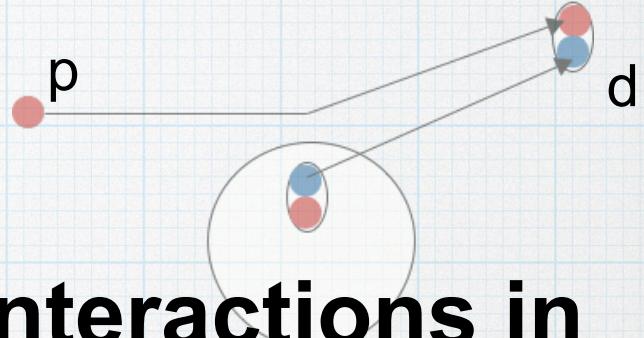


International Nuclear Physics Conference  
September 13, 2016

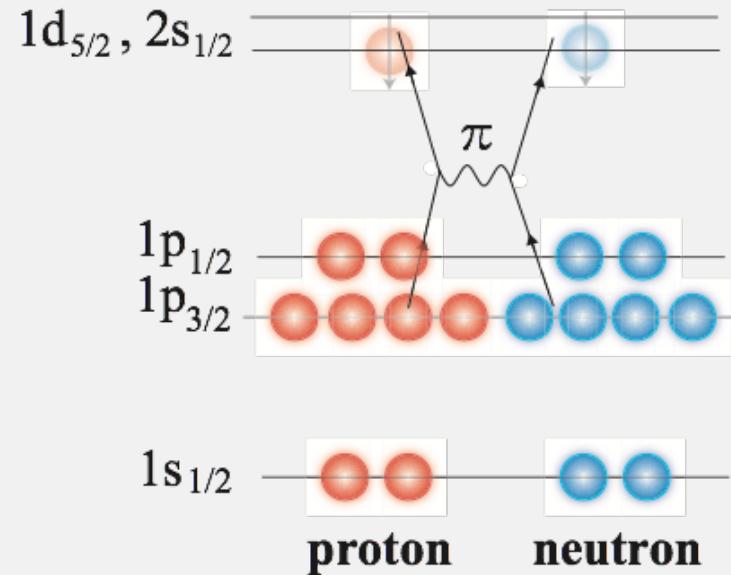
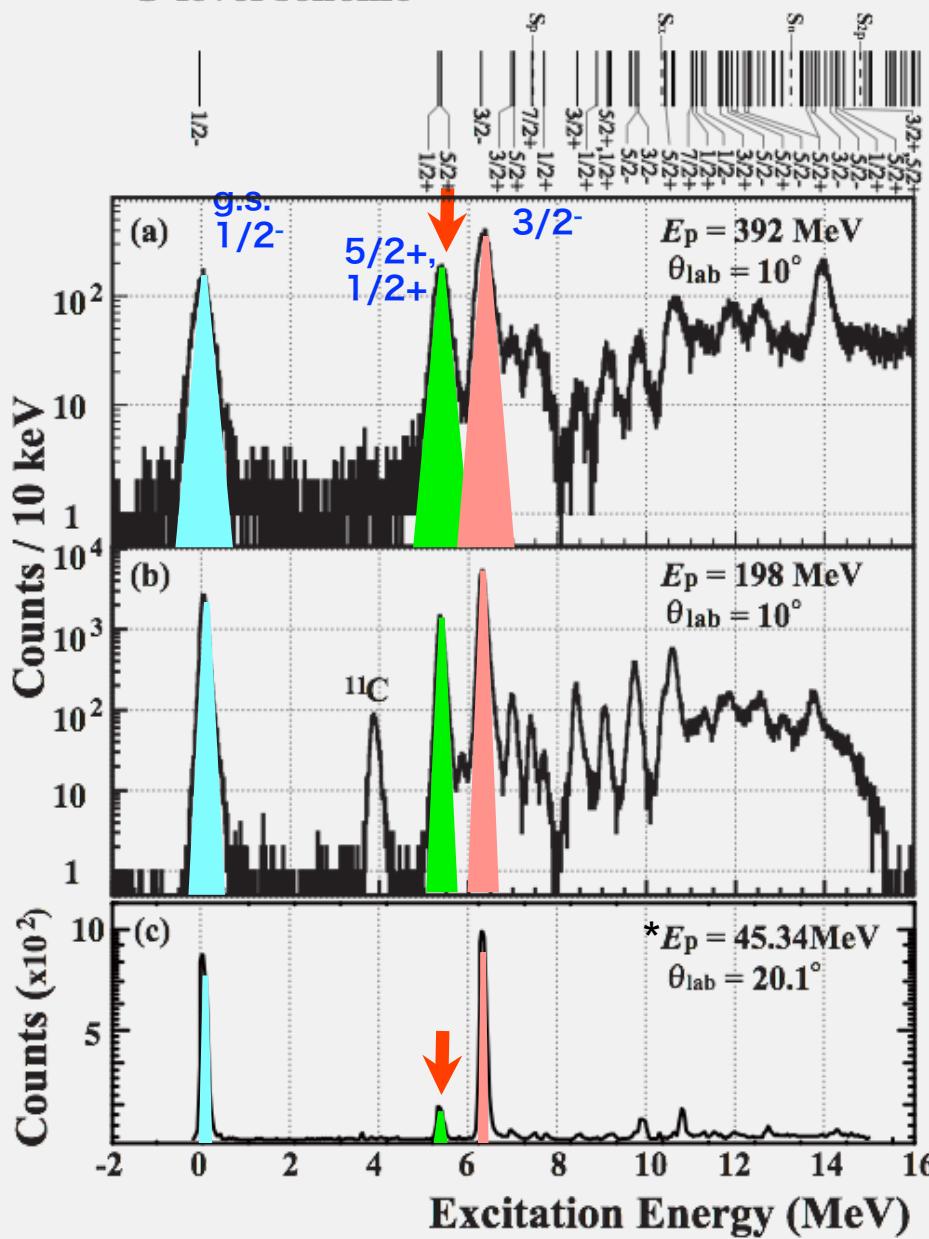


# Probing Effect of Tensor Interactions in Light Nuclei via High-Momentum Neutron-Transfer Reaction

Hooi Jin ONG (RCNP, Osaka University)

