sPHENIX TPC Performance in First Two Runs

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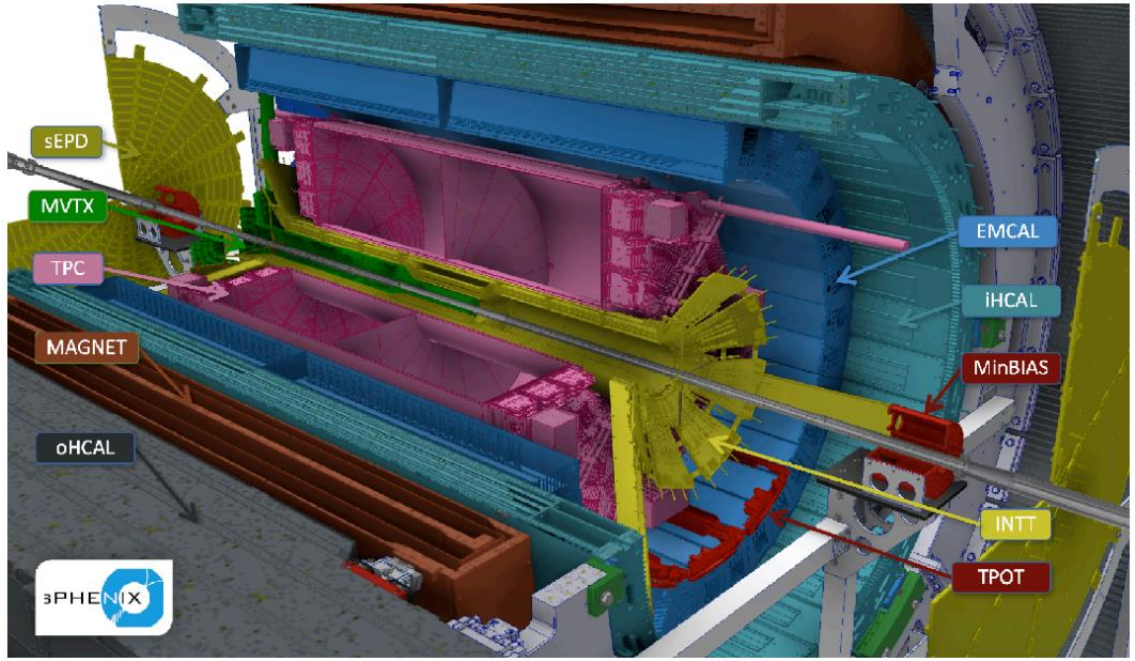
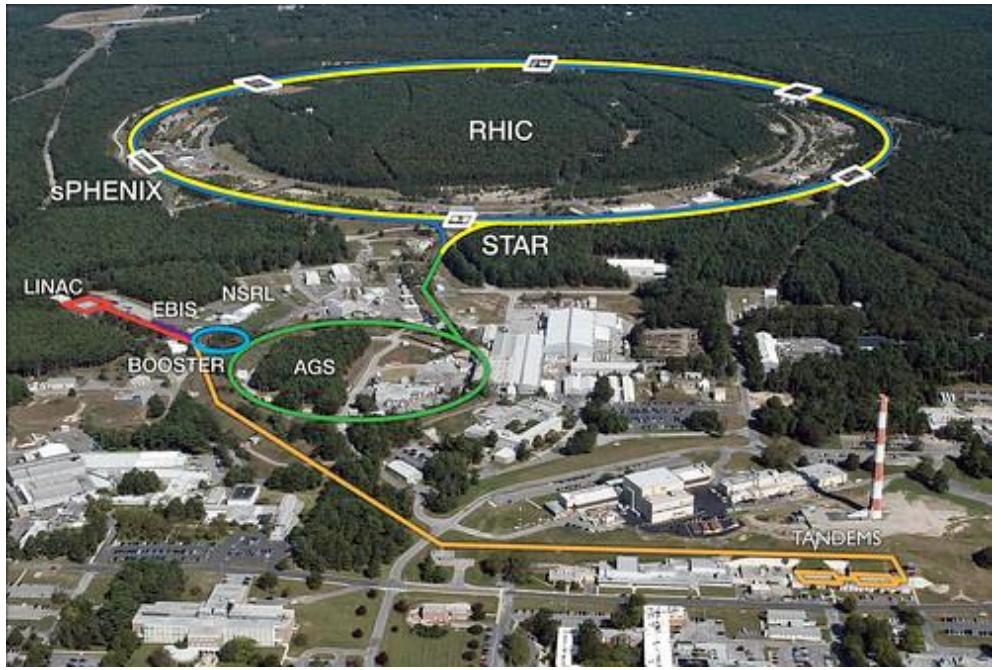
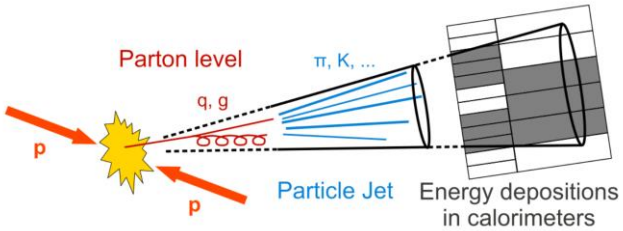
The sPHENIX Experiment

