Silicon detectors for high energy physics

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Contents

The new detector Heavy Flavor Tracker (HFT) for STAR:

- will improve measurements with heavy flavor hadrons for low p_T
- pixel part uses technology of CMOS monolithic APS
- **main purpose:** systematic study of QGP

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Heavy quarks in ultrarelativistic heavy-ion collisions:

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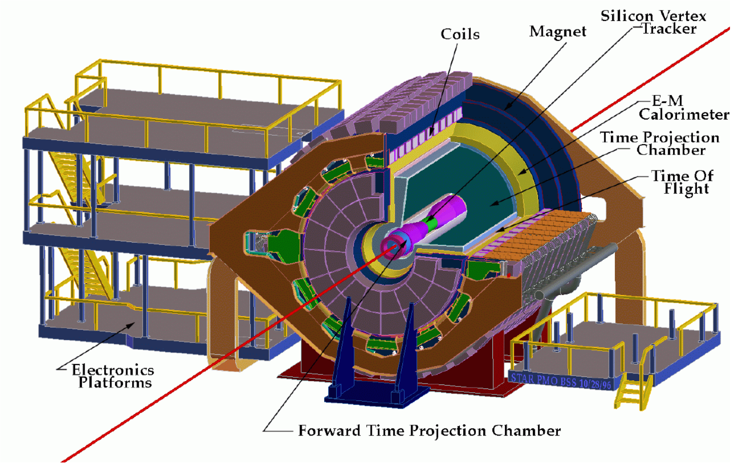
The purpose of the HFT:

- improve precision of measurements of these quantities

➔ do the direct topological reconstruction of heavy flavor hadrons

The STAR detector and the HFT



RHIC: collisions p+p, d+Au, Cu+Cu, Au+Au při $\sqrt{s_{NN}}$ = 20, 62, 130, 200 GeV

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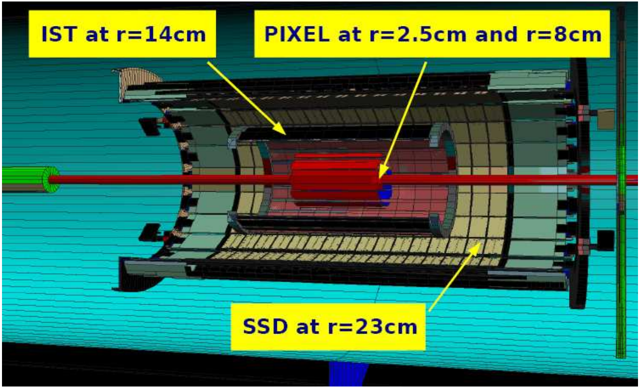

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Design of the HFT detector

Three detector subsystems of the HFT:

- Pixel detector (PXL), low mass monolithic APS,
  (2 layers, $r_1 = 2.5$ cm, $r_2 = 8$ cm)
- Intermediate STAR Tracker (IST), fast single-sided strip detector,
  (1 layer, $r = 14$ cm)
- Silicon Strip Detector (SSD), double-sided strip detector,
  (1 layer, $r = 23$ cm), (already fabricated)

These detectors along with the Time Projection Chamber (TPC) form the STAR inner tracking system

Simulations

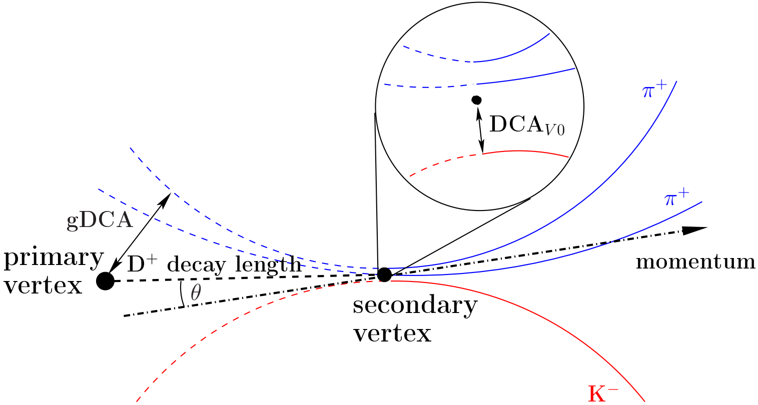
Properties of the simulated data

- 10 000 events
- collisions Au + Au at $\sqrt{s_{\mathrm{NN}}} = 200$ GeV (HIJING)
- 5 embedded D^+ with flat p_T spectra in each event
- latest STAR geometry with the HFT ("upgr15")

