Exclusive Central Meson Production in Proton Antiproton Collisions at the Tevatron

Maria Żurek
together with Artur Święch,
Jagiellonian University, Kraków

on behalf of the CDF Collaboration

MESON 2012

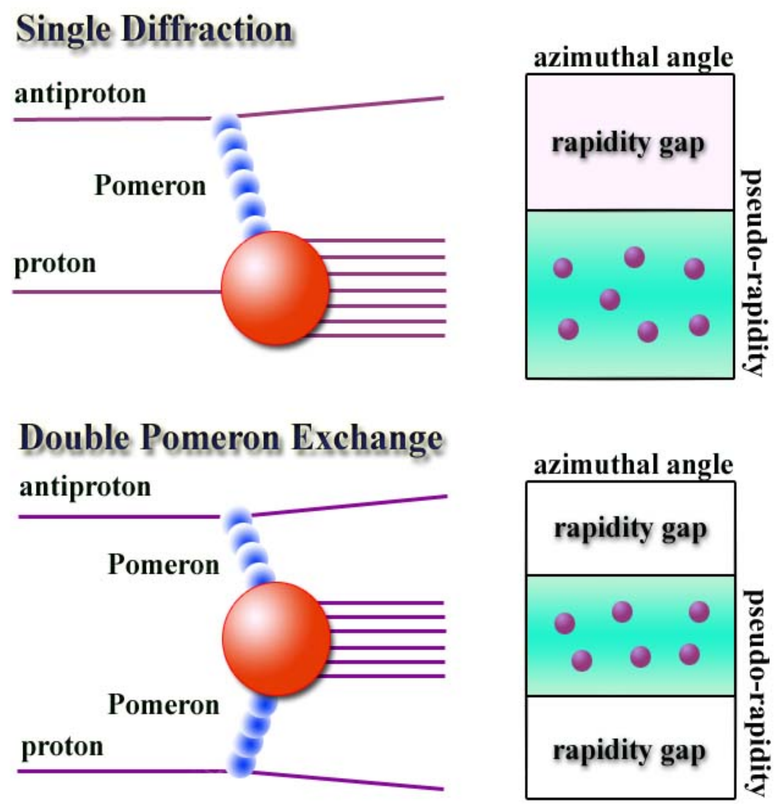
Contents

- Physics Motivation
- CDF Detector Setup
- Low Mass Central Hadronic State Analysis
- Conclusions

Physics Motivation
Double Pomeron Exchange

Pomeron:

- Carrier of 4-momentum between protons
- Strongly interacting color singlet combination of quarks or/and gluons
- Quantum numbers of vacuum
- LO: P = *gg*



Analysis

GXG reaction

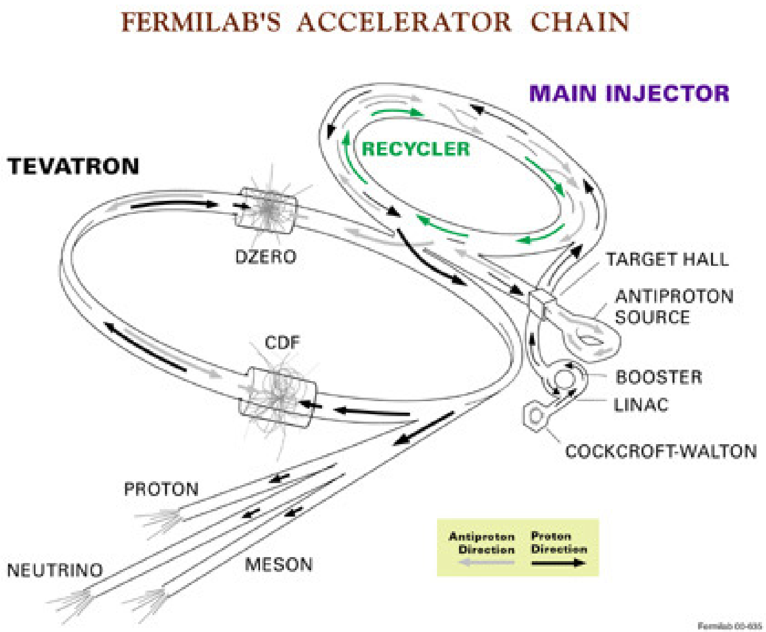
$$\boxed{\bar{p} + p \rightarrow \bar{p} + \mathrm{GAP} + X + \mathrm{GAP} + p}$$

