MEIC Collaboration Meeting 2015:
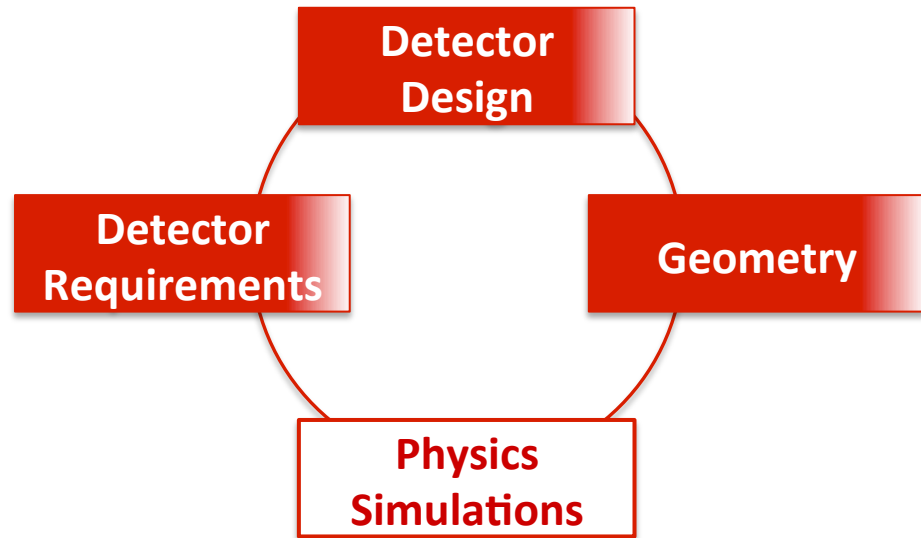
MEIC Detector Software and Simulation

Markus Diefenthaler

Software R&D as part of (Detector) R&D

2015

Detector Simulations + Physics Simulations

2025

Online and offline software framework

One decade of software development

Web Applications

Big Data - A possible paradigm shift for NP / HEP?

- **Big Data** is not about size
- **Big Data** is about the ability to quickly analyze large amounts of data. i.e.
    - have all raw and processed data permanently stored
    - in a scaleable random access storage
    - with fast, efficient data indexing (lookup) capabilities
        - resulting in a) more efficient use of computational resources (CPU) and b) fast data (re)processing and analysis
- statistical language for **R**:
    - emerging as the leader in statistical languages for **Big Data**
    - an alternative to ROOT?
    - NP should acquire some knowledge here (cooperate with other fields / industry)
- **NoSQL** (non-relational) databases:
    - more flexible
    - better scaleable than traditional, relational databases
    - e.g., a graph database (e.g., used by Facebook)

- **R&D project:**
    - combine data of various SIDIS experiments
    - in a graph database
    - extract observables for TMDs
    - exploring modern data science methods
    - perhaps taking advantage of a supercomputer (exascale computing project)

EIC Software Meeting (09/24 and 09/25)

- organized by Elke-Caroline Aschenauer (BNL) and Markus Diefenthaler
- 36 participants from both BNL (mostly remotely) and Jefferson Lab

Thursday, September 24, 2015 (F326/327)

Time	Session	Speaker
09:00 - 09:15	Welcome, Meeting goals	Markus Diefenthaler
09:15 - 10:45	**Monte Carlo Generators - Part I**	
09:15 - 10:00	Monte Carlo Generators for EIC	Elke-Caroline Aschenauer
10:00 - 10:30	mPYTHIA - Towards an Event Generator for TMD	Hrayr Matevosyan
10:30 - 10:45	*Coffee Break*	
10:45 - 11:59	**Monte Carlo Generators - Part II**	
10:45 - 11:00	Simulating spectator nucleon tagging with EIC	Christian Weiss
11:00 - 11:30	Forward Spectator Tagging Event Generator	Kijun Park
11:30 - 11:59	Hadron Elecro and Photo Production Generators Overview	Rakitha Beminiwattha
12:00 - 01:00	*Lunch*	
01:00 - 02:15	**Monte Carlo Generators III**	
01:00 - 01:45	Recent developments in Pythia 8	Stefan Prestel
01:45 - 02:15	Discussion about Monte Carlo Generators	
02:15 - 02:30	*Break*	
02:30 - 5:00	**Software Tools**	
02:30 - 03:00	EicRoot software framework	Alexander Kiselev
03:00 - 03:30	GEant4 Monte Carlo	Maurizio Ungaro
03:30 - 04:00	EicRoot for tracking R&D studies	Alexander Kiselev
04:00 - 04:15	*Break*	
04:00 - 05:00	**Discussion on interfaces**	
06:00 - 08:00	*Dinner at Fin SeaFood*	

