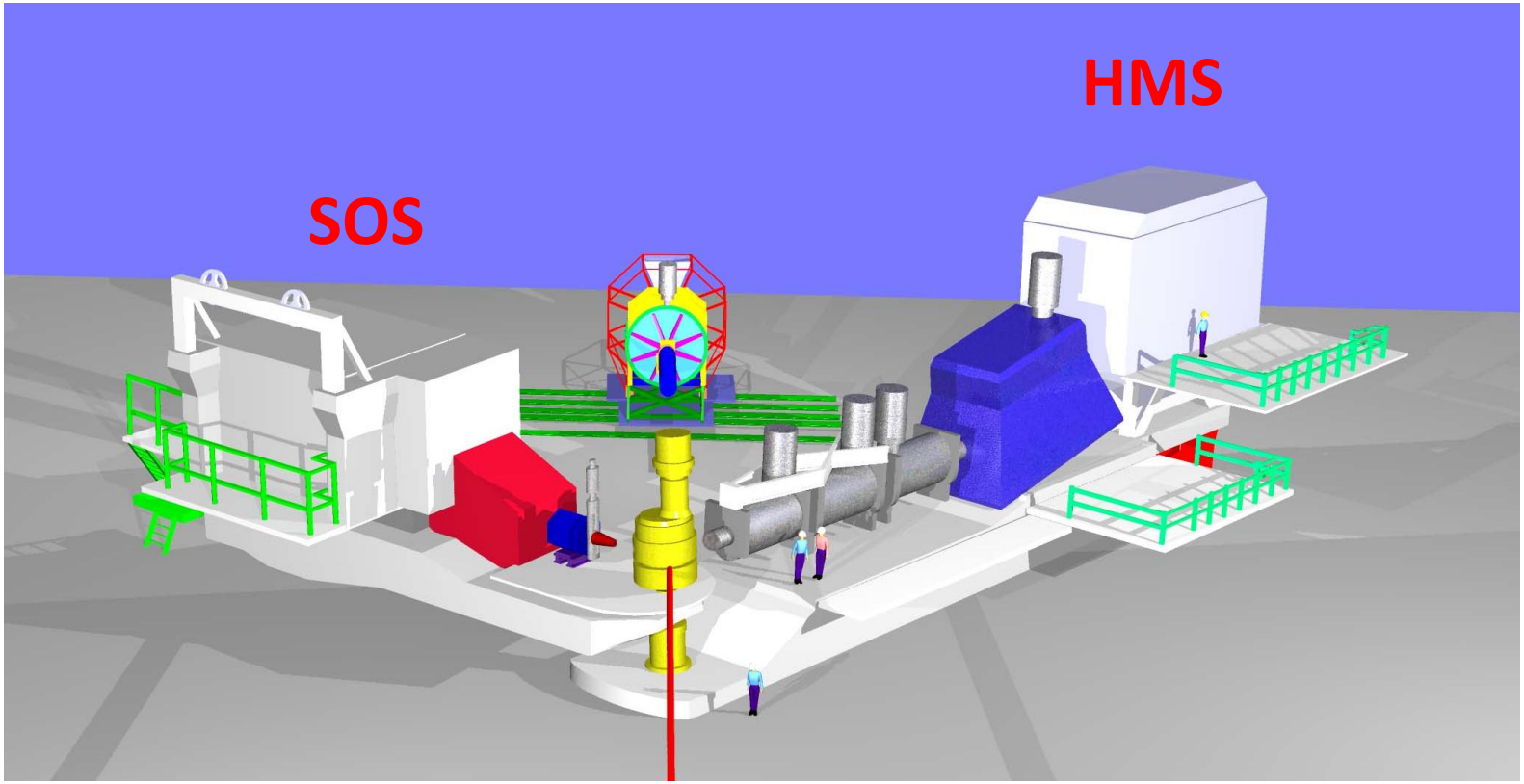
- Summary

6 GeV Hall C spectrometers configuration

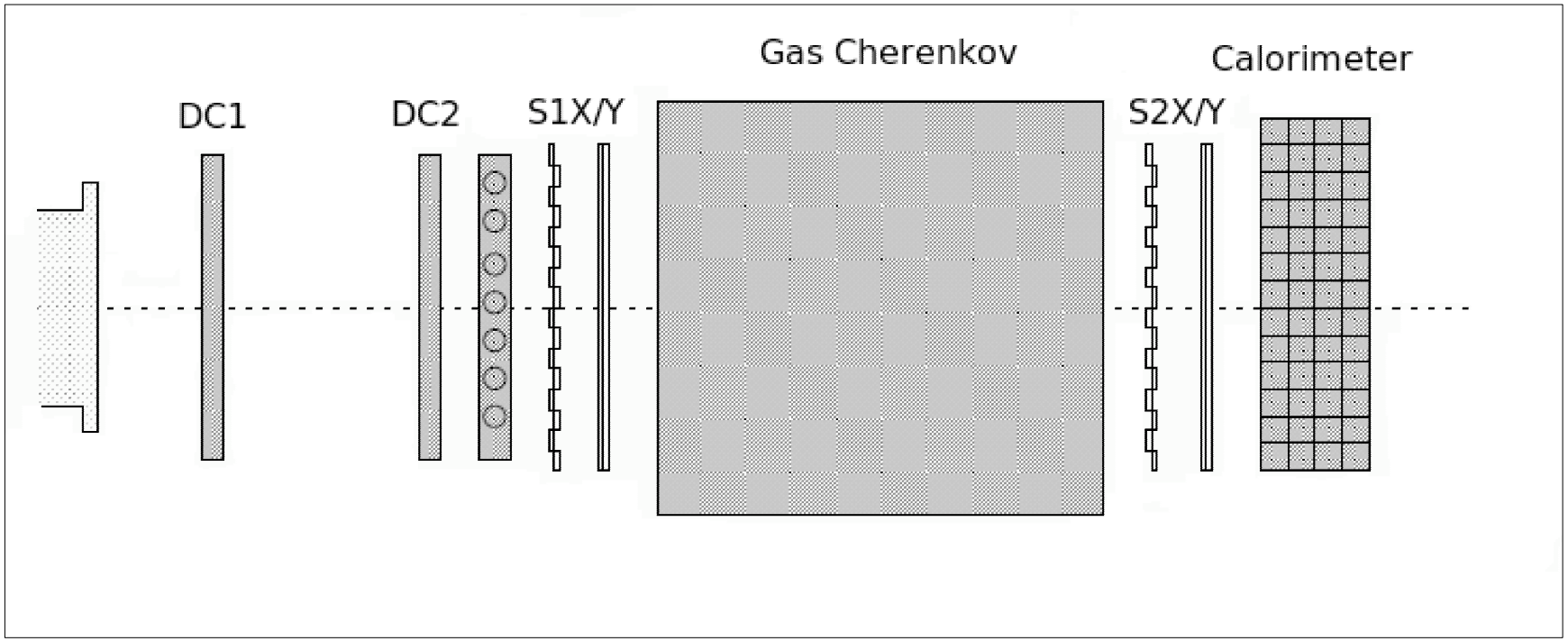
Hall C configuration at 6 GeV CEBAF beam energy: HMS and SOS magnetic spectrometers for coincident electro-production.