# Search for Effect of Tensor Interactions

$^{15}\text{O}$  level scheme



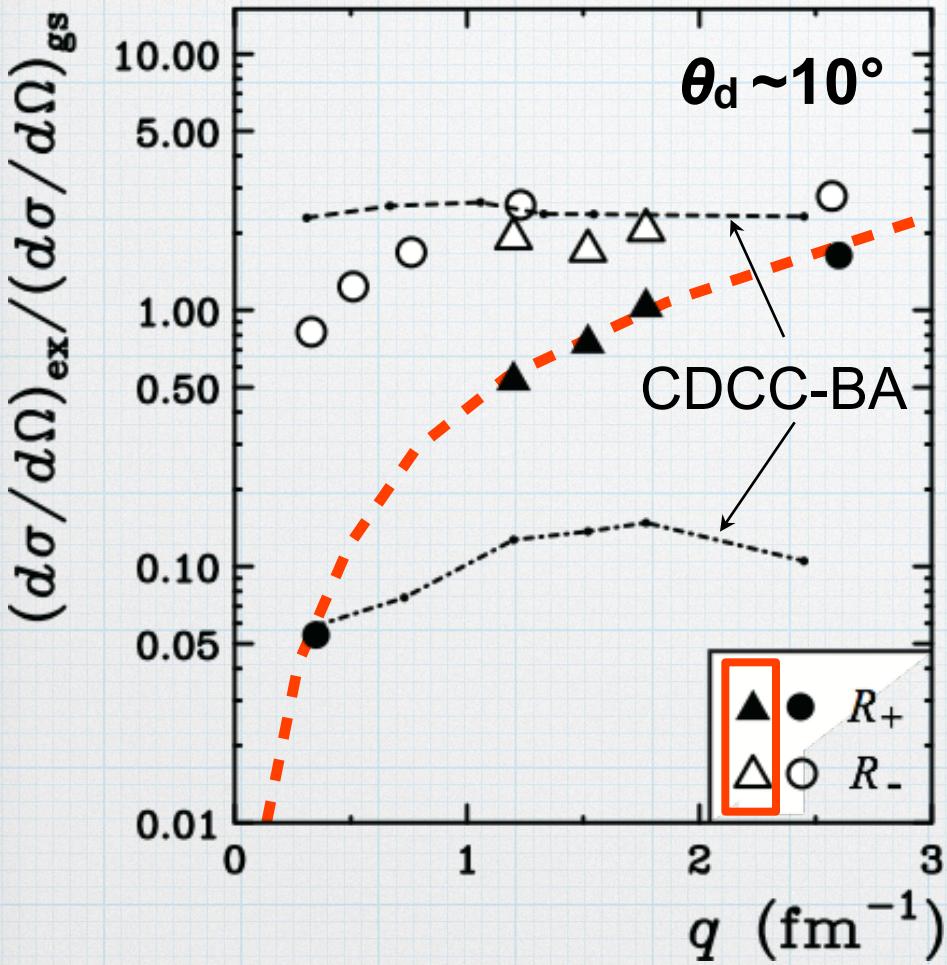
Ground-state of  $^{16}\text{O}$ :  
mixing of 2p-2h configuration \*\*

Selection Rule:  $\Delta J=0$ ,  $\Delta L=\Delta S=2$

\* J.L. Snelgrove *et al.*, PR 187 (1969) 1246

\*\* T. Myo, private communication

# Possible Signature of Tensor Interactions

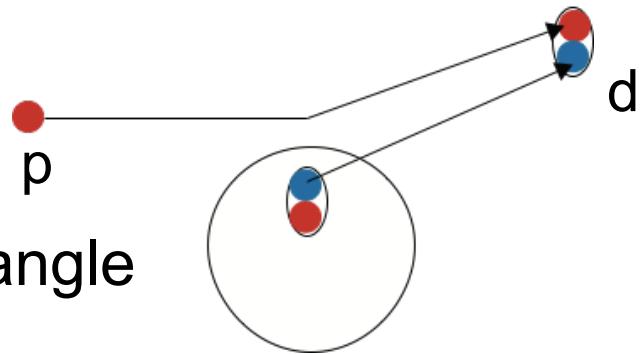


HJO, IT *et al.*, PLB 725, 277 (2013)

- CDCC-BA calculation with known spectroscopic factors:
  - ✓ qualitatively agree with ratios for the neutron-hole states (3/2- to 1/2-)
  - ✓ cannot explain the ratios for the positive-parity state (1/2+ or 5/2+ to 1/2-)
- Two(Multi)-step process does not help
- TOSM-type momentum wave functions that include high-momentum components “fit” the data well.

# Issues to be addressed...

(p,d) at finite ( $\geq 10$  deg) scattering angle



reaction mechanism effect  
at finite angle

$\Rightarrow$  0 degree measurement

- (p,d) at 0 deg with 400-MeV proton  
-> RCNP-E396
- (p,d) at 0 deg with 400~1200-MeV proton to cover  $2 \text{ fm}^{-1}$   
-> **GSI-S436/S437 (NUSTAR Super-FRS collaboration)**

ambiguity of contributions  
from p-n and/or n-n pairs

$\Rightarrow$  (p,dp) and (p,dn) measurements

- (p,dp), (p,dn) at finite angles with 400-MeV proton to study p-n and n-n correlations  
-> RCNP-E443

Terashima

- (p,dp), (p,dn) at higher energy to cover  $2 \text{ fm}^{-1}$  is being planned at the future SuperFRS at FAIR/GSI, Germany.