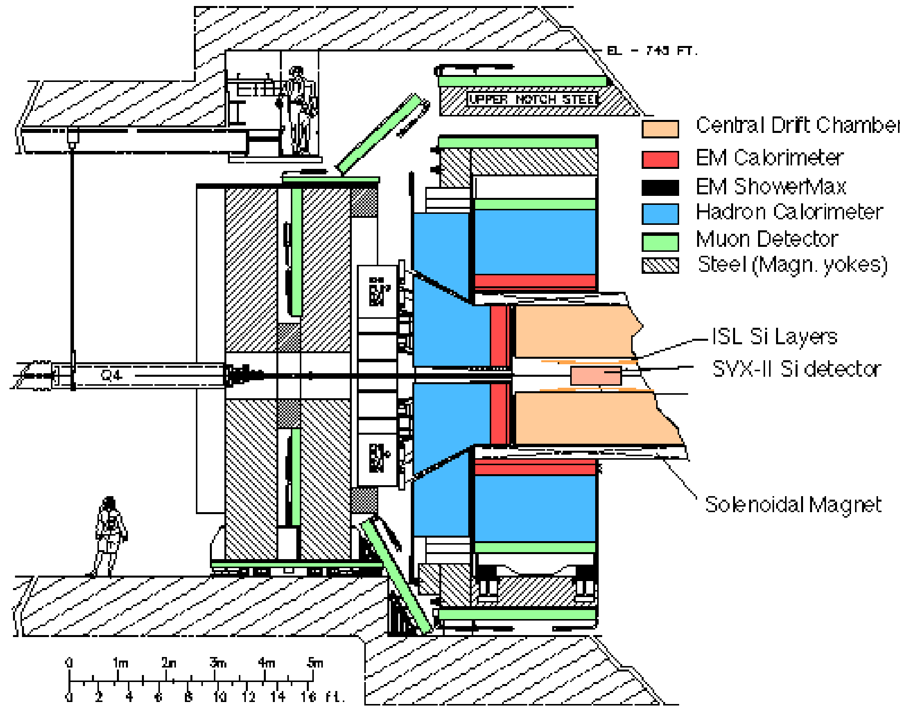
X (in this study)**:**

- hadron pair mostly $\pi^+ \pi^-$
- central $y \approx 0$
- between rapidity gaps $\Delta y \approx 4$
- $Q = S = 0$, $C = +1$, $J = 0$ or 2, $I=0$

Expected to be dominated by DPE in the t-channel!

Collider Detector at Fermilab

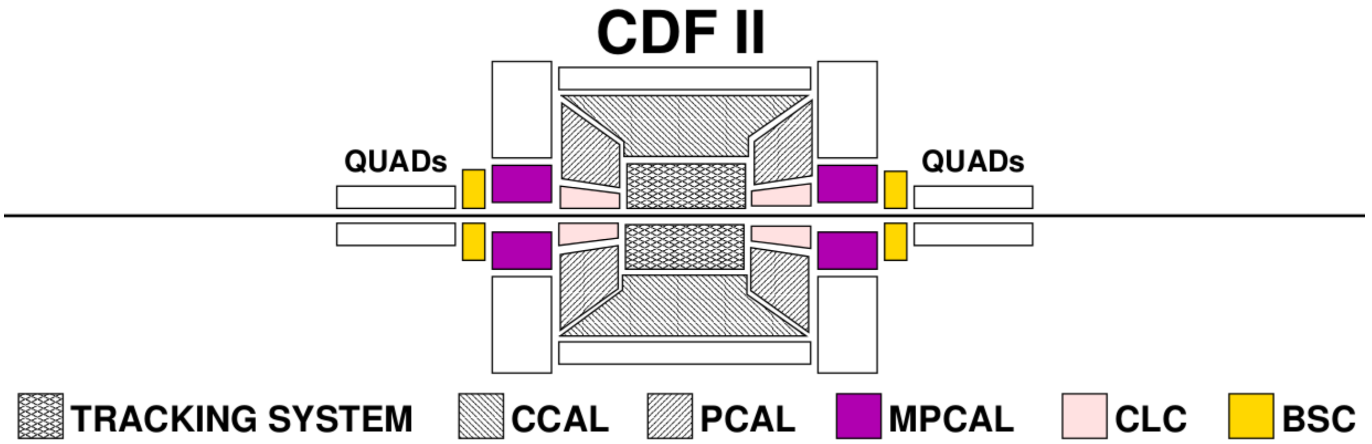




$\sqrt{s}$ = 1960 GeV

$\sqrt{s}$ = 900 GeV

Collider Detector at Fermilab



- we do not detect outgoing protons
- forward detectors in veto

- BSC – Beam Shower Counters
- CLC – Cherenkov Luminosity Counters
- PCAL – Plug Calorimeter

