What you need to do:

The detection efficiency calibration of real germanium detector arrays!

- Install GRSISort
- Fit gamma-ray photopeaks with GRSISort
- Edit and run the RootEffi script
- Submit your fitted peaks, your edited RootEffi script and your efficiency curve ☺

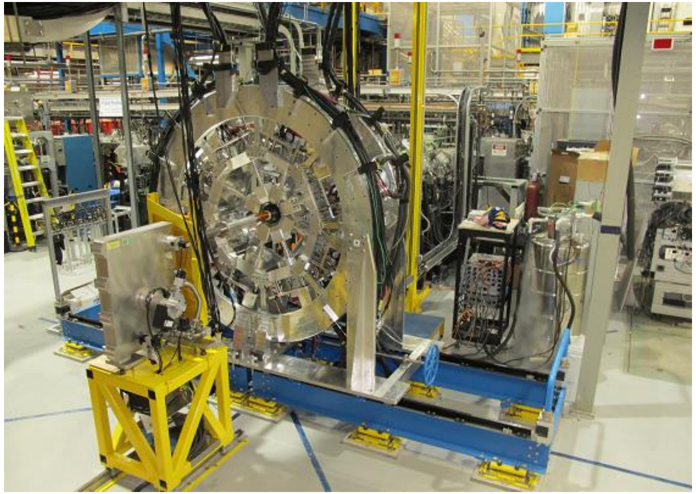
What you need to know:

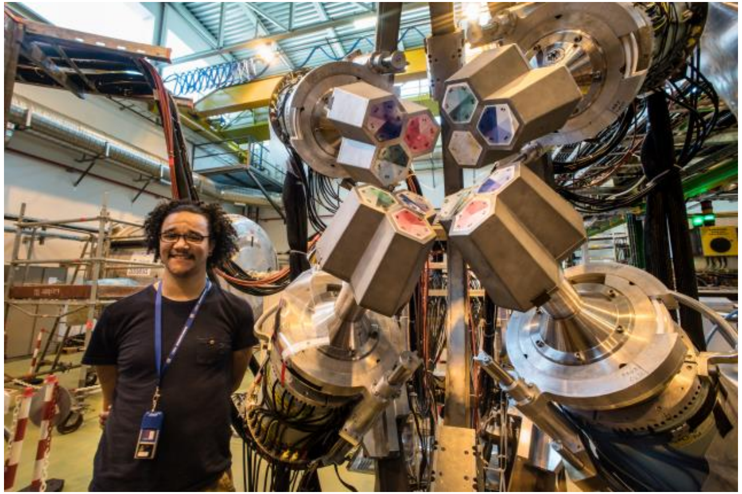
- How semiconductor detectors work
- How to determine the detection efficiency
- How to find nuclear information
- How to compile a code
- How to fit peaks with GRSISort
- How to run a script in ROOT and GRSISort

