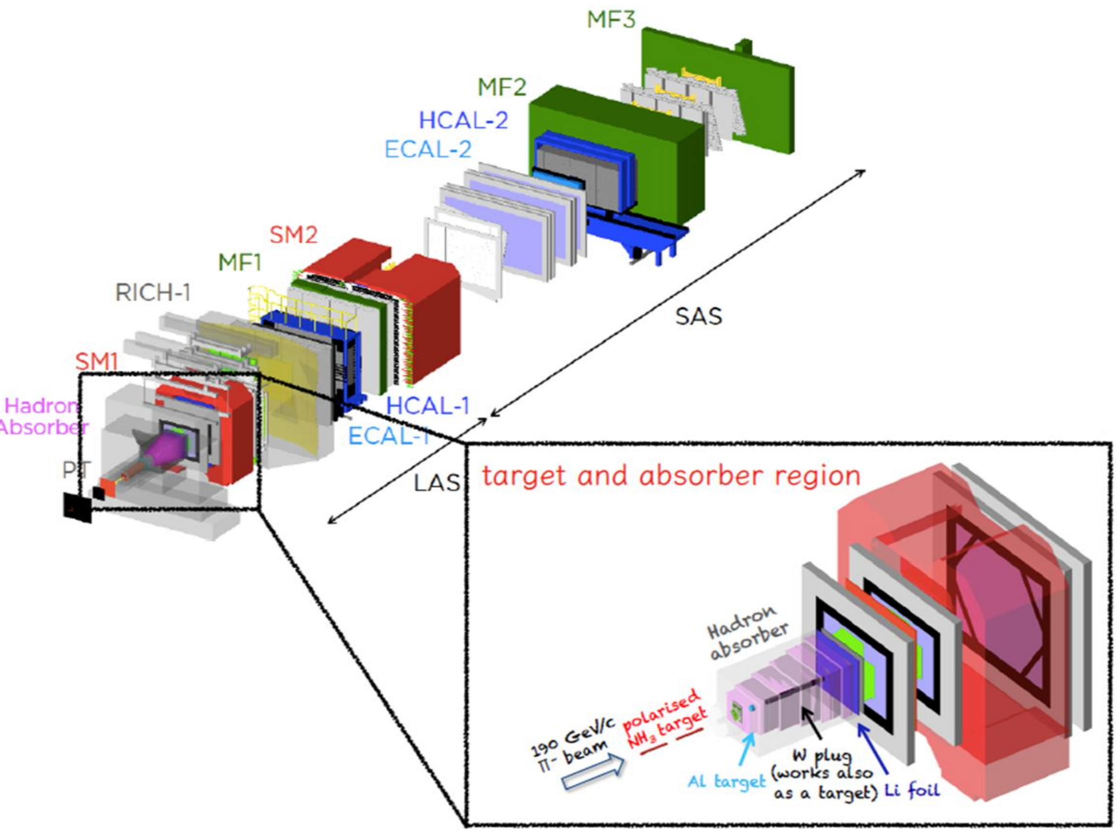
Measurement of Pion-induced Drell-Yan and JPsi Cross Section at COMPASS

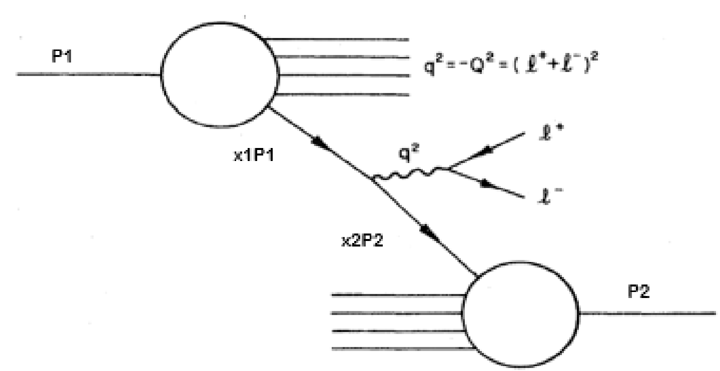
Chia-Yu Hsieh

Wen-Chen Chang, Stephane Platchkov,

Takahiro Sawada, Marcia Quaresma, Vincent Andrieux,
Charles Joseph Naim, Marco Meyer, Yu-Shiang Lian

COMPASS Setup





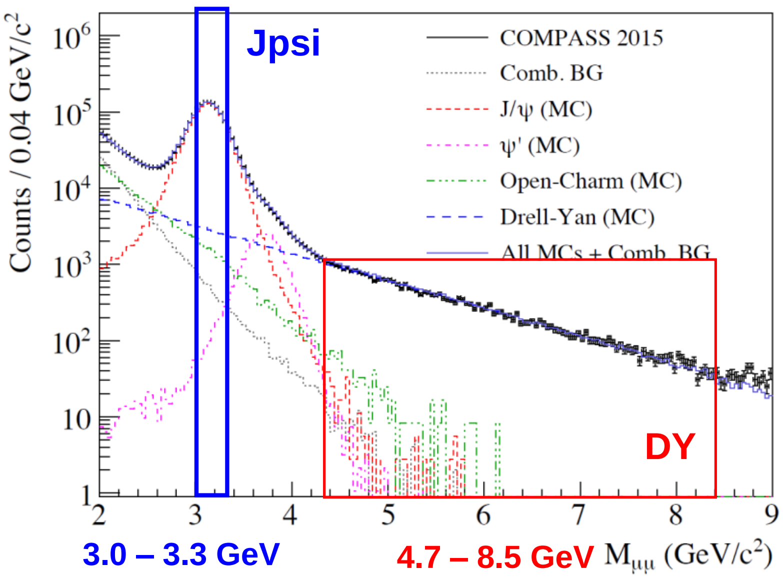
$\pi^- + p \rightarrow \mu + \mu^- + X$

π^- beam | NH_3, Al, W targets | *Dimuon events* | *Hadron absorber*

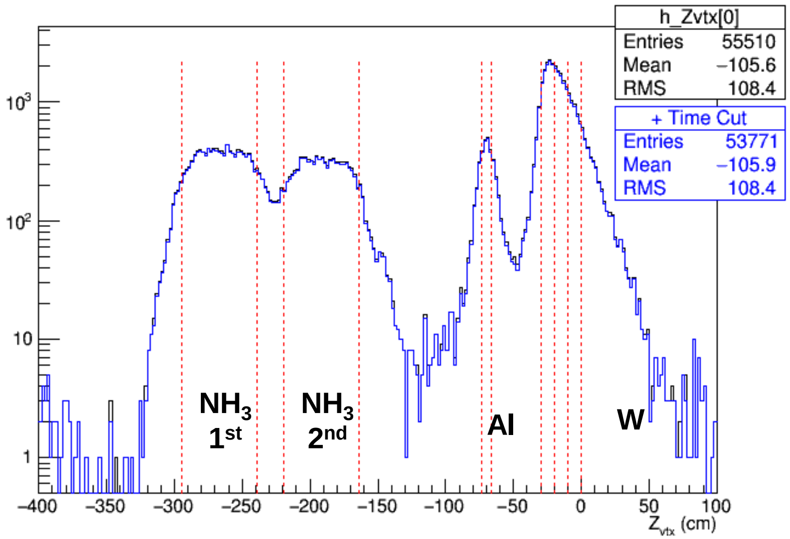
- **hA fix target experiment**
- **Pion beam :** π^- beam at 190 GeV/c
- **Multiple targets are used to study nuclear effect:** NH_3, Al, W
- **Hadron absorber is used to have a clean dimuon sample**

