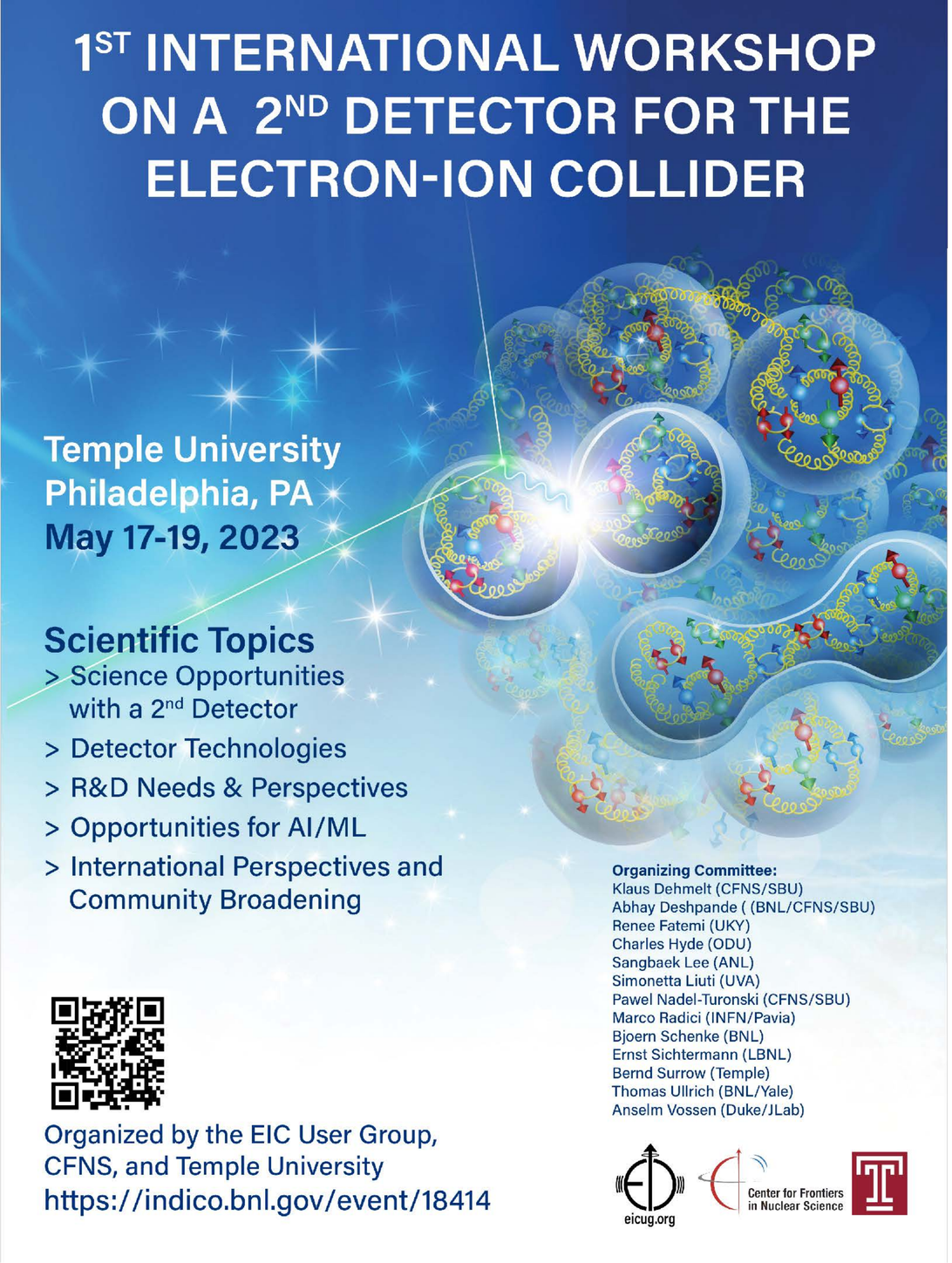


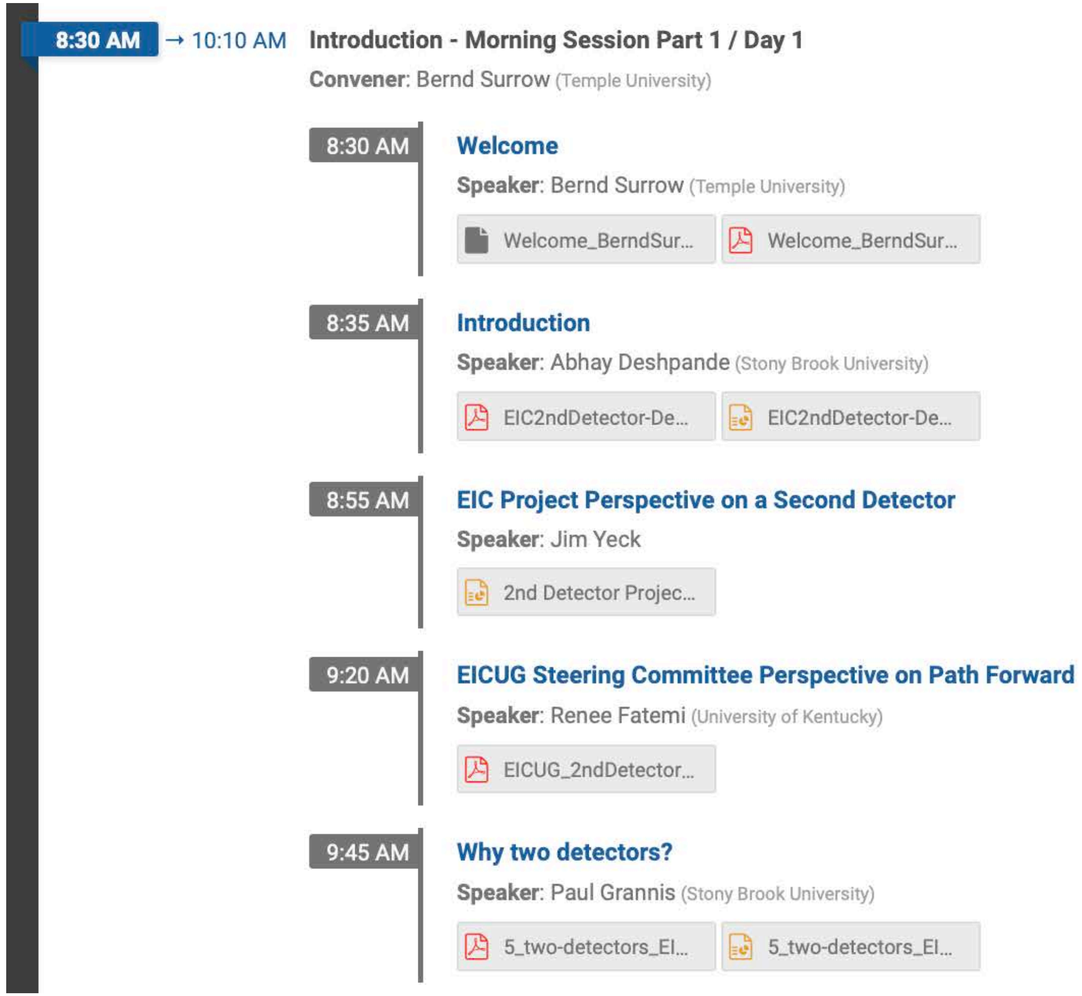
A Brief Summary

Thomas Ullrich

May 25, 2023

BROOKHAVEN NATIONAL LABORATORY

Highlights: Opening Sessions (I)



Jim

- *Project Design Goals: Accommodate a Second Interaction Region (IR)*
- *DOE, and BNL and JLab as the Host Labs, are establishing a governance structure intended to support the EIC. This includes the construction of a 2nd IR and detector.*
- *2nd IR and Detector will be installed after the EIC project is complete*
- *IR and detector technologies should be state of the art*
- *International engagement should be significant*
- *Organized effort needed now to prepare plans and build support for the 2nd IR and Detector*

(imho very encouraging talk)

Highlights: Opening Sessions (II)

arXiv:2303.08228

- Paul Grannis
  - *Why Two Detectors for Colliders?*
  - Lots of interesting examples on
    - *Instances where two independent experiments were critical for confirmation of major new discoveries*
    - *Instances where a second experiment corrected a mistaken observation by the other experiment*
    - *Instances where a one experiment had a unique capability such that the second experiment could not corroborate*

JLAB-PHY-23-3761

Motivation for Two Detectors at a Particle Physics Collider

Paul D. Grannis* and Hugh E. Montgomery†
(Dated: March 27, 2023)

It is generally accepted that it is preferable to build two general purpose detectors at any given collider facility. We reinforce this point by discussing a number of aspects and particular instances in which this has been important. The examples are taken mainly, but not exclusively, from experience at the Tevatron collider.

