Open charm simulations with the HFT.

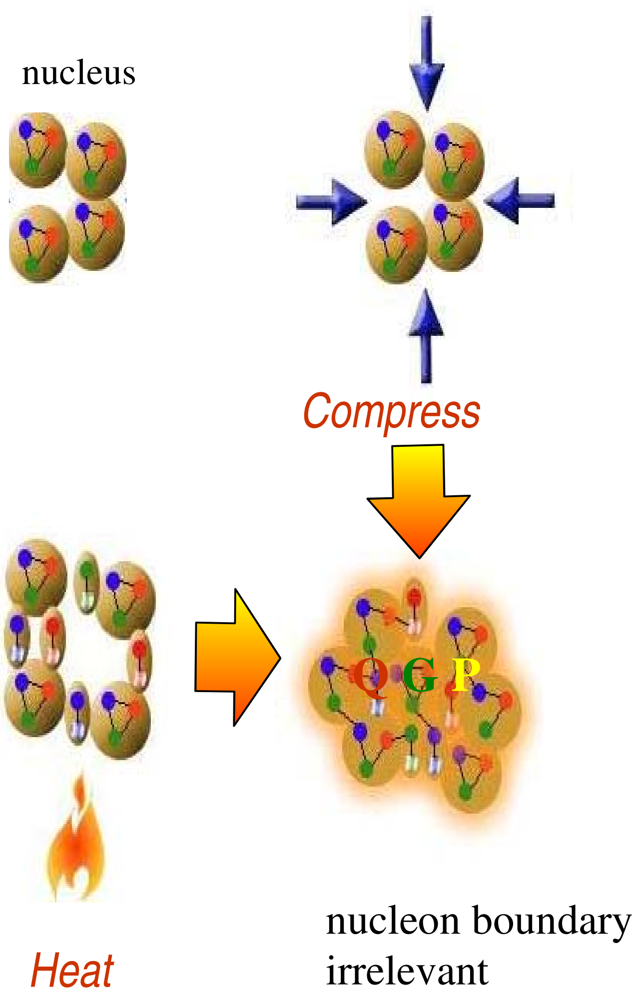
(Update)

Alexandre SHABETAI

Outline

- Physics Motivations
- Is the HFT usefull for reconstuction?
- Where is it in Star
- TOOLS :
  - Minuit
  - Neural Net
- Resilts
  - Number of events for 3 sigma vs. Position Resolution and thickness
  - Performences
  - Efficiency Study
  - Elliptic Flow
- Conclusion

Physics motivations



J.C. Collins and M.J. Perry, Phys. Rev. Lett. 34 (1975) 1353.

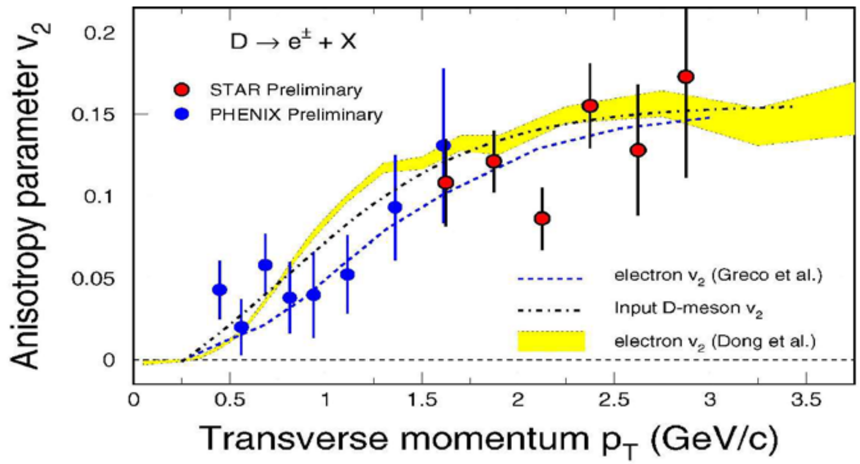
Quark Gluon Plasma: **Deconfined** and **thermalized** state of quarks and gluons

- ❖ Equilibration: hadron yields
- ❖ Partonic Collectivity: Spectra of multi-strange baryons at **low pt**
- ❖ Thermalization:

If heavy quarks flow:

→ **frequent interactions** among all quarks

→ **light quarks** (u,d,s) likely to be **thermalized**



→ large stat. and syst. uncertainties

→ *Need **direct** open charm **reconstruction** !*

Introduction

The HFT is The Heavy-Flavor Tracker.

