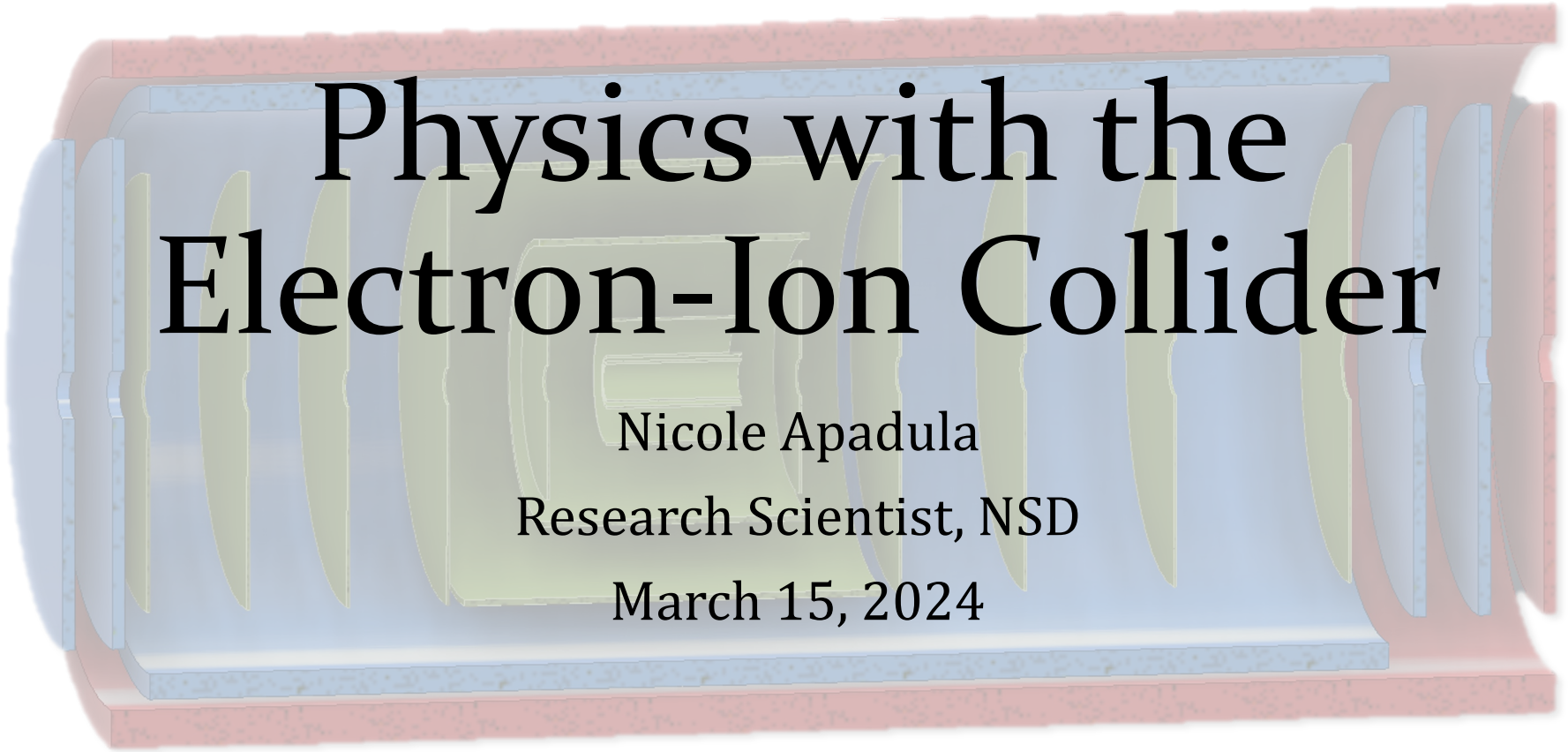


Physics with the Electron-Ion Collider

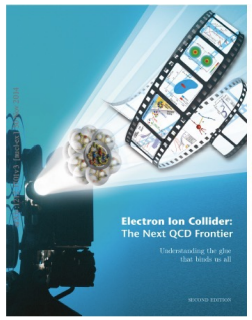
Nicole Apadula

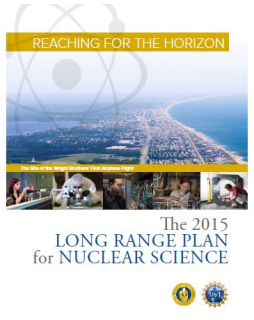
Research Scientist, NSD

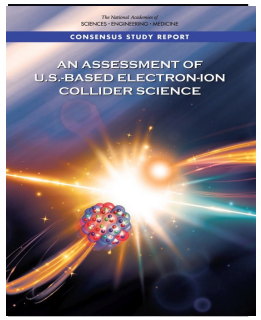
March 15, 2024

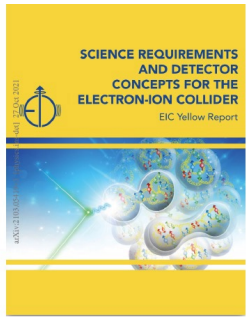
EIC science program

- How does nucleon **mass** & **spin** emerge from partons?
- How are partons inside the nucleon distributed in **momentum** & **position**?
- How do partons **interact** with a **nuclear medium**?
- How are nuclear bindings & hadronic states formed from partons → **hadronization**?
- Gluon density → **saturation**

