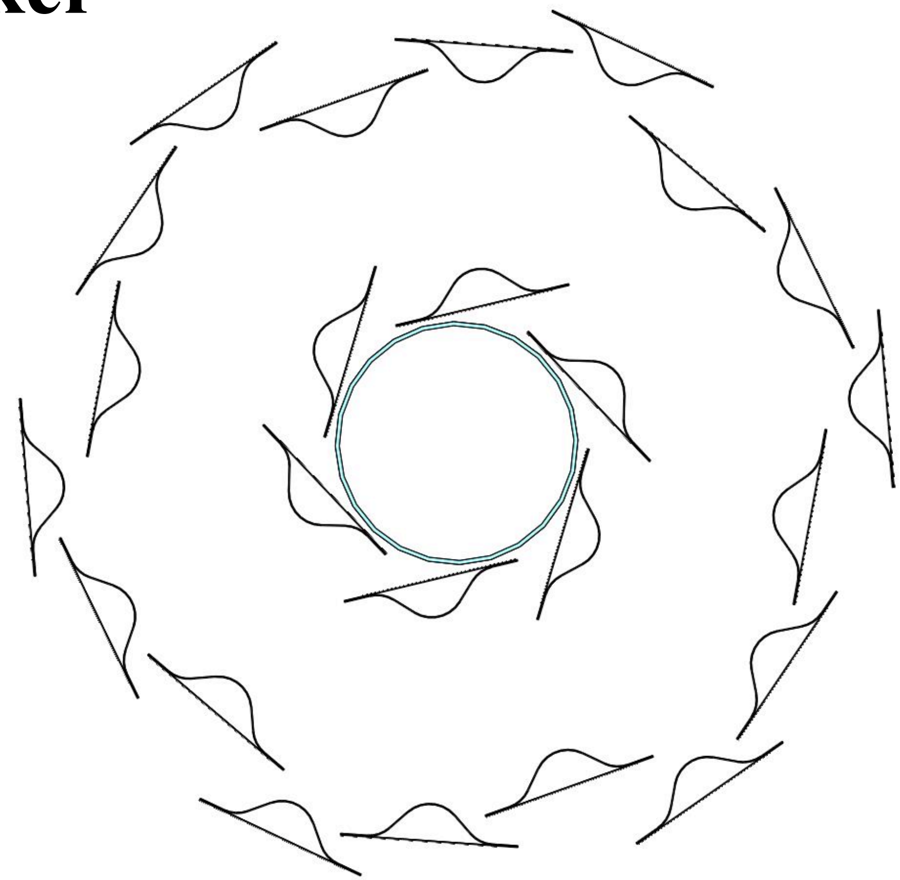
Heavy Flavor Tracker Performance



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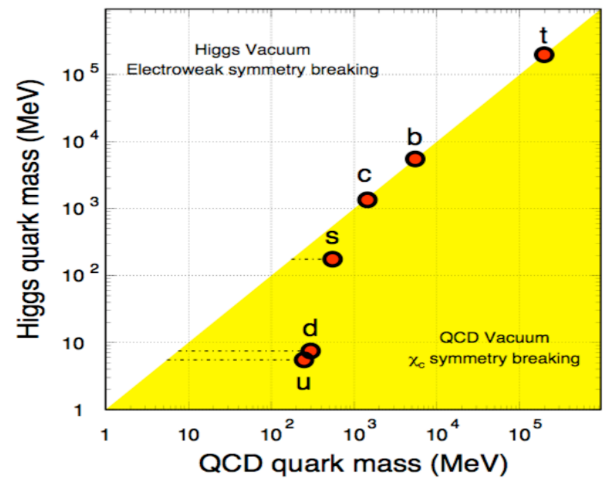
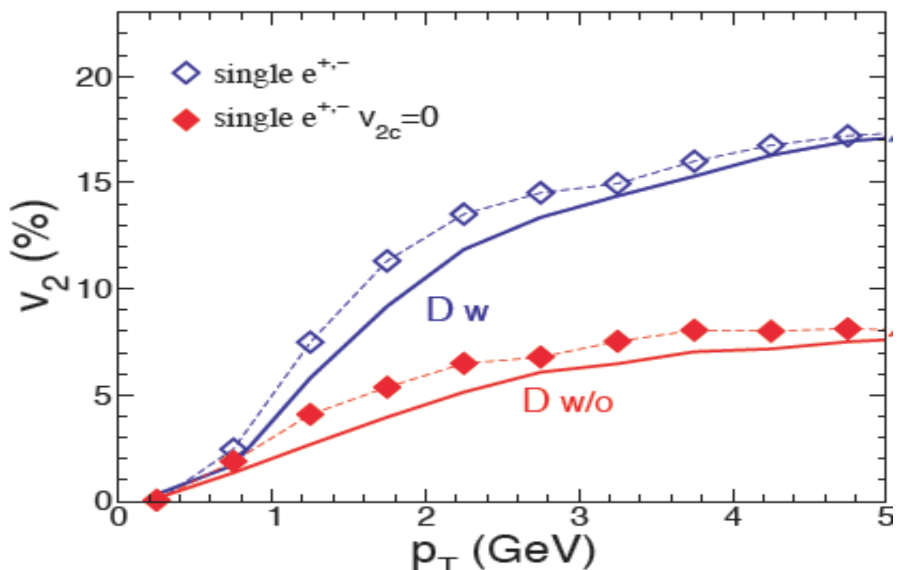
Introduction

- HFT Design and Structure
- Event Reconstruction
- Vertex Reconstruction
- Charm Hadron Analysis
- Conclusions

