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ATOMIC PHYSICS DIVISION

Applications of Position Sensitive Germanium Detectors for X-Ray Spectroscopy of Highly-Charged Heavy Ions

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Position sensitive germanium detector (PSGD) systems play an important role for future x-ray spectroscopy experiments with highly charged heavy ions, especially for a precise test of QED in the heaviest one-electron systems

The unique properties of such systems are:

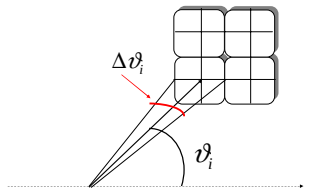
- Millimeter to sub-millimeter spatial resolution
- Good time and energy resolution for the hard x-ray energy regime above 15 keV.
- Segmentation - allows for an event-by-event Doppler correction of the registered x-rays.
- Sensitivity to the photon polarization

In combination with a focusing crystal spectrometer, a PSGD permits the measurement of an energy spectrum wide enough to investigate the interesting energy regime simultaneously. In addition, the good energy resolution enables discrimination against background events of the recorded spectra arising from various source.

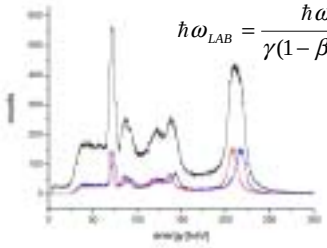
Nowadays, PSGD detectors (pixel detector and Clover detector, strip detector in combination with crystal spectrometer) are also developed (Forschungszentrum Jülich [1]) and tested for the high-precision x-ray spectroscopy program at the **ESR storage ring** (GSI Germany).

Pixel detectors

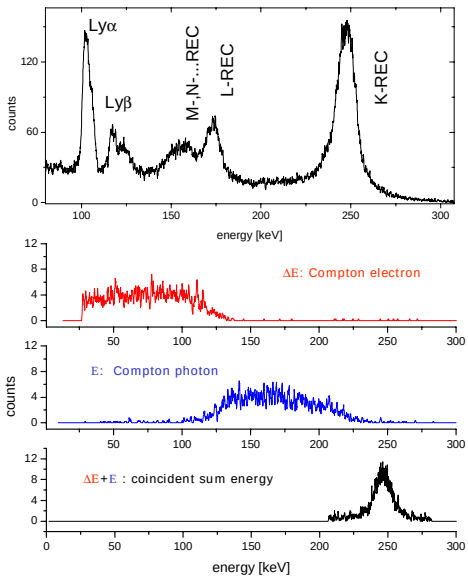
Spectra of H-like uranium produced in $U^{92+} \rightarrow N_2$ collisions at a collision energy of 49 MeV/u corresponding to a velocity of ≈ 30% speed of light [1] shows a large Doppler shift of the x-ray line centroid.



$$\hbar\omega_{LAB} = \frac{\hbar\omega_{proj}}{\gamma(1-\beta\cos\vartheta_i)}$$

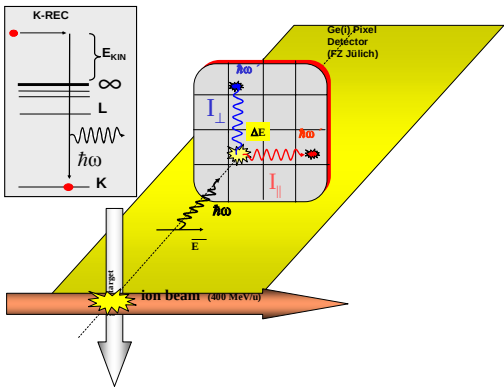


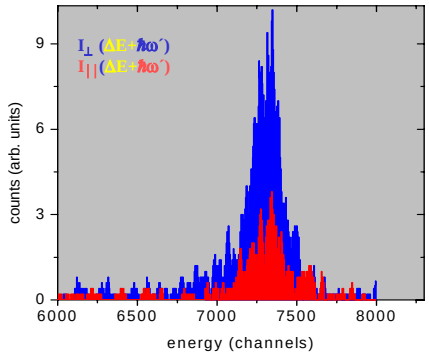
For a conventional detector the shift would result in a considerable Doppler broadening. Segmentation of PSGD detectors allows for an event-by-event Doppler correction of the registered x-rays.



