TECHNISCHE UNIVERSITÄT DRESDEN

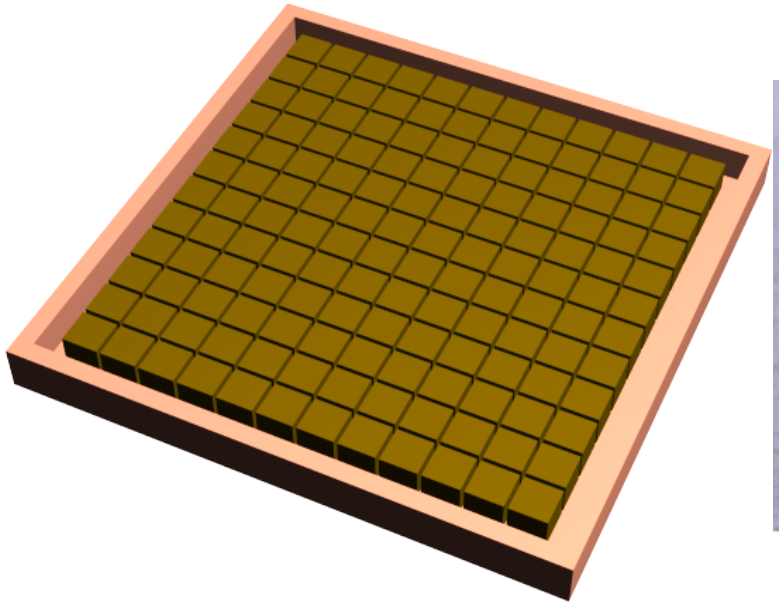
DRESDEN concept

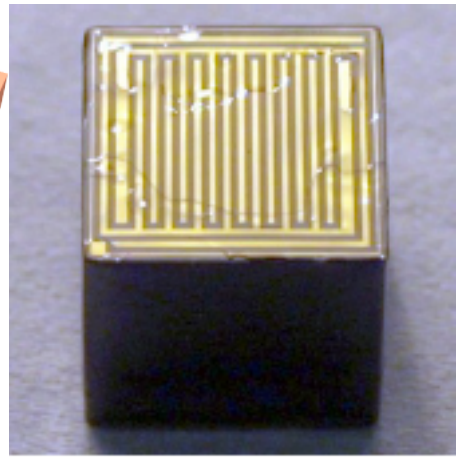
# The C0BRA double beta decay experiment

K.Zuber, LNGS Open session 13.11.2014

# COBRA

**Use large amount of CdZnTe Semiconductor Detectors**





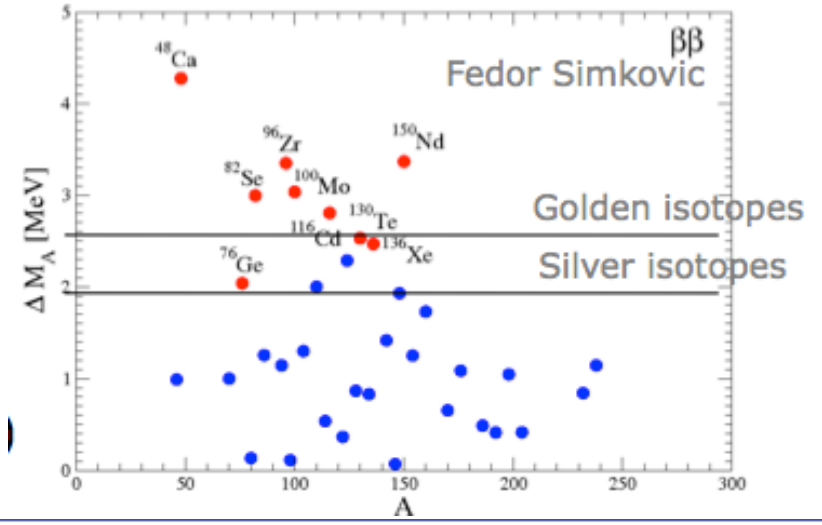
Large array of CdZnTe detectors

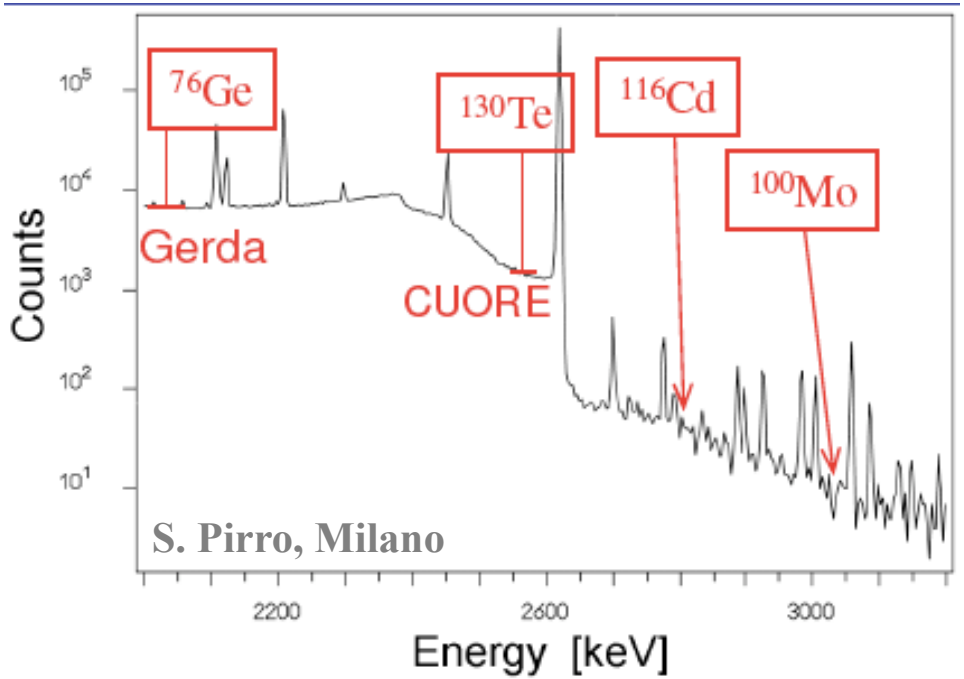
**K. Zuber, Phys. Lett. B 519,1 (2001)**

# COBRA

## Advantages

- Q-value at 2813.50 keV, above all major gamma lines from natural chains
- Room temperature
- Semiconductor (clean)
- Good energy resolution
- Enrichment (>90%) feasible and purification as well
- Coincidences
- Pulse shape analysis
- Very modular design
- Tracking option
- Located between hall A and B at LNGS

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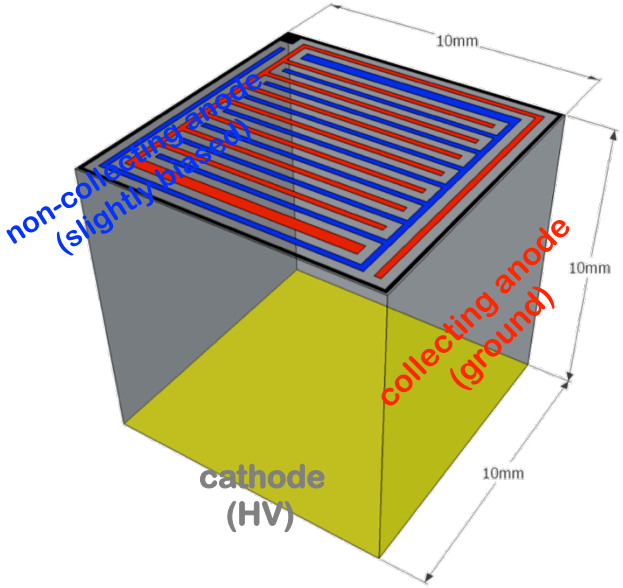
## Isotopes

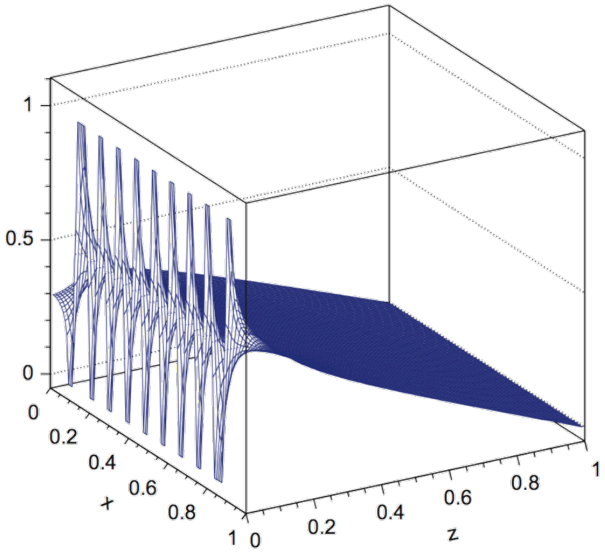
- A variety of double beta isotopes and Cd-113

