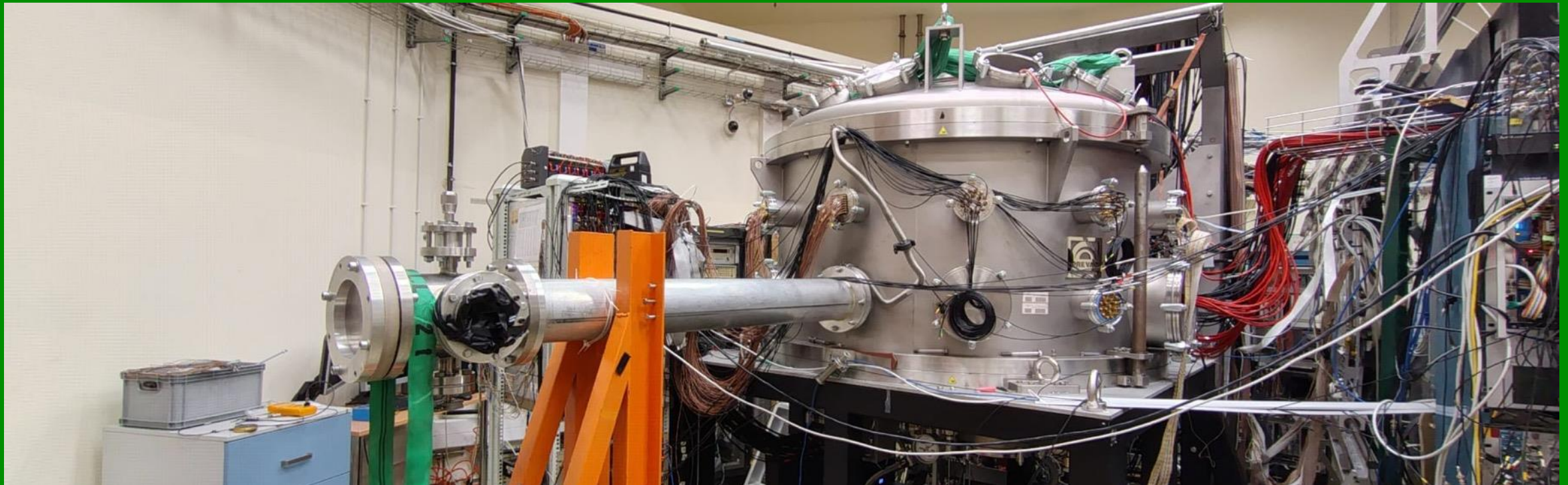


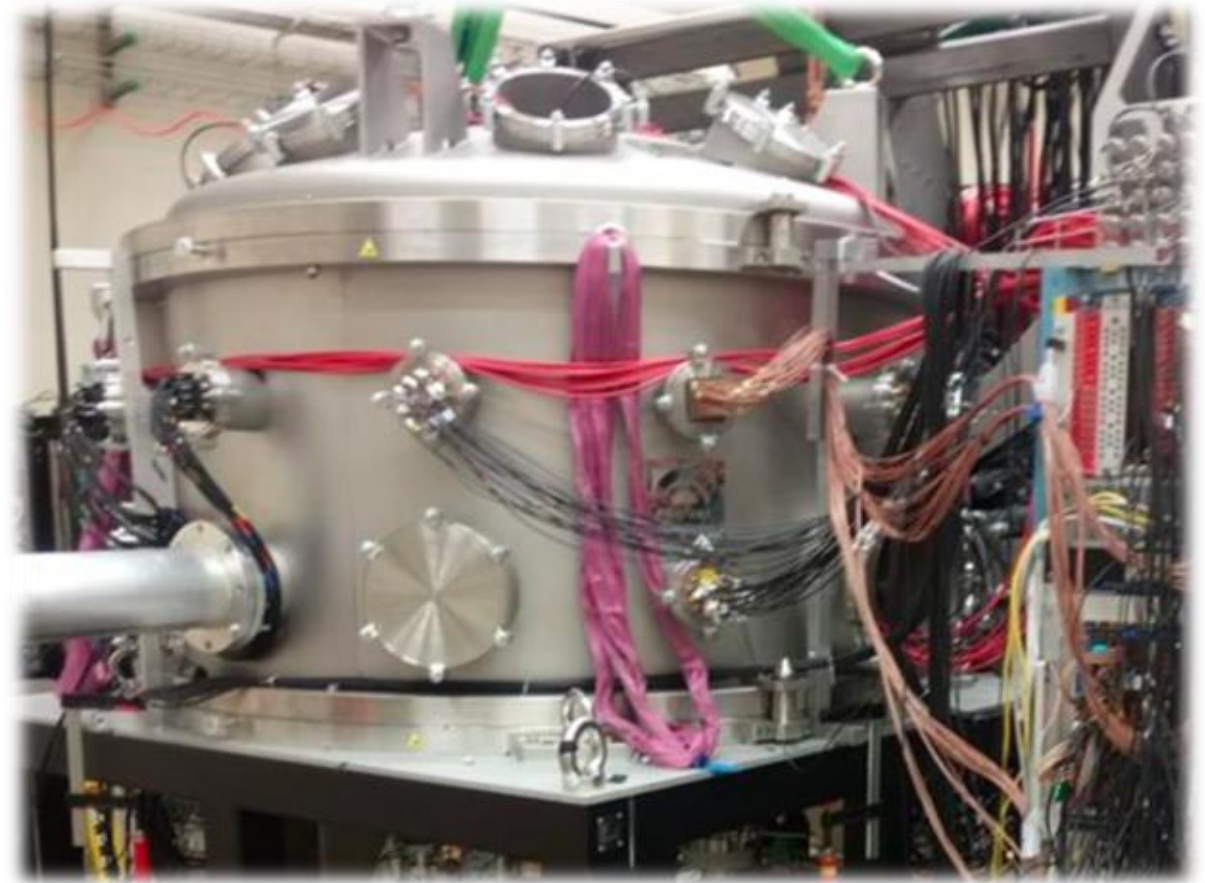
INVESTIGATION OF THE PYGMY DIPOLE RESONANCE IN THE DEFORMED NUCLEUS ^{66}Zn WITHIN THE SYSTEMATIC STUDY OF THE $A \approx 60$ MASS REGION

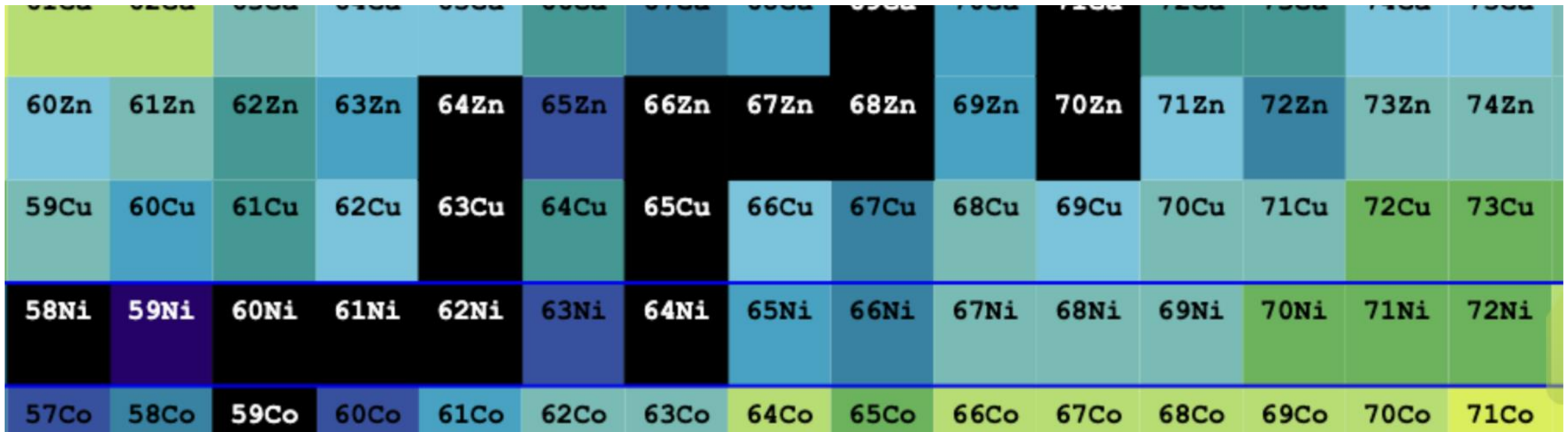
Spokepersons: A. Giaz, M. Ciemala



OUTLINE

- Motivations
- PDR in $A = 60$ mass region: Ni chain and ^{64}Zn and ^{66}Zn
- Experimental setup & the experimental techniques
- Previous experimental results
- Beam time estimations
- Summary





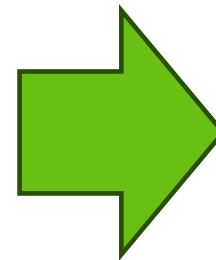
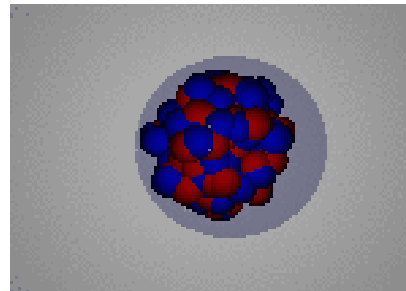
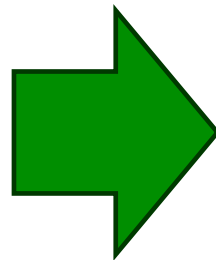
MOTIVATIONS: PDR IN A=60 MASS REGION

NEW PROPOSAL: ^{66}Zn

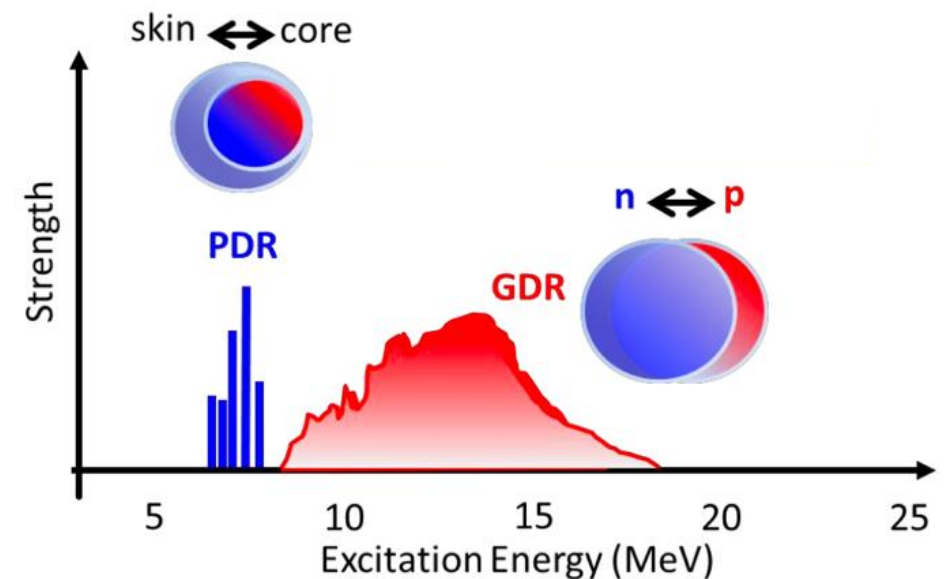


MOTIVATION: PYGMY RESONANCE

PDR has been mostly interpreted as **collective oscillation** of **neutron skin** against the core

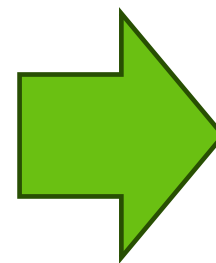
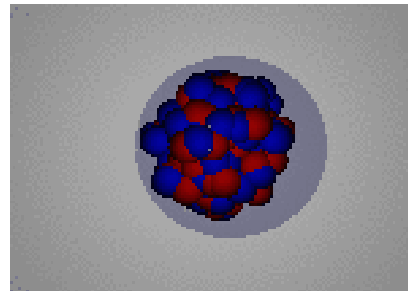
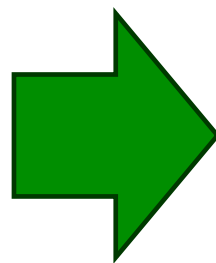


Manifests itself as **E1 strength concentration** around the particle binding energy



MOTIVATION: PYGMY RESONANCE

PDR has been mostly interpreted as **collective oscillation** of **neutron skin** against the core

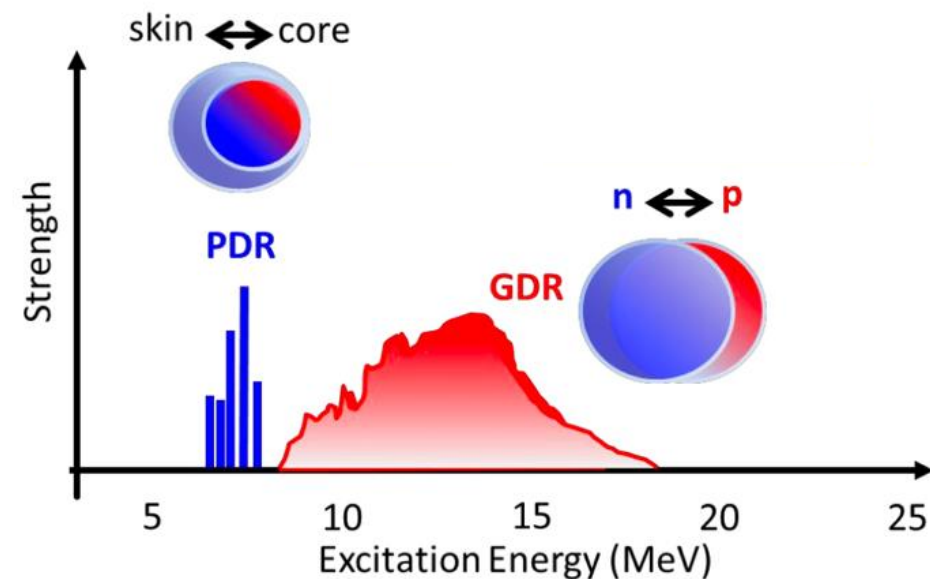


Manifests itself as **E1 strength concentration** around the particle binding energy

Theory: Different approaches give varied predictions in terms of collectivity, strength and line-shape of the PDR

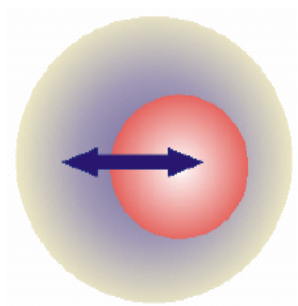


A **broad systematic** study it is necessary using complementary approaches.



IMPORTANCE OF PYGMY RESONANCE

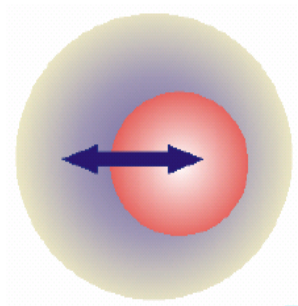
Implications beyond nuclear structure of the low-lying E1 strength



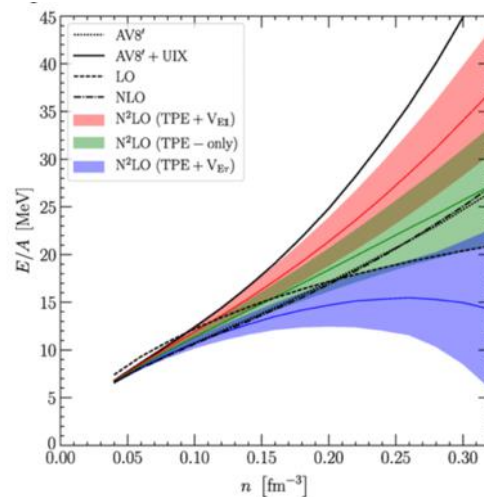
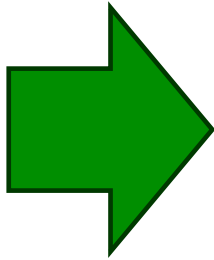
**Neutron
rich nuclei**

IMPORTANCE OF PYGMY RESONANCE

Implications beyond nuclear structure of the low-lying E1 strength



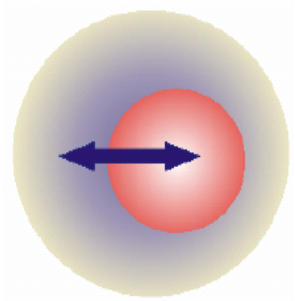
Neutron
rich nuclei



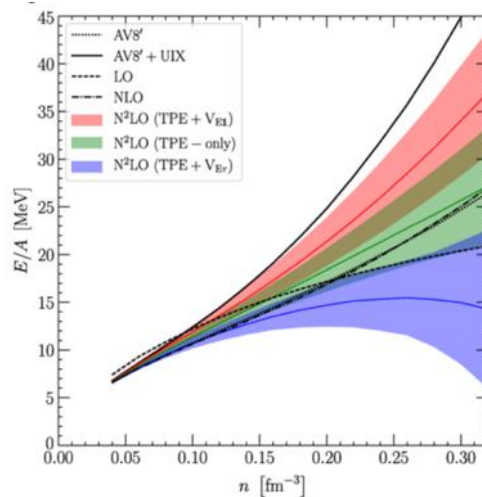
related to determination of
nuclear symmetry energy
(n rich matter)

IMPORTANCE OF PYGMY RESONANCE

Implications beyond nuclear structure of the low-lying E1 strength

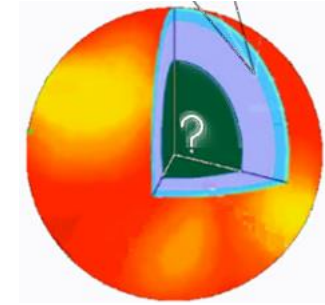


Neutron
rich nuclei

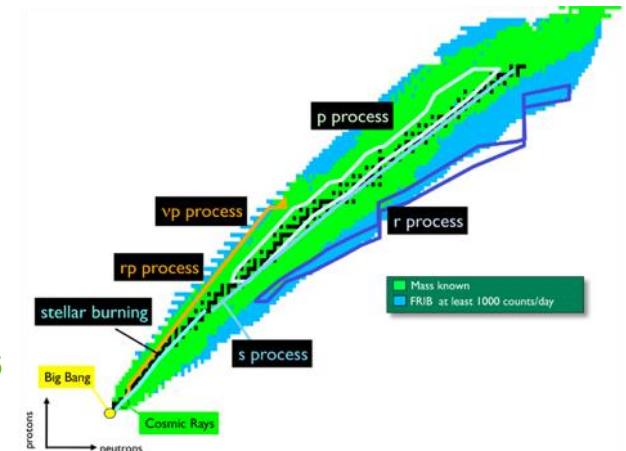


related to determination of
nuclear symmetry energy
(n rich matter)

can be used for
**neutron skin
thickness**
determination
(**neutron stars radius**)



Possible impact
on the
**r-process
nucleosynthesis**



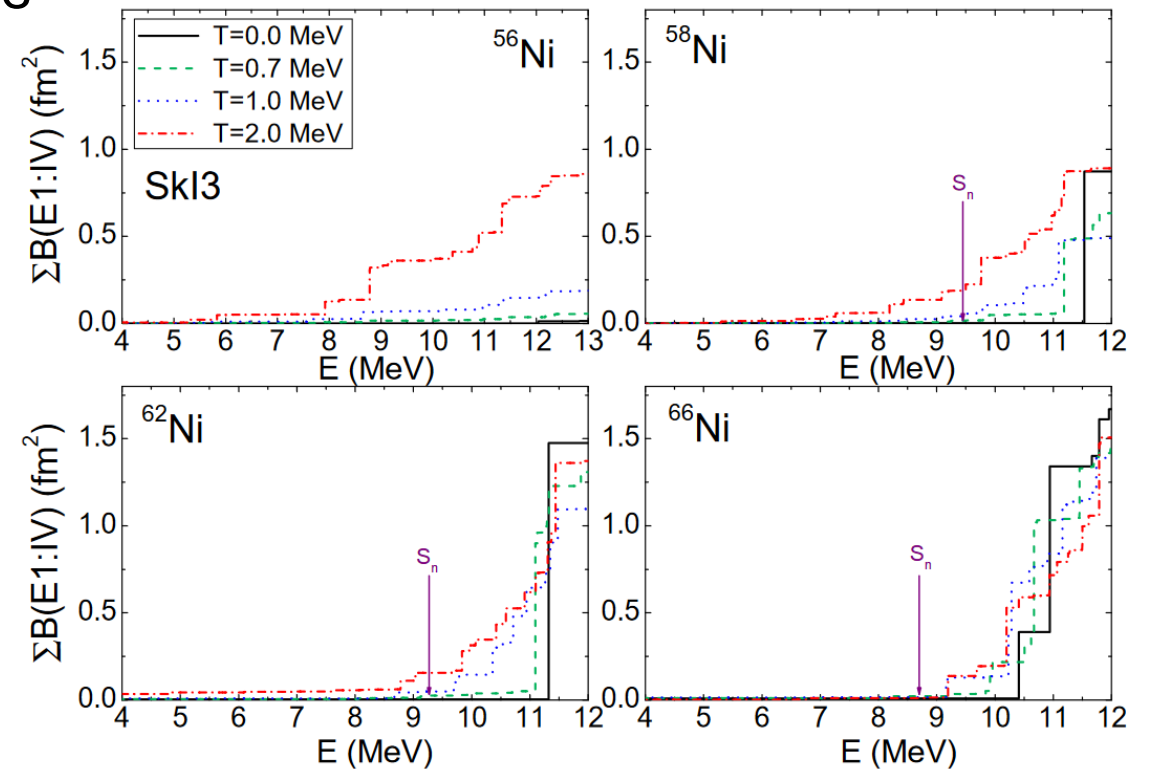
THE PREVIOUS EXPERIMENT: PYGMY IN NICKEL CHAIN

Why Ni chain?

PDR strength and position change as a function of the N/Z ratio

A lot of Ni isotopes are experimental available

Ni is part of the r-process



E. Yüksel et al., Eur. Phys. J. A (2019) 55: 230

THE PREVIOUS EXPERIMENT: PYGMY IN NICKEL CHAIN

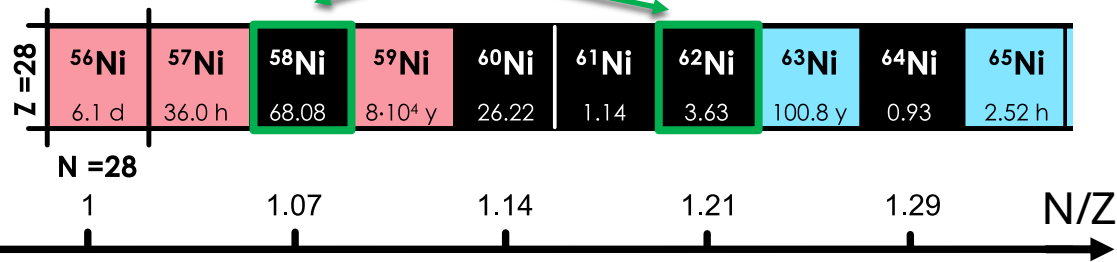
Why Ni chain?

PDR strength and position change as a function of the N/Z ratio

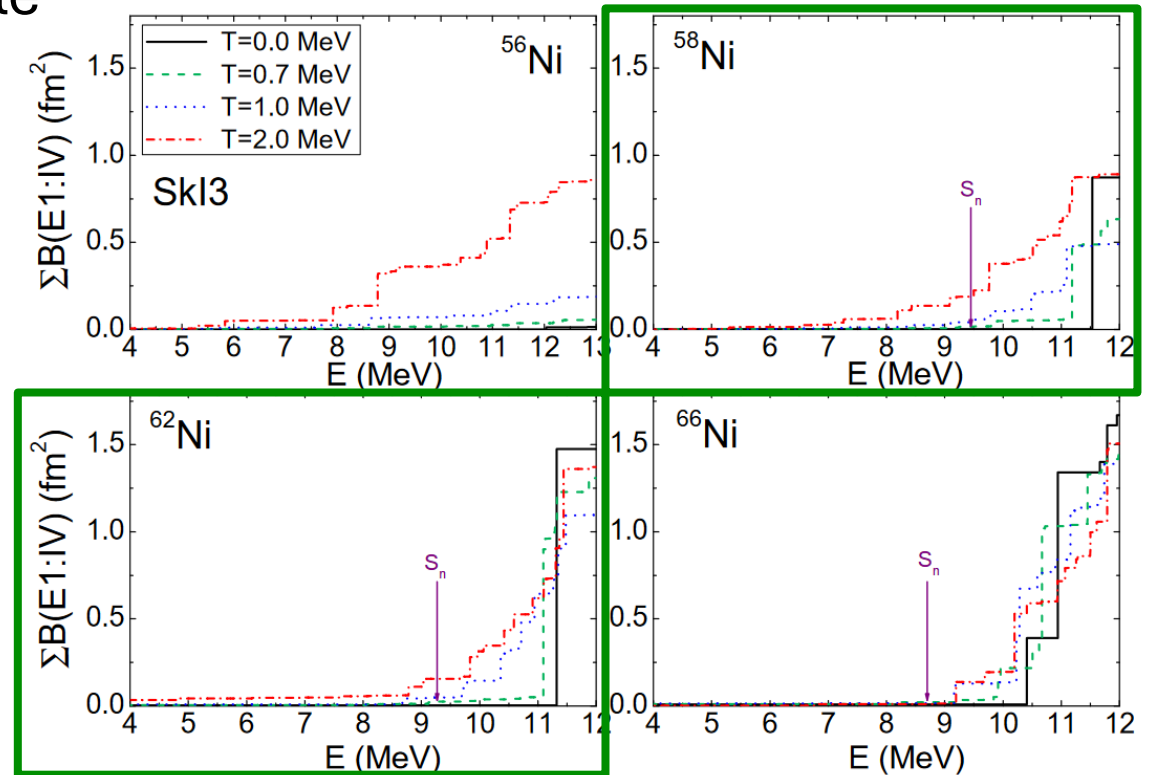
A lot of Ni isotopes are experimental available

Ni is part of the r-process

March- June 2024



^{58}Ni is not far away from the
N=Z & ^{62}Ni N/Z = 1.21
both measured with (p, p' γ)



E. Yüksel et al., Eur. Phys. J. A (2019) 55: 230

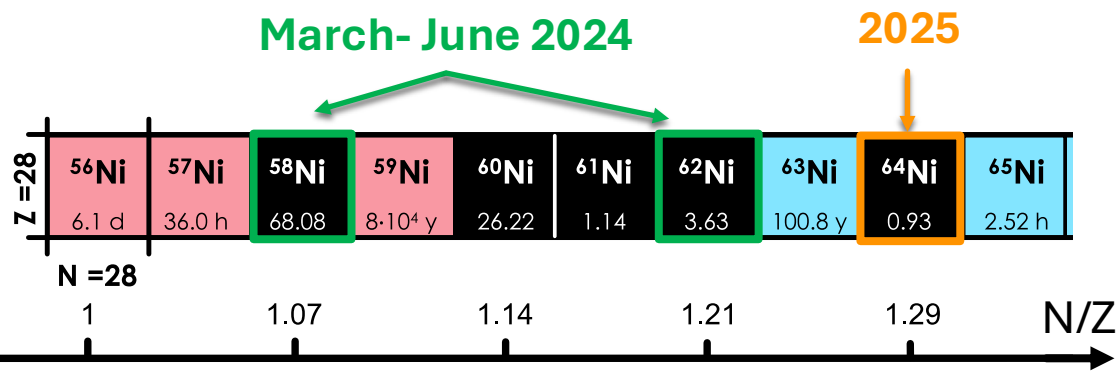
THE PREVIOUS EXPERIMENT: PYGMY IN NICKEL CHAIN

Why Ni chain?