SOS & HMS spectrometers' parameters

Parameter	SOS	HMS
Configuration	$QD\bar{D}$	$QQQD$
Momentum Range	0.1 ⇒ 1.8 GeV/c	0.5 ⇒ 7.5 GeV/c
Momentum Bite	40%	20%
Momentum Resolution	<0.1%	<0.1%
Angular Range	14.5° ⇒ 168.4°	12.5° ⇒ ~90°
Solid Angle	~9 msr	>6 msr
Useful Target Length	4 cm	10 cm
Luminosity	$10^{38}cm^{-2}sec^{-1}$	> $10^{38}cm^{-2}sec^{-1}$

HMS & SOS detector packages



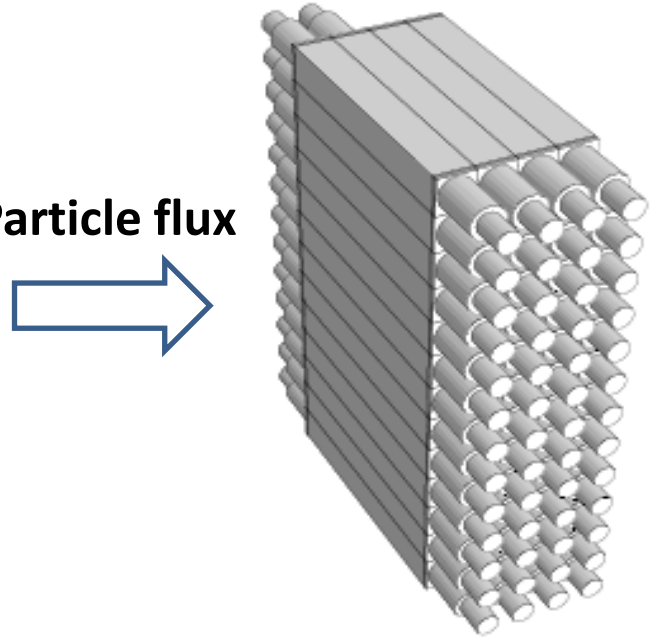
- A pair of MWDC's at the FP, for track reconstruction.
- 4 planes of X and Y oriented scintillator hodoscopes for timing.
- Gas Č counter & EM calorimeter for electron/hadron separation.
- Aerogel detector for separation of hadrons.

SOS detector package was similar to the HMS package.

HMS & SOS calorimeters' construction

HMS calorimeter

Particle flux

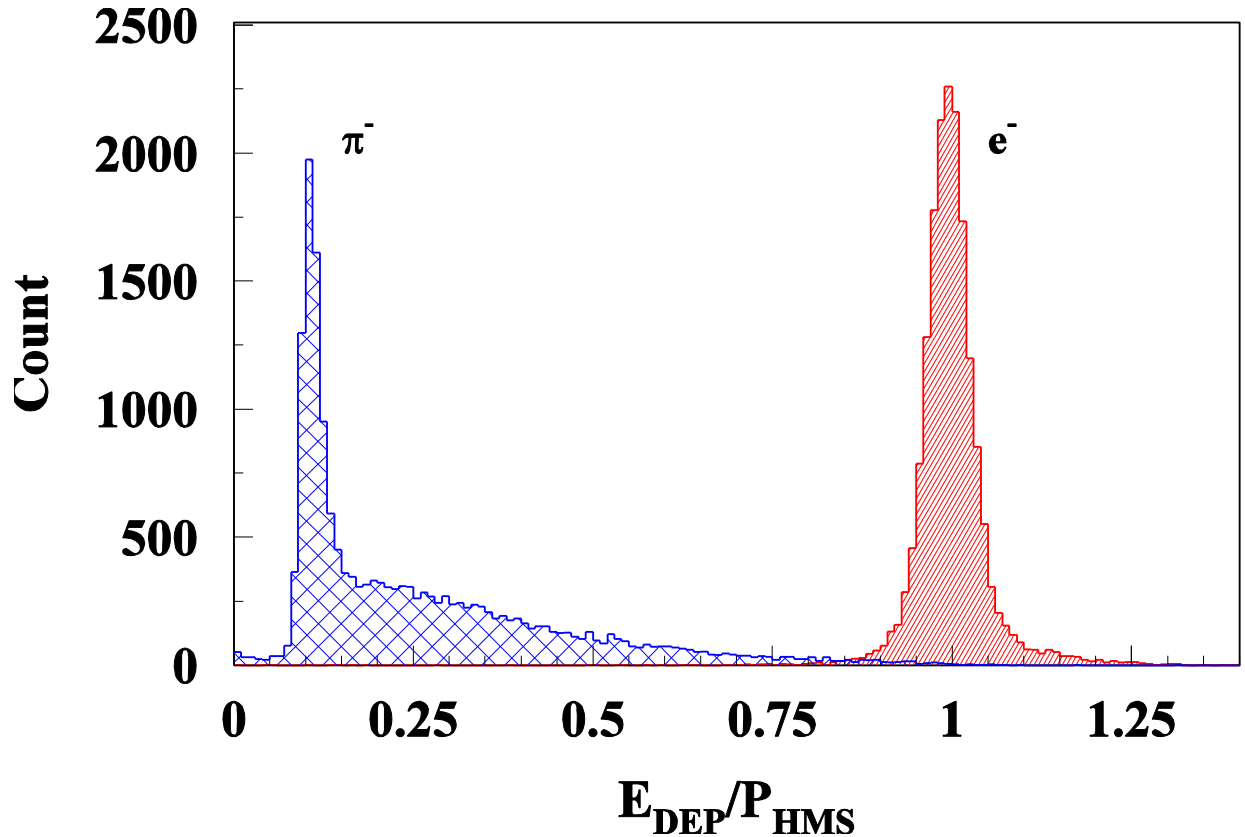


Thickness14.6 rad.length	
Effective area	60×120 cm^2
# of modules	52
# of channels	78
Arrangement	4×13
Block sizes	10×10×70 cm^3
Radiator	TF-1 lead glass
Light detector	XP3462B PMT
In operation	1995 - present

- HMS and SOS calorimeters have similar design.
- Blocks are arranged in four planes.
- Each block is a lead glass optically isolated with aluminized Mylar and black Tedlar film.
- The total thickness of material along the particle direction is about