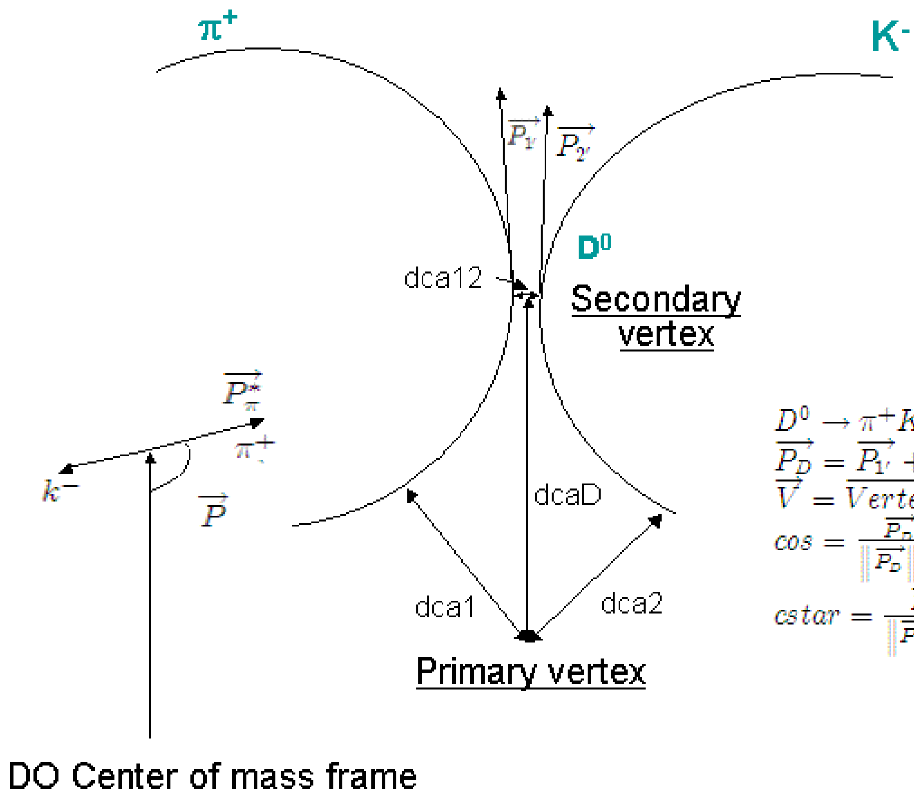
Main purpose : Charm and Beauty studies

To estimate the physics preformences of the HFT some simulations have been done.

- D⁰ study : $D^0 \rightarrow \pi^+ K^-$: Number of events for 3 sigmas + Efficiency + flow study
- D_s^+ study : $D_s^+ \rightarrow \phi \pi^+$: Number of events for 3 sigmas + Efficiency study
- D^+ study : $D_s^+ \rightarrow K^+K^-\pi^+$: is coming

Reconstruction

Reconstruction of D^0 --> π+ K^-



$$D^0 \rightarrow \pi^+ K^- : \quad c\tau = 124.4\ \mu m$$

$$\vec{P_D} = \vec{P_{1'}} + \vec{P_{2'}}$$

$$\vec{V} = \overrightarrow{Vertex2} - \overrightarrow{VertexP}$$

$$cos = \frac{\vec{P_D} \cdot \vec{V}}{\|\vec{P_D}\| \|\vec{V}\|}$$

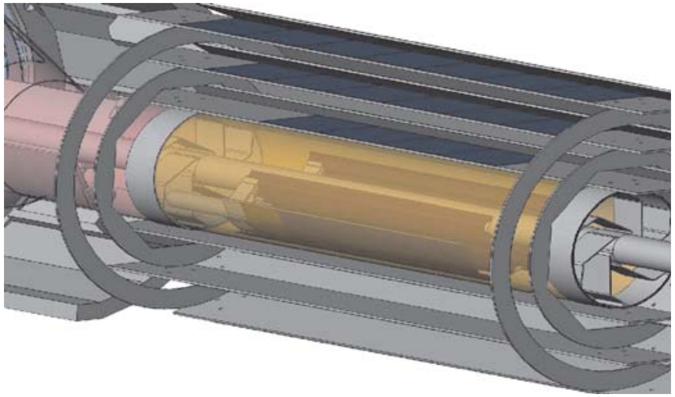
$$cstar = \frac{\vec{P^*_\pi} \cdot \vec{P}}{\|\vec{P^*_\pi}\| \|\vec{P}\|}$$

