EIC PID summary

EIC PID review, 9/19/19

eRD14 – an evolving consortium

The EIC PID consortium was originally formed from

1) eRD4: DIRC-based PID for the EIC Central Detector
2) eRD10: R&D for 10 ps Timing Detectors at the EIC
3) eRD11: RICH detector for the EIC'S forward region particle identification
   Simulations & Characterization of LAPPD 6x6 cm^2 sample #28

The eRD14 effort today is broader, but also more focused on the EIC requirements

1) mRICH and DIRC activities continue (the latter also being applied to near-beam detection)
2) The dRICH has been developed entirely within eRD14
   (the original large proximity-focused RICH concept from eRD11 was inadequate for the EIC)
3) The ps-TOF R&D has been completed – but could return in the future with a different focus
   (high-resolution TOF is important for the EIC to, for instance, correct for crab crossing effects)
4) The goals of the LAPPD effort have been integrated with the requirements of the Cherenkov detectors
5) The photosensor testing program at JLab (commercial) and ANL (LAPPD) has been expanded
6) A new readout electronics effort has been started

Generic R&D phase is complete or nearing completion

1) A reference design, adaptable to the proposed EIC detector concepts, exists for each subsystem.

2) The largest technical risks have been addressed for the reference designs
- Compatibility with commercially available photosensors
- Radiation hardness of key optical components

3) A path for significant cost reduction exists for each system
- Use of SiPMs or LAPPDs as photosensors instead of commercial MCP-PMTs

4) Performance validation through prototyping is underway for all systems
- Timelines currently vary somewhat, but all are on track for 2023.

5) Interim readout electronics exist for all systems
- PADIWA for DIRC, Maroc for mRICH/dRICH.

6) Electronics for beam tests in the final R&D configuration and for future use the EIC is in development.
- In line with the committee's comments about reducing risk, alternatives have been discussed with the BNL electronics group.

7) Significant progress has been made on photosensors
- Performance in high-B fields and adaptation of LAPPDs to EIC requirements

Is the R&D on track for TDR readiness in 4 years?

Yes – but the next R&D phase will require increased funding

Major goals of specific/targeted R&D over the next 4 years

1) A cost-optimized baseline design for each subsystem (for the first EIC detector at the selected site).

2) Completed performance validation in test beams with prototypes for all subsystems.

3) Completed validation of readout electronics compatible with EIC requirements.

4) Investigation of broader integration issues – both mechanical and readout-related

What are the bottlenecks?

The main bottleneck is performance validation. Development of a baseline design and electronics can be speeded up by "throwing money (postdocs) at the problem," but test beams have a natural cycle, where lessons learned need to be incorporated in-between tests. Thus,

full support for prototyping for all systems is critical.

Short-term (FY20) funding needs and priorities

The 4 year plan developed by the consortium only assumes funding increases in FY21-23. It is, however, ***essential that the submitted FY20 proposal is funded***.

Priorities

1) All three Cherenkov projects (DIRC, dRICH, mRICH) are ***core systems*** for a future EIC detector. Not funding one of them at the required level would create a major challenge for the EIC overall.
In contrast, the TRD is of marginal relevance for an EIC, but has received funding than eRD14 subprojects. Perhaps a more global prioritization would be possible?

2) Within the consortium, the priorities have been outlined in the three budget scenarios. More generally, however, the top priority is to fund activities where delays will be most problematic in terms of achieving the four-year goal. Key examples are:

- Moving the DIRC prototype to the US
- Building the dRICH prototype
- Efforts necessary to determine (within two years) whether LAPPDs could become a feasible photosensor alternative for the EIC Cherenkov detectors.

Long-term (FY21-23) funding needs and priorities

For years 2, 3, and 4 the total funding profile for the consortium is summarized in the table on the next slide. The details of the individual work packages can be found in the system presentations.

