EEEMCAL – Electromagnetic Endcap EM calorimeter for EIC

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For the EEEmCal team

Expression of Interest – EEEmCal

Please indicate the name of the contact person for this submission:

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Please indicate all institutions collectively involved in this submission of interest:

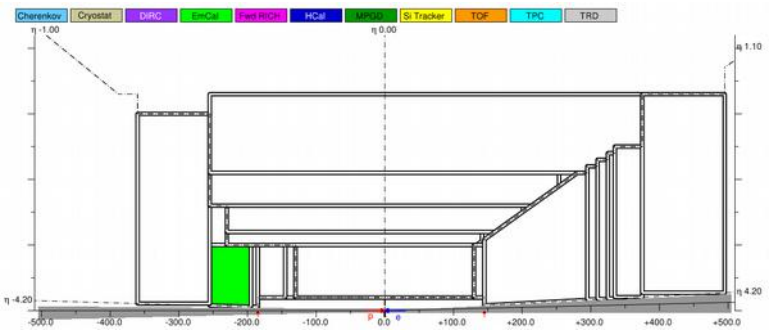
CUA (contact: Tanja Horn), Lehigh U. (contact: Rosi Reed), MIT and MIT-Bates Research and Engineering Center (contact: Richard Milner), U. Kentucky (contact: Renee Fatemi), AANL (contact: Ani Aprahamian), FIU (contact: Lei Guo), Charles U.-Prague (contact: Miroslav Finger), IJCLab-Orsay (contact: Carlos Munoz-Camacho)

Please indicate the items of interest for potential equipment cooperation:

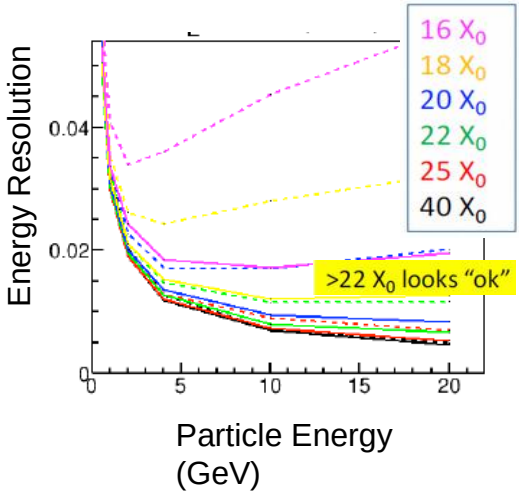
Electron Endcap Electromagnetic Calorimeter (Crystal/Glass)

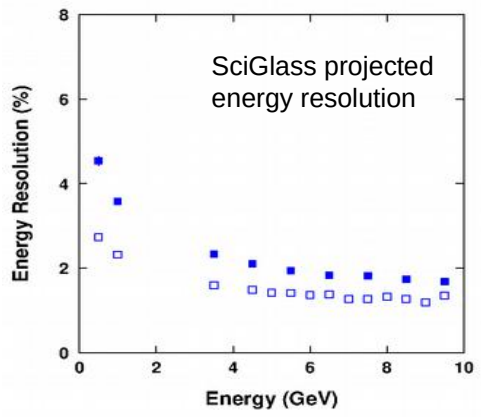
- Radiator: crystal/glass fabrication and characterization
- Frame design/construction - to hold the crystal/glass bars
- Readout, electronics, detector cabling and infrastructure
- Prototype construction/commissioning and beam tests
- Slow controls and online software
- Calorimeter assembly
- Monte Carlo simulation and comparison with test beam results
- Calibration and monitoring of performance

Electron Endcap EM Calorimeter for Electron Detection - Goal



We aim to design and construct the scattered electron detection in the Lepton Endcap covering pseudorapidity -3.5 to -1 with an electromagnetic calorimeter (**EEEMCal**).





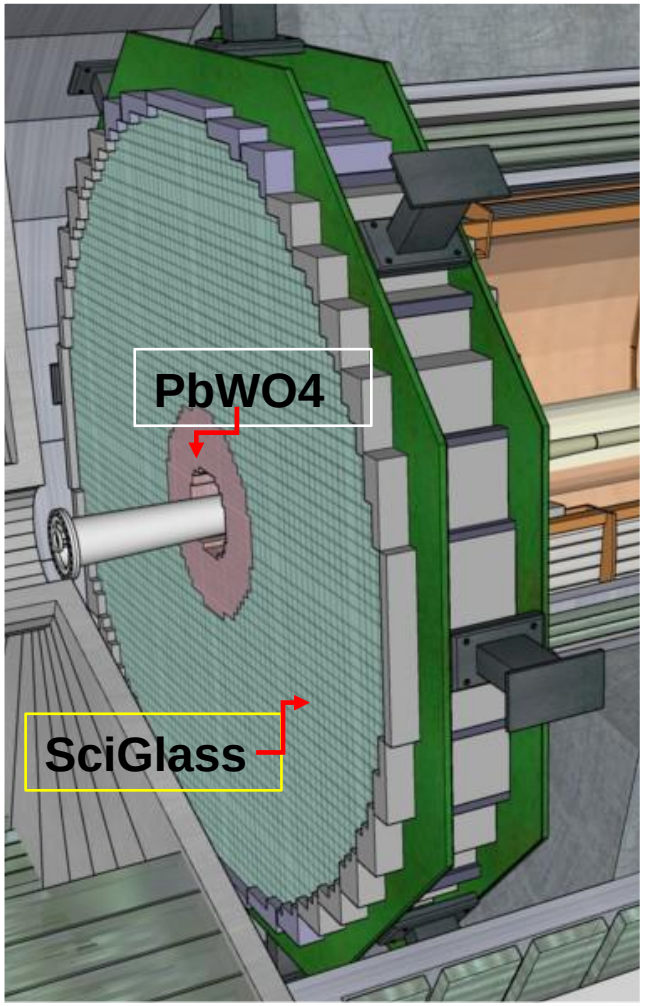
REFERENCE

PbWO4 crystals (inner)

