Analysis of np->d $\pi^+\pi^-$ reactions at 1.25 GeV with HADES spectrometer

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List of content

- Motivation
- Data Analysis
- WASA di-baryon resonance model
- Summary and Outlook

Why analyzing $pn \rightarrow d\pi^+\pi^-$?

- Specific interest of systematic study of 2π channels in pp and pn:
  $N^*(1440) \rightarrow \Delta\pi$, $N^*(1440) \rightarrow N\ (\pi\pi)$s-wave, $N^*(1440) \rightarrow \rho N$, $\Delta\Delta$ excitation

- Indication for a I=0 dibaryon resonance in the $pn \rightarrow d\pi^0\pi^0$ reaction (ABC effect)
  Signal expected to be smaller in the $pn \rightarrow d\pi^+\pi^-$ channel (I=0 and I=1) ,
  but it is important to check the description of all isospin channels

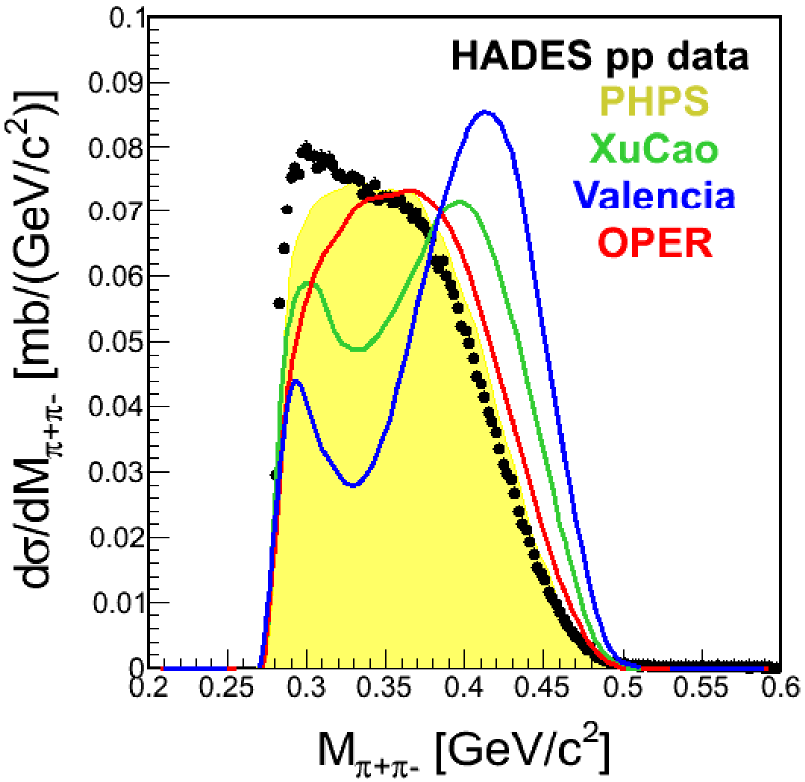
- comparison $pn \rightarrow NN\pi\pi$, $pp \rightarrow NN\pi\pi$, $pd \rightarrow NN\pi\pi$ extensively studied with WASA-at-Cosy $\rightarrow$ comparison of the data.

- In connection to $pn \rightarrow Xe^+e^-$ HADES data, constraints on the contribution of $pn \rightarrow de^+e^-$ can be obtained from $pn \rightarrow d\pi^+\pi^-$

Other double-π results from HADES – E_k=1.25GeV

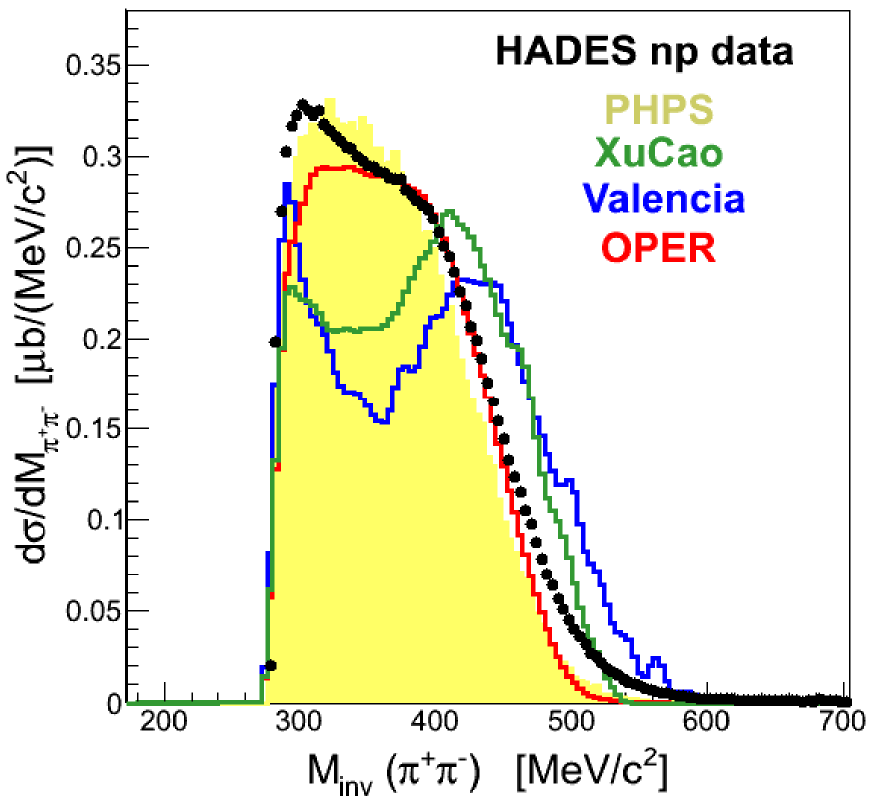
$pp \rightarrow pp\pi^+\pi^-$

M. Gumberidze (IPN Orsay)



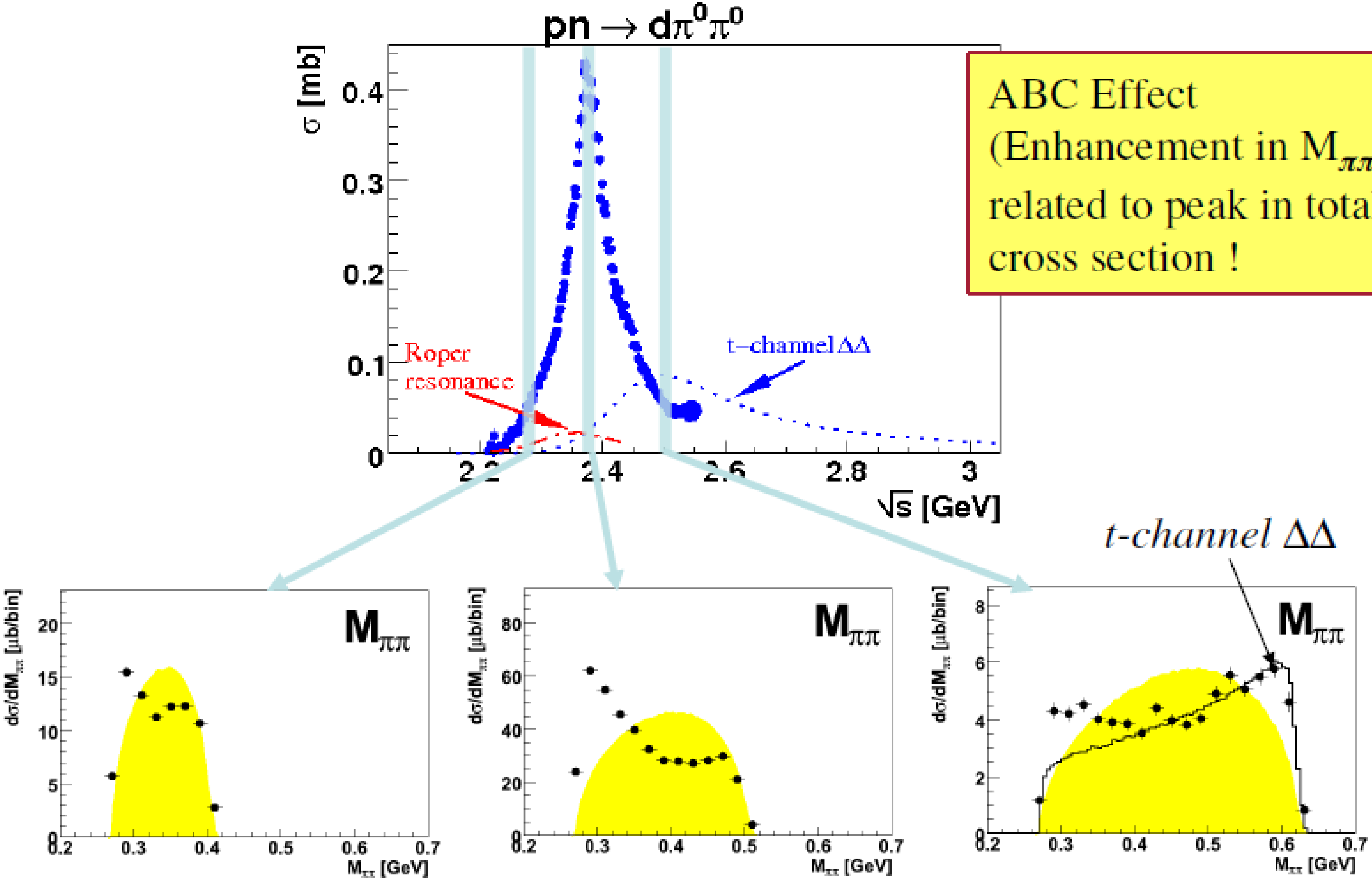
$np \rightarrow np\pi^+\pi^-$

A. Kurilkin (Dubna)



Data shows sensitivity to different models, ongoing comparisons.

