sPHENIX upgrade at mid-rapidity

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contents:

• Hadrons
• Electrons
• Photons
• Jets

Workshop on:
“Future Directions in High Energy QCD”
20-22/Oct/2011
Nishina Hall, Riken, Japan
sPHENIX & ePHENIX
TOF vs $1/p$ (with ACC veto)

Aerogel Cherenkov Counter
Thermal / chemical freeze-out properties from PIDed spectra and ratios
Partonic and hadronic expansion / collectivity from PIDed $v_2$
Advanced MRPC

- Advanced MRPC
- 24 gas gaps
- 160 micron width
- Time resolution [ps]
  - Time resolution of MRPC
  - Time difference between MRPC1 and MRPC2

Cosmic ray

- Cosmic rays 12.5 kV
  - Time resolution $\sigma = 35.3$ ps
  - Time resolution $\sigma = 24.9$ ps

- 12.5 kV T10 test beam
  - Time resolution $\sigma = 22.35$ ps
  - Time resolution $\sigma = 22.35/\sqrt{2} = 15.8$ ps

ASICs for fast timing

- Will mount NINO ASICs as close to the pick up pads as possible
- Read out both ends of strip
- Compared to 10 gap (250 micron) ALICE TOF expect
- Intrinsic jitter decrease from 20 ps to 9 ps (more primary ionising clusters - faster electron velocity in avalanche)
- Rise time to decrease by factor 2 (faster electron velocity in avalanche)
- Narrower charge spectrum further displaced from zero (slewing corrections easier)
FAST mRPC TOF for PID from Mickey Chiu

- Full coverage hadron PID that works in heavy ion collisions, even at forward rapidities (most other technologies fail at high multiplicities). Very large acceptance.
- Despite small size of sPHENIX, comparable performance to current TOF, but with full acceptance. Performance scales with distance, so larger sPHENIX is better.
- With dE/dx measurement, will have PID from very low to high $p_T$, and eID down to low $p_T$ (under study what dE/dx would be required).
- Physics: 1. Critical point search/study 2. Onset of deconfinement 3. PID study of jet fragments (what happens to lost energy?) 4. Quantitative tests of 3D hydro 5. Transverse spin studies (OFF×Transversity, $\pi/K/p/\Lambda A_N$) 6. $\Lambda$ spin transfer, etc…
Beam Energy Scan Program from STAR experiment

- net-proton distribution
- $n$-quark scaling of $v_2$
(Amazing) similarity between RHIC and LHC ($v_2$ and $R_{AA}$)
Small deviations in \((m_T-m_0)/n_q\) scaled \(v_2\)

**Pb+Pb 2.76TeV**

**Au+Au 200GeV**

**Au+Au 39GeV**

- Roughly \((m_T-m_0)/n_q\) scaled for all energies
- Larger \(p_T\) shift for heavier particles
- Radial flow increases with energy

M. Krzewicki, QM11
Geometrical source anisotropy via HBT measurement at the end of freeze-out

It might be different from the $v_2$-$v_4$ relation

T. Niida, WPCF2011, 20/Sep/2011

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Ring-Imaging Cherenkov Detector

E/p ratio: $1.1 \text{GeV/c} < p < 1.2 \text{GeV/c}$
Charm suppression and flow from single electrons

Thermal photon spectra from electron-pairs ($\gamma^*$)
Direct photon $R_{AA}$

Prompt $\gamma$ dominance:
- no suppression and
- small $v_2$ at high $p_T$

Large $v_2$ for thermal photon from combined real and virtual $\gamma$ measurements
Electron-pair mass spectra in p+p / Au+Au
Hadron Blind Detector

Pairs in Central Arms

Pairs matched to HBD

Pairs after HBD rejection

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Charged hadrons and jets
High $p_T$ photons and electrons

\[ \Delta p/p = 0.007 + 0.0015p \]
J/Psi $R_{AA}$ and $v_2$

different $J/\psi$ $R_{AA}(p_T)$ dependence between RHIC(↑) and LHC(↓)
Jet energy asymmetry
+
Out-of-Cone radiation

ΔR > 0.8

ΔR < 0.8

arXiv:1102.1957 [nucl-ex]
Fragmentation function with direct photon trigger
\( \gamma, \text{Jet, } \pi^0 \) - hadron correlation

Comparisons are the most important!

Closer and closer to the initial parton energy

More and more surface bias given by energy loss

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$v_2$ in p+p $\leftrightarrow$ $v_3$ in A+A
Higher harmonic event anisotropy and azimuthal correlation
\[ \phi_s = [-2,-1] \pi/8 \]  
\[ \phi_s = [1,2] \pi/8 \]  
\[ \phi_s = [2,3] \pi/8 \]  
\[ \phi_s = [3,4] \pi/8 \]  

200GeV Au+Au -> h-h (run7)  
(\( p_T^{\text{Trig}} = 2 \sim 4 \text{GeV/c} , p_T^{\text{Asso}} = 1 \sim 2 \text{GeV/c} \))  
mid-central : 20-50%  

\( \Delta \phi = \phi_{\text{Asso.}} - \phi_{\text{Trig.}} \) (rad)  

PHENIX preliminary
the same data in polar plots (R.P. is x axis) --- associate distribution for a given trigger direction ---

200GeV Au+Au -> h-h
($p_T^{Trig}=2$~$4\text{GeV}/c$, $p_T^{Asso}=1$~$2\text{GeV}/c$)

out-of-plane trigger $3\pi/8 < |\phi_{Trig} - \phi_{R.P.}| < \pi/2$

in-plane trigger $|\phi_{Trig} - \phi_{R.P.}| < \pi/8$

averaged over all trigger angles
heavy-flavor (b/c tagged) electron identified open heavy-flavor meson multi-hadron/jet correlations with R.P. / large $\eta_{\text{Trig}}$
higher harmonic event anisotropy
Summary

• Calorimetric detector for jets, electrons and photons at high $p_T$
• How about low $p_T$ electrons, photons and identified hadrons?
• What about fluctuation/correlation variables with particle identification using a large acceptance detector…