Exclusive Photoproduction of ρ-meson with leading neutron at HERA

Iakov Vazdik 11.09.13

Status report

Some addition to previous talk

Introduction

We 'd like to measure process:
Gamma + p --> rho + n + Y,

Where Y – small mass.

We can expect two main contribution to this process -

1 – usual proton – dissociative photoproduction

2 - pion exchange process - Y = pi+

We can observe some new feature of proton dissociation and to mesure cross-section of pion – exchange process in some kinematic range.

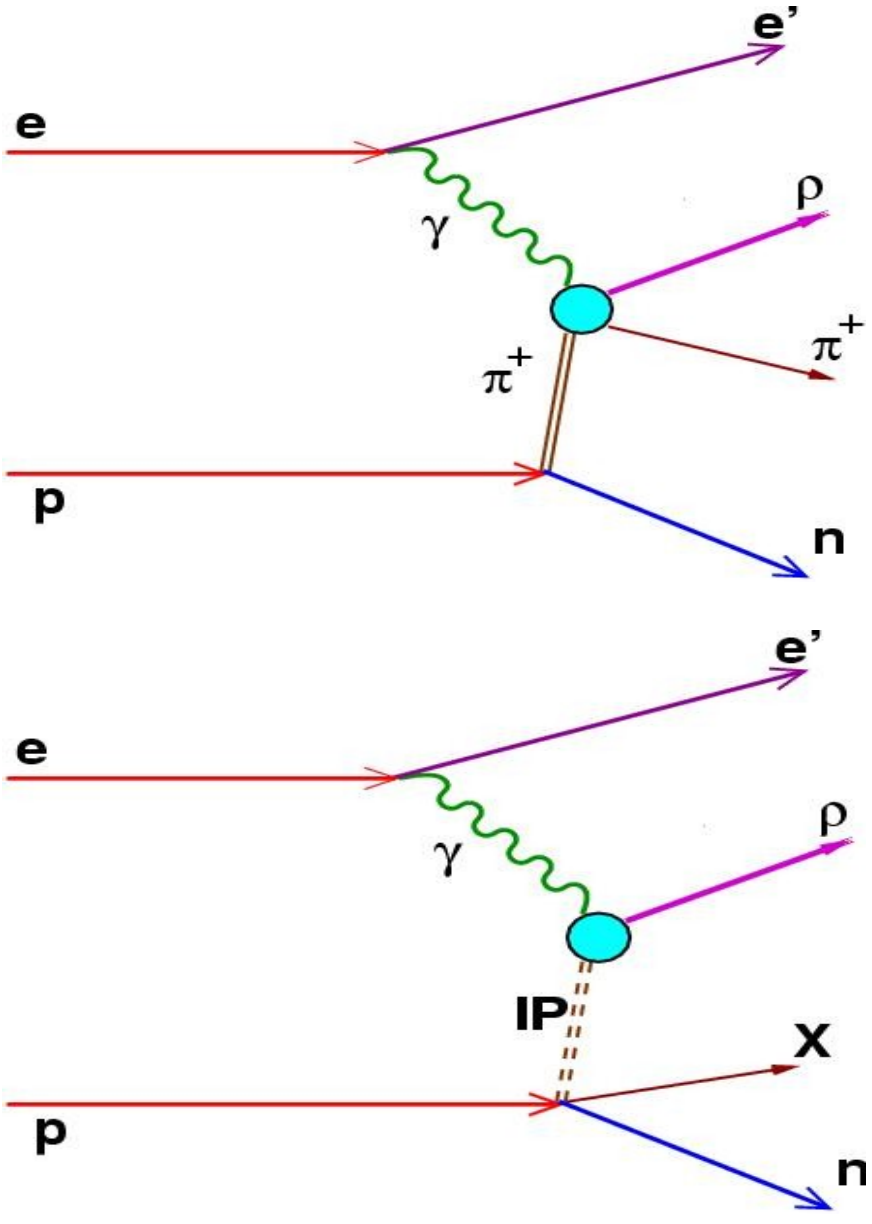
Introduction

Motivation:

- first observation of photoproduction of on virtual pion
- measurement of t-slope ($b \sim R^2$)
- measurement of P_T^2 of neutron
- possibility of measurement π^+ cross-section

Main problem of analysis – relative weight of pion-exchange and p-dissociative ρ^0 photoproduction.

To separate this signals we use 2 sensitive distributions – Energy of neutron and P_T^2 of ρ^0



Pion exchange quasi-elastic process.

Main competitive processes:

Proton dissociative rho photoproduction process.

(also DD and elastic are considered)

Pion exchange reaction:

$\gamma + p \rightarrow \rho + n + \pi^+$

we observe:

n ---> from FNC

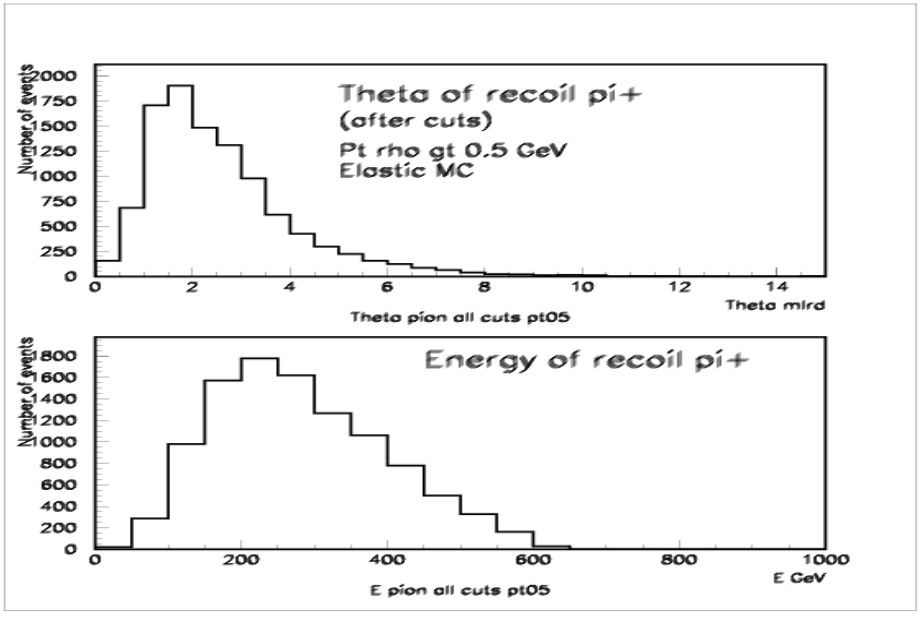
$\rho \rightarrow \pi^+\pi^-$ in tracking system

π^+ disappears in the beam pipe

$<\Theta_{\pi^+}> \sim 2.6$ mlrd

$<E_{\pi^+}> \sim 282$ GeV

Θ_{π^+} after cuts



E_{π^+}

Additional contribution from:
1 - double diffraction (DD) ~ 8.1%

2 – Rho elastic photoproduction (EL) ~ 2.9%

3 – gamma-dissociative photoproduction(GD) ~ 0.3%

We can define relation between this contributions from Sigma-total photoproduction article:

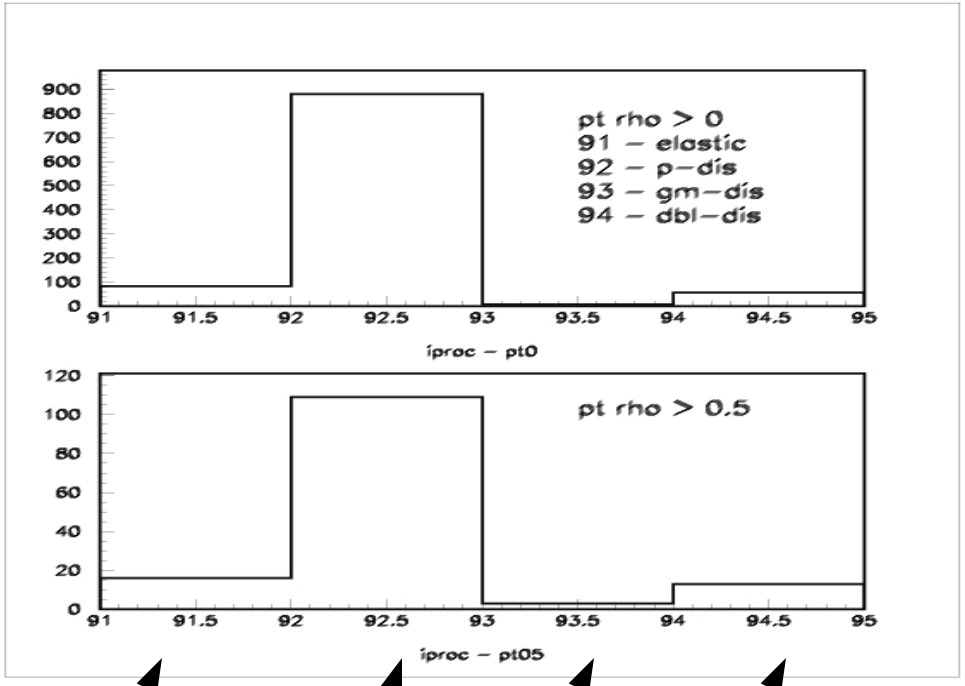
EL:PD:GD:DD = 1 : 0.5 : 1.25 : 1
(PD – proton dissociative photoproduction)

After this we fit Pt**2 distribution of Rho with pion-exchange and with this combination.
We have ~ 60% of pion + ~ 40% of this combination
We take as background DD + EL + GD + PD-Mx>4 GeV

Check structure of background

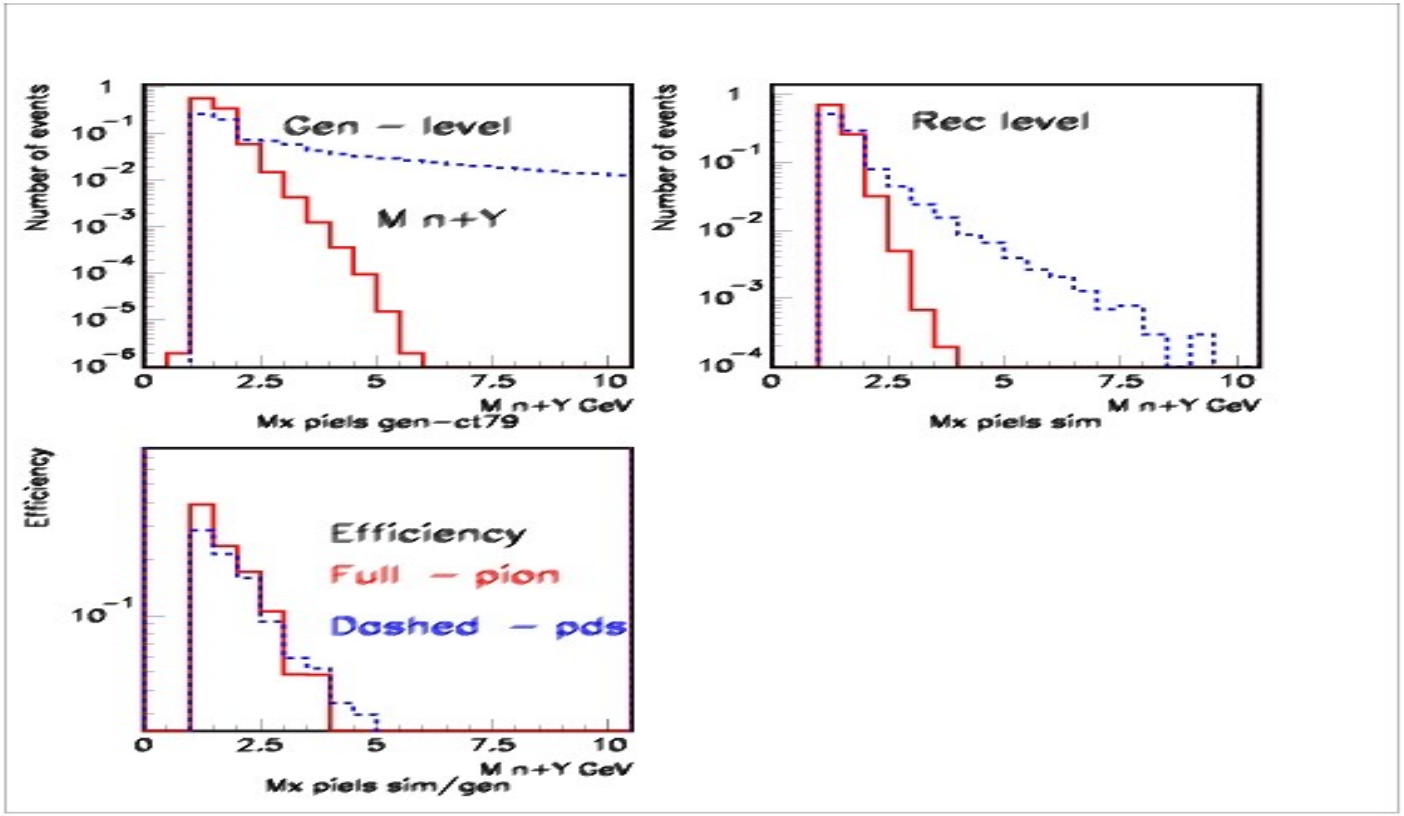
MC minbias 10^6 events

(no any cuts)

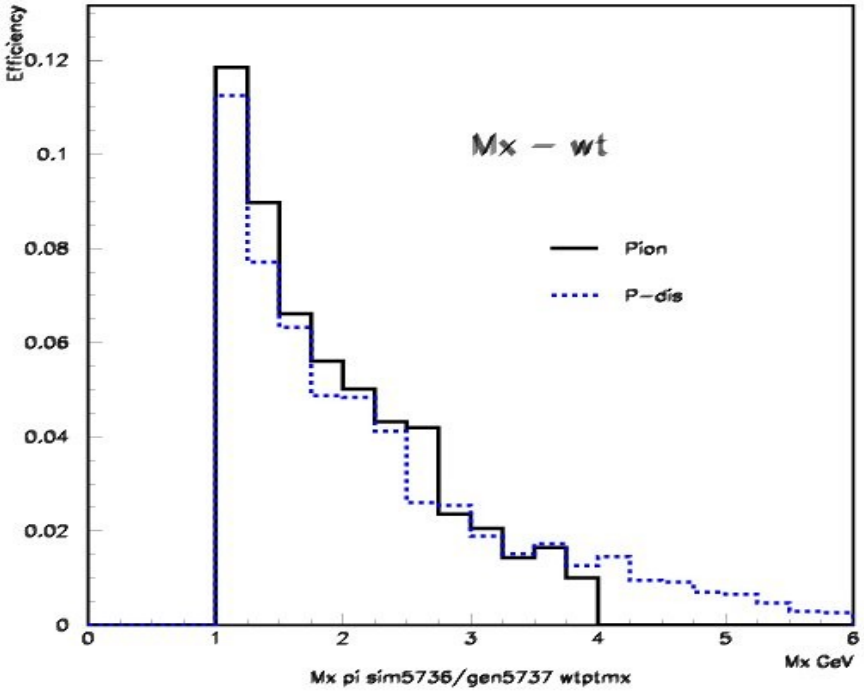


Elastic p-dis γ dis double

Mass n + Y system



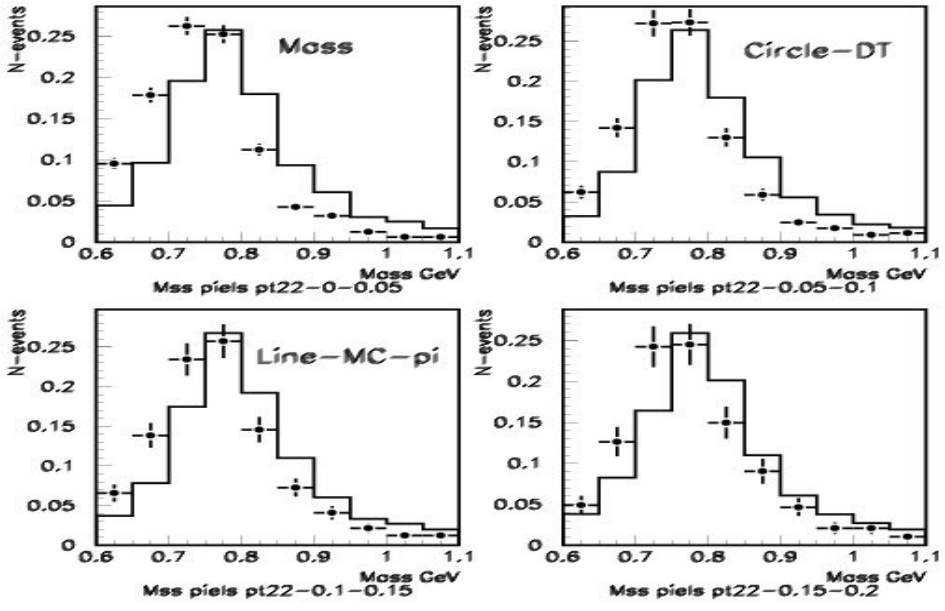
Efficiency of Mx - pion + pdis



For MC we use Pythia for pion-exchange
and DIFFVM for all other processes.

We have problem with mass distribution.