I. INTRODUCTION

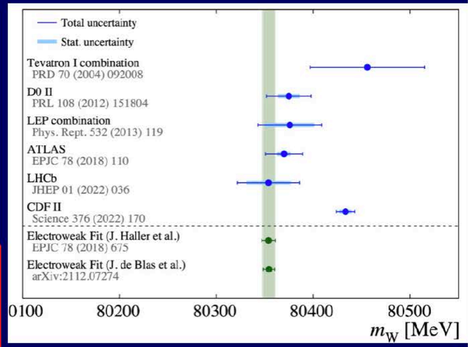
The Electron Ion Collider (EIC) [1] is a new facility being constructed at Brookhaven National Laboratory in collaboration with Thomas Jefferson National Accelerator Laboratory and their domestic and international partners. In early 2022, the experimental program was discussed by a distinguished "blue Ribbon" panel of physicists. The committee was asked to adjudicate on the choice of a first detector based on the submission of different designs by three collaborations. While choosing one of the three, the committee also commented on the potential for improvement

Divergent results on W mass

Prior to 2022, all precision measurements of W boson mass (LEP, CDF, D0 ATLAS, LHCb) were in good agreement.

But in 2022, CDF superseded its previous Run II result with a much more precise measurement that disagreed with the others at the level of 3 – 4σ.

New measurements of comparable precision for cross checking the CDF result are not likely until the advent of future e^+e^- colliders.



Thus considerable uncertainty remains on how to interpret the new result

5

Highlights: Opening Sessions (II)

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The benefit of two experiments is large.

- Complementary results give needed confidence for validating discoveries or verifying unexpected results.
- Since any one experiment will be wrong some of the time, having only one detector compromises the program.

Highlights: Physics Talks (I)

Many good interesting talks. Not always entirely focussed on EIC but related and valuable.

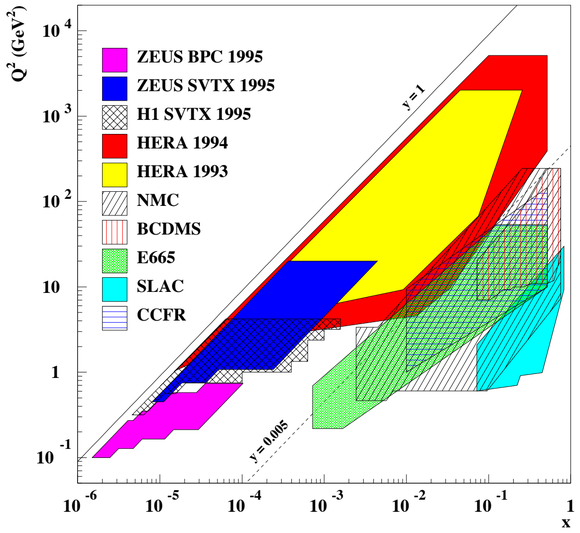
- Felix Ringer
  - Nature of Jets at EIC
  - progress on separating quark versus gluon jets using AI/ML at LHC
  - studies show that it is very promising at EIC as well
  - important at EIC: soft particles & PID (need more studies and requirements)
- Helen Caines
  - (Di-)jets & di-hadrons from HI studies to ep and eA
  - Lepton-jet correlations in DIS in eA (sensitive to energy loss in CNM)
- Dima
  - Entanglement entropy and saturation at the EIC
  - Indications from experiment that the link between EE and parton distributions is real, and proton at small x is a maximally entangled state.
  - Further tests at EIC (requirements for detector design for target fragmentation region)

