LABORATÓRIO DE INSTRUMENTAÇÃO
E FÍSICA EXPERIMENTAL DE PARTÍCULAS
partículas e tecnologia

NUC-RIA

(a success story in Pandemic times)

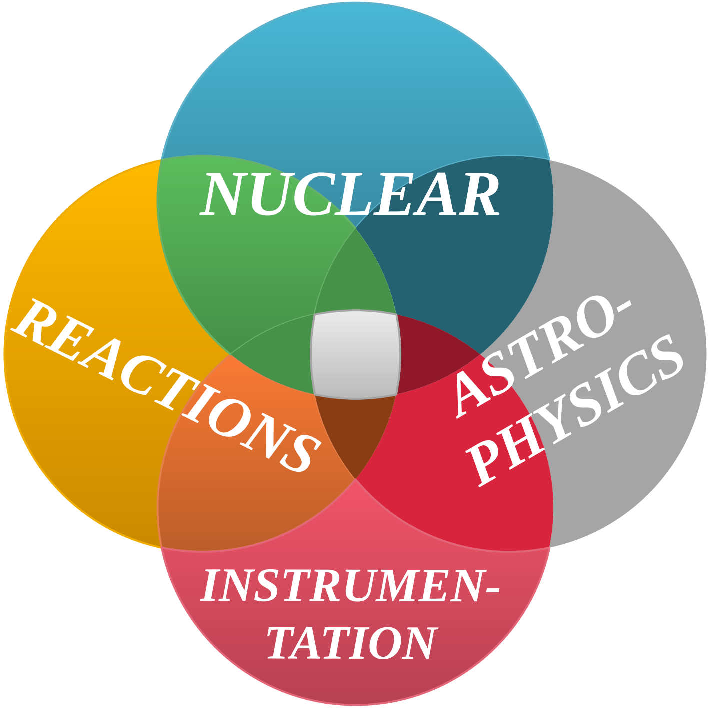
D. Galaviz

Jornadas LIP

Coimbra, July 9th 2022

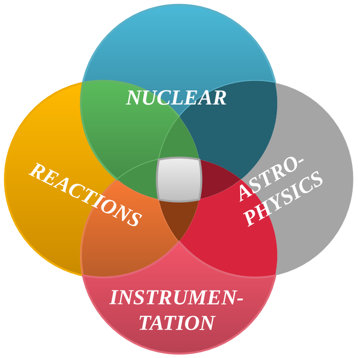
Outline

NUC-RIA



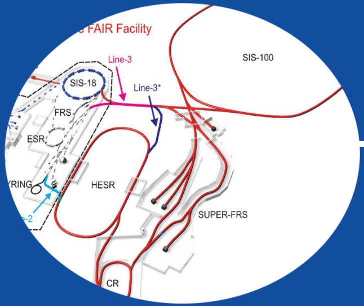
Outline

- Nuclear *Reactions* @ Relativistic Energies: ***R^3B***
- Nuclear *Reactions* @ Low Energies:
  - ***ISOLDE/CERN***
  - ***CTN***
- Nuclear *Astrophysics*
- Nuclear *Instrumentation*: ***Target Laboratory***
- *People & Synergies*



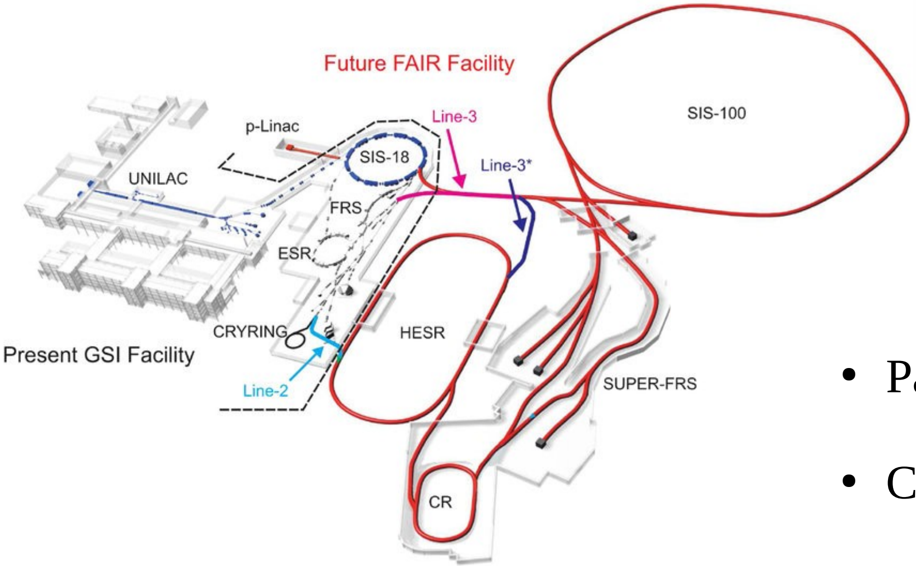
Nuclear Reactions

at Relativistic Energies

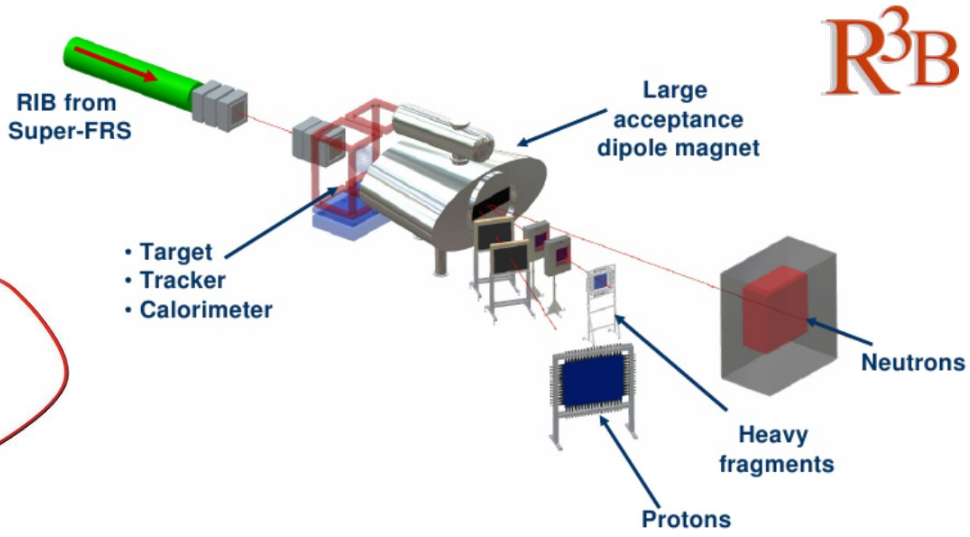


R^{3}B

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

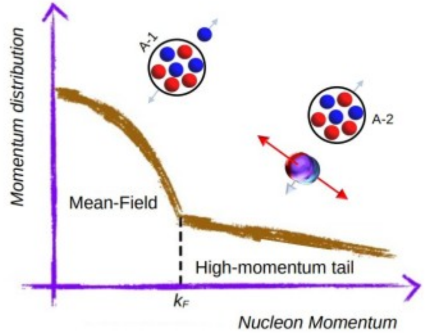


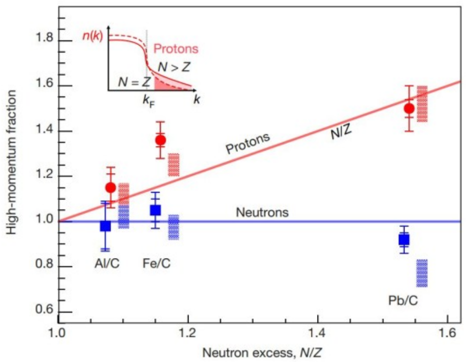
Reactions with **R**elativistic **R**adioactive **B**eams



