DESIGN AND COMMISSIONING OF THE sPHENIX TIME PROJECTION CHAMBER

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OUTLINE

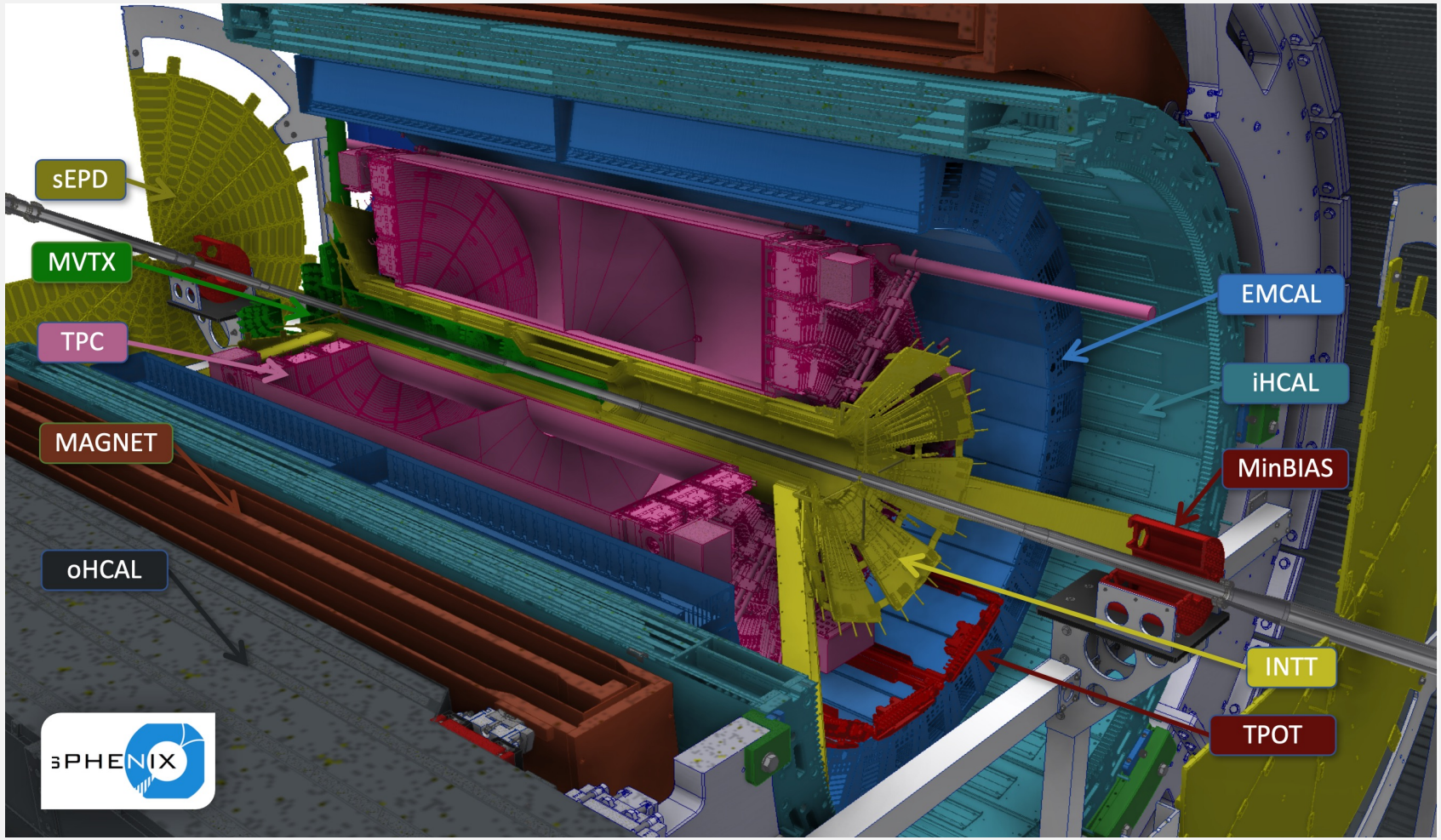
sPHENIX TPC Design

Installation of the TPC

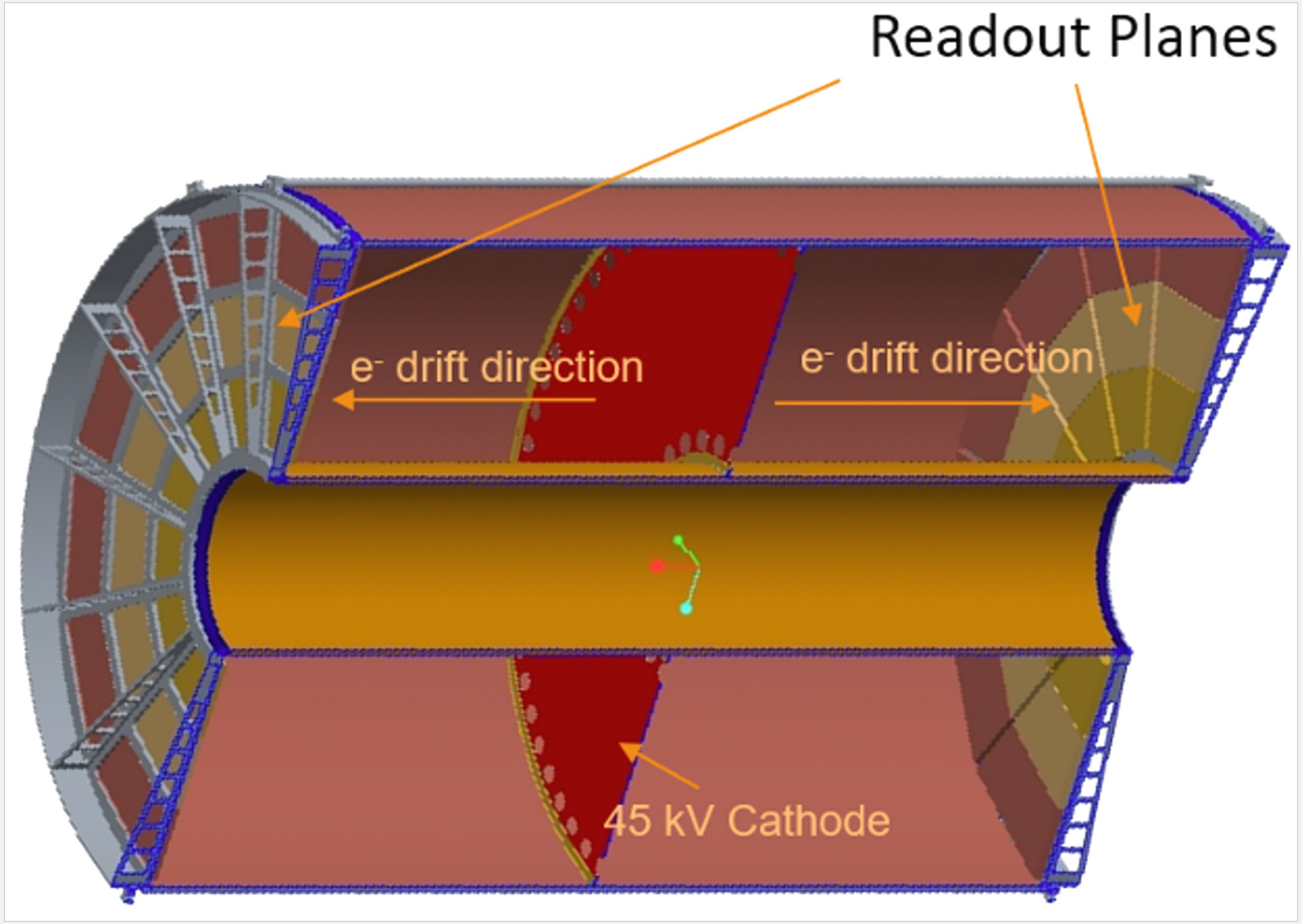
TPC Commissioning

THE sPHENIX DETECTOR

- Large acceptance and varied subsystems designed to precisely measure jets, photons, and quarkonia
- Equipped with large acceptance electromagnetic and hadronic calorimetry (including the first HCal with full azimuthal coverage at RHIC)
