20 years of RHIC

October 22-23, … sers' Meeting

Topical works… ctober 23

Status & Plans of sPHENIX

Parallel sPHENIX talks yesterday:
- Heavy flavor (H. Okawa)
- Jet measurements (C. McGinn)
- Cold QCD (D. Shangase)

sPHENIX EMCal posters:
- X. Wang
- M. Mazeikis
- M. Housenga

Caroline Riedl (UIUC)
on behalf of the sPHENIX Collaboration

October 22-23, 2020

RHIC & AGS Annual Users' Meeting 2020

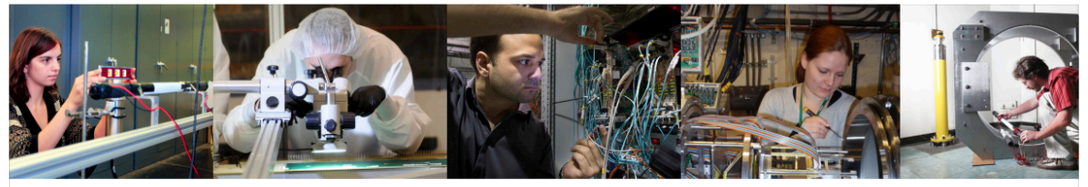
online

ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

sPHENIX Science Mission

Goal: probe the inner workings of the **Quark Gluon Plasma** by resolving its properties at shorter and shorter length scales.

The **complementarity** of the two facilities [RHIC & LHC] is essential to this goal, as is a **state-of-the-art jet detector**, called sPHENIX.



The 2015
LONG RANGE PLAN
for NUCLEAR SCIENCE

The conceptual design of sPHENIX is based on 3 principles:

(1) Design a detector to meet the Science Mission of jets and ϒ measurements at RHIC
"A barrel detector optimized to study jet- and heavy-quark physics in a heavy-ion environment"
(2) Maximize cost effectiveness and utilize modern technologies where appropriate (SiPM, fast TPC RO)
(3) Build on existing $20M+ PHENIX equipment, infrastructure and support facilities.

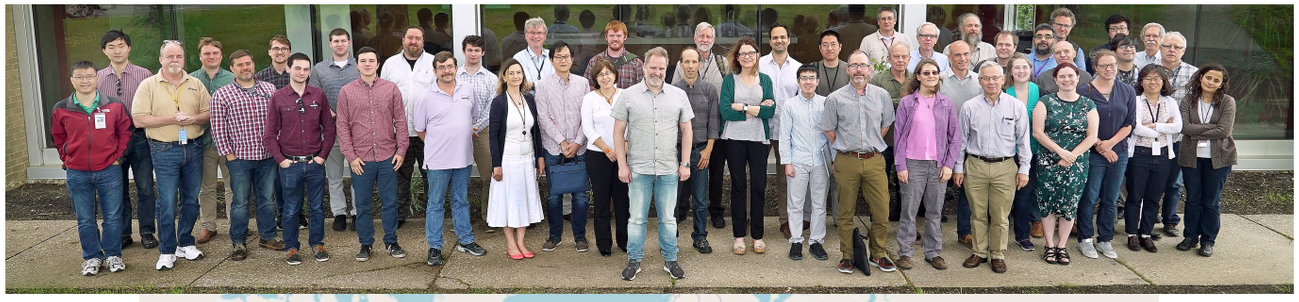
"Super PHENIX" as successor to the Pioneering Hadron Electron Nuclear Interaction eXperiment (PHENIX)

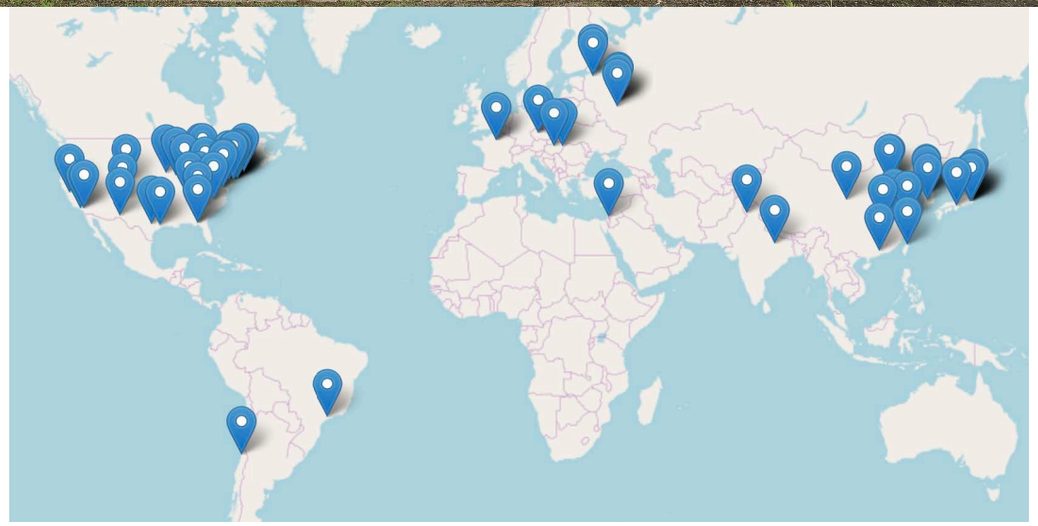
The next-generation detector for heavy-ion physics at RHIC with also cold-QCD potential.

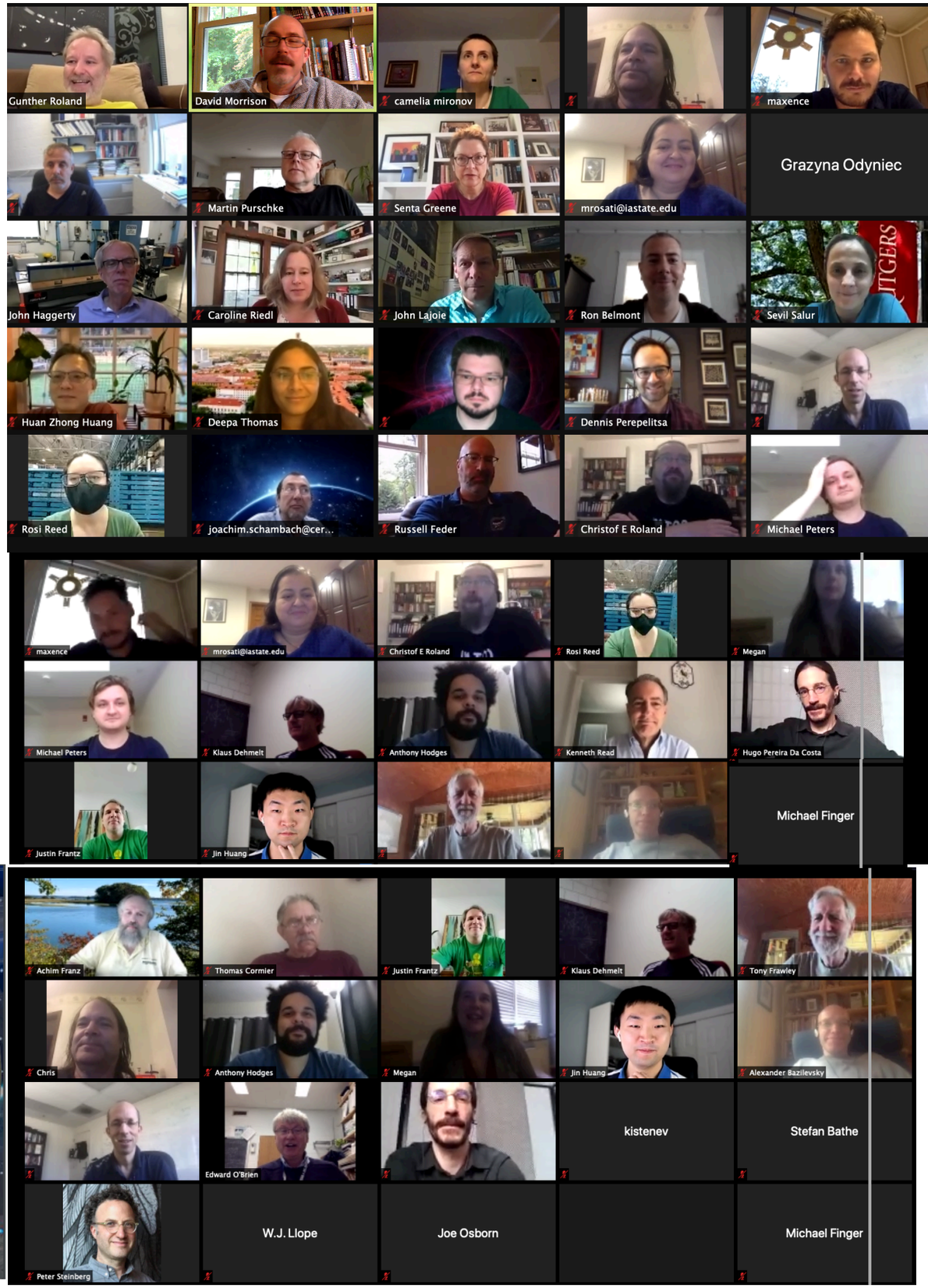
The 2020 PAC report lists sPHENIX as the highest priority for Runs 2023-2025.

sPHENIX and its people

- sPHENIX collaboration formed in 2016
- As of early 2020, the collaboration has more than 320 members from 80 institutions in 13 countries.







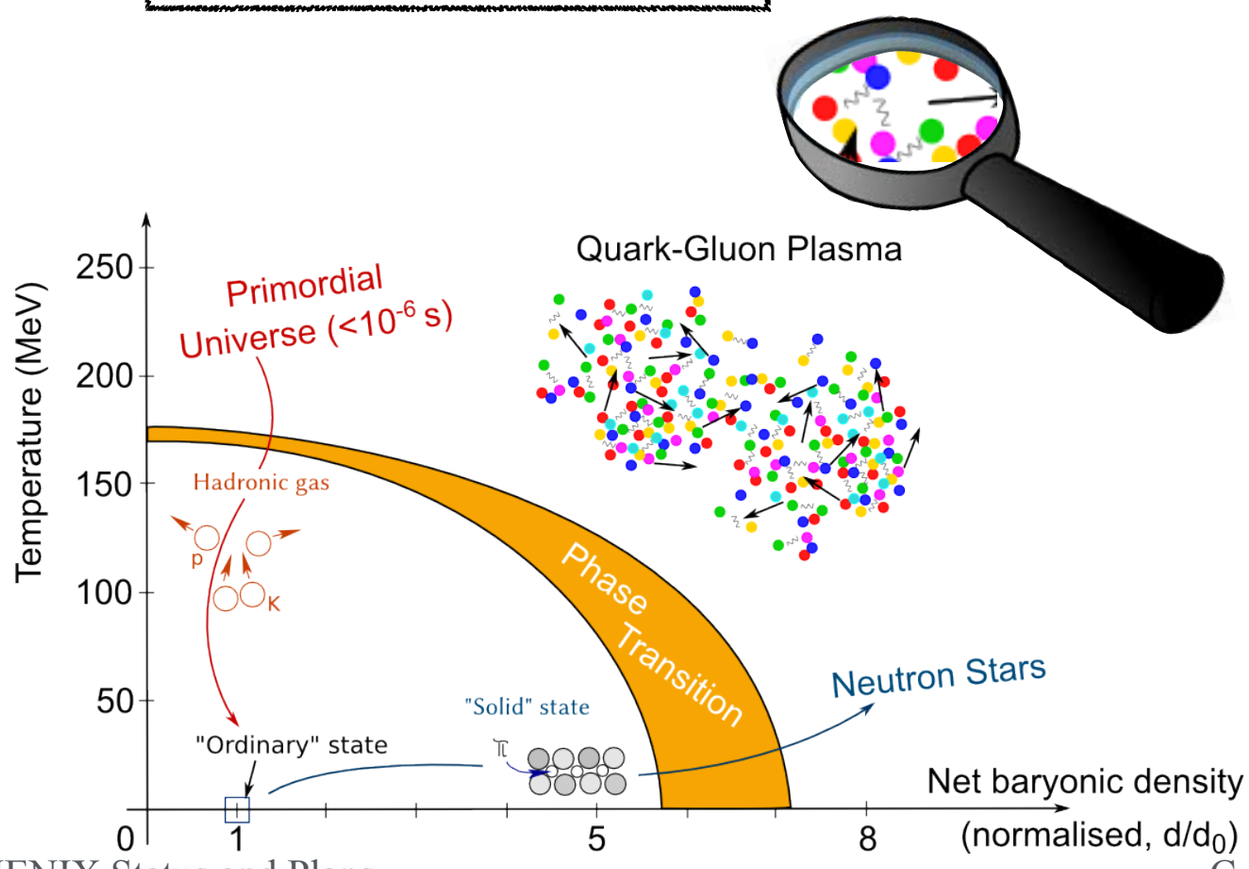
THE 100TH BI-WEEKLY GENERAL MEETING OCTOBER 16, 2020



The Quark Gluon Plasma

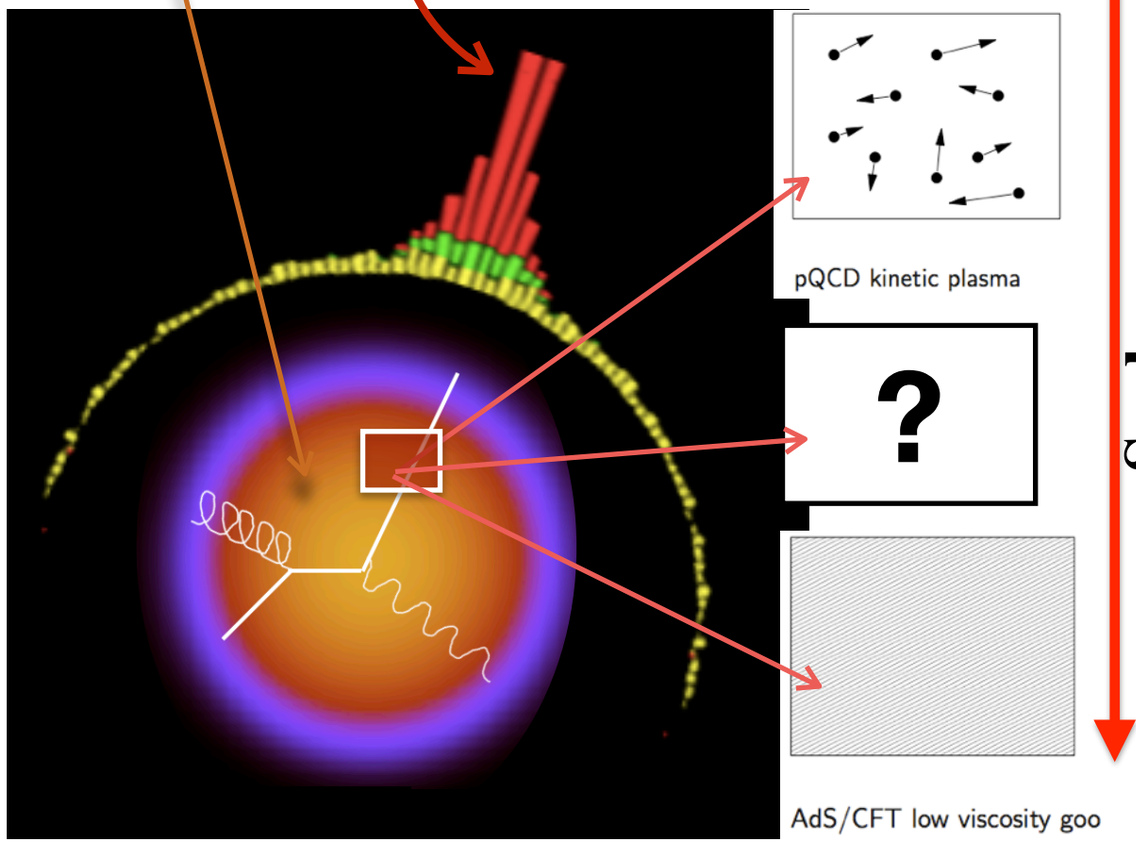
- Heavy-ion collisions at RHIC and the LHC have produced a unique hot and dense state of matter - the Quark Gluon Plasma (QGP)
- How do the well-known macroscopic QGP properties arise from fundamental interactions of quarks and gluons, i.e. from the laws of Quantum Chromo Dynamics?

What is the microscopic structure of the QGP?



Different QGP initial conditions and evolution at RHIC and LHC

Ability to tag initial state & excellent characterization of final state drive sPHENIX detector design



Core physics program with sPHENIX

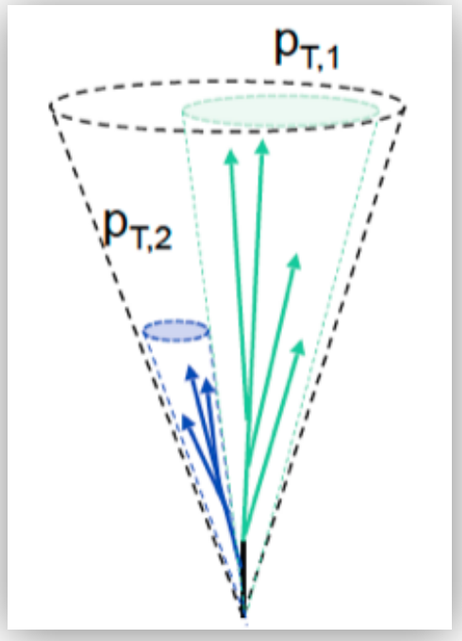
Hot QCD program

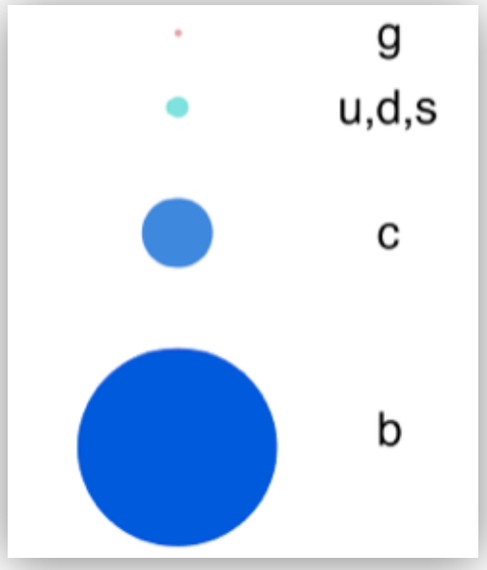
Study the quark-gluon plasma using a variety of probes.