- Participation since more than **10 years**
- Contributions to **CALIFA** and **NeuLAND**

SRCs @ R³B





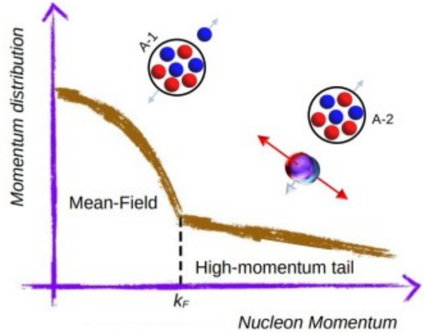
Nucleon-nucleon Short Range Correlations

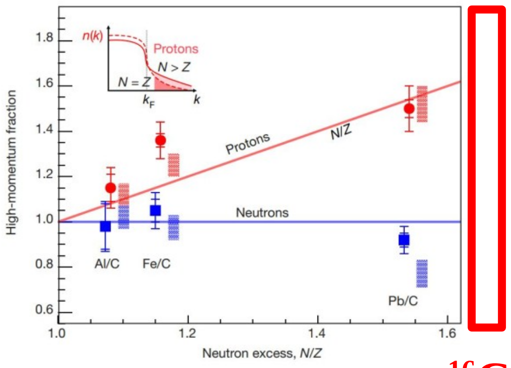
- **High** relative **momentum**
- **Low center-of-mass** momentum
- Fraction of high momentum nucleons: **20%**

- Observed in **inelastic (e,e') scattering** (CLAS)
- Confirmed in **inverse** kinematics **(p,2p)**

- Experiments limited to **stable nuclei**

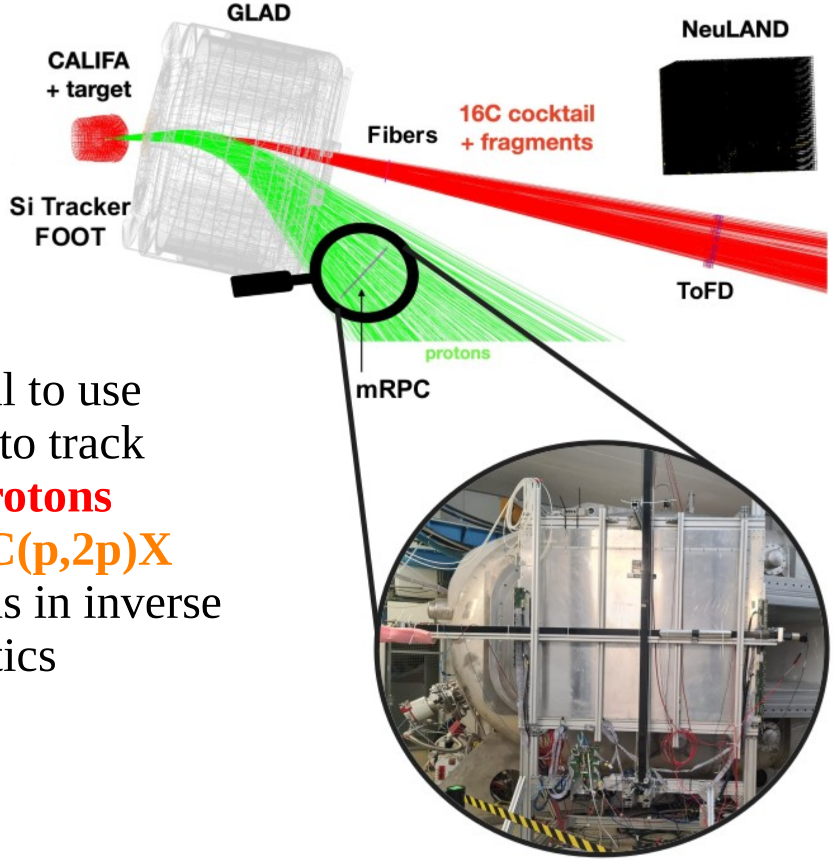
SRCs @ R³B



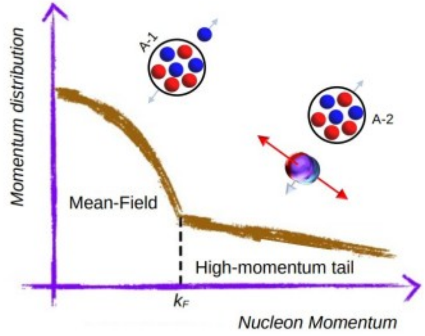


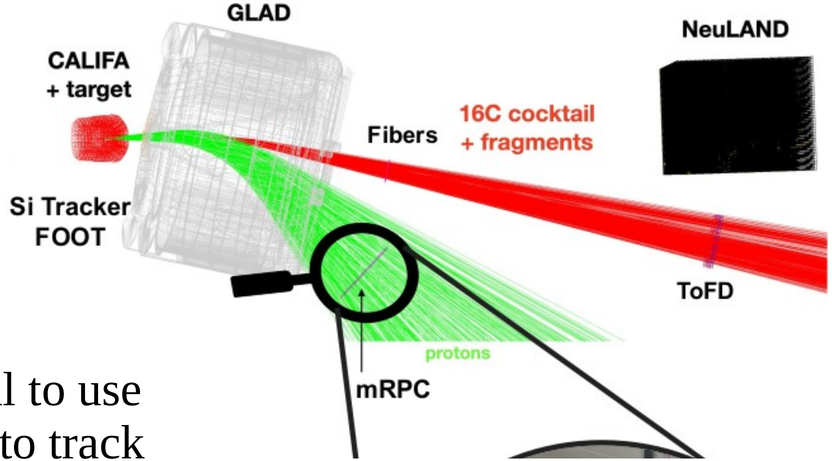
^{16}C

- Proposal to use **mRPC** to track **SRC protons** from **^{16}C(p,2p)X** reactions in inverse kinematics



SRCs @ R³B





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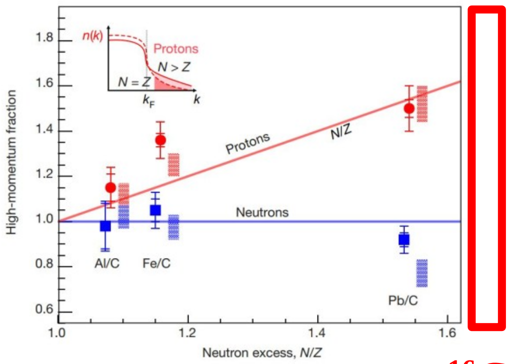
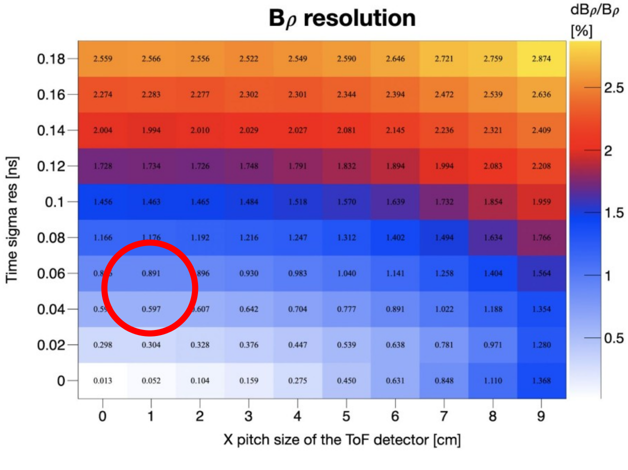