If funding would be available, the scope of the R&D could be expanded to include a muon telescope for use both in the initial R&D and later on. ODU has expressed interest in taking a lead on this project.

Priorities

1) Keeping the prototype program on schedule to avoid irrecoverable delays
- This includes development of readout electronics for the R&D phase

2) Development of a cost-optimized baseline design
- Essential, but schedule is somewhat flexible
- Direct support of postdocs at GSI and INFN in addition to domestic institutions important (MoU?)
- Includes selection of final photosensors

3) Development and validation of final electronics.

4) If a future EIC detectors would use a 3 T rather then 1.5 T field, then SiPMs become a top priority
- It is the only photosensor for visible- and near-UV light that can operate in such high magnetic fields
- Also with lower B-fields SiPM can be a way of cost reduction for the RICH systems

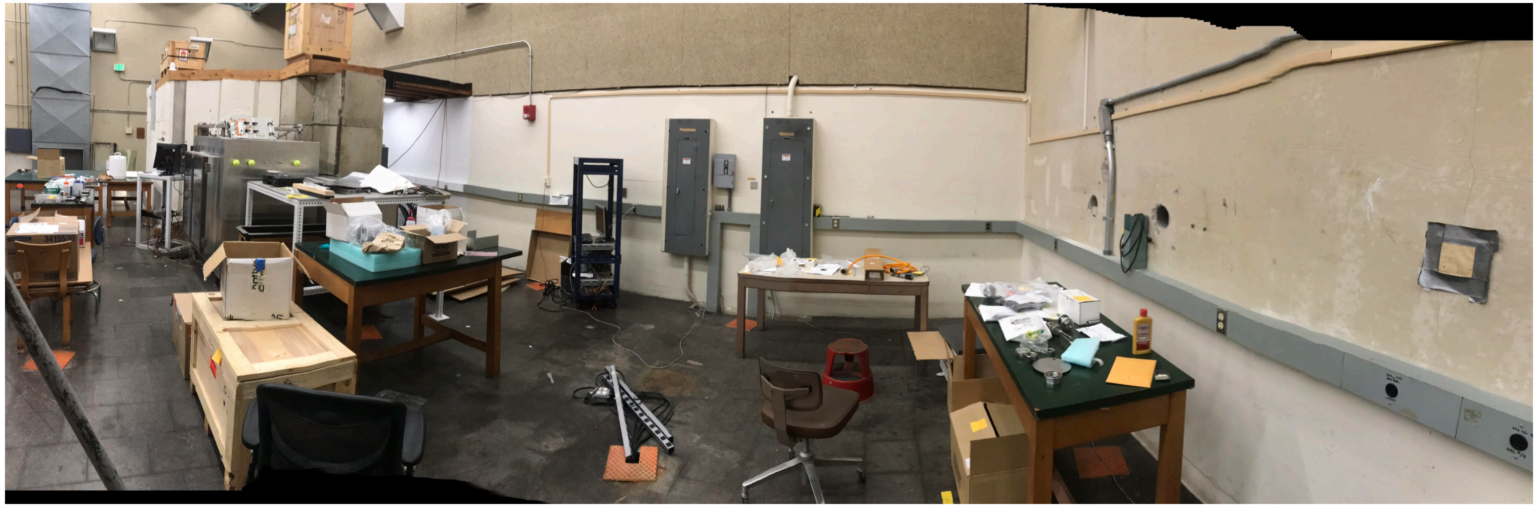
Four-year (FY20-23) funding profile

		FY20	FY21	FY22	FY23	total
DIRC	personnel	60	190	190	130	570
	materials	89	255	55	50	449
	total	*149*	*445*	*245*	*180*	*1019*
dRICH	personnel	44	120	120	42	326
	materials	18	110	120	90	338
	total	*62*	*230*	*240*	*132*	*664*
mRICH	personnel	110	206	206	110	632
	materials	10	27	17	10	64
	total	*120*	*233*	*223*	*190*	*696*
high-B	personnel	11	11	11	11	44
	materials	28	21	21	21	91
	total	*39*	*32*	*32*	*32*	*135*
LAPPD	personnel	95	95	30	30	250
	materials	20	10	10	10	50
	total	*115*	*105*	*40*	*40*	*300*
Electronics	personnel	25	65	122	69	281
front end	materials	10	85	215	75	385
	total	*35*	*150*	*337*	*144*	*666*
Electronics	personnel	24	60	60	34	178
back end	materials	10	50	30	20	110
	total	*34*	*110*	*90*	*54*	*288*