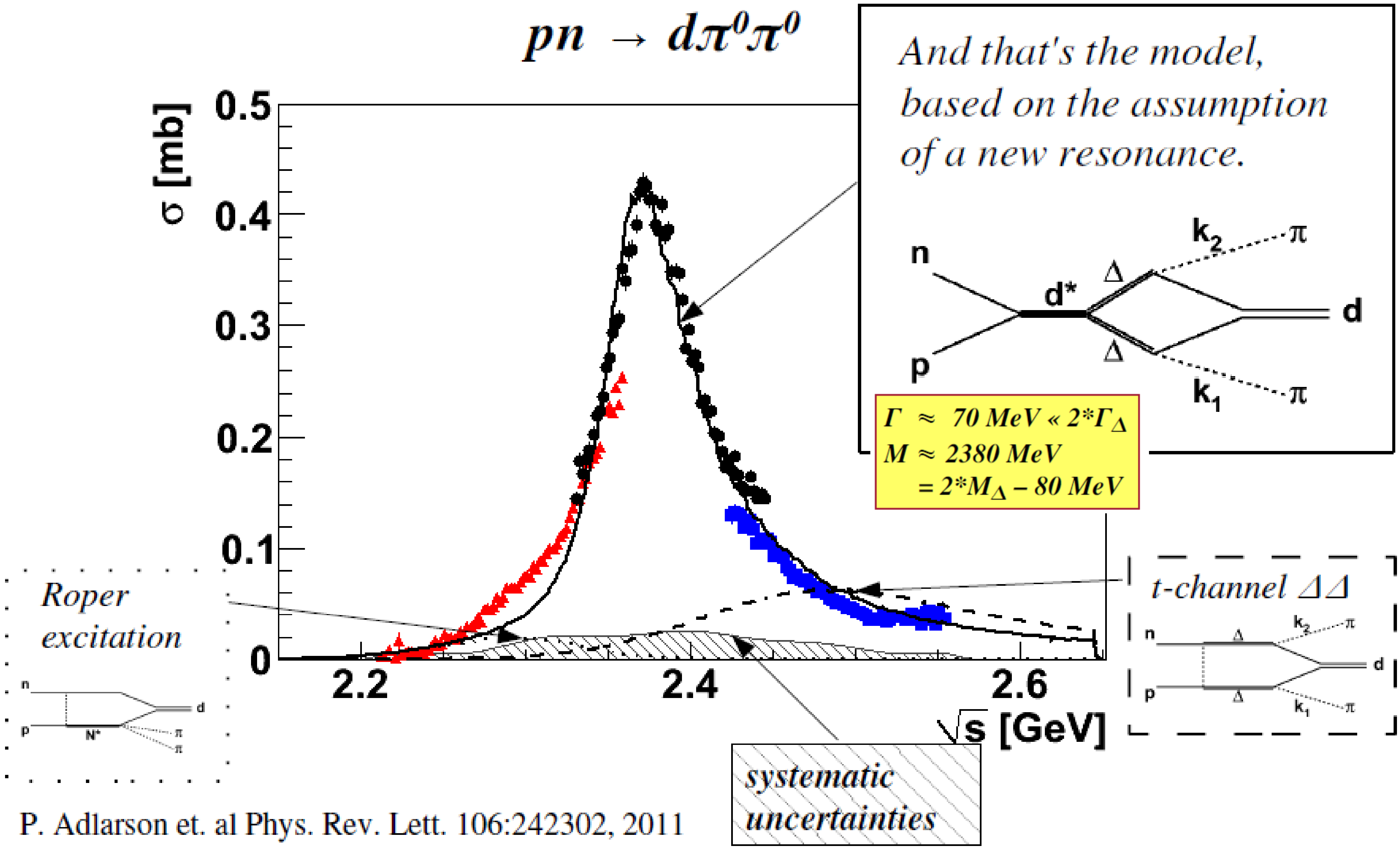
$M_{\pi\pi}$ for different beam energies



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

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

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



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

The HADES spectometer

• **Detector geometry**
full azimuthal range covered, 6 sectors
polar angle: $16^{o}<\theta<84^{o}$

•**Tracking**
Superconducting coils, toroidal field
24 Mini Drift Chambers

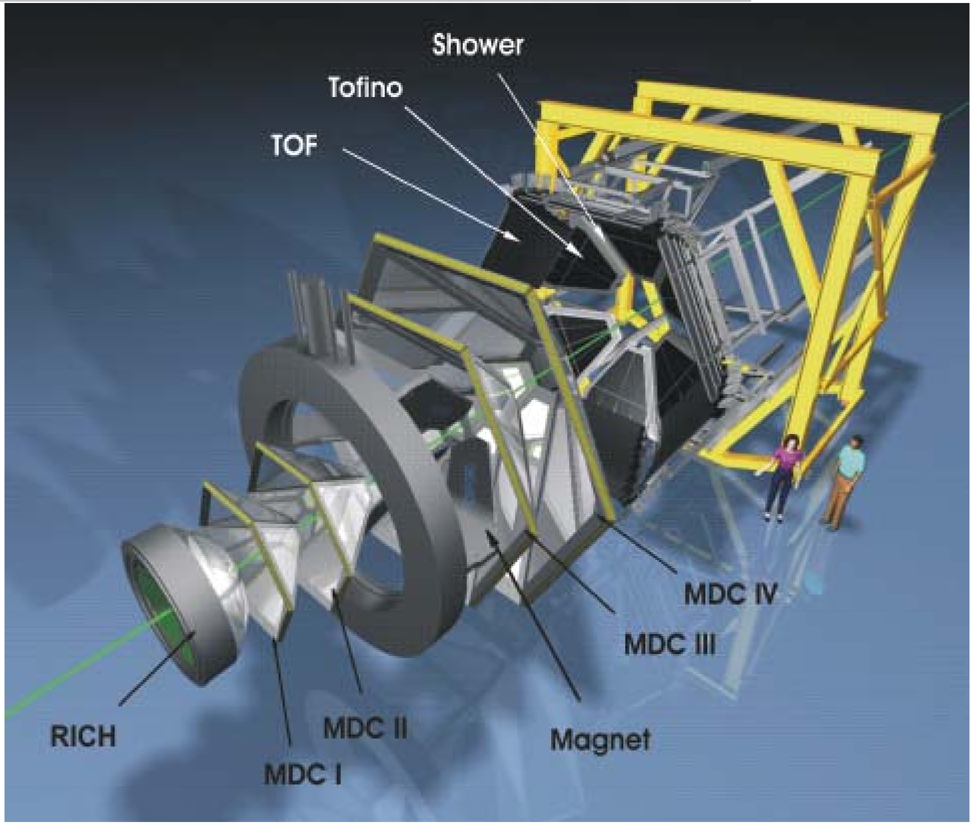
•**Particle identification (e, p, K, p)**
RICH, MDC, TOF, TOFINO, Shower (RPC)

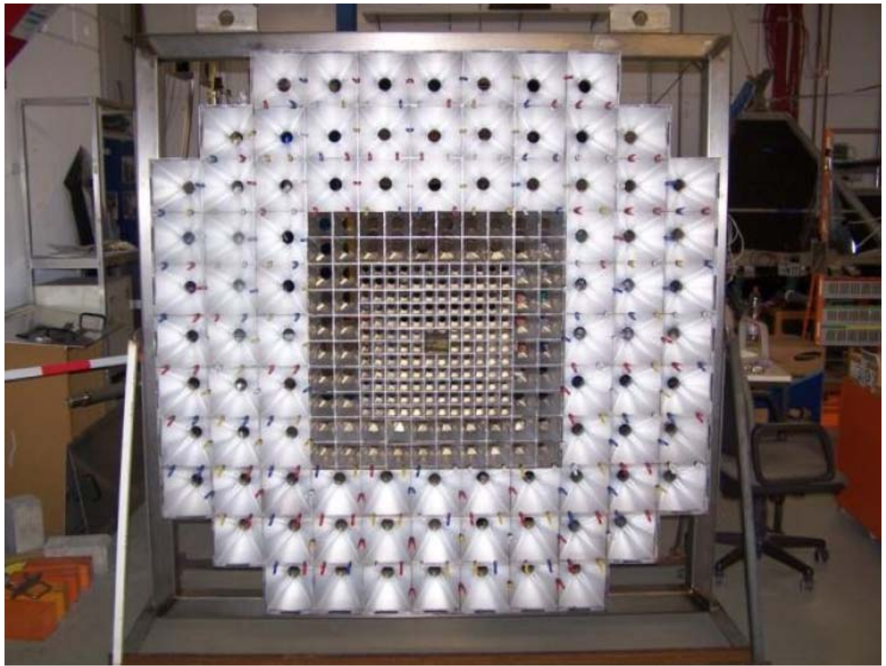
•**Resolutions**
$\Delta M\omega/M\omega \sim 2.1\%$ at ω peak
$\Delta p/p \sim$ 2-3% for proton and π

• **Forward Wall:**
Plastic scintillators covering θ angles up to 7^{o}
Detector dedicated to tag proton spectator

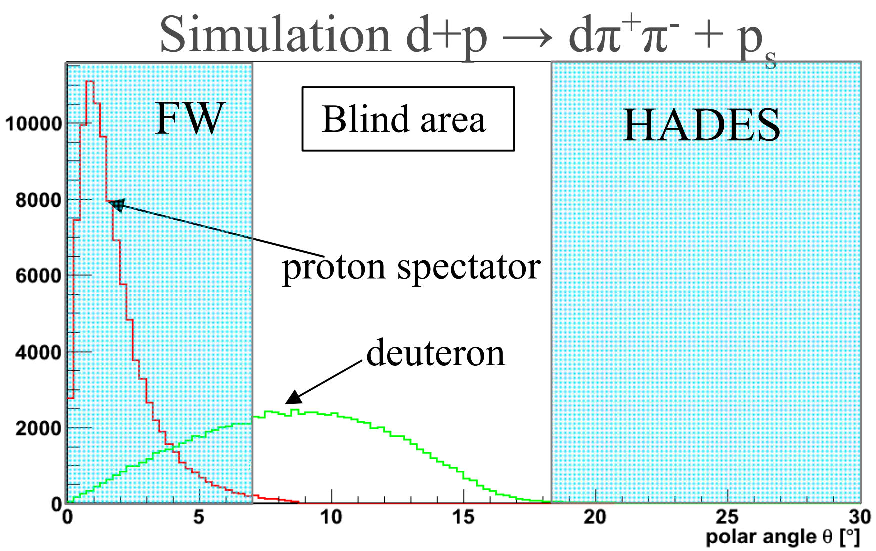
• **Cells in FW:**
140 small 4x4cm → $(0^{o}< \theta <2^{o})$
64 middle 8x8cm → $(2^{o}< \theta <3.3^{o})$
84 large 16x16cm → $(3.3^{o}< \theta <7.2^{o})$