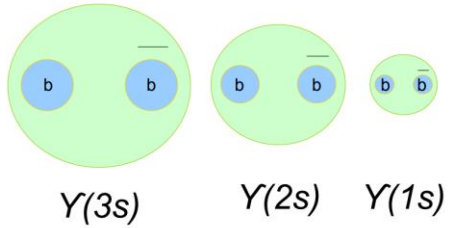




Physics Goals → Probe nature of Quark Gluon Plasma

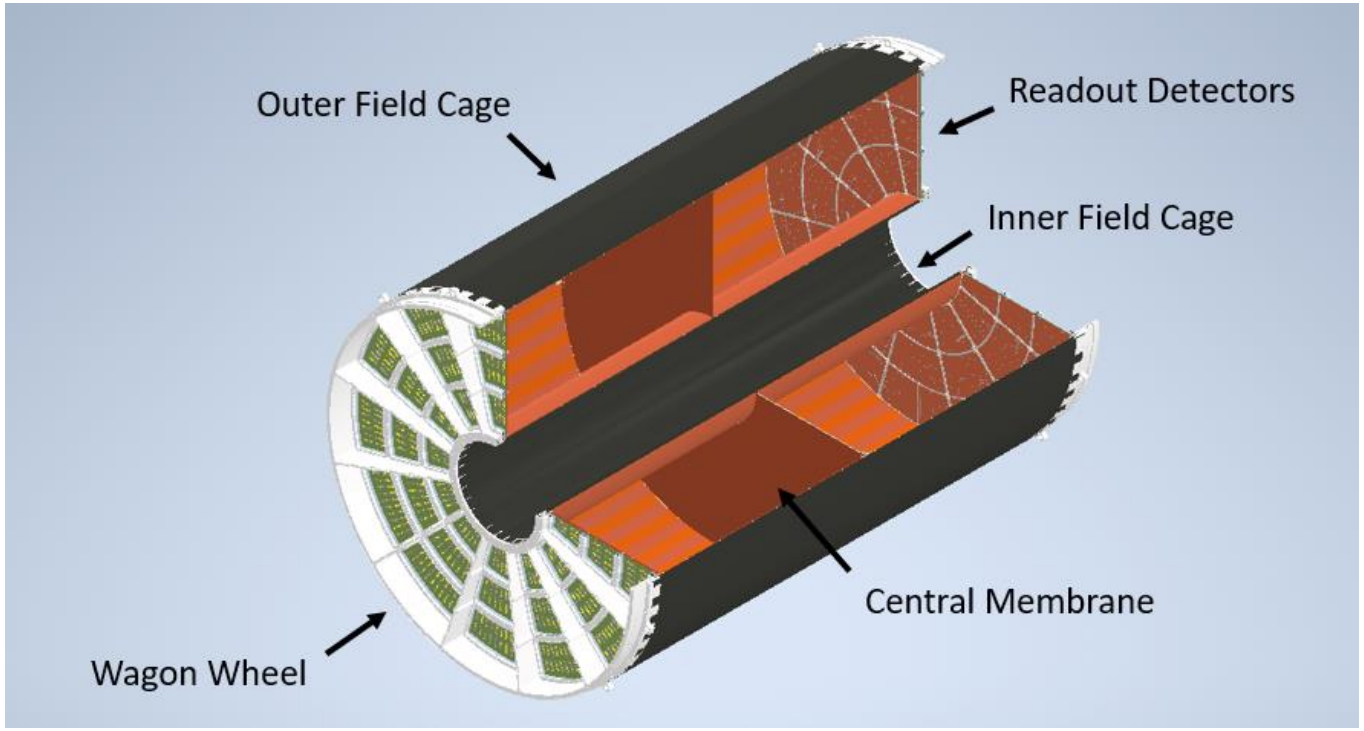


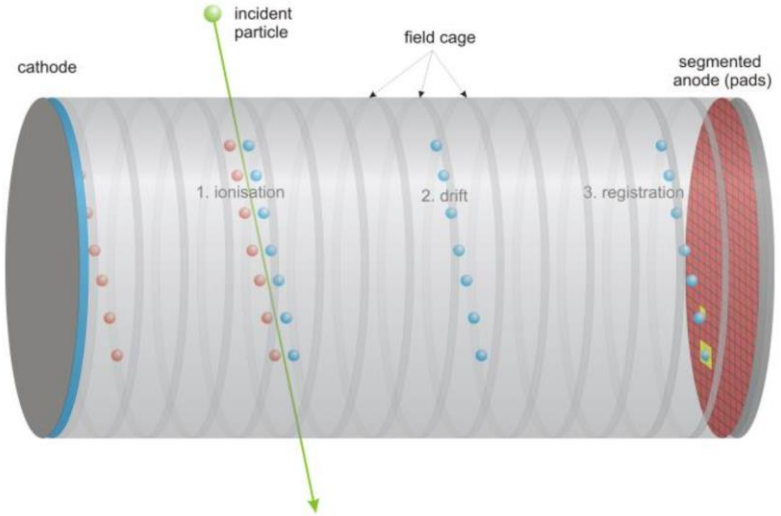
Jet Measurements

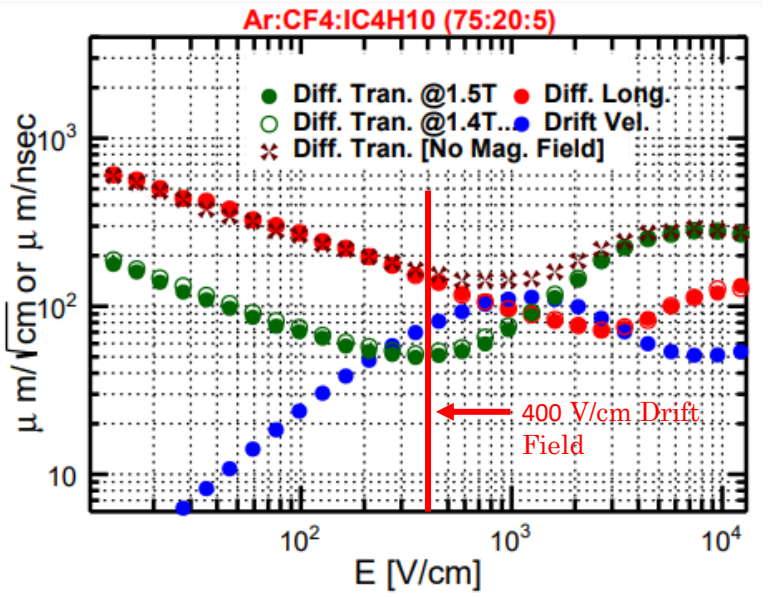


Upsilon Spectroscopy

Time Projection Chamber



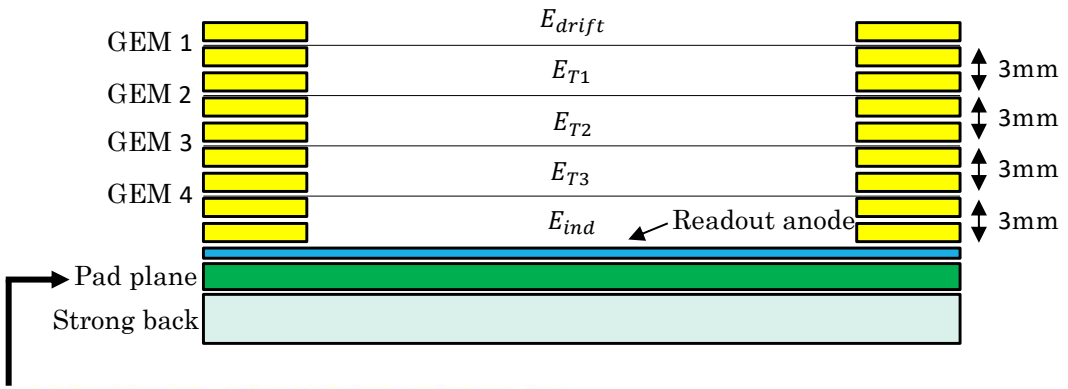


