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Monte-Carlo simulations for Jlab Hall C SHMS Aerogel detector

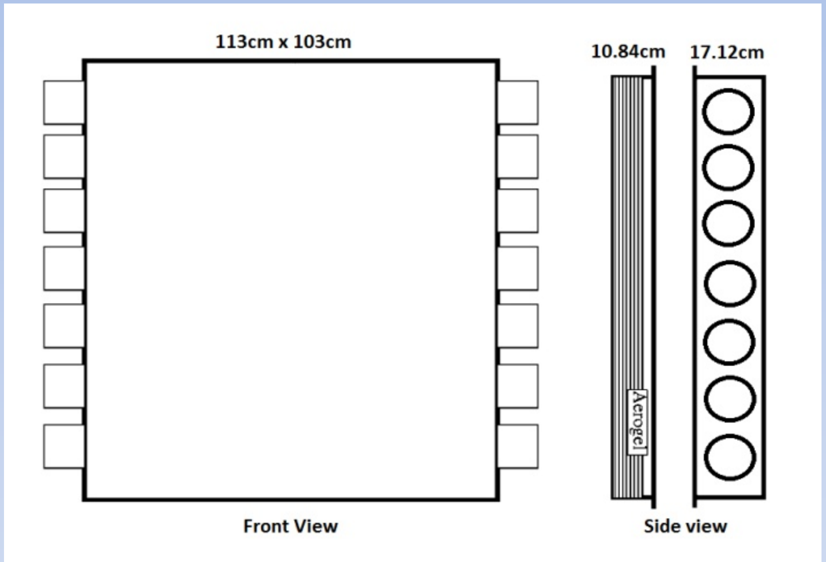
Hall C++ analyzer development

Aerogel detector Geant4 simulations

The simulation code incorporates:

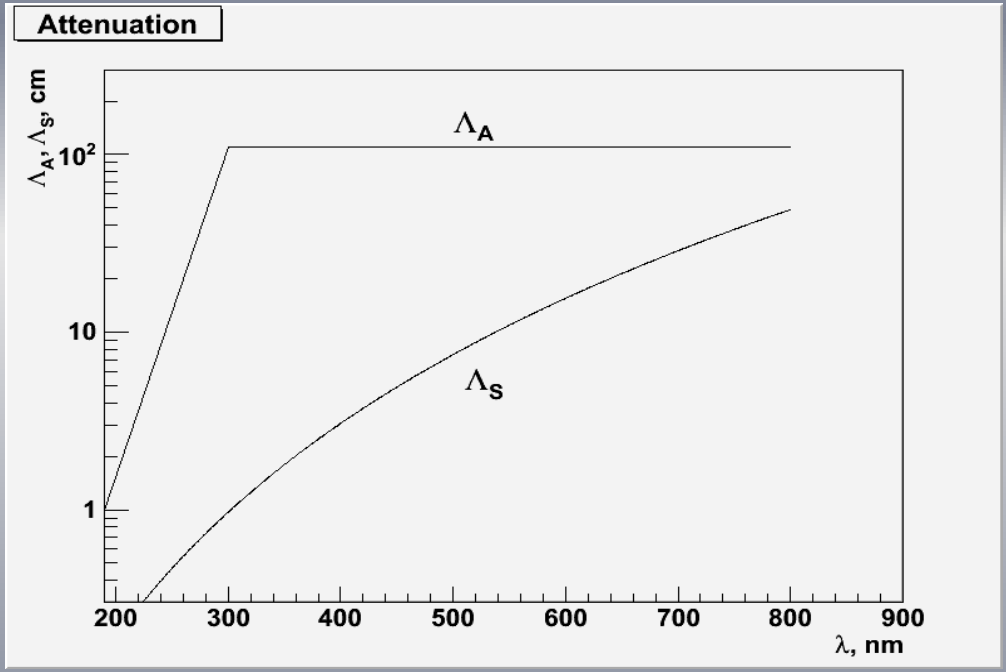
❖ Actual geometry detailed modeling
❖ Cherenkov light tracing
❖ Attenuation effects
❖ Millipore paper reflectivity
❖ Quantum efficiency spectrum of PMT photocathodes
❖ The initial particles coordinate, energy, and angular distributions

- **Geometry**



- **Initial particles** coordinate, energetic and angular distributions are generated according to appropriate conditions

- **Refractive index** assumed to be constant
- **Transmittance:** attenuation and scattering lengths