# **RCNP-E396 collaboration**

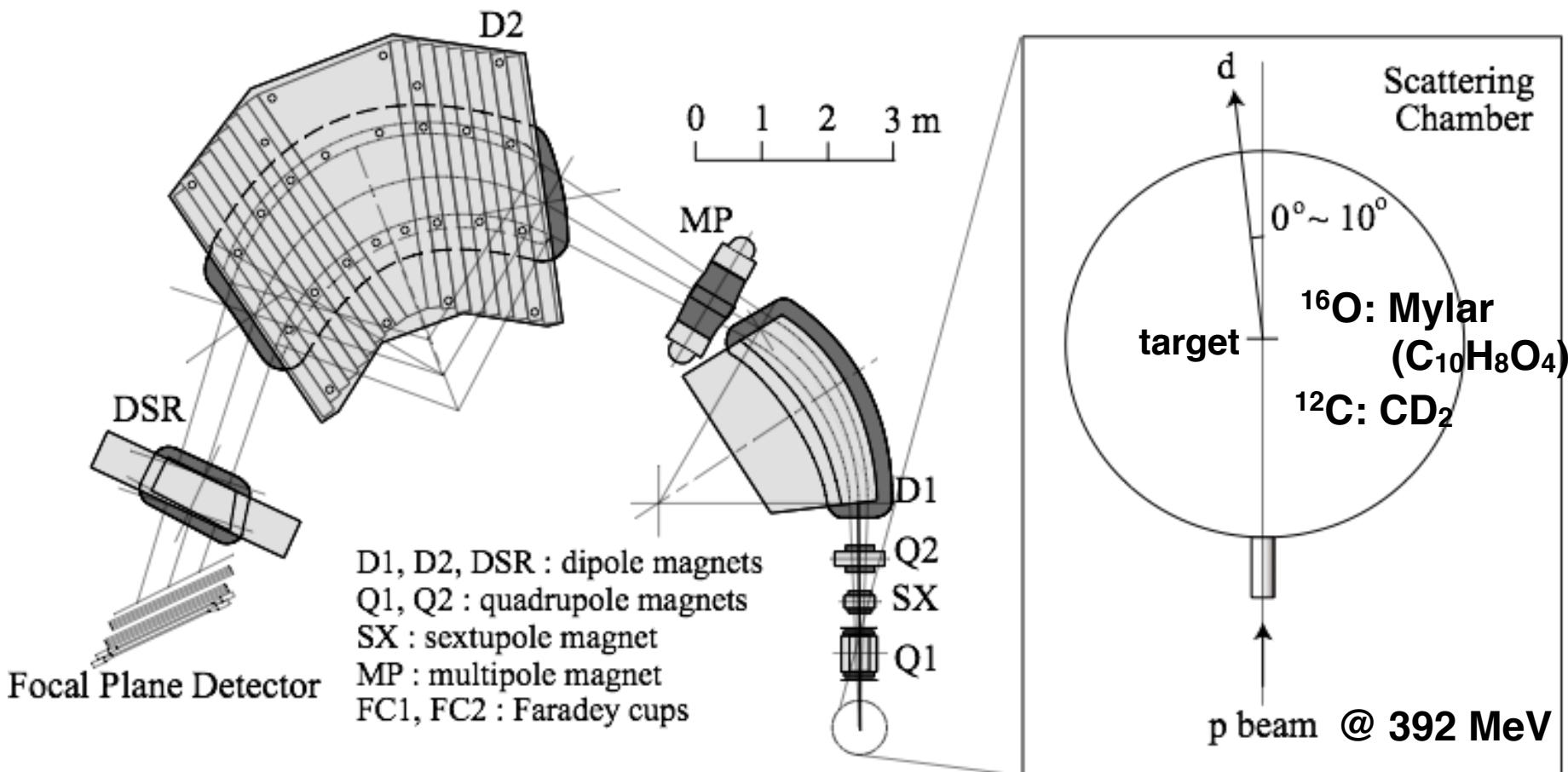
C.L. Guo, H.J.Ong, S. Terashima, I. Tanihata, N. Aoi, Y. Ayyad,  
M. Fukuda, T. Hashimoto, A. Inoue, T. Ito, C. Iwamoto,  
T. Kawabata, X.Y. Le, Y. Matsuda, K. Matsuta, M. Mihara, K. Miki,  
M. Miura, T. Myo, K. Ogata, D.Y. Pang, W.W. Qu, H. Sakaguchi,  
B.H. Sun, A. Tamii, H. Toki, D.T. Tran, T.F. Wang, T. Yamamoto,  
L. Yu, G.L. Zhang, J.W. Zhao, L.H. Zhu

Beihang University, RCNP Osaka University,  
Michigan State University/NSCL, Osaka University,  
Kyoto University, Osaka Institute of Technology

# Experiment @ RCNP

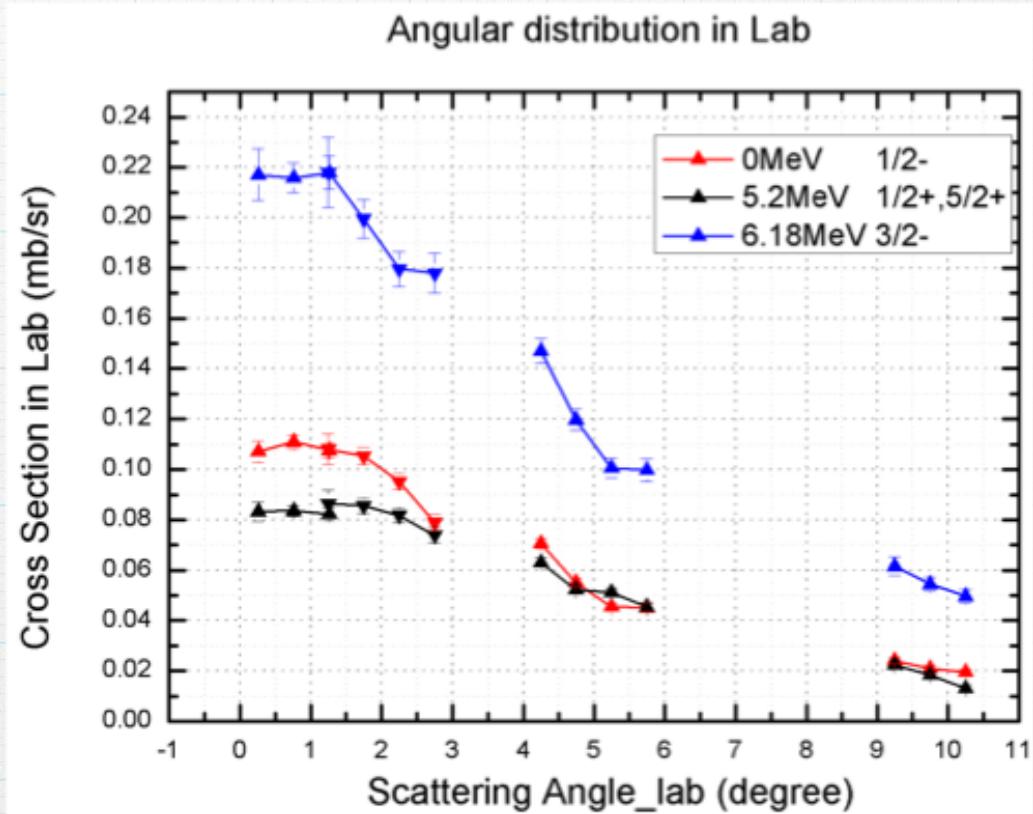
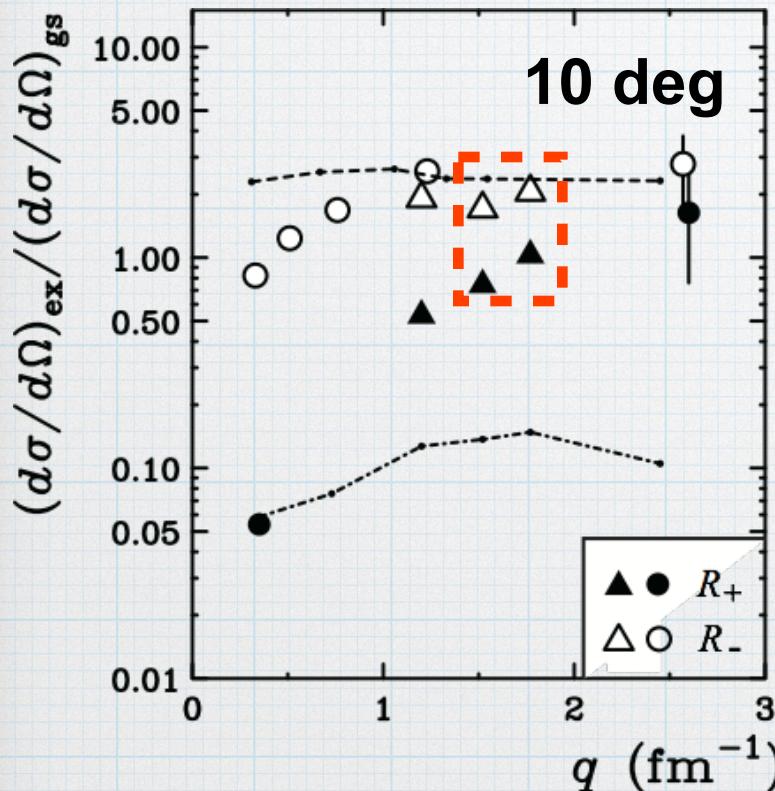
**Grand RAIDEN**  
 $(p/\Delta p \sim 37000)$