Friday, September 25, 2015 (L102)

Time	Session	Speaker
09:00 - 10:30	**Software Frameworks I**	
09:00 - 09:50	Framework design experience from art	Marc Paterno
09:50 - 10:10	The JANA Design	David Lawrence
10:10 - 10:30	Software design ideas for SoLID	Ole Hansen
10:30 - 10:45	*Coffee Break*	
10:45 - 11:40	**Software Frameworks II, Monte Carlo Generators IV**	
10:45 - 11:10	Fun4all	Christopher Pinkenburg
11:10 - 11:40	TMD Evolution and QCD Theory at An EIC	Ted Rogers
11:40 - 12:10	**Meeting summary and common goals**	
12:10 - 01:00	*Lunch*	

- **focus on detector and physics simulations:**
  - Monte Carlo generators for the EIC physics program
  - tools for detector simulations
  - tracking software
  - tools for detector development
- **goal of the EIC software meetings:**
  - review the software status
  - identify interfaces between the BNL and JLab software
 - chance for an active collaboration

Fast Monte Carlo Productions

- MEIC detector and physics simulations based on **GEMC**
- **GEMC**: framework for the Geant4 toolkit (C++), developed by Maurizio Ungaro (Jlab)
- simulation of simple and full featured detectors (including estimated detector responses)
- fast running mode will full detector acceptance for physics simulations
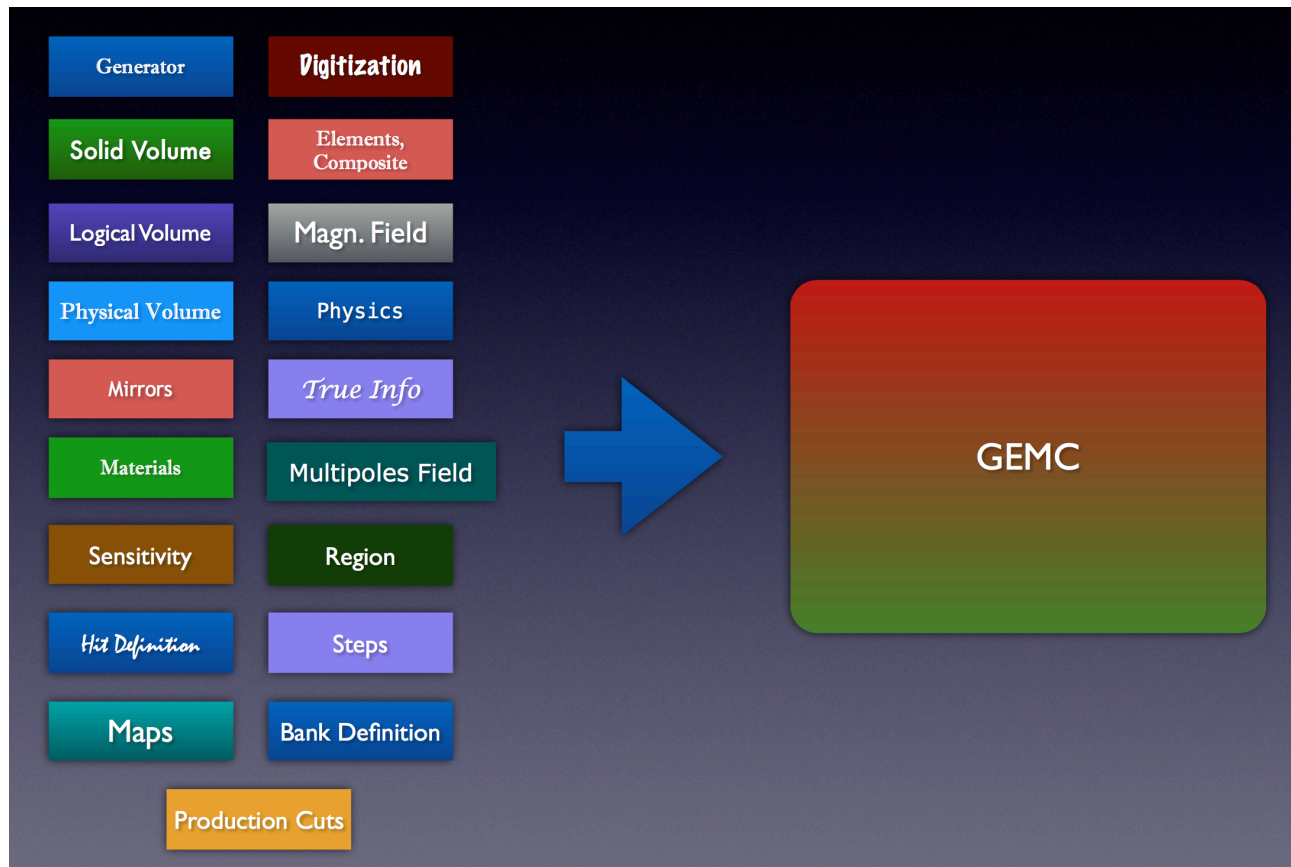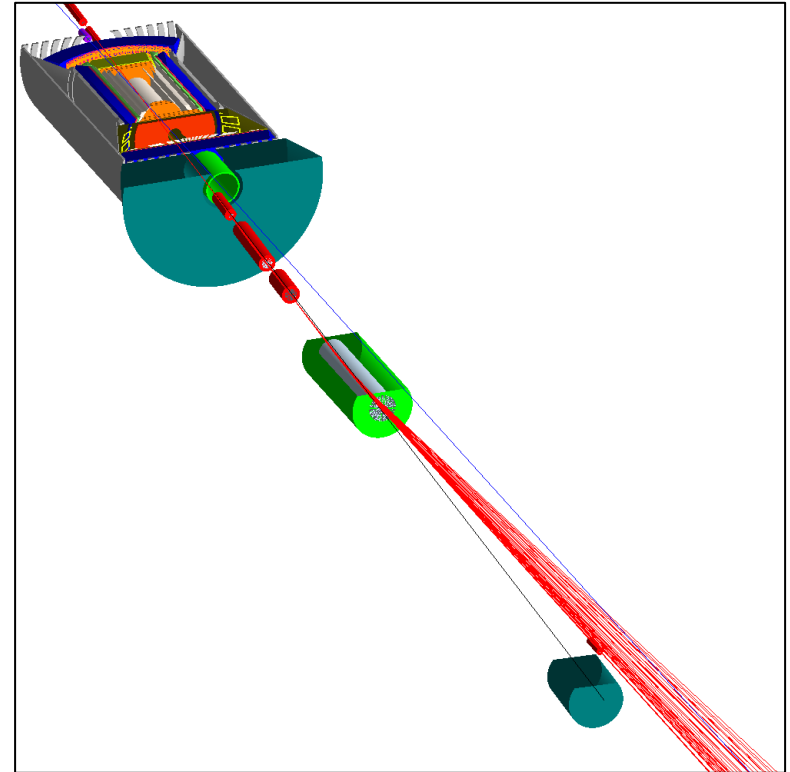
Example for GEMC simulations

