sPHENIX Status

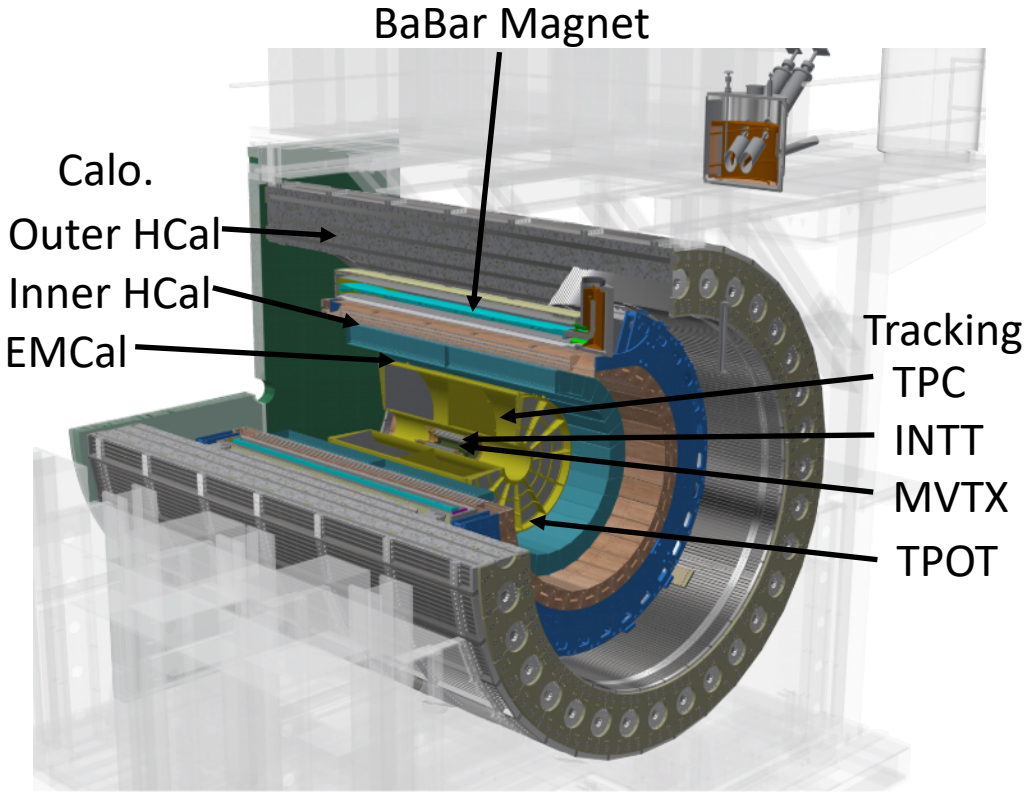
Cameron Dean,
on behalf of the sPHENIX collaboration

MIT

10th June 2022

RHIC/AGS Annual Users' Meeting

The sPHENIX detector



Not shown: sEPD and MBD

First run year	2023
$\sqrt{s_{NN}}$ [GeV]	200
Trigger Rate [kHz]	15
Magnetic Field [T]	1.4
First active point [cm]	2.5
Outer radius [cm]	270
$\lvert\eta\rvert$	$\leqslant$1.1
$\lvert z_{vtx}\rvert$ [cm]	10
N(AuAu) collisions*	1.43x10^{11}

* In 3 years of running

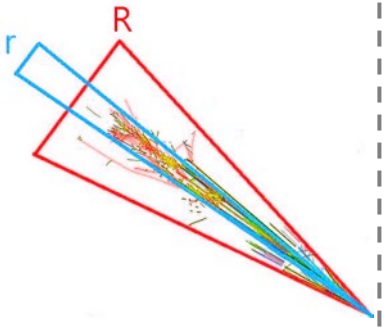
Run schedule

Year	Species	$\sqrt{s_{NN}}$ [GeV]	Cryo Weeks	Physics Weeks	Rec. Lum. $\lvert z\rvert$ <10 cm	Samp. Lum. $\lvert z\rvert$ <10 cm
2023	Au+Au	200	24 (28)	9 (13)	3.7 (5.7) nb^{-1}	4.5 (6.9) nb^{-1}
2024	$p^{\uparrow}p^{\uparrow}$	200	24 (28)	12 (16)	0.3 (0.4) pb^{-1} [5 kHz] 4.5 (6.2) pb^{-1} [10%-*str*]	45 (62) pb^{-1}
2024	$p^{\uparrow}$+Au	200	–	5	0.003 pb^{-1} [5 kHz] 0.01 pb^{-1} [10%-*str*]	0.11 pb^{-1}
2025	Au+Au	200	24 (28)	20.5 (24.5)	13 (15) nb^{-1}	21 (25) nb^{-1}

Core physics program

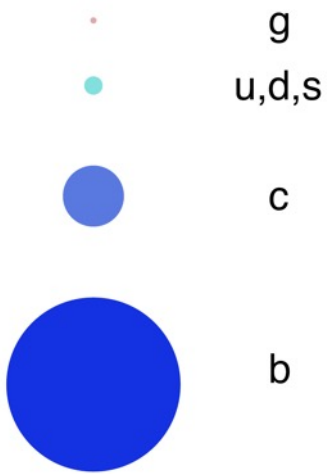
Jet correlation & substructure

Vary momentum/ angular size of probe



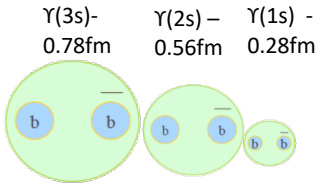
Parton energy loss

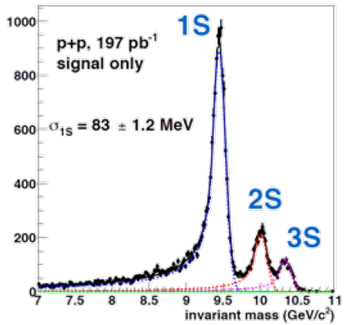
Vary mass/ momentum of probe



Upsilon spectroscopy

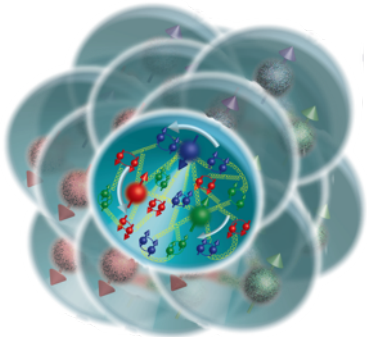
Vary size of the probe





Cold QCD

Vary temperature of QCD matter



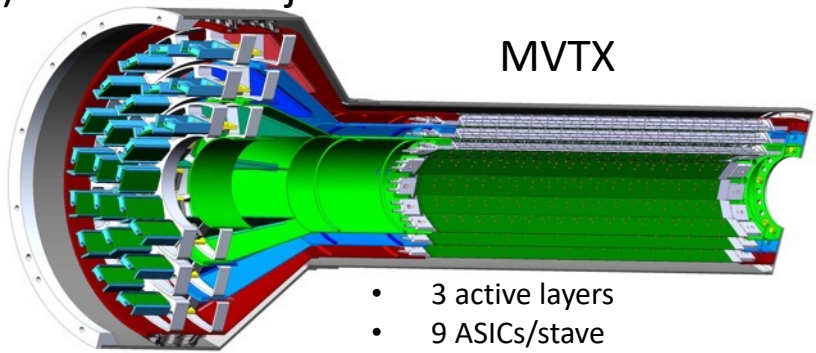
Tracking at sPHENIX

- Tracking currently consists of 4 sub-detectors; Pixel Vertex Detector (MVTX), Intermediate Silicon Tracker (INTT), Time Projection Chamber (TPC) and Time Projection Outer Tracker (TPOT)