Charm at RHIC

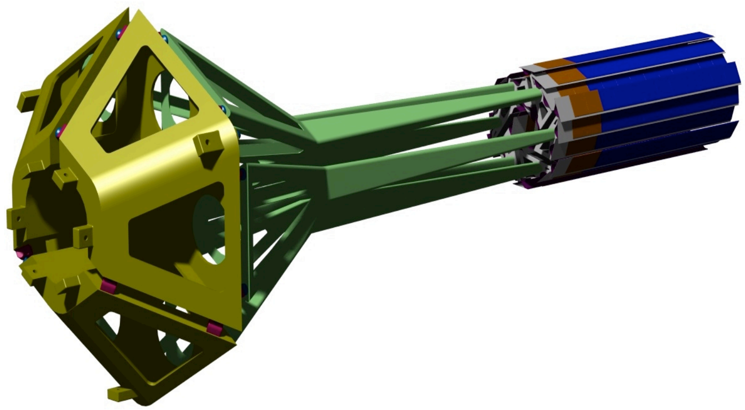
- Charm Quarks primarily created *early* in collision
- The Charm Quark keeps most mass - light quarks don't
- Flow of charm would indicate significant rescattering - more so for light quarks
- Measurement at *low* p_t - where hydrodynamics holds



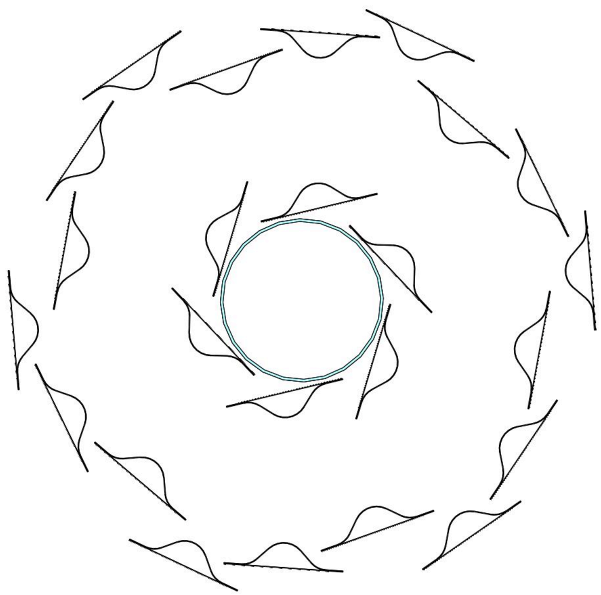


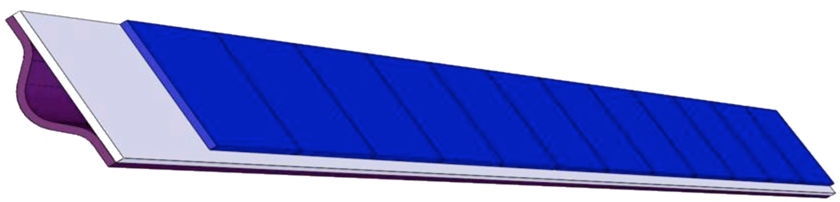
V. Greco, C.M. Ko, nucl-th/0405040

STAR and the HFT



- Low mass design
- Close as possible to interaction





24 ladders of 1x10 CMOS Detectors

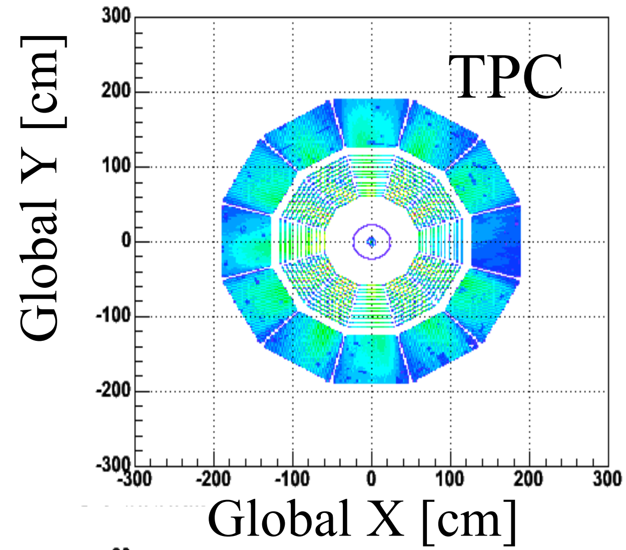
Simulation Configurations

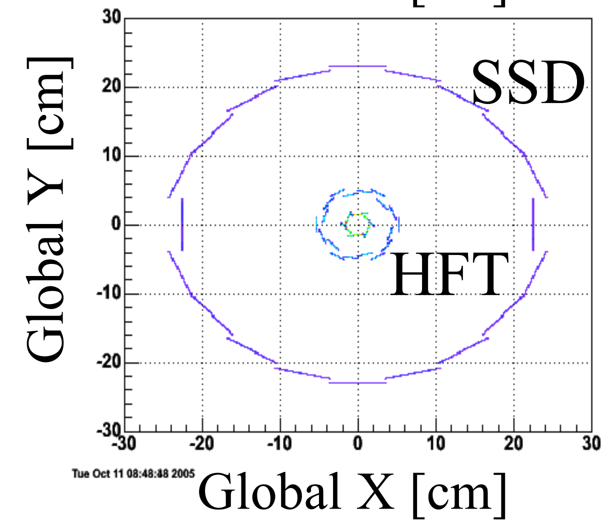
- TPC+SSD+HFT
  - Protoype detector configuration
  - Simulation reconstruction requires some modifications to current STAR software
- TPC+SSD+(Svt-1)+HFT
  - Simulations use the outer two layers of the SVT as a placeholder for the IST
- TPC+SSD+IST+HFT
  - Newly available to simulation

