WISArD

Weak Interaction Studies with ^{32}Ar Decay

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Search for Physics Beyond the Standard Model…

The V-A theory of Electroweak Interaction [1]

- Vector-axial vector coupling constants: $C_V \equiv 1 \qquad C_A = -1.27$
- Maximal parity violation: (only left-handed ν) $C_V = C'_V \qquad C_A = C'_A$
- No scalar (S) or Tensor (T) components: $C_S = C'_S = C_T = C'_T = 0$ ➪ **possible exotic currents ?**
- Time reversal conservation: *all Cs are real*

…with β–ν Correlation in Nuclear β Decay

Nuclear β decay rate for non polarized nuclei

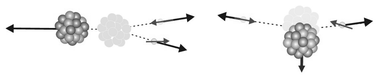
$$dW = dW_0\left(1 + a\frac{\mathbf{p}_e \cdot \mathbf{p}_\nu}{E_e E_\nu} + b\frac{m_e}{E_e}\right)$$

β–ν correlation coefficient — Fierz interference coefficient

➪Best measurement of a_F compatible with SM at 0.45% [2]

Pure Fermi transition ΔJ=0 S=0

$$a_F \cong 1 - \frac{|C_S|^2 + |C'_S|^2}{|C_V|^2} \qquad b^F \approx \pm Re\left(\frac{C_S + C'_S}{C_V}\right)$$

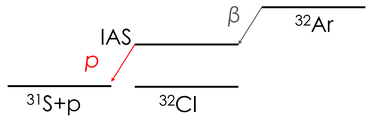


SM : Vector (C_s=C_s'=0) **BSM** : Possible Scalar

Nuclear Recoil Measurement with β–Delayed p Emitter ^{32}Ar [3]

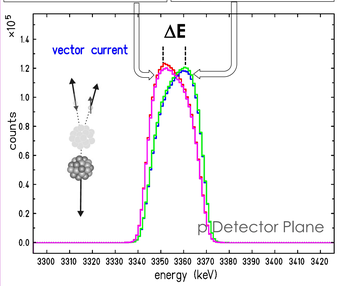
Kinematic effect in β delayed p emission

- Nuclear recoil from β emission : ~ keV
- β delayed p emission : ~ 3 MeV
- IAS : Γ ~ 20 eV⇔$T_{1/2}$ ~ 10^{-17}s ➪ p emission in flight
- kinematic *shift* in p detector plane between p emitted in parallel/opposite direction to the β

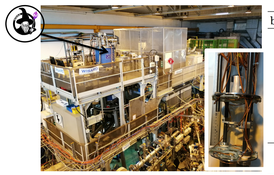


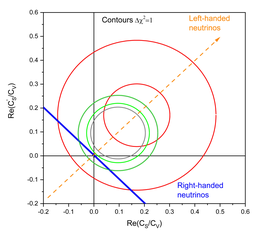
Proof-Of-Principle Experiment : nov. 2018 [4]