M. Fujiwara et al.,  
NIMA422, 484(1999)



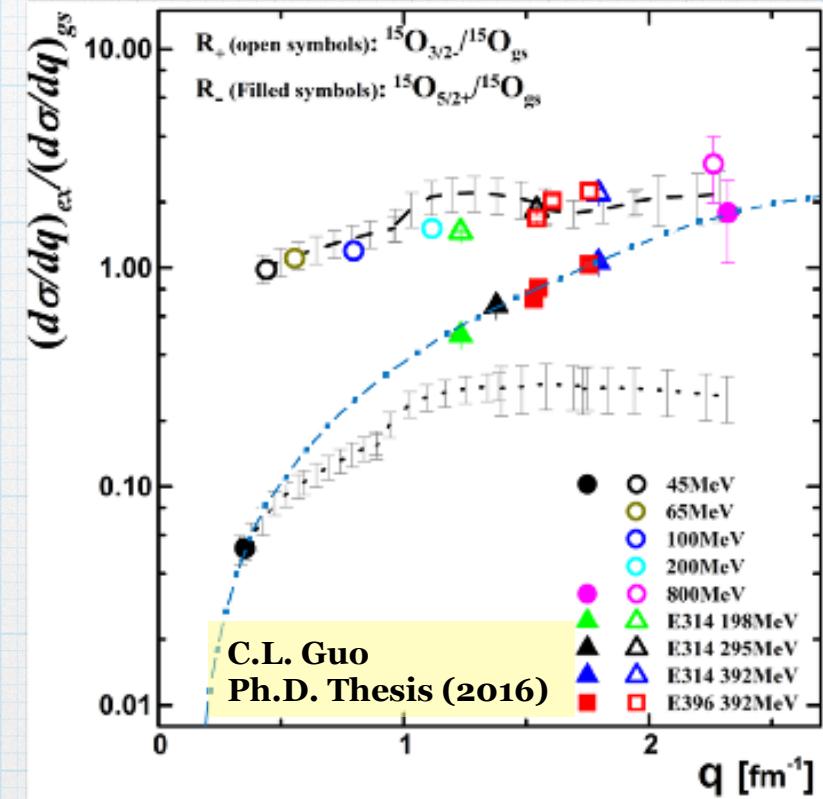
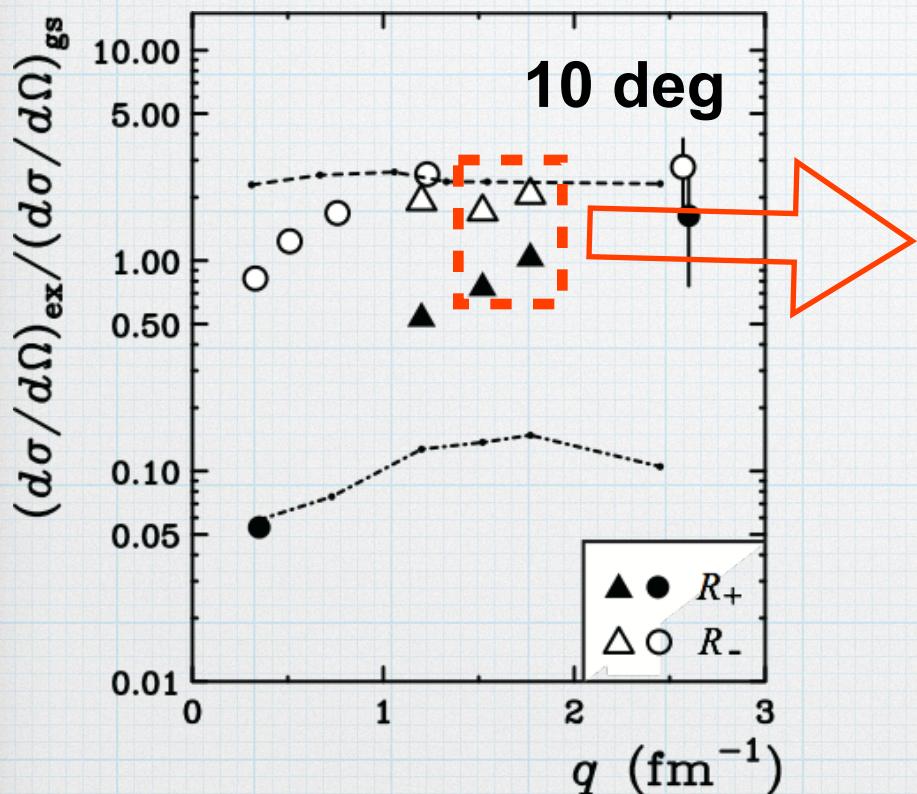
[RCNP-E396]

# $^{16}\text{O}(\text{p},\text{d})$ reactions at forward angles with 392 MeV proton beam



[RCNP-E396]

