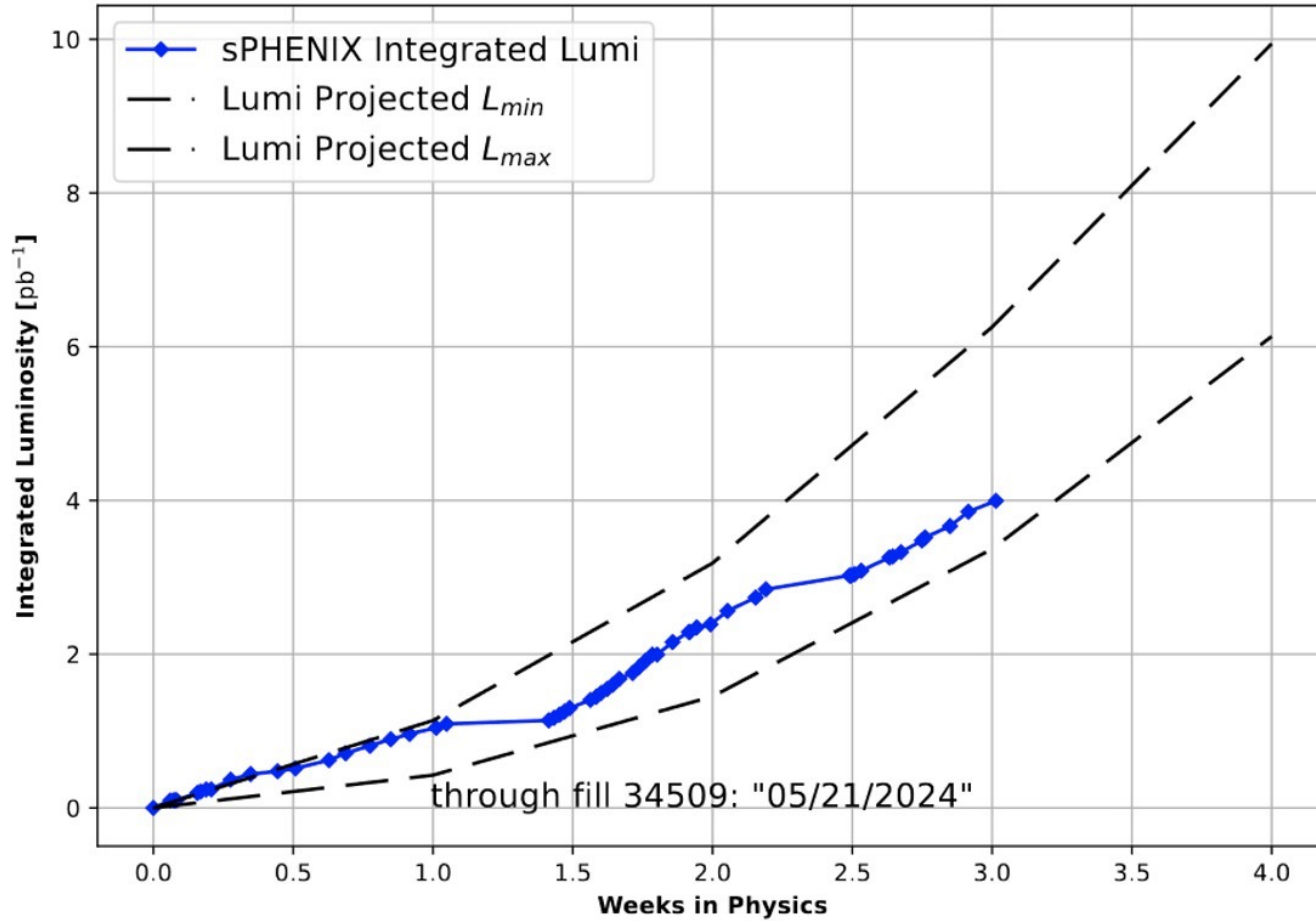# Run24 Update

RIKEN/RBRC

Itaru Nakagawa

FY24 Delivered Luminosity to sPHENIX
100 GeV p^ x 100 GeV p^
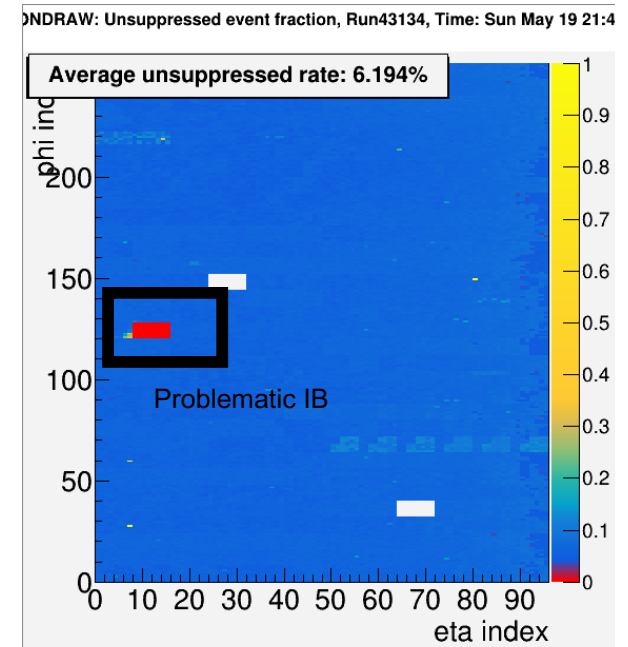
We are close to the lower boundary of the projected luminosity

Calorimeters

EM Cal

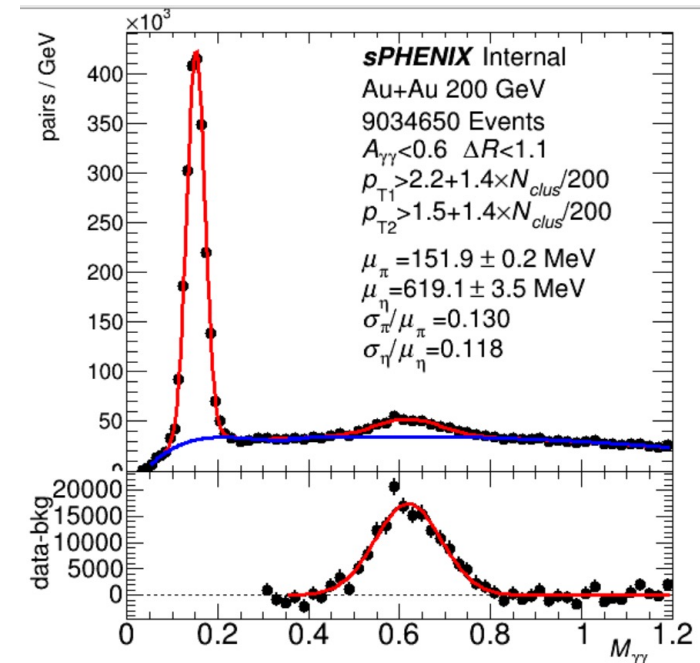## Radiation and Background Complications...

- However, not all trips were false positives

- Increase in trip rate found to be correlated to single event upsets of interface boards

- Causes them to load improper bias offsets, some too high, some too low

- This causes trips *and* the appearance of IB-sized "high gain" regions
  - NB: not calibrated, 16x high gain, just over-biasing of the SiPM

- Implemented ramping procedure similar to trackers, seems to mitigate issues

ONDRAW: Unsuppressed event fraction, Run43134, Time: Sun May 19 21:4

Average unsuppressed rate: 6.194%

Problematic IB

eta index

EMCal

Towards Fully Calibrated Data

- An agenda item for this week's work fest
- Close collaboration with production team (Sasha Lebedev and Jason Webb)
- Preliminary calibration available
- Implementation goal is fully-automated production and calibration scheme that masks problematic towers and handles the relative and absolute energy calibrations
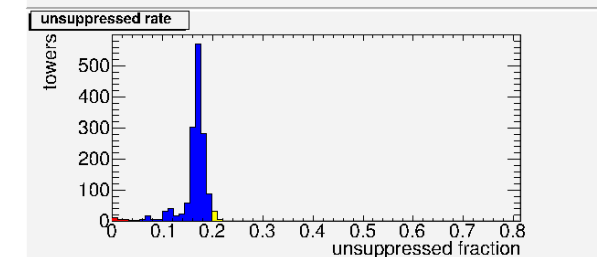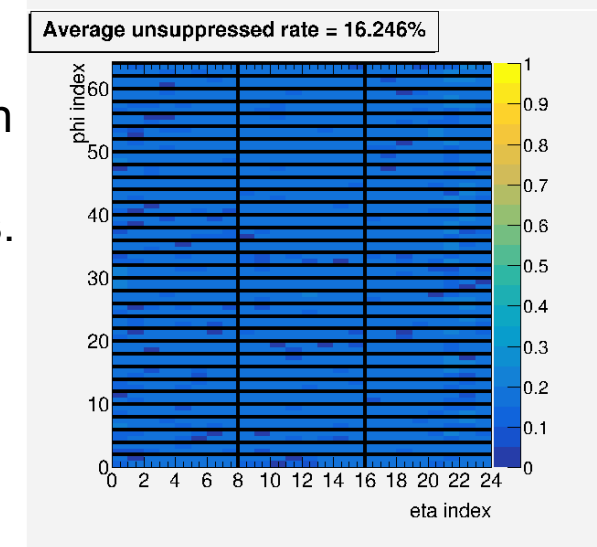

sPHENIX Internal
Au+Au 200 GeV
9034650 Events
$A_{\gamma\gamma}<0.6$ $\Delta R<1.1$
$p_{T1}>2.2+1.4\times N_{clus}/200$
$p_{T2}>1.5+1.4\times N_{clus}/200$
$\mu_{\pi}=151.9\pm0.2$ MeV
$\mu_{\eta}=619.1\pm3.5$ MeV
$\sigma_{\pi}/\mu_{\pi}=0.130$
$\sigma_{\eta}/\mu_{\eta}=0.118$

