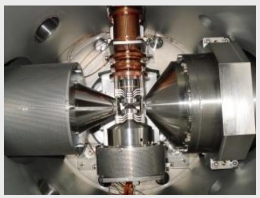
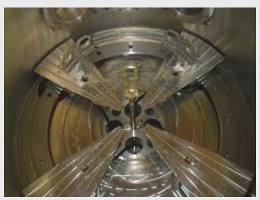
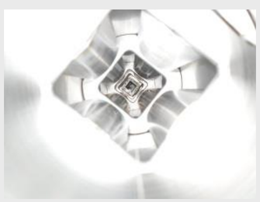
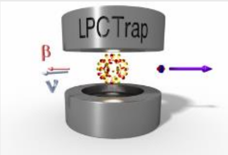


$\beta-\nu$ correlation measurements in nuclear decays with LPCTrap

E. Liénard

LPC Caen, University of Caen

Development of LPCTrap : context in 1997

- *Exotic couplings in weak interaction : situation of "a" measurements*

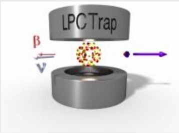
  - GT : ^{6}He (Johnson *et al.* PRC 1963) $\rightarrow a_{GT}$ = -0.3308 (30)
  - F : ^{32}Ar (project Adelberger *et al.*) $\rightarrow a_F$ = 0.9989 (65) published in 1999
    ^{38m}K (project Gorelov *et al.*) $\rightarrow a_F$ = 0.9981 (48) published in 2005

  [➡ Current limits : C_T/C_A < 9% C_S/C_V < 7%]

- *SPIRAL project @ GANIL*

  - Light n-rich beams (noble gases) : ^{6}He, ^{8}He, ^{18}Ne, ^{19}Ne, ^{32}Ar, ^{35}Ar, … with high intensities
  - First beam in 2001

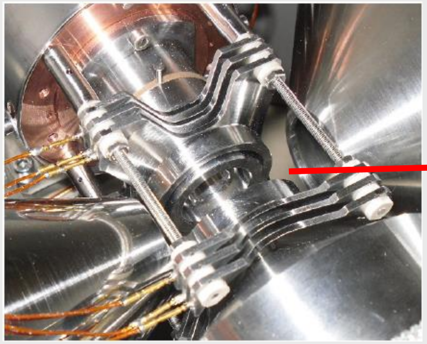
⇨ *Aim of LPCTrap : improvement of a_{GT} precision using up-to-date technologies*

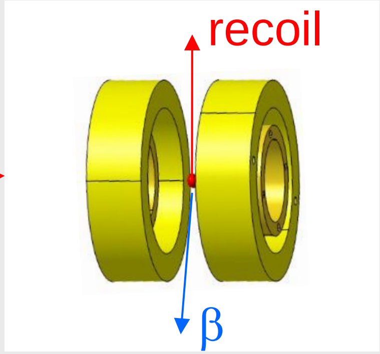


The LPCTrap setup

- *Decay source confined in a transparent Paul trap*

beam

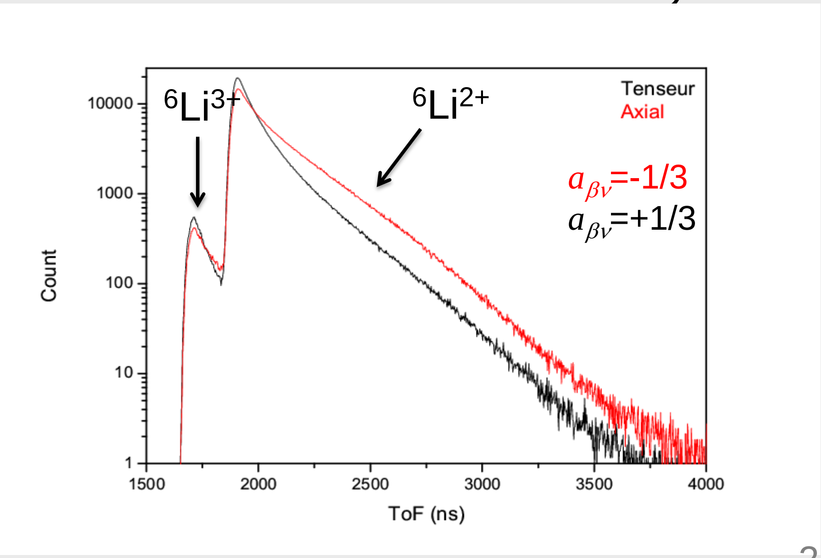




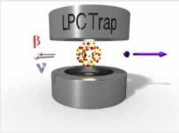
- β - recoil ion detection in coincidence
- *a* deduced from recoil time-of-flight distribution

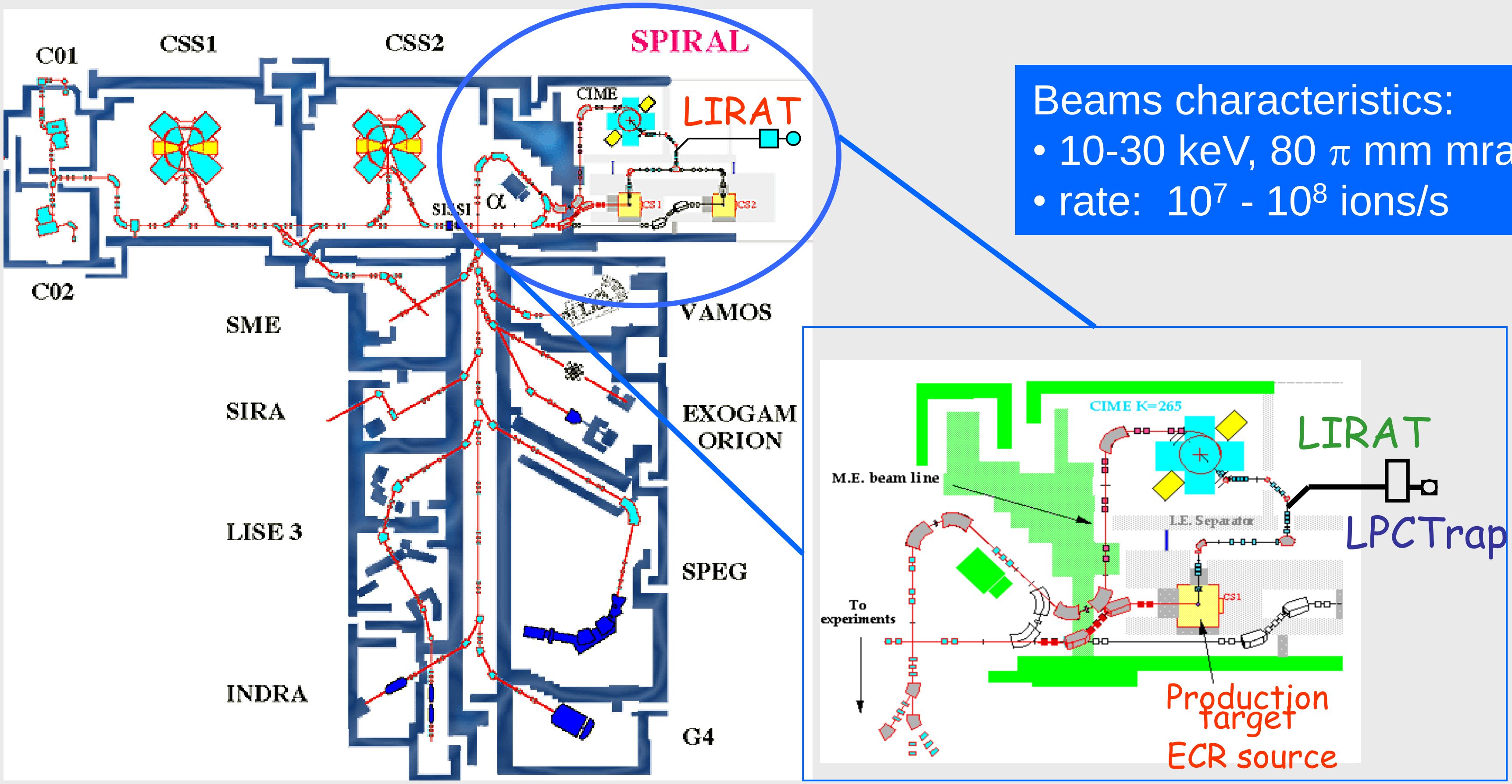
- *^{6}He : good candidate*
  - Pure GT transition
  - 100% G.S. to G.S.
  - Reasonable $T_{1/2}$ = 806.7 ms
  - High Q_β = 3.51 MeV, T_{max} = 1.4 keV
  - High production rate: 2 10^8 ions/s

Simulation for $^6He^+$ decay

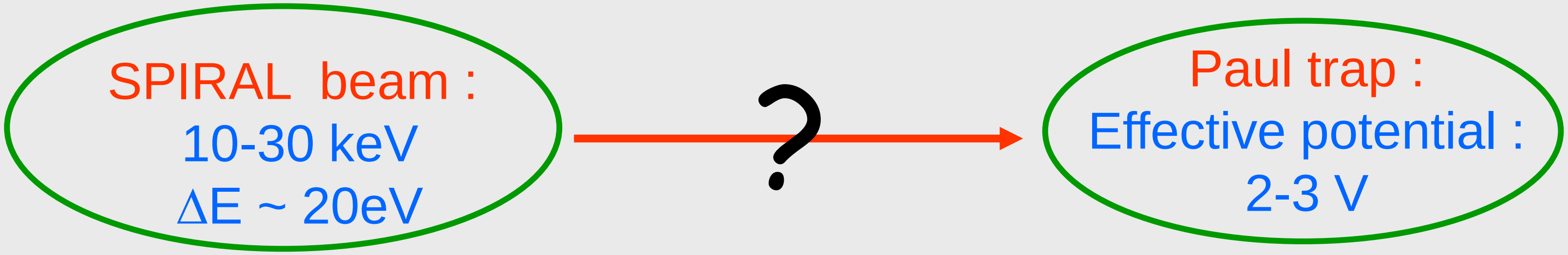


LPCTrap @ GANIL



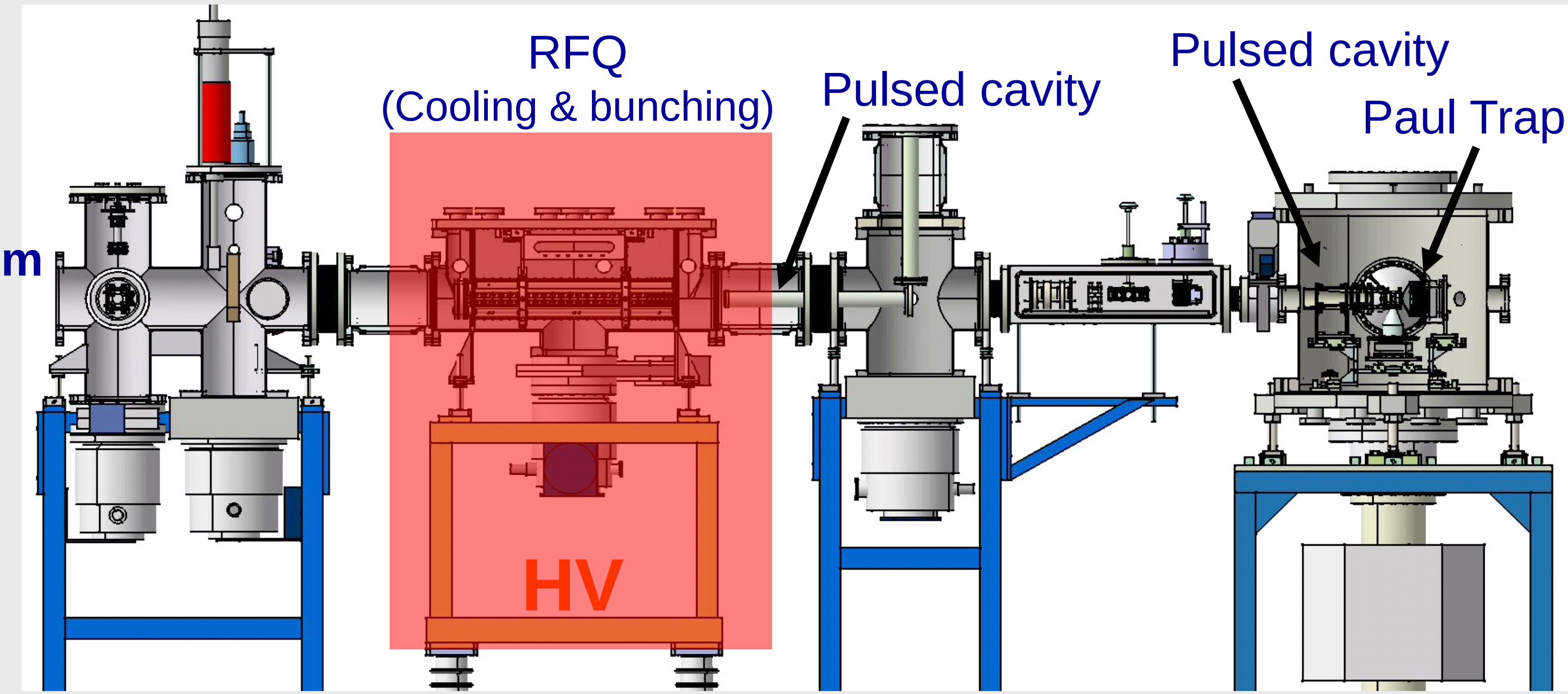


Beams characteristics:
- 10-30 keV, 80 π mm mrad
- rate: 10^7 - 10^8 ions/s



LPCTrap @ LIRAT

Beam from LIRAT



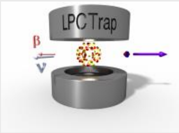
KE$_{ion}$:	*10 keV*	*100 eV - <1 eV*	*1 keV*	*100 eV*	*0 eV*
ΔKE:	*~20 eV*	*~1 eV*			*~0.1 eV*

