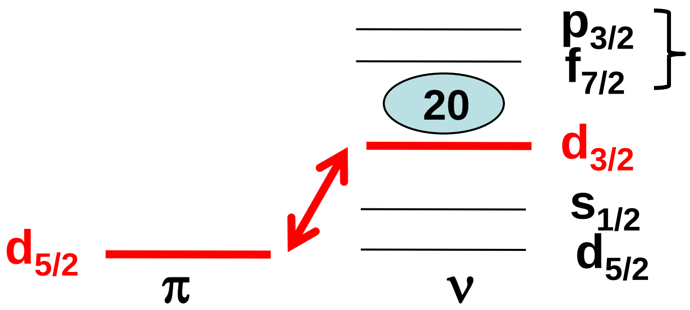
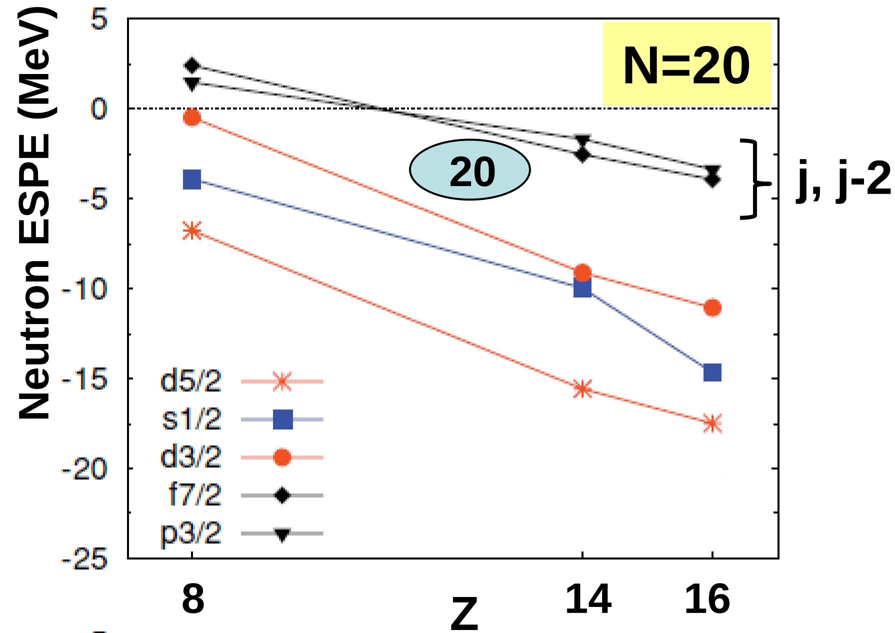
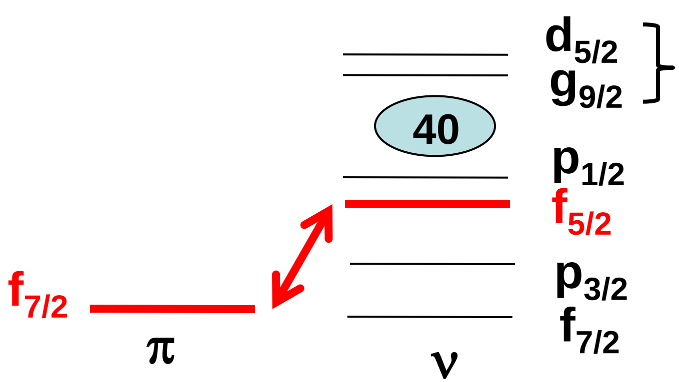
Evolution of Harmonic Oscillator Shell Closures

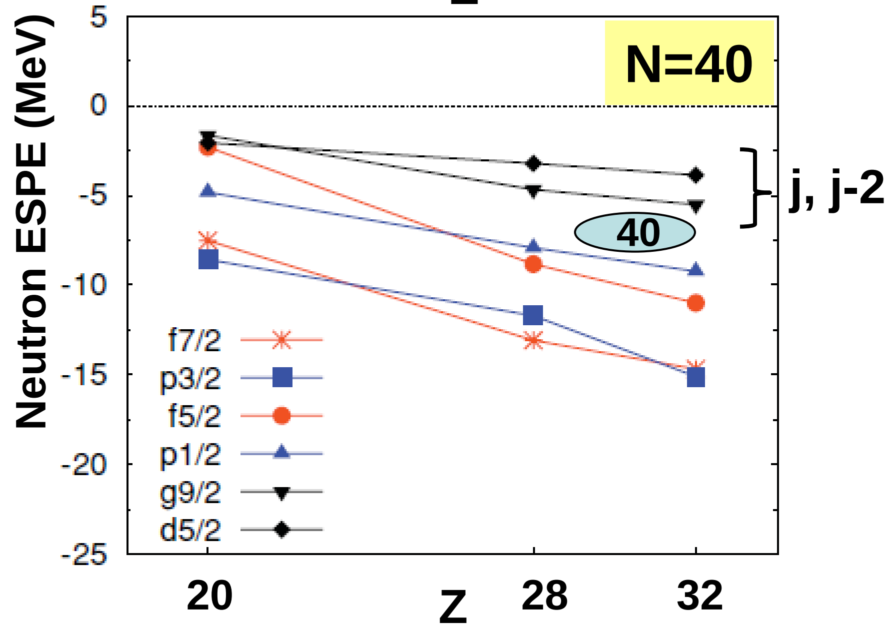




- *reduction of the gap when Z decreases*
- *quasi-degeneracy of a j,j-2 sequence above the fermi surface*