Low Mass Central Hadronic State Analysis

Candidates selection

Trigger requirement:

- 2 central (|η|<1.3) towers with
  Et > 0.5 GeV
- PCAL (2.11<|η|<3.64) in veto
- CLC (3.75<|η|<4.75) in veto
- BSC1 (5.4<|η|<5.9) in veto

Gap cuts:

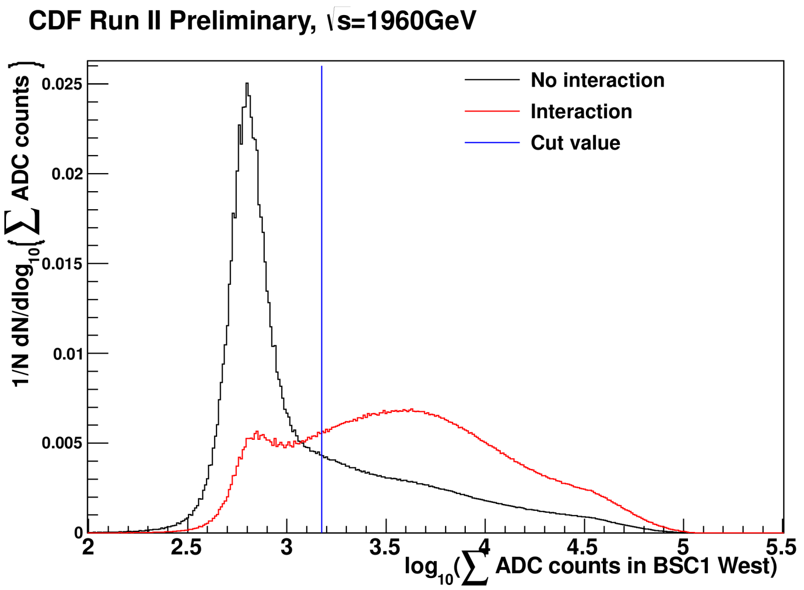
To determine noise levels in subdetectors we divide zero-bias sample from same periods into two sub-samples:

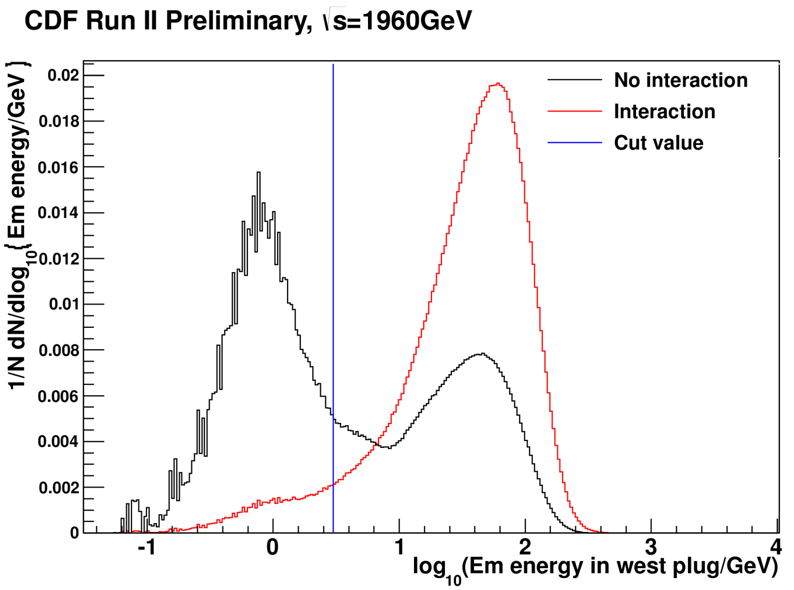
No Interaction:	**Interaction:**
•No tracks and •No CLC hits and •No muon stubs	At least one • Track or • CLC hit or • Muon stub

