KU LEUVEN

Institute for Nuclear and Radiation Physics

Towards a beta spectrum shape measurement

S. Vanlangendonck,[1†] D. Atanasov,[2] V. Araujo-Escalona,[1] P. Alfaurt,[3] P. Ascher,[3] B. Blank,[3] L. Daudin,[3] L. De Keukeleere,[1] X. Fléchard,[4] M. Gerbaux,[3] J. Giovinazzo,[3] S. Grévy,[3] L. Hayen,[1] T. Kurtukian-Nieto,[3] E. Liénard,[4] G. Quéméner,[4] M. Roche,[3] N. Severijns,[1] M. Versteegen,[3] and D. Zakoucky[5]

[1]KU Leuven (Belgium) [2]CERN (Switzerland) [3]CENBG (France) [4]LPC Caen (France) [5]Rez (Czech Republic)

[†]simon.vanlangendonck@kuleuven.be

Motivation

Beyond standard model physics

$$N(W)dW \propto 1 + \frac{\gamma}{W} b_{Fierz}$$

with $\gamma = \sqrt{1-(\alpha Z)^2}$

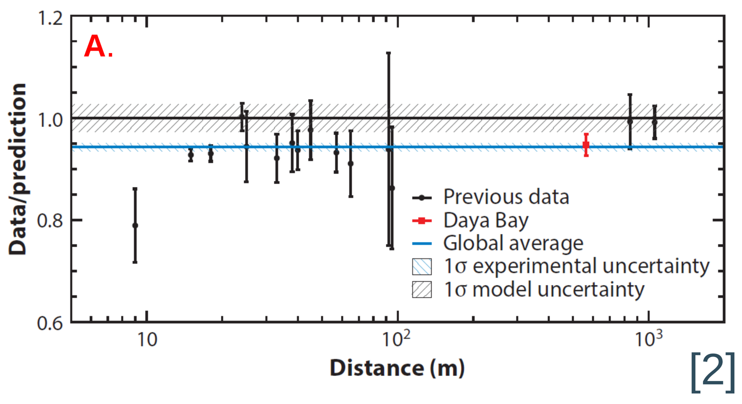
Tensor currents: $b_{Fierz}^{GT} = Re\left(\frac{C_T + C_T'}{C_A}\right)$

Scalar currents: $b_{Fierz}^{F} = Re\left(\frac{C_S + C_S'}{C_V}\right)$

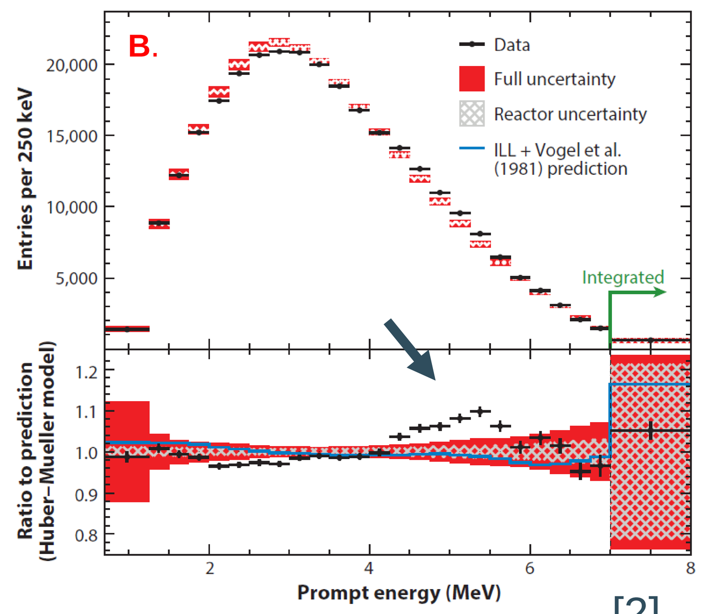
Reactor neutrino anomaly

The QCD influence on β-decay (dominated by Weak Magnetism) has never been measured for mass A>70

A. 6% and 3σ data/prediction deficit in neutrino #'s emerging from a reactor
B. Bump in the same ratio in the neutrino energy spectrum



[2]



[2]