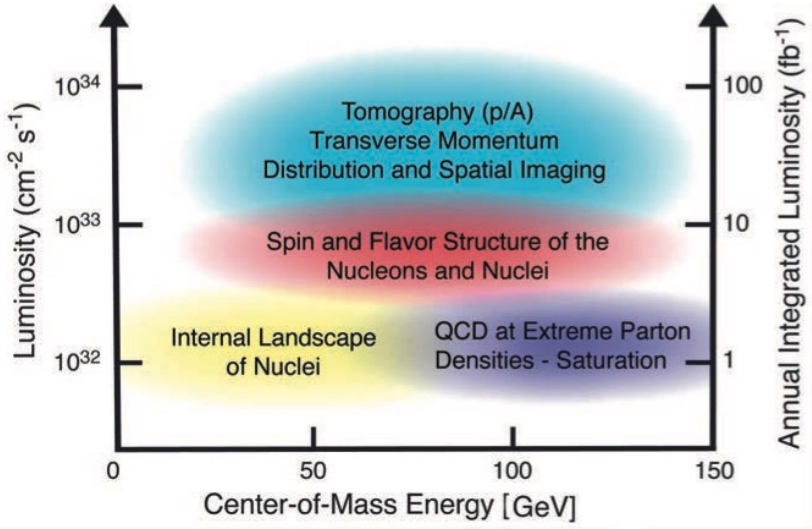


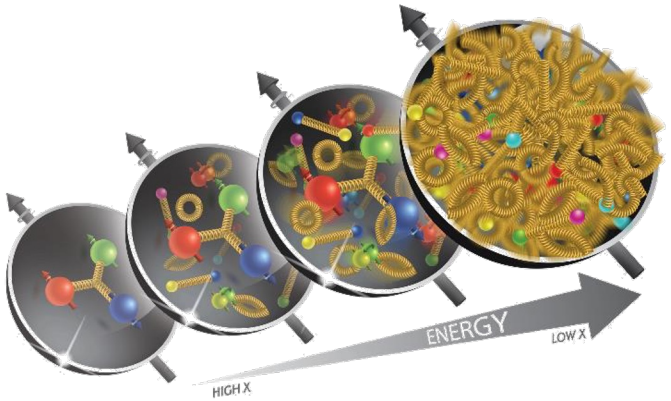


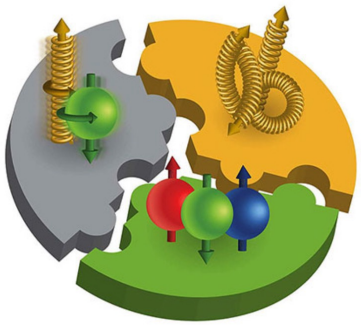




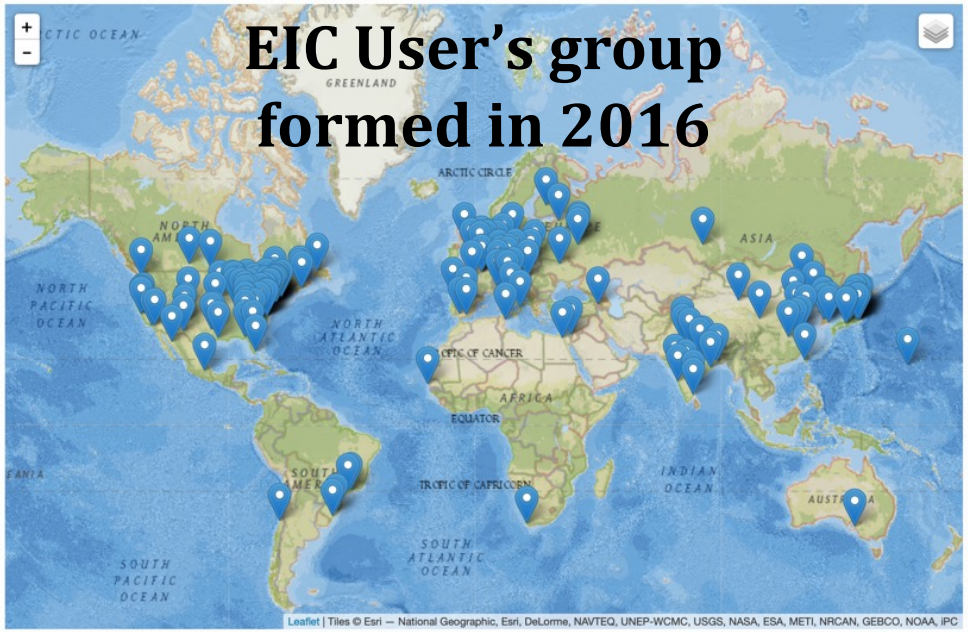
2012 2015 2018 2020



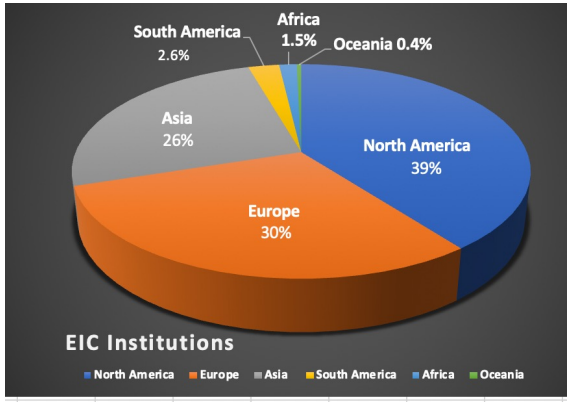