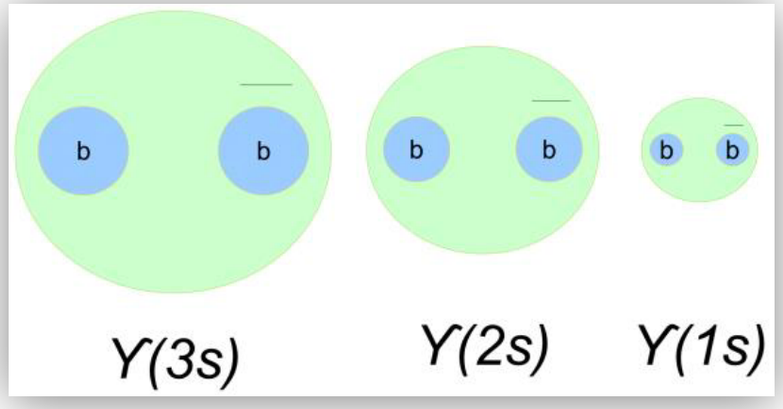
Jet correlations & substructure: *Vary probe momentum & angular scale*

Open heavy flavors: *Vary probe mass & momentum*

ϒ spectroscopy: *Vary probe size*





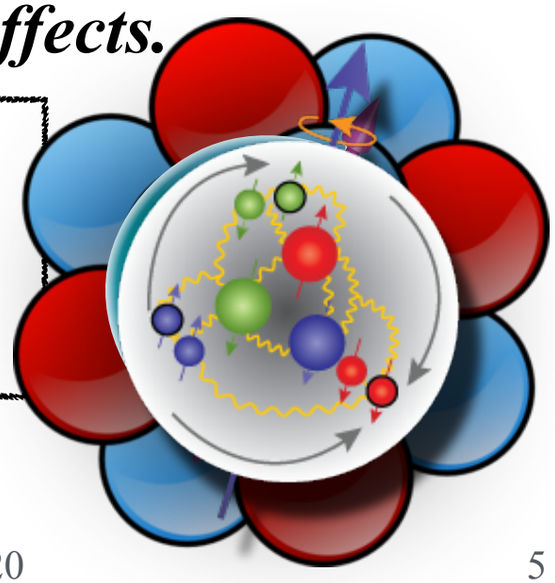


Cold QCD program

Study proton spin, transverse-momentum, and nuclear effects.

Spin-orbit correlations in the transversely polarized nucleon: *single-spin asymmetries*

Nuclear effects and hadronization



sPHENIX: a short history & plan

2010 sPHENIX proposed as upgrade / replacement of PHENIX

2012 Initial proposal

2014 Full proposal

2015 BaBar magnet arrives from SLAC

2016 Collaboration formed

2016 Final PHENIX run

2016 Test beam HCal, EMCal

2016 **CD-0** (mission need)

2018 **CD-1/3a** (begin final design, place long lead-time procurements)

2018 Test beam EMCal

March 2019 Approved CERN experiment

Sept 2019 **PD2/3** (review complete)

Aug 2020 Beam-use proposal

Oct 2020 RHIC 20 YEARS

Begin construction…

Transition from MIE detector pre-production to production

Construction of detectors, infrastructure, software

Dec 2021 End of construction

Installation

Dec 2022 **PD-4** date

Run 2023 Commis. & AuAu candles

Dec 2023

Run 2024 pp ref. & cold QCD

Dec 2024

Run 2025 AuAu high stat

Dec 2025

Data Campaign 1

Data Campaign 2?

Dec 2027

Towards a potential relationship with the EIC

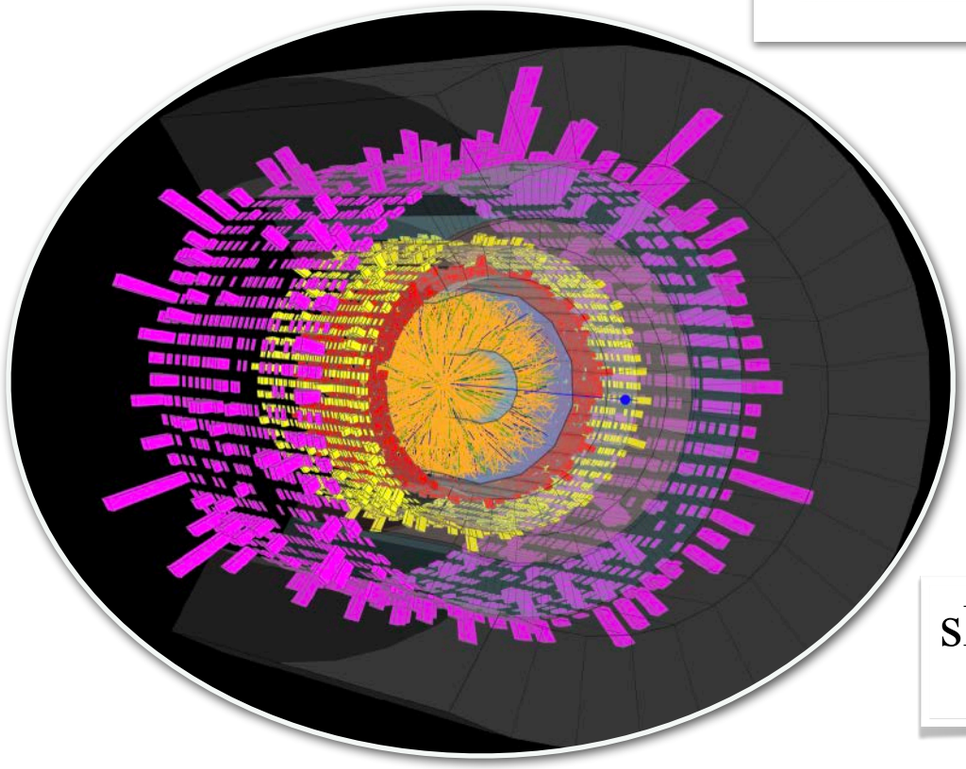
sPHENIX proposed RHIC run plan

Year-1: commissioning, calibration, reco; Au+Au standard candles.

Year-2: p↑+p↑, p↑+Au: HI reference set & coldQCD

Year-3: very large Au+Au HI set

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}

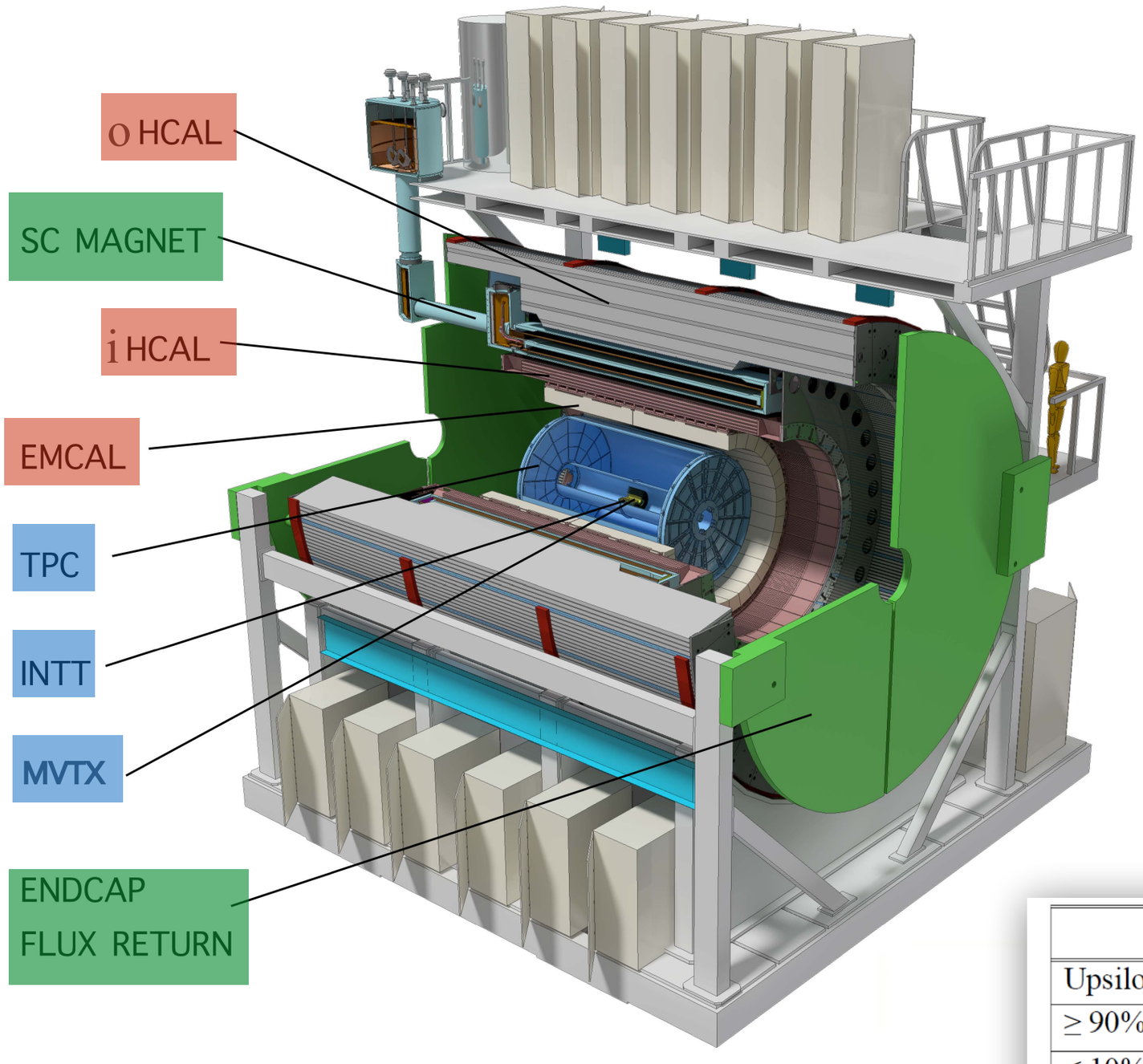


- Years 1-3 consistent with EIC reference schedule
- sPHENIX science mission will be accomplished with the 23-25 data - while the physics potential will not be exhausted
- If opportunity arises, sPHENIX will run beyond 25

sPHENIX Beam Use Proposal (BUP) sPH-TRG-2020-001
August 31, 2020

Projection plots shown are for years 1-3 of sPHENIX running & 28 cryo-week scenario

sPHENIX: detector overview



Superconducting Magnet (1.4 T solenoid)

Tracking system:
MAPS-based Vertex Tracker (MVTX)
Intermediate Silicon Tracker (INTT)
Time Projection Chamber (TPC)

Calorimetry:
Electromagnetic Calorimeter (EMCal)
inner Hadronic Calorimeter (iHCal)
outer Hadronic Calorimeter (oHCal)

High rate:
15 kHz Trigger, >10 GB/s DAQ
+ 10% streaming DAQ (trackers) 2024^{++}

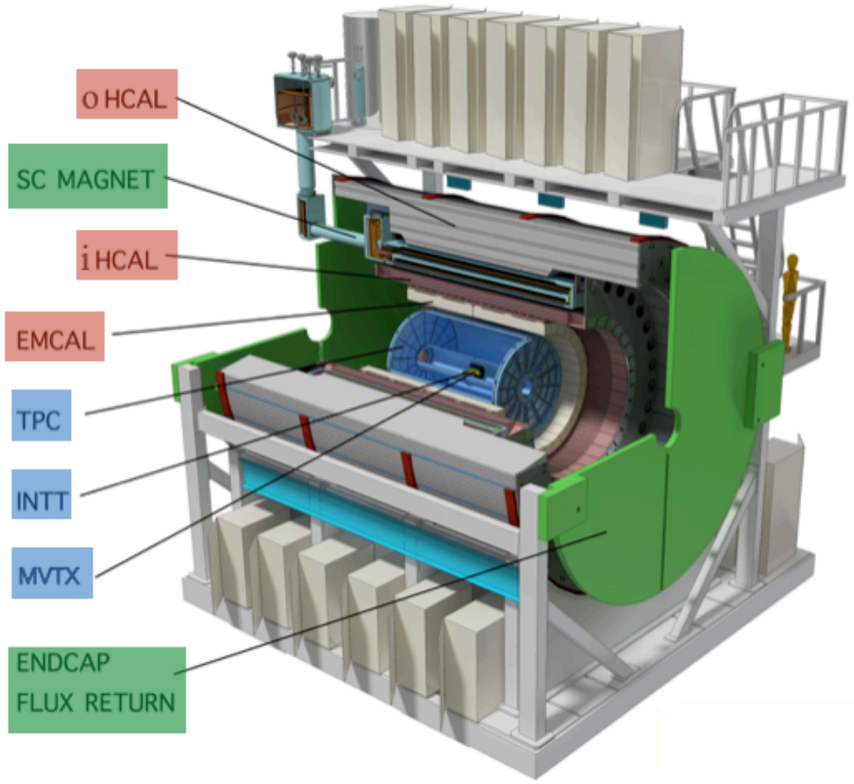
Large acceptance:
full ϕ coverage; for $|z|<10$ cm: $|\eta|\leq 1.1$

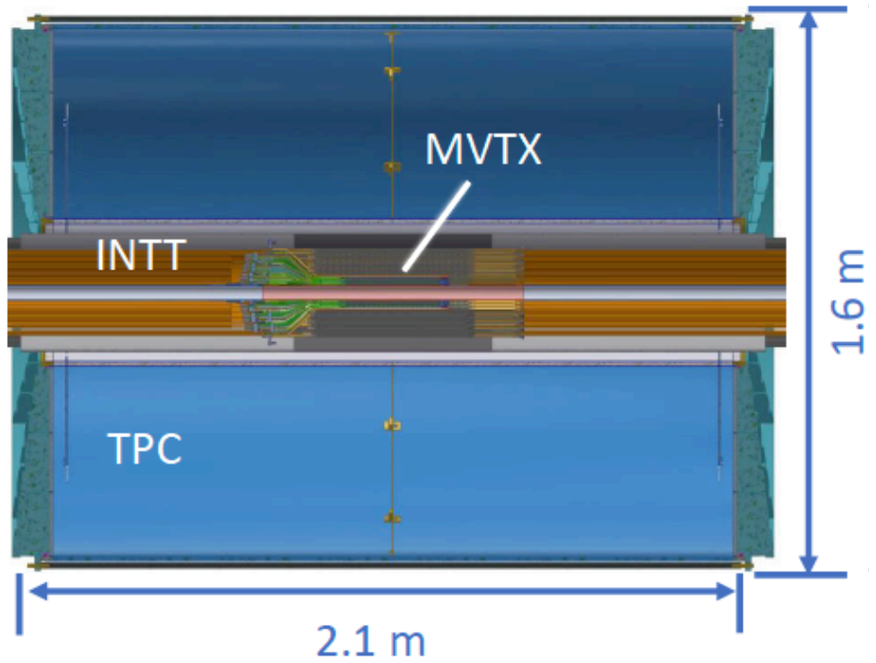
Ultimate Performance Parameters	Approved at CD1/3A
Upsilon (1S) mass resolution $\leq$ 125 MeV	
$\geq$ 90% Tracking Efficiency	
$\leq$ 10% momentum resolution at 40 GeV /c	
$\leq 150\% / \sqrt{E_{jet}}$ jet-energy resolution for R=0.2 jets	
$\leq$ 8% single photon energy resolution at 15 GeV	

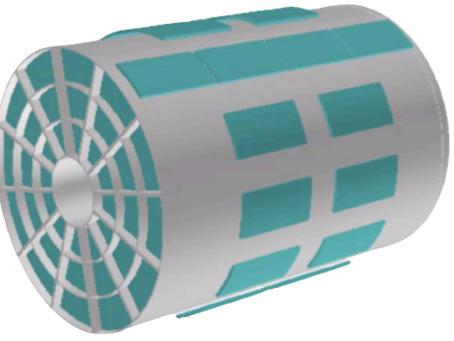
Table 1a: Preliminary Ultimate Performance Parameters. UPPs for measurements made at 10% central Au+Au RHIC events at the average RHIC store luminosity

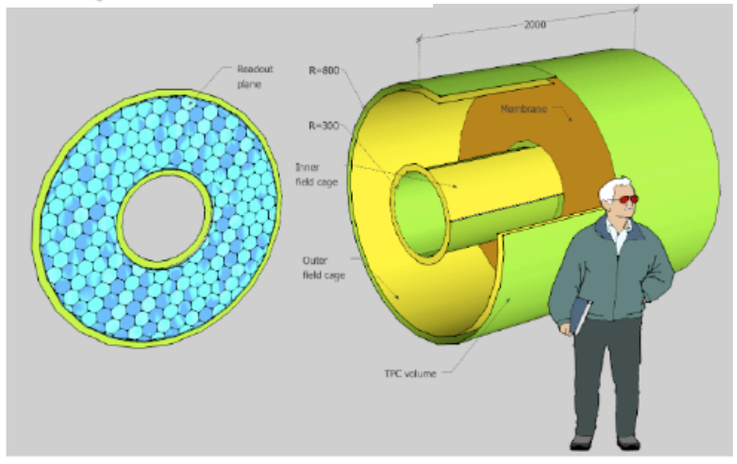
MAPS = monolithic active pixel sensor

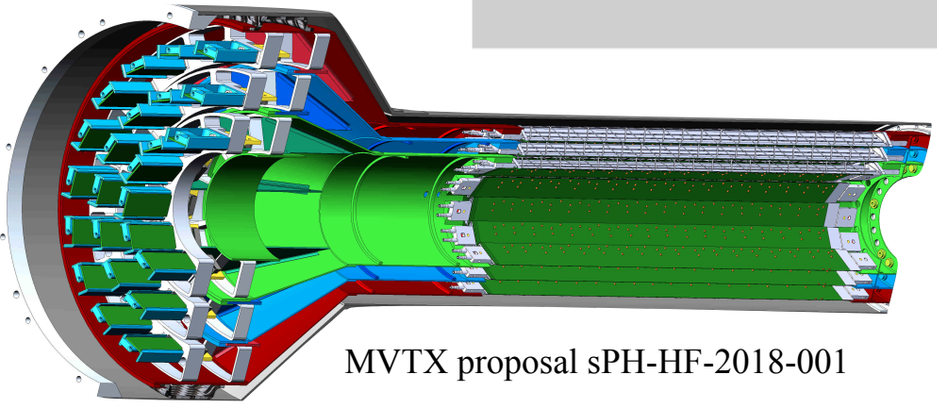
sPHENIX: tracking system











MVTX proposal sPH-HF-2018-001

Time Projection Chamber (TPC)

momentum measurement

- **Compact**: 20 < r [cm] < 78 (active (>30cm)
- **Spatial resolution** < 200 μm
- Charge collection via **GEMs** → ALICE SAMPA
- **Gateless and continuous readout** (IBF-avoiding GEMs)
- Careful study of space-charge distortion effects