The Maps VerTeX detector

- Comprises of 3 layers of monolithic active pixel sensors using the ALICE ALPIDE
- The front-end readout uses the ALICE Readout Unit
- The back-end uses the ATLAS FELIX

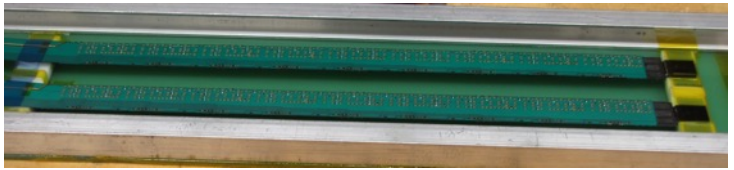
MVTX



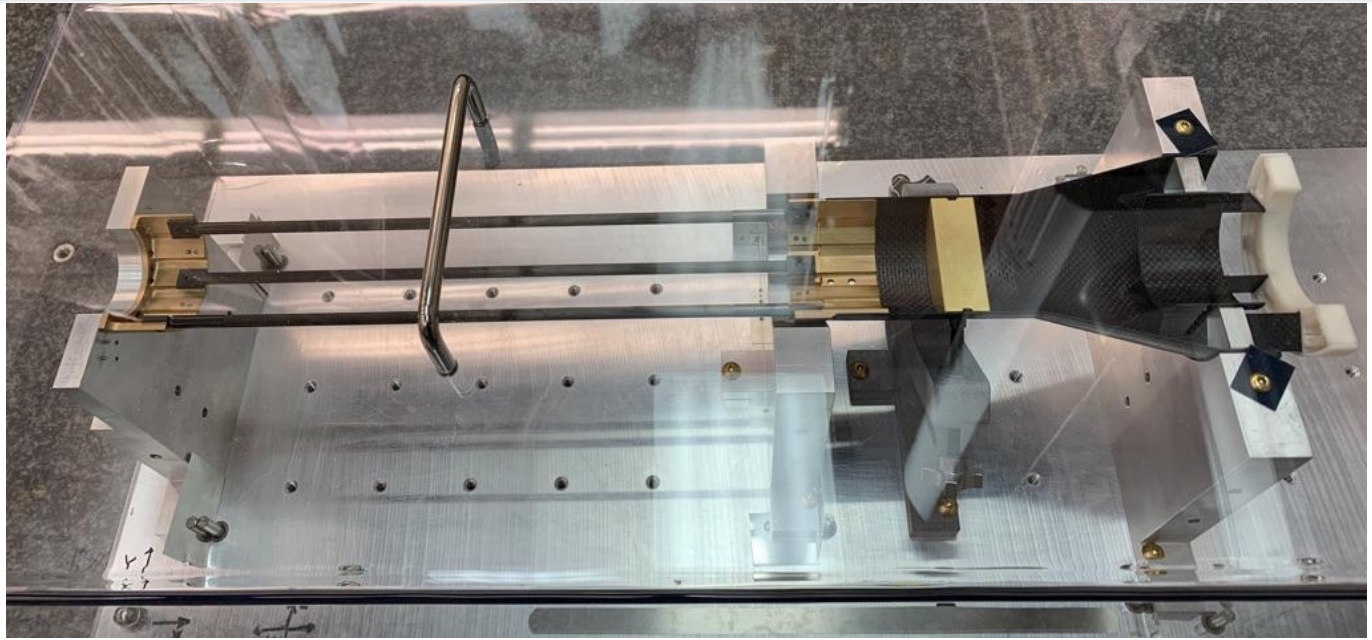
- 3 active layers
- 9 ASICs/stave
- 27 cm active length/stave

ALPIDE thickness [µm]	50
Pixel size [µm] / matrix	29 x 27 / 1024 x 512
Technology	180nm CMOS
Power Consumption [mW/cm^2]	40 (mean), 300 (peak)
Stave Material Budget	0.3% X_0
Timing resolution	A few µs (tunable)
XZ spatial resolution [µm]	< 6

MVTX staves



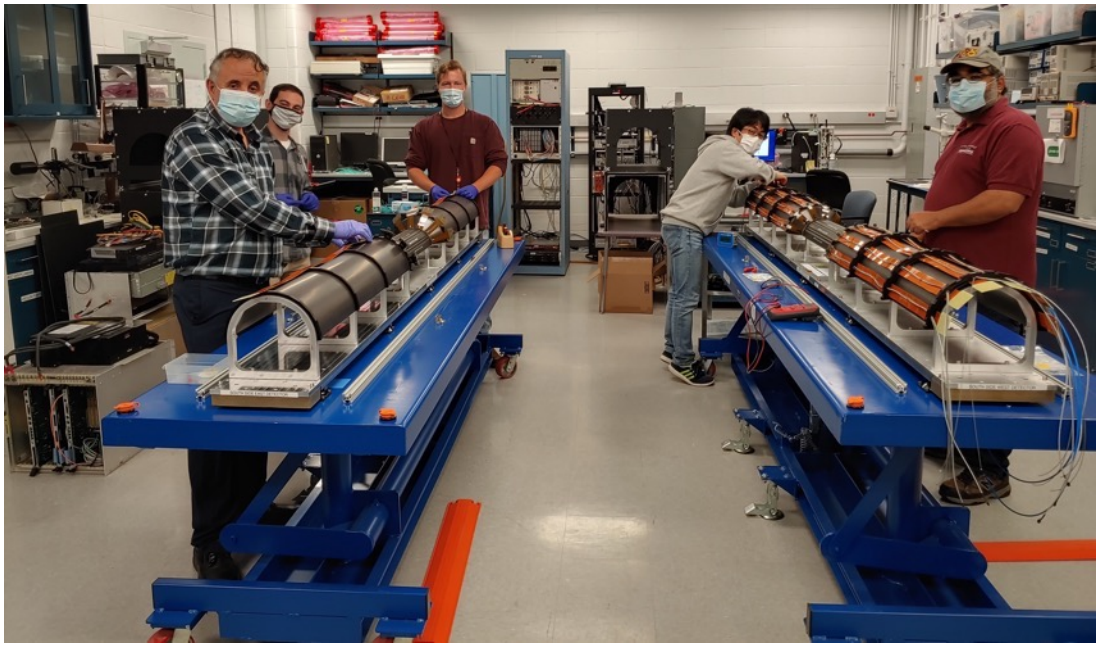
MVTX



- All sensor, stave and board production is complete
- Detector assembly underway at Lawrence Berkeley Lab
- Overall displacement from nominal position < 40 um over 4 cm
- Final assembly pieces arrived Wednesday
- Detector insertion: end of January

