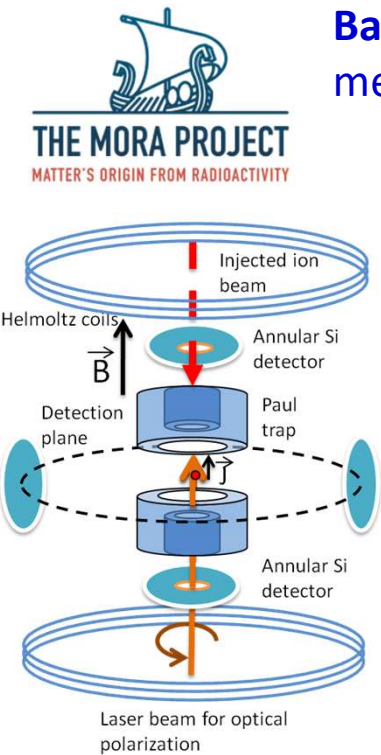


ACCLAIM_MORA project: AdvanCed CaLcium radioActive Isotope Manipulation for MORA 1/4



Based on MORA: looking for the origin of the matter – antimatter asymmetry through the measurement of the D correlation in the decay of trapped and polarized $^{23}\text{Mg}^+$ and $^{39}\text{Ca}^+$

$$D \frac{\vec{J} \cdot (\vec{p}_e \times \vec{p}_\nu)}{J(E_e E_\nu)} \quad \text{is violating T / CP}$$

State of the art techniques

- Intense beam production techniques at
- Ion trapping and cooling developed at
- Innovative polarization technique at



Originally funded by Région Normandie and for PhD postdocs by l'ANR

Theoretical sensitivity studies @



MORA PI: P. Delahaye, GANIL

+ 1 PhD Université de Caen + 1 PhD région

2022-2028: Proof-of-principle of the laser polarization technique at JYFL and first measurement of D at JYFL with 10^5 pps $^{23}\text{Mg}^+$
 2028/29-....: data taking at DESIR with 10^7 pps beams

Foreign partners:



University of Jyväskylä
(host of MORA)

+



Laser polarization expert

ACCLAIM_MORA project: **AdvanCed CaLcium radioActive Isotope Manipulation for MORA 2/4**

- **$^{23}\text{Mg}^+$ & $^{39}\text{Ca}^+$ as natural candidates for MORA**
 - Criteria: mirror nuclei; alcalino-earth isotopes; $A < 40$
- **Proof of principle of laser polarization:** recently achieved in Jyväskylä with $^{23}\text{Mg}^+$
 - Postponed by contamination issue – but $^{23}\text{Na}^+ : ^{23}\text{Mg}^+$ now strongly reduced: < 10 vs 1000 originally



29.10.2025
**RÉSULTATS SCIENTIFIQUES
PHYSIQUE NUCLÉAIRE**
Première mesure du degré
de polarisation d'ions
radioactifs avec
l'expérience MORA

N. Goyal et al., «Performance of the MORA Apparatus for Testing Time-Reversal Invariance,», EPJ. A 61 (10), 221 (2025), in the IN2P3 news 29.10.2025

- D correlation measurement ready to start
- **Sensitivity Objectives :** $^{39}\text{Ca}^+$ required to complement a measurement with $^{23}\text{Mg}^+$
 - Falkowski, A., Rodríguez-Sánchez, A. On the sensitivity of the D parameter to new physics. *Eur. Phys. J. C* **82**, 1134 (2022). <https://doi.org/10.1140/epjc/s10052-022-11085-3>
 - Jyväskylä/IGISOL 10^{-4} - competitive measurement compared to $D_n < 2 \cdot 10^{-4}$
 - GANIL/DESIR 10^{-5} to look for specific New Physics and complement nEDM measurements
 - $^{39}\text{Ca}^+$ et $^{23}\text{Mg}^+$ are required to disentangle New Physics from Final State Interaction effects

Isotope / Installation	trapped ions /cycle	Acquisition time	Uncertainty σ_D
IGISOL / ^{23}Mg	$2 \cdot 10^4$	32 d	$5 \cdot 10^{-4}$
IGISOL / ^{39}Ca	$2 \cdot 10^4$	32d	$1.5 \cdot 10^{-4}$
DESIR / ^{23}Mg	$5 \cdot 10^6$	24 d	$4 \cdot 10^{-5}$
DESIR / ^{39}Ca	$5 \cdot 10^6$	24 d	$1 \cdot 10^{-5}$

- **$^{39}\text{Ca}^+$ challenging but presents higher sensitivity potentials than $^{23}\text{Mg}^+$**

ACCLAIM_MORA project: **AdvanCed CaLcium radioActive Isotope Manipulation for MORA 3/4**

- **Challenges for $^{39}\text{Ca}^+$**
 - **Production**
 - At IGISOL 10^5 pps ~ok
 - 10^7 pps at SPIRAL 1/DESIR is challenging – high reactivity of vs short half-life
 - **Purity**
 - At IGISOL ratio $^{39}\text{K}^+ : ^{39}\text{Ca}^+ > 100$ - too high
 - At DESIR HRS should solve the situation
 - **Stacking / bunching**
 - A few 10^5 ions from minibuncher at IGISOL – but could ideally be more
 - Up to 10^7 ions/bunch at DESIR is challenging
 - **Ion polarisation**
 - At IGISOL and DESIR 1 IR + 1 Visible laser beams vs 1 UV laser for $^{23}\text{Mg}^+$
 - **Ion polarisation vs systematic effects**
 - Transverse polarization as dominant source of systematic effects

ACCLAIM_MORA project: **AdvanCed CaLcium radioActive Isotope Manipulation for MORA 4/4**

- Project organization



PI: **Pierre Delahaye**



L. Hayen



T. Eronen



R. De Groote

2026 – 2029 **686k€** **Advanced manipulation techniques $^{23}\text{Mg}^+$ & $^{39}\text{Ca}^+$**

	Production	Purification	Bunching	Polarisation	Analyse
	1 PhD at SPIRAL 1 Design & test - TISS dedicated to ^{39}Ca			Transverse polarization optics (65 k€)	1 Postdoc 24m for the reduction of systematic effects
		Stacking trap (150k€) purchasing components	Buncher section of the MORA RFQ at DESIR (70k€)		
		Design, construction & test with MR-ToF		Implementation of lasers for ^{39}Ca	
		Technical support design/construction		Design support transverse polarisation	
+40k€ missions GANIL (25) & LPC Caen (15)					

ACCLAIM MORA collaboration

Thanks a lot for your attention!



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R.P. De Groote
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G. Neyens
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A. Rodriguez – Sanchez
M. Gonzalez-Alonso

In **blue** PhD and Master students hired for MORA