Here it's 4 channel of pt**2 distribution

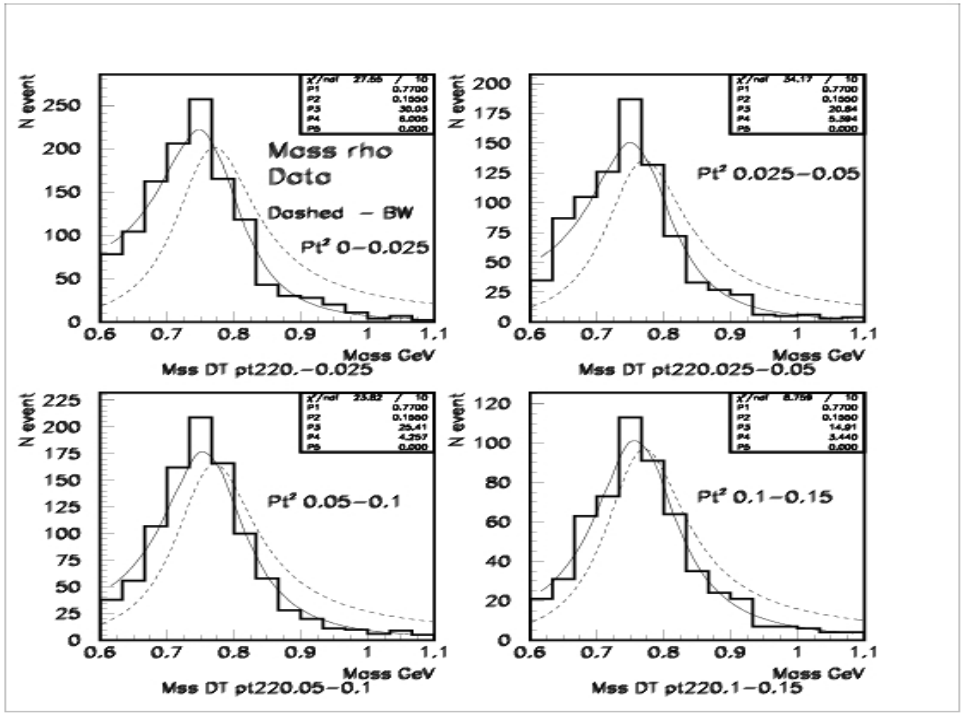


Fit Mass – Data in different range Pt**2 rho

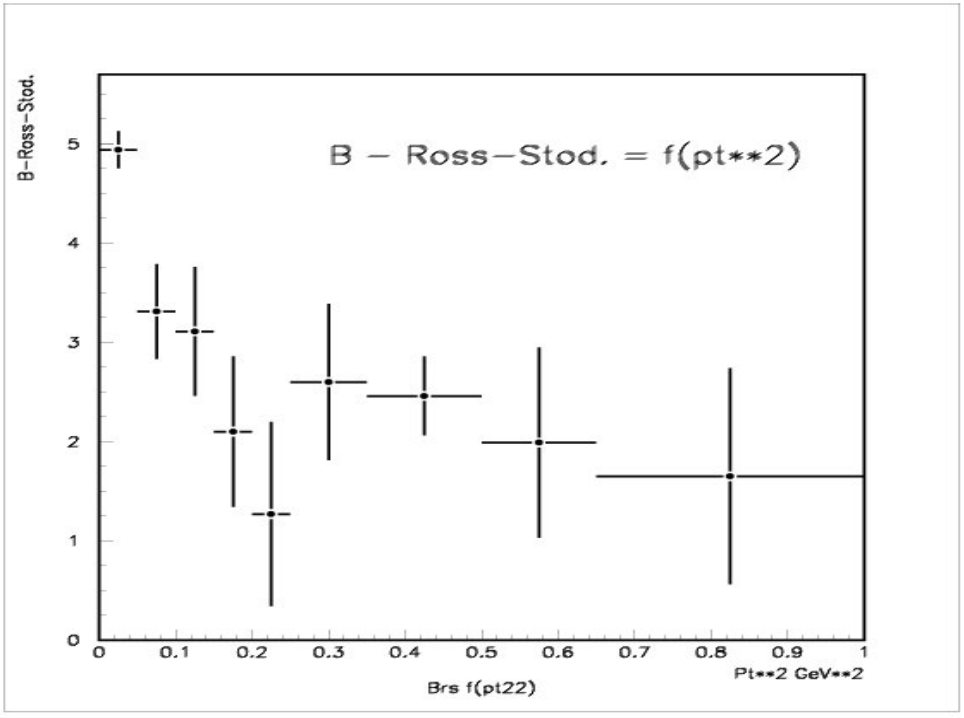
0-0.025 0.025-0.05 GeV**2

0.05-0.1 0.1-0.15 GeV**2

Dotted line – BW



B – of Ross-S. Distibution from fit of Data



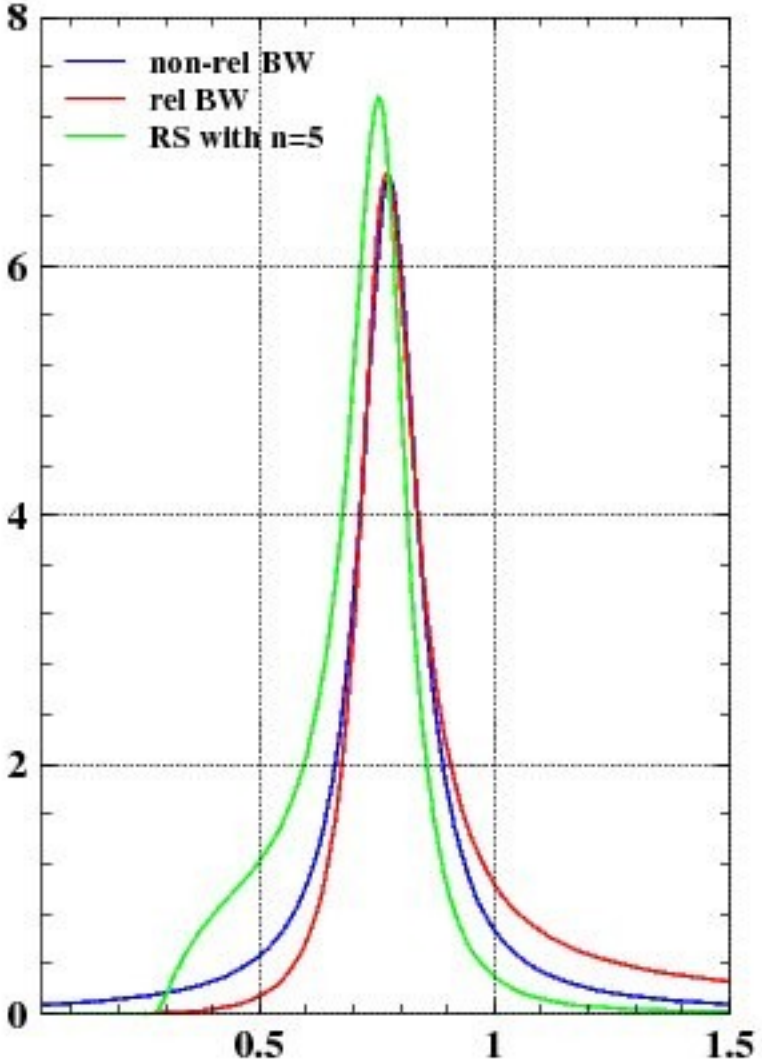


Figure 10

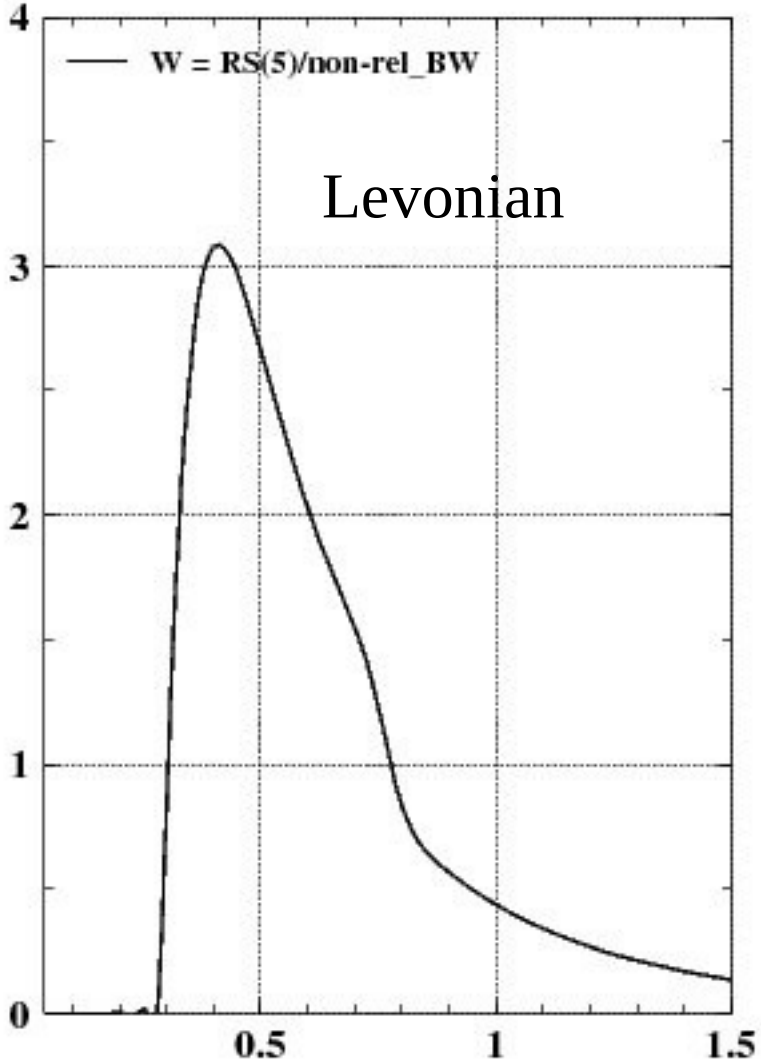
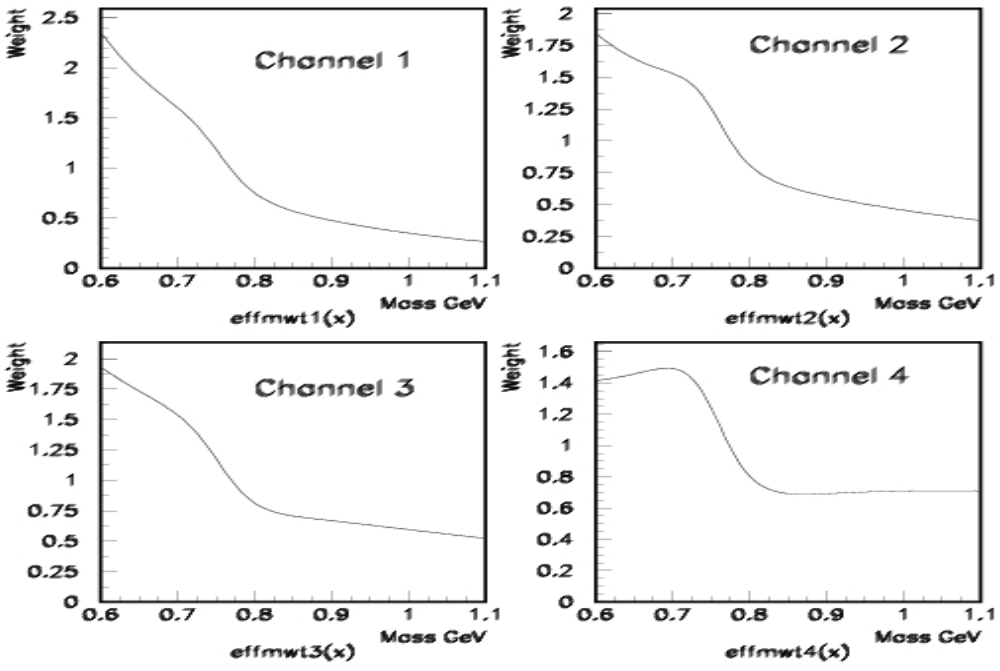
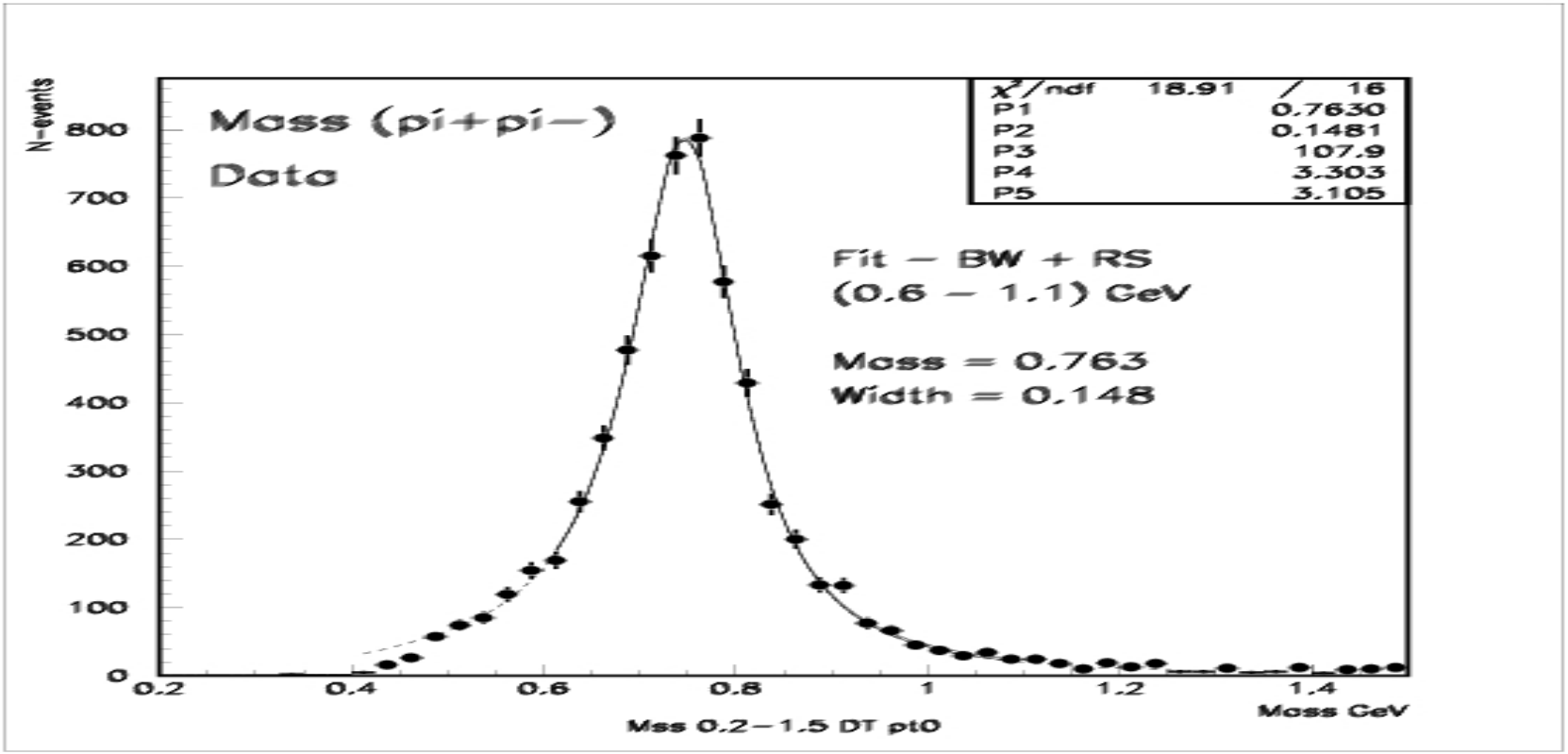


Figure 11

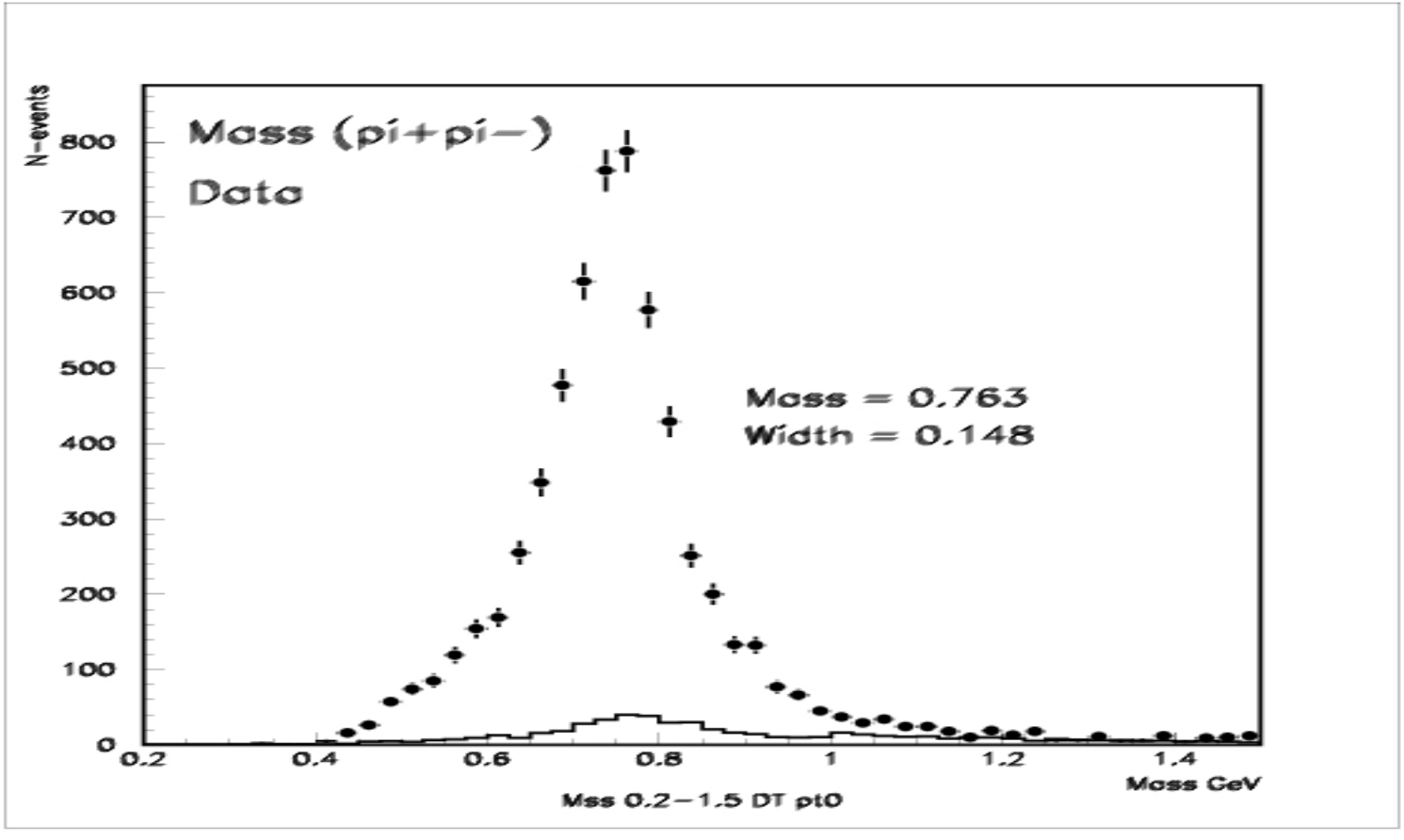
Weight mass


Channel 1
Weight
Mass GeV
effmwt1(x)
Channel 2
Weight
Mass GeV
effmwt2(x)
Channel 3
Weight
Mass GeV
effmwt3(x)
Channel 4
Weight
Mass GeV
effmwt4(x)