INTT

INTT ladder placement at BNL on 6th June 2022

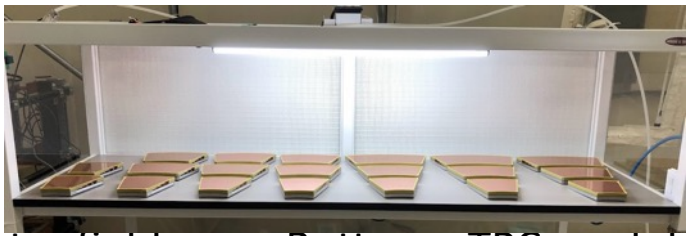


- Silicon strip detector
  - Gives 2 hit points
- Fast, can resolve beam crossings

- All ladders are produced, detector is under final construction
- Detector insertion: middle of January

TPC

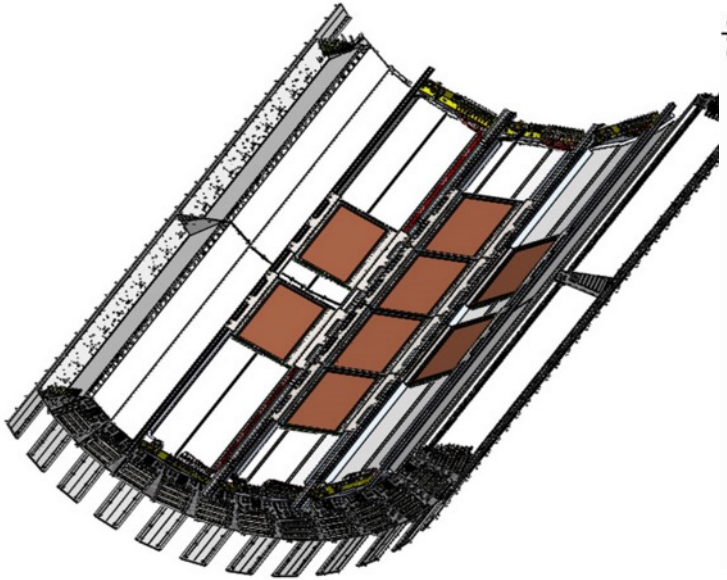
- Compact TPC, 20 < r [cm] < 78 (active volume r > 30cm)
- IBF is minimized, TPC is live at all times
  - IBF < 0.5% at a few kV in GEMs
- Detector installation: middle of November

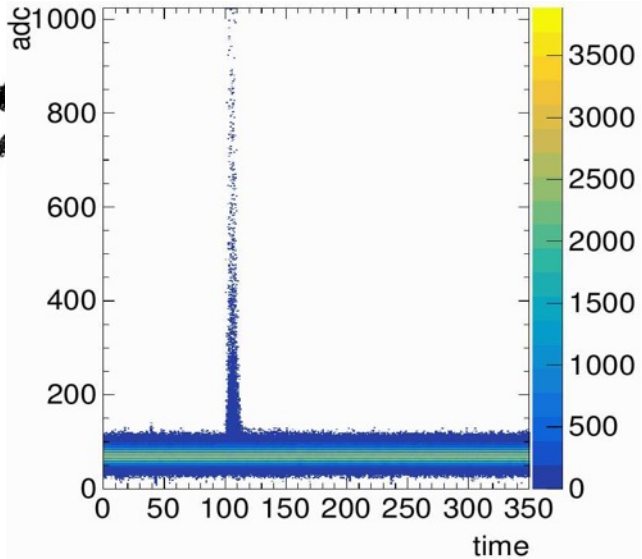


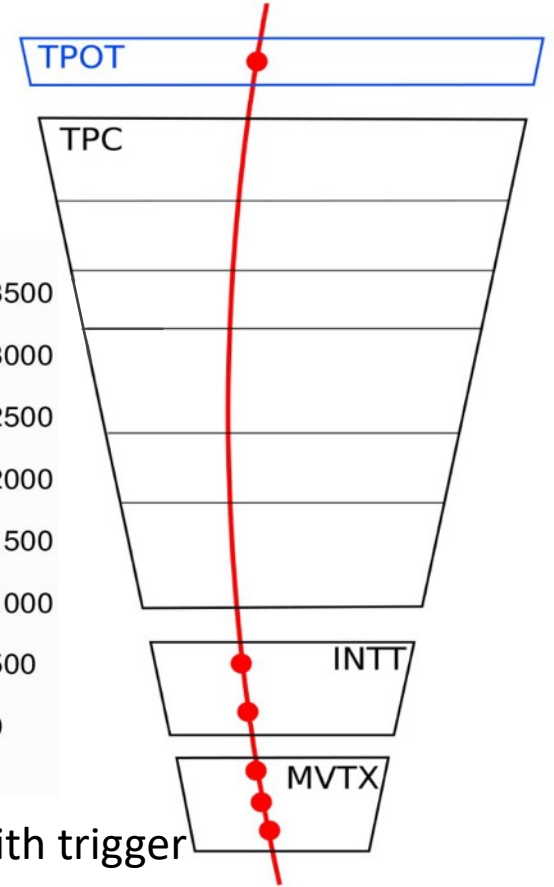
Top –Outer field cage. Bottom - TPC modules.

TPOT

- TPOT adds another hit point for tracking detectors
- Allows calibration of beam-induced space charge distortions
- Uses micromegas for detection
- Detector installation: early October

