OPTIMIZATION OF ELECTRON SPECTROMETER IN LENS-MODE OPERATION

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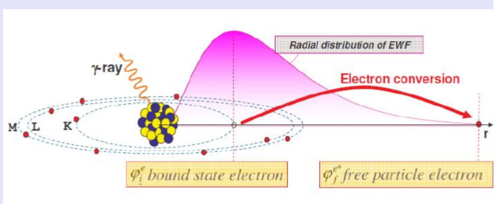
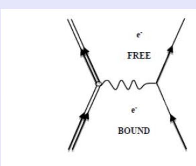
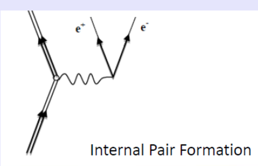
Scientific Motivation

- The atomic nuclei of an excited nucleus is usually relieved by emitting gamma rays, however, in some cases the an orbital electron is emitted due the overlapping of the nuclear wavelength with that of the orbital electron close to the nucleus.





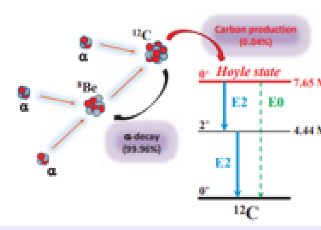


Transition rates

$$\Gamma rad = \Gamma_\gamma + \Gamma_{CE} + \Gamma_{IP}$$

For example, the total rate of ^{12}C producing decays from the Hoyle state depends directly on the radiative width, Γrad, which includes the width for gamma emission (Γ_γ), internal conversion (Γ_{CE}), and pair production (Γ_π) [1].

$$\Gamma_{rad} = \Gamma_\gamma^{E2} + \Gamma_\pi^{E0} + \Gamma_\pi^{E2} + \Gamma_{CE}^{E0} + \Gamma_{CE}^{E2}$$



- In order to broaden our knowledge of nuclear structure, it is imperative that transitions which compete favourably with gamma emission such as internal conversion as well as IPF be studied.

