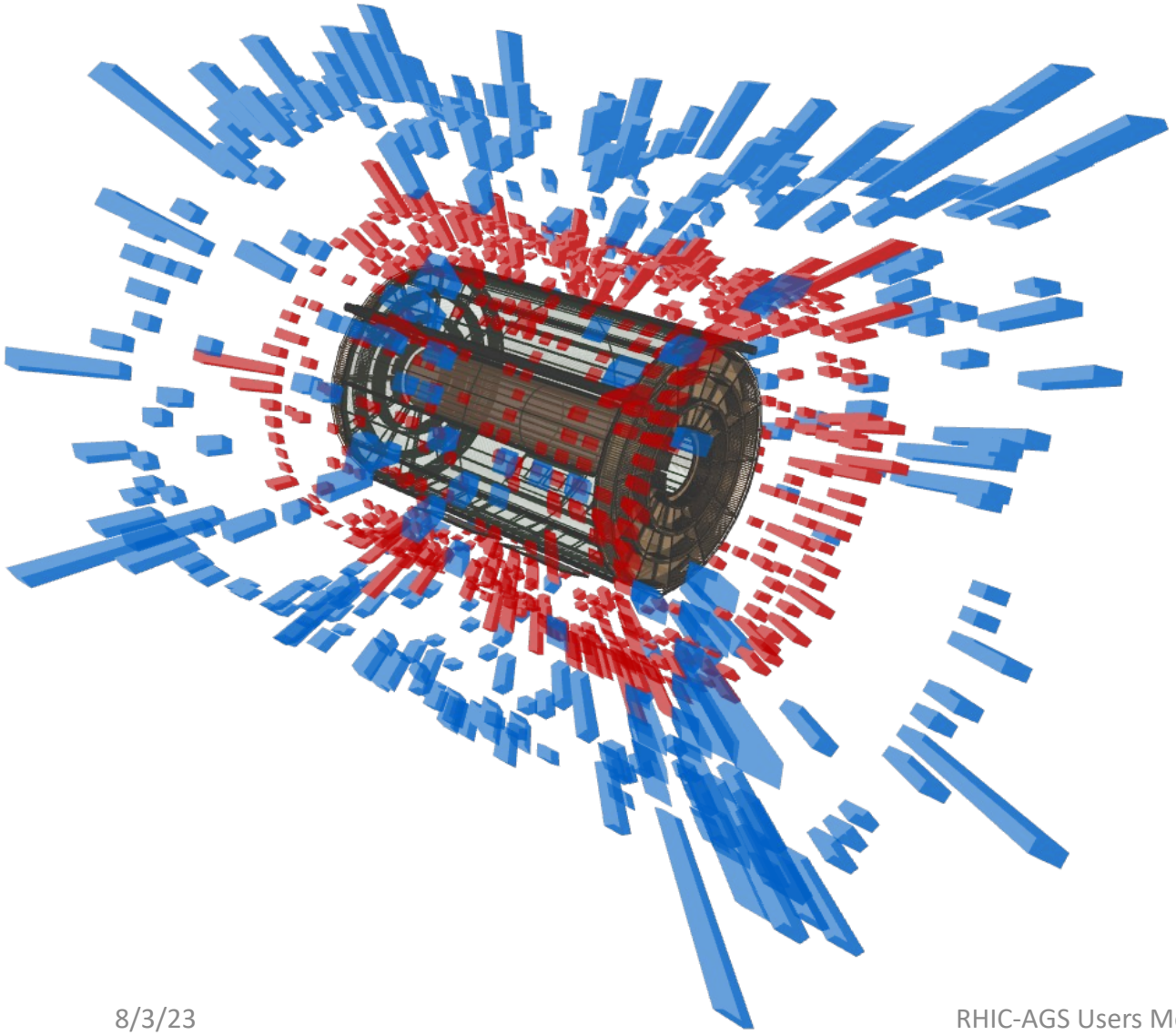
sPHENIX Experiment at RHIC
Data recorded: 2023-05-22, 02:07:00 EST
Run / Event: 7156 / 12
Collisions: Au + Au @ 200 GeV