^{16}C

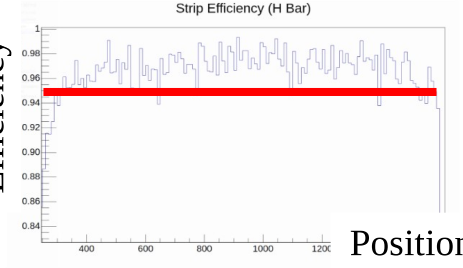
- Proton momentum resolution **below 1%**



R^{3}B (future)

- **Excellent performance** in two experiments of the **FAIR-Phase0**

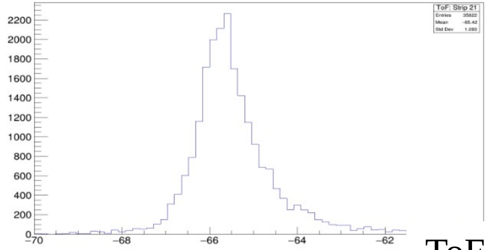
Efficiency



95%

Position (mm)

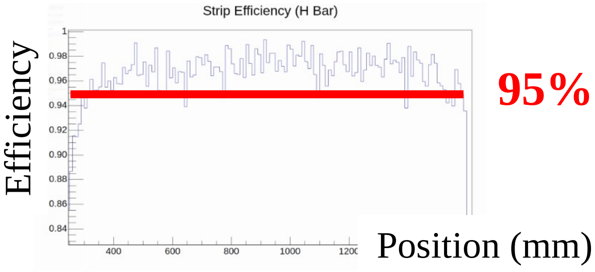
Counts

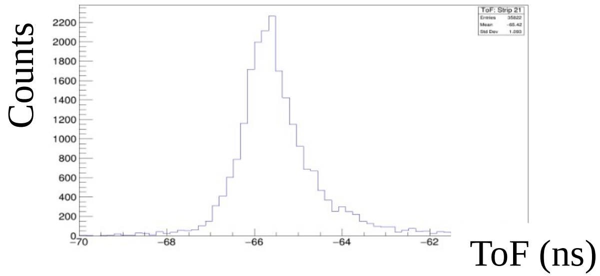


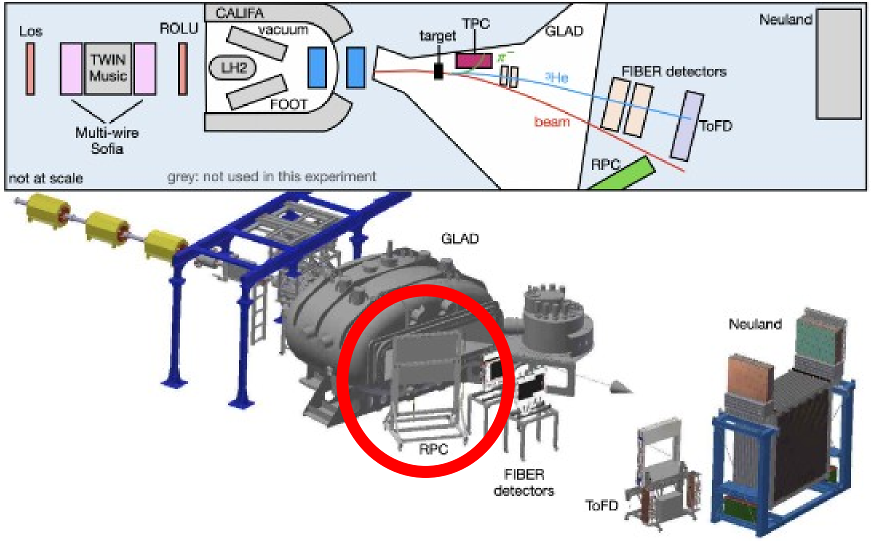
ToF (ns)

R^{3}B (future)

- **Excellent performance** in two experiments of the **FAIR-Phase0**



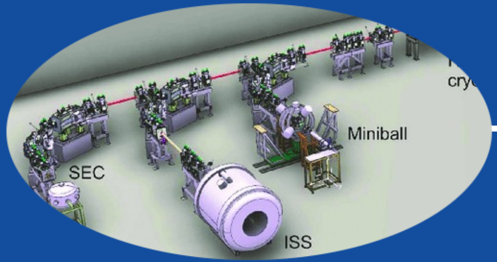




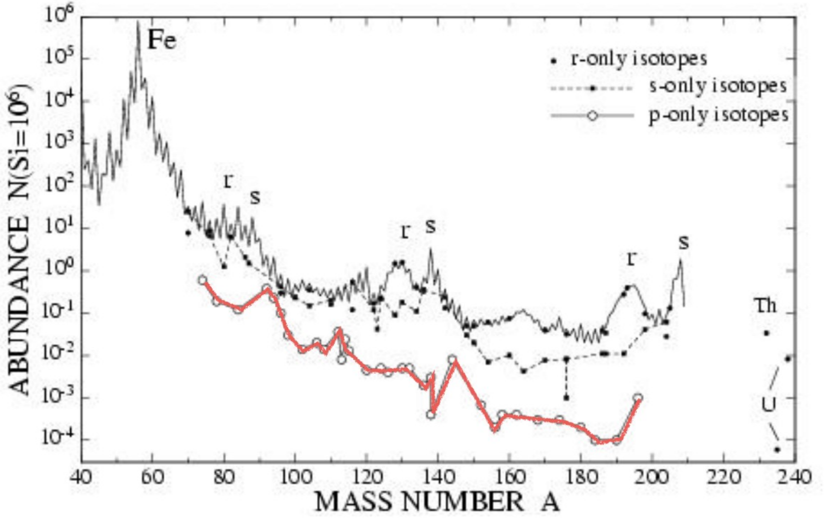
- mRPC considered as part of the **standard R^{3}B** setup for upcoming **2023-2024 campaigns**
- Considering creation of **PAS-ToF Working Group** for future detector