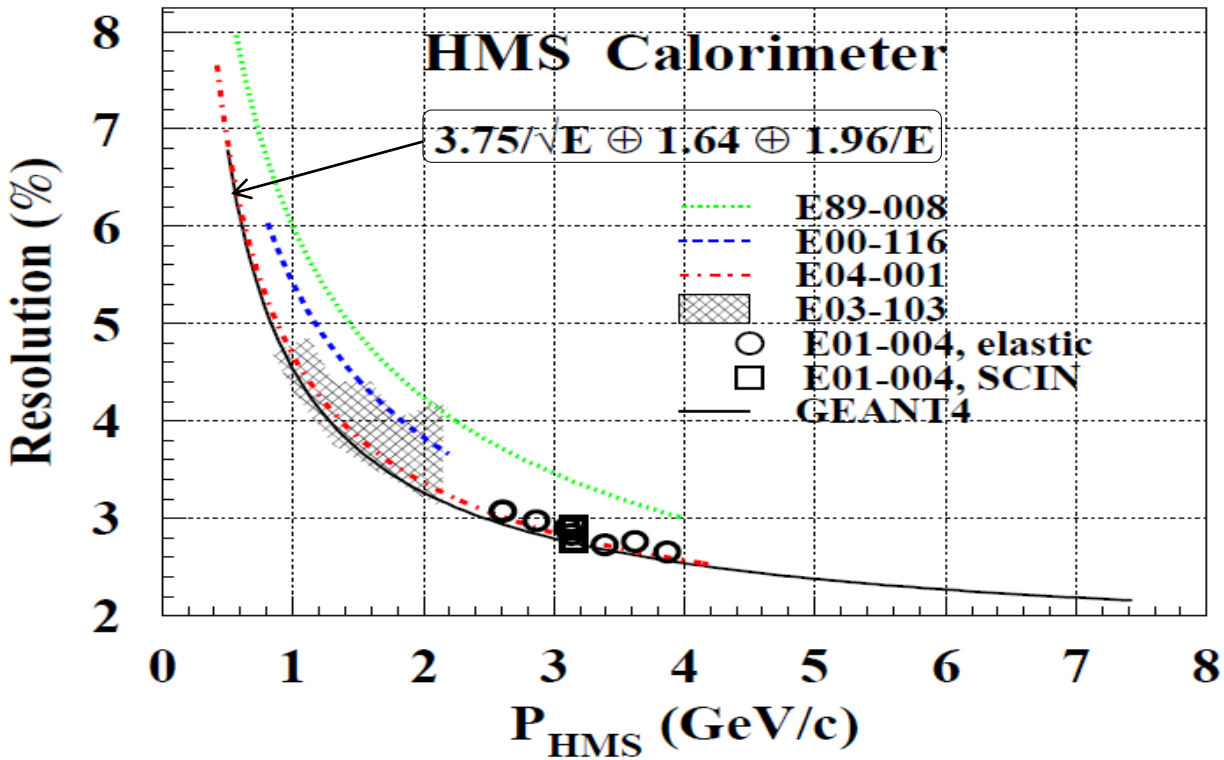
14.6 rad.length which is enough to absorb the major part of electrons energy.

Energy deposition from incident pions and electrons



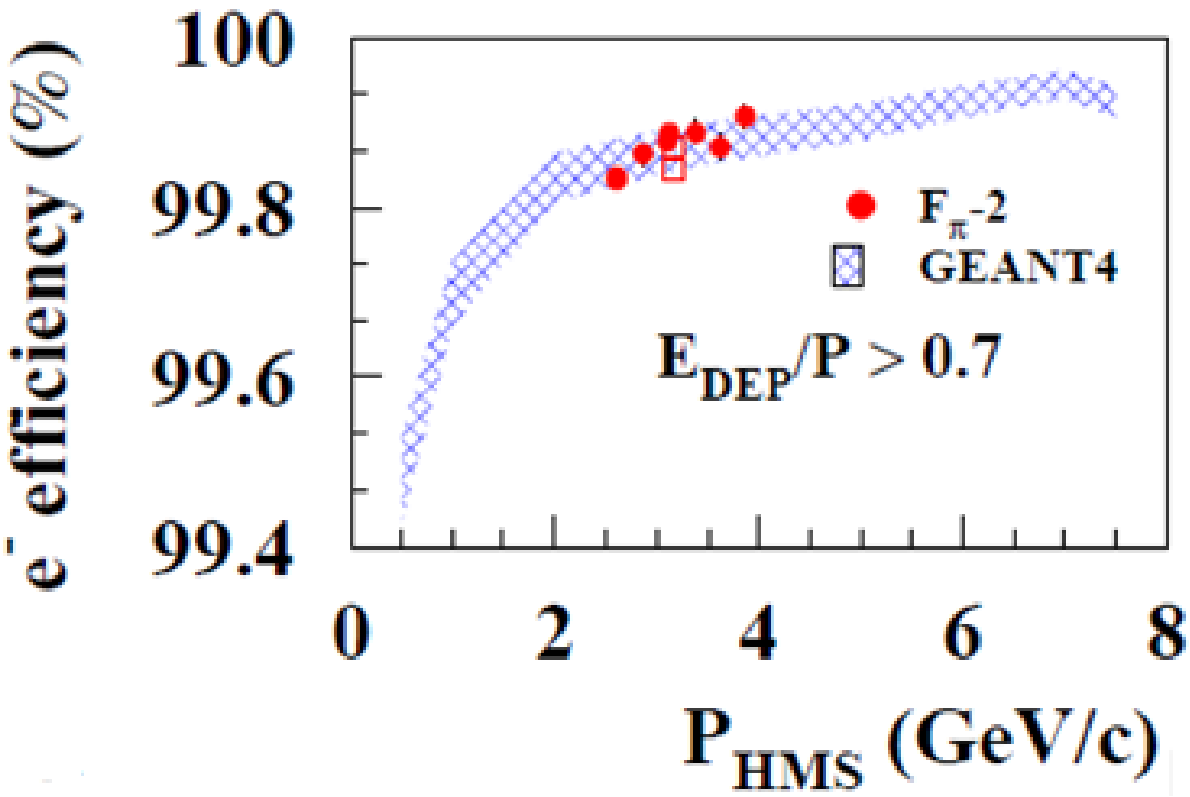
In few GeV/c range we have good separation between pions and electrons.