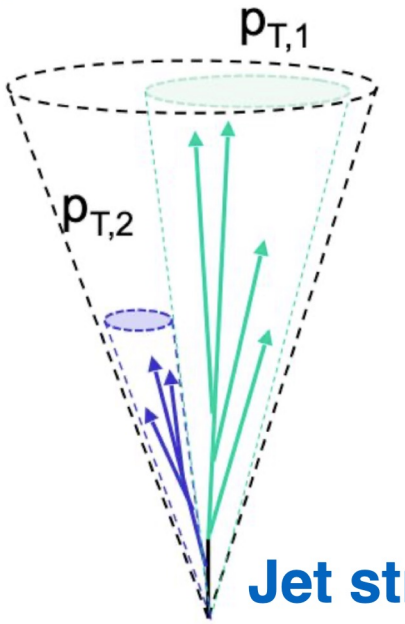
sPHENIX Run 2023 Report

Stefan Bathe

Baruch College, CUNY

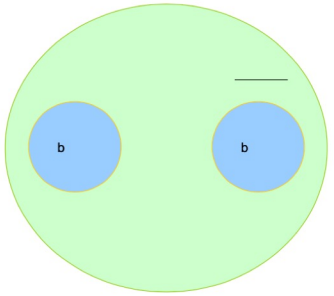
Run Coordinator

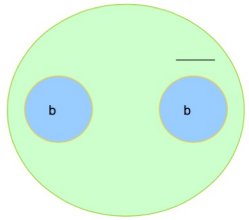
sPHENIX Physics Program

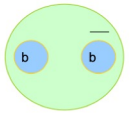


Jet structure

vary momentum/angular scale of probe



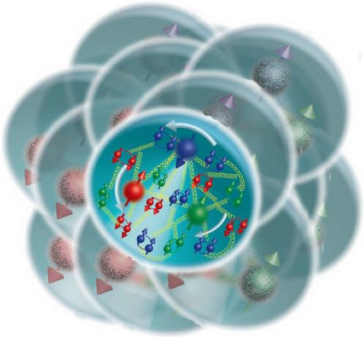




Quarkonium spectroscopy

vary size of probe

sPHENIX



Cold QCD

study proton spin, transverse-momentum, and cold nuclear effects

Parton energy loss

vary mass/momentum of probe

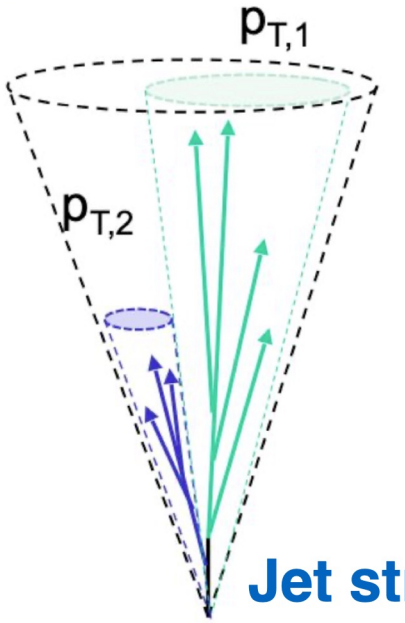
photon
gluon

u,d,s

c

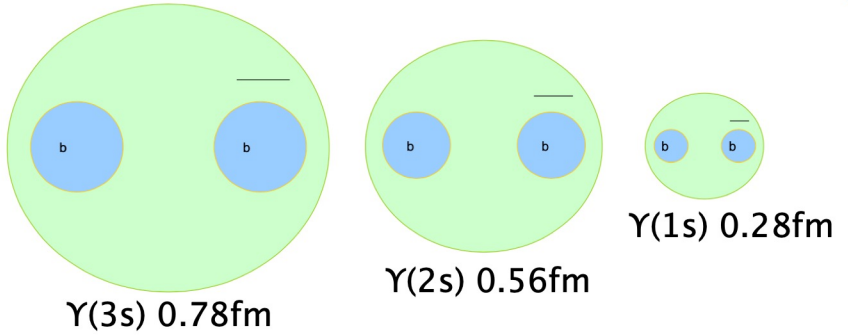
b

sPHENIX Physics Program



Jet structure

vary momentum/angular scale of probe



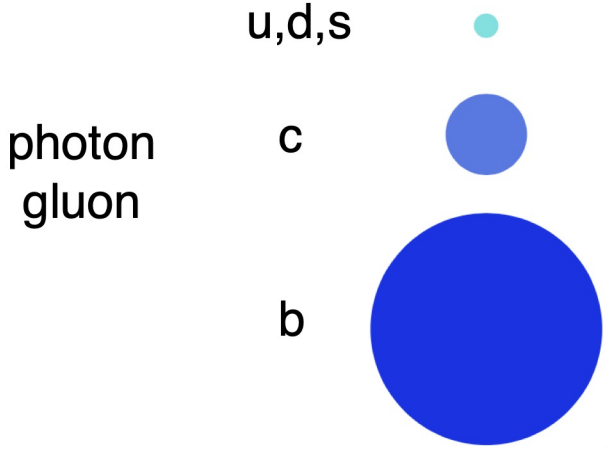
Quarkonium spectroscopy

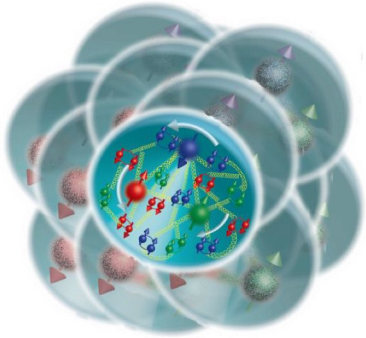
vary size of probe

sPHENIX

Parton energy loss

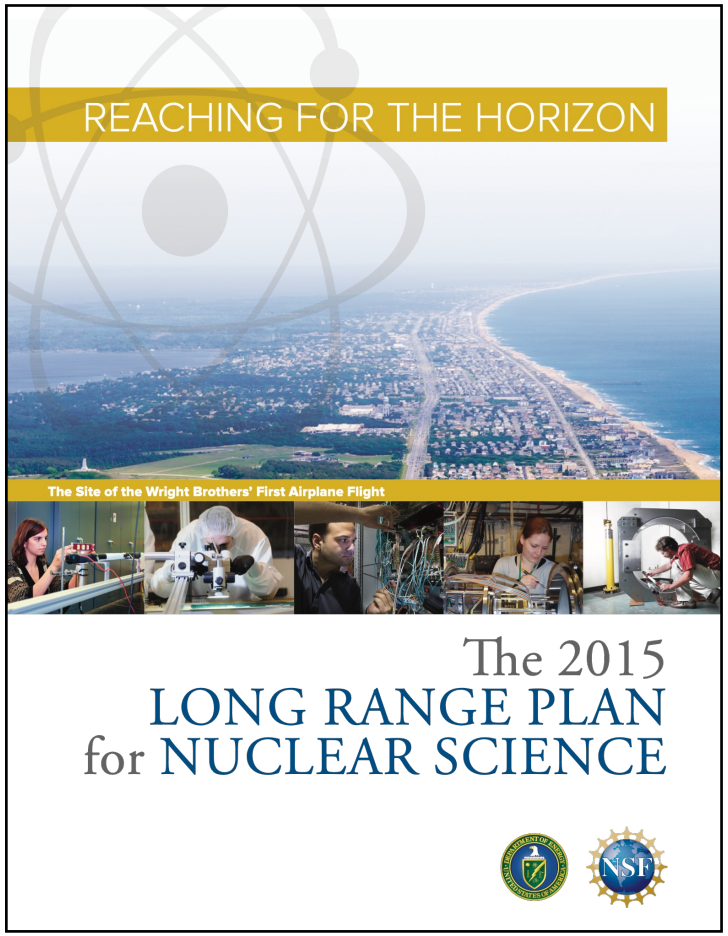
vary mass/momentum of probe



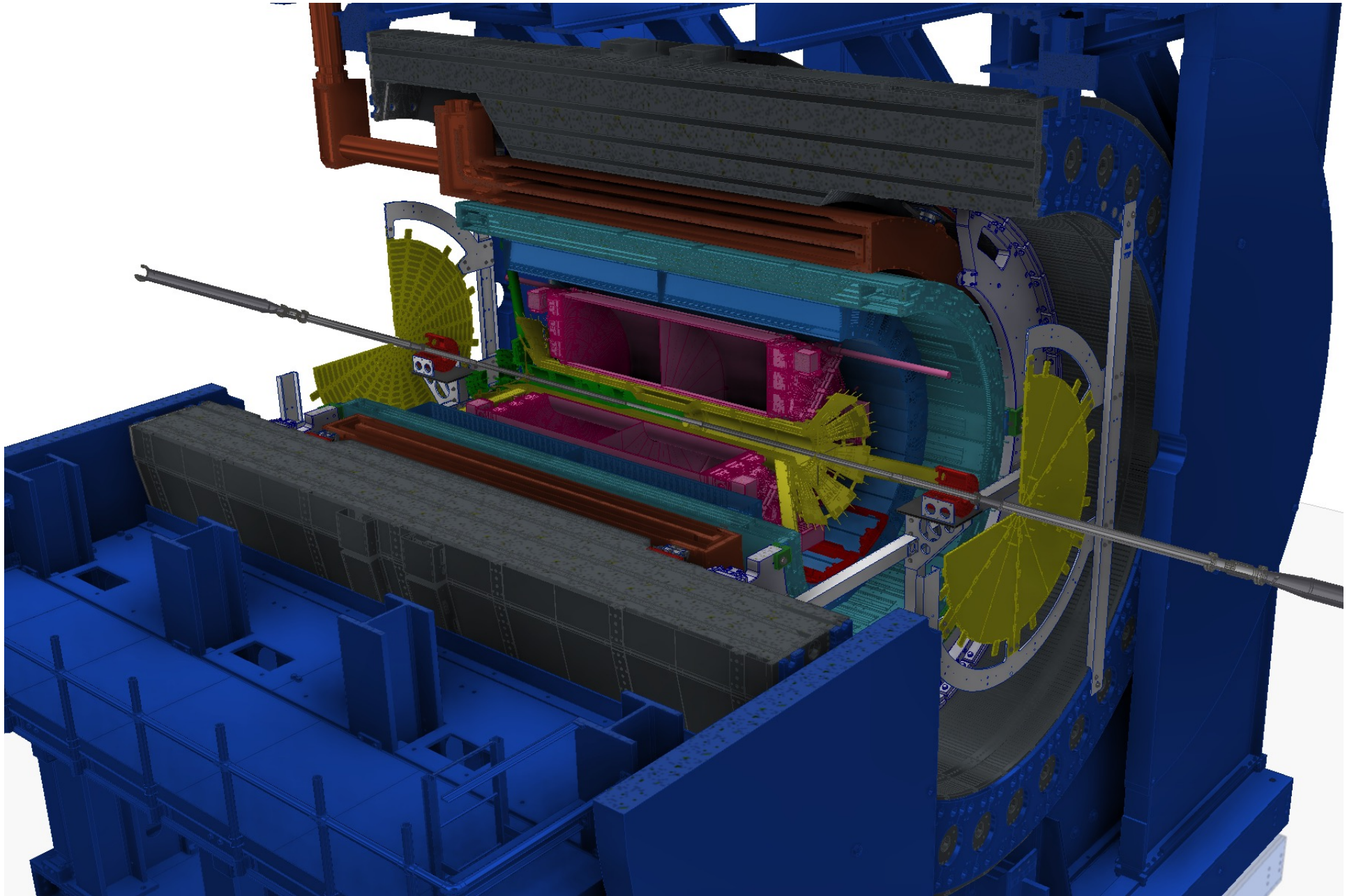


Cold QCD

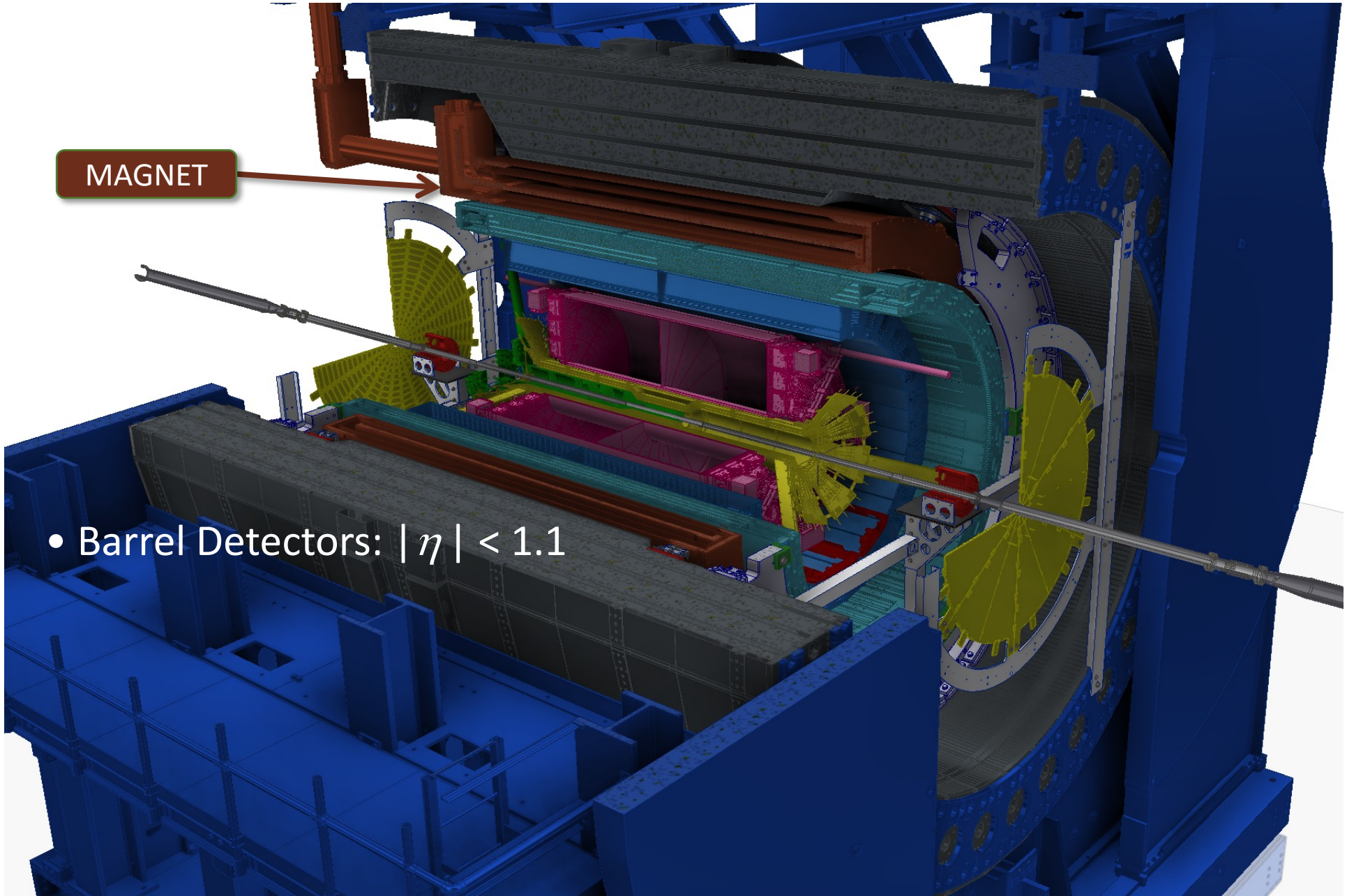
study proton spin, transverse-momentum, and cold nuclear effects