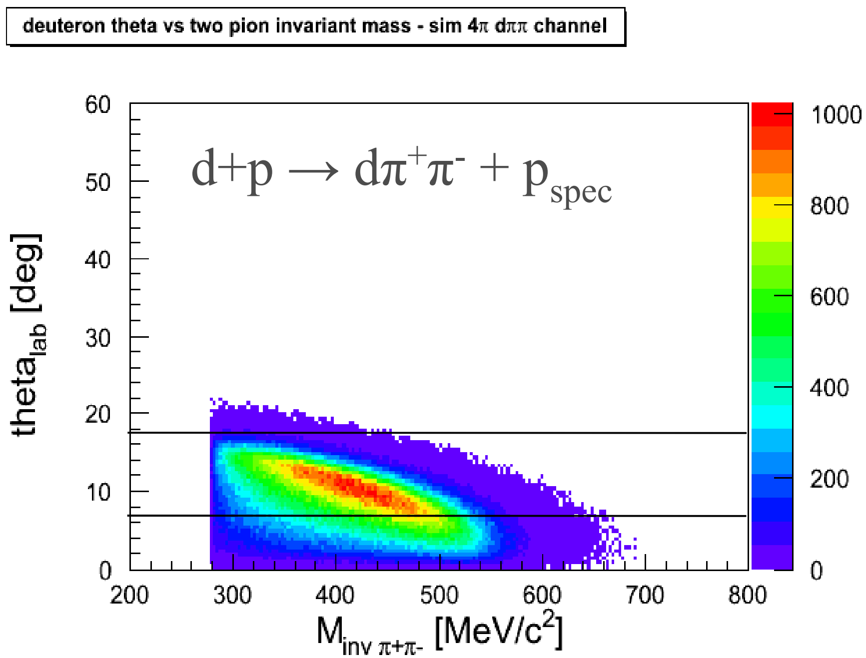
Designed for di-electron spectroscopy,
also suited for the charged hadron detection

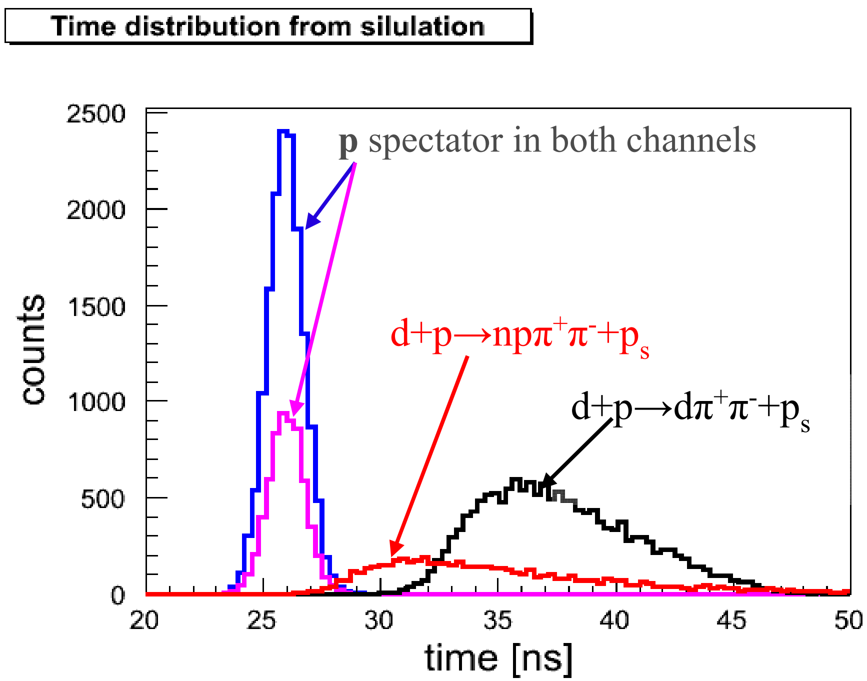


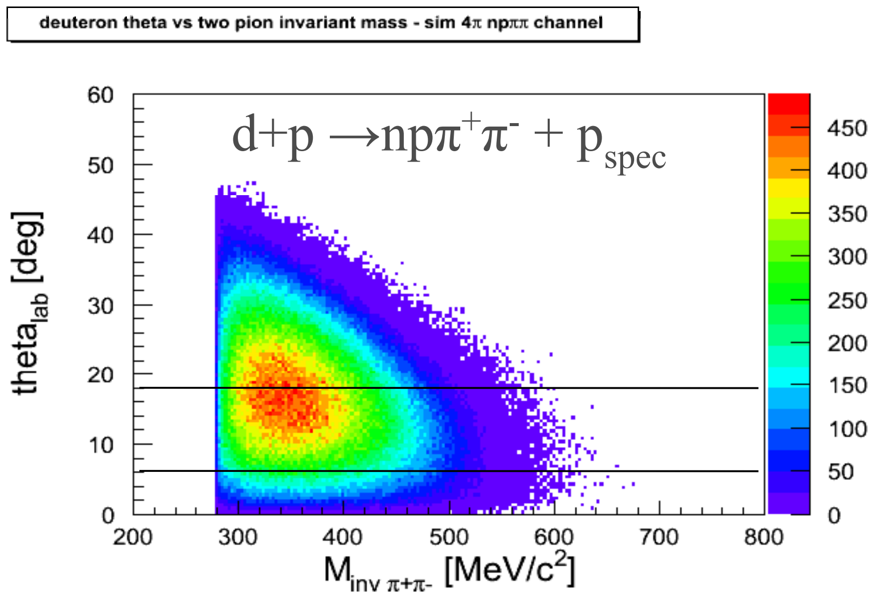


Kinematics and phase space simulation









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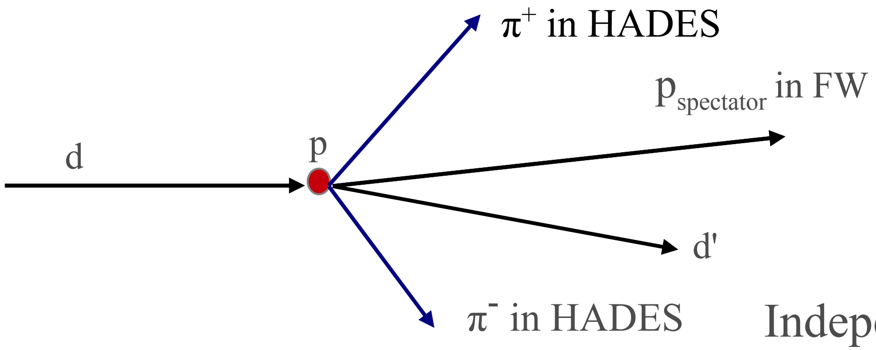
Kinematics - co-planarity

Signal: $d+p \longrightarrow d\pi^{+}\pi^{-} + p_{spec}$



$n = p_{pspect} \times p_d$

Independent on FW momentum. Only depends on directions.

Coplanarity condition:

Opening angle ($p_{beam}-p_{\pi\pi-}$,n) = 90 deg

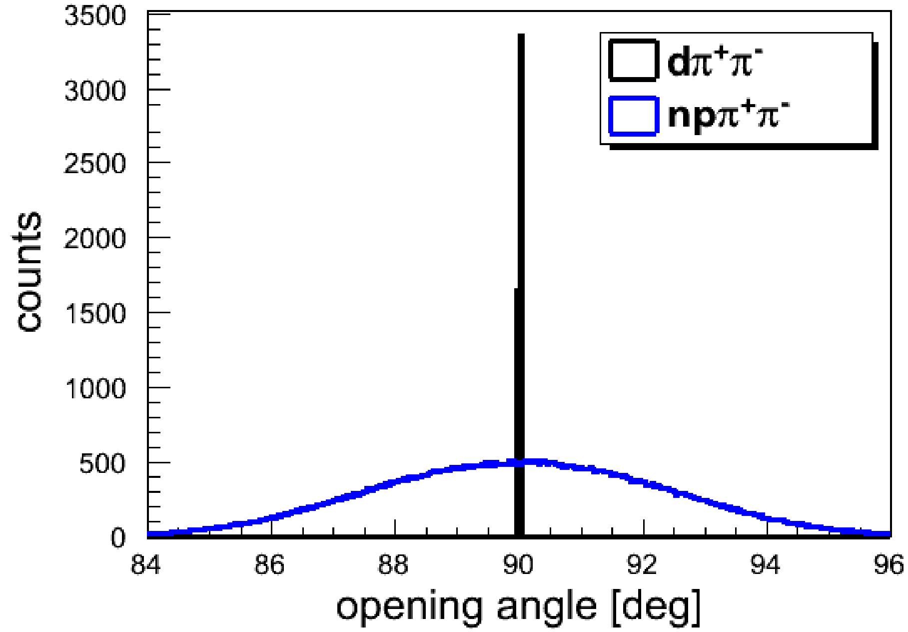
Background: $d+p \longrightarrow np\pi^{+}\pi^{-} + p_{spec}$

Simulations in quasi free kinematics:

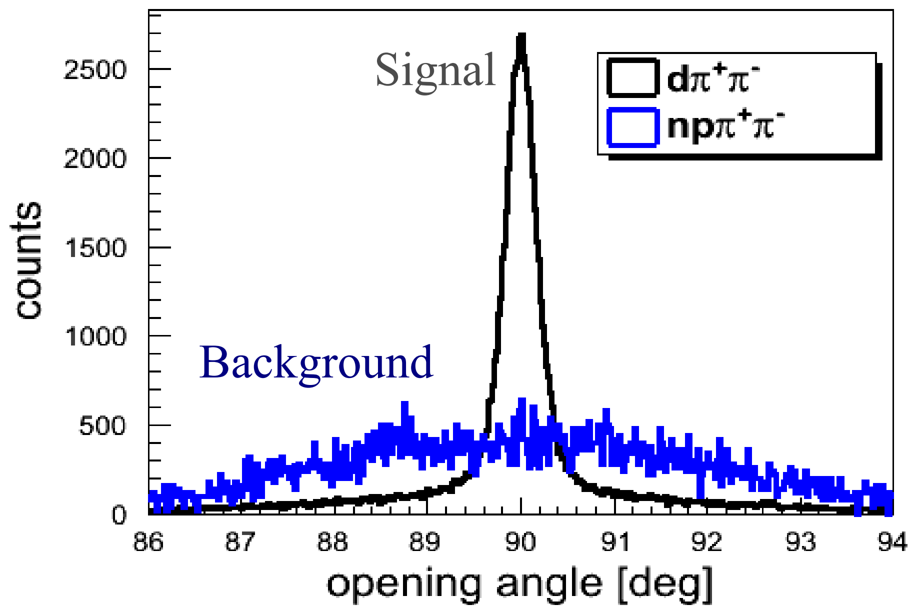
$'n'+p \longrightarrow d\pi^{+}\pi^{-}$ - phase space

