

# Beta Spectroscopy in Penning Traps

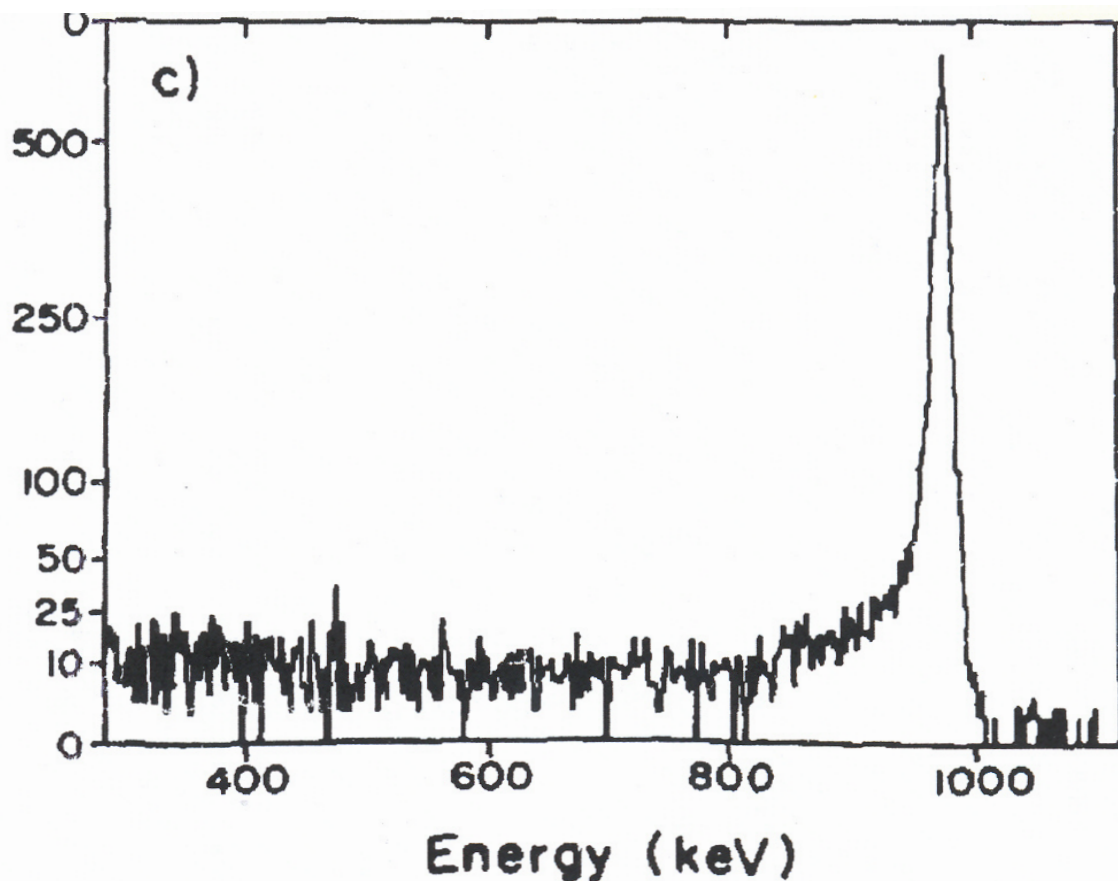
The backscatter problem and a  
potential solution

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# 1. The Problem

The peak efficiency of the response function of the detector should be as high as possible



Response function of a Si(Li) detector for monoenergetic electrons, from R.D. von Dincklage and J.Gerl, NIM A 235 (1985) 198

# Effects that lead to a decrease of the peak efficiency for electrons

- Scattering in the source
- Energy loss between the source and the detector
- Backscattering from the detector
- Bremsstrahlung that escapes from the detector
- X-rays that escape from the detector
- Incomplete collection of the e-h pairs in the detector
- Problems with the electronics

# Backscattering

Total Backscatter probability

$$\eta = \eta_1(E)\eta_2(\theta)$$

For detectors from Silicon

$$\eta_1(E) = \frac{0.14}{1 + 0.25 \left( \frac{E_{in}}{m_e c^2} \right)^{1.24}}$$

(T.Tabata, R.Ito and S.Okabe, NIM 94 (1971) 509 eq.1)

