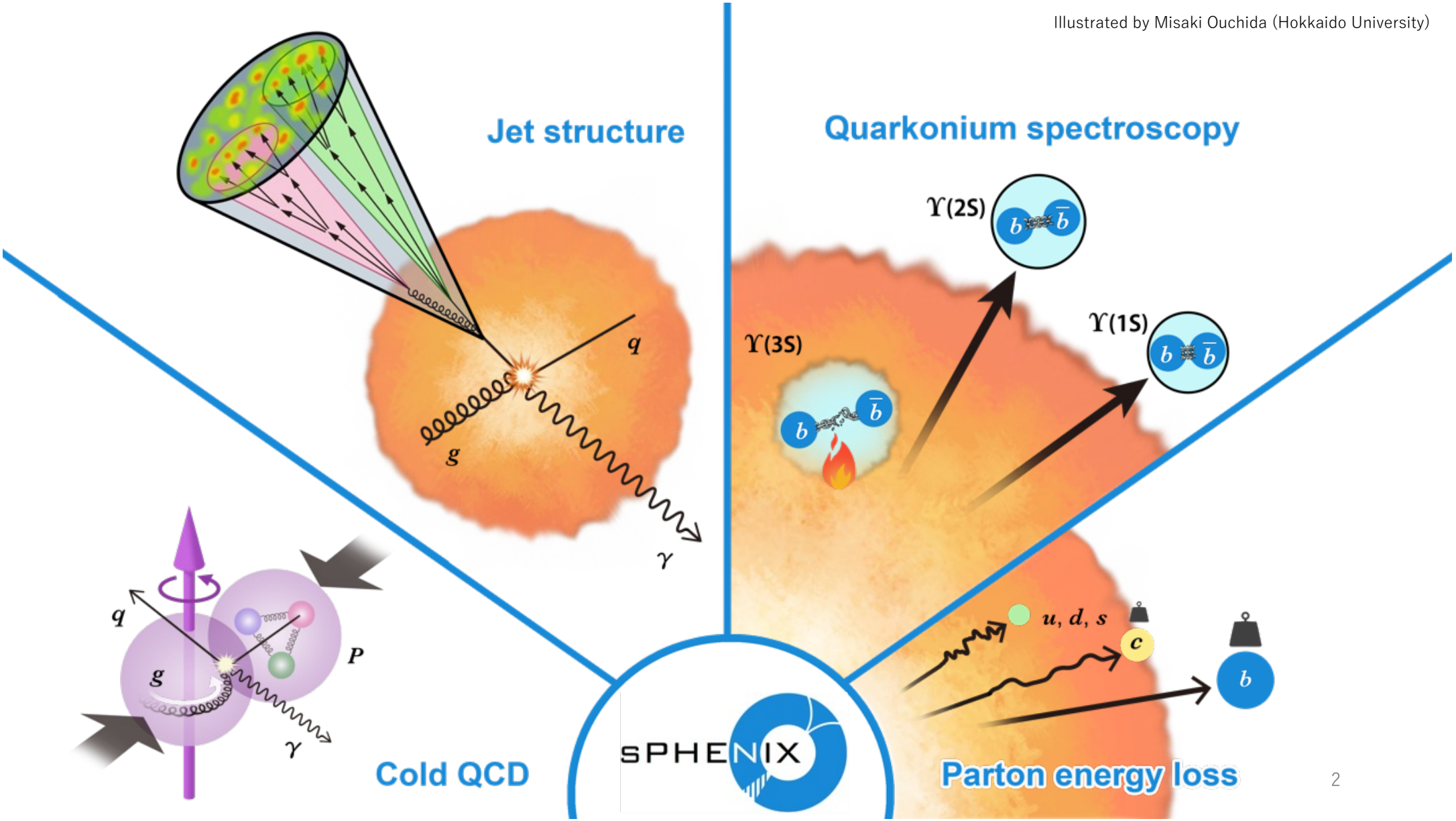
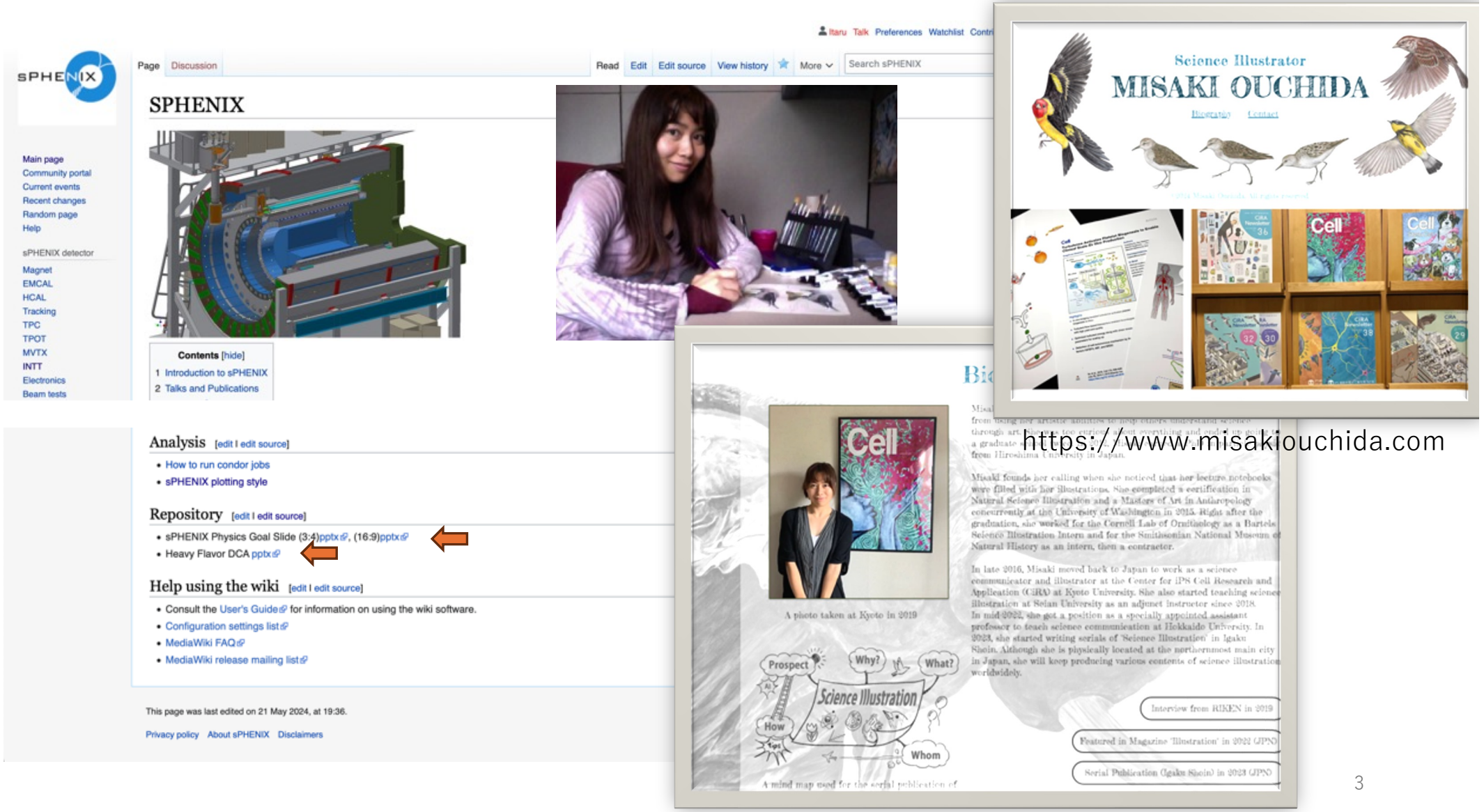
Spin Coordinator Update

RIKEN/RBRC
Itaru Nakagawa
On Behalf of
sPHENIX Cold-QCD Group

Illustrated by Misaki Ouchida (Hokkaido University)



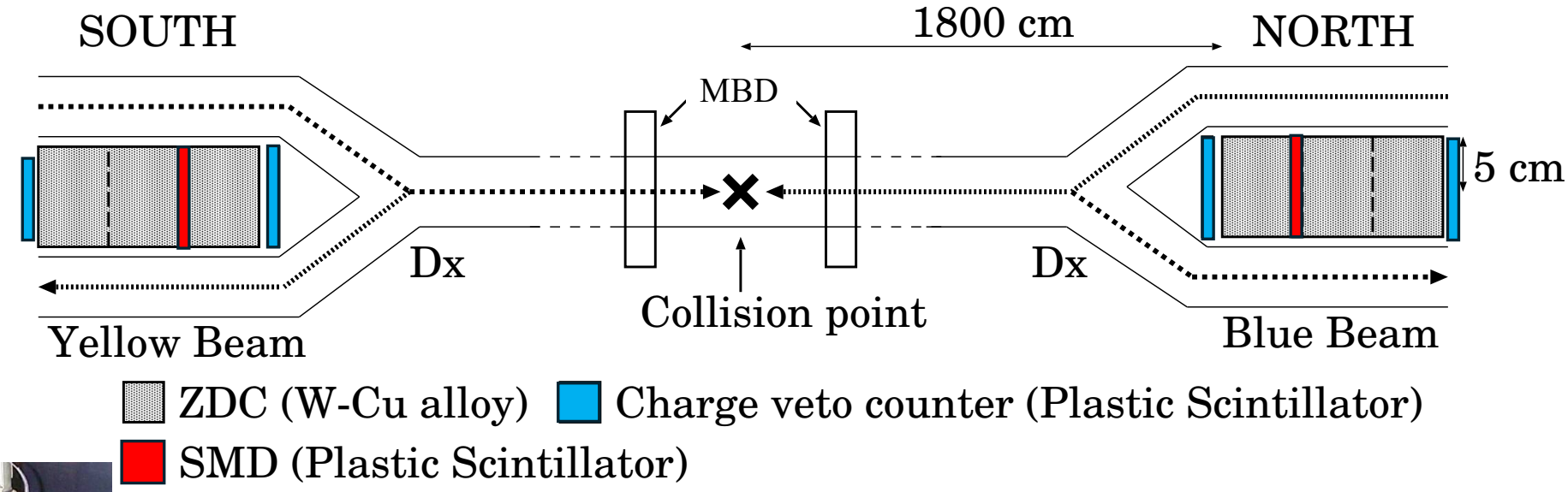


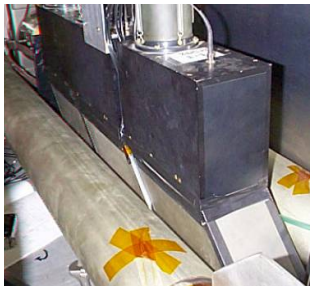
https://www.misakiouchida.com

Spin Tasks Present Status at a Glance

Item		Hardware/Firmware	Testing	Software
SMD	North	• Module Installation ✓ • Cabling ✓ • Channel Mapping/Labeling ✓	• Run23 beam data ✓ • Half of SMD OK ✓ • Scope Check ✓ • ~~Cosmic rcdaq~~	• Online monitor ✓ • Offline asymmetry analysis code ✓
	South	• Module Installation ✓ • Cabling ✓ • Channel Mapping/Labeling ✓	• Scope Check ✓ • ~~Cosmic rcdaq~~	
	Scaler	• ADC digitizer/LL1/GL1p Firmware		LocalPol Online monitor to be developed using Run23 data
Veto		• Power Supply Installation ✓ • Cabling ✓ • Differential Module ✓ • Channel Mapping ✓	• Signal Check ✓	• Online monitor ✓ • Offline analysis code ✓ • Neutron cut optimization ✓
Relative Luminosity		• GL1p firmware (version 1.0 by Joe)	• Testing by Martin • Testing by Cold-QCD group.	Spin online monitor to be developed with test data
Spin Pattern Recording				http-based delivery from CAD and saved in the spin database ✓ (Used to be broad casted via V124)
Vernier Scan (1st attempt of the scan at 2mrad crossing)		• GL1p firmware		Analysis code development using PHENIX data?

Detector for Spin : Shower Max Detector (SMD)



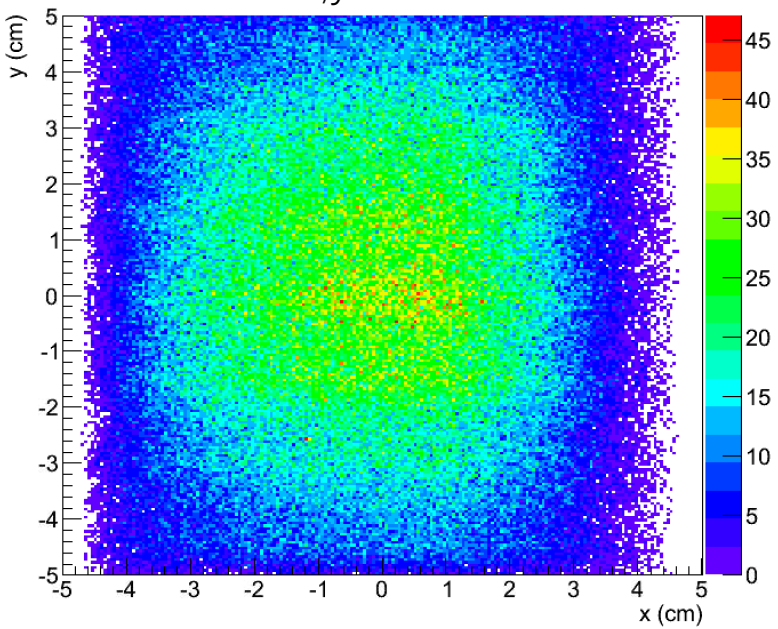


Run23 : only **ZDC** was operated
Run24 : **ZDC+SMD+Veto** are under operation

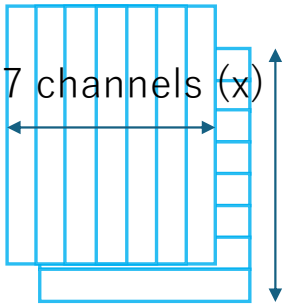
SMD Detectors Back in Operation

- X-Y plastic strip scintillator hodoscopes ($\Delta x, \Delta y \sim 1$ cm)
- $x, y = \frac{\sum_i^{\#SMD} E(i) \times pos(i)}{\sum_i^{\#SMD} E(i)}$