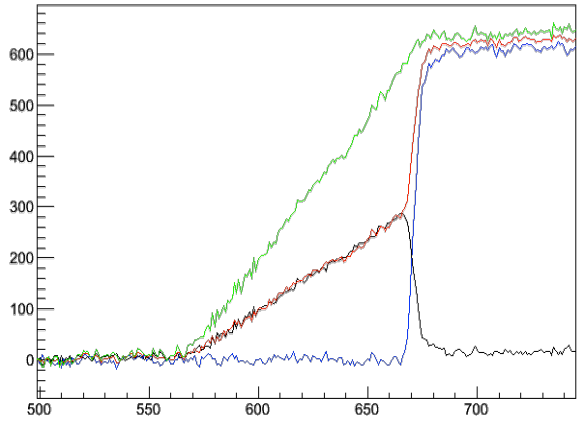
| isotope | decay mode | Q-value / keV | natural abundance / % |
|---|---|---|---|
| $^{64}$Zn | $\beta^+/EC$; $EC/EC$ | 1096 | 48.6 |
| $^{70}$Zn | $\beta^-\beta^-$ | 1001 | 0.6 |
| $^{106}$Cd | $\beta^+\beta^+$; $\beta^+/EC$; $EC/EC$ | 2771 | 1.25 |
| $^{108}$Cd | $EC/EC$ | 231 | 0.89 |
| $^{114}$Cd | $\beta^-\beta^-$ | 534 | 28.72 |
| $^{116}$Cd | $\beta^-\beta^-$ | 2814 | 7.74 |
| $^{120}$Te | $\beta^+/EC$ ; $EC/EC$ | 1722 | 0.096 |
| $^{128}$Te | $\beta^-\beta^-$ | 868 | 31.69 |
| $^{130}$Te | $\beta^-\beta^-$ | 2527 | 33.8 |

# Coplanar grid technology (CPG)

Invented by P, Luke (LBNL)

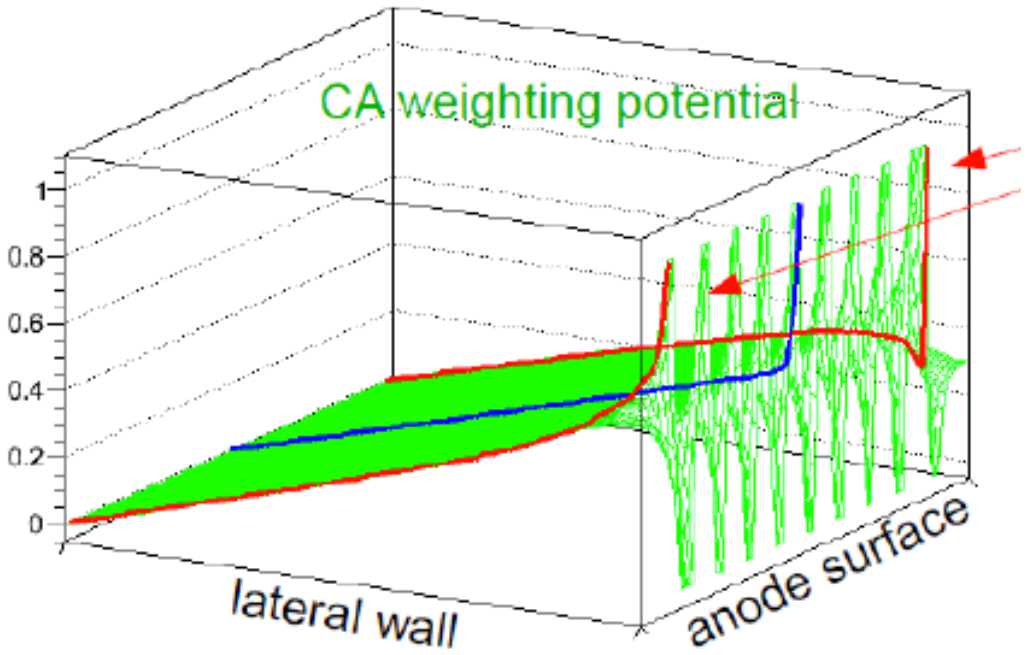


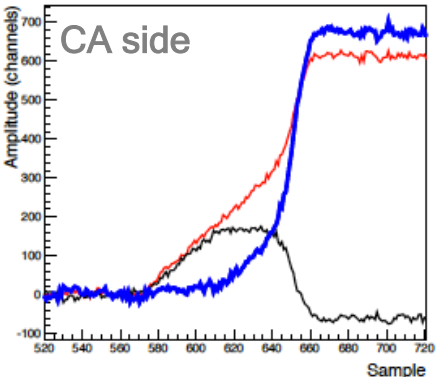



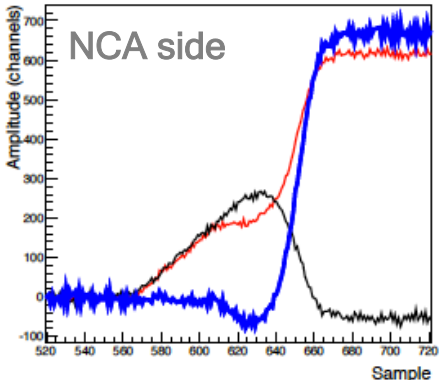



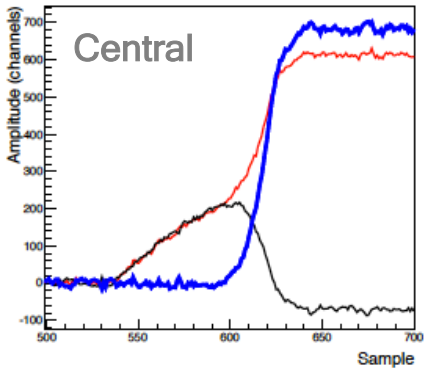

Pulse shape allows - Determination of interaction depth
- Identification of lateral surfae events
- Multiple site interactions