- compact, radiation hard, luminescence yield to achieve high energy resolution, including the lowest photon energies
- Sensor: SiPMs (TBC)

SciGlass (outer)

- EIC eRD1
- radiation hard, luminescence yield similar or better than crystals depending on longitudinal length
- Sensor: SiPMs (TBC)



EEEMCal Team – Examples of Infrastructure and Expertise

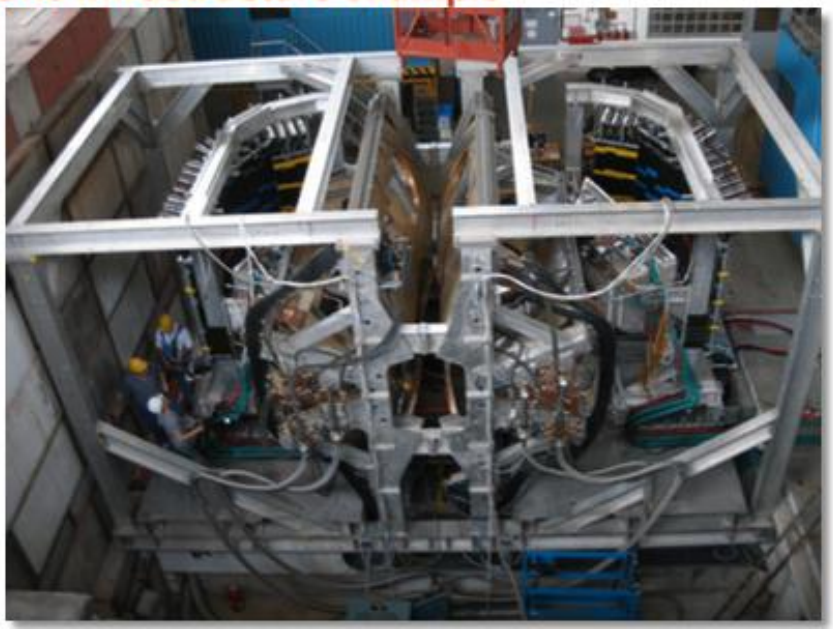
Selected calorimeters

SHMS EMCal: 28 TF-1 (preshower) and 224 F-101 (shower) blocks

NPS: 1080 $PbWO_4$ (CRYTUR, SICCAS)

STAR: installed ECAL of the forward upgrade

One infrastructure example

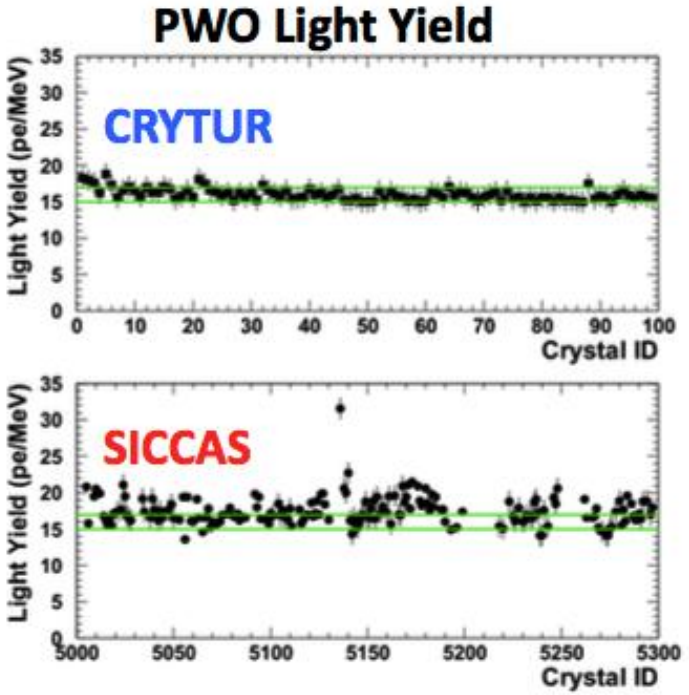


- Collective experience includes detector design and construction, technical support and infrastructure, readout electronics, crystal/glass fabrication and characterization
- Collective background includes hadron and heavy ion physics at BNL and JLab

OLYMPUS/DESY (BLAST) spectrometer: designed, fabricated, commissioned and operated at Bates