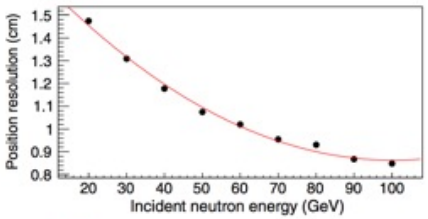
Reconstructed x,y Position of Neutrons

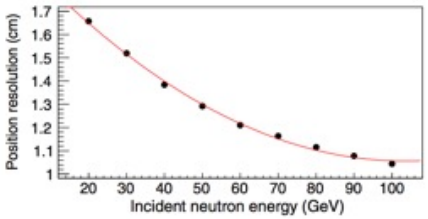


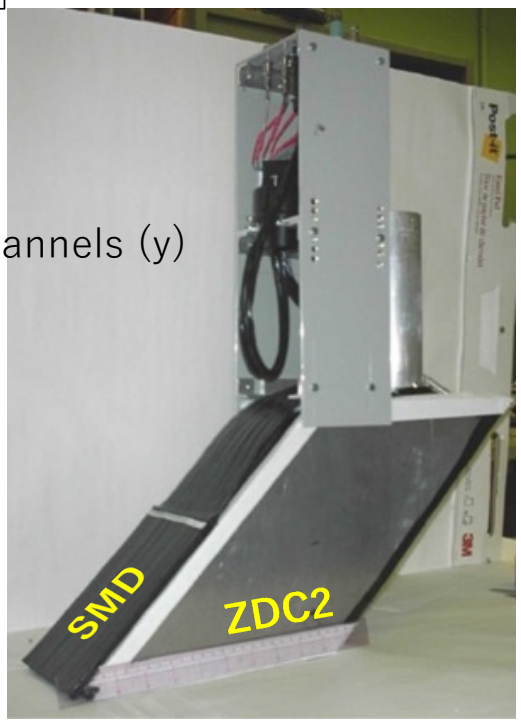
11 cm x 17 cm
Tilted by 45°



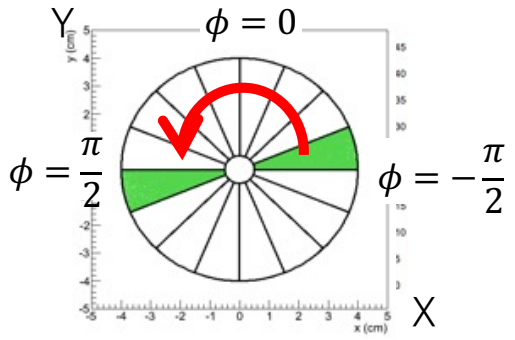
SMD Scintillator Paddles

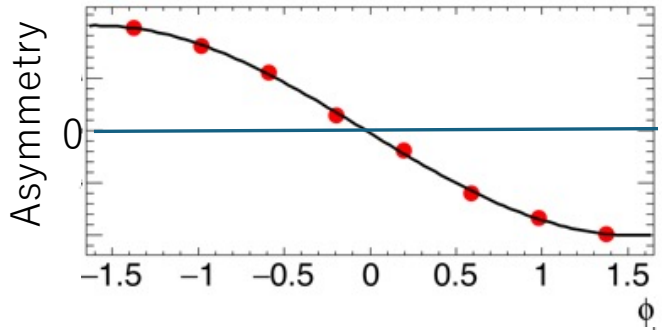






Local Polarimeter





- 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

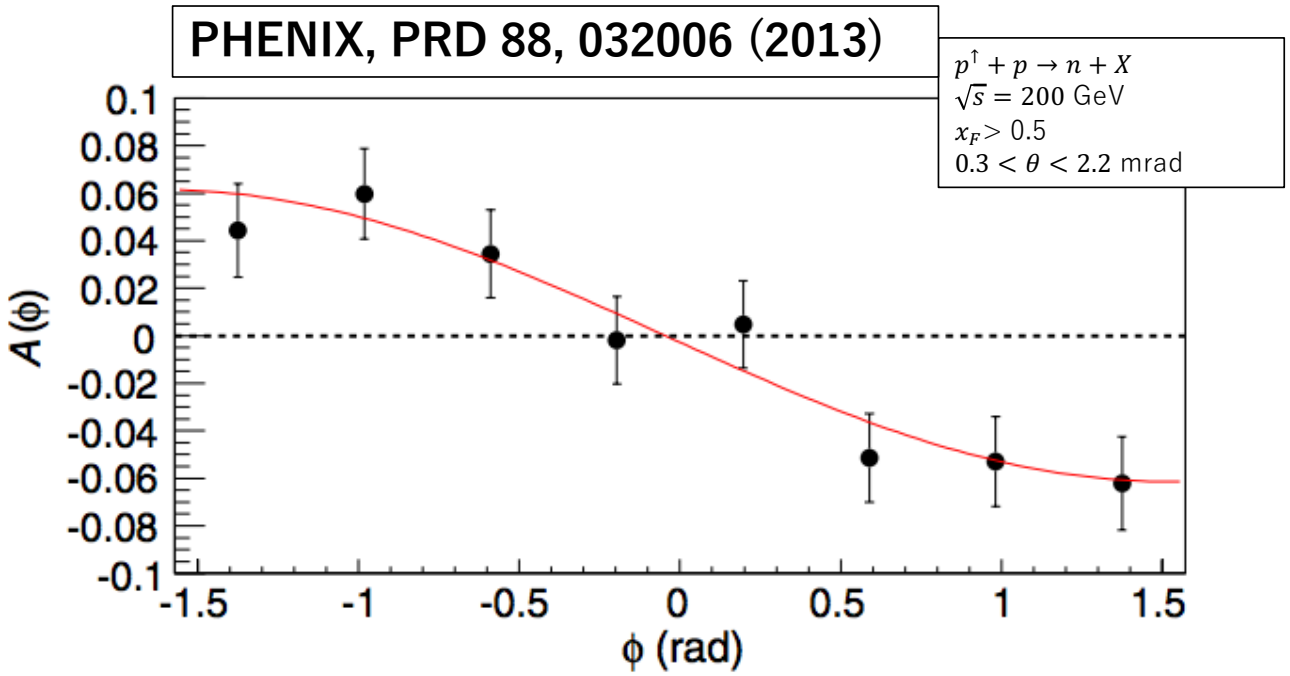
$$A_N = \frac{\sqrt{\sigma_L^\uparrow \sigma_R^\downarrow} - \sqrt{\sigma_L^\downarrow \sigma_R^\uparrow}}{\sqrt{\sigma_L^\uparrow \sigma_R^\downarrow} + \sqrt{\sigma_L^\downarrow \sigma_R^\uparrow}}$$

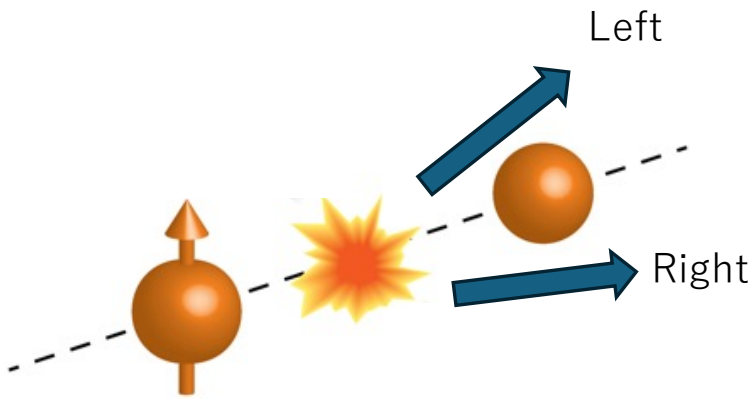
$$A_N = \frac{e_N(\phi)}{\sin(\phi - \phi_0)} \frac{1}{C_\phi} \frac{1}{P}$$

Local Polarimeter

RHIC polarimeters from IP12

Forward Neutron Asymmetry

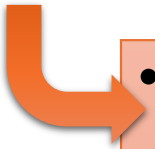




Known to be ~5% Left-Right Asymmetry at 200 GeV

Preparation for Spin Experiment at sPEHNIX

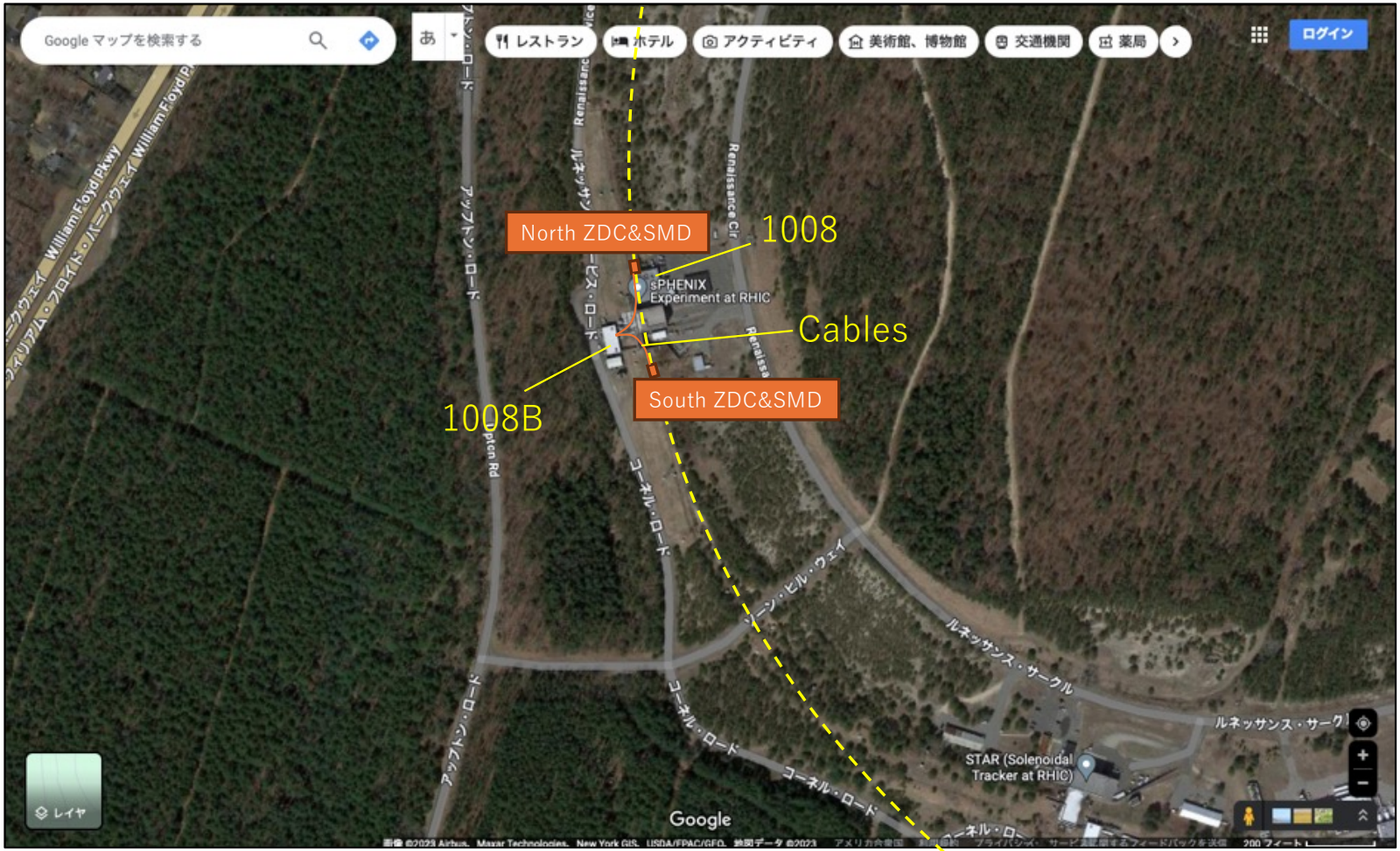
- The last polarized p+p run in PHENIX was 2016.
- SMD was operated at least every other year.
- Readout electronics for ZDC/SMD/Veto used to be in 1008.



- Restore SMD/Veto after 8 years. No guarantee they functions as they used to be due to aging and radiation damage.
- Readout electronics for ZDC/SMD/Veto are new and in new location, 1008B.
- All software have to be developed from scratch.
- Operating condition needs to be optimized again.

1008B Building

ZDC/SMD Electronics are implemented in 1008B



Building 1008B

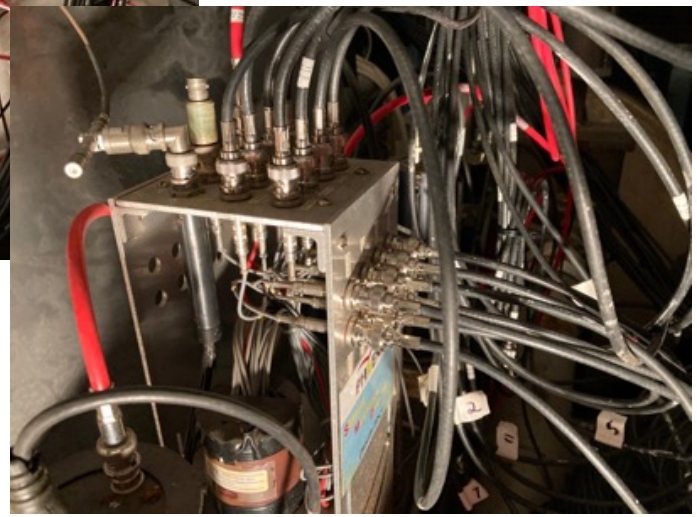
1008

1008B

Run24 Spin Preparation

Devon Loomis from Michigan State U.

John Haggerty



Run24 Spin Preparation @ onsite

- Cheng-Wei Shih (NCU)
- Jaein Hwang (Korea U.)
- T. Kikuchi (Rikkyo/RIKEN)

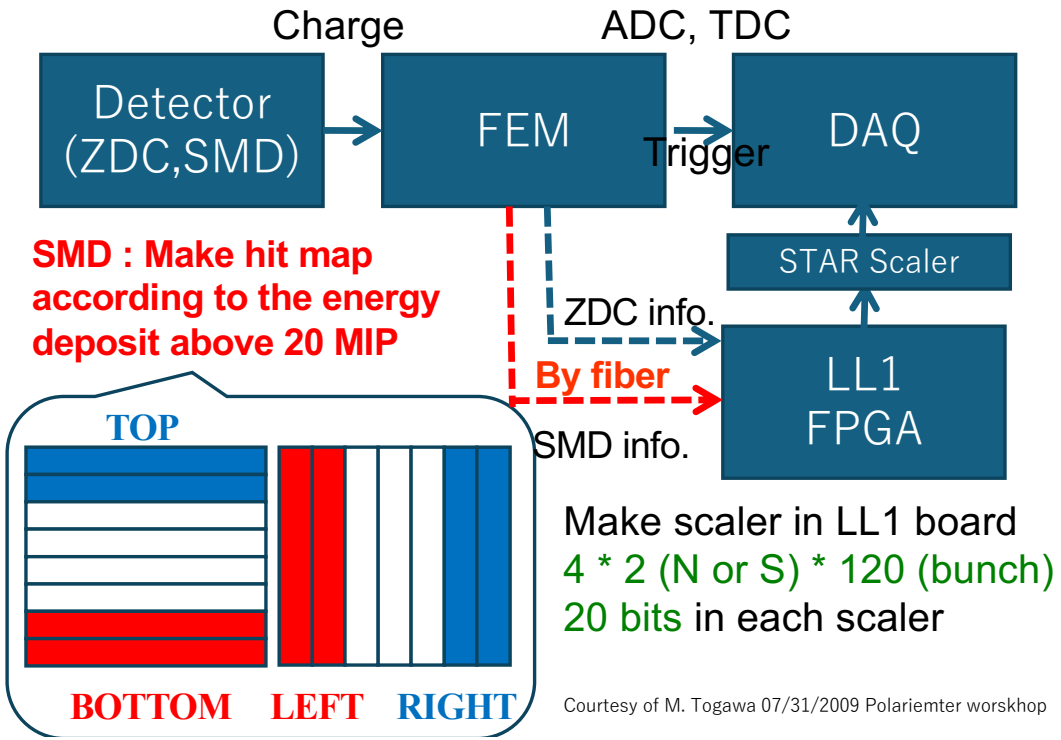
Thanks to Sean for help

R. Sidle (RIKEN)
C. Riedl (UIUC)

- A. Vijayakumar (UIUC)
- G. Mattson (UIUC)
- V. Andrieux (UIUC)
- D. Neff (Saclay)
- A. Francisco (Saclay)
- M. Garcia (Michigan)

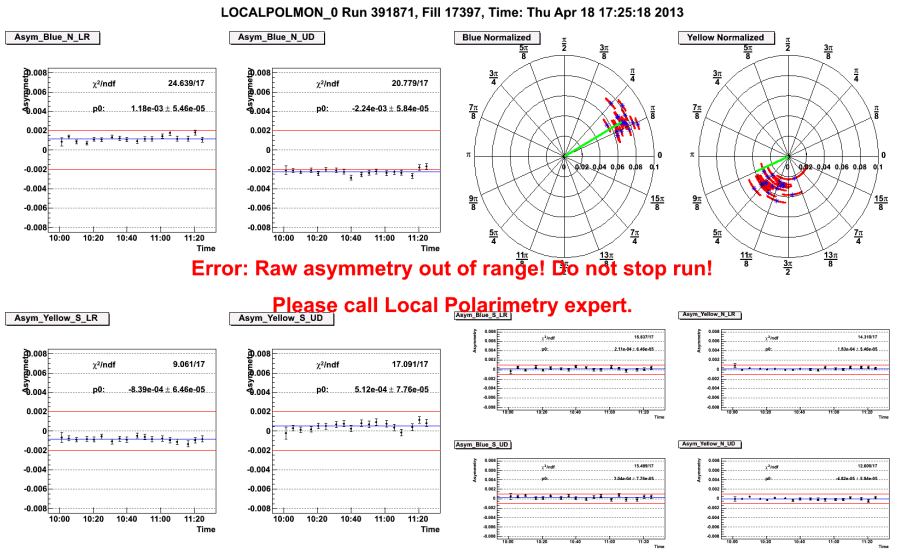
Local polarimeter scaler @ PHENIX

- Scaler mode improves,
  - ☹ Human resource. (during commissioning time, waiting for beam at CH)
    - Also offline analysis is slow operation
  - ☹ Occupation of PHENIX DAQ band
    - During physics data taking, it is only 100-200 Hz



