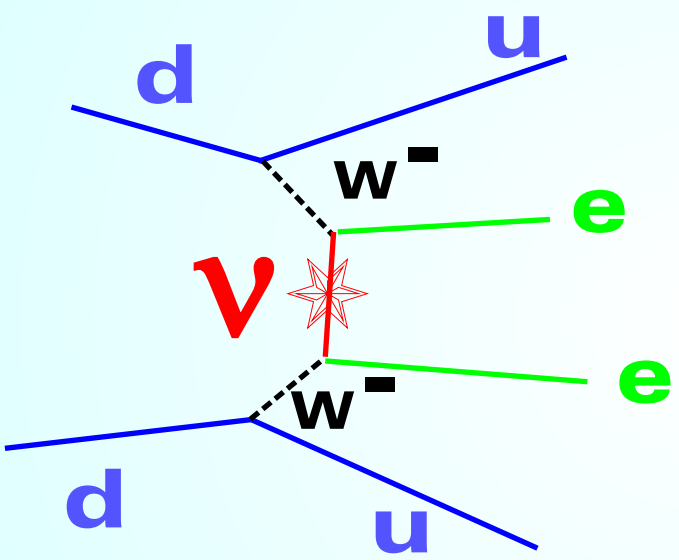
A Germanium 1-ton Experiment?

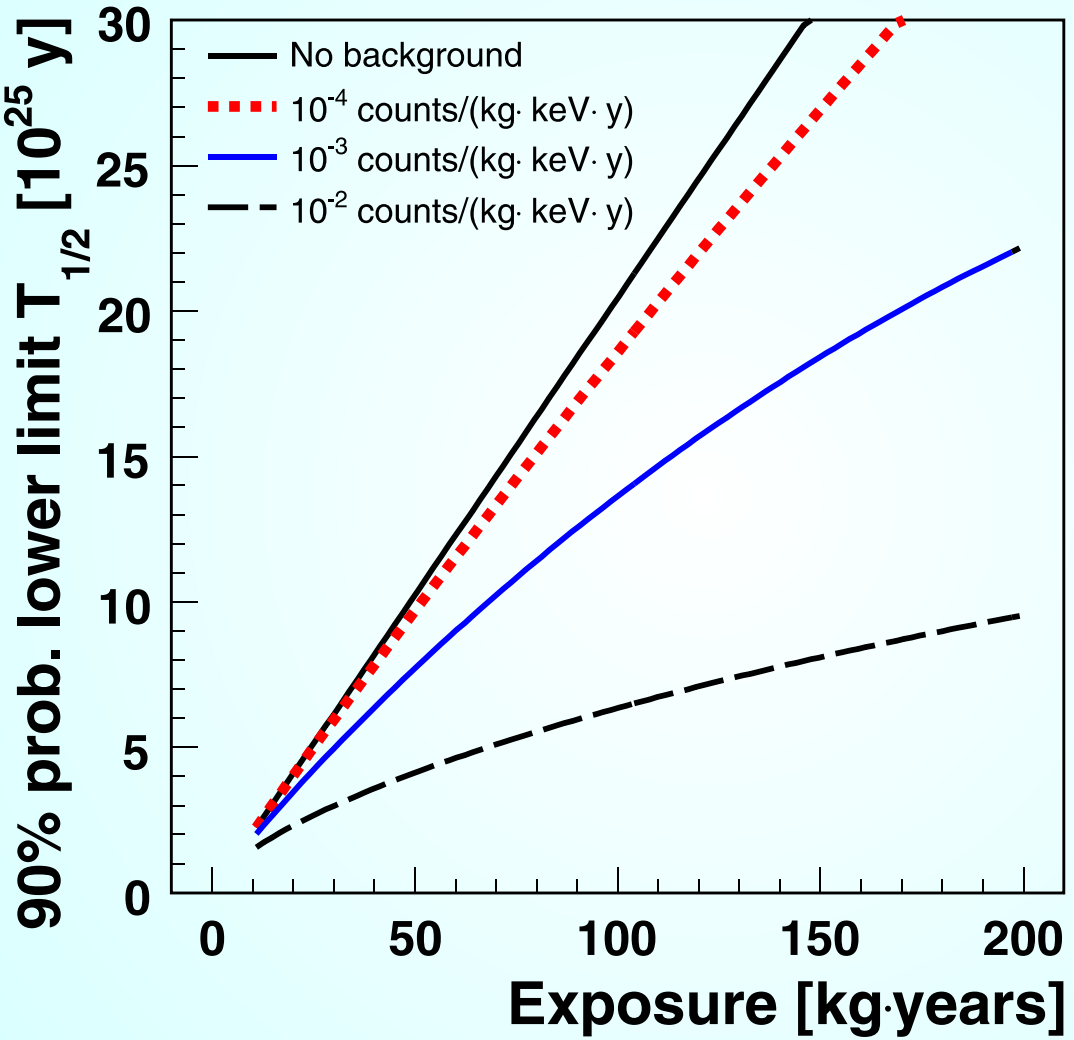


Seattle, Feb. 2010
I.Abt, MPI München

Challenge or Madness

Disclaimer:
all opinions expressed are mine only and probably not shared by others.

