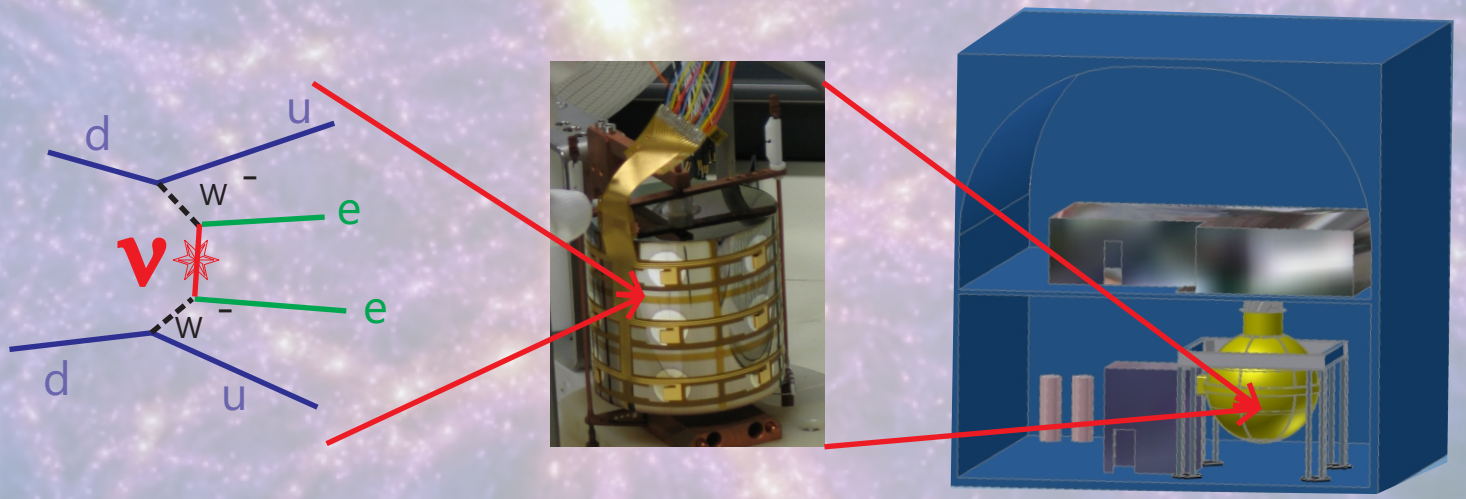
Germanium Detector Development

GeDet



Project Review 2012

I.Abt, B.Donmez, Olexander Volynets

L. Garbini, S.Irlbeck, M.Palermo,

B.Majorovits, O.Schulz

Germanium, what for?

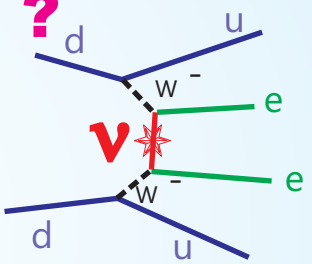
Neutrinos and **Dark Matter**

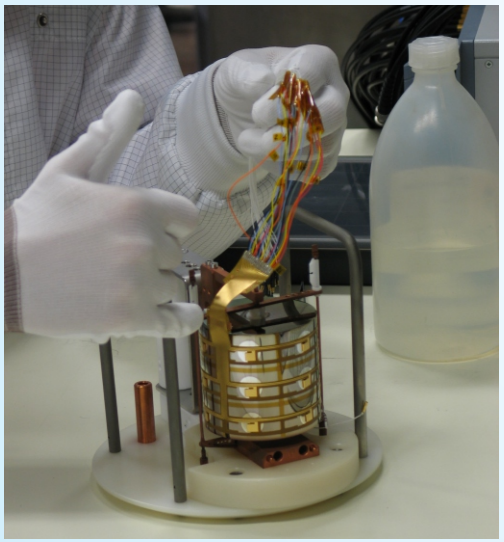
→ **GERDA**

→ **future projects ?**

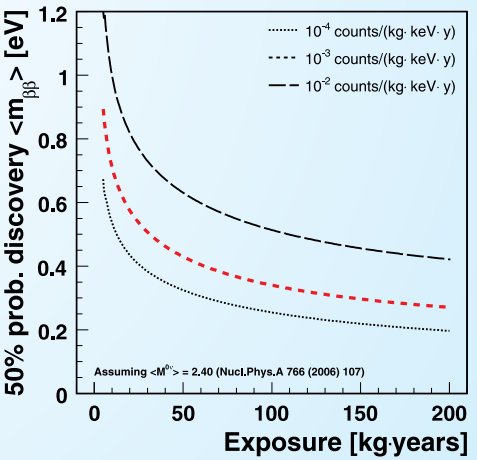
Majorana mass

not with Ge
at MPI (yet?)





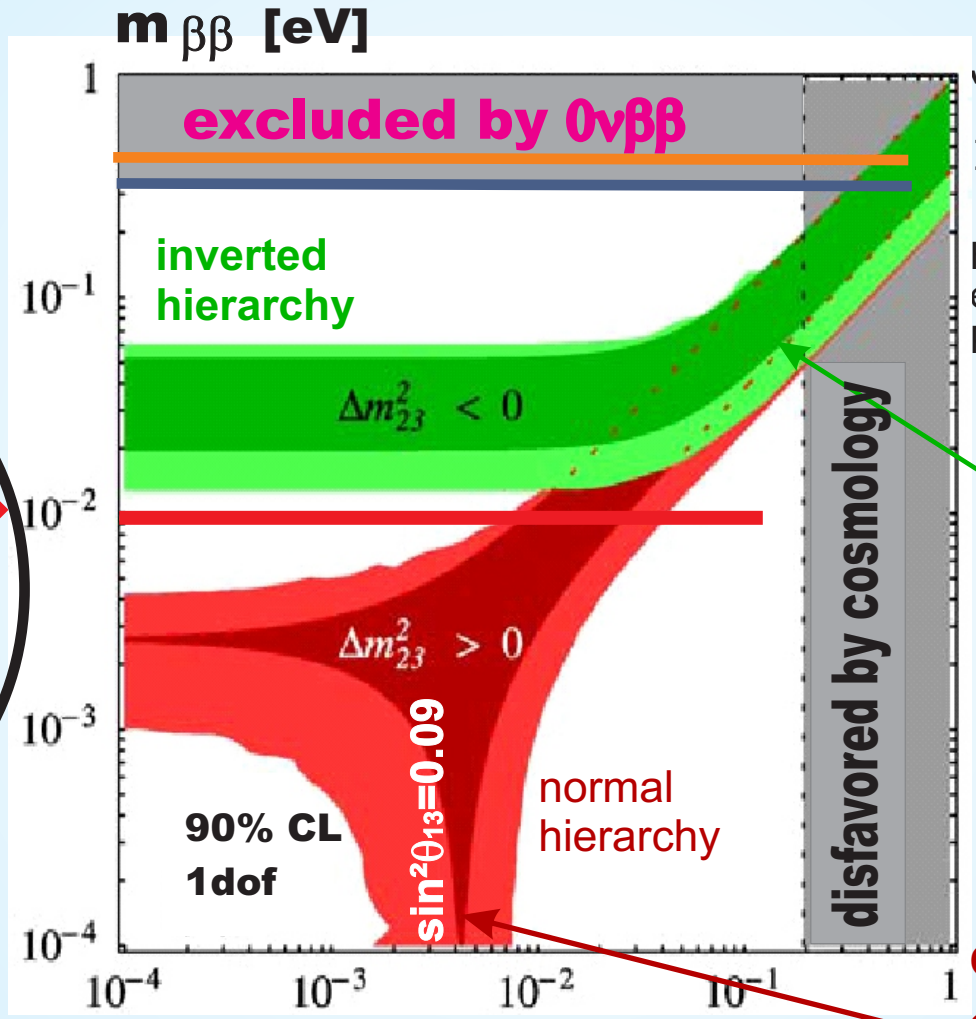
- **Goals**
- **Experimental Reach**
- **Detector Technology**
- **Future**



Expectations and Goals

CLAIM

EXO



10 meV

good goal

Feruglio Strumia Vissani NPB 637

"Evidence for 0νββ"
$1.2 \cdot 10^{25}$
(0.69-4.18 3σ)
H.V.Klapdor - Kleingrothaus et al
Phys. Lett. B 586 (2004)

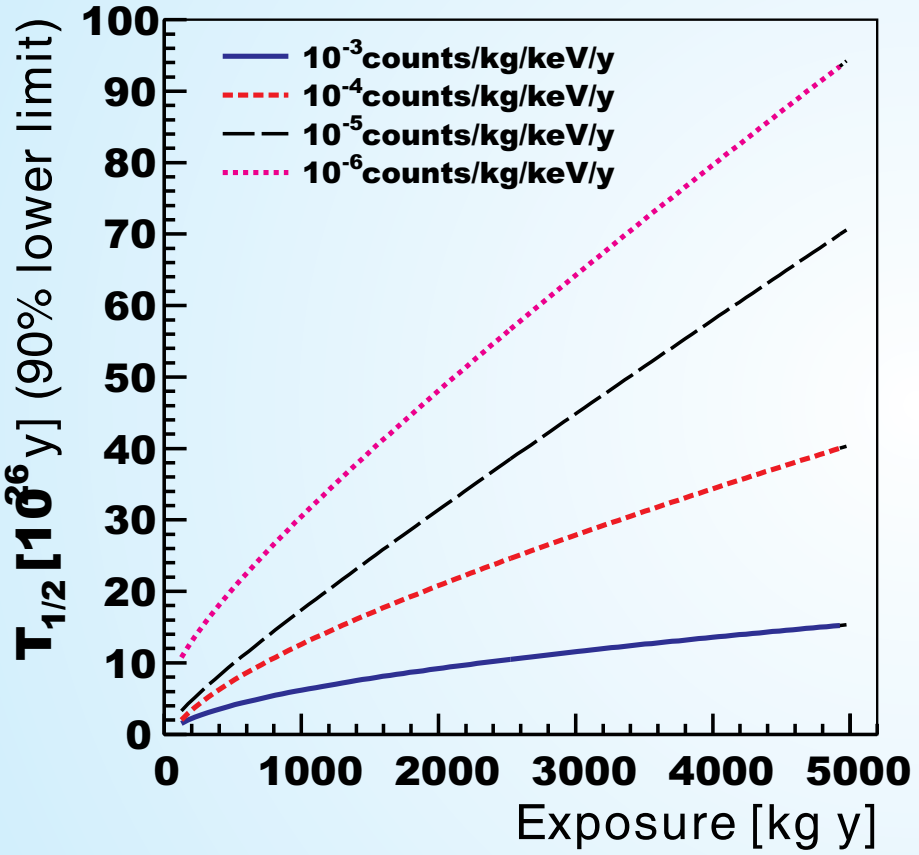
uncertainty from Majorana CP phases

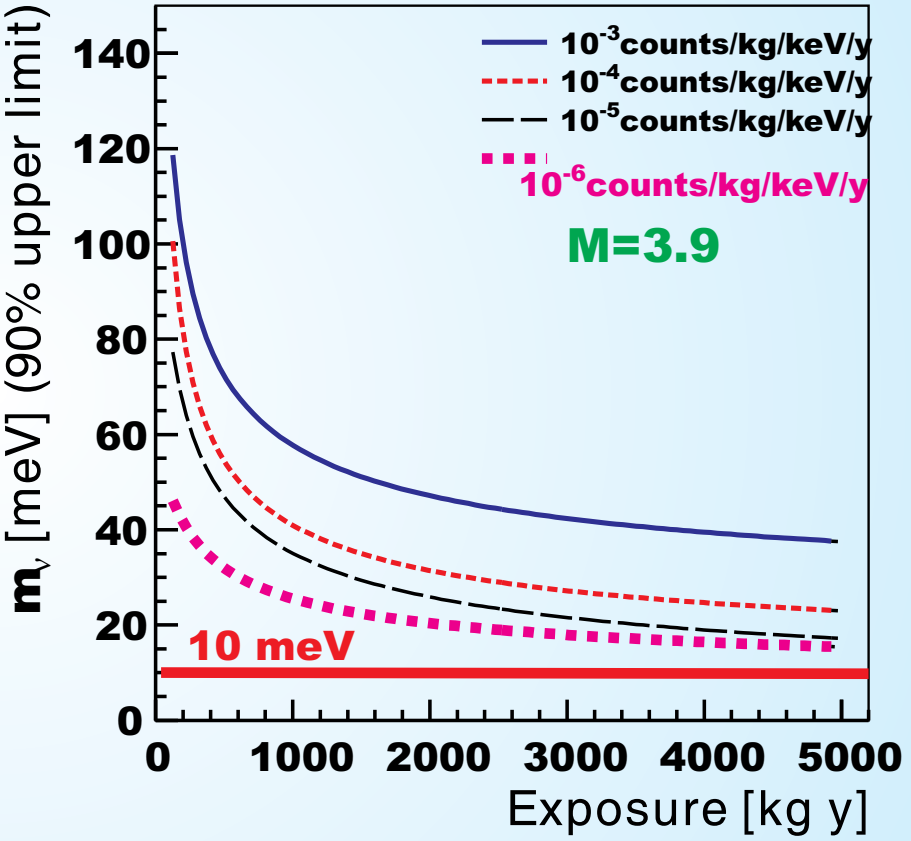
This assumes that the neutrino is purely Majorana.

Conspiracy of Majorana phases

Importance of Background

$1/T_{½}$ = phase-space • matrix-element • coh.neutrino mass²



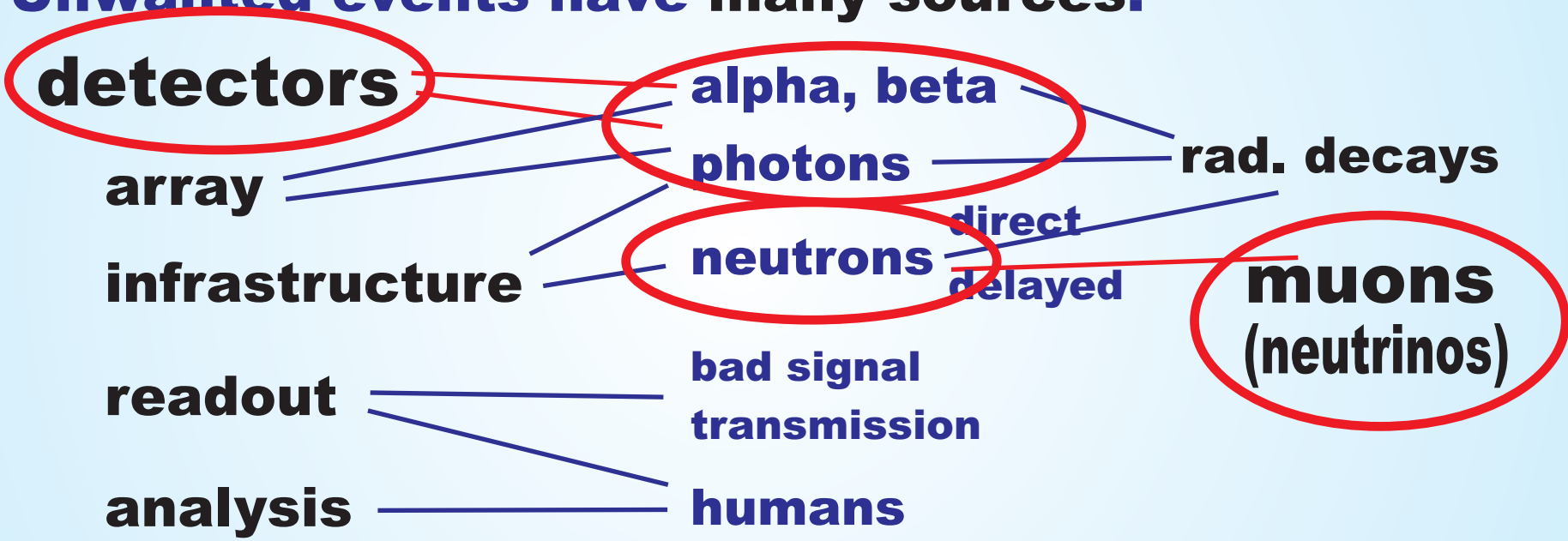


10 meV will be very difficult, even with 5000 kg y .

Reality of Background

We need a detector with a large mass [1ton] and minimal background.

Unwanted events have many sources:



All this needs to be understood and prevented and we focus on .

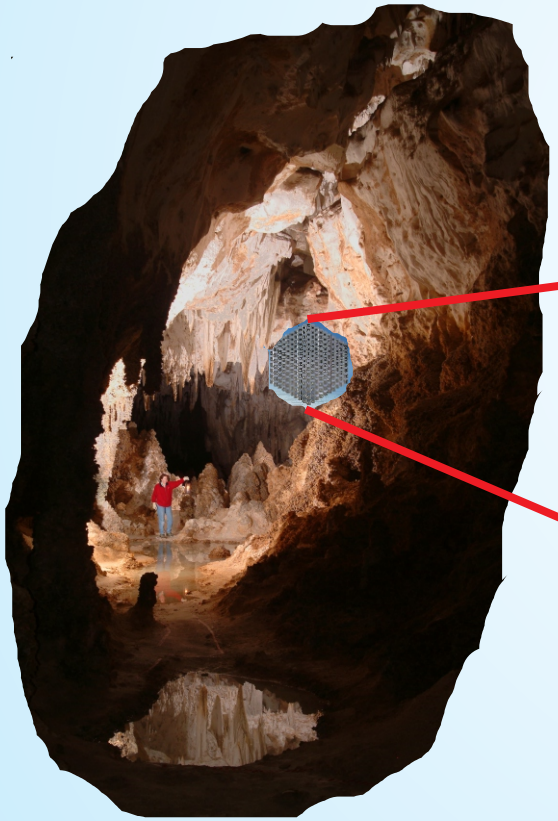
Reality of a 1ton Ge Experiment

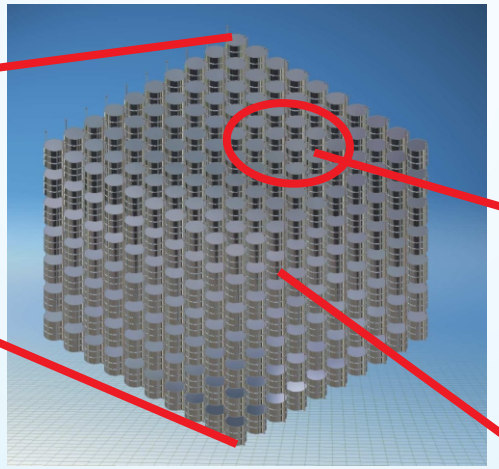
Of course there is no reality yet, but for the expectation of price:

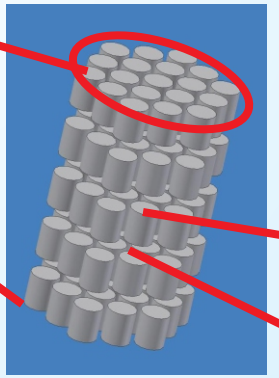
~500 M€

Infrastructure

Enrichment, Crystal Growing, Detector Manufac-turing, Array







Infrastructure of the Future

Sphere

Can this be done?

and if, where ?

