



Updates on Simulation of D_s Semileptonic Decay

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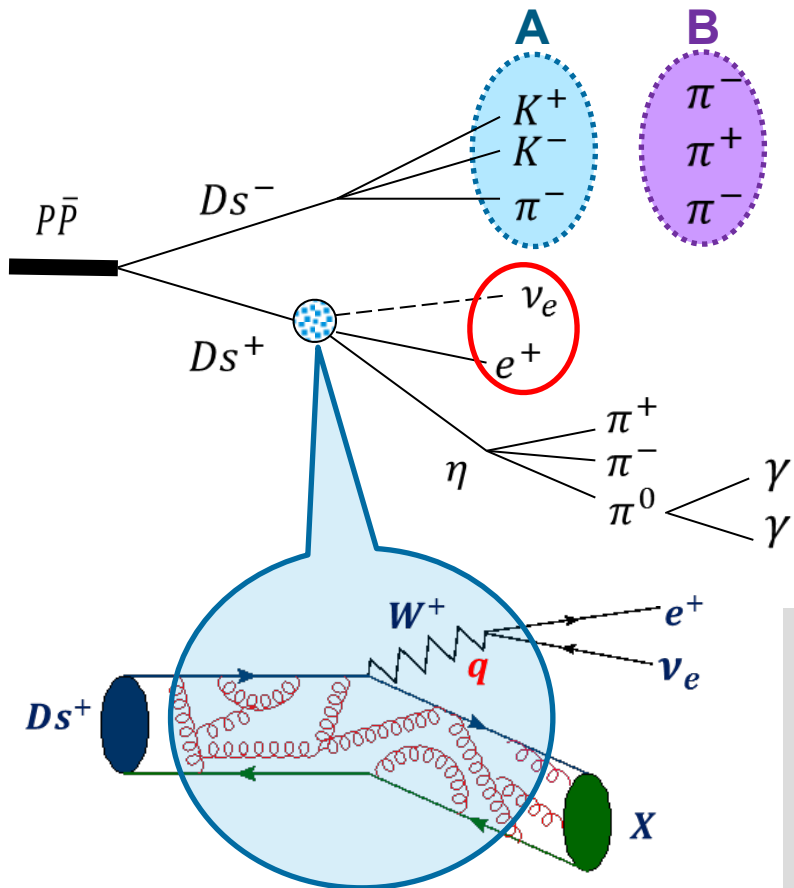
IKP1, Forschungszentrum Jülich

Dec. 1st, 2015

Outline

- Overview of decay chain
- Simulation settings
- Beam momentum dependency
- Result on lepton-neutrino system (GenFit 1, GenFit 2, Bremsstrahlung Corr.)
- Estimate on event rate
- Summary & outlook

Overview fo Decay Chain



- Single tagging D_s^-
- Two tagging modes of D_s^- :
 - A:** $D_s^- \rightarrow K^- K^+ \pi^-$
 - B:** $D_s^- \rightarrow \pi^- \pi^+ \pi^-$
- $q^2 \equiv M^2(e^+ \nu_e)$

pbarpSystem

$\rightarrow D_s^- D_s^+$	$BR_{PDG2014}$	Decay Model
$ \rightarrow \eta e^+ \nu_e$	2.67%	ISGW2
$ \rightarrow \pi^+ \pi^- \pi^0$	22.92%	ETA_DALITZ
A $ \rightarrow K^- K^+ \pi^-$	5.39%	DS_DALITZ
B $(\rightarrow \pi^- \pi^+ \pi^-)$	1.09%	D_DALITZ

$$\frac{d\Gamma(D_s \rightarrow \nu_l X)}{dq^2} = \frac{G_F^2}{24\pi^3} |V_{cx}|^2 p_x^3 |f_+(q^2)|^2$$