sPHENIX Detector

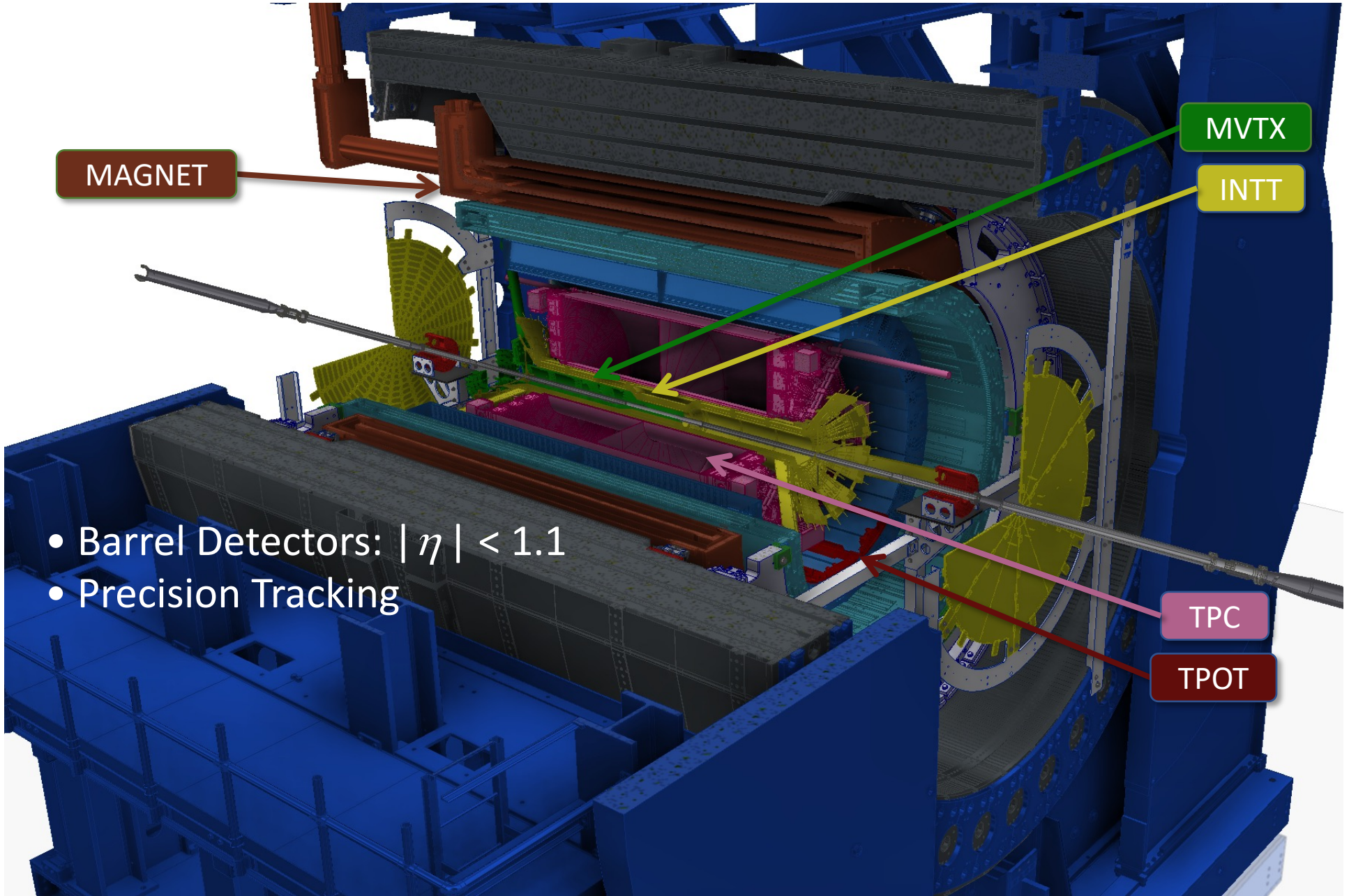


sPHENIX Detector

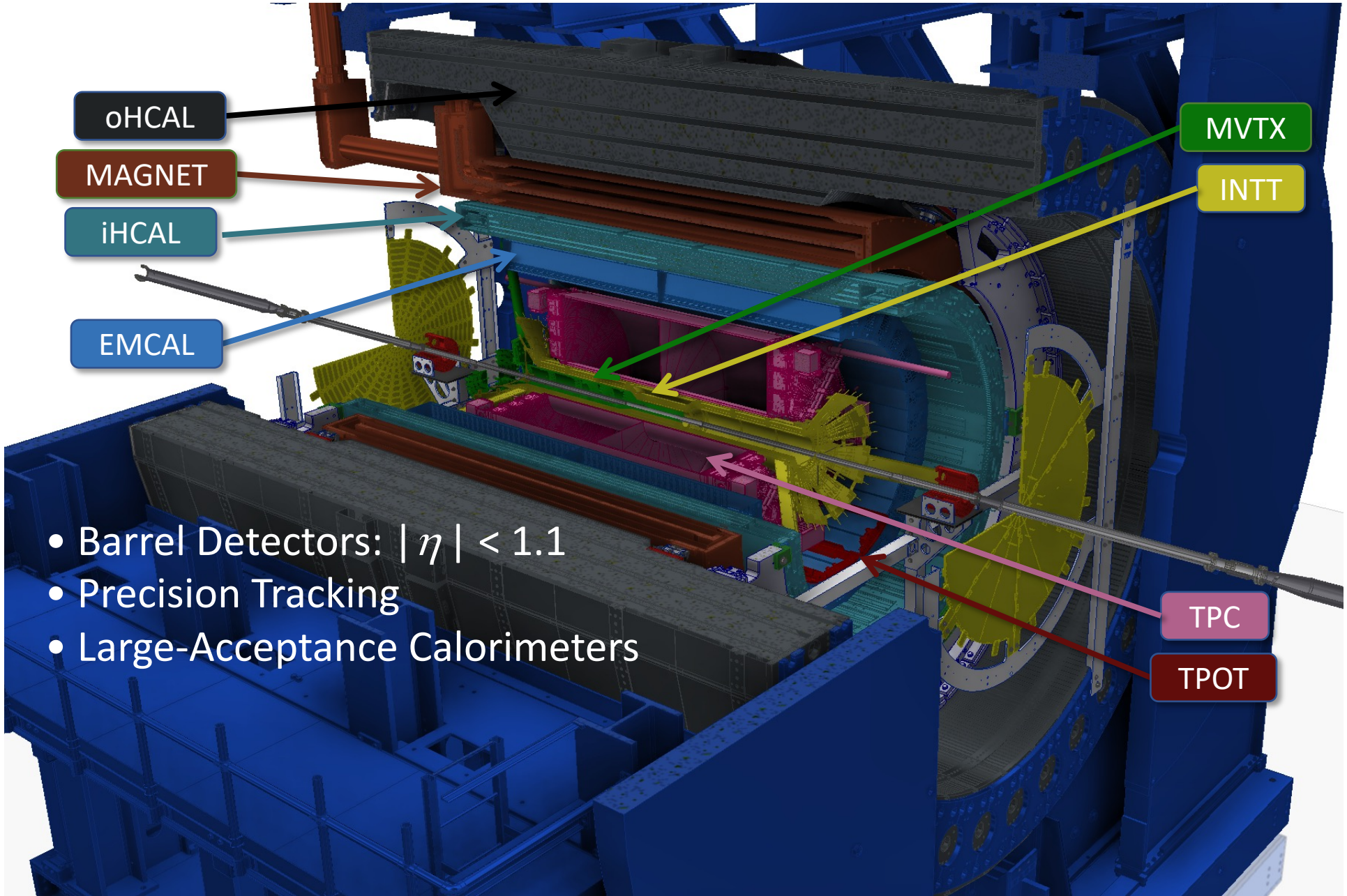


- Barrel Detectors: $|\eta| < 1.1$

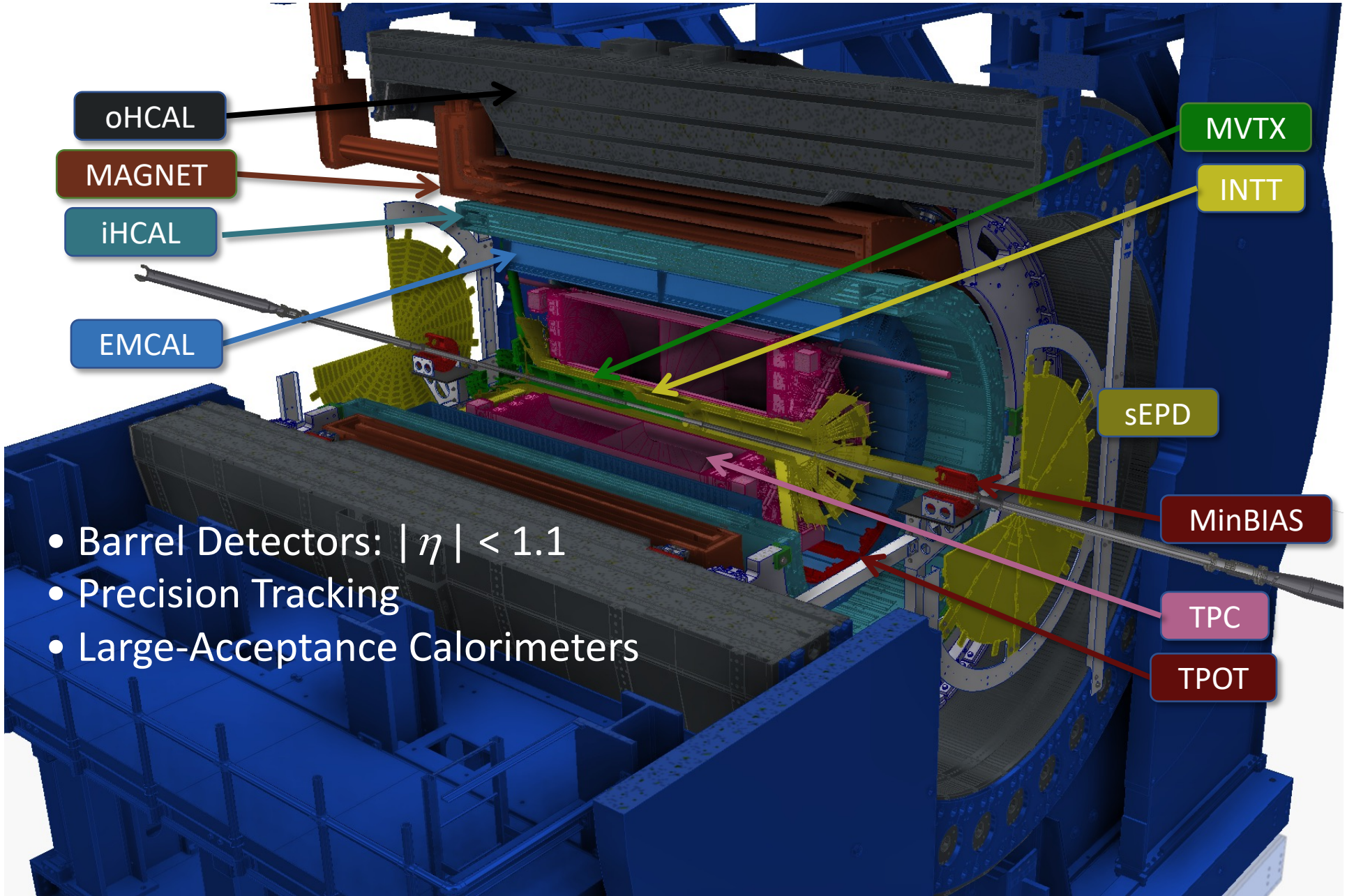
sPHENIX Detector



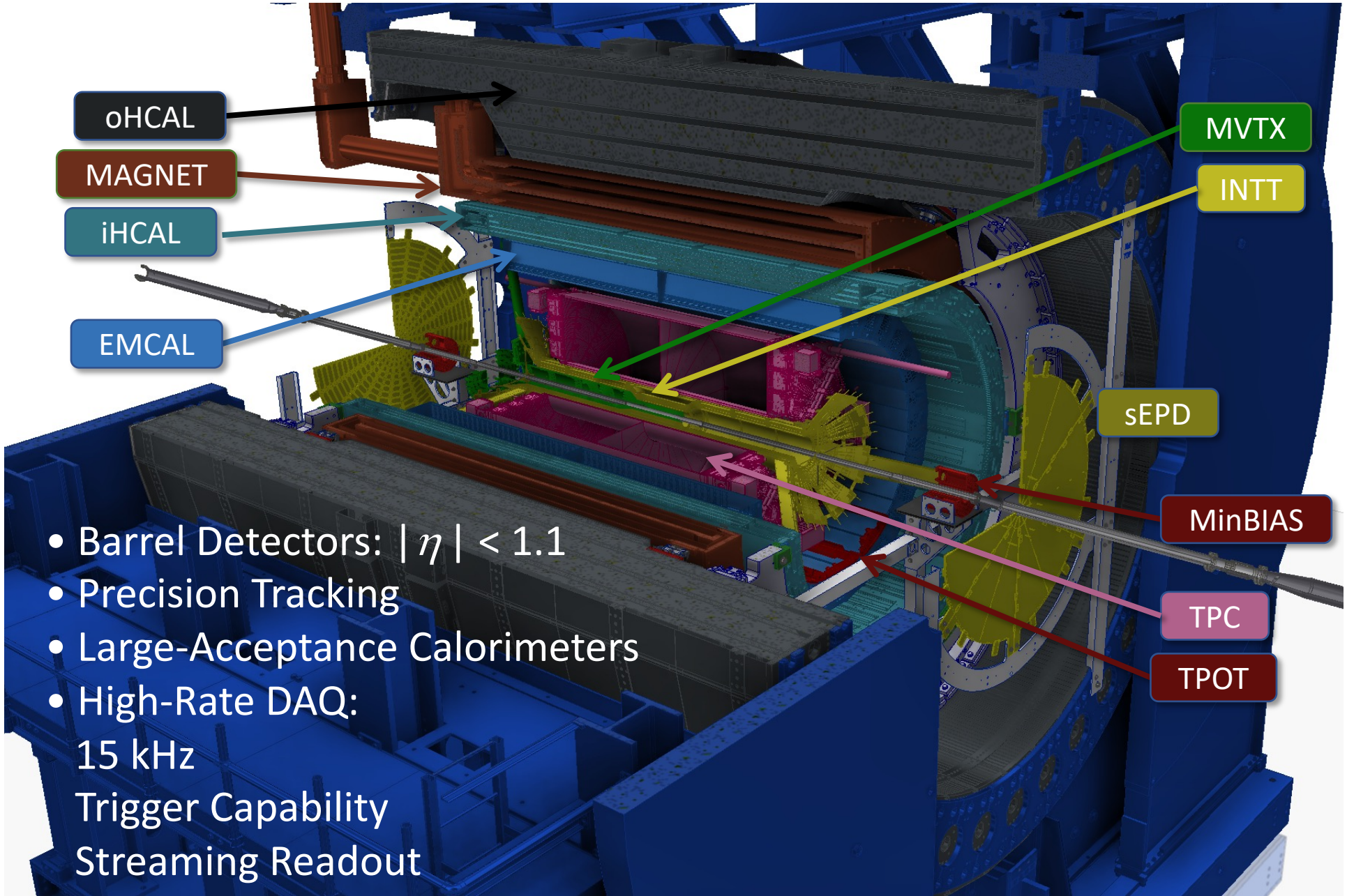
sPHENIX Detector



sPHENIX Detector



sPHENIX Detector



- Barrel Detectors: $|\eta| < 1.1$
- Precision Tracking
- Large-Acceptance Calorimeters
- High-Rate DAQ:
  15 kHz
  Trigger Capability
  Streaming Readout

Feb 28, 2022

March 31, 2023

Inaugural Run

April

Su	Mo	Tu	We	Th	Fr	Sa
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

May

Su	Mo	Tu	We	Th	Fr	Sa
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

June

Su	Mo	Tu	We	Th	Fr	Sa
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

July

Su	Mo	Tu	We	Th	Fr	Sa
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

August

Su	Mo	Tu	We	Th	Fr	Sa
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

September

Su	Mo	Tu	We	Th	Fr	Sa
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

- 20 cryo weeks, Au+Au @ 200 GeV: 5/8 – 9/25
- Approval to operate (magnet, operating gas): 5/18
- 12-week commissioning plan: 5/19 – 8/11
- 6 weeks physics running

- Highest priority of Run 2023: commissioning detector for Runs 2024 and 2025

Commissioning Plan

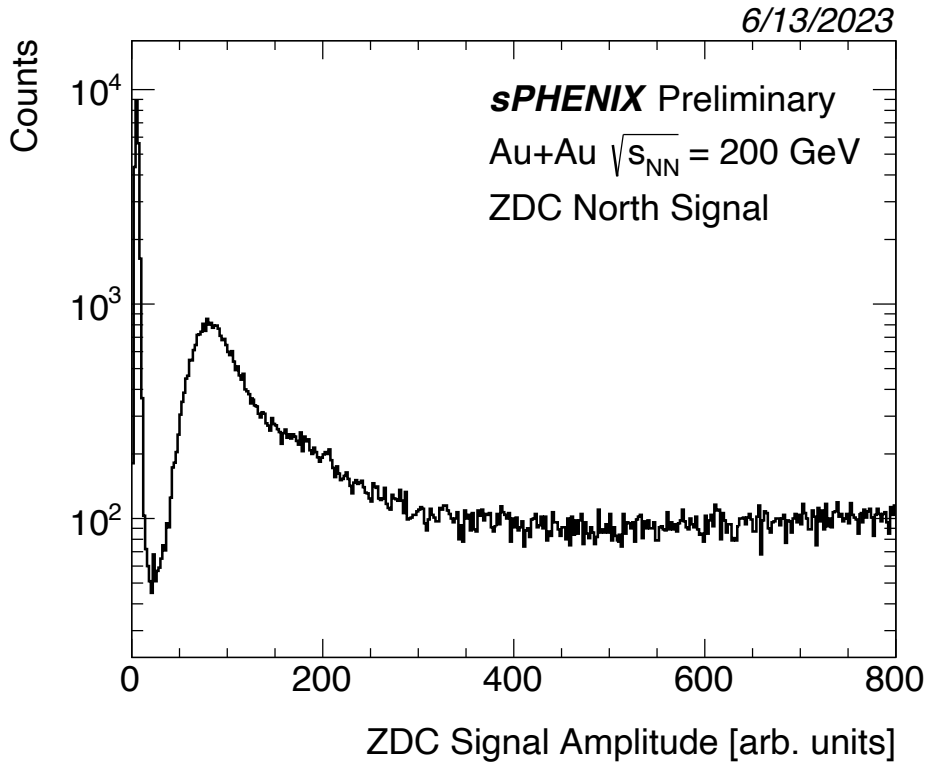
Weeks	Details
2.0	low rate, 6-28 bunches
2.0	low rate, 111 bunches, MBD L1 timing
1.0	low rate, crossing angle checks
1.0	low rate, calorimeter timing
4.0	medium rate, TPC timing, optimization
2.0	full rate, system test, DAQ throughput
12.0	**total**

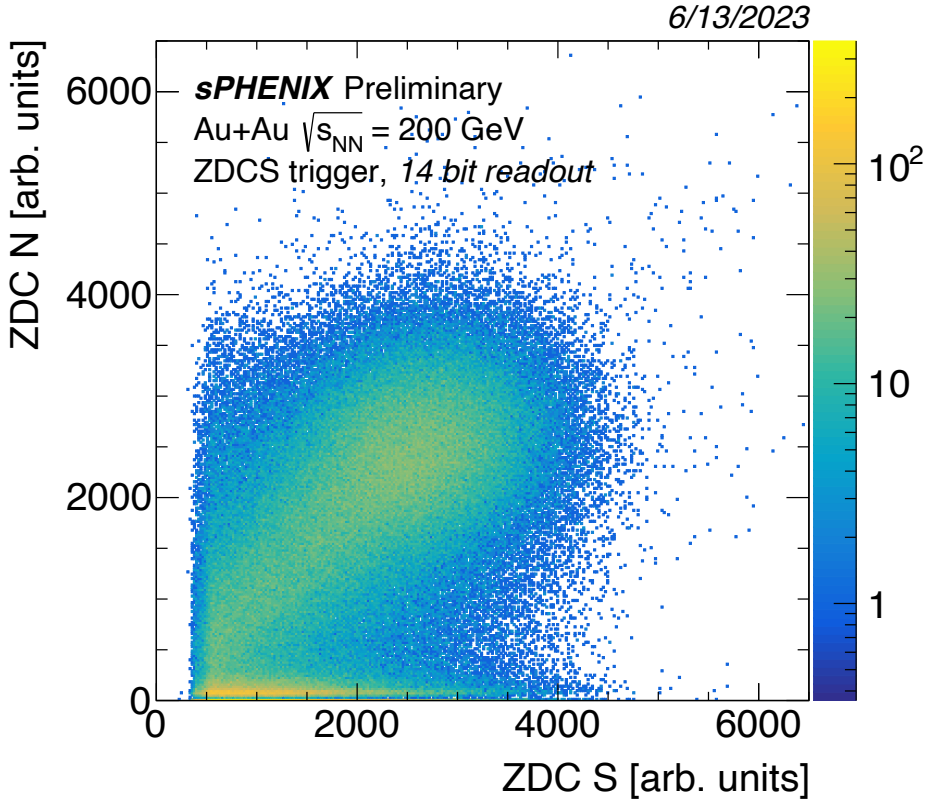
- Initial timing and triggering
- Optimize trigger, time in calorimeters
- Turn on calorimeters, crossing angle studies
- Optimize calorimeters, measure radiation
- Initial operation of tracking detectors
- Stress test DAQ at high rates

Commissioning highlights

- Commissioning so far has been tremendous success
- Lots of young people!
- Lots of enthusiasm!

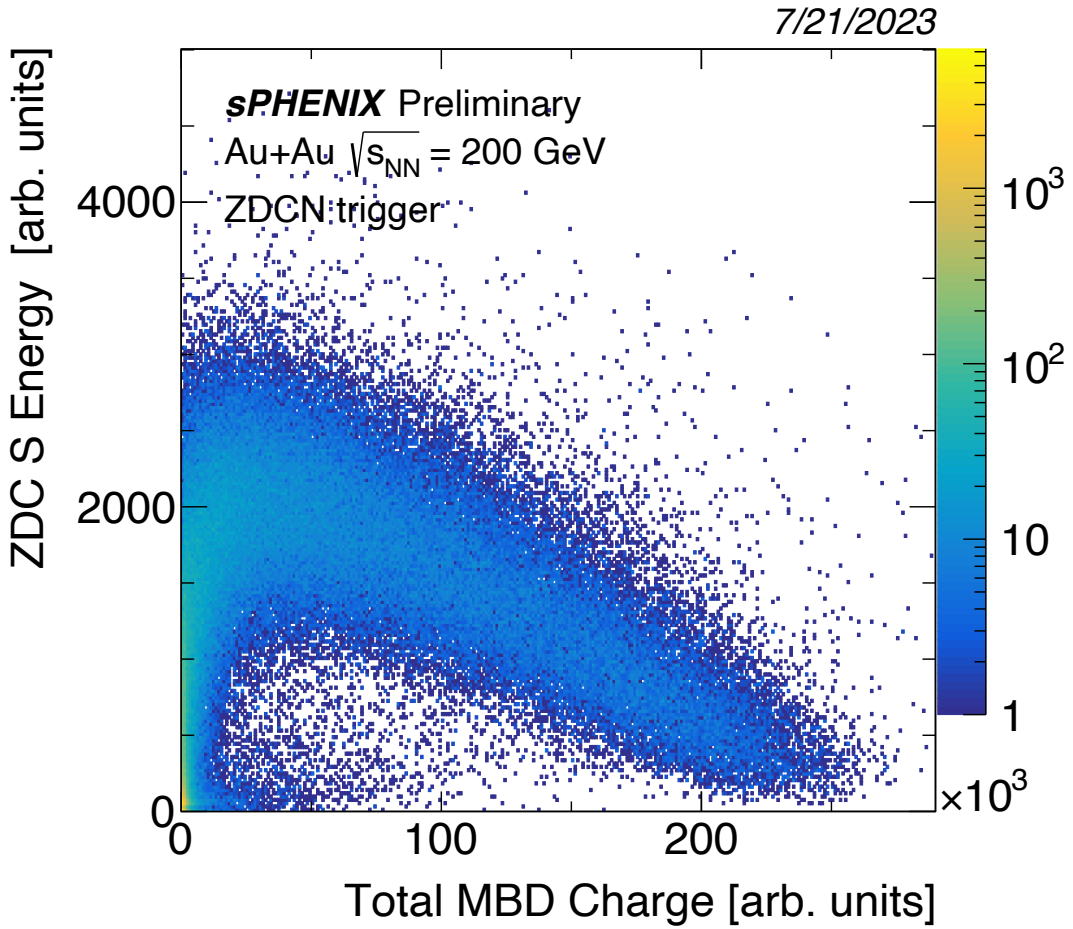
Zero Degree Calorimeter (ZDC)





