Measurement of $D_{(s)}^{(*)}D_{(s)}^{(*)}$ Cross Sections

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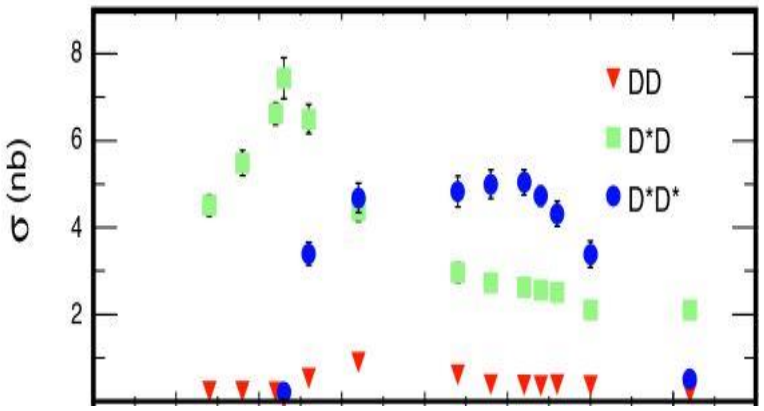
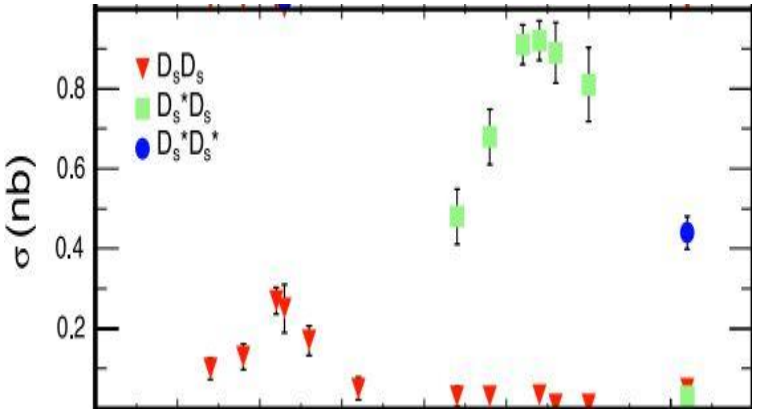
Outline

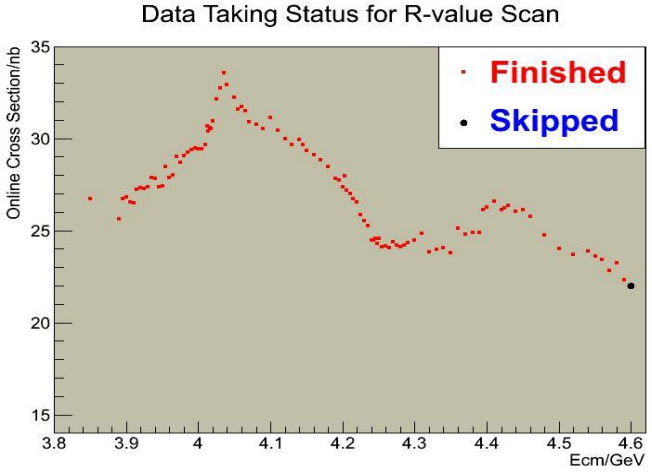
- Motivation
- Data set
- D-tag mode and Event selection
- Analysis about the momentum of D candidate
- Fitting result
- Cross section measurement
- Summary

Motivation

- It is the dominant hadronic production process in open charm energy region.
- CLEC-C collaboration performed a observed cross section of e+e-→D(s)$^{(*)}$D(s)$^{(*)}$ at 13 energy points between 3.97 and 4.26GeV --PRD 80, 072001(2009)







- We have more energy points, wider energy range (104 points between 3.85GeV and 4.59GeV) and better statistics.
- Results are input parameters of LundARLW MC tuning for R measurement.

Data set

- BOSS version: 6.6.4.p01
- Data : R-scan data: 3.85GeV~4.59GeV(totally 104 points)

  XYZ data: 4.260GeV (~826pb^{-1}) (for study of event selection)
- Exclusive MC :

  for D0/D0bar processes :

  D0D0bar , D0*D0bar , D0*D0*bar , D0*D π , D0*D* π , D+*D- (D+* → D0 π+), D+*D*- .

  for D+/D- processes :

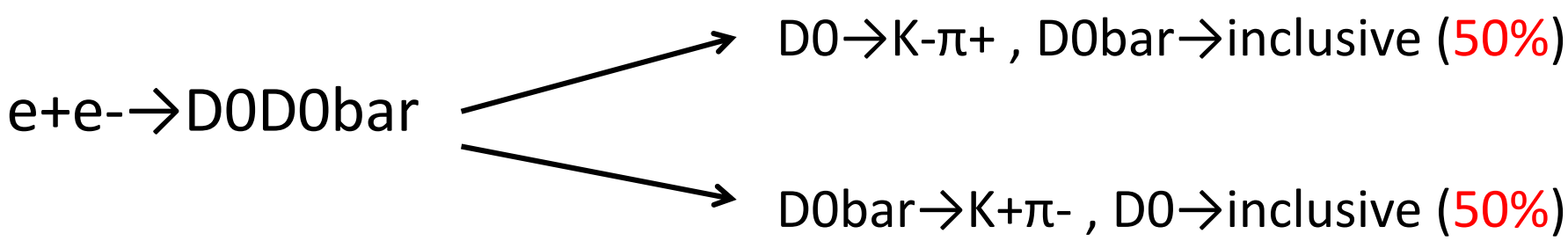
  D+D- , D+*D- , D+*D*- , D+*Dπ (D+*-> π0/γ + D+), D+*D-*π .

Data set

for Ds+/Ds- processes :

Ds+Ds- , Ds+*Ds- , Ds+*Ds-*.

** Each channel of exclusive MC is **conjugate separated** , for example :



Dtag mode

- Tag D0/D0bar by : D0→K-π+ and D0bar→K+π-
  (branching fraction : 3.89%)
- Tag D+/D- by : D+→K-π+π+ and D-→K+π-π-
  (branching fraction : 9.4%)
- Tag Ds+/Ds- by : Ds+→K+K-π+ and Ds-→K+K-π-
  (branching fraction : 5.5%)

$$\sigma = \frac{N_{obs}}{L \cdot \varepsilon \cdot (1+\delta) \cdot Br}$$

Event selection

- Get D0/D+/Ds+ candidates using the D-tag mode mentioned before

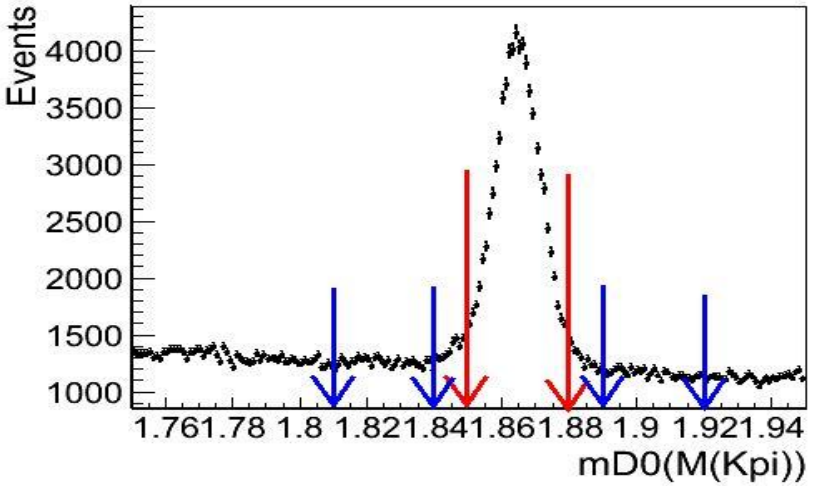
- Signal region:

  |M-M(D)| <15MeV

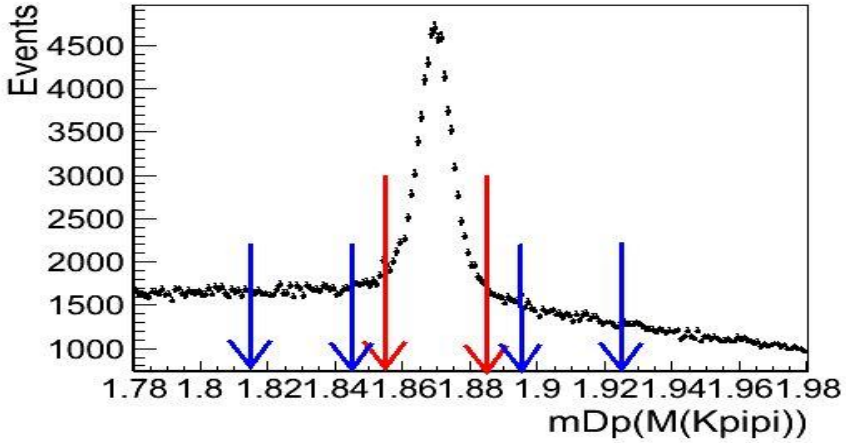
  Sideband region :

  25MeV<|M-M(D)|<55MeV

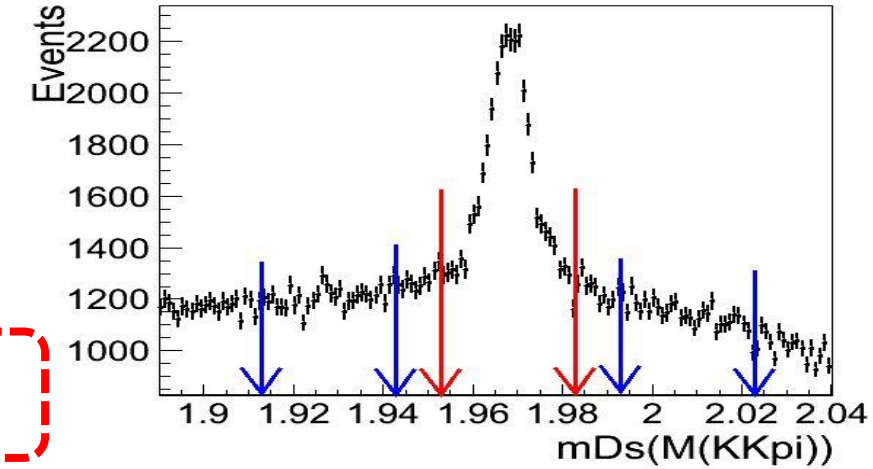
M(D0) :