PDR strength and position change as a function of the N/Z ratio

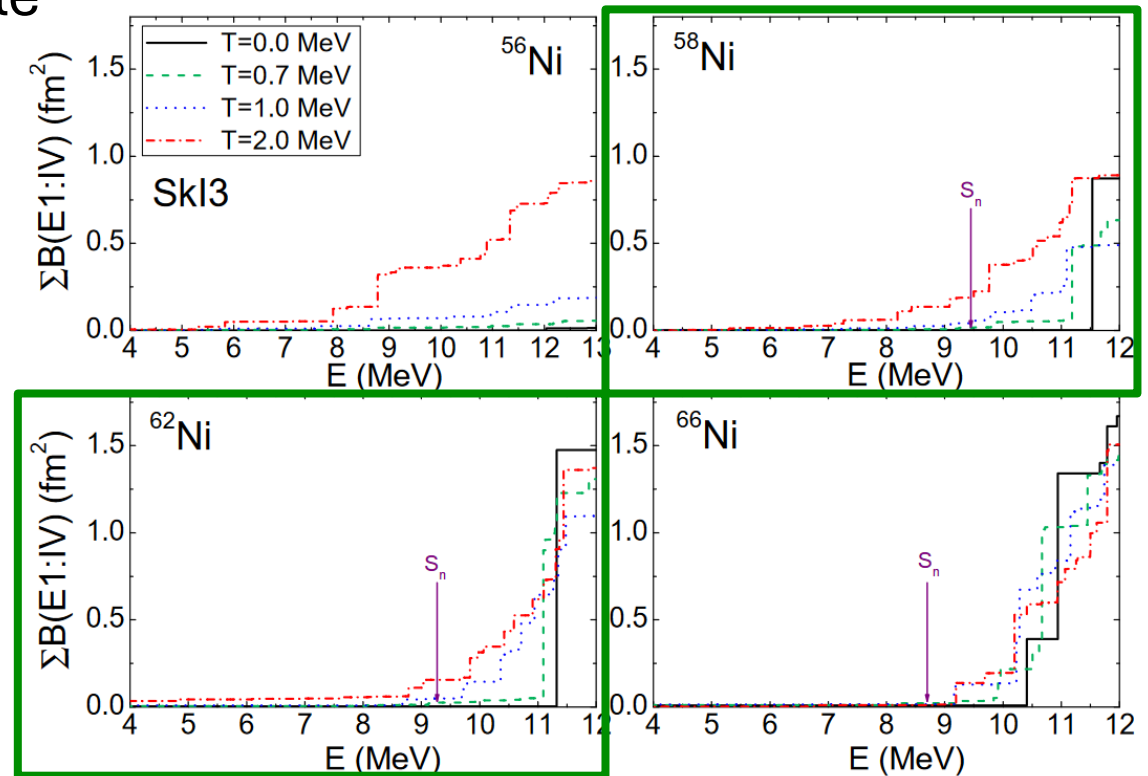
A lot of Ni isotopes are experimental available

Ni is part of the r-process



^{58}Ni is not far away from the
N=Z & ^{62}Ni N/Z = 1.21
both measured with (p, p' γ)

^{64}Ni has the
highest N/Z
among stable
nuclei



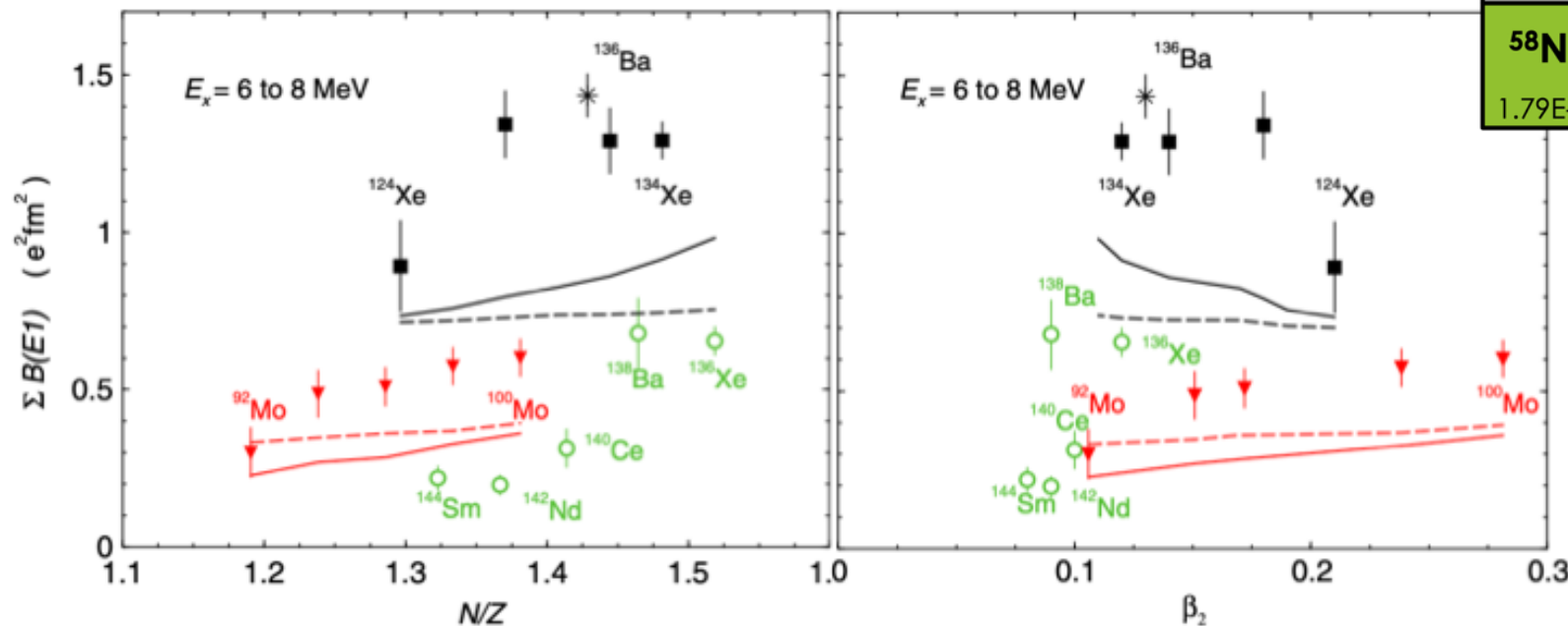
E. Yüksel et al., Eur. Phys. J. A (2019) 55: 230

ONGOING: PDR IN ^{64}Zn

Why ^{64}Zn ?

PDR depend on N/Z and quadrupole deformation parameter β_2
 The nucleus with the highest β_2 in A=60 mass region is ^{64}Zn .

^{60}Zn	^{61}Zn	^{62}Zn 2.16E-1	^{63}Zn	^{64}Zn 2.36E-1	^{65}Zn	^{66}Zn 2.21E-1
^{59}Cu	^{60}Cu	^{61}Cu	^{62}Cu	^{63}Cu	^{64}Cu	^{65}Cu
^{58}Ni 1.79E-1	^{59}Ni	^{60}Ni 2.05E-1	^{61}Ni	^{62}Ni 1.96E-1	^{63}Ni	^{64}Ni 1.57E-1



R. Massarczyk et al. Phys. Rev. Lett. 112, 072501 (2014)

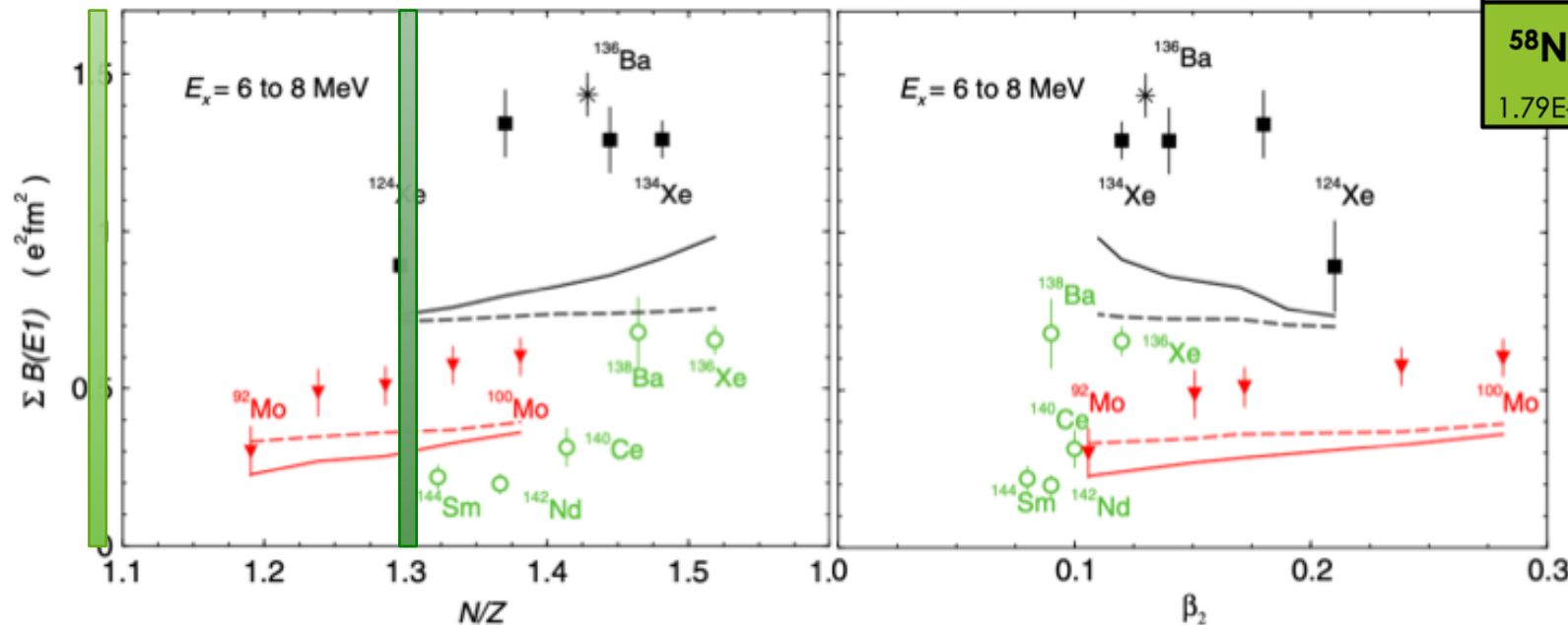
The ongoing experiment

ONGOING: PDR IN ^{64}Zn

Why ^{64}Zn ?

PDR depend on N/Z and quadrupole deformation parameter β_2
 The nucleus with the highest β_2 in $A=60$ mass region is ^{64}Zn .

^{60}Zn	^{61}Zn	^{62}Zn 2.16E-1	^{63}Zn	^{64}Zn 2.36E-1	^{65}Zn	^{66}Zn 2.21E-1
^{59}Cu	^{60}Cu	^{61}Cu	^{62}Cu	^{63}Cu	^{64}Cu	^{65}Cu
^{58}Ni 1.79E-1	^{59}Ni	^{60}Ni 2.05E-1	^{61}Ni	^{62}Ni 1.96E-1	^{63}Ni	^{64}Ni 1.57E-1



R. Massarczyk et al. Phys. Rev. Lett. 112, 072501 (2014)

The ongoing experiment

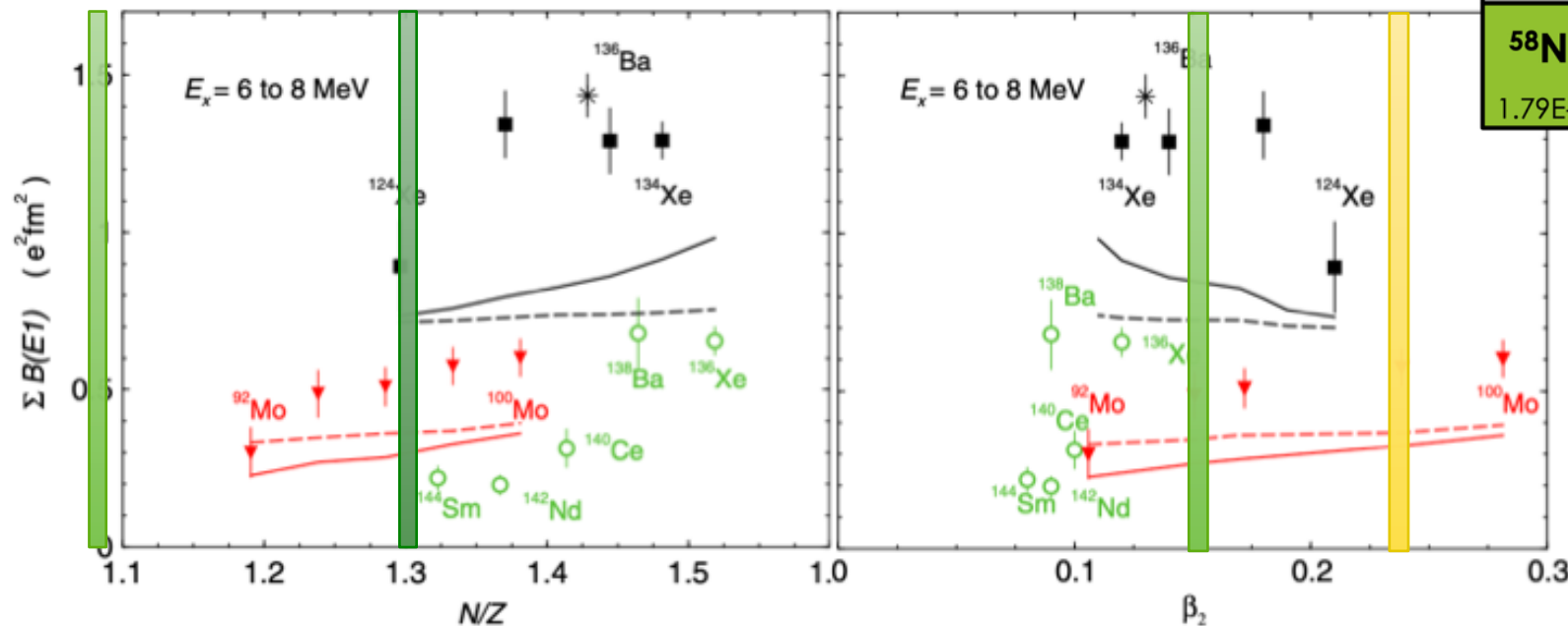
ONGOING: PDR IN ^{64}Zn

Why ^{64}Zn ?

PDR depend on N/Z and quadrupole deformation parameter β_2
 The nucleus with the highest β_2 in A=60 mass region is ^{64}Zn .

^{60}Zn	^{61}Zn	^{62}Zn 2.16E-1	^{63}Zn	^{64}Zn 2.36E-1	^{65}Zn	^{66}Zn 2.21E-1
^{59}Cu	^{60}Cu	^{61}Cu	^{62}Cu	^{63}Cu	^{64}Cu	^{65}Cu
^{58}Ni 1.79E-1	^{59}Ni	^{60}Ni 2.05E-1	^{61}Ni	^{62}Ni 1.96E-1	^{63}Ni	^{64}Ni 1.57E-1

The ongoing experiment



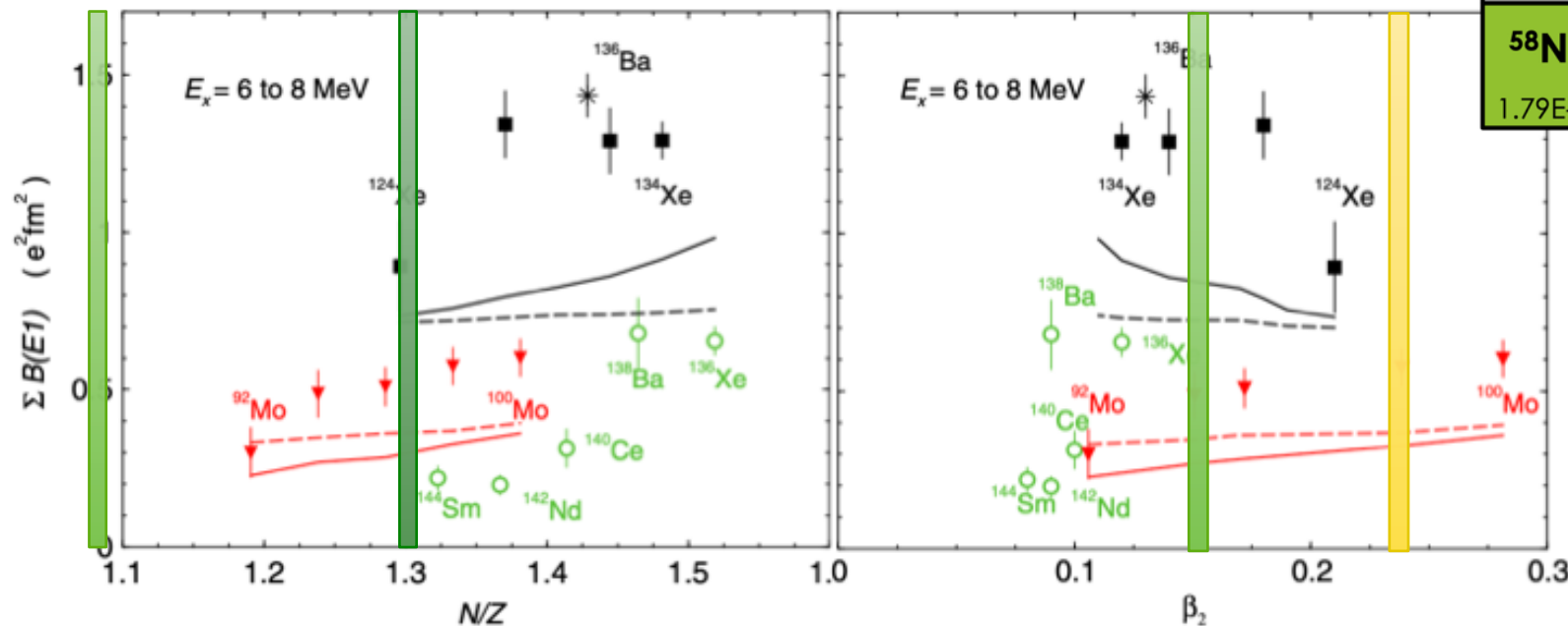
R. Massarczyk et al. Phys. Rev. Lett. 112, 072501 (2014)

ONGOING: PDR IN ^{64}Zn

Why ^{64}Zn ?

PDR depend on N/Z and quadrupole deformation parameter β_2
 The nucleus with the highest β_2 in A=60 mass region is ^{64}Zn .

^{60}Zn	^{61}Zn	^{62}Zn 2.16E-1	^{63}Zn	^{64}Zn 2.36E-1	^{65}Zn	^{66}Zn 2.21E-1
^{59}Cu	^{60}Cu	^{61}Cu	^{62}Cu	^{63}Cu	^{64}Cu	^{65}Cu
^{58}Ni 1.79E-1	^{59}Ni	^{60}Ni 2.05E-1	^{61}Ni	^{62}Ni 1.96E-1	^{63}Ni	^{64}Ni 1.57E-1



R. Massarczyk et al. Phys. Rev. Lett. 112, 072501 (2014)

The ongoing experiment

In Zn isotopes case, too, a complementary experiment on HOT-PDR will be proposed at the IFIN-HH tandem.

THE NEW PROPOSAL: PDR IN ^{66}Zn

Why ^{66}Zn ?

- PDR strength depends on both the N/Z ratio and the quadrupole deformation parameter β_2 .
- ^{66}Zn is deformed, similarly to ^{64}Zn .
- ^{66}Zn and ^{62}Ni have the same N/Z ratios.

^{60}Zn	^{61}Zn	^{62}Zn 2.16E-1	^{63}Zn	^{64}Zn 2.36E-1	^{65}Zn	^{66}Zn 2.21E-1
^{59}Cu	^{60}Cu	^{61}Cu	^{62}Cu	^{63}Cu	^{64}Cu	^{65}Cu
^{58}Ni 1.79E-1	^{59}Ni	^{60}Ni 2.05E-1	^{61}Ni	^{62}Ni 1.86E-1	^{63}Ni	^{64}Ni 1.57E-1

This proposal

THE NEW PROPOSAL: PDR IN ^{66}Zn

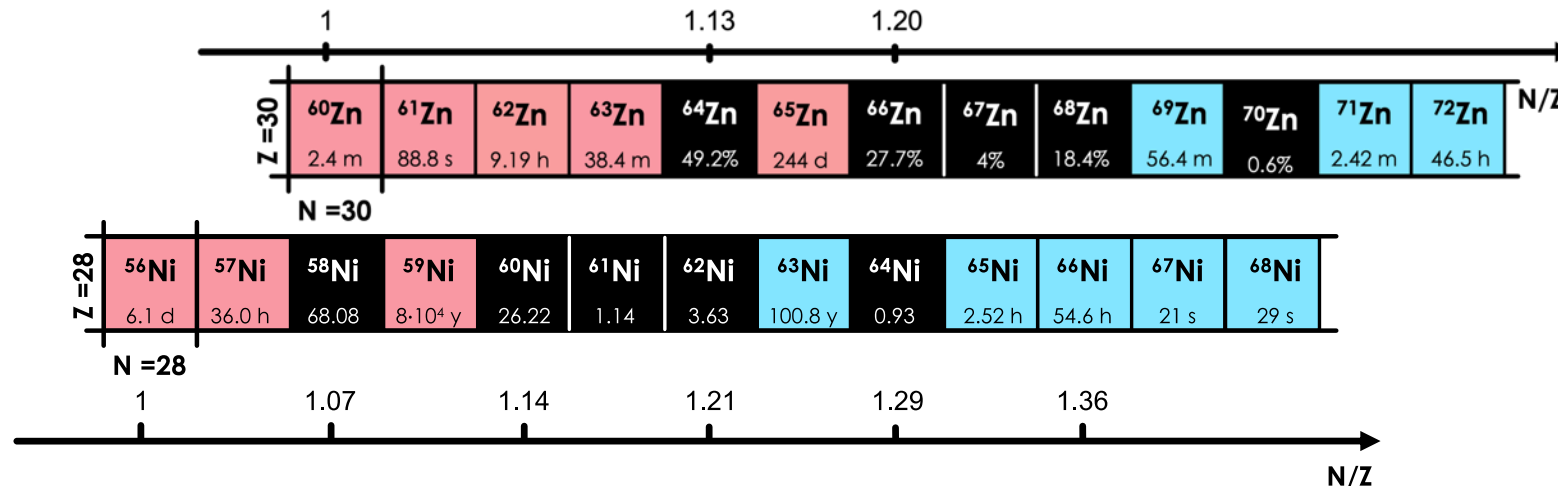
Why ^{66}Zn ?

- PDR strength depends on both the N/Z ratio and the quadrupole deformation parameter β_2 .
- ^{66}Zn is deformed, similarly to ^{64}Zn .
- ^{66}Zn and ^{62}Ni have the same N/Z ratios.

Comparison with ^{62}Ni allows us to disentangle N/Z and deformation effects on the PDR.

^{60}Zn	^{61}Zn	^{62}Zn 2.16E-1	^{63}Zn	^{64}Zn 2.36E-1	^{65}Zn	^{66}Zn 2.21E-1
^{59}Cu	^{60}Cu	^{61}Cu	^{62}Cu	^{63}Cu	^{64}Cu	^{65}Cu
^{58}Ni 1.79E-1	^{59}Ni	^{60}Ni 2.05E-1	^{61}Ni	^{62}Ni 1.86E-1	^{63}Ni	^{64}Ni 1.57E-1

This proposal



THE NEW PROPOSAL: PDR IN ^{66}Zn

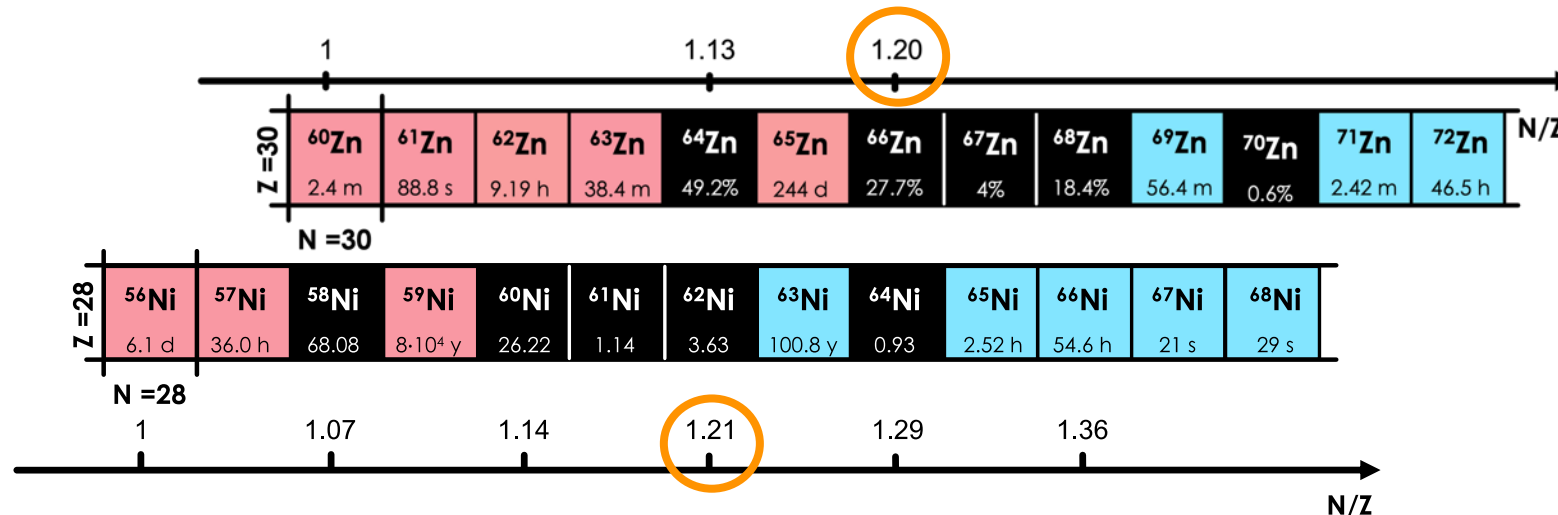
Why ^{66}Zn ?

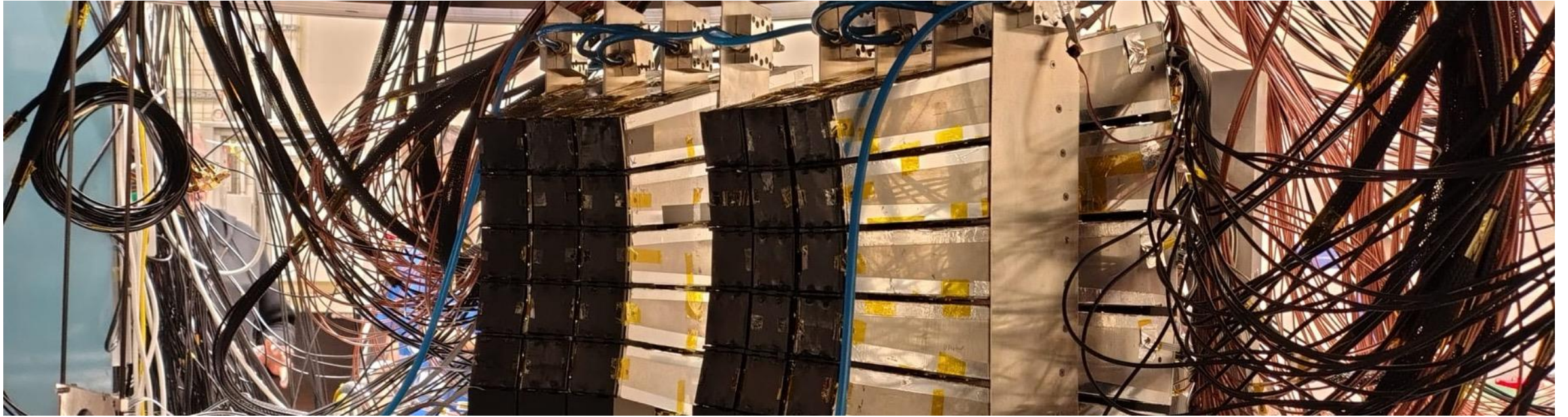
- PDR strength depends on both the N/Z ratio and the quadrupole deformation parameter β_2 .
- ^{66}Zn is deformed, similarly to ^{64}Zn .
- ^{66}Zn and ^{62}Ni have the same N/Z ratios.

Comparison with ^{62}Ni allows us to disentangle N/Z and deformation effects on the PDR.

