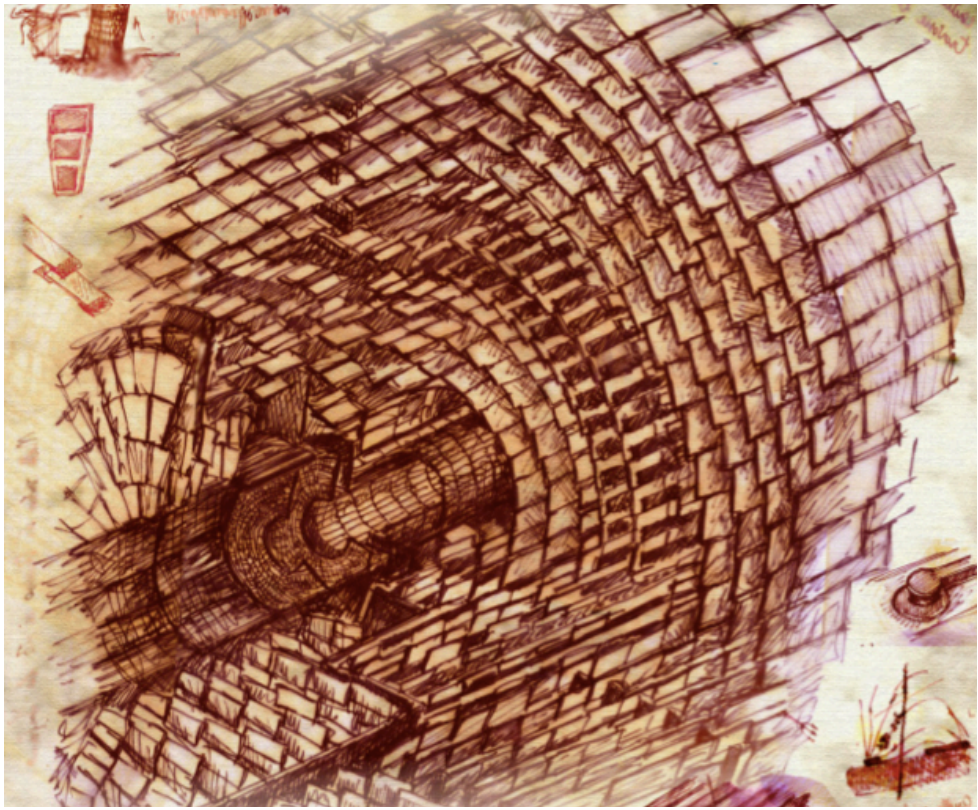
EIC Users Group Detector Workshops

What's happened so far

Where do we go from here?



R. Yoshida

Thursday, August 2, 18

Ad-Hoc Workshop model

- EIC UG Steering Group, in discussions after Trieste, decided not to immediately form working groups.
  - Large membership (>800) in UG. But real time that people can devote to EIC is limited (hopefully increasing from now).
  - Already (too) many meetings, conferences.
  - Organization can be artificial→ lack of shared interest → all work falls to the conveners.
- Ad-Hoc Workshops model
  - Bottom up workshops either loosely tied to the UG, or independent.
  - Encouraged by EIC UG—and sometimes JLab or BNL helps in organization.
- Many of physics plenary talks at this meetings are connected to these meetings.

Plenary Talks Here and associated (ad-hoc) Physics Meetings

- Nucleon Sea (Aidala)
  - INT-17-68W
- Pion and Kaon Structure (Cloët) –whitepaper forthcoming
  - Argonne June, 2017
  - CUA, May, 2018
- Jets and Heavy Flavors (Neill)
  - 2017 Santa Fe Jets and Heavy Flavor meeting
- Fragmentation (Radici)
  - Fragmentation Function 2018
- Light Ions (Cosyn) –whitepaper forthcoming
  - Polarized Light Ions Workshop 2018
- There were other ad-hoc meetings: represented in parallel sessions.
  - e.g. BSM and EW

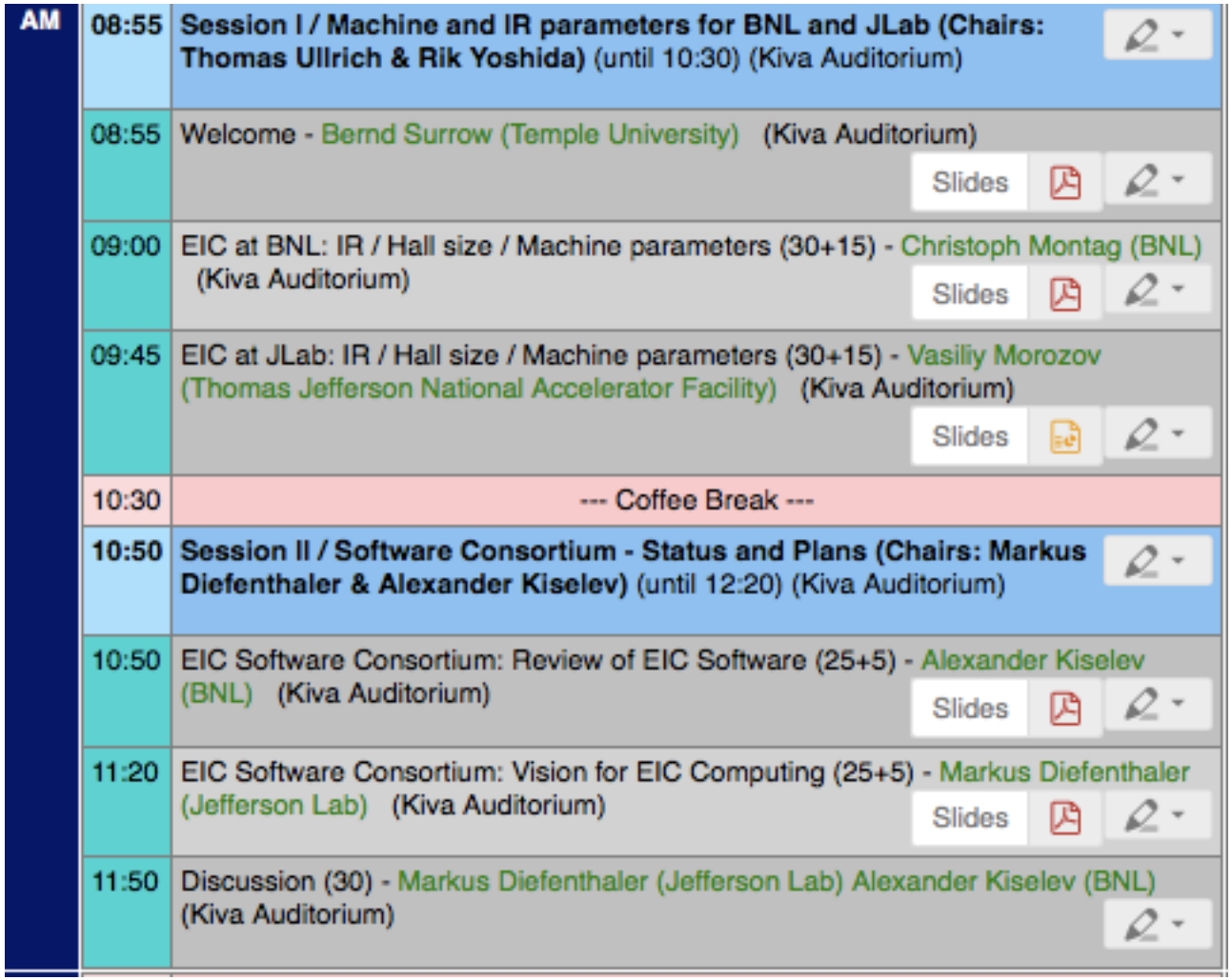
Detector Brainstorming Meeting

Temple University, Philadelphia
November 30-December 1, 2017

https://indico.bnl.gov/event/3737/timetable/view=standard

The purpose of this meeting is to start a discussion on the design choices of EIC detectors, we as a user group, envision in order to exploit the rich physics program of an EIC. Clearly, the expected physics and the accelerator's parameters drive the design in a significant way but many other aspects, constraints and boundary conditions have to be taken into account. This meeting is not aiming to come up with a final solution but to start a process of brainstorming and exchange of ideas that might ultimately result in a better understanding of how an experimental program of an EIC can be realized within the given boundaries. Follow-up workshops will help to refine and expand on the ideas that will emerge at this meeting. The actual process for selection and approval of experiments will be eventually handled by the relevant lab.

