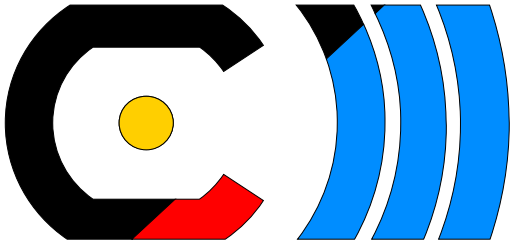
ABC Effect in Double Pionic Fusion

-

A New Resonance ?

Annette Pricking
University of Tübingen



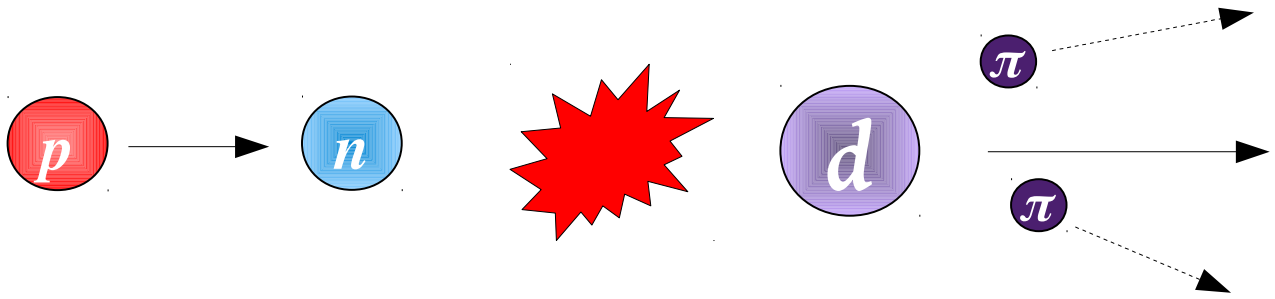
for the WASA-at-COSY Collaboration

MESON 2012 *June 4th 2012*

Outline

- ABC Effect in Double Pionic Fusion
- WASA Detector
- A New Resonance ?
- What do we do to investigate that further ?
- Summary

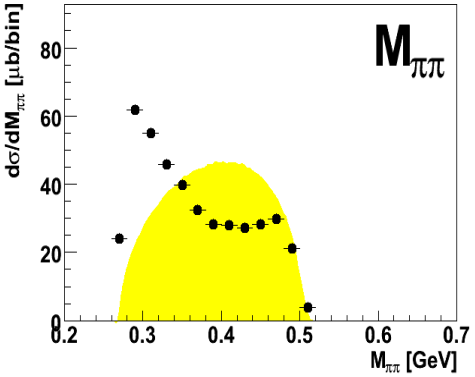
ABC Effect in Double Pionic Fusion



If ππ system in Isospin I=0 : Enhancement in $M_{\pi\pi}$

$pn \rightarrow d\,\pi^0\,\pi^0$

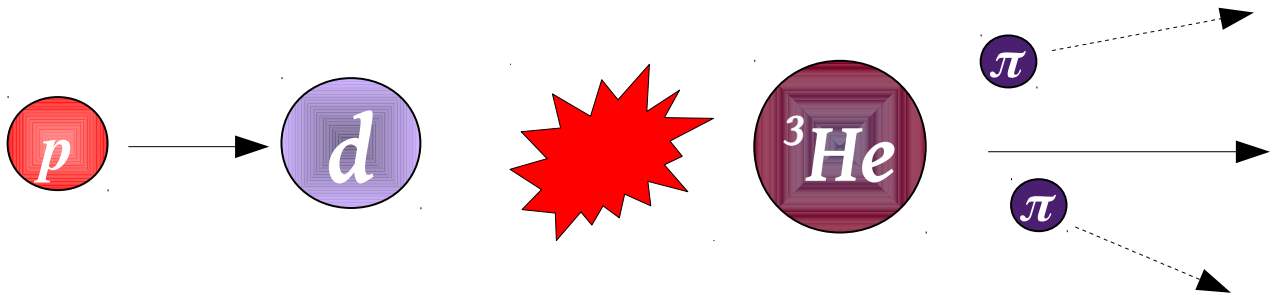
@ $\sqrt{s}$ = 2.38 GeV



Phasespace (always)

P. Adlarson et. al
PRL 106:242302, 2011

ABC Effect in Double Pionic Fusion



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pn → d π⁰ π⁰

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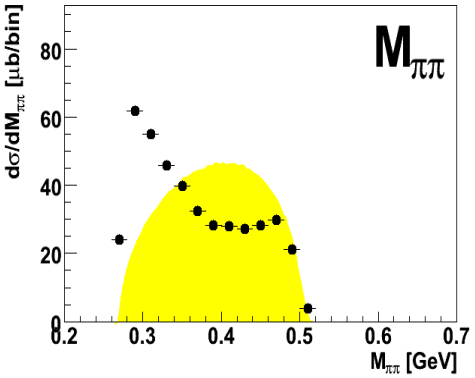

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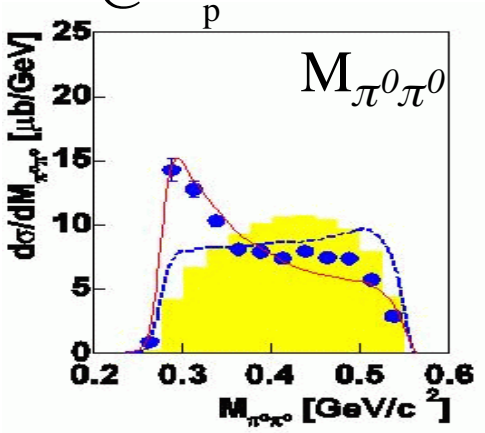
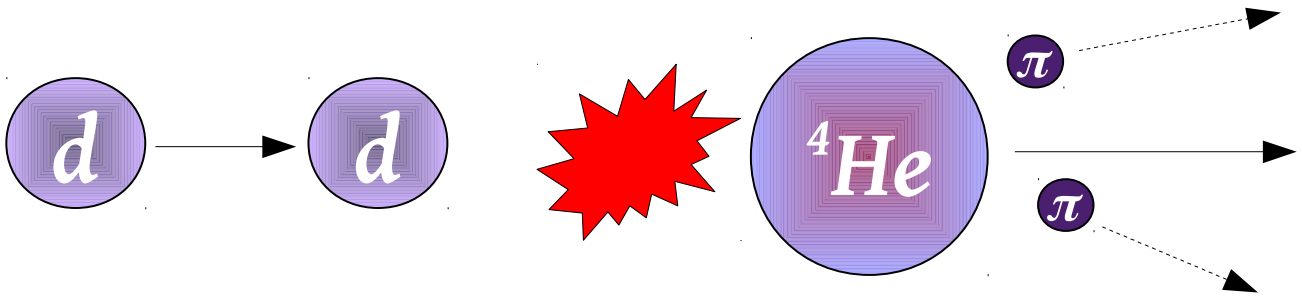
pd→ ³He π⁰π⁰

@ T_p = 0.9 GeV



PL B 637 (2006) 223

ABC Effect in Double Pionic Fusion



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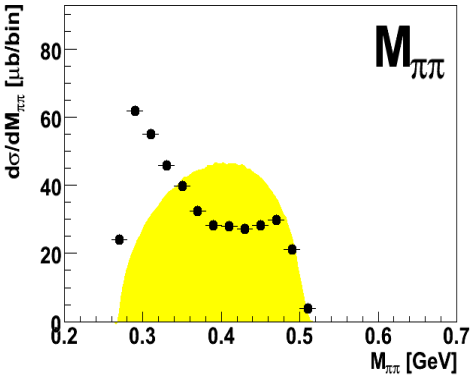

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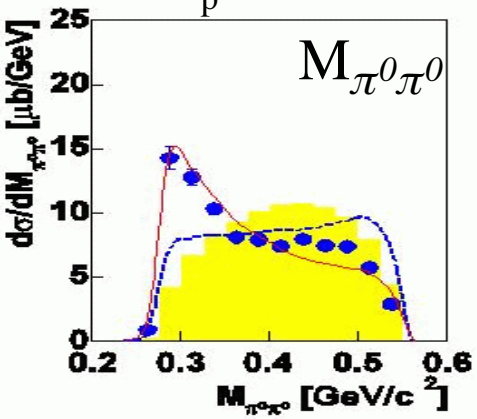
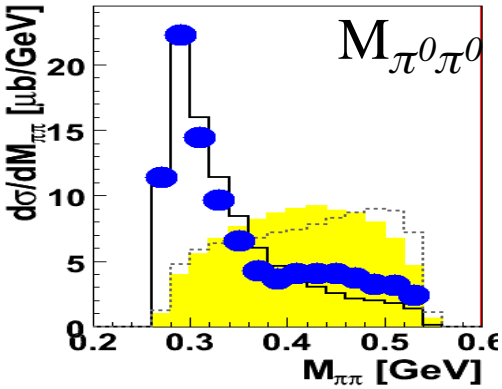


PL B 637 (2006) 223

dd→ ⁴He π⁰π⁰

@ T_d=1.05 GeV

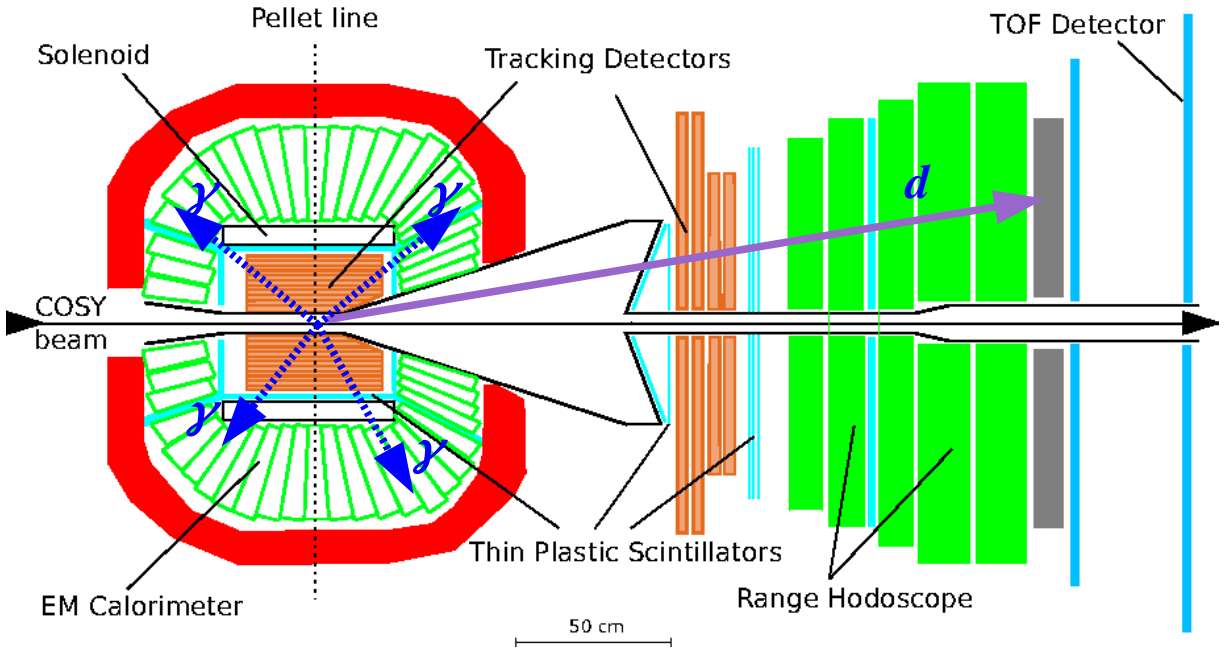


publication in preparation

WASA Detector: Wide Angle Shower Apparatus

Central Detector:
- Measure charged and neutral particles

Forward Detector:
- Measure charged (neutral) particles



Pellet Target:
- deuterons or protons

COSY beam:
- protons or deuterons
- polarised and unpolarised
- 0.6 - 3.7 GeV/c beam momentum

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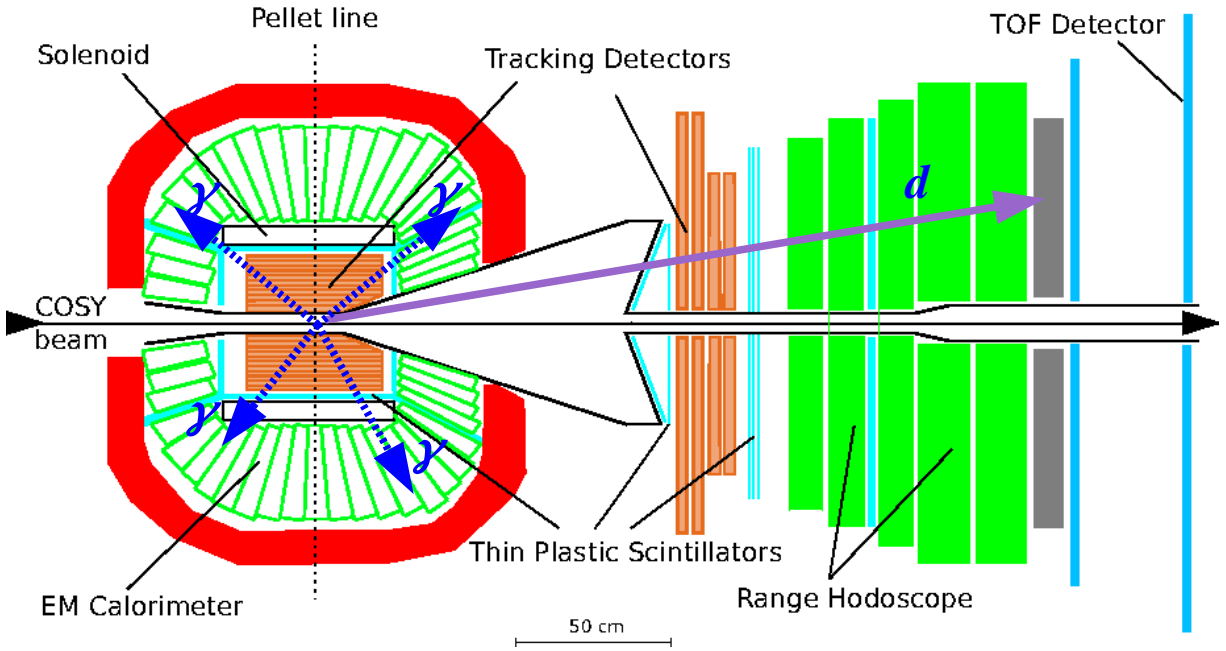
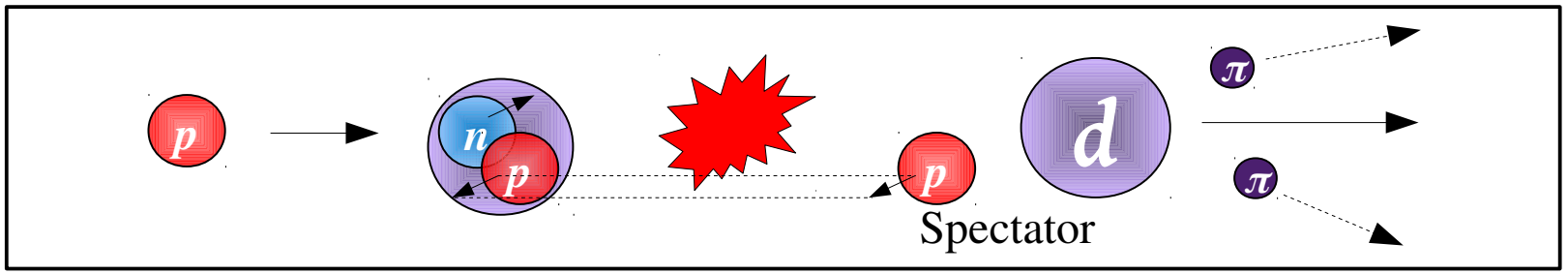
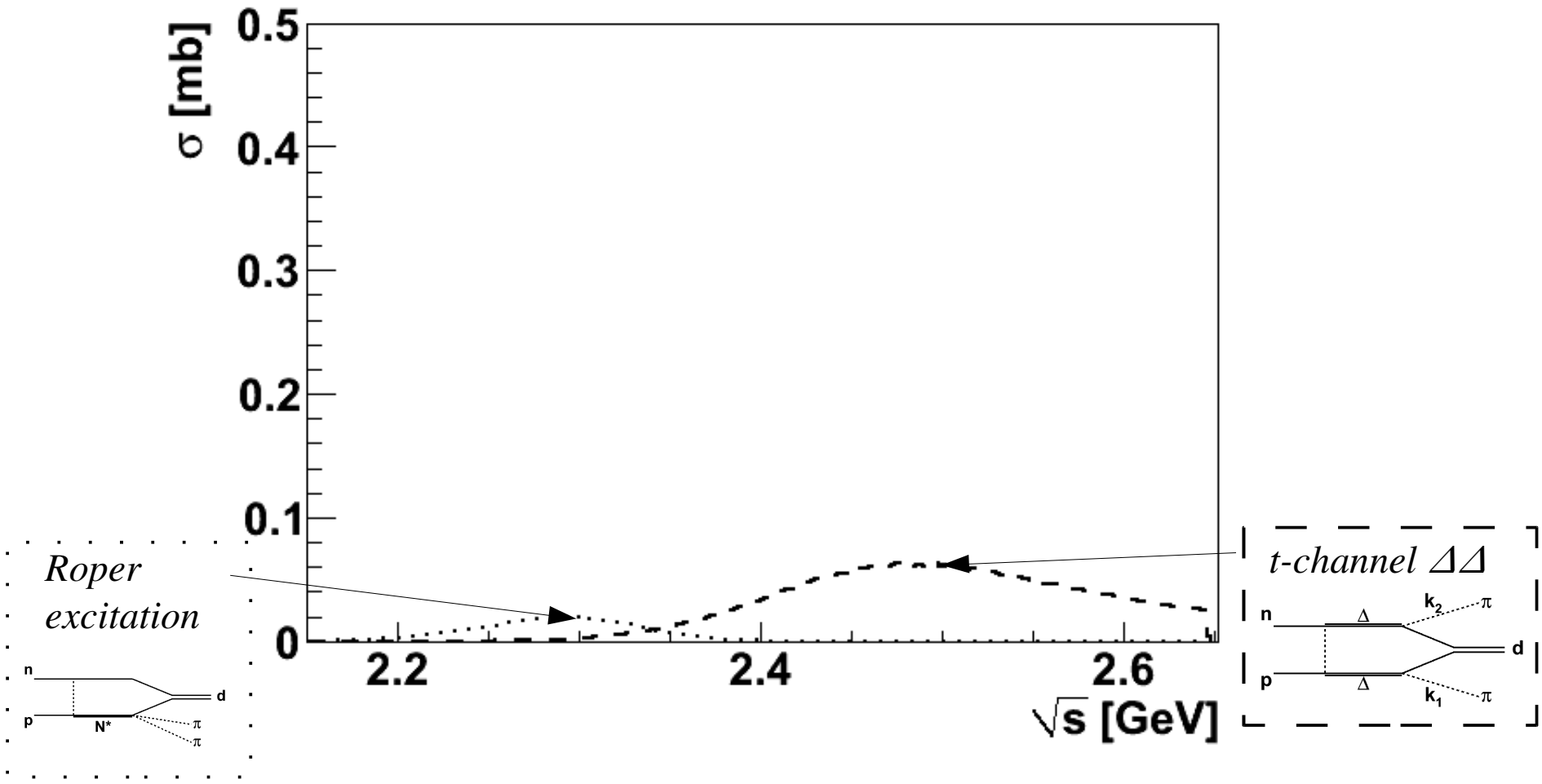