p and β emitted in parallel directions | p and β emitted in opposite directions



ΔE is proportional to a_F and b_F



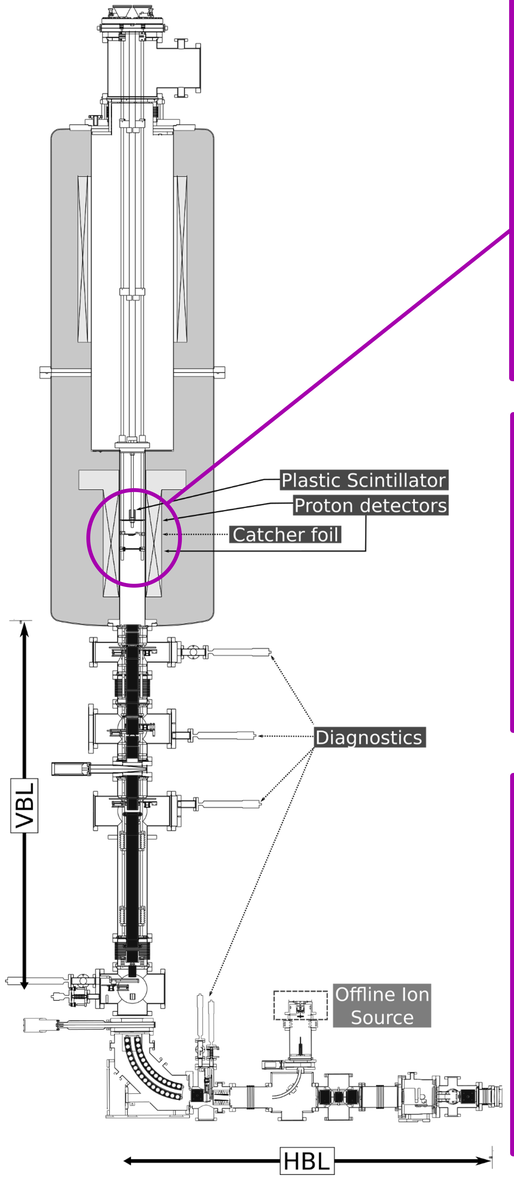


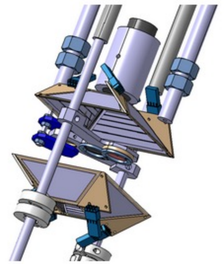
	Source	Uncertainty	$\Delta\tilde{a}_{\beta\nu}(10^{-3})$
background	false coinc.	8%	< 1
proton	detector calibration	0.2%	2
	detector position	1 mm	< 1
	source position	3 mm	3
	source radius	3 mm	1
	B field homogeneity	1%	< 1
	silicon dead layer	0.3 μm	5
	mylar thickness	0.15 μm	3
positron	backscattering	10%	15
	threshold	12 keV	8
total			19

$$\Delta E_F = 4.49(3)\,\text{keV}$$
$$\tilde{a}_F = 1.007(32)_{\text{stat}}(25)_{\text{syst}}$$

- 3rd most precise measurement of $\tilde{a}_F$
- account of major sources of systematic errors
- access to Gamow Teller transitions

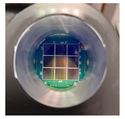
➪**WISArD : 1‰ level on a_F and b_F**





Proton Detectors :
- Two hemispheres covering a 40% solid angle
- 4 actively cooled SSSSD per hemisphere
- 10 keV resolution @ 3 MeV
- dead layer of ~60nm

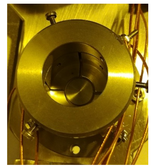
Beta detector :
- plastic scintillator coupled to a 9 SiPM array
- 4 T magnetic field to ensure ~50% detection efficiency
- ~10 keV detection threshold
- 500 nm thick mylar catcher foil

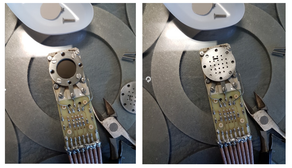


➪ high proton detection sensitivity with maximum solid angle to increase statistics
➪ thin catcher foil and beta detection threshold as low as possible to minimize systematics due to backscattering

Beam lines and Magnet
- Magnetic field homogeneity measured down to 0.1 mT
- high transmission through the HBL and VBL
- Segmented Faraday Cups in VBL
- MCP + resistive anode for beam implantation profile characterization

➪ improve statistics and charaterize systematics on proton detection due to the beam position



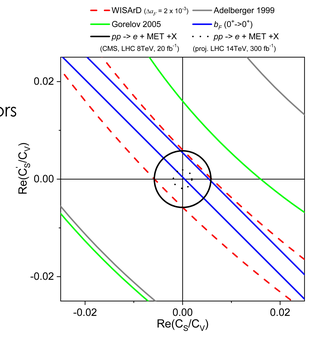


Next data taking : fall 2021 + spring 2022

Beam time
- 6 days of ^{32}Ar
- 0,5 days of ^{33}Ar for calibration of the proton detectors
- 1,5 days of stable beam for beam line tuning

Expected uncertainty on $\tilde{a}_F$ and b_F : 0.2%

➪ 3×10^7 β-p correlated events to reach this level of precision and be competitive with future search at LHC [5]



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[5] M. Gonzalez-Alonso et al, 2019, Prog. Part. Nucl. Phys. **104**, 165