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SPIDER: A NEW PARTICLE DETECTOR FOR COULOMB EXCITATION MEASUREMENTS

- ▶ Detector characteristics
- ▶ Recent results of ${}^7\text{Li}$ Coulomb excitation @LABEC in Florence
- ▶ Next future: SPIDER as ancillary device for GALILEO @LNL
- ▶ Far future: Coulomb excitation with radioactive beams from SPES

LOW-ENERGY COULOMB EXCITATION

▶ Introduction

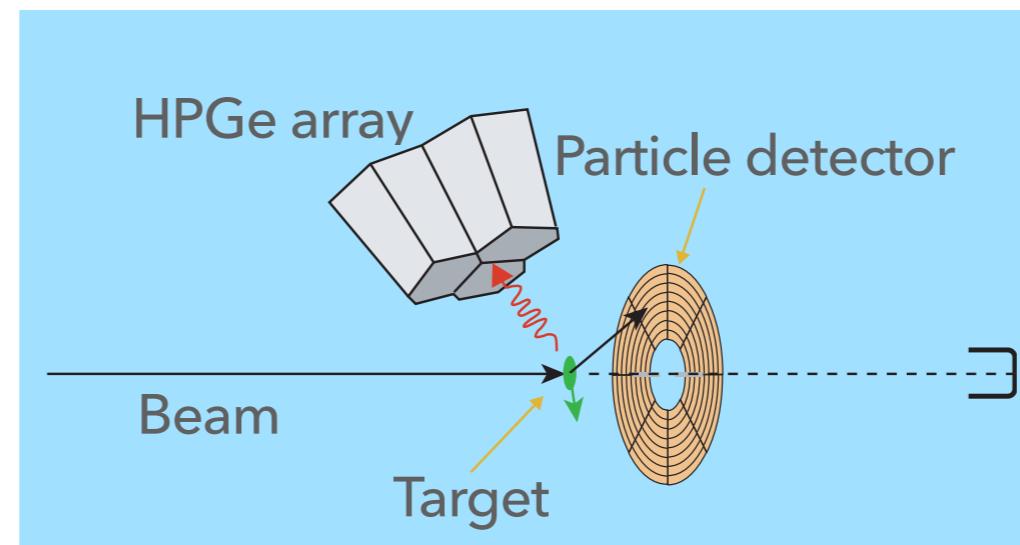
- ▶ Electromagnetic interaction, no hypothesis on nuclear interactions are required: experimental values can be obtained in a model-independent way

▶ SPIDER

- ▶ High cross sections (barns for the first 2^+)

▶ SPIDER @LABEC: ^7Li

- ▶ Typical set-up: HPGe array to detect gamma rays and a particle detector



▶ SPIDER& GALILEO @LNL

- ▶ Particle detector: to have a clean trigger, to perform the Doppler correction, to study the angular dependence of the cross section

SiliconPleDEtector

▶ Introduction

- ▶ SPIDER has been developed as ancillary detector for ~4n HPGe arrays for Coulomb excitation measurements

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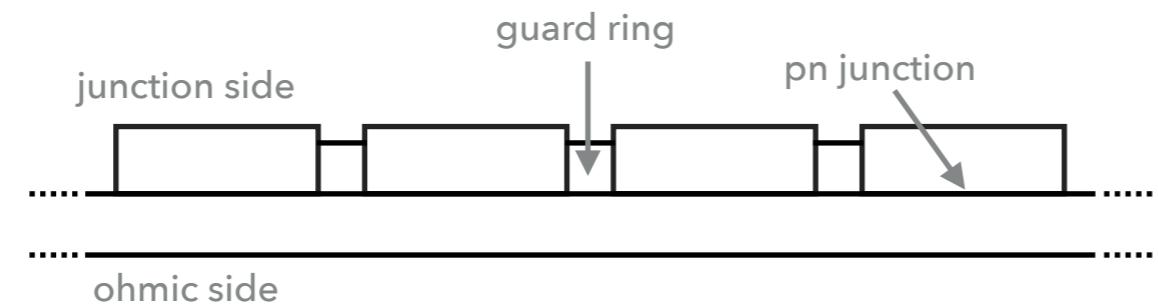
- ▶ We started from the silicon detectors of the second stage of the Ring Counter detector (GARFIELD apparatus @ LNL)

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 ^7Li

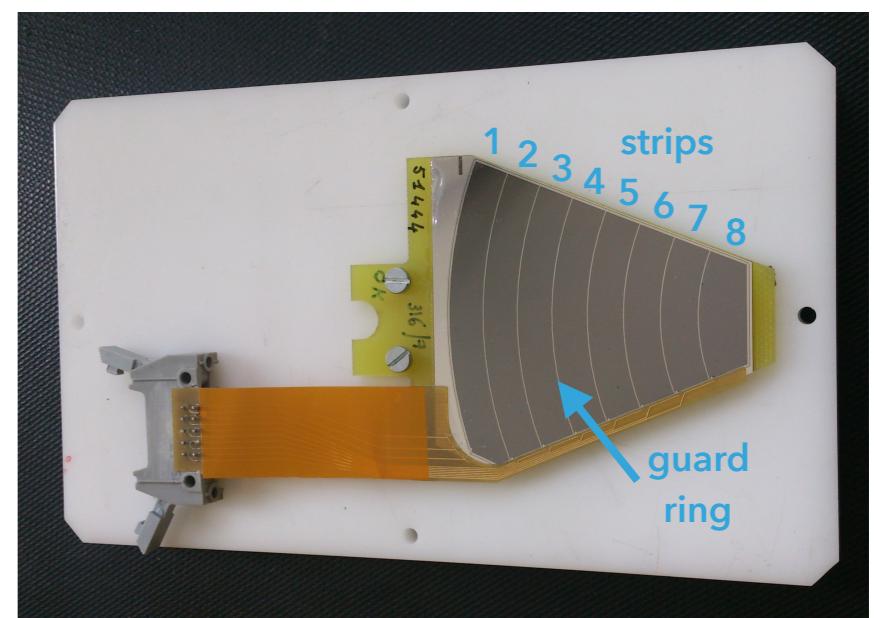
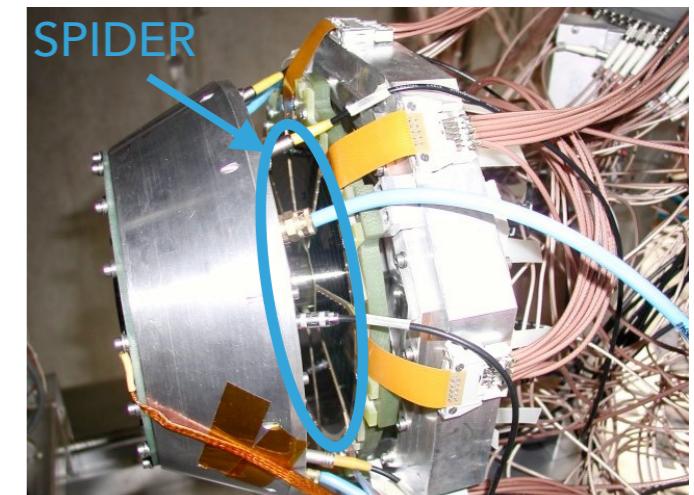
- ▶ Sectors: 8 independent strips, guard ring (to minimize cross-talk between contiguous strips)
- ▶ Detector thickness: ~300 μm , dead layers: 50 nm in the junction side and 350 nm in the ohmic side