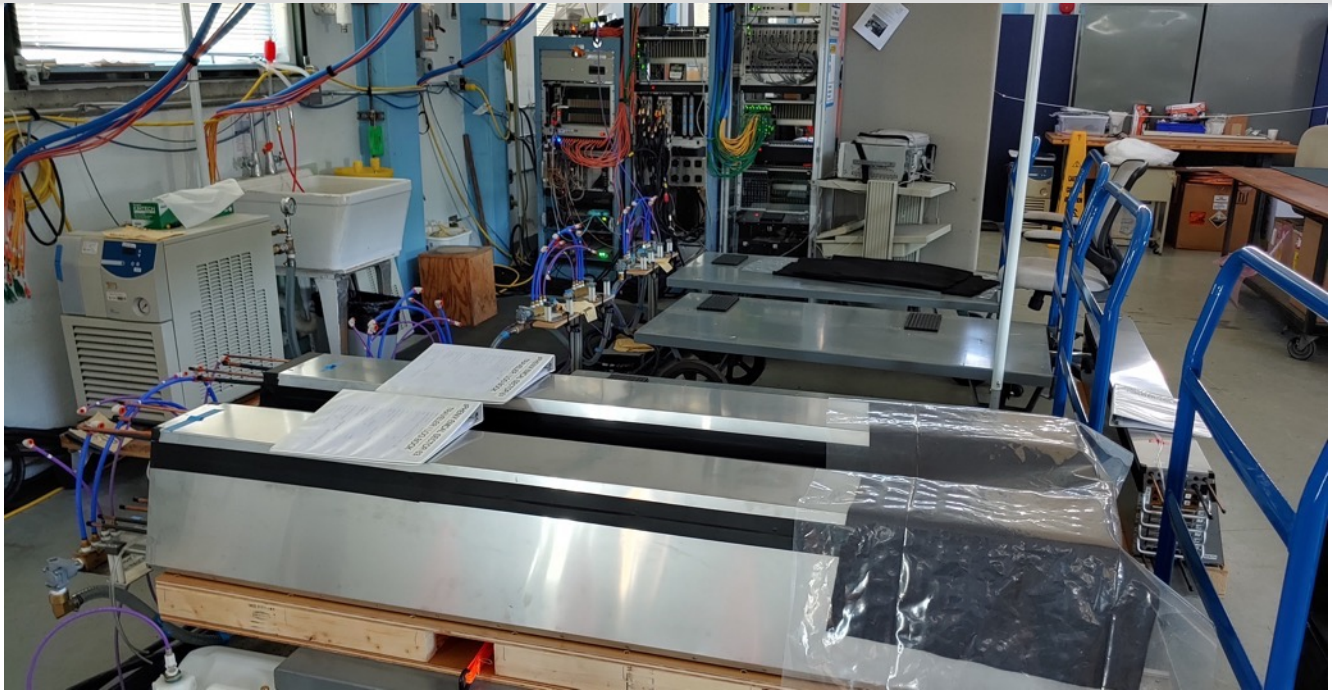






Left – TPOT module looking for cosmics. Center – signal coincident with trigger

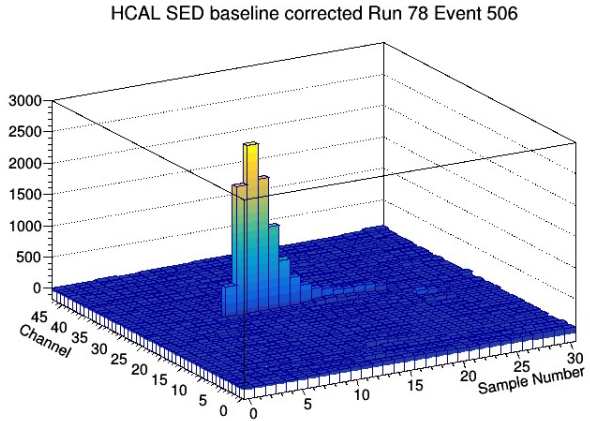
EM calorimetry



- Sampling EMCal, using SciFi in tungsten and epoxy
- $20.1X_0$ and $0.83\lambda_{int}$
- All sectors are complete! Performing final burn ins
- Detector installation: end of June

Hadron calorimetry

- Two detectors on inside and outside of the magnet
- Alternating tiles of steel (outer) or aluminum (inner) and scintillator
- Both detectors are complete and inserted by 06/09/2022!
- First cosmics seen in sPHENIX using OHCal!

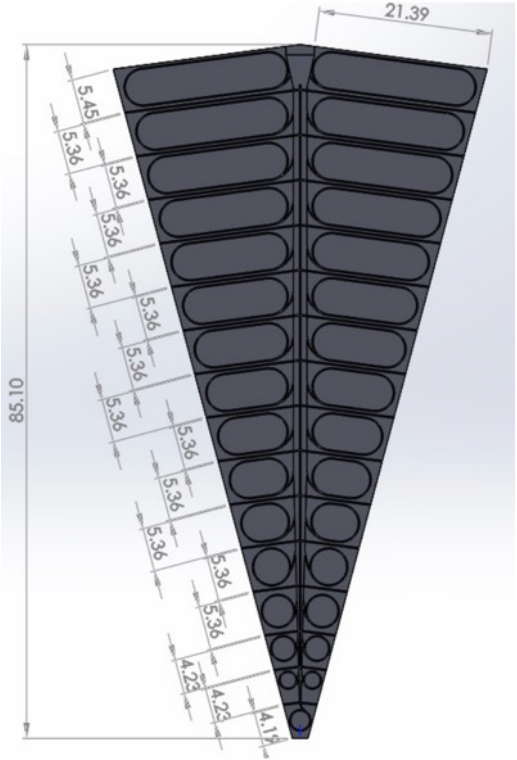


Left – Cosmic ray in outer HCal. Right – Inner HCal under installation, taken from the magnet

Event Plane Detector

- EPD is based off STAR design
- Adapted for use in sPHENIX
- Covers $2.0 \leq |\eta| \leq 4.9$
- 2 disks, with 12 sectors and 31 tiles/sector
- 9 sectors fully complete
- On track for end-of-summer construction
- Detector installation: end of January (north) and beginning of February (south)

