Reconstruction of charmed decays using microvertexing technique with the STAR Silicon Detectors

1. Physic motivation
2. STAR detector and microvertexing technique
3. Initial tests : D^0 ($\rightarrow K^- \pi^+$) decay
4. Summary and perspectives

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Charmed mesons in Heavy Ion collisions

A. Heavy flavor is produced at the earlier stages of the collision via gluon fusion:
   1. Give insights of the medium created :
      - Nuclear modification factor R_{AA} → energy loss of charmed quarks in medium.
      - Elliptic flow v_2 → indication of thermalization reached during the earlier steps of the collisions.

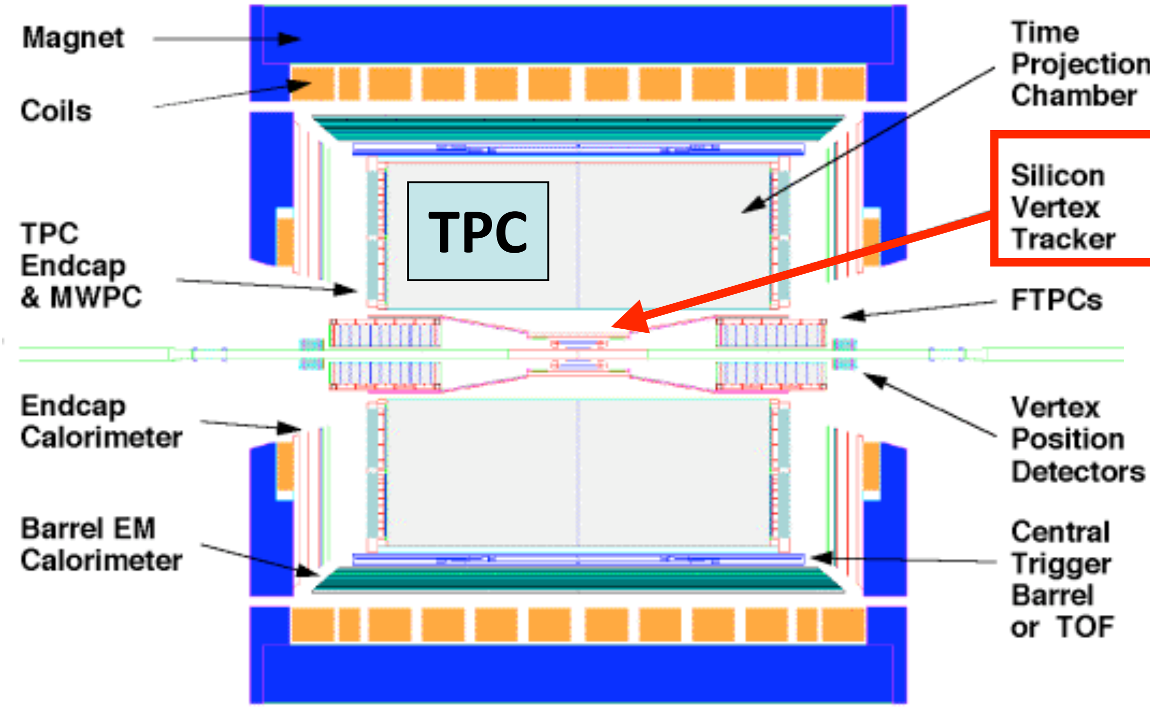
B. Measurements :
   1. Indirect method via semi leptonic decays [1]:
      - $D^0 \rightarrow e^+ + X$, BR : 6.9 % ; $D^{+/-} \rightarrow e^{+/-} + X$ BR : 17.2%
   2. Direct method via measurement of hadronic decays [2]:
      - D^0 ($\overline{D^0}$)$\rightarrow K^-\pi^+$($K^+\pi^-$)BR : 3.8 % ; $D^{+/-} \rightarrow K\pi\pi$ BR : 9.2%