All events after cuts

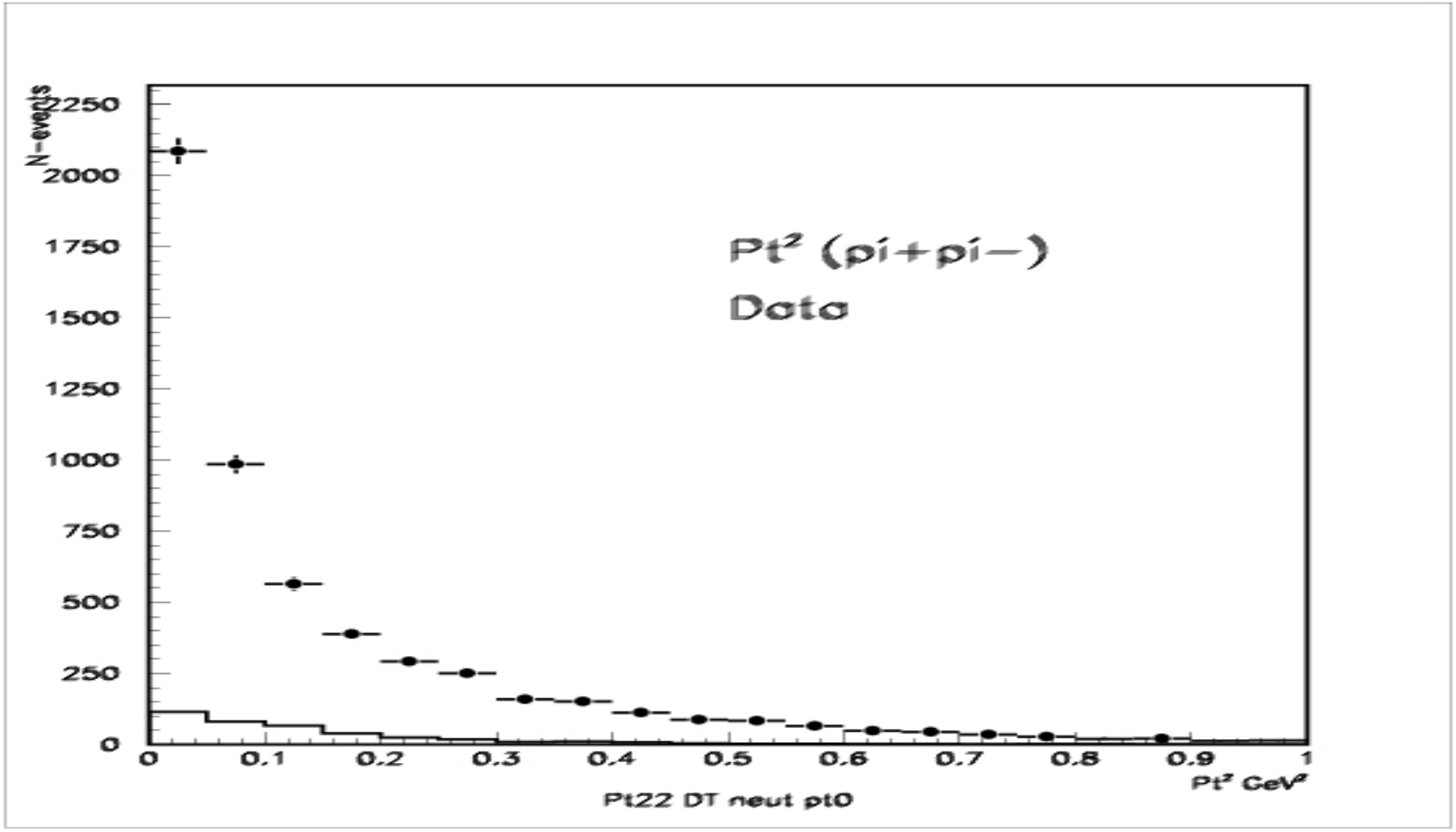


Mass pi+pi- + background



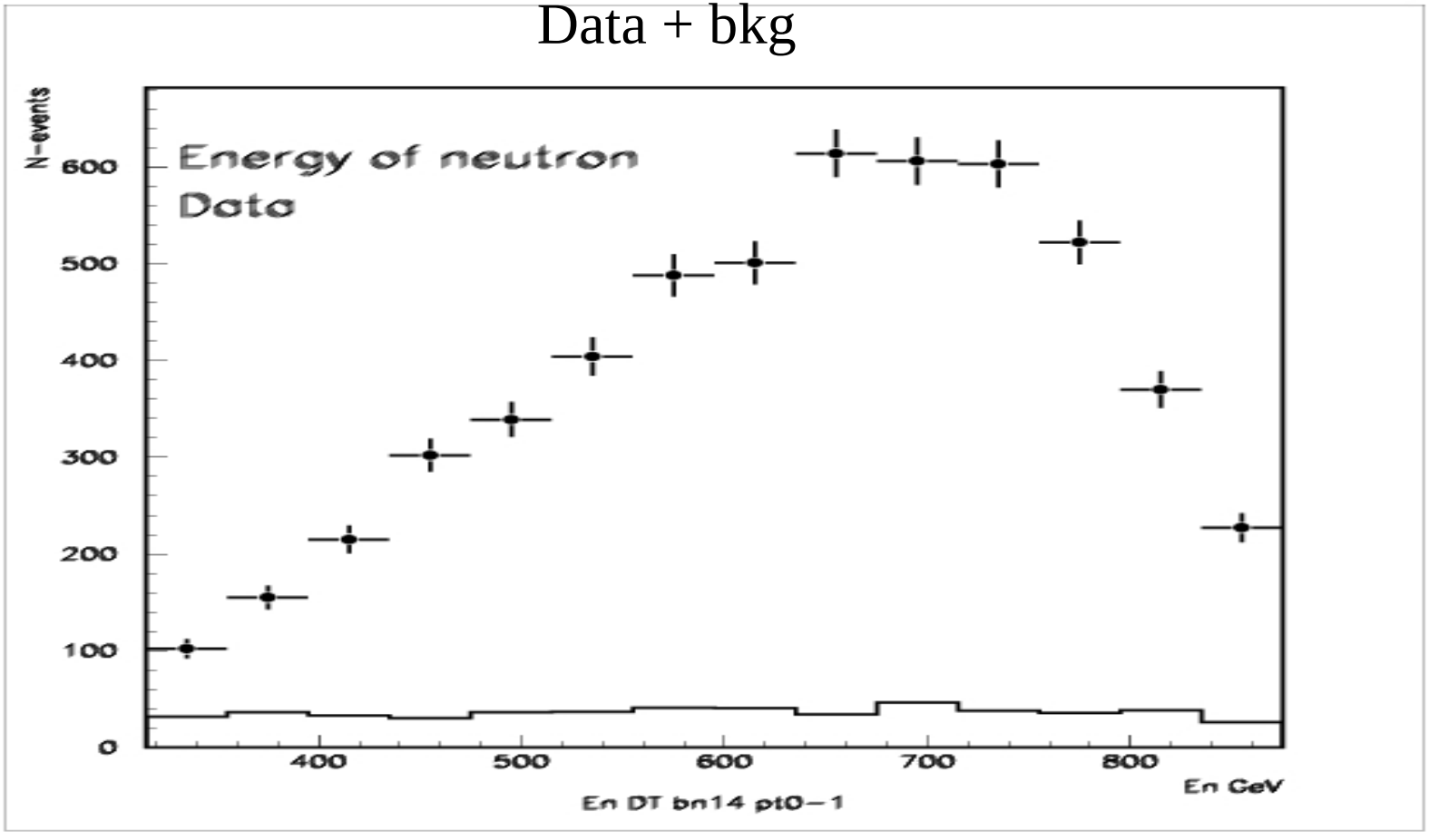
Background ~ 12%

Pt**2 Data + bkg

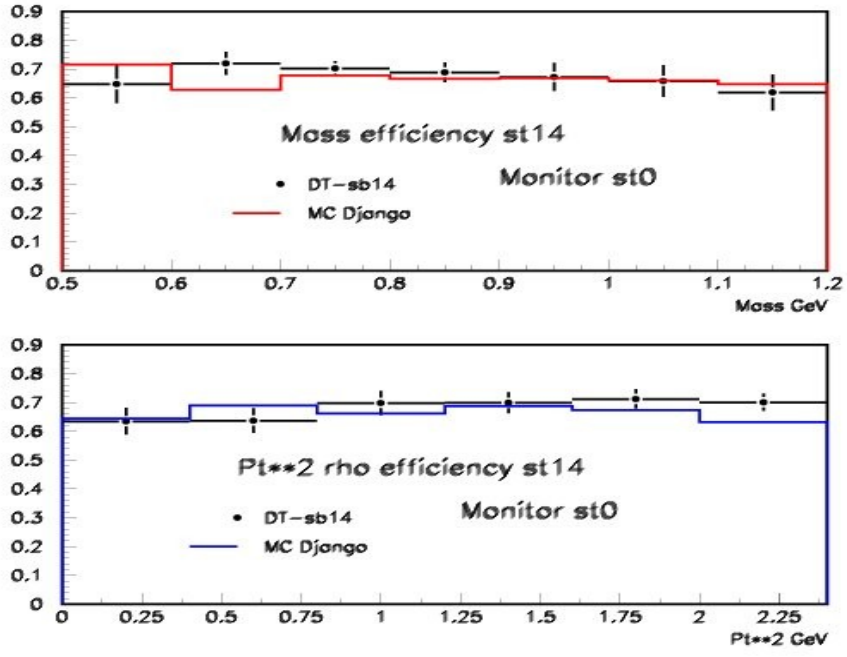

N-events
2250
2000
1750
1500
1250
1000
750
500
250
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Pt² GeV²
Pt² (pi+pi−)
Data
Pt22 DT neut pt0

Energy of neutron

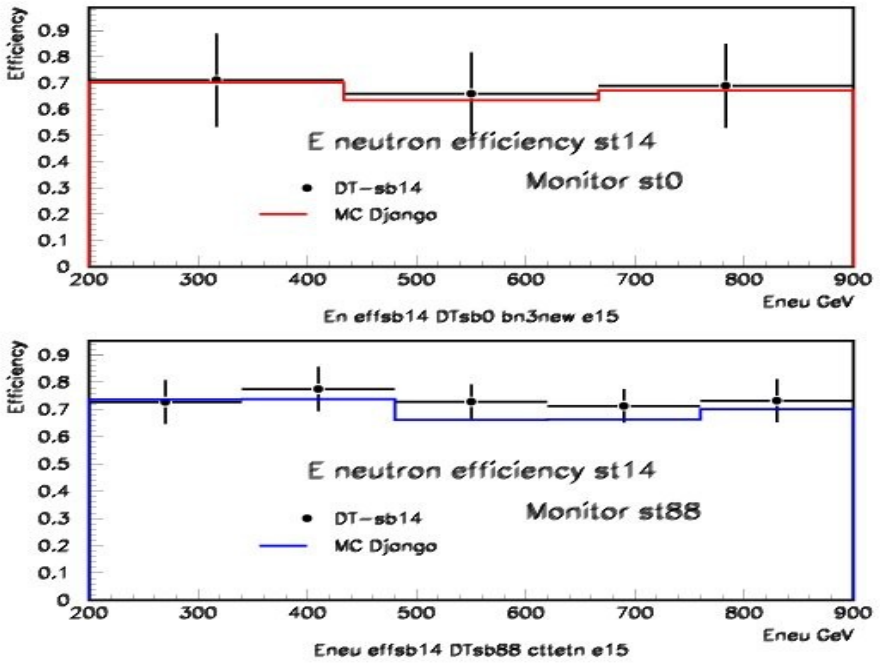
Data + bkg



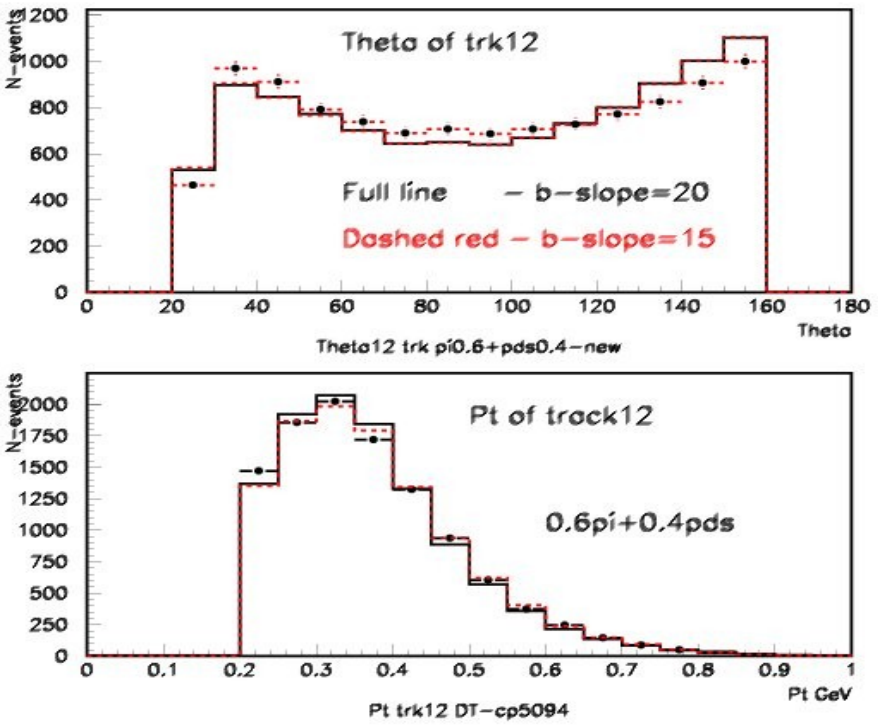
Trigger efficiency – Monitor st0



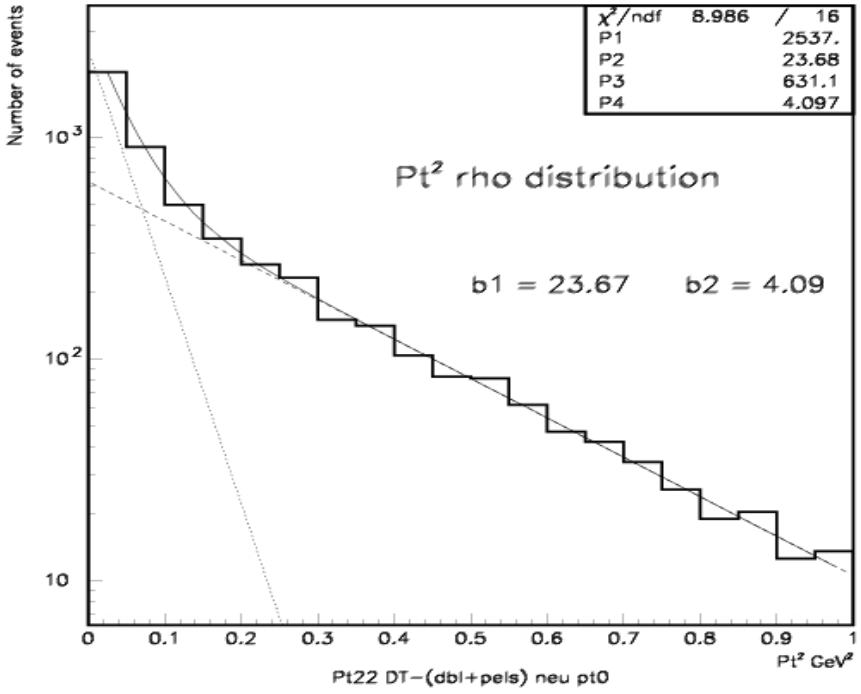
Trigger efficiency – Monitor st0



Control plots b-slope = 15 and 20



DT - bkg(dbl+pels)



