university of groningen

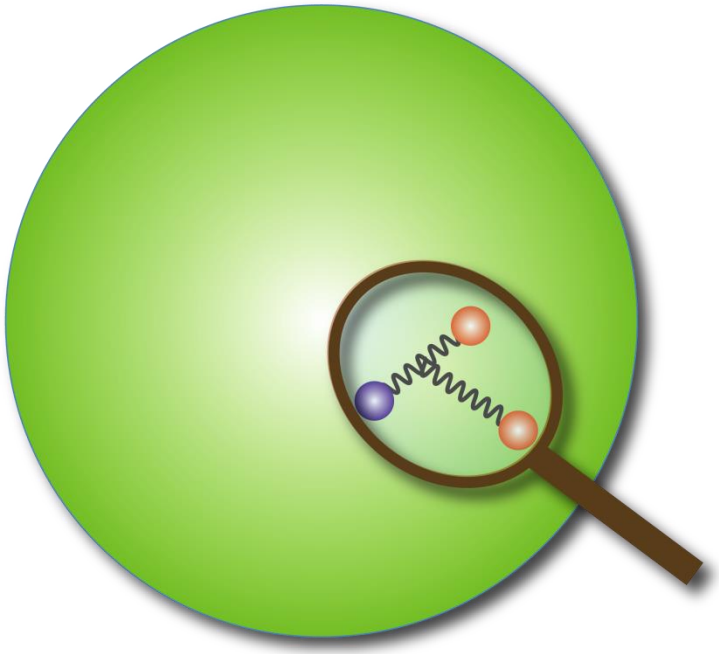
kvi - center for advanced radiation technology

Comprehensive study of proton-deuteron breakup channel

Hajar Tavakoli-Zaniani

outline

- Introduction
- Experimental setup
- Results
- Conclusion

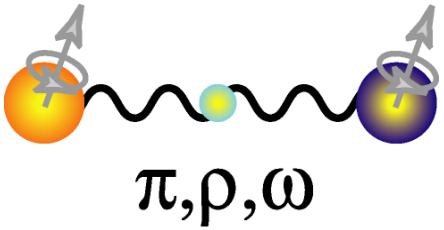


Two Nucleon Force (2NF)

1935 Yukawa's meson theory (2NF)

Theory :

- One Pion Exchange Model
- One Boson Exchange Model
- Heavier Meson Exchange e.g. ρ and ω



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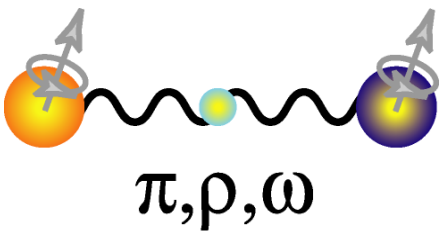
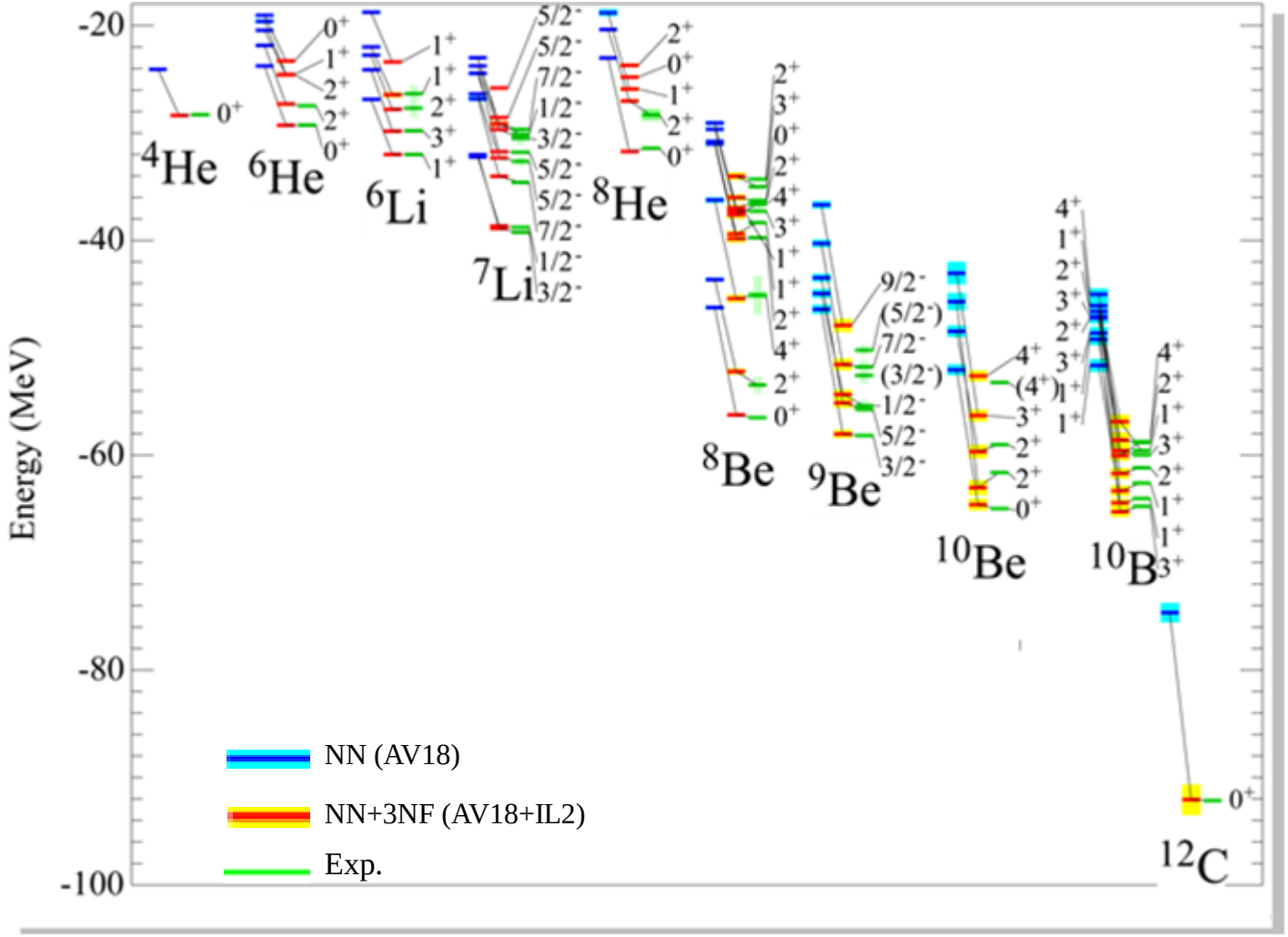


NN Force models

- ✓ Nijmegen I
- ✓ Nijmegen II
- ✓ Reid 93
- ✓ CD-Bonn
- ✓ Argonne V18
- ✓ ChPT

with high precision, $\chi^2 \sim 1$

Where could we see 3NF effects ?



S.C. Pieper et al. PRC 64, 14001 (2001)

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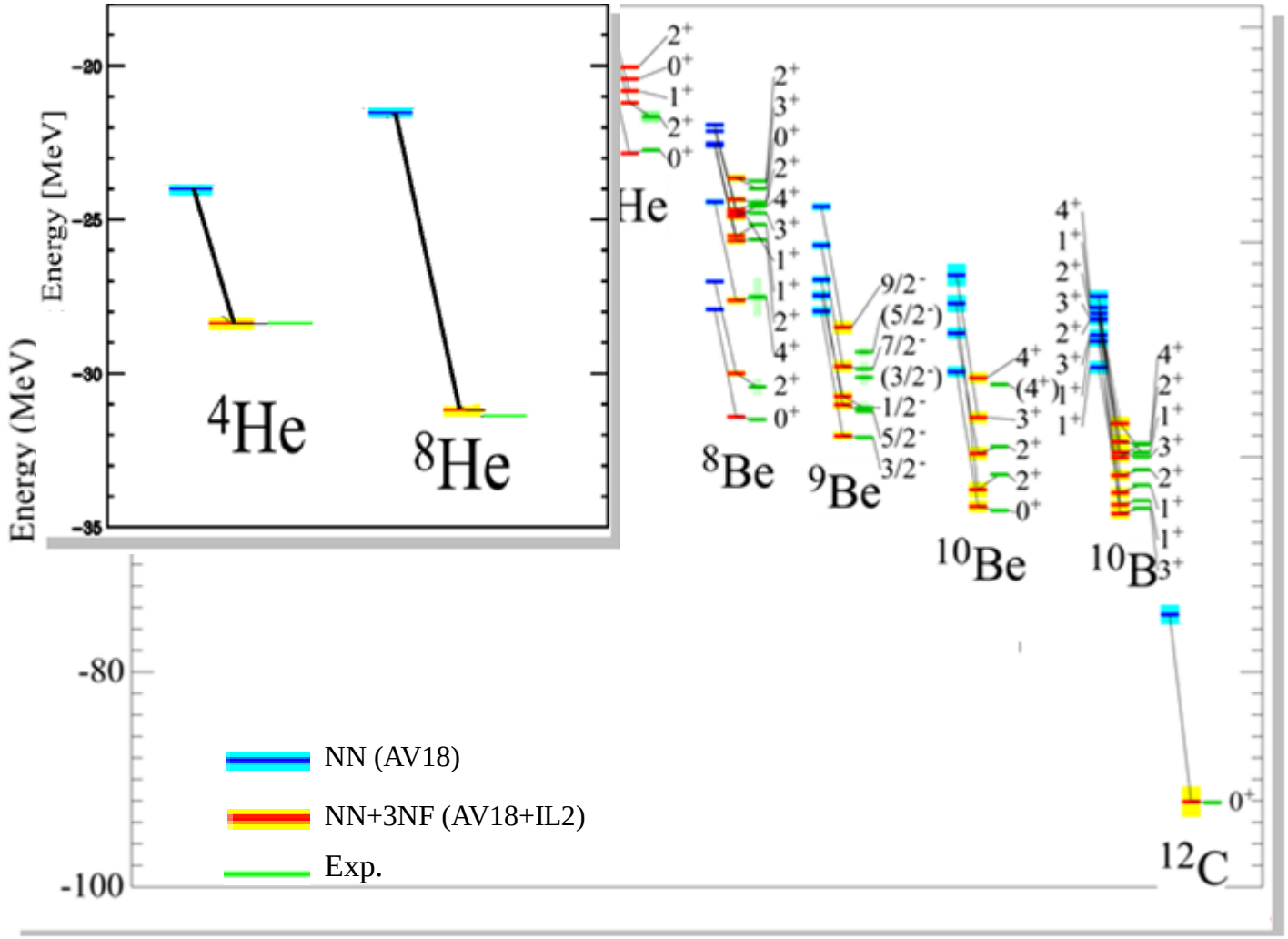