Germanium Detector Arrays

GRIFFIN, TRIUMF, Vancouver, Canada

64 crystals



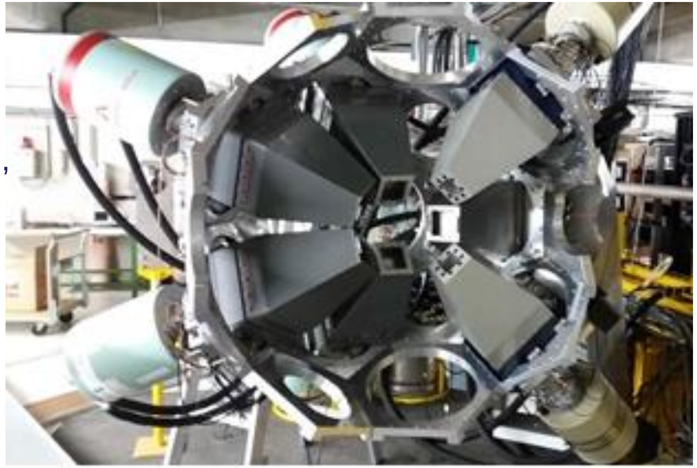


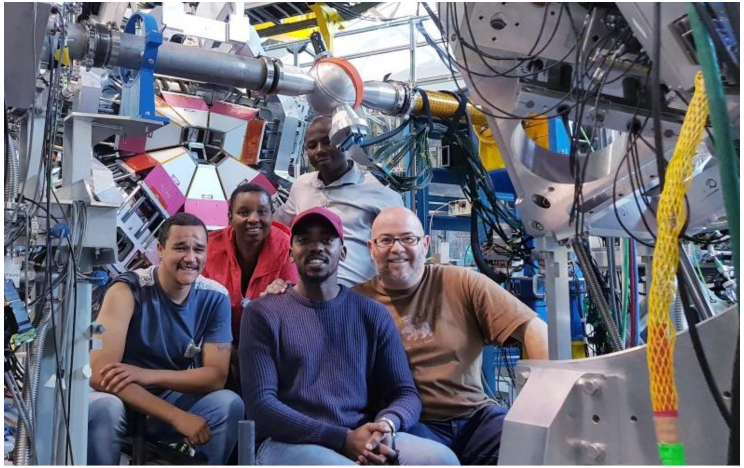
MINIBALL, CERN, Geneva, Switzerland

24 crystals

Soccer Ball, iThemba LABS, Cape Town, South Africa

52 crystals





TIGRESS, TRIUMF, Vancouver, Canada

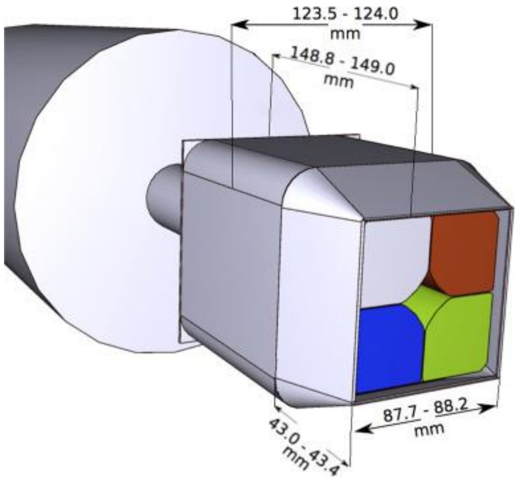
56 crystals

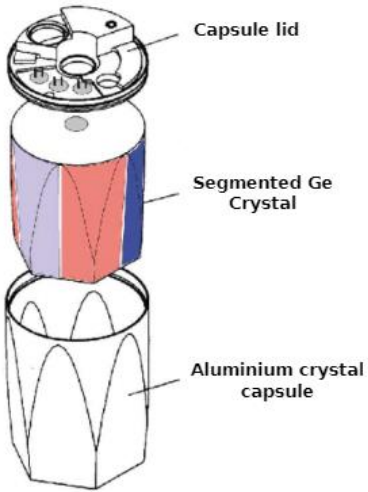
Configurations of Germanium Detectors

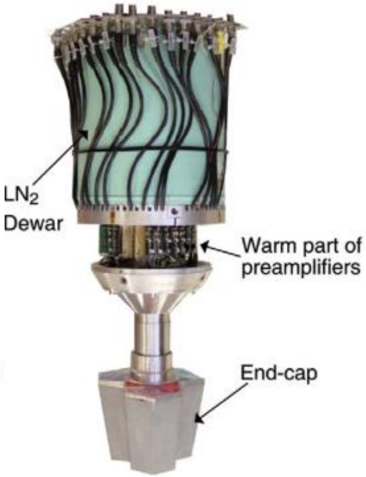
GRIFFIN, TRIUMF, Vancouver, Canada

64 crystals

(16 clovers, not segmented)







MINIBALL, CERN, Geneva, Switzerland

24 crystals

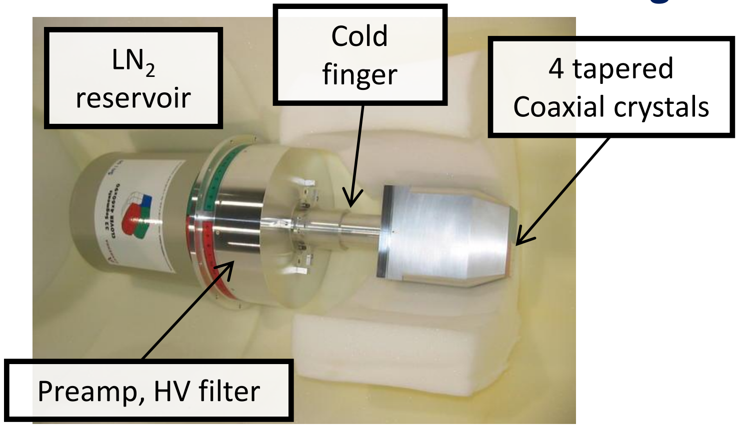
(8 triple clusters, 6-fold segmented)

