EIC Dual Readout Simulations

ECCE Calorimetry Group Meeting
June 8, 2021

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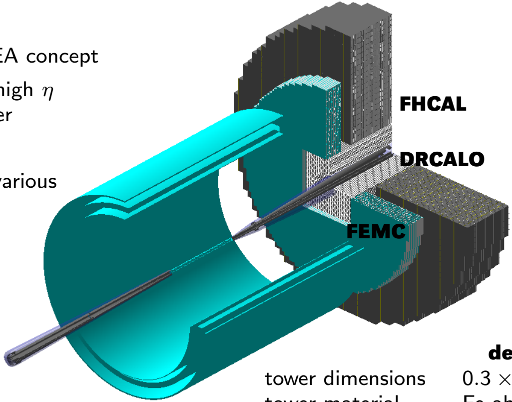
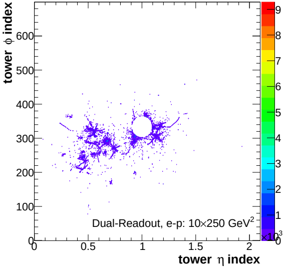
Calorimeter Setups in Fun4All - Dual Readout

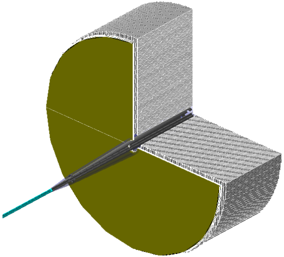
`fun4all_eicdetectors/simulation/g4simulation/g4drcalo/PHG4ForwardDualReadoutSubsystem.cc`

Forward Dual Readout Calorimeter:

- Baseline design derived from IDEA concept
- Replaces FEMC and FHCAL at high η
  $\rightarrow$ or both calorimeters altogether
- See [link] for more info
- Tower design being worked on (various designs available)







Caveats:

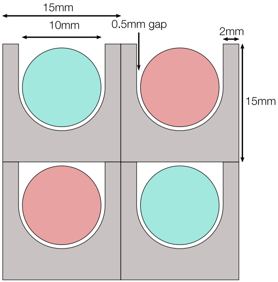
- no support structures and services implemented
- no light propagation and electronics simulation
- clusterization not solved (ML?)
- steel material required for flux return

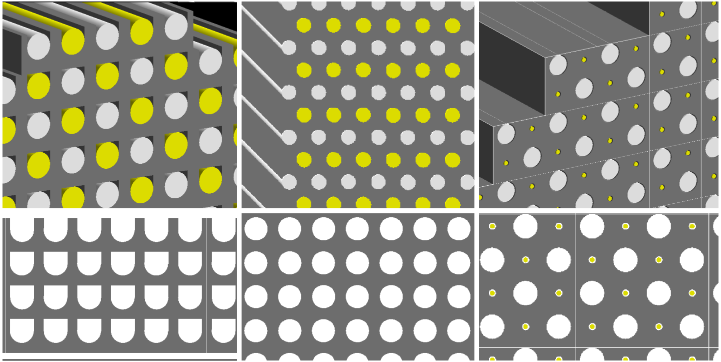
default design:

tower dimensions	$0.3 \times 0.3 \times 150$ cm^3
tower material	Fe absorber
	2 Sci fibers, 2 quartz fibers
interaction length	$L \sim 6\lambda$
pseudorapidity	$2.7 < \eta < 3.7$
global position	center at 3.75m from IP
	width of $\sim$ 55cm

Dual Readout Calorimeter - Tower designs

- Variety of tower designs already implemented
  → focused around different fibers or machining processes
- Detailed studies yet to be performed regarding performance and design optimizations





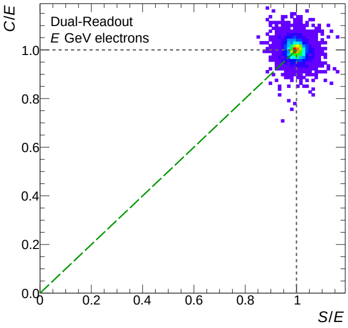
Dual Readout Calorimeter - First results

Step 0: Reconstruction

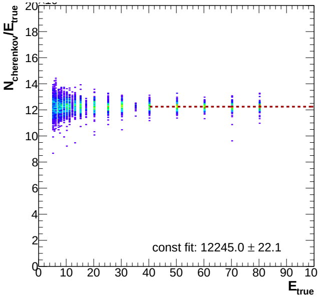
- currently clusters are just the sum of all tower energies
- clusterizer will need separate serious development (maybe ML-based?)