Simulation Settings - New Features

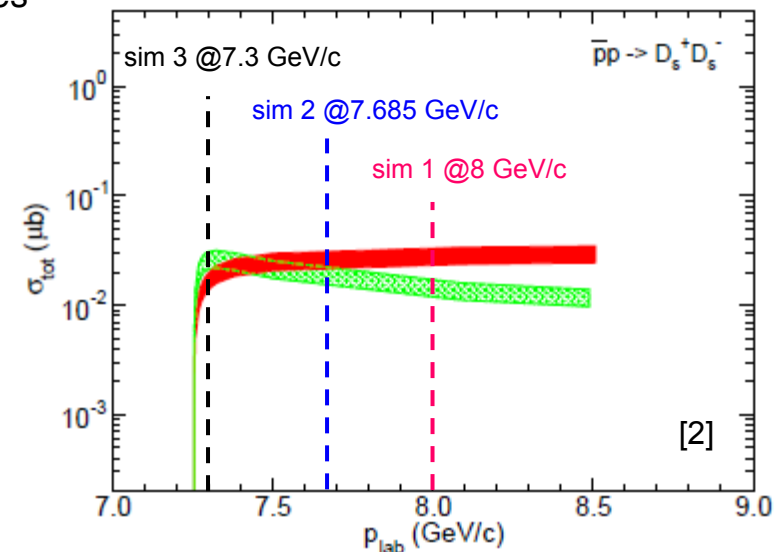
- New data set simulated with GenFit 2

GENFIT2: a generic toolkit for track reconstruction with [significant improvements](#) in Kalman fitters, tracking algorithms and several additional aspects [1].

- Study beam momenta dependency

Theoretical prediction of $p\bar{p} \rightarrow D_s D_s$ cross section gives a wide range. Reconstruction efficiency has been studied with three beam settings.

	\sqrt{s} [GeV]	p_{beam} [GeV/c]
threshold	3.936	7.257
simulation 1	4.108	8.0
simulation 2	4.036	7.685
simulation 3	3.946	7.3

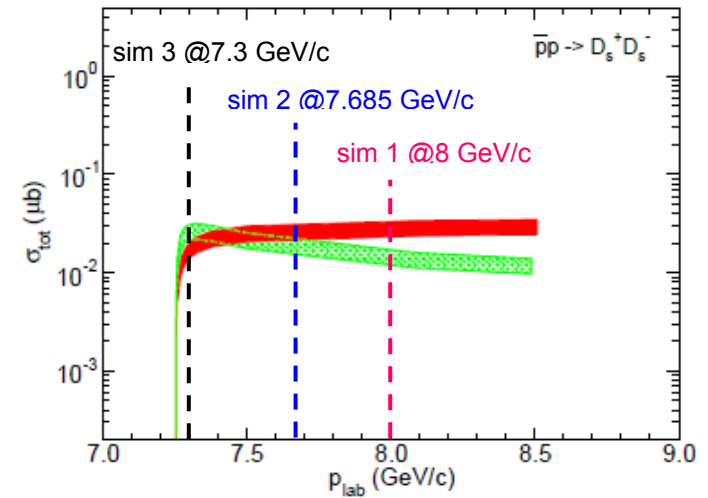


[1]Phys. Conf. Ser., 608(1):012042, 2015.

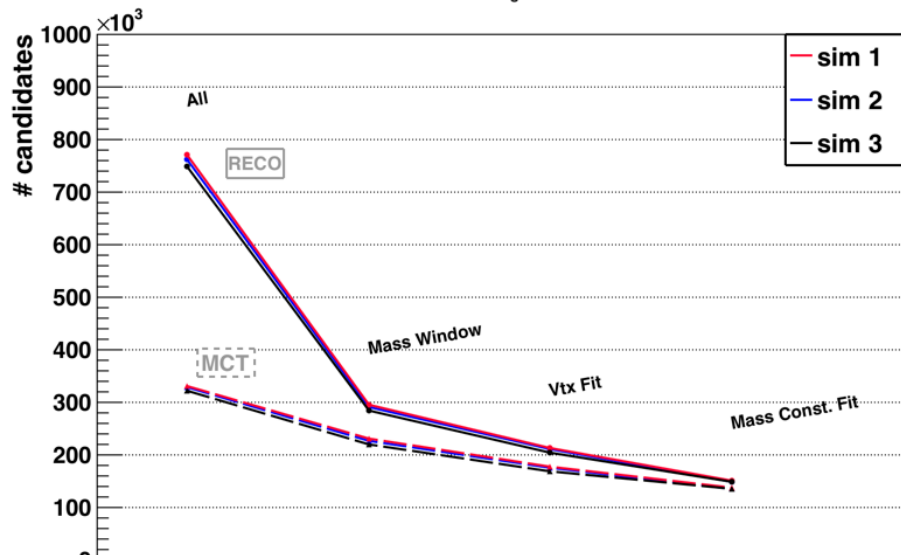
[2]Phys. Rev. D, 89:114003, 2014.