Physics Topic

Mass spectrum



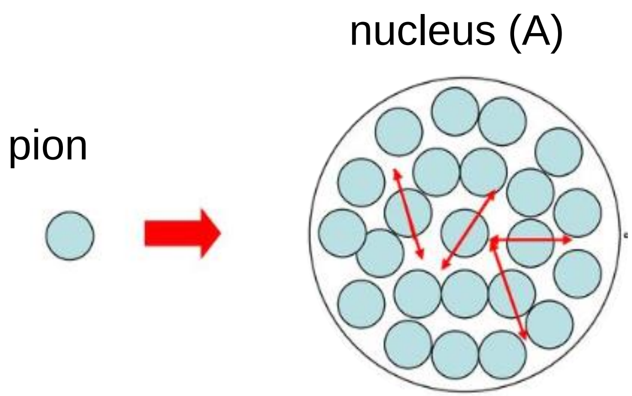
Zvtx spectrum

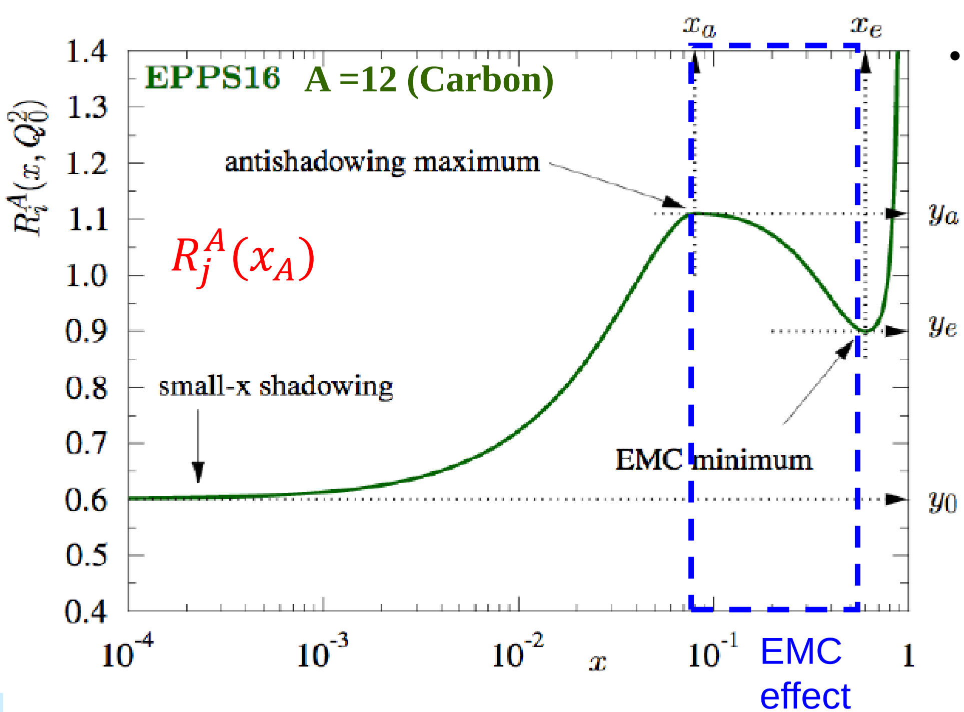


- **Subject :**
- Absolute Xsection of J/Psi, DY process
- Nuclear PDF
- Cold Matter Nuclear effect

- **We will take a look of the absolute Xsection and nuclear effect from J/Psi, DY process with COMPASS data.**

Cold Nuclear Matter Effect (1) : Nuclear Modification in PDF





- ***hA collision***

$$\frac{d\sigma(hA)}{dx_F} = \sum_{i,j=q,\bar{q},g} \int_0^1 dx_h \int_0^1 dx_A \, f_i^h(x_h) f_j^A(x_A) \frac{d\sigma_{hard}}{dx_F}$$

pion PDF *nuclear PDF*

- ***free PDF***

$$\boldsymbol{f_{free}^A(x_A)} = \frac{Z}{A} f_p(x_A) + \frac{A-Z}{A} f_n(x_A)$$

- ***nuclear PDF***

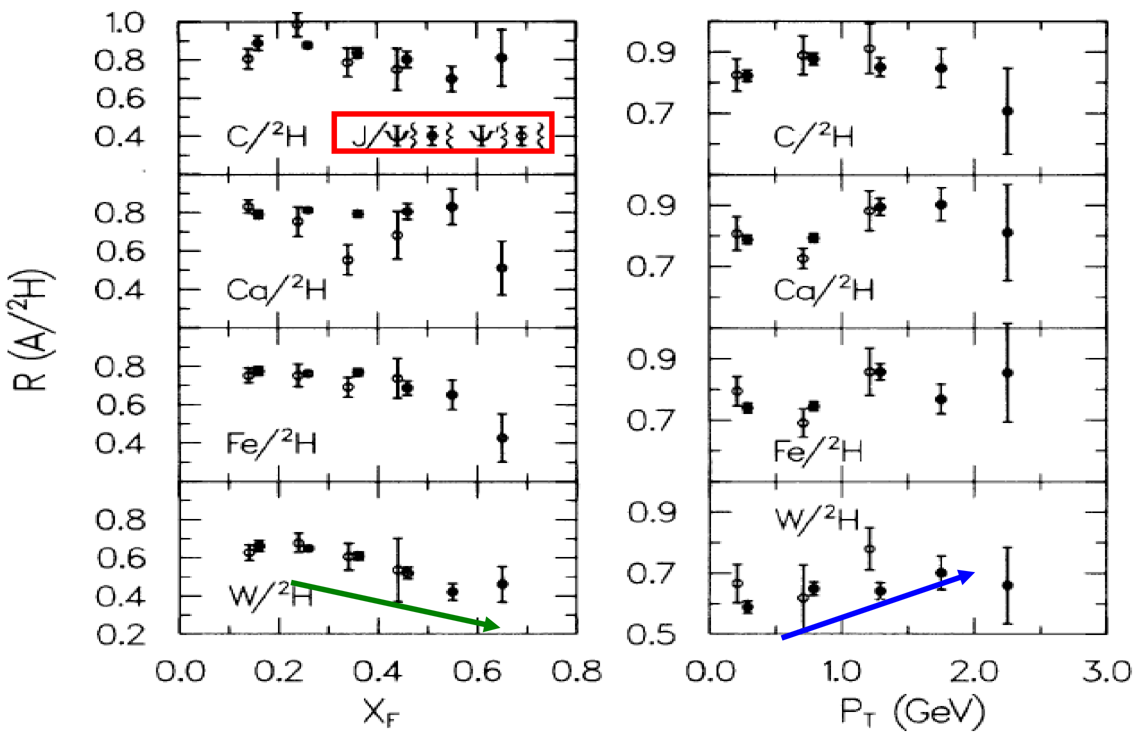
$$\boldsymbol{f^A(x_A)} = R_j^A(x_A) * f_{free}^A(x_A),$$

nuclear modification

Nuclear modification is strong x_A (x_F) dependent.

