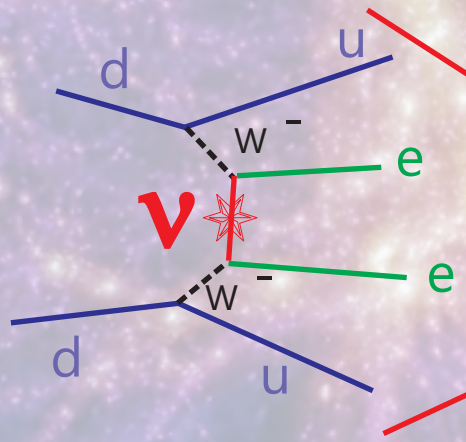
Germanium Detectors for Neutrinoless Double Beta Decay

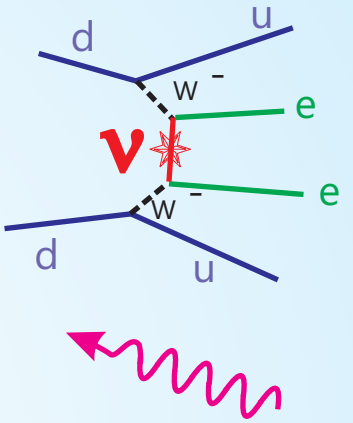


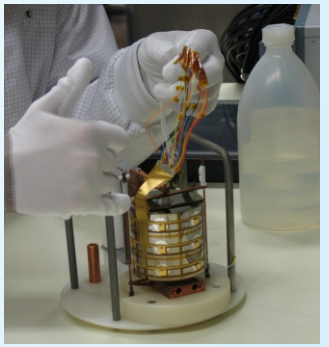
GDT Symposium 2013

I.Abt, MPI für Physik

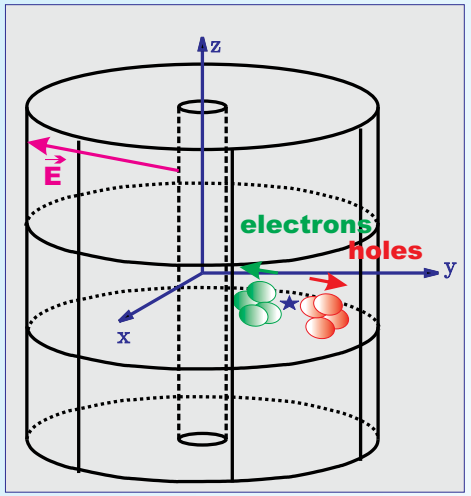
Items to consider

- Signal effciency
- Background Rejection Capacity
- Homogenious Response
- Reproducible Results
- No bulk contamination
- No surface contamination
- Robust
- Easy to produce = cheap





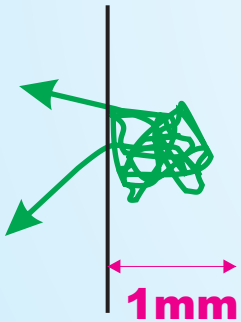
Signal Efficiency



Task:

Find a single energy deposit of 2 MeV.

Assuming a reasonably perfect crystal, that should not be so difficult.