M(D+) :



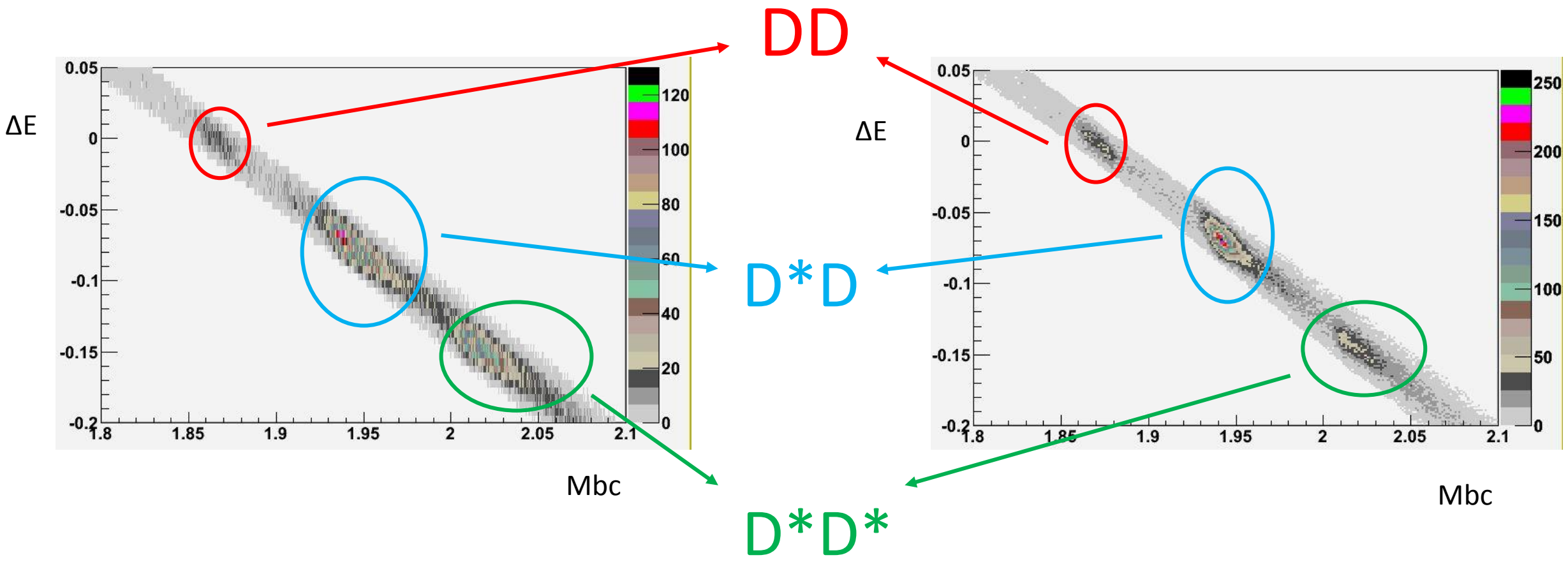
M(Ds+) :



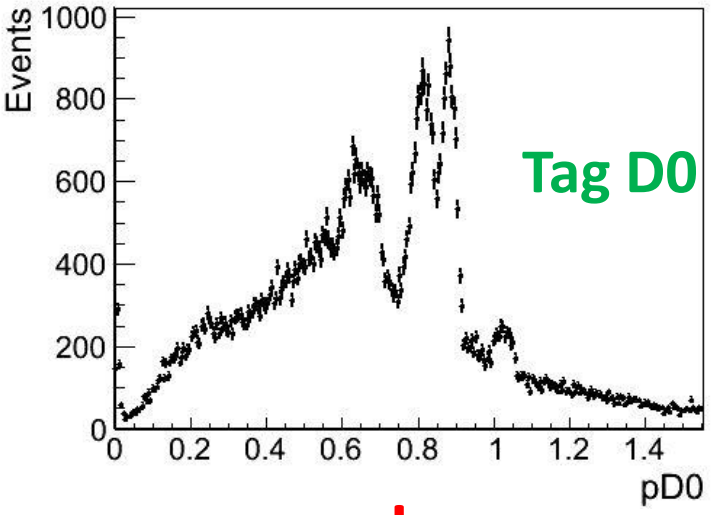
Using 826pb-1@4.260GeV data!

Event selection

2C of ΔE vs. Mbc

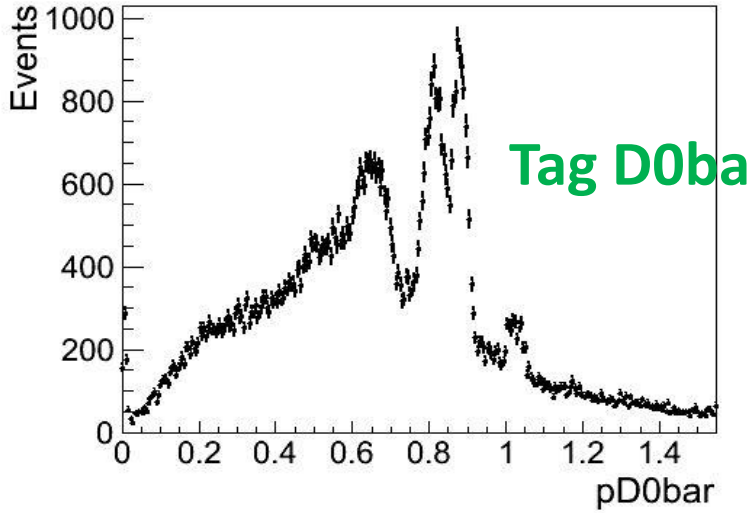


Momentum distribution of D0



Tag D0

+

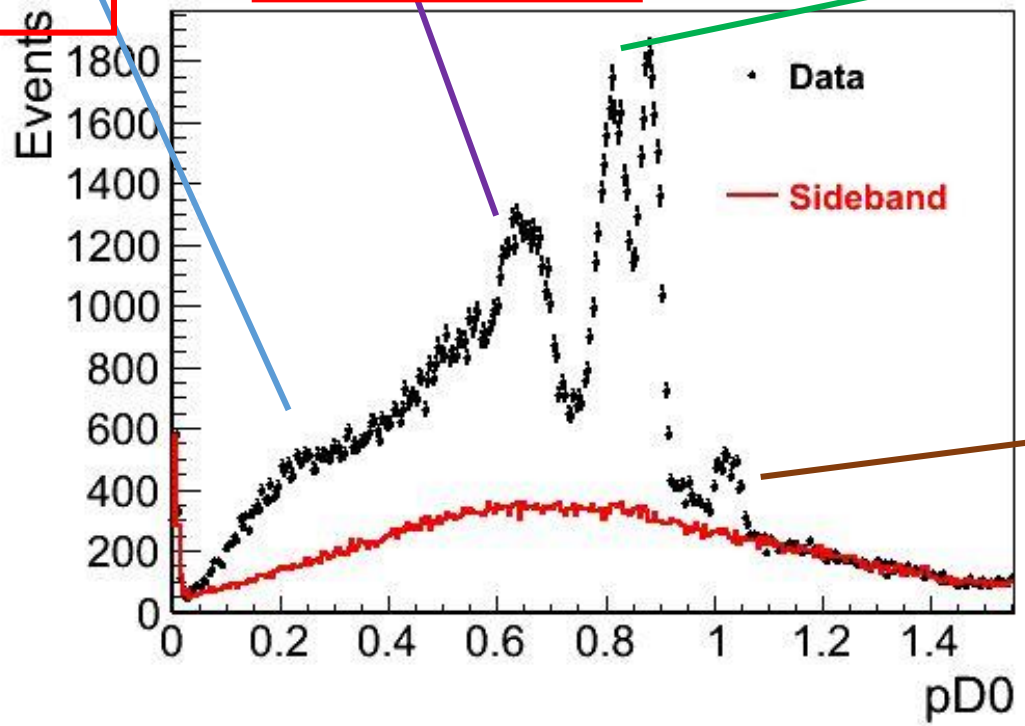


Tag D0bar

=

Higher order ?
or
D*D*π

D0*D0*bar
or
D+*D-*



D0*D0bar
or
D+*D-

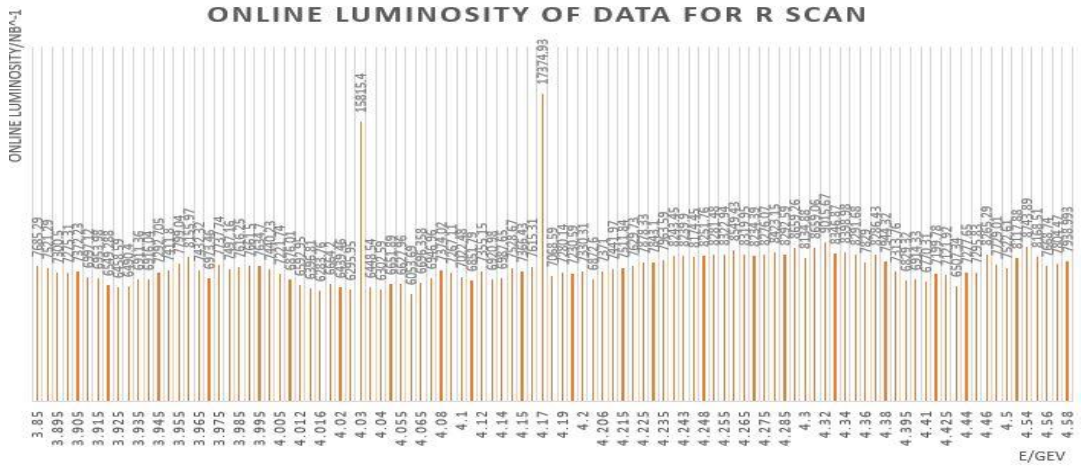
D0D0bar

Sideband can describe the continuum background well !