Intermediate Silicon Tracker (INTT)

pattern recognition & timing

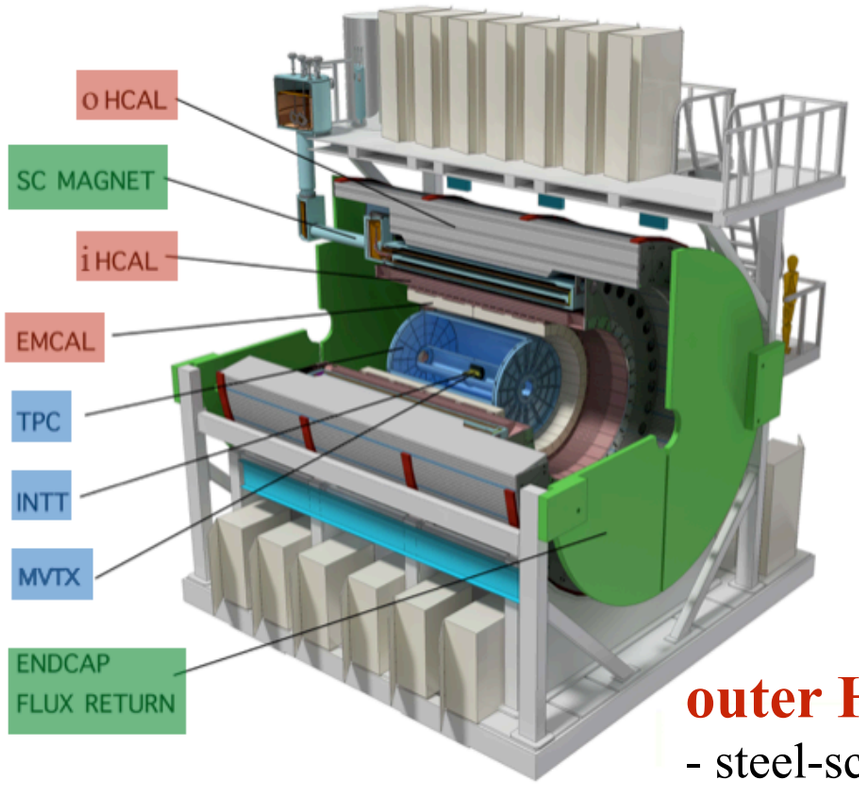
- 2 layers of strip silicon sensors

MAPS-based Vertex Tracker (MVTX)

precise vertexing

- 3 layers of Monolithic Active Pixel Sensors (ALICE **ALPIDE**)
- **Integration time**: few μs
- **XZ spatial resolution** [μm]: <6
- Ultra-thin ~0.3%X_0
- High efficiency and low noise

sPHENIX: calorimetry

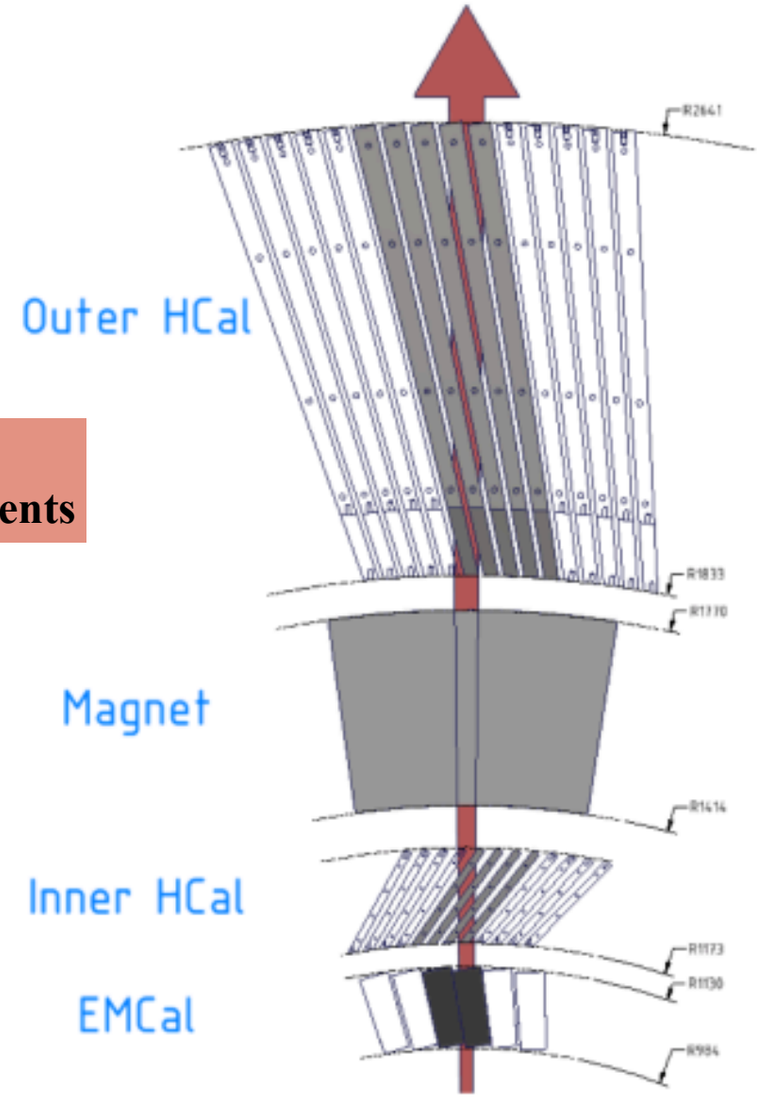


Designed around **density, uniformity and granularity**

Novel **sampling calorimetry** with novel deep longitudinal segmentation *("towers tilted in azimuth, near-pointing in rapidity")*

Common **SiPM-based optical readout** complemented with low-cost 60 MHz waveform digitizers

Coverage ±1.1 in η, 2π in ϕ



outer Hadronic Calorimeter (oHCal)

- steel-scintillating tiles with embedded WLS fibers
- $\Delta\eta \times \Delta\phi \approx 0.1 \times 0.1$ ($\rightarrow$ R<0.4 jets)
- also acts as magnet return and support

Jet measurements

inner Hadronic Calorimeter (iHCal)

- aluminum-scintillating tiles with embedded WLS fibers

Electromagnetic Calorimeter (EMCal)

- tungsten-scintillating-fiber SPACAL with ~7mm radiation length
- $\Delta\eta \times \Delta\phi \approx 0.025 \times 0.025$
- compact to fit & work inside the BaBar magnet

Electron / hadron separation > 100:1 at 4 GeV
(driven by Upsilon $\Upsilon \rightarrow ee$)
Energy resolution (*): $\sigma_E/\langle E\rangle = 3.5\% \oplus 13.3\% /\sqrt{E}$

(*) 2018 test beam: arXiv:2003.13685 & acc. by IEEE TNS

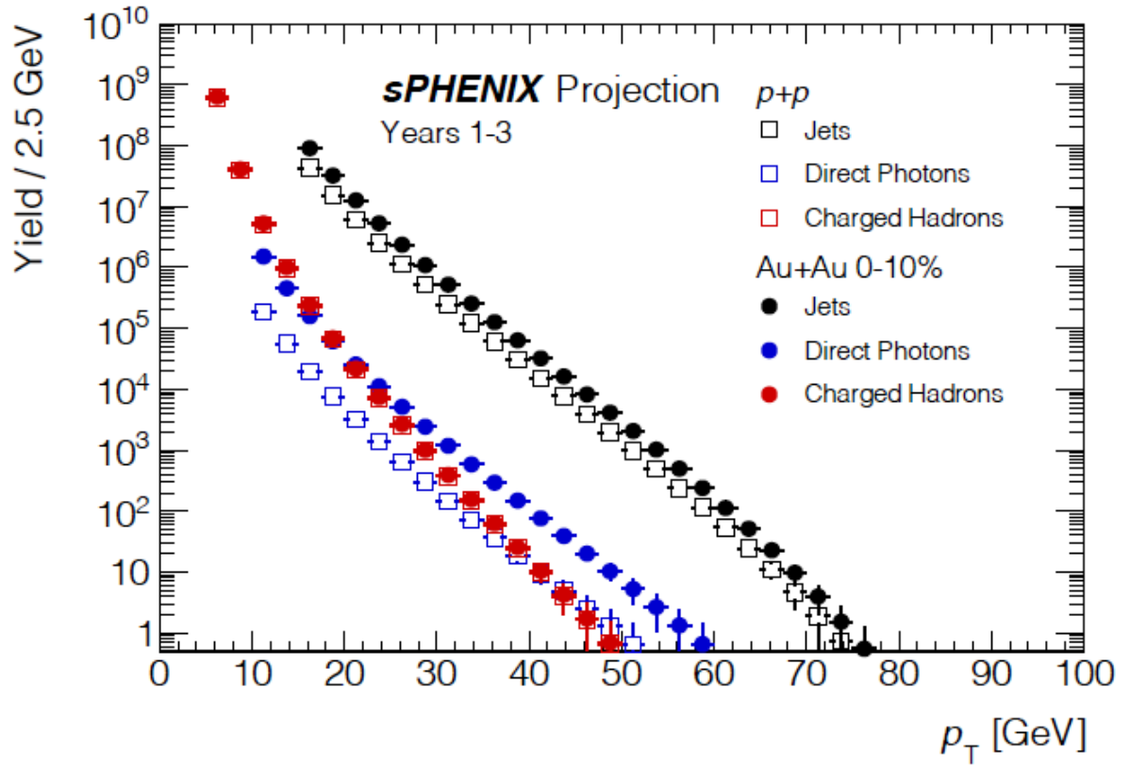
sPHENIX: jets & photons

EMCal & HCAL + Tracker

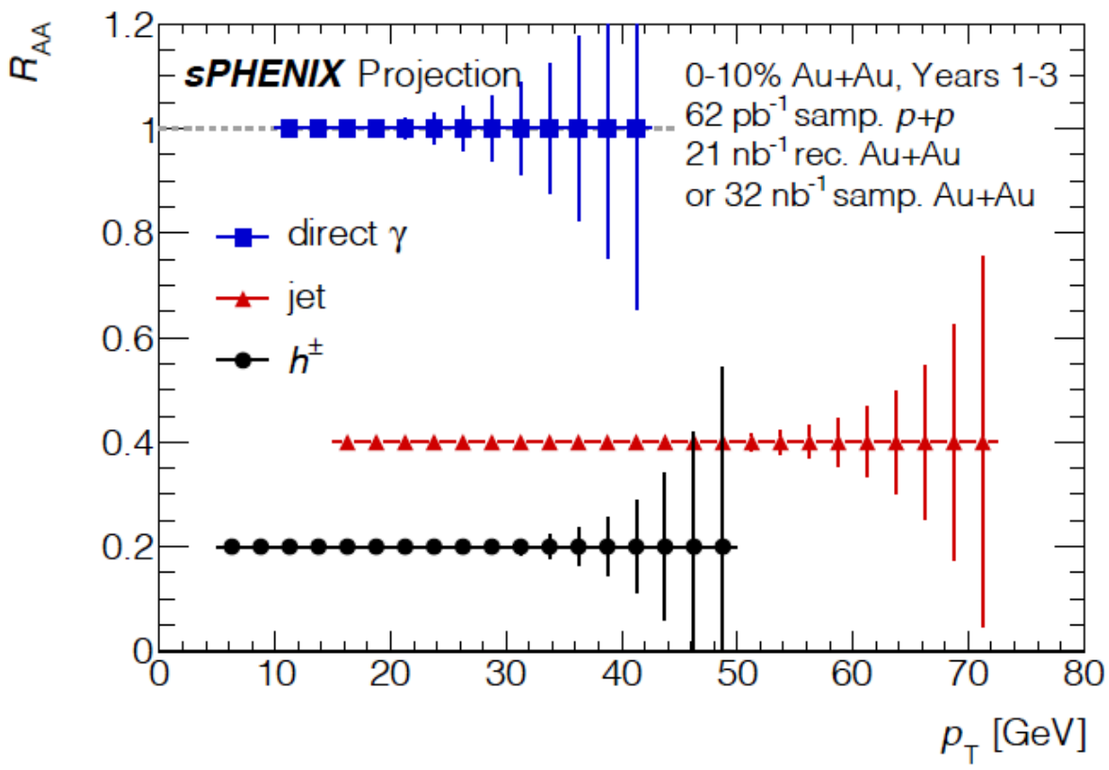
High-statistics data sample for multi-dimensional jet studies & high reach in p_T
(70 GeV jets, 50 GeV hadrons & photons)*
including high-stat p+p ref. sample due to efficient trigger

p+p (open symbols) vs. Au+Au (closed symbols)

Jet, direct-photon, hadron yield vs. p_T



Nuclear modification vs. p_T



Projections for light-flavor jets; heavy-flavor jets in HF section

Extensive simulations of the detector demonstrate the capability to measure photons & jets (yield, substructure, correlations)

sPHENIX will resolve varying theoretical predictions for R_{AA} at higher p_T

[BUP] sPH-TRG-2020-001

$$R_{AA} \equiv \frac{1}{N_{coll}} \frac{\frac{d^2N_{AA}}{dyd^2p_\perp}}{\frac{d^2N_{NN}}{dyd^2p_\perp}}$$

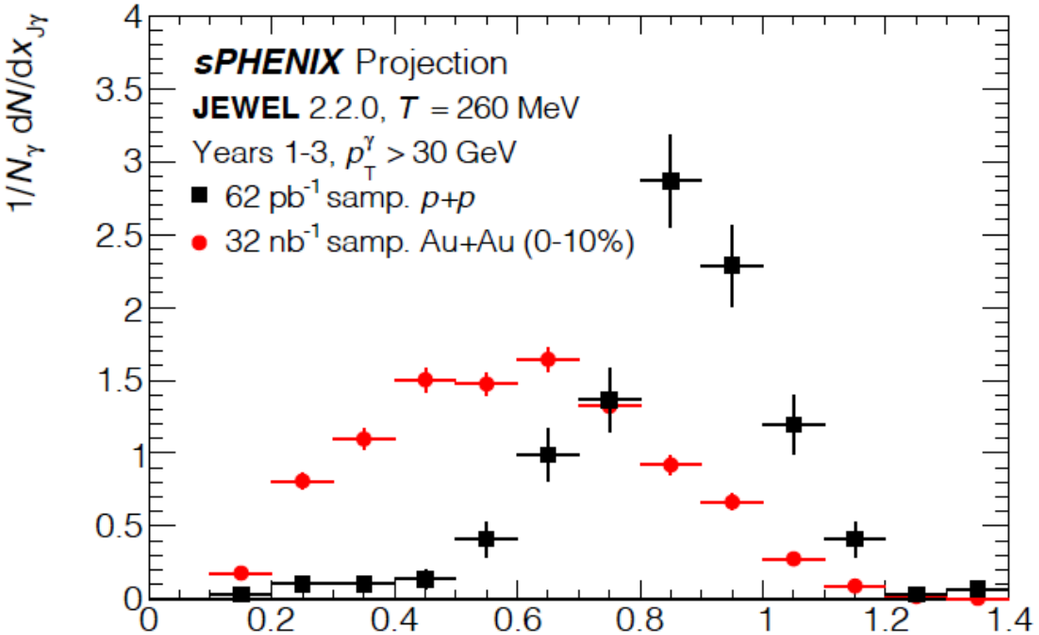
* years 1-3

sPHENIX: jets & photons

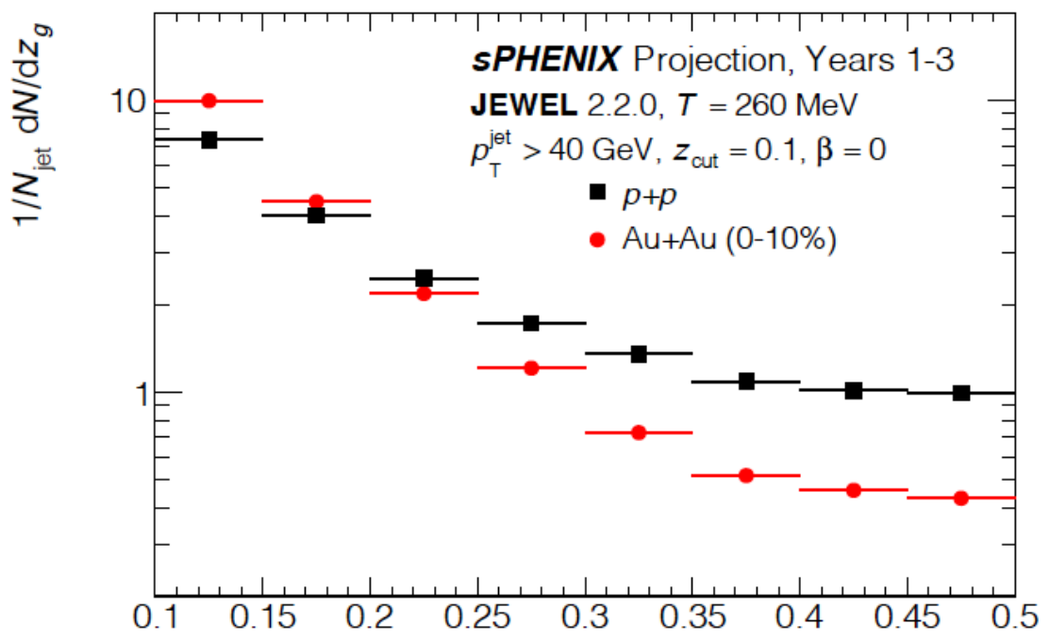
Unique data set for highly differential high-p_T observables

