Protvino Diffractive group

V. Petrov, R. Ryutin, A. Godizov, A.Sobol, V. Samoilenko, I. Azhgirey, A. Kuznetsov

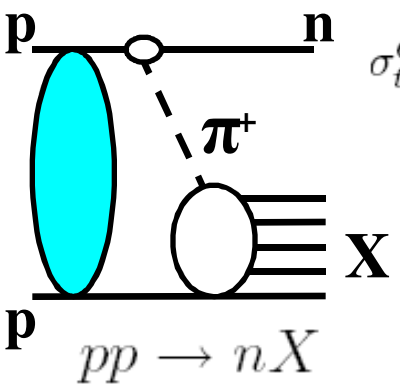
Leading neutron measurements at 0.9, 2.36 and 10 TeV

What could we extract from data

Speakers: R. Ryutin, A. Sobol

Charge Exchange and Double Charge Exchange study with CMS&ZDC

V.Petrov, R.Ryutin, A.Sobol, **LHC as πp and $\pi\pi$ Collider**, Jun 2009, arXiv:0906.5309 [hep-phl]



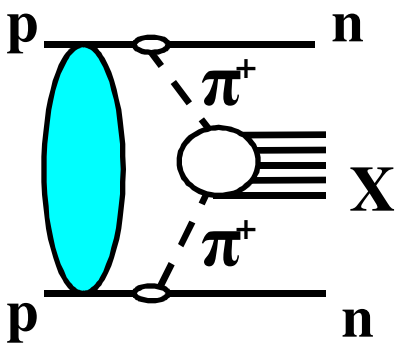
$pp \to nX$

Estimated cross section

$\sigma^{CE}_{total} \sim 2.6\text{mb at } \xi_n < 0.4$

Expected result

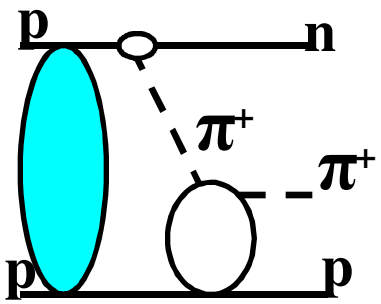
$\sigma^{total}_{\pi^+ p}$



$pp \to nXn$

$\sigma^{DCE}_{total} \sim 0.2$ mb

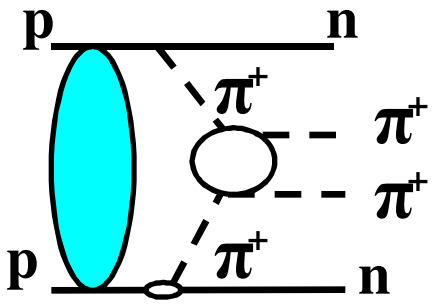
$\sigma^{total}_{\pi^+\pi^+}$



$pp \to n\pi^+ p$

$\sigma^{ES}_{SCE} \sim 0.36$ mb

$\sigma^{elastic}_{\pi^+\pi^+}$

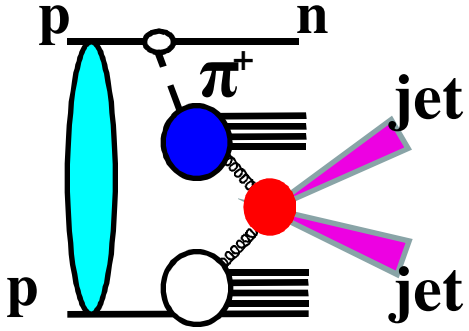


$pp \to n\pi^+\pi^+ n$

$\sigma^{ES}_{DCE} \sim 24\ \mu$b

$\sigma^{elastic}_{\pi^+ p}$

$pp \to n\ jet\ jet\ X$

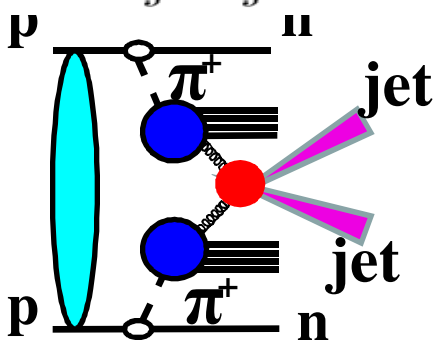


$\sigma^{CE}_{(\pi^+ p)hard} \sim 20$ nb

Hard πp and ππ scattering

gives access to a
- **parton distributions in a pion in a still unexplored domain of Q^2 and x**
- **possible extraction of effective strangeness, charm, and beauty content of the pion**
- **study of the d-u asymmetry in the pion**