HCal

HCal Zero-Suppression

- Zero-suppression is working for calorimeter systems.
  - The ZS threshold is set channel by channel based on the pedestal noise size.
  - Speeds up waveform processing more than 10 times.

```
HCALOUTBUILDER_TOP: accumulated time (ms):  2.66679e+06
HCALOUTBUILDER_TOP: per event time (ms):     266.679
```
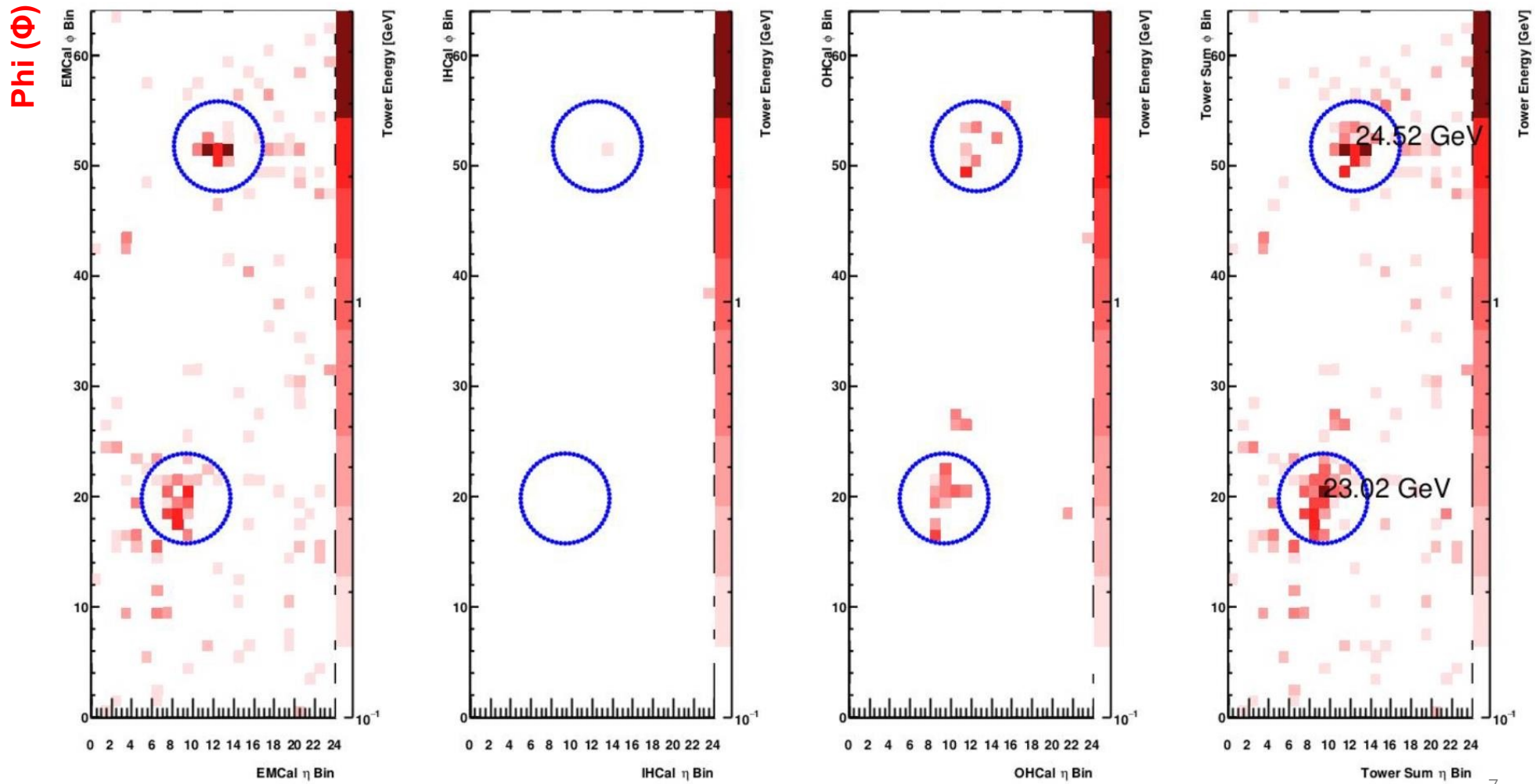
No ZS run reconstruction time

```
HCALOUTBUILDER_TOP: accumulated time (ms):  136141
HCALOUTBUILDER_TOP: per event time (ms):    13.6141
```
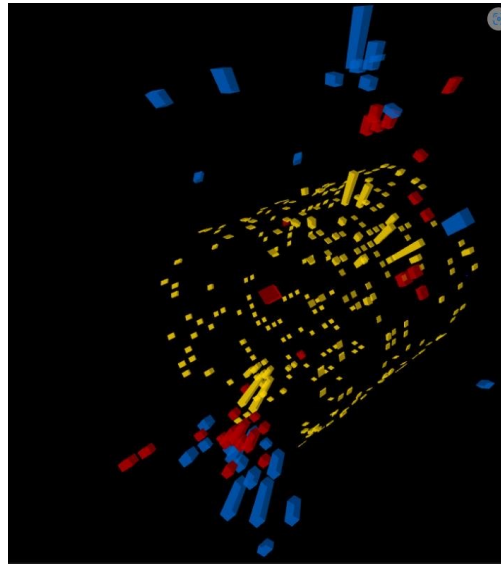
ZS run reconstruction time

ONDRAW: Unsuppressed event fraction, Run44008, Time: Mon May 27 15:2:
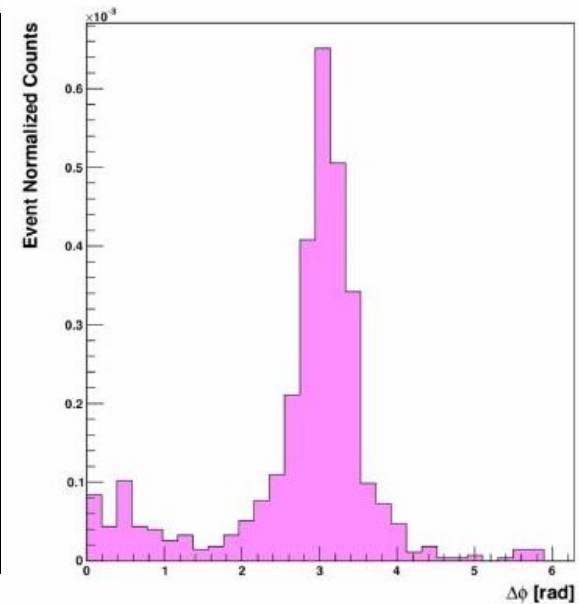
Average unsuppressed rate = 16.246%

Di-Jet Event Display

Dijets Event

Dijets

Select events with at least 2 jets > 5 GeV
Most of the time the two jets are back-to-back in azimuth ($\Delta\phi = \pi$) Indicates these
are real di-jet events

Something that only sPHENIX can do at RHIC

# Trackers

MVTX

Run '24 performance, beam spot

- Beam spot finding leads on from alignment

- Work ongoing to find beam spot in our runs with tracking setup
  - Can take alignment information
  - Used to verify it's correct

- Amplitude of modulation will tell you x/y position of beam spot, relative to input parameters

- Plot on the right:
  - Only a 5mm shift west is applied to the data to account for approximate global shift
  - No internal or precise misalignment info added (yet)
  - There are 12 periodic tilts and 12 staves on layer 0
  - Constant offset indicative of internal layer misalignments

- Big task of our workfest this week

Work by Alex Patton, MIT

Plot y-axis: DCA_{xy} [cm], x-axis: ϕ [rad]