World-wide EIC interest

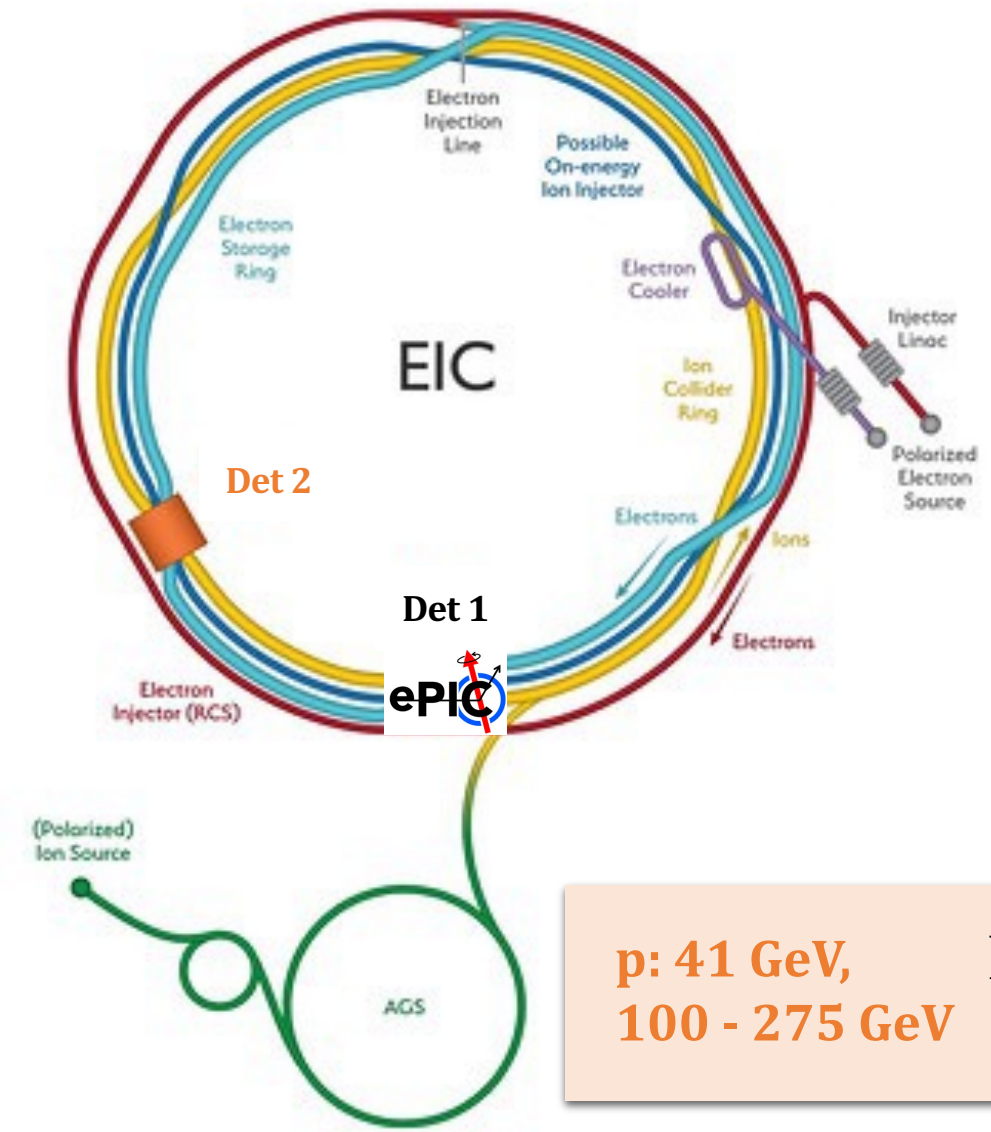


Grown from 400 to ~1400 collaborators



ePIC Collaboration
160+ institutions
24 countries
500+ participants

The Machine

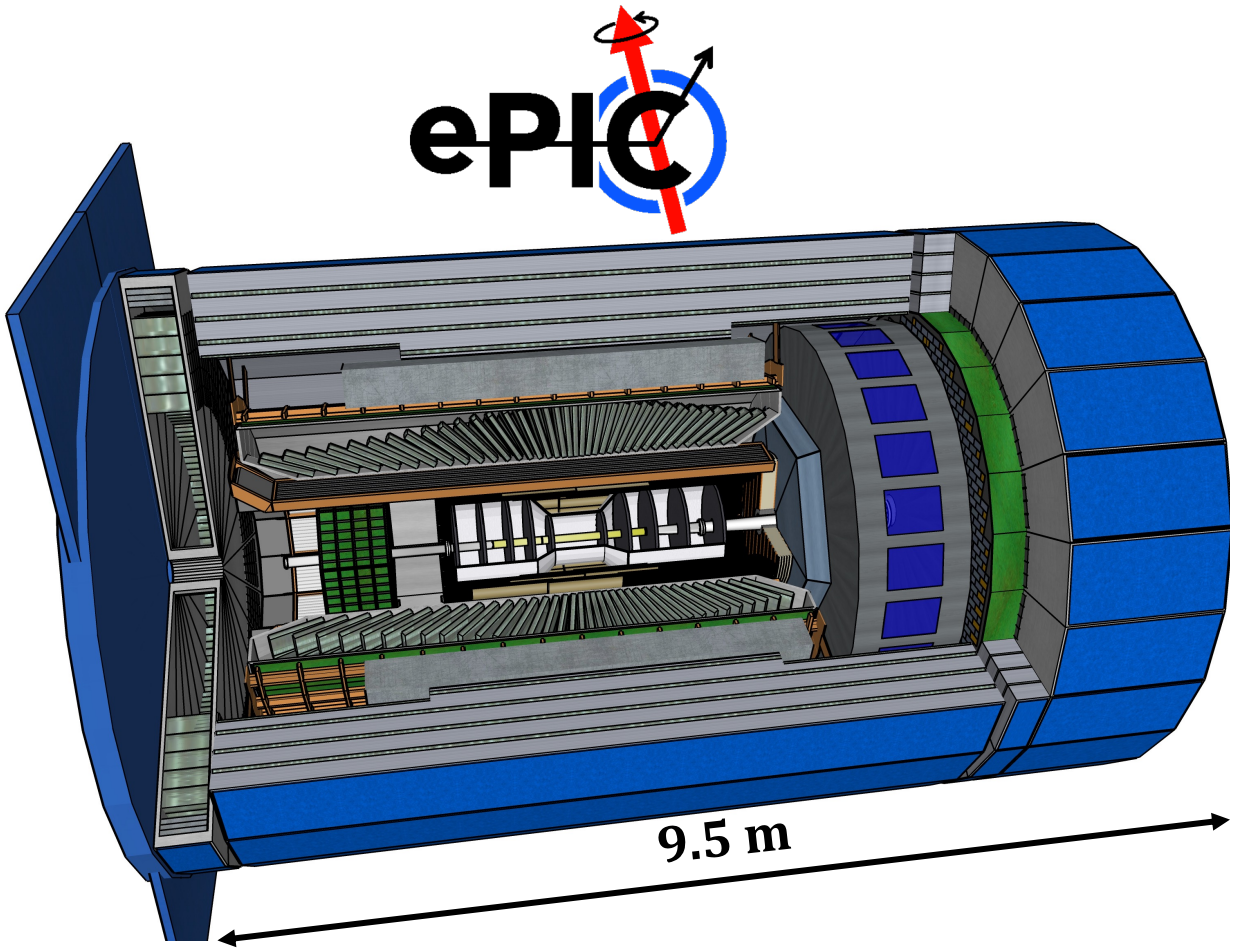


CD-1 granted in June 2021

- High luminosity
  - **$L = 10^{33} – 10^{34} cm^{-2} sec^{-1}$**
- Highly polarized beams
  - **70% for both e^- & ion**
- Center of Mass Energy Range
  - **$E_{cm} = 29 – 140$ GeV**
- Ion species
  - **protons – uranium**

