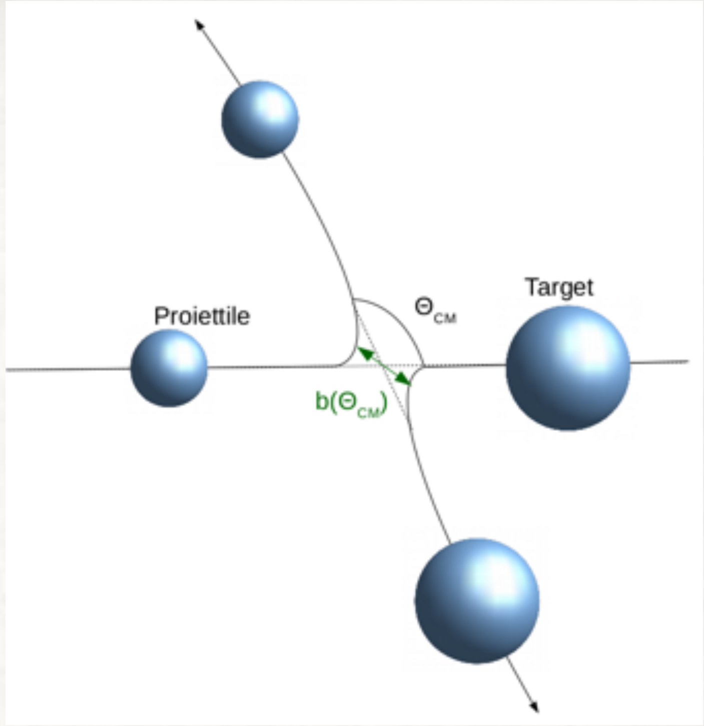
Istituto Nazionale di Fisica Nucleare

ADRIANA NANNINI
INFN — FIRENZE

COULOMB EXCITATION AT LNL WITH SPIDER-GALILEO SETUP AND OPPORTUNITIES AT SPES

SSNET'2018 - Gif-sur-Yvette 5-9/11/2018

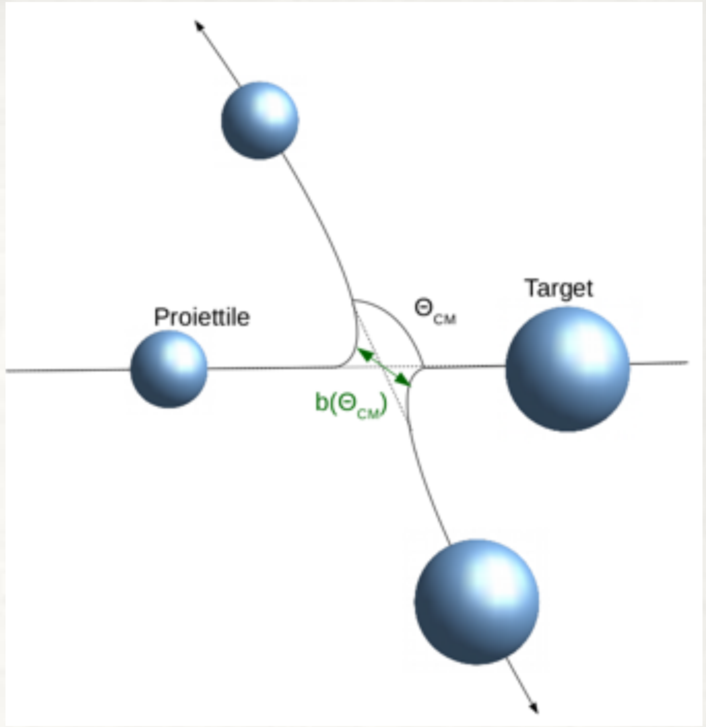
WHY COULOMB EXCITATION



COULEX is the most powerful and direct experimental method to study nuclear collectivity and shapes.

- the excitation process is purely electromagnetic

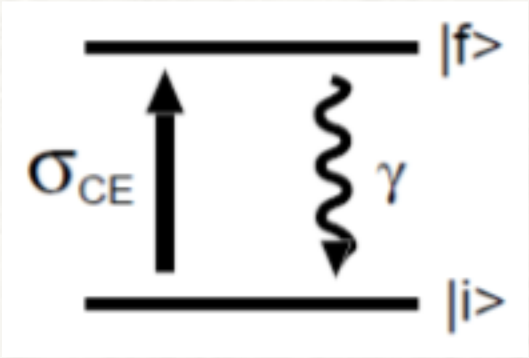
WHY COULOMB EXCITATION



COULEX is the most powerful and direct experimental method to study nuclear collectivity and shapes.

- the excitation process is purely electromagnetic
- cross-sections give a direct measure of the matrix elements of the e.m. multipole operators

$$B(\Omega L; J_i \longrightarrow J_f) = \frac{1}{2J_i + 1} |\langle J_f || M(\Omega L) || J_i \rangle|^2$$



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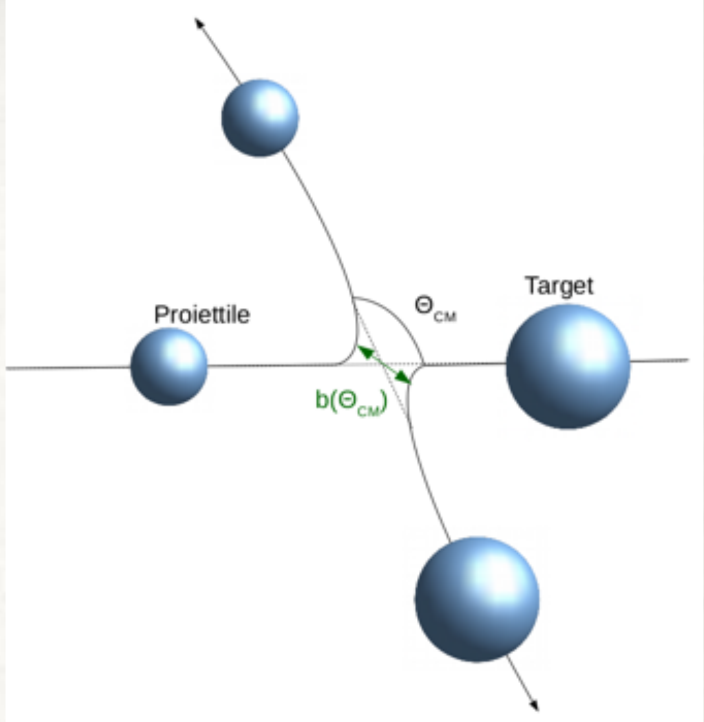

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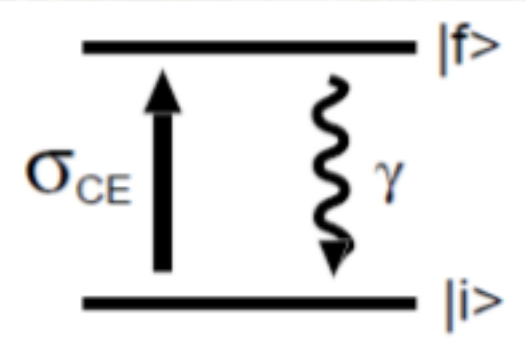
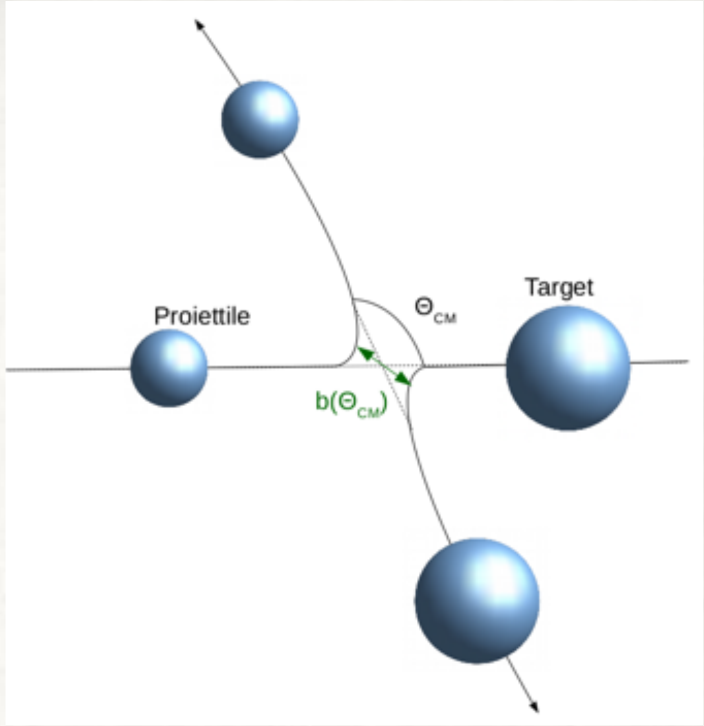