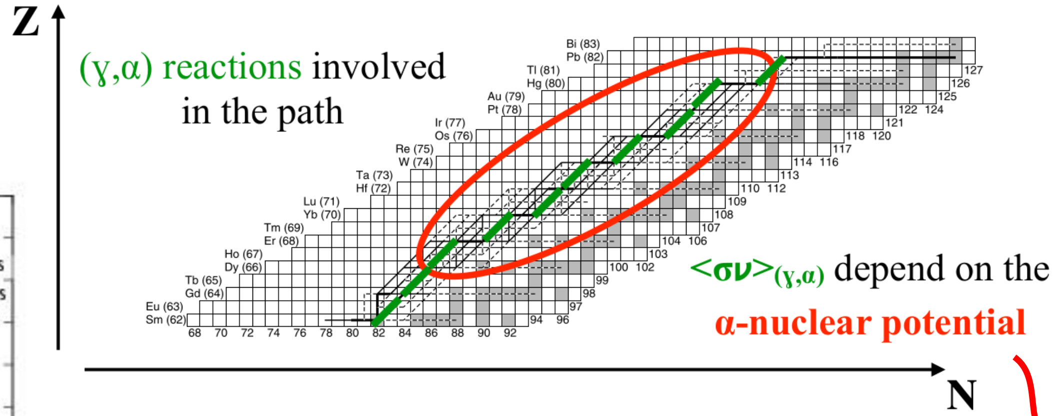
Nuclear Reactions

for Nuclear Astrophysics

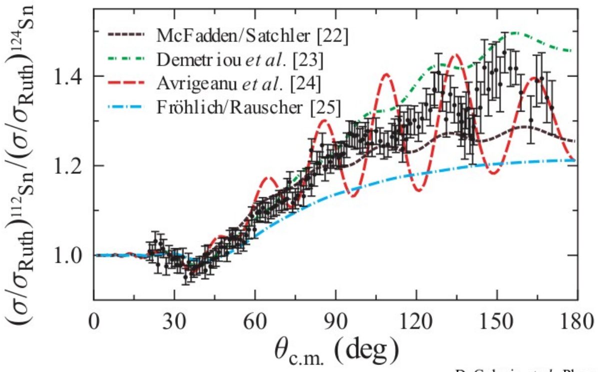


Astrophysical *p*-process





W. J. Rapp *et al.*, Astrophys. J 653, 474 (2006)

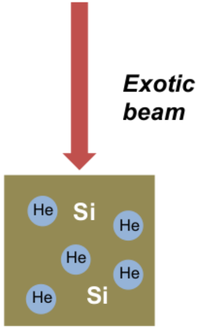


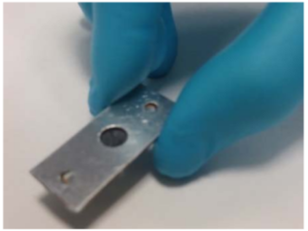
D. Galaviz *et al.*, Phys. Rev. C 71, 065802 (2005)

Uncertainties in extrapolation

ISOLDE

Target developments in **Seville**

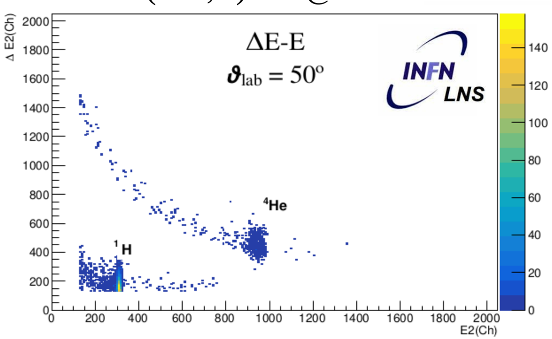




Self-supported Si:He target

Allowed experiment in **inverse kinematics**

$^{4}He(^{58}Ni,\alpha)^{58}Ni$ @ 150 MeV



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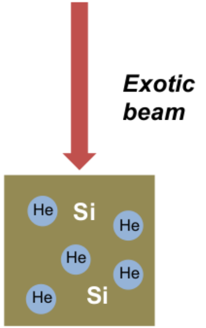

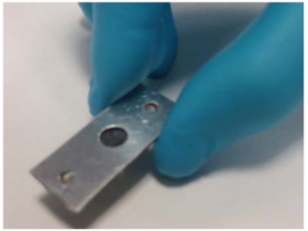

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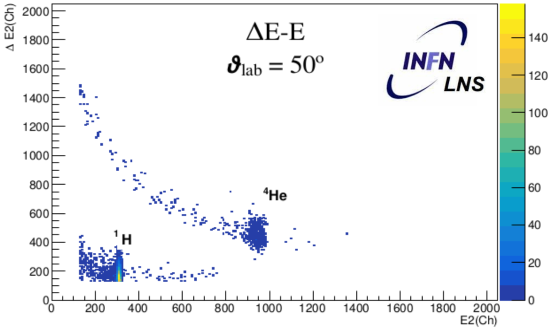
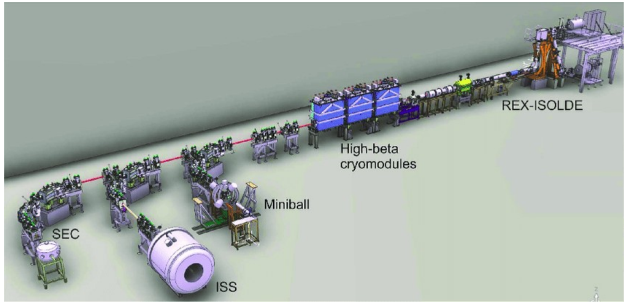


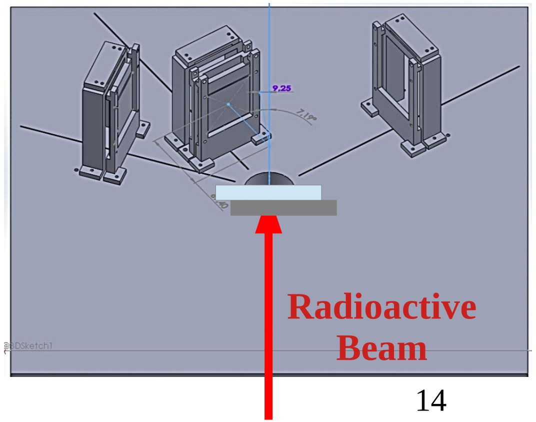
Proposal of **experiment**, leaded by LIP team, of experiment on **exotic Sn** isotopes at **HIE-ISOLDE**



Proposal **approved** by INTC

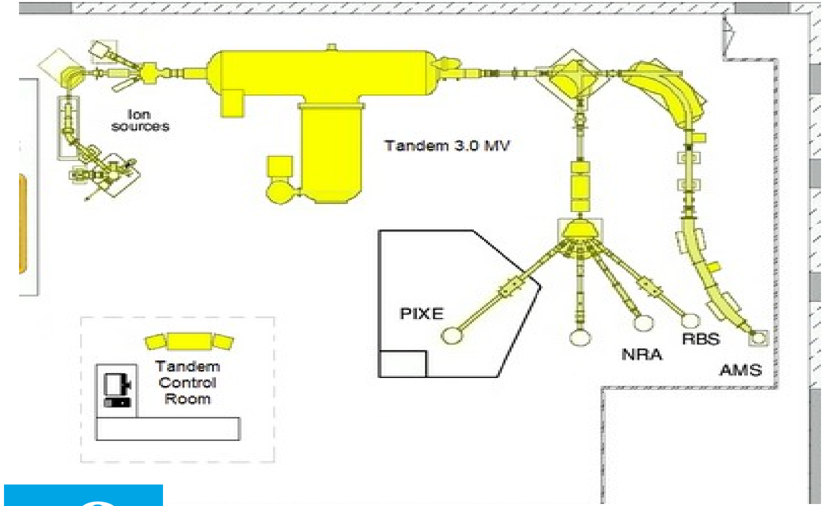
IS698 experiment currently **under preparation**