Temple Meeting Agenda



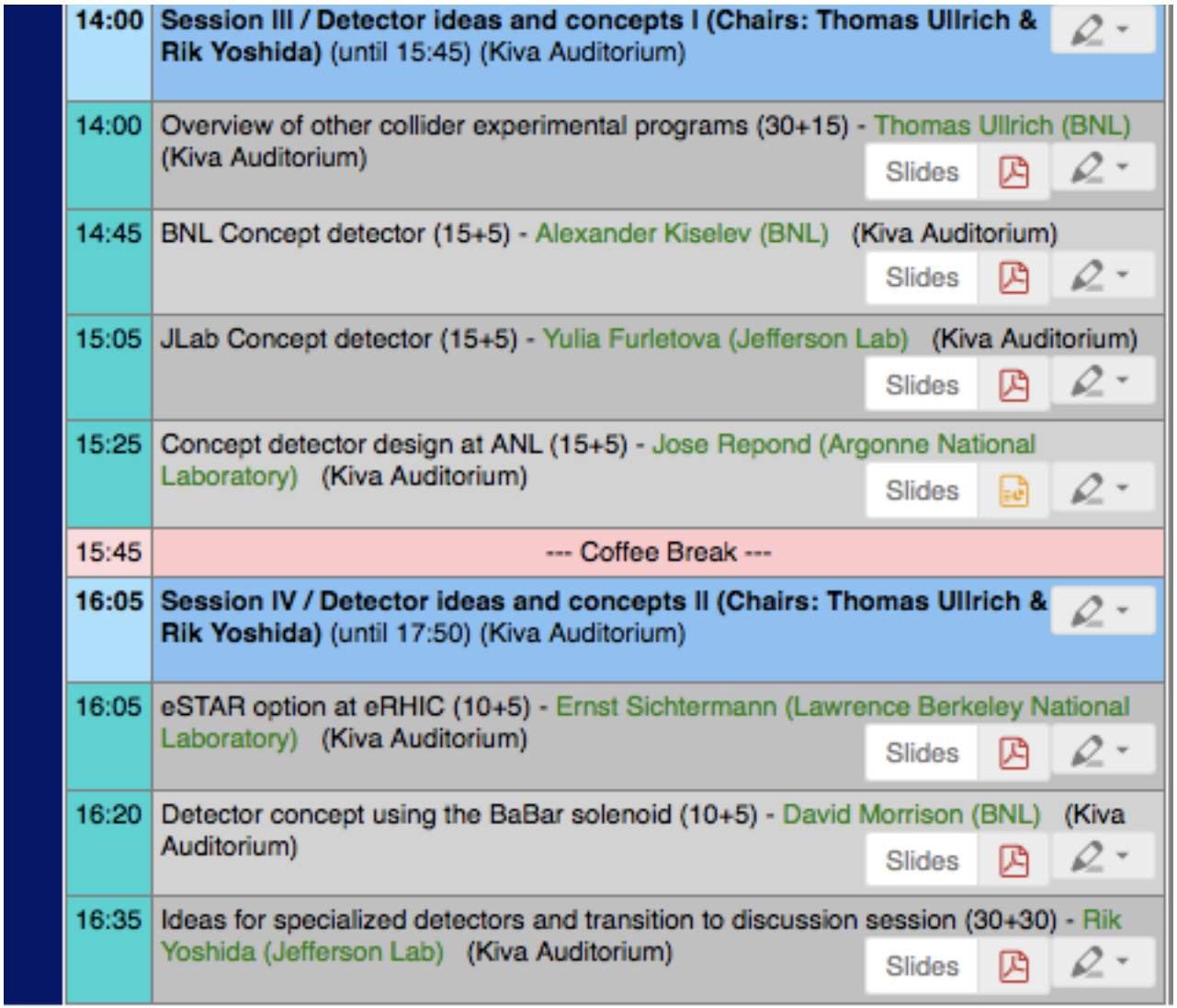
AM	08:55	**Session I / Machine and IR parameters for BNL and JLab (Chairs: Thomas Ullrich & Rik Yoshida)** (until 10:30) (Kiva Auditorium)
	08:55	Welcome - Bernd Surrow (Temple University) (Kiva Auditorium) Slides
	09:00	EIC at BNL: IR / Hall size / Machine parameters (30+15) - Christoph Montag (BNL) (Kiva Auditorium) Slides
	09:45	EIC at JLab: IR / Hall size / Machine parameters (30+15) - Vasiliy Morozov (Thomas Jefferson National Accelerator Facility) (Kiva Auditorium) Slides
	10:30	--- Coffee Break ---
	10:50	**Session II / Software Consortium - Status and Plans (Chairs: Markus Diefenthaler & Alexander Kiselev)** (until 12:20) (Kiva Auditorium)
	10:50	EIC Software Consortium: Review of EIC Software (25+5) - Alexander Kiselev (BNL) (Kiva Auditorium) Slides
	11:20	EIC Software Consortium: Vision for EIC Computing (25+5) - Markus Diefenthaler (Jefferson Lab) (Kiva Auditorium) Slides
	11:50	Discussion (30) - Markus Diefenthaler (Jefferson Lab) Alexander Kiselev (BNL) (Kiva Auditorium)

Machine Parameters
Hall size, etc.

Software,
Simulation etc.

→Software
working group

Temple Meeting Agenda



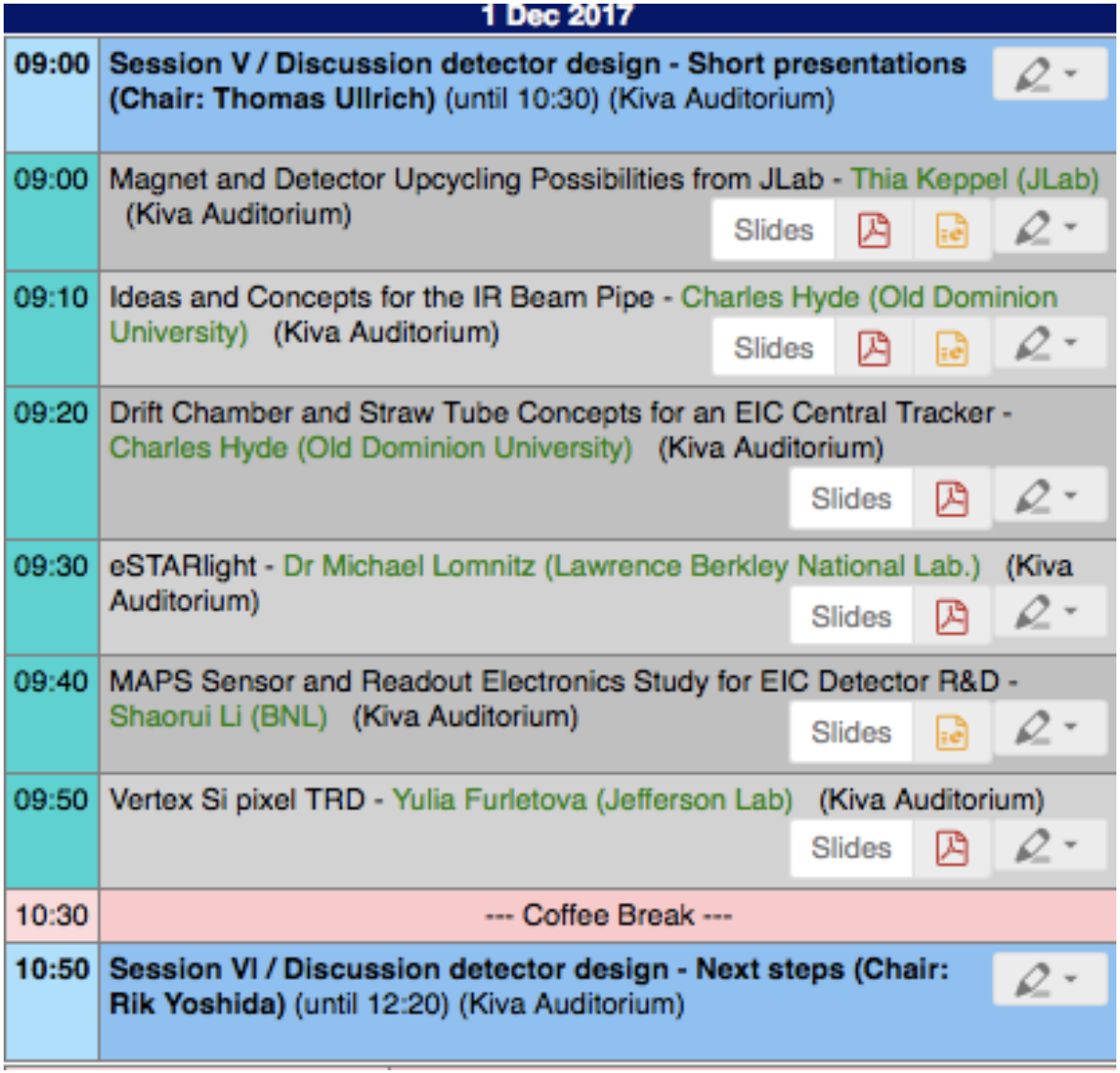
14:00	**Session III / Detector ideas and concepts I (Chairs: Thomas Ullrich & Rik Yoshida)** (until 15:45) (Kiva Auditorium)
14:00	Overview of other collider experimental programs (30+15) - Thomas Ullrich (BNL) (Kiva Auditorium) Slides
14:45	BNL Concept detector (15+5) - Alexander Kiselev (BNL) (Kiva Auditorium) Slides
15:05	JLab Concept detector (15+5) - Yulia Furletova (Jefferson Lab) (Kiva Auditorium) Slides
15:25	Concept detector design at ANL (15+5) - Jose Repond (Argonne National Laboratory) (Kiva Auditorium) Slides
15:45	--- Coffee Break ---
16:05	**Session IV / Detector ideas and concepts II (Chairs: Thomas Ullrich & Rik Yoshida)** (until 17:50) (Kiva Auditorium)
16:05	eSTAR option at eRHIC (10+5) - Ernst Sichtermann (Lawrence Berkeley National Laboratory) (Kiva Auditorium) Slides
16:20	Detector concept using the BaBar solenoid (10+5) - David Morrison (BNL) (Kiva Auditorium) Slides
16:35	Ideas for specialized detectors and transition to discussion session (30+30) - Rik Yoshida (Jefferson Lab) (Kiva Auditorium) Slides

