# D Mesons at SPD

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# D Meson Production at SPD

- One of the quantitative measures of the impact of future SPD data is how much the uncertainties will reduce
- Contacted PROSA coll. members for advice on impact on unpolarized gluon PDF some time ago
- We need D meson predicted cross-section at SPD and statistical uncertainties
- Our Samara colleagues (Karpishkoff et al.) calculated D0/D0bar and D+/D- cross-sections
- We look at MC event generator to estimate counts in 1 year of data to obtain statistical uncertainty

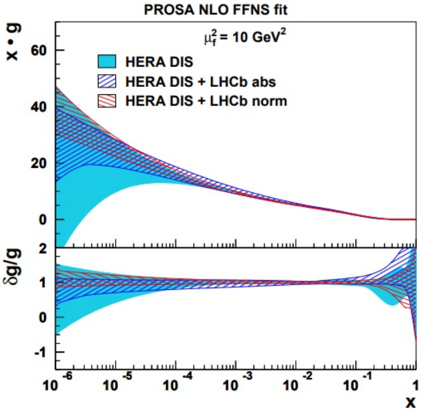



Figure 1: Refit of gluon unpolarized PDF

# Produced D Meson Distributions

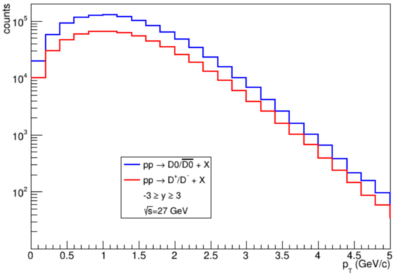



Figure 2: Transverse momentum distributions of D mesons produced at SPD

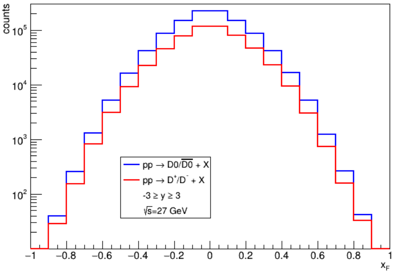



Figure 3: Feynman-x distributions of D mesons produced at SPD

1 Million open charm events (gg2ccbar+qqbar2ccbar) in PYHTIA using default (NNPDF23 LO) PDF : total process cross-section $2.482x10^{-3}$ mb

Process cross-section varies with a choice of $\hat{p_T}_{min}$

# $D^0/\bar{D}^0$ Production Cross-sections

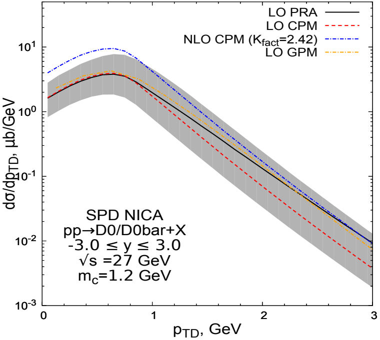



Figure 4: Theoretical prediction of neutral D meson cross-section at SPD : courtesy Anton Karpishkoff

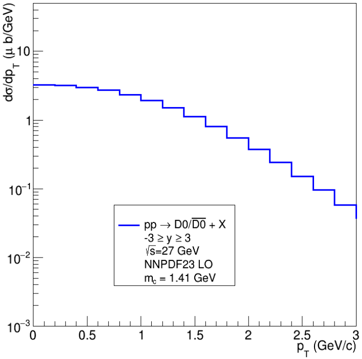



Figure 5: PYTHIA production of neutral D mesons

$p_T$ dependence do not quite match

# $D^+/D^-$ Production Cross-sections

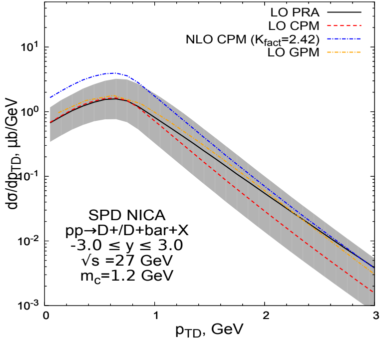



Figure 6: Theoretical prediction of charged D meson cross-section at SPD : courtesy Anton Karpishkoff

