Study of Λ^0 Production in DIS with HERA II

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Liverpool, UK

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Outline

Strange production mechanism and Motivation

Data information and selection criteria of DIS events and Λ^0 baryon

Λ^0-invariant mass distribution spectra in DIS

Λ^0 production cross-sections in DIS

Ratio of K^0_S and Λ^0

Summary and plans

Strange production mechanism

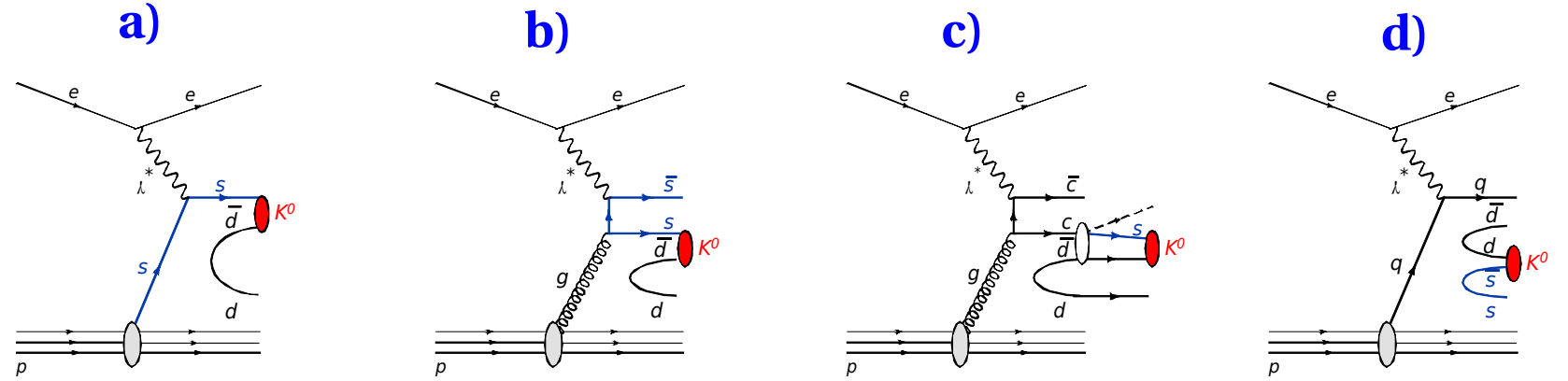


Fig-1

hard process

Boson gluon fusion

Heavy quark decays

hadronisation

All mechanisms contribute significantly

Measurements of strange particle production (K^0_S, Λ):

-understanding QCD

-test of models of fragmentation/hadronisation

-optimisation of the Monte Carlo parameters

-test of λ_s universality

Data Information: Data sets

DST7 files, H1OO-4.0.24 release
Run selection applied
Oolumi: S0, S2, CJC1, CJC2, CIP, LAR, TOF, LUMI, VETO, SPAC

Data	Run period	Lumi [pb-1]
0607e+	468531 - 500611	108.658

Tab-1

S0, S2 prescaled

MC sets

Weight: Zvtx, QCD
Django, Rapgap: CTEQ6L⇒ H1 PDF 2009

Rapgap: ID= 8686 ÷ 8695; Lumi = 658.935/pb

Django: ID= 7141 ÷ 7150; Lumi = 575.5/pb

DIS event selection

Kinematic cuts:

$7 < Q_e^2 < 100\ \mathrm{GeV}^2$ where $Q_e^2 = 4E'_e E_e \cos^2(\theta_e/2)$

$0.1 < y_e < 0.6$ where $y_e = 1\text{-}E'_e/E_e \sin^2(\theta_e/2)$

$E_e' > 11\ \mathrm{GeV}$

Technical cuts:

Trigger = S0, S2 (pure Spacal), R_clus > 20 cm

$35 < E\text{-}p_z < 70\ \mathrm{GeV}$

$\mathrm{Ecra} < 4\ \mathrm{cm}$

$|z_{vtx}| < 35\ \mathrm{cm}$

Type_Primary_vertex = 1

Λ selection

$\Lambda \to p\pi^-$ ($\Lambda \to p\pi^+$), BR = 63.9%, m_Λ = 1.115683 GeV

Cuts on Λ^0 selection:

$|D'_{CA}/\sigma| > 2.0$ on π^+ and π^-

$|D'_{CA}/\sigma| > 1.0$ for p tracks

Opposite charge tracks: dca1$*$dca2 < 0.0

dE/dx for proton > 0.003

0.5 < Pt(Λ^0) < 3.5 GeV

$|\eta(\Lambda^0)| < 1.3$

Pt(π^+, π^-) > 0.12 GeV

Radial decay length > 2 cm

Tracklength > 15 cm

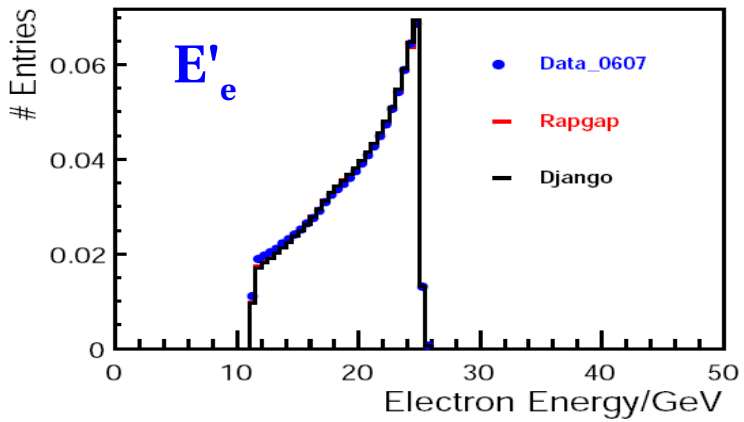
Chi2 =< 5.0

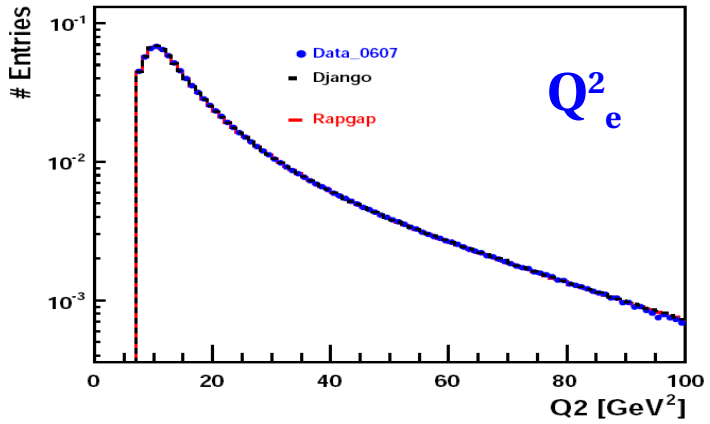
M(e^-e^+) > 50 MeV

475 < M($\pi^-\pi^+$) < 530 MeV

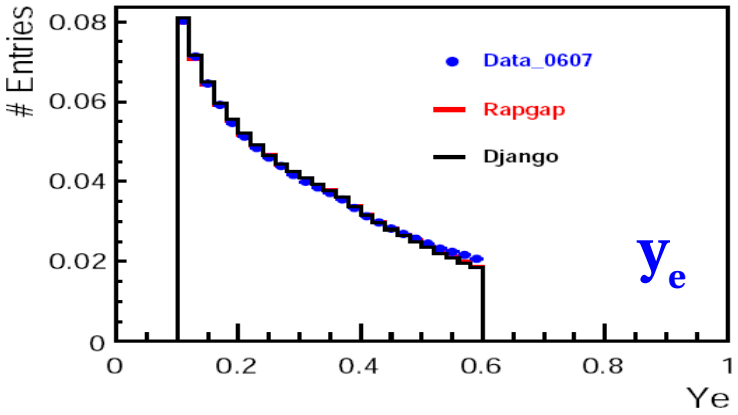
Pt^{rel} < 0.114 GeV

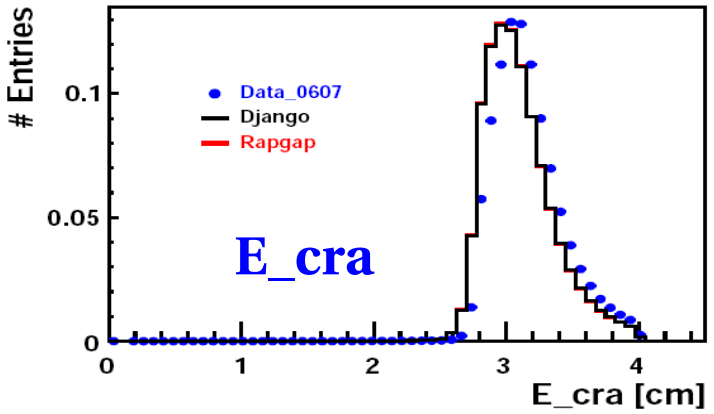
Inclusive DIS Control Plots

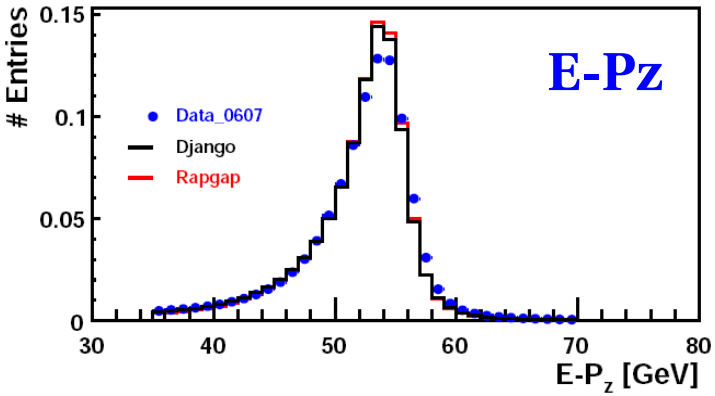




Unit area







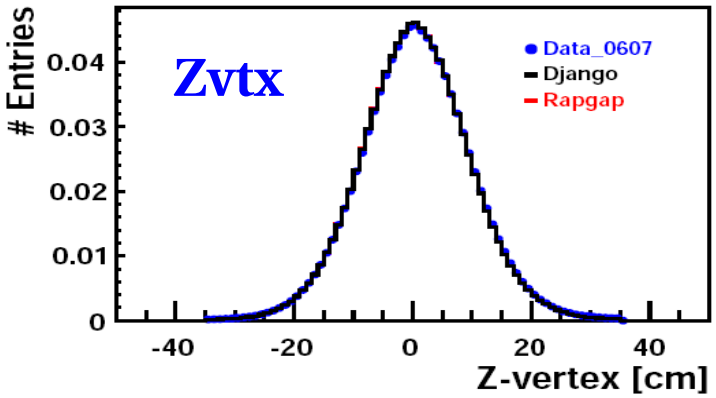
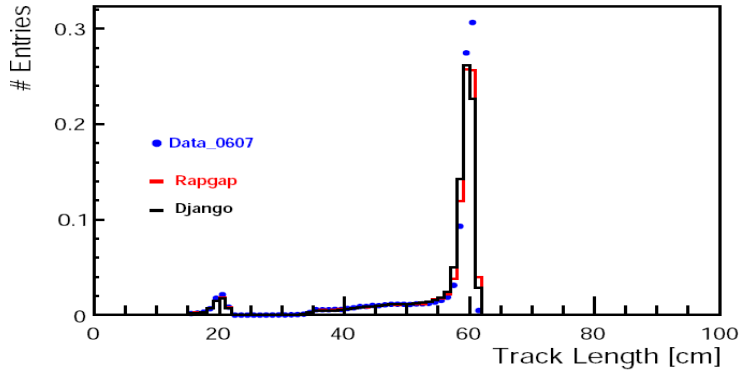
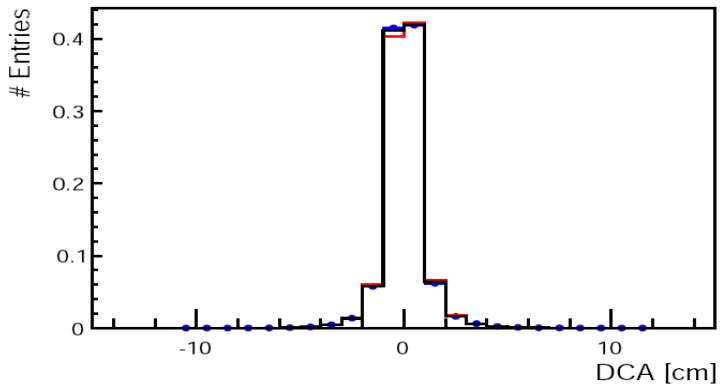


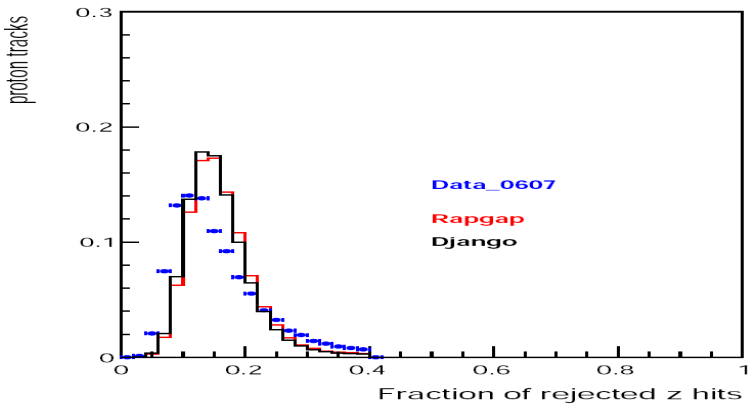
Fig-2

Λ^0 Track's Control Plots

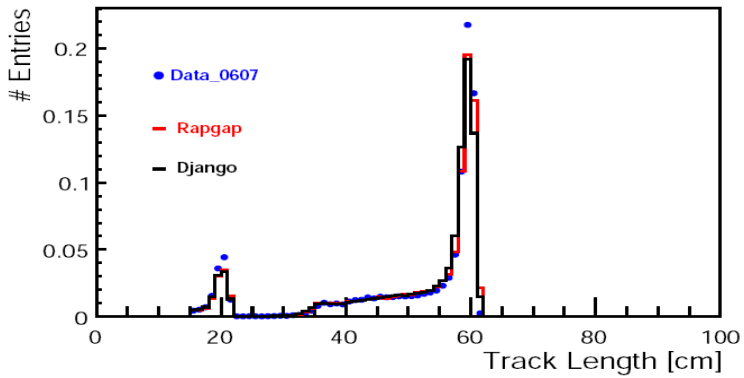
Proton Track

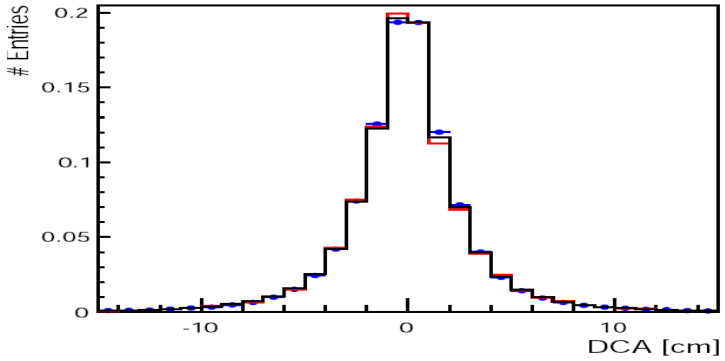


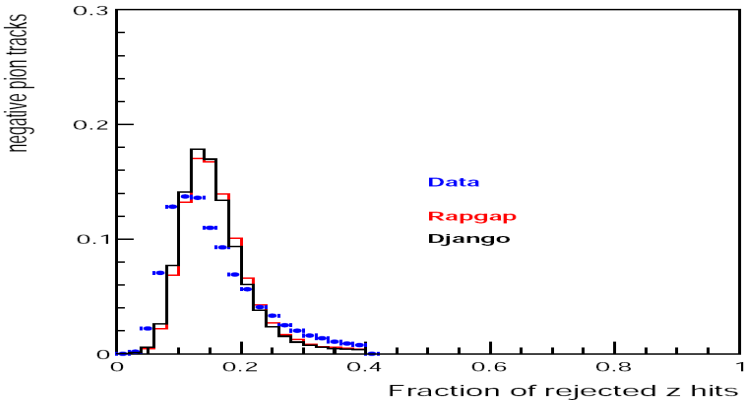




Pion Track







Unit area

Fig-3

Λ^0 mass distribution in DIS

$$F = F_{BG} + F_{\text{skewed-student's}};$$

$$F_{BG} = p5\cdot(x-m_t)^{p6}\cdot\text{Exp}(-p7\cdot(x-m_\Lambda)); \quad m_t = 2\sqrt{m_\Lambda^2 + (P_t^{rel})^2}$$