~1.5 10^8 $^6He^+/s$

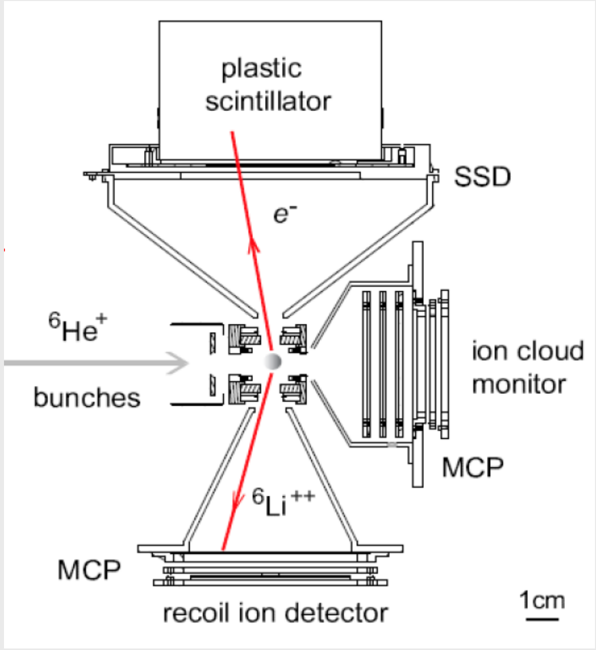
- Buffer-gas: H_2 (He for heavier nuclei)
- accumulation: 200ms (cycle)

~4 10^4 $^6He^+$ /cycle
Total efficiency: ~ 10^{-3}

LPCTrap : the detection setup



- < 2010



E. Liénard et al., NIMA551(2005)

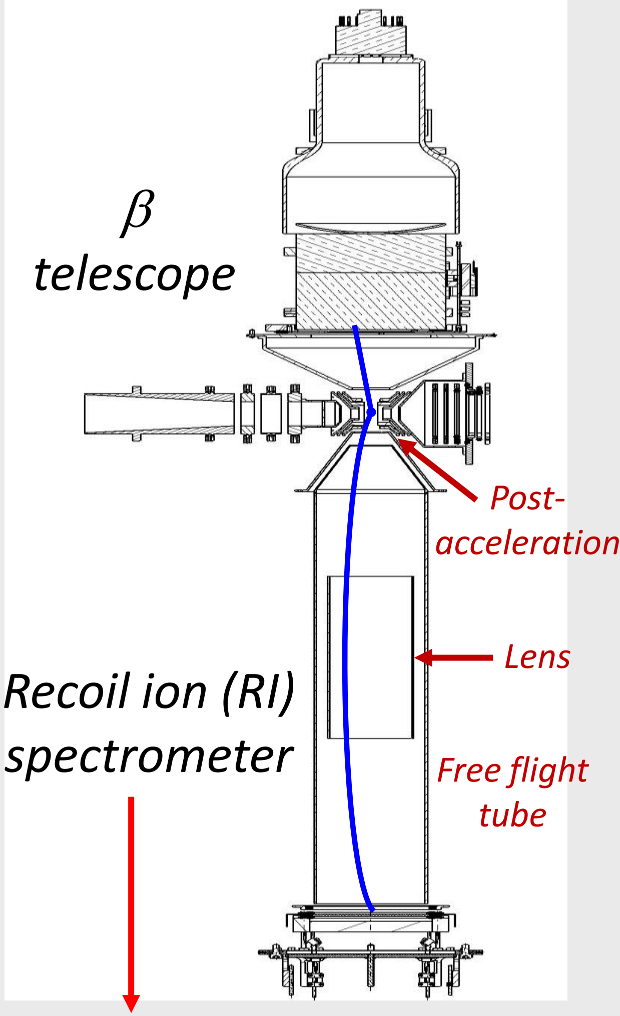
Trigger: β scintillator

Parameters:

- β energy
- β position
- recoil ion ToF
- recoil ion position

+ timestamp in cycle & trap RF phase

- ≥ 2010

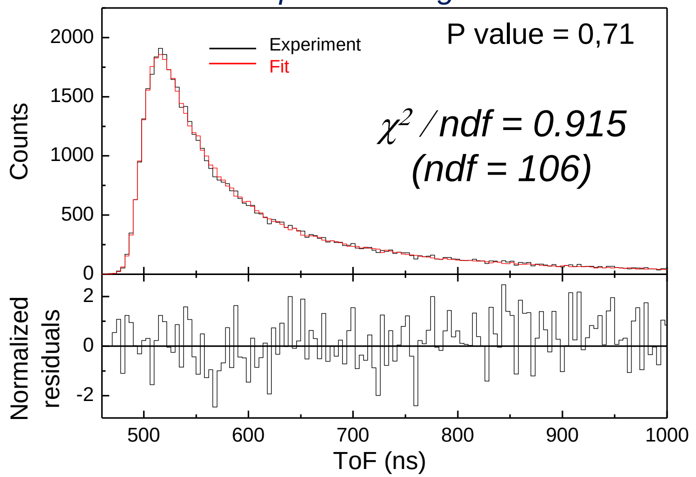


RI charge state distribution (shakeoff)

- *Time of flight of RI*
- *BG suppression*
- *Control of systematic effects*
- *Control of results consistency*

^{6}He : first results

- *First experiment in 2006*



$a_{\beta\nu}$ = - 0.3335 (73) $_{stat}$ (75) $_{syst}$

Fléchard et al., J.Phys.G 38 (2011)

- Best precision on a_{GT} using coincidence technique ($\Delta a/a$ = 3%)
- Good control of experimental & simulation parameters

Systematic error budget

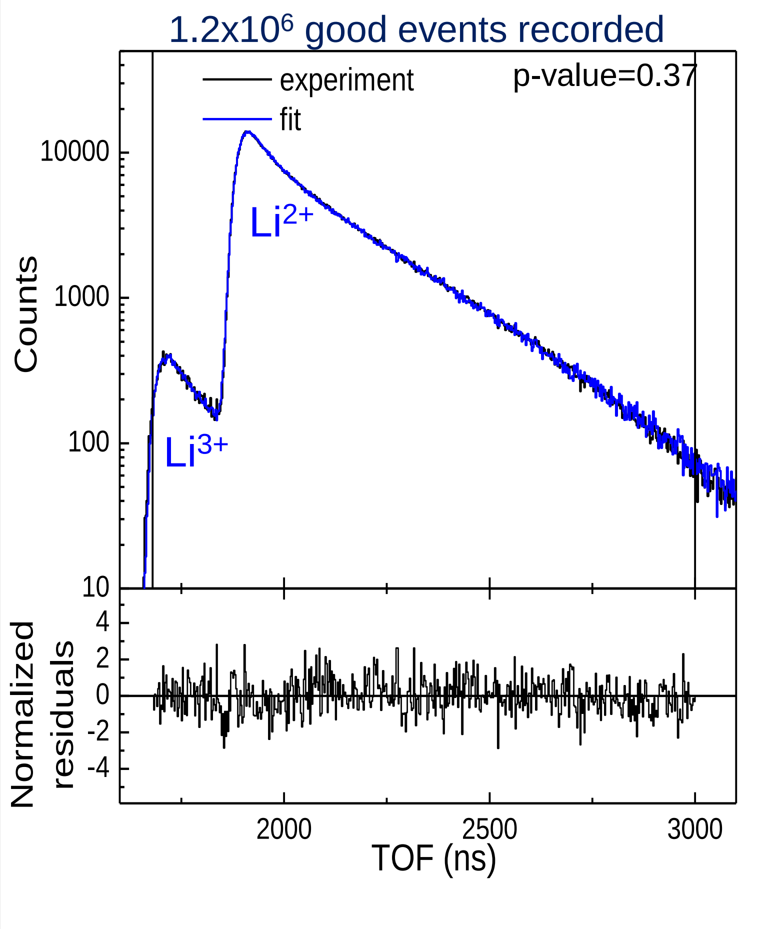
Source	Uncertainty	$\Delta a_{\beta\nu}$ (x 10^{-3})	Method
Cloud temperature	6.5%	6.8	off-line measurement
θx_{MCPPSD}	0.003 rad	0.1	present data
θy_{MCPPSD}	0.003 rad	0.1	present data
MCPPSD offset (x,y)	0.145 mm	0.3	present data
MCPPSD calibration	0.5 %	1.3	present data
d_{DSSSD}	0.2 mm	0.3	present data
E_{scint}		0.8	present data
E_{si}	10%	0.8	GEANT4
Background		0.9	present data
β Scattering	10%	1.9	GEANT4
Shake off	0 - 0.05	0.6	theoretical calculation
V_{RF}	2.5%	1.7	off-line measurement
total		7.5	

<u>First need</u> : data on β scattering !

possible @ Bordeaux electron spectrometer (^{90}Sr source)

^{6}He : first results

- *Last experiment in 2010*



- Analysis performed to extract P_shakeoff (complete simulation @ low statistics : ~ 4x10^{5})

$P_{shake\text{-}off} = 0.02339(35)_{stat}(07)_{syst}$

- High precision : $\Delta P_{shake\text{-}off} = 3.6\ 10^{-4}$
- Excellent agreement : theoretical value 0.02322

Couratin et al., PRL108 (2012)

- About a_{GT} :

- $(\Delta a_{GT} / a_{GT})_{expected} \sim 0.63$ %
- difficulties to properly reproduce different experimental distributions → bad Chisquare !

Improvement of ion cloud modelling including gas cooling & space charge effects (GPU's, CUDA) → *Xavier Fabian*

Second need : extraction of "a" requires dedicated simulations including systematic parameters under perfect control...

Measurements in the mirror decays of ^{35}Ar & ^{19}Ne

- *Mirror decays = source of data to determine V_{ud}*

Naviliat et al., PRL102(2009)

$$V_{ud}^2 = \frac{K'}{(f_V T_{1/2}/BR)(1+C\rho^2)}$$

parameters to be measured :

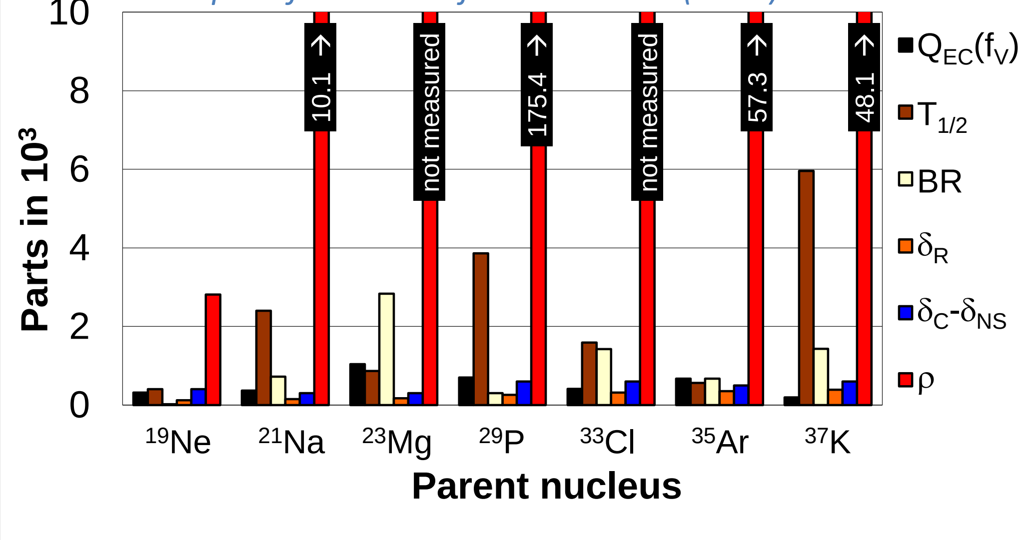
M (f_V), $T_{1/2}$, BR and ρ

- *Status for some decays*

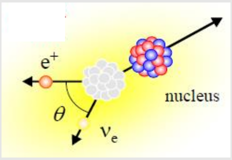
ρ = GT/F :

- the least or even not known quantity !
- precisely determined from correlation measurements

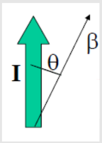
adapted from Severijns et al PRC78(2008)