Beam Momentum Dependency

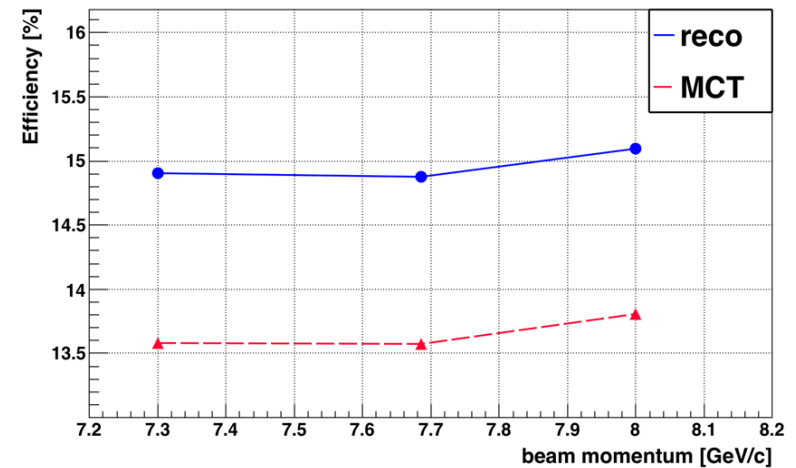
- 1M evt
- trk28748 (Nov. 20) with GenFit2
- $p=8$ GeV/c gains higher efficiency in reconstructing $D_s \rightarrow KK\pi$



Counts Flow of D_s^- Reconstruction



Reconstruction Efficiency of $D_s^- \rightarrow K^+ K^- \pi^-$



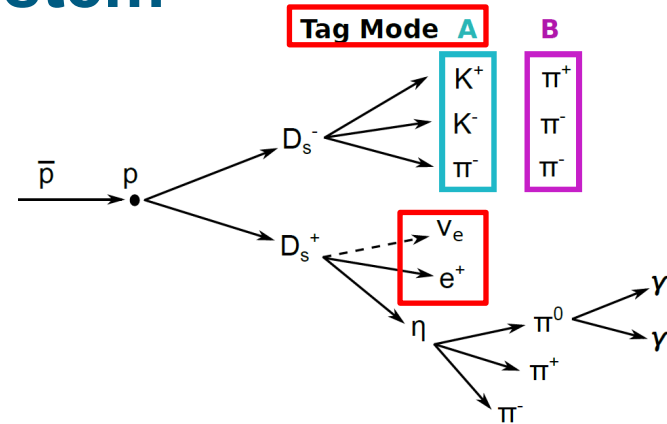
Reconstructed Lepton-neutrino System

$$\frac{d\Gamma(Ds \rightarrow v l X)}{dq^2} = \frac{G_F^2}{24\pi^3} |V_{cx}|^2 p_x^3 |f_+(q^2)|^2$$

$$M^2(v_e e^+) = (E_{p\bar{p}} - E_{D_s^-} - E_\eta)^2 - |\vec{P}_{p\bar{p}} - \vec{P}_{D_s^-} - \vec{P}_\eta|^2 \equiv q^2$$

