



LOI for EIC R&D Consortium:

# Analysis Techniques and Tools

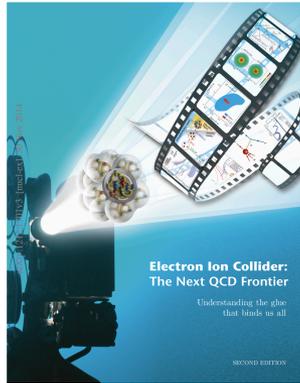
Markus Diefenthaler (JLab), Elke-Caroline  
Aschenauer (BNL), Alexander Kiselev (BNL)

# Computing R&D as part of EIC Detector R&D

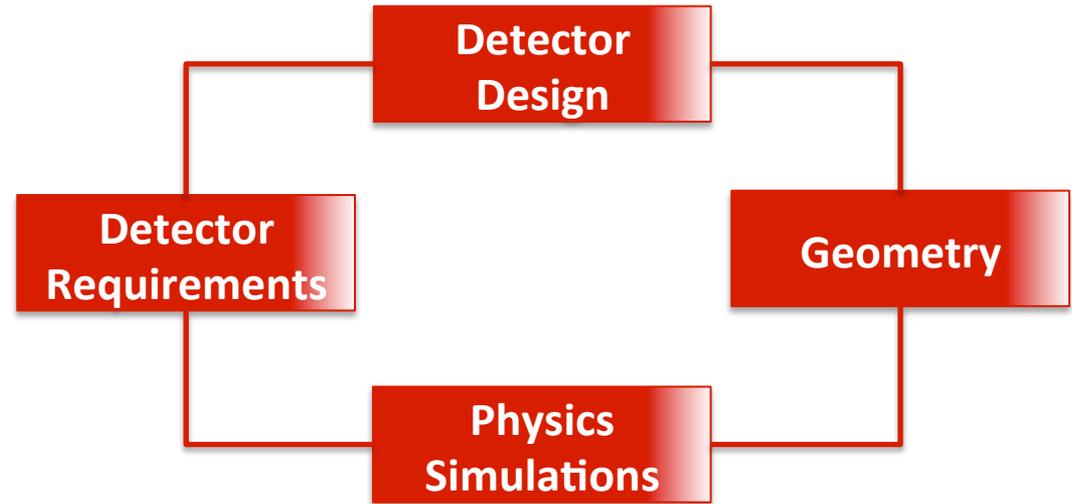
2016

## Detector & Physics Simulations:

one decade  
of software  
development



+ physics beyond  
the White Paper



2025

## Online & Offline Framework

Current focus: **Analysis Tools and Techniques**

# Towards an active collaboration

## 09/2015: Workshop **EIC Software Meeting**

- **organizers:** Elke-Caroline Aschenauer (BNL), Markus Diefenthaler (JLab)
- 36 participants from both BNL (mostly remotely) and Jefferson Lab
- **workshop goals:**
  - review software status with focus on detector and physics simulations
  - identify interfaces between existing BNL and JLab software
  - foster active collaboration
- **website:** <https://www.jlab.org/conferences/eicsw/>

## 2016: **EIC R&D Consortium:** Analysis Techniques and Tools

- **scope:**
  - development of Monte Carlo generators for broad EIC physics program
  - development of EIC simulation tools
  - integration of detector simulations
- **funding request** for traveling of developers and working meetings

# Workshop review of MC generators for EIC

- **MC generators for ep processes:**
  - several excellent MC generators available
  - but essential pieces are missing:
    - MC generator for (un)-polarized  $p_T$  dependent physics
    - radiative corrections not integrated in many generators, required as physics and detector smearing don't factorize
- **MC generators for eA processes:**
  - significantly worse situation than ep
  - need a SIDIS generator w/o saturation
  - need CASCADE like eA generator

