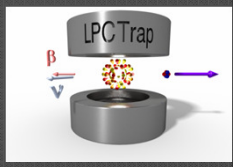


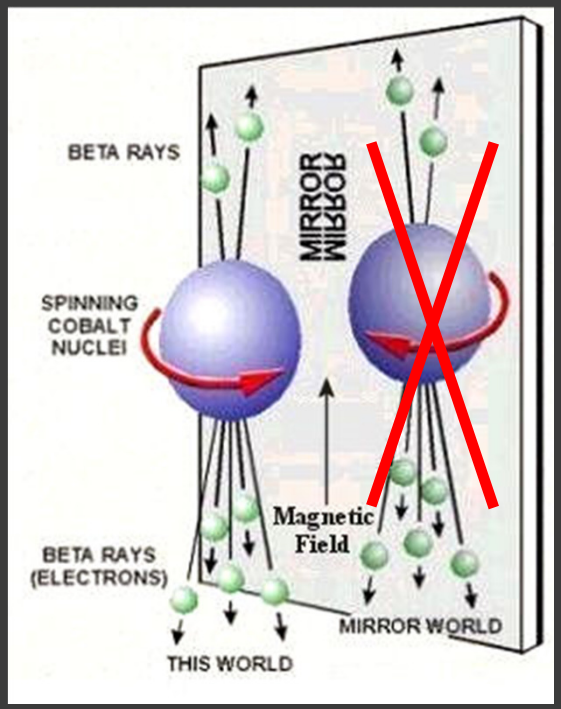
IN TRAP POLARISATION OF RADIOACTIVE ION BEAMS

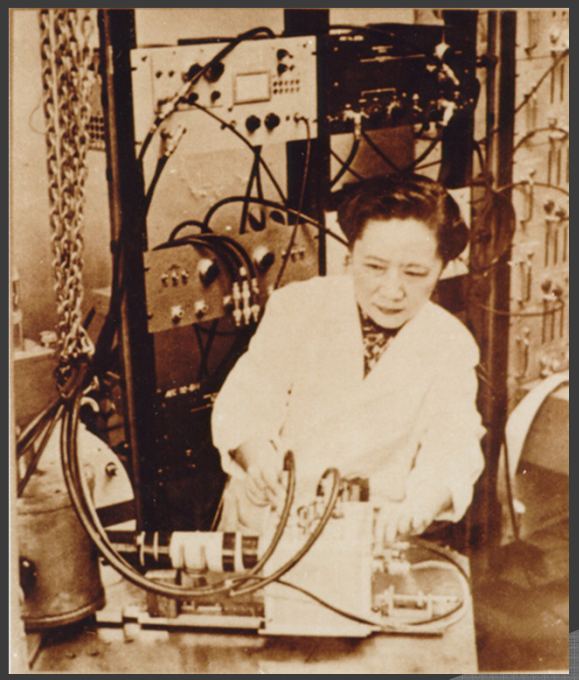
P. Delahaye for WINNINGMOTIONS

β-decay as a laboratory for weak interaction

- Probing intrinsic symmetries

C. S. Wu et al., Phys Rev 105(1957)1413





Parity violation in ^{60}Co decay

Table of contents

- Paul trapping of radioactive isotopes
  - LPCTrap at GANIL: achievements
- Laser Polarisation of ions
  - Experience from COLLAPS
  - Laser polarization at LPCTrap?
- *D* correlation measurement

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See former presentations!