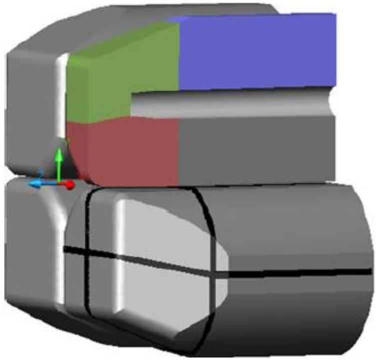
Closed-end coaxial right cylinders ☺

Soccer Ball, iThemba LABS, Cape Town, South Africa

52 crystals

(13 clovers, 4 segmented and 9 not segmented)





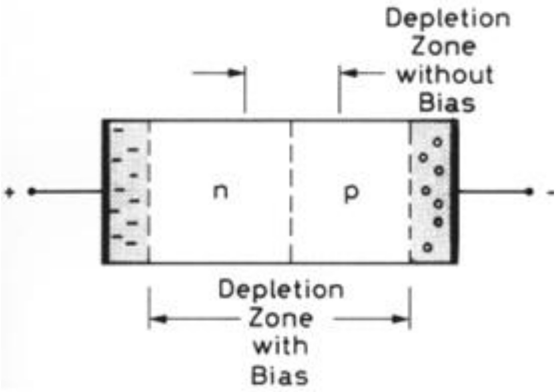
TIGRESS, TRIUMF, Vancouver, Canada

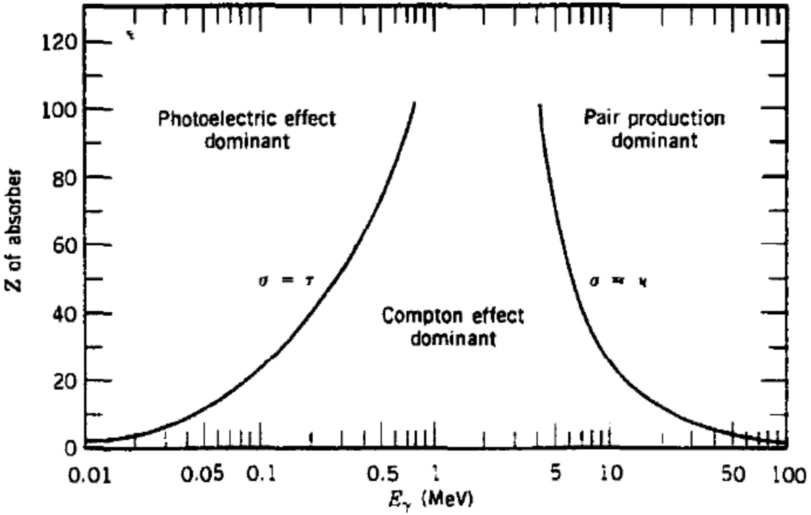
56 crystals

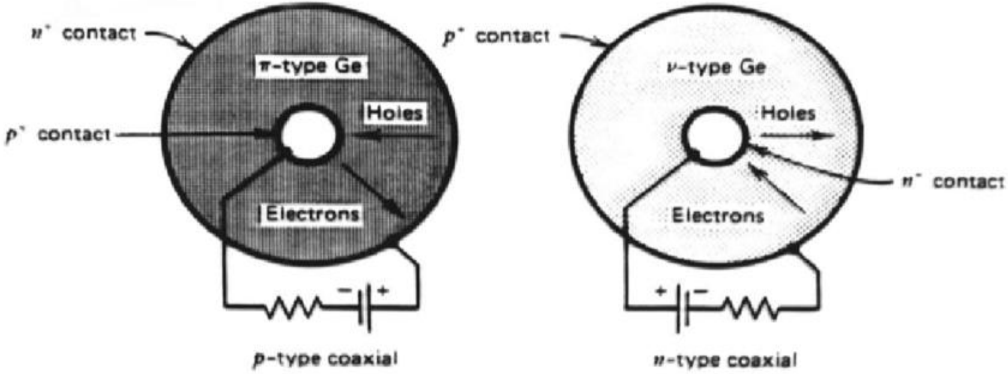
(14 clovers, 8-fold segmented)

How Semiconductor Detectors Work

- An external field creates an area depleted of free charge carriers.
- Radiation interacts with the crystal and produces of electron-hole pairs.
- The electrons and holes drift towards electrodes and the electric pulse is amplified and processed.