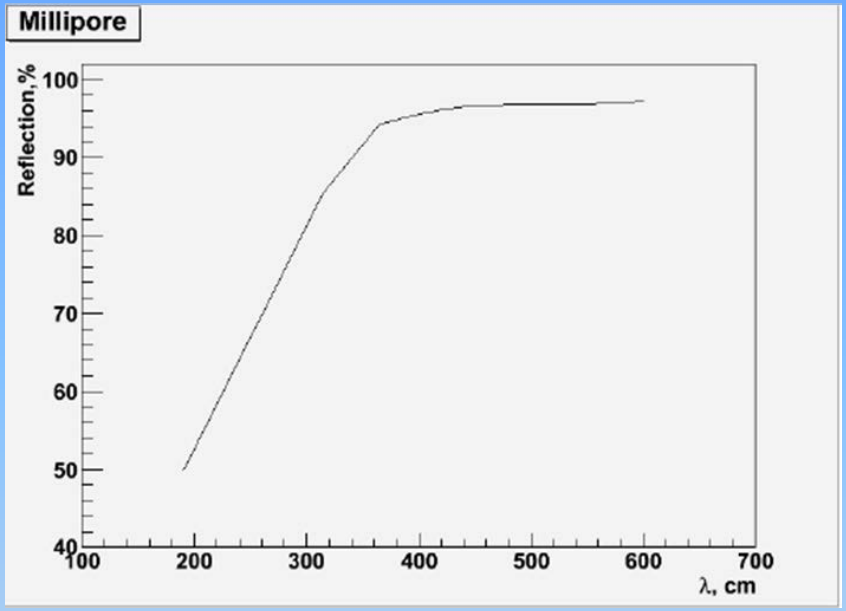


$$T = e^{-t(1/\Lambda A + 1/\Lambda s)}$$

where t is thickness of the material

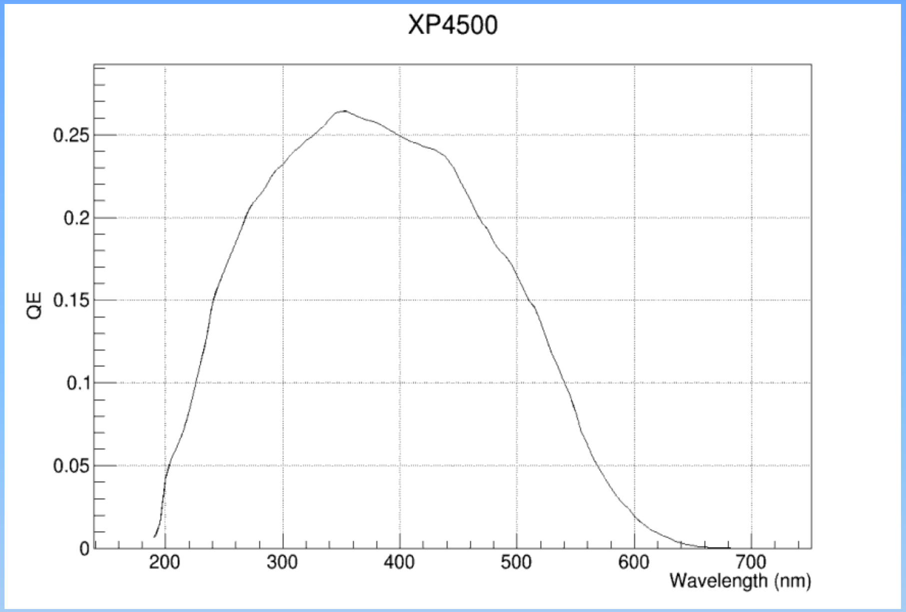
Λ_A and Λ_S may vary from tile to tile in wide range. In most simulations the averaged values were used. Simulations with randomized Λ_A and Λ_S show similar results

- **Millipore reflectivity**



From M. BENOT and P. J. CARLSON, TESTS OF LARGE CERENKOV DETECTORS WITH SILICA AEROGEL AS RADIATOR, NIM-A, 154 (1978) 253-260

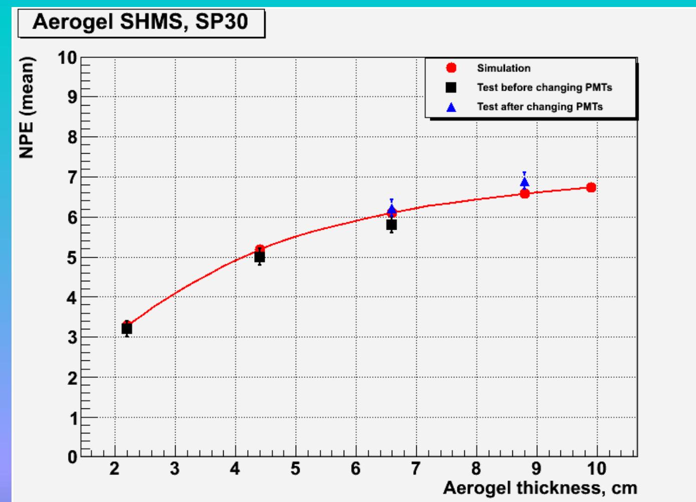
- **PMT quantum efficiency**



Derived from the radiant sensitivity curve provided by Photonis

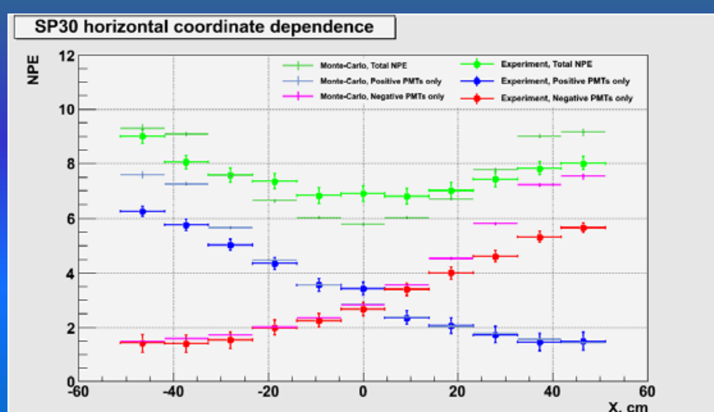
In simulations the QE spectrum provided by vendor is corrected by factor 0.6 to take into account the PMT degradation

