Search for explosive mines

political problems in our community?

extremely exciting physics questions?

.... or what?

Mine detection with γ backscattering

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GSI

presented at

ECT workshop

γ-ray spectroscopy in Europe

8-12 May 2006, Trento

- The land mine problem .....
- Backscatter Imaging .....
- Mine verification .....

Detection of Land Mines

10^8 Land mines layed worldwide!

10^6 additional one‘s per year!

Only 10^5 mines are removed per year!

Main detection techniques:

– Metal detector

– Search needles

No other technique is really estabished!

→ New Approach: **Backscatter Imaging**

Task: Find the mine!!!

ATM

Size: ∅ = 15…30 cm, d = 6…10 cm

Depth: D = 0…30 cm

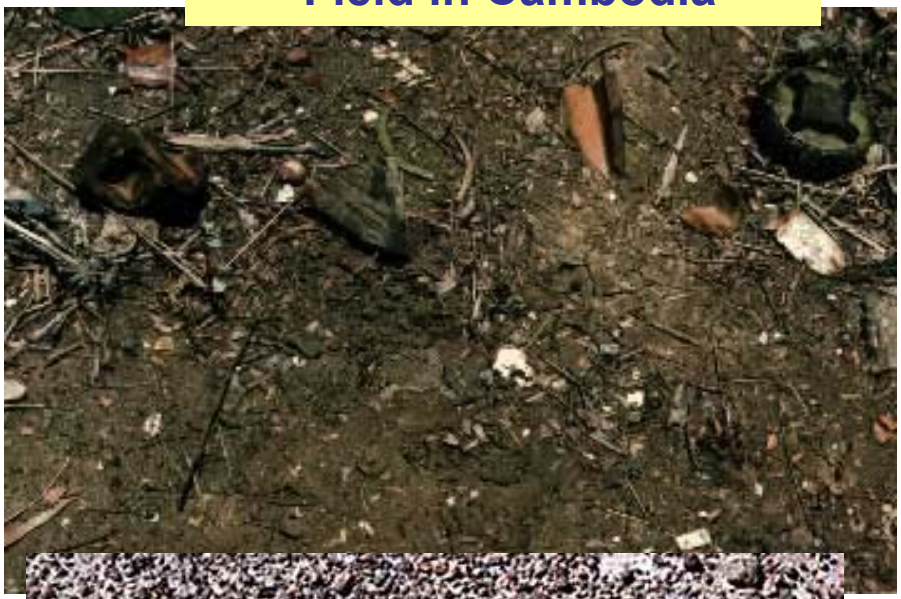
APM

Size: ∅ = 8…12 cm, d = 4…6 cm

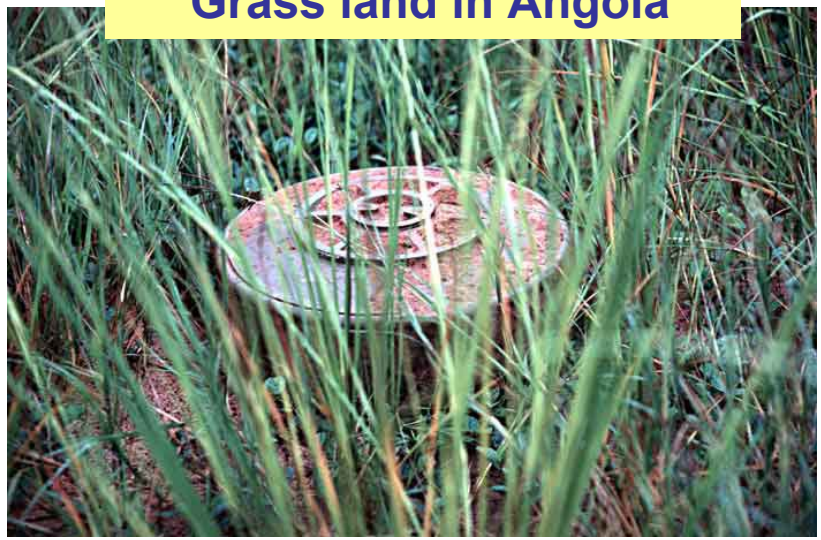
Depth: D = 0…10 cm

Mines can be everywhere

Field in Cambodia



Grass land in Angola



Gravel in Angola

Field in Cambodia

Mines can be everywhere…

Every 22 minutes somebody is injured or killed by a land mine!!!

Searching and preparing for de-mining

Metal detector false alarm rate: 1000/1

Mine prodding in practice

A de-miner can clear 2 m^2 of land per day

An APM costs 3$

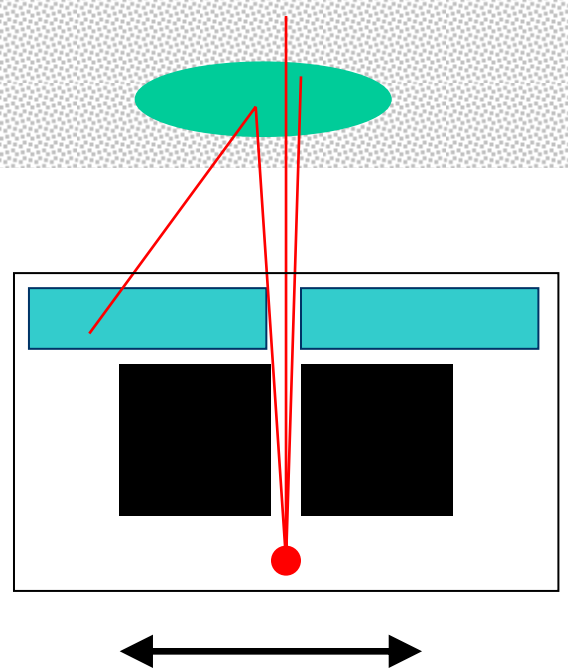
To remove it costs 300$ to 1000$

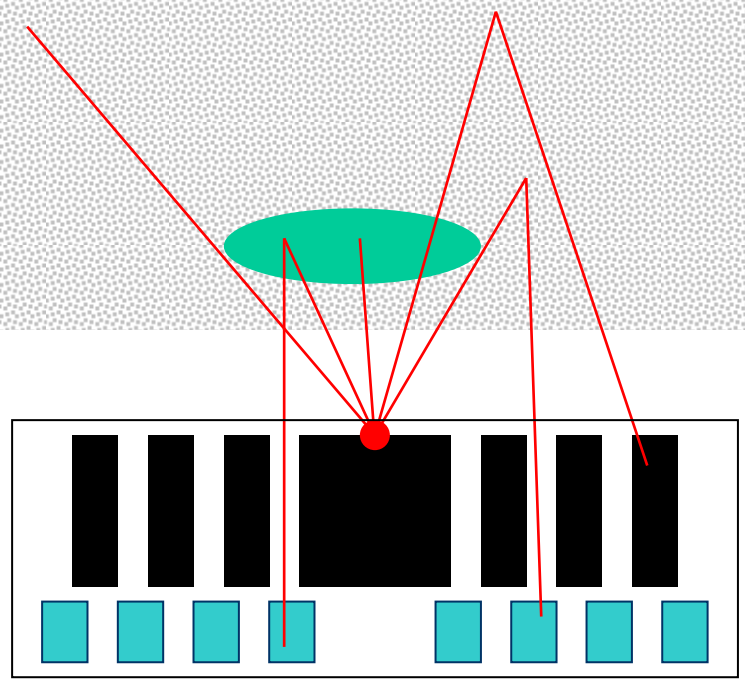
Conventional Backscatter Imaging

How to image an object being accessible from one side only?

Land mines in soil; Internal corrosion; …..

γ backscatter techniques …

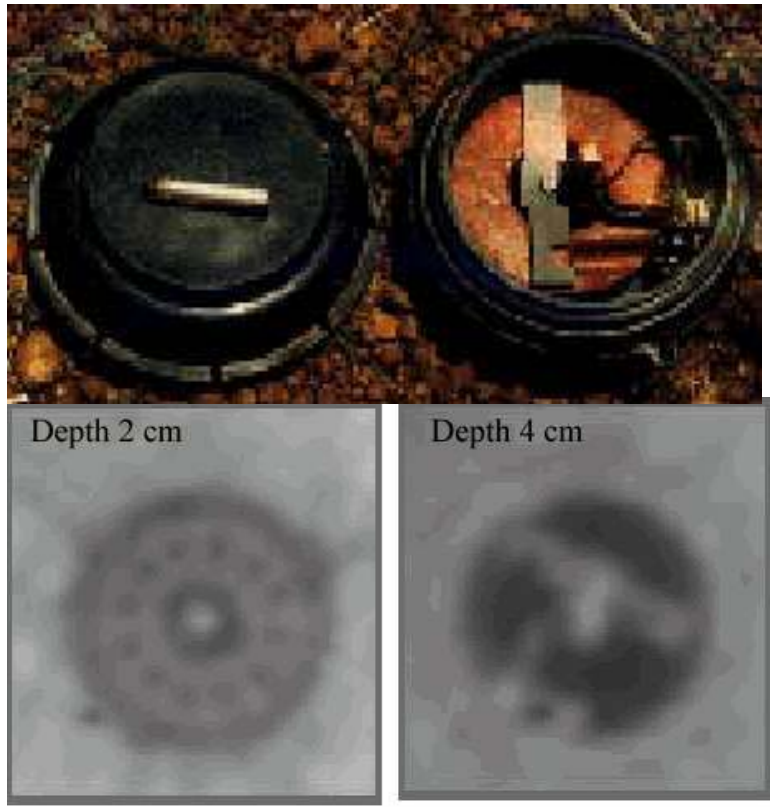




… but strong sources, heavy shielding

High power X-ray Imaging

APM: PPM2, 12cm ∅

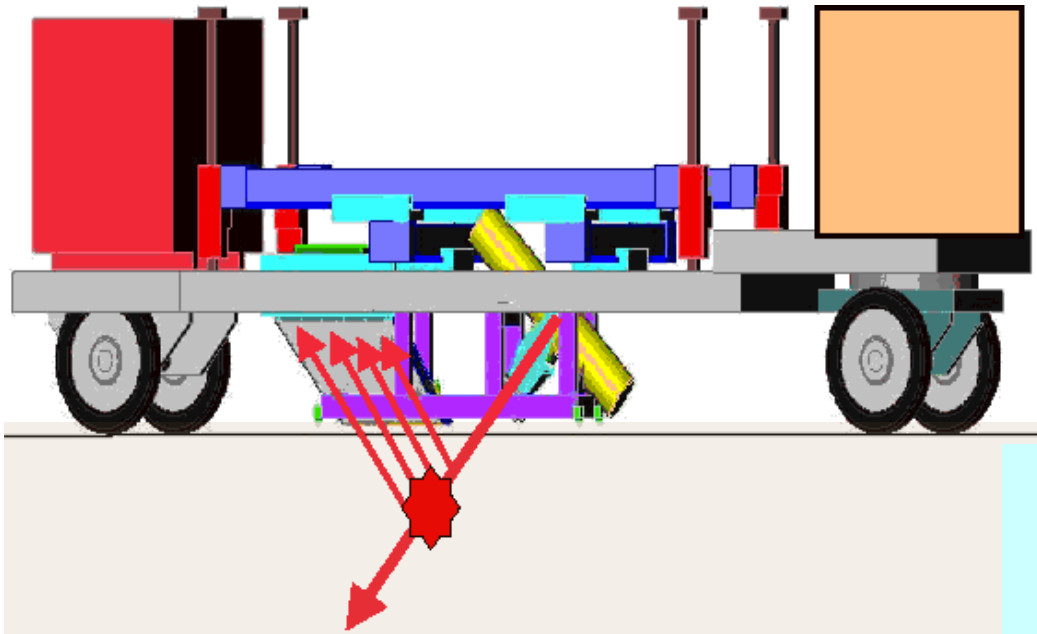


ComScan 450

YXLON, Hamburg

450 kV high flux x-ray tube

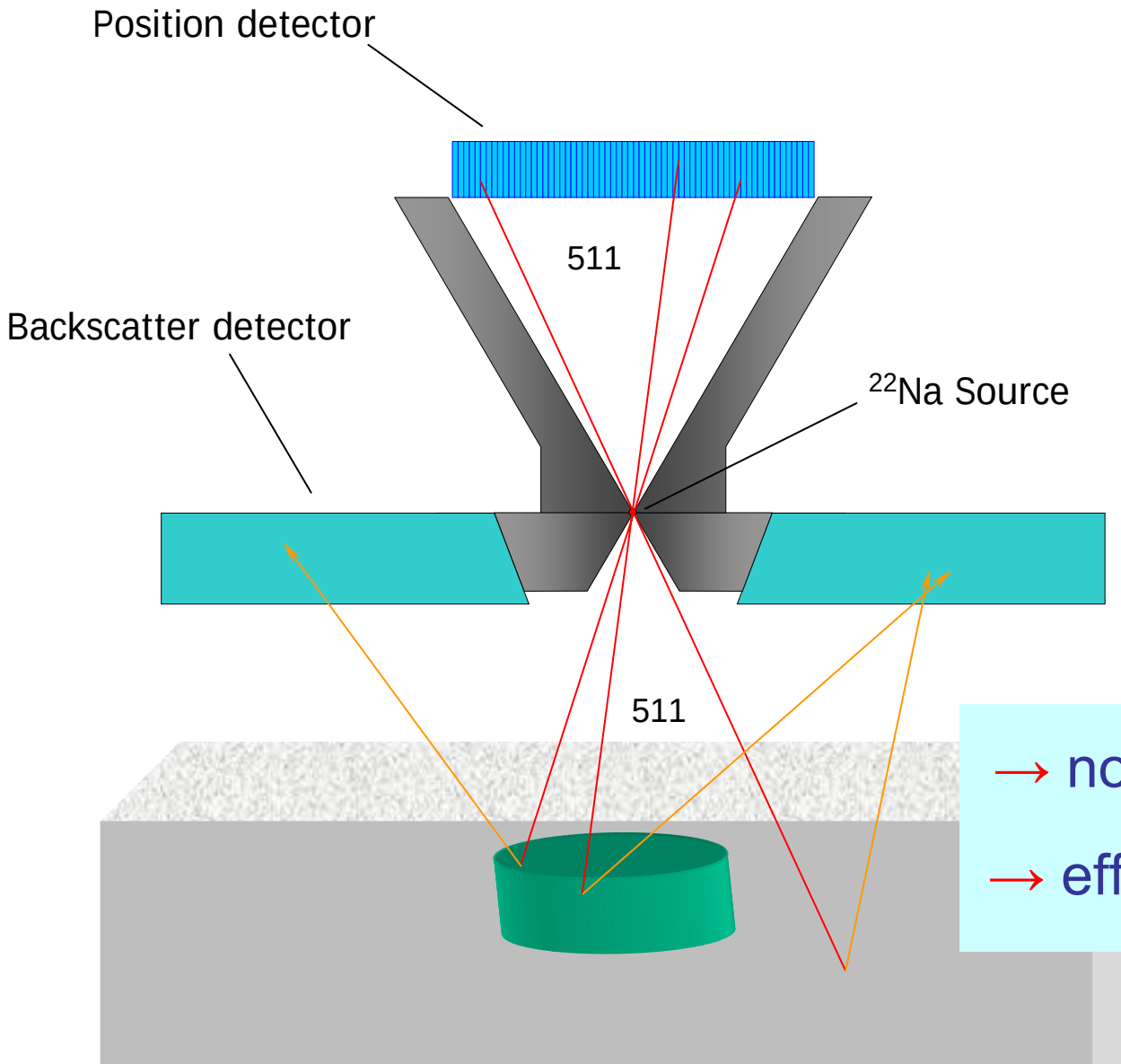
pixelated x-ray detector



→ Heavy power generator

→ Truck required

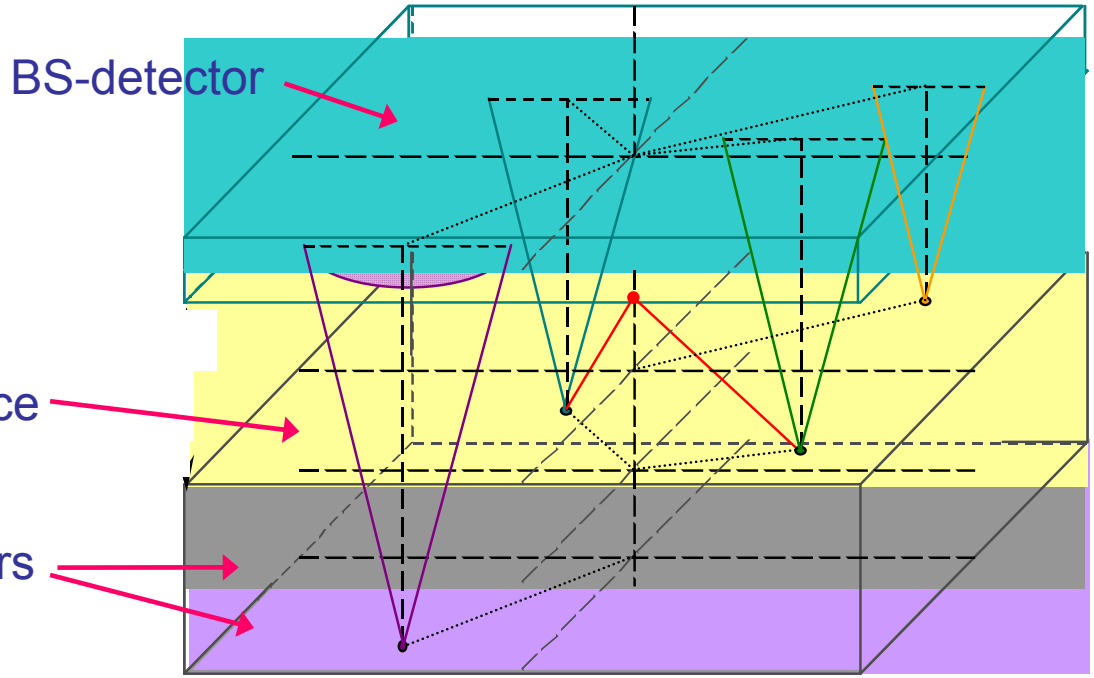
Backscatter Imaging with Positron Annihilation Radiation

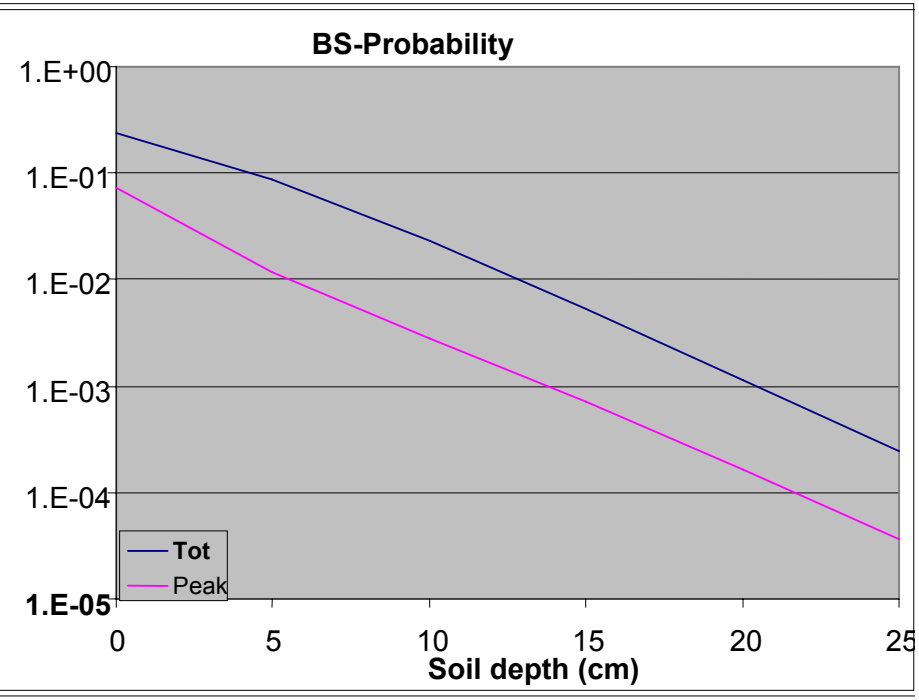


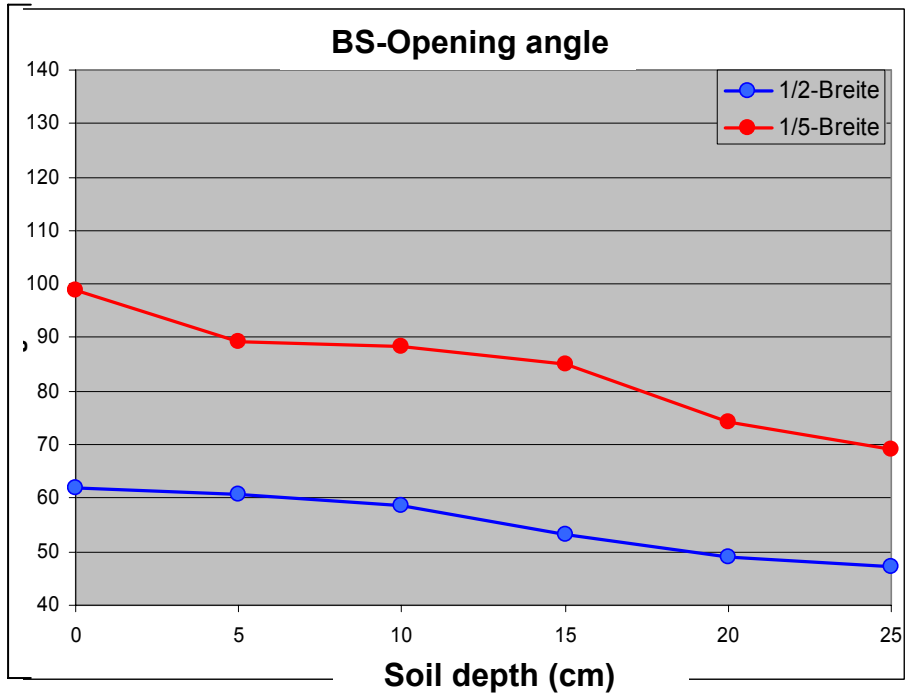
→ no BS-collimator

→ efficient use of source

Backscattering of γ-rays in earth

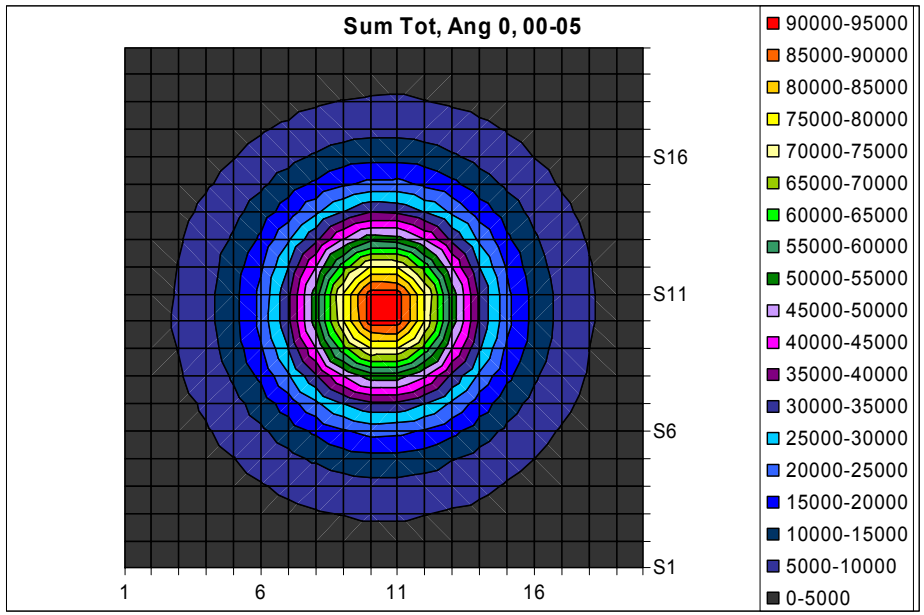


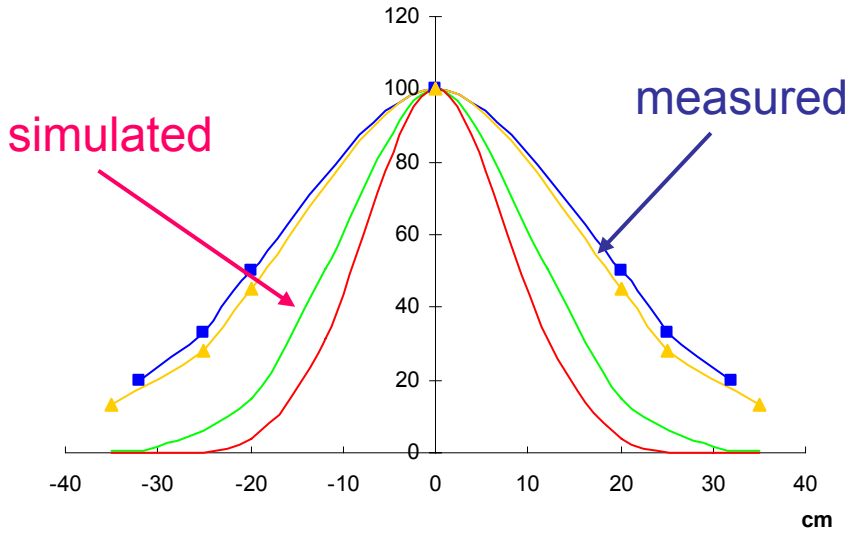




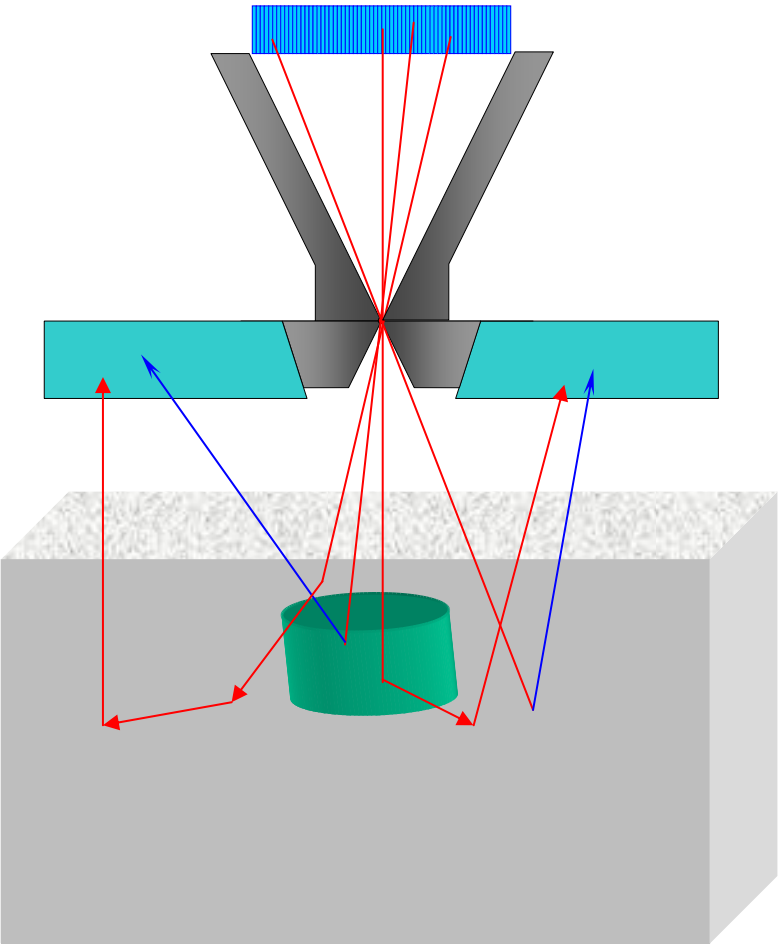
Backscatter intensity distribution

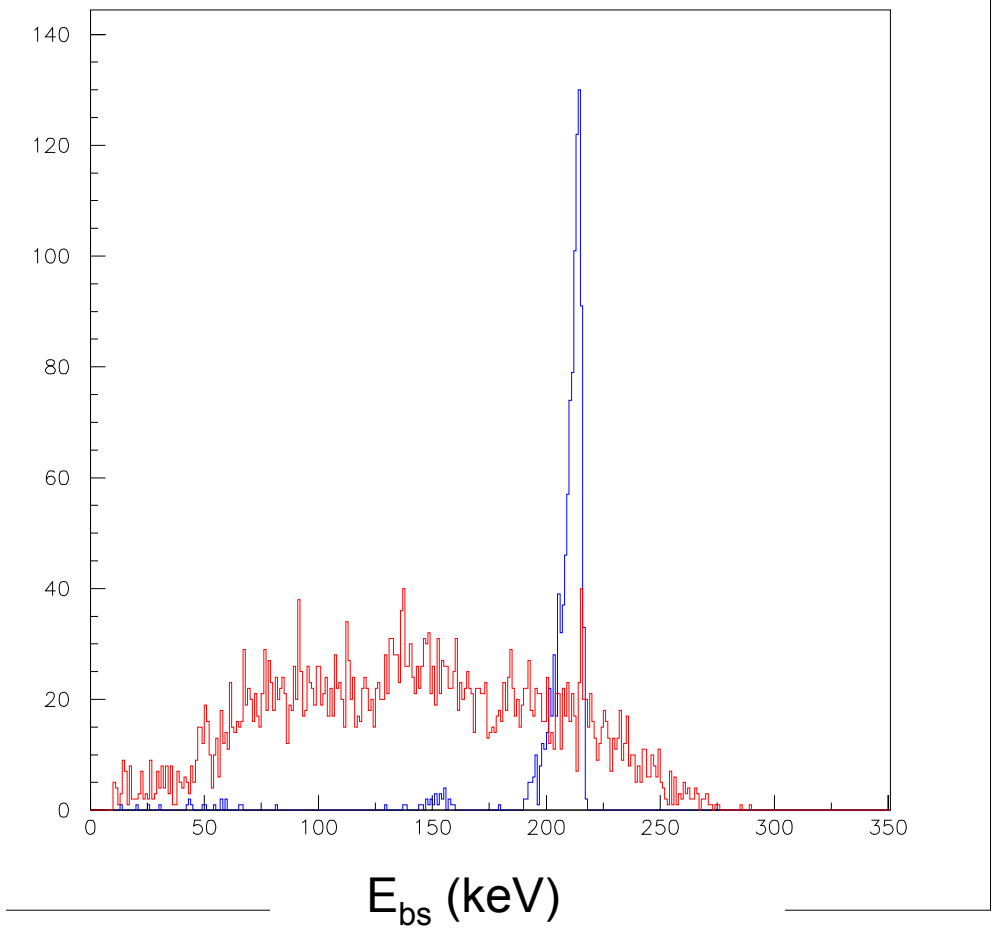
Depth: 0…5 cm



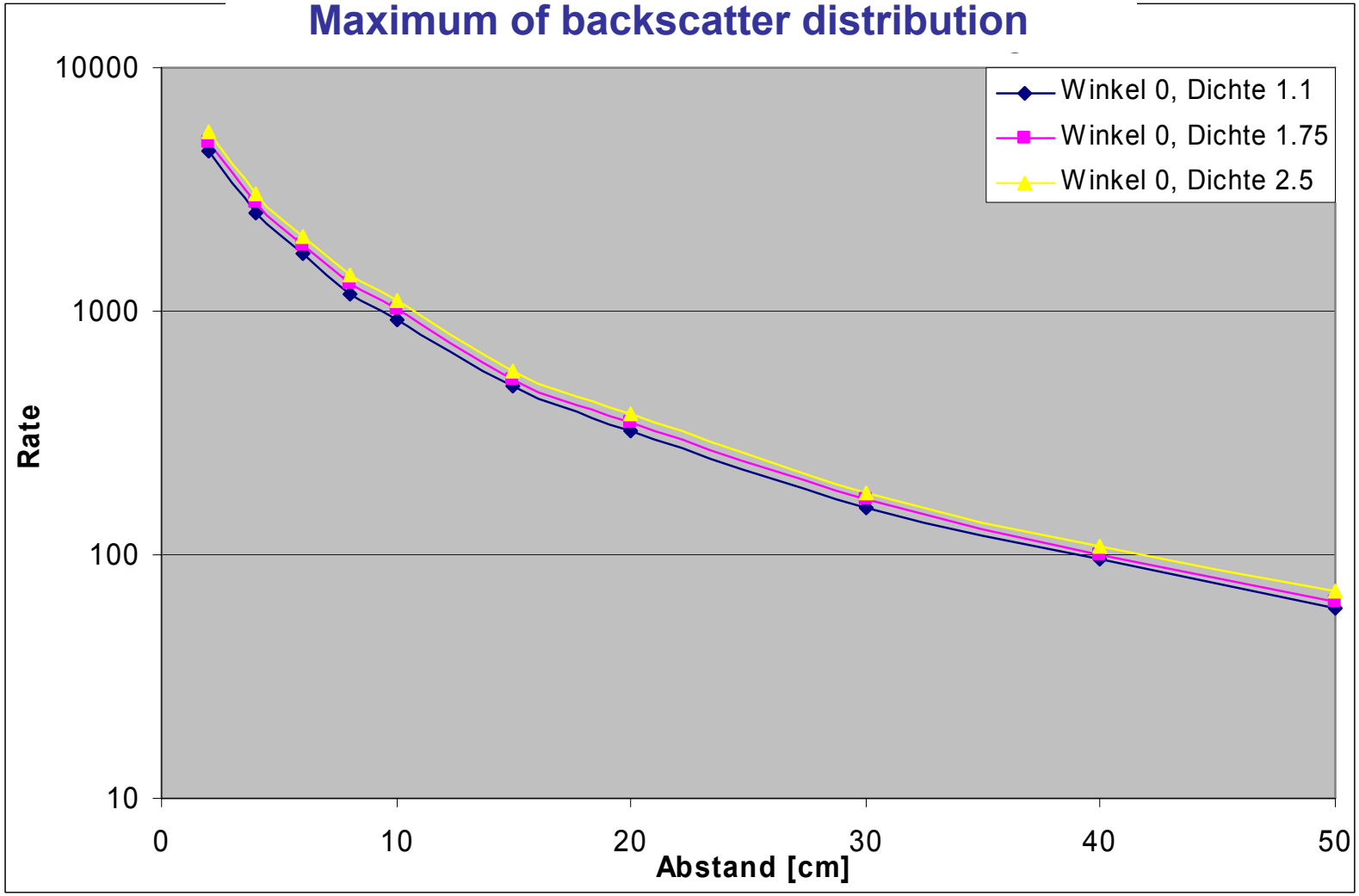


Single vs. multiple scattering





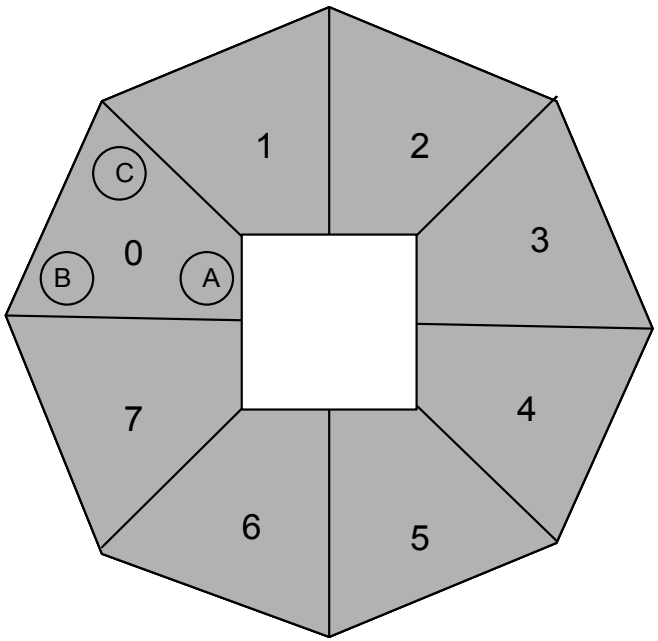
Distance determination



BS-Detector array

Eight NaI(Tl) detectors

Thickness:	16 mm
Array diameter:	≈ 50 cm
Light read-out:	3 PMT



→ BS-efficiency: > 80%

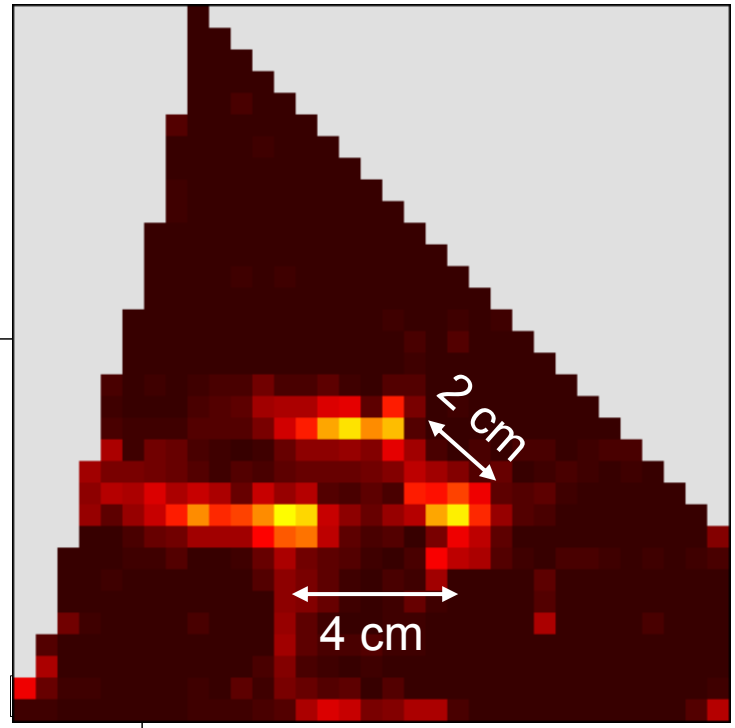
→ Position resolution: ≈ 2 cm

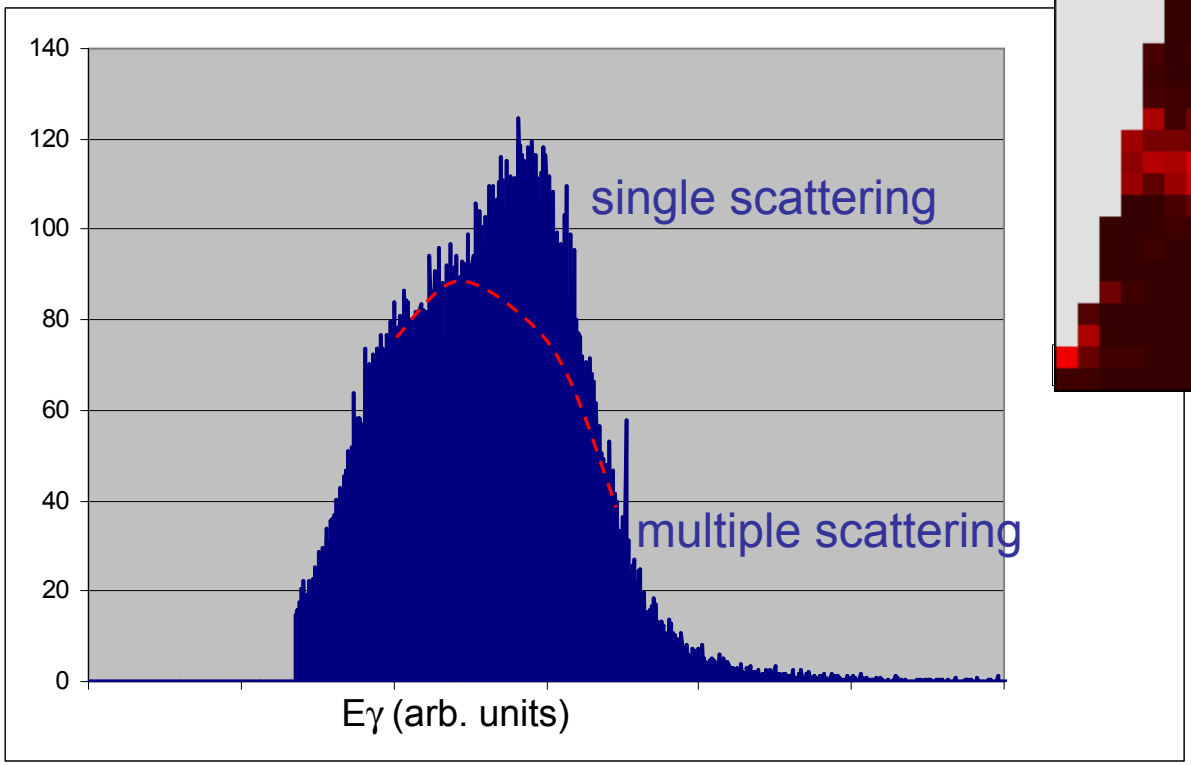
(light division)

BS detector energy and position resolution

Energy resolution : ≈10% at 200 keV

Position resolution: ≈ 2 cm





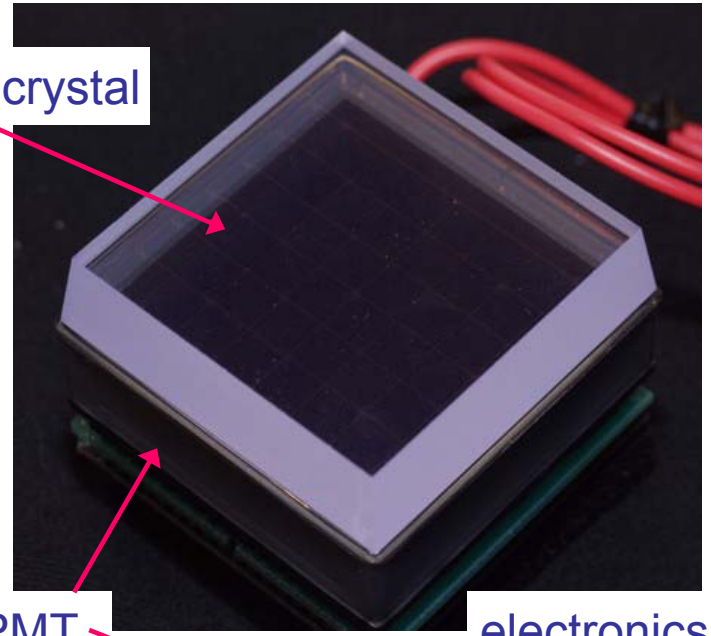
Position-Detector array

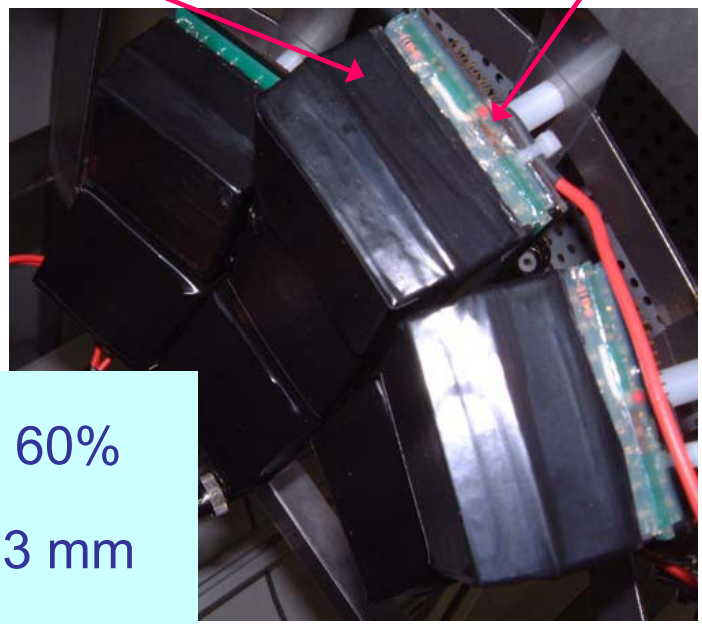
Nine LYSO detectors

Thickness: 18 mm

Size: 50 x 50 mm^2

Light read-out: 8x8 anode PMT



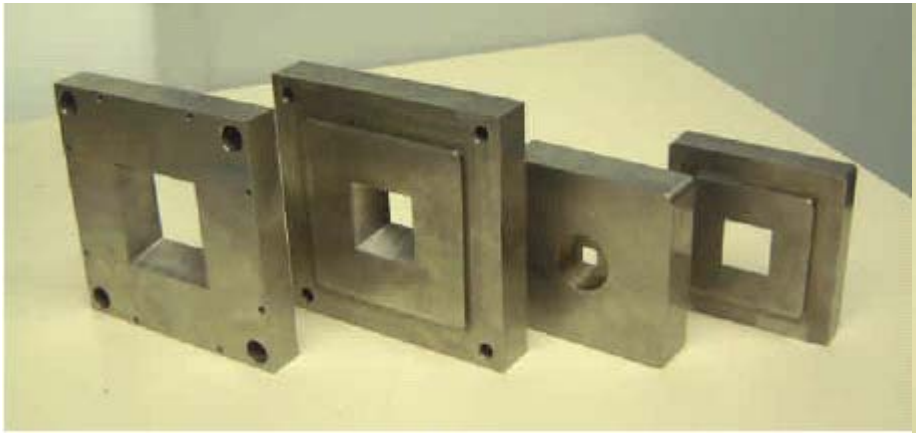


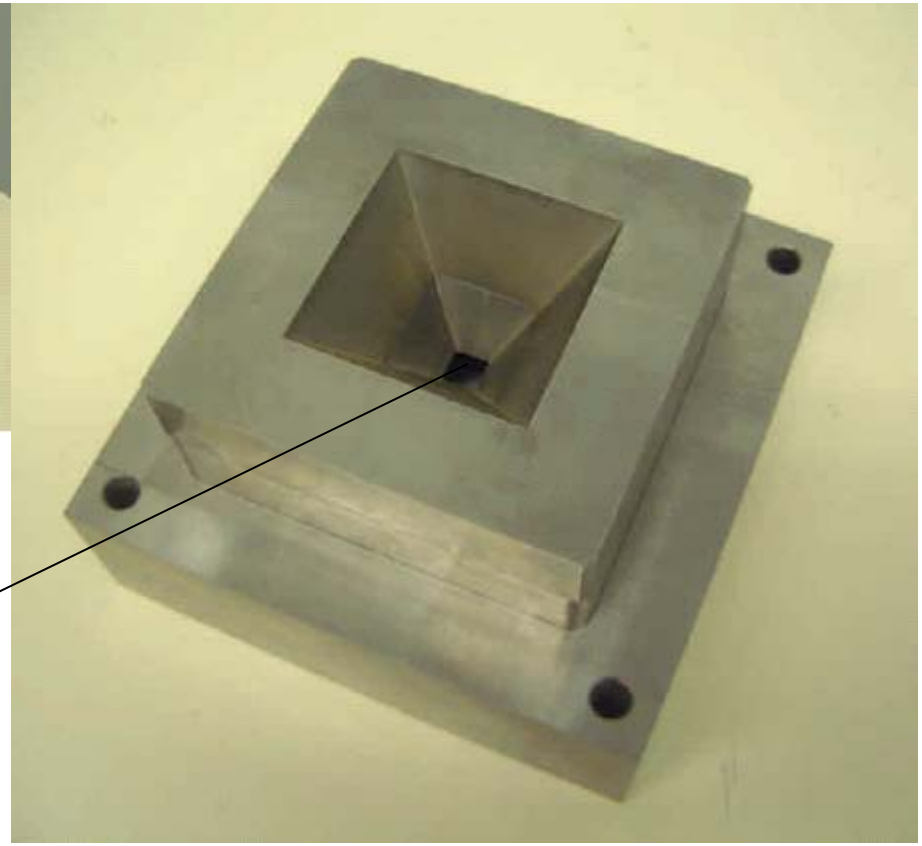
→ 511 keV Efficiency: > 60%

→ Position resolution: ≈ 3 mm

(light division)

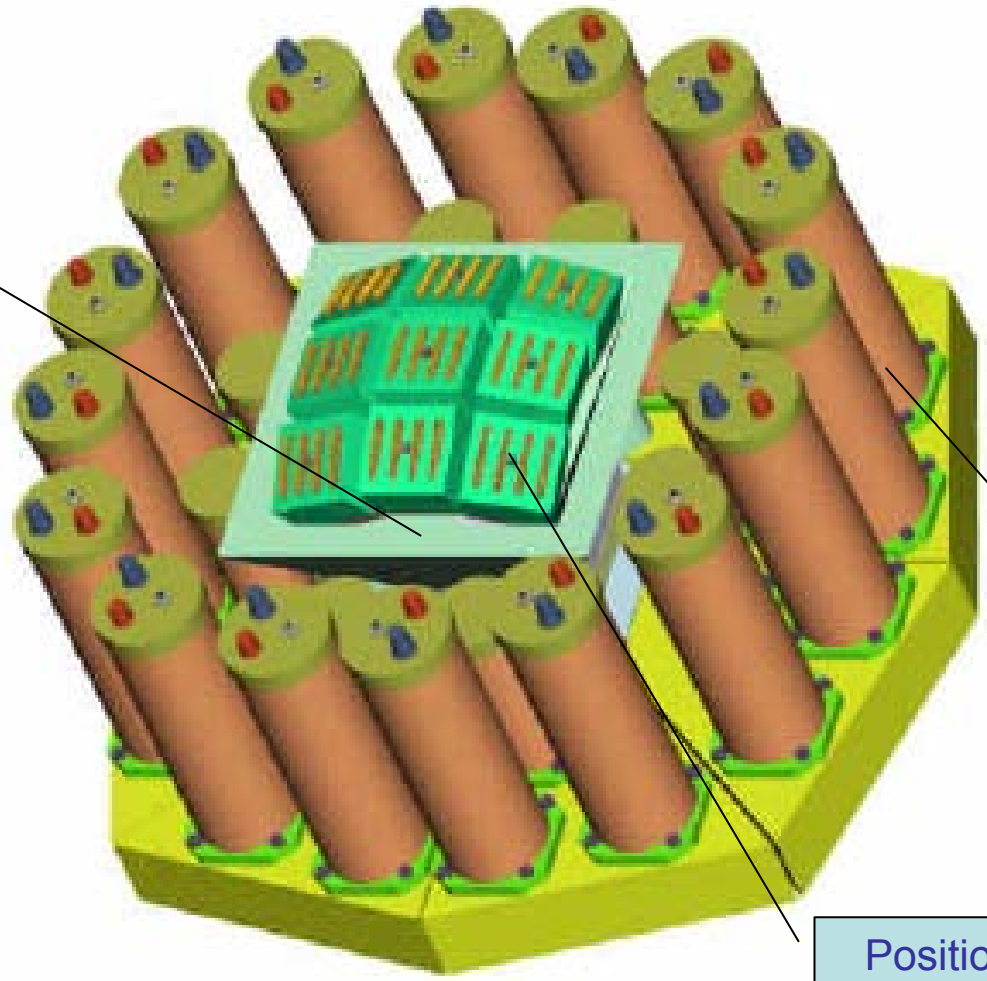
Densimet source collimator





22Na source
10 MBq

Detector arrangement



Shielding of the ^{22}Na source

Backscatter detector

Position detector

EDAQ requirements

Position detector

9 x 4 position signals, total rate ≈ 5 MHz

9 x 1 E, t signals

Backscatter detector

8 x 3 position signals, total rate ≈ 500 kHz

8 x 1 t signals

Trigger

Scaled down singles (position) ≈ 500 kHz

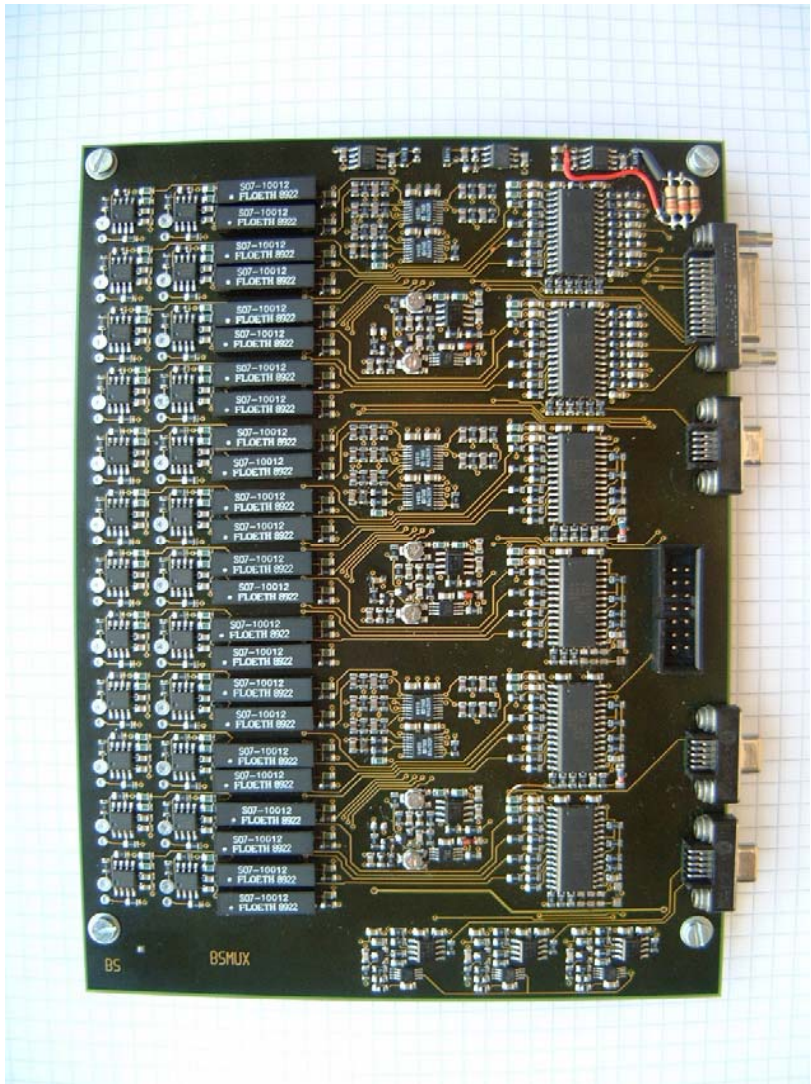
Pos-BS coincidences ≈ 150 kHz

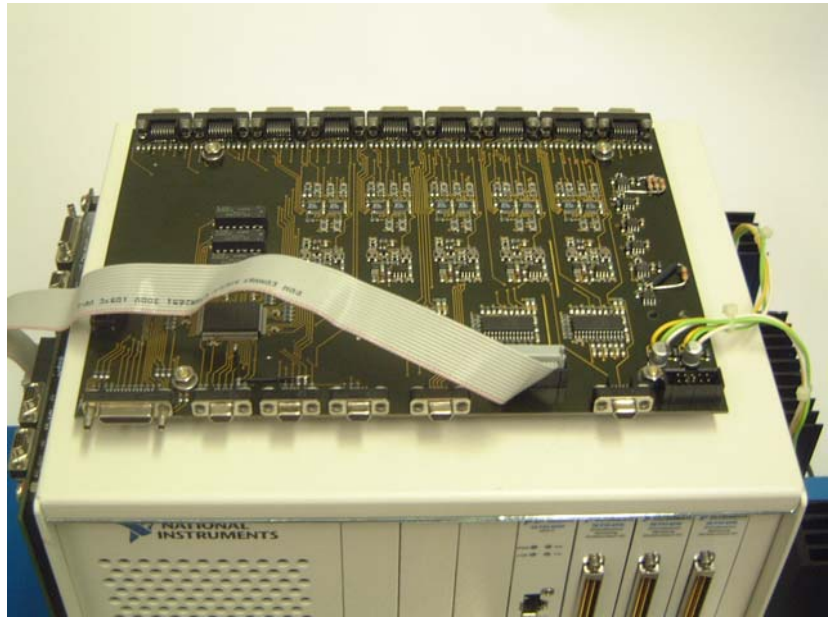
→ dedicated front-end electronics

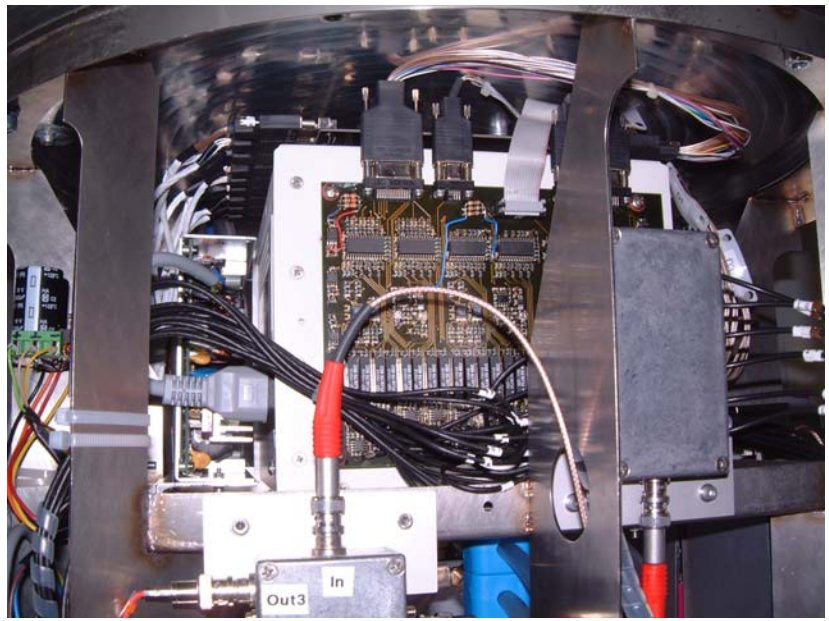
→ fast PCI A/D cards *(NI-6115)*

12 bit, 200ns cycle time

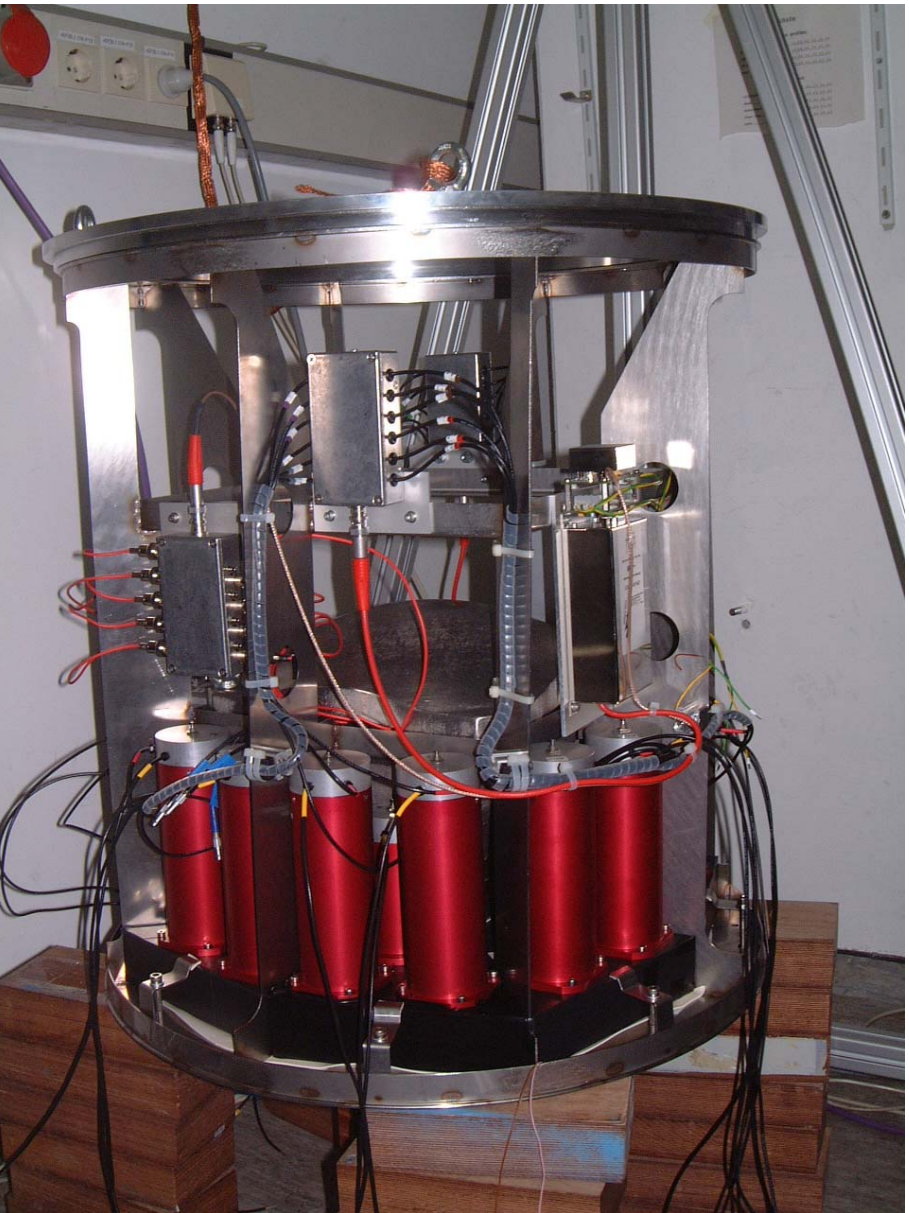
Electronics hardware







Mine-Verificator (prototype)



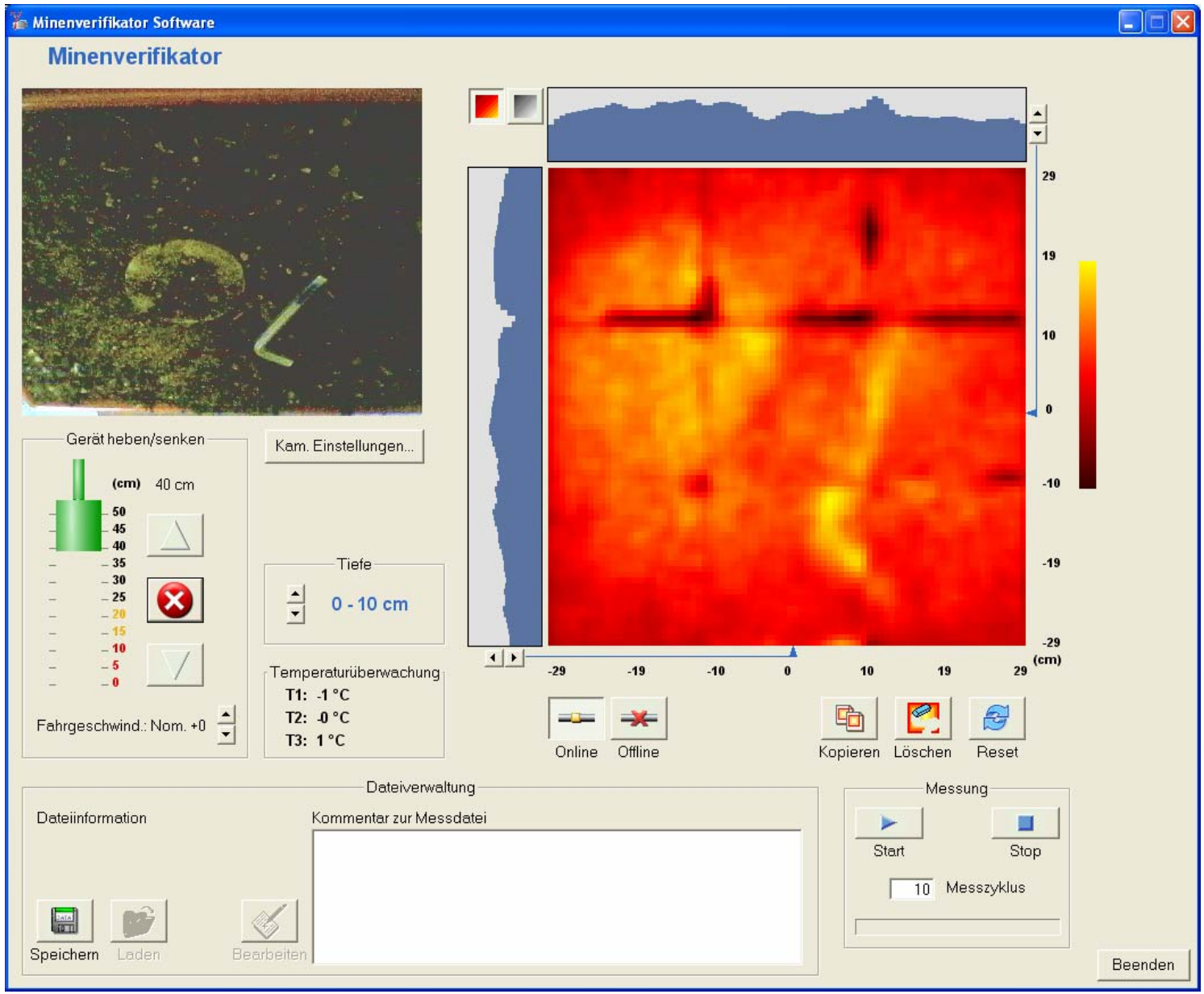
γ-source: 10 MBq ^{22}Na

field of view: ≥ 20x20 cm^2

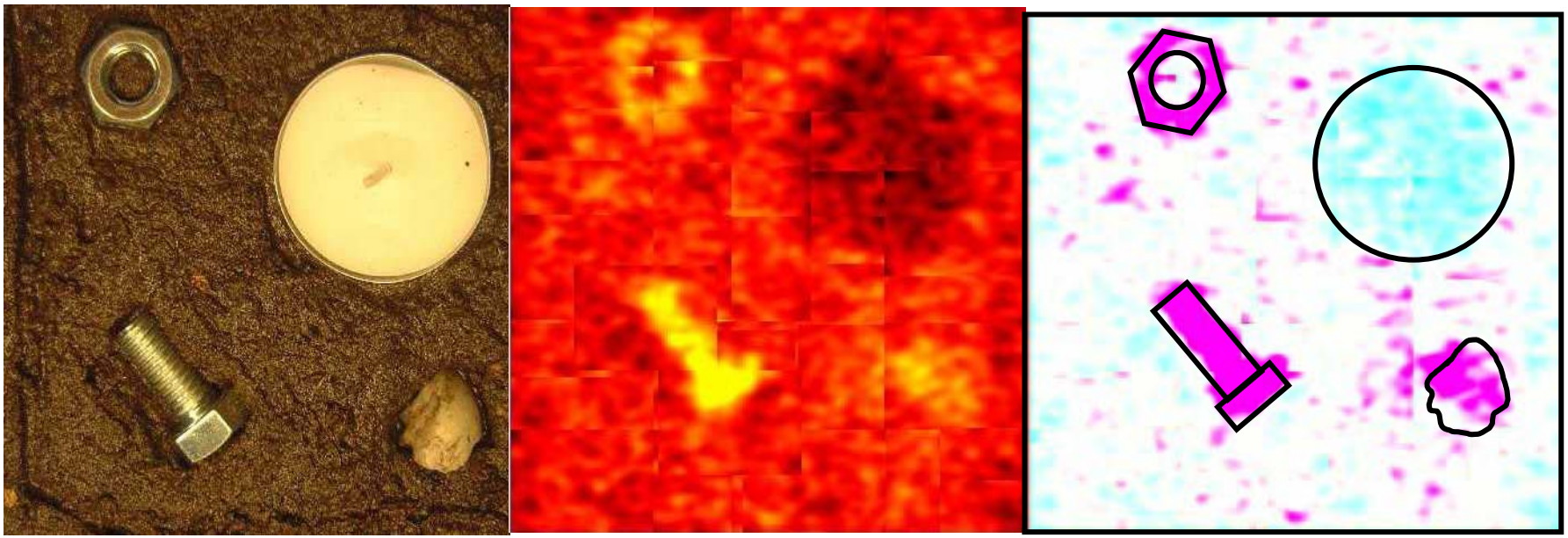
max. penetration: 30 cm

eff. resolution: 60x60 pixels

User Interface



First results

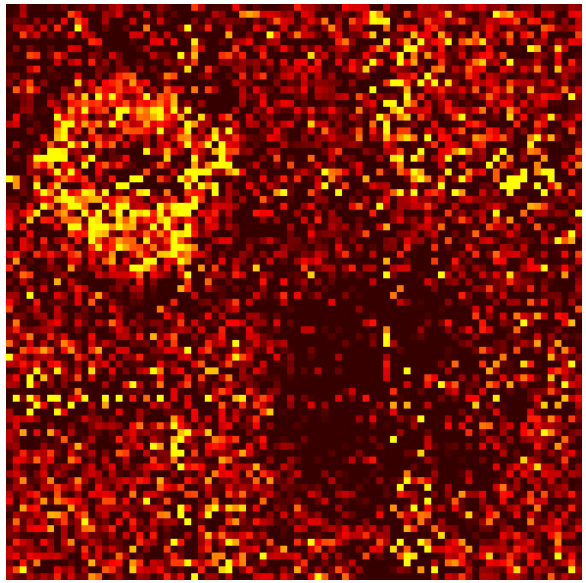


Verification by

→ Shape

→ Density

Another example



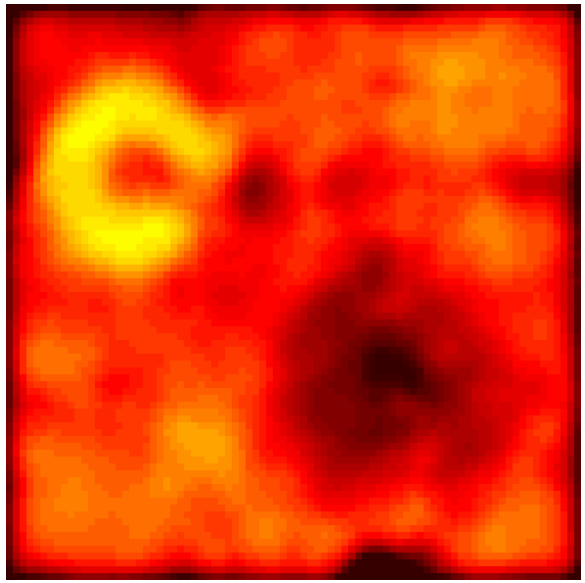
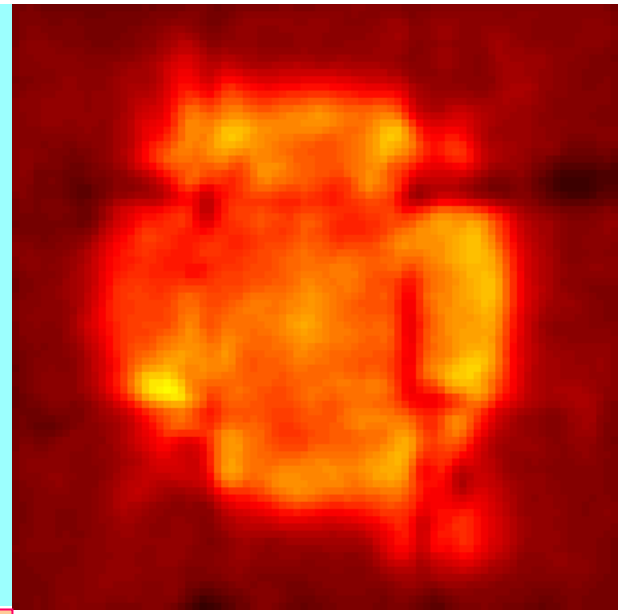


Image of a standard land mine



PPM-2

Thickness: 5 cm

Diameter: ≈ 11 cm

Load: 110 g TNT

Image processing method

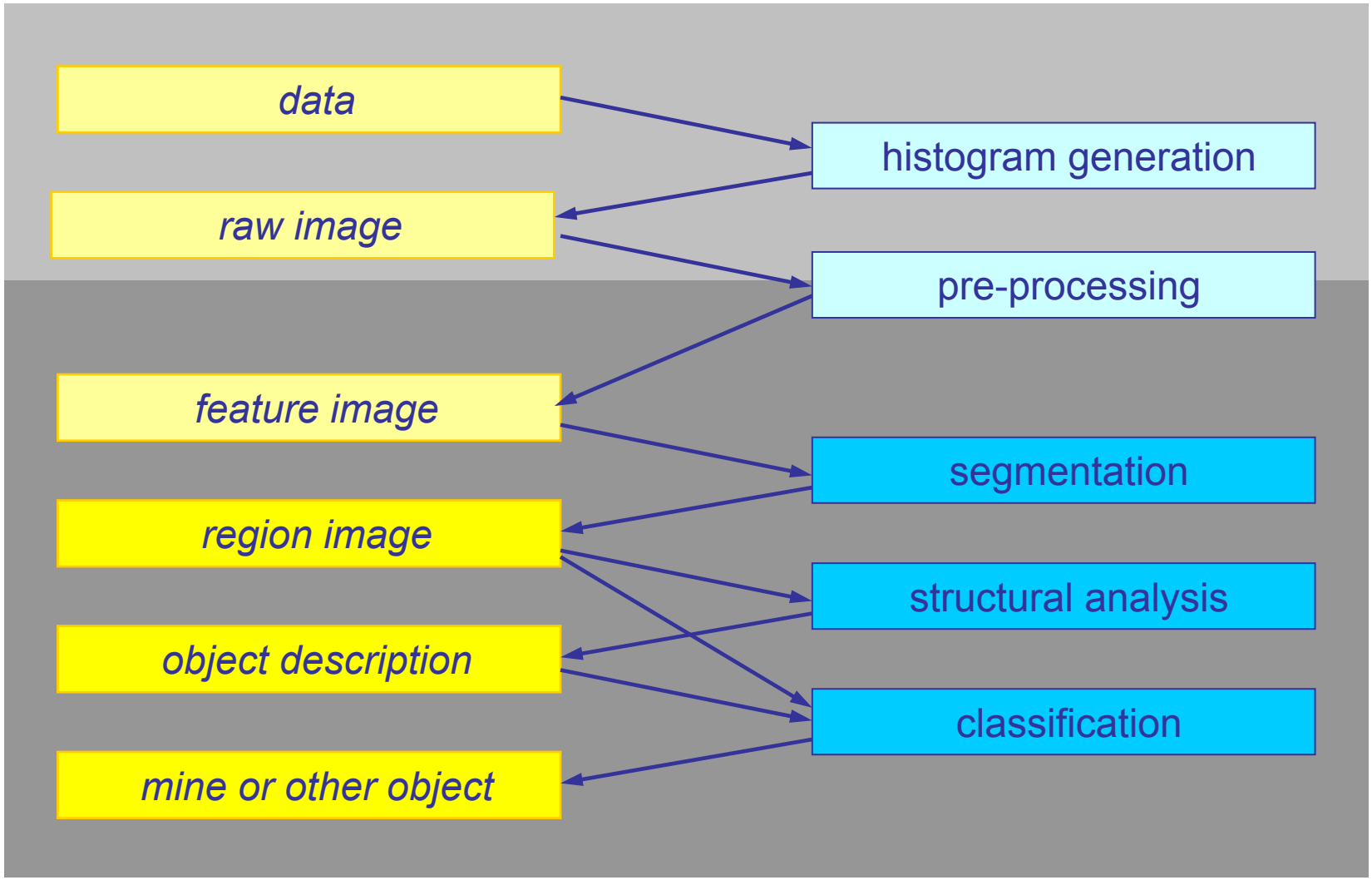
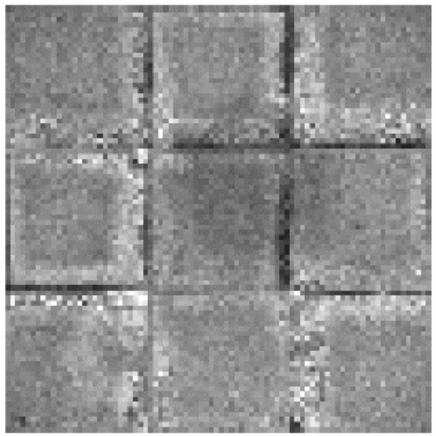
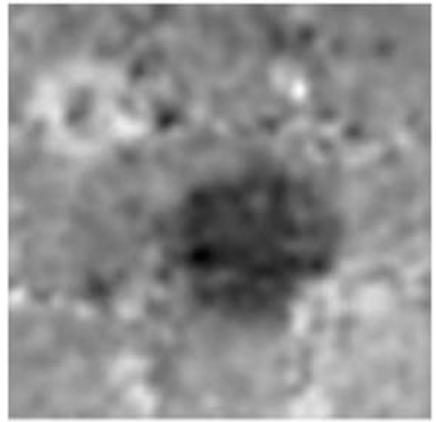


Image processing results

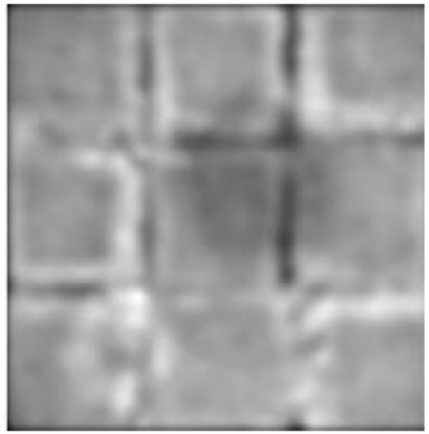
Raw data



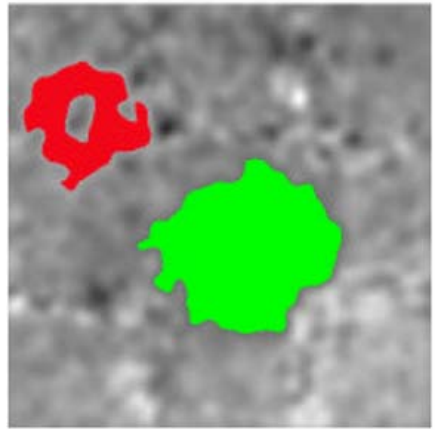
Artefact removal



Filtered data