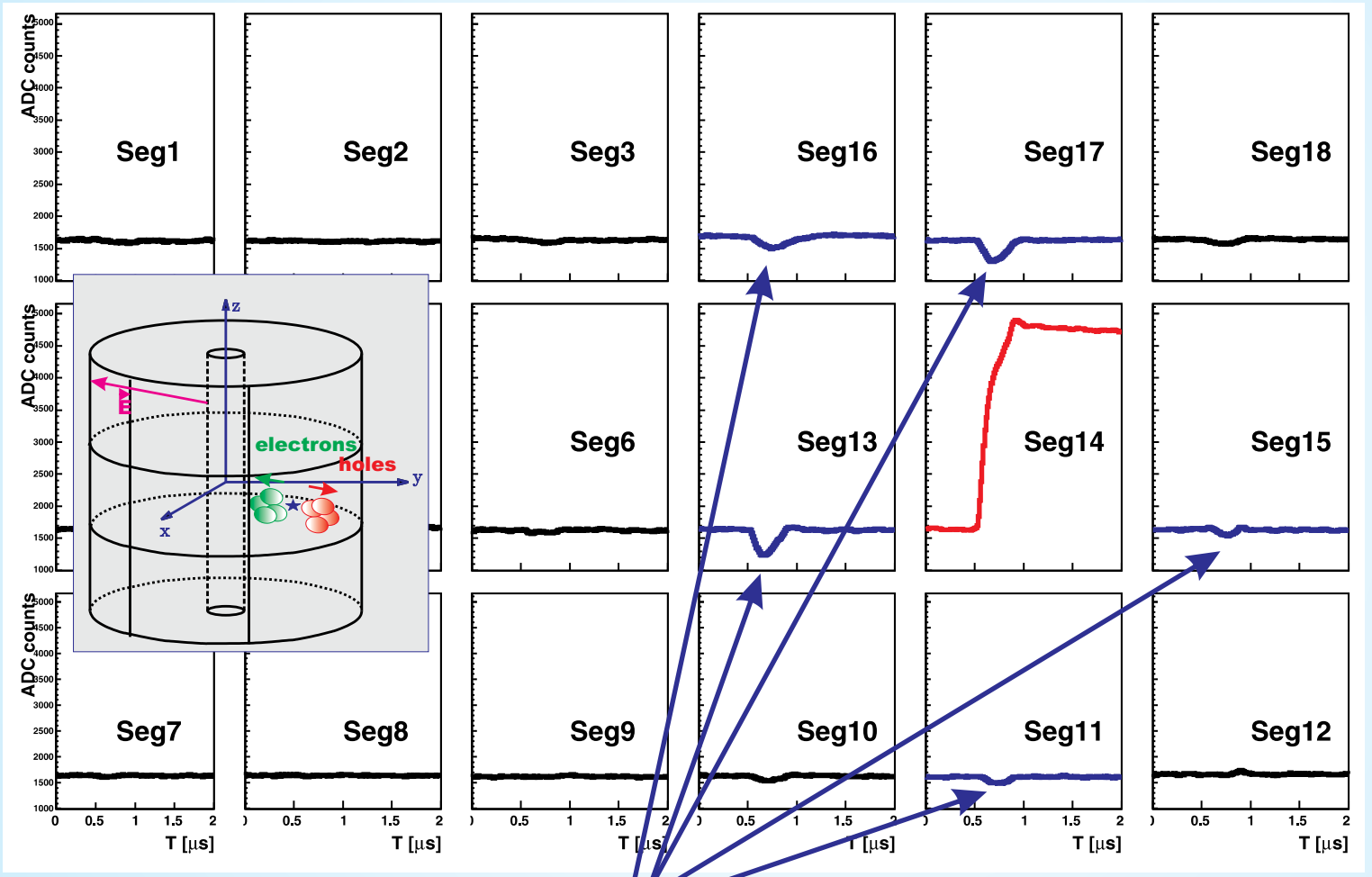


Decays close to the surface can loose some energy.

5% for a
h=7cm d=7.5cm
crystal

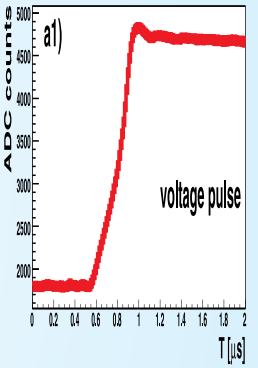
Large crystals are preferable.