$'n'+p \longrightarrow np\pi^{+}\pi^{-}$ - phase space

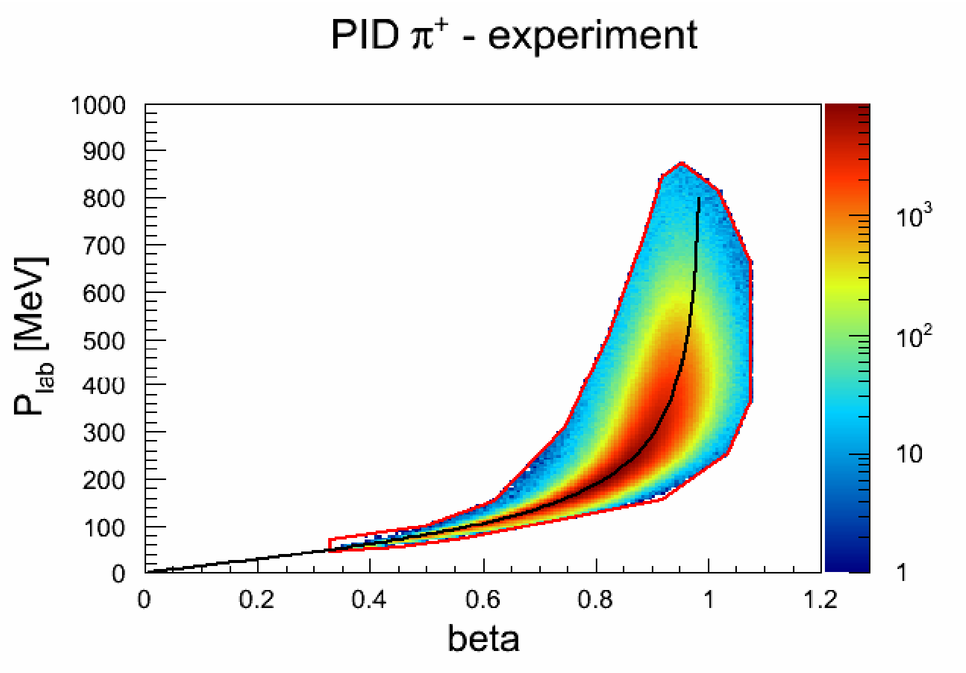
4π - ideal

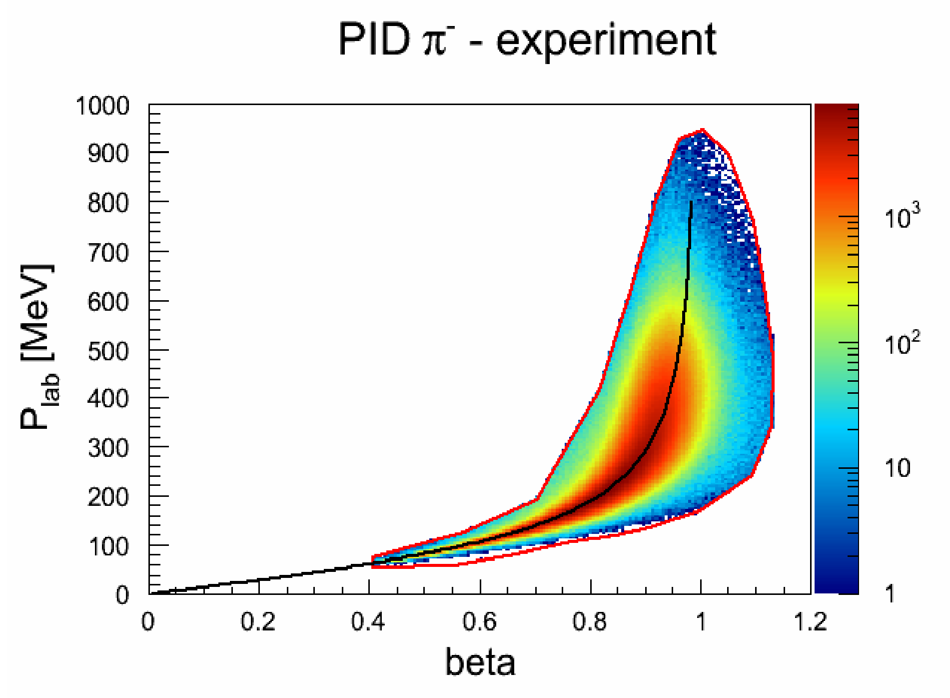


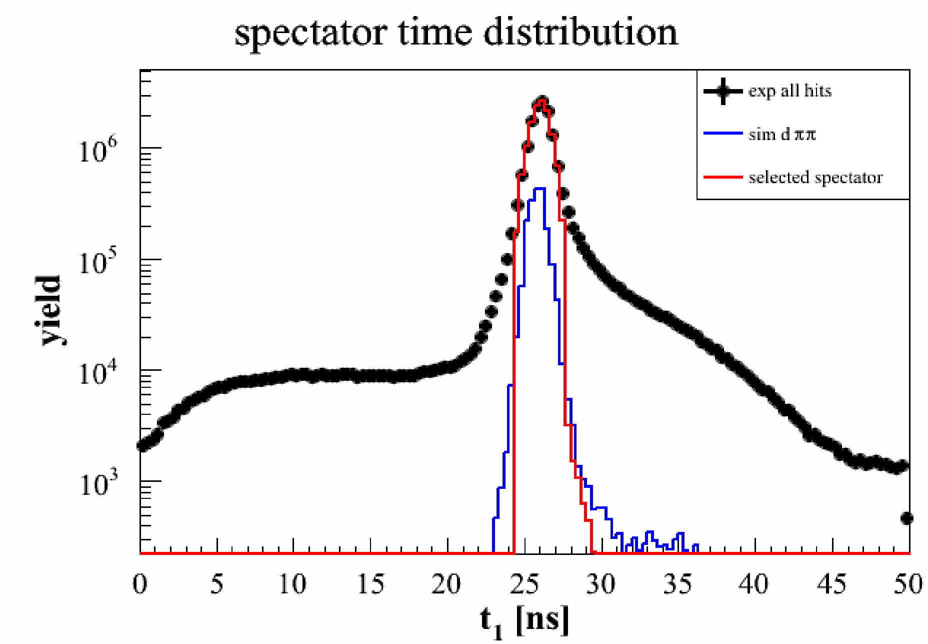
In acceptance

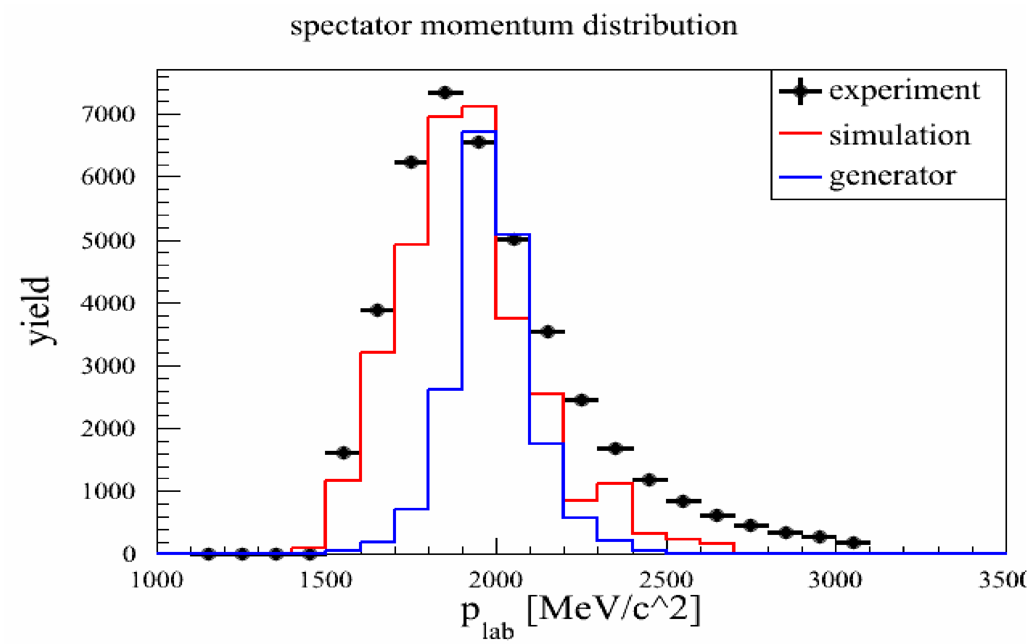


PID in HADES and Forward Wall

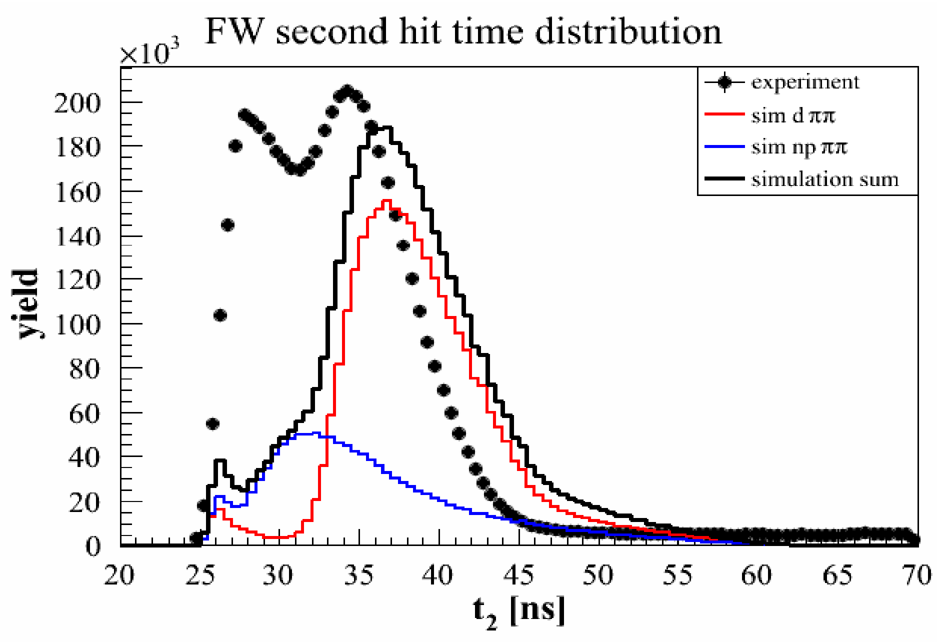


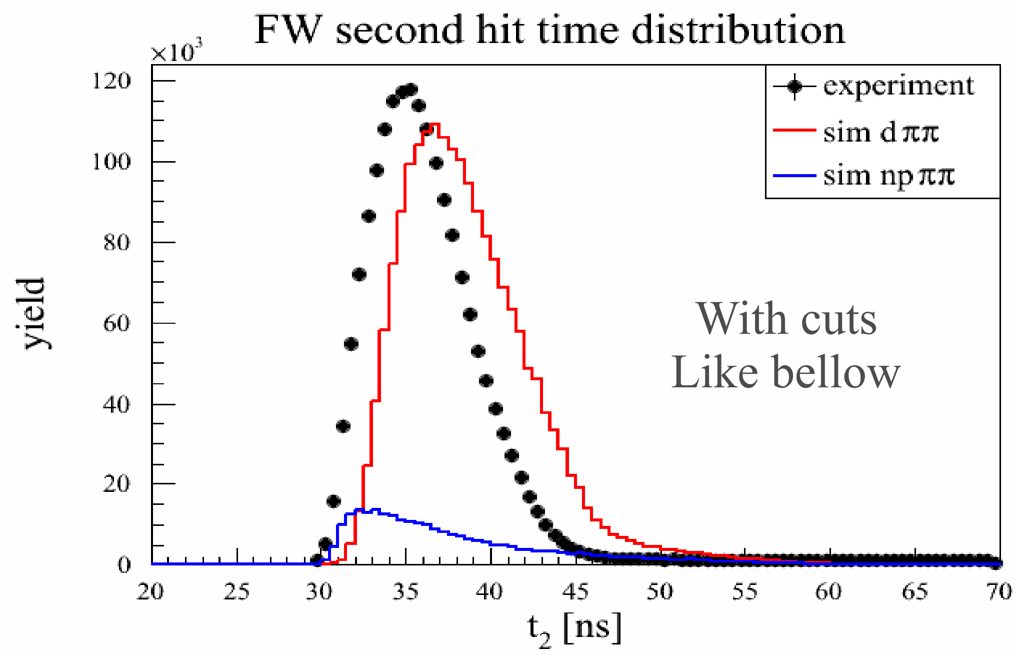


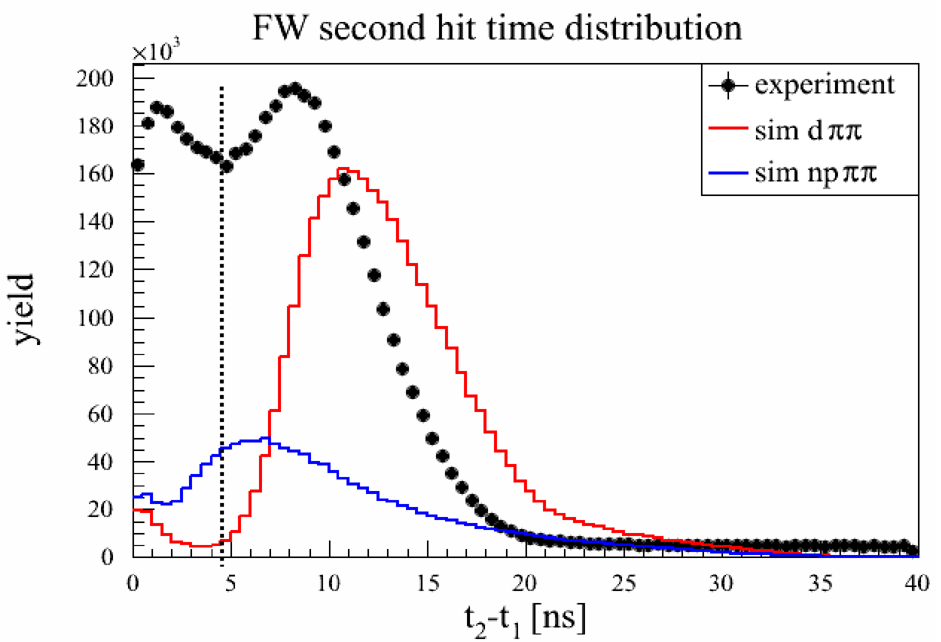


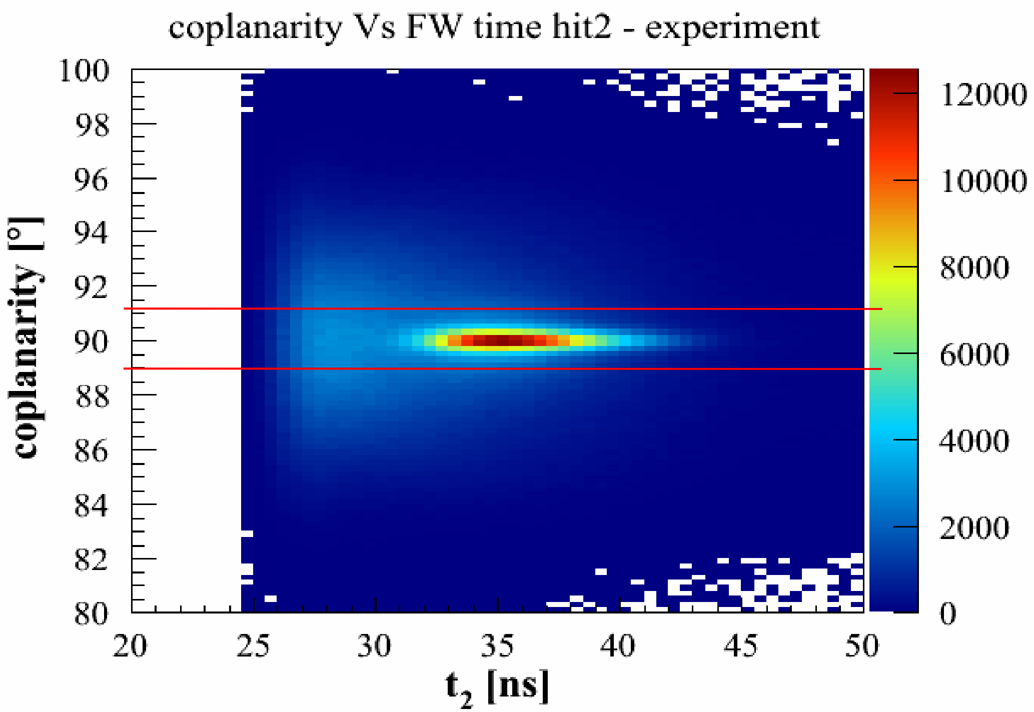


Deuteron in FWall time distribution

