FFWD/FBKWD/Exclusive, Diffractive, Tagging and eA Workfest Summary

Raphael Dupre (IJCLab), Simon Gardner (U. Glasgow), Dhevan Gangadharan (U. Houston), Alex Jentsch (BNL), Rachel Montgomery (U. Glasgow), Nathaly Santiesteban (UNH), Kong Tu (BNL), Nick Zachariou (York)

Goals of this meeting

- Review physics channels which have been studied before.
  - Use that as a starting point to guide our work toward the TDR, the associated physics paper and in general getting "ePIC approved" plots.
- Summarize what is present in the DD4HEP simulations in terms of geometry and reconstruction.
  - Discuss how to run simulations, things to watch out for, etc.
- Use overview of physics channels to define needed benchmarks which will provide a way to track detectors updates, and allow for standardization of plots to use for TDR *et al.*
- *ASK QUESTIONS – HOPEFULLY GET SOME ANSWERS.*

Overview

Wednesday Morning Block:

- General Physics overview and review of previous plot strategy (**presentation**)
- Rough overview of beamline detectors (**presentation**)
- More in-depth review of plots in ECCE/ATHENA/CORE proposals (**hands-on/working session**)
- Needed plots for TDR – planned reproduction of plots from previous proposals and discussion of additional plots (**hands-on/working session**)
  - Goal is to come up with concise set of plots which show how the ePIC detectors meet the NAS requirements for the EIC.
  - Provide help for people to process events through npsim and begin analyzing output.

Wednesday Afternoon Block:

- Detailed detector discussion and DD4HEP implementation (**presentation**)
  - E.g. what output branches does an analyzer access to extract their information.
- Running simulations with particle gun and example of physics input (**hands-on/working session**)
- How issues in simulations relate to measurements (e.g. beam line magnet field settings for simulation and EICrecon) (**hands-on/working session**)
  - Discussion of needed tasks and assignment of people
  - Solving of open issues

Overview

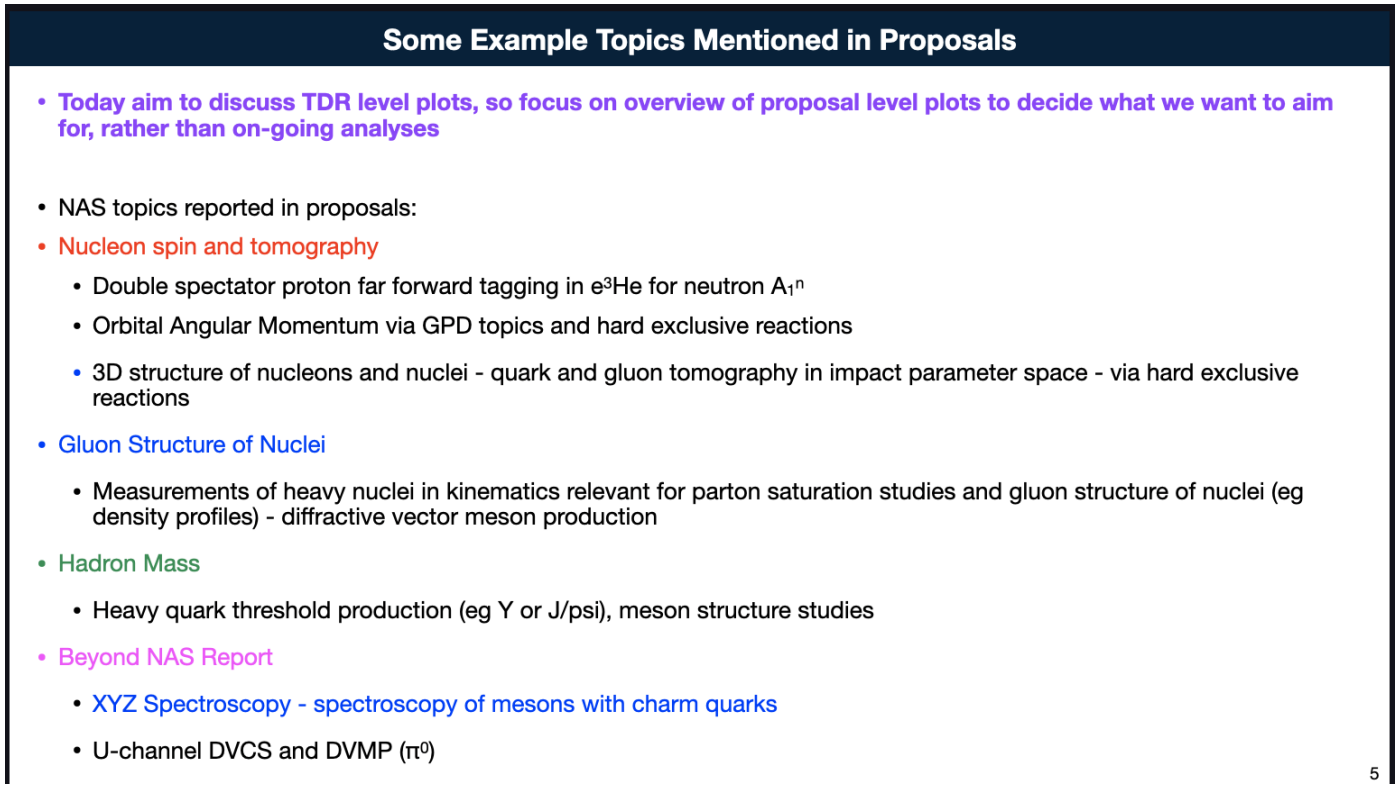
Thursday Morning Block:

- Overview of benchmarks in ePIC framework (**presentation)**
- Translation of plots from Wednesday morning to specific benchmarks (**working session**)
- Coding benchmarks and testing them (**working session**)

Thursday Afternoon Block:

- Discussions between detector experts on open tasks
- Continued work from first three sessions
- Open mic for short presentations to generate discussion
  - Dhevan - Lumi-LowQ2 Coincidence
- Next steps and tracking of progress?

Review of physics channels from previous studies



Some Example Topics Mentioned in Proposals

- **Today aim to discuss TDR level plots, so focus on overview of proposal level plots to decide what we want to aim for, rather than on-going analyses**
- NAS topics reported in proposals:
- Nucleon spin and tomography
  - Double spectator proton far forward tagging in e^3He for neutron A_1^n
  - Orbital Angular Momentum via GPD topics and hard exclusive reactions
  - 3D structure of nucleons and nuclei - quark and gluon tomography in impact parameter space - via hard exclusive reactions
- Gluon Structure of Nuclei
  - Measurements of heavy nuclei in kinematics relevant for parton saturation studies and gluon structure of nuclei (eg density profiles) - diffractive vector meson production
- Hadron Mass
  - Heavy quark threshold production (eg Y or J/psi), meson structure studies
- Beyond NAS Report
  - XYZ Spectroscopy - spectroscopy of mesons with charm quarks
  - U-channel DVCS and DVMP (π^0)