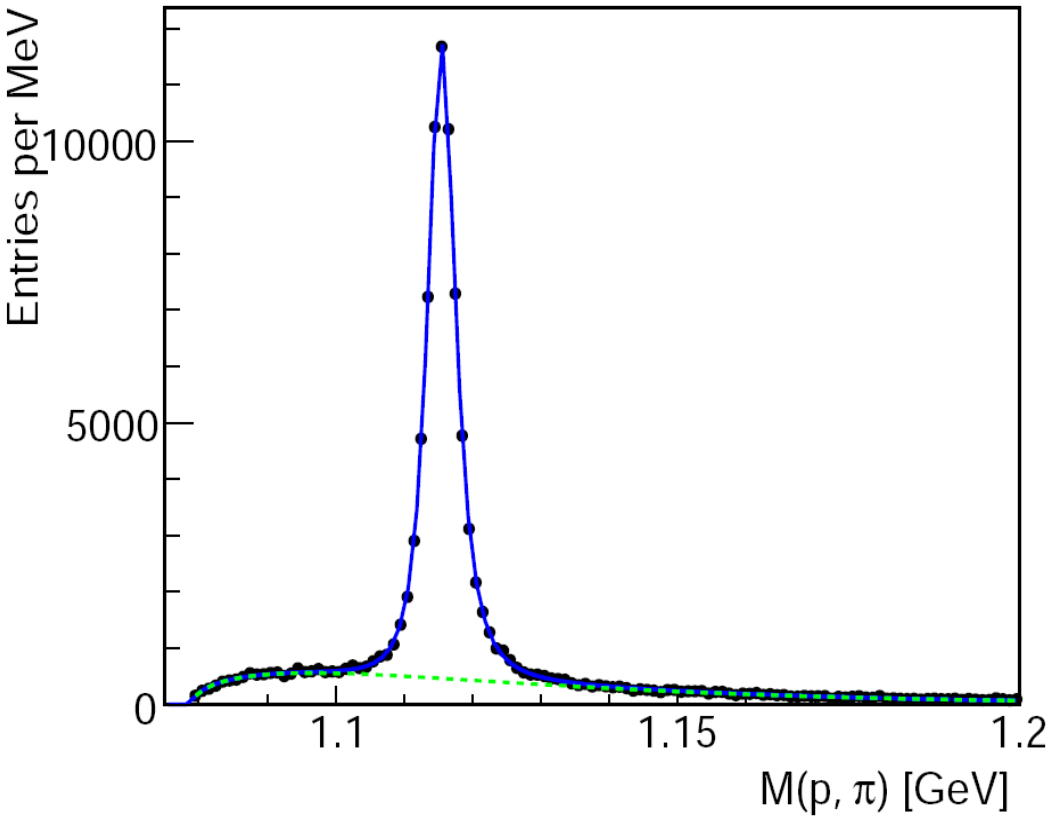


Fig - 4

Fit range: 1.079 - 1.2 GeV

χ^2 / ndf = 189.15/113 = 1.67;

$N^{fit}_{\Lambda} = 69'652 \pm 368;$

$m^{fit}_{\Lambda} = 1'115.4 \pm 0.02$ MeV;

$m^{pdg}_{\Lambda} = 1'115.683 \pm 0.006$ MeV;

The problem with Λ cross sections

Status April 2013 for Λ DIS

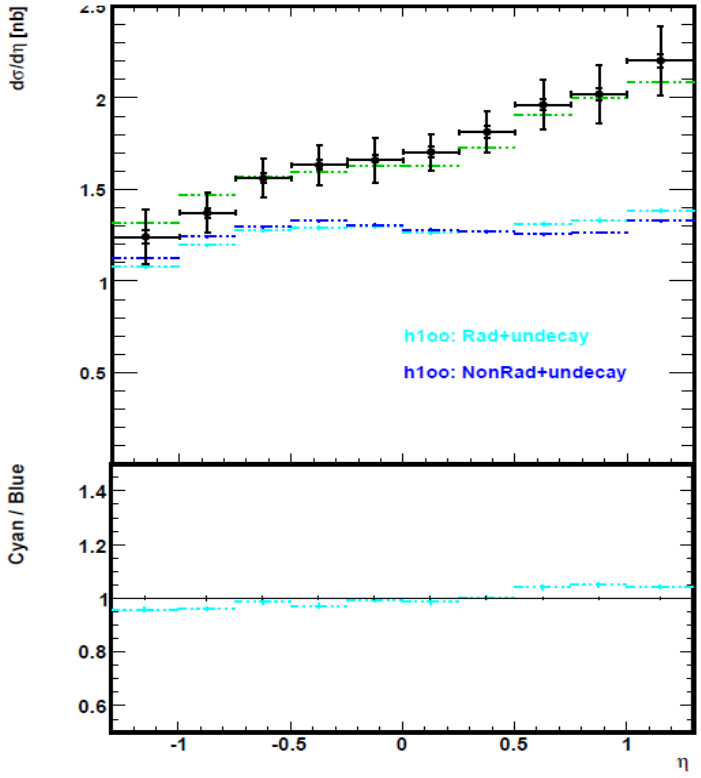


Fig-5

MC prediction calculated the same way as cross sections for data

$$\sigma_{vis}^{MC} = \frac{N_{rec}^{MC}}{L \cdot \epsilon_{rec} \cdot (1 + \delta_{QED})} \qquad (1)$$

MC studies were requested to use generated events only

$$\sigma_{vis}^{MC} = \frac{N_{gen}^{MC}}{L} \qquad (2)$$

Where does the difference come from?

H1oo: Norad ⇒ ID = 5856, 5857, 5859, 5860, Lumi = 810.67/pb

The problem with cross sections

Standard H1 generation: all particles with $c\tau > 1$ mm are "undecayed"

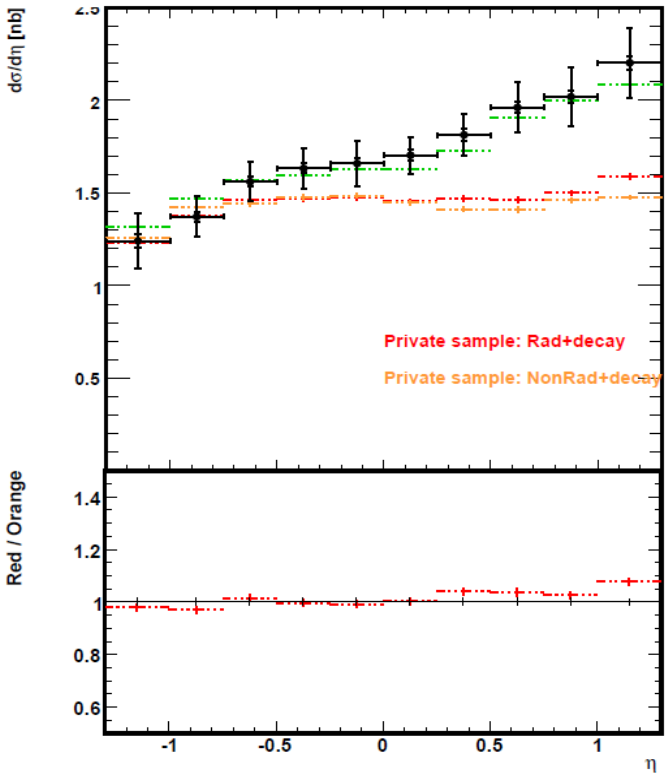


Fig-6

$\Rightarrow$ K^0_s, Λ, Ω^-, $\Sigma^\pm$, Σ^0, $\Xi^\pm$, Ξ^0 are not decayed in the generator (stable)

$\Rightarrow$ in simulation these particles may interact prior to decay(lost).