D0 5 variables

Ds / D+ 9 variables

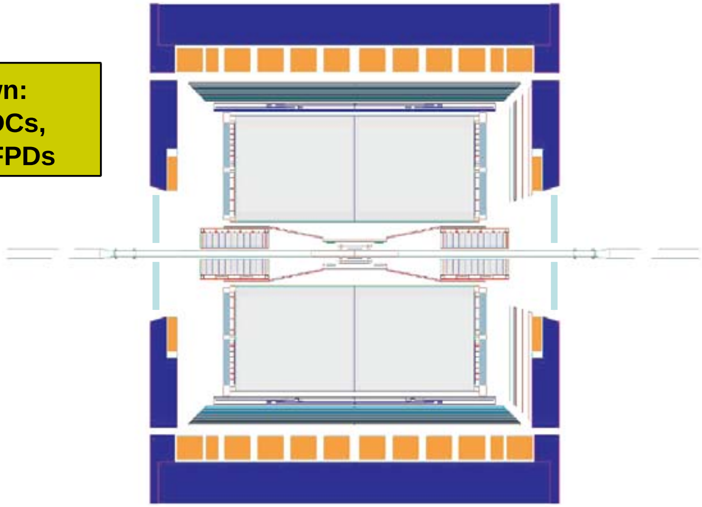
We can't reconstruct the vertex with the the current STAR apparatus !

The detector

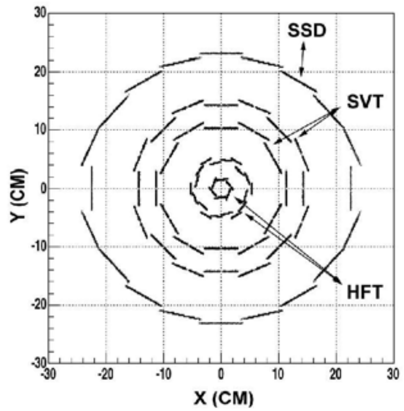


The HFT in STAR

Not Shown: pVPDs, ZDCs, PMD, and FPDs



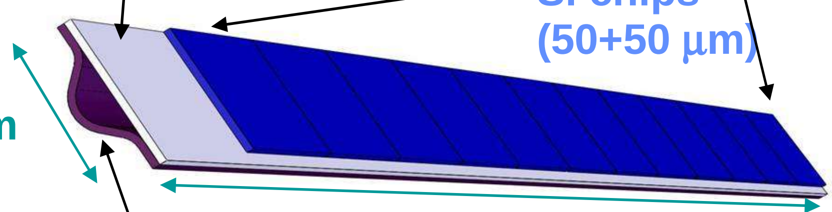
The STAR detector at RHIC.



- •2 layers
  1.6 cm and 4.8 cm of radius
- •24 ladders
  -2 cm x 20 cm each

CMOS censors because we want :

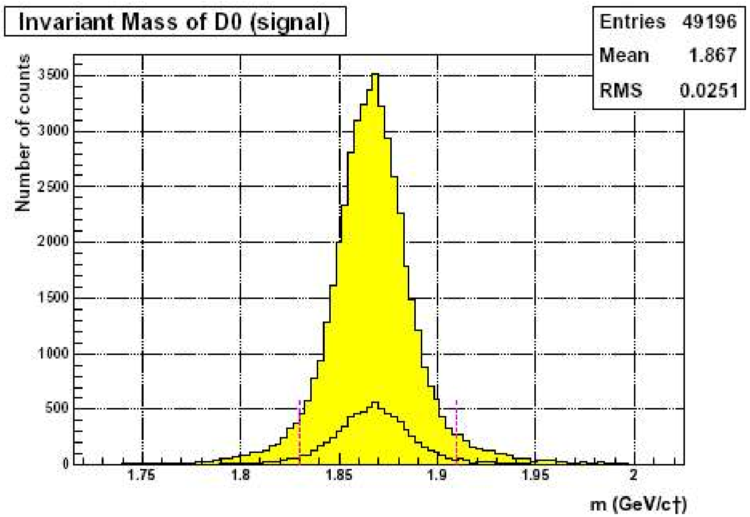
- a high **Precision** (resiotion : a few µm)
- a **thin detecor**
- a **fast detector**
- a low power consumption
- low radiation sensitivity