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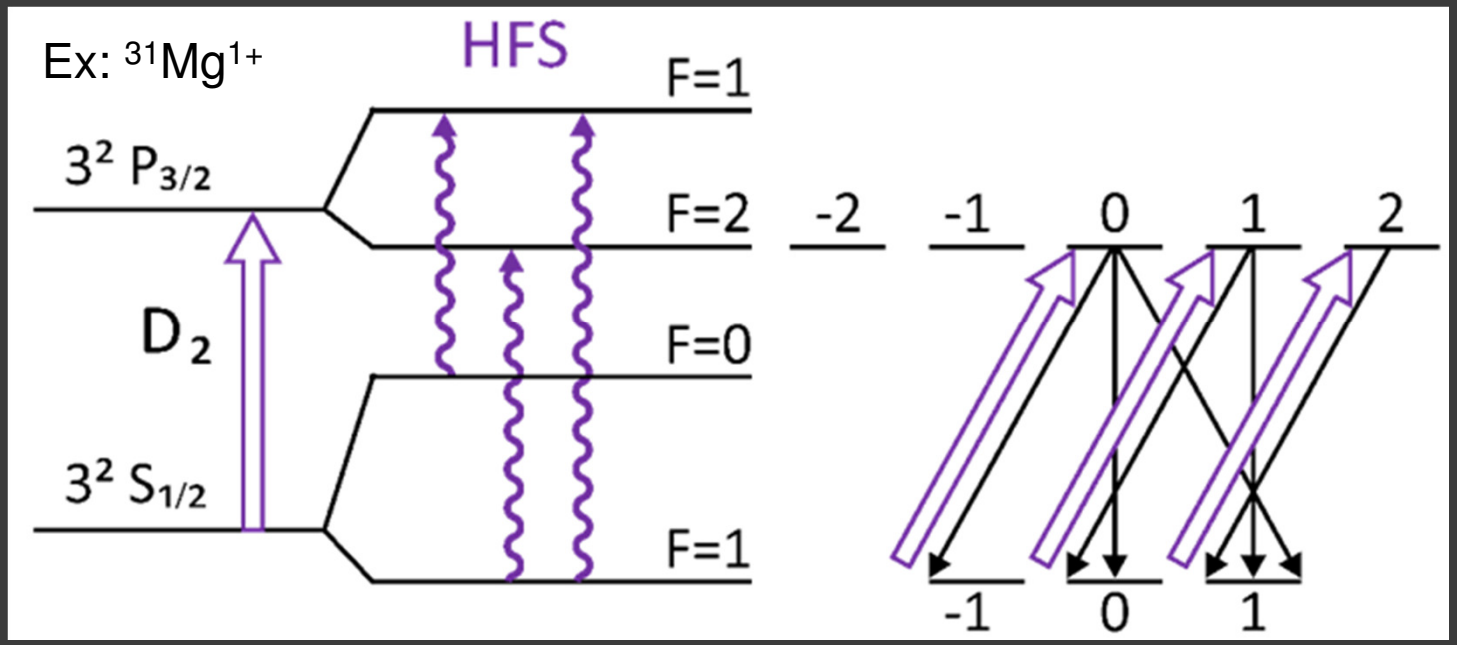
Polarization by optical pumping @ COLLAPS

- The nuclear spin I interacts with the atomic one J → F=I+J
- σ+ or σ- light to scan the hyperfine structure forces ions in the $m_F=\pm F$ state



Polarization of Mg isotopes:

^{31}Mg: G. Neyens et al, PRL 94, 022501 (2005)
^{33}Mg: D. T. Yordanov et al, PRL
$^{21-32}$Mg: D. T. Yordanov et al, PRL 108, 042504 (2012)

Similar possibilities using LUMIERE at DESIR

Table of contents

- Paul trapping of radioactive isotopes
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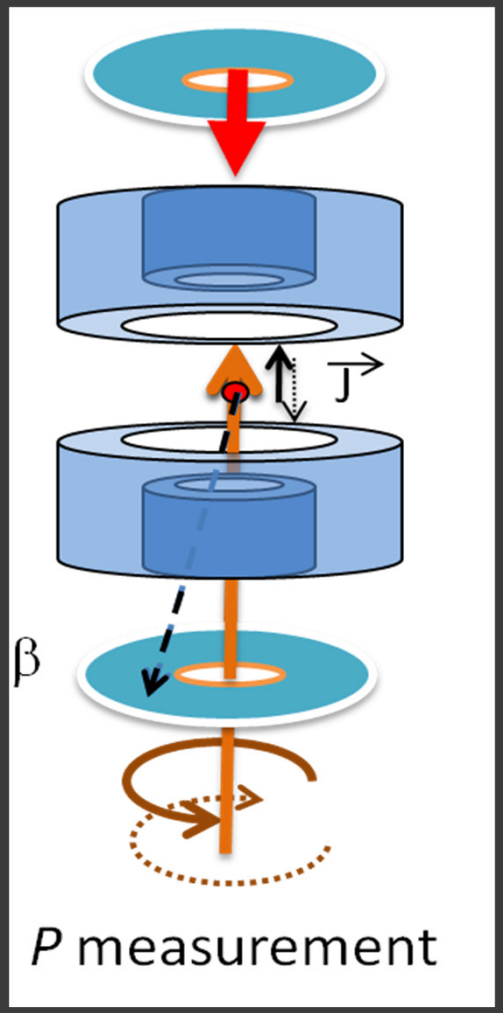
Measurement of polarization