Make scaler in LL1 board
4 * 2 (N or S) * 120 (bunch)
20 bits in each scaler

Courtesy of M. Togawa 07/31/2009 Polariemter worskhop

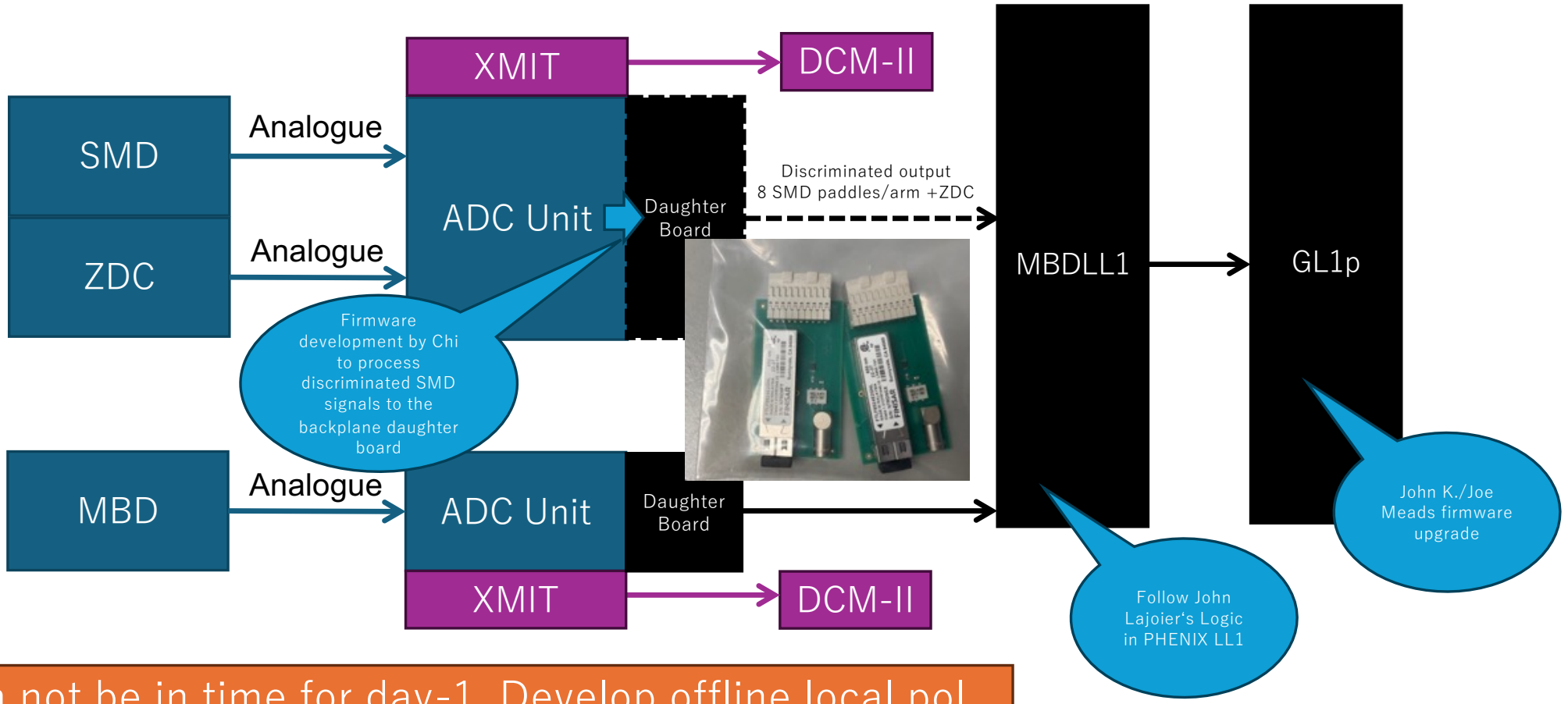


PHENIX Local Polarimter Online Monitor

SMD Scaler Proposed Schematics for sPHENIX

To be installed

The concept is to use existing calorimeter/MBD LL1 trigger scheme for SMD scalers so that only firmware to be developed and no hardware.

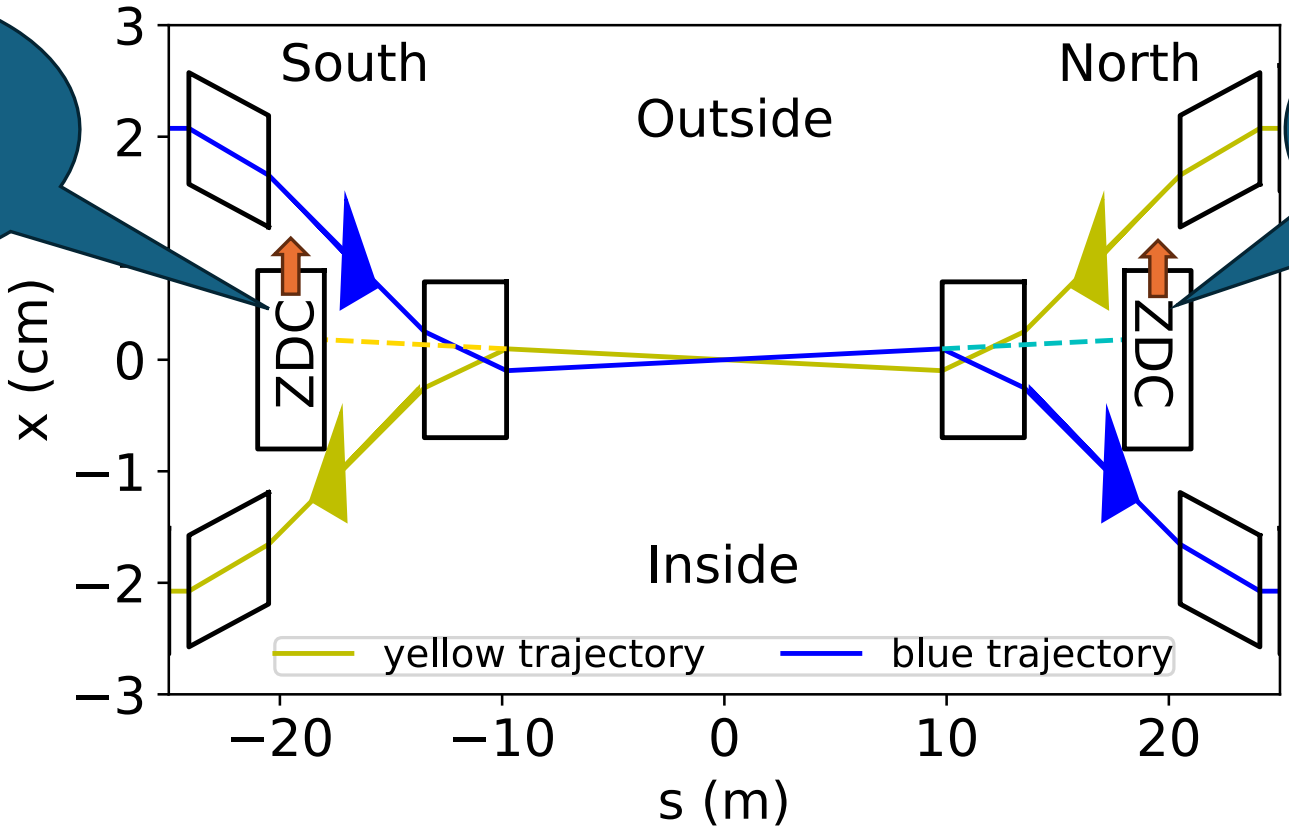


Can not be in time for day-1. Develop offline local pol.

2mrad Beam Opening Angle

Crossing Angle Effect for Spin

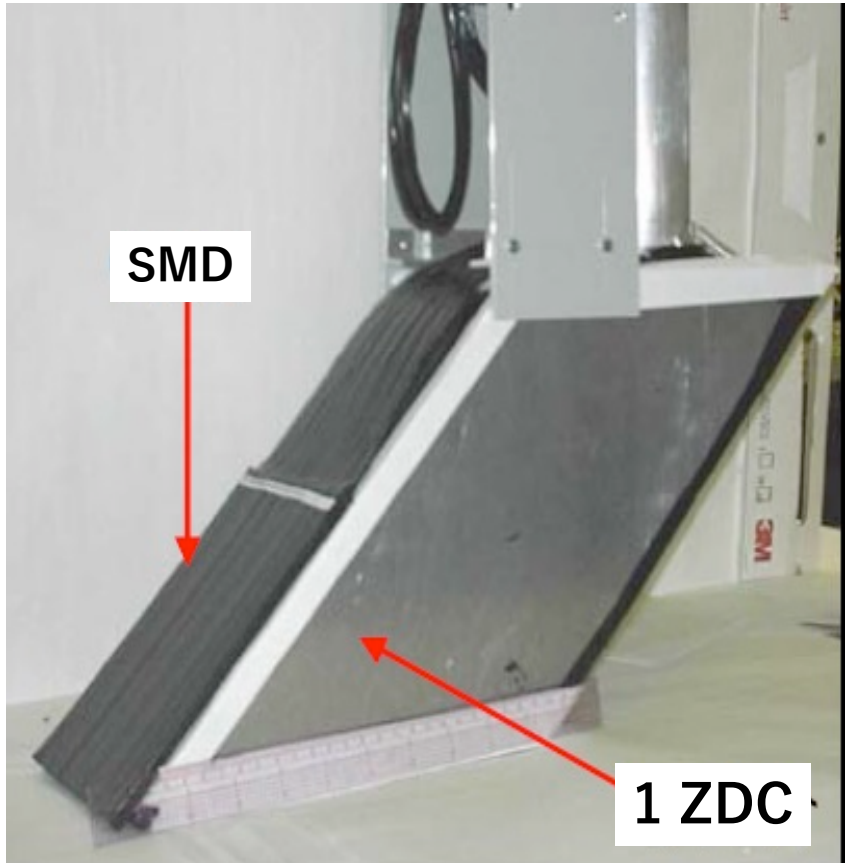
South ZDC is to be moved towards blue beam by 1.8cm