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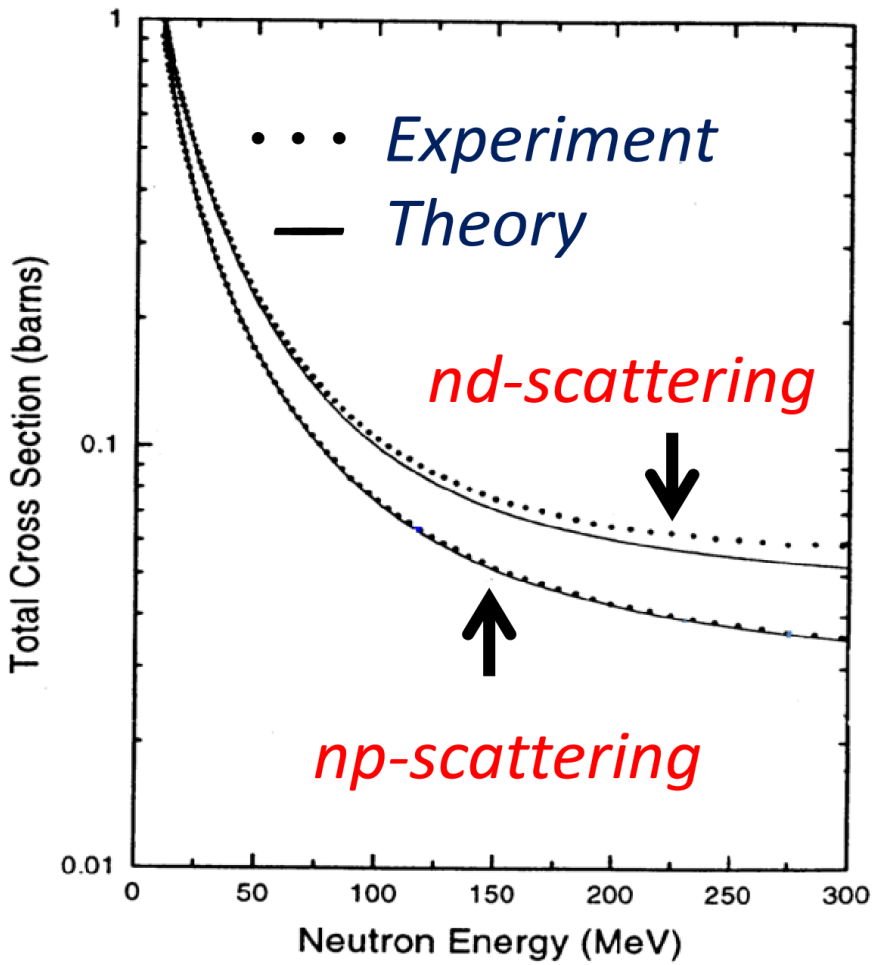
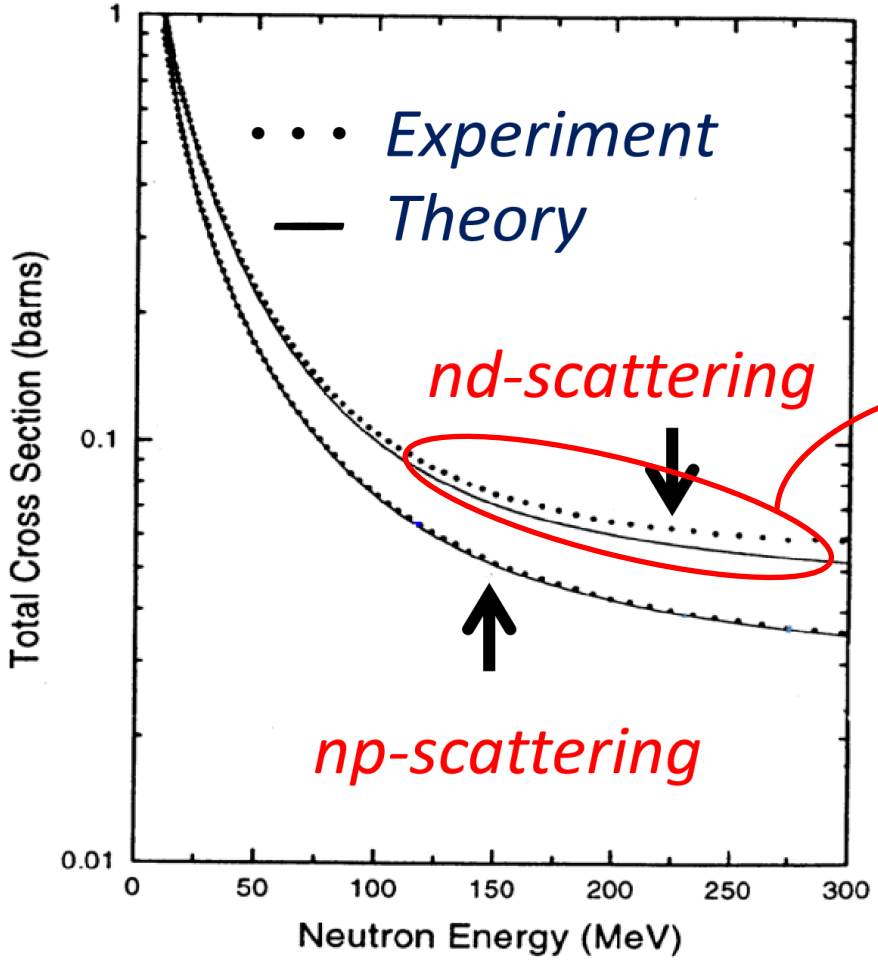


$$n + d \rightarrow n + d$$

&

$$n + d \rightarrow n + n + p$$

W.P. Abfalterer et al., PRL 81, 57 (1998)



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Small discrepancy

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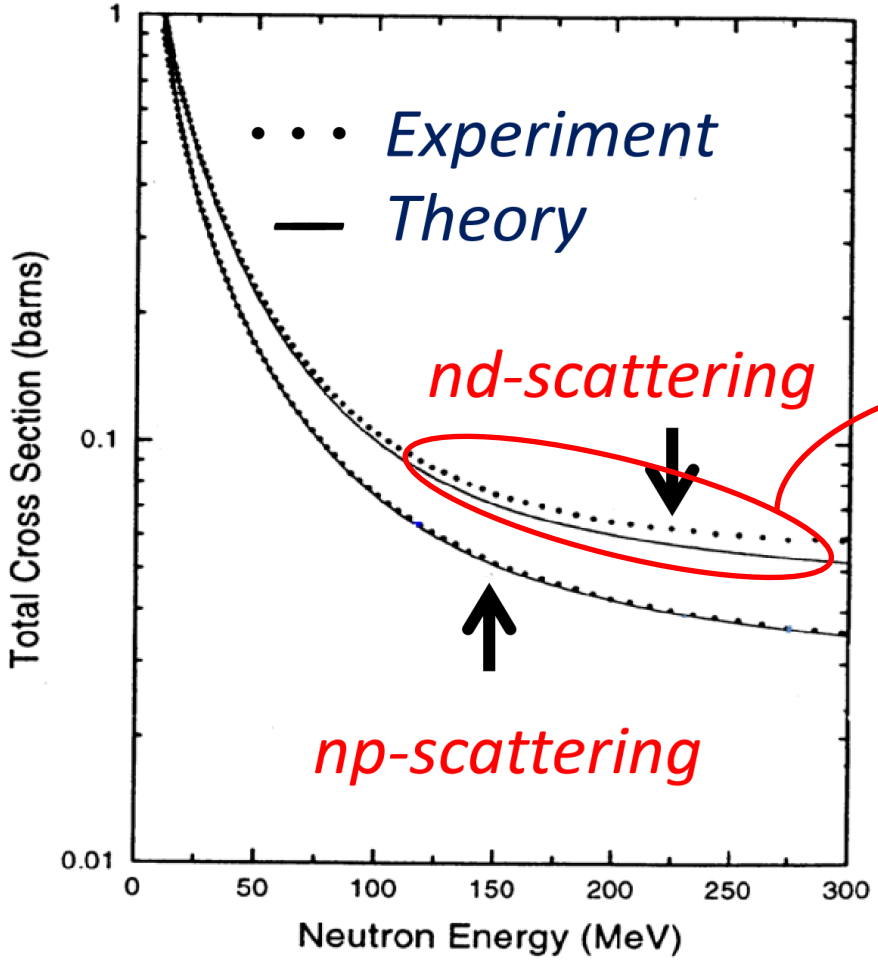