Low Mass Central Hadronic State Analysis

Candidates selection

Examples of exclusive requirements – empty forward detectors





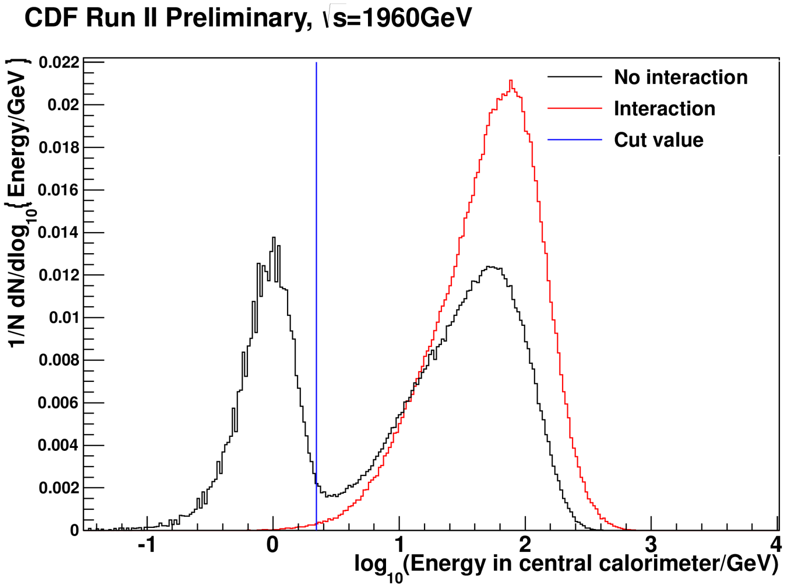
Low Mass Central Hadronic State Analysis

Candidates selection

Exclusivity cuts

To determine exclusive 2-4 tracks we apply similar technique in central region, just excluding cones of R=0.3 around each track extrapolation.

$$R=\sqrt{(\Delta\eta)^2+(\Delta\phi)^2}$$



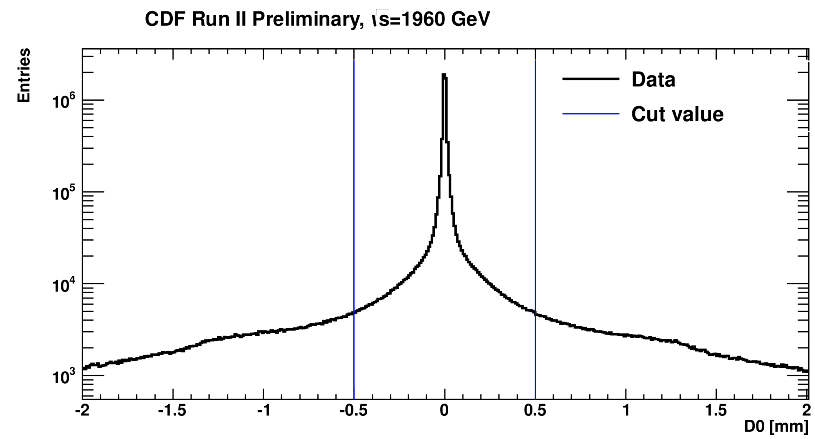
Low Mass Central Hadronic State Analysis

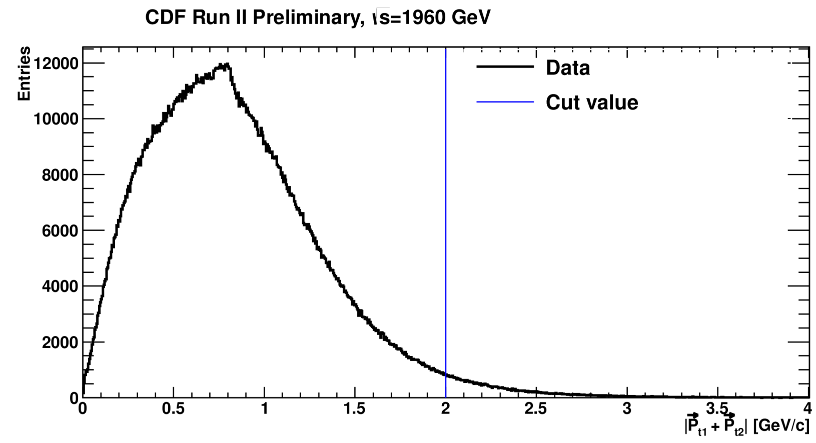
Candidates selection

Additional cuts:

- quality of tracks
- cosmic ray rejection
- 2 oppositely charged tracks

Examples:
d_0, |Missing P_t|





Low Mass Central Hadronic State Analysis

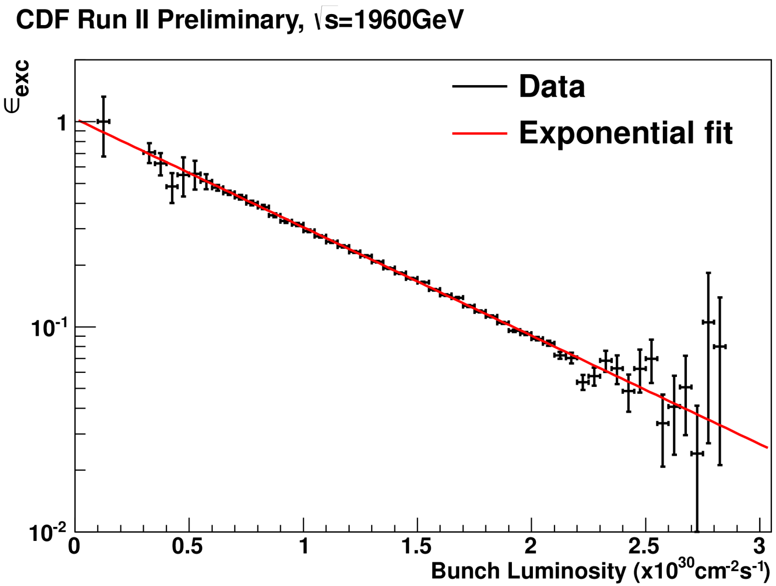
Exclusive efficiency for 1960 GeV

- Determination of efficiency of having no-pileup using zero-bias sample.

  We measure ratio of empty events (all detectors on noise level) to all events.

- Exponential drop with bunch luminosity

- Slope corresponds to total detected inelastic cross section



56.7 mb – 1960 GeV

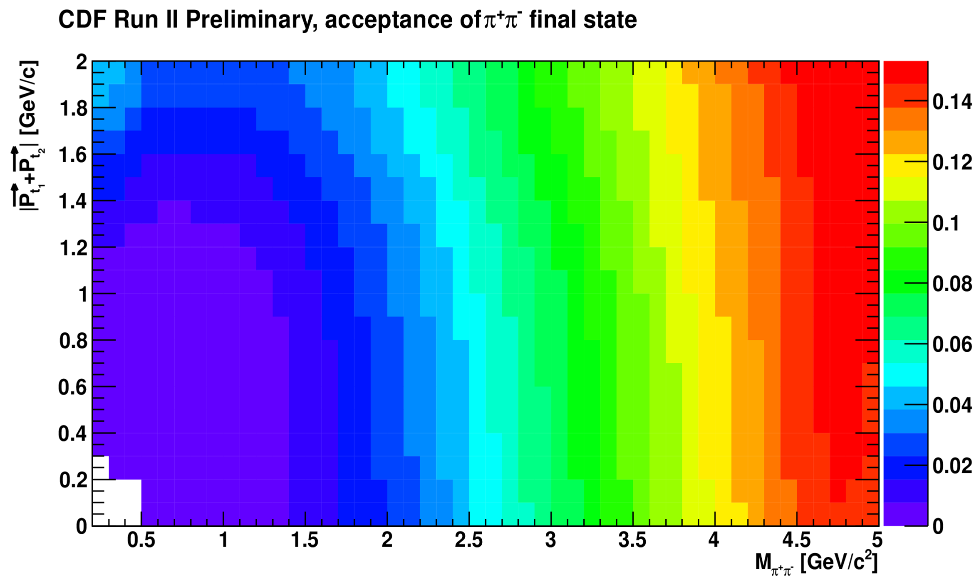
Effective luminosity:

1.16/pb – 1960 GeV

Low Mass Central Hadronic State Analysis

Simple model of acceptance

Generation X → $\pi^+\pi^-$



Flat distribution in:

- rapidity of X (-2.1 – 2.1)

