LEHRI: Towards the first Phase-0 experiments at FAIR

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Outline

- **LERHI**
  - Presentation
  - Background
  - Perspectives: Upcoming experiments in **Phase-0** @ **FAIR**
- The **R^{3}B** experiment
  - Study of **nuclear halos** via **knock-out** reactions
  - Characterisation of **CALIFA** at CTN/IST
- Summary

LERHI

Low Energy Reactions with Hadrons and Ions

HADES


Alberto Blanco


Celso Franco


João Saraiva


Américo Pereira


Luís Lopes


Paulo Fonte


Nuno Carolino

R3B


Daniel Galaviz


Luís Peralta

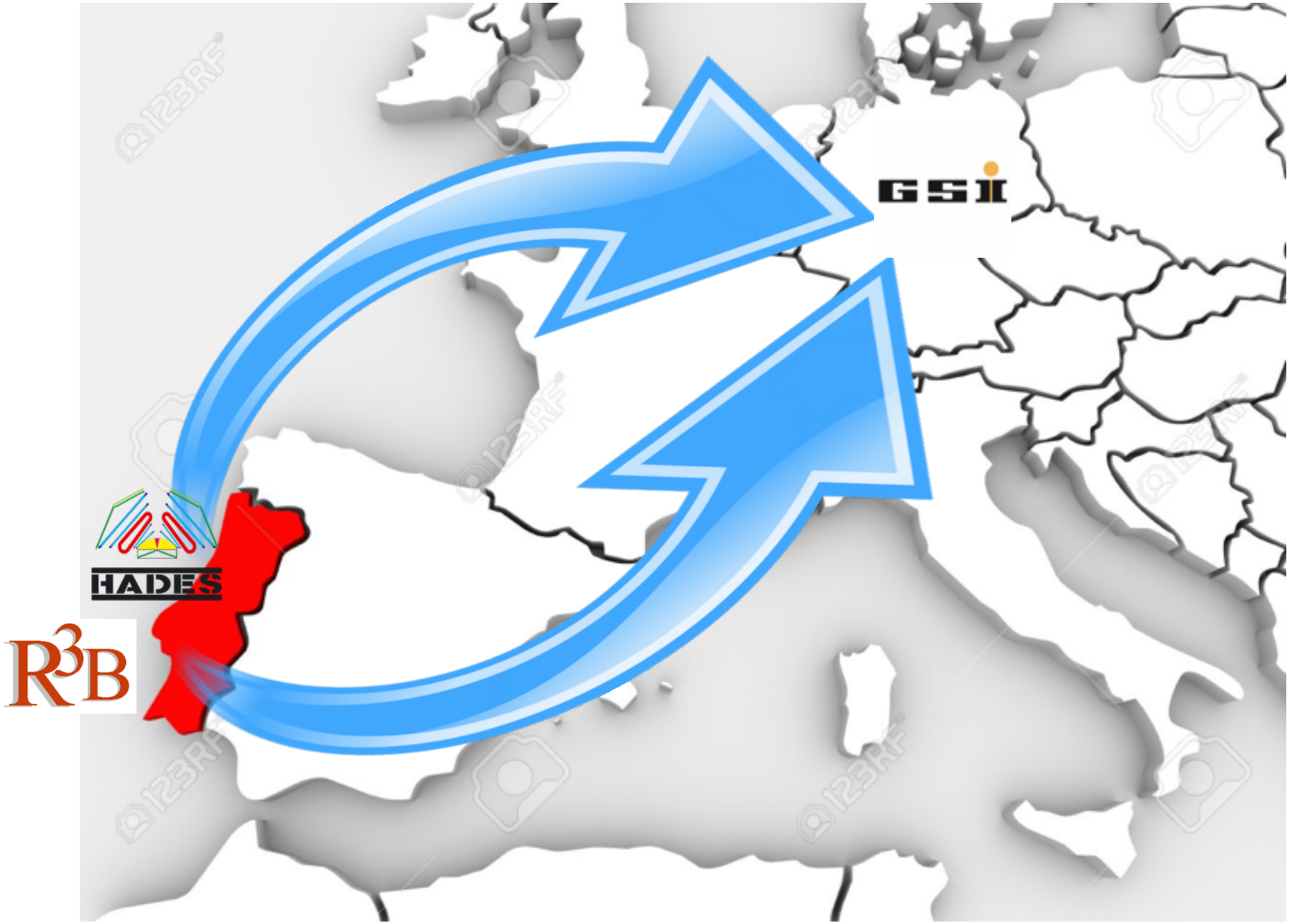

Pamela Teubig

Ana Henriques