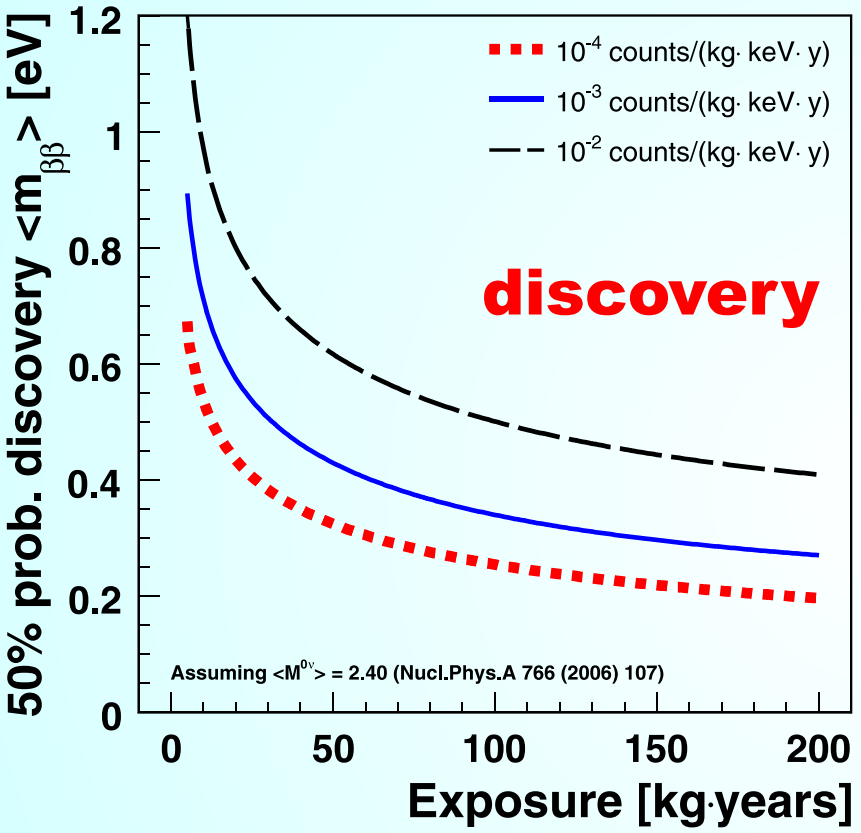
It is all in the Background

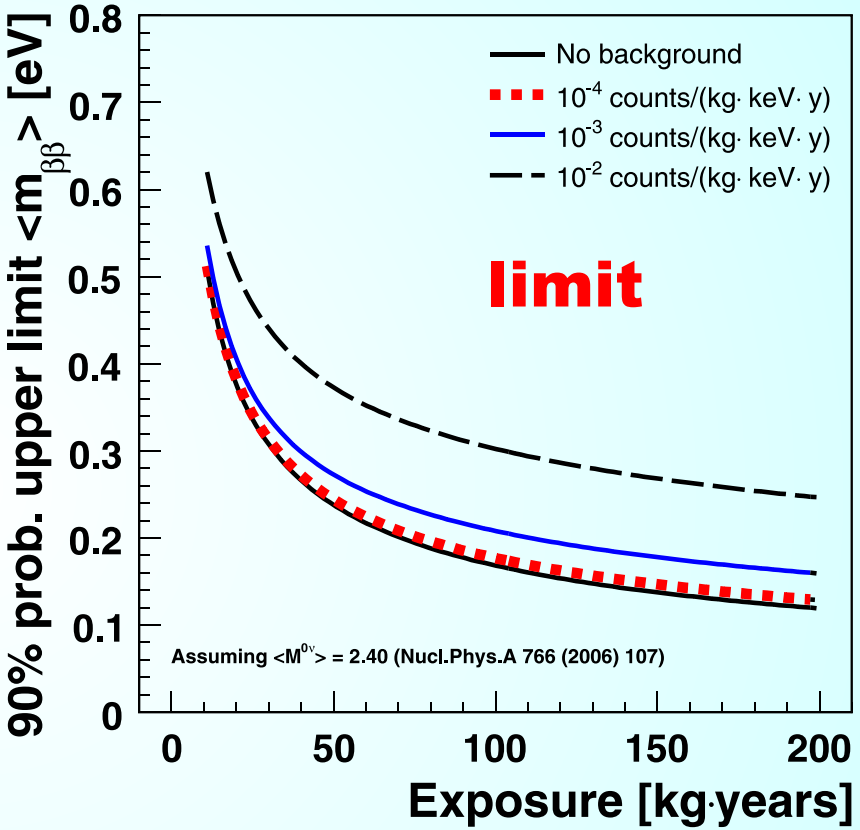


Exposure larger than 100 kg year is wasted for background of 10^{-3} /(kg keV y)

Need to understand, simulate the truely rare event.