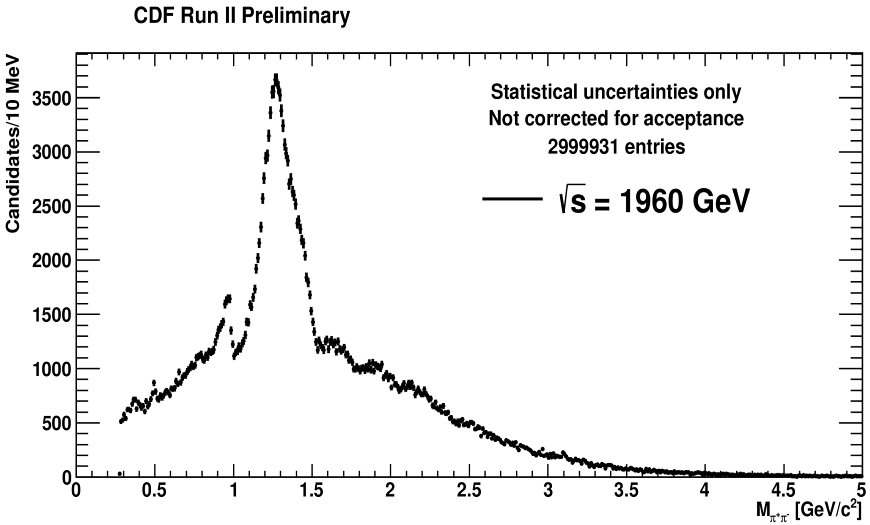
- mass of X (0 – 5.0 GeV/c^2)

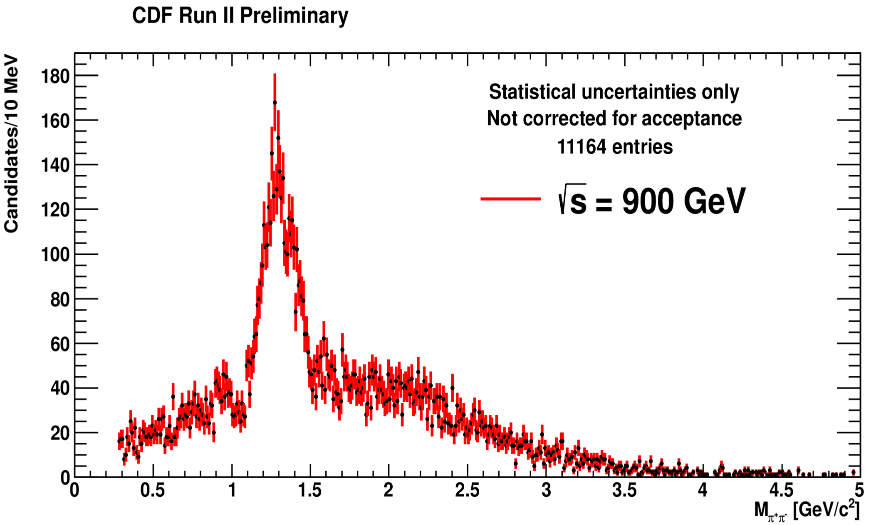
- P_t of X (0 – 2.5 GeV/c)