Overview of collider detectors

Short description of existing concepts

New Ideas

Temple Meeting Agenda



1 Dec 2017	
09:00	**Session V / Discussion detector design - Short presentations (Chair: Thomas Ullrich)** (until 10:30) (Kiva Auditorium)
09:00	Magnet and Detector Upcycling Possibilities from JLab - Thia Keppel (JLab) (Kiva Auditorium) Slides
09:10	Ideas and Concepts for the IR Beam Pipe - Charles Hyde (Old Dominion University) (Kiva Auditorium) Slides
09:20	Drift Chamber and Straw Tube Concepts for an EIC Central Tracker - Charles Hyde (Old Dominion University) (Kiva Auditorium) Slides
09:30	eSTARlight - Dr Michael Lomnitz (Lawrence Berkley National Lab.) (Kiva Auditorium) Slides
09:40	MAPS Sensor and Readout Electronics Study for EIC Detector R&D - Shaorui Li (BNL) (Kiva Auditorium) Slides
09:50	Vertex Si pixel TRD - Yulia Furletova (Jefferson Lab) (Kiva Auditorium) Slides
10:30	--- Coffee Break ---
10:50	**Session VI / Discussion detector design - Next steps (Chair: Rik Yoshida)** (until 12:20) (Kiva Auditorium)

New Ideas

Next Steps

Outcome of Discussions (what next)

- Formation of some working groups on some central topics
  - IR and Luminosity
  - Polarimetry
  - Software

  Reports on these this afternoon.

More general Detector Topics

- Carry on with detector meetings in the ad-hoc style.
  - Calorimetry Apr 9, 2018 on-line only https://indico.bnl.gov/event/4468/
  - Tracking July 24, 2018 UVA
  - Streaming Readout Jan 29-31, 2018 MIT (followed by monthly phone meetings) [continuing contact hasell@mit.edu]

  These were meant to go beyond the current R&D consortia

EIC Detector Workshop: 29 July CUA

Sunday 29 July 2018 (Caldwell Auditorium)

Morning: 09:00AM - 12:30PM / 3.0h talk time with 1/2h break

(a) Streaming readout WG Summary: Doug Hasell (MIT)

(b) Particle ID R&D programs: Silvia Dalla Torre (INFN)

(c) Tracking WS summary: Matt Posik (Temple U.)

(d) Calorimetry WS summary: Tanja Horn (CUA)/Craig Woody (BNL)

Review of ad-hoc workshops

Afternoon: 02:00PM - 05:15PM 2.75h talk time with 1/2h break

(e) The LHeC and its Detector: Paul Newman (Birmingham)

(f) Hadronic barrel calorimeter / Forward detectors: Oleg Tsai (UCLA)

(g) Discussion on next steps with possibility to present new ideas: ALL / Discussion

Will not summarize: big overlap in audience, and also
Detectors & Computing parallel session summary will cover much of the same ground.

Detector Concepts Discussion at Temple

Two Detector regions

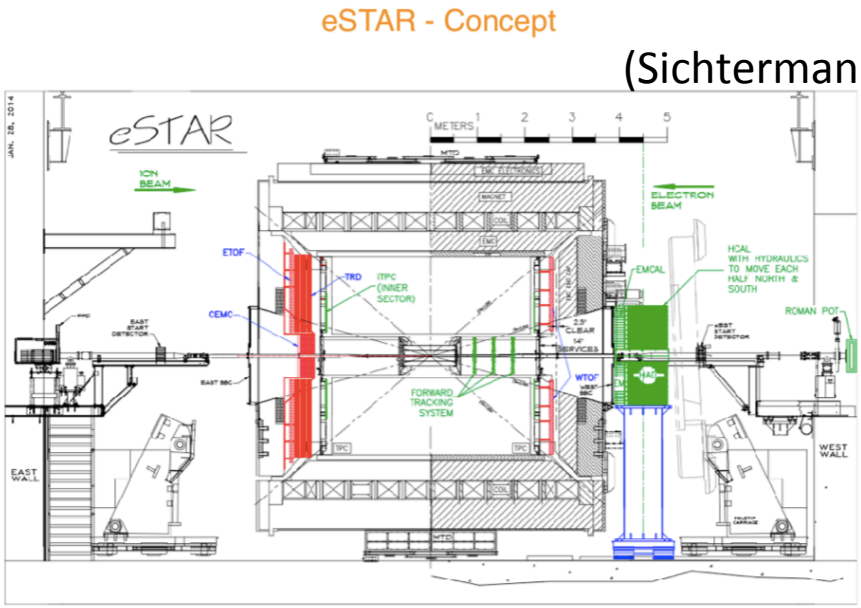
- If 2nd Detector, how should we think about it.