- diagonal matrix elements give information on the shape

$$Q_s(J) = \sqrt{\frac{16\pi}{5}} \frac{\langle J J 20 | J J \rangle}{\sqrt{2J+1}} \langle J || E2 || J \rangle$$

WHY COULOMB EXCITATION



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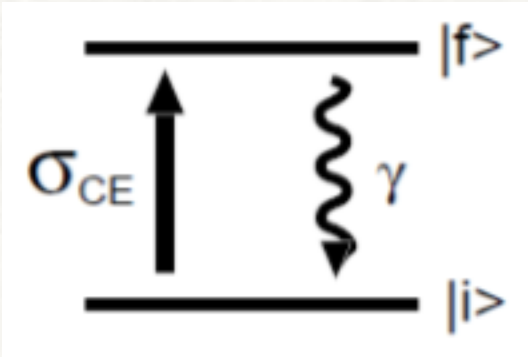
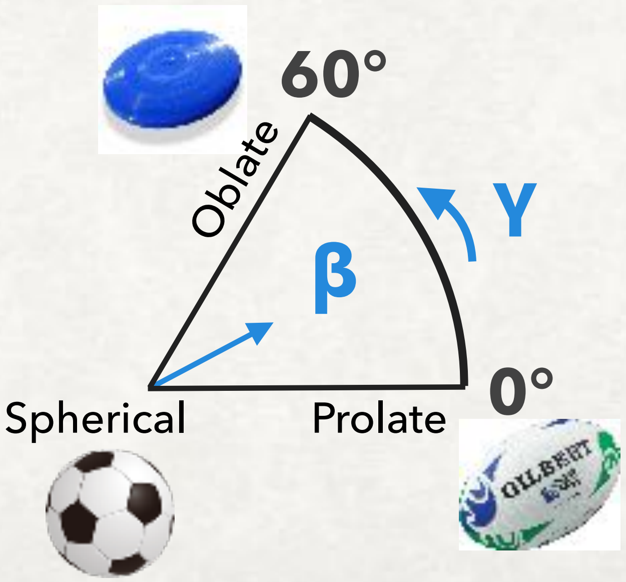


- diagonal matrix elements give information on the shape

$$Q_s\left(J\right) = \sqrt{\frac{16\pi}{5}} \frac{\langle JJ20|JJ\rangle}{\sqrt{2J+1}} \langle J\,||E2||\,J\rangle$$

- relative signs of matrix elements give information on the shape parameters (quadrupole sum rules)

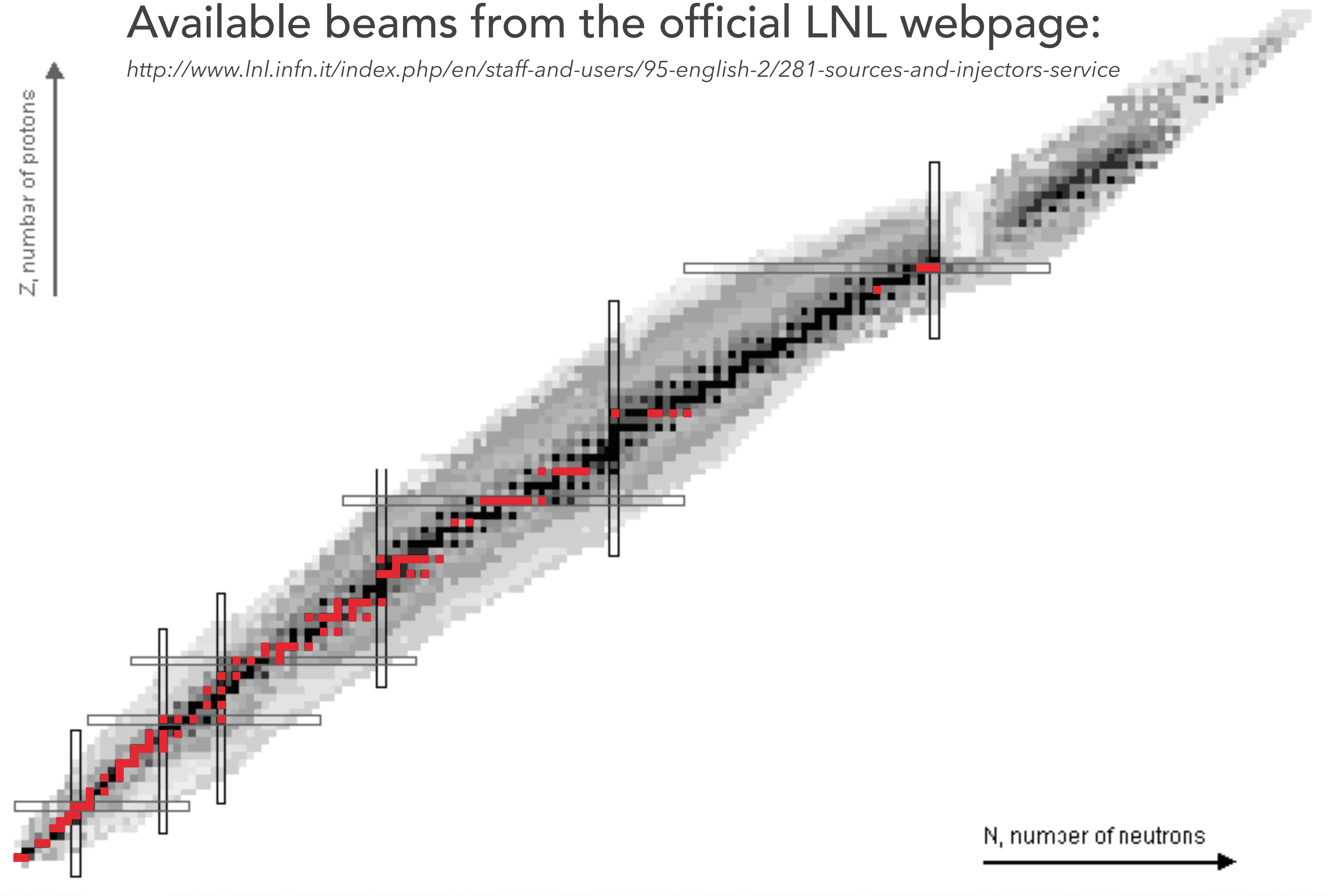


WHY COULOMB EXCITATION @ LNL

- **Many possibilities for Coulex with stable beams**

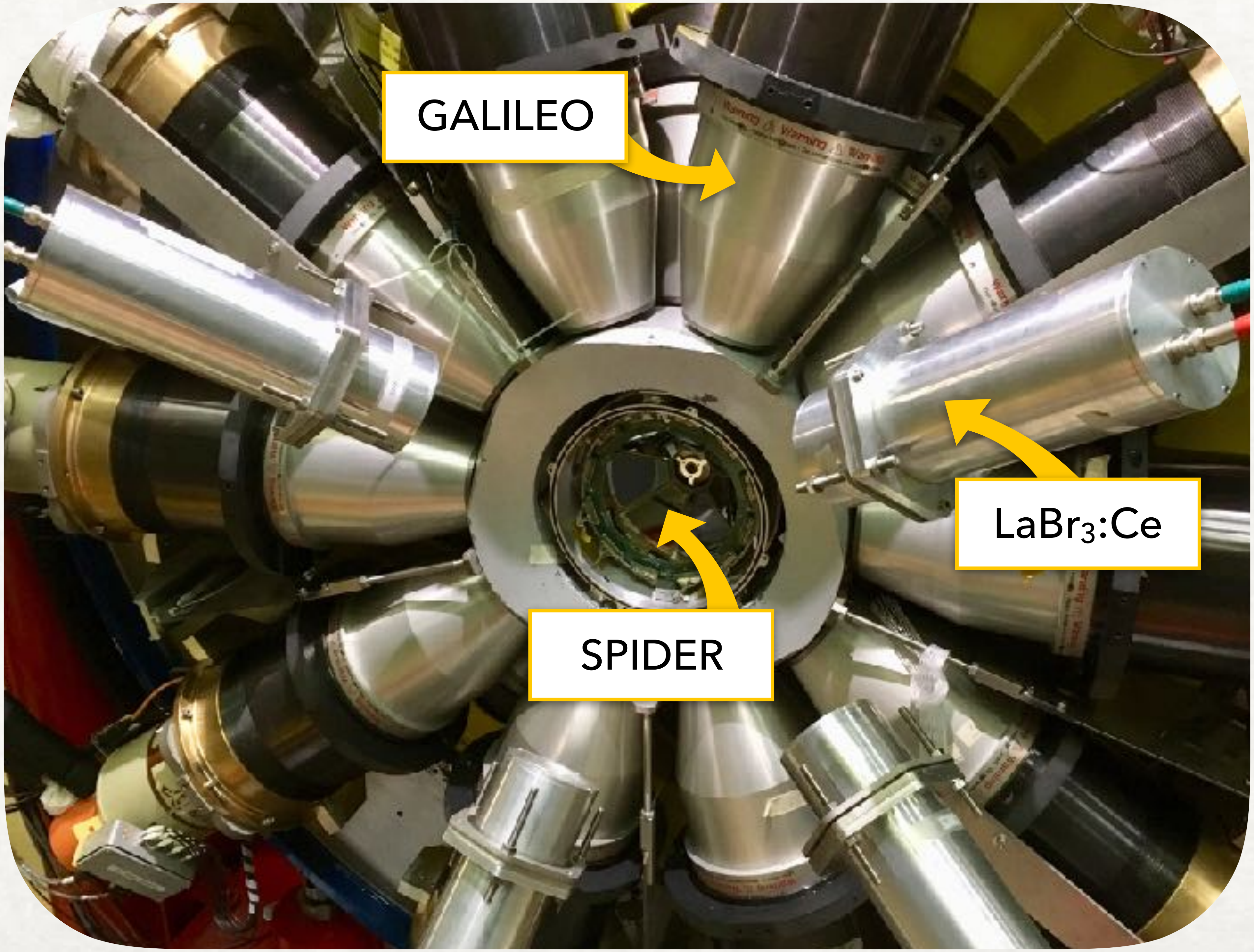
Available beams from the official LNL webpage:

http://www.lnl.infn.it/index.php/en/staff-and-users/95-english-2/281-sources-and-injectors-service



WHY COULOMB EXCITATION @ LNL

- **A new setup is available**



COULEX @ LNL SPIDER&GALILEO

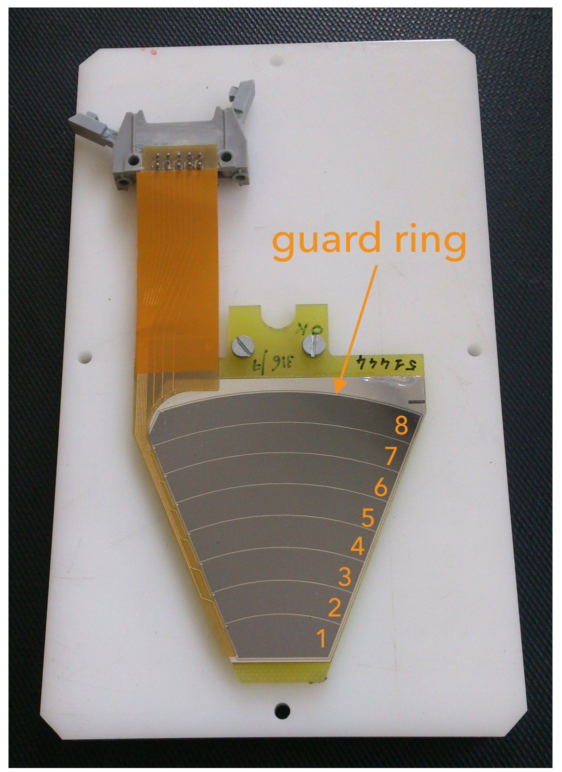
GALILEO 1st Phase

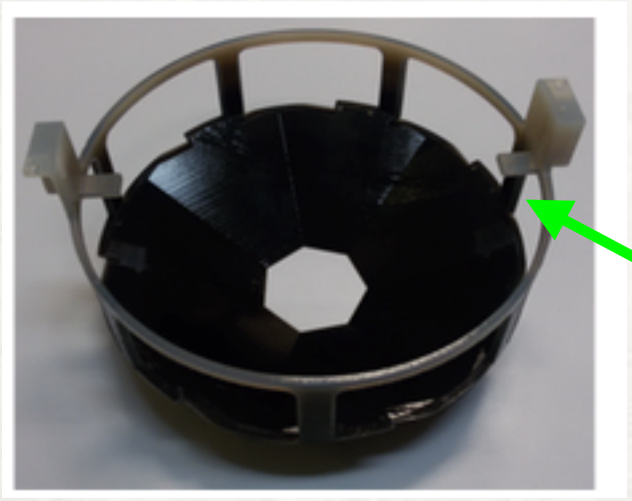
- 25 **HPGe** Compton-suppressed detectors (GASP type)
- **FWHM** (@1332.5 keV) < 2.4 keV
- **Efficiency** (@1332.5 keV) = 2.1%
- Complete **digital DAQ** (takes advantage of the developments made for AGATA):
    - Trigger-less mode
    - Typical operational rate ~ 20 kHz/det
    - Common clock synchronization

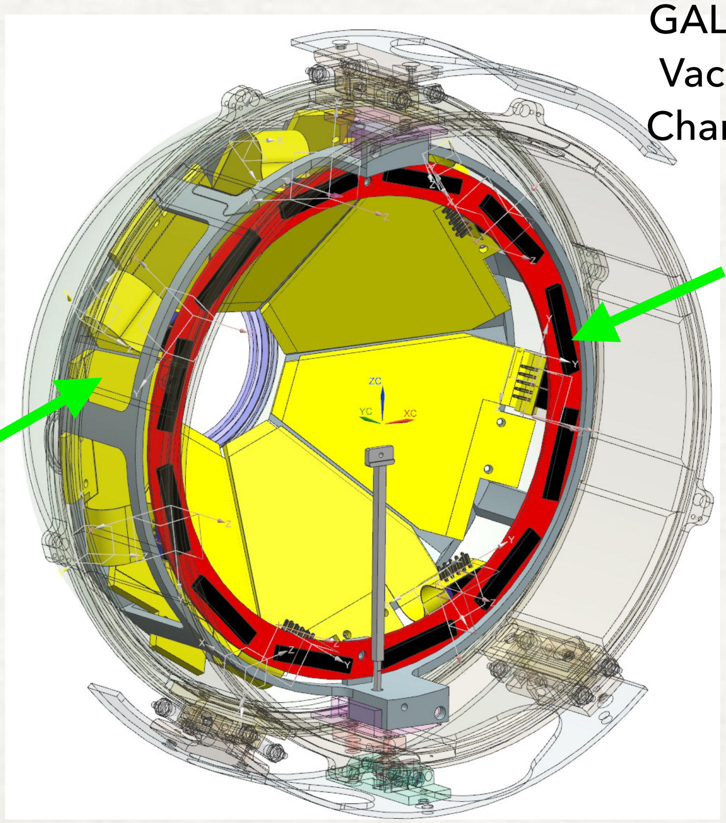
COULEX @ LNL SPIDER&GALILEO

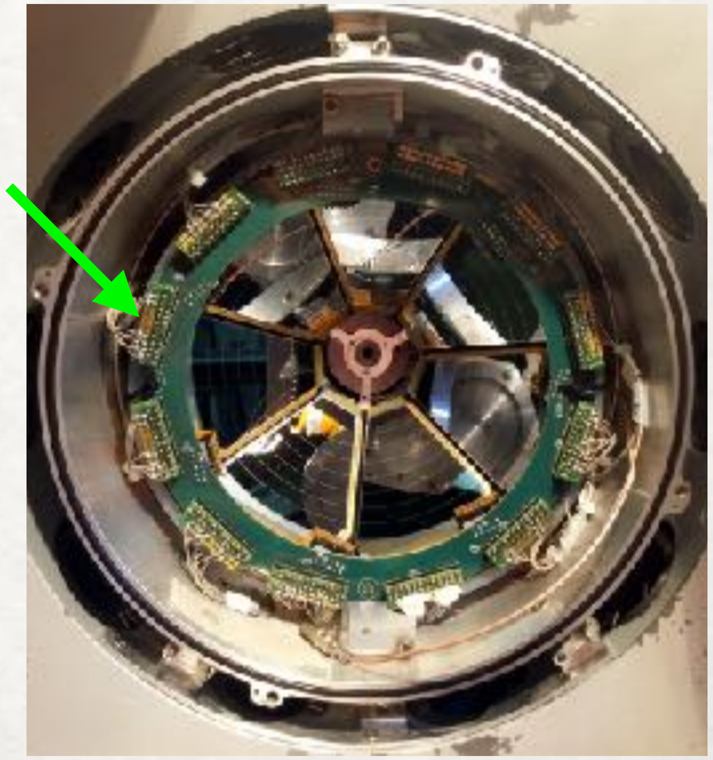
SPIDER Silicon PIe DEtectoR

- 8 independent **sectors**, 8 **strips** + guard ring
- Detector **thickness** ~ 300 μm
- **FWHM** ~21 keV for **α**-particles @ ~5.5 MeV
- modularity: with GALILEO **cone configuration** (7 sectors) at **backward angles** ⟹ $\Delta\Theta$ = 37.4°, $\Omega/4\pi$ = 17.3%







