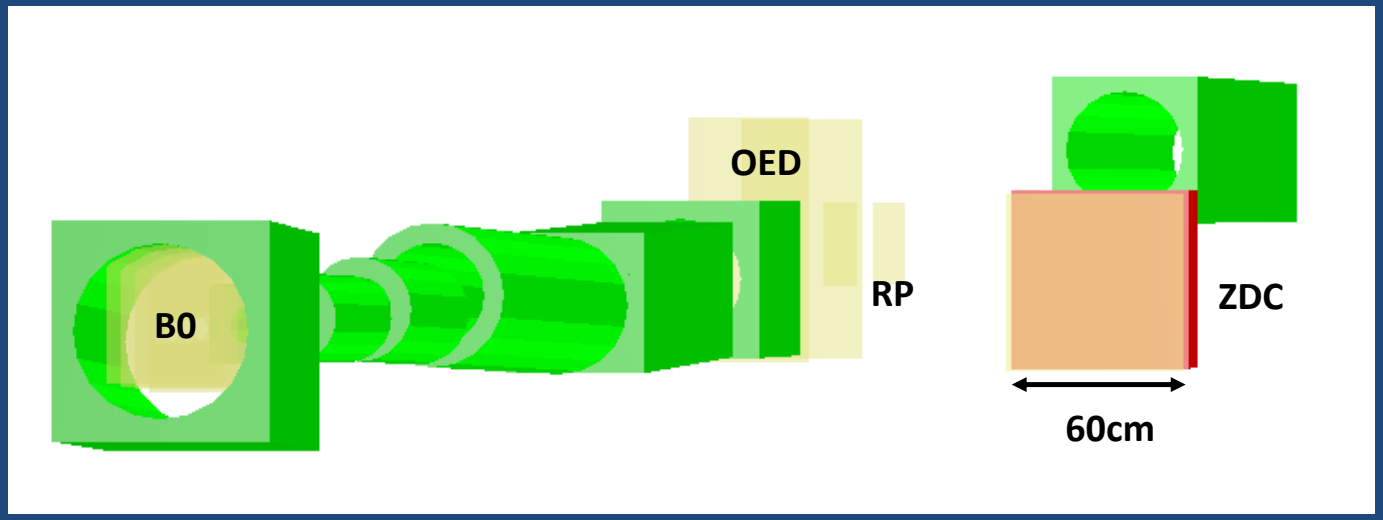
Developing a high resolution ZDC for EIC

- Groups from the US and Japan are planning to design a ZDC for the EIC.
- For 2021 we will focus on simulations.
- The project leverages ongoing work on several fronts but has no critical external or internal dependencies in 2021.