- "Upcycled" Detectors
  - eSTAR
  - BaBar solenoid / sPHENIX
  - CLEO solenoid / SoLID

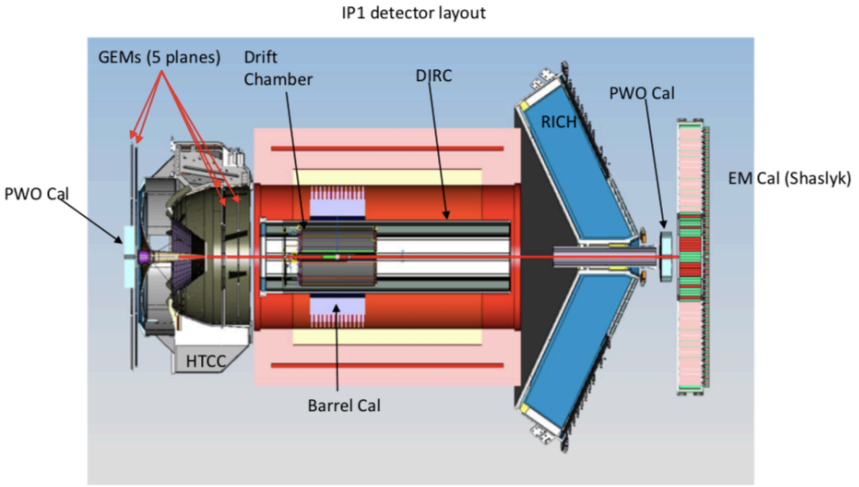
- Specialized detector
  - Ideas on low-x and high-x detectors

- Full 2nd Multipurpose Detector

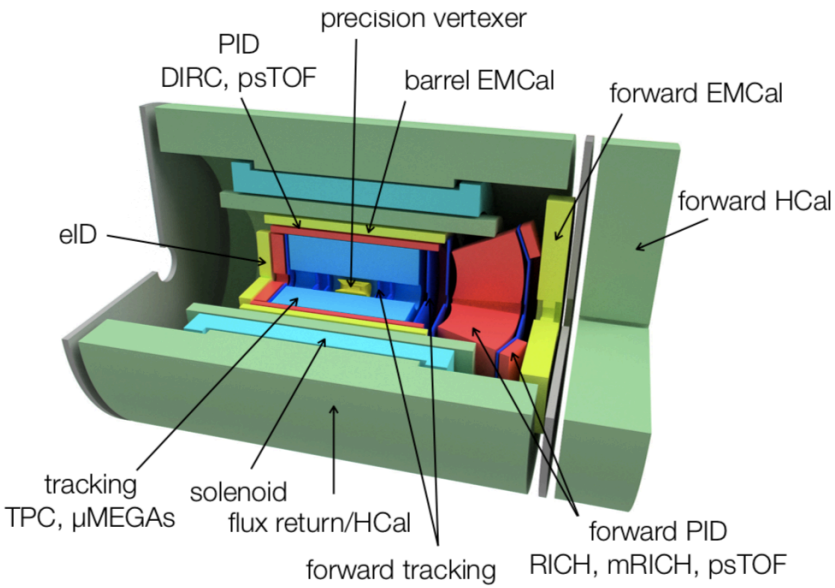
Upcycle options



(Sichtermann)



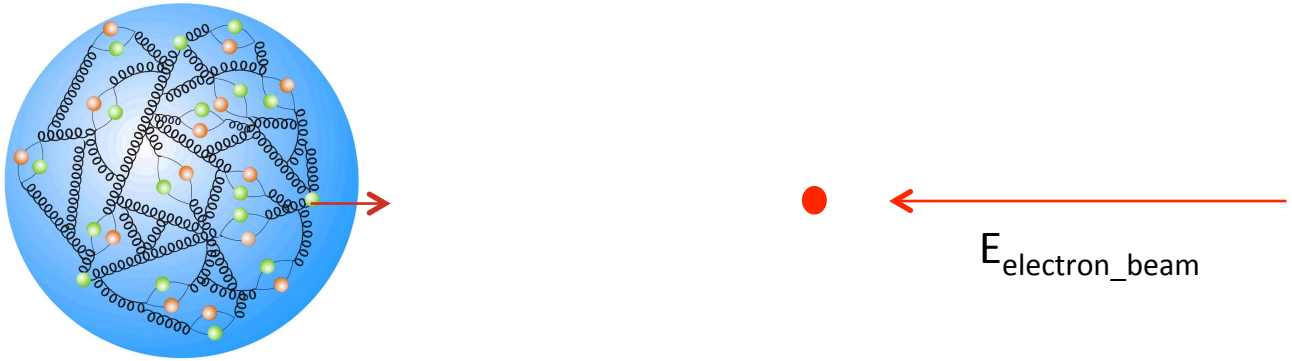
Jefferson Lab Upcycle (Keppel)



BaBar magnet/ePHENIX Cencept (Morrison)
LOI in the works

Specialized Detectors: think about lox-x

Highly asymmetric collision at the parton level



Since x → 0, energy is tending to 0
at x = 10^{-4-5}

Beam Energy ~10 GeV

Parton energy ~ 10 MeV

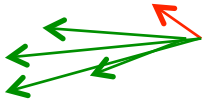
Where does the final state go?

Final States for low-x

y ~ 1 (lowest x)

10 GeV total

electron energy < E_{beam} Relatively high angle



"remnant", p for diff.

y ~ 0.1 (same Q^2, somewhat larger x)

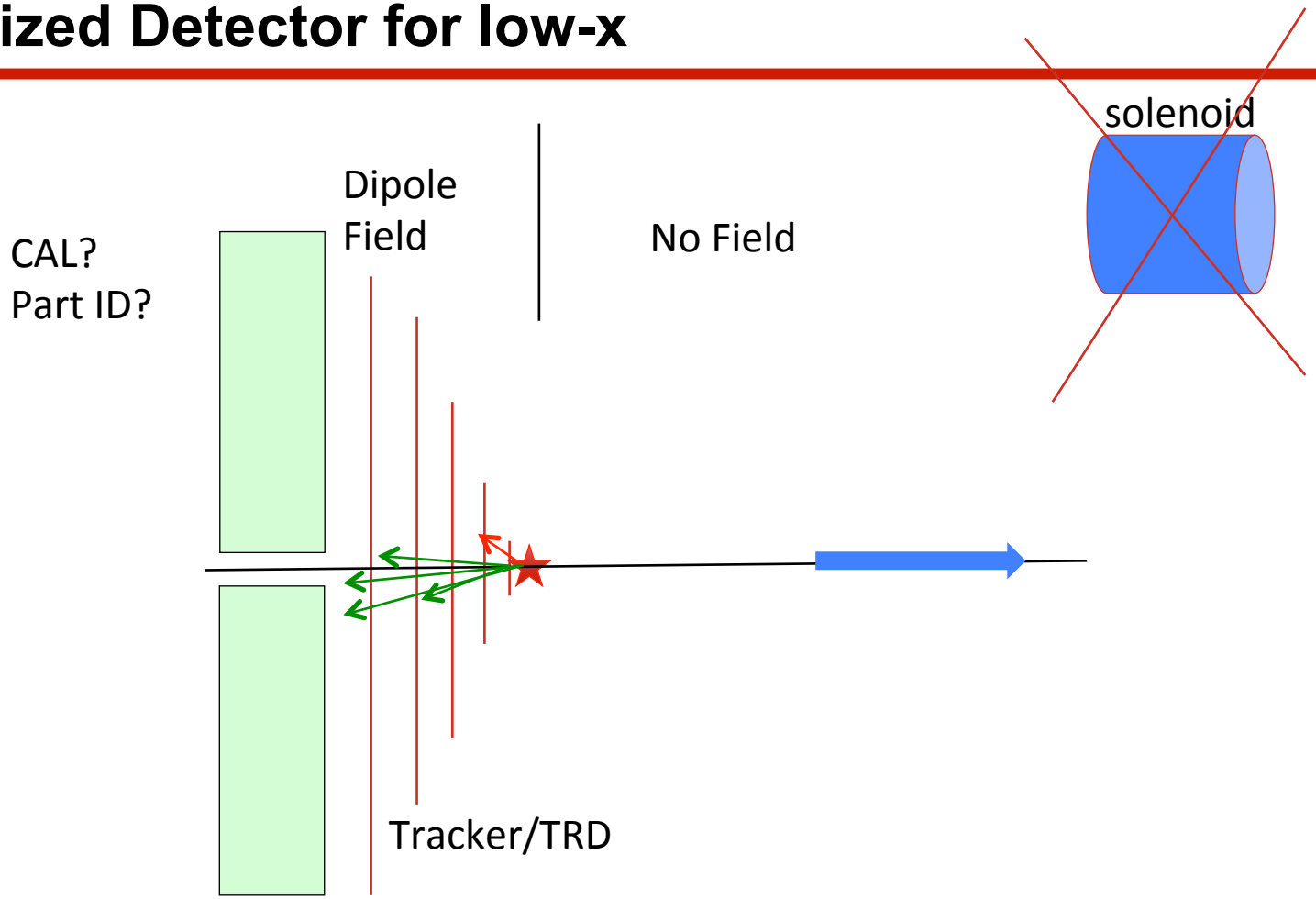
10 GeV total

"remnant", p for diff.