**LEPTO**  
(DIS)

**PEPSI**  
(polarized DIS)

**PYTHIA 6**

**PYTHIA 8**

**GMC\_TRANS**  
(SIDIS)

**CASCADE**  
(ep + pp,  $p_T$ )

**MILOU**  
(DVCS)

**PARTONS**  
(exclusive)

**DJANGO**  
(radiative effects)

**many more generators**

**PYTHIA +**  
**DPMJET**

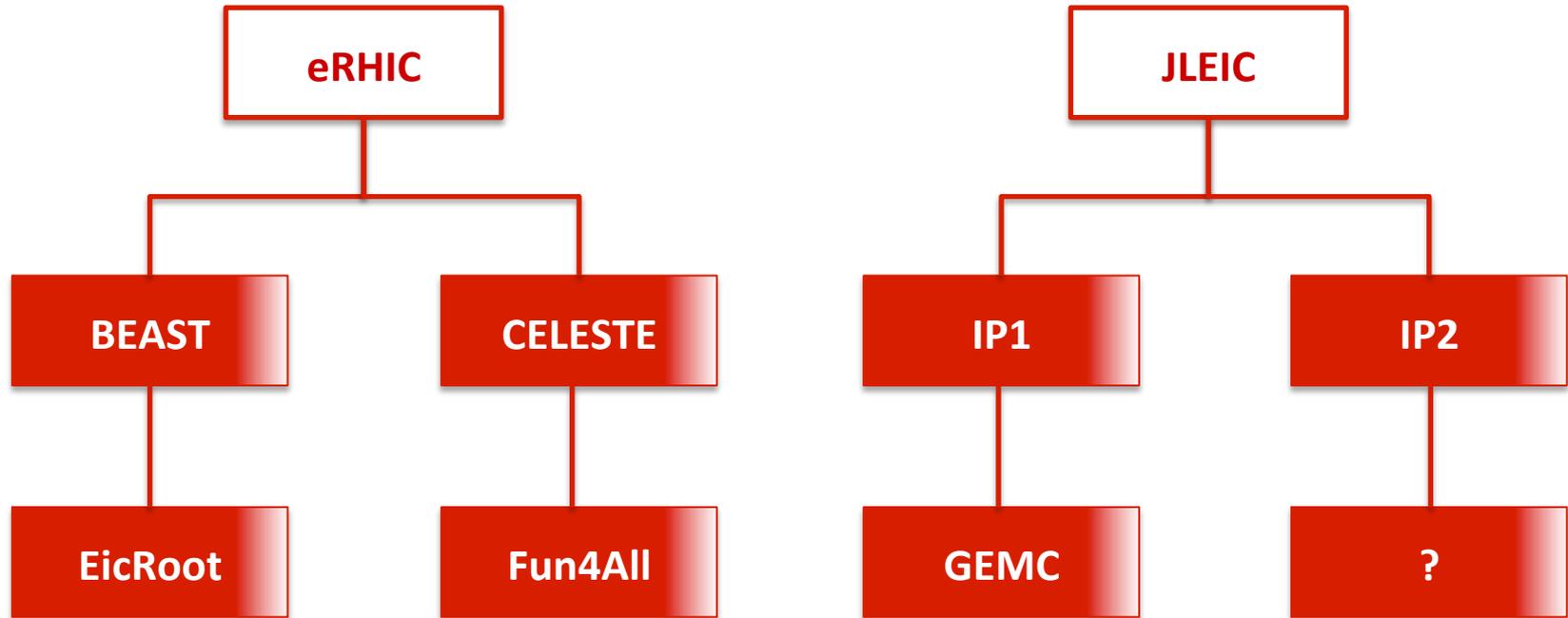
**DJANGO**  
(radiative effects)

**SARTRE**  
(diffractive, DVCS)

# R&D on Monte Carlo generators

- **develop Monte Carlo generator for TMDs based on Pythia8** (Aschenauer, Diefenthaler, Prestel):
  - DIS simulation available in Pythia8.2 (but not yet fully tested, no diffractive processes yet, no high  $Q^2$  yet)
  - work with DIRE parton shower by **Stefan Prestel** (Pythia developer)
  - **work towards a generator for spin-independent TMDs:**
    - use Drell-Yan as model process
    - use TMDlib as library for  $p_T$  dependent, unintegrated PDF
    - validate simulation of spin-independent TMDs with Drell-Yan data
  - **work towards a generator for spin-dependent TMDs:**
    - use shower splitting kernels in TMDlib to guide evolution
    - use Markov chain evolution (a la SMALLX) to evolve TMDs from small to high scales
- **radiative corrections in Monte Carlo simulations** (Aschenauer, Diefenthaler, Spiesberger):
  - develop library for radiative effects that can be easily integrated in existing Monte Carlo generators
  - collaborate with **Hubert Spiesberger** (HERACLES),
  - participate in “Workshop on Radiative Effects in Precision Electron Scattering
- **eA Monte Carlo generators** (Aschenauer, Toll, Ullrich):
  - collaborate with **Mark Baker** and **Liang Zheng** on DPMJetHybrid 2.0 (eRD17)