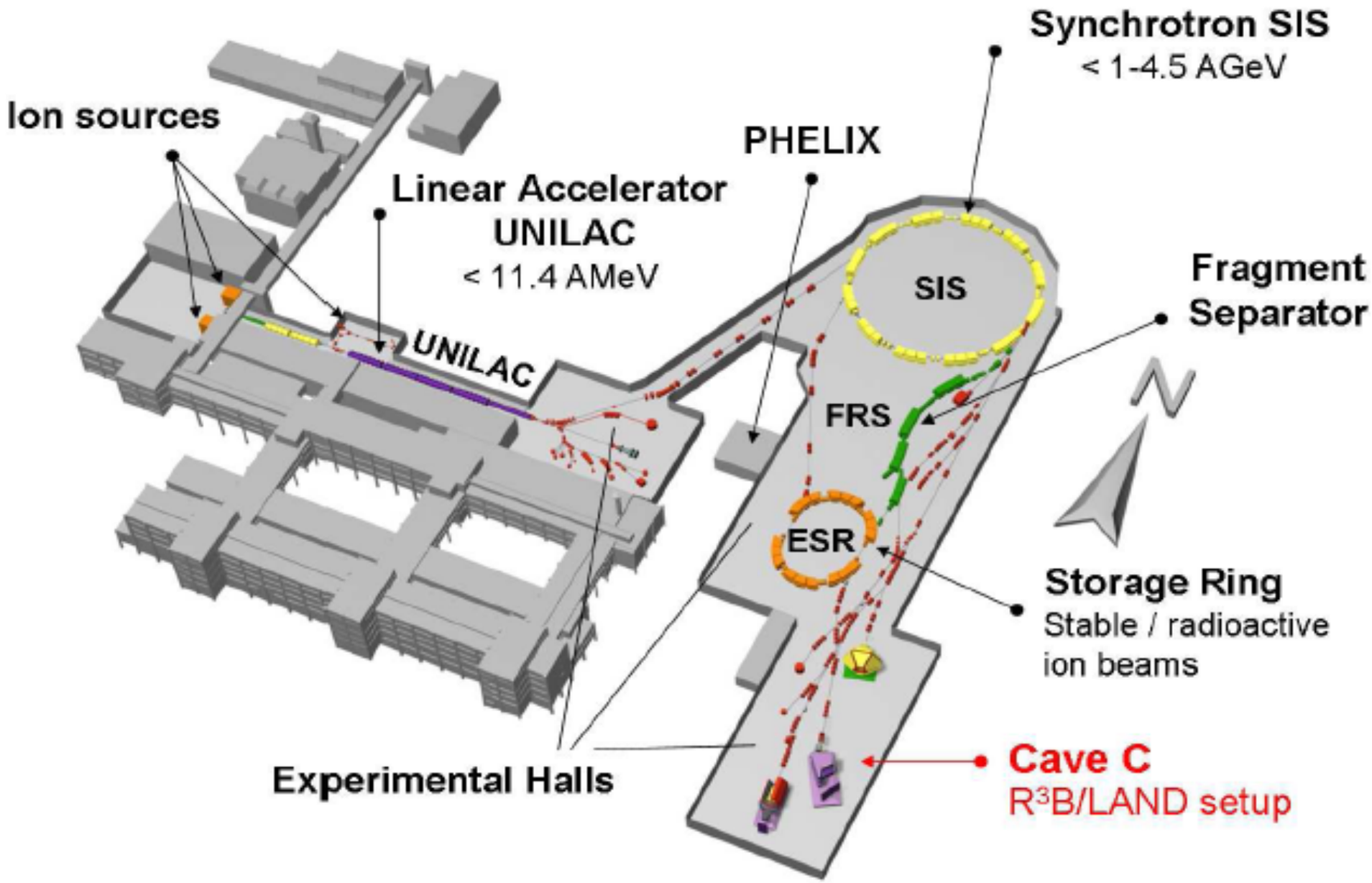

Paulo Velho


Elisabet Galiana

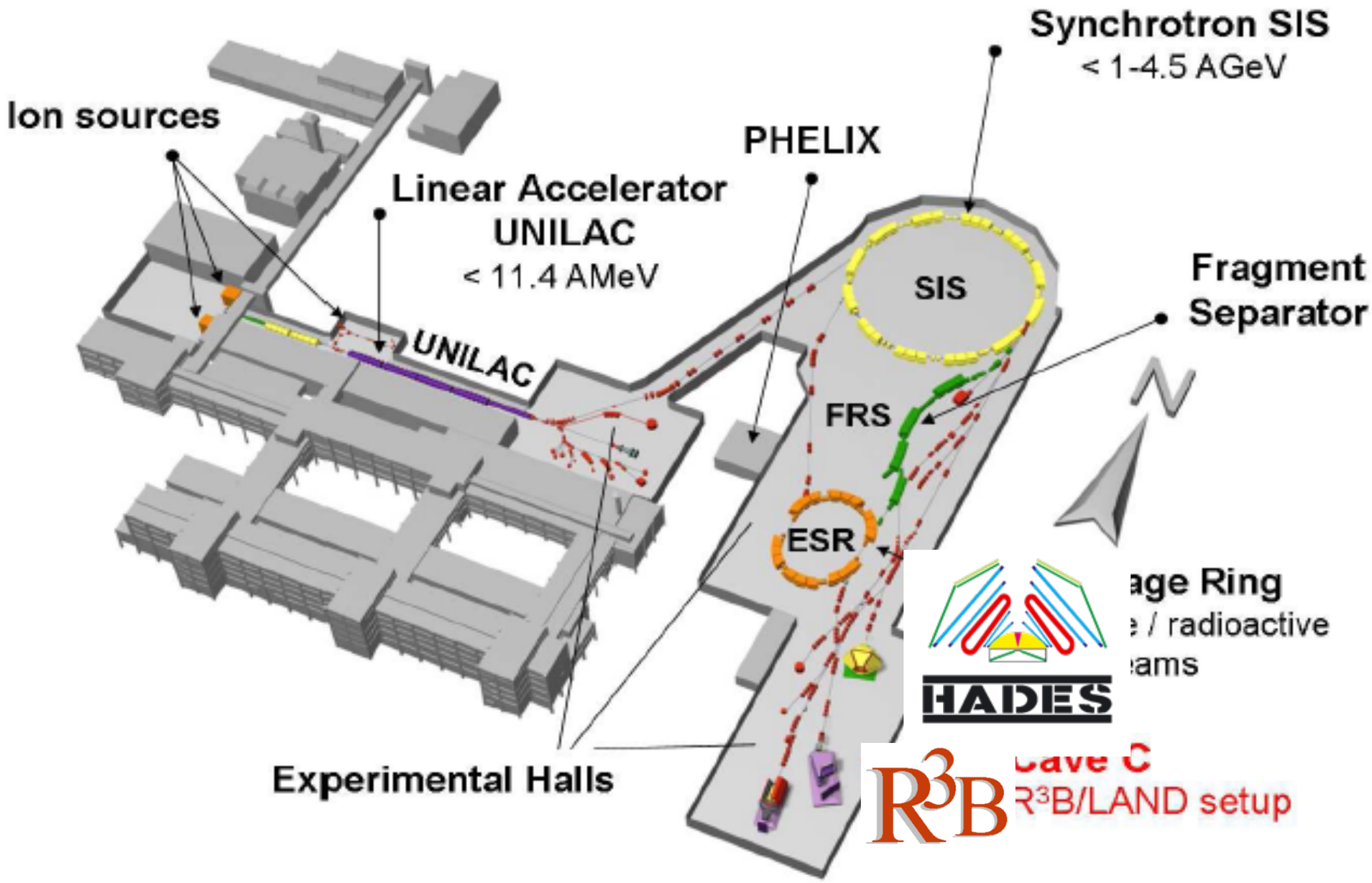
LERHI's Reason of Being



GSI Laboratory



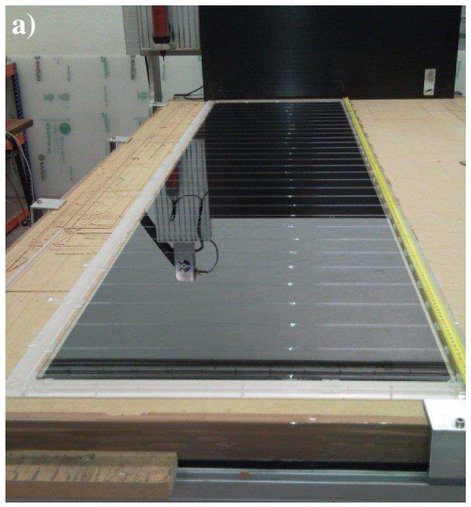
GSI Laboratory

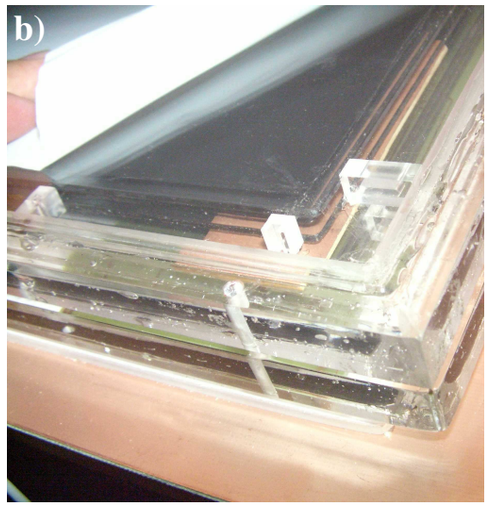


NeuLAND @ R³B

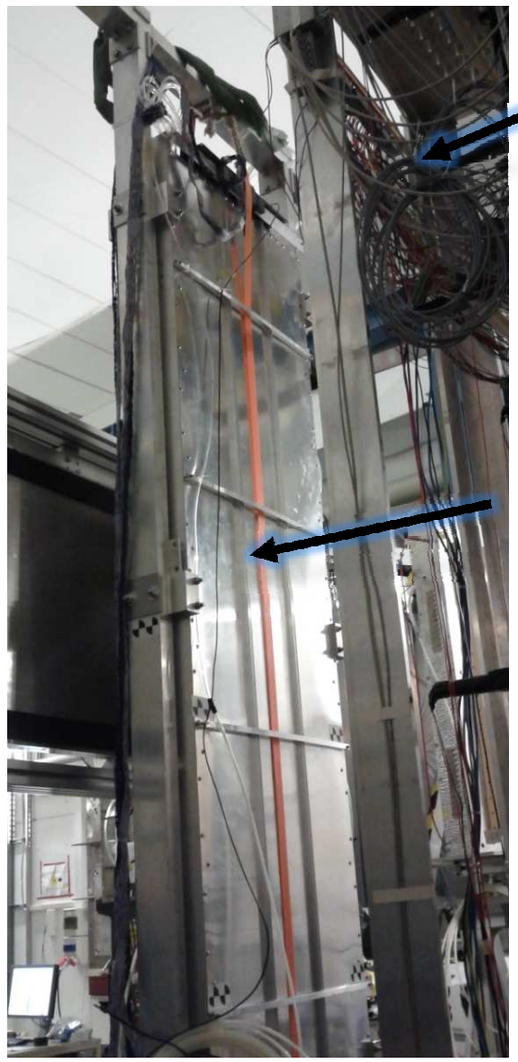
Detector R&D for R³B

Relativistic Neutron Detector based on tRPCs



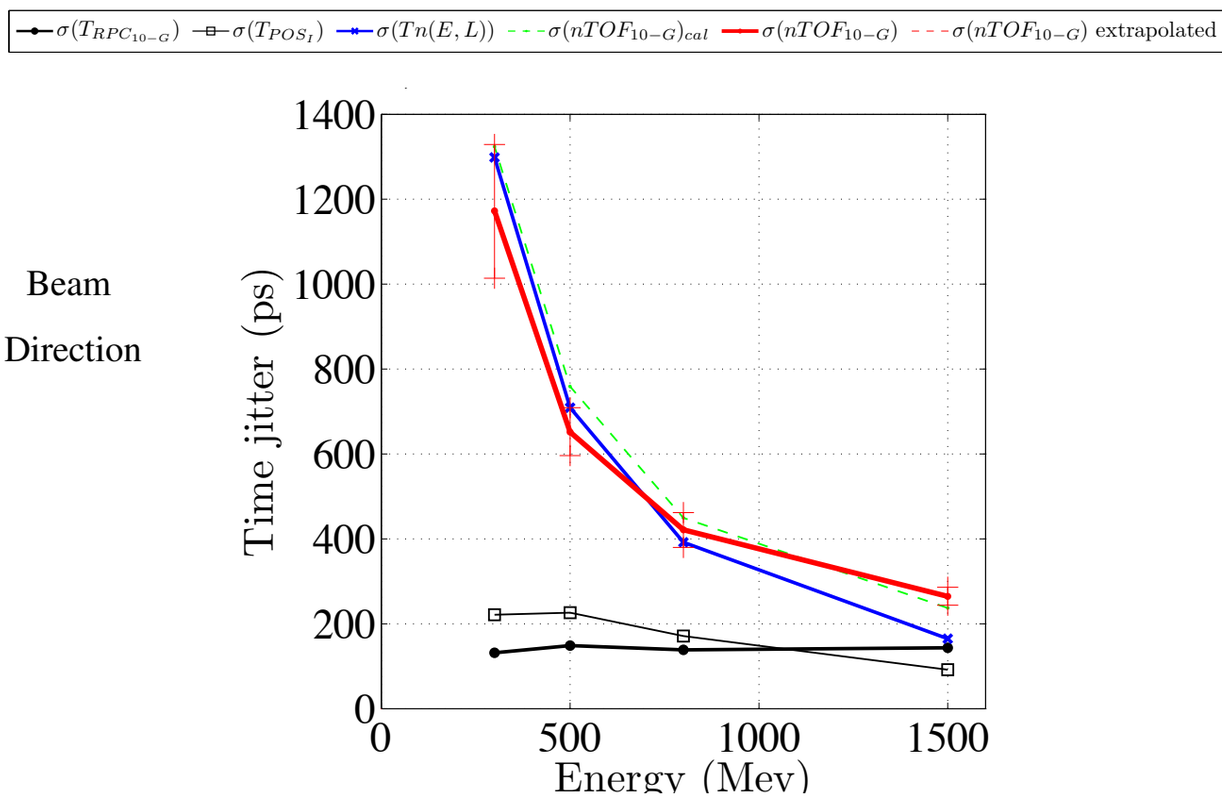


Built in Coimbra



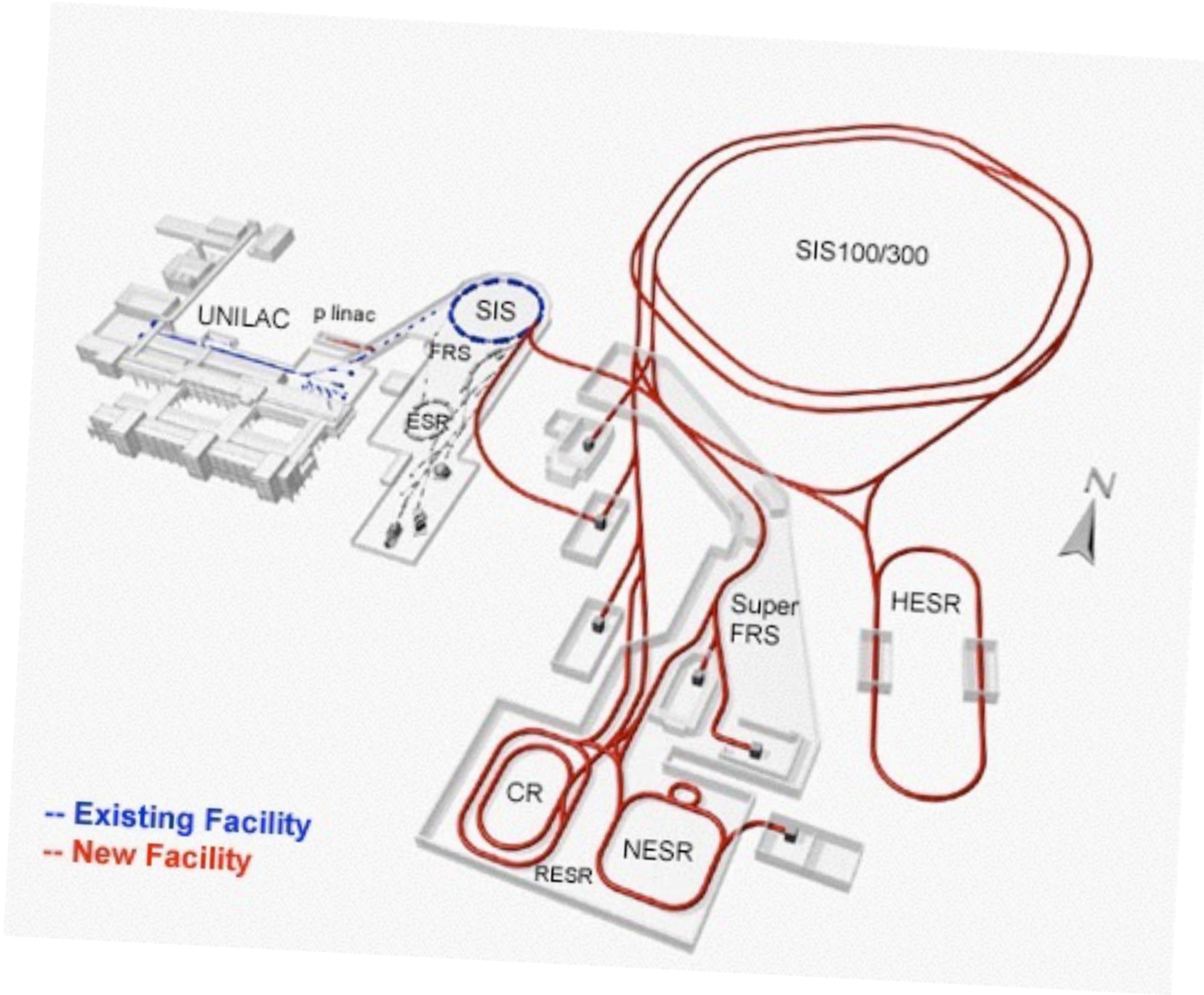
Tested at GSI

A. Blanco *et al.* , JINST 10, C02034 (2015)
J. Machado *et al.* , JINST 10, C01043 (2015)
J. Machado *et al.* , JINST 8, P07020 (2013)