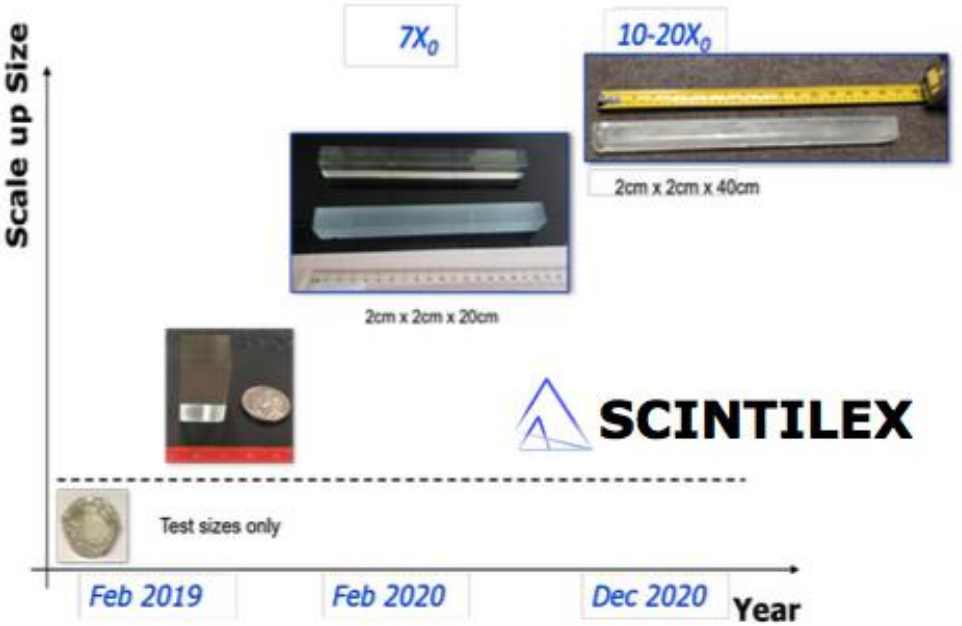
Electron Endcap EM Calorimeter for Electron Detection – $PbWO_4$ crystals

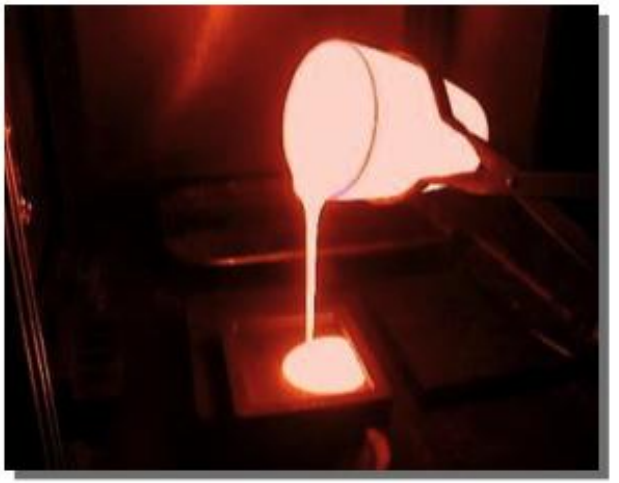
- Up to 2010 – PWO-II production at BTCP, Russia
  - Missing funding -> bankruptcy of BTCO
- Limited availability of reliable SICCAS (China) crystals that would be compatible with experiment requirements
  - ~900 produced for JLab projects since 2017 – Q&A concerns, 30-40% rejection
- 2014 – restart of high-quality PWO-II production at CRYTUR, Czech Republic
  - ~900 produced for JLab projects since 2018 at rate of ~20-30 crystals /month
- Cost of PWO crystals ($15-25/cm^3)



Electron Endcap EM Calorimeter for Electron Detection – SciGlass

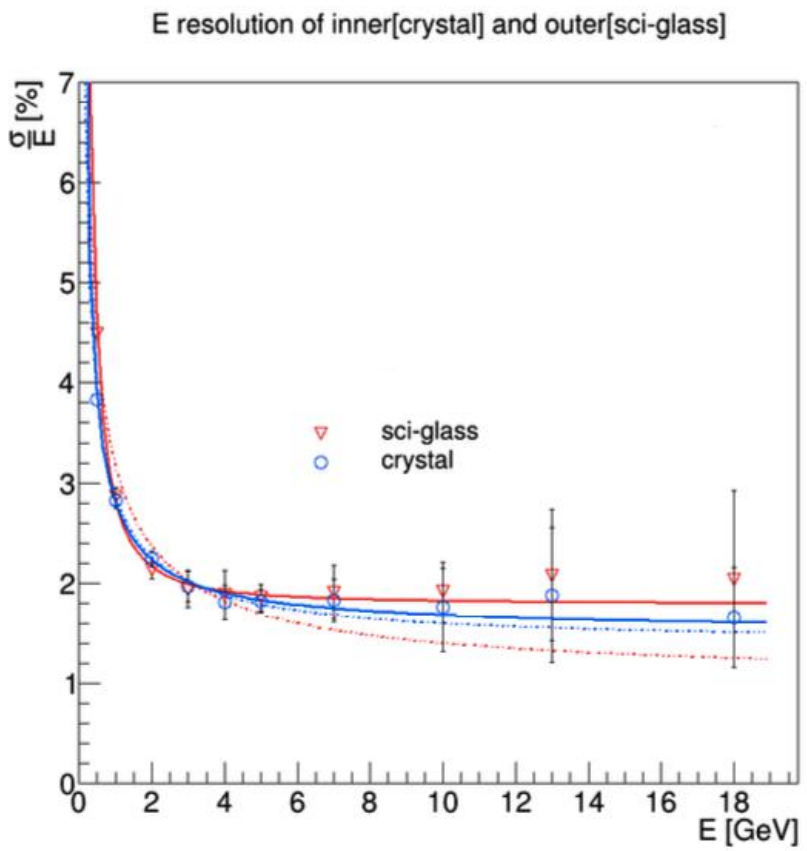
- 2019 – start of SciGlass R&D at Scintilex and VSL
  - Production of ~90-100 test size samples to optimize formulation
- 2020 – demonstration of initial scale up to 20cm long bars (~10X_0)
  - Initial evaluation with R&D prototype together with simulation suggests that resolutions comparable to PWO can be reached when comparable radiation lengths are used
- 2020/21 – production of the first 15-20X_0 long SciGlass block
  - Ongoing R&D includes prototype beam tests, consistency of product quality over many repetitions, selection and optimization of process features towards large scale production, etc.
- Anticipated cost of SciGlass ($2/cm^3)

