

# EIC Detector eRD21 Progress Report

## January 18, 2018

**Project Name:** EIC Background Studies and the Impact on the IR and Detector Design

**Period Reported:** from 10/01/2017 to 12/29/2017

**Project Leader:** Latifa Elouadrhiri\* and Charles Hyde

(\* *Contact Person*)

# Outline

- Project Goals
- Project Members
- Deliverables: Planned/Achieved for this Period
- Future Plans
- Documentation and Publications
- Summary & Path Forward

# Project Goals

Study background generated by machine operation in simulation:

- **Synchrotron radiation**
- **Beam-gas interactions**
- Beam halo effects and beam losses
- Neutron flux
- Others

**Focus of this proposal**

➤ **Quantify background rates and radiation doses in order to assess the impact on**

- **Detectors' operation, electronics, beamline components, etc.**

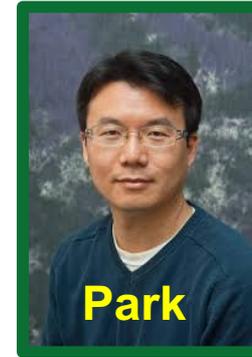
➤ **Provide input**

- **Machine lattice, IR design: beam pipe, magnets, vacuum/pumping**
- **Detector design, technology choices & Support structures, etc.**

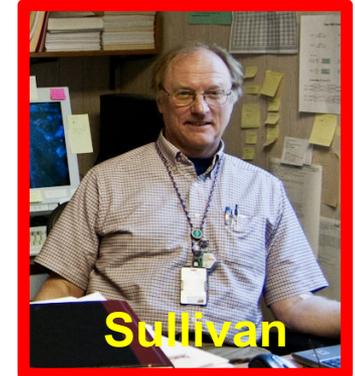
It is critical to perform a thorough study of the type/dose and distribution of machine induced background **NOW** that the IR is being designed

# Project members (FY18) – As presented in the proposal

 Background  
Simulation studies



 Machine/IR design  
& SR modeling



 Detector design

 CAD modeling  
& Vacuum calculation

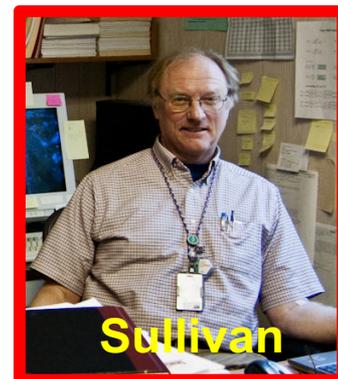


# Project members (FY18) – Current Status

 Background  
Simulation studies

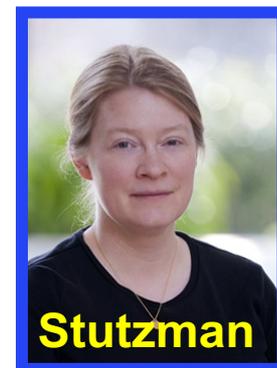


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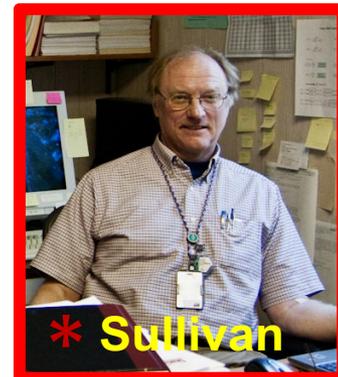


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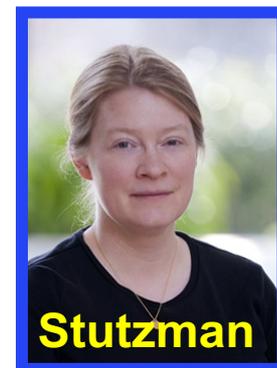
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Simulation studies



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 Detector design



 CAD modeling  
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**\* Funded by the project**

# Budget/Personnel Status

- Funds available to ODU mid-November to support 75% of undergraduate student  
**C. Ploen started immediately**
- Funds available to Jefferson Lab- end of November to support travel  
**M. Sullivan visited Jefferson Lab from SLAC  
Dec 18-21. His next visit planned for Feb 26- Mar 2.**
- Contract submitted to UCONN to support 40% of post-doc, waiting for the final signature  
**N. Markov being trained and ready to start**

# Planned Deliverables for FY18 – as in the proposal

## FY18: First and second quarters

- Complete HERA simulation & documentation
- Model the current baseline design of JLEIC IR beam pipe concept in GEMC/GEANT4 simulations.
- Benchmark synchrotron radiation rates produced within GEANT4 and compare with SR code simulations.
- Develop an interface of the SR code to GEMC
- Model the current baseline design of JLEIC IR beam pipe concept in a 3D CAD model.

## FY18: Third and fourth quarters:

- Determine background rates as a function of vacuum levels for the JLEIC configuration
- Determine the intensity and distribution in the beam pipe and in the various detectors using GEMC interfaced with SR code
- Using validated software tools and result of beam pipe design, evaluate background contributions from hadron beam/gas interactions under nominal vacuum levels.
- Interface CAD drawings with Molflow+ and Synrad+ in preparation of FY19 project

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# Deliverables: Planned and Achieved for this Period

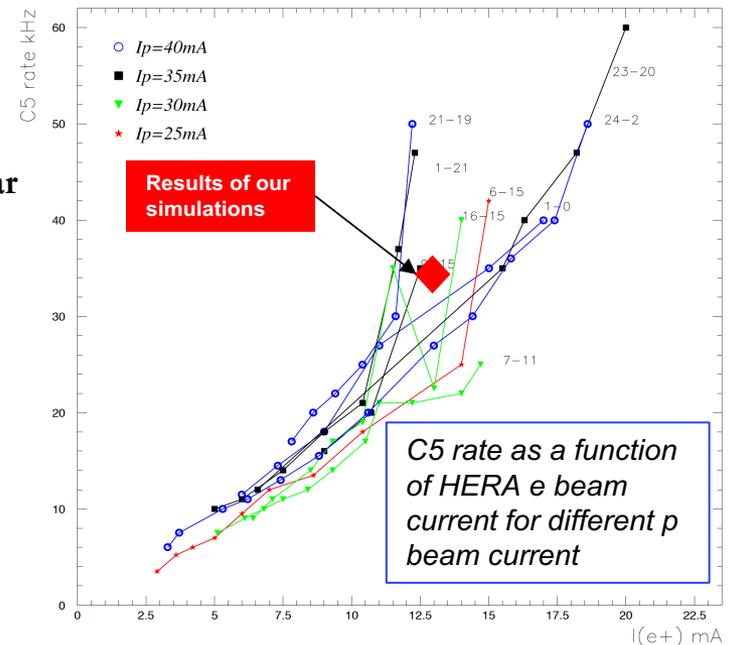
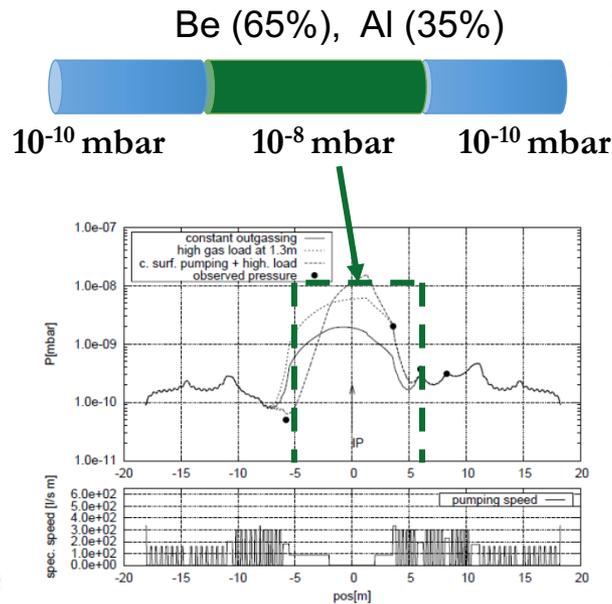
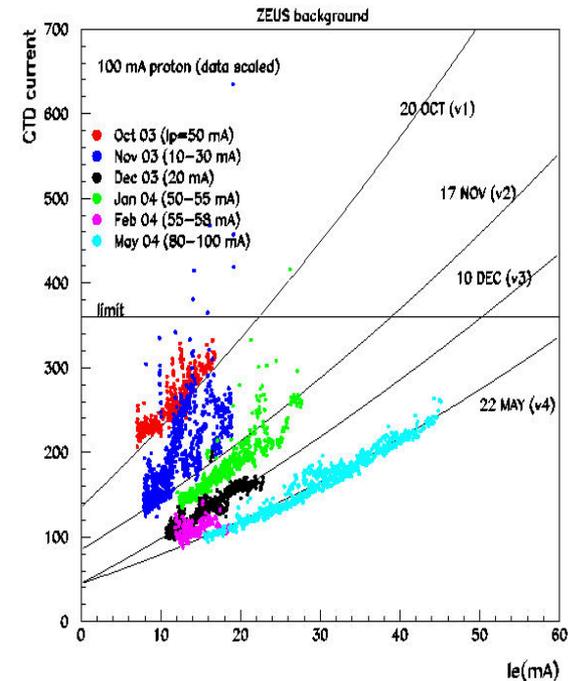
## FY18: First and second quarters:

- Complete HERA benchmarking  
**Analysis completed draft paper produced will be finalized by end of February. Tools to analyze/evaluate background developed**
- Model the current baseline design of JLEIC IR beam pipe concept in GEMC/GEANT4 simulations  
**Implementation procedure from CAD to GEANT developed, tested and being used to model beam-pipe components in GEANT**
- Benchmark synchrotron radiation rates produced within GEANT4 and compare with SR code simulations  
**Work has started, infrastructure in place and quantitative studies is the focus for next quarter**
- Develop an interface of the SR code to GEMC  
**Interface developed and being used**
- Model the current baseline design of JLEIC IR beam pipe concept in a 3D CAD model.  
**Updated Beam pipe design produced with close discussion with engineering & accelerator physicists to meet physics requirements  
CAD model has started, this becomes the input to GEANT simulations and background evaluation**

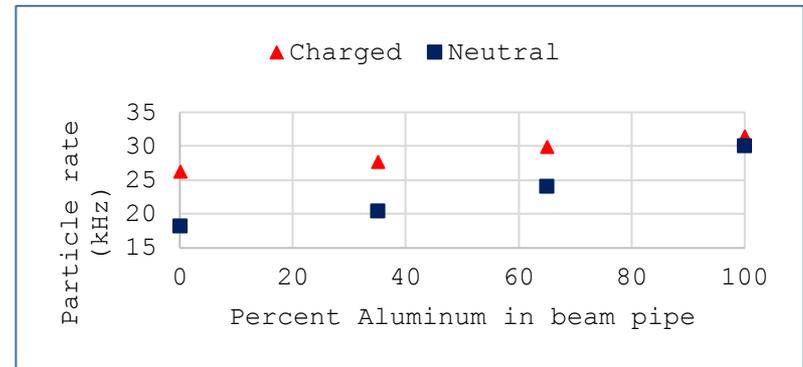
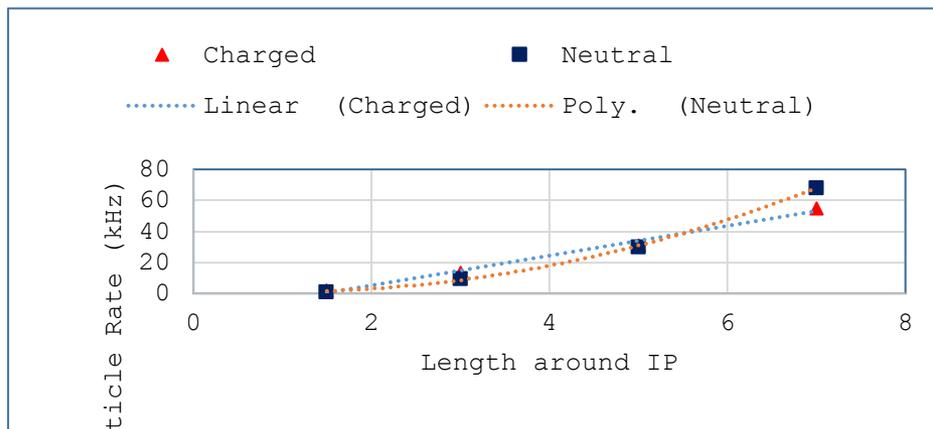
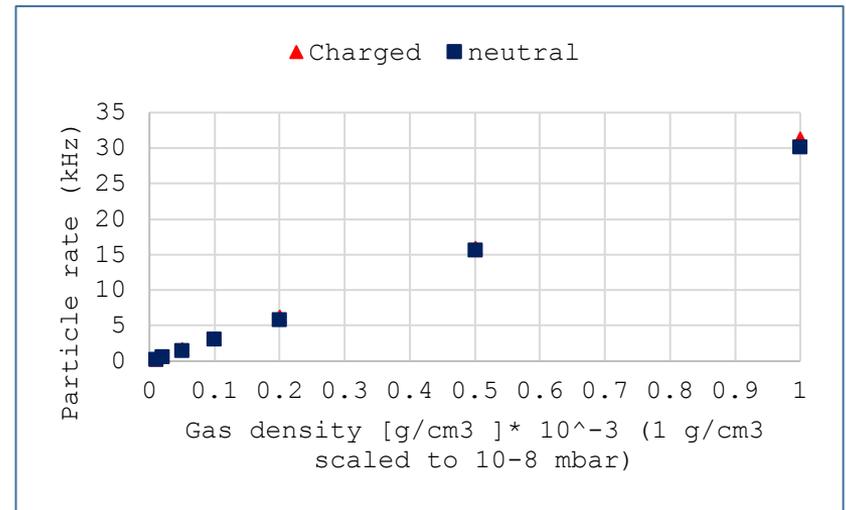
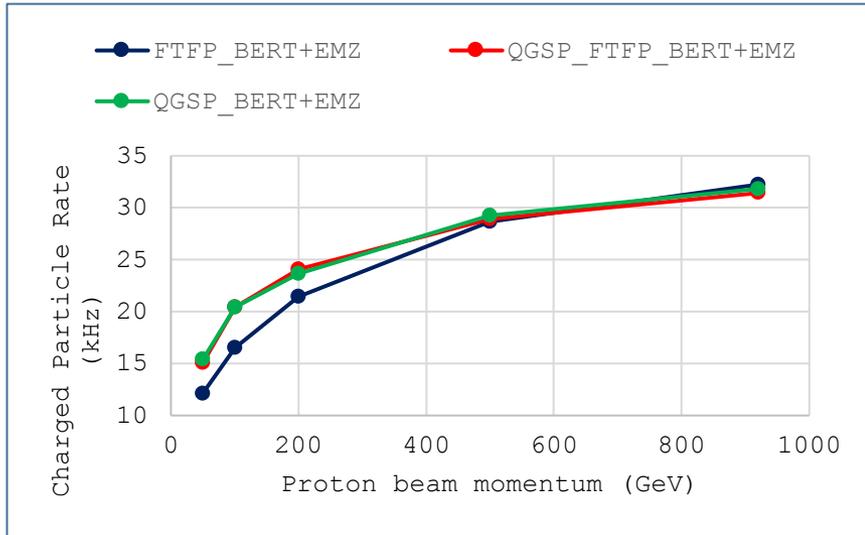
# HERA Benchmarking & Development/validation of background analysis tools/procedures

# HERA Benchmarking

- Performance of ZEUS at HERA was limited by background in the Central Tracking Detector (CTD)
  - No careful background simulations prior to running
- Background was generated by ion beam scattering on residual gas generated by electron beam's synchrotron radiation
- Background was monitored using a small scintillator counter C5
- Simulation tools and procedures validated using HERA data (L. Elouadrhiri et al.)