$pp \to n\ jet\ jet\ X\ n$



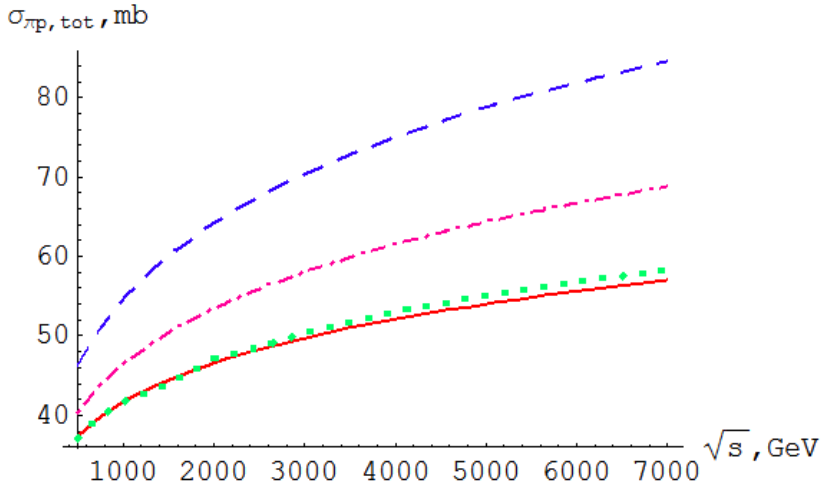
$\sigma^{DCE}_{(\pi^+\pi^+)hard} \sim 0.5$ nb

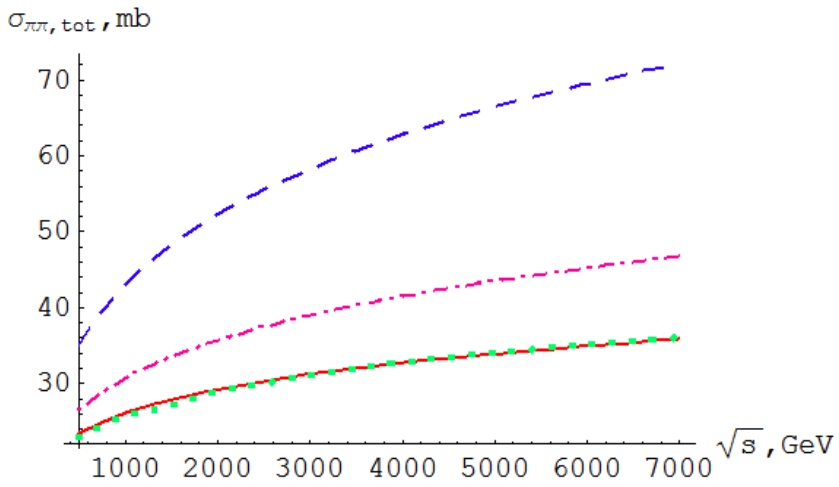
$p_t^{jet} > 40$ GeV and $\xi_n < 0.2$

Motivations

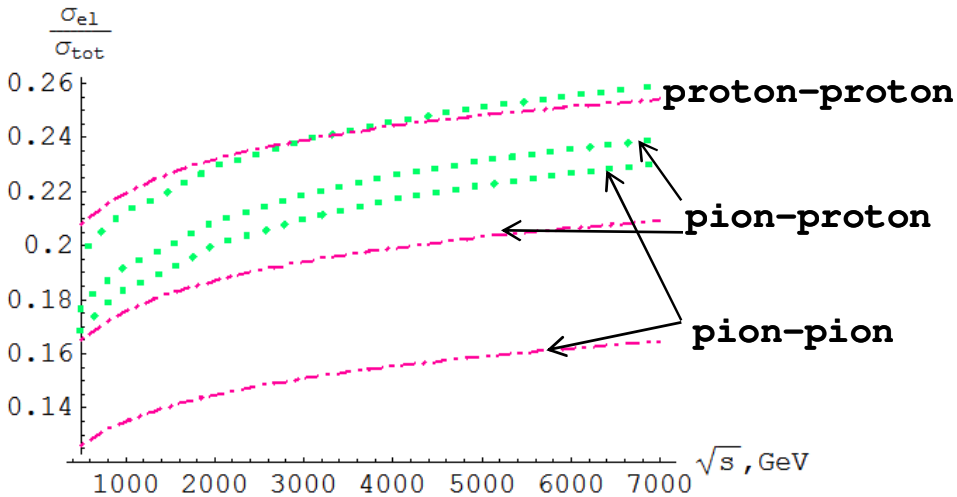
PDG, COMPETE — Godizov, Petrov — Bourrely, Soffer, Wu — Donnachie, Landshoff

Total pion-proton and pion-pion cross-sections (universal behaviour?)