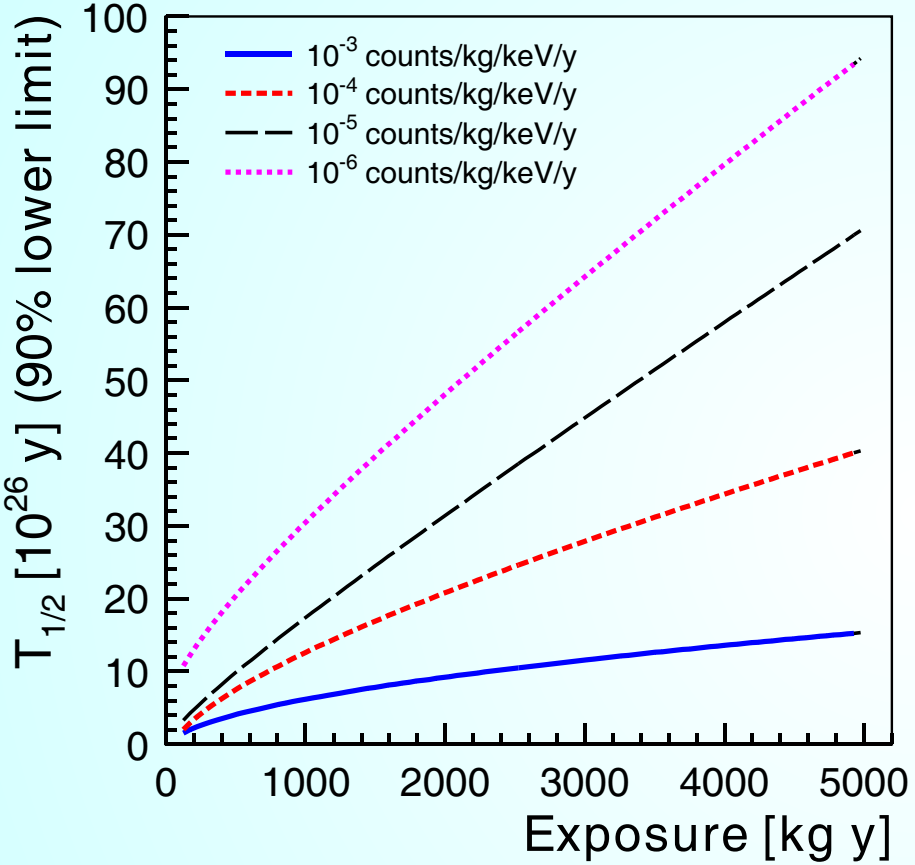
Importance of Background

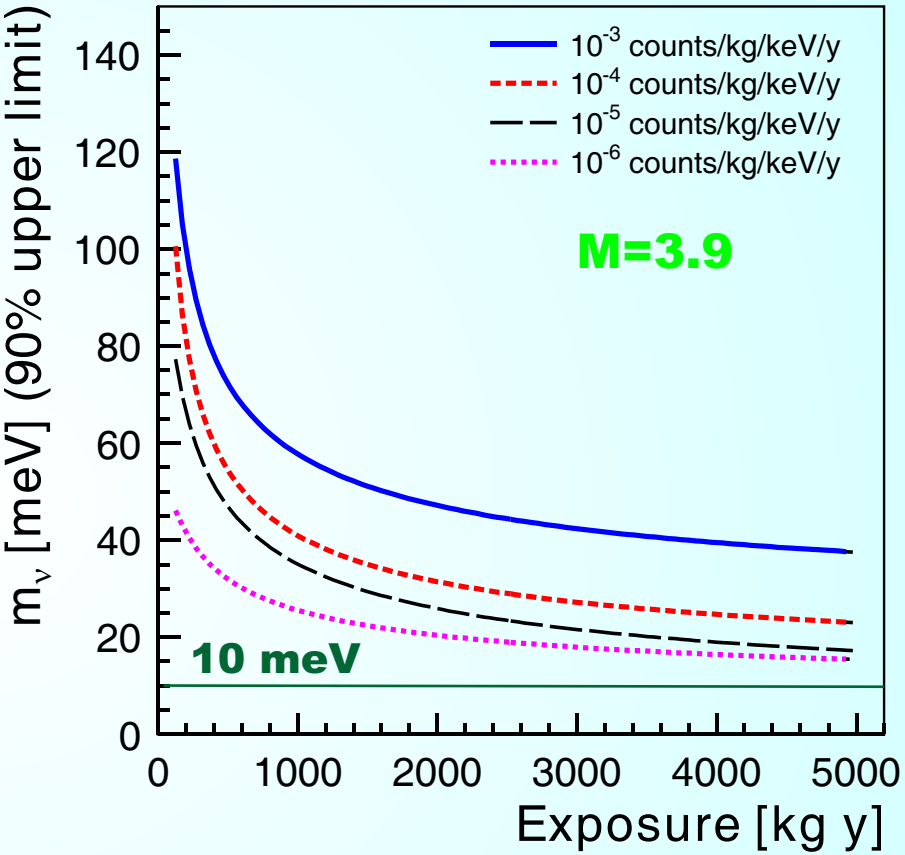




Is 10^{-4} good enough to reach 10meV to exclude inverted hierarchy ?

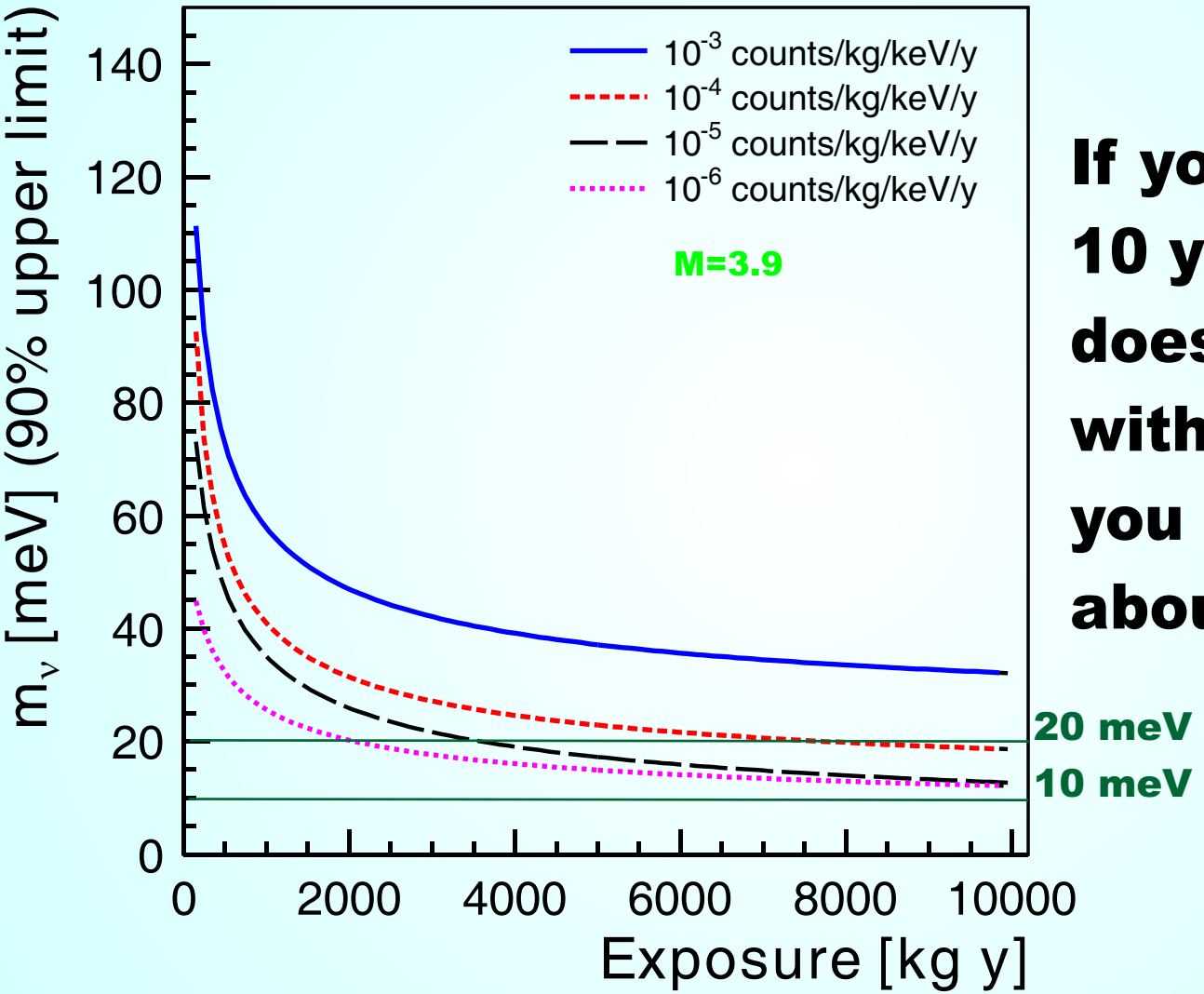
Importance of Background





Even 10^{-6} is not good enough to reach 10 meV with 5000 kg y .