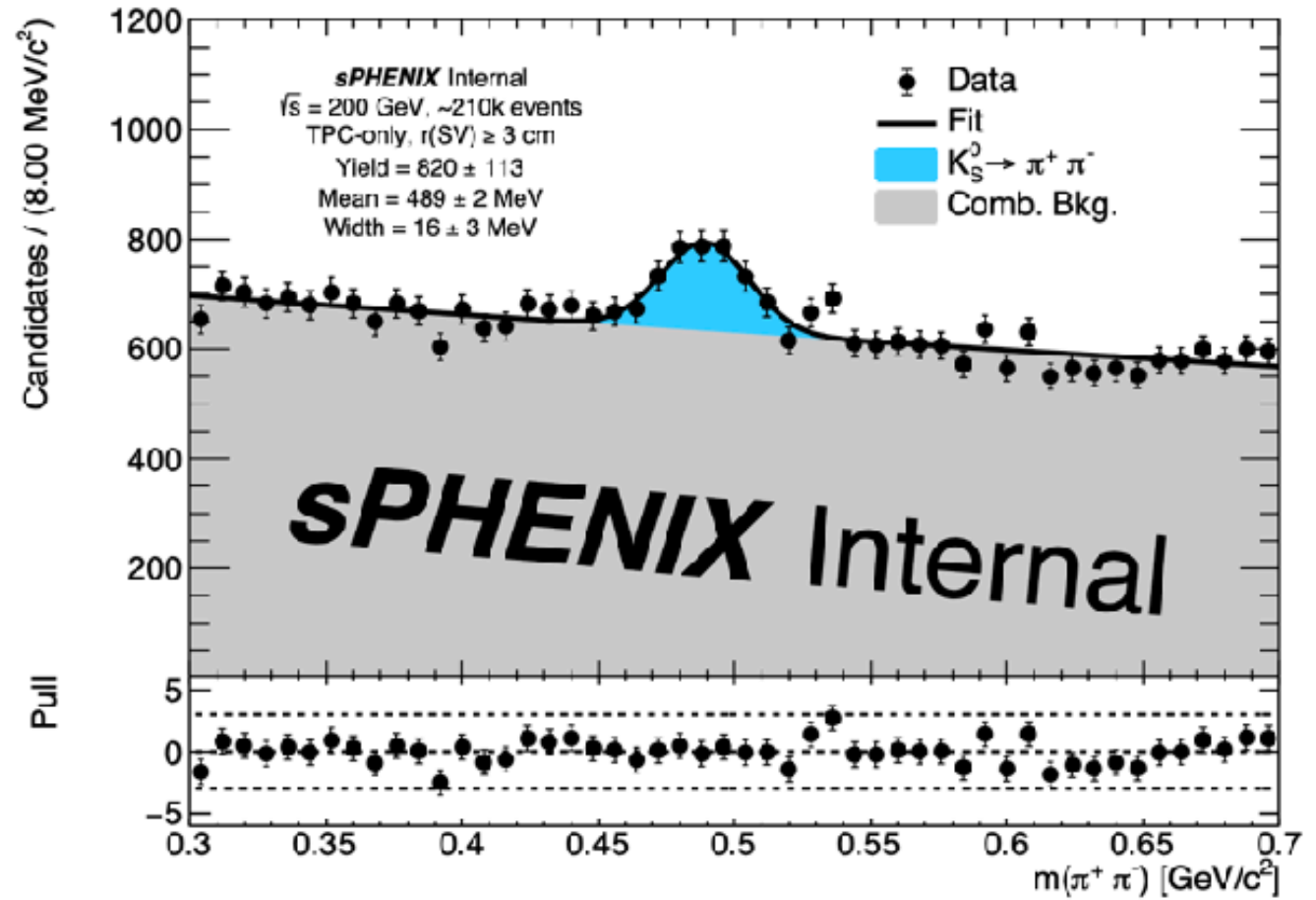Fit: $-0.9 + -0.045\sin(\phi) + -0.33\cos(\phi)$
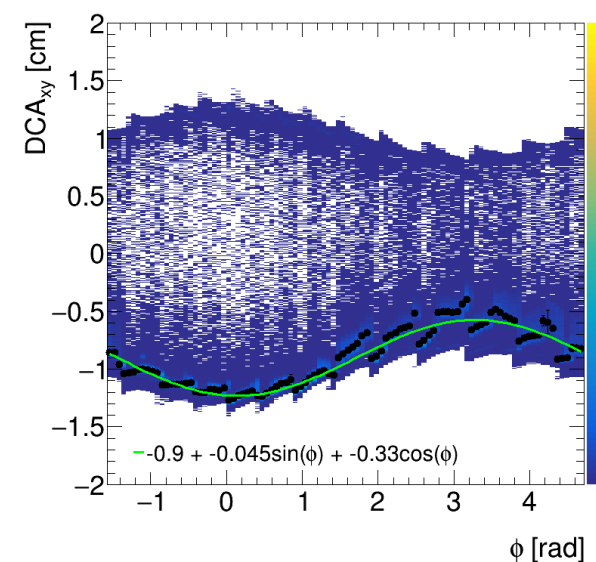
MVTX

Absorbers have arrived. Needs full assessment of installation time and whether we want to put these in place during the pp run.
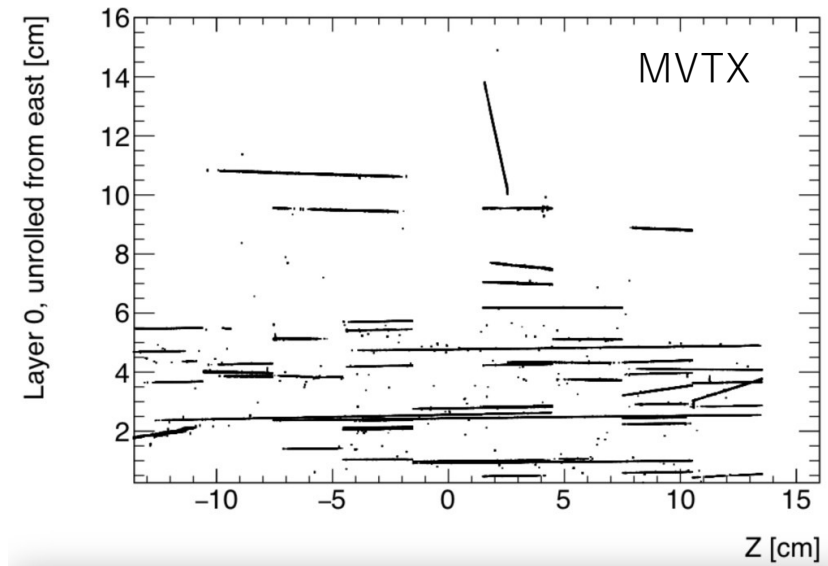
Highlights the critical needs for more timely assessment of MVTX performance and backgrounds.   We need to avoid other distractions – this is the critical time.
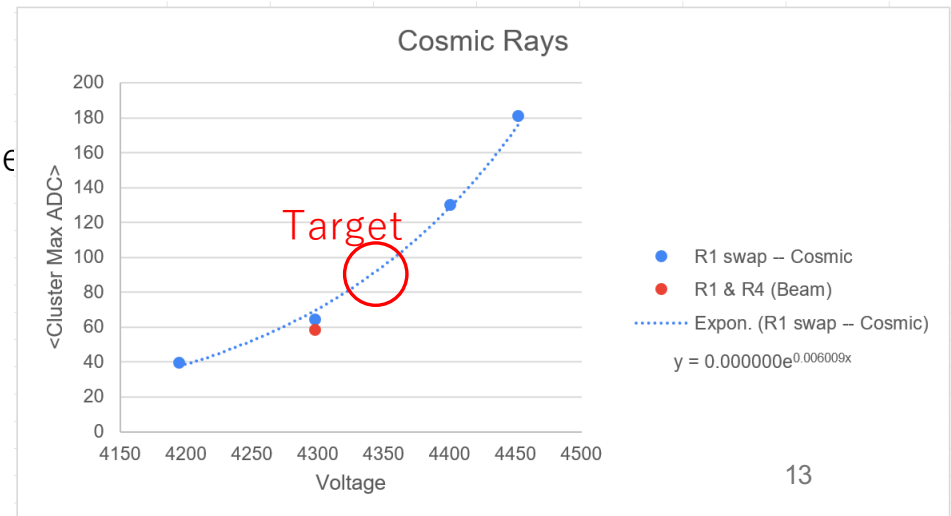
TPC

Cosmic Running

4400 Volts

Stable running with cosmics at 4400 V

- Offline analysis shows excellent gain.
- "glitches" only during ramp
  - Current and voltage measurement are out of phase
- Desired for beam running condition: 4350 V

Cosmic Rays

Target

- R1 swap – Cosmic
- R1 & R4 (Beam)
- Expon. (R1 swap – Cosmic)

$y = 0.000000e^{0.006009x}$

TPC holds HV in region of optimal gain for cosmic data taking

TPC does not hold HV in region of optimal gain with collisions

- Hypothesis: probably is in the GEM4 which is at highest Voltage
- Test: last wednesday changed Resistor Chain configuration to lower GEM4 Voltage by 15%. This is not a running option (IBF too high)
- Result: No significant improvement