D^+ properties

- D^+ rest mass is 1869 MeV/c^2
- studied decay channel: $D^+ \to K^- + \pi^+ + \pi^+$
- B.R. = 9.51 %
- $c\tau = 312$ μm

D^+ decay and explanation of cut quantities

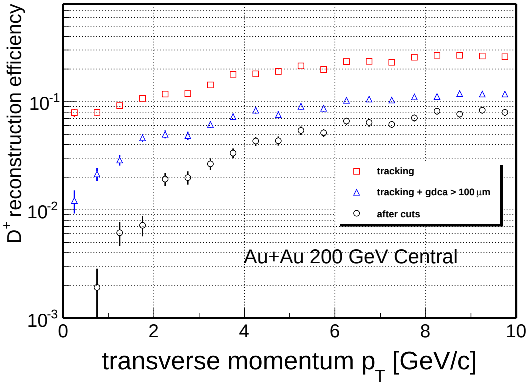


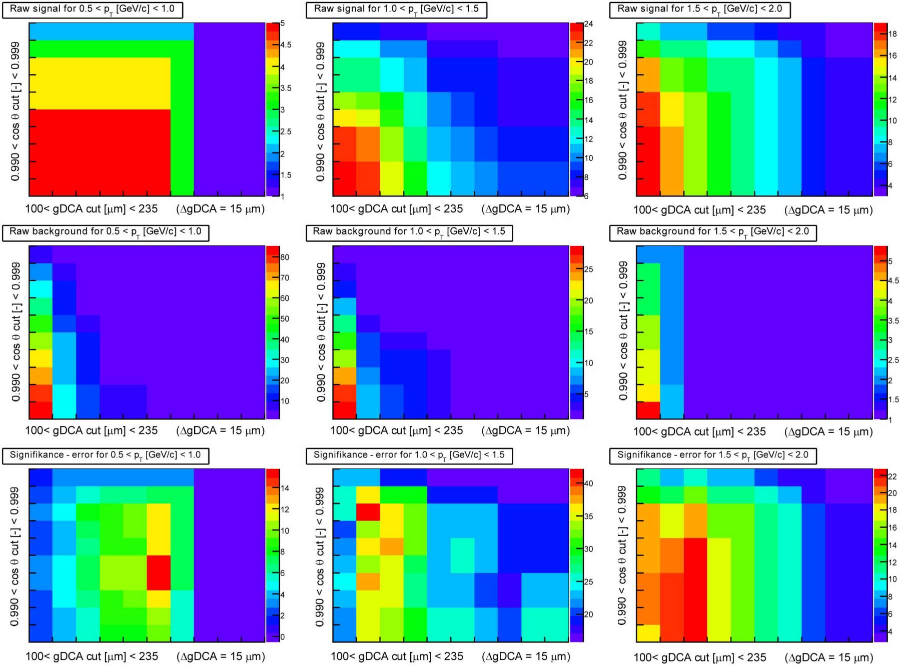
$$D^+ \rightarrow K^- + \pi^+ + \pi^+$$

D^+ reconstruction efficiency

In the plot used best significance cuts ($1.0 < p_T < 1.5$):

- $1819 < M_{inv} < 1919$ MeV/c^2
- gDCA > 115 µm
- $\cos\theta > 0.997$
- $DCA_{V0}/resolution < 2$




Raw signal for 0.5 < p_T [GeV/c] < 1.0
Raw signal for 1.0 < p_T [GeV/c] < 1.5
Raw signal for 1.5 < p_T [GeV/c] < 2.0
Raw background for 0.5 < p_T [GeV/c] < 1.0
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Signifikance - error for 0.5 < p_T [GeV/c] < 1.0
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0.990 < cos θ cut [-] < 0.999
100< gDCA cut [μm] < 235 (ΔgDCA = 15 μm)

Summary and Conclusions

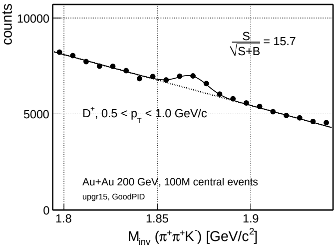
- HFT uses low mass APS, single- and double-sided strip detectors
- HFT will extend STAR measurement capabilities:
    - partonic energy loss
    - charm collectivity