A New Resonance: Total Cross Section $pn \rightarrow d\pi^0\pi^0$



P. Adlarson et. al Phys. Rev. Lett. 106:242302, 2011

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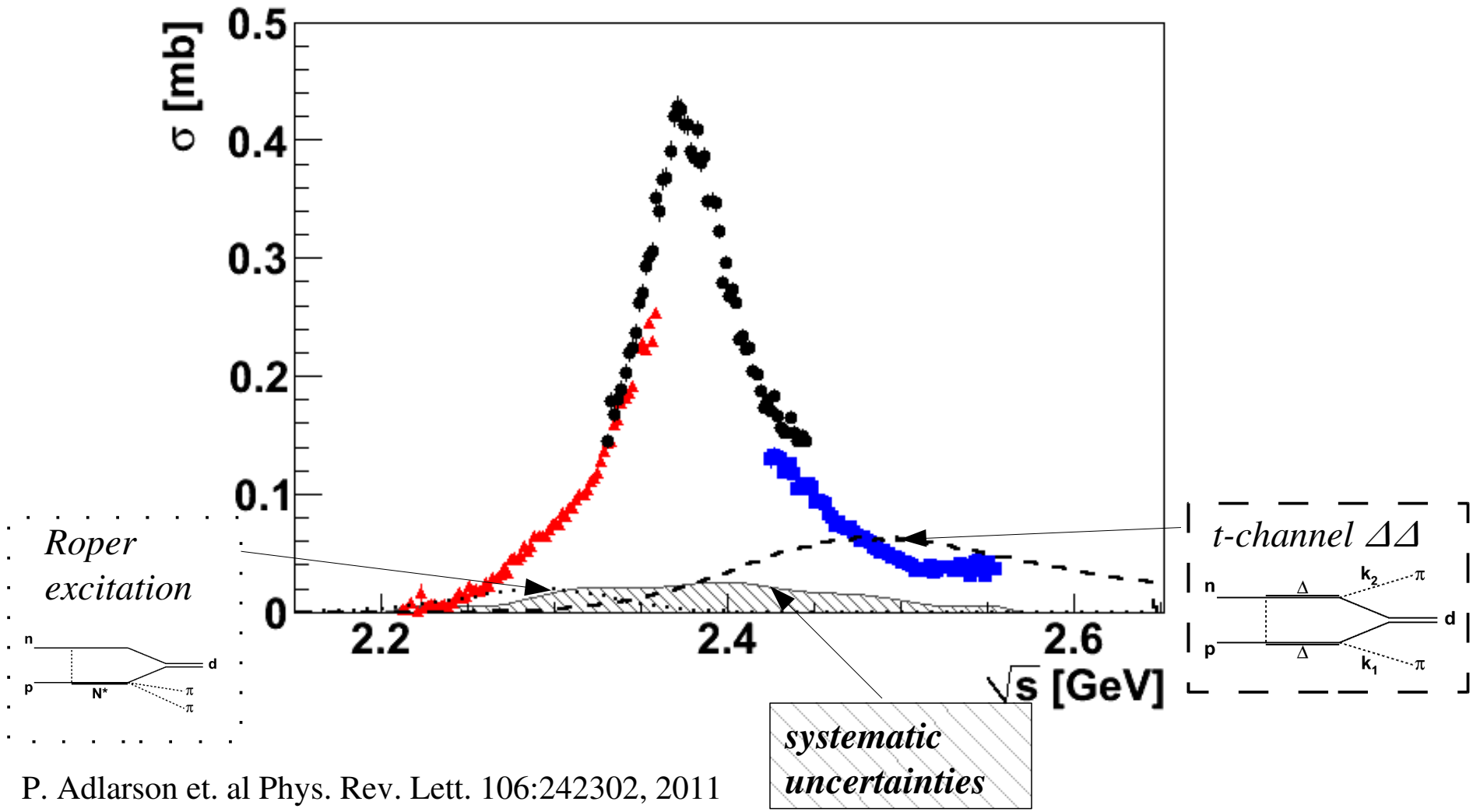

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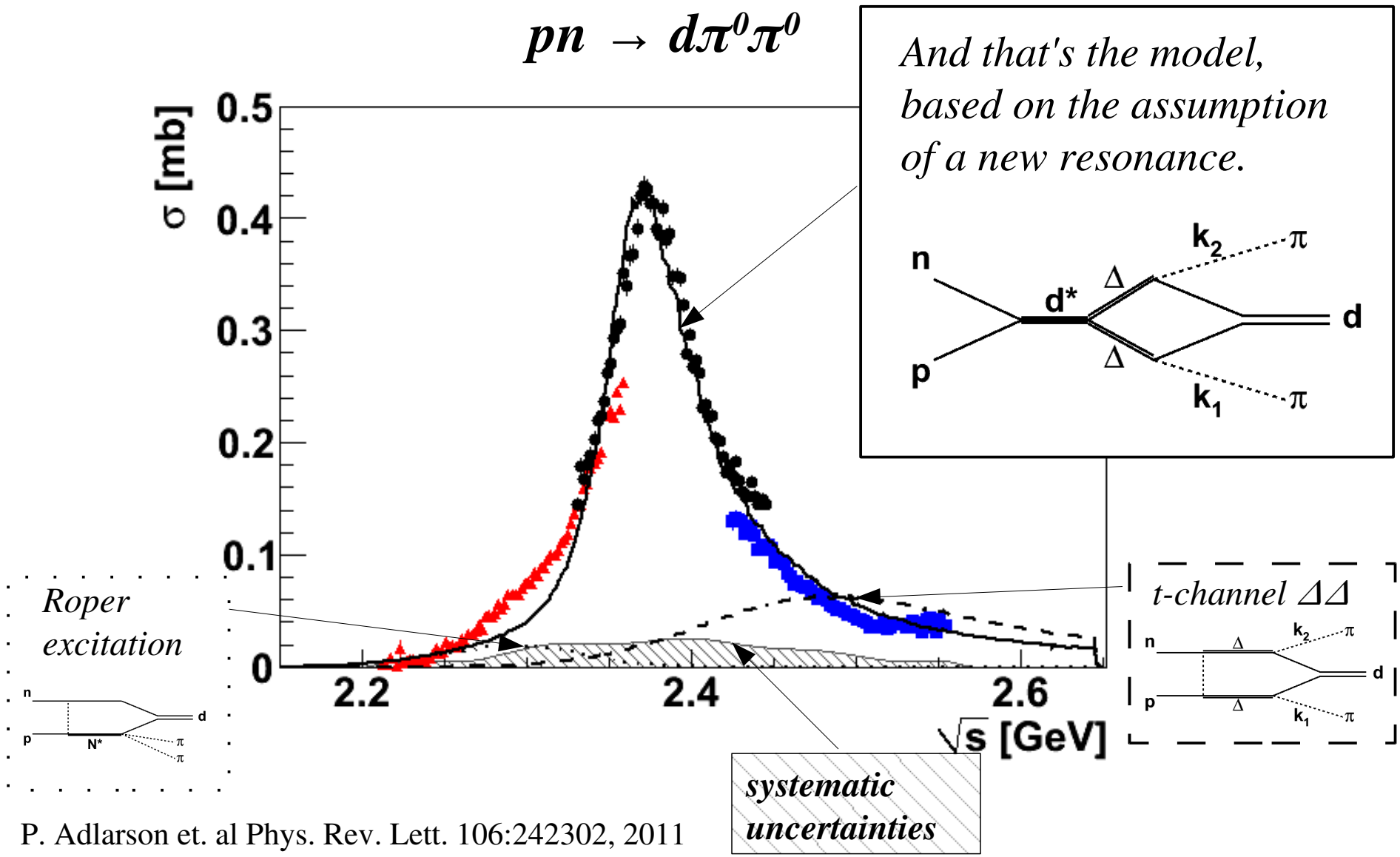

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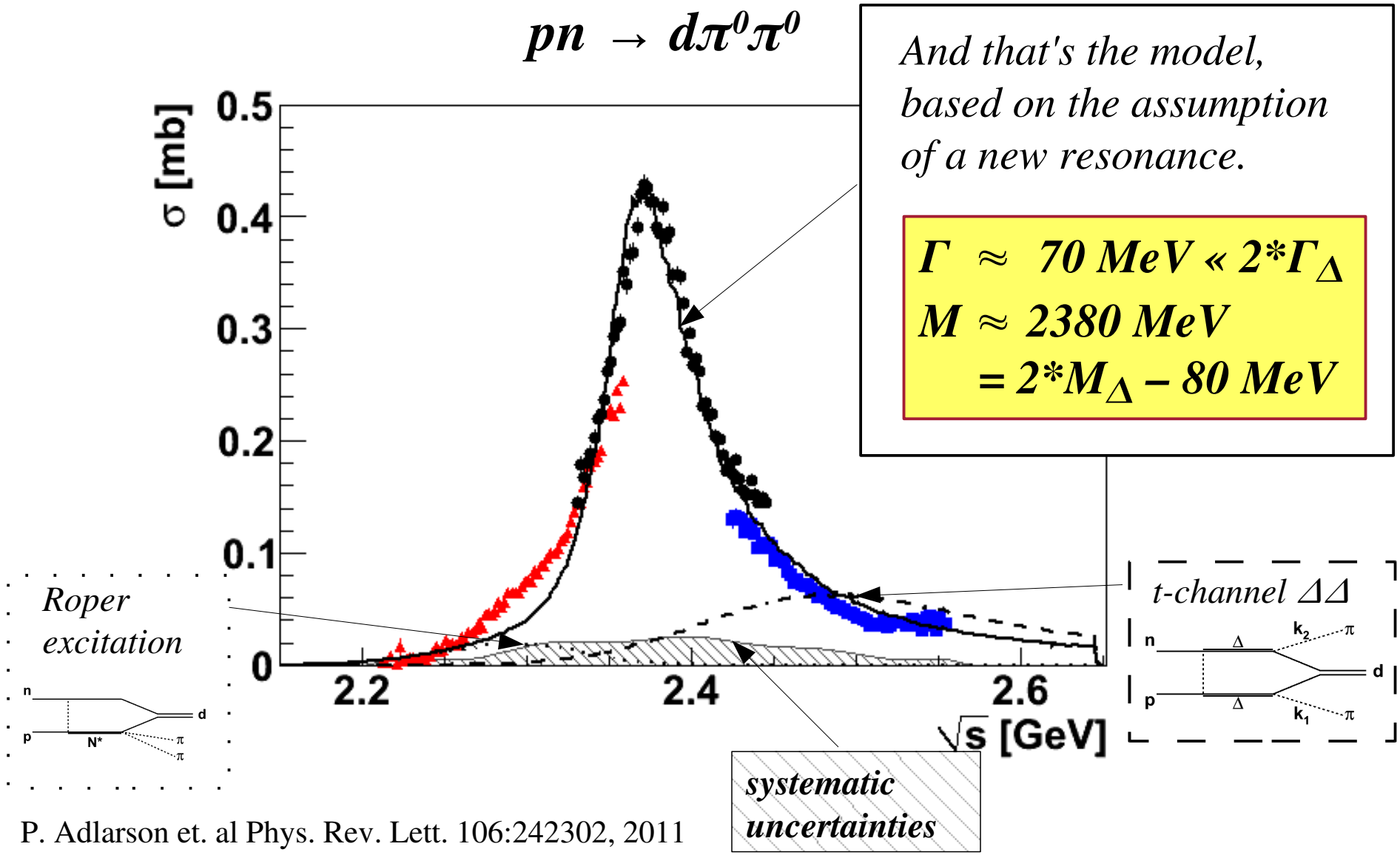

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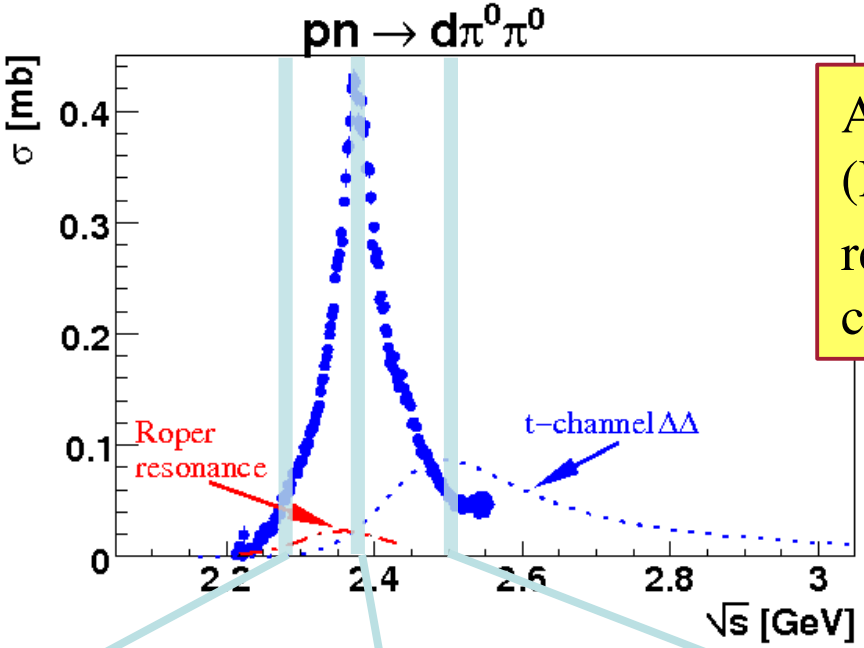
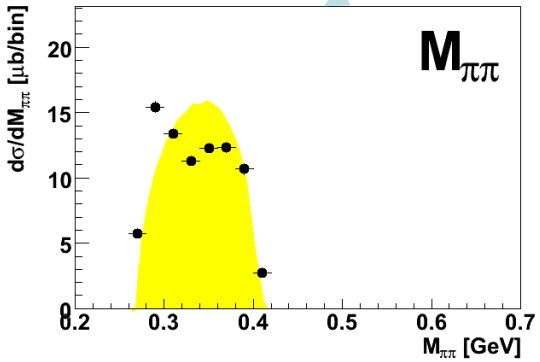
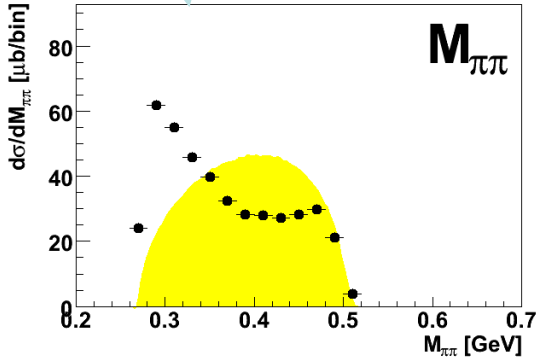
$M_{\pi\pi}$ for different beam energies

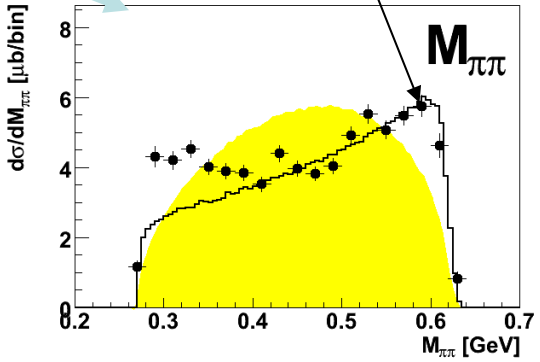


ABC Effect (Enhancement in $M_{\pi\pi}$) related to peak in total cross section !