Similar situation for N=40

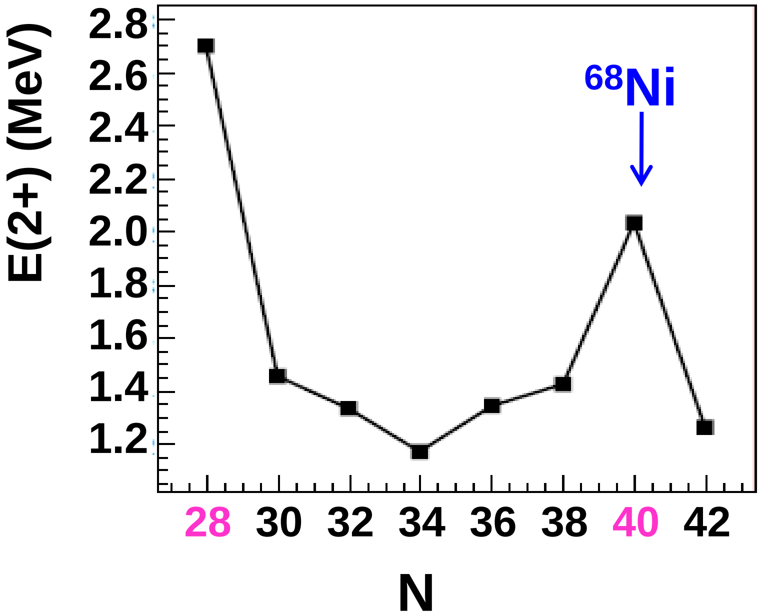


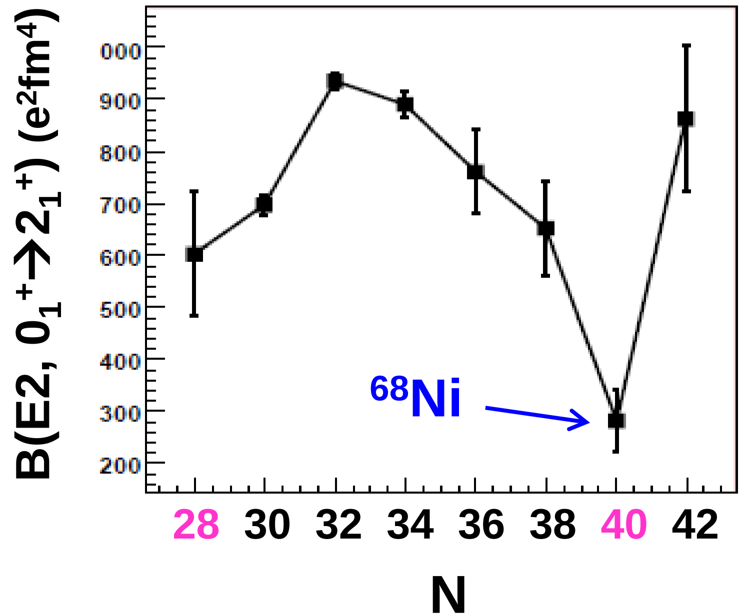


(and also at N=8)

From S.M. Lenzi et al., PRC 82 (2010)

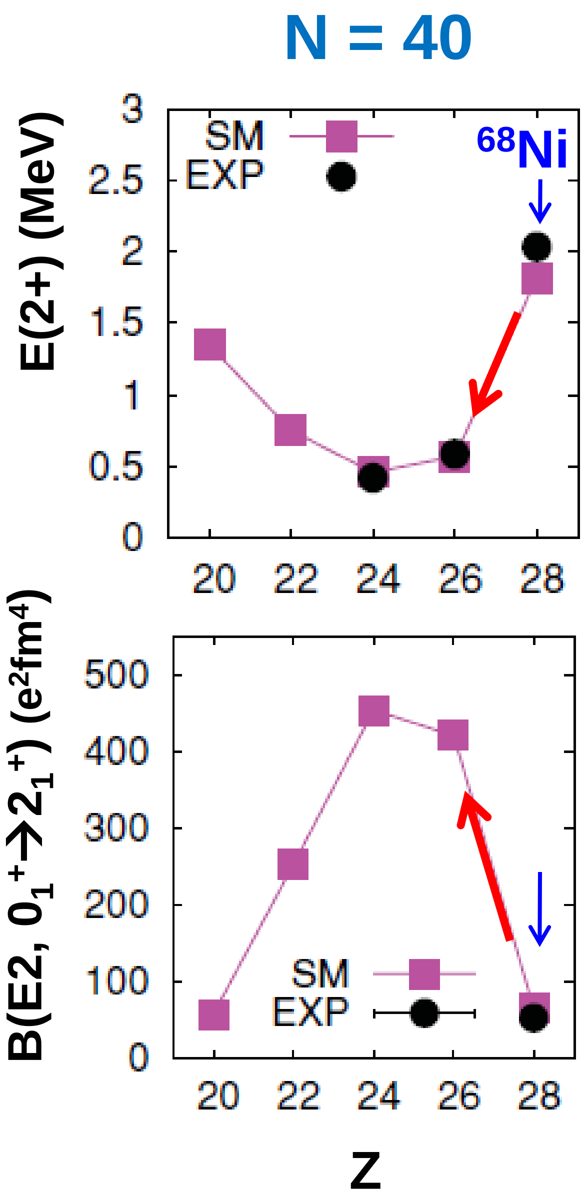
The Nickel isotopes





For ^{68}Ni :
- ➢ **Doubly magic character of E(2+)/B(E2)**
- ➢ **No sign of shell closure in neutron separation energy**

Southwest of Nickel's



Large valence space SM calculations

S.M. Lenzi, F.Nowacki, A. Poves, and K. Sieja, PRC 82 (2010)

LPNS interaction

fp shell + $1g_{9/2}$ + $2d_{5/2}$

Nucleus	$\nu g_{9/2}$	$\nu d_{5/2}$	0p0h	2p2h	4p4h	6p6h	E_{corr}
^{68}Ni	0.98	0.10	55.5	35.5	8.5	0.5	−9.03
^{66}Fe	3.17	0.46	1	19	72	8	−23.96
^{64}Cr	3.41	0.76	0	9	73	18	−24.83
^{62}Ti	3.17	1.09	1	14	63	22	−19.62
^{60}Ca	2.55	1.52	1	18	59	22	−12.09

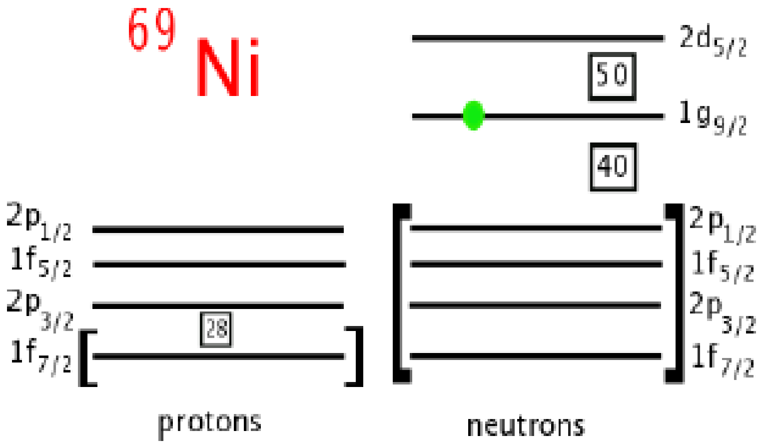
- **Drastic change with only 2 protons removed**
- **Strong gain in correlation energy**