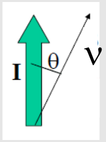
$$a_m = \frac{(1-\rho^2/3)}{(1+\rho^2)}$$



$$A_m = \frac{\rho^2 - 2\rho\sqrt{J(J+1)}}{(1+\rho^2)(J+1)}$$

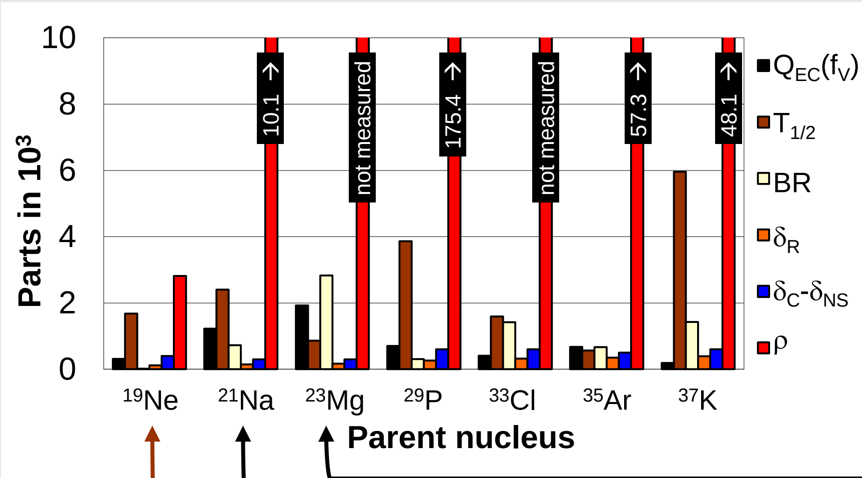


$$B_m = -\frac{\rho^2 + 2\rho\sqrt{J(J+1)}}{(1+\rho^2)(J+1)}$$

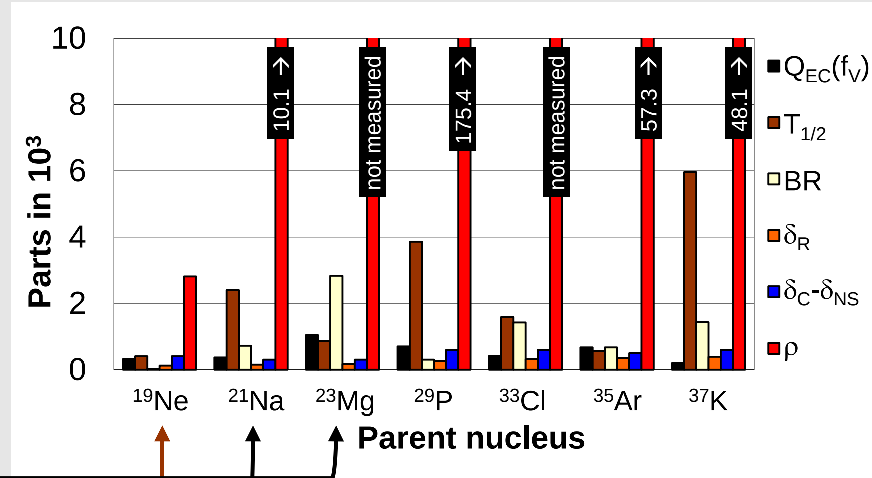


Update of data in 2014: *M*, $T_{1/2}$, *BR*

2009 — *Naviliat et al., PRL102(2009)*



2014



Q(^{23}Mg): *AME2012* → gain of a factor 1.9

Q(^{21}Na): *Mukherjee et al EPJA35(2008)* → gain of a factor 3.3

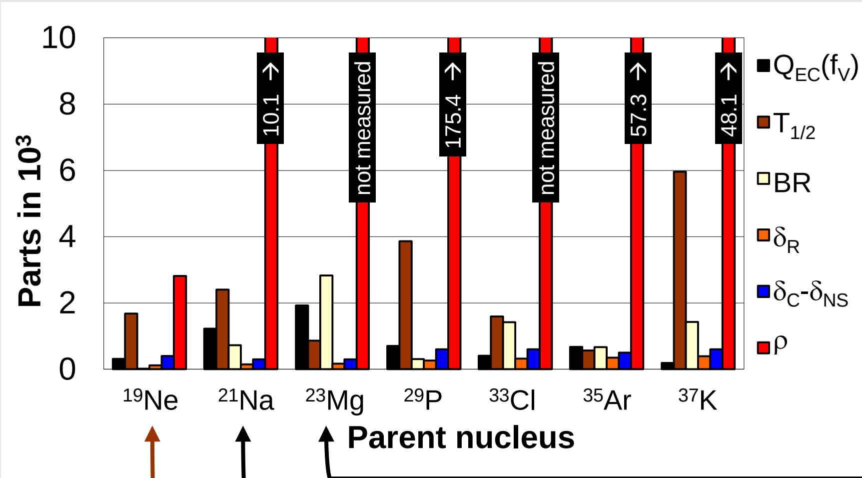
$T_{1/2}$(^{19}Ne): *Triambak et al PRL101(2012)* → gain of a factor 8.5
Broussard et al PRL112(2014)

should change V_{ud} "mirror" value….

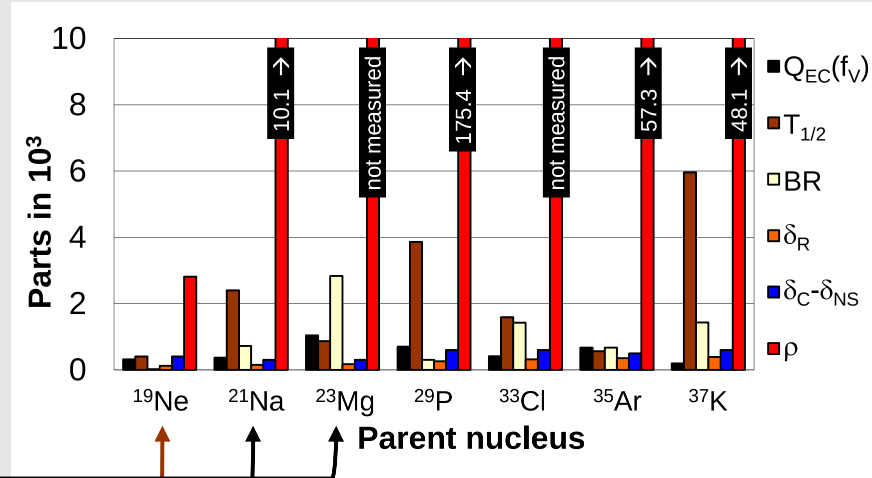
V_{ud} (2009) = 0.9719 (17)

Update of data in 2014: *M, $T_{1/2}$, BR*

2009 *Naviliat et al., PRL102(2009)*



2014



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should change V_{ud} "mirror" value….

V_{ud} (2009) = 0.9719 (17) → V_{ud} (2014) = 0.9717 (17) !!

__Third need__ : for V_{ud} determination, ρ improvements are necessary ...

• ρ precisely determined from correlation measurements

$$a_m = \frac{\left(1 - \rho^2/3\right)}{\left(1+\rho^2\right)} \qquad A_m = \frac{\rho^2 - 2\rho\sqrt{J(J+1)}}{\left(1+\rho^2\right)(J+1)}$$

Severijns & Naviliat PST152(2013)

a or *A* @ 0.5% ?

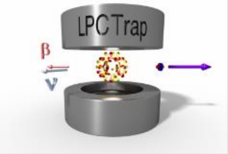
	a			A		
Parent nucleus	ΔV_{ud}	$(\Delta V_{ud})^{\text{limit}}$	Factor $\Delta\mathcal{F}t$	ΔV_{ud}	$(\Delta V_{ud})^{\text{limit}}$	Factor $\Delta\mathcal{F}t$
^{3}H	0.0011	0.0010	2.1	0.0011	0.0009	2.3
^{11}C	0.0025	0.0016	4.0	0.0207	0.0207	0.3
^{13}N	0.0017	0.0017	1.0	0.0123	0.0123	0.1
^{15}O	0.0020	0.0016	2.4	0.0023	0.0020	1.9
^{17}F	0.0019	0.0013	3.1	0.0341	0.0341	0.1
^{19}Ne	0.0011	0.0010	1.5	0.0011	0.0011	1.5
^{21}Na	0.0022	0.0017	2.7	0.0036	0.0034	1.3
^{23}Mg	0.0025	0.0018	3.1	0.0034	0.0030	1.9
^{25}Al	0.0019	0.0018	1.7	0.0056	0.0056	0.5
^{27}Si	0.0029	0.0018	4.1	0.0068	0.0066	1.1
^{29}P	0.0026	0.0018	3.4	0.0024	0.0014	4.3
^{31}S	0.0038	0.0018	5.9	0.0068	0.0061	1.8
^{33}Cl	0.0021	0.0018	2.0	0.0013	0.0006	6.0
^{35}Ar	0.0019	0.0018	1.1	0.0007	0.0004	4.8
^{37}K	0.0034	0.0017	5.8	0.0050	0.0041	2.3
^{39}Ca	0.0024	0.0016	3.5	0.0032	0.0027	2.2
^{41}Sc	0.0029	0.0022	2.7	0.0299	0.0299	0.2
^{43}Ti	0.0076	0.0018	13.2	0.0167	0.0151	1.6
^{45}V	0.0112	0.0020	17.7	0.0115	0.0032	11.2

"*A*" more sensitive than "*a*" in a few cases

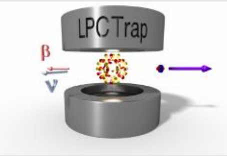
and it is more difficult

to measure precisely...

A part of job could be achieved with LPCTrap….



Update of data in 2014-2015 : ρ ?

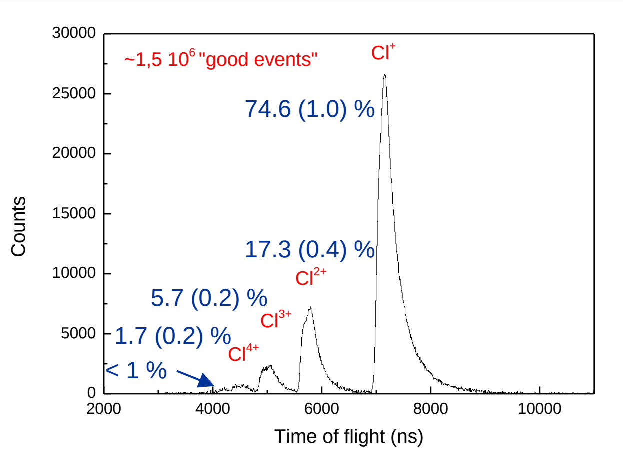


LPCTrap @ GANIL (LIRAT)

- Measurements of $a_{\beta\nu}$ and shakeoff probabilities in decay of $^{35}Ar^{1+}$ & $^{19}Ne^{1+}$

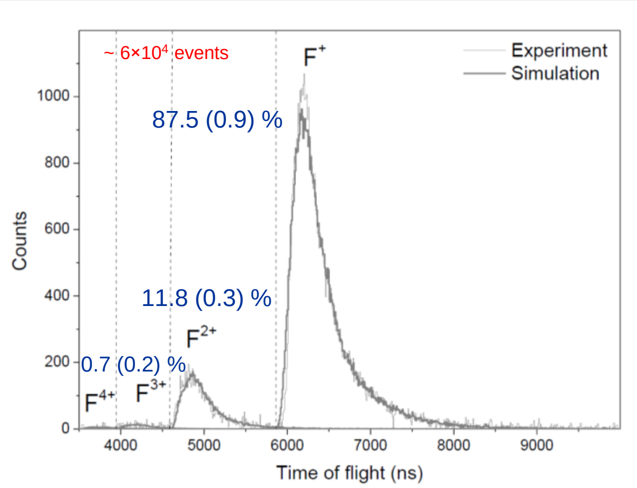
Ban et al., ADP525 (2013)

2011-2012 : ^{35}Ar

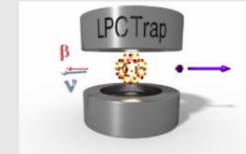


Shakeoff : Couratin et al., PRA (2013)

2013 : ^{19}Ne



Analysis of data in progress (development of new simulation tools…)



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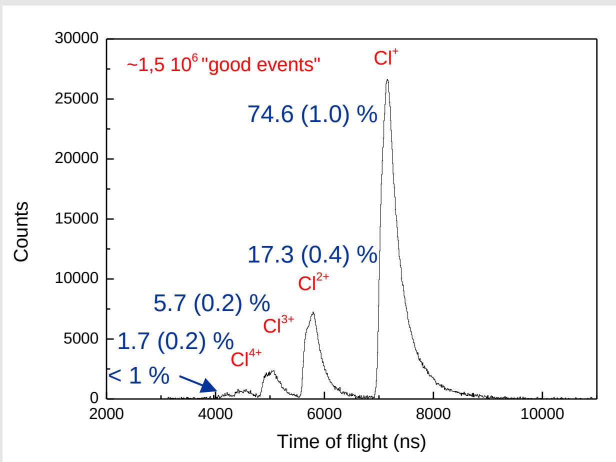

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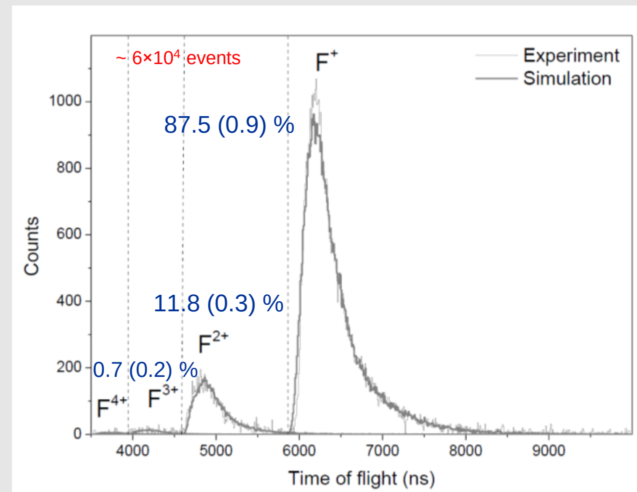


Analysis of data in progress (development of new simulation tools…)

- Expected results ($\Delta a / a$) : *~ 0.25 %* *~ 18 % (a ~ 0...)*
- Factor gained on $\Delta\rho / \rho$: *~ 4.5* *~ 1*

V_{ud} (2009) = 0.9719 (17) → V_{ud} (expected) = 0.9734 (10) !!