$\sigma(T_{RPC}) \sim 150$ ps

FAIR



Facility for **A**ntiproton and **I**on **R**esearch

Production of **relativistic exotic beams** never studied before

Events

Ground-breaking ceremony, July 4

adopted from N. Kalantar

FAIR construction

adopted from N. Kalantar

Phase-0 @ FAIR (2018-2020)

NUSTAR: R3B

S444	SIS18	Gernhäuser, Roman	TU-München Physik-Department ZTI	Simon, Haik	R3B - 2018 COMMISSIONING (CALIFA, L3T, GLAD, NeuLAND & Tracking)	25	5	2018	A	16	19
S465	SIS18	Aumann, Thomas	TU Darmstadt Inst. für Kernphysik Schlossgartenstr. 9	Simon, Haik	Dipole response of the drip-line nuclei ^{6}He and ^{22,24}O	39	-	2018 /19	A	12	0
S442	SIS18	Sorlin, Olivier	GANIL, 15 Bd Henri	Simon, Haik	Study of multi-neutron configurations in atomic nuclei towards the drip line	22	-	2019	A	22	0
S467	SIS18	Paschalis, Stefanos	University of York, U	Simon, Haik	Single-particle structure of neutron-rich Ca isotopes: shell evolution along Z=20	14	-	2019	A	14	0
S455	SIS18	Taieb, Julien	CEA DAM IdF Bruyeres le Chatel 92297 Arpajon	Simon, Haik	Fission investigated with relativistic-radioactive beams and the advanced SOFIA@R3B setup	30	15	2018	A	21	15

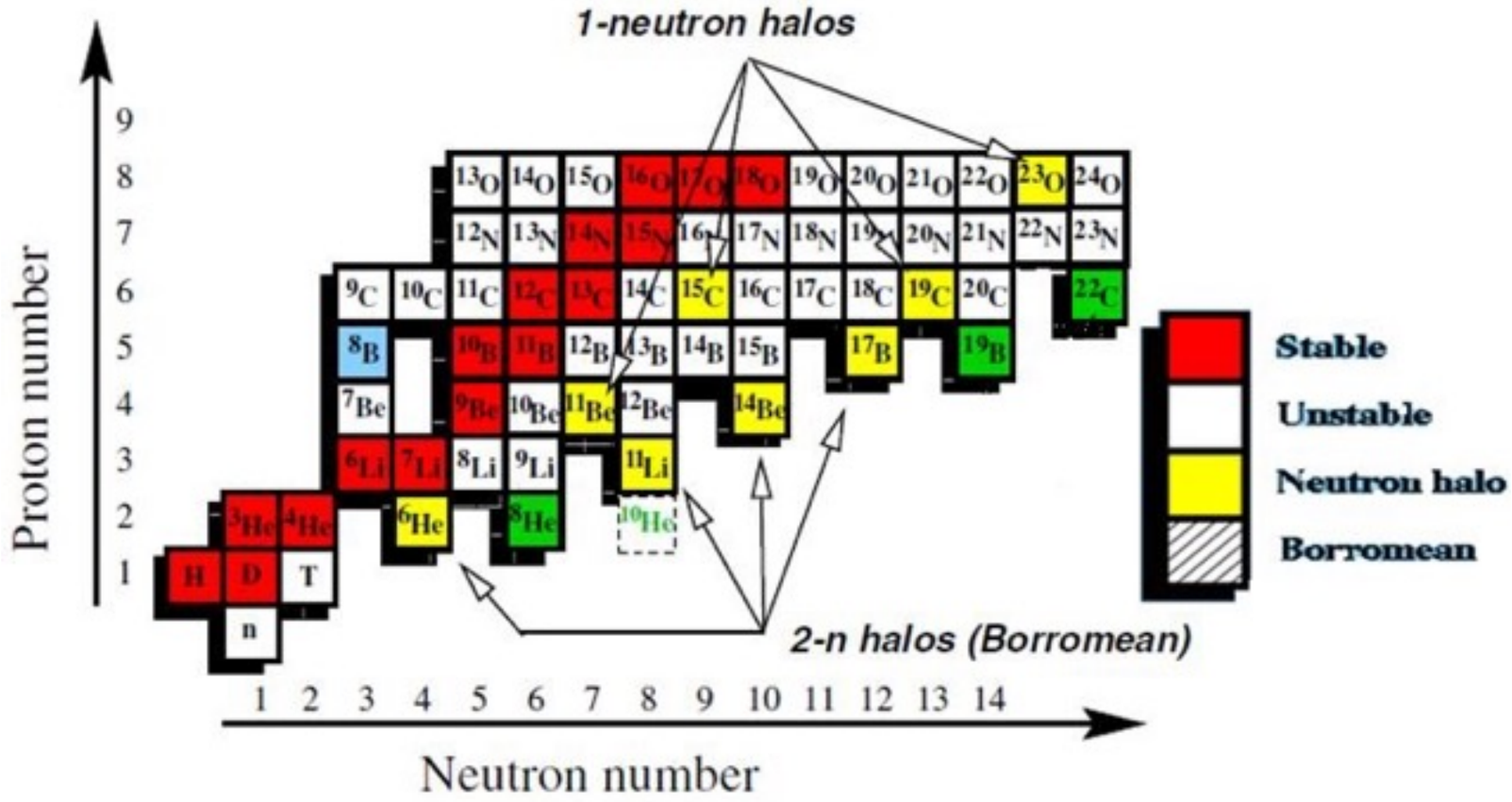
HADES

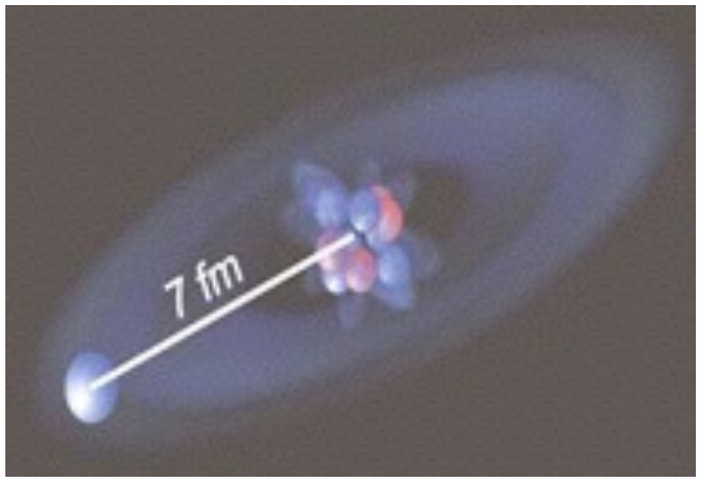
GSI

Proposal for experiments at SIS18 during FAIR Phase-0

The HADES Collaboration

Halo nuclei





^{11}Be

- **Cluster** structure + **halo** particle(s)
  - **Extended** mass distribution
- Low **separation energy** (< 1 MeV)
  - Low angular momentum state (**s-wave**)

Halo nuclei: ^{11}Be & ^{15}C

	S_n (MeV)	g.s. (J^π)	g.s. conf.
^{11}Be	0.5	$1/2^+$	$\alpha[^{10}\text{Be}(0+) \otimes 1\nu\,(2s_{1/2})] \oplus \beta[^{10}\text{Be}(2+) \otimes 1\nu\,(1d_{5/2})]$
^{15}C	1.2	$1/2^+$	$^{14}\text{C}(0+) \otimes 1\nu\,(2s_{1/2})$

^{11}Be

T. Aumann *et al.*, Phys. Rev. Lett. **84**, 35(2000)

J. A. Tostevin *et al.*, Phys. Rev. C **66**, 024607 (2002)

N. Fukuda *et al.*, Phys. Rev. C **70**, 054606 (2003)

^{15}C

J. A. Tostevin *et al.*, Phys. Rev. C **66**, 024607 (2002)

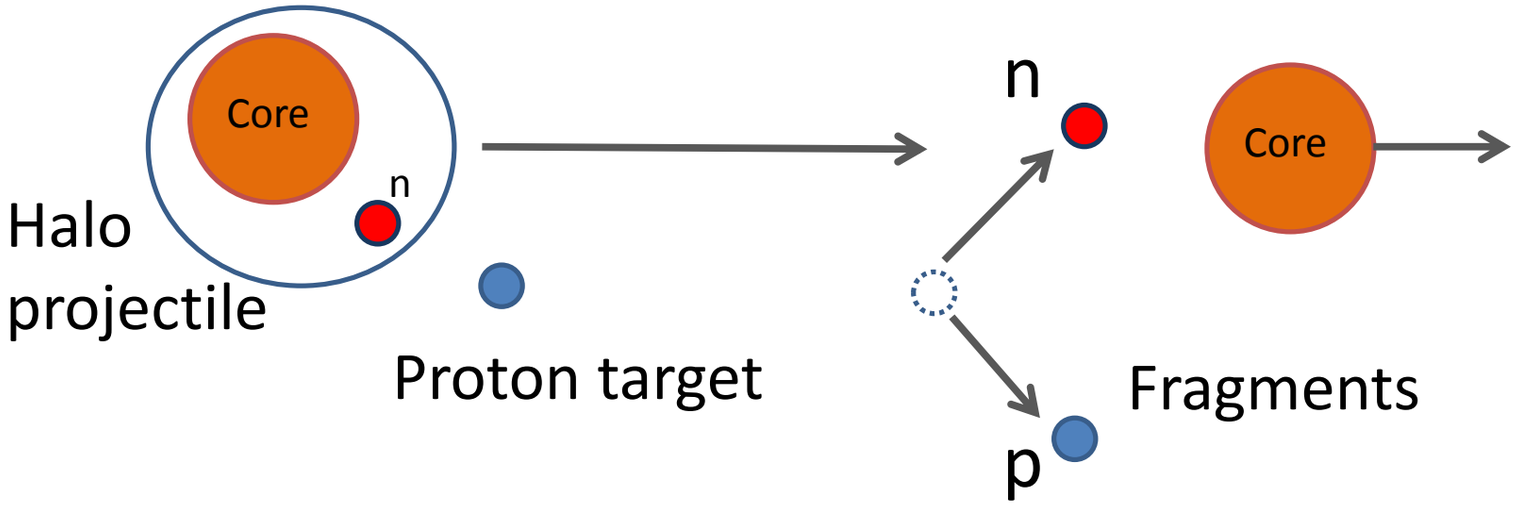
U. Datta Pramanik *et al.*, Phys. Lett. B **551**, 63 (2003)

