Abstract

The proposed sPHENIX detector design is focused mainly on a physics program of precise inclusive spectroscopy and jet measurements, which require a high tracking efficiency and excellent momentum resolution. A time projection chamber (TPC) is proposed as the outer tracking detector for sPHENIX, which has a rapidity coverage of |y| < 1.1 and full azimuthal coverage. The sPHENIX TPC design has to be optimized for operation in the high rate, high charged particle multiplicity environment that is anticipated at RHIC in 2022. In this poster, we show the results of R&D, its related simulations and describe the ongoing efforts to optimize the design of the sPHENIX TPC.

sPHENIX Time Projection Chamber

- **Coverage**
  - 25 cm < r < 75 cm
  - |y| < 1.1 (2.11 meter of full length)
  - Full azimuthal coverage

- **Ne based Gas mixture**
  - Ne × CF₂× IC₄H₁₀ [95:5:2] & Ne × CF₂× [90:10] are explored
  - Dominantly Neon: Low Space Charge
  - Low diffusion: Better Resolution
  - Plateau in v, Stability @ 400 V/cm

- **Quad GEM Based Readout for Low Ion-back-flow**
  - Energy Resolution observed is ~10% (Sigma)
  - Ion back-flow measurements reproduced ALICE results
  - Energy resolution gets worse at lower IBF << will need to be optimized

- **Gas Properties Measurements**
  - Flow ~ 1.4 lpm at 140°C/1 atm (high purity)
  - 4 GEM stack of CERN Cx 4-way segmented foils (pitch/inner/outer hole : 140-50/70 µm)
  - Used for fast source, no recalibration
  - Wire mesh to block most of the positive ions with good ion blocking

- **Optimize resolution**: More sharing – More accuracy
  - Less sharing – Less occupancy
  - 100 µm intrinsic resolution with 2mm pad structure & Linearity across the structure
  - Chevron patterns guided by simulation
  - Manufactured for testing in the lab condition
  - X-ray scan facility with collimated X ray source
  - Module anodes segmented into 16×16 pad "wedges" in terms of FEI cards.
  - Each FEI card supports a single wedge
  - High intrinsic resolution (σE < 100 µm) with relatively large pads (2mm×10mm)
  - Minimum differential non-linearity
  - Maximize overlap of adjacent pads
  - Minimize gap between adjacent pads

- **Mechanical Tolerance and Electric Field Distortions**
  - Unique feature of the field cage is its internal potential defining system designed to provide a highly uniform electric field with small radial distortions.

- **Passive Gating Option for TPC**
  - The feedback of positive ions in drift volume of a time projection chamber (TPC) causes adverse effects on the electric field in the drift region, thereby degrading the spatial resolution of the TPC.
  - A gating device located between the drift volume and the gas amplification is used to prevent positive ions from entering the drift region.
  - Multiple ANSYS and Garfield++ simulations are performed for square/circular hole grid, wire mesh and Photo-etched mesh to study the electron transparency and ion blocking.

- **Ion blocking**
  - More sharing – Less occupancy
  - Less sharing – More accuracy

- **Zero Crossing for sPHENIX TPC**
  - B × cosθ = Etest

- **Distorted Field Maps are imported to Garfield++ with the Magnetic Field (1.5 T)**
  - after tilting the Central Membrane to study the Errors in Electron’s Position in Ne2K gas near the Outer Field Cage

- **Stray Magnetic fields guide the electrons and hole electric field imperfections**

- **More on Mechanical Design updates**
  - by Niveditha Ramasubramanian

- **Optimize resolution**: More sharing – More accuracy
  - Less sharing – Less occupancy
  - 100 µm intrinsic resolution with 2mm pad structure & Linearity across the structure
  - Chevron patterns guided by simulation
  - Manufactured for testing in the lab condition
  - X-ray scan facility with collimated X ray source
  - Module anodes segmented into 16×16 pad "wedges" in terms of FEI cards.
  - Each FEI card supports a single wedge
  - High intrinsic resolution (σE < 100 µm) with relatively large pads (2mm×10mm)
  - Minimum differential non-linearity
  - Maximize overlap of adjacent pads
  - Minimize gap between adjacent pads

