EIC-ZDC

Far-Forward and IR Integration YR meeting

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EIC Detector R&D Proposal

- Submitted on May 29, 2020
  - "Developing a High Resolution ZDC for EIC"
- Soft photon detection
  - Detector & acceptance simulation
- EM and hadron calorimeter
  - Detector simulation
  - Calibration scheme
  - (ALICE-FoCal R&D by RIKEN)
  - (LHC-ZDC R&D by Kansas Univ.)
- Radiation hardness
  - Simulation study
  - Radiation test

Performance requirements and resources requested

Detector R&D	Physics	Performance requirements	Resource requested	Support & collaboration
Soft photon detection	e+A nuclear breakup veto	$E_\gamma \leq 300$ MeV	detector simulation	This proposal Calorimeter consortium
		acceptance	acceptance simulation	This proposal BeAGLE group
		detector technology	detector R&D	N/A in FY21
EM + hadron calorimeter	e+A collision geometry	neutron multiplicity	high resolution not necessary	BeAGLE group
	spectator tagging	energy & position resolution	detector simulation	This proposal
	meson structure	neutron & Λ acceptance	detector simulation	This proposal Meson structure WG
		detector technology	FoCal R&D	RIKEN
			LHC-ZDC R&D	Kansas Univ.
		calibration scheme	design & simulation	This proposal
			system test	N/A in FY21
Radiation hardness		radiation dose	simulation study	This proposal Kobe Univ.
		detector technology	radiation test	This proposal Calorimeter consortium

Table 1: Table of performance requirements.

Soft photon detection

- Photons from nuclear excitation
  - Necessary to identify coherence of the collision
  - Collaboration with BeAGLE group (eRD17)
- Large (as large as possible) aperture
  - Only 20% of such decay photons are detectable in the ZDC aperture of 4.5 mrad
  - Second IR design will allow a larger ZDC acceptance
- Full absorption calorimeter
  - With good enough energy resolution
  - e.g. crystal scintillator (LYSO, PWO, …)
  - Collaboration with the calorimeter consortium (eRD1)

EM and hadron calorimeter

- Acceptance
  - 60 x 60 cm^2 for vetoing spectator neutrons from nuclear breakup
- Energy, position, and p_T resolution
  - Hadron energy resolution < 50% / $\sqrt{E}$ (GeV) $\oplus$ constant term
  - Sufficient longitudinal size of 10 interaction length
  - Sufficient transverse size of 2 interaction length
    - to avoid leakage for good hadron energy resolution

EM and hadron calorimeter

- EM calorimeter
  - ALICE-FoCal-E
    - Si + W sampling calorimeter
  - Longitudinal segmentation
  - Low granularity layers (Si-pad) for energy measurement
  - High granularity layers (Si-pixel) for accurate position information
- Hadron calorimeter
  - Energy resolution < 50% / $\sqrt{E}$ (GeV) $\oplus$ constant term
  - Angular resolution < 3 mrad / $\sqrt{E}$ (GeV)
  - ALICE-FoCal-H
    - Pb + Scintillator (spaghetti design)
    - No final design yet
  - LHC-ZDC
    - Quartz fiber with traditional scintillators

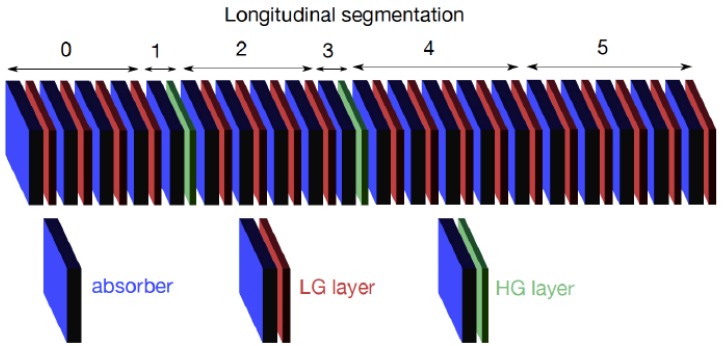

Figure 2: Schematic of the FoCal electromagnetic calorimeter. The blue absorber is tungsten, the red low grantularity silcon layers are used for energy measurement while the green high granularity layers give precise position information [3].

Radiation hardness

- Estimated to be ~100K-1M Gy or n_{eq}~$10^{14\text{-}15}$ for 1-year operation of e+p collisions or $10^{15\text{-}16}$ for lifetime
  - More simulation study to be performed
    - Beam-gas rate, …
- Plastic sceintillator is an attractive option for good *e/h* or hadron energy resolution
  - e.g. PEN may stand for > 0.1 MGy radiation
- Calibration contribute to constant term of the energy resolution
  - Expected to be 3%
  - Spoiled by channel-by-channel variation changing by radiation damage

Simulation studies

- ALICE FoCal-E on the g4e framework
- Hadron calorimeter to be added
  - LHC-ZDC w/ fused silica Cerenkov fibers

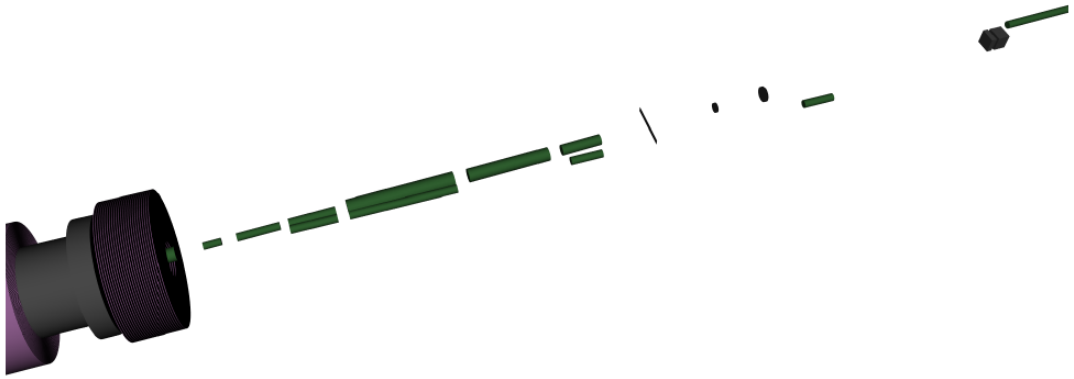

Figure 5: Schematic view of the forward region of the EIC showing the central detector, magnets, the off momentum detectors, Roman Pots and the ZDC.

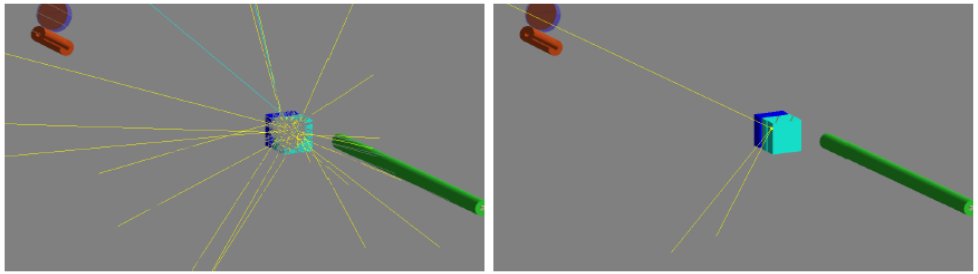

Figure 6: Event displays for (Left) a 20 GeV neutron and (Right) a 500 MeV photon impinging upon the ZDC