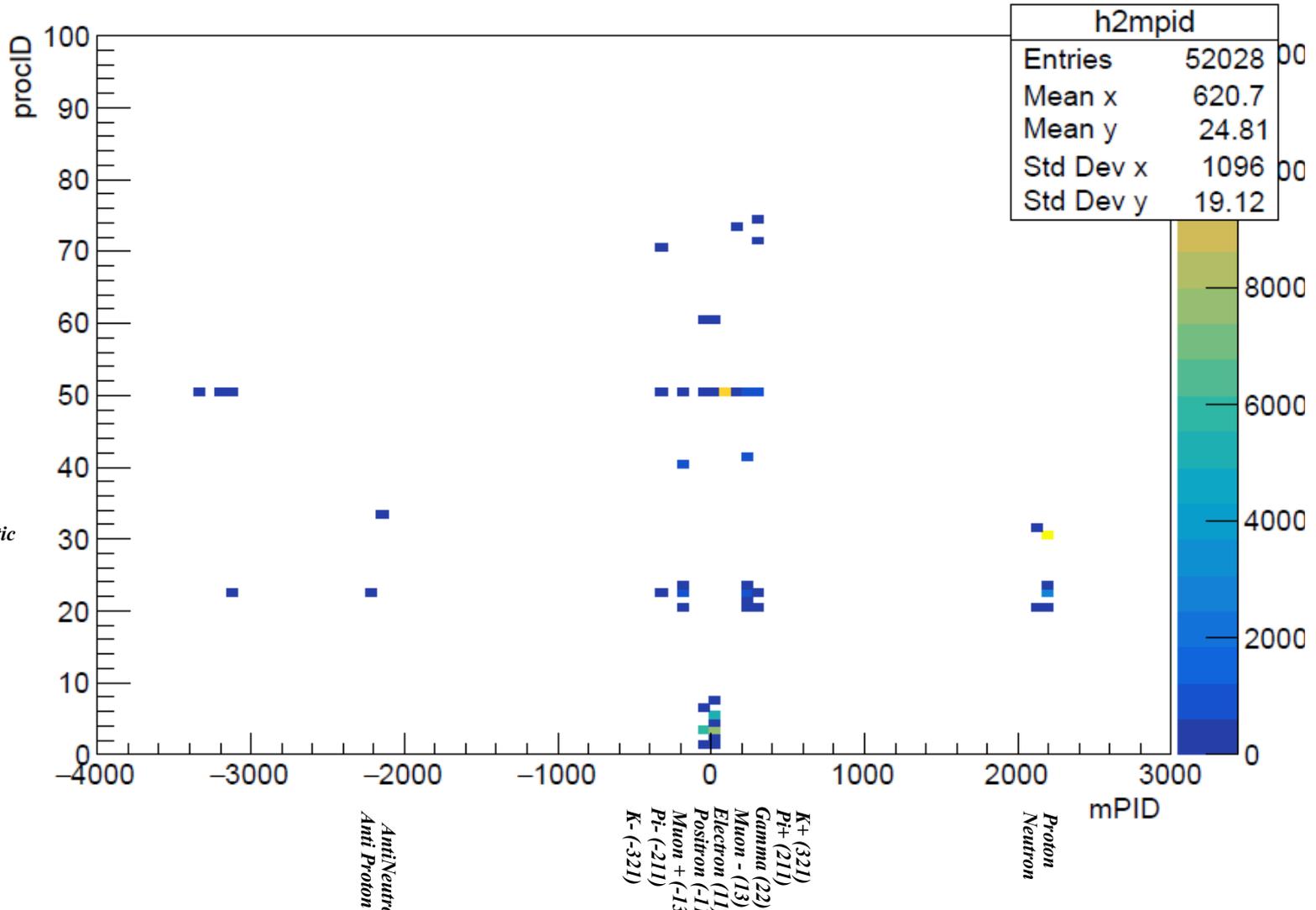
# HERA Benchmark: Systematic Studies Complete!



