

# Julia in the Lab

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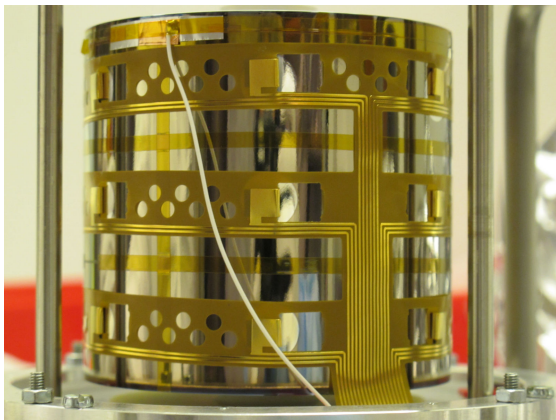
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# Julia in the Lab?

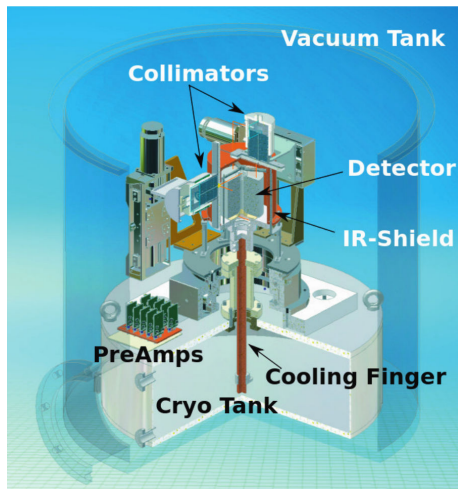
- ▶ Where: MPP Germanium detector research group.
- ▶ In the past, used a mix of C++ code, Labview, Scala-code and other stuff for lab device control and data acquisition
- ▶ Problem: Awkward, often limits possibilities, also fights with Labview, driver problems and so on.
- ▶ Now: (Almost) our whole lab runs on Julia.
- ▶ Will show two example lab setups.

# Challenge: Surface response of HPGe detectors



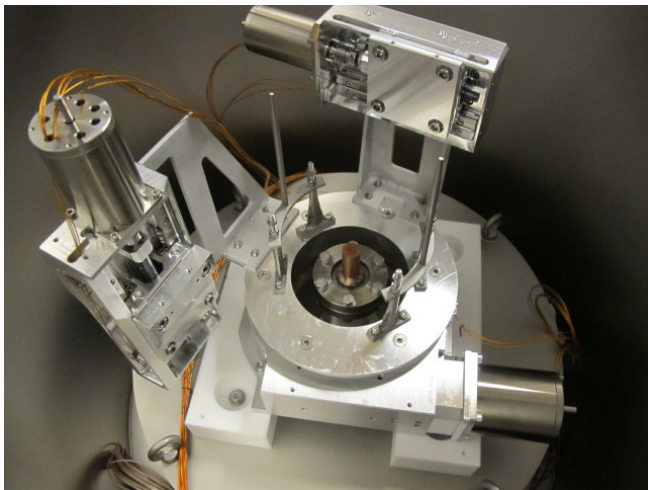
- ▶ Exemple: Segmented high-purity germanium (HPGe) detector.
- ▶ Reponse to surface hits not well enough understood yet.

# Germanium detector surface scanner



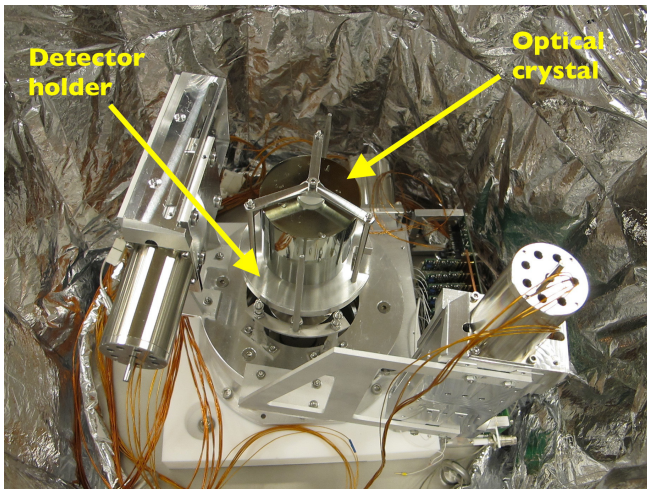
- ▶ Apparatus to scan HPGe-detector surface with  $\alpha$ - and  $\beta$ -radiation in vacuum.