p: 41 GeV, 100 - 275 GeV p/A beam  e^- beam **e^-: 5 - 18 GeV**

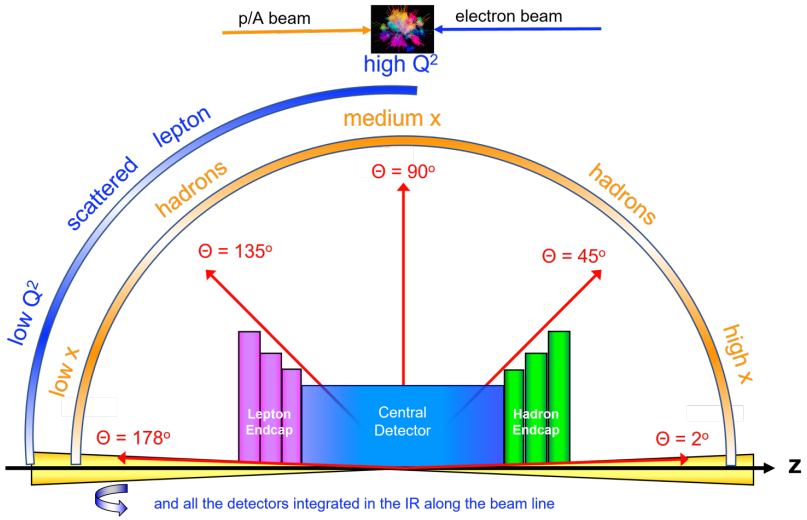
The ePIC Detector



- Asymmetric barrel with electron and hadron endcaps
- **Compact detector**
  - **Tracking, PID, EMCal, HCal**
- Streaming readout electronics model

ePIC Detector: Tracking requirements

- Wide kinematic coverage
- Excellent momentum resolution
- High-precision primary vertex determination
- Secondary vertex separation

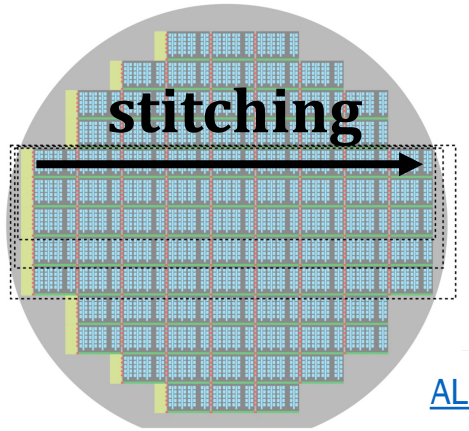


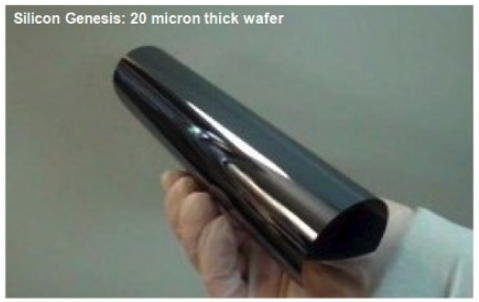
- **Spatial resolution**
  - **≤ 5 μm for tracking layers & discs**
  - **~3 μm for vertex layers**
- **Material budget**
  - **≤ 0.1% X/X_0 for vertex layers**
  - **≤ 0.3% X/X_0 for discs**
- **Power consumption**
  - **< 40 mW/cm^2**

Goal: Minimize material, maximize acceptance → Silicon

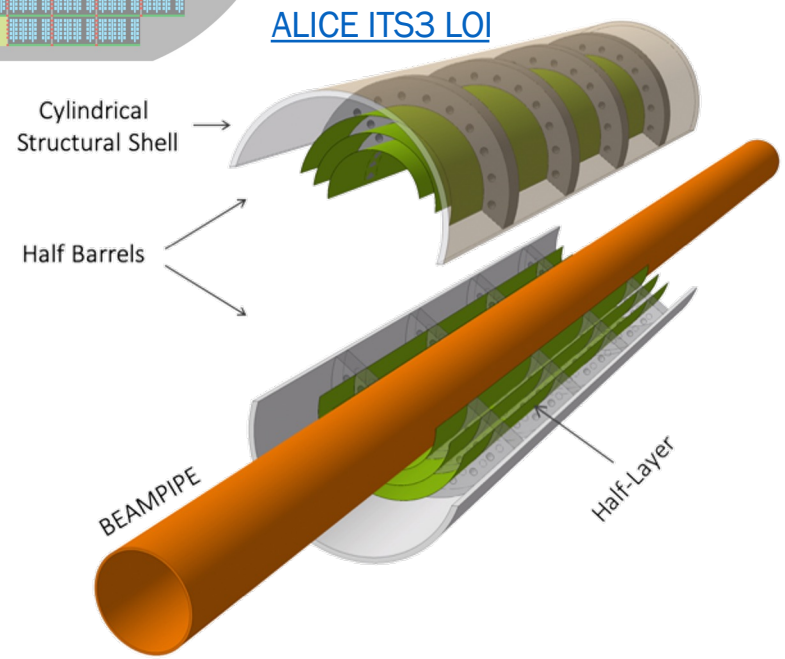
Silicon Sensor Technology: MAPS

- **ALICE ITS3**
  - **Monolithic Active Pixel Sensors (MAPS)**
    - **65 nm technology**
  - **Stitched** wafer-scale (up to **~28 x 10 cm**)
  - **Ultra-thin** (**20 – 40 μm**)
  - **Bent**