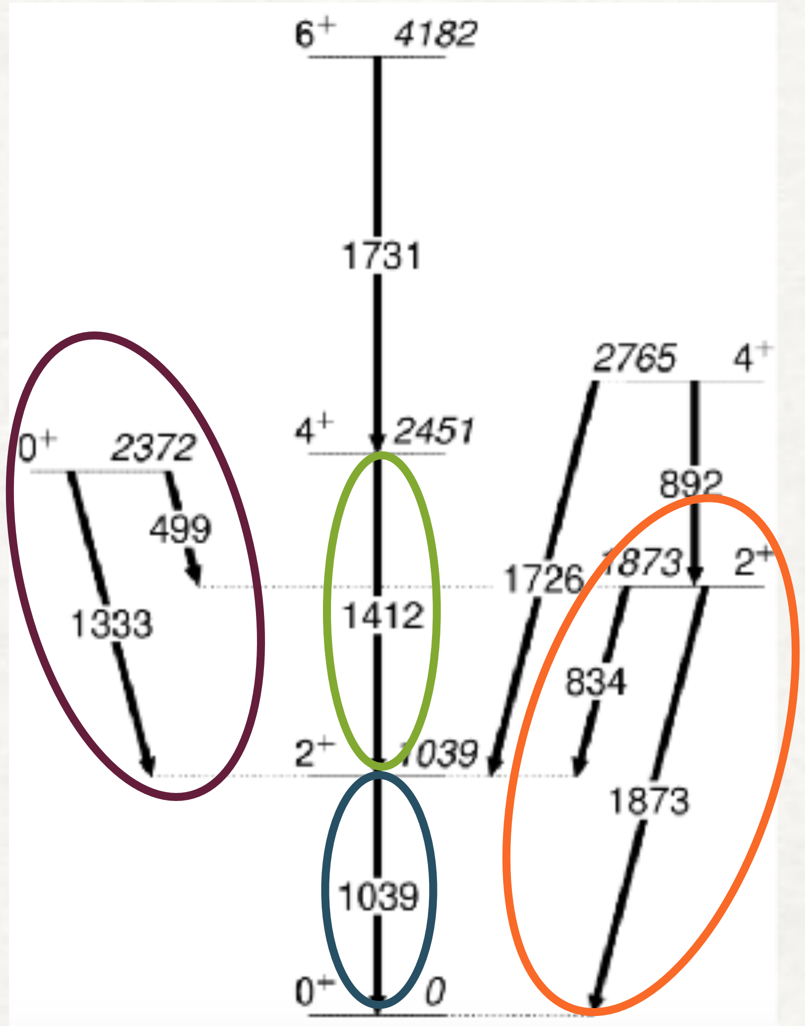


COULEX @ LNL SPIDER&GALILEO

First Experiment: Coulomb Excitation of ^{66}Zn

Spokespersons: M. Rocchini, K. Hadynska-Klek

- Commissioning: B(E2; 2_1^+ —> 0_1^+) and Q(2_1^+) known with high precision.
- But also new physics:
  - Shape of 0_2^+ ? B(E2) value unknown
  - Is the 2_2^+ high-collective or not? Discrepant values for its lifetime
  - Is the 4_1^+ collective or not? Discrepant values for the B(E2; 4_1^+ —> 2_1^+)
- Beam: ^{66}Zn (240 MeV, 1 — 1.5 pnA)
- Target: 1 mg/cm^2 of ^{208}Pb



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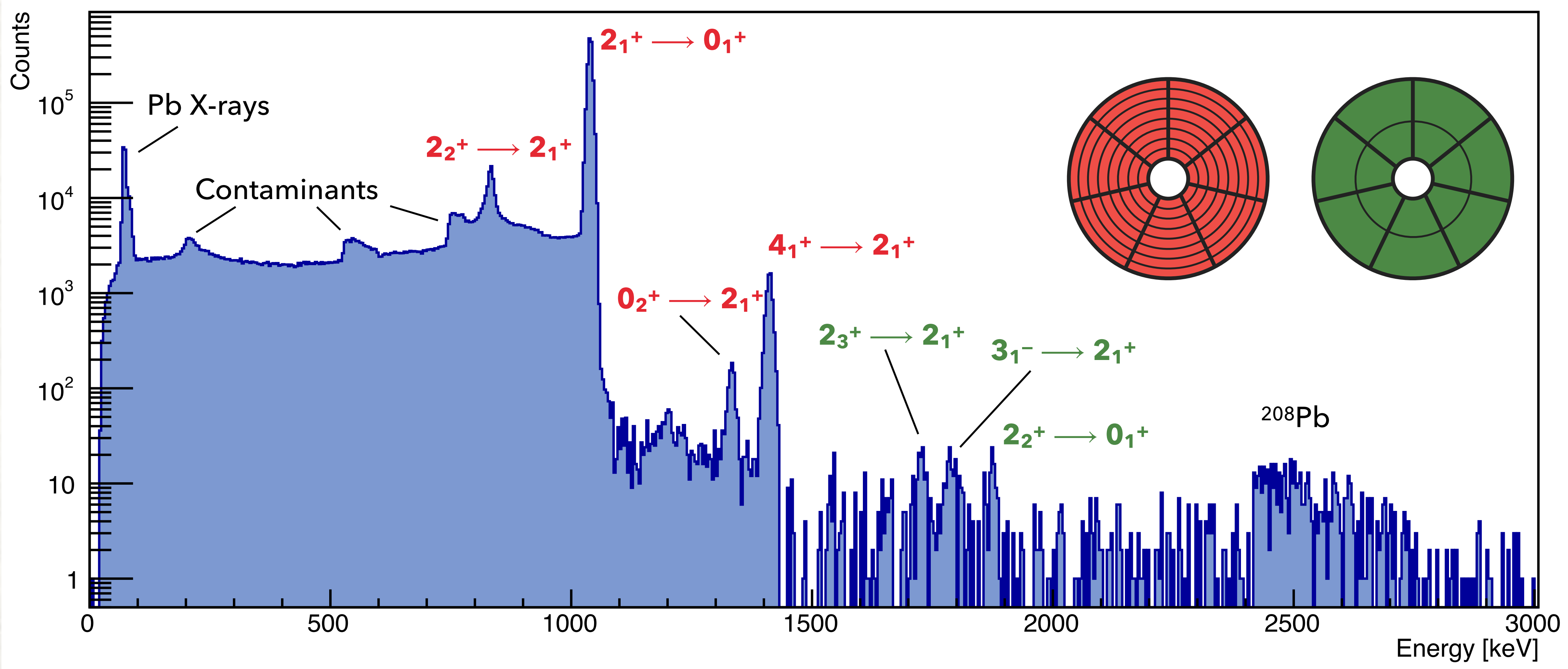
- Coincidences between GALILEO and SPIDER
- 38 experimental yields
- Analysis with the GOSIA code (T. Czosnyka, D. Cline, C. Wu, Bull. Amer. Phys. Soc. 28 (1983) 745)



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- validation of the setup performances: the **data already available in the literature have been confirmed**