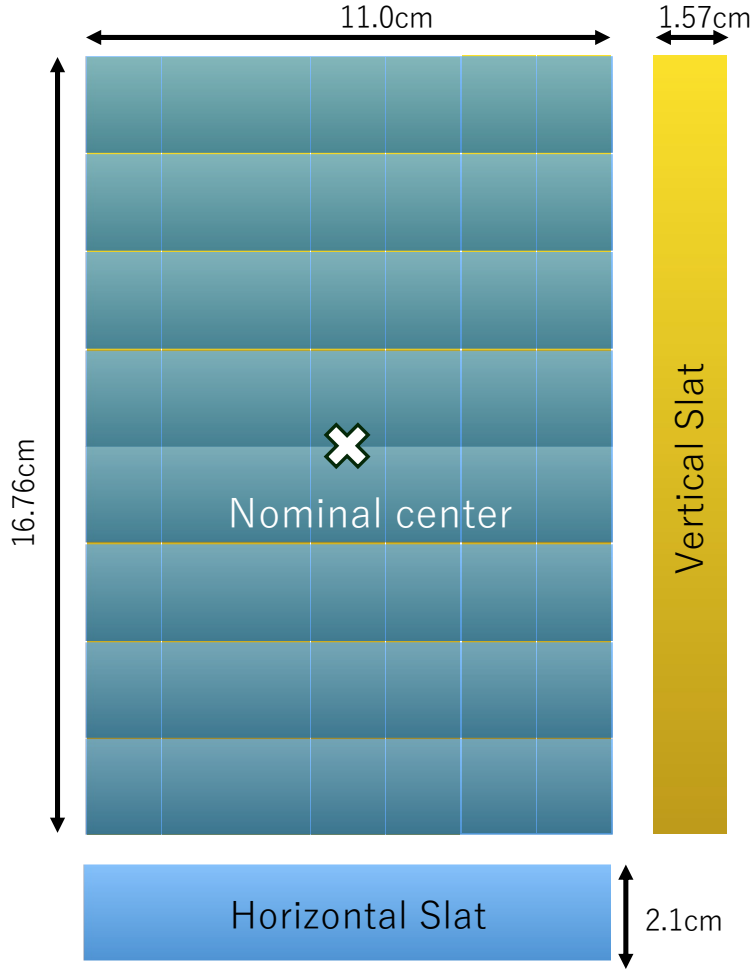


North ZDC is to be moved towards yellow beam by 1.8cm

SMD Paddles

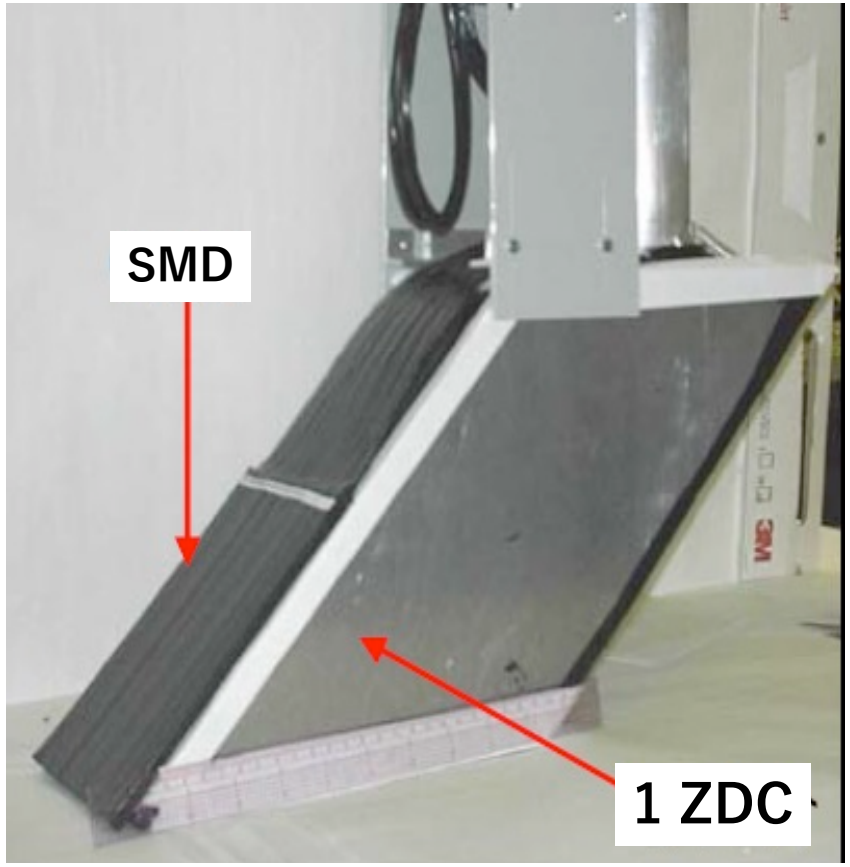
Segments : 8 Horizontal x 7 Vertical

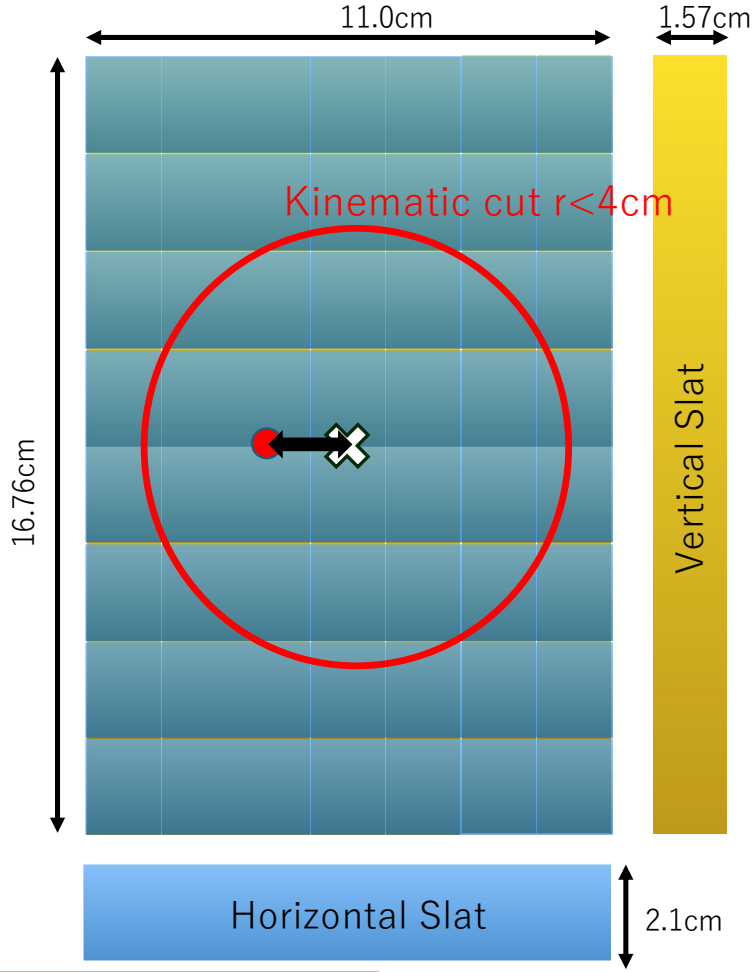




SMD Paddles

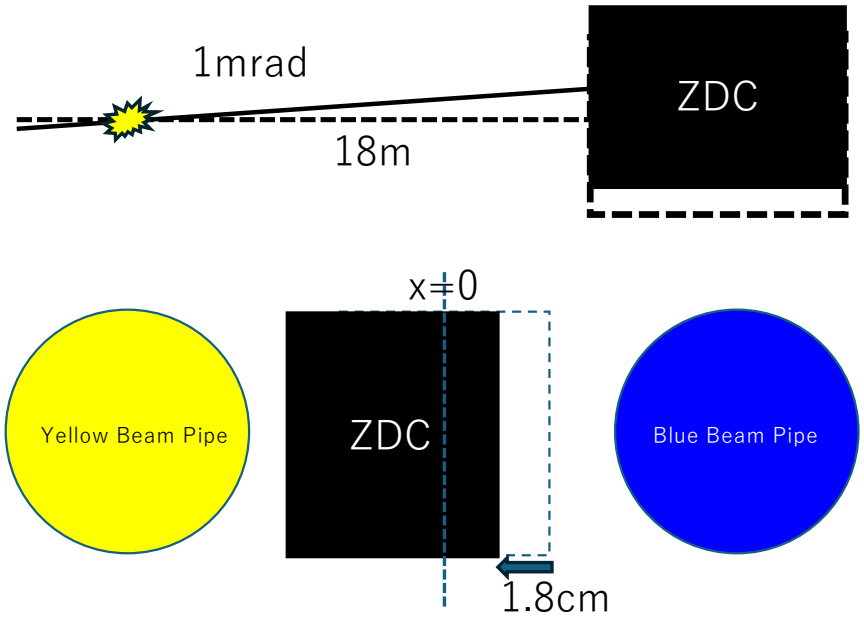
Segments : 8 Horizontal x 7 Vertical





1.8 cm off centered neutron position is severe in terms of limited fiducial volume

Beam Angle Dependence of Horizontal Neutron Beam Center



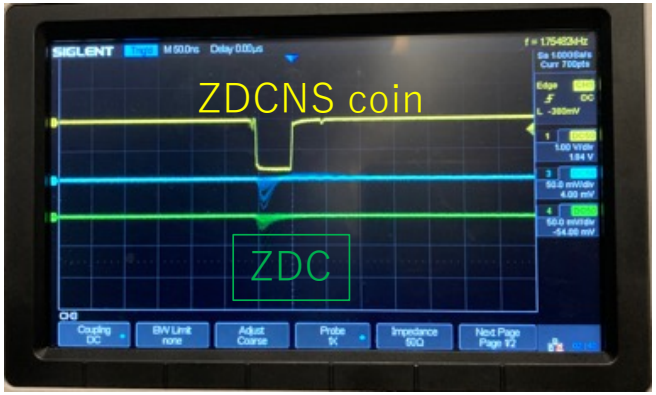
ZDC was moved to 1.8cm toward outer side of the ring before Run24 so that zero degree neutron suppose to be landed at the center of ZDC

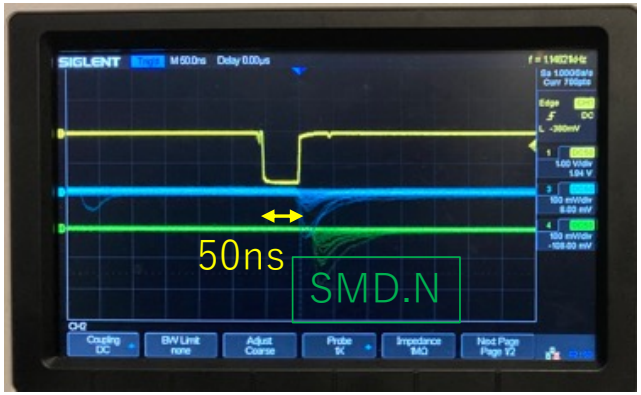
Beam Commissioning

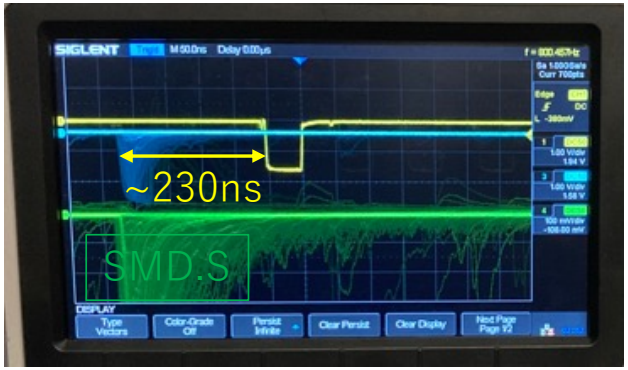
1. Signal Timing
2. Online Monitors
3. Offline Local Polarimeter Analysis

ZDC/SMD Signal Cable Length Measurement

	Length [feet]	Length [m]	Transmission Time [ns]	Relative to ZDC
ZDC	460	140	700	0
SMD.N	490	150	750	+50ns (+2.8)
SMD.S	320	98	488	-212ns (-11.9)



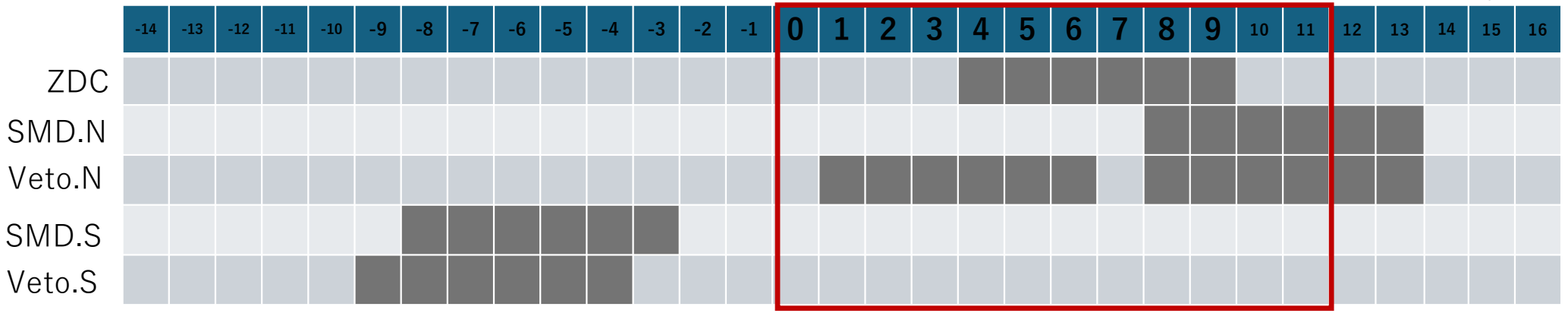




The cable length are different between ZDC vs. SMDN and SMDS. Observed signal timing are consistent with the cable length measurement.

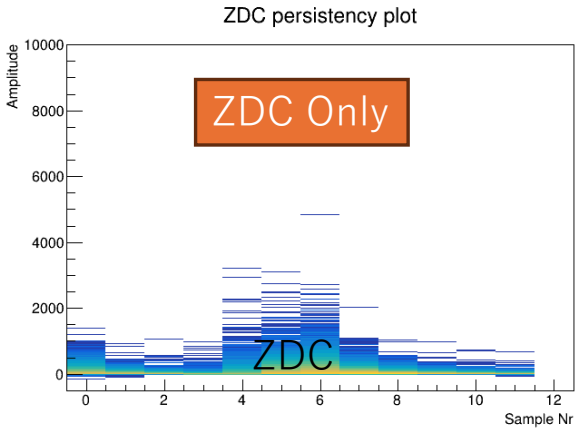
ZDC/SMD/Veto Signal Timing w.r.t ADC Sampling range

17.8ns/unit

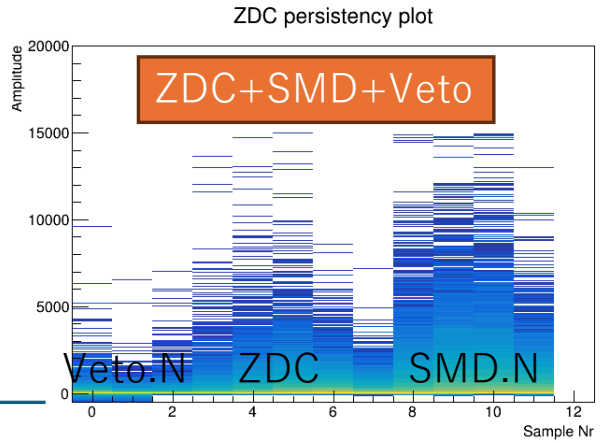


Current ADC Sampling Range (12ticks)

Need to Expanded ADC Sampling Range (28ticks)

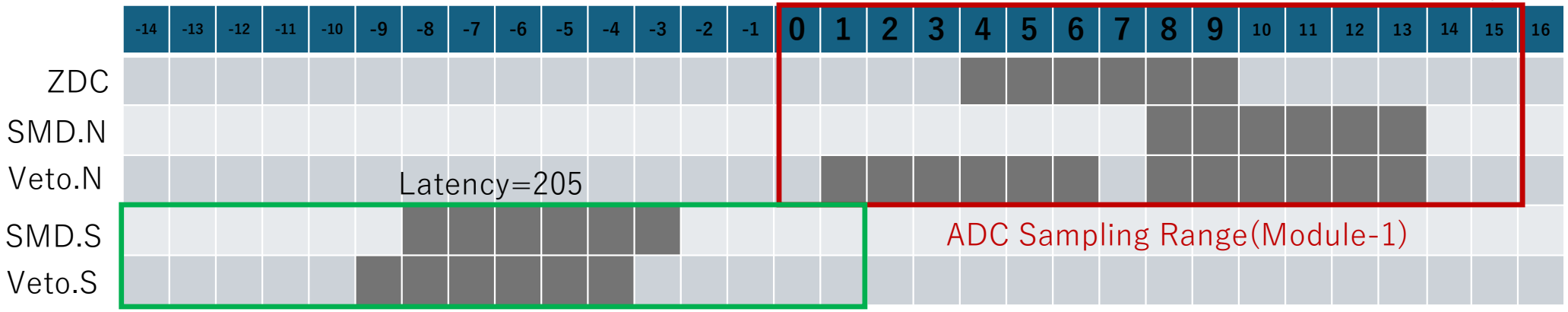


SMD.S signal is way ahead of sampling range

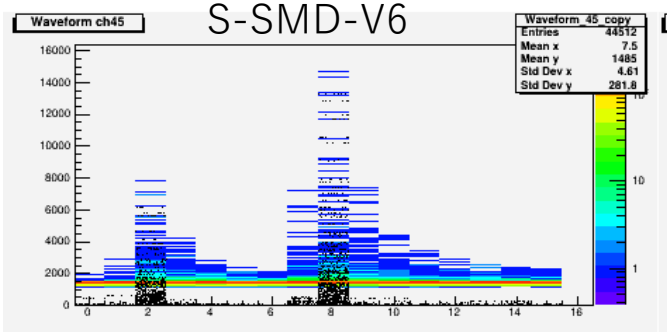


ZDC/SMD/Veto Signal Timing w.r.t ADC Sampling range

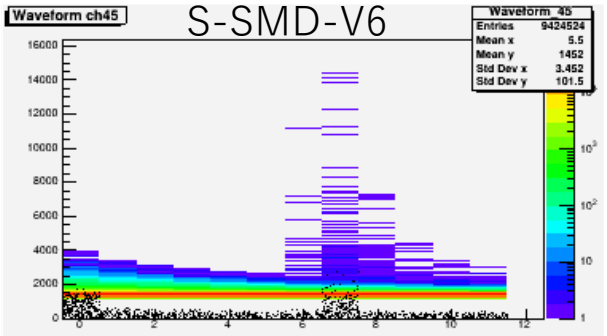
17.8ns/unit



ADC Sampling Range(Module-2)



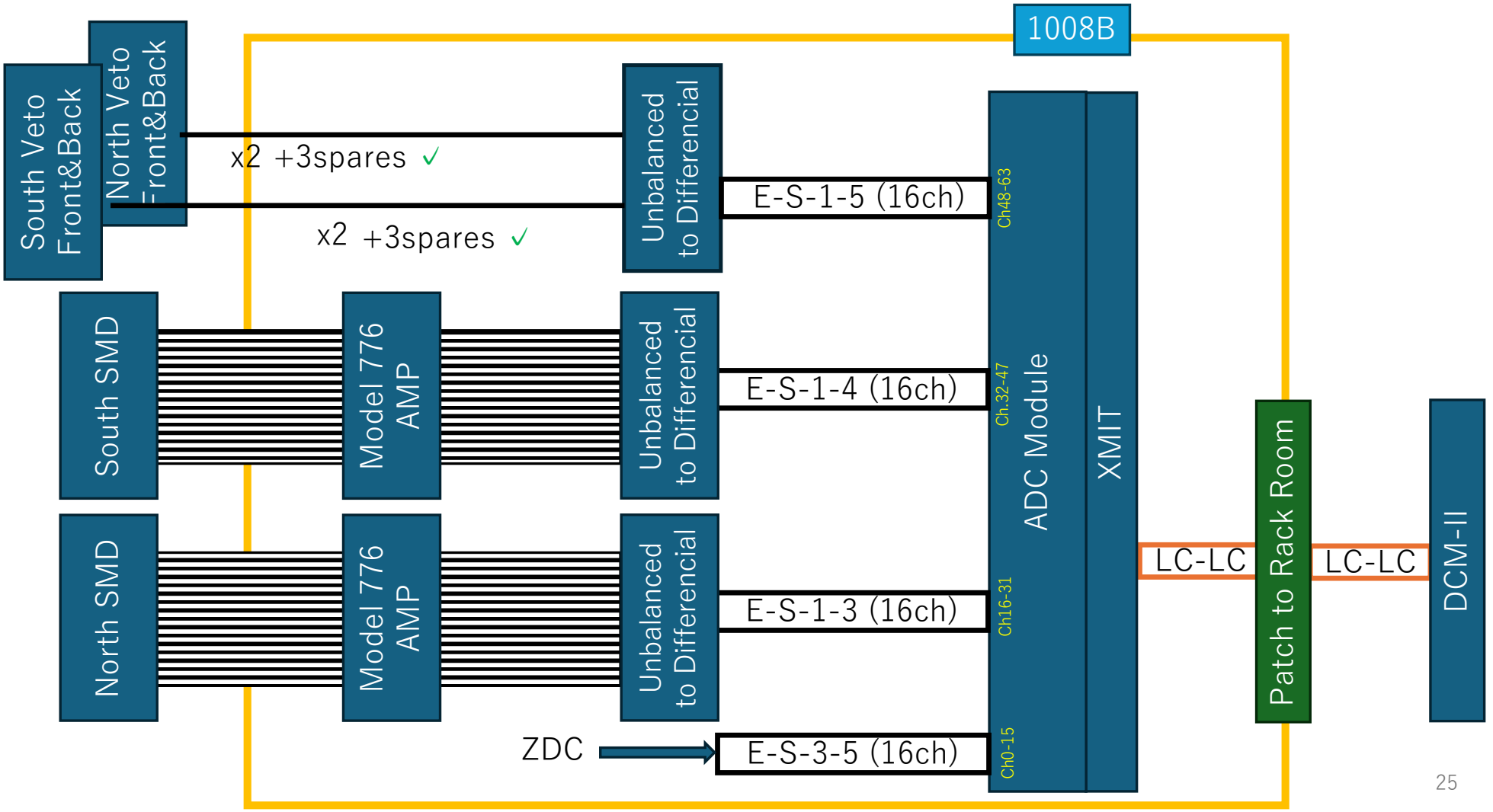
Run#41262 (Latency=205)