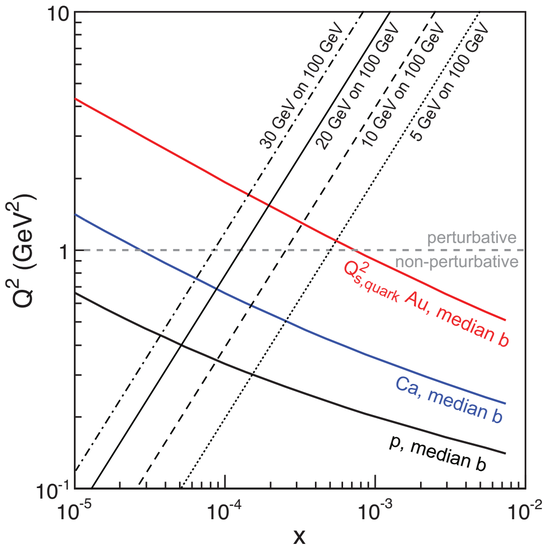
Highlights: Physics Talks (II)

- Hatta
  - Exclusive Reactions at low-x: GPDs or Color Dipole?
  - *Two approaches to exclusive processes*
    - *moderate energy→GPD factorization*
    - *very high energy→color dipole, kt factorization*
  - *The two communities rarely interacted* (see Bjoern's et al. LDRD)
- Blair Seidlitz
  - High multiplicity eA events: azimuthal anisotropies
  - *Evidence for a possible observation of collectivity at the EIC is mixed*
  - *Measurements of collectivity at the EIC could allow systematic control of the initial state which is not possible in any other collision system*
- Ivan
  - Hadronization and Jet Substructure Analysis in eA and ep
  - *EIC and especially its eA program can answer fundamental questions about hadronization, many-body QCD, transport properties of matter, the effects of heavy quark mass on parton showers*

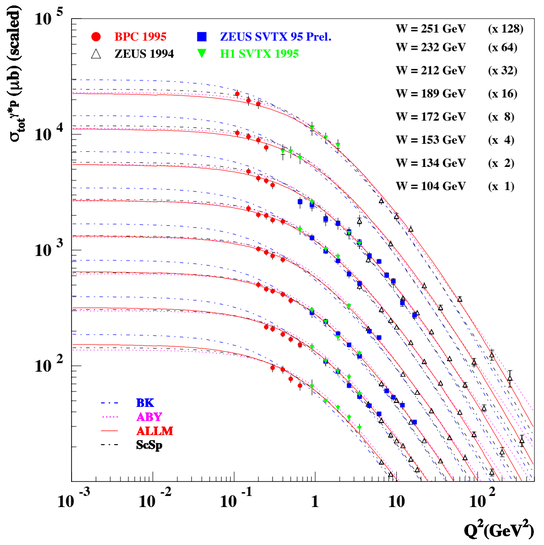
Highlights: Physics Talks (III)

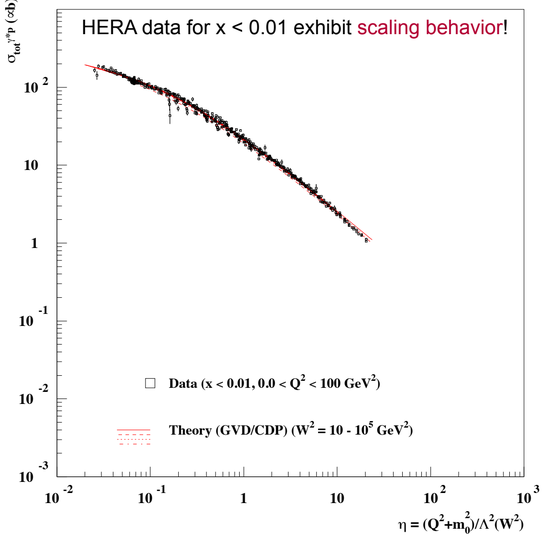
- Bernd Surrow
  - Physics at Low-Q^2
  - Many examples from HERA how they tried to fix low-Q^2 gap
  - *The physics program of exploring saturation phenomena requires continuous coverage below Q^2=1 GeV^2, at least an order of magnitude below Q^2=1 GeV^2, where pQCD description fails, i.e. to at least Q^2=0.1 GeV^2*
  - *ePIC low Q^2 tagger is a photoproduction tagger - critical for photoproduction physics and Q^2 acceptance well below Q^2=0.1 GeV^2!*
  - *Opportunity for 2nd detector: Maximize Q^2 tagger down to at least Q^2=0.1 GeV^2 / Integrate detector design with appropriate IR layout concerning small electron-angle () acceptance!*





$$Q^2 = 4E_e E_e^{'} \sin^2\left(\frac{\vartheta_e^{'}}{2}\right) \simeq E_e E_e^{'} \vartheta_e^{'2}$$