Signal dependence on aerogel thickness

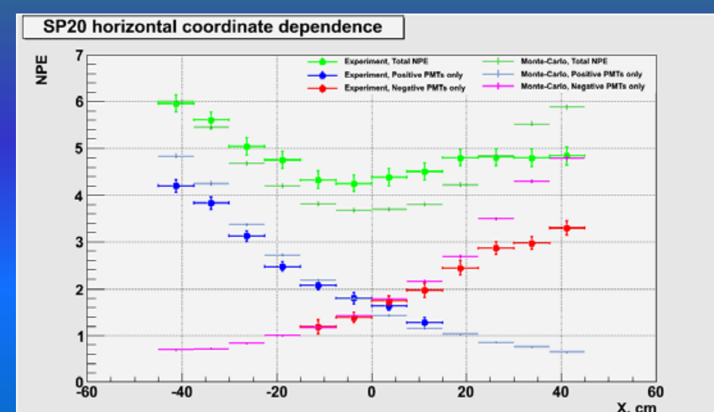


n = 1.03

Coordinate dependence

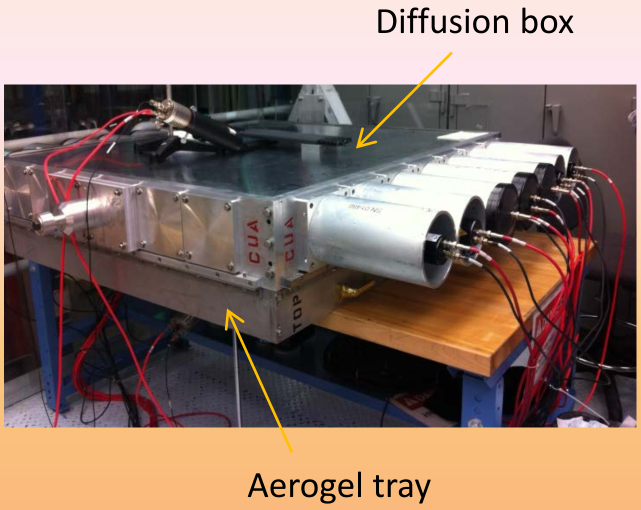


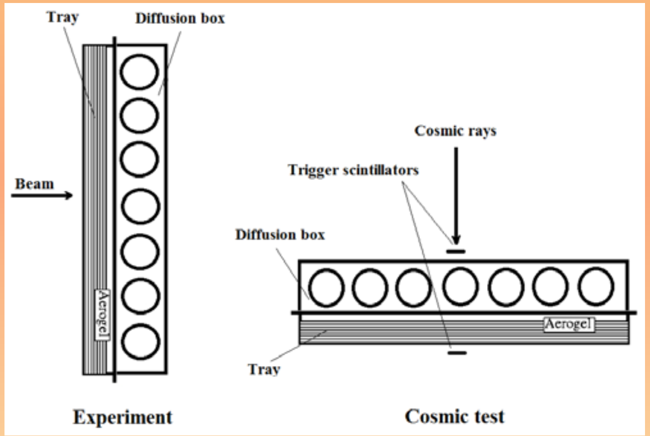
n = 1.03

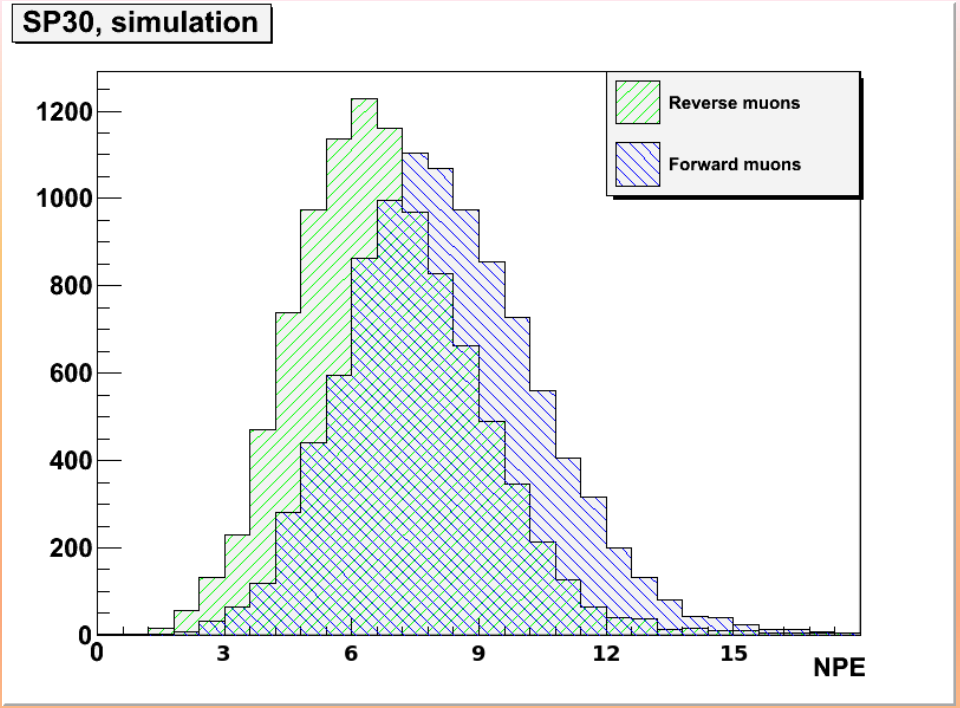


n = 1.02

Charged particle direction

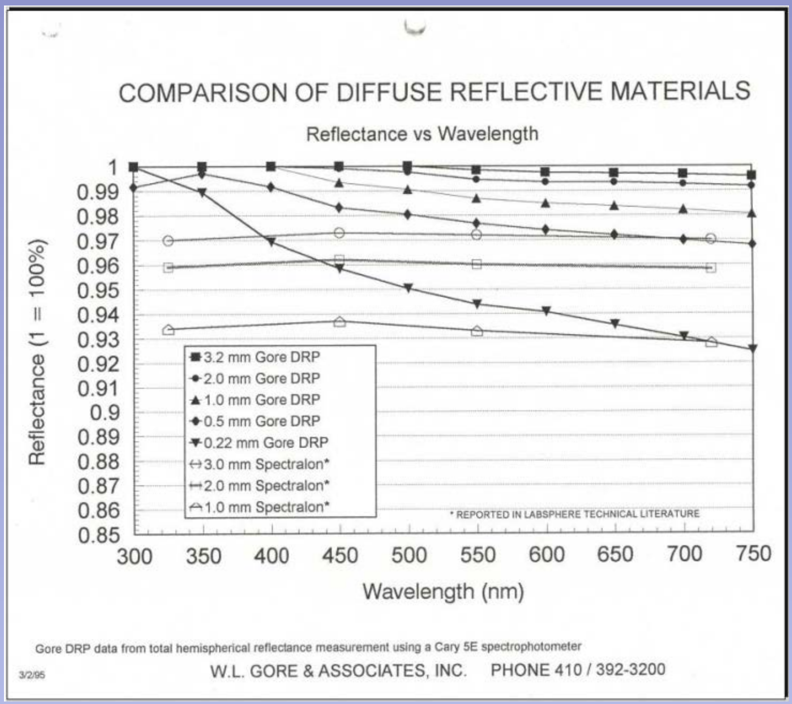


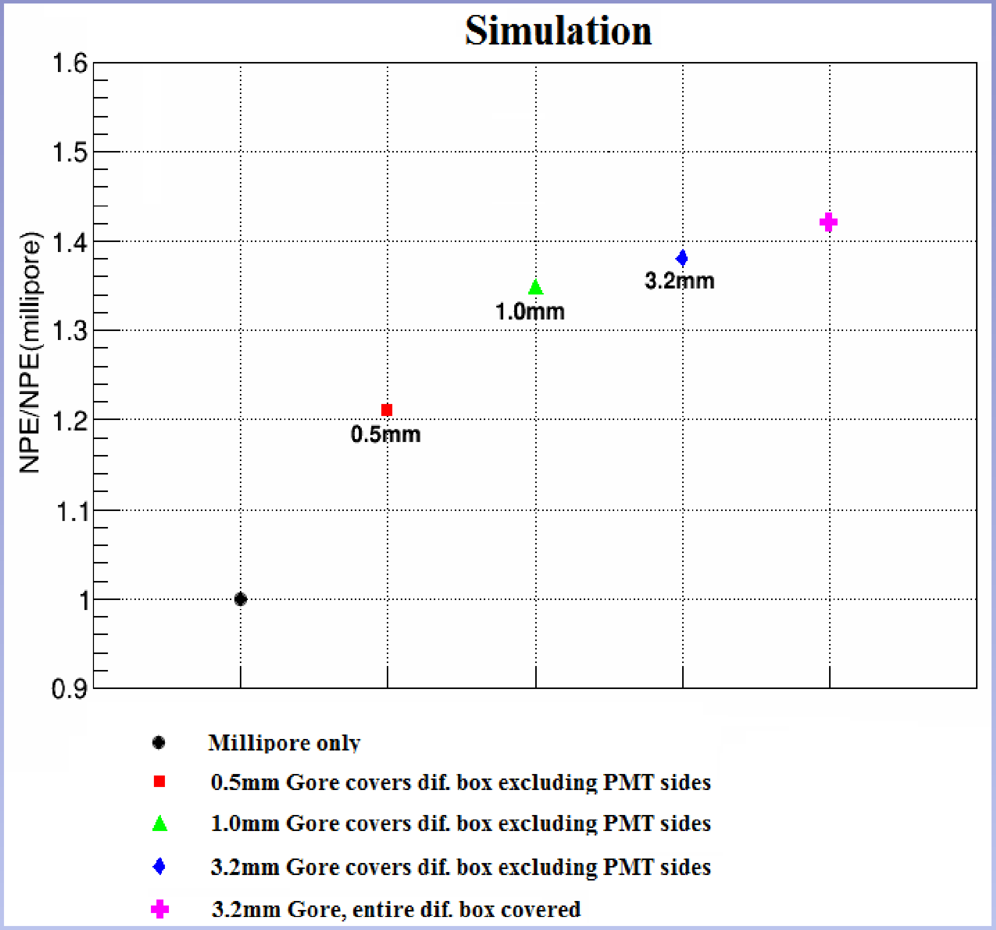




The cosmic tests are performed in reverse geometry. In actual experiment the signal is expected to be ~20% higher