Momentum distribution of D0

Why we use this method?

- Luminosity of each energy point is about 8 pb^{-1}.



- Using the simplest event selection requirements, we can get the largest scale of signal.
- Momentum spectra can separate all the exclusive channels well.

Evidence for Multi-body processes

- Whether D(*)D(*)π exist?

Using 826pb-1@4.260GeV data!

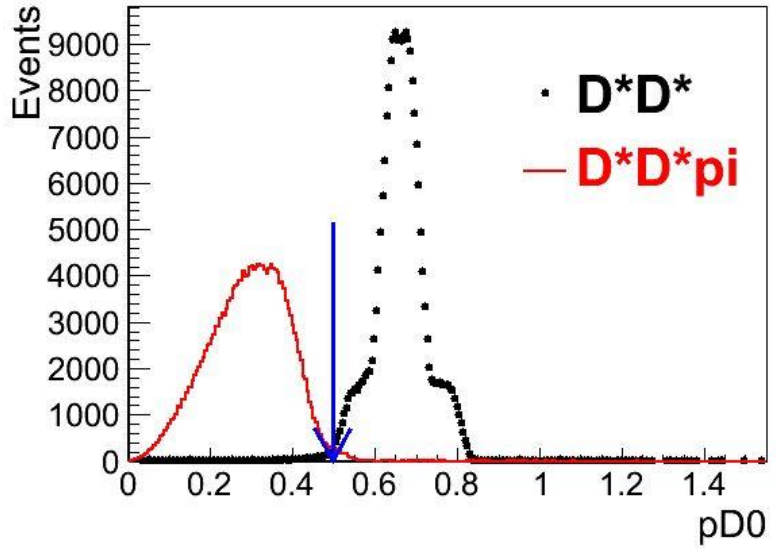
✓Tag D0 with Kπ mode

✓Tag D0* with π0+D0

✓At least one π+ or π- from other tracks ,in addition to D0

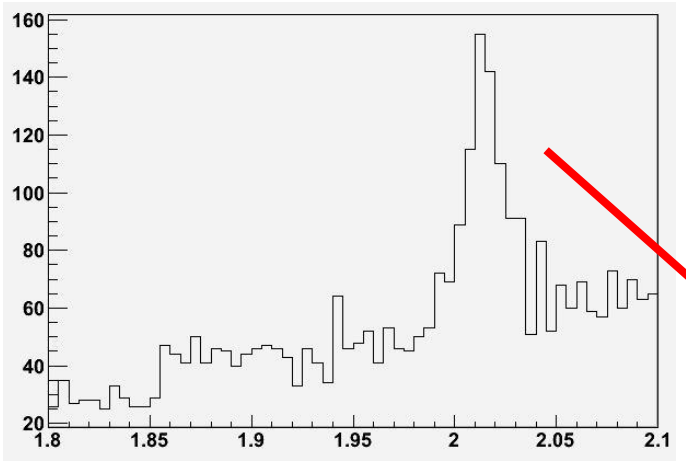
✓Mass of X in D0(*) π(±) + X while the momentum of D0 is less than 0.5GeV (D0 is not from D0(*)D0(*))

Momentum of D0 :

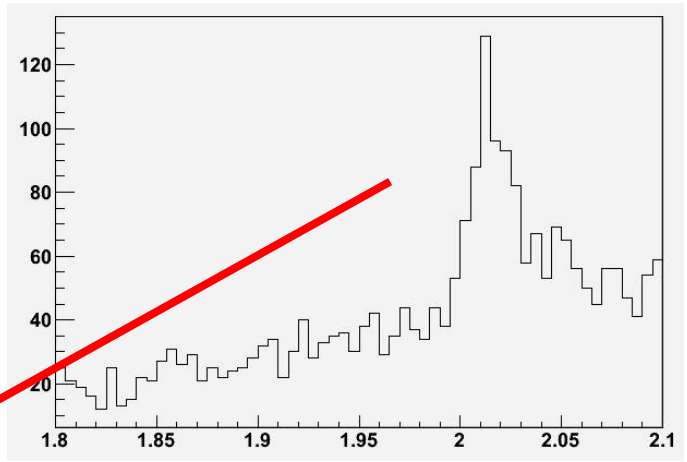


Evidence for Multi-body processes

Recoil mass of D0π+:

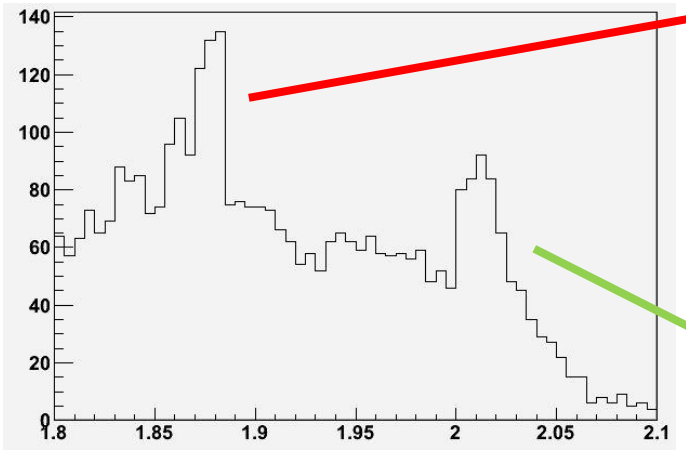


Recoil mass of D0barπ-:

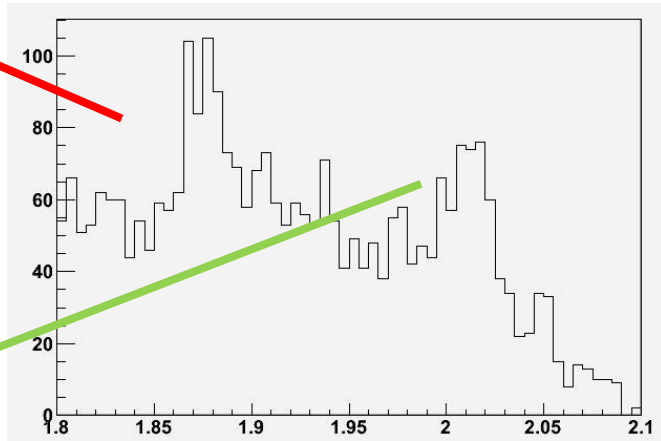


D*Dπ signal!

Recoil mass of D0*π+:



Recoil mass of D0*barπ-:



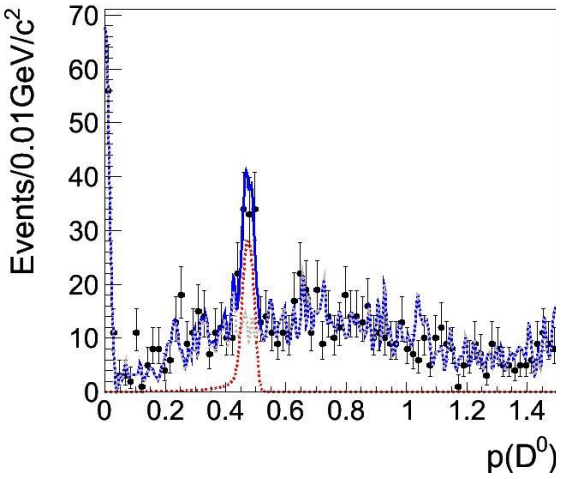
D*D*π signal!

Conclusion: D*Dπ and D*D*π processes are showed up , but no obviously evidence for DDπ! Any other ?

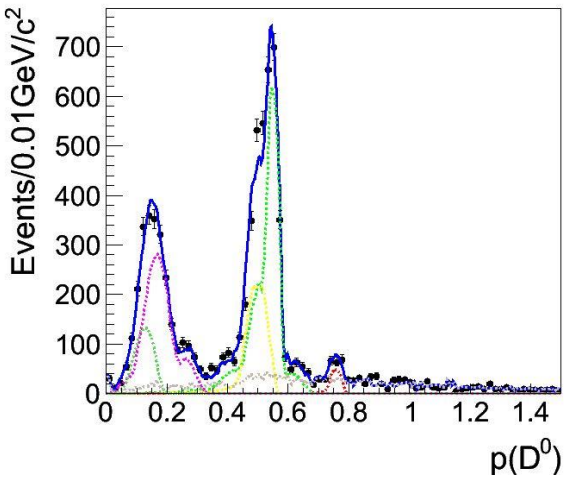
Thresholds of different channels

For D0 :		For D+ :		For Ds+ :	
Channel	Energy /GeV	Channel	Energy / GeV	Channel	Energy / GeV
D0D0bar	3.73	D+D-	3.74	Ds+Ds-	3.94
D0*D0bar	3.872	D+*D-	3.88	Ds+*Ds-	4.082
D+*D-	3.88	D*Dπ	4.017	Ds+*Ds-*	4.225
D0*D0*bar	4.015	D+*D-*	4.021		
D*Dπ	4.017	D*D*π	4.157		
D+*D-*	4.021				
D*D*π	4.157				

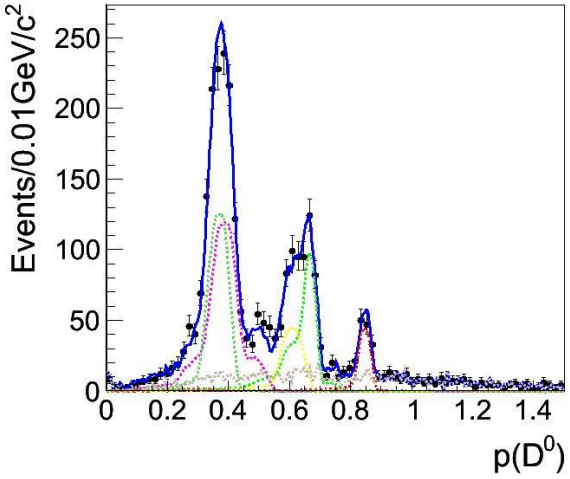
Fitting result of R-scan data(D0)