# EIC simulation frameworks

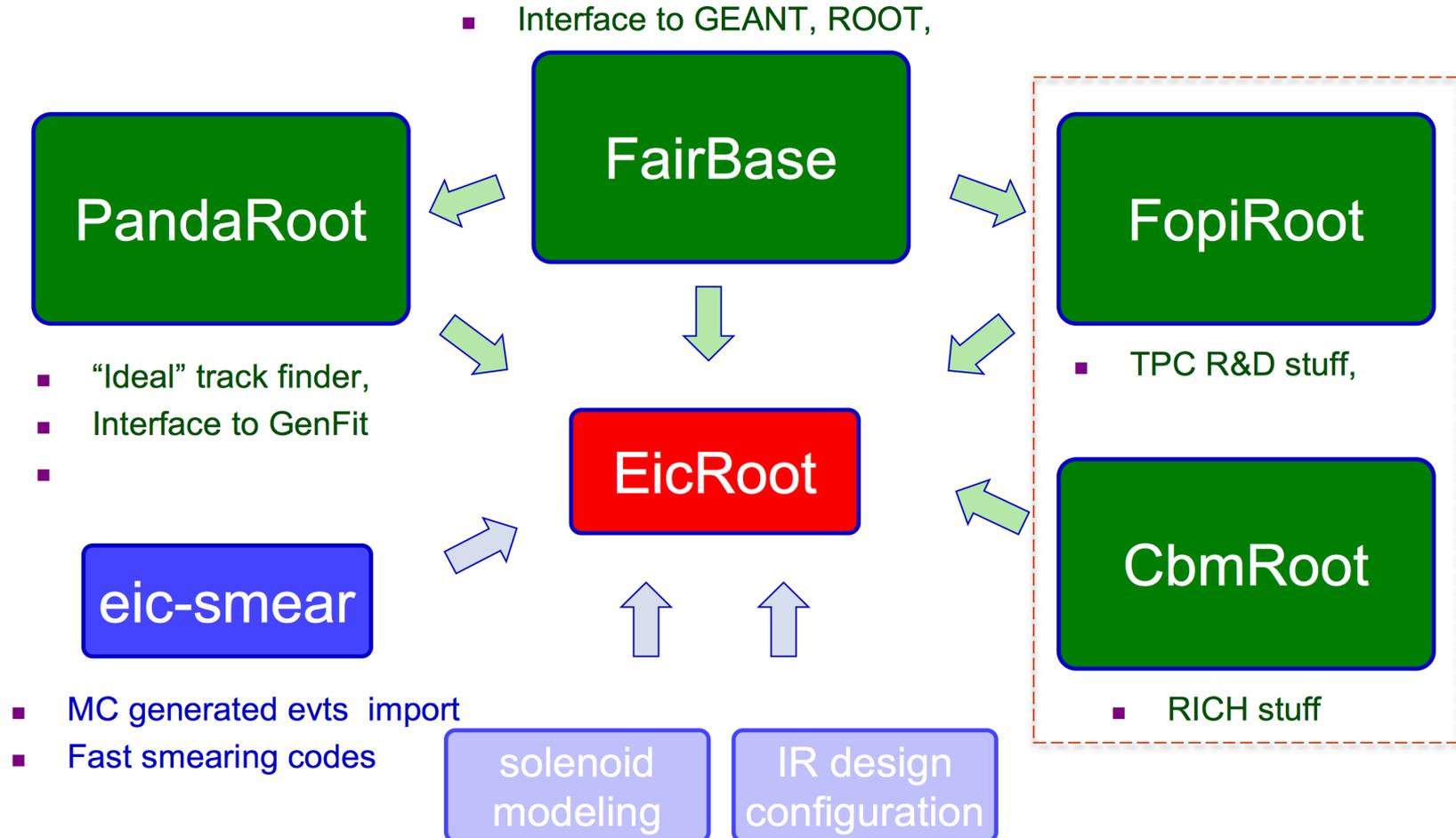


## Collaboration among developers of EIC simulation frameworks:

- EicRoot, Fun4All, and GEMC have been reviewed in the EIC Software Meeting in 09/2015.
- Goal of “Analysis Techniques and Tools ”R&D consortium