A_β measurement

$$A_\beta \frac{\langle \vec{J} \rangle}{J} \cdot \frac{\vec{p}_e}{E_e}$$

Remember: C. S. Wu et al., Phys Rev 105(1957)1413

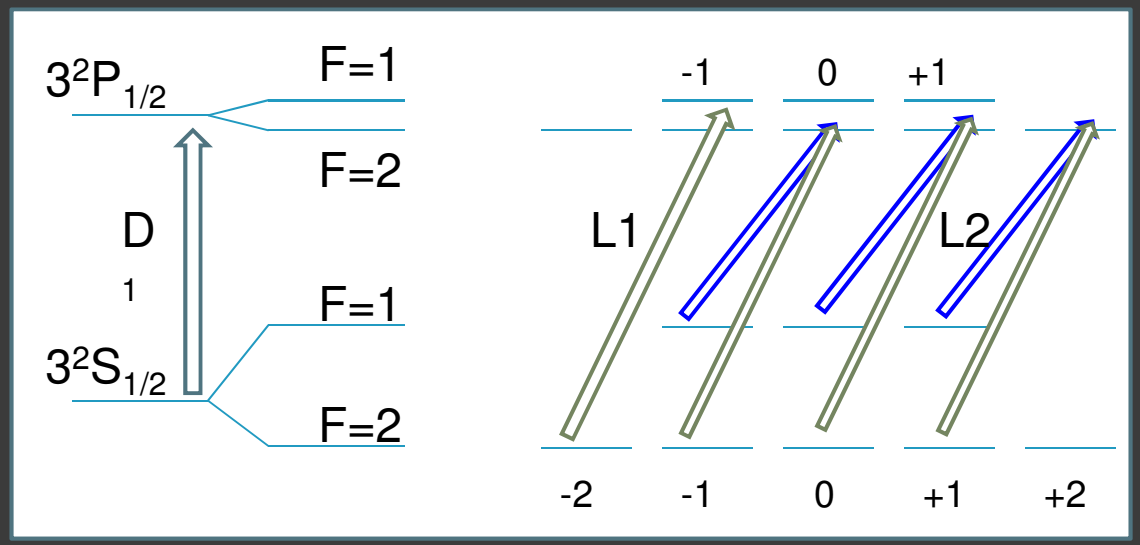
Extended interaction time with laser light
>95 % polarization could be hoped for

Using:
- ISCOOL for beam cooling and bunching
- the COLLAPS laser setup for polarization
- A LPCTrap – like transparent trap

