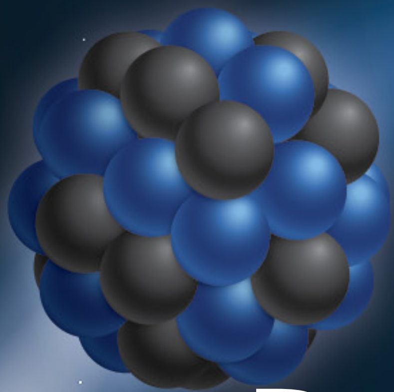


Detector R&D needs

Patrizia Rossi & Thomas Ullrich

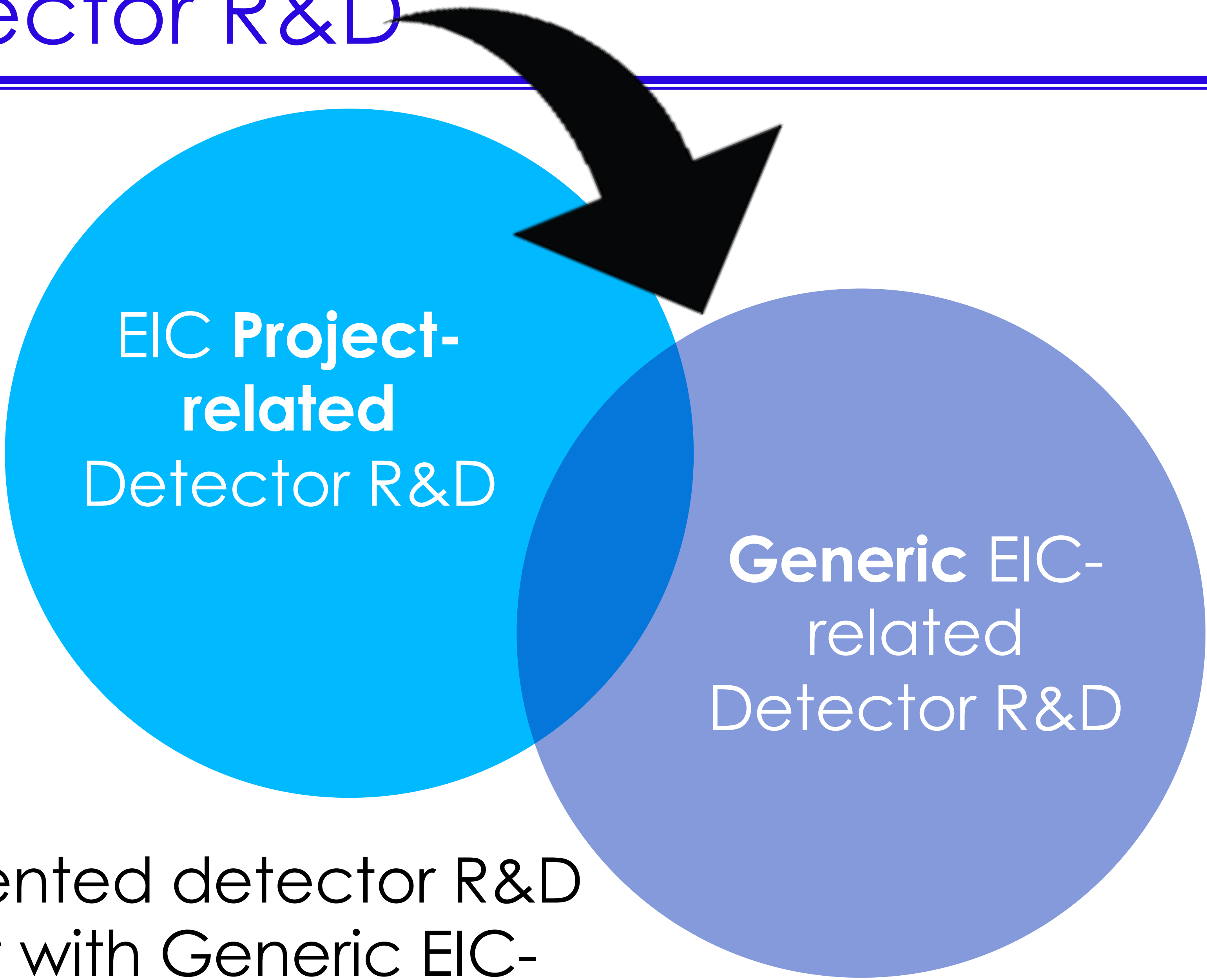
November 19-21, 2020

YR Berkley Workshop

Electron-Ion Collider

BROOKHAVEN NATIONAL LABORATORY · Jefferson Lab · U.S. DEPARTMENT OF ENERGY | Office of Science