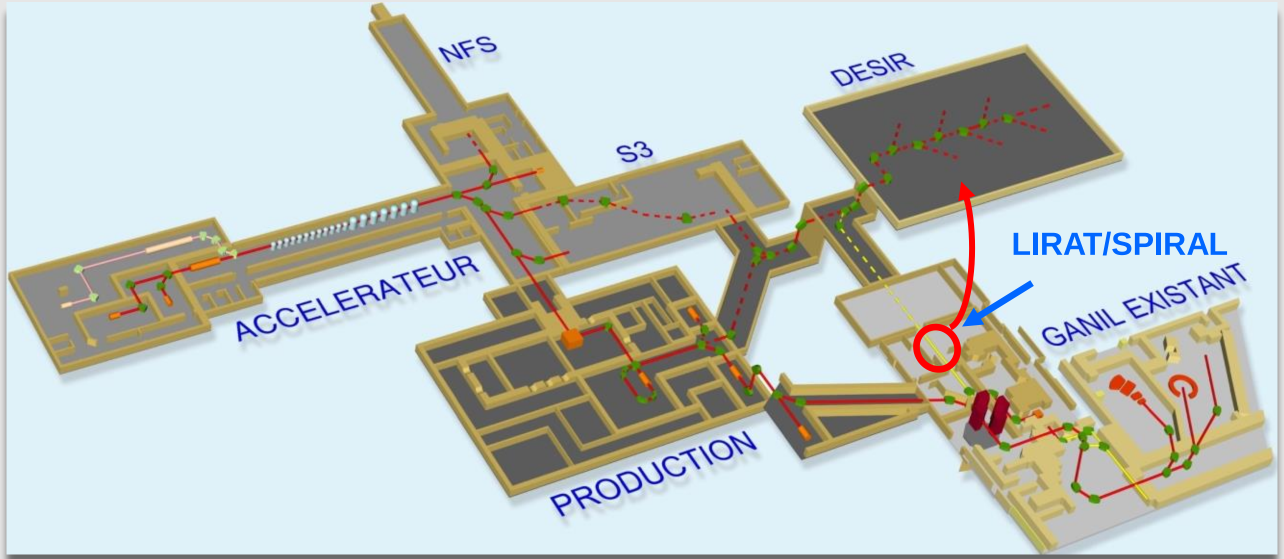
Future @ GANIL ?

- *Development of new beams @ SPIRAL*

Ion	$T_{1/2}$ (s)	Expected rate (pps)
^{21}Na	22.49	1.8E+08
^{23}Mg	11.32	4.3E+07
^{33}Cl	2.51	1.8E+07
^{37}K	1.22	1.1E+07

- Contact : Pierre Delahaye
- Available in 2016 ?

- *DESIR @ SPIRAL2 φ1+* (LoI 2011, 2014)

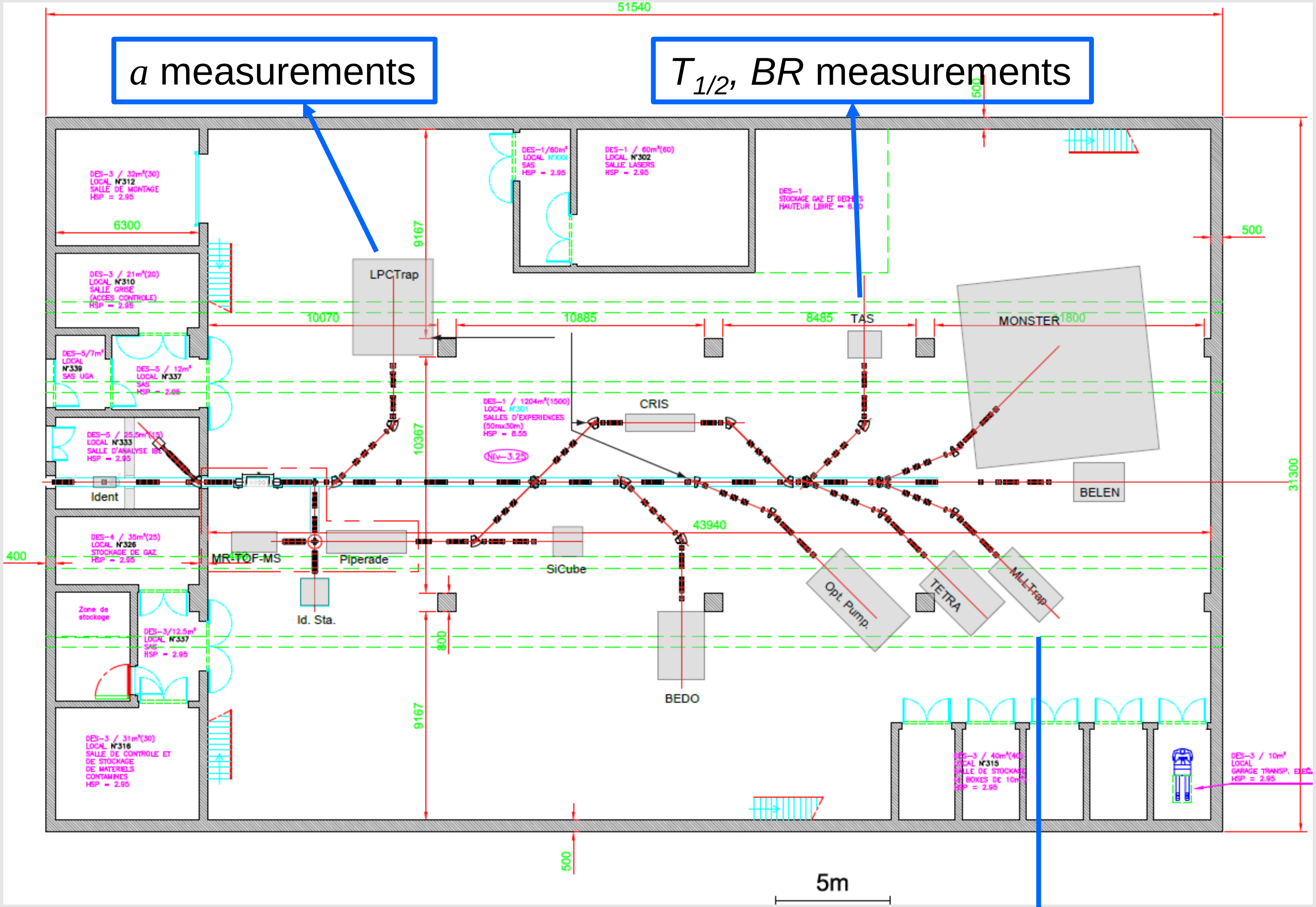


- In 2018 ?

DESIR layout (draft version)

a measurements

$T_{1/2}$, BR measurements



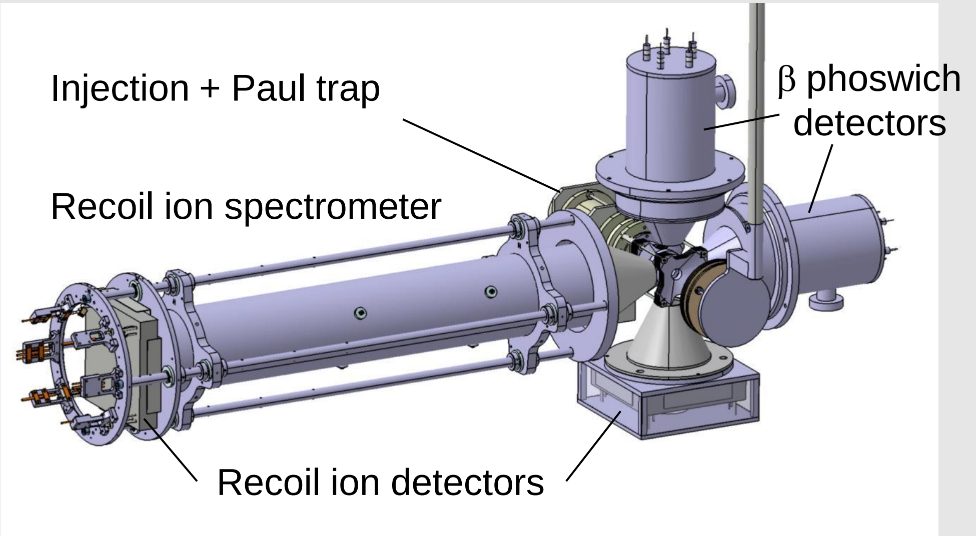
M measurements

What can we expect from a measurements ?

- Ion with rate > 1E+07 pps

Ion	$T_{1/2}$ (s)	Expected rate (pps)	Expected nb of coinc.	Estimated $a \pm \sigma_a$	New $\rho \pm \sigma_\rho$	Gain factor
^{21}Na	22.49	1.8E+08	1.7E+06	0.5587(18)	-0.7041(20)	3.6
^{23}Mg	11.32	4.3E+07	8.1E+05	0.6967(26)	0.5426(30)	new
^{33}Cl	2.51	1.8E+07	1.5E+06	0.8848(19)	0.3075(27)	new
^{37}K	1.22	1.1E+07	1.9E+06	0.6580(17)	0.5872(19)	14.2

- Estimation of coinc. (1 week):
  - Based on ^{35}Ar experiment
  - $T_{1/2}$ taken into account
  - LPCTrap → LPCTrap2
    - phoswich for β detection
    - detectors number X 2
    - FASTER DAQ system



➡ Gain in stat: factor of ~ 4

What can we expect from a measurements ?

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^{33}Cl	2.51	1.8E+07	1.5E+06	0.8848(19)	0.3075(27)	new
^{37}K	1.22	1.1E+07	1.9E+06	0.6580(17)	0.5872(19)	14.2

- Estimation of coinc. (1 week):
  - Based on ^{35}Ar experiment
  - $T_{1/2}$ taken into account
  - LPCTrap → LPCTrap2
    - phoswich for β detection
    - detectors number X 2
    - FASTER DAQ system

- Error estimation on a :
  - Based on ^{6}He experiment
  - $\sigma_{stat} = \sigma_{syst}$

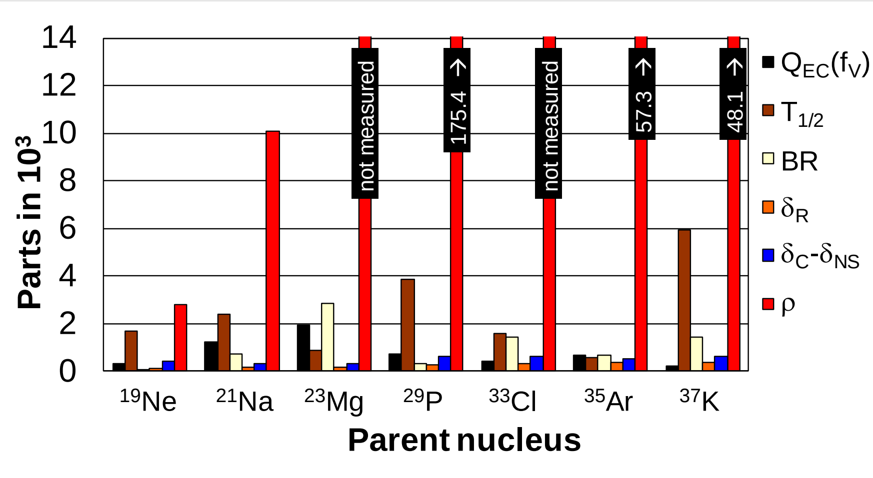
Fléchard et al., JPG38(2011)

$\rho^2 = (1-a)/(a+1/3)$
+ combination with existing results

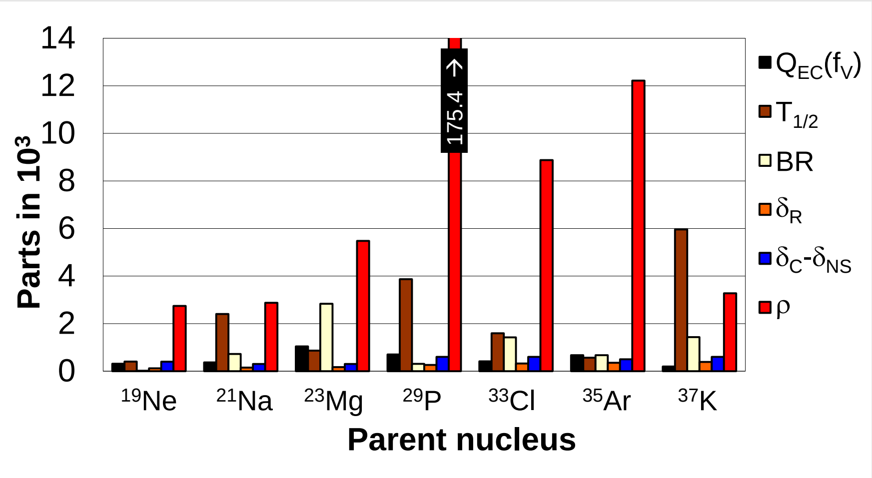
→ Gain in stat: factor of ~ 4

What can we expect from *a* measurements ?