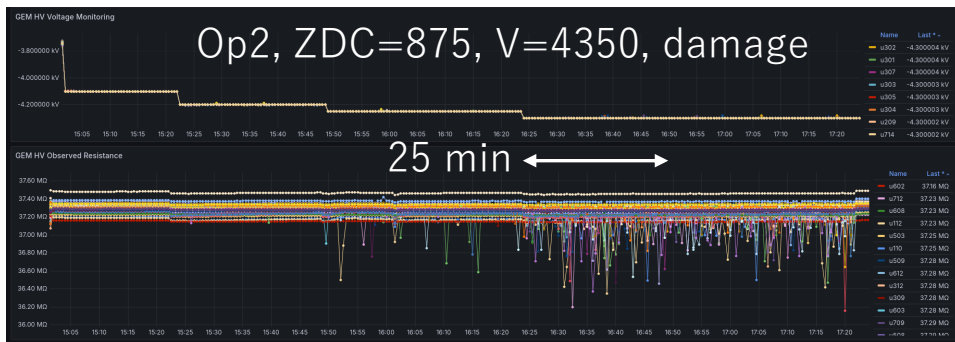
Quad-GEM Gain Stage
Operated @ low IBF
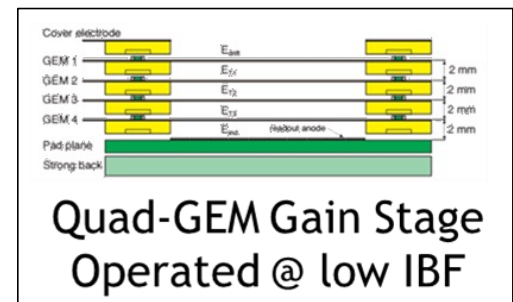
Mini-Review on Mon. May 20, 2024

- Change R-Chain back on maintenance day (Wed., May 22, 2024)
- Run with lower Voltage for now
- Developing tests to increase gain
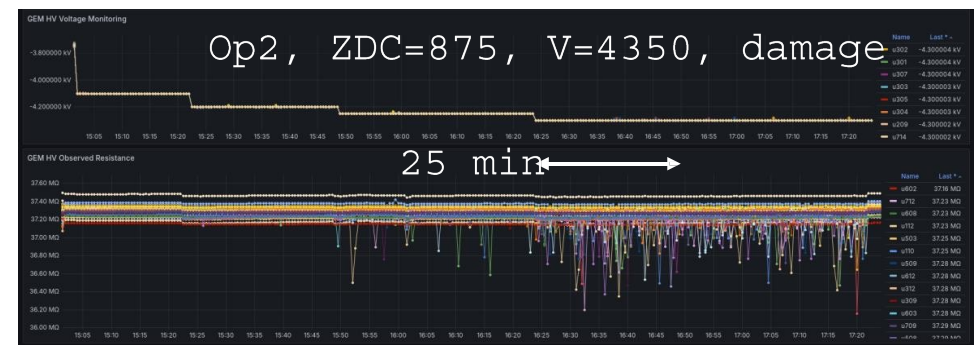
Op2, ZDC=875, V=4350, damage

25 min
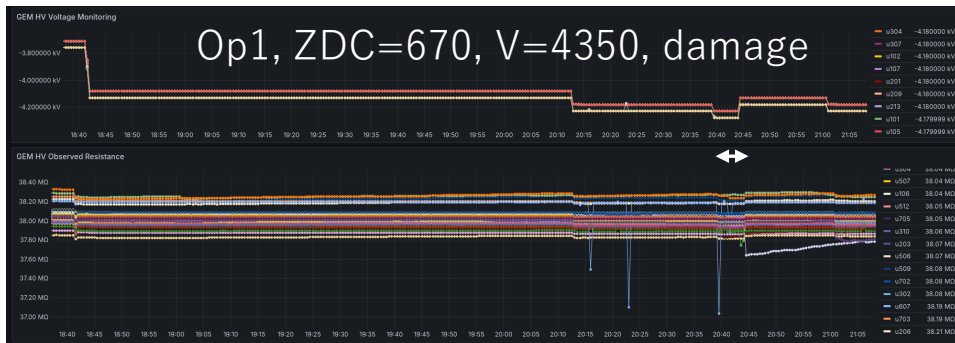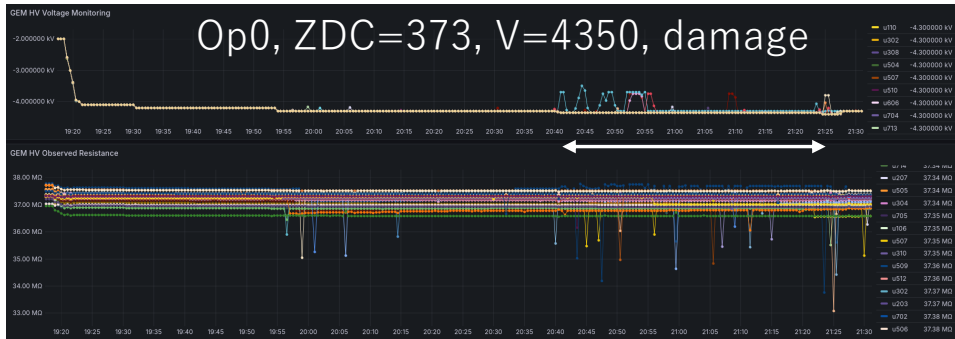
- Two dramatic changes in the G4 voltage did NOT move the maximum achievable gain.
- These changes certainly have major deleterious effects on IBF.
- Possibility that we should roll them back.

- Spike rates vary from fill to fill.
  - Spikes rise faster than ZDC coincidence?

15
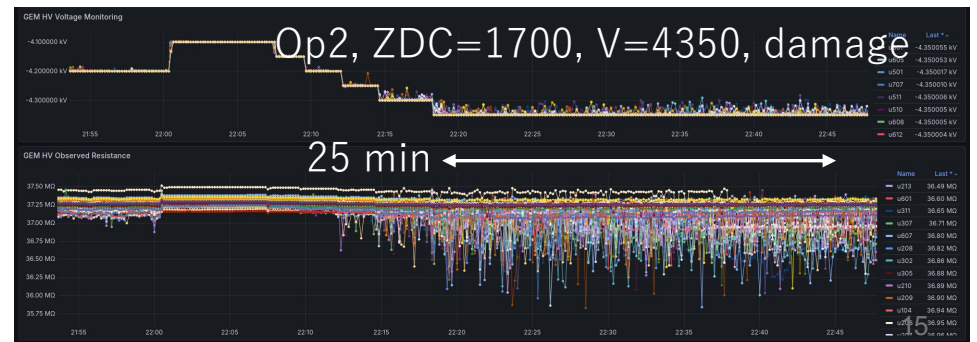
Mini-Review Conclusions

Recommendations

0. Return the GEM stack voltage configuration to Operating Point 0 as originally planned. ← Done
1. Attempt to operate the TPC with reduced voltage at Operating Point 0 in order to collect data from collisions, gain experience with the detector, and exercise many other operational and analysis techniques. ← Ongoing
2. Consider small changes to the gas mixture which can be tested with the "canary chamber" before attempting to implement them in the full detector. ← Ongoing
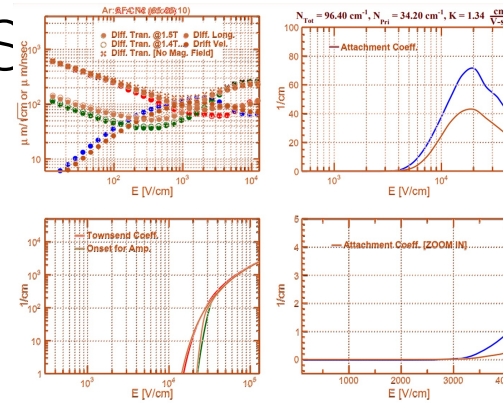3. Prepare the CAEN high voltage system for operation by testing the new crates and modules, and developing a plan for terminating the cables presently hard-wired to the contingency boxes. ← Soon
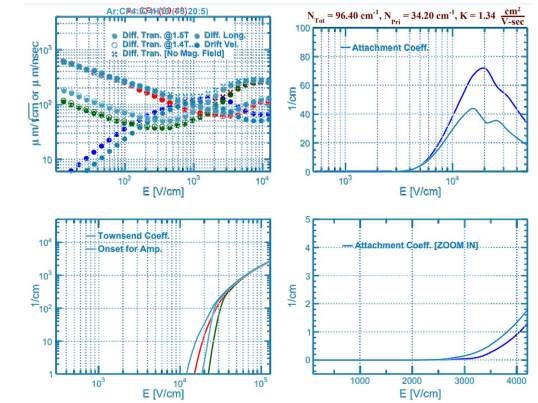
$Ar:CF_4:N_2$ 65:25:10 $Ar:CF_4:iC_4H_{10}$ 65:25:10

- Test running at 4300 V over a longer time & as a function of beam intensity.
  - Two steps:
    - Study backgrounds via vertical beam displacement scan (intermediate voltage) — Done
    - Push for 4300 V under full beam load (requires proof since full load not yet seen) — Soon
- Work on small changes in gas mixture to "quench harder"
  - Isobutane (<= 5%) suggested by committee — Ongoing
  - Analyzed 16 alternatives (5 more to go···two promising bench tests) — Ongoing