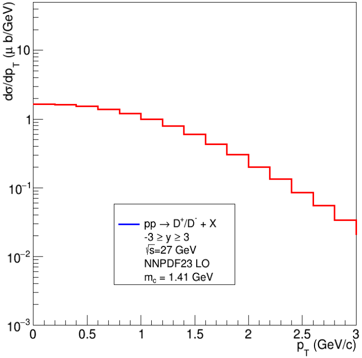



Figure 7: PYTHIA production of charged D mesons

$p_T$ dependence do not quite match

# Comments On Using SPD Mock Data

- Probably understandable that PYTHIA is not reliable when it comes to $k_T$ dependence of PDF and that causes the shape difference
- Varying PDF sets in PYTHIA does not alter the distribution too much
- We can use theoretical (model dependent) estimation for uncertainties as well
- Calculate particle counts by multiplying with the integrated luminosity for 1 year of recorded data
- Use to refit
- Any other idea?

# D Meson Detection at SPD

- Looking at D meson detection at SPD using decays into pions and kaons
- $D0 \to \pi^+ K^-$
- $D^+ \to \pi^+ \pi^+ K^-$
- SpdRoot simulation : version 4.1.3
- SpdRCKFpartV0Finder for secondary vertex
- Signal : ‘gg2ccbar + qqbar2ccbar’ : Pythia8
- Background : SoftQCD processes EXCEPT elastic : Pythia8

# Secondary Vertex Resolution : Vertex Detector Dependency

- First stage : MicroMegas
- Second stage : DSSD or MAPS?
- Need to look at performance of secondary vertex resolution
- D-meson measurements are an important focus at the later stage SPD, seondary vertex resolution within a hundred micrometers are important
- Igor suggested looking at the impact on secondary vertex resolution of different posible Inner Tracker configurations

# Secondary Vertex Resolution

- SpdRCKFpartV0Finder for secondary vertex
- Requires PID of daughters to fit
- From the fitted vertex parameters :
- Decay length ($L$) and the polar ($\theta$) and azimuthal ($\phi$) angles of the invariant particle gives position of the secondary vertex (*relative to the primary vertex position*)
- Error of decay length ($dL$) from the fit procedure is 'a' measure of the resolution of the reconstructed secondary vertex
- Another measure can be the disance between the reconstructed secondary vertex and the true secondary vertex from MC info (we'll compare them later)

# Dependence on Vertex Detector

- To study performance of possible Inner Trackers, considered :
- 5 layers of DSSD (default in SPDRoot, 300$\mu m$ thickness)
- 3 layers of DSSD (300$\mu m$ thickness)
- 4 layers of MAPS
- Stored L and dL in bins of cosine of absolute value of polar angle $\theta$ of the D meson
- Only signals were considered ($D0 \rightarrow \pi^+ K^-$)