# $^{16}\text{O}(\text{p},\text{d})$ reactions at forward angles with 392 MeV proton beam



Effect of reaction mechanism is negligible

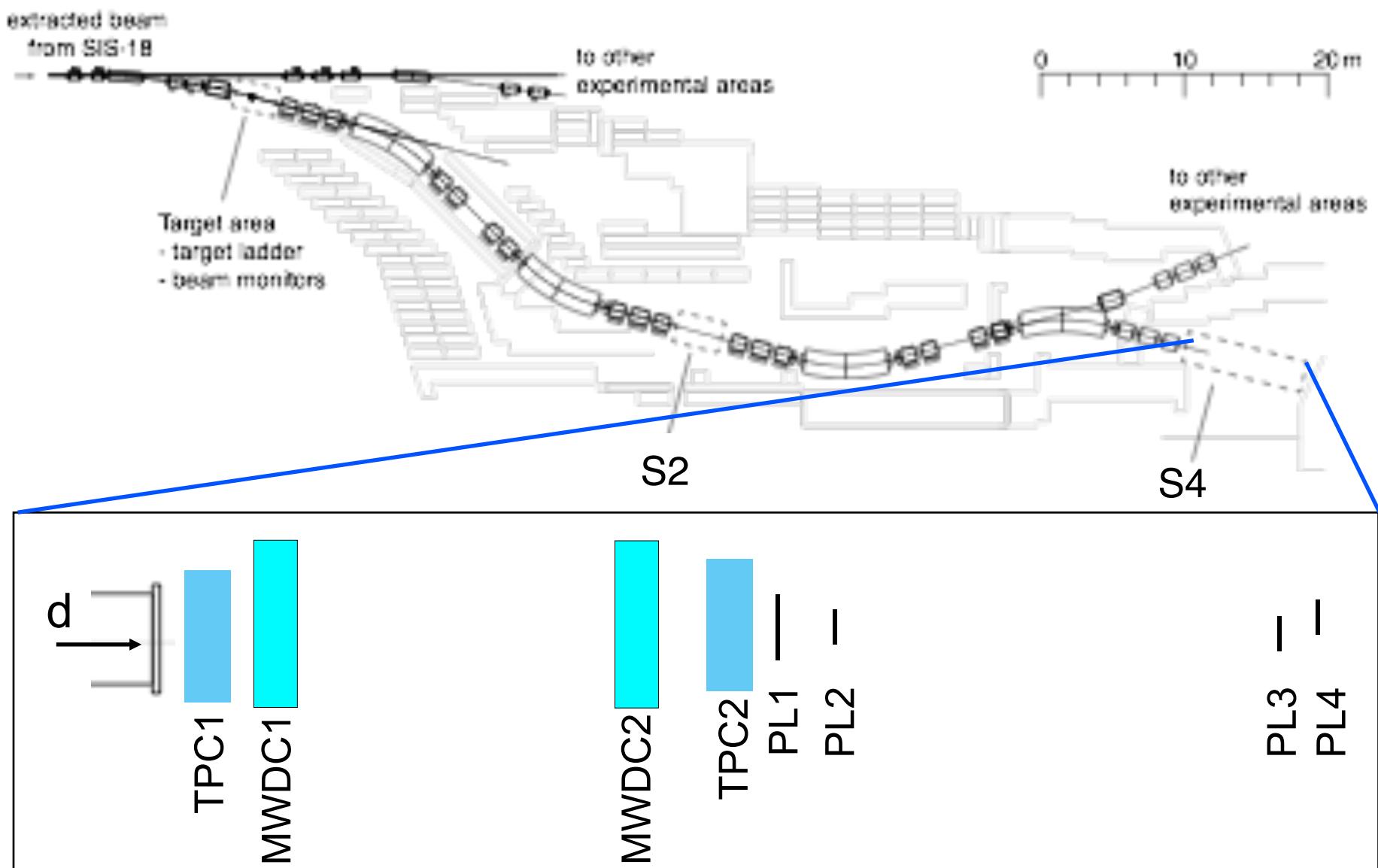
# **NUSTAR Super-FRS collaboration**

H.J.Ong, S. Terashima, I. Tanihata, Y. Ayyad, J. Benlliure, F. Farinon,  
S. Friedrich, H. Fujioka, H. Geissel, J. Gellanki, C.L. Guo, E. Gutz,  
E. Haettner, M.N. Harakeh, R.S. Hayano, C. Hornung, K. Itahashi,  
N. Kalantar-Nayestanaki, R. Kanungo, R. Knoebel, K. Miki, I. Mukha,  
T. Myo, T. Nagae, M. Nanova, T. Neff, T. Nishi, C. Nociforo, K. Ogata,  
D.Y. Pang, S. Pietri, A. Prochazka, C. Rappold, M.P. Reiter,  
J.L.Rodriguez-Sanchez, C. Scheidenberger, H. Simon, B. Sitar,  
P. Strmen, B.H. Sun, K. Suzuki, I. Szarka, M. Takechi, Y. Tanaka,  
H. Toki, H. Weick, J.S. Winfield, X.D. Xu, D. Yamakami, J.W. Zhao

RCNP Osaka University, Beihang University, Michigan State University/NSCL,  
University of Santiago de Compostela, GSI, University Giessen,  
Kyoto University, KVI-CART University of Groningen, The University of Tokyo,  
RIKEN Nishina Center, TRIUMF and Saint Mary's University,  
Osaka Institute of Technology, Comenius University Bratislava,  
Stefan Meyer Institut fur Subatomare Physik, Niigata University

[NUSTAR Super-FRS]

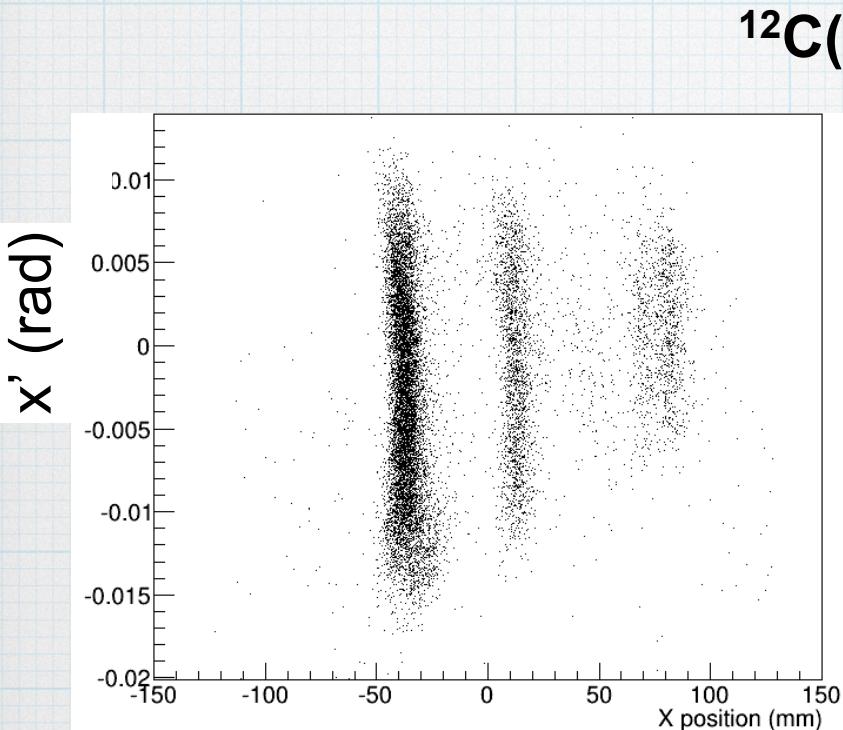
# Experiment @ GSI-FRS



[NUSTAR Super-FRS]