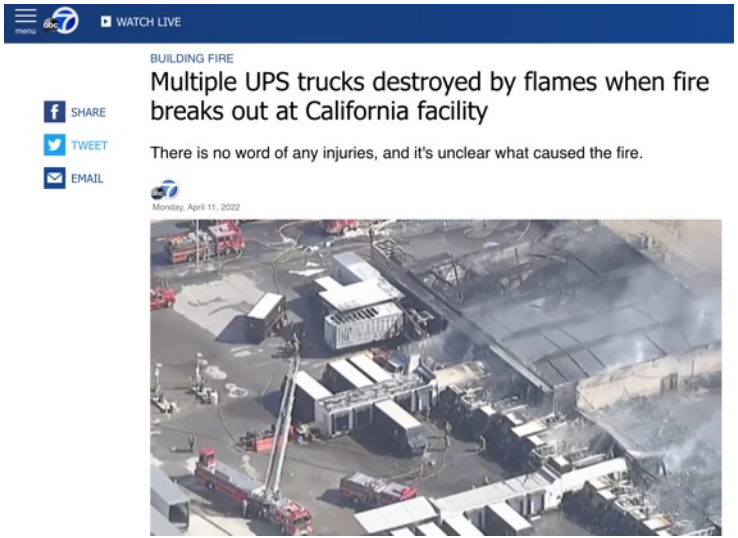
EPD sectors under construction

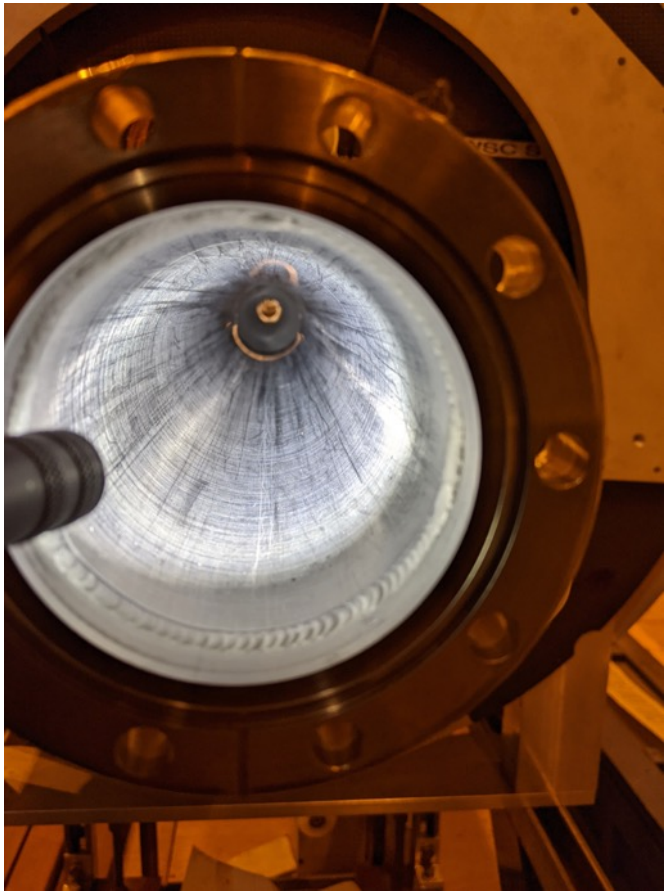


One EPD sector

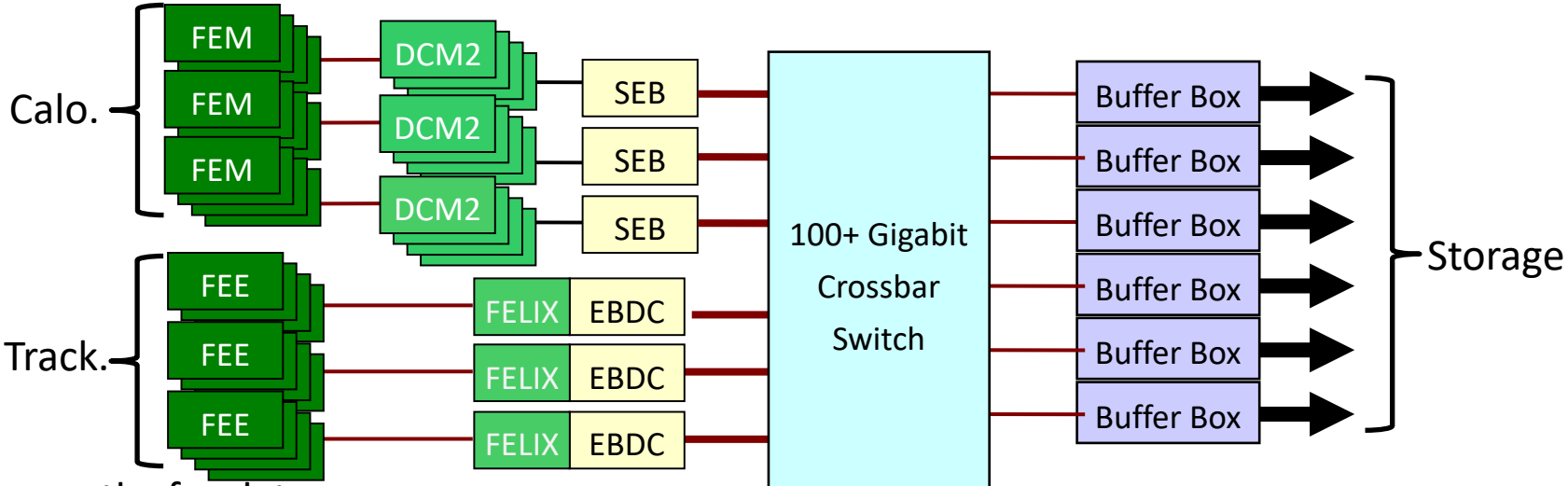
Beam pipe

- sPHENIX beam pipe was sent to California for work
- Sadly, pipe was lost in warehouse fire
- Luckily, STAR had a beam pipe that met our specs!
- After inspection, NEG coating looked good
- Discussed with MVTX team, no obvious issue with installation





Data Acquisition

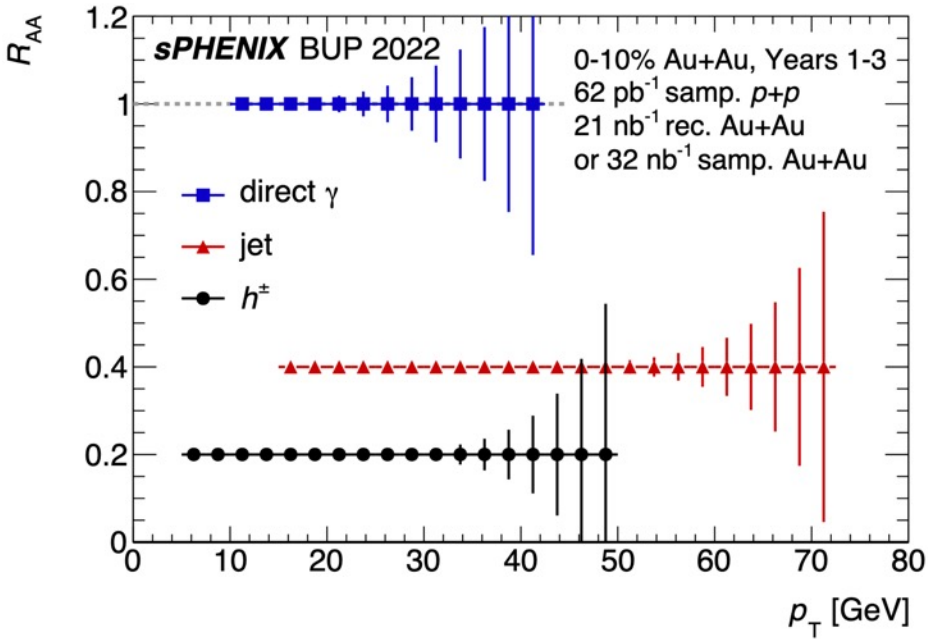


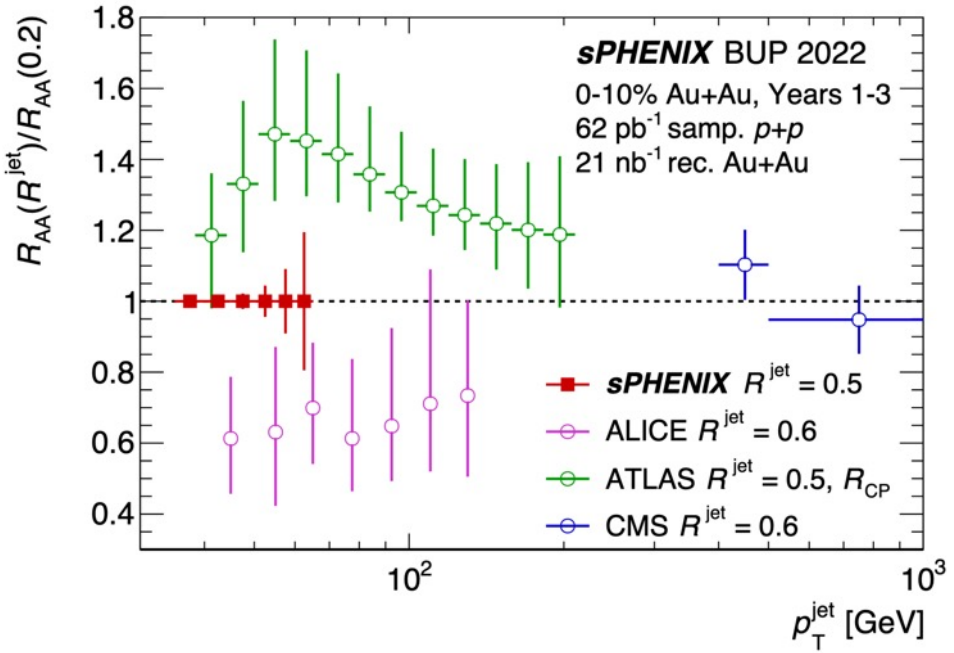
- Two paths for data
  1. Triggered (calorimeters)
  2. Streamed (trackers)
- Front ends produce packets
- Event builder combines packets offline
  - Less risky than doing online
- Using streamed data increase HF *pp* sample by 50 – 500