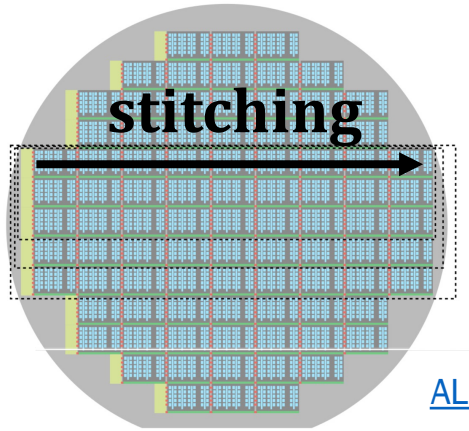


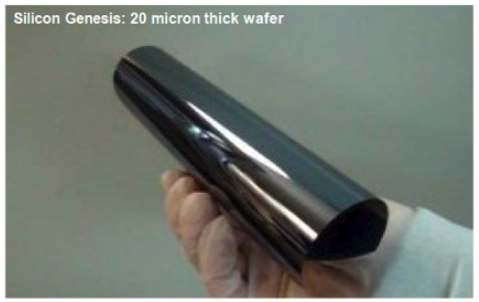
ALICE ITS3 LOI



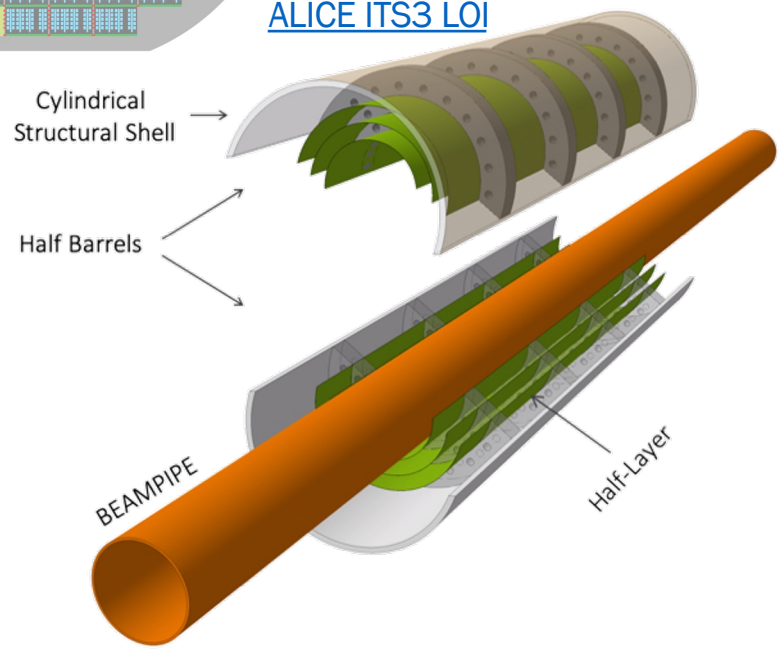
Silicon Sensor Technology: MAPS

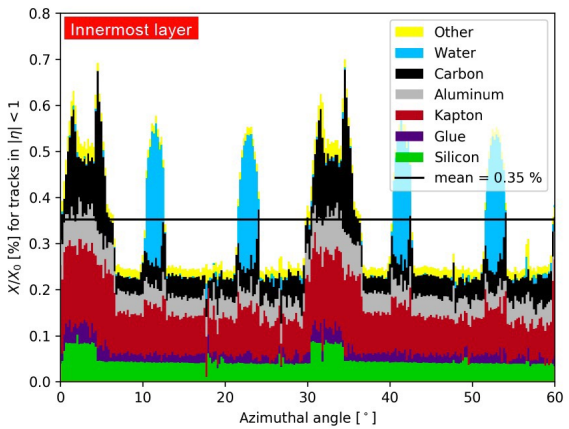
- **ALICE ITS3**
  - **Monolithic Active Pixel Sensors (MAPS)**
    - **65 nm technology**
  - **Stitched** wafer-scale (up to **~28 x 10 cm**)
  - **Ultra-thin** (**20 – 40 μm**)
  - **Bent**
- Low material budget (**~0.05% X_0**)