# Scanning State

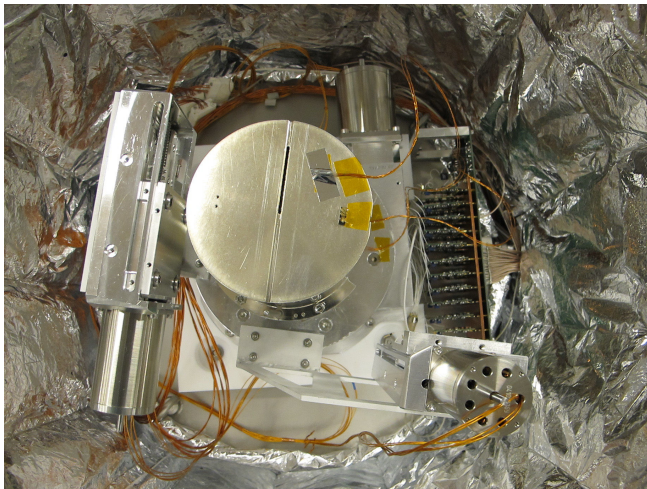


- ▶ One rotational and two translational cryo- and vacuum-rate stepper motors

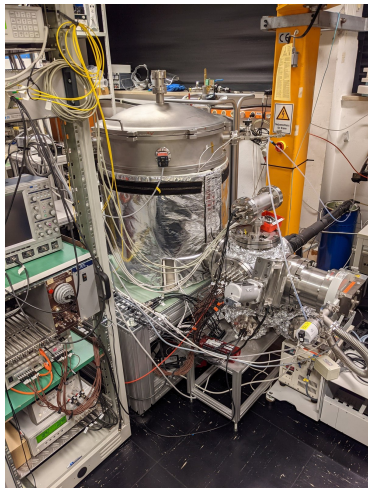
# Scanning Stage with Detector



# Scanning Stage with Heat-Shielded Detector



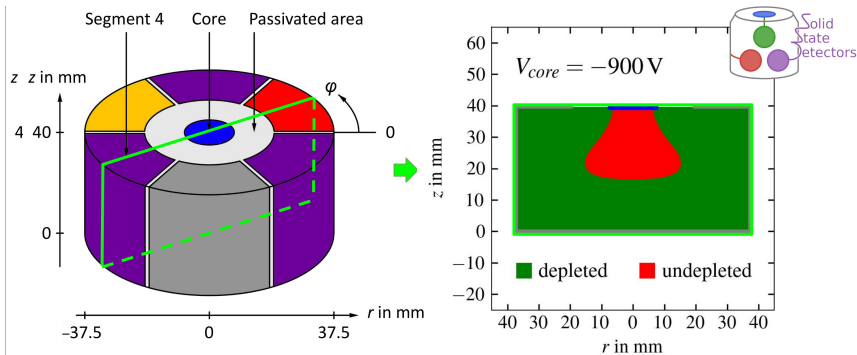
# Complete Surface Scanner Setup



- ▶ vacuum chamber heating system
  - ▶ different vacuum gauges
  - ▶ multi-point temperature monitoring
  - ▶ stepper motor controllers
  - ▶ piezo screw motor controllers
  - ▶ high-voltage source
  - ▶ fast signal digitizer
- ▶ Julia does everything, slow control and fast DAQ.

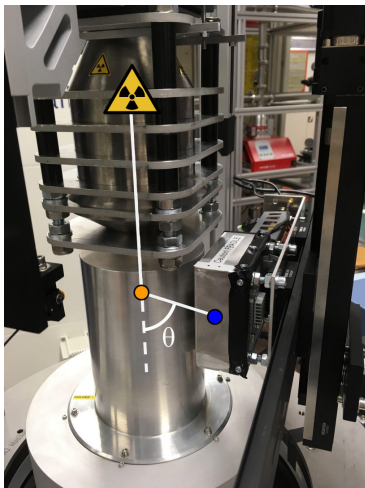


# Setup 2: Depletion and Response of HPGE Detectors



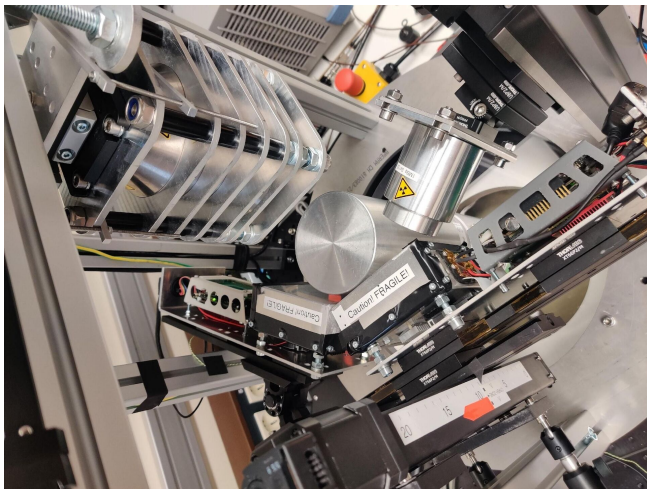
- ▶ Depletion characteristic and signal shapes of detector depend on poorly bulk properties (different for each detector).
- ▶ Need measurements to verify simulation and estimate better values.

