Pressure Simulations for the EIC Interaction Region

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For the EIC Interaction Region Background Collaboration

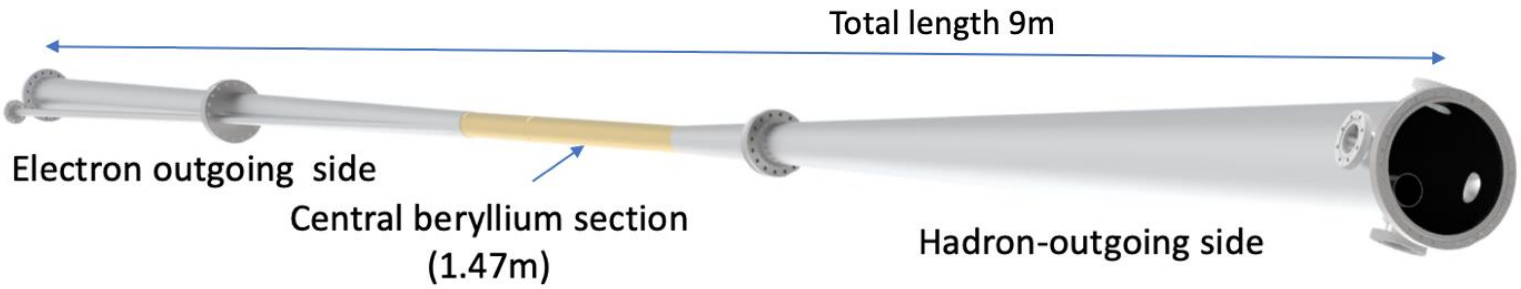
Electron-Ion Collider

BROOKHAVEN NATIONAL LABORATORY

Jefferson Lab

U.S. DEPARTMENT OF ENERGY | Office of Science

Vacuum Chamber Design



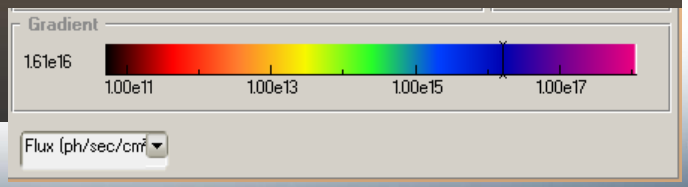
- Design Considerations include
  - Magnet integration
  - Detector integration
  - Vacuum materials choice
  - Impedance
  - **Detector background mitigation**
- See poster by H. Witte

  WEPAB002

- Interaction Region vacuum materials
  - Aluminum
  - Copper
  - Beryllium
  - Gold
  - Non-evaporable Getter coatings
- Considerations
  - atomic mass, z
  - Outgassing
  - Fabrication and cost