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Other observables

W.P. Abfalterer et al., PRL 81, 57 (1998)

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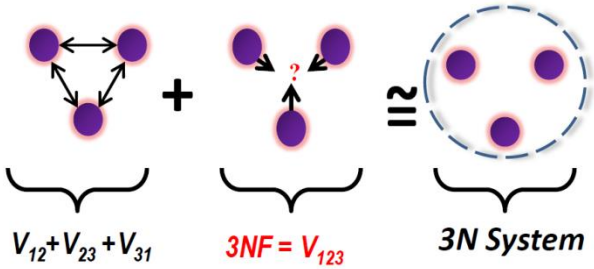
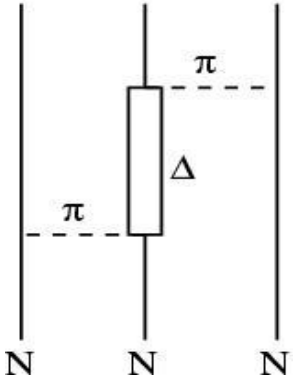


1957 Fujita and Miyazawa 3NF theory

Prog. Theor. Phys. 17, 360 (1957)

2π-exchange 3NF :

Δ-isobar excitations in the intermediate



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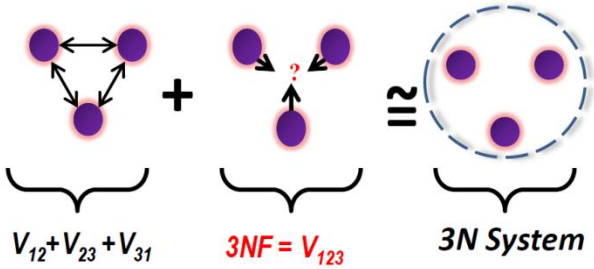

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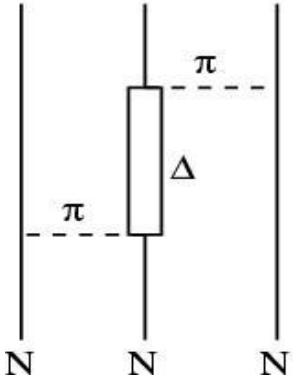
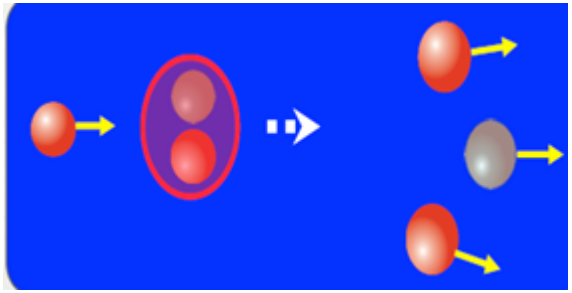


3N Force models

- ✓ Tucson-Melbourne (TM)
- ✓ Urbana IX
- ✓ Brazil
- ✓ ChPT
- ✓ …

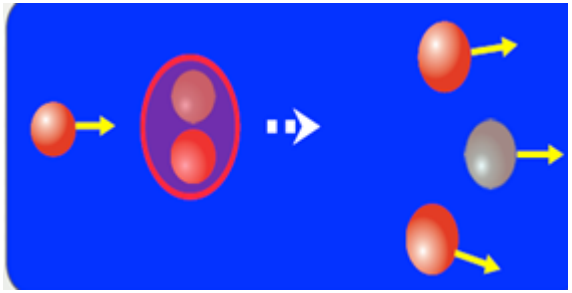
pd breakup reaction



✓ Rich phase space

pd breakup reaction

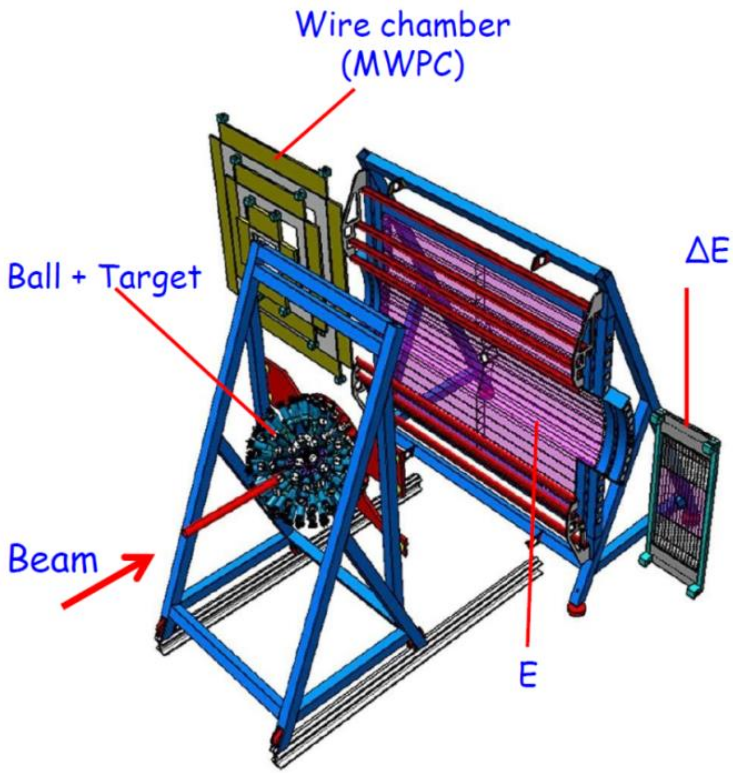
50-250 MeV/A (without KVI-CART measurements)

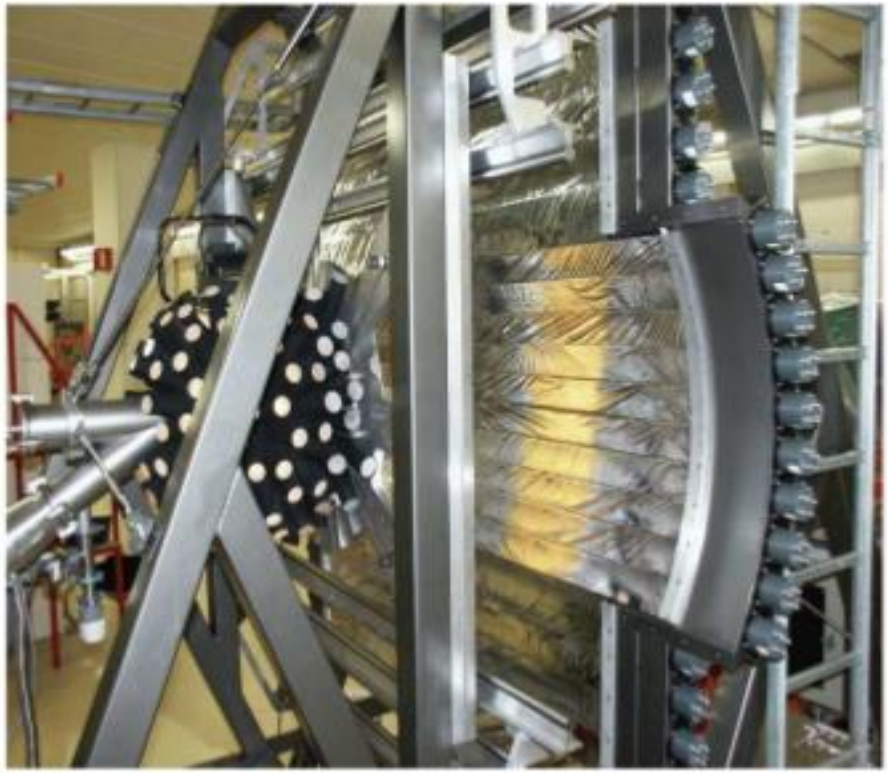


✓ Rich phase space

Observable		100	200	300
$\frac{d\sigma}{d\Omega}$		● ●	●	●
$\vec{p}$	A_y^p	●	● ●	●
	A_x^p			
	A_z^p		●	
$\vec{d}$	A_y^d		●	
	A_{yy}		●	
	A_{xx}		●	
	A_{xz}		●	
$\vec{d} \to \vec{p}$	$K_{yy}^{y'}$		●	
$\vec{p}\vec{d}$	C_{ij}		●	

BINA (Big Instrument for Nuclear-polarization Analysis)