Highlights: Physics Talks (IV)

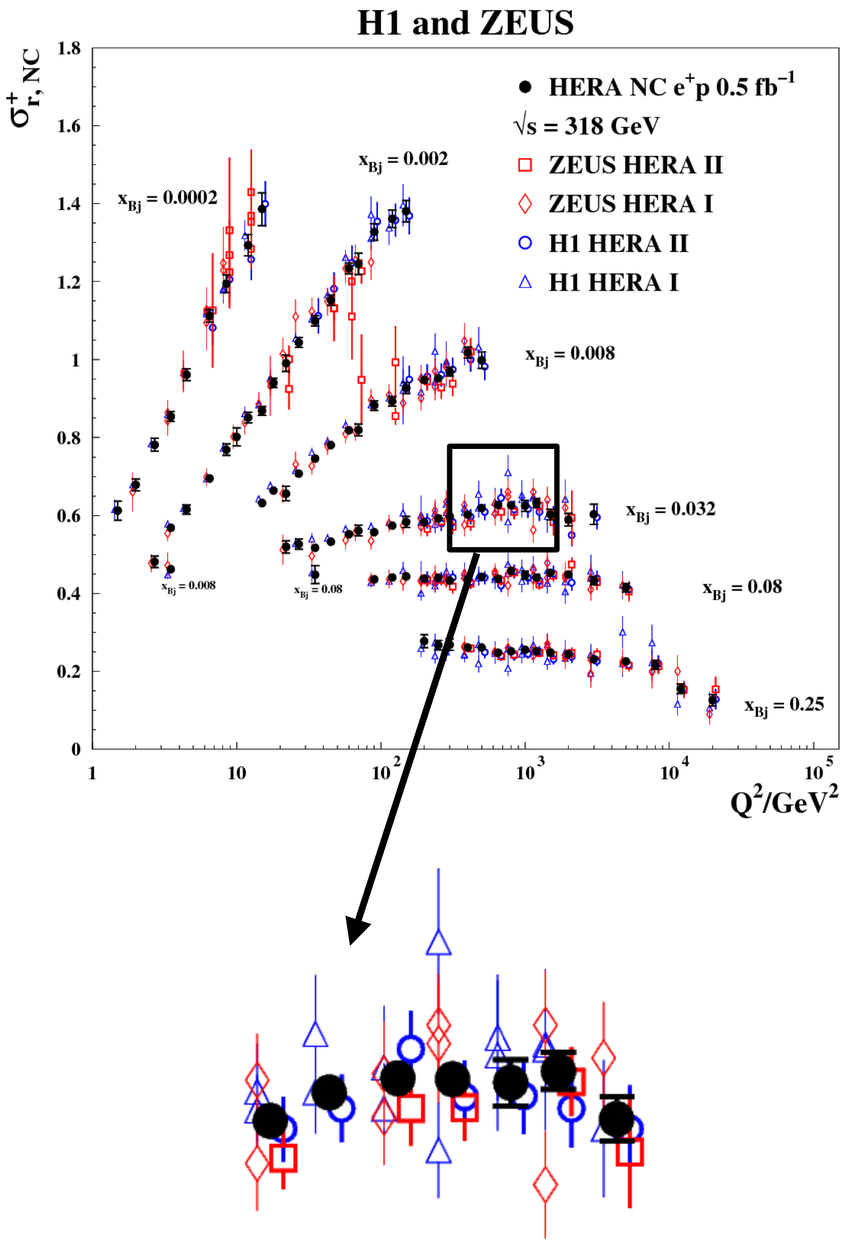
- John Terry
  - Nucleon and Nuclear TMDs
  - *find that one can absorb medium modifications into the intrinsic widths of the TMDs to define nTMDs*
  - *perform the first extraction of both the nTMD PDF and nTMD FF from the world data of Semi-Inclusive DIS and Drell-Yan.*
- Hannu Paukkunen
  - Nuclear Parton Distributions
  - Improvements from CMS, LHCb data.
    - Some are good: e.g. CMS 8TeV $W^{\pm}$
    - Some are less sensitive or have issues: CMS 8 TeV Z, double diff. D and B mesons, exclusive J/Ψ production
    - Danger: shoveling non-factorizable effects into nuclear PDFs
    - EIC will ultimately tell