HFT Design and Simulation

- Use STAR simulation environment
  - Realistic simulation of TPC dead areas and performance
  - SSD and HFT "idealized" with design performance accuracy, perfect cluster finding
- Simplifying geometric assumptions
  - Electronics and ladder as "extra" silicon
  - Support structure not present

Reconstructed Hits





Detector Occupancies

Occupancy Background Contribution: Prototype Configuration

	HFT Outer Layer	HFT Inner Layer
Radius	5.0 cm	1.5 cm
Hit Flux	5600 Hz/cm^2	28,750 Hz/cm^2
Hit Density 4 ms Integration	22.5/cm^2	115/cm^2
Projected Tracking Window Area	0.6 mm^2	0.15 mm^2
HFT Hit Resolving Area	0.001 mm^2	0.001 mm^2
Probability of HFT Pileup	0.3%	1%

Occupancy Same Event Contribution

	HFT Outer Layer	HFT Inner Layer
Radius	5.0 cm	1.5 cm
Hit Density Au + Au Central Collision	1.8/cm^2	7.4/cm^2
Projected Tracking Window Area	0.6 mm^2	0.15 mm^2
HFT Hit Resolving Area	0.001 mm^2	0.001 mm^2
Probability of HFT Pileup	0.02%	0.09%

Detector Occupancies

Full, Fast detector a factor of 20 faster than prototype

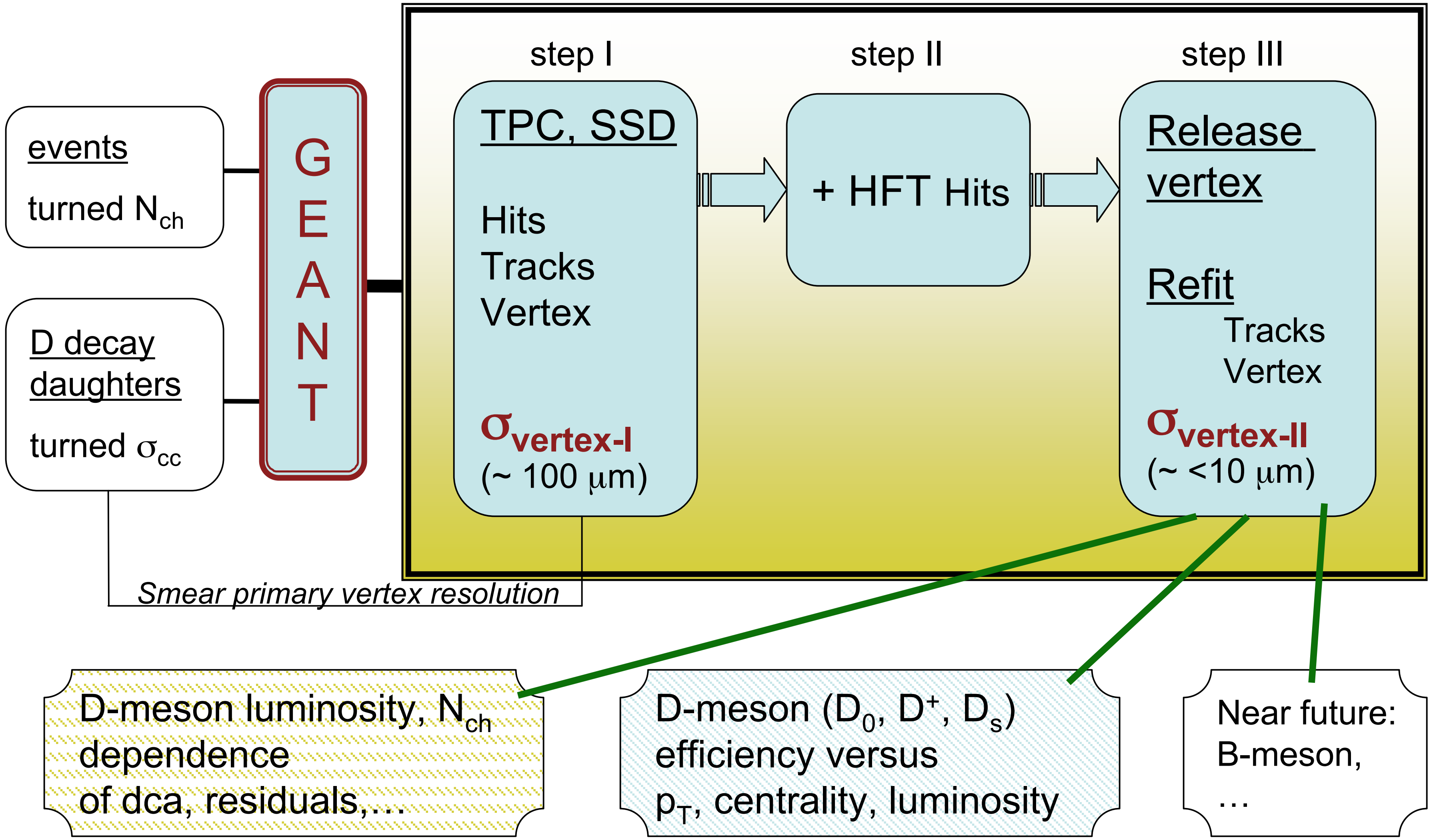
Occupancy Background Contribution

	HFT Outer Layer	HFT Inner Layer
Radius	5.0 cm	1.5 cm
Hit Flux	280 Hz/cm^2	1437.5 Hz/cm^2
Hit Density 200μs Integration	1.1/cm^2	5.8/cm^2
Projected Tracking Window Area	0.6 mm^2	0.15 mm^2
HFT Hit Resolving Area	0.001 mm^2	0.001 mm^2
Probability of HFT Pileup	0.015%	.05%