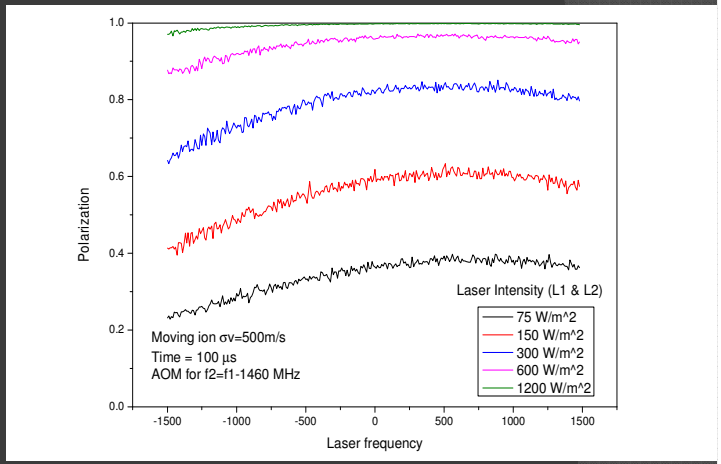
Optical pumping simulations

Transition probabilities: numerical simulations W. Gins and X. Fléchard

Taking into account the velocity of the trapped ions



L1+L2 lasers using an optical modulator



Collisions with He atoms (no spin) do not depolarize