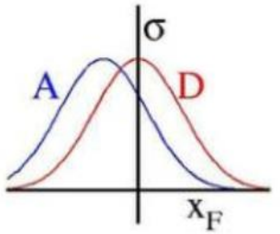
Cold Nuclear Matter Effect (2) : Nuclear Effect in xf and pt Distributions

E772 : 800GeV proton beam [PhysRevLett.66.133]



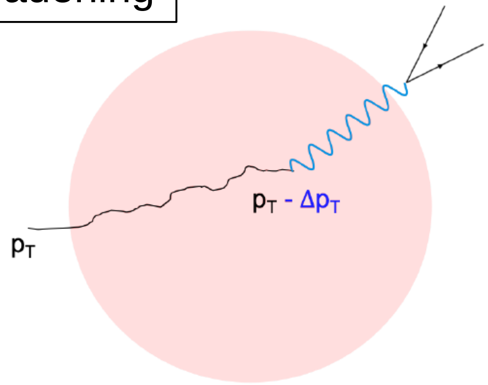
One common way to study nuclear effect is to measure the Xsection of several targets and study the ratio of Xsection between light and heavy target.

Parton energy loss



Energy loss of incident parton shifts effective x_F and produces nuclear suppression which increases with x_F

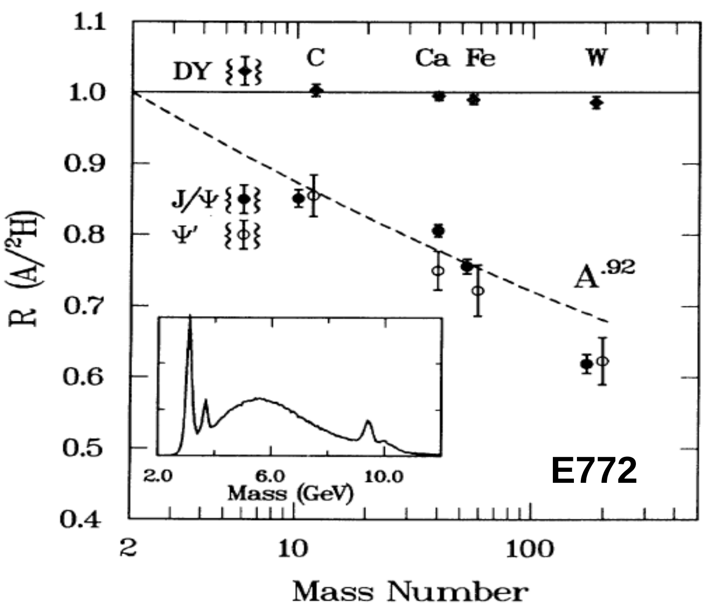
Pt Broadening



Parton energy loss : so call gluon radiation. It suppress the Xsection of heavy target in high xf region.

Pt Broadening : Multiple scattering of parton broaden the pt distribution for heavy target.

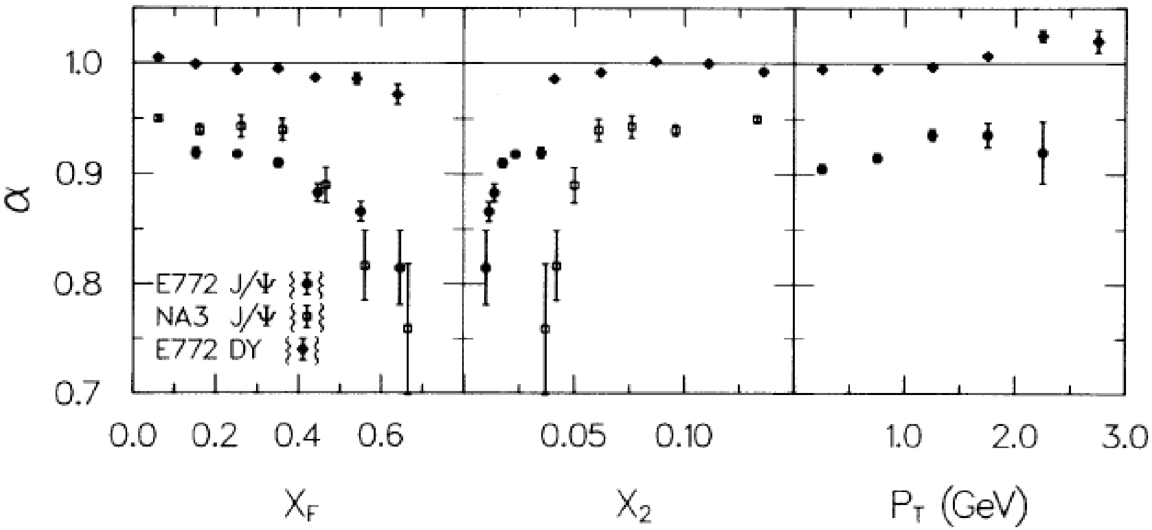
Cold Nuclear Matter Effect (3) : Parameterization of Nuclear Effect α



$$\sigma_A = \sigma_p A^{\alpha} \quad (Xsection\ per\ nucleus)$$

$$\Rightarrow R = \frac{\sigma_A/A}{\sigma_{H_2}/2} = \left(\frac{A}{2}\right)^{\alpha-1} \quad (Xsection\ per\ nucleon)$$

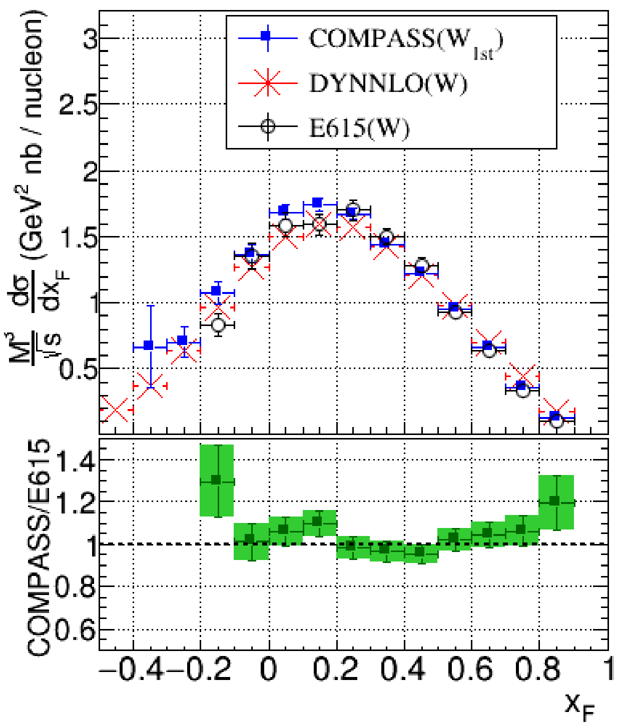
① σ_A: $Xsection\ of\ material$
② σ_N: $Xsection\ of\ proton/neutron$
③ $A = mass\ number$
④ $\alpha = strength\ of\ nuclear\ effect$