Occupancy Same Event Contribution

	HFT Outer Layer	HFT Inner Layer
Radius	5.0 cm	1.5 cm
Hit Density Au + Au Central Collision	1.8/cm^2	7.4/cm^2
Projected Tracking Window Area	0.6 mm^2	0.15 mm^2
HFT Hit Resolving Area	0.001 mm^2	0.001 mm^2
Probability of HFT Pileup	0.02%	0.09%

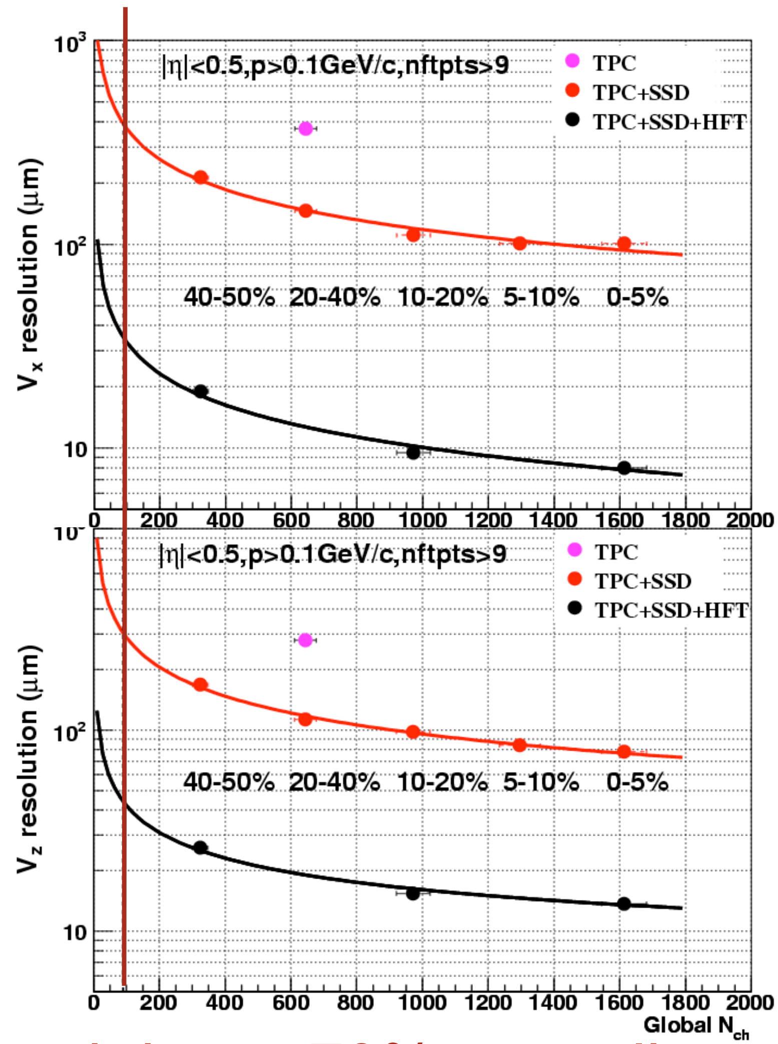
Event Reconstruction (Prototype)



Vertex Resolution Results

- Prototype Configuration Vertex Resolution
  - TPC+SSD+HFT
  - Final resolution ~ 8μm in x,y
  - Order of magnitude improvement

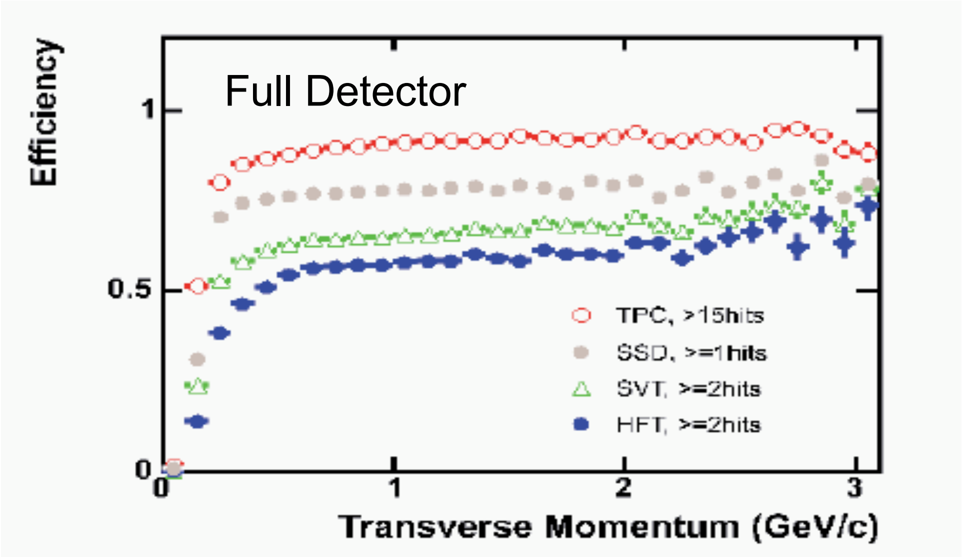
- TPC+SSD Vertex Resolution sets minimum multiplicity for tracking with prototype