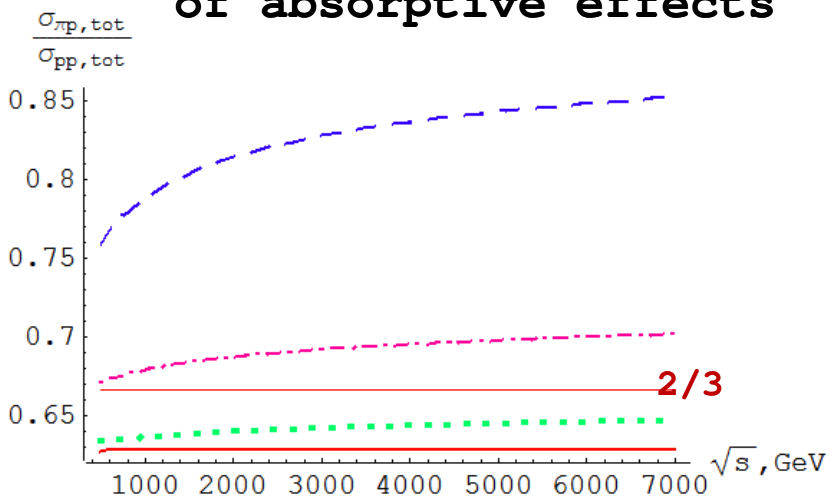




elastic/total ratio



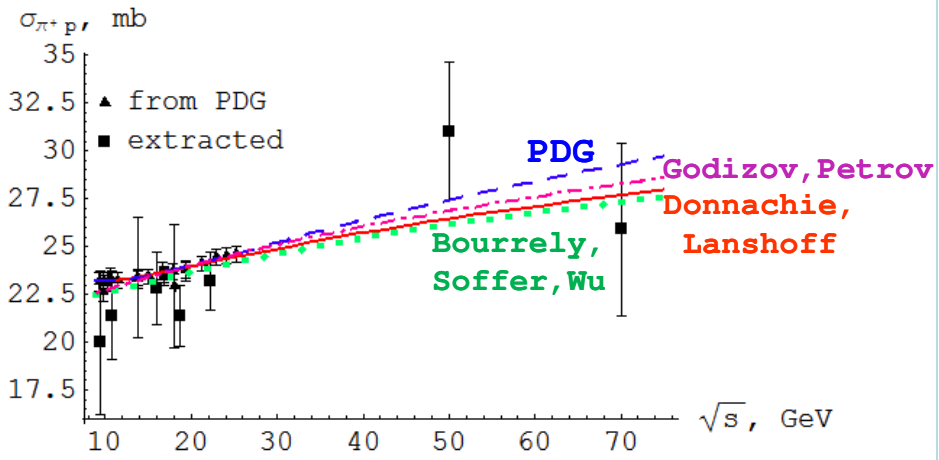
counting rules and role of absorptive effects



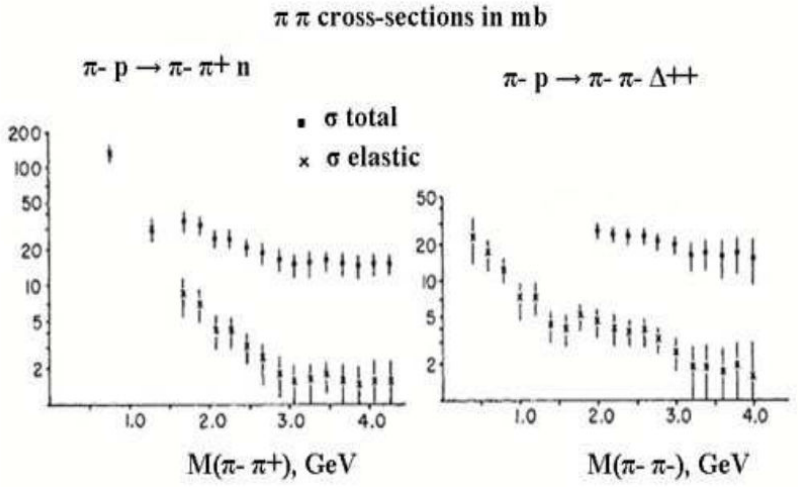
CE and DCE study : present and previous exercises with extraction of πp and ππ csections

Extracted σ(πp) versus parametrization for real data from Particle Data Group

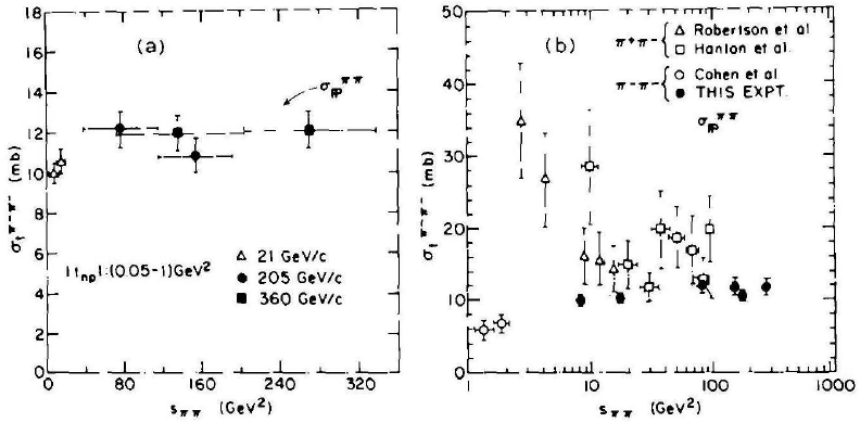
Experiment	√s	σ(ext.)	σ(PDG)
NA49	9.4	21.4±2.3	23.2
ISR	10.8	21.4±2.3	23.19
	15.9	22.8±1.9	23.55
	18.7	21.4±1.6	23.85
	22.2	23.2±1.5	24.27
HERA	50	31±3.6	27.43
PHENIX	70	25.9±4.5	29.3



