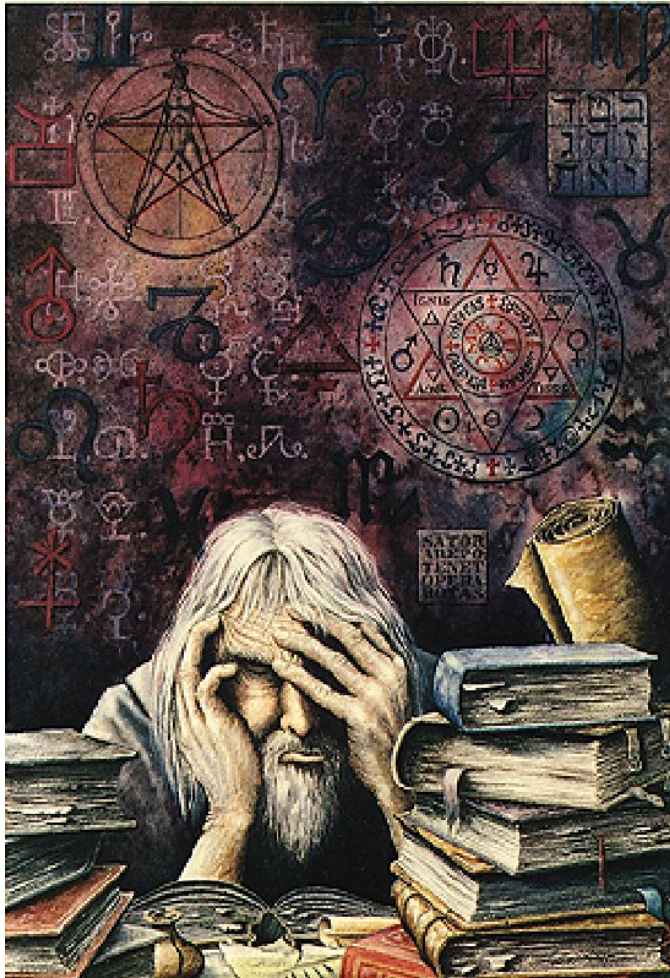


Status and perspectives of the COBRA double beta experiment



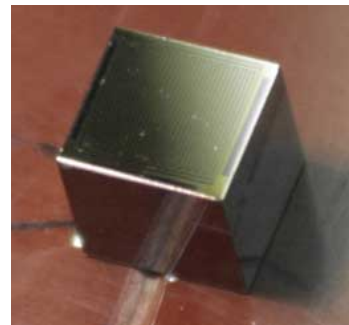
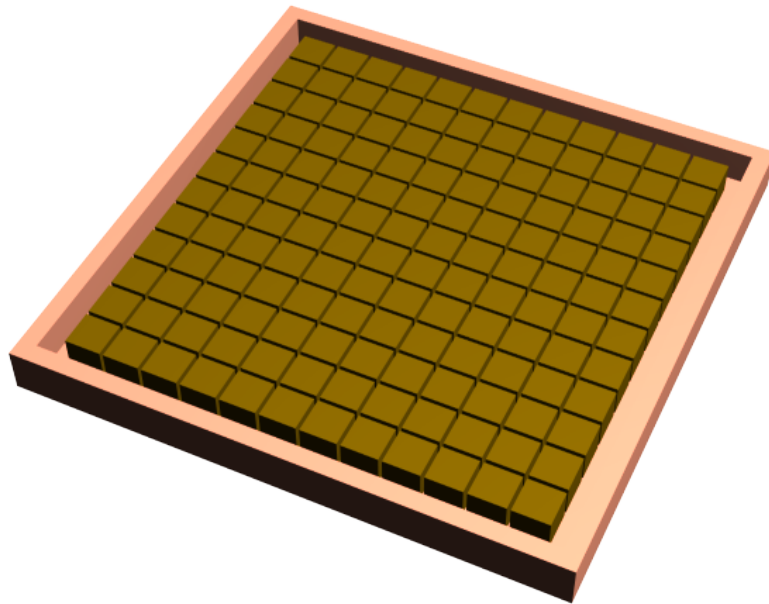
K.Zuber, NOW 2012, 10.9.2012



- The physics
- Idea of COBRA
- CPG activities, Background measurements
- Pixel detector studies
- Outlook and future
- Summary



Use large amount of $\text{CdZnTe}/\text{CdTe}$ Semiconductor Detectors



**Large array of
 $\text{CdZnTe}/\text{CdTe}$
detectors**

K. Zuber, Phys. Lett. B 519,1 (2001)

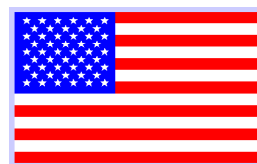
K. Zuber



Technical University Dresden
Technical University Dortmund
University of Hamburg
University of Erlangen-Nürnberg
Freiburger Materialforschung (FMF)
Laboratori Nazionali del Gran Sasso



Czech Technical University Prague
Washington University at St. Louis
University of Jyväskylä
University of de la Plata
University of Bratislava
JINR Dubna



K. Zuber

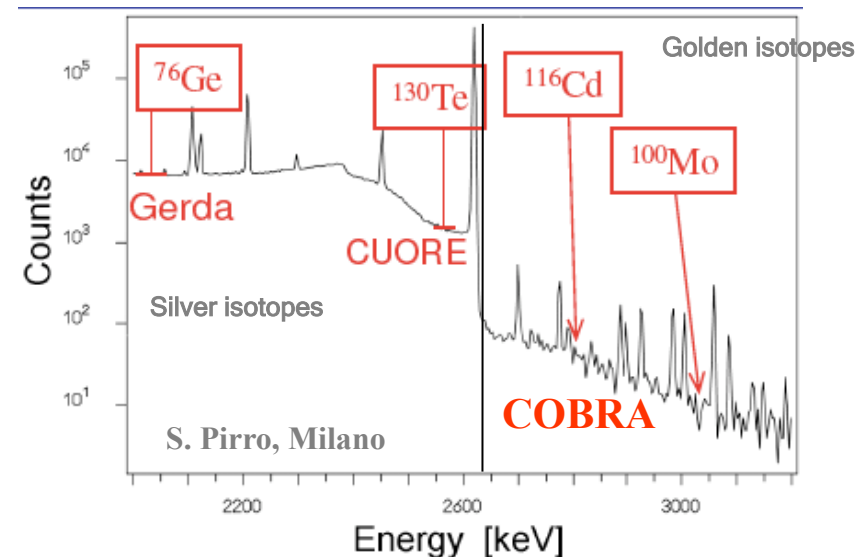
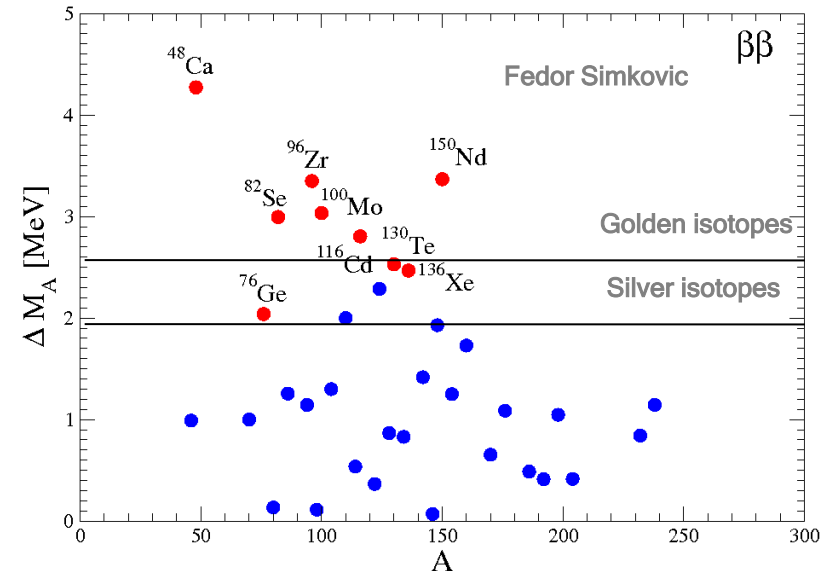


Isotopes



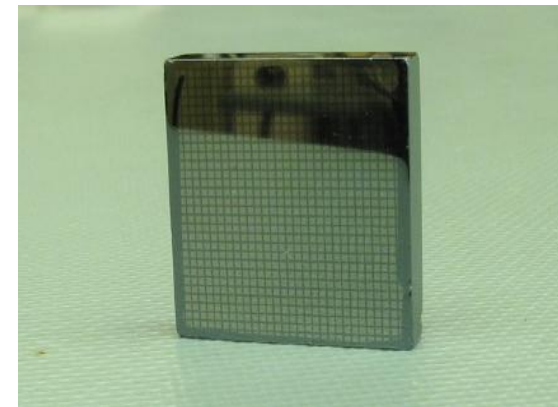
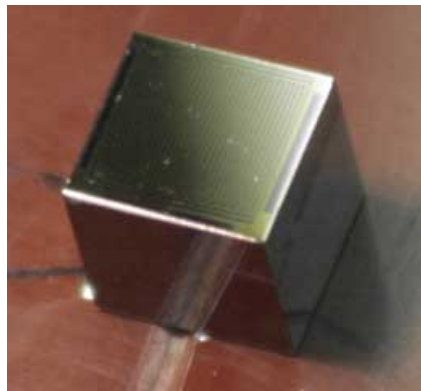
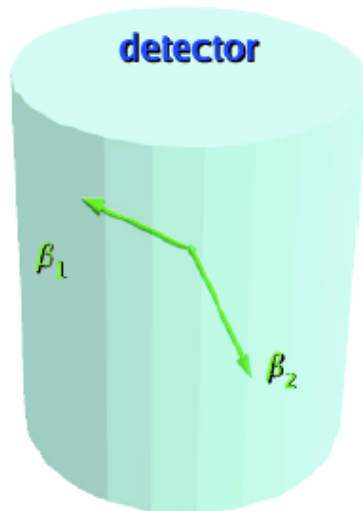
	nat. ab. (%)	Q (keV)	Decay mode
Zn70	0.62	1001	$\beta\text{-}\beta\text{-}$
Cd114	28.7	534	$\beta\text{-}\beta\text{-}$
→ Cd116	7.5	2814	$\beta\text{-}\beta\text{-}$
Te128	31.7	868	$\beta\text{-}\beta\text{-}$
→ Te130	33.8	2527	$\beta\text{-}\beta\text{-}$
Zn64	48.6	1096	$\beta\text{+}/\text{EC}$
→ Cd106	1.21	2771	$\beta\text{+}\beta\text{+}$
Cd108	0.9	231	EC/EC
Te120	0.1	1722	$\beta\text{+}/\text{EC}$

- Source = detector
- Semiconductor (Good energy resolution, clean)
- Room temperature
- Modular design (Coincidences)
- Industrial development of CdTe detectors
- ^{116}Cd above 2.614 MeV
- Tracking („Solid state TPC“)



Sum energy of 2814 keV for both electrons
(Single electron spectra and opening angle)

Source = detector



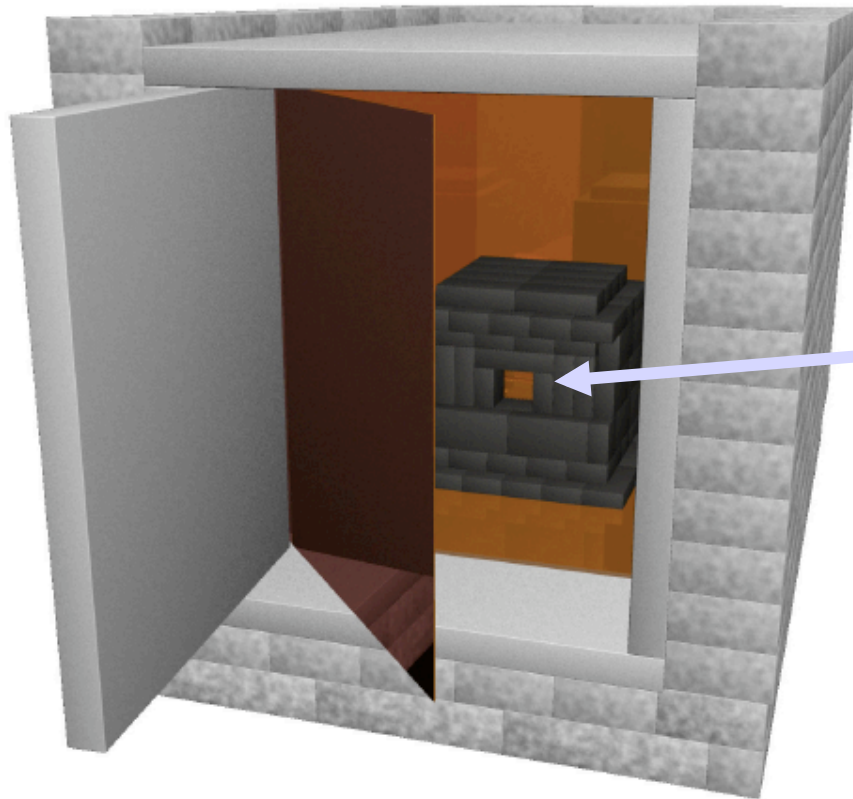
- Two strategies:
- Coplanar grid detectors
 - Pixelated detectors

All low background!!!!