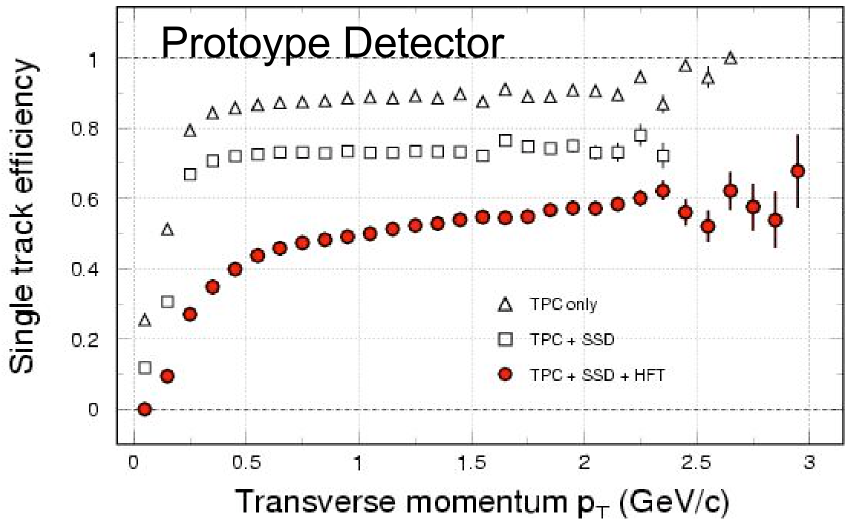


Vertex Constraint Breakdown: 70% centrality

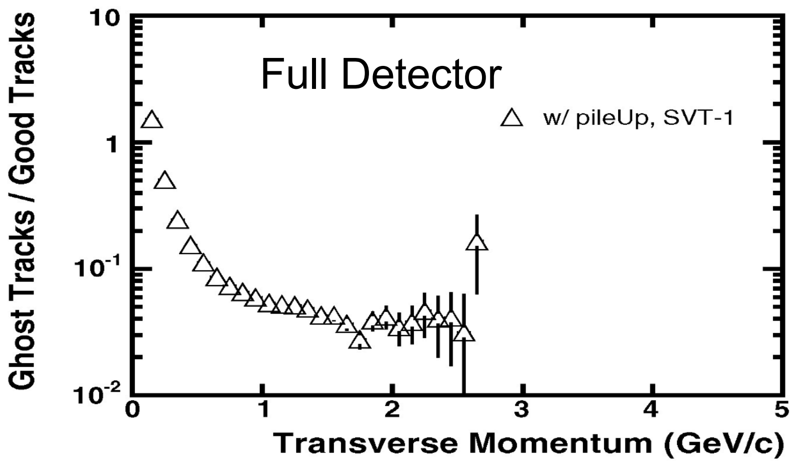
Performance

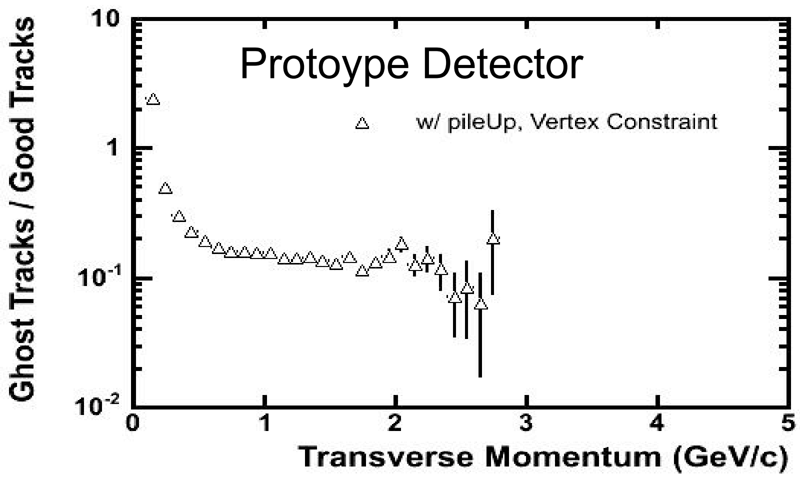
- Full detector efficiency
  - TPC+SSD+SVT-1+HFT
  - ~56%-60%, .7 GeV/c < pt< 3. GeV/c
- Prototype efficiency
  - Vertex Constraint
  - TPC+SSD+HFT
  - 45%-60% in same range
- All efficiencies quoted as absolute efficiency
  - Candidate tracks for the HFT have TPC and Ssd efficiency folded in





Performance - Ghosting





- Impure tracks: 1 or more incorrect HFT hit
- 4% for full detector, 14% for the prototype configuration