# Lateral surface events



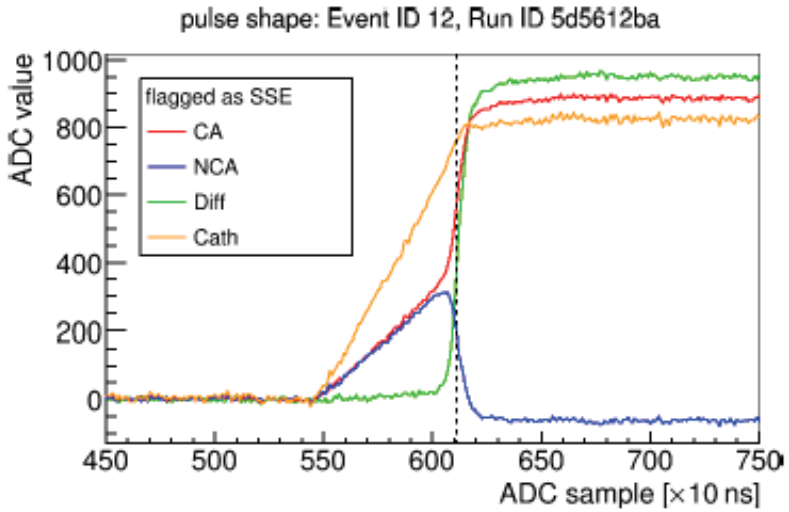



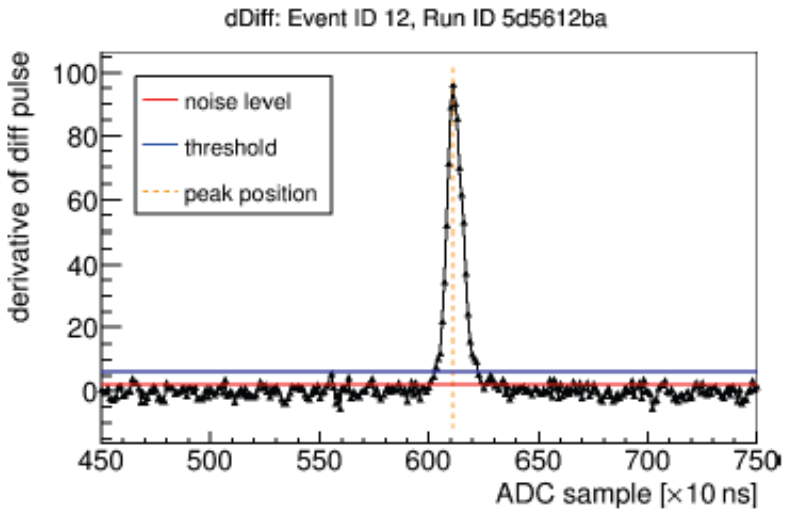



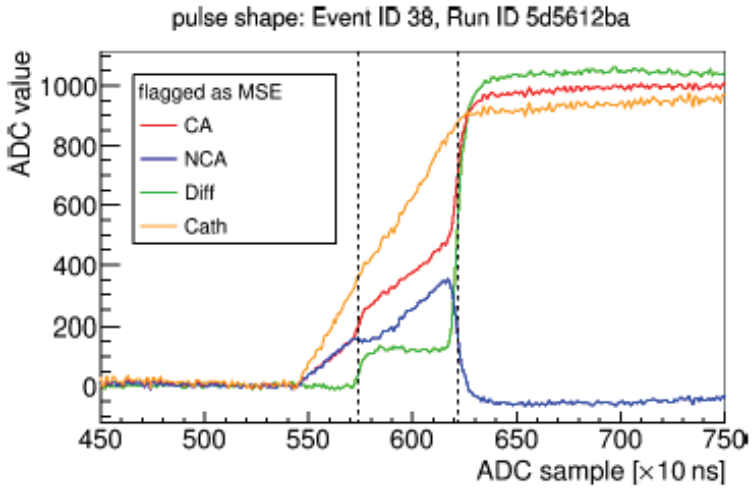

Distortion of pulses at lateral surfaces

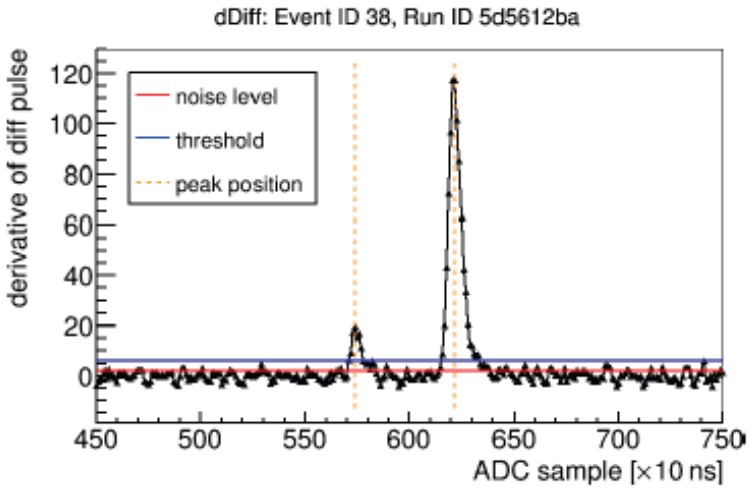
M. Fritts et al., NIM A 749, 27 (2014)

# Multi-site and single site event discrimination

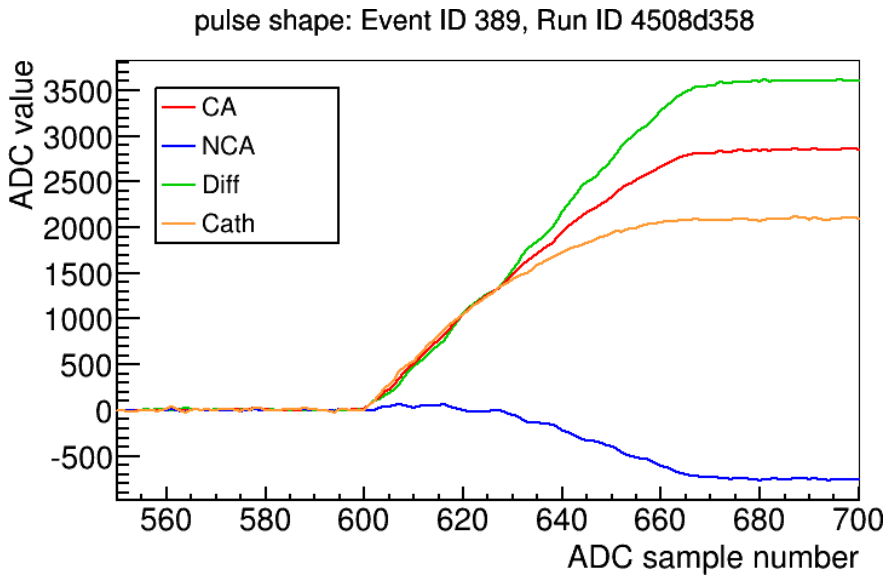


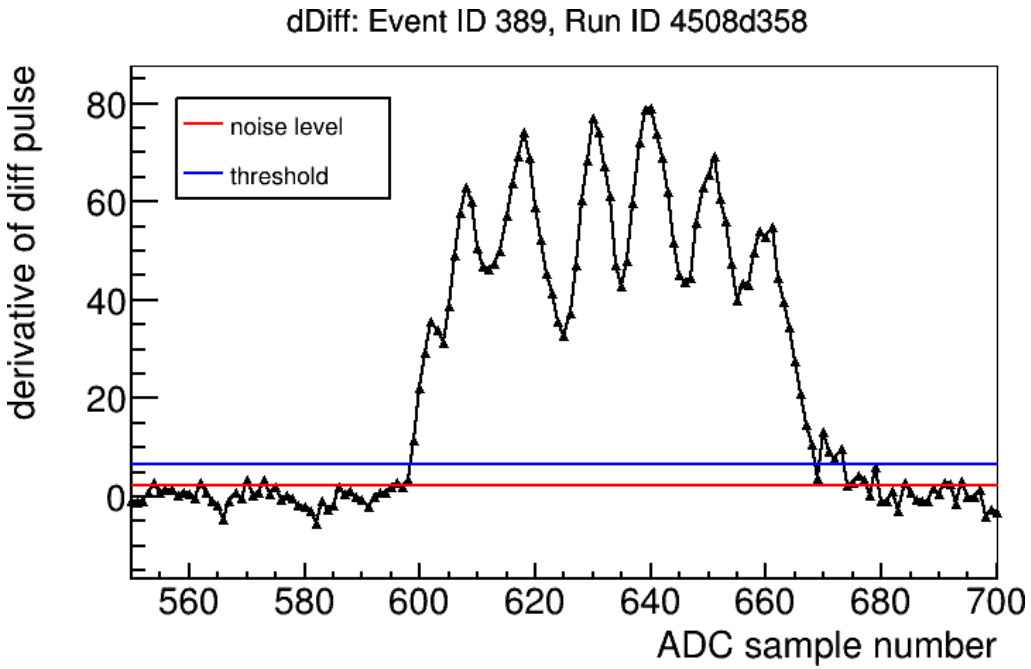



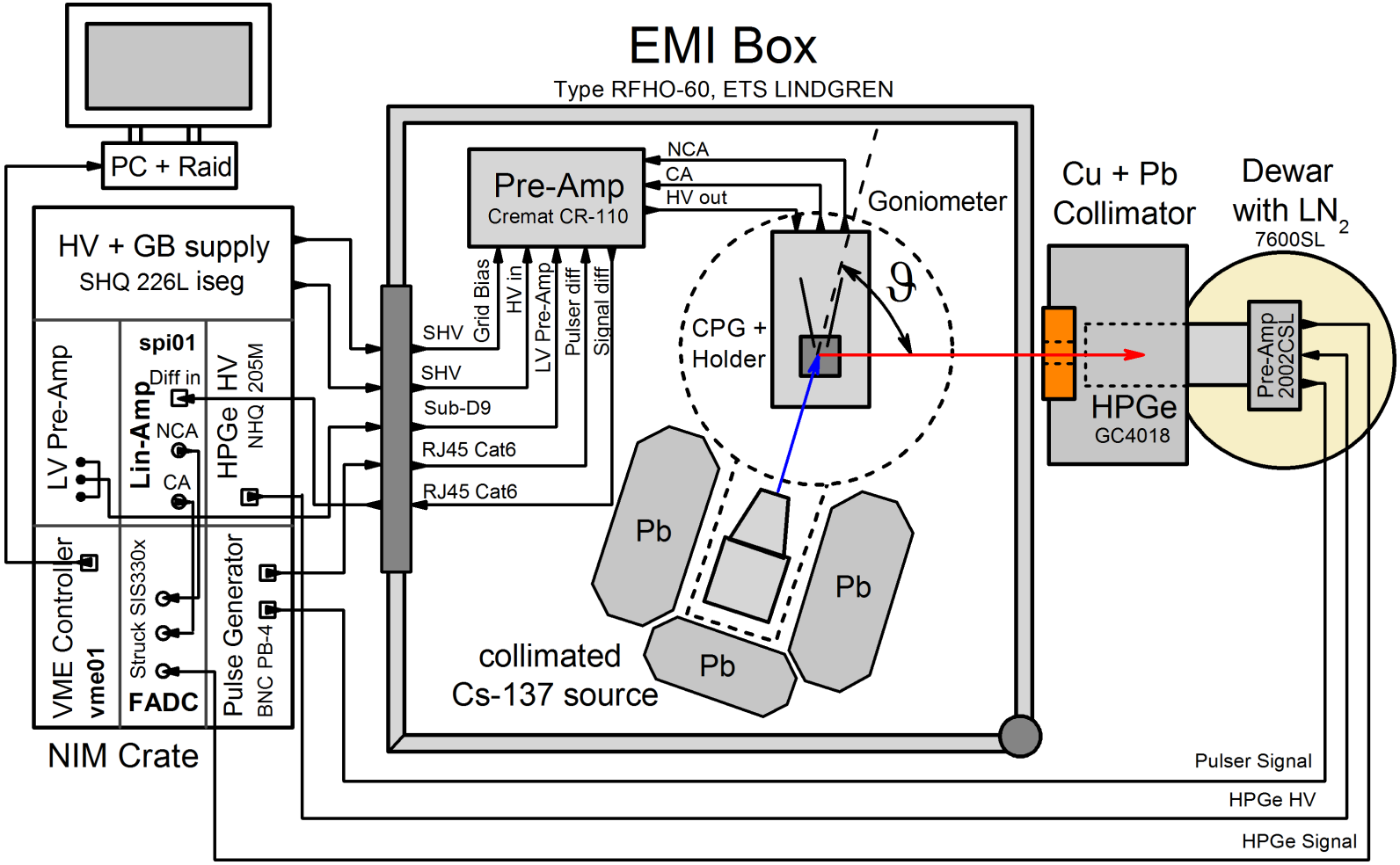



# Muons...


pulse shape: Event ID 389, Run ID 4508d358
ADC value
ADC sample number
CA
NCA
Diff
Cath
3500
3000
2500
2000
1500
1000
500
0
-500
560
580
600
620
640
660
680
700


dDiff: Event ID 389, Run ID 4508d358
derivative of diff pulse
ADC sample number
noise level
threshold
80
60
40
20
0
560
580
600
620
640
660
680
700