Other particles may interact and produce K^0_s, Λ, Ω^-, $\Sigma^\pm$, Σ^0, $\Xi^\pm$, Ξ^0. Since the analysis requires $|Z^{prim}_{vertex}| < 35$ cm and $|\eta(\Lambda)|<1.3$,

K^0_s, Λ... may be counted on generator even if they are produced by interactions(e.g. collimators)

Cure: Let all stable particles decay in generator $\Rightarrow$ "decayed"

Reconstruction Efficiency for Λ

$$\epsilon_{rec,i}(X) = \frac{N^{MC}_{rec,i}(X)}{N^{MC}_{gen,i}(X)}.$$

R_clus > 20 cm

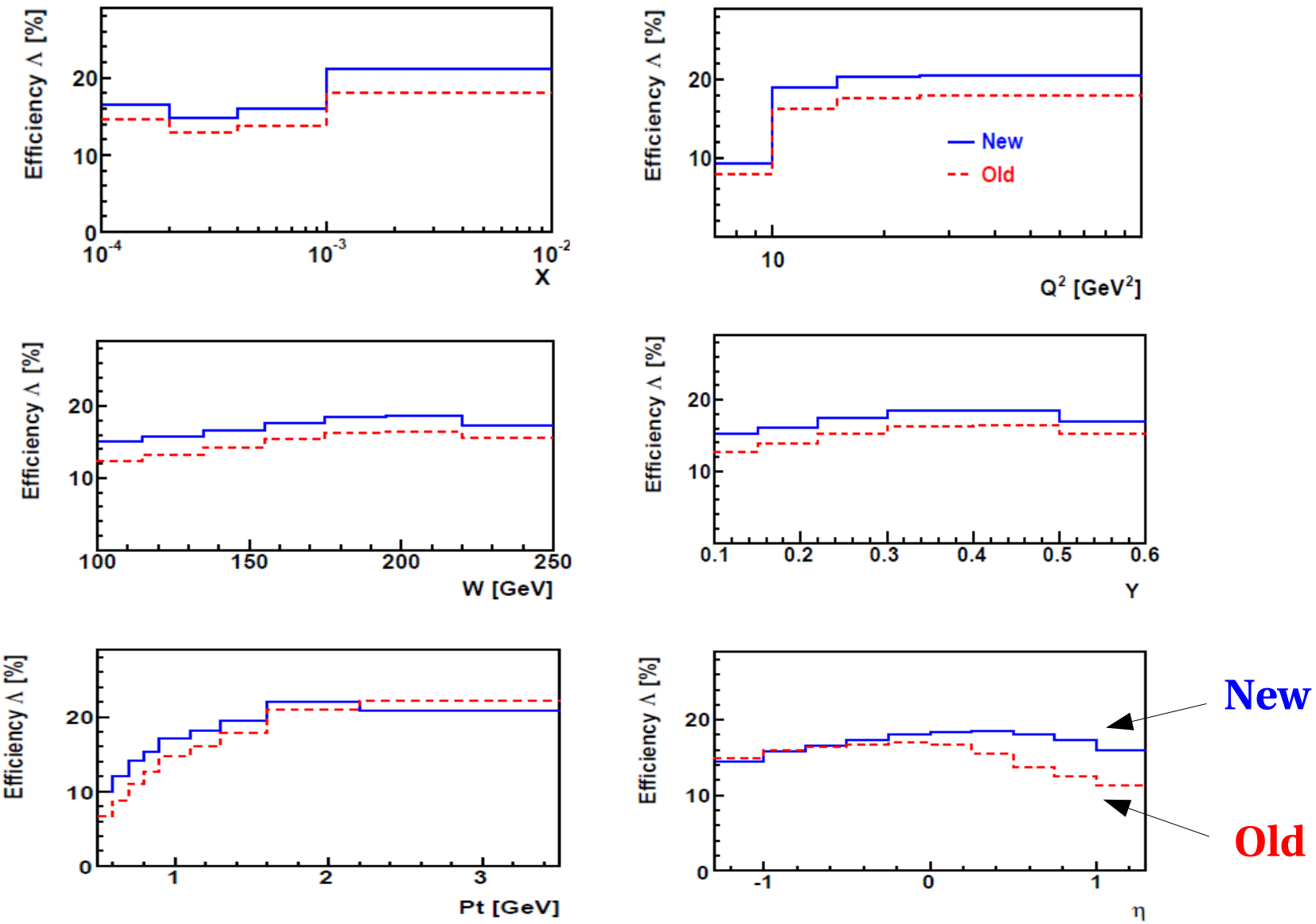


Fig-7

Correction to Born Level

Private Django samples

Django samples with radiation: 267.36 pb^{-1}

Django samples without radiation: 278.94 pb^{-1}

In both set of samples heave strange baryons are decayed

$$1 + \delta_{QED} = \frac{N^{i}_{gen}(\Lambda^{0})^{rad}}{N^{i}_{gen}(\Lambda^{0})^{non\text{-}rad}} \times \frac{L^{non\text{-}rad}}{L^{rad}}$$

Correction to Born Level

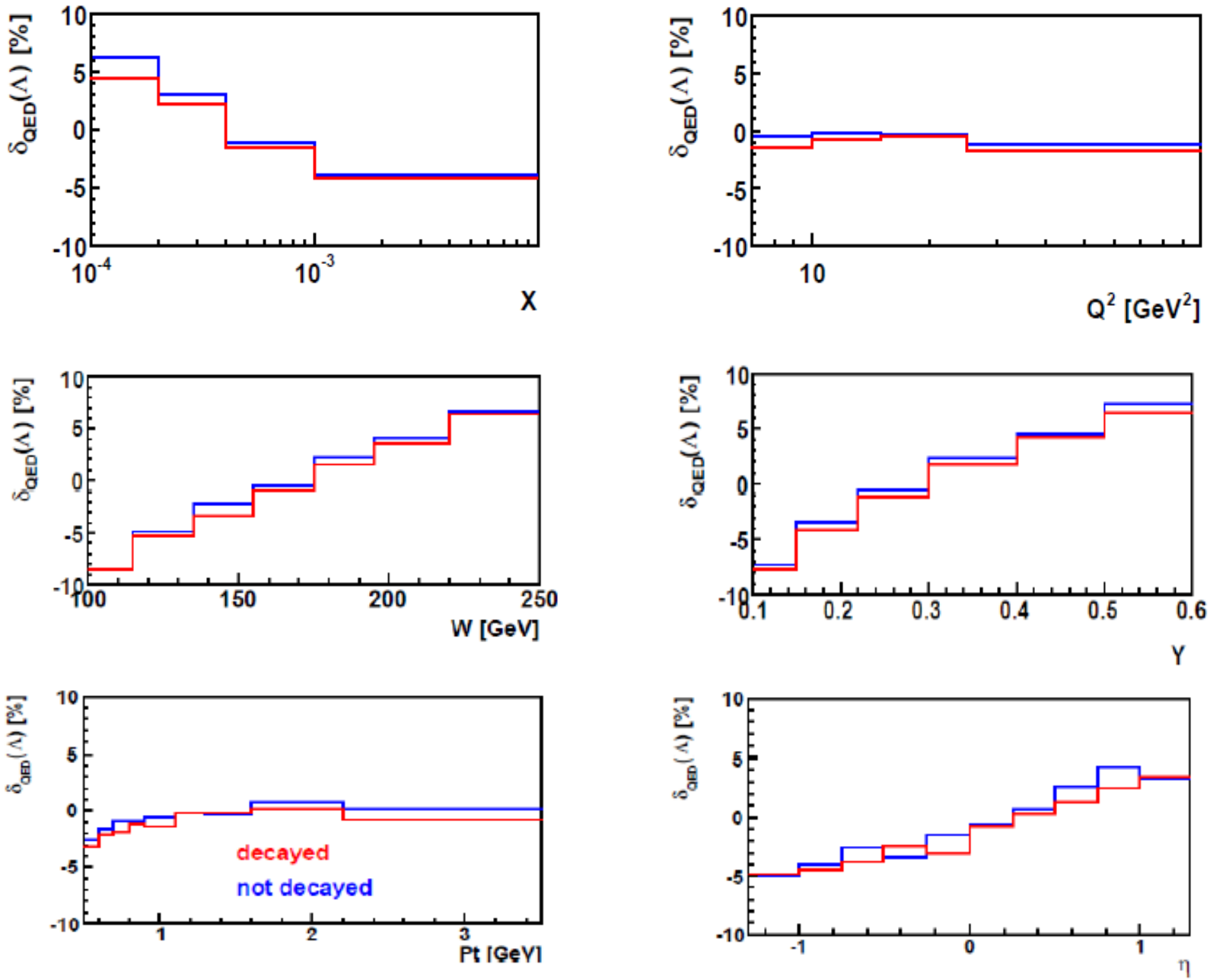


Fig-8

Visible Λ^0 Cross Section in DIS

$7 < Q^2_e < 100\ \mathrm{GeV}^2$; $0.5 < Pt < 3.5$ GeV similar to HERA I

$0.1 < Ye < 0.6$; $-1.3 < \eta < 1.3$

$$\sigma_{vis}(ep \to e' V^0 X) = \frac{N}{L \cdot \epsilon_{rec} \cdot (1 + \delta_{QED})} = 4.23 \pm 0.022(\mathrm{stat.})\ \mathrm{nb}.$$

$$\epsilon_{rec}(Q^2) = \frac{N^{MC}_{rec}}{N^{MC}_{gen}}; \qquad N^{MC}_{gen} \text{ - includes all } \Lambda \text{ decay modes}$$

