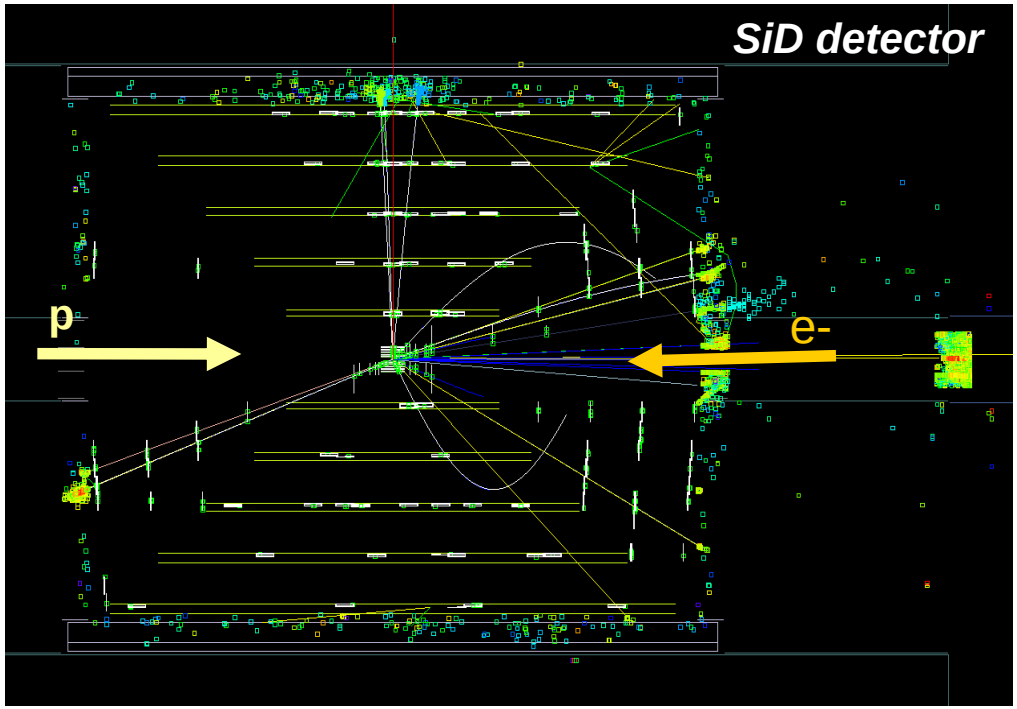
Performance characteristics of the SiD detector for deep inelastic events at the electron-ion collider



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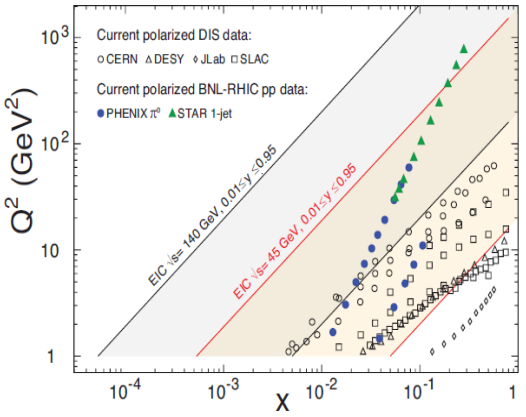
HEP/ANL

Motivation

- Precise measurement of deep inelastic scattering (DIS) events are the key to the success of the EIC
- Two main characteristics of DIS events:
  - negative four-momentum transfer squared, Q^2
  - Bjorken x variable
- In the so-called electron method Q^2 and x are expressed in terms of the scattered electron: *energy (E_e')*

  and scattering angle (θ_e) :