EIC Detector R&D



:

Project-oriented detector R&D concurrent with Generic EIC-related detector R&D program

EIC Detector R&D Projects

- Need to have *two separate components* to distinguish between R&D on which the EIC project <u>will depend</u> versus other R&D.

- **Project R&D** funds can only address those detector technologies that have a risk for the project, i.e., could harm the KPPs or L2/L3 milestones. In DOE wording: *R&D is that on which the "capital acquisition project" depends.*

:

- We expect the EIC Project-related detector R&D to mostly occur in FY21-FY22

EIC Detector R&D Projects

- **Generic EIC-related detector R&D** is driven by:
  - pursuing alternate detector technologies for a complementary second EIC detector
  - more risky technologies not feasible to present as reference detector
  - preparing for future cost-effective detector upgrades to enhance capabilities addressing new nuclear physics opportunities.

:

- Generic R&D may address:
  - particle identification reach at higher momenta
  - cost-effectiveness of readout of PID detectors
  - possible glass-based electromagnetic calorimetry
  - new ASIC needs required for SRO modes
  - improvement of the achievable HCAL resolutions
  - ....

EIC Detector R&D Projects

- The Generic EIC-related detector R&D can be best realized as continuation of the ongoing generic EIC-related detector R&D program, but <u>in strong coordination with the EIC Project to underscore the strong connection to EIC detectors</u>

- It is important to continue this program to not lose momentum and continue to build on past investments

- Discussion with DOE is underway

:

Generic EIC Detector R&D Program

- Started in 2011 BNL in association with JLab and the DOE-NP. Since 2014 managed by T. Ulrich
- Initially focused on 'generic' R&D turned more targeted over the years
- Work on various technologies related to major detector components organized in consortia
- International endevour: over 281 participants from 75 institutions , 37 non-US
- R&D program is making good progress on many components vital for an EIC detector
- Thanks to the ongoing generic EIC-related detector R&D the detector technologies for the day-one EIC detector are mainly established or in reach

R&D for Technologies Needed in Any Case

- Photosensors in B-Field
  - RICHs
- DMAPS sensor development
  - Si-Vertex + TPC
  - All Si-Tracker
- AC-LGAD sensor development
  - Roman Pots
  - Roman Pots and ToF
- Electronics: ASIC/FEB/FEP
  - Estimate need for ~3 ASICS
  - SiPM, 2x GEM/MMG, Si-Sensors (use ALICE ASICs?)

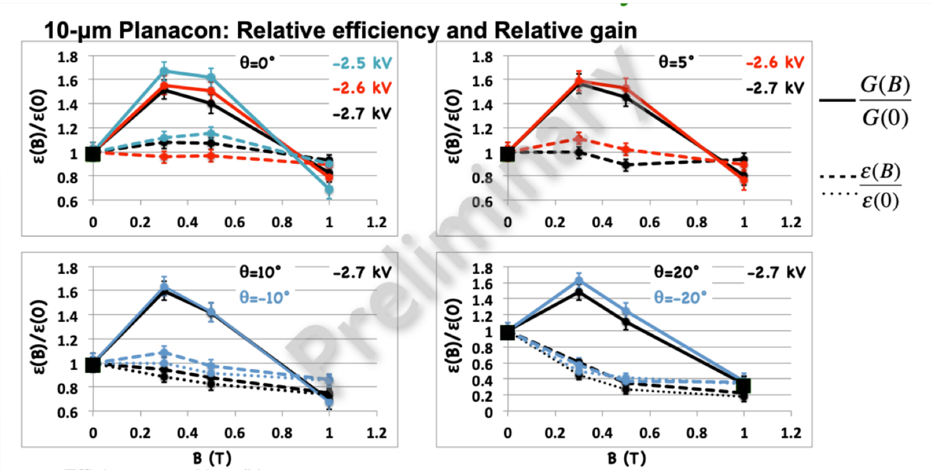
- Service Reduction
  - Radiation tolerant multiplexing
  - High-speed multi-fiber optical transmission