^{60}Zn	^{61}Zn	^{62}Zn 2.16E-1	^{63}Zn	^{64}Zn 2.36E-1	^{65}Zn	^{66}Zn 2.21E-1
^{59}Cu	^{60}Cu	^{61}Cu	^{62}Cu	^{63}Cu	^{64}Cu	^{65}Cu
^{58}Ni 1.79E-1	^{59}Ni	^{60}Ni 2.05E-1	^{61}Ni	^{62}Ni 1.86E-1	^{63}Ni	^{64}Ni 1.57E-1

This proposal





EXPERIMENTAL SETUP & EXPERIMENTAL TECHNIQUE

PDR VIA (p,p') INELASTIC SCATTERING

USED AND REQUESTED EXPERIMENTAL SETUP

TARGETs:

^{64}Ni 30 mg/cm²

^{62}Ni 100 mg/cm²

^{58}Ni 200 mg/cm²

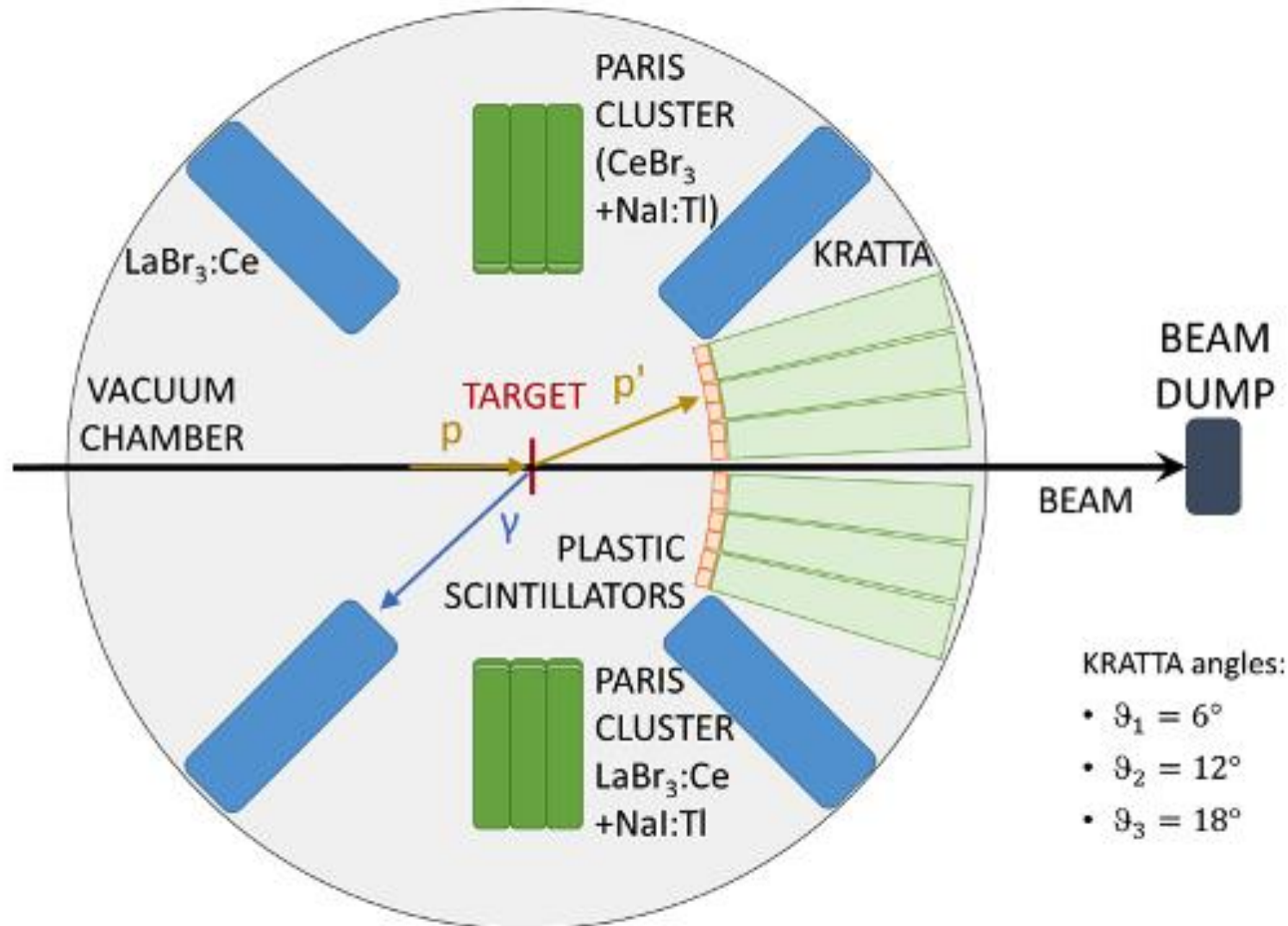
^{64}Zn 50 mg/cm²

^{66}Zn 23 mg/cm²

PROTON BEAM:

180 MeV

0.4 nA



USED AND REQUESTED EXPERIMENTAL SETUP

TARGETs:

^{64}Ni 30 mg/cm²

^{62}Ni 100 mg/cm²

^{58}Ni 200 mg/cm²

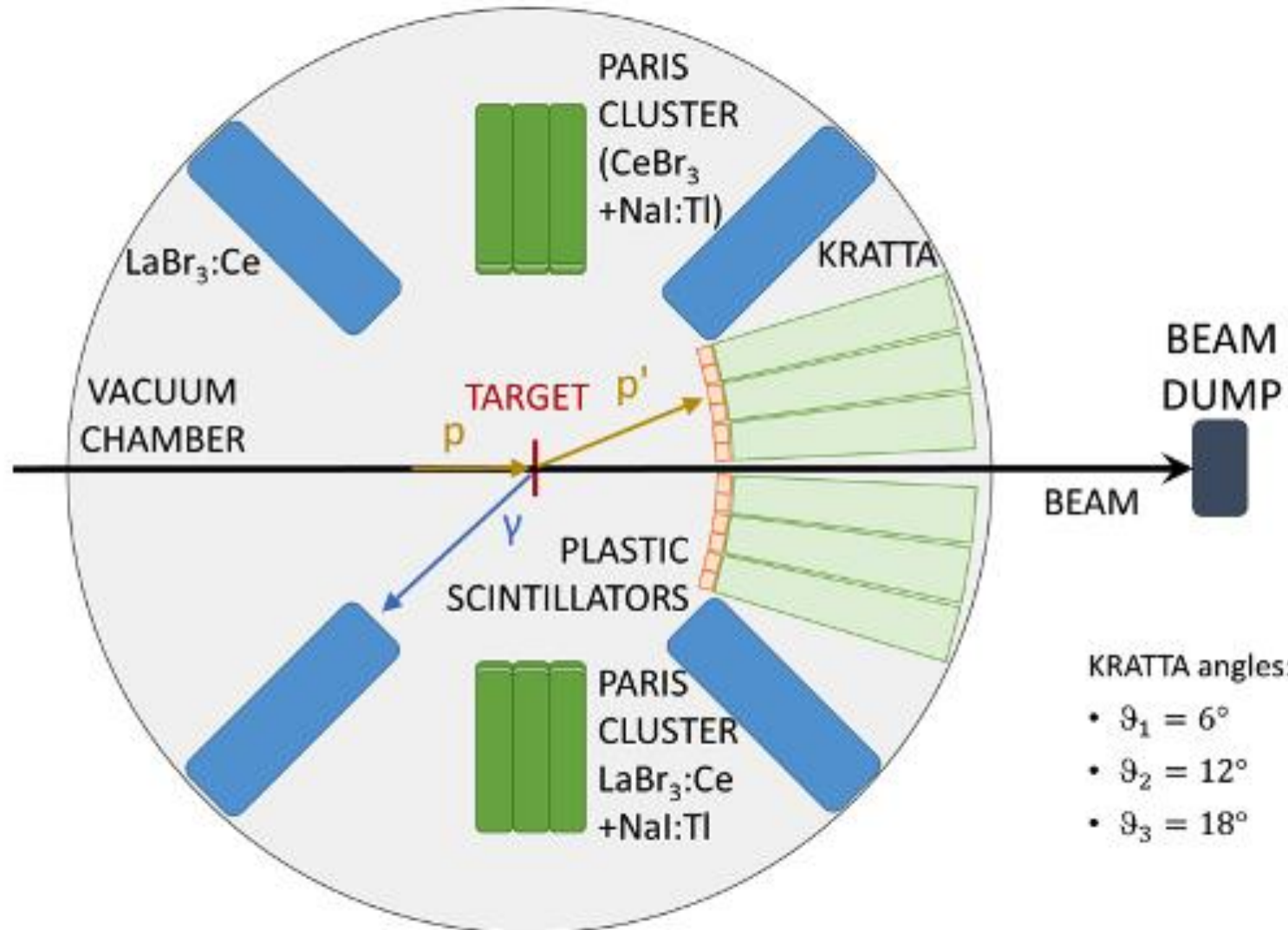
^{64}Zn 50 mg/cm²

^{66}Zn 23 mg/cm²

PROTON BEAM:

180 MeV

0.4 nA



32 KRATTA TELESCOPES:

6 column of 5 detectos each

Resolution:

2 MeV (FWHM)

Angular resolution:
0.8°

USED AND REQUESTED EXPERIMENTAL SETUP

TARGETs:

^{64}Ni 30 mg/cm²
 ^{62}Ni 100 mg/cm²
 ^{58}Ni 200 mg/cm²
 ^{64}Zn 50 mg/cm²
 ^{66}Zn 23 mg/cm²

PROTON BEAM:

180 MeV

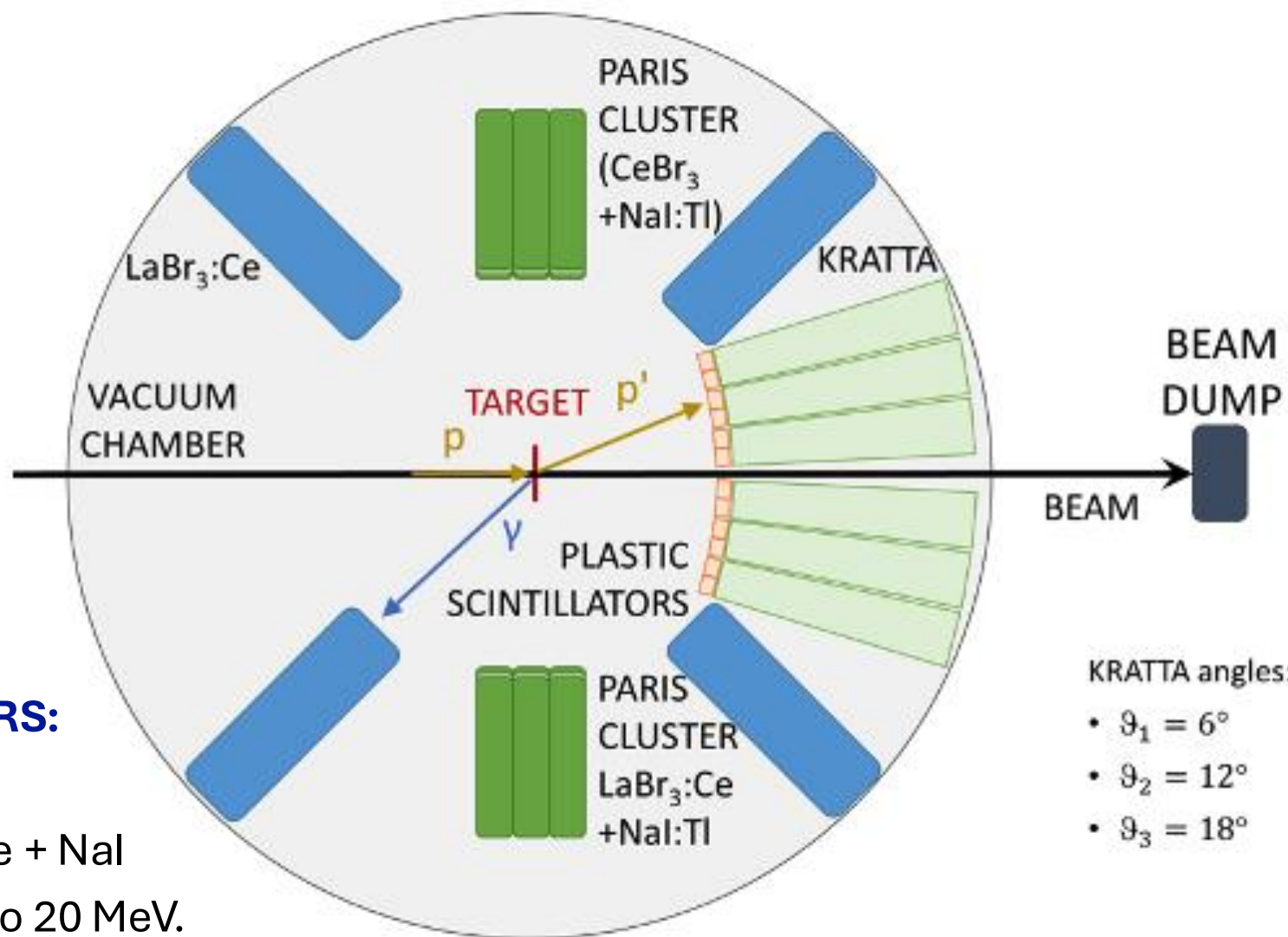
0.4 nA

PARIS DETECTORS:

Phoswich

CeBr₃ or LaBr₃:Ce + NaI

Energy range up to 20 MeV.



32 KRATTA TELESCOPES:

6 column of 5
detectos each

Resolution:

2 MeV (FWHM)

Angular resolution:
0.8°

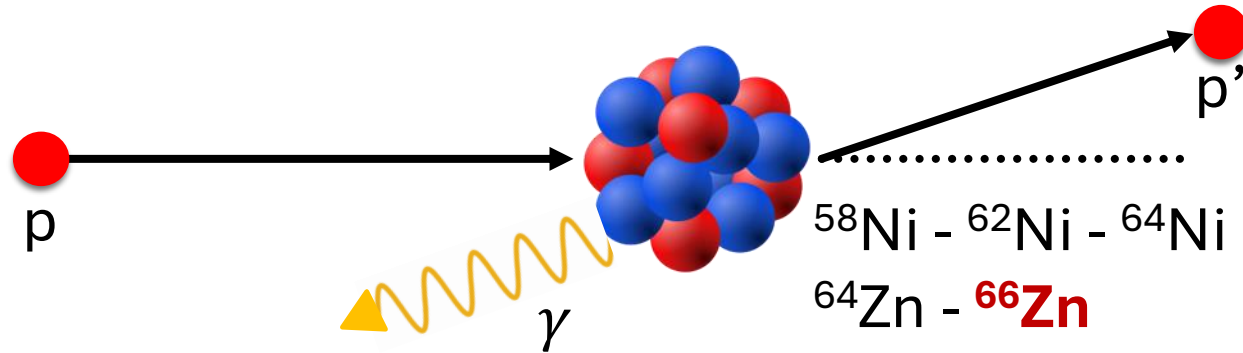
KRATTA angles:

- $\vartheta_1 = 6^\circ$
- $\vartheta_2 = 12^\circ$
- $\vartheta_3 = 18^\circ$

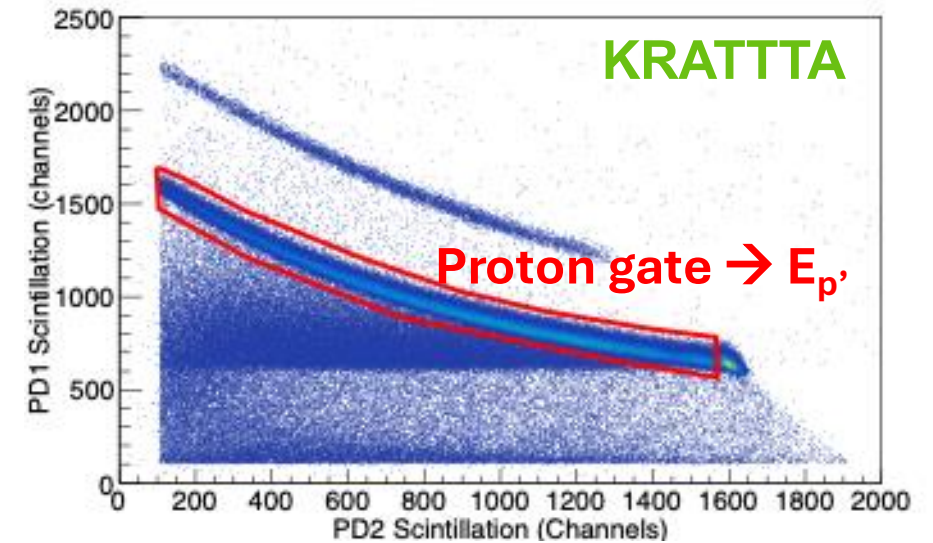
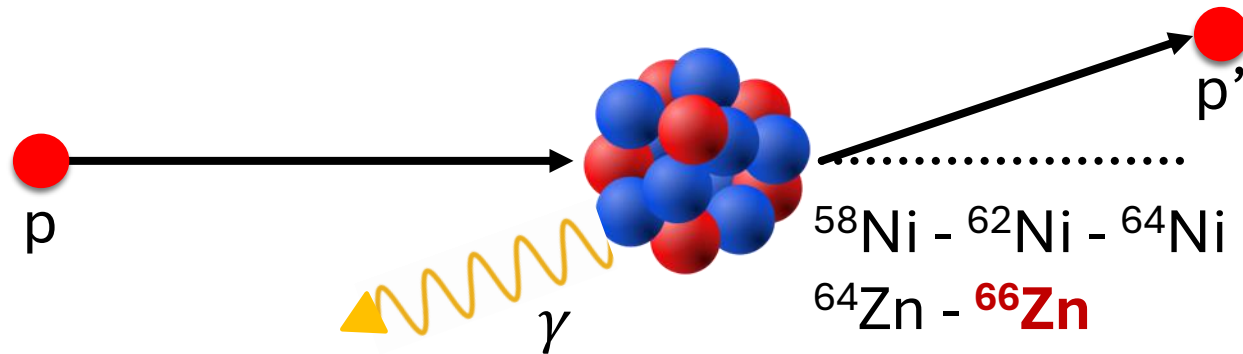
4 LaBr₃:Ce

Size: 3.5" x 8"

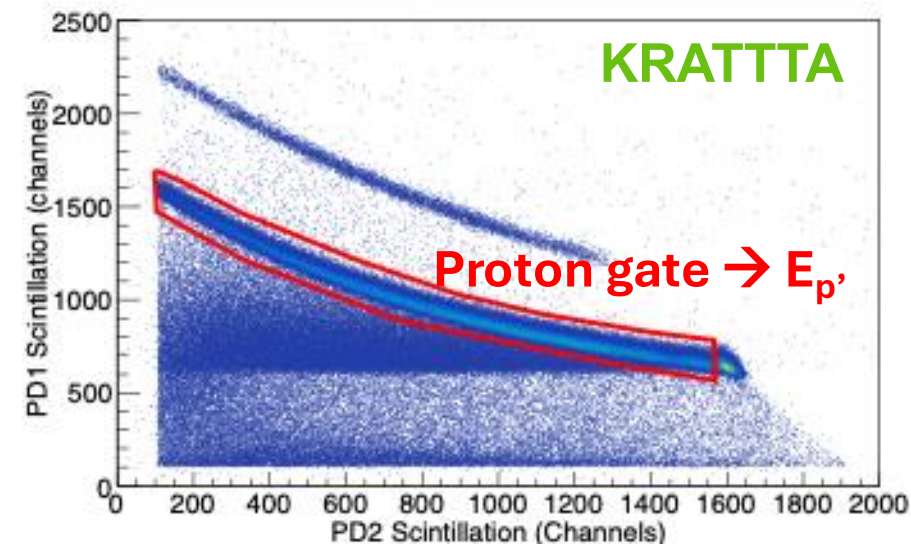
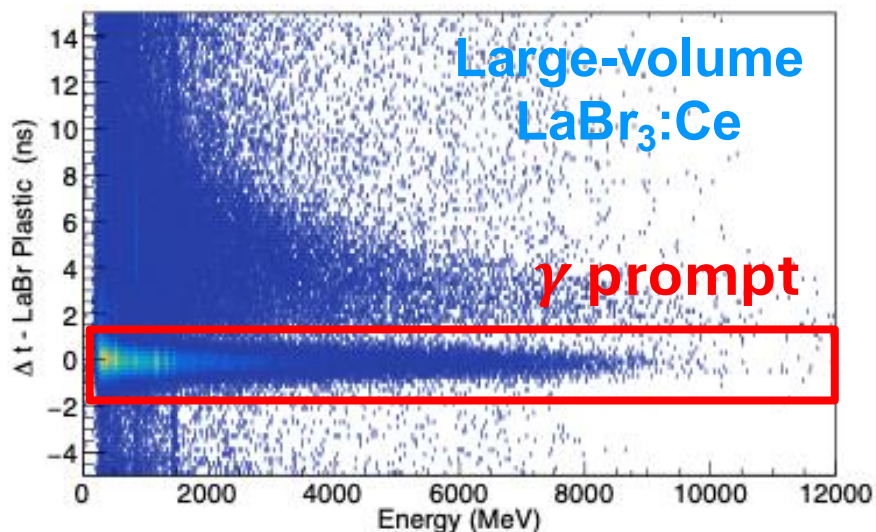
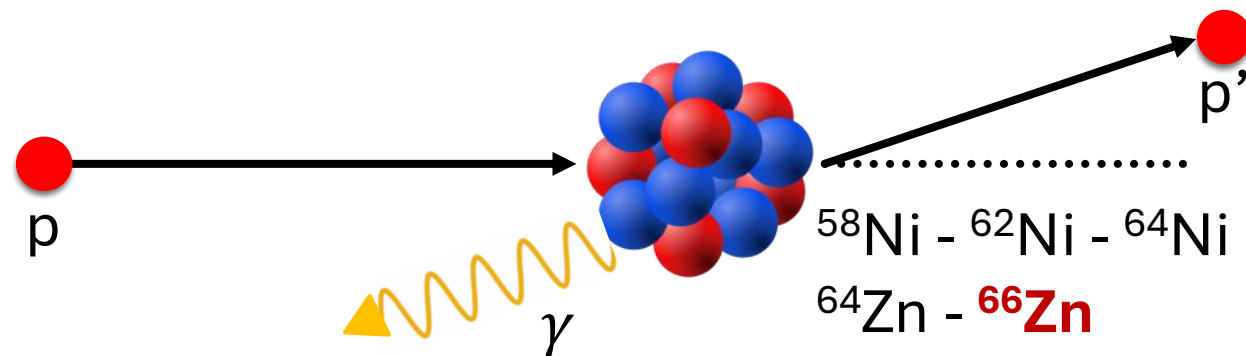
THE EXPERIMENTAL TECHNIQUE



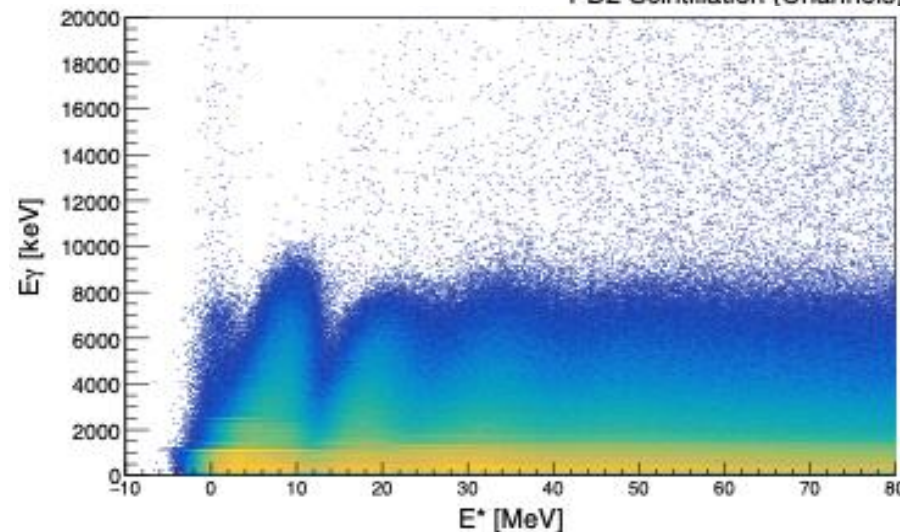
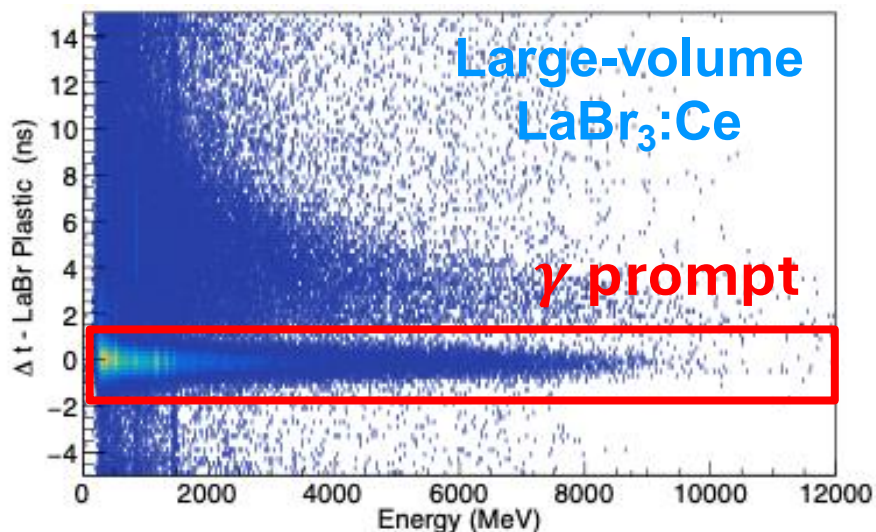
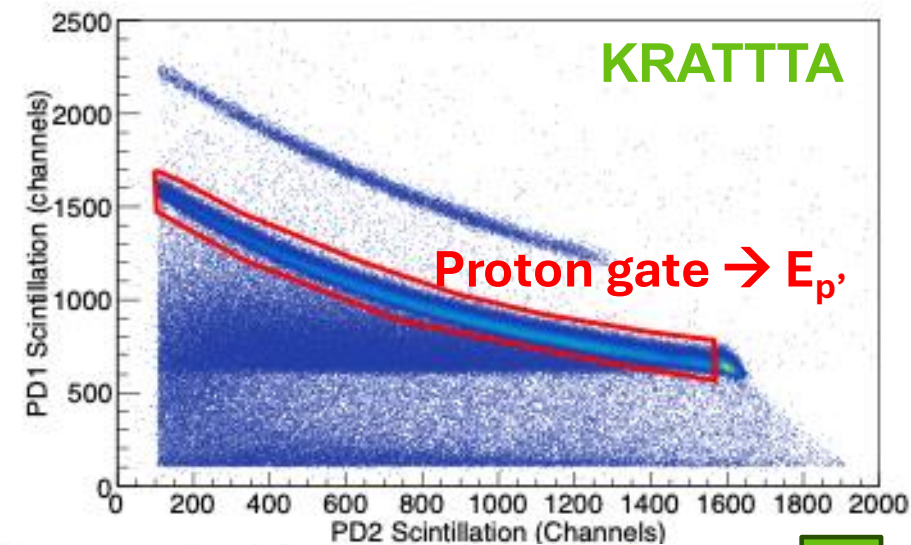
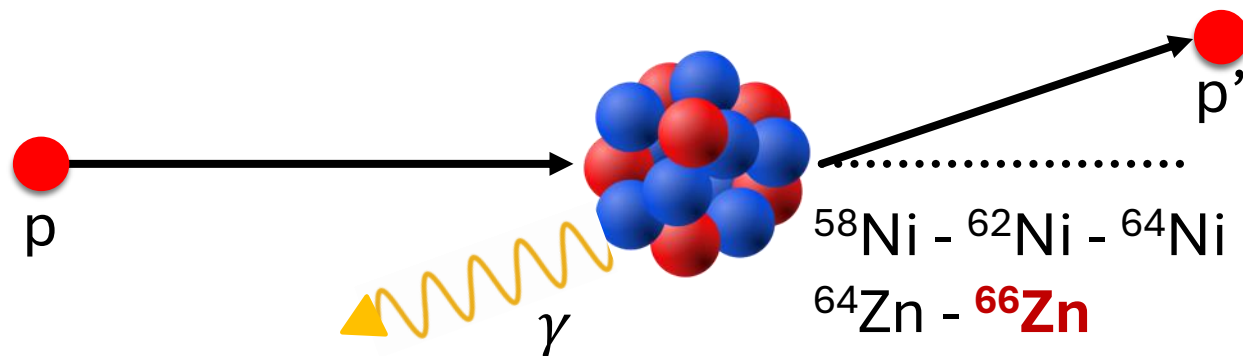
THE EXPERIMENTAL TECHNIQUE