→ thickness = 360 µm and PR = 6 µm

Simulation

- Signal : exp(-pT²/T) with T = 1.3 GeV
- Background : (MEVSIM) are in diferent files.
  - Central events used
- D°
  - NSigEvents : 1.5 M events
  - NbackEvents w/o Event Mixing : 11 k



Cuts

D0 : cuts for Svt-1 and Svt-Out configuration

Cuts	Value
Decay length l	> 150 µm
Δm	± 40 MeV/c^2
$DCA_{\pi K}$	< 35 µm
cos(θ)	θ < 5.0 °

Tools

There are lots of variable to study :
A Multi-variable method is needed!

Neural Networks and Minuit are using relations between variables

→Results are expected to be better than using a classical method

Minuit

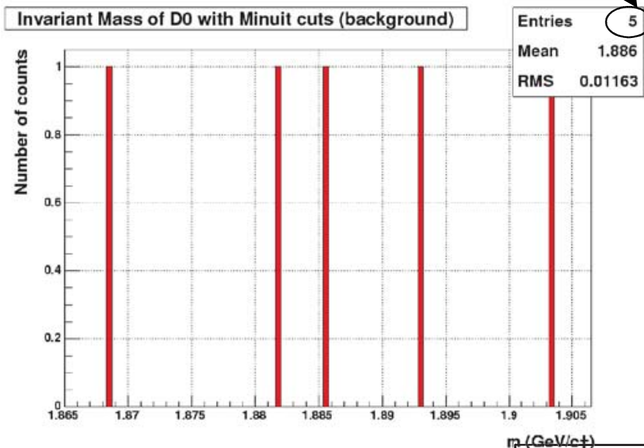
Maximize the Significance →

Minimize $N = 3^2 * (S+B) / S^2$

Less background,
But sometimes it goes to 0!

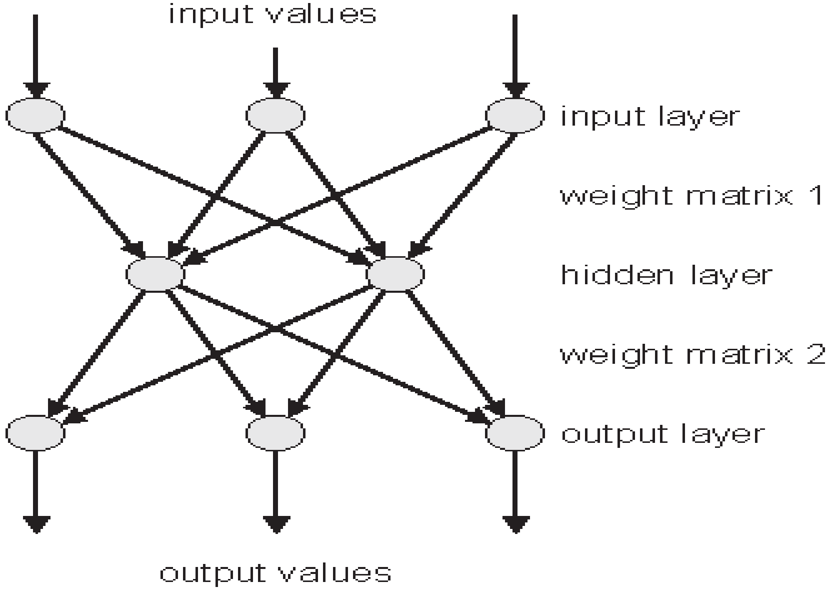
n)	n)	dca12 (cm)	dcad (cm)	cos	c*	Inv Mass Min (Gev)	Inv Mass Max (GeV)	nts)
3	80	0.002592	0.011811	0.996943	0.854565	1.772301	1.96769	11853
6	80	0.007934	0.015779	0.999457	0.888059	1.222892	2.517108	12346
18	80	53	0.019841	0.991872	0.802094	1.827590	1.912410	83509

Event Mixing is used
to get more statistics



Neural Netork : Why? How? What to expect?

What's a Neural Networks ?