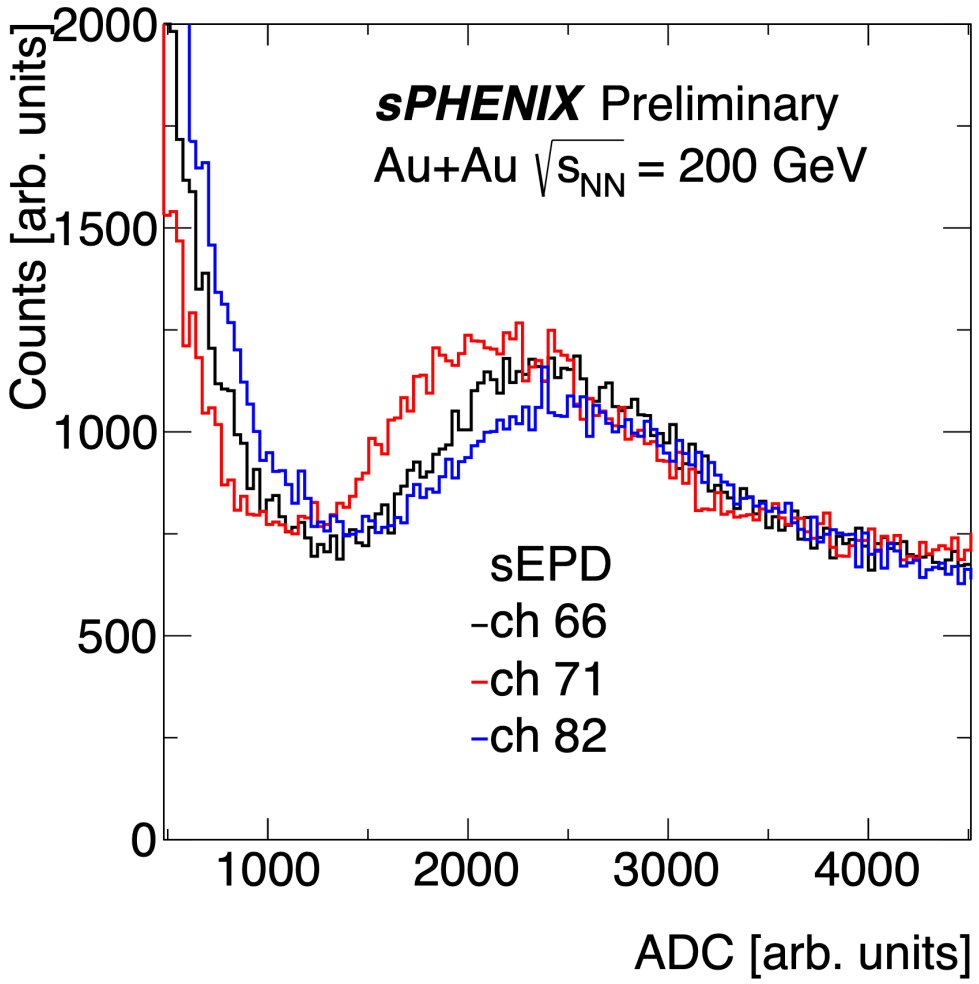
- Trigger on ZDC S, measure single-neutron peak in ZDC N and ZDC N-S correlations
- ZDC had not been read out in several years
- ZDC is ready for triggering and centrality determination!

Minimum Bias Detector (MBD)



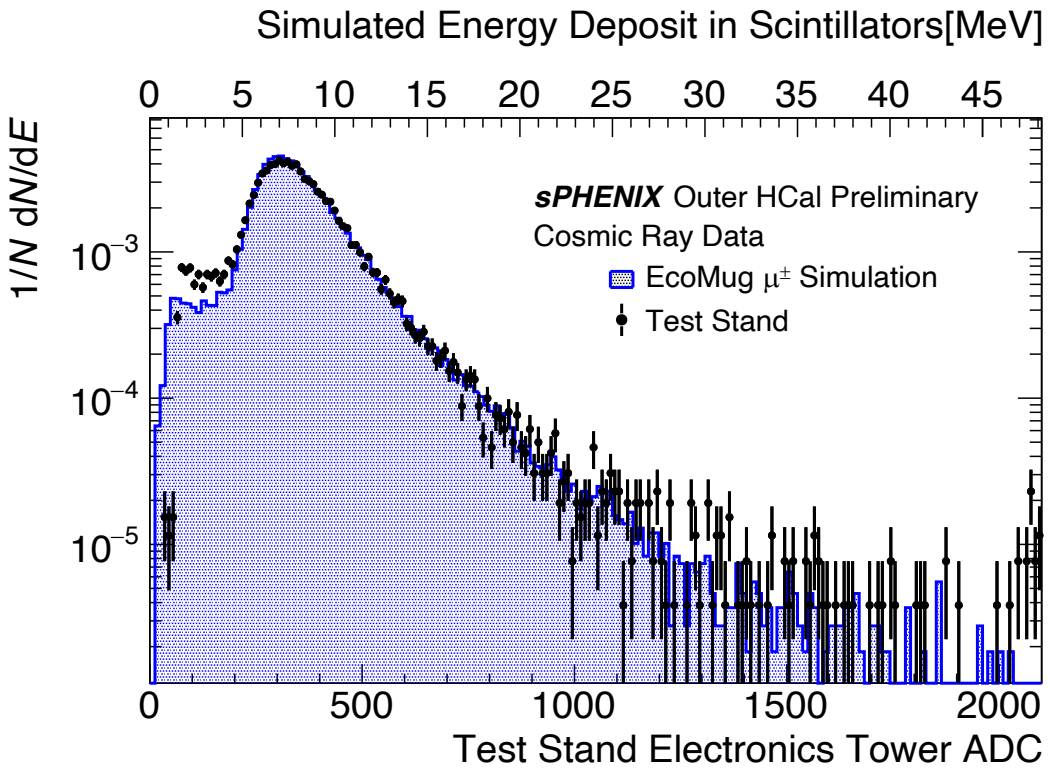
- MBD has provided minimum bias triggers from day 3 of collisions
- Measures z vertex position
- Measures centrality of collision

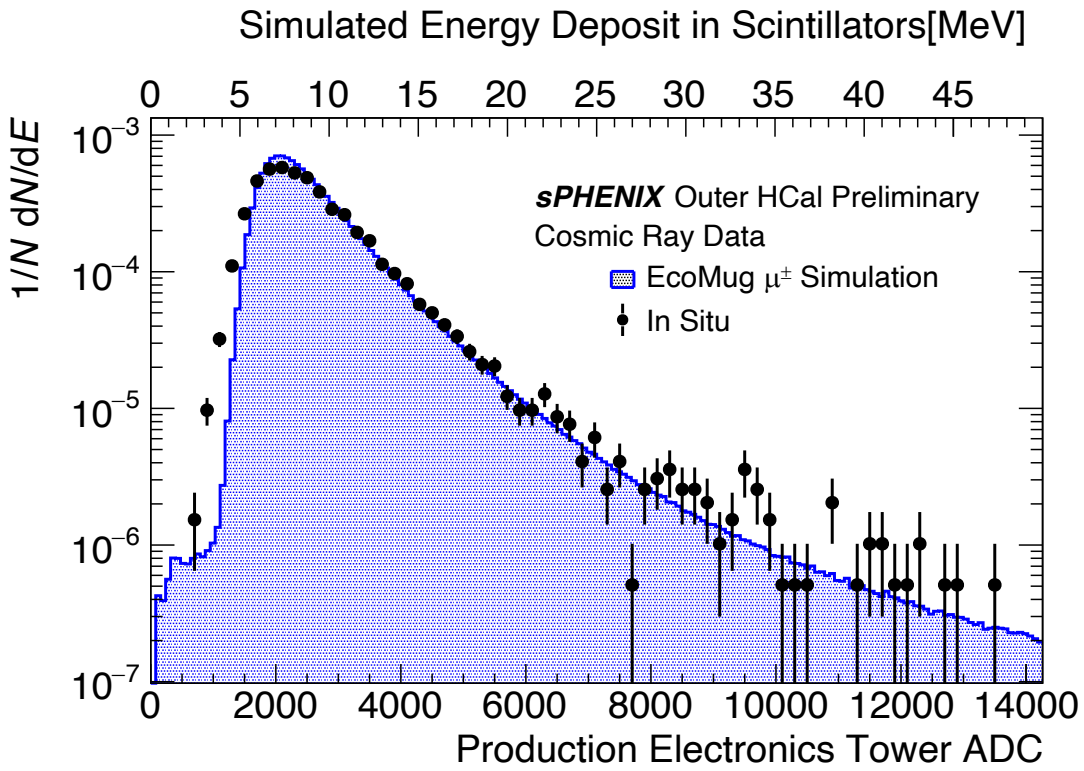
sPHENIX Event Plane Detector (sEPD)



- Installed during run
- Read-out partially installed
- MIP peak observed in first night after installation

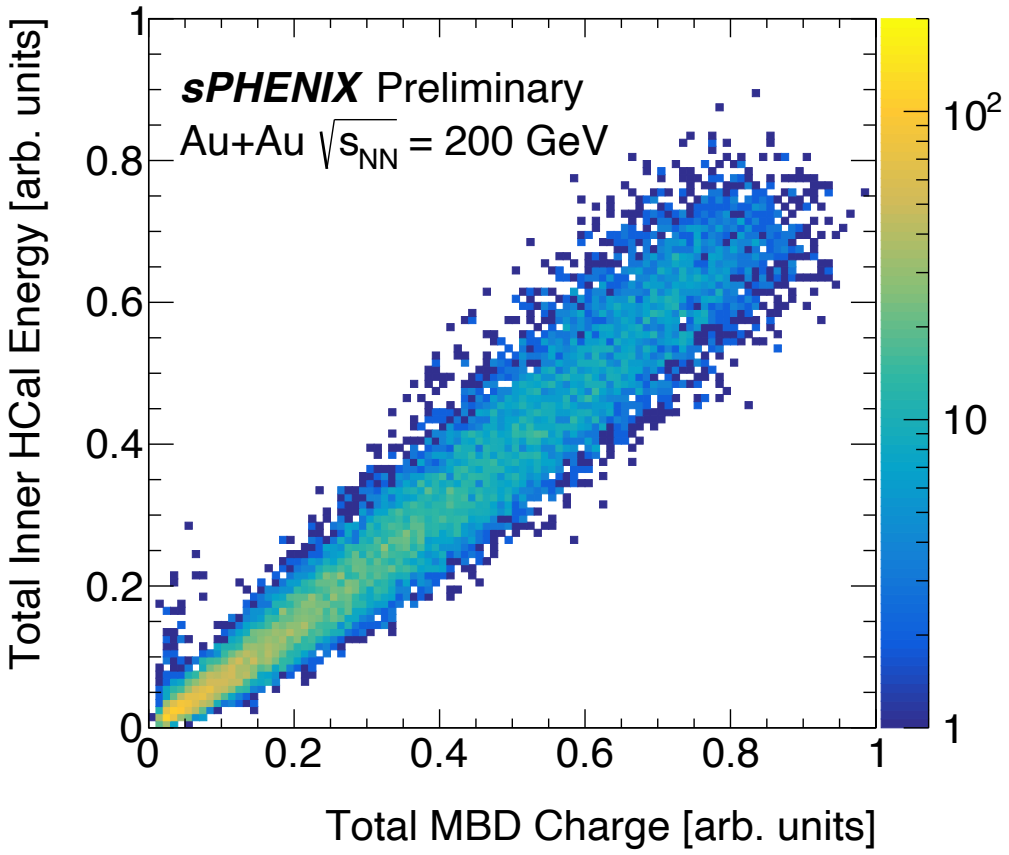
Hadronic Calorimeter (HCal): cosmics calibration

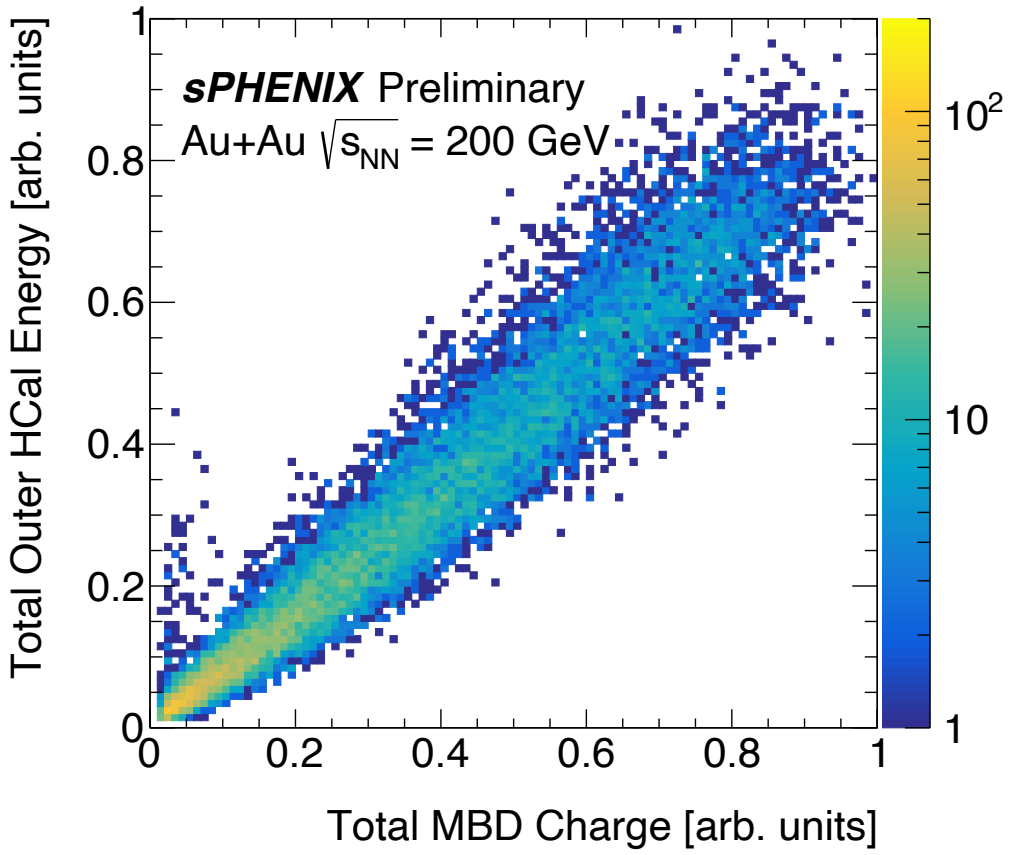




- Took cosmics data with each HCal sector after assembly (left)
- Taking cosmics data in situ in no-beam periods (right); now with calorimeter trigger
- Shape of energy distribution matches Geant simulation of cosmic muons
- Provides calibration at EM scale