T. Nakamura *et al.*, Phys. Rev. C **79**, 035805 (2009)

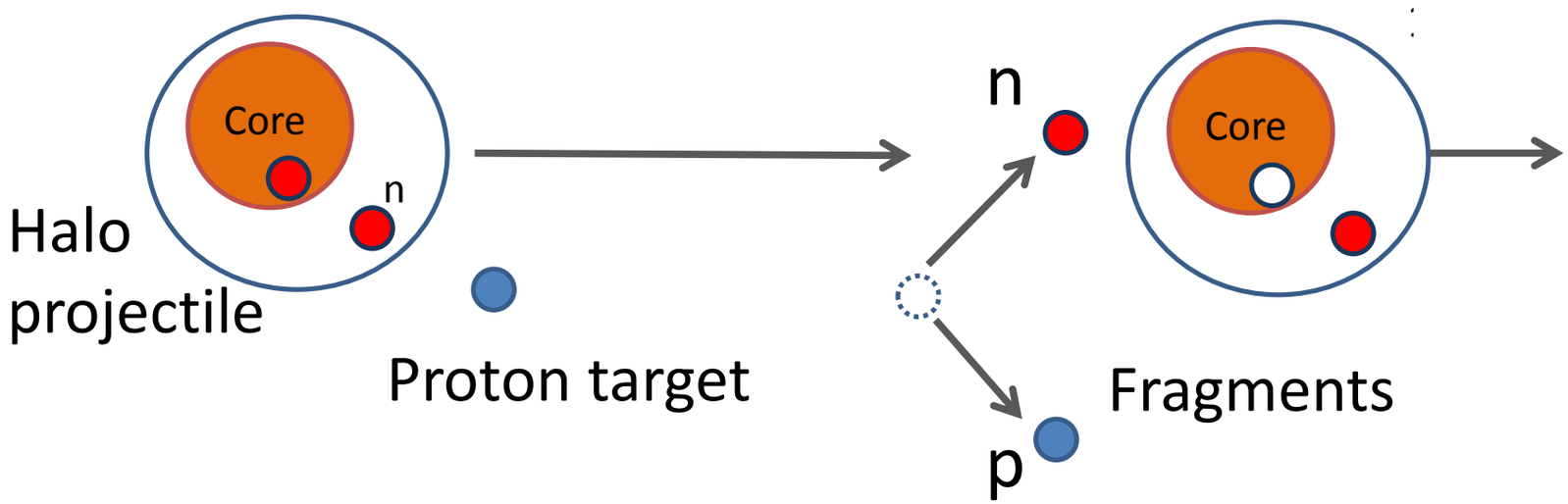
Suitable cases for the verification of the **reaction mechanism** studying its **break-up** on a **proton** target at **relativistic energies**