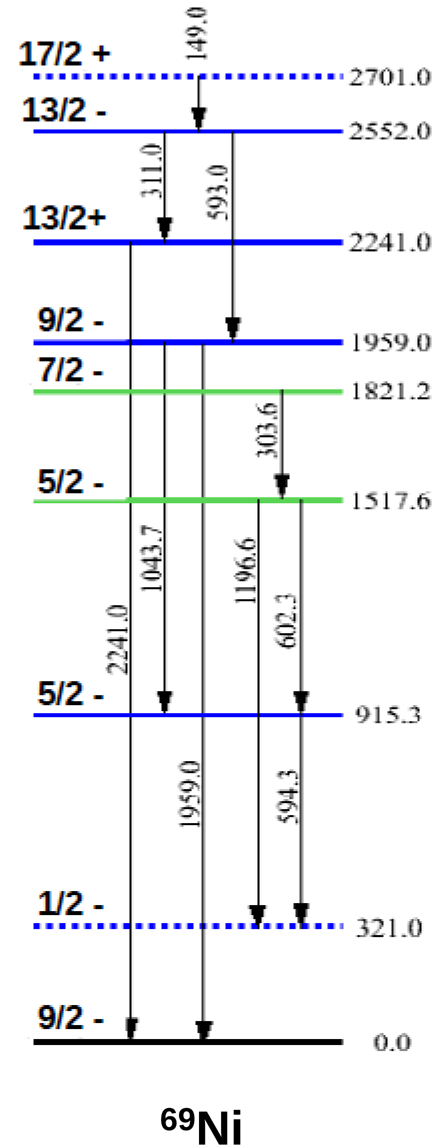
similar to ^{34}Si / ^{32}Mg

New island of inversion

$2d_{5/2}$ plays a major role in the deformation mechanism at N = 40 *Caurier et al. EPJ, A, 15, 2002, 145*

Our approach : the ^{68}Ni(d,p) reaction





<u>**Previous experiments**</u>**:**

- **Isomer-state decay**
  (Grzywacz et al., PRL 81 (1998))
- **β-decay**
  (Mueller et al., PRL83 (1999))
  $2d_{5/2}$ (5/2+) was not observed

We proposed to measure ^{68}Ni(d,p)

- **Selective of single-particle state**
- Promotion of the single neutron from g9/2 g.s. to d5/2

g9/2 – d5/2 gap

Collaboration

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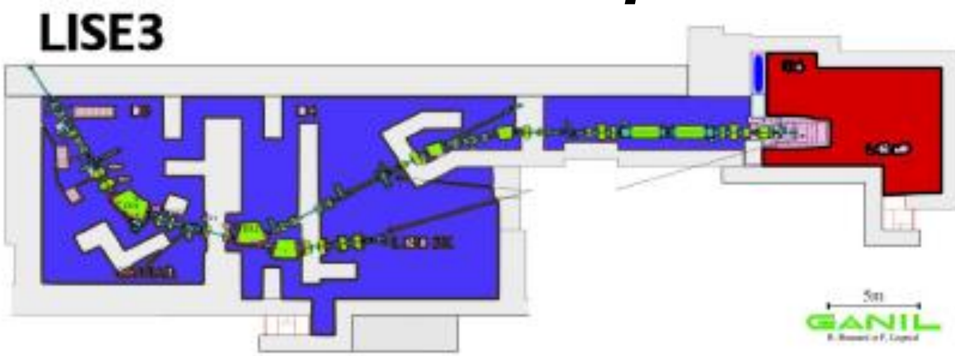
SPhN - Saclay, France