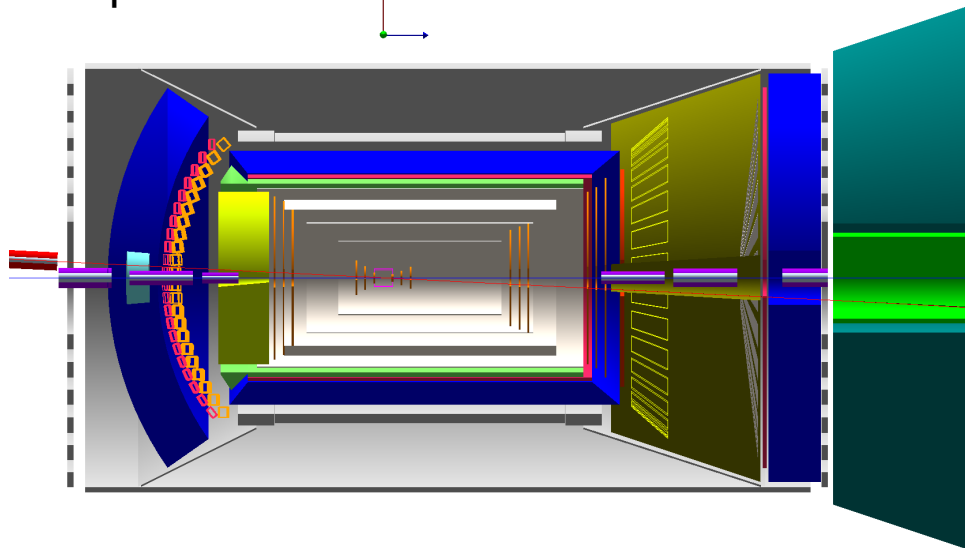**Electron Downstream View**
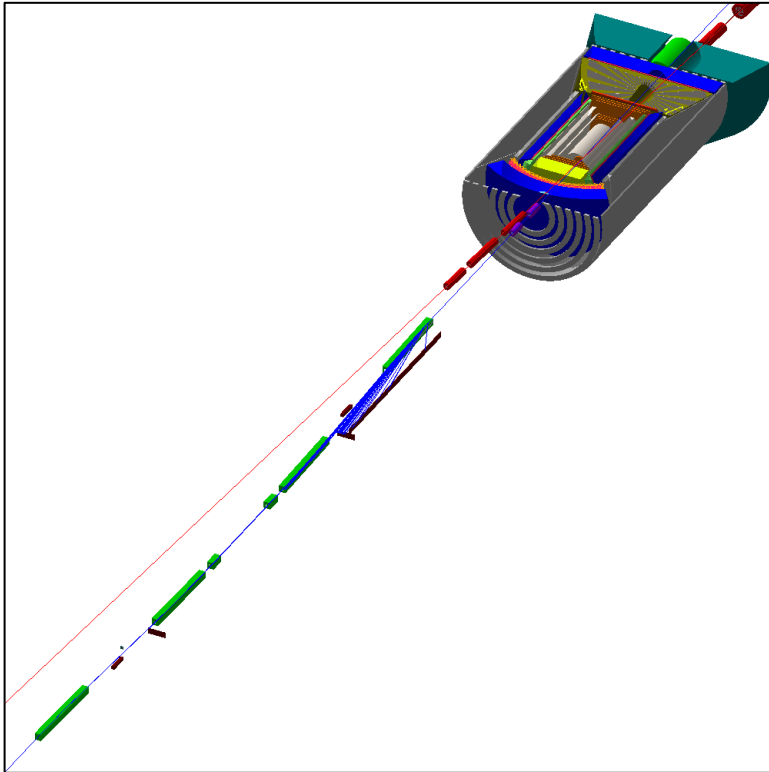
Ion Downstream View

Towards a full track reconstruction

- implement full track reconstruction in the central detector:

  - using all subsystems
  - realistic layout of support structures, cooling, and other *dead* material
  - base track reconstruction on EICRoot tracking with generic track fitting (Kalman Filter)
  - requires ROOT interface in GEMC