THE EXPERIMENTAL TECHNIQUE

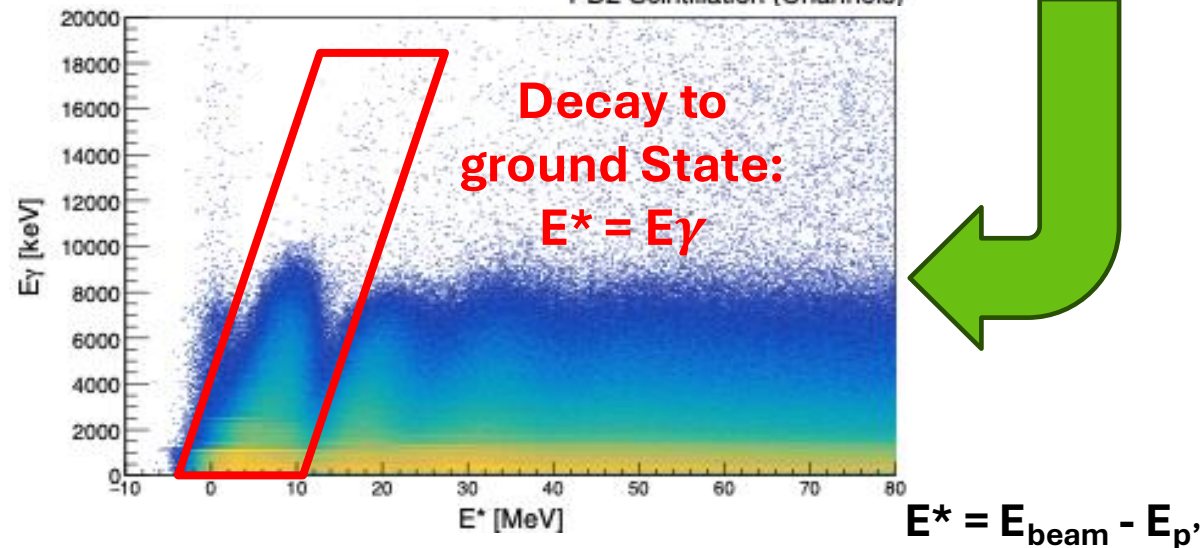
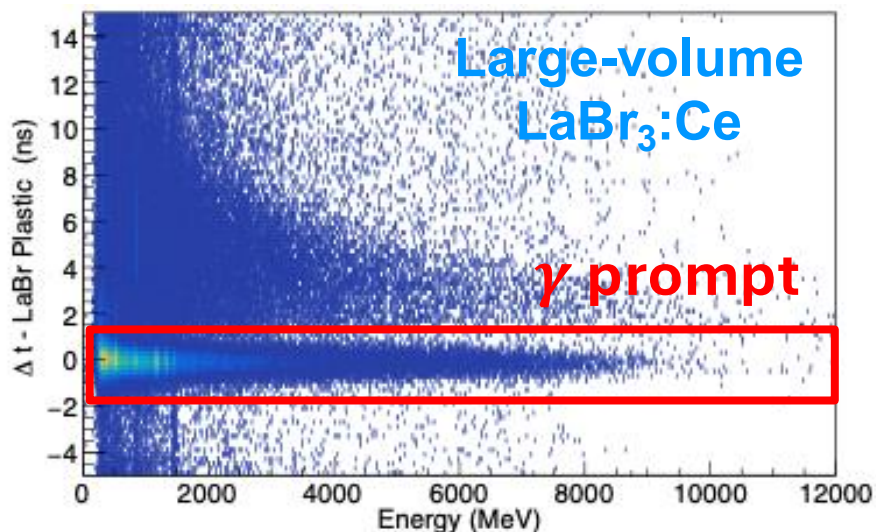
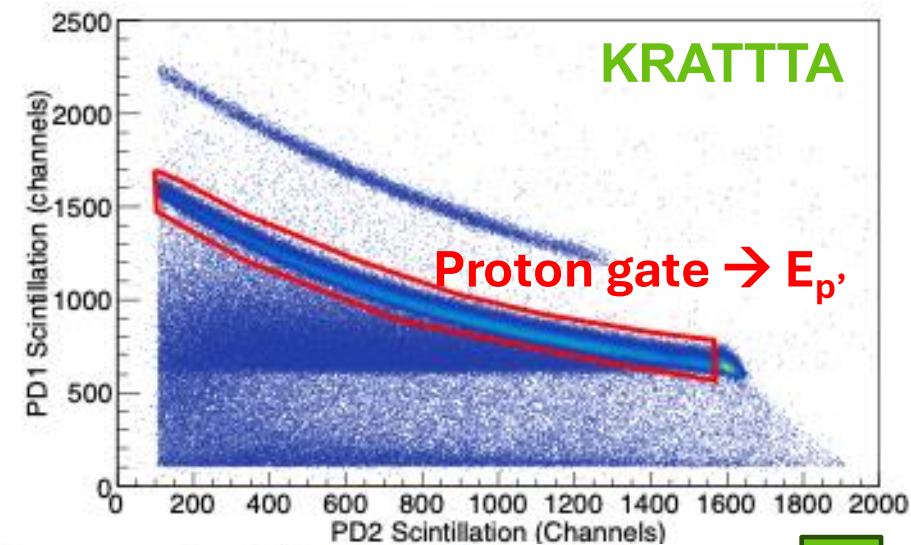
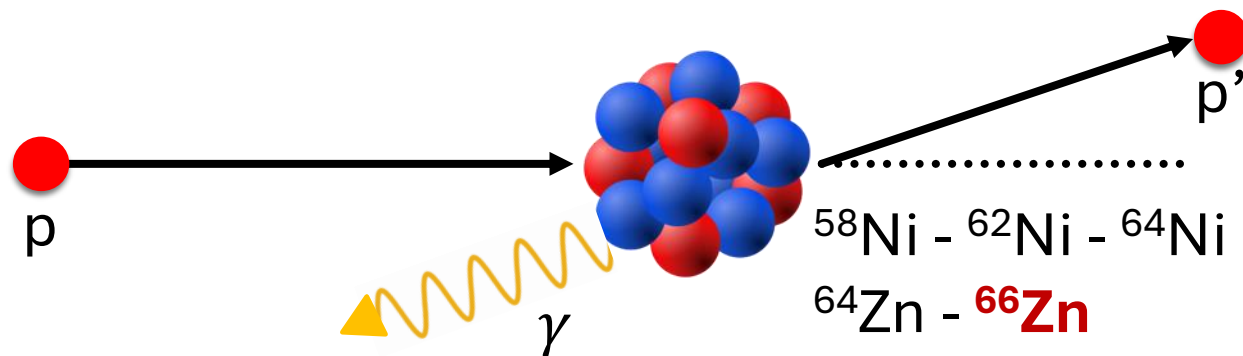


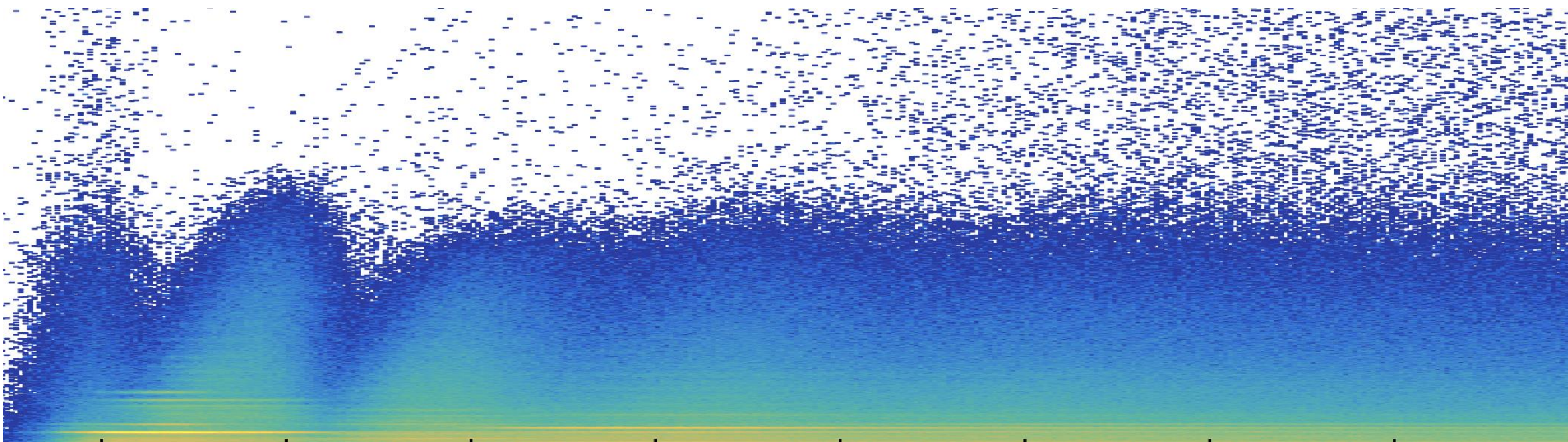
THE EXPERIMENTAL TECHNIQUE



$$E^* = E_{\text{beam}} - E_{p'}$$

THE EXPERIMENTAL TECHNIQUE



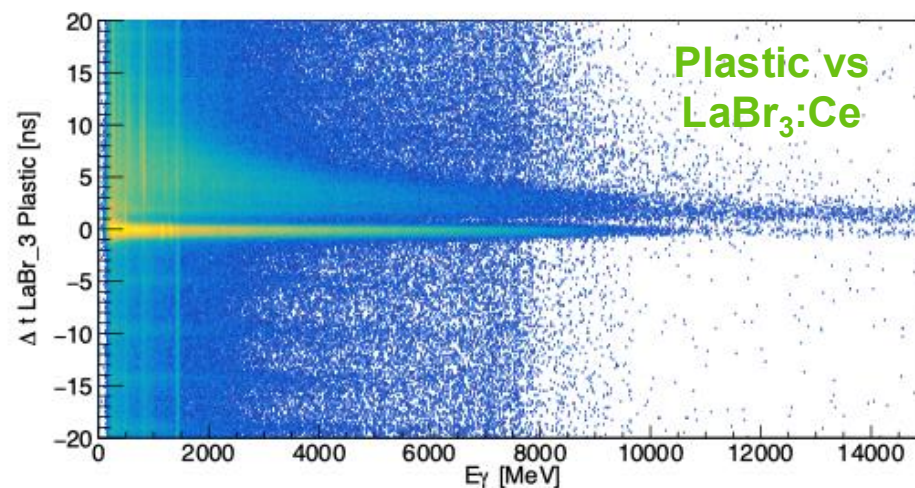


PREVIOUS MEASUREMENTS RESULTS

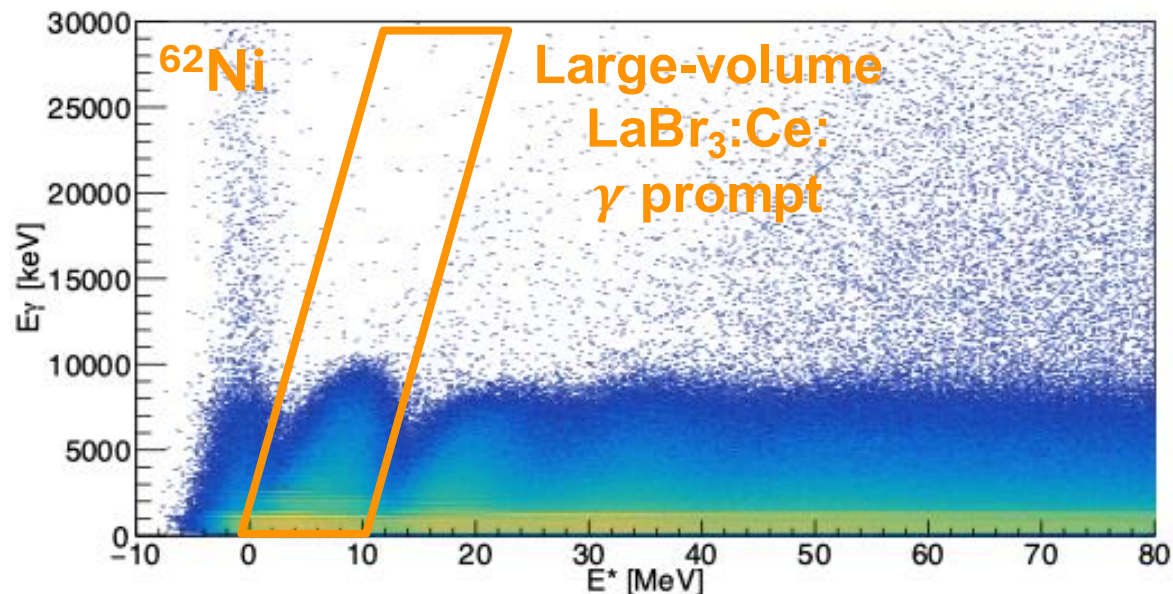
PRELIMINARY RESULTS: ^{58}Ni , ^{62}Ni & ^{64}Ni



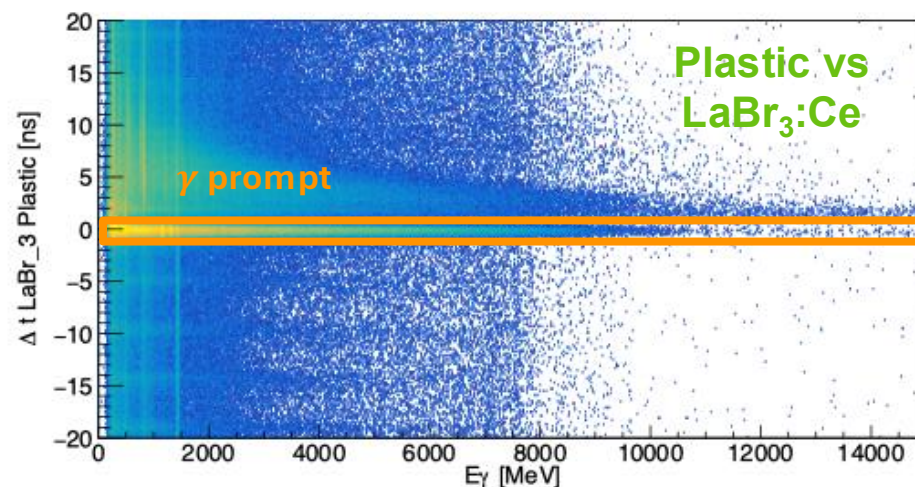
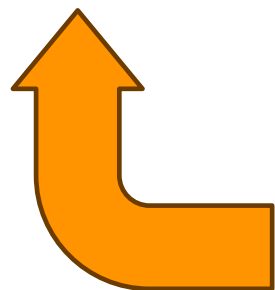
^{62}Ni & ^{58}Ni DATA ANALYSIS: TIME SELECTION



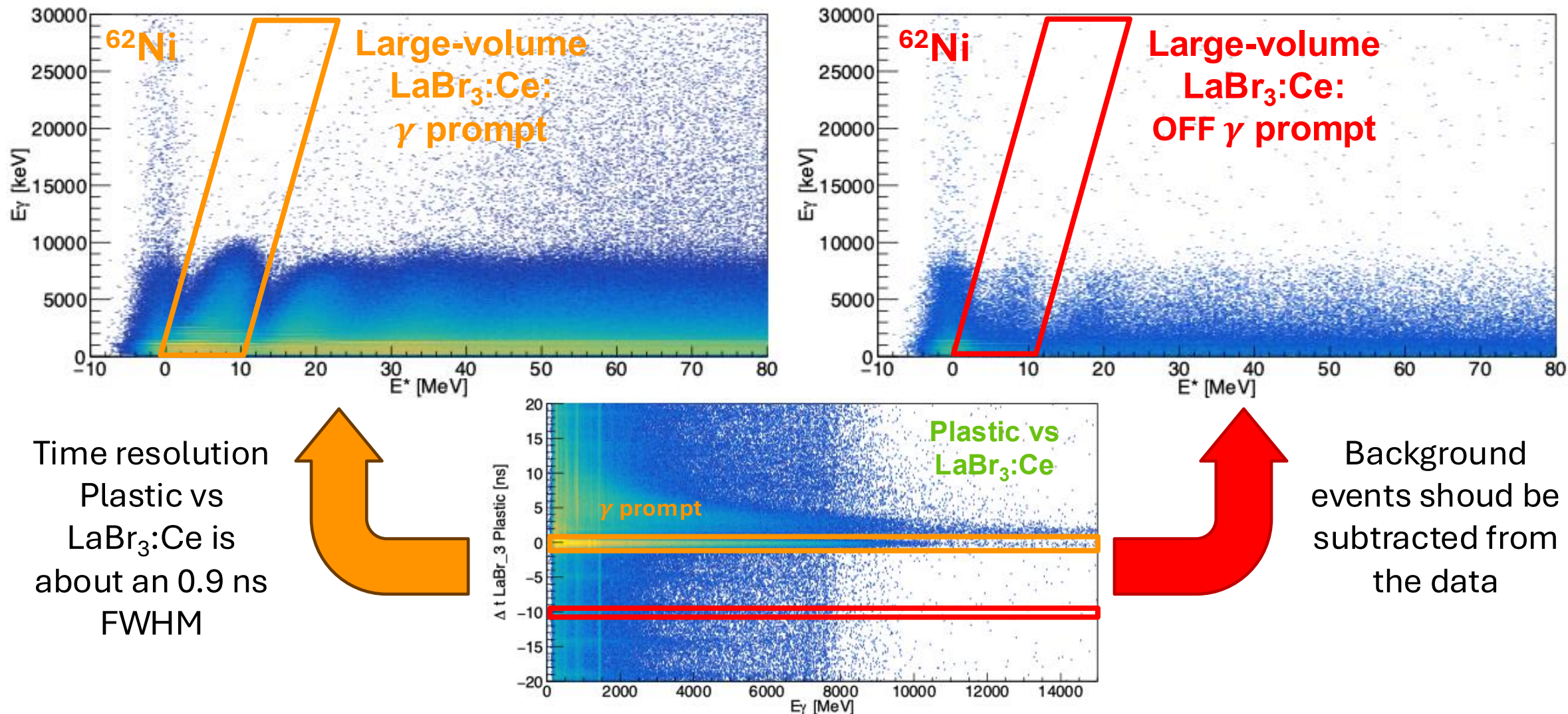
^{62}Ni & ^{58}Ni DATA ANALYSIS: TIME SELECTION



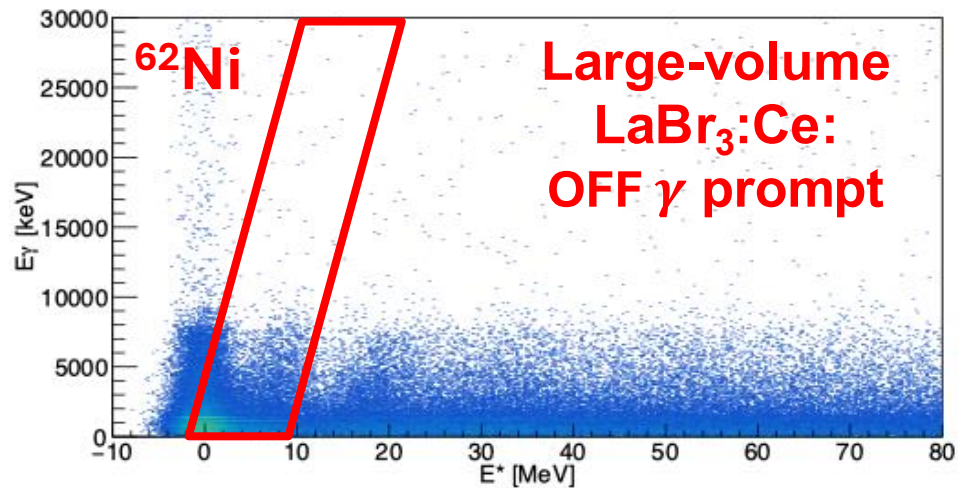
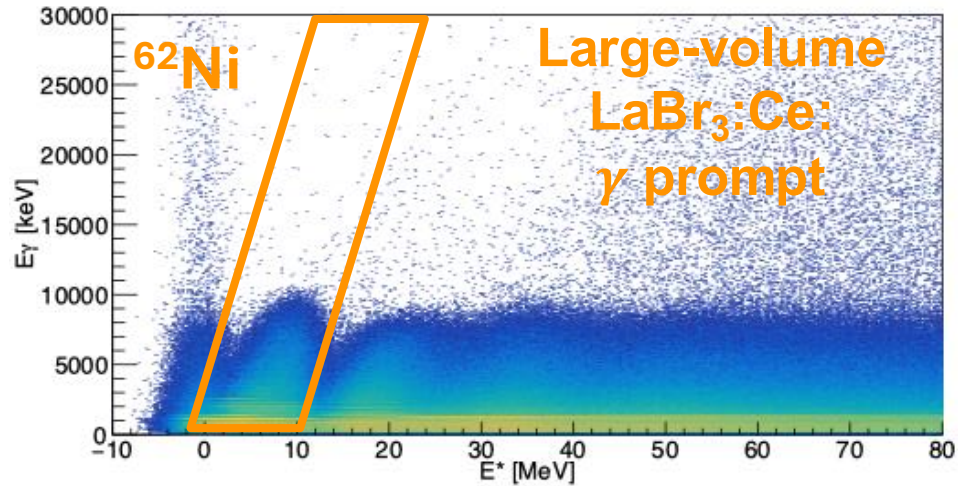
Time resolution
Plastic vs
LaBr₃:Ce is
about an 0.9 ns
FWHM



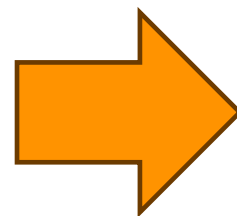
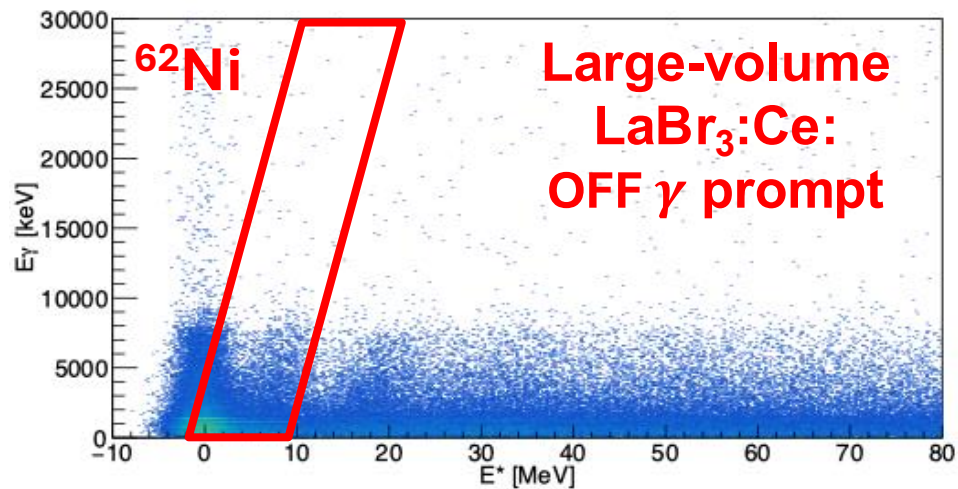
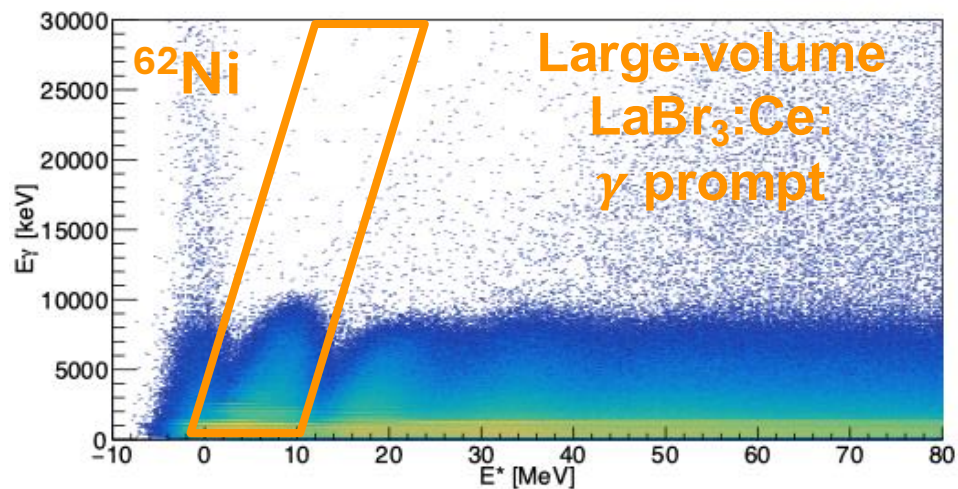
^{62}Ni & ^{58}Ni DATA ANALYSIS: TIME SELECTION



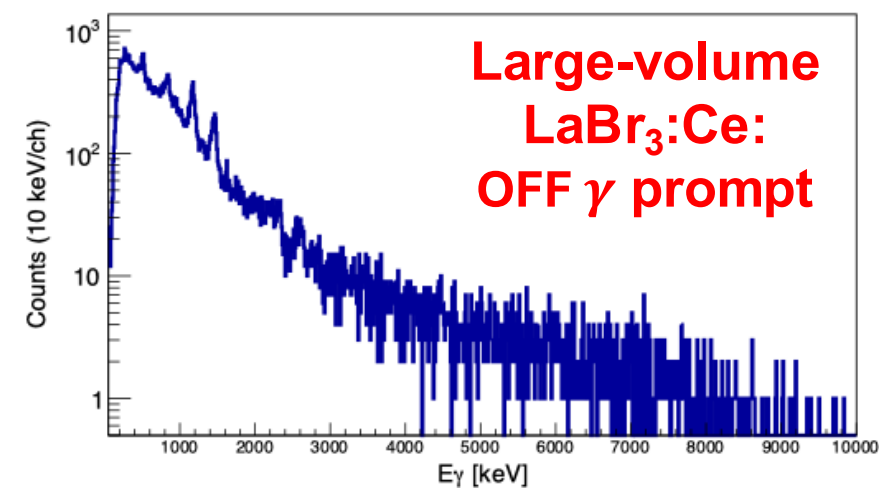
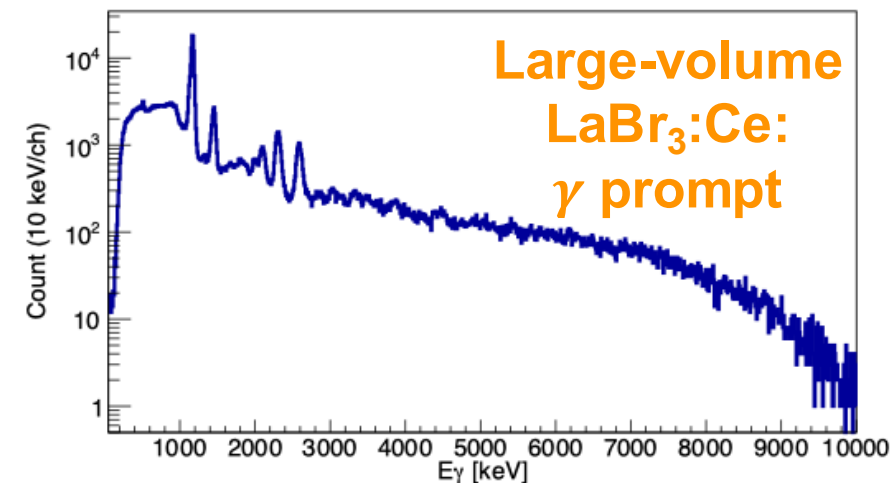
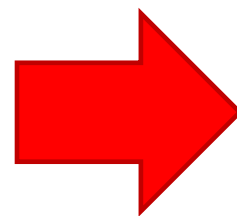
^{62}Ni & ^{58}Ni DATA ANALYSIS: DECAY TO THE GROUND STATE



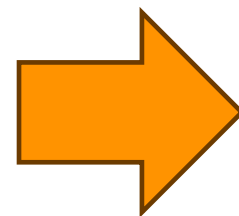
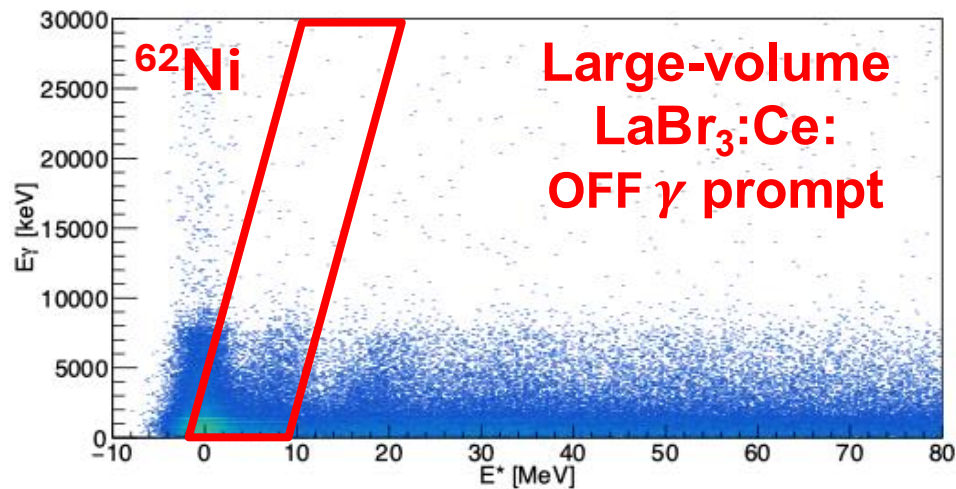
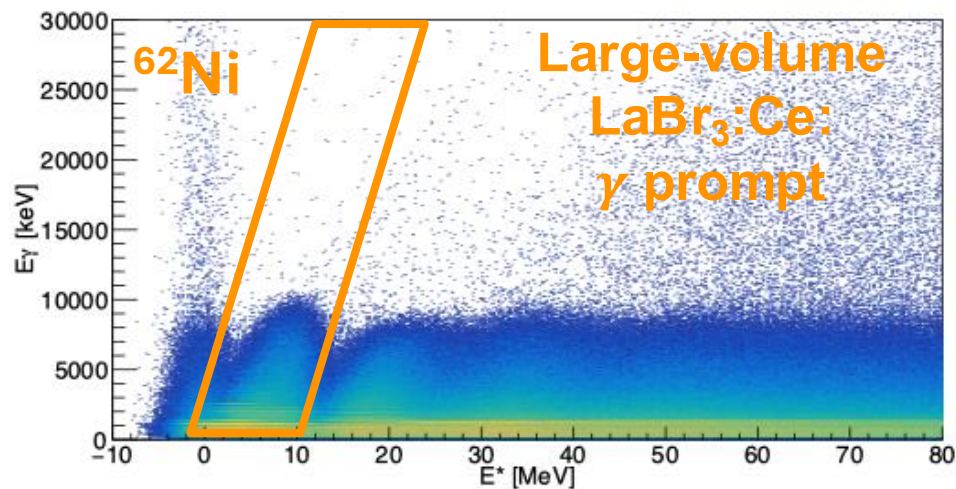
^{62}Ni & ^{58}Ni DATA ANALYSIS: DECAY TO THE GROUND STATE