Extracted σ(π π) at low energies



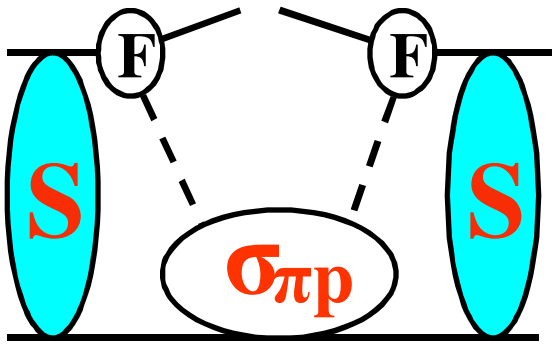
[W.J. Robertson, W.D. Walker, J.L. Davis, Phys. Rev. D7 (1973) 2554]

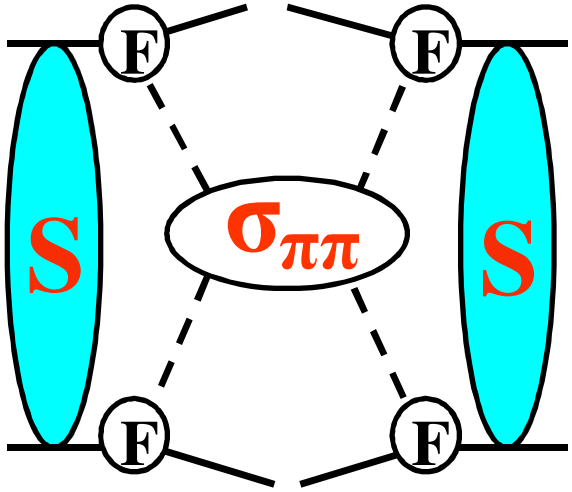


[H.Abramowicz et al., Nucl. Phys., B166, (1980), 62]

Model dependent extraction

ξ=0.1
M(CE) ~ 3 TeV
M(DCE) ~ 1 TeV





$$F_0(\xi,t) = \frac{G^2_{\pi^+pn}}{16\pi^2}\frac{-t}{(t-m_\pi^2)^2}\mathrm{e}^{2bt}\xi^{1-2\alpha_\pi(t)}$$

$$-t \simeq \frac{\vec{q}^{\,2}+m_p^2\xi^2}{1-\xi},\ G^2_{\pi^+pn}/(8\pi) = 13.75$$

$$\alpha_\pi(t) \simeq 0.9(t-m_\pi^2),\ b \sim 0.3\ \mathrm{GeV}^{-2}$$

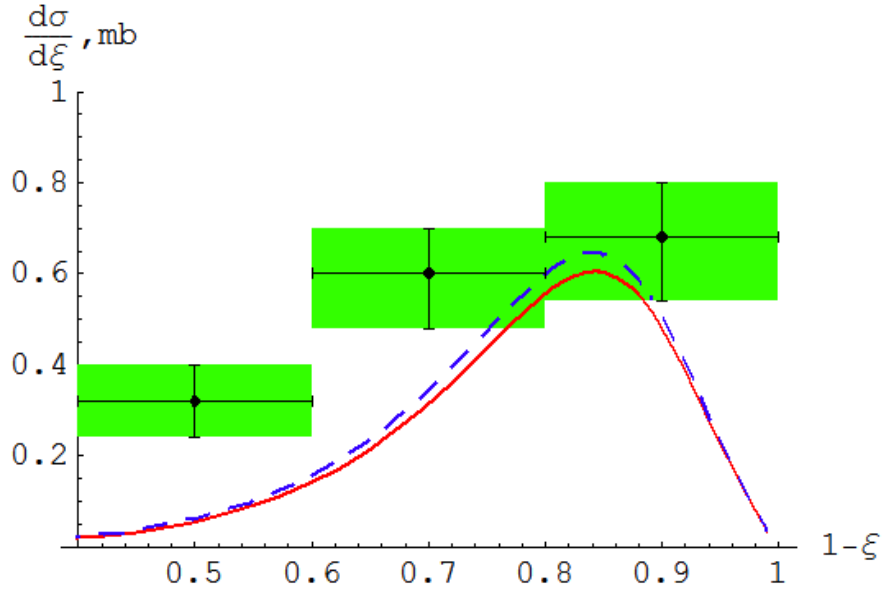
$$\sigma_{\pi^+\mathbf{p}}(\xi s) = \frac{\frac{d\sigma_{SCE}}{d\xi}}{\int\limits_{t_{min}}^{t_{max}} dt F_0(\xi,t)S(s/s_0,\xi,t)}$$

Theoretical error < 10% !

$$\sigma_{\pi^+\pi^+}(\xi_1\xi_2 s) = \frac{\frac{d\sigma_{DCE}}{d\xi_1 d\xi_2}}{\int\limits_{t_{min}}^{t_{max}} dt_1 dt_2 F_0(\xi_1,t_1)F_0(\xi_2,t_2)S_2(s/s_0,\xi_{1,2},t_{1,2})}$$

Model for S:
[V. Petrov, A. Prokudin, EPJC 23 (2002) 135]