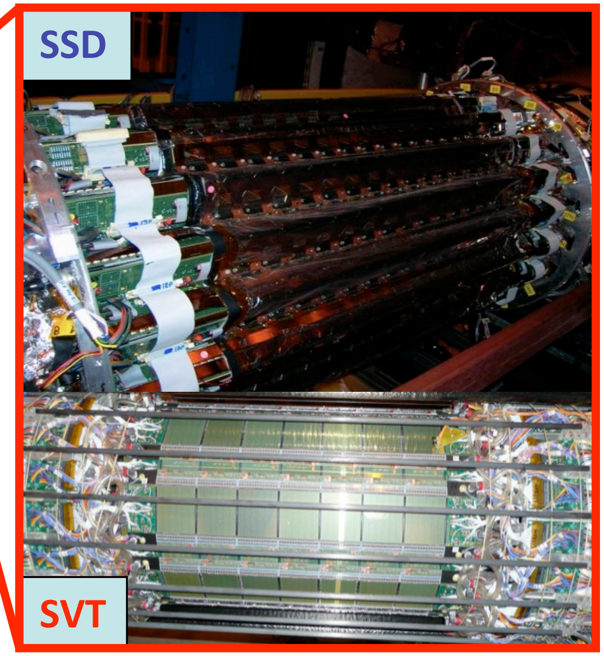
- Limitations of semi leptonic channels :
  1. uncertainty of difference charm and bottom hadron contributions.
  2. incomplete kinematics measurement.
- To achieve precision measurement on the heavy quark production, a full topological reconstruction of the decaying particle is needed.

➔Challenging for charmed particles due to the small decay length ($c\tau$ (D^0) ~ 123 μm).

[1]Adare A et al. (PHENIX) 2010 (Preprit1005.1627)
[2] dAu : Open charm yields in d+Au collisions at sqrt{s_{NN}} = 200 GeV, Phys. Rev. Lett. 94 (2005) 62301
AuAu : Abelev et al., Charmed hadron production at low transverse momentum in Au+Au collisions at RHIC, *arXiv:0805.0364*
CuCu : Measurement of the open charm cross-section in GeV Cu+Cu collisions at the STAR experiment at RHIC, 2008 *J. Phys. G: Nucl. Part. Phys.* 35 104112

STAR detector (in 2007)





The tracking system consisted of :

•Time Projection Chamber (**TPC**) provides measurements of :

➔track momentum, particle identification.

•2 silicon detectors :

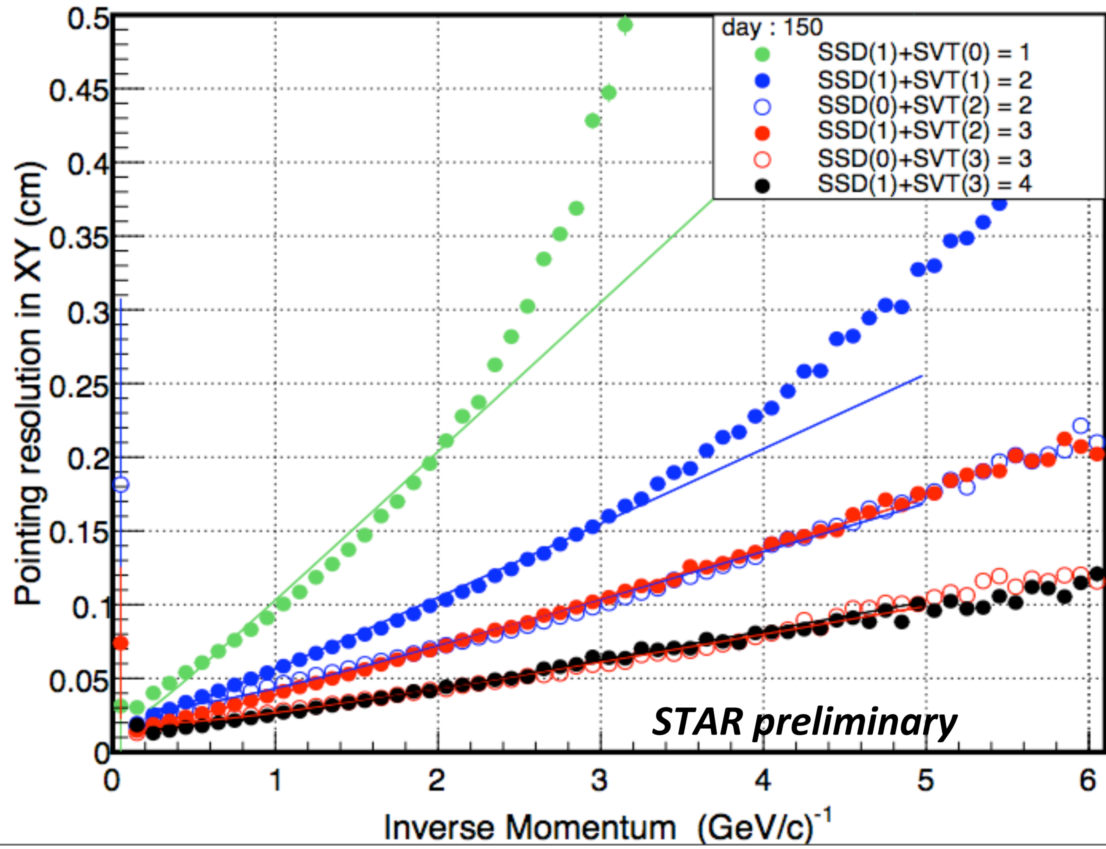
▪1 layer of silicon strip detectors (**SSD**) and 3 layers of silicon drift detectors (**SVT**).