- Are the straight lines "spikes"?
- Probably not, this is one 18 μsec sample and spikes are very rare compared to this

TPC CLUSTER MULTIPLICITY vs ZDC Rate

$f(x) = 379012.81778978 x + 247797.290895937$
$R^2 = 0.96526564246281$

hysteresis

Bkg: ~2500 clus/evt without collision

16
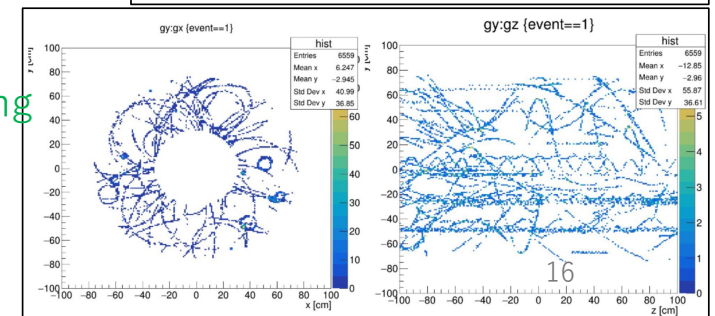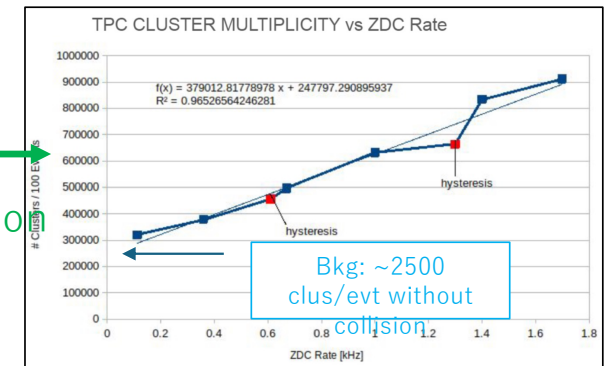
TPC Operation at High DAQ Rate

- TPC ZS operation in big partition
  - Joined big partition with 15kHz GL1 MBD trigger, zero suppression, 13+5us extended trigger time frame configuration
  - The goal is to test TPC zero suppression stability with radiation upset and varying noise. Used low HV (3800V) and high threshold, 50 and 60 ADUs above pedestal. Automatic stuck fee masking was repurposed to perform automatic noisy/misconfigured FEE masking
  - TPC worked well in the big partition, and observed/rode over the high beam background event at 14:33 when CAD adjusted the beam to increase STAR collision rate which increased sPHENIX rate by x7 too.
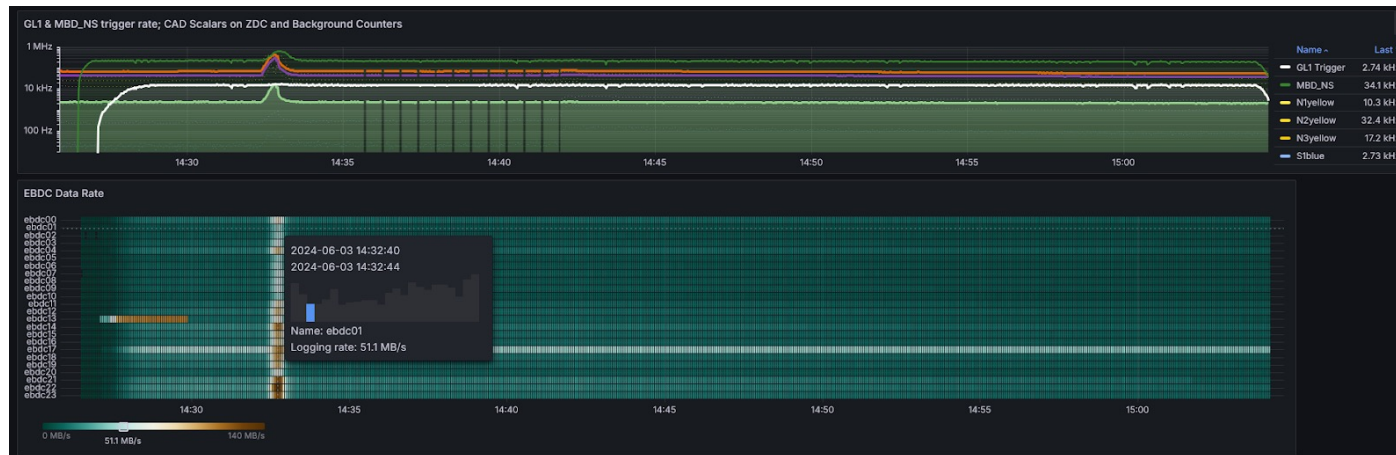
Beam & Trigger

Rare Event Trigger (Photon Trigger)
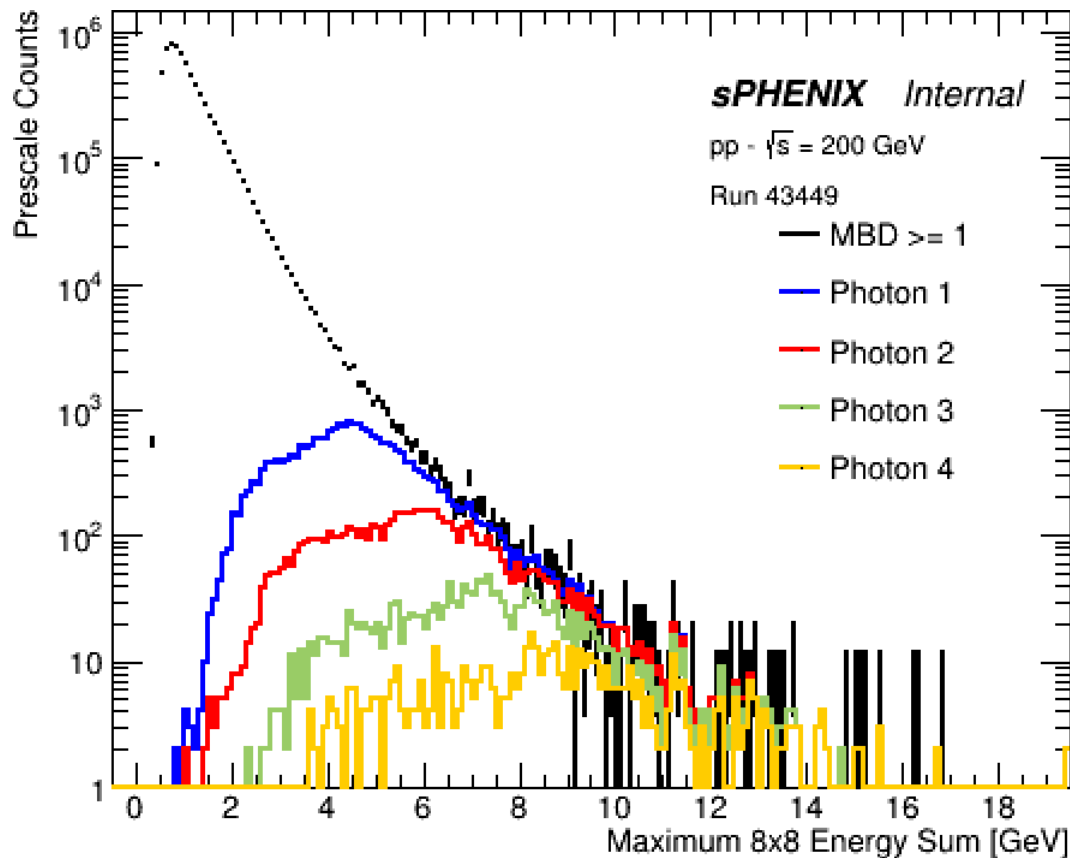
First look turn-on curves from Dan Lis.

Need some modifications to lower thresholds for Υ physics when tracking detectors are online

Also, bringing jet triggers online.
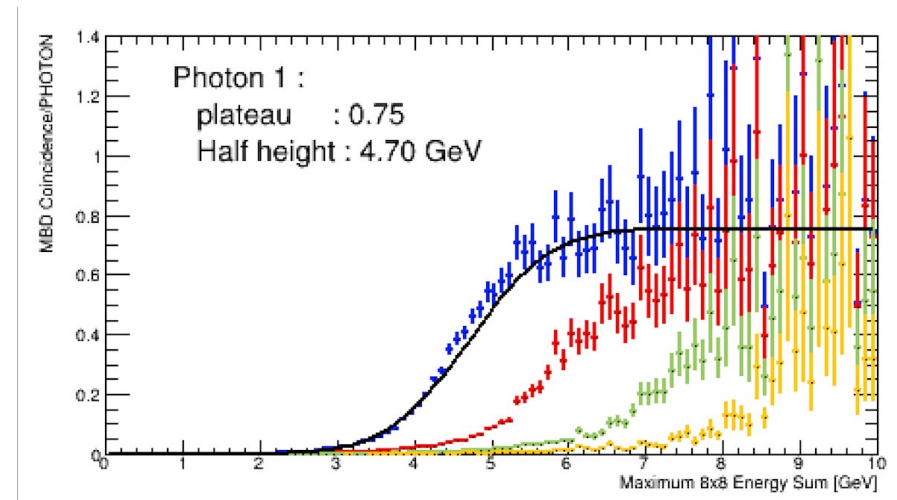
Jet Trigger Rejection Factor

Rejection Factors

0.8 x 0.8 sliding window in the EMCAL+HCAL tower grid: at 10 GeV we should see a rejection of 2000.