Resolution of HMS & SOS calorimeters



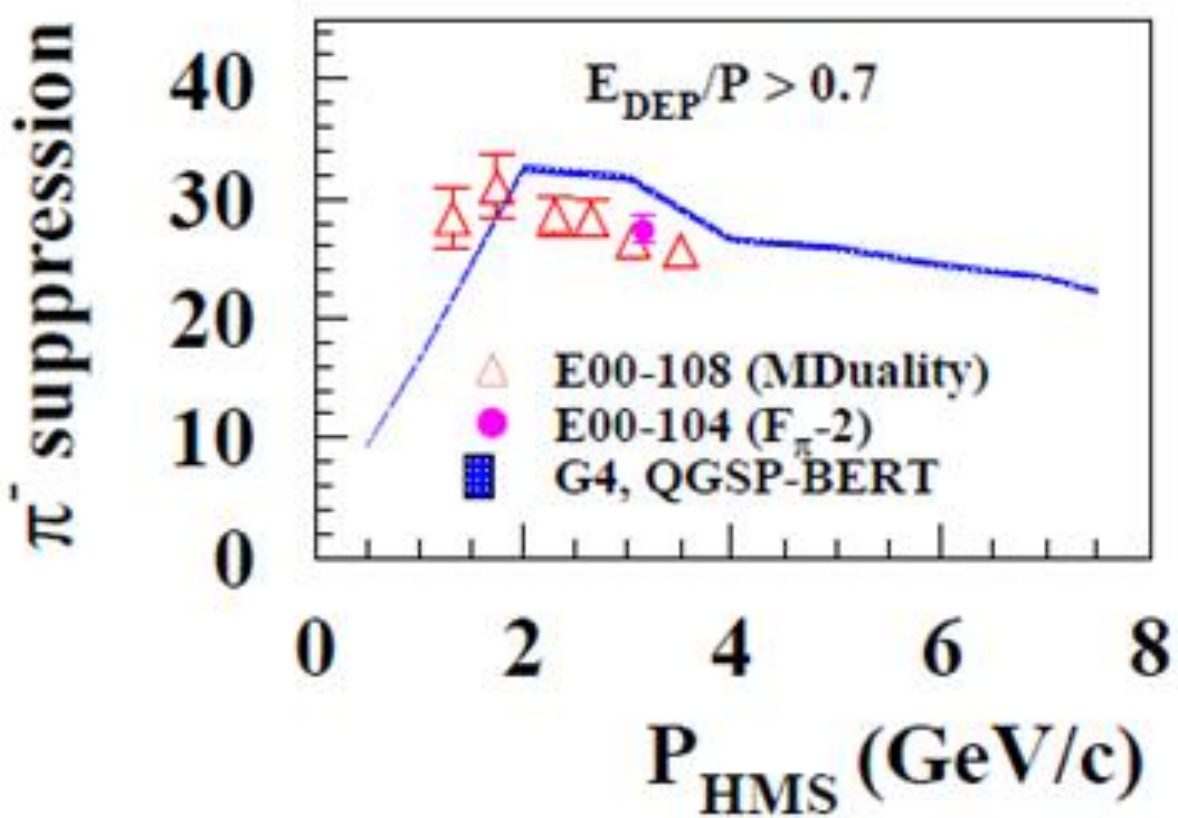
- **We define calorimeter resolution as the width of Gaussian fit to the electron peak in the distribution of energy deposition.**
- **In this figure we compare resolution of HMS calorimeter from different HALLC experiments with simulation.**
- **SOS calorimeter 's experimental resolution was reported ~5%/√E.**

Electron detection efficiency in the HMS calorimeter



- **Electron detection efficiency is the ratio of number of electron events over the total number of electrons.**
- **e^- detection efficiency from GEANT4/QGSP_BERT simulations agrees well with experiment in few GeV energy range.**

Pion suppression in the HMS calorimeter

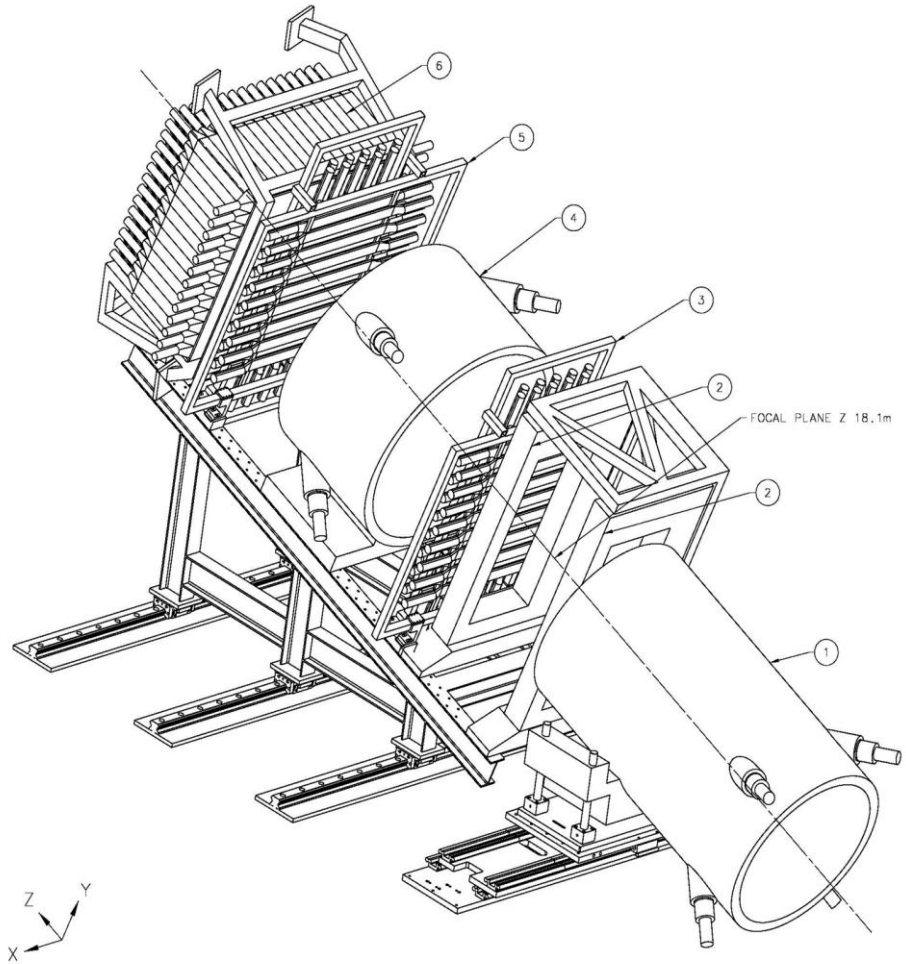


- **Pion suppression factor is ratio of total number of pionic events over the number of pions counted as electrons.**
- **Pion suppression from GEANT4 simulation with QGSP-BERT physics list agrees well with experimental data.**

Summary on the HMS & SOS calorimeters

- **HMS and SOS calorimeters have been in operation for more than 15 years, showed remarkably stable performance;**
- **Resolution of the detectors is similar to the other lead glass calorimeters;**
- **Pion suppression of a few tens and electron detection efficiency better than 99% was routinely achievable under the Hall C experimental conditions;**
- **GEANT4 based simulations show that the performance of the HMS calorimeter agrees well with existing experimental data in few GeV energy range;**