# Pulse shapes

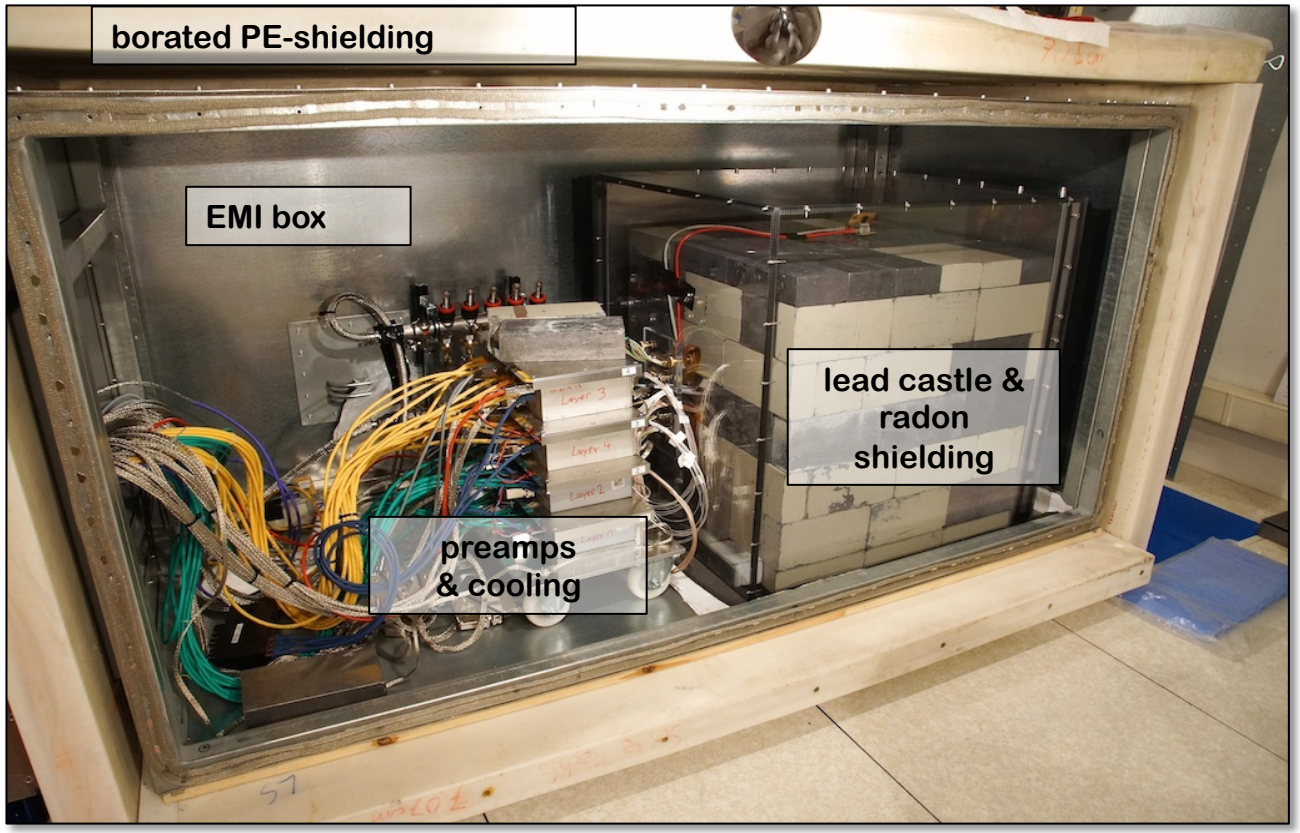


## Major setup work at LNGS

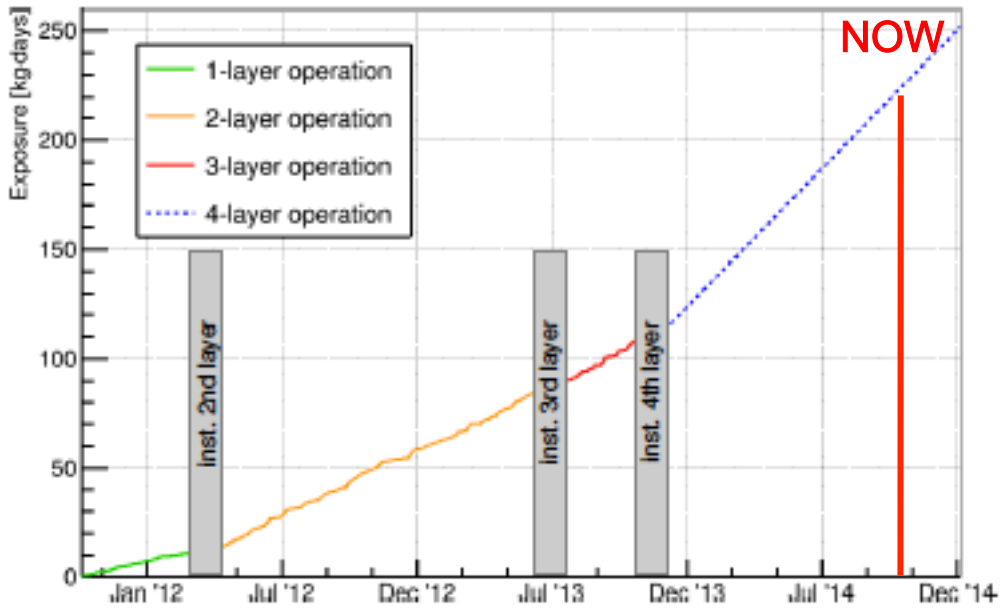
- Moved detector manipulation tools to LNGS
- Finalised the installation of 64 detectors
- New airtight box
- New Faraday cage
- Decoupling of preamps from detectors
- Pulser system for preamps
- Synchronisation of ADC clocks
- Installation of a UPS system
- Cooling system
- Built a dedicated setup for detector tomography
- Built a dedicated setup for pulse shape analysis
- Full shielding Monte Carlo for large scale setup assuming we can stay where we are

# LNGS Set-up using 1 $cm^3$ 64 CZT detectors

- Full 64 array running since Nov. 2013 (more than 0.7 kg*years)



# Data taking at LNGS (about 0.8 kg years)




Improvement of setup leads to better data taking efficiency

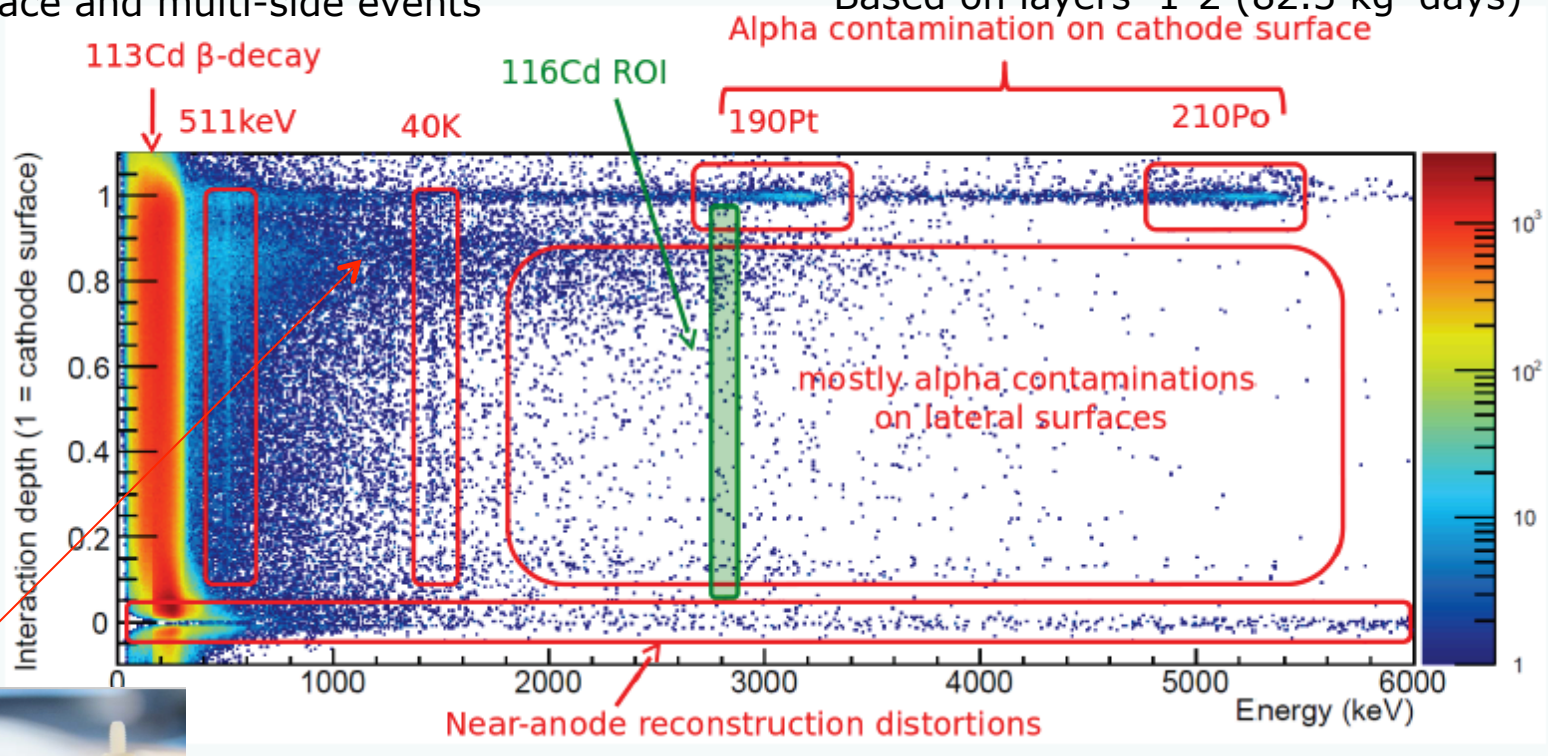
Currently reprocessing of all data taken in HdMo-building