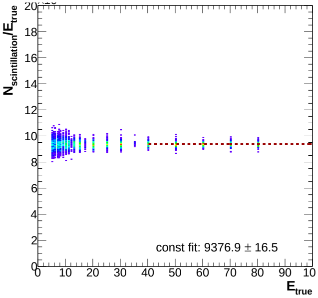
Step 1: Calibration

- calibration based on electrons of known energy
  $\rightarrow$ result: $\langle S \rangle = \langle C \rangle = E$
- electrons will be located around (1,1) in *S*-*E* distribution



S-E distribution independent of particle energy!

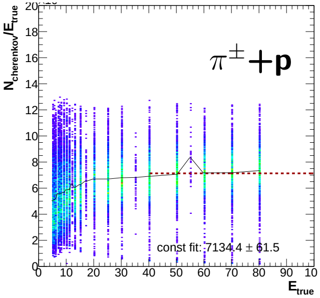


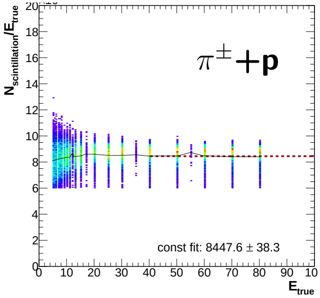


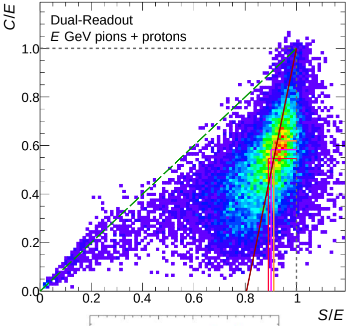
Dual Readout Calorimeter - First results (2)

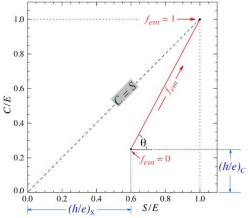
Step 2: h/e determination

- value determined from high E fits on $N_{\mathrm{cher,scin}}/E_{\mathrm{true}}$ of electrons and hadrons
  $\rightarrow$ values indicated as lines in right plot (red=pions, yellow=protons,pink=hadrons)
- red line determined from fit of h/e values and constrained to include (1,1)









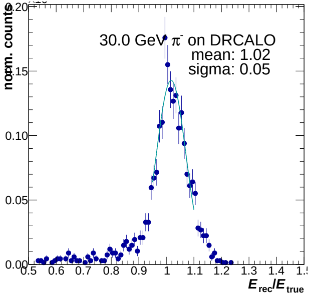
Dual Readout Calorimeter - First results (3)

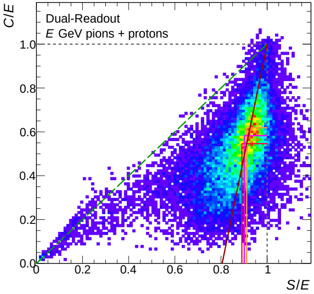
Step 3: rotation of points

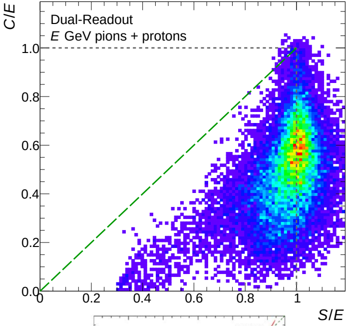
- distribution is independent of particle type and energy
  $\rightarrow$ rotation method allows for high precision energy measurement
- energy for each particle can be calculated as:

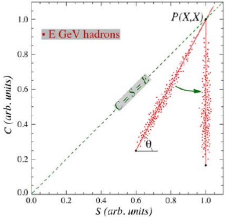
$$E = \frac{S - \chi C}{1 - \chi} \qquad (1)$$

with $\chi = \frac{1-(h/e)_S}{1-(h/e)_C} = \cot\theta$









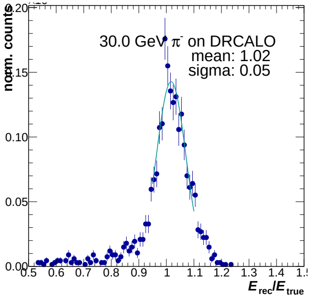
Dual Readout Calorimeter - First results (4)

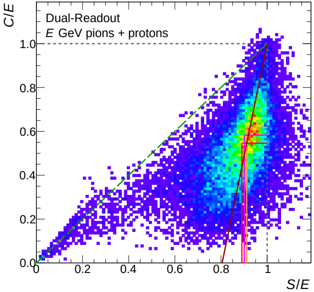
Step 4: energy resolution

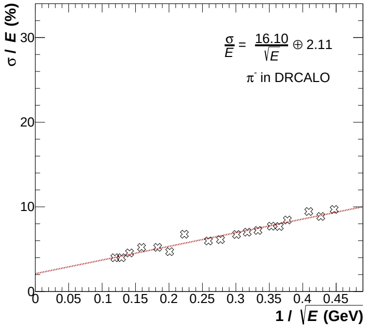
- energy resolution determined via gaussian fits on $E_{\mathrm{rec}}/E_{\mathrm{true}}$ in multiple bins
- resolution appears too good

Step 5: optimizations

- Further improvements of simulation needed
- tower geometry/reconstruction treatment
- material optimization



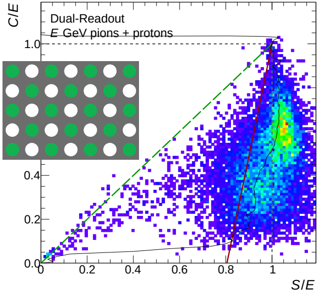


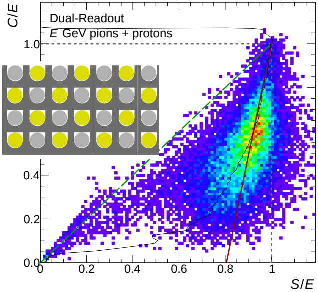


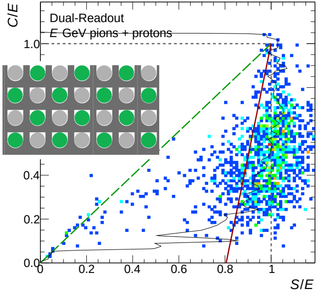
C-S for different tower designs

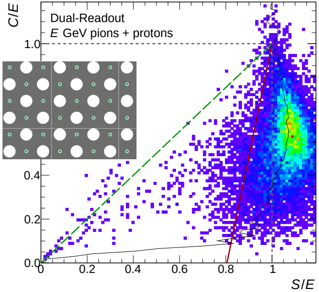
- Steel absorber in dark gray
- Scintillation fibers in light gray or white
- Cherenkov fibers in yellow (PMMA) and green (Quartz)
- Red line indicates fit ob default design (bottom left)
- Black line gives mean value of distribution

Not sure why for some designs distribution shifted to S/E > 1









Next Steps

- Collaborate with Korean colleagues to improve simulation
  $\rightarrow$ e.g. implementation of light yields, efficiencies, light propagation, ...
- Test tungsten as absorber for ECCE (more radiation lengths over 1.5m)
- Performance studies of standalone and combined setup with FEMC and FHCAL
  $\rightarrow$ e.g. γ and π^0 separation, jet reconstruction, ...

Backup