Summary table of the budgets for FY20-23 (in k$). Materials include everything except personnel (also travel).

The budget only includes the US contribution. The DIRC and dRICH in particular will also receive substantial support from GSI and INFN, respectively.

Stony Brook University support for EIC PID prototype effort



Stony Brook has agreed to provide lab space (upper picture) for the DIRC prototype when it arrives in the US in a joint effort with CUA and GSI. The lab space is quite extensive and has all the necessary infrastructure.

Stony Brook can also provide undergraduate students.

In addition to storing the DIRC prototype, it can also be used as a staging area for multiple systems (*e.g.*, the dRICH prototype) in preparation for test beams at Fermilab.

Potential synergies with other SBU activities such as tracking (eRD6).

Role of the consortium

The consortium has unified the PID projects into a suite of *complementary core systems* for the EIC providing primary hadron ID and secondary electron ID over the full angular range.

The funding for EIC PID is particularly challenging. Tracking, calorimetry, etc, to a large extent rely on HEP funding, and use EIC R&D mostly to adapt HEP-funded technologies for EIC use. In contrast, PID has limited HEP support and uses the R&D funds to develop novel concepts.

Despite limited funding, the consortium has been able to find a consensus in the community allowing all core systems to successfully pass the generic R&D phase. Without these internal (re-)prioritizations, it is unlikely that the EIC R&D program would today have all the PID systems required for the EIC ready to go – and catching up would be difficult and costly.

The consortium has also brought together a large group of PID experts, both domestic and foreign (GSI, INFN), laying a foundation for future collaboration. This aspect has been further expanded for instance by organizing activities such as the recent CFNS EIC PID workshop (July 9-10, 2019).
https://indico.bnl.gov/event/6351/

Role of the consortium - future

Pending the formation of the detector collaborations, the PID consortium still has an important role to play in coordinating the various activities, maximizing synergies, and maintaining the collaborative effort that has been established.

The EIC User Group have so far not created a widespread user involvement (not just in PID but in general) partly due to that the steering committee has appointed conveners with a charge to start new activities instead of building on existing user engagement and active collaborations. This may change in the future, but until then the PID consortium will be the natural forum for broader EIC-related PID discussions.

In terms of specific R&D activities, the consortium is important for

- Coordination of test beam related activities and support systems (e.g., supplementary tracking)
- Coordination of photosensor activities, readout electronics, and DAQ
- Integration of PID systems into the EIC detector
- Evaluation of PID performance on EIC physics

Backup

Precision Cosmic Ray Telescope for RICH detectors

- Goal: Tag muons with sufficient resolution to identify an ensemble of events with ≤ 1mrad rms angular spread of the Cherenkov light in the fused silica DIRC radiator.

- Proposed technology:
  - Tracker with 1 mrad angular resolution above DIRC
  - Tracker with space point resolution 1 mm below DIRC
  - CO_2 Cherenkov for energy threshold on muons
  - 10cm x 10cm tagged impact area on DIRC bar
  - Iron free for portability

- ODU B.S. Senior Thesis project: Both items below independently constrain DIRC Cherenkov cone angle to within 1 mrad
  - Constrain multiple scattering within DIRC to ≤ 1 mrad
  - CO_2 Cherenkov threshold

- Ongoing design study at ODU funded from non-eR&D sources
  - Funding proposal to follow