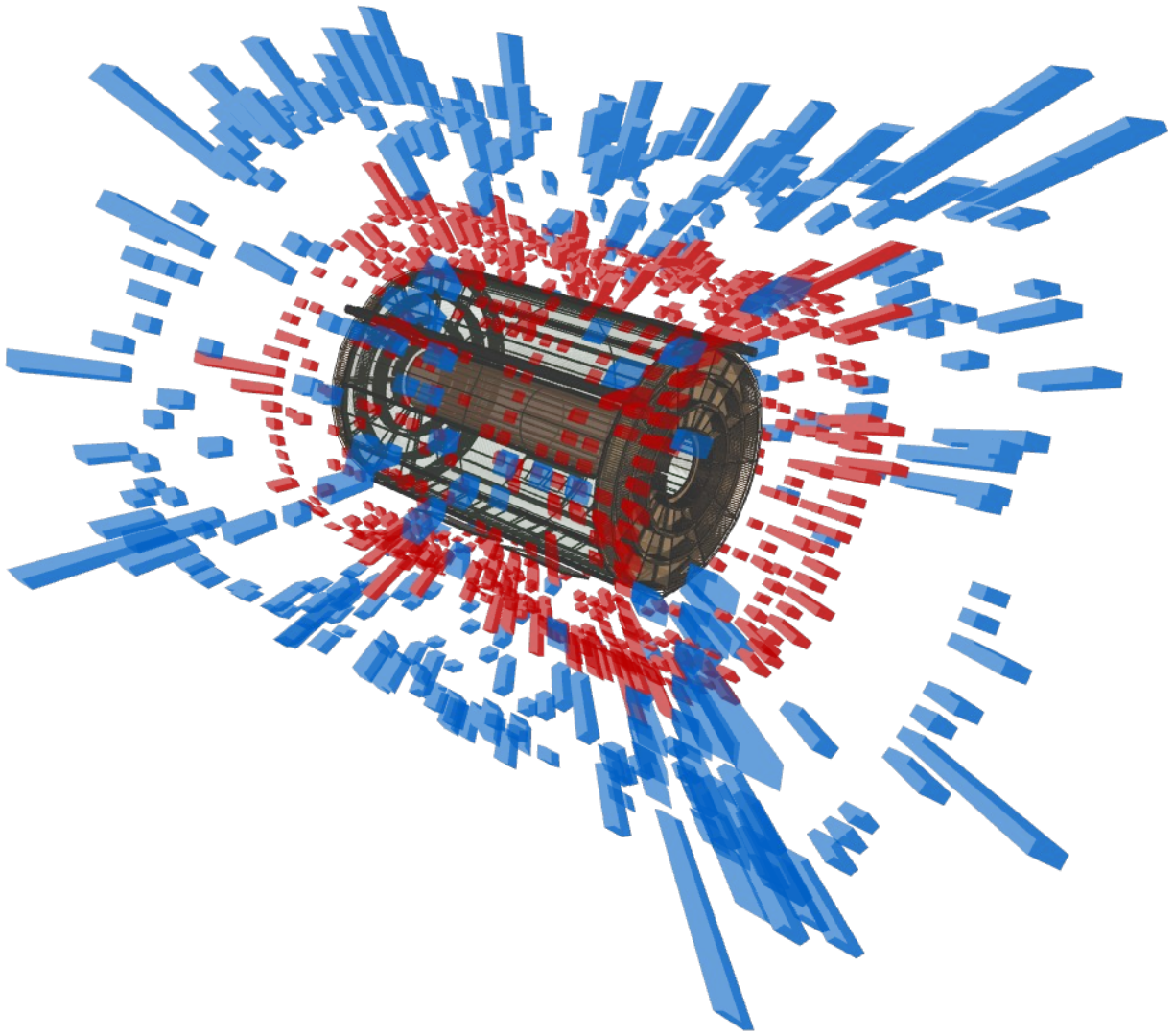
Correlations of inner and outer HCal with MBD



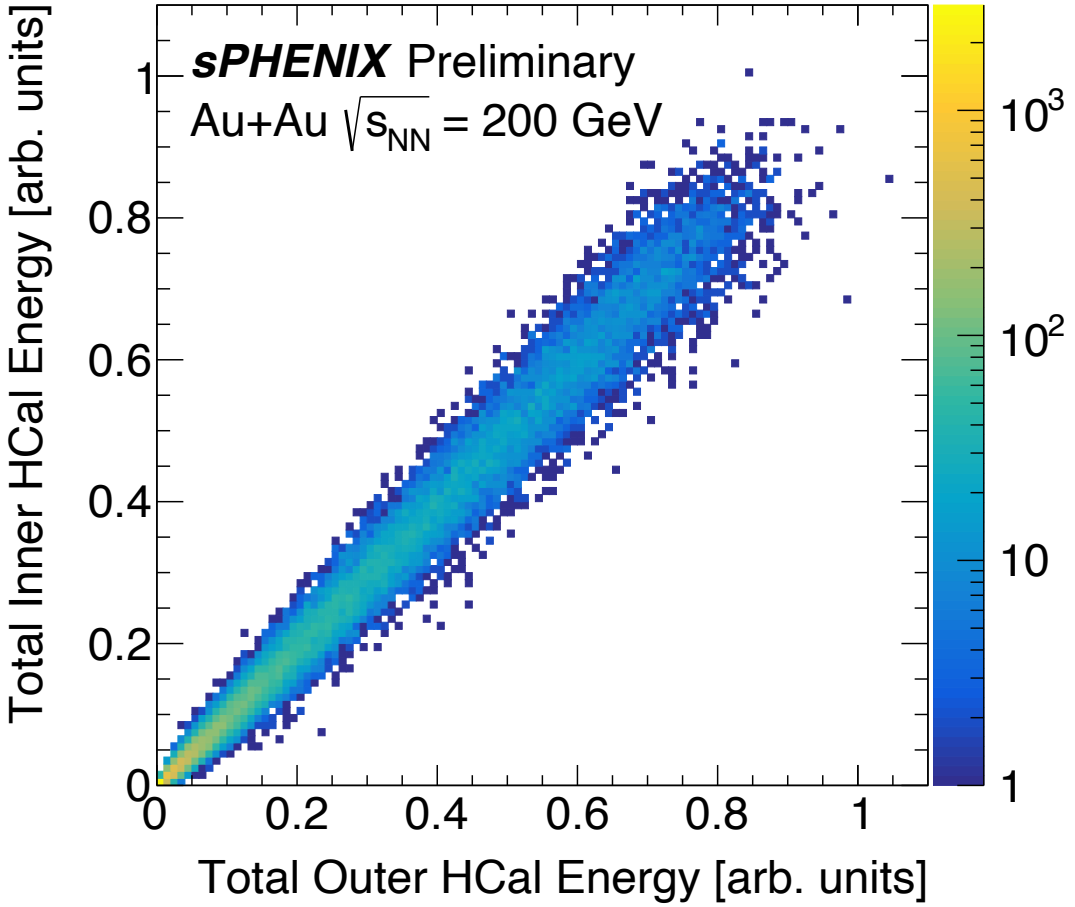


- Hadronic calorimeters at mid-rapidity are correlated with MBD at forward rapidity
- 99 % of HCal channels working and being read out

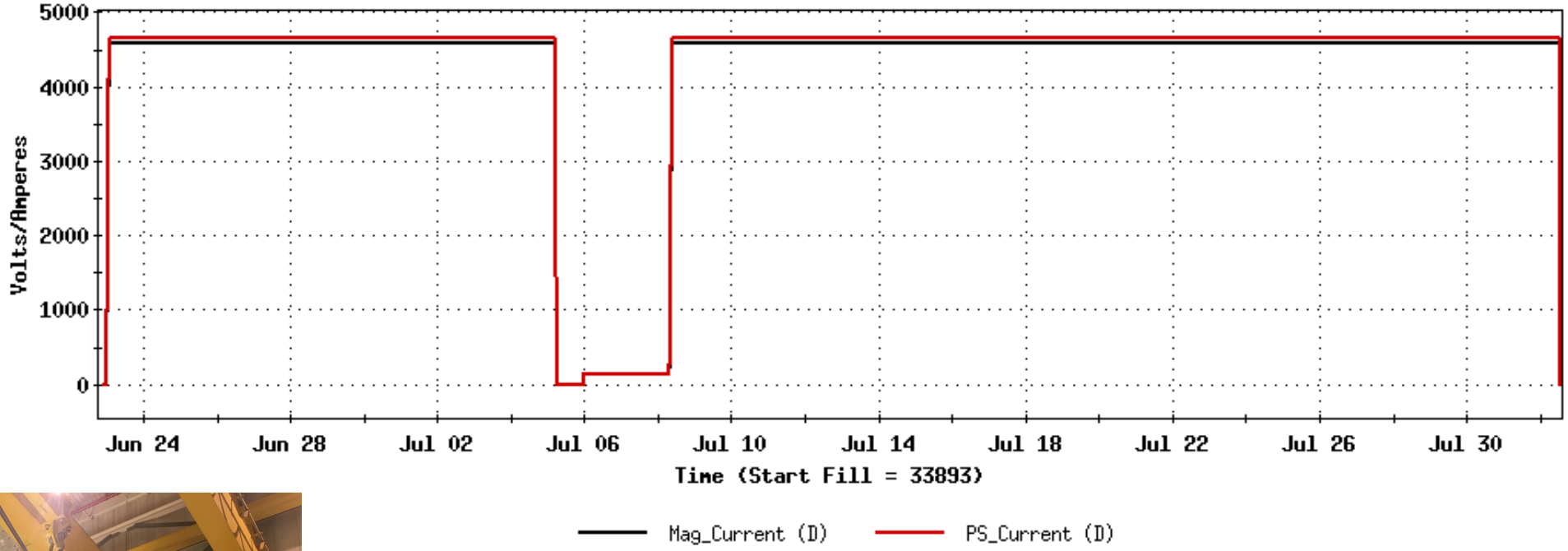
sPHENIX Experiment at RHIC
Data recorded: 2023-05-22, 02:07:00 EST
Run / Event: 7156 / 12
Collisions: Au + Au @ 200 GeV