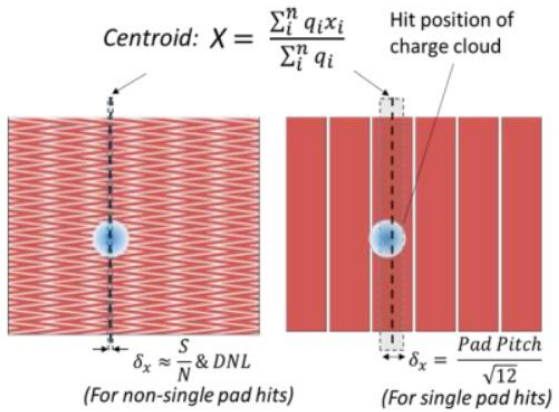


- 1m drift length on either side; Radius: 20cm < R < 78cm
- $|\eta| < 1.1$ with full azimuthal coverage
- Gas mixture: Ar:CF_4:iC_4H_{10} → 75/20/5 split (Switched from Ar/CF_4 → 75/30)

GEM Modules

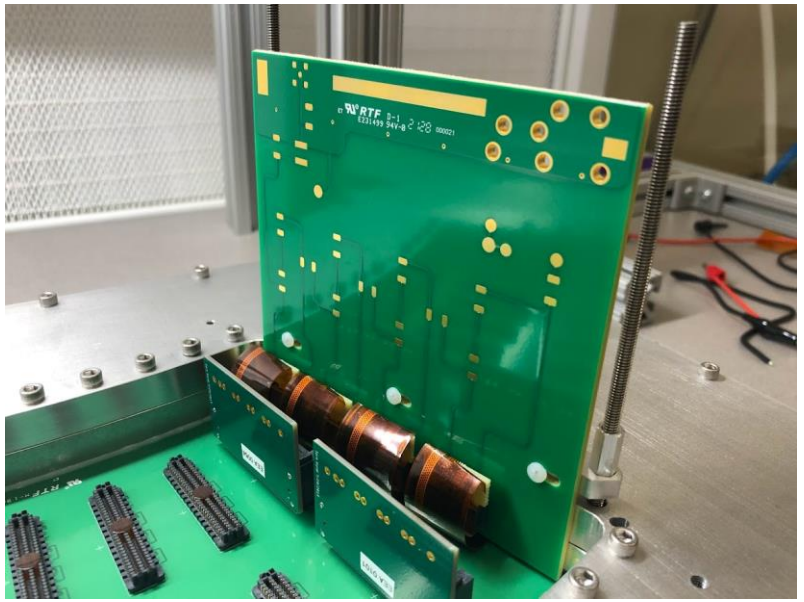
Quad stack of Gas Electron Multiplier (GEM) foils