$$y = \frac{Q^2}{sx} \quad \text{... inelasticity}$$

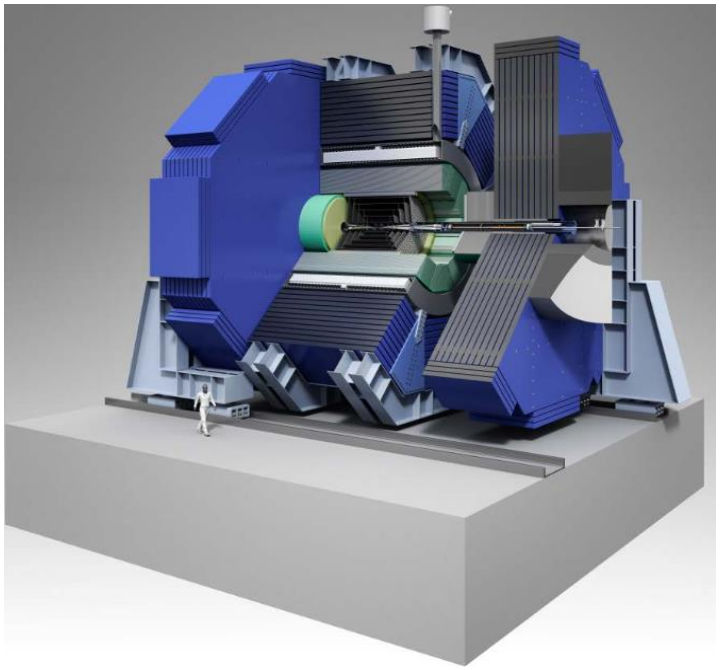


$$Q_e^2 = 4E_eE_e'\cos^2(\theta_e/2), \qquad x_{\mathrm{BJ}} = \frac{E_eE_e'\cos^2(\theta_e/2)}{E_p(E_e - E_e'\sin^2(\theta_e/2))}$$

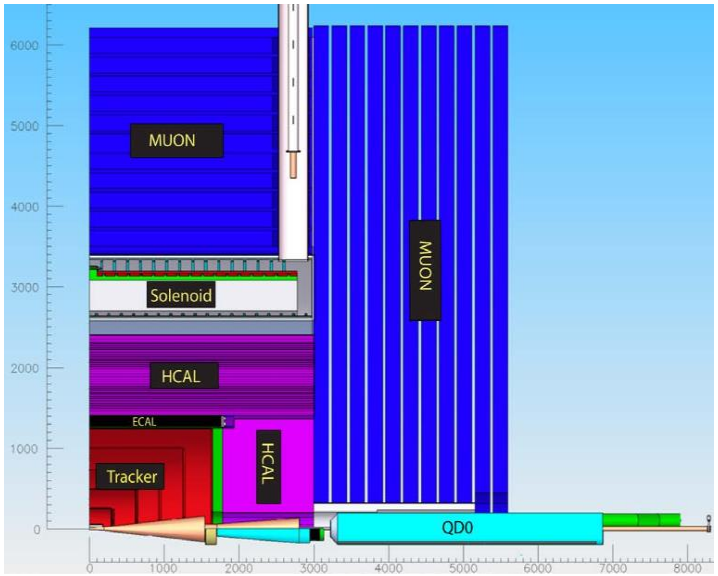
- A future EIC detector must be optimized for the measurement of the energy and angle of the scattered electron (among other things…)

SiD detector for the ILC

Large investment in detector R&D and development of SLIC software used in the past by the ILC community (SiD+ILD)



- Multi-purpose detector for the ILC
- The key characteristics of the SiD detector:
  - 5 Tesla solenoid
  - Silicon tracker: 50 um readout pitch
  - ECAL: (0.35 cm cell size, W / silicon)
  - HCAL:
    - 1x1 cm cell size (RPC)
    - 40 layers for barrel (HCAL) ~4.5 λ_I
- Optimized for particle-flow algorithms (PFA)
- Fully configurable using SLIC software



Proposal

- Adapt Sid detector to EIC environment (lower $\sqrt{s}$)
- Characterize the SiD detector in terms of DIS variables Q^2 and Bjorken x
- Calculate:
  - Reconstruction efficiency in bins of Q^2 and x
  - Resolution of kinematic variables
  - Misidentification rates