t-channel ΔΔ





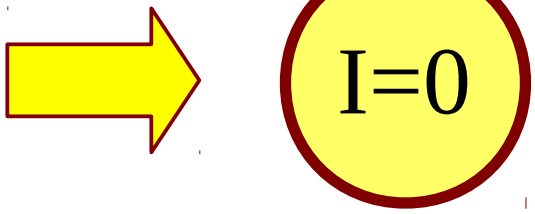


P. Adlarson et. al Phys. Rev. Lett. 106:242302, 2011

Quantum Numbers of the Resonance

ABC Effect related to peak in total cross section !

$$\underbrace{pn}_{I=0,1} \rightarrow \underbrace{d}_{I=0} \quad \underbrace{\pi^0\pi^0}_{I=0,2}$$



$$\underbrace{pn}_{I=0,1} \rightarrow \underbrace{d}_{I=0} \quad \underbrace{\pi^+\pi^-}_{I=0,1,2}$$

$$\underbrace{pp}_{I=1} \rightarrow \underbrace{d}_{I=0} \quad \underbrace{\pi^+\pi^0}_{I=1,2}$$

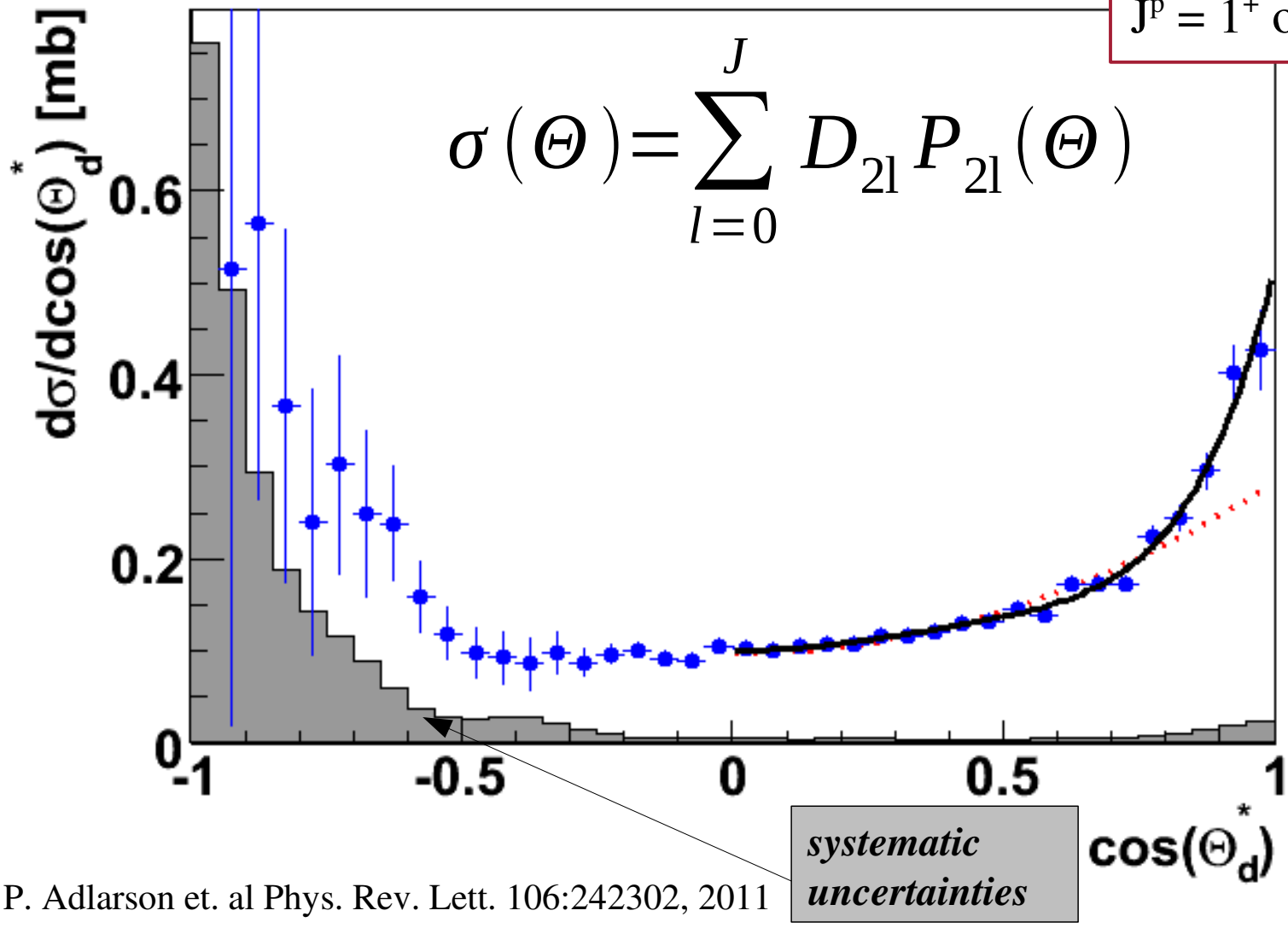
I=0 and I=1 admixture

Purely I=1

Angular Distributions at the Peak

Antisymmetrisation:
$J^p = 1^+$ or 3^+ if $L_{\Delta\Delta}=0$

$$\sigma(\Theta) = \sum_{l=0}^{J} D_{2l} P_{2l}(\Theta)$$



J=3

J=1

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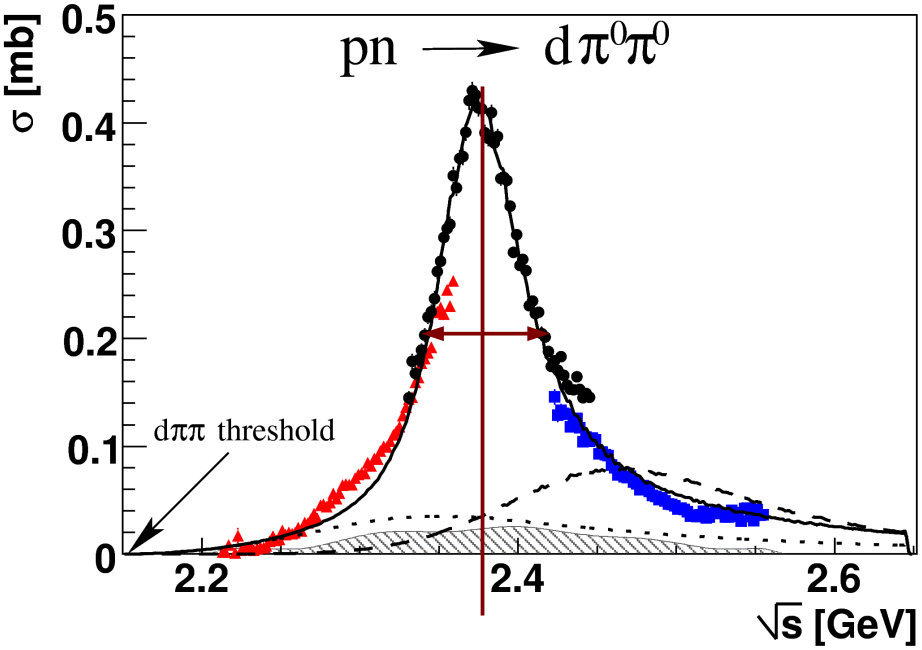
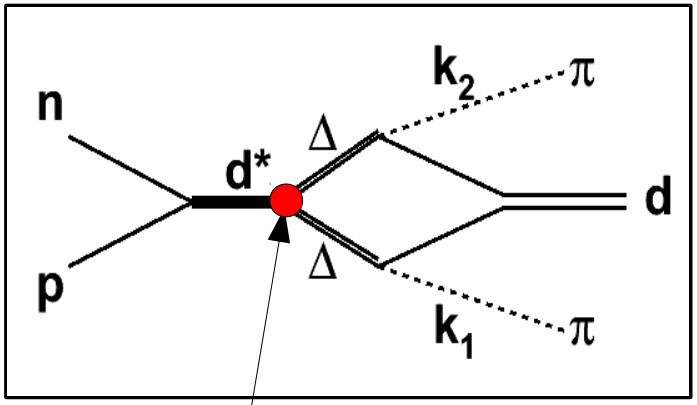
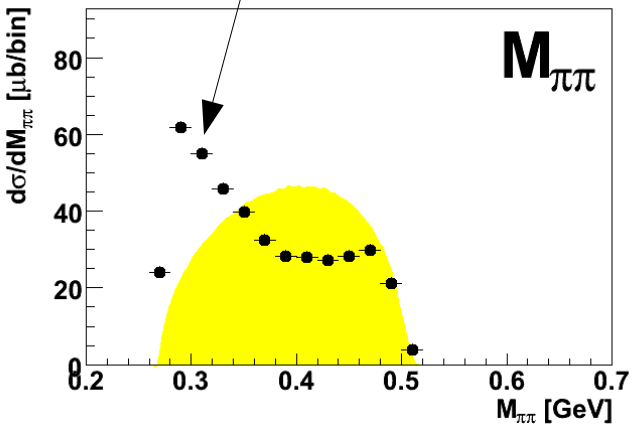
ABC Resonance Model





Formfactor



$\Gamma \approx 70\ MeV$

$M \approx 2380\ MeV$

$I(J^p) = 0(3^+)$

What do we do to check that ?

- $pn \rightarrow d\pi^0\pi^0$ (I=0) ABC Effect

- $pn \rightarrow d\pi^+\pi^-$ (I=0 and I=1) ABC Effect

- $pd \rightarrow {}^3He\pi\pi$ ABC Effect
- $dd \rightarrow {}^4He\pi\pi$ ABC Effect

What do we do to check that ?

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- $pn \rightarrow pn\pi^0\pi^0$ — some ABC Effect
- $pn \rightarrow pp\pi^-\pi^0$ — No ABC Effect
- $pn \rightarrow pp\pi^-$ — No ABC Effect

Non-Fusion Pion Production: Some ABC Resonance

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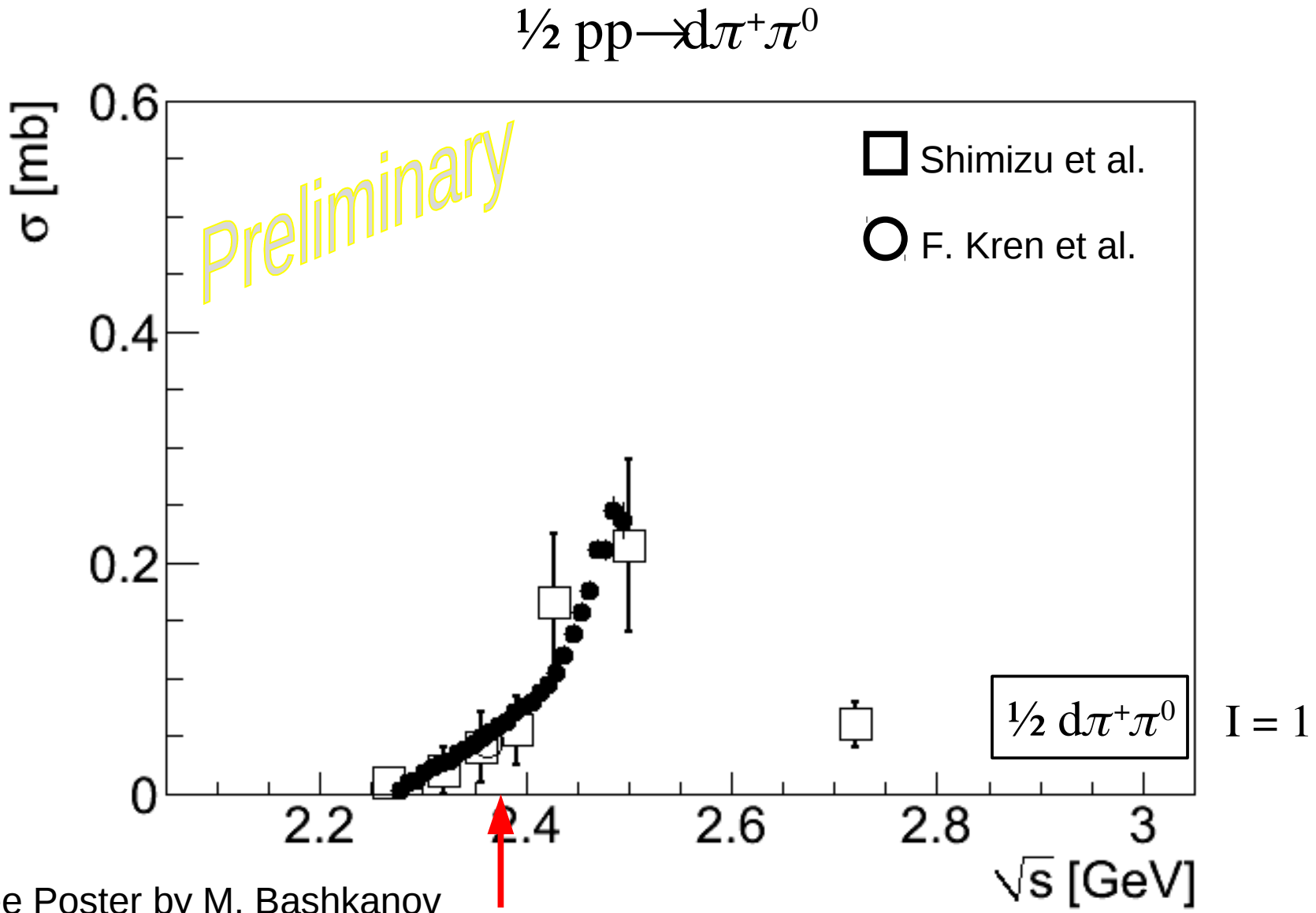
Connected by Isospin Relations:

$$\sigma\left[pn \rightarrow d\pi^+\pi^-\right] = \frac{1}{2}\sigma\underbrace{\left[pp \rightarrow d\pi^+\pi^0\right]}_{I=1} + 2\sigma\underbrace{\left[pn \rightarrow d\pi^0\pi^0\right]}_{I=0}$$

Total Cross Section pN → dππ



See Poster by M. Bashkanov

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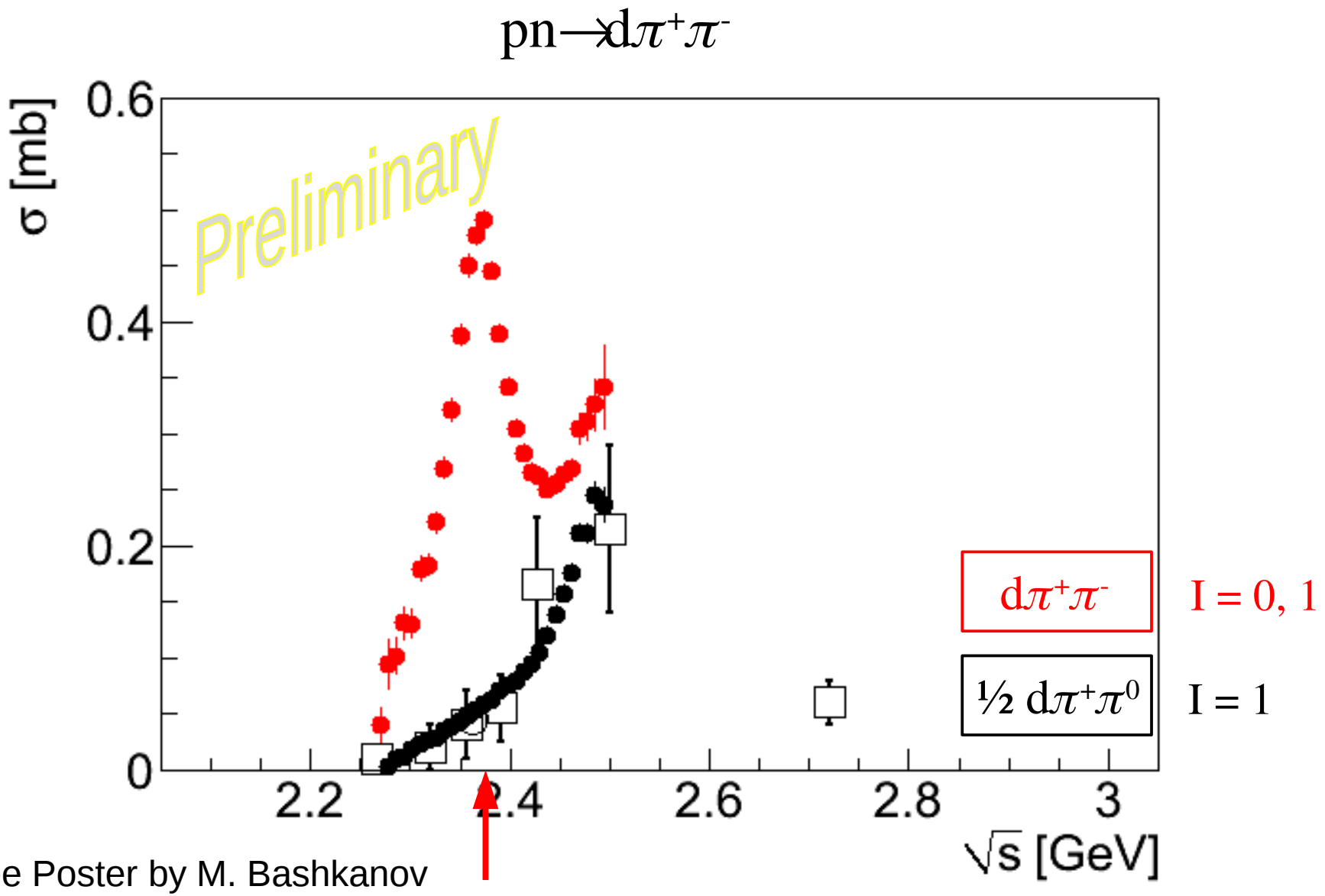