▪ **High spatial resolution** : pointing resolution of 280μm in transverse direction was achieved with Cu+Cu data in run 5 (y2005)[1].

[1] Fisyak Y V et al. 2008 J. Phys. Conf. Ser. 119 032017

Distance of Closest Approach resolution

- run 7 Au+Au@200GeV (MinBias trigger).
- DCA resolution as a function of inverse momentum.
- Reflect the (detector+alignment) resolution and Multiple Coulomb Scattering (MCS).



➔Including the silicon detectors in the tracking improves the pointing resolution.

➔with 4 silicon hits, the pointing resolution to the interaction point ~ 220µm at P = 1GeV/c.

Strategy of reconstruction

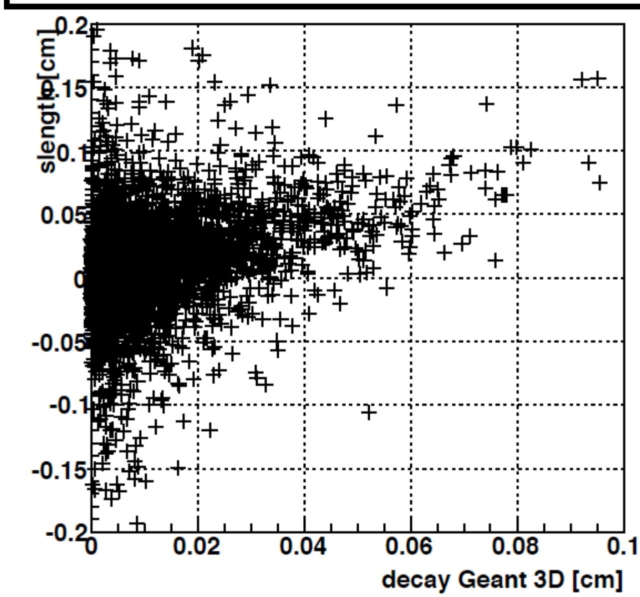
➔Apply cuts in reconstruction code and analysis to reduce the combinatorial background and select good quality tracks and pairs.