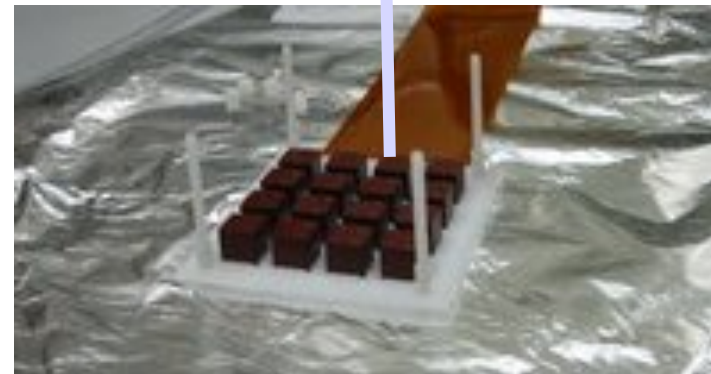
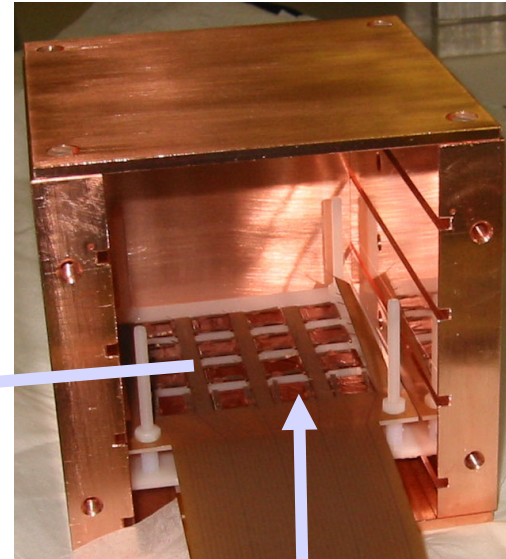


Recently upgraded into the
former Heidelberg-Moscow hut

The set-up



Learn about background using 1cm^3
CPG CZT detectors



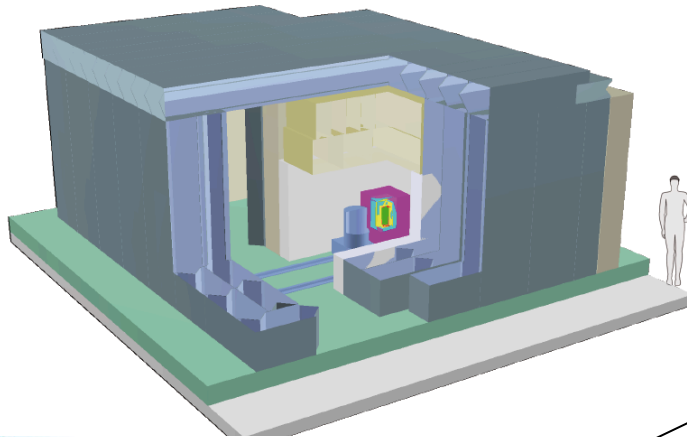
K. Zuber

Next step: The 64 Array

Major aim: Achieving a background below 1 count/keV/kg/yr

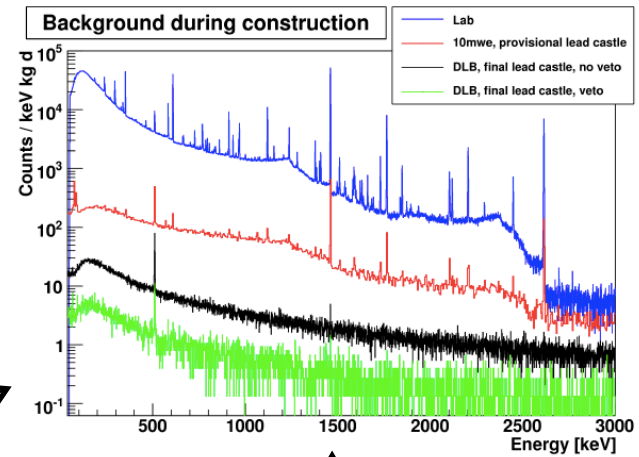
- Improvement on shielding
- New data acquisition , pulse shapes
- New contacting scheme
- Increasing data taking efficiency
- Better understanding of detectors
- More ideas (veto, signal enhancer, cooling...)

Dortmund Low Background Facility



1

2



3



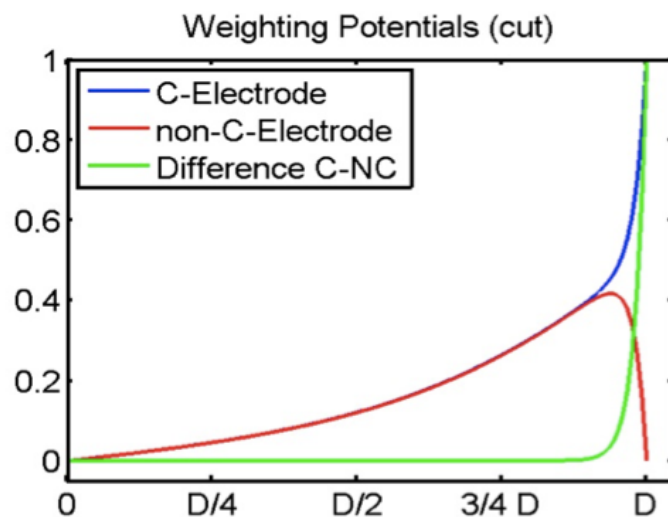
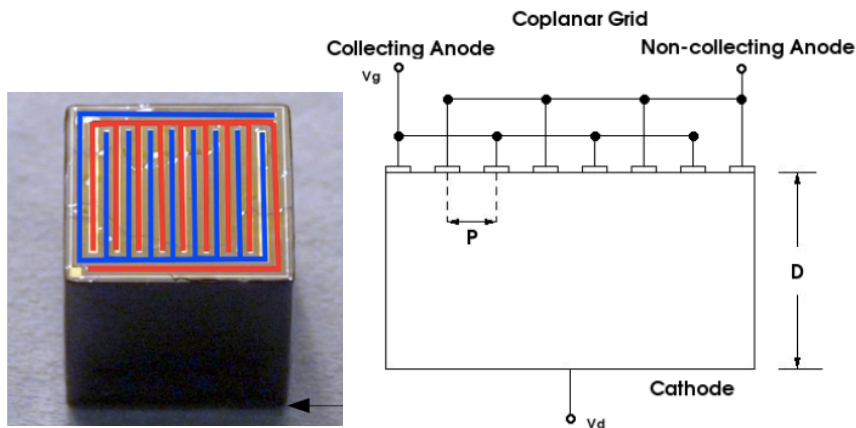
Felsenkeller Underground Lab Dresden



Gran Sasso Underground Lab (Italy)

CPG detector works like a Frisch grid in wire chambers
P. Luke, IEEE Trans. NS 42, 207 (1995)

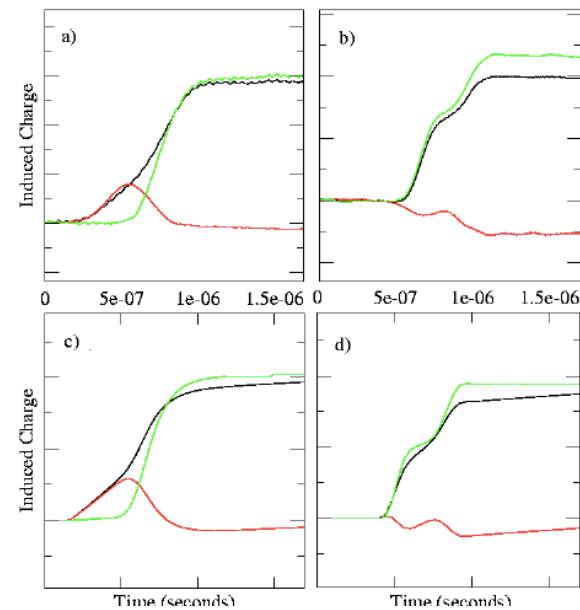
J. McGrath et al., NIM A 615,57 (2010)