Run#4 (Latency=193)

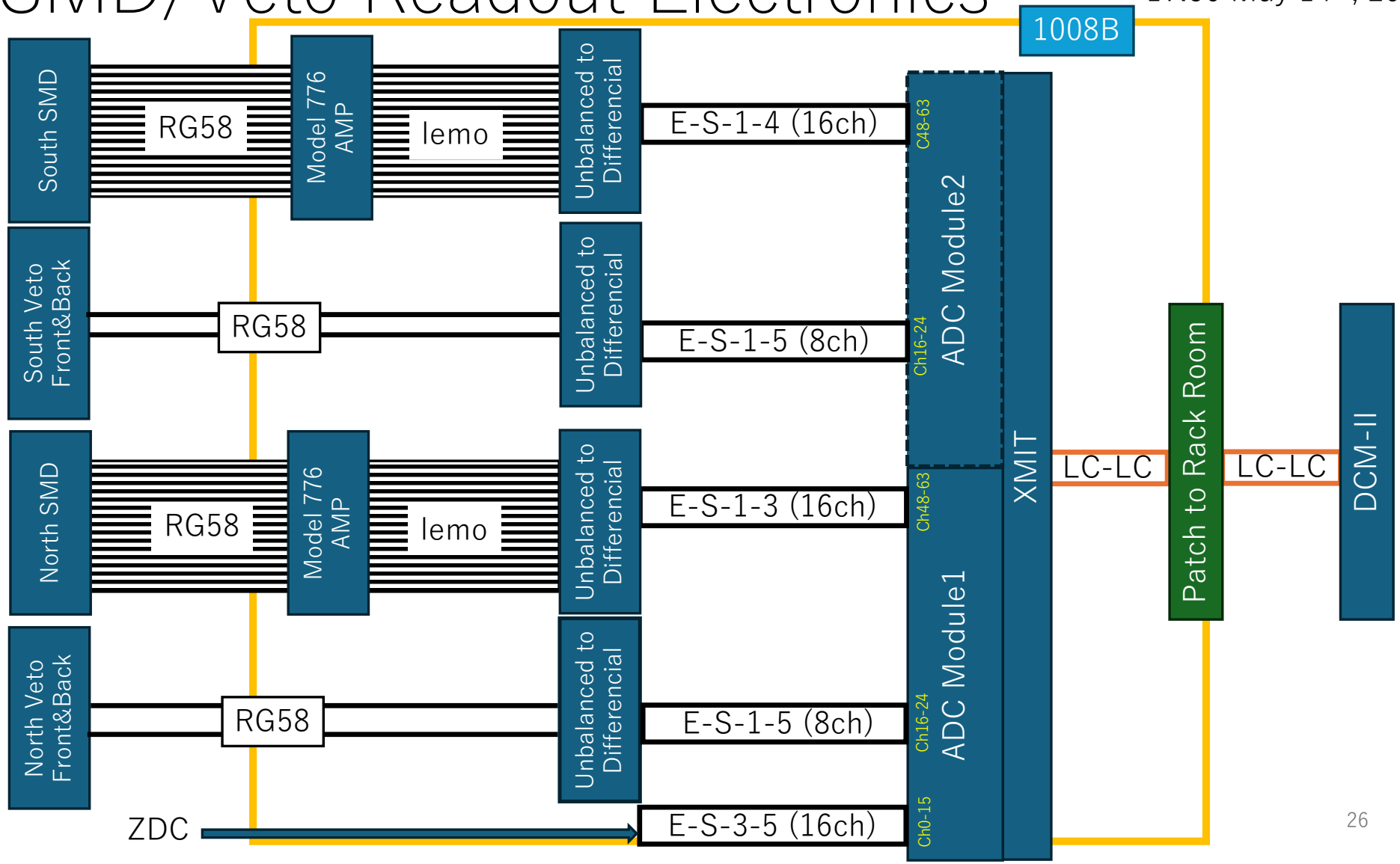
SMD/Veto Readout Electronics

~17:50 May 14th, 2024



SMD/Veto Readout Electronics

17:50 May 14th, 2024 ~

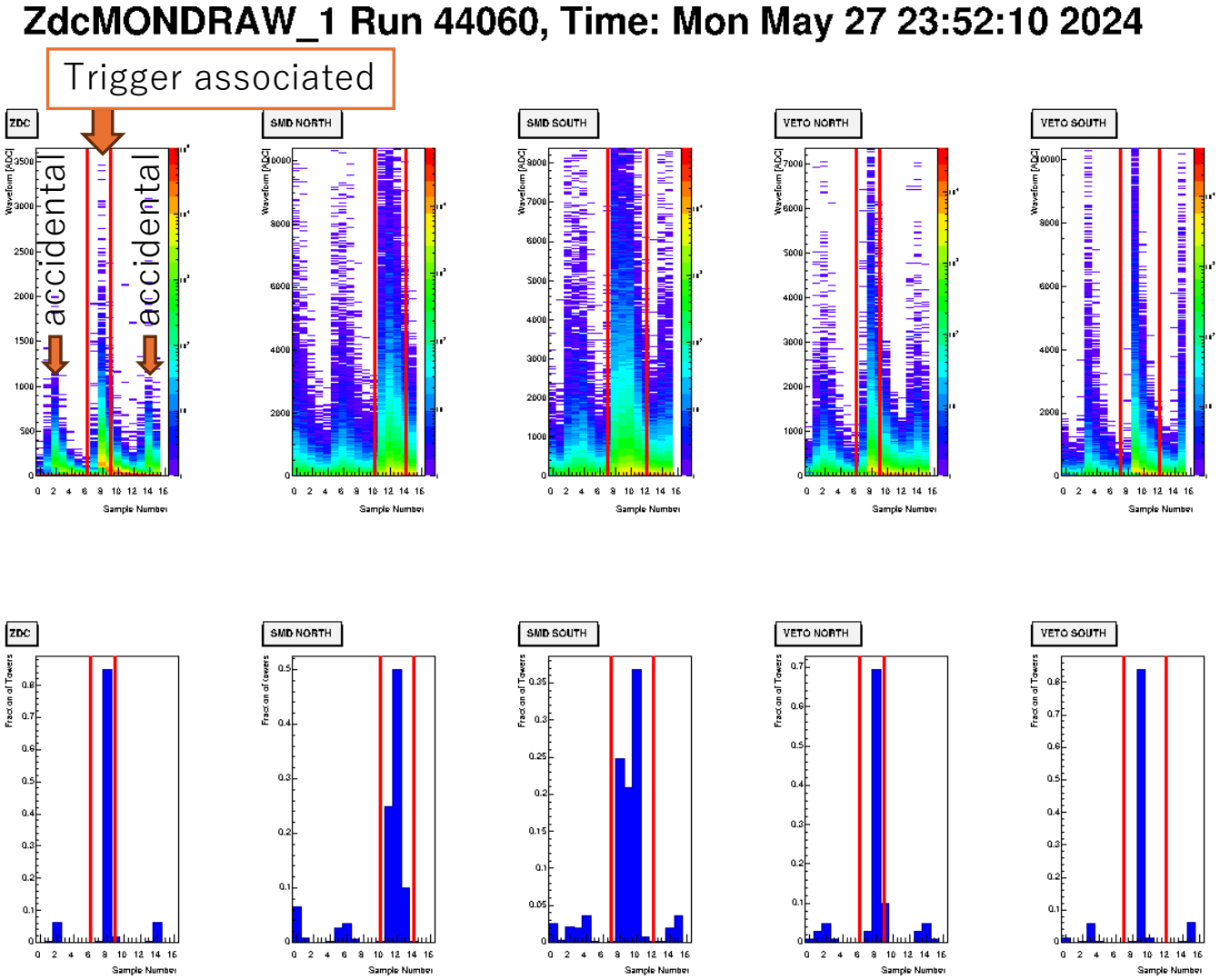


Online Monitor

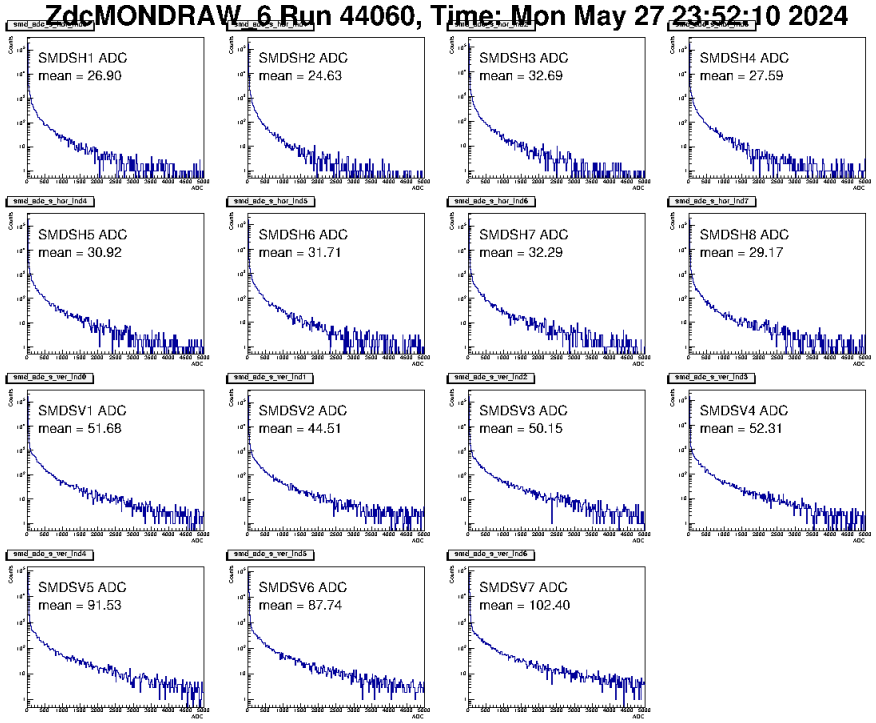
Work Done by

- M. Garcia, D. Loomis (Michigan)
- E. Umaka (BNL)
- V. Andrieux (UIUC)

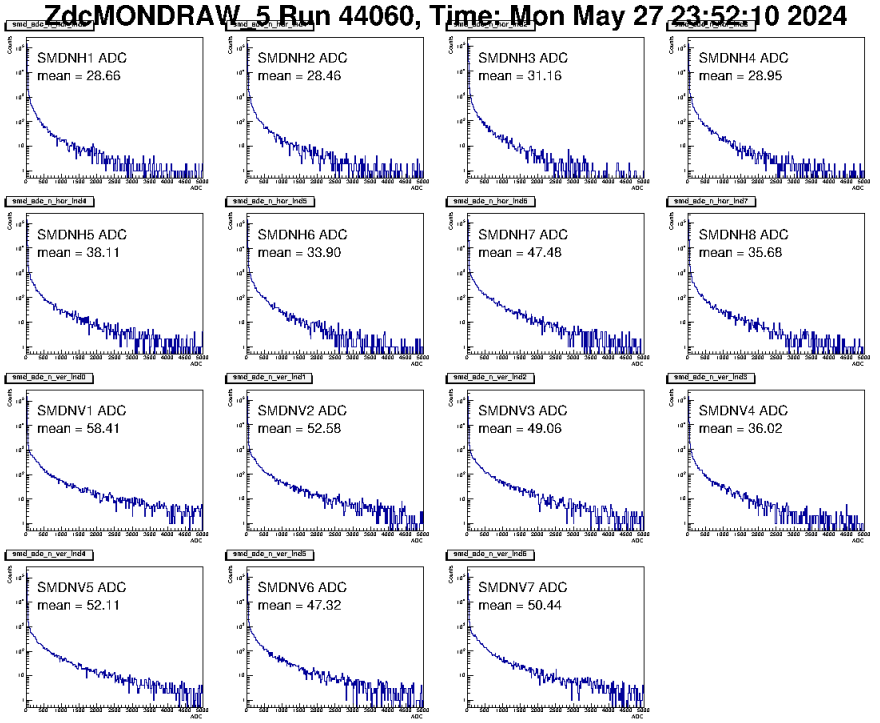
WaveForm


ZdcMONDRAW_1 Run 44060, Time: Mon May 27 23:52:10 2024
Trigger associated
accidental
accidental
ZDC
SMD NORTH
SMD SOUTH
VETO NORTH
VETO SOUTH
Waveform [ADC]
Fraction of Towers
Sample Number

SMD ADC Spectra



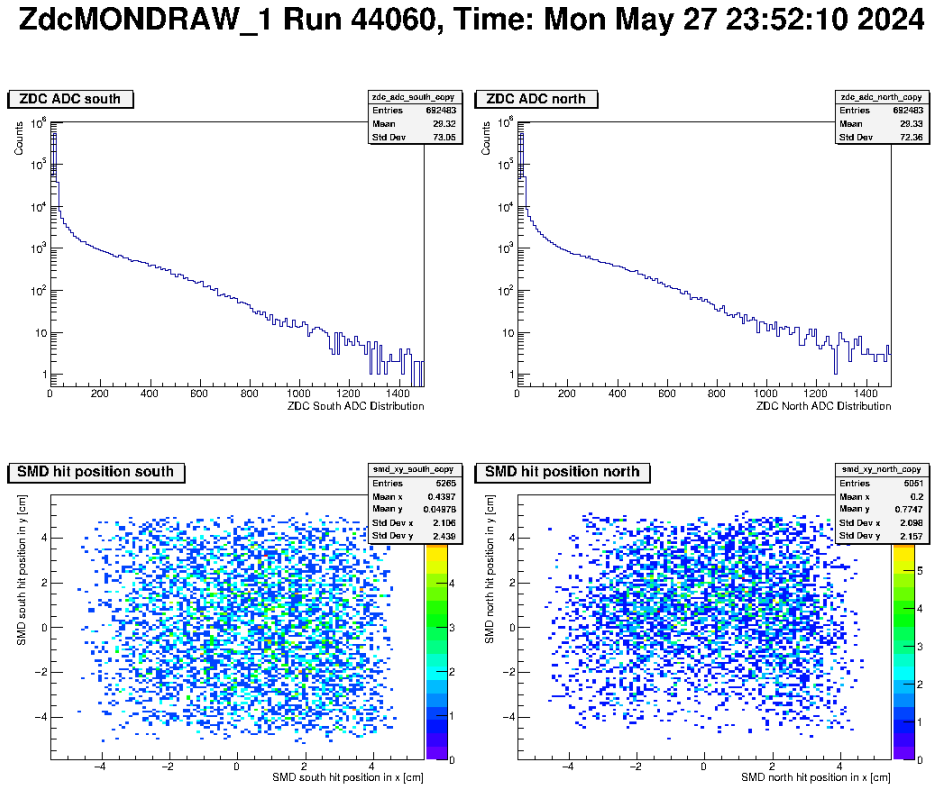
SMD South

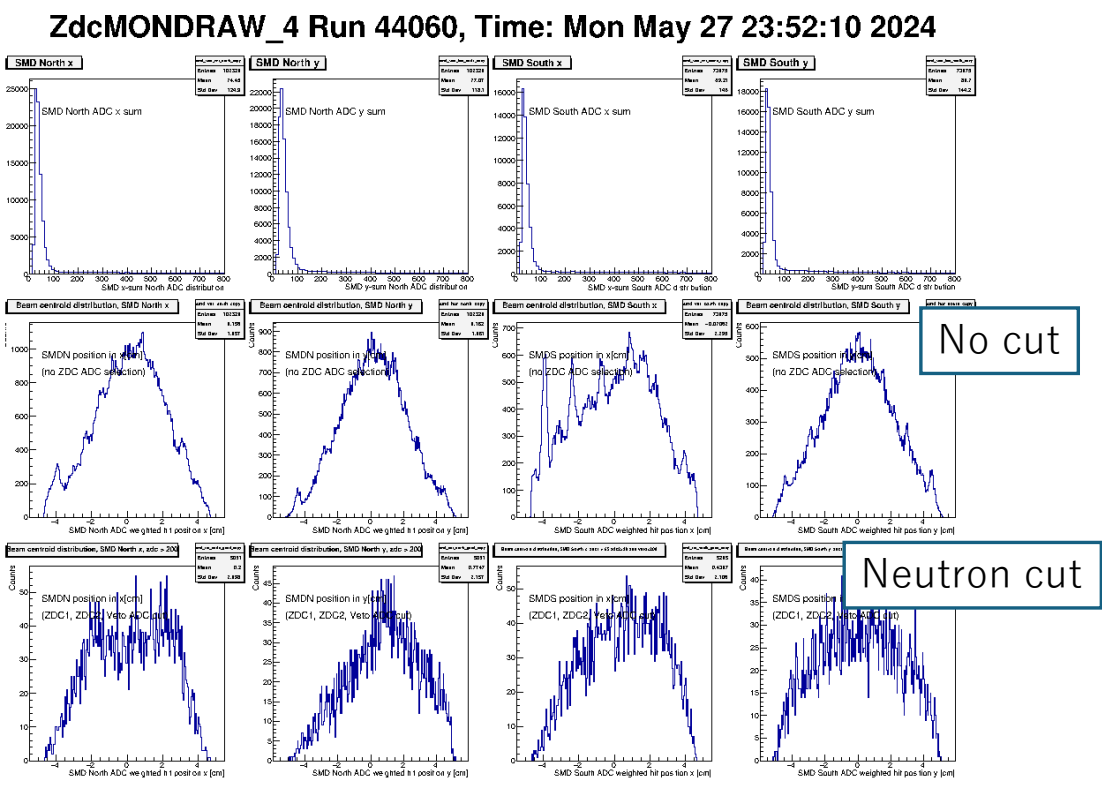


SMD North

All channels are alive.