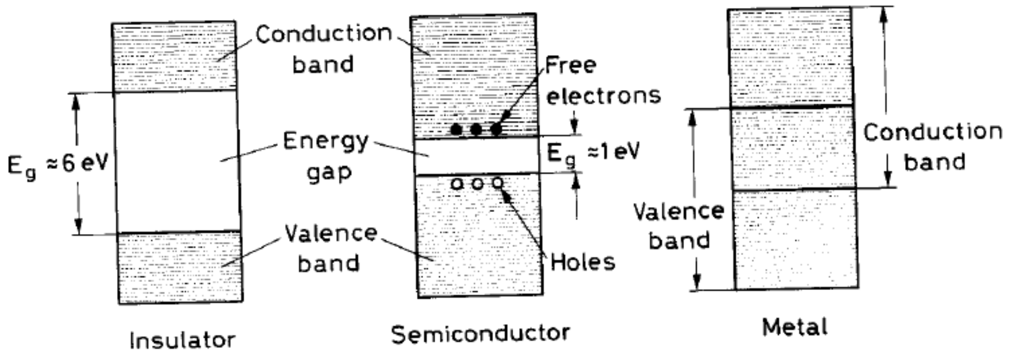


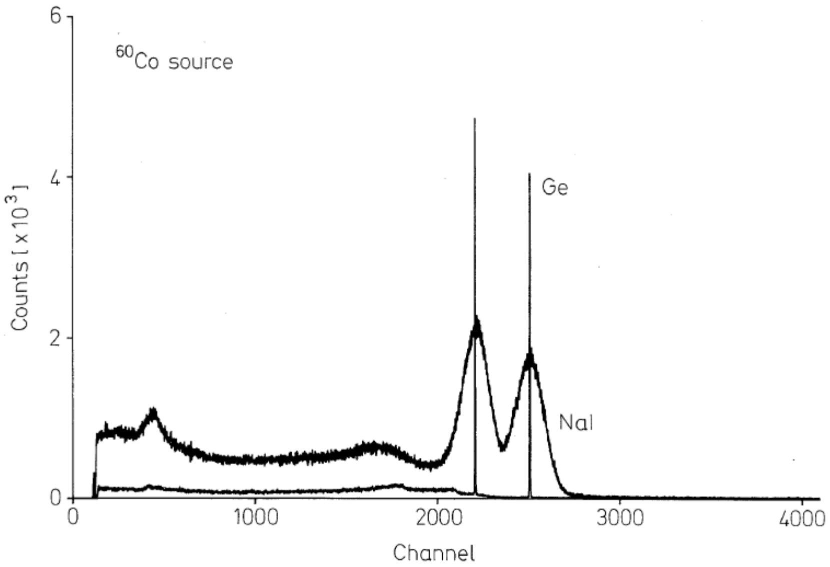




K.S. Krane, *Introductory Nuclear Physics* (1988).
G.F. Knoll, *Radiation Detection and Measurement* (1989).
W.R. Leo, *Techniques for Nuclear and Particle Physics Experiments* (1994).

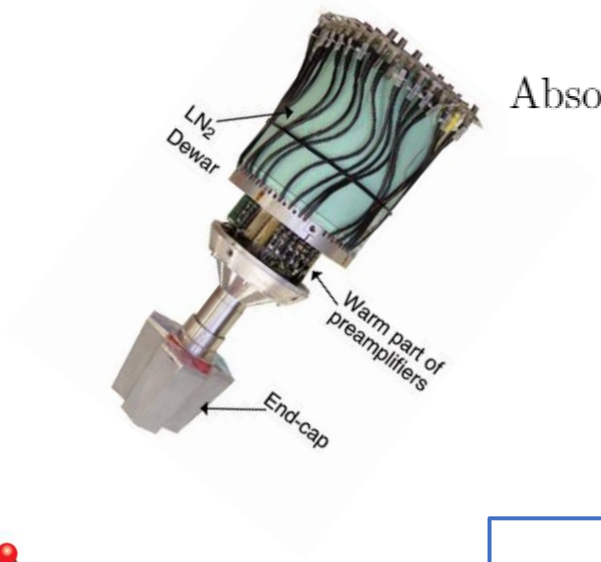
Semiconductors vs. Scintillators





Material Property	NaI(Tl)	Germanium	Silicon
Type	Scintillator	Semiconductor	Semiconductor
Cooling	No	~ 95 K	No
Density (g/cm^2)	3.7	5.3	2.3
Band gap energy (eV)	20	2.9	3.8
Energy resolution at 1332 keV (keV)	13	1.9	