Possibility of using alternative reflector





Gore reflector is claimed to be highly (~0.99 and higher) reflective in all operating range of the PMT

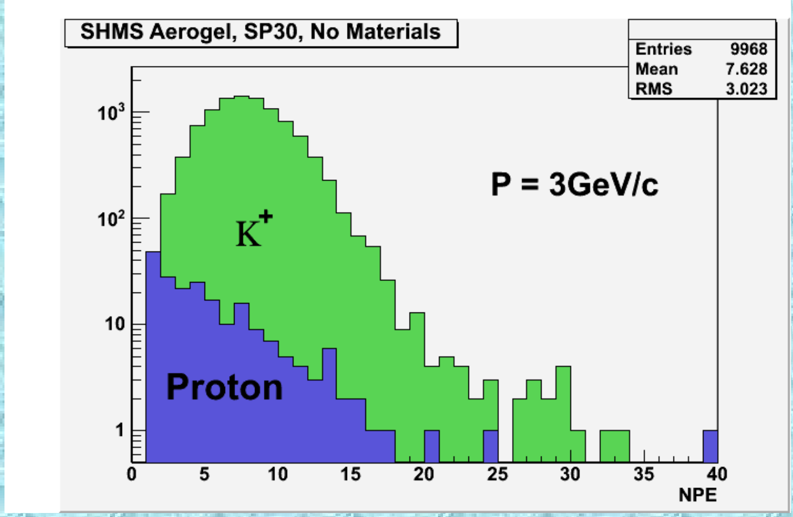
Simulations predict up to 40% signal improvement by using Gore diffuse reflector instead of millipore

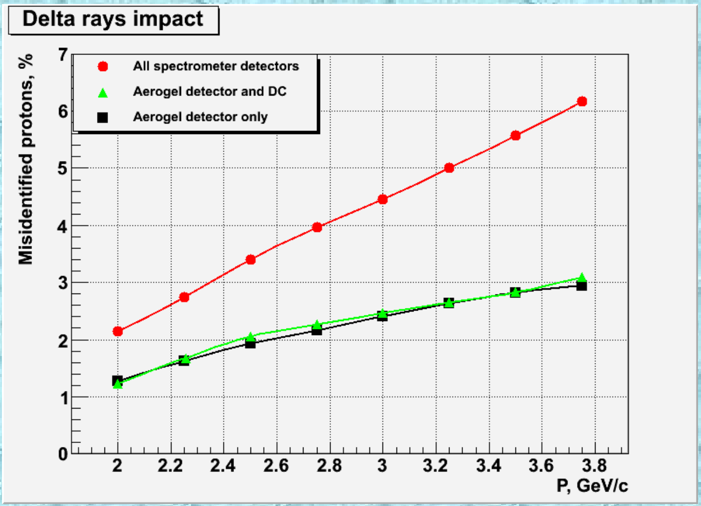
Delta-rays impact

Refractive Index	π threshold (GeV/c)	K threshold (GeV/c)	P threshold (GeV/c)
1.030	0.57	2.00	3.80
1.020	0.67	2.46	4.67
1.015	0.81	2.84	5.40
1.011	0.94	3.32	6.31

Electron threshold: 2.1 MeV/c (n = 1.03)

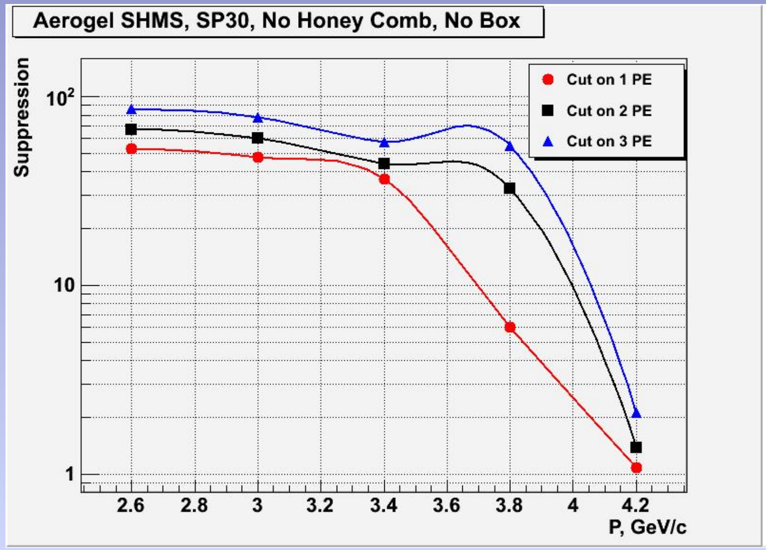
An under-threshold particle may create above threshold delta-particles in a material and generate signal