Francisco Barba



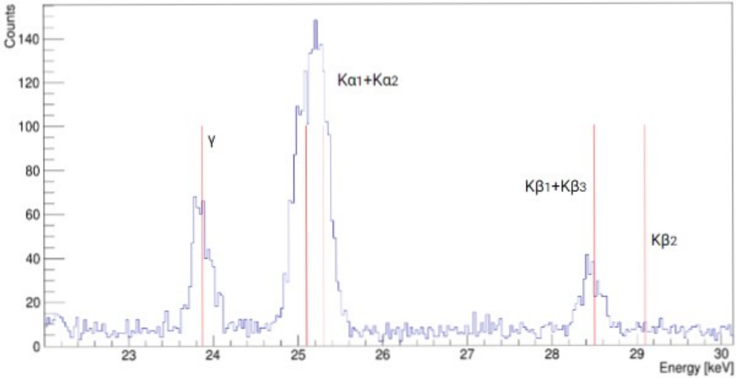
CTN

Low energy beams → Ideal for **Nuclear Astrophysics**



First (p,γ)
cross section measurement using **X-rays**

$^{nat}Sn(p,\gamma)Sb$



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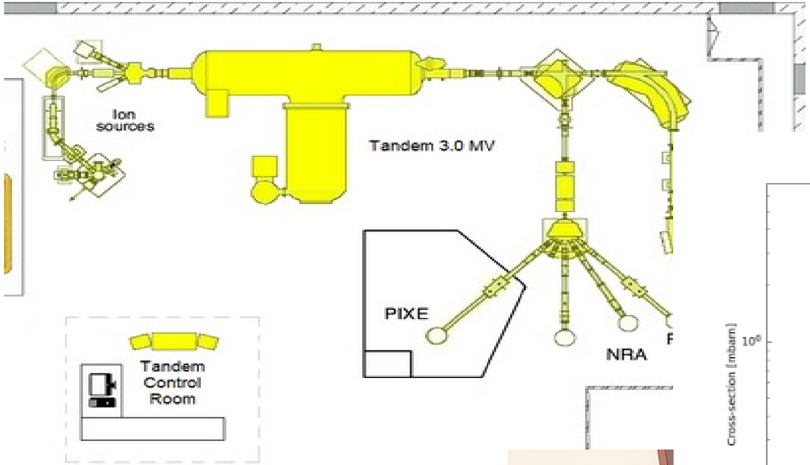

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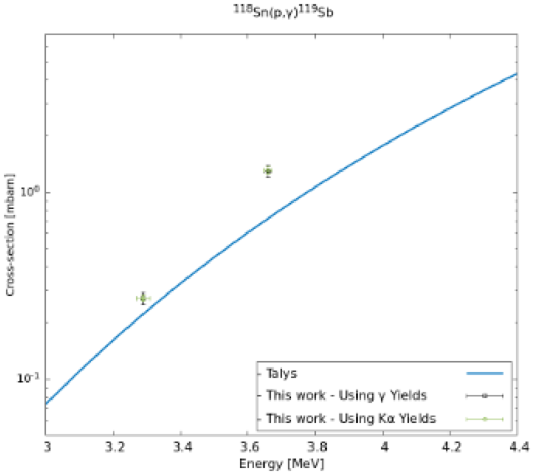
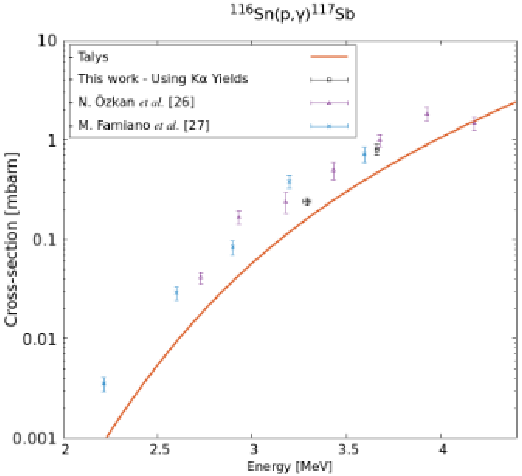
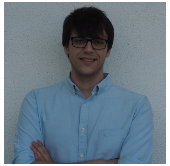






Manuel Xarepe

Ricardo Pires

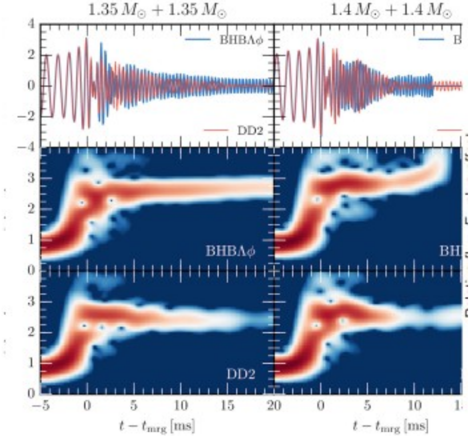
Margarida Paulino

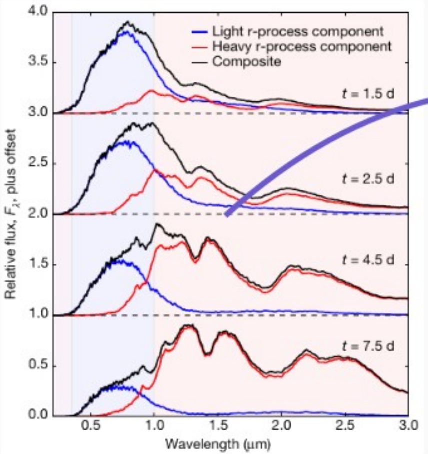
Local **training** prior to participation at **larger scale** facilities