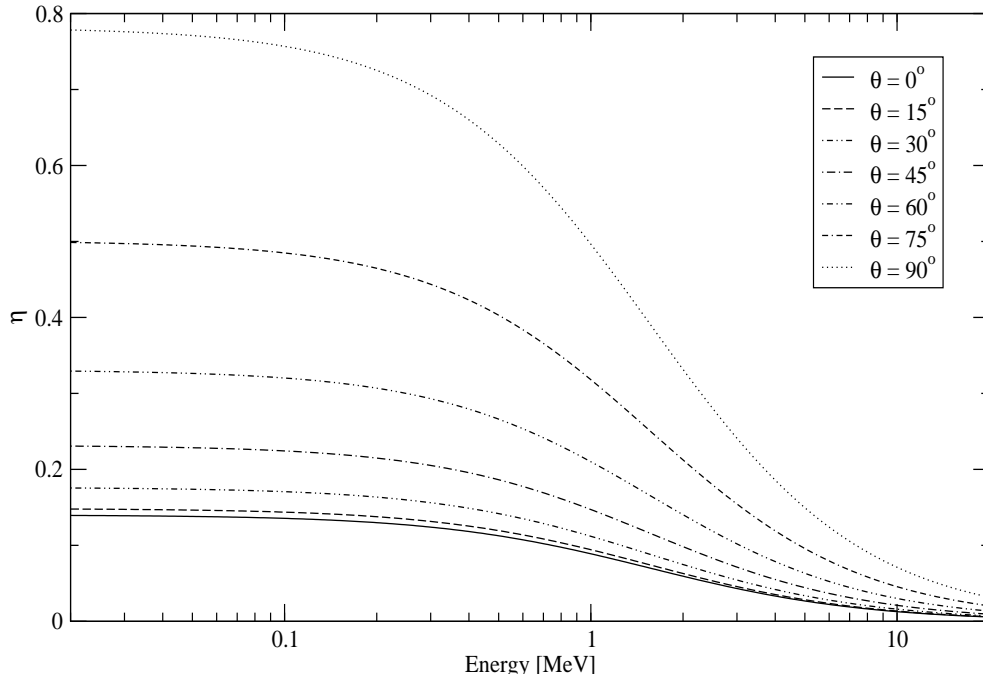
$$\eta_2(\theta) = e^{1.72(1-\cos\theta)}$$

(K.Kanaya and S.Ono, J. Phys. D 11 (1978) 1495, eq.18 & fig.6)