High-rate streaming DAQ

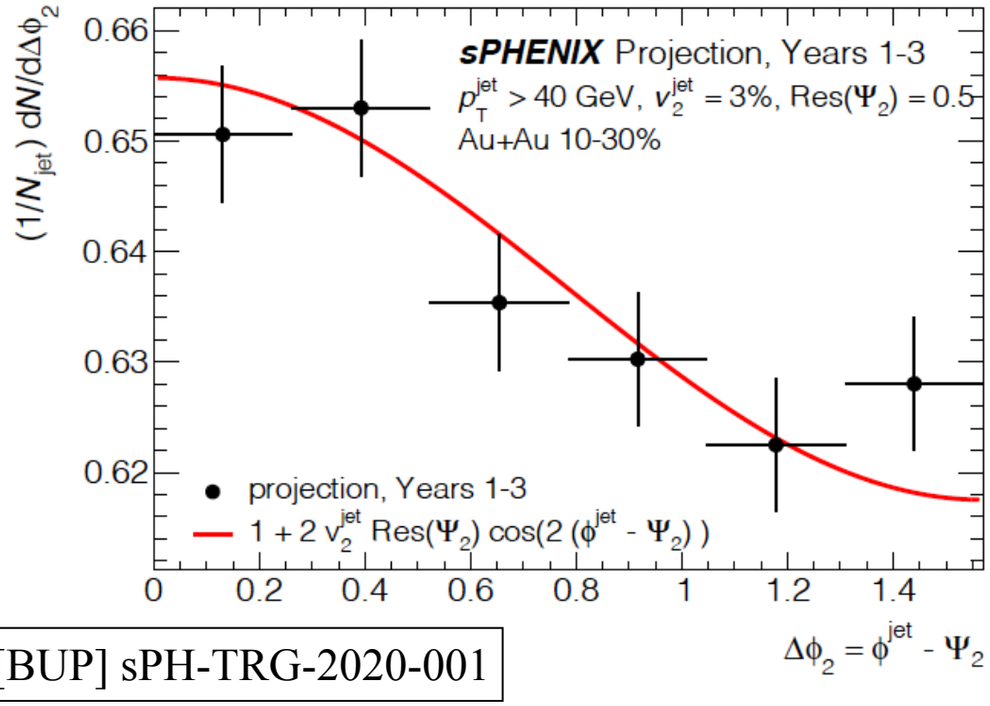
jet-to-photon p_T balance



Subjet splitting function

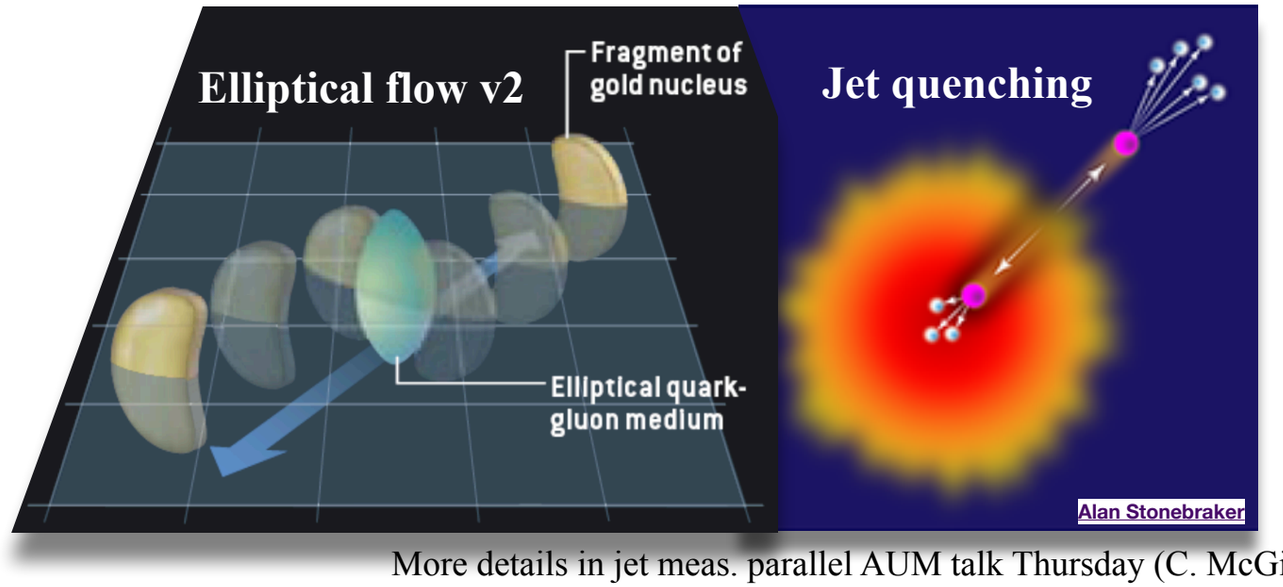


jet yield vs. azimuthal distance from event plane



[BUP] sPH-TRG-2020-001

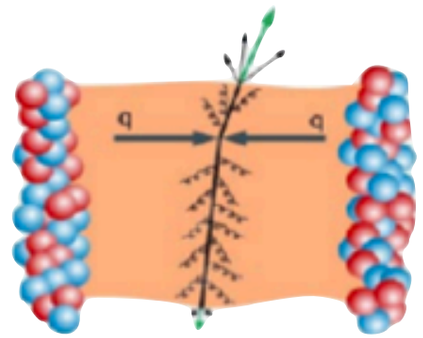
Measure azimuthal dependence of jet quenching to improve simultaneous theoretical description of suppression & anisotropy



More details in jet meas. parallel AUM talk Thursday (C. McGinn)

sPHENIX: heavy-flavor program

- charm and bottom quarks: unique lever arm to study QGP
  $m \gg \Lambda_{QCD}$ & $m \gg T_{medium} \Rightarrow$ created mostly by initial hard scattering

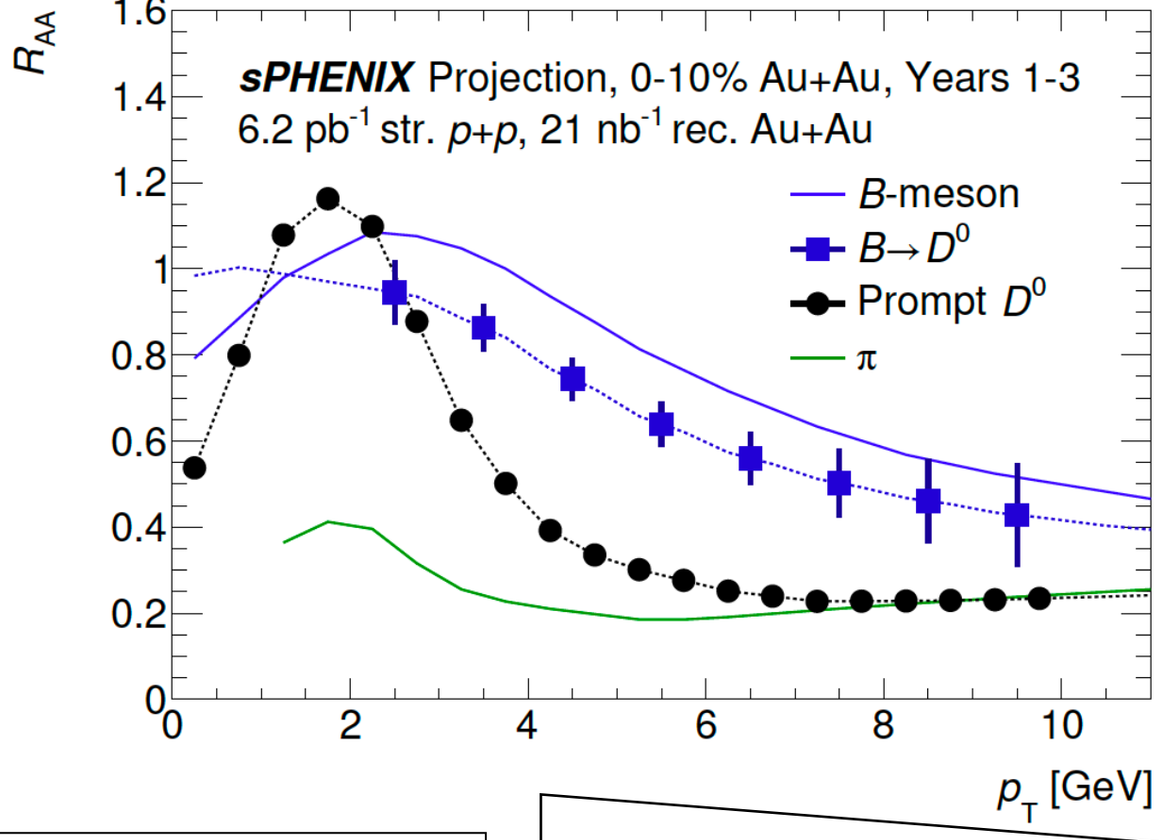


Vertex Tracker
MVTX
High-rate
streaming DAQ

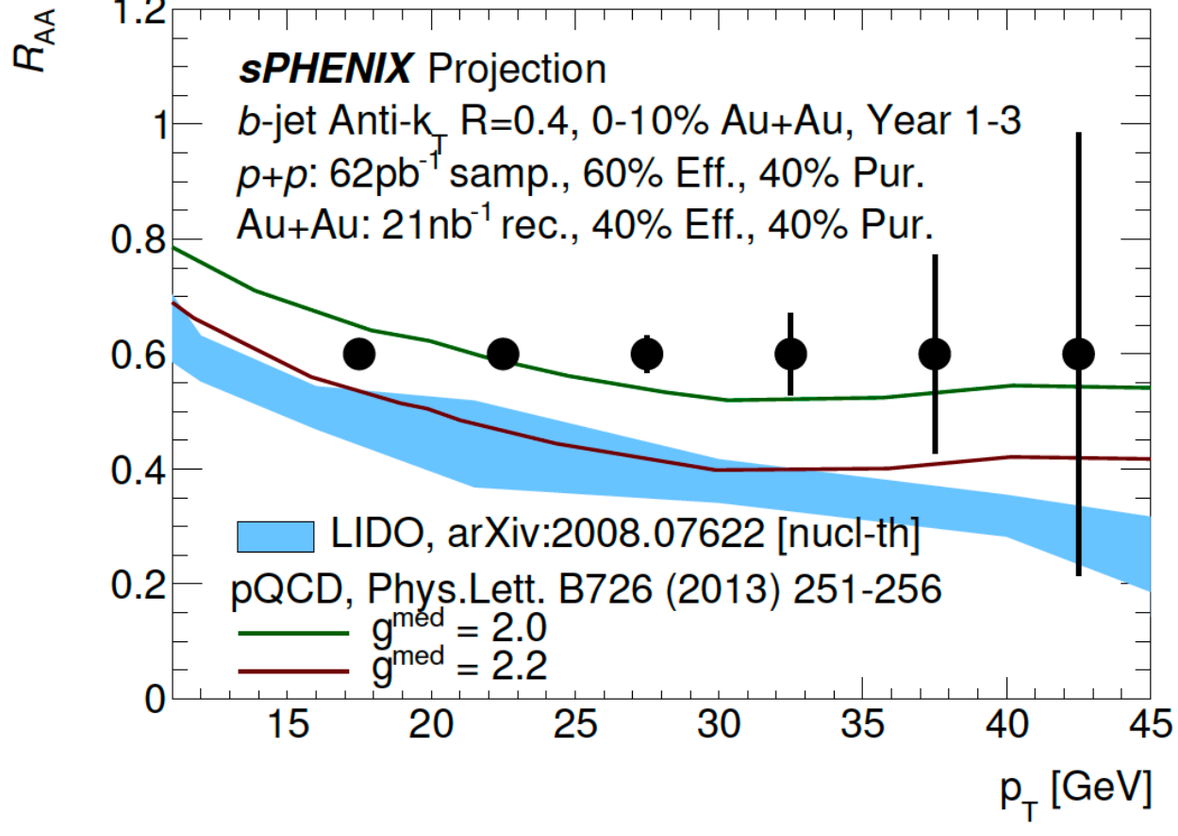
Probing mass-dependent energy loss & collectivity in the QGP

sPHENIX will enable precision bottom measurements at RHIC over broad kinematic range
First b-jet tagging with MVTX

prompt / non-prompt D^0 mesons



b-jets



[BUP] sPH-TRG-2020-001

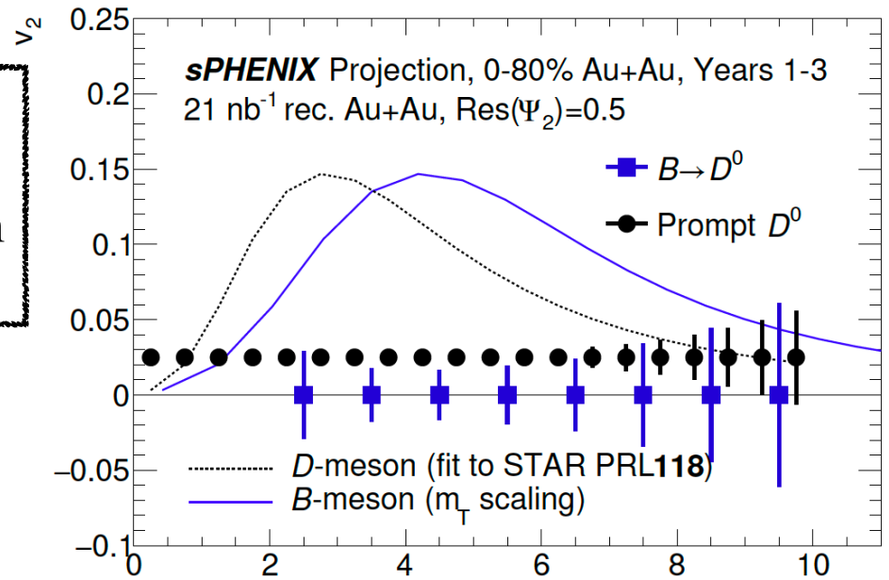
effect of mass difference between light and heavy quarks

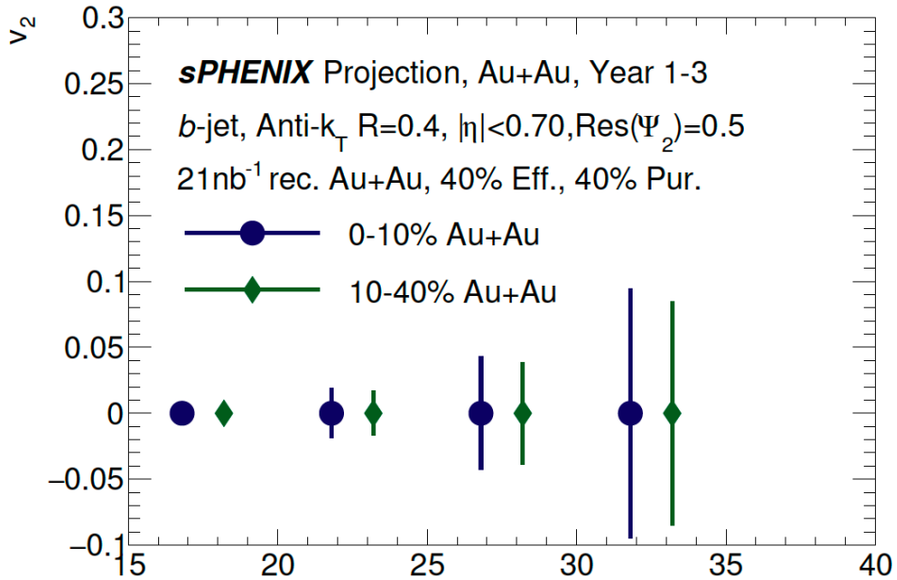
sPHENIX: heavy-flavor program

Study QGP transport coefficient via precision **bottom** measurements over wide p_T range

Elliptical flow v2: prompt / non-prompt D^0 mesons (left) and for b-jets (right)

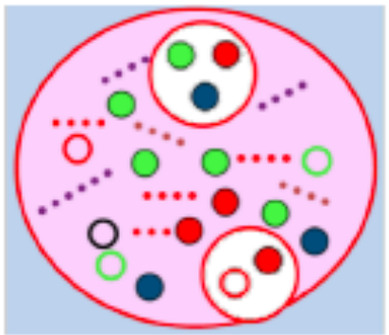
Probing the diffusion of the b-quark in the QGP