- Barrel PID detectors
- DIRC
- dRICH/mRICH
- fwb/bckw low-mass GEM Tracker
- ZDC
- Low-Q^2 tagger
- Barrel HCAL: Sampling

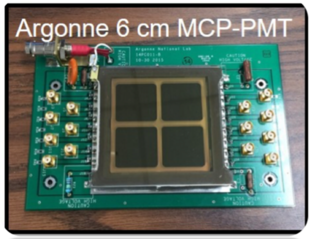
Photosensors

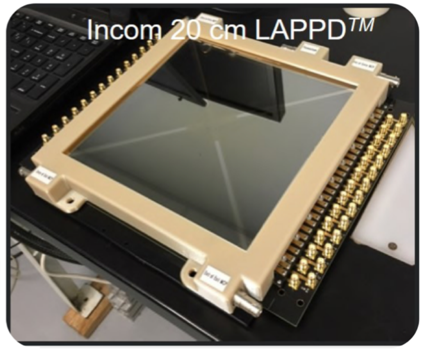
- Detection of visible and/or UV photons must maintain QE and much of the gain while immersed in the magnetic field of 1.5-3 T of the spectrometer.

- 10 μm Planacon **MCP PMT** tolerant to at normal field incidence up to ~ 1T



- Very expensive
- Critical parameter: incident angle of the field



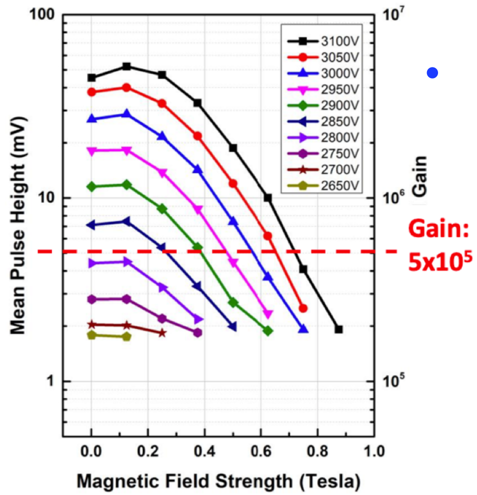


LAPPD

:

- **SiPM**: capable to operate up to 3T but sensitive to neutron damage

- Investigation ongoing
- Series of tests performed to validate the use of SiPM for the CLAS12 RICH
- Results with pion beams validate the use of SiPM as single photon detector

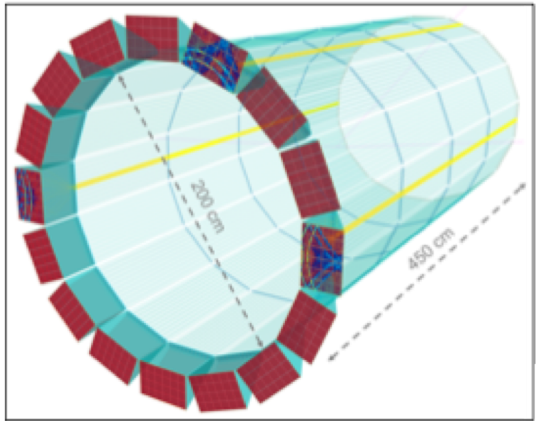


- Promising (less expensive) but still not fully applicable for EIC
  - Need pixelization
  - Not optimal response to B field

NIMA 876 (2017)89

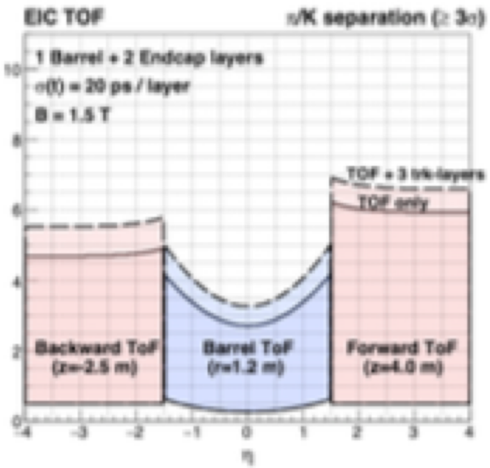
eID & PID in the Barrel

Reference: hpDIRC



π Sopp. Reference	π Sopp. Required	π/k (GeV/c) Reference	π/k (GeV/c) Required
10^{-2}	10^{-4}	0.6 - 6	10 -15

Solutions? It requires some thinking and creativity…and space!