Systematic analysis completed, analysis tools developed draft paper produced

# Process ID vs mother PID

HERA Configuration: Process ID versus mPID

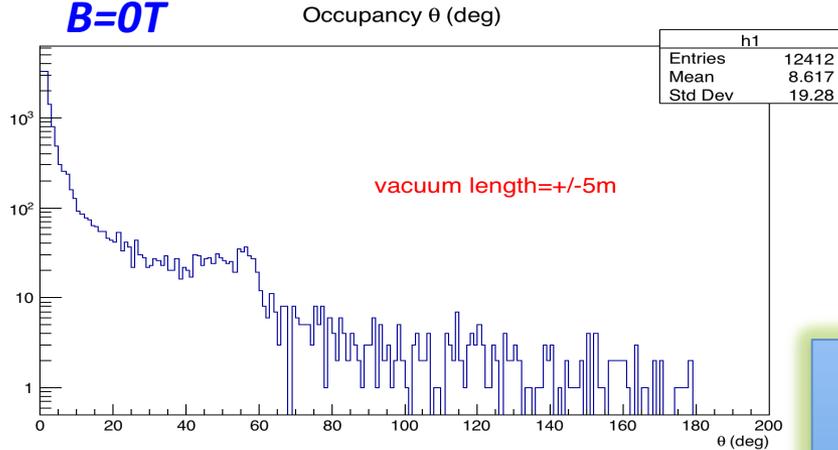


# Physics Model Dependence

**FTFP**

**$E_0=900\text{GeV}$**

**$B=0\text{T}$**

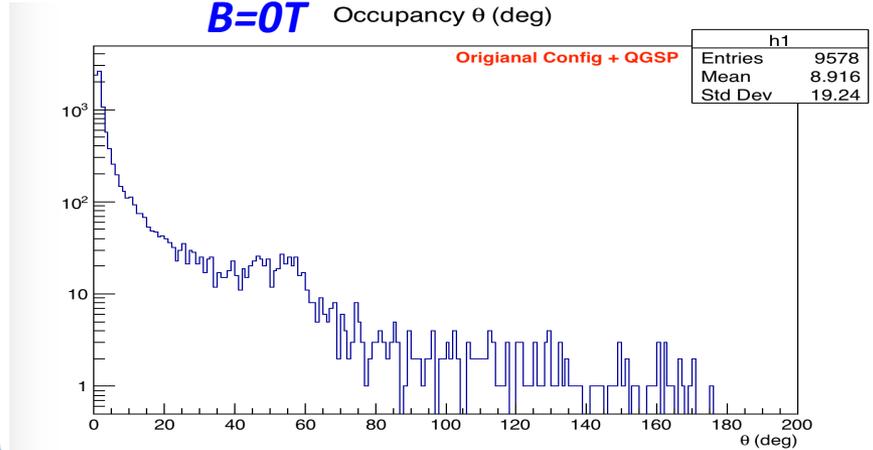


- 23 %, less BG event

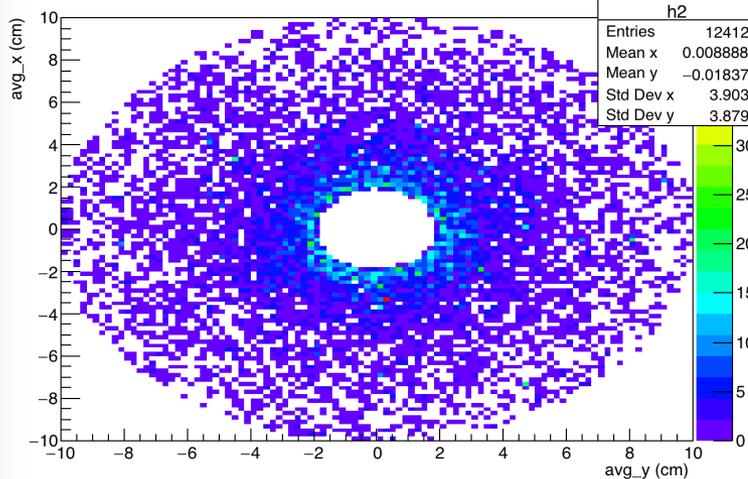
**QGSP**

**$E_0=900\text{GeV}$**

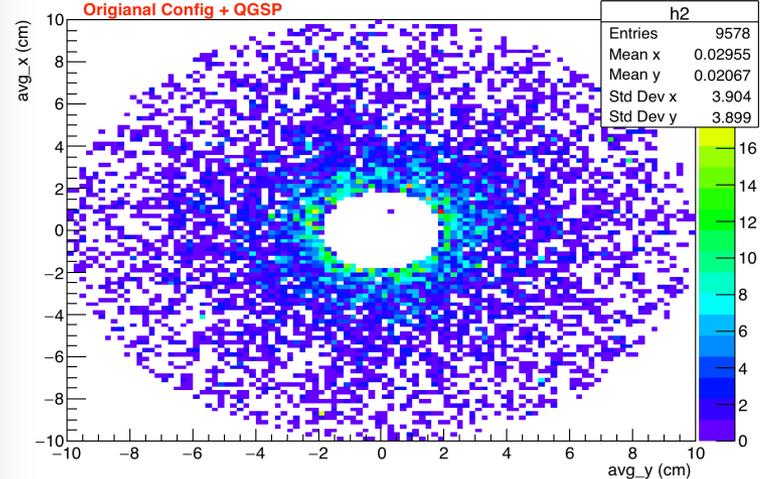
**$B=0\text{T}$**



Occupancy avg\_y vs. avg\_x for all Ptls



Occupancy avg\_y vs. avg\_x for all Ptls



# Beam-pipe Material Dependence

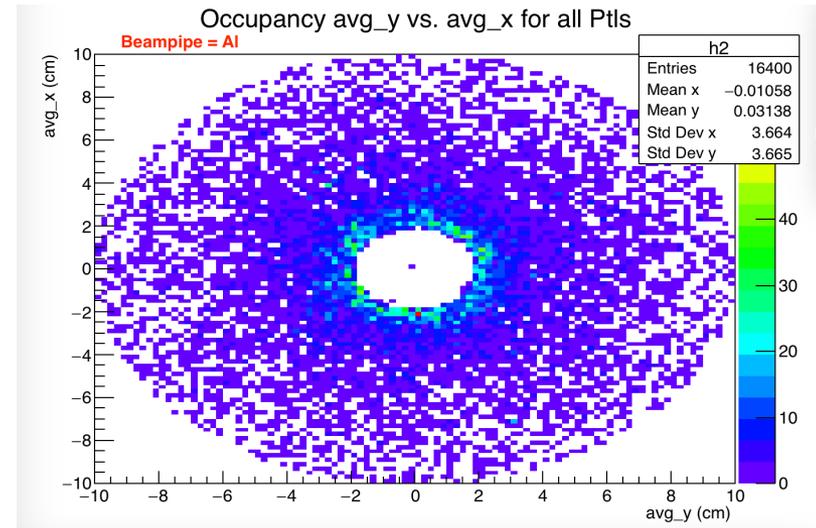
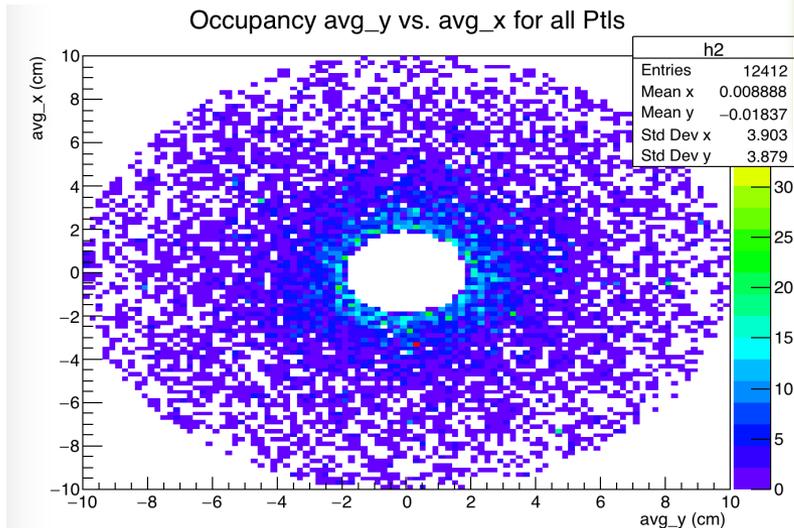
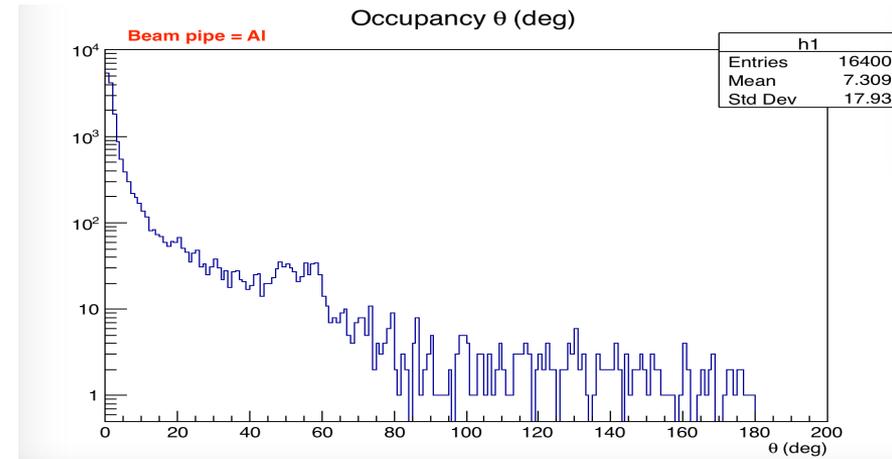
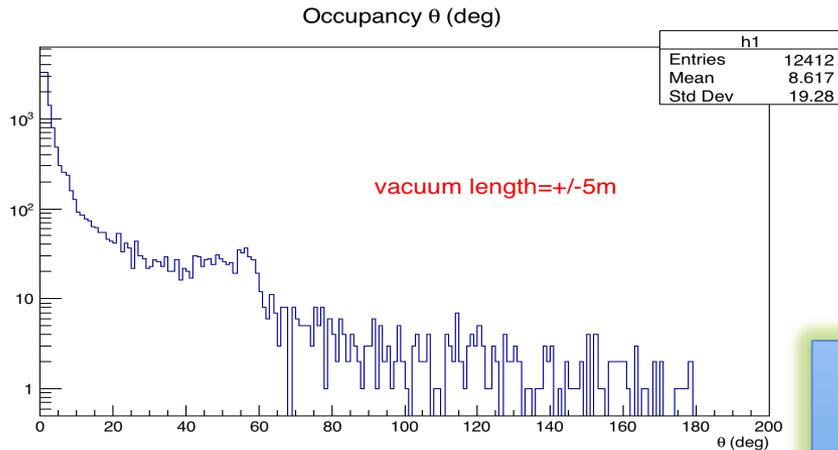
FTFP,  $E_0=900\text{GeV}$

$B=0T$ , Beam-pipe = BeAl Be (65%), Al (35%)

+ 25 %, more BG event.