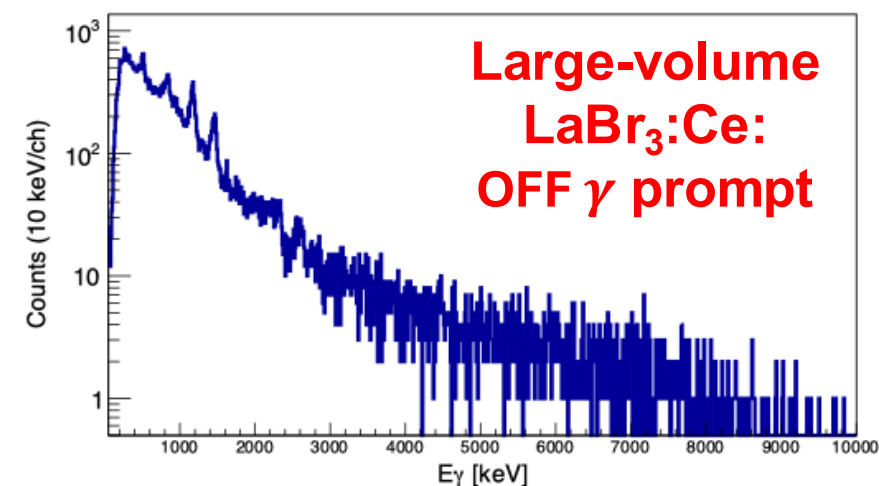
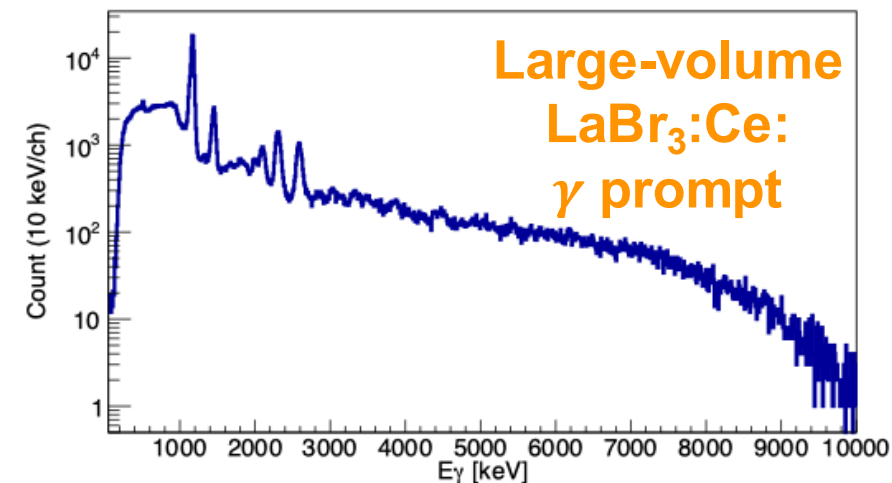
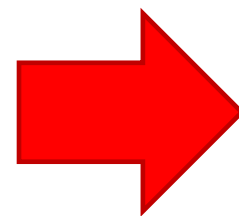
y-axis
projection to
extract the γ
decay to the
ground state



^{62}Ni & ^{58}Ni DATA ANALYSIS: DECAY TO THE GROUND STATE



y-axis
projection to
extract the γ
decay to the
ground state

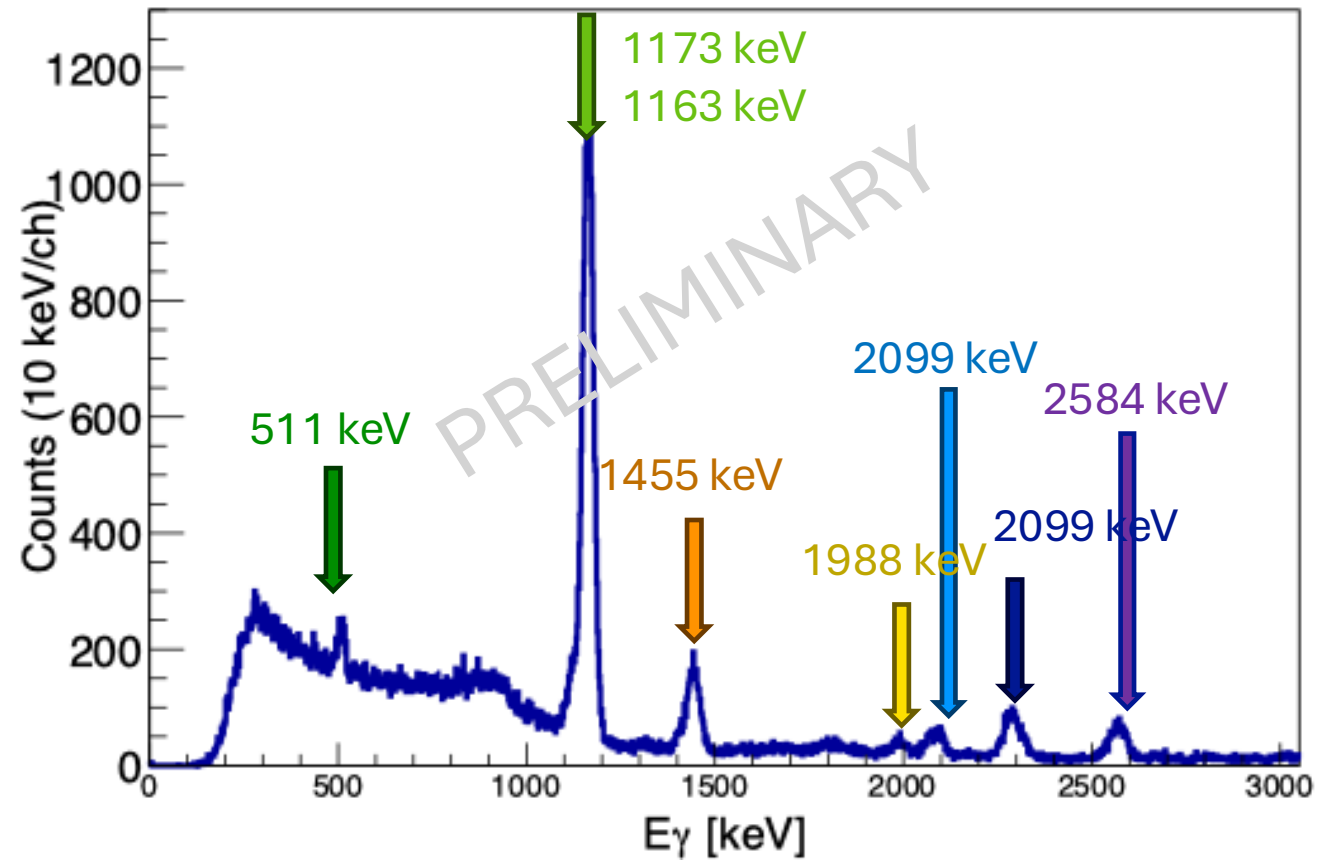


LaBr₃:Ce: γ prompt – LaBr₃:Ce: OFF γ prompt

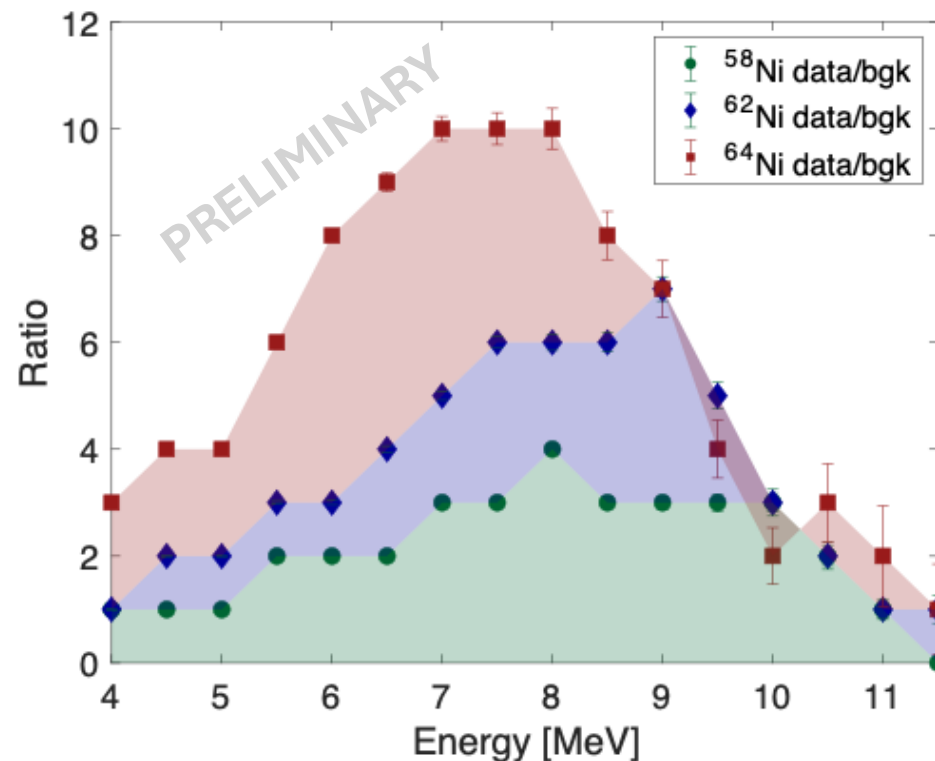
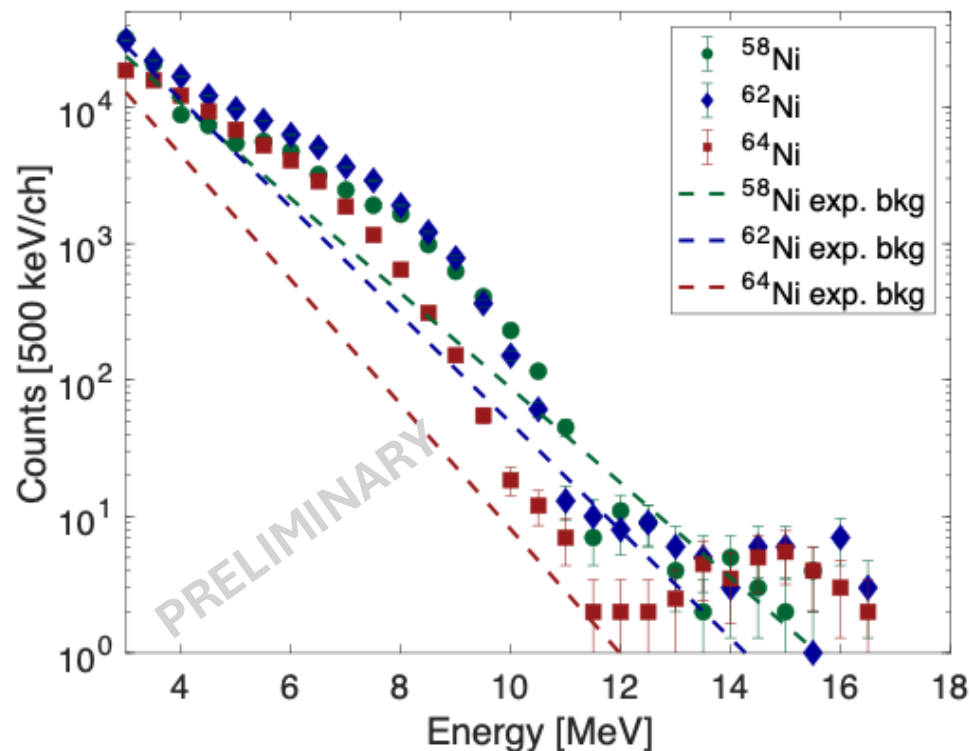
LaBr₃:Ce: ⁶²Ni LOW ENERGY TRANSITIONS

The calibration need to be refined

Measured Energy [keV]	Possible Transition	Real Energy [keV]
505	-	511
1165	$2^+ \rightarrow 0^+$ $4^+ \rightarrow 2^+$	1173 1163
1435	$3^- \rightarrow 2_2^+$	1455
1988	$4_2^+ \rightarrow 2^+$	2004
2099	$4_3^+ \rightarrow 2^+$	2104
2289	$2_1^+ \rightarrow 0^+$	2301
2577	$3^- \rightarrow 2^+$	2584



PDR IN Ni ISOTOPES



^{62}Ni & ^{64}Ni

$N/Z = 1.21$

$N/Z = 1.29$

Pygmy

expected

^{58}Ni

$N/Z = 1.07$

No Pygmy or

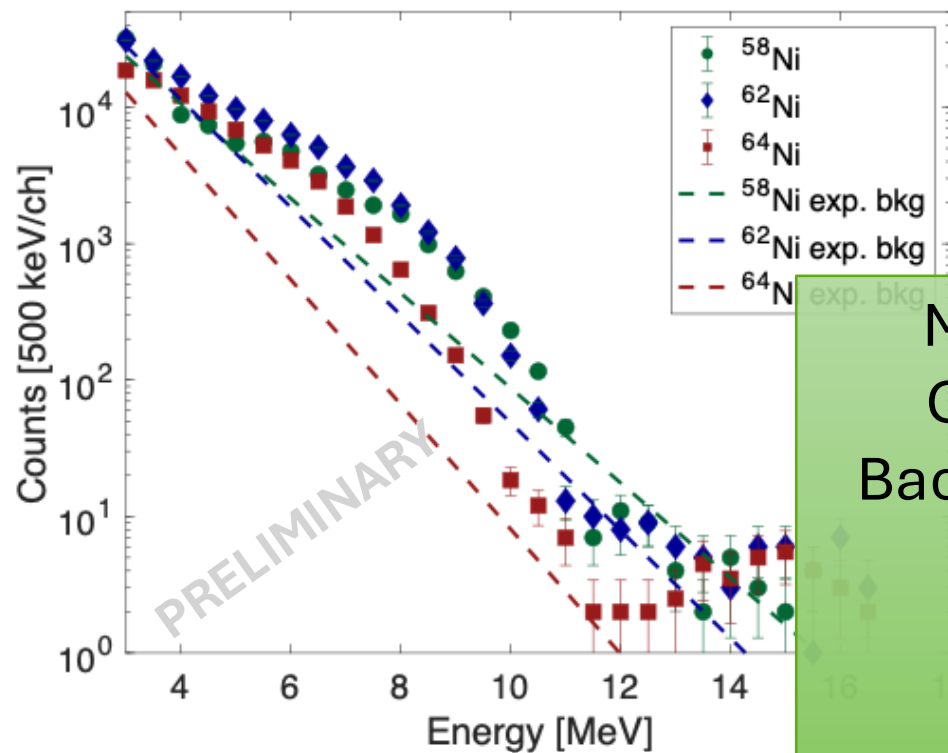
negligible

Pygmy

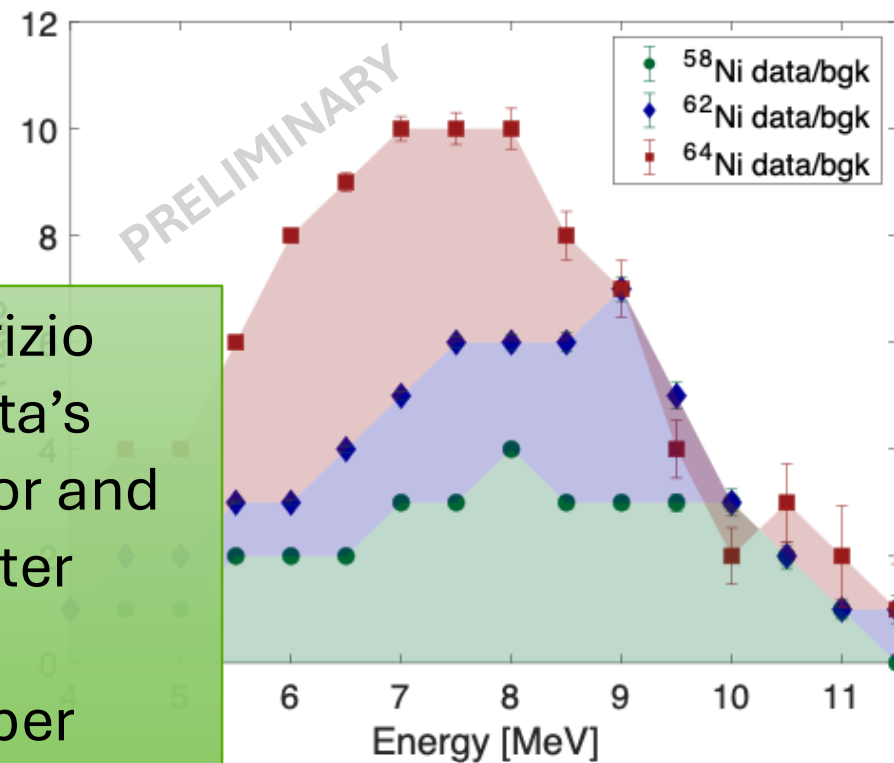
expected

The data for ^{64}Ni are based on a semi-online analysis.

PDR IN Ni ISOTOPES



Maurizio
Giunta's
Bachelor and
Master
&
Kacper
Proszowski's
Master



^{62}Ni & ^{64}Ni

$N/Z = 1.21$

$N/Z = 1.29$

Pygmy
expected

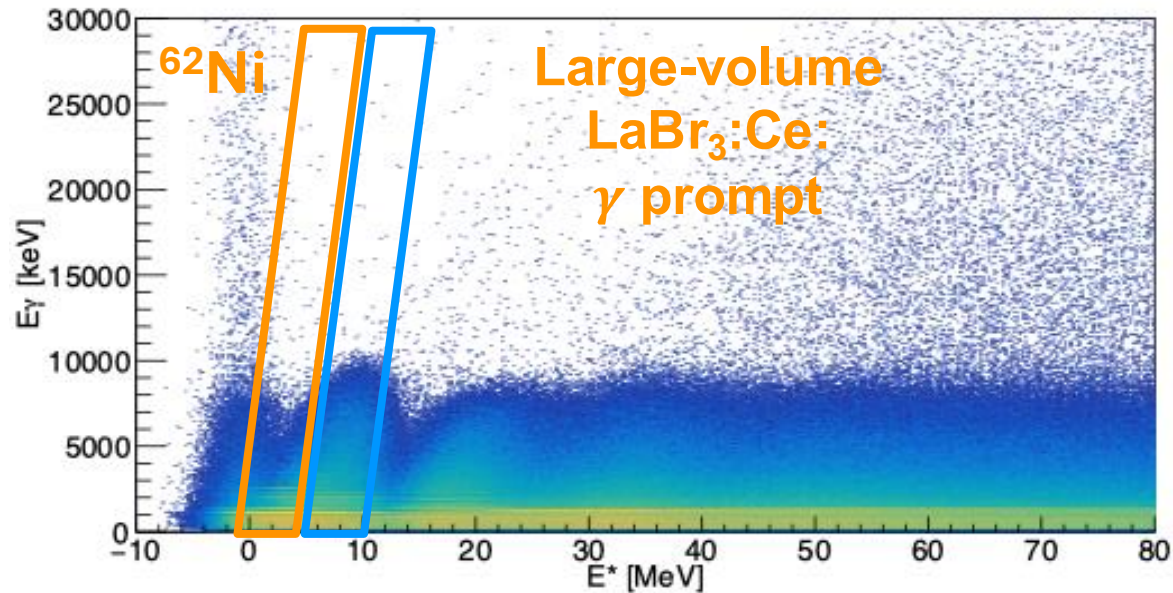
^{58}Ni

$N/Z = 1.07$

No Pygmy or
negligible
Pygmy
expected

The data for ^{64}Ni are based on a semi-online analysis.

PDR DECAY TO GROUND STATE IN ^{62}Ni



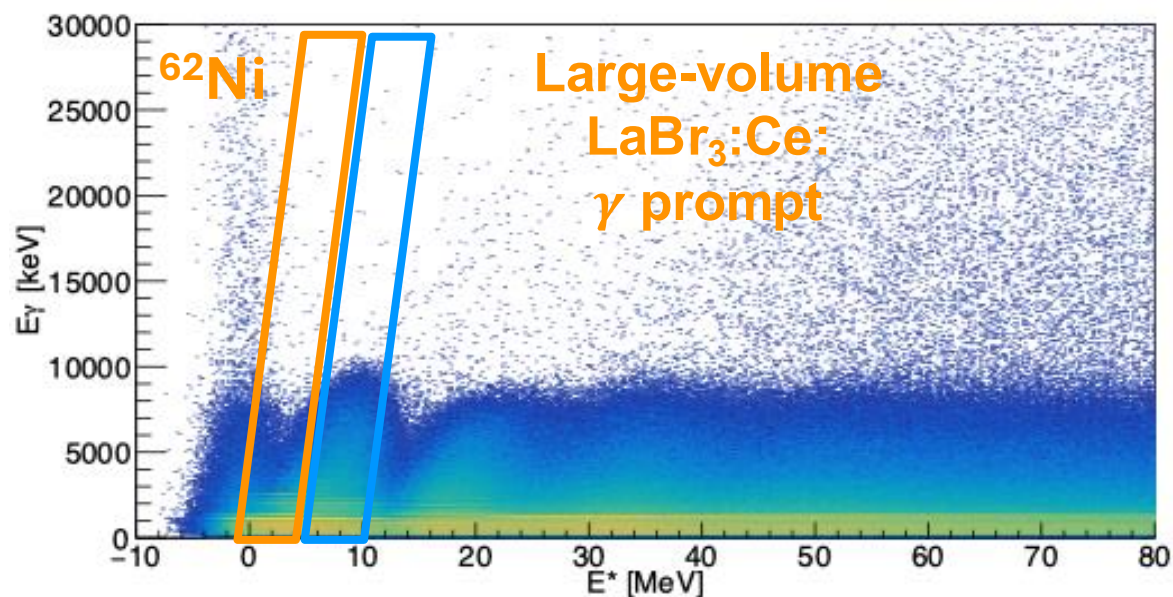
Two different cuts:

1) $E_x = E_\gamma$ (decay to the ground state)

2) $E_x + 5 \text{ MeV} = E_\gamma$

Gate width 5 MeV

PDR DECAY TO GROUND STATE IN ^{62}Ni

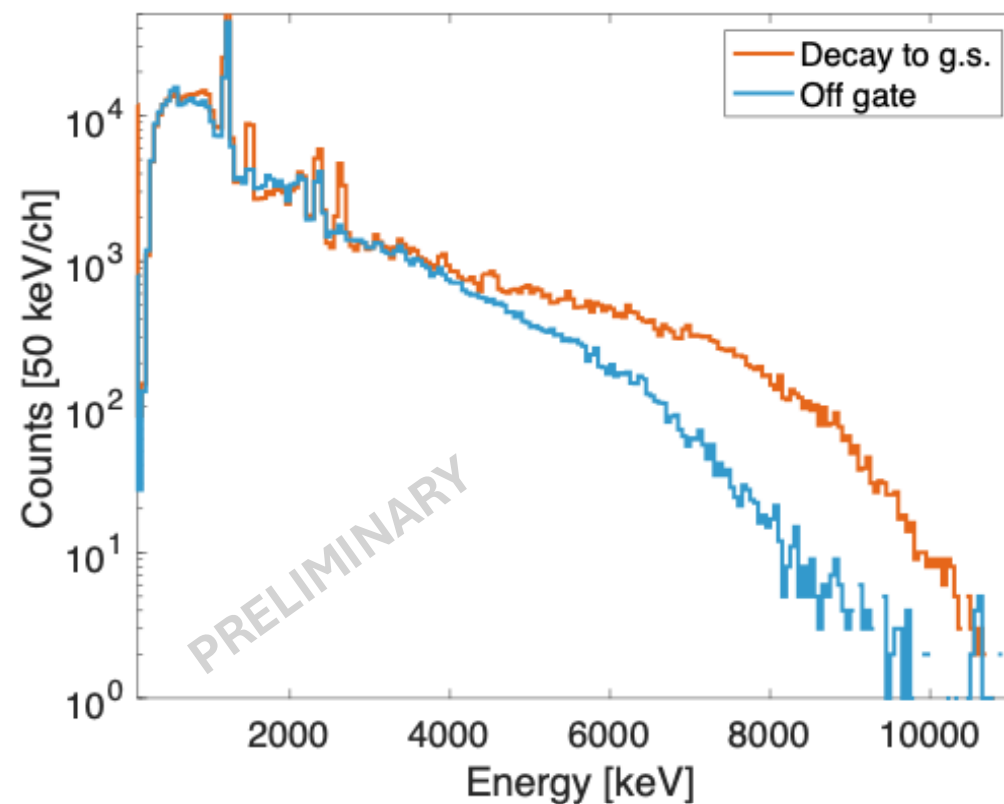


Two different cuts:

1) $E_\gamma = E^*$ (decay to the ground state)

2) $E_\gamma = E^* + 5 \text{ MeV}$

Gate width 5 MeV



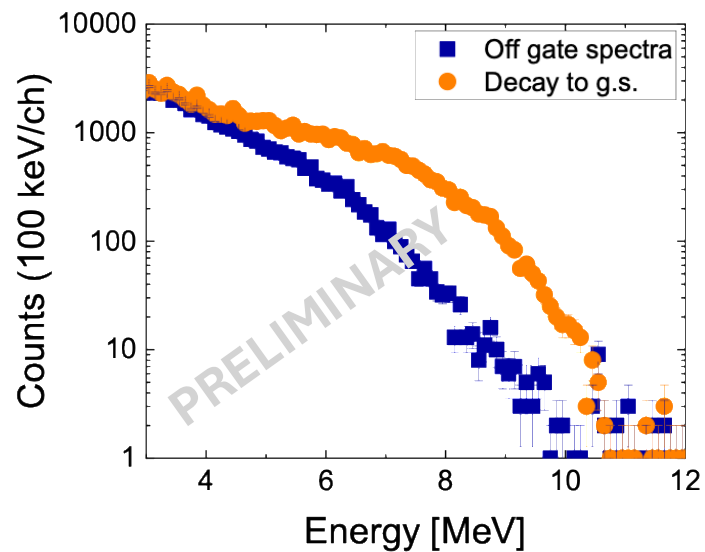
PDR decays to the ground state

PDR IN ^{62}Ni

Cut width 2
MeV as KRATTA
resolution

$$E_x = E_\gamma$$

$$E_x + 2 \text{ MeV} = E_\gamma$$

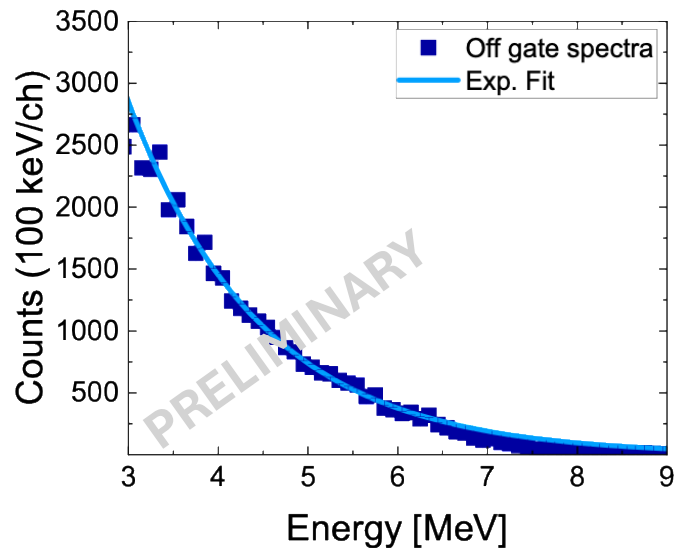
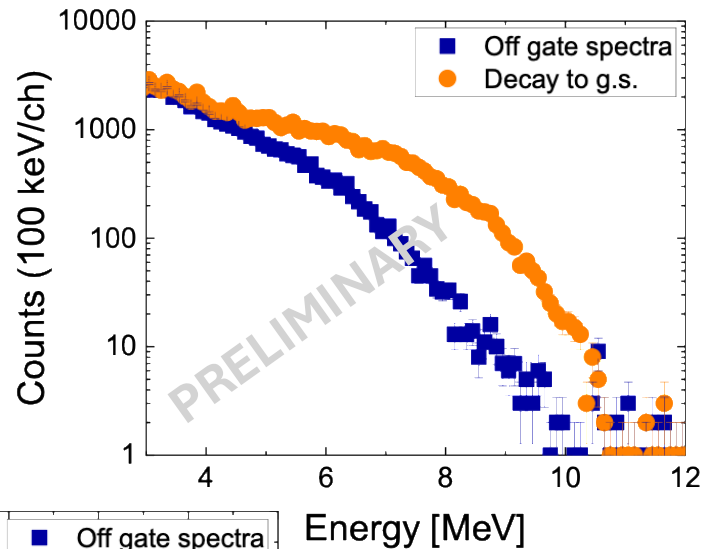