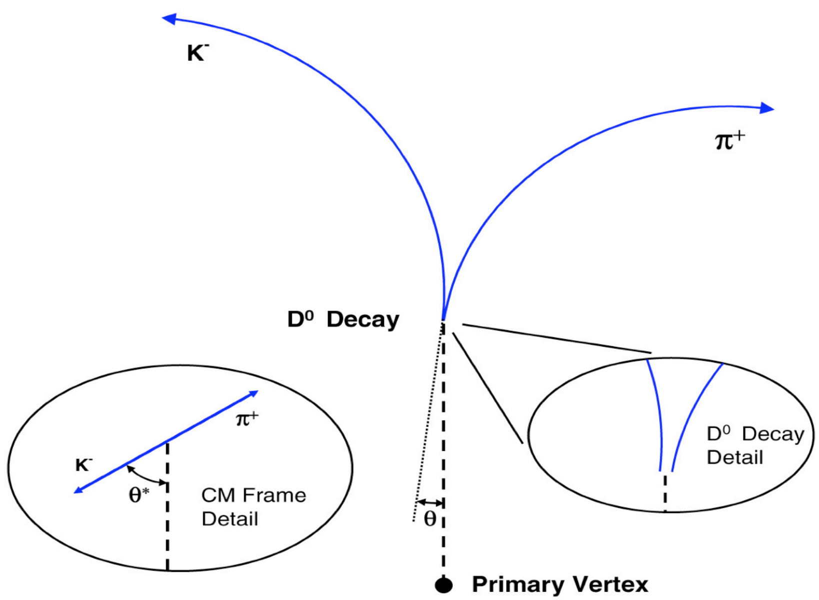
Charm Hadrons

Need to reconstruct 2 and 3 body decays

Excellent track pointing to resolve secondary vertex

particle	daughters	$c\tau$ (μm)	Mass (GeV)
D^0	$K^-\pi^+$ (3.8%)	123	1.8646
$D^\pm$	$K^-\pi^+\pi^+$ (9.2%)	312	1.8694
D_s	$K^+K^-\pi^+$ (4.4%) $\pi^+\pi^+\pi^-$ (1.0%)	147	1.9683
Λ_c	$p K^-\pi^+$ (5.0%)	59.9	2.2849