Input:
m , dca12, dcaD,c*
and cos

How to use it :

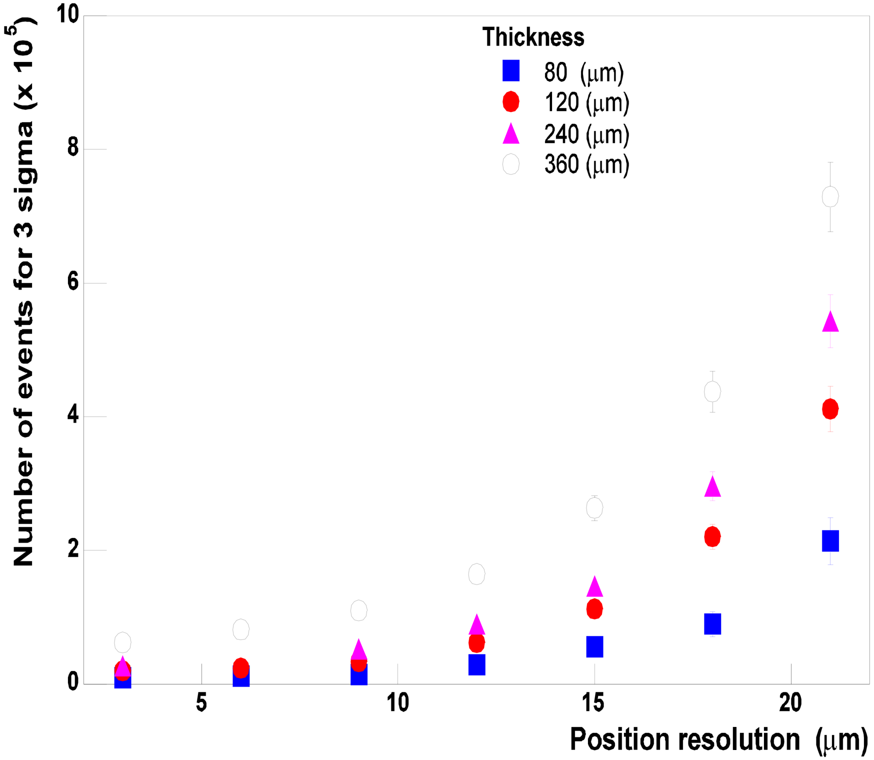
It takes a TTree as input (merges signal and background)
You can set weights manually (I did not).
Set the number of **hidden neurons (12 in 1 layer)**
Set 2 EventLists : training and test

Output :
- signal (0)
- background (1)

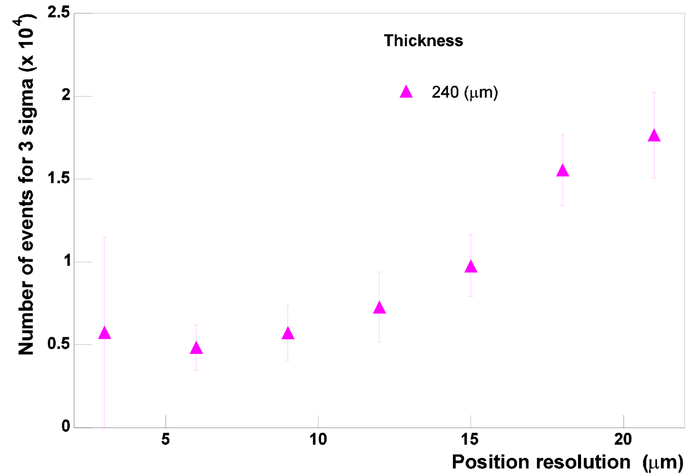
Results

Number of events v.s Position resolution and thickness

D° Manual cuts – With perfect PID (TOF) (Old)



D° Minuit ITTF – With perfect PID (TOF)



Thickness

- Position resolution:

1 to 10 μm is OK

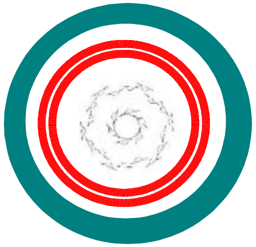
- Thin detector

Position resolution

Performances

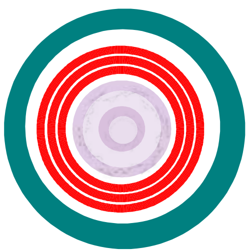
Sub detectors	D^0 N evt for 3 σ	D^+_s N evt for 3 σ (SVT-1 config.)
TPC+SVT	12.6 M	500 M ($K^0_s + K^+$)
TPC+SVT+TOF	2.6 M	100M
TPC+SVT+HFT (PR = 6 μm thickness = 240 μm)	1O0k (manual) 8 k Minuit	1.5 M Manual ($\phi+\pi^+$) eff. 2 10^{-5}
TPC+SVT+HFT + Perfect Pid (TOF) (PR = 6 μm)	Manual: 80k now Minuit 5 k (thickness = 360 μm)	Manual 7.7M Minuit 800 k ($\phi+\pi^+$) (thickness = 360 μm)