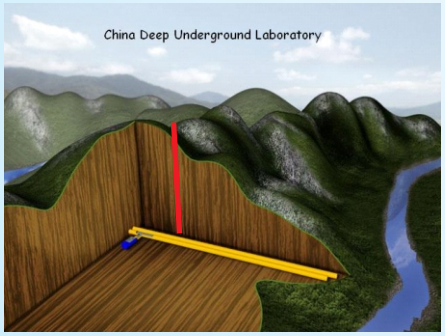
Some
bad dreams.

multiply the lower hall

Jinping Laboratory China

CJPL

CDEX dark matter experiment



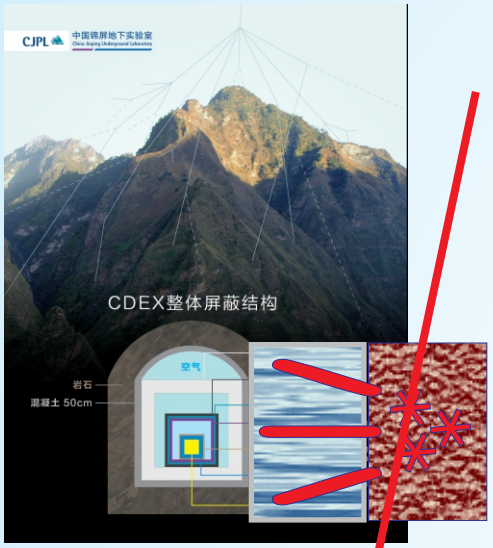
2400m of rock

7500 mwe

Cooperation with Tsinghua (Beijing) and Jaotong (Shang-hai) on detector and lab R&D

Muon Induced Showers

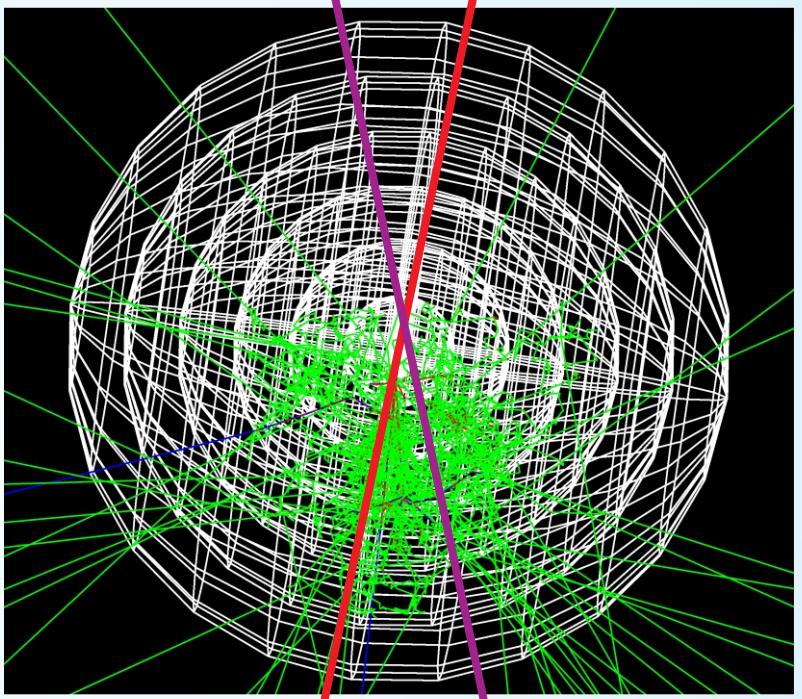
CJPL muon rate is $2 \cdot 10^{-20}$ /cm²/s



lab R&D: neutron shield

μ

What has the wall to do?

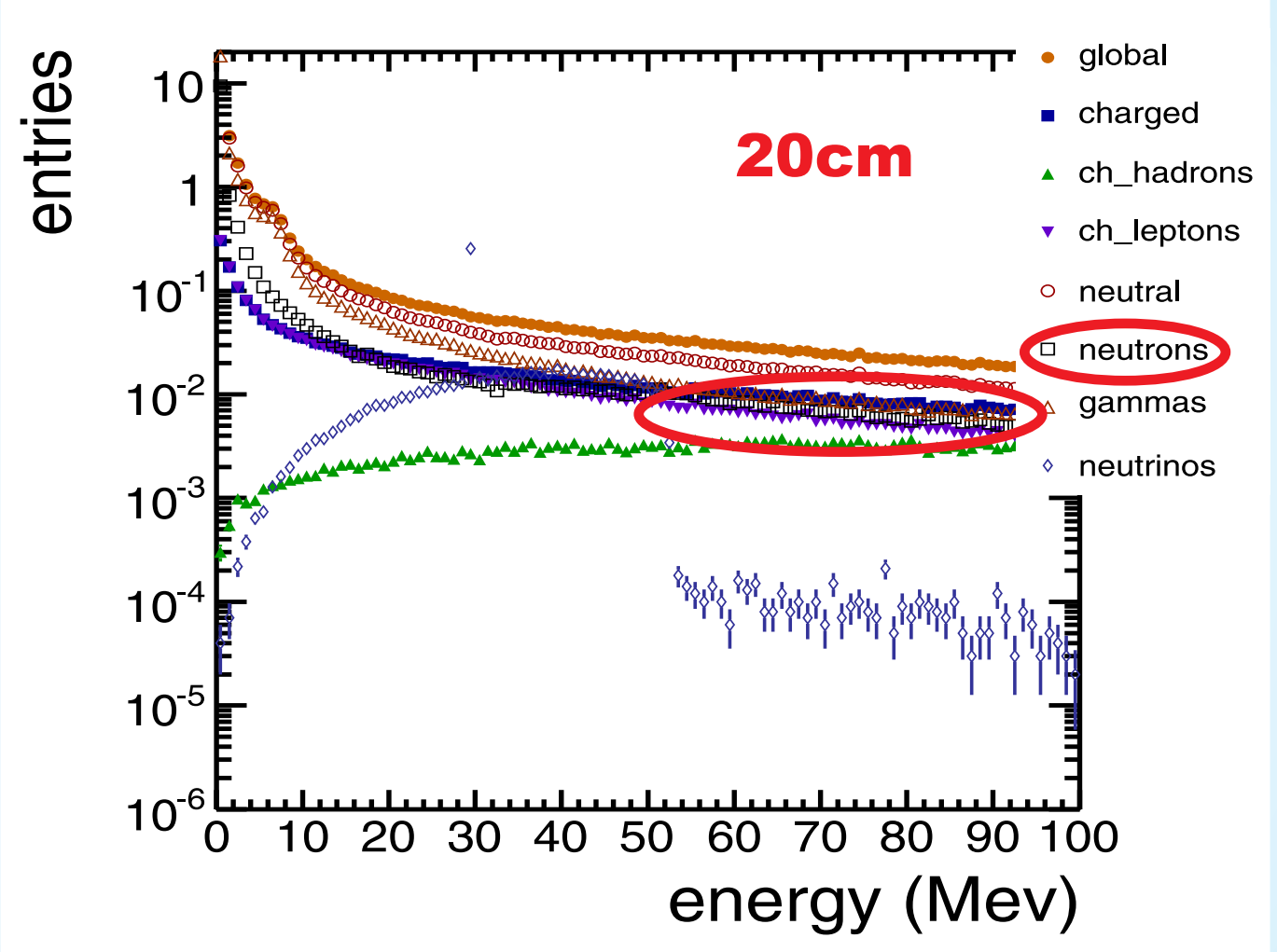


What do we expect in fast neutrons ?

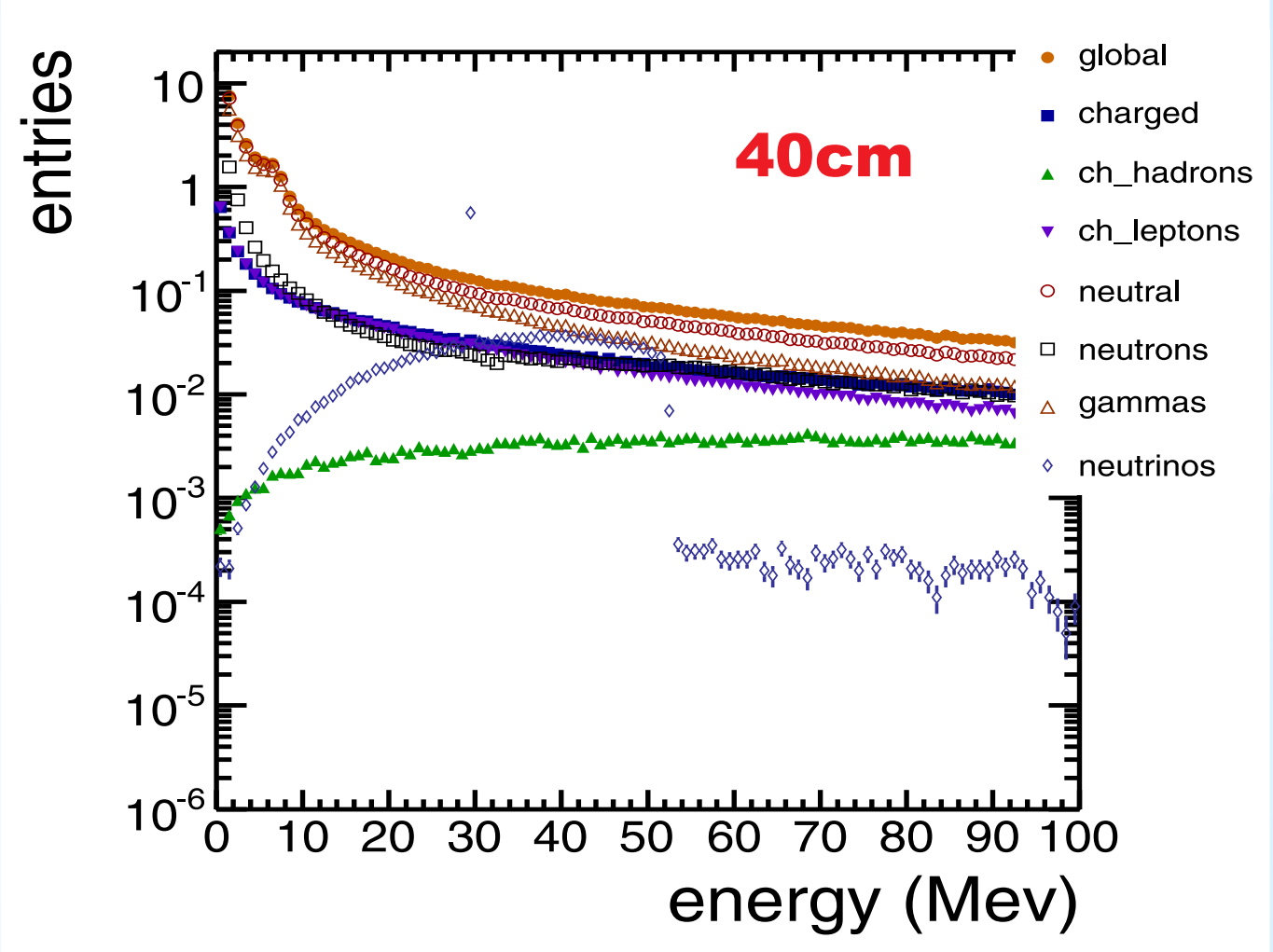
What can be measured?