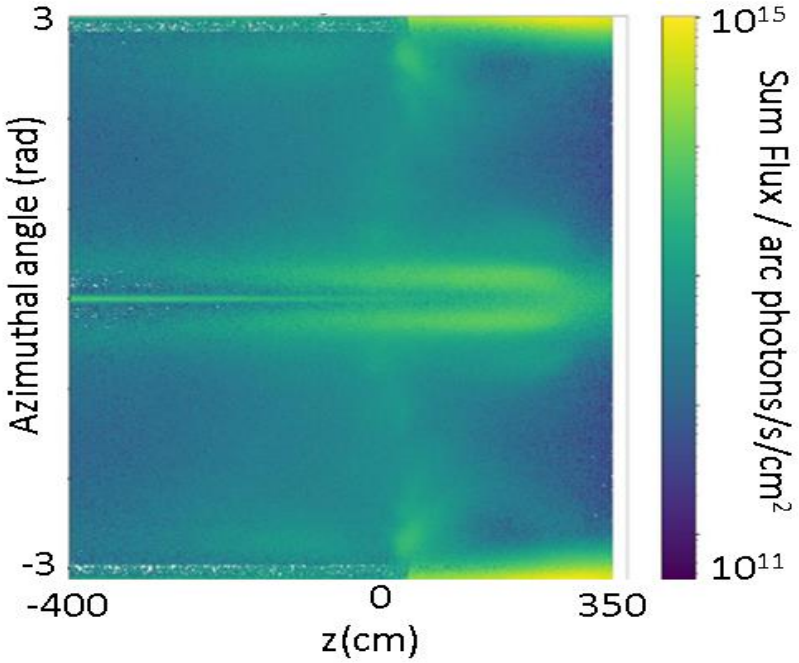
SynRad+ Software

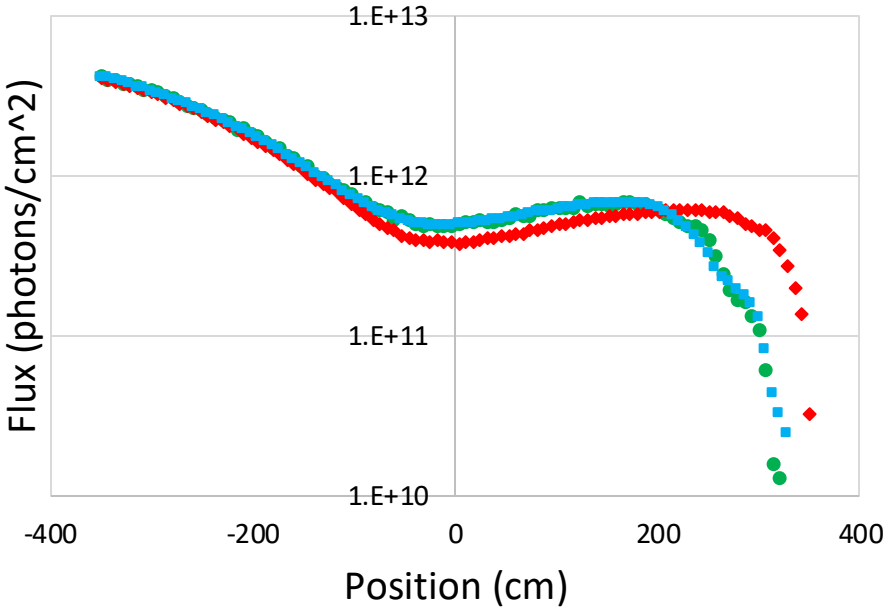
- Same geometry file format
- Input
  - Electron Beam
    - Current
    - Position
    - Energy
    - Emittance
    - Profile
  - Magnets
    - Bending Dipoles
    - Focusing Quads
- Output
  - Synchrotron radiation flux and energy on every facet
  - Individual Photon Tracking: position, direction, energy



R. Kersevan and M. Ady, "Recent developments of Monte-Carlo codes Molflow+ and Synrad+", 10th International Particle Accelerator Conference, (2019). doi: 10.18429/JACoW-IPAC2019-TUPMP037

Synchrotron Radiation Simulation





Photon flux as a function of azimuthal angle and position, z, along the beamline. The electron beam propagates from left to right, and the high flux regions at ϕ=0° and 180° are due to scattering of photons generated in the horizontal dipole.

Simulated photon flux on the beam-right IR vacuum chamber vs. position z for circular FPA with diameter 4 cm located at: (blue) -380 cm extending to -345 cm, (green) -345 cm and zero length, and (red) -415 cm and zero length.