- State-of-the-art tracking detectors, including the TPC, INTT, and MVTX, provide precise vertex and momentum determination



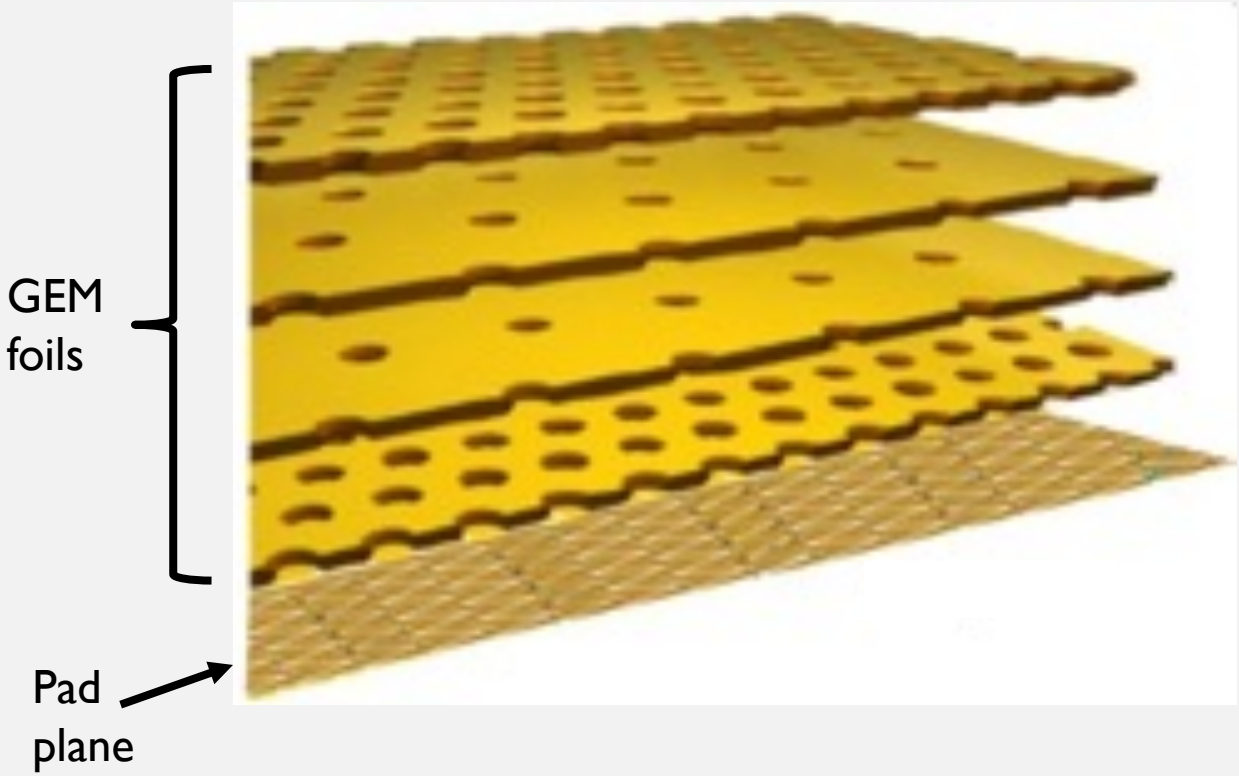
THE sPHENIX TIME PROJECTION CHAMBER



- The Time Projection Chamber (TPC) is the core tracking subsystem of sPHENIX
- Length in z-direction of 211 cm
- Radial extent 20-78 cm
- Charged particles ionize Ar-CF_4 in volume, freeing electrons which drift in electric field from central membrane (CM) to endcaps
  - Time of arrival gives z-coordinate due to constant drift velocity
  - R and ϕ coordinates given by which pad on endcap measured electron cloud