2009

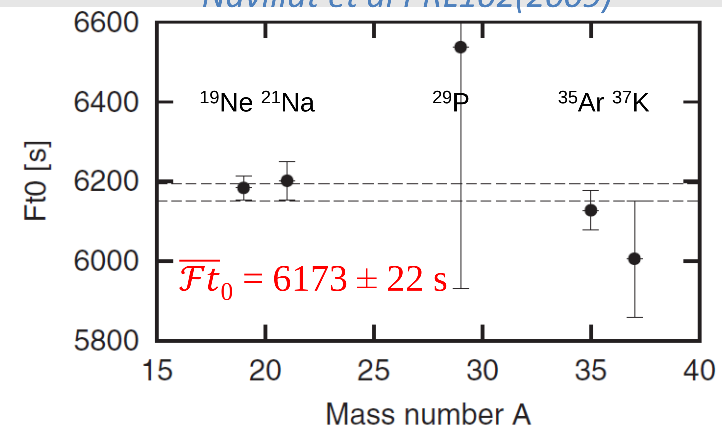


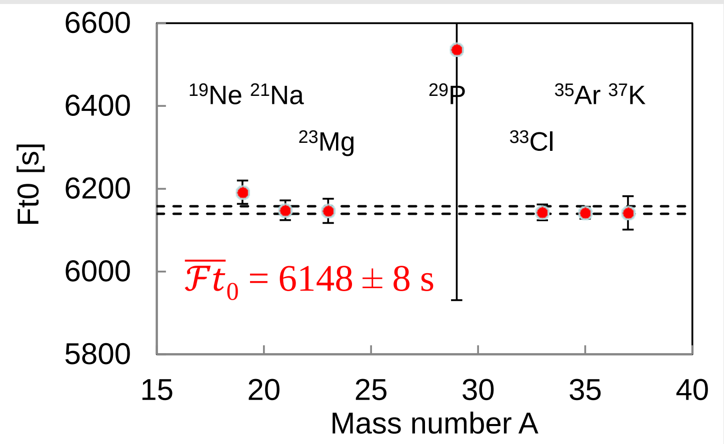
LPCTrap2 @ GANIL



Naviliat et al PRL102(2009)

$Ft0 = Ft(1+C\rho^2)$





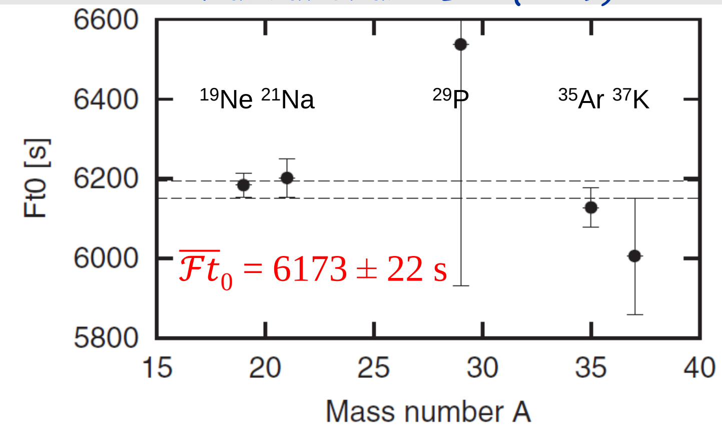
Test of CVC @ 3.6×10^{-3} level ⇨ Test of CVC @ 1.3×10^{-3} level

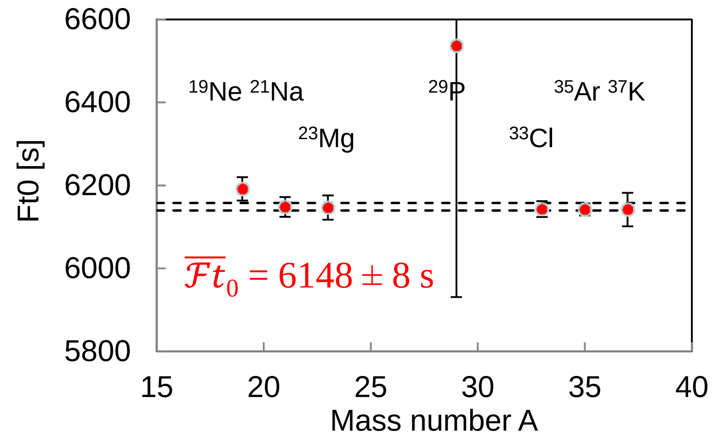
What can we expect from *a* measurements ?

2009 | **LPCTrap2 @ GANIL**

$Ft0 = Ft(1+C\rho^2)$

Naviliat et al PRL102(2009)





Test of CVC @ 3.6×10^{-3} level ⇒ Test of CVC @ 1.3×10^{-3} level

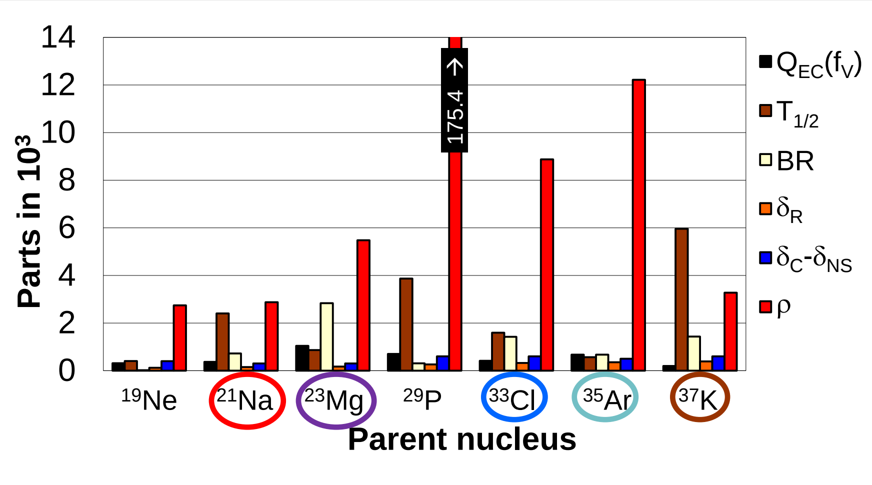
$$V_{ud}^2 = \frac{Constant}{\mathcal{F}t_0}$$

$V_{ud} = 0.9719\ (17)$ ⇒ $V_{ud} = 0.97391\ (68)$

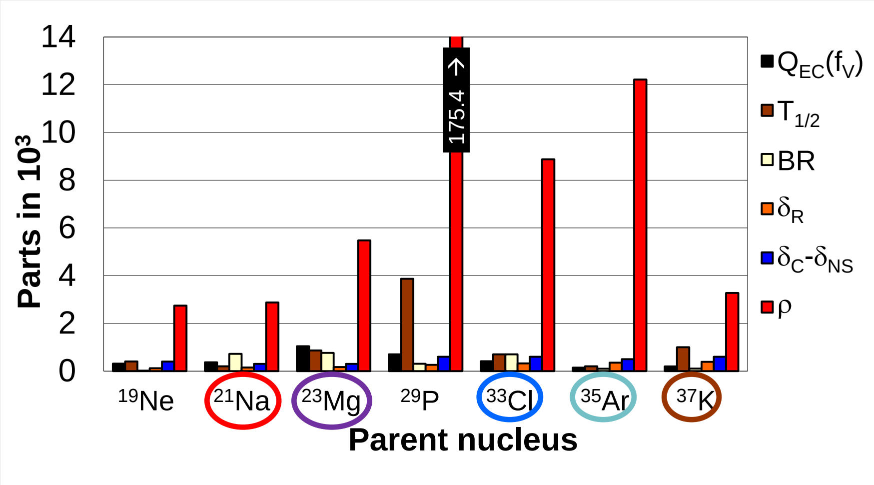
- Gain: factor of 2.5
- To be compared to $V_{ud} = 0.97425\ (22)$ from pure Fermi

What can we expect from a, $T_{1/2}$, *BR* & *M* measurements ?

LPCTrap2 @ GANIL



+ $T_{1/2}$, BR & M improvements

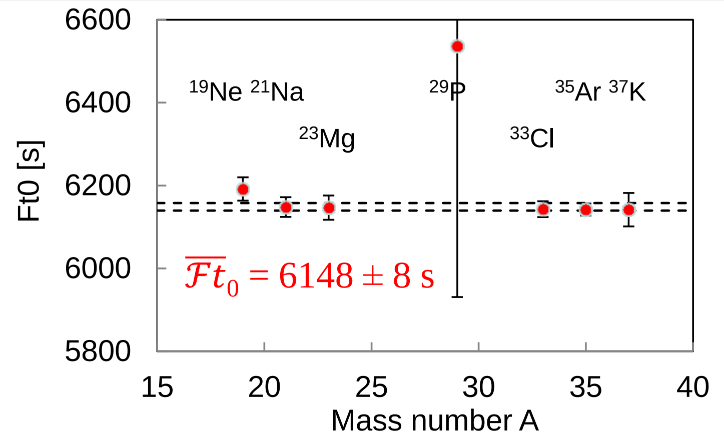


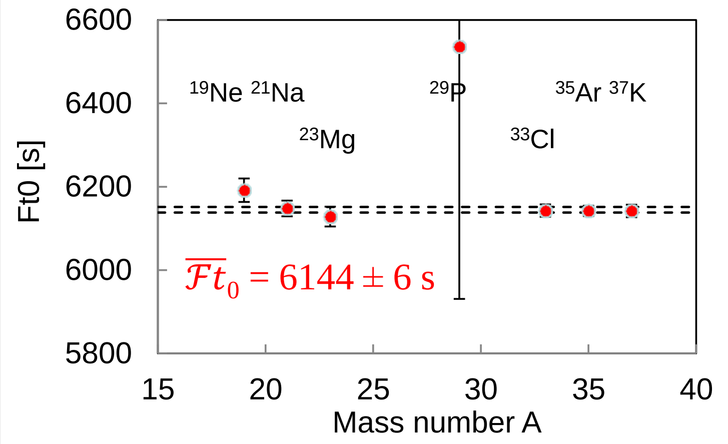
- ^{21}Na, expected gain: 10 ($T_{1/2}$) *Finlay et al @ TRIUMF 2014*
- ^{23}Mg, expected gain: 3.7 (*BR*) *Blank et al @ JYFLTRAP (performed)*
- ^{33}Cl, expected gain: 2.2 ($T_{1/2}$), 2 (*BR*) *Kurtukian et al @ SPIRAL1 ?*
- ^{35}Ar, expected gain: 2.8 ($T_{1/2}$), 6.6 (*BR*), 4.7 (*M*) *Finlay et al @ TRIUMF 2015 ?*
- ^{37}K, expected gain: 6.1 ($T_{1/2}$), 14 (*BR*) *Kurtukian et al @ ISOLDE 2015 ?*

What can we expect from a, $T_{1/2}$, BR & M measurements ?

LPCTrap2 @ GANIL

+ $T_{1/2}$, BR & M improvements



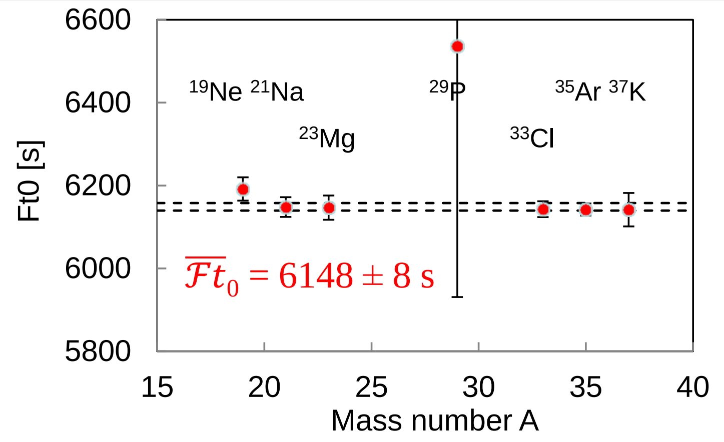


V_{ud} = 0.97391 (68) ⇨ V_{ud} = 0.97423 (49)

- Gain of a factor 1.4
- To be compared to V_{ud} = 0.97425 (22) from pure Fermi
- Best cases: ^{35}Ar, ^{33}Cl and ^{37}K

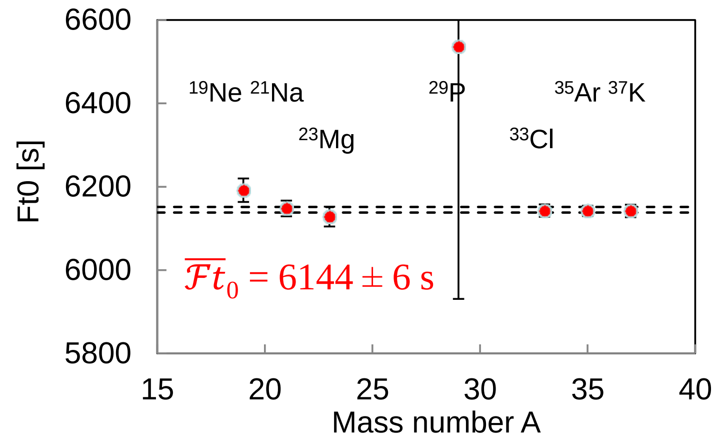
What can we expect from a, $T_{1/2}$, BR & M measurements ?