M. N. Harakeh
GSI - Darmstadt, Germany

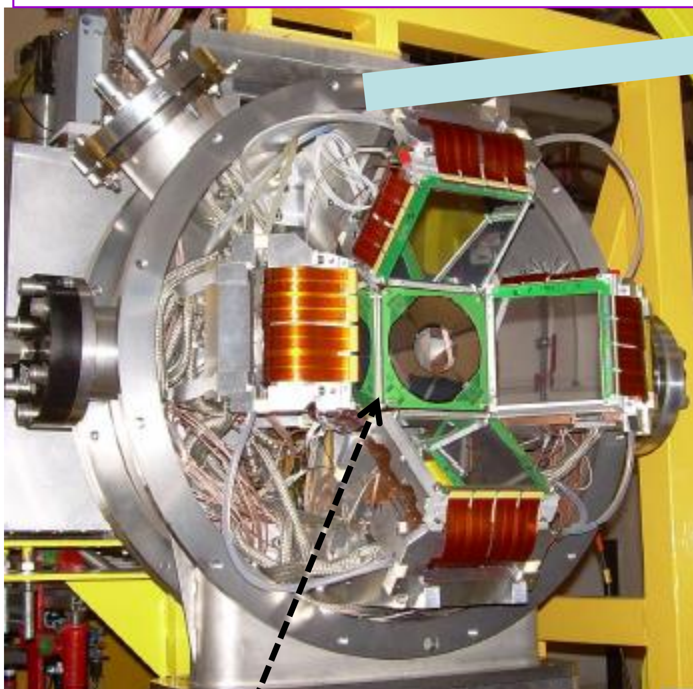
J. Gibelin
LPC - Caen, France

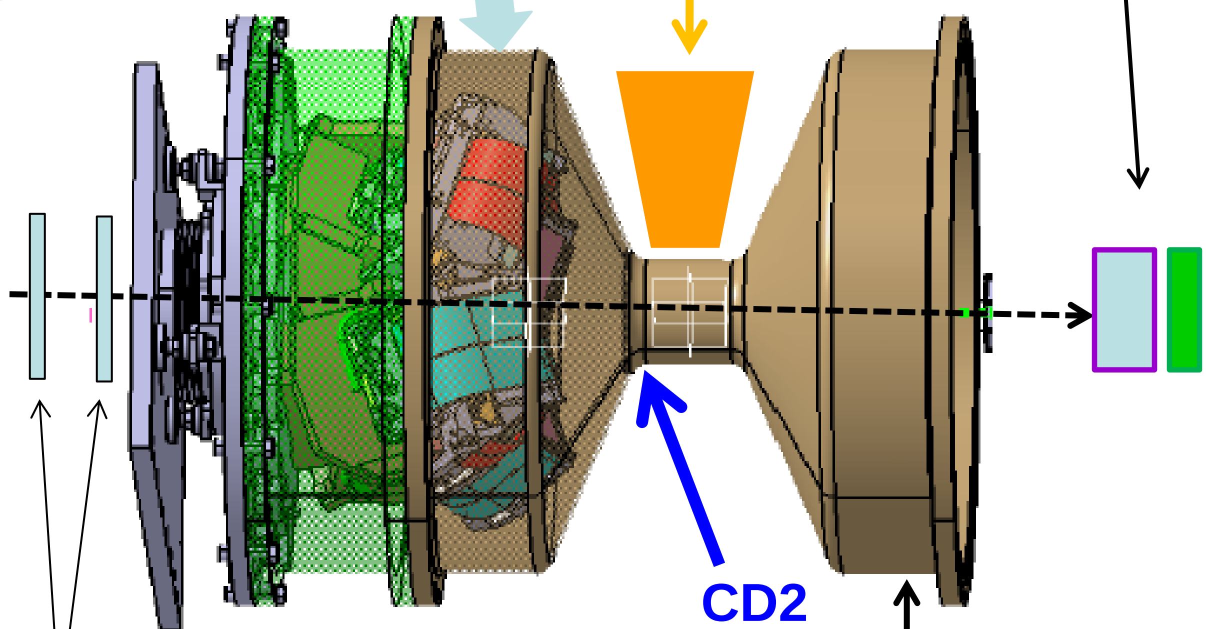
K. Kemper
Florida State University, USA

Experimental setup

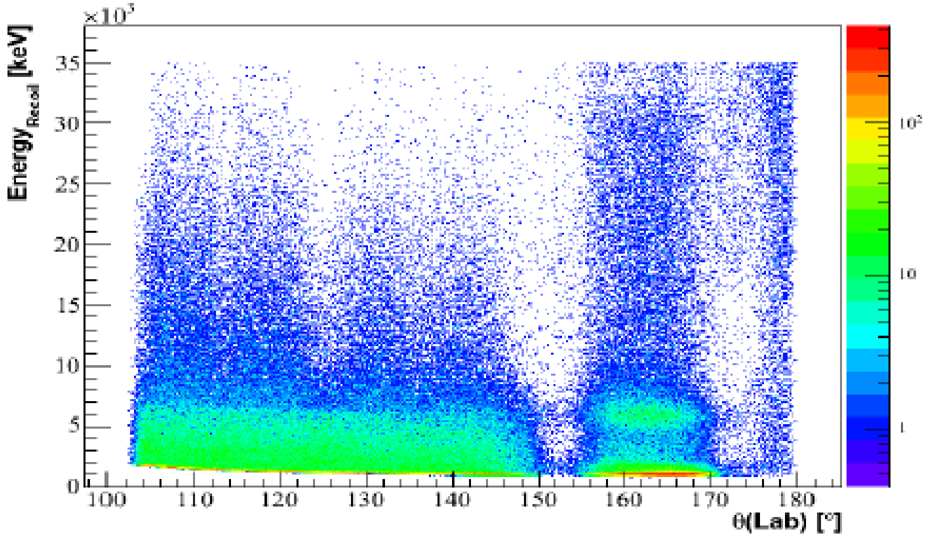


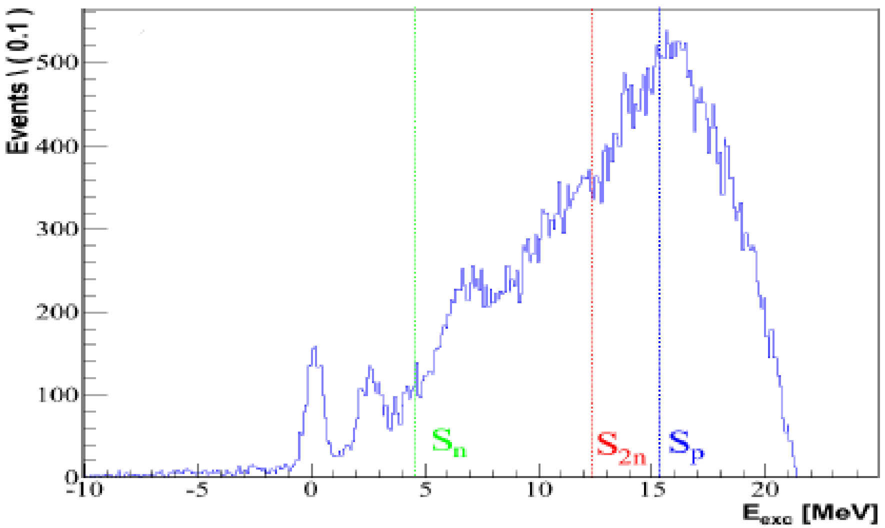
Primary beam: ^{70}Zn
^{68}Ni @ 25 MeV/u, rate: ~8.10^{4} pps
Purity : 86%