^{60}Co pulse

Single site event

Multiple site event



Experiment

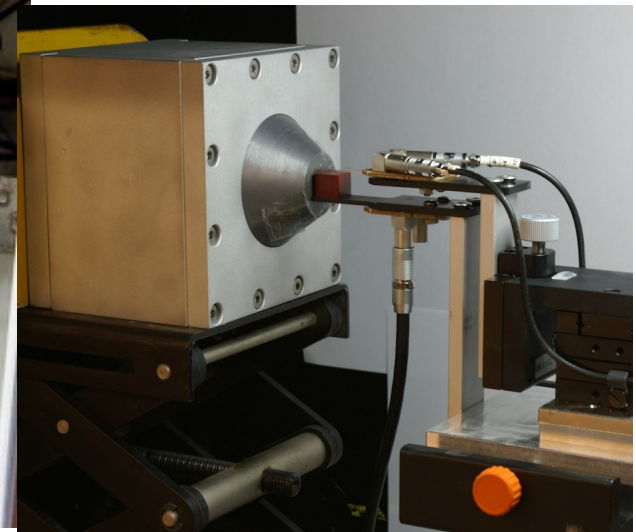
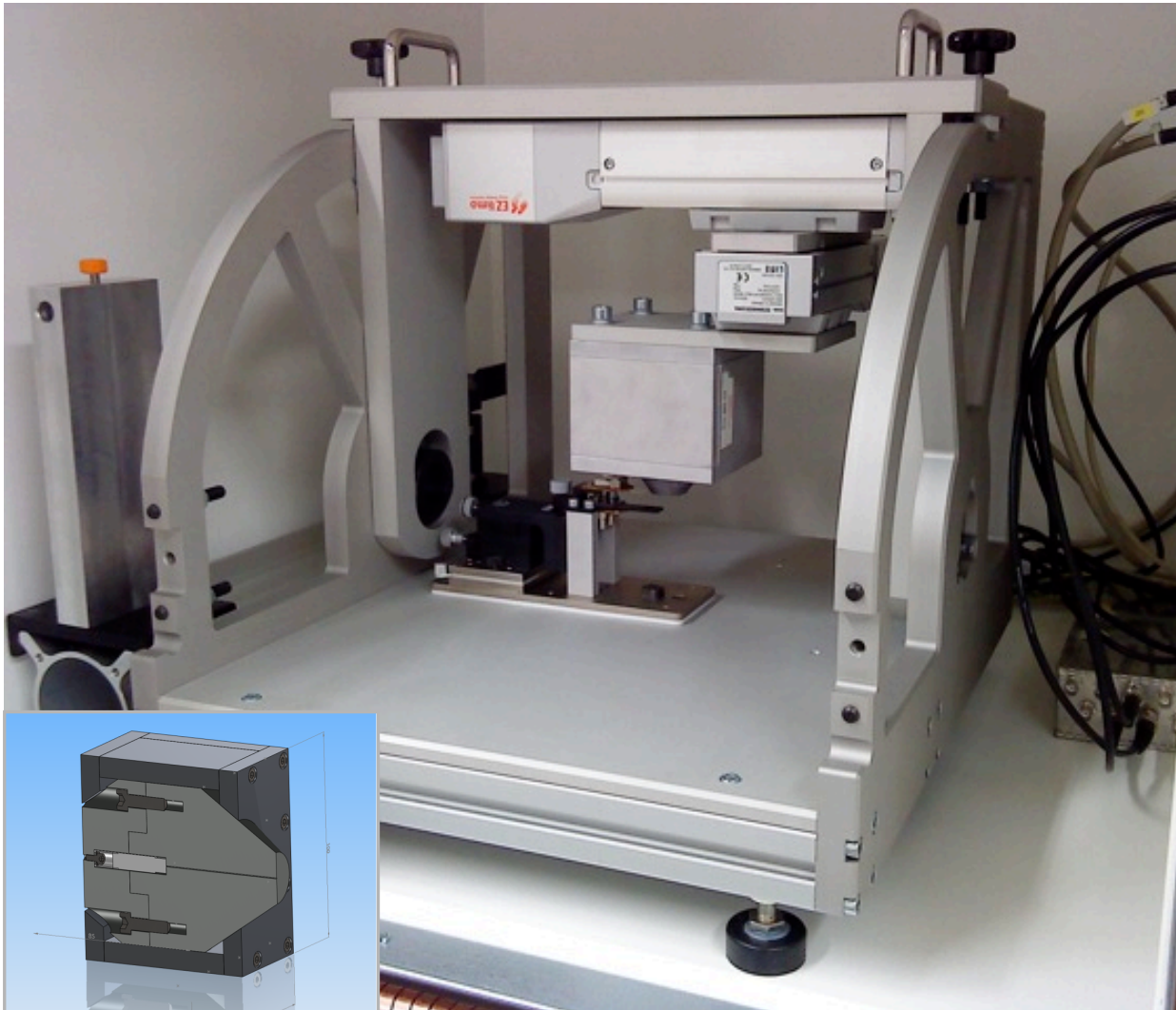
TCAD simulation

Also allows to reject noise events,
strange pulses and depth information!

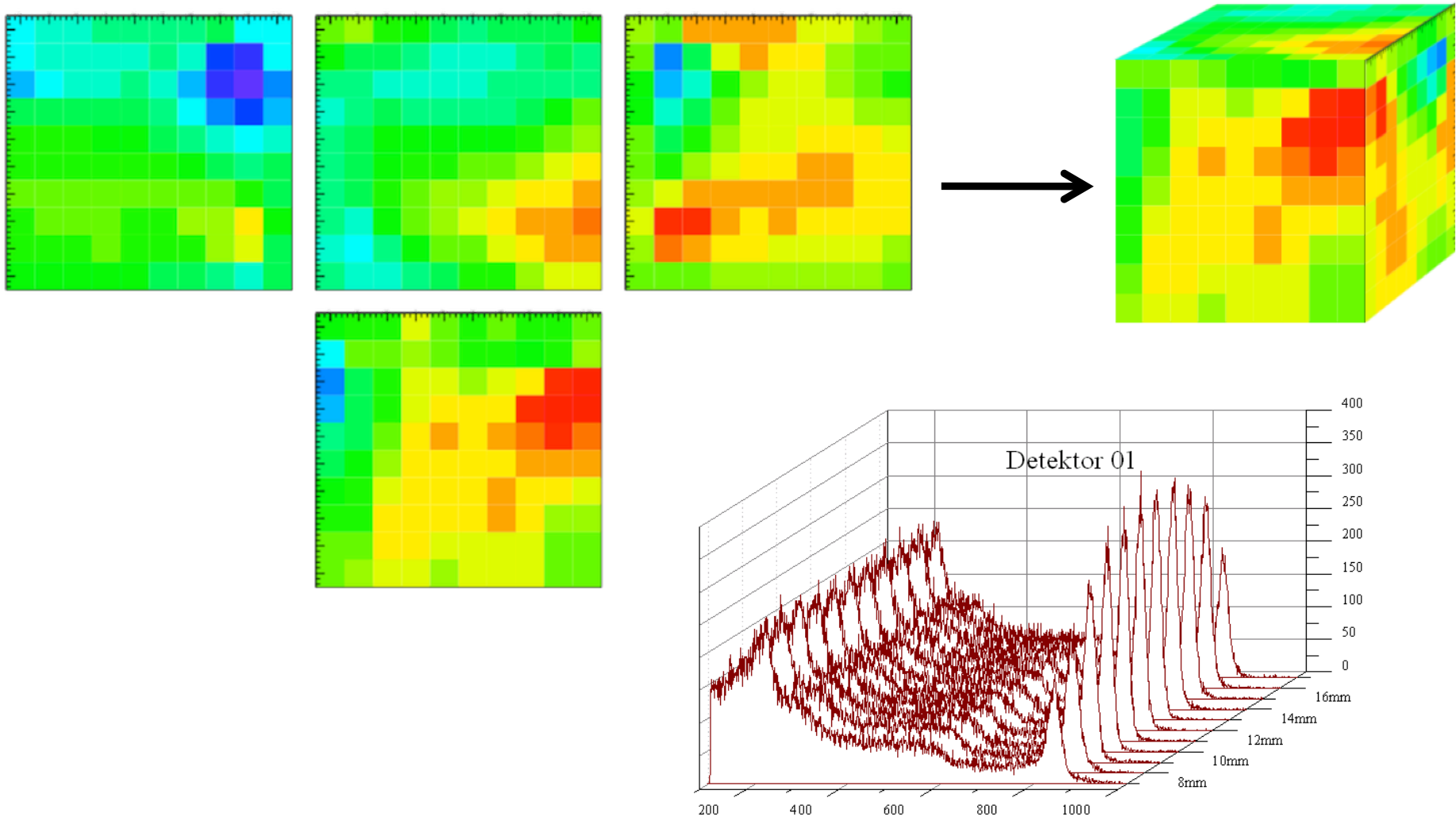
K. Zuber

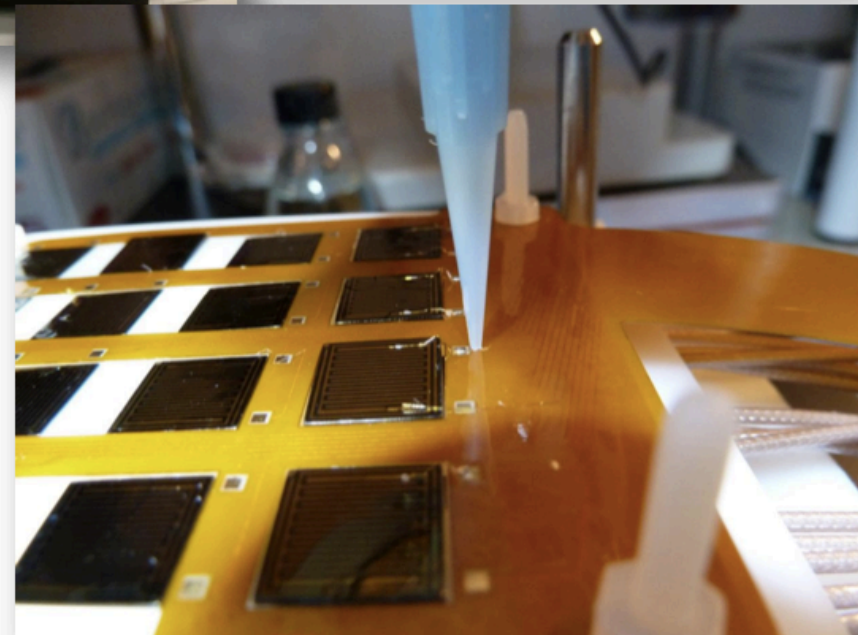
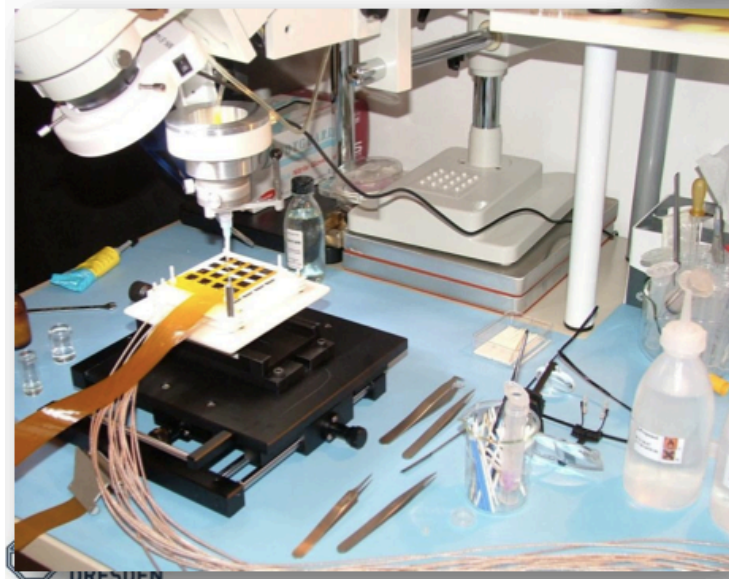
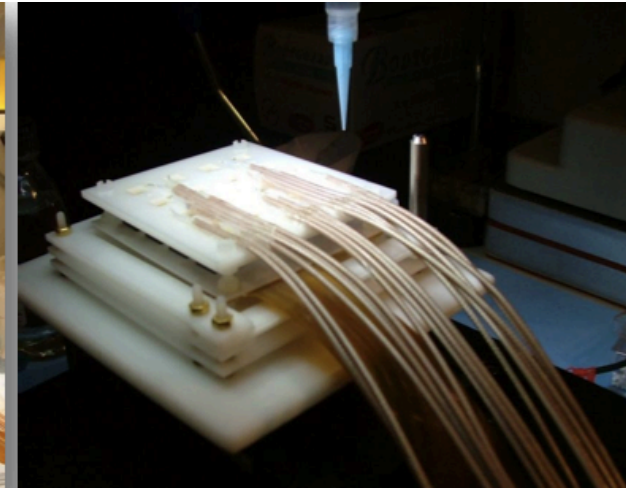
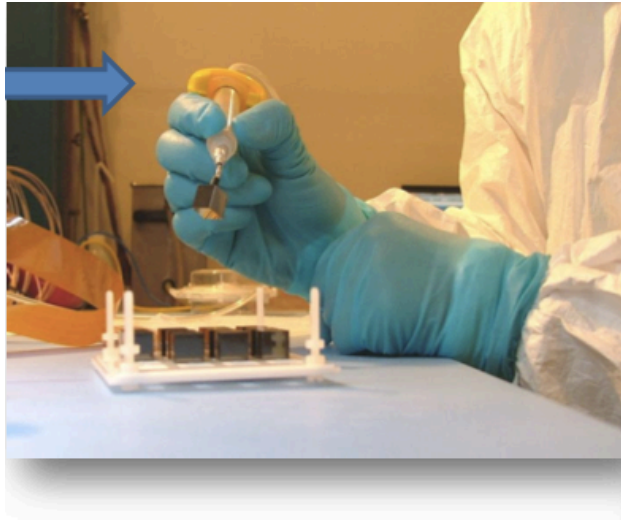
Collimator-channel