sPHENIX under construction

sPHENIX under construction

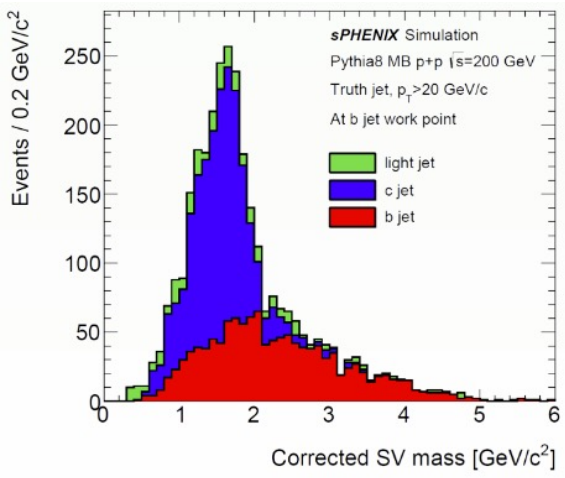
Jets

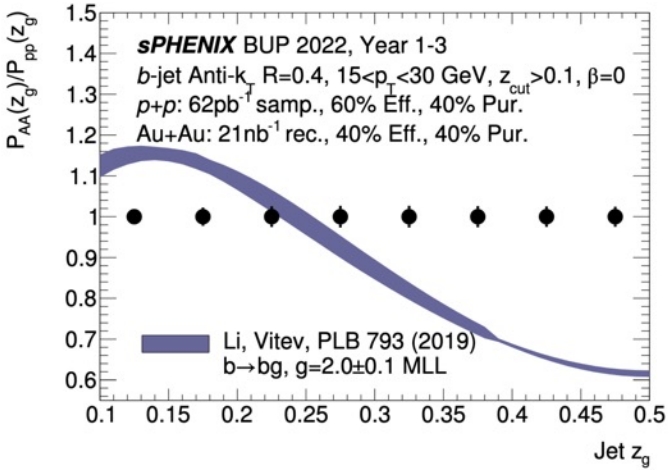


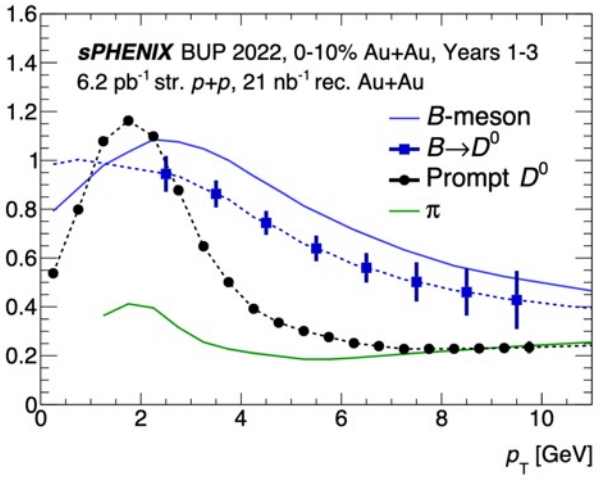


- sPHENIX will collect significant statistics for jets up to high p_T
- We expect increased sensitivity below 100 GeV where LHC is in tension

Jet and heavy flavor physics

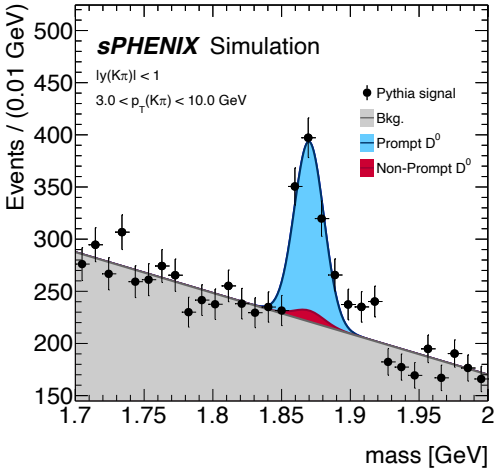


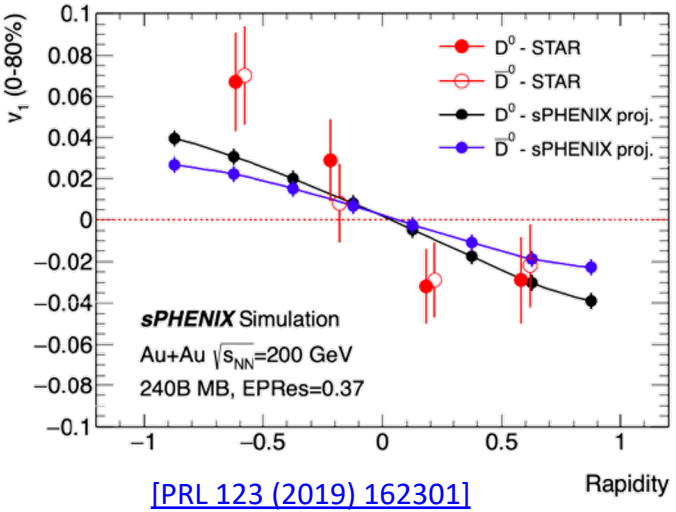




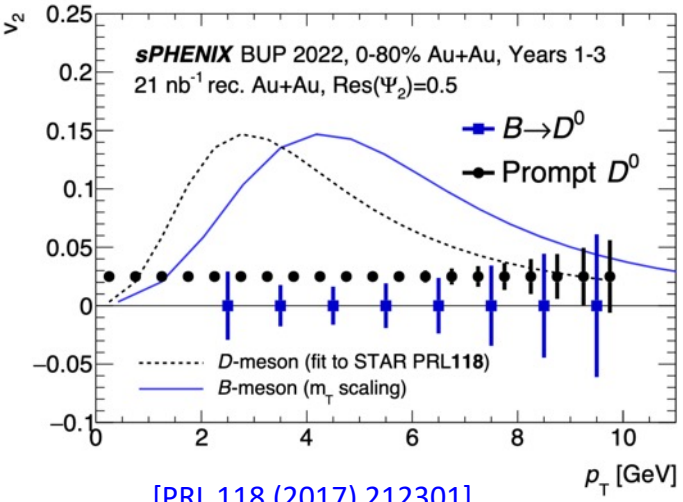
Left – c/b jet distributions from secondary vertex mass
Middle – Predicted b-jet subjet splitting sensitivity
Right - R_{AA} predictions from prompt and non-prompt D^0