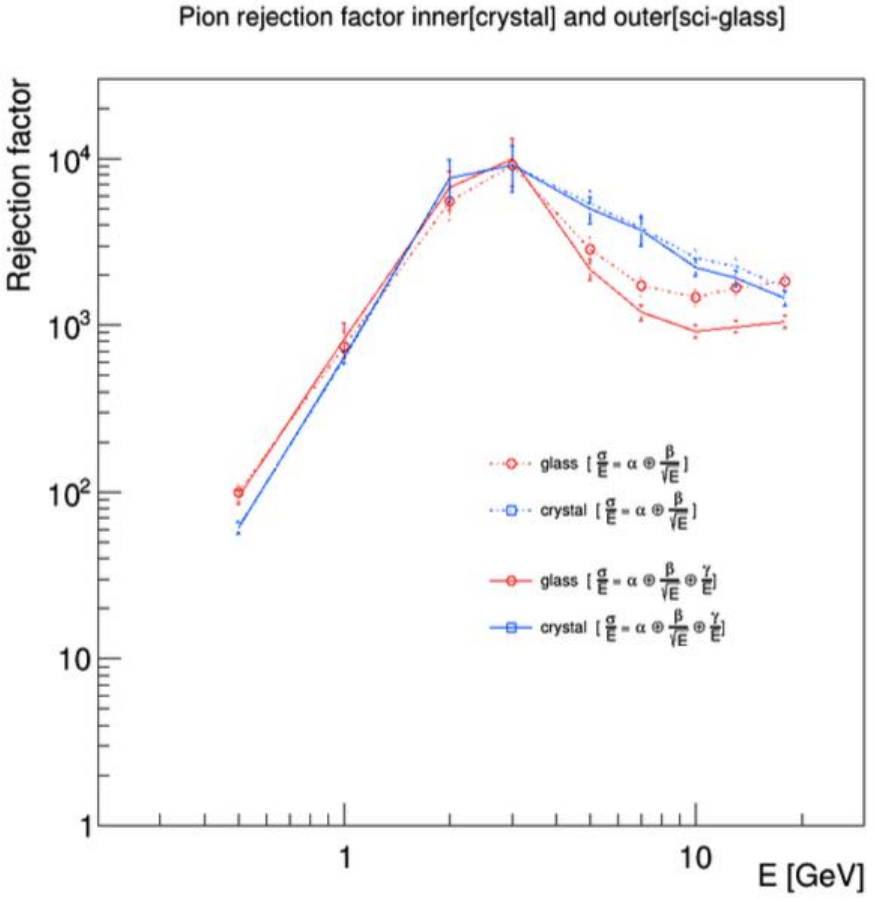




Premier materials science facility with unique

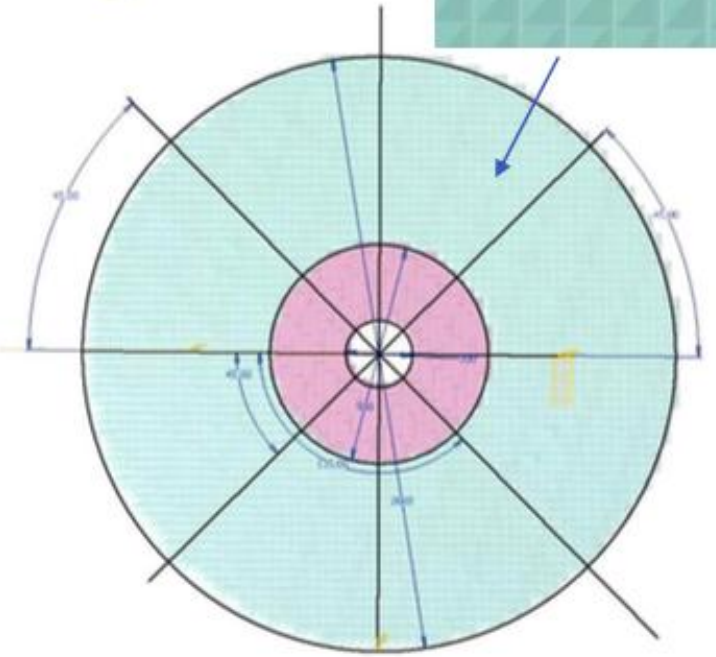
EEEmCal performance, recent GENAT4 simulations