PDR IN ^{62}Ni

Cut width 2
MeV as KRATTA
resolution

$$E_x = E_\gamma$$

$$E_x + 2 \text{ MeV} = E_\gamma$$



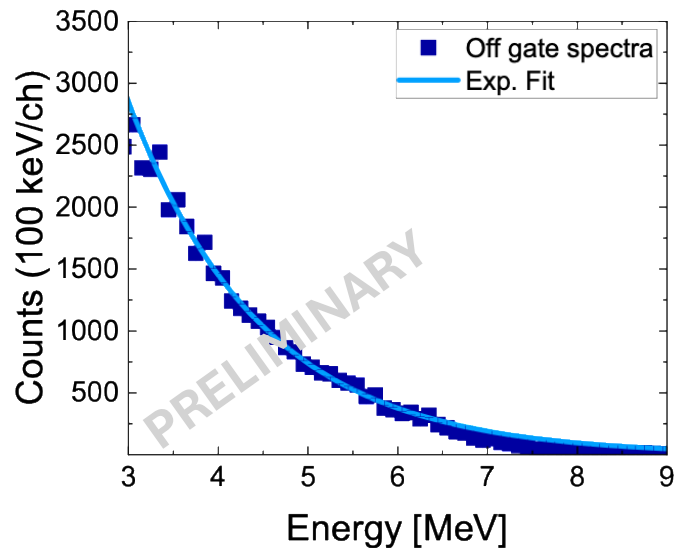
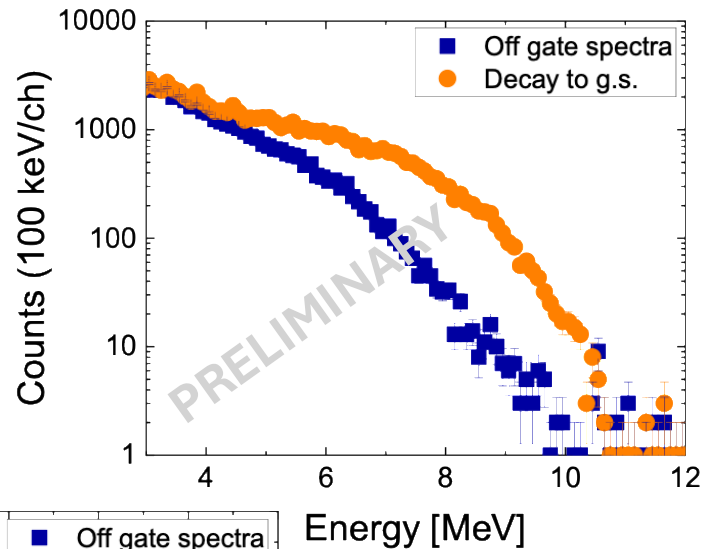
Off gate spectra
fitted with an
exponential
Exponential fit
subtracted to the
data

PDR IN ^{62}Ni

Cut width 2
MeV as KRATTA
resolution

$$E_x = E_\gamma$$

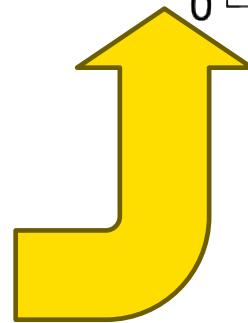
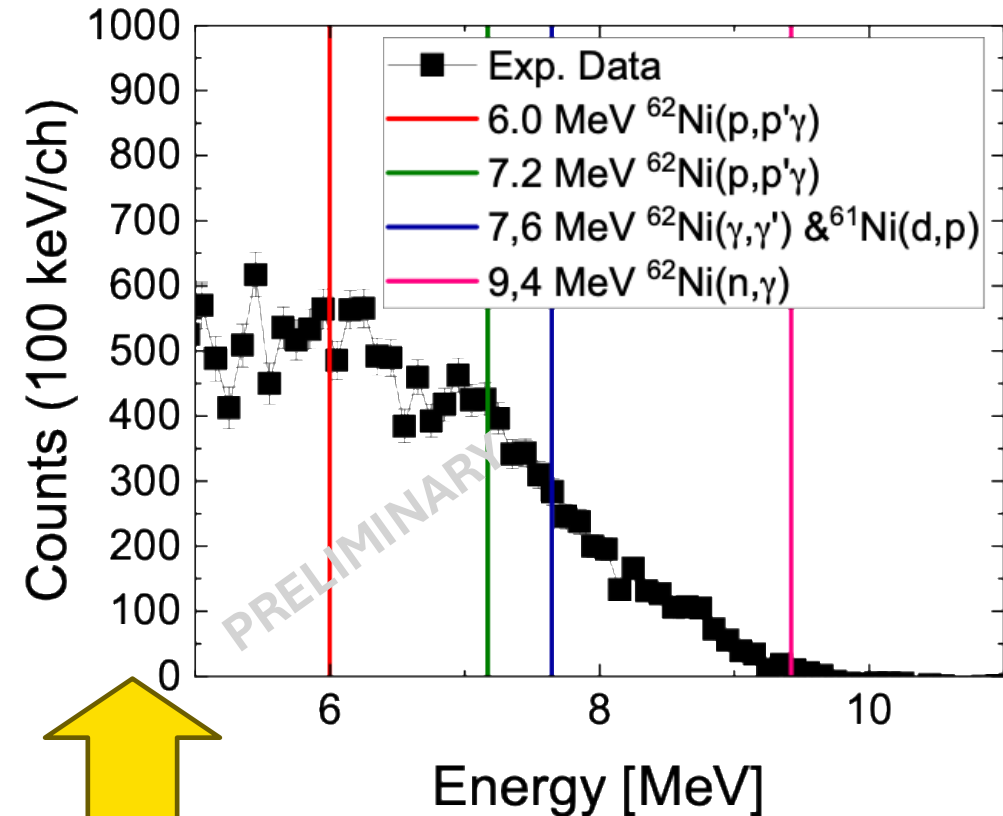
$$E_x + 2 \text{ MeV} = E_\gamma$$



Off gate spectra
fitted with an
exponential

Exponential fit
subtracted to the
data

The calibration need to be refined

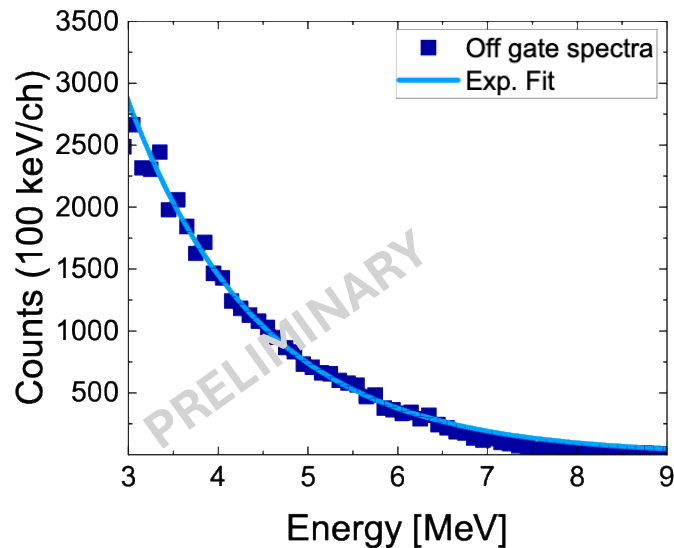
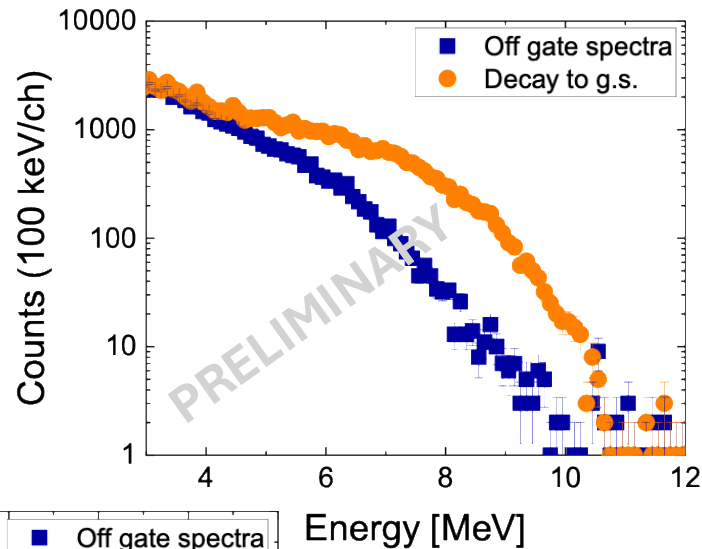


PDR IN ^{62}Ni

Cut width 2
MeV as KRATTA
resolution

$$E_x = E_\gamma$$

$$E_x + 2 \text{ MeV} = E_\gamma$$

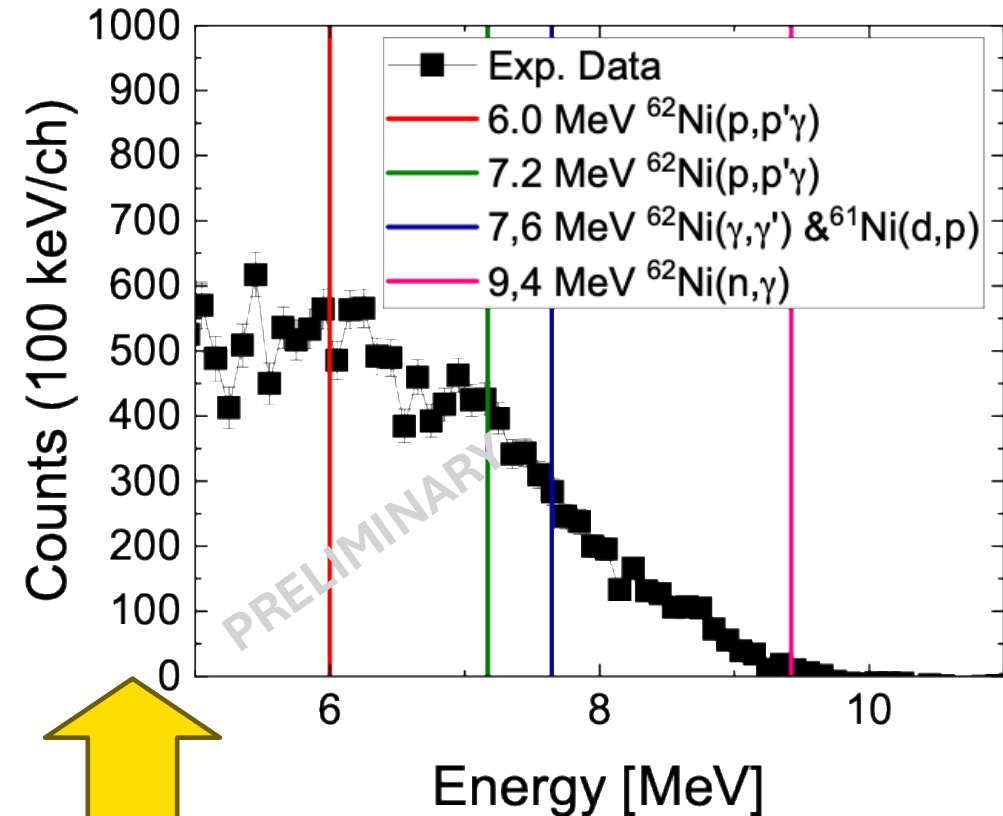


Energy [MeV]

Off gate spectra
fitted with an
exponential

Exponential fit
subtracted to the
data

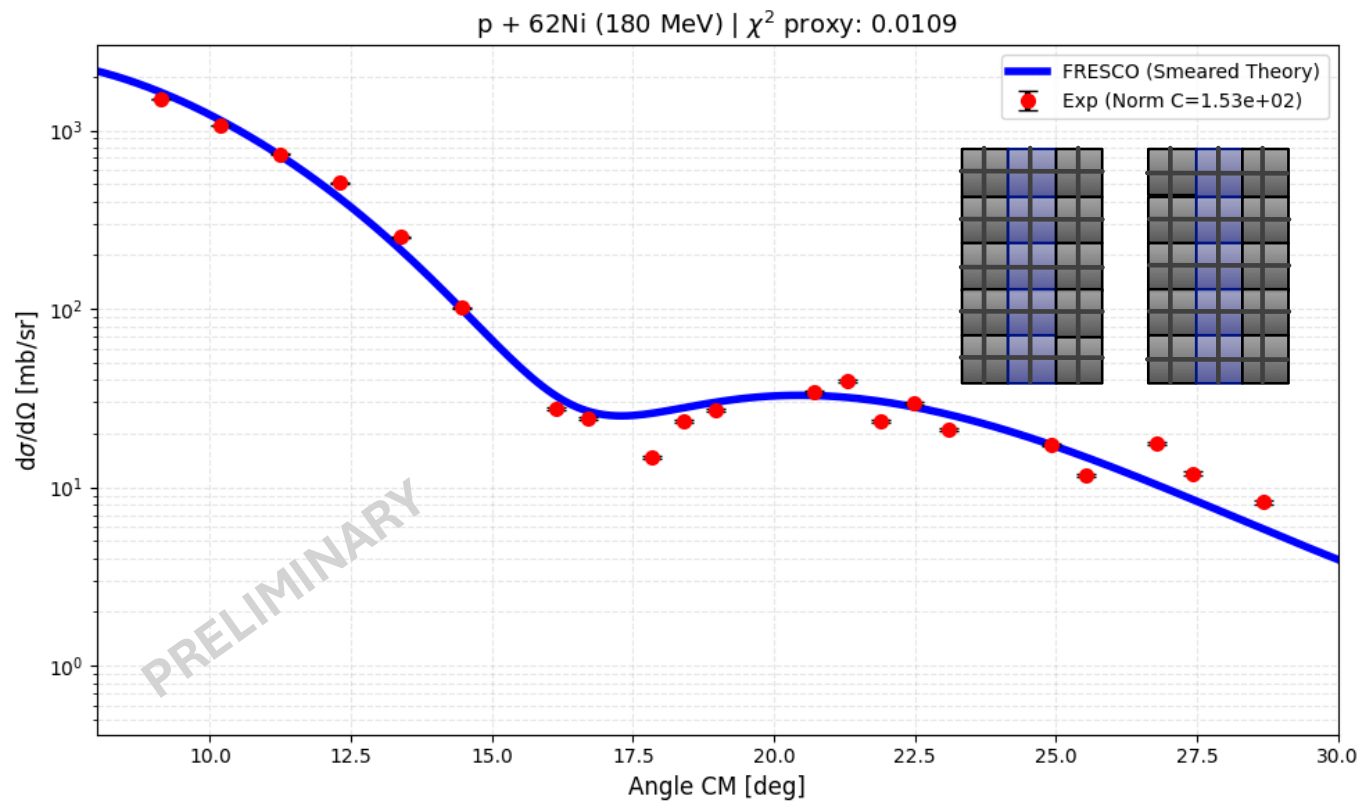
The calibration need to be refined



Final goal : extraction of the PDR cross
section

ELASTIC CROSS SECTION: ^{62}Ni

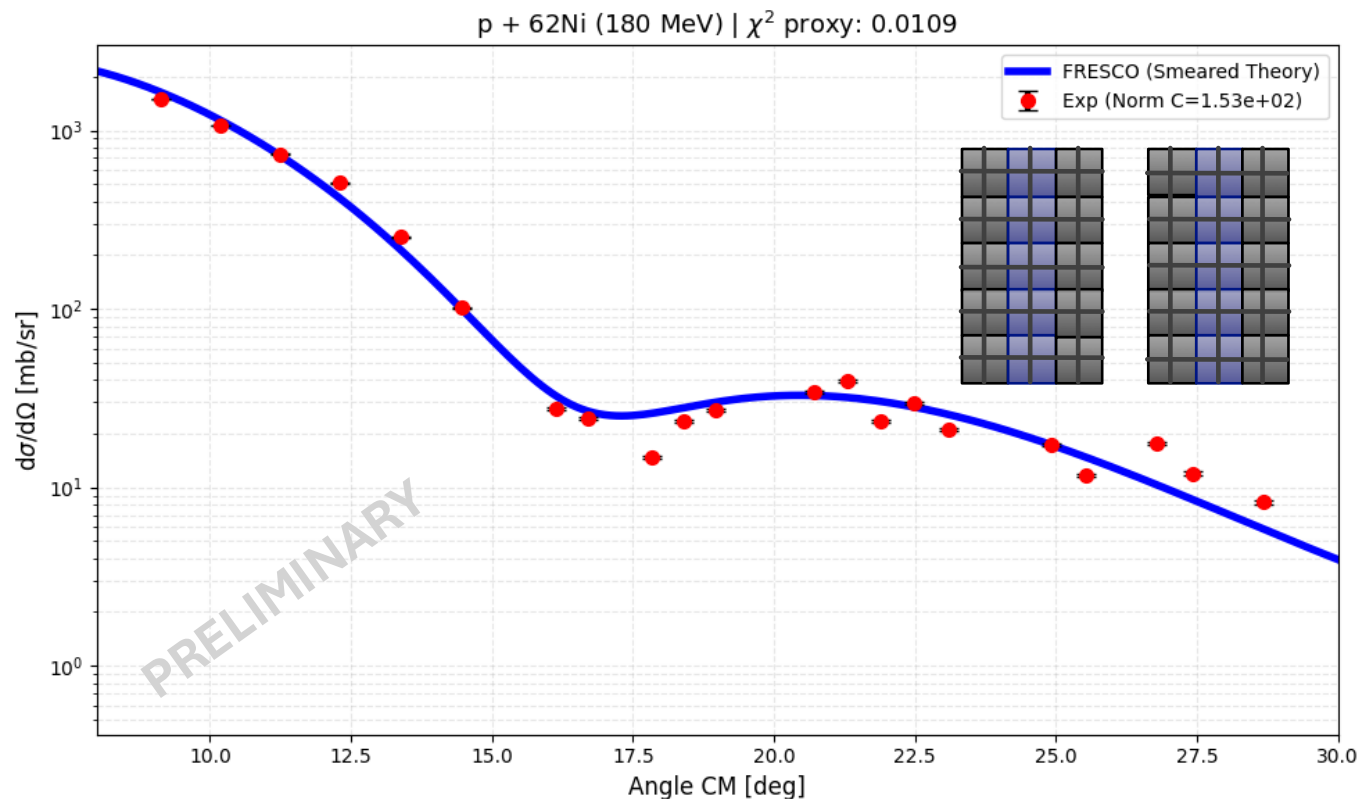
By using plastic angles, the elastic cross section can be reproduced over the angular range from 8° to 30° .



Courtesy of M. Ciemala

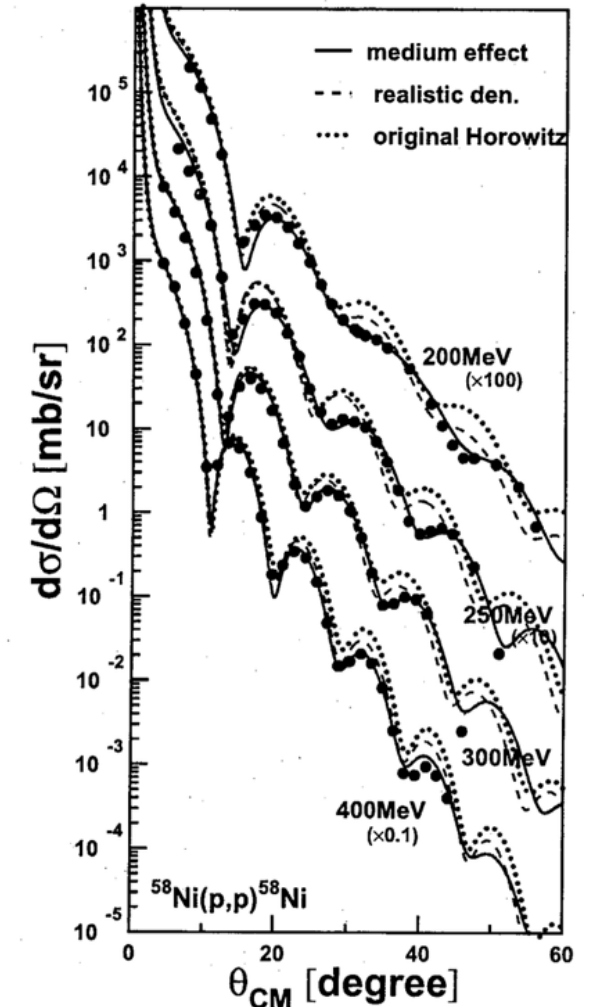
ELASTIC CROSS SECTION: ^{62}Ni

By using plastic angles, the elastic cross section can be reproduced over the angular range from 8° to 30° .



Courtesy of M. Ciemala

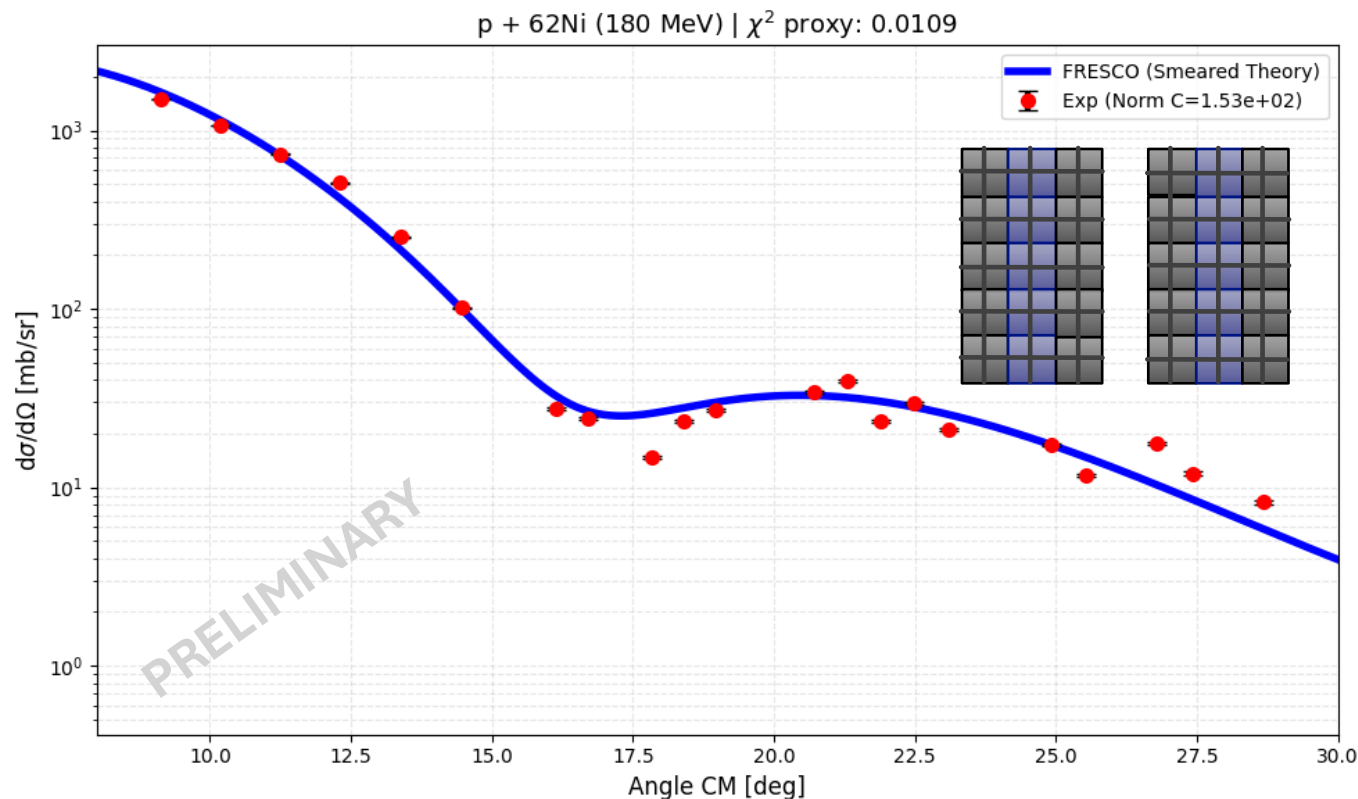
It was previously measured in Osaka for ^{58}Ni at 200 MeV. We can compare our data with those results.



Y. Takeda, Mem. Fac. Sci. Kyoto Univ., Ser. Phys., **44**, 1, (2003)

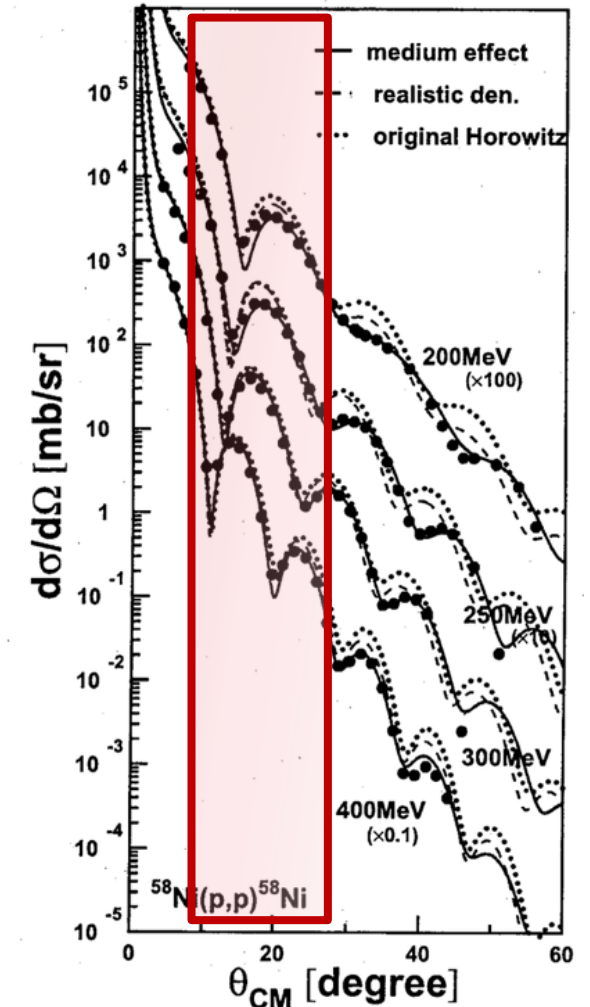
ELASTIC CROSS SECTION: ^{62}Ni

By using plastic angles, the elastic cross section can be reproduced over the angular range from 8° to 30° .



Courtesy of M. Ciemala

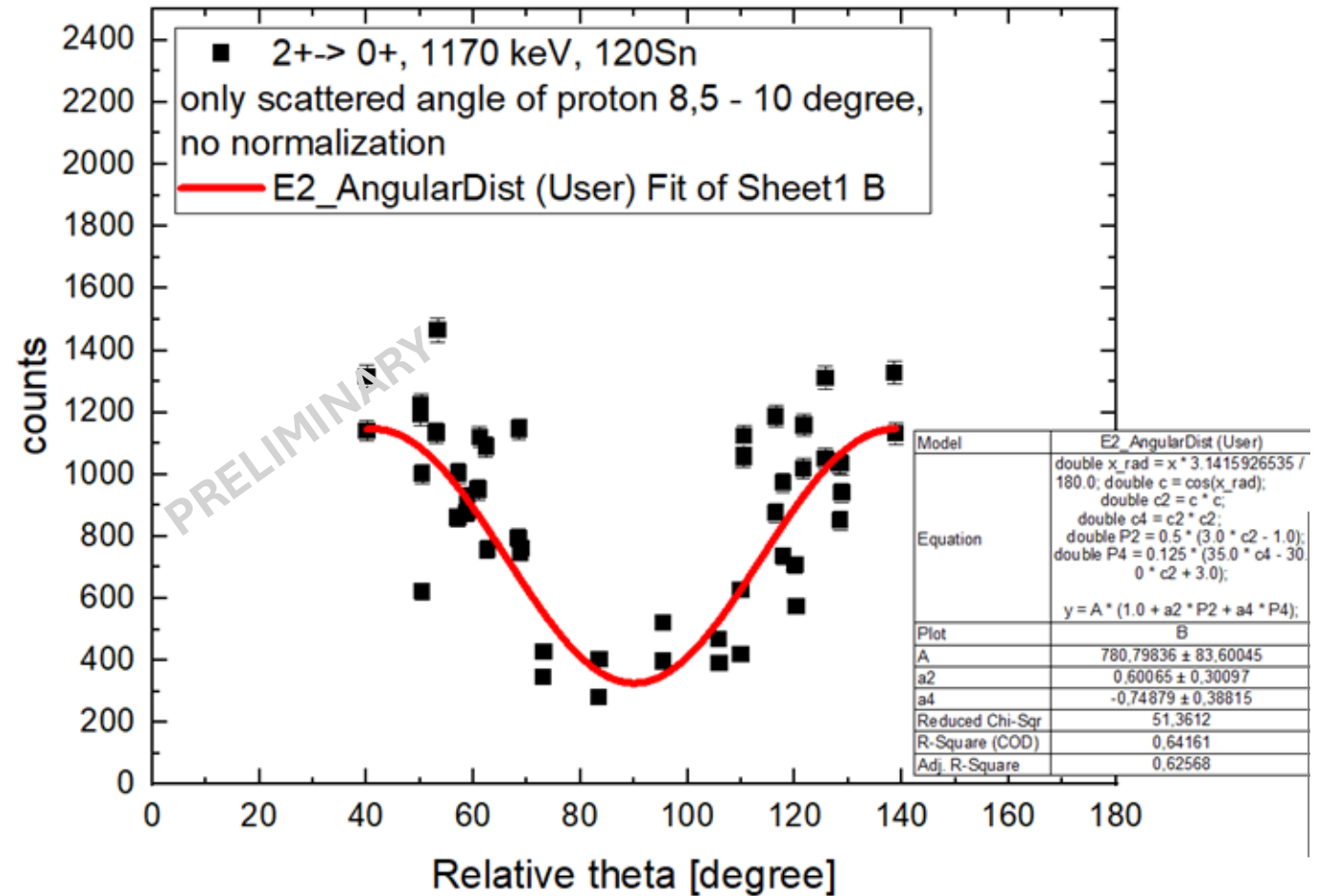
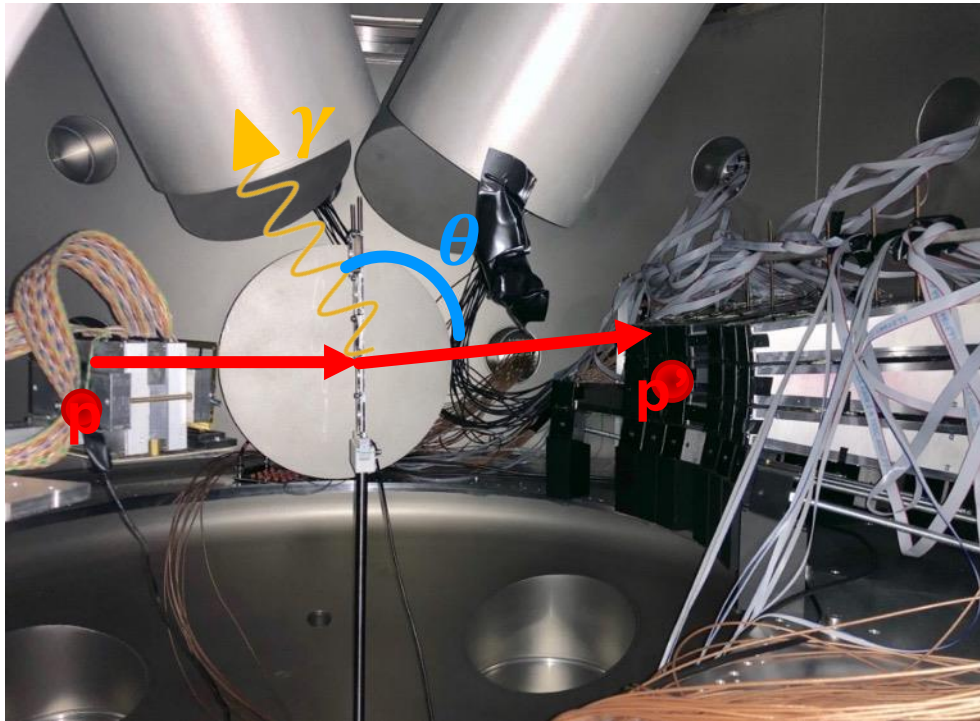
It was previously measured in Osaka for ^{58}Ni at 200 MeV. We can compare our data with those results.