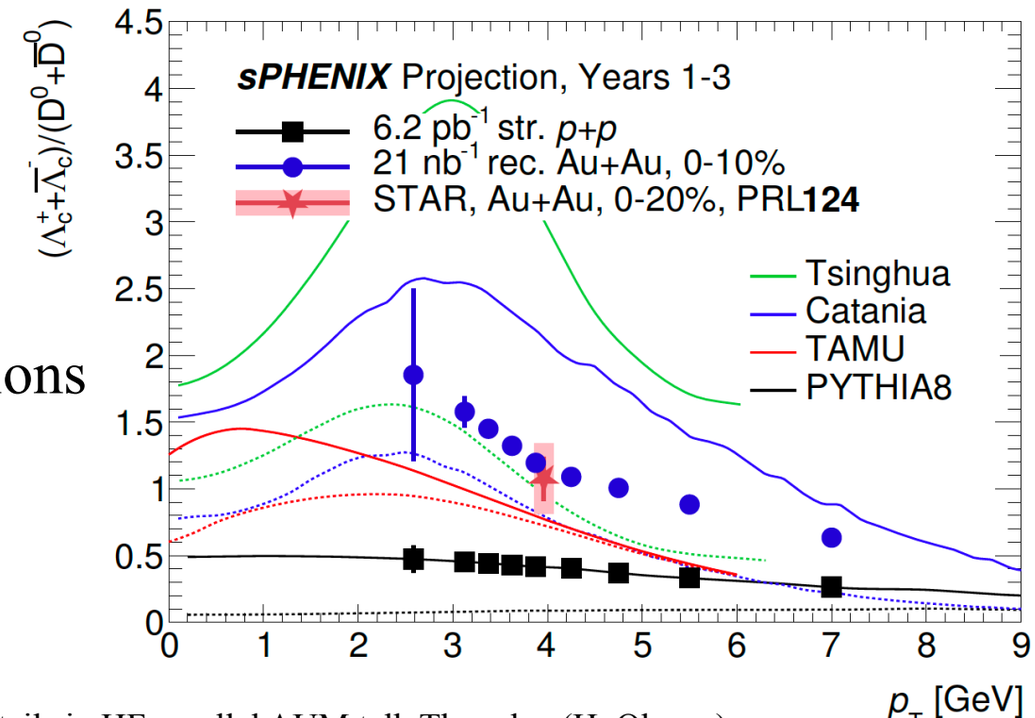


Probing the path-length differential energy loss of the b-quark

Detailed **charm** hadronization studies in the QGP



- First measurement of Λ_C/D^0 enhancement in p+p collisions at RHIC
- First direct comparison of p+p vs A+A at RHIC



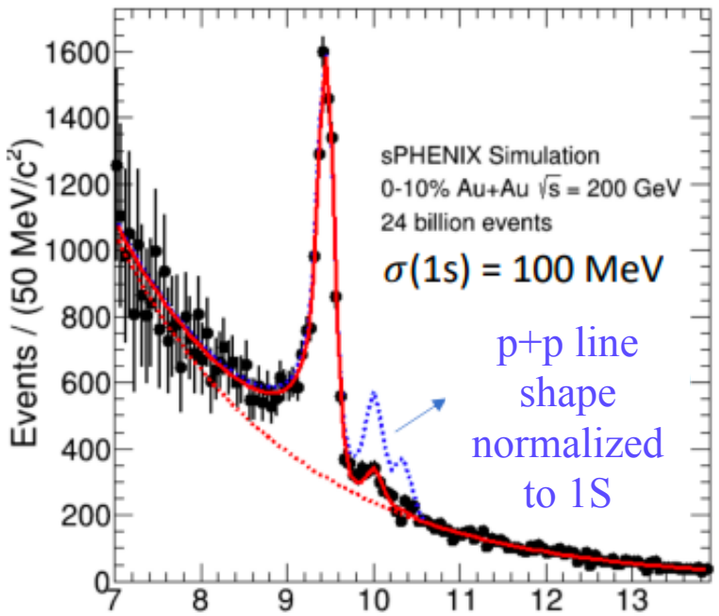
[BUP] sPH-TRG-2020-001

More details in HF parallel AUM talk Thursday (H. Okawa)

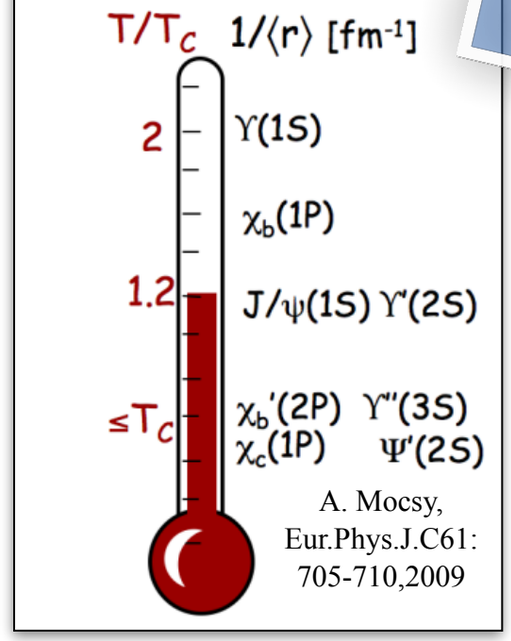
sPHENIX: Upsilon spectroscopy

- Mass resolution of sPHENIX tracking allows clear separation of Υ states for the first time at RHIC

- Enables precision measurements of Υ(1S) and Υ(2S)
  - R_{AA} Upsilon melting observations for $0<p_T<7$ GeV
  - Measuring Υ(3S) modification will be challenging due to suppression. Feasibility studies ongoing



The QGP thermometer

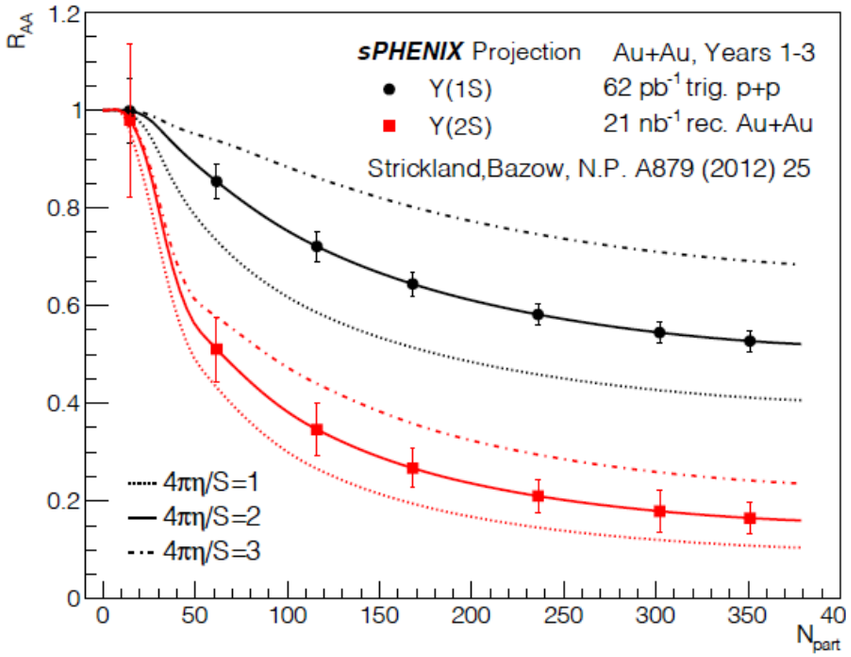


Vertex Tracker MVTX

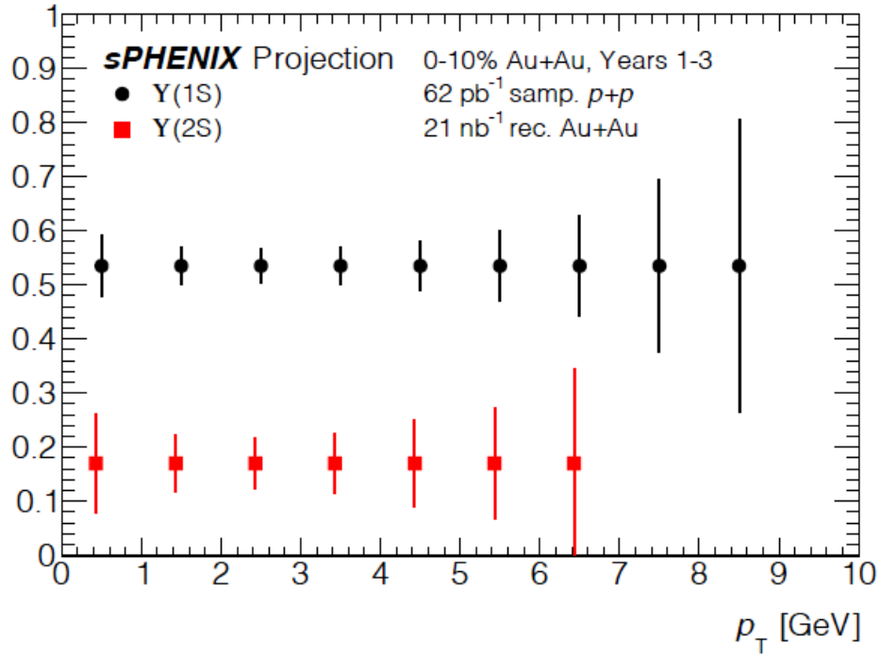
Temperature profile RHIC vs. LHC: measurements of centrality & p_T dependences are critical

Temperature profiles from hydrodynamic calculations show important differences with collision energy

R_{AA} vs. number of participants



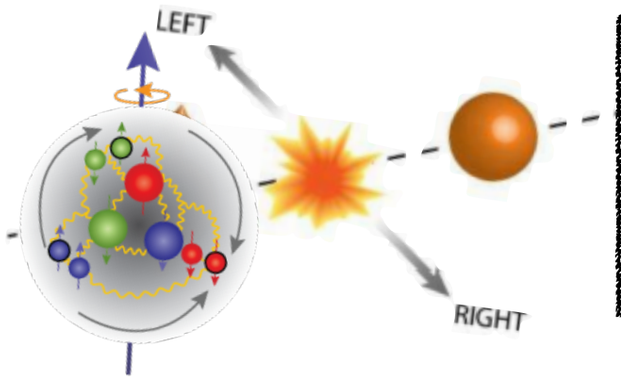
p_T-dependence for most-central collisions



[BUP] sPH-TRG-2020-001

sPHENIX: cold QCD [spin-dependent]

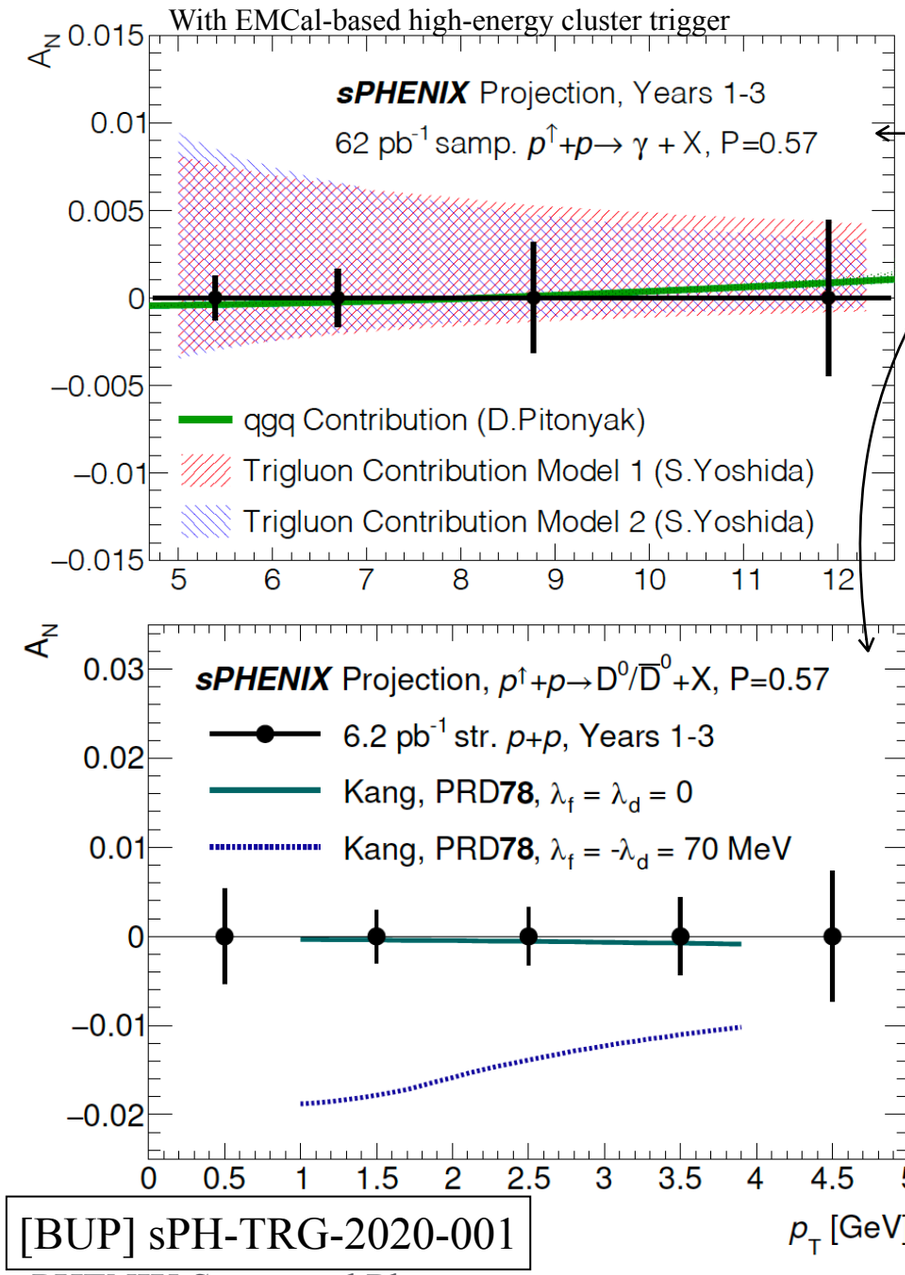
projection plots with barrel only



Further the understanding of the large measured transverse single-spin asymmetries (TSSAs)

Provide constraints for collinear twist-3 framework

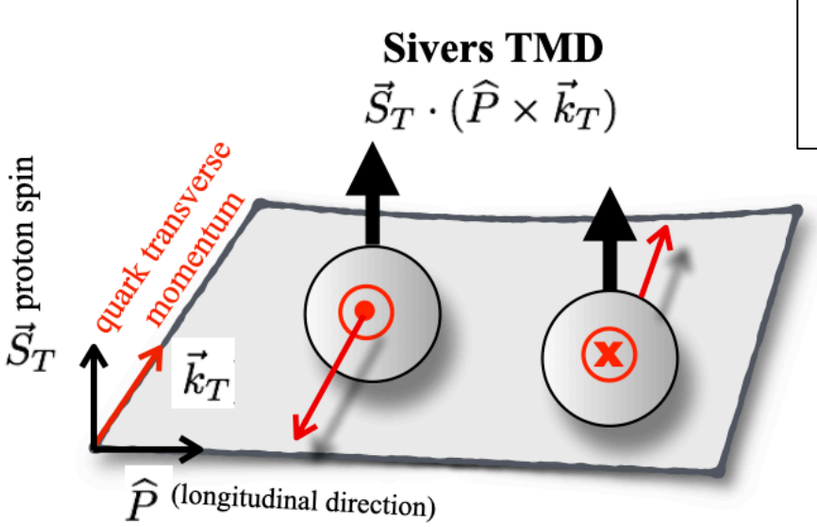
Excellent hadron & jet calorimetric trigger capabilities + high-rate streaming DAQ



[BUP] sPH-TRG-2020-001

Gluon Sivers TMD

- TSSA in direct-γ and heavy-flavor production
- photon-jets measurements (→ qg Compton at LO)



u- & d-quark Sivers TMD

inclusive jets w/ hadron-charge tagging

Di-hadron IFF asym. & Collins mechanism / transversity TMD

hadron-charge tagging & hadron-in-jet

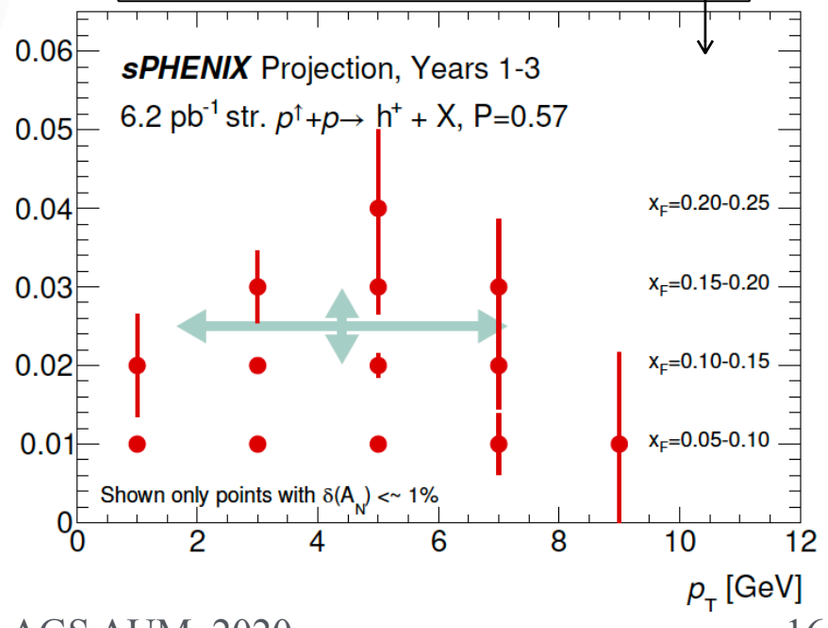
Access to intrinsic transverse parton momentum k_T