Can be obtained from energy and position of scattered electrons

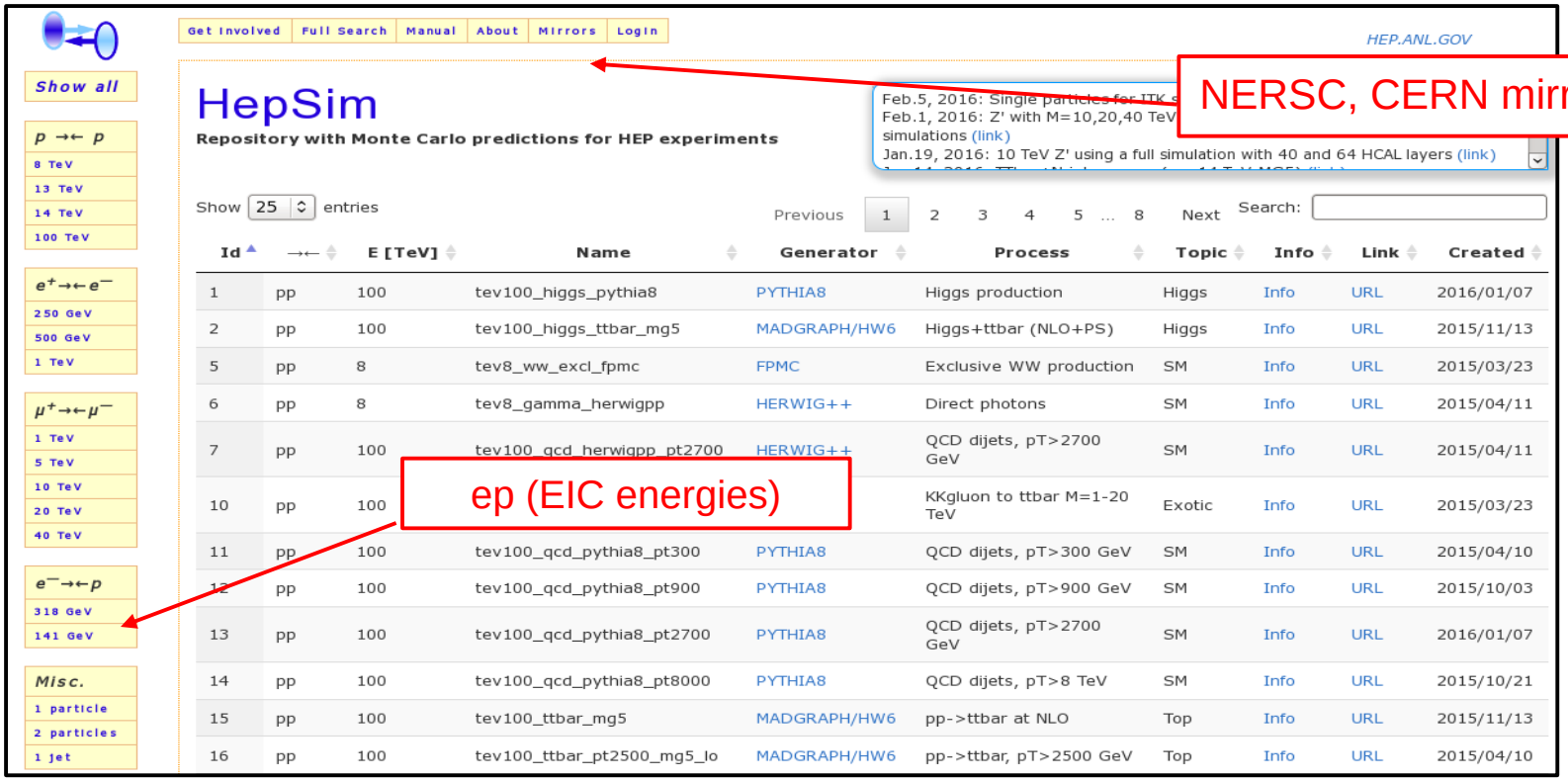
- Use the standard SiD method to identify electrons (tracking+calorimeters) based on particle flow algorithms (PFA)
- Optimize this algorithm or use other reconstruction methods (for example, a neural network used in ZEUS etc.)

