sPHENIX Status

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on behalf of the sPHENIX collaboration

MIT

10th June 2022

RHIC/AGS Annual Users' Meeting
The sPHENIX detector

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>First run year</td>
<td>2023</td>
</tr>
<tr>
<td>$\sqrt{S_{NN}}$ [GeV]</td>
<td>200</td>
</tr>
<tr>
<td>Trigger Rate [kHz]</td>
<td>15</td>
</tr>
<tr>
<td>Magnetic Field [T]</td>
<td>1.4</td>
</tr>
<tr>
<td>First active point [cm]</td>
<td>2.5</td>
</tr>
<tr>
<td>Outer radius [cm]</td>
<td>270</td>
</tr>
<tr>
<td>$</td>
<td>\eta</td>
</tr>
<tr>
<td>$</td>
<td>z_{vtx}</td>
</tr>
<tr>
<td>N(AuAu) collisions*</td>
<td>$1.43 \times 10^{11}$</td>
</tr>
</tbody>
</table>

* In 3 years of running

Not shown: sEPD and MBD
<table>
<thead>
<tr>
<th>Year</th>
<th>Species</th>
<th>$\sqrt{s_{NN}}$ [GeV]</th>
<th>Cryo Weeks</th>
<th>Physics Weeks</th>
<th>Rec. Lum.</th>
<th>Samp. Lum.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2023</td>
<td>Au+Au</td>
<td>200</td>
<td>24 (28)</td>
<td>9 (13)</td>
<td>3.7 (5.7) nb$^{-1}$</td>
<td>4.5 (6.9) nb$^{-1}$</td>
</tr>
<tr>
<td>2024</td>
<td>$p^\uparrow p^\uparrow$</td>
<td>200</td>
<td>24 (28)</td>
<td>12 (16)</td>
<td>0.3 (0.4) pb$^{-1}$ [5 kHz]</td>
<td>45 (62) pb$^{-1}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4.5 (6.2) pb$^{-1}$ [10%-str]</td>
<td></td>
</tr>
<tr>
<td>2024</td>
<td>$p^\uparrow$+Au</td>
<td>200</td>
<td>–</td>
<td>5</td>
<td>0.003 pb$^{-1}$ [5 kHz]</td>
<td>0.11 pb$^{-1}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.01 pb$^{-1}$ [10%-str]</td>
<td></td>
</tr>
<tr>
<td>2025</td>
<td>Au+Au</td>
<td>200</td>
<td>24 (28)</td>
<td>20.5 (24.5)</td>
<td>13 (15) nb$^{-1}$</td>
<td>21 (25) nb$^{-1}$</td>
</tr>
</tbody>
</table>
Core physics program

Jet correlation & substructure
Vary momentum/ angular size of probe

Parton energy loss
Vary mass/ momentum of probe
- g
- u,d,s
- c
- b

Upsilon spectroscopy
Vary size of the probe
- $\Upsilon(3s) - 0.78\text{fm}$
- $\Upsilon(2s) - 0.56\text{fm}$
- $\Upsilon(1s) - 0.28\text{fm}$

Cold QCD
Vary temperature of QCD matter

06/10/2022
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

<table>
<thead>
<tr>
<th>ALPIDE thickness [μm]</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pixel size [μm] / matrix</td>
<td>29 x 27 / 1024 x 512</td>
</tr>
<tr>
<td>Technology</td>
<td>180nm CMOS</td>
</tr>
<tr>
<td>Power Consumption [mW/cm^2]</td>
<td>40 (mean), 300 (peak)</td>
</tr>
<tr>
<td>Stave Material Budget</td>
<td>0.3% X₀</td>
</tr>
<tr>
<td>Timing resolution</td>
<td>A few μs (tunable)</td>
</tr>
<tr>
<td>XZ spatial resolution [μm]</td>
<td>&lt; 6</td>
</tr>
</tbody>
</table>
• 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 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
Compact TPC, $20 < r\ [\text{cm}] < 78$ (active volume $r > 30\text{cm}$)

- IBF is minimized, TPC is live at all times
  - IBF < 0.5% at a few kV in GEMs
- Detector installation: middle of November
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.
• Sampling EMCal, using SciFi in tungsten and epoxy
• $20.1 X_0$ and $0.83 \lambda_{\text{int}}$
• 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
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
• 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

- **Prediction** that transient mag. field can influence $\nu_1$
- This effect is odd under charge-conjugation, resulting in splitting
- $D^0$ is complicated, requires good production knowledge

\[ PRL 123 (2019) 162301 \]
\[ PRL 118 (2017) 212301 \]

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06/10/2022

sPHENIX Status
Quarkonia

- 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
LHC vs RHIC

sPHENIX Status
Installation

(1) Cradle Base, AH
- The base will be built on top of the AH rails

(2) oHCAL Sector 1-13, AH
- Magnet mount hardware is also attached

(3) Magnet mount, AH
- The magnet is lowered into the oHCAL bore

(4) Inner Rings, AH
- The rings also work to stabilize the magnet

(5) oHCAL Sector 14-32, AH
- The full oHCAL barrel weighs ~480 tons

(6) Inner HCAL
- The HCAL barrel slides in from the North

(7) EMCAL
- There are 64 EMCAL sectors each installed one at a time with a special tool

(8) Open Shield Wall
- Work on sPHENIX will stop for the time needed to remove the shield wall

(9) Carriage, platforms, Pole Tips, AH
- There is a 5-foot move North in the IR

(10) Move sPHENIX to IR
- Results from an sPHENIX OPERA EM FEA

(11) Connect, Map Magnet
- TPC slides in the EMCAL bore from North

(12) TPC, IR

(13) INTT Supports, IR

(14) Beam Pipe Install, IR
- Beam pipe is supported temporarily as a few locations for MVTX installation

(15) INTT Device, IR

(16) MVTX, IR
- MVTX has a 2mm clearance to the beam pipe

(17) Secure Beam pipe, IR

(18) MBD, IR

06/10/2022
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