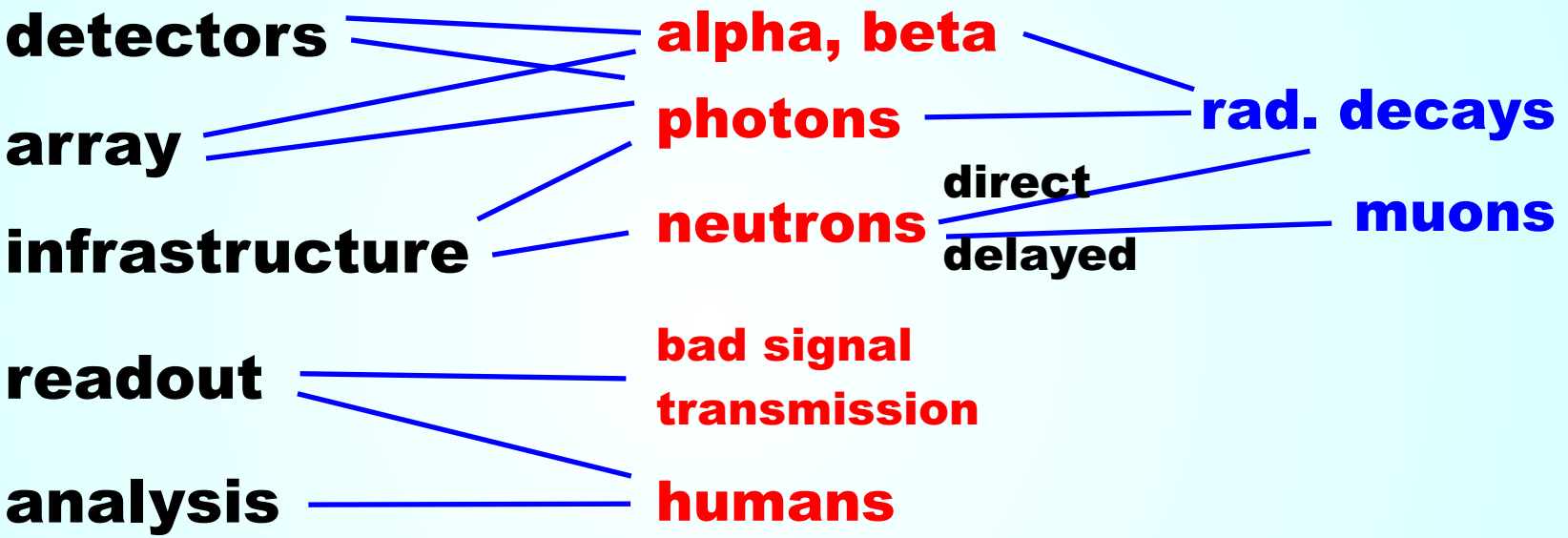
Importance of Background



If you measure 10 years, 10^{-6} does not help; with $10^{-5/-4}$ you can reach about 13/20 meV.

Reality of Background

Unwanted events have many sources:



All this needs to be understood and prevented at levels of less than one event in a million.

Almost infinite simulation and screening needed.

Detectors

Germanium Enrichment
~50 M€

Easy, but for cos-mogenic activation

Crystal Growing
~?0 M€

Alchemie
Many problems
plus cosm. activ.

Detector Manu-facturing ~100 M€

Very few sources!
n-type segmented detectors – one...

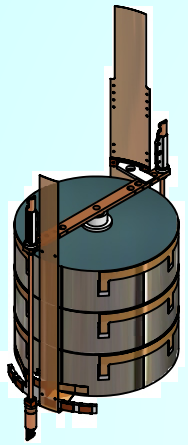
Detector Testing

1000 x 3 months = 250 years

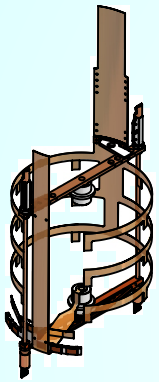
All this can probably be solved by spending money.

System Integration will require thinking!

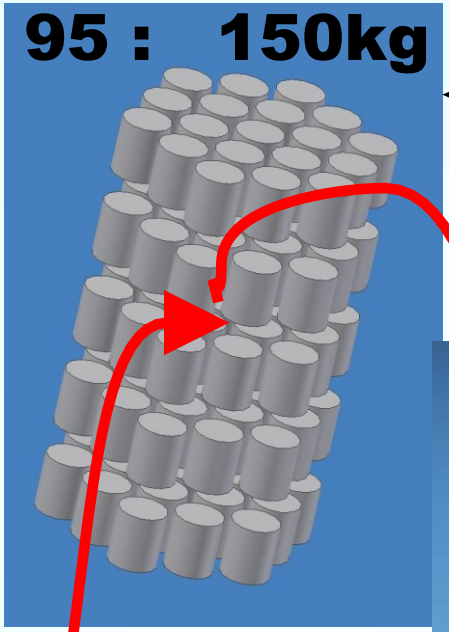
Array



18-fold segmented detectors

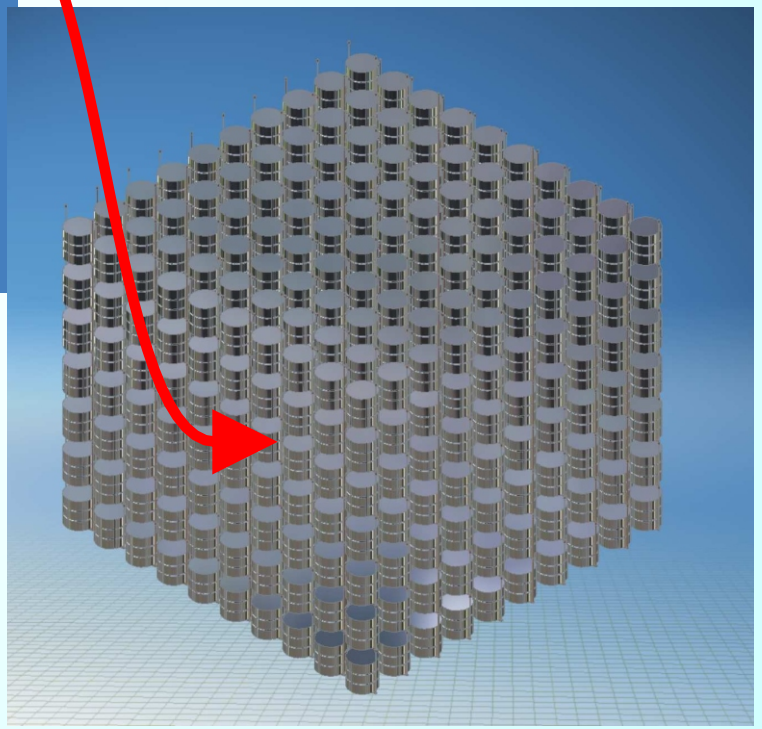


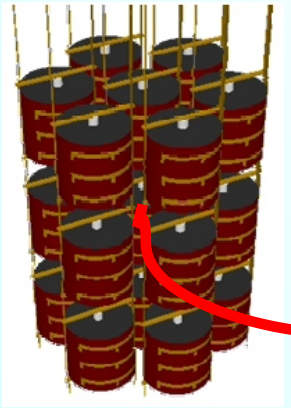
1.6 kg Ge
31 g Cu
8 g Teflon



This is technically possible.