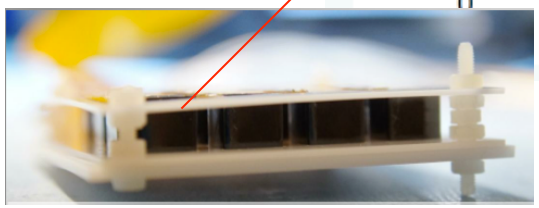
Should be done by end of the year

# Interaction depth vs. energy

Pulse shape allows to determine interation depth & identifying surface and multi-side events

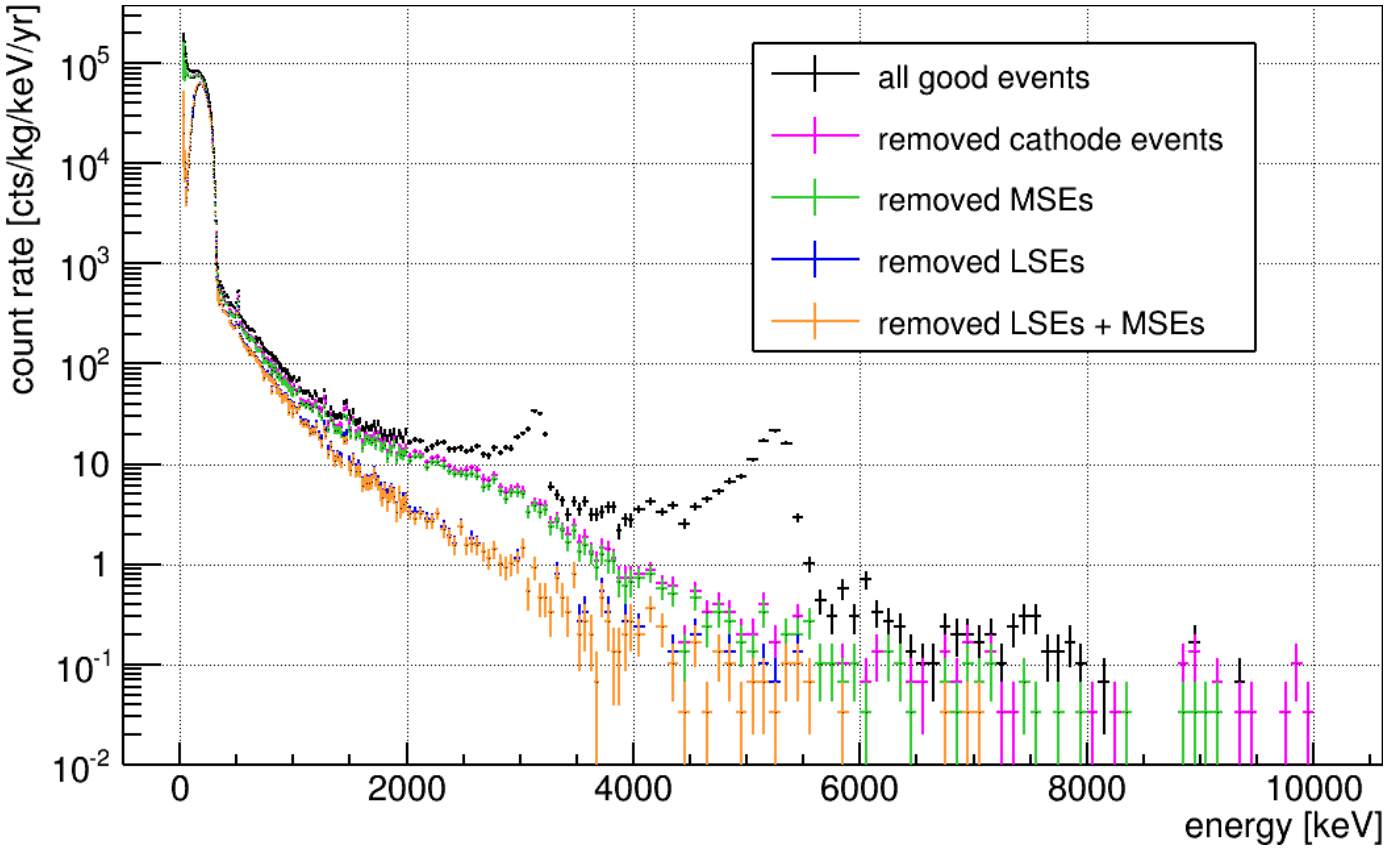
Based on layers 1-2 (82.3 kg*days)



Background in ROI is about 1 count/keV/kg/yr
Without z=0.8 region about 0.3 counts/keV/kg/yr

# LNGS spectrum (about 110 kg*days)




No multi detector cut applied yet

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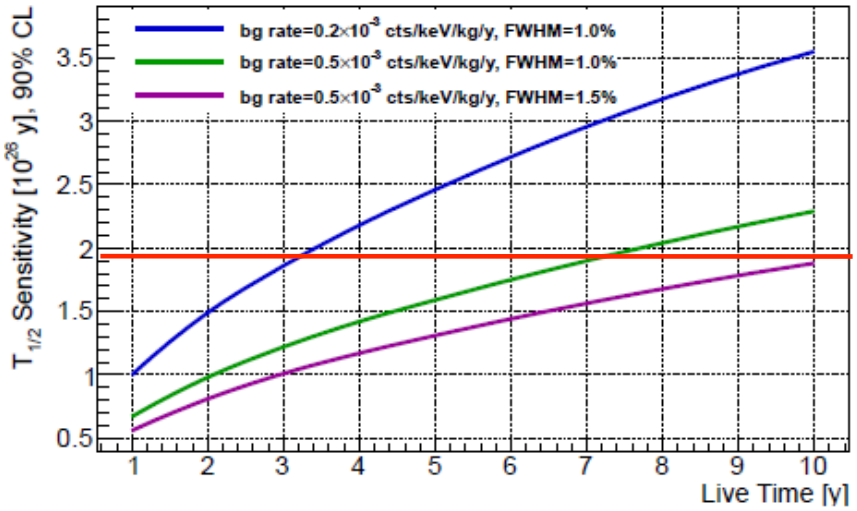
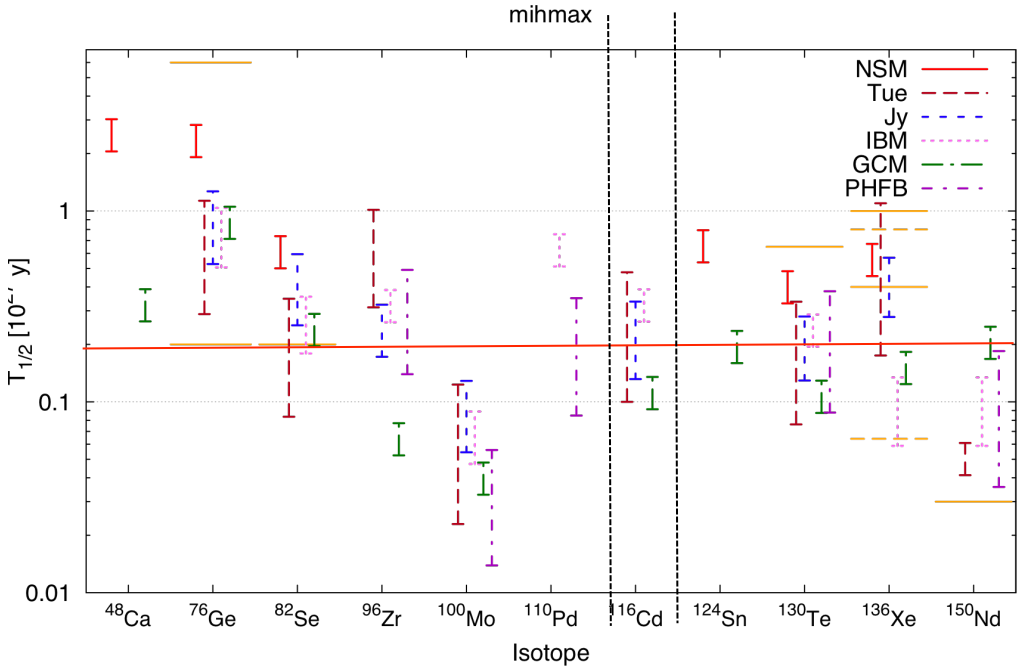
# KING COBRA – Touching the IH