# Decay Length Distributions : MAPS 4

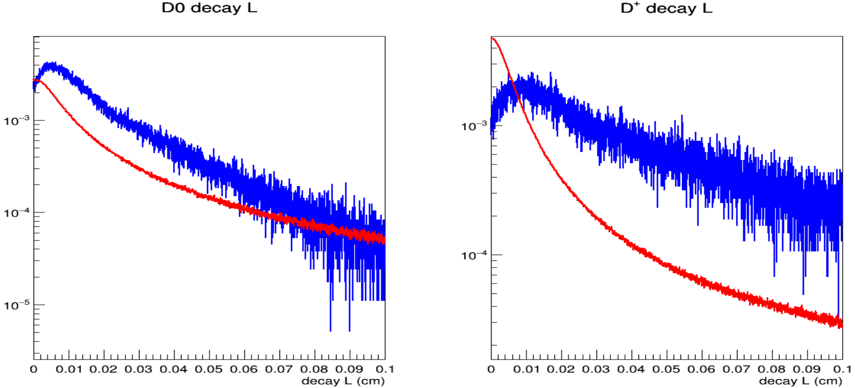



Figure 8: Decay length for $D0$ (left) and $D^+$ (right) : signal, background

# Decay Length and Uncertainty vs. $cos(\theta)$

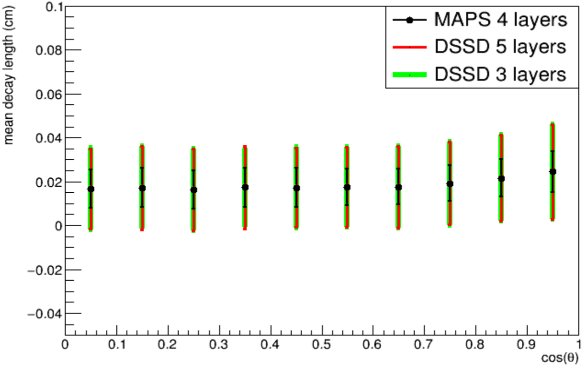



Figure 9: Mean decay length and uncertainty as function of cosine of polar angle for three different vertex detector configurations

Plotted here : mean $L$ and $dL$ of the 1-D distributions for each $cos(\theta)$ bin

Notice the mean value is quite shifted from the peak value because of long tail

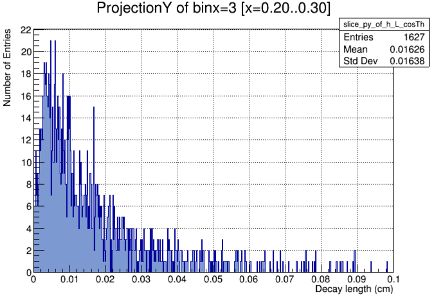



Figure 10: Decay length distribution in $cos(\theta) = (0.2 - 0.3)$ bin for 4 layers MAPS

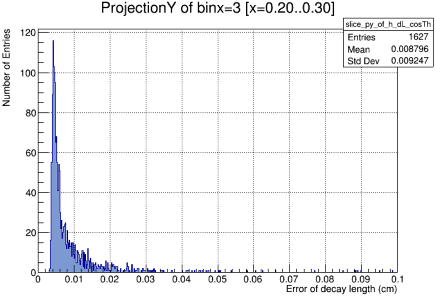



Figure 11: Decay length error distribution in $cos(\theta) = (0.2 - 0.3)$ bin for 4 layers MAPS

# Sample $L$ and $dL$ Distributions : DSSD 3

Notice the mean value is quite shifted from the peak value because of long tail

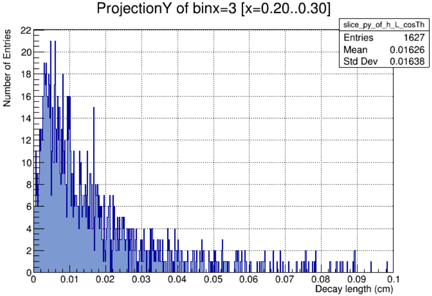



Figure 12: Decay length distribution in $cos(\theta) = (0.2 - 0.3)$ bin for 3 layers DSSD

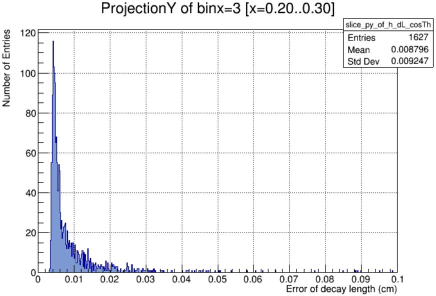



Figure 13: Decay length error distribution in $cos(\theta) = (0.2 - 0.3)$ bin for 3 layers DSSD

Is peak (most probable) value a better quantity to study?