- validate the resolution of single tracks in the central detector
- study the impact of secondaries and random backgrounds
- extend reconstruction to near- and far forward regions

p

e

central detector at IP

low-Q^2 electron detection and Compton polarimeter

far forward hadron detection
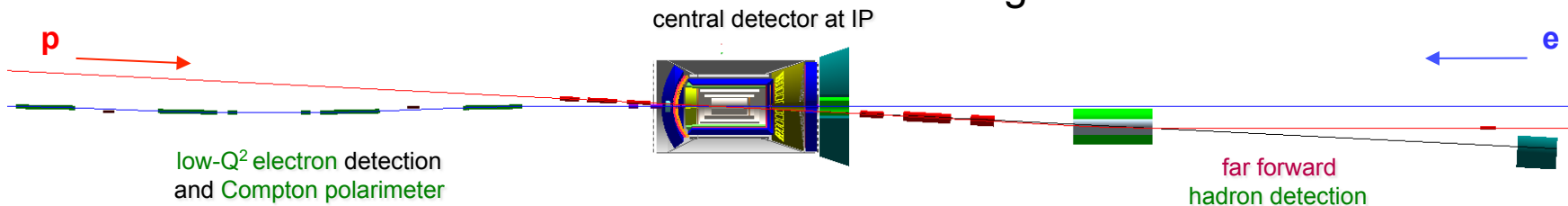
- develop a full reconstruction code for analysis of EIC data
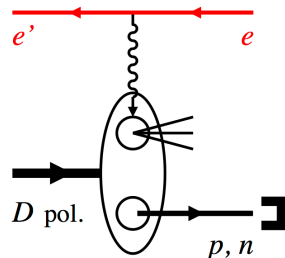
Jefferson Lab

Spectator Tagging Simulations

Simulating spectator nucleon tagging with EIC

C. Weiss (JLab), EIC Software Meeting, JLab, 24–Sep–15

Jefferson Lab

- High-energy eD scattering with detection of forward proton/neutron

Identify active nucleon, control quantum state

Spectator momentum $\sim$ few 10 MeV in nucleus rest frame, boosted longitudinally in collider

Unique for collider: No target material, forward detectors, deuteron polarization longitudinal & transverse
Fixed target CLAS BONUS limited to recoil momenta > 100 MeV

Great potential: Neutron spin structure, nuclear modification of quark/gluon structure, coherent effects at small x

- R&D project to develop physics potential
https://www.jlab.org/theory/tag/

FY14/15 LDRD Project: W.Cosyn, V.Guzey, D.Higinbotham, Ch.Hyde, K.Park, P.Nadel–Turonski, M.Sargsian, C.Weiss. Open for collaboration with users!

Develop **physics models, event generators, and analysis tools** for spectator tagging.
Perform process simulations with schematic modeling of MEIC beam and detector chars.
Quantify physics impact.