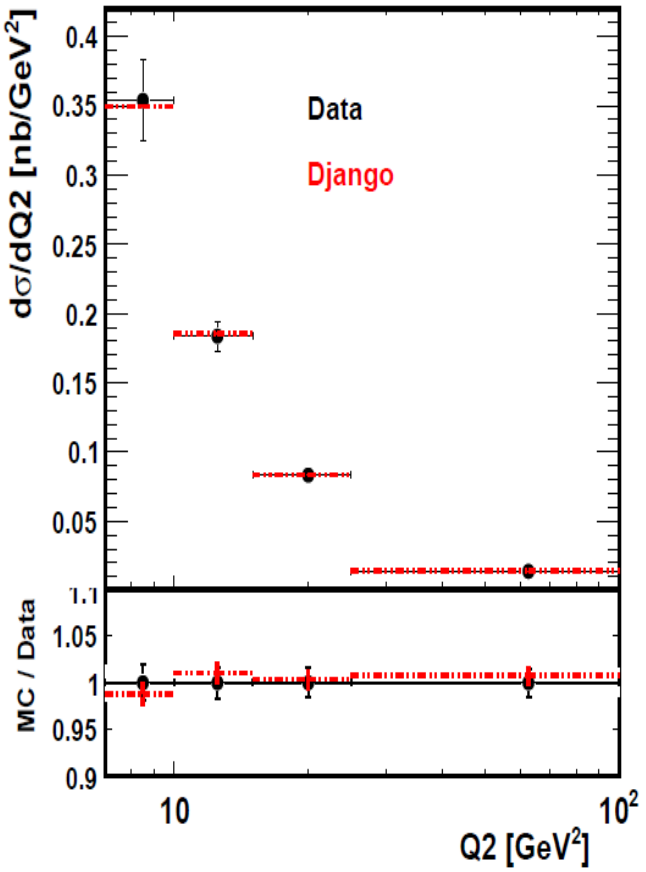
$\epsilon_{rec}(\mathrm{dj}) = 15.34\ \%$ (14.8%), $\delta_{QED}(\mathrm{dj}) = -1.12\ \%$

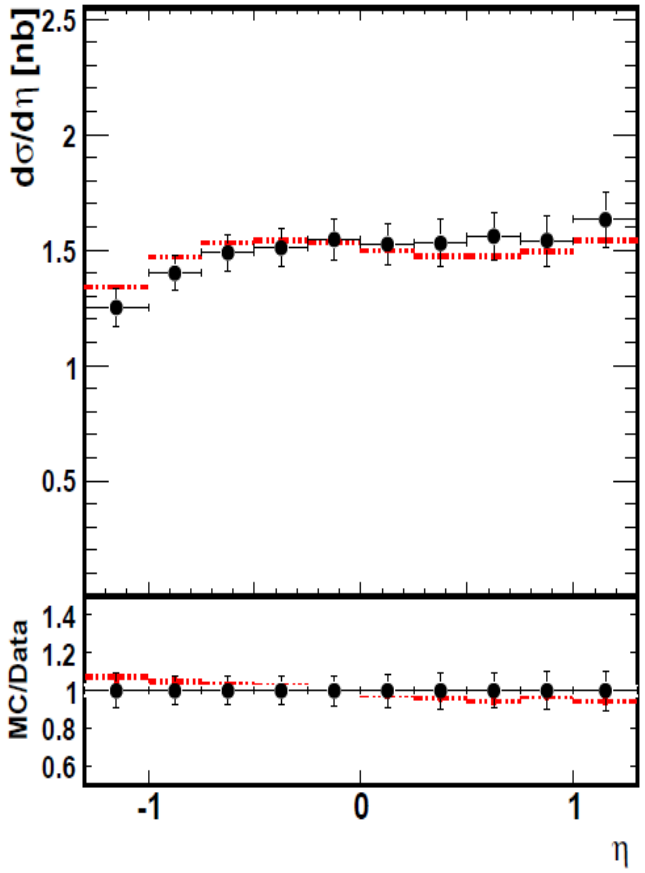
Django $\Rightarrow \sigma_{vis}(ep \to e' V^0 X) = 4.42 \pm 0.001(\mathrm{stat})\ \mathrm{nb}.$

Data(old) $\sigma_{vis}(ep \to e' V^0 X) = 4.15 \pm 0.022(\mathrm{stat})\ \mathrm{nb}.$

Differential Cross Section in DIS

Django / Data





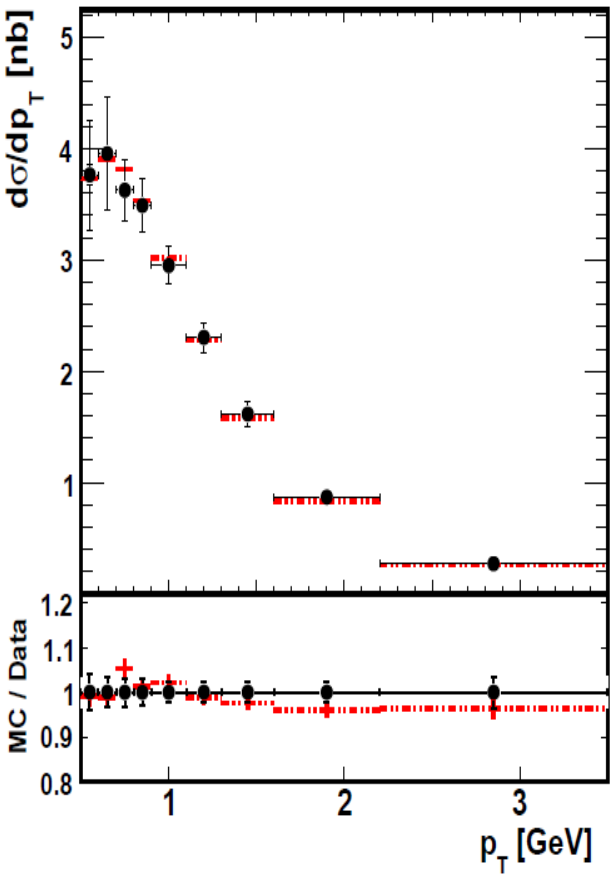
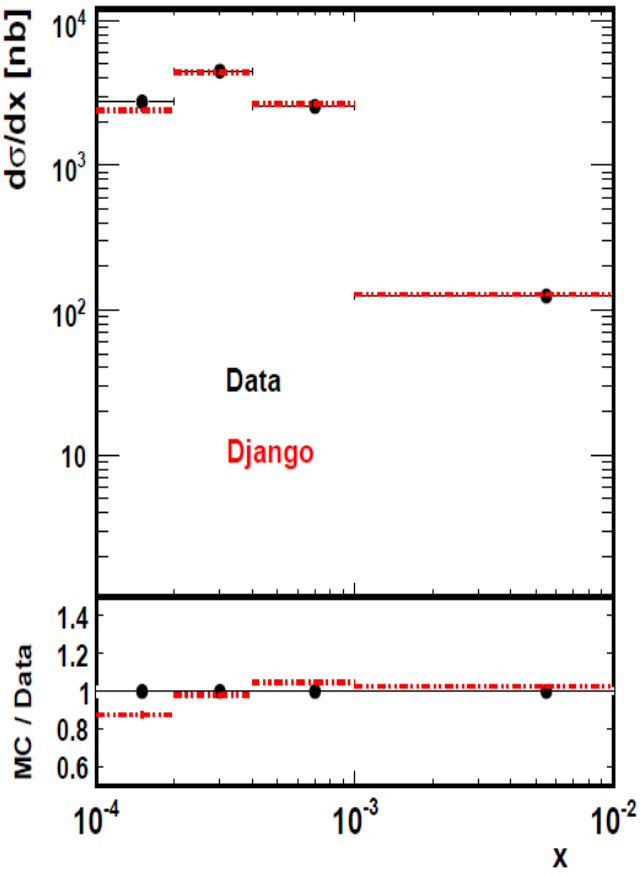
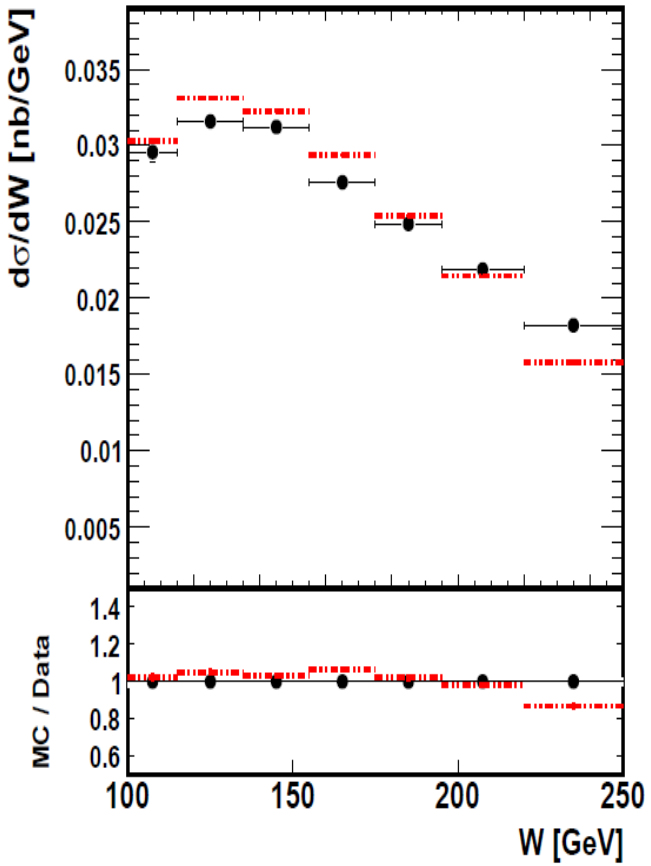