:

TOF for π/k separation

- Several technologies reviewed, no one chosen yet
- AC-LGADs could provide a good tracking layer (~100 um) + timing (20 ps)

A couple of more ideas at embryonic stage (only speculative so far)

Long Shadow Detector (LSD) (claster counting) – π/k separation)

Hadron Blind Detector ++ – for pion rejection only

R&D that Dependents on Detector/Technology Choice

- TPC
  - in baseline but all Si-tracker is strong alternative
  - RO: 4 GEM, 2 GEM + MMG, MMG
  - large prototypes desirable
- ToF (LAPPD or AC-LGAD)
  - not in baseline

:

- GEM TRD (forward)
  - not in baseline
- CAL/Sc. Glass
  - depends on success of 40cm manufacturing
- ECAL

  Options:
  - W powder SciFi
  - Pb(W)/Sci Shashlik
  - Lead Glass
- HCAL

  Options

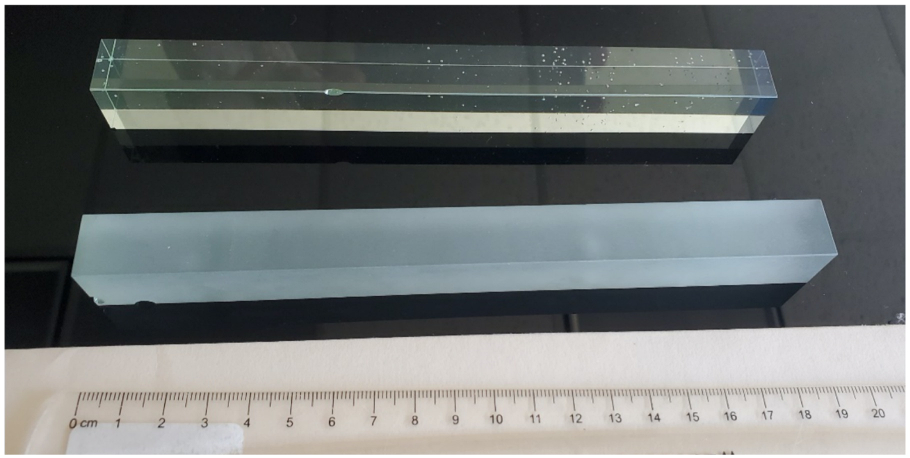
  -fwd std (~50%/√E)

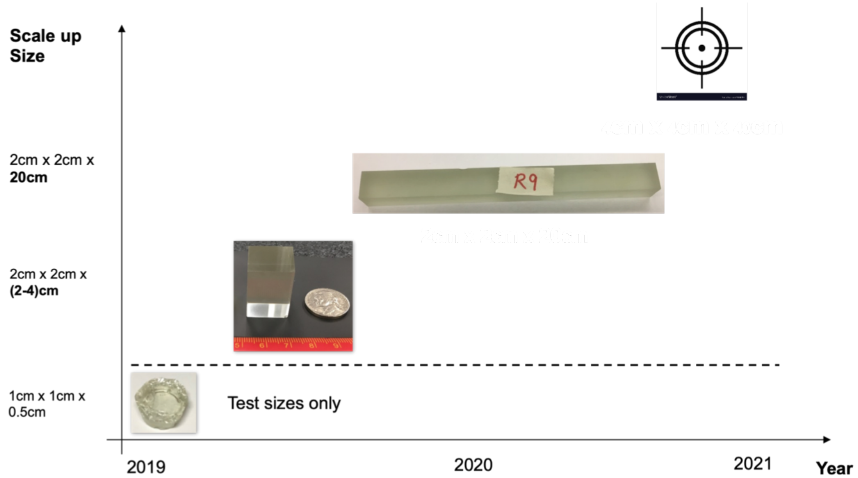
  -fwd high res. (~ZEUS like resolution)
- Cylindrical Tracker layer μRwell
- Cylindrical Tracker layer MMG