LPCTrap2 @ GANIL



$V_{ud} = 0.97391\ (68)$

+ $T_{1/2}$, BR & M improvements



$V_{ud} = 0.97423\ (49)$

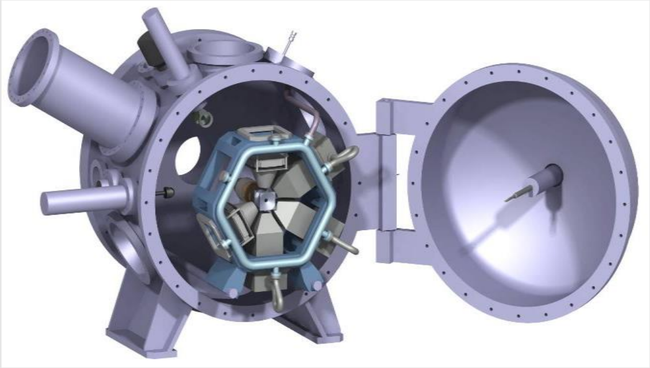
- Gain of a factor 1.4
- To be compared to $V_{ud} = 0.97425\ (22)$ from pure Fermi
- Best cases: ^{35}Ar, ^{33}Cl and ^{37}K

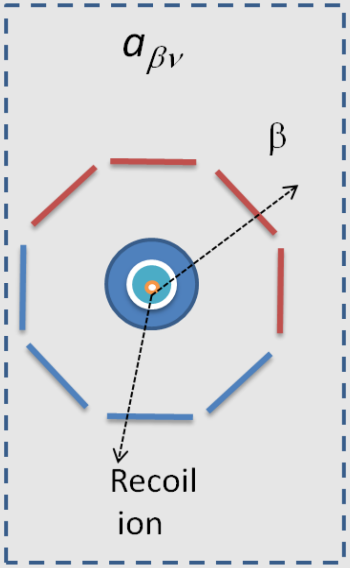
with only these 3 cases: $V_{ud} = 0.97402\ (55)$

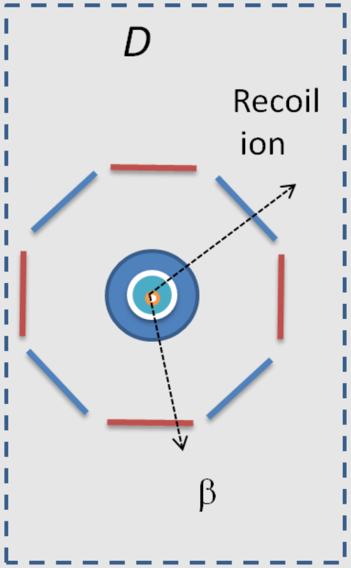
^{33}Cl, ^{37}K: good candidates for first experiments

Further development : cloud polarization

- New chamber, lasers & detectors

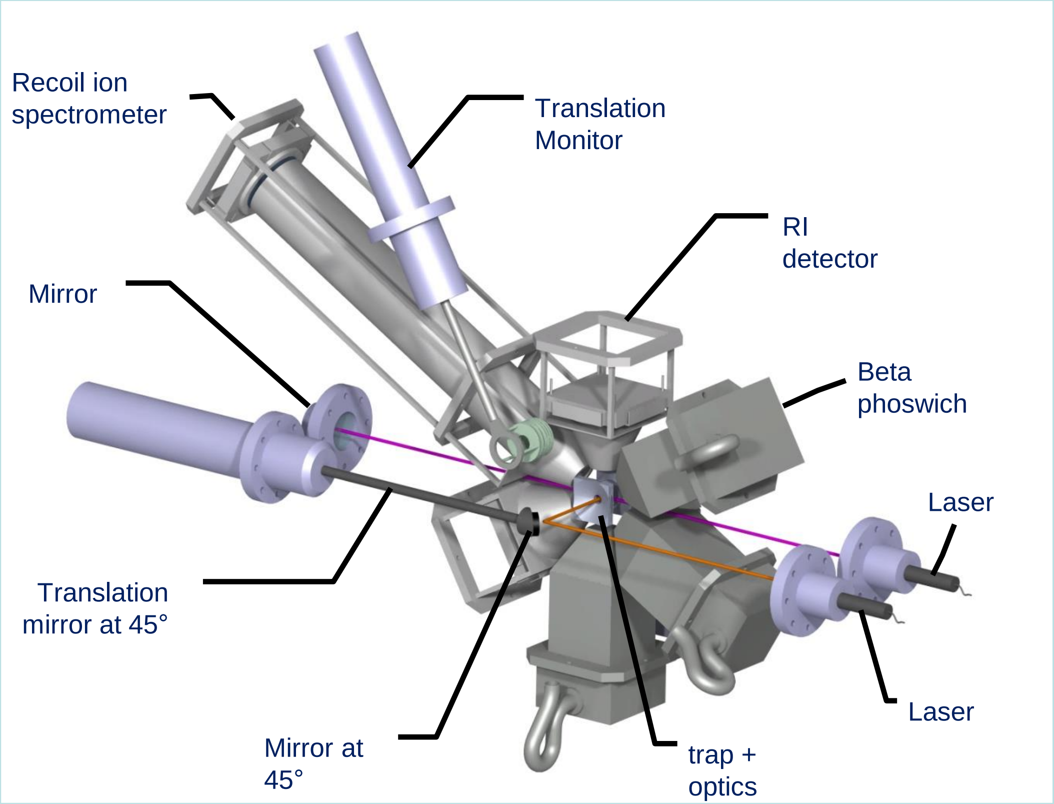






$$a_{\beta\nu}\frac{\vec{p}_e}{E_e}\frac{\vec{p}_\nu}{E_\nu}$$

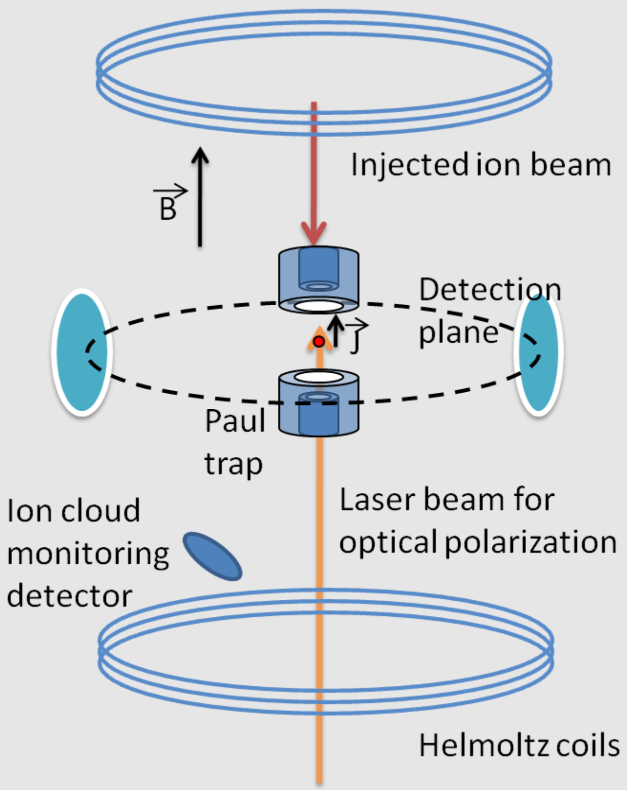
$$D\frac{\langle\vec{J}\rangle}{J}\cdot\left(\frac{\vec{p}_e}{E_e}\times\frac{\vec{p}_\nu}{E_\nu}\right)$$



- Upgrade of the detector setup :

→ *arrangement of maximum 6 detector modules according to the experiment performed*

Example : measurement of D in the decay of ^{23}Mg



- ^{23}Mg = "good" candidate :
  - Expected yield @ SPIRAL : 4.3×10^7 pps
  - Can be laser polarized as ions : optical pumping → 80%
  - Trapping : 5×10^4 ions / cycle
  - Optimized solid angle of detection

$\sigma_D < 5 \times 10^{-4}$ (assuming $\sigma_{syst} = \sigma_{stat}$)

is accessible in 1 week of beam time

Final aim → $\sigma_D < 1 \times 10^{-4}$

Current best results in nuclear decays :

^{19}Ne decay → ***D*=0.0001 ±0.0006** Calaprice et al., Hyp. Int. 22 (1985)

n decay → ***D*= (−0.94 ±1.89±0.97) 10^{-4}** Mumm et al., PRL 107 (2011), Chupp et al., PRC 86 (2012)

Conclusion

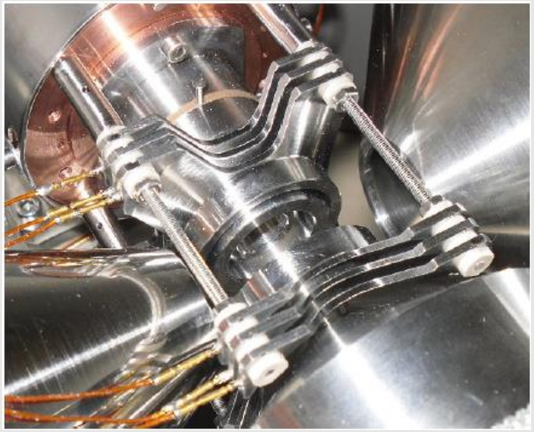
- LPCTrap
  - Transparent Paul trap for $\beta-\nu$ correlation measurements
  - Measurements performed in ^{6}He, ^{35}Ar, ^{19}Ne
    - charge state distributions : unique in 1+ ions decay
    - $\beta-\nu$ correlation coefficient :
      - development of new dedicated simulation tools (CUDA & GPU's)
      - need for data on β scattering (e^- spectrometer in Bordeaux)
      - ^{6}He pure GT decay → $(\Delta a_{GT} / a_{GT})_{\mathrm{expected}} \sim 0.6\ \%$
      - ^{35}Ar mirror decay → $(\Delta a_{m} / a_{m})_{\mathrm{expected}} \sim 0.25\ \%$

- Perspectives
  - "Short"- range plan : measurements of "a" in mirror decays at LIRAT & DESIR with LPCTrap2 using the new beams provided by SPIRAL (^{21}Na, ^{23}Mg, ^{33}Cl, ^{37}K)
    - required to improve ρ & V_{ud} deduced from mirror transitions
    - with M, T & BR improvements → "only" a factor 2.2 worse than "pure" Fermi
    - ^{33}Cl & ^{37}K : good candidates for first experiments
  - "Mid"- range plan : measurement of the triple correlation D in ^{23}Mg decay
    - cloud polarization with laser in LPCTrap of second generation
    - final aim : $\sigma_D < 1\times10^{-4}$

Thank you …

LPC Caen:

Gilles Ban
Dominique Durand
Xavier Fabian
Xavier Fléchard
Etienne Liénard
François Mauger
Gilles Quéméner



GANIL: Pierre Delahaye
Jean-Charles Thomas

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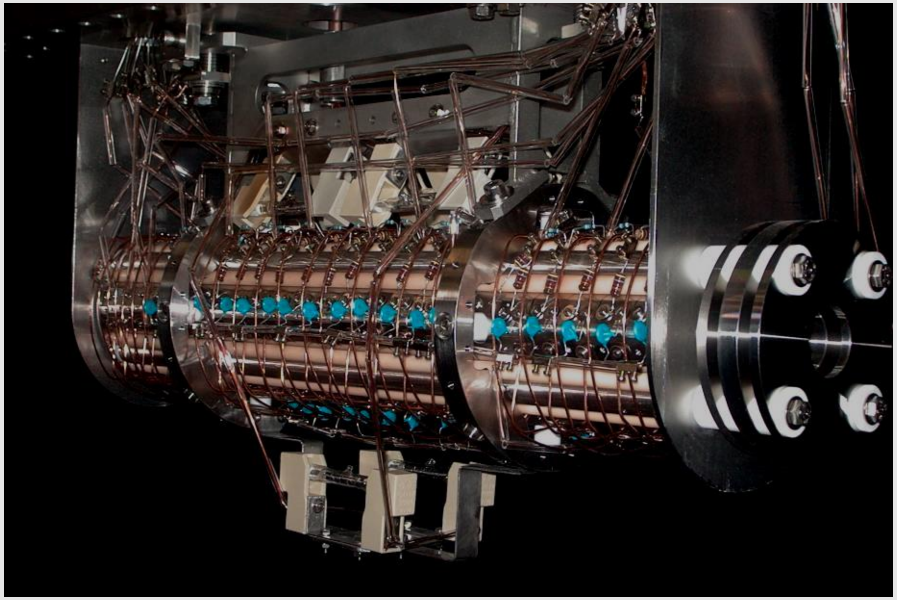
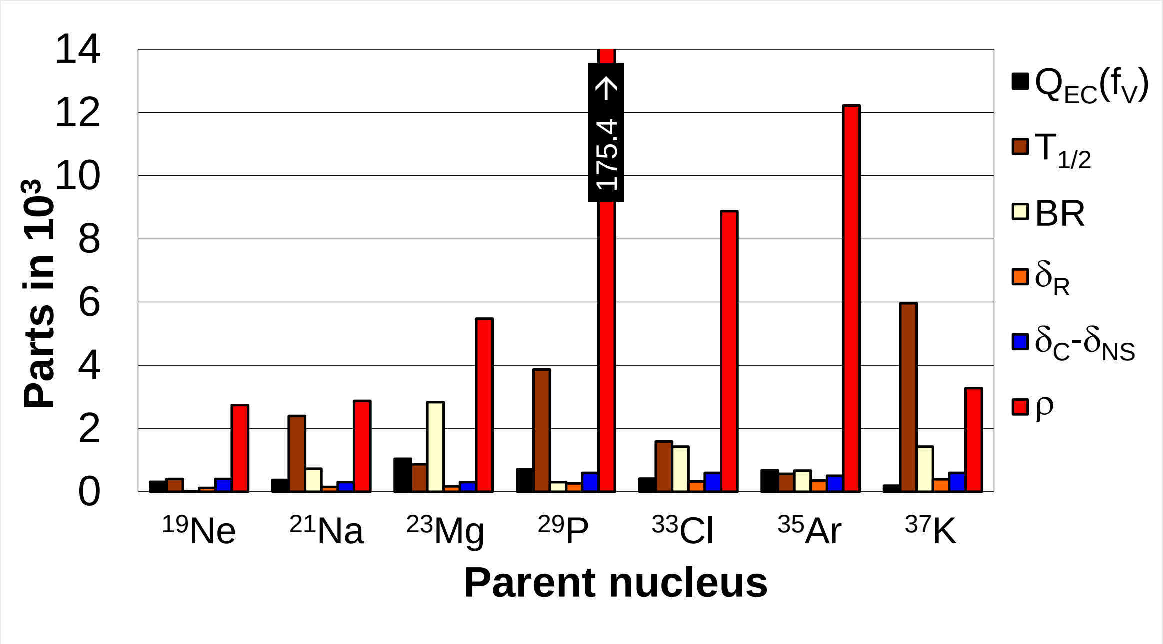
CELIA: Bernard Pons
Baptiste Fabre