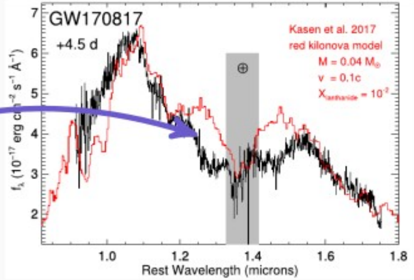
Modelling

for Nuclear Astrophysics

Kilonova







Heavy r-process models (lanthanides) close to match observations

Opacity

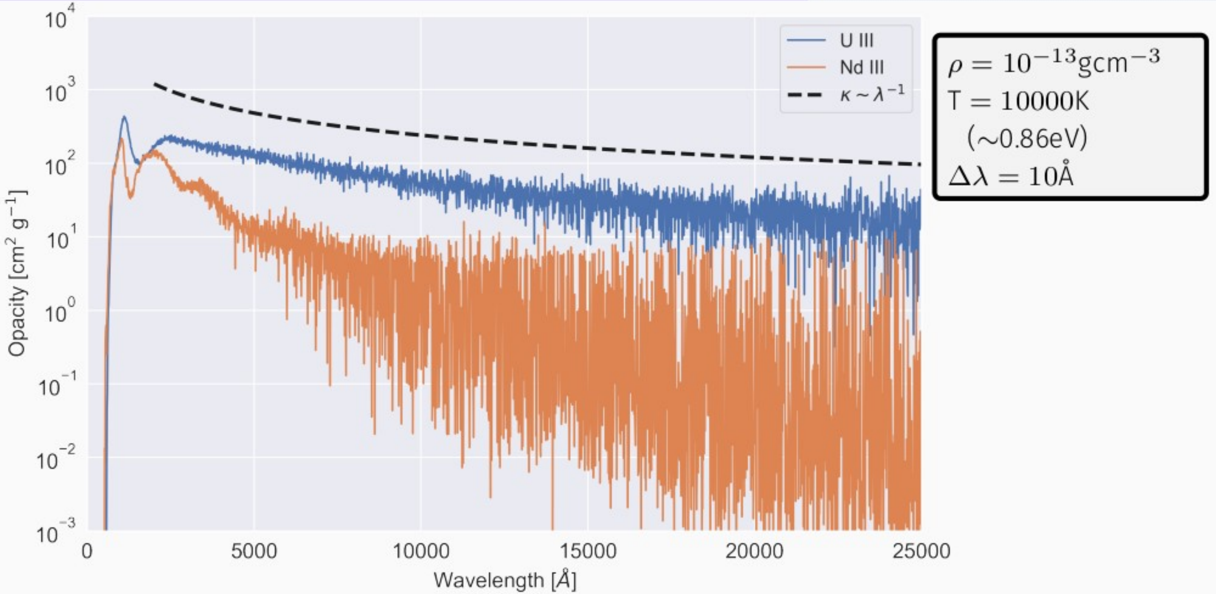
$$\mathcal{L} \approx 5 \times 10^{40}\,\mathrm{erg\,s^{-1}} \times \left(\frac{M}{0.01 M_\odot}\right)^{1-\frac{\alpha}{2}} \left(\frac{v_{ej}}{0.1c}\right)^{\frac{\alpha}{2}} \left(\frac{\kappa}{1\ \mathrm{cm^2\ g^{-1}}}\right)^{-\frac{\alpha}{2}}$$

- Old simulations using Fe-like ions
  ⇒ need of complete set of atomic data for heavy r-process ions
- What about actinides?

Left plot: Kasen et al. *Nature* (2017)
Right plot: R. Chornock et al. *ApJL* (2017)

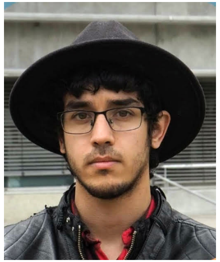
Kilonova

Opacities U III VS Nd III



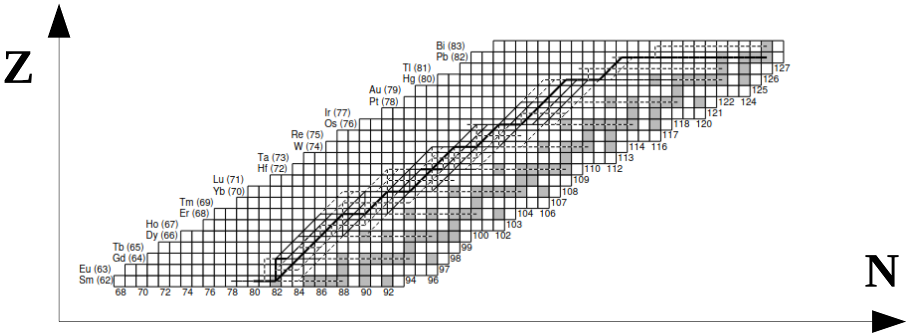
- Higher density of low lying levels ⇒ higher opacity (in LTE)
- Actinide opacities may have a non-negligble impact in kilonovae lightcurves

R.F. Silva *et al.* Atoms 10, 18 (2022)