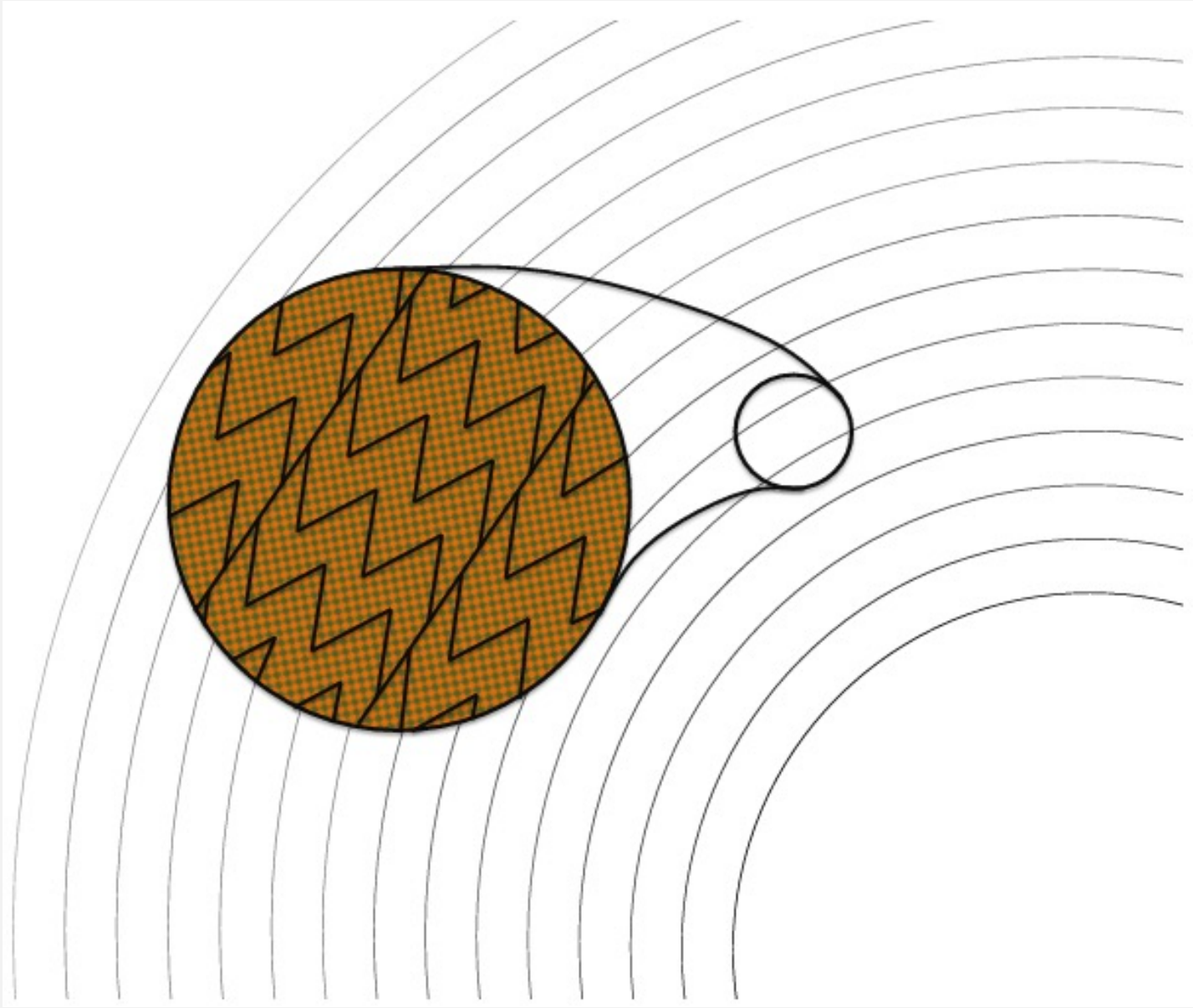
AMPLIFICATION OF ELECTRON SIGNAL

- Avalanche generated by a stack of four Gas-Electron Multiplier (GEM) foils
- Large difference in potential across sides of foil creates large field in holes that amplifies electron signal and guides them toward pad plane
- Careful design of GEM stack limits number of ions that return to gas volume, which minimizes space charge from ion back flow