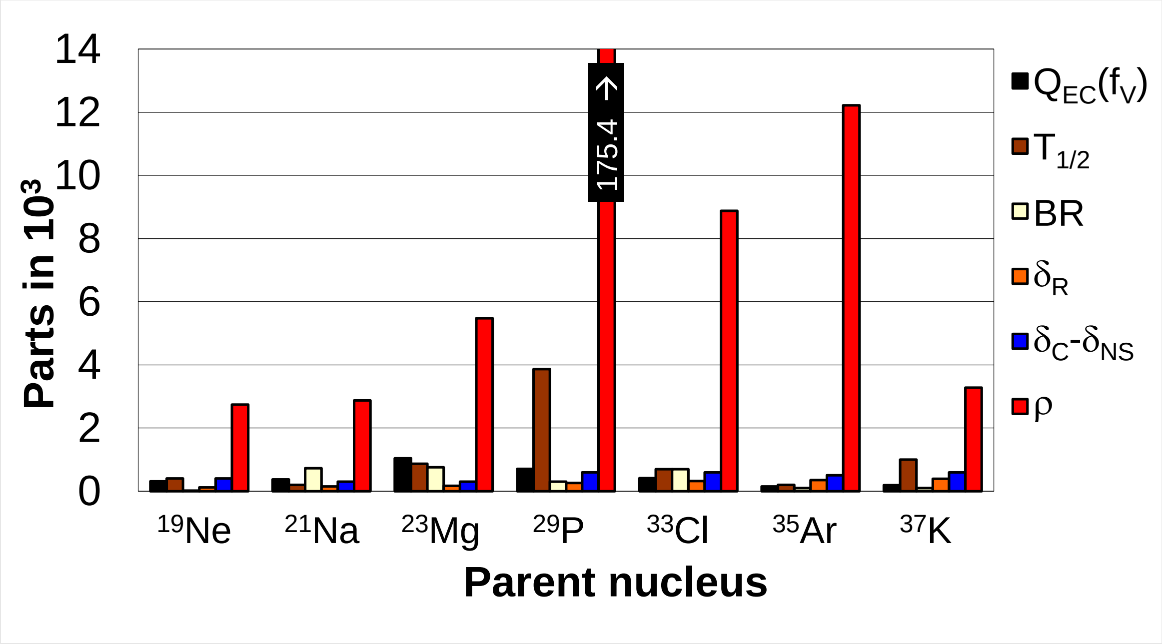
NSCL MSU: Oscar Naviliat-Cuncic

IKS KUL: Claire Couratin
Paul Finlay
Tomica Porobic
Nathal Severijns
Philippe Velten



and the LPC & GANIL technical staffs ….


14
12
10
8
6
4
2
0
Parts in 10³
175.4
Q_EC(f_V)
T_1/2
BR
δ_R
δ_C-δ_NS
ρ
19Ne
21Na
23Mg
29P
33Cl
35Ar
37K
Parent nucleus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23Mg
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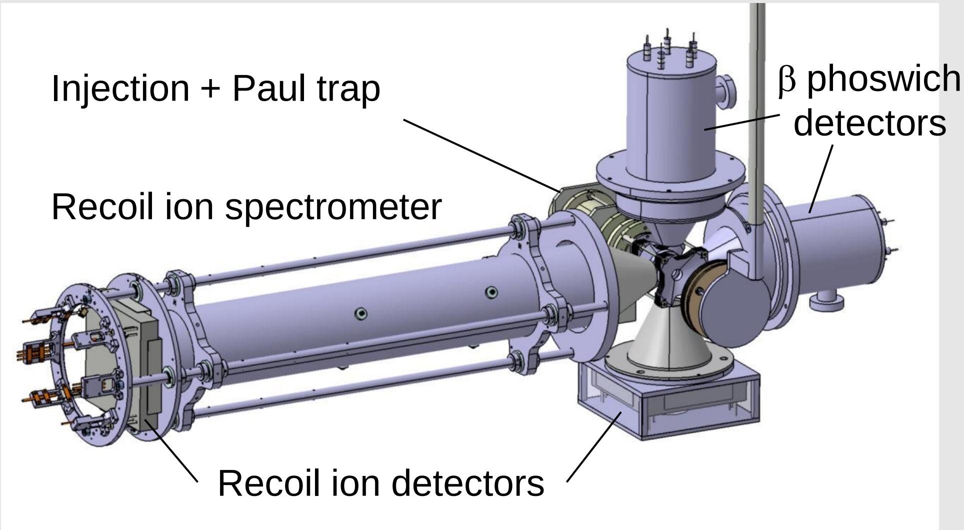
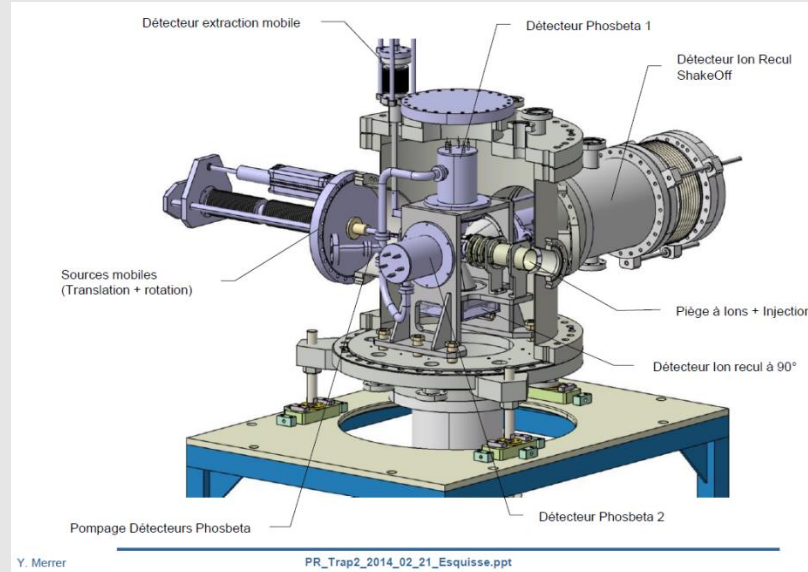
33Cl
35Ar
37K
Parent nucleus

LPCTrap2 = minimal upgrade of LPCTrap



In the current chamber

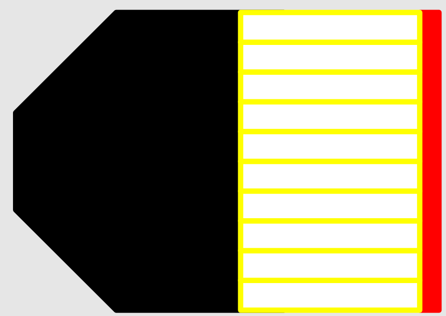


β phoswich:

- association of 2 plastic scintillators (thin & thick) with ≠ decay constants and read by a single PM
  → β-γ discrimination
- thick plastic = scintillating fibers and PM sensitive to position
  → β location

First tests will start soon …

ΔE: > 5.5 MeV 200 keV
3 cm 1 mm

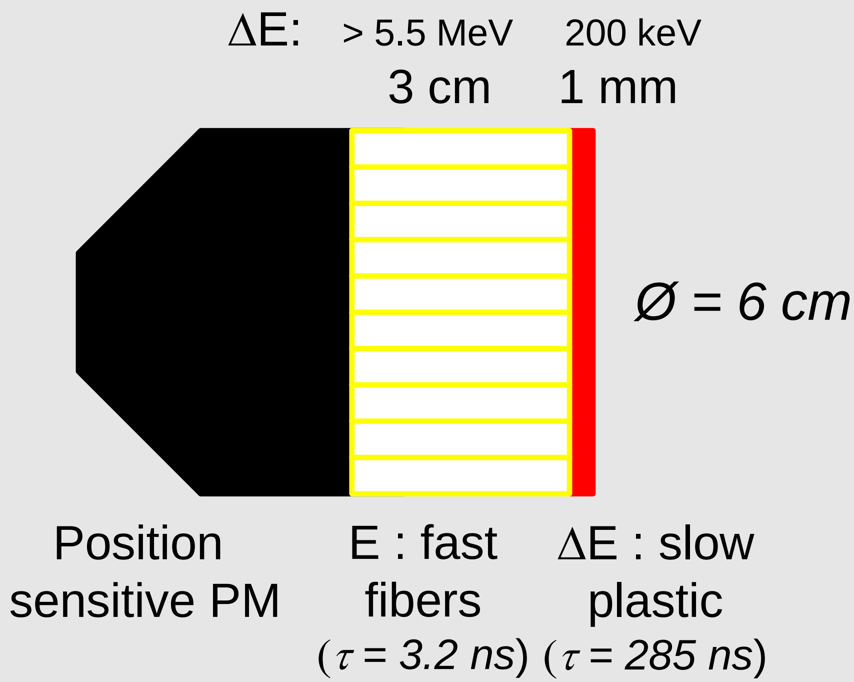


Ø = 6 cm

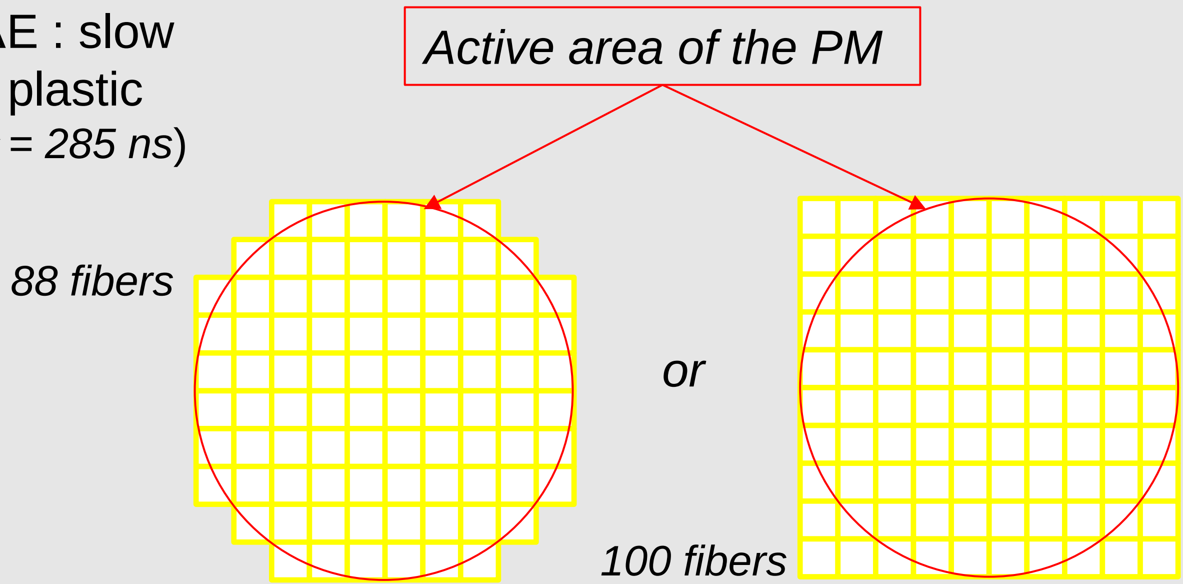
Position sensitive PM	E : fast fibers (τ = 3.2 ns)	ΔE : slow plastic (τ = 285 ns)

β phoswich: progress

- Further tests: with scintillating fibers

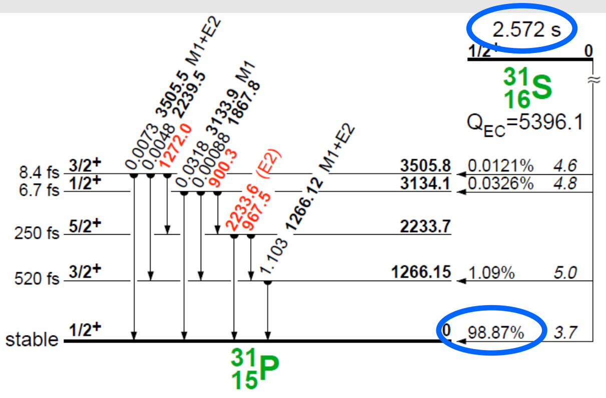


- Square section of 0.5 cm side
- Direct light
- No glue → system assembly ?