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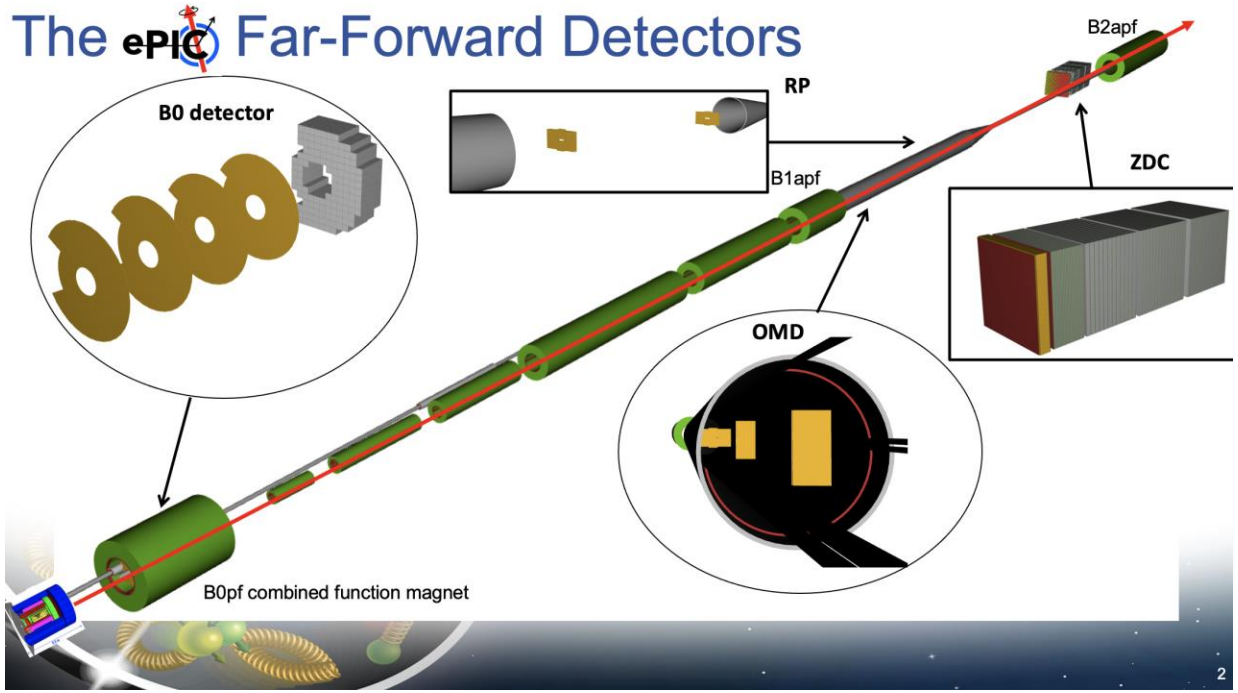
- Reviewed past material to develop action plan and discuss strategy for TDR plots (and wider physics paper)
- Discussed several reactions which can be linked to NAS topics
  - Nucleon Spin and nucleon tomography
  - Gluon structure of nuclei
  - Hadron mass
  - (as well as a couple beyond the NAS report)
- Also discussed potential new plots to aim for and new studies for diffractive topics (eg diffractive PDFs)

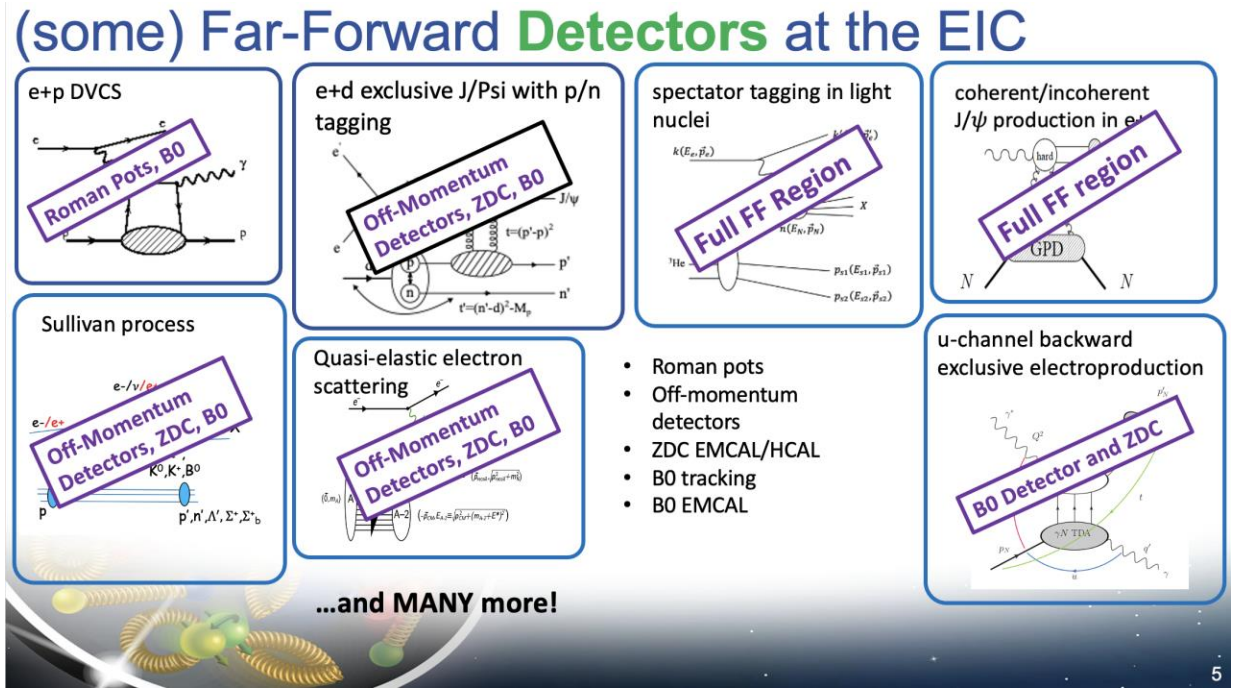
Resulting topics (so far) that we are planning:

- Diffractive PDFs (but may not be ready for TDR); DVCS and pi0 in ep and en; DVCS in eHe; vector mesons in eA; vector mesons in ep; Meson form factors and structure functions; Tagged DIS on light nuclei; u-channel DVCS/DVMP; XYZ spectroscopy; elastic ep; vector mesons in light nuclei

Overview of Far-Forward/Far-Backward Detectors and How They Work in DD4HEP

- Discussed why each detector is important and for which types of final states.





Overview of Far-Forward/Far-Backward Detectors and How They Work in DD4HEP

- Discussed why each detector is important and for which types of final states.
- Provided detailed overview of how each detector geometry is implemented (and what is missing).
- Discussed reconstruction capabilities for each sub-system and provided tools for basic analysis.

Reconstruction – Roman Pots

- Matrix method is used for reconstruction.
  - Matrix is dependent on the magnets – has to be re-calculated for any changes/abnormal circumstances.
  - Beam energy used for simulations MUST be given to ElCrecon***
    - **ElCrecon/src/algorithms/fardetectors/MatrixTransferStaticConfig.h**

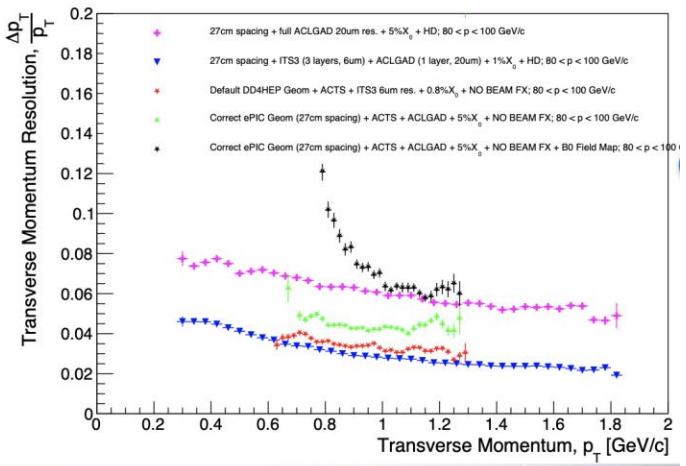
See "ForwardRomanPotRecParticles" branch.

```
#pragma once

namespace eicrecon {

  struct MatrixTransferStaticConfig {

    float     partMass  {0.938272};
    float     partCharge{1};
    long long partPDG   {2212};

    // Defaults here are for RPOTS
    double local_x_offset      {0.0};
    double local_y_offset      {0.0};
    double local_x_slope_offset{-0.00622147};
    double local_y_slope_offset{-0.0451035};
    double crossingAngle       {0.025};
    double nomMomentum         {275.0};

    std::vector<std::vector<double>> aX = {{2.102403743, 29.11067626},
                                           {0.186640381, 0.192604619}};
    std::vector<std::vector<double>> aY = {{0.0000159900, 3.94082098},
                                           {0.0000079946, -0.1402995}};

    double hit1minZ{0};
    double hit1maxZ{0};
    double hit2minZ{0};
    double hit2maxZ{0};

    std::string readout{""};
```

***we need to automate this – has not proven to be straight-forward previously.

B0 Tracker

- In principle works out of the box.
  - See "ReconstructedChargedParticles" branch.
  - Uses ACTS, should function just like analysis with main tracker.
  - For now, still using constant dipole + quad field – fieldmap is available and will be the "standard" soon.