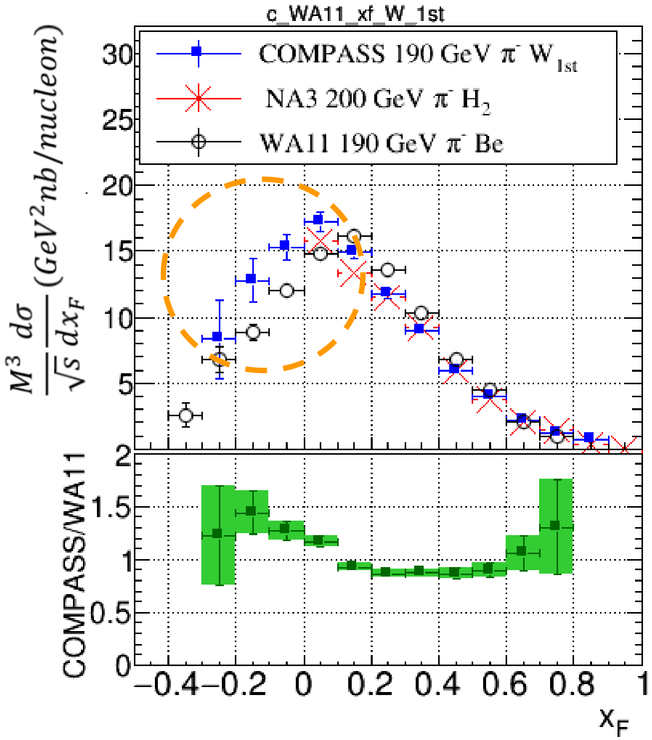
- α represents the strength of nuclear effect. When α is equal to 1, it means no nuclear effect.
- α doesn't scale with beam energy in xf and pt.

DY and J/Psi Xsection for W target

DY Xsection of W targe (10cm)



J/Psi Xsection of W target (10cm)



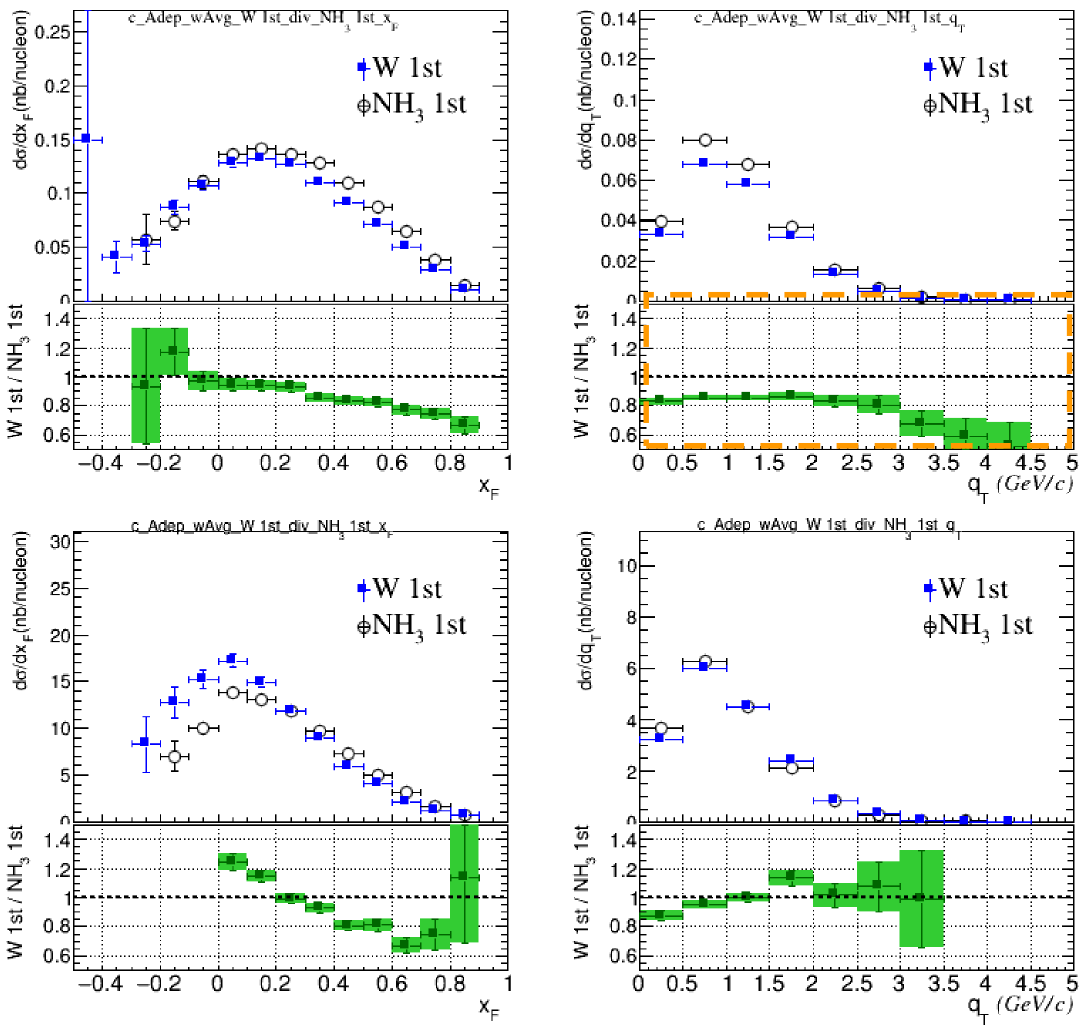
COMPASS results shows reasonable normalization for both DY and J/Psi Xsection. But there are small discrepancy in low and high xf region.

W 1st / NH_3 1st

xf **pt**

DY

JPsi



- The trend of Xsection ratio between W(heavy) and NH3(light) targets is like expected.

① Ratio in xf drops toward higher xf region.
② Ratio in pt raised toward high pt region. However, there is no obvious pt boardening effect observed in DY process.

- J/Psi process has stronger nuclear effect than DY process in general.