Data – double – p-elastic

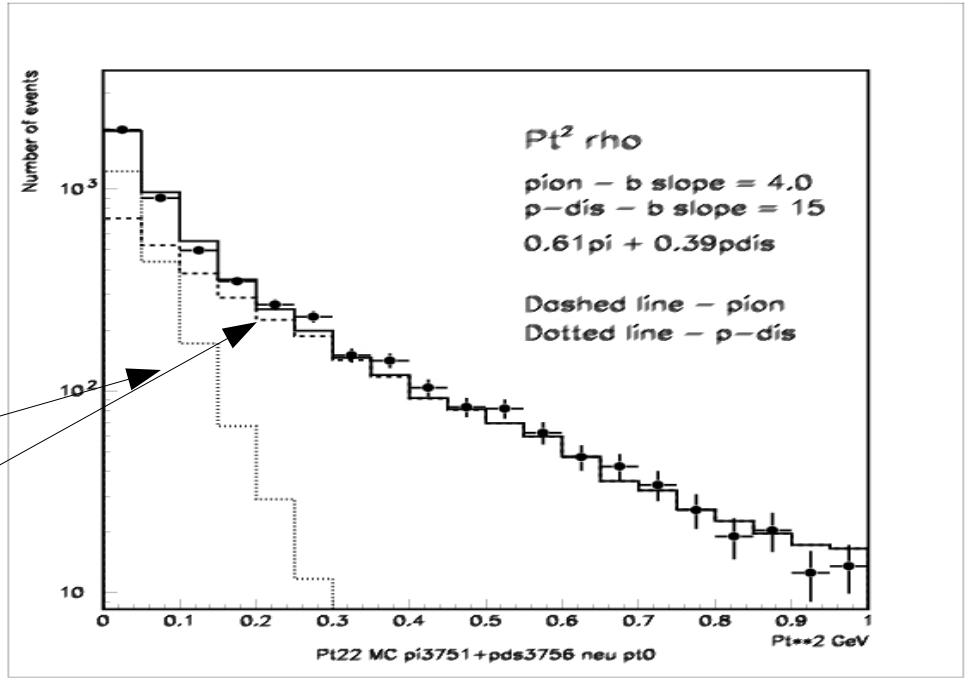
MC – pion + p-dis

0.61pi + 0.39pdis

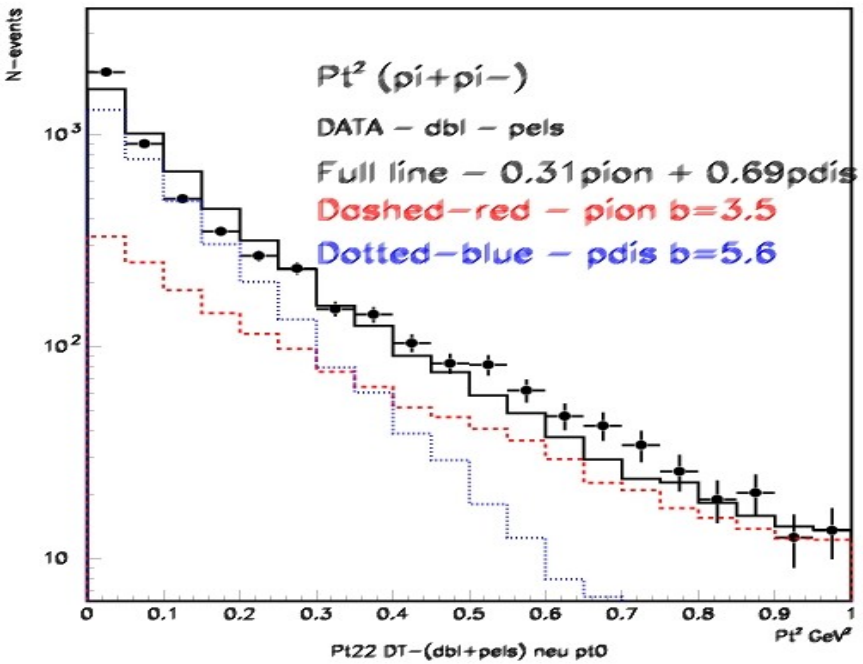
b-pi = 4 b-pds=15

p-dis

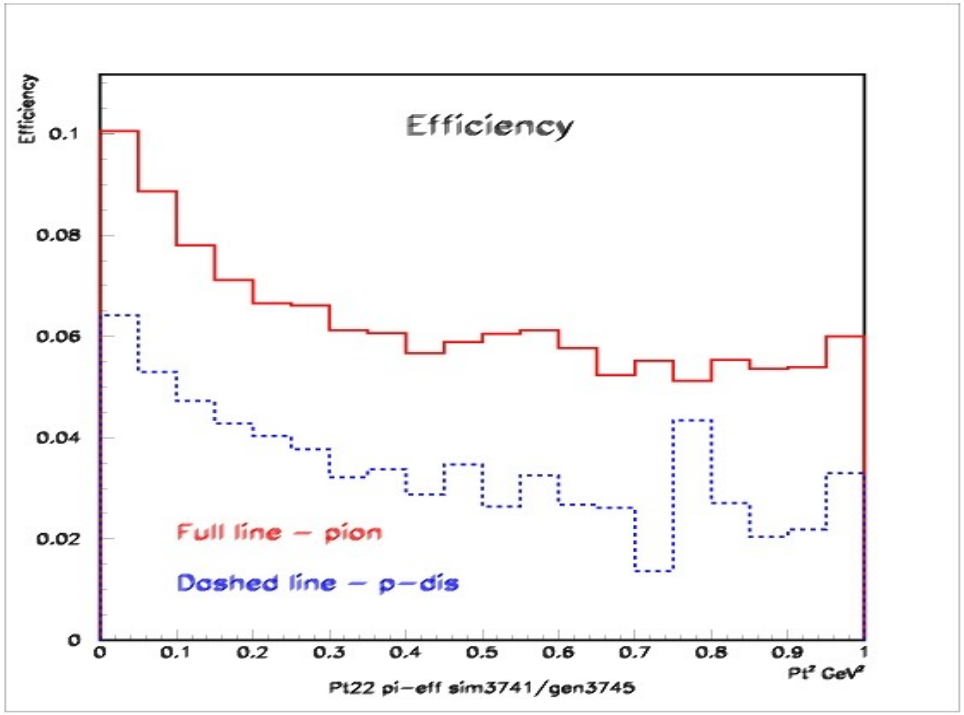
pion



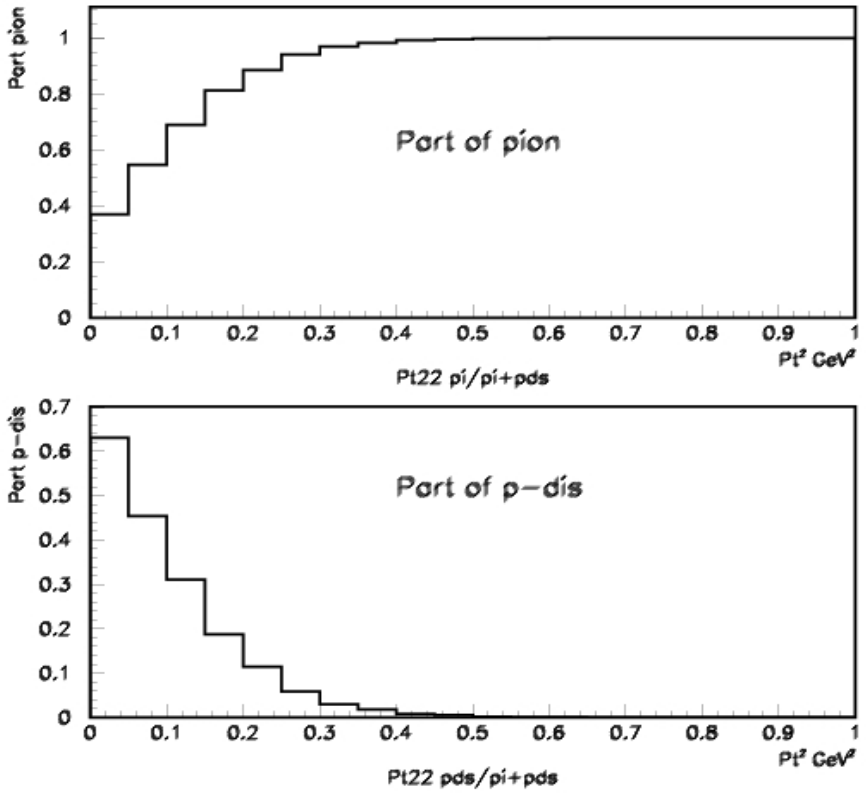
0.31 pion + 0.69 pdis



Pt**2 rho efficiency



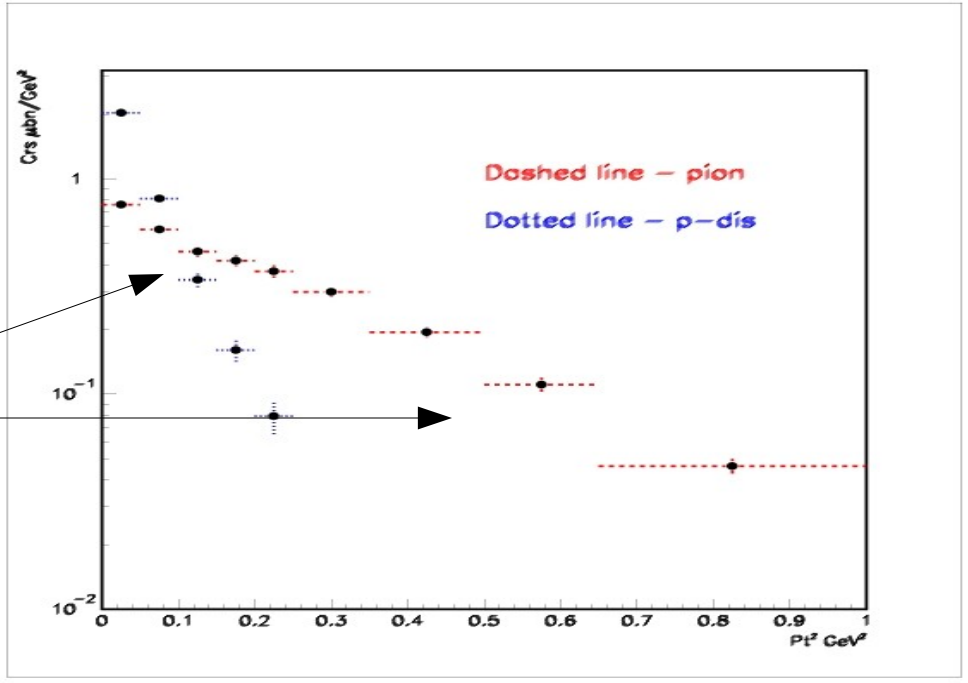
Part of pion and p-dis



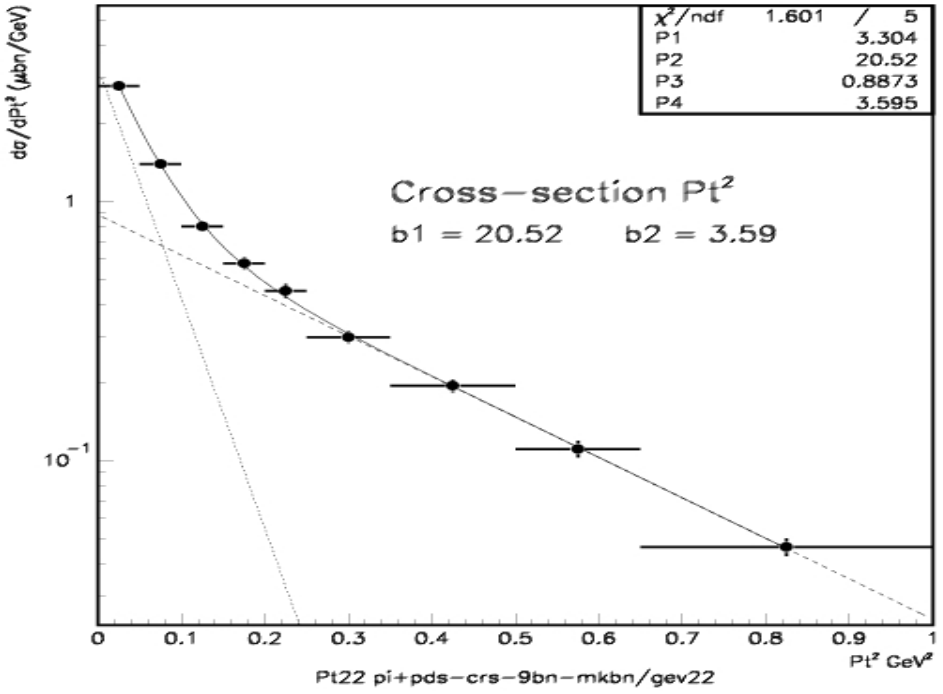
Pt**2 crs pi+pi-

Pion

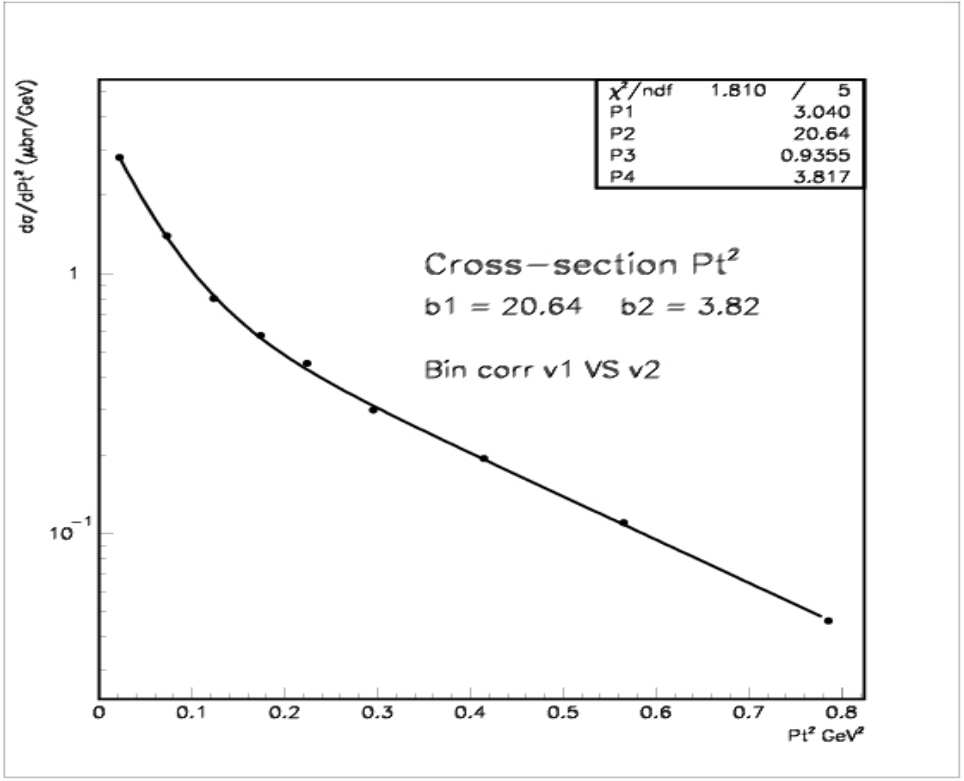
pdis



Cross-sec. Pi + Pdis



Cross-sec. With bin corr.



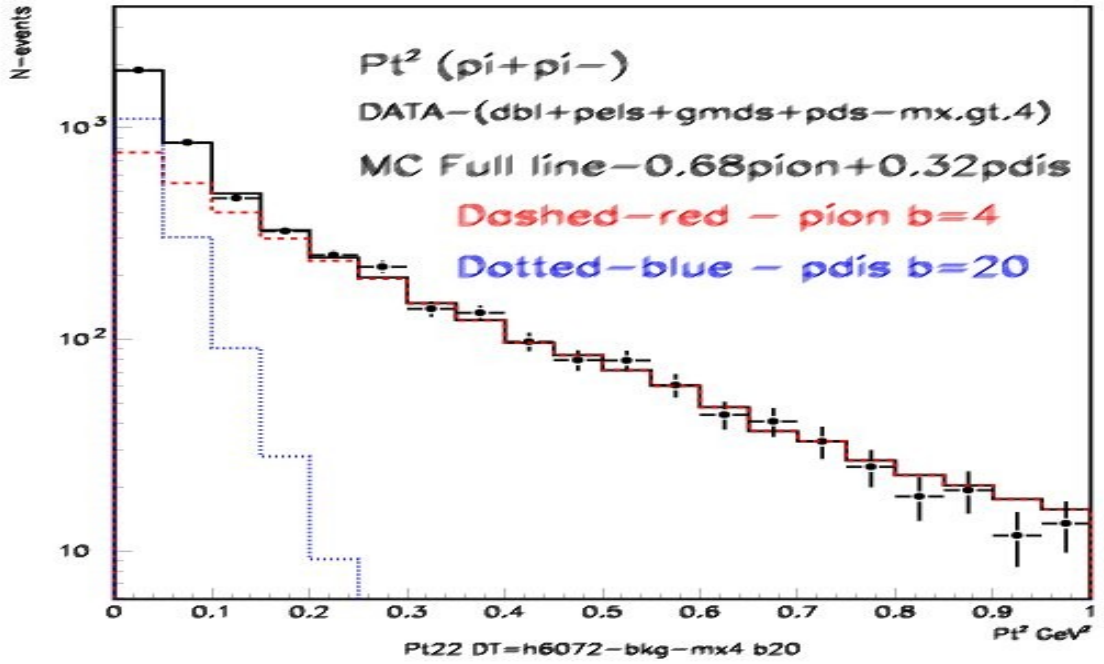
We recalculate cross-sec. Pt**2, Eneutron, Mass

1 – new b-slope of Pt**2 distribution – pdis – b=20

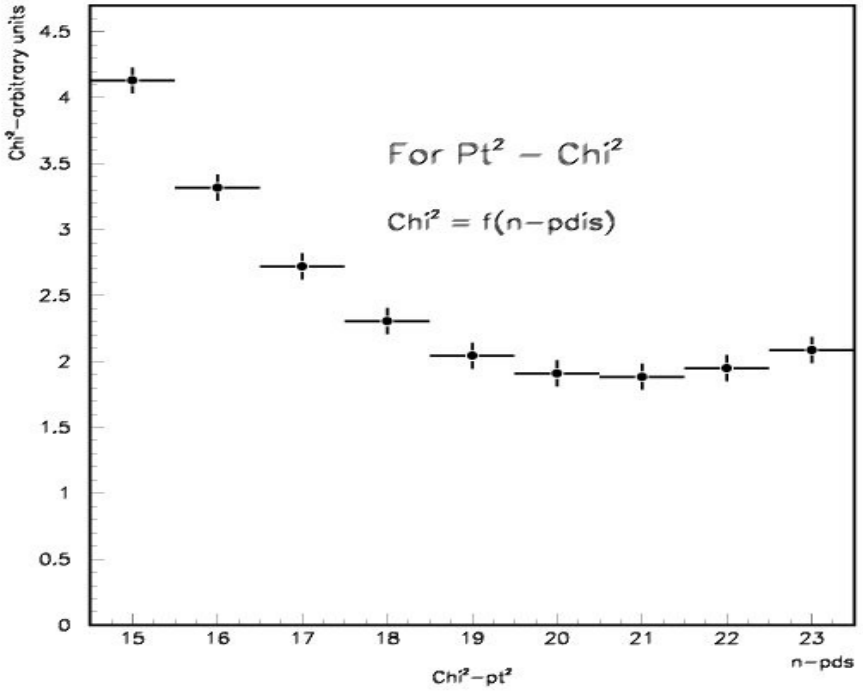
2 – new mass correction

3 – Background = dbl + pelas + gamma-dis + Pdis (Mx>4 GeV)

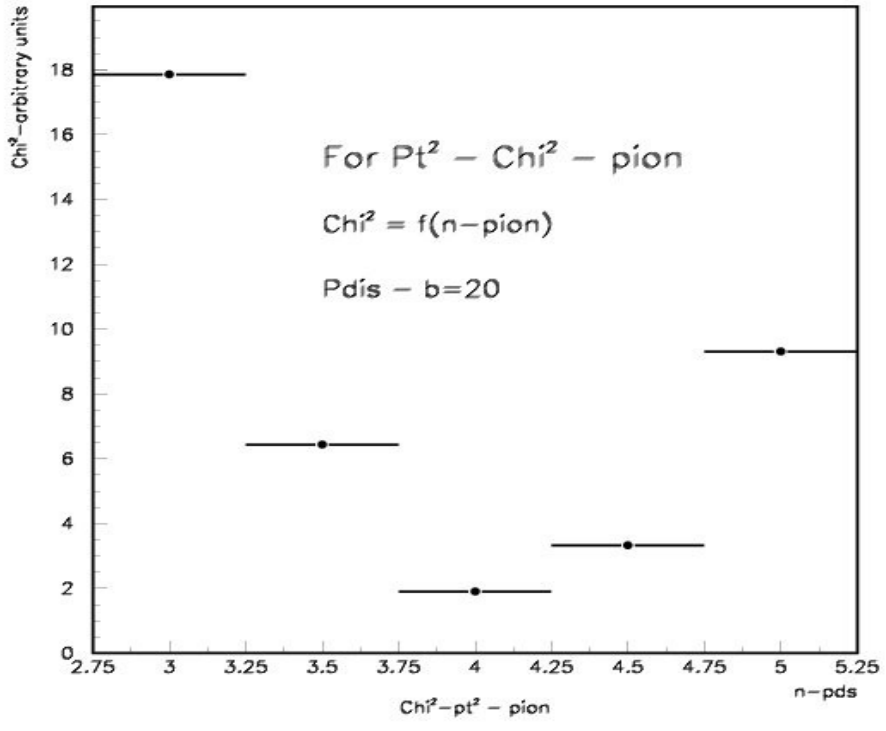
Pt**2 distribution – b-slope pdis = 20, pion=4