This is not



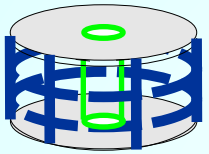


21:
34kg

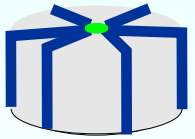
Screen every piece used.
But, HOW?

Array of the Future

Path to 1 ton is not clear at all. Need < 10^{-4} bgr.

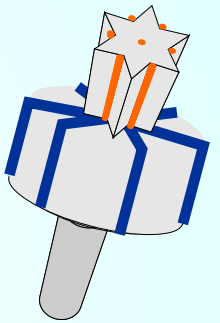


6 x 3 true coax

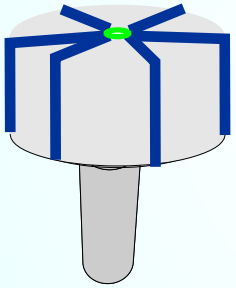


6

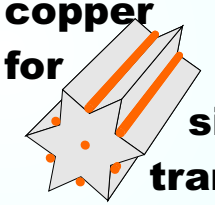
Point contact segmented detectors



Support out of "Optical" germanium crystals



Laminate copper for signal transfer



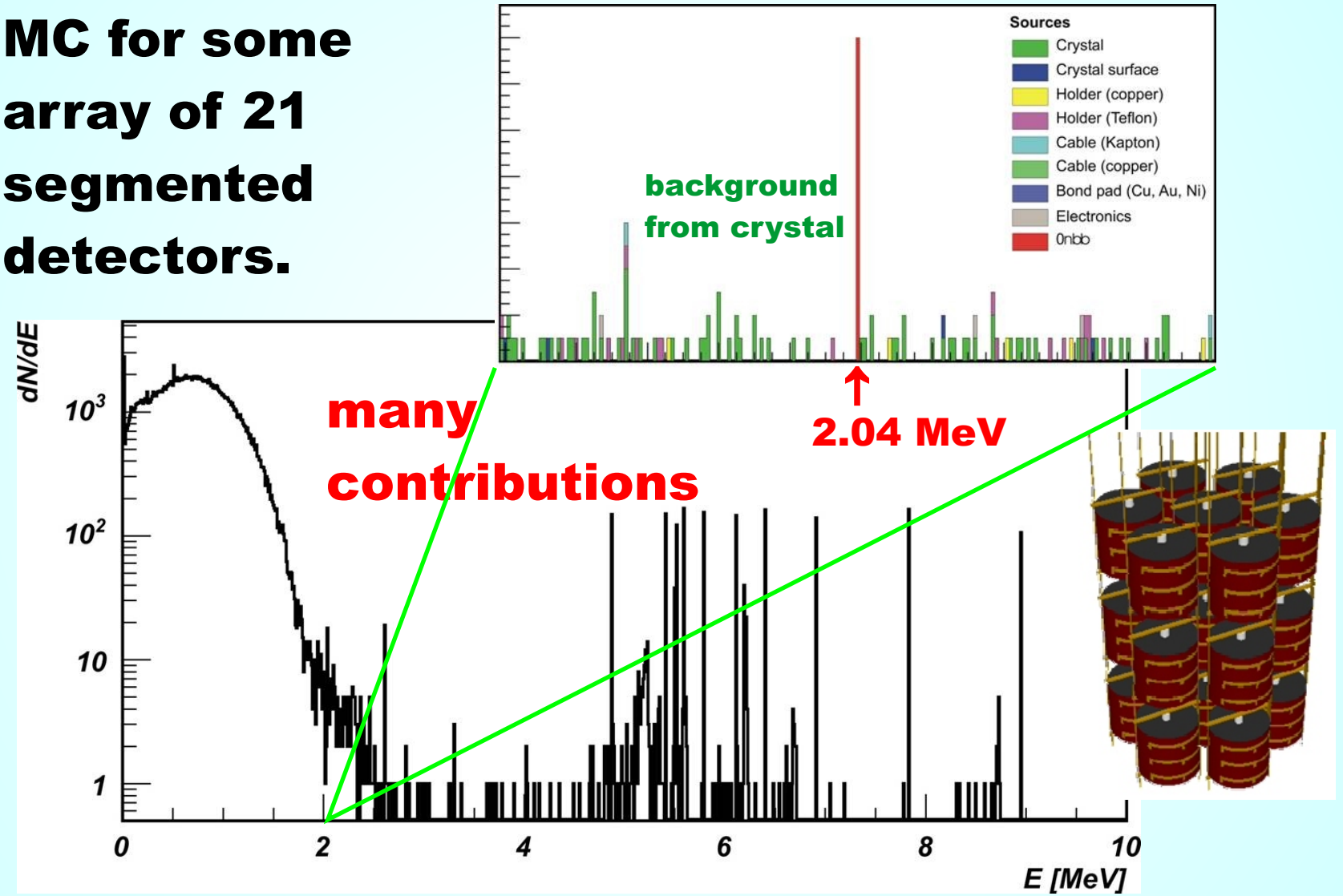
We need new technology!

We need MC to guide new technology. We need to simulate every configuration with a lot of statistics and with correct tails of distributions.

→ **We need MC bench marks.**

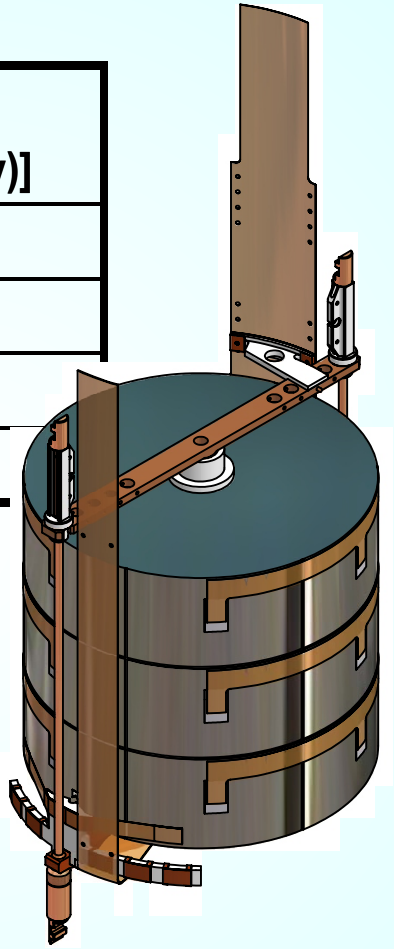
MC Example

MC for some array of 21 segmented detectors.