Scintillating Glasses

- Past: Limited to small samples due to difficulties with scaling up while maintaining the required purity.
- Now: Possible path to inexpensive high resolution EM calorimeters
    - 40cm long bars will match $PbWO_4$ resolution (20 cm achieved)
    - Radiation test very positive (~1 MeV Co-60, 160 keV Xray, 40 MeV protons)
    - SBIR/STTR Phase 2: Consistency of product quality for mass production

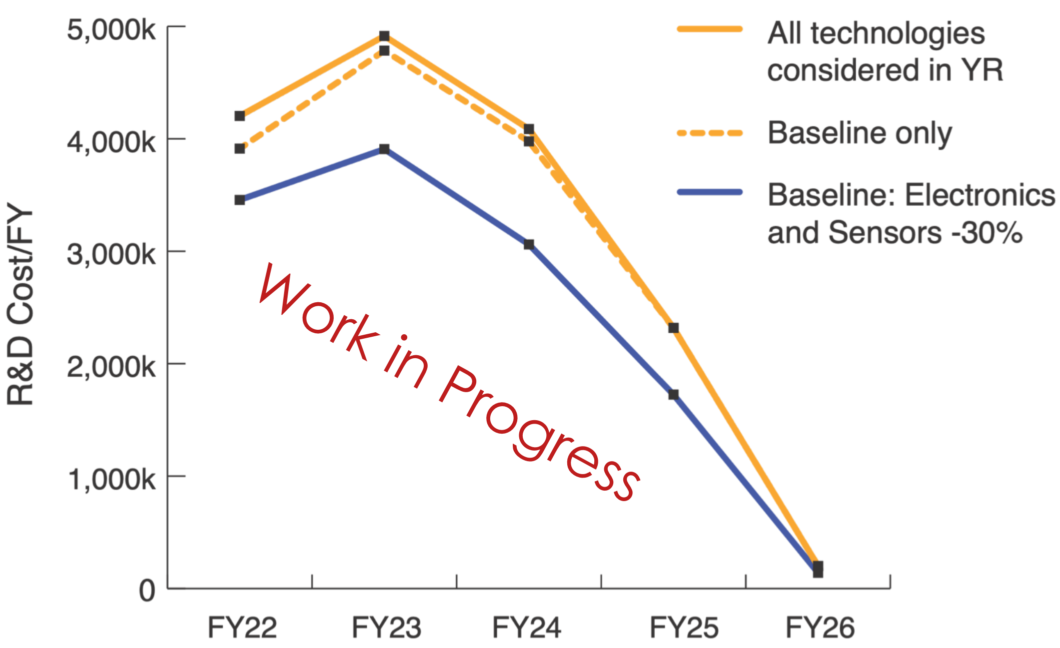
:





NIM A 956 (2020) 163375

Cost Estimates of R&D and Future Aspects



:

Input: Estimates from subsystem experts and experience from generic program

- Work on a estimate for project driven R&D in progress
- Dependence on ultimate choice of detector technologies is moderate
- Cannot free load on HEP as in the past as EIC requirements are unique (PID, low-mass) compared to LHC. Much of efforts have to be in-house (EIC/NP)

Conclusions

Our intention is to have a detector R&D program with two components , a project R&D combined with a generic R&D, to ensure it is all synchronized for the EIC detectors. The generic EIC R&D is not yet established.

1) The current generic EIC R&D program
   - is a crucial part of the EIC efforts with many active participants making good progress on many components vital for an EIC detector
   - Helped to reduce risk of many technologies
   - Needs to continue if EIC wants to stay on edge of technology and performance over the long term through upgrades

:

2) Project Driven R&D
   - Many subsystems are clearly defined, others will depend on collaboration's choice of technologies
   - Cost mainly driven by sensor development and electronics and prototyping
   - Most non-sensor/electronics development requires ~2 years to complete