Highlights: Physics Talks (V)

- Zhangbu
  - Tracking the origin of baryon number with electron- ion collisions
  - Talk caused some excitement, many heard this for the first time
  - *Baryon Number: We do not know what its carrier is; it has not been experimentally verified*
  - *EIC can measure the baryon junction distribution function* (⇒ requirements)
- Feng
  - Diffractive Dijets & Wigner Functions
  - *Contribute to the key physics goals at the EIC*
    - *Spin/tomography of nucleon, e.g., probe the Gluon GPD*
    - *Gluon Orbital Angular Momentum*
    - *Small-x gluon saturation*
  - *Compelling: nucleon tomography through parton Wigner distributions*
    - more complex and tricky than initial assumed (gluon radiation, NLO, ….)

Highlights: Physics Talks (VI)

- Katarzyna Wichmann
  - Complementarity - H1 and Zeus at HERA
  - *H1 and ZEUS detectors complementary by chance, EIC has a chance to do it on purpose*
  - *Combination of inclusive DIS data samples*
  - *done using HERAverager: wiki-zeuthen.desy.de/HERAverager*
    - *162 correlated systematic sources taken into account*
    - *Improvement well beyond statistical factor of $\sqrt{2}$ → cross-calibration of systematic uncertainties*
      - *different dominant H1 and ZEUS systematics*
      - *effectively use H1 electrons with ZEUS hadrons*



Flashtalks

4:00 PM → 6:45 PM **Flash Talks - Afternoon Session Part 2 / Day 2**

Convener: Simonetta Liuti (University of Virginia)

4:00 PM **Gluon TMD opportunity with quarkonium production at a 2nd EIC detector**
Speaker: Francesco Giovanni Celiberto (UAH Madrid)
talk_2nd_Detector_...

4:10 PM **Search for baryon junctions in isobar collisions at EIC**
Speaker: Niseem (Magdy) Abdelrahman (Research Associate)
Baryon_Junctions_...

4:20 PM **A quick review on different Semiconductor Detector Technologies used in High Energy Physics Experiments**
Speaker: Shyam Kumar (Universita e INFN, Bari (IT))
3_Semiconductor_D...

4:30 PM **Mirror Reflectivity at Far UV - A Mirror Evaporation Facility at SBU**
Speaker: Wenliang Li (Stony Brook University CFNS)
2023_5_17_Temple...

4:40 PM **Rare Isotope Production and Detection in the Far Forward Region of IP8**
Speaker: Brynna Moran (Stony Brook University)
5_Rare Isotope Flas...

4:50 PM **Overview of the Temple University MPGD lab facility**
Speaker: Matt Posik (Temple University)
posik-EIC2ndDetWo...

5:00 PM **Research and development for an EIC 2nd detector KLM**
Speaker: Simon Schneider (Duke University)
7_2ndDetectorKLM...

5:10 PM **Passive bi-Polar Grid for Ion Back-Flow suppression**
Speaker: Evgeny Shulga (Stony Brook University)
BPG_05162023_es...

5:20 PM **Optimization of the detection of the scattered electron in the electron-going direction**
Speaker: Renee Fatemi (University of Kentucky)
DetII_FlashTalks_R...