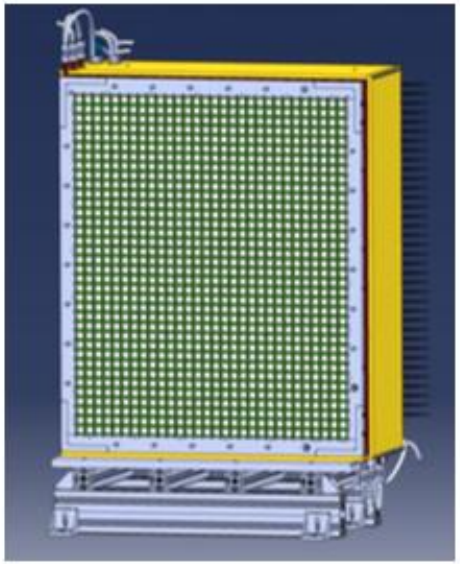




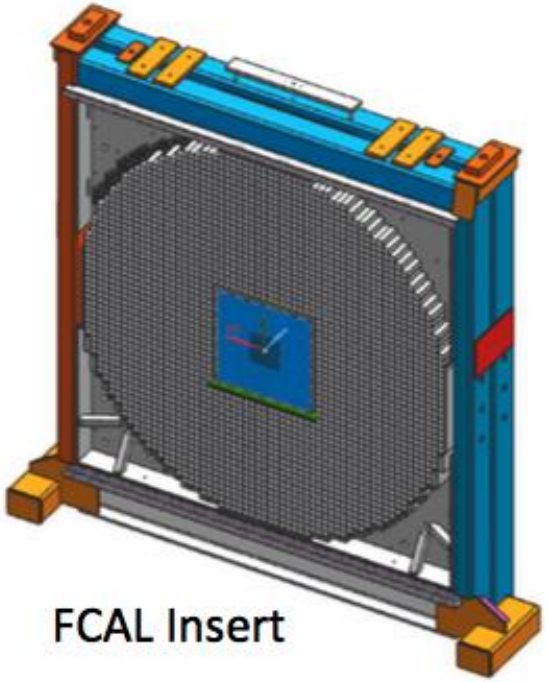
Electron Endcap EM Calorimeter for Electron Detection – Support Structure modeling

- **EEEMCal model** – scintillator support
  - **Crystals: 1628 blocks (2cm x 2cm)**
  - **SciGlass: ~11000 blocks (2cm x 2cm)**
    Or 2778 blocks (4cm x 4cm)
  - **Total radiator weight: 8573 kg (9.5 US tons)**





NPS

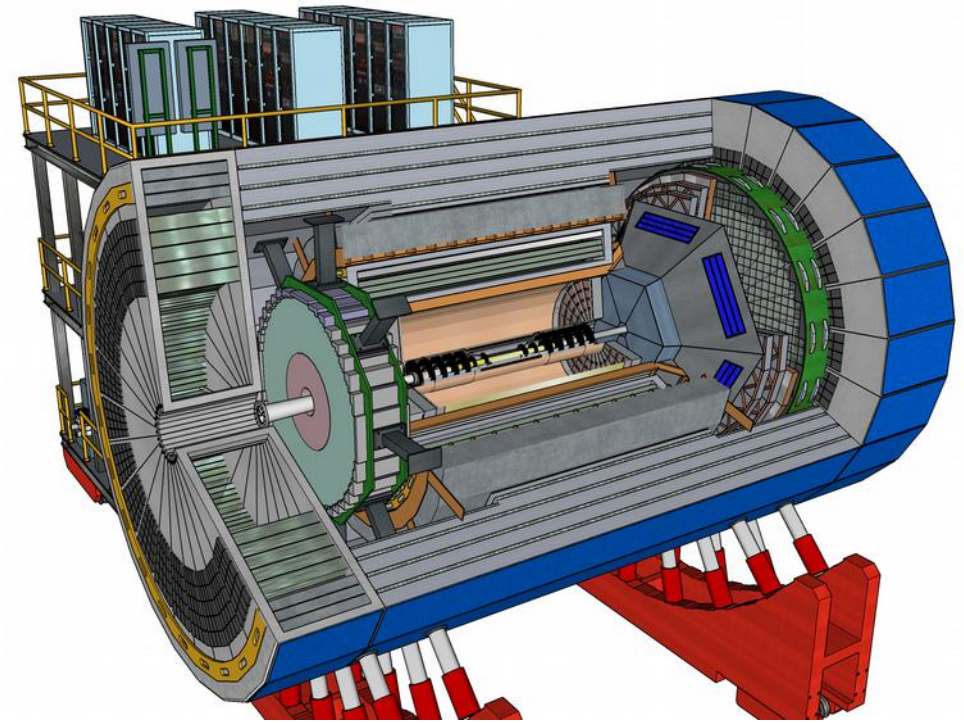


FCAL Insert

- Starting to investigate possible EEEMCal mechanical models, e.g. the Hall C NPS that was built by our team, and the Hall D FCAL insert
  - Support frame, requirements
  - Temperature zones, cooling
  - ….