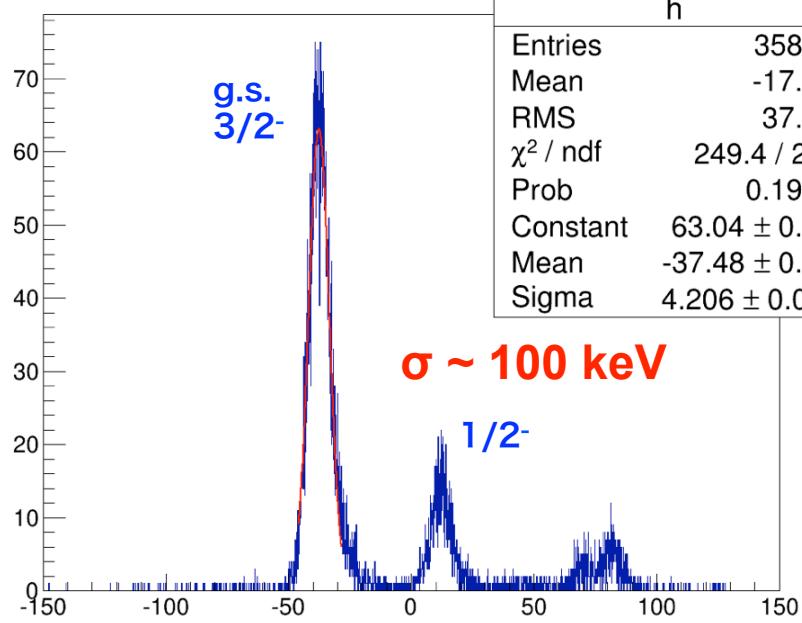
# $^{16}\text{O}(\text{p},\text{d})$ , $^{12}\text{C}(\text{p},\text{d})$ reactions at forward angles with 400 - 1200 MeV/u proton beams

Proton beam @400 MeV/u, with 107 mg/cm<sup>2</sup>  $^{nat}\text{C}$  target



FRS CalibrEvent.focal\_plane

h	
Entries	35872
Mean	-17.38
RMS	37.06
$\chi^2 / \text{ndf}$	249.4 / 231
Prob	0.1929
Constant	$63.04 \pm 0.92$
Mean	$-37.48 \pm 0.05$
Sigma	$4.206 \pm 0.051$

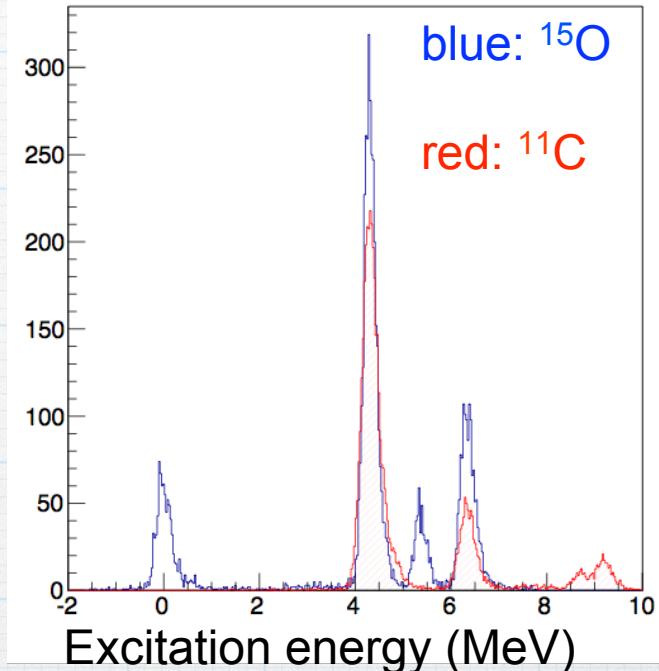
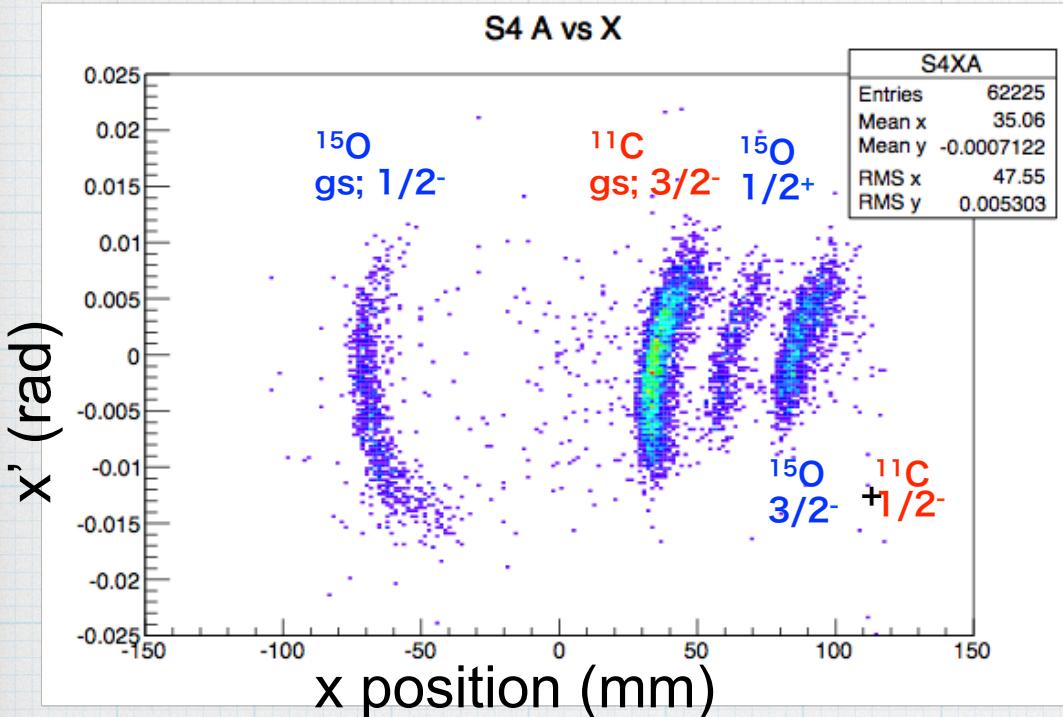


Horizontal position @ focal plane [mm]