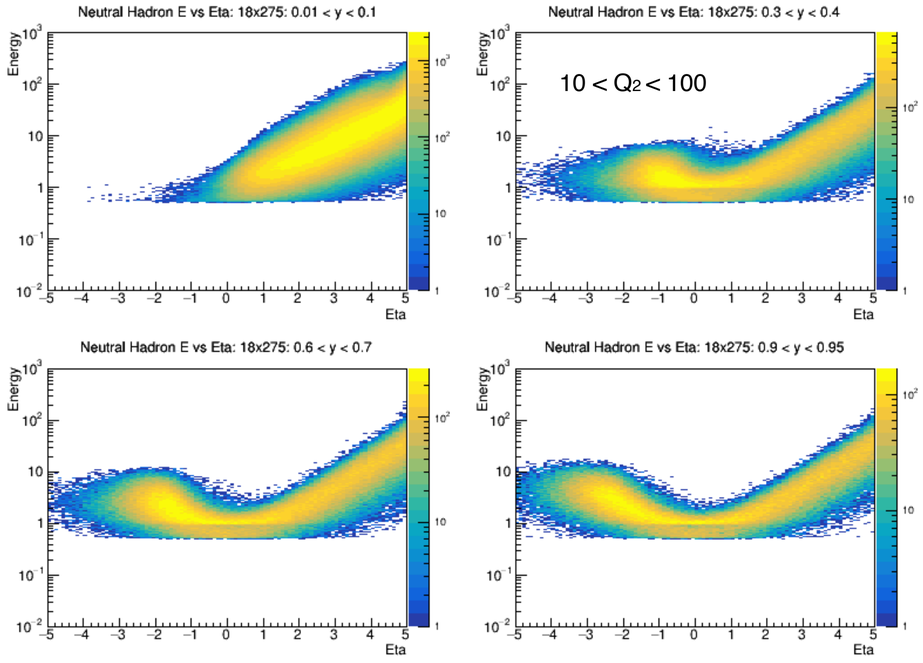
- 9 flash talks
- nothing too provocative
- Physics
  - TMD, baryon junctions, rare isotopes
- Facilities
  - SBU, TU
- Technologies
  - Si-Det, KLM, TPC grid, SciGlass

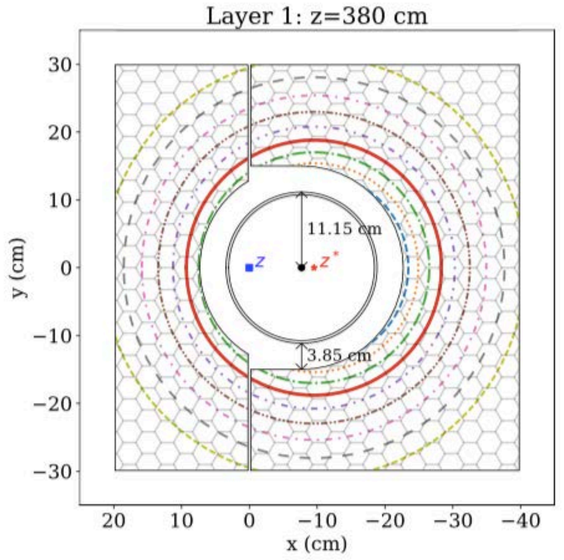
Detector/Technology Talks (I)

- Dave Mack
  - EIC-related Generic Detector R&D Program (current organized by Lab)
- TU
  - EIC Technology Inventory / Quest for Complementarity
  - Discussion of technologies that are (or might become) available for D2
- Maria Zurek
  - ePIC Overview
- Nicolas Schmidt
  - Electromagnetic Calorimeters at the EIC
  - Large pool of alternative approaches possible compared to ePIC
- Tom Hemmick
  - Gridpix miniTPC

Detector/Technology Talks (II)

- Brian
  - Hadron Calorimetry
  - *Need to take this into account that different regions see different energies when deciding the function, and therefore the form, of calorimeter systems at a second detector*
  - *Helps outline potential areas of complementarity*
    - *Some amount of 'inner calorimetry'?*
    - *Energy measurements vs neutral hadron ID / veto?*
    - *KLM / Muon tagging capability?*
  - *Larger crossing angle will pose challenges for forward acceptance – think holistically about beam pipe design, calorimeter design and position to maximize coverage*





Detector/Technology Talks (III)

- Kondo Gnanvo
  - μRWell PICOSEC
  - MPGD-PICOSEC detectors provide alternative options to Si-based fast timing detectors
  - MMG-PICOSEC achieves ~20 ps, μRWell behind needs R&D
- Zhenyu Ye
  - AC-LGAD-ToF
- Whitney Armstrong
  - Superconducting nanowire detectors
  - Photodetector: almost 100% efficient, radiation hard, B insensitive, GHz fast
  - Significant R&D effort tackling cryogenic readout architecture is underway
  - Many application at auxiliary detectors

Detector/Technology Talks (IV)

- Greg
  - hpDIRC
  - Improvements with xpDIRC (might ramp up p reach)
- Prakhar Garg
  - pfRICH
- Yordanka
  - Photosensors R&D
- Alexey Lyashenko (Incom Inc.)
  - An Update on HRPPD/LAPPD Application Specific Developments for EIC
- Renuka
  - Design considerations and constraints for the ePIC magnetic field