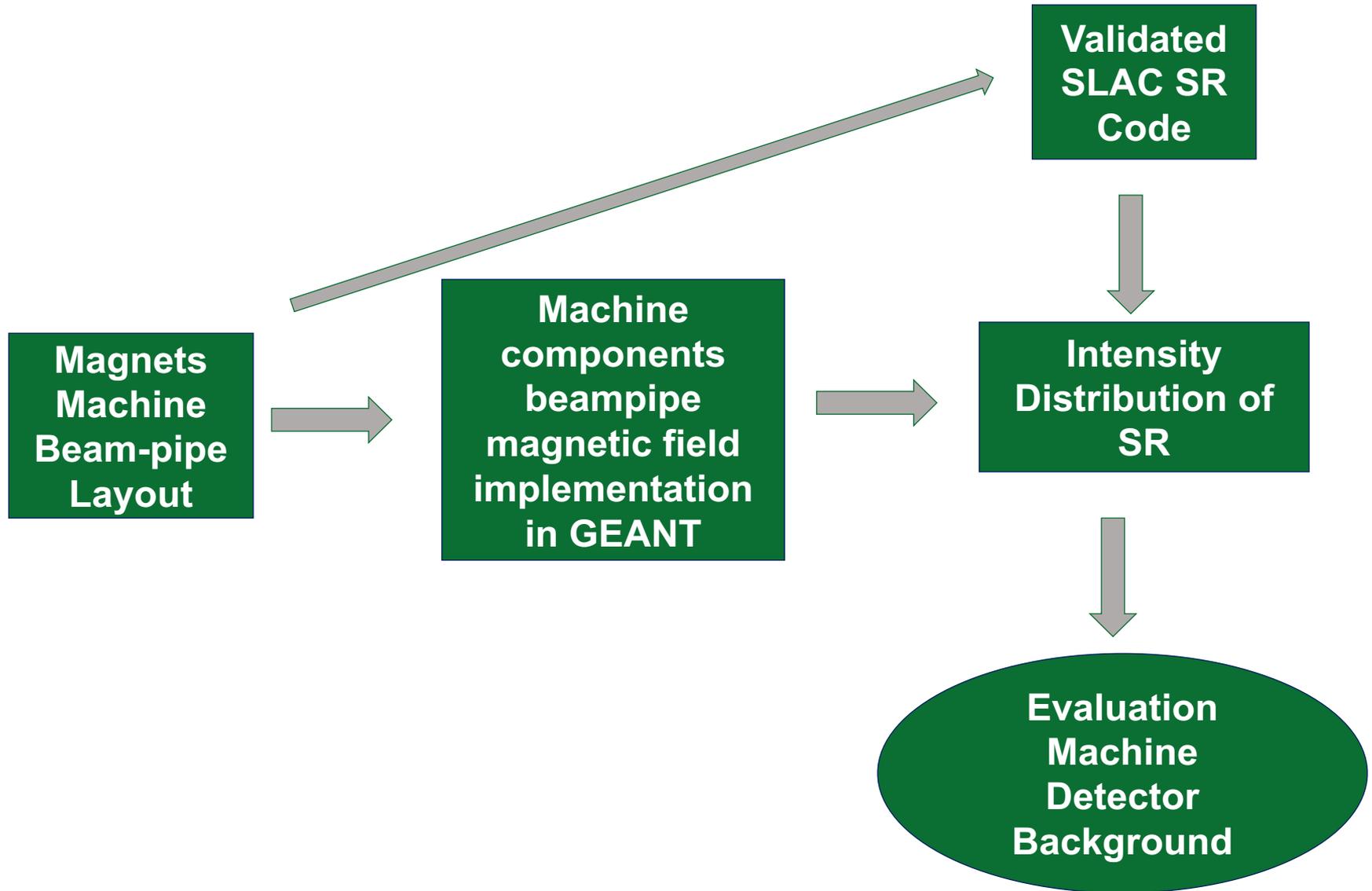
FTFP,  $E_0=900\text{GeV}$

$B=0T$  & Beam-pipe = Al Al(100%)

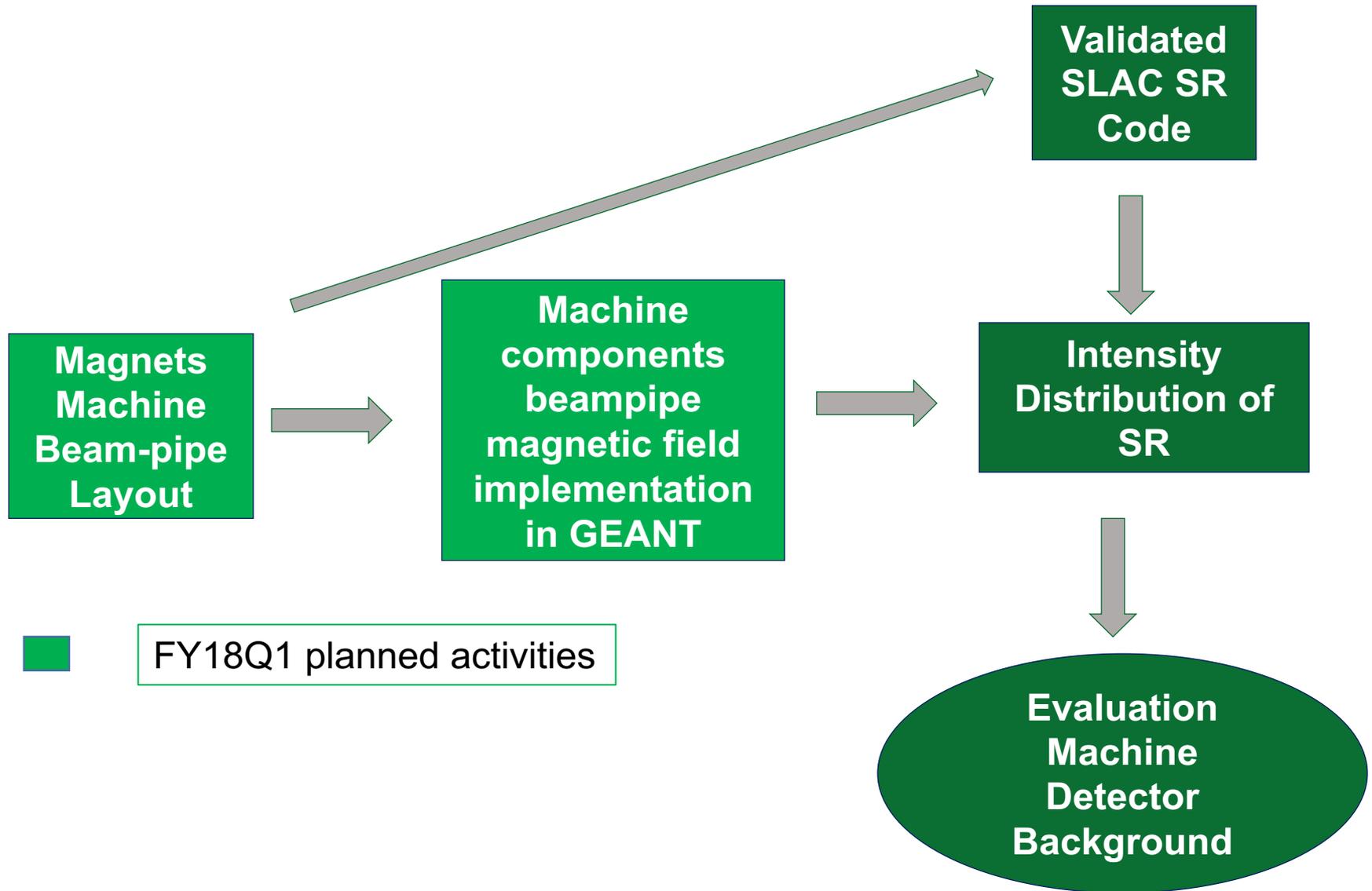


# EIC – Infrastructure for Background Studies being developed

# Background Studies Workflow

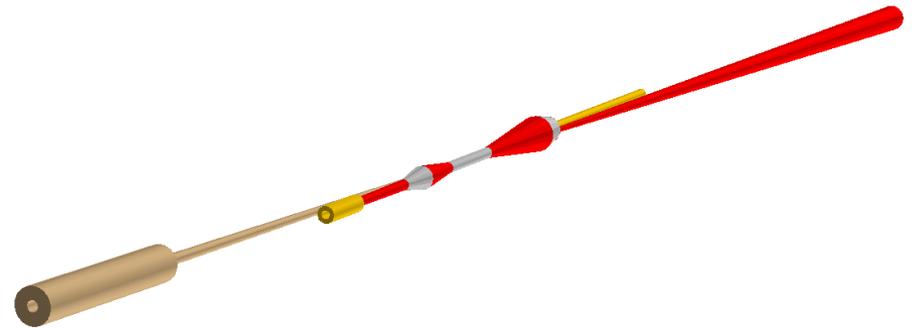
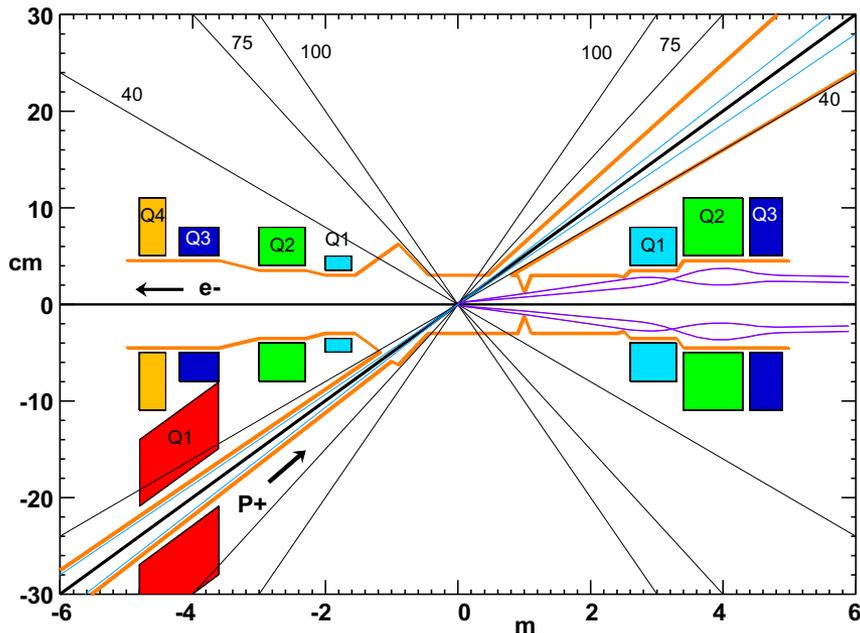