The Result of TDR and Detector Validation Discussion

Process	Previous simulation	Generator(s)	Needed figures/tasks	Detectors needed now	Interested parties (currently)
DVCS (e+p)	ECCE full ATHENA full	MILOU ECCE EpIC ATHENA	t-distributions, gamma/pi0 separation	ePIC main detector; Roman pots, B0 tracker	Oliver Jevons
DVCS on neutron with tagging	Not previously done	TOPEG (need upgrade)	t-distributions, gamma/pi0 separation	ePIC main detector; Roman pots, OMD, B0 tracker	Raphael Dupré
Timelike Compton scattering	ATHENA full ECCE full	EpIC	TSSA (A_UT)	RP + ePIC main	
U-channel DVCS/DVMP (pi0, rho, omega, etc.)	Not previously done	eSTARLIGHT	Differential cross section; missing mass	B0 + ZDC	Zach Sweger
DVMP of Pi0 on p	Not previously done	EpIC	Overlap with DVCS	ePIC main detector; Roman pots, B0 tracker	Hao Jiang TBD
DVCS on He4	ECCE full	TOPEG	Differential cross section	RP	Gary Penman (TBD)
Coherent VMP on light nuclei	Not previously done	?	t-distribution	ePIC main detector; RP	Whitney Armstrong, Sangbaek Lee
J/Psi & Phi production (Au)	ATHENA full ECCE full	BeAGLE and SARTRE	t-distribution	ePIC main; full FF	Kong Tu (Phi), Peter Steinberg (J/psi)
J/Psi DVMP (proton)	ECCE full ATHENA?	LAGER	t-distributions in x_v bins	Main detector; full FF	Nathaly Santiesteban
Upsilon production (3 state separation)	ATHENA full CORE??	eSTARLIGHT RAPGAP for e+p	t-distributions; mass resolution for states	ePIC main	Mingjung Kim
XYZ Spectroscopy	ECCE full	eLSPeCTRo	Invariant mass distributions	Low-Q2 tagger + ePIC main	Derek Glazier
Pion Form factor/Kaon Form factor	ECCE	DEMPgen	Cross section, form factor as function of Q2; Lambda/Sigma reco.	ePIC main; ZDC & B0 tracker/EMCAL primarily	Garth Huber, Stephen Kay, Love Preet
Tagged DIS (deuteron)	Yellow report full (far-forward)	BeAGLE	Tagged cross section	B0 + OMD	Alex Jentsch
Tagged DIS (He3)	Yellow report full (far-forward); ECCE hybrid (real acceptance; fast reco)	CLASDIS	Tagged cross section; spin asymmetry	RP + OMD	Tyler Hague, Dien (TBD)

⋮

And more...just a snippet here!!!

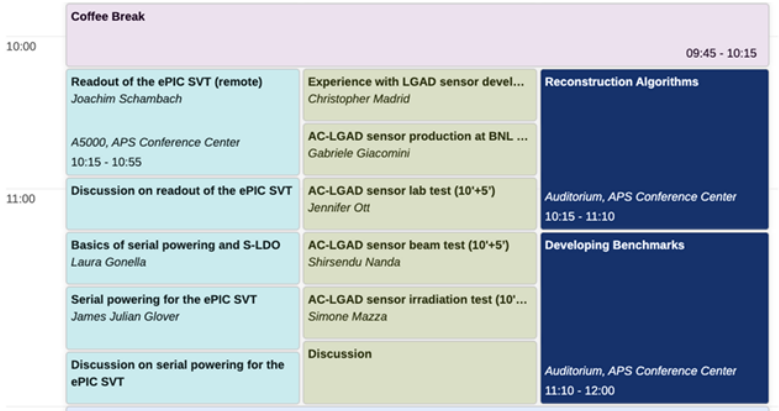
If you are interested in any topic please get in touch