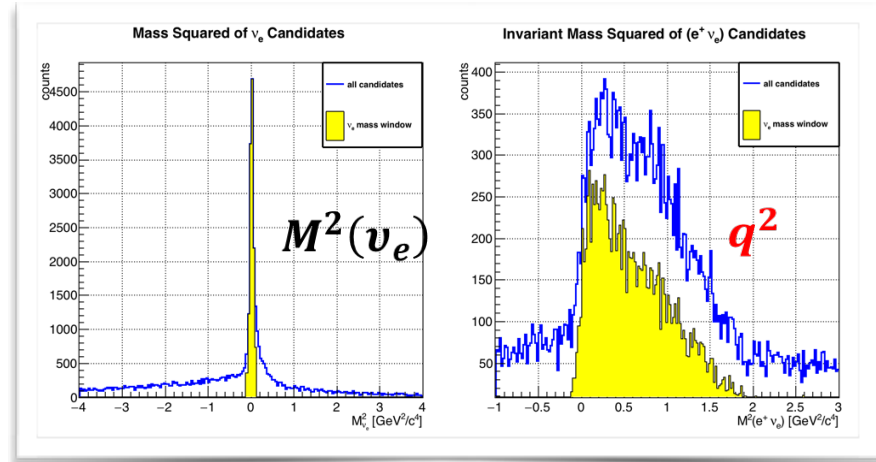
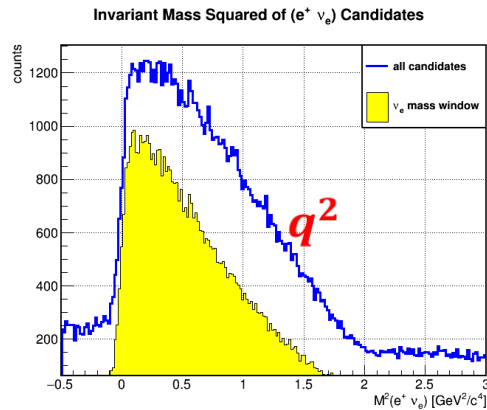
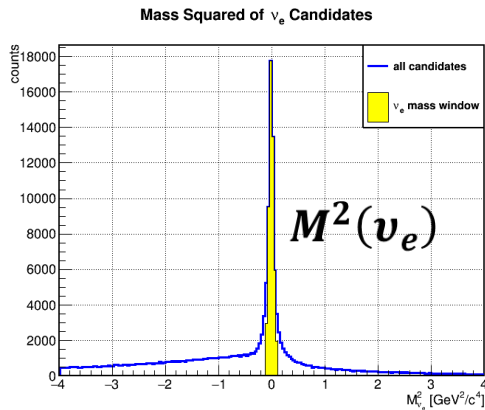
physical range: $0 \leq q^2 \leq (M_{D_s} - M_\eta)^2 \approx 2.02 \text{ GeV}^2/c^4$