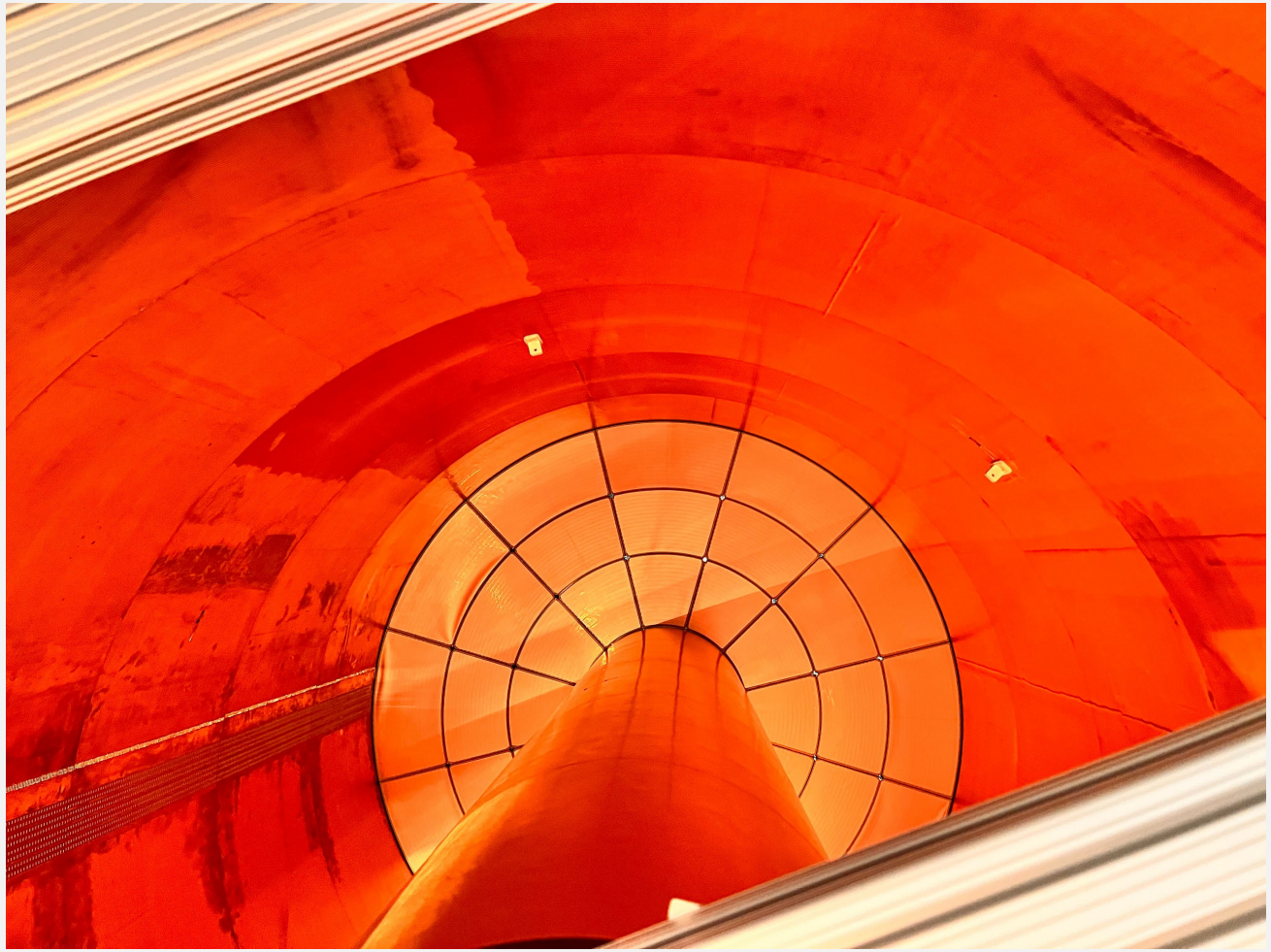


SIGNAL DETECTION

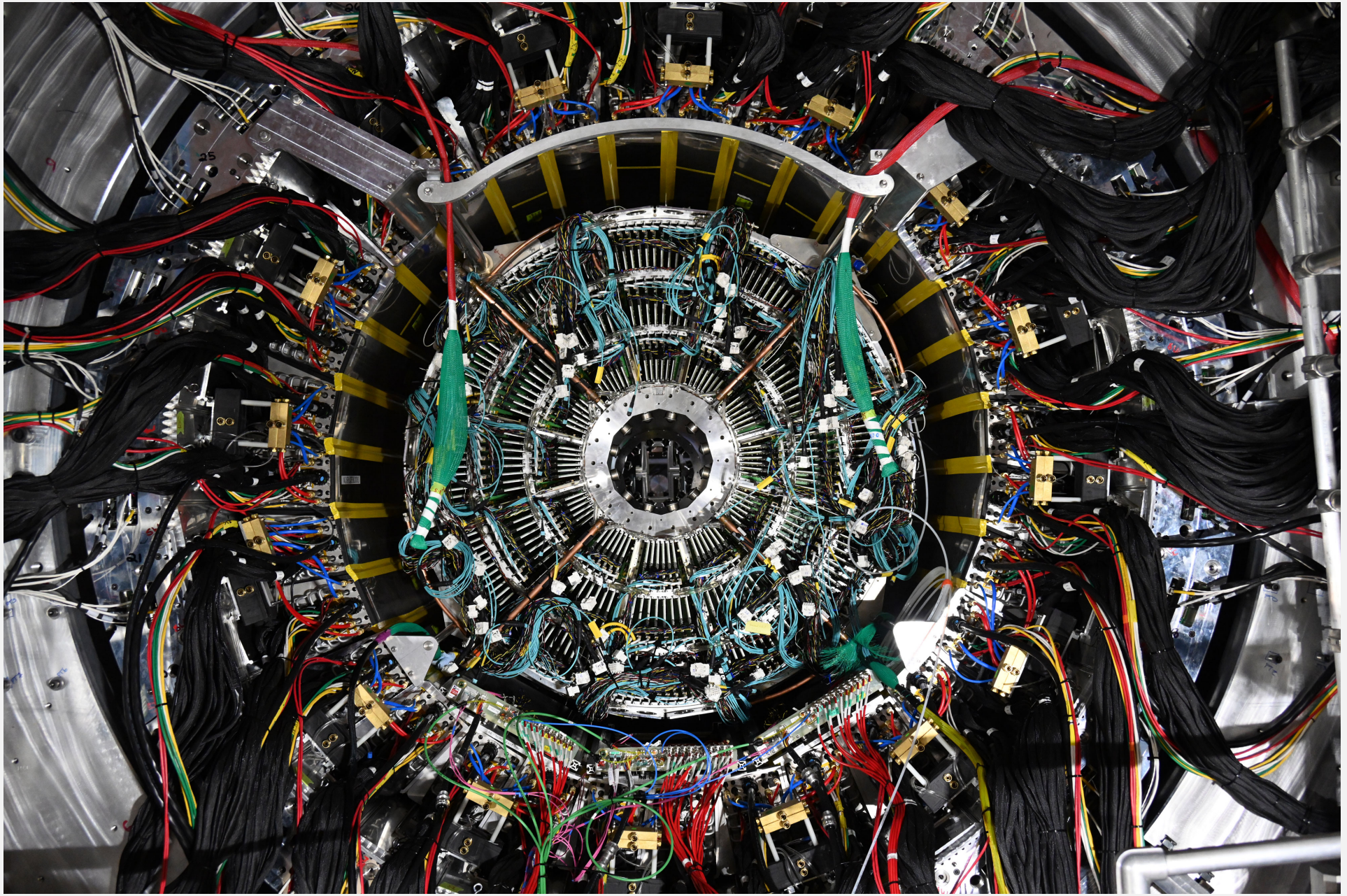
- Pad plane consists of zig-zag shaped pads
- Unique design allows for charge sharing of electron cloud across pads, even in cases of small signal
- This charge sharing allows for more precise position determination