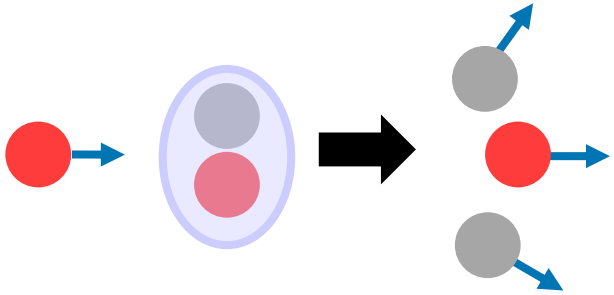




pd breakup reaction at KVI-CART

Intermediate energy: 100 - 200 MeV

pd breakup cross section



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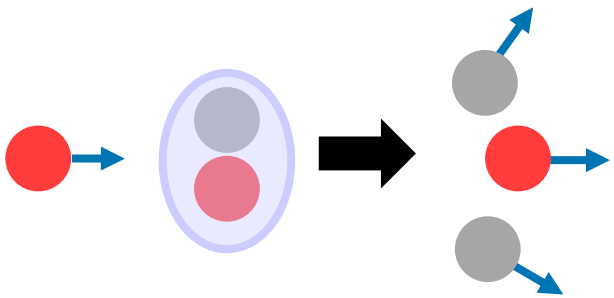

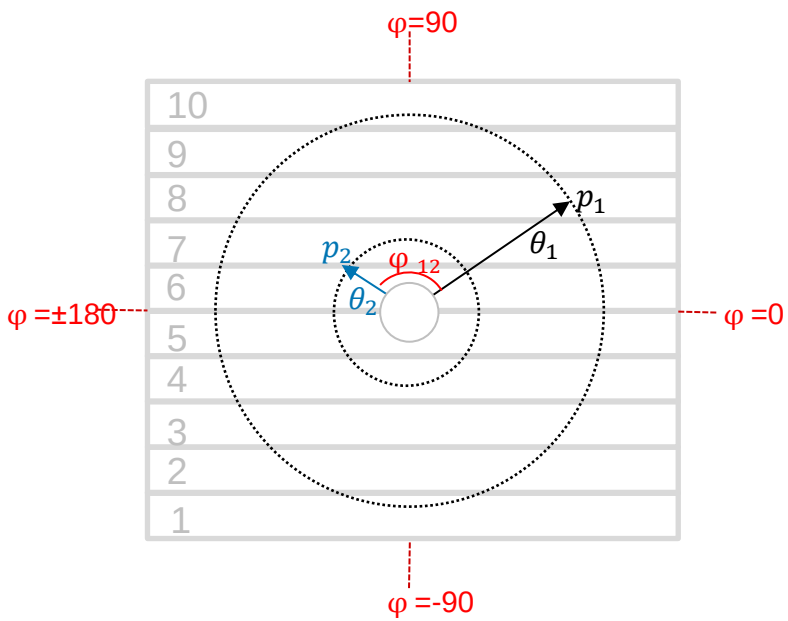

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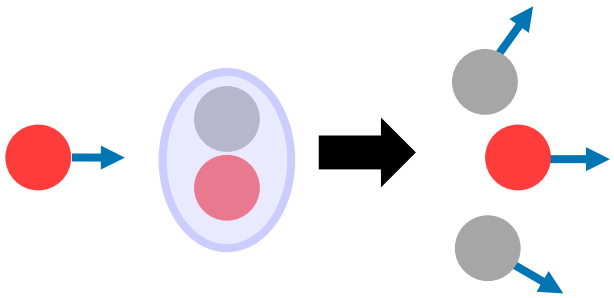