dijets with hadron-charge tagging

Similar uncertainties expected for p+Au

↔ PHENIX range with observed strong nuclear dependence

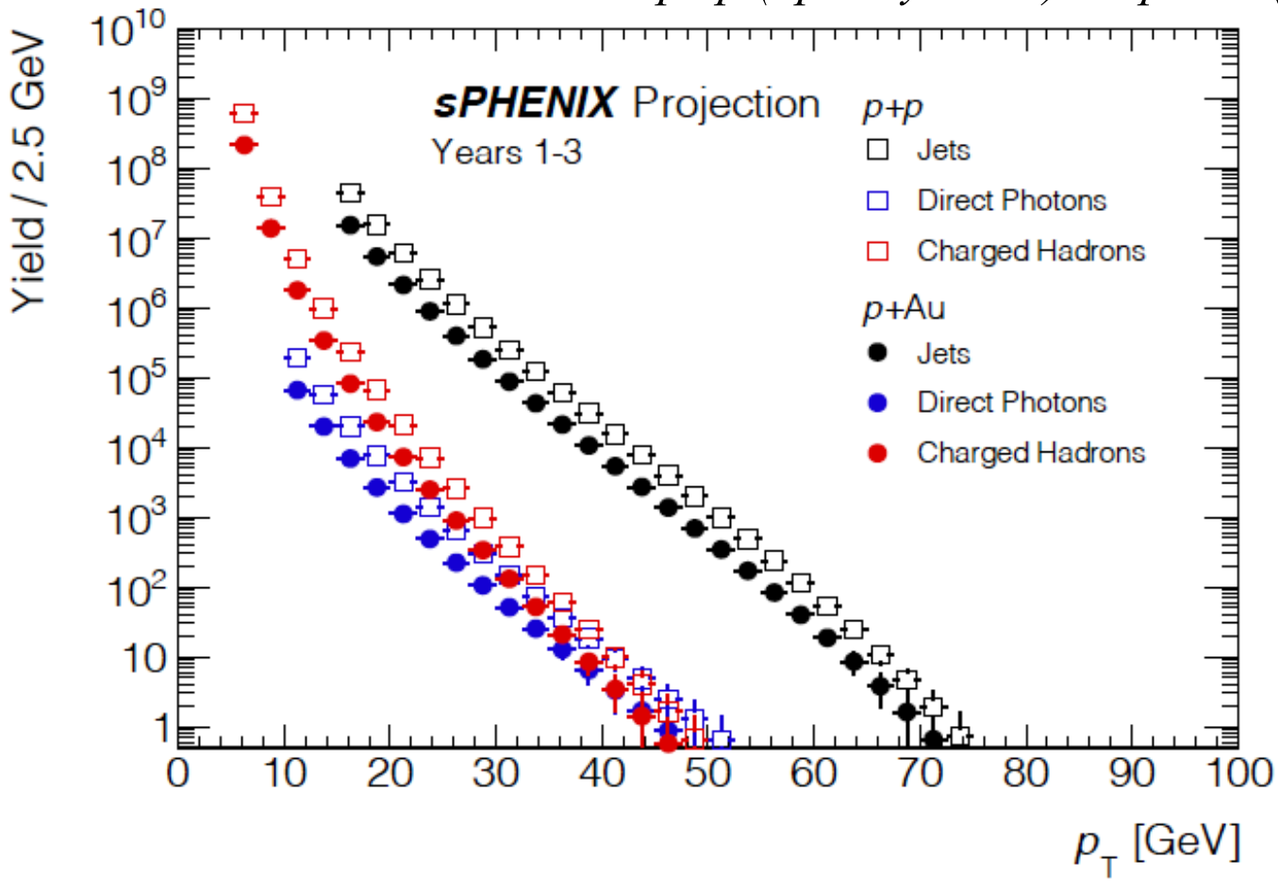
Spin effects in the nuclear environment

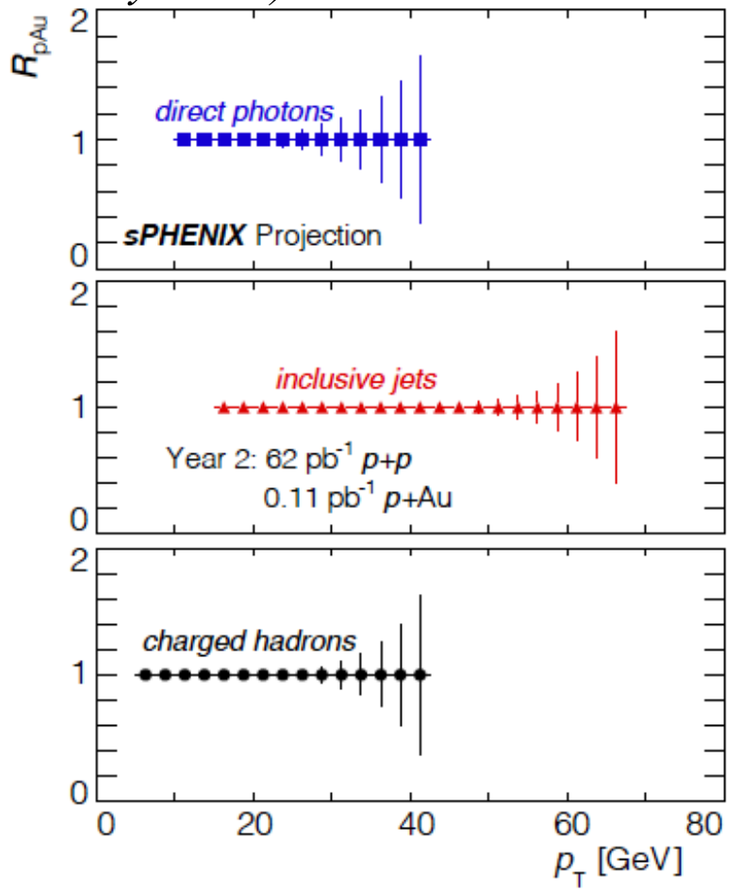


sPHENIX: cold QCD [spin-averaged]

projection plots with barrel only

p+p (open symbols) vs. p+Au (closed symbols)





- Measurements of nuclear modification factor R_{pA}: direct γ, inclusive jets, charged hadrons
- Hadronization studies and nuclear modification of hadronization:
  multidimensional (z, j_T, r) hadron-in-jets measurements
- Separation of effects associated with nucleon / nucleus k_T & fragmentation transverse momentum j_T:
  dijet and photon-jet measurements
- Heavy quarkonium production mechanism:
  ϒ and J/ψ polarization measurements

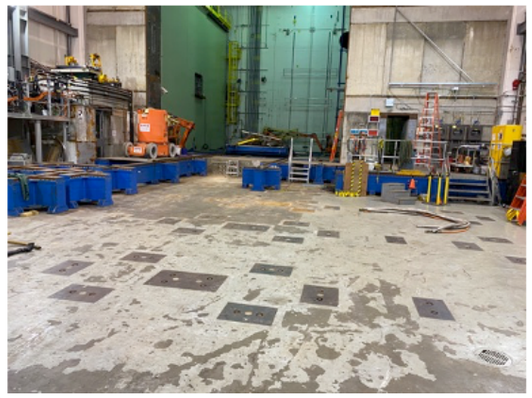
sPHENIX will greatly improve p_T coverage for all of these probes

[BUP] sPH-TRG-2020-001

More details in cold QCD parallel AUM talk Thursday (D. Shangase)

sPHENIX: factories

After the **COVID-19 lockdown** in spring 2020: staff, postdocs and students returned to labs or adapted to work from home.
(Early completion slipped but PD-4 unaffected)



BaBar **SC-magnet** tested to full current at BNL

Engineering design work for large infrastructure proceeding at fast pace

MVTX: all RU's delivered
Staves production has resumed at CERN

Experimental hall 1008 is cleared and ready for construction

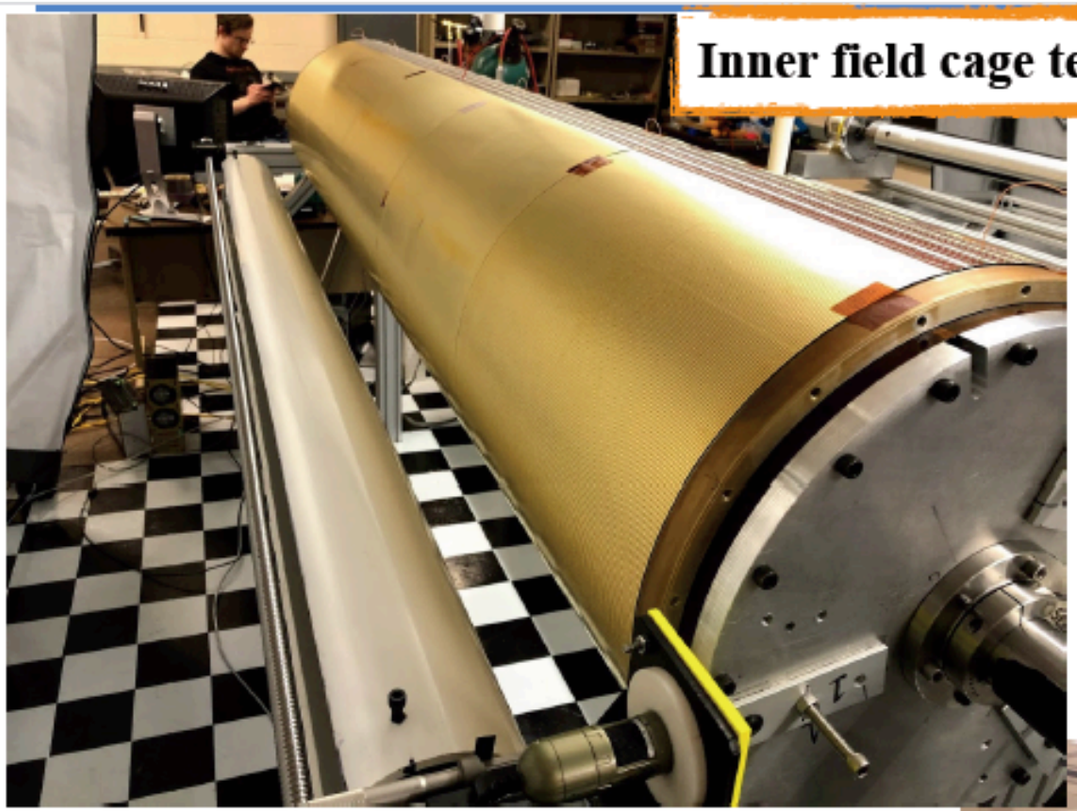
INTT: stave delivery started
Ladder production at Taiwan and BNL

TPC:
- Field cage constructed at SBU
- GEMs ordered from CERN
- SAMPA ASIC testing at Lund U.

oHCAL: tile delivery complete
- 94% tiles tested at GSU, 93% shipped to BNL
- 5/32 sectors assembled at BNL

EMCal: tungsten powder & SiPMs delivery complete, 79% of scint. fibers
- 13/64 sectors of blocks built at UIUC (pre-production complete)
- ~2/64 high-rapidity blocks at Fudan U.
- 6/64 sectors assembled at BNL

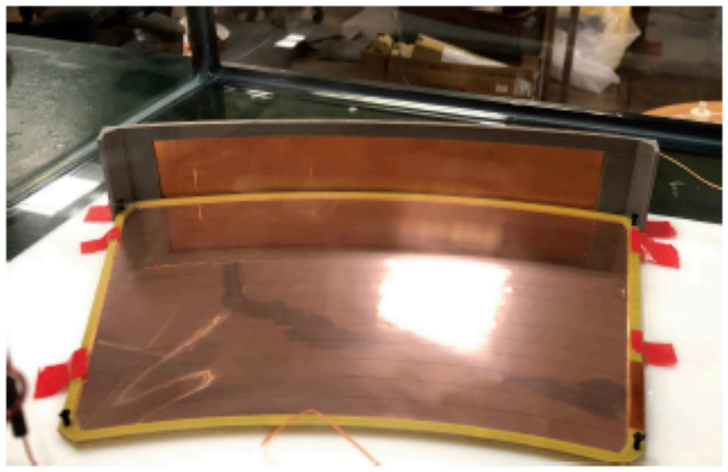
sPHENIX: TPC factories



Inner field cage test



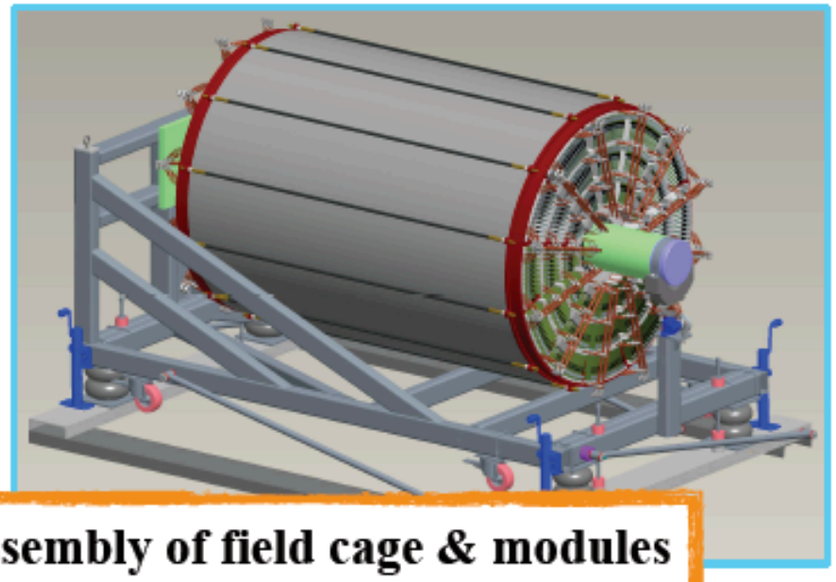
GEM HV tests



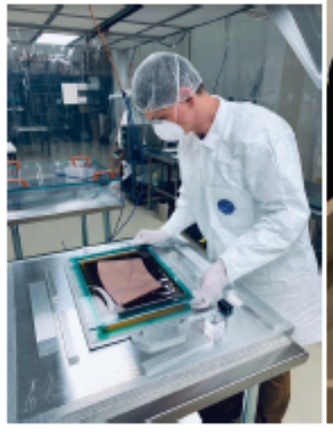


In the GEM factory





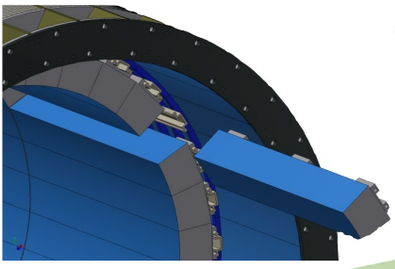
Assembly of field cage & modules



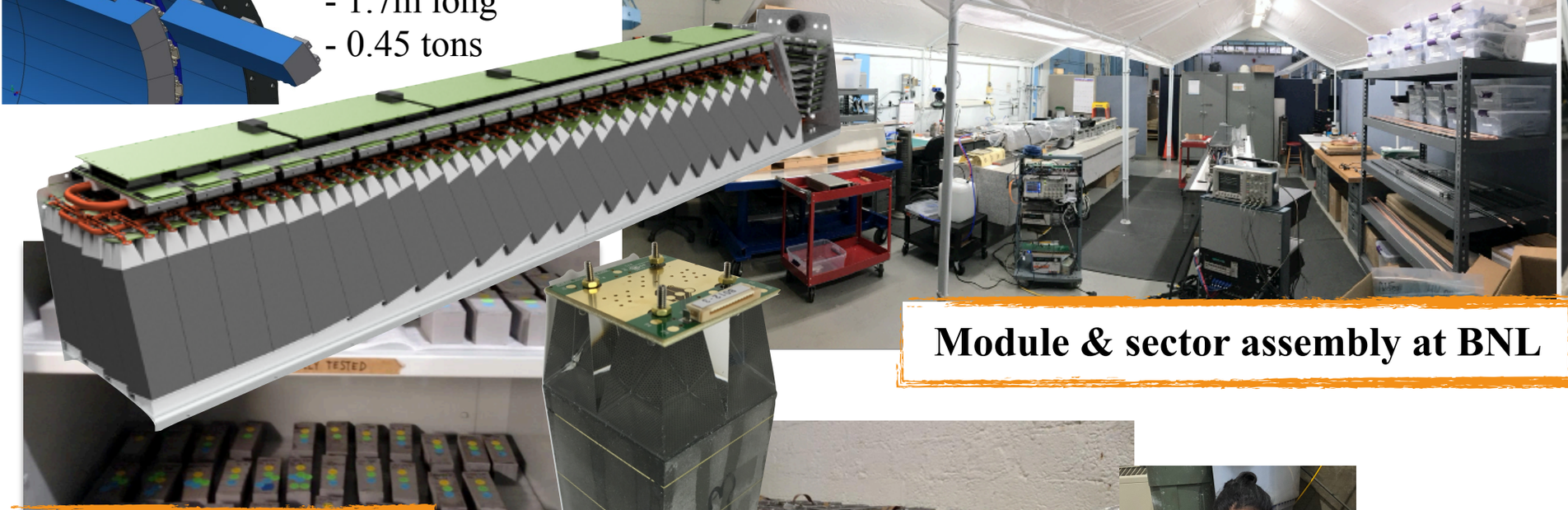


Wagon wheel at SBU

sPHENIX: EMCal factories



64 sectors, each:
- 0.9m < r < 1.16m
- 1.7m long
- 0.45 tons



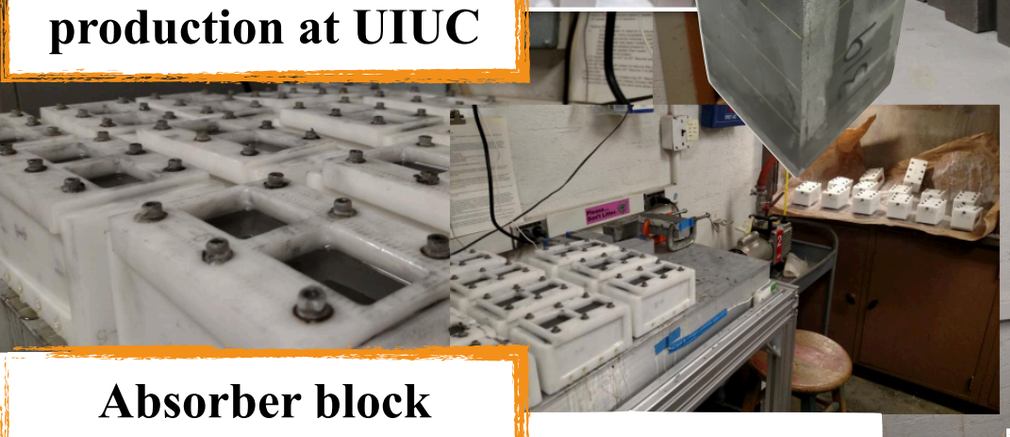


Module & sector assembly at BNL

Sector testing at BNL



Absorber block production at UIUC



Absorber block production at Fudan

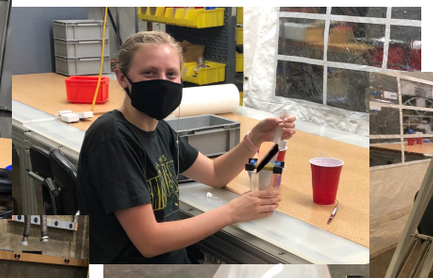




Fiber filling & block testing at UIUC

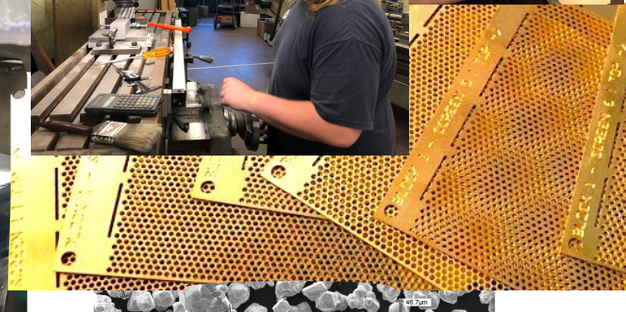


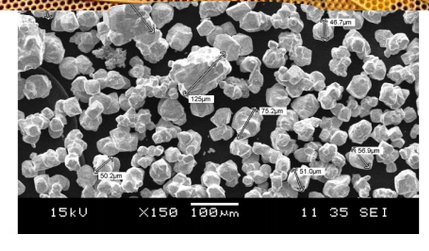












sPHENIX: HCal factories

21_6 Assembly: 50% pre amps, fibers & power cables done; needs preamps, boxes

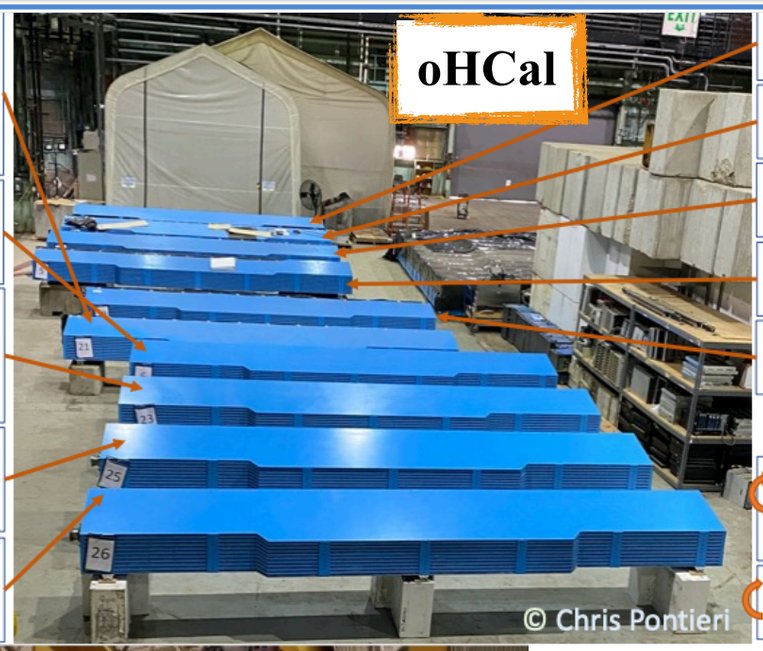
6_7 Assembly: power cables complete, fibers underway