SHMS detector package



1 – Nobel Gas Cerenkov

2 – MWDC

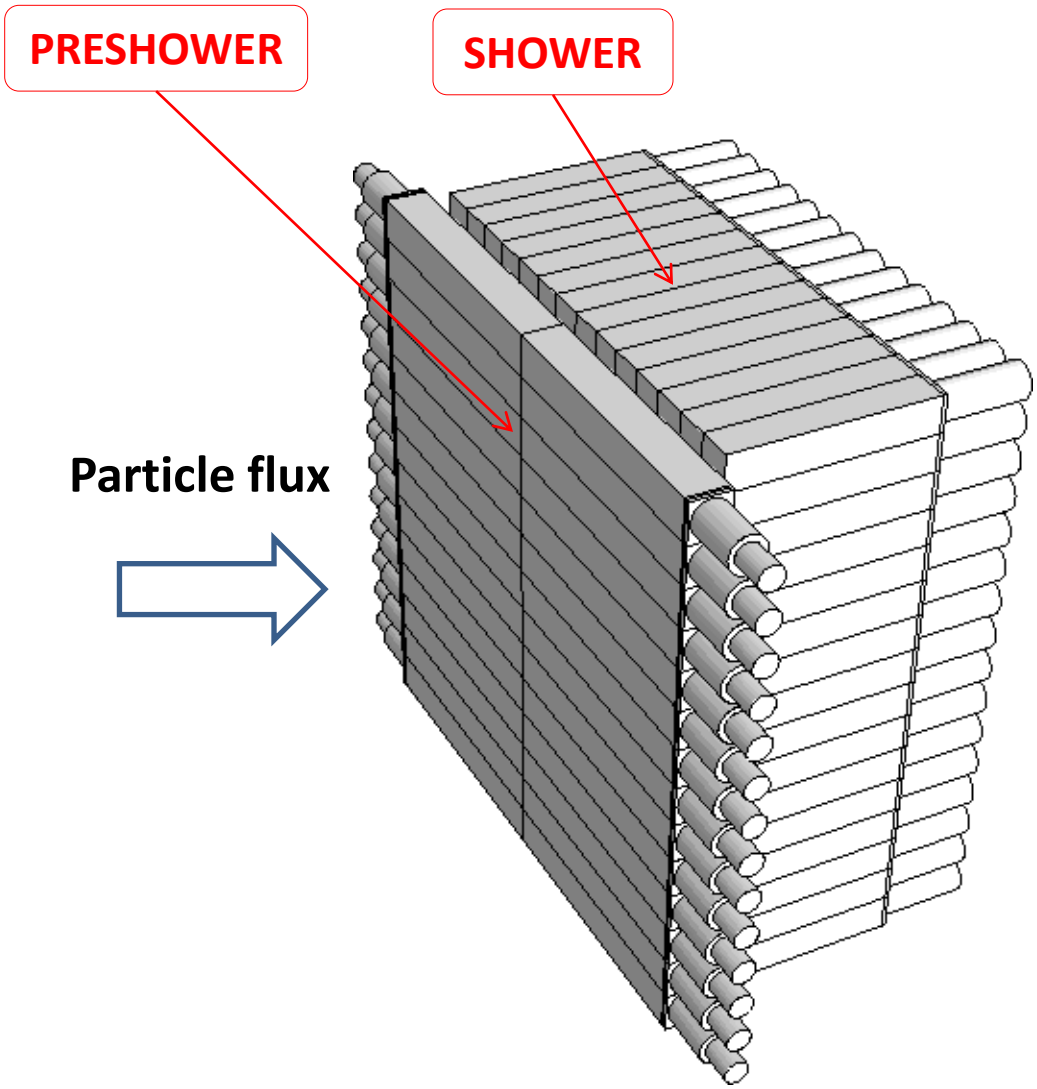
3 – Scint. Hodoscope

4 – Heavy Gas Cerenkov

5 – Quartz Hodoscope

6 – EM calorimeter

Design construction of SHMS calorimeter



CALORIMETER:

Number of channels	252
Effective Area (cm^2)	116x134
Thickness (Rad.L.)	21.6

PRESHOWER:

Number of blocks	28
Blocks & PMTs from	SOS
Block size (cm^3)	10x10x70
Lead Glass type	TF-1
Thickness (Rad.L.)	3.6

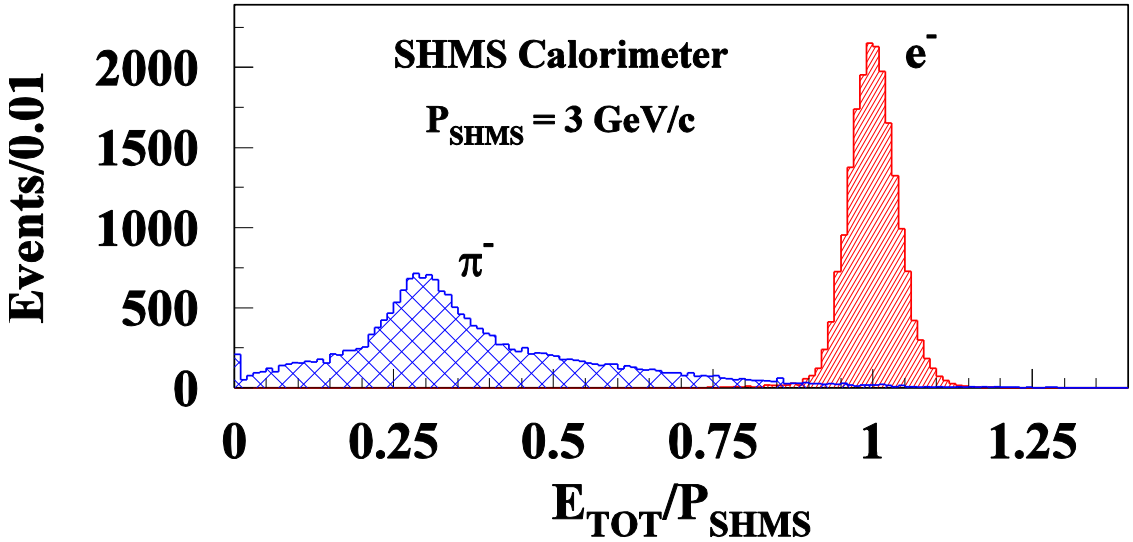
SHOWER:

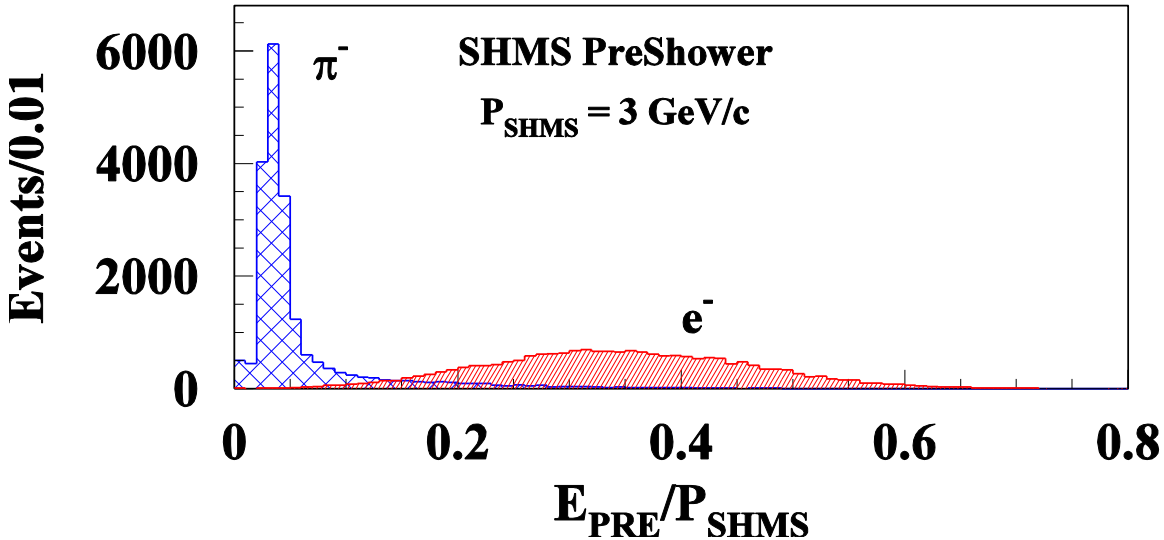
Number of blocks	224
Modules from	HERMES
Block size (cm^3)	9x9x50
Lead Glass type	F-101
Thickness (Rad.L.)	18.0