Fig -9

Differential Cross Section in DIS

Django / Data





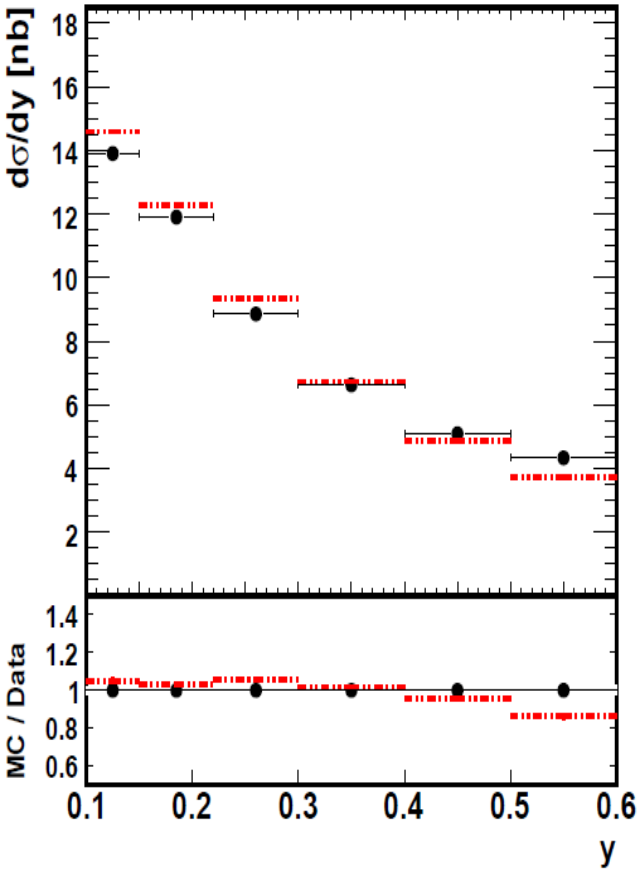


Fig -10

Ratio of the differential K^0_s and Λ Cross Sections

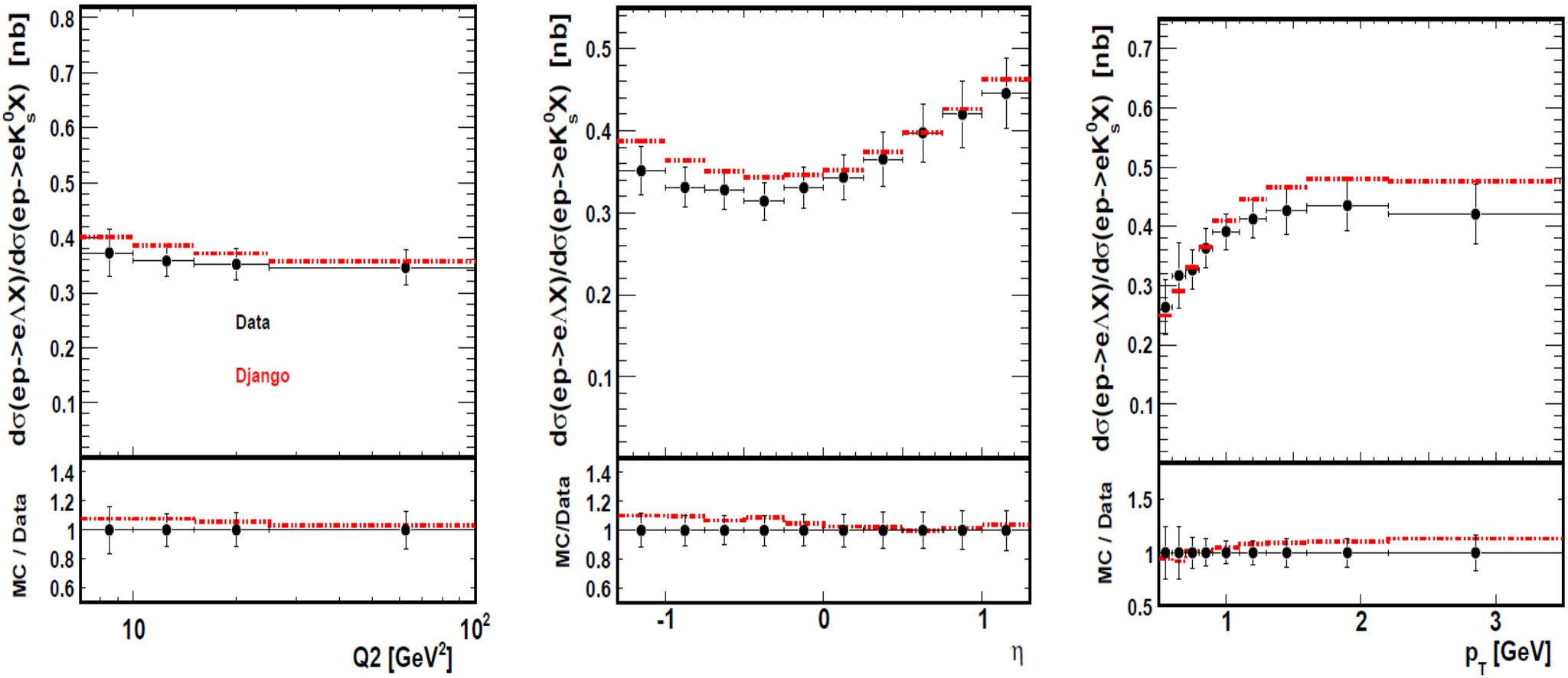


Fig -11

Summary and plans

- Corrected Inclusive Λ cross-section σ_{vis} is measured and found to be: $\sigma_{vis} = 4.23 \pm 0.022(stat) nb$

Plans:

Extend phase space to $|\eta| < 1.5$ and $p_T > 0.3$ GeV (also for K^0_S)