To be confirmed with turn on curves.
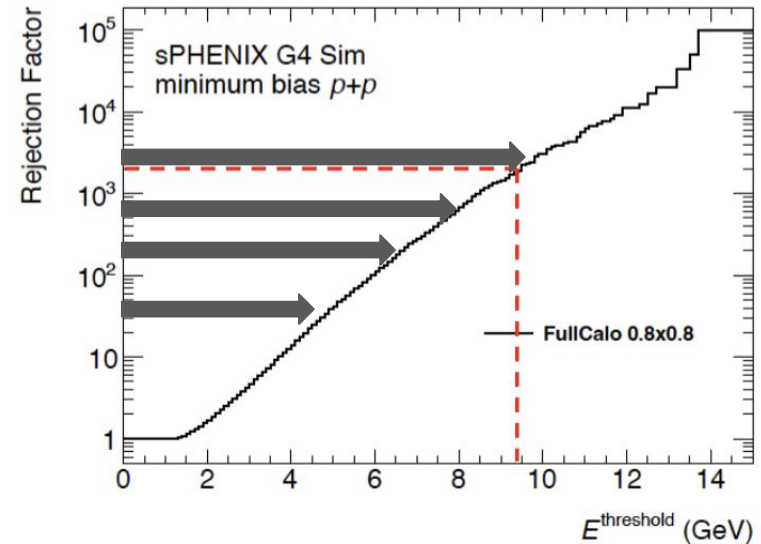
	10: MBD N&S >= 1	70		Modify	107307.17 Hz	92322.60 Hz	1300.31 Hz	86.04%
40	16: Jet 1 + MBD NS >= 1	off		Modify	2732.64 Hz	2321.20 Hz	0.00 Hz	84.94%
340	17: Jet 2 + MBD NS >= 1	10		Modify	314.00 Hz	267.17 Hz	24.20 Hz	85.09%
891	18: Jet 3 + MBD NS >= 1	off		Modify	120.70 Hz	105.61 Hz	0.00 Hz	87.50%
2377	19: Jet 4 + MBD NS >= 1	0		Modify	45.89 Hz	40.86 Hz	40.86 Hz	89.04%

Beam Background Issue

John Haggerty and Stefan have been pushing checks on backgrounds.

This figure was shown to C-AD last week, with follow up.

Analysis from Pedro Marin. This is a concern and is also impacting the stability of zero suppression for Calorimeters
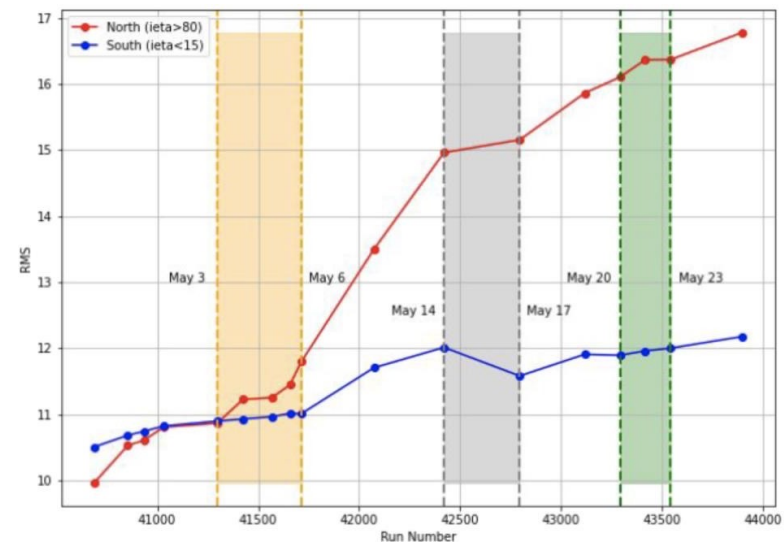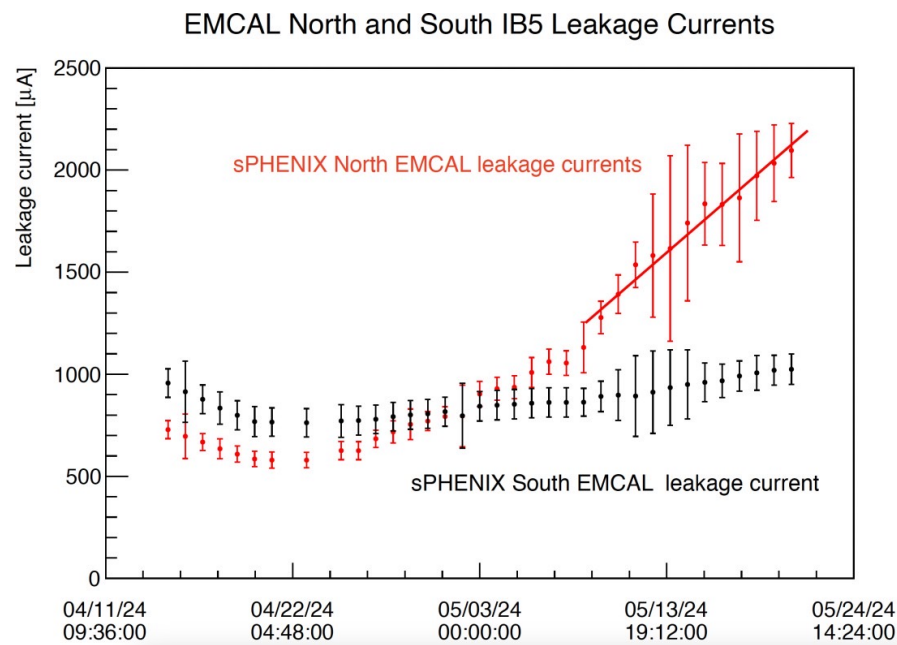
Luminosity and where we want to be …

C-AD Broadcast May 7, 2024 07:53:52

RHIC Store

Fill #	34424	Store Start	Tue May 07 03:06:50 EDT 2024
Fill Pattern	111x111_P2	Physics Start	Tue May 07 03:06:50 EDT 2024
		Time@store	04:46:58
STAR (corrected) ZDC rate	378 Hz	Scheduled Dump Time	Tue May 07 11:06:50 EDT 2024
sPHENIX ZDC rate	531 Hz	Dump Timer	-03:13:01

Blue

Species	PP	Beam Energy	100.2 GeV
Bunches	111 / 111	Intensity	1.01e+13 ions
RMS	Emittance	Loss Rate	1.32 %/hr
Horizontal	[8.2] µm		
Vertical	[7.5] µm	Abort Kicker Mode	Delayed

Yellow

Species	PP	Beam Energy	100.2 GeV
Bunches	111 / 111	Intensity	1.16e+13 ions
RMS	Emittance	Loss Rate	1.17 %/hr
Horizontal	[8.7] µm		
Vertical	[3.2] µm	Abort Kicker Mode	Delayed

Current luminosities yield collision rates at sPHENIX with 2 mrad of ZDCNS ~ 700-800 Hz (all z).

2015 levels would be ~ 5000 Hz (all z)
Goal for this run ~ 10,000 Hz (all z)
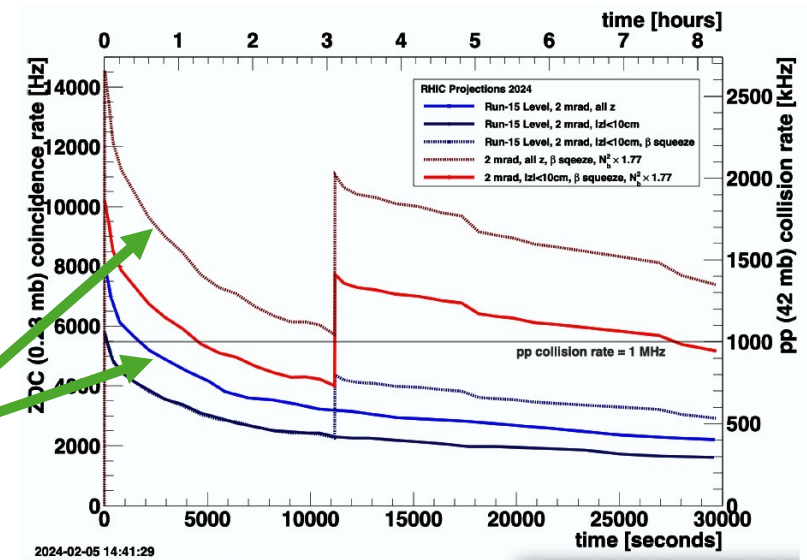
Polarization

- It has been poor polarization 30~40% until the last weekend.
- As emittance blow up issue is resolved, the polarization was improved.
- The polarization is >50% stably over last 7 stores since the last weekend.