# Background Studies Workflow



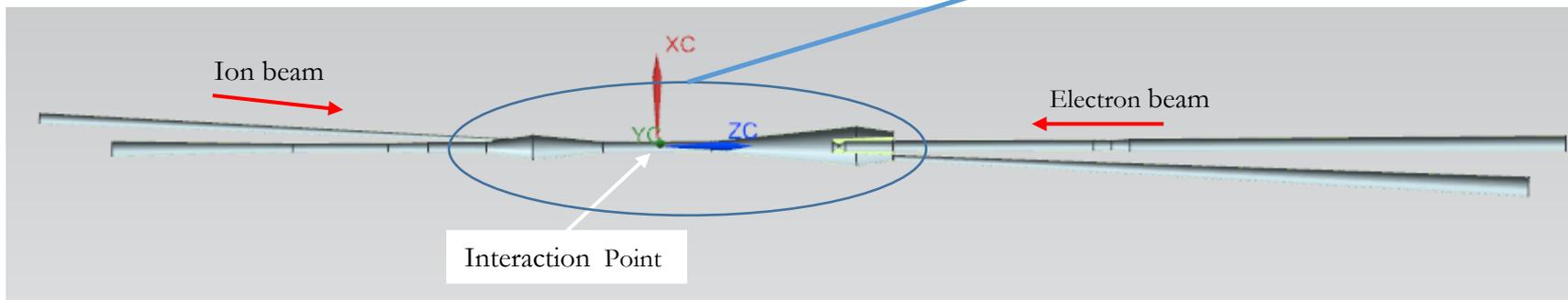
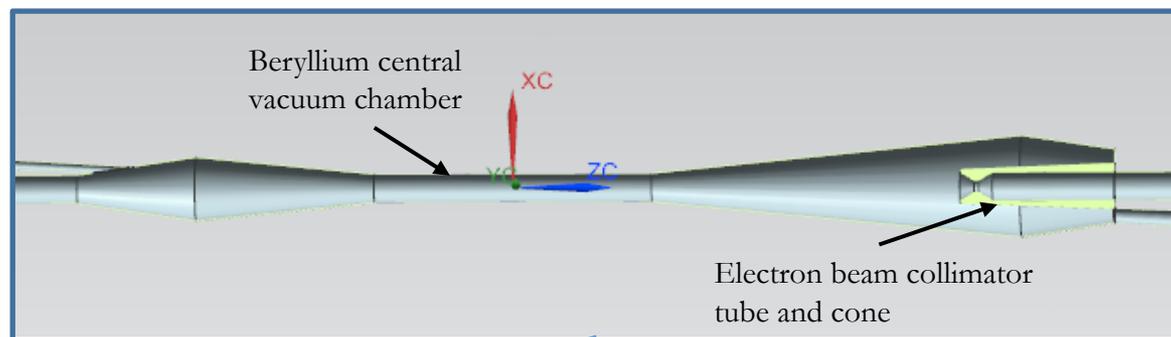
# Beam Pipe Conceptual Design Updated

- Minimum multiple scattering in the beam pipe material
- Synchrotron radiation collimation
- Impedance
- L. Elouadrhiri et al. (JLab), C. Hyde (ODU), M. Sullivan (SLAC)



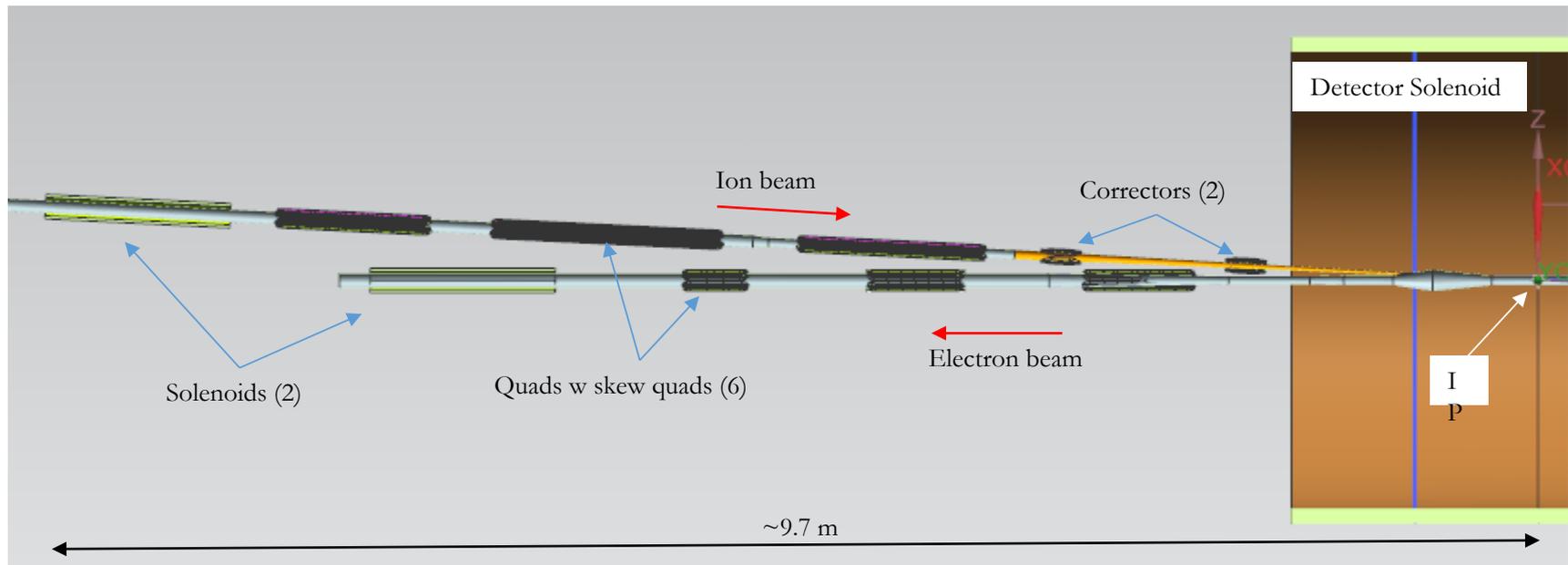
# IR Vacuum Chamber – Detailed Modeling

- A CAD model has been generated in NX based on detector and beam transport requirements
- STP files from NX have been translated into GEMC and used in preliminary studies



