sPHENIX TPC simulation studies

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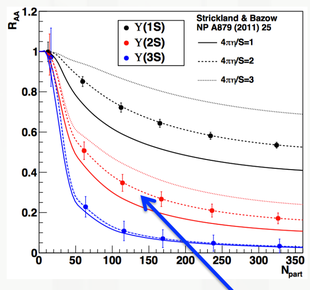
Abstract

Proposed upgrade of PHENIX to sPHENIX at RHIC is focused on measuring jets, jet correlations and three states of upsilons to determine the temperature dependence of transport coefficients of the quark-gluon plasma and complementing measurements being made at LHC. The sPHENIX detector will have GEM based Time Projection Chamber (TPC) as an outer tracking detector with a length of 211 cm and outer radius of 78 cm spanning phase space of full azimuth and 2.2 units in pseudo rapidity. Space charge due to the accumulation of less mobile positive ions within TPC volume is considered one of the important factor determining the performance of GEM-based TPC in Heavy Ion collision environment. Also, selection of suitable gas mixture is important to achieve high mobility of ionized electrons and ions within TPC gas volume. This poster is intended to present the simulation of the effect of space charge and diffusion coefficients of different gas mixtures in TPC on tracking performance.

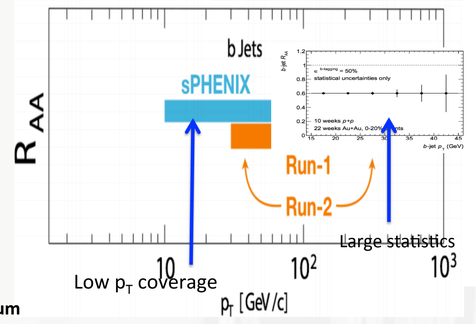
Tracking Physics Motivations

Quarkonia measurement



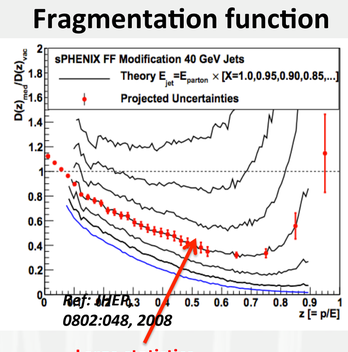
Y(1s,2s,3s) separation require momentum resolution of ~1.2% in 4 GeV < p < 10 GeV

b-tagged jets measurement



Require measurement of displaced vertex of D or B meson decay with high precision.

Fragmentation function

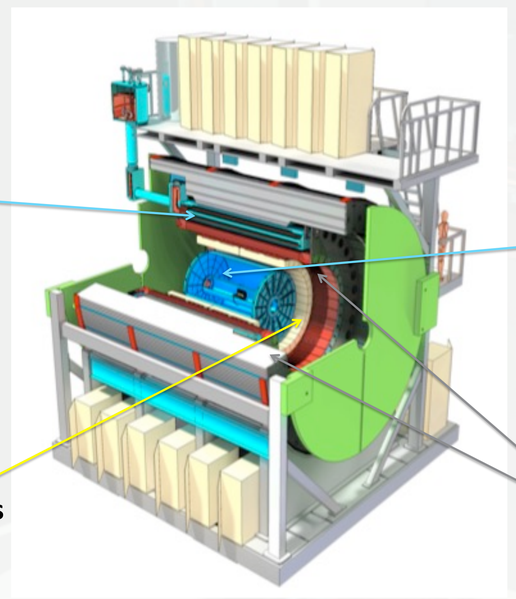


Large statistics

Requires momentum resolution of 1% at low z while 0.2% at high z along with uniform acceptance

Detector Overview

-1.1 < η < +1.1, ΔΦ= 2π, High rate DAQ , 15kHz



Babar solenoid, 1.5T

MAPS, silicon strip tracker and TPC for tracking charged particles.

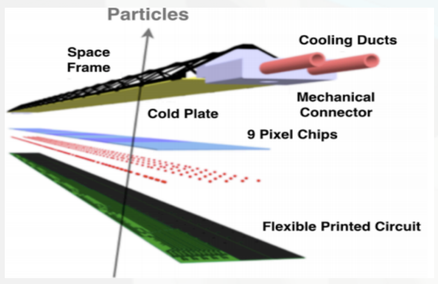
EMCal for measuring electrons and photons

Inner & Outer HCAL for jet measurement.