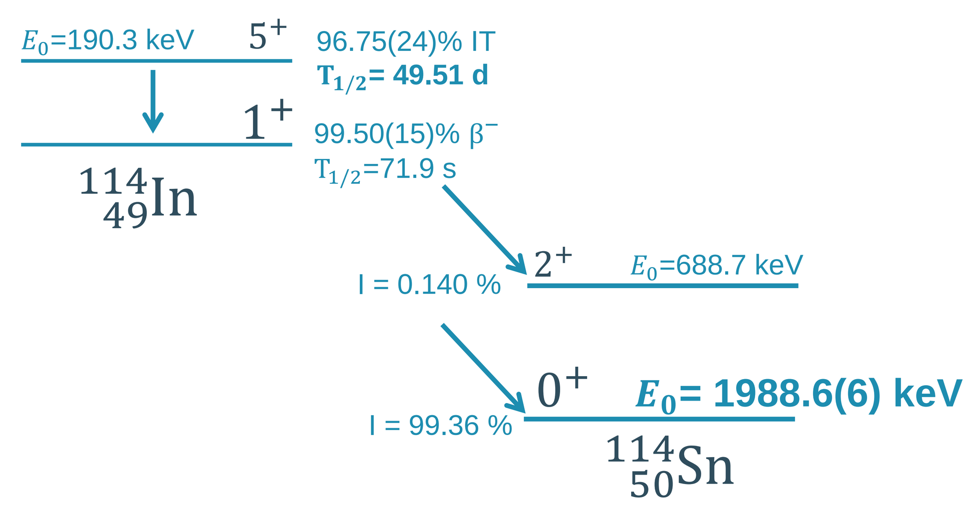
Shortcomings in predictions?
Effect of weak magnetism?

The spectrum shape

Analytical SM description [1]

- ✓ Phase space factor
- ✓ Fermi function + corrections
- ✓ Influence of nuclear structure
- ✓ Radiative corrections
- ✓ Atomic and molecular effects

^{114}In: allowed Gamow-Teller transition



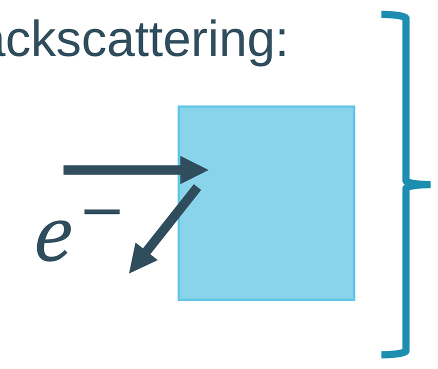
Difficulties

Precise measurement of the electron energies:

Energy loss (source): Detector dead layer:

Rely on technical progress and improvement in simulations

Backscattering:

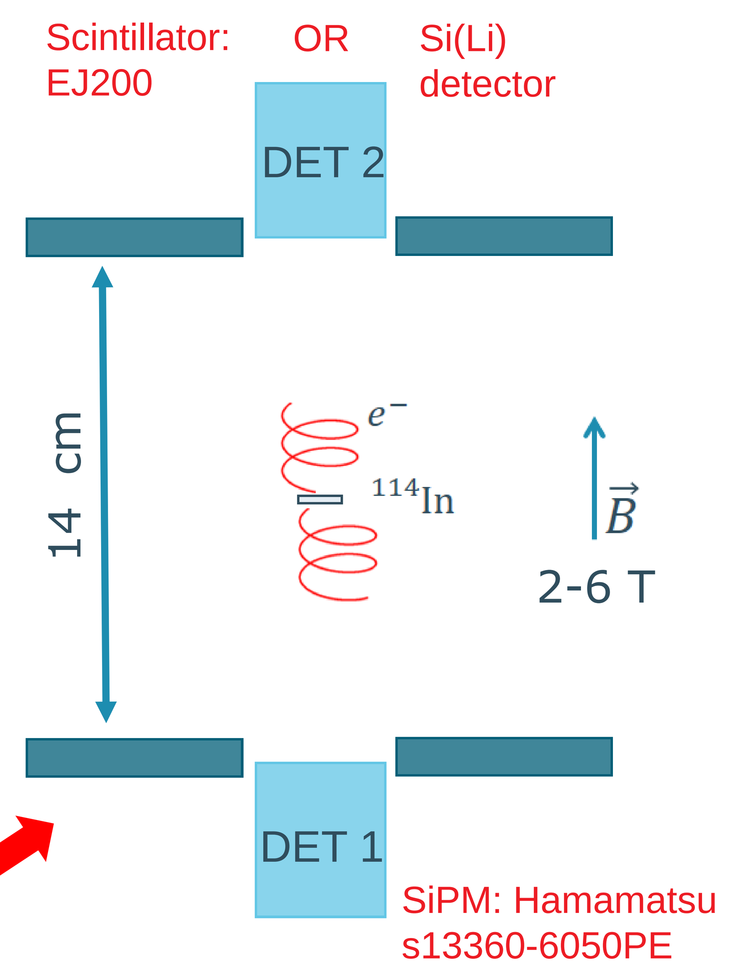


Intrinsic problem!