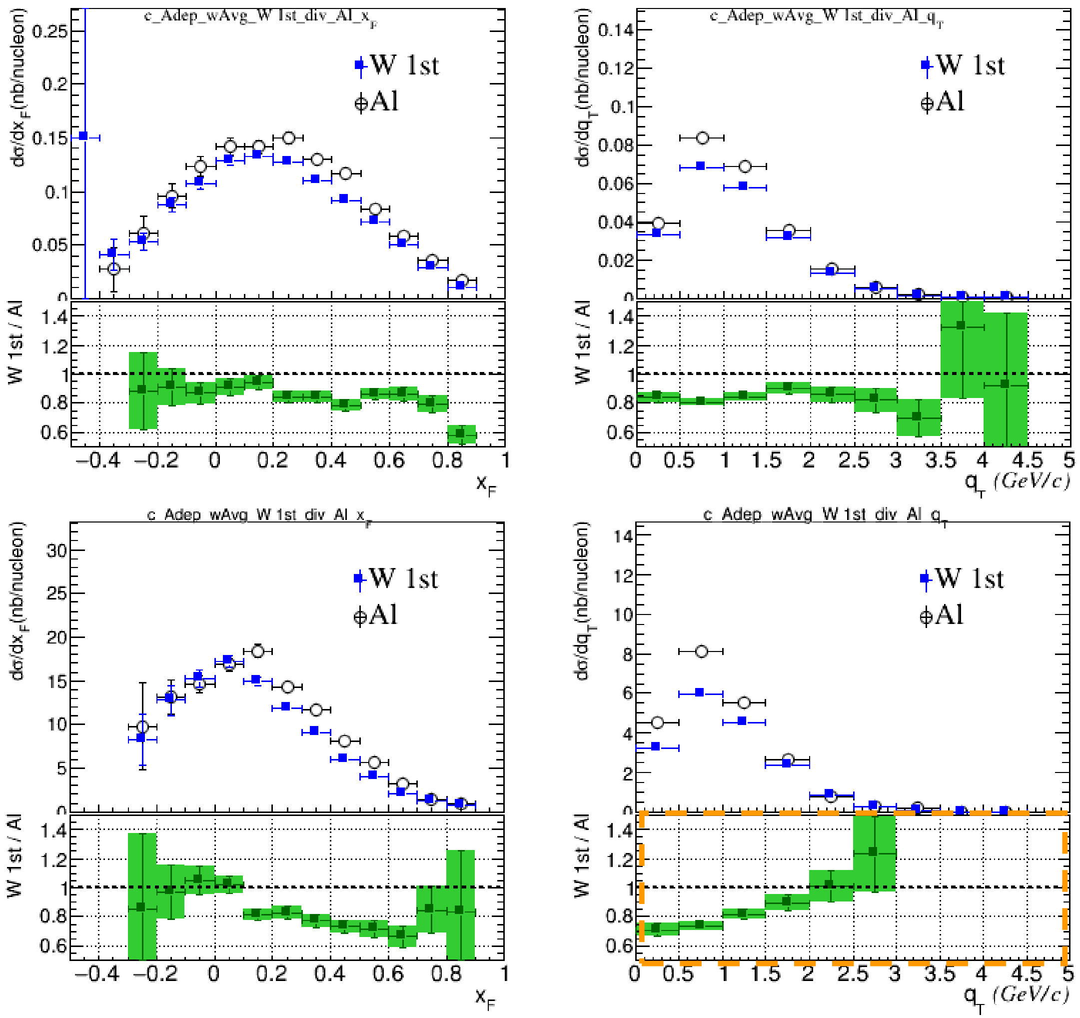
W 1^{st} / Al

xf

pt

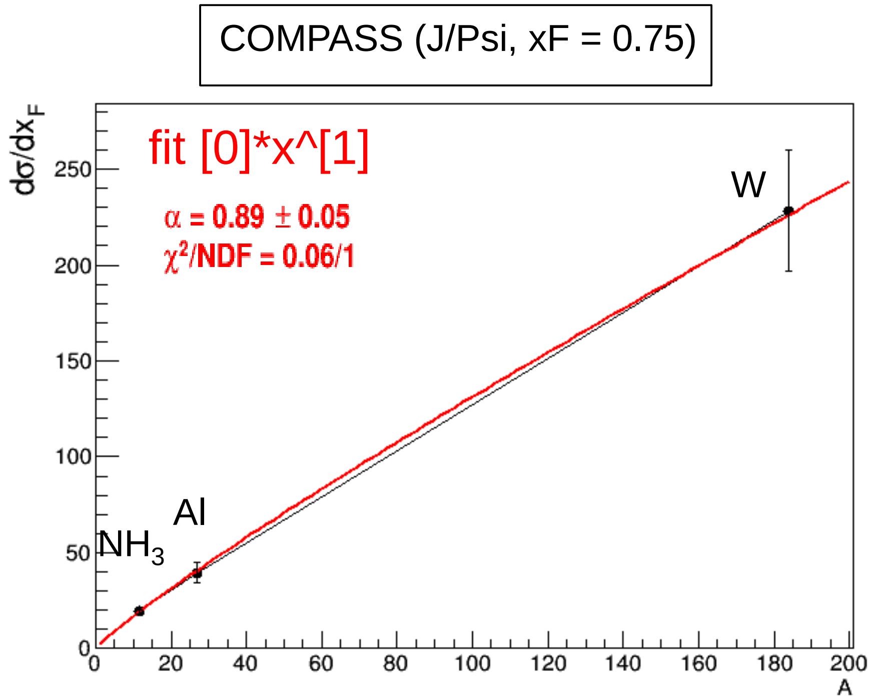
DY

JPsi



Like expected, stronger nuclear effect observed in [W 1^{st}, NH_3 1^{st}] than [W 1^{st}, Al].