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Side View



▶ Coulomb
excitation
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▶ Introduction

▶ SPIDER

▶ SPIDER
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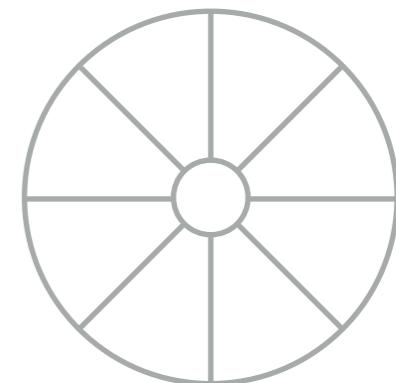
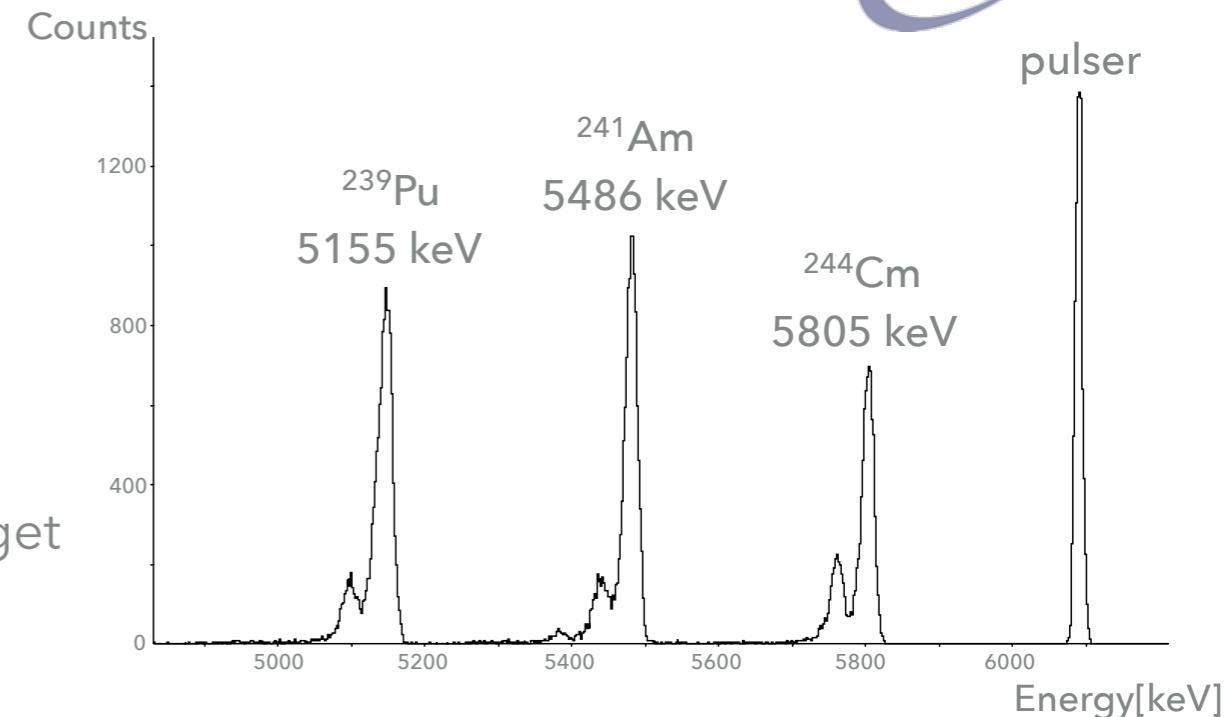
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▶ Coulomb
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SiliconPleDEtector

- ▶ Energy resolution: FWHM ~ 21 keV for α -particles @ ~ 5.5 MeV
- ▶ Intrinsic efficiency: ~ 1
- ▶ Angular ranges at 80 mm from the target (8 sectors, disk configuration):

strip	int. radius [mm]	ext. radius [mm]	theta min. [deg]	theta max. [deg]	theta dif. [deg]	solid angle [sr]
1	76.7	85.0	43.8	46.7	3.0	0.02892
2	68.1	76.5	40.4	43.7	3.3	0.03035
3	59.5	67.9	36.6	40.3	3.7	0.03134
4	50.9	59.3	32.5	36.5	4.1	0.03161
5	42.3	50.7	27.9	32.4	4.5	0.03085
6	33.8	42.1	22.9	27.8	4.9	0.02872
7	25.2	33.6	17.5	22.8	5.3	0.02491
8	16.6	25.0	11.7	17.3	5.6	0.02090



Solid angle coverage: 14.5 %

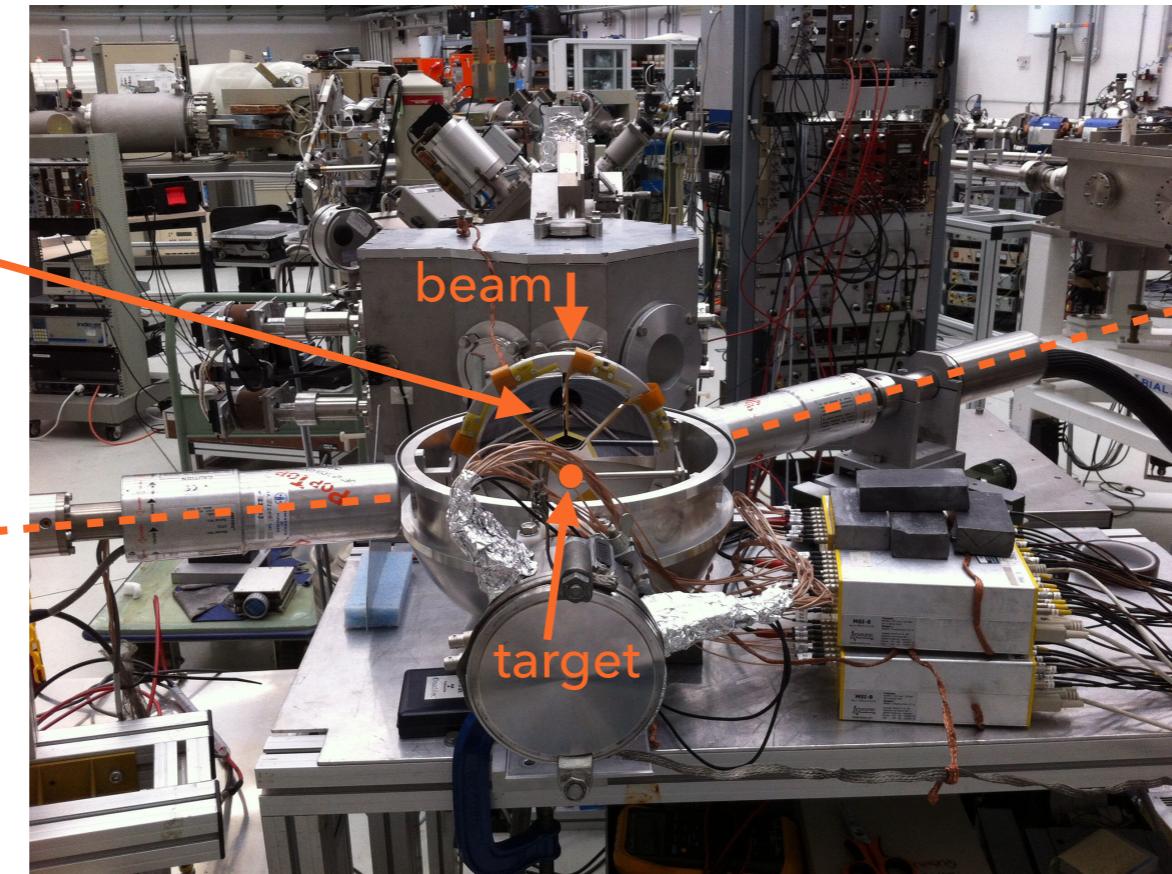
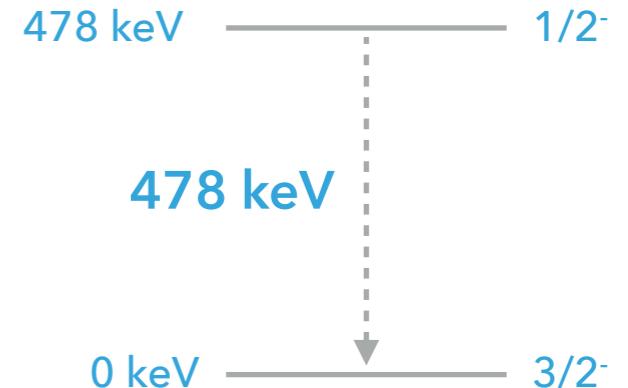
Polar angle coverage: 19.4 %