# eRHIC: EicRoot simulation framework

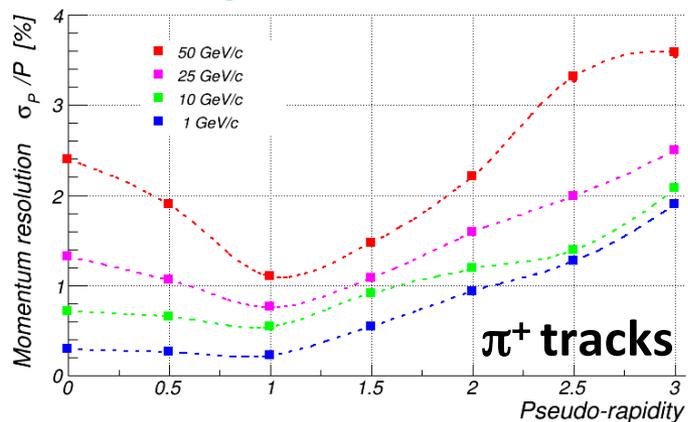
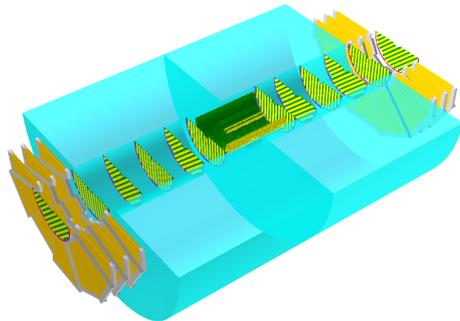
- based on FairRoot, developed by Alexander Kiselev (BNL) for eRHIC
- available for standalone R&D studies



# EicRoot tracking

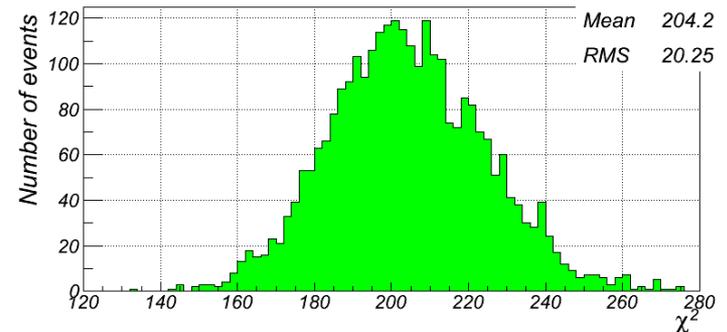
adapted from other experiments:

- **PandaRoot**: *ideal* track finder, GenFit fitter, (...)
- **FopiRoot**: TPC digitization, realistic track finders (Hough transform; Riemann sphere fit), GenFit fitter, RAVE vertex builder, (...)
- **HERMES**: linearized Kalman filter