Yuji Goto & Michael Murray for
ZdEiC team 27th July 2020

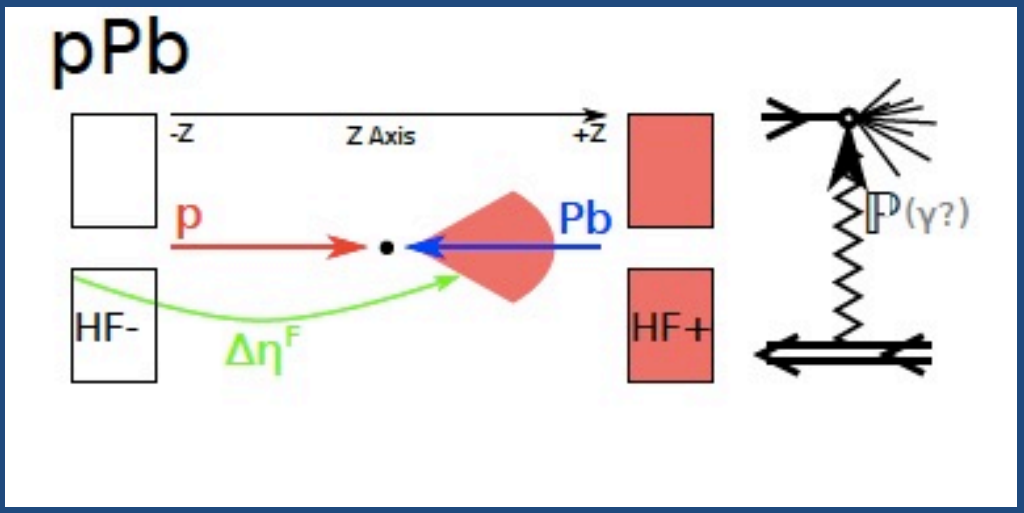
ZdEiC

Physics drives detector requirements

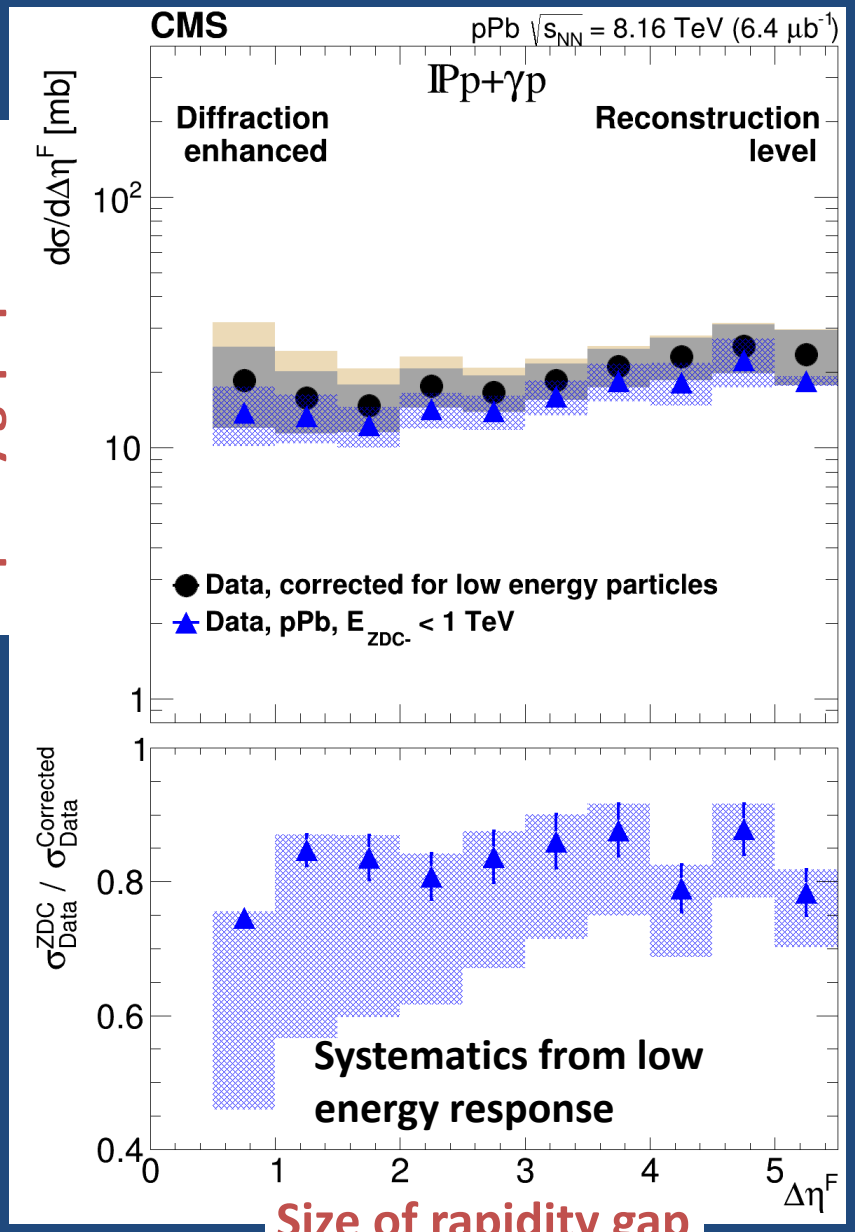
Detector R&D	Physics	Performance requirements	Resource requested	Support & collaboration
Soft photon detection	e+A nuclear breakup veto	$E_\gamma \leq 300$ MeV	detector simulation	This proposal Calorimeter consortium
		acceptance	acceptance simulation	This proposal BeAGLE group
		detector technology	detector R&D	N/A in FY21
EM + hadron calorimeter	e+A collision geometry	neutron multiplicity	high resolution not necessary	BeAGLE group
	spectator tagging	energy & position resolution	detector simulation	This proposal
	meson structure	neutron & Λ acceptance	detector simulation	This proposal Meson structure WG
		detector technology	FoCal R&D	RIKEN
			LHC-ZDC R&D	Kansas Univ.
		calibration scheme	design & simulation	This proposal
			system test	N/A in FY21
Radiation hardness		radiation dose	simulation study	This proposal Kobe Univ.
		detector technology	radiation test	This proposal Calorimeter consortium

Need excellent photon & neutron energy resolution in energy and position.

CMS vetoing nuclear breakup in pPb



For pPb we study events in which the proton is hit by a photon or pomeron & their is a large rapidity gap.
Vetoing on the ZDC eliminates events with very soft particles at forward eta.