electron energy ≈ E_{beam} Low angle

Left side is essentially fixed target kinematics

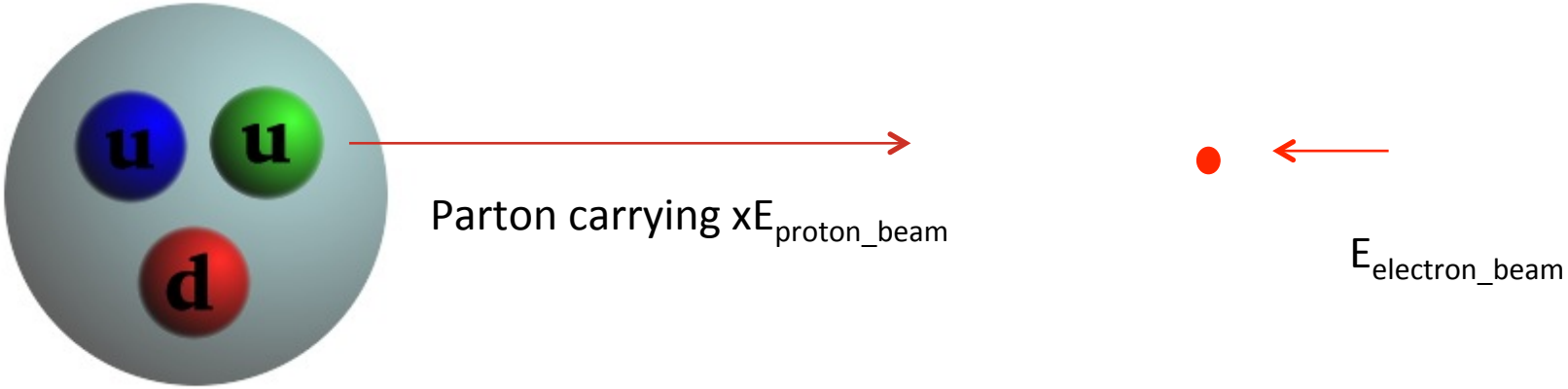
Specialized Detector for low-x



We're only reconstructing ~10 GeV worth of particles
-and the diffractive forward state.

High-x Kinematics

Highly asymmetric collision at the parton level (the other way)



Since x ->1, this is like the beam energy

Parton energy ~100 GeV

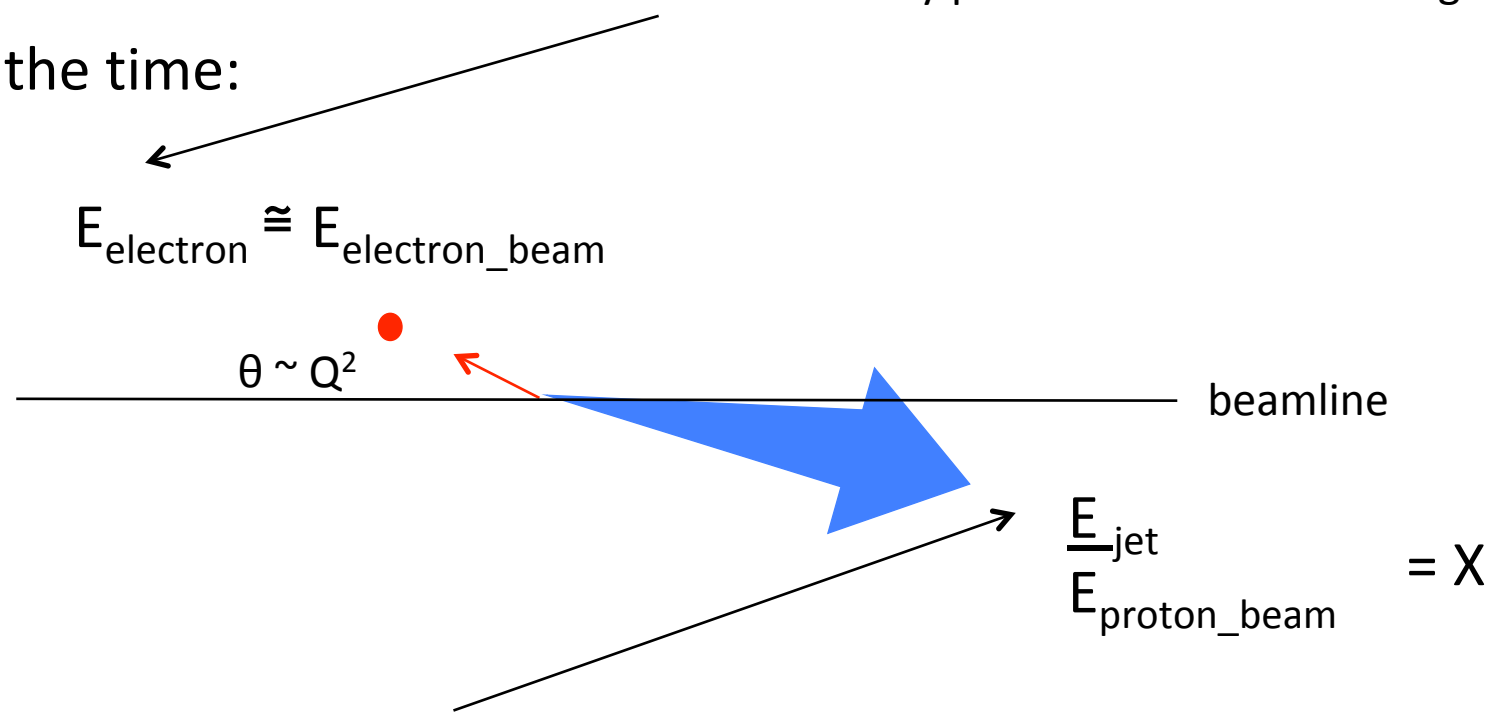
Electron Beam ~10 GeV

Where does the final state go?

Where do the particles go?

Need a very precise measurement to get x

Most of the time:



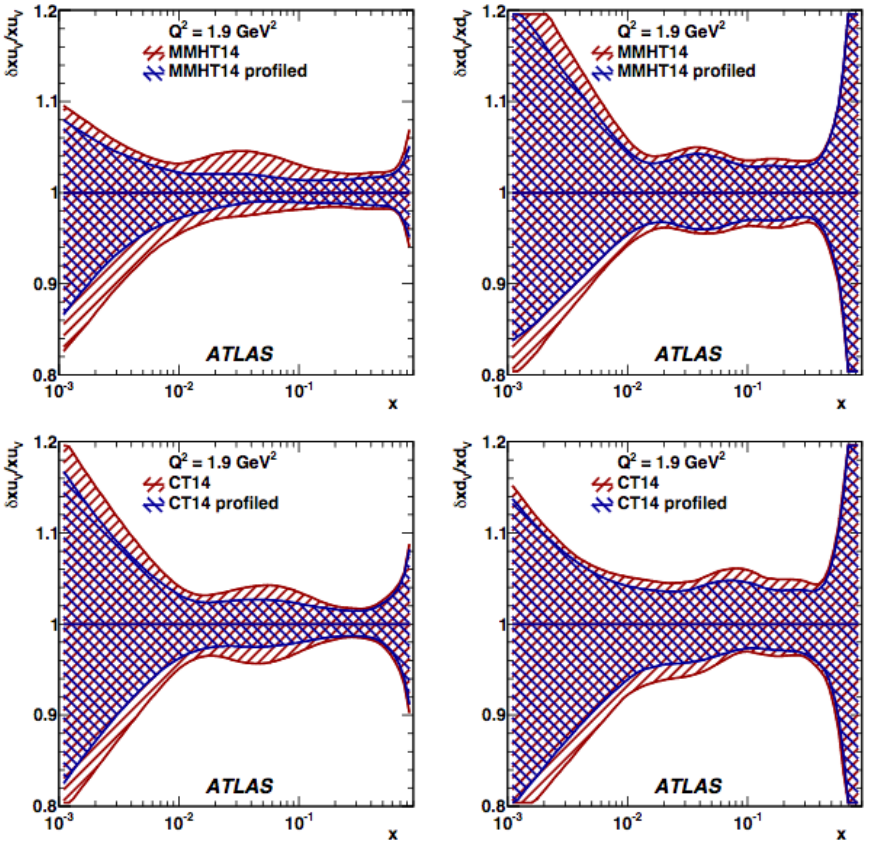
This is hard to measure: a jet close to beam pipe

This is why HERA measurement have big bins for high-x
Can we do better at LHeC and EIC? Yes.. in principle..