$M^2(v_e)$ window = $\pm 0.1 \text{ GeV}^2/c^4$



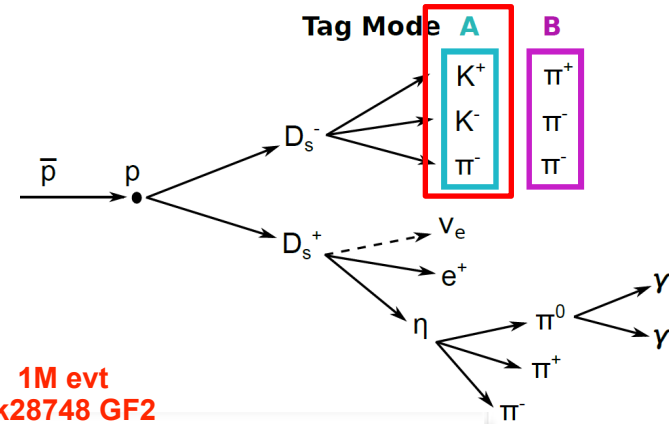
10M evt
trk27806 GF1

1M evt
trk28748 GF2

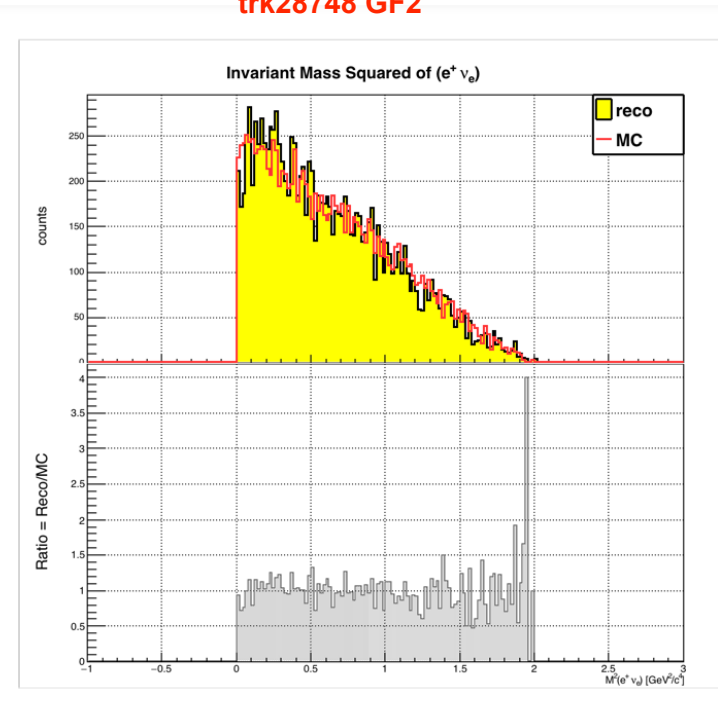
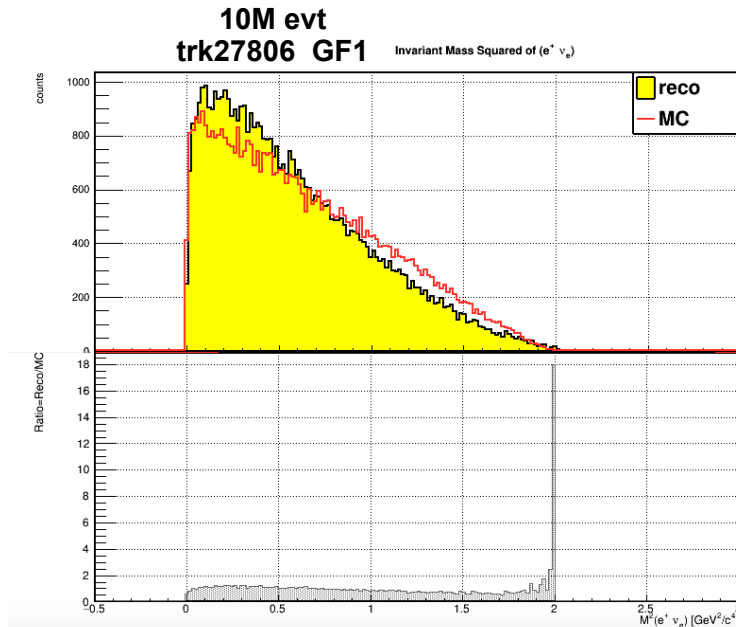


Result on Lepton-neutrino System (GF1/GF2)

	Efficiency
trk27806 GF1	0.49 %
trk28748 GF2	1.22 %



1M evt
trk28748 GF2



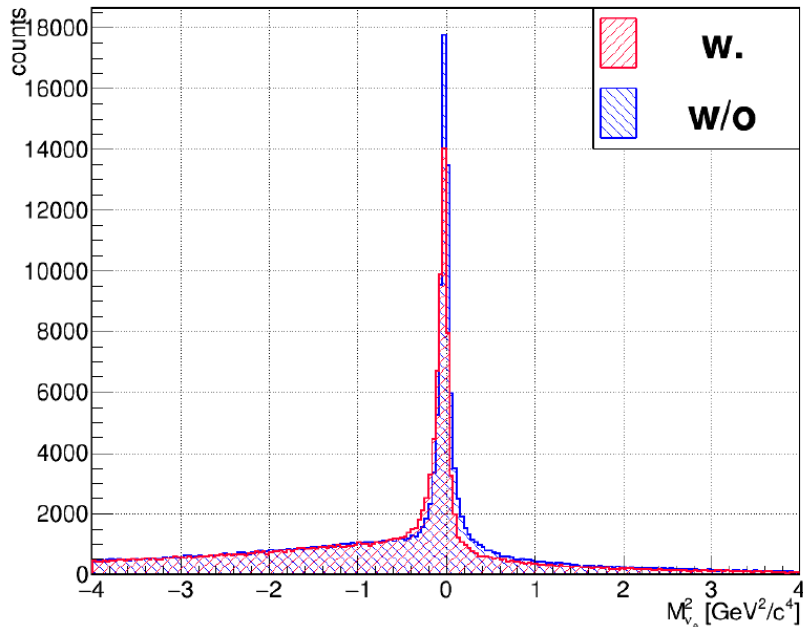
reco: reconstructed q_2 in physical range
MC: simpleEvtGen truth