From Table of Channels to Concrete Benchmarks

Benchmarks in ePIC

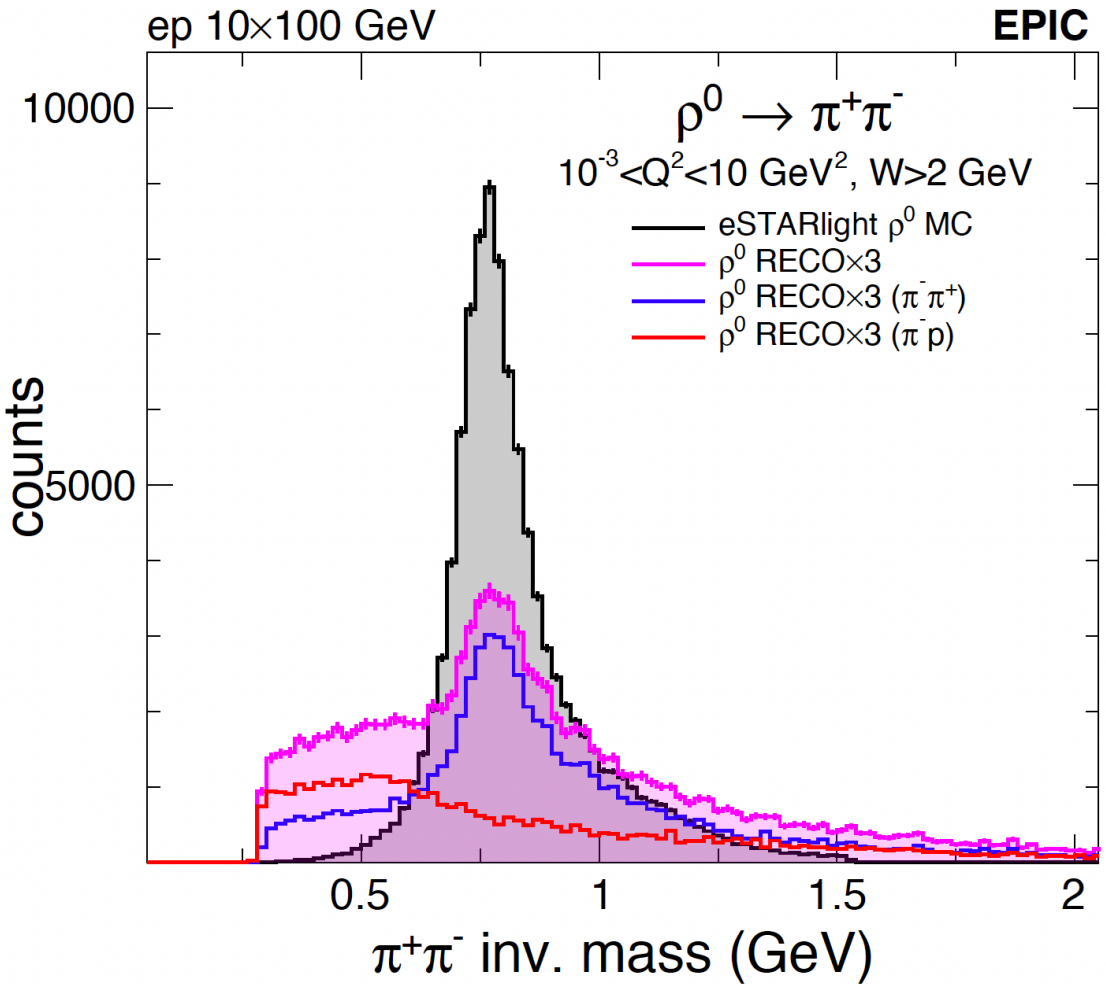
Slide from Kong Tu

- "*Developing benchmarks*" was part of the first day software tutorials – the official introduction.
- The simple idea is to *freeze* the analysis so that it can be run over and over against different developments in geometry, reconstruction, software, etc.



Here I'll walk you through an example of physics benchmark, how to run it, how to access the simulation output files, what the macro looks like, etc.

Analysis Progress during the Workfest



Workfest Plot: Z. Sweger (UC Davis)

- Several channels reported direct progress during the working sessions:
  - B0 benchmark progress for backward (u-channel) production of rho mesons (Z. Sweger, UC Davis)
  - DVCS ep and FF region benchmark (O. Jevons, U. Glasgow)
  - DVMP ep analysis (N. Santiesteban, U. North Hampshire)
  - Meson form factors (S. Kay, U. York, and L. Preet, U. Regina)
  - And others were also working…
- All are work in progress and some issues still being worked out
- It was impressive how quickly things progressed in this setting with laptops out (including for remote participants)