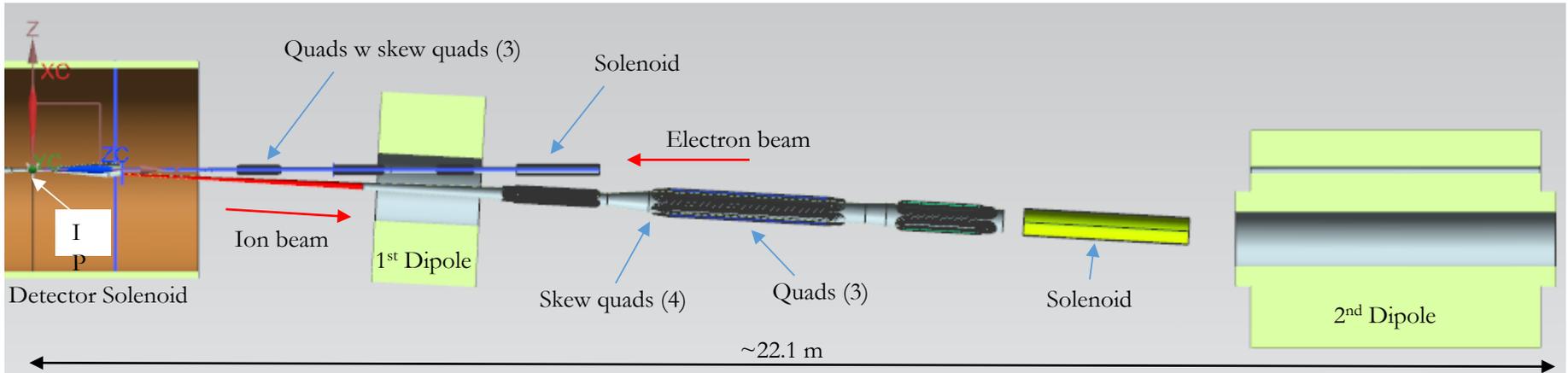
# Beam Transport – Ion Entrant Side

- Preliminary vacuum beam pipe geometry has been generated
- Preliminary quad, skew quad, solenoid, and corrector designs exist
- Started work on fringe field and multipole corrector designs
- Design has focused on the beamline spacing of magnets
  - The radial space will be looked at as more details are generated



# Beam Transport - Ion Exit Side

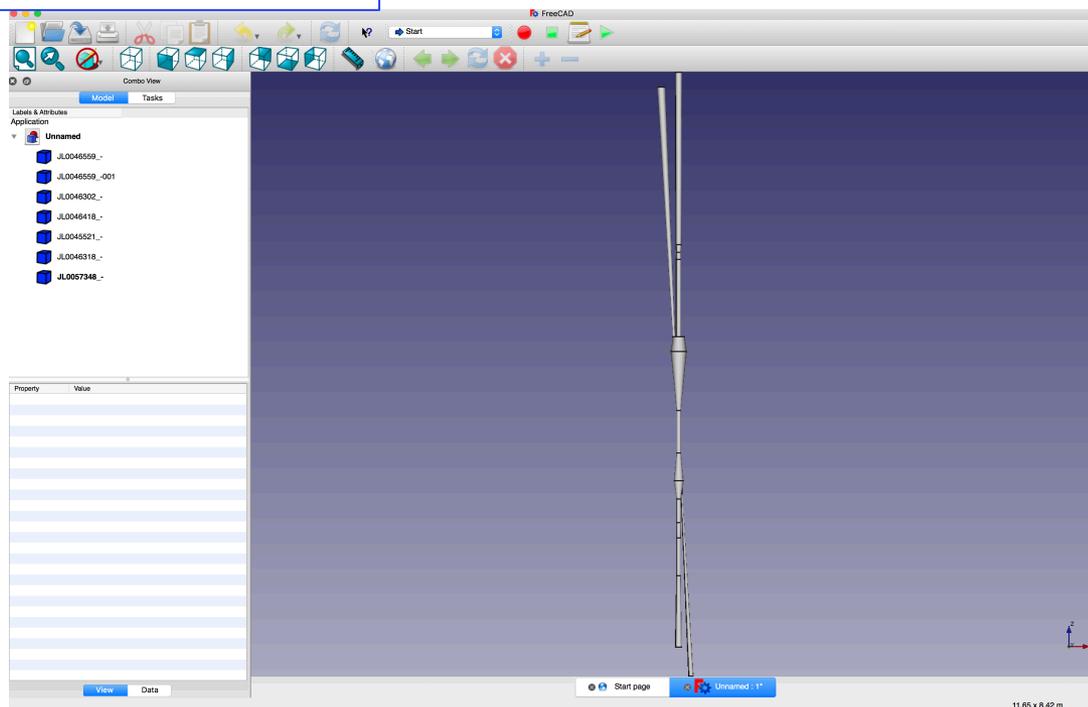
- Same overall status as ion entrant side
  - Preliminary dipole designs exist
  - Working on ion beam preliminary corrector designs
  - Working on interfaces near the detector solenoid and around the first dipole magnet
  - Need to add preliminary detector designs along the beamline
- Need synchrotron radiation, impedance, vacuum, etc., requirements to consider for the whole area
- **Discussed the overall design, status, and requirements for optimization of background due to SR, with Mike Sullivan (SLAC) on December 18-21, 2017 (funded by this project)**



# From Drawing to GEANT

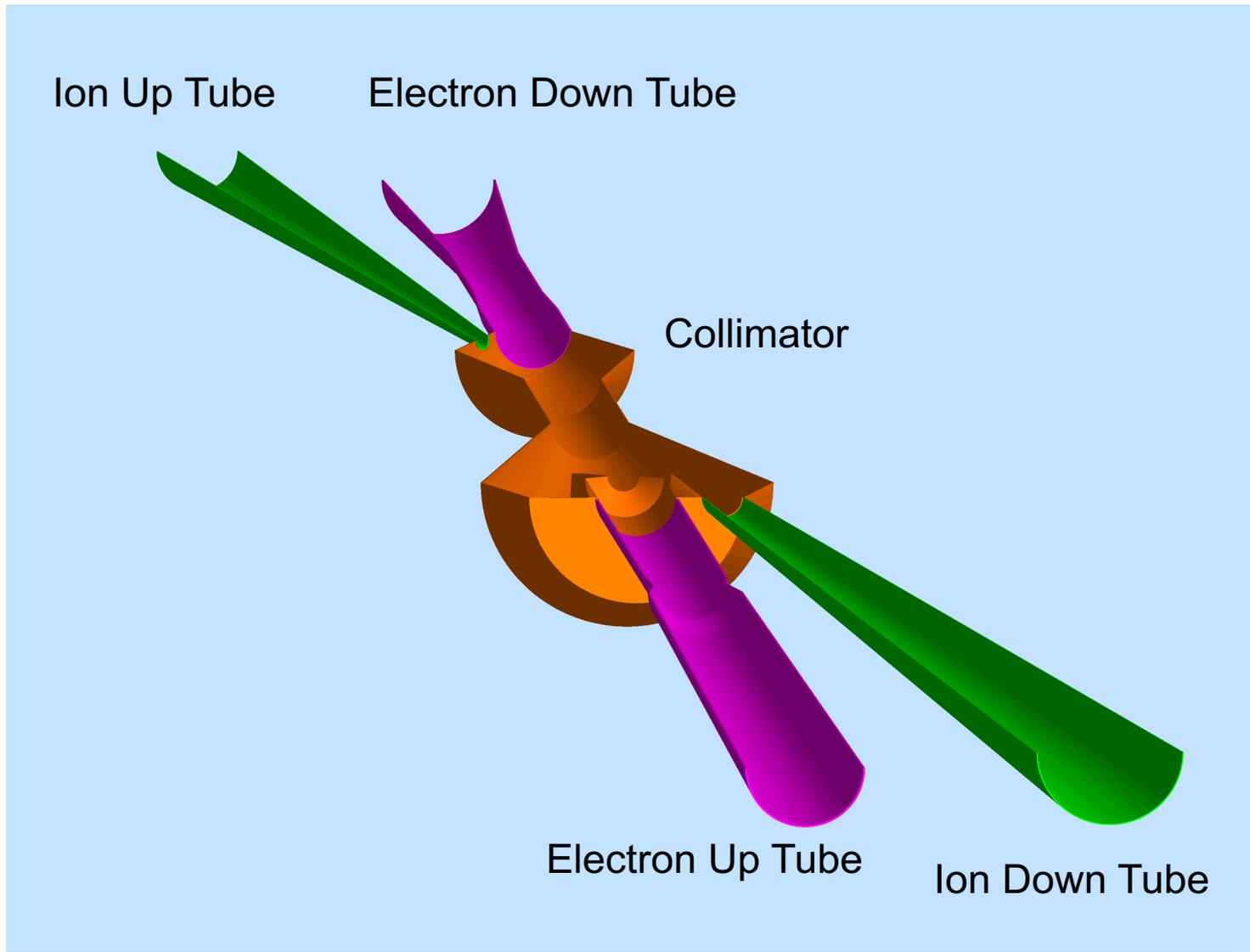
- Start with stp file which contains full design
- Save each object as a separate file
- Assign material to each object
- Put into the GEMC/GEANT4