- 6cm length
- 500 μ m diameter
- Opening angle $<1^\circ$
- Special resolution: <1 mm
- 100MBq ^{137}Cs

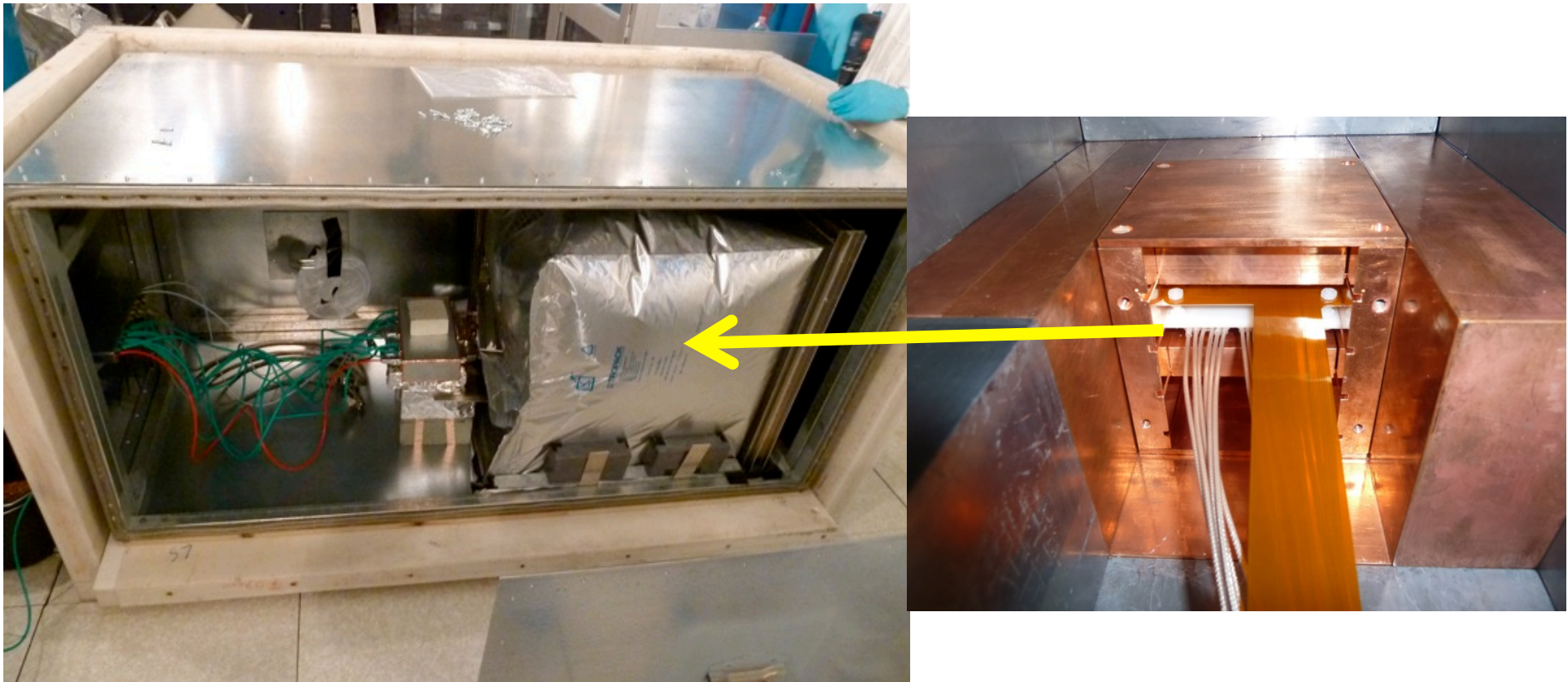


Pulse shapes recorded, efficiency determination, allows better energy resolution





Installation



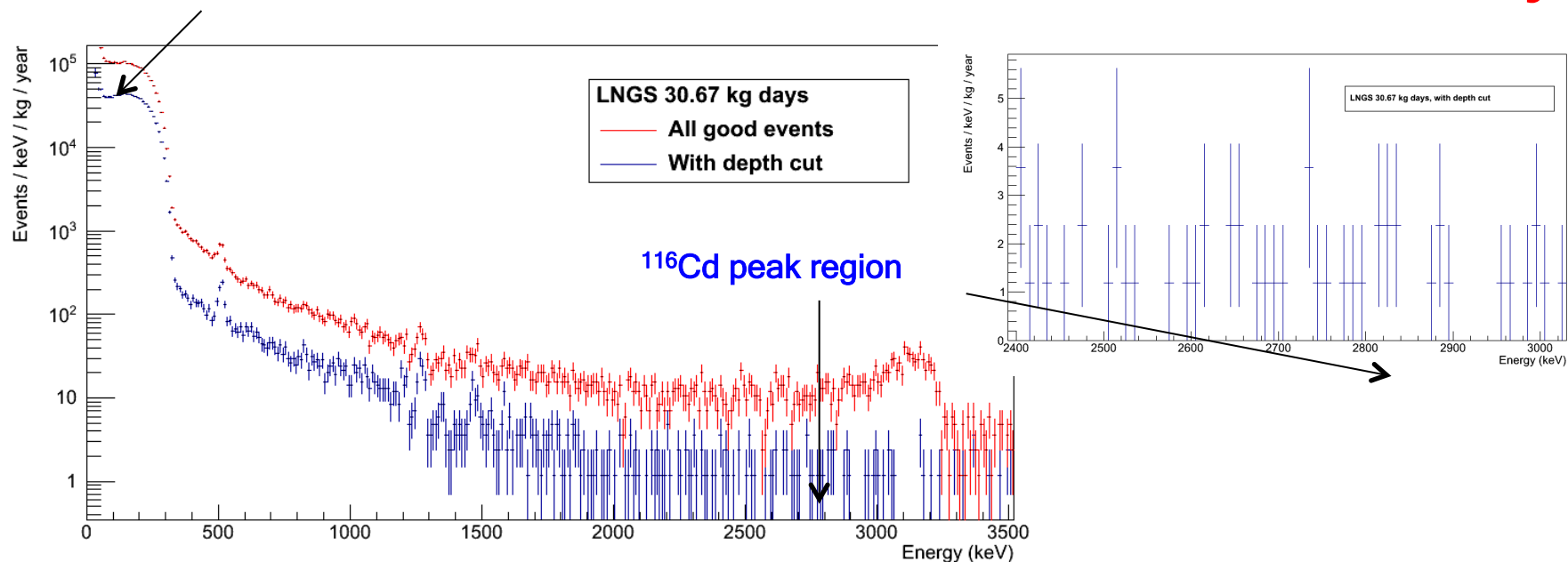
First layer installed in November 2011, second layer in March 2012,
remaining two layers planed until end of the year

First background spectrum from 32 detectors in new location (30.67 kg*days)

No further cuts applied like multidetector hits, pulse shapes, ...

^{113}Cd beta decay with half-life of 8×10^{15} years

Preliminary



Onubb limits (preliminary):

$$T_{1/2} > 9.9 \cdot 10^{20} \text{ yrs (Cd116)}$$

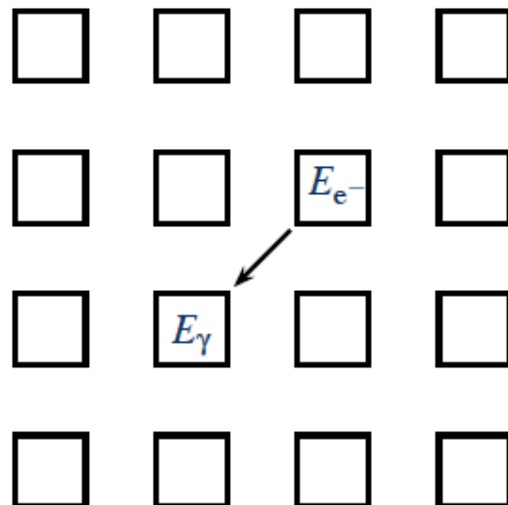
$$T_{1/2} > 5.1 \cdot 10^{21} \text{ yrs (Te130)}$$

$$T_{1/2} > 8.9 \cdot 10^{20} \text{ yrs (Cd114)}$$

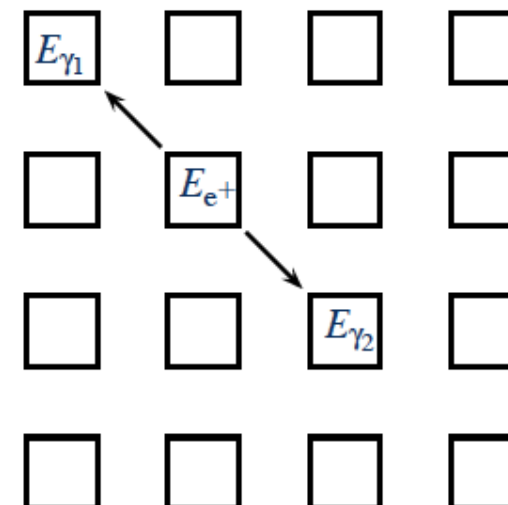
Considered events

Decays into excited states or decays via positron emission

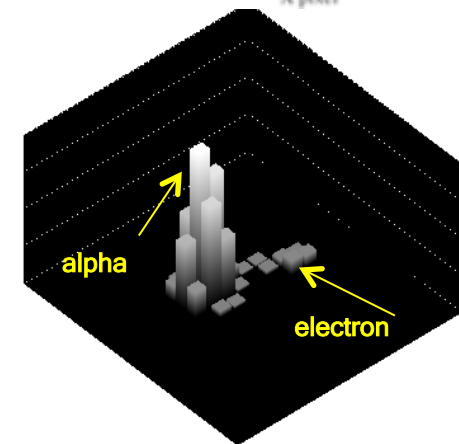
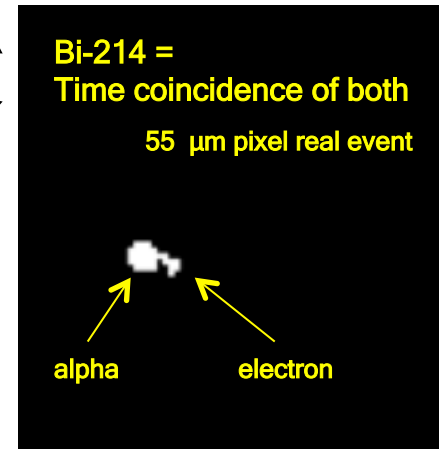
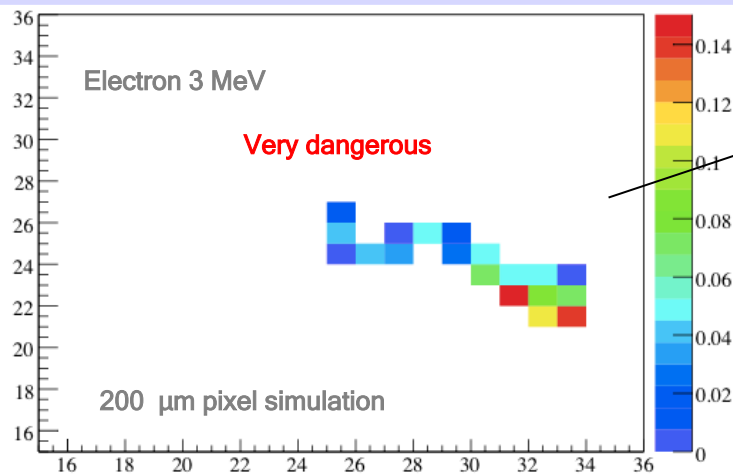
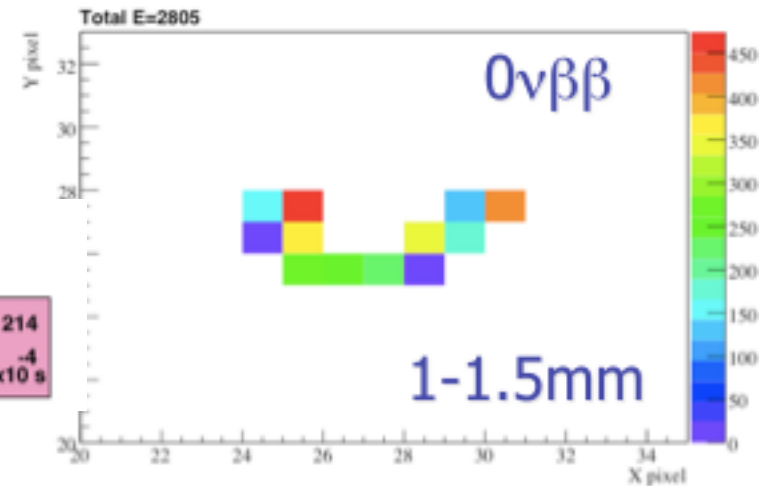
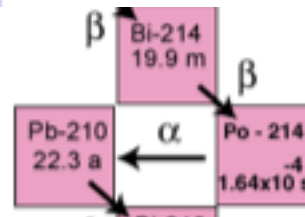
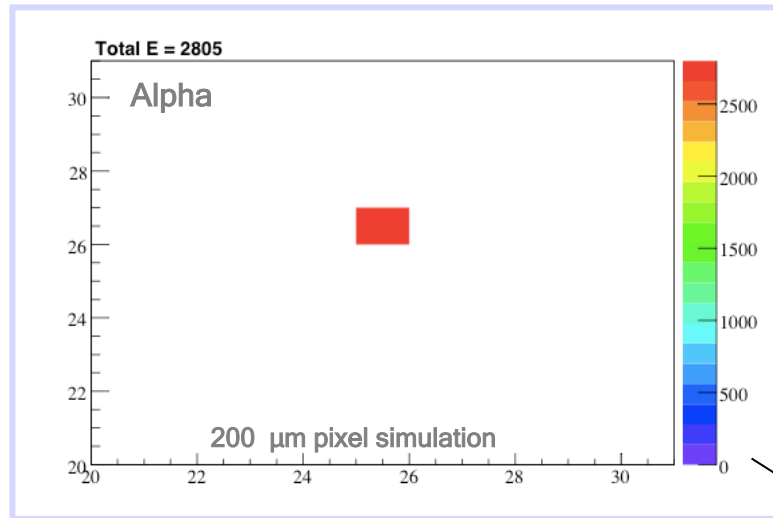
no geometric relation