CMS PAS HIN-18-019

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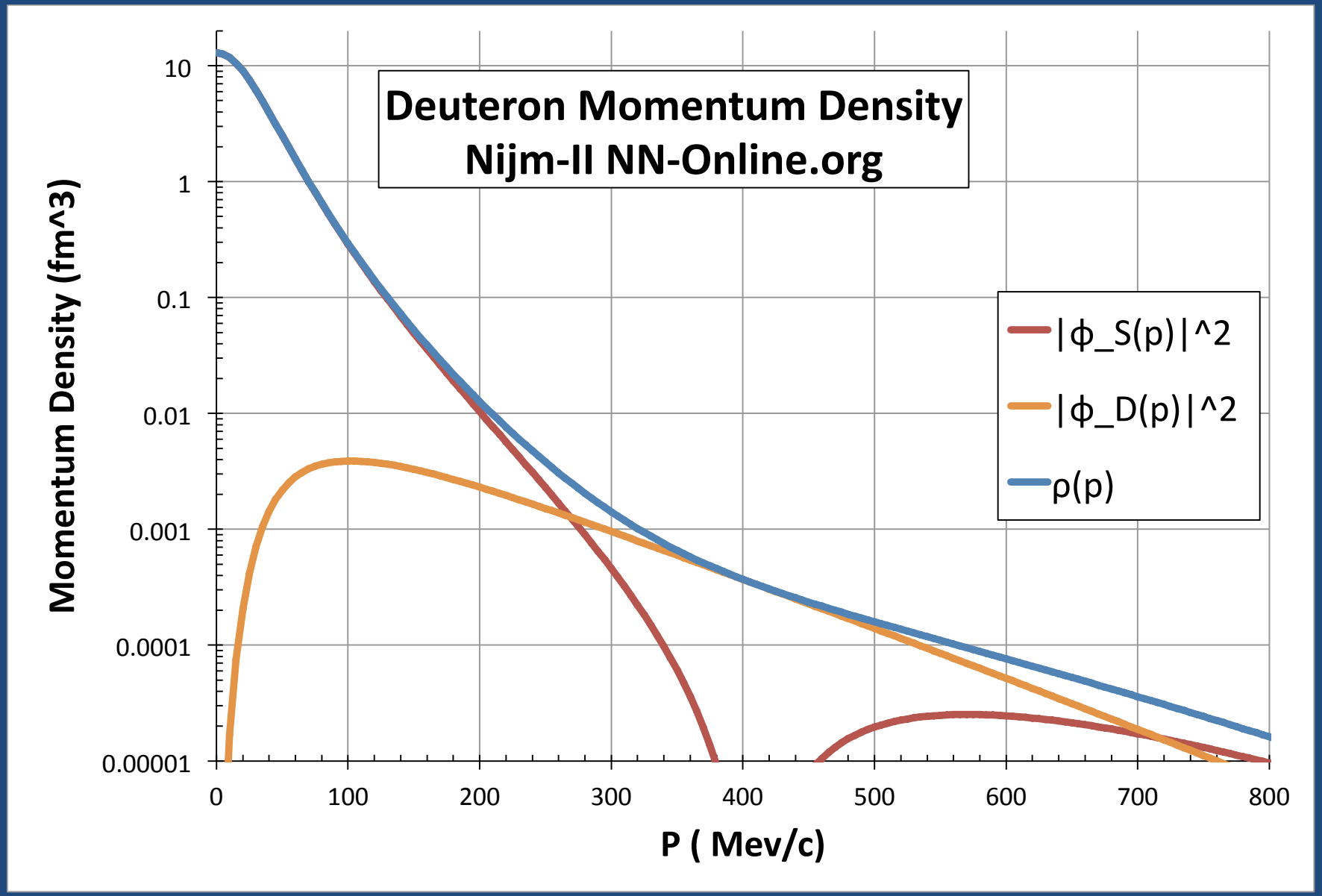
The deuteron momentum distribution