# Decay Length and Uncertainty vs. $cos(\theta)$

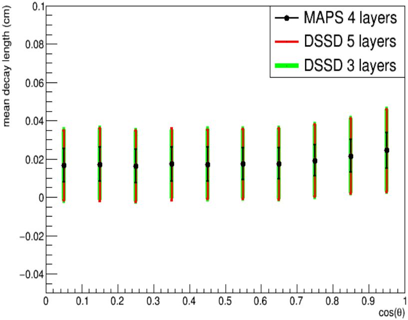



Figure 14: Average decay length and uncertainty

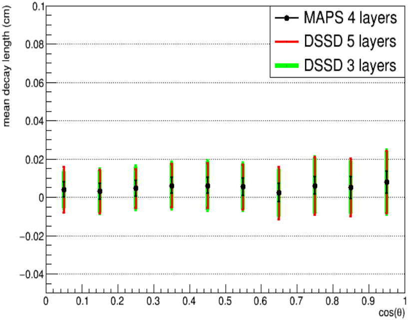



Figure 15: Most probable decay length and uncertainty

Peak decay length is smaller than or comparable to known $D0\ c\tau$. In both cases, MAPS resolution is roughly half that of the DSSD configurations

# Decay Length Divided by Uncertainty vs. $cos(\theta)$

Relative size is also important, resolution comparable to decay length implies we can not trust the secondary vertex position

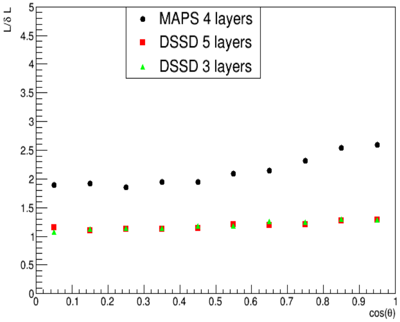



Figure 16: Average values

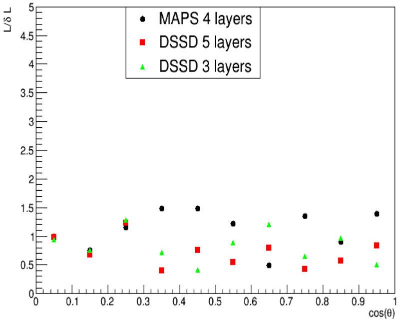
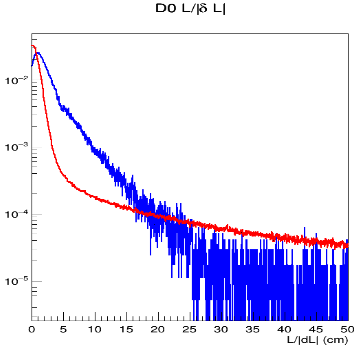



Figure 17: Most probable values

Although it might look bleak, the ratio often close to 1, it's not that bad ...

# Decay Length Divided by Error Distributions

We know low values of the ratio are dominated by backgrounds and we can put cuts to choose uncertainties small compared to decay lengths. Requiring $L/\delta L \geq 5$ ensures $\delta L$ is at most 20% of L



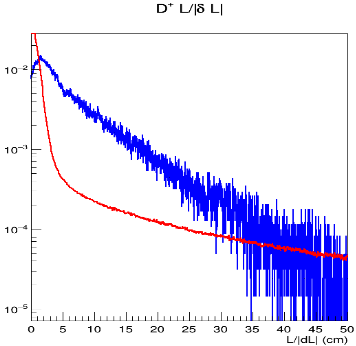




Figure 18: Decay length divided by error for $D0$ (left) and $D^{+}$ (right) : signal, background

# About the 'Other' Resolution

They are corrrelated, but not very well. Is one a better measure of the resolution of secondary vertex position than the other?

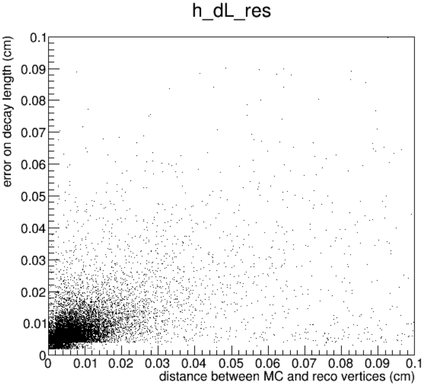



Figure 19: Uncertainty of decay length from fit vs. distance between MC and reco secondary vertices

# Outlook

- I'll contact Maria Garzelli and/or Oleksandr Zenaiev about unpol. gluon PDF refit with mock SPD data
- Plan to look at secondary vertex resolution along beam/z direction and perpendicular ($r - \phi$ plane)

Thank You