Example of EIC  
beam pipe  
implementation

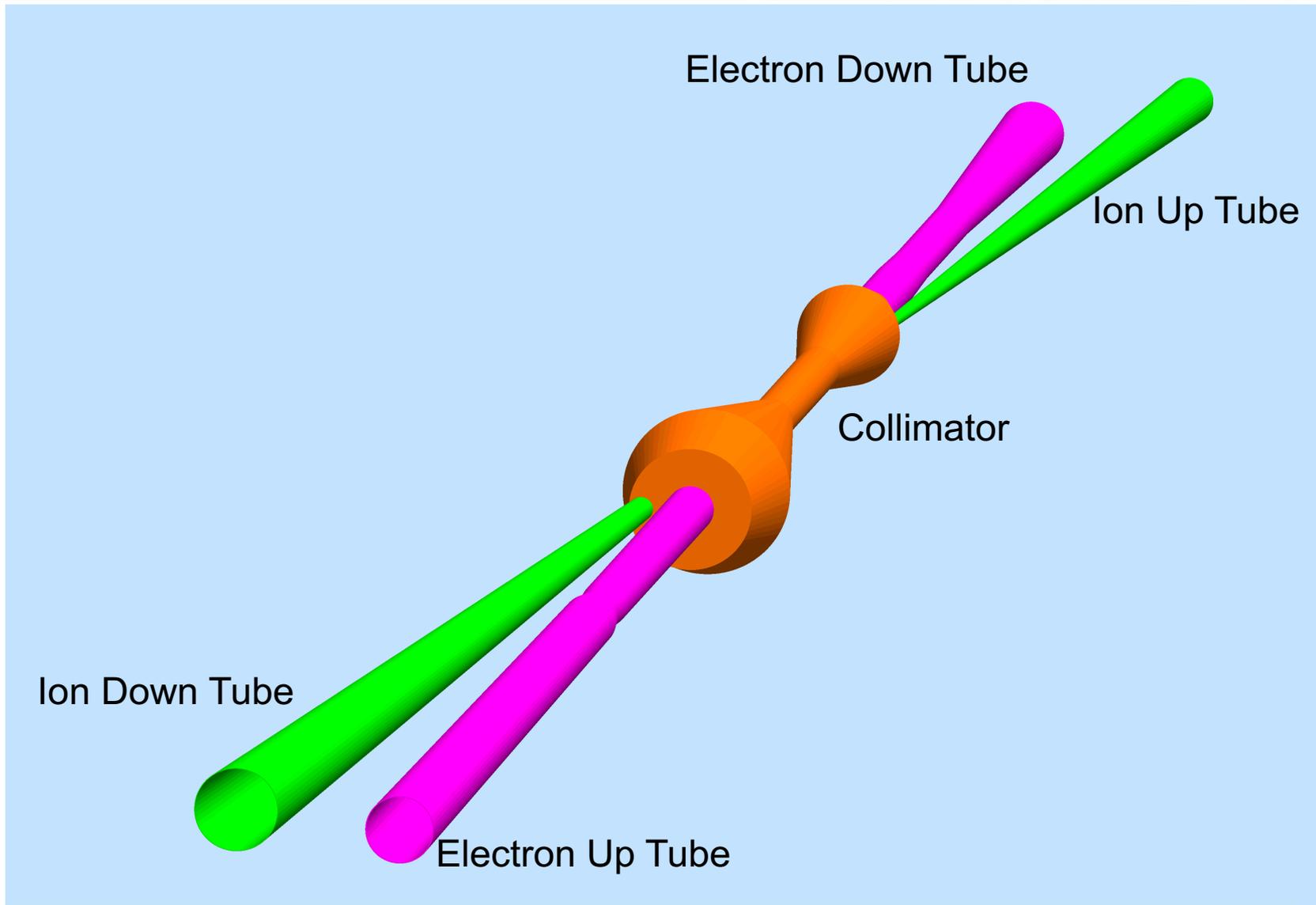


Technical note will be written, as part of making our procedure accessible

# Beam-pipe in GEANT Simulation



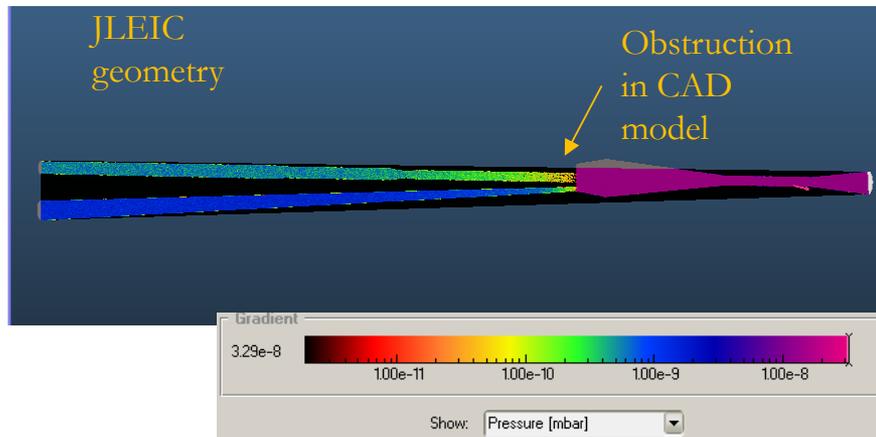
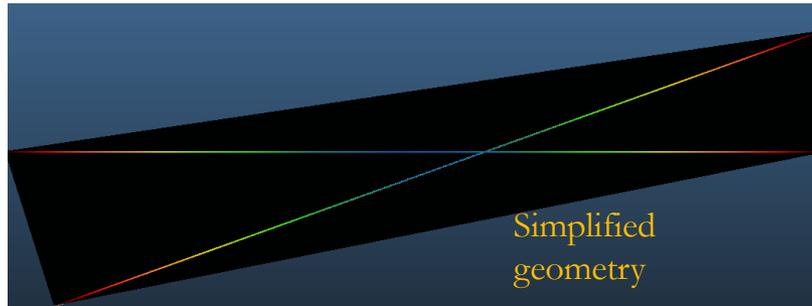
# Beam-pipe in GEANT Simulation: another view



# EIC – Background Studies Future Plans

# Molflow+ for Vacuum Simulations

Activities planned for FY18Q3 & FY18Q4



- Will work for modeling vacuum
  - Used to simulated LHC, KEK
- Requires work with designers to simplify/modify CAD drawings
  - intersections between segments must be transparent
  - Reduce facets to speed calculations
- Complementary Synrad can be used for synchrotron radiation induced gas load (FY19 Project)

**Note:** N. Markov will be assigned to work with our vacuum engineer on this part of the project

# EIC Technical Notes and Publications

## EIC technical notes in development or planned:

1. HERA Benchmarking hadronic beam-gas in GEANT4-based GEMC for an EIC (L. Elouadrhiri & C. Ploen et al.)
2. Interaction Region Optics and Beam Stay Clear for Ion Injection: Impact on Central Vacuum Pipe Design (C. Hyde & M. Sullivan et al.)
3. From CAD to GEANT (N. Markov et al.)
4. SR Code Validation (C. Ploen & M. Sullivan et al.)
5. ...

# Summary & Path Forward

**Funding request completed and funds received (*UCONN contract to be completed this month*)**

**Experienced team assembled & resources in place**

**No requested changes from the proposal**

**Ready to be integrated with BNL team & the user's IR working group**

**Achieved all planned activities for this period**

- Completed HERA benchmarking: analysis completed, draft paper produced will be finalized by end of February
- Tools to analyze/evaluate background developed
- Updated Beam pipe design produced with close discussion with engineering & accelerator physicists to meet physics requirements
- CAD model and detailed GEANT simulations has started

**On track to meet the deliverables of FY2018!**

THANK YOU!