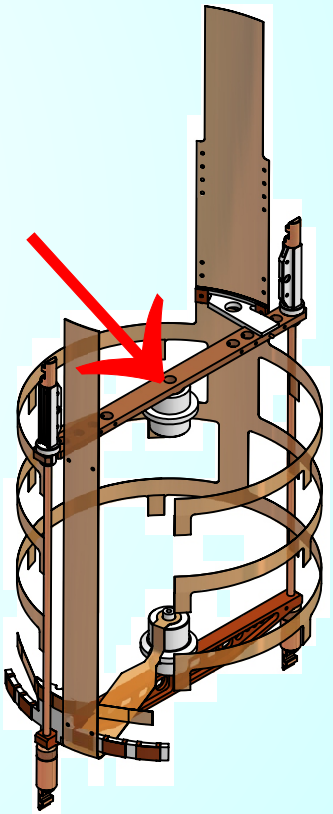


Need to focus

Part	Background index [10^{-4} counts/(kg·keV·y)]
Crystal	5
Holder (copper)	4
Holder (Teflon)	8
Cabling	6



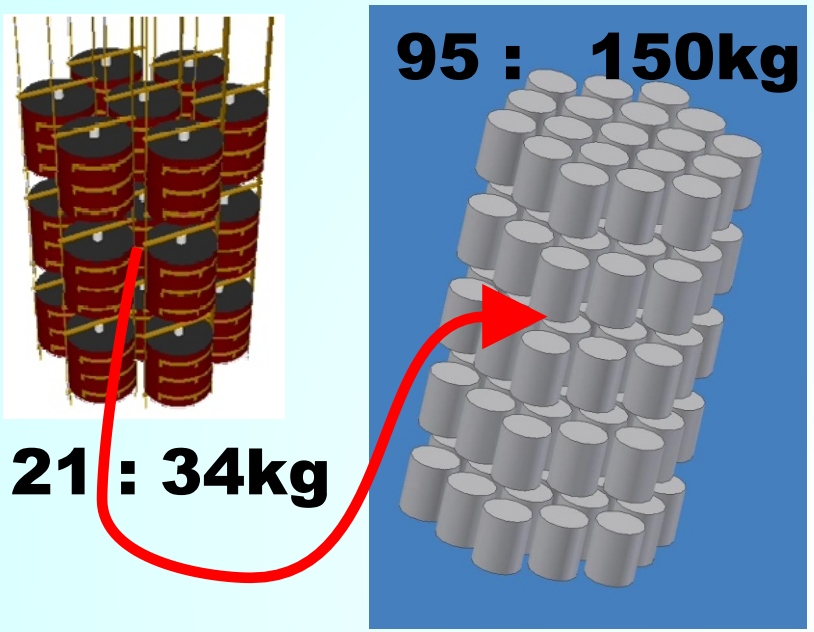
18-fold segmented detectors



Something will have to touch and hold.

We need to focus on key elements of any system.

Just the Insulator



Assume scaling:
The inner part of the large array should behave like the center crystal of the small array.

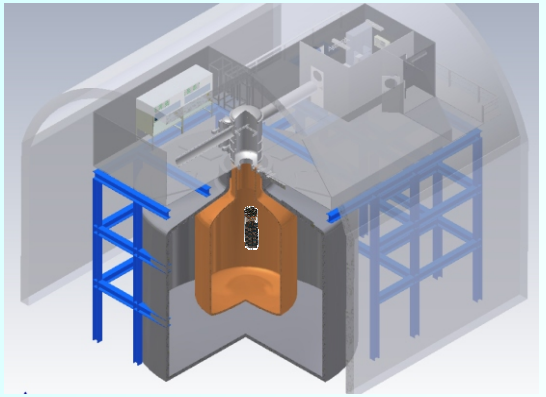
Simulate Thorium chain for the insulators that touch.

21 Million decays: survical prob. 0.0002 ± 8%.
A 1t array requires 625 detectors ⇒ 625 M decays.

Assume 1g insulator / detector ⇒ 50μBq/kg for 10^{-5}
without segmentation ⇒ 10μBq/kg

And the outer detectors can only be worse....

Infrastructure of the Future

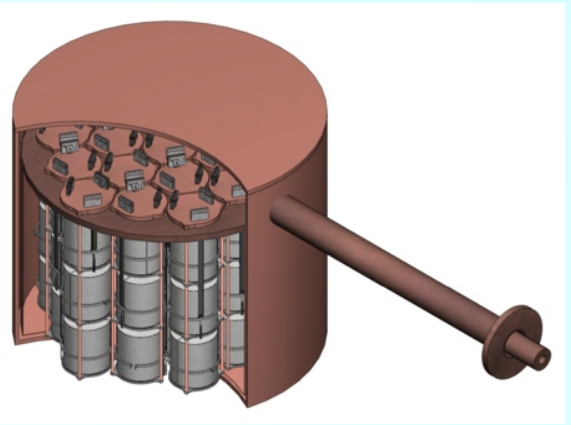


Gerda

or

Majorana

or .....



Cryogenic Shield

homogenous

longer signal path

~~**submerged detectors**~~

Copper Shield

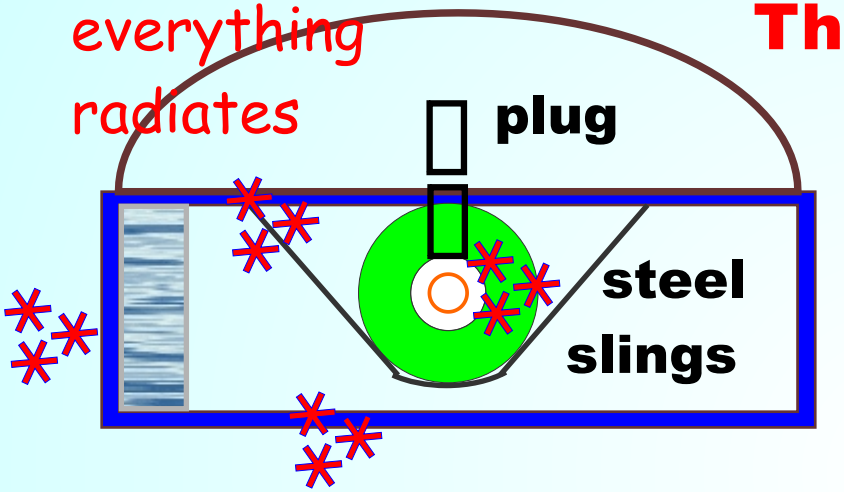
compact

cracks

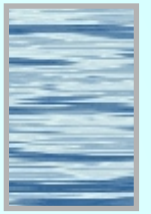
high Z material

Does it matter ? Probably not .....