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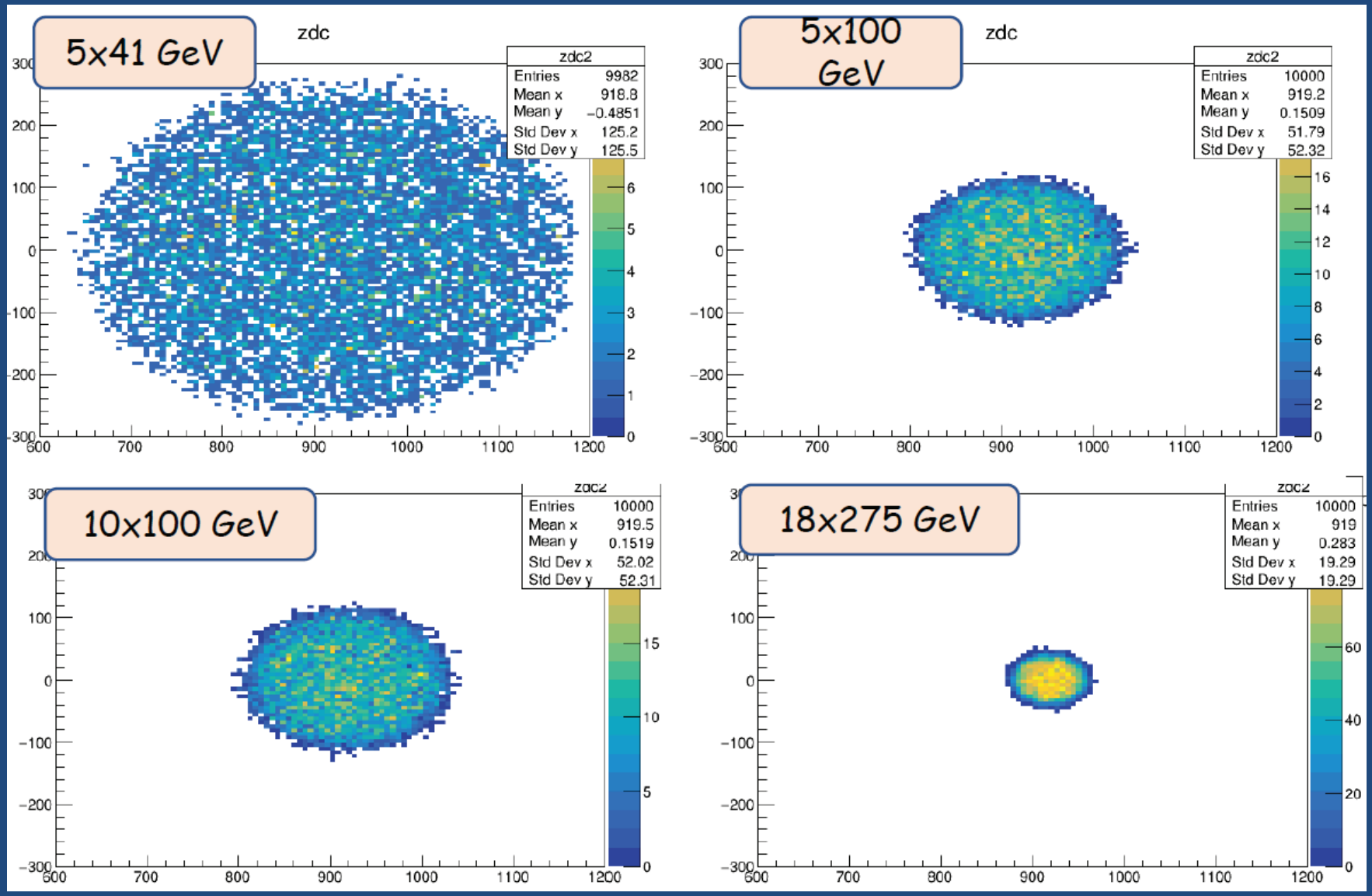
Size of 60cm x 60cm should be sufficient



Y distance from beam (mm)

X distance from beam (mm)