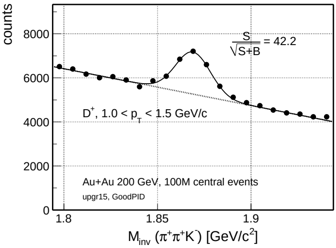
➔ systematic study of QGP at RHIC-II luminosity

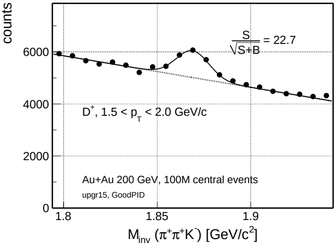
p_T [GeV/c]	signal significance
0.5 - 1.0	15.7
1.0 - 1.5	42.2
1.5 - 2.0	22.7

Expected D^+ signal significance for 100 M central $Au + Au$ events at $\sqrt{s_{NN}} = 200$ GeV

Expected D^+ signal for 100 M central $Au + Au$ collisions at $\sqrt{s_{NN}} = 200$ GeV







Silicon photomultipliers (SiPM)

Introduction

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- single photon detection capability

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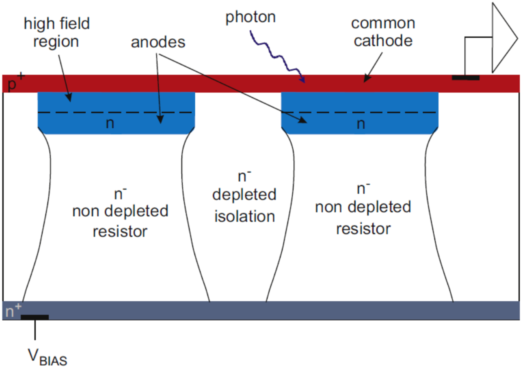
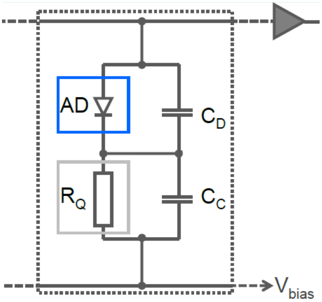
- consist of an array of avalanche photodiodes (APD) connected in parallel
- operation in Geiger mode $\Rightarrow$ binary detector

Architecture and operation

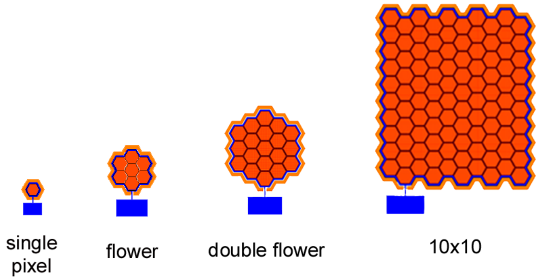




SiPM testing

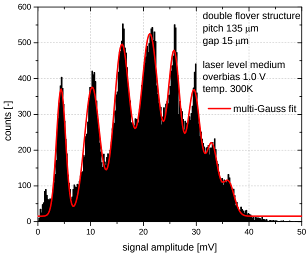
In Max Planck Institut for Physics (MPI) in Munich

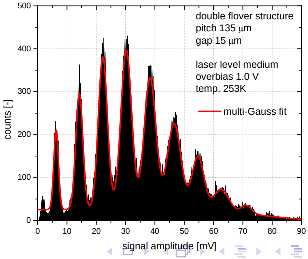
- samples of second development series built in MPI
- detectors with bulk integrated quenching resistor
- checking of basic characteristics
- measurement of response to 800 nm laser illumination



Measurement results

- check measurements showed proper operation of the SiPM samples
- better results for cooled down devices, for larger arrays cooling necessary
- for “double flower” obtained encouraging results concerning possibility of single photon detection





Overall summary

STAR Heavy Flavor Tracker - D^+ meson simulation

- obtained excellent results for direct topological reconstruction of D^+ at low p_T (signal significance $\sim$ 20)
- the results show capability of the new STAR upgrade of improving charm measurement precision

Silicon photomultipliers

- check measurements successfully done
- obtained encouraging results concerning possibility of single photon detection