Coincident photon spectra for K-shell REC into bare uranium ions associated with Compton scattering in a segmented Ge(Li) detector

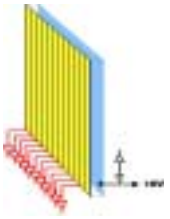
The **polarization sensitivity** of two-dimensional PSGD detectors via the Compton effect provides an important key to reveal the physics of these processes.

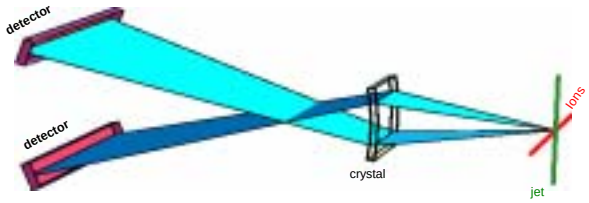




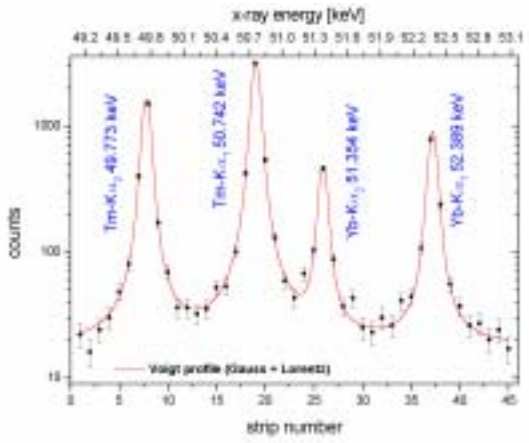
First Polarization Measurement for Recombination Transitions (U^{92+} + $e^- \Rightarrow U^{91+} + \hbar\omega$) (preliminary data from the ESR beam time May 2002)

Strip detector in combination with focusing cristal spectrometer

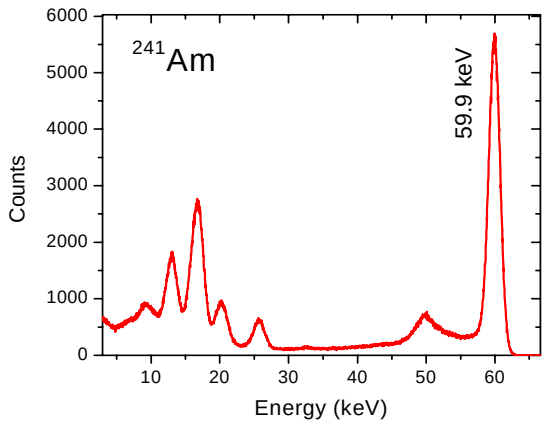




Energy resolution: 1.6 –1.9 keV @ 60 keV
Position resolution 200 µm
Time resolution 50 ns



Result obtained with the germanium microstrip detector mounted at the FOCAL crystal spectrometer. The intensity pattern as function of the position (energy) identifies well resolved the two components of the Ka-doublet of Tm as well as those of Yb [2].



A sample photon spectrum recorded with one individual strip. For this purpose a standard ^{241}Am γ-ray source was used. The energy resolution achieved corresponds to 1.8 keV [FWHM] at 60 keV.

[1] D. Protic et al., IEEE Transactions on Nuclear Science 48 (2001), 1048.
[2] H.F. Beyer, Nucl. Instr. Meth. in Phys. Res. A, vol. 400, pp. 137-148, 1997.
[3] J. Eichler and W. Meyerhof," Relativistic Atomic Collisions" , Academic Press, San Diego, 1995