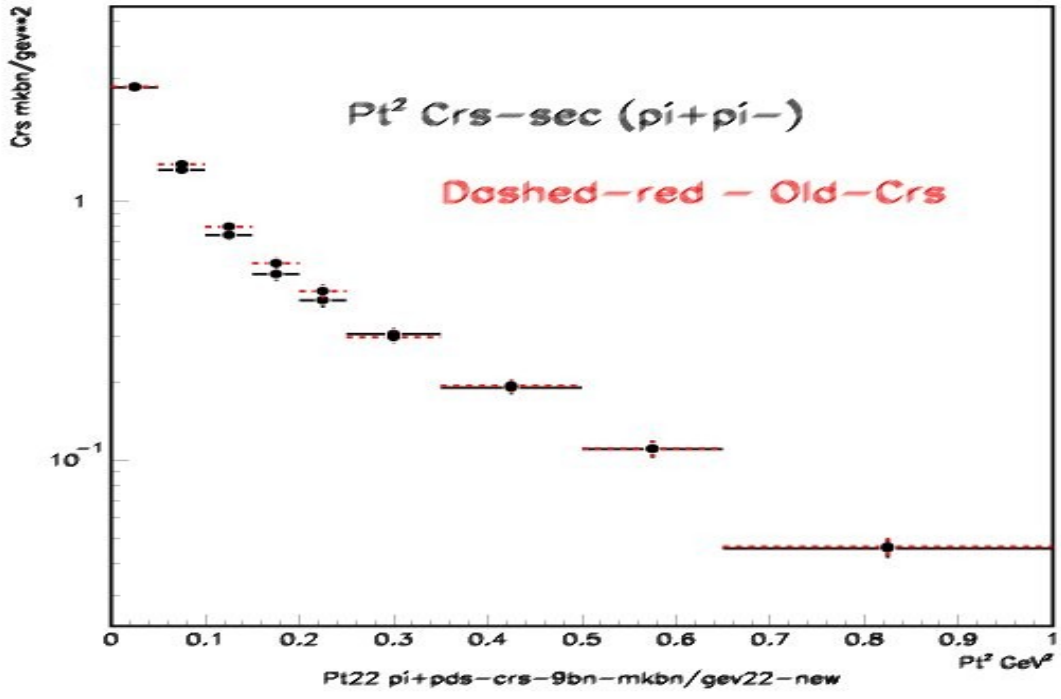
Chi**2 as function of b-slope - p-dis



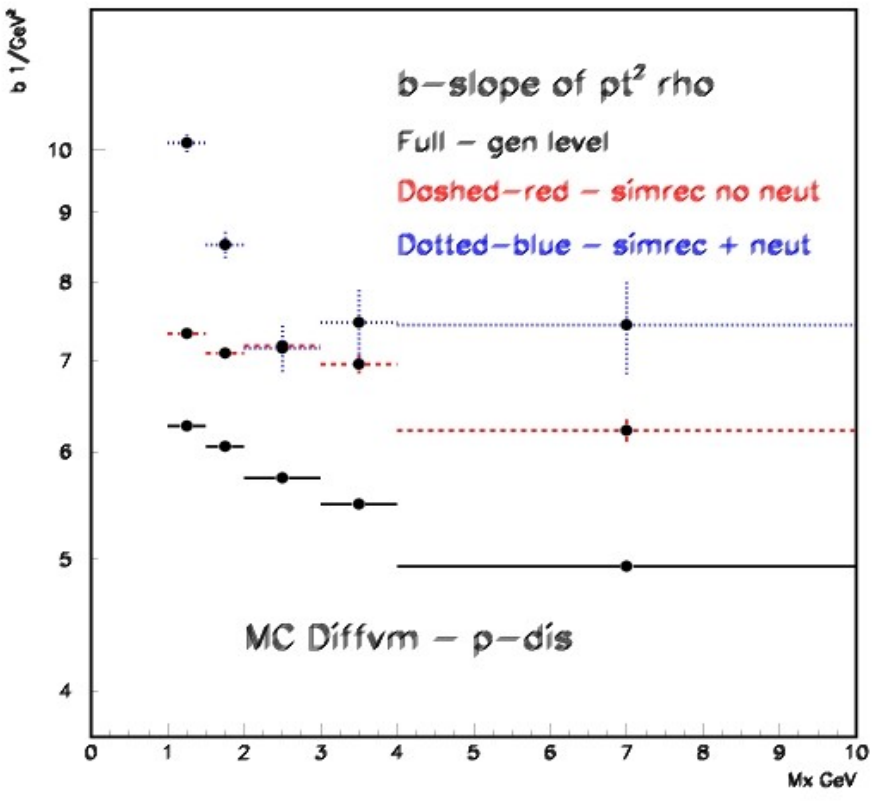
Chi**2 as function of b-slope - pion



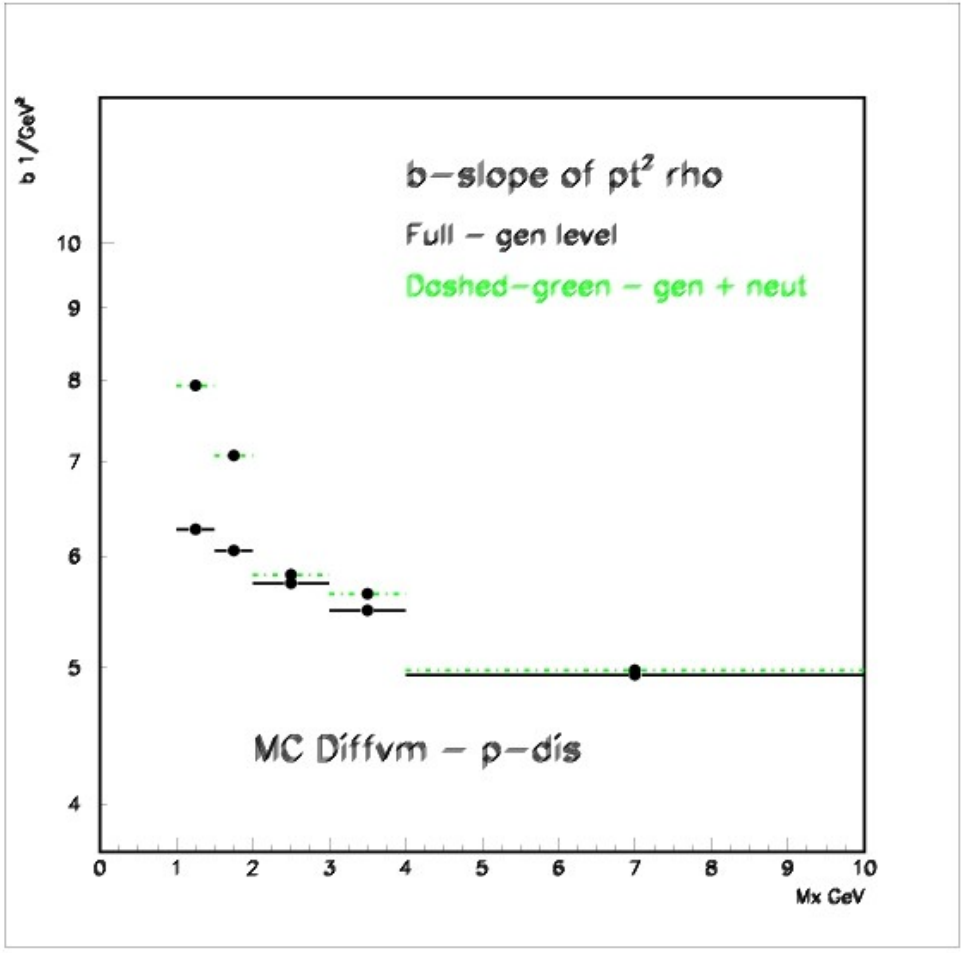
Cross-sec. for b-slope 15 and 20

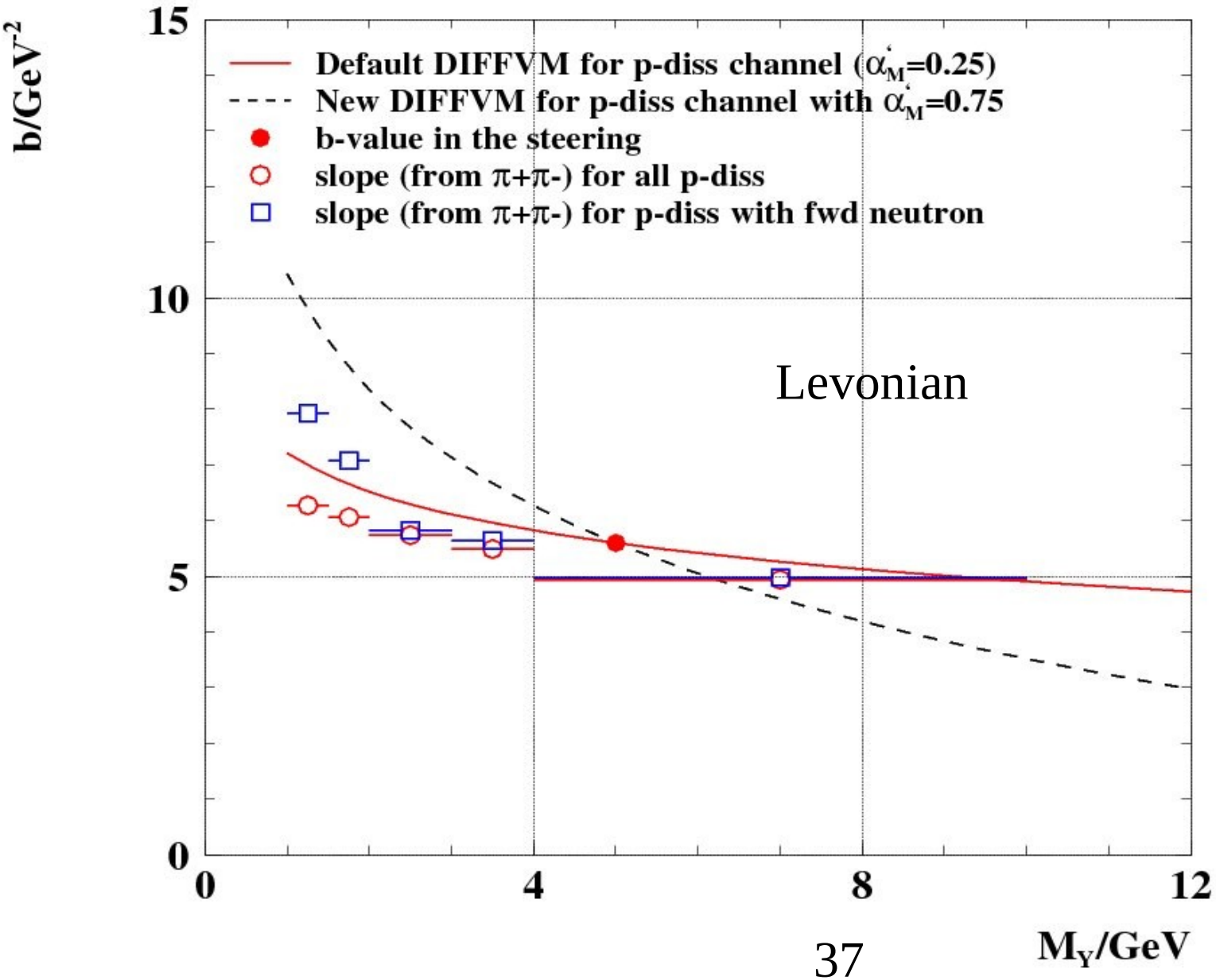


B-slope pt**2 rho



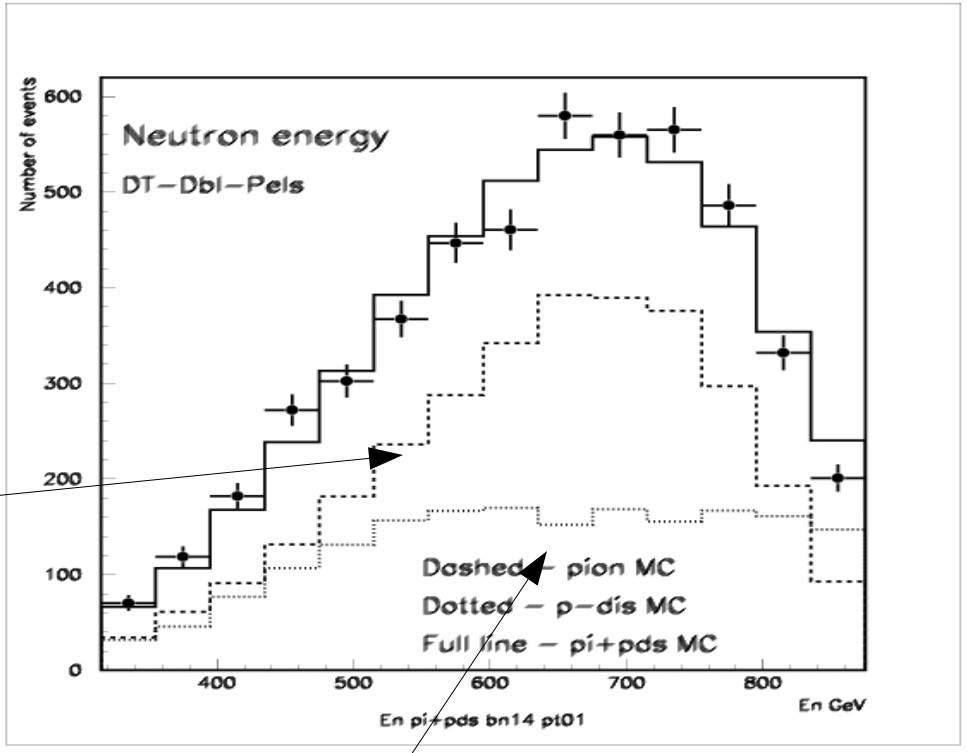
b-slope


b 1/GeV²
b−slope of pt² rho
Full − gen level
Doshed−green − gen + neut
MC Diffvm − p−dis
10
9
8
7
6
5
4
0
1
2
3
4
5
6
7
8
9
10
Mx GeV


b/GeV^{-2}
15
10
5
0
0
4
8
12
M_Y/GeV
Default DIFFVM for p-diss channel (α'_M=0.25)
New DIFFVM for p-diss channel with α'_M=0.75
b-value in the steering
slope (from π+π-) for all p-diss
slope (from π+π-) for p-diss with fwd neutron
Levonian

Data-double-pelas

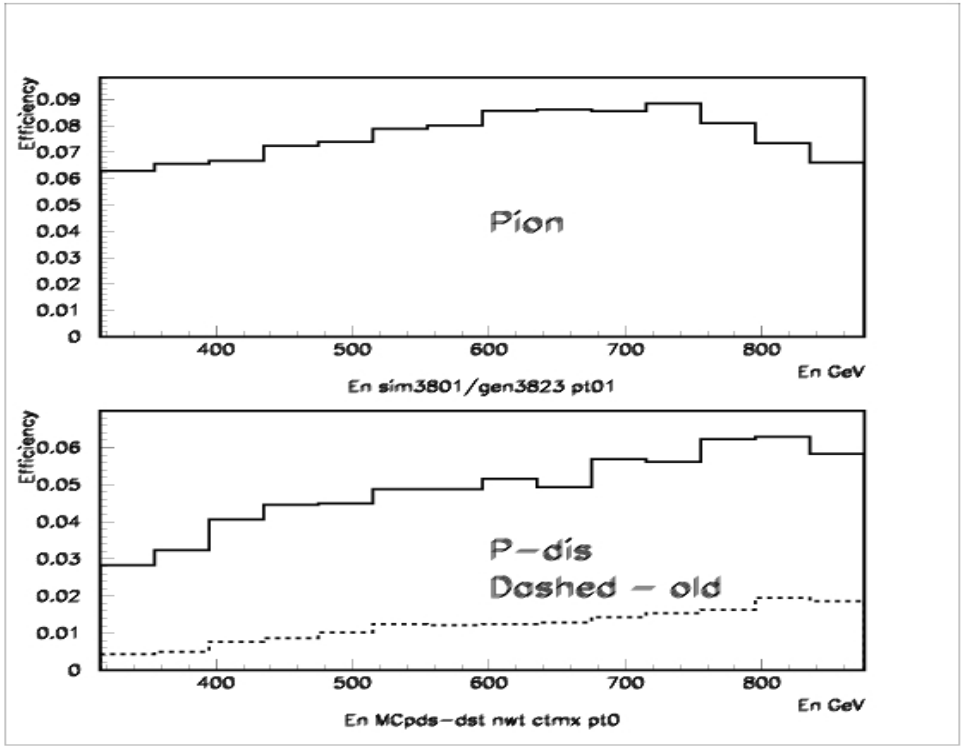
pion



0.62pion+ 0.38 pds - fit

p-dis

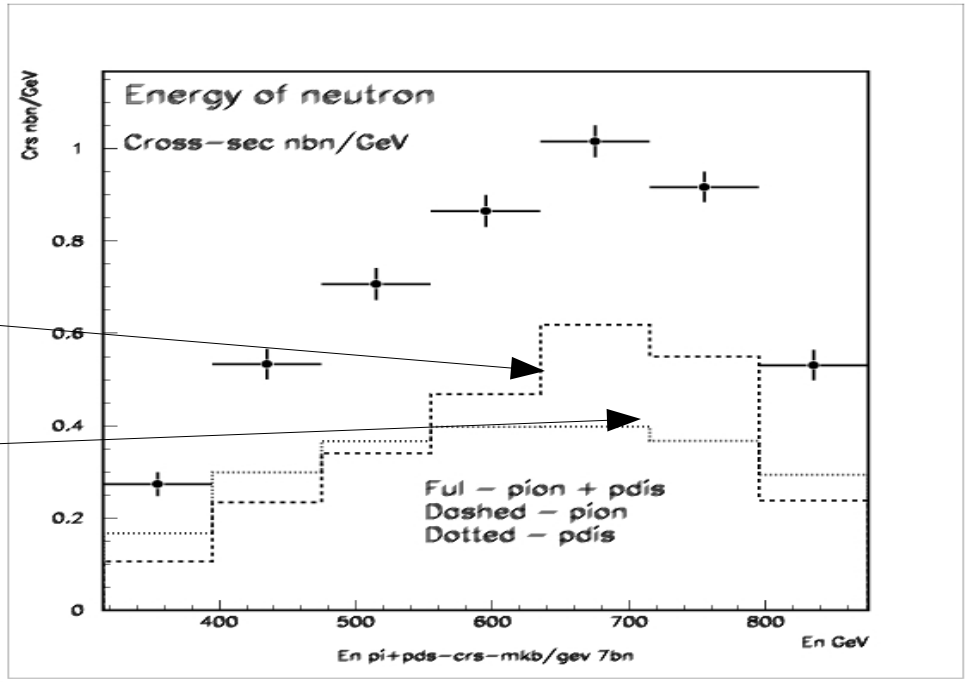
E neutron efficiency



Neutron crs pi+pi-

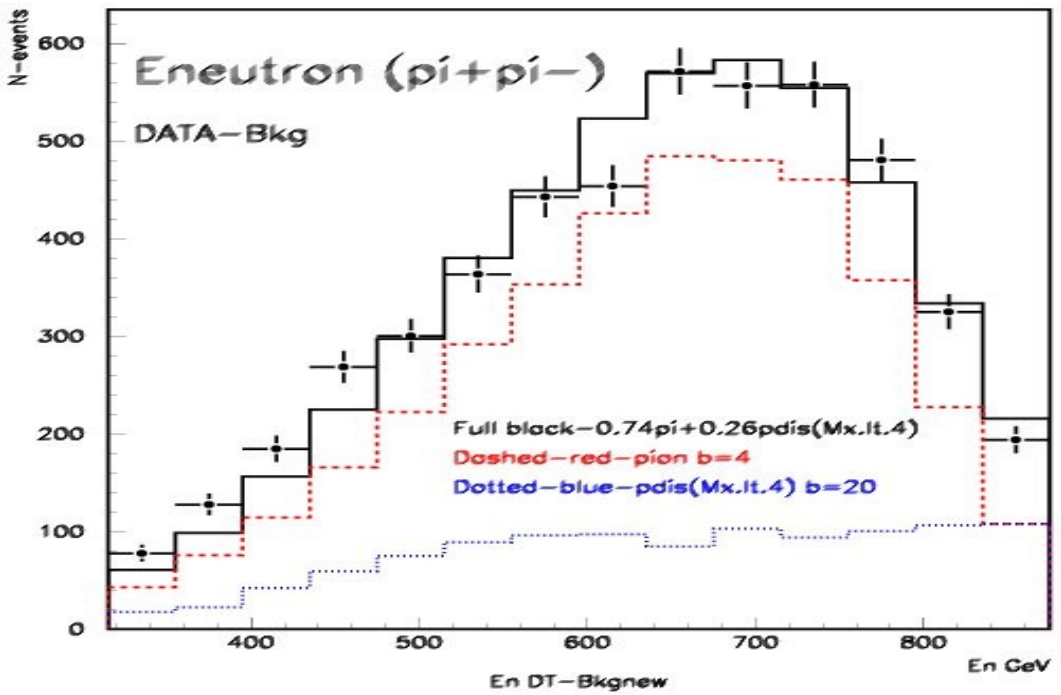
Pion

pdis

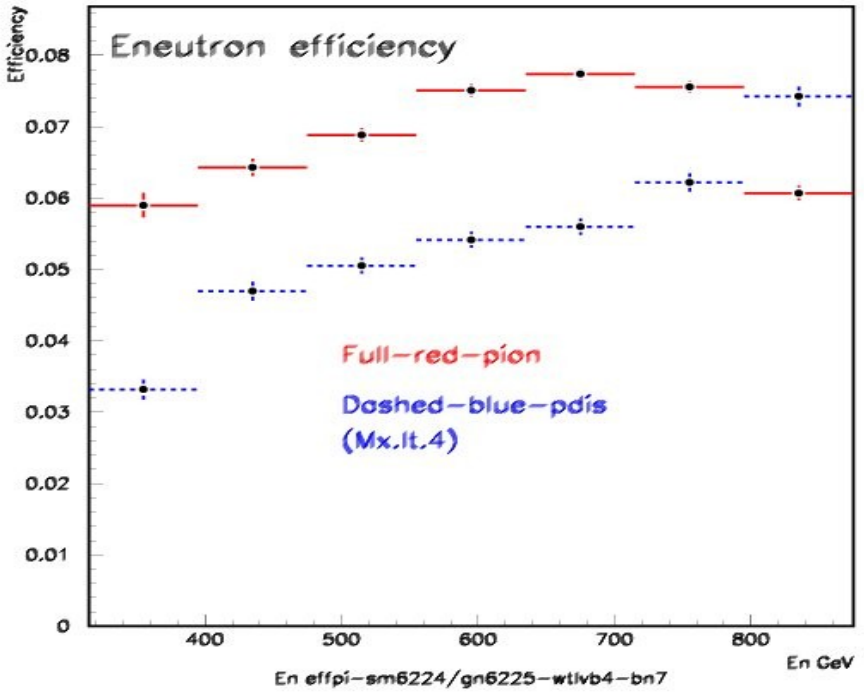


Recalculated E neutron distribution

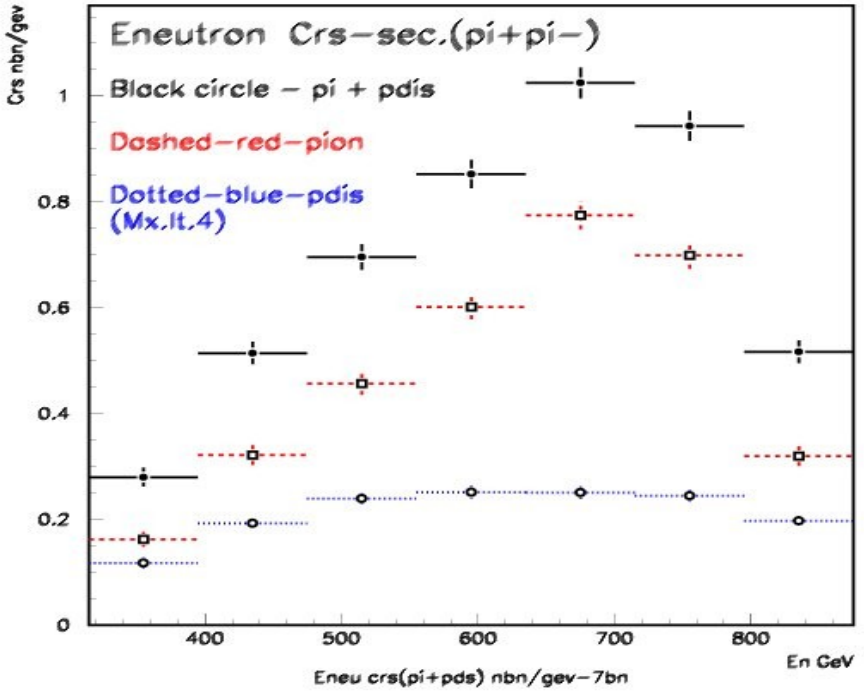
Mc – 0.74pion + 0.26 pdis



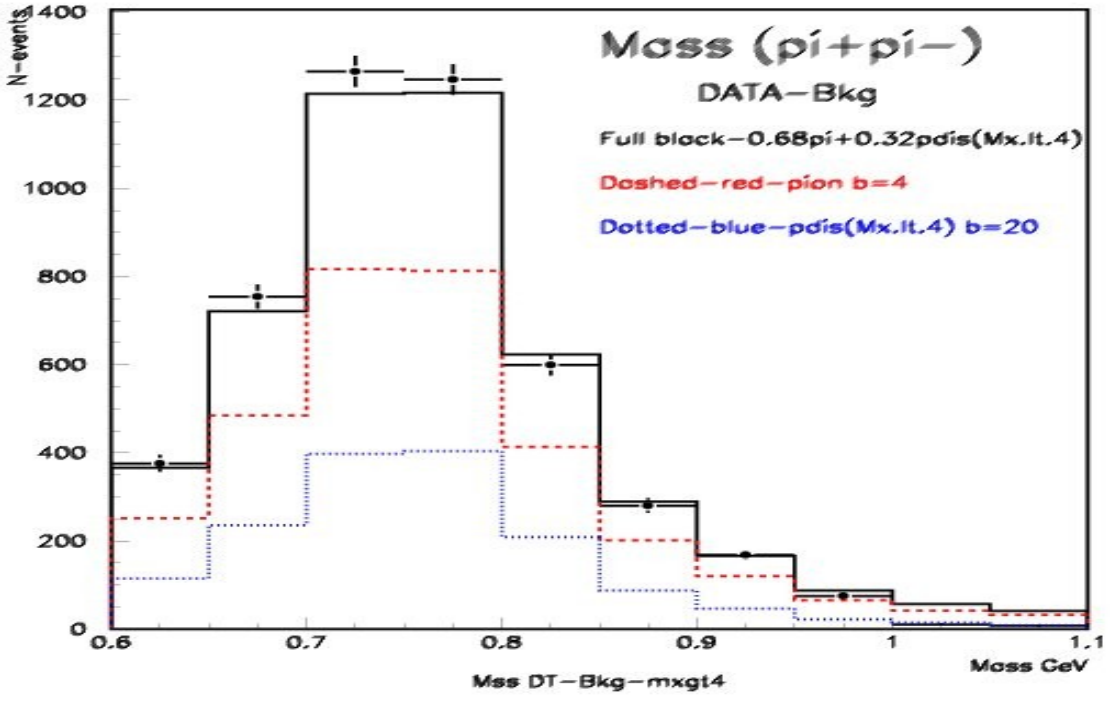
Efficiency of neutron energy - pion + pdis



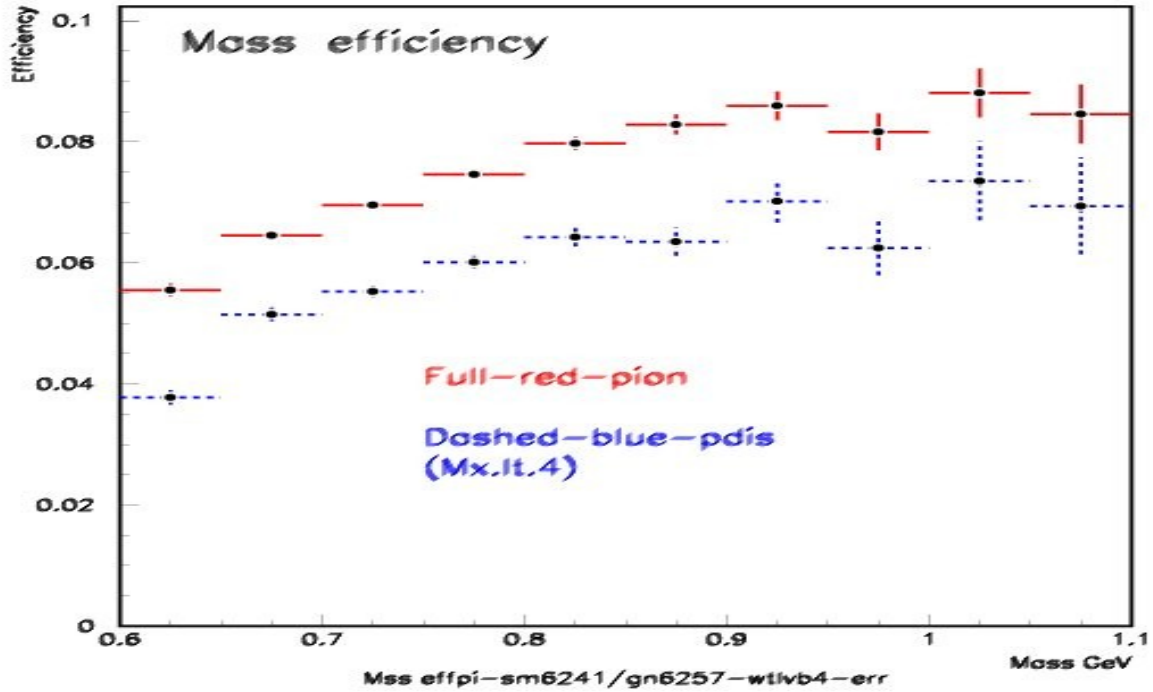
Cross-sec. of neutron energy



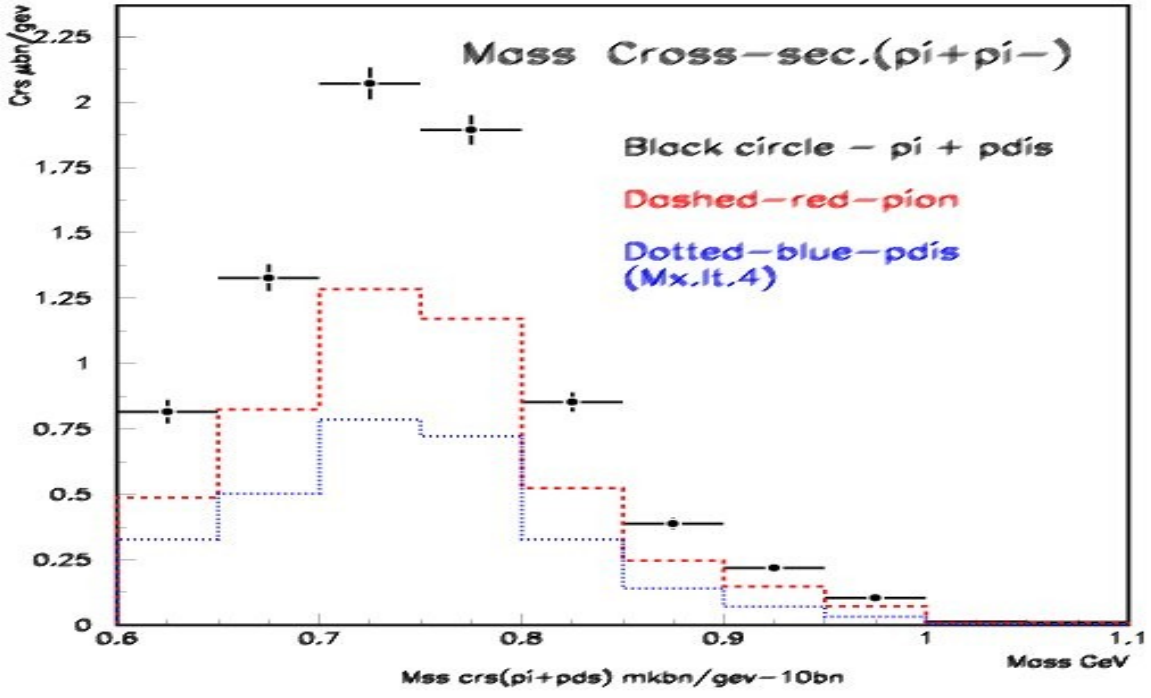
Mass distribution 0.68pi + 0.32pdis
Red – pion Blue - pdis