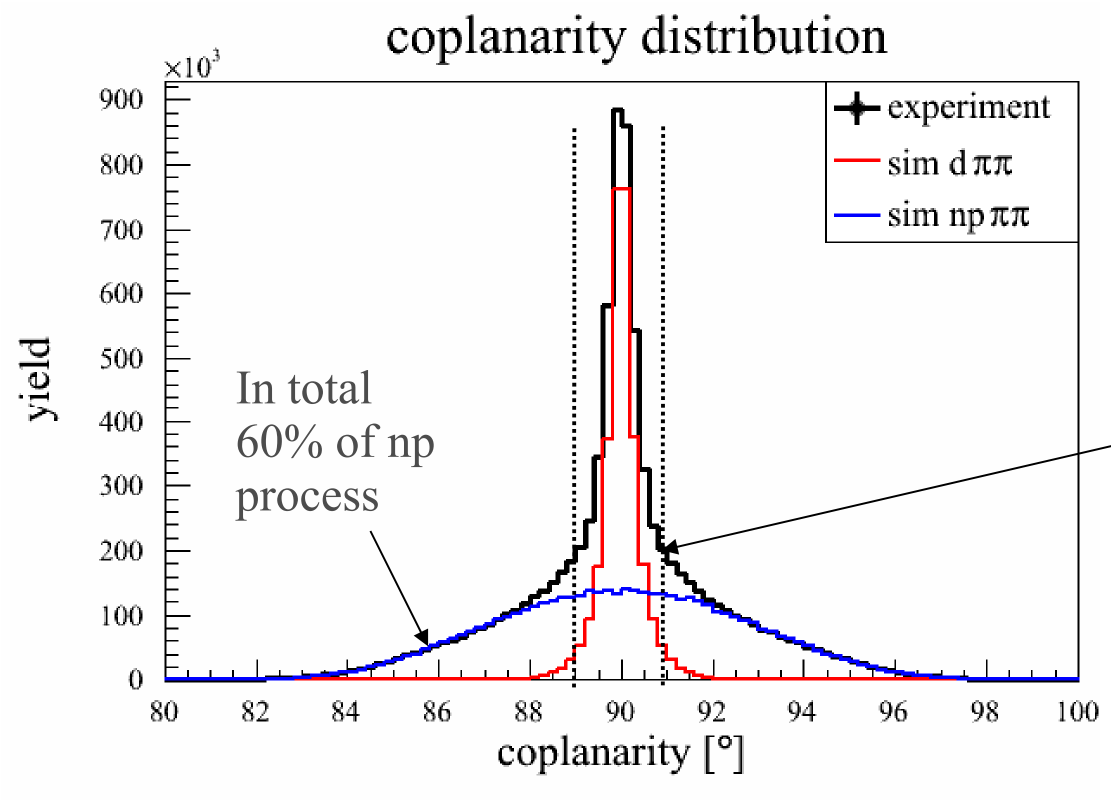








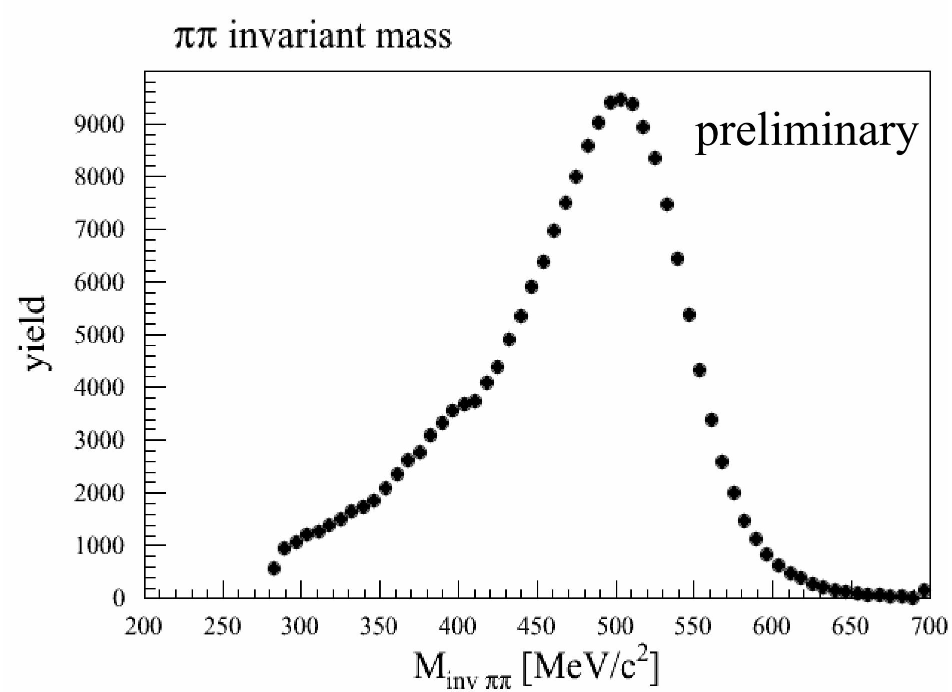
Coplanarity - Signal and Background estimation $d\pi^+\pi^-$ / $np\pi^+\pi^-$



Efficiency corrected data

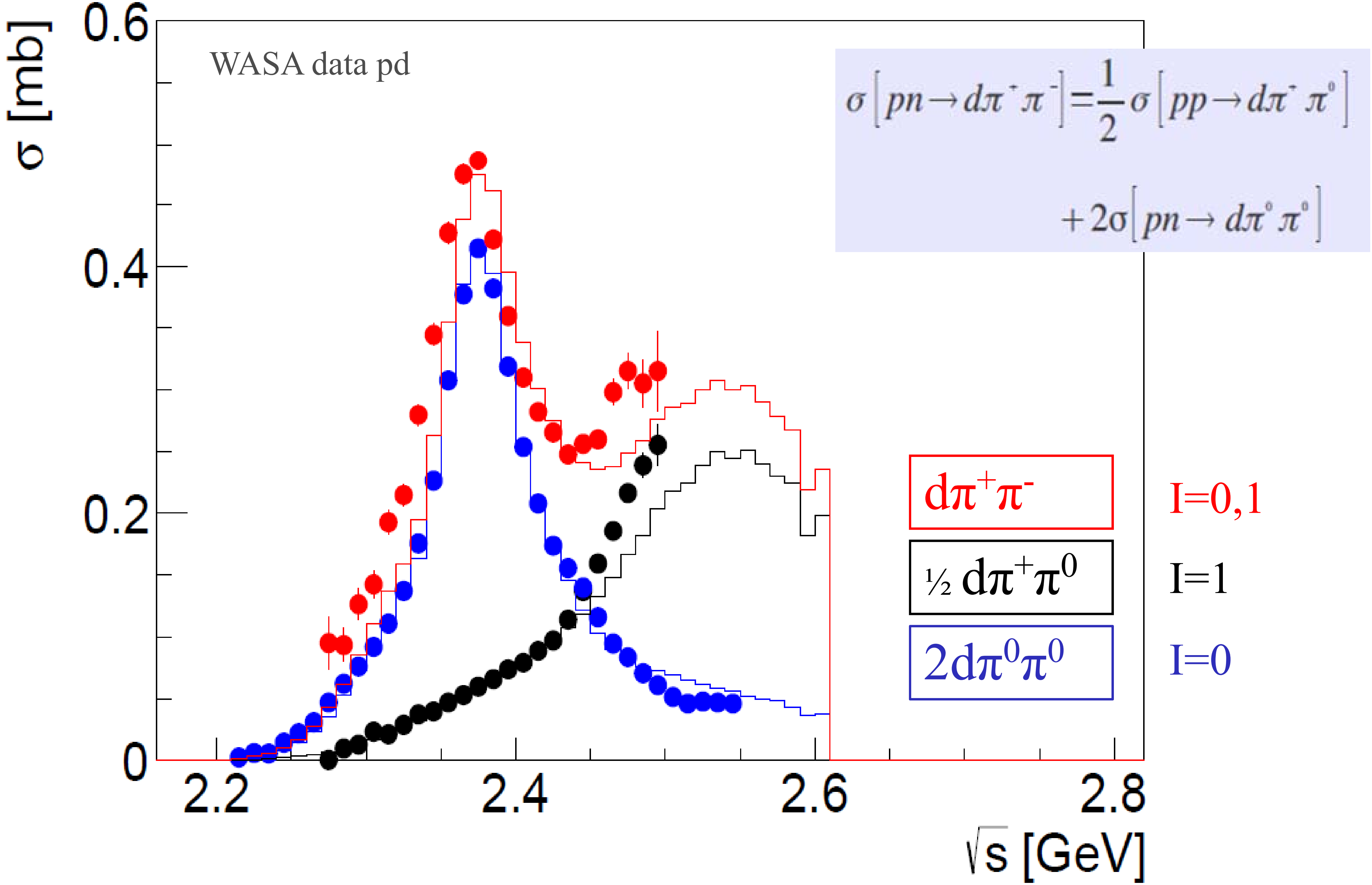
In coplanarity window, np process is 30% of the signal

with coplanarity condition



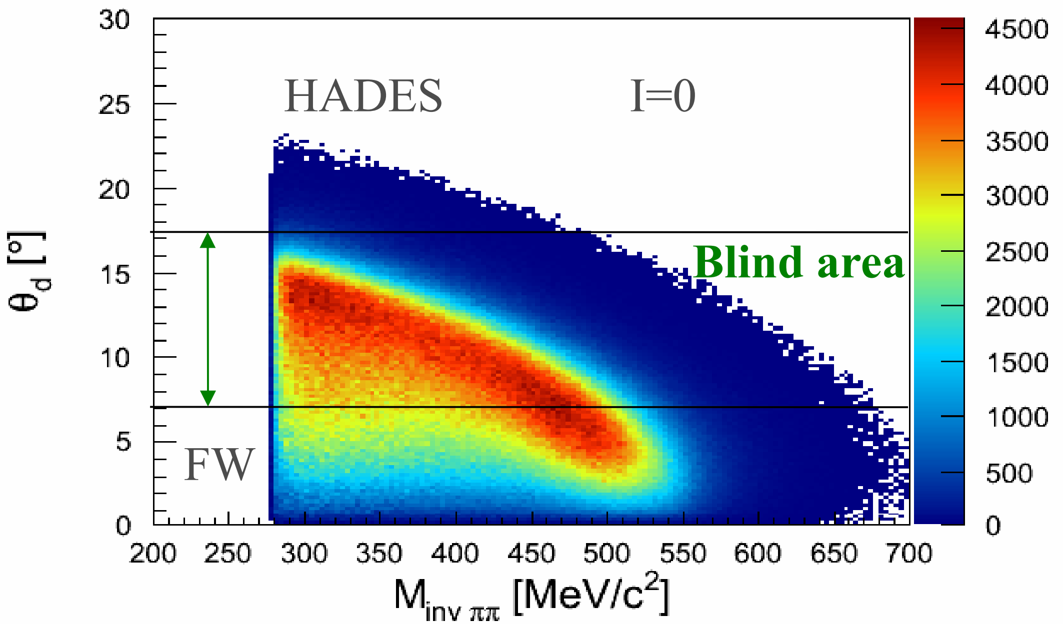
Still background subtraction needed

Model of the di-baryon resonance - M. Bashkanov (WASA-at-COSY coll.)