Many talks likes this build on ePIC and extrapolate forward

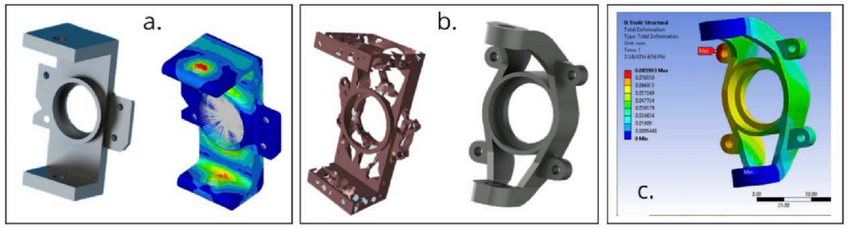
Detector/Technology Talks (V.a)

If there is one talk I will not forget than it is this:

- Andreas Jung (Purdue)
  - Advanced mechanics and composites
- Why?
  - ePIC: in the middle of integration efforts, cooling, construction, mechanics etc
  - Typically these issues are less talked about until you need it and then it's often too late (lesson for D2)
  - Andreas is in eRD112 (AC-LGAD), CMS member
- There are actually physicist who made this into an art form
- After his talk he was non stop busy talking to many of us

Detector/Technology Talks (V.b)

- Completed in summer 2016:
  - Composite manufacturing & simulation center (CMSC)
  - Multi-disciplinary center: Aeronautics, Chemical E, Materials E, Aviation Tech, Computer graphics
- A Purdue Center of Excellence:
- Experts in simulation as a decision making tool for composites
- Dassault Systems Simulation Center of Excellence
- Process-specific engineering workflows
- Carbon Fiber: Gold-standard and versatile material
  - Laminates, Compression, join with 3D printing



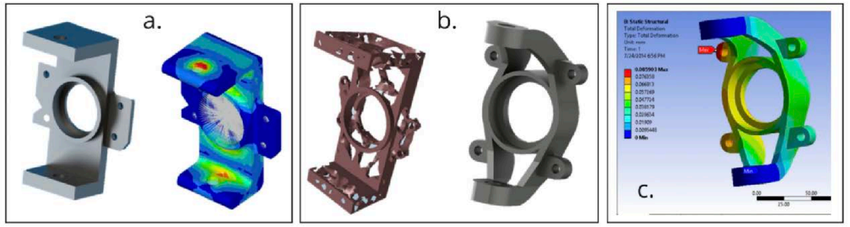
Example: Optimization with stress analysis and AI/ML

Detector/Technology Talks (V.b)

- Completed in summer 2016:
  - Composite manufacturing & simulation center (CMSC)
  - Multi-disciplinary center: Aeronautics, raphics

Detector mechanics can play a significant role in a detector's performance, improvements require:

- In-depth study of total mass folded w thermal performance
- Novel ways to reduce the total mass
- Improved performance compared to current state-of-the-art solutions



Example: Optimization with stress analysis and AI/ML

  - Laminates, Compression, join with 3D printing

Discussion Session: Golden Channels

Golden Channels

- These channels are just a starting point, a way to initially focus activities within the group
- Characteristic for various EIC key fields, good place to explore comlementarity

CHANNEL	PHYSICS	DETECTOR II OPPORTUNITY
Diffractive dijet	Wigner Distribution	detection of forward scattered proton/nucleus + detection of low p_T particles
DVCS on nuclei	Nuclear GPDs	High resolution photon + detection of forward scattered proton/nucleus
Baryon/Charge Stopping	Origin of Baryon # in QCD	PID and detection for low p_T pi/K/p
F_2 at low x and Q^2	Probes transition from partonic to color dipole regime	Maximize Q^2 tagger down to 0.1 GeV and integrate into IR.
Coherent VM Production	Nuclear shadowing and saturation	High resolution tracking for precision t reconstruction

Discussion Session: Future Activities & Milestones

Launch dedicated letter writing campaign to grow detector II effort through international grass-roots networking. Reach out to our colleagues and ask for help finding potentially interested groups that are available on detector II timeline

Plan on an international workshop series to discuss

- Detector requirement for Det II golden channels
- New and/or complementary technologies to measure Det II golden channels
- Introduction of new physics channels and ideas for the EIC

Work towards an expression of interest or letter of intent that summarizes opportunities and complementarity of Det II @ EIC