Background Rejection



DEP 85

^{208}Tl

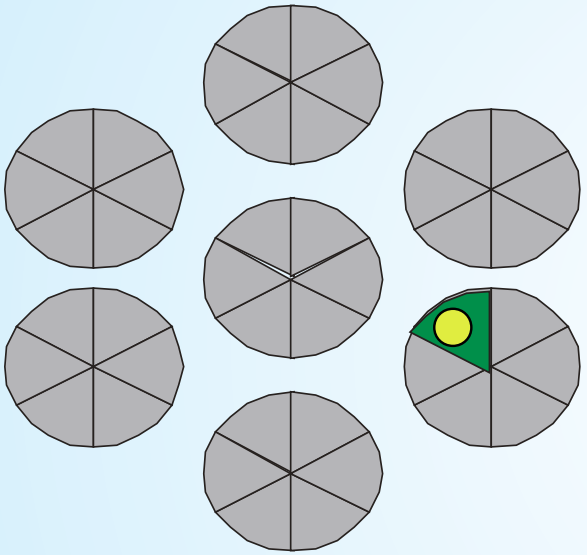


Single Segment and Neighbors

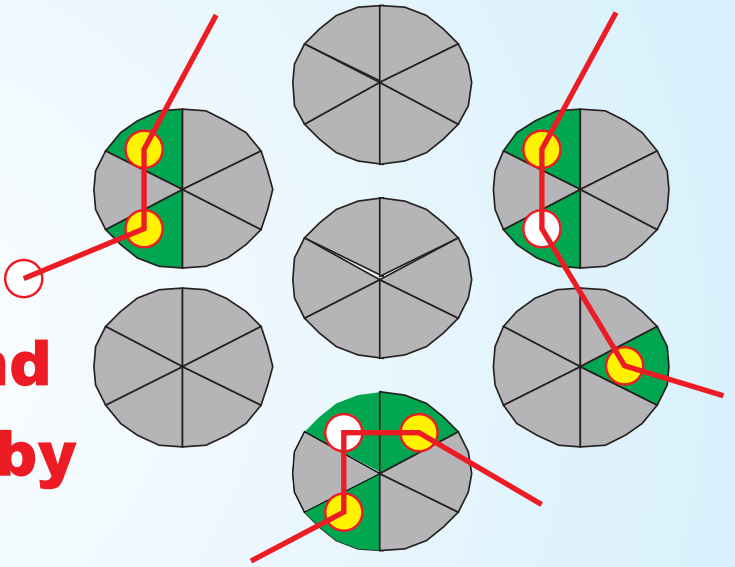
Position reconstruction

Background Rejection

$0\nu\beta\beta$



γ or 2γ



background reduction by factor 10

localized deposit
single site event

several deposits
multi site event

Segmentation is desirable.

Background Rejection

Photons make multi-site events - easy...

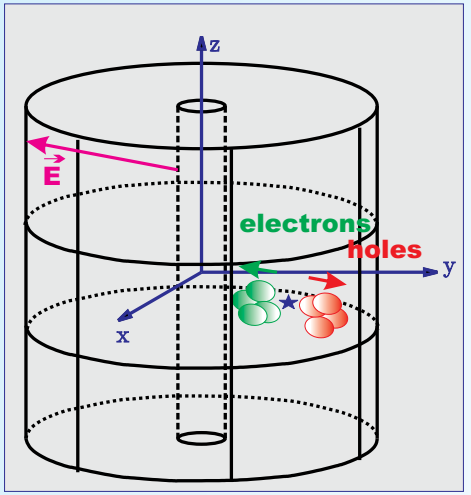
Beta emitters are nasty. Any background electron is nasty.

Neutrons are everywhere. They come fast or slow.

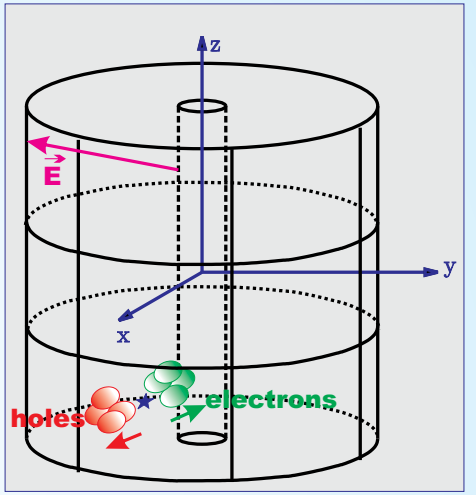
Neutrons will be a subject of investigation for our collaboration. Can their energy deposits, recoils, be identified?

Alphas which are partially seen are nasty.

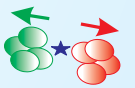
Homogenious Response



We work with spectra. It would be nice, if both events produced the same response.



Crystals are never really homogenious. The pulses will look different because of changes in impurities.

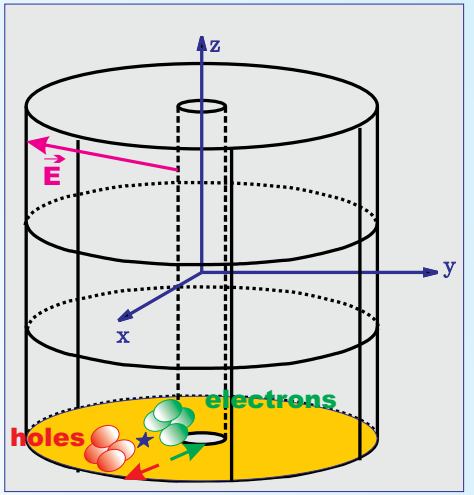


Crystals need to be good enough, so that trapping does not cause loss in resolution.

Reproducible Results

If some volume is dead,

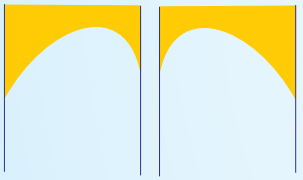
it should at least stay dead.