Vacuum Modeling Software: Molflow+

Test Particle Monte Carlo Simulation

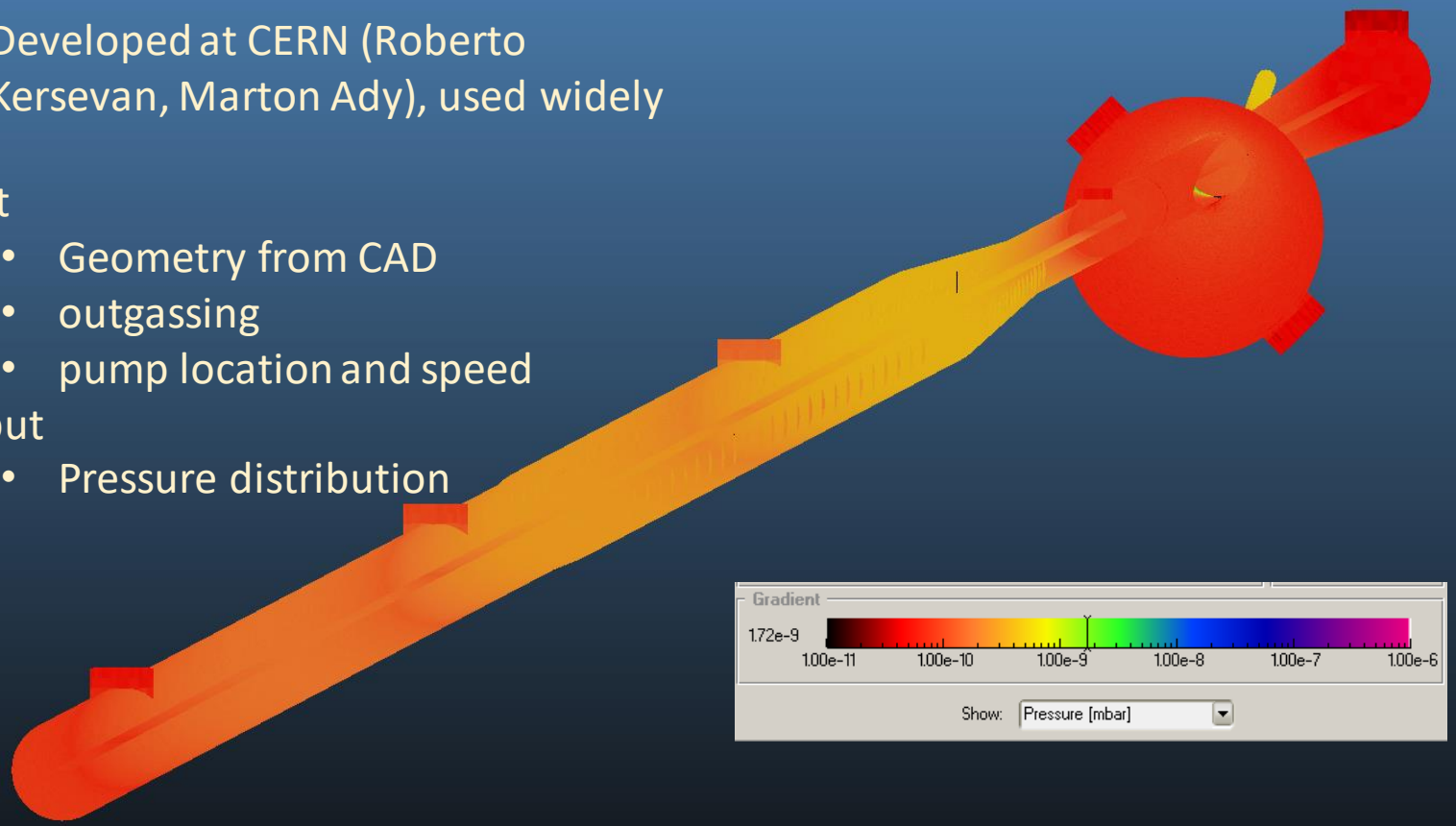
- Developed at CERN (Roberto Kersevan, Marton Ady), used widely

Input

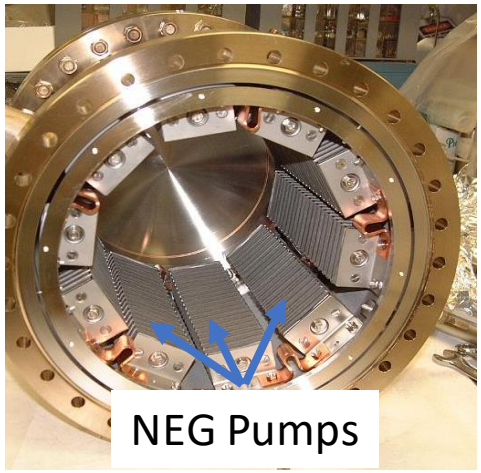
- Geometry from CAD
- outgassing
- pump location and speed