Redo Systematics

Diff.cross-sections in Breit frames + Breit systematics

Λ-$\overline{\Lambda}$ Asymmetry

Extract suppression factor λ_{qq}

Backup slides

Default cuts for K0 and Λ

// sets default cuts for K0:
// pT(pion) >= 0.07 GeV
// track length(pion) >= 10 cm
// invariant mass(K0): 0 <= M <= .8 GeV
// radial distance of secondary vertex >= 1cm
// pT,rel(pions,K0) >= 0.10
// Chi2 of secondary vertex fit < 10
// cut against lambdas: m(pi,p) > 1.125

// sets default cuts for Lambda
// pT(proton) >= 0.2 GeV
// pT(pion) >= 0.1 GeV
// track length(pion) >= 10 cm
// invariant mass(Lambda): M <= 1.5 GeV
// radial distance of secondary vertex >= 1.5cm
// pT,rel(proton/pion,Lambda) < 0.15
// Chi2 of secondary vertex fit < 5 (can be smaller than for K0)

Ratio of the differential K^0_s and Λ Cross Sections

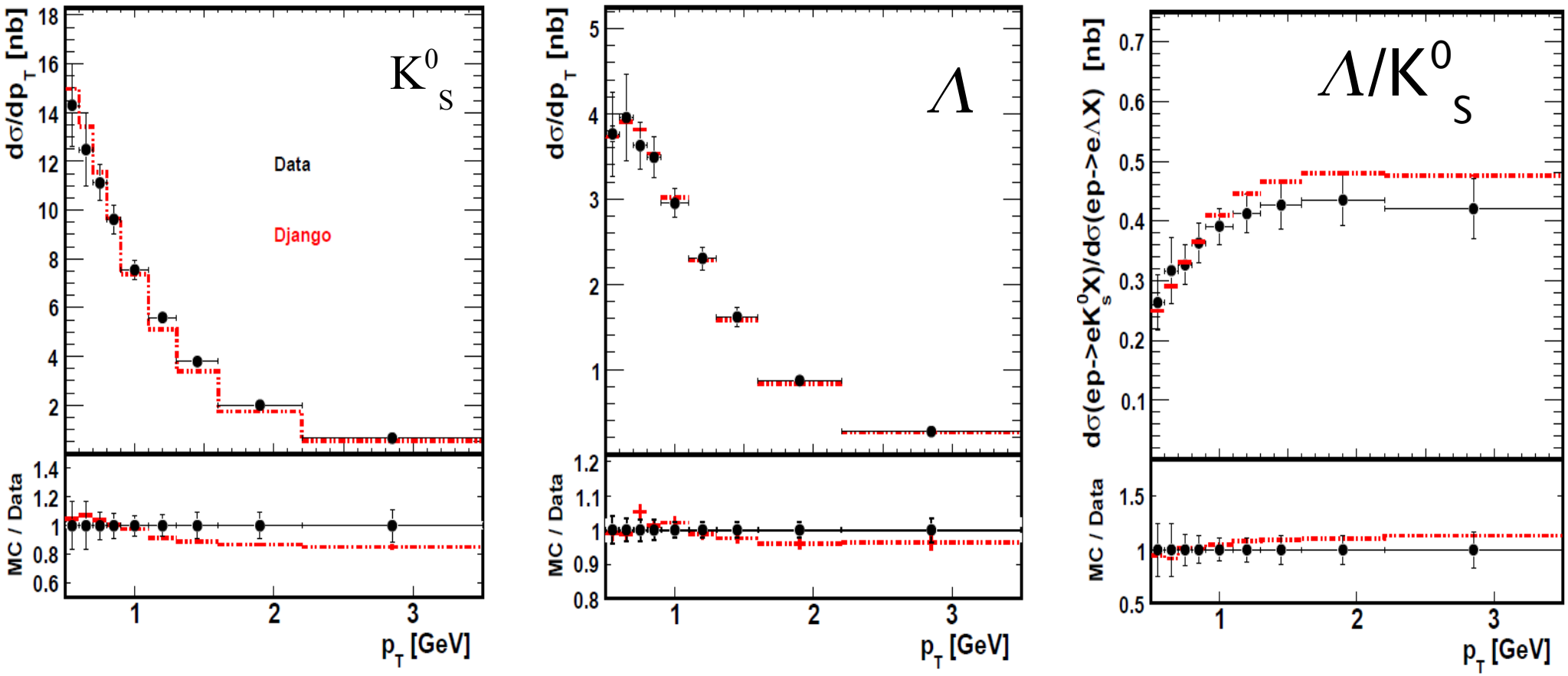


Fig -12