Nucleon knock-out contributions

Valence knock-out

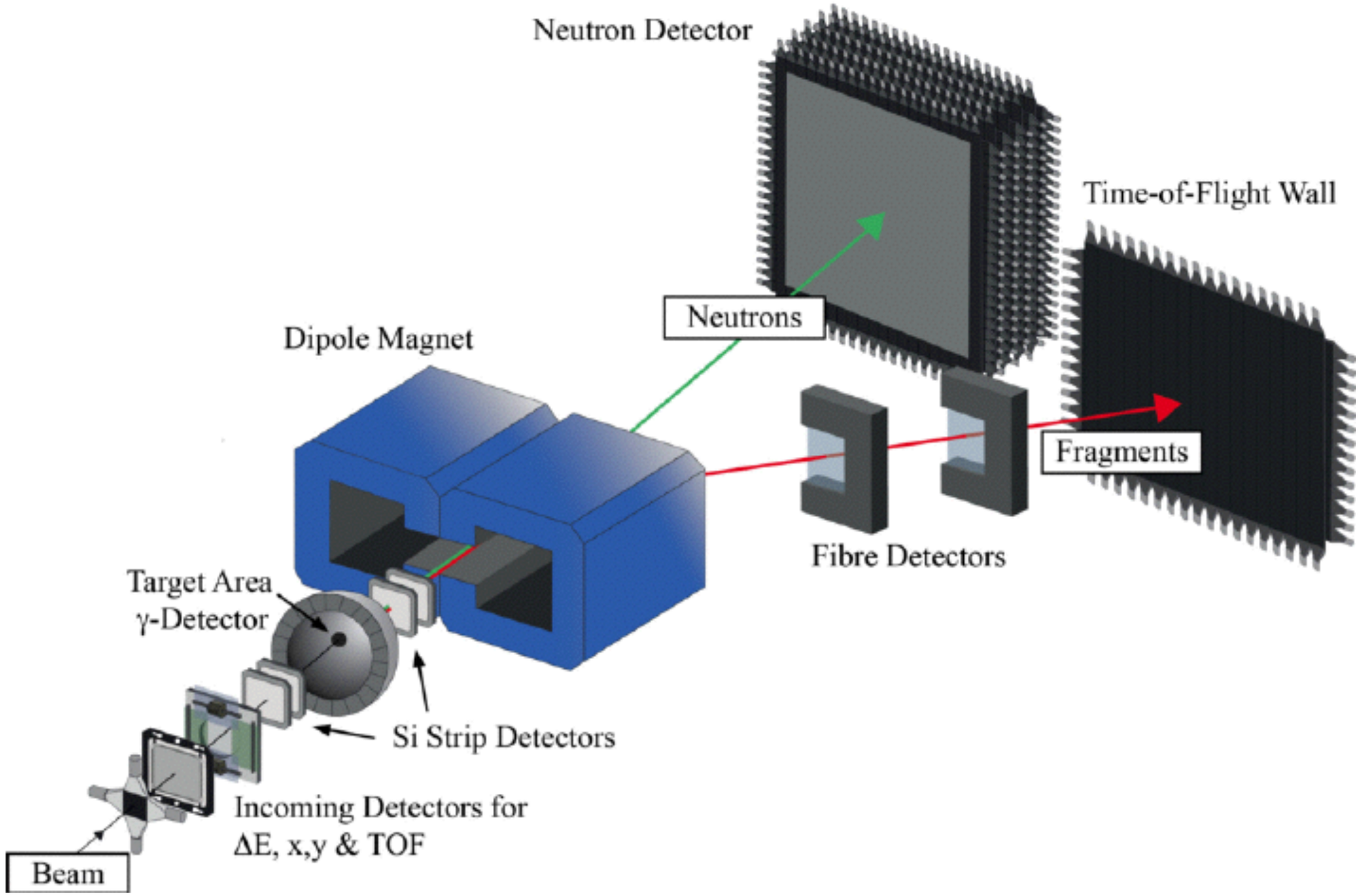


Inner shell knock-out

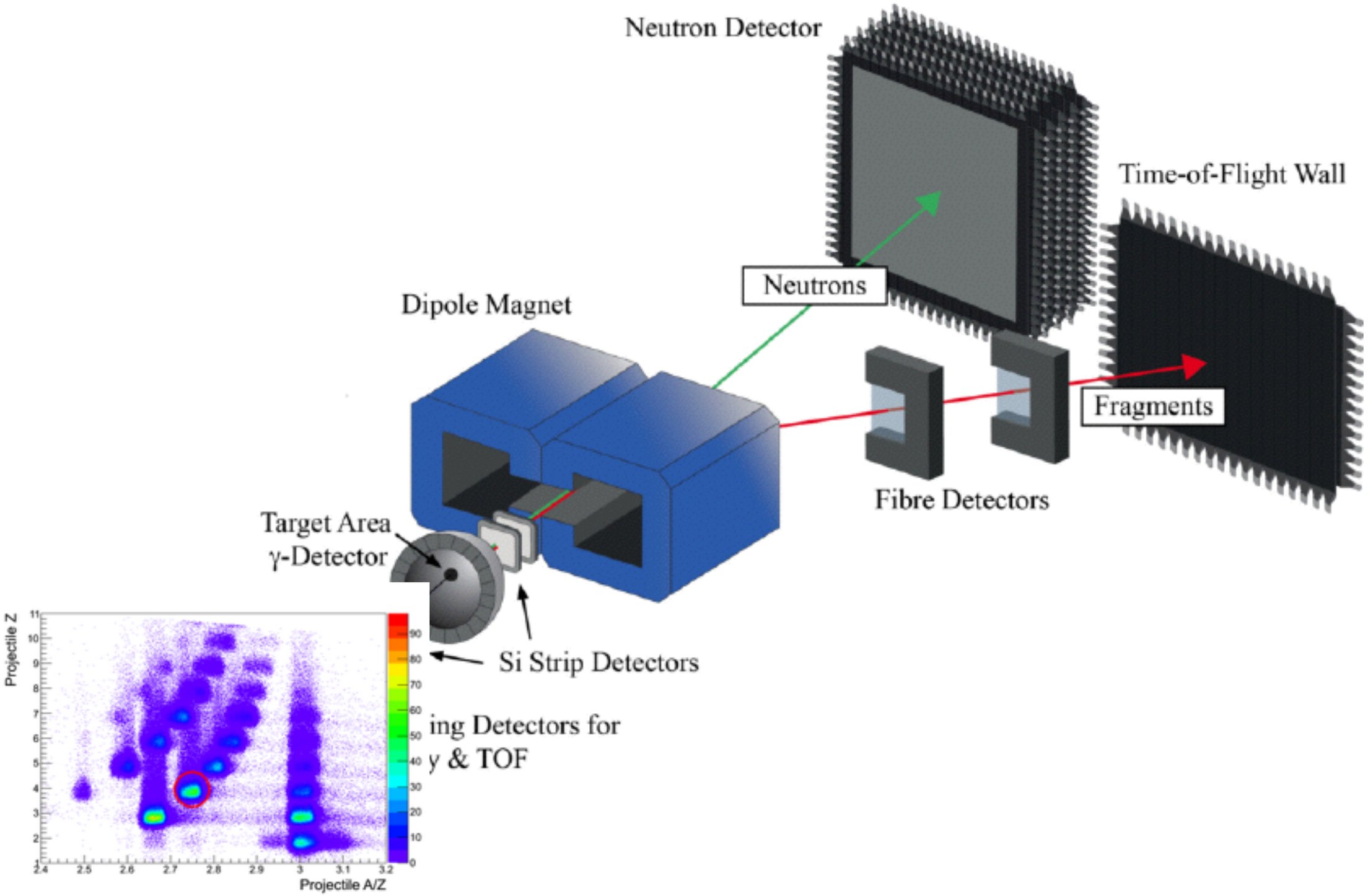


1

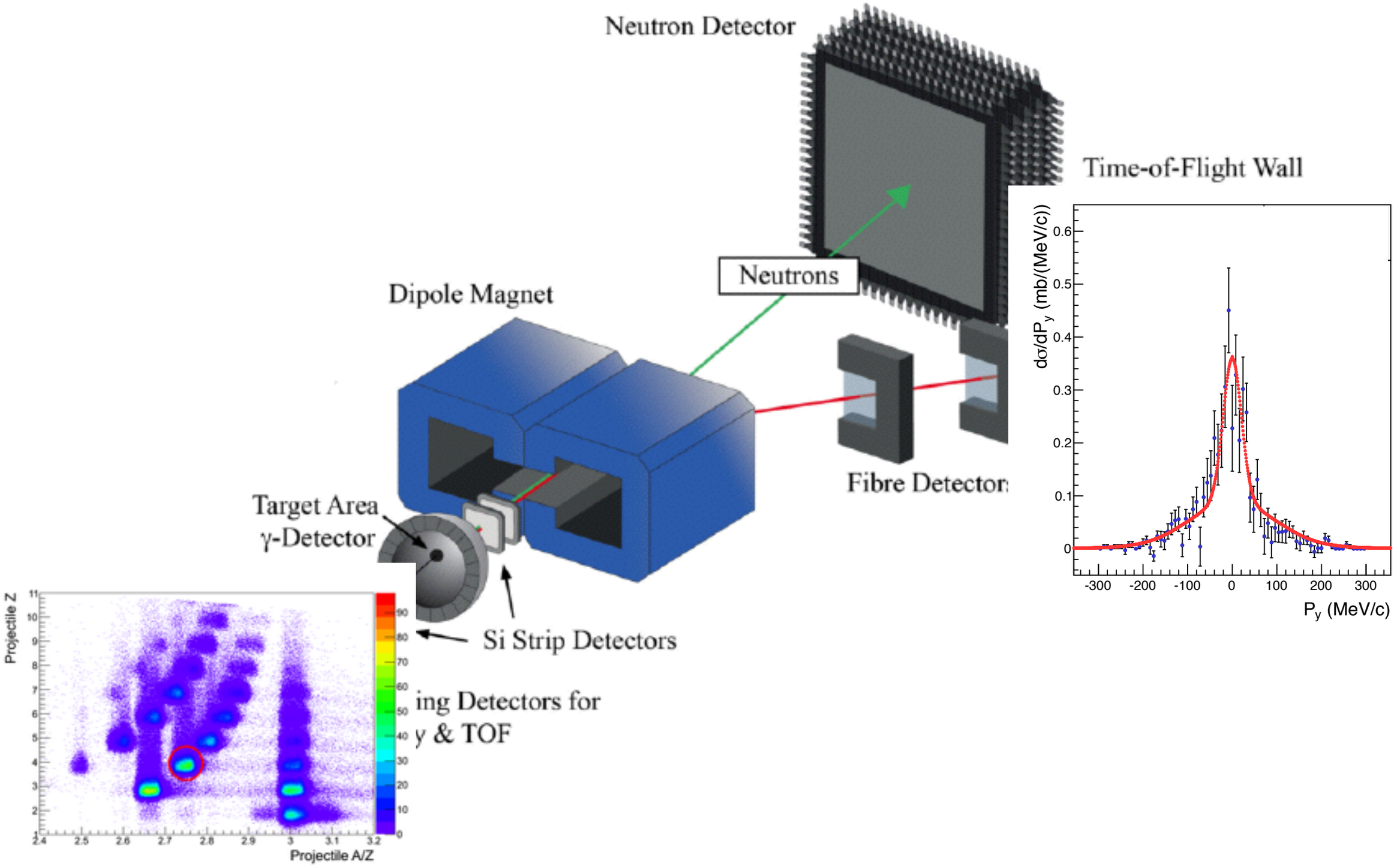
S393 Experiment @ GSI



S393 Experiment @ GSI

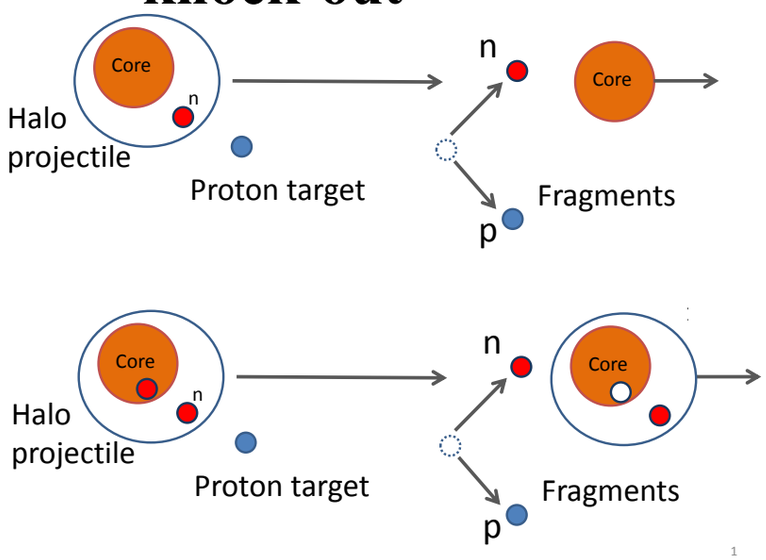


S393 Experiment @ GSI

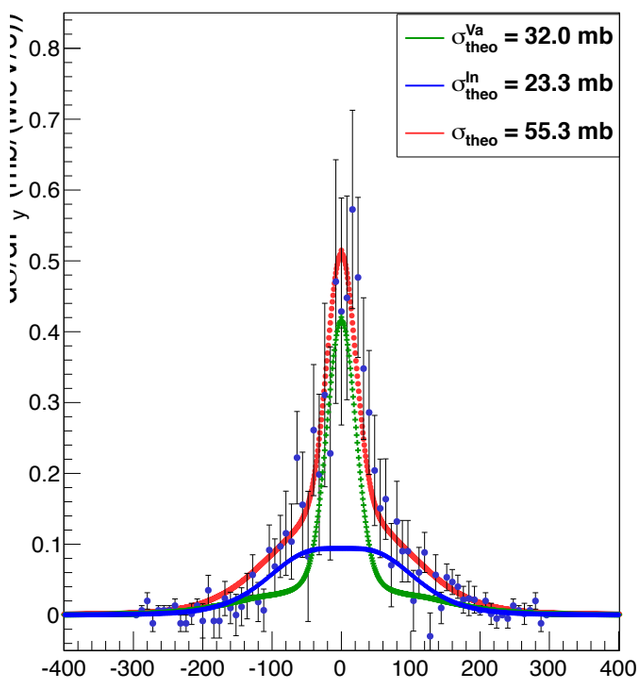


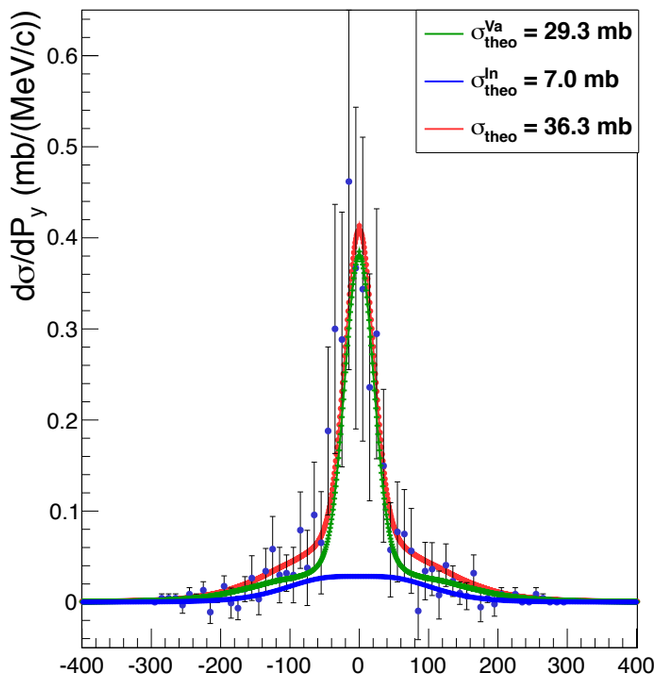
^{11}Be(p,pn)^{10}Be

Valence knock-out



Inner shell knock-out





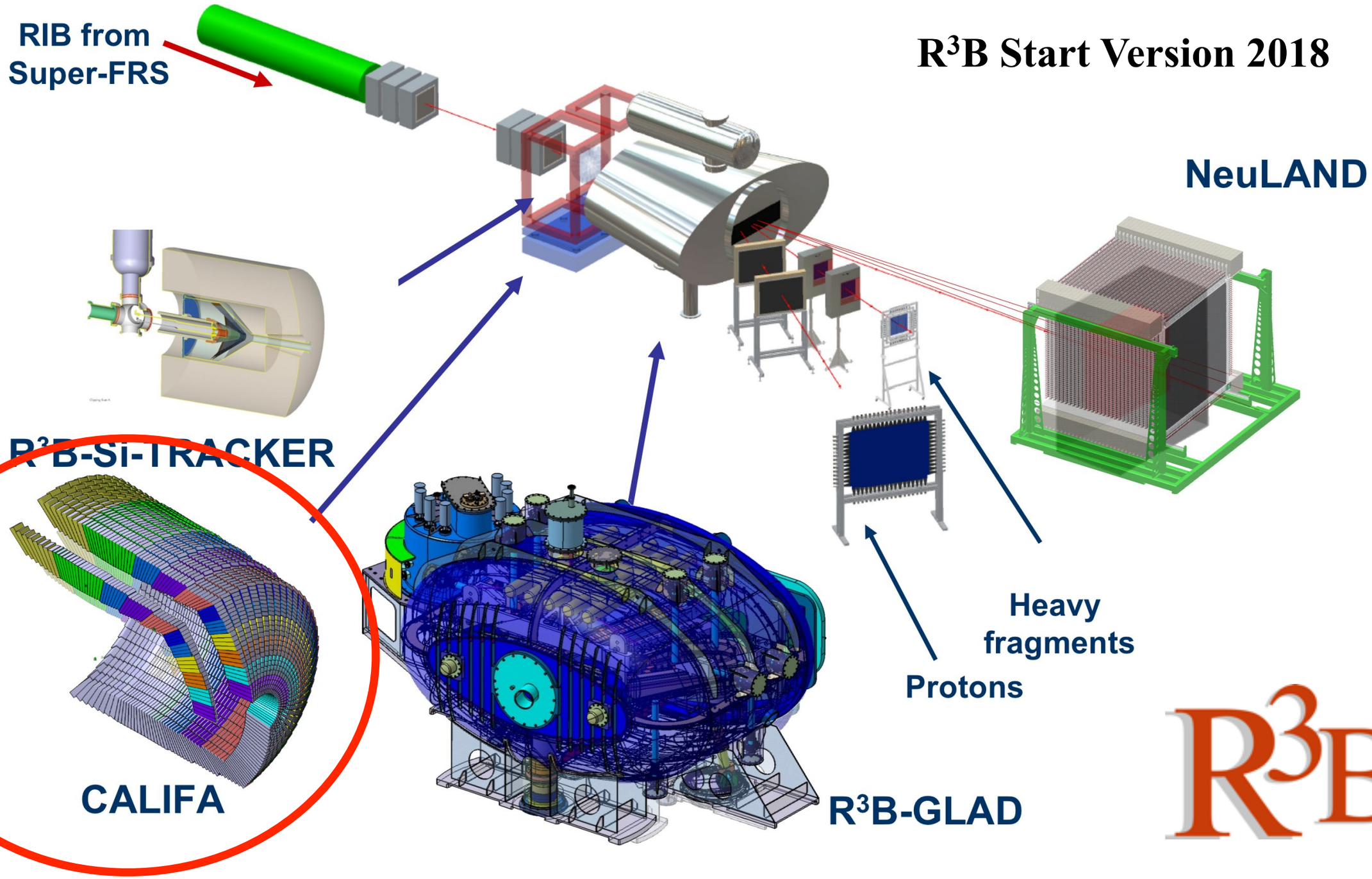
Theoretical analysis by R. Crespo *et al.*