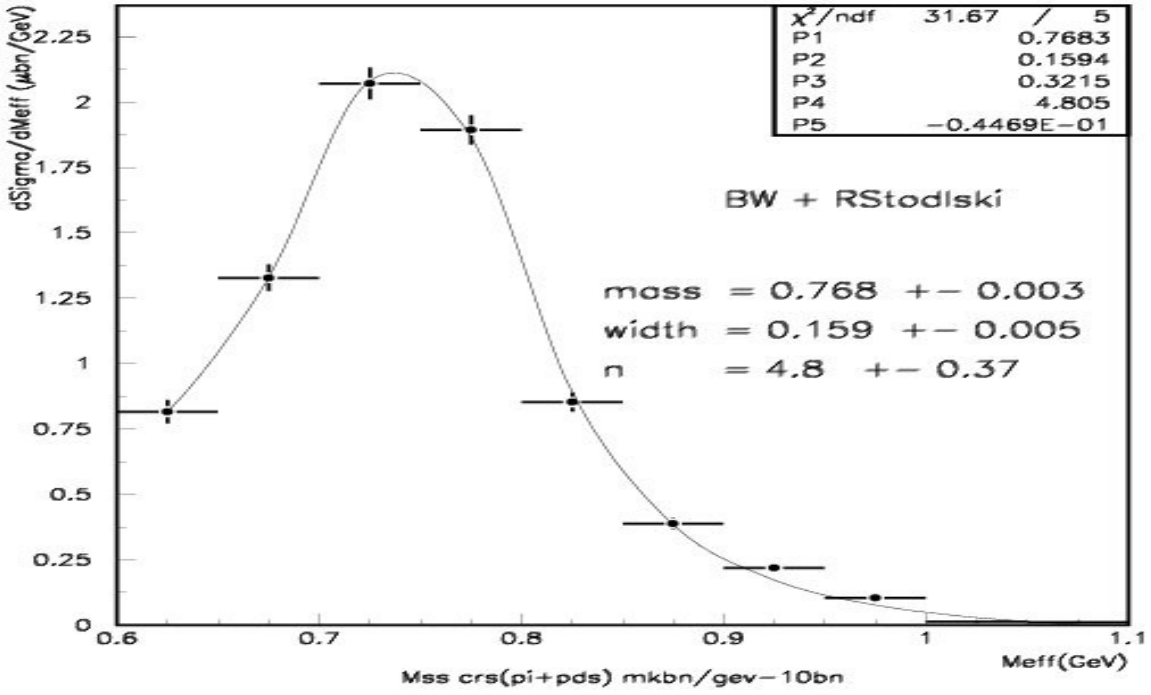
Mass efficiency
Red – pion Blue – pdis



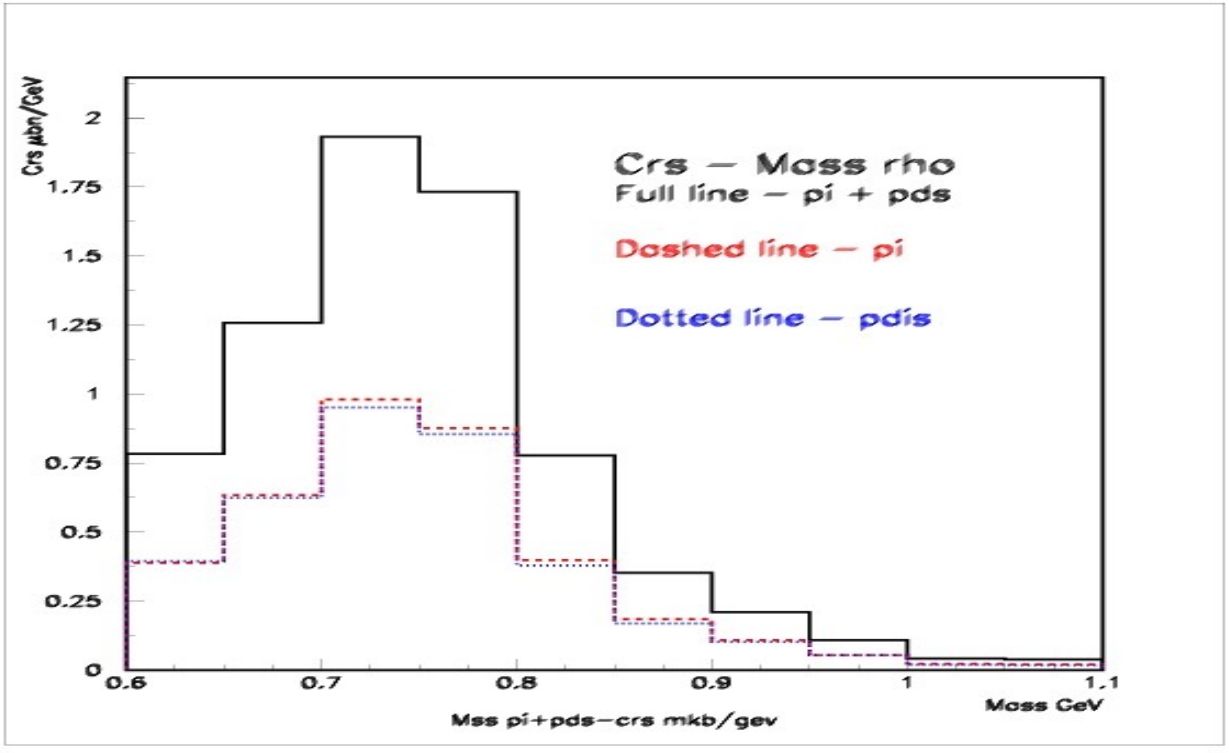
Mass cross-sec.
Red – pion Blue – pdis



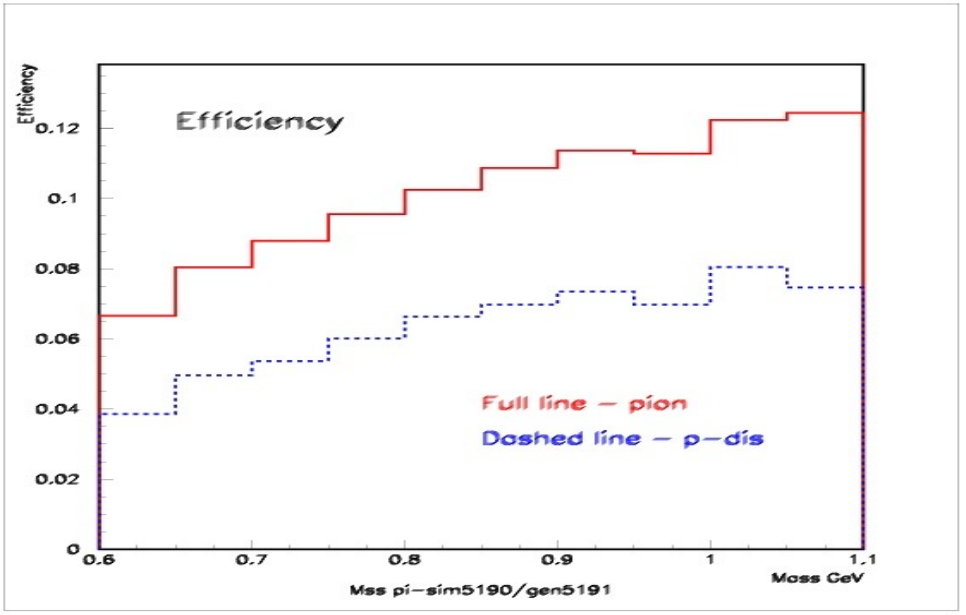
Mass cross-sec. - fit



Mass cross-section - old



Efficincy mass

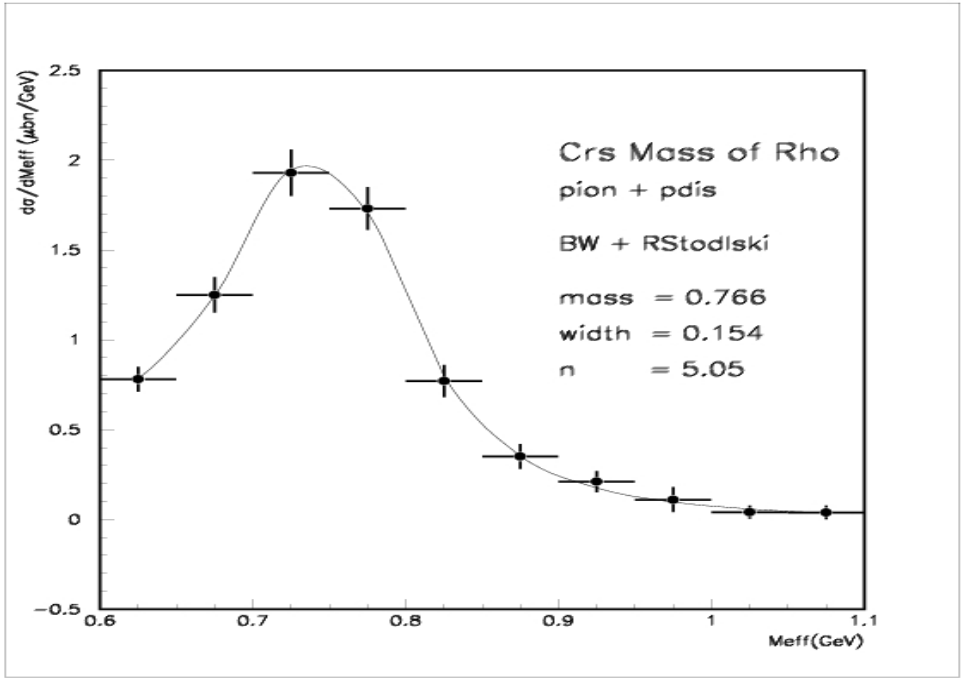


Fit mass cross-section

Cross-pi+pdis 0.43 mkb

Cros-sc pion 0.22 mkbn

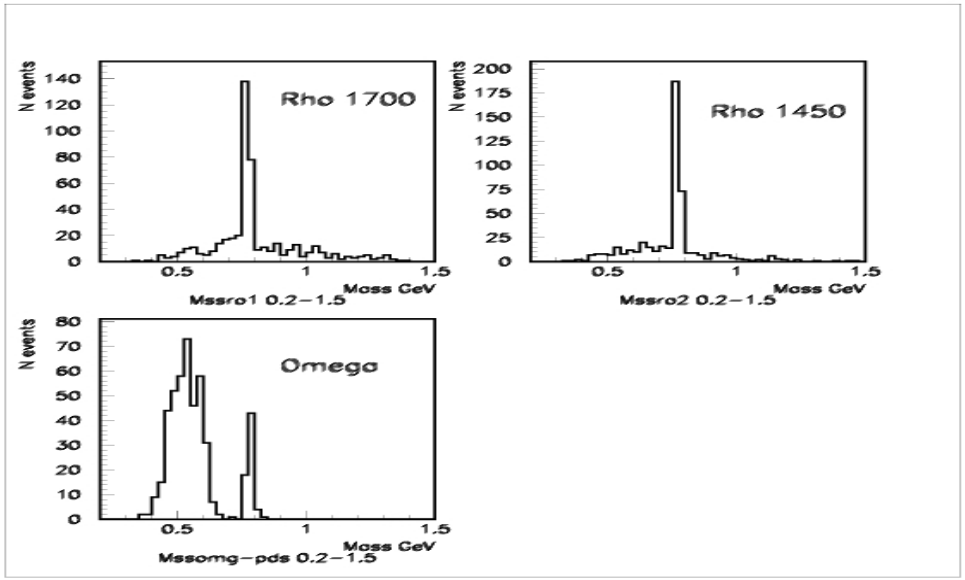
(0.3 – 1.5)



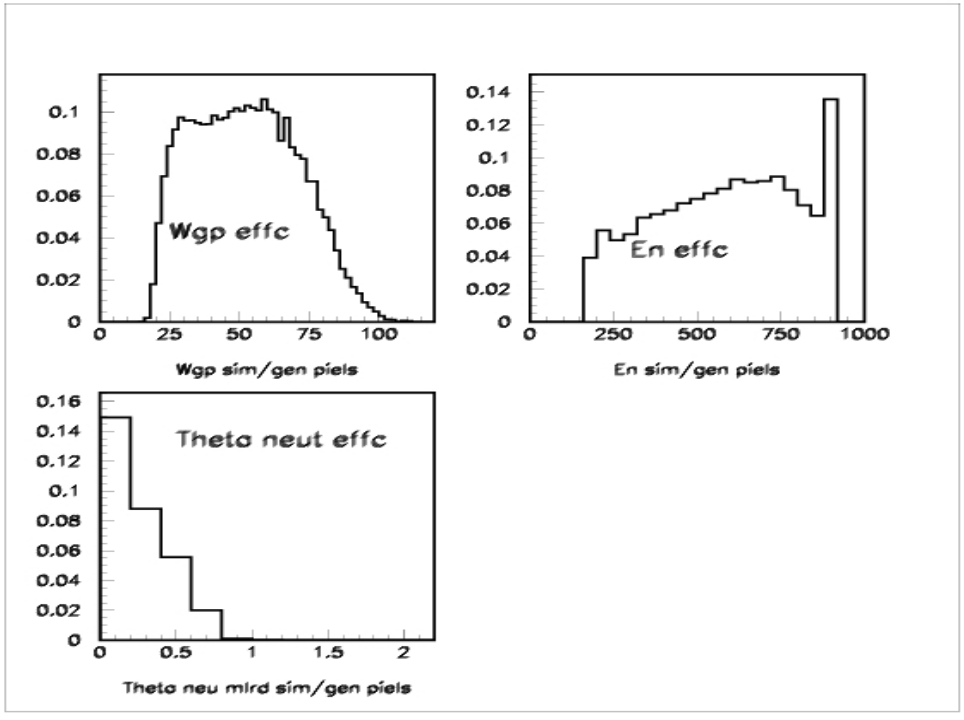
To do -

another systematic
(energy calibration ...)

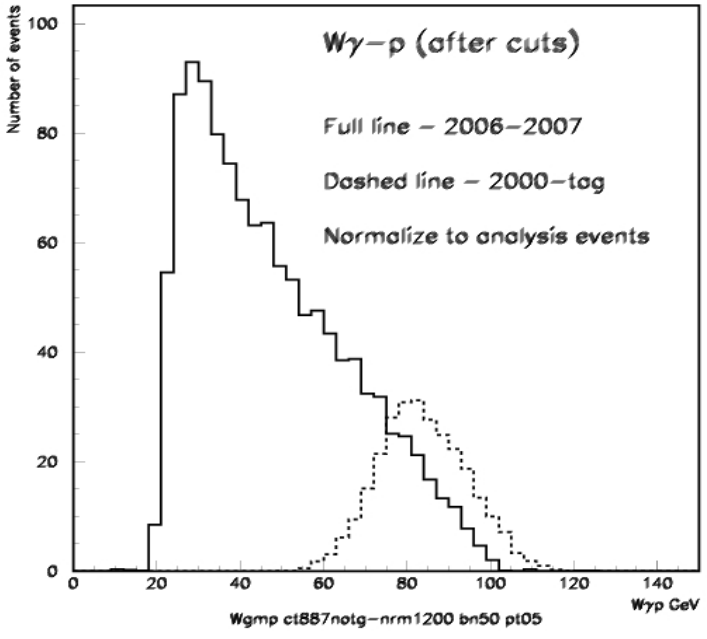
Rho 1700 1450 omega



Kinematic range



HISTORY



HERA1 analysis 2006-2008

- data 2000, 9 pb-1
- tagged gamma – etag44
- W ~77 GeV ~ 280 ev
- (Pt rho > 0.7 GeV)

HERA2 – 2009 – 2012

- data 06 -07, 1.12 pb-1
- untagged gamma (high presc.)
- W ~ 48 GeV ~ 1200 ev
- (Pt rho > 0.5 GeV)

* Improved FNC

* DST3 --> DST7 (improved rec)

Fortran analysis

Standart FNC cuts:

- neutral cluster type – 2 and 3
- x and y in the FNC aperture
- energy > 200 GeV

Event selections

Data quality cuts

Data 2006 – 2007 e+ st14 (FTT, CIP, !LAR_IF)

Remove FNC and FTT bad runs

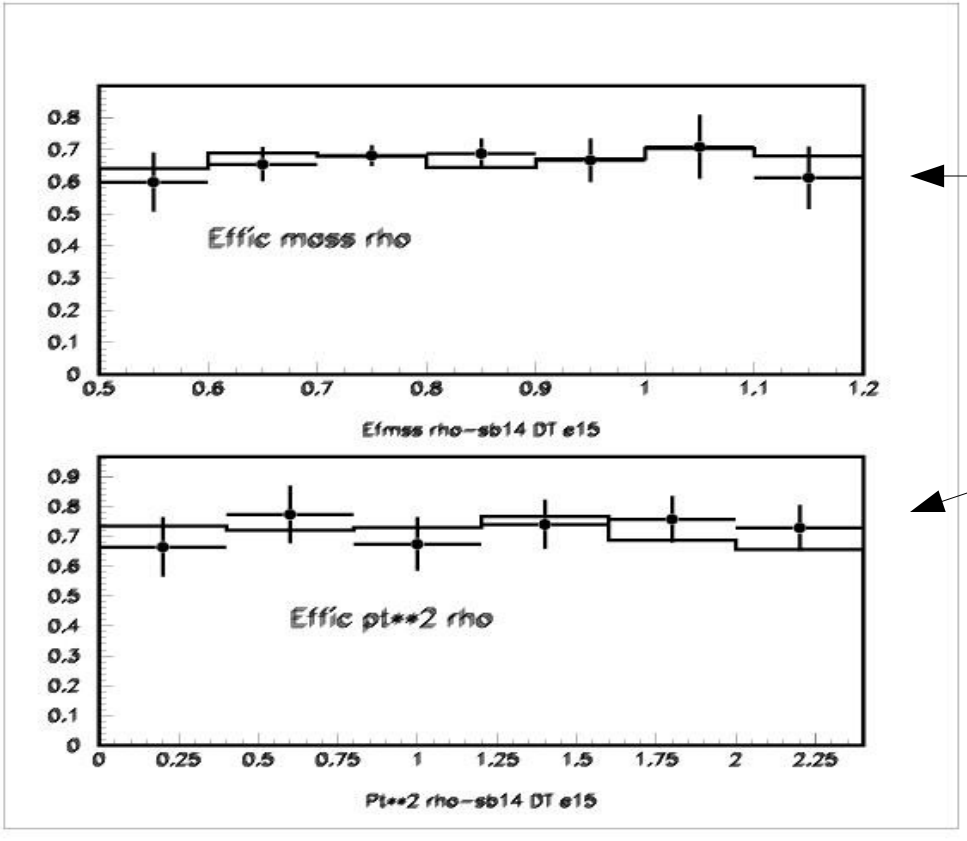
Lumi = 1.12 pb-1 (averadge prescale – 95)

Tracking cuts

* Only 2 oppositely charged tracks
* Primary vertex fitted tracks, dp/p<0.5, pt>0.15 GeV
* central or combined tracks
* to increase efficiency:
  - pt_tracks > 0.2 GeV
- θ tracks in the interval 20^{o} – 160^{o} degrees
* anti ϕ cut – Mkk > 1.05 gev
* E-Pz < 10 GeV (from 2 tracks)
* | Zvertex | < 30 cm