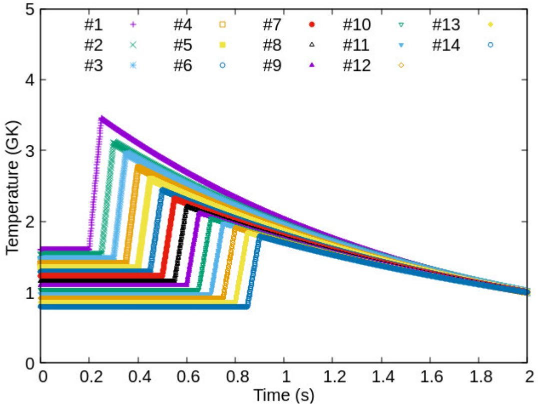


Ricardo F. Silva

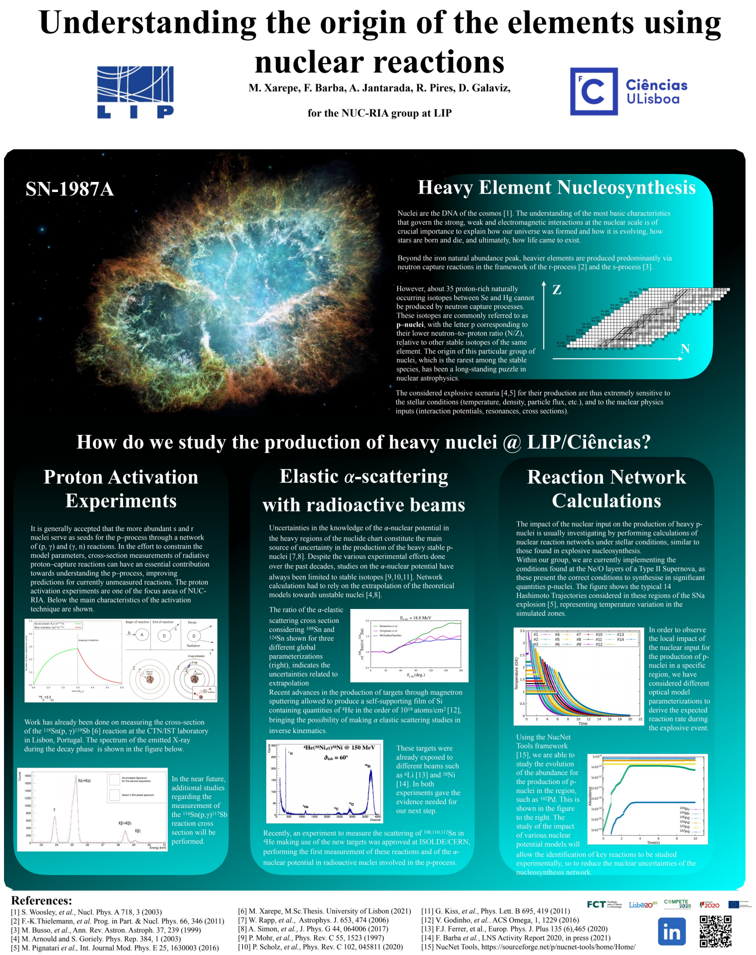
p-process



W. Rapp, *et al.* Astroph. J. 653, 474 (2006)



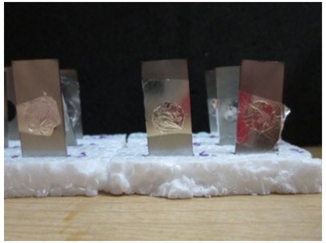
João
Afonso
Jantarada



Instrumentation

for Nuclear Reaction Experiments

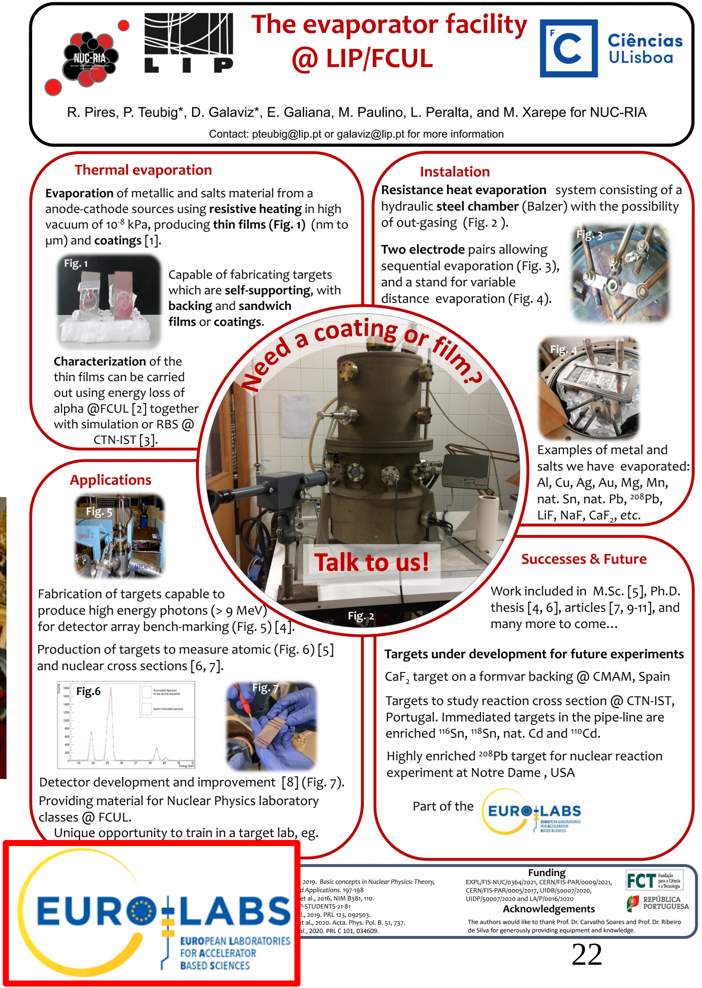
Target Lab



Production of **thin targets** for **experiments**

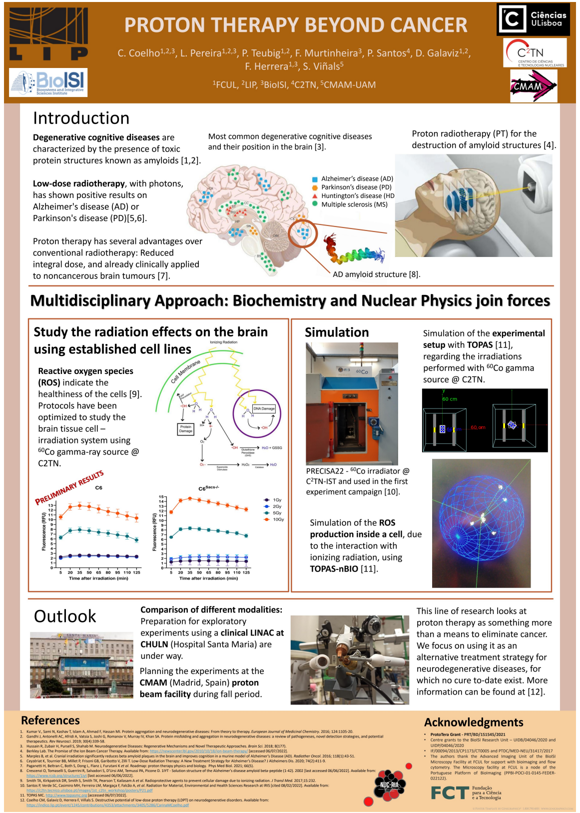
Possibilities for **thin coating** production