geometric relation

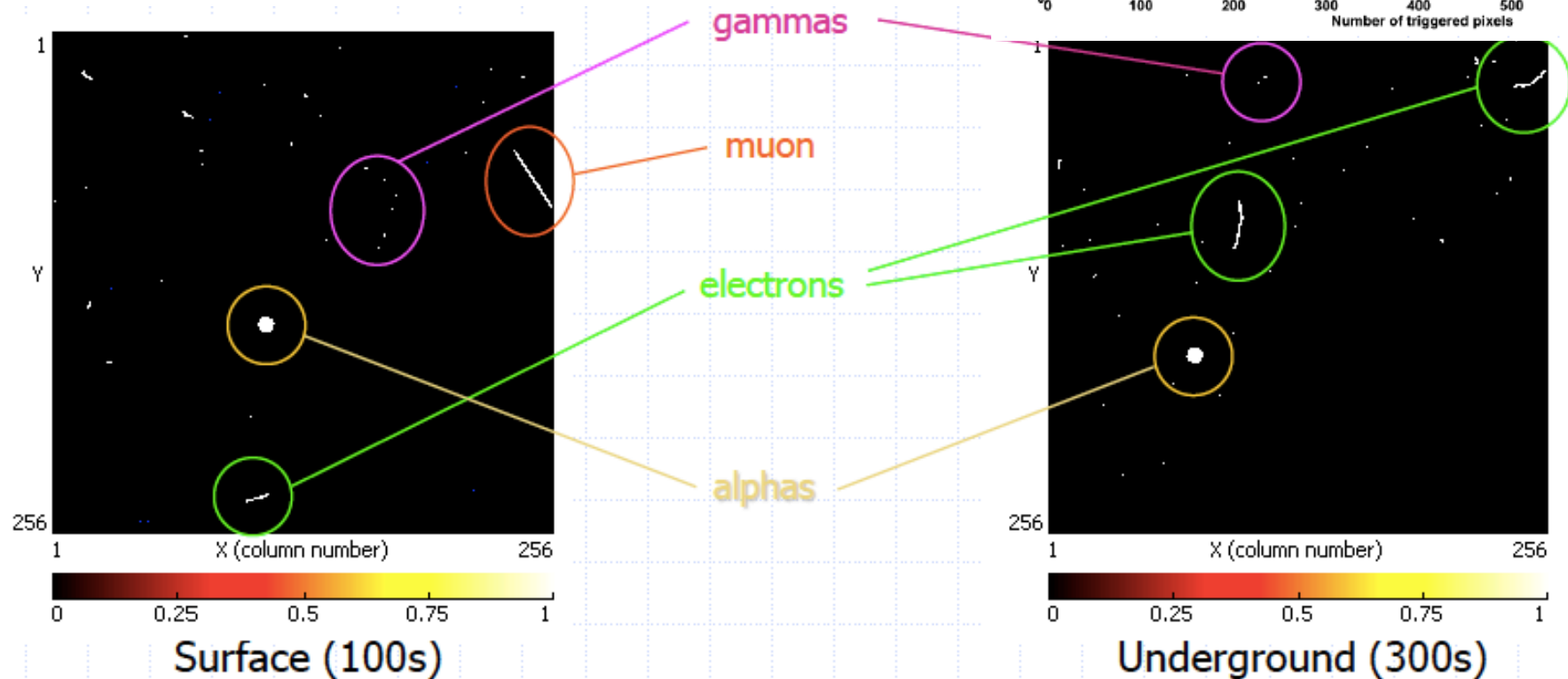
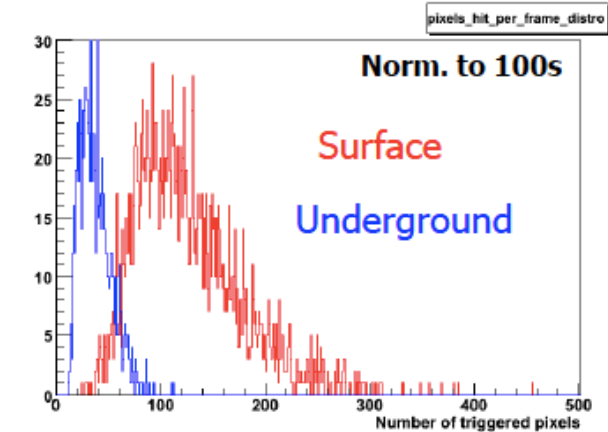


Idea: Massive background reduction by particle identification



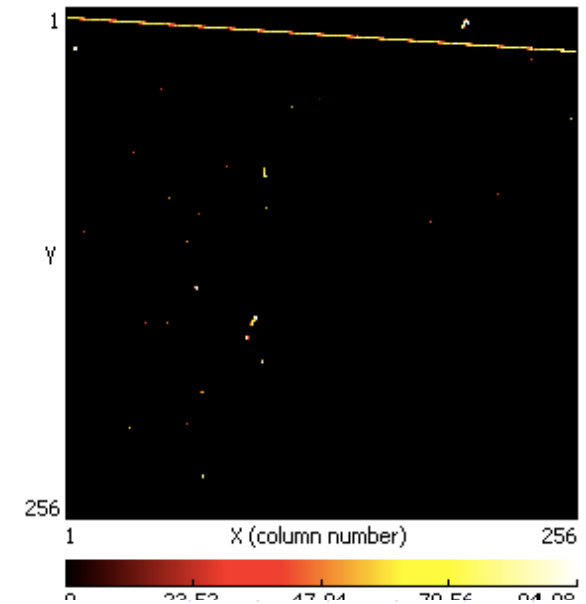
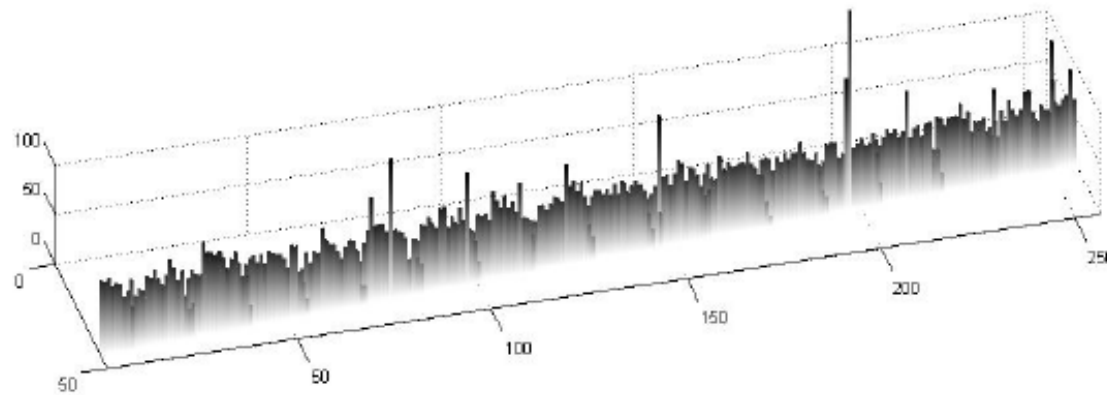
55 μm pixel Si Timepix device,
14x14x1 mm³ detector