34573.303	Jun 03, 2024 18:27:44 Mon	Y2U	56.3 ± 2.6	4.6 ± 2.7	0.06 ± 0.14	sweep	100.22	H3	56/9/55	49,699,860	db	—	v2.2.10M	Jun 03, 2024 18:40
34573.104	Jun 03, 2024 18:26:46 Mon	Y1D	56.1 ± 2.2	3.2 ± 3.2	0.08 ± 0.10	sweep	100.22	V3	56/9/55	51,500,352	db	—	v2.2.10M	Jun 03, 2024 18:28
34573.003	Jun 03, 2024 18:25:53 Mon	B1U	46.6 ± 2.8	7.7 ± 3.4	0.39 ± 0.23	sweep	100.22	H3	55/9/56	48,274,055	db	—	v2.2.10M	Jun 03, 2024 18:39
34573.204	Jun 03, 2024 18:25:09 Mon	B2D	45.3 ± 2.3	2.0 ± 4.1	0.38 ± 0.11	sweep	100.22	V1	55/9/56	47,004,164	db	—	v2.2.10M	Jun 03, 2024 18:26
34573.302	Jun 03, 2024 16:25:25 Mon	Y2U	55.3 ± 2.7	5.0 ± 2.8	0.26 ± 0.17	sweep	100.22	H3	56/9/55	47,588,994	db	—	v2.2.10M	Jun 03, 2024 16:37
34573.103	Jun 03, 2024 16:23:56 Mon	Y1D	50.9 ± 3.0	7.8 ± 4.7	-0.10 ± 0.13	sweep	100.22	V3	56/9/55	28,474,582	db	—	v2.2.10M	Jun 03, 2024 16:25
34573.002	Jun 03, 2024 16:22:18 Mon	B1U	41.4 ± 2.9	-3.9 ± 4.1	0.49 ± 0.27	sweep	100.22	H3	55/9/56	43,036,591	db	—	v2.2.10M	Jun 03, 2024 16:35
34573.203	Jun 03, 2024 16:21:18 Mon	B2D	47.4 ± 2.4	8.8 ± 4.0	0.13 ± 0.10	sweep	100.22	V1	55/9/56	44,580,532	db	—	v2.2.10M	Jun 03, 2024 16:22
34573.301	Jun 03, 2024 12:49:00 Mon	Y2U	55.6 ± 2.8	4.2 ± 2.9	0.13 ± 0.14	sweep	100.22	H3	56/9/55	41,656,282	db	—	v2.2.10M	Jun 03, 2024 13:01
34573.102	Jun 03, 2024 12:48:11 Mon	Y1D	52.5 ± 2.5	4.6 ± 3.9	0.02 ± 0.11	sweep	100.22	V3	56/9/55	38,807,073	db	—	v2.2.10M	Jun 03, 2024 12:49
34573.001	Jun 03, 2024 12:47:23 Mon	B1U	49.7 ± 2.8	7.4 ± 3.2	0.10 ± 0.16	sweep	100.22	H3	55/9/56	45,041,227	db	—	v2.2.10M	Jun 03, 2024 12:55
34573.202	Jun 03, 2024 12:46:39 Mon	B2D	52.2 ± 2.1	2.2 ± 3.3	0.05 ± 0.07	sweep	100.22	V1	55/9/56	52,277,525	db	—	v2.2.10M	Jun 03, 2024 12:55
34573.201	Jun 03, 2024 12:39:10 Mon	B2D	51.4 ± 1.9	-4.7 ± 3.0	-0.00 ± 0.08	sweep	23.81	V1	55/9/56	69,119,705	db	—	v2.2.10M	Jun 03, 2024 12:40
34573.101	Jun 03, 2024	Y1D	52.7 ± 2.0	10.5 ± 3.1	0.06 ±	sweep	23.81	V3	56/9/55	54,130,650	db	—	v2.2.10M	Jun 03, 2024

Local Polarimeter

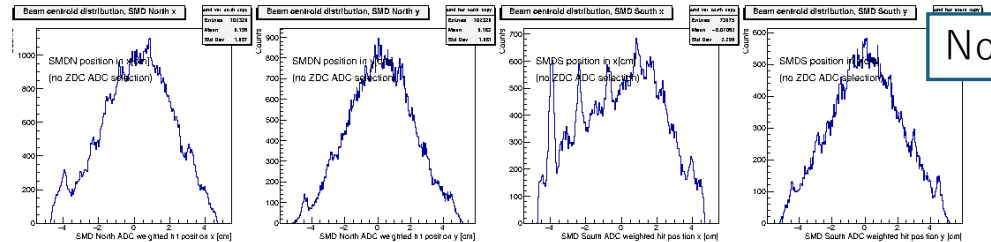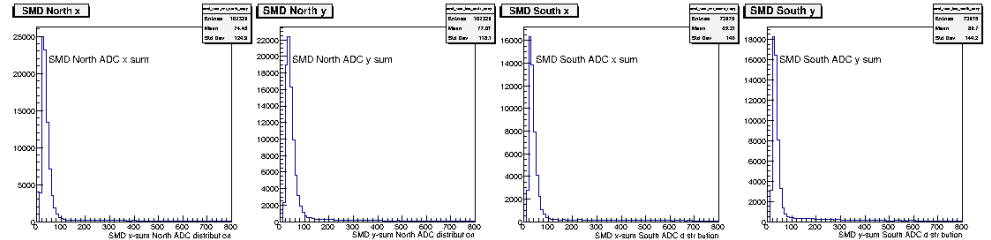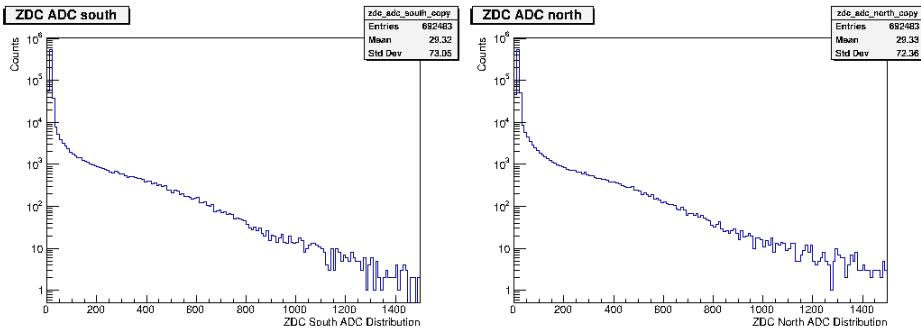# SMD Position Reconstruction

$$x = \sum_{i=1}^{7}\left(\frac{E_i x_i}{\sum E_i} - \frac{x_i}{7}\right),$$
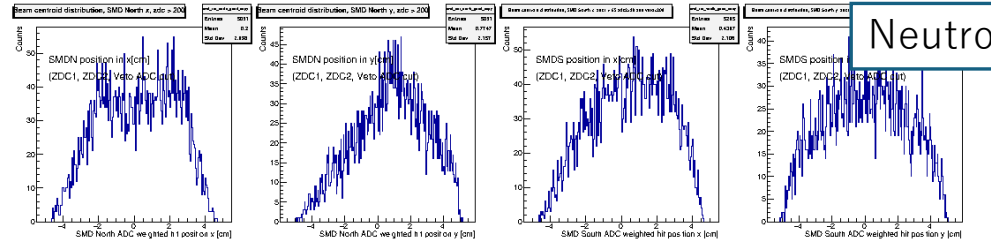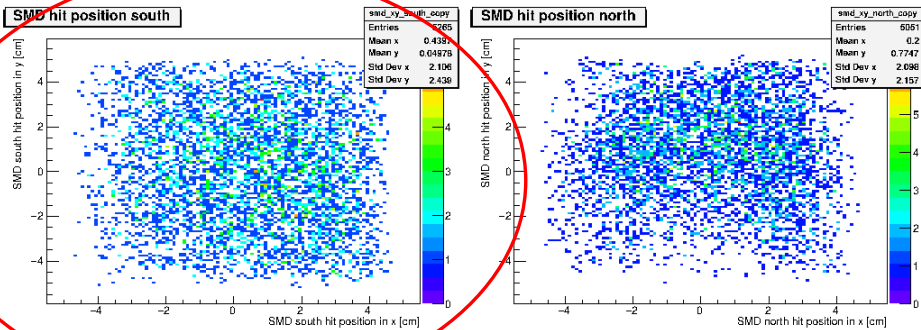
$$y = \sum_{i=1}^{8}\left(\frac{E_i y_i}{\sum E_i} - \frac{y_i}{8}\right),$$