including upwards going from neutrino

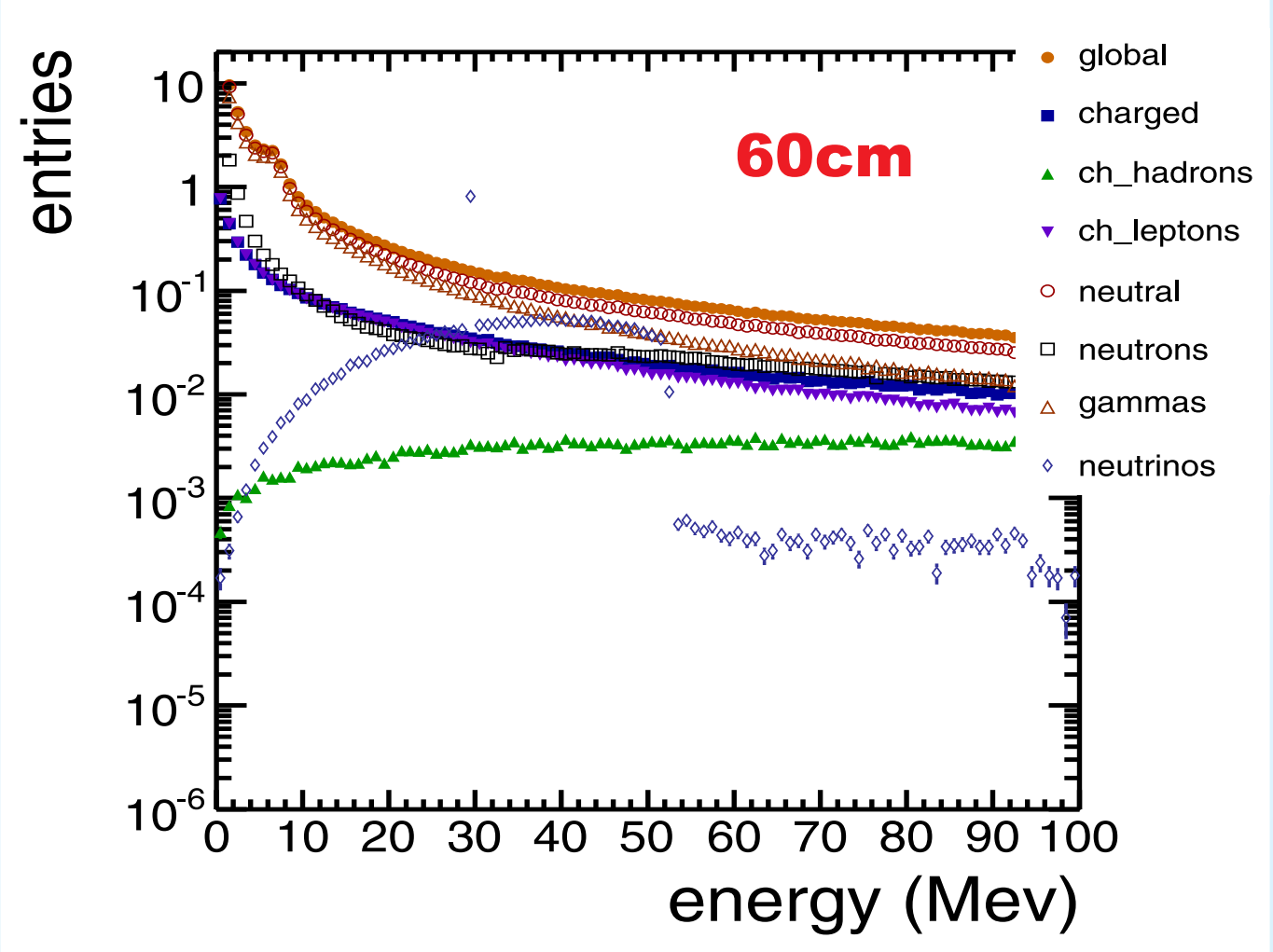
MC on Showers in Rock



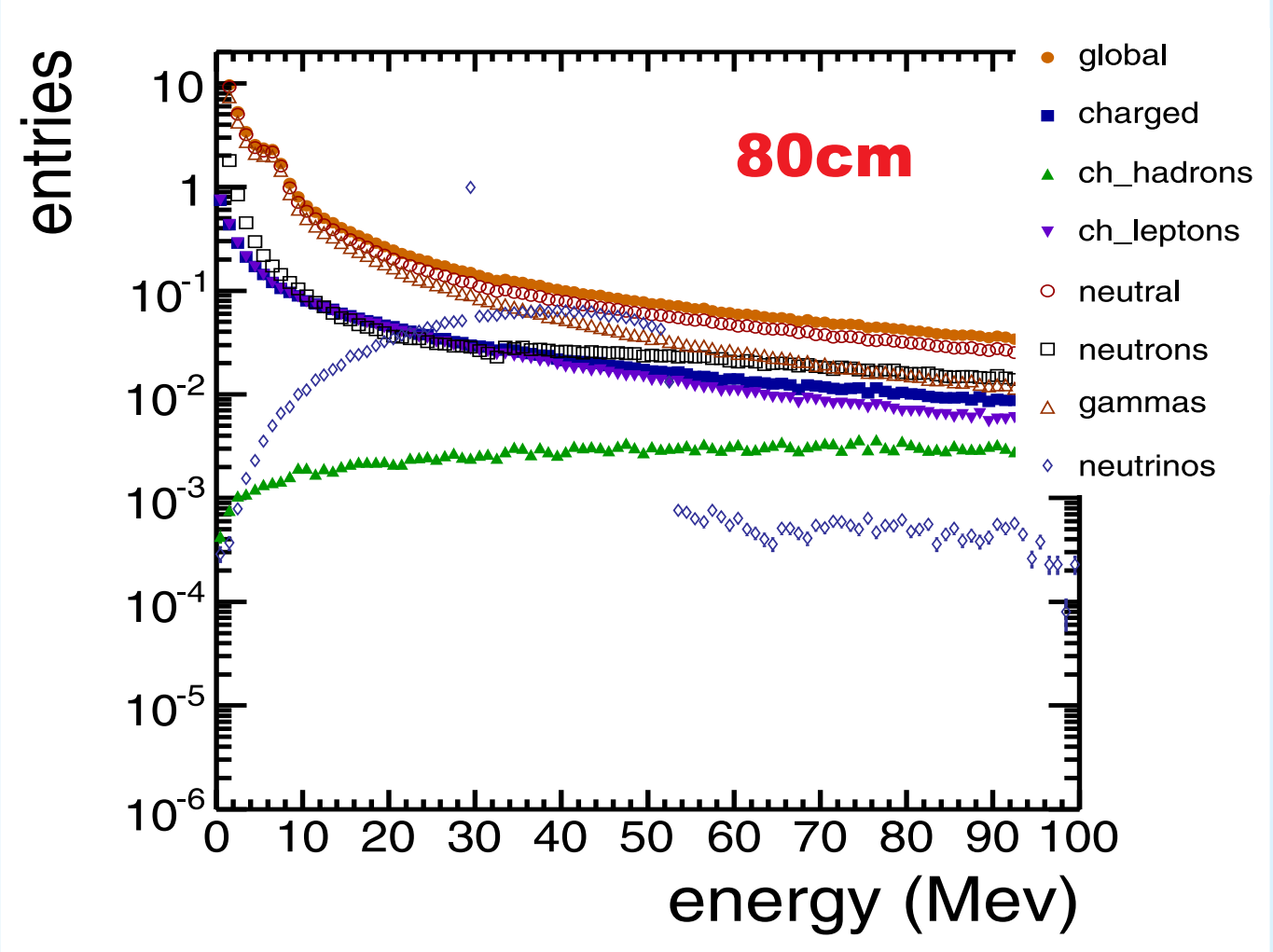
MC on Showers in Rock



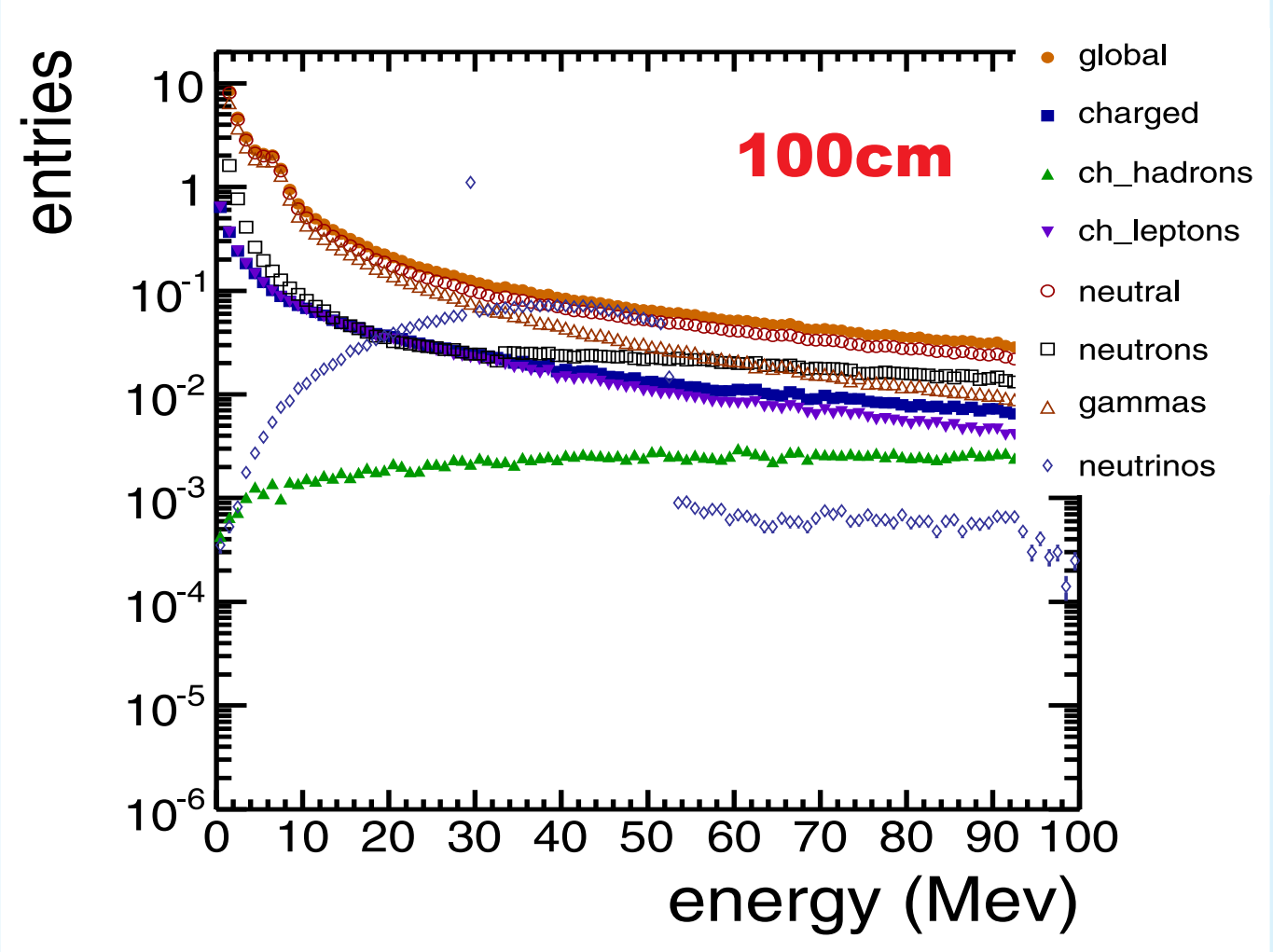
MC on Showers in Rock



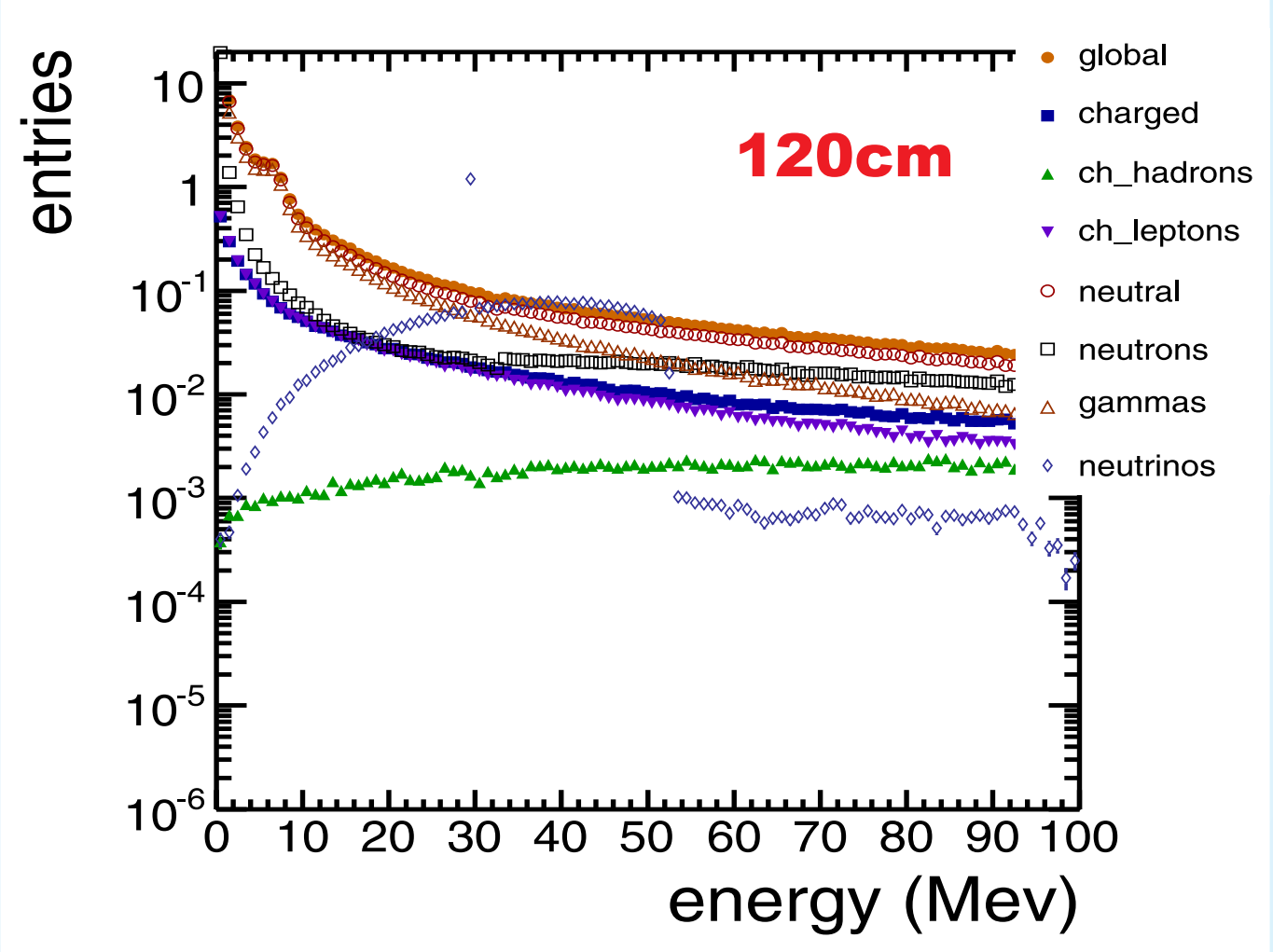
MC on Showers in Rock



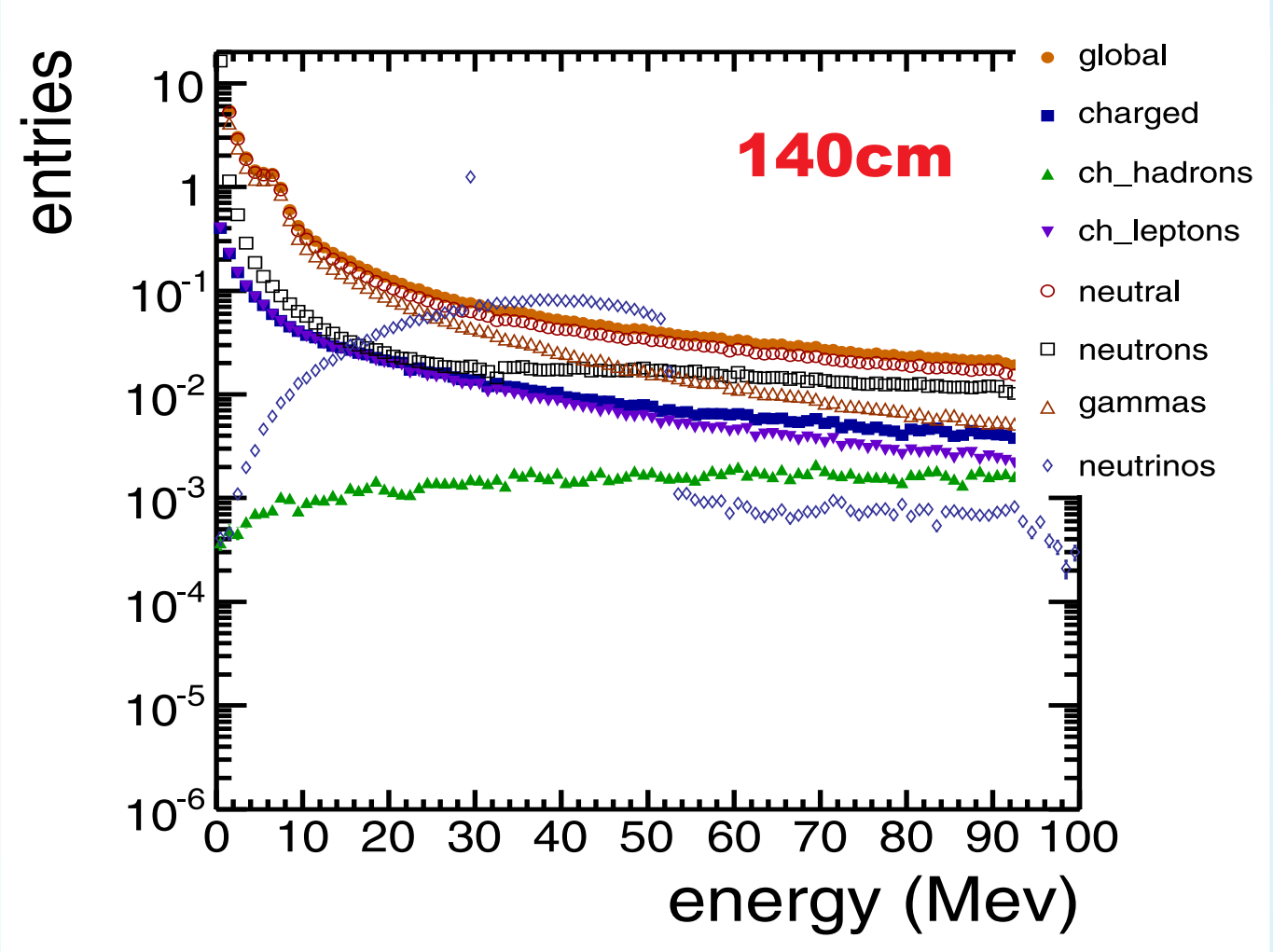
MC on Showers in Rock



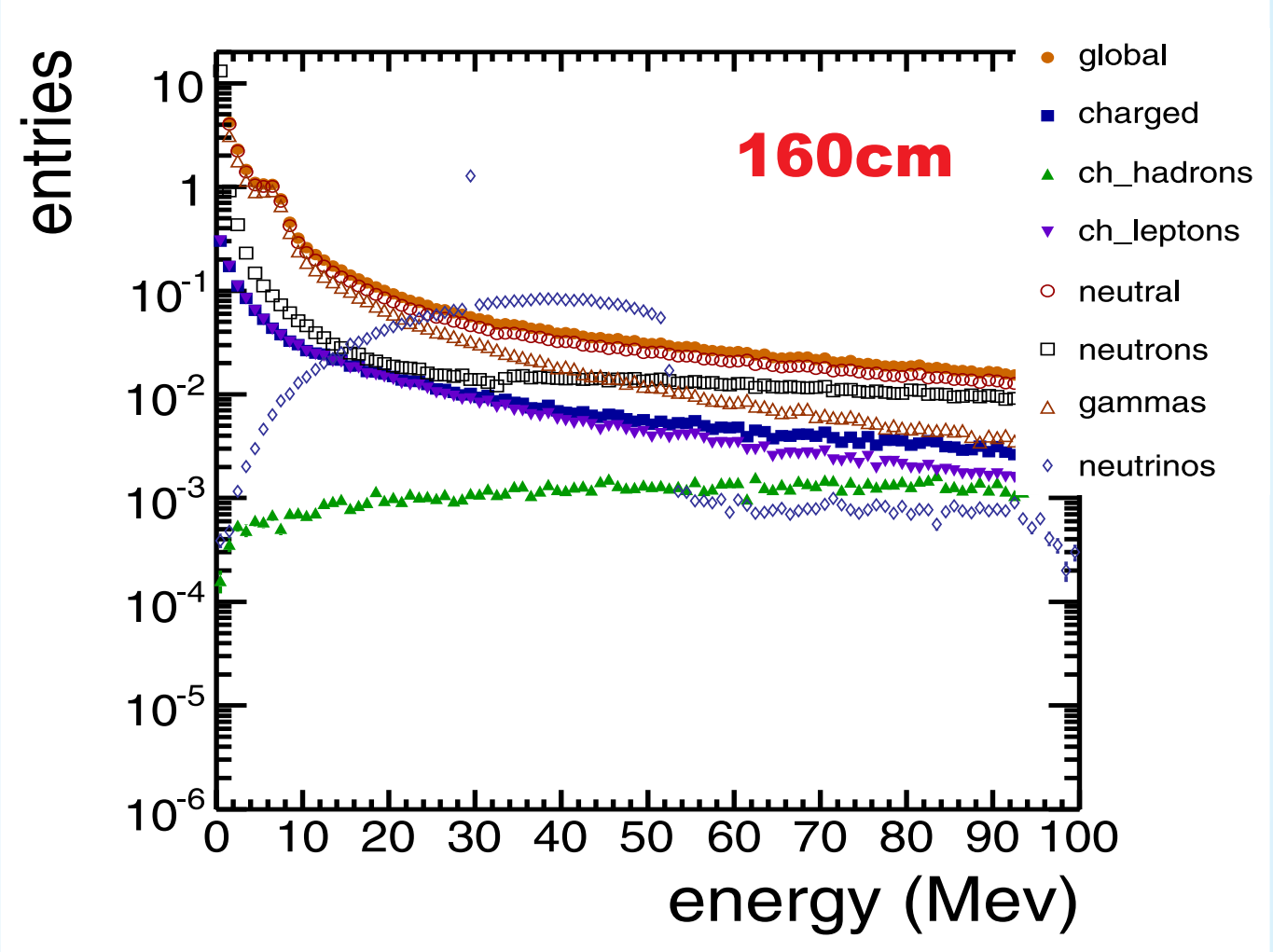
MC on Showers in Rock