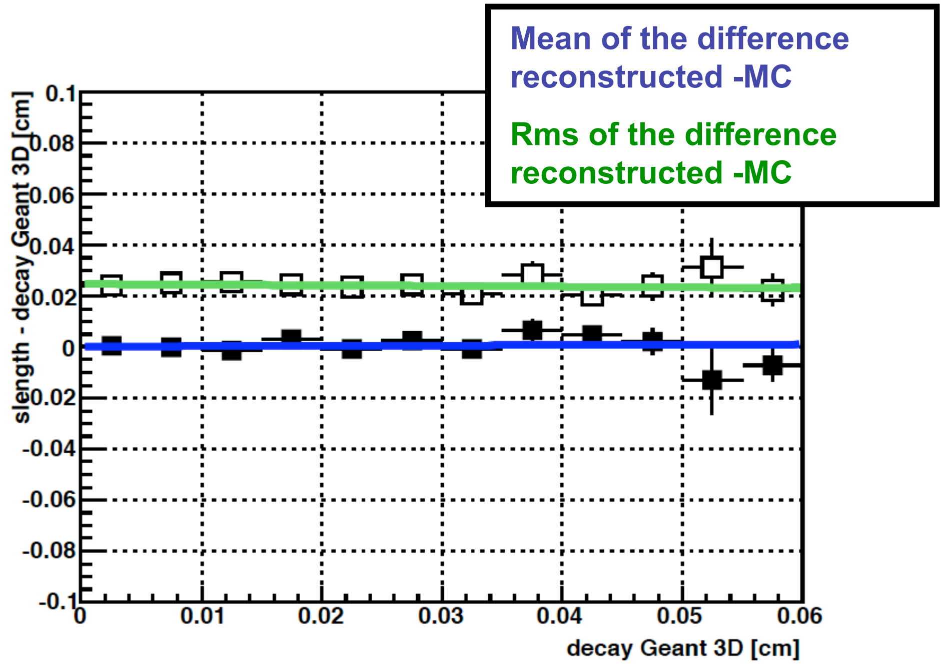
1. EVENT level :
   - Primary vertex position and its error (ensured by trigger detectors).
2. TRACKS level
   - Number of hits in the vertex detectors : **Silicon Hits > 2** (tracks with sufficient DCA resolution).
   - Number of fitted **TPC hits > 20** (avoid splitting tracks).
   - Particle identification : ndEdx : $|n\sigma_K|<2$, $|n\sigma_\pi|<2$ (select kaon and pion candidates).
   - Pseudo-rapidity : $|\eta|<1$ (Silicon detector acceptance).
   - DCA to Primary vertex (transverse) $DCA_{xy} < .1$ **cm** (remove tracks compatible with strange particles decays).
3. PAIR ASSOCIATION level
   - Sum of momentum of pairs.
   - results given by the secondary vertex fit.
   - Pairs with opposite charges.

Secondary vertex fit (simulation studies)

- Least square fit of the decay vertex [1] :
  a) In 2 body decay, combination of 2 tracks + constraints driven by physical considerations.
  b) The Kalman filter machinery gives the best estimate of track parameters and their associated errors near the primary vertex.

Correlation between the reconstructed decay and MC



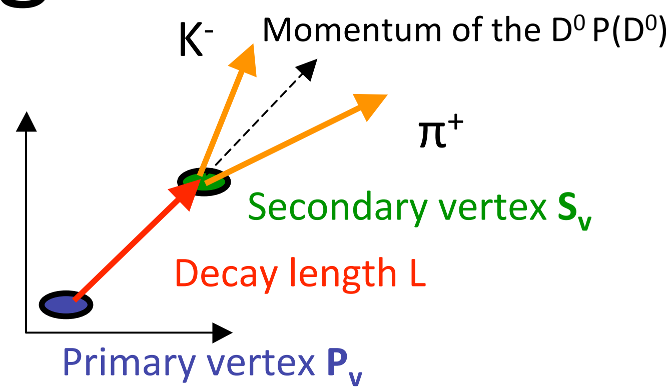


- There is no systematic shift in reconstructed quantities.
- The standard deviation of the distribution is flat at ~ 250 μm , which is of the order of the resolution of (SSD+SVT).

[1]Decay Chain Fitting with a Kalman Filter,W. D. Hulsbergen (arxiv:physics,0503191)

Using decay length significance

- Motivation :
  - to use the knowledge of errors (from Kalman) to have an unbiased way to cut.