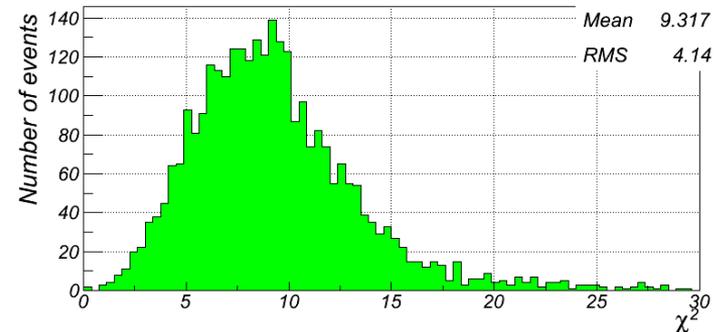


**Kalman filter fit quality:**

**1 GeV  $\pi^+$  tracks at  $\eta=0.5$ :**

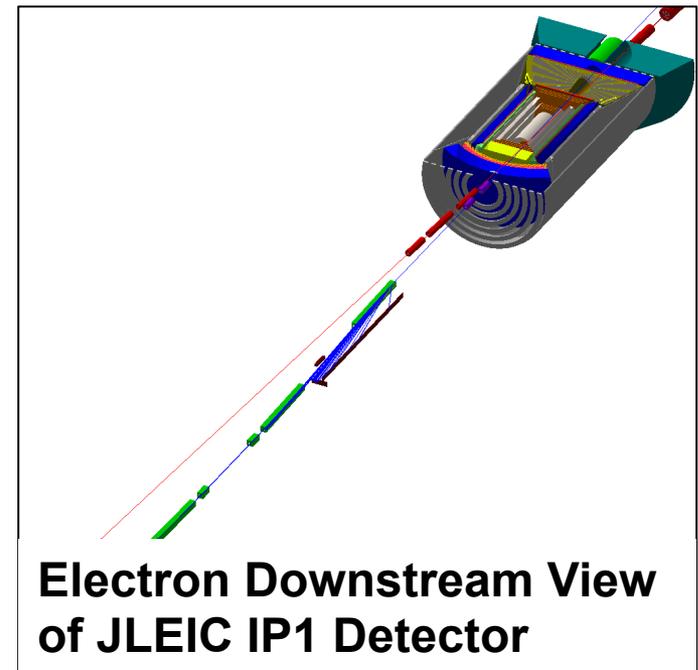
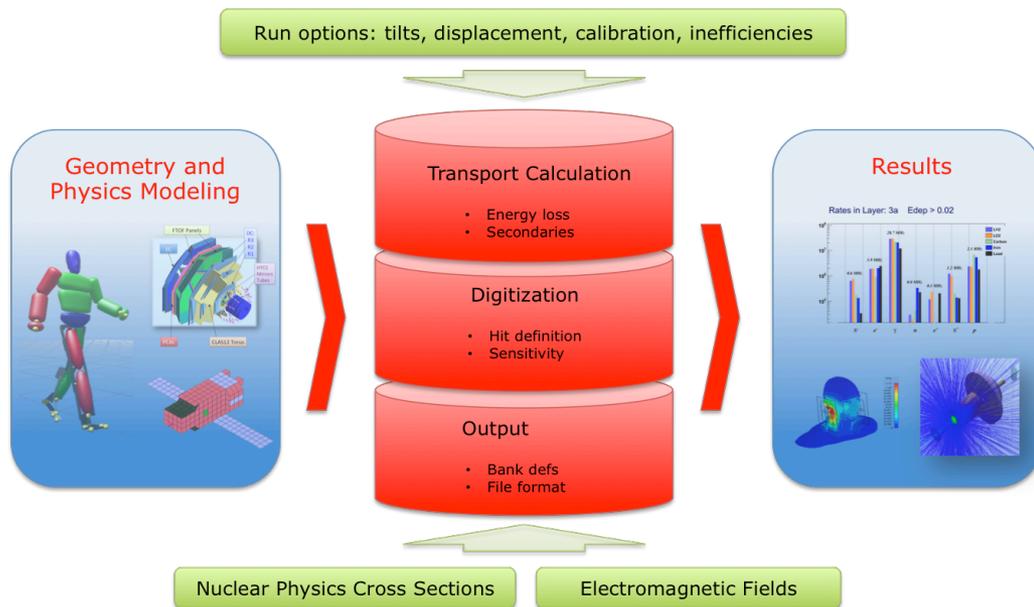


**32 GeV  $\pi^+$  tracks at  $\eta=3.0$ :**



# JLEIC: GEMC simulation framework

- C++ framework for Geant4, developed by Maurizio Ungaro (JLab)
- simulation package for JLab 12 GeV program, fully supported by JLab
- simulation and visualization of simple and full featured detectors
- fast running mode with accurate magnetic fields but analytics detector responses



# Collaboration on analysis tools

- **Interface between simulation frameworks** (Armstrong, Diefenthaler, Kiselev, Ungaro):
  - develop geometry interface between EicRoot and GEMC
  - integrate EicRoot tracking with GEMC
  - improve documentation for new users and work towards common documentation
- **Work on tracking software frameworks** (Armstrong, Diefenthaler, Kiselev):
  - implement generic track finder in EicRoot for central rapidities
- **Integration of other simulation tools** (Diefenthaler, Kiselev):
  - collaborate with other R&D consortia and integrate simulations tools, e.g. calorimeter clustering or RICH PID identification algorithm in EicRoot and GEMC
  - maintain list of available simulation tools
- **Ensure future compatibility** (Diefenthaler, Kiselev):
  - integrate new developments, e.g. new geometry standards from HEP
  - validate tools on Distributed Computing platforms (Grid, super computers)

# EIC R&D consortium

- Software R&D consortium **Analysis Techniques and Tools**
- **Scope:**
  - development of Monte Carlo generators for broad EIC physics program
  - development of EIC simulation tools with initial focus on:
    - interfaces between existing software
    - tracking development
  - integration of detector simulations into EIC simulation tools
- **Plan for first year:**
  - work on funding proposal for 2016/2017
  - build an active collaboration
  - work towards a TMD Monte Carlo generator
  - work on a radiative effects library
  - work on interfaces between GEMC and EicRoot
  - work on tracking development
- **Funding request:** USD 30,000 per year for traveling for working meetings