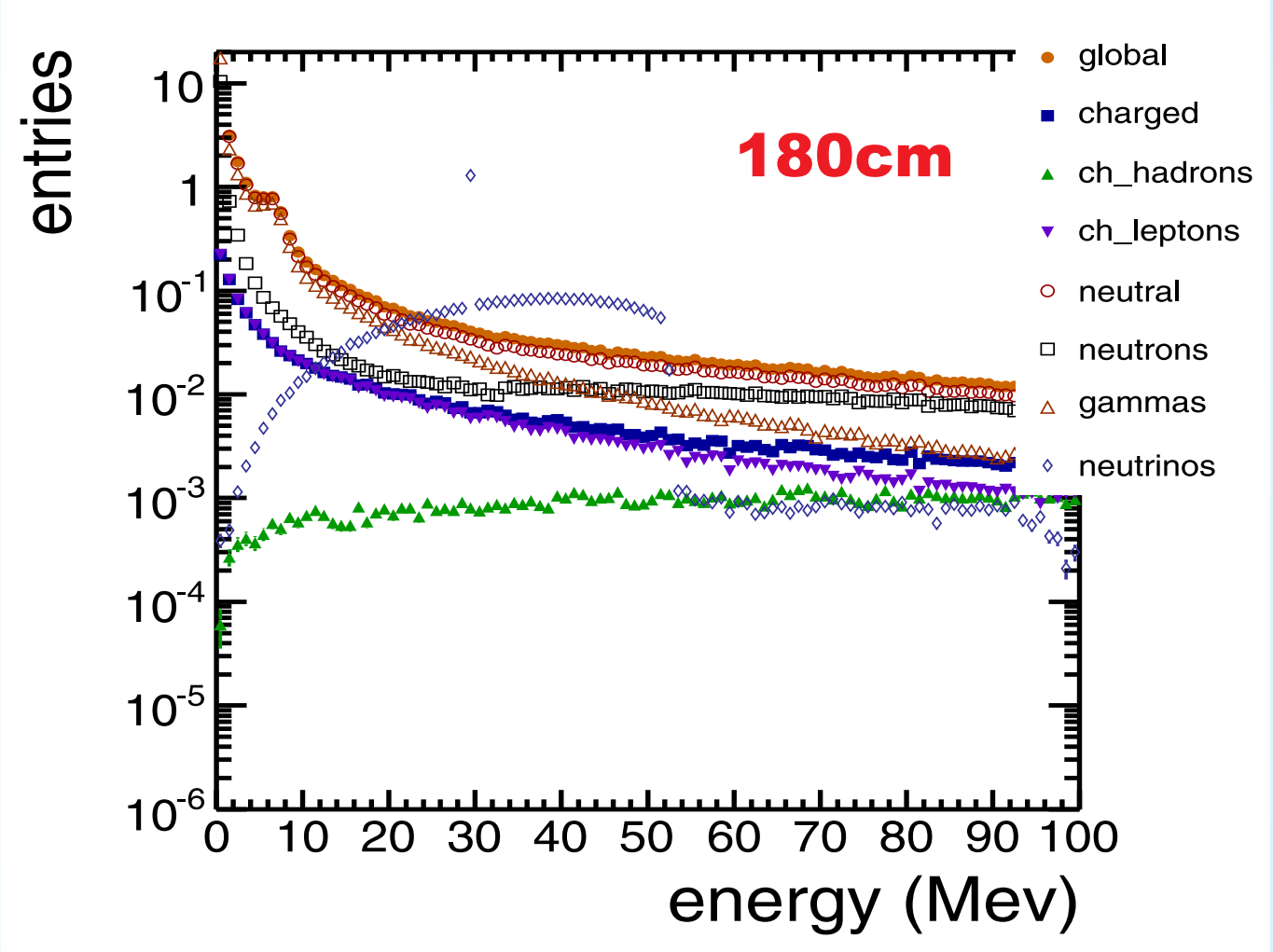
MC on Showers in Rock



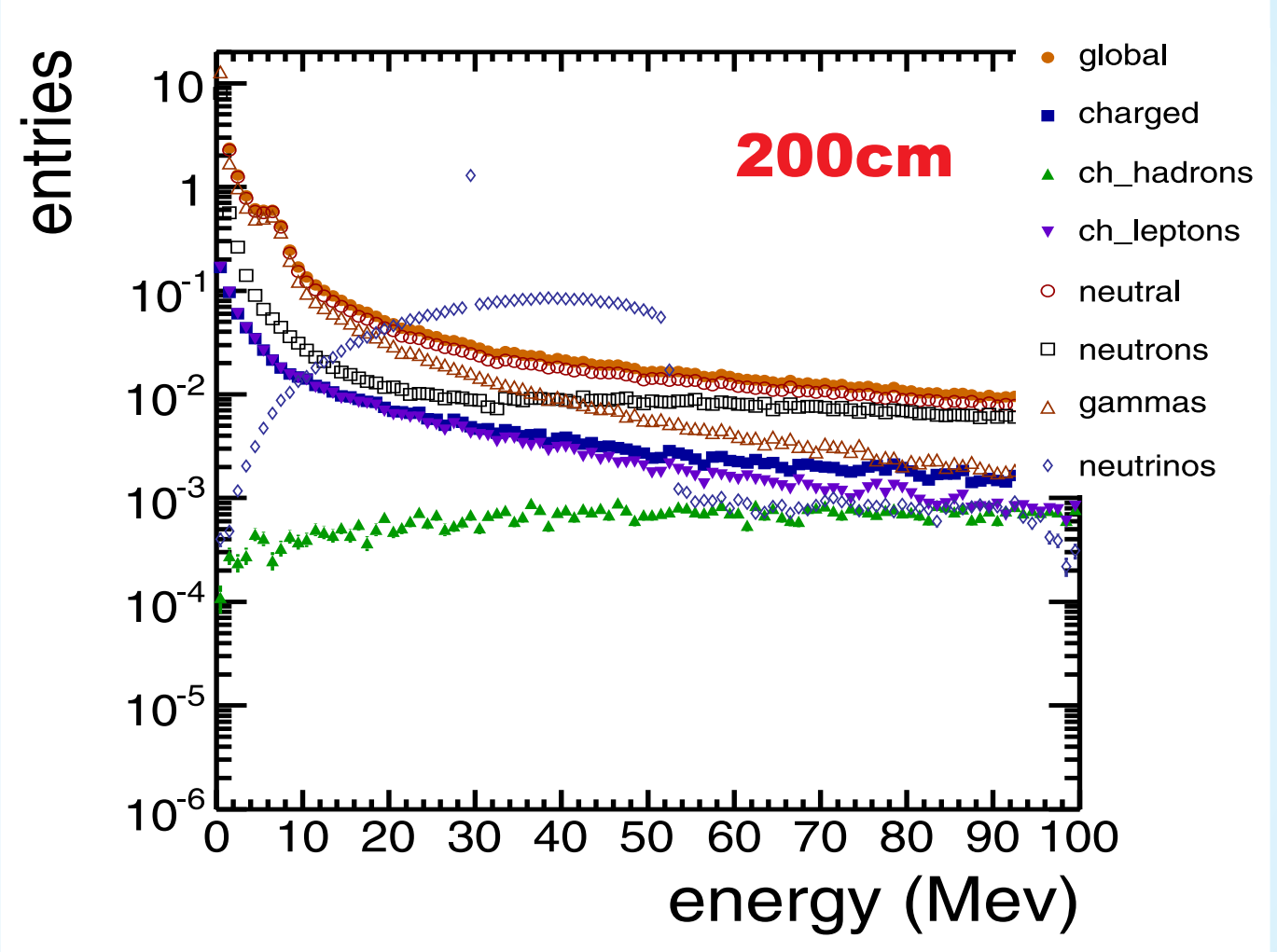
MC on Showers in Rock



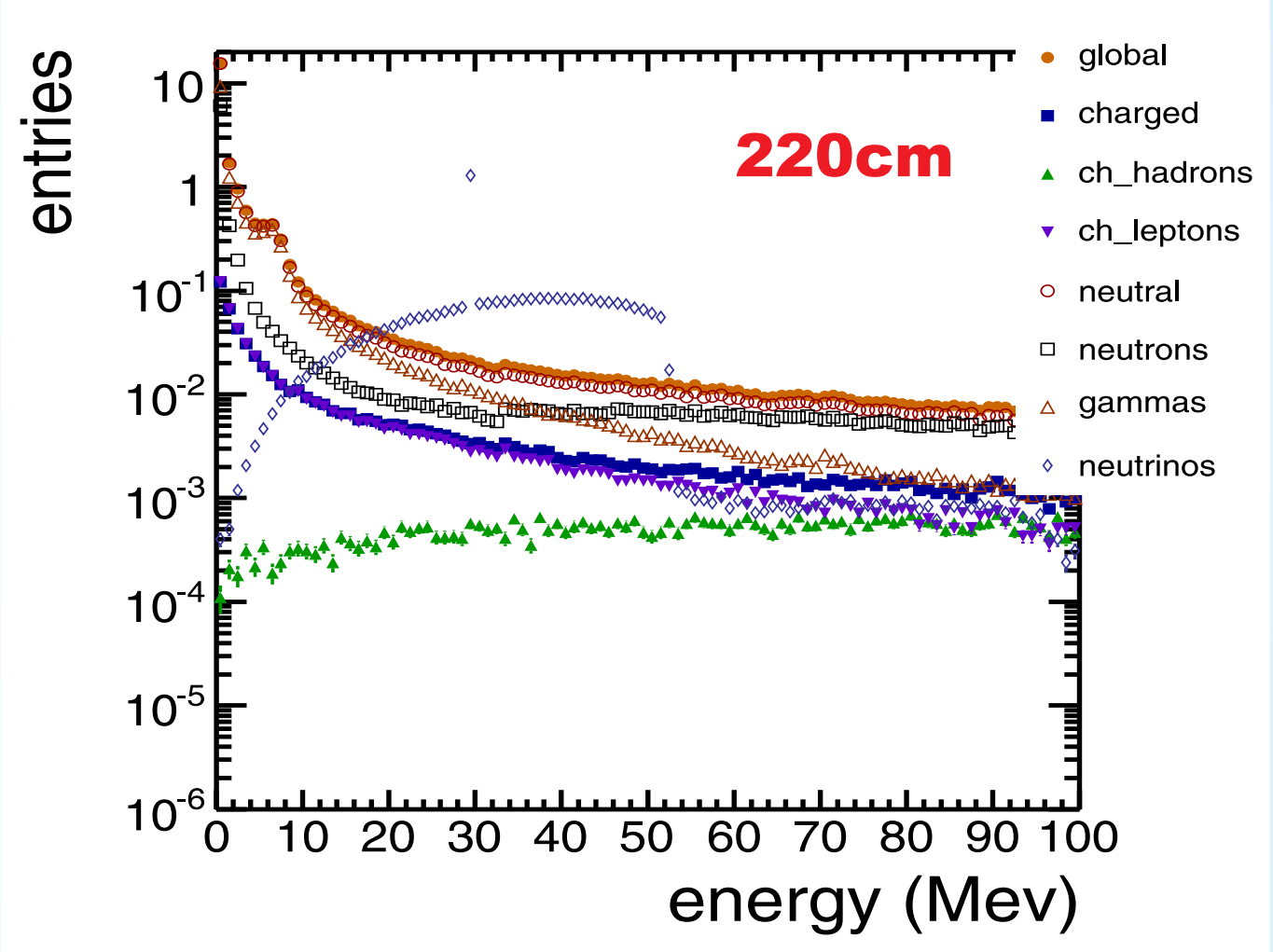
MC on Showers in Rock



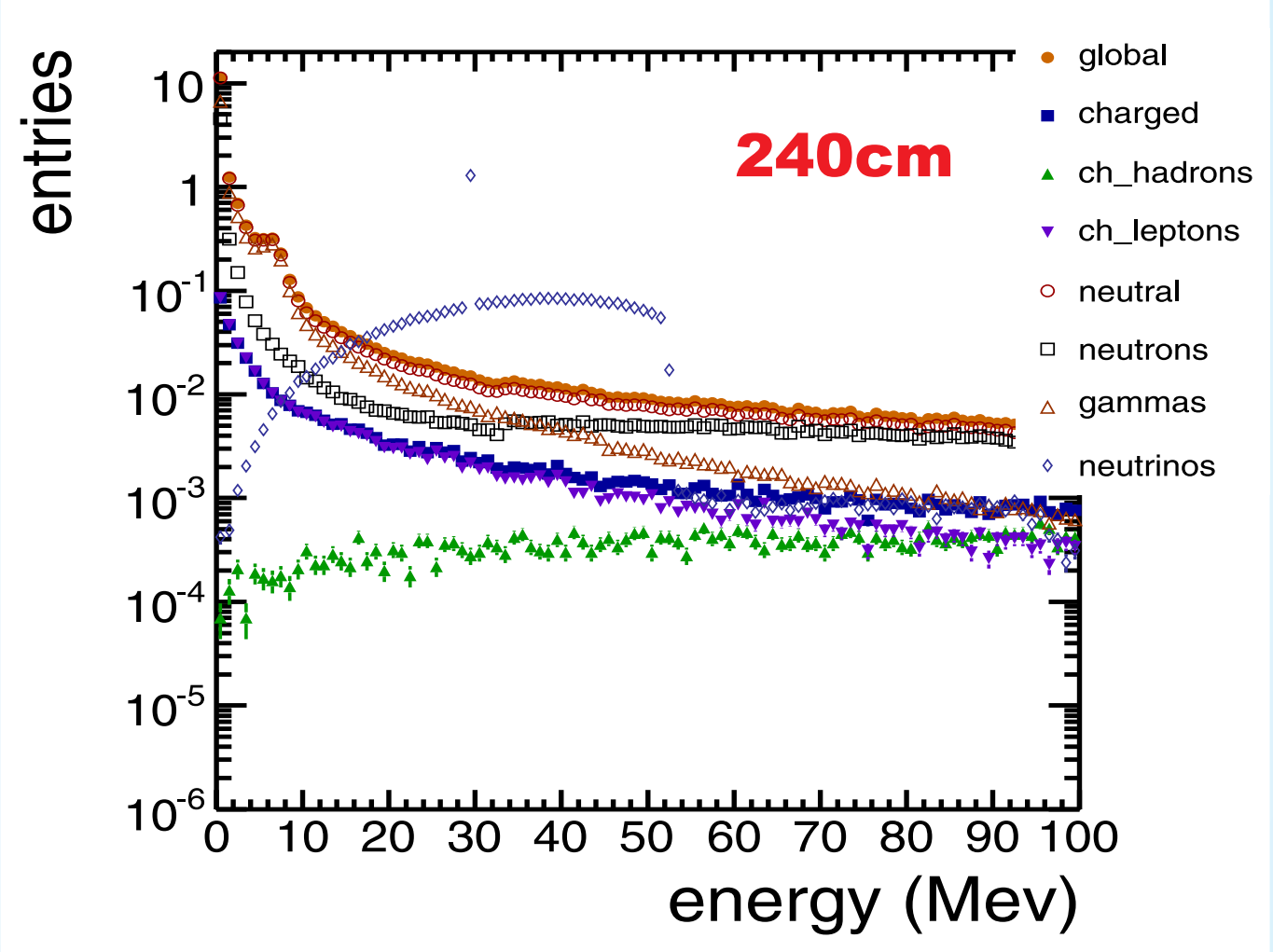
MC on Showers in Rock



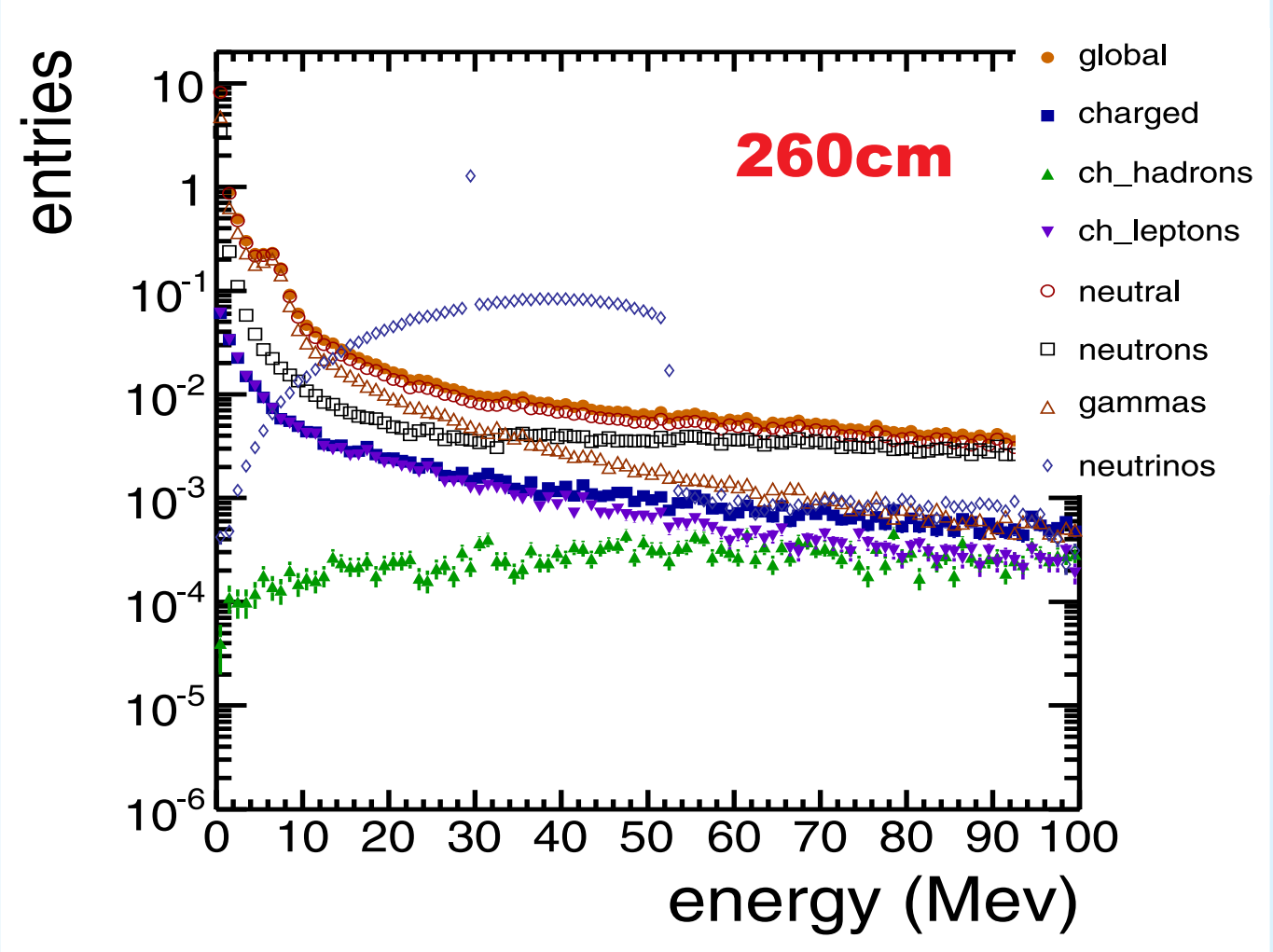
MC on Showers in Rock



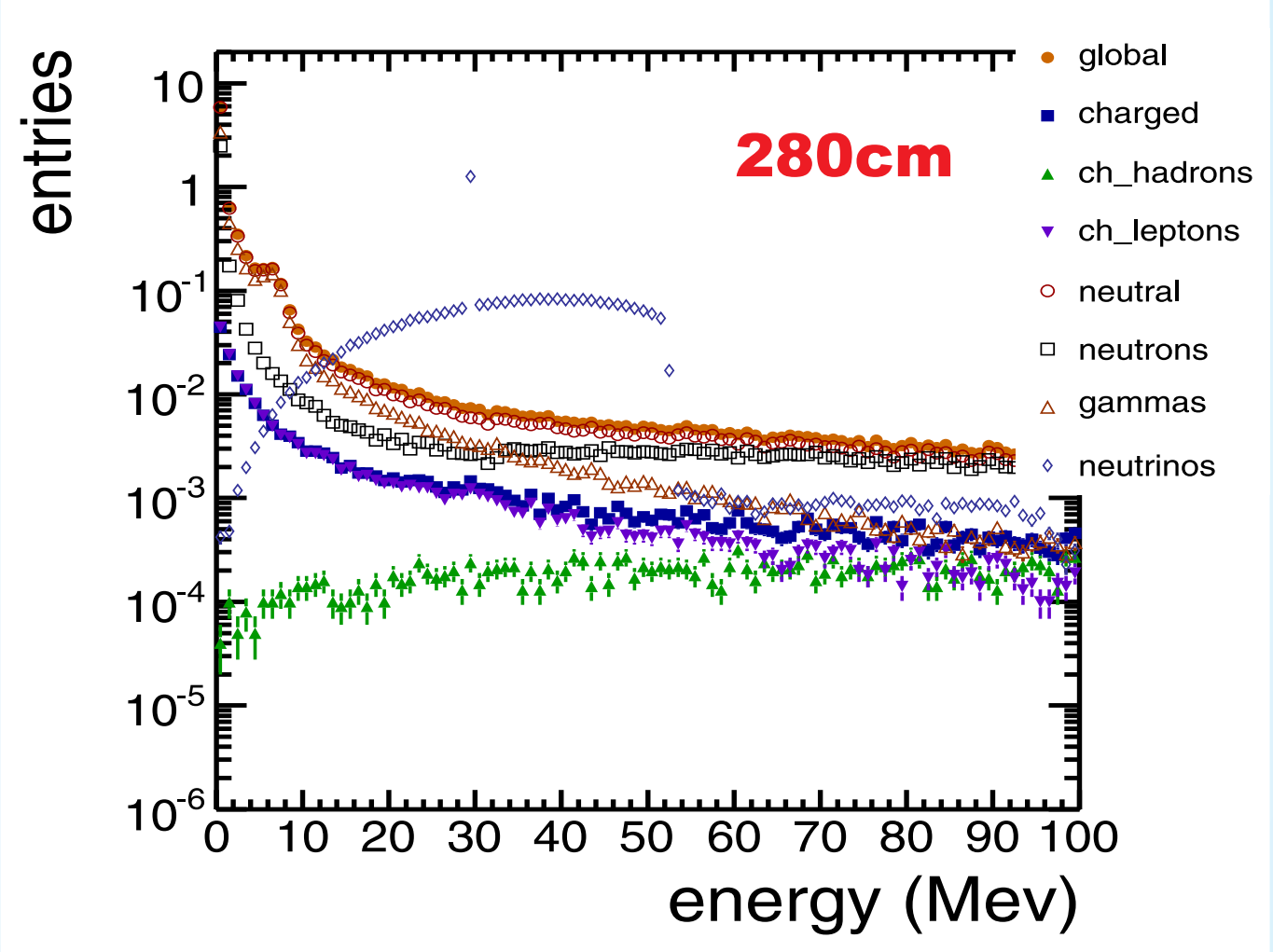
MC on Showers in Rock



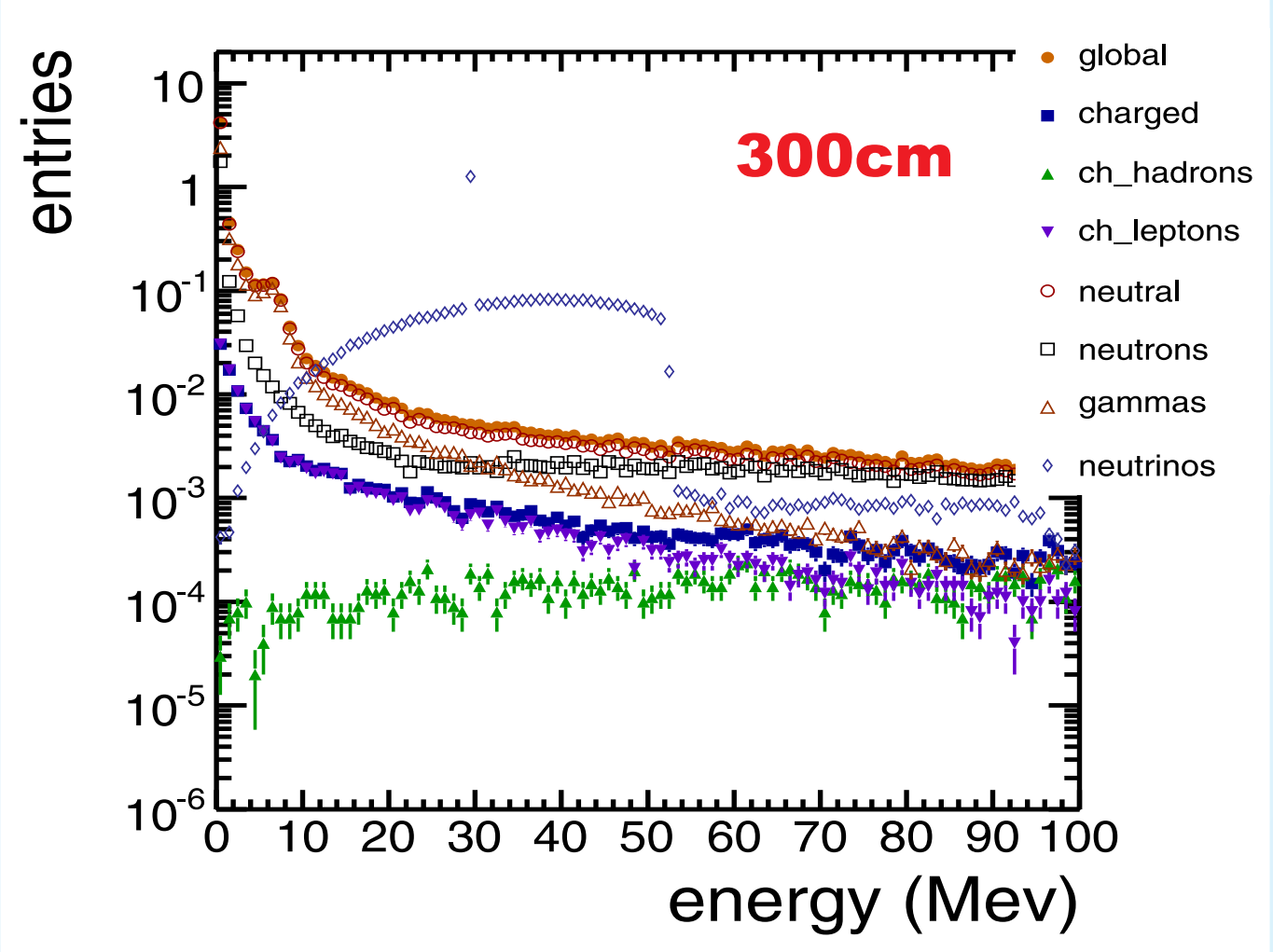
MC on Showers in Rock