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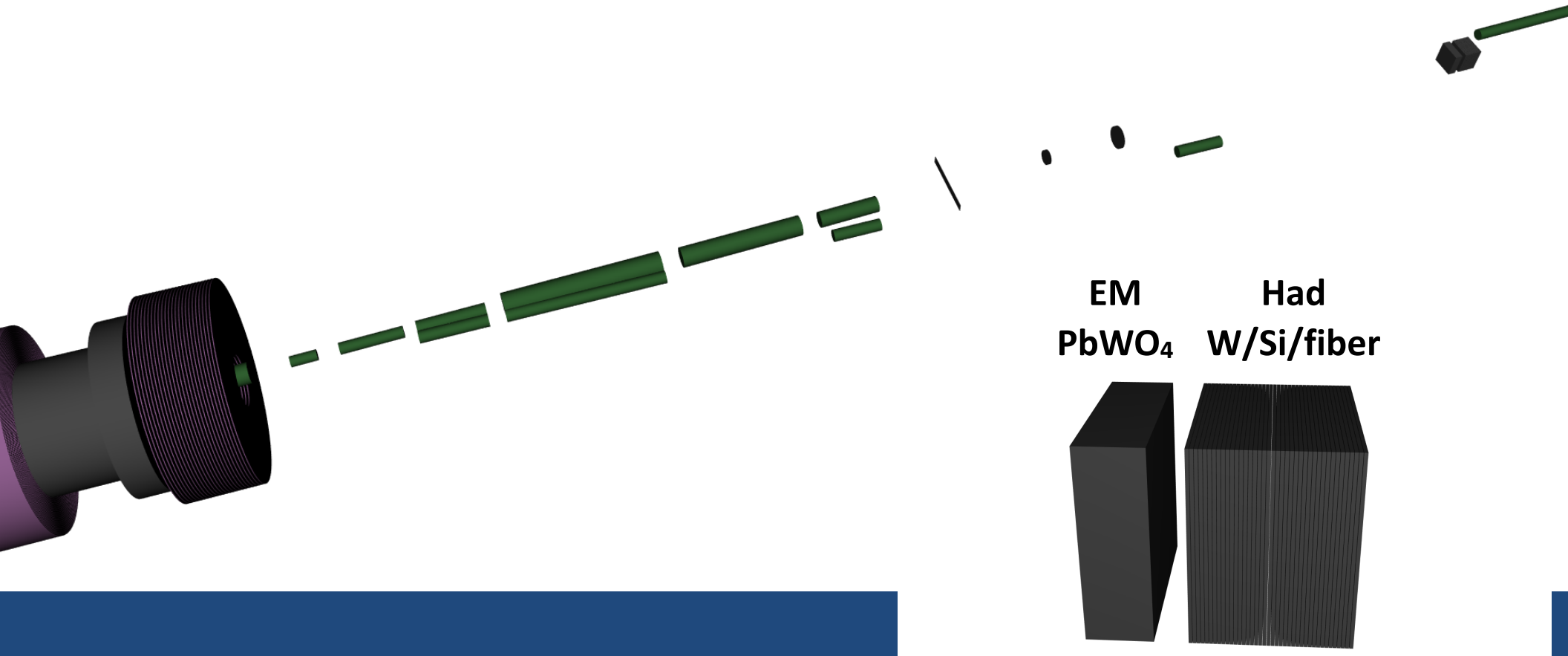
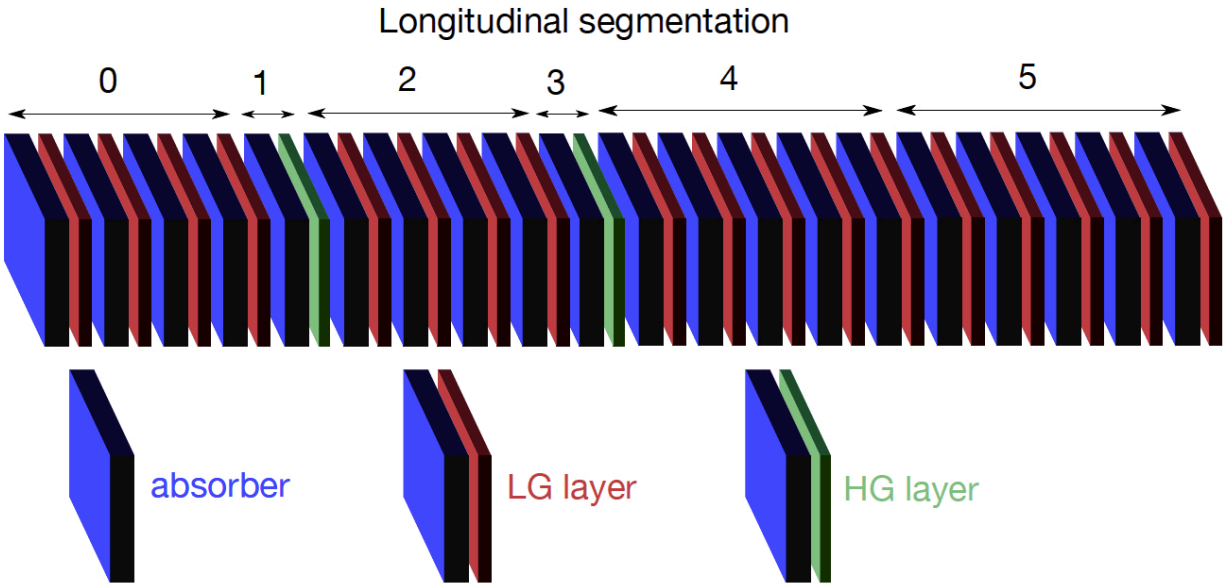
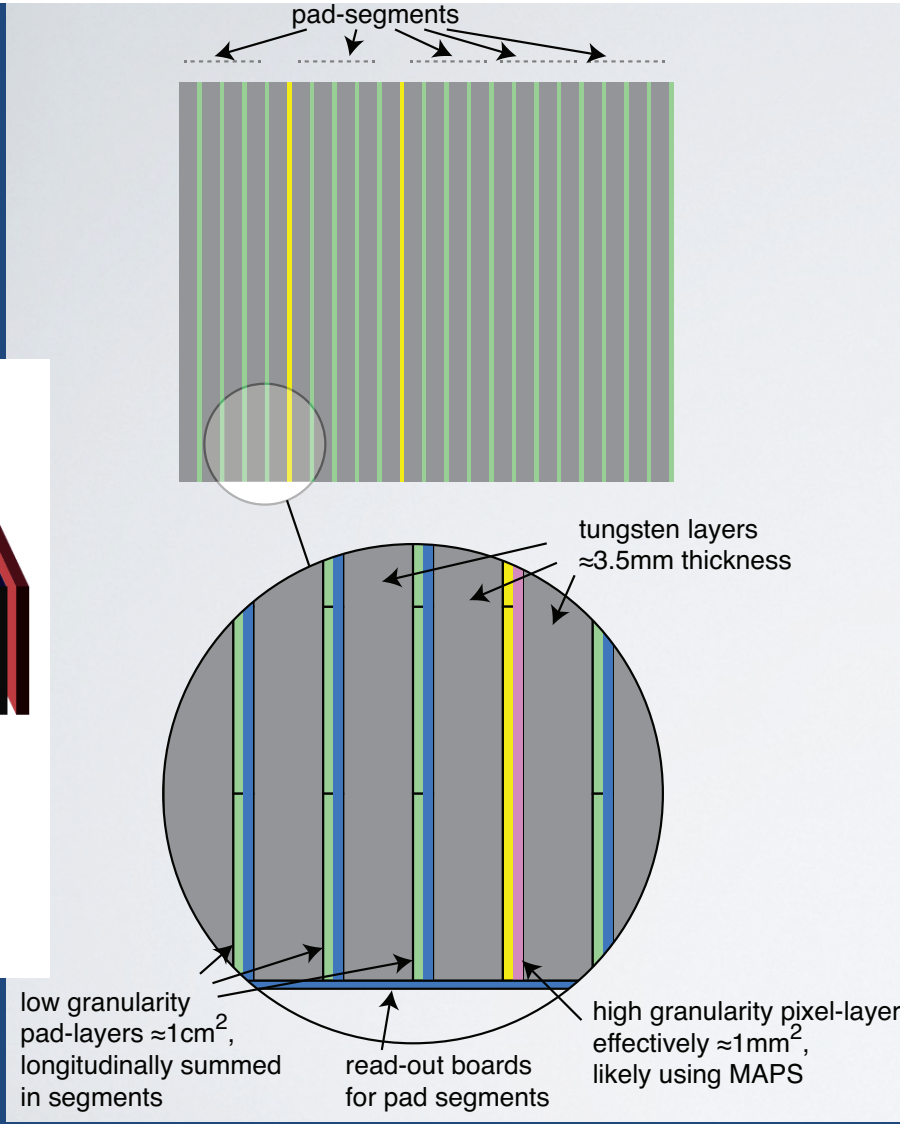
First implementation in EIC framework