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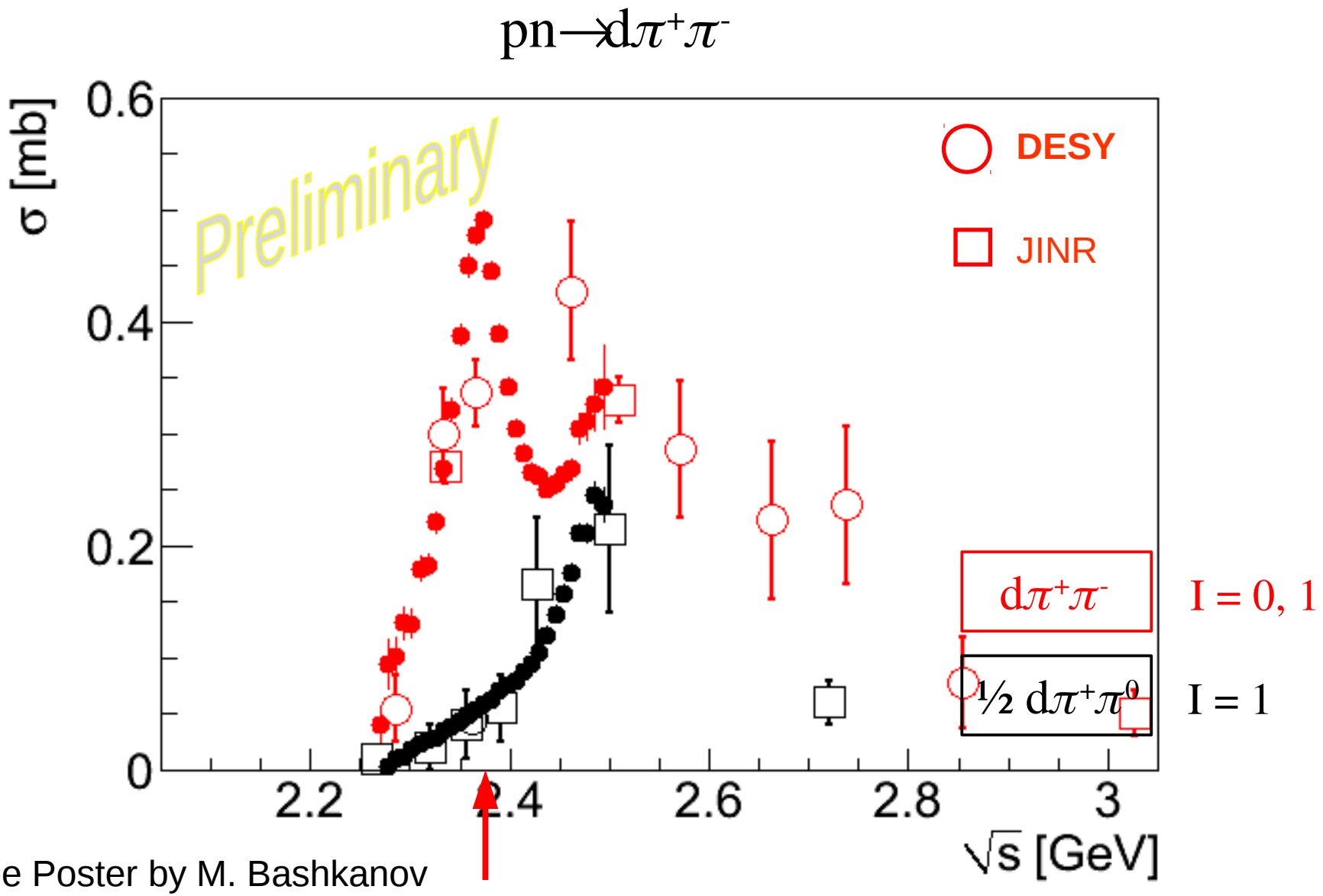

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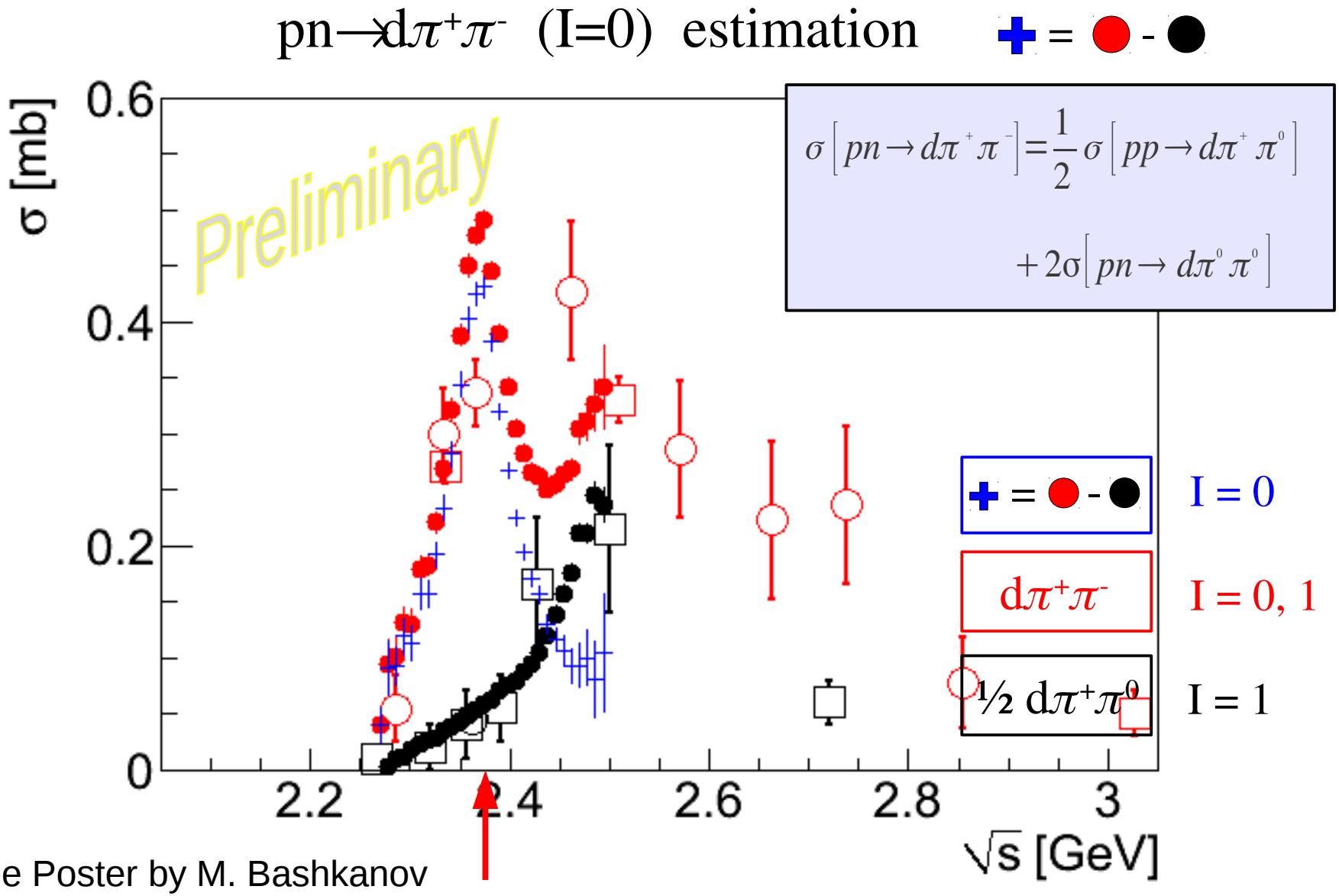

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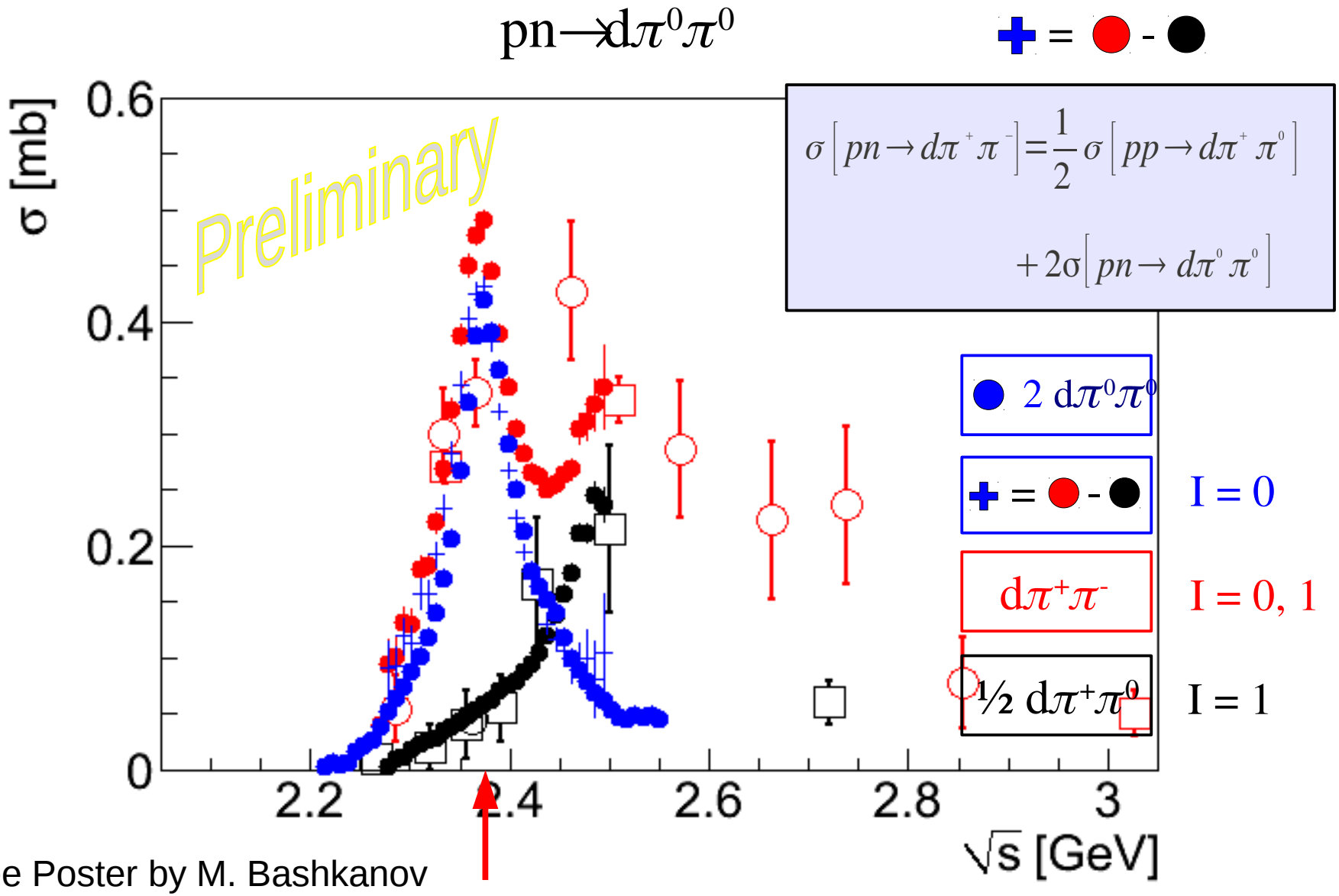
Total Cross Section $pN \rightarrow d\pi\pi$



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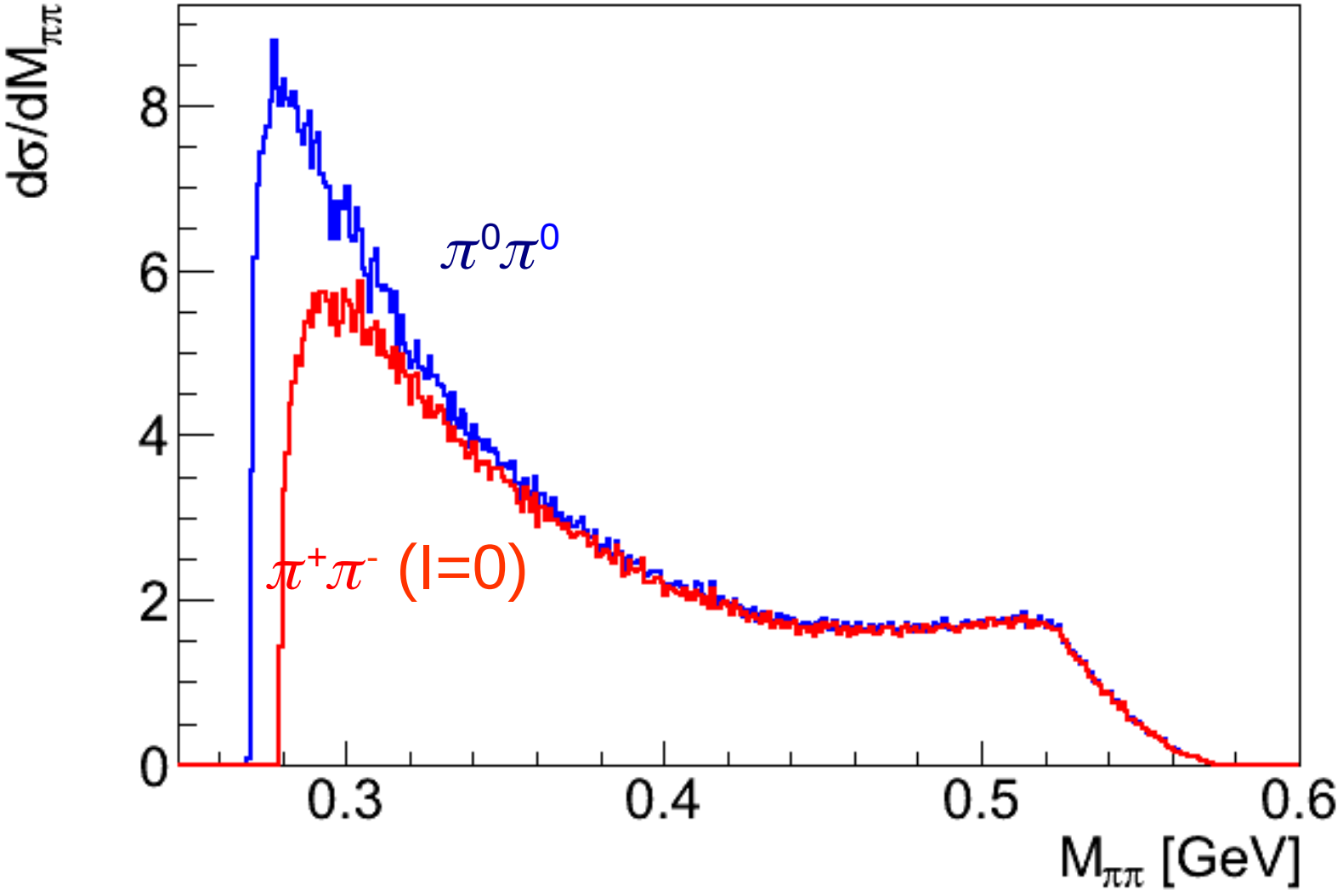
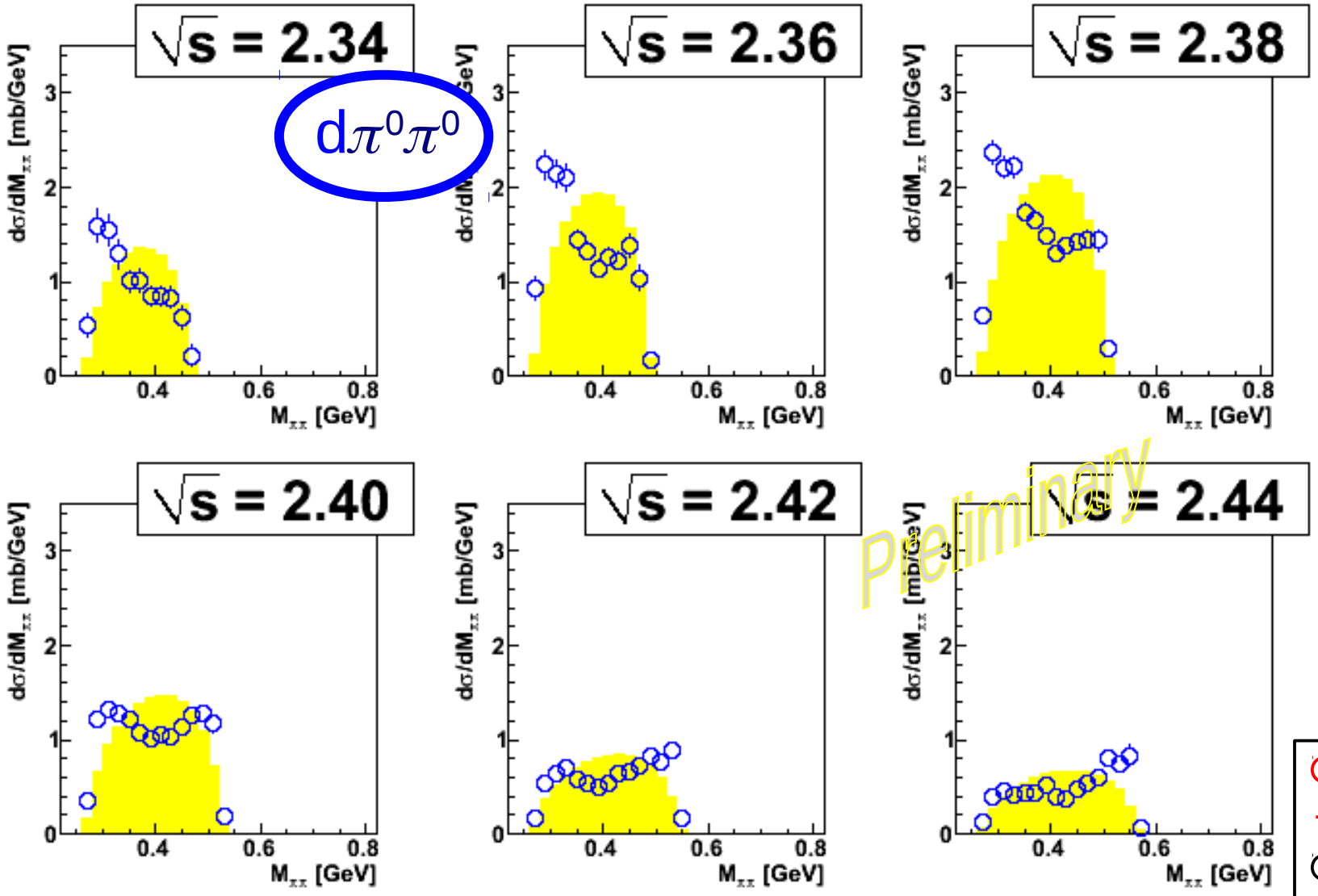
Isospin Violation