Y. Takeda, Mem. Fac. Sci. Kyoto Univ., Ser. Phys., **44**, 1, (2003)

γ -RAY ANGULAR DISTRIBUTION

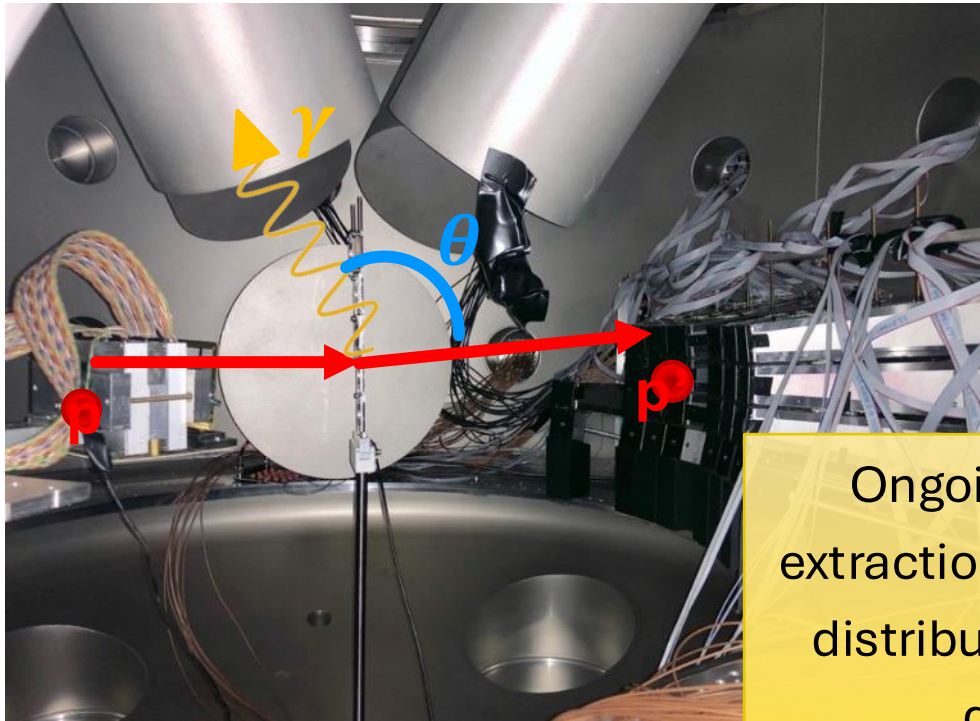
The plastic detector granularity allows us to extract the angular distribution (**transition character**).



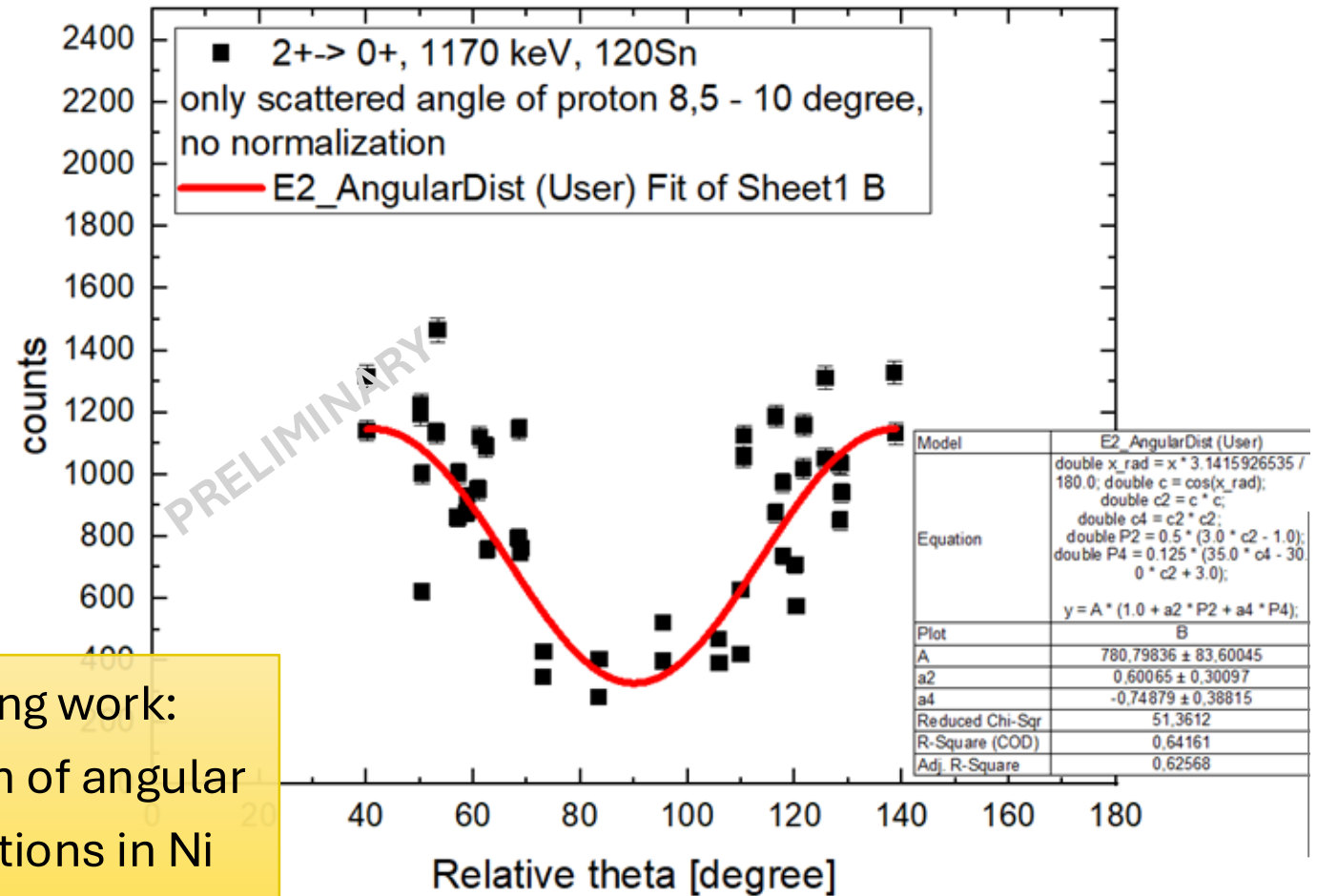
Courtesy of M. Ciemala

γ -RAY ANGULAR DISTRIBUTION

The plastic detector granularity allows us to extract the angular distribution (**transition character**).



Ongoing work:
extraction of angular
distributions in Ni
data

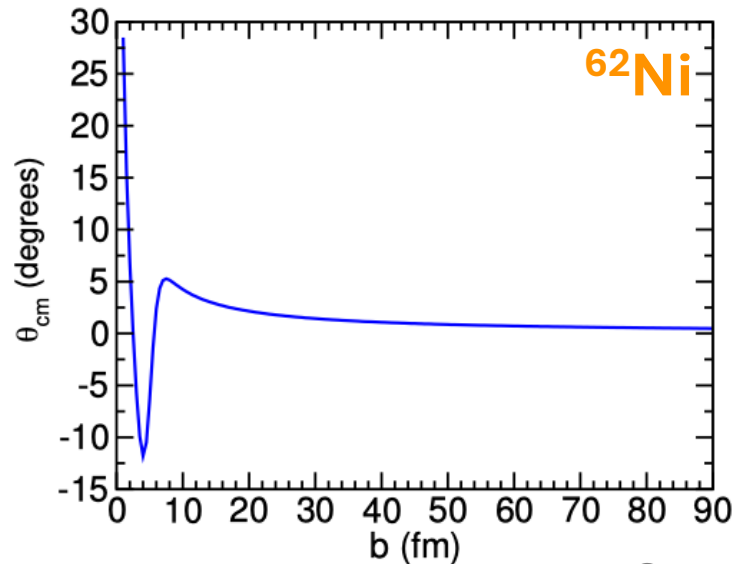


Courtesy of M. Ciemala

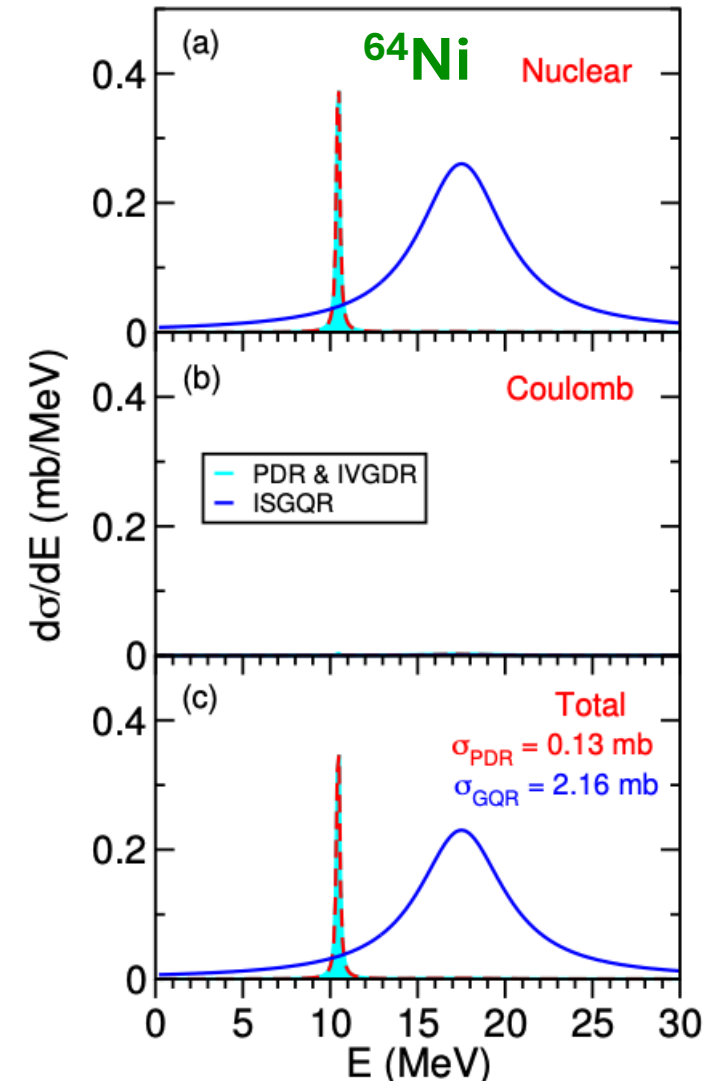
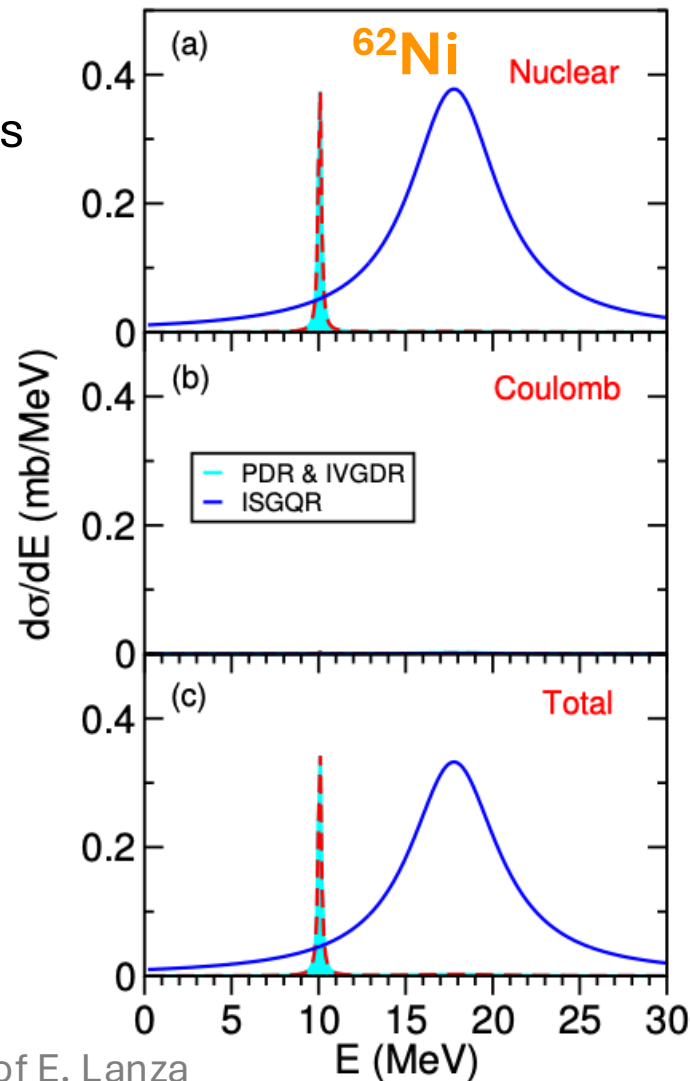
THEORETICAL PREDICTIONS

Calculations by **E. Lanza**:

- PDR, ISGQR, and IVGDR contributions
- Separate evaluation of nuclear and Coulomb excitation
- **Indication that the observed strength is with nuclear excitation.**



Courtesy of E. Lanza



VME 1 (RIO4-1)								Trigger rate in VME 1			
	address	type	name	byte rate	count rate	bytes/event	Status		count rate	byte rate	dead time
Slot 03:	0x0a040000	V1724	fadc4	0.00 kB/s	0 Ev/s	0 B/Ev	OK	Total :	8 Ev/s	15.82 kB/s	0.272 %
Slot 04:	0x0a050000	V1724	fadc5	2.09 kB/s	1 Ev/s	2088 B/Ev	OK	Trg 1:	0 Ev/s	0.00 kB/s	0.000 %
Slot 05:	0x0a060000	V1724	fadc6	2.09 kB/s	1 Ev/s	2088 B/Ev	OK	Trg 2:	6 Ev/s	9.43 kB/s	0.095 %
Slot 06:	0x0a070000	V1724	fadc7	4.18 kB/s	2 Ev/s	2088 B/Ev	OK	Trg 3:	1 Ev/s	6.33 kB/s	0.170 %
Slot 07:	0x0a080000	V1724	fadc8	2.09 kB/s	1 Ev/s	2088 B/Ev	OK	Trg 4:	0 Ev/s	0.00 kB/s	0.000 %
Slot 08:	0x0a090000	V1724	fadc9	2.09 kB/s	1 Ev/s	2088 B/Ev	OK	Trg 5:	0 Ev/s	0.00 kB/s	0.000 %
Slot 09:	0x0a0a0000	V1724	fadcA	2.09 kB/s	1 Ev/s	2088 B/Ev	OK	Trg 6:	0 Ev/s	0.00 kB/s	0.000 %
Slot 10:	0x0a0b0000	V1724	fadcB	0.00 kB/s	0 Ev/s	0 B/Ev	OK	Trg 7:	0 Ev/s	0.00 kB/s	0.000 %
Slot 11:	0x0b100000	V1190	tdc10	0.54 kB/s	5 Ev/s	67 B/Ev	OK	Trg 8:	1 Ev/s	0.06 kB/s	0.007 %
Slot 20:	0x0d000000	V24955	sc110	0.67 kB/s	1 Ev/s	672 B/Ev	OK				
								2000-01-22 23:49:21			

VME 2 (RIO4-2)								Trigger rate in VME 2			
	address	type	name	byte rate	count rate	bytes/event	Status		count rate	byte rate	dead time
Slot 07:	0x0b000000	V1730B	dig0	0.34 kB/s	5 Ev/s	68 B/Ev	OK	Total :	7 Ev/s	0.98 kB/s	0.041 %
Slot 08:	0x0b010000	V1730B	dig1	0.32 kB/s	5 Ev/s	64 B/Ev	OK	Trg 1:	0 Ev/s	0.00 kB/s	0.000 %

Event Builder

detach

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0 0.00 0000 01

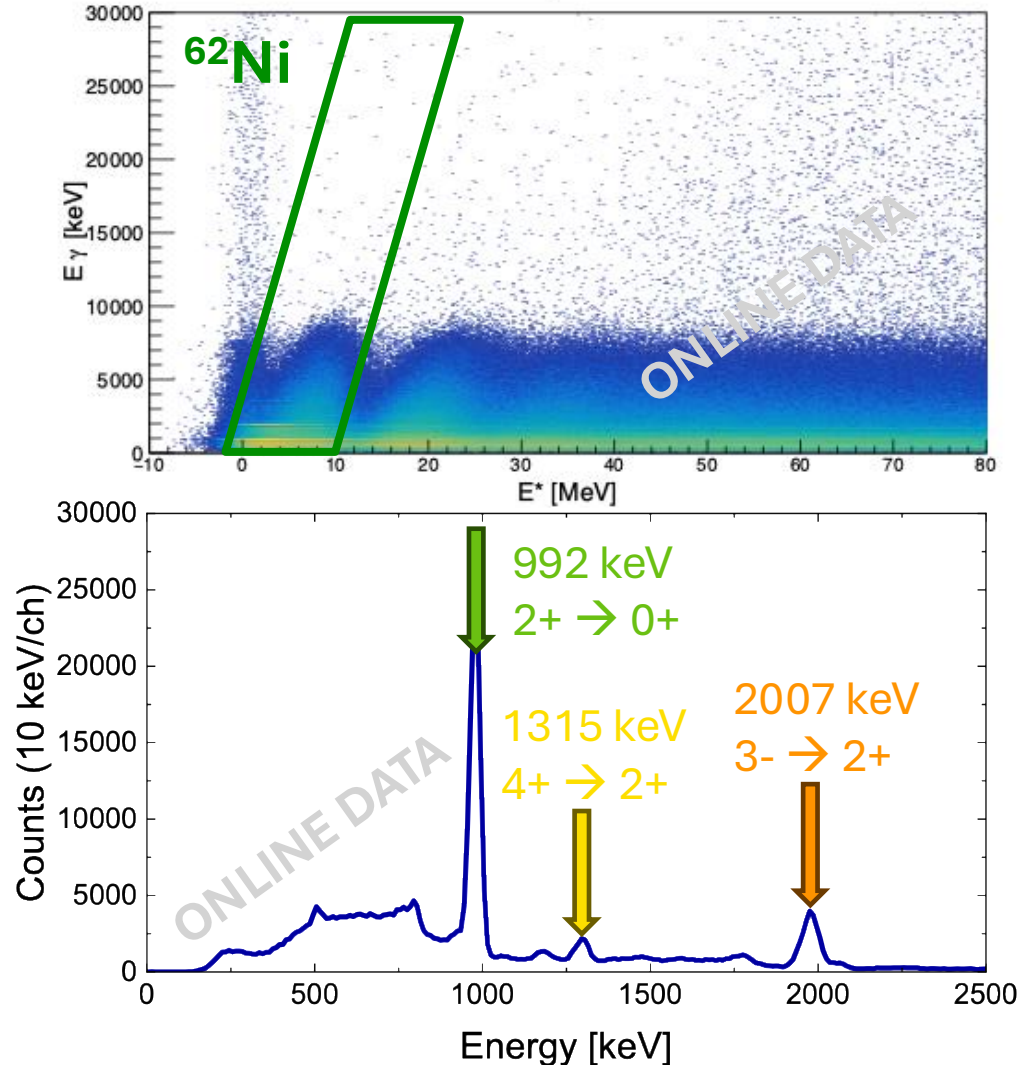
0x00000000 0.00 0 0.00 0000 01

0x00000000 0.00 0

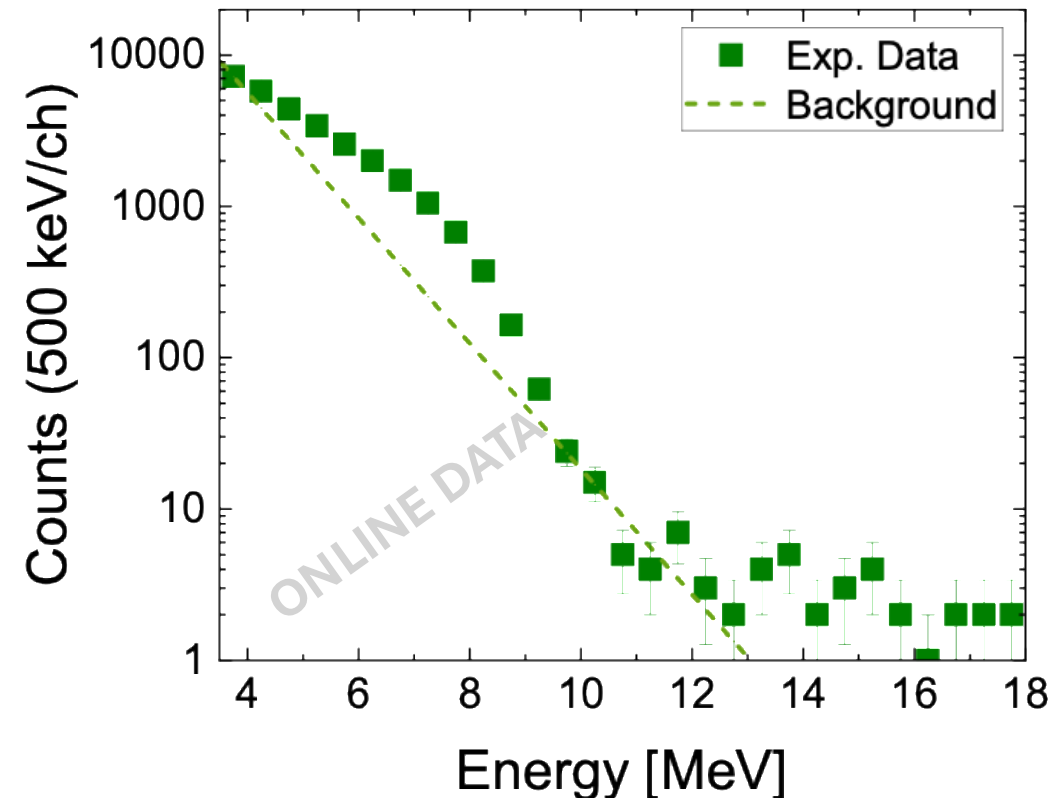
PREVIOUS MEASUREMENTS RESULTS

ONLINE RESULTS: ^{64}Zn

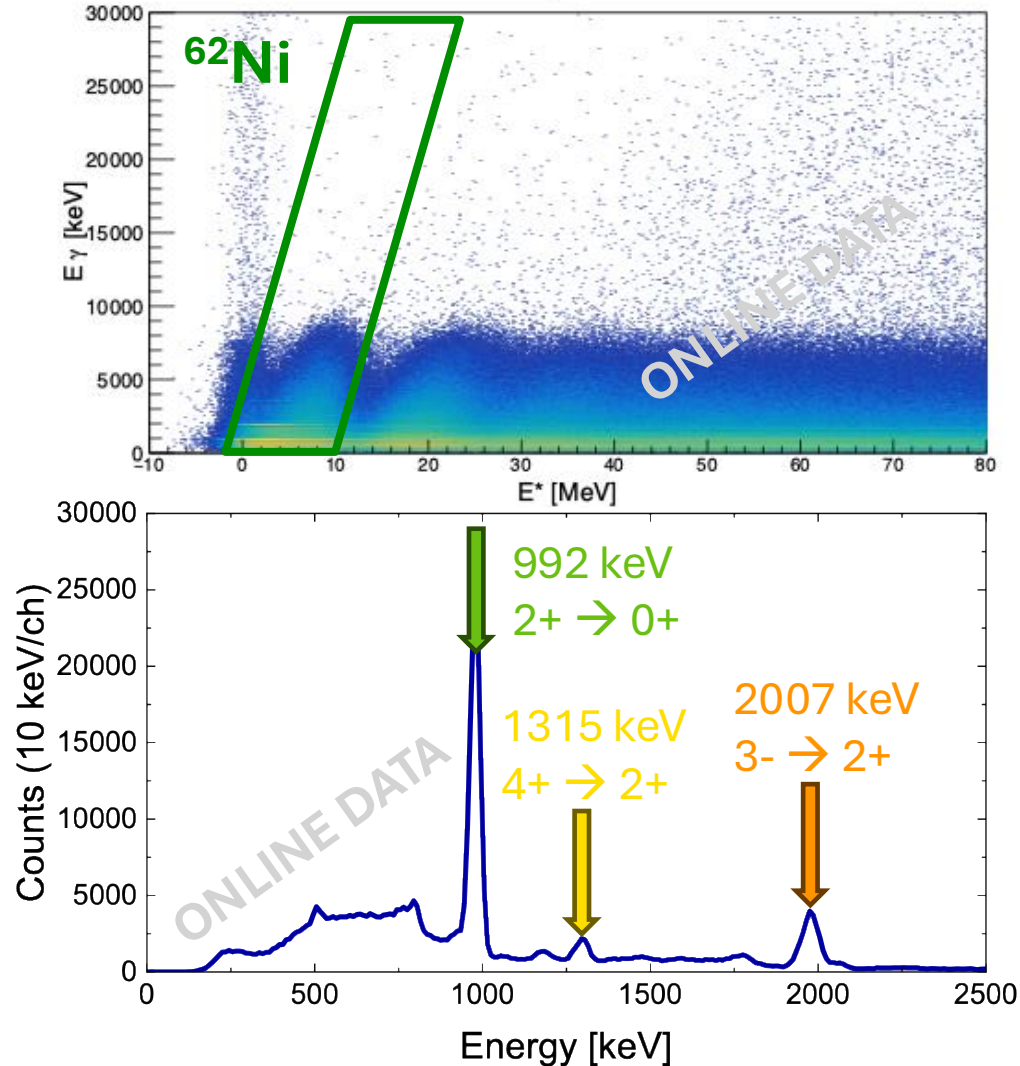
ONGOING: PDR IN ^{64}Zn



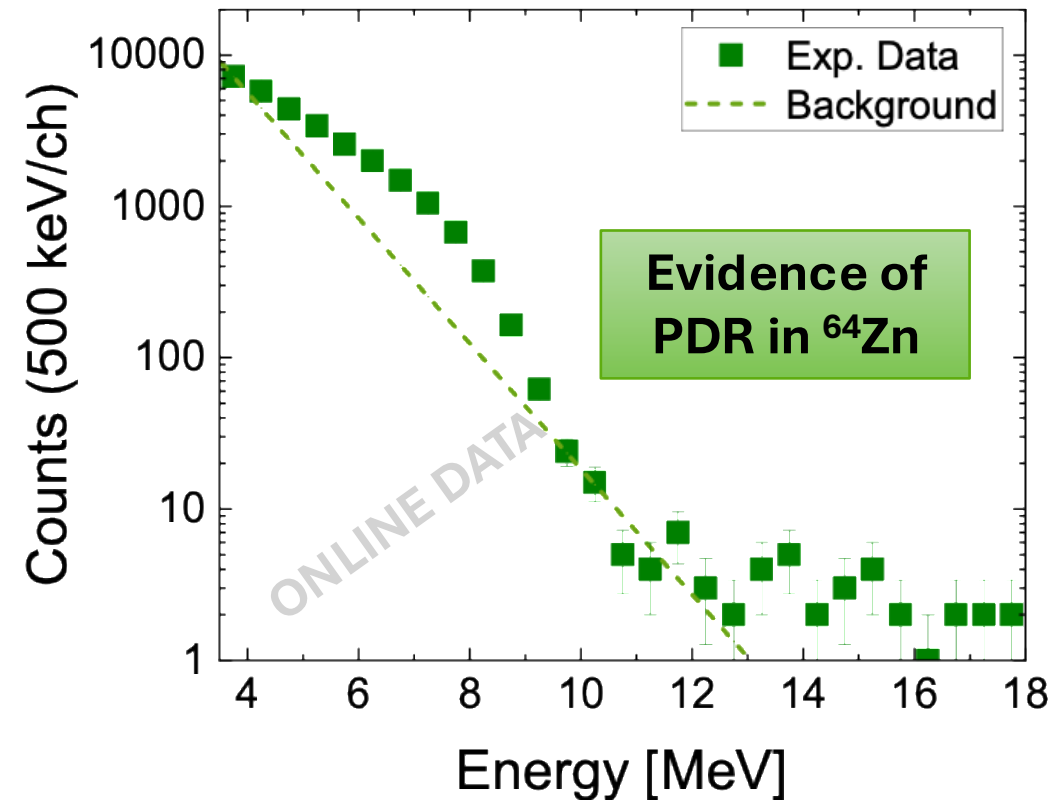
The same analysis procedure was applied to the just acquired ^{64}Zn data to investigate the presence of the PDR.