Result on Lepton-neutrino System

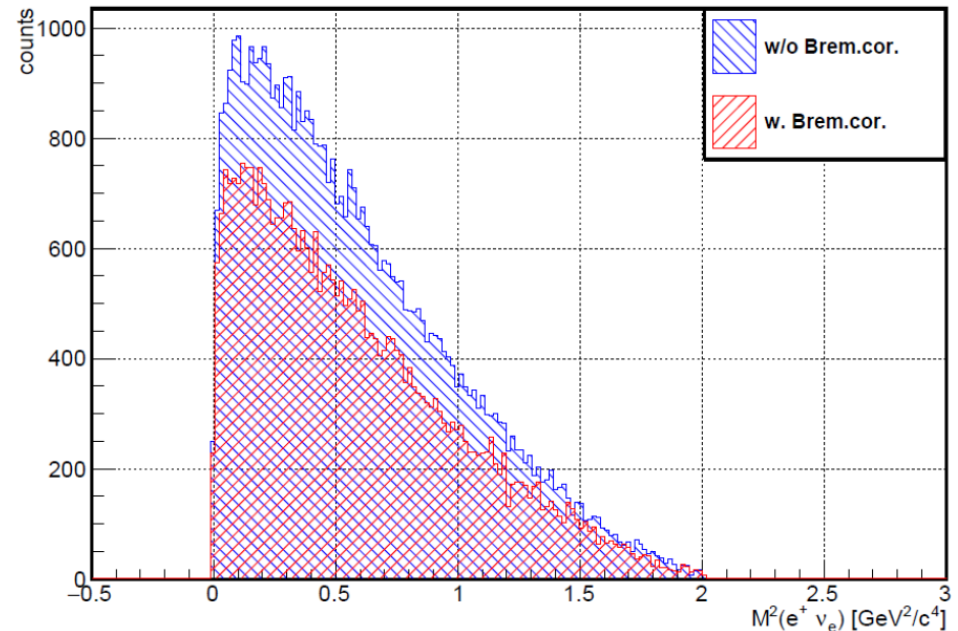
Considering Bremsstrahlung Correction on e+

10M evt
trk27806 GF1

Mass squared of ν_e w. and w/o BremCorr e+



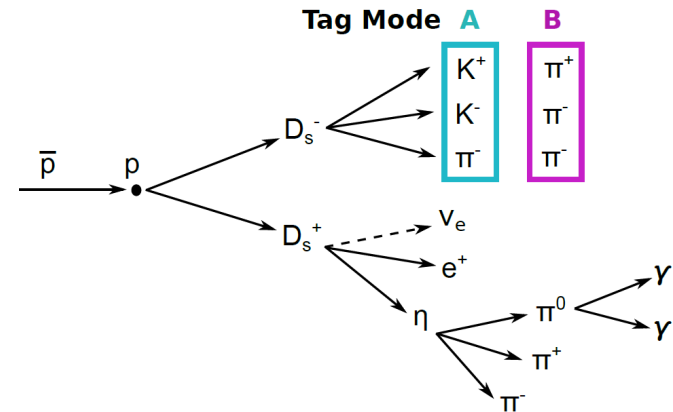
Invariant Mass Squared of $(e^+ \nu_e)$ (w. vs w/o BremCorr e+)



- Every positron correlates with a Bremsstrahlung photon
- If wrong photon is correlated, kinematics of lepton-neutrino system gets worse

Estimate on Event Rate

pbarpSystem	
→ Ds- Ds+	$BR_{PDG2014}$
→ eta e+ nu_e	2.67 %
→ pi+ pi- pi0	22.92 %
→ 2 gamma	98.8 %
→ K- K+ pi-	5.39 %
(→ pi- pi+ pi-)	1.09 %



	Efficiency
Mode A	1.22 %
Mode B	4.84 %

$$R(e^+v_e) = \mathcal{L} \cdot \sigma \cdot \varepsilon \cdot t \cdot BR$$

$$= 2 \times 10^{32} (\text{cm}^{-2} \text{s}^{-1}) \cdot 20 (\text{nb}) \times 10^{-24} (\text{cm}^2 / \text{b}) \cdot 3 \times 10^6 (\text{s}) \cdot 2.67\% \times 22.92\% \times 98.8\% \\ \times (1.22\% \times 5.39\% + 4.84\% \times 1.09\%) + \text{c.c.}$$

~ 172 evts

with high luminosity mode in 35 days

CLEO 2009: 82 evts
Phys.Rev. D, 80:052007, 2009.

Summary & Outlook

- High reconstruction efficiency obtained with beam momentum 8 GeV/c
- Good precision of reconstructed lepton-neutrino system with GenFit 2
- Estimated 172 events/month in measuring $D_s \rightarrow \eta$ semileptonic decay form factor

- Study of background channels ongoing
- Documentation

Thank you !