How to Determine the Detection Efficiency



$$\text{Absolute Efficiency } \epsilon_\gamma = \frac{\text{Number of } \gamma\text{-rays detected}}{\text{Number of } \gamma\text{-rays emitted}}$$

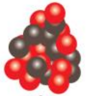
$$= \frac{N_{\gamma,detected}}{I_\gamma \cdot A \cdot t}$$

Area of the photopeak

Data collection time

Activity of the source

Absolute intensity of the gamma ray

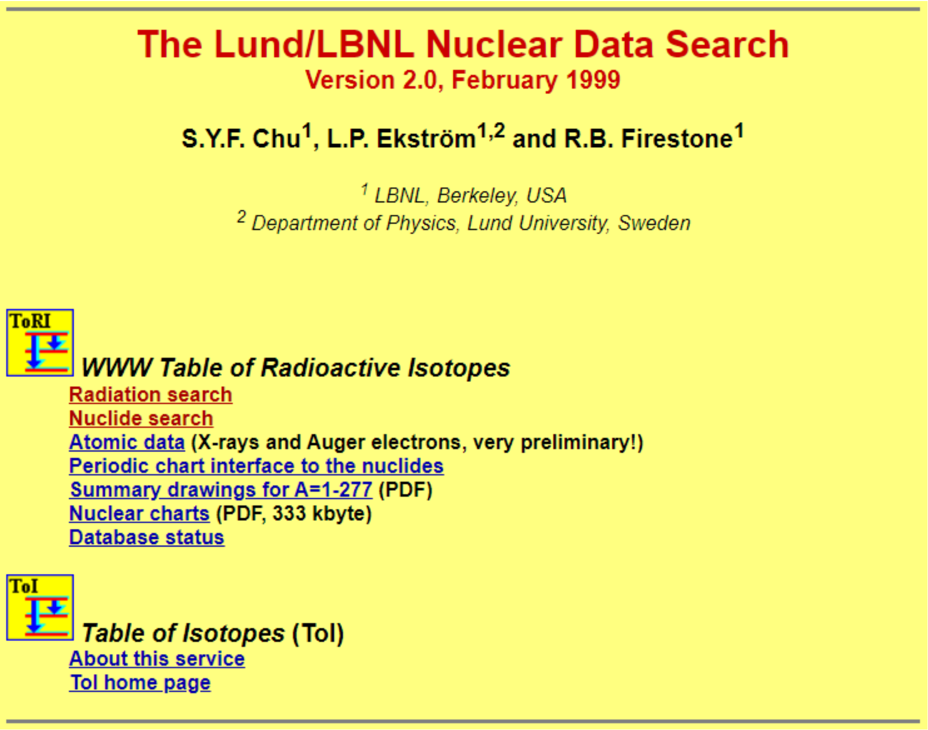


$$\boxed{\epsilon_\gamma(E) = 10^{p_0 + p_1 \log(E) + p_2 \log^2(E) + p_3/E^2}}$$

$$\text{Relative Efficiency } \epsilon_\gamma = \frac{\frac{N_{\gamma 1,detected}}{I_{\gamma 1} \cdot A \cdot t}}{\frac{N_{\gamma 2,detected}}{I_{\gamma 2} \cdot A \cdot t}} = \frac{N_{\gamma 1,detected}/I_{\gamma 1}}{N_{\gamma 2,detected}/I_{\gamma 2}}$$

How to Find Nuclear Information

- Lund/LBNL Nuclear Data Search: http://nucleardata.nuclear.lu.se/toi/
- National Nuclear Data Center: https://www.nndc.bnl.gov/