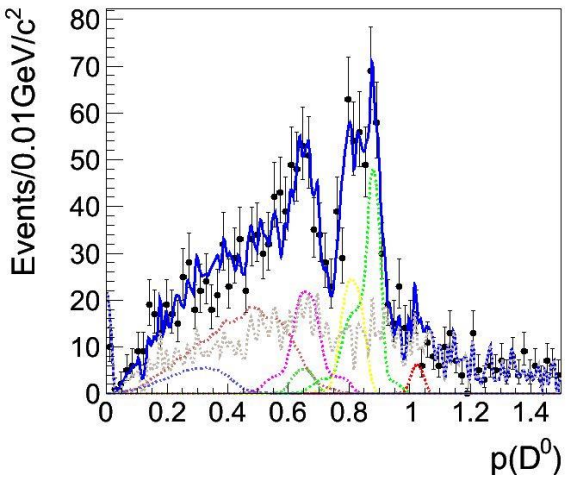
@3.850GeV



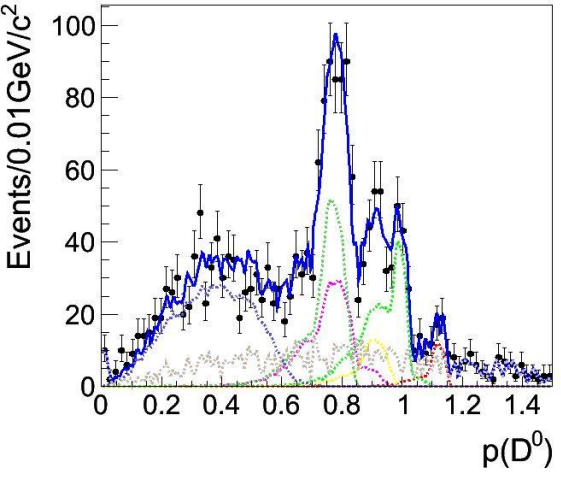
@4.030GeV



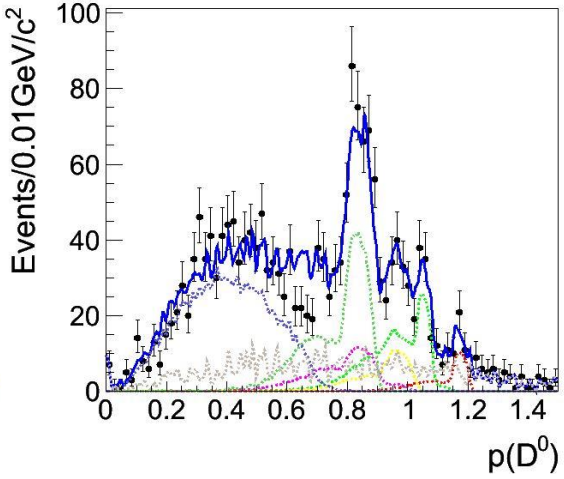
@4.100GeV



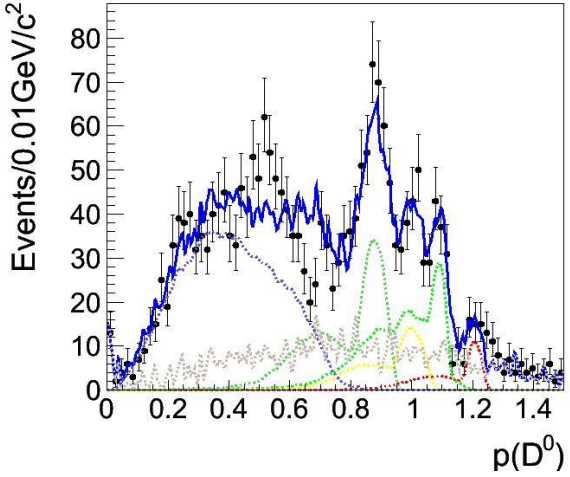
@4.260GeV



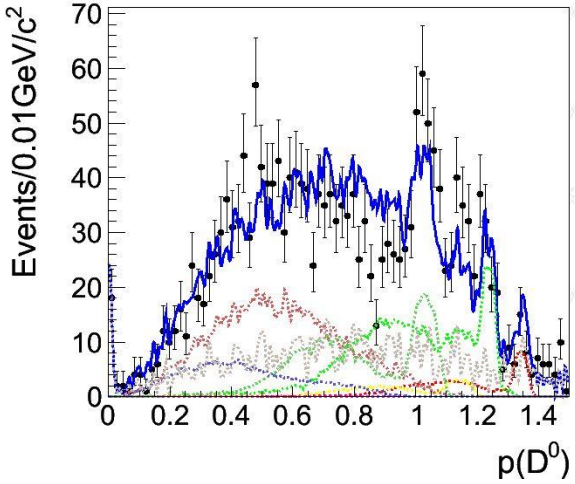
@4.360GeV



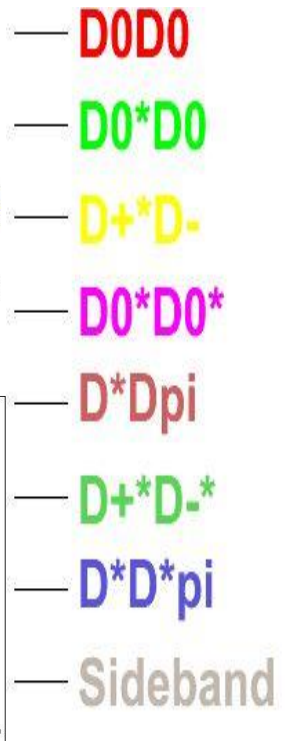
@4.410GeV



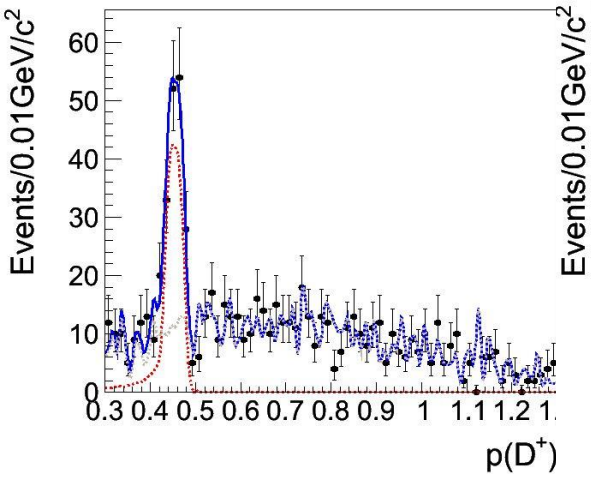
@4.450GeV



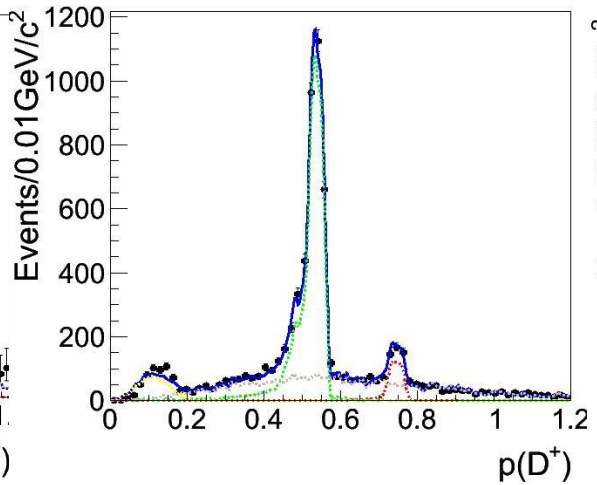
@4.590GeV



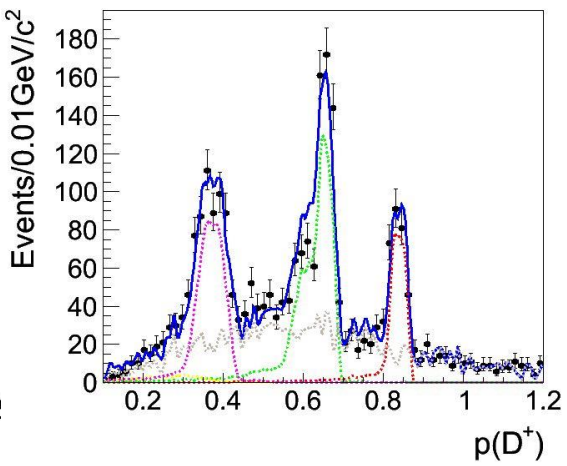
Fitting result of R-scan data(D+)