Decay according to J=0 phase space

Low Mass Central Hadronic State Analysis

$M_{\pi+\,\pi-}$ for $\sqrt{s}$ = 900 GeV and 1960 GeV

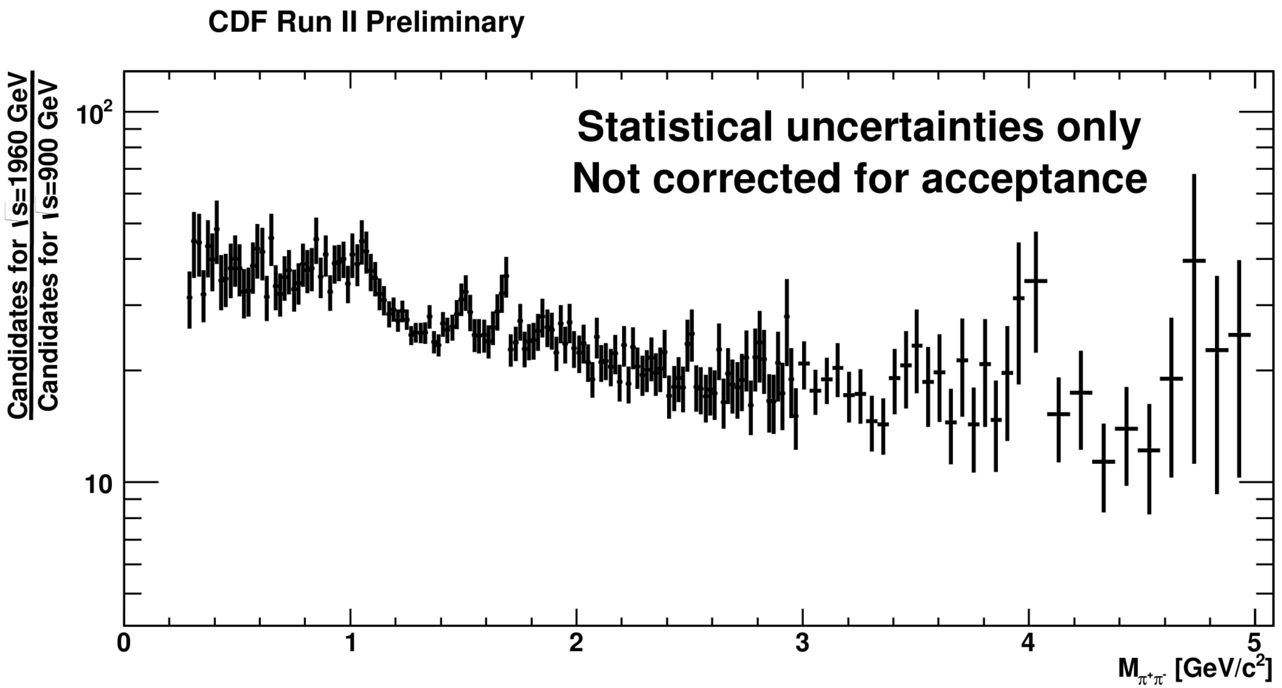




Mass resolution ~10-20 MeV/c^2.

Low Mass Central Hadronic State Analysis

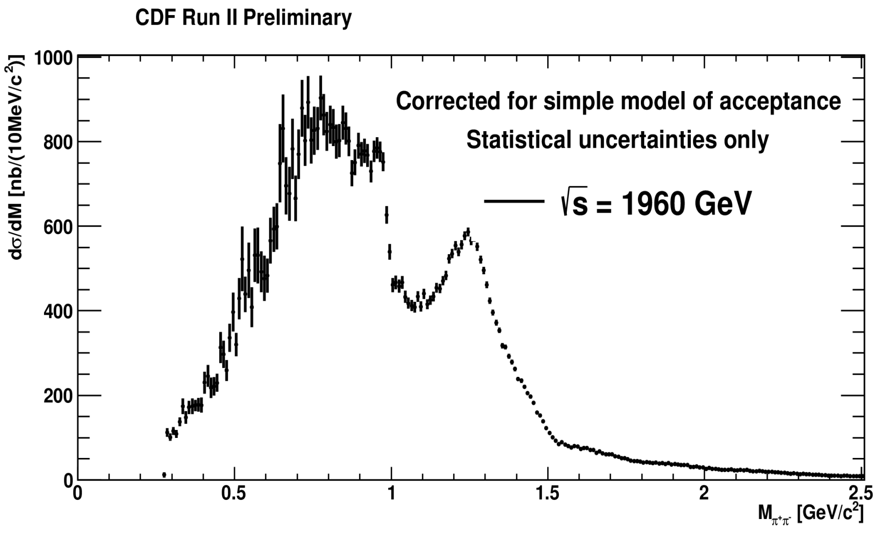
$M_{\pi+\,\pi-}$ for √s = 900 GeV and 1960 GeV