Diameter: 17 cm

SPIDER @LABEC: ^7Li

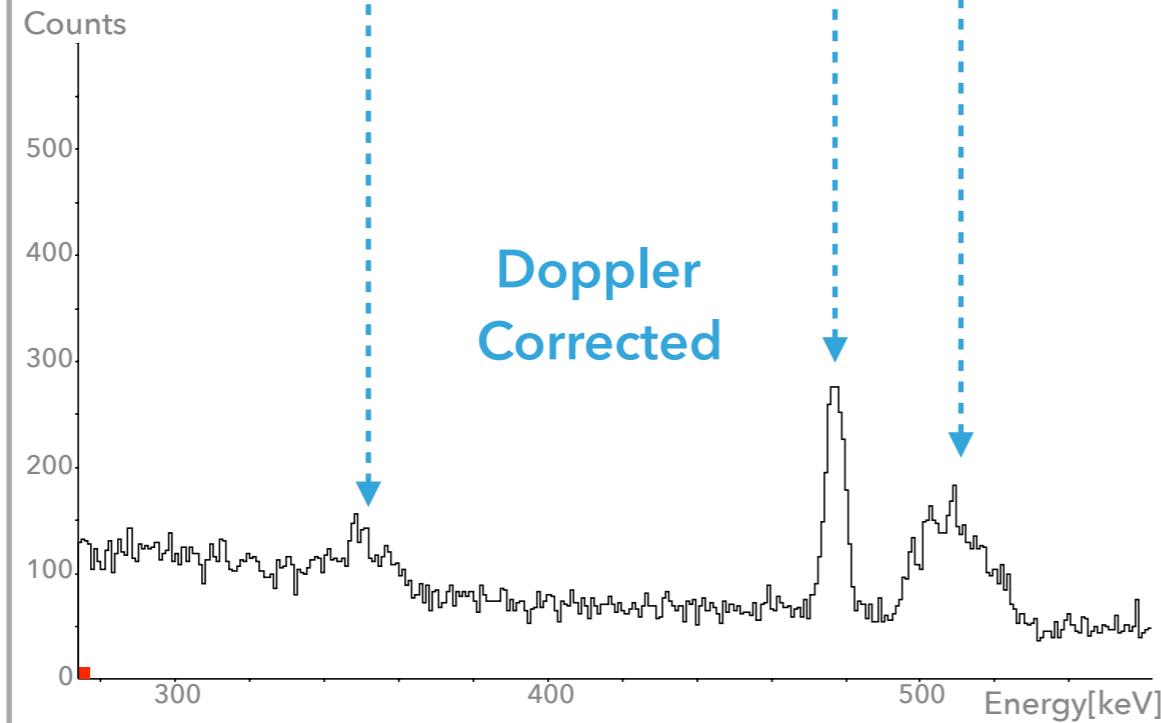
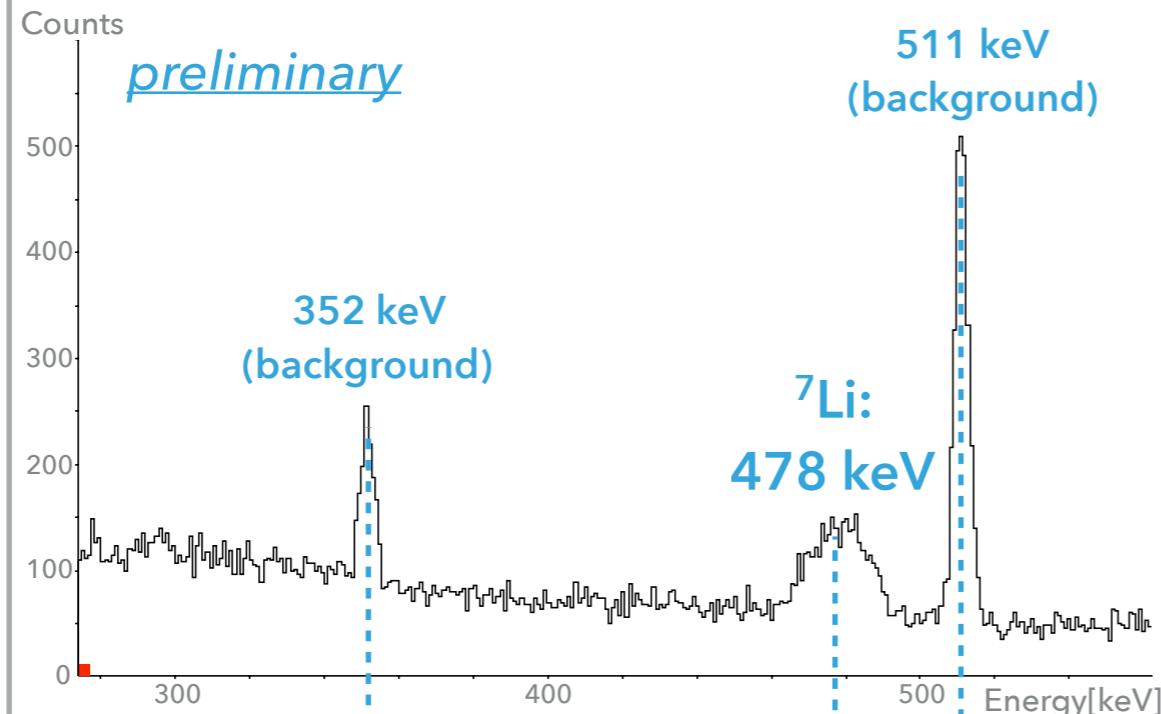
- ▶ Introduction
- ▶ SPIDER
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 ^7Li
- ▶ SPIDER&
GALILEO
@LNL
- ▶ Coulomb
excitation
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- ▶ ^7Li @ 6 MeV on 0.5 mg/cm^2 ^{27}Al target
- ▶ Safe energy (180°) = 6.35 MeV
- ▶ 4 SPIDER sectors (backward angles), 2 HPGe detectors
- ▶ 31 h of beam time ($\sim 1 \text{ pnA}$)