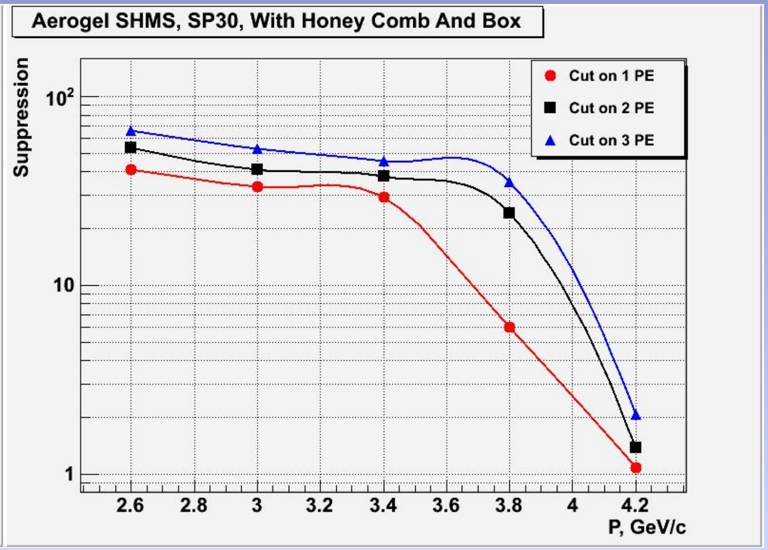


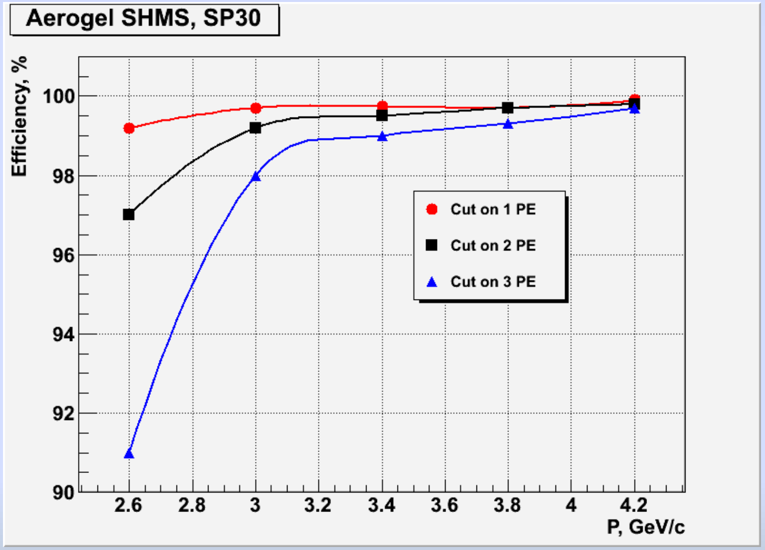


About 2% of 3 GeV protons generate non-zero signal due to delta-electrons created in 10cm of aerogel material

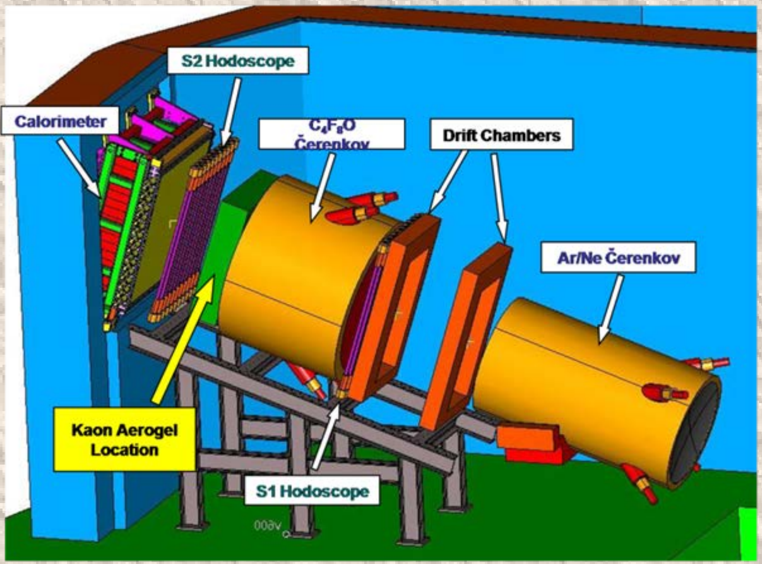
PID efficiency: kaon-proton suppression







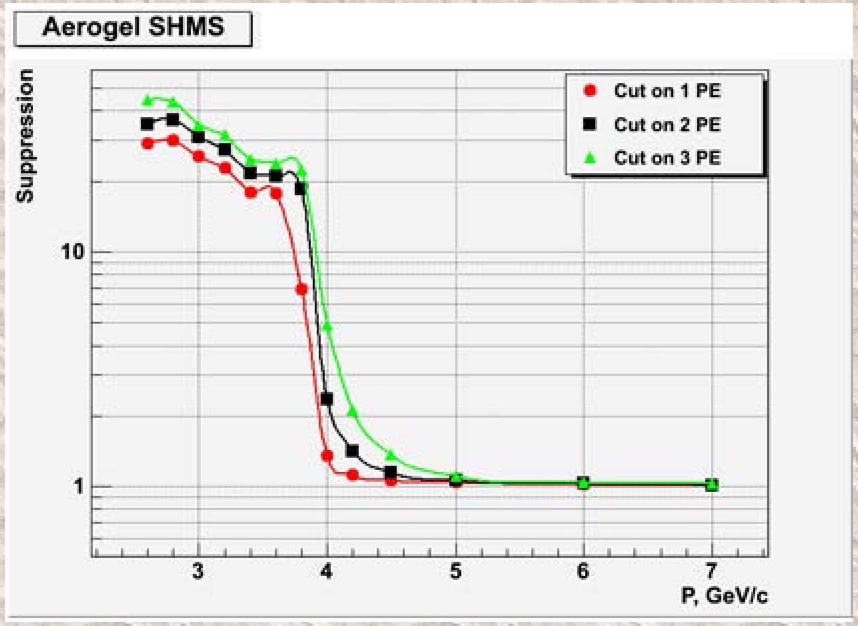
The detector itself (if no other spectrometer detectors are placed before it) is expected to provide suppression factor ~40-50 with kaon detection efficiency higher than 98%

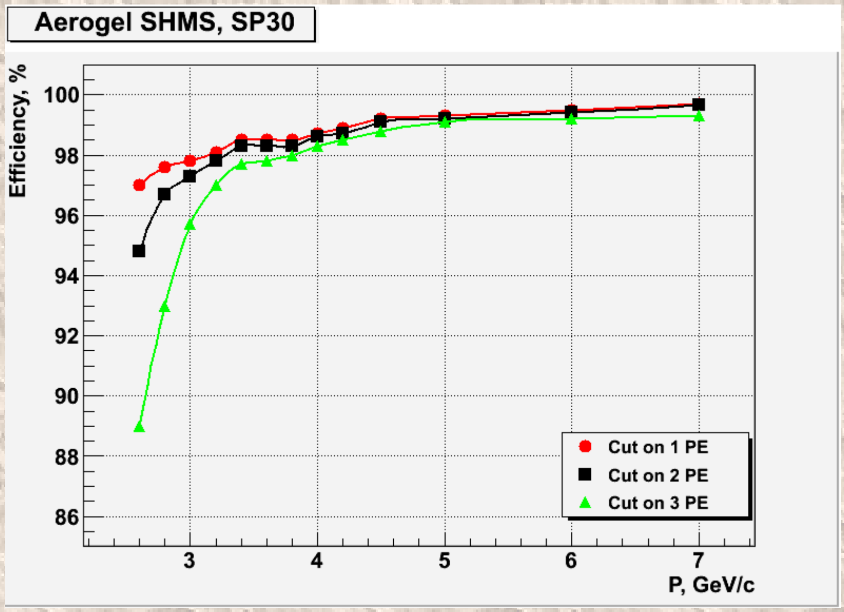


Detectors before the Aerogel Cerenkov in SHMS:

- **Heavy gas Cherenkov**
- **Drift chambers**
- **Hodoscope**
- **Noble Gas Cherenkov**

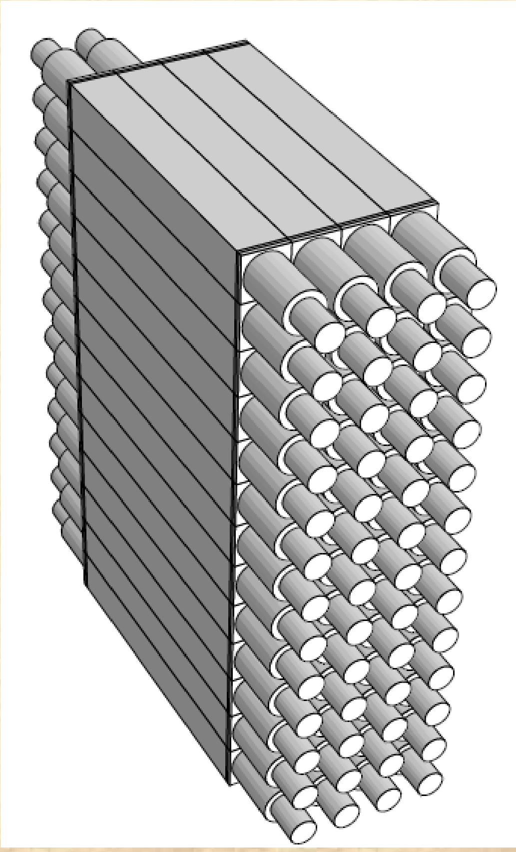
Due to delta-electrons from these detectors kaon-proton suppression of Aerogel Cerenkov drops to ~20-30





Hall C++ Analyzer progress: Calorimeter (Shower detector)

- The Shower detector consists of 52 lead glass blocks, arranged in 4 layers and 13 rows
- In the 1st and 2nd layers PMTs are attached to both right and left sides ("positive" and "negative" ADC channels)
- In the 3rd and 4th layers PMTs are on the right side only ("positive" ADC channels)



Analysis process: Init, Read DB

- **Run initialization**
  - Determining run number
  - Determining database
  - Determining detectors

- **Reading data from database:**
  - Geometrical parameters
  - Pedestal values
  - ADC channel to Shower block number mapping
  - Calibration constants

Analysis process: Decode

- **Decoding data**
  - Distinguishing pedestal events
  - Calculating pedestals mean values and sigma's
  - Calculating signal thresholds:

    $$Thr = Max(50, Min(10, 3*\sigma))$$

  - Reading raw ADC value
  - Calculating pedestal subtracted values

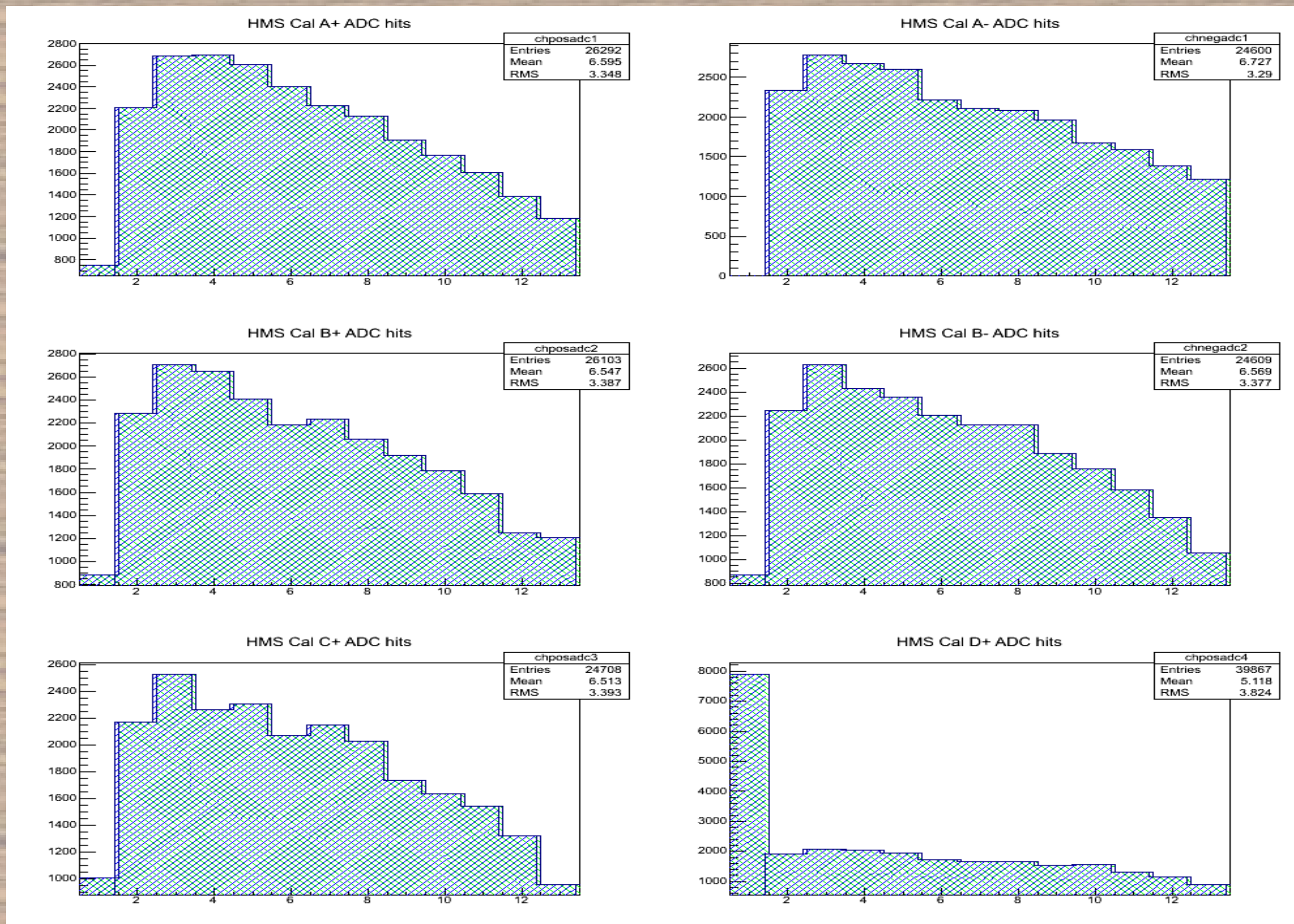
- **Output**
  - Determining basic variables
  - Filling the tree
  - Filling and saving histograms