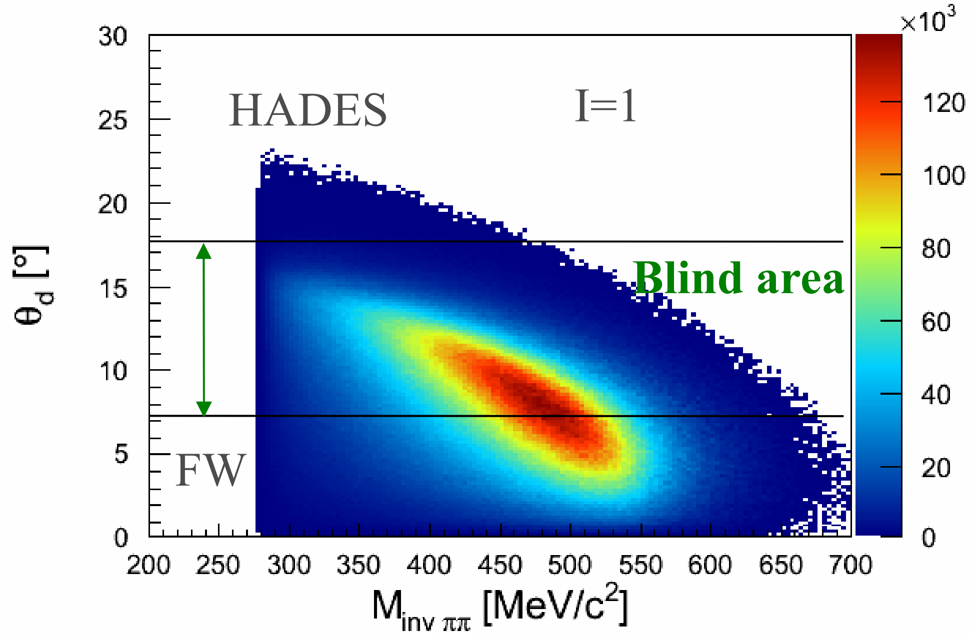


Di-baryon resonance d* – model from Mikhail Bashkanov (WASA)

pion invariant mass vs deuteron theta (I=0 channel in 4π)

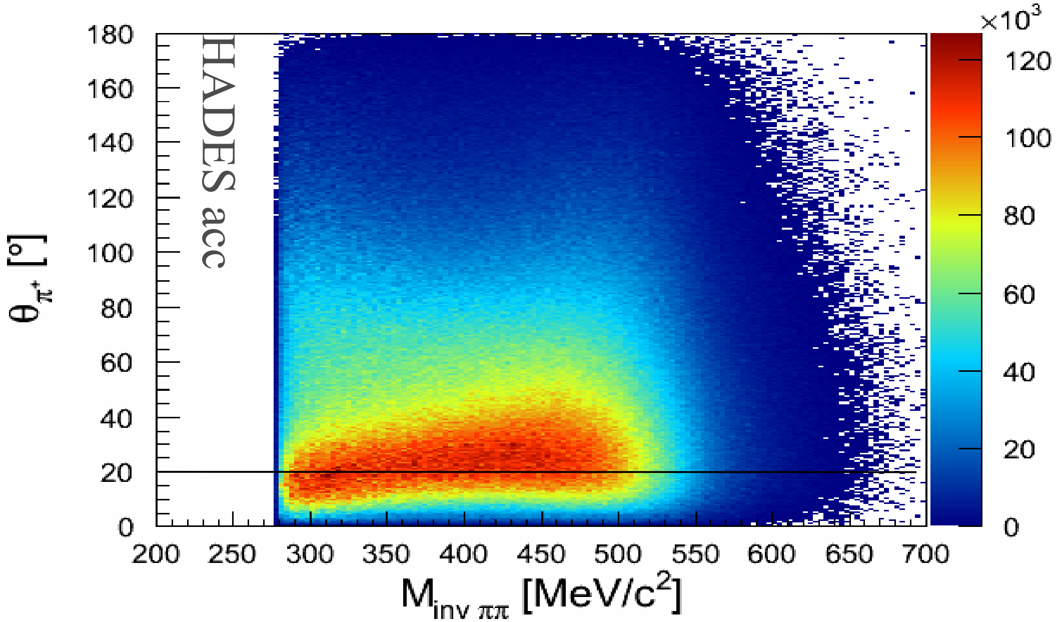


pion invariant mass vs deuteron theta (I=1 channel in 4π)