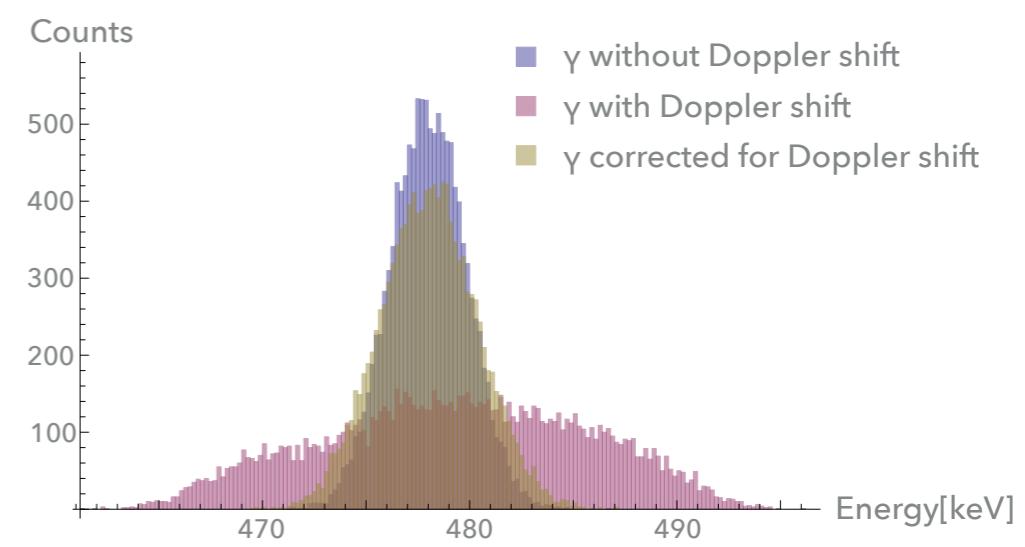


SPIDER @LABEC: ^7Li

- ▶ Introduction
- ▶ SPIDER
- ▶ SPIDER @LABEC: ^7Li
- ▶ SPIDER& GALILEO @LNL
- ▶ Coulomb excitation @SPES



- ▶ Gamma spectra: 478 keV (from the first excited level $1/2^- \rightarrow 3/2^-$)
- ▶ Random coincidences: natural background
- ▶ Doppler correction: from FWHM = 18.4 keV to FWHM = 5.7 keV (intrinsic FWHM (@ 478 keV) = 4.3 keV)
- ▶ Simulations: FWHM after Doppler correction = 5.3 keV



SPIDER @LABEC: ^7Li

▶ Introduction

- ▶ Total number of counts: ~1500 (GOSIA estimations confirmed) -> ~190 for each angular range

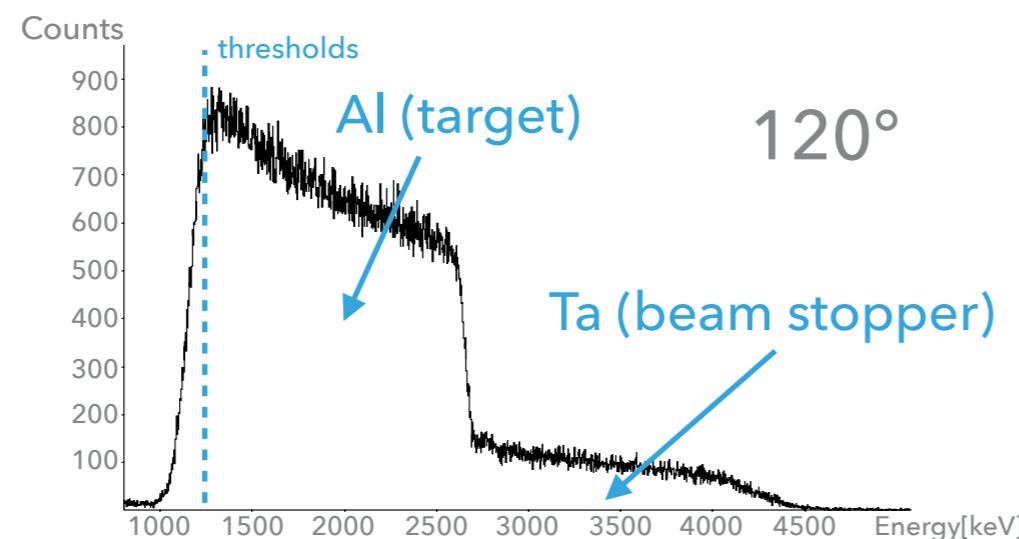
▶ SPIDER

- ▶ Possibility to study the angular dependence of the cross section

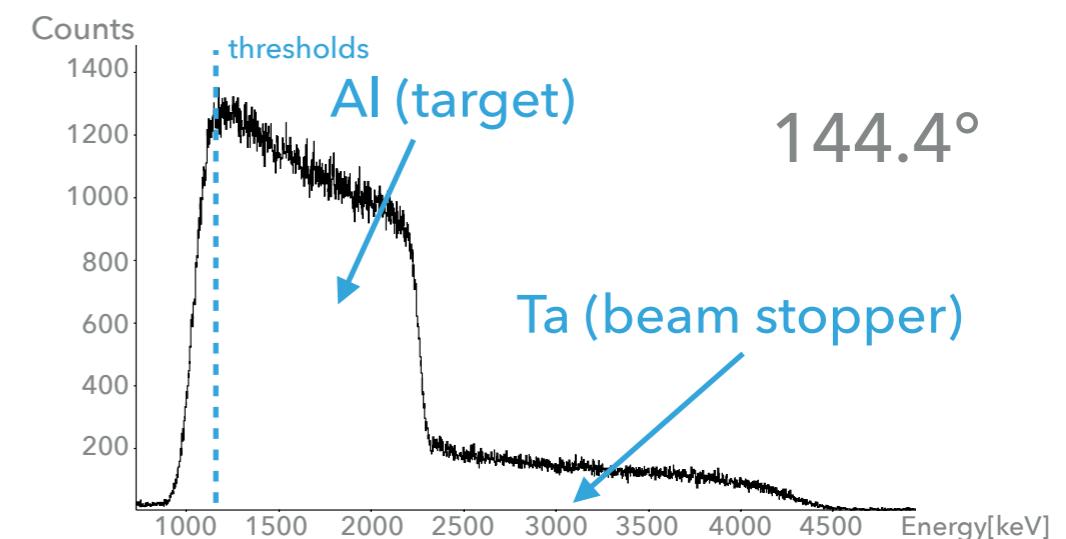
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excitation
@SPES