**Sufficient resolution achieved**

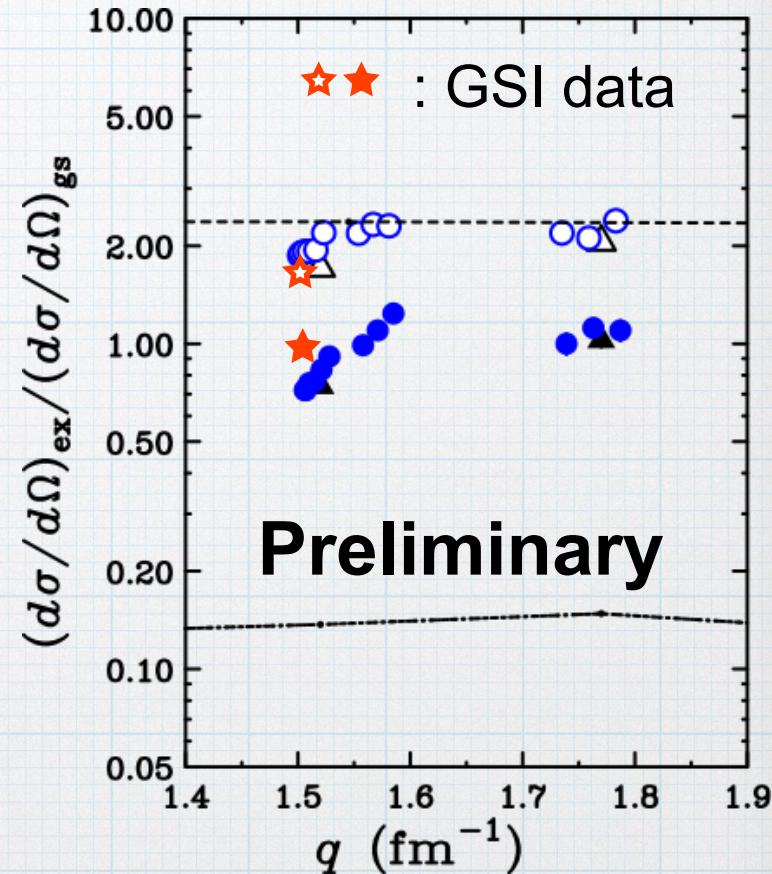
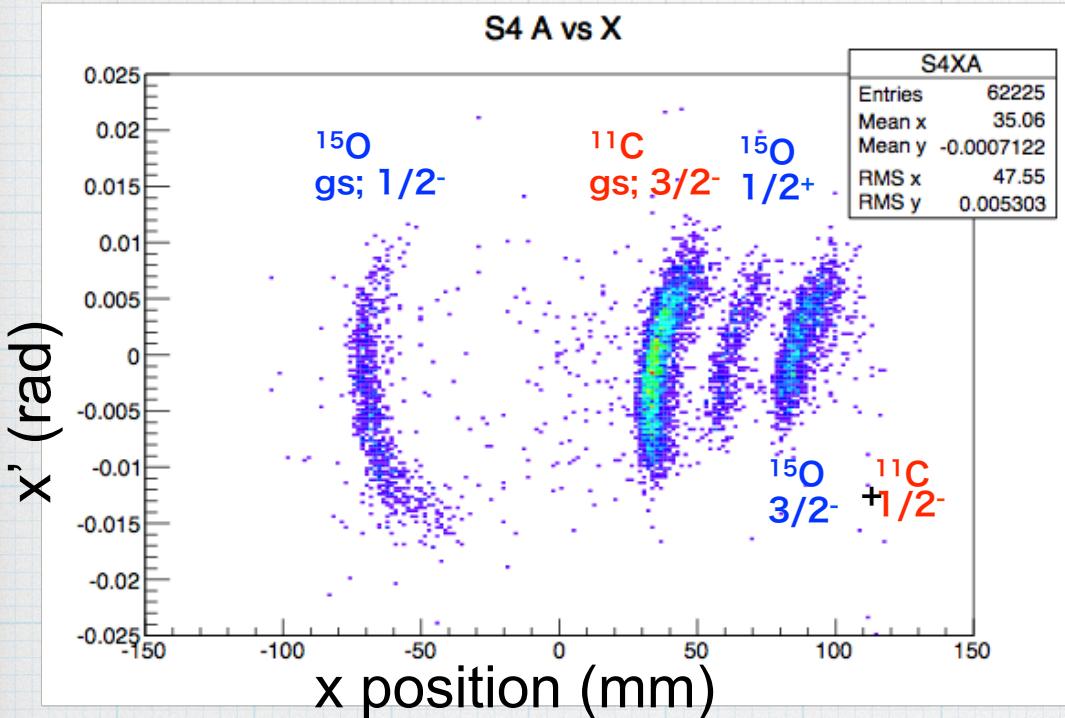
# [NUSTAR Super-FRS]

## Results for $^{16}\text{O}(\text{p},\text{d})$ @ 400 MeV/u



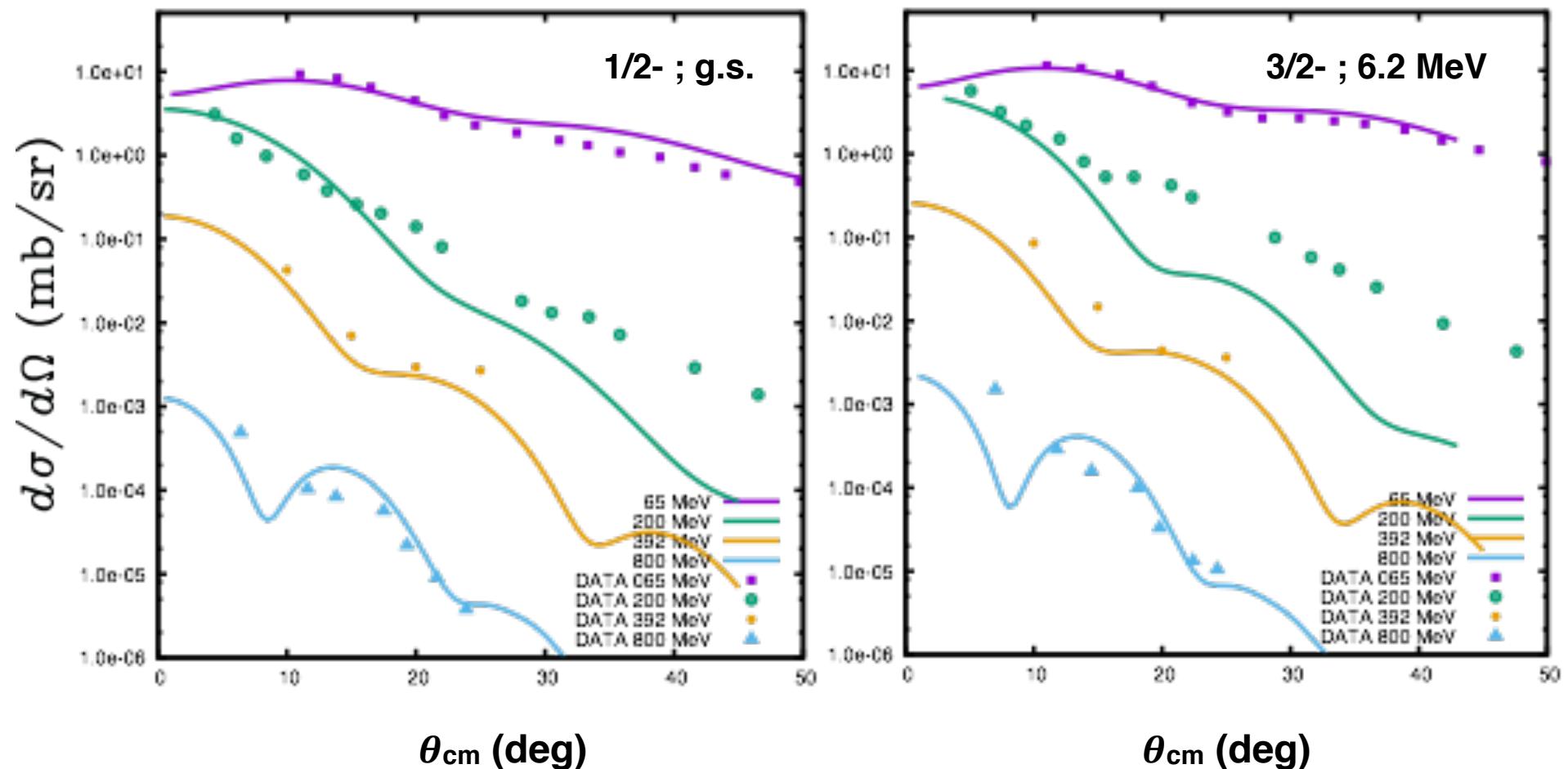
[NUSTAR Super-FRS]