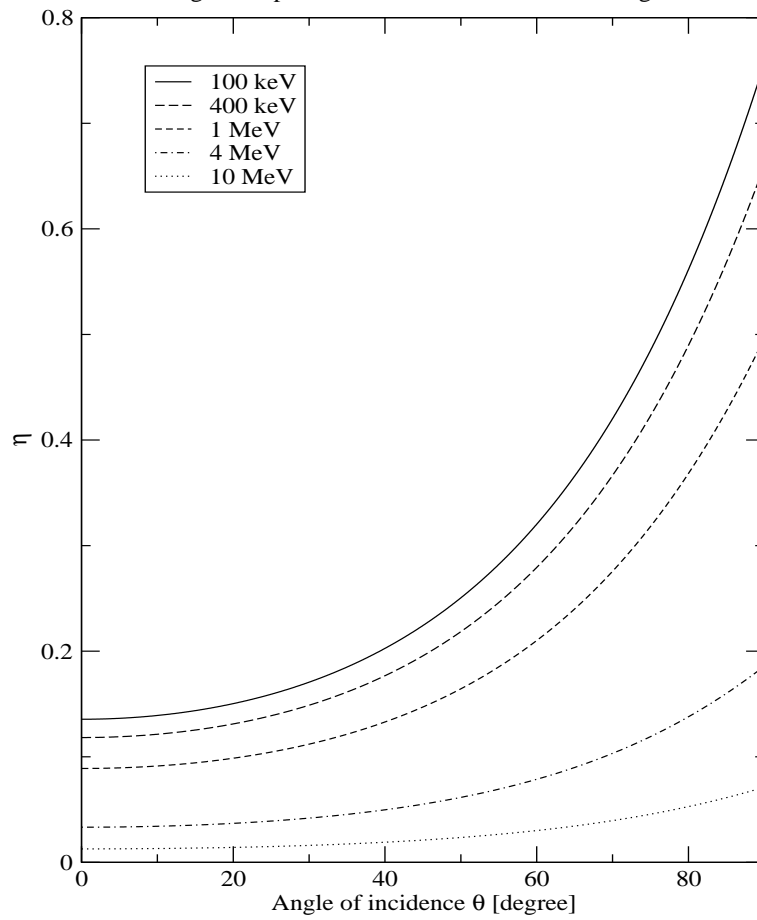
resulting in

$$\eta = \frac{0.14}{1 + 0.25 \left( \frac{E_{in}}{m_e c^2} \right)^{1.24}} \cdot e^{1.72(1-\cos\theta)}$$

Backscatter probability  $\eta$  for  $e^-$  on Si  
energy dependence for different angles of incidence  $\theta$



Backscatter probability  $\eta$  for  $e^-$  on Si  
angular dependence for different electron energies



# Effects of a Penning trap

## A Penning trap

- removes scattering in the source
- introduces scattering in the buffer gas
- increases (!) backscattering from the detector
- introduces energy loss due to synchrotron radiation

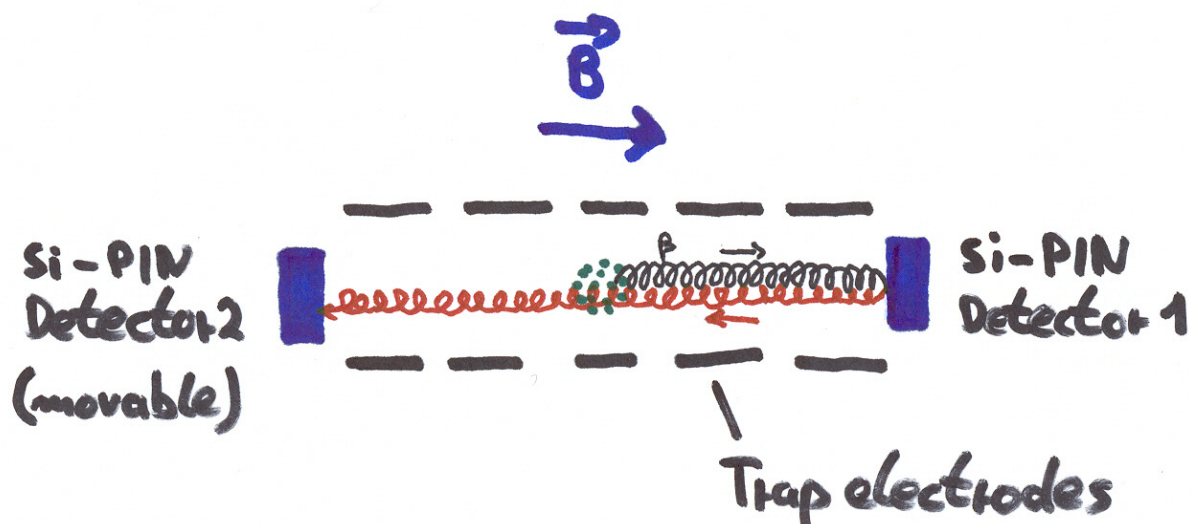
So why use a Penning trap for beta-spectroscopy?

Because we can get around the backscatter problem by measuring the backscattered beta-particle!

## 2. Penning trap with two detectors

The Penning trap collimates the beta-particles into two directions. It also collimates the backscattered beta-particles into the same directions.

Principle:



The backscattered beta-particle moves through the ion cloud to the opposite detector.

Two potential modes of operation:

I. Do not use events with a delayed coincidence in the second detector

Disadvantage: Change in spectral shape

II. Use the sum of the signals of the two detectors from (multiple) delayed coincidences

Disadvantage: For low countrates only

### 3. Summary

It may be possible to reduce the effect of backscattering on the response function by using a Penning trap.

- The outgoing distribution of  $E_{out}$  and  $\theta_{out}$  are needed
  - Simulations have to be done
  - What is the effect of the other processes like Bremsstrahlung?
- Much work still has to be done