Under passivated areas,

so called surface channels

can eat holes or electrons.



The problematic area can be mapped.

But: Does it stay stable?

Is it the same for different detectors?

Reproducible detectors are needed.

Long and distorted pulses can be identified.

Pulse shape analysis requires suitable readout.

Bulk Contamination

Cosmogenic Activation: ^{60}Co ^{68}Ga

< 300 keV electron

^{68}Ga

< 1900 keV electron

Produce underground

Intrinsic Contaminants: Uranium, Thorium?

There are only limits....

Don't enrich in a uranium centrifuge.

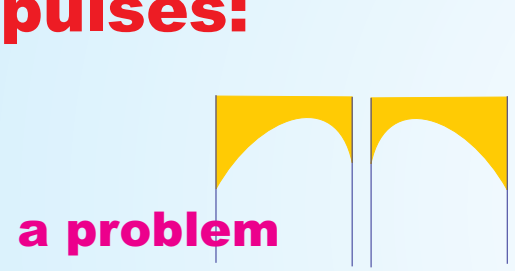
Segmentation helps.

Surface Contamination

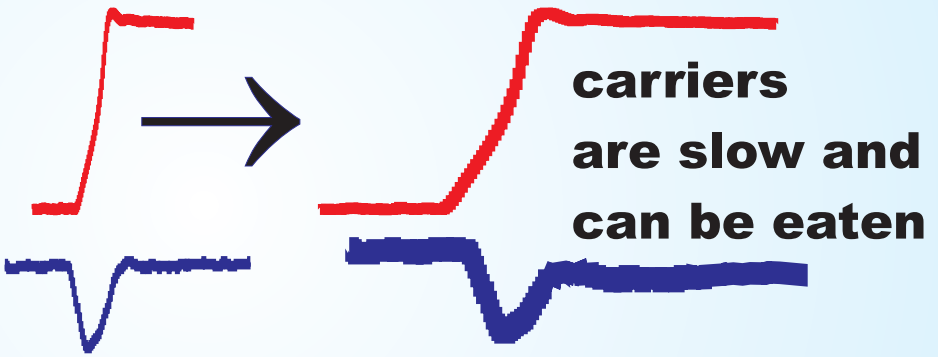
Specialtyare alphas like ^{210}Pb.

They produce partially seen energy deposits.

We need to identify long and odd shaped pulses:



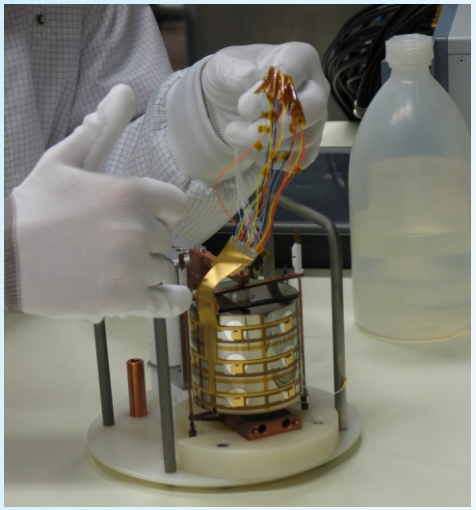
a problem turned solution



Produce and store and operate in Radon free environment.

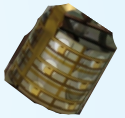
The manufacturer has to be careful about acids and such; Pollonium likes germanium.

Robust Detectors



Detectors have to be handled with great care.

Especially their passivation is a problem.



It would be nice to have something as robust as silicon.
Dear manufacturers,
Is there a chance?

Cheap Detectors

Let us assume 1000 detectors.

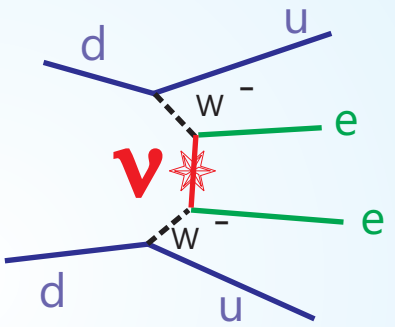
System price is not only purchase price, but also testing and integrating.

If you spend 3 month on each detector, it will be 50 years for 5 teams.....

We need an assembly line with quick testing.

[In]Famous Last Words

Germanium detectors are a good tool to search for neutrinoless double beta decay.



A large scale, 1 ton, experiment will require significant progress in manufacturing, testing and integration.

It is "easy" to deal with one detector, but with a thousand.