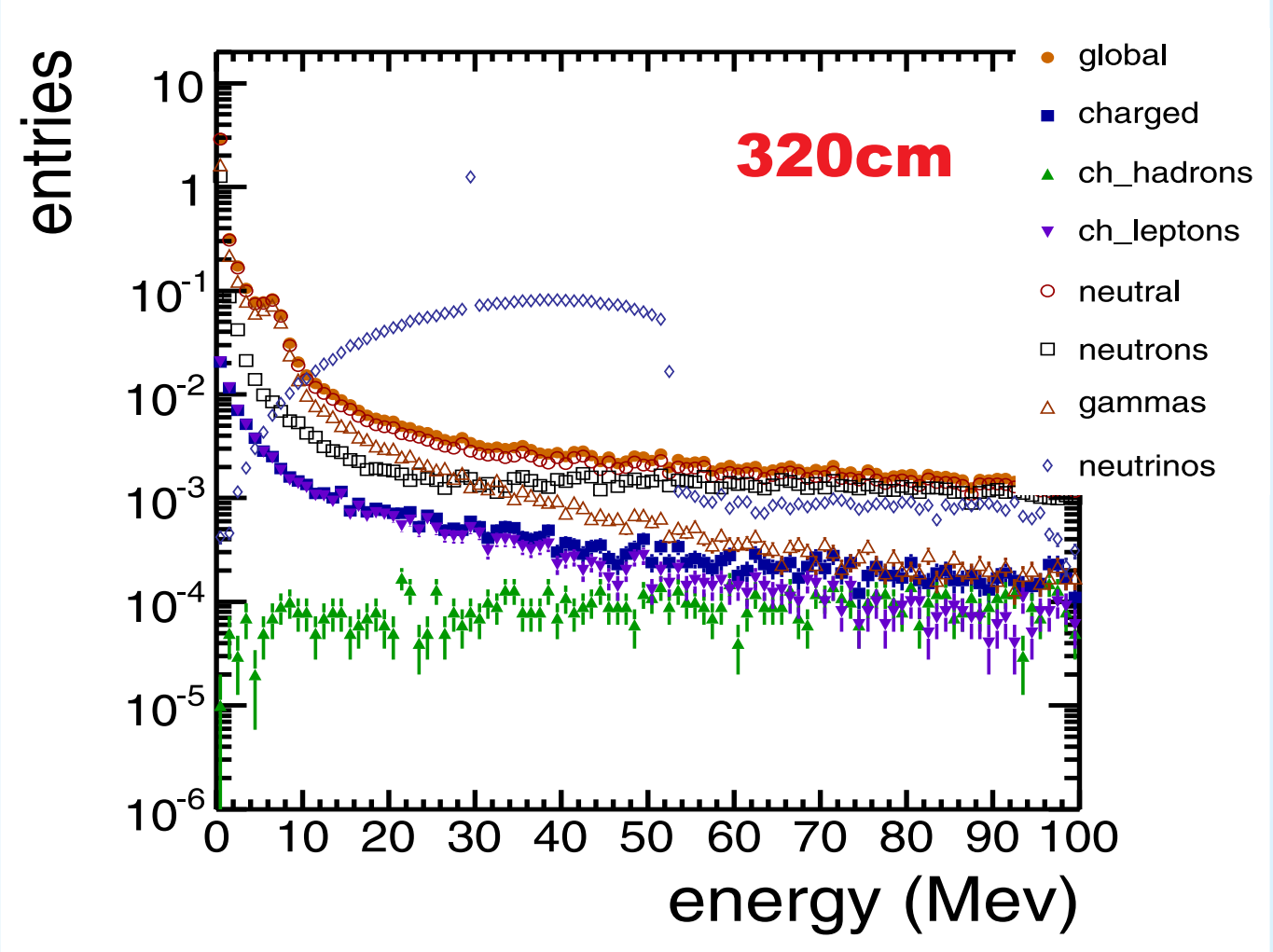
MC on Showers in Rock



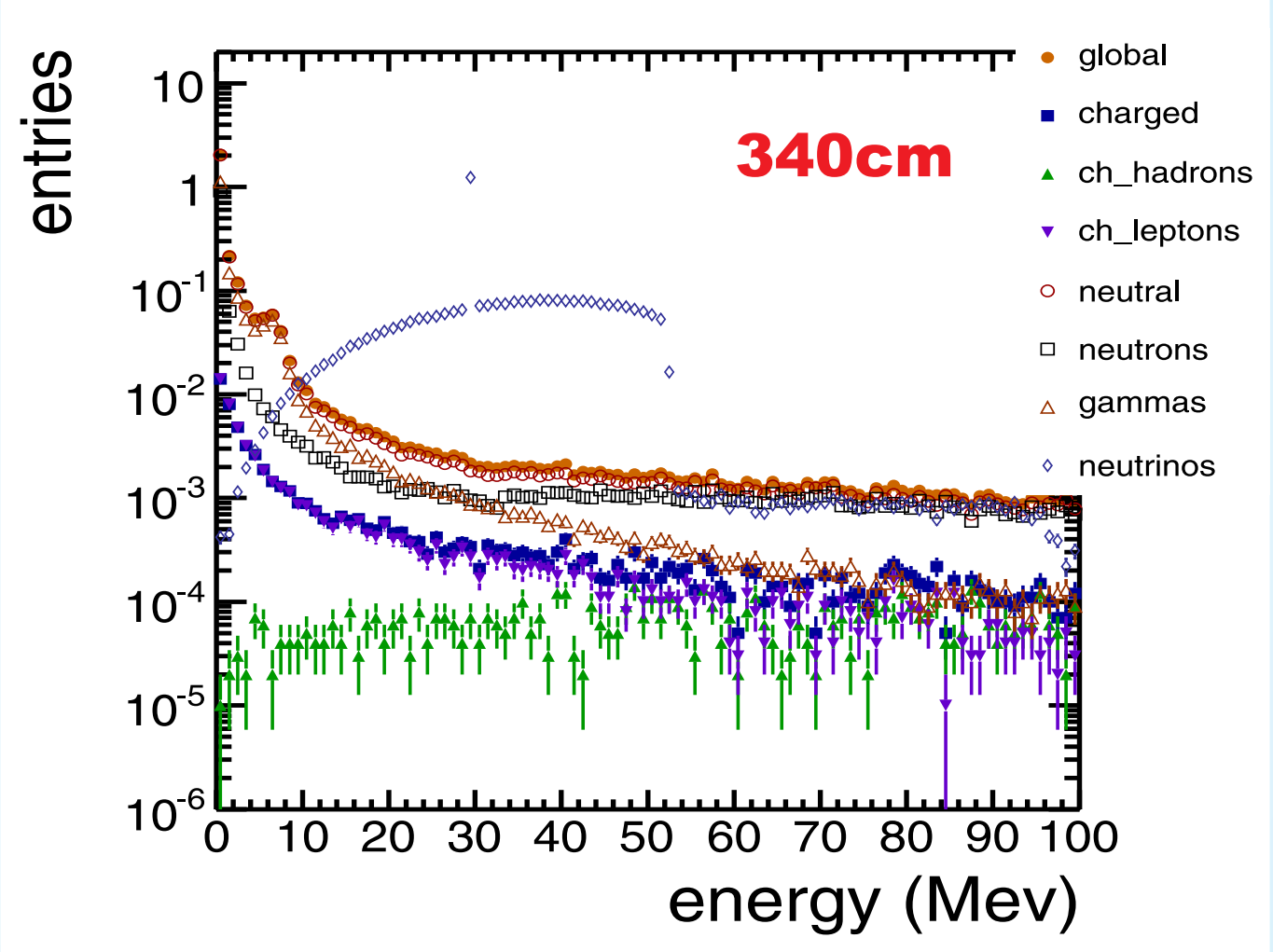
MC on Showers in Rock



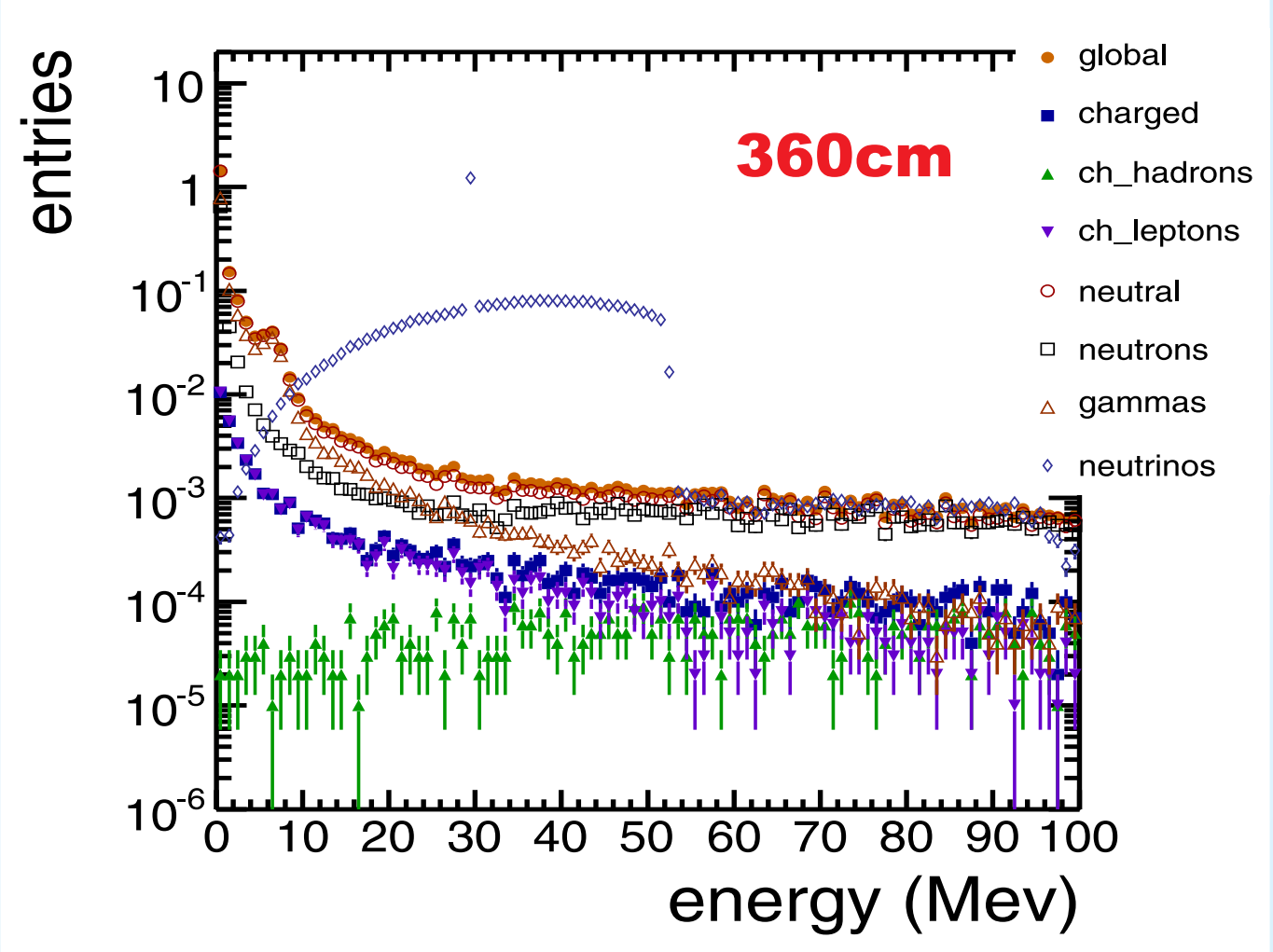
MC on Showers in Rock



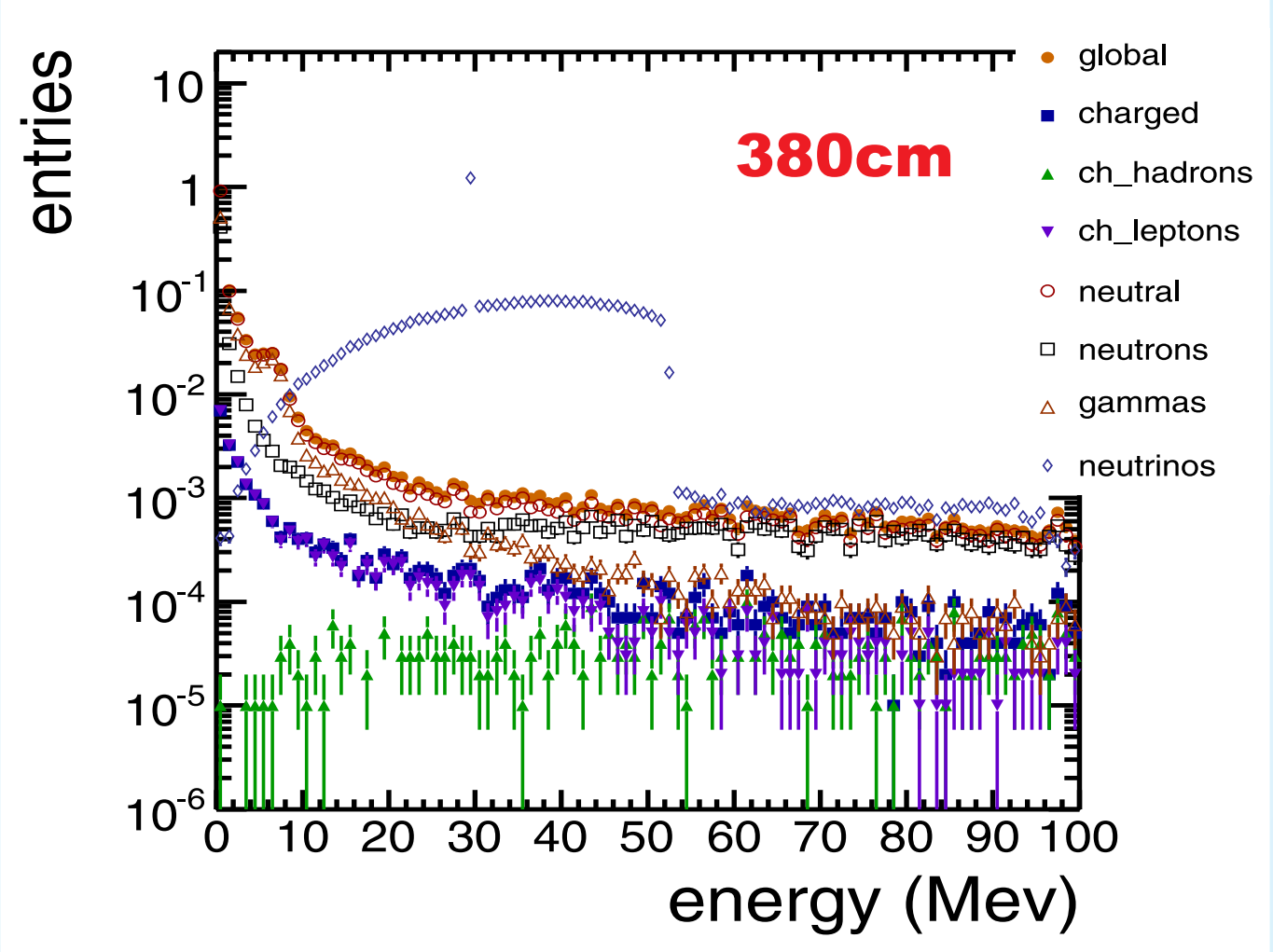
MC on Showers in Rock



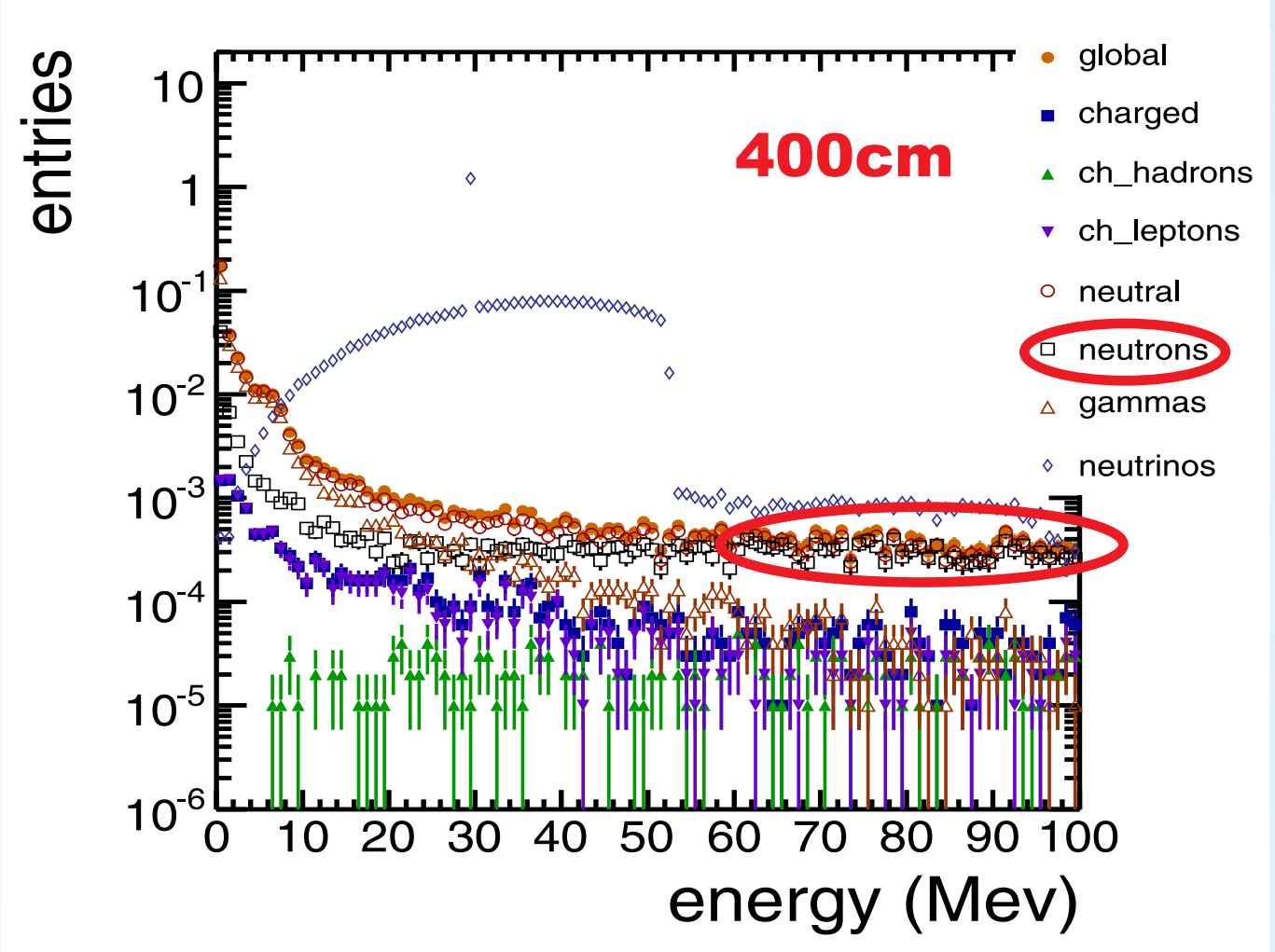
MC on Showers in Rock



MC on Showers in Rock

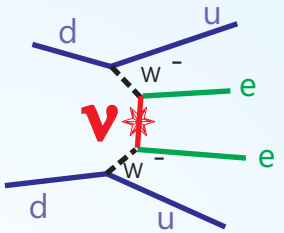


MC on Showers in Rock



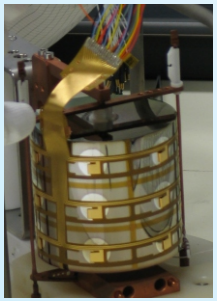