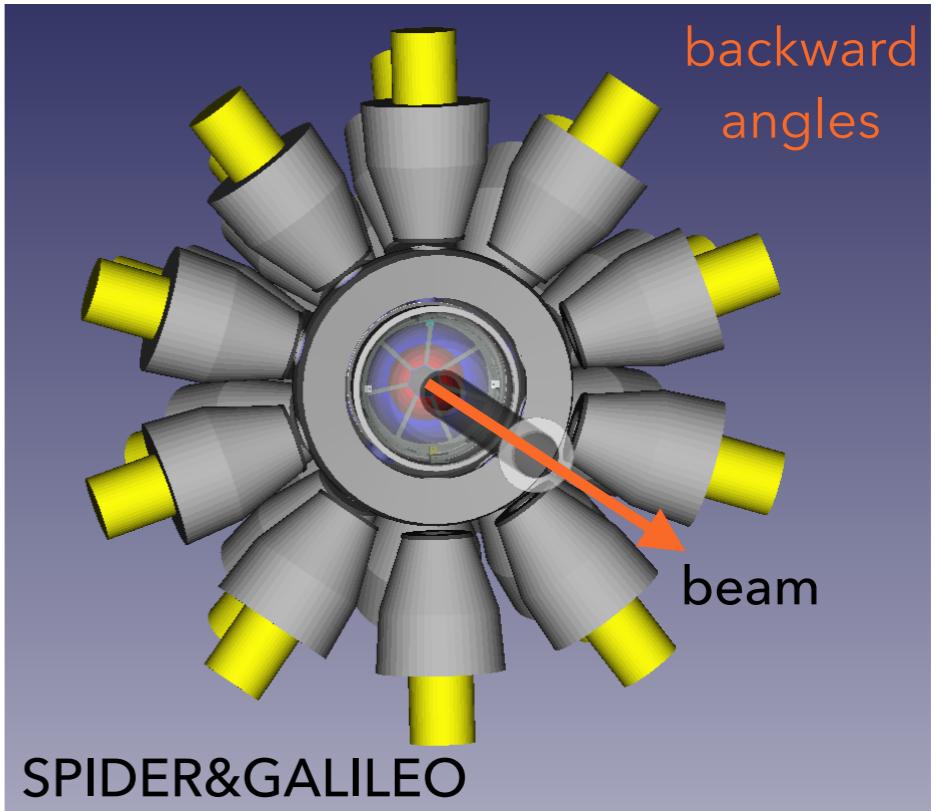


120°



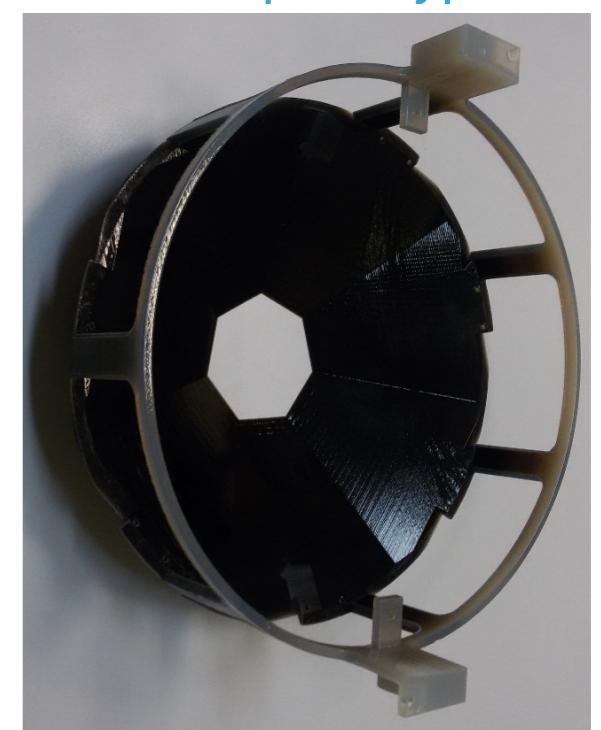
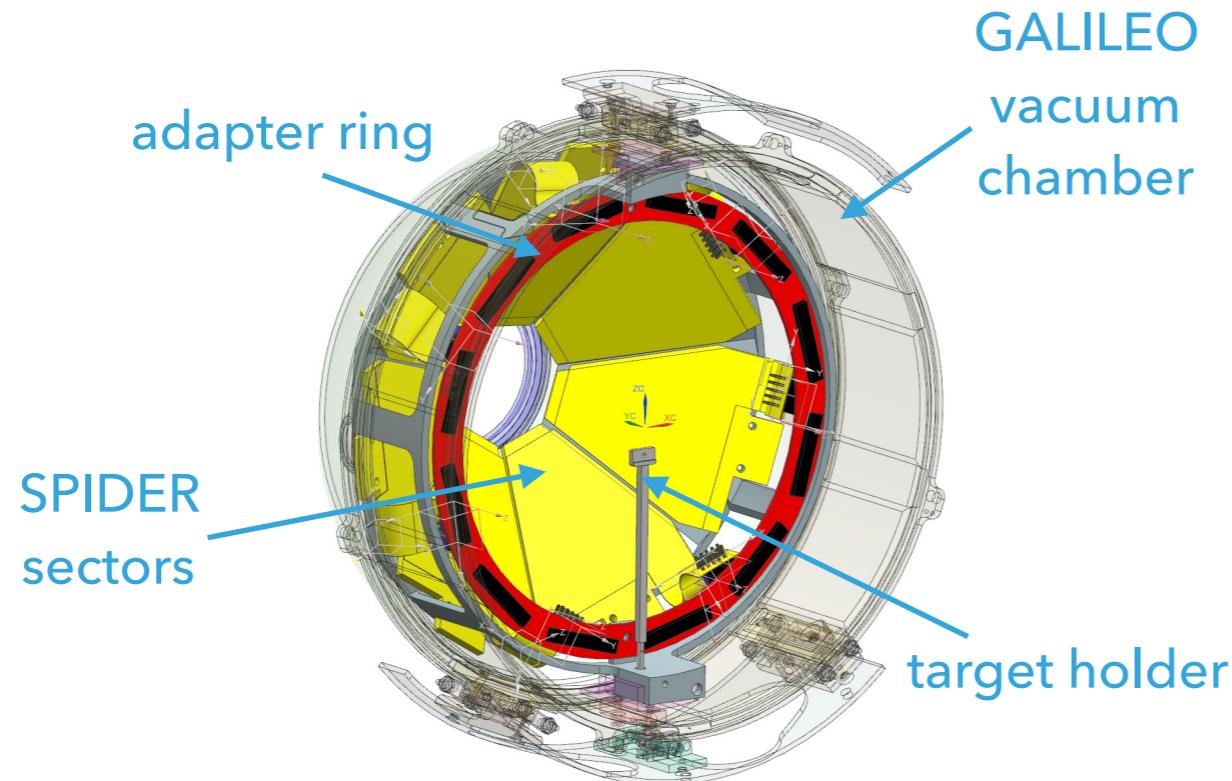
144.4°