- Signed decay length :
  - reconstructed decay length can be positive or negative.
  - real signal expected for positive decay length.
  - an excess can be observed on the positive side of the decay length distribution, indicating the presence of long- lived decays.

$$L = \frac{(\mathbf{S_v} - \mathbf{P_v}).\mathbf{P}(D^0)}{|\mathbf{P}(D^0)|}$$

σ: error associated to the decay length L

$S_L = L / \sigma_L$

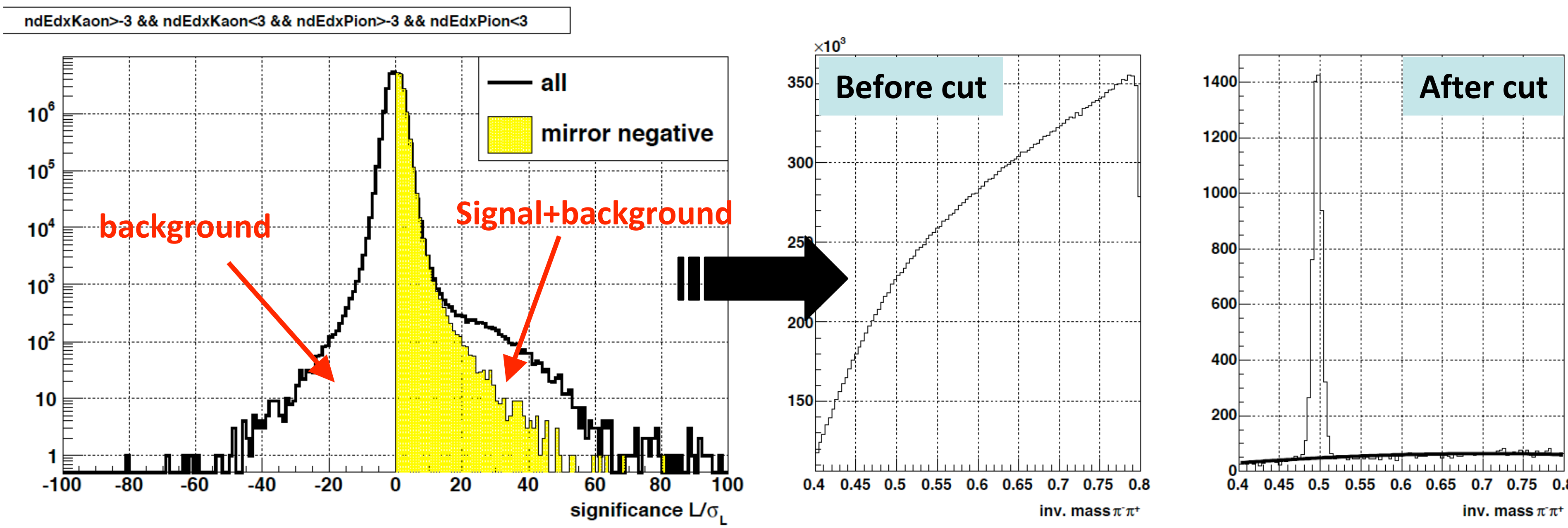
- Idea :
  - use the decay length significance L/σ_L to improve the signal.
  - more appropriate because of the momentum dependence of the decay length.

Proof of principle

- K^0_s decay reconstruction :

  $K^0_S \rightarrow \pi^+ \pi^-$ (BR = 69.2%)