The Goal for Detectors

Build a detector with which we can search for neutrinoless double beta decay and which can also be used to search for dark matter.

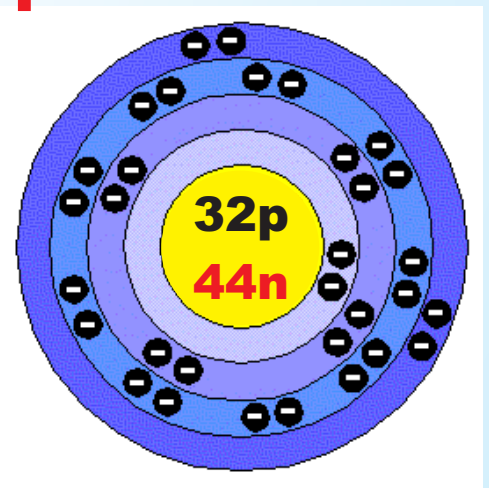


💰 💰 💰 💰 💰 **demands multi purpose**

Why Germanium (76) ?

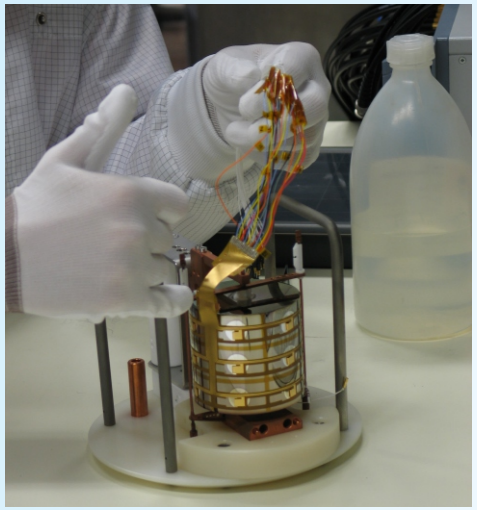


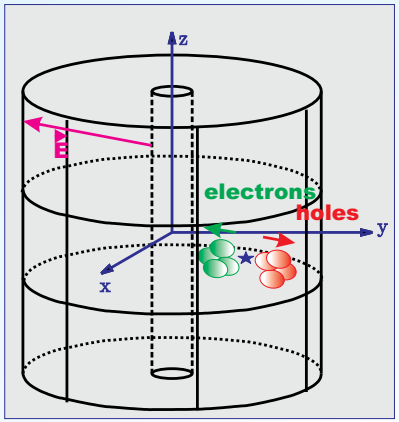
It's a semiconductor with double beta decay.



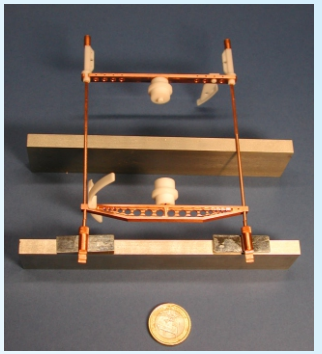
We have some experience...