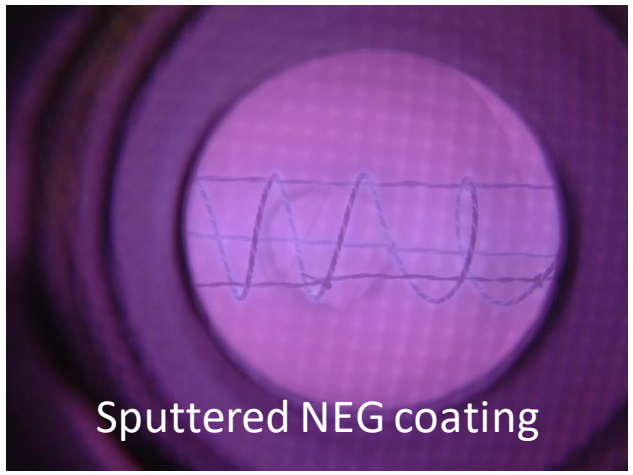
Output

- Pressure distribution

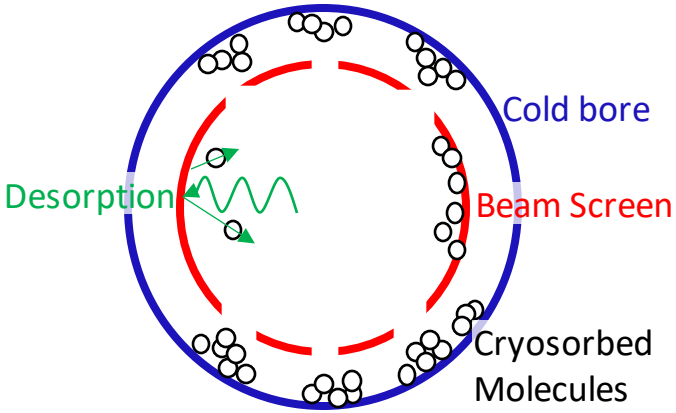


EIC IR Vacuum Pumps



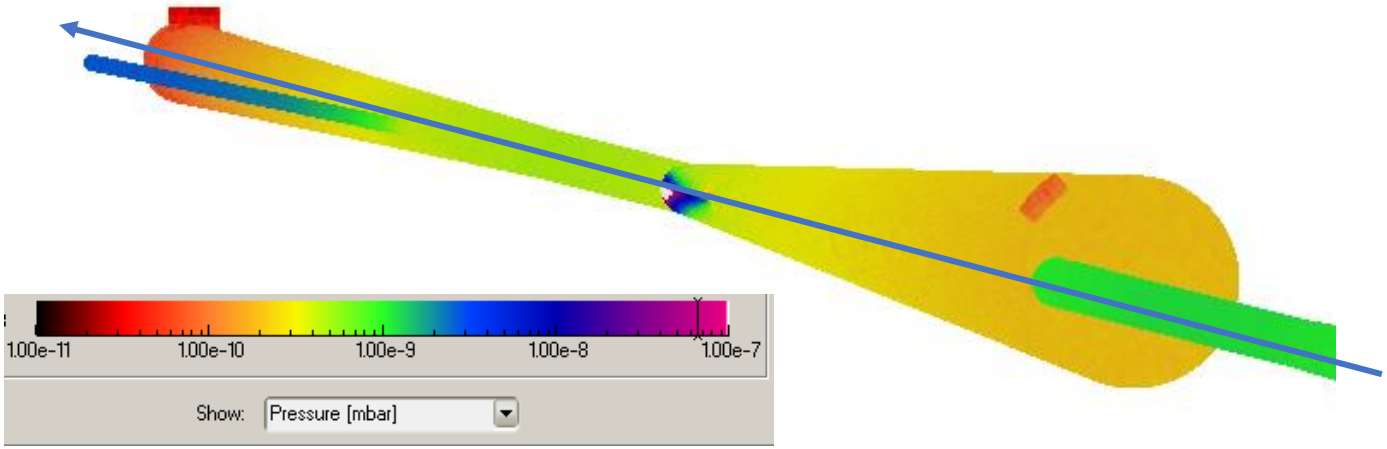


Combination NEG/Ion pump

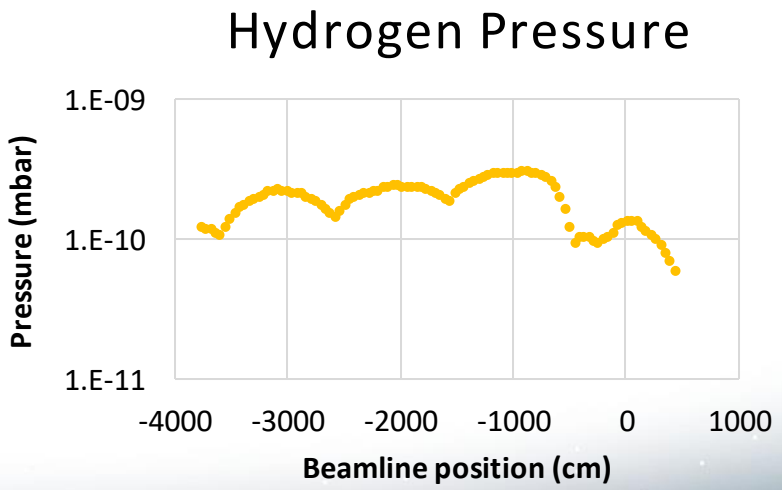


Cryopumping

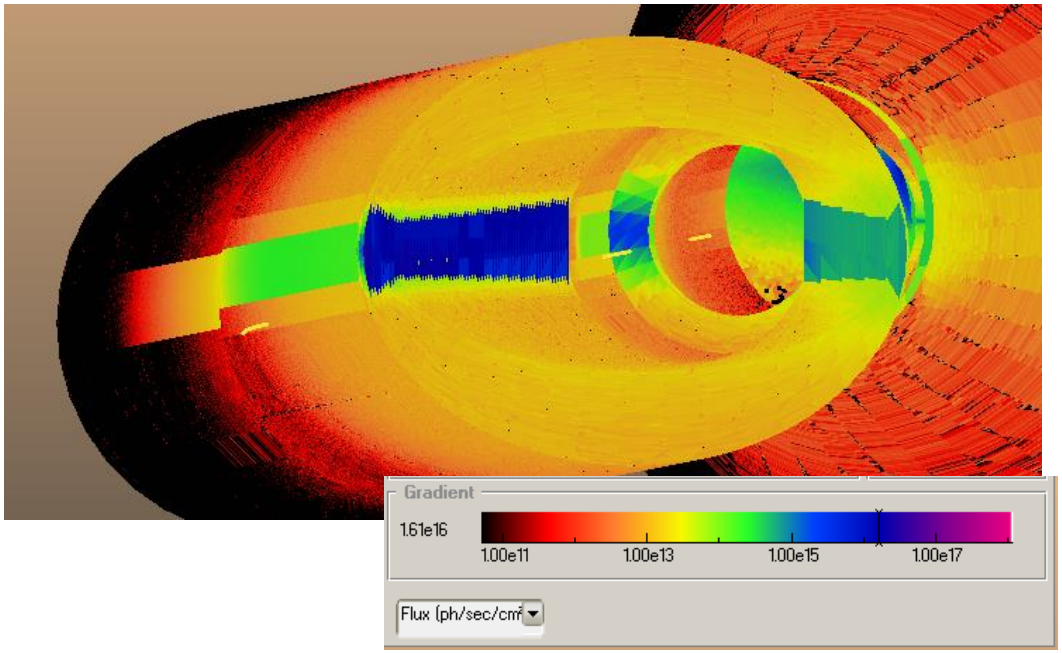
Hydrogen Pressure Distribution