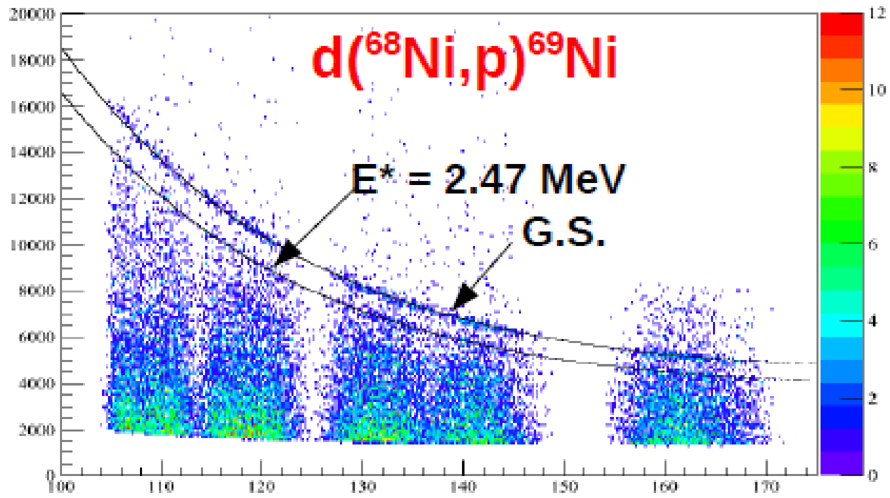




Kinematical plots and E spectrum*



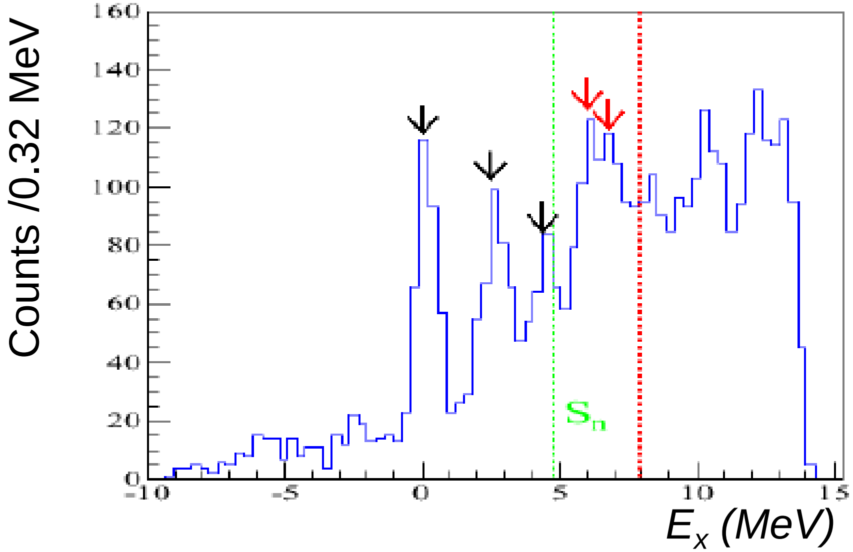


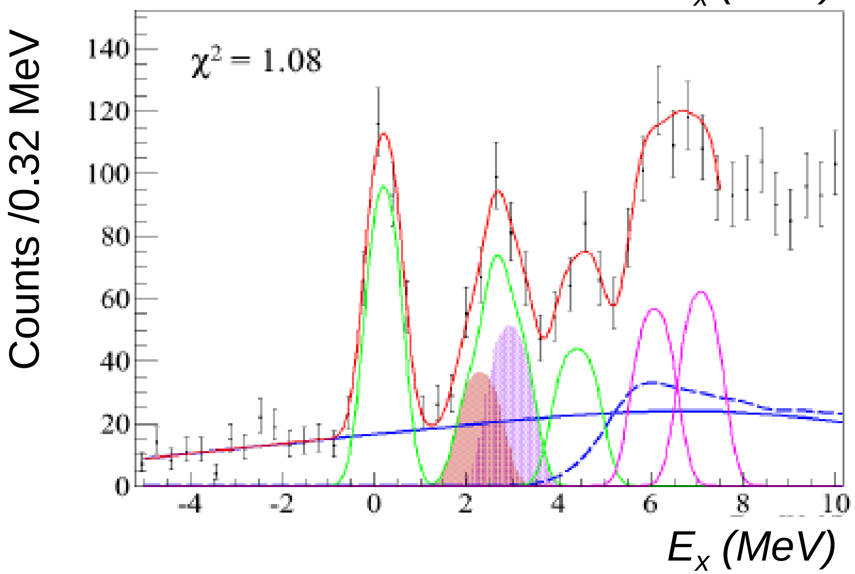


- Pronounced G.S.
- 1st excited state at ~ 2.5 MeV
- Structures ~ 4 MeV and 6−7 MeV (> S_n)

Excitation energy spectrum

Backward (fwd) Lab(CM) angles



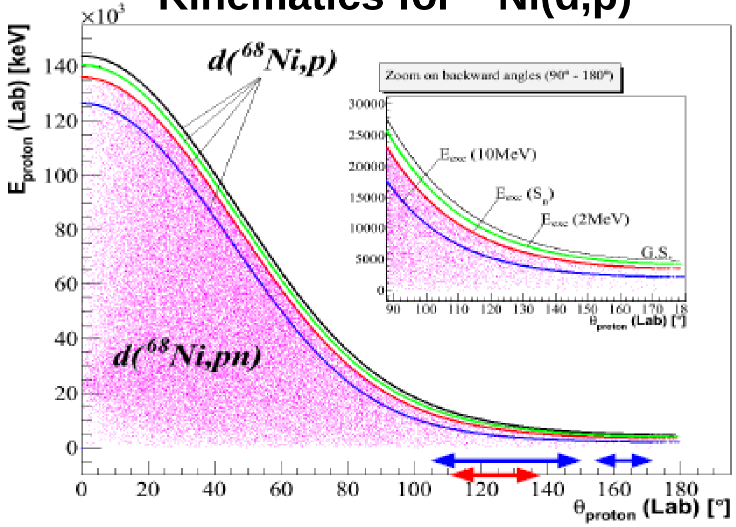


- 3 bound states
- 2 resonances above S_n
- Background reactions (2 different ways)

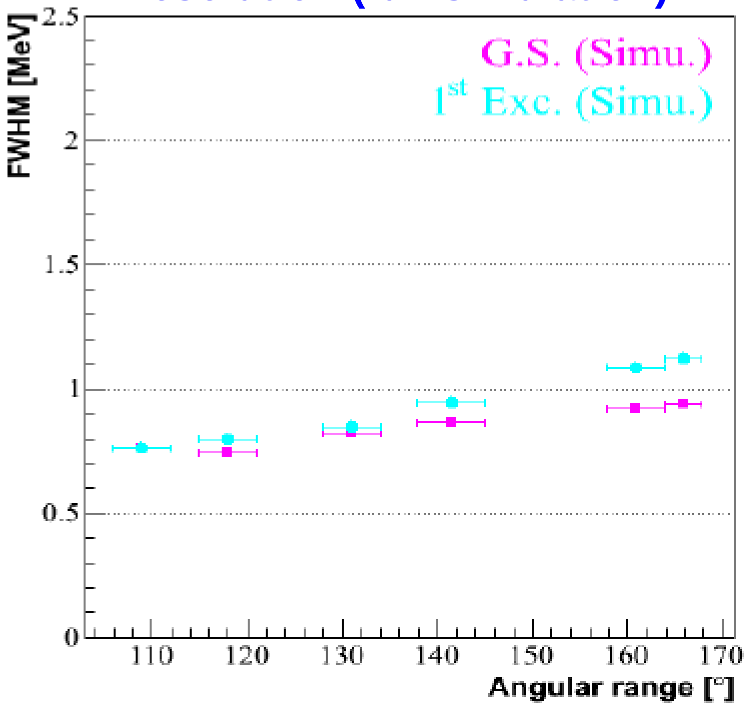
Pic #	Energy [MeV]	FWHM [MeV]
G.S	0.00	1.04
1	2.47	**1.43**
2	4.19	1.27
3	5.88	1.39
4	6.89	1.39

Evidence for a doublet state at E*~2.5MeV

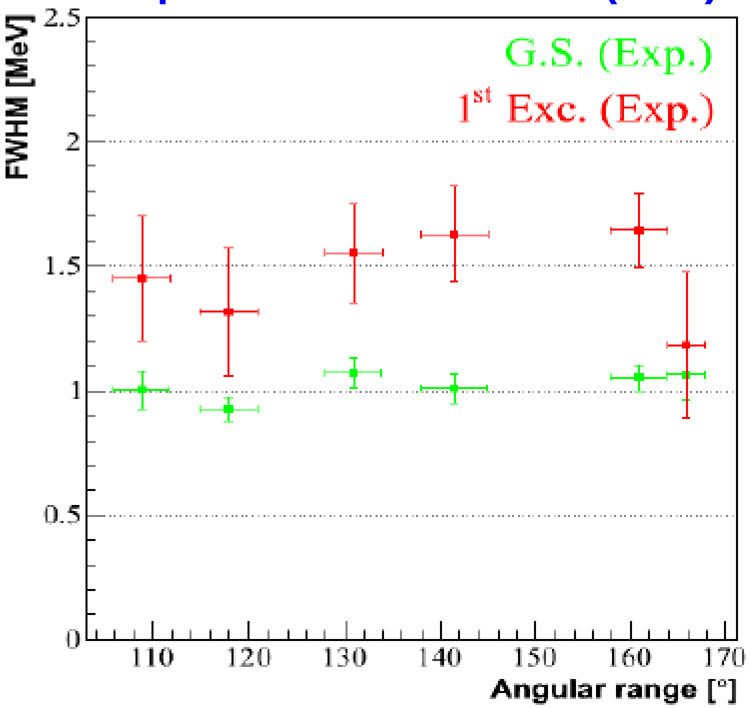
Kinematics for ^{68}Ni(d,p)