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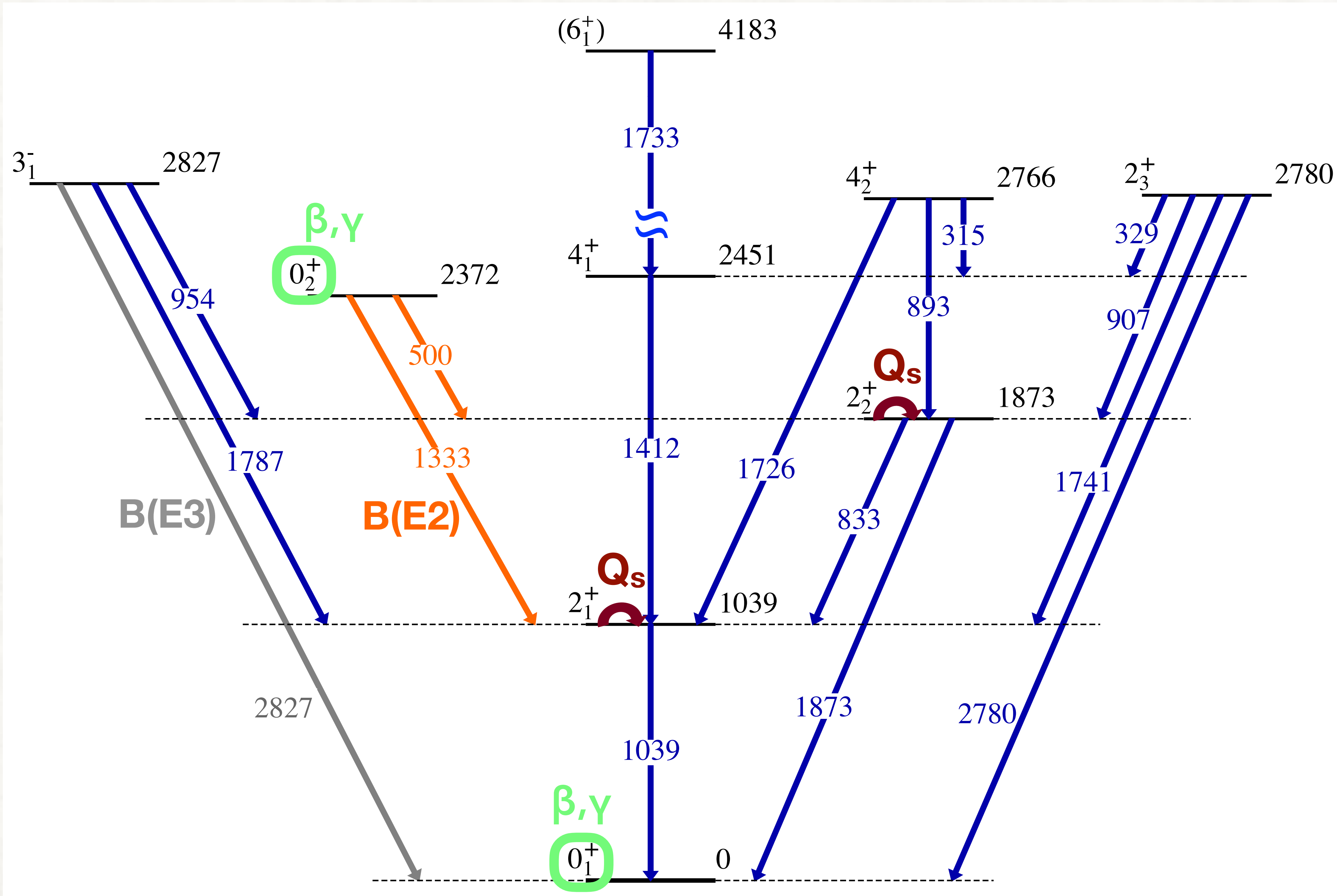


PhD thesis M. Rocchini (University of Florence)

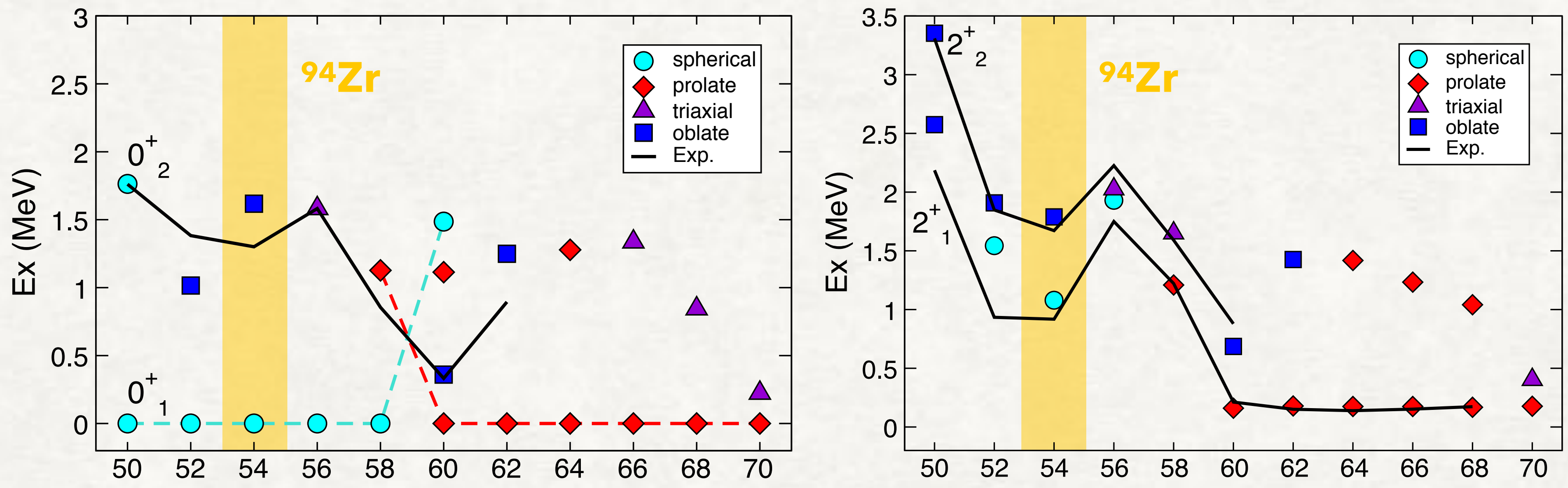
COULEX @ LNL SPIDER&GALILEO

Probing collectivity and configuration coexistence in ^{94}Zr with low-energy Coulomb Excitation

Spokespersons: D. Doherty, M. Rocchini, M. Zielinska

- Recent state-of-the-art Monte Carlo shell model calculations predict shape coexistence in Zr isotopes.

T. Togashi, Y. Tsunoda, T. Otsuka e N. Shimizu, Phys. Rev. Lett. ***117****, 172502 (2016)*



- Observation of a strong $2^+_2 \rightarrow 0^+_2$ transition (19 W.u.*) suggests a deformed band built on 0^+_2

* *A. Chakraborty et al., PRL 110, 022504 (2013).*

COULEX @ LNL SPIDER&GALILEO

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- Beam: ^{94}Zr (370 MeV, 1 — 1.5 pnA)
- Target: 1 mg/cm^2 of ^{208}Pb
- Six 3”X3” $LaBr_3$:Ce used for the first time in COULEX @LNL
  - FWHM (@1332.5 keV) ~ 2%
  - Efficiency (@1332.5 keV) = 4%

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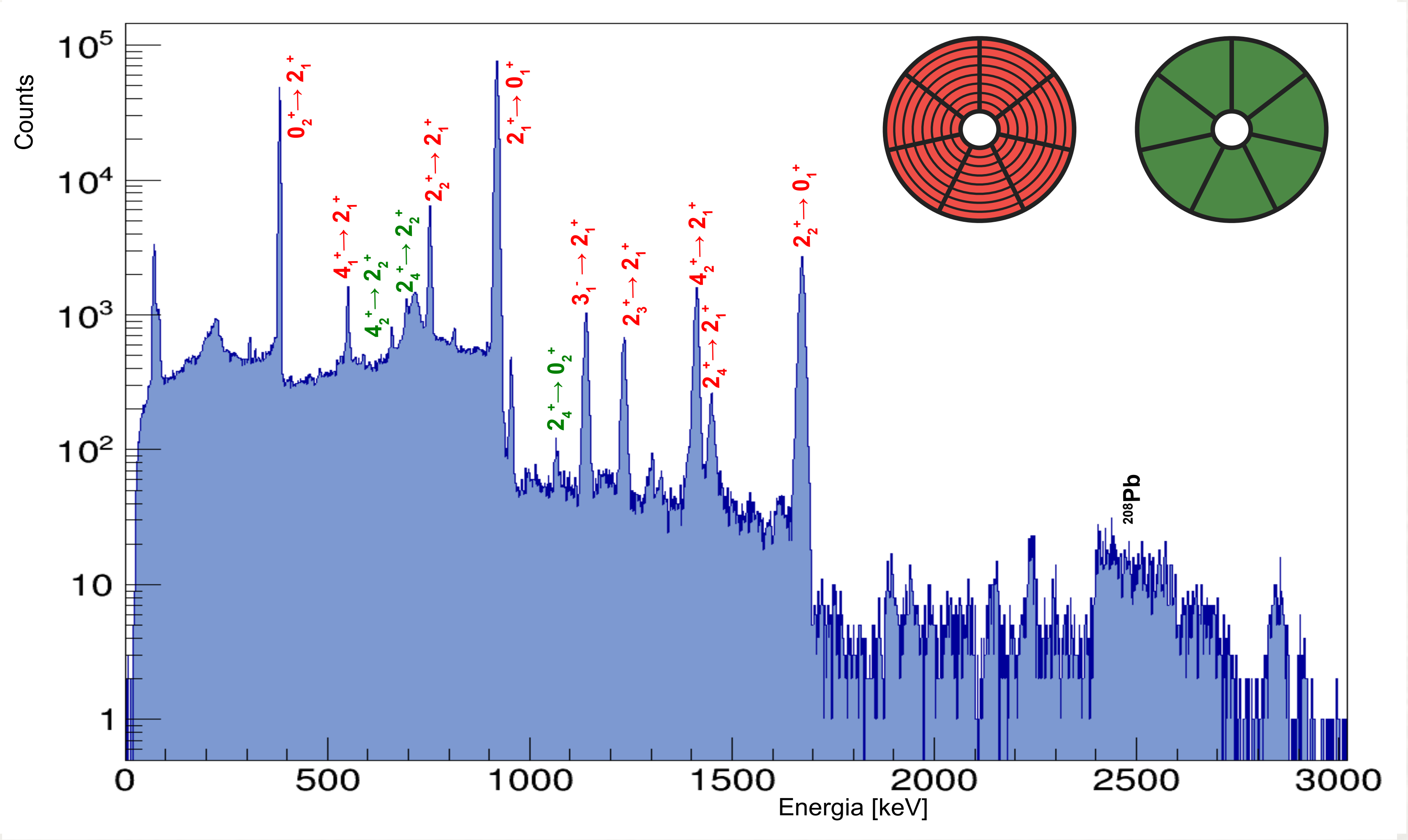