Correlation of inner and outer HCal

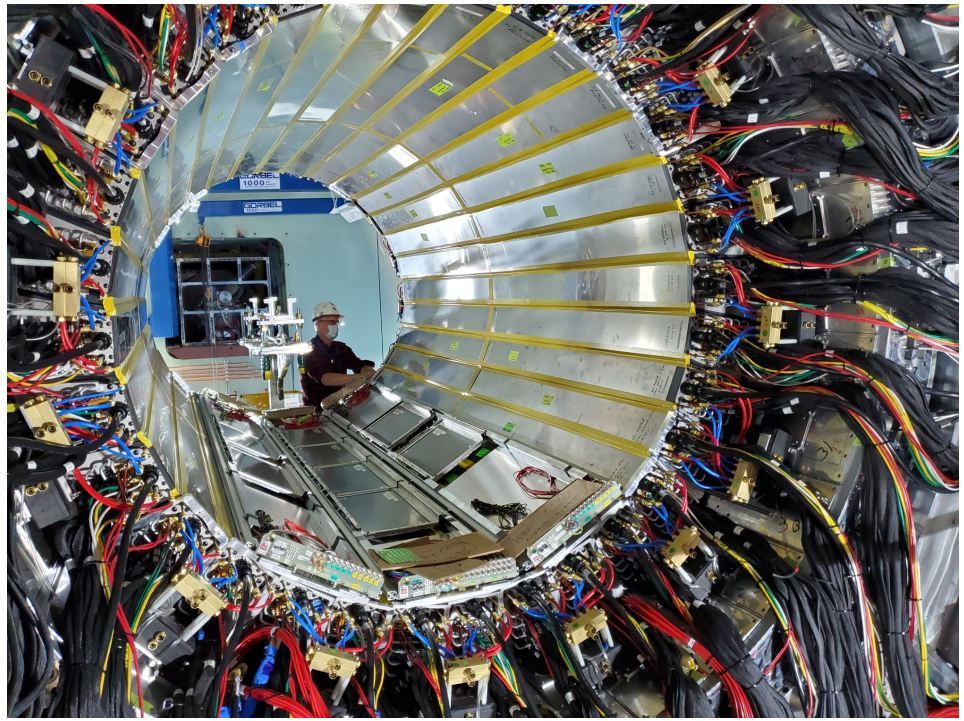


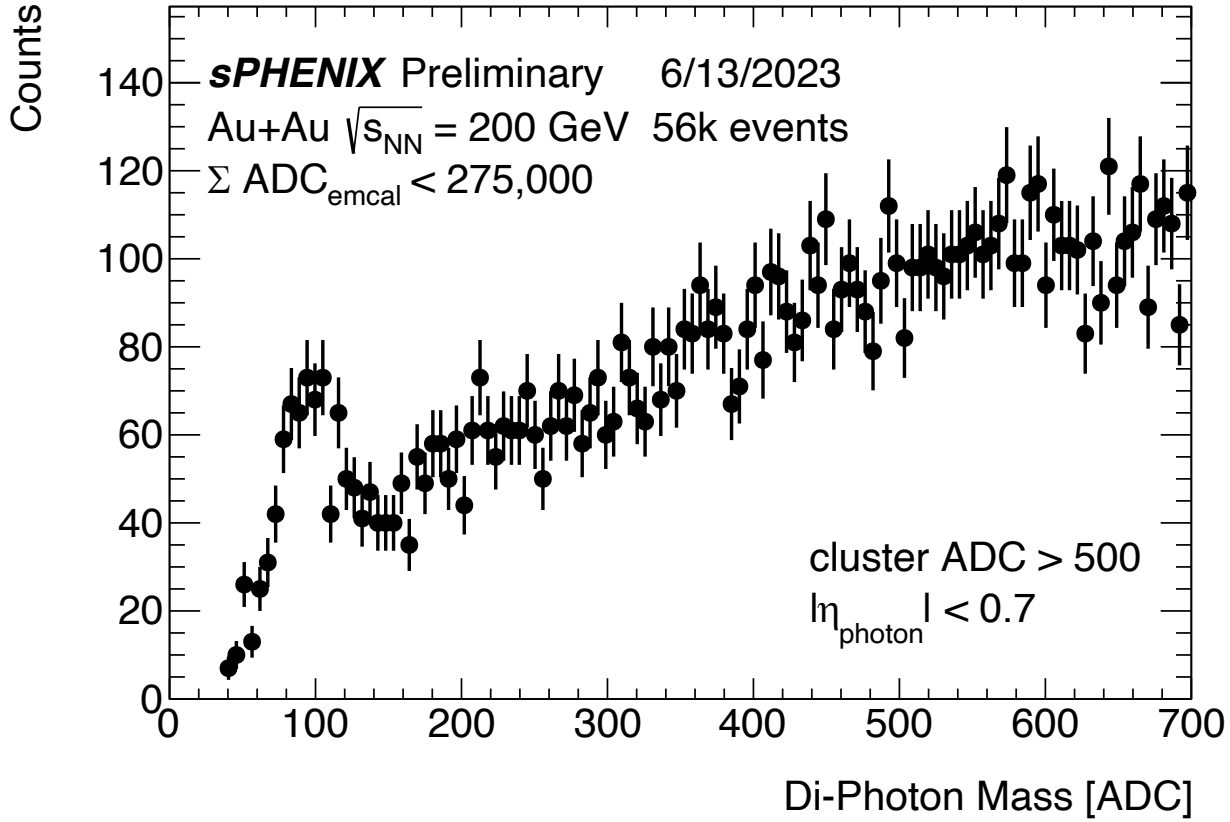
Magnet



Stable operation

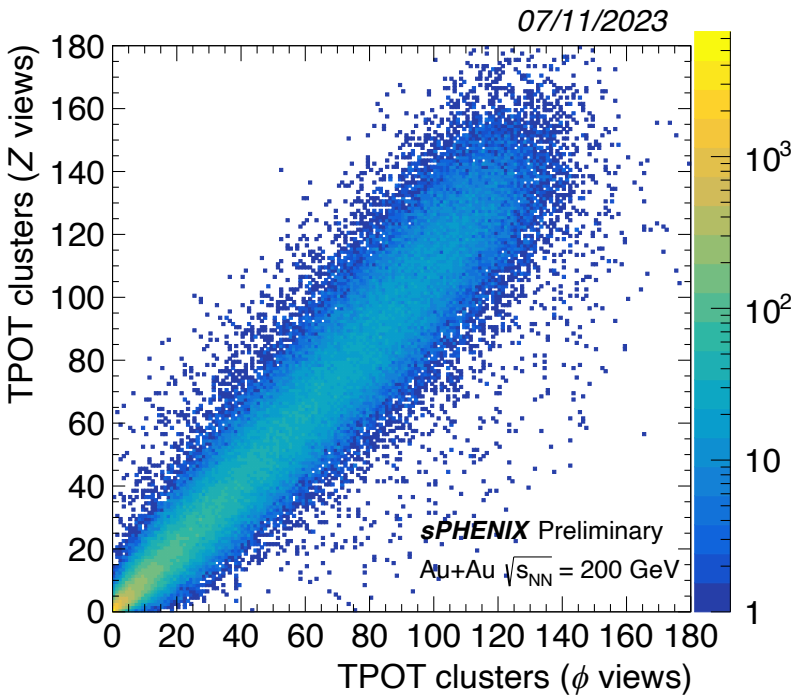
Electromagnetic Calorimeter (EMCal)

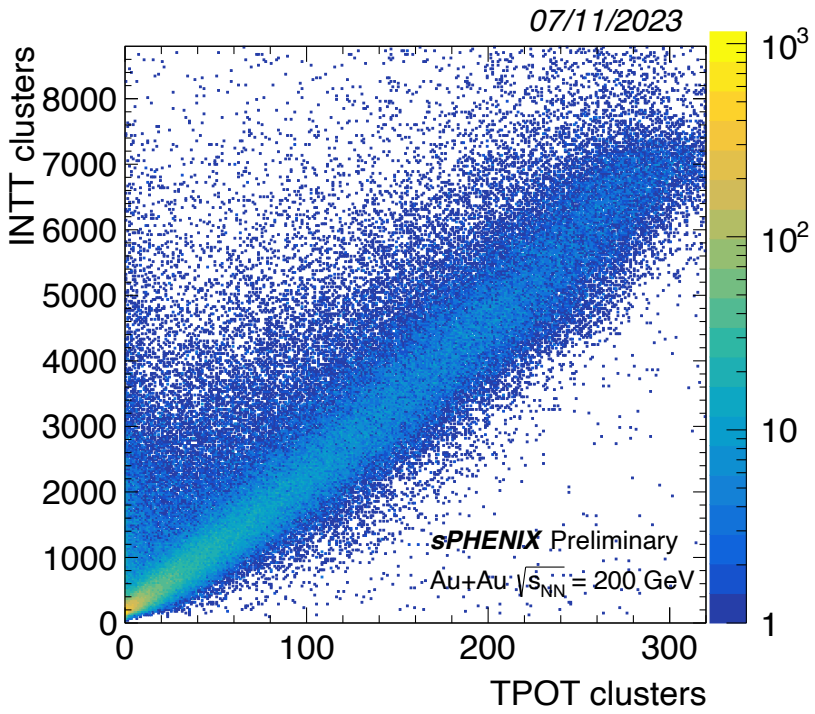


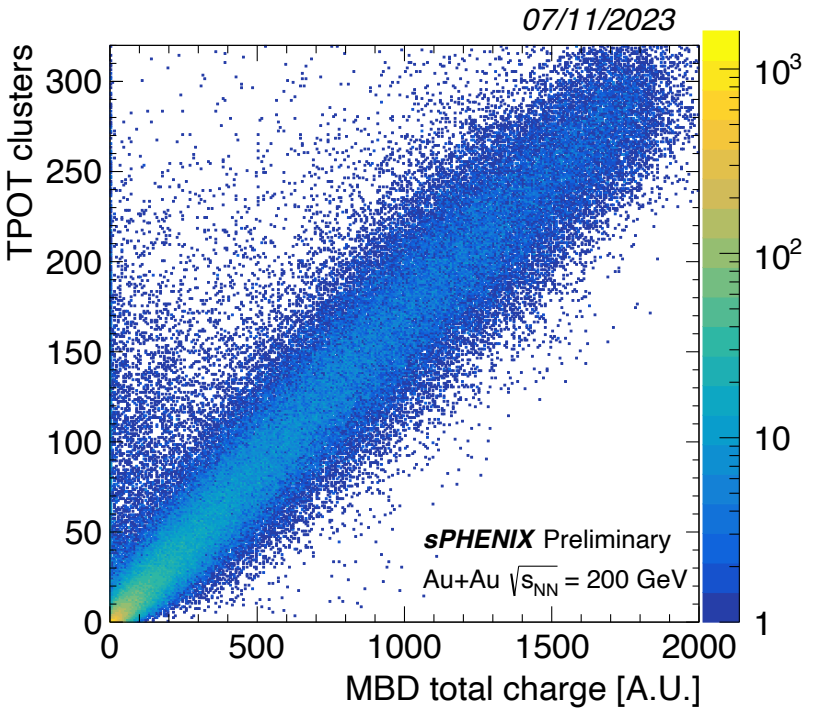


- Di-photon invariant mass distribution
- shows peak at position consistent with π^0 mass

TPC Outer Tracker (TPOT): correlations

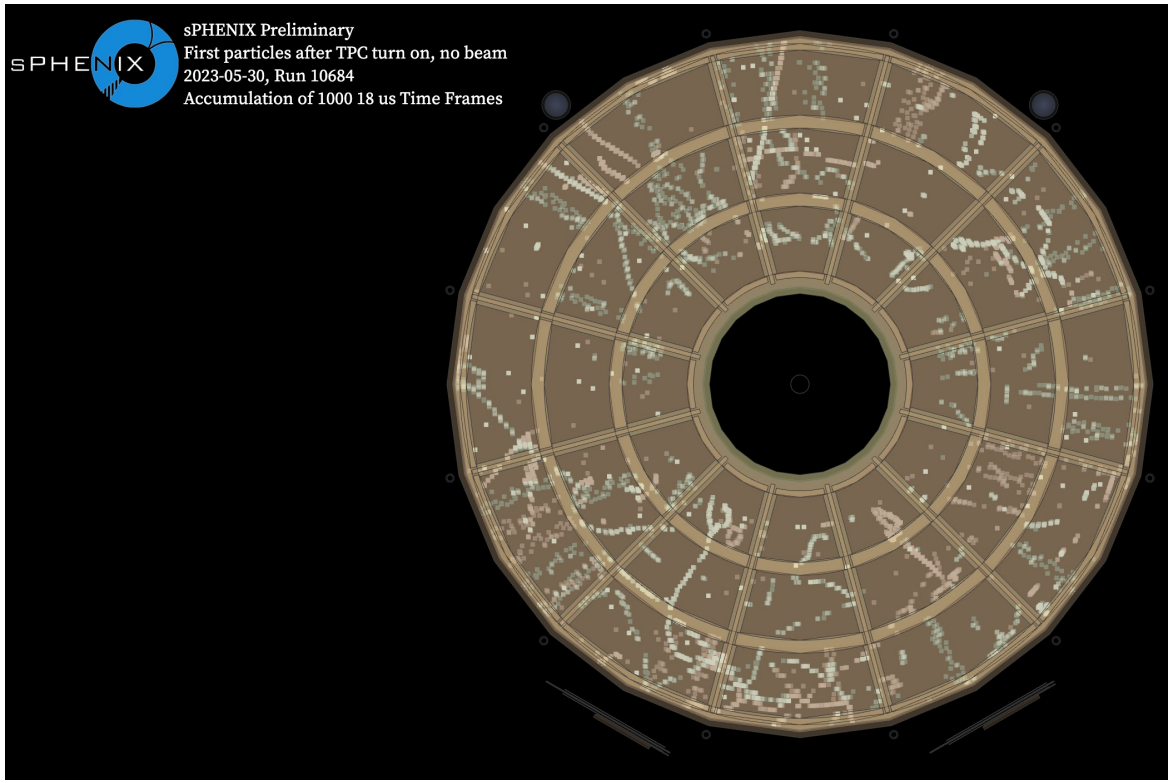


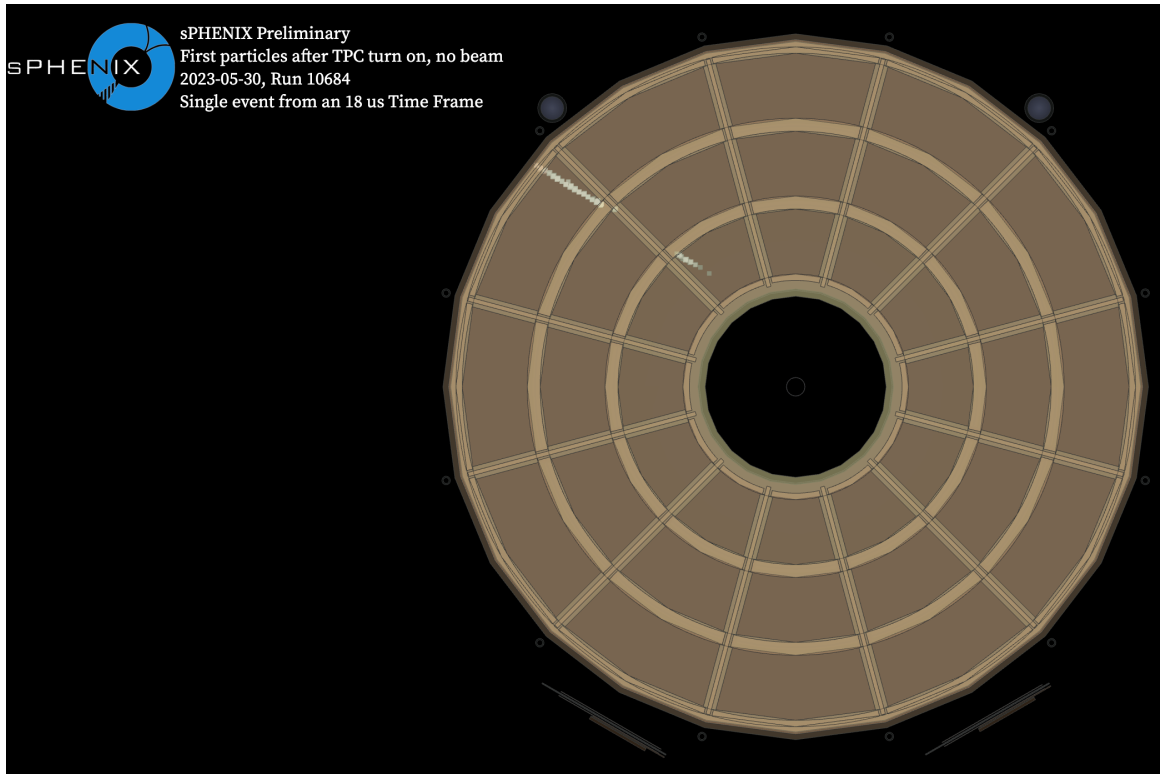




- partial acceptance
- one layer of micromegas
- read out with streaming
- ϕ, z measurement