Why measure at high-x?

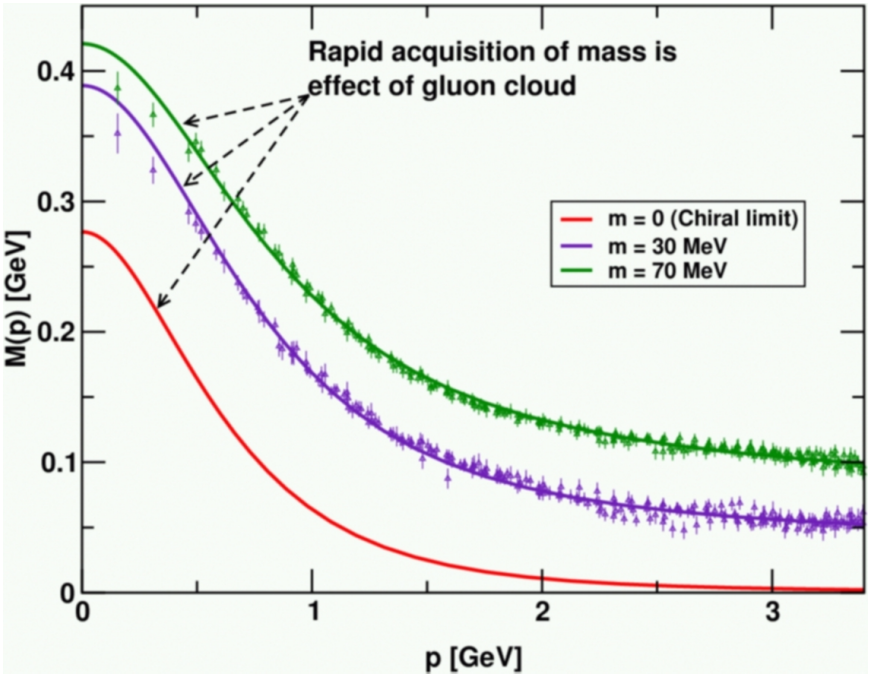
(See Olness)

High-x uncertainties and LHC searches



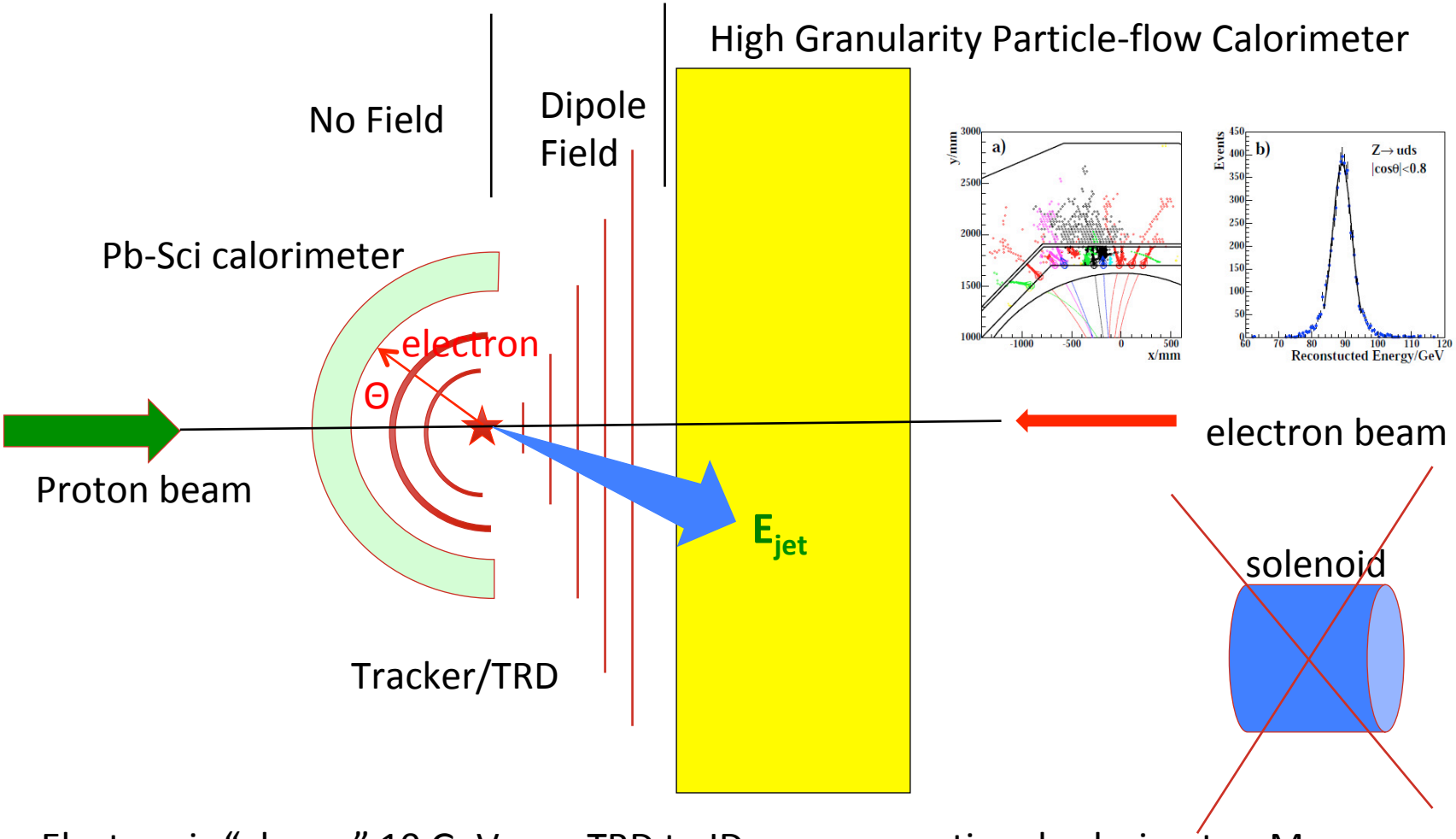
Dynamical Symmetry Breaking (see Cloet)

Pion/Kaon structure at high-x and origin of mass



Many reasons to do high-x at EIC

Specialized Detector for High-X

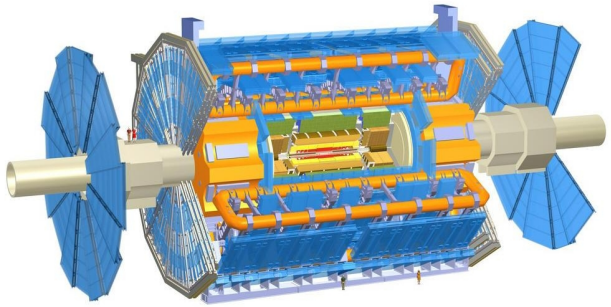


Electron is “always” 10 GeV: use TRD to ID, use conventional calorimeter. Measure angle to get Q^2.