- Which beam for a day-1 experiment ?

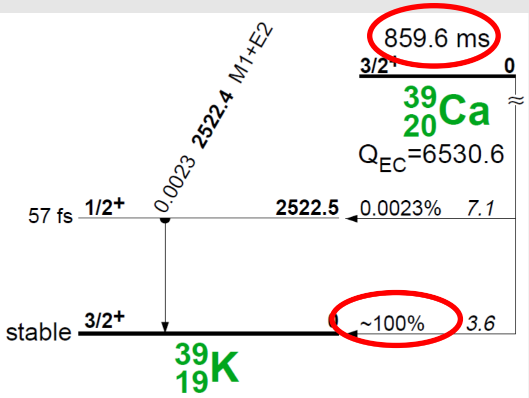
LoI 8: Status in 2011



^{31}S or ^{39}Ca

SPIRAL2
I ~ 2 10^8 pps

SPIRAL1
I ~ 4 10^7 pps



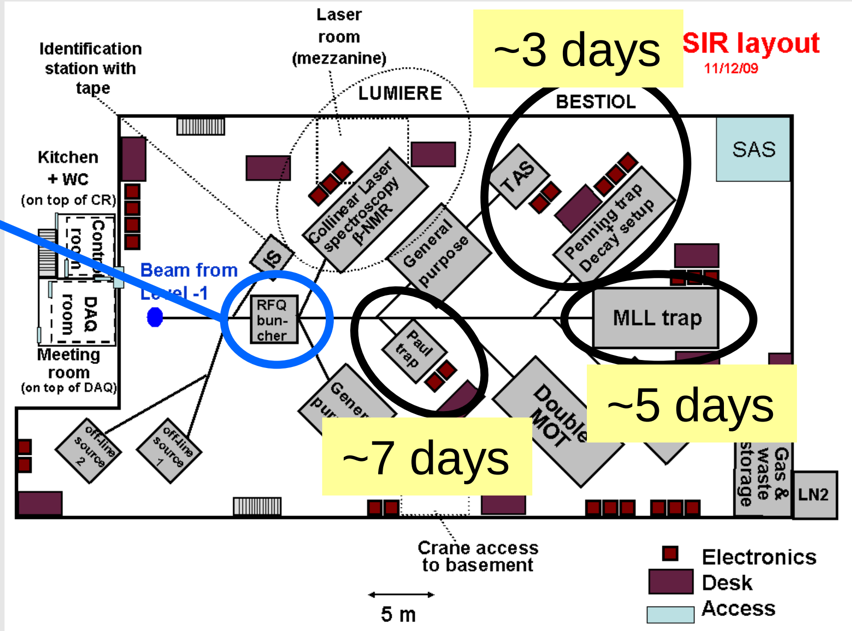
M (f_V), $T_{1/2}$, a(ρ) measurements

Bunches sent alternatively in the 3 setups

⇓

Optimization of the beam time :

(7+5+3)days ~ 12days !



3 experiments in 1 shot !!

without "lost" beam period

⇓

Final request ~ 12 days

LoI to DESIR March 2014

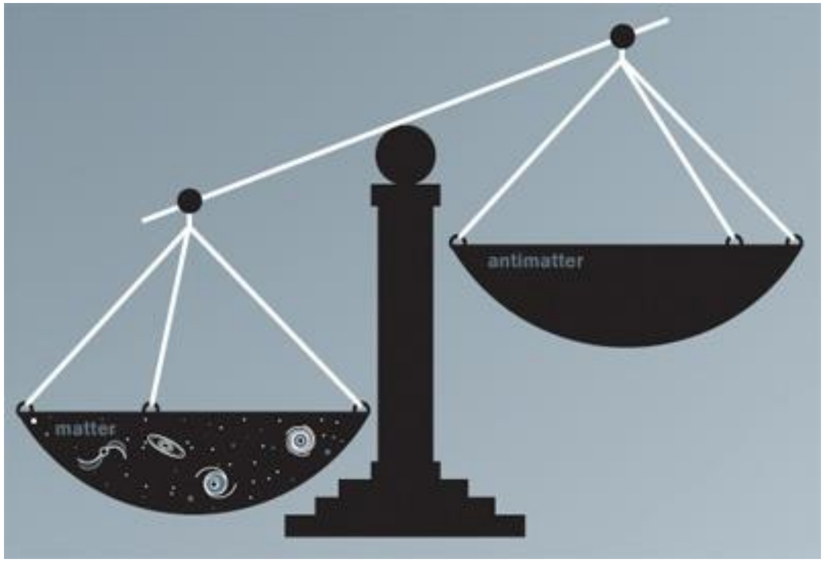
Test of the Time reversal symmetry in the beta decay of ^{23}Mg and ^{39}Ca using an in-trap polarization method at DESIR

P. Delahaye, E. Lienard, D. T. Yordanov , N. Severijns, P. Chauveau, JC Thomas, F. De Oliveira, G. F. Grinyer, N. Lecesne, R. Leroy, X. Fléchard, G. Ban, X. Fabian, G. Neyens **et al**

GANIL – LPC Caen – IPN Orsay – IKS Leuven collaboration

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



Precision measurements of the triple correlation *D*

- A non-zero *D* can arise from CP violation
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  - 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, $\boldsymbol{D_n = (-0.94 \pm 1.89 \pm 0.97)\ 10^{-4}}$, 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: $\sigma_D \leq 10^{-4}$

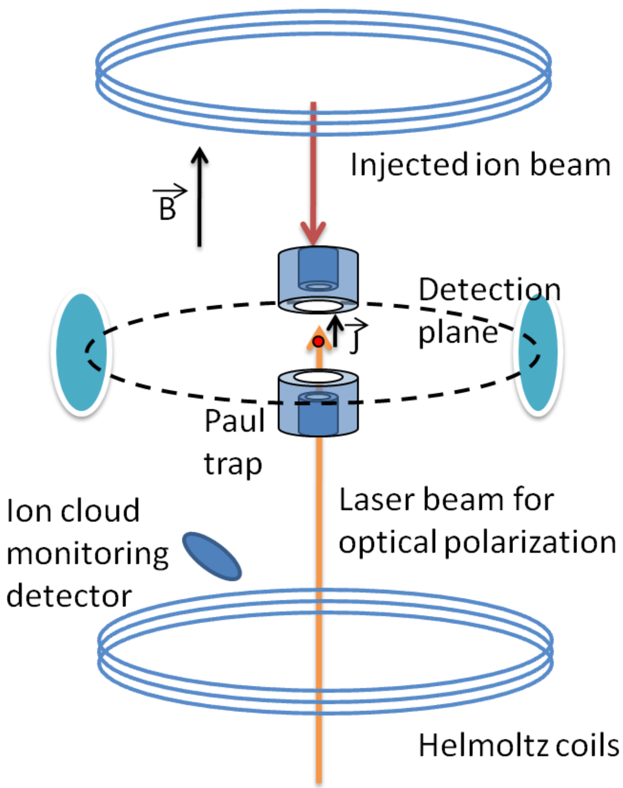
Making use of intense RIBs at SPIRAL, polarized by LUMIERE , and of a specific arrangement of LPCtrap!

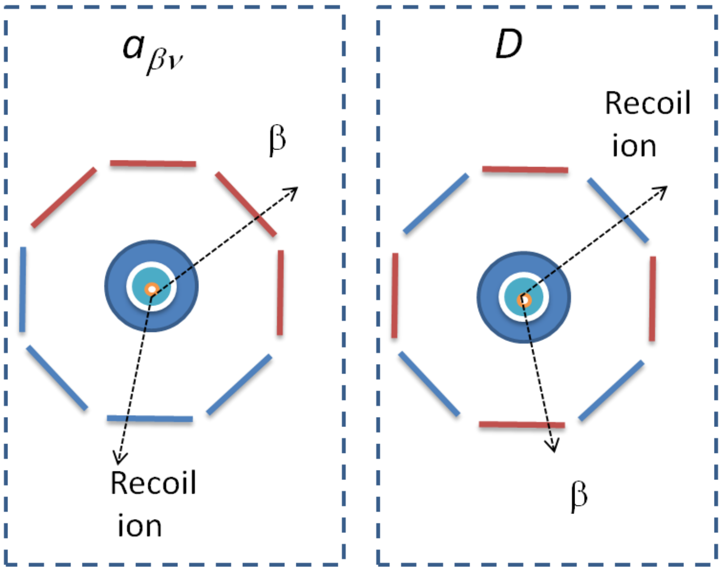
Possible candidates

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}5pps (estimated!)	$4.7\ 10^{-5}$

Can be laser polarized as ions!

Experimental setup





β–ν correlation

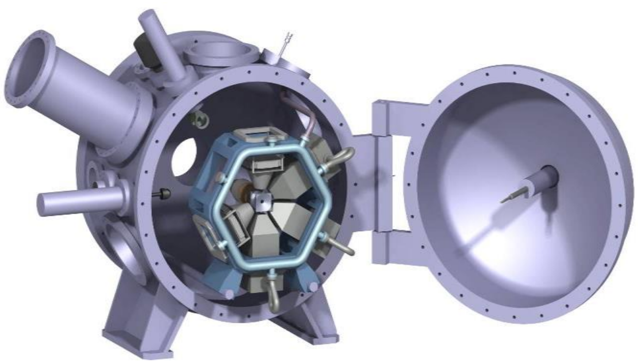
Triple correlation

$$a_{\beta\nu}\frac{\vec{p}_e}{E_e}\frac{\vec{p}_\nu}{E_\nu}$$

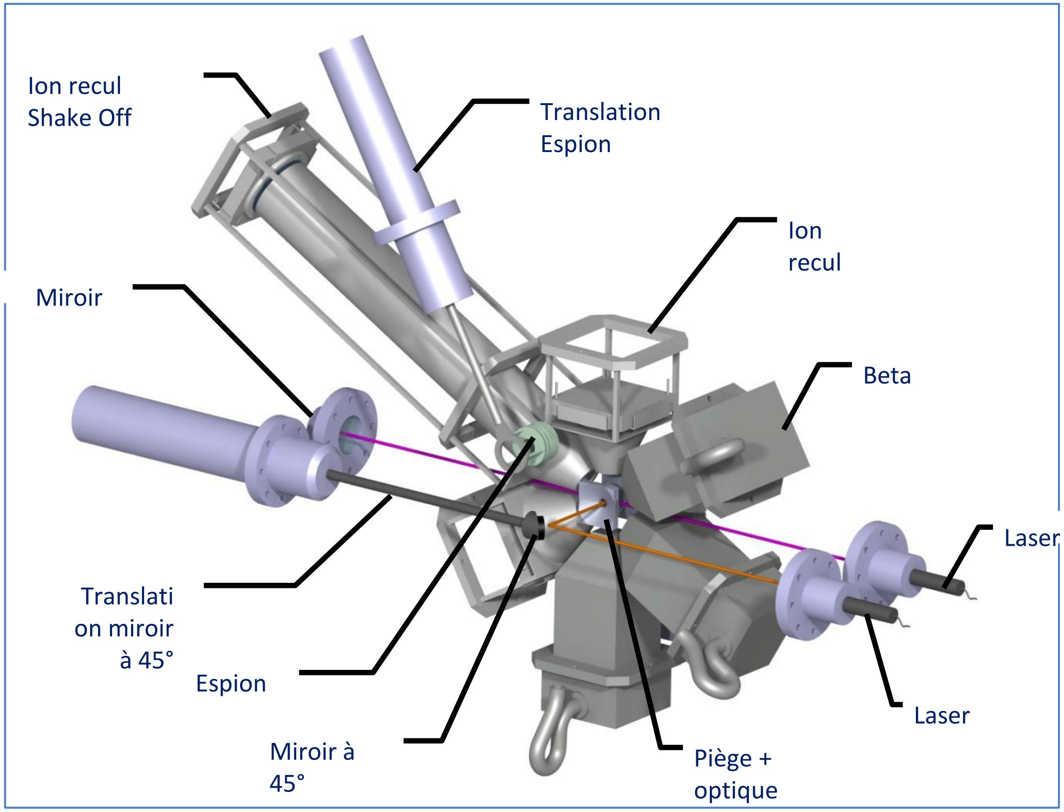
$$D\frac{\langle\vec{J}\rangle}{J}\cdot\left(\frac{\vec{p}_e}{E_e}\times\frac{\vec{p}_\nu}{E_\nu}\right)$$

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

Possible upgrades of the LPCtrap detector and trapping setup



Upgrade of the detector setup
3 telescopes instead of 1
from 5‰ to 1‰ precision on $a_{\beta\nu}$



Simpler beta and recoil ion detectors may be used

Statistical considerations

- 5.10^4 ions trapped / 200ms
  - Ok for $^{23}Mg^+$
  - Some R&D for $^{39}Ca^+$
- 80% polarization
- Upgraded / suitable detector setup
  - 8 detectors instead of 2 → 16x higher solid angle coverage
- Sensitivity on *D*: $\sigma_D \approx 4/\sqrt{2N}$ with N the number of coincidences
- 30% time for interruptions

1 week of beam time:

$\sigma_D \approx 4.310^{-4}$ ^{23}Mg

$\sigma_D \approx 1.310^{-4}$ ^{39}Ca

Stat+syst (both equal)