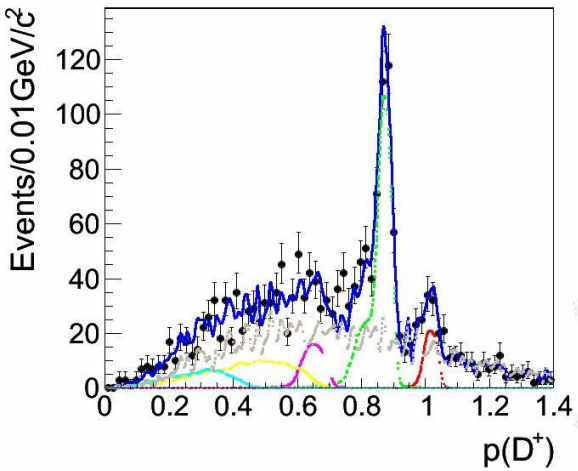
@3.850GeV



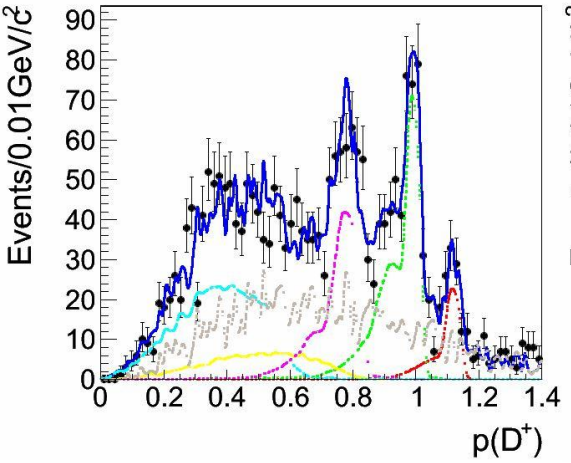
@4.030GeV



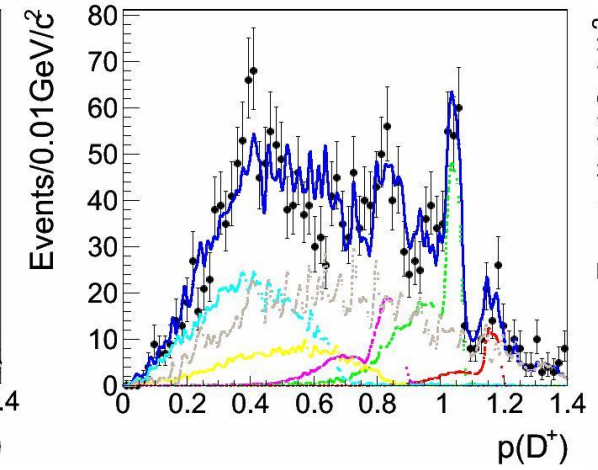
@4.100GeV



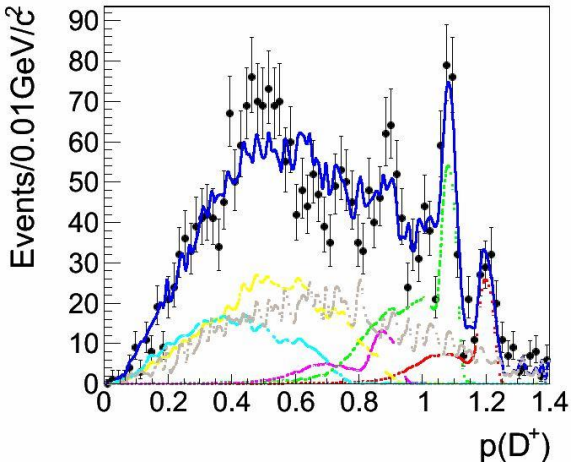
@4.260GeV



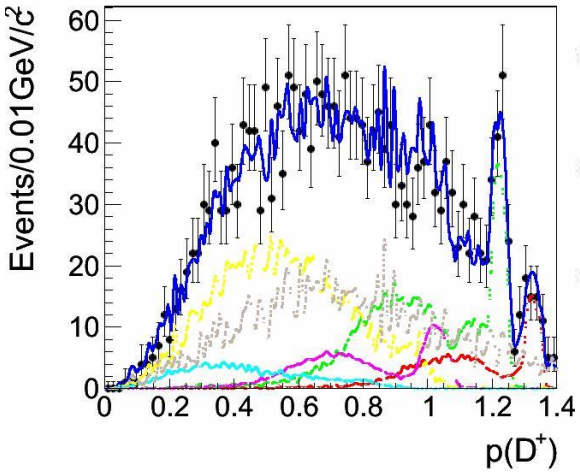
@4.360GeV



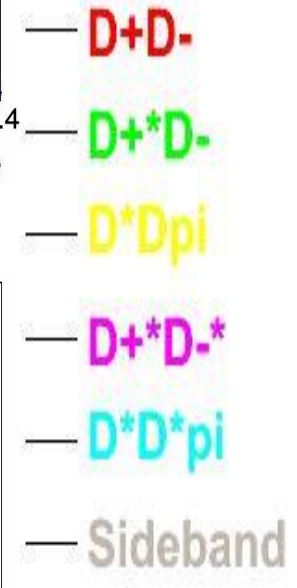
@4.410GeV



@4.450GeV



@4.590GeV



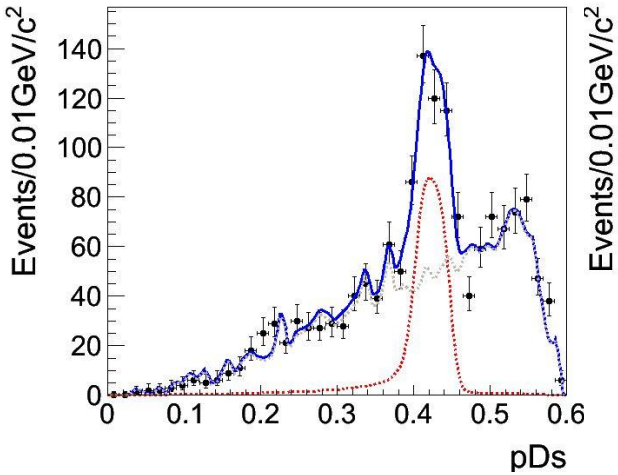
Fitting result of R-scan data(Ds+)