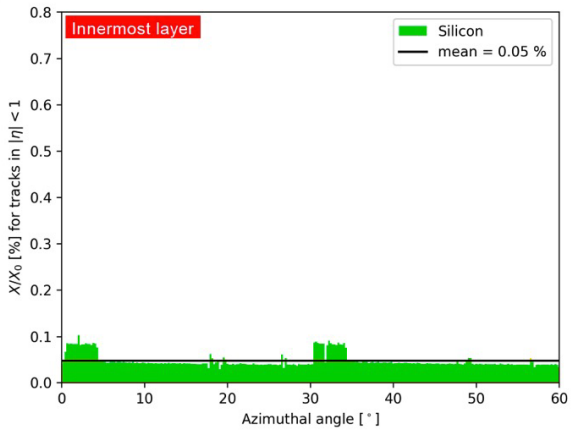




ALICE ITS3 LOI

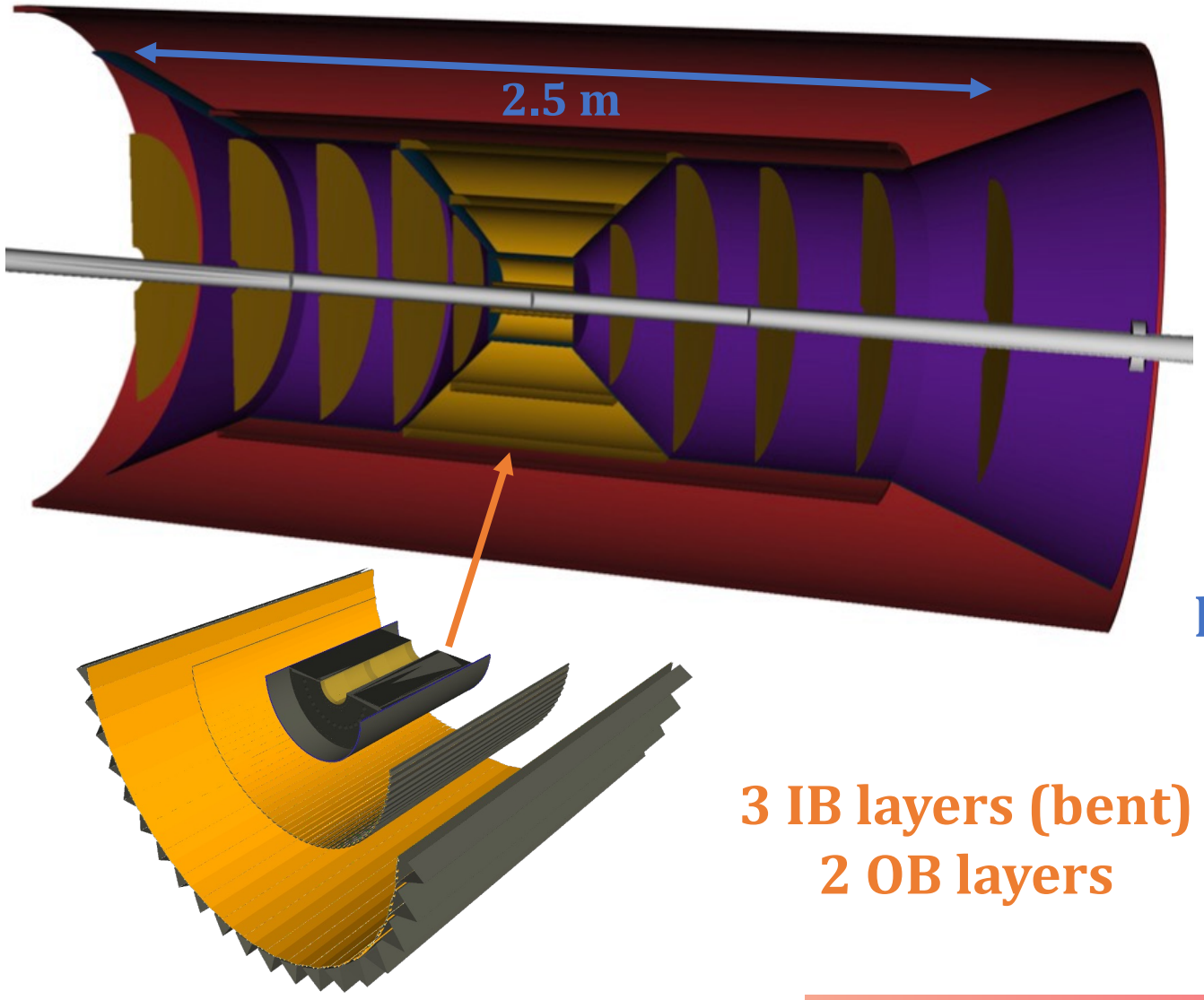






ePIC SVT

LBNL led design/geometry



5 discs per side

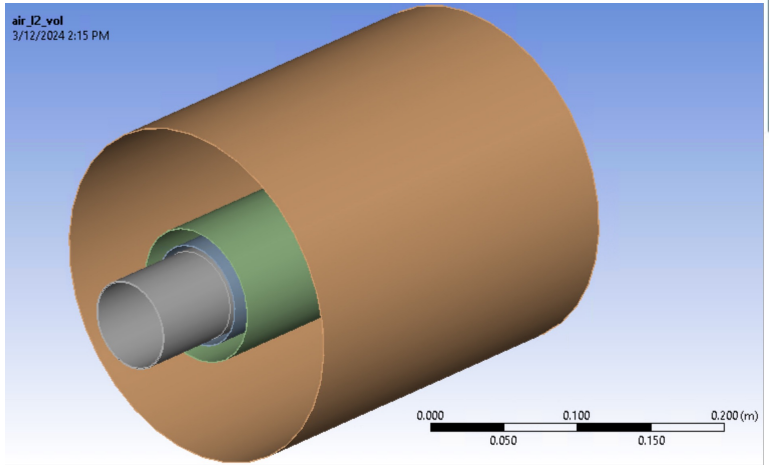
3 IB layers (bent)
2 OB layers

- **Inner Barrel (IB)**
  - Wafer-scale sensors
    - Length: ~26 cm
  - Radii: 36 - 120 mm
- **Outer Barrel (OB)**
  - Outer radius: 42 cm
  - Length: 54 & 84 cm
- **Discs**
  - Radii: ~20 – 40 cm