Simulation



$M_{\pi\pi}$ in $pN \rightarrow d\pi\pi$



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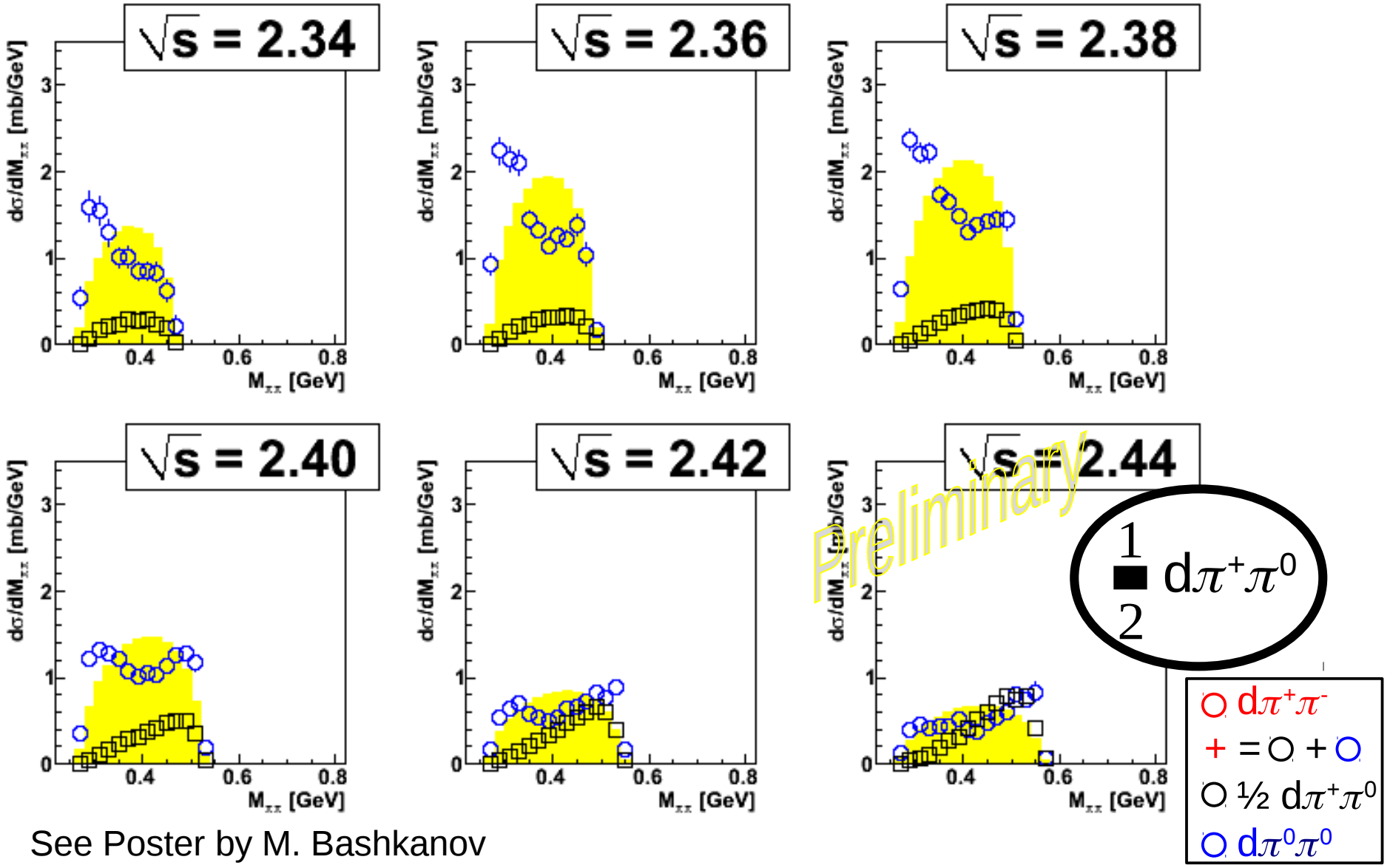

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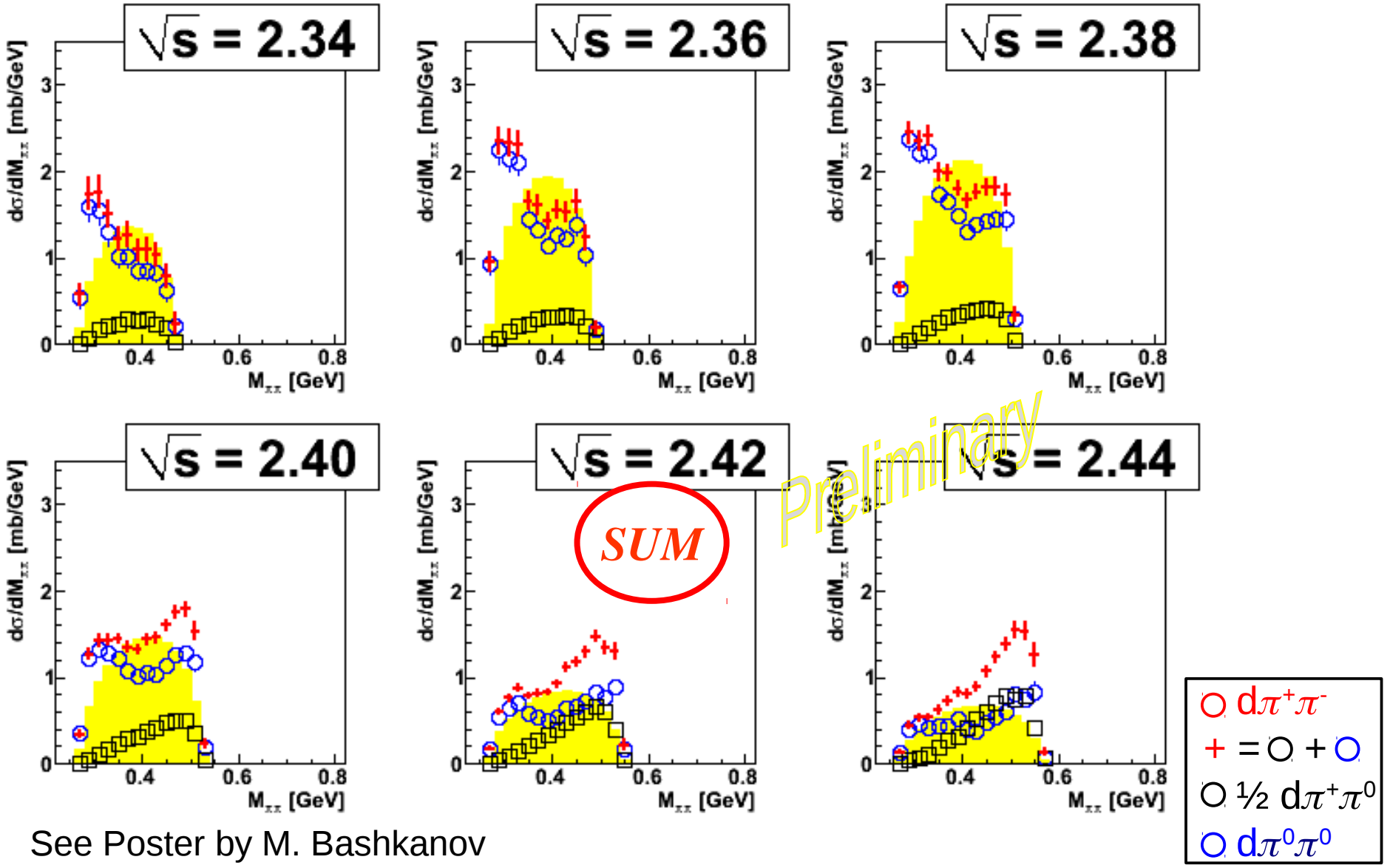

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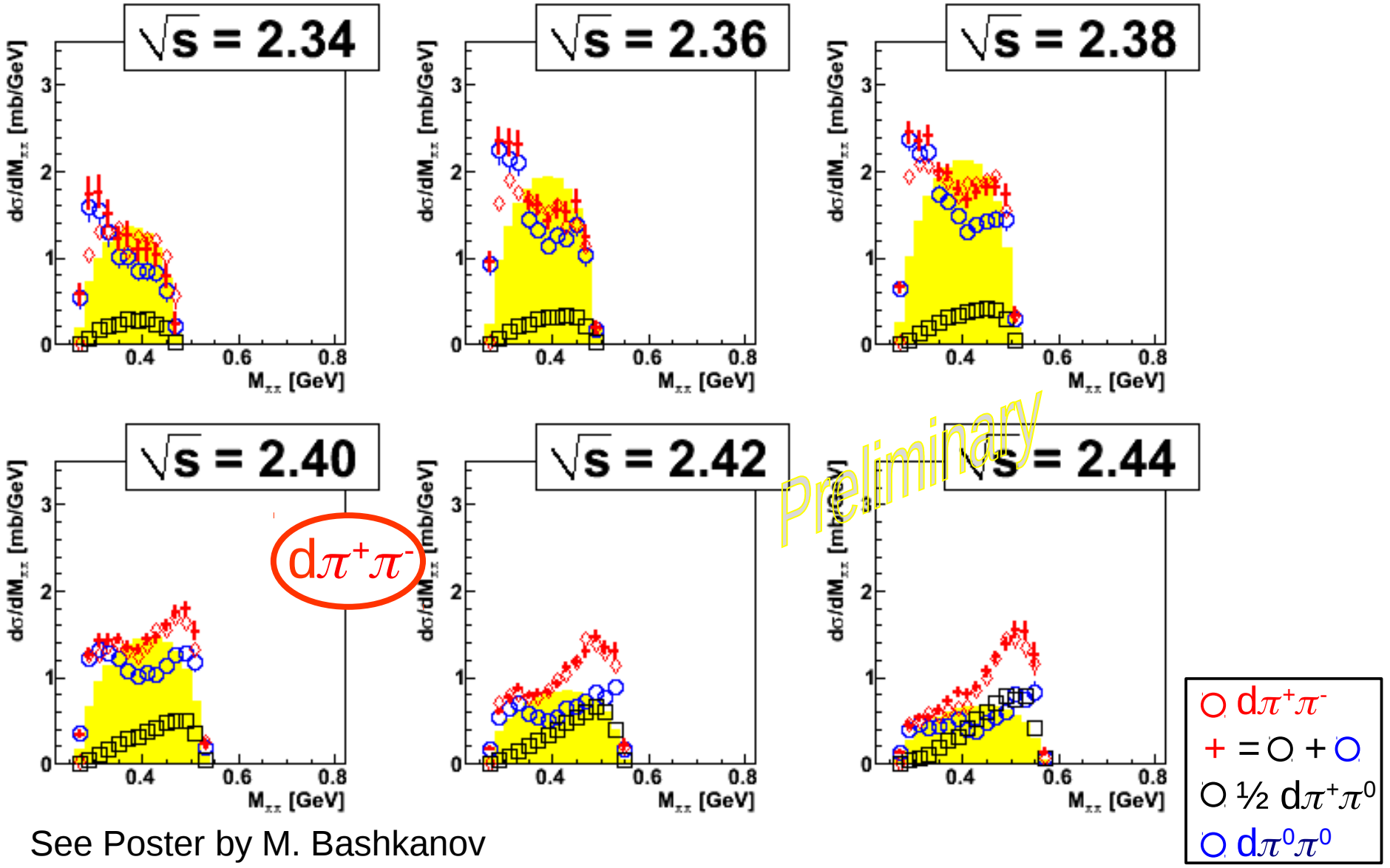


See Poster by M. Bashkanov

What do we do to check that ?

- $pn \rightarrow d\pi^0\pi^0$ (I=0) — ABC Effect
- $pp \rightarrow d\pi^+\pi^0$ (I=1) — No ABC Effect, No ABC Resonance (I=1)
- $pn \rightarrow d\pi^+\pi^-$ (I=0 and I=1) — ABC Effect

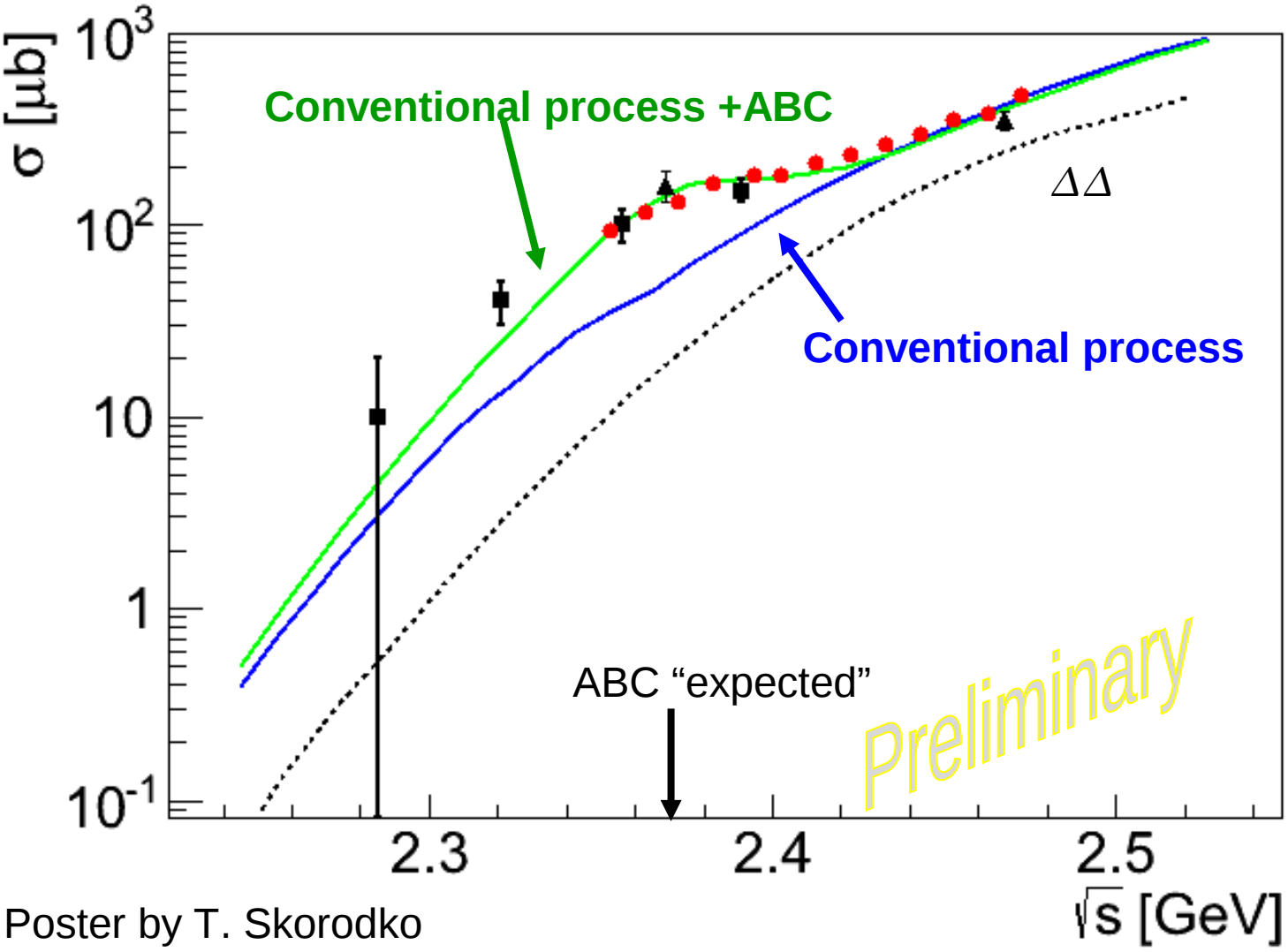
- $pn \rightarrow pn\pi^0\pi^0$ — some ABC Effect
- $pn \rightarrow pp\pi^-\pi^0$ — No ABC Effect
- $pn \rightarrow pp\pi^-$ — No ABC Effect

→ Non-Fusion Pion Production: Some ABC Resonance

- $pd \rightarrow {}^3He\pi\pi$ — ABC Effect
- $dd \rightarrow {}^4He\pi\pi$ — ABC Effect