Strength of Nuclear Effect in COMPASS

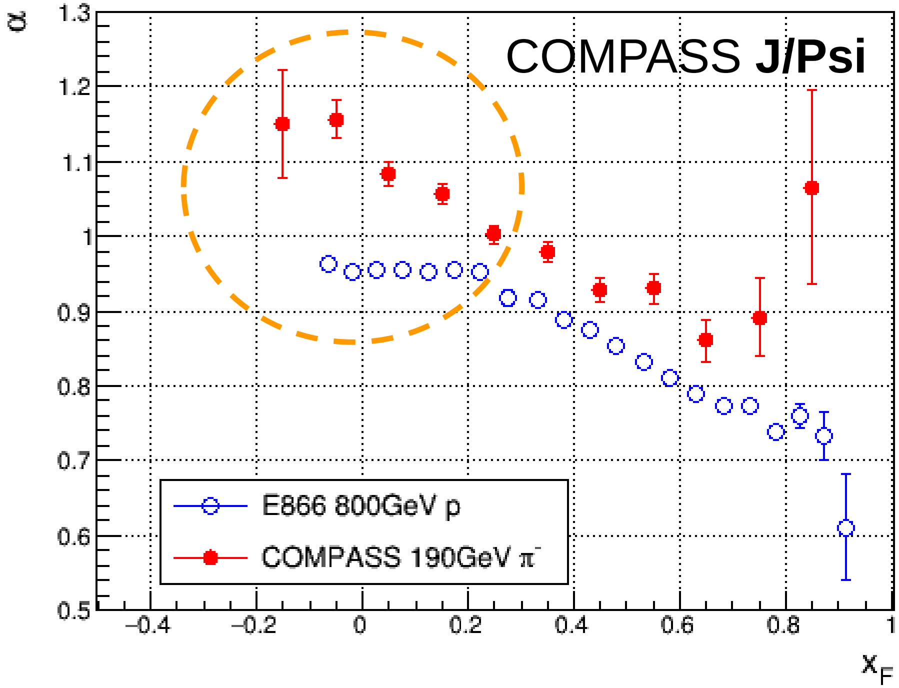


$$\sigma_A = \sigma_N A^{\alpha}.$$

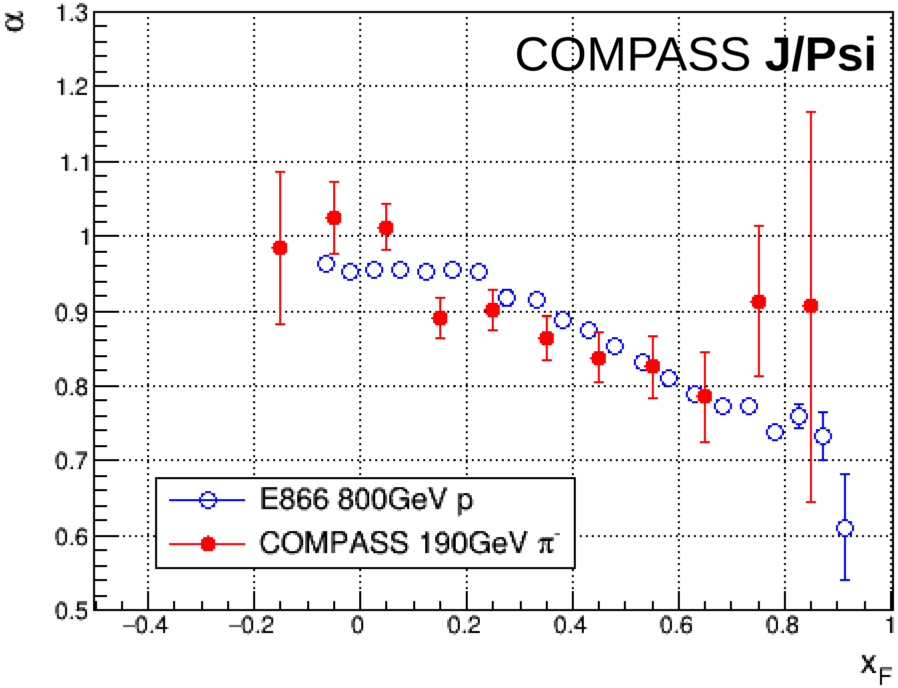
- σ_A: $Xsection\ of\ material\ (per\ nucleus)$
- σ_N: $Xsection\ of\ proton/neutron$
- $A = mass\ number$
- $\alpha = strength\ of\ nuclear\ effect$
- $if\ \alpha = 1, no\ nuclear\ effect$

Consider NH3 Target?

Fit NH3, Al, and W

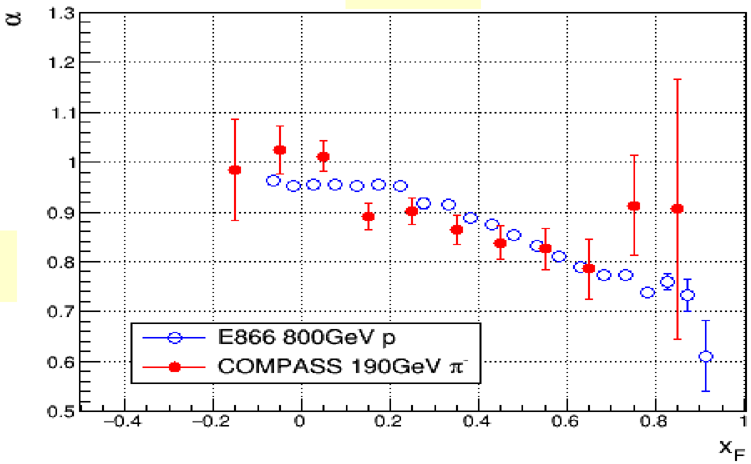
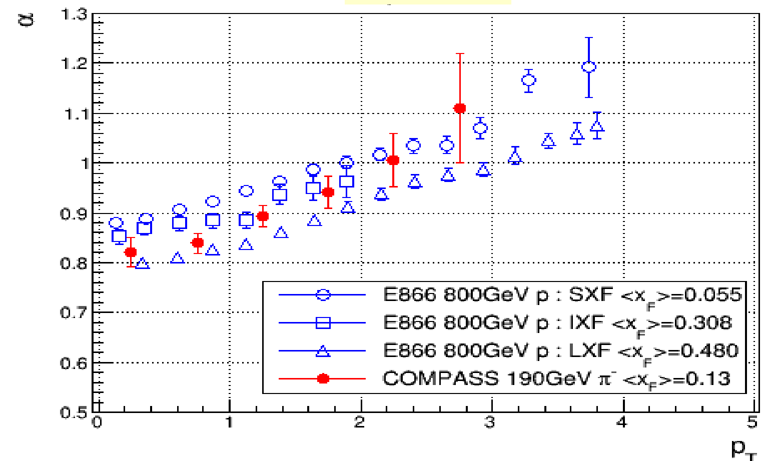
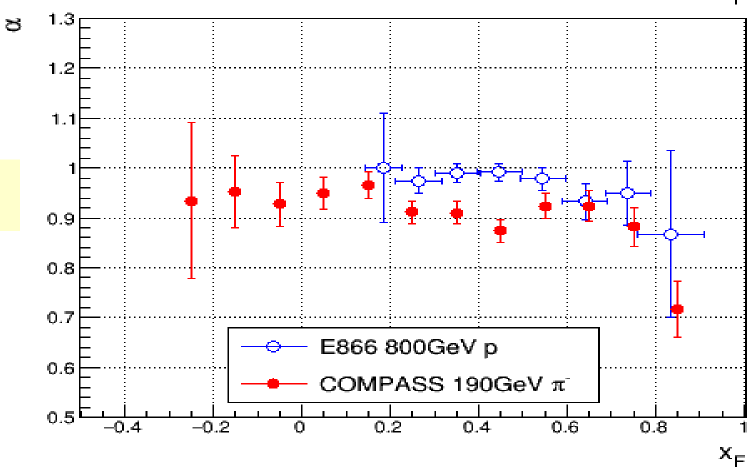
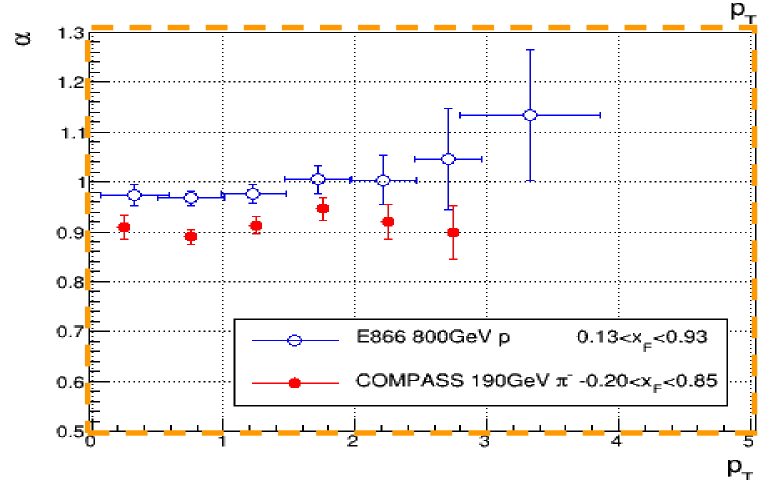


Fit Al, and W



- Results include NH3 is in general higher.
- NH3 is compound, maybe we should drop it when studying nuclear dependence?