# Results for $^{16}\text{O}(\text{p},\text{d})$ @ 400 MeV/u



Ratios consistent with RCNP data

# Reaction Analysis



# Summary

- We have performed (p,d) reaction at around 0 degrees on  $^{12}\text{C}$  and  $^{16}\text{O}$  targets at RCNP and GSI-FRS using proton beams at 400, 600, 900 and 1200 MeV.
- Preliminary results from RCNP and GSI-FRS experiments for  $^{16}\text{O}(\text{p},\text{d})$  at 400 MeV are consistent with earlier results of RCNP experiment.
- Effect of reaction mechanism (angular dependence) is negligible.

## Upcoming experiment

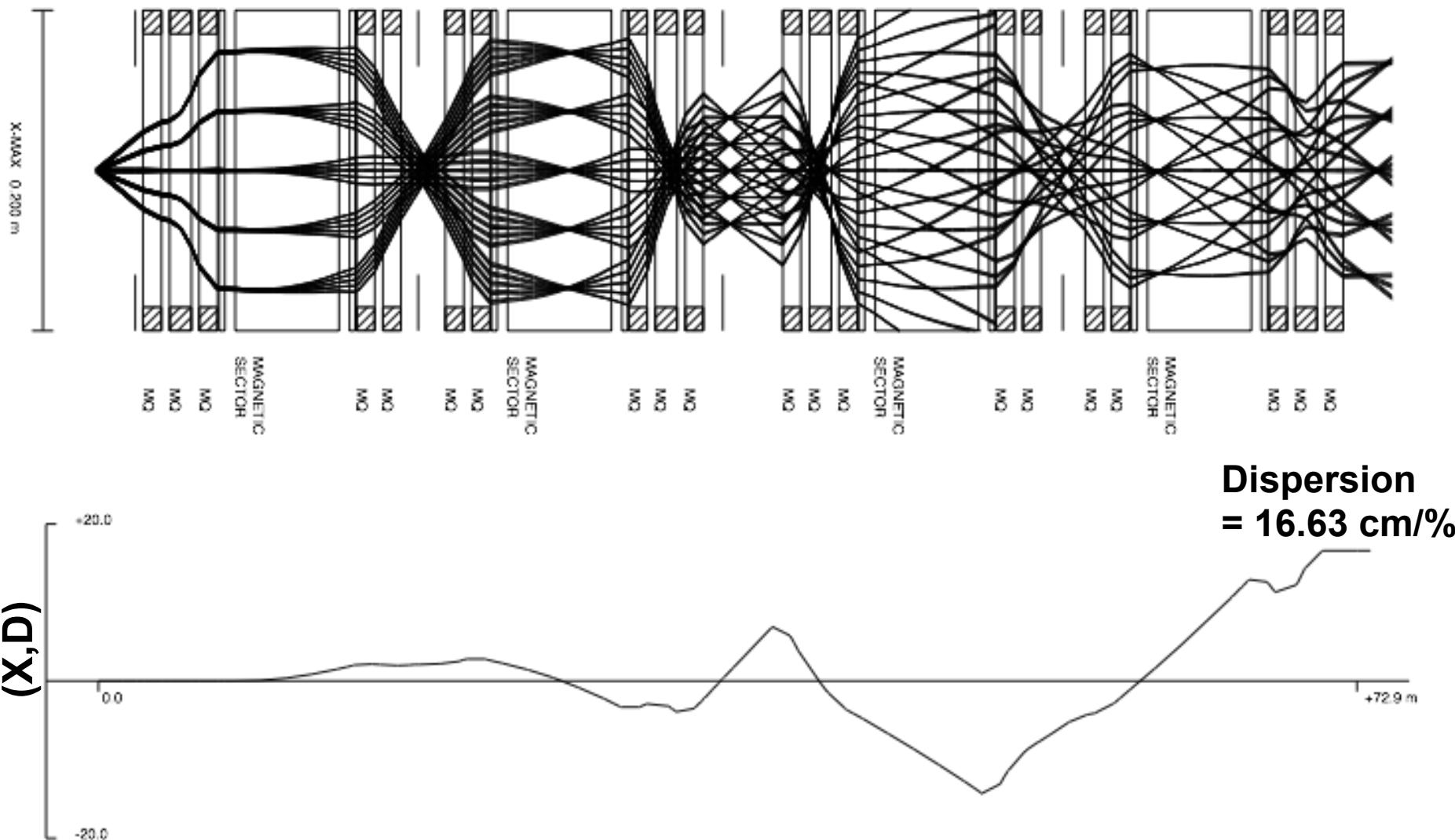
- $^{40,48}\text{Ca}(\text{p},\text{d})$  measurements at 65, 200, 400 MeV

**Thank you very much for your attention!**

[NUSTAR Super-FRS]

# Experiment @ GSI-FRS

S436: Dispersive Spectrometer Mode



# $^{40,48}\text{Ca}(\text{p},\text{d})$ : Final states of interest