- $pn \rightarrow pn$ — pn elastic scattering

Total Cross Section $pn \rightarrow pp\pi^-\pi^0$

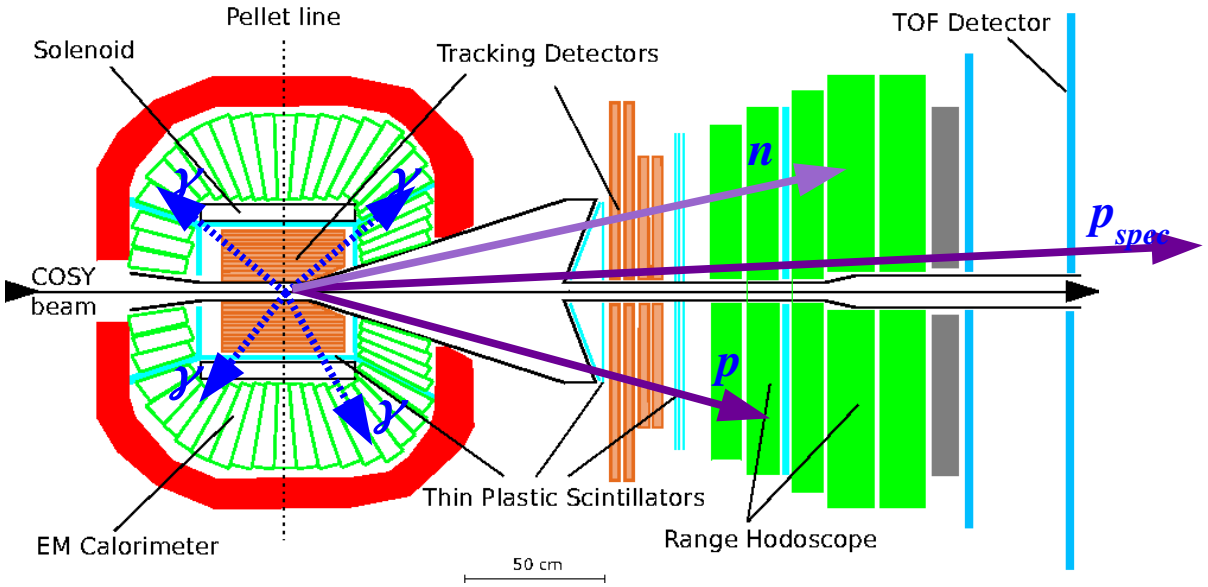


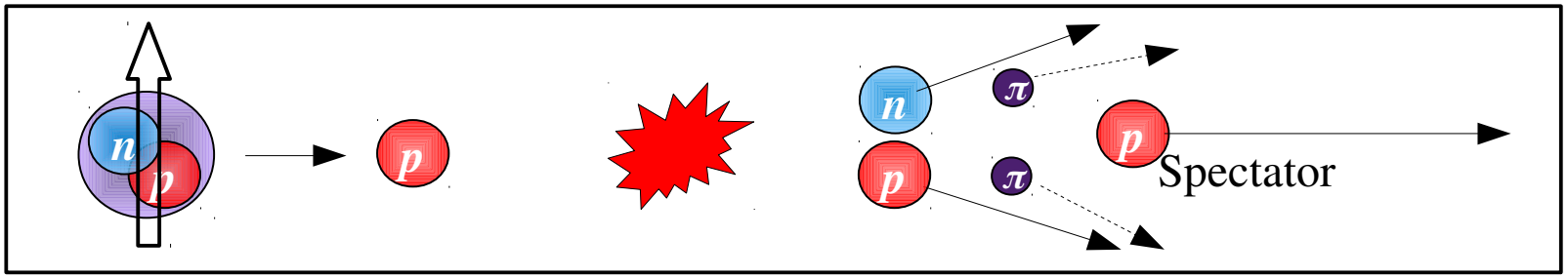
See Poster by T. Skorodko

Non-Fusion Pion Production

1 week beamtime over easter: polarized deuterons on proton target

- $pn \rightarrow pn\pi^0\pi^0$
  - Measured in inverse kinematics $\vec{dp} \rightarrow np\pi^0\pi^0 + p_{sp}$





Non-Fusion Pion Production

1 week beamtime over easter: polarized deuterons on proton target

- $pn \rightarrow pn\pi^0\pi^0$
  - Measured in inverse kinematics $\vec{d}p \rightarrow np\pi^0\pi^0 + p_{sp}$

- $pn \rightarrow pp\pi^-$
  - contains I=1 and I=0
  - I=1 can be extracted from already analyzed $pp \rightarrow pp\pi^0$

What do we do to check that ?

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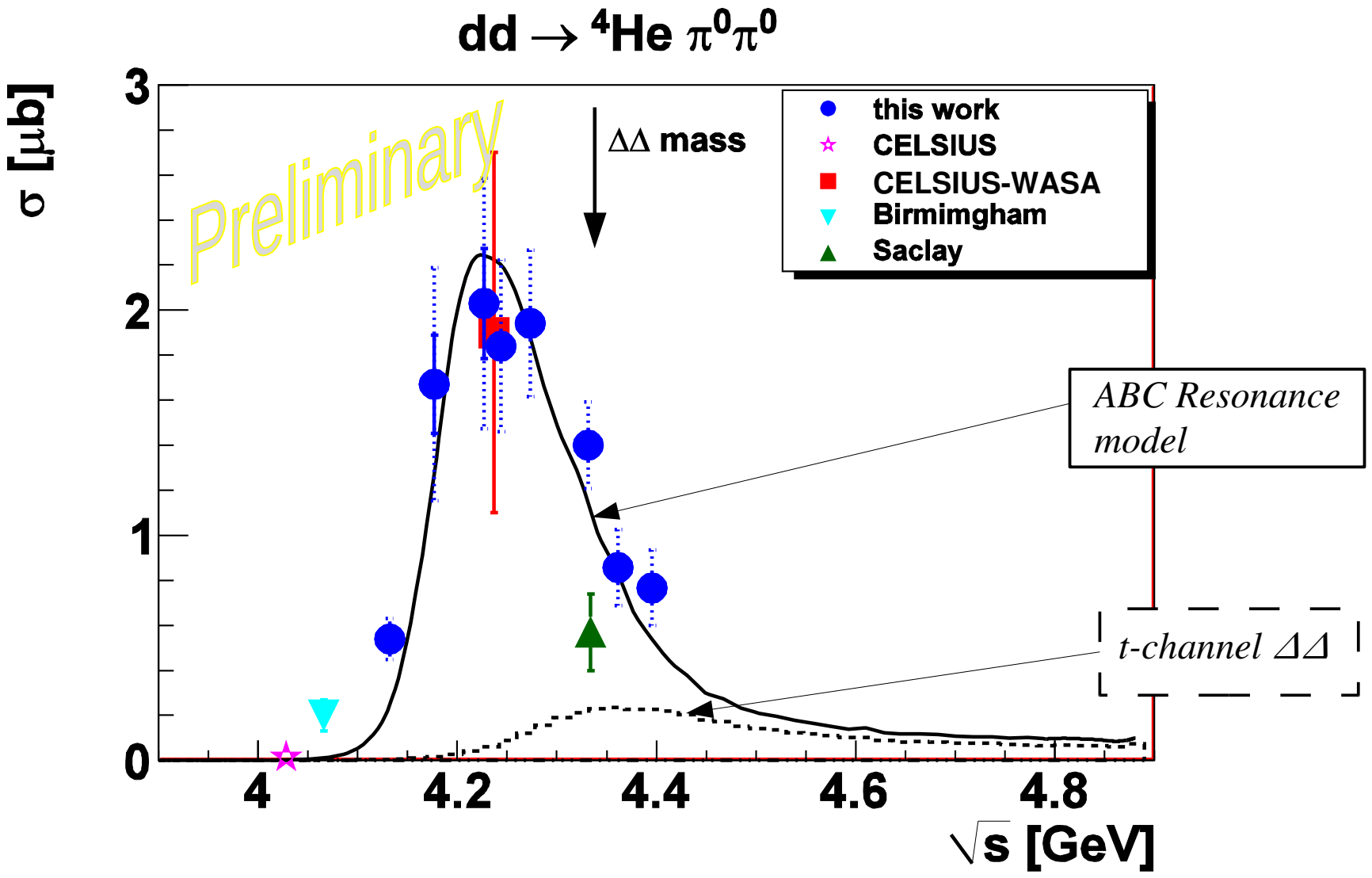
- $pn \rightarrow d\pi^+\pi^-$ (I=0 and I=1) — ABC Effect
- $pn \rightarrow pn\pi^0\pi^0$ — some ABC Effect
- $pn \rightarrow pp\pi^-\pi^0$ — No ABC Effect
- $pn \rightarrow pp\pi^-$ — No ABC Effect

Non-Fusion Pion Production: Some ABC Resonance

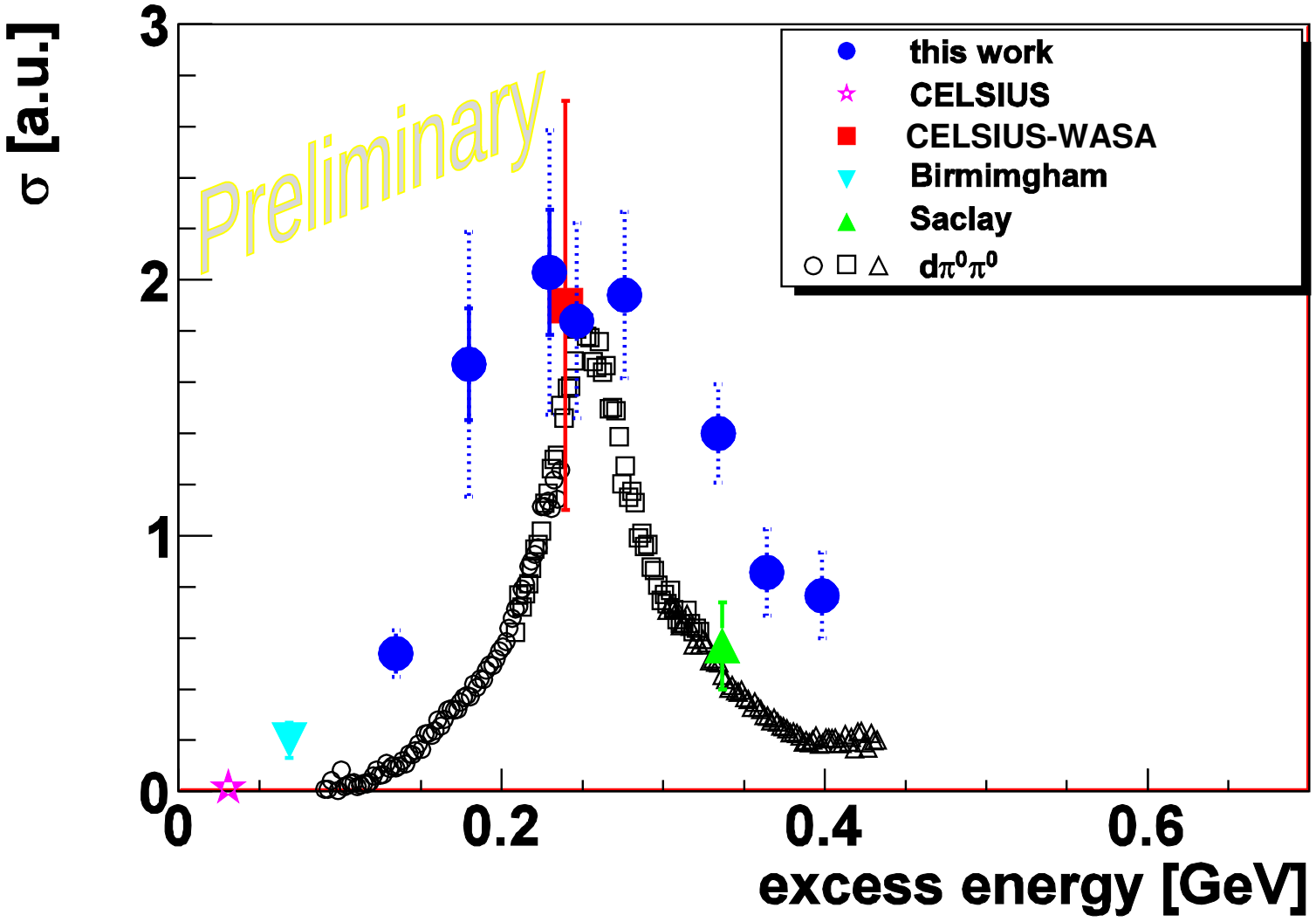
- $pd \rightarrow {}^3He\pi\pi$ — ABC Effect
- $dd \rightarrow {}^4He\pi\pi$ — ABC Effect

- $pn \rightarrow pn$ — pn elastic scattering

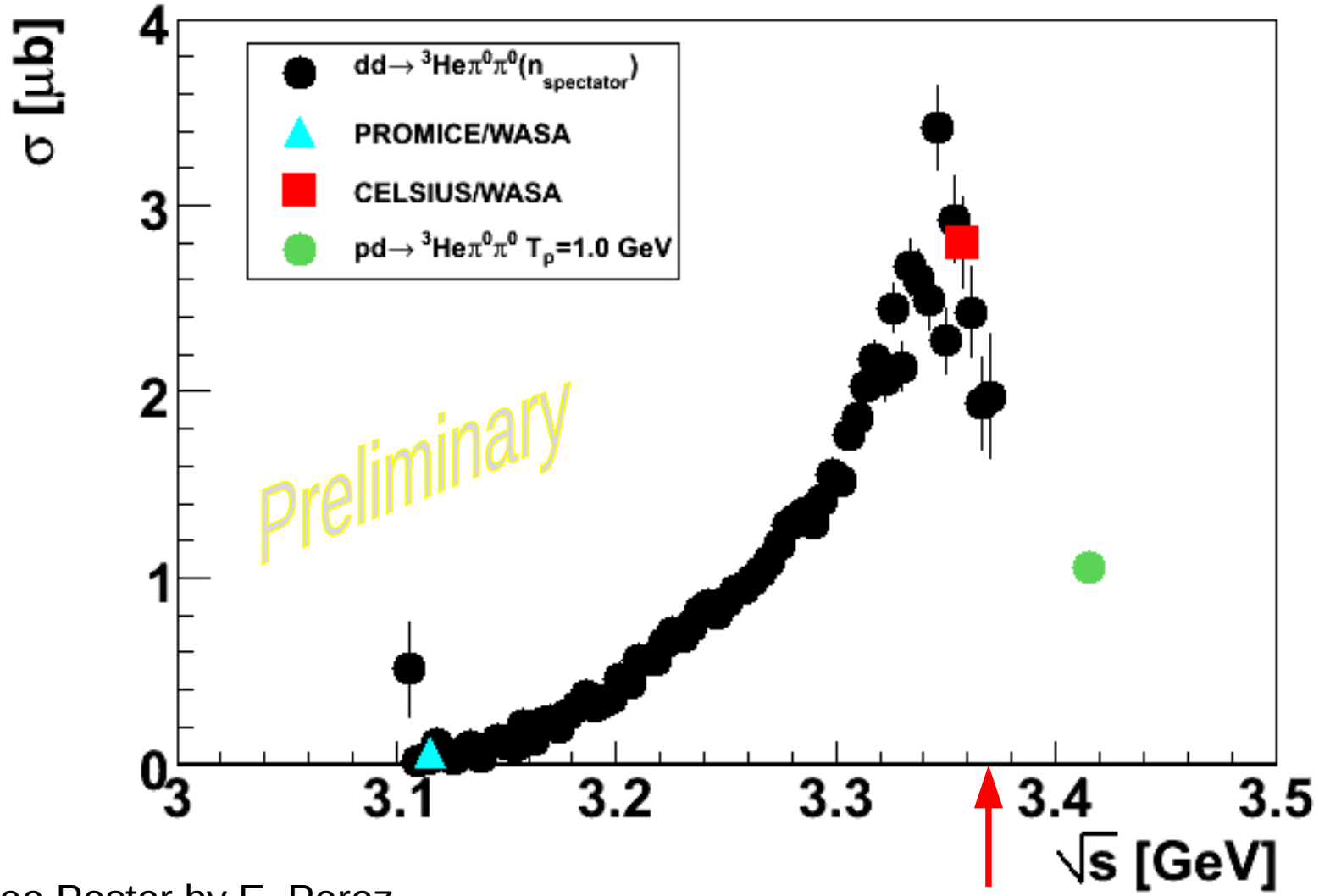
Total Cross Section $dd \rightarrow {}^4He\ \pi^0\pi^0$



Comparison: $dd \rightarrow {}^4He\pi^0\pi^0 \Leftrightarrow pn \rightarrow d\pi^0\pi^0$