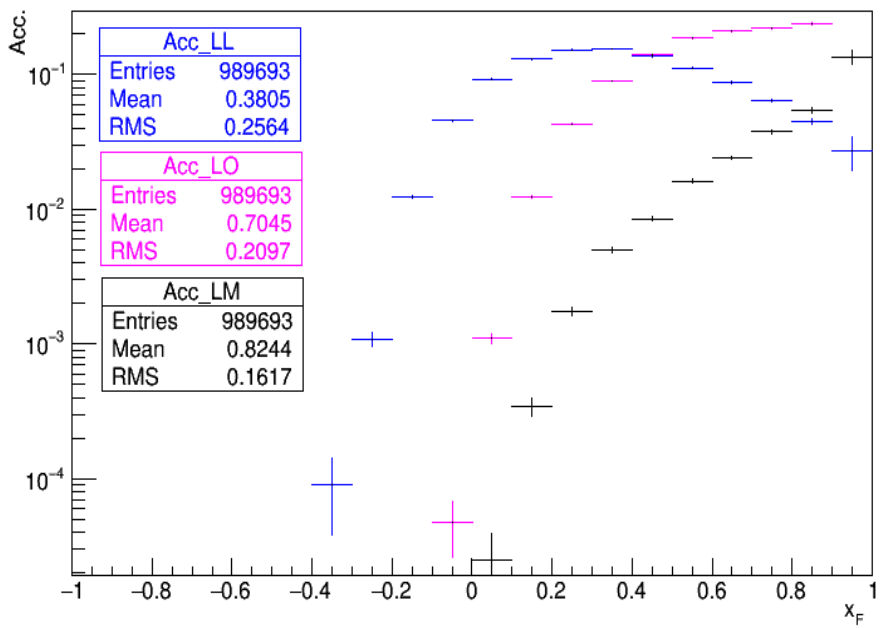
Strength of Nuclear Effect α (Exclude NH3 target)

	xf	pt
JPsi		
DY		

- Only fit Xsection of Al and W targets to access alpha.
- COMPASS is compatible w/ E866 in JPsi process.
- But in DY process, COMPASS has stronger nuclear effect than E866. (beam type, related?)

Systematics : Trigger Dependence

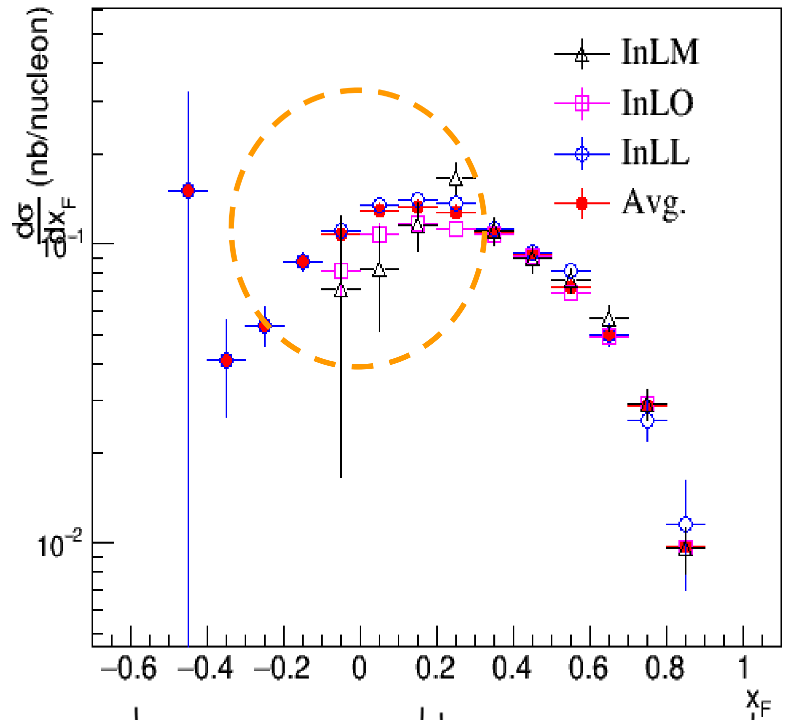
Acceptance Coverage of 3 Triggers



There are 3 kinds of dimuon trigger in COMPASS and they covers different xf regions of acceptance.

① **L**AS**x**LAS : low xf regions ()
② **L**ASx**O**ut : middle xf region
③ **L**ASx**M**T : high xf region (more energetic dimuon)

COMPASS DY Xsection of W target (10cm)



xf< 0.2 : mainly **LL** **xf>0.4** : mainly **LO**

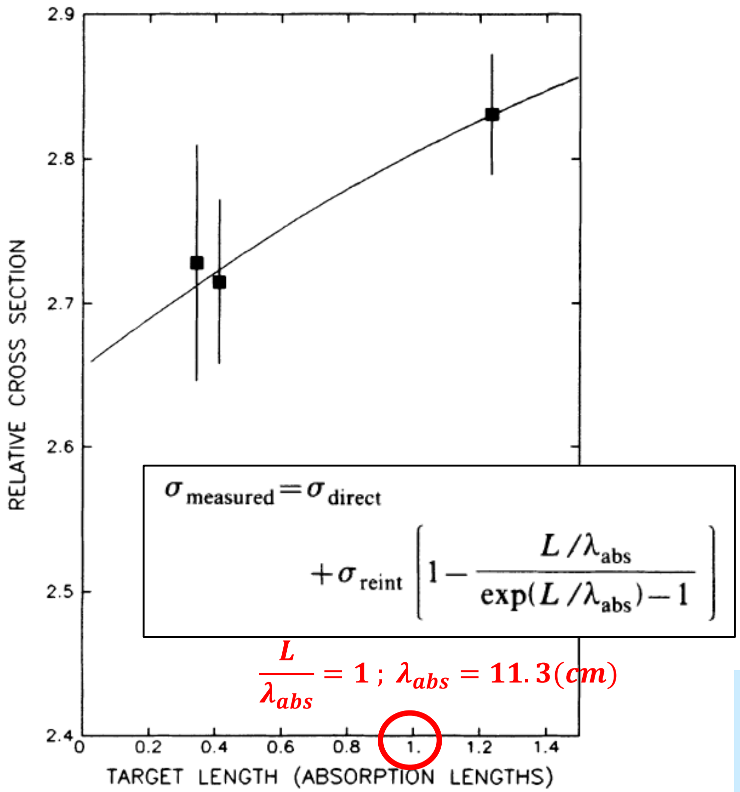
Discrepancy (~20%) in Xsection between LL and LO around xf = -0.2~0.2. It is the largest systematic uncertainly observed till now.