Heavy flavor physics





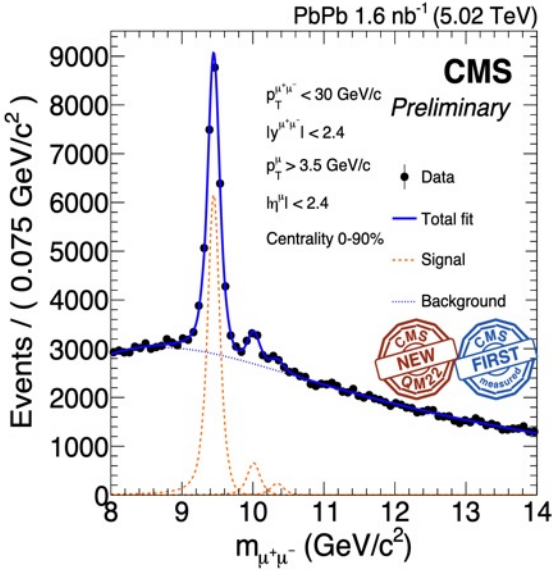
[PRL 123 (2019) 162301]

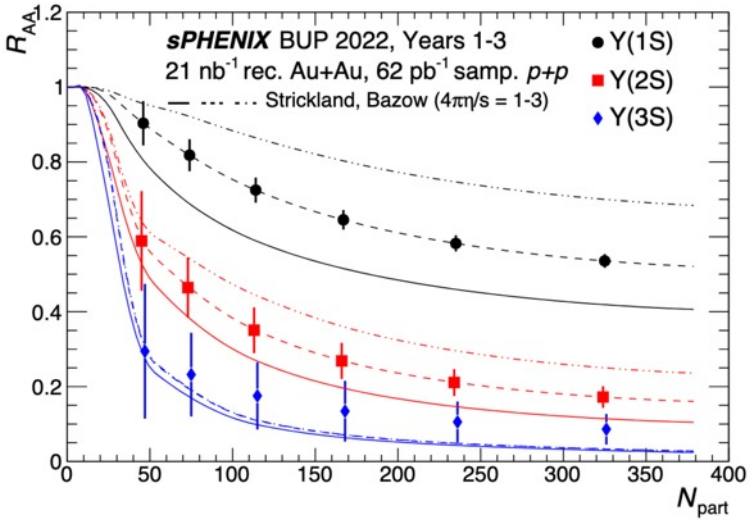


[PRL 118 (2017) 212301]

- Prediction that transient mag. field can influence v_1
- This effect is odd under charge-conjugation, resulting in splitting
- D^0 is complicated, requires good production knowledge

Quarkonia

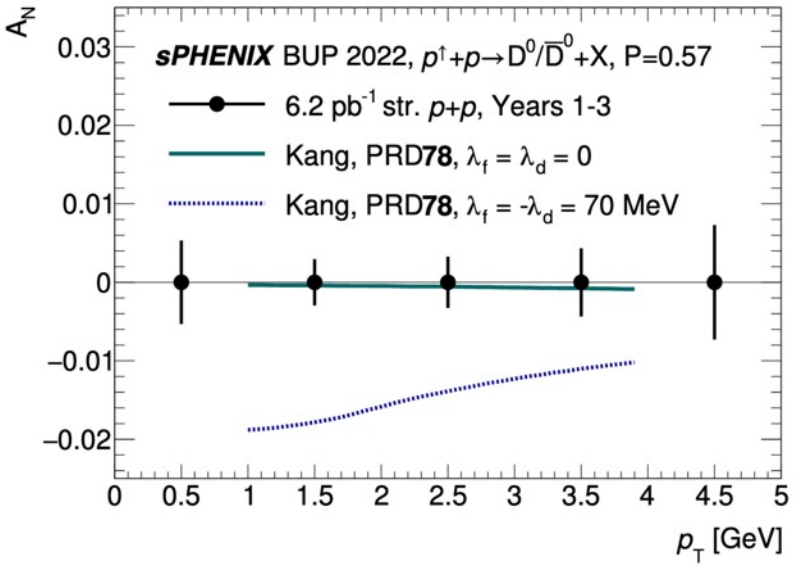


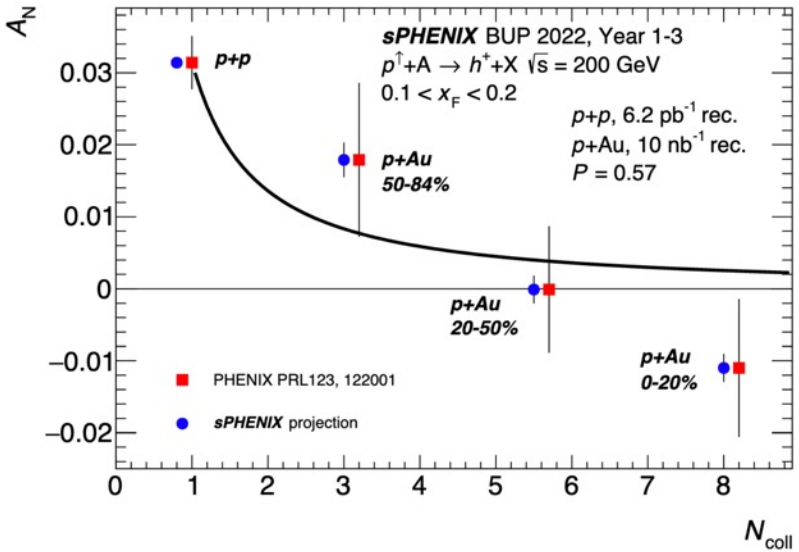


CMS-PAS-HIN-21-007

- sPHENIX aims to separate all three Upsilon states for the first time at RHIC
- Recently observed Y(3S) suppression < theory prediction
- sPHENIX is developing ML algorithms to reject hadronic bkg.

Cold QCD





- Cold QCD program is greatly extended using streaming readout
- PHENIX saw strong nuclear dependence on Transverse Single Spin Asymmetry measurements for charged hadrons
  - sPHENIX will collect much more statistics here