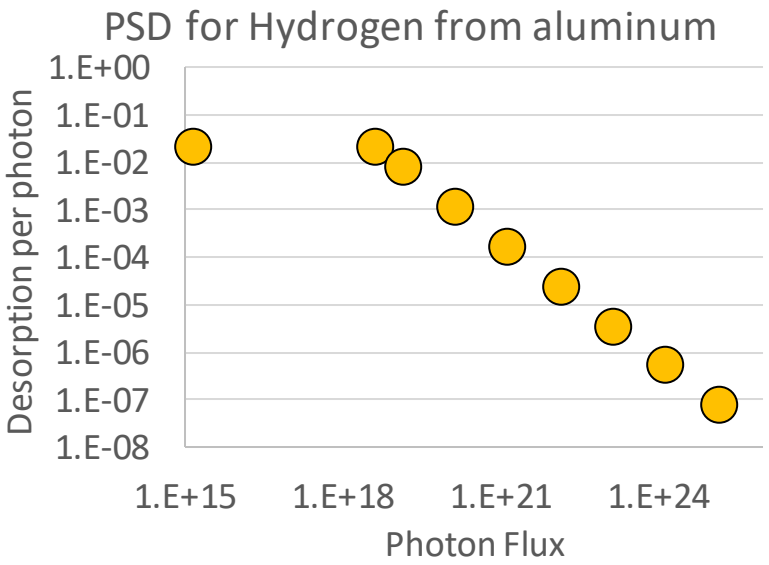


Hydrogen pressure distribution through the IR. The vacuum chamber is shown as displayed in Molflow, with the color scale corresponding to pressure and the arrow indicating electron beam direction. The graph shows a pressure profile along the axis of the electron beamline at base pressure without the electron beam.