## Minimum half-life to touch inverted hierarchy




A. Dueck, W. Rodejohann, K. Zuber,
arXiv:1103.4152, Phys. Rev. D 83,113010 (2011)



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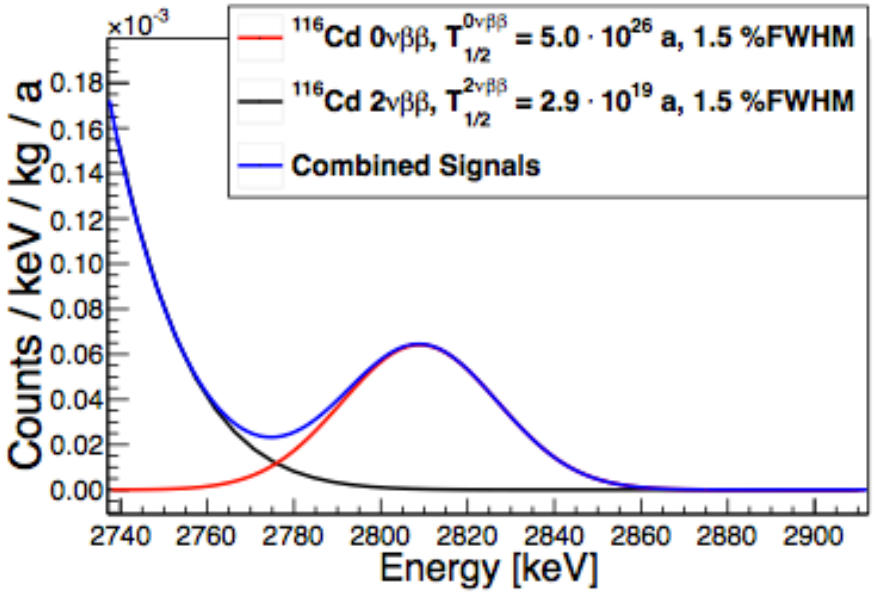
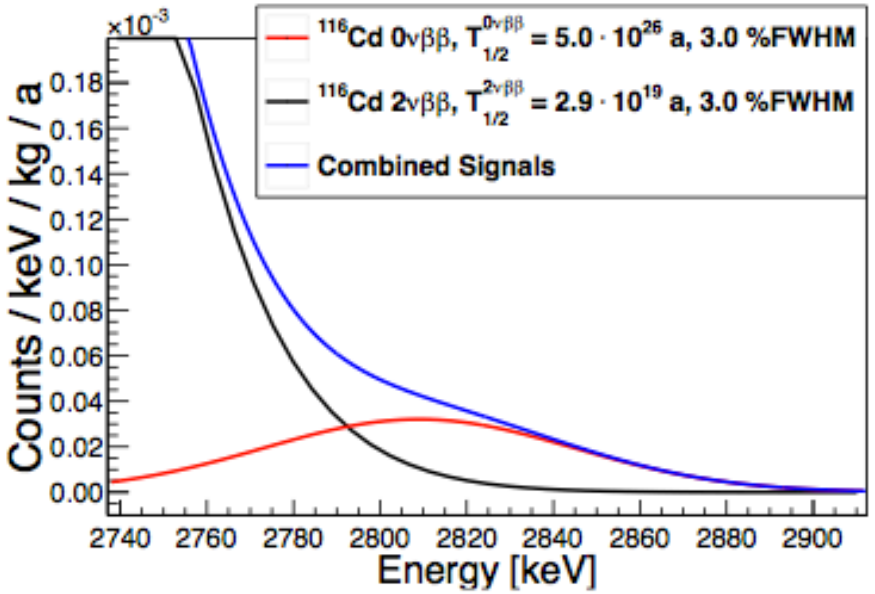
# Energy resolution




(a) 1.5 % relative energy resolution




(b) 3 % relative energy resolution

All LNGS detectors (low grade quality) have resolution less than 2% at 2.8 MeV

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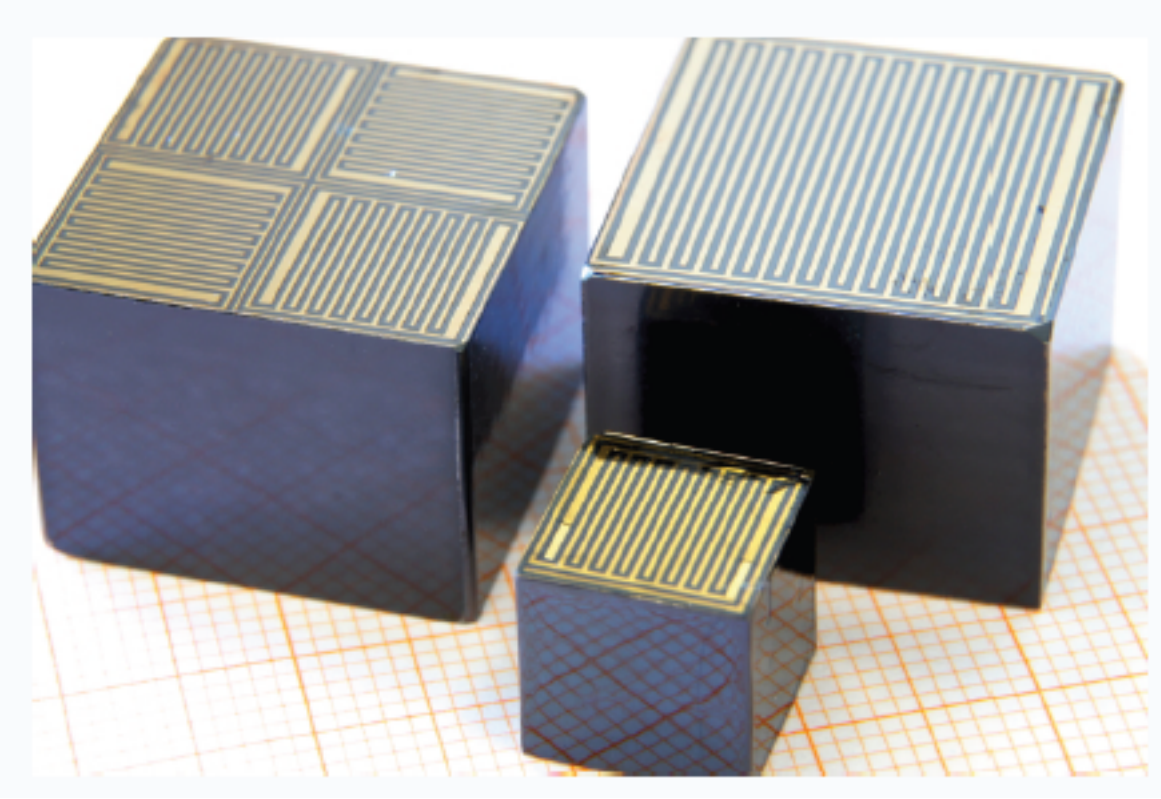
# King COBRA experiment