- **Passive Gating Option for TPC**
  - The feedback of positive ions in drift volume of a time projection chamber (TPC) causes adverse effects on the electric field in the drift region, thereby degrading the spatial resolution of the TPC.
  - A gating device located between the drift volume and the gas amplification is used to prevent positive ions from entering the drift region.
  - Multiple ANSYS and Garfield++ simulations are performed for square/circular hole grid, wire mesh and Photo-etched mesh to study the electron transparency and ion blocking.

- **Ion blocking**
  - More sharing – Less occupancy
  - Less sharing – More accuracy

- **Zero Crossing for sPHENIX TPC**
  - B × cosθ = Etest

- **Distorted Field Maps are imported to Garfield++ with the Magnetic Field (1.5 T)**
  - after tilting the Central Membrane to study the Errors in Electron’s Position in Ne2K gas near the Outer Field Cage

- **Stray Magnetic fields guide the electrons and hole electric field imperfections**

- **More on Mechanical Design updates**
  - by Niveditha Ramasubramanian

- **Optimize resolution**: More sharing – More accuracy
  - Less sharing – Less occupancy
  - 100 µm intrinsic resolution with 2mm pad structure & Linearity across the structure
  - Chevron patterns guided by simulation
  - Manufactured for testing in the lab condition
  - X-ray scan facility with collimated X ray source
  - Module anodes segmented into 16×16 pad "wedges" in terms of FEI cards.
  - Each FEI card supports a single wedge
  - High intrinsic resolution (σE < 100 µm) with relatively large pads (2mm×10mm)
  - Minimum differential non-linearity
  - Maximize overlap of adjacent pads
  - Minimize gap between adjacent pads

- **Passive Gating Option for TPC**
  - The feedback of positive ions in drift volume of a time projection chamber (TPC) causes adverse effects on the electric field in the drift region, thereby degrading the spatial resolution of the TPC.
  - A gating device located between the drift volume and the gas amplification is used to prevent positive ions from entering the drift region.
  - Multiple ANSYS and Garfield++ simulations are performed for square/circular hole grid, wire mesh and Photo-etched mesh to study the electron transparency and ion blocking.

- **Ion blocking**
  - More sharing – Less occupancy
  - Less sharing – More accuracy

- **Zero Crossing for sPHENIX TPC**
  - B × cosθ = Etest

- **Distorted Field Maps are imported to Garfield++ with the Magnetic Field (1.5 T)**
  - after tilting the Central Membrane to study the Errors in Electron’s Position in Ne2K gas near the Outer Field Cage

- **Stray Magnetic fields guide the electrons and hole electric field imperfections**

- **More on Mechanical Design updates**
  - by Niveditha Ramasubramanian

- **Optimize resolution**: More sharing – More accuracy
  - Less sharing – Less occupancy
  - 100 µm intrinsic resolution with 2mm pad structure & Linearity across the structure
  - Chevron patterns guided by simulation
  - Manufactured for testing in the lab condition
  - X-ray scan facility with collimated X ray source
  - Module anodes segmented into 16×16 pad "wedges" in terms of FEI cards.
  - Each FEI card supports a single wedge
  - High intrinsic resolution (σE < 100 µm) with relatively large pads (2mm×10mm)
  - Minimum differential non-linearity
  - Maximize overlap of adjacent pads
  - Minimize gap between adjacent pads

- **Passive Gating Option for TPC**
  - The feedback of positive ions in drift volume of a time projection chamber (TPC) causes adverse effects on the electric field in the drift region, thereby degrading the spatial resolution of the TPC.
  - A gating device located between the drift volume and the gas amplification is used to prevent positive ions from entering the drift region.
  - Multiple ANSYS and Garfield++ simulations are performed for square/circular hole grid, wire mesh and Photo-etched mesh to study the electron transparency and ion blocking.