SPIDER & GALILEO @LNL

- ▶ Introduction
 - ▶ Next future: SPIDER as ancillary device for GALILEO for Coulomb excitation measurements
 - ▶ SPIDER
 - ▶ Developing Coulomb excitation technique at LNL: new possibilities with GALILEO and stable beams, priority for radioactive beams from SPES
 - ▶ SPIDER @LABEC:
 ^7Li
 - ▶ SPIDER&
GALILEO
@LNL
 - ▶ Coulomb
excitation
@SPES
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SPIDER & GALILEO @LNL

- ▶ Introduction
 - ▶ Cone configuration to fit the GALILEO vacuum chamber
- ▶ SPIDER
 - ▶ Same acquisition system of EUCLIDES: 56 electronic channels can be used as trigger signals -> 56 needed for SPIDER (8 strips for 7 sectors)
- ▶ SPIDER
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 - ▶ New mechanical frame and electronic adapter to connect SPIDER
- ▶ SPIDER&
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 - ▶ frame prototype
- ▶ Coulomb
excitation
@SPES

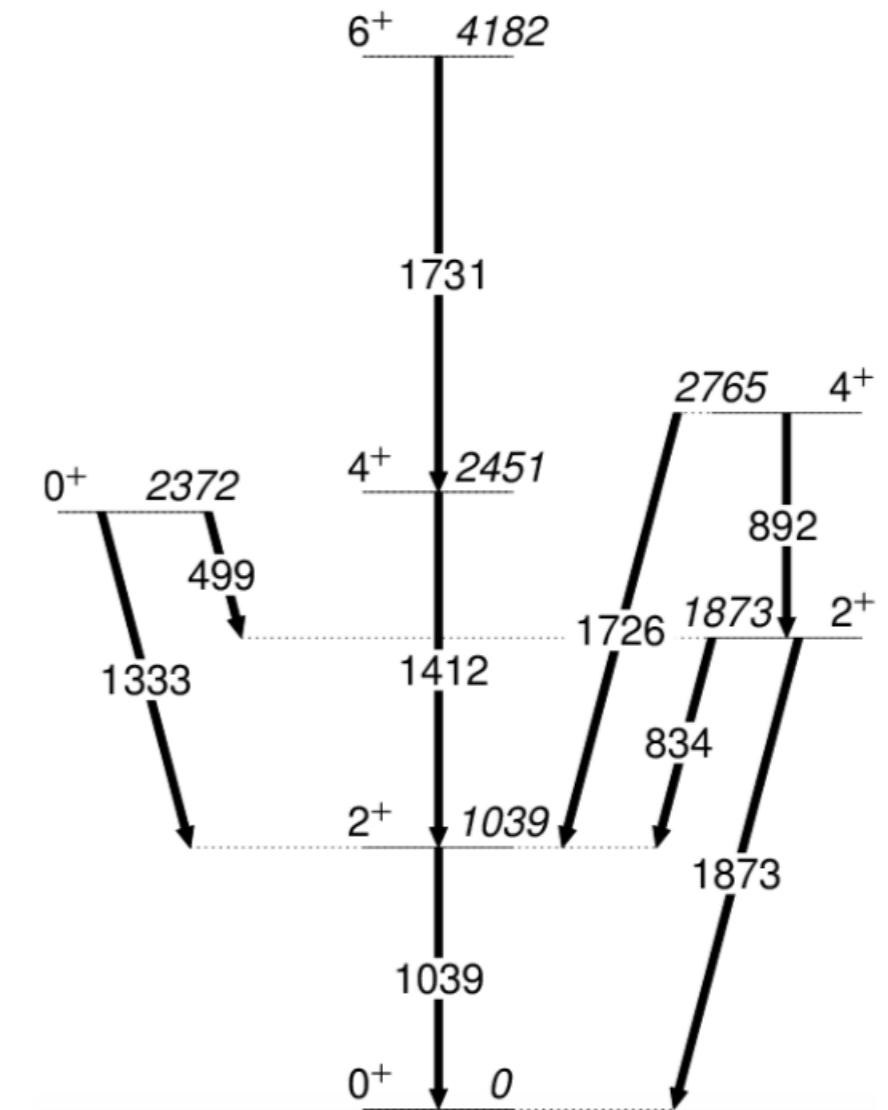


SPIDER & GALILEO @LNL

- ▶ Introduction
- ▶ SPIDER
- ▶ SPIDER @LABEC:
 ^7Li
- ▶ SPIDER& GALILEO @LNL
- ▶ Coulomb excitation @SPES

- ▶ First commissioning with GALILEO: from 11/07/2016 to 14/07/2016 @LNL
- ▶ ^{66}Zn @ 240 MeV on 1mg/cm² ^{208}Pb target *, 4 days obtained
- ▶ High populated states (test), physics behind
- ▶ Similar kinematic respect to the ^7Li test

Transition	Energy [keV]	N/day x1000	N total x1000
$2_1 \rightarrow 0_1$	1040	1500	7500
$4_1 \rightarrow 2_1$	1411	10	50
$(6_1) \rightarrow 4_1$	1734	0.013	0.6
$2_2 \rightarrow 2_1$	834	145	780
$2_2 \rightarrow 0_1$	1872	0.15	0.7
$0_2 \rightarrow 2_1$	1333	16	80
$0_2 \rightarrow 2_2$	500	0.1	0.5
$4_2 \rightarrow 2_1$	893	0.2	1
$4_2 \rightarrow 2_2$	1726	0.2	1