How we got started





18-fold,
(6φ , 3z)
segmented
detectors



Segmentation for background reduction

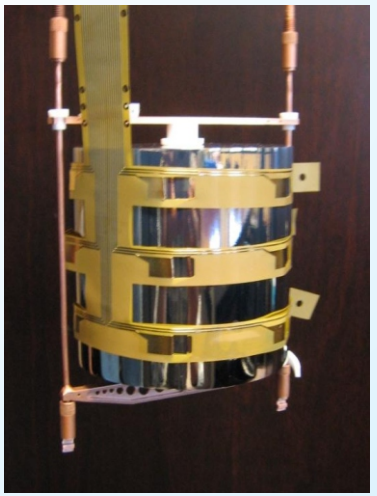
r = 75mm h = 70mm

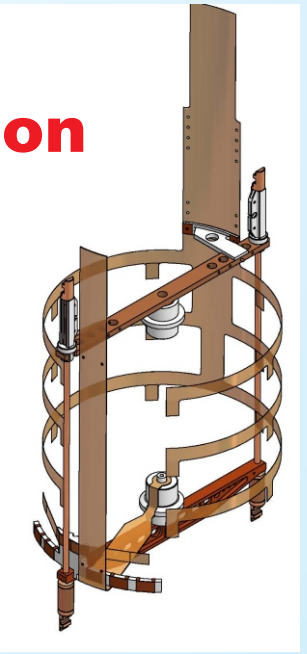
1.6 kg Ge in 34 g of Cu

7 g of Teflon

Kapton cables → PEN

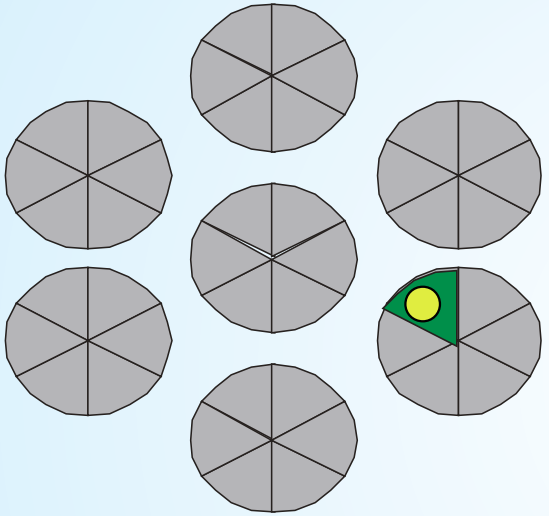
with Cu snap contacts



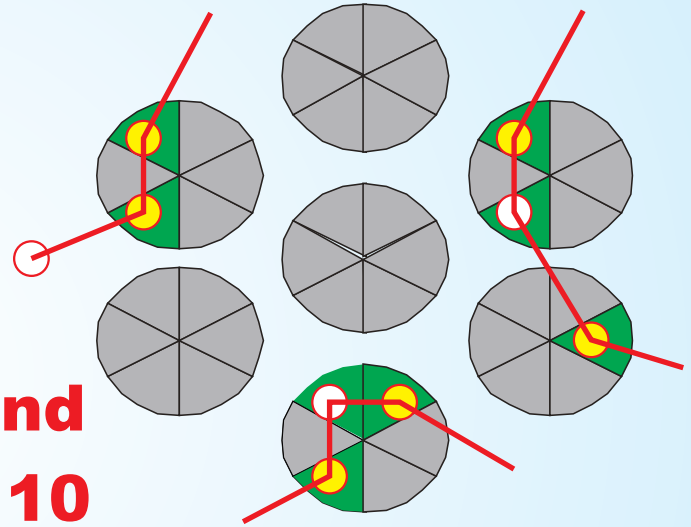


Segmentation

$0\nu\beta\beta$

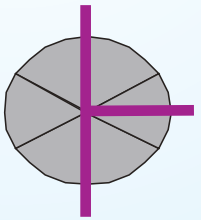


γ or 2γ



reduces background by factor 10

localized deposit
single site event

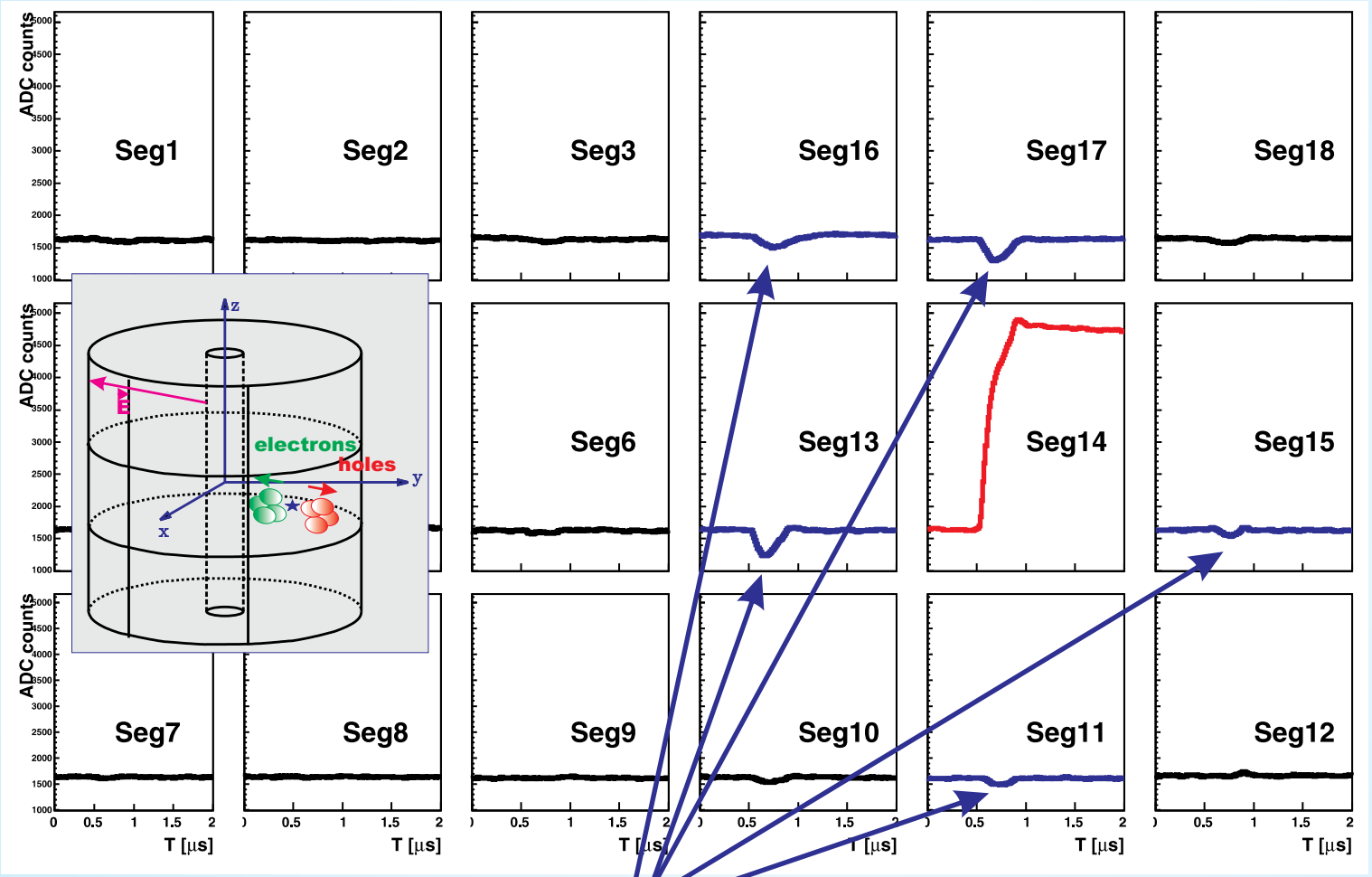


several deposits
multi site event

Eur. Phys. J. C 72 (2012) 1950

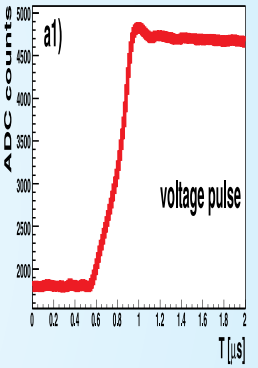
Axes determination for segmented true-coaxial HPGe detectors

A Real Event



DEP 85

^{208}Tl

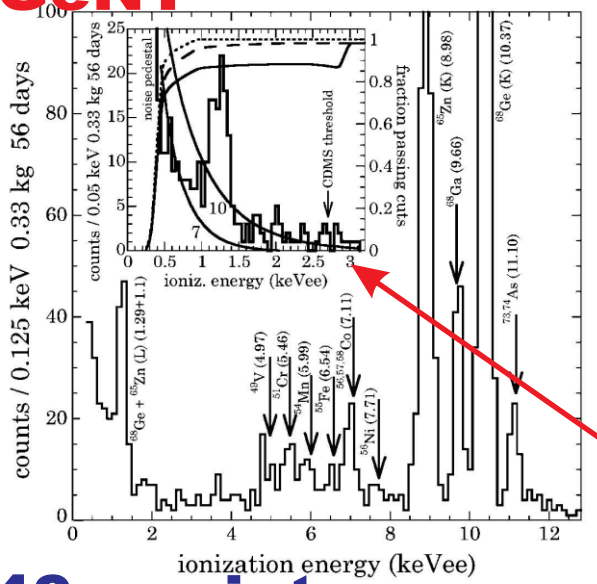


Single Segment and Neighbors

Position reconstruction

Dark Matter Demands

CoGeNT



Spectrum below 3keV

Why can we not use these segmented detectors for dark matter ?

They have too much capacitance, threshold ≈ 10 keV.

440g point contact detector

We need a detector that is good at 0.2 keV and at 2 000 keV and has substantial mass.

The egg-laying woolly Ge milk-pig

= one size/technology fits all

large volume

threshhold of 0.1 keV

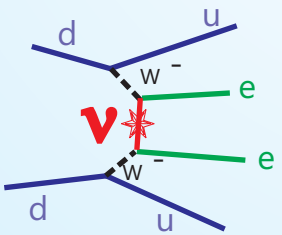
perfect separation of multi/single-site

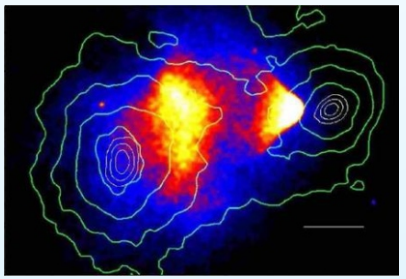
position resolution 1mm

separation of gammas and neutrons

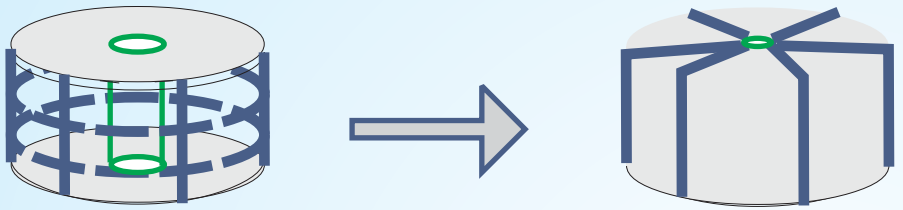
energy resolution 1keV at 1MeV

no contamination: bulk and surface





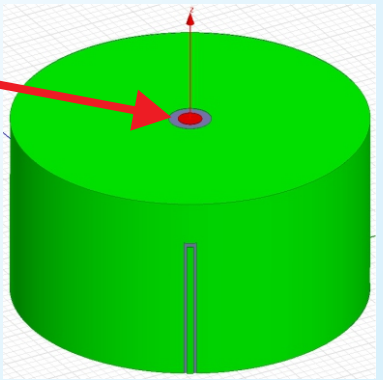
What we try



no egg
for the
moment.

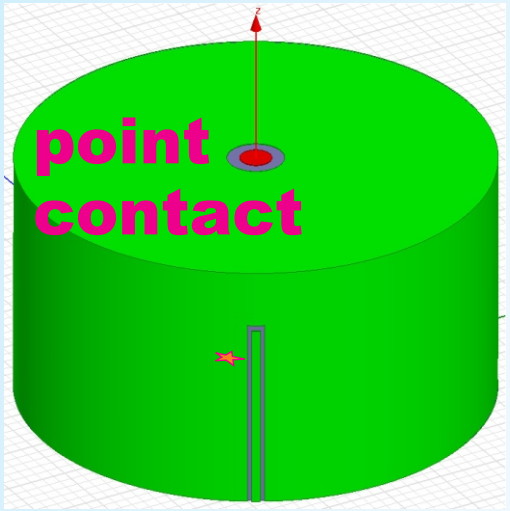
Marry segmentation [position resolution]
[event topology]
with point contact [low threshold]

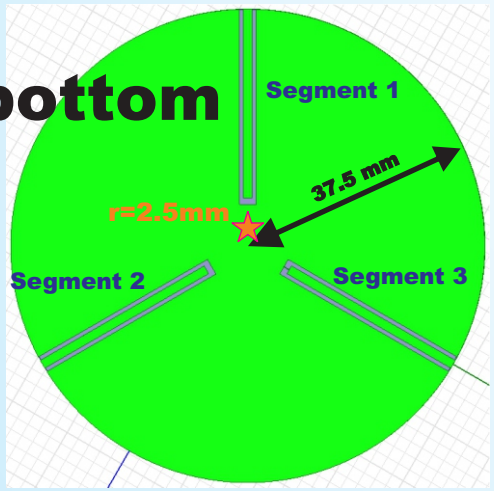
We simulated many options to find out what is best and what could be built.

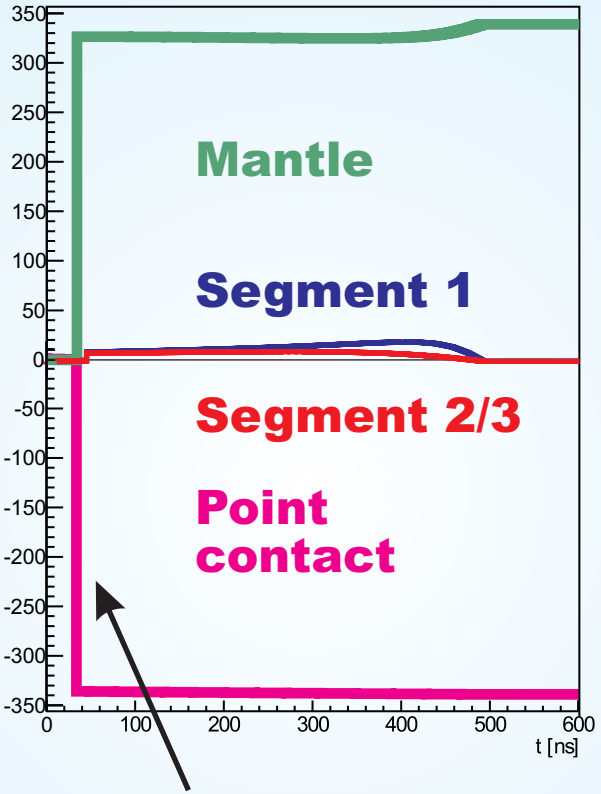


Canberra France

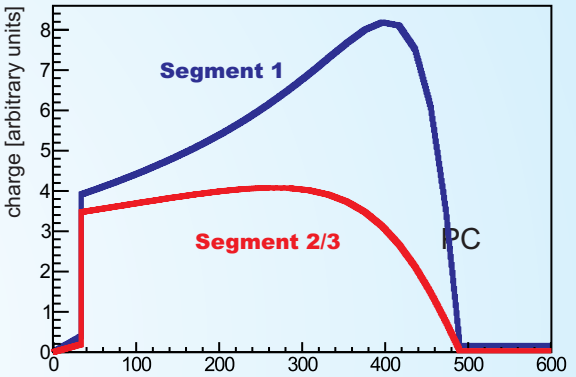
Segmented Point Contact Detector







Spatial Information

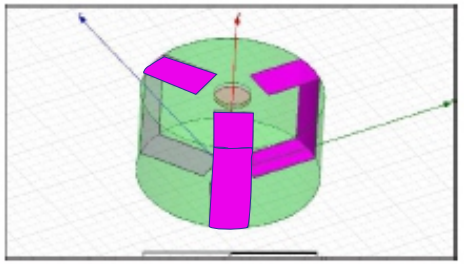
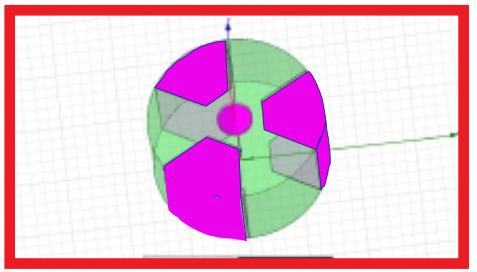
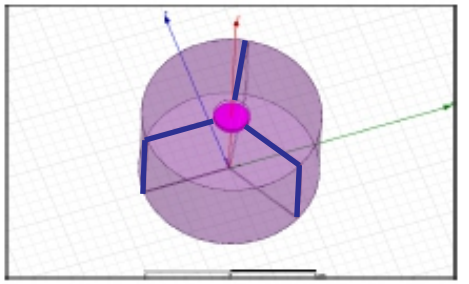


is available, but the signals are too small.

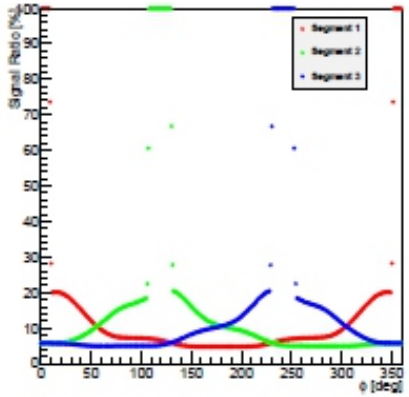
Multi-site events become multi-signal events due to fast rise of signal.

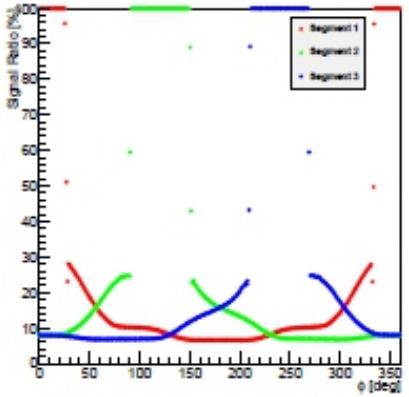
Detector of the Future

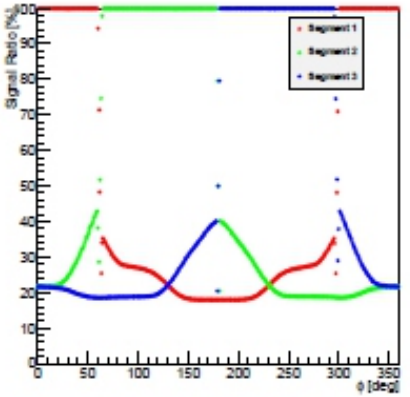
studied a multitude of designs: z=40mm r=75mm

Phi dependence of the signals at r=25mm, z=20mm



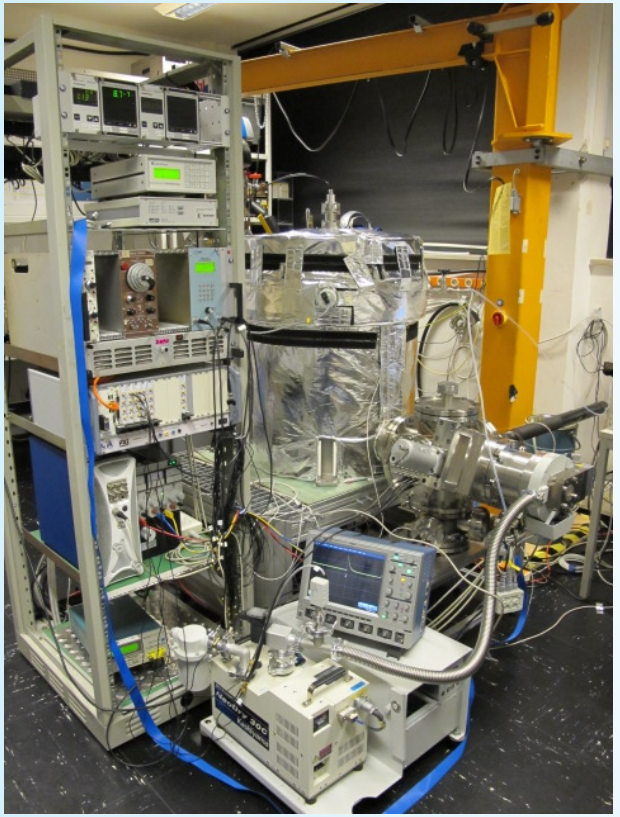




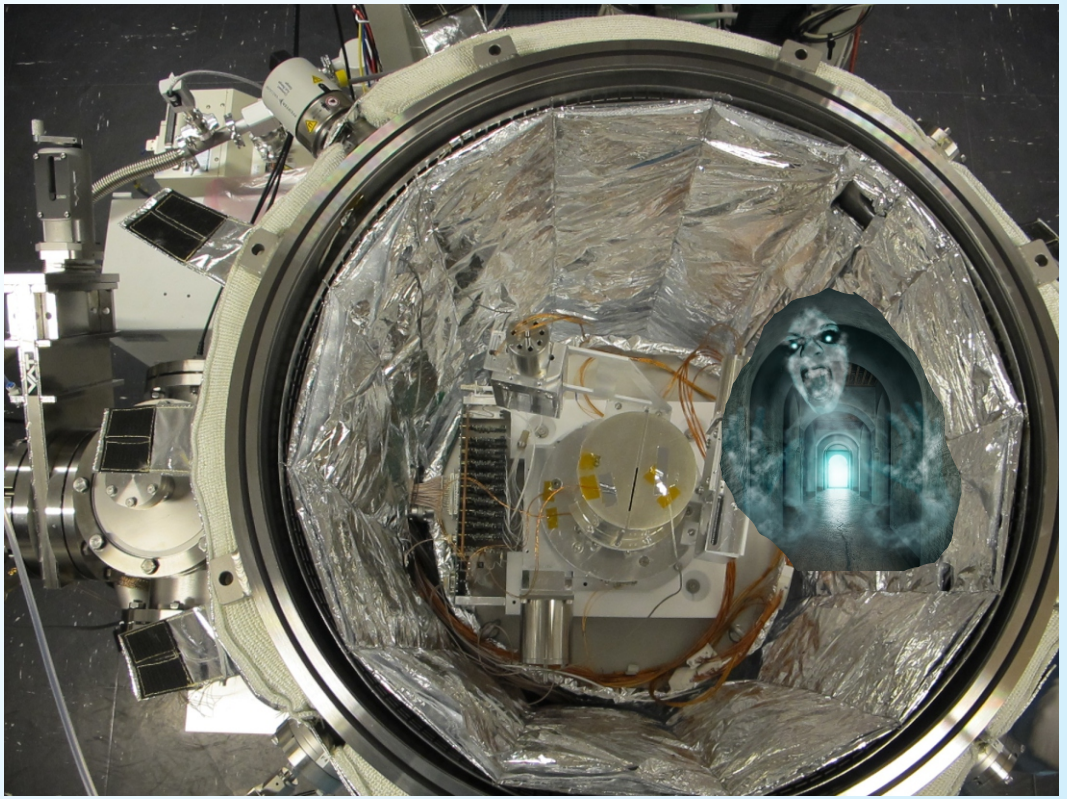
Chose detector with best grip on topology.