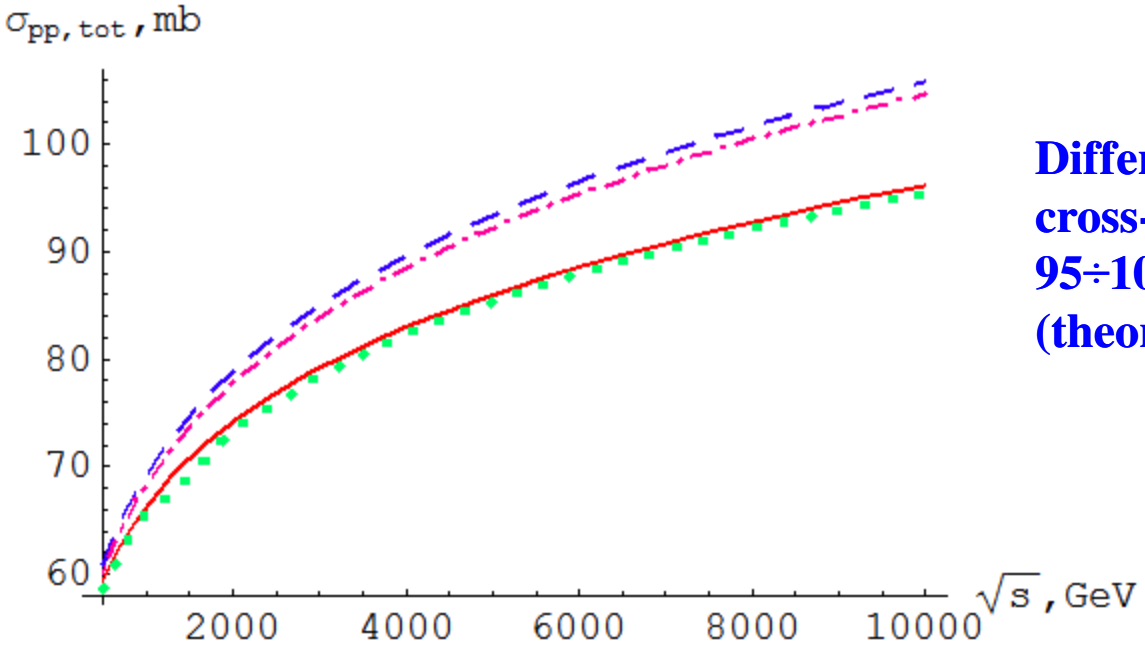
Model dependent extraction



CE cross-section integrated in the interval 0<pt<0.11 (1-ξ)

Extracted pion-proton cross-section 25.9 +/- 4.5 mb at sqrt(s)=70 GeV

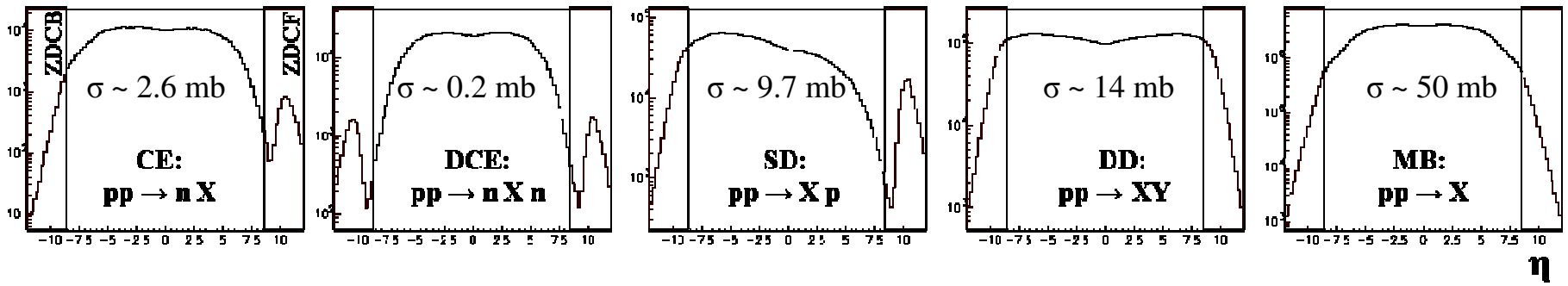
Parametrizations give 27.3 ÷29.3 mb



Different models give total pp cross-sections at sqrt(s)=10 TeV 95÷105 mb (theoretical uncertainty)