* Special thanks to M. Zielinska that help us to find this physical case

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▶ Introduction

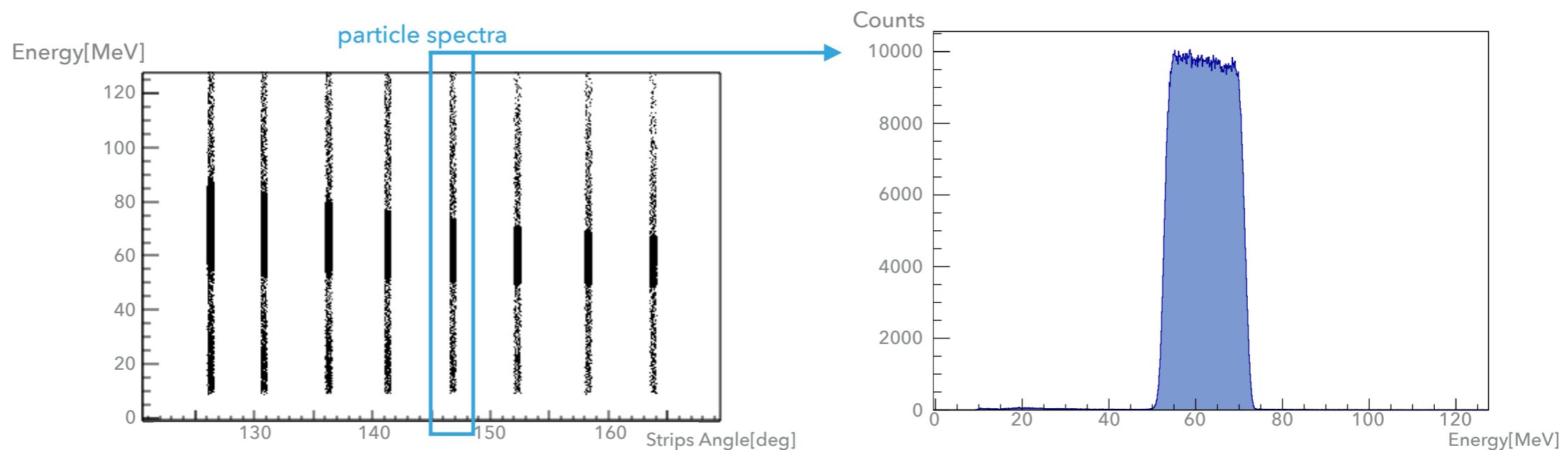
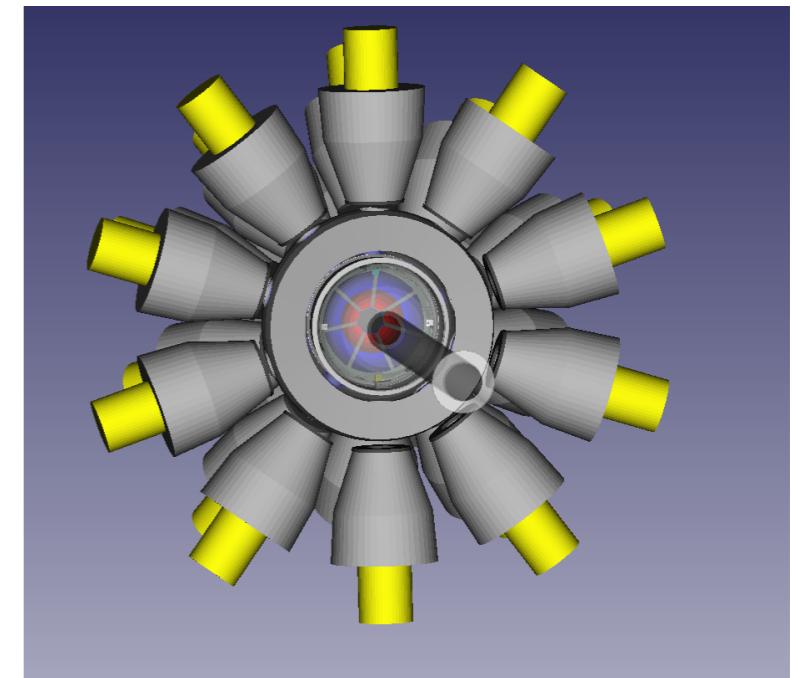
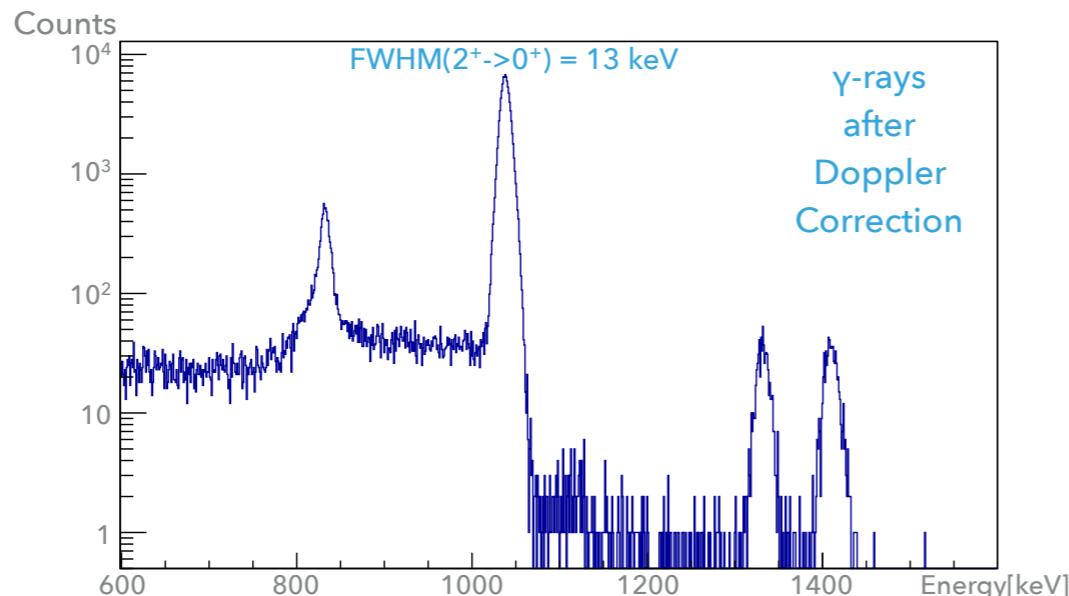
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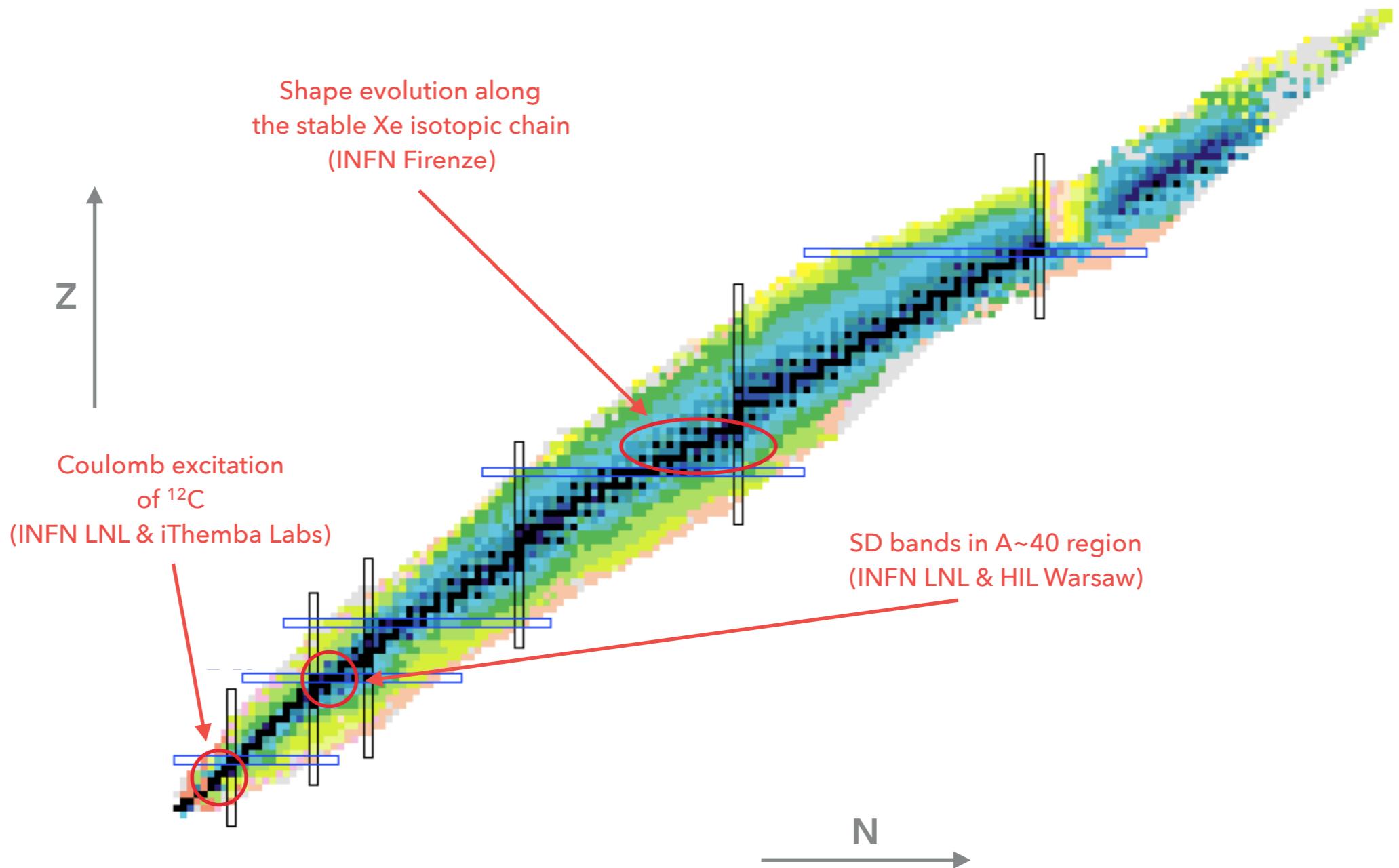
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▶ New GEANT4 simulations (A. Goasduff): ^{66}Zn