COULEX @ LNL SPIDER&GALILEO

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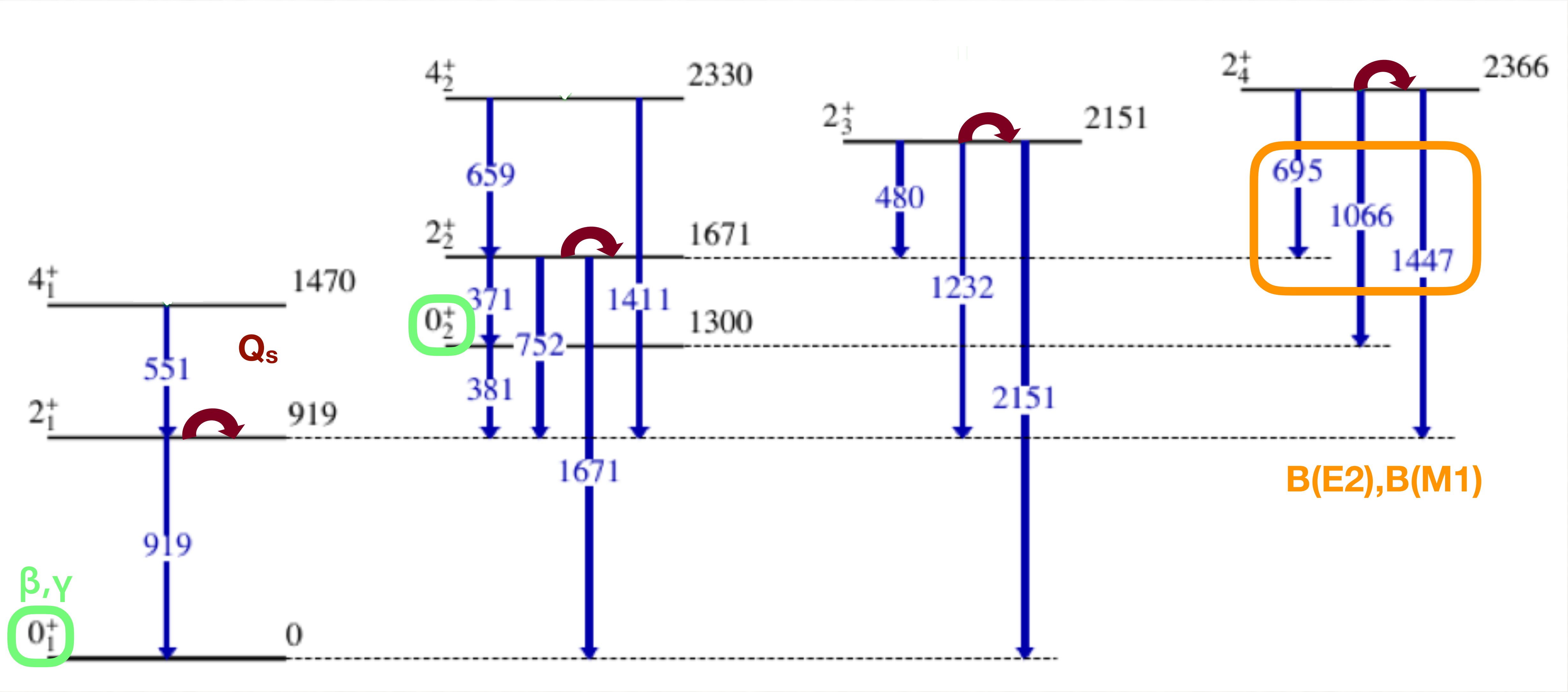
Sezione di Firenze

Probing collectivity and configuration coexistence in ^{94}Zr with low-energy Coulomb Excitation

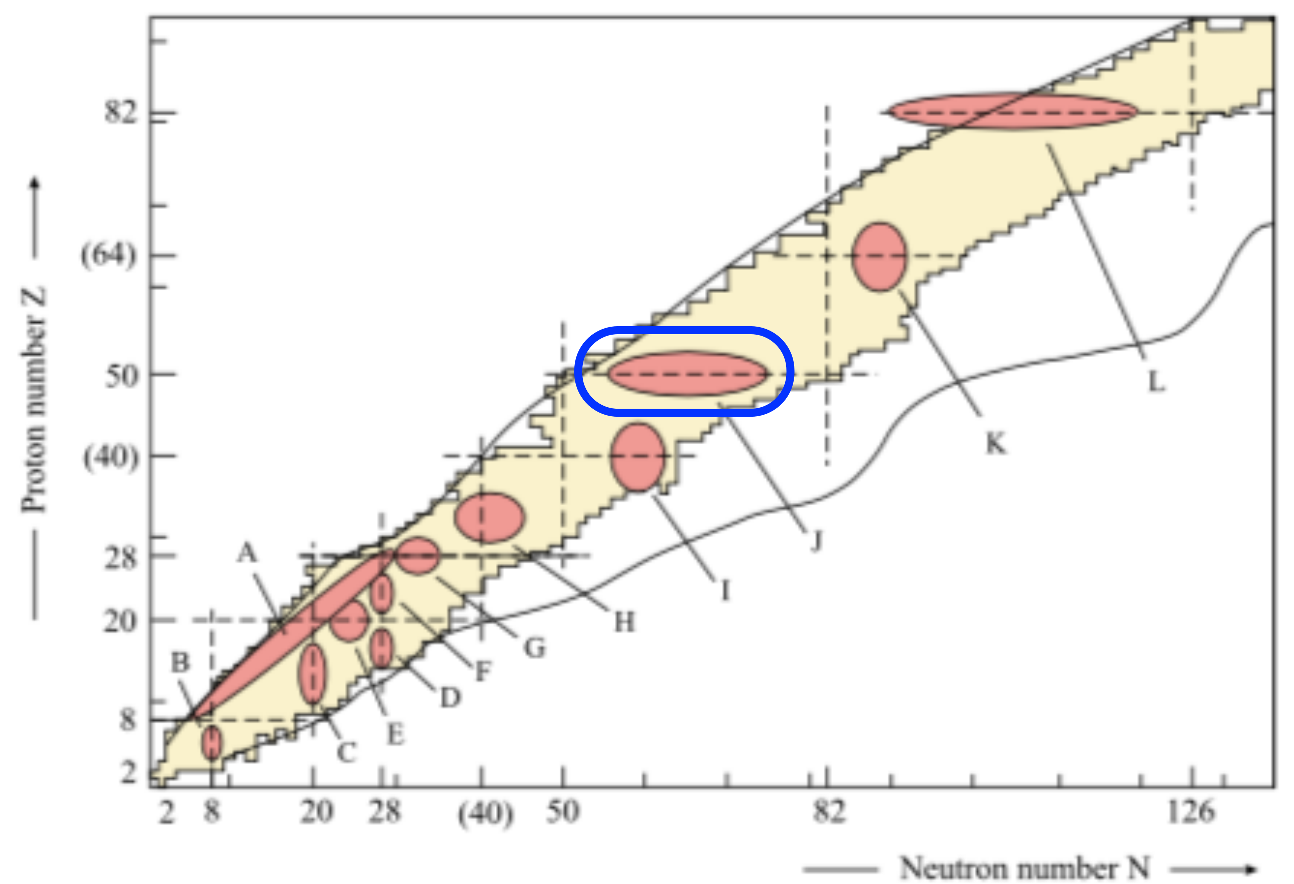
Spokespersons: D. Doherty, M. Rocchini, M. Zielinska

First results of GOSIA analysis: **master thesis** N. Marchini (University of Florence)



Shape Coexistence in the Tin isotopic chain: Coulomb Excitation measurement of ^{116}Sn

Spokespersons: M. Saxena, M. Siciliano, A. Illana



K. Heyde and J. Woods, Rev. Mod. Phys. 83 (2011) 1467

- The semi-magic Sn isotopes represent a good case to study shape coexistence
- Within Sn isotopes ^{116}Sn intriguing position Z=50, N=66
- Discrepant values for the 2_1^+ quadrupole moments in the literature

- Presence of isomer limits the investigation of the electromagnetic properties of low-lying states —> Coulomb Excitation

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- Beam: ^{58}Ni @ 180 MeV 4 pnA, continuous
- Target: ^{116}Sn 1 mg/cm^2 ^{12}C backing
- Setup: GALILEO (25 HPGe) 6 $LaBr_3$ SPIDER

EXPERIMENT PERFORMED LAST WEEK…..