Focal W/si calorimeter





High granularity allows reconstruction of individual showers for precise position resolution and timing. We will add $PbW0_4$ crystals in front for low energy photons and may also add silica fibers to tag high energy core of the shower.

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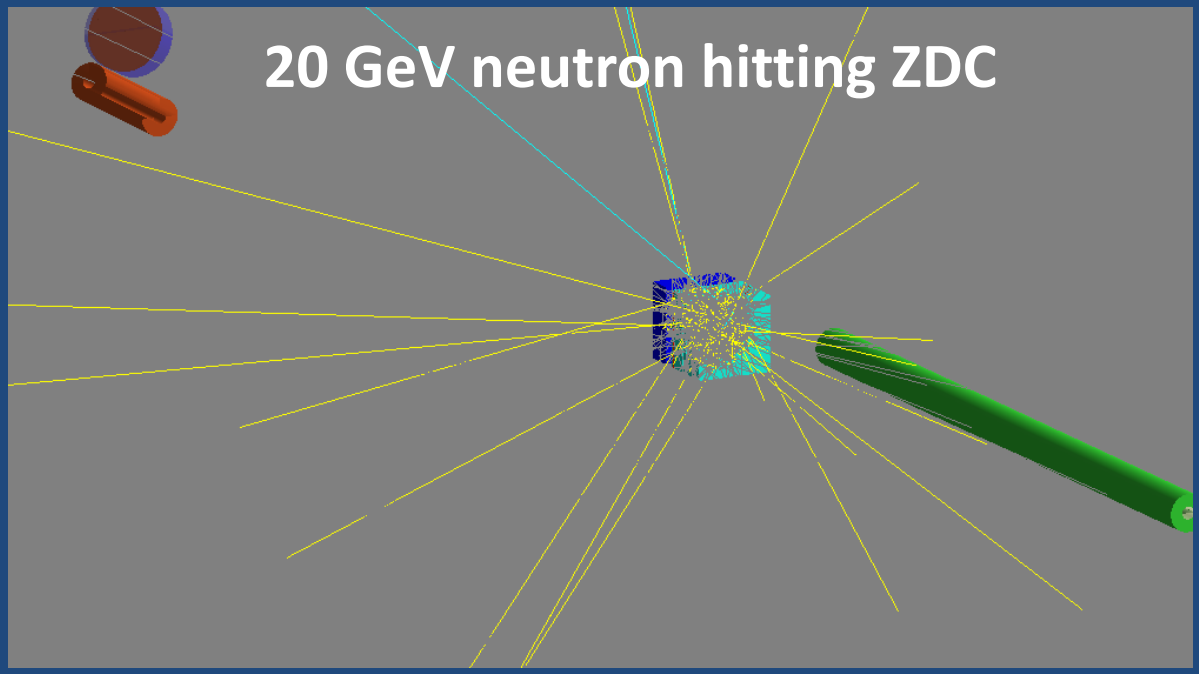
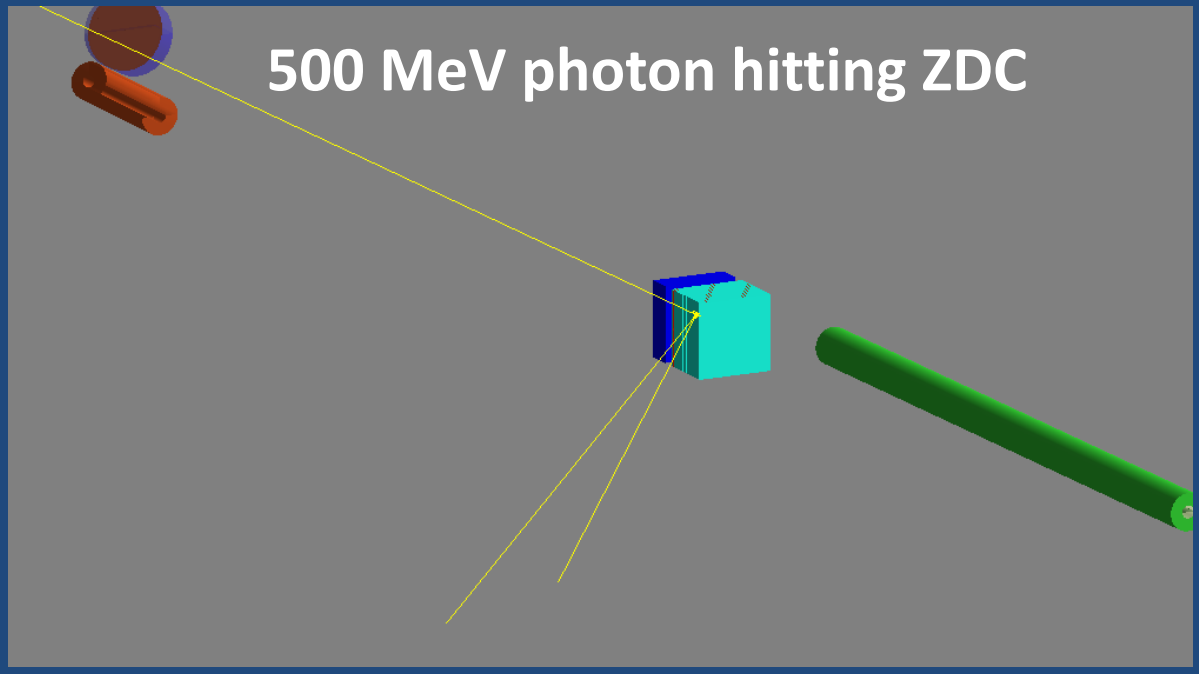
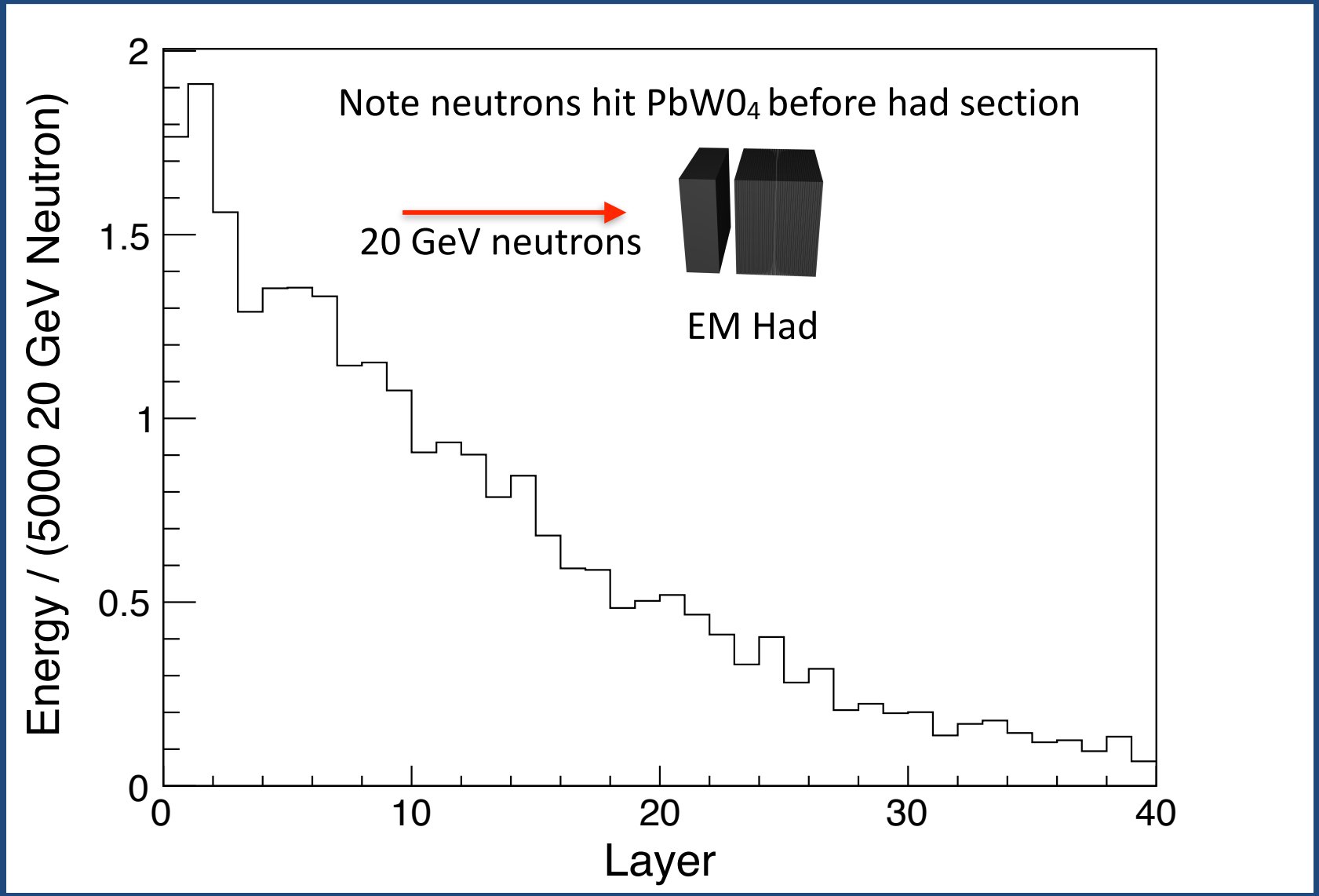
Event Displays