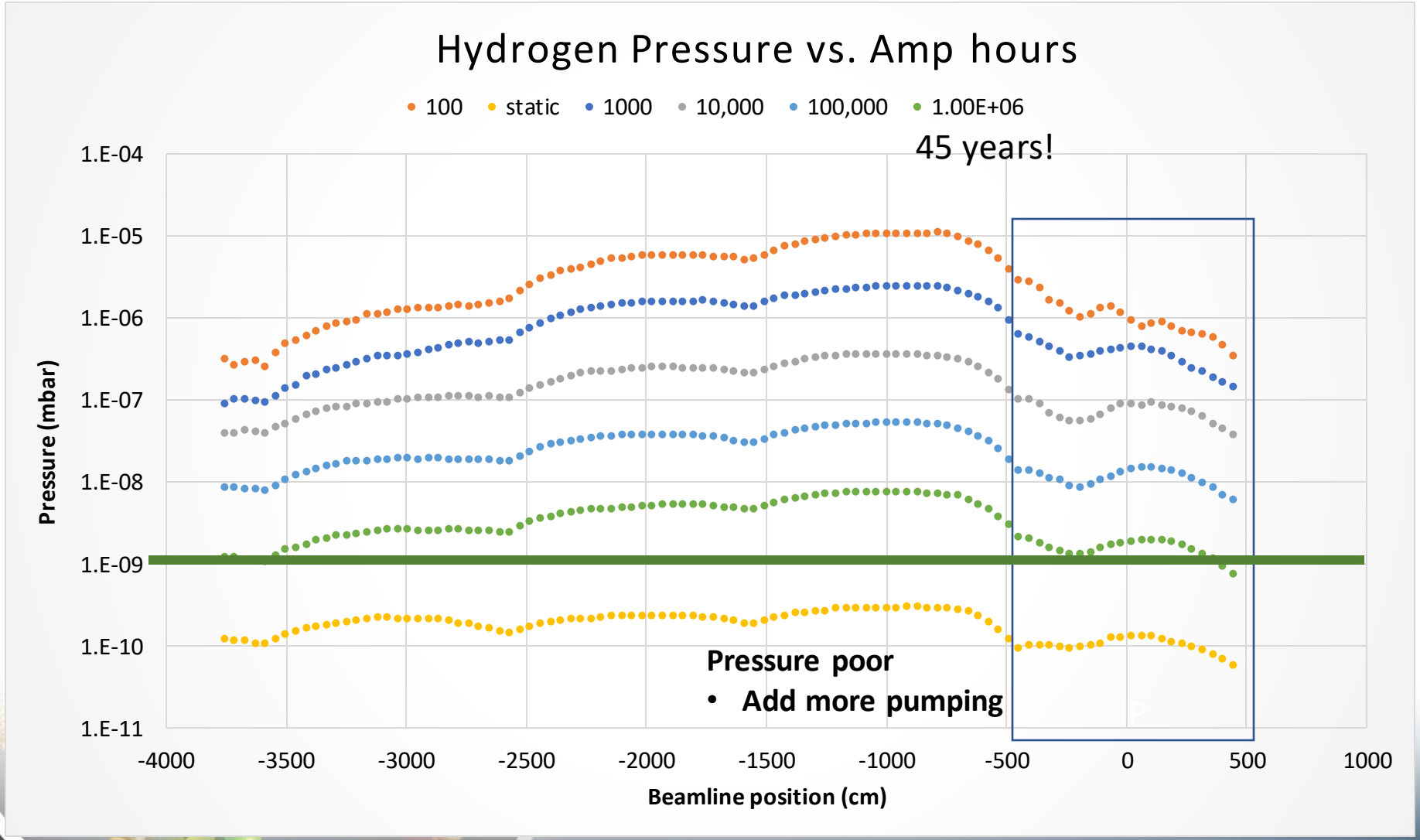
Coupled Synrad & Molflow+ dynamic vacuum