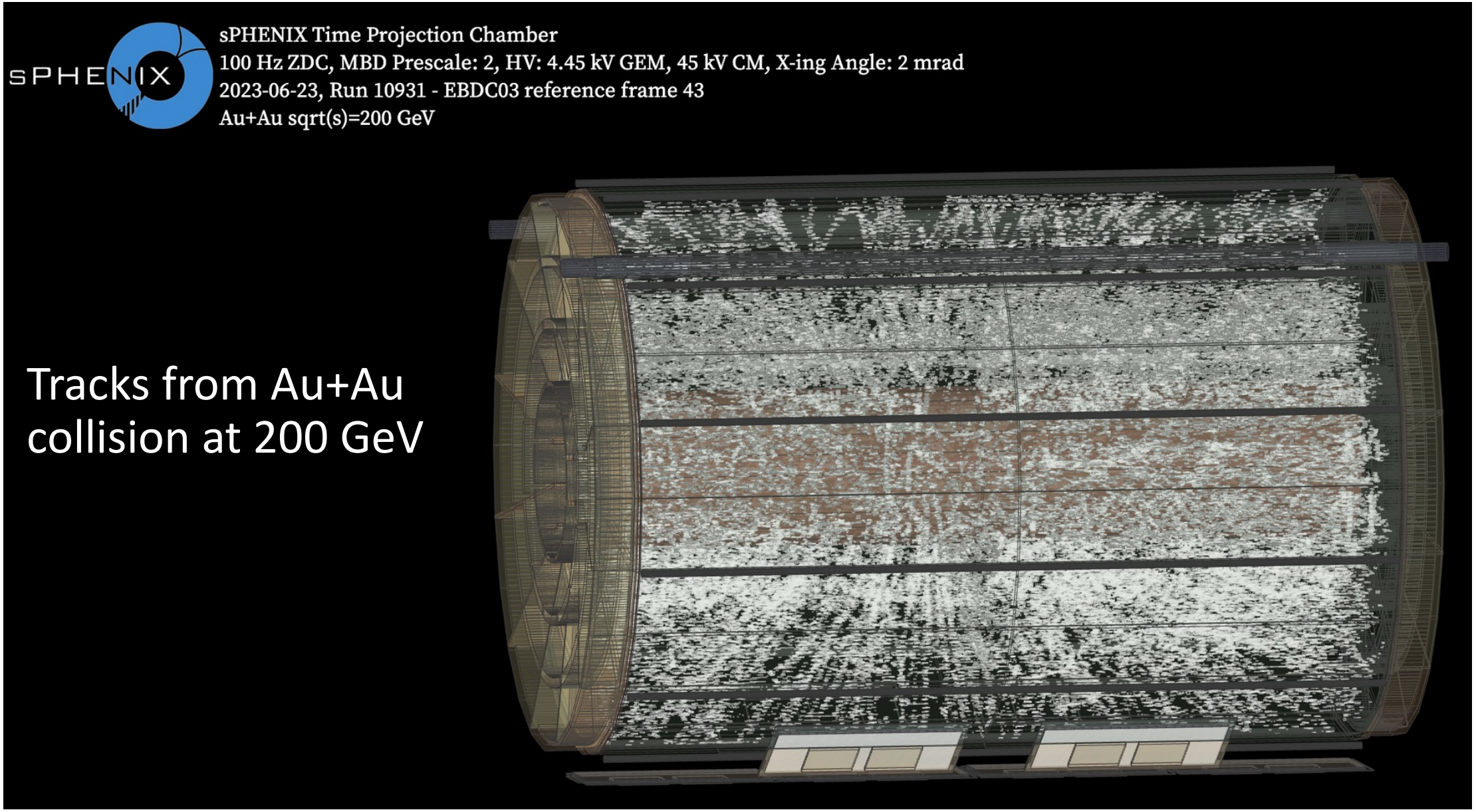
Time Projection Chamber (TPC): cosmic muons



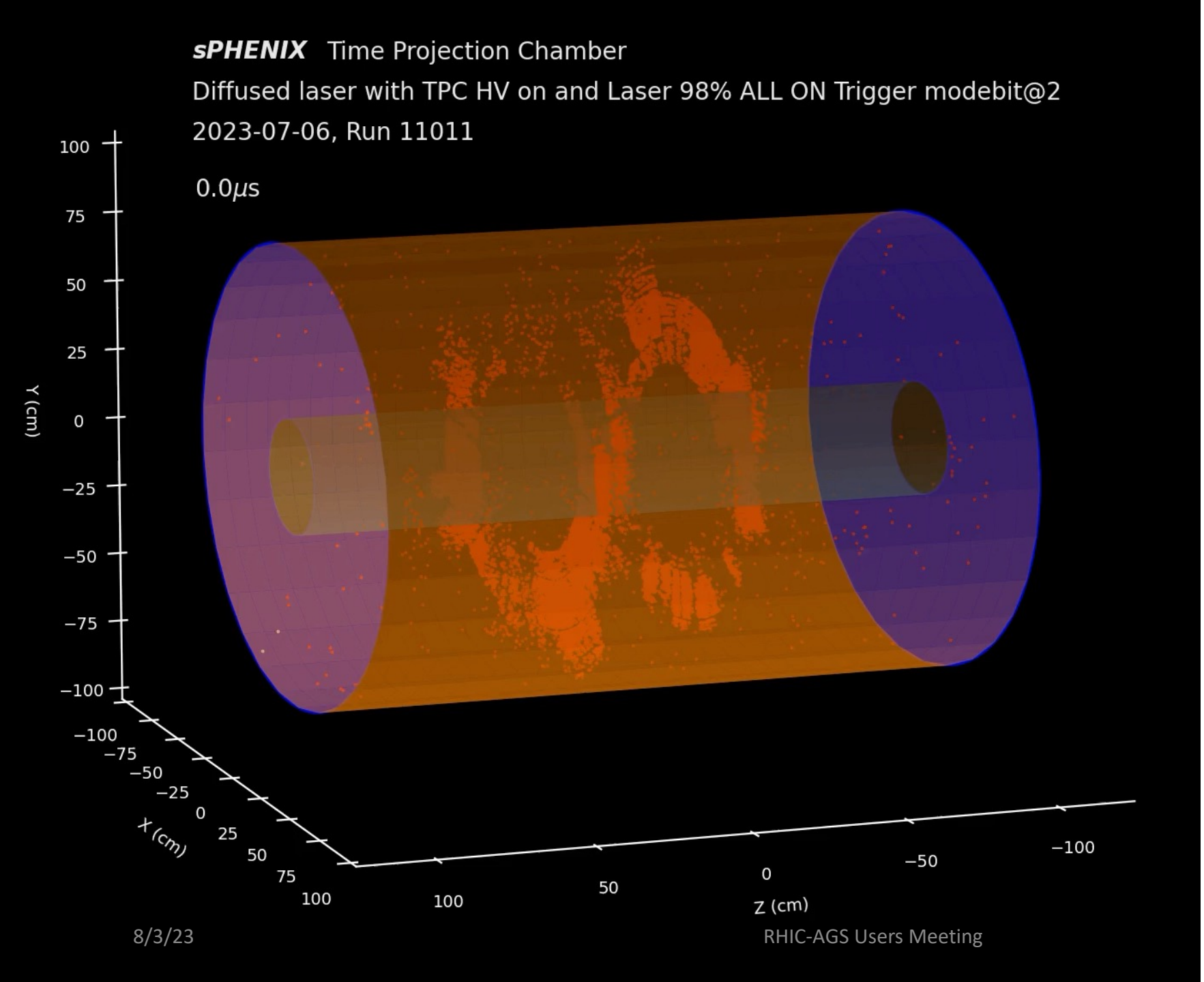


- Tracks from cosmic events
- Streaming read-out: continually producing data
- Left: accumulated 1,000 fundamental time frames (18 ms)
- Right: single time frame (18 us)

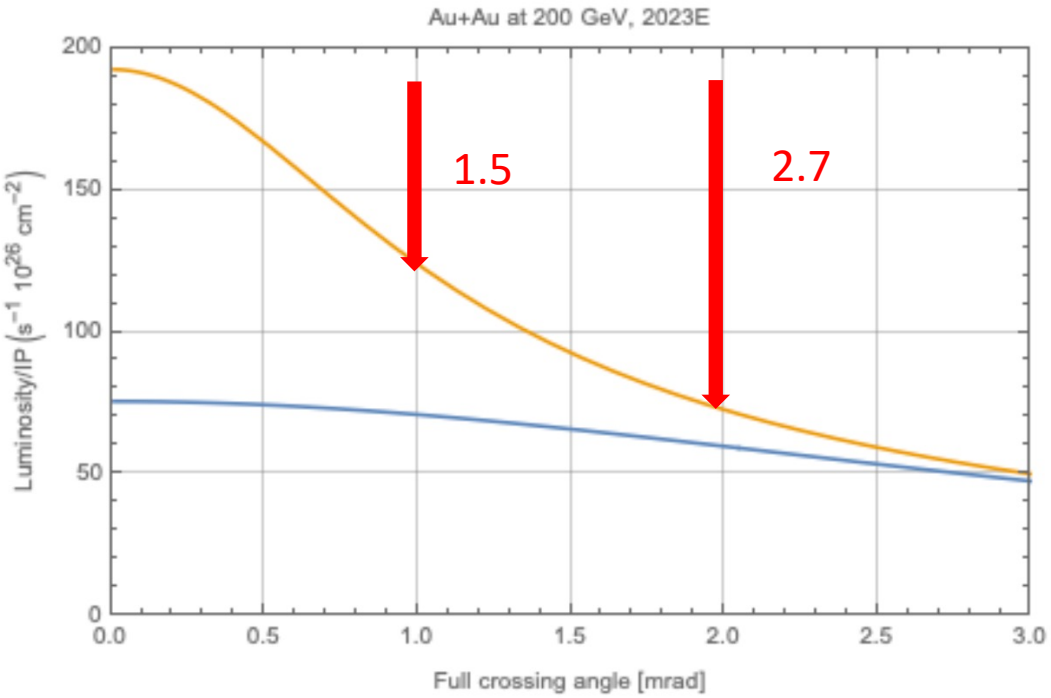
TPC Collision data

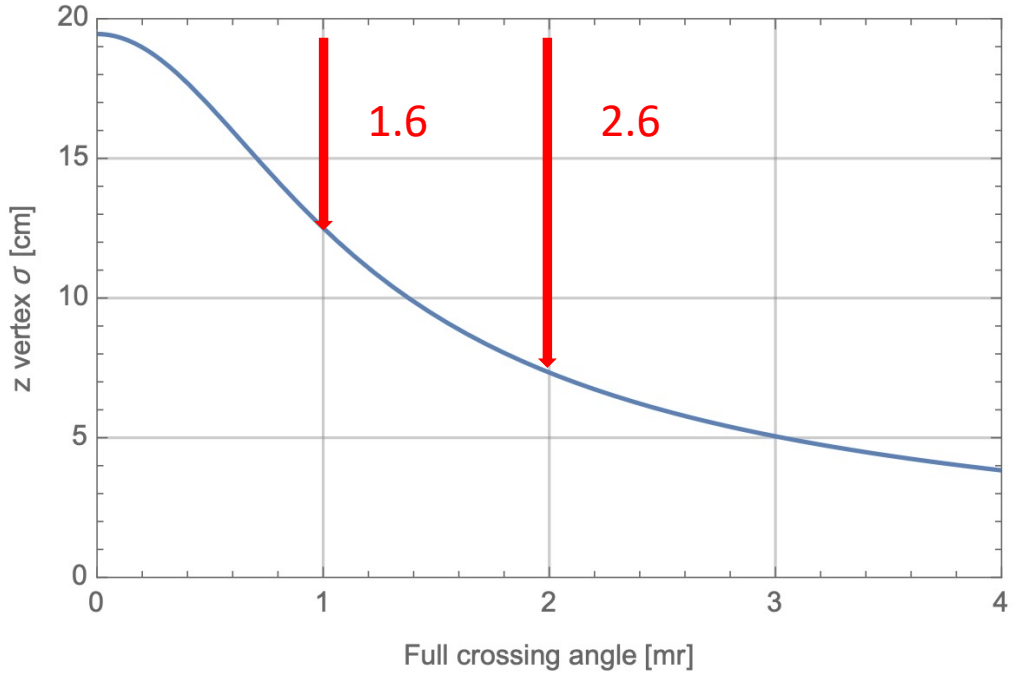


Tracks from Au+Au collision at 200 GeV



Diffuse laser system





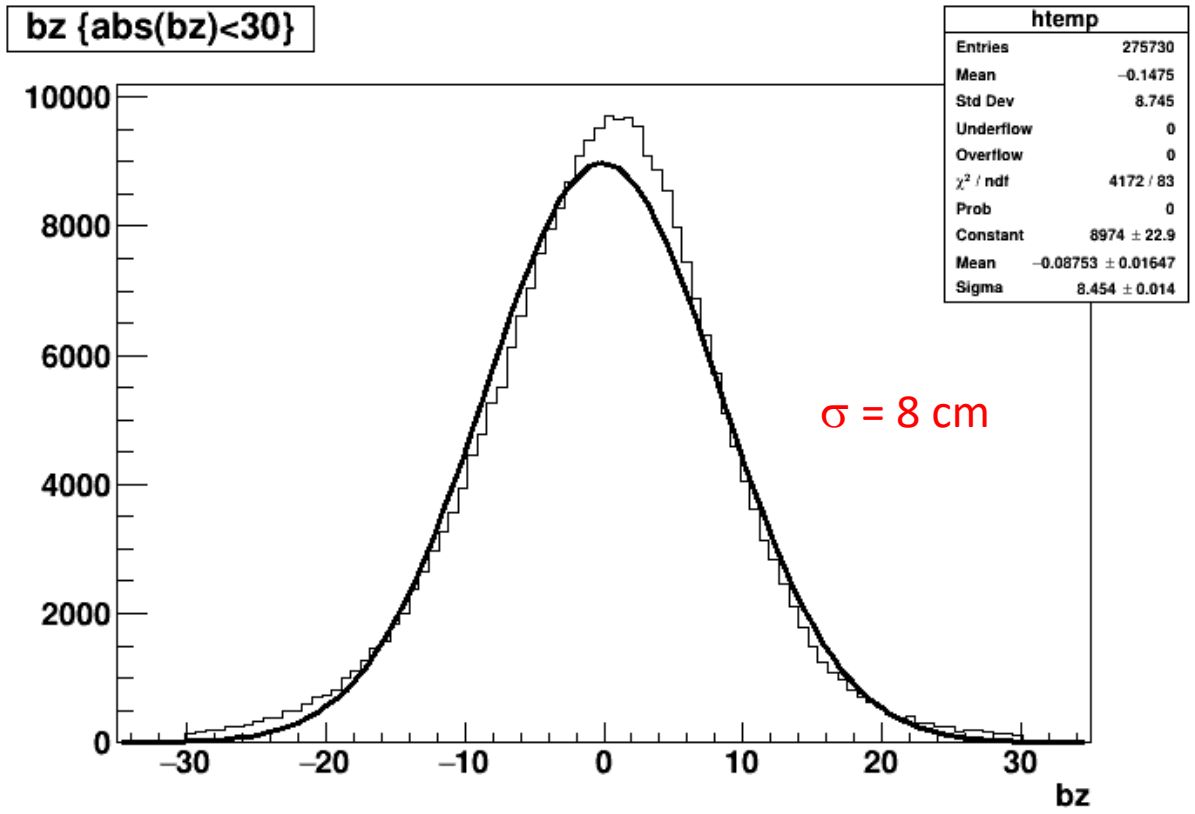
Crossing angle observations

- ZDC coincidence rate (no vertex cut)
  - Projection/observation
    - 0 – 2 mrad: factor 2.7/6-7 reduction
- Vertex distribution sigma
  - Projection/observation
    - 0 – 1 mrad: factor 1.6/2.0 reduction
    - 0 – 2 mrad: factor 2.6/2.4 reduction