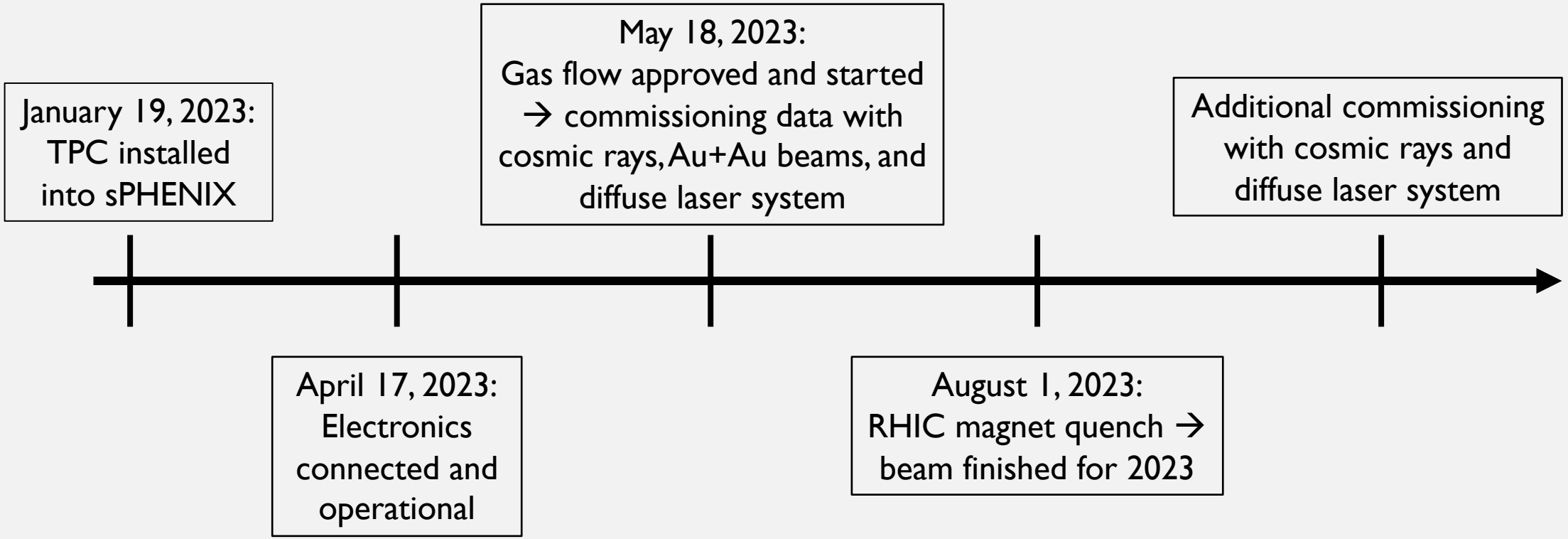
TPC INSTALLATION



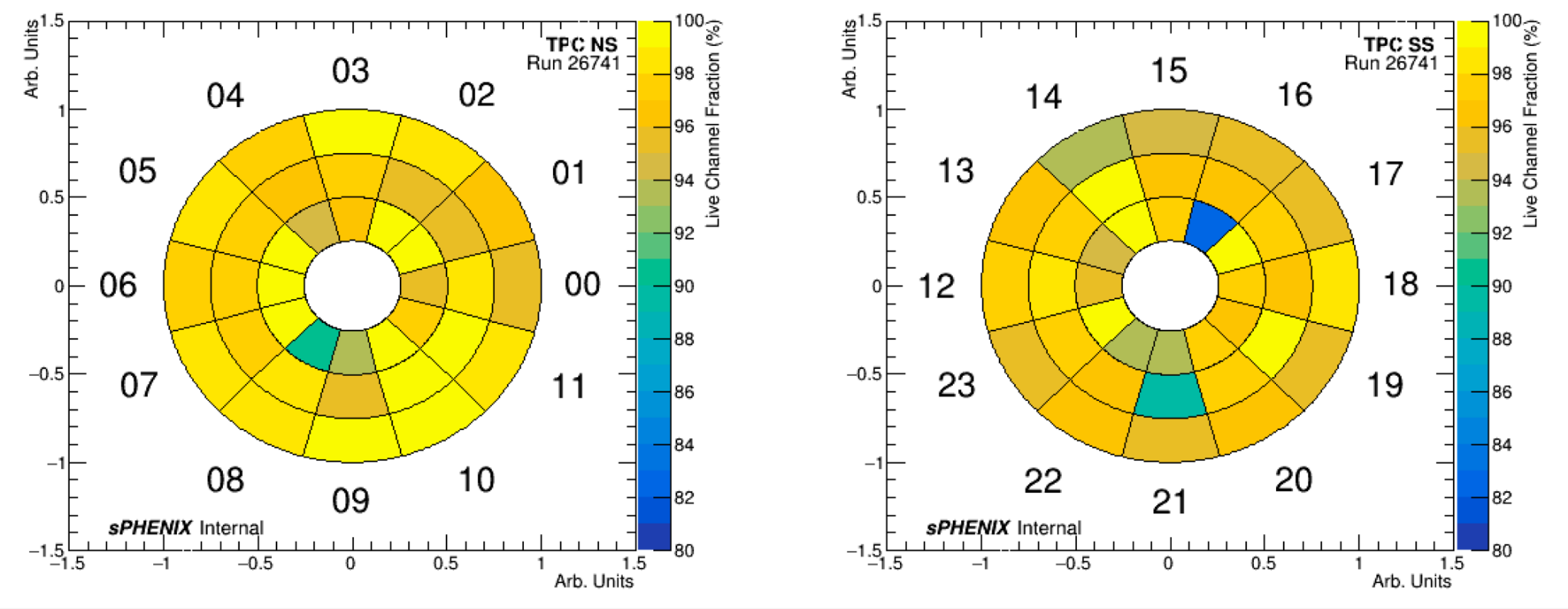
INSTALLED TPC



TPC COMMISSIONING TIMELINE



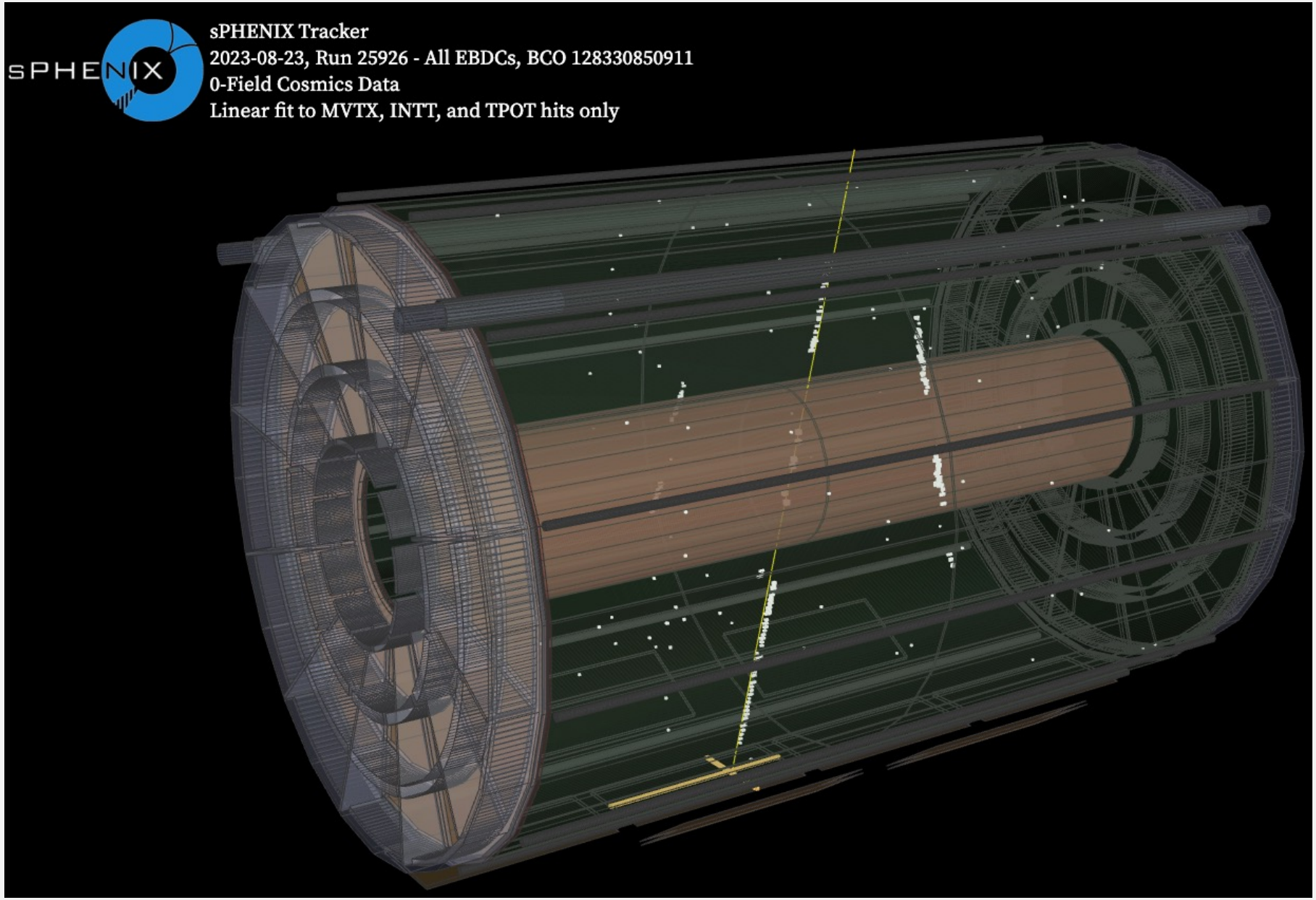
ELECTRONICS PERFORMANCE



High live channel fraction in all 72 TPC modules – see Jennifer James' talk for more details