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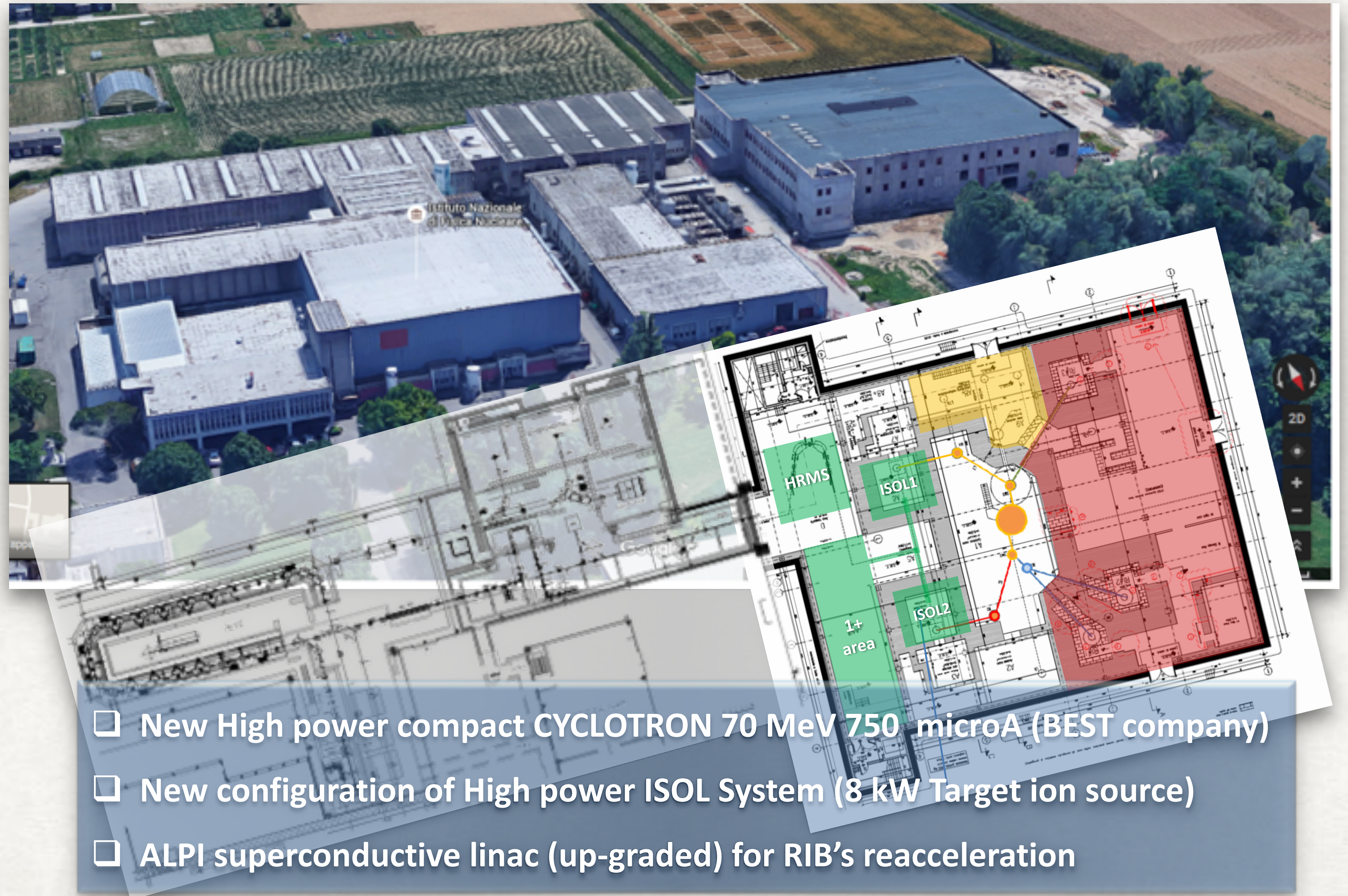
A second experiment on Coulomb Excitation of a ^{58}Ni beam on a ^{196}Pt target will be performed next year.

Coulomb Excitation of ^{58}Ni: Collectivity Near the Doubly Magic ^{56}Ni Nucleus