Expected Deliverables

- Comprehensive map of the SiD detector in terms of electron characteristics and corresponding DIS variables
- Identification of problematic areas → use the obtained information as input for improved detector designs

Leveraging HEP resources

- Utilizing HepSim repository and SLIC software with the SiD detector
- Use Open-Science Grid (OSG) for event production

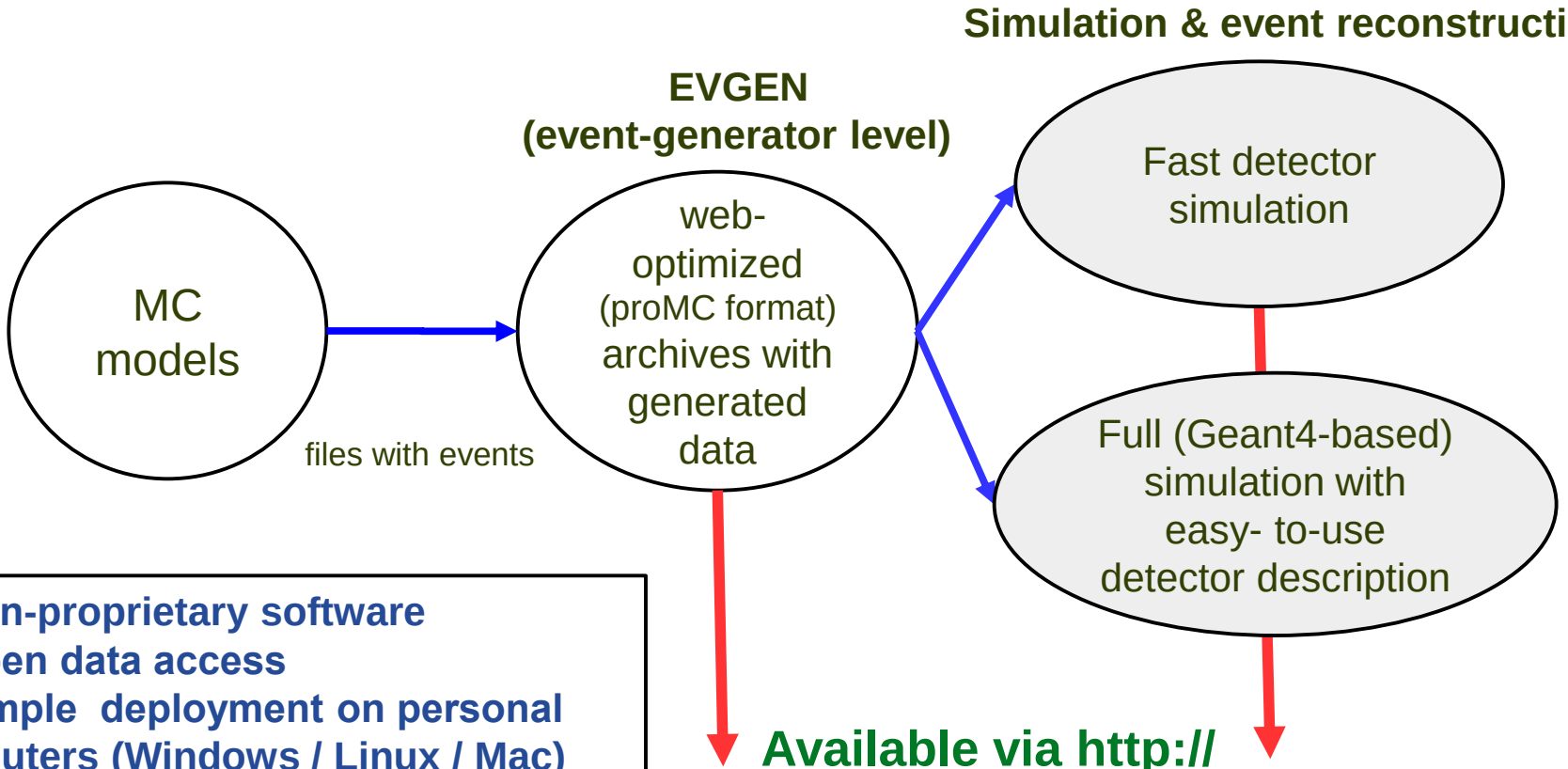


Id	→←	E [TeV]	Name	Generator	Process	Topic	Info	Link	Created
1	pp	100	tev100_higgs_pythia8	PYTHIA8	Higgs production	Higgs	Info	URL	2016/01/07
2	pp	100	tev100_higgs_ttbar_mg5	MADGRAPH/HW6	Higgs+ttbar (NLO+PS)	Higgs	Info	URL	2015/11/13
5	pp	8	tev8_ww_excl_fpmc	FPMC	Exclusive WW production	SM	Info	URL	2015/03/23
6	pp	8	tev8_gamma_herwigpp	HERWIG++	Direct photons	SM	Info	URL	2015/04/11
7	pp	100	tev100_qcd_herwigpp_pt2700	HERWIG++	QCD dijets, pT>2700 GeV	SM	Info	URL	2015/04/11