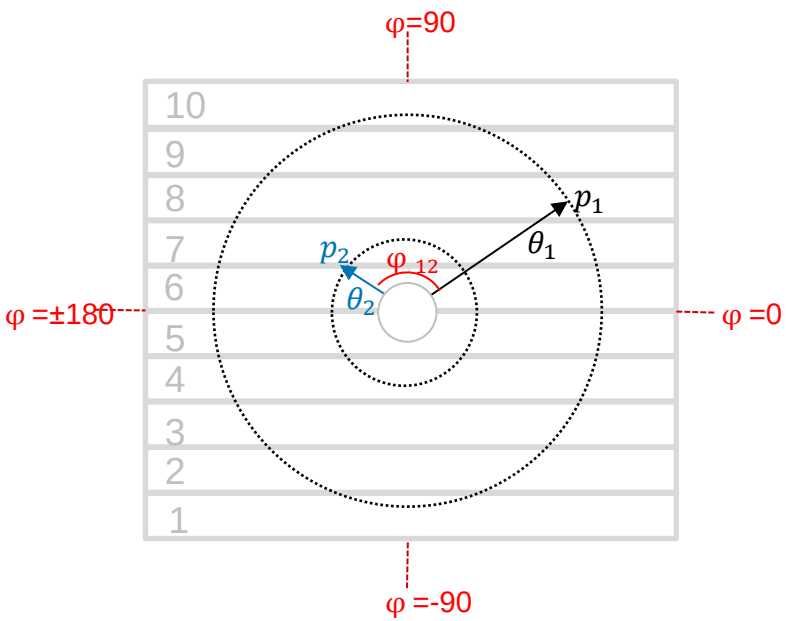

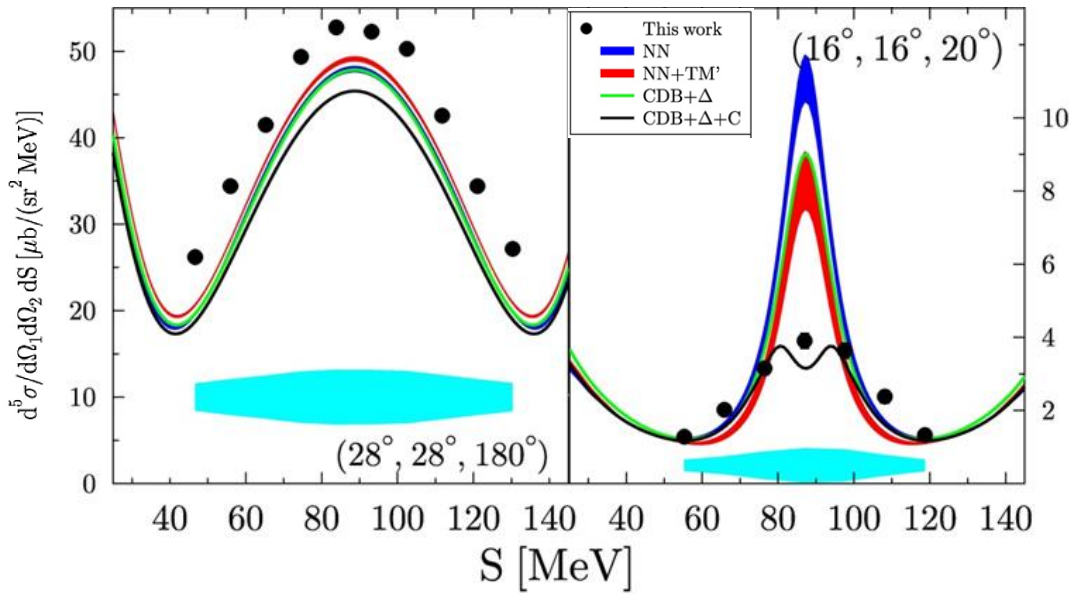

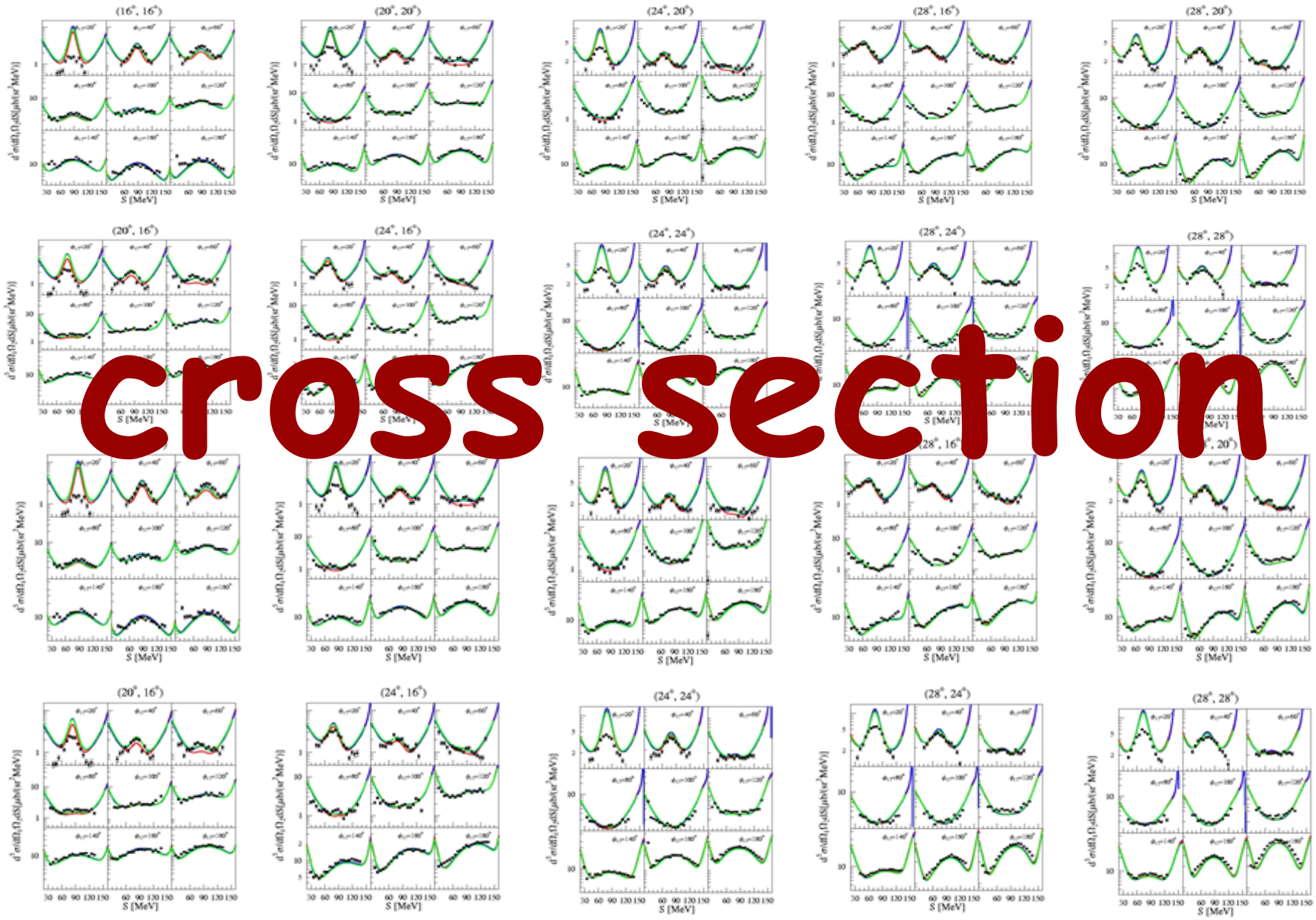

cross section

Dalitz analysis of observed cross section

$$m_{pp}^{2} = (p_1 + p_2)^2$$

$$m_{pn}^{2} = (p_1 + n)^2$$

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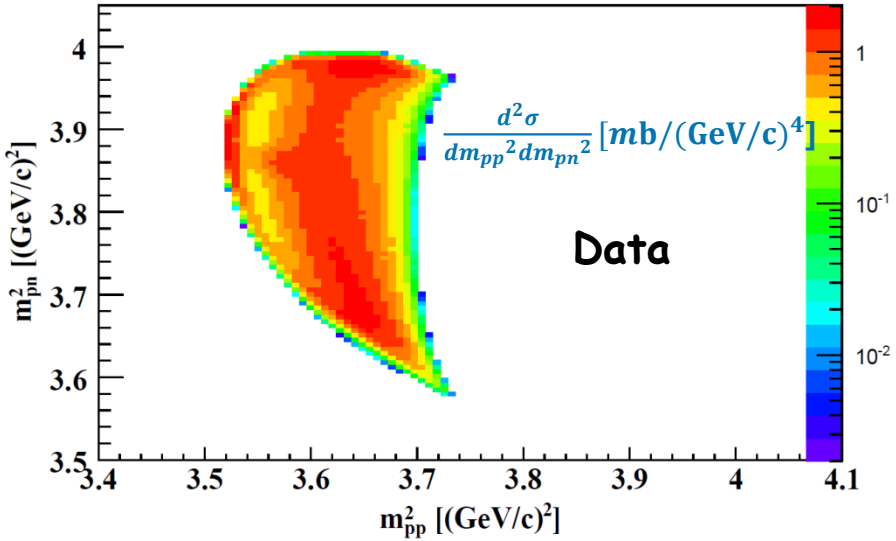

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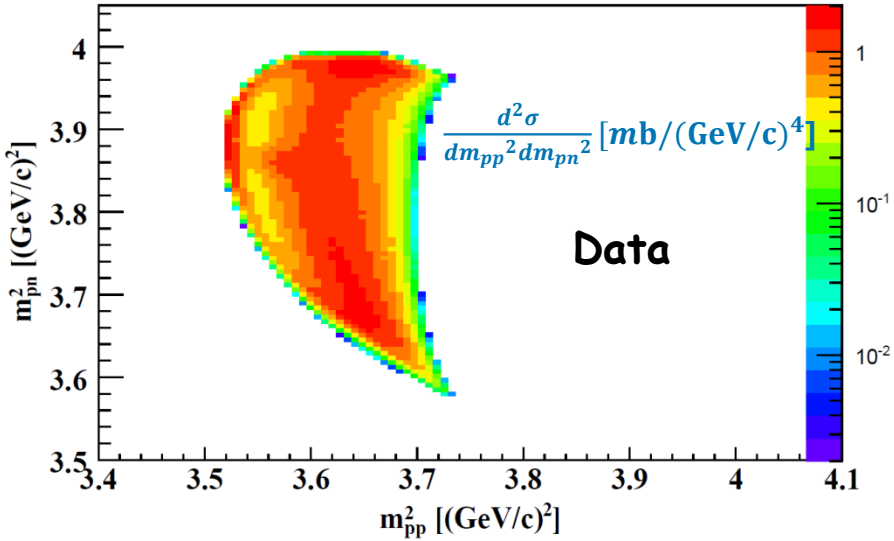