Calibrations

Detection Efficiency

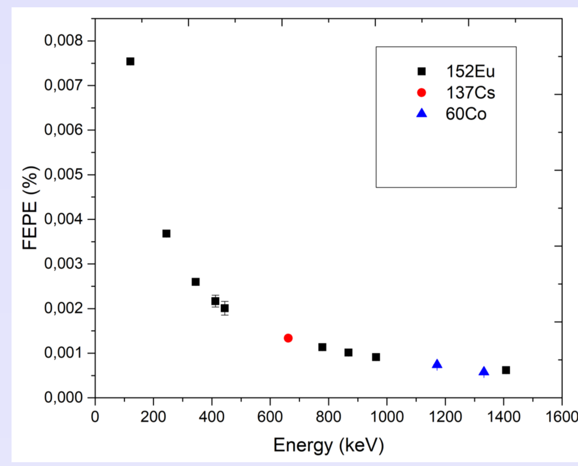


Fig.5. Gamma-ray efficiency of the 2′′×2′′ LaBr3 detector

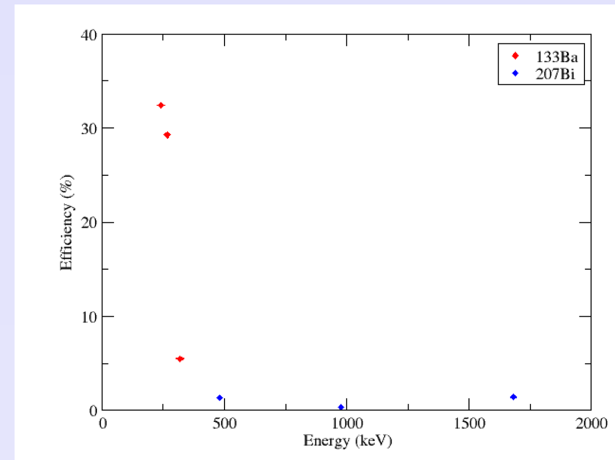


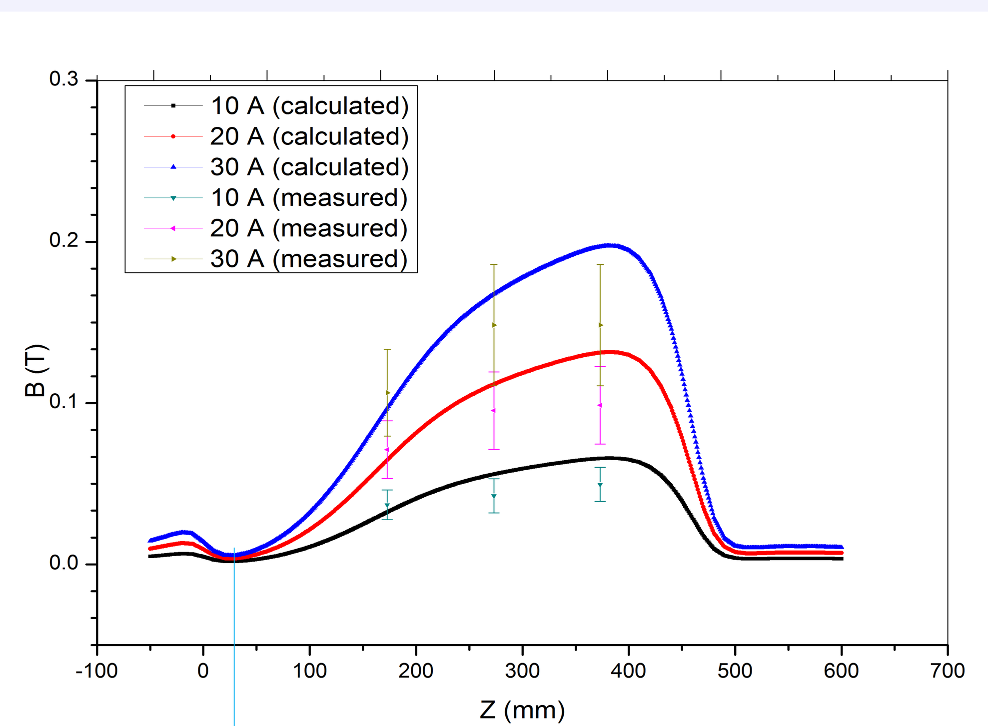
Fig.6. Absolute electron detection efficiency of K electrons measured with a swept magnetic field.

Electrons spectrometer development

- In order to measure Ice, an electron transporter is required, Thus the development of solenoid electron spectrometer

Fig.1. SK magnetic lens (solenoid) previously used at Orsay

Magnetic induction along the lens axis



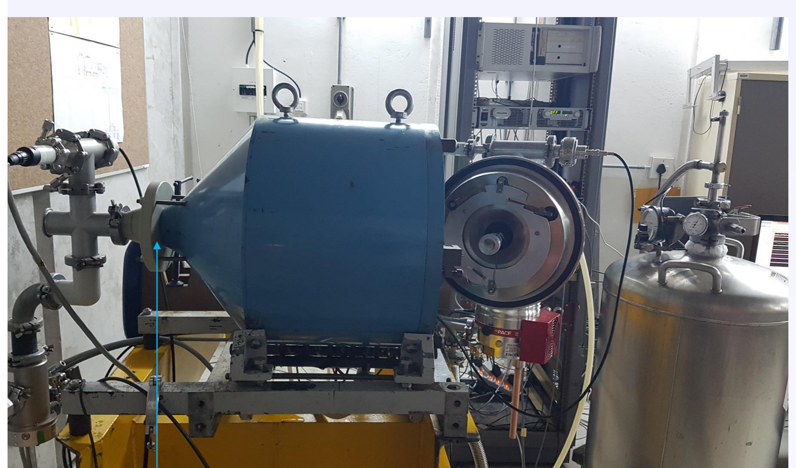


Fig.2 . Calculated and measured magnetic induction on the axis. The induction at the source/target position (z = -50 mm) is 7% of the maximum value. The measured and the calculated field values differ by 25%