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- ▶ Introduction
- ▶ SPIDER
- ▶ SPIDER @LABEC:
 ^7Li
- ▶ SPIDER&
GALILEO
@LNL
- ▶ Coulomb
excitation
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- ▶ Physical cases: stable beams



SPIDER & GALILEO @LNL

▶ Introduction

▶ Physical cases: stable beams

▶ SPIDER

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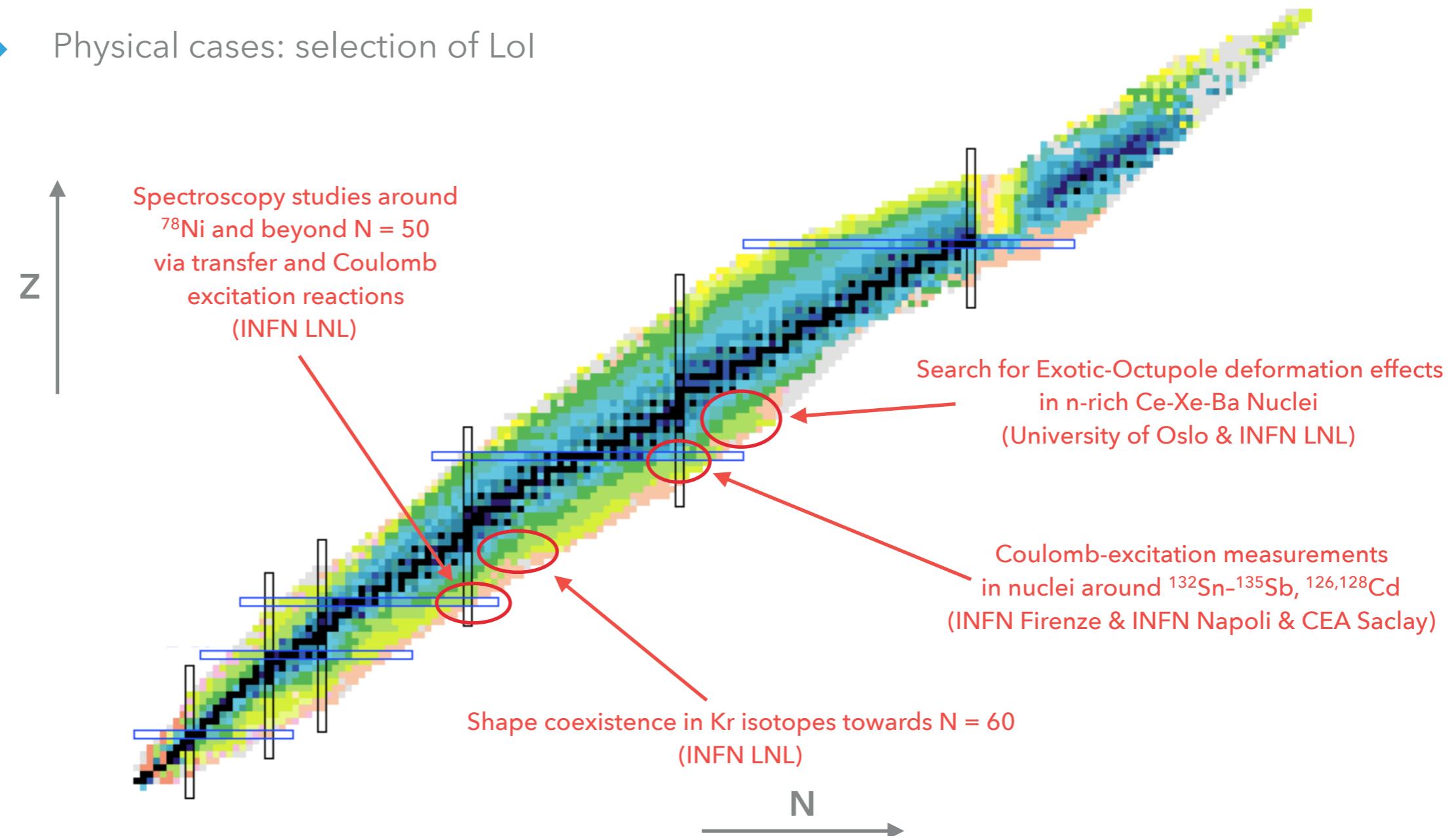
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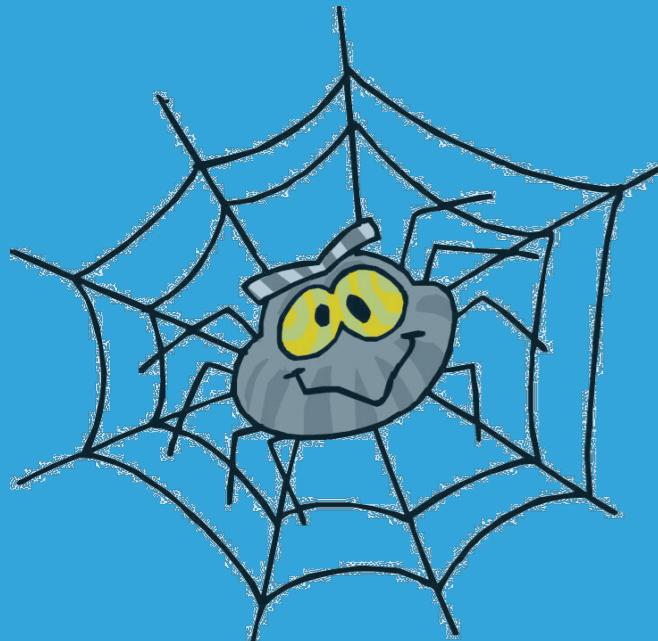
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COULOMB EXCITATION @SPES

- ▶ Introduction
- ▶ SPIDER
- ▶ SPIDER @LABEC:
 ^7Li
- ▶ SPIDER& GALILEO @LNL
- ▶ Coulomb excitation @SPES





THANK YOU FOR THE ATTENTION

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