	Cross Section (mb)	
	p.Inclusive	p.Exclusive
a · σ^{theo}_{sp}(**valence**)	**32** (58%)	**29** (81%)
b · σ^{theo}_{sp}(**inner**)	**23** (42%)	**7** (19%)
Total^{theo}	55	36
Total^{exp}	**52±5**	**37±15**

Analysis by A. Henriques

R^3B @ FAIR

Reactions with Relativistic Radioactive Beams

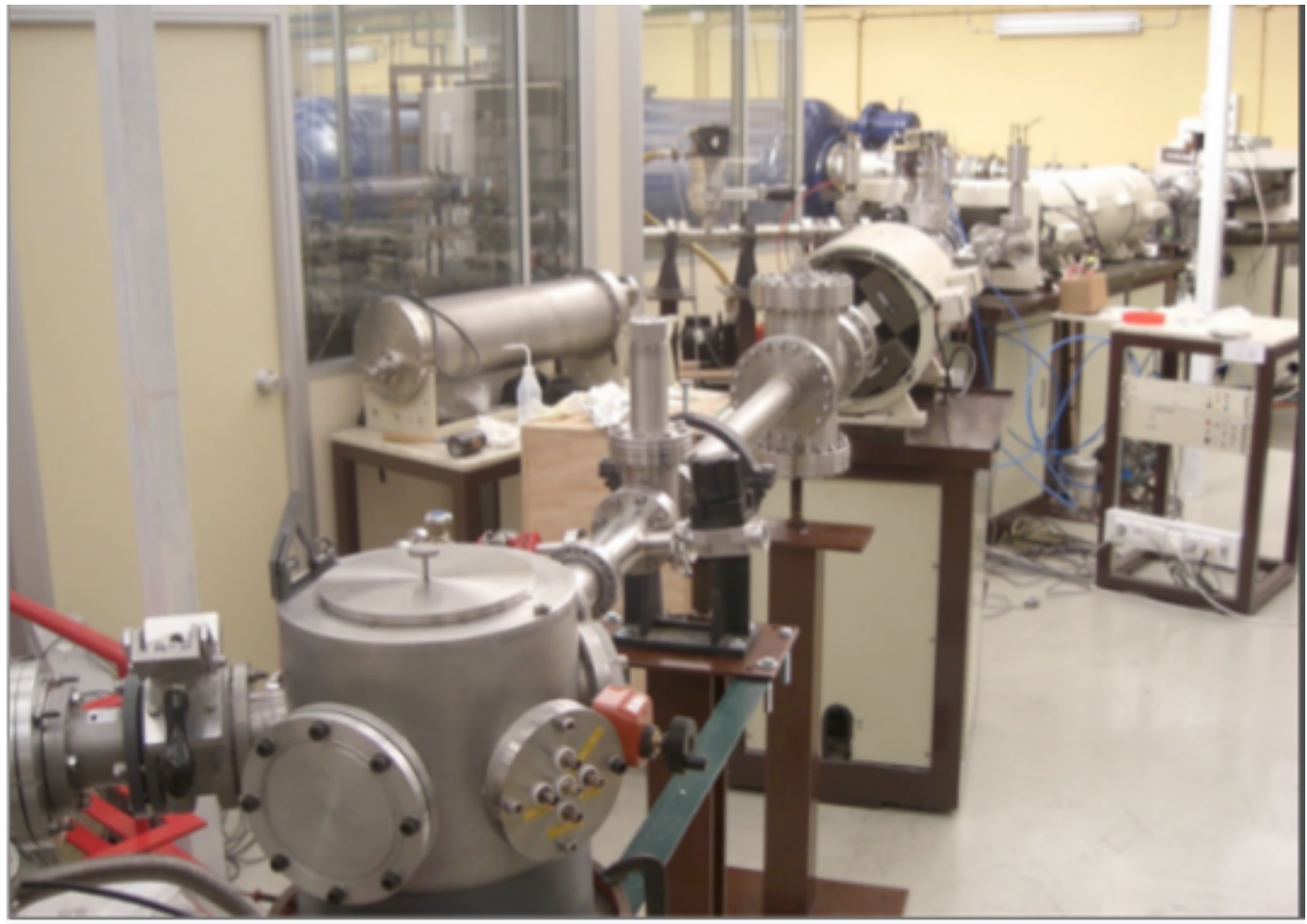


CALIFA Benchmark @ Lisbon

PIGE reaction

$^{27}Al(p,\gamma)^{28}Si$

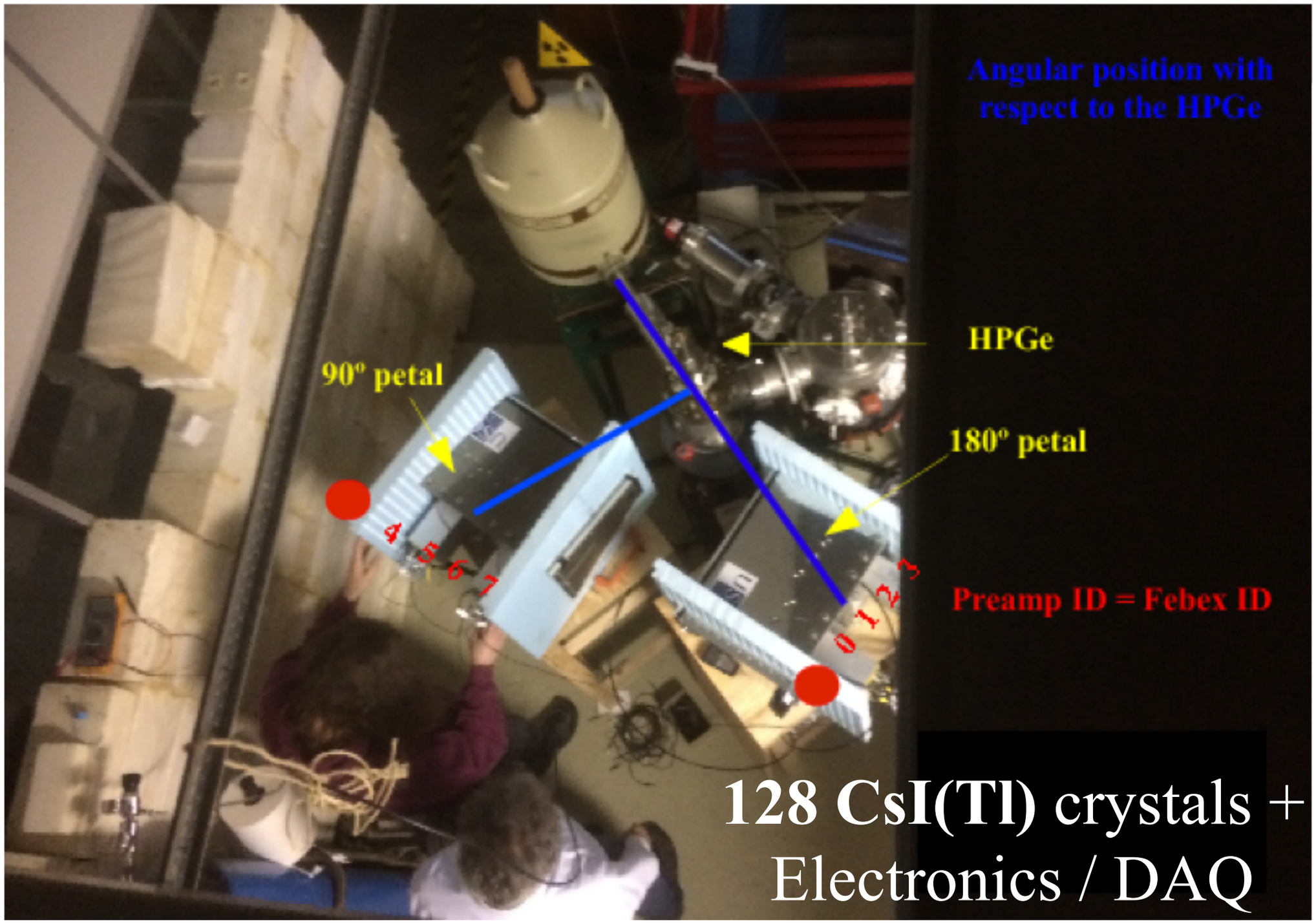
to produce $\gamma > 10$ MeV
to challenge **CALIFA prototype**



Nuclear reaction line @ tandem accelerator at LATR-CTN

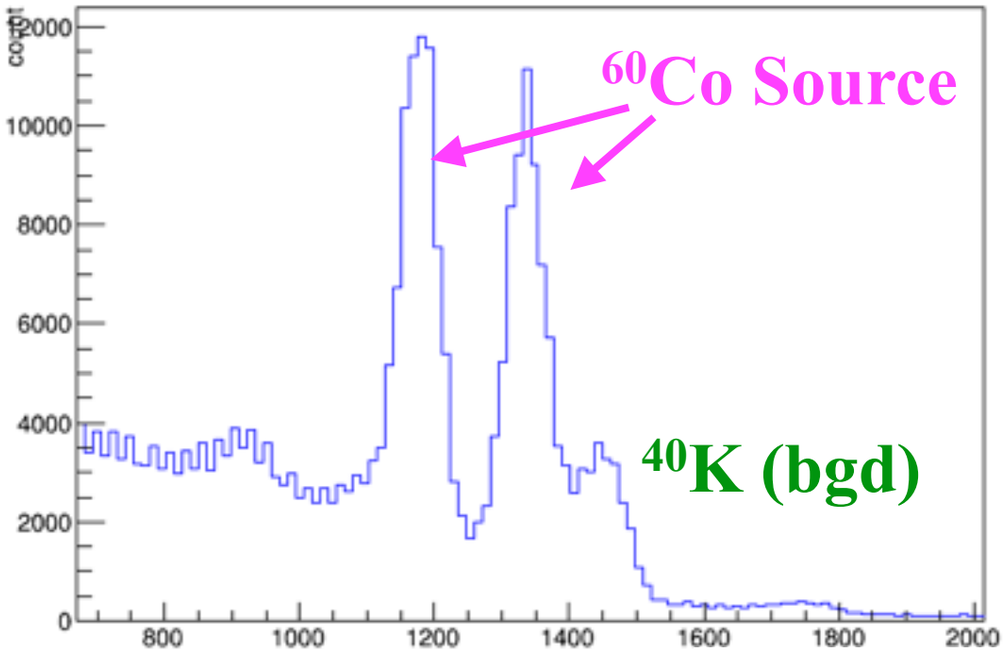
More Information under
http://www.ctn.tecnico.ulisboa.pt