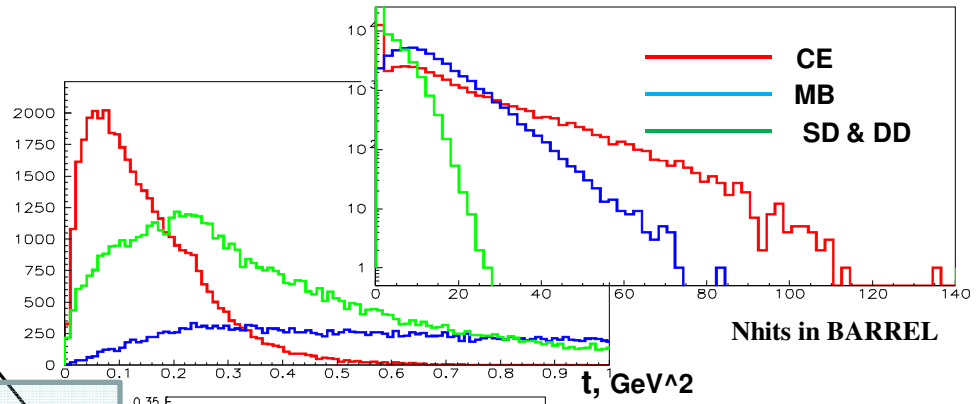
CE and DCE study at 10 TeV

Signal **Background**



S/B optimization (CE as example)

$$\left[\begin{array}{lll} N_n^f = 1 & .and. & N_n^b = 0 \\ N_n^b = 1 & .and. & N_n^f = 0 \end{array}\right\} \quad N_{hits}^{EB} > 50$$

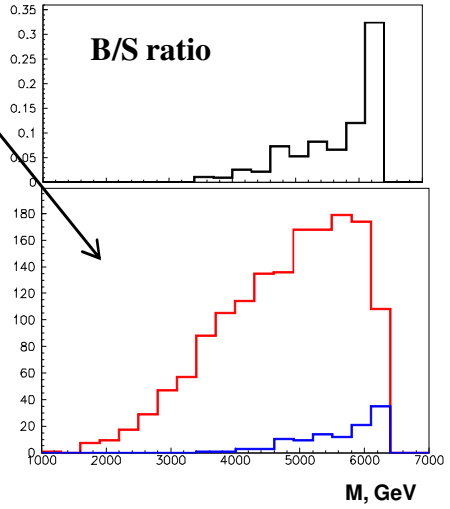


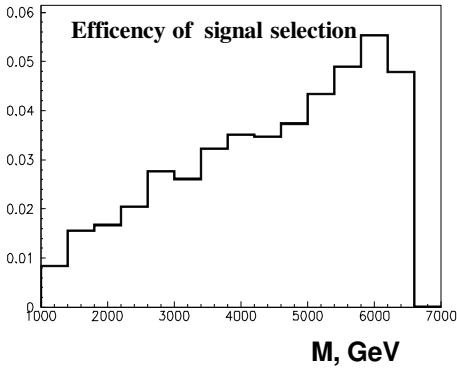
CE and DCE processes measured at LHC could provide us with unique data of π+p and π+π+ cross sections at very high c.m. energy (up to several TeV)

With the information from ZDC and CMS CALO we could suppress background for CE and DCE events effectively and collect around 3x10^6 CE events and 10^6 DCE events at 1 pb^-1 (very rough estimates on the generator level)

Using model-dependent methods we could extract total cross sections for π+p in the mass region 1-6 TeV and for π+π+ in the mass region 0.5-4 TeV.

For model-independent cs measurements t _neutron should be measured





CE and DCE at 900 GeV

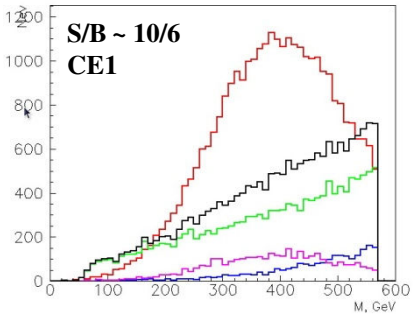
Process	CE	DCE	SD	DD	MB	Elastic	Total
σ, mb	1.76	0.14	11.7	6.4	32.5	12.8	65.3

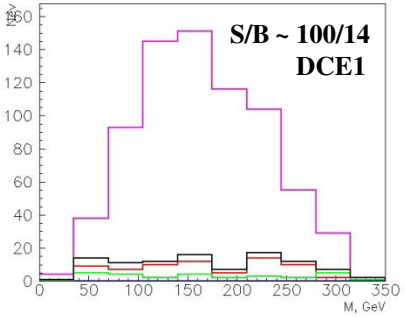
CE selection	CE :	DCE :	Diffraction :	MB	$(S:B)_{CE}$
NO	1 :	0.08 :	10.3 :	19.5	1:30
CE1	1 :	0.11 :	0.44 :	0.07	10:6
CE1 & CE2	1 :	0.07 :	0 :	0.007	100:8

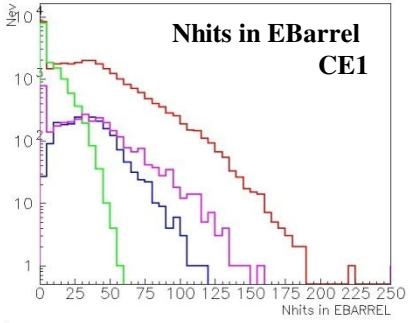
DCE selection	DCE :	CE :	Diffraction :	MB	$(S:B)_{CE}$
NO	1 :	12.5 :	128.8 :	243.8	1:385
DCE1	1 :	0.1 :	0.04 :	0	100:14
DCE1 & DCE2	1 :	0.03 :	0 :	0	100:3