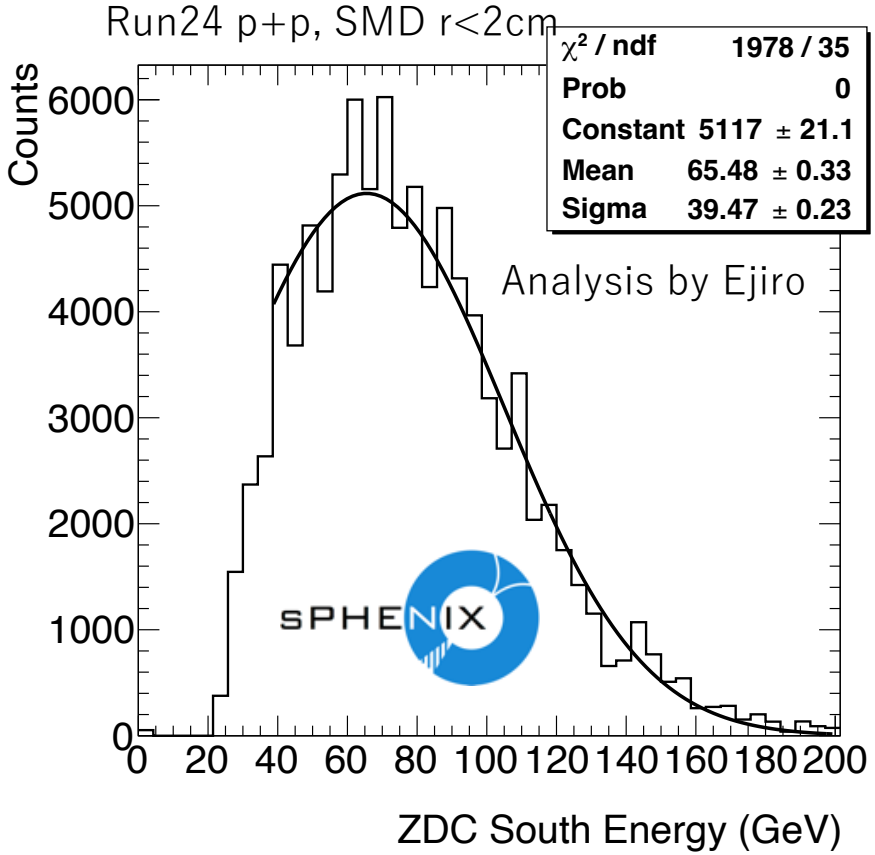
SMD Position Reconstruction



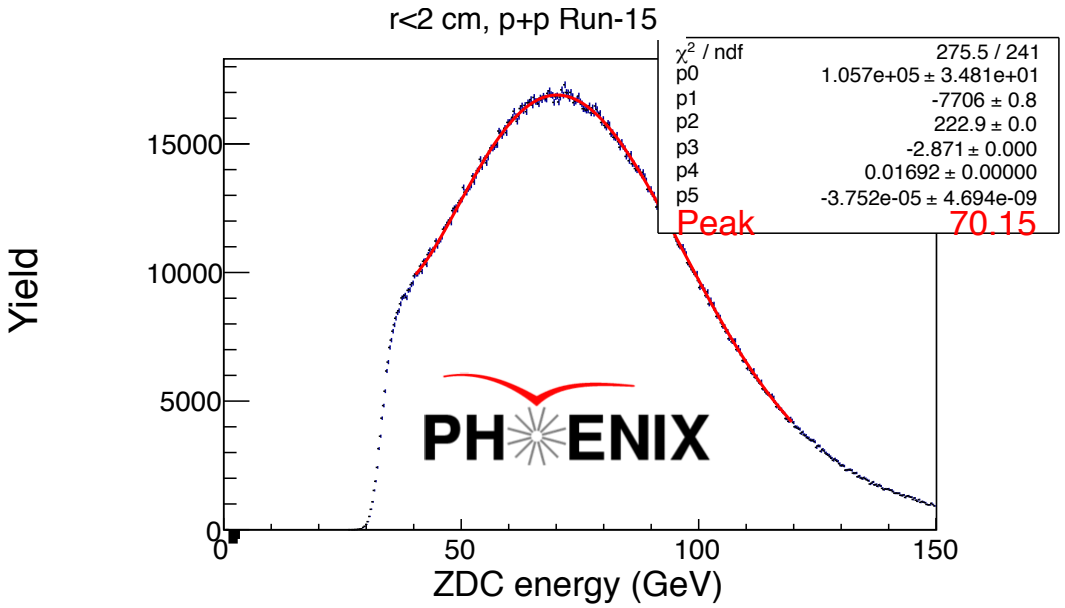


Reconstructed x,y profile of neutrons seems to be reasaonble

ZDC Energy Calibration

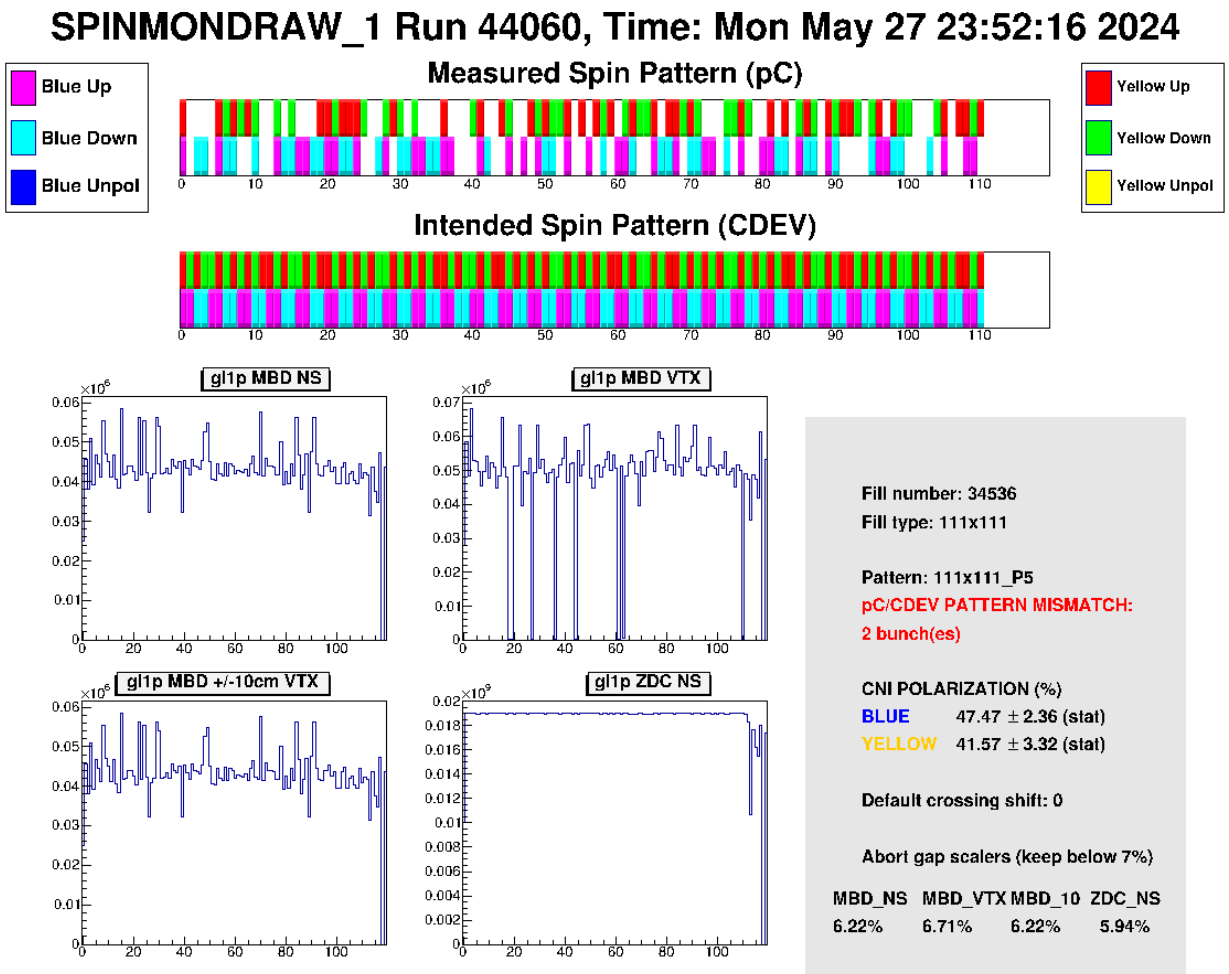


M. Kim, Ph.D Thesis Section 5.4.3.



(c) Run-15 p+p without charge veto cut.

ZDC threshold in hardware seems to be reasonably consistent with the one in PHENIX era.



Bunch-by-bunch counting

Spin Monitor

- Spin pattern seems to be consistent with what is observed in pC.
- GL1p scalers are necessary for relative luminosity
- Abort gap becomes less distinctive depending on trigger (ZDC single, rare triggers…)

Work done by D. Loomis

Offline Local Polarimeter Commissioning

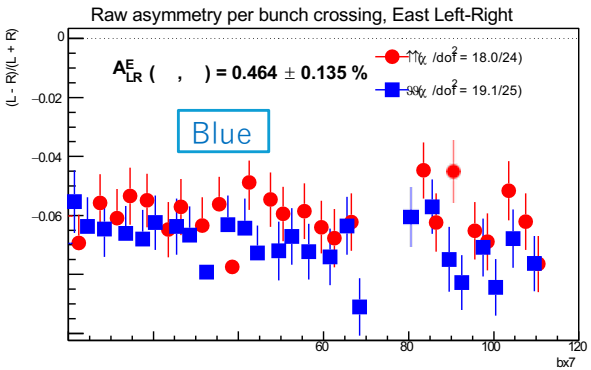
Dedicated Runs for Local Pol Commissioning

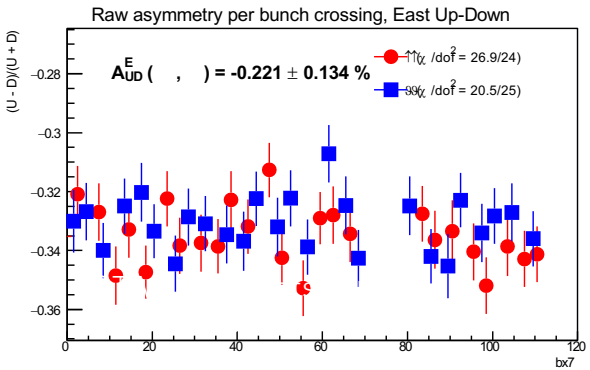
Tirgger: ZDC North single and ZDC South single (not ZDC N&S coincident trigger)
Trigger Rate: Expected DAQ rate of ~10kHz without prescale.
Readout Subystems: Enable only ZDC/sEPD and GL1 nodes (remove all other detectors)
Duration : 1 hour (Goal is total of 36~50 Mevents at >10kHz)

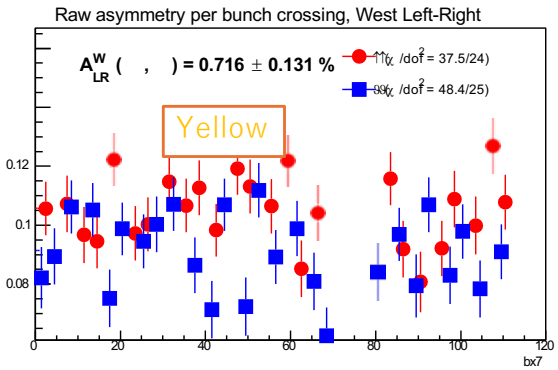
Date	Fill#	Run#	Trigger	Partition	#Events	Polarization
May 17, 7~9AM	34485	42796	ZDCS||N	ZDC+EMCal	17 M	~30%
		42797		ZDC	32 M	
May 18, 2 ~ 4AM	34492	42836	ZDCS||N	ZDC	47 M	~40%
		42861	ZDCS&N	ZDC	4.5 M	

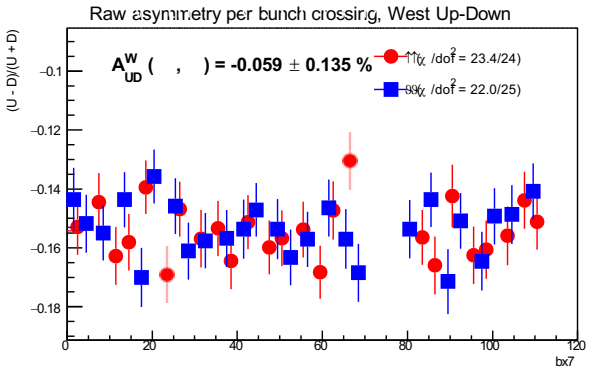
STAR
Local Polalimeter

STAR local polarimeter
observed ~1% asymmetry
@ 30% polarization









	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Blue	-	+	-	+	+	-	+	-	+	-	+	-	-	+	-	+	+	-	+	-	-	+
Yellow	-	-	+	+	-	-	+	+	-	-	+	+	-	-	+	+	-	-	+	+	-	-