It reacts on environment, ie. not
completely dominated by internal
background

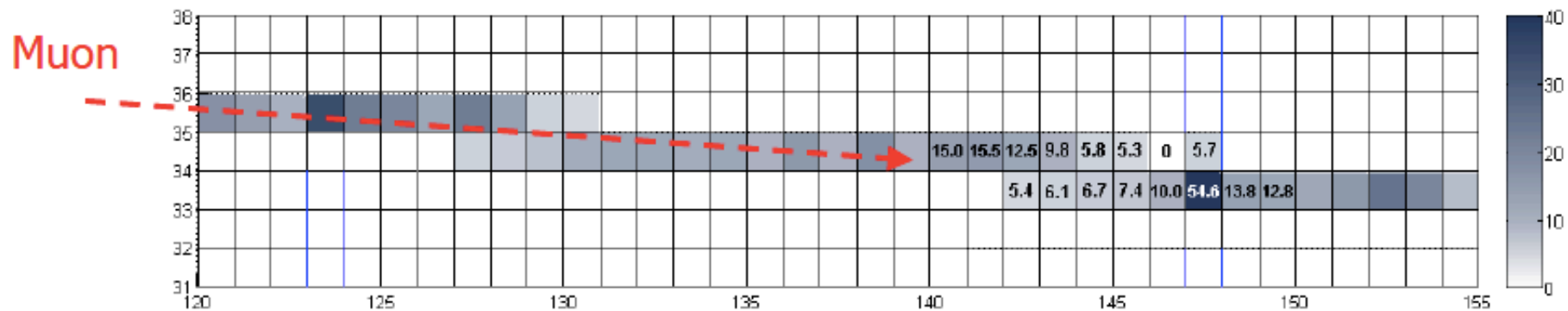




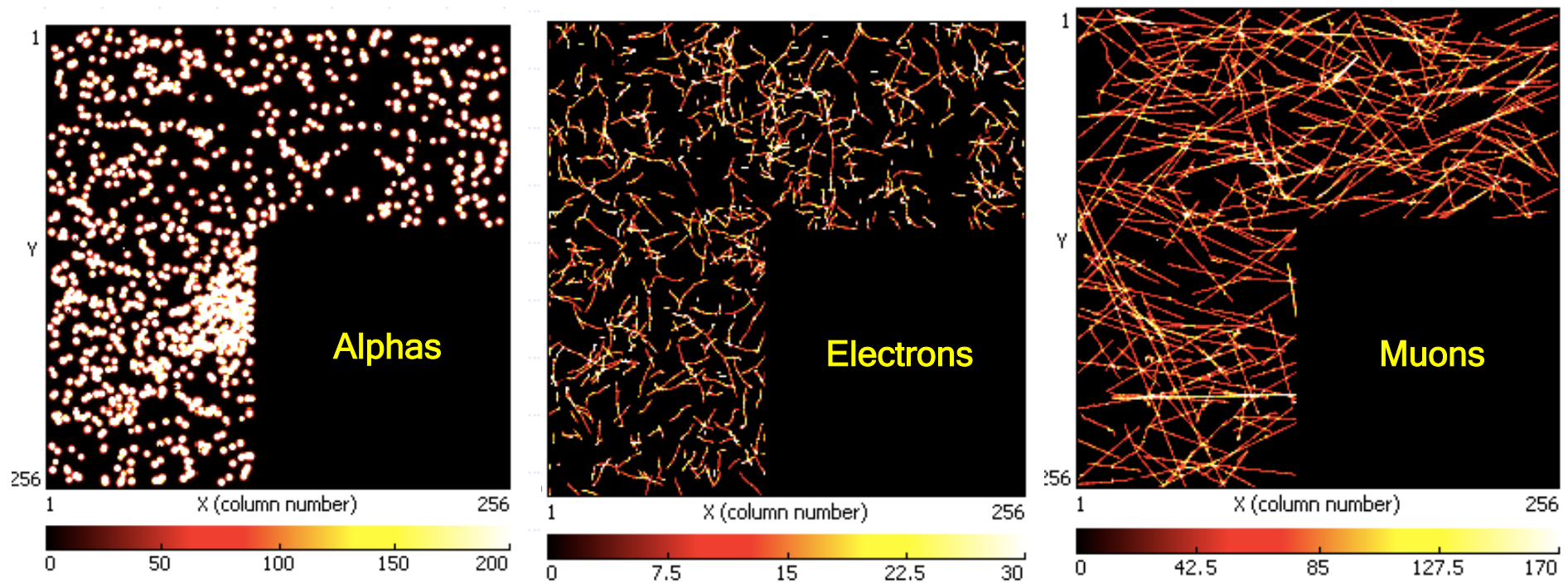
◆ Track crossing whole detector



◆ Top view + deposited energy, charge sharing effect

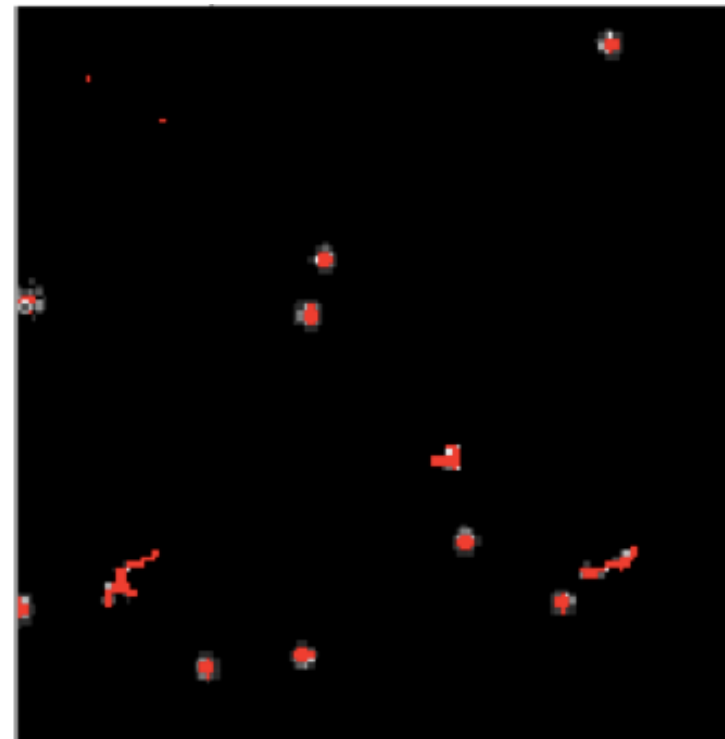
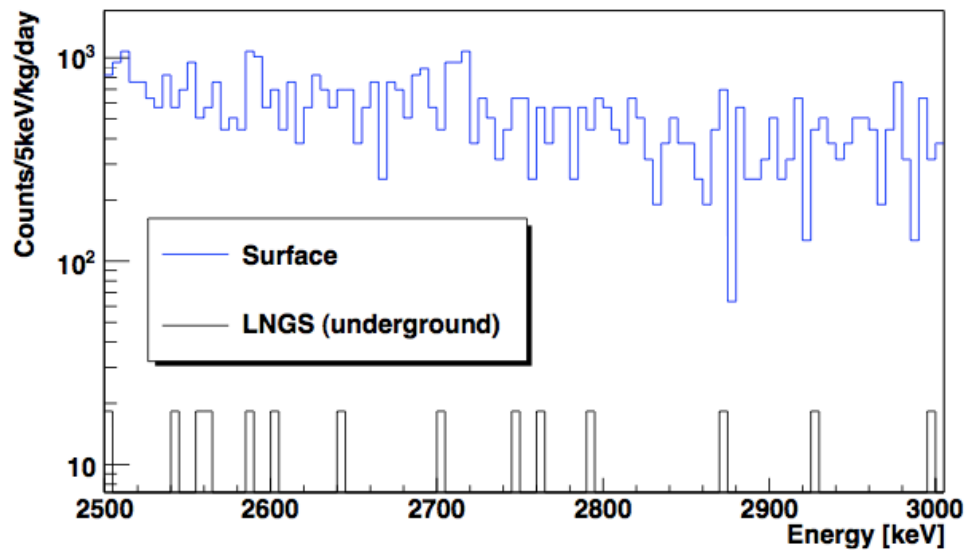


256x256 pixels, 55 μ m

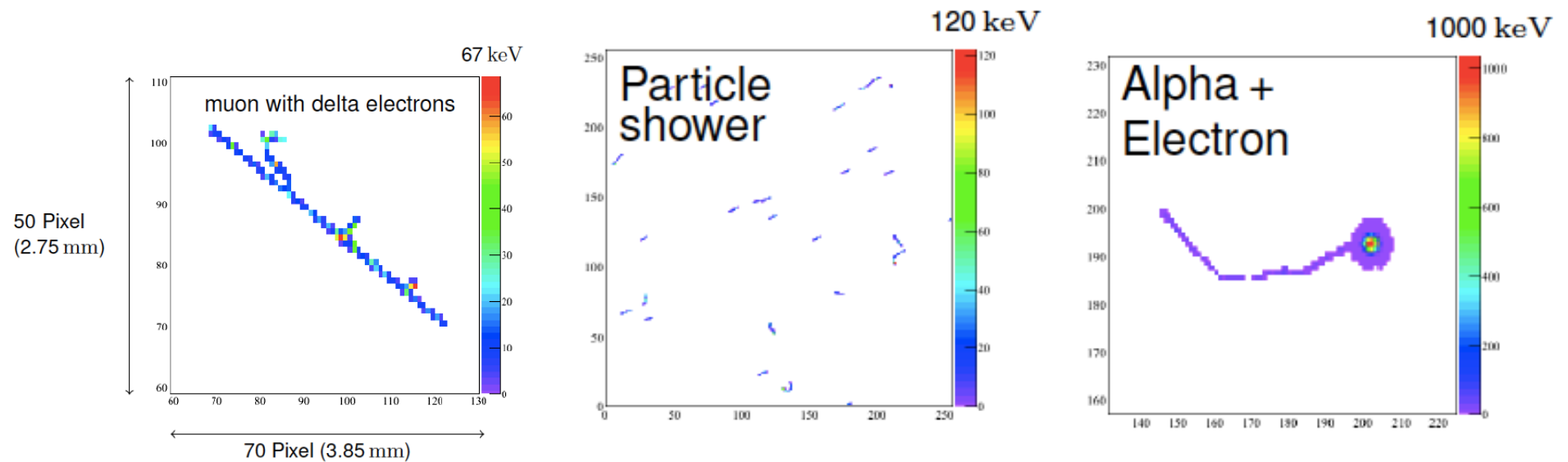


According to simulations particle identification due to pixels should reduce background by 3 orders of magnitude

45 days of measurement

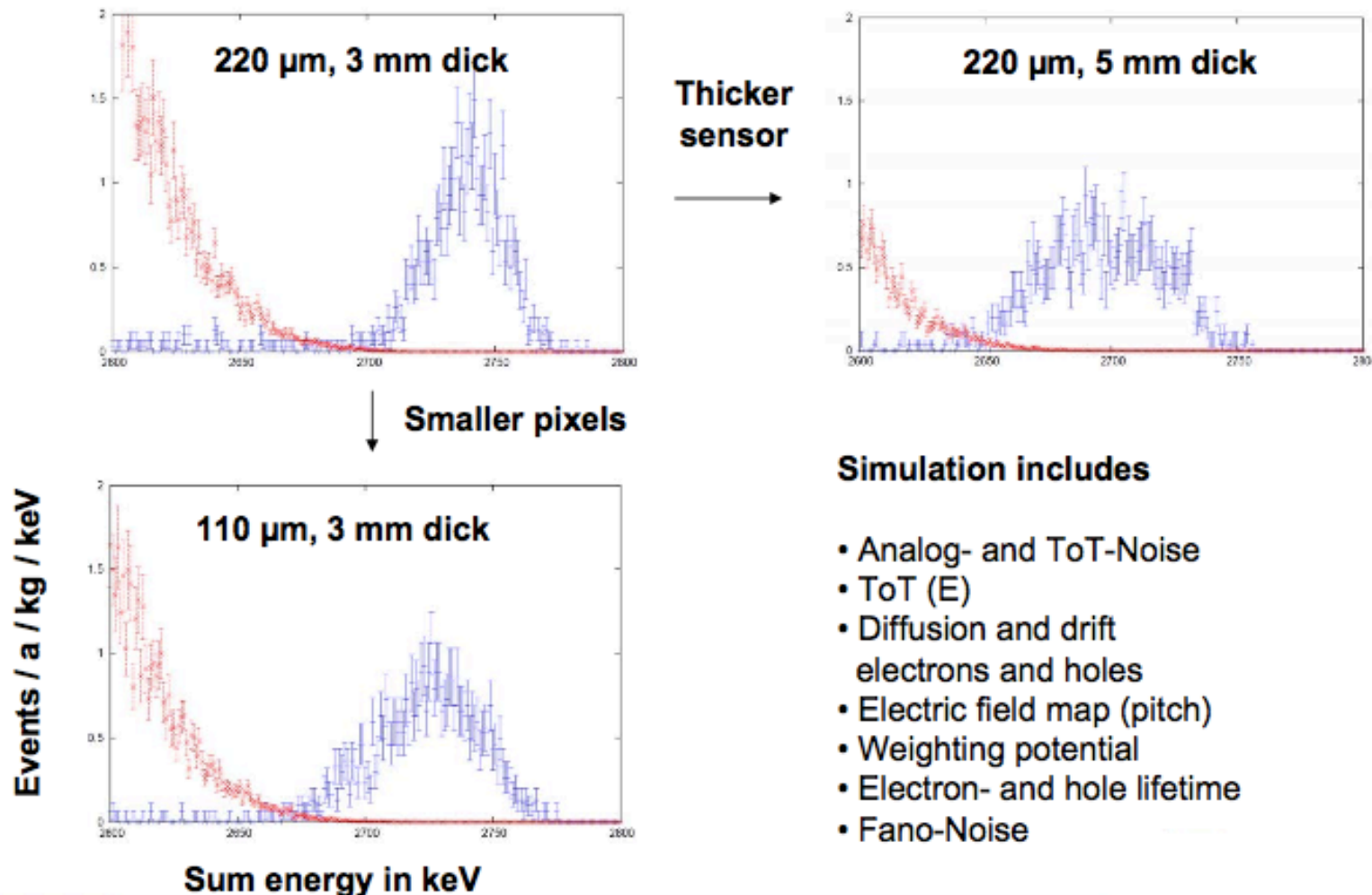


Shallow depth , 110 mwe, minor shielding



NO event in 117.5 days in energy range between
2.7 and 3 MeV which looks like 1(2) electrons