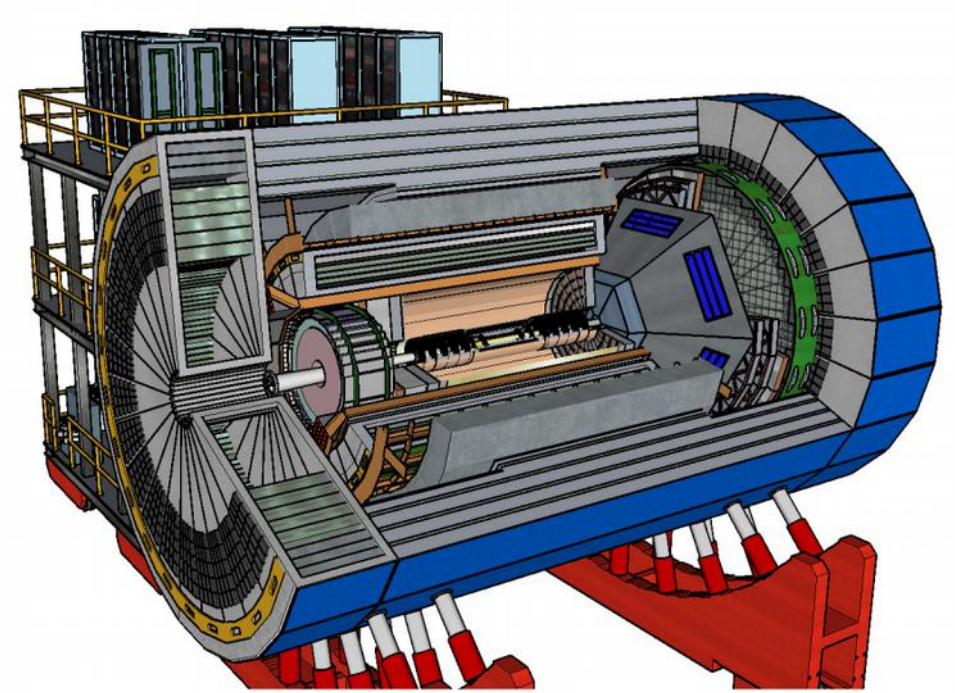
EEEmCal in ECCE detector

ECCE Central Detector – Original EEEMCal/DIRC Conf guration



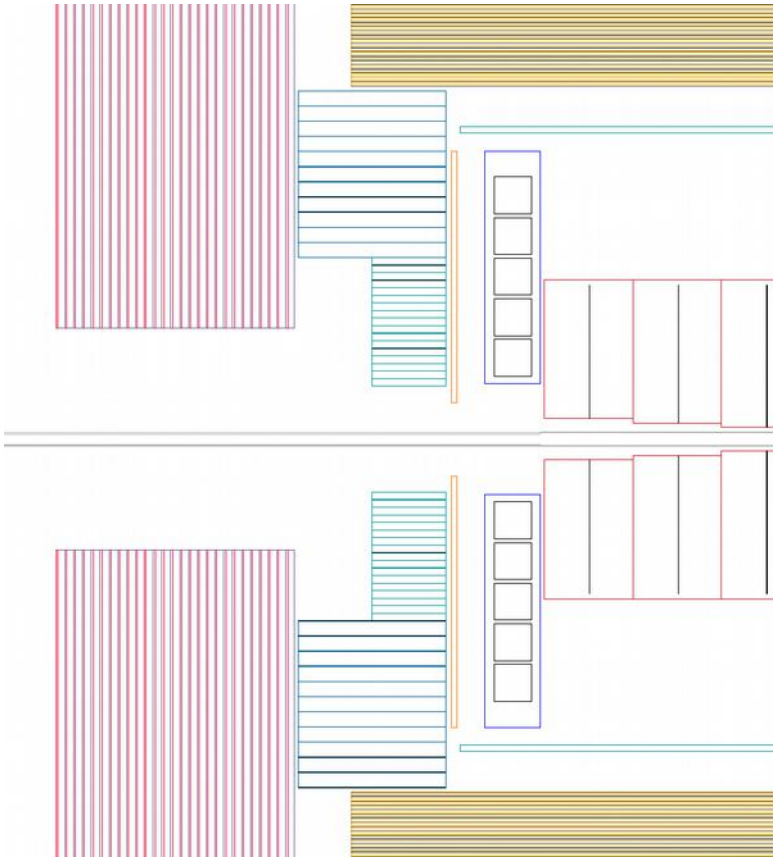
DIRC Prism on hadron side
Interference with dRICH

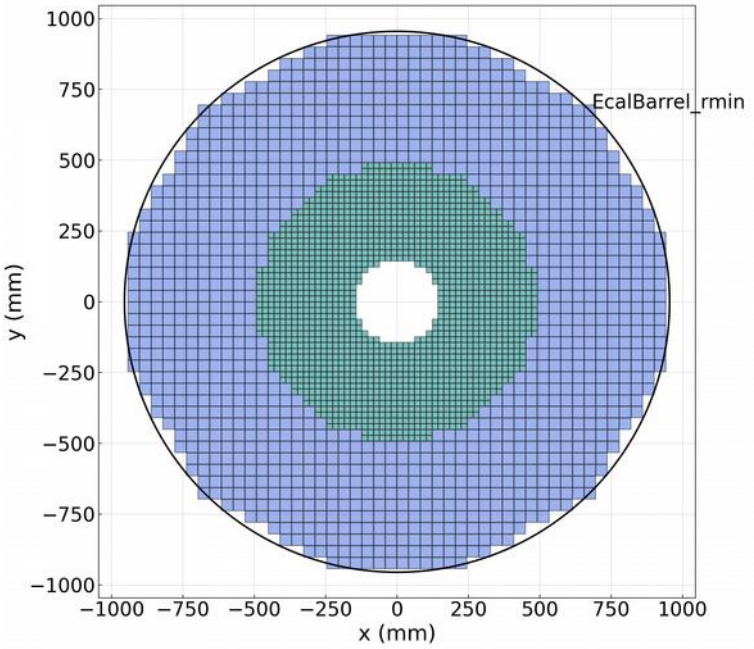
ECCE Central Detector – PRESENT EEEMCal/DIRC Conf guration