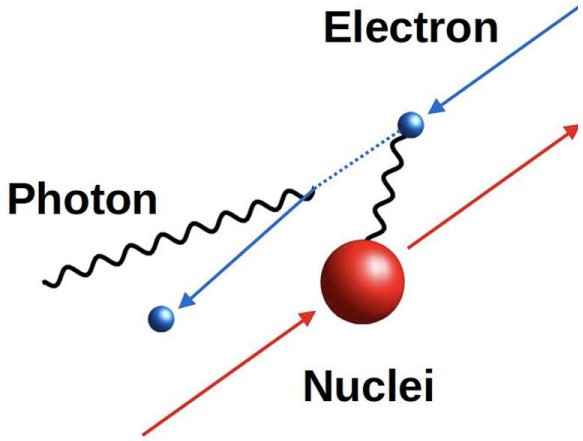
We Even Had Room for Some Crucial Discussions

Slides from Jaroslav Adam, Dhevan Gangadharan, Simon Gardner

Measure the Entire Bremsstrahlung Process

1) Measure photon energy with Pair Spectrometer / direct-γ CAL
2) Measure scattered electron energy with low-Q2 taggers.

Powerful tool to empirically validate the acceptances and calibrations
→ reduce systematic uncertainties of lumi and low-Q2 measurements



$E_{scat\ electron} = E_{beam} - E_{brem}$

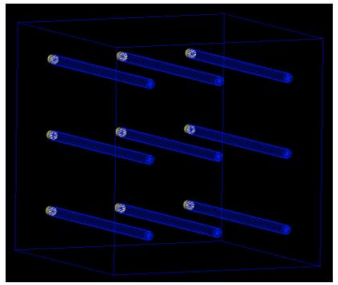
Slides from Ayanabha Das

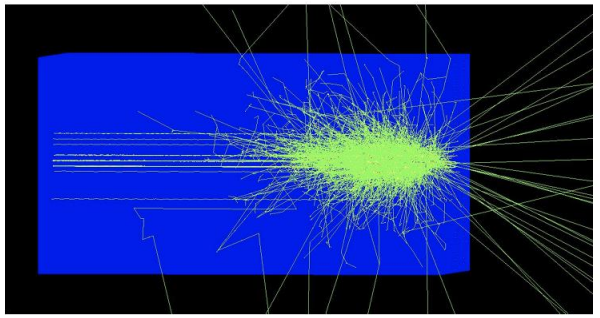
Direct Photon Calorimeter

- **One possibility:** $PbWO_4$ homogeneous calorimeter (PWO)

  (Conclusion: Efficiency of the scintillation light yield fluctuates with the temperature variation)

- **Second possibility:** Quartz (SiO_2) fiber calorimeter (QCAL)
  - Size-xy: 16 cm, Size-z: 30 cm
  - Fiber details: r_{core} = 500 μm, r_{clad} = 540 μm, and dx = 4 mm
  - Absorber material: W or Pb





Other Important Tasks (to add to the heap…)

- Solve pass-through issues for event-level information to EICrecon (e.g. beam energy/species).
- Add/complete benchmarks for various final states for purposes of evaluating impacts of various changes to geometry/reconstruction.
- Solve remaining issues related to reconstruction, with real time feedback from users on needed information in output branches (e.g. ACTS reconstruction specifying which detector subsystem produced the track).
- Evaluate impacts of various backgrounds on specific observables and discuss mitigation strategies.
- Standardize some basic analysis tools for common observables (e.g. t-reconstruction), and create an analysis repository for them to expedite the starting of analyses for others in the future.
- …

Summary

- Reviewed previous plots and the plans for future analysis
  - Discussed action plan for TDR plots which are relevant to NAS topics
- Assigned contacts for these plots
  - Please note this does not mean others are not welcome to join and work on *ANY* channel – get in touch if any existing or new activity interests you
  - There are still some channels without contact people
- Discussed the detailed status and analysis of FF/FB detectors and provided tools for analysis
- Benchmarking tutorial was a great success in progressing analyses via a hands on session
  - Thank you to the experts that made themselves available for the session
- Discussed open issues and possible future paths to solve them

- *Thanks very much to the organizers and to all who participated for making this a great workfest*