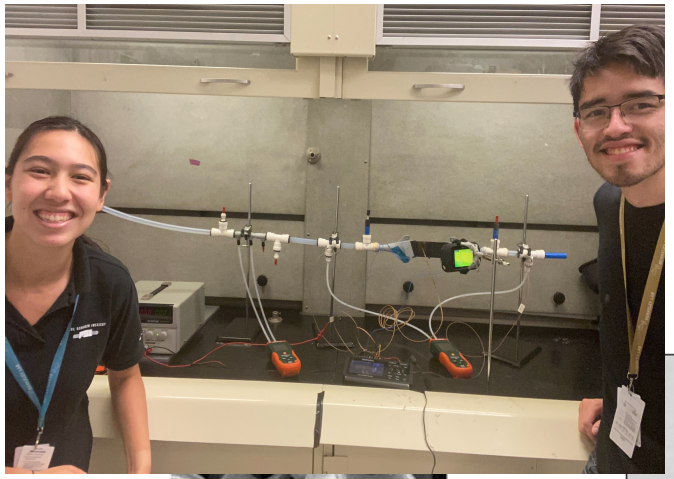
~8.5 m^2 of Silicon

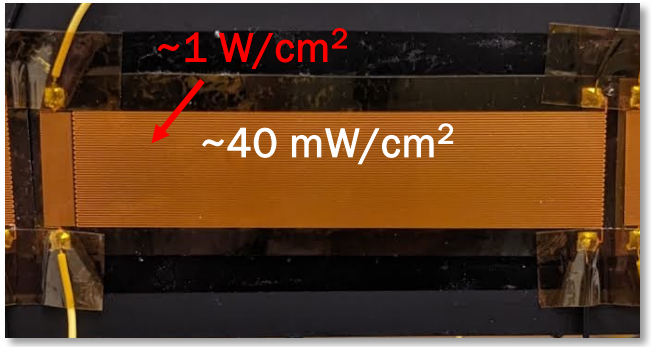
(Small subset of) Work at LBNL

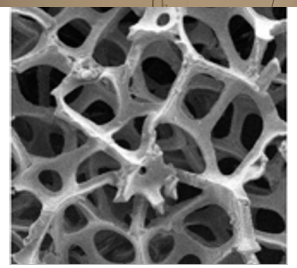
- Disc design
  - Corrugated carbon fiber, sensor layout, air cooling
- Beam-pipe bake-out

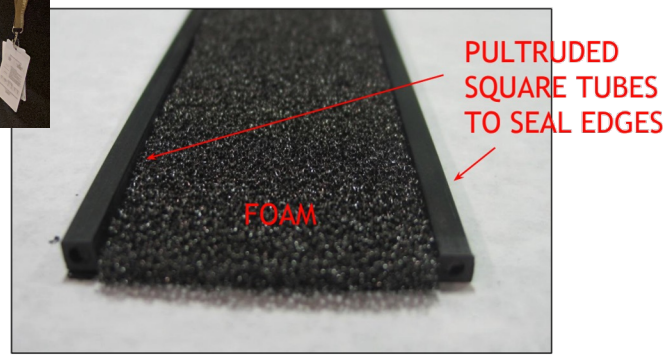


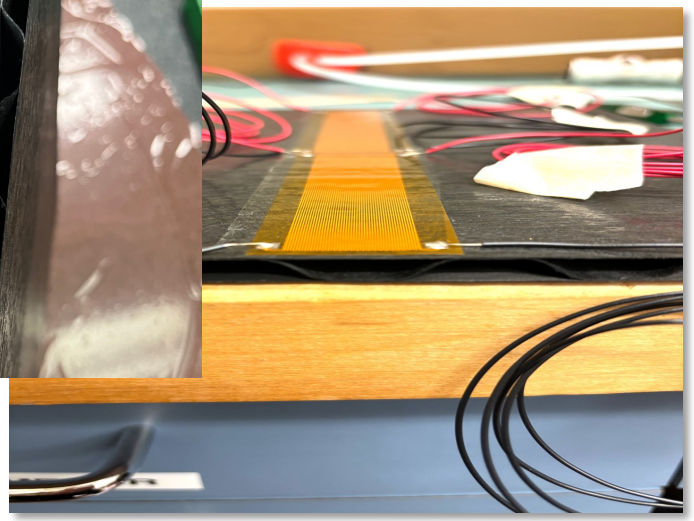
ANSYS simulations











Summary

- The EIC/ePIC will allow us to image nucleon/nuclear 3D structure, search for gluon saturation, explore proton spin structure, & hadronization
- Substantial work has been achieved towards the EIC & ePIC
  - Detector design, simulations, physics studies
- Still a lot of work to be done, but on track for first beams in the 2030s
- LBNL has a lead role in the SVT → exciting time for high-energy nuclear physics!