Charm Reconstruction and Analysis

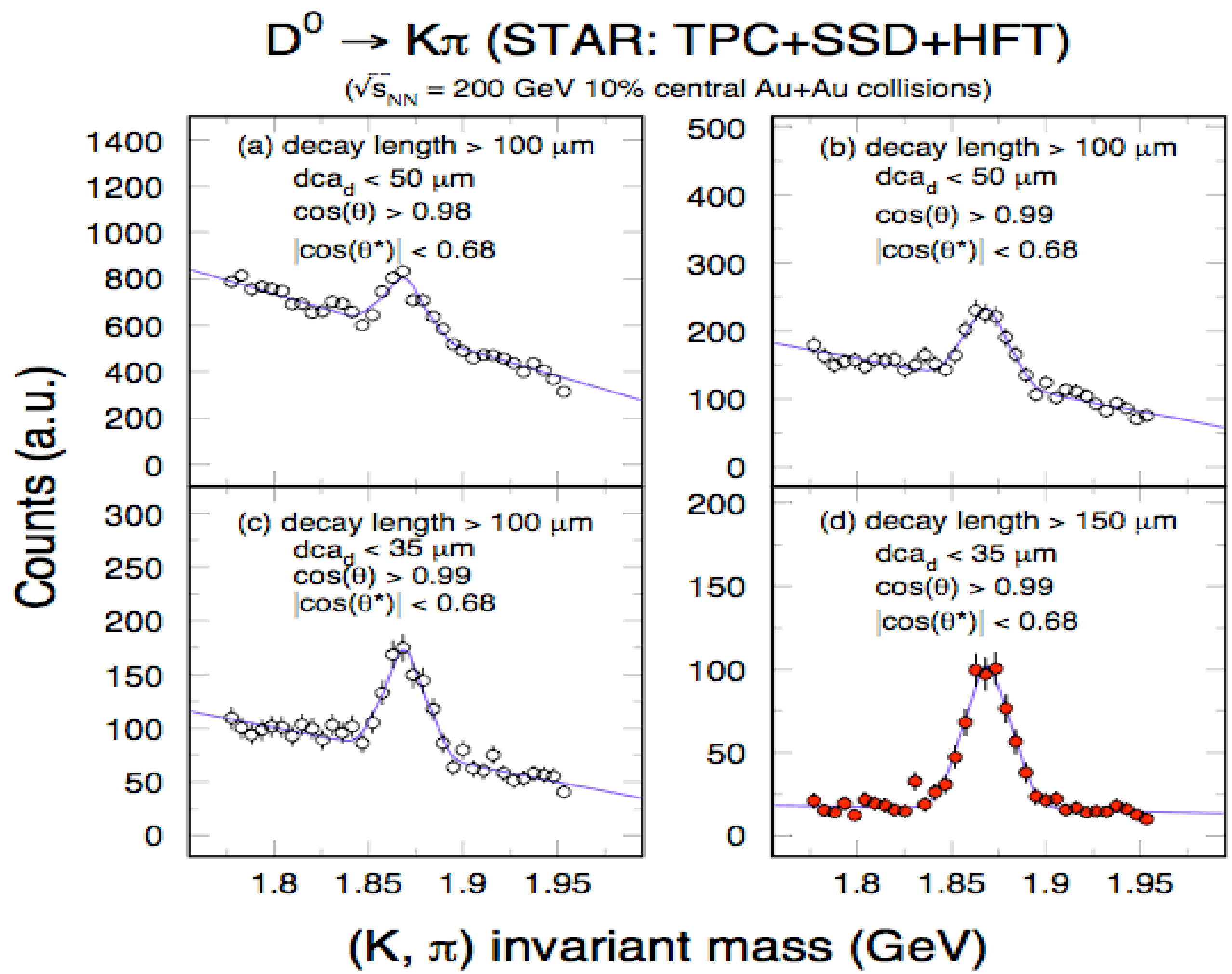


Direct reconstruction of Charm hadrons - only experiment to do this at RHIC

Cuts

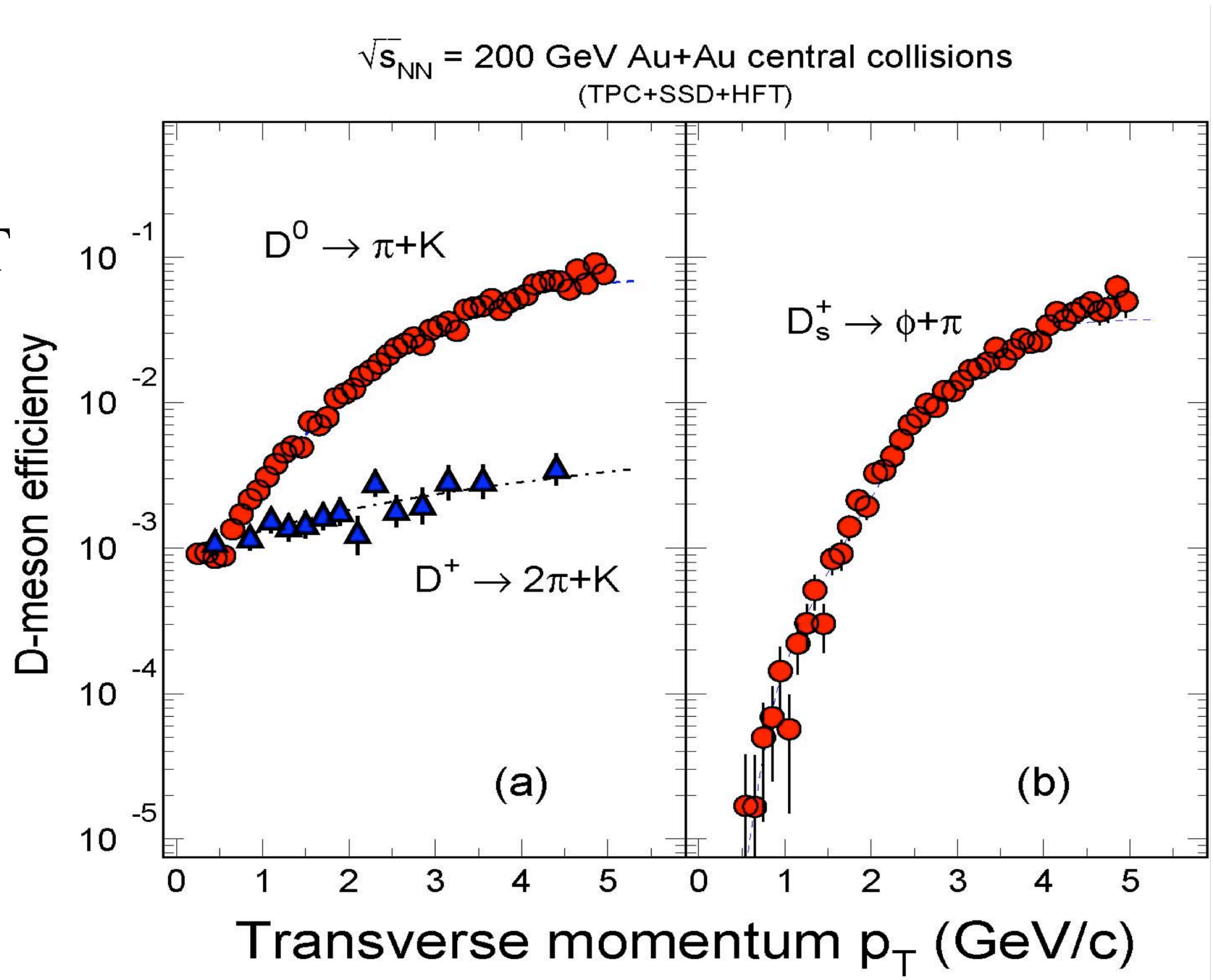
	D_0	D_+
Hits (TPC)	≥15	≥15
Hits (HFT)	≥2	≥2
$\|\eta\|$	<1	<1
DCA		>100μm
Decay Length	>150 μm	>150μm
DCA (V_0)	>35μm	>100μm
cos(θ)	.996	