Jet energy needs to be measured as well as possible for x: use particle flow. 30%/root(E)? If so 3-5% resolution on x (0.5 to 1)

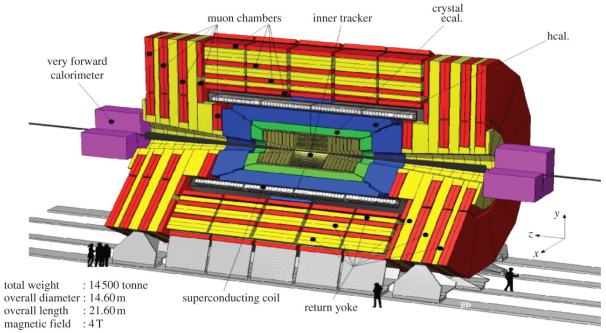
Two Multi-purpose detectors

ATLAS

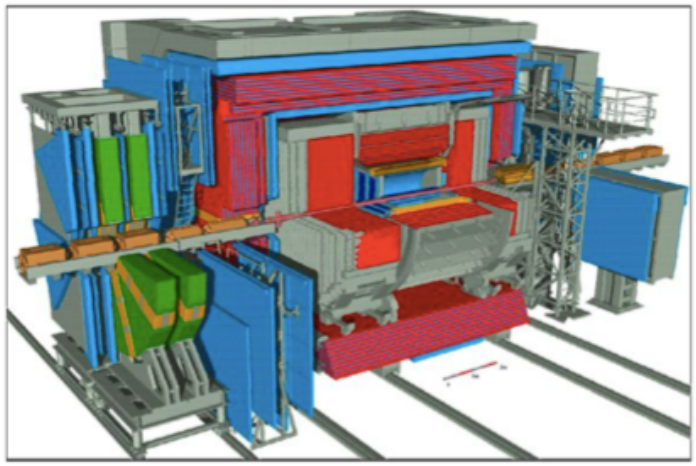


and

CMS

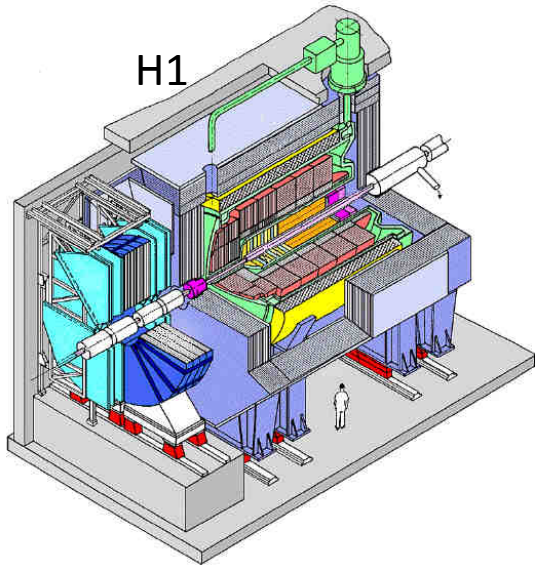


ZEUS



and

H1



Two Detectors Combined results

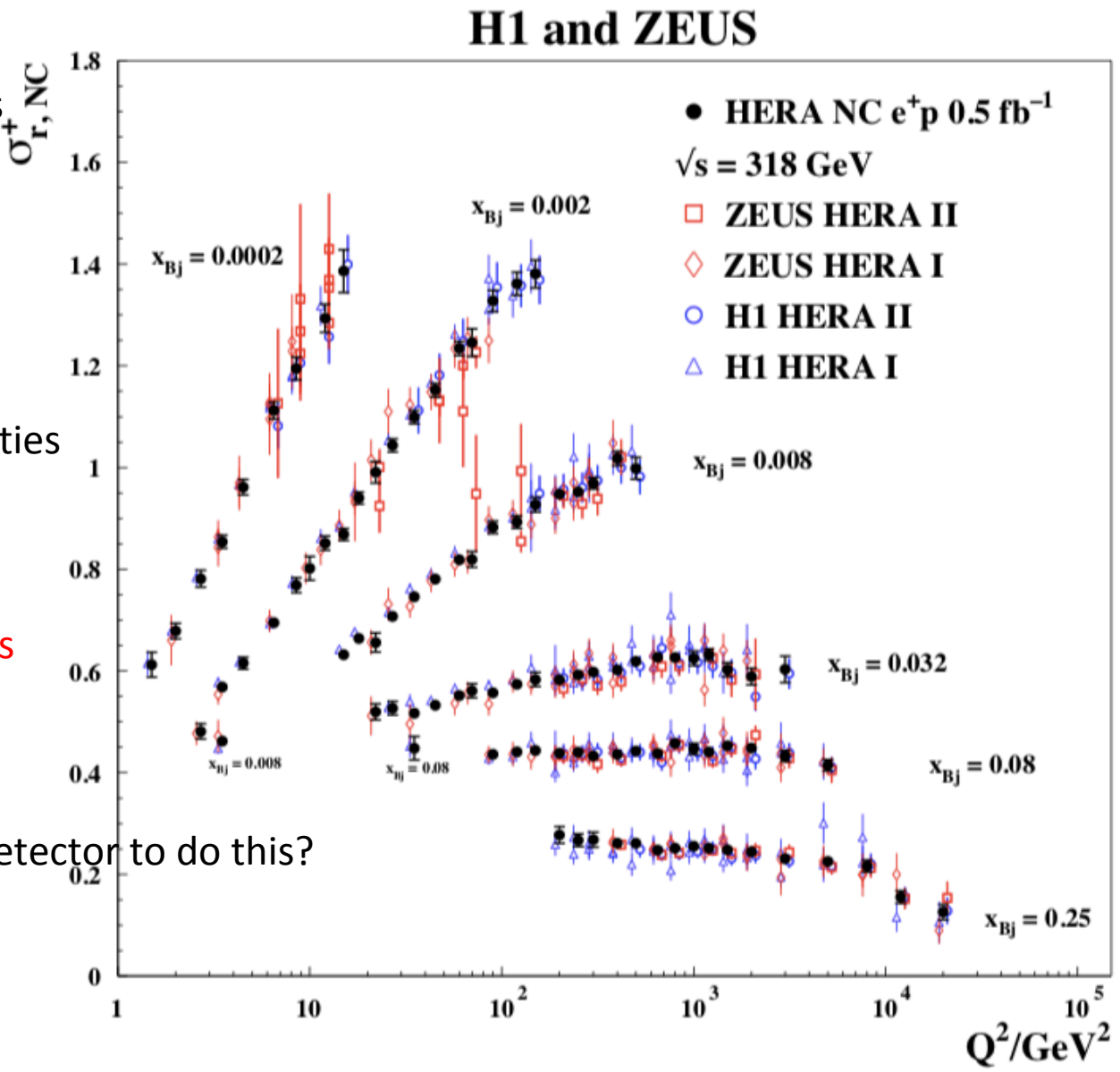
Dramatic cancellation of systematic uncertainties

(How this happens is a talk in itself)

Cannot be duplicated by just "being careful" about systematic uncertainties in a single detector.

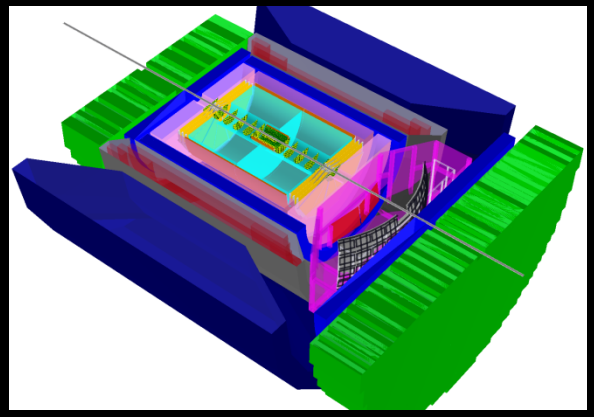
Has to do with multiple measurements of quantities using different methods and detectors.

Q: can we design a single detector to do this?