Amount of material tuned to touch IH, strong modular design

Changing to 6x larger detectors



K. Zuber

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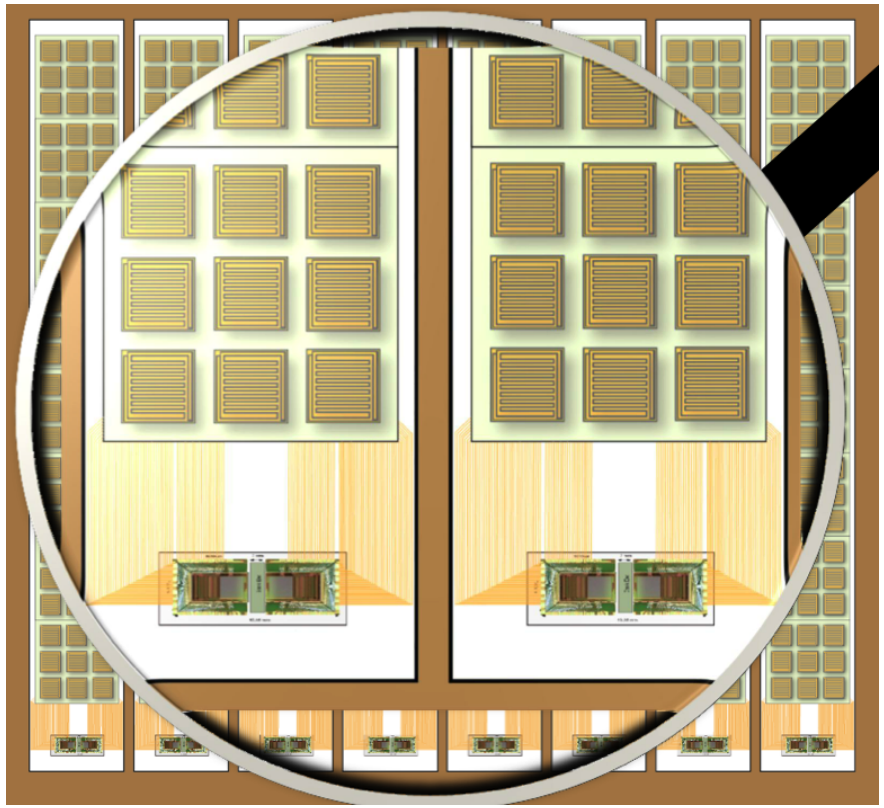
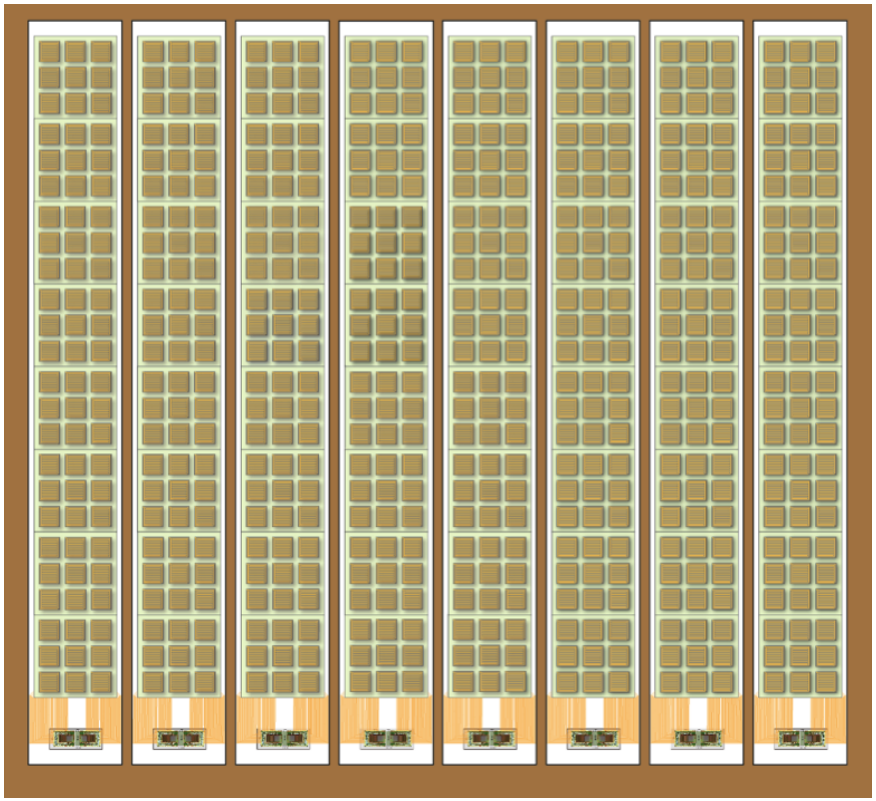
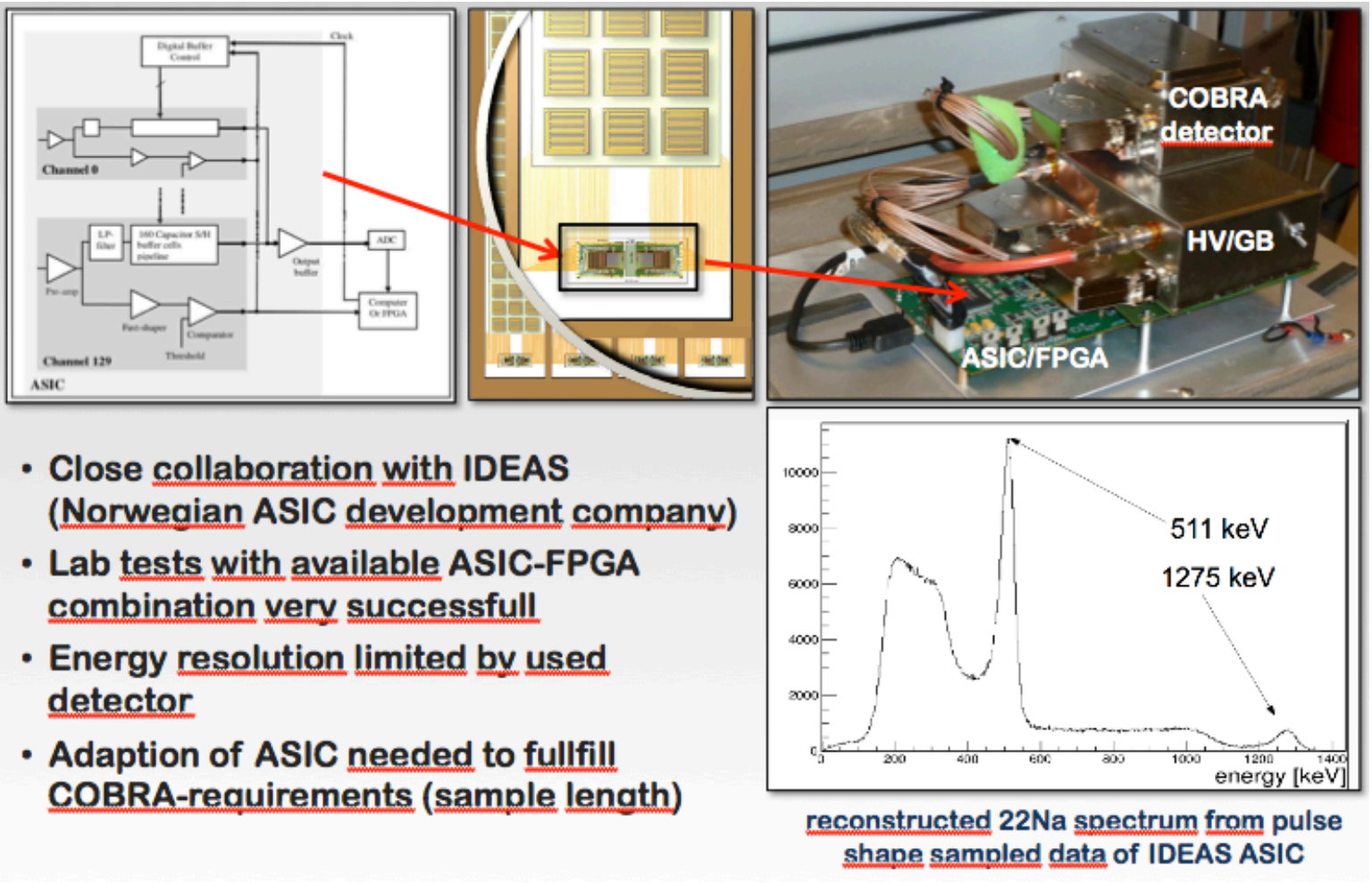
# King COBRA experiment

- strong modular design, easy scalable
- 3x3 detectors one module, 8 modules are 1 ladder, 8 ladders are 1 layer





# First ASIC tests




- Close collaboration with IDEAS (Norwegian ASIC development company)
- Lab tests with available ASIC-FPGA combination very successfull
- Energy resolution limited by used detector
- Adaption of ASIC needed to fullfill COBRA-requirements (sample length)