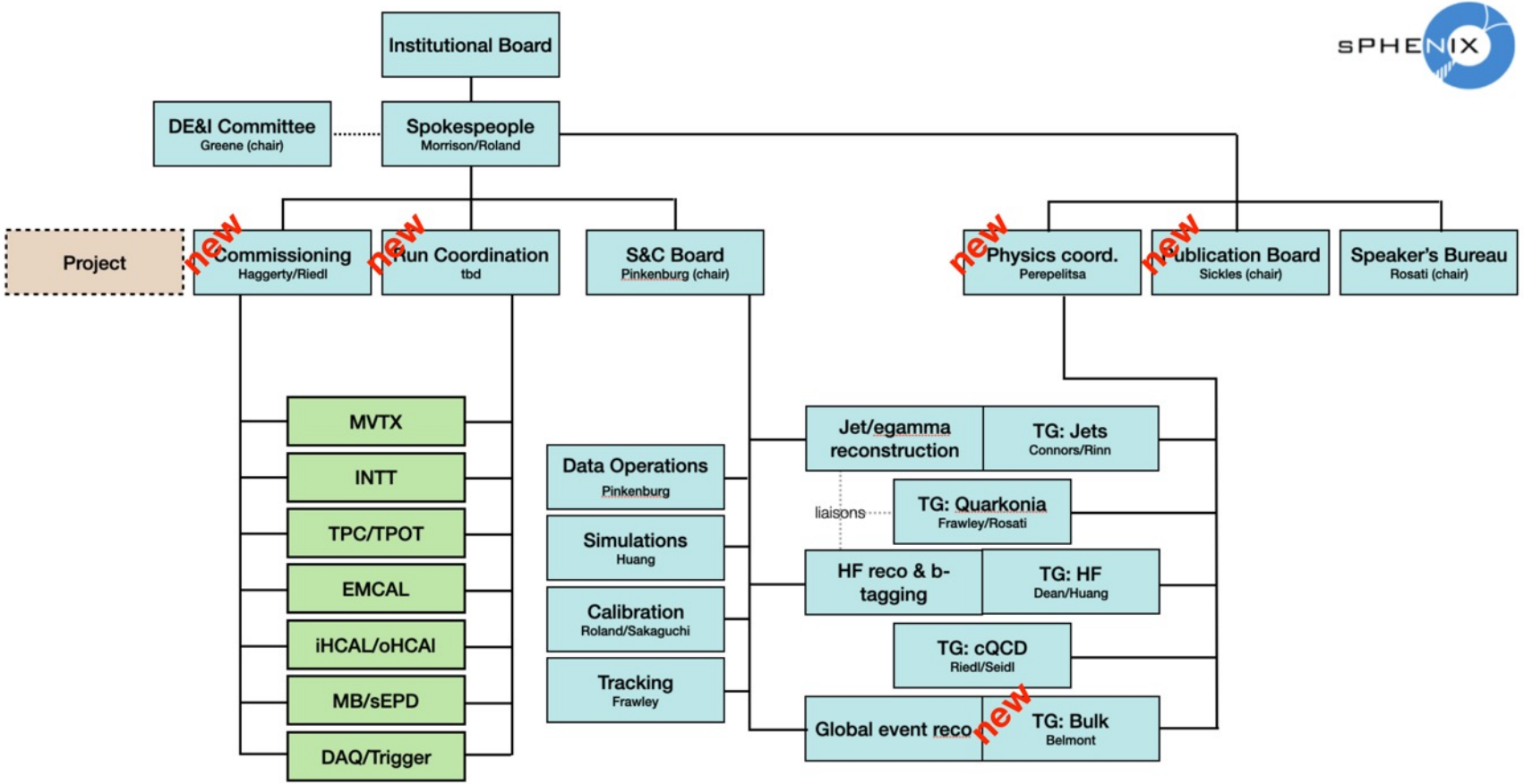
Conclusions

- The collaboration has adapted to the challenges posed by the pandemic and external factors
- Production and construction is progressing well
  - Hadronic calorimeters and magnet are all in place
  - EMCal is performing final burn-ins
  - All tracking detectors are under construction
  - EPD production is on track for end-of-summer
- The collaboration has maintained its engineering, hardware and computing work force
- We are now putting together more formal ”first physics” teams
- sPHENIX is on track to see first collisions in February 2023

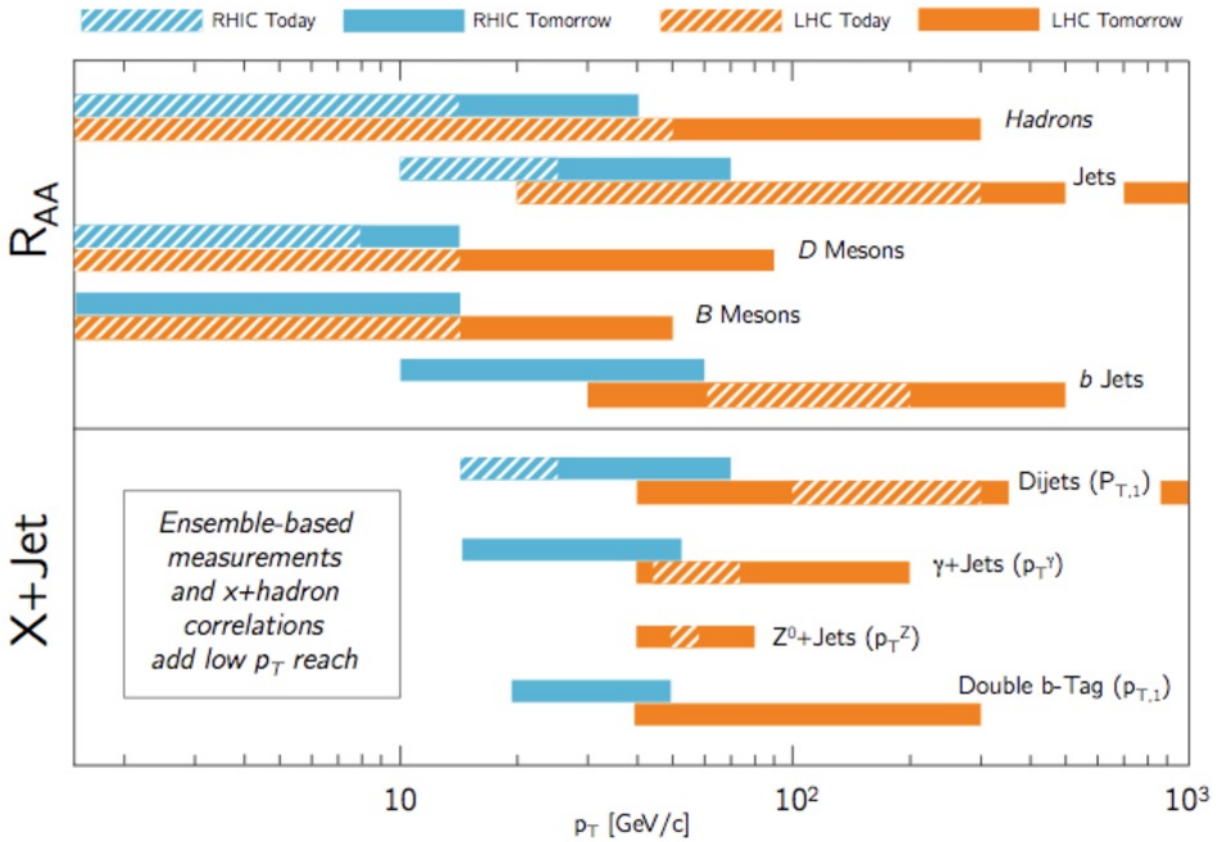
Thank you

Back Up

Collaboration structure



LHC vs RHIC


RHIC Today
RHIC Tomorrow
LHC Today
LHC Tomorrow
R_{AA}
Hadrons
Jets
D Mesons
B Mesons
b Jets
X+Jet
Ensemble-based measurements and x+hadron correlations add low p_T reach
Dijets ($P_{T,1}$)
γ+Jets (p_T^{γ})
Z^0+Jets (p_T^Z)
Double b-Tag ($p_{T,1}$)
10
10^2
10^3
p_T [GeV/c]

Installation