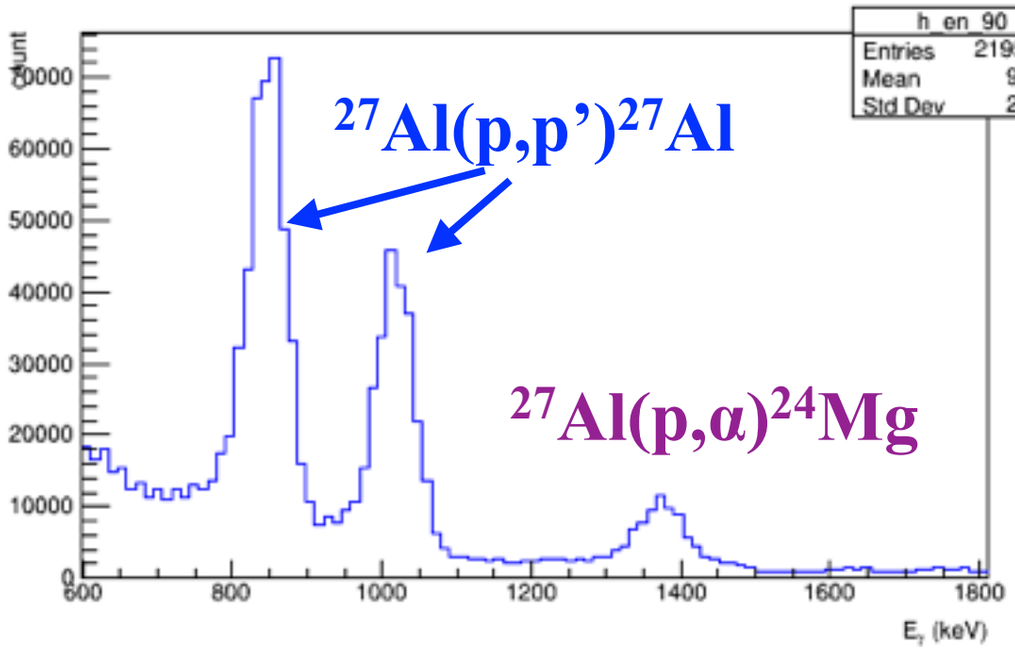
CALIFA Benchmark @ Lisbon

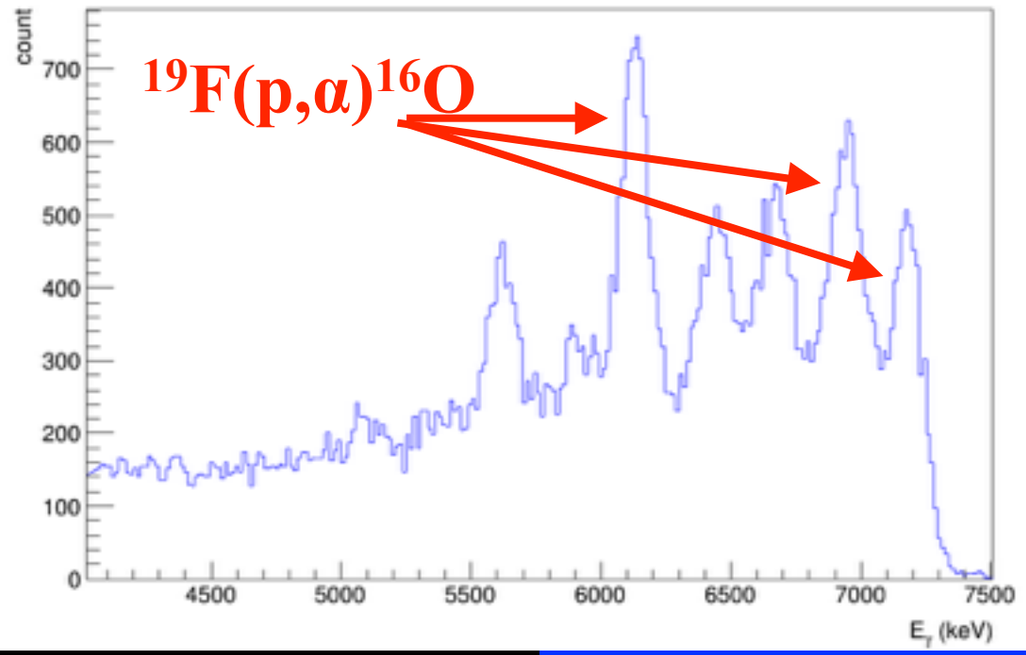


CALIFA Benchmark @ Lisbon

Individual Crystal response

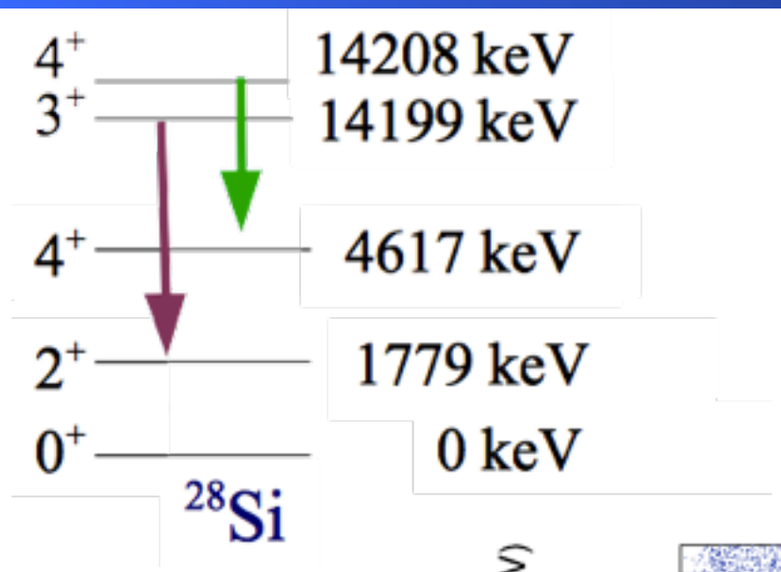




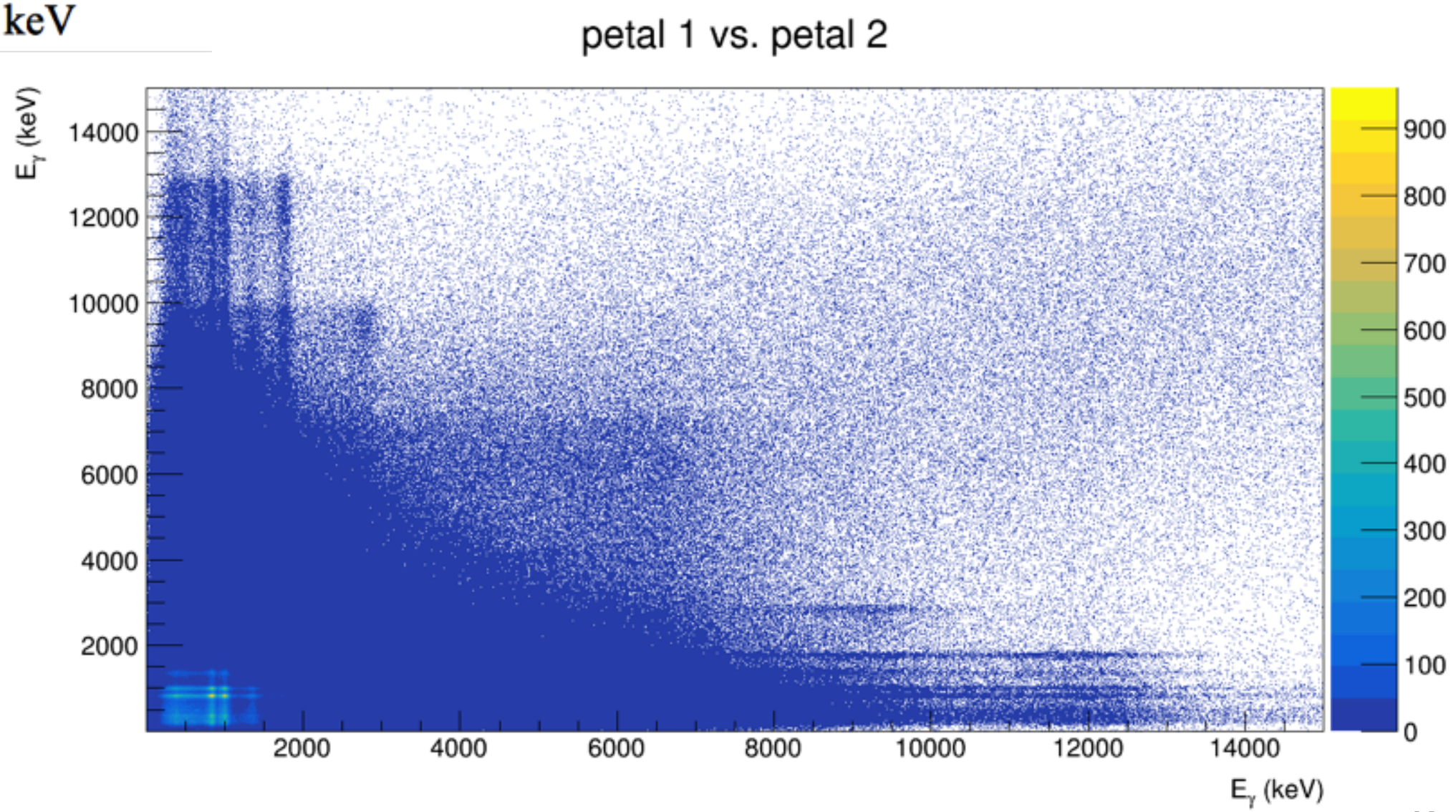


Analysis by P. Teubig

CALIFA Benchmark @ Lisbon

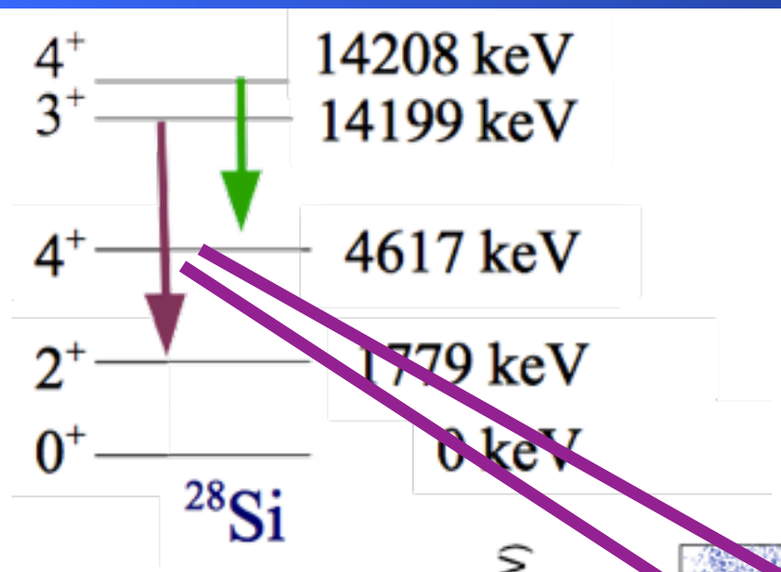


Populating the **14199 & 14208 keV** resonances of ^{28}Si



Analysis by P. Teubig

CALIFA Benchmark @ Lisbon



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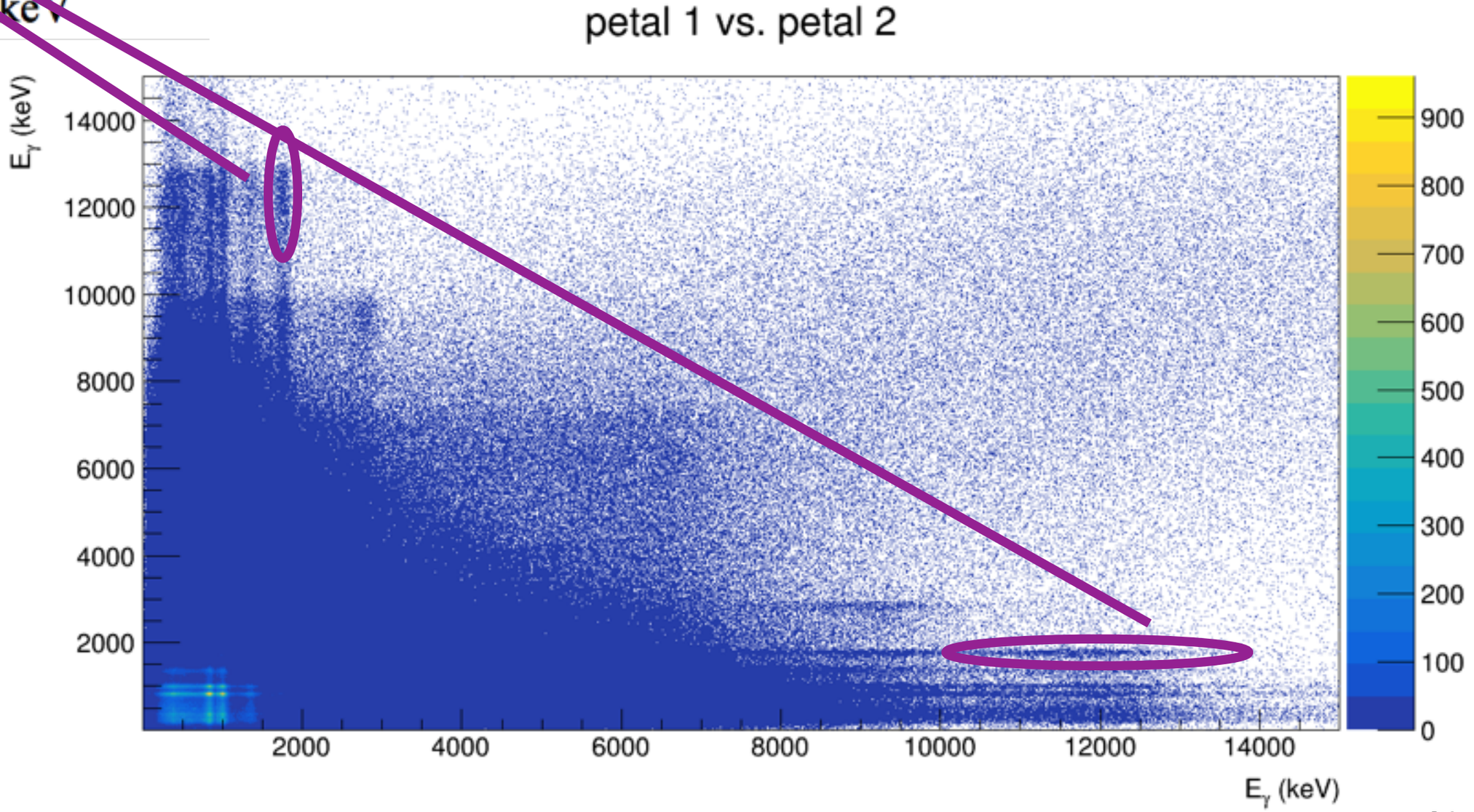