Did R&D with manufacturer. Order early 2013.

GALATEA



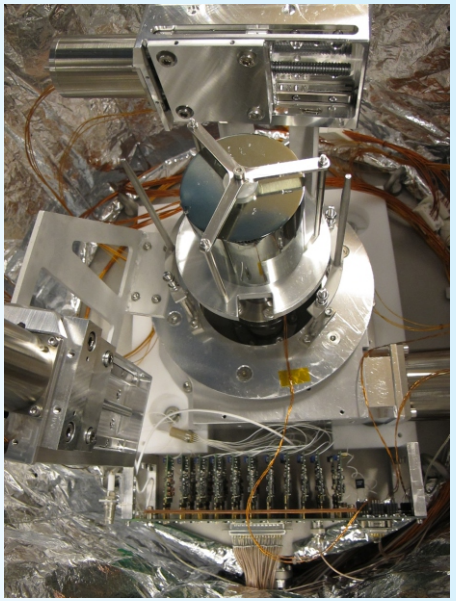
This is were we want to test detectors, but....



we had a Poltergeist

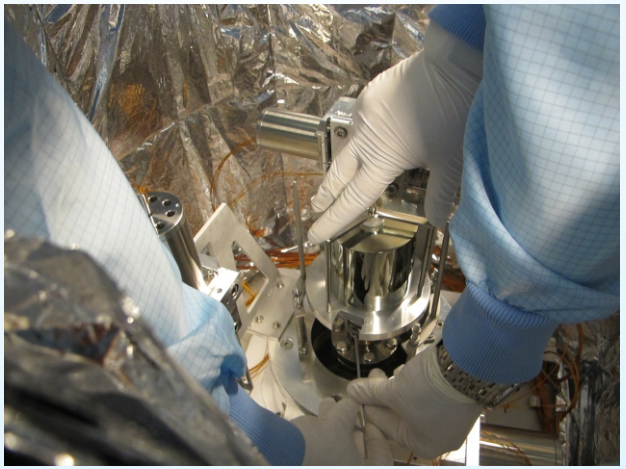
GALATEA

Optical crystal



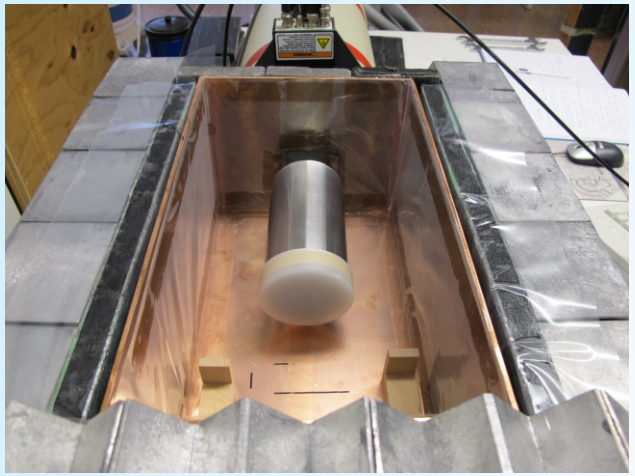
cage against

Upgrade ready

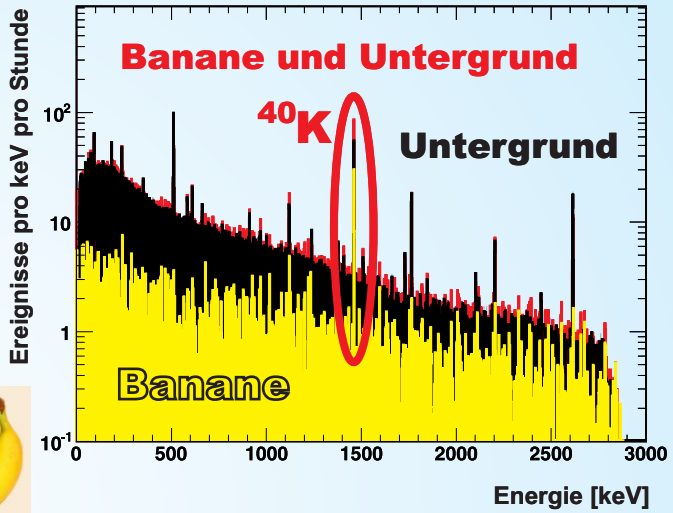


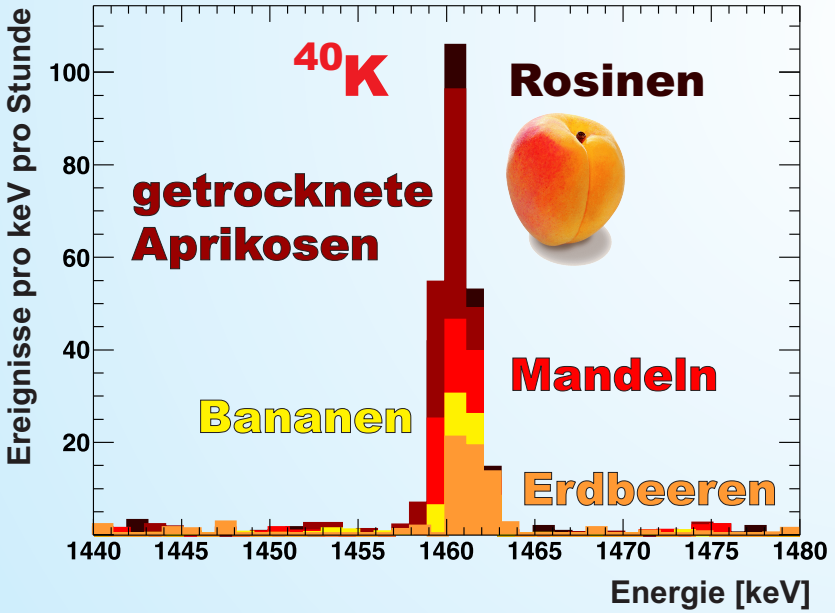
to calibrate temperatures and test electronics

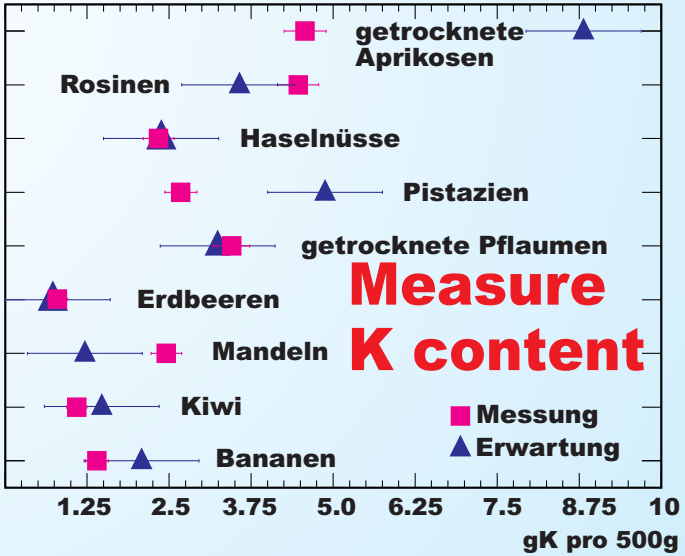
Reference Detector



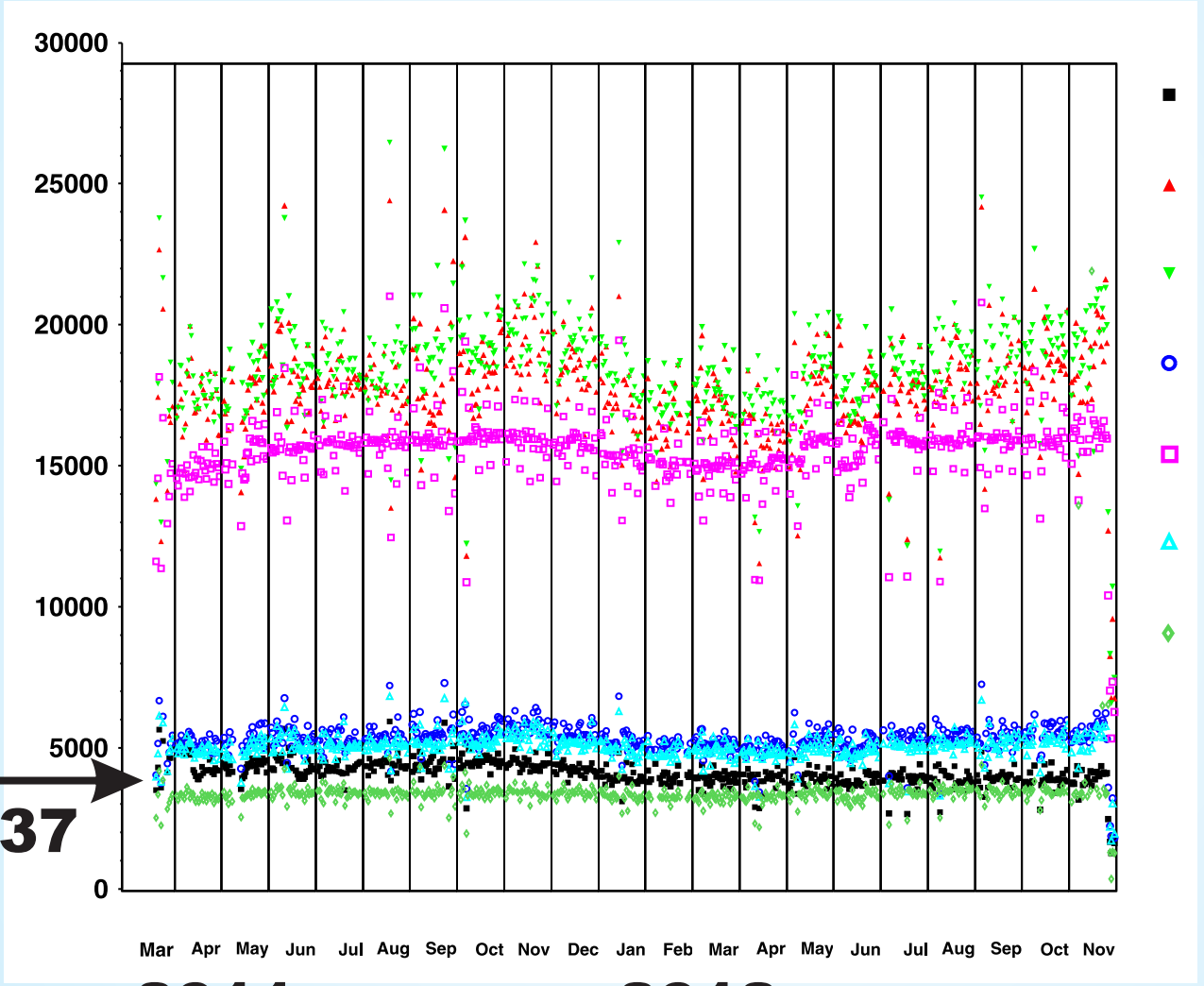
Xtra: test collimators and MC/ analysis software







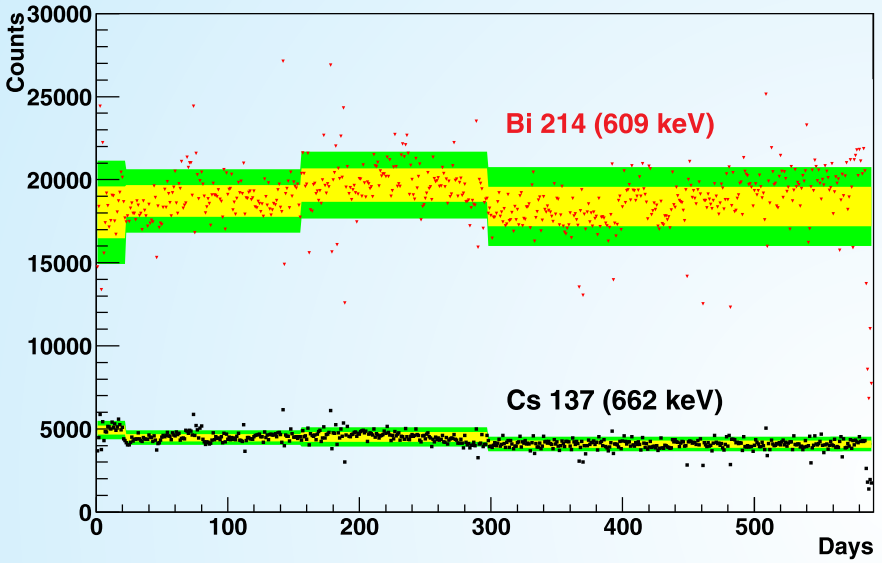
Monitor Environmental Radiation



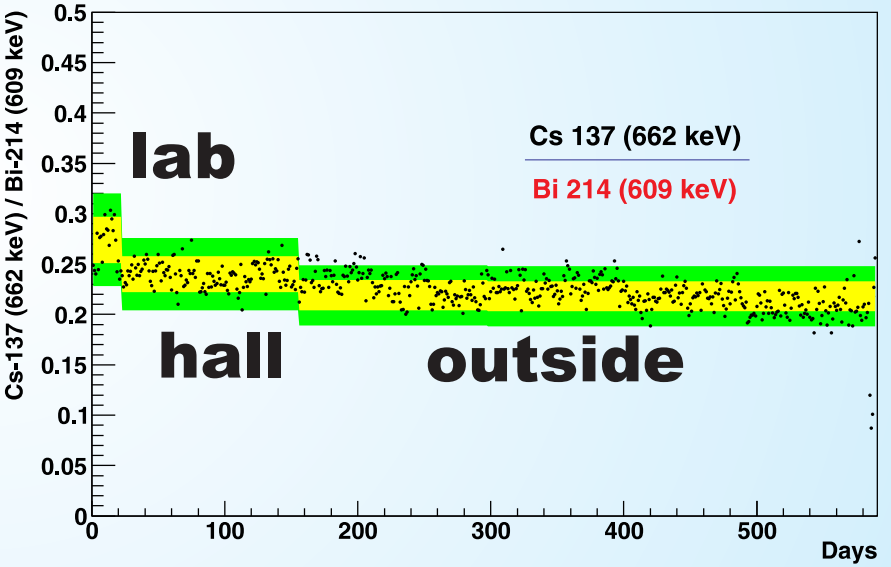
Cs137

started 10 days after Fukushima

Monitor Environmental Radiation



Fukushima:
too little and/or too late

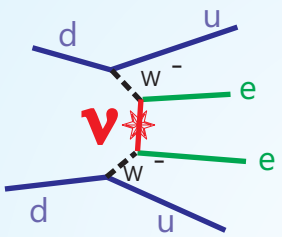


We are ready for the next event.

A collapse of the earth magnetic field would be nice.

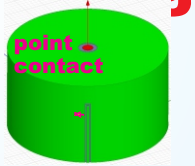
[In]Famous Last Words

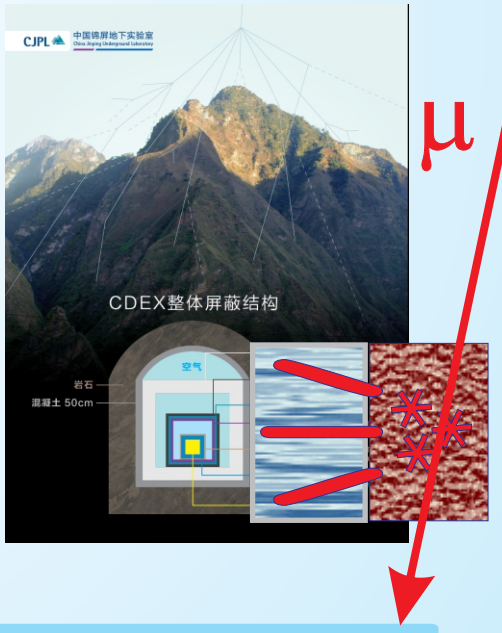
Germanium detectors might give us the chance to address some very fundamental questions.



.....

We need new detector technologies to get to the next level.



We need large infrastructure and we need to understand the requirements.

We work on R&D to evaluate the chances and problems