With the power available at COLLAPS:
More than 99% achievable in 0.2ms

Probable limitation: laser light polarization

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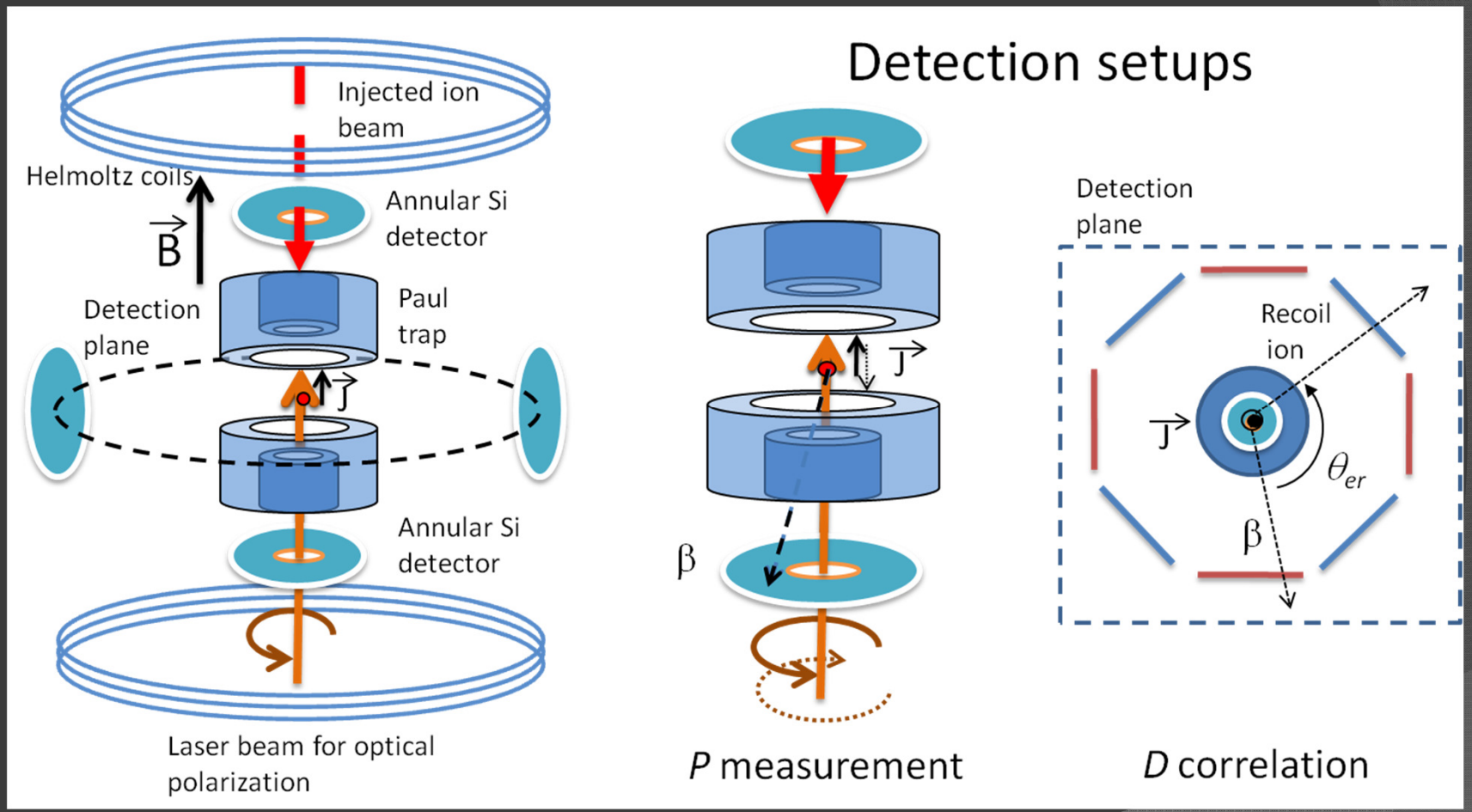
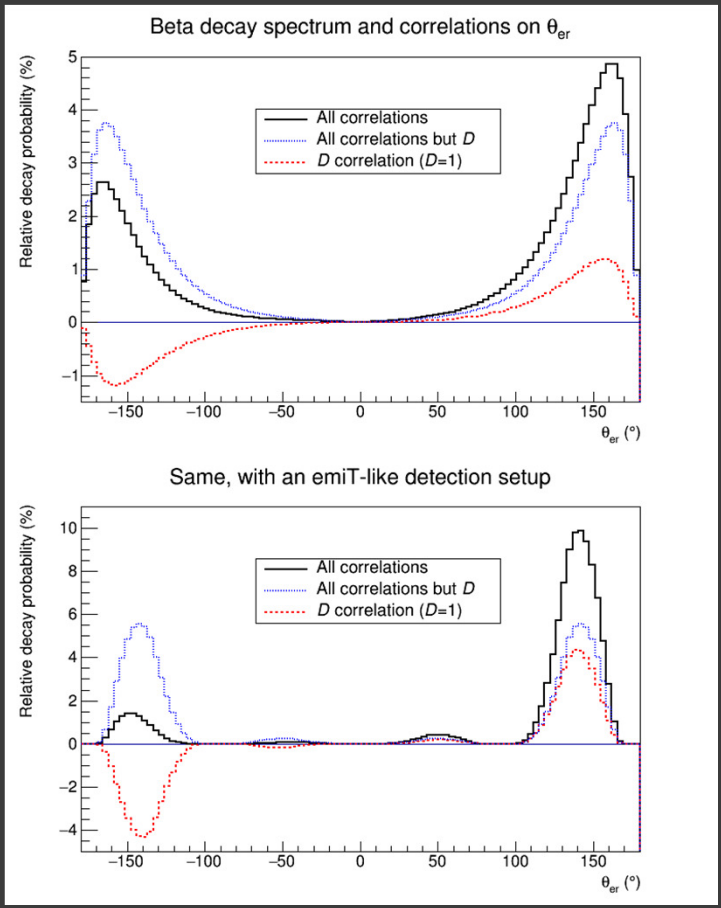
D correlation measurement