Comparing results with Fortran ENGINE

ADC hit maps; MDUALITY experiment, run # 50017

ENGINE histograms are deliberately shifted to be seen together with the C++ analyzer histograms

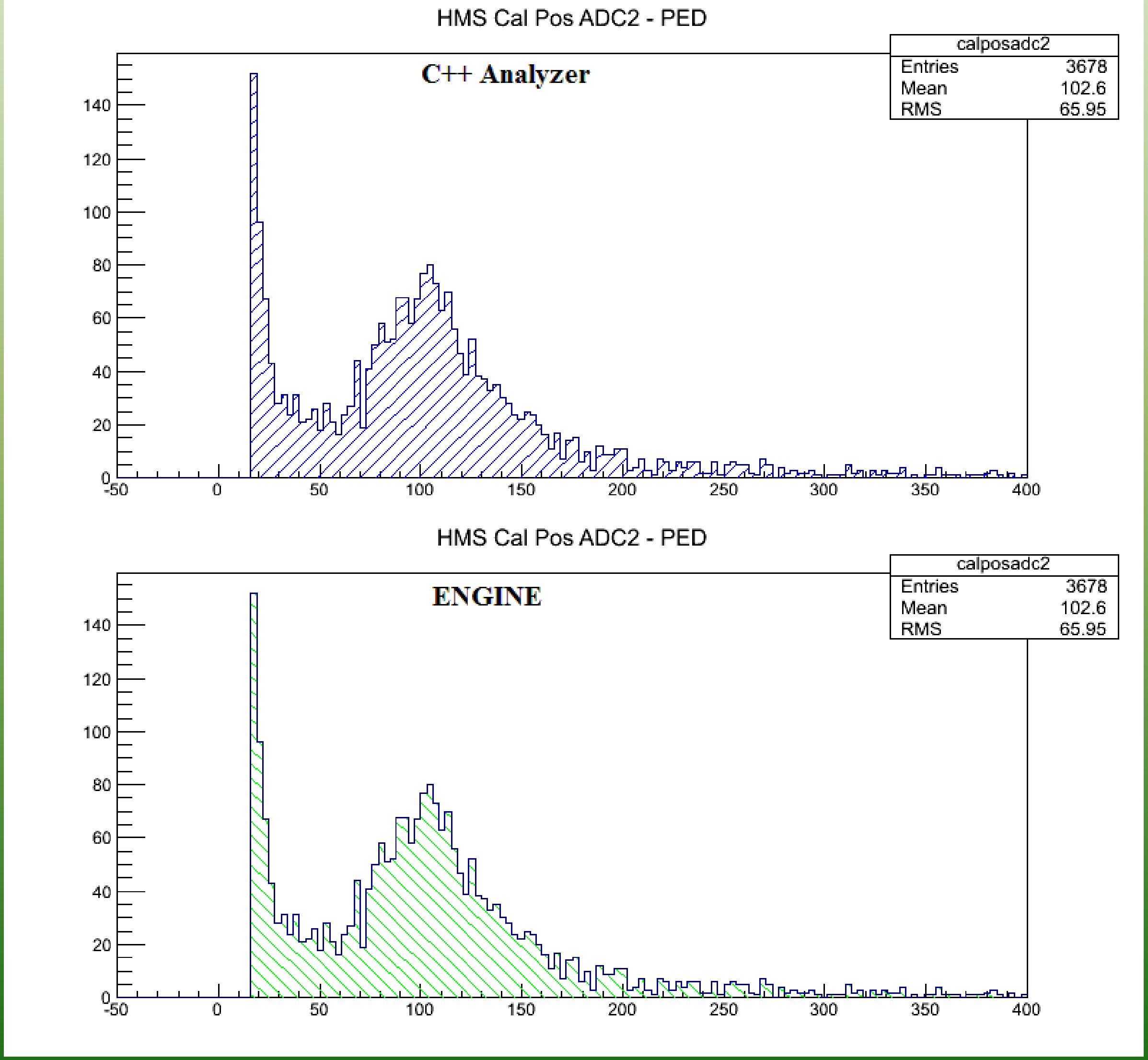
Results match

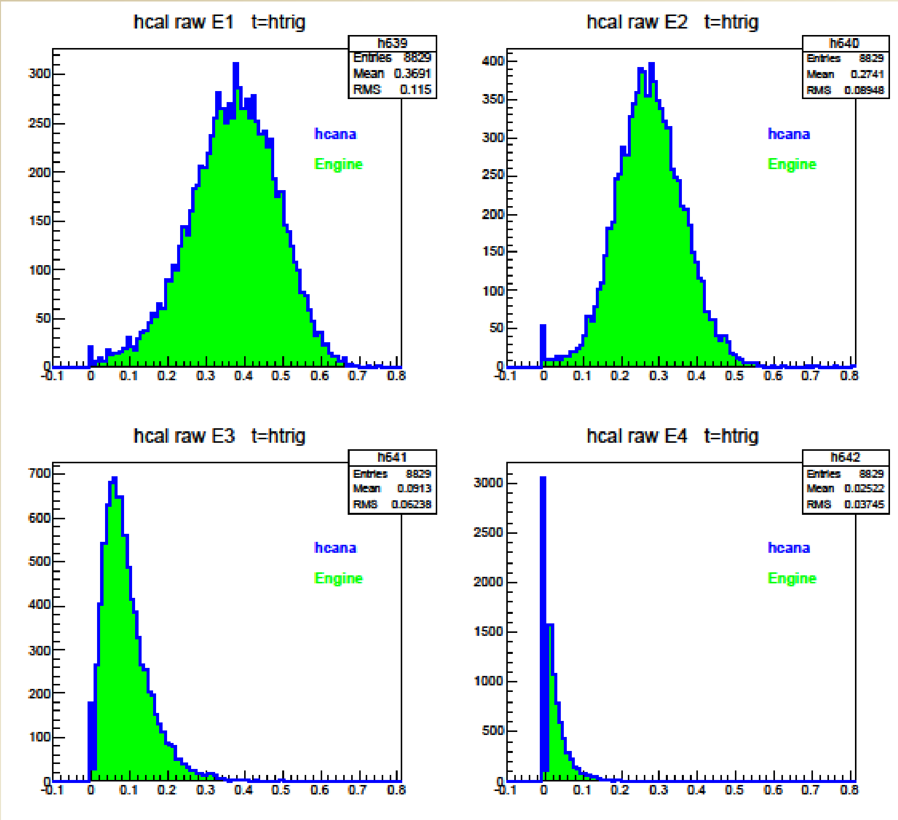


Comparing results with Fortran ENGINE

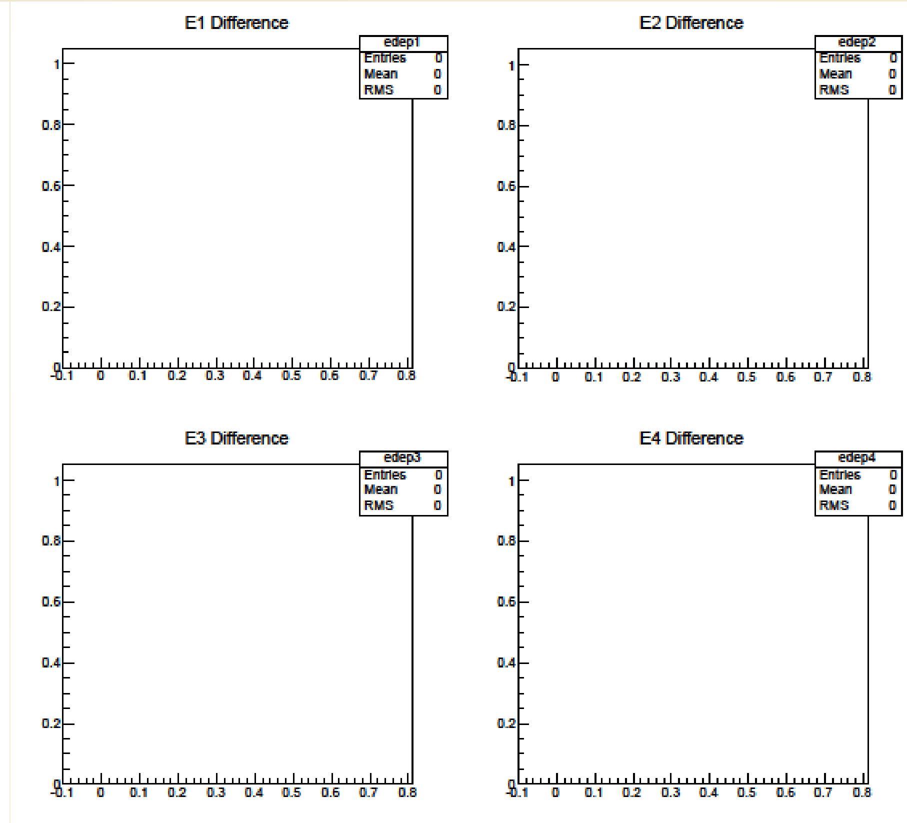
ADC – pedestal example, thresholds applied; MDUALITY experiment, run # 50017

Results match