Fig.3. **Connection of electron spectrometer to beam line**

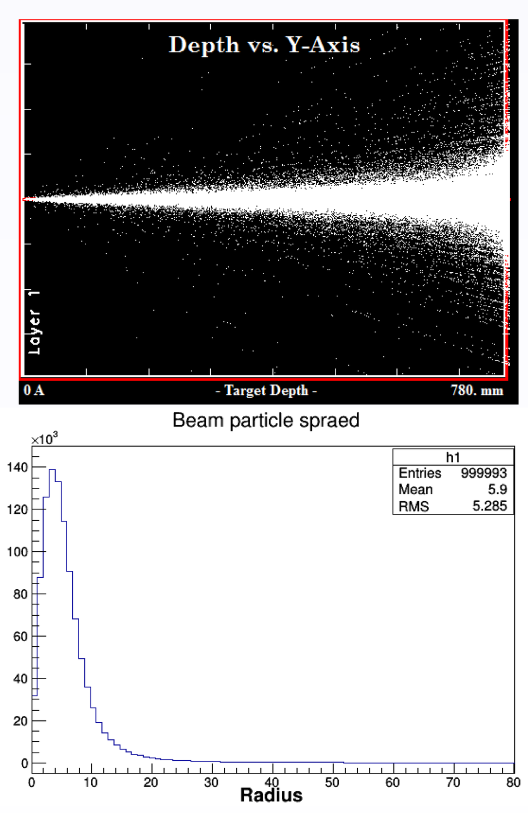


Fig.4. SRIM calculation of post target beam particle spread

Acceptance characteristics of the spectrometer

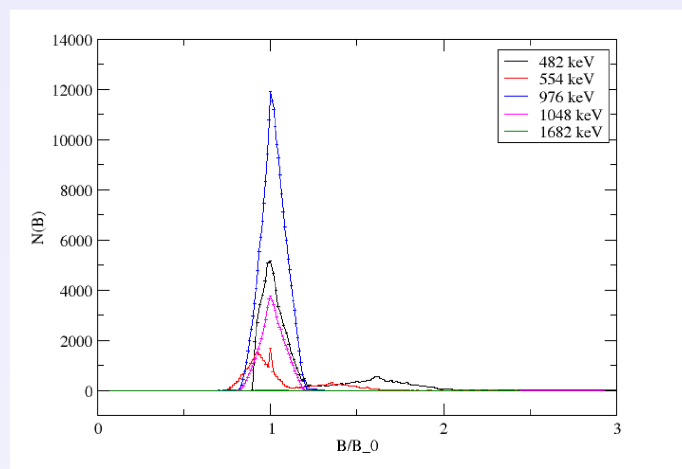


Fig.7. Acceptance window for the K and L lines in ^{207}Bi source. The distribution has been normalised for the maximum field

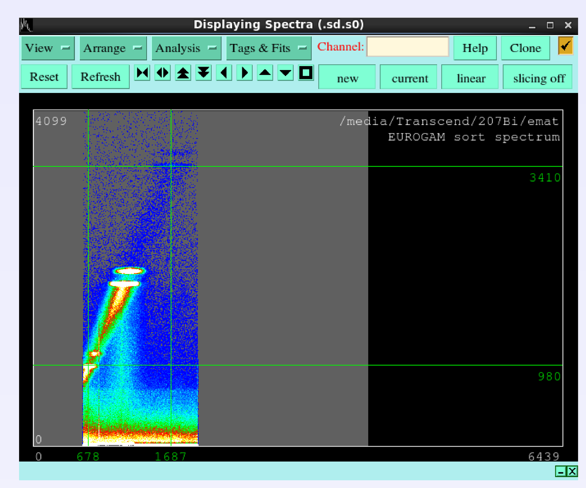
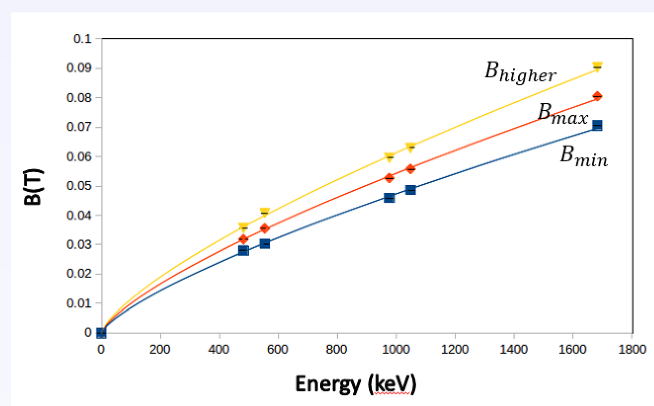