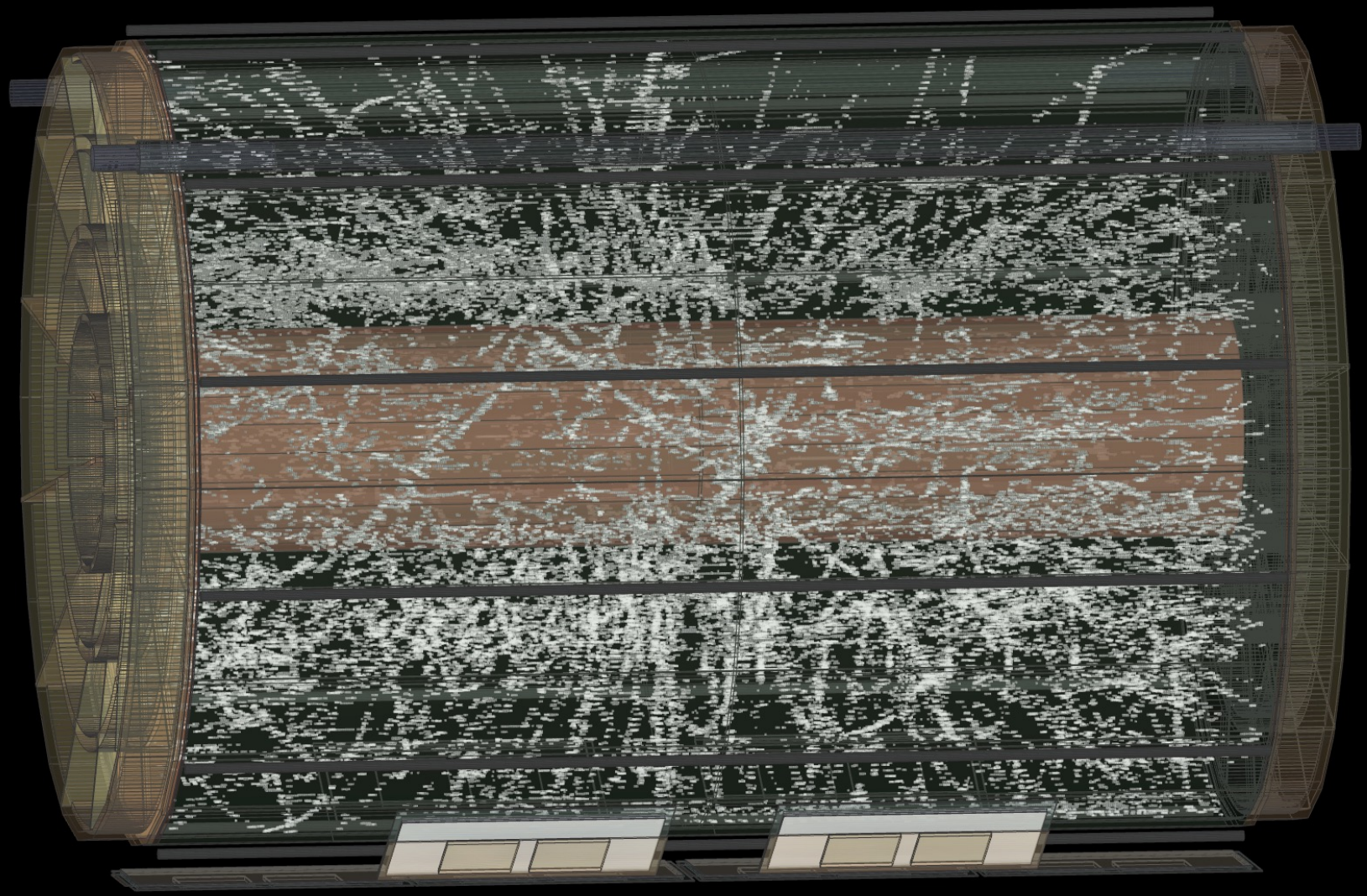
COSMIC RAY DATA

- No magnetic field
- Linear fit with hits only from MVTX, INTT, and TPOT

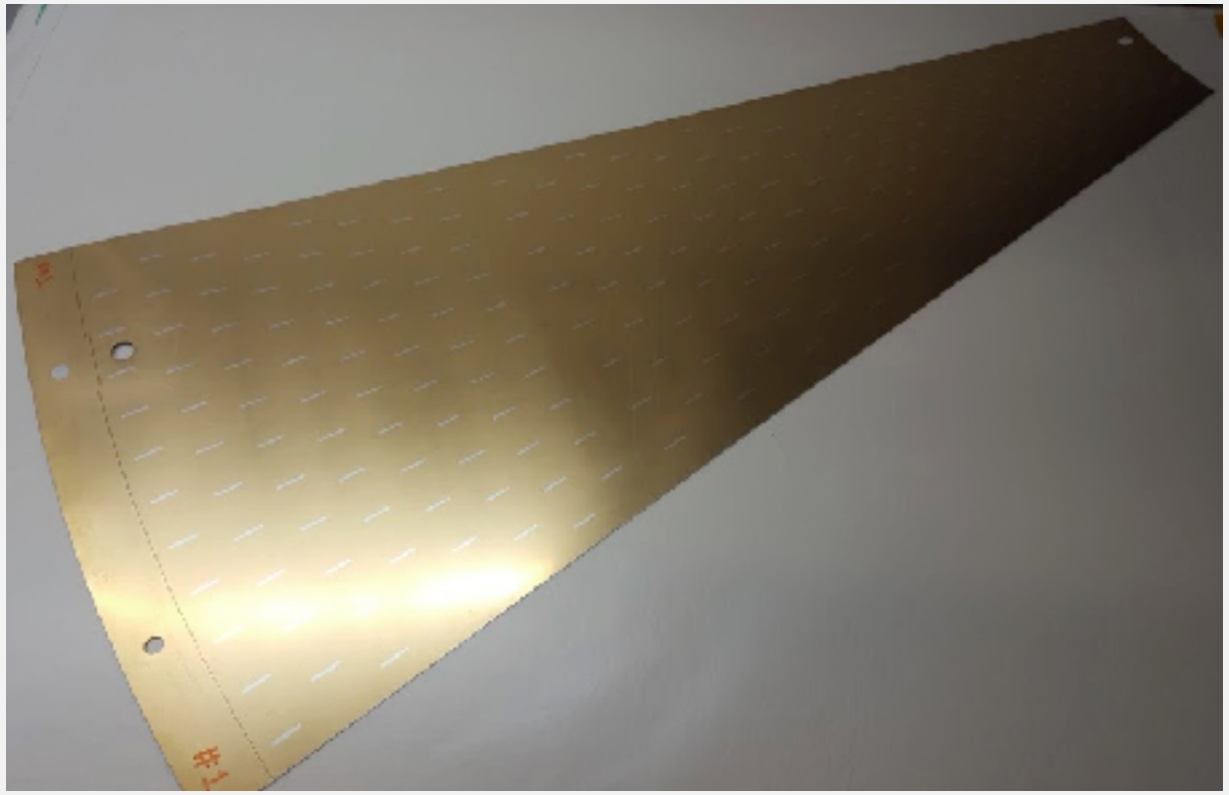


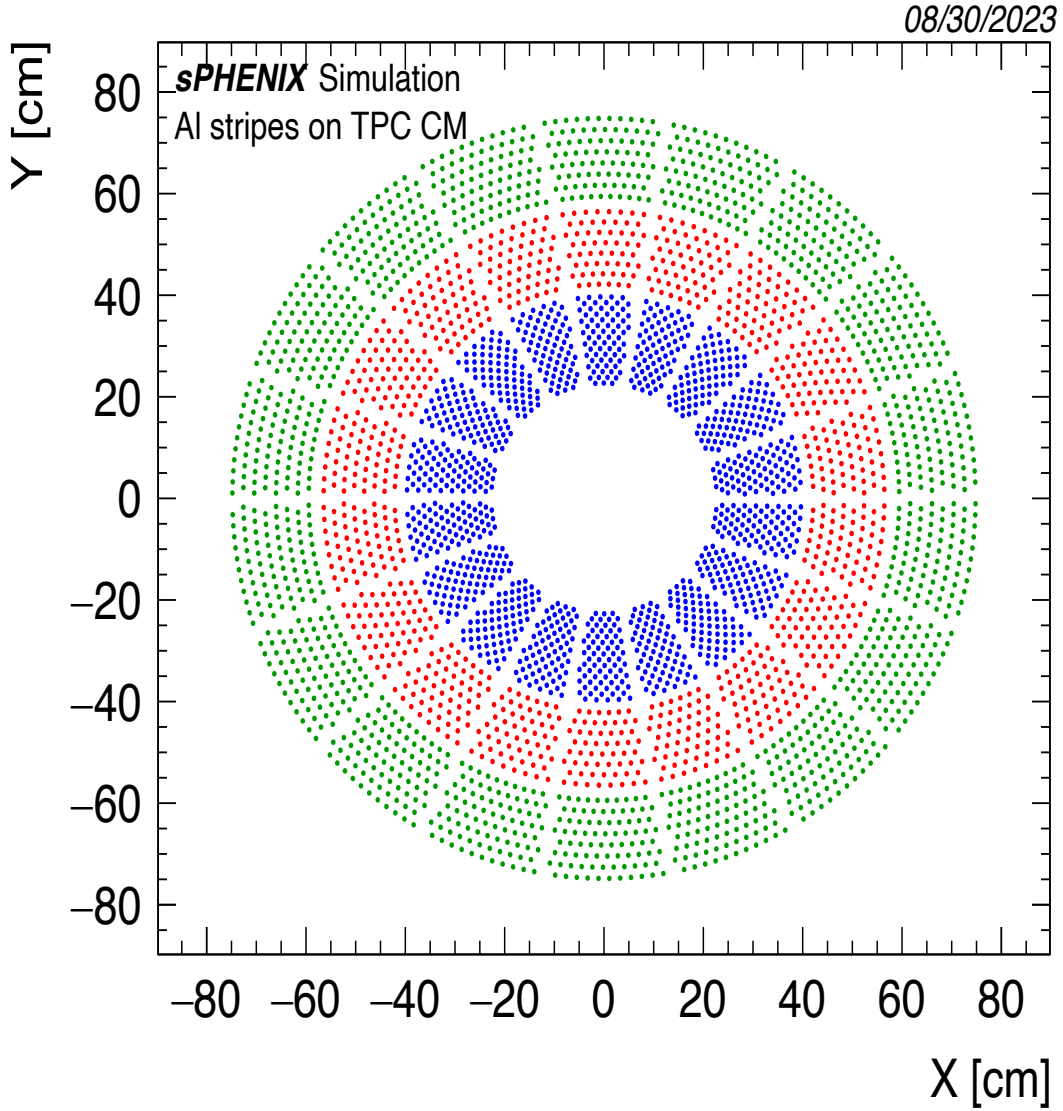
sPHENIX Time Projection Chamber
100 Hz ZDC, MBD Prescale: 2, HV: 4.45 kV GEM, 45 kV CM, X-ing Angle: 2 mrad
2023-06-23, Run 10931 - EBDC03 reference frame 89
Au+Au sqrt(s_{NN})=200 GeV