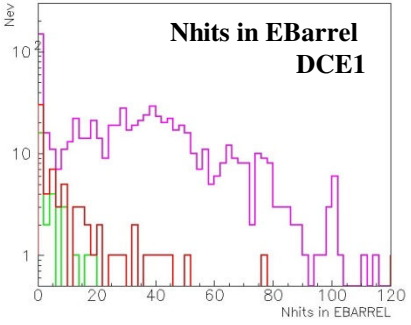
$$(\text{CE1}): \begin{bmatrix} N_n^f > 0 & \& & N_n^b = 0 \\ N_n^f = 0 & \& & N_n^b > 0 \end{bmatrix} \qquad (\text{DCE1}): \begin{cases} N_n^f > 0 \\ N_n^b > 0 \end{cases}$$

$$(\text{CE2}): \; N_{hits}^{EB} > 100 \qquad (\text{DCE2}): \; N_{hits}^{EB} > 20$$







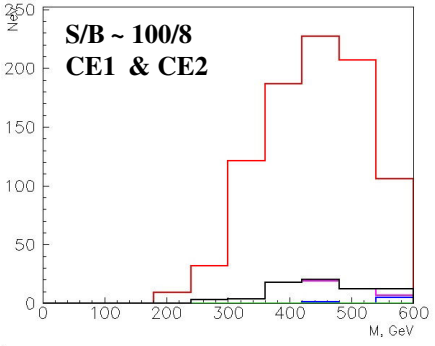


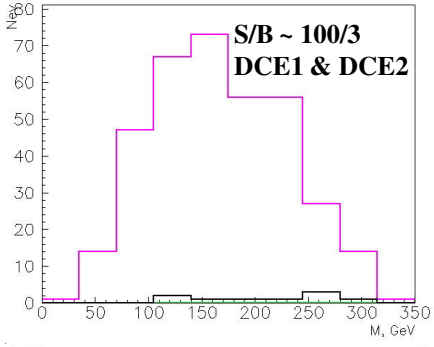
Diffraction

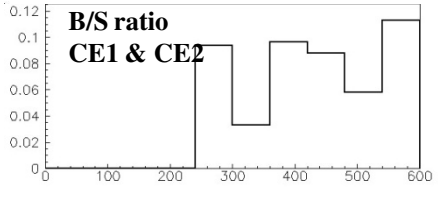
MB

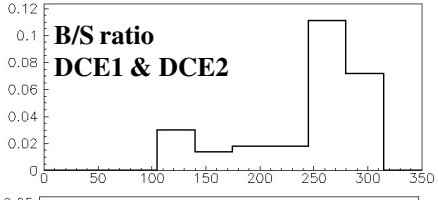
DCE

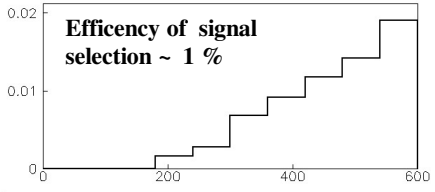
CE

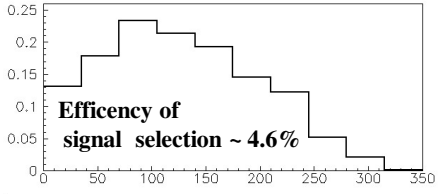












Conclusion: at 900 GeV we have good chances to get

~10^7 CE and ~ 10^6 DCE events at 1 pb^-1

using information from ZDC and CMS Calorimeters only. Total ππ and πp cross sections can be extracted from this data by model-dependent methods in the mass region

200-600 GeV for πp and 50-300 GeV for ππ

CE and DCE study at 2.36 TeV

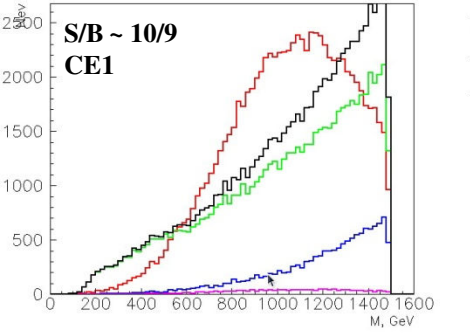
Process	CE	DCE	SD	DD	MB	Elastic	Total
σ, mb	2.1	0.16	12.7	7.7	37.9	15.6	76.2

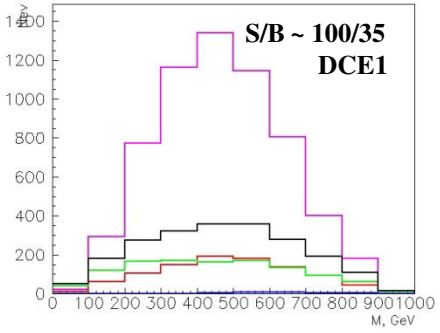
CE selection	CE	:	DCE	:	Diffraction	:	MB	$(S:B)_{CE}$
NO	1	:	0.08	:	9.7	:	18.0	1:28
CE1	1	:	0.02	:	0.76	:	0.15	10:9
CE1 & CE2	1	:	0.01	:	0	:	0.01	100:2