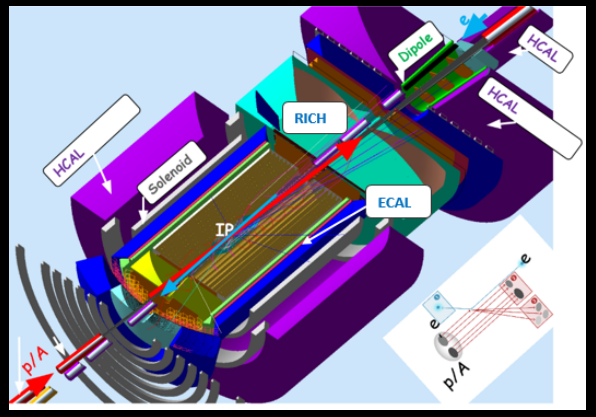


4 Detector Concepts for the EIC

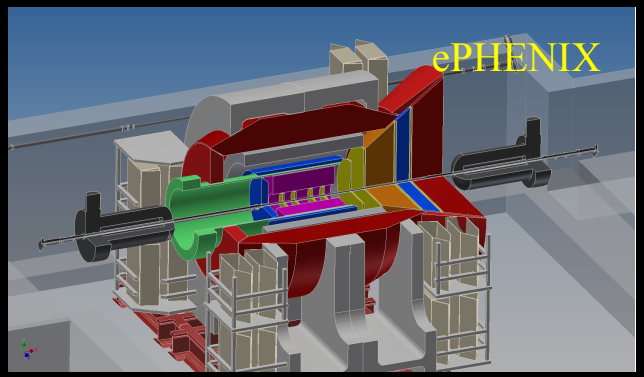
Brookhaven concept: BEAST



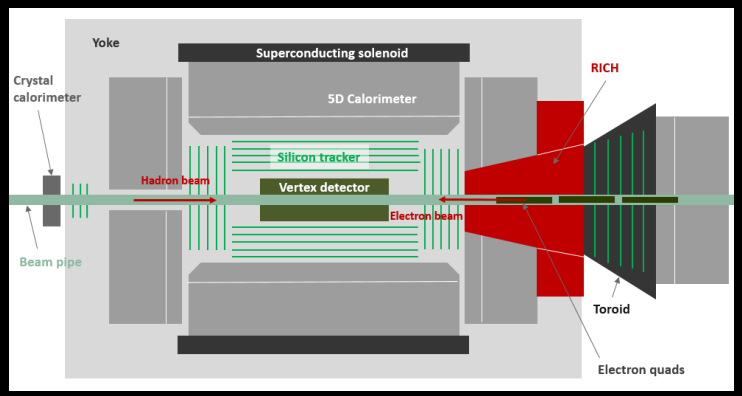
Jefferson lab concept: JLEIC



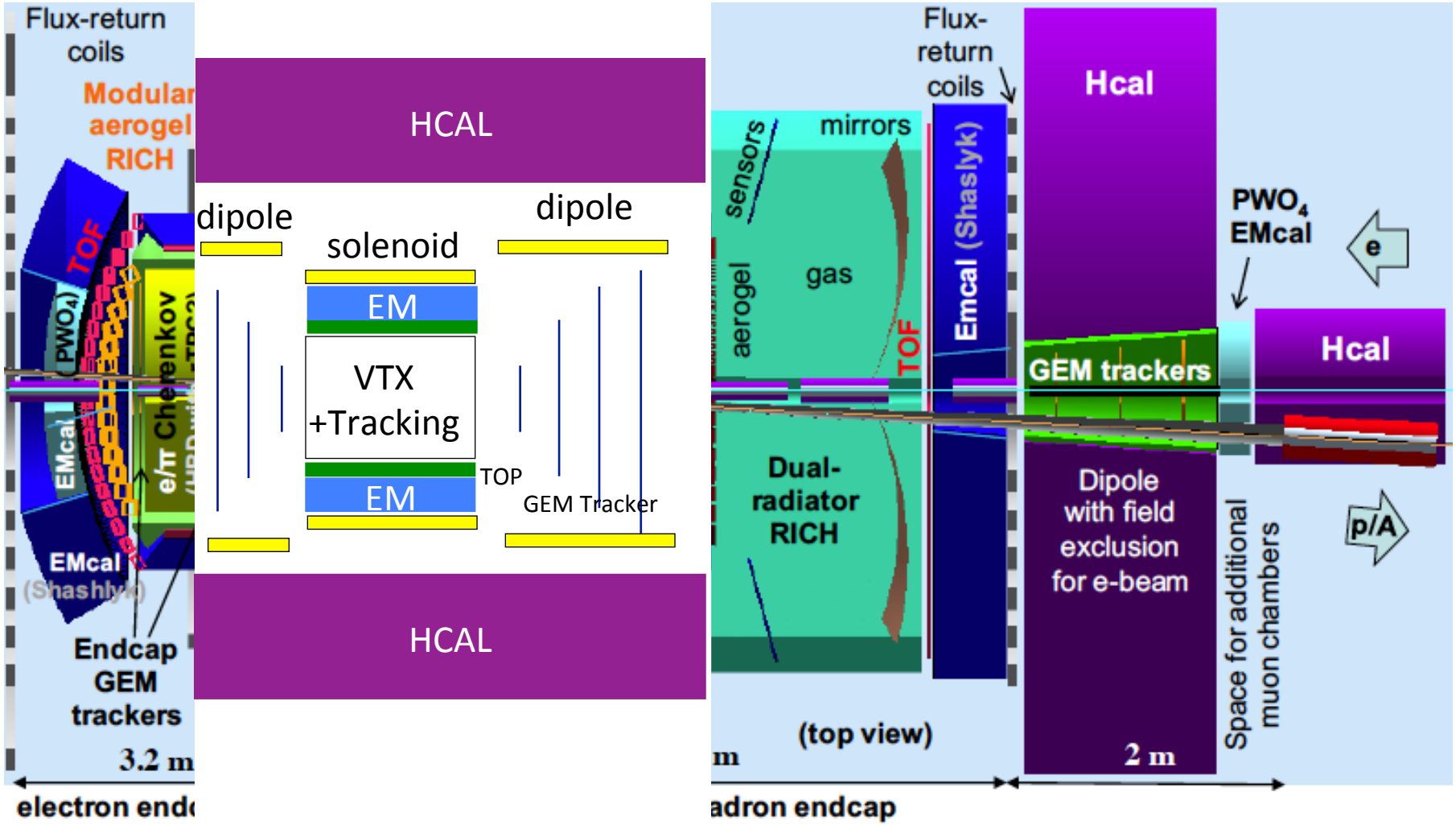
sPhenix → ePhenix



Argonne concept: TOPSiDE



A Different Concept?



Detector Workshop

- From past experience: after its establishment, the EIC laboratory will likely solicit detector proposals from the community.
- Existing detector concepts will certainly play a major role in this process.
- However, detector ideas will, and should, develop in the coming years. In the end, the detector(s) we will build—in my view—will be very different from the current concepts.
- There is plenty of scope for new ideas and contributions—from specific sub-detectors to entire detector concepts.

Backup

Streaming Readout Summary

Conclusion

Streaming readout is possible !

- advances in technology → ASIC, FPGA, muti-core CPU, ...
- falling costs in electronics, computing, storage, and networking
- advances in software → neural networks, machine learning, TPUs, ...
- can expect further improvements over the next decade

Future EIC experiments will benefit from streaming readout

Implications for detector, electronics, software, and analysis

Important that streaming readout approach be endorsed now

So all groups can include this in their designs !

Particle-ID Ad-hoc Workshop Summary

- An overall good panorama to provide input for choices
  - Important also to form a community to elaborate choices as soon as the EIC context is mature
- A relevant open question
  - The use of SiPM in RICHes
    - a very long way to go to understood if SiPM are real options for RICHes
- My favorite R&D activities (addressing the most crucial points):
  - EIC DIRC
    - Ultimate performance of the DIRC concept
  - LAPPD
    - Relevant for DIRC, TOP, high-p RICH … (almost for everything !)
  - Going further with MPGD PDs
    - it supports one of the two only options for hPID @ high-p
- The blue skies R&D, not to be abandoned:
    - It is not obvious that they will converge or that they will be on time for EIC
    - Nevertheless a relevant novel project (EIC) must have space also for a bit of dream and you never know …

Tracking ad-hoc meeting summary

Summary

- Several gas and silicon technologies were discussed
  - $\mu RWELL$, straw tubes, and INGRID
  - 4D (fast silicon), micro-channel cooling, and DEPFETs for tracking
- Three companies are currently pursuing commercial GEM development
- Ideas discussed
  - Gas trackers moving to integrate PID *i.e. GEM-TRD*
  - Using cluster counting rather than dE/dx for PID
  - Fast gas detector (ps detector) *ala* 4D silicon
  - ps MPGD for TOF

Calorimeter Ad-hoc Meeting Summary

Guidance for path forward

- Initial R&D for the central region EIC calorimeters is essentially complete. Main issue seems space and cost, while maintaining radiation tolerance
- Forward R&D is making progress. Excellent resolution in energy and position is required. Works needs to continue with PbWO4 vendors and on understanding and reducing the constant term
- Development of cost effective, high performance material is essential
- Suitable technologies for auxiliary detectors needs to be identified and evaluated

A follow-up workshop to further discuss the different opportunities and explore synergies with university and laboratory groups is planned