Acceptance*Efficiency/BR



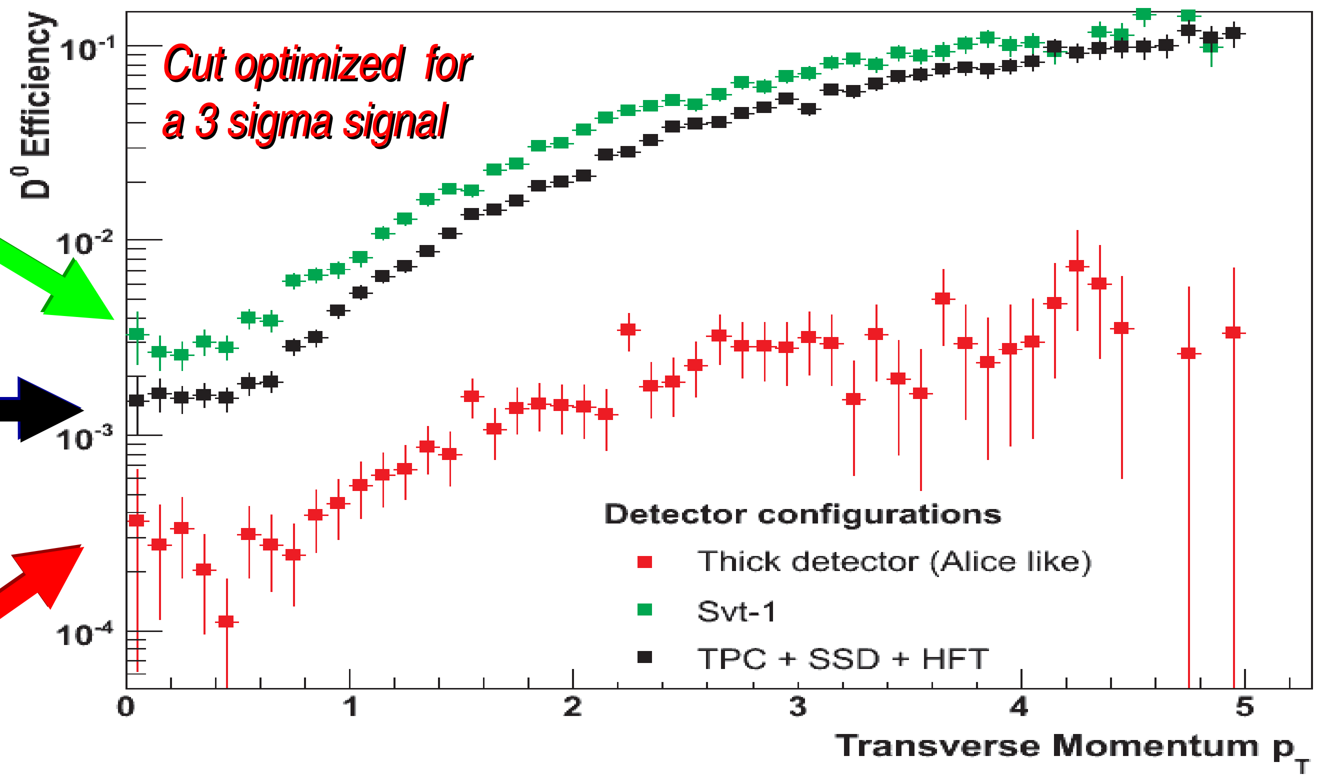
1. Remove inner layer of SVT

2 TPC + SSD + HFT



3. Thicken HFT layers to 1000 m, simulating conditions in the ALICE detector

3 Detector Configurations studied



Efficiency small at low momentum:

•Decay length cut > 150 μm

•Increases with pT and then saturate

ALICE config : Efficiency drops by factor 8!