Infrastructure of the Future



The hall has to be large!



water shielding

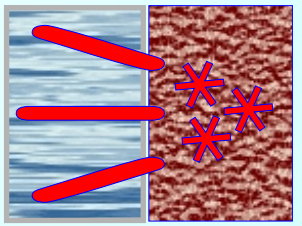
LAr shielding

Copper vessel with vacuum holds array

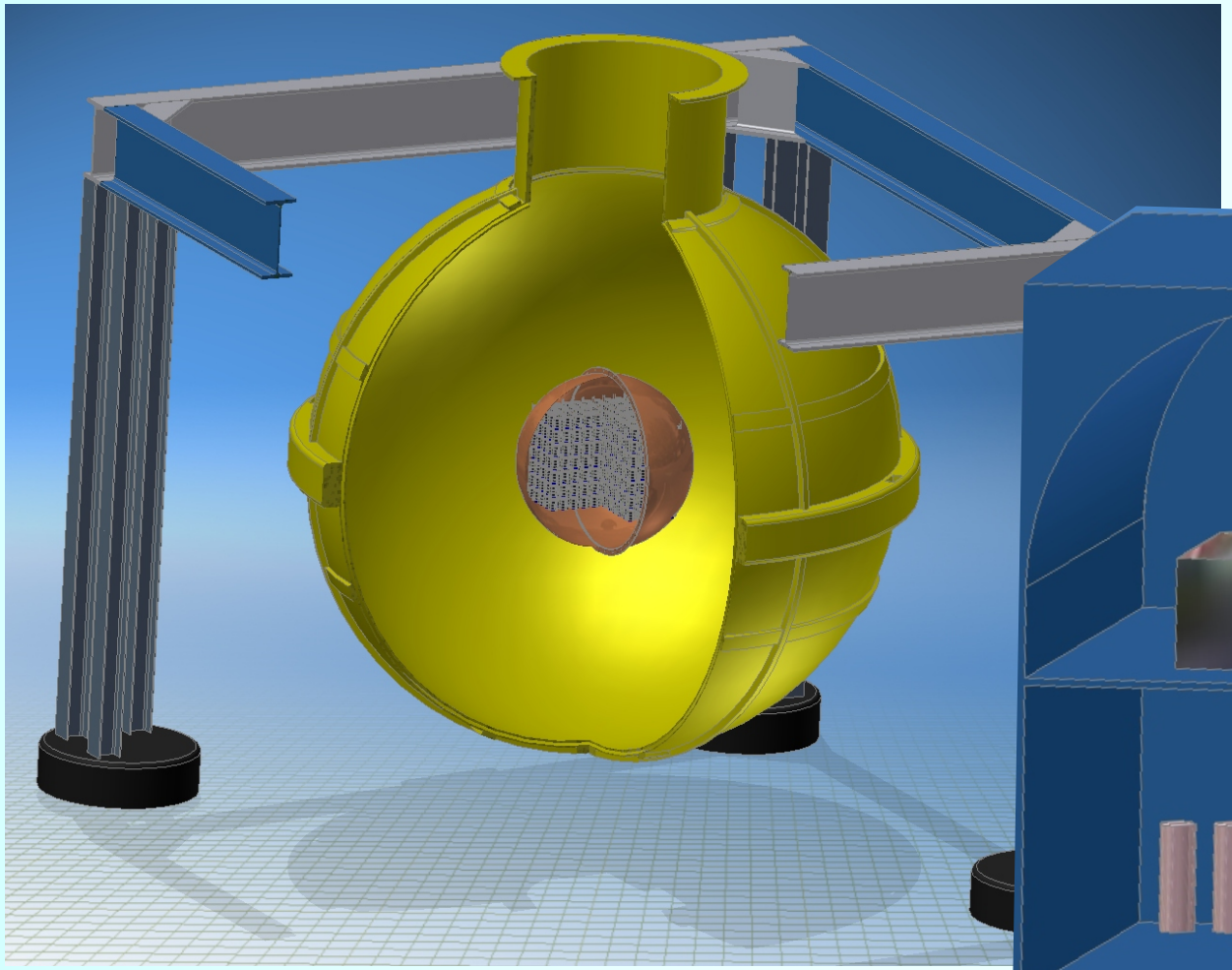
NO compromises!

It will be necessary to use some intelligence to simulate large infrastructure and it has to be done before digging starts.

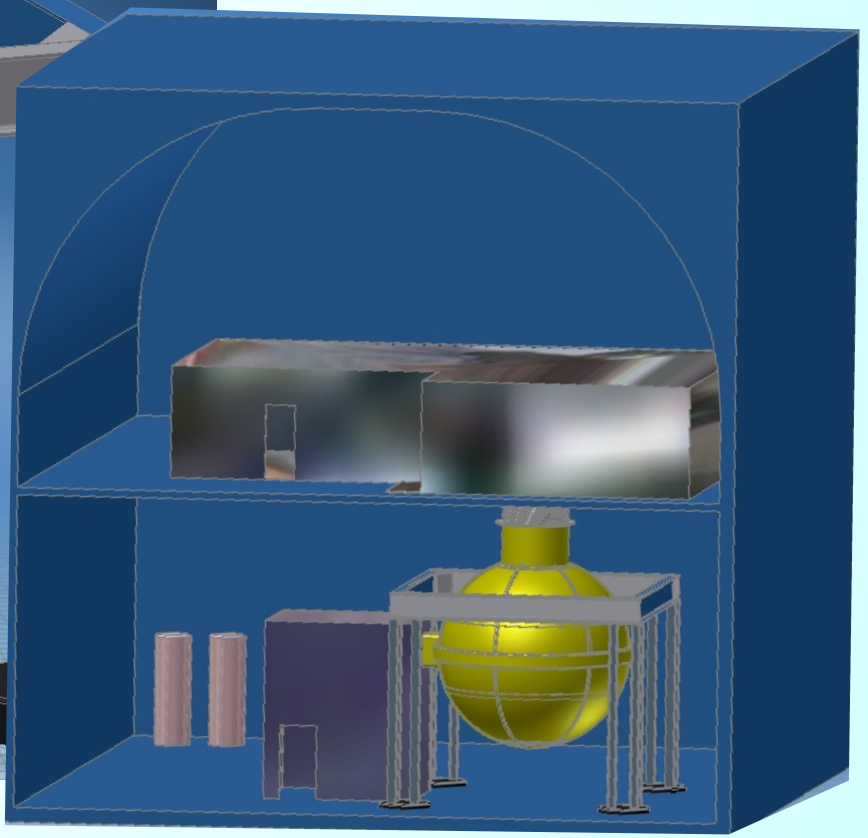
We need MC benchmarks for "little" things and for large structures.