Ds+Ds-

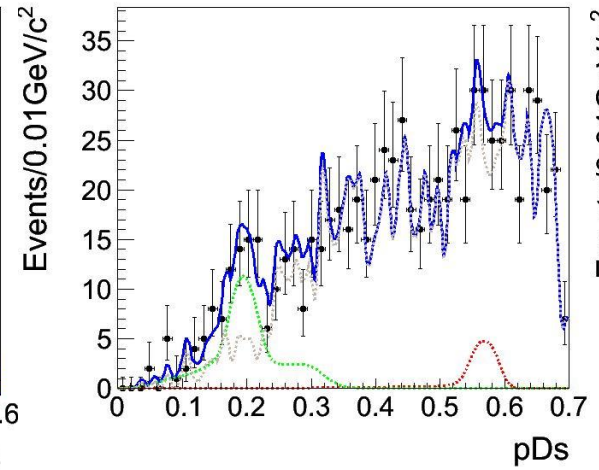
Ds+*Ds-

Ds+*Ds-*

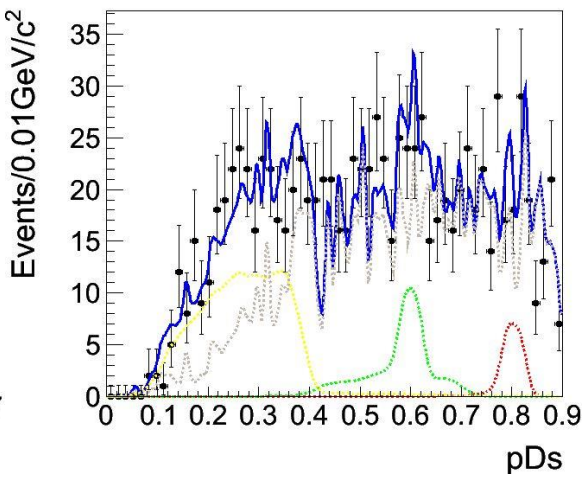
Sideband



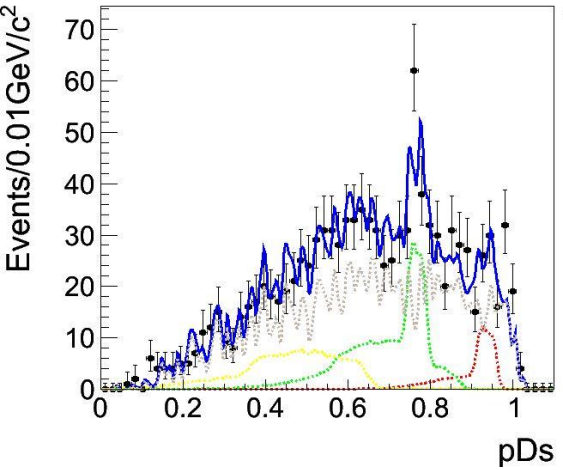
@4.030GeV



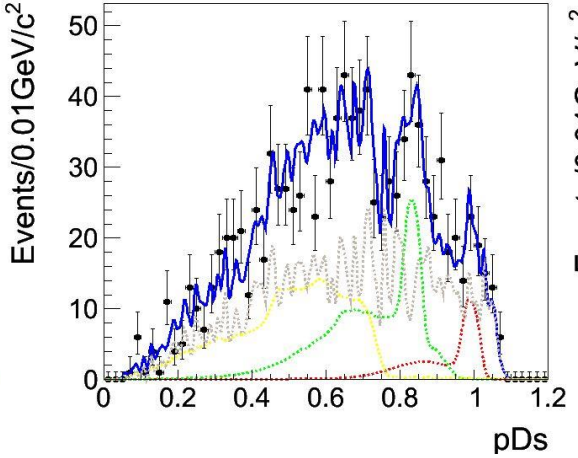
@4.100GeV



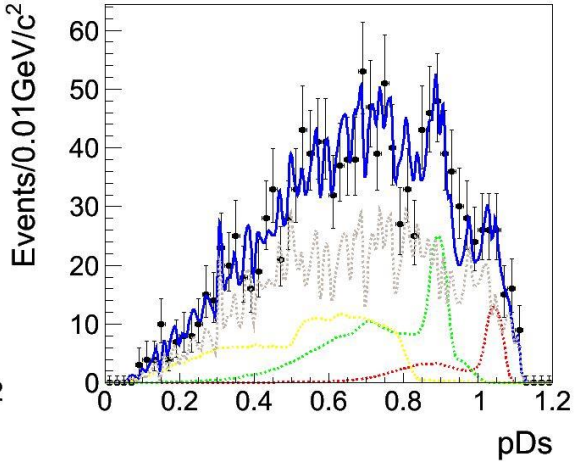
@4.260GeV



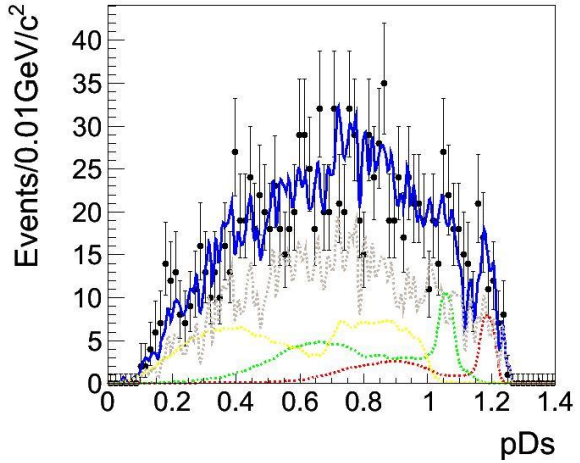
@4.360GeV



@4.410GeV



@4.450GeV



@4.590GeV

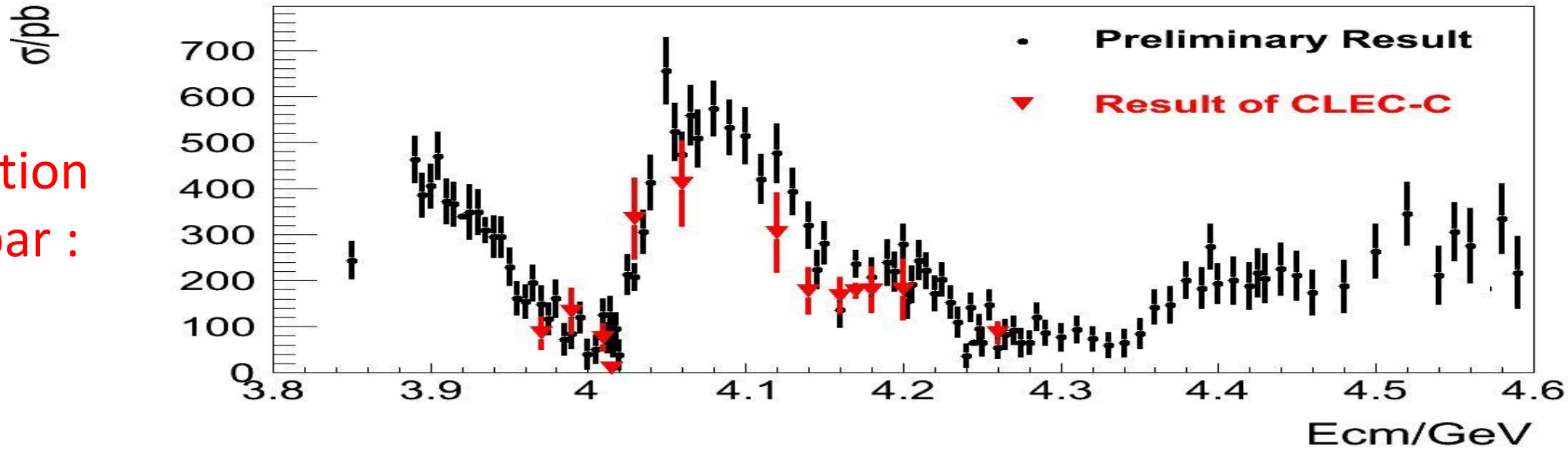
Cross section measurement

- N_{obs} : fitting result of each exclusive channel at each energy point.
- L : luminosity for R-scan data from Prof. Zhang Binxin's result.
- 1+δ : ISR correction from KKMC generator.
- Br : branching fraction of each tag mode.
- ε : detection efficiency

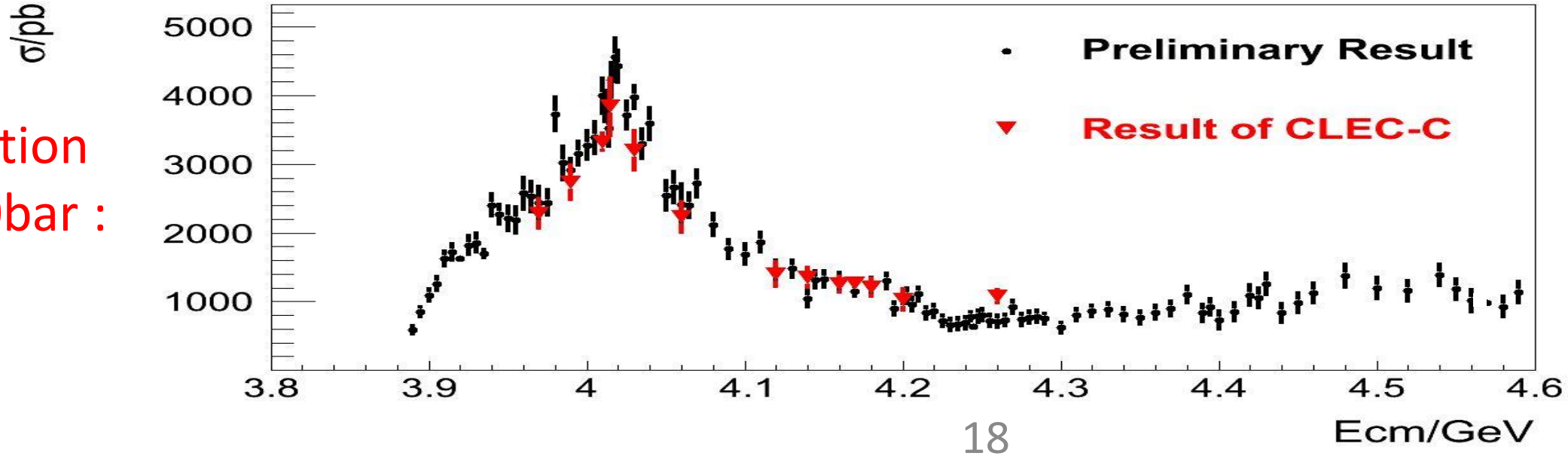
$$\sigma = \frac{N_{obs}}{L \cdot \varepsilon \cdot (1+\delta) \cdot Br}$$

Cross section(D0D0bar and D0*D0bar)

Cross section of D0D0bar :

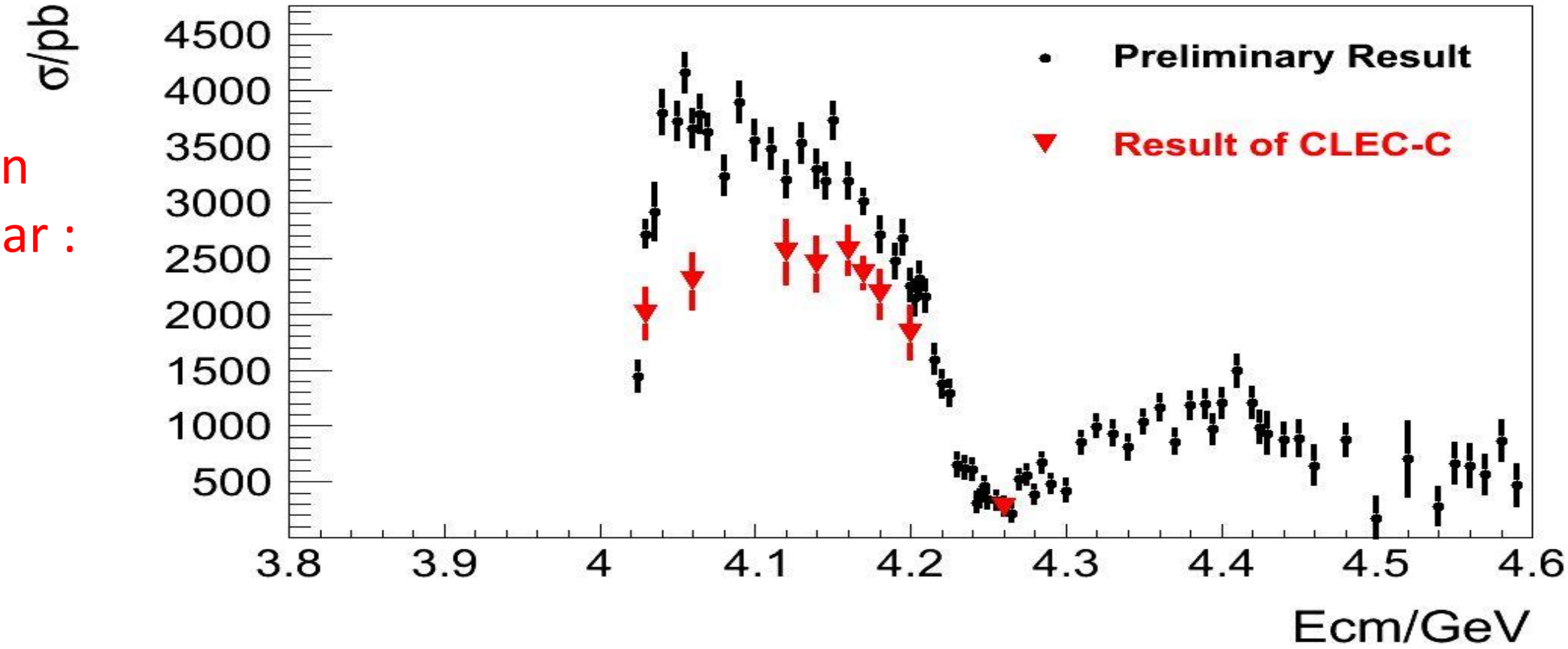


Cross section of D0*D0bar :