23_8 Assembly: power cables complete, fibers underway

25_9 Assembly: power cables complete

26_{10} Assembly: power cables underway

oHCal



27_{11} Assembly: 100% tiles & SiPMs

16_{12} Assembly: 58% tiles & SiPMs

17_{13} Assembly: waiting for tiles

18_{14} Assembly: waiting for tiles

19_5 Done: waiting for move to storage

20_{15} Assembly: waiting for move to blocks

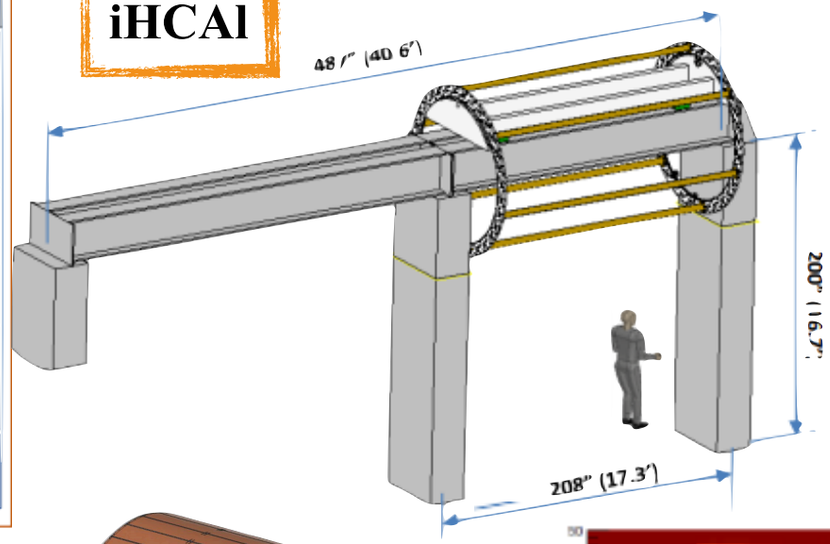
5_4 Storage: waiting for LED driver board

oHCal

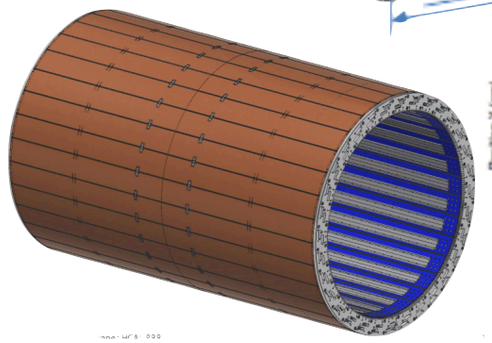


Sector 22_1 being put in storage

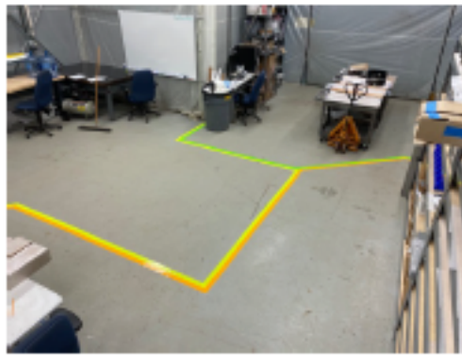
iHCAl

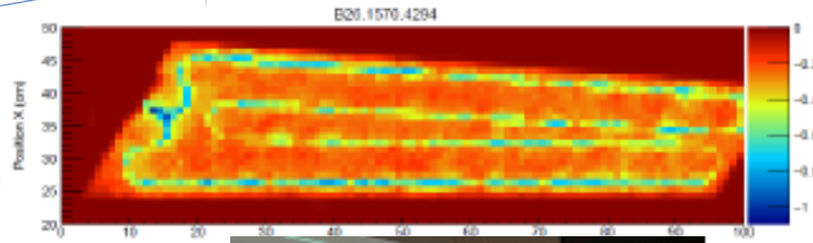


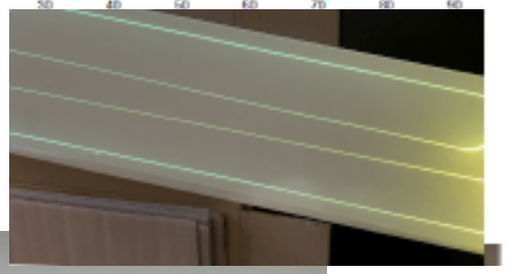
32 sectors, each:
- 1.9m < r < 2.6m
- 6.3m long
- 13.5 tons



Tile testing at GSU







Tiles at GSU



v5 Sampa chips at USP





sPHENIX: infrastructure factories

Many important sPHENIX items are on order and being manufactured (carriage/cradle, liquid helium cryogenic lines), or about to be placed (beam pipe, liquid nitrogen, track reinforcement)



Carriage / cradle at manufacturer

On schedule for Dec. 2020 delivery







sPHENIX: online and offline

TESTBEAMS AT FNAL

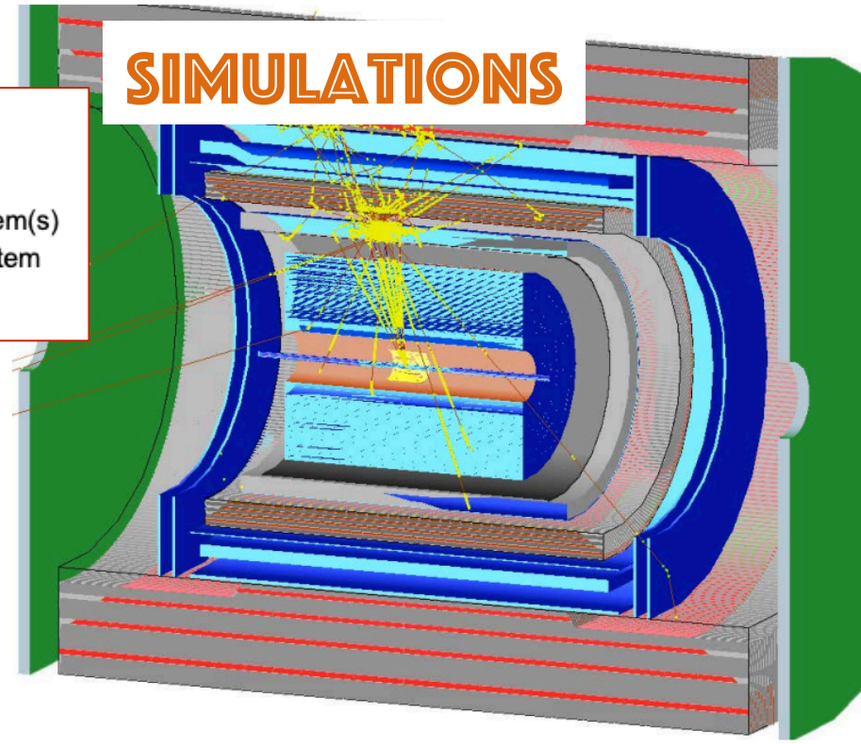


TRACKING

improvement by 2 orders of magnitude

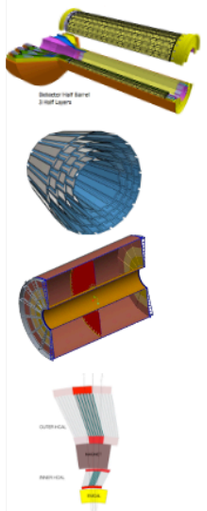
Track reconstruction CPU time approaches the goal of **5 s/event** (Au+Au minimum-bias events embedded in 100 kHz pile-up events), tuning continues.

SIMULATIONS



DAQ

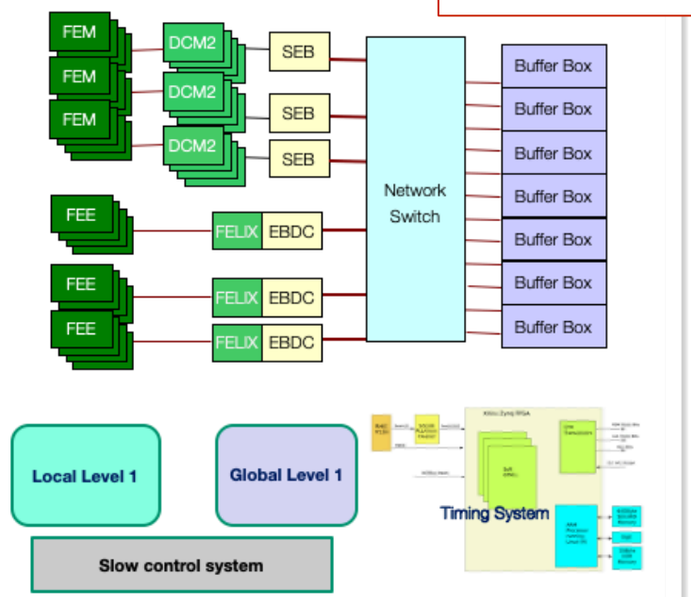
Data rates after buffering



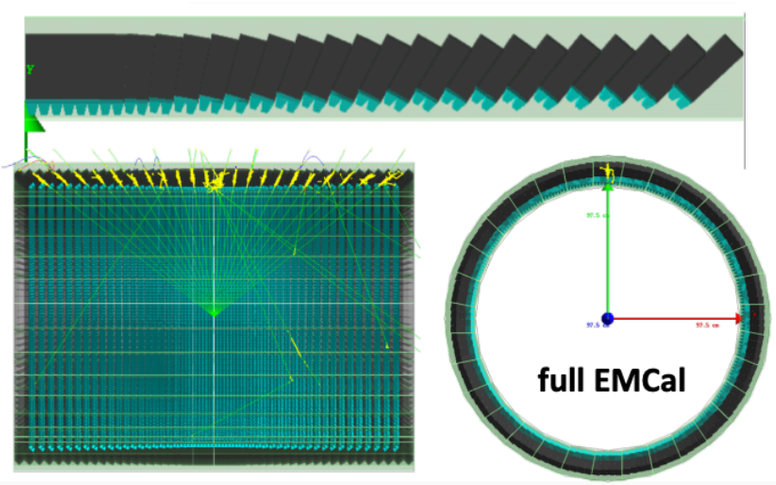
MVTX (MAPS)	~ 20GBit/s
Intermediate Silicon Strip Tracker (INTT)	~ 7GBit/s
Compact Time Projection Chamber (TPC)	~ 100Gbit/s
Calorimeters (primarily Emcal, hadronic cal.)	~ 8GBit/s
	135GBit/s

Makes for an event size of about 1MByte (or more)

DAQ System overview



4 Components:
- Core DAQ system
- Local Level 1 system(s)
- Global Level 1 system
- Timing system



Possible readout upgrades:
- Streaming readout of the tracking detectors may be available at 10% capacity for the 2024 run (+ at 100% capacity for running in 2026–2027 if applicable)
- Demultiplexing of the readout electronics for the calorimeter system enabling a doubling of the Level-1 calorimeter trigger rate from 15 kHz to 30 kHz.

sPHENIX: towards the EIC

- The **potential reuse of parts of the sPHENIX detector** and **its infrastructure for a possible EIC detector** is being considered.

- PAC Meeting September 2020:

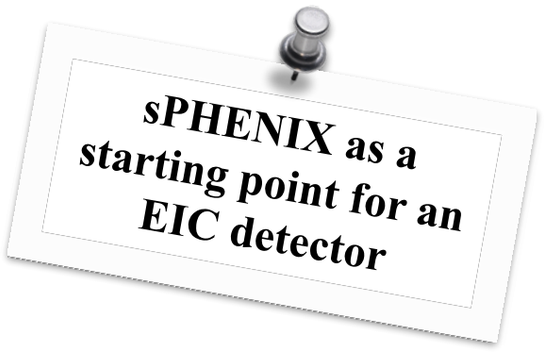
  - The PAC encourages the sPHENIX Collaboration to "**continue the exploration of the connection to the future EIC.**"

  - The **Cold QCD physics** is an important component of the sPHENIX program.

- A **broad and independent consortium** has been formed including non-sPHENIX members from the lepton-scattering physics community to prepare a response to the call of **Expression of Interest** from the **EIC Project**.

Editorial Board:
Or Hen, Tanja Horn, John Lajoie

Contact this EB if you are interested!



sPHENIX: Summary

- **sPHENIX is being constructed** in various factories nationwide and internationally:
  - Hall 1008 ready, large infrastructure progressing, SC-magnet tested
  - GEM production at CERN (for TPC)
  - 6/64 EMCal sectors assembled
  - 5/32 oHCal sectors assembled

  Despite COVID-19 challenges!

- **First data taking at RHIC in 2023!**

  Proposed run plan submitted:
  - 2023: Au+Au candles
  - 2024: p↑+p↑, p↑+Au: HI reference set & coldQCD
  - 2025: Au+Au very large HI set

- **Unique rich program** enabling studies of the **microscopic nature of the QGP** and **cold-QCD**:
  - **Jet correlations & substructure**
  - **Open heavy flavors**
  - **ϒ spectroscopy**
  - **Spin-orbit correlations, nuclear and hadronization effects**

sPHENIX is distinguished by high-rate capability and large acceptance, combined with high-precision tracking and electromagnetic & hadronic calorimetry

☎ Interested in joining sPHENIX and its exciting physics program?

Contact our spokespersons, Dave Morrison and Gunther Roland

Thank you to the numerous sPHENIX collaborators who helped in the preparation of this talk!

Physics goals vs. detector performance

Physics Goal	Analysis Requirement	Performance Goal
Maximize statistics for rare probes	Accept/sample full delivered luminosity	**Data taking rate of 15kHz for Au+Au**
Precision Upsilon spectroscopy	Resolve Y(1s), Y(2s), (Y3s) states	**Y(1s) mass resolution ≤ 125MeV in central Au+Au**
High jet efficiency and resolution	Full hadron and EM calorimetry Jet resolution dominated by irreducible background fluctuations	**$\sigma/\mu \leq 150\%/\sqrt{p_{Tjet}}$ in central Au+Au for R=0.2 jets**
Full characterization of jet final state	High efficiency tracking for $0.2 < p_T < 40$GeV	**Tracking efficiency ≥ 90% in central Au+Au** **Momentum resolution ≤ 10% for p_T = 40 GeV**
Control over initial parton p_T	Photon tagging with energy resolution dominated by irreducible higher order	**Single photon resolution ≤ 8% for p_T = 15 GeV in central Au+Au**
Control over initial parton p_T	Topological identification of heavy flavor hadron decays	**High resolution secondary vertex identification (DCA < 30μm @ 1GeV)**

sPHENIX: more data years?