Infrastructure of the Future



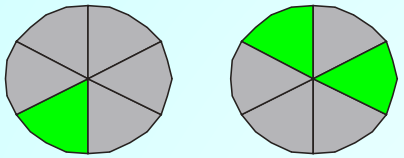
Some
bad dreams.



MC to be done soon.

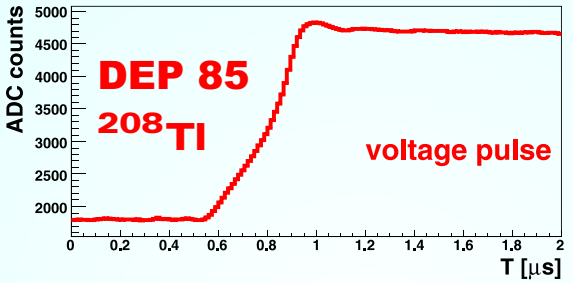
multiply the lower hall

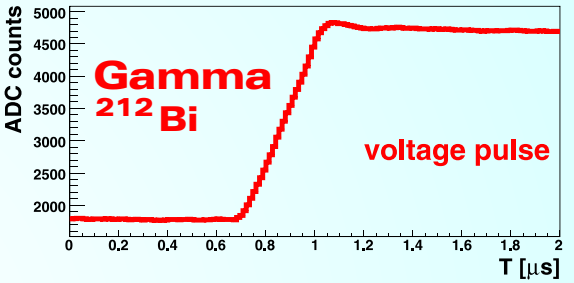
Analysis

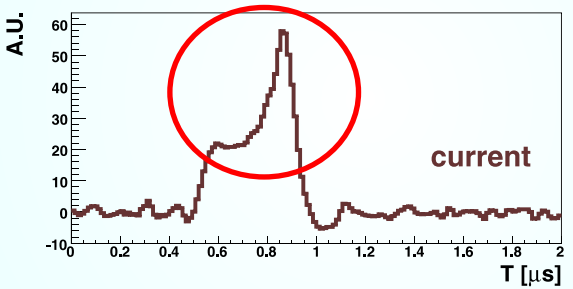


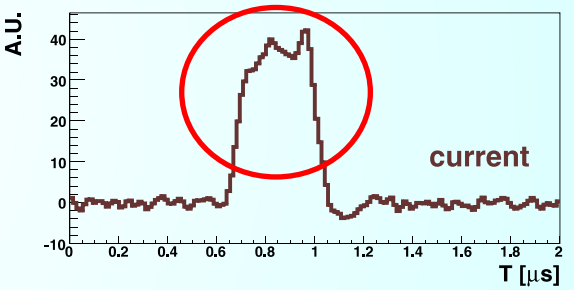
factor ≈ 10

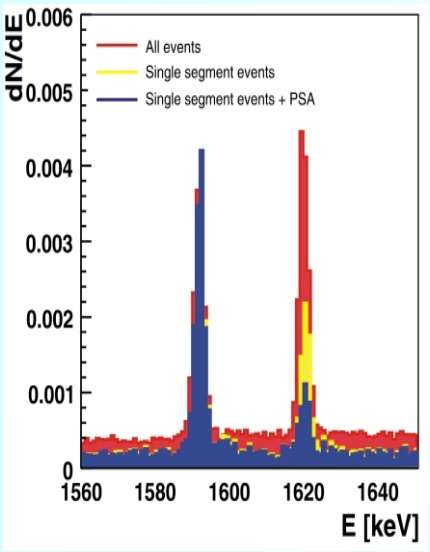
Background suppression from counting segments is easy and robust.











Pulse shape analysis gets you an extra factor of 1.4 for single segment events.

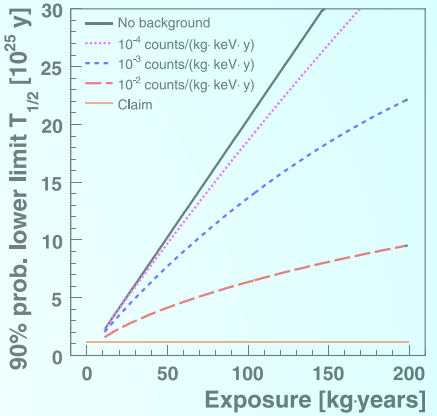
Should we use current sensitive devices ?

Can we afford the more/better cables ?

[In]Famous Last Words

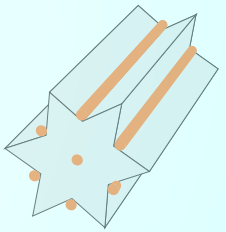
A 1t experiment will be all about background.

I am absolutely not convinced that 1 ton Ge experiment makes sense.



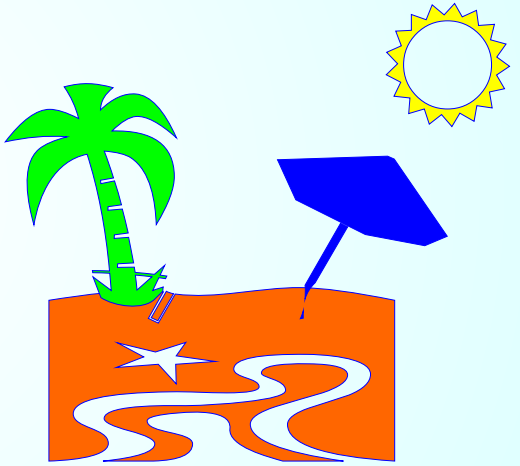
New technology will be needed together with a gigantic amount of simulation and screening.

We need benchmarks to verify our simulations and we need another experiment to screen.



A 1t experiment will need a lot of good engineering, also electronics engineering.

Absolutely no compromises !



There might be better places to waste time.