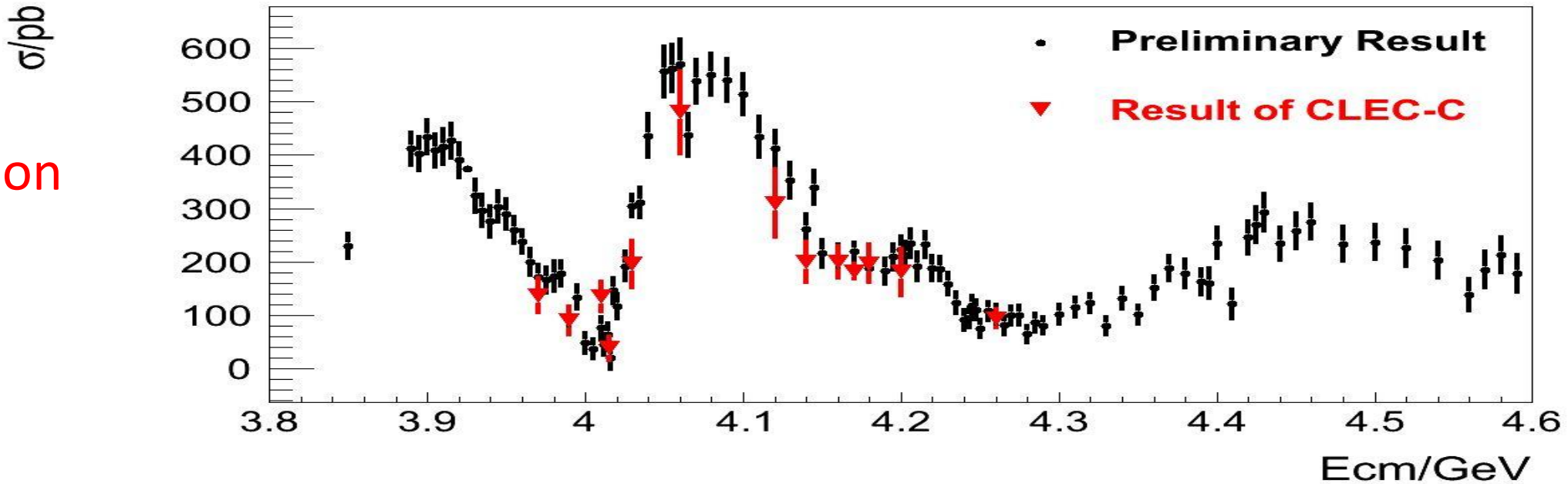
Cross section(D0*D0*bar)

Cross section of D0*D0*bar :

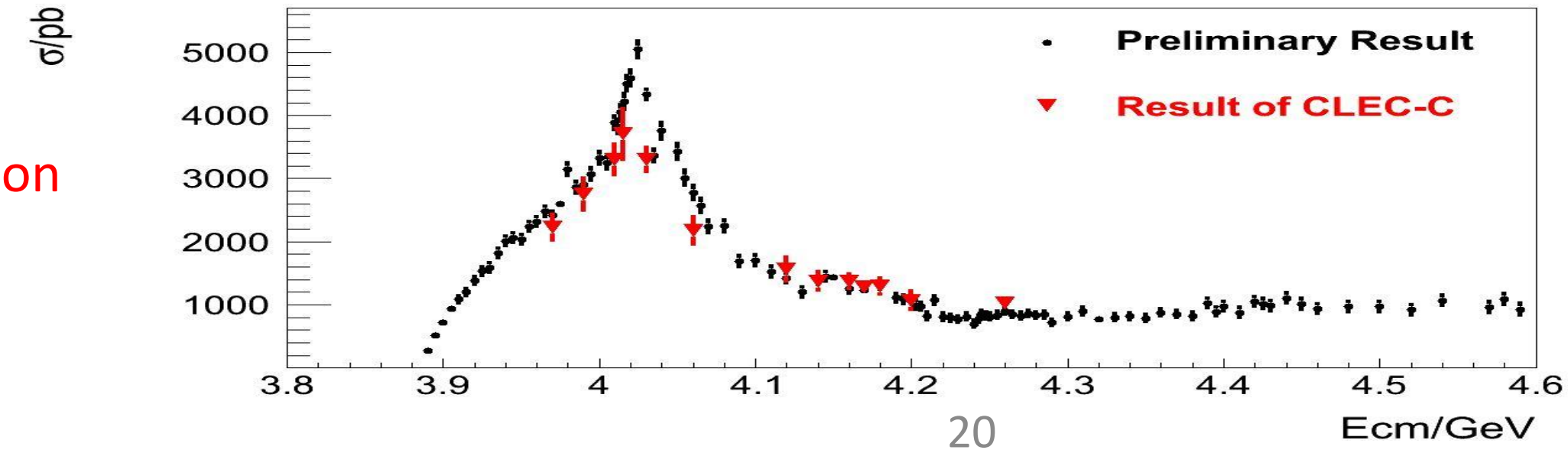


Cross section(D+D- and D+*D-)

Cross section of D+D- :

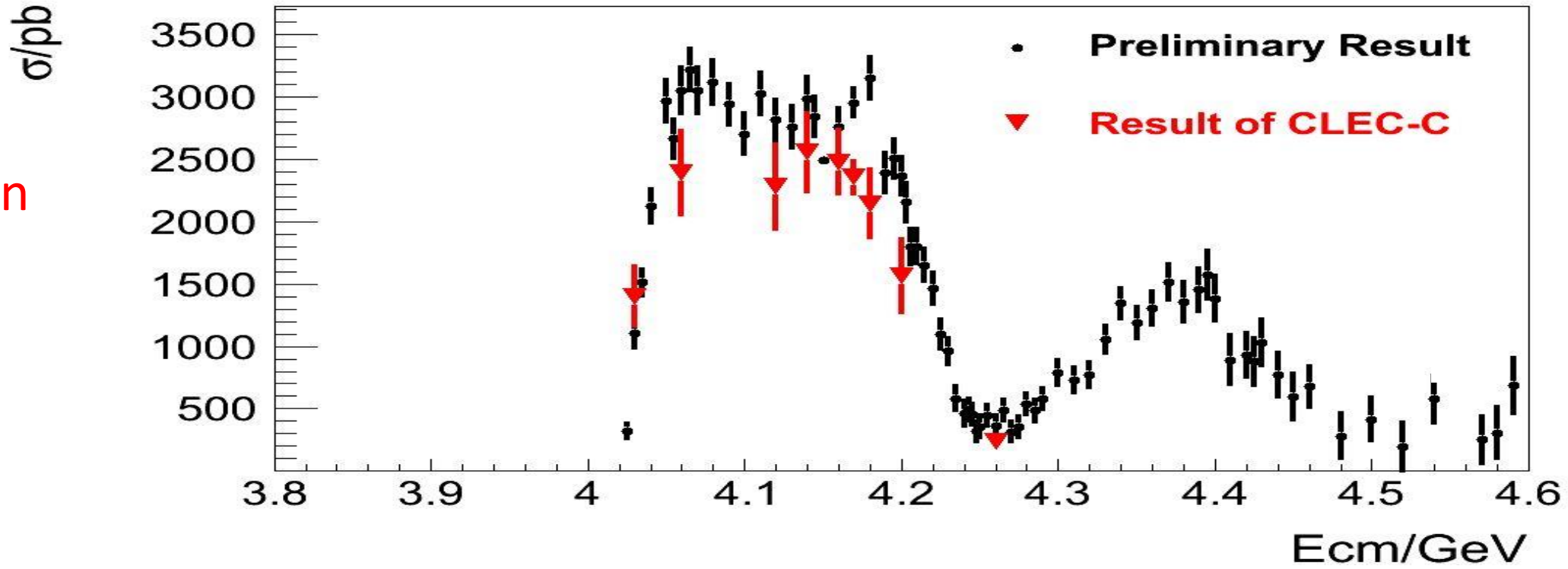


Cross section of D+*D- :



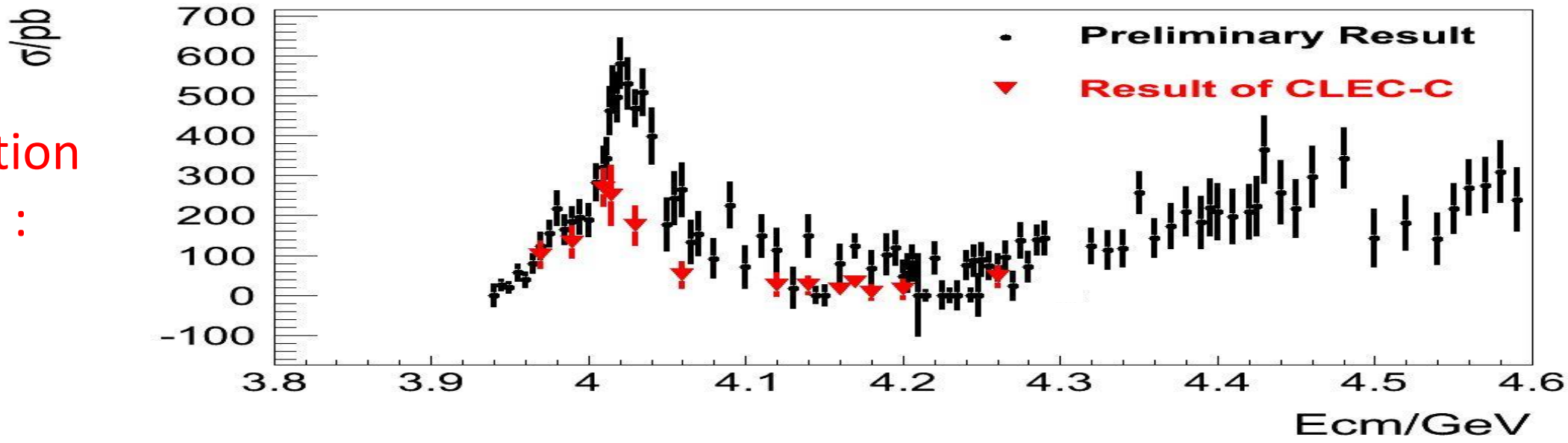
Cross section(D+*D-*)

Cross section of D+*D-* :