Courtesy of Kin&STAR to provide us their measurement

Ongoing Independent Analyses

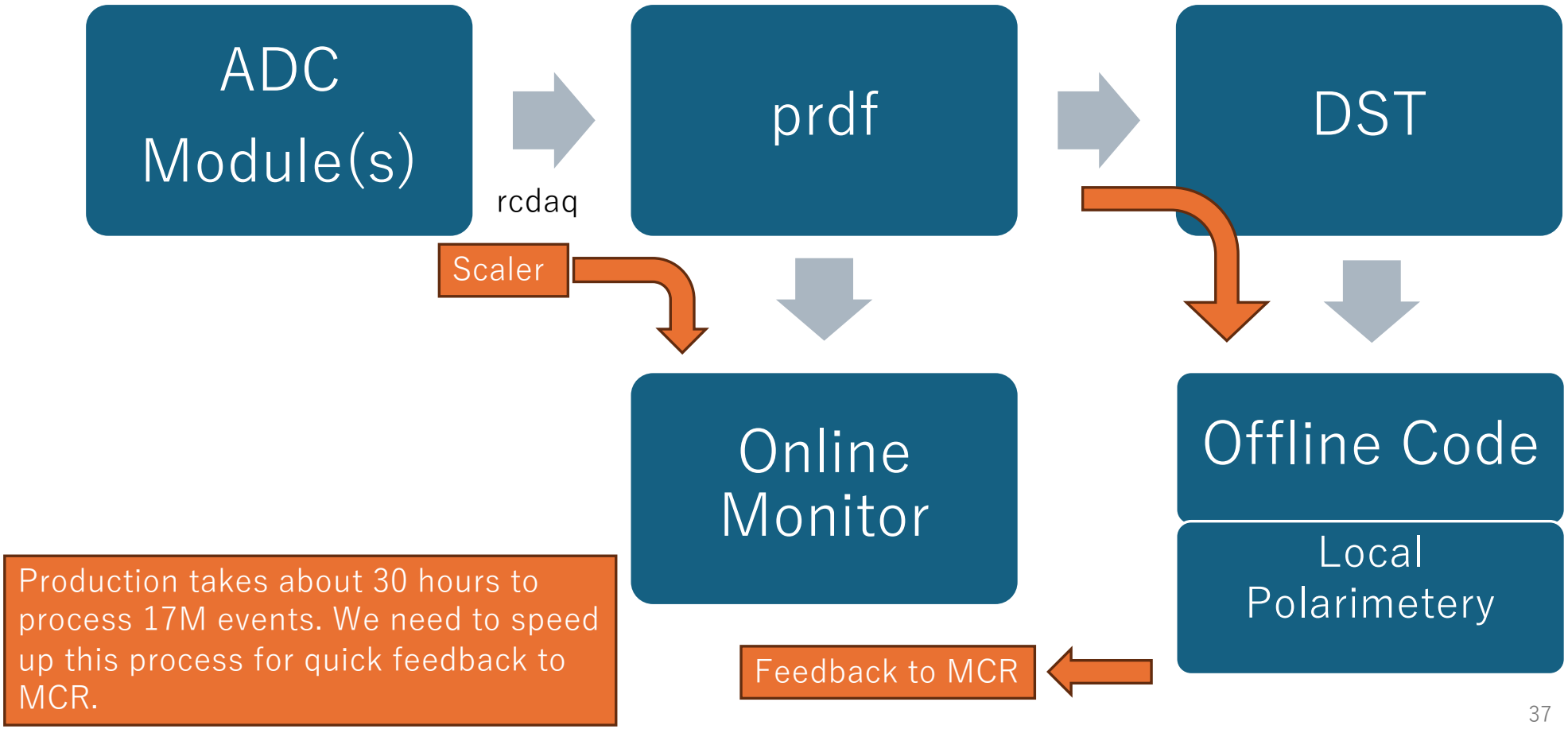
	Run15/Run8	Greg	Devon	Jaein	Athira
ZDC (**Eujiro**)	ADC_{ZDC2}/ADC_{sum} >0.03	ADC_{ZDC1}>100 & ADC_{ZDC2}>15	ADC_{ZDC1}>100 & ADC_{ZDC2}>15	ADC_{ZDC1}>100 & ADC_{ZDC2}>15	
SMD ADC	ADC_{SMD} > 3 MeV	ADC_{SMD} > 5	ADC_{SMD} > 50	**ADC_{SMD} > 5**	
SMD hit paddles	n_x>1 & n_y>1	n_x>1 & n_y>1	n_x>1 & n_y>1	n_x>1 & n_y>1	
Charge Veto **Volunteer?**	ADC_{veto}<50 (1/2 MIP)	ADC_{veto}<150	ADC_{veto}<150	ADC_{veto}<150	
ZDC Energy	40 – 120 GeV				
SMD radial position	0.5<|r|<4.0cm	2.0<|r|<4.0cm	2.0<|r|<4.0cm		
SMD Gain Matching	$[0]e^{-[1]x} + [2]e^{-[3]x}$		**Deven's ana***		

*Same method w/ Run15

First pass calibration and cut optimization are nearly completed by now.

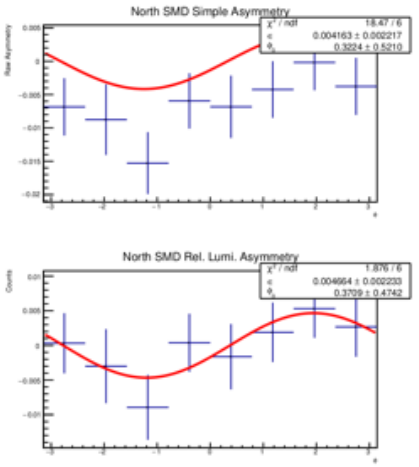
Person in charge to optimize cut

DST for Offline Analysis

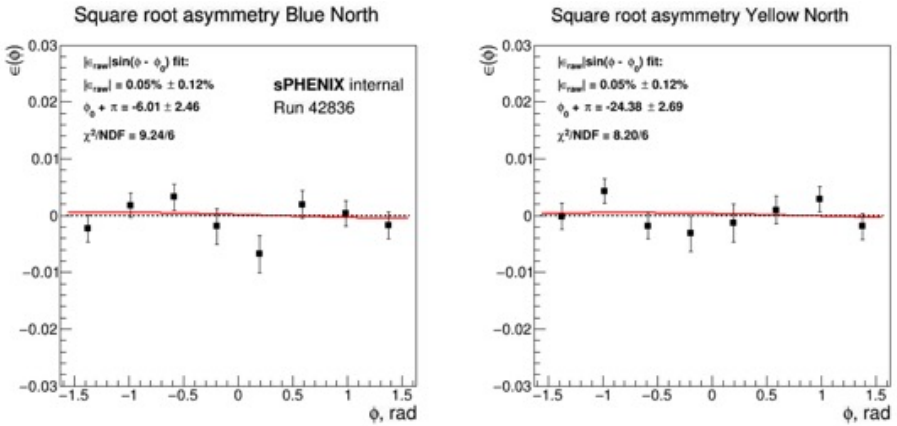


Production takes about 30 hours to process 17M events. We need to speed up this process for quick feedback to MCR.

Asymmetry Results



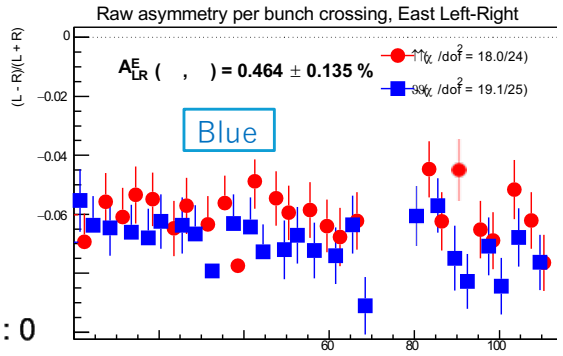
Analyzer 1

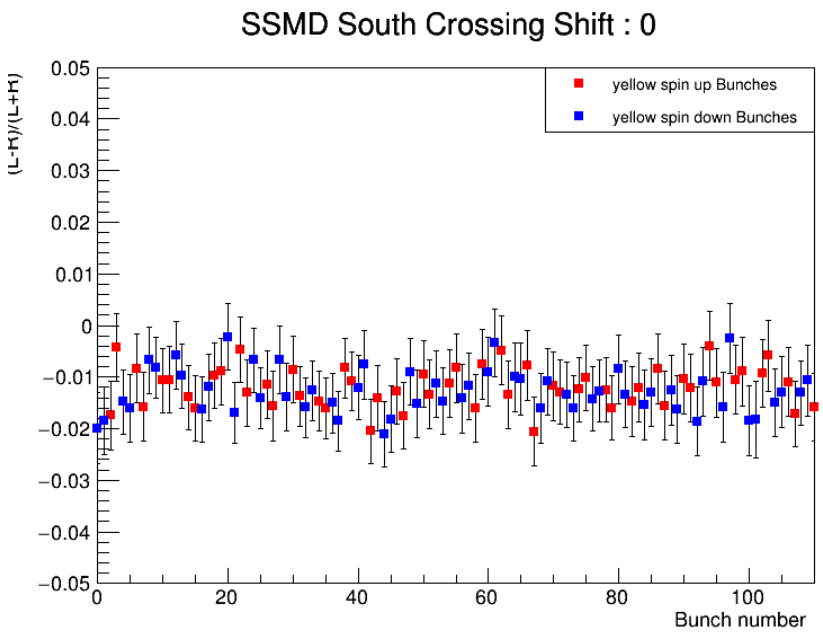


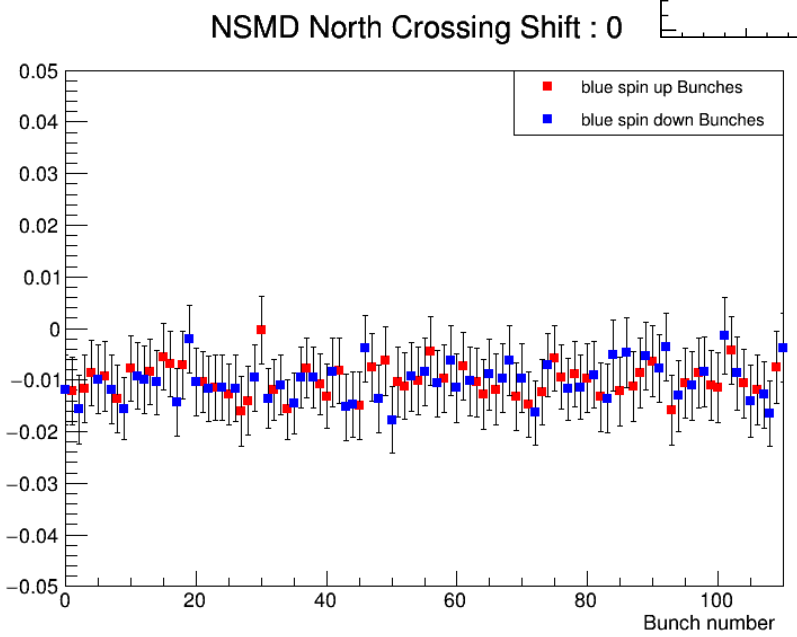
Analyzer 2

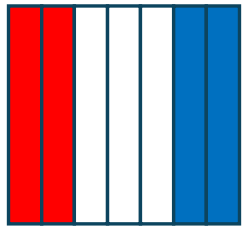
Either zero consistent or smaller asymmetry than STAR observed one. Cross checking between different analyzers are currently ongoing.

Bunch-By-Bunch Asymmetry









Simple asymmetry
Don't rely on x reconstruction
Less sensitive to beam center

No clear asymmetry observed. Higher polarization will separate positive and negative bunch more distinctively. It helps to know if the spin pattern is correctly assigned.
May also need to check event alignment as well.

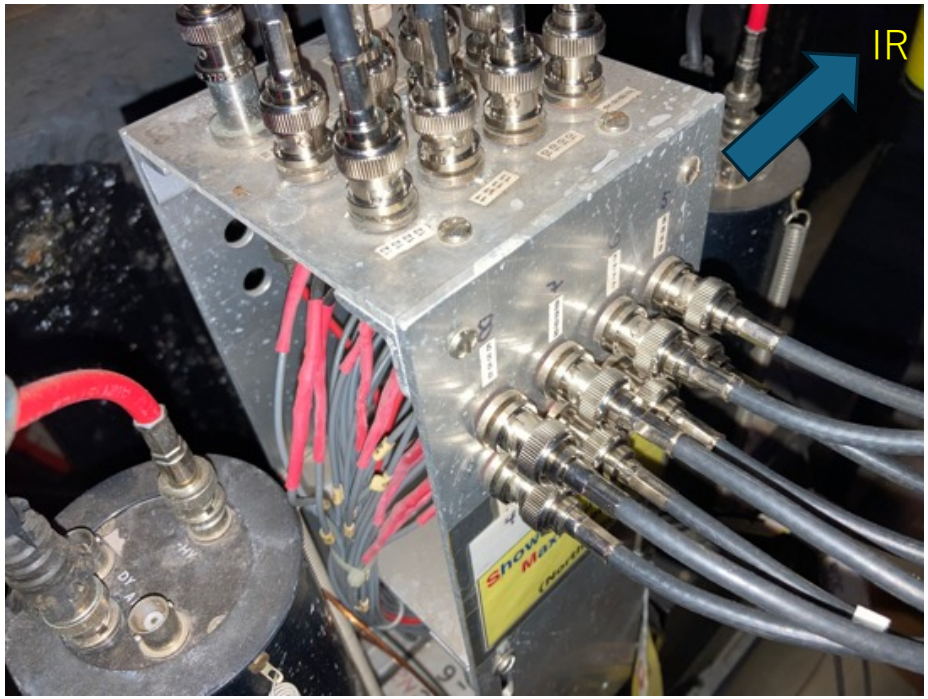
Analysis by Jaein

Summary

- SMD/Veto, GL1p scalers have been setup for the Spin program in Run24.
- Optimization of the operation conditions (HV, threshold, timing, etc) has been completed by now.
- GL1p scalers are to be debugged for Vanier scan.
- Offline local polarimeter commissioning is underway. So far, no firm evidence of the asymmetry observation at sPHENIX yet.
- Production time needs to be speeded up for dynamic feedback to MCR