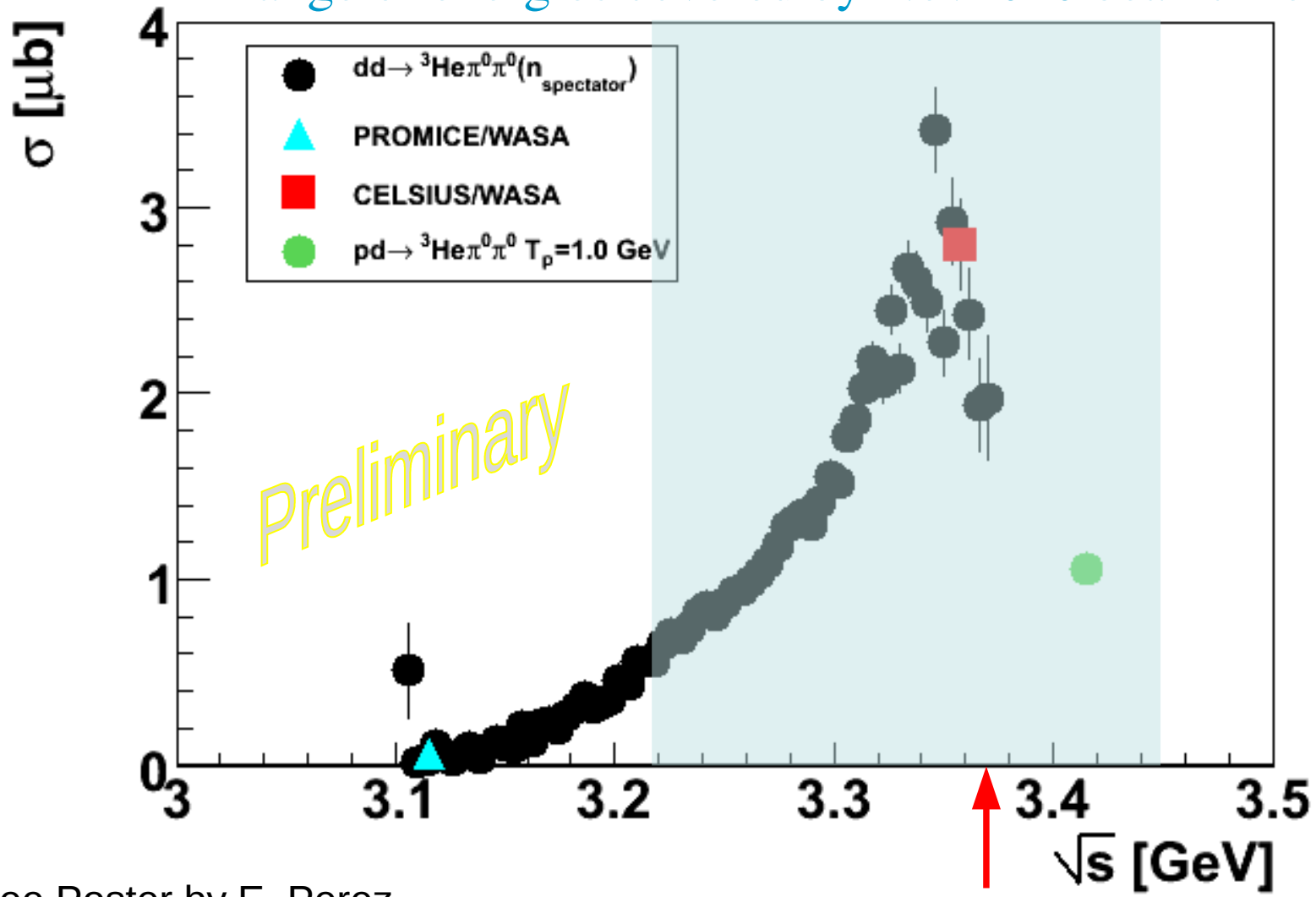
Total Cross Section $pd \rightarrow {}^{3}He\,\pi^0\pi^0$



See Poster by E. Perez

Total Cross Section $pd \rightarrow {}^3He\,\pi^0\pi^0$

Range of energies covered by Nov2010 beamtime



See Poster by E. Perez

What do we do to check that ?

- $pn \rightarrow d\pi^0\pi^0$ (I=0) — ABC Effect
- $pp \rightarrow d\pi^+\pi^0$ (I=1) — No ABC Effect, No ABC Resonance (I=1)
- $pn \rightarrow d\pi^+\pi^-$ (I=0 and I=1) — ABC Effect
- $pn \rightarrow pn\pi^0\pi^0$ — some ABC Effect
- $pn \rightarrow pp\pi^-\pi^0$ — No ABC Effect
- $pn \rightarrow pp\pi^-$ — No ABC Effect

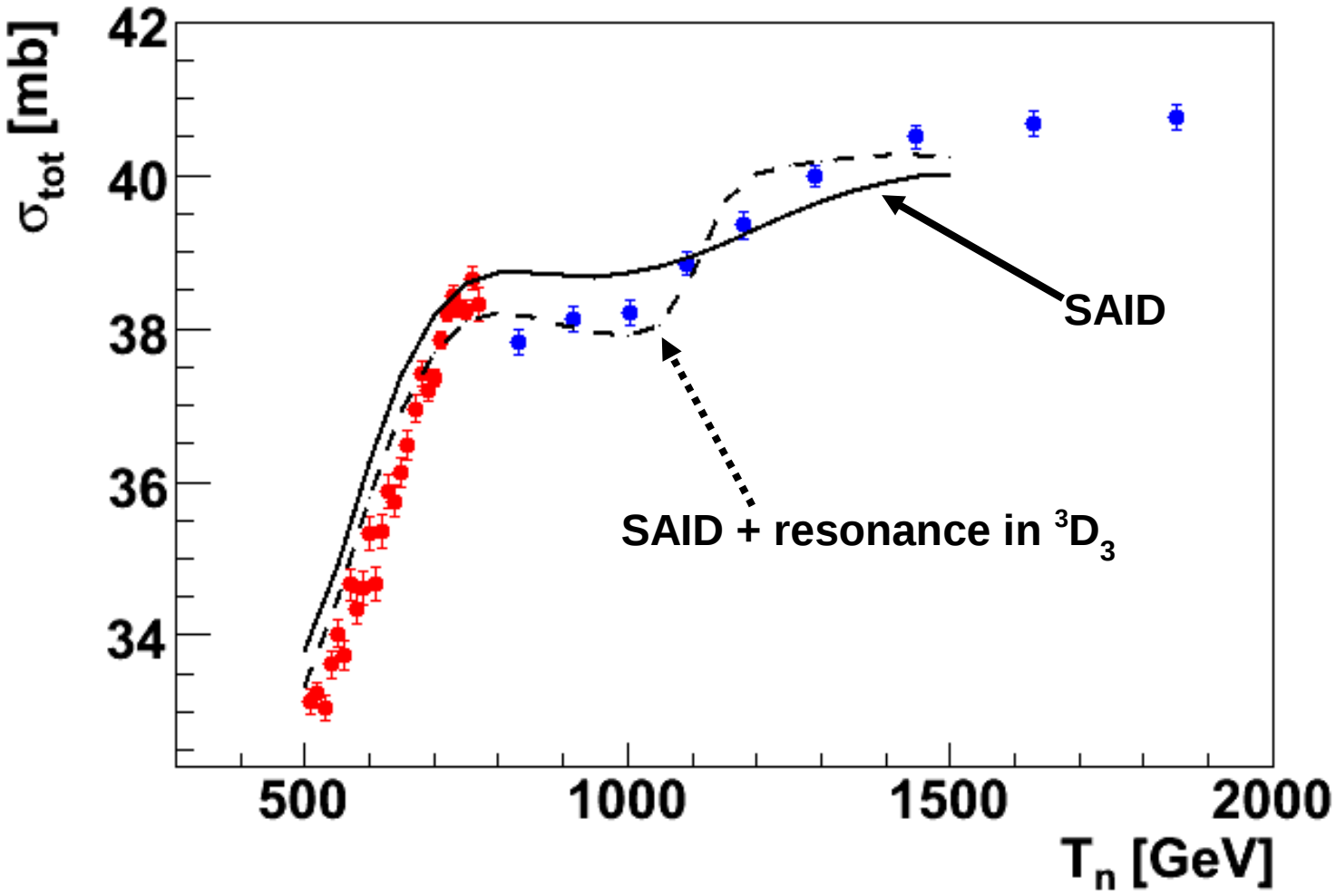
Non-Fusion Pion Production: Some ABC Resonance

- $pd \rightarrow {}^3He\pi\pi$ — ABC Effect
- $dd \rightarrow {}^4He\pi\pi$ — ABC Effect

- $pn \rightarrow pn$ — pn elastic scattering

pn total cross section

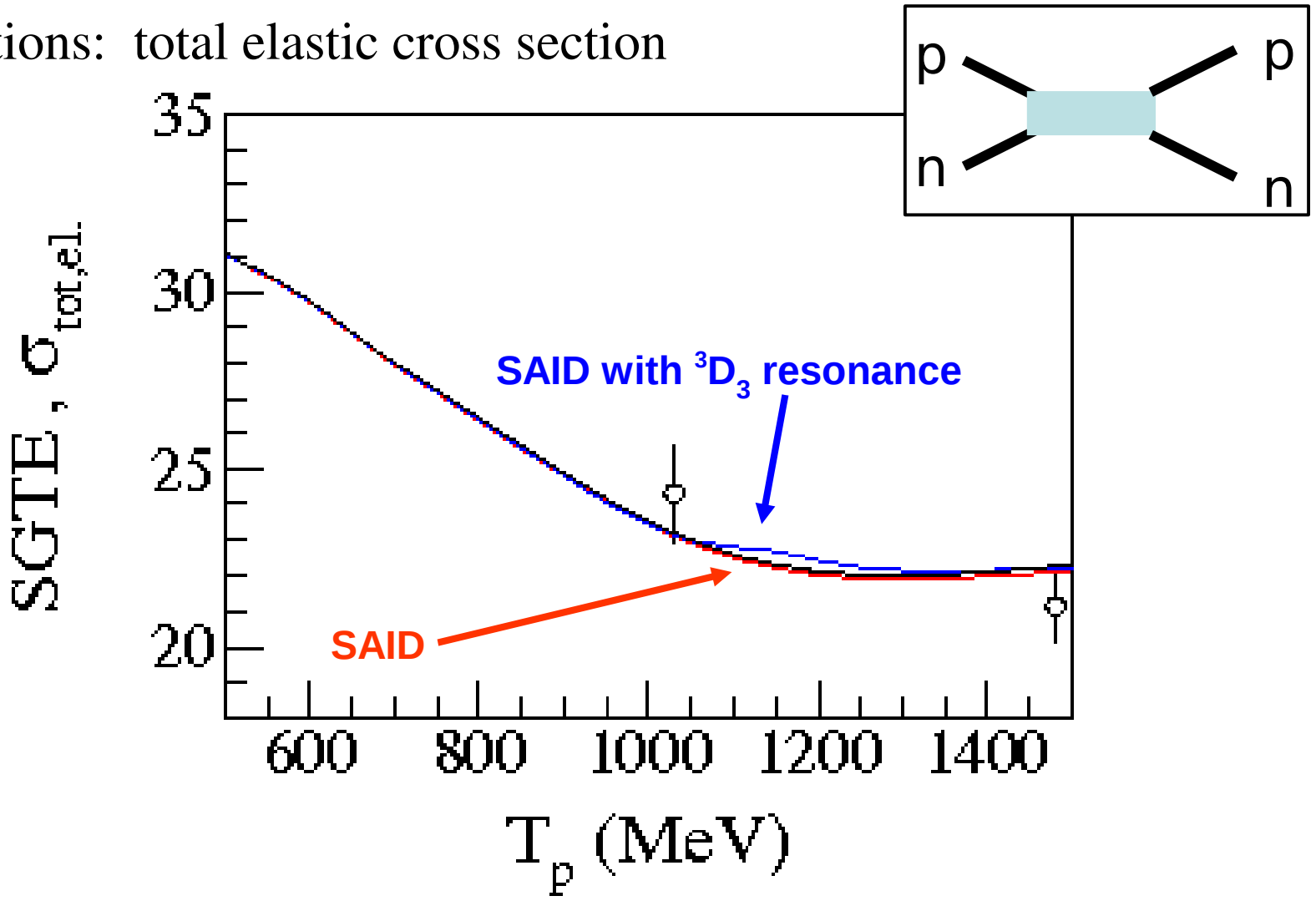
existing data



pn → pn elastic scattering

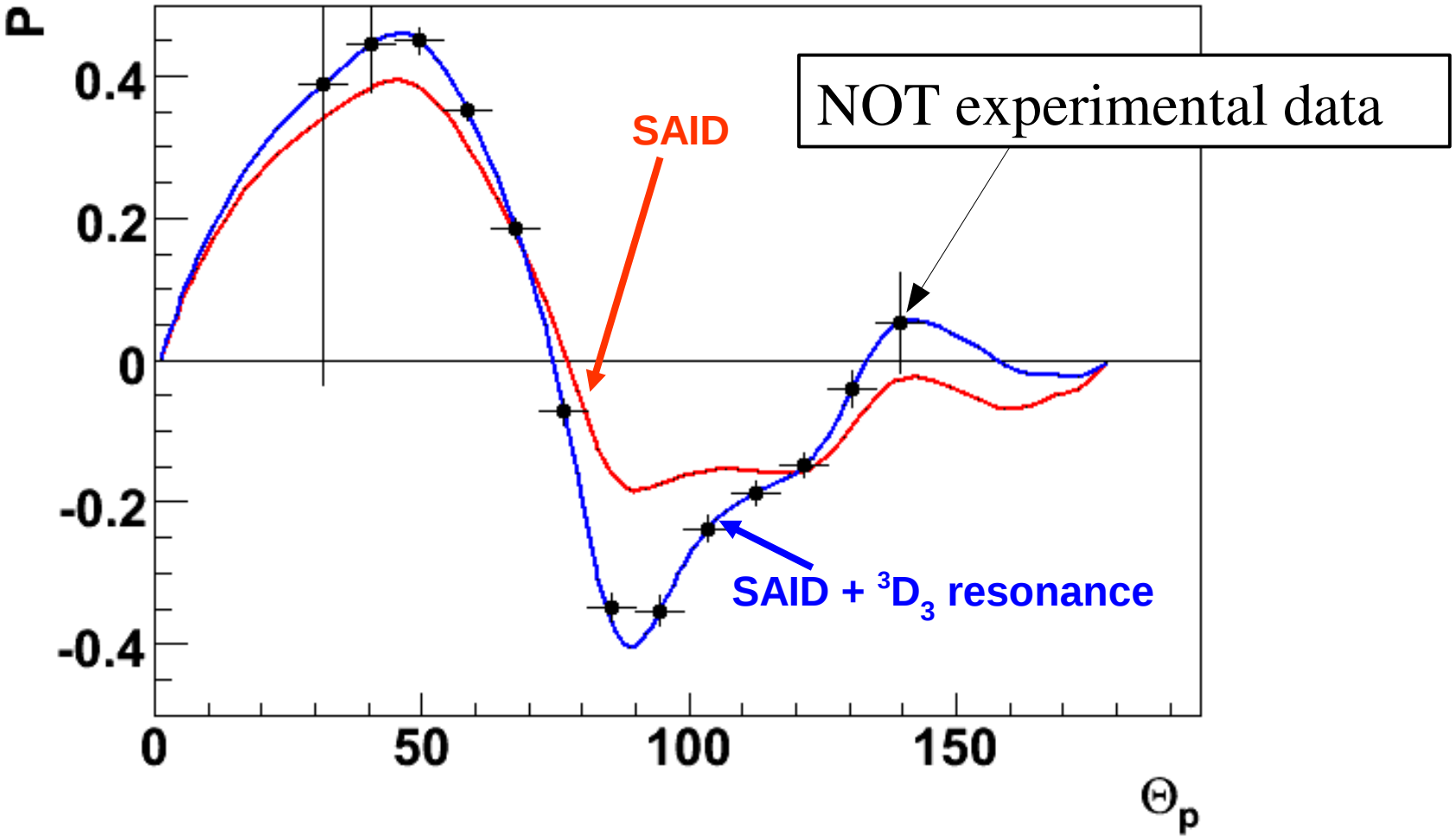
measured in last WASA beamtime (easter)