Elliptic Flow

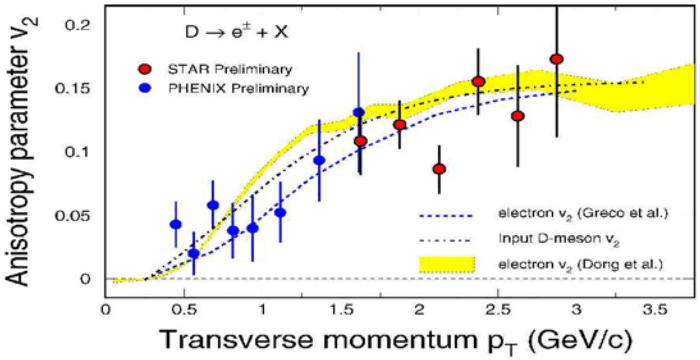
Au + Au, 50M central events

D0 → π+ K^-

Stat. uncertainties small

→ Probe charm quark

With HFT



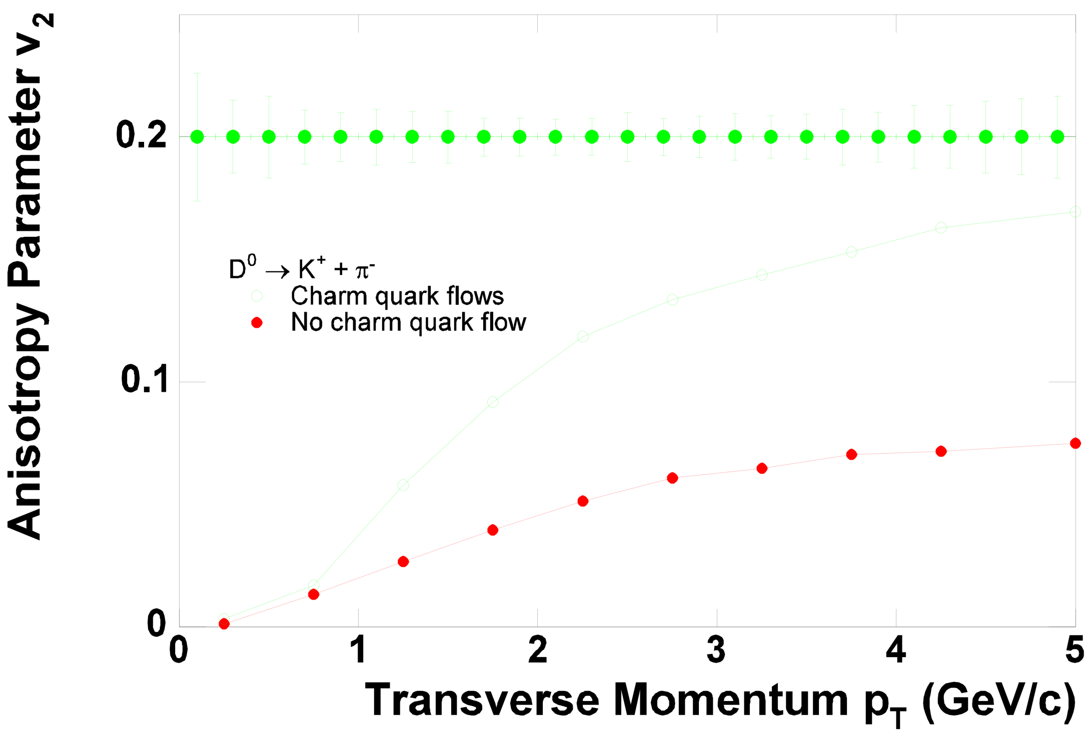
Before HFT

We measure electrons from :

c, b → e + X

Large stat. and syst. errors !

Need direct open charm reconstruction !



In progress

✓ $D_s^+ \rightarrow \phi\,\pi^+$ ($c\tau$=147 μm)

✓ $D^+ \rightarrow K^+K^-\pi^+$ ($c\tau$=311 μm)

3 body decay
More sensitive : Larger stat. errors !
But ct > D0

What about B physics ?

✓ $B^+ \rightarrow e^- + X$

Conclusion

The HFT will be a Thin detector (< 0.36% X_0) using CMOS sesnsors.

It will enable us to do precise measurements

- **D_0**
  - **Precise measurement of D0-spectra (possible with about 5k events** for 3 sigmas)

    The HFT will enable v2 (elliptic flow) measurement (not possible w/o)
- **Enables other D-meson measurement**
  - **i.e. Ds : Spetra (starts to be possible with about 800k event** for 3 sigmas)