Au+Au COLLISION DATA



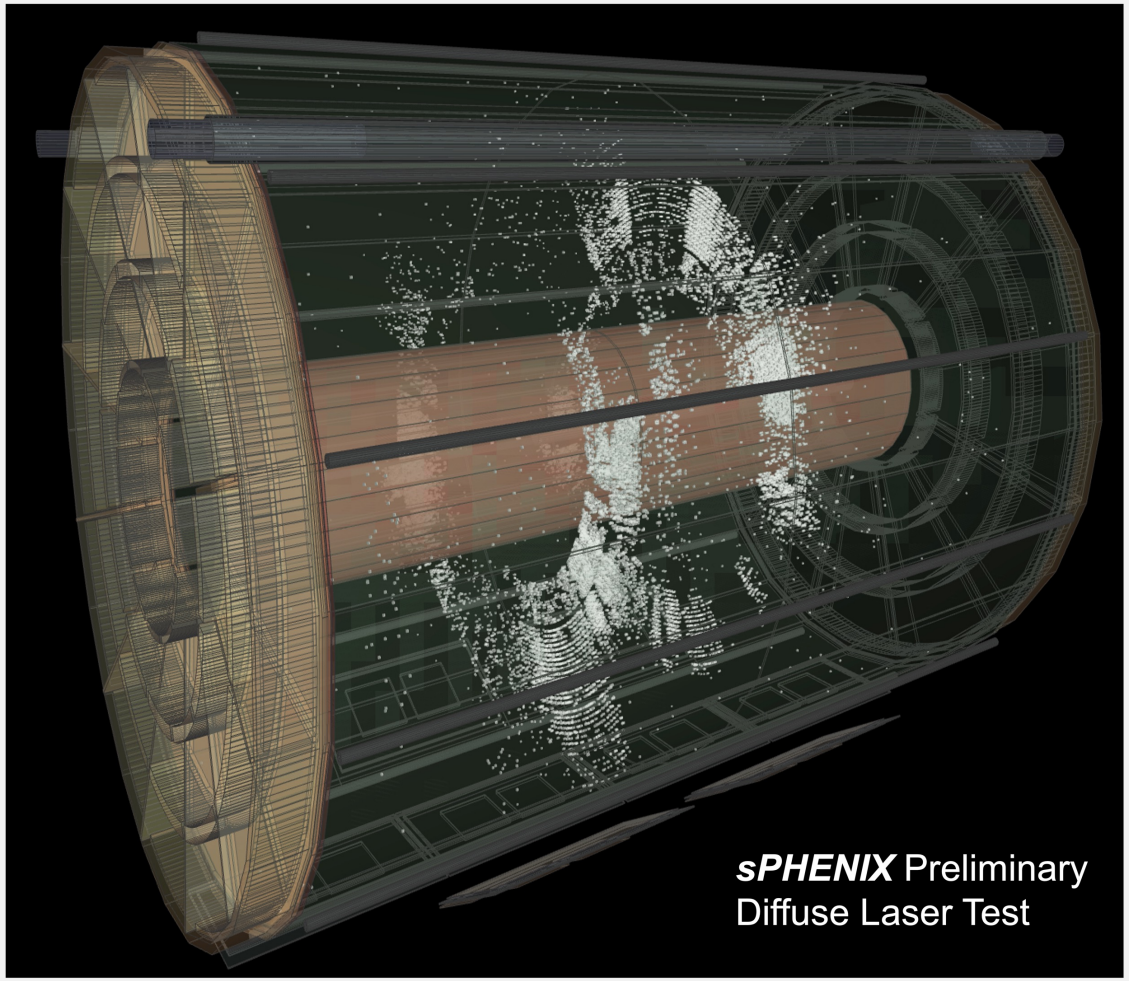
DIFFUSE LASER SYSTEM

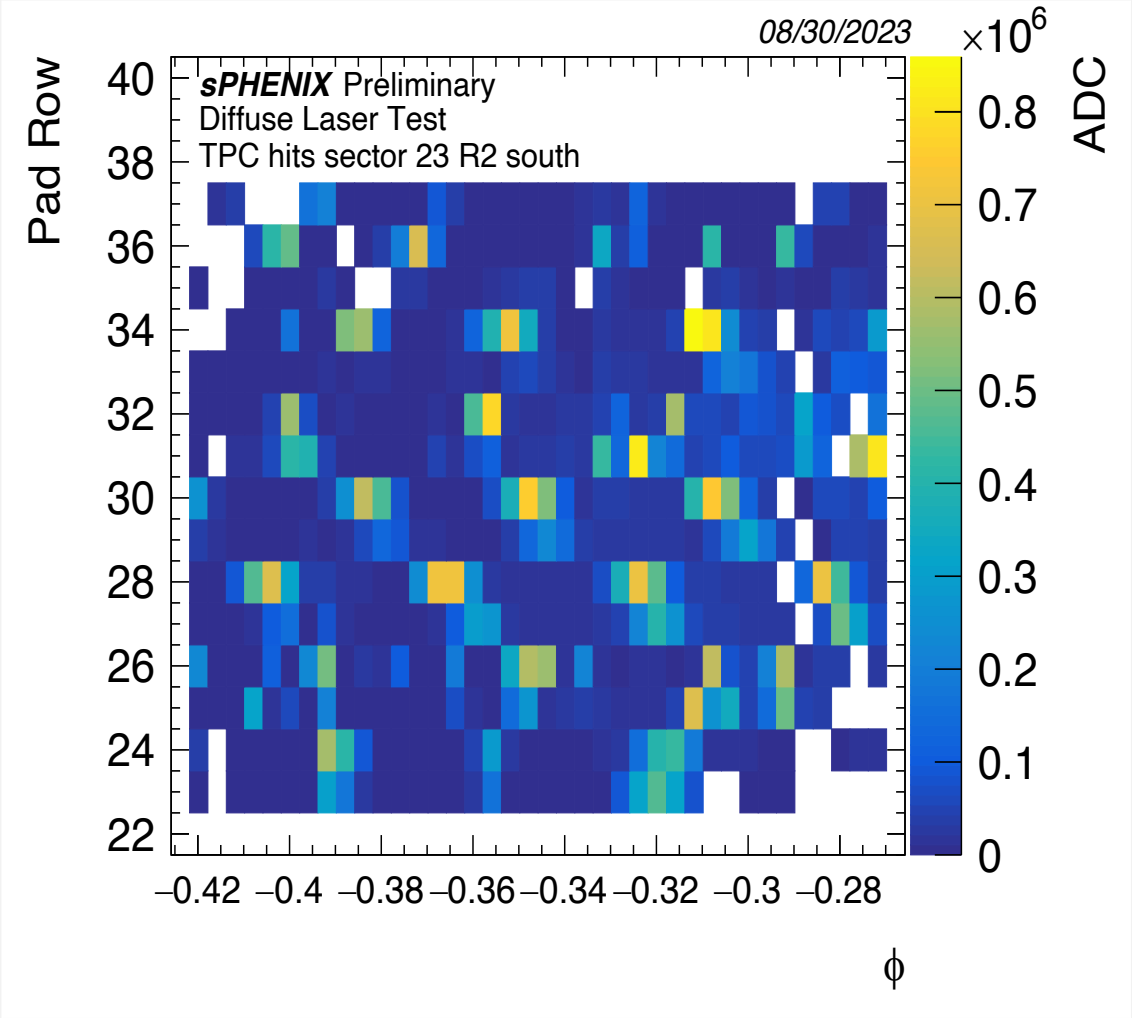




- Al stripes in well-defined pattern on Central Membrane (CM)
- Set of lasers incident on CM release photoelectrons

DIFFUSE LASER DATA





- Hits in TPC from test laser flash shows clear indication of CM stripe pattern and sheets of electrons

CONCLUSIONS

- The sPHENIX TPC is designed to provide precise tracking and momentum determination for various essential analyses within sPHENIX
- Installation was successfully completed, and operation began in May 2023
- Commissioning using cosmic rays, Au+Au beams, and the diffuse laser system has begun and allowed us to start understanding the performance of the TPC
- Commissioning continues as we prepare for p+p beams in early 2024