10	pp	100			KKgluon to ttbar M=1-20 TeV	Exotic	Info	URL	2015/03/23
11	pp	100	tev100_qcd_pythia8_pt300	PYTHIA8	QCD dijets, pT>300 GeV	SM	Info	URL	2015/04/10
12	pp	100	tev100_qcd_pythia8_pt900	PYTHIA8	QCD dijets, pT>900 GeV	SM	Info	URL	2015/10/03
13	pp	100	tev100_qcd_pythia8_pt2700	PYTHIA8	QCD dijets, pT>2700 GeV	SM	Info	URL	2016/01/07
14	pp	100	tev100_qcd_pythia8_pt8000	PYTHIA8	QCD dijets, pT>8 TeV	SM	Info	URL	2015/10/21
15	pp	100	tev100_ttbar_mg5	MADGRAPH/HW6	pp->ttbar at NLO	Top	Info	URL	2015/11/13
16	pp	100	tev100_ttbar_pt2500_mg5_lo	MADGRAPH/HW6	pp->ttbar, pT>2500 GeV	Top	Info	URL	2015/04/10

http://atlaswww.hep.anl.gov/hepsim

Public Repository for Simulated Data Sets: HepSim

http://atlaswww.hep.anl.gov/hepsim/



→ **Non-proprietary software**
→ **Open data access**
→ **Simple deployment on personal computers (Windows / Linux / Mac)**