Radiators:

TF-1 Rad.L.(cm)	2.74
F-1 Rad.L.(cm)	2.78
Density (g/cm^3)	3.86
Refractive Index	1.65

Simulation code for SHMS calorimeter

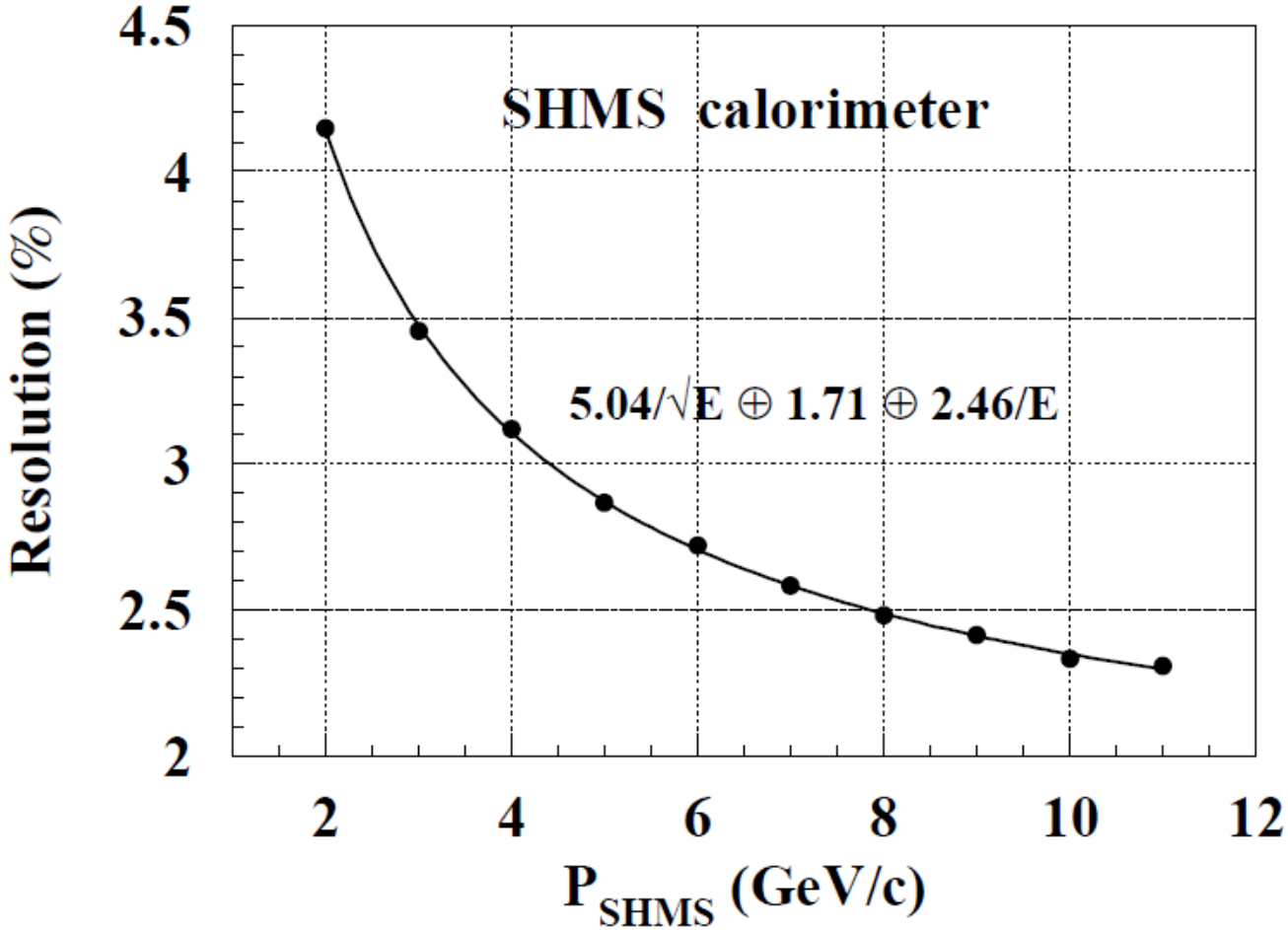




Based on GEANT4-9.2, QGSP-BERT physics list was choosen to model hadron interactions.

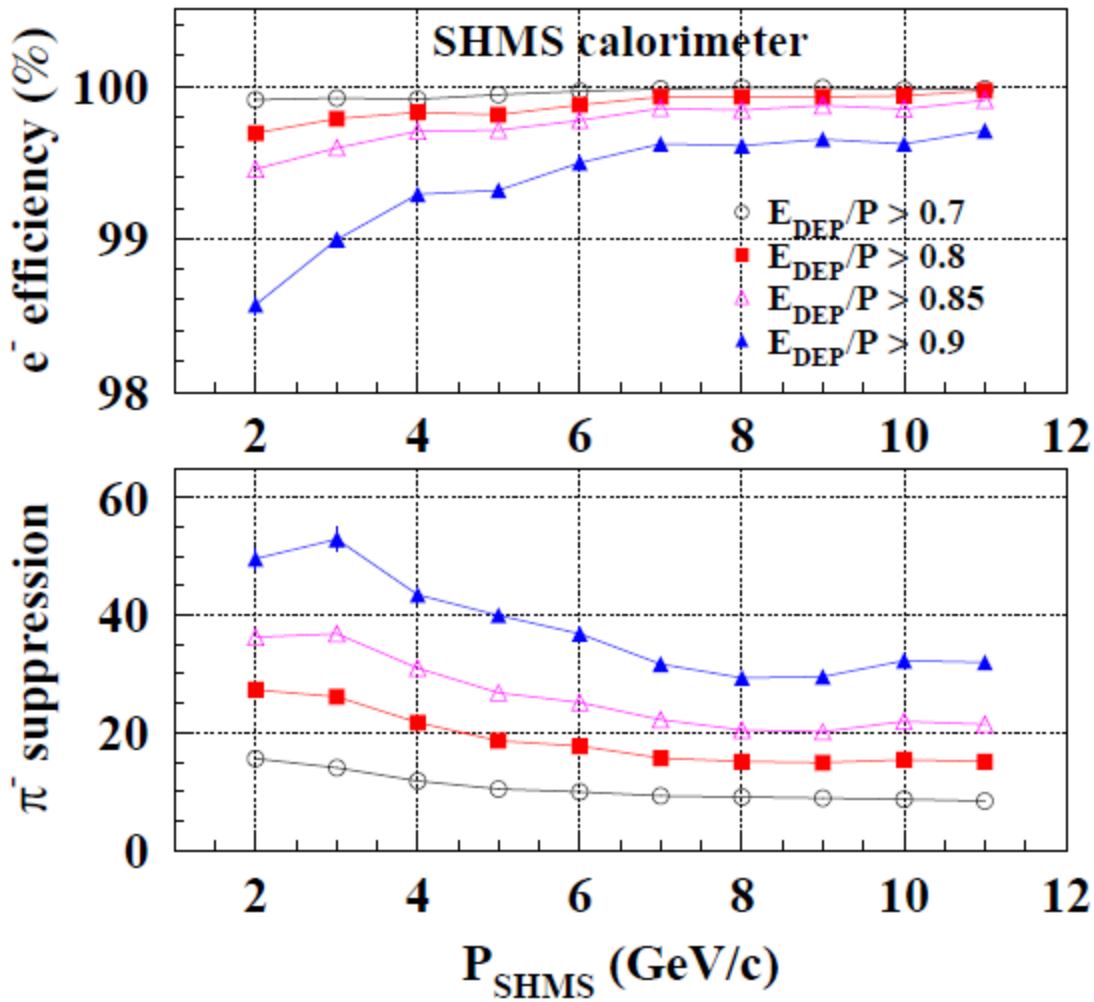
- Track sampling at FP
- Passage through material before the calorimeter,
- Čerenkov light generation and tracing
- p.e. knock-out from PMT photocathode
- Digitization