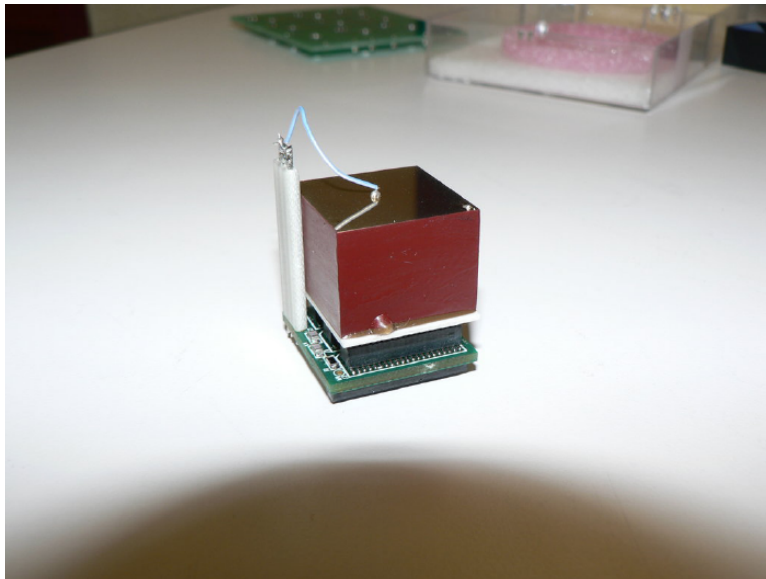
Optimization of sensor thickness and pitch



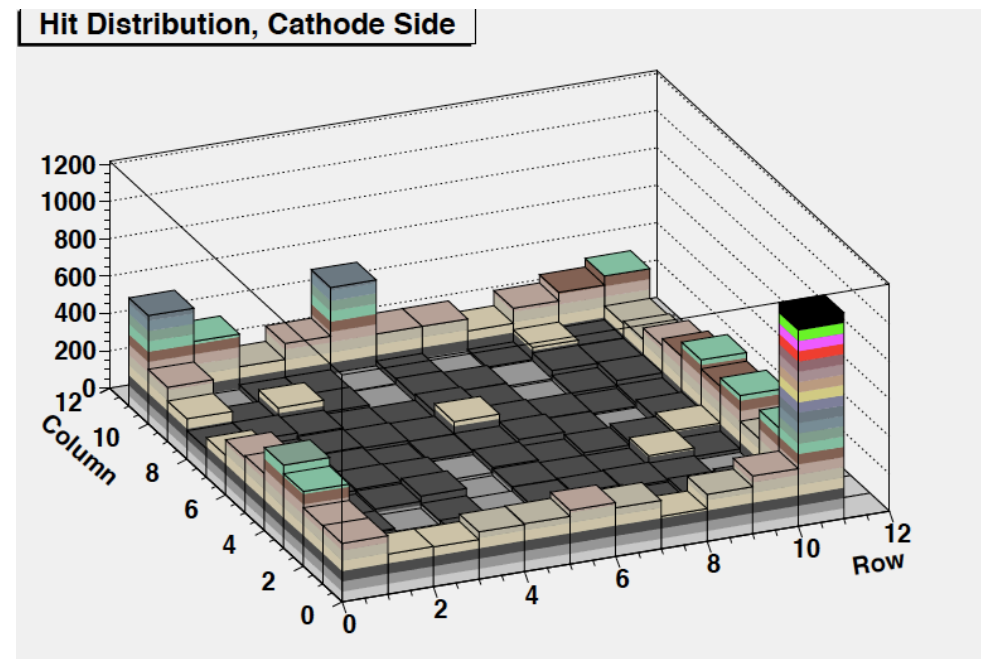
In collaboration with group of Z. He (Univ. Michigan)

The power of pixels!

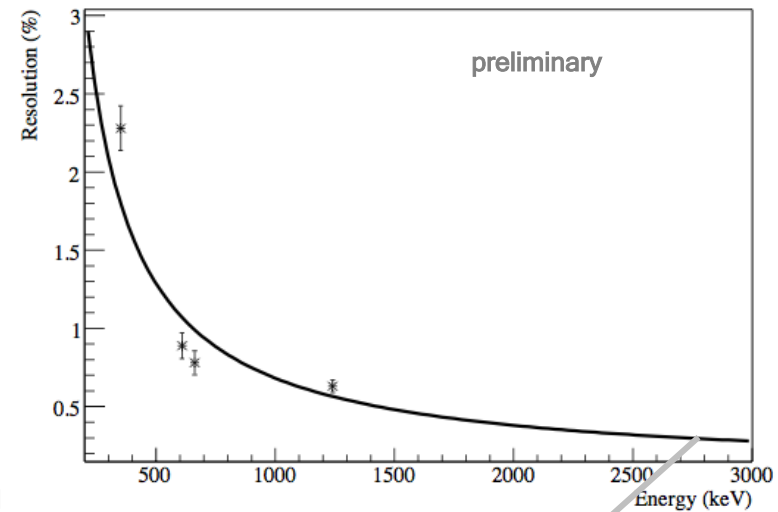
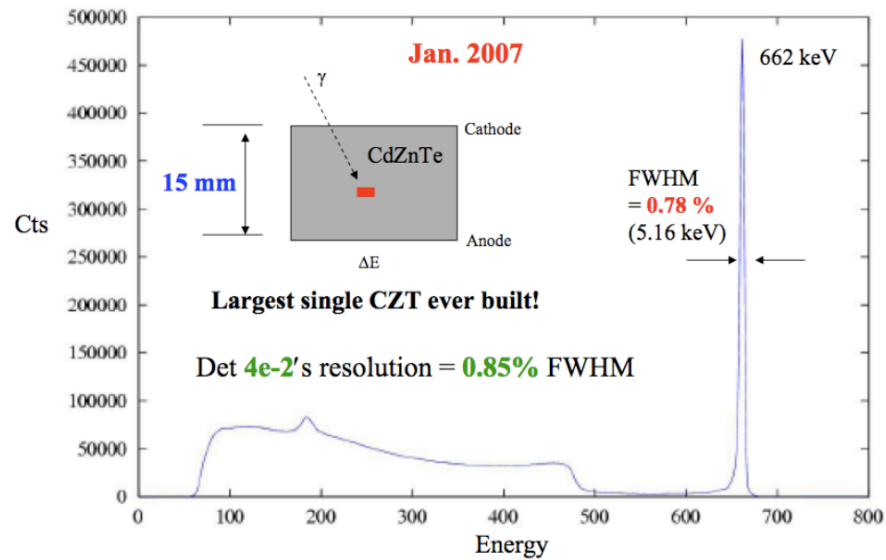
Running at Gran Sasso Sep. 2009 - January 2010



20x20x15 cm³ CZT detector (as used in Polaris system)
11x11 pixels

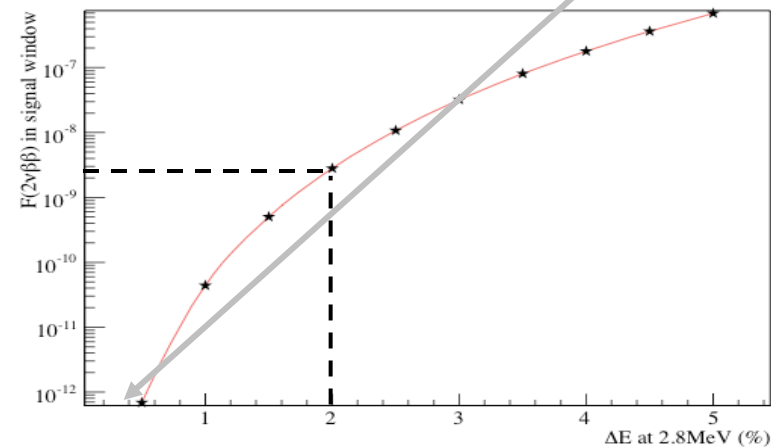


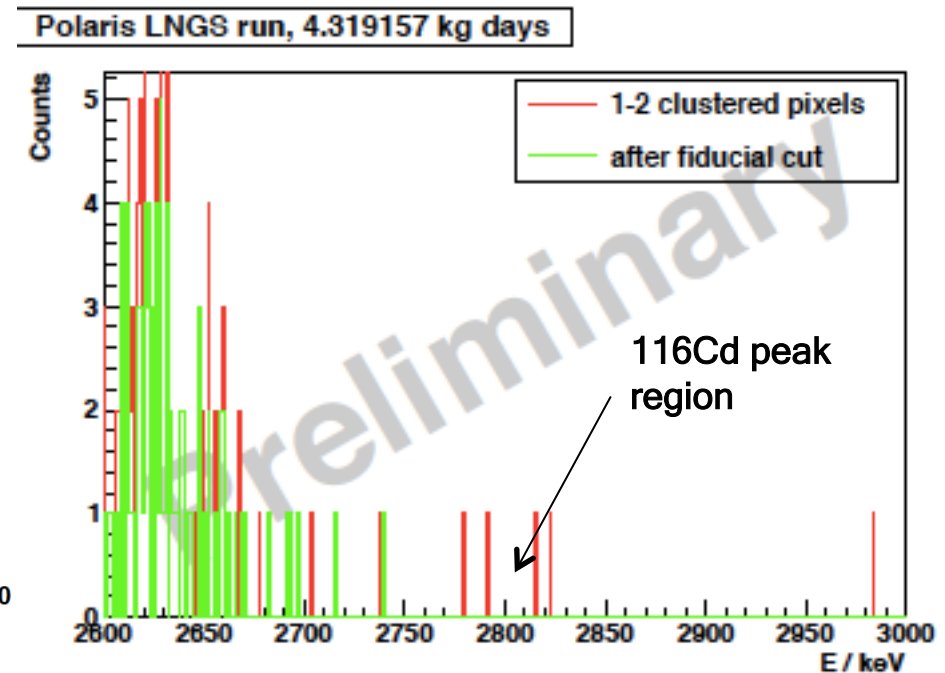
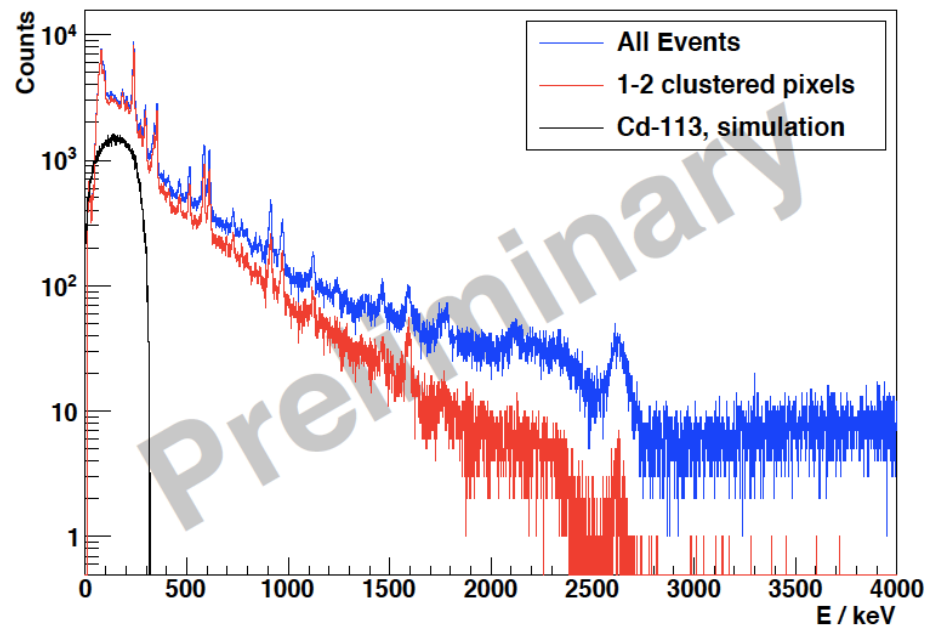
NB: Also running a pixel system developed at Washington University at St. Louis at Gran Sasso