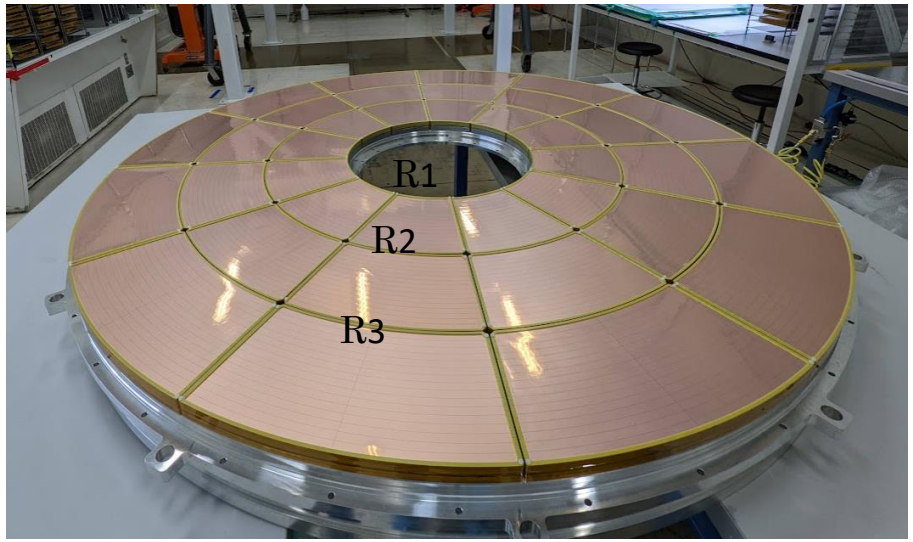


Improved charge sharing → Higher spatial resolution

HV Card supplies voltage to each GEM foil

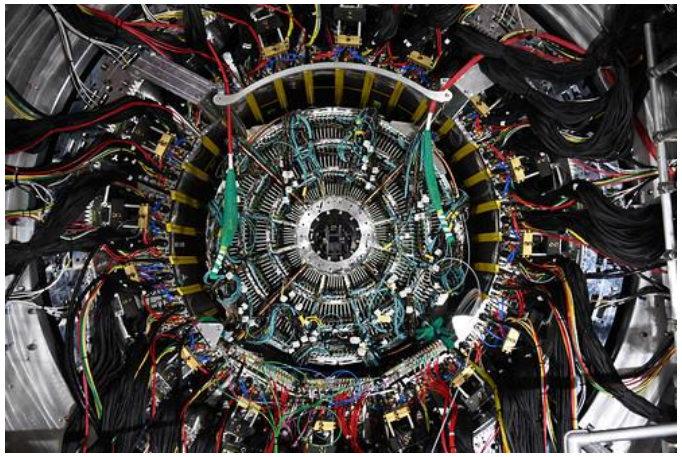


12 modules in ϕ and 3 in radius

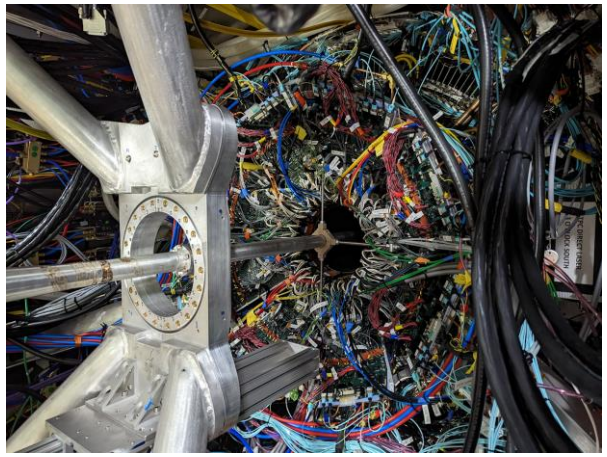


Run 23: Installation & Struggles

January: TPC Installed into sPHENIX

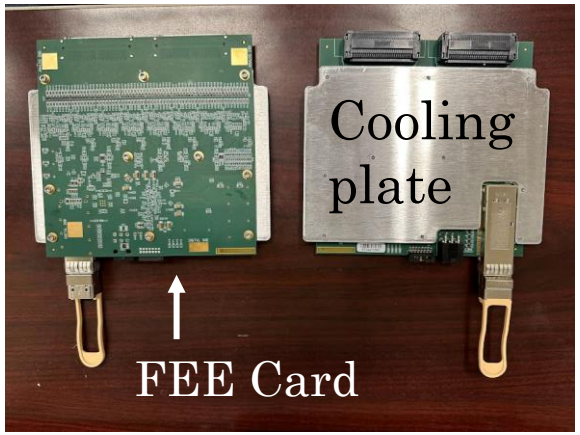


Feb: Detector instrumented

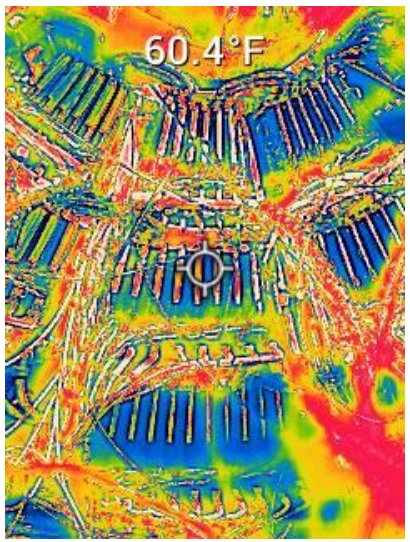


May: Beam arrived & TPC turned on

- Cooling issues with TPC FEEs caused instability with GEM performance ⟶ Damage to modules (linear + nonlinear shorts)
- Restricted to limited moments of operation until cooling issues were resolved