  $c\tau$ = 2.68 cm ; Mass = 0.497 MeV/c^2

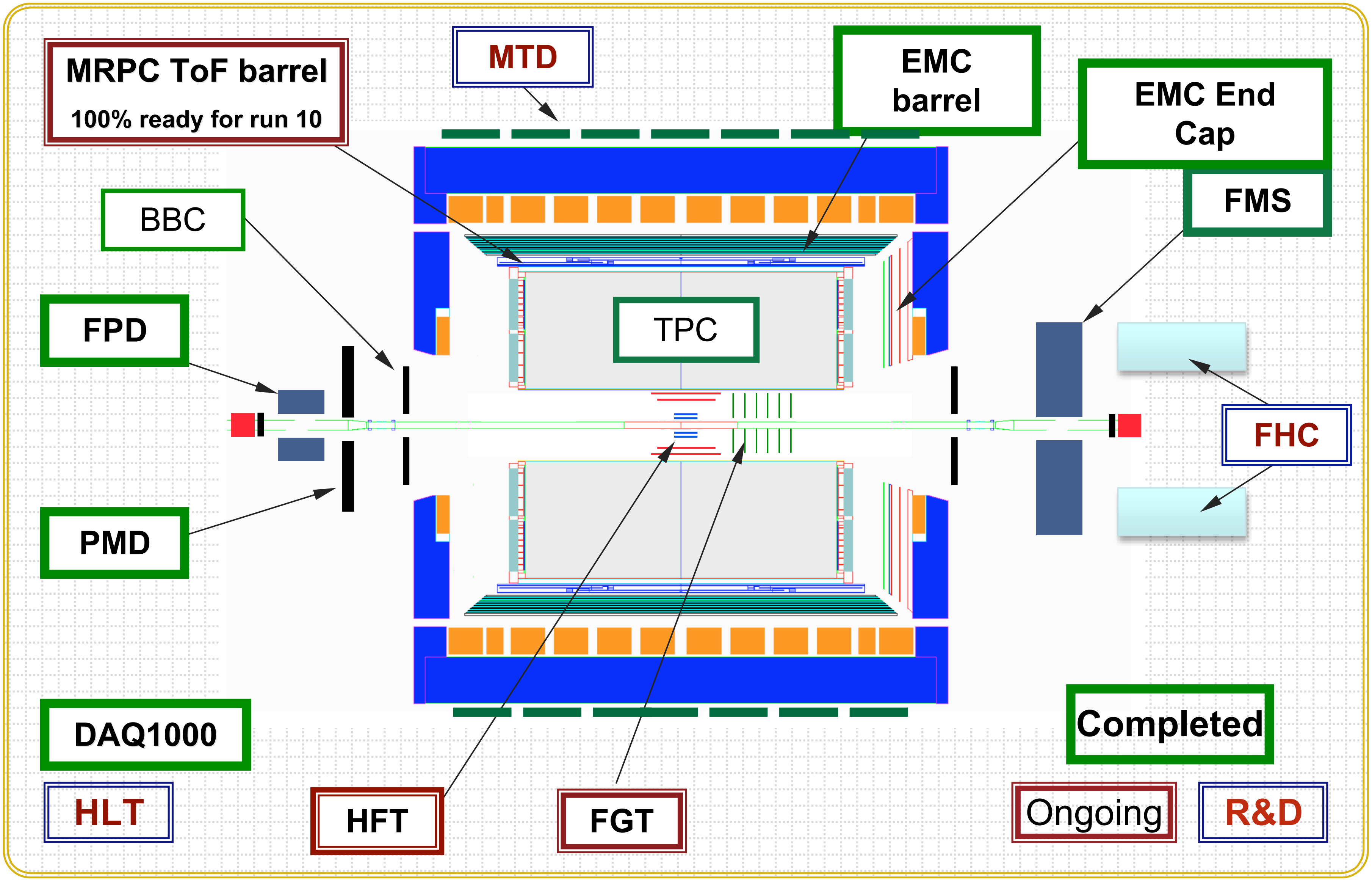


✔ After using a cut $S_L > 10$, a clear peak at the K^0_S mass is observed.

Summary and perspectives

- We presented a method using full track information to obtain high precision of decay vertex.
- This technique has been tested for strange particle decay.
- Ongoing efforts :
  - to tune cuts to maximize S/N
  - evaluate background
  - estimate efficiency correction
  - analyze Cu+Cu@200 GeV

STAR detector (current)



Inner tracker system

	Number of layer (radius)	technology	Sensor size (mm^2)	Intrinsic resolution (design)	Radiation length
SSD	1 (23 cm)	Double sided silicon strips	42 x 73	r/φ ~ 20 µm Z ~ 700 µm	~1% X_0
SVT	3 (6.8 cm ; 10.8 cm ; 14.8 cm)	Silicon drift	60 x 60	r/φ ~ 20 µm Z ~ 20 µm	~1.5% X_0 per layer