Charged Particle Tracking detectors

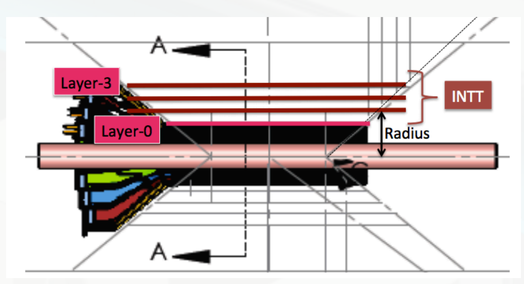
Requirements :
Excellent Momentum resolution , track pattern recognition , mass resolution < 100 MeV/c^2 and DCA resolution < 100 um

Inner pixel detector (MAPS)



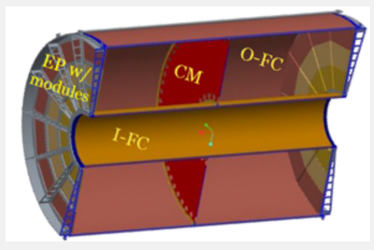
- 3-layers of pixel detector based on ALICE sensor technology
- -1.1 < η < +1.1, ΔΦ= 2π
- Precise vertex measurement and QGP b-jet Physics

Intermediate tracker (INTT)



- 4-layers of Silicon strips
- |η| < 1.1
- TPC/MAPS matching helping in Jet physics, upsilon measurement

Time Projection Chamber (TPC)

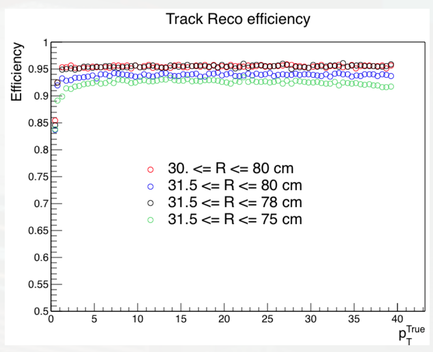


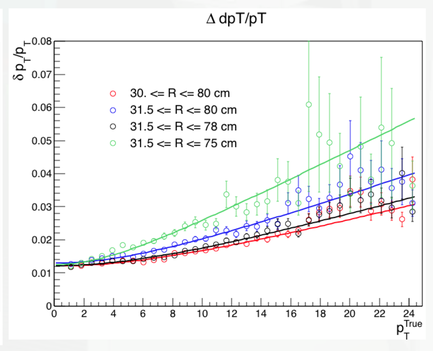
- Gaseous Electron multiplier (GEM) readout based gas detector.
- -1.1 < η < +1.1, ΔΦ= 2π, L = 211 cm, 30 < R < 75 cm
- Outer tracking detector providing good p_T resolution important for upsilon measurement

Mechanical design and R&D ref: Posters from Prakhar Garg and Nivedita Ramasubramaniam

Tracking performance studies

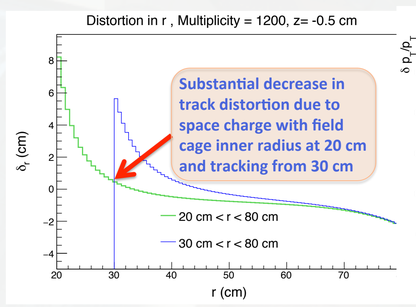
3 layers MAPS + 4 layers INTT + TPC (Effect of changing TPC readout dimension)

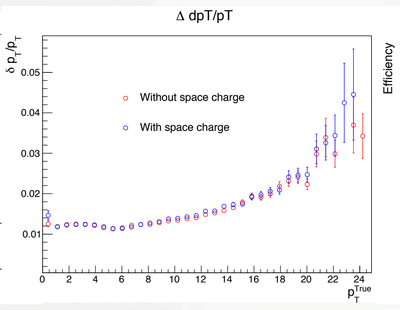


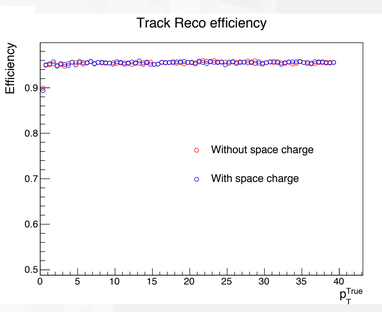


- **> 90% track reconstruction efficiency with change in TPC readout dimension**
- **p_T resolution < 1.2%, good enough to resolve three states of Y**