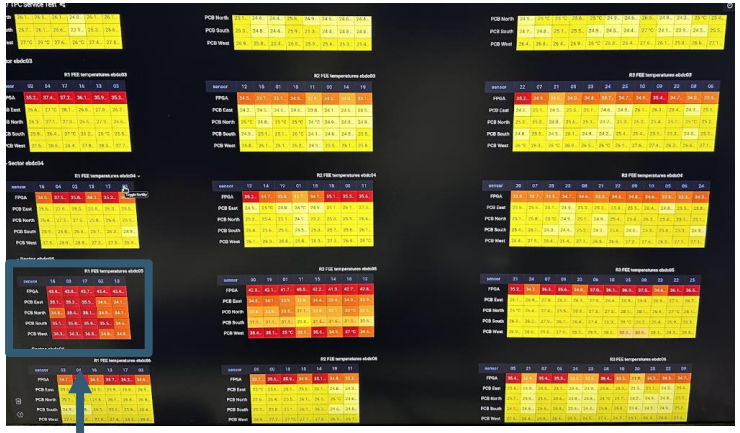
FLIR cam. of FEEs →



Run 23: Remediations

Fix 1: Chiller + Sophisticated Monitoring

- Chiller added to keep FEEs at target temp.
- Grafana page to monitor cooling

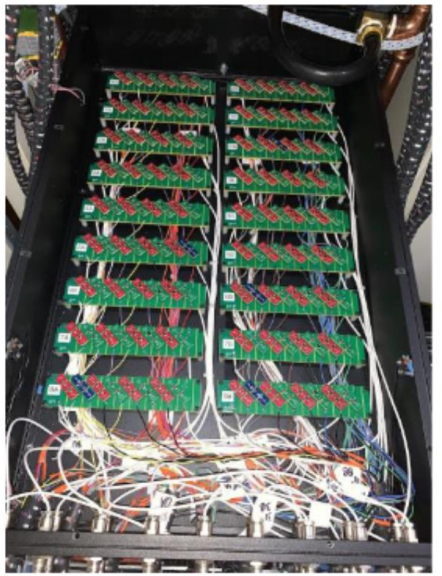


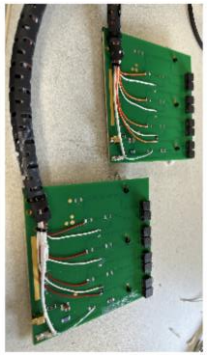
Hot FEE

Individual temp. probes to identify hot FEEs

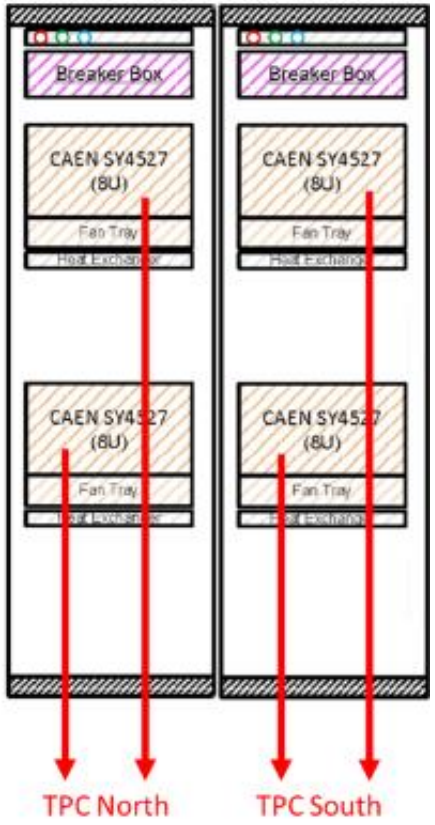
Fix 2: Modify GEM resistor chain

Phase 1: Adjustable Chain



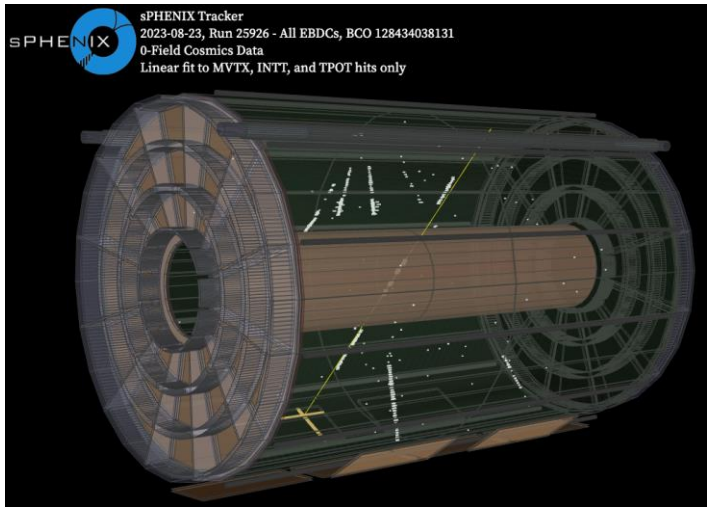


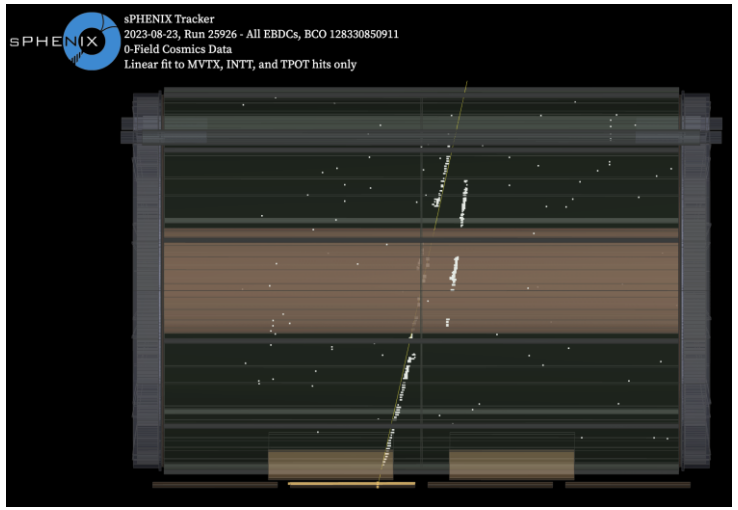
Phase 2: Cascading Power Supplies



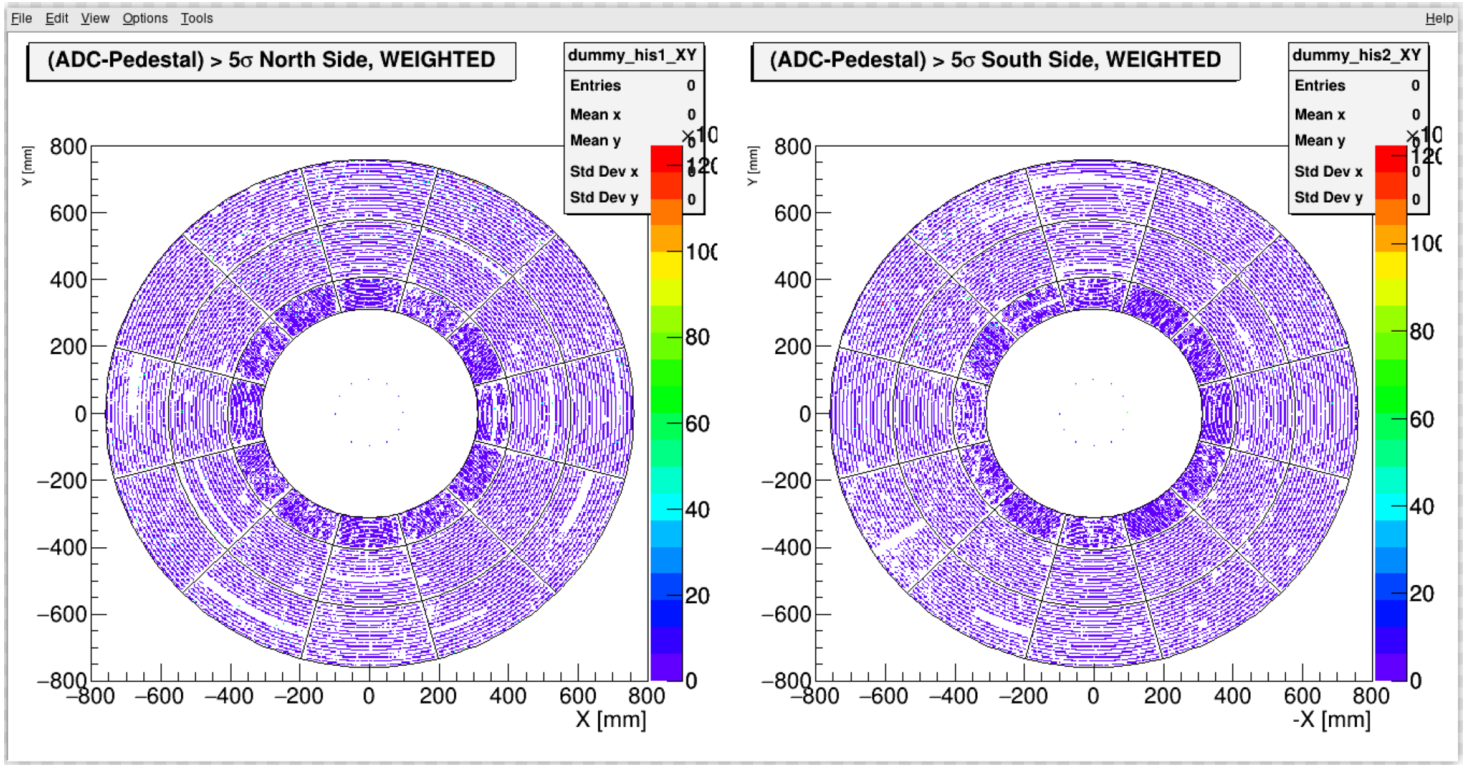