Partial energy deposition

➡ use WISArD

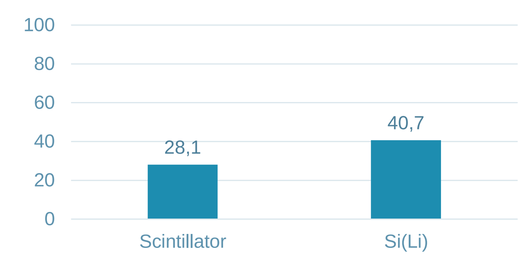
The WISArD's properties



Located at ISOLDE/CERN

4π solid angle

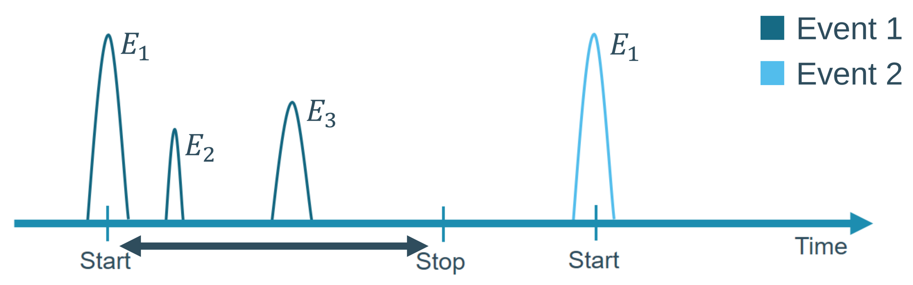
- ✓ High statistics
- ✓ BUT backscattering probability is even higher due to grazing angles



Backscattering probability

Limiting the backscattering effect

- ✓ Backscatters are not lost: **closed system** (magnetic field)
- ✓ Add E-signal ($E_1, E_2, \ldots$) of both detectors in an integration time window
- ✓ Energy loss is limited



Fixed integration time = 250 ns

Proposed analysis

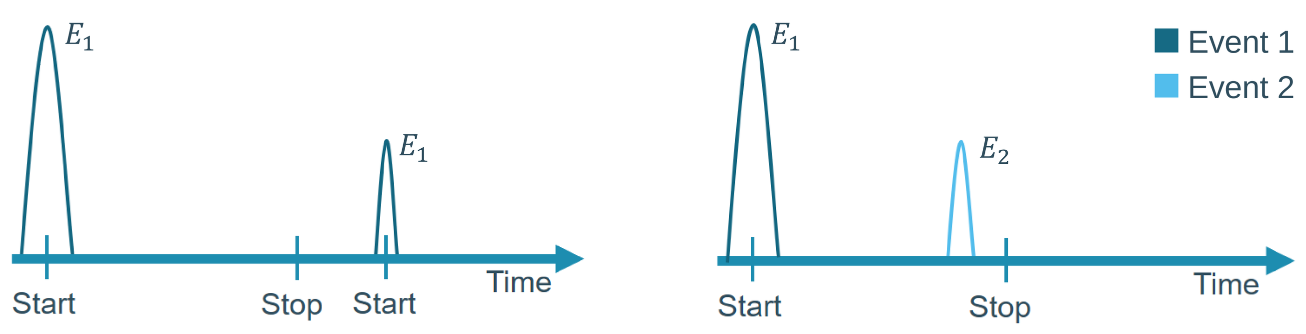
Fit the experimental spectrum to theory⊗response

Estimate systematic uncertainties

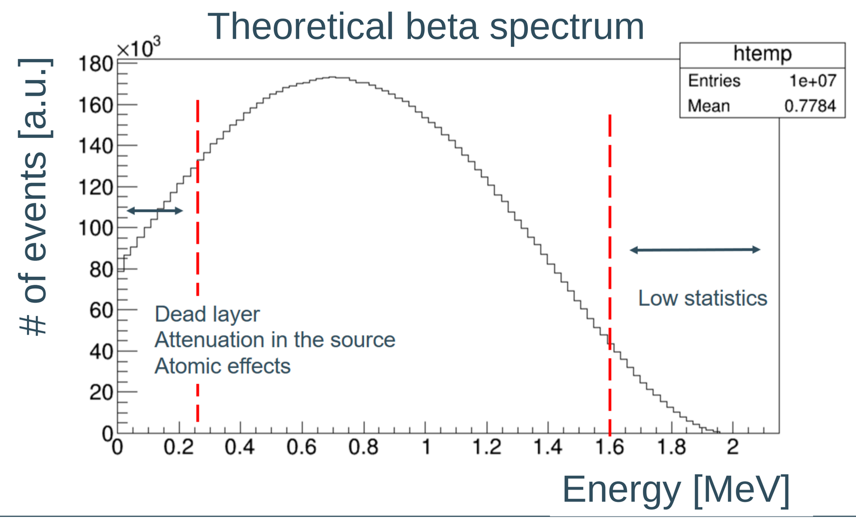
Geant4

Limit the effect of the integration time:

Fake Event ($\approx 10^{-4}$) Pile-up Using 1kBq: $< 2.5 \times 10^{-4}$



Determine optimal fit window:



Conclusion/outlook

Feasibility study with Geant4 is finished and motivates us that good results can be expected

A precision of 10^{-3} on the spectrum shape is needed to extract Weak Magnetism

Detector preamp is under preparation (CENBG) and should be ready in short notice

First measurement of the QCD influence on the weak interaction in this mass range

References

[1] *Beta Spectrum Generator: High precision allowed β spectrum Shapes.* L. Hayen et al. 2019
[2] *Reactor Neutrino Spectra* A. Hayes and P. Vogel. 2016