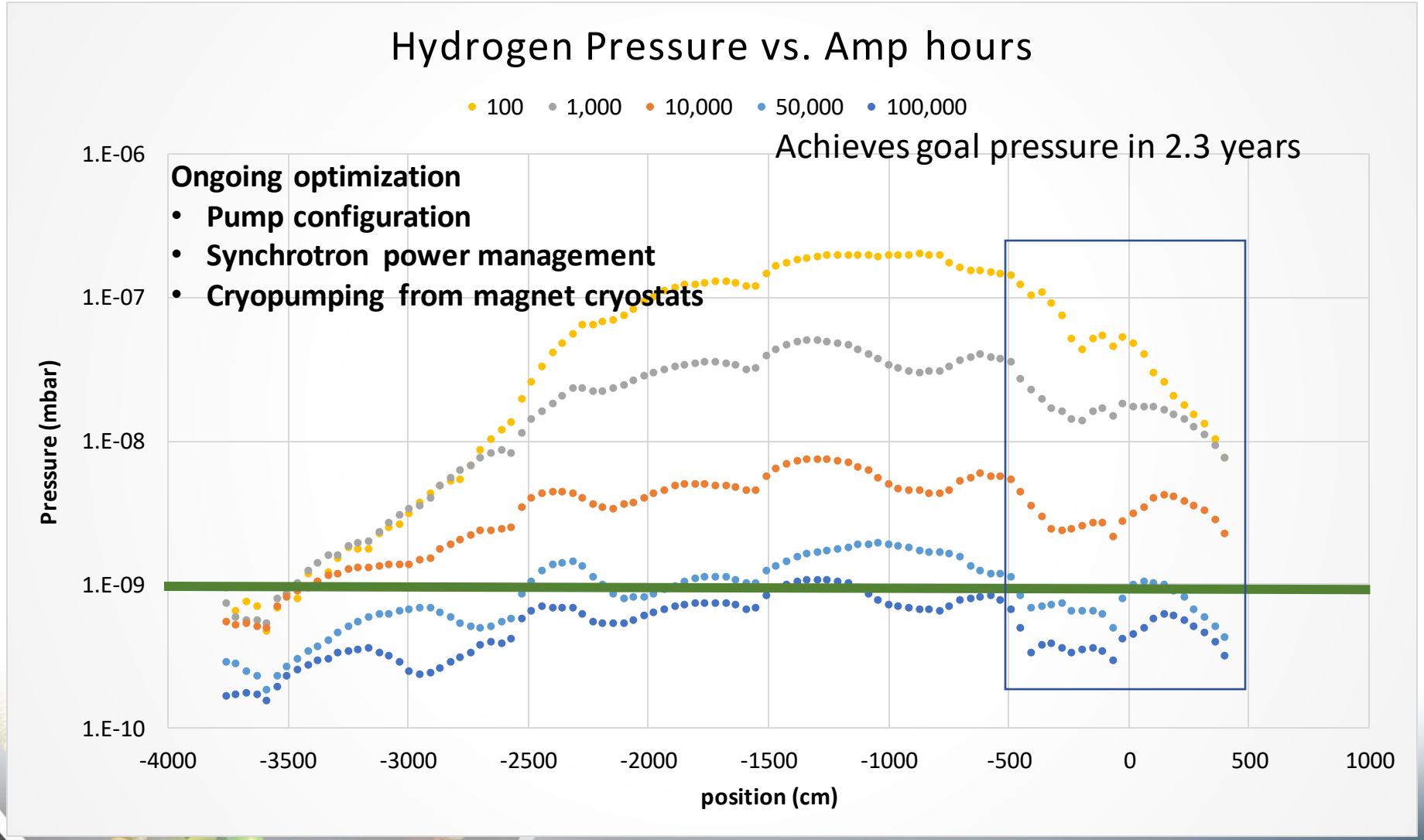


- Outgassing for each facet calculated due to the integrated flux
- Outgassing falls as system conditions
- Low energy photons included for PSD

First results: Original pump configuration



Add distributed NEG pumping



Conclusions

- Synrad+ is being used to model photon flux and aid in geometry optimization
- Molflow+ is being used to calculate pressure distributions
- Coupled Synrad/Molflow simulations can estimate required conditioning time
- Detector backgrounds due to both synchrotron radiation and beam-gas interactions are being simulated to build a low-background interaction region

Many thanks to Charlie Hetzel, Jin Huang, Mike Sullivan and the EIC Interaction Region Background working group