Run 23: Performance

Early Run Cosmics



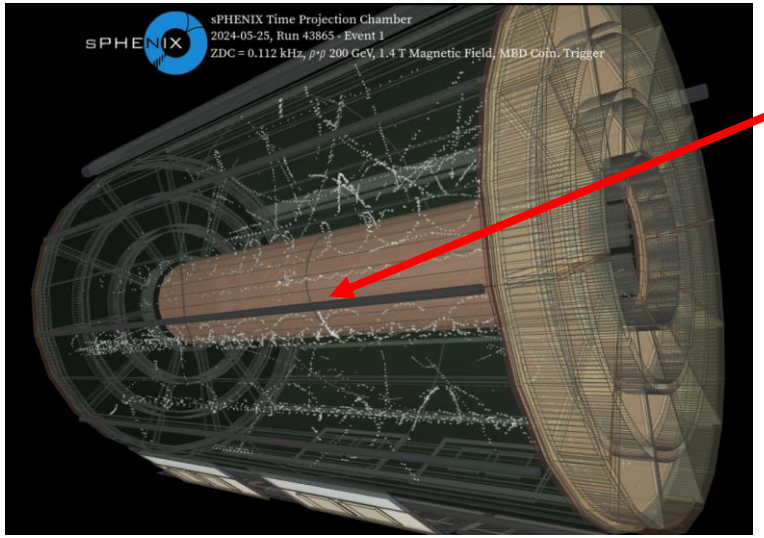


Cosmics Data: After Remediations



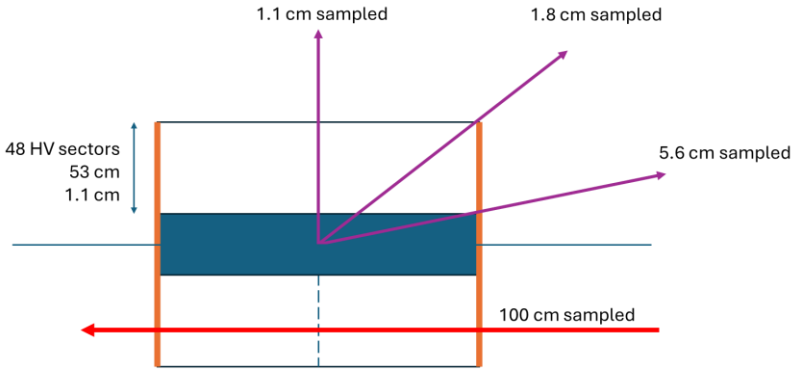
- Cosmic data after remediations confirmed TPC functionality under operating conditions
- Months of stable running with cosmics (Aug. 2023 – Apr. 2024)

Run 24: Beam Arrival



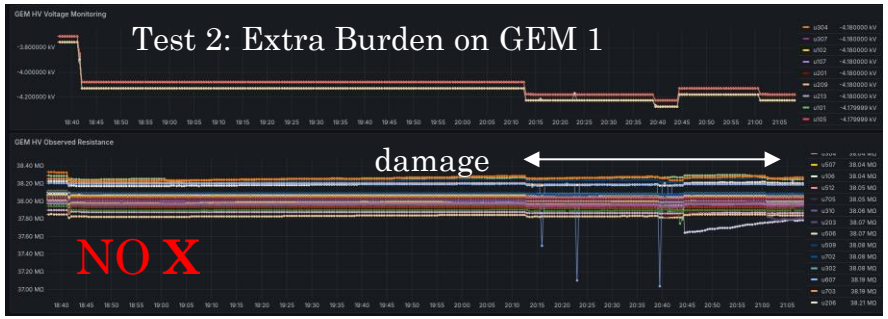
Unexpected "streakers" in beam background

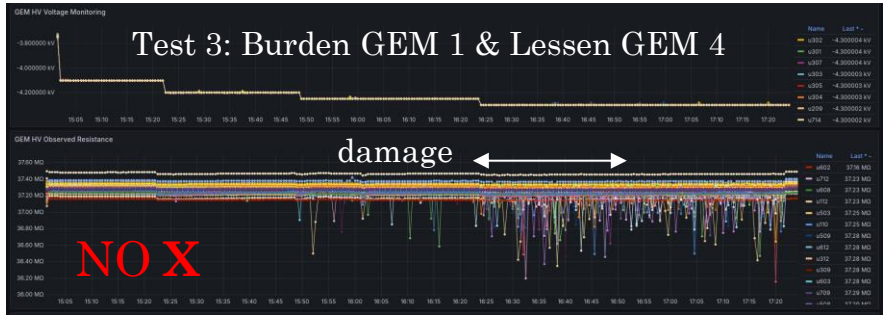
Large signals from background posed dynamic range issues for detector



Streakers deposit across full drift length of TPC → Enormous signals to GEMs and further damage