Effect of space charge in tracking performance

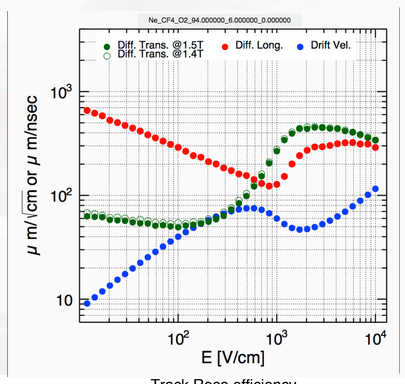


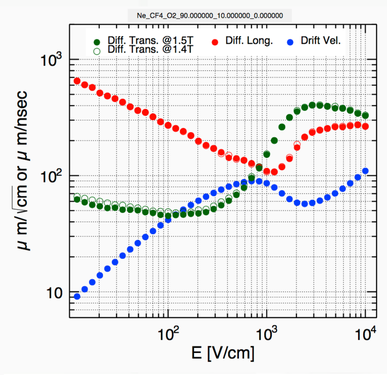




- Field cage at R = 20 cm and starting tracking from R = 30 cm reduces track distortion due to space charge by a factor 16. [ref: Poster from Carlos Eugenio Perez Lara]
- Space charge in TPC has almost no effect on p_T resolution and tracking efficiency.

Tracking performance using different gas in TPC

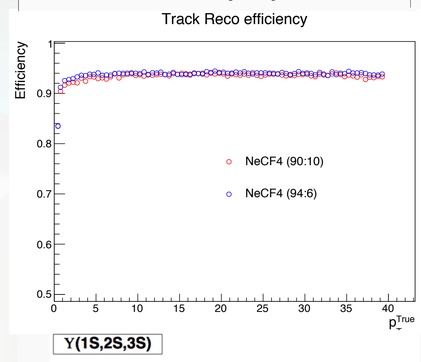


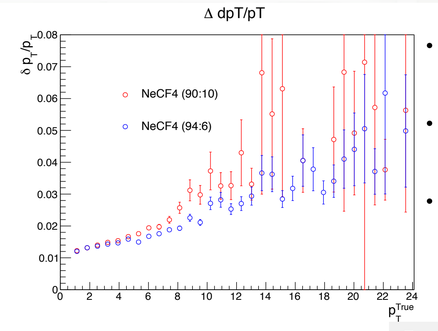


Simulation studies for TPC gases :

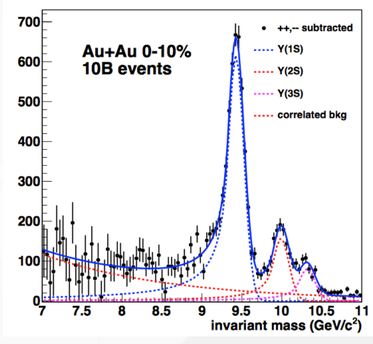
NeCF4(94:6)
Transverse diffusion = 80 um/sqrt(cm)
Longitudinal diffusion = 160 um/sqrt(cm)
Drift velocity = 70 um/nsec

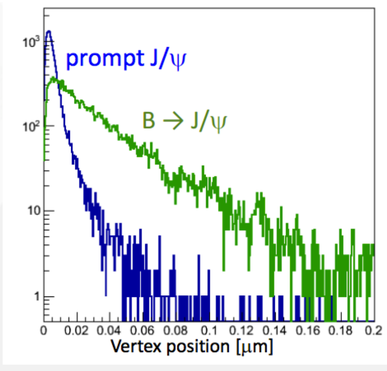
NeCF4(90:10)
Transverse diffusion = 64 um/sqrt(cm)
Longitudinal diffusion = 120 um/sqrt(cm)
Drift velocity = 80 um/nsec





- **Tracking efficiency for both NeCF4 , 90:10 AND 94:6 mixtures are almost the same**
- **p_T resolution for both gas mixtures are same upto p_T = 5 GeV**
- **NeCF4 (90:10) is considered to be better option for dE/dx measurement**





- **Excellent momentum resolution with current tracking configuration**
- **Well resolved upsilon states from Geant4 using TPC as sPHENIX tracking component**
- **Promising results in separating prompt and displaced J/Ψ**
- **sPHENIX tracking configuration with TPC is completely capable of delivering sPHENIX Physics goal**

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