Fig.8. Chan vs current matrix with a ^{207}Bi source



Fih.9. Measured Brho for the momentum windows for the conversion lines of ^{207}Bi

- One characteristics of a lens spectrometer that stands out is that, at a given field, only a part of the full energy spectrum is with a well defined relation between energy and the solenoid field is focused on the detector [2]. A 2D matrix was constructed to determine to determine the relation over the full energy range. By projecting on the matrix in Fig. 8, a field spectrum as shown in fig.7 is obtained. The FWTM of the nearly Gaussian distribution gave the three field values marked in Fig. 9, B_{min} , $\boldsymbol{B_{max}}$, B_{higher}

	Measured	Calculated
Momentum window		
Acceptance angle [deg]		11-49
Solid angle of acceptance [% of2π]		9
Maximum transmission [% of 2π]	5.7 ± 0.2	
Momentum Resolution ($\Delta p/p$)	16	
Field and energy relationship coefficients		
C_{lower}	$1.68 \pm 0.0047E-2$	
$C_{max.}$	$1.93 \pm 0.0032E-2$	
C_{high}	$2.10 \pm 0.0097E-2$	

In beam measurement

Fig.10.Complete array of electrometer connected to g-line.

- The spectrometer was commissioned with an beam experiment using the reaction $70_{Ge}(\alpha,\alpha')70_{Ge}$ with an alpha beam of 30 MeV on 0.5 mg/cm² ^{70}Ge target

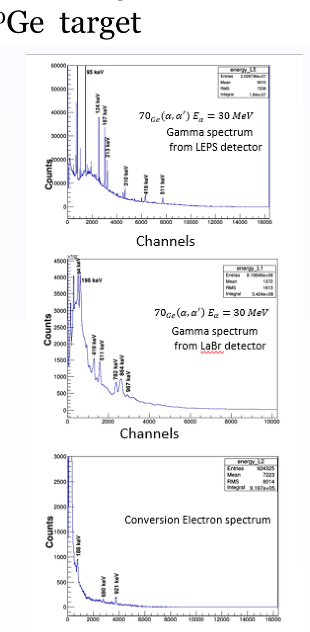


Fig.12. gamma-ray & conversion electrons spectra of ^{70}Ge(α,α') reaction

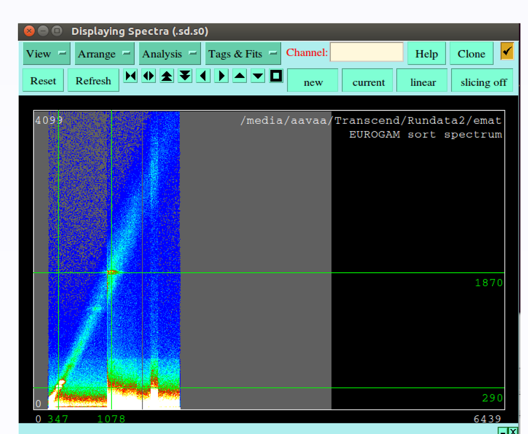


Fig.11. Energy vs current matrix of ^{70}Ge(α,α') reaction

Outlook

- The electron spectrometer is set for CE measurement, however plans are on the way to adapt it for internal pair formation measurement as well.
- The set up is mobile, thus can be integrated to any of the exiting iThemba labs facilities such as K600 and AFRODITE.

References

[1] Alshahrani *et al*; (2013) *EPJ Web conferences*

[2]Kibedi T., Dracoulis G.D. and Byrne A.P (1990) *Nucl. Ins and meth.* A294 523-533