Tried to improve Dynamic Range of GEMs



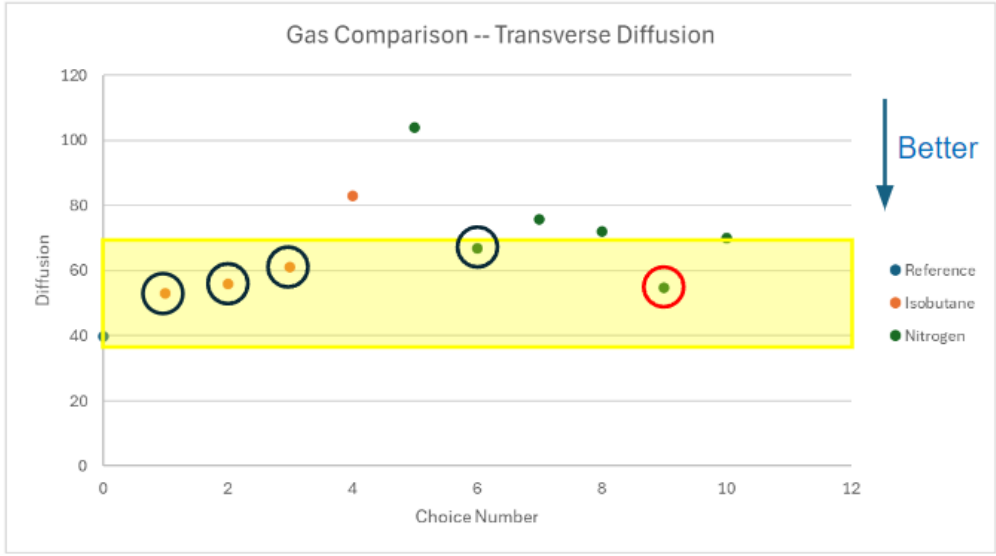


Run 24: Further Remediations

Solution: Improve dynamic range through the gas

Gas Mixtures	Ratios
Ar:CH_4	60/40
Ar:CH_4:iC_4H_{10}	75/20/5
Ar:CH_4:iC_4H_{10}	85/10/5
Ar:CH_4:iC_4H_{10}	80/15/5
Ar:CH_4:iC_4H_{10}	90/5/5
Ar:CH_4:N_2	80/5/15
Ar:CH_4:N_2	80/10/10
Ar:CH_4:N_2	75/10/15
Ar:CH_4:N_2	75/15/10
Ar:CH_4:N_2	65/25/10
Ar:CH_4:N_2	60/20/20

60+ initial candidates ⟶ Brought down to 10
⟶ New gas decided with bench tests

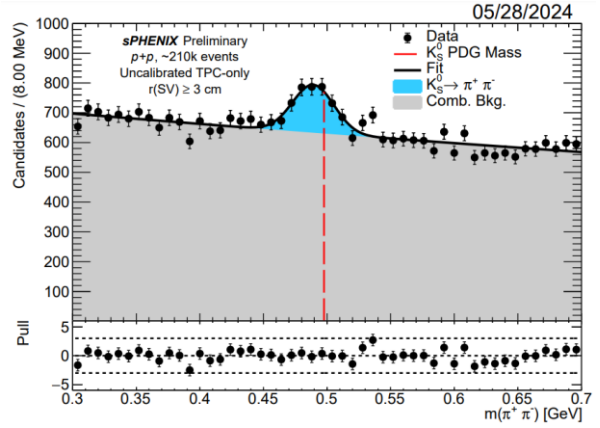


Gas Mixture	Ratio	Instability (MIPs)
Ar:CF_4	60:40	6-20 MIPs
Ar:CF_4:N_2	65:25:10	50 MIPs
Ar:CF_4:iC_4H_{10}	75:20:5	460 MIPs

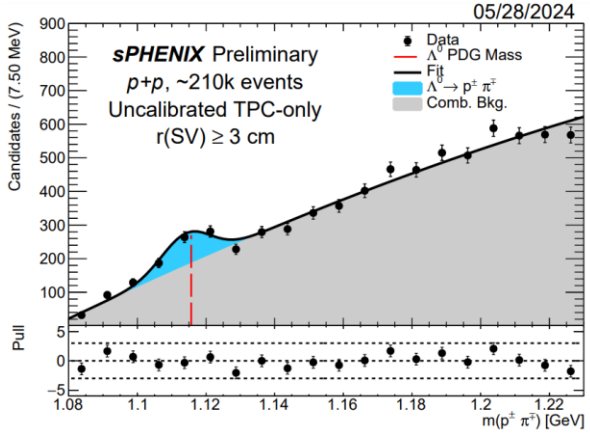
Low Diffusion & high instability point ⟶
Ar:CF_4:iC_4H_{10} best choice