Resolution of SHMS calorimeter



Resolution similar to other lead glass calorimeters. Lower than for HMS, due to excess of light absorption in the Shower, and more material in front.

Pion suppression in SHMS calorimeter

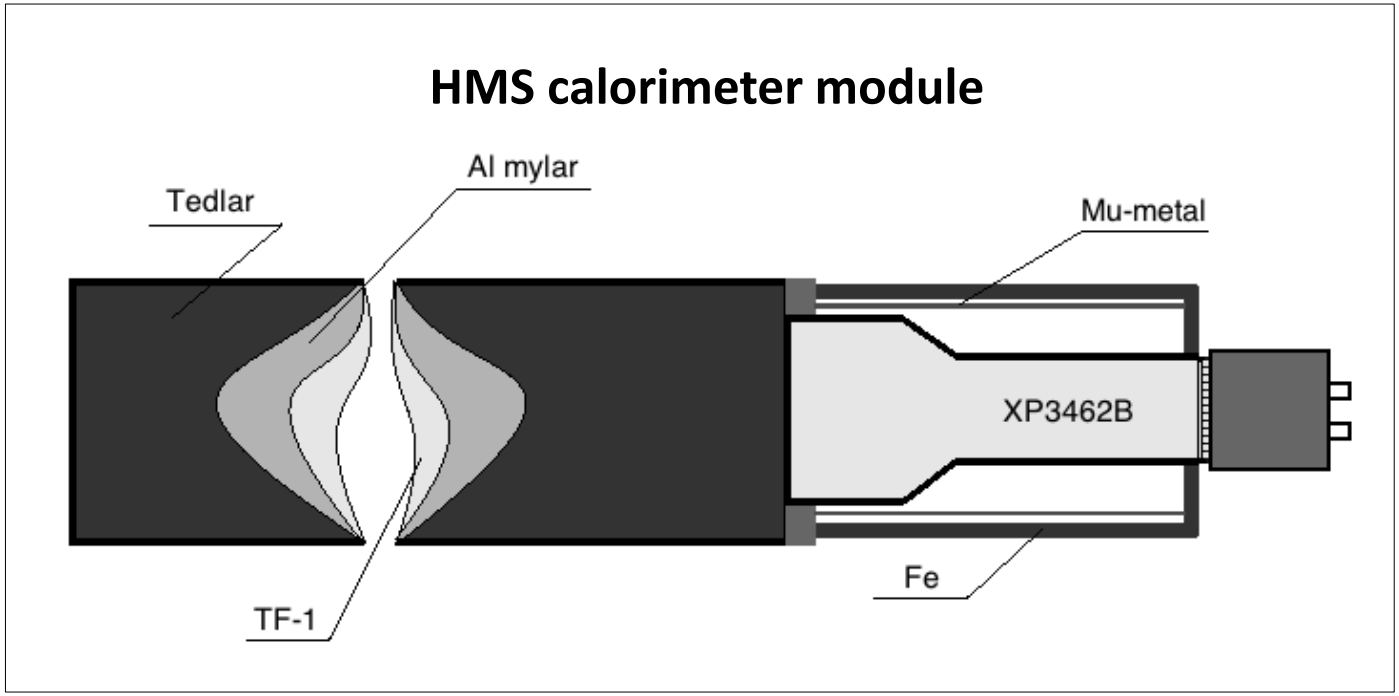


e– detection efficiency and pion suppression factor for different cuts on the deposited energy.