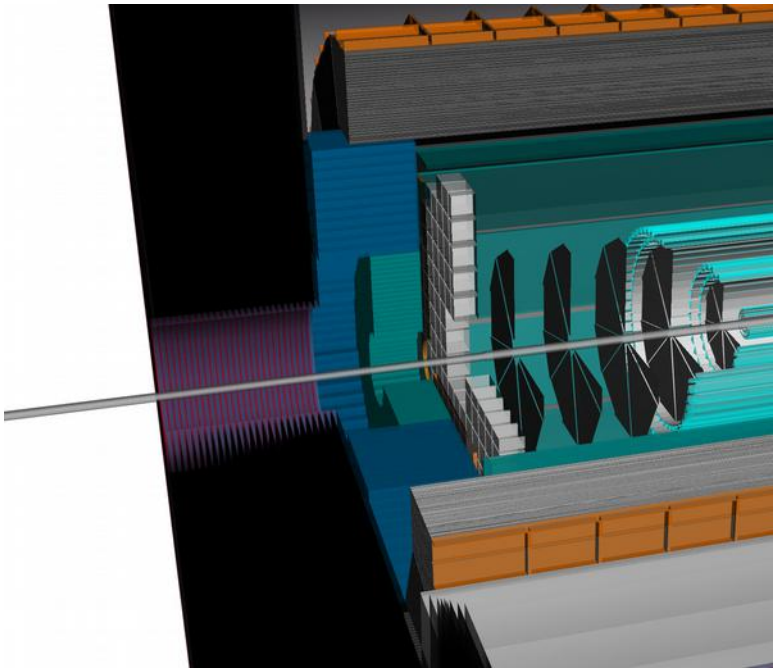


DIRC Prism on electron side
Move in EEEMCal – need new frame
Prism in “shadow” of EMCal

EEEmCal in Athena, DD4HEP implementation



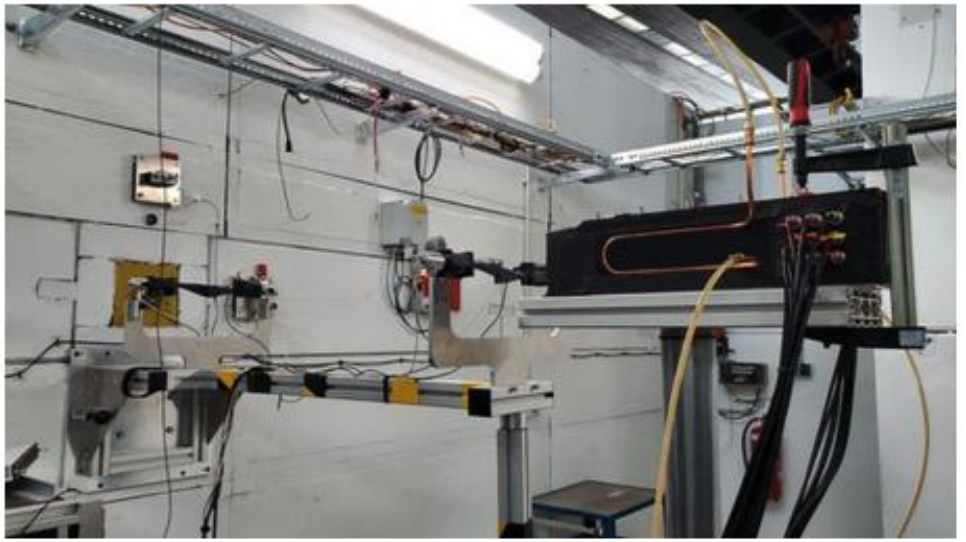




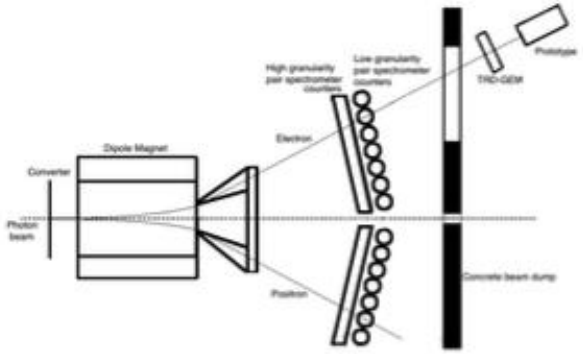
EEEMCal – prototype beam test program

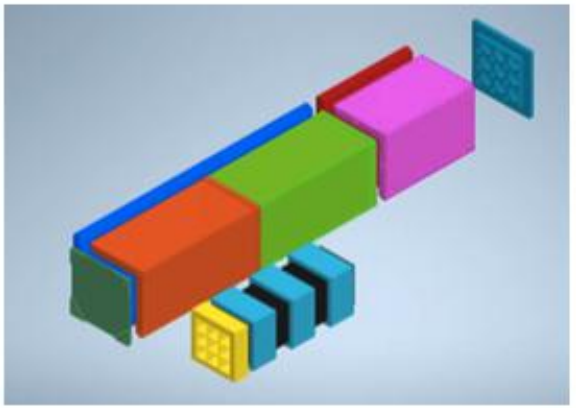
Tests of: EMCal characteristics, photosensor, readout

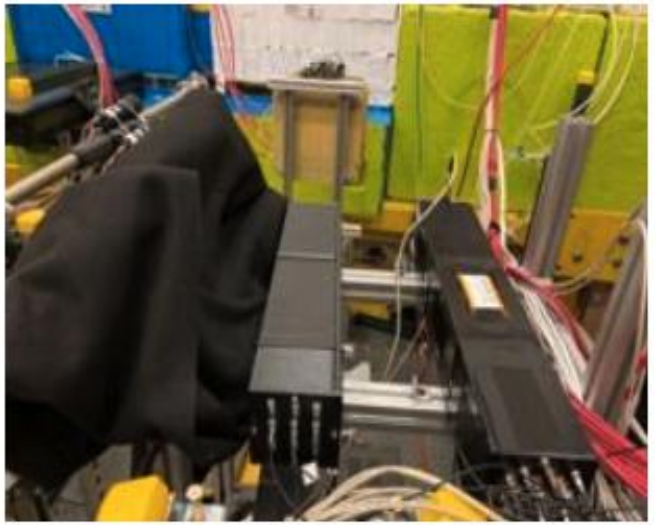
- Prototype beam tests at DESY



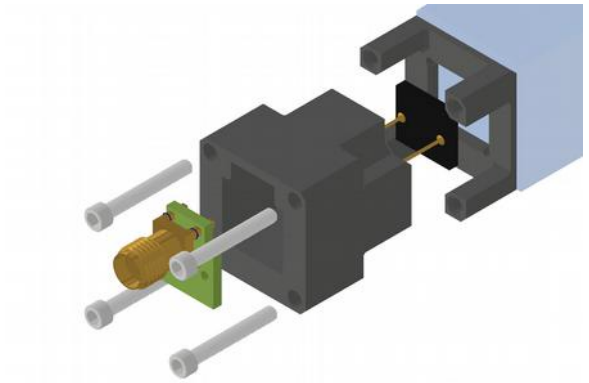
- Prototype beam tests in Hall D at Jlab