# Tomography via Compton Scanning



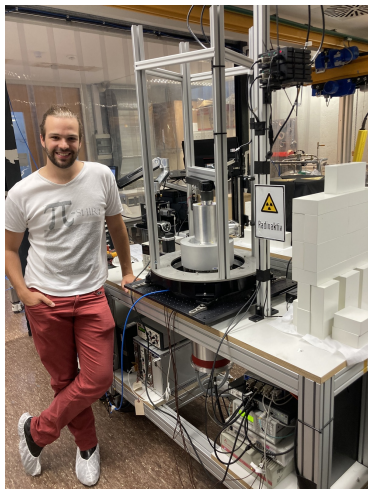
- Approach: Detector tomography with vertical gamma beam (fixes x and y) and compton camera (measures z).

# Source, HPGe Detector and Cameras



- ▶ Source: 740 MBq Cs-127, 20 kg tungsten collimator, motorized
- ▶ Camera: is two pixelated CdZnTe detectors, motorized

# Compton Scanner: Complete Setup



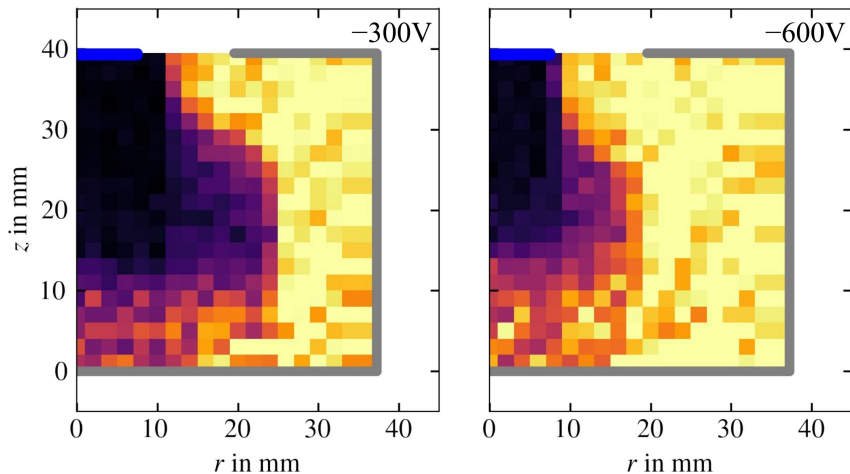
- ▶ stepper-motor-controller
- ▶ cryo-cooler
- ▶ multi-point temperature monitoring
- ▶ high-voltage source
- ▶ fast signal digitizer
- ▶ DAQ PC with Julia
- ▶ Phd student

- ▶ Phd student controls Julia
- ▶ Julia controls all the rest and records all data.

# Compton Scanner: Second-Level Trigger

- ▶ Hardware-trigger in FPGA of Ge-detector digitizer
- ▶ Problem: Way to much data, only a few HPGe detector hits result in usable Compton-Camera hits
- ▶ Initially: Record everything, filter files with Julia much later
- ▶ Now: Event filter (second level trigger) in Julia part of DAQ process.
- ▶ Event filter shares code with overall analysis code
- ▶ Was be developed and tested offline, can now run as as part of DAQ on DAQ PC.

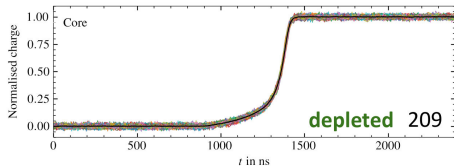
# Result: Measured Undepleted Zones



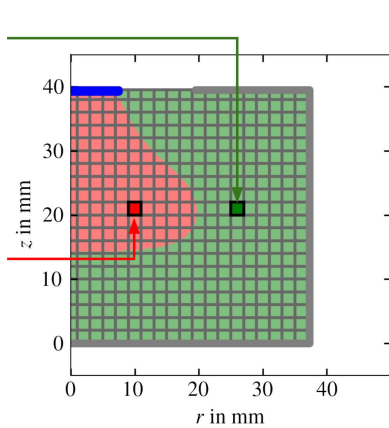
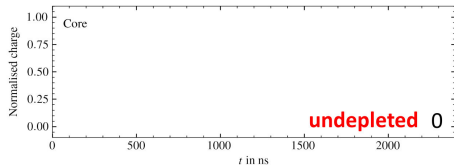
- ▶ Julia end to end - from simulated undepleted zones to tomographic images of them.

# Result: Detector Response

From events with **2 hits** in the camera:



From events with **2 hits** in the camera:



- Can now build position-resolved pulse-shape libraries, compare with simulation to correct bulk property values, and much more

# Julia Lab Code at MPP

Code to control resp read out:

- ▶ Various stepper motor controllers
- ▶ Various vacuum gauges (Pfeiffer and Vacom)
- ▶ Modbus devices like heater controllers
- ▶ Struck fast ADC signal recorders
- ▶ Various temperature sensors
- ▶ Labjack devices (via Ethernet)
- ▶ ...

Scattered over a bunch of unregistered packages.



# Conclusions and Outlook

- ▶ Moving everything to Julia took time
- ▶ Julia in productive use in lab across two generations of PhD students
- ▶ One it runs, it usually keeps running!
- ▶ Really need to clean up and package a few things properly.
- ▶ Other people here interested in lab hardware control?