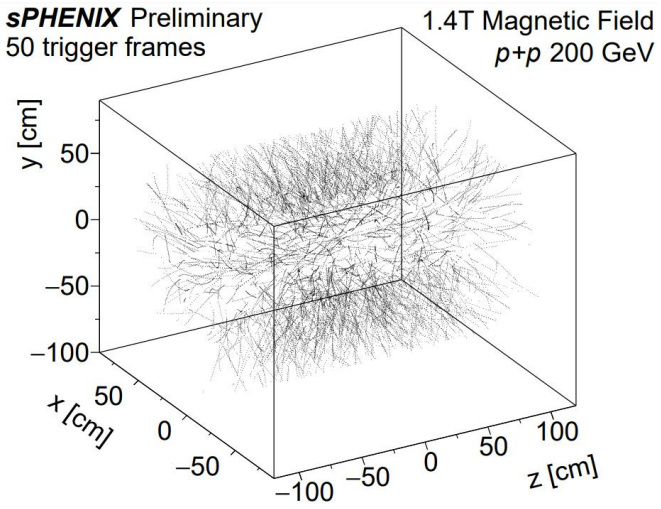
Run 24: Performance

k_s^0 Peak Measurement



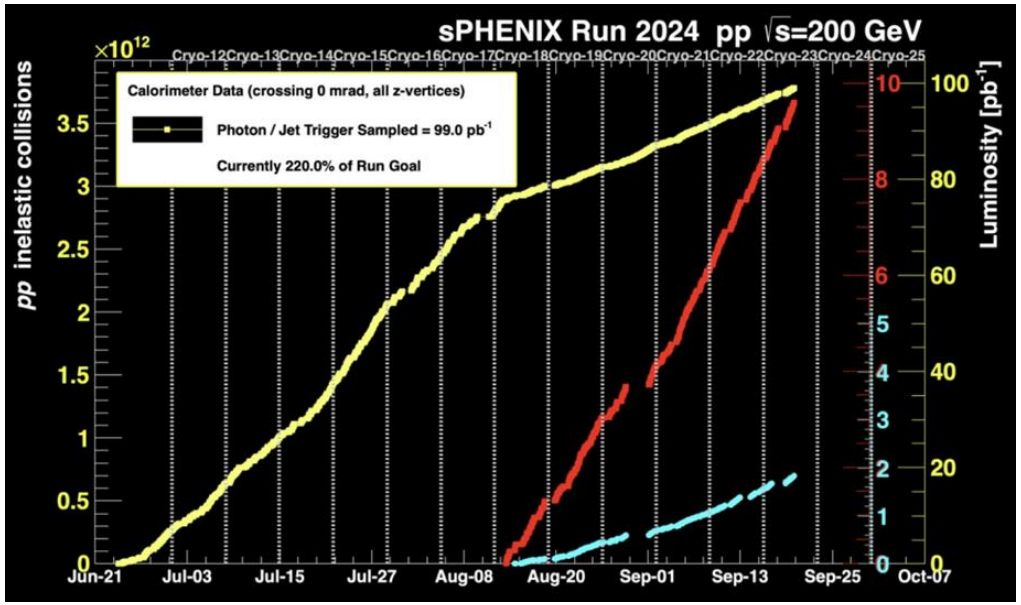
Λ^0 Peak Measurement





Early p+p running gave signs of progress, even before the addition of Isobutane

Placeholder until Jamie sends updated plot!



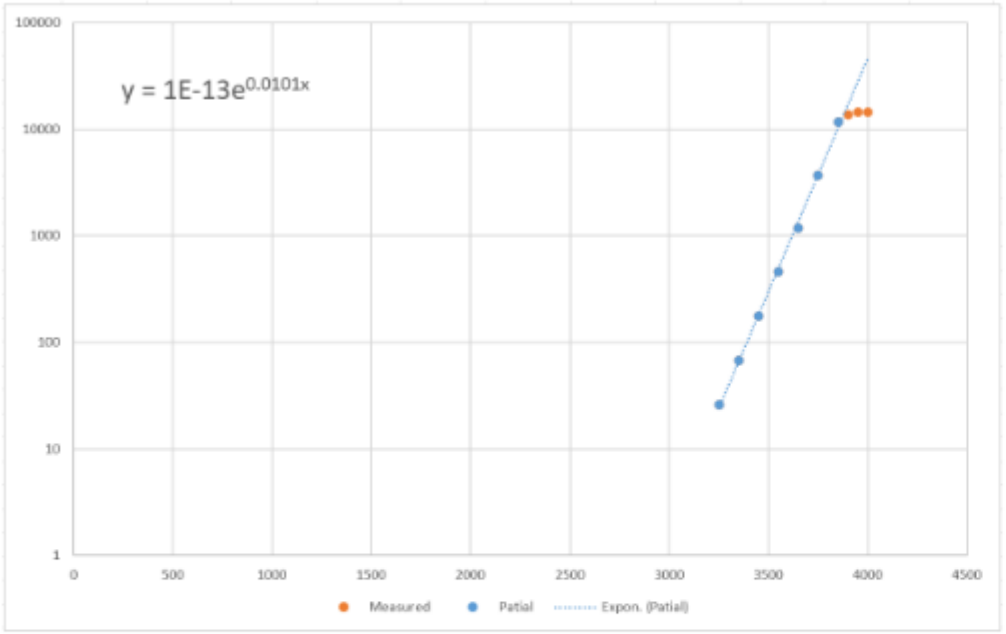
After Isobutane switch, TPC stability has dramatically improved!

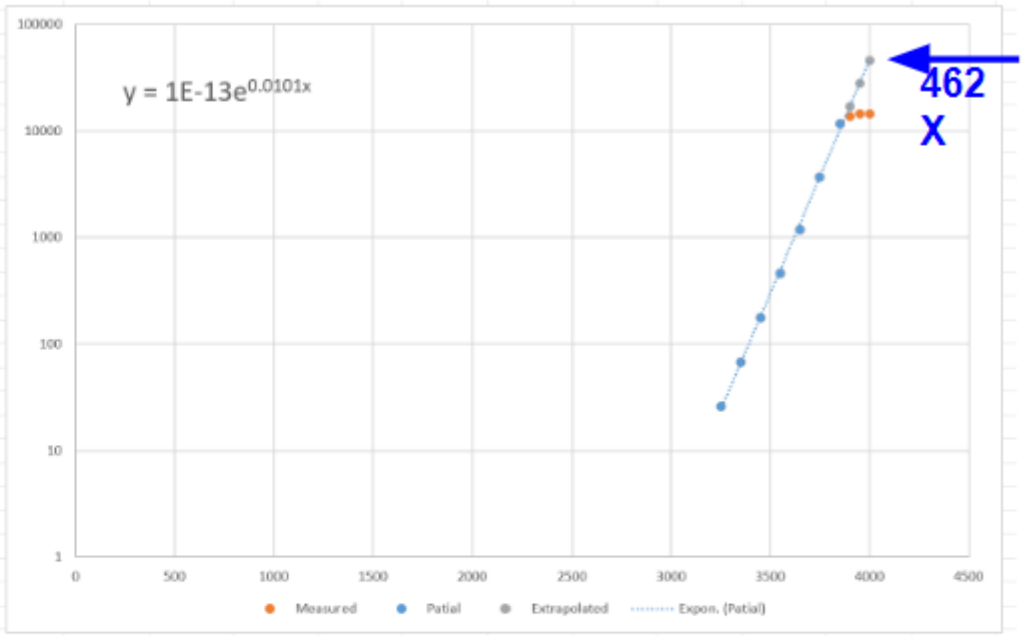
Summary & Future Outlook

- Issues with GEM stability due to cooling and beam background
- Cooling problems resolved with chiller and improved temperature monitoring
- Switch over to Isobutane increased dynamic range of GEMs, allowing for more stable running with large beam backgrounds
- sPHENIX entering the last few weeks of Run 24 → switch from p+p to Au+Au
- Collaboration will use these early runs to prepare for further Au+Au running in Run 25

Backup Slides

Further Isobutane Results





- The electronics saturated, but we can extrapolate.
- Following the gain curve that gain makes ^{55}Fe have 462 MIPS.
- No sparks at that point.