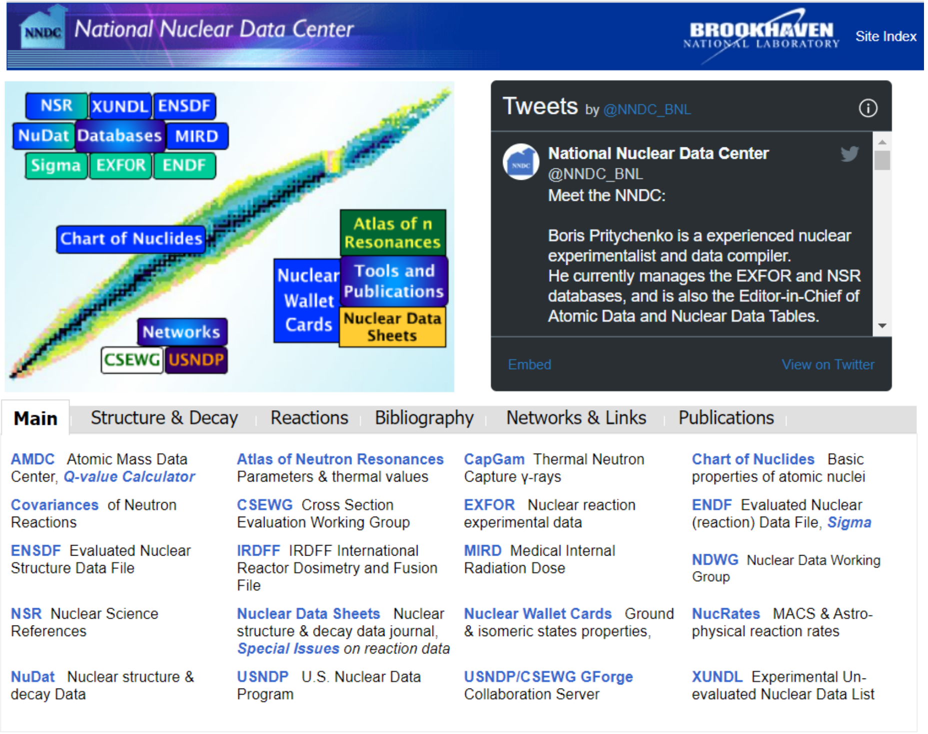
The Lund/LBNL Nuclear Data Search
Version 2.0, February 1999

S.Y.F. Chu[1], L.P. Ekström[1,2] and R.B. Firestone[1]

[1] LBNL, Berkeley, USA
[2] Department of Physics, Lund University, Sweden

ToRI
WWW Table of Radioactive Isotopes
Radiation search
Nuclide search
Atomic data (X-rays and Auger electrons, very preliminary!)
Periodic chart interface to the nuclides
Summary drawings for A=1-277 (PDF)
Nuclear charts (PDF, 333 kbyte)
Database status

ToI
Table of Isotopes (ToI)
About this service
ToI home page



How to Fit Peaks with GRSISort

- Installation instructions at https://github.com/UWCNuclear/UbuntuSetUp

- Open the file with “ grsisort -l Eu152_***ARRAYNAME***.root ”
- See the list of histograms in the file with “.ls”
- Draw histogram with “ gammaSingles->Draw() ”
- Display rough peak energies by pressing “s”
- Click and drag on x-axis to zoom in, zoom out by pressing “o”
- Click and drag on y-axis to zoom in, right click and click “UnZoom” to zoom out
- Click and click on spectrum to set the fitting boundaries around your peak
- Fit by pressing “f”
- Remove all markers by pressing “n”
- “.q” to quit

- Save screenshots of your fitted peaks and the number of counts (Sum) in your peaks.
- More tools at https://github.com/GRIFFINCollaboration/GRSISort/wiki/Interactive-Analysis

git clone https://github.com/UWCNuclear/PeakFitting.git

How to Fit the Detector Efficiency with RootEffi

- Download with “ git clone https://github.com/UWCNuclear/RootEffi.git ”
- Download the data files with “ git clone https://github.com/UWCNuclear/PeakFitting.git ”
- In gedit, edit RootEffi.C with the peak areas and uncertainties obtained from your data file.
- Whenever you edit a script, you should save it and close ROOT/GRSISort to run it again.
- To run RootEffi, type in the command line “ grsisort -l RootEffi.C ”
  or “ grsisort -l ” and then “ .x RootEffi.C ”
- Save your edited script and your new efficiency curve
- In one file, submit your fitted peaks, your edited RootEffi script, and your efficiency curve ☺