If the opportunity arises - more p+p data and data with smaller nuclei; 100% streaming DAQ

Year	Species	$\sqrt{s_{NN}}$ [GeV]	Cryo Weeks	Physics Weeks	Rec. Lum. $\lvert z\rvert$ <10 cm	Samp. Lum. $\lvert z\rvert$ <10 cm
2026	$p^{\uparrow}p^{\uparrow}$	200	28	15.5	1.0 pb^{-1} [10 kHz] 80 pb^{-1} [100%-*str*]	80 pb^{-1}
–	O+O	200	–	2	18 nb^{-1} 37 nb^{-1} [100%-*str*]	37 nb^{-1}
–	Ar+Ar	200	–	2	6 nb^{-1} 12 nb^{-1} [100%-*str*]	12 nb^{-1}
2027	Au+Au	200	28	24.5	30 nb^{-1} [100%-*str*/DeMux]	30 nb^{-1}

sPHENIX beam use more details

Weeks	Designation
0.5	Cool Down from 50 K to 4 K
2.0	Set-up mode 1 (Au+Au at 200 GeV)
0.5	Ramp-up mode 1 (8 h/night for experiments)
11.5	sPHENIX Initial Commission Time
9.0 (13.0)	Au+Au Data taking (Physics)
0.5	Controlled refrigeration turn-off
24.0 (28.0)	Total cryo-weeks

Table 4.2: Year 2023 run plan for 24 (28) cryo-weeks with Au+Au 200 GeV collision

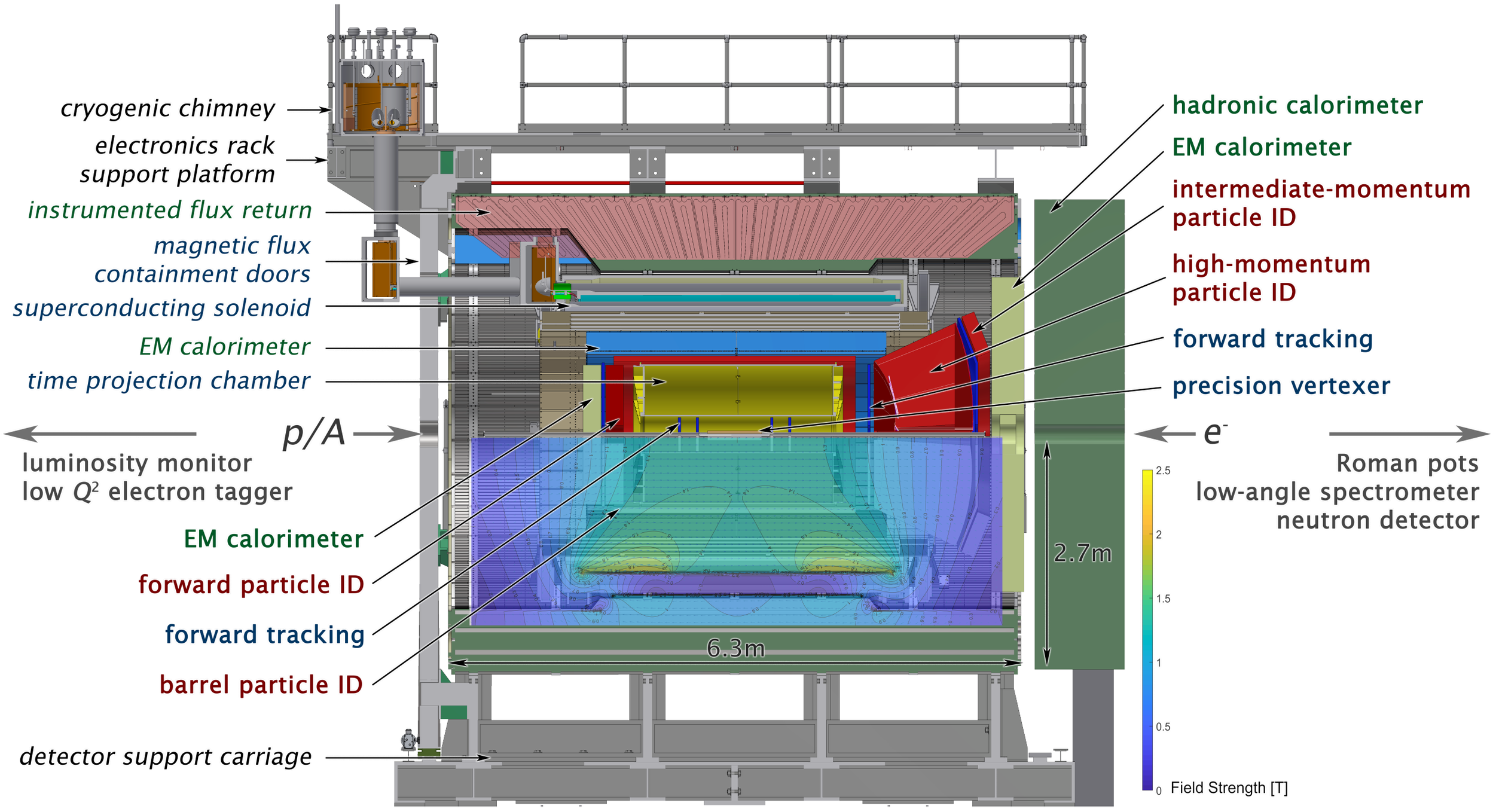
Weeks	Designation
0.5	Cool Down from 50 K to 4 K
2.0	Set-up mode 1 ($p^{\uparrow}p^{\uparrow}$ at 200 GeV)
0.5	Ramp-up mode 1 (8 h/night for experiments)
12.0 (16.0)	Data taking mode 1 ($p^{\uparrow}p^{\uparrow}$ Physics)
1.0	Move DX magnets
2.0	Set-up mode 2 ($p^{\uparrow}$+Au at 200 GeV)
0.5	Ramp-up mode 2 (8 h/night for experiments)
5.0	Data taking mode 2 ($p^{\uparrow}$+Au Physics)
0.5	Controlled refrigeration turn-off
24.0 (28.0)	Total cryo-weeks

Table 4.3: Year 2024 run plan for 24 (28) cryo-weeks with $p^{\uparrow}p^{\uparrow}$ and $p^{\uparrow}$+Au 200 GeV collisions.

Weeks	Designation
0.5	Cool Down from 50 K to 4 K
2.0	Set-up mode 1 (Au+Au at 200 GeV)
0.5	Ramp-up mode 1 (8 h/night for experiments)
20.5 (24.5)	Au+Au Data taking (Physics)
0.5	Controlled refrigeration turn-off
24.0 (28.0)	Total cryo-weeks

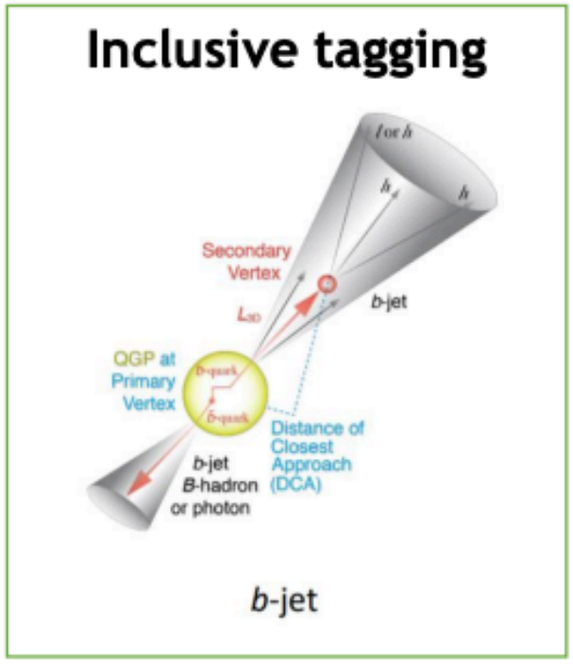
Table 4.4: Year 2025 run plan for 24 (28) cryo-weeks with Au+Au 200 GeV collisions.

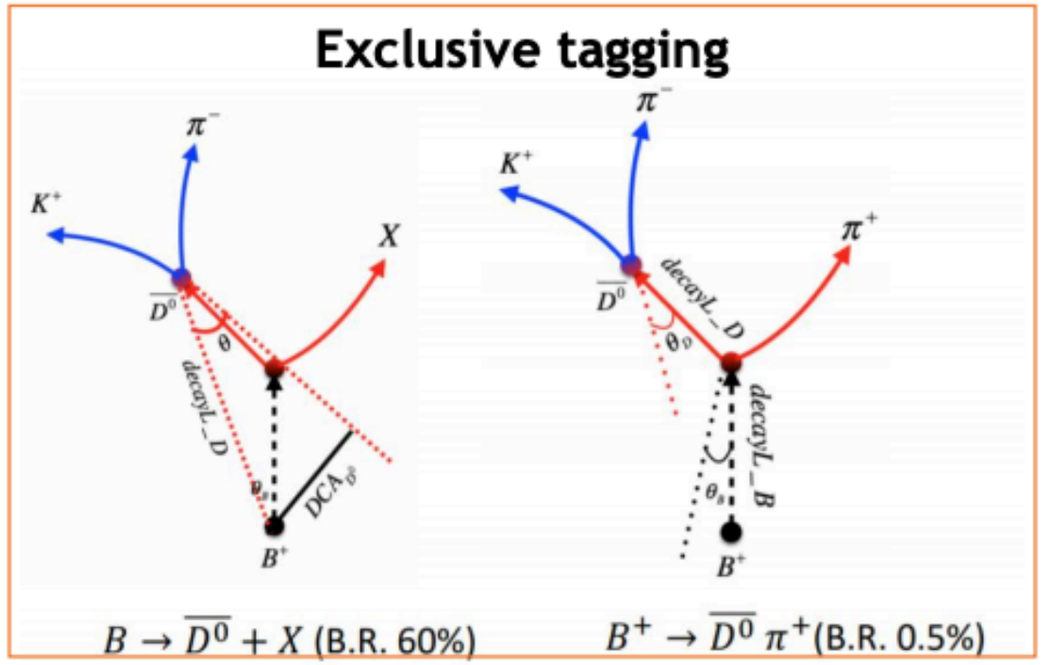
Possible EIC detector based on sPHENIX



courtesy Jin Huang

sPHENIX: open heavy flavor w/ MVTX





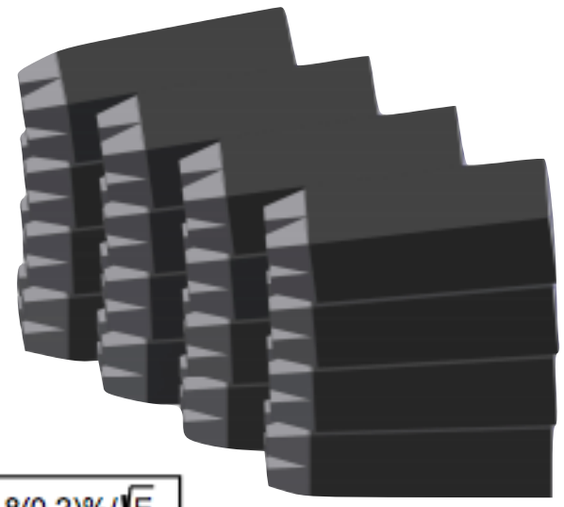
- Precise identification of secondary vertex allows high-purity b-jet samples
- Heavy flavor decays: marked by **distinctive decay topology**
  - High-resolution DCA, precise vertexing, high rate
  - Detection of heavy-flavor mesons possible even without p/K/π PID

sPH-HF-2018-001

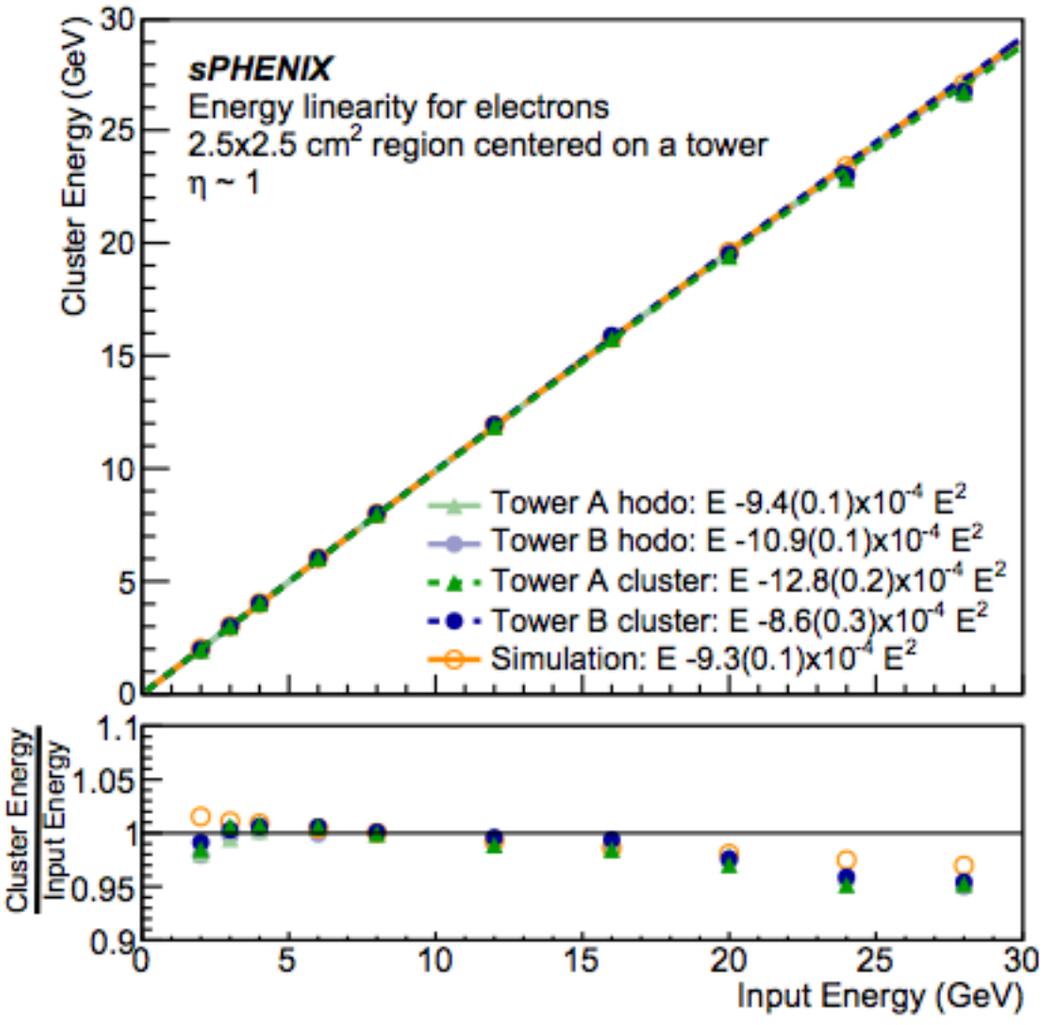
6/2/2020 Hard Probes 2020 14

Design and Beam Test Results for the 2D Projective sPHENIX Electromagnetic Calorimeter Prototype

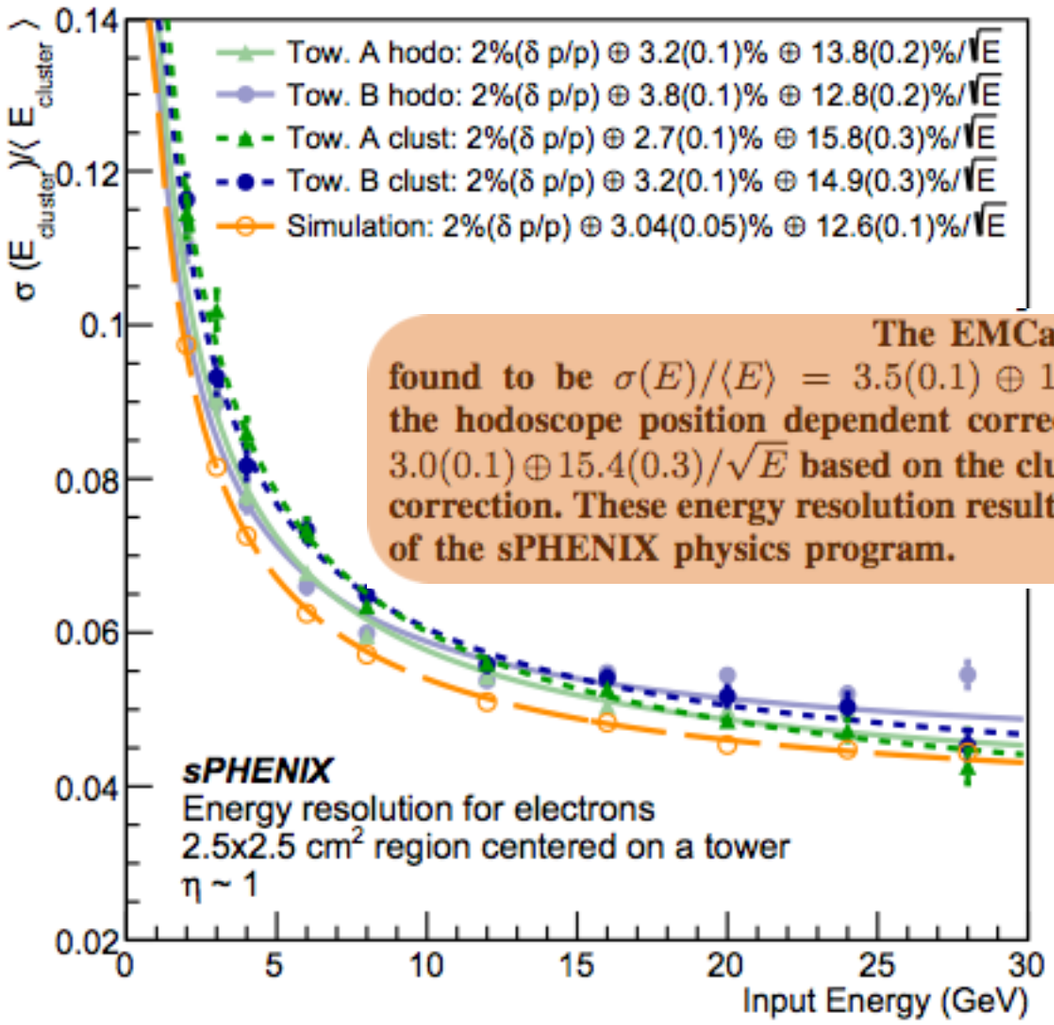
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linearity



energy resolution



The EMCal energy resolution was found to be $\sigma(E)/\langle E\rangle = 3.5(0.1) \oplus 13.3(0.2)/\sqrt{E}$ based on the hodoscope position dependent correction, and $\sigma(E)/\langle E\rangle = 3.0(0.1) \oplus 15.4(0.3)/\sqrt{E}$ based on the cluster position dependent correction. These energy resolution results meet the requirements of the sPHENIX physics program.

- arXiv:2003.13685 & submitted to IEEE TNS. Analysis and paper drafting led by Anabel Romero Hernandez (UIUC)
- Data from 2018 FNAL test-beam effort