expectations: total elastic cross section

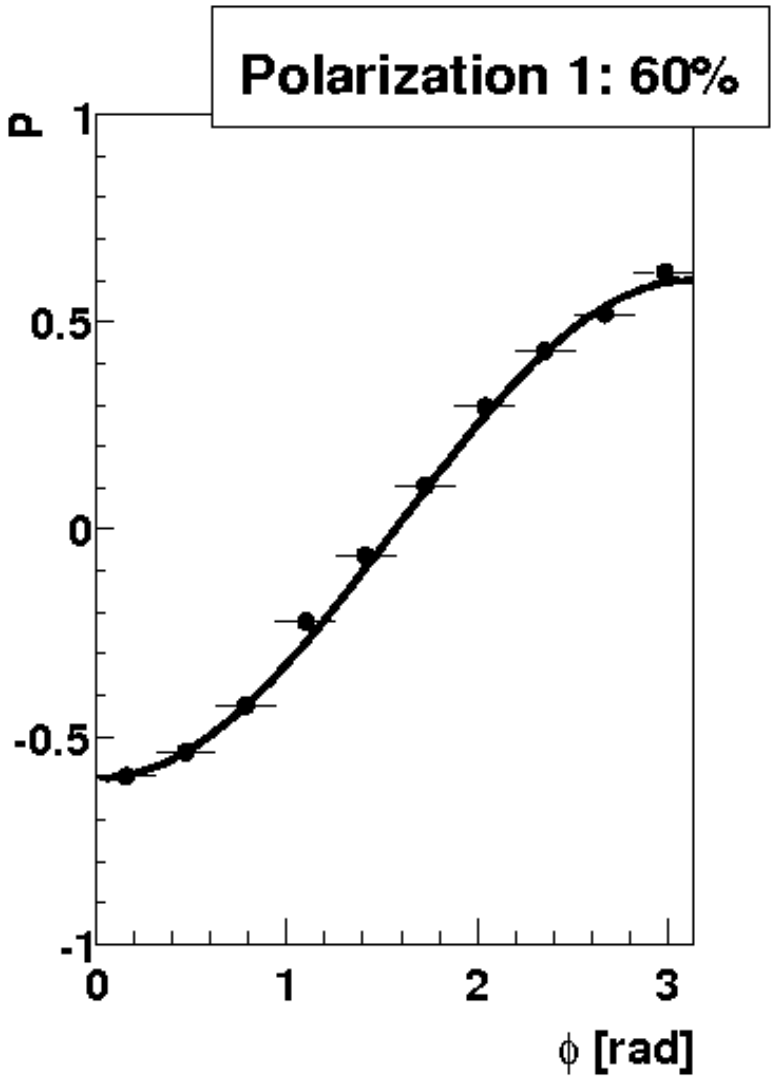


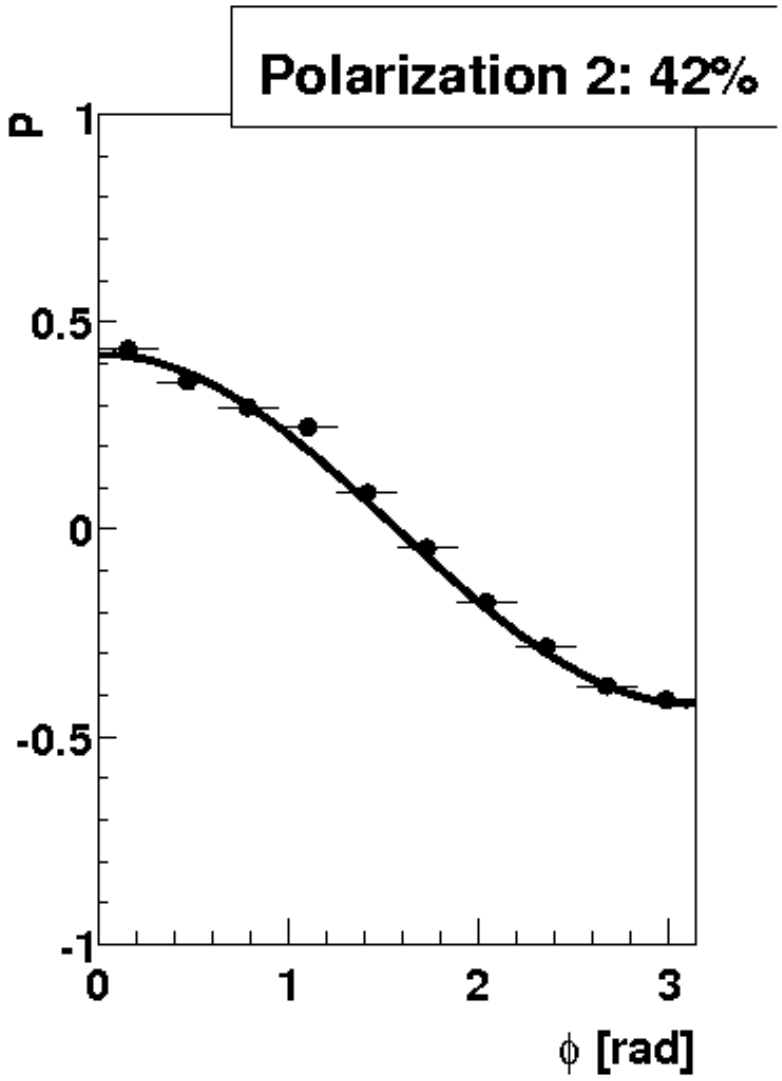
pn → pn Analysing Power

Accuracy expected from one day measurement



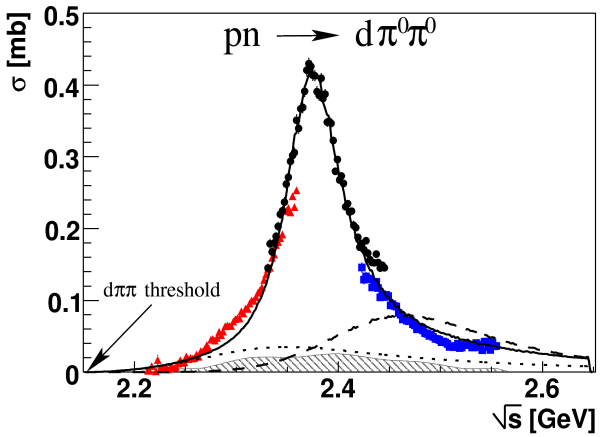
Proton Polarization

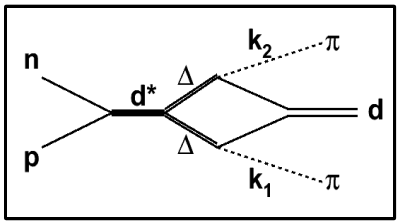




Summary

- Resonance like structure observed
  - $pn \rightarrow d\pi^0\pi^0$, $pn \rightarrow d\pi^+\pi^-$
  - heavier systems:
    - $dd \rightarrow {}^4He\pi^0\pi^0$
    - $pd \rightarrow {}^3He\pi^0\pi^0$
  - hints in $pn \rightarrow pp\pi^0\pi^-$





Γ ≈ 70 MeV

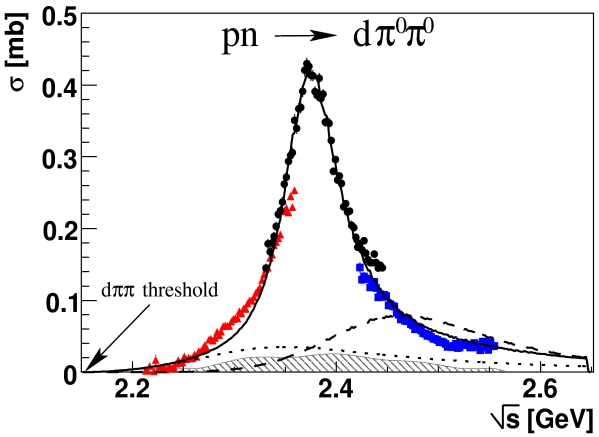
M ≈ 2380 MeV

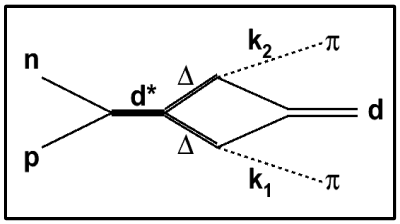
= 2*M$_\Delta$ – 80 MeV

I(J^p) = 0(3$^+$)

Summary

- Resonance like structure observed
  - $pn \rightarrow d\pi^0\pi^0$, $pn \rightarrow d\pi^+\pi^-$
  - heavier systems:
    - $dd \rightarrow {}^4He\pi^0\pi^0$
    - $pd \rightarrow {}^3He\pi^0\pi^0$
  - hints in $pn \rightarrow pp\pi^0\pi^-$
- under investigation: $pn \rightarrow pn\pi^0\pi^0$, $pn \rightarrow pp\pi^-$
- recent WASA beamtime will give access to:
  - $\pi^0\pi^0$-channels with polarized beam in inversed kinematics
  - pn-elastic (analyzing power, angular distributions)





Γ ≈ 70 MeV

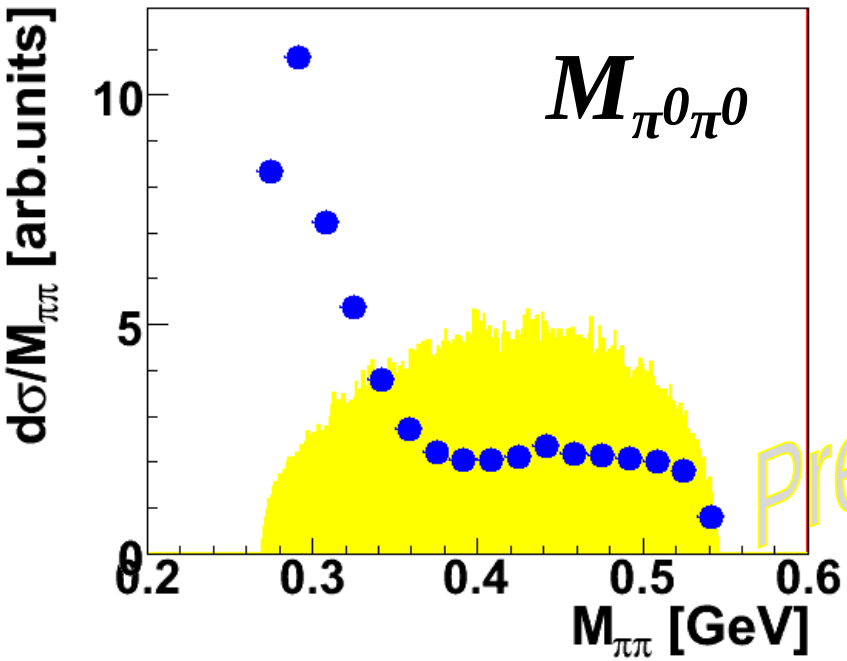
M ≈ 2380 MeV

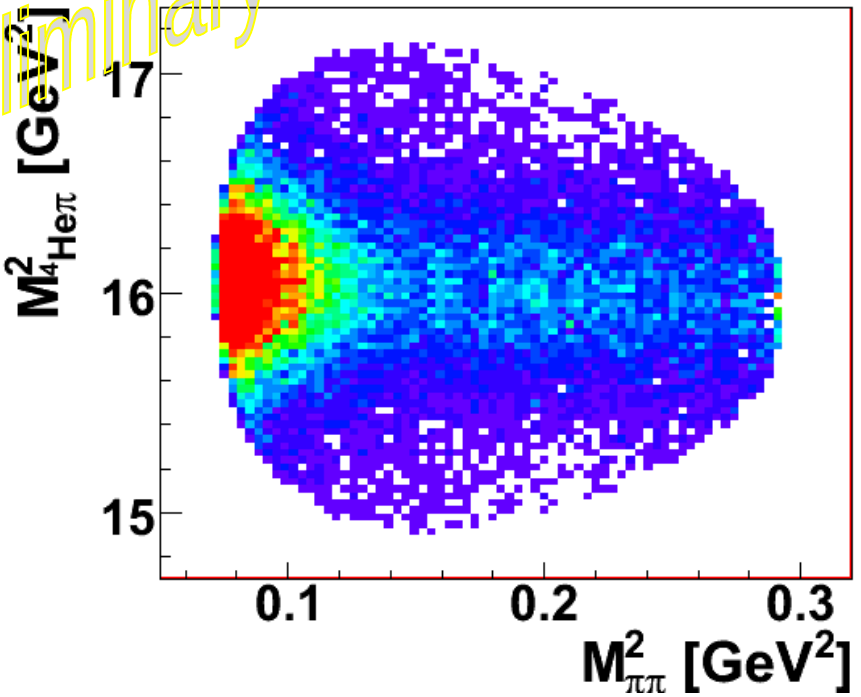
= 2*M$_\Delta$ – 80 MeV

I(J^p) = 0(3$^+$)

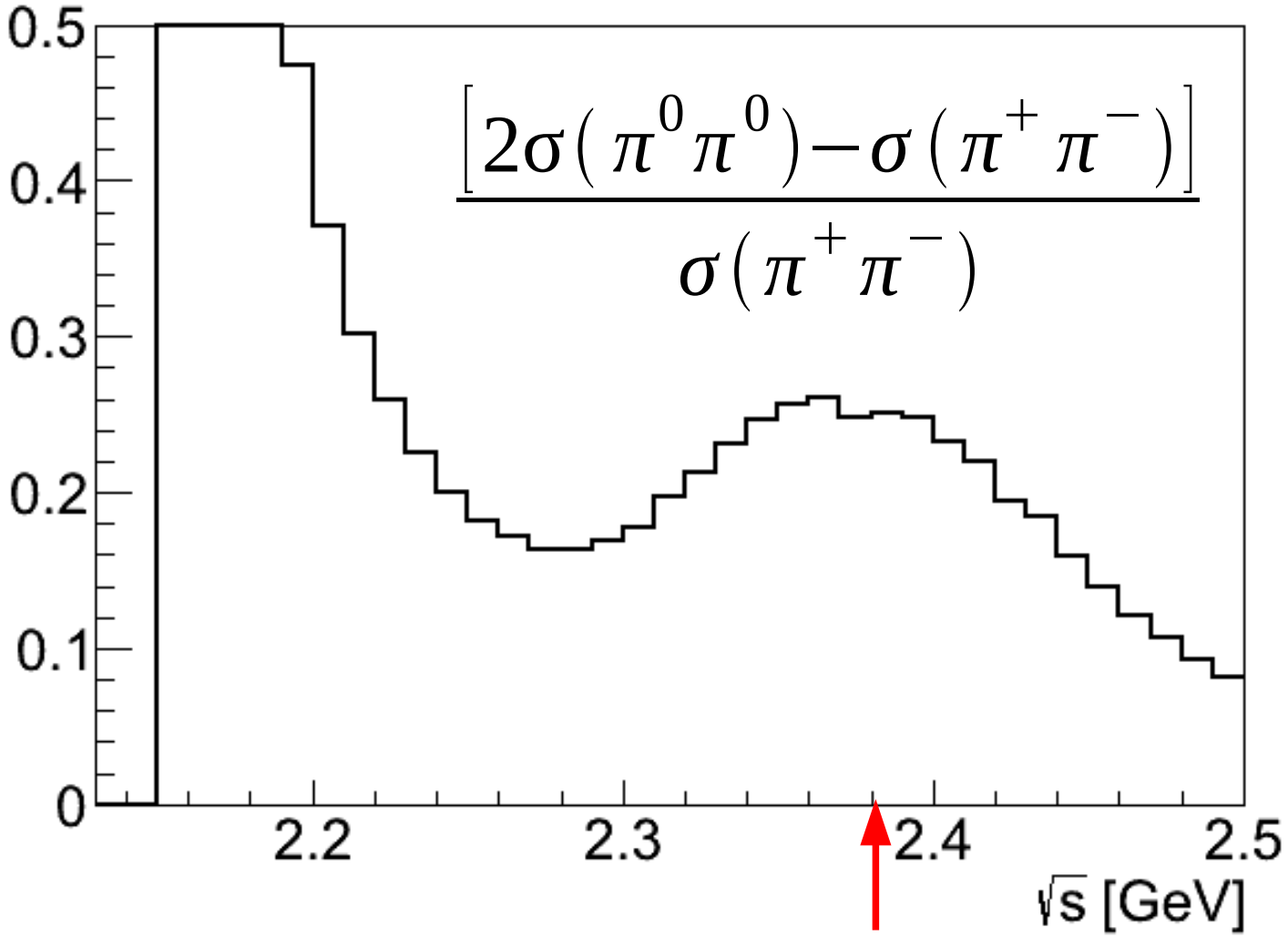
backup

$dd \rightarrow {}^4He\pi^0\pi^0$ $M_{\pi\pi}$ @ 1.117 GeV



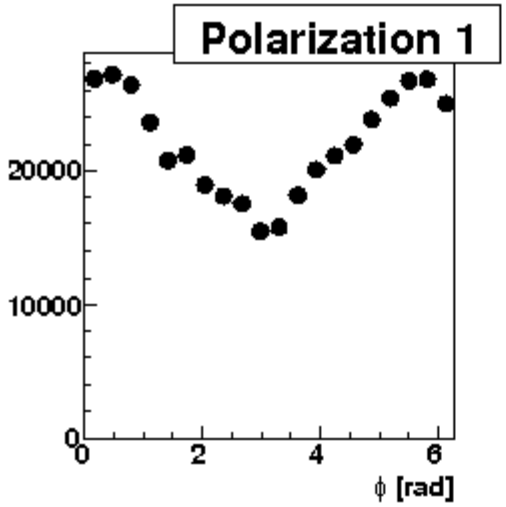


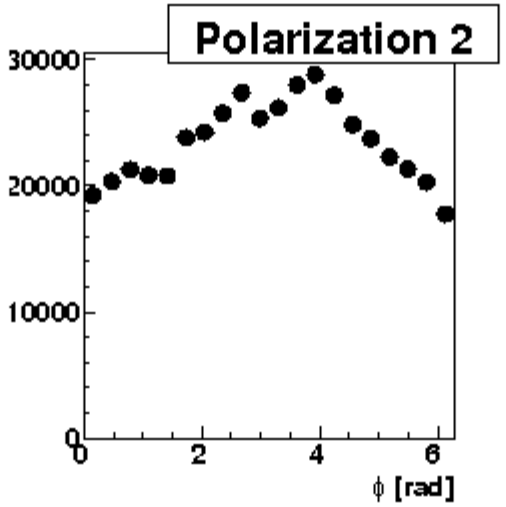
Isospin Violation

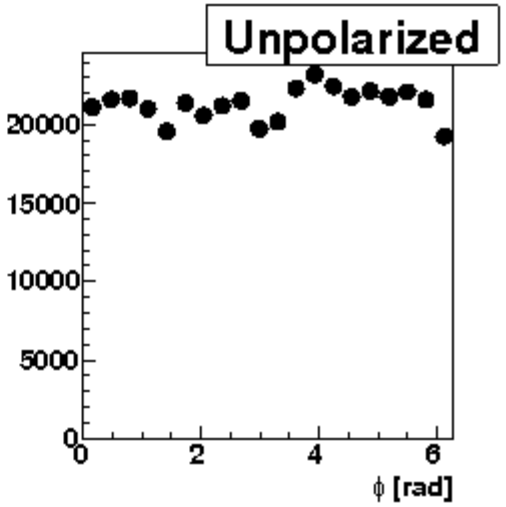


Proton Polarization - ϕ Distribution

uncorrected







corrected