Response of Had section to 20 GeV neutrons



ZdEiC

Schedule & deliverables for 2021

Period	Task	Group
10/2020 - 12/2020	Integration of simulation tools	KU
1/2021 - 3/2021	Test against physics requirements	KU/SBU
	Acceptance, σ_E, σ_{pT}	KU
3/2021 - 5/2021	Comparison of different crystals	KU
3/2021 - 9/2021	Optimize neutron reconstruction	KU
6/2021 - 9/2021	Background studies	ODU
10/2020 - 12/2020	Radiation dose estimate	Japan
1/2021 - 7/2021	Test of Focal prototype	Japan
1/2021 - 7/2021	Test of CMS prototype	KU
7/2021 - 9/2021	Prepare publication	All

Budget for 2021

Item	Institute	Cost
Postdoc 1/3 FTE	Kansas	\$ 40K
Travel to BNL 3 people	Riken	\$ 10k
US Travel	Old Dominion	\$ 2k
Grad student summer	Old Dominion	\$ 10.5k
Total		\$ 62.5k

Committee report on preliminary proposal

The committee very much welcomes submission of the full proposal. The physics clearly motivates the research proposed. The project has a broad scope and a relatively small budget and seems to depend on efforts that are outside of the scope of this proposal (see Table 1 in the proposal). It would be appreciated if these external dependencies can be addressed during the meeting and what the internal dependencies are. For example, how does the FoCal R&D at RIKEN depend on elements of this proposal and vice versa.

The project has 4 external dependencies

- BeAGLE for simulation of nuclear breakup
- Yellow report group on meson structure for forward neutron, pi0 production
- FoCal R&D for ALICE
- Rad hard fiber technology from ATLAS & CMS.

Dependence on BeAGLE for breakup

- The ZDC can veto nuclear breakup, see CMS-PAS-HIN-18-019 on diffraction in pPb.
- To estimate our efficiency we need to know the spectra of photons & neutrons from breakup
  - For example it may be considerably easier to tag Pb breakup than that of Au
- We can use current estimates to start but it would be very helpful to refine the breakup breakup sequence within BeAGLE.
- For a ZDC at a second IR with complimentary acceptance it would also be important to have the most realistic physics possible in our simulations.

Dependence on meson structure studies

- ZDCs help measure electron scattering off the π cloud around the proton by reconstruction forward neutrons & π^0.
- This process is being studied by the Diffraction & Tagging YR group, see https://indico.bnl.gov/event/7352/timetable/
- CFNS workshop on π, k structure functions
- There is not yet a full specification of detector requirements but we can already start to estimate our ability to reconstruct π^0.

Dependence on FoCal R&D

- The FoCal project is vital to ALICE upgrade, see https://cds.cern.ch/record/2696471 and is already well advanced.
- Several Japanese groups are funded for this.
- We have leveraged this work for our initial idealized design
- Moving to a more realistic design with dead areas for readout & services we will benefit from their experience.
- Focal groups already planning on radiation tests.

Dependence on ATLAS/CMS ZDC

- We may incorporate rad hard fused silica developed for LHC forward detectors.
- These fibers are already tested at higher doses than we expect to see at EIC.
- LHC group also has done significant work on calibrating Fluka dose simulations and we can benefit from this.
- LHC group planning new test beam campaign when Covid permits. This will help calibrate simulations.

External Dependencies not critical for 2021

- Although the ZdEiC benefits from external input from serval sources none of these can derail the goals we have set for 2021.

Internal Dependencies

- For 2021 we are proposing 1/3 of FTE to work on simulations.
- KU nuclear group as 3 postdocs, 7 students and 4 faculty so this level of effort should work
- ODU and SBU groups are very knowledgable of physics and backgrounds
- Japanese groups are well funded for FoCal and have access to radiation facilities & test beams.
- Covid may delay some non-simulation activities

Summary

- ZdEiC group has sufficient depth & expertise to design a ZDC that meets physics specifications
- The project leverages ongoing work by BeAGLE, EIC tagging group, FoCal and LHC ZDC but has no critical external dependencies in 2021.
- The group is large enough to execute the project without the need to hire new personnel.
- Covid may slow some aspects of the project but we are confident that simulations will succeed.

Backup