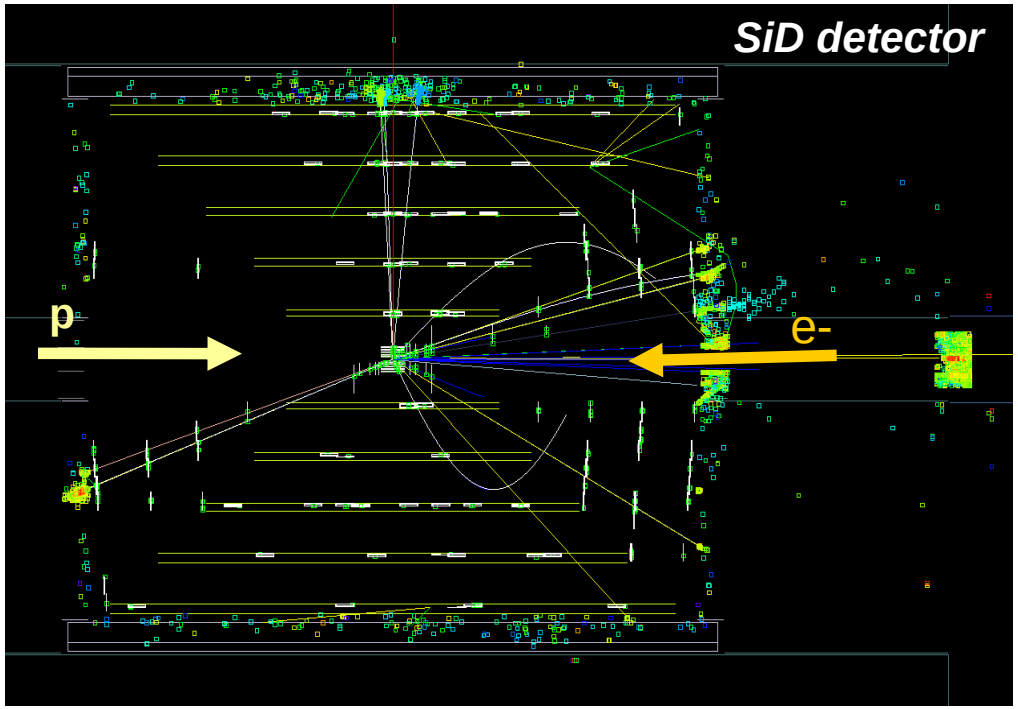
Available via http://

OPEN ACCESS

Long-term availability & preservation

ep collisions in the SiD detector

- Test reconstruction of an ep event in the original SiD detector



DIS sample ($Q^2 > 5$ GeV^2)
CM energy $\sqrt{s}$ = 141 GeV ("EIC-like")

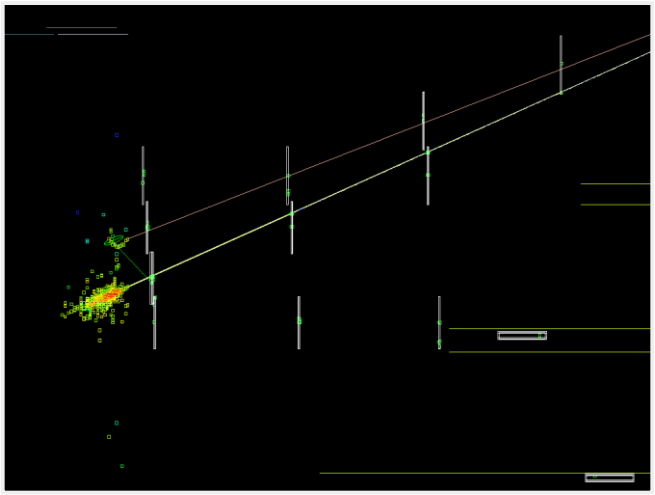
HepSim Monte Carlo samples:

http://atlaswww.hep.anl.gov/hepsim/info.php?item=159

Reconstructed electron energy from PFA: **E=16.92 GeV**

"EVGEN" energy: **16.90 GeV**

Scattered electron in ECAL



Work plan

- **Year 1:**
  - Generate single-electron samples with random energy and pseudorapidity
  - Simulate and reconstruct events using Open-Science Grid
  - Calculate efficiency and resolutions for single electrons (energies, positions)
  - Calculate efficiency and resolutions in terms of Q^2 and x
- **Year 2:**
  - Calculate mis-reconstruction rates of electrons
    - Requires simulations of a large number of realistic ep (eA) events (about 100k events) using the OSG grid
  - Optimize the detector for the measurement of DIS electrons
  - Study other reconstruction methods for DIS kinematics (Jacquet-Blondel, double angle)

Required resources

- One postdoc ($110k/year)
- Travel ($5k/year)
- M&S ($30k/year). Includes computer servers to store/process ep/eA events
  - Other resources for large-scale simulations and event reconstruction will be provided by the OSG grid