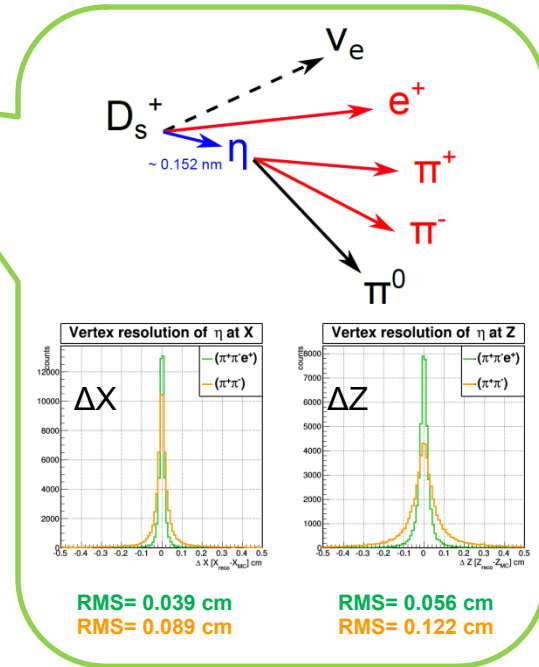
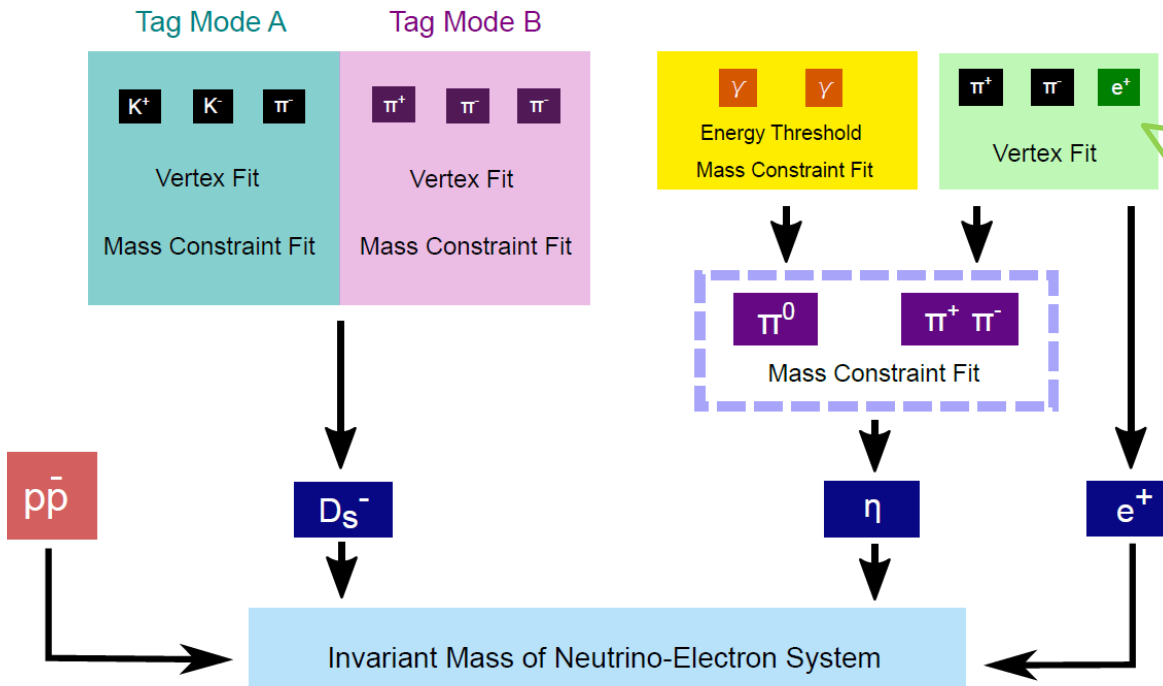
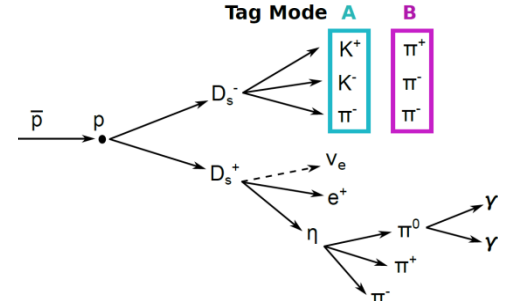
Picture cited from Internet