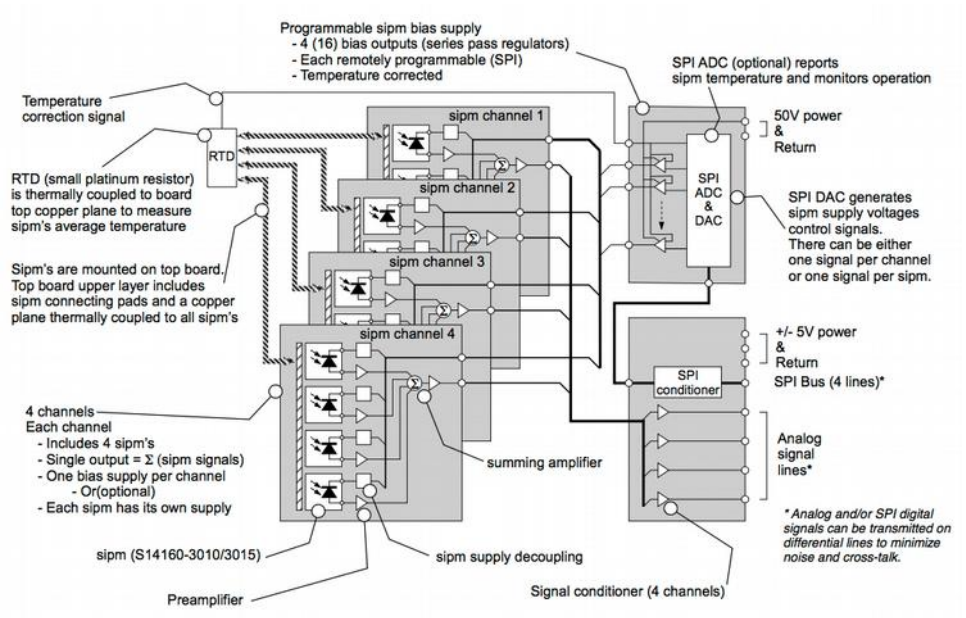


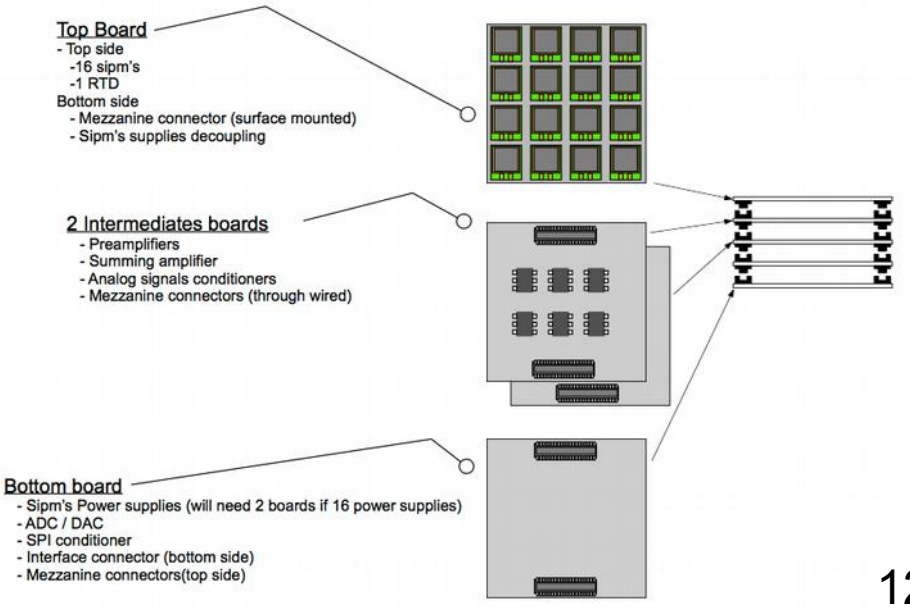




SiPM Read Out preparations for the beam tests at JLab







Summary and Outlook

- Nearly all physics processes at the EIC require the detection of the scattered electron in the electron endcap
  - Excellent electromagnetic calorimeter resolution is required at small scattering angles, while very good resolution is acceptable at larger angles.
  - The highest resolution in electromagnetic calorimeters can be provided by homogeneous materials, e.g. PWO crystals and glass

- The EEEMCal team plans to realize scattered electron detection in the electron-going direction with an electromagnetic calorimeter

- The team has a long-standing track record with the construction of homogeneous EM calorimeters based on high-resolution crystals and glass.
  - Collective experience spans a wide range of activities including detector design and construction, technical support and infrastructure, readout electronics, crystal/glass fabrication and characterization, etc.

- This project is well-defined and could fit with any global effort to realize an EIC detector with high precision EM calorimetry at forward rapidities.

- The EEEMCal team welcomes additional groups in the consortium and is open for collaboration with other calorimetry efforts.