36 gram detector,
6 times larger than
current COBRA detectors

Pixelated in 11x11,
Can be sliced in z
up to 40 slices
due to drift time

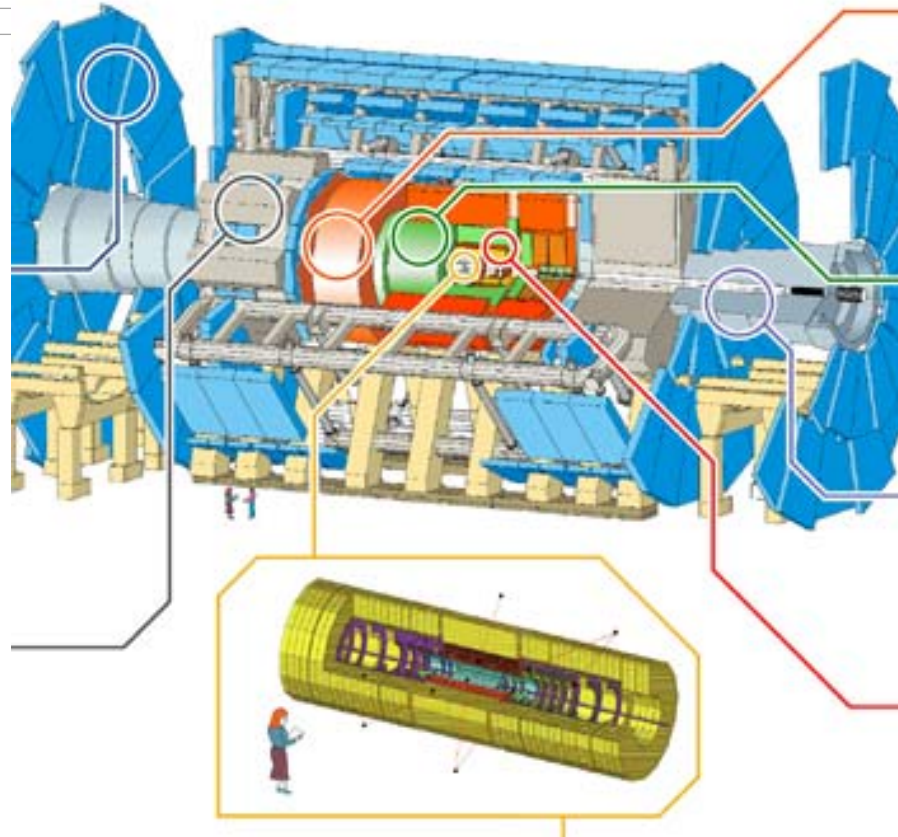




No survivor after 125 days of data taking!!!

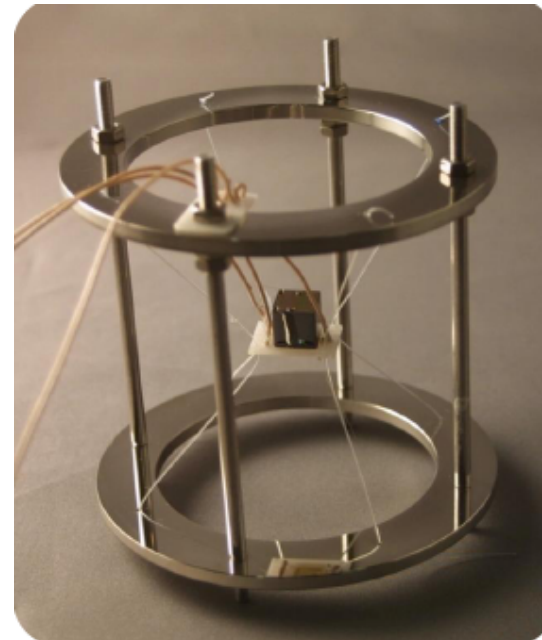
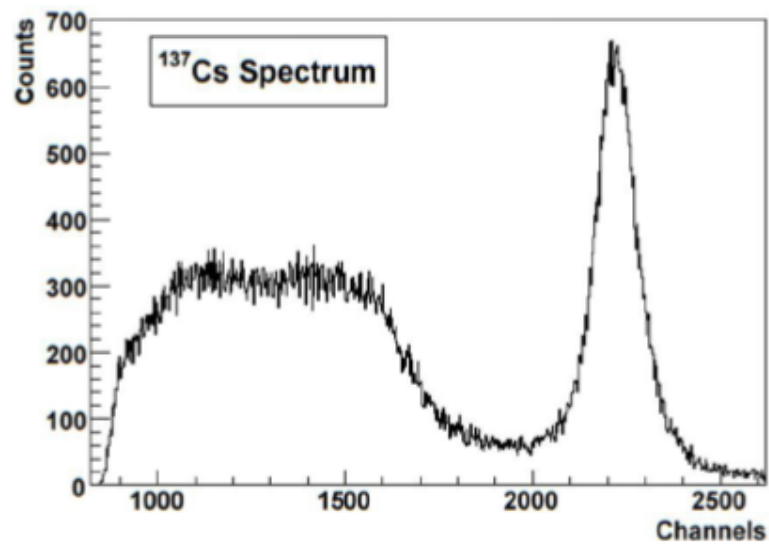
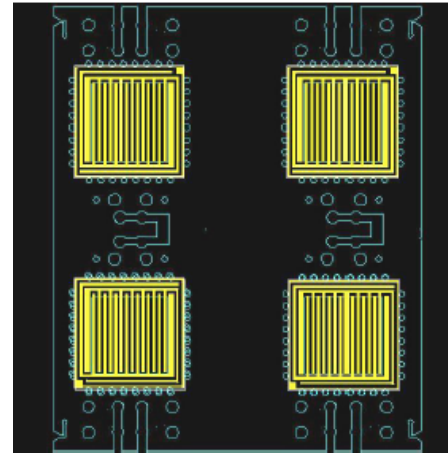
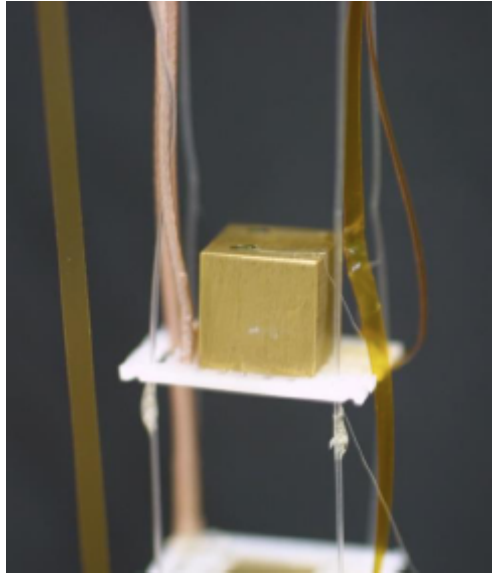
Detector not tuned for low background

ATLAS Detector Photos

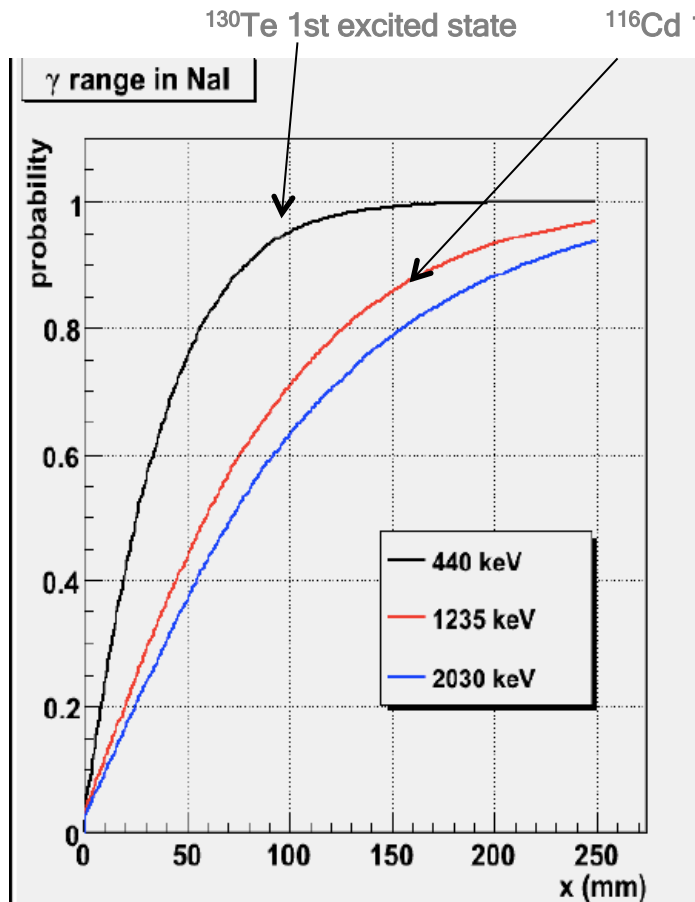


Yes we can! B. Obama

Bare crystals in LScintillator II



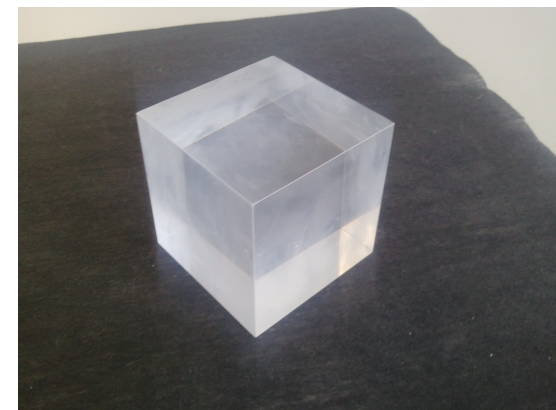
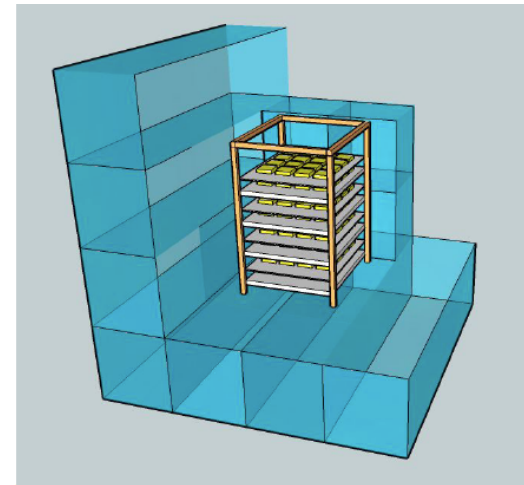
Aim : Improve excited state and positron decay sensitivity by factor 10-30



Done for :
NaI, CsI , BGO, CdWO_4

Exploring various
readout concepts

Note:
Can tolerate some impurities
because of coincidence
requirement



K. Zuber

- **COBRA is a promising next generation experiment to explore double beta decay of Cd-116. First scientific results have been obtained , major upgrades ongoing/planned 2011/12**
- **Unique option would be the semiconductor tracker (solid-state TPC) in form of a pixel CZT, first measurements are very promising**