Analysis Cut Studies

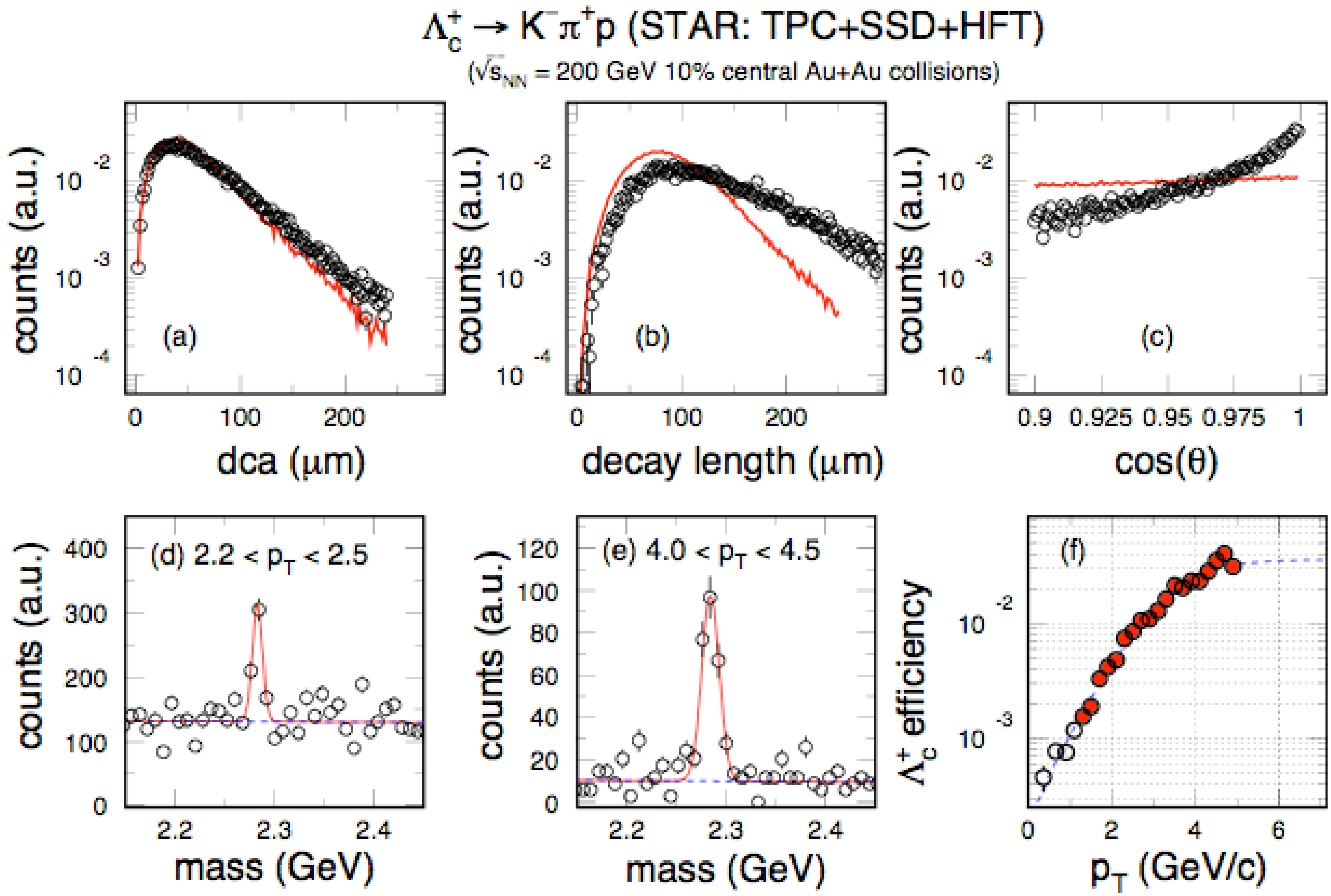


Charm Meson Efficiencies

- Prototype configuration
  - TPC+SSD+HFT
  - Vertex Constraint
- D_0, D_s^+, D^+ studied
- Significant Efficiencies



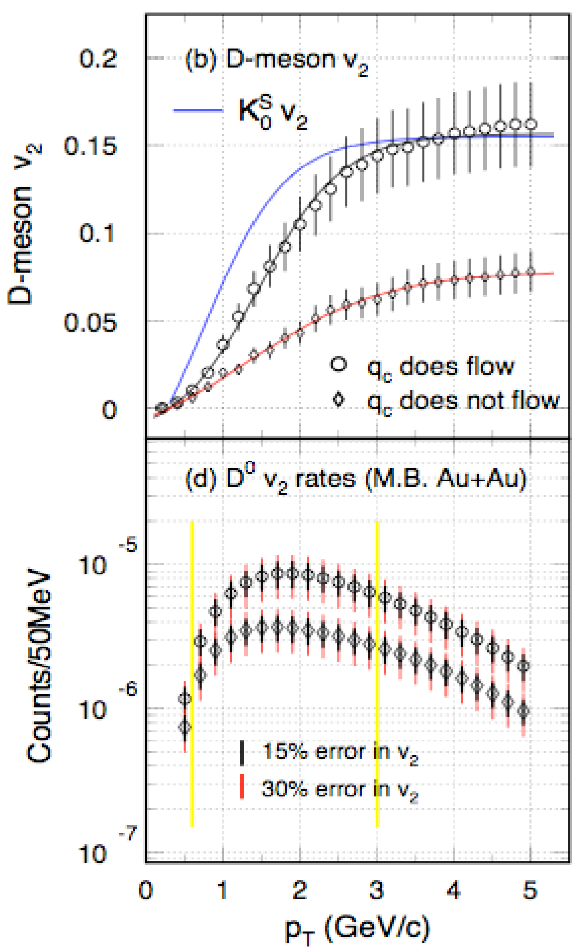
Charm Baryons: Λ_C



Flow Measurement Assumptions

- Luminosity: $1x10^{27}$
- D0 integrated yield dN/dy = 0.03, as measured in p + p collisions at 200 GeV
- Require better than 10% statistical errors for collective flow measurements
- Charm-hadron spectra information is from Pythia calculations
- Assume full multiplicity coverage (intermediate tracker)

Rate Estimates



Rates for Spectra:

p_T (GeV/c)	Δp_T (GeV/c)	# of Events (p + p)	# of Events 0-10% Au + Au (N_{bin} = 950)	# of Events 0-80% Au + Au (N_{bin} = 290)
1.0	0.5	44×10^6	0.45×10^6	1.75×10^6
2.0	0.5	70×10^6	0.45×10^6	1.75×10^6
3.5	1.0	70×10^6	0.45×10^6	1.75×10^6
5.5	1.0	350×10^6	0.75×10^6	3×10^6
7.5	1.0	1200×10^6	3.5×10^6	11×10^6
10.5	1.5	7500×10^6	9×10^6	30×10^6

Rates for Flow:

p_T (GeV/c)	Δp_T (GeV/c)	# of Events q_c does flow	# of Events q_c does not flow
0.6	0.2	260×10^6	525×10^6
1.0	0.5	70×10^6	140×10^6
2.0	0.5	53×10^6	125×10^6
3.0	1.0	105×10^6	175×10^6
5.0	1.0	210×10^6	440×10^6

Conclusions

- Direct Charm Hadron reconstruction is possible with a low mass detector very close to the interaction region
- HFT will allow unambiguous measurement of charm yields and flow at RHIC
- Prototype can address medium thermalization
- With the IST, will enhance our measurements in peripheral Au+Au collisions and charm-hadron spectrum in p+p collisions