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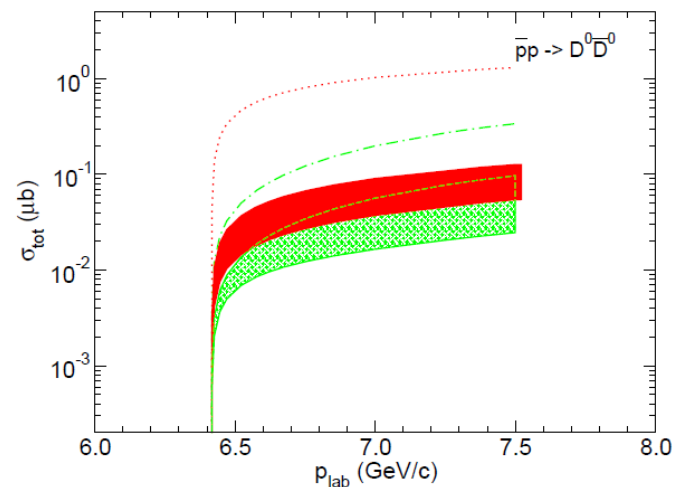
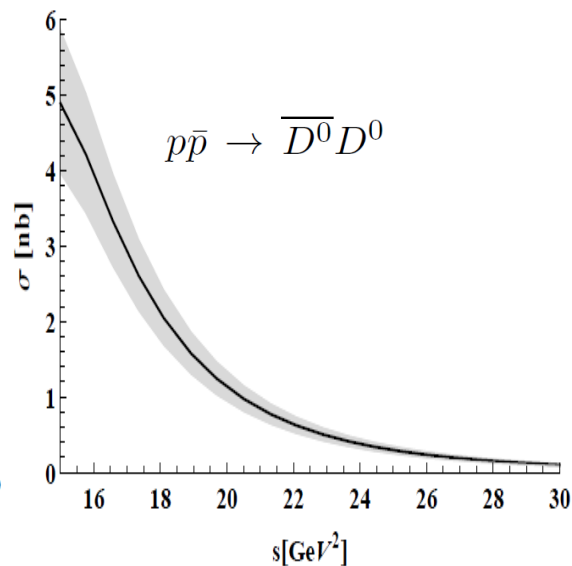
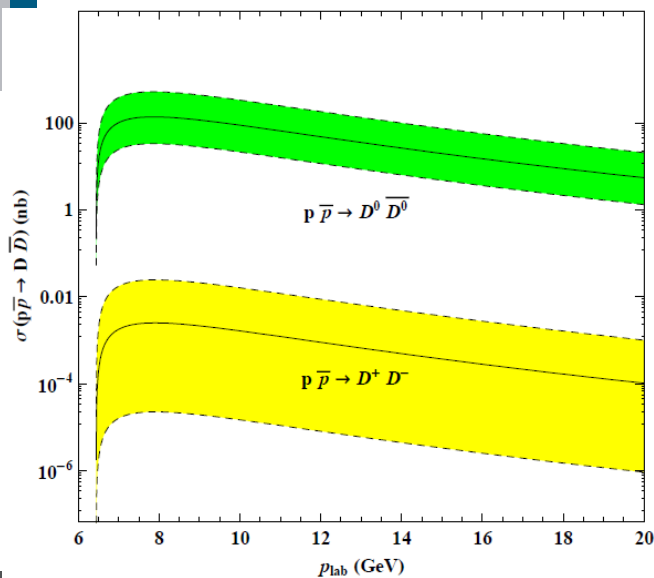
Reconstruction Strategy

$$M^2(\nu_e) = (E_{p\bar{p}} - E_{D_s^-} - E_\eta - E_{e^+})^2 - |\vec{P}_{p\bar{p}} - \vec{P}_{D_s^-} - \vec{P}_\eta - \vec{P}_{e^+}|^2$$

$$q^2 \equiv M^2(\nu_e e^+)$$



Charm Production Cross Section in $\bar{p}p$



EPJA 48, 31(2012), arXiv:1111.3798v2

- quark-gluon string (QGS) model
- uncertainties introduced by the strong couplings obtained from LCSR

JPCS 503, 012012(2014), arXiv:1311.1607

- double handbag approach
- in accordance with NPB 316, 373(1989) using a quark-diquark model

PRD 89, 114003(2014), arXiv:1404.4174

- hadronic interaction model
- baryon exchange (shaded band)
- quark model (grid)
- Results obtained in Born approximation are indicated by the dotted (baryon exchange) and dash-dotted (quark model) lines