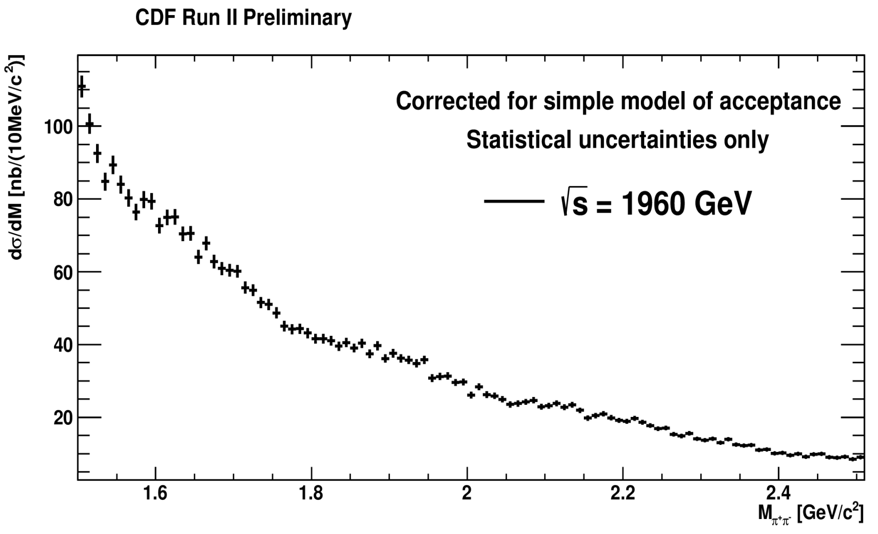


Low Mass Central Hadronic State Analysis

$M_{\pi+\pi-}$ for 1960 GeV

intial acceptance correction based on MC simulation only





Conclusions

- **We have measured $\pi^+\pi^-$ pairs between large rapidity gaps at the Tevatron, which should be dominated by double pomeron exchange.**
  The background from K^+K^- is small.
- **We do not see a ρ(770), confirming that photoproduction and ρ-exchange, are negligible.**
- **This is the only measurement from the Tevatron, and has much higher statistics than preliminary data from the LHC experiments.**
- **The mass spectra show several structures:**
  - Broad continuum below 1 GeV/c^2,
  - Sharp drop at 1 GeV/c^2
  - Resonant enhancement around 1.0 – 1.5 GeV/c^2.
- **The s-dependence is mass dependent.**
- **We plan to do a partial wave analysis to distinguish different spin states.**

MESON 2012

Thank you

Backup slides

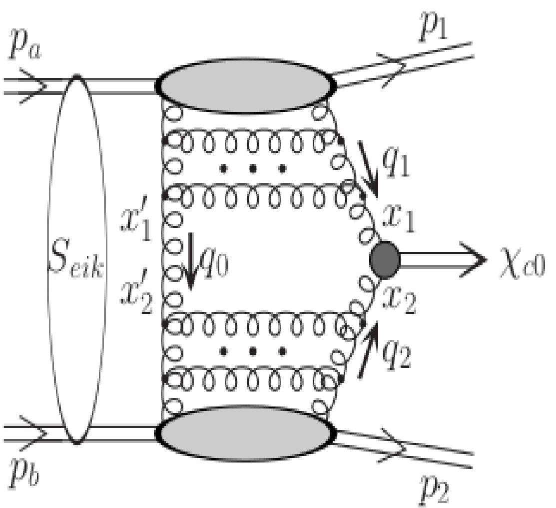
χ_c searching

$$\chi_c\,(c\bar{c}) \rightarrow J/\psi + \gamma \rightarrow \mu^+\mu^-\gamma$$

- a cross section

$$d\sigma/dy|_{y=0} = 76 \pm 10(\mathrm{stat}) \pm 10(\mathrm{syst})\ \mathrm{nb}$$
$$(7.6 \times 10^{-32}\ \mathrm{cm}^2)$$

- We are looking for hadronic decays which will resolve the J=0,1,2 states.



arXiv:1103.5642 Szczurek et al

χ_c searching

State $I^G J^{PC}$	$\chi_{c0}(3415)$ 0^+0^{++}	$\chi_{c1}(3511)$ 0^+1^{++}	$\chi_{c2}(3556)$ 0^+2^{++}
Mass(MeV): Width (MeV): BF(Channel)	3414.76±0.35 10.4±0.7	3510.66±0.07 0.89±0.05	3556.20±0.09 2.06±0.12
$J/\psi + \gamma$	1.16±0.08	35.6±1.9	20.2±1.0
Above with $J/\psi \to \mu^+\mu^-$	0.077	0.021	0.012
$\pi^+\pi^-\pi^+\pi^-$	2.27±0.19	0.76±0.26	1.11±0.11
$\pi^+\pi^-K^+K^-$	1.80±0.15	0.45±0.10	0.92±0.11
$3(\pi^+\pi^-)$	1.20±0.18	0.58±0.14	0.86±0.18
$\pi^+\pi^-$	0.56±0.03	<0.1	0.159±0.009
$\pi^+\pi^-K^0_sK^0_s$	0.58±0.11	<0.1	0.92±0.11
Above with $K^0_S \to \pi^+\pi^-$	0.27±0.05	<0.1	0.43±0.05
$K^+K^-K^+K^-$	0.28±0.03	0.06±0.01	0.18±0.02
$\pi^+\pi^-p\bar{p}$	0.21±0.07	<0.1	0.13±0.03
Total %	7.2	1.9	4.7

χ_c searching

- χ_c has as the same quantum numbers as the Higgs (apart from its strong interactions).
- It is produced the same way but with a c-loop replacing the t-loop.
- It is a good control of the theoretical calculations.