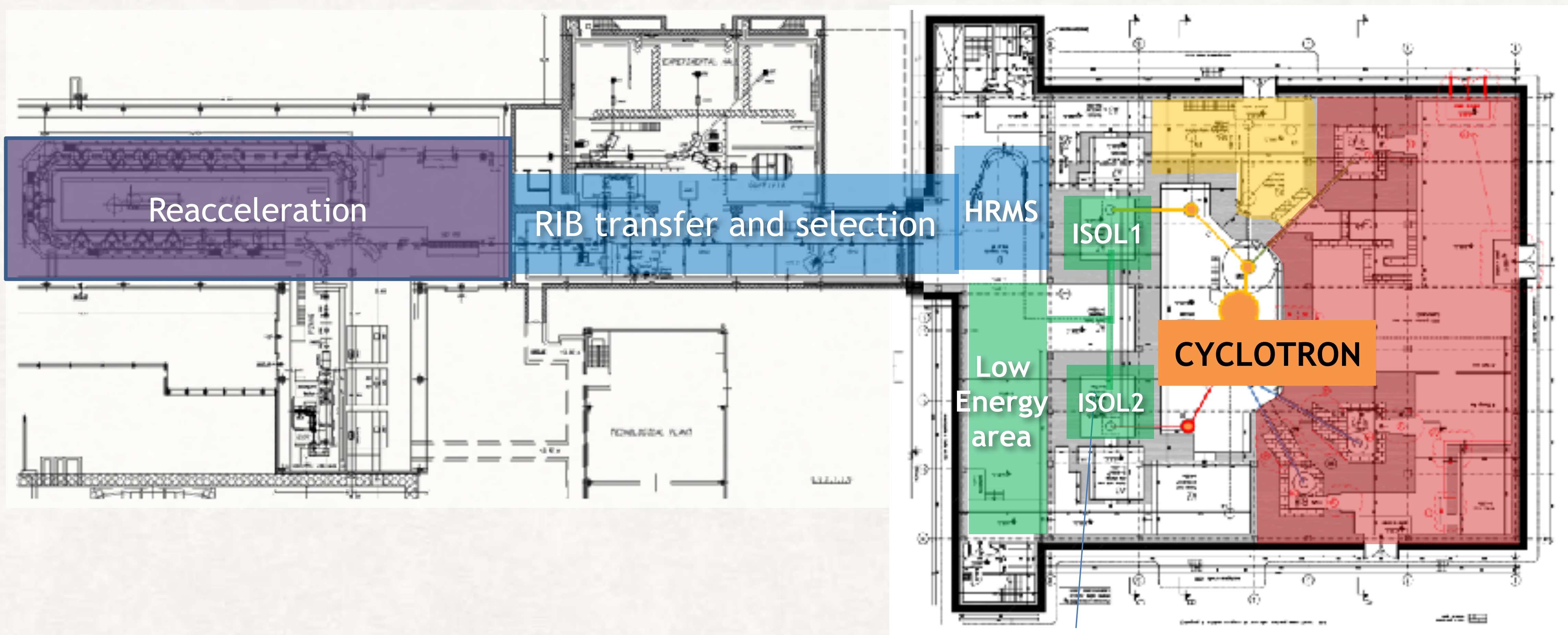
Spokespersons: M. Rocchini, A. Nannini

RADIOACTIVE BEAMS @LNL



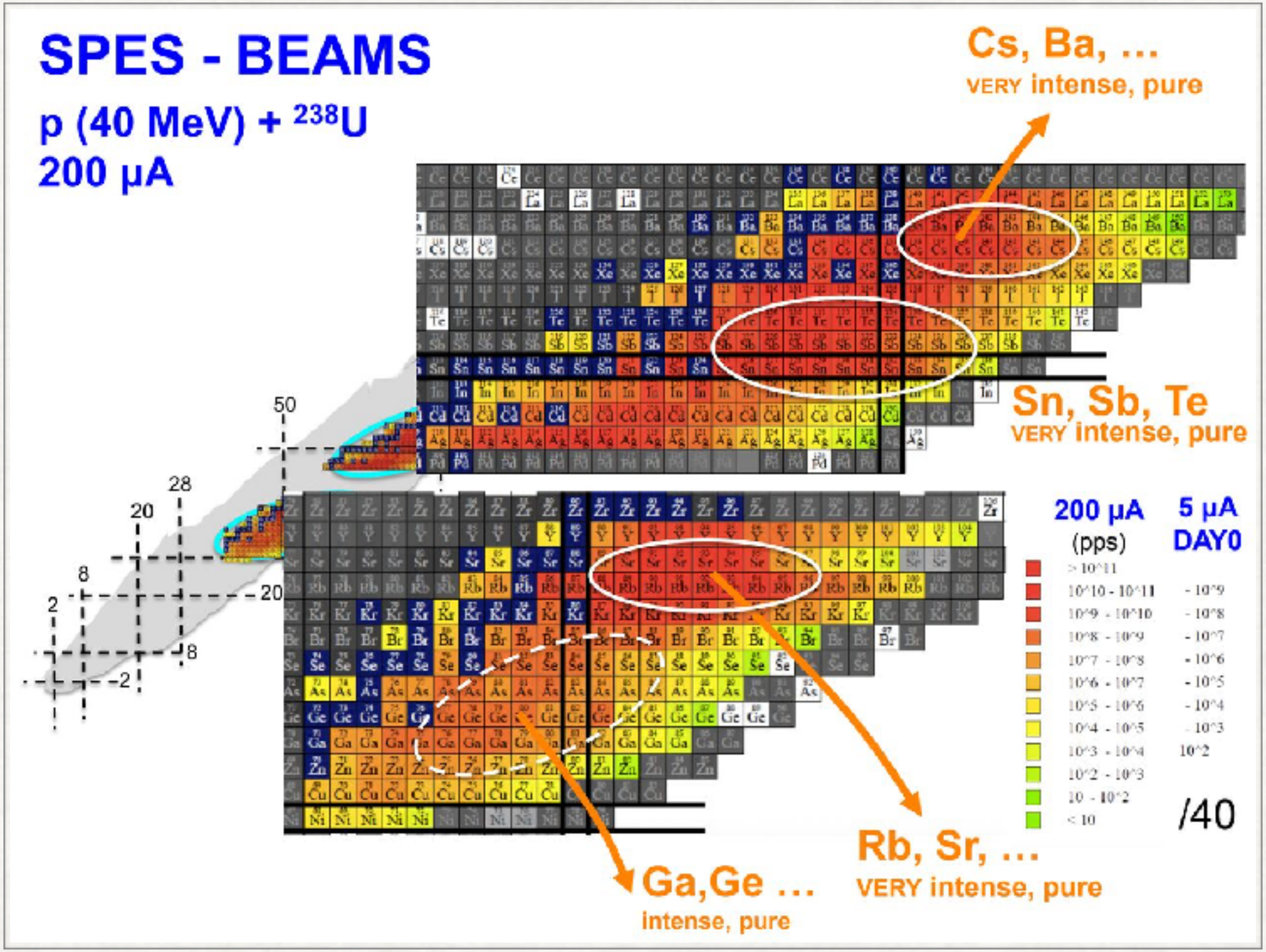
- New High power compact CYCLOTRON 70 MeV 750 microA (BEST company)
- New configuration of High power ISOL System (8 kW Target ion source)
- ALPI superconductive linac (up-graded) for RIB's reacceleration

SPES layout

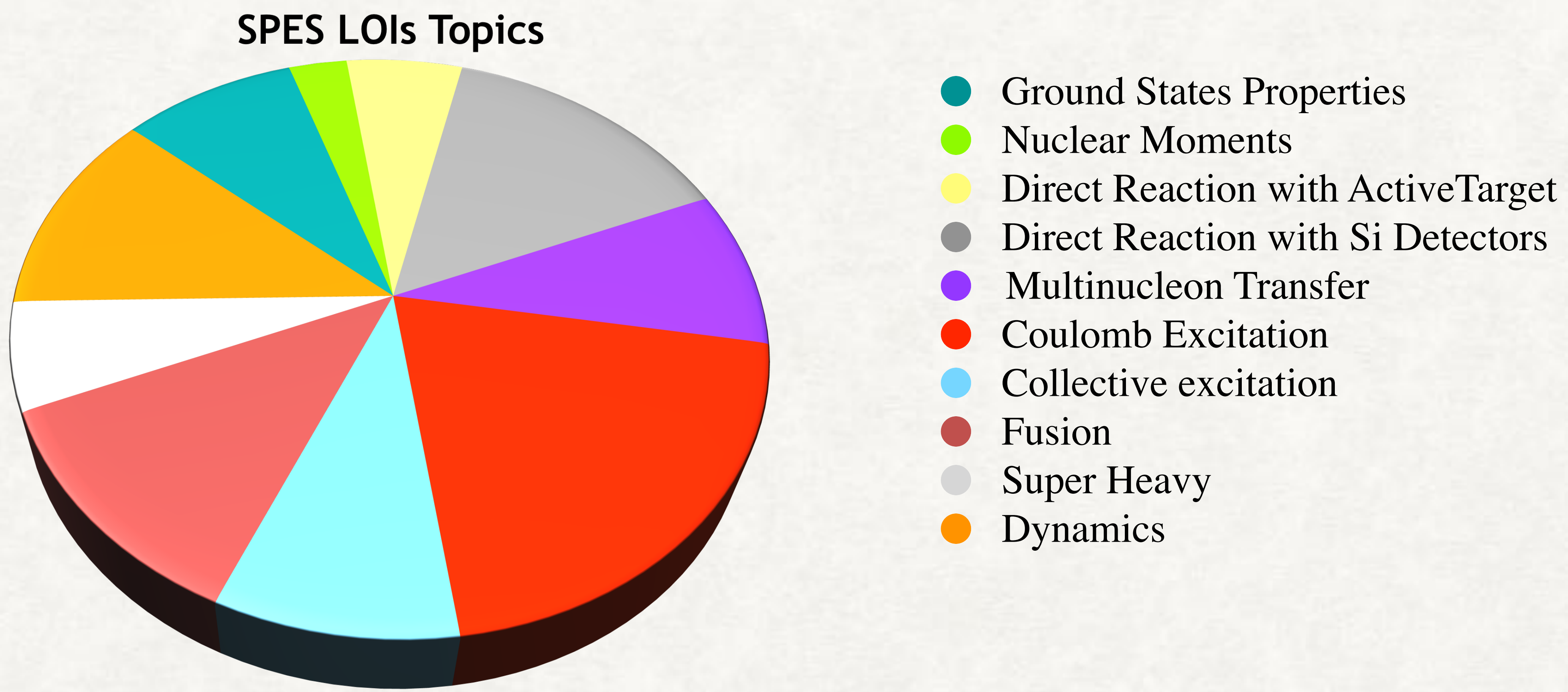


RIB reacceleration: • new RFQ • ALPI	1/20.000 Mass separator (Beam Cooler + HRMS) Electrostatic beam transport Charge Breeder (n+) 1/1000 mass separator	ISOL bunkers 1/200 mass separator low energy experimental area	Radioisotopes production area

RADIOACTIVE BEAMS @LNL



SPES International Workshop: 47 Letter of Intents



SUMMARY AND OUTLOOK

- Coulomb Excitation @LNL with stable beams is on-going
- Proposals for the next years are under discussion
- Near future: 2nd phase GALILEO 30 GASP detectors + 10 triple cluster
- Far future: Coulex @LNL with SPES radioactive beams

THANK YOU FOR THE ATTENTION

A. N[1], M. Rocchini[1], N. Marchini[1,2], K. Hadyńska-Klęk[3],J. J. Valiente-Dobón[3], A. Goasduff[4,5], D. Testov[4,5], D. Mengoni[4,5], M. Zielińska[6], D. Bazzacco[4,5], G. Benzoni[7], P. Cocconi[3],M. Chiari[1,2], D. T. Doherty[8], M. Komorowska[6,9], M. Matejska-Minda[9],B. Melon[2], P. Napiorkowski[9], M. Ottanelli[2], A. Perego[1,2], L. Ramina[5],M. Rampazzo[5], F. Recchia[4,5], D. Rosso[3], M. Siciliano[3,4] and P. Sona[1]

[1] INFN, Sezione di Firenze, Firenze, Italy, [2] Dipartimento di Fisica e Astronomia, Università degli Studi di Firenze, Firenze, Italy, [3] INFN, Laboratori Nazionali di Legnaro, Legnaro (Padova), Italy, [4] Dipartimento di Fisica e Astronomia, Università degli Studi di Padova, Padova, Italy, [5] INFN, Sezione di Padova, Padova, Italy, [6] CEA Saclay, IRFU/SPhN, France, [7] INFN, Sezione di Milano, Milano, Italy, [8] University of Surrey, Guildford, United Kingdom, [9] Heavy Ion Laboratory, University of Warsaw, Poland