Observed the expected relative reduction in the width of the vertex distribution

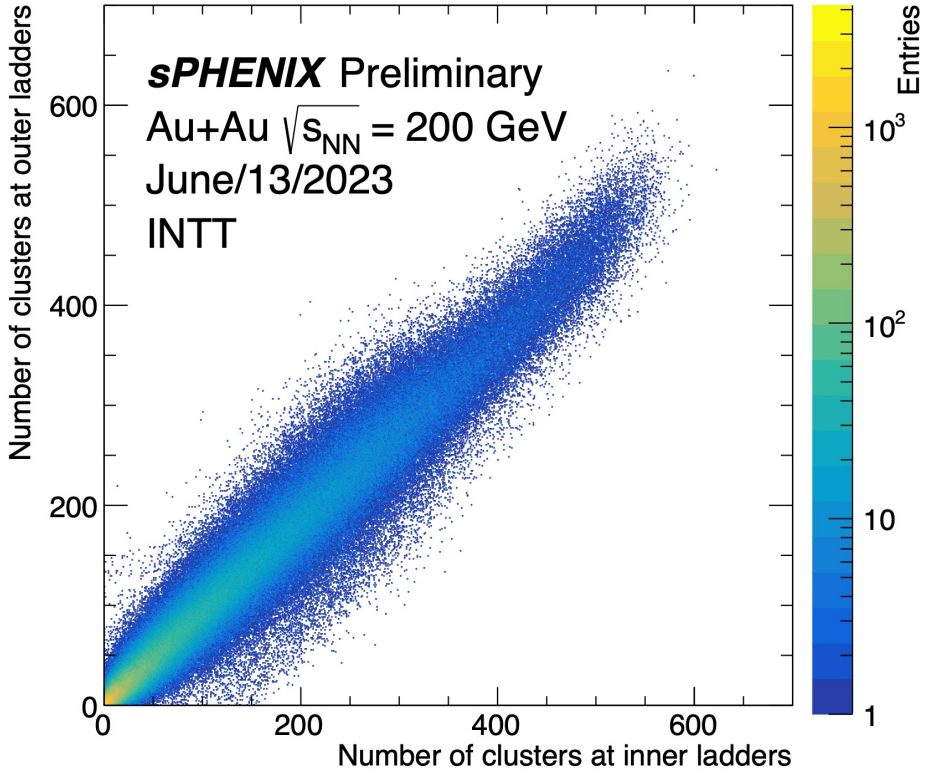
CAD projections

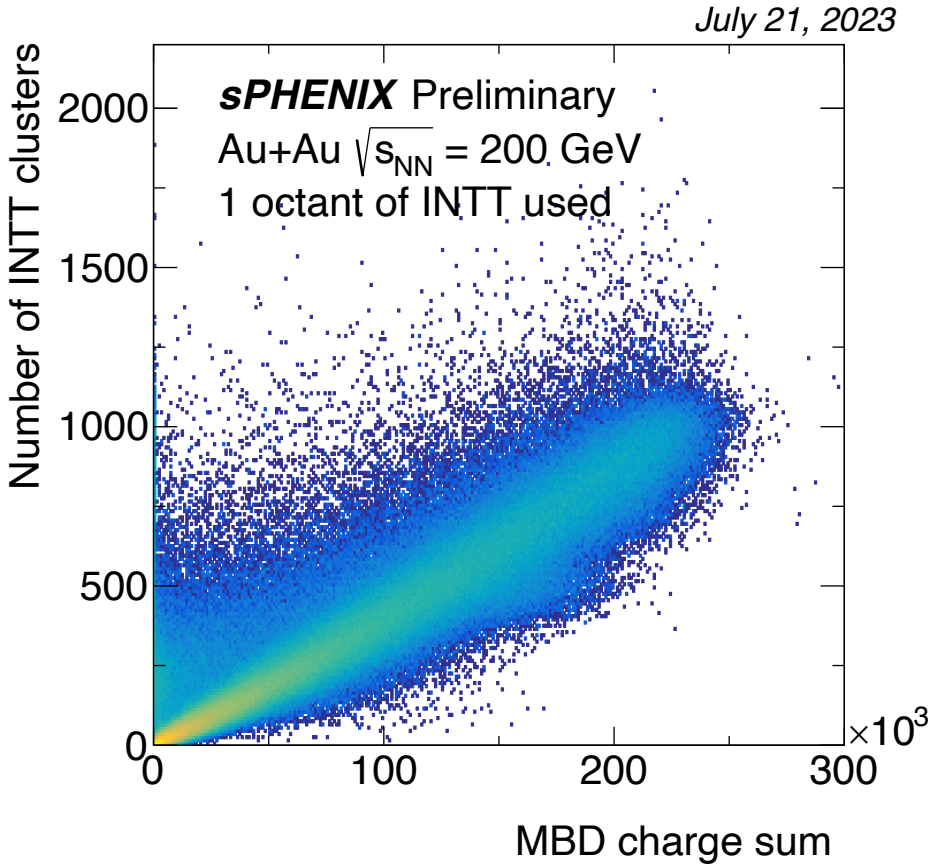
MBD: Improved Timing Calibrations



- Absolute width of vertex distribution close to expectation

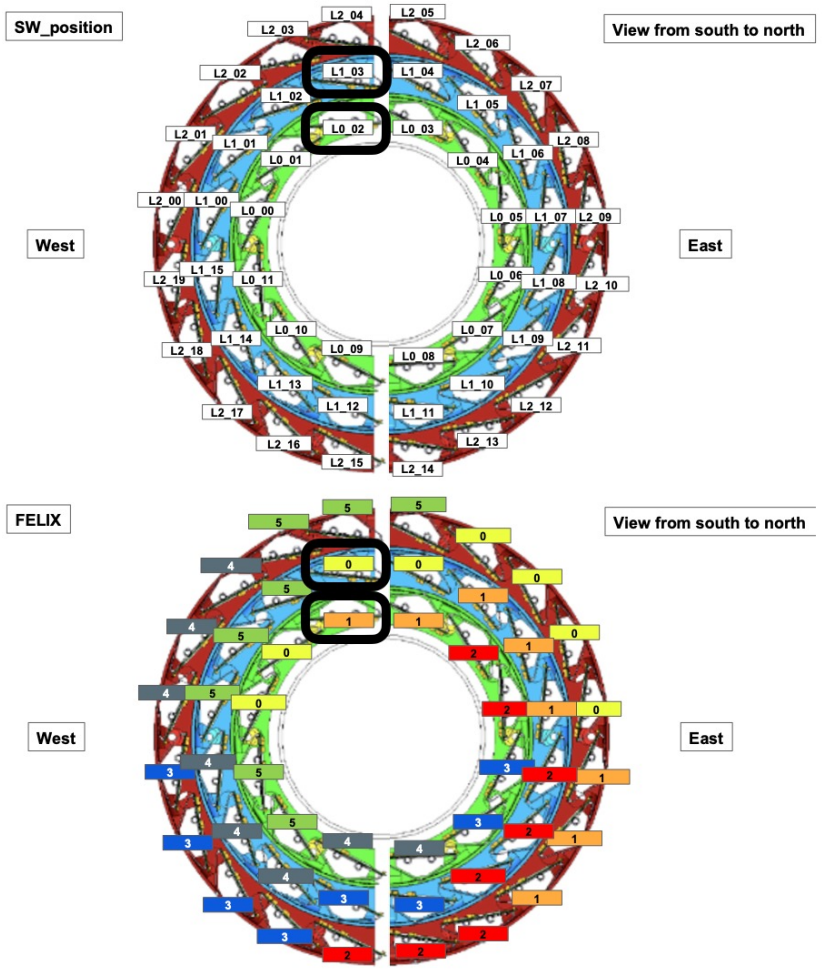
Intermediate Tracker (INTT)

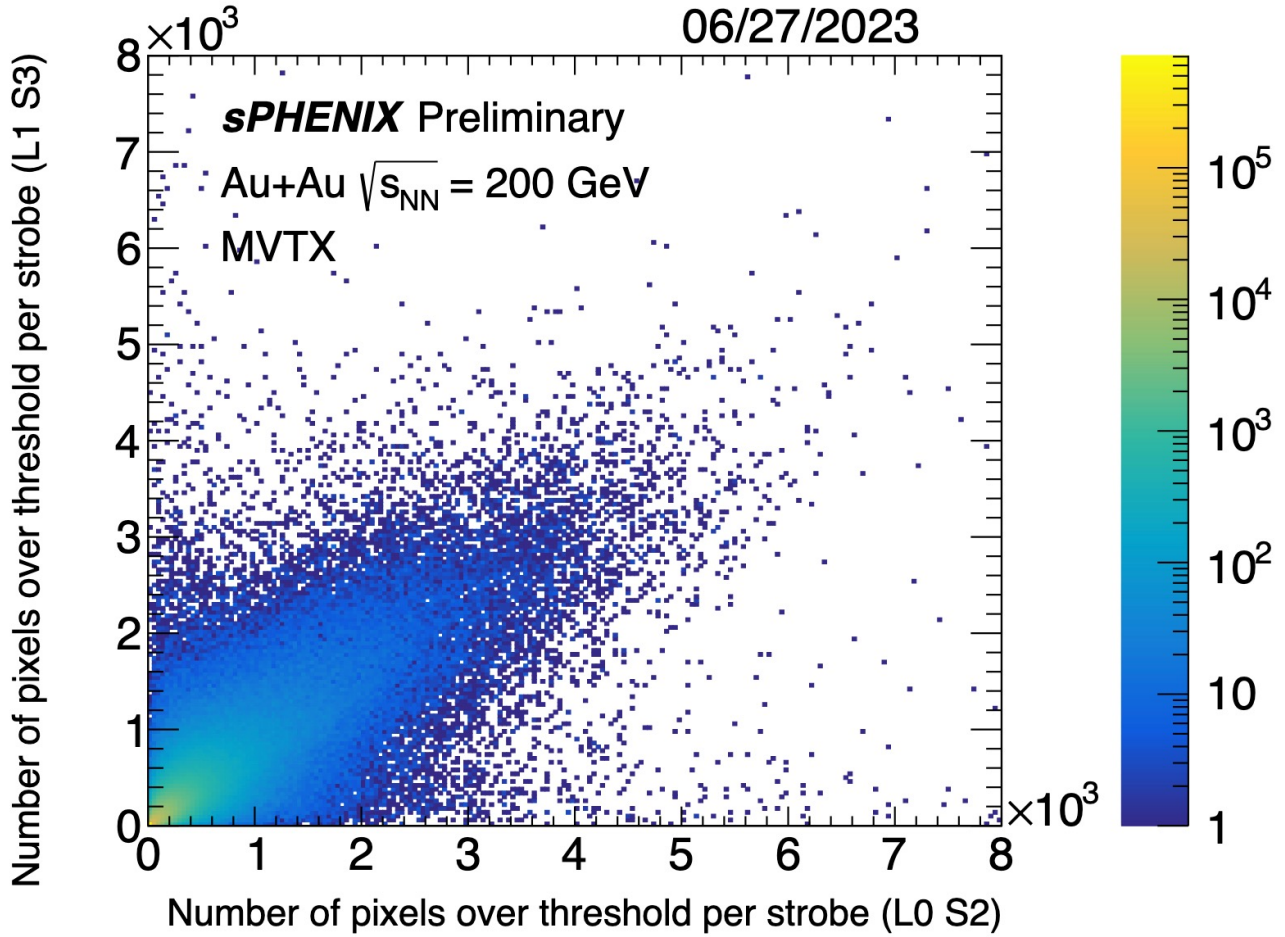




- 99 % of channels working
- Robust read-out
- Correlated with MBD
- Two technologies: FELIX (streaming) and ADC (triggered)

MAPS Vertex Detector (MVTX)





- Correlation seen between different MVTX layers

Commissioning Plan

Weeks	Details
2.0	low rate, 6-28 bunches
2.0	low rate, 111 bunches, MBD L1 timing
1.0	low rate, crossing angle checks
1.0	low rate, calorimeter timing
4.0	medium rate, TPC timing, optimization
2.0	full rate, system test, DAQ throughput
12.0	**total**

- Initial timing and triggering
  - Trigger worked within 3 days
- Optimize trigger, time in calorimeters
  - Calorimeters worked on first weekend
- Turn on calorimeters, crossing angle studies
  - Calorimeters turned on on first weekend
  - Fraction read out, read-out stability, and read-out speed gradually improved
  - Full calorimeters read out reliably at kHz speed for weeks
  - Crossing angle works to narrow vertex distribution
  - Luminosity loss still larger than expected
    - Will be addressed by 56 MHz cavity or further optimizing crossing angle
- Optimize calorimeters, measure radiation
  - Assessed level of radiation exposure to silicon photomultipliers: small and in line with expectations

Commissioning Plan

Weeks	Details
2.0	low rate, 6-28 bunches
2.0	low rate, 111 bunches, MBD L1 timing
1.0	low rate, crossing angle checks
1.0	low rate, calorimeter timing
4.0	medium rate, TPC timing, optimization
2.0	full rate, system test, DAQ throughput
12.0	**total**

- Initial operation of tracking detectors
  - Tracking detectors initially turned on ahead of schedule
  - INTT and TPOT operating and read-out for months
  - characterization of GEM behavior: working to establish stable operation of TPC at full operating voltage
    - Will be addressed by spark protection system coming online as we speak
  - MVTX read-out impacted by beam background
    - Working on firmware modification
    - Have worked with CAD to study and reduce beam background
- Stress test DAQ at high rates
  - Have already started to increase read-out speed of calorimeters by reducing sample size, introducing multi-event buffering, and zero suppression
  - Zero suppression of TPC and TPOT data and duty factor of tracking read-out are challenges that we still need to address

Summary

- First new collider detector in quarter of century
- Commissioning 10 brand new detectors
- Has been extremely successful
- Some remaining challenges
- Whole collaboration excited to get to physics

- Thanks to CAD and the trades people for their support; it has been invaluable in this extremely complicated environment
- Thanks to DOE and NSF for their support

sPHENIX Talks and Posters

- sPHENIX Highlights—Anne Sickles—today, 3:50pm
- sPHENIX Jet program (workshop talk)--Anthony Hodges
- Heavy flavor physics (workshop talk)—Antonio Carlos Oliveira da Silva
- sPHENIX Detector (workshop talk)—Ejiro Umaka
- sPHENIX Calorimeters (workshop talk)—Hanpu Jiang
- sPHENIX Tracking (workshop talk)—Joseph Bertaux
- Construction and Installation of sEPD (poster)—Micah Meskowitz—today, 6:00pm
- Tracking in Jets for the sPHENIX cold-QCD Program (poster)—Athira Vijayakumar—today, 6:00pm
- Performance and Commissioning of sPHENIX MBD (poster)—Lameck Mwibanda—today, 6:00pm
- Heavy Flavor Physics in sPHENIX (poster)—Antonio Carlos Oliveira da Silva—today, 6:00pm
- Commissioning of sPHENIX Intermediate Silicon Tracker (poster)—Jaein Hwang—today, 6:00pm
- Commissioning Status of the sPHENIX EMCal (poster)—Abraham Holtermann—today, 6:00pm