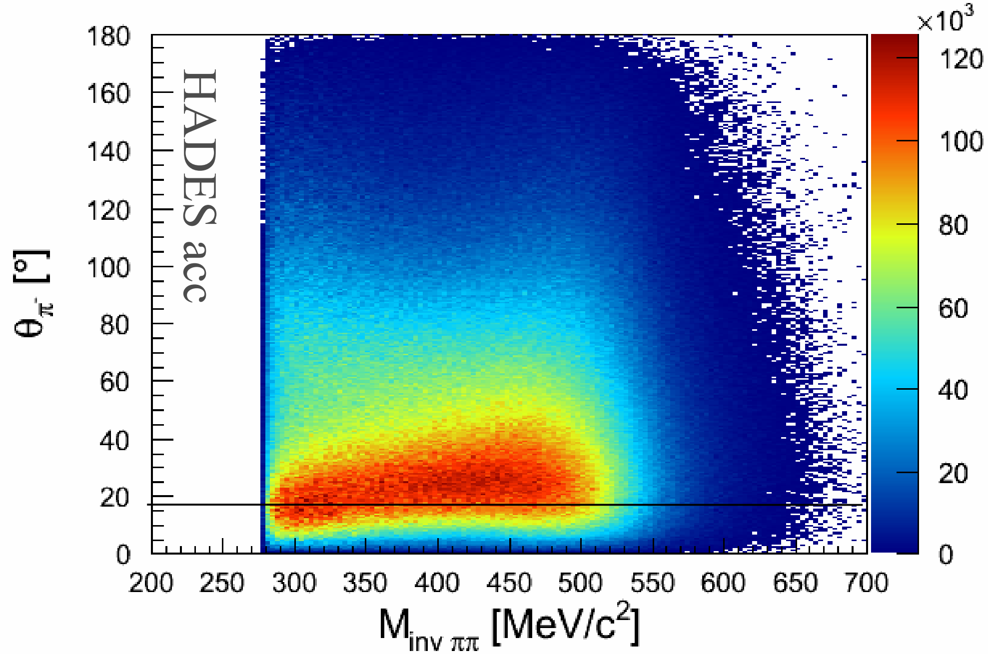


acc ~0.55%

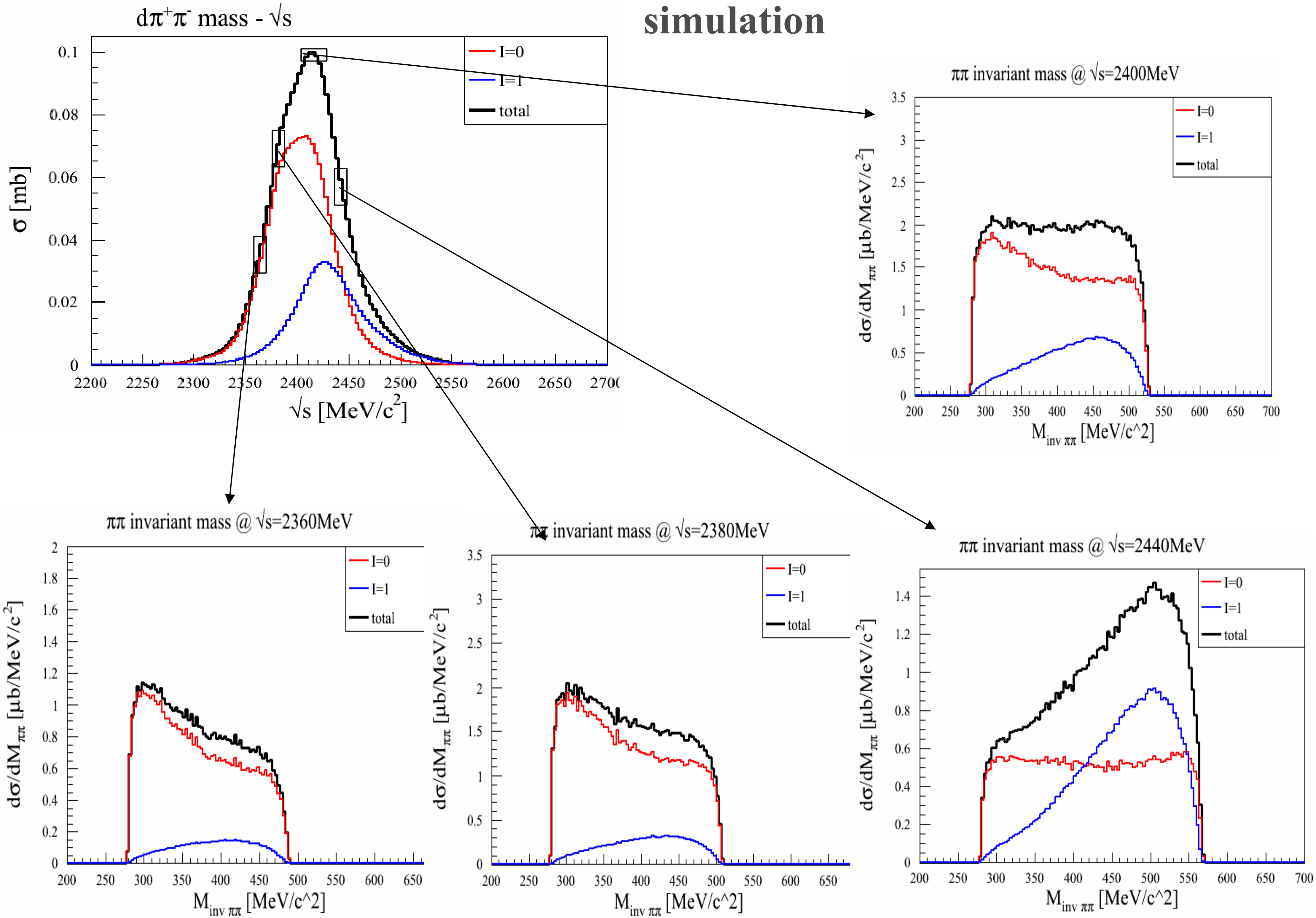
pion invariant mass vs pion theta - 4π



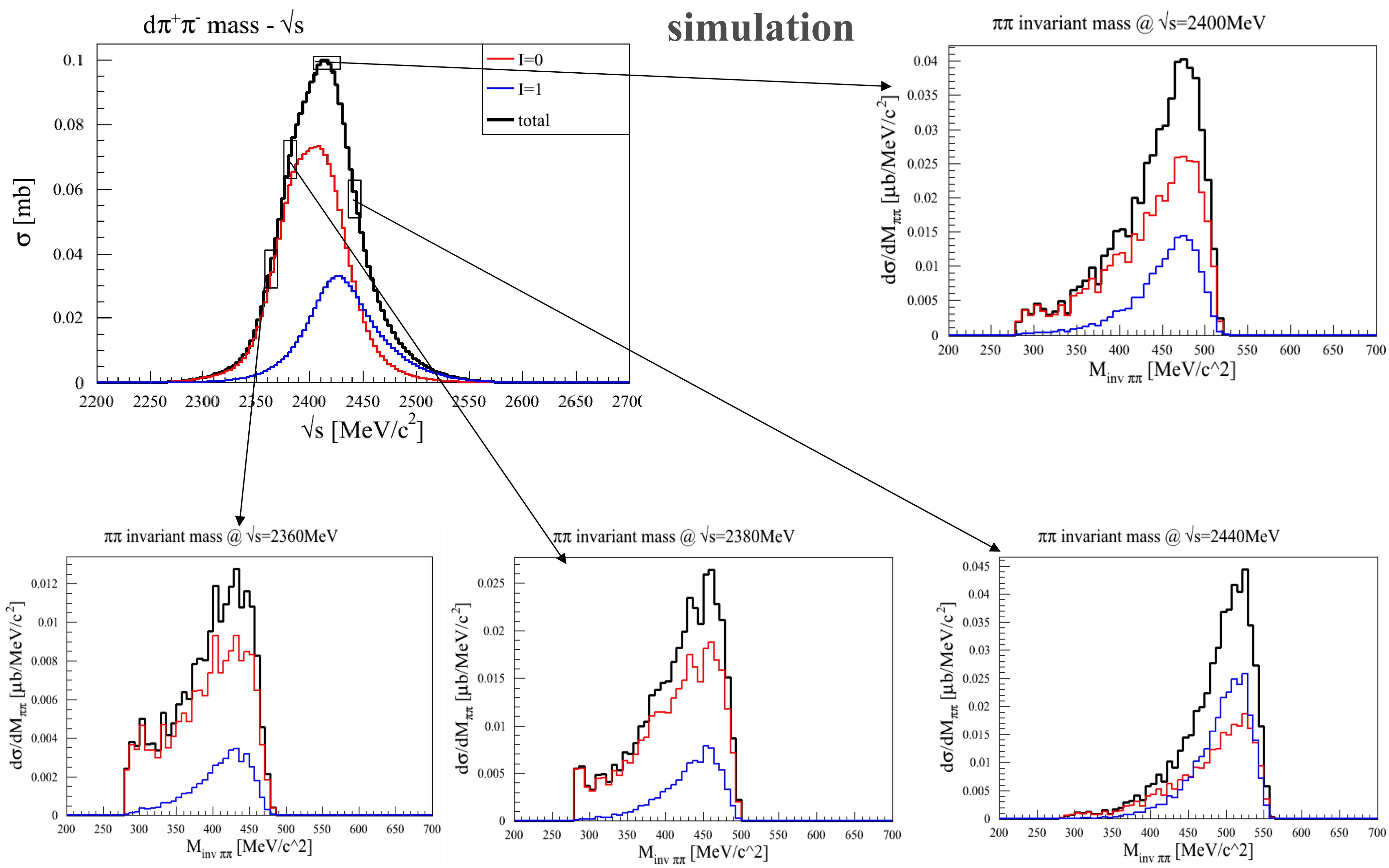
pion invariant mass vs pion theta - 4π



Di-pion mass changes with total energy - 4π



Di-pion mass changes with total energy – HADES acceptance



Summary and Outlook

$$d+p \rightarrow d\pi^+\pi^- + p_{spec}$$

$$d+p \rightarrow np\pi^+\pi^- + p_{spec} \quad \text{(background)}$$

- Full chain phase space simulation for the $d\pi^+\pi^-$ and $np\pi^+\pi^-$ channels to improve PID and estimate signal/ background ratio
- Acceptance and Efficiency matrices
- Experimental data corrected for efficiency simulation filtered by acceptance and smeared
- ABC effect and WASA di-baryon resonance model compared with HADES experimental data

<u>To Do:</u>

- Improvement of the signal extraction
- Deuteron selection by missing mass method ($pn \rightarrow \pi^+\pi^- X$): extension to the „blind" area
- Application of the method of deuteron selection and coplanarity to e+e- analysis

Thank you.

The end

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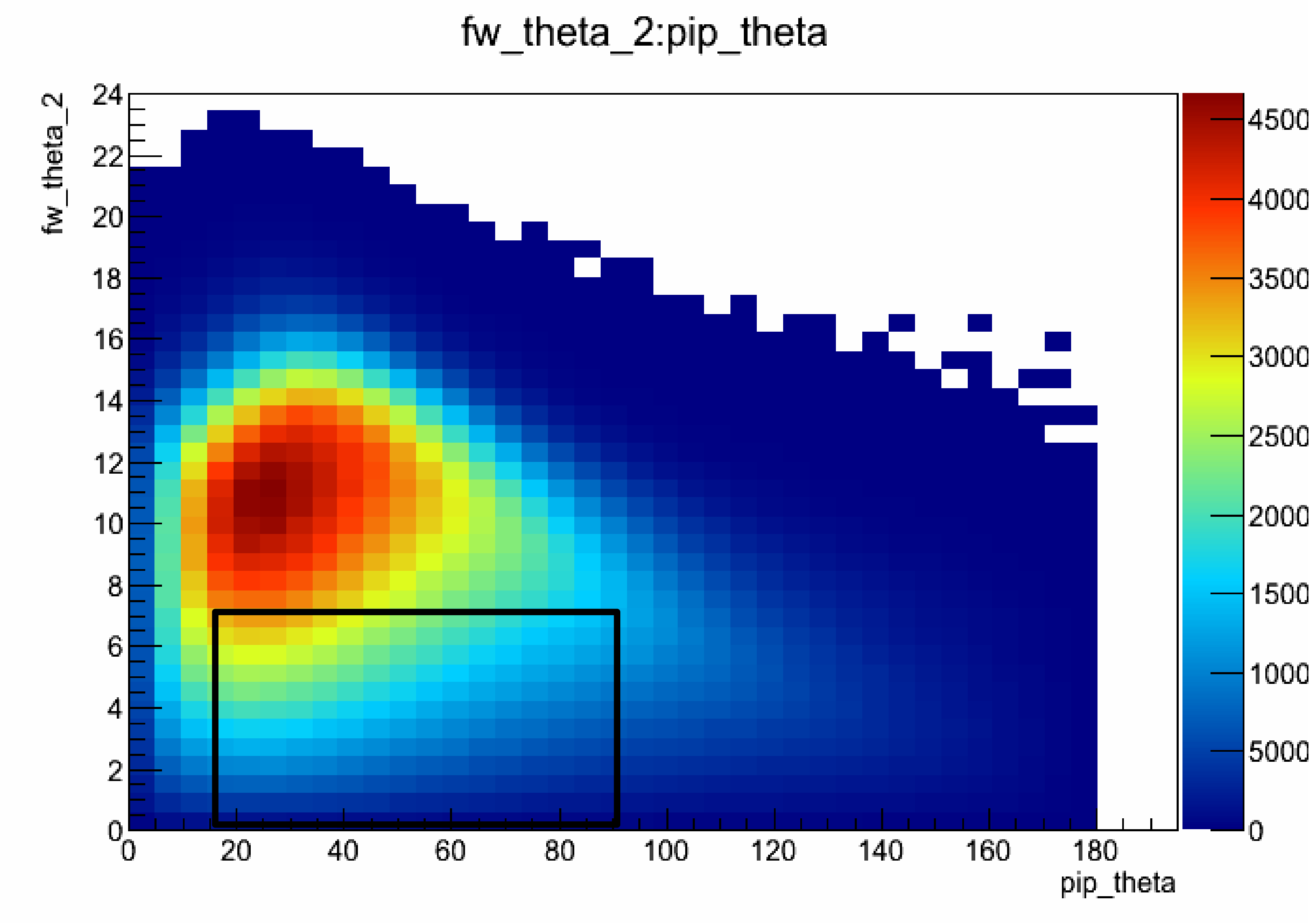

fw_theta_2:pip_theta
fw_theta_2
pip_theta
0
20
40
60
80
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120
140
160
180
0
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4
6
8
10
12
14
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18
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22
24
4500
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2000
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0