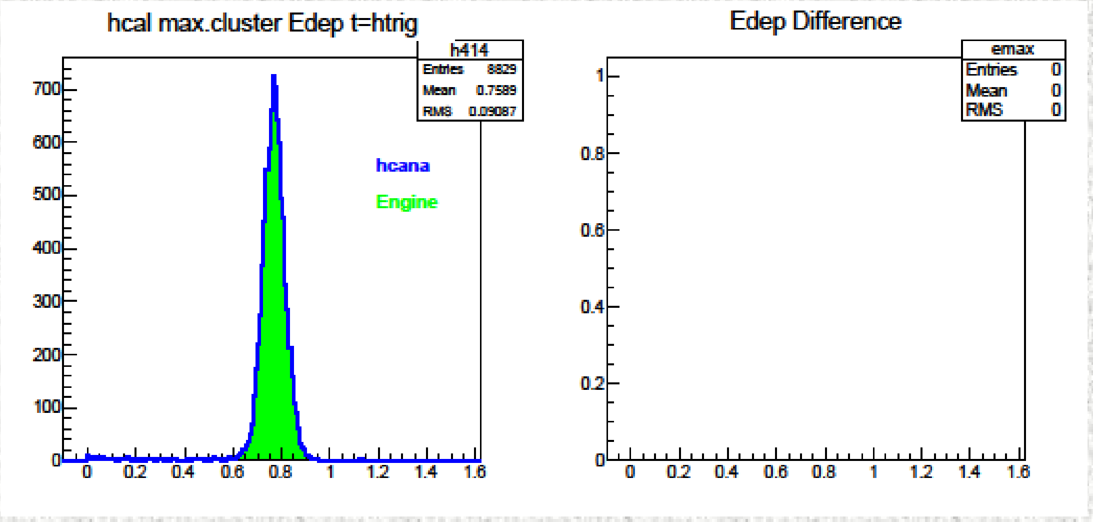




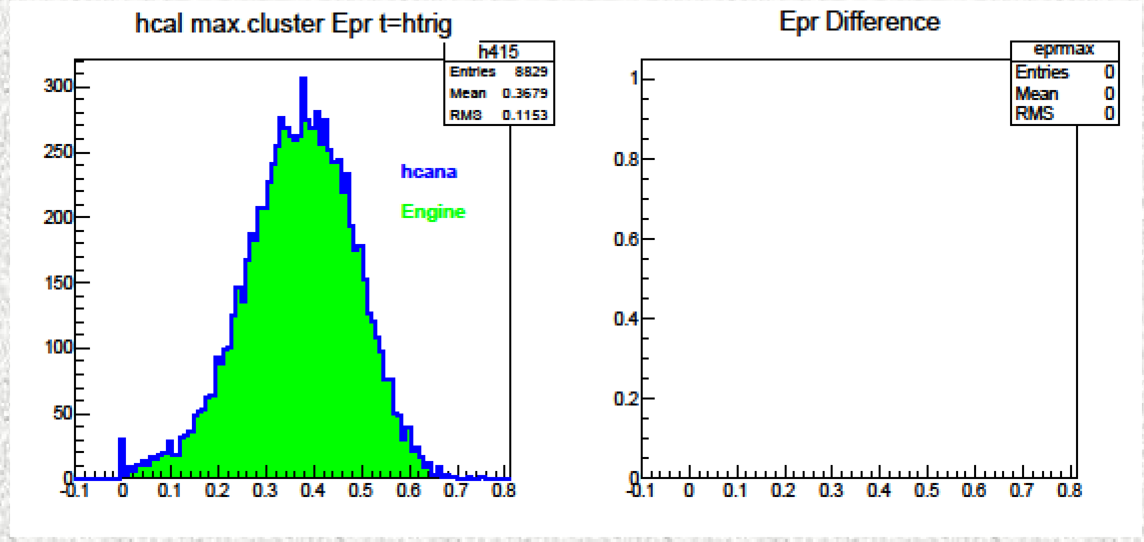
Raw energy depositions in 4 layers of the HMS calorimeter, from Engine and hcana



Differences in the raw energy depositions for the 4 layers



The largest energy deposition in the hit clusters (left) and difference between hcana and Engine (right)



Energy deposition in the Preshower (1-st layer) for the cluster with largest energy deposition (left) and the difference between hcana and Engine (right)