ZdcMONDRAW_1 Run 44060, Time: Mon May 27 23:52:10 2024

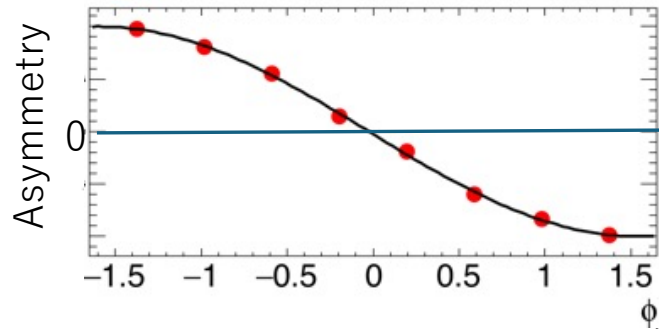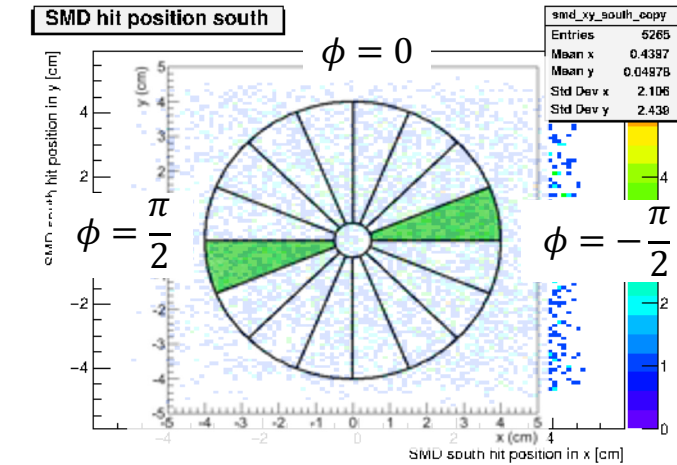**ZdcMONDRAW_4 Run 44060, Time: Mon May 27 23:52:10 2024**

No cut

Neutron cut

Reconstructed x,y profile of neutrons seems to be reasonable

25

Local Polarimeter

SMD hit position south

$\phi = 0$

$\phi = \dfrac{\pi}{2}$

$\phi = -\dfrac{\pi}{2}$

smd_xy_south_copy
Entries	5265
Mean x	0.4387
Mean y	0.04978
Std Dev x	2.106
Std Dev y	2.438

Asymmetry

- Raw asymmetry of neutron yields

$$e_N(\phi) \equiv \frac{\sqrt{N_\phi^\uparrow N_{\pi-\phi}^\downarrow} - \sqrt{N_\phi^\downarrow N_{\pi-\phi}^\uparrow}}{\sqrt{N_\phi^\uparrow N_{\pi-\phi}^\downarrow} + \sqrt{N_\phi^\downarrow N_{\pi-\phi}^\uparrow}}$$

- Normalization by polarization P
- Correction C_ϕ

$$A_N = \frac{\sqrt{\sigma_L^\uparrow \sigma_R^\downarrow} - \sqrt{\sigma_L^\downarrow \sigma_R^\uparrow}}{\sqrt{\sigma_L^\uparrow \sigma_R^\downarrow} + \sqrt{\sigma_L^\downarrow \sigma_R^\uparrow}}$$
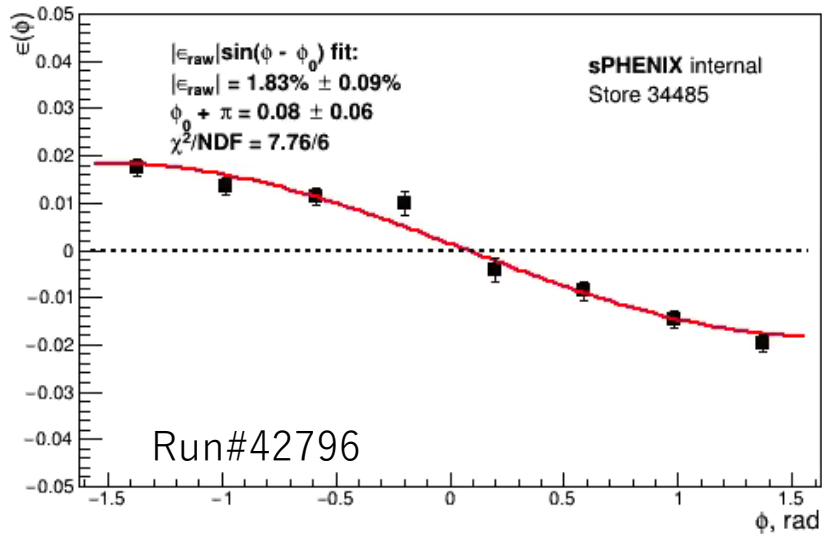
$$A_N = \frac{e_N(\phi)}{\sin(\phi - \phi_0)} \frac{1}{P}$$

Local Polarimeter

RHIC polarimeters from IP12

Observed Asymmetry

Courtesy of Devon

Square root asymmetry Blue North

$|\epsilon_{raw}|\sin(\phi - \phi_0)$ fit:
$|\epsilon_{raw}| = 1.83\% \pm 0.09\%$
$\phi_0 + \pi = 0.08 \pm 0.06$
$\chi^2/\text{NDF} = 7.76/6$

sPHENIX internal
Store 34485

Run#42796

34485.203	May 17, 2024 10:17:58 Fri	B2D	0.0 ± -100.0	0.0 ± -57.3	0.00 ± -1.00	sweep	100.22
34485.102	May 16, 2024 23:46:11 Thu	Y1D	39.6 ± 2.3	-1.3 ± 4.9	0.22 ± 0.17	sweep	100.22
34485.202	May 16, 2024 23:44:16 Thu	B2D	33.0 ± 2.5	3.0 ± 4.4	0.87 ± 0.44	sweep	100.22

P~33% 8hours ago
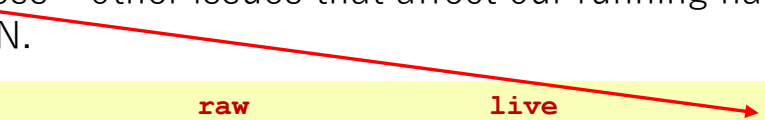
$$A_N = \frac{e_N(\phi)}{\sin(\phi - \phi_0)}\frac{1}{P}$$

0 rad.

~33%

$$A_N = \frac{1.83}{0.33} \sim 0.054$$

Consistent!

PHENIX, PRD 88, 032006 (2013)
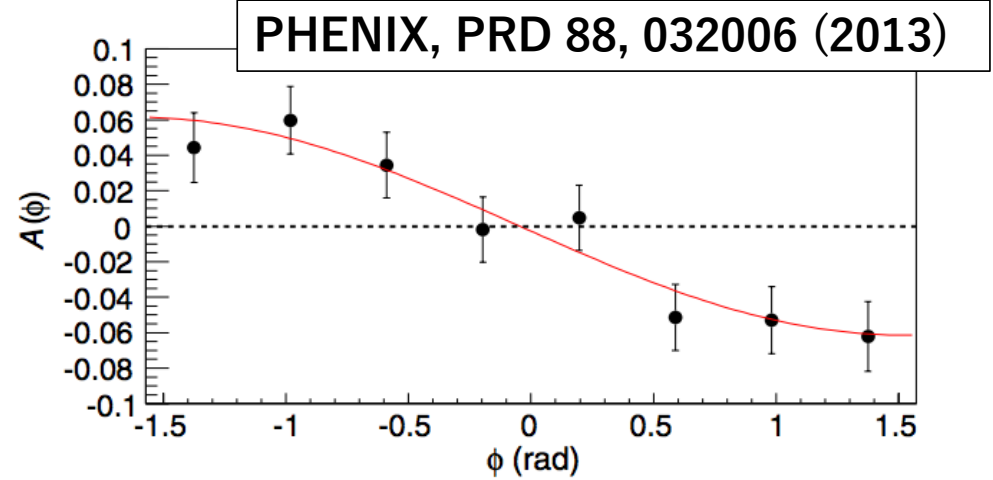
GL1-p Scalers

Still work in progress – other issues that affect our running have slightly higher priority. RSN.

Gl1P #	raw	live	scaled
0	446	376	19088743
1	531	438	19088743
2	446	376	19088743
3	31	26	19088743
4	338	279	19088743
5	145422	123440	19088743
6	0	0	19088743
7	0	0	19088743
8	5866	5001	19088743
9	3604	3088	19088743
10	2184	1885	19088743
11	1132	992	19088743
12	585	522	19088743
13	1415	1226	19088743
14	1941	1628	19088743
15	310	276	19088743

The scaled counter has just implanted in the GTM firmware version 66 today.

Summary

- Overall, the detectors are taking physics data except for TPC while developing rare triggers.

- The TPC is still a lot to overcome before joining to the BigPartion together with other detectors.

- We observed the first asymmetry in sPHENIX local polarimeter last Tuesday.

- GL1p scalers are almost ready. To be checked.

- sPHENIX is ready for pp spin data once GL1p scalers working.