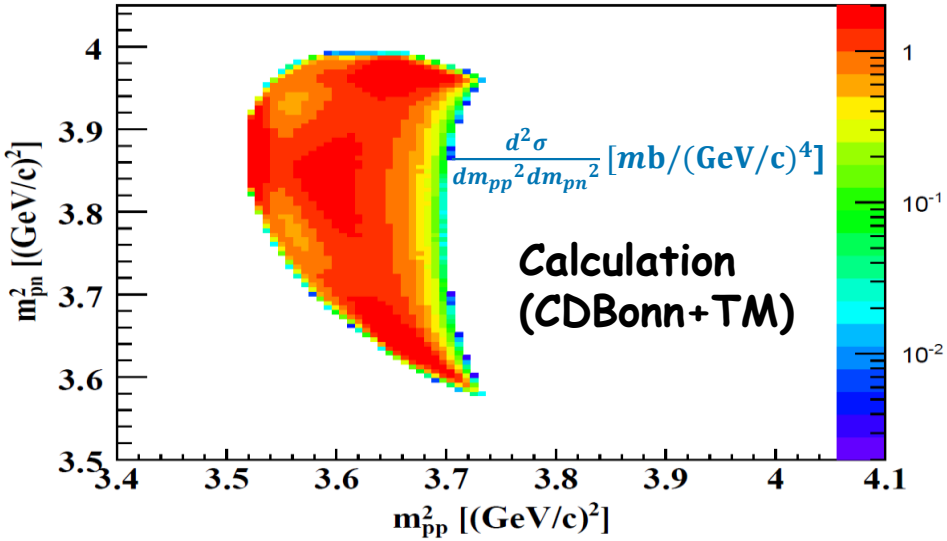

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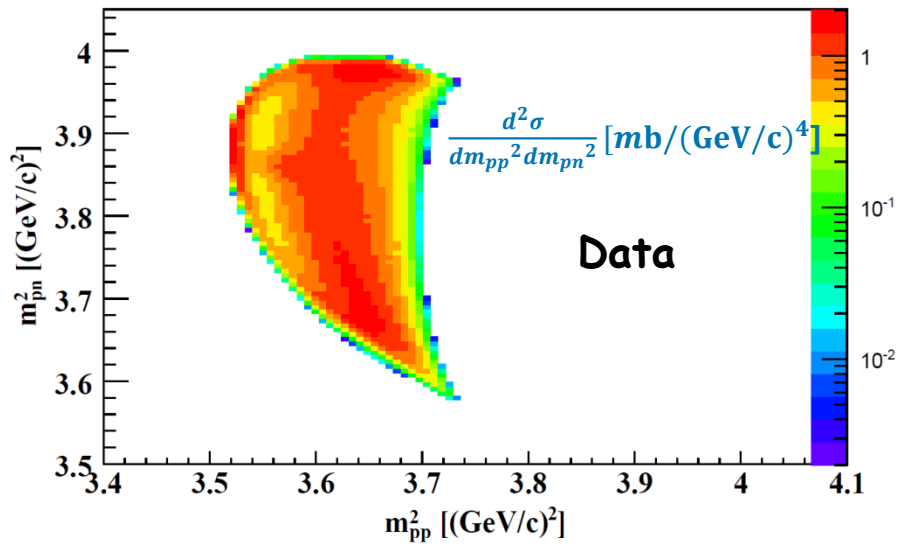
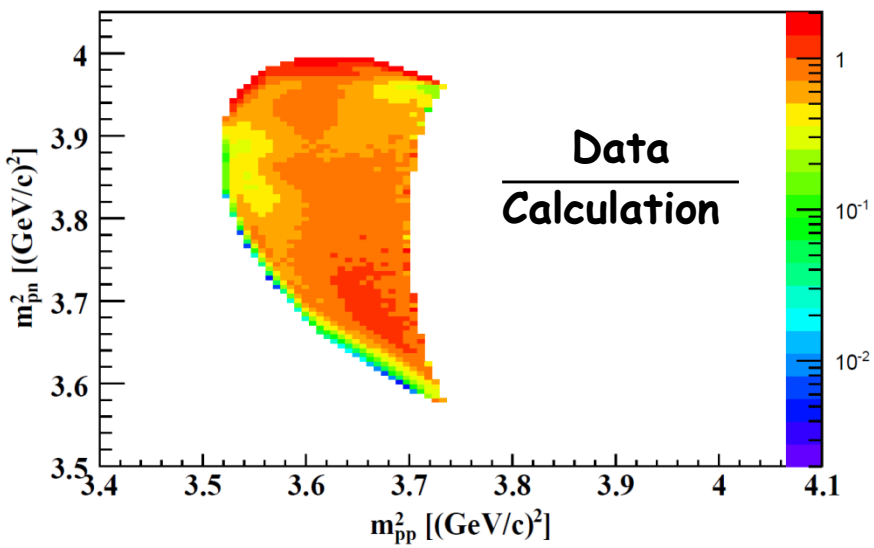
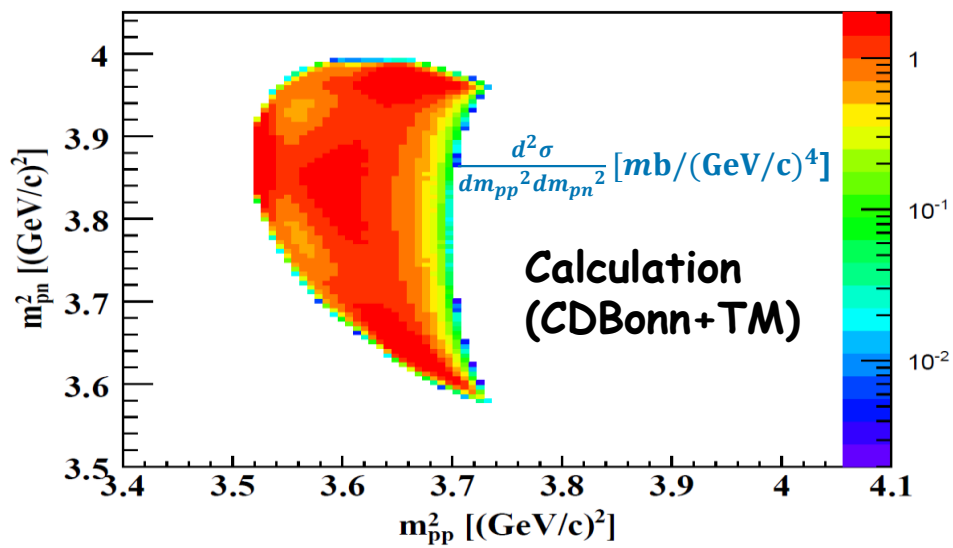
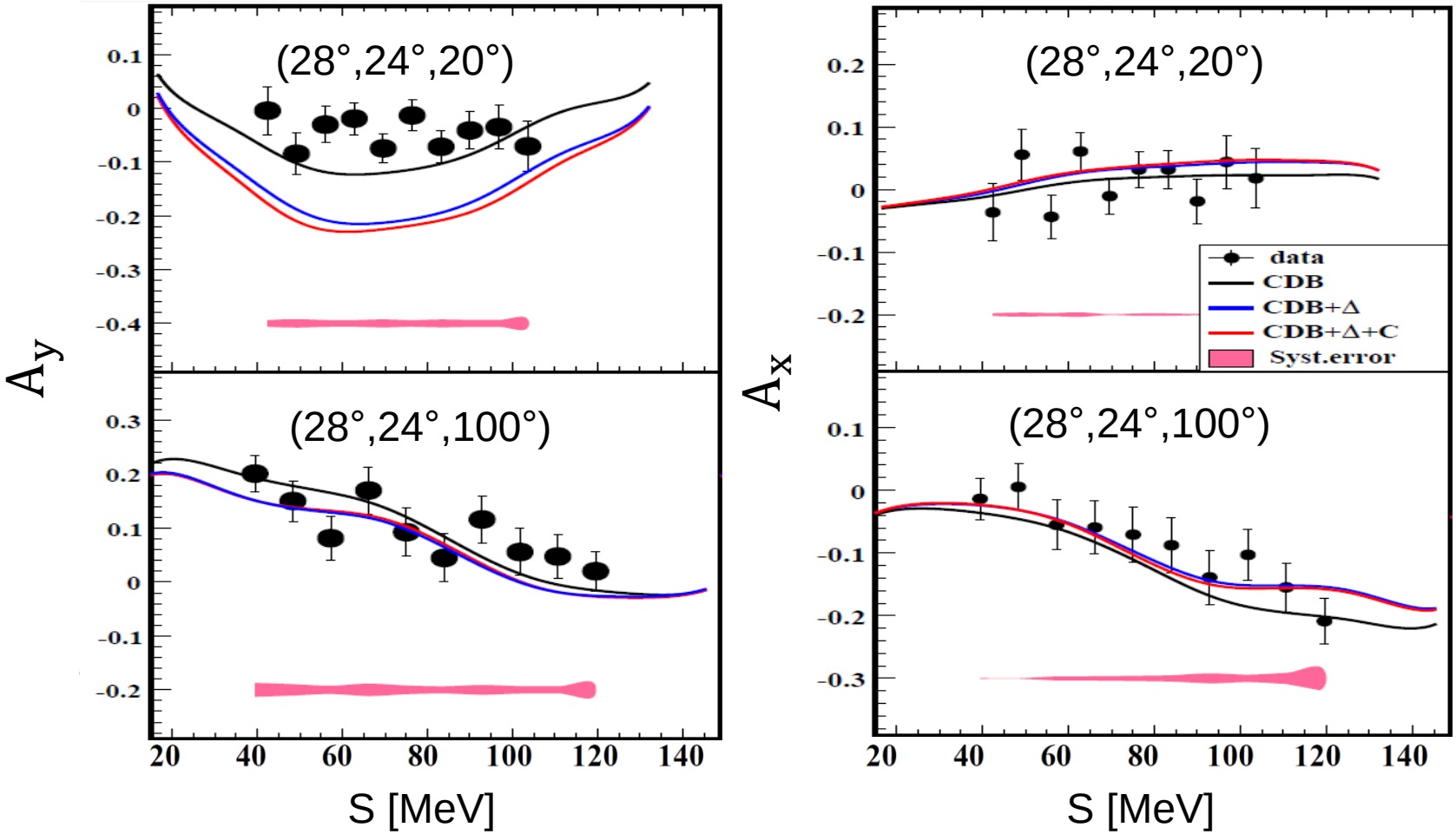