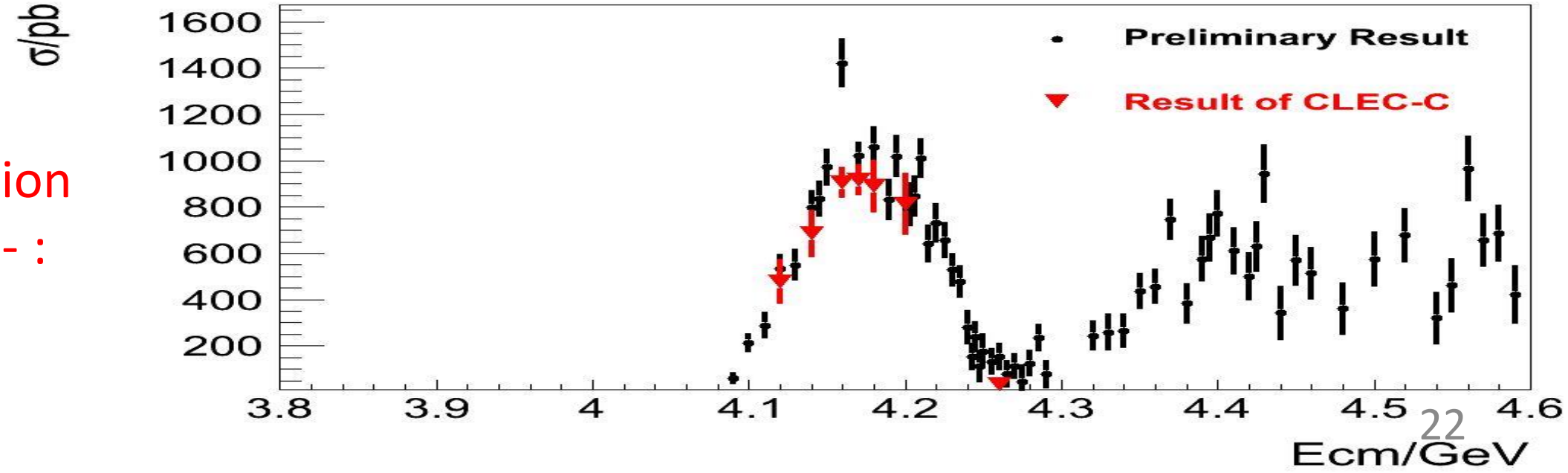


Cross section(Ds+Ds- and Ds+*Ds-)

Cross section of Ds+Ds- :

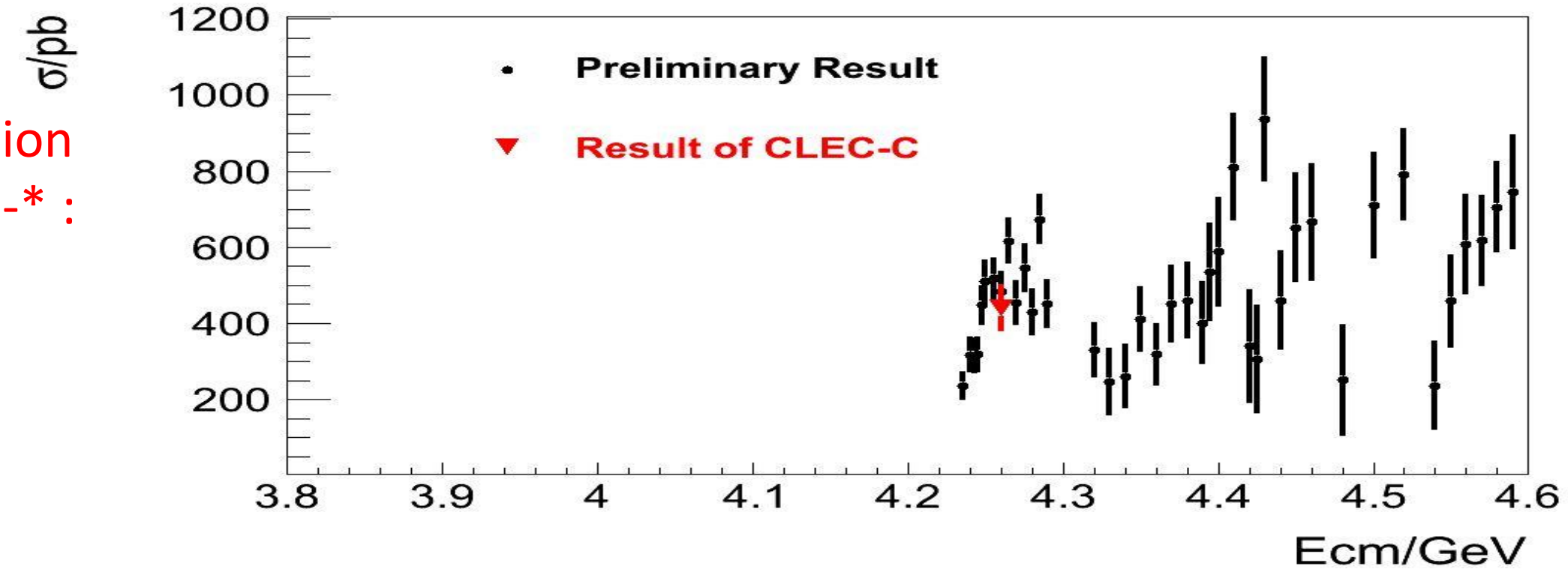


Cross section of Ds+*Ds- :



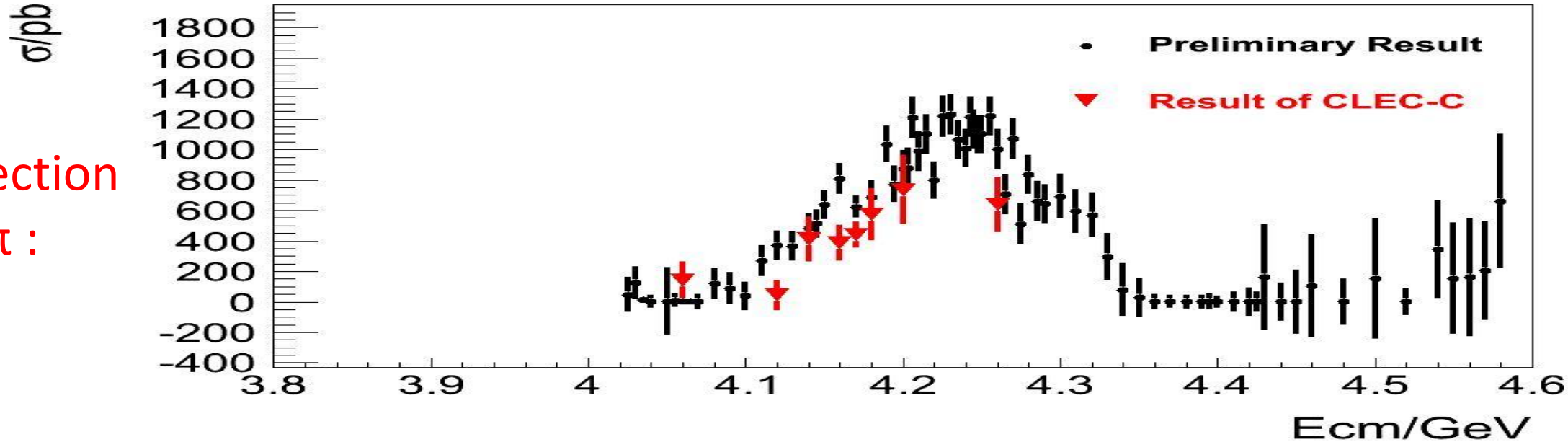
Cross section(Ds+*Ds-*)

Cross section of Ds+*Ds-* :

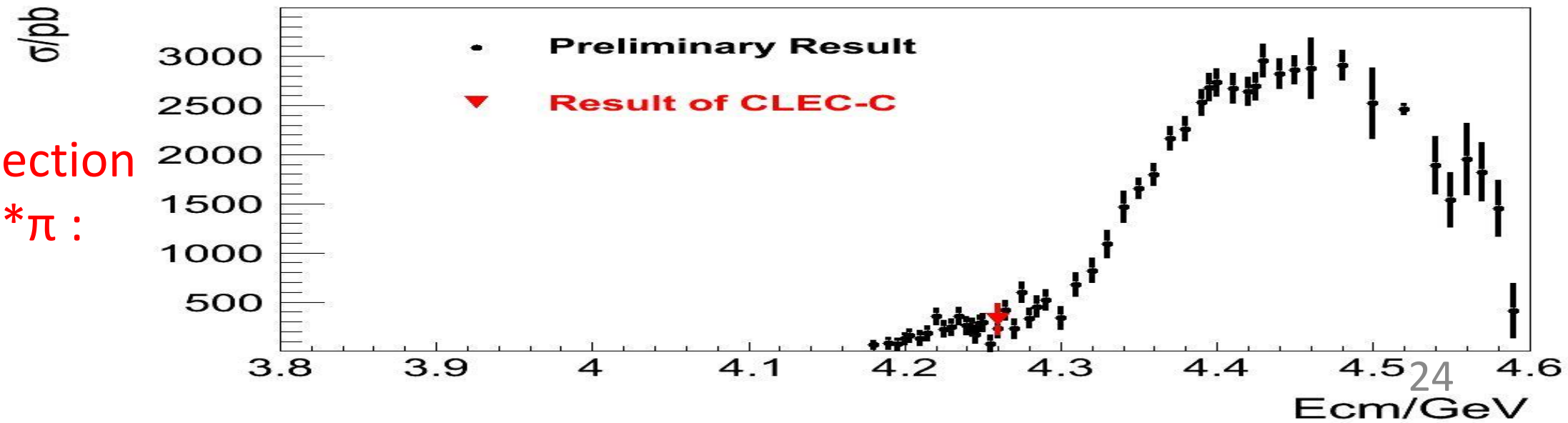


Cross section($D^*D^{(*)}\pi$)

Cross section of $D^*D\pi$:



Cross section of $D^*D^*\pi$:



Discussion

- The cross sections of exclusive channels for D0(*)D0(*), D+(*)D-(*), Ds+(*)Ds-(*) and D*D(*)π are presented .

- In low energy range, DD, D*D, D*D* can be well separated as three peaks in the distribution of momentum, so the fitting results seem to be good. But at the higher energies, the three peaks are getting closer and thus hard to get good results.

- For multi-body processes, since there are no obvious peaks for D*D π and D*D*π, the fittings are not so stable.

Summary

- Preliminary results of open charm cross sections from 3.85GeV to 4.59GeV are presented using R-scan data(2013--2014).
- Different components are separated according to their momentum distributions, but the method does not work well at higher energies.
- For some channels, the MC can not describe data well.
- First round of inputs for LundARLW tuning is ready.
- Further study of ISR correction factor is still needed.