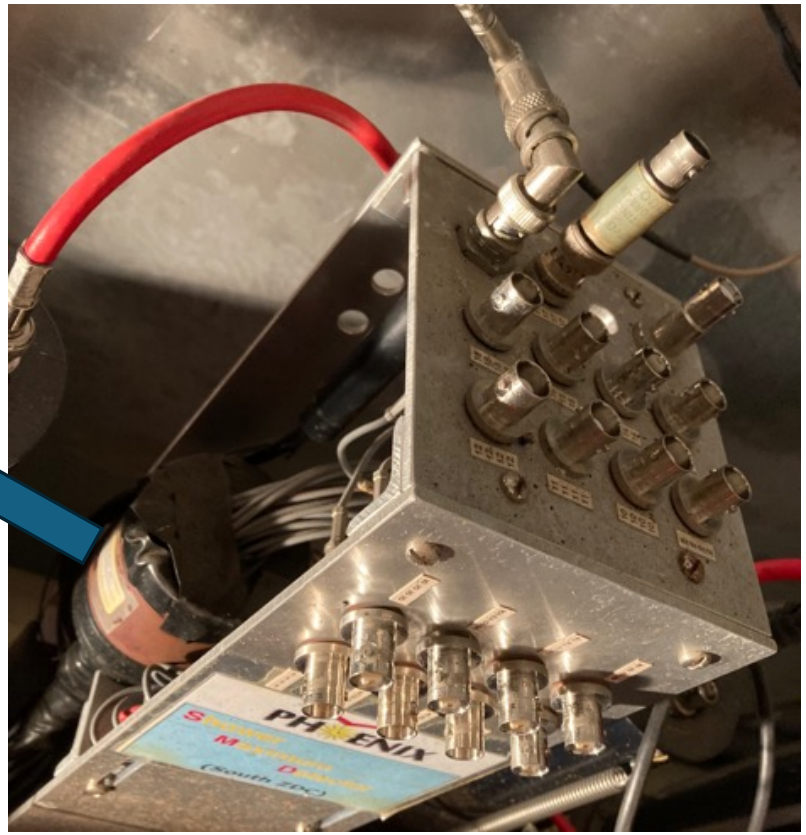
Backup Slides

SMD Patch Panels



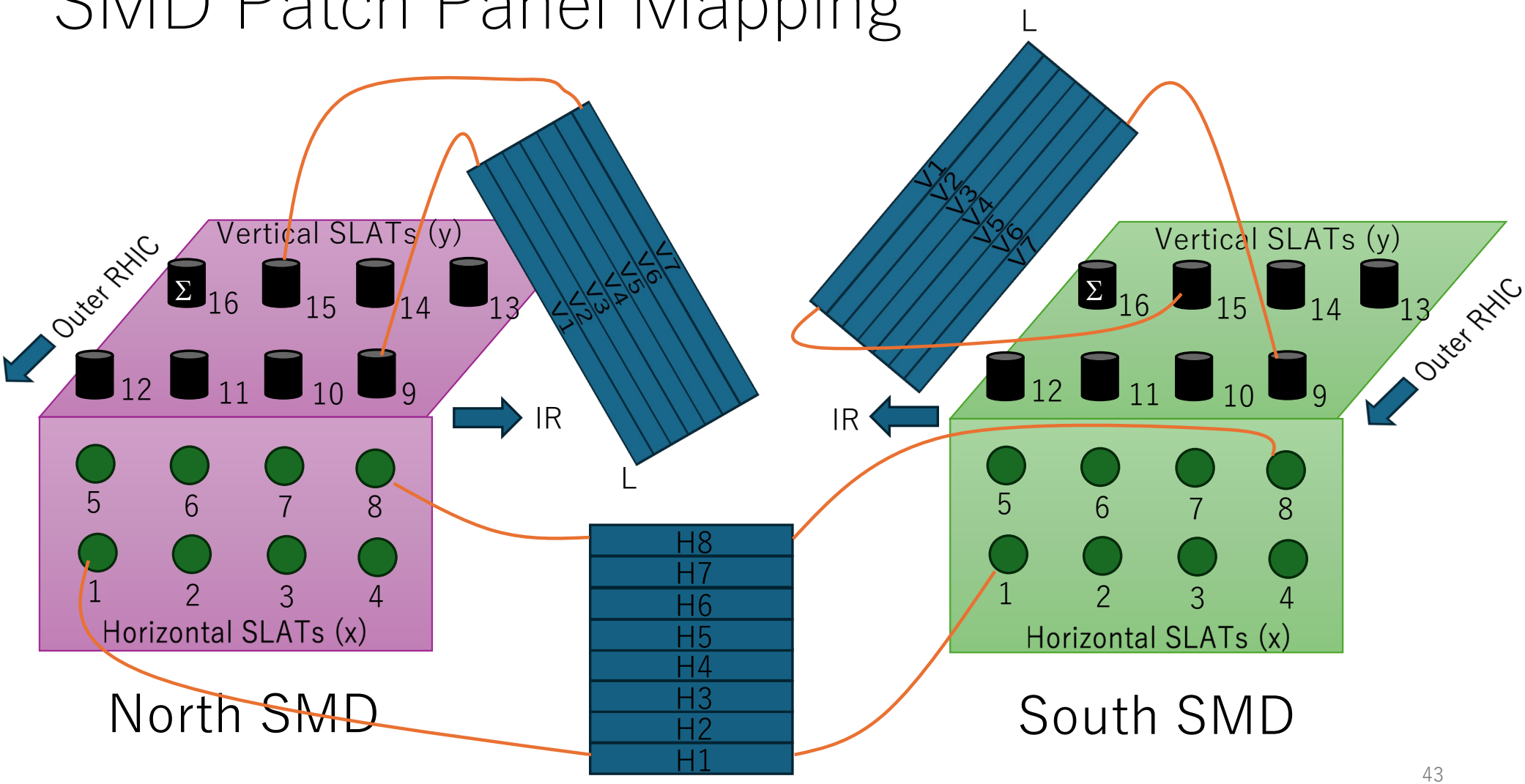
North SMD

IR



South SMD

SMD Patch Panel Mapping



After May-7

SMD Signal Cable Mapping

North

SLAT	Patch Channel	RG58 Cable Label	Model 776 Input
H1	1	1	1
H2	2	17	2
H3	3	3	3
H4	4	18	4
H5	5	5	5
H6	6	4	6
H7	7	7	7
H8	8	20	8
V1	9	9	9
V2	10	10	10
V3	11	11	11
V4	12	12	12
V5	13	13	13
V6	14	19	14
V7	15	15	15
SUM	16	16	16

South

SLAT	Patch Channel	RG58 Cable Label	Model 776 Input
H1	1	1	1
H2	2	2	2
H3	3	3	3
H4	4	4	4
H5	5	5	5
H6	6	6	6
H7	7	7	7
H8	8	8	8
V1	9	9	9
V2	10	10	10
V3	11	11	11
V4	12	12	12
V5	13	13	13
V6	14	14	14
V7	15	15	15
SUM	16	18	16

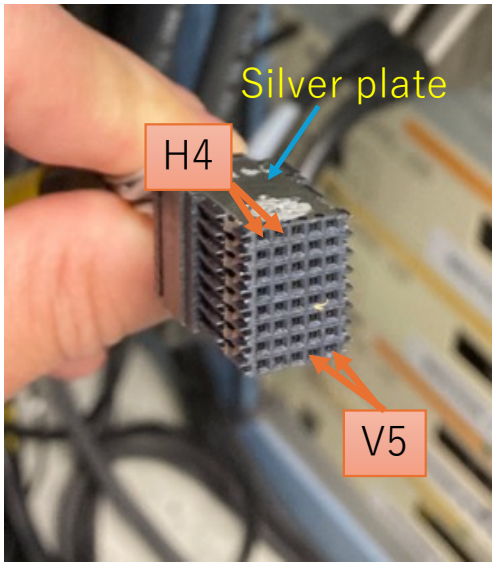
SMD Diff. Module - HardMetric Connector Channel Map

Reverse Configuration

Differential Module Front Panel Channel*			
14	V5	15	V6
12	V7	13	Σ
10	V1	11	V2
8	V3	9	V4
6	H5	7	H6
4	H7	5	H8
2	H1	3	H2
0	H3	1	H4

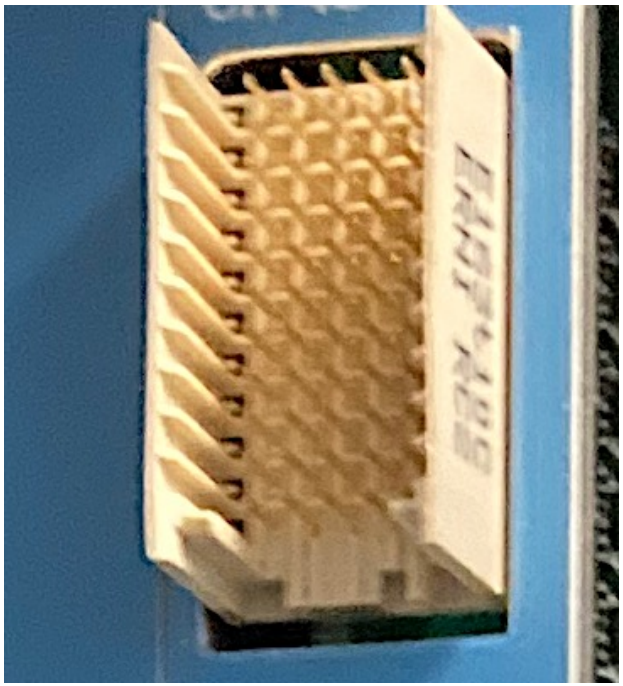
HardMetric Connector Silver Plate (top)				
14	H4	-	15	H3
12	H2	-	13	H1
10	H8	-	11	H7
08	H6	-	09	H5
06	V4	-	07	V3
04	V2	-	05	V1
02	Σ	-	03	V7
00	V6	-	01	V5

ADC Input End Connector Front View

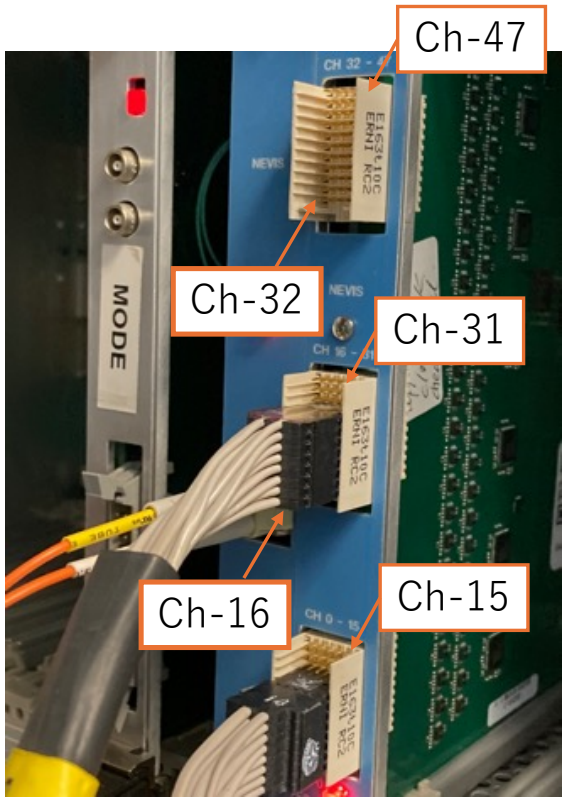


*The limo input cables are not in order of H1->VΣ at the differential module front panel, but they are in the order at the ADC input

ADC Module Input Channel Map



ADC Input Pin Assignment		
14	-	15
12	-	13
10	-	11
8	-	9
6	-	7
4	-	5
2	-	3
0	-	1

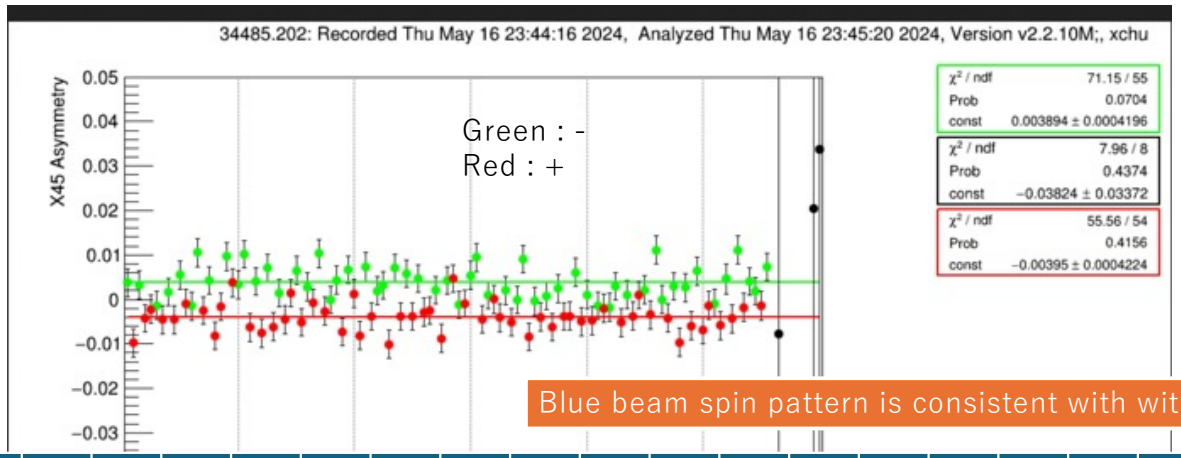


See details in Devon's documentation

Fill #34485.102 (pC Blue)

May 16, 2024 23:44:16 Thu

P=33.0 ± 2.5 %



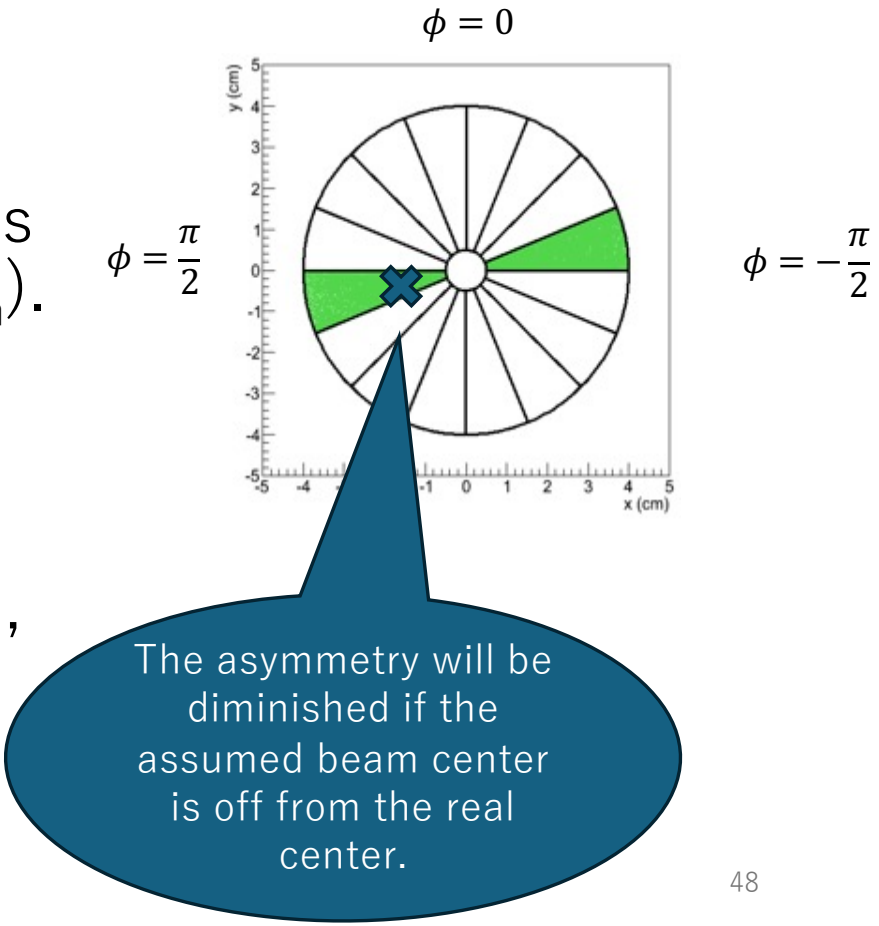
Blue beam spin pattern is consistent with with sPHENIX

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
pC	-	+	-	+	+	-	+	-	+	-	+	-	-	+	-	+	+	-	+	-	-	+
sPHENIX	-	+	-	+	+	-	+	-	+	-	+	-	-	+	-	+	+	-	+	-	-	+

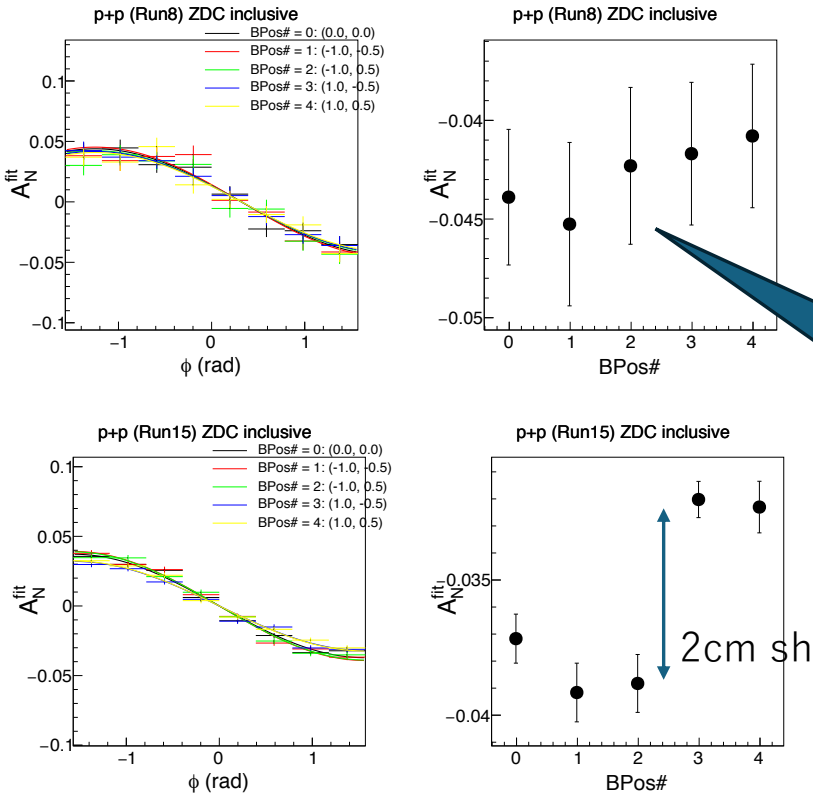
−+−+ +−+− +−+− −+−+ +−+− −+−+ −+−+ +−+− +−+− −+−+ +−+− −+−+ −+−+ +−+−

Beam Center Position Test

1. Reconstruct x,y position distribution for selected neutron events only.
2. Take mean values for both x and y as the neutron beam center (x_{mean},y_{mean}).
3. Recalculate asymmetry based on (x_{mean},y_{mean})
4. Also calculate asymmetry assuming following beam centers (-2,0), (-1,0), (+1,0), (+2,0).



Beam Center Position Test in Run8, 15



5.11.4 Beam position

The uncertainty from the beam center ambiguity is estimated by varying the assumed beam center position ± 10 mm in x and ± 5 mm in y direction. The position survey results give a few mm deviation between the zero degree line and the ZDC center. However, for the x-direction, we assigned conservative uncertainty as 10 mm of deviation because 1 cm difference explains the different asymmetric background fraction between Run8 and Run15.

Statistical error is not small enough to see the effect

2cm shift in x-position makes > 0.5% effect in the asymmetry.