Trigger efficiency

Monitor trig sb88
(FNC + Spacal)



ε mass

ε Pt^2 ρ

5% Uncertainty
of ε trig

Background suppresion cuts:

1 – Only 2 particles in final state:

* track – cluster matching:

  $|\phi_{trk} - \phi_{cls}| < 30$ degree

  $|\theta_{trk} - \theta_{cls}| < 10$ degree

* no other LAR clusters with energy > 0.4 GeV

* LAR_IF< 0.4 GeV (trigger verification)

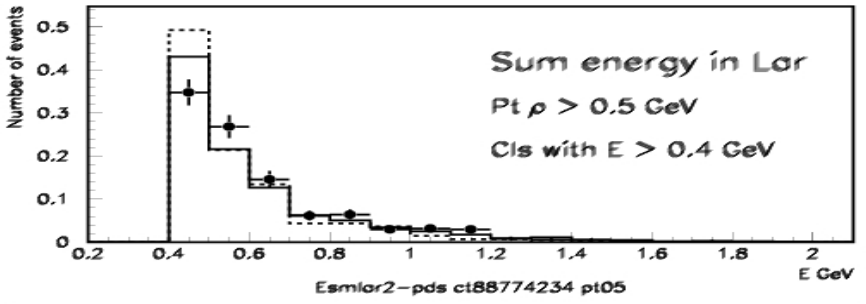
2 – Forward detector cuts:

* FMD – sum of pair hits in 3 first layers < 2

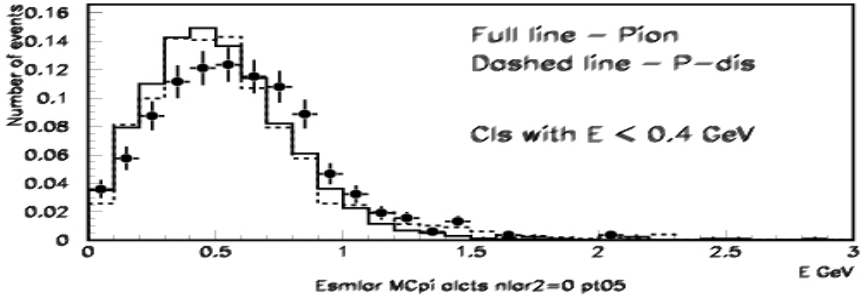
* FTS - no hits in plane 28 m

Lar - Control plots – pt rho > 0.5 gev

Sum energy of clusters with energy > 0.4 GeV →



Sum energy of cluster with energy < 0.4 gev →



Background : (from MC)

Proton – diss - main – 0.7 of background

Double diss. - 0.16

Elastic rho production - 0.12

gamma-diss – 0.02

- from normalize to lumi

MC – DIFFVM and PYTHIA

(close results)

For signal (pion exchange) – Pythia + Pompyt

Use for background - (p-dis + double + pelas)

We have after cuts:

MC pion – 10388 ev

MC p-dis – 1252 ev

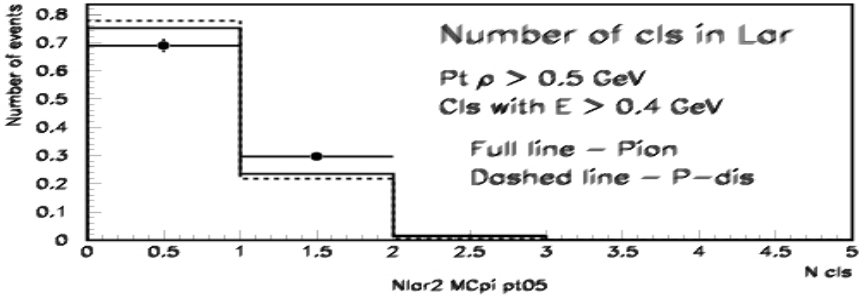
MC dbl - 401 ev

MC p-elas- 71 ev

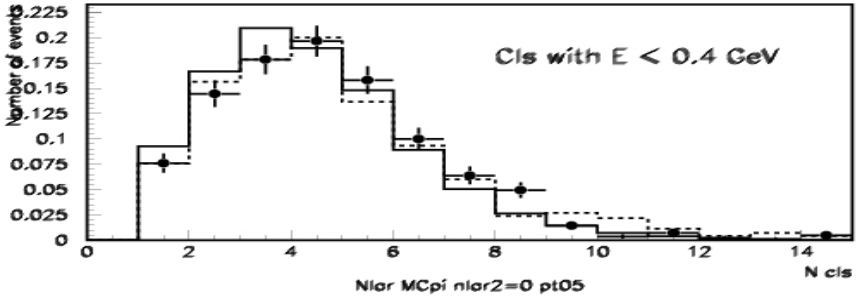
Data - 1211 ev

Lar control plot – pt rho > 0.5 GeV

Number of clusters with energy > 0.4 GeV →



Number of clusters with energy < 0.4 GeV →



- fragmentation mode for the state X;
- VDM model parameters;
- pomeron trajectory.

This paper is organized as follows. In section 2 a description of the model is given and section 3 illustrates the program itself. Section 4 contains a control cards example file with the explanation of the meaning of each card and the output plots produced by Diffvm with the entries described in tab.5.

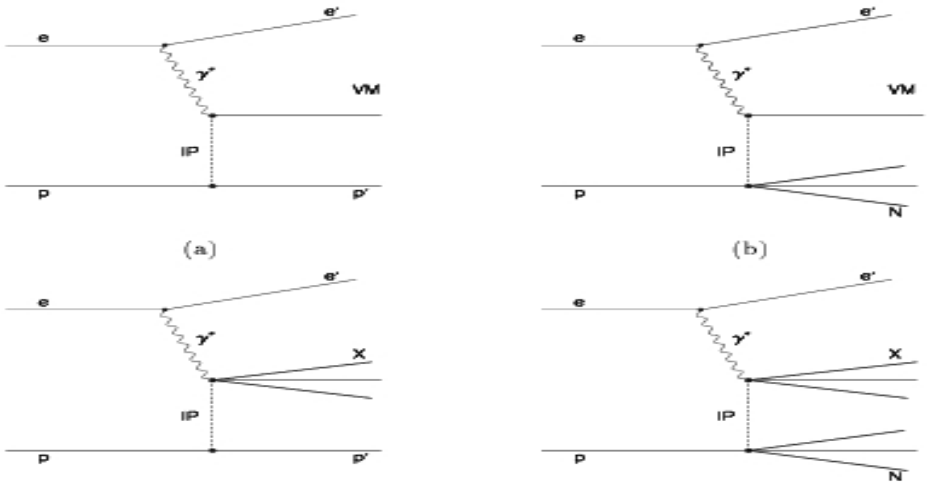
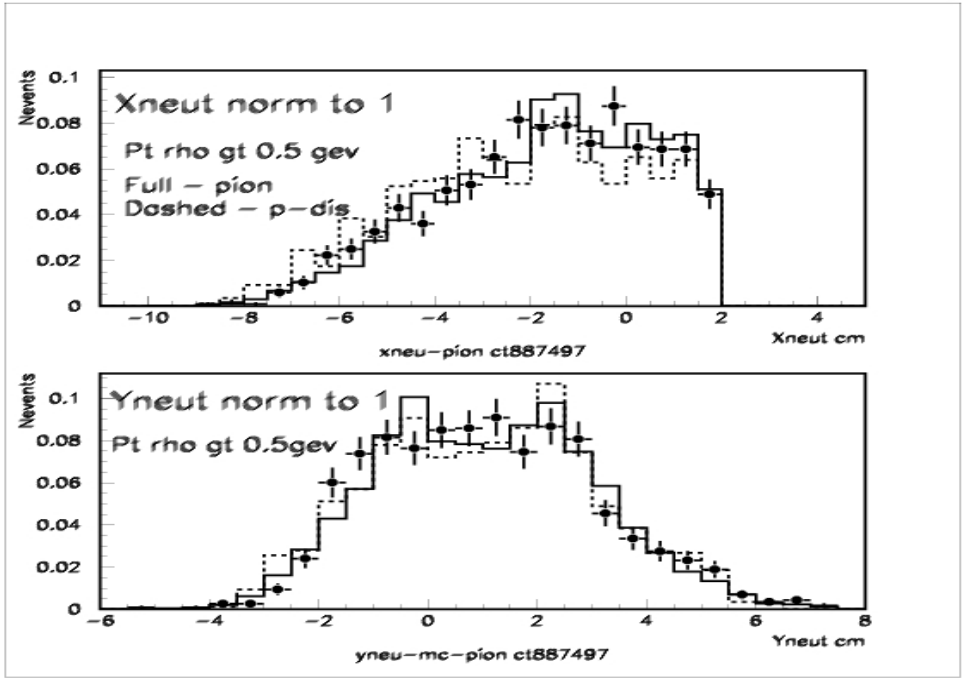


Figure 1: (a): elastic vector meson production, (b): vector meson production with proton dissociation, (c): single diffractive dissociation of the photon, (d): double diffractive dissociation.

FNC - Control plots – pt rho > 0.5 gev

X neutron →

Y neutron →



Fuill line – pion

Dashed line – p-dis

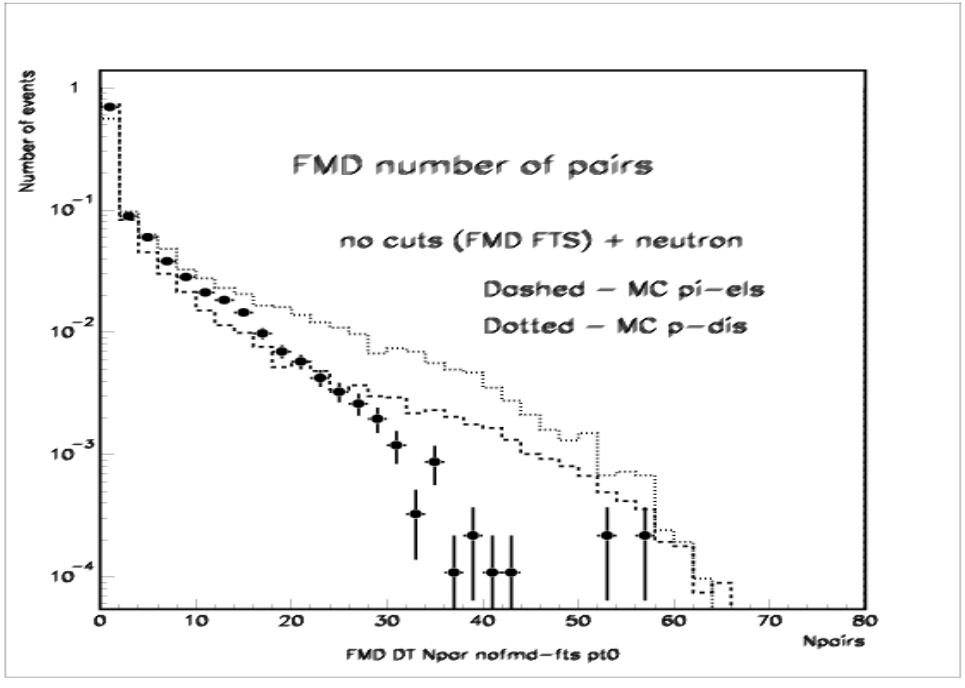
FMD - control plots pt rho > 0.5 gev

Number of pairs hits
in first 3 layers

Dashed – pion elas

Dotted – p-dis

(norm to 1)

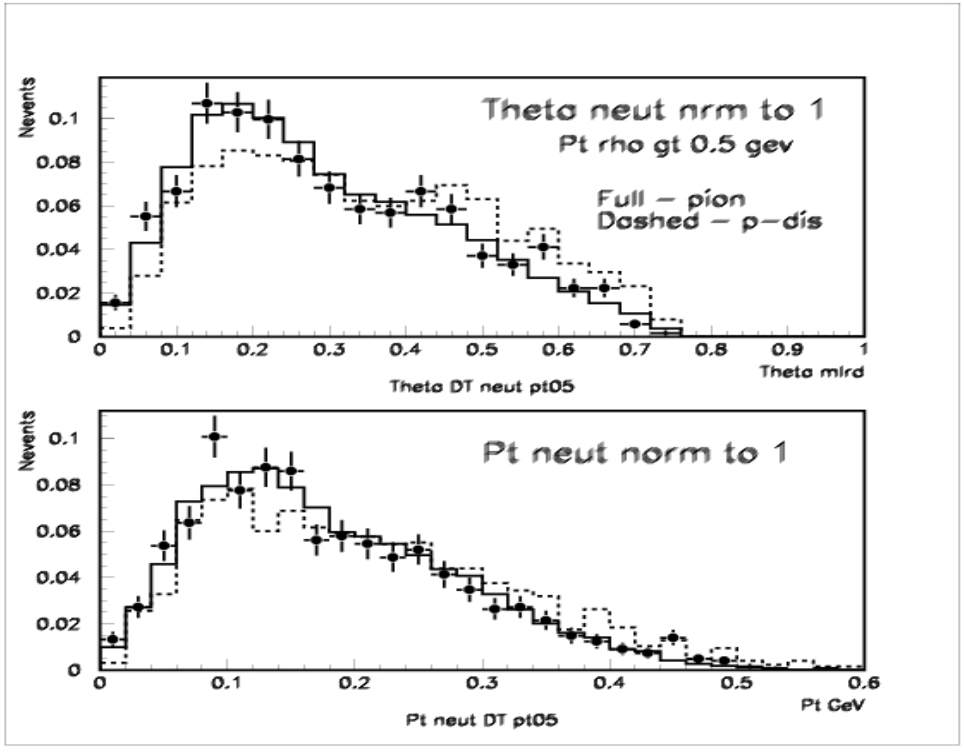


Tail in MC after ~ 30 ~ 1%
FMD decrease p-dis ~ 30%
(FMD reject ~ 39% pion
and ~ 56% p-dis)

FNC - Control plots – pt rho > 0.5 gev

Theta neutron →

Pt of neutron →



Full line – pion

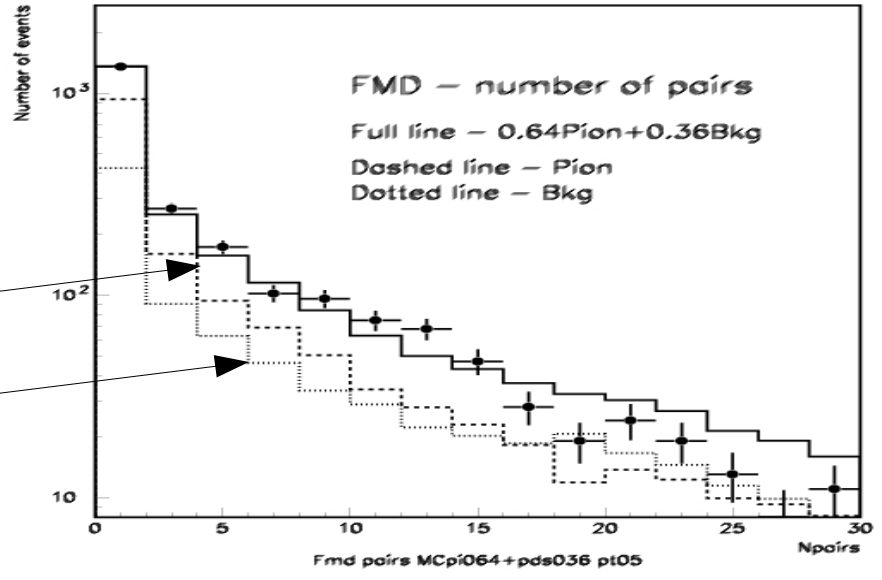
Dashed line – p-dis

FMD - control plots pt rho > 0.5 GeV

Full line – 0.64Pi + 0.36Bkg

Dashed – pion

Dotted - p-dis



FMD – control plots pt rho > 0.5

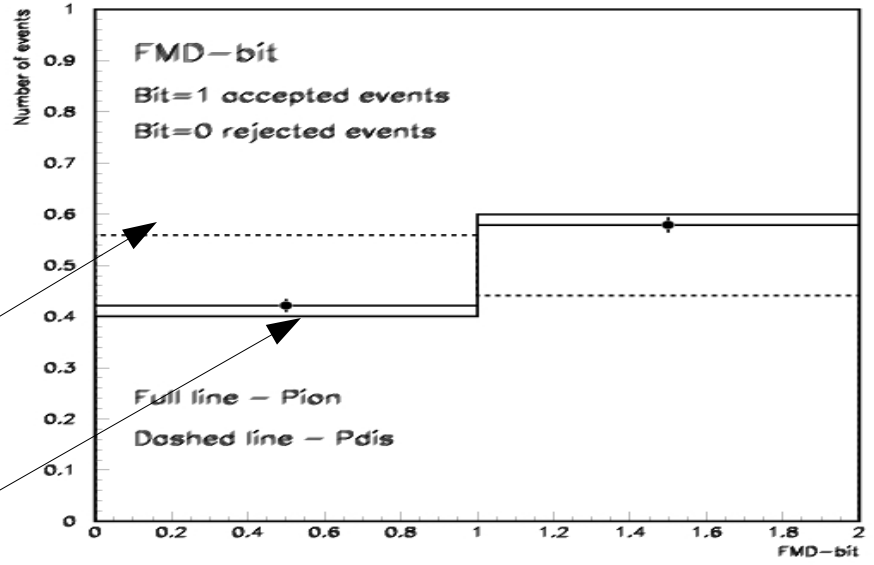
FMD – bit

bit = 1 – event accepted

bit = 0 – event rejected

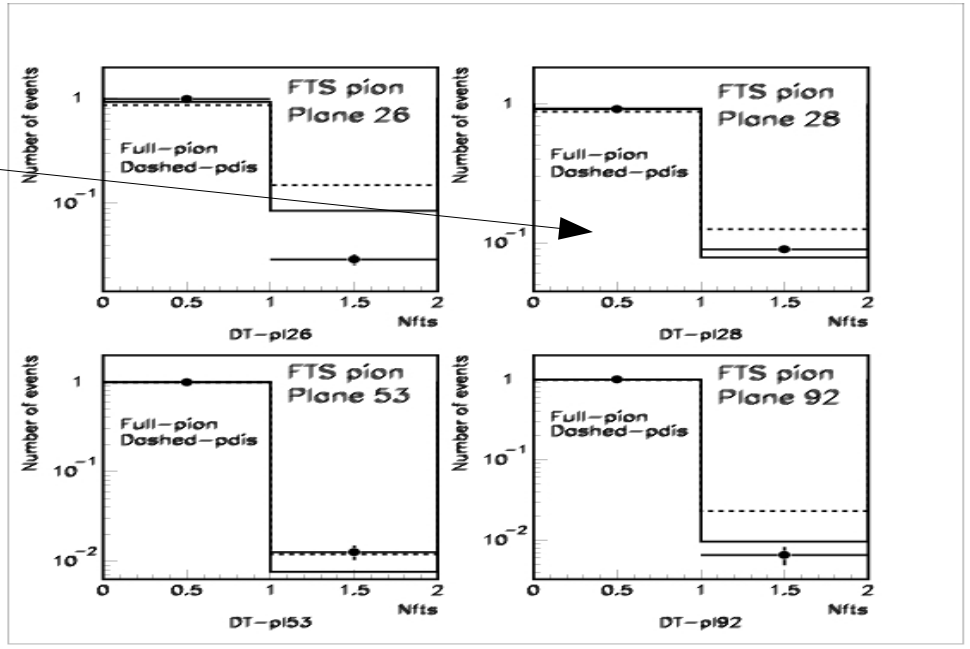
Dashed line – p-dis

Full line - pion



FTS – control plots

Use plane 28



Full line – pion MC

Dashed line – p-dis

After FMD decrease p-dis ~ 5%

Cross-section

$\sigma(\gamma p)$ = (Nev-Nbkg)/(Lumi*eff*flux)

Lumi = 1.12 pb
Flux = 0.1743

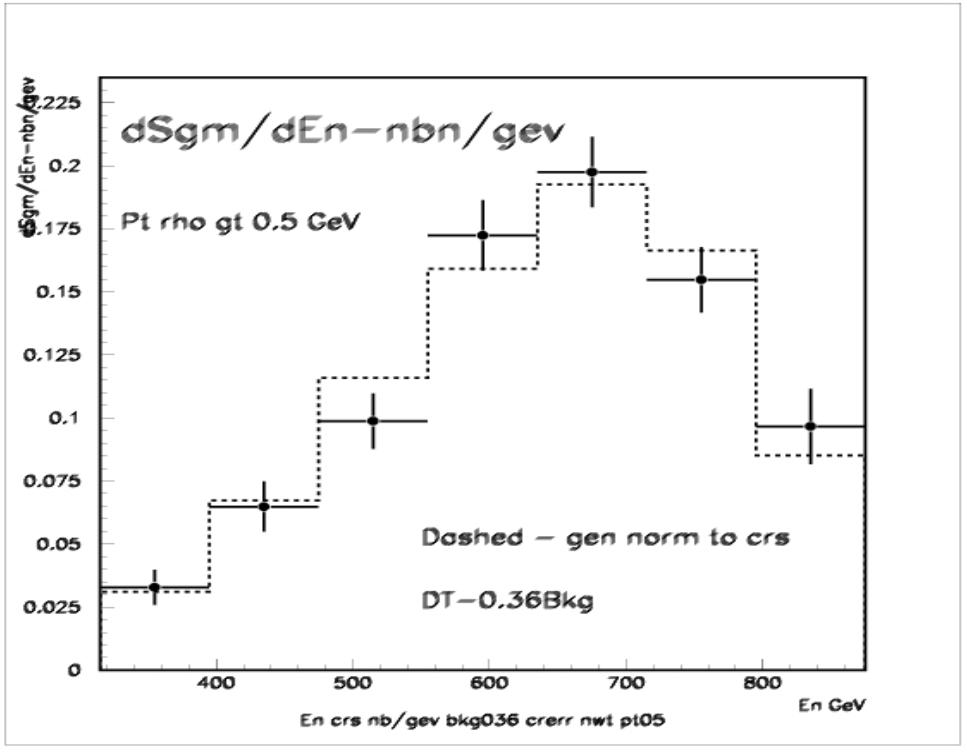
Conditions:

* θ neutron < 0.75 mlrd
* 20< W(γ p)< 100 GeV
* energy of neutron = 315 – 875 GeV
* 0.6 <mass rho < 1.1

<W(gm-p)> ~ 50GeV

Cross-section dSgm/dEn

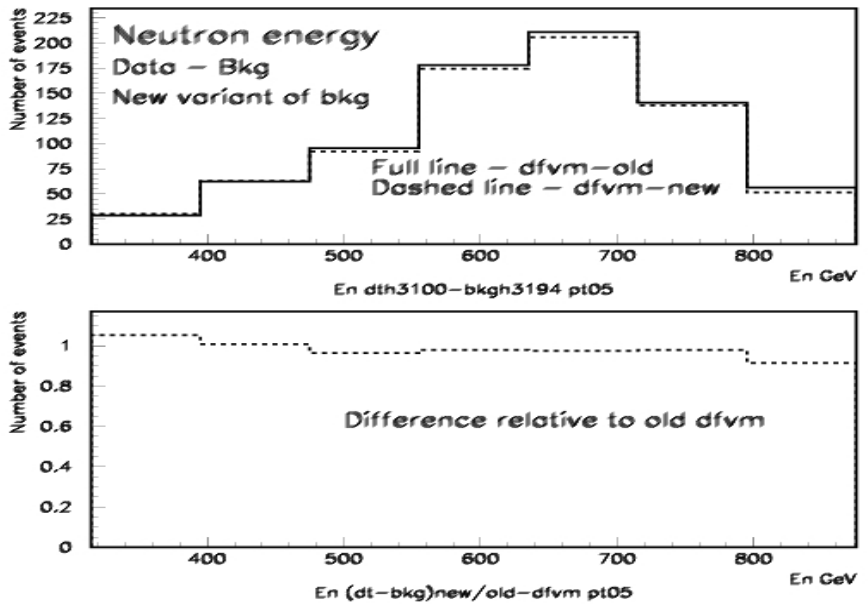
Dotted line – Pompyt gen norm to data



Energy of neutron – systematical error

Old – EL:PD:DD= 1:0.36:0.33
(from normalize to lumi)

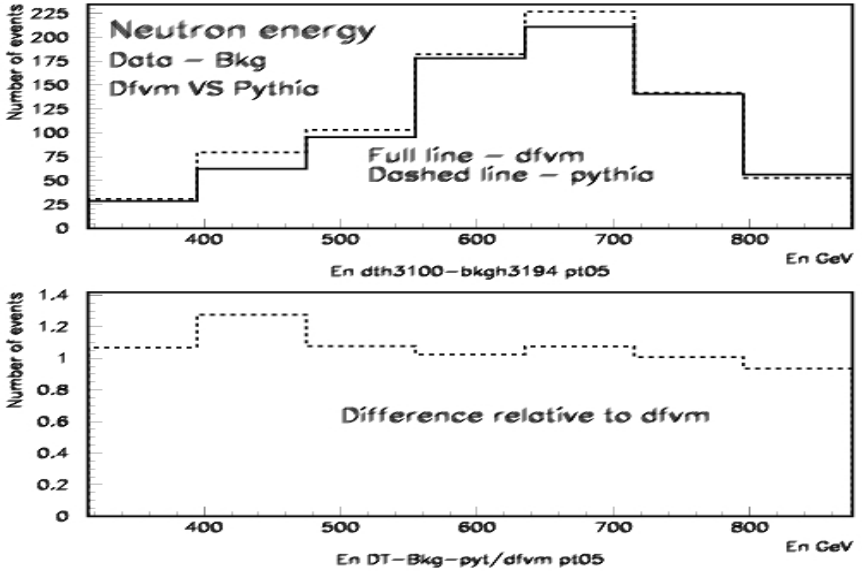
New – EL:PD:DD = 1:0.53:0.88
(from σtot - article)



Energy of neutron – systematical error

Diffvm VS Pythia

(full line - dfvm)



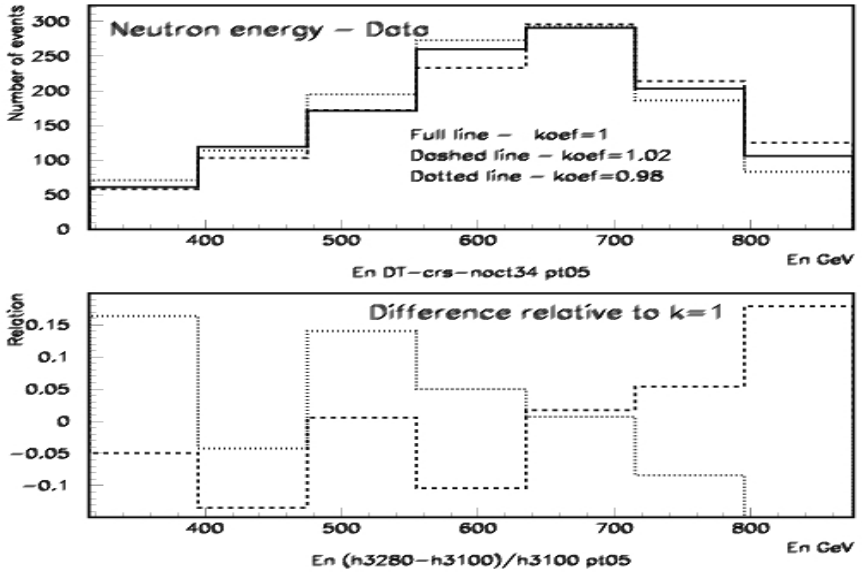
Energy of neutron – systematical error

Calibr. Koef. ± 2 %

Dashed – Data*1.02

Dotted – Data*0.98

relations



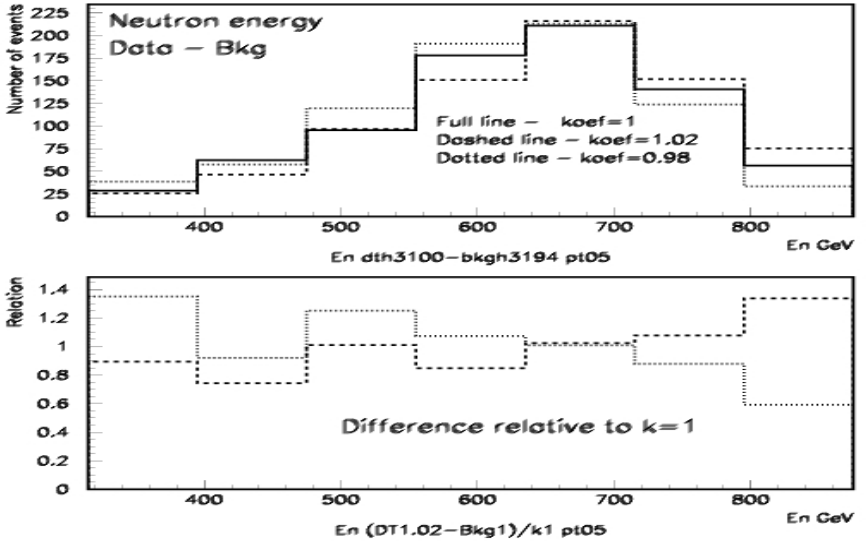
Energy of neutron – systematical error

Data – Background

Calibr.koef ±2%

(up to 30%)

relations →



Cross-section dσ/dXl nb

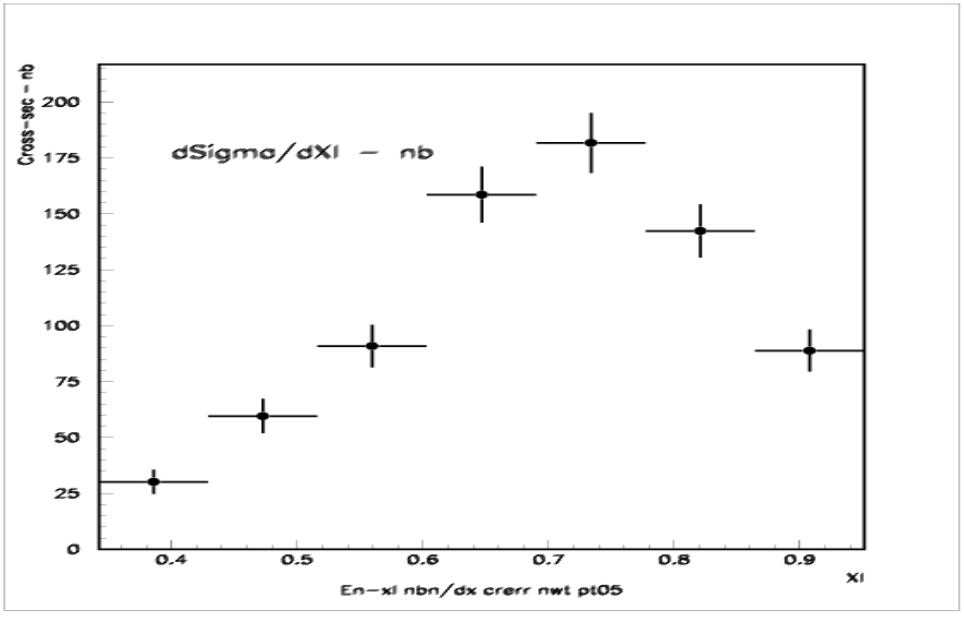
Xl = En/Ep

dσ/dXl (max) = 182 nb

flux pion = 0.385
(tmin=0.085, tmax=0.434)

σ(gamma-pi)=dσ/dXl/flux
= 472 nb

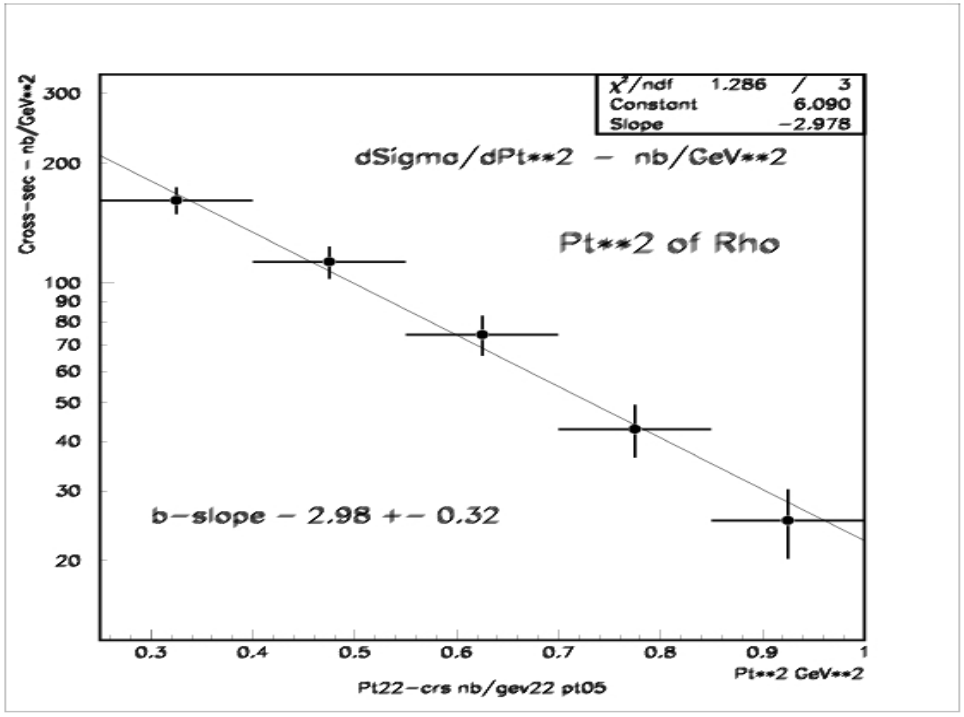
<Wgm-pi> ~ 26 gev



Pt^2 - Cross-section – nb/GeV**2

DT – Bkg

b-slope – 2.98 ± 0.32

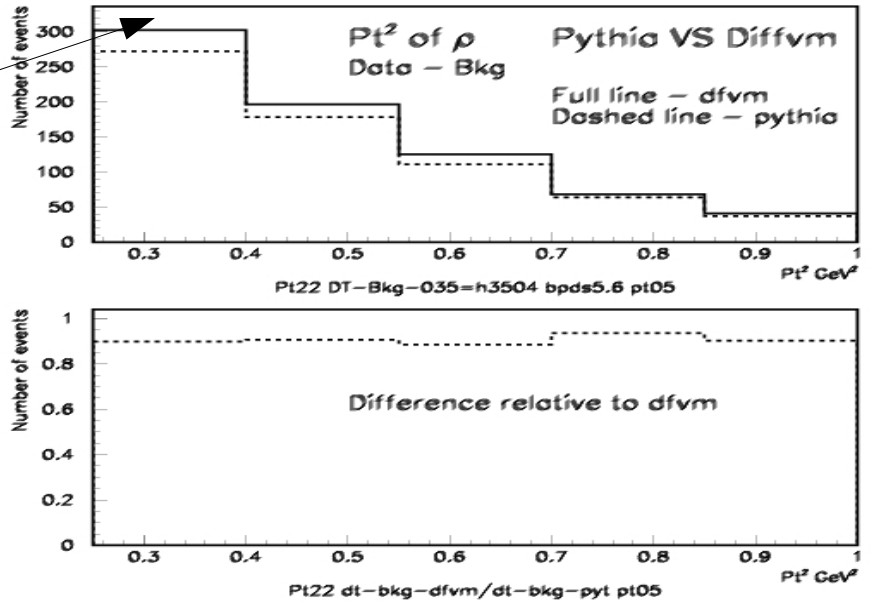


Pt^2 of ρ systematical error

Diffvm VS Pythia
(full line – dfvm)

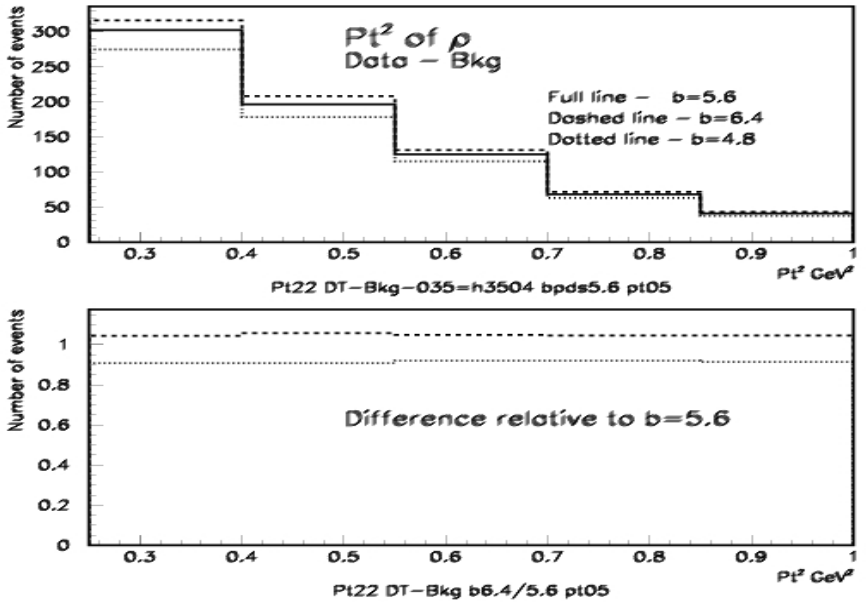
Data – Background

Pythia less for ~ 10%



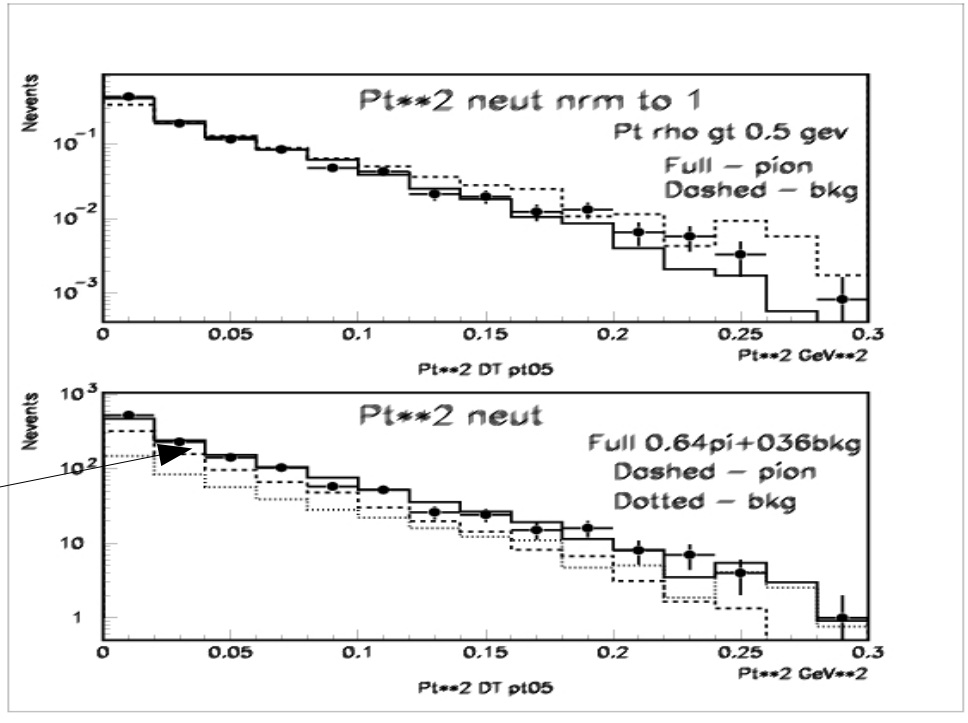
Pt^2 of ρ Psystematical error

B-slope p-dis = 5.6 ±0.8
(ZEUS data)
error +5% and -8 %



Pt^2 distribution of neutron

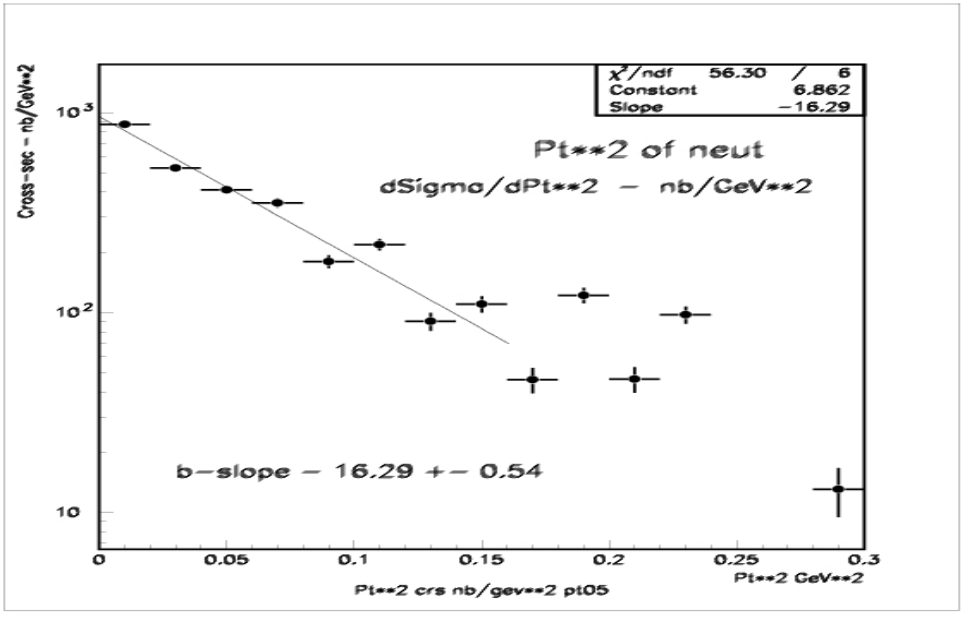
Norm to 1
Full line – pion
Dashed – bkg



Full line – 0.64pion+0.36bkg
Dashed line – pion MC
Dotted line – bkg

Cross-section pt^2 of neutron nb/GeV^2

Slope – b=16.29 ± 0.54



Systematics

Main value :

lumi ~ 5%

Trigg eff – 5%

background ~ 10 %

vary b-slope of pt^2 ± 1 ~ 8%

Energy scale FNC ± 2%

(~ up to 30% in Energy Crs-sec in some bins)