Ratio of the differential K^0_s and Λ Cross Sections

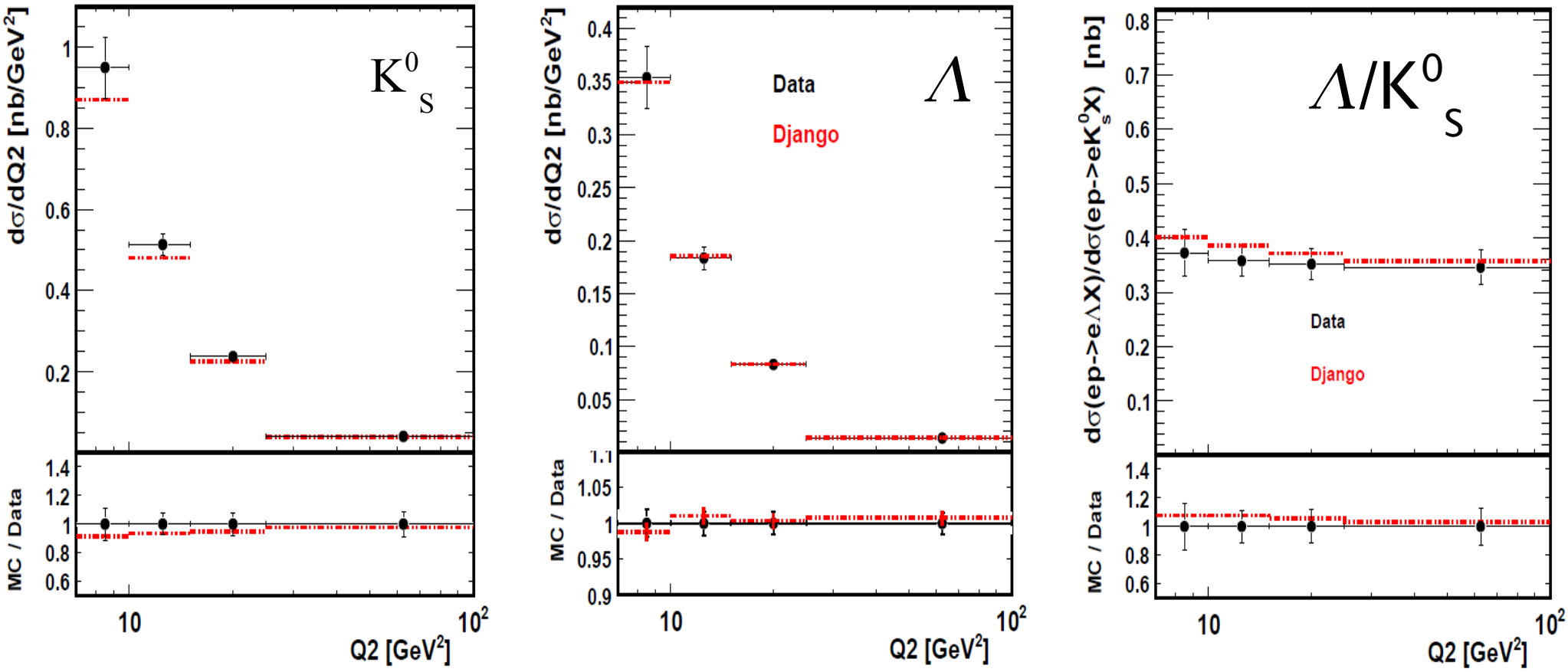
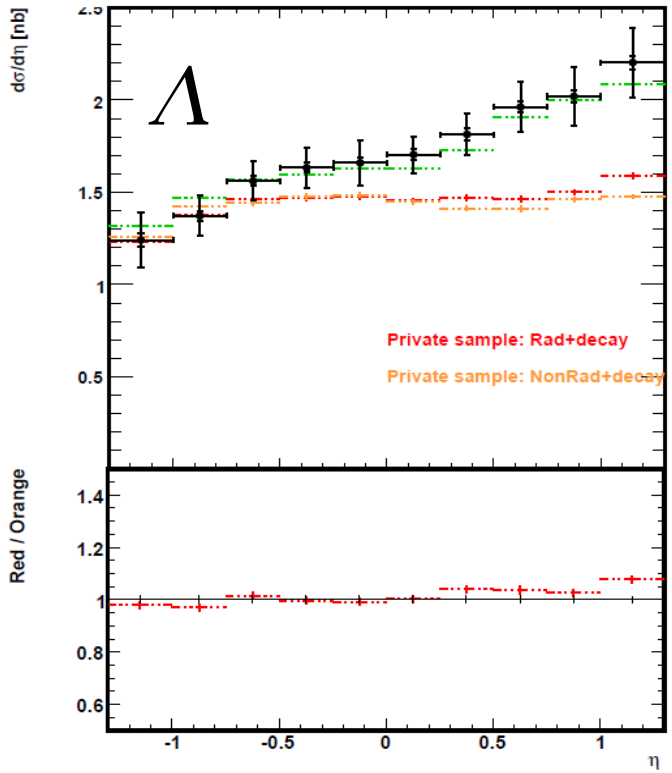
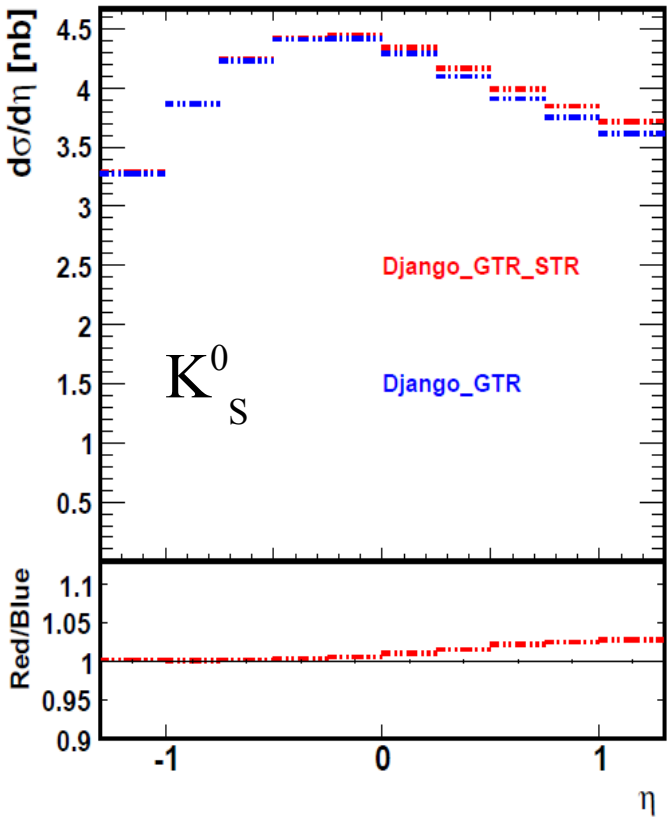
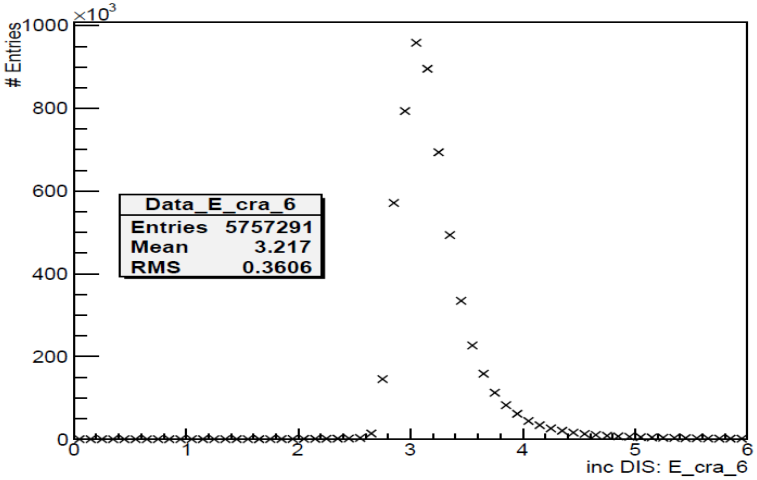


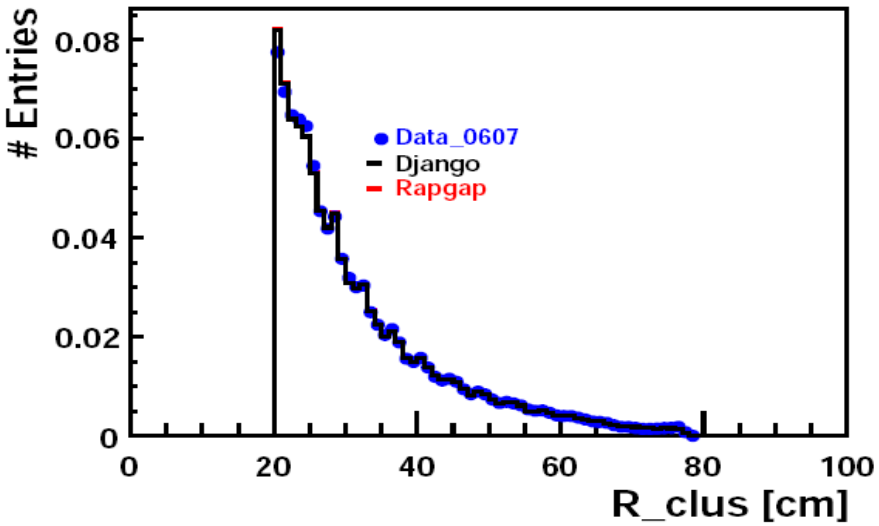
Fig -13

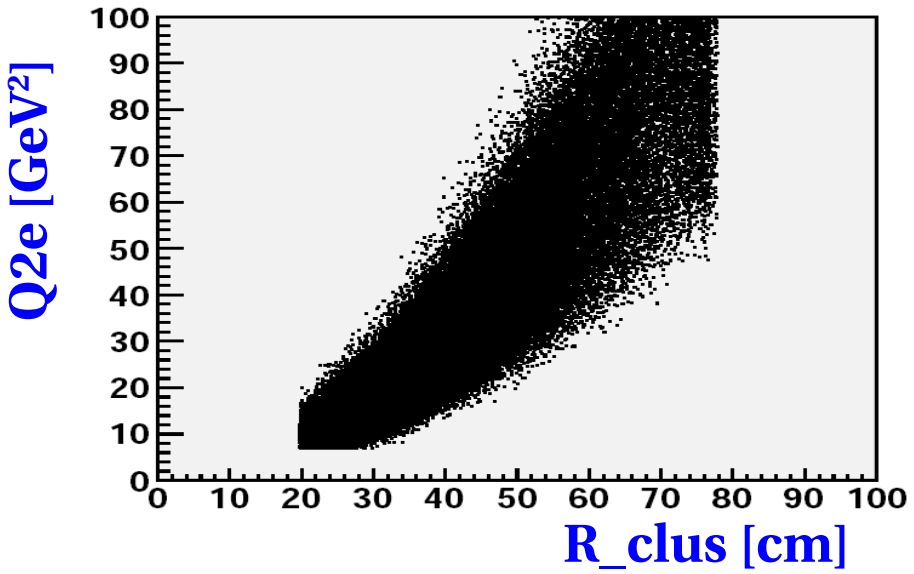
$\Lambda,\ \Omega^{-}, \Sigma^{\pm},\ \Sigma^{0},\ \Xi^{\pm},\ \Xi^{0}$






×10³
Entries
1000
800
600
400
200
0
Data_E_cra_6
Entries 5757291
Mean 3.217
RMS 0.3606
0
1
2
3
4
5
6
inc DIS: E_cra_6


Entries
0.08
0.06
0.04
0.02
0
Data_0607
Django
Rapgap
0
20
40
60
80
100
R_clus [cm]


Q2e [GeV²]
100
90
80
70
60
50
40
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20
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0
0
10
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30
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70
80
90
100
R_clus [cm]