Pamela Teubig



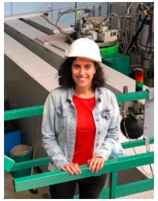
Synergies

Dosimetry

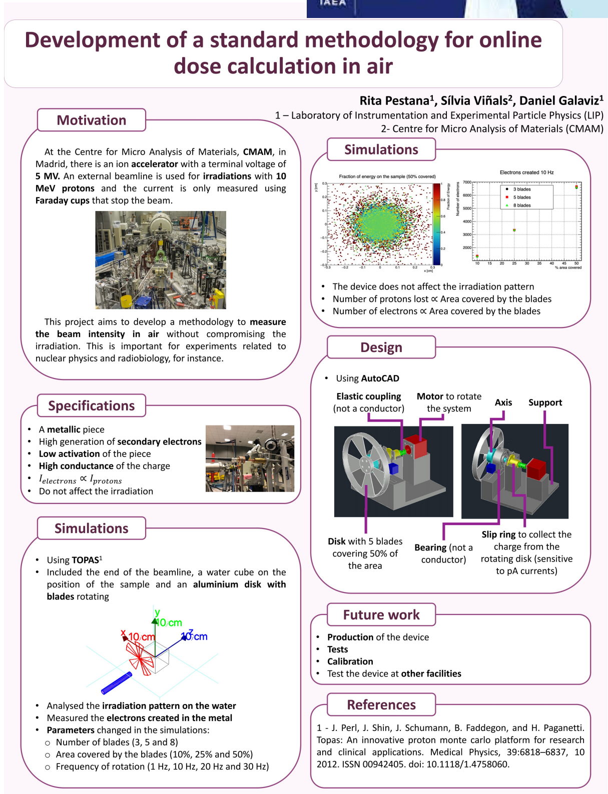


Carina Coelho

Lia Pereira

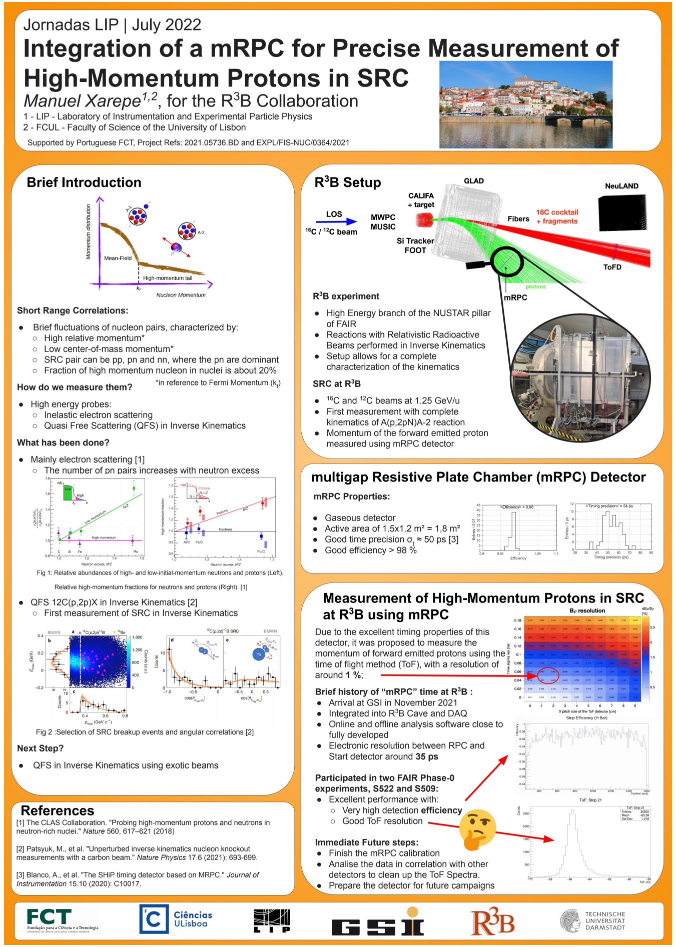


Rita Pestana



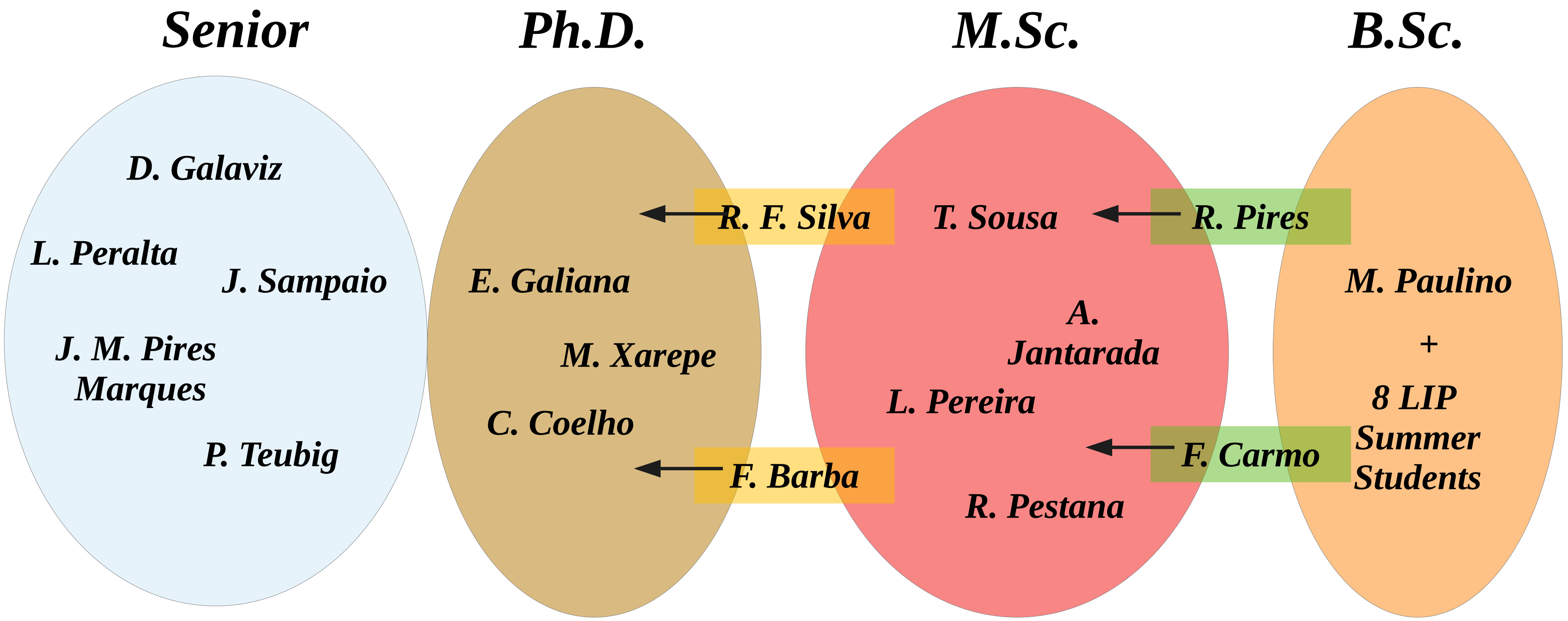
RPC

Manuel Xarepe



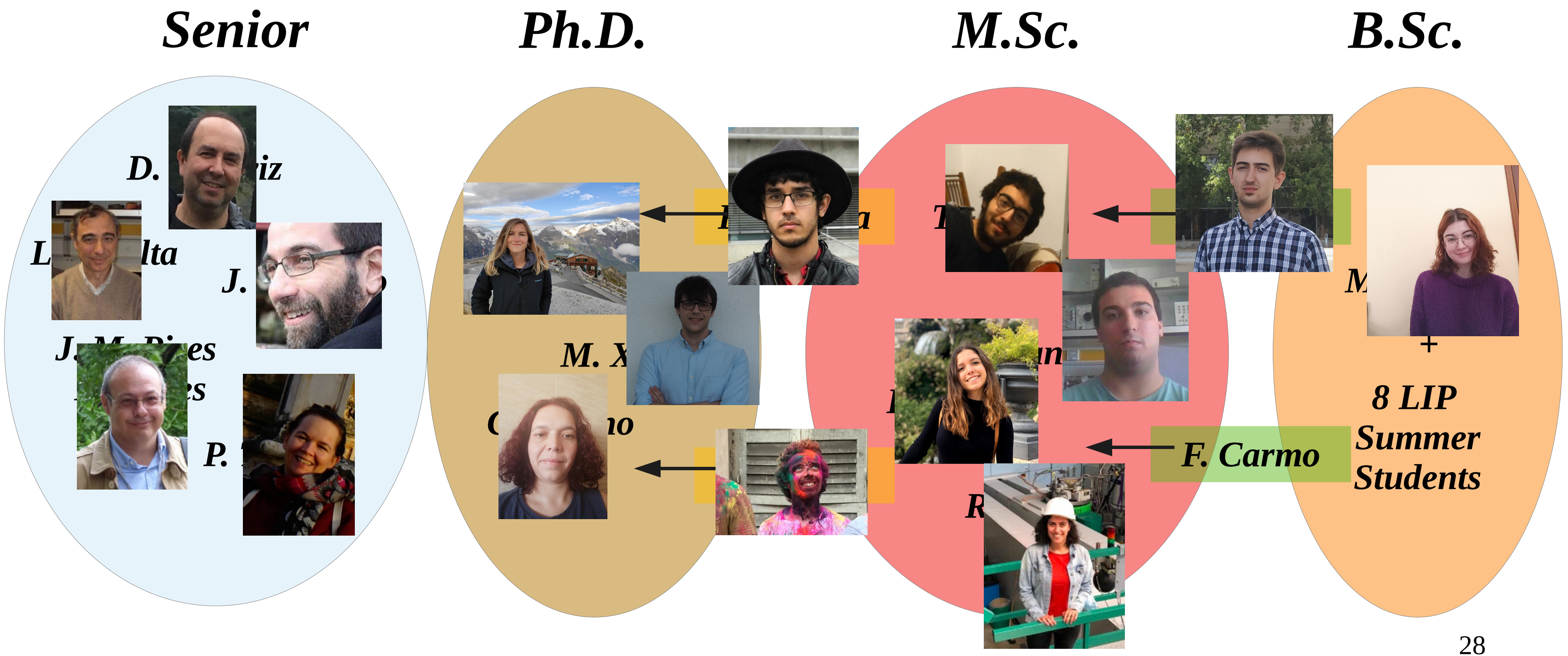
People

People



Senior
Ph.D.
M.Sc.
B.Sc.
D. Galaviz
L. Peralta
J. Sampaio
J. M. Pires Marques
P. Teubig
E. Galiana
M. Xarepe
C. Coelho
R. F. Silva
F. Barba
T. Sousa
A. Jantarada
L. Pereira
R. Pestana
R. Pires
F. Carmo
M. Paulino
+
8 LIP Summer Students

People



Thanks!

Any questions?

You can contact us nucria@lip.pt