# Measurement of the Giant Monopole and Quadrupole Resonances in $^{68}$Ni using Maya Active Target

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Colloque GANIL
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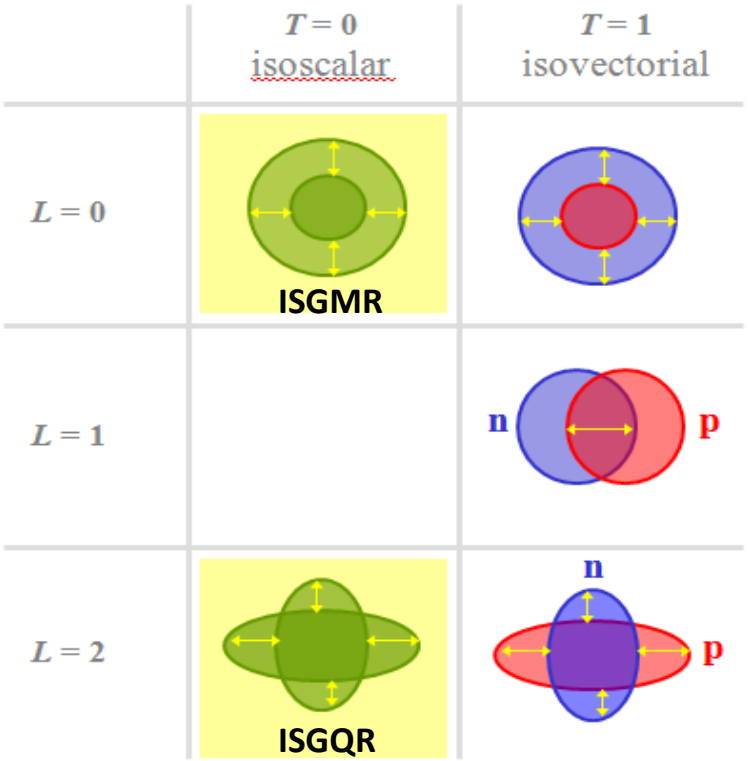
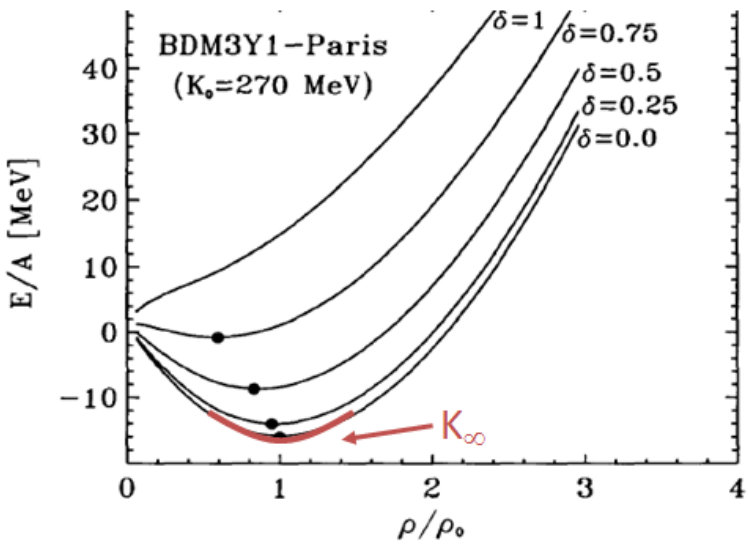
# Contents

# Giant Resonances

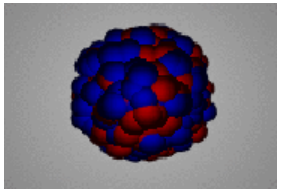



- Compression modulus of the nucleus can be related to nuclear matter incompressibility $K_\infty$
- $K_\infty$ has been well determined for symmetric matter
- Concerning asymmetric matter, data is missing