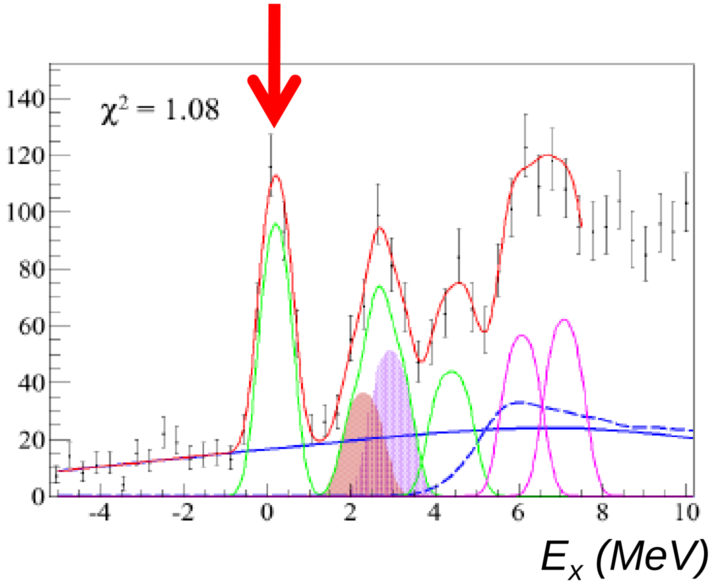
resolution (full simulation)

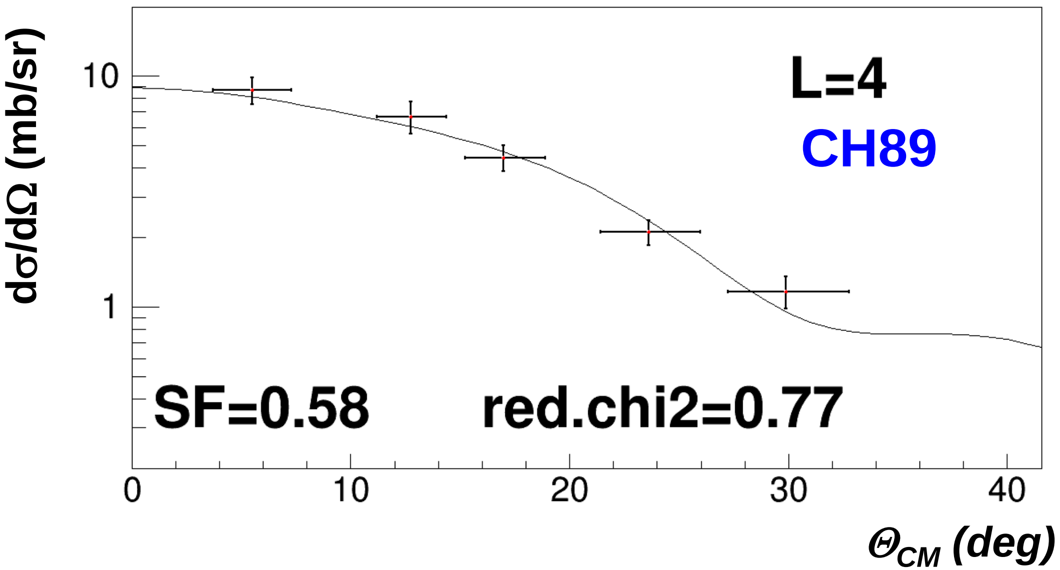


Experimental resolution (data)