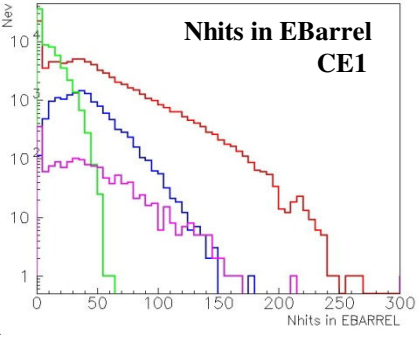
DCE selection	DCE	:	CE	:	Diffraction	:	MB	$(S:B)_{CE}$
NO	1	:	13.1	:	127.5	:	236.9	1:378
DCE1	1	:	0.16	:	0.18	:	0.005	100:35
DCE1 & DCE2	1	:	0.02	:	0	:	0	100:2

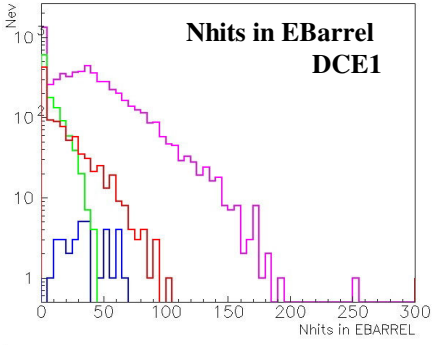
$$(CE1): \begin{bmatrix} N_n^f > 0 & \& & N_n^b = 0 \\ N_n^f = 0 & \& & N_n^b > 0 \end{bmatrix} \qquad (DCE1): \begin{cases} N_n^f > 0 \\ N_n^b > 0 \end{cases}$$

$$(CE2): \quad N_{hits}^{EB} > 120 \qquad (DCE2): \quad N_{hits}^{EB} > 70$$







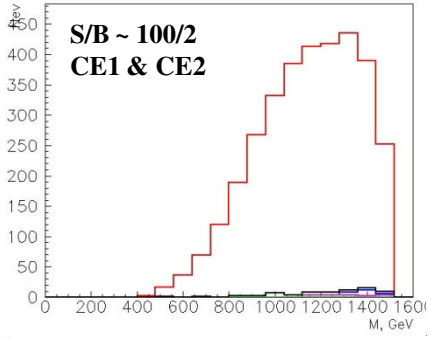


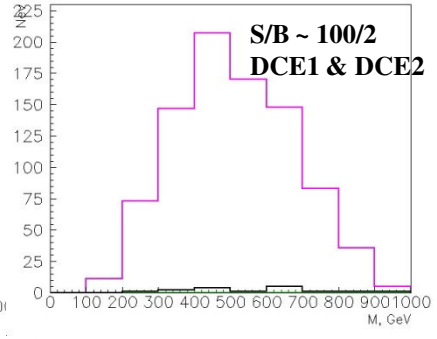
Diffraction

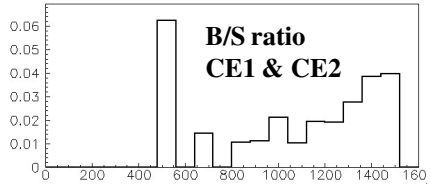
MB

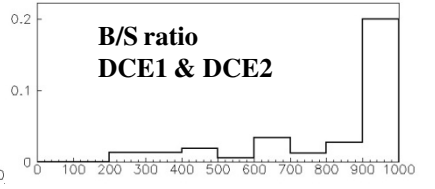
DCE

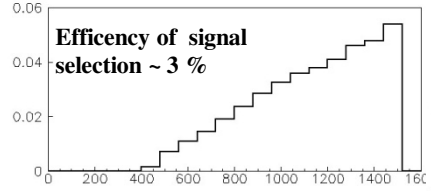
CE

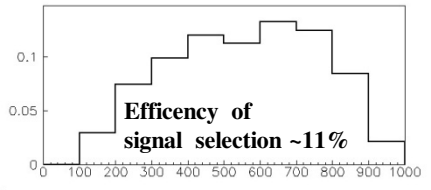












Conclusion: at 900 GeV we have good chances to get

~6x10^7 CE and ~ 2x10^7 DCE events at 1 pb^-1

using information from ZDC and CMS Calorimeters only. Total ππ and πp cross sections can be extracted from this data by model-dependent methods in the mass region

400-1500 GeV for πp and 100-1000 GeV for ππ

ππ and πp mass at different √s

√s, GeV	πp mass, GeV	ππ mass, GeV
900	200 - 600	50 - 300
2360	400 - 1500	100 - 1000
10000	1000 - 6000	500 - 4000

✓CE and DCE processes measured at LHC could provide us with unique data of π+p and π+π+ cross sections at very high c.m. energy (up to several TeV)

✓With the information from ZDC and CMS CALO we could trigger signal and suppress background for CE and DCE events effectively

✓Data from 3 LHC energies cover wide mass interval. Using model-dependent methods we could extract total cross sections

for π+p in the mass region 200-6000 GeV and
for π+π+ in the mass region 50-4000 GeV

✓ππ total cs extracted from 900 GeV data are placed in the mass interval 50 – 300 GeV, where we have cs obtained from the real exp. data. We have real possibility to compare results