δ=(N-Z)/A




ISGMR

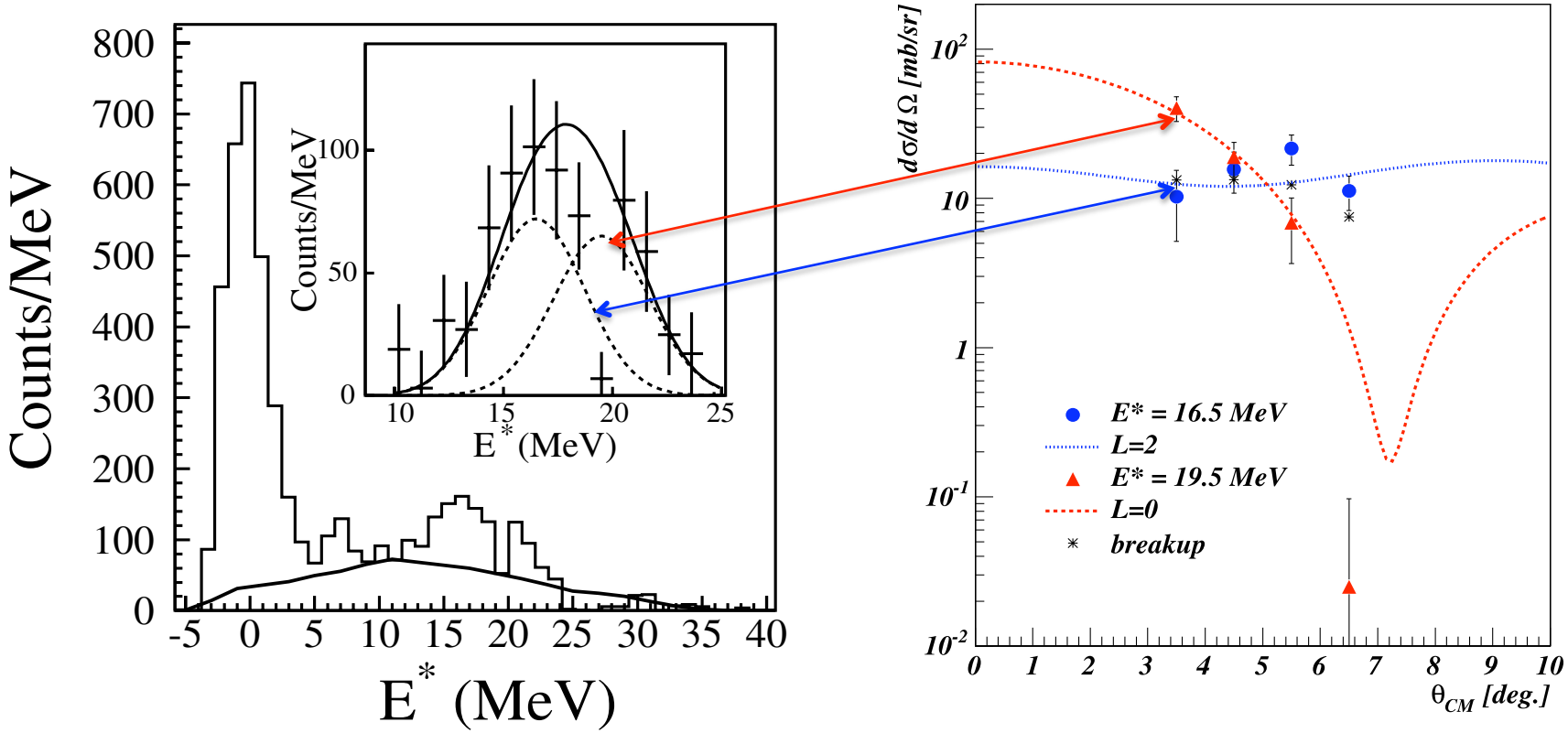


Determination of the compression modulus of the nucleus

# Status of GR in Exotic Nuclei

- Understand these excitation modes from stable to exotic nuclei : the IVGDR has been measured in $^{68}$Ni, neutron rich Oxygen and Tin isotopes at GSI, in $^{26}$Ne at Riken

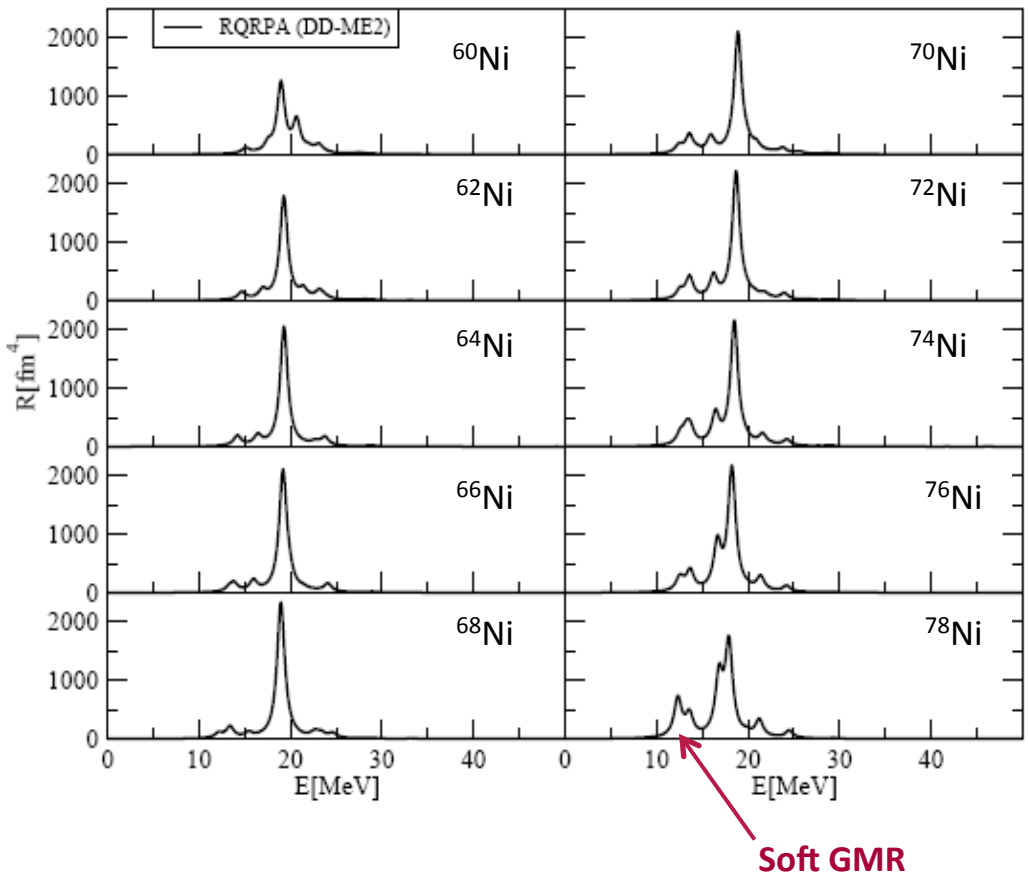
- 1st measurement of the ISGMR and ISGQR in unstable nuclei $^{56}$Ni : $^{56}Ni + d \rightarrow d' + {}^{56}Ni^*$

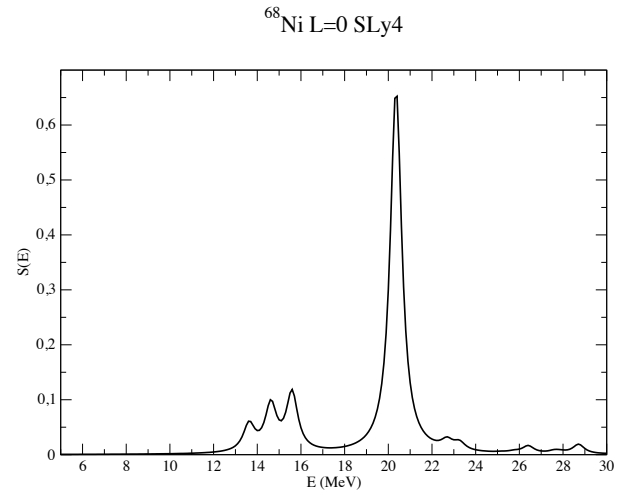


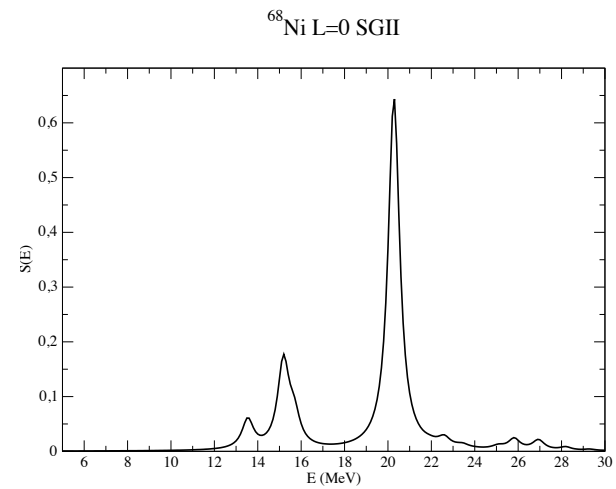

C. Monrozeau *et al.*, *Phys. Rev. Lett.* **100,** 042501 (2008)

# Soft GMR in neutron rich Ni isotopes

- Prediction of Monopole strength in Ni neutron rich isotope




E. Khan, N. Paar and D. Vretenar, *Phys. Rev. C.* **84**, 051301 (2011)

**Study ISGMR in a neutron-rich Ni : $^{68}$Ni**

# The Active Target MAYA

$^{68}$Ni is an exotic nucleus, we have to consider :
- Inverse kinematic with a low recoiling energy
- Low production rate

Use of an Active Target :
- low detection threshold
- thick target

| Beam @ Energy (A.MeV) | Facility | Reaction | Gas | Pressure (mbar) | Aim | |
|---|---|---|---|---|---|---|
| $^{8}$He @ 3.9 | SPIRAL* | p( $^{8}$He, $^{8}$He)p | $C_4H_{10}$ | 1 $10^3$ | | NIM 583, 341 (2007) |
| $^{8}$He @ 15.4 | SPIRAL* | $^{12}$C( $^{8}$He, $^{7}$H) $^{13}$N | $C_4H_{10}$ | 30 | $^{7}$H | PRL 99, 062502 (2007) |
| $^{25,26}$F @ 50 | SISSI* | d( $^{25,26}$F,X) $^{3}$He | D2 | 2.2 $10^3$ | | |
| $^{56}$Ni @ 50 | SISSI* | d( $^{56}$Ni, $^{56}$Ni$^*$)d | D2 | 1 $10^3$ | GMR | PRL 100, 042501 (2008) |
| $^{11}$Li @ 3.6 | ISAC2† | p( $^{11}$Li, $^{9}$Li)t | $C_4H_{10}$ | 100-600 | | PRL 100, 192502 (2008) |
| $^{9}$Li @ 3.6 | ⋮ | p( $^{11}$Li, $^{10}$Li)d | | | | PRC 79, 031603 (2009) |
| $^{9}$Li @ 3.6 | ⋮ | p( $^{11}$Li, $^{11}$Be)n | | | | |
| $^{36}$Ar @ 3.0 | CIME* | $\alpha$( $^{36}$Ar, $^{36}$Ar$^*$)$\alpha$ | He/$CF_4$ | ? $10^3$ | TEST | |
| $^{68}$Ni @ 50 | LISE* | d( $^{68}$Ni, $^{68}$Ni$^*$)d | D2 | 1 $10^3$ | GMR | |
| $^{68}$Ni @ 50 | ⋮ | $\alpha$( $^{68}$Ni, $^{68}$Ni$^*$)$\alpha$ | He/$CF_4$ | 0.5 $10^3$ | GMR | |
| $^{56}$Ni @ 50 | LISE* | $\alpha$( $^{56}$Ni, $^{56}$Ni$^*$)$\alpha$ | He/$CF_4$ | 500 | ISGDR | |
| $^{8}$He @ 15.4 | SPIRAL* | $^{19}$F( $^{8}$He,4n+ $^{3}$H) $^{20}$Ne | $CF_4$ | 20 | $^{7}$H | |
| $^{12}$C @ max | ORSAY | $^{12}$C($\alpha$,3$\alpha$)$\alpha$ | He/$CF_4$ | $10^3$ | 3$\alpha$ TEST | |
| $^{12}$Be @ 3. | REX‡ | p( $^{12}$Be, $^{12}$B)n | $C_4H_{10}$ | 100 | $^{13}$Be | |

* GANIL † TRIUMF ‡ ISOLDE

# The Active Target MAYA

$^{68}$Ni is an exotic nucleus, we have to consider :
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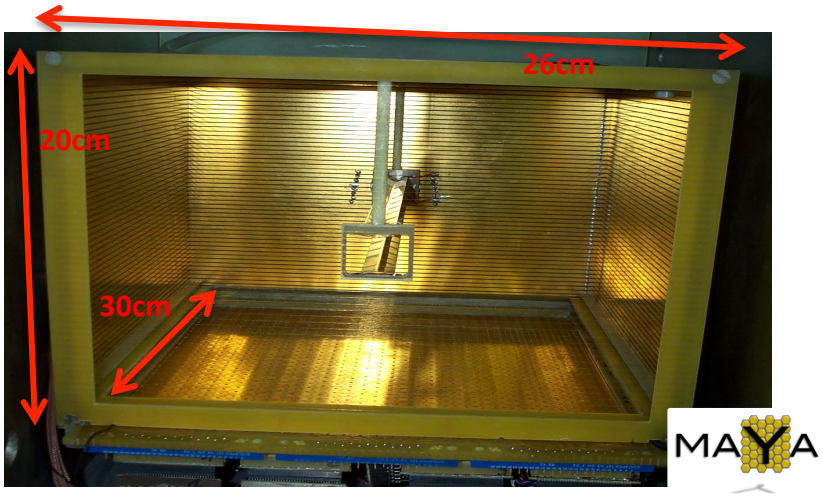
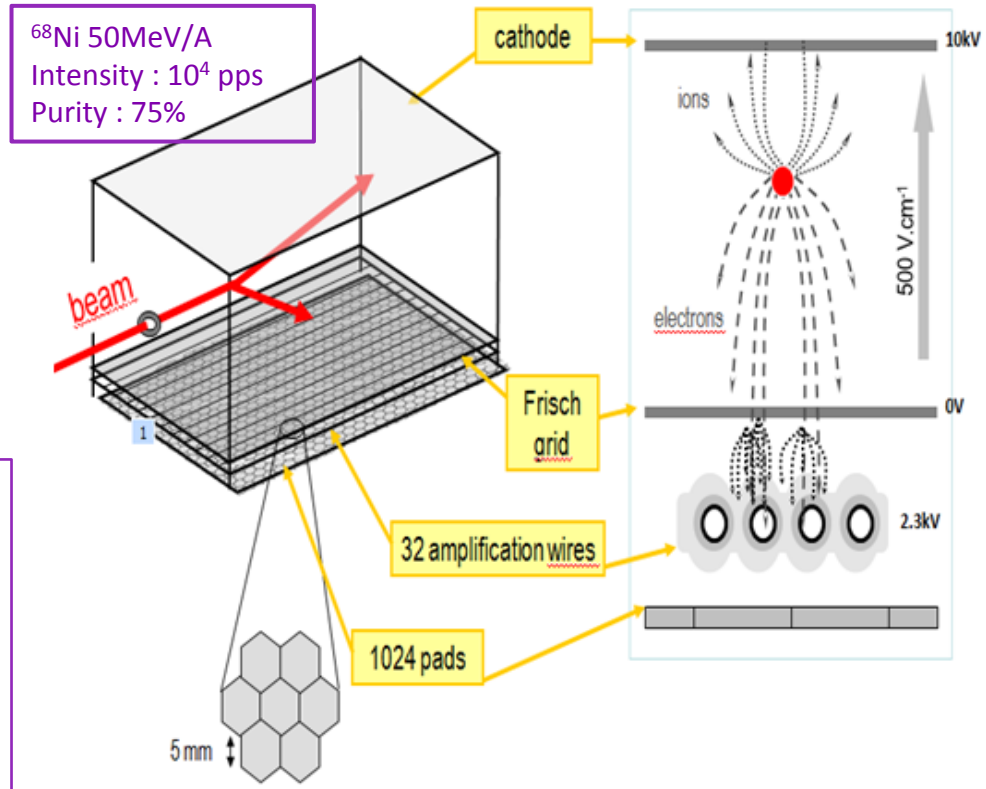


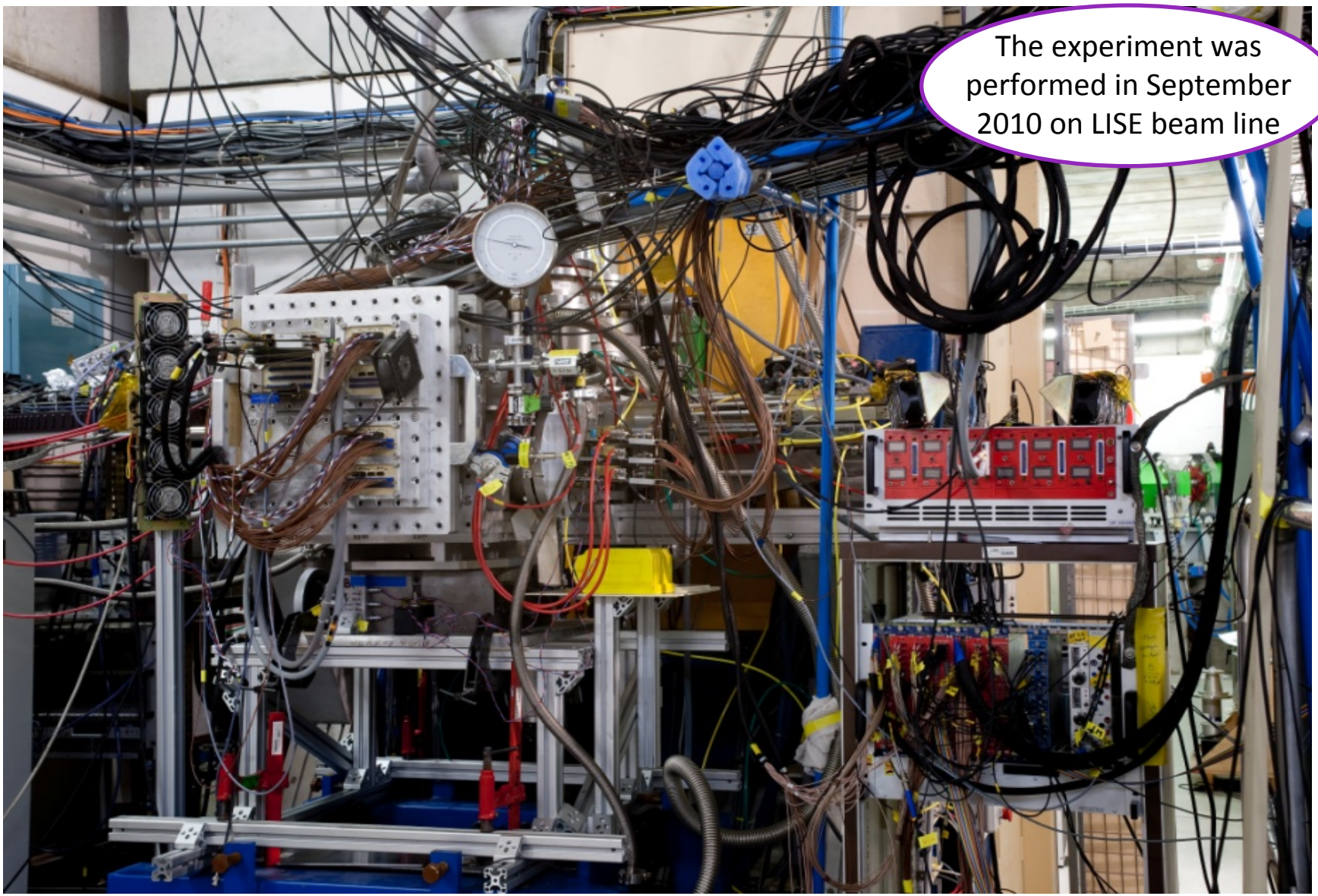




- Gaseous detector
- Time Projection Chamber :
  - the scattered deuton or α ionizes the gas
  - the electrons move towards the wires
  - amplification on the wires
- The amount of electrons and the drift time are collected

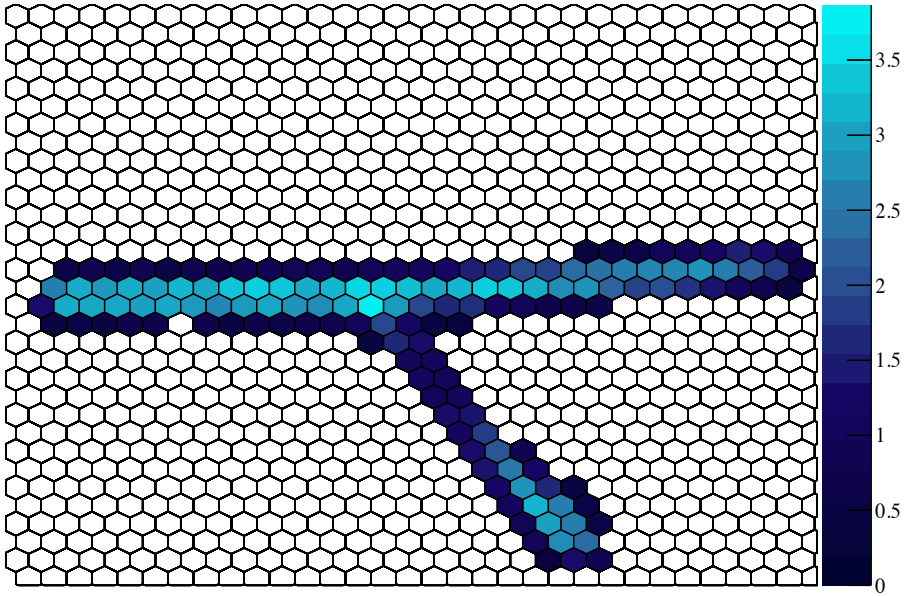
Gas : D2
Pressure : 1 bar
$^{68}Ni + d \rightarrow d' + {}^{68}Ni^*$

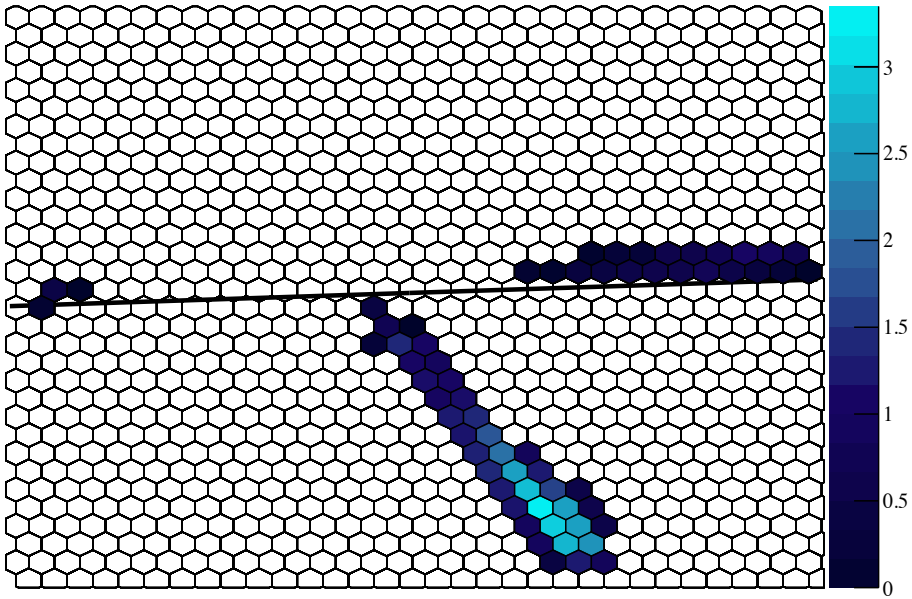
Gas : Helium 98% + CF4 2%
Pressure : 0.5 bar
$^{68}Ni + \alpha \rightarrow \alpha' + {}^{68}Ni^*$

# The Experiment at GANIL



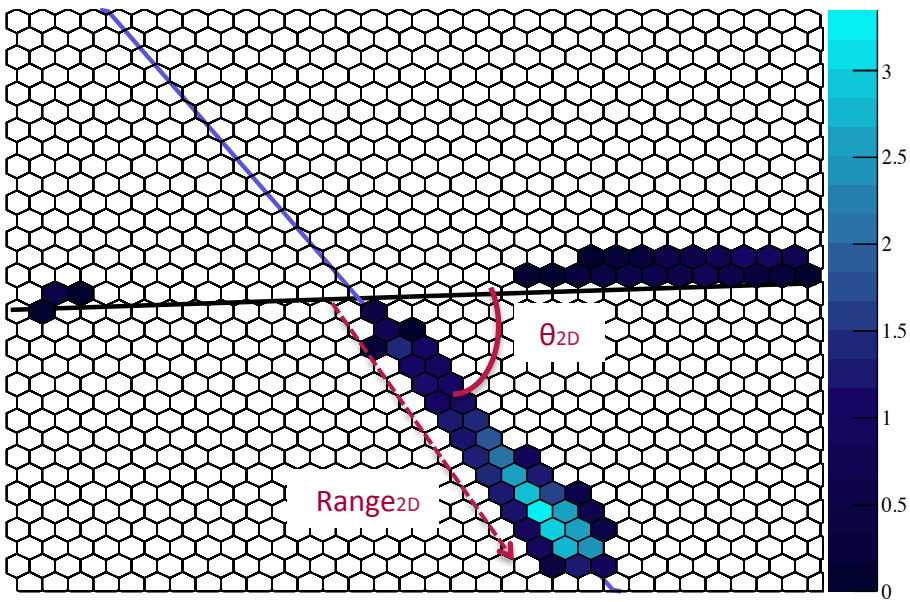
# Data analysis

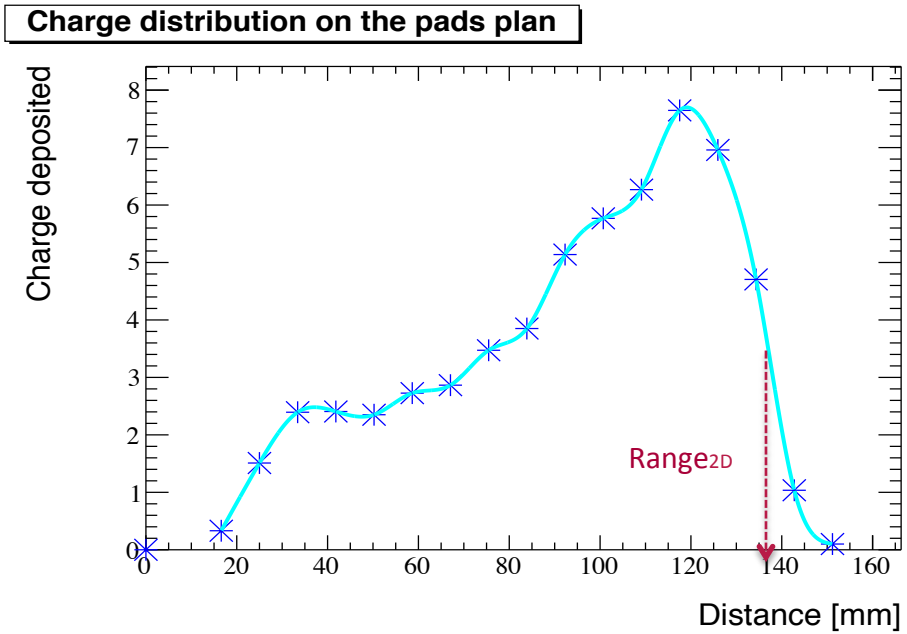



1. Reconstruction of the 2D trajectory
   - Beam fit
   - Subtraction of the average beam

# Data analysis

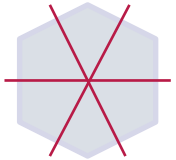



1. Reconstruction of the 2D trajectory
   - Beam fit
   - Subtraction of the average beam
   - Scattered particle fit

→ $\theta_{2D}$

2. Projection of the charges along the 2D trajectory : they are projected according 1 of the 3 MAYA axis



→ $Range_{2D}$

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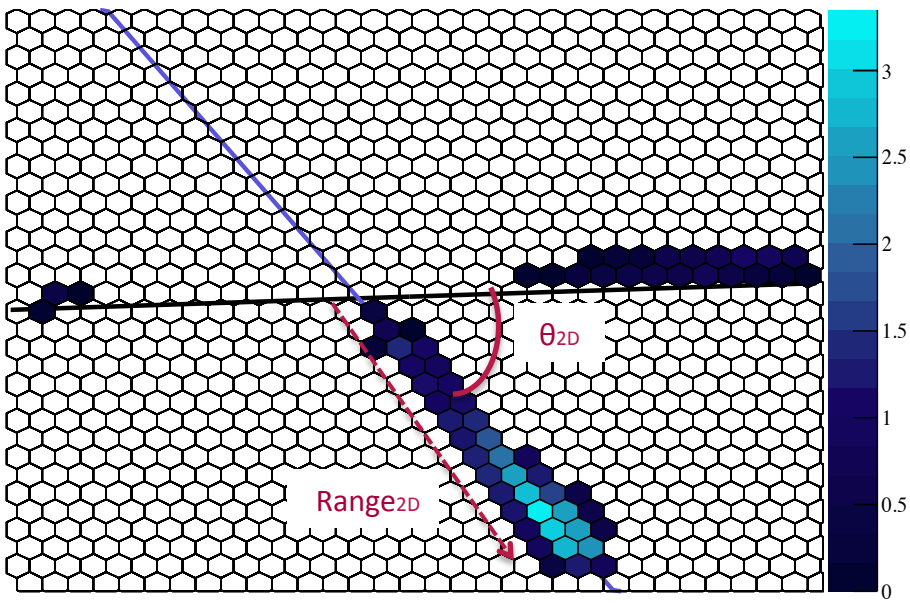


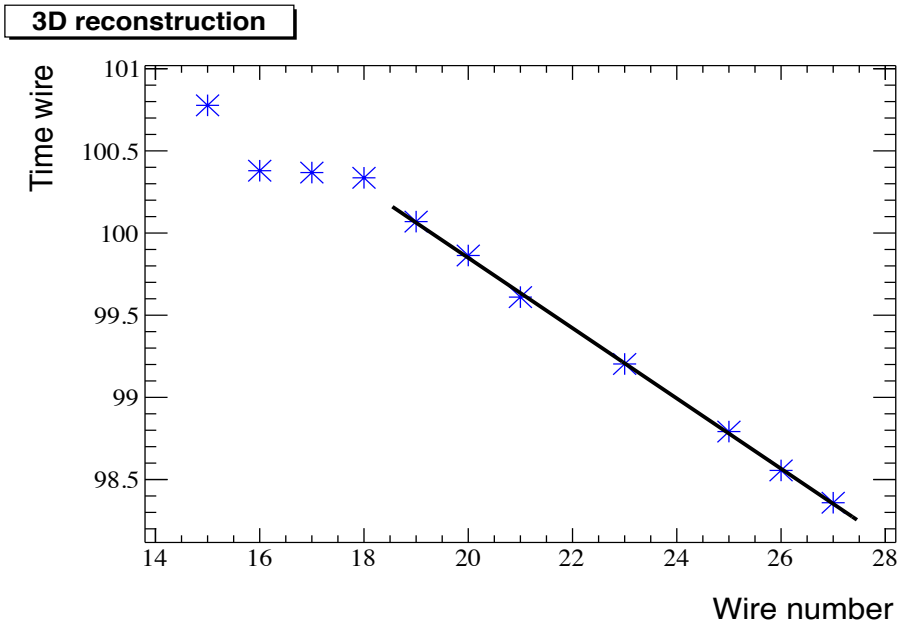


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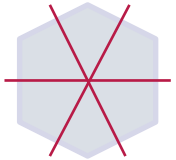


   ⇒ $Range_{2D}$

3. Reconstruction of the third dimension using time on the wires

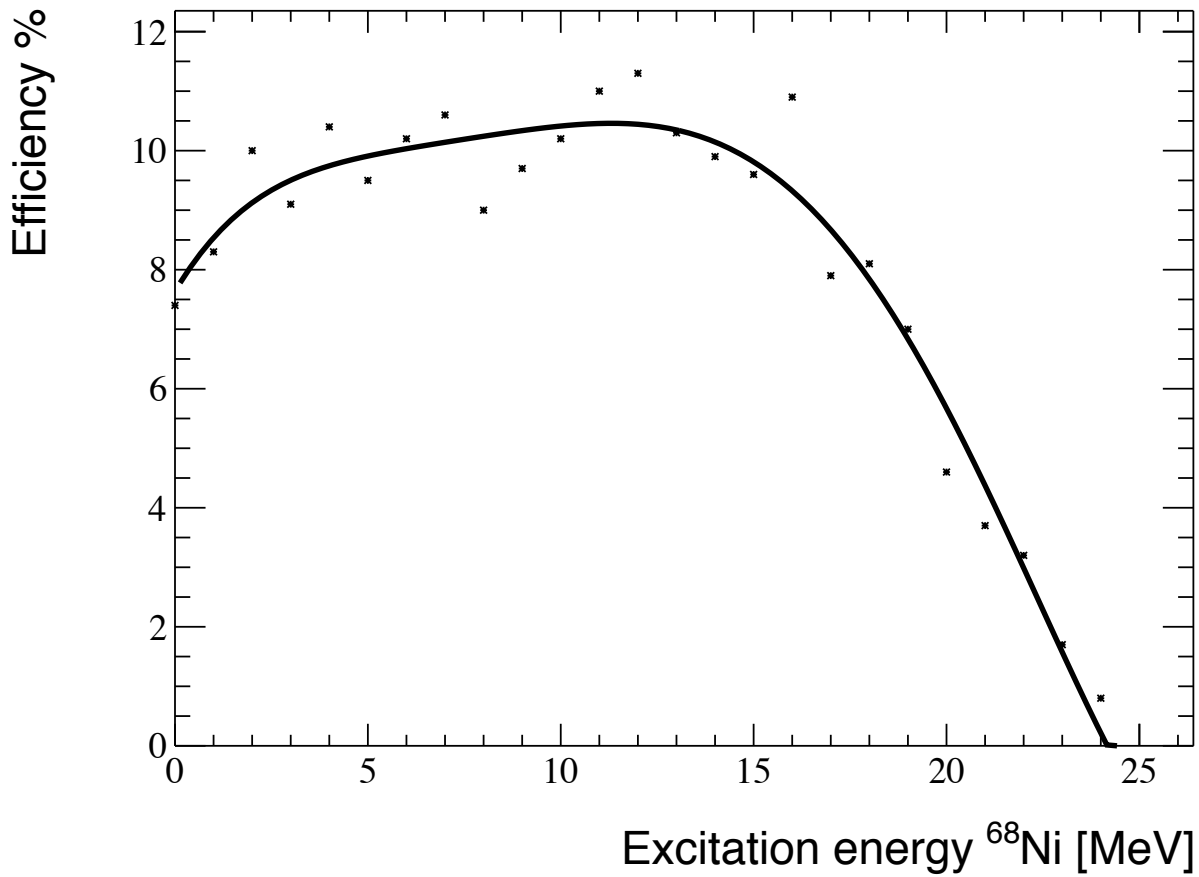
   ⇒ $\varphi$

Range et θ
↓
$E_{deuton}$
↓
Energy excitation $^{68}Ni$

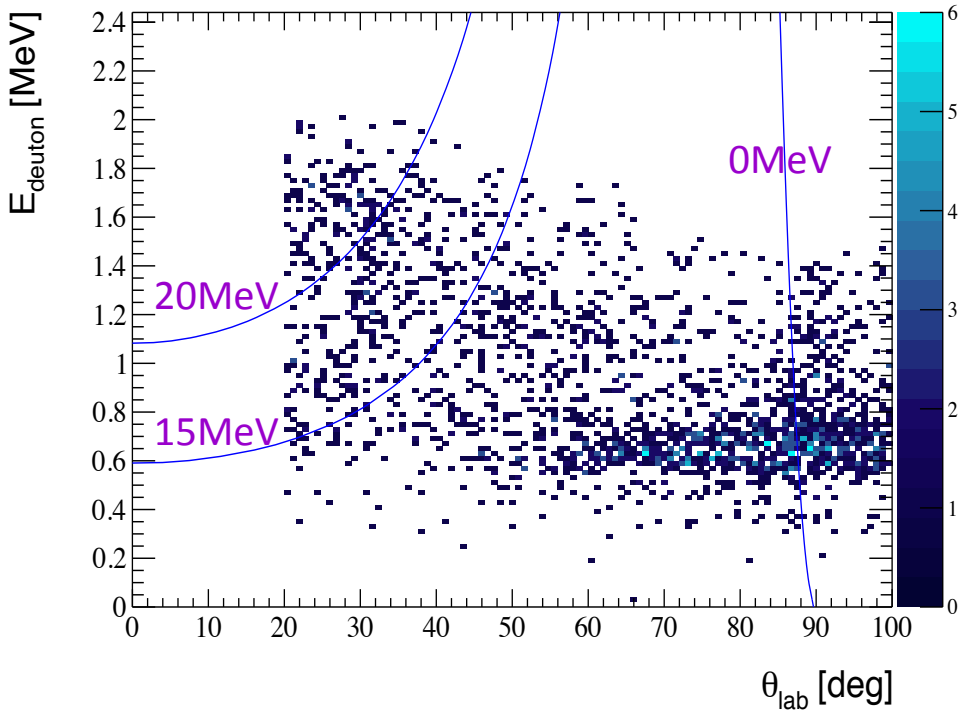
# Geometric efficiency

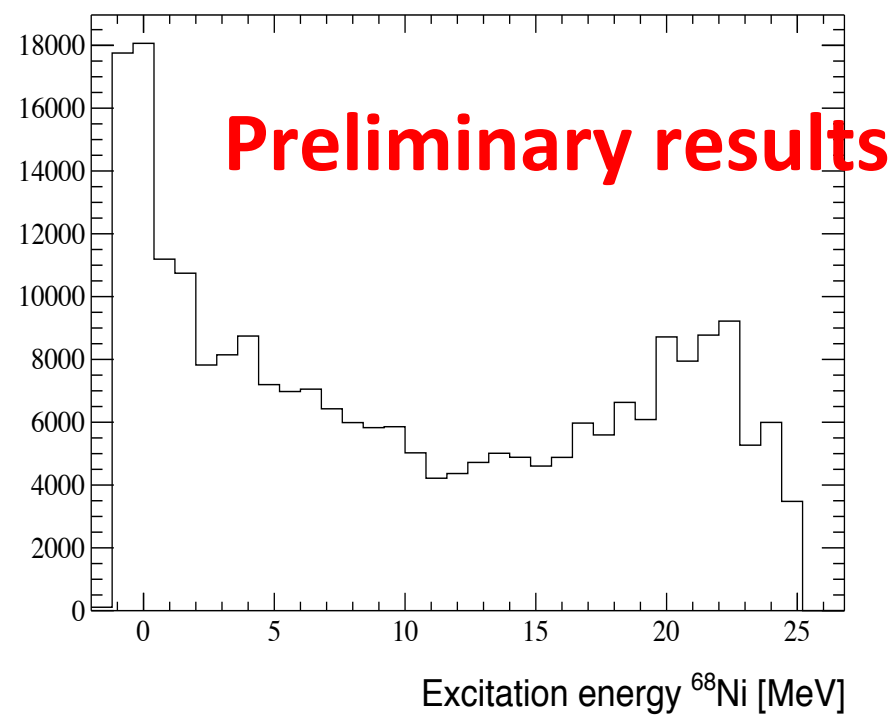
Geometric efficiency using ActarSim code :

- 1000 events generated per MeV
- 0 deg < $\theta_{CM}$ < 8 deg
- -180 deg < φ < 180 deg
- 0 mm < $X_{vertex}$ < 300 mm



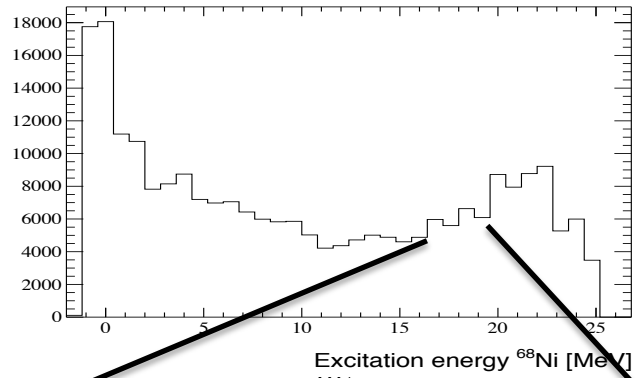
# Results




- Elastic peak
- First excited states included in the elastic peak
- Need angular distribution to study 15-20MeV region

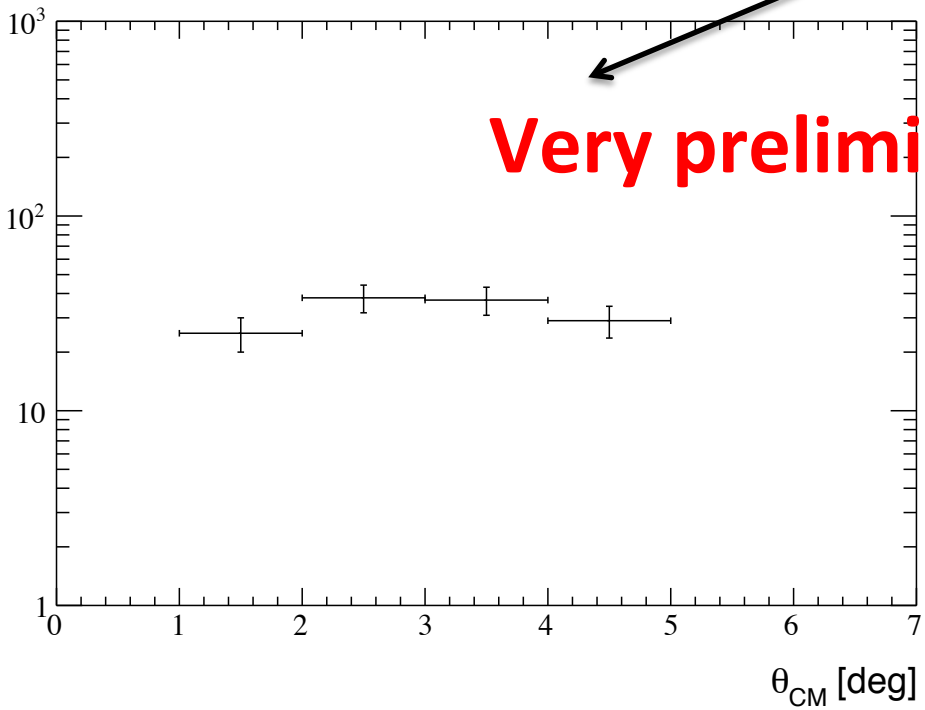
# Angular Distribution

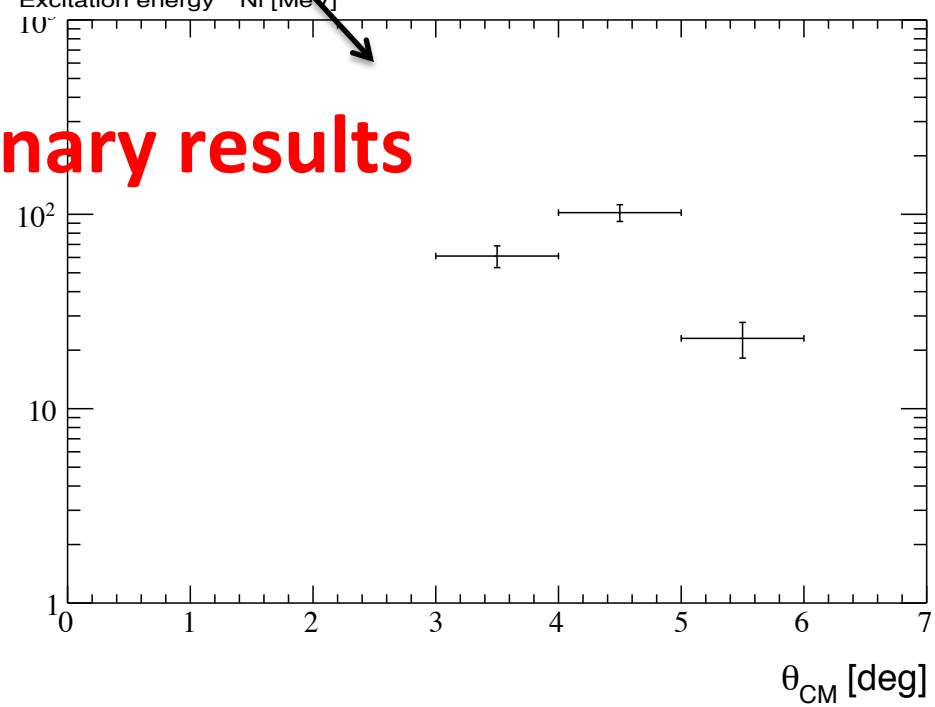



Angular distribution
14-18MeV ⇨ ISGQR
**Not corrected** for efficiency

Angular distribution
18-22MeV ⇨ ISGMR
**Not corrected** for efficiency

**Very preliminary results**




- Angular distribution **not corrected for efficiency**
- Geometric efficiency will play a major role for small $\theta_{CM}$

# Future work

- Status of the analysis in deuteron gas
  - Improve the simulation of the geometric efficiency
  - Work on the angular distribution
  - Evaluate the deuteron break up background
  - Microscopic calculations with multipole decomposition analysis and comparaison to theory

- Analyse the experiment in Helium gas

# Collaboration

M. Vandebrouck[1], J. Gibelin[2], E. Khan[1], N.L. Achouri[2], H. Baba[3], D. Beaumel[1], M. Caamaño[4], L. Caceres[5], F. Delaunay[2], B. Fernandez-Dominguez[4], U. Garg[6], G.F. Grinyer[5], M.N. Harakeh[7], N. Kalantar[7], W. Mittig[8], R. Raabe[9], T. Roger[5], P. Roussel-Chomaz[10], H. Savajols[5], O. Sorlin[5], C. Stodel[5], D. Suzuki[1], J.C. Thomas[5].

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