Spectator Tagging in GEMC

MC Simulation / GEMC - Event Display -

$[x_{BJ}:Q^2]=[0.01\text{-}0.1:10\text{-}20]$
phase-space event

- deuterons: - magenta -
- e^-: - cyan -
- protons: - orange -
- Hall: vacuum
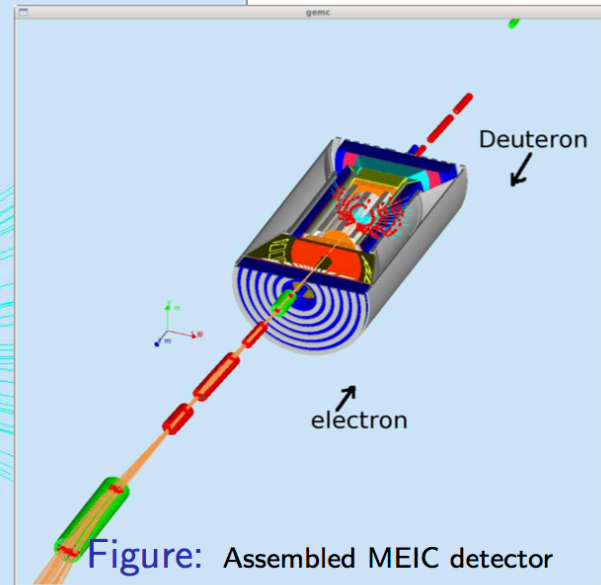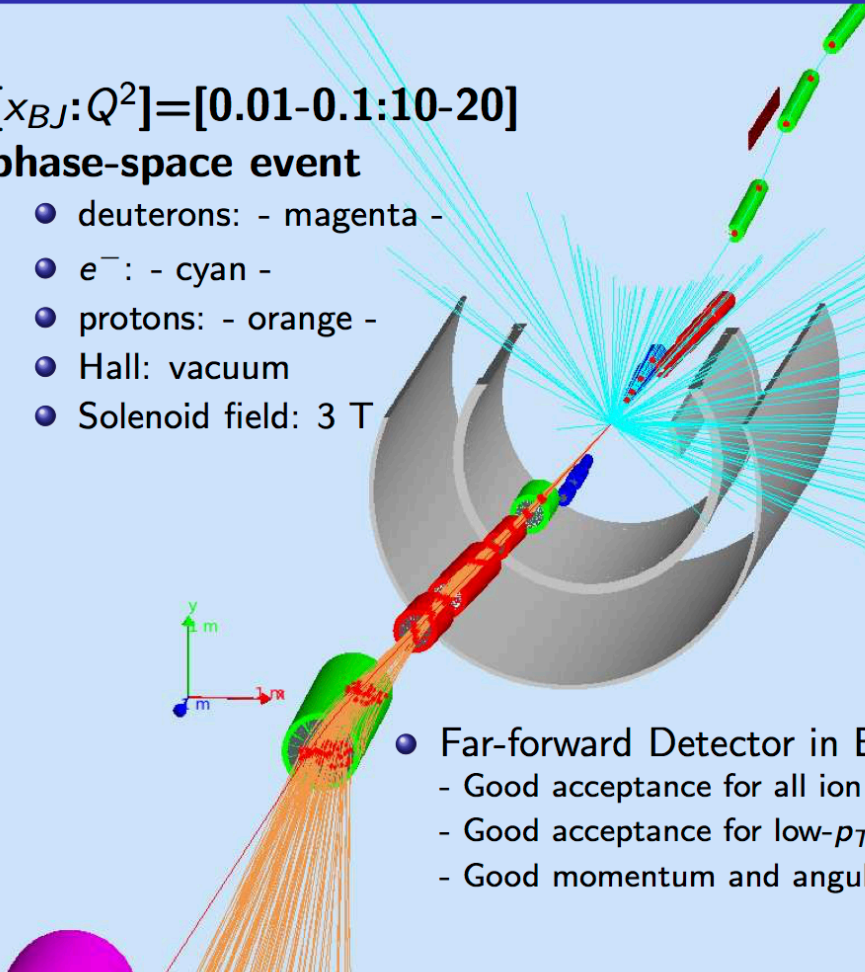- Solenoid field: 3 T

Deuteron

electron

Figure: Assembled MEIC detector

- Far-forward Detector in EIC
  - Good acceptance for all ion fragments - rigidity different from beam
  - Good acceptance for low-p_T recoils - rigidity similar to beam
  - Good momentum and angular resolution

K.Park (ODU)　　　　　EICSW2015　　　　　September 24, 2015　　　14 / 20

MEIC Collaboration Meeting, October 7th 2015　　　10　　　Jefferson Lab

Software development for the EIC

- detector and physics simulations based on GEMC framework
- R&D projects identified after **EIC Software Meeting**:
  - Monte Carlo generator for TMDs
  - take advantage of Pythia8 developments
  - work on interfaces between Jefferson Lab and BNL software:
    - ROOT API for GEMC
    - standalone track reconstruction software based on EICRoot
- R&D project for using Big Data ideas for NP / HEP, possibly facilitating supercomputing (exascale computing project)
- chance to learn from the past and implement an elegant (and thus simple) framework

- chance to contribute already now to the EIC project
- chance for an **active collaboration**:

  - among future experiments at Jefferson Lab
  - between Jefferson Lab and BNL
  - between Jefferson Lab and users