Search for CP violation in nuclear beta decay
The Matter's Origin from RadioActivity (MORA)

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THE MORA PROJECT
MATTER'S ORIGIN FROM RADIOACTIVITY

1 Motivations of the MORA project[1] :

- D correlation measurement for search of new CP-violating interactions.
- D needs mixed transitions (GT and F transitions) such as mirror nuclei (N=Z-1) or neutrons.
- Here the ^{23}Mg has been chosen and the ^{39}Ca will be chosen for the DESIR campaign measurement.
- For now the best D measurements are : $D_n = (-0.94 \pm 1.89 \pm 0.97) \cdot 10^{-4}$ and $D_{19Ne} = (1 \pm 6) \cdot 10^{-4}$
- MORA aims to a final sensitivity of 10^{-5}.

2 Experimental set-up

Current status of the commissioning of the MORA line done in 2022:

Offline source:

- Spark source → has given a stable and steady beam.
  Need to change quite often the Na sample (1time per 2 days of use)
  Ions are bunched the same way than the radioactive ions

Online beam:

- Radioactive beam → ^{24}Mg(p,d)^{23}Mg with a 30 MeV proton beam
  Intensity of 2e5 pps at 10μA proton
  Contamination decreasing over time from 80 pA to 27 pA

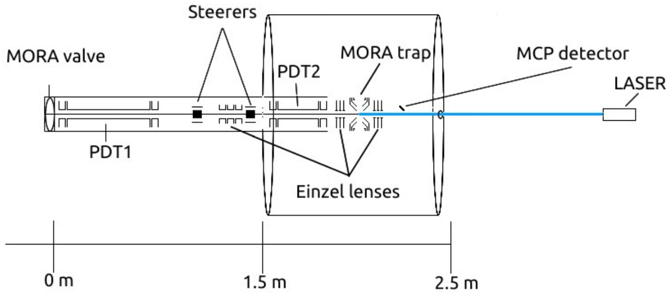

Fig.1 : Schematic view of the line currently within the IGISOL facility

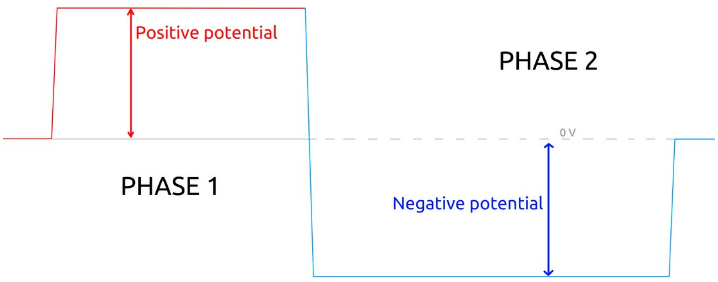

Fig.2 : Process used by the Pulsed Drift Tubes for slowing down the ions bunches.
A first positive tension is applied, reducing the kinetic energy of the bunch, then when the ions are inside the PDT's, a negative tension is applied removing more kinetic energy and focusing the beam.

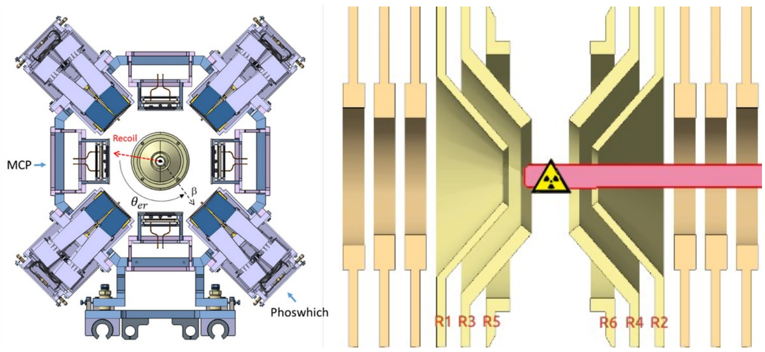

Fig.3 : On the left, cross section view of the trap chamber. Four Recoil Ion Detectors (RIDE) placed at the cardinal positions and four phoswich detectors placed at intercadinal positions.
On the right, a cross section view of the trap[2] with the offline radioactive source finger in red.

3 Experimental results of the commissioning

First beam time: February 18-21, 2022	Second beam time: May 27-31, 2022	Third beam time: November 11-14, 2022
10^5 Mg+/μA of proton beam	10^5 Mg+/μA of proton beam	10^5 Mg+/μA of proton beam
^{23}Na contamination: 20000:1 to 2000:1	^{23}Na contamination: 2000:1 to 500:1	^{23}Na contamination: 3000:1 to 1000:1
Wide bunches 20-100μs, 500 ms cycle	Narrow bunches of 700 ns, 130 ms cycle	Trapping time up to 11s with some loss, 3s cycles
Trapping efficiency of 1%	Trapping efficiency of 1%	Trapping efficiency ranging from 1% to 15%

Conclusion of the third campaign:

Achievements:

First "real" data acquisition, alternation of Sigma+, Sigma- and no laser config.
→ More than **~30h of data** acquisition which are currently analyzed.
First online test with Helium gas cooling in order to increase the ε_{trap}, reducing the size of the cloud and thus a better polarization expected
→ ~10h of data acquired

Troubles:

Still a large contamination of ^{23}Na: ~ 1000:1
→ Reduction tested with 2+ charged state w/o success!
No direct way to monitor correctly the efficiency in the line/trap

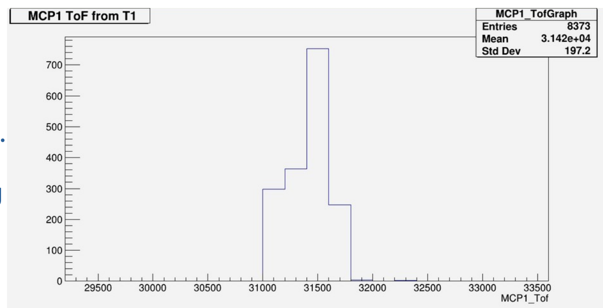

Fig.4: First data acquired during the November campaign

4 Outlook:

New experimental campaign in May: Testing a new source of production with the hot cavity for lowering contaminants
Optimization of the minibuncher RF (increase of space charge capacity)

New data taking experiment in Fall 2023: expecting to reach <10% accuracy on P measurement

References:

1. P. Delahaye et al. The MORA project. Hyperfine Interact., 240(1):63, 2019

2. M.Benali et al. The European Physical Journal A, vol 56, no. 6, jun 2020.

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