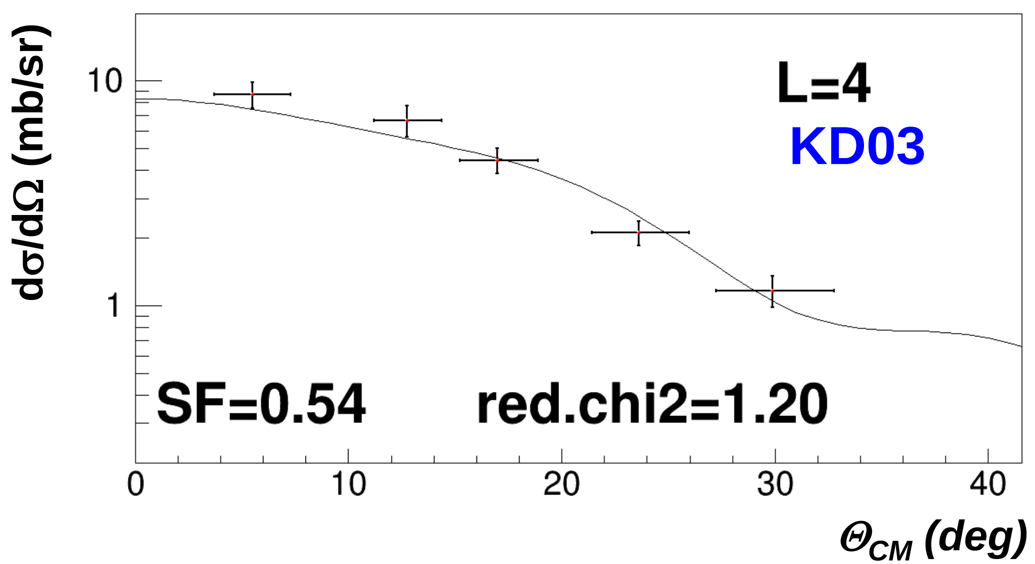


Differential cross-sections for ground-state





0 keV

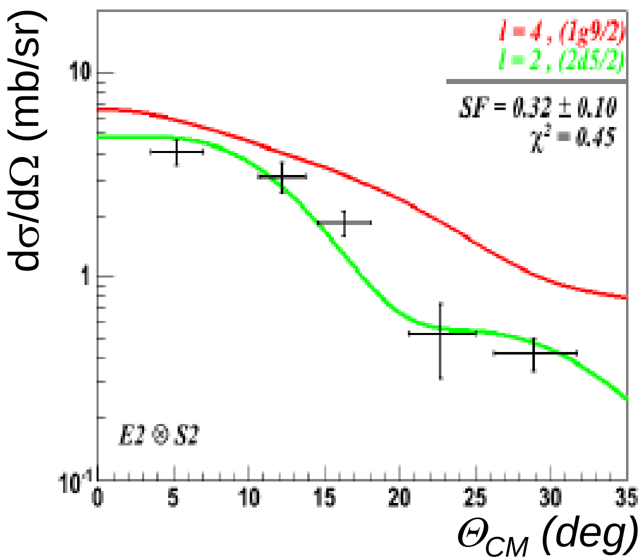


ADWA calculations
Code TWOFNR
L = 0,1,2,4
Proton potentials :
CH89 and KD03

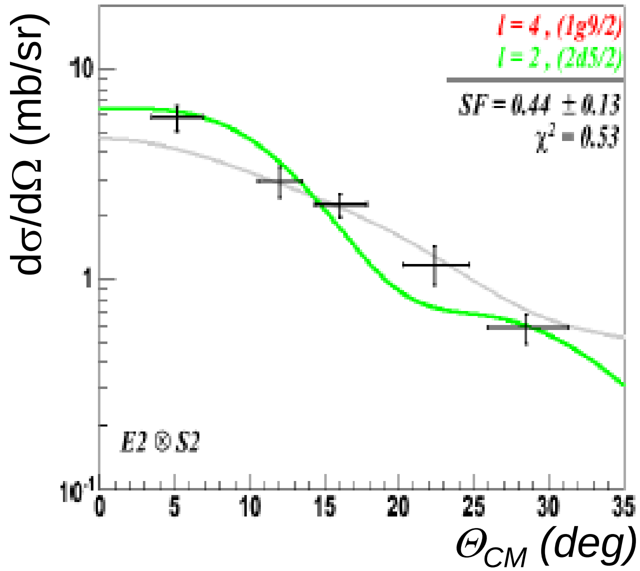
- **Weak dependence on the exit channel pot.**
- **Significant dependence on the entrance pot.**

Differential cross-sections: 1st excited peak

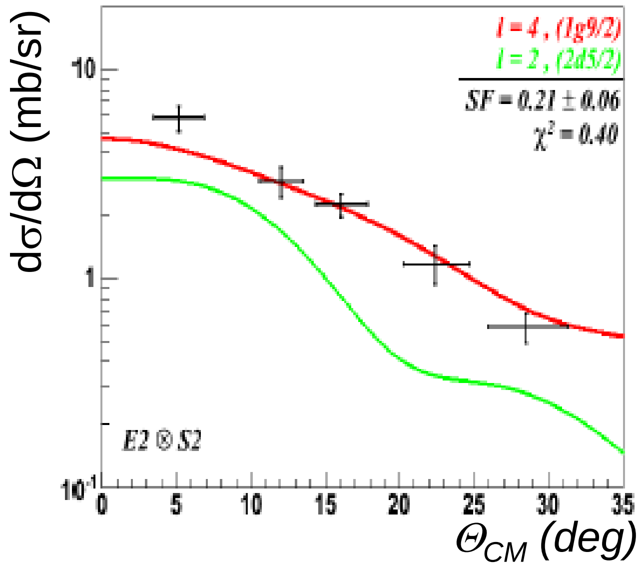
E_x = 2.05 MeV



E_x = 2.74 MeV



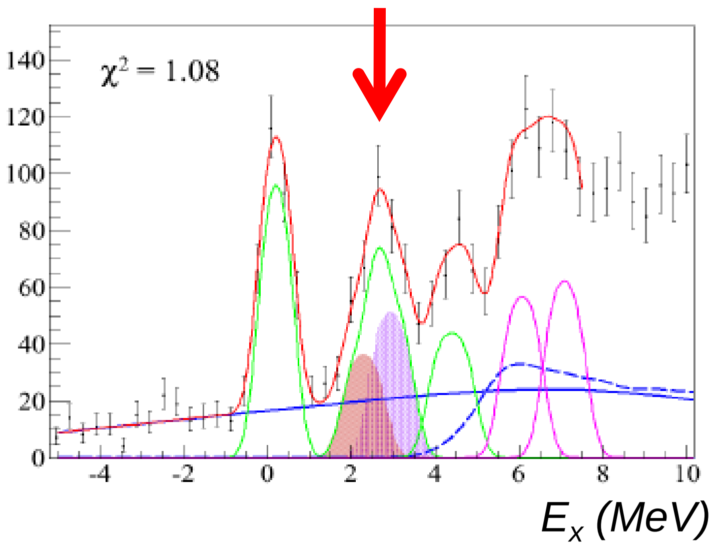
L=2
C^2S = 0.44 ± 0.13

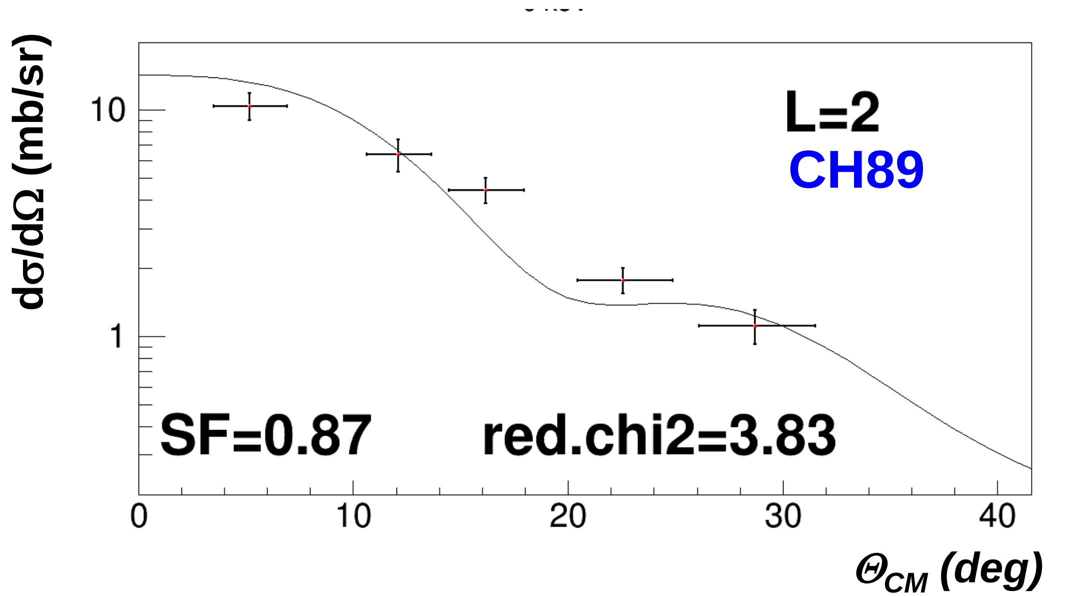


L=4
C^2S = 0.21 ± 0.06

We favor the interpretation in terms of two l=2 fragments

Differential cross-sections at Ex~2.5 MeV





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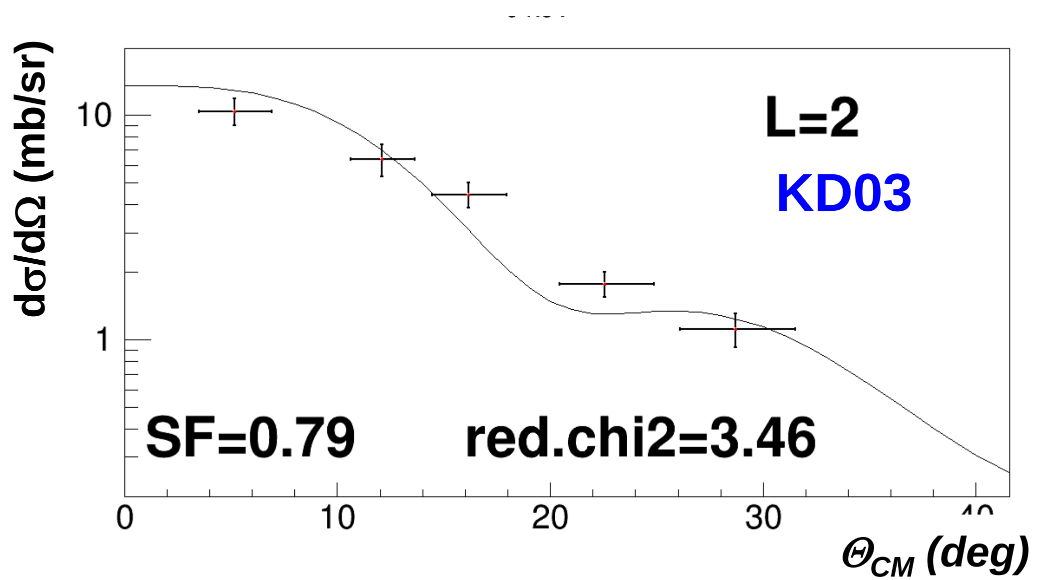

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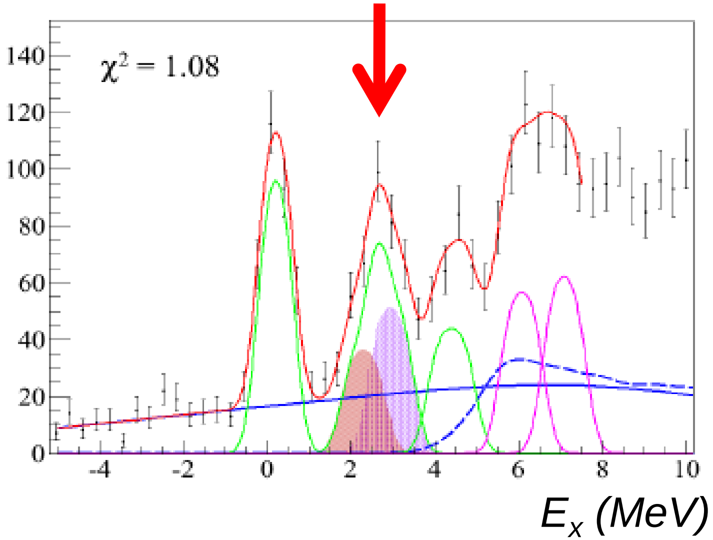
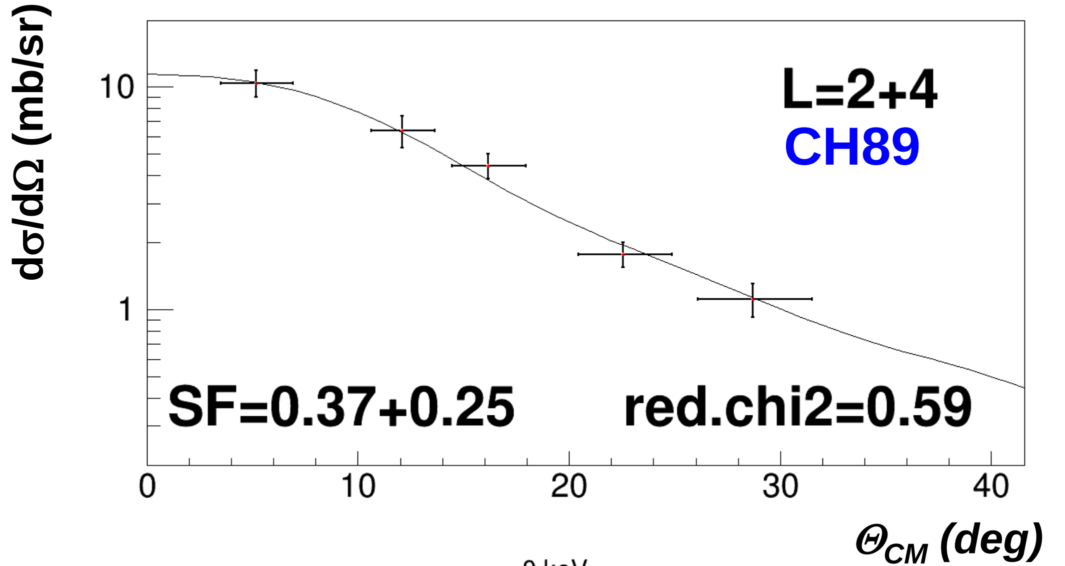
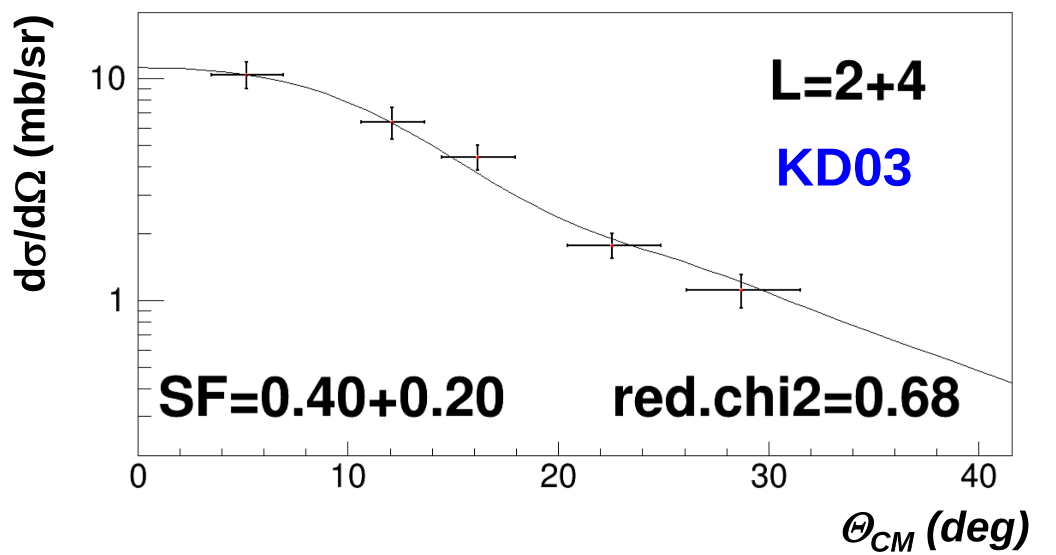
Differential cross-sections at Ex~2.5 MeV





0 keV



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