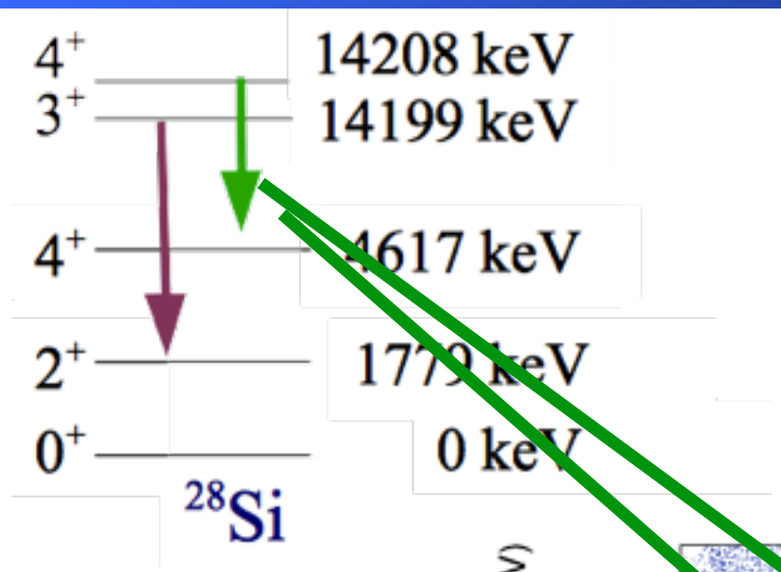
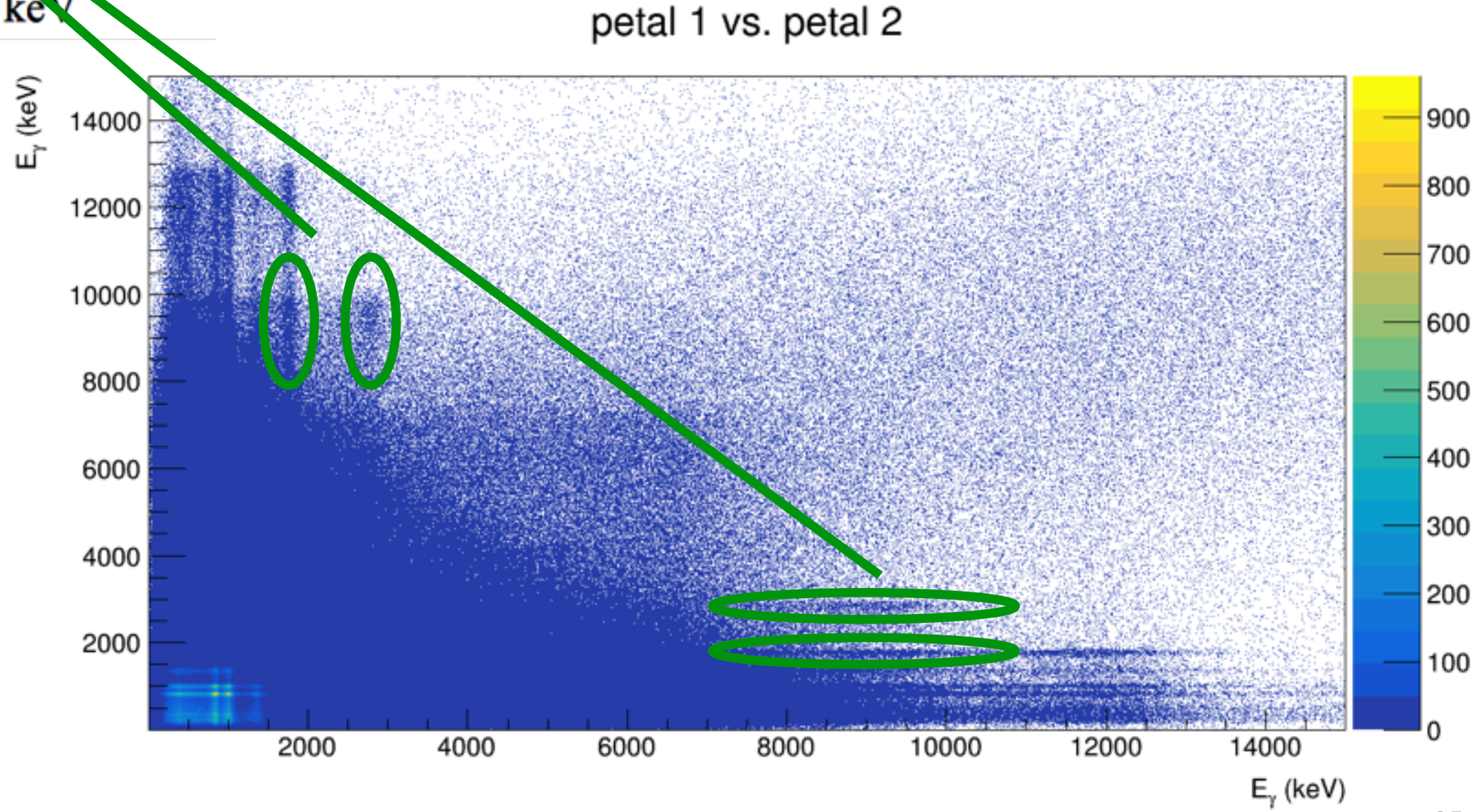


Analysis by P. Teubig

CALIFA Benchmark @ Lisbon



Populating the **14199 & 14208 keV** resonances of ^{28}Si



Analysis by P. Teubig

Summary

- Introduction to the **LERHI** research line
- Past **joint efforts** and **future perspectives** (Phase-0 @ FAIR)
- Study of **nuclear halos** via **knock-out** reactions
- Benchmark of **CALIFA** prototypes with **high-energy photons**