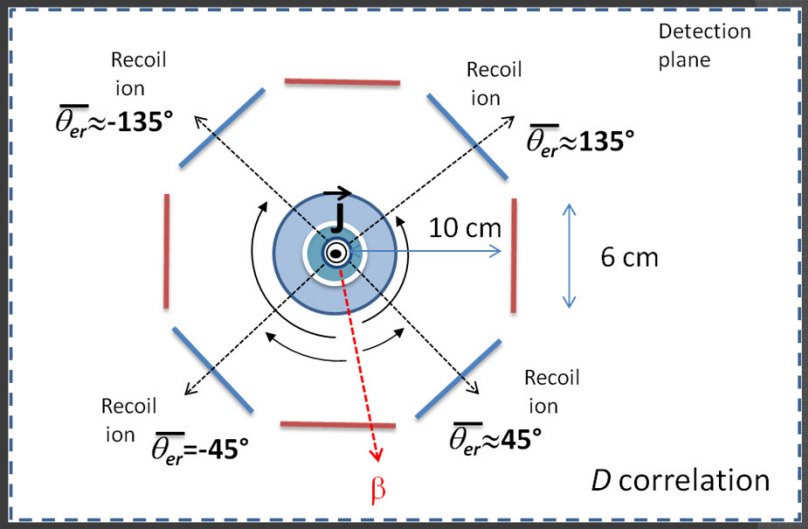


In trap optical polarization of $^{23}Mg^{+}$ and $^{39}Ca^{+}$

P. Delahaye et al, IKS-LPC meeting- 2015

D correlation measurement

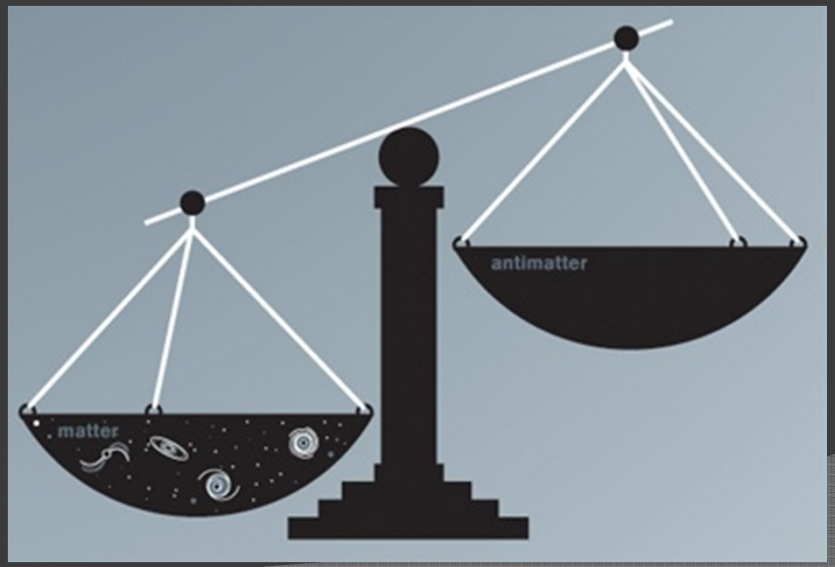




Correlation max around 135°

Precision measurements of the triple correlation *D*

- A non-zero *D* can arise from CP violation
  - CP violation observed in the K and B - meson decays is not enough to account for the large matter – antimatter assymetry
  - T-odd correlations in beta decay (*D* and *R*) and n-EDM searches are sensitives to larger CP violations by 5 to 10 orders of magnitude



Possible candidates

Isotope	Yield SPIRAL (pps)	D_{FSI}
^{21}Na	>1e8pps	$6.7\ 10^{-5}$
^{23}Mg	$>1^{e}8$ pps	$-1.3\ 10^{-4}$
^{37}K	$>1^{e}8$ pps	$-1.9\ 10^{-4}$
^{39}Ca	$5.7^{e}5$pps (estimated!)	$4.7\ 10^{-5}$

Can be laser polarized as ions!

Precision measurements of the triple correlation *D*

- A non-zero *D* can arise from CP violation
  - CP violation observed in the K and B - meson decays is not enough to account for the large matter – antimatter assymetry
  - T-odd correlations in beta decay (*D* and *R*) and n-EDM searches are sensitives to larger CP violations by 5 to 10 orders of magnitude
- *D* correlation measurements
  - Best values
    - neutron decay, ***Dn*= (–0.94 ±1.89±0.97) 10^{-4}**, emiT collaboration, PRL 107, 102301 (2011), Phys. Rev. C 86 (2012) 035505
    - ^{19}Ne decay, ***D*=0.0001 ±0.0006** Calaprice et al, Hyp. Int. 22 (1985) 83, **limited by statistics**
- Aim of the experiments: $\sigma_D \leq 10^{-4}$

Making use of intense RIBs at SPIRAL, polarized by LUMIERE , and of a specific arrangement of LPCtrap

Proof of principle in ISOLDE → COLLAPS + adapted trapping setup!

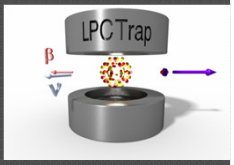
Conclusions

- New perspectives with polarized beams using LPCTrap
  - Proof of principle could be done at ISOLDE
    - COLLAPS Laser setup
    - LA1/2 beam line
    - Using ISCOOL
    - Adapted trapping setup
- *D* correlation measurement with unprecedented accuracy is within reach
  - 2 weeks of beam time: at least same order of magnitude as for the neutron with existing techniques
  - Can go down to the 10^{-4} level with some beam, laser and trapping R&D
    - First attempt at ISOLDE (Contamination of ^{23}Na?)
    - Final experiment at DESIR
  - First approach /probe of D_{FSI} for ^{23}Mg
  - Great physics with great challenges!
- Ongoing application to the french ANR

Questions

- D_{FSI} calculation
- How can we control the polarization degree
  - A_β and B_ν measurements
- …

Thanks a lot for your attention



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And the COLLAPS collaboration