Summary

- COMPASS measured pion-induced DY and J/Psi Xsection and nuclear effect with NH_3, Al and W targets.
- DY and J/Psi Xsection of W target shows reasonable normalization compare to other experiments, E615, WA11, and NA3.
- We compare DY(J/Psi) Xsection between light and heavy targets (W/Al, W/NH3) and quantify nuclear effect. Nuclear effect of J/Psi is comparable with E886, but stronger nuclear effect is observed with COMPASS data. We suspect it could be the reason of beam type.
- The largest systematic uncertainty is caused by the trigger. COMPASS has 3 kinds of trigger. They show nice consistency of Xsection in high xf region. However, there is are 20% difference in Xsection between LL and LO triggers in low xf region.

Back up

Reinteraction Effect

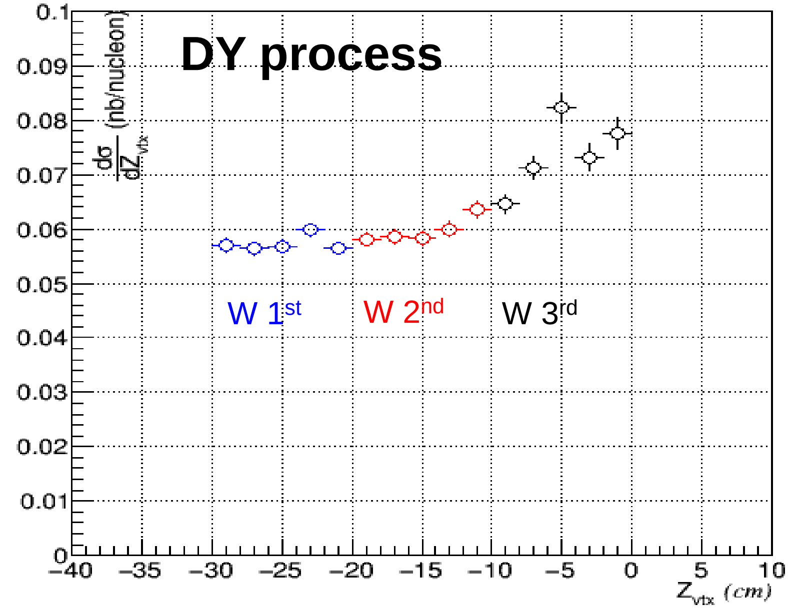


$$\sigma_{\text{measured}} = \sigma_{\text{direct}} + \sigma_{\text{reint}} \left[1 - \frac{L/\lambda_{\text{abs}}}{\exp(L/\lambda_{\text{abs}}) - 1} \right]$$

$$\frac{L}{\lambda_{abs}} = 1 \,;\ \lambda_{abs} = 11.3(cm)$$

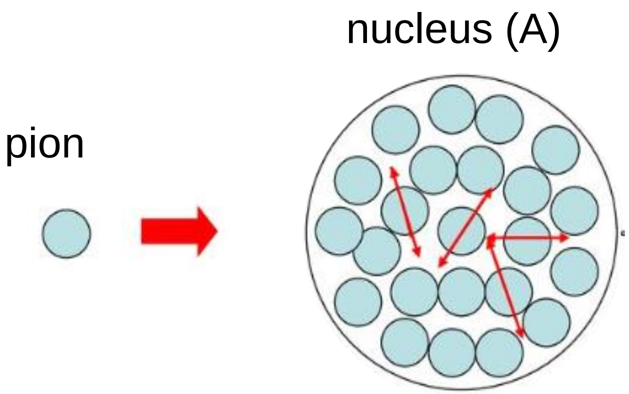
FIG. 6. Relative cross sections for ψ production by π^- as a function of tungsten target thickness. The increase with target thickness is due to reinteraction.

PRD Vol.38 Num.5

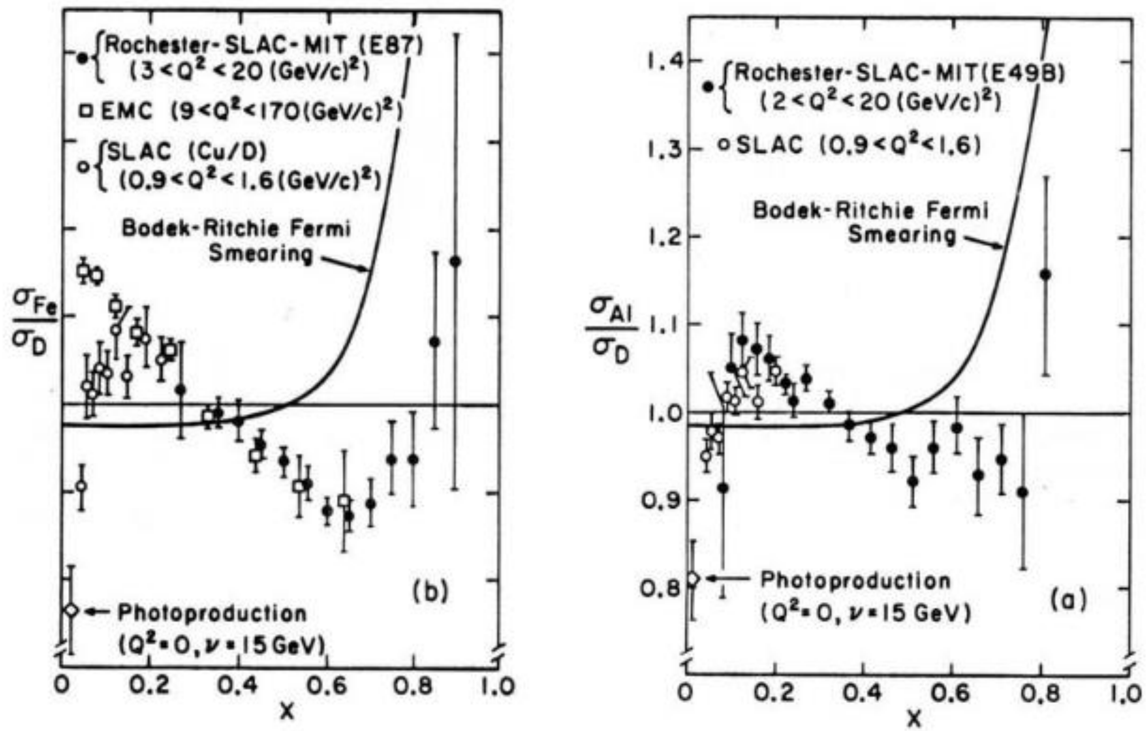


The secondary pion are not simulated in MC, therefore we see an increase of Xsection in the more downstream W target. We are currently use only 10cm W target (blue). If we are able to distinguish reinteraction events, we could use 20cm or event 30cm W target to increase the statistics.

Cold Nuclear Matter Effect (1)



A. Bodek et al., PRL 50 (1983) 1431; PRL 51 (1983) 543



First nuclear effect observed in 1983 by EMC group at CERN.