reconstructed 22Na spectrum from pulse shape sampled data of IDEAS ASIC

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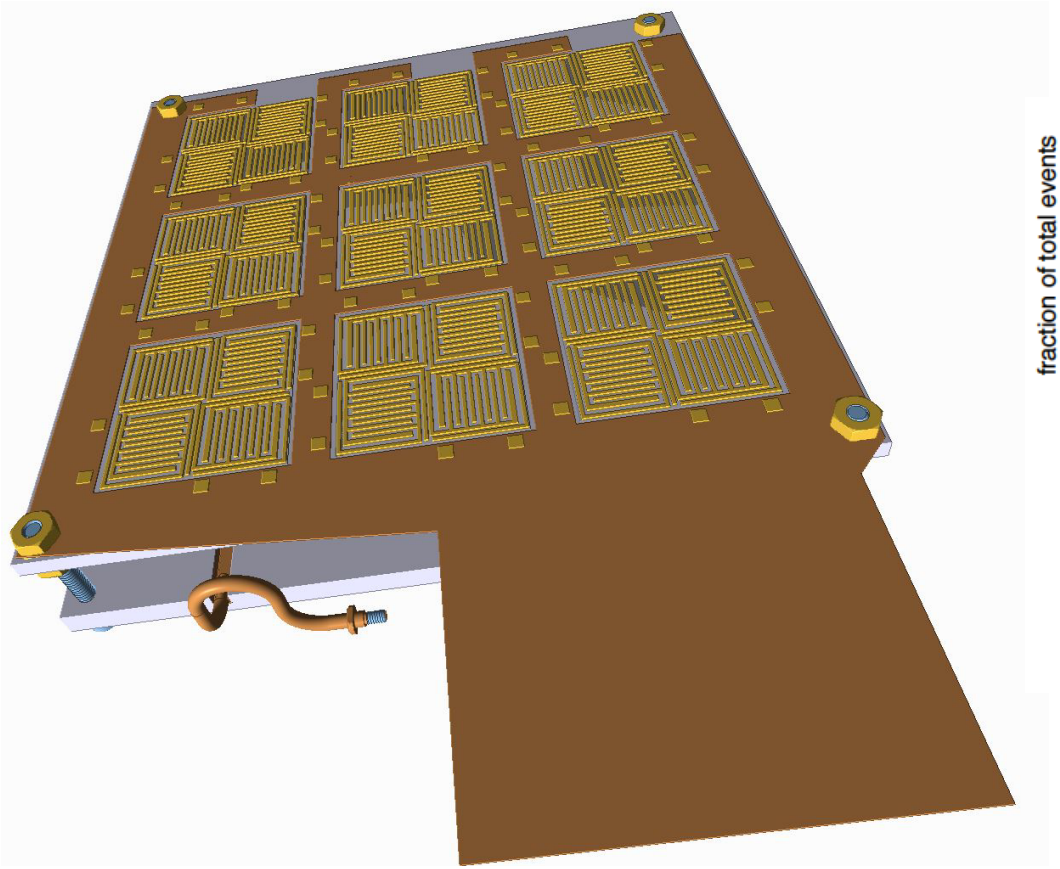
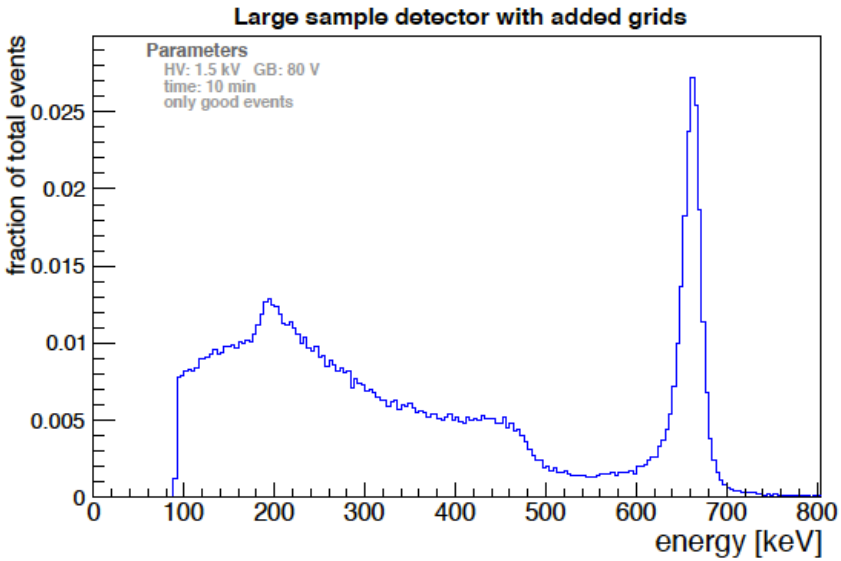
# First spectrum of Quad-CPG and full MC

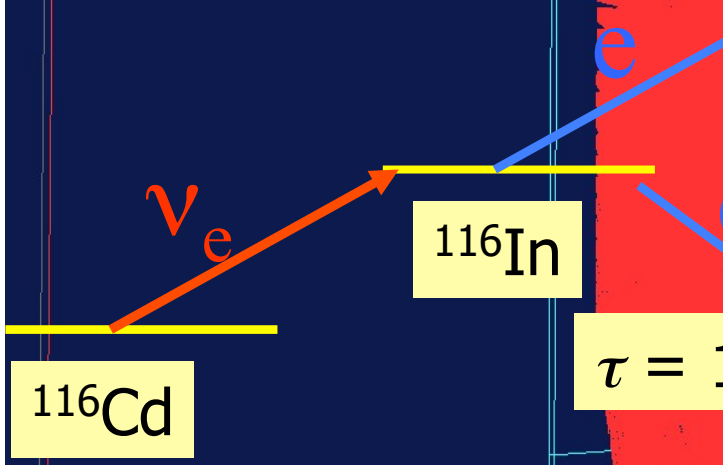


Cs-137



# A REAL large scale experiment

A real time low-energy solar neutrino and Supernova experiment?




Threshold energy: 464 keV

$^{7}$Be contribution g.s. alone: 227 SNU

K. Zuber, Phys. Lett. B 571,148 (2003)

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# Supernova detection

NC interactions:

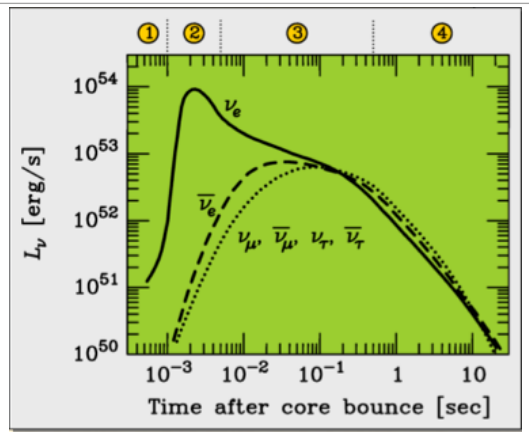
$$\nu_l + {}^{116}\mathrm{Cd} \rightarrow {}^{116}\mathrm{Cd}^* + \nu_l',$$

$$\bar{\nu}_l + {}^{116}\mathrm{Cd} \rightarrow {}^{116}\mathrm{Cd}^* + \bar{\nu}_l',$$

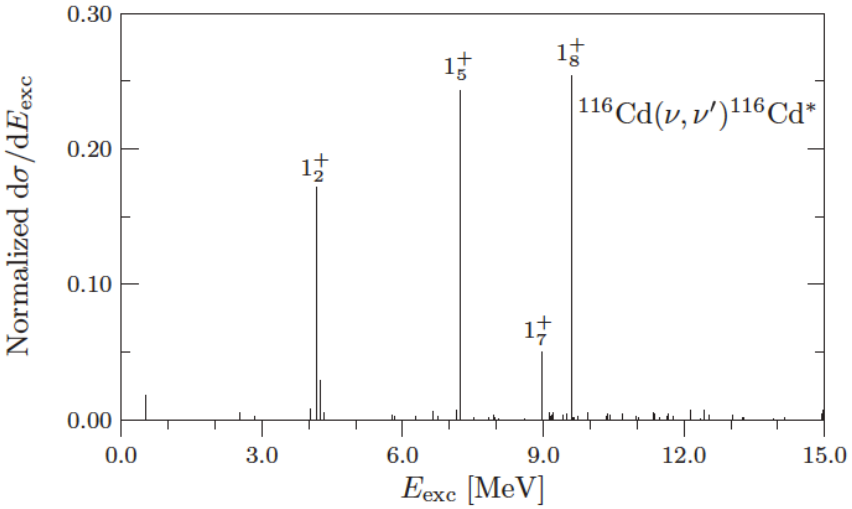
CC interactions:

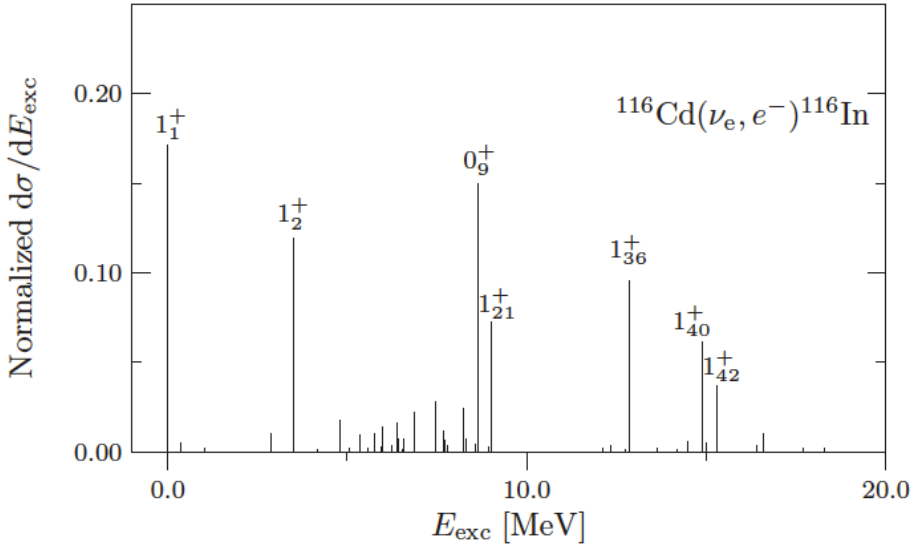
$$\nu_l + {}^{116}\mathrm{Cd} \rightarrow {}^{116}\mathrm{In} + l^-,$$

$$\bar{\nu}_l + {}^{116}\mathrm{Cd} \rightarrow {}^{116}\mathrm{Ag} + l^+$$




W. Almosly, E. Ydrefors, J. Suhonen, JPG 40,095201 (2013)



# Summary

- COBRA is a room-temperature DBD experiment using CdZnTe to search for Cd-116 decay
- The installation of 64 1 $cm^3$ detectors was finalised Nov. 2013
- A major upgrade on almost all parts of the experiment was performed
- Data taking is now running with higher stability and efficiency, about 0.7 kg*yrs accumulated
- Pulse shape analysis was developed for CPG detectors
- Background level achieved at 2.8 MeV is less than 1 count/keV/kg/yr
- Currently reprocessing of all data is performed, should be done soon
- Focus in the near future will now be more on physics and background studies