Summary on the SHMS calorimeter

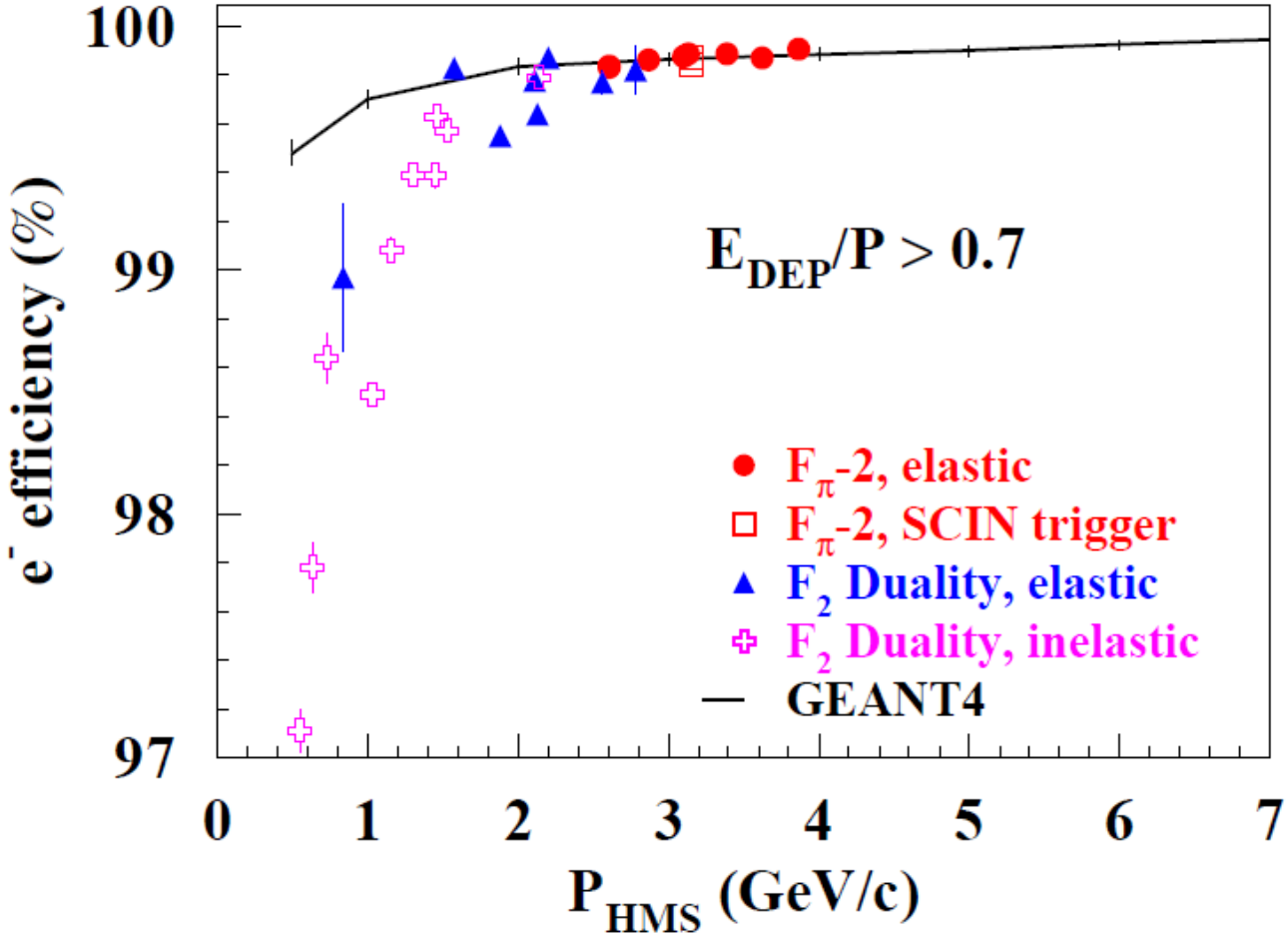
- **Design construction of the SHMS calorimeter is chosen, based on Monte Carlo simulations.**
- **A simulation code, based on GEANT4 package and QGSP-BERT physics model, was developed and used for evaluation of the performance of the calorimeter.**
- **The expected resolution is similar to the other lead glass calorimeters, but somewhat lower than for the HMS calorimeter.**

HMS & SOS calorimeters' construction continued 1



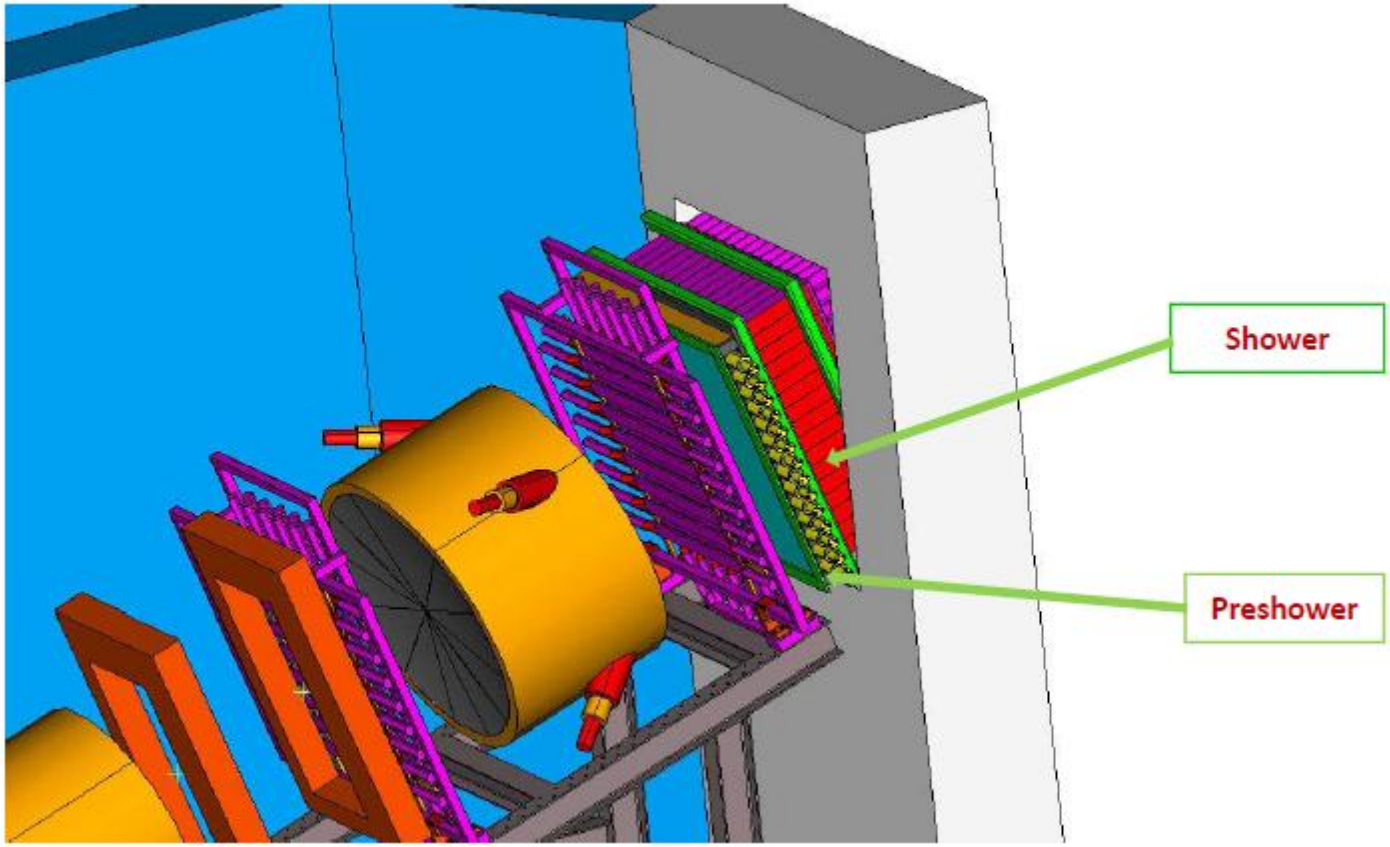
- **10×10×70 cm^3 TF-1 lead glass block optically isolated with 25 µm aluminized Mylar and 40 µm black Tedlar film.**
- **3" XP3462B Photonis PMT optically connected to the block with Bycron ND-703 optical grease of refractive index 1.46.**
- **6 turns of 100 µm thick µ-metal foil for magnetic shielding of the PMT.**

Electron detection efficiency in the HMS calorimeter cont'd



Disagreement between experimental and GEANT4/QGSP_BERT e- detection efficiencies at low energies < 1.5 GeV.

SHMS detector package continued



The calorimeter will partially sit in the rear concrete wall of the HMS shield house.