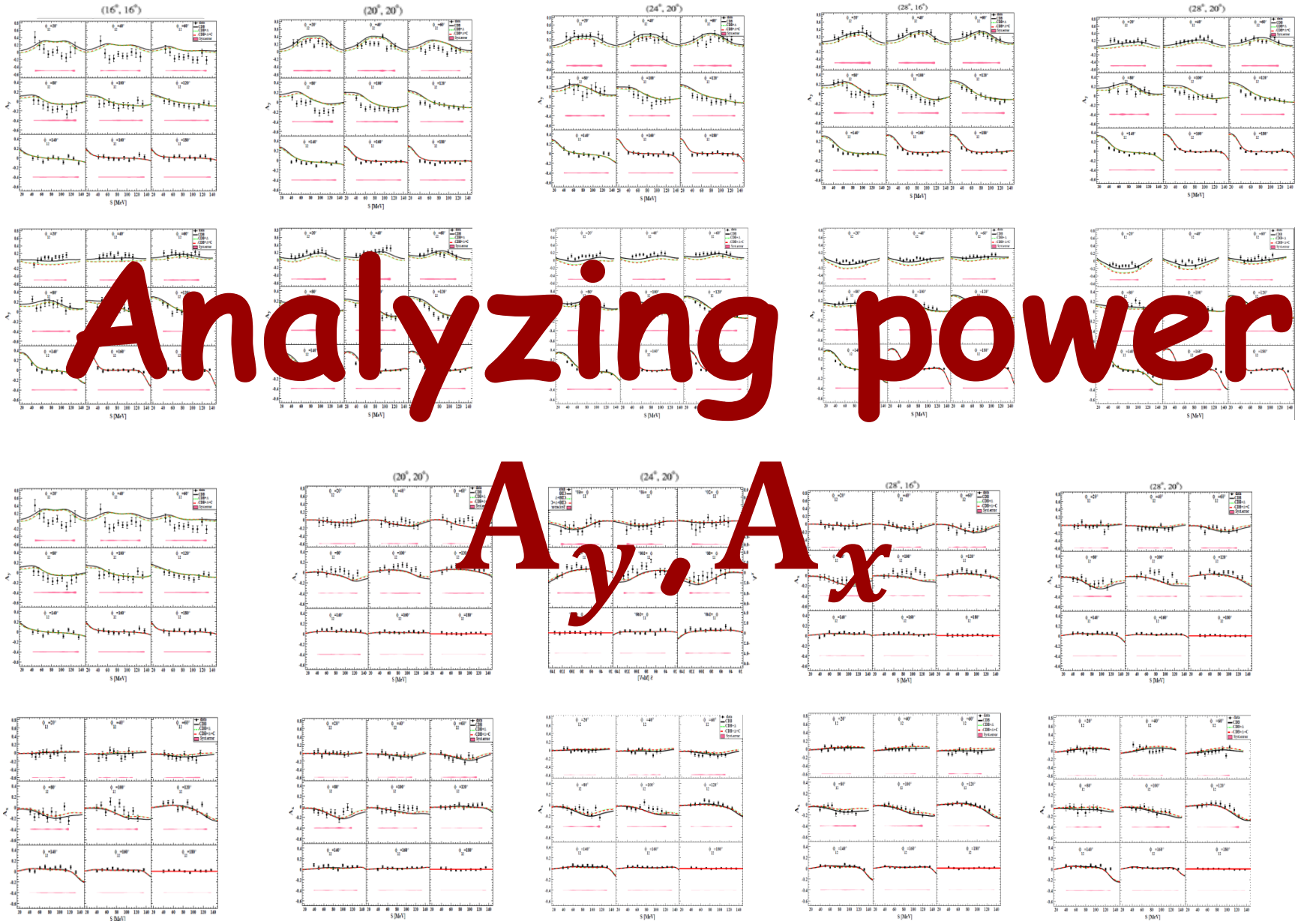


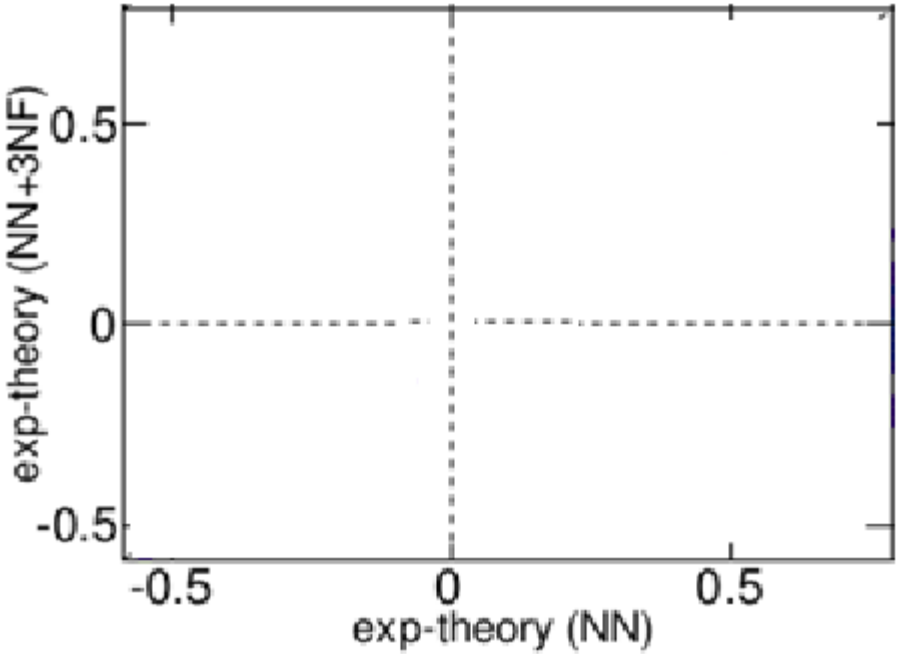


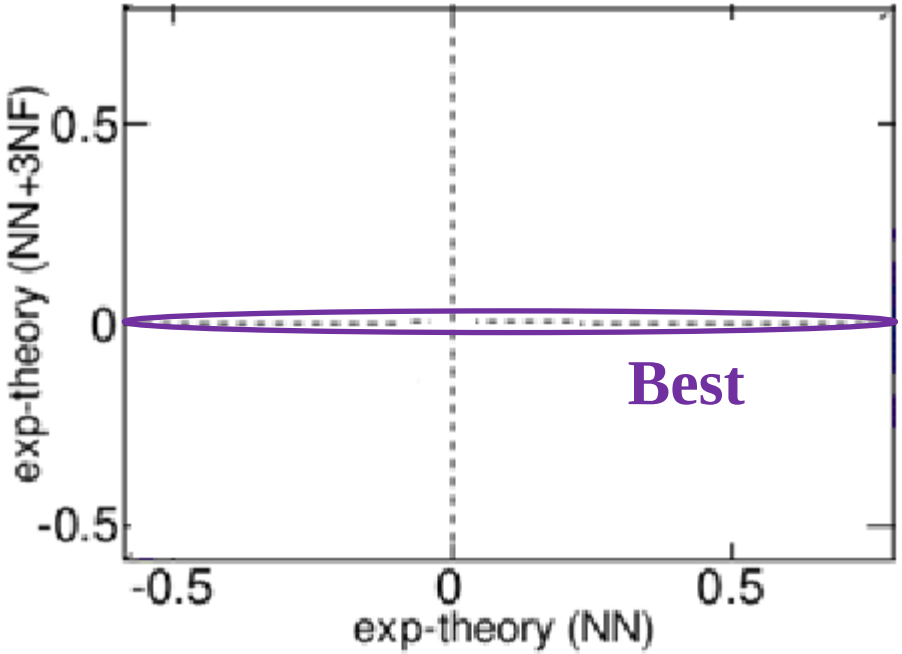
pd breakup Analyzing powers

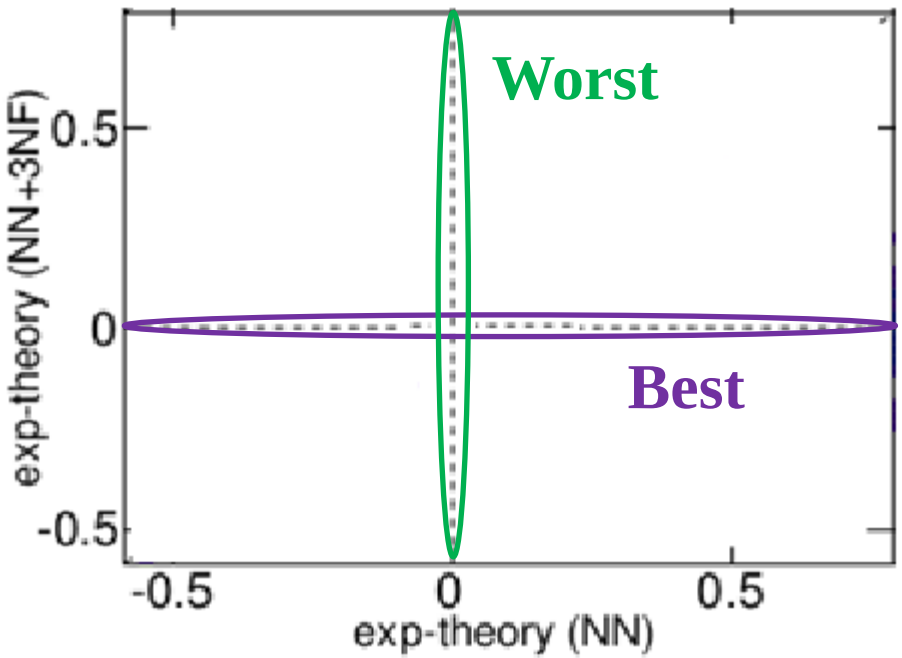


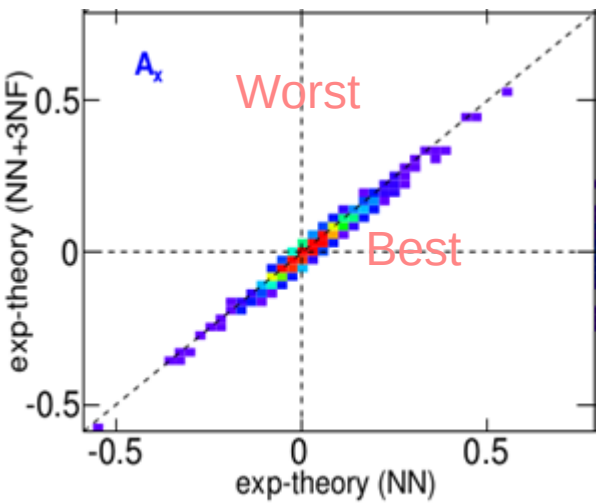
Analyzing power A_y, A_x




0.5
0
-0.5
exp-theory (NN+3NF)
-0.5
0
0.5
exp-theory (NN)


exp-theory (NN+3NF)
0.5
0
-0.5
-0.5
0
0.5
exp-theory (NN)
Best


Worst
Best
0.5
0
-0.5
-0.5
0
0.5
exp-theory (NN+3NF)
exp-theory (NN)

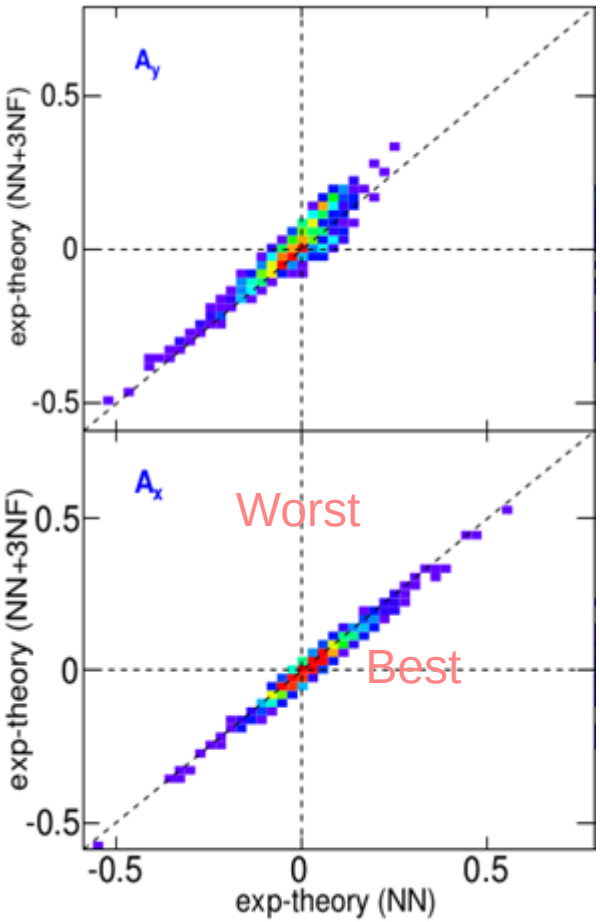


- ✓ Most data points around 0:

2NF is sufficient and 3NF is small

- ✓ Deviation extend on both side:

The calculations overestimate or underestimate the data

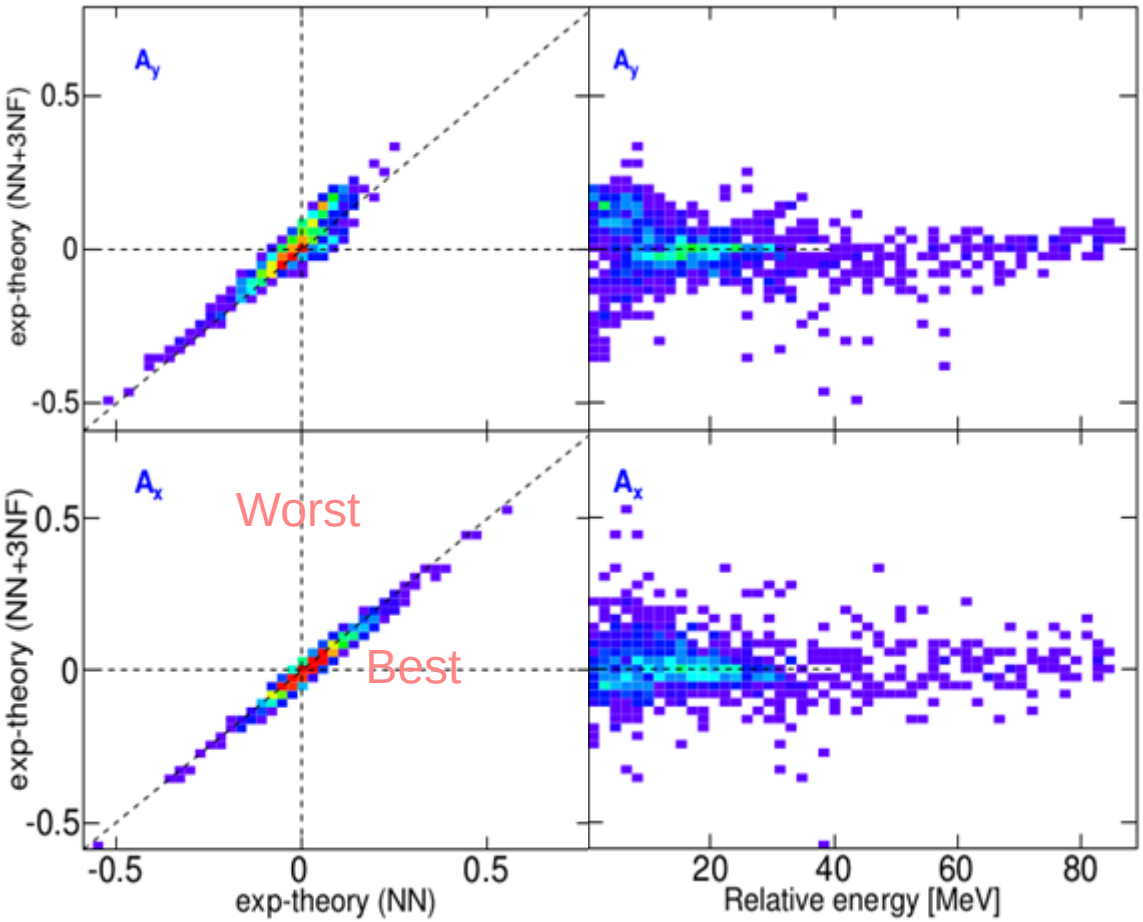


- ✓ Some data points around 0:

2NF is sufficient and 3NF is small

- ✓ Some data off frome diagonal:

Adding 3NF makes the agreement even worse



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Adding 3NF makes the agreement even worse

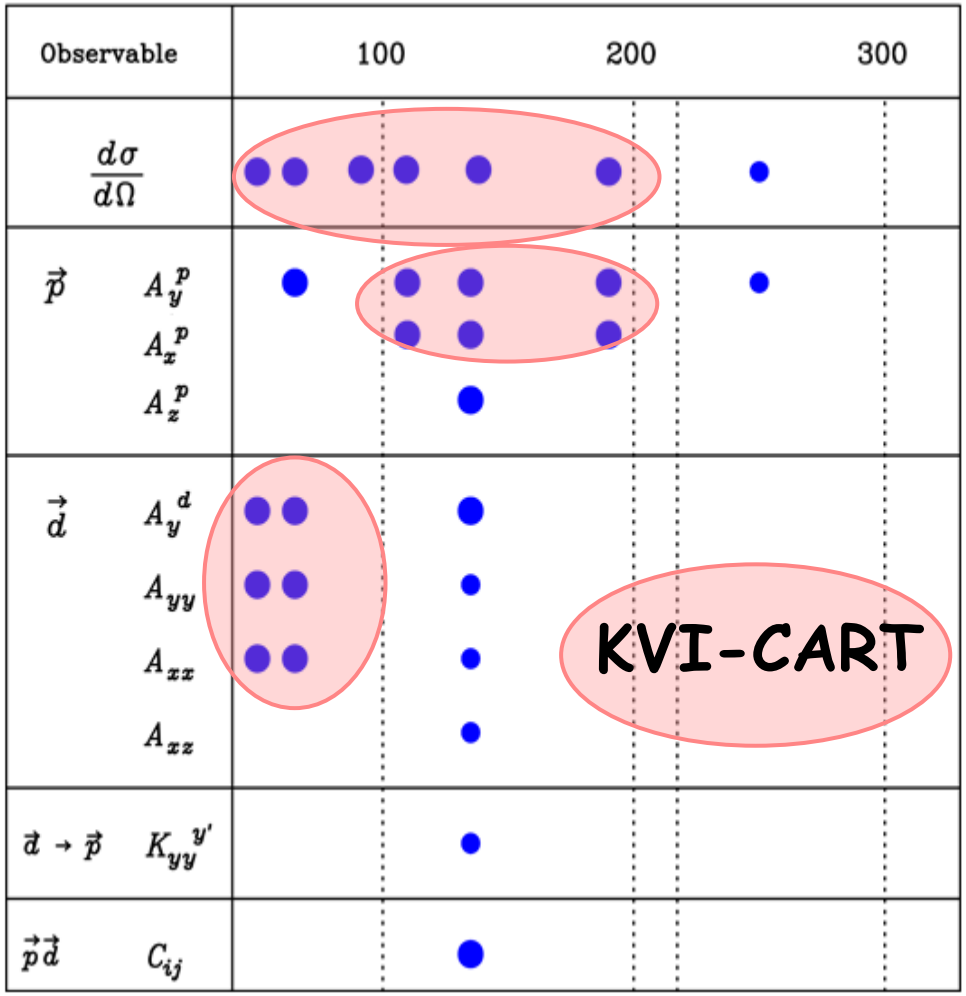
pd breakup reaction at 50-250 MeV/A

Observable		100	200	300
$\frac{d\sigma}{d\Omega}$		● ●	●	●
$\vec{p}$	A_y^p	●	● ●	●
	A_x^p			
	A_z^p		●	
$\vec{d}$	A_y^d		●	
	A_{yy}		●	
	A_{xx}		●	
	A_{xz}		●	
$\vec{d} \rightarrow \vec{p}$	$K_{yy}^{y'}$		●	
$\vec{p}\vec{d}$	C_{ij}		●	

pd breakup reaction at 50-250 MeV/A

Observable		100	200	300
$\frac{d\sigma}{d\Omega}$		●● ●	●● ●	●
$\vec{p}$	A_y^p	●	●● ●	●
	A_x^p		●● ●	
	A_z^p		●	
$\vec{d}$	A_y^d	●●	●	
	A_{yy}	●●	•	
	A_{xx}	●●	•	
	A_{xz}		•	
$\vec{d} \rightarrow \vec{p}$	$K_{yy}^{y'}$		•	
$\vec{p}\vec{d}$	C_{ij}		●	

pd breakup reaction at 50-250 MeV/A



KVI-CART:

- ✓ Rich data set of pd breakup at intermediate energies
- ✓ The first precise data set of pd breakup

  $\mathbf{A_x}$ AND $\mathbf{A_y}$ for 4π phase space

H. Tavakoli-Zaniani[1,2], M. T. Bayat[1], M. Eslami-Kalantari[2], N. Kalantar-Nayestanaki[1] , St. Kistryn[3], A. Kozela[4], J. G. Messchendorp[1], M. Mohammadi-Dadkan[1,5], R. Ramazani-Sharifabadi[1,6], E. Stephan[7]

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[3]Institute of Physics, Jagiellonian University, Krakow, Poland
[4]Institute of Nuclear Physics, PAN, Krakow, Poland
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[7]Institute of Physics, University of Silesia, Chorzow, Poland

Thanks