ONGOING: PDR IN ^{64}Zn

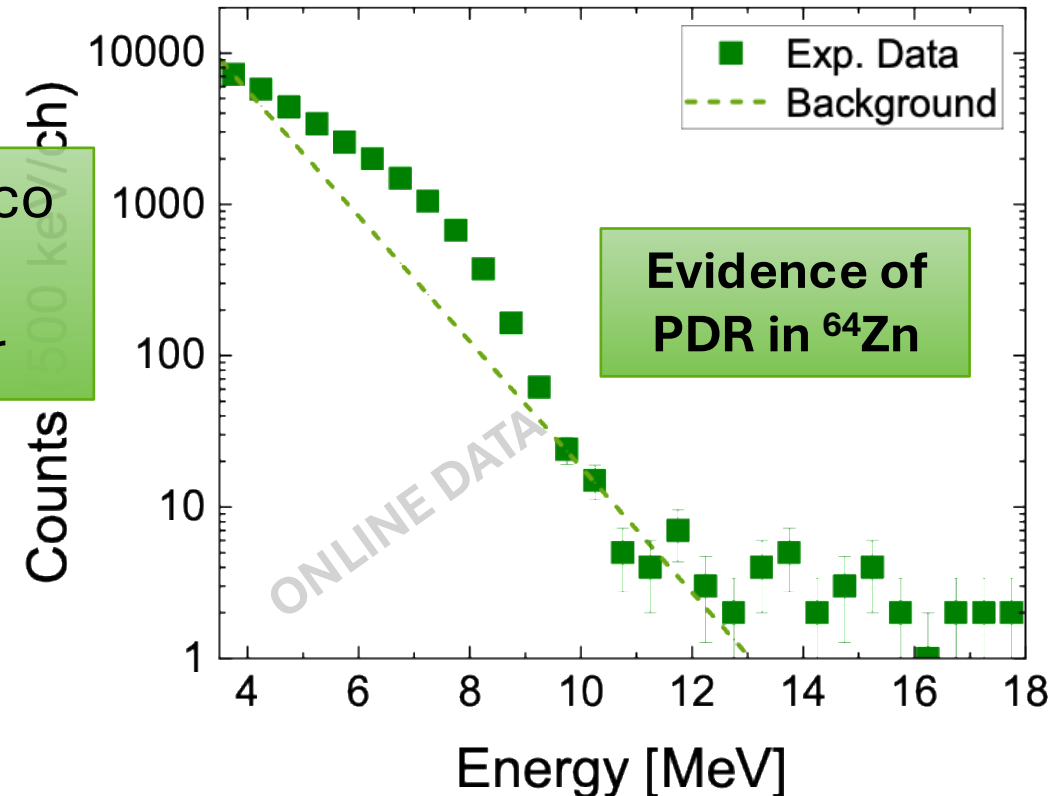
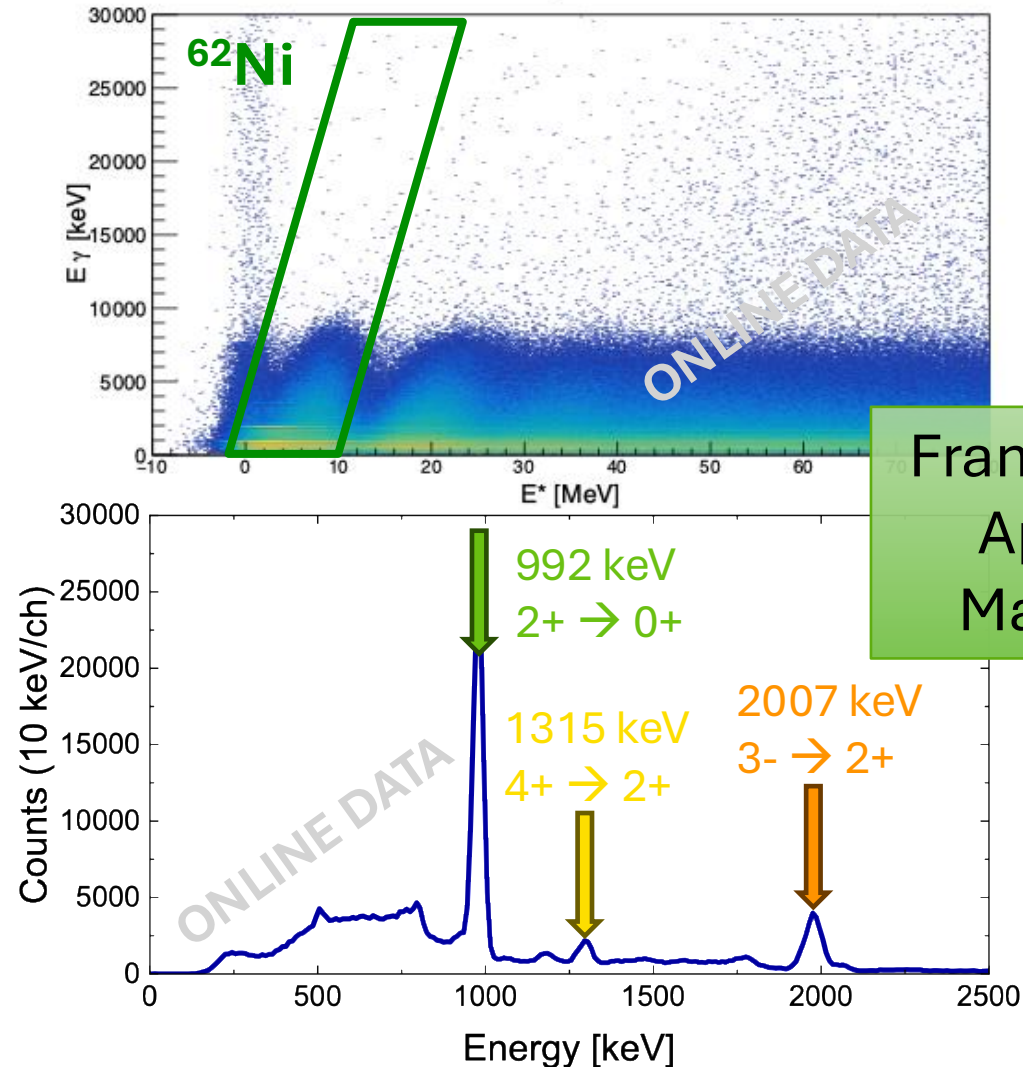


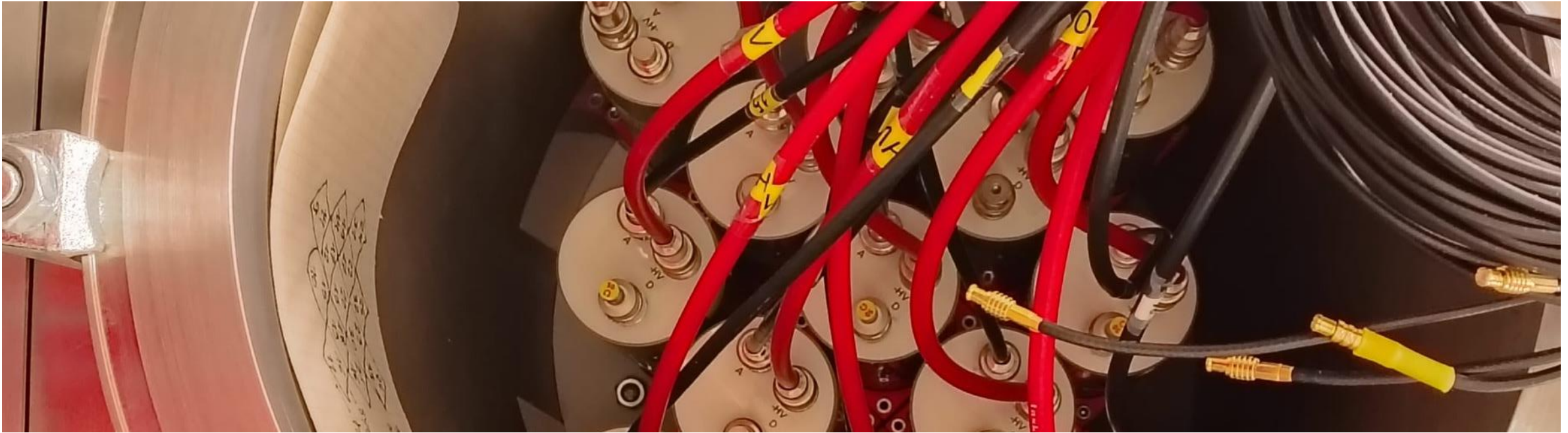
The same analysis procedure was applied to the just acquired ^{64}Zn data to investigate the presence of the PDR.



ONGOING: PDR IN ^{64}Zn

The same analysis procedure was applied to the just acquired ^{64}Zn data to investigate the presence of the PDR.





THE PROPOSED EXPERIMENT

BEAM TIME ESTIMATIONS

BEAM TIME ESTIMATIONS

We based our estimation on previous Ni isotope measurements.

	Previous Experiment: ^{64}Ni	Proposed Experiment: ^{66}Zn
BEAM ENERGY	180 MeV	180 MeV
BEAM CURRENT	0.4 nA	0.4 nA
CROSS SECTION	$^{64}\text{Ni} \approx ^{66}\text{Zn}$	$^{64}\text{Ni} \approx ^{66}\text{Zn}$
DEAD TIME	50%	20 %
TARGET THICKNESS	30 mg/cm ²	23 mg/cm ²
BEAM TIME	50 UTs	47 UTs

We scale for the target thickness and the dead time reduction.

47 UTs + 1 UT for KRATTA

calibration = **48 UTs**

~ **8 weekends**

BEAM TIME ESTIMATIONS

We based our estimation on previous Ni isotope measurements.

	Previous Experiment: ^{64}Ni	Proposed Experiment: ^{66}Zn
BEAM ENERGY	180 MeV	180 MeV
BEAM CURRENT	0.4 nA	0.4 nA
CROSS SECTION	$^{64}\text{Ni} \approx ^{66}\text{Zn}$	$^{64}\text{Ni} \approx ^{66}\text{Zn}$
DEAD TIME	50%	20 %
TARGET THICKNESS	30 mg/cm ²	23 mg/cm ²
BEAM TIME	50 UTs	47 UTs

We scale for the target thickness and the dead time reduction.

47 UTs + 1 UT for KRATTA calibration = **48 UTs**

~ **8 weekends**

TARGET:

- Target material purchased by INFN
- Target successfully manufactured by LNL-INFN
- **Target already available at the Kraków laboratory ready for the experiment**

SUMMARY

- We propose to measure **PDR in the deformed isotope ^{66}Zn to disentangle N/Z and deformation effects**
- It is **sequel** of a previous experiment on PDR in Ni & Zn isotopes
- Experimental set up: **KRATTTA + large-volume $\text{LaBr}_3\text{:Ce}$ + PARIS**
- Considering target thickness ($^{64}\text{Ni} \sim 30 \text{ mg/cm}^2$ while $^{66}\text{Zn} \sim 23 \text{ mg/cm}^2$) and dead time reduction we ask for 47 UTs for ^{66}Zn measurement and 1 UTs for KRATTTA calibration
- **Total beam request: 48 UTs** corresponding to 8 weekends

EXPERIMENT PARTECIPANTS

- **INFN and Uni Milano (Italy):** A. Giaz, O. Wieland, F. Apa, G. Benzoni, S. Bottoni, A. Bracco, S. Brambilla, F. Camera, F. Conca, F. Crespi, D. Genna, M. Giunta, S. Leoni, M. Luciani, B. Million,
- **IFJ PAN Krakow (Poland):** M. Ciemala, M. Kmiecik, P. Bednarczyk, N. Cieplicka-Orynczak, B. Fornal, K. Gajewska, J. Grębosz, P. Kulessa J. Łukasik, A. Maj, M. Matejska-Minda, K. Mazurek, S. Panwar, K. Proszowski, P. Pawłowski, M. Ziębliński,
- **University of Groningen (The Netherlands):** M.N. Harakeh,
- **INFN LNL e Uni Padova (Italy):** M. Balogh, D. Stramaccioni, J.J. Valiente-Dobon
- **GANIL (France):** M. Lewitowicz,
- **IJCLab Orsay (France):** A. Dey, I. Matea, J. Wilson,
- **CEA Saclay (France):** P. Miriot-Jaubert, M. Vandebrouck,
- **SLCJ UW (Poland):** K. Hadyńska-Klęk, C. Hiver, P. Napiorkowski,
- **USTHB Algiers (Algeria):** N. Benouaret,
- **Ithemba (South Africa):** R. Neveling, L. Pellegri,
- **IFJ PAN Krakow (Poland) & IPHC Strasburg (France):** C. Schmitt,
- **ELI-NP Bucharest:** D. Balabanski, A. Kusoglu, P-A Söderström, R. S. Ban.
- **INFN Catania:** E. Lanza





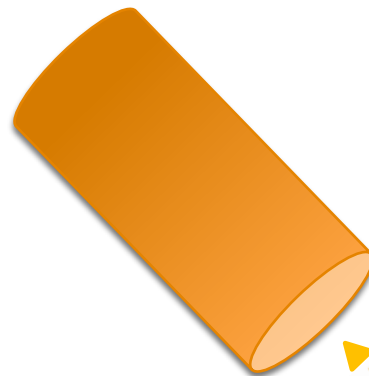
THANK YOU FOR THE ATTENTION!



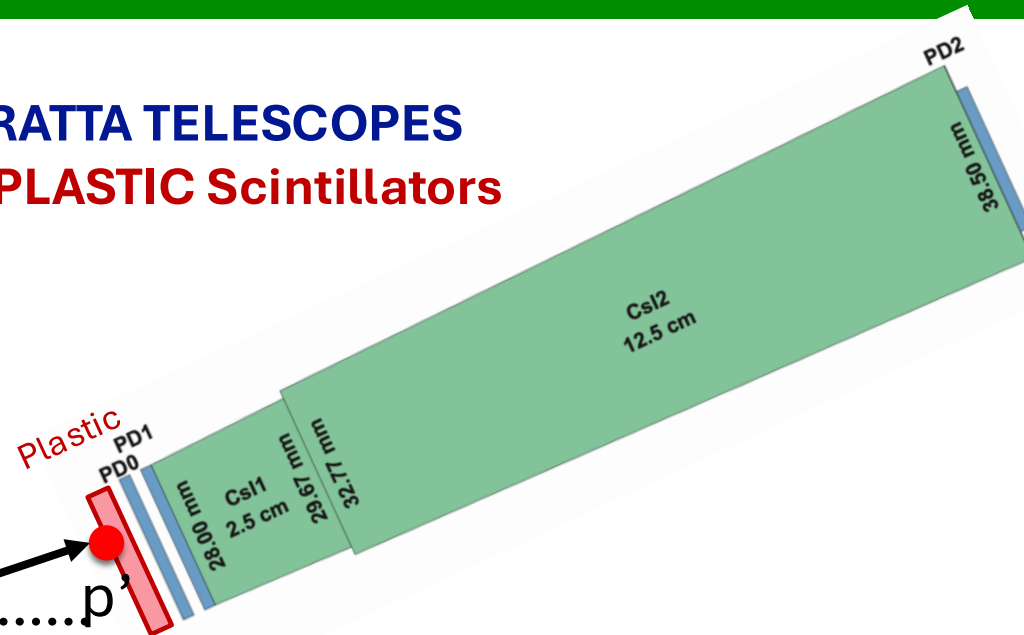
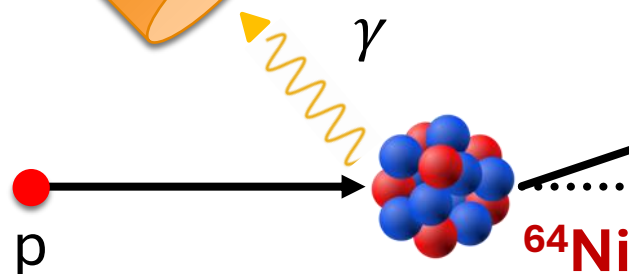
BACKUP SLIDES

^{64}Ni TRIGGER IMPROVEMENT

LaBr₃:Ce +
PARIS



KRATTA TELESCOPES
+ PLASTIC Scintillators



OLD TRIGGER: PARIS & PLASTIC
NEW TRIGGER: PARIS & PLASTIC & KRATTA

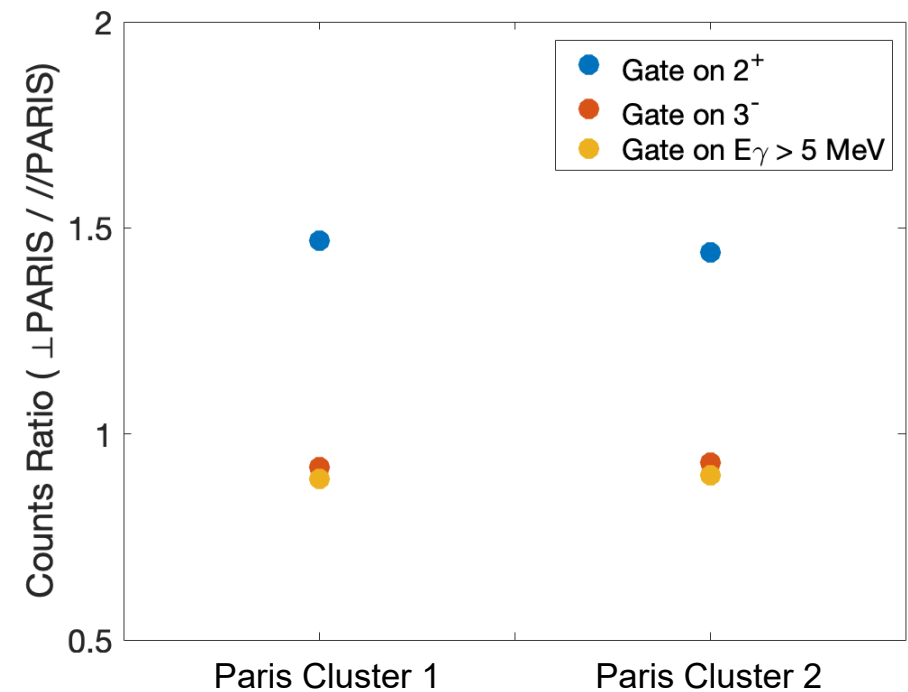
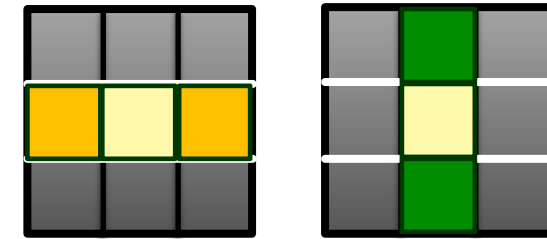
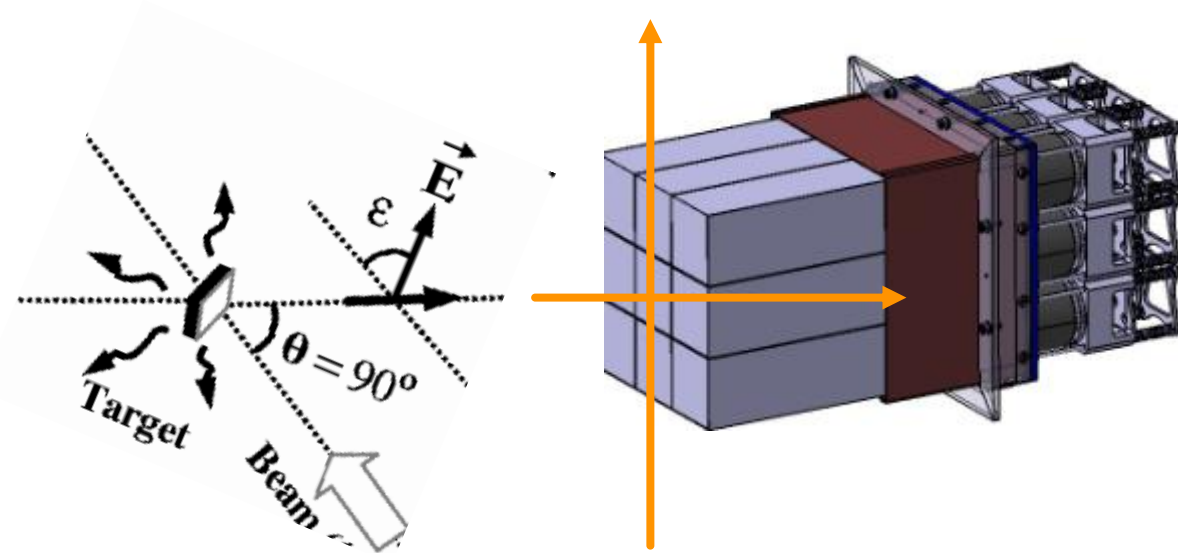
We compensate the reduction in the target thickness (from 30 to 23 mg/cm²).

Dead time reduction from 50% to 20% - **Good events increasement**

POLARIZATION MEASUREMENTS WITH PARIS

Parity distinction:

On basis of scattering ratio vertical ($\perp$ PARIS)
horizontal ($\parallel$ PARIS)

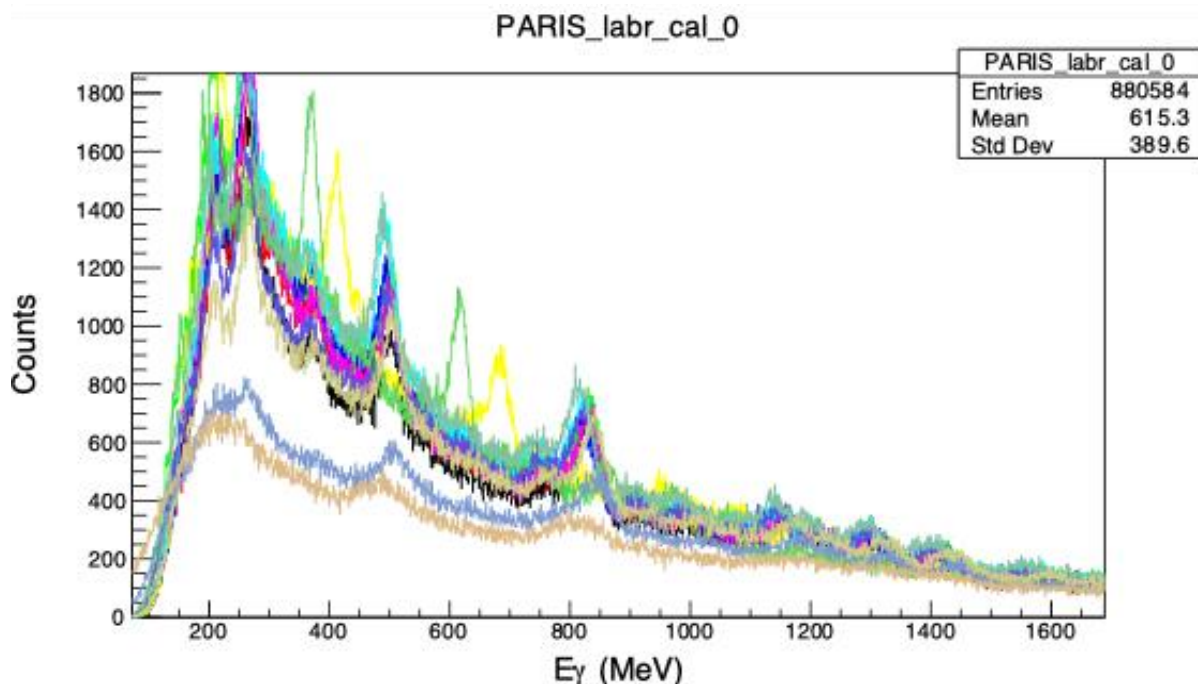


PARIS LaBr₃:Ce & CeBr₃ DETECTOR ISSUES

CLUSTER 1: detector from 0 - 12

2 detectors with wrong calibration: det 4 & 7

2 detector with low statistics: det 10 & 12

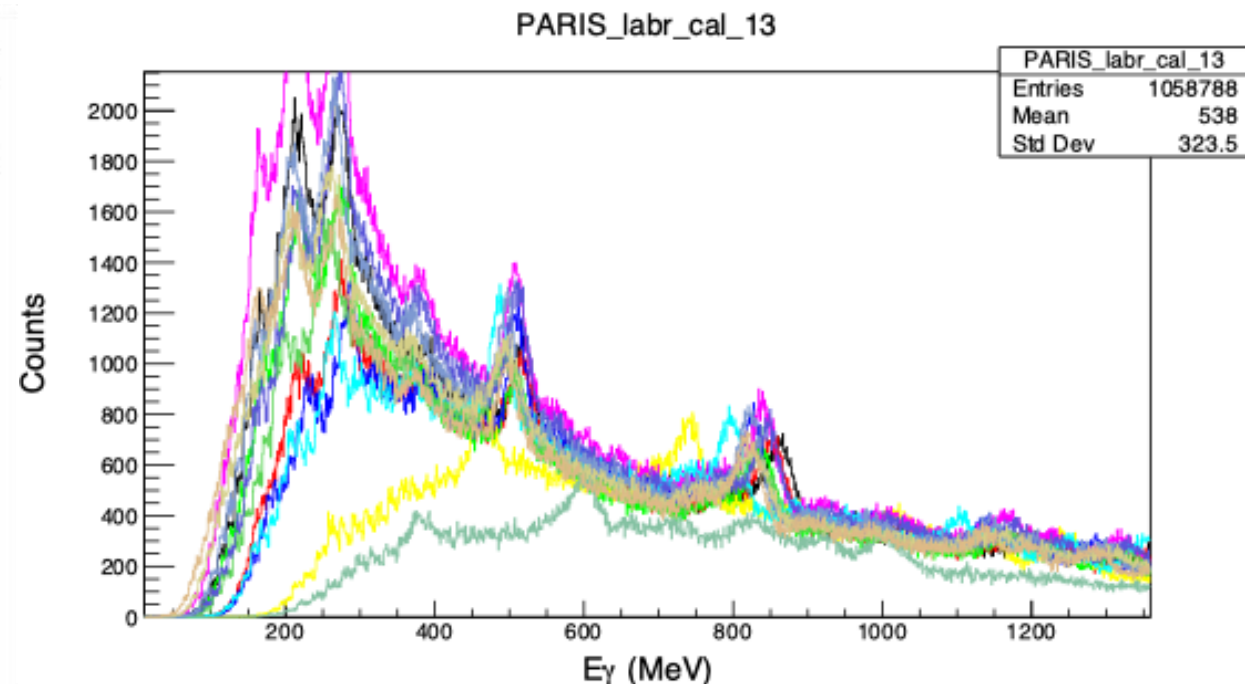


CLUSTER I1: detector from 13 - 25

1 detector with wrong calibration: det 17

1 detector with low statistics: det 22

1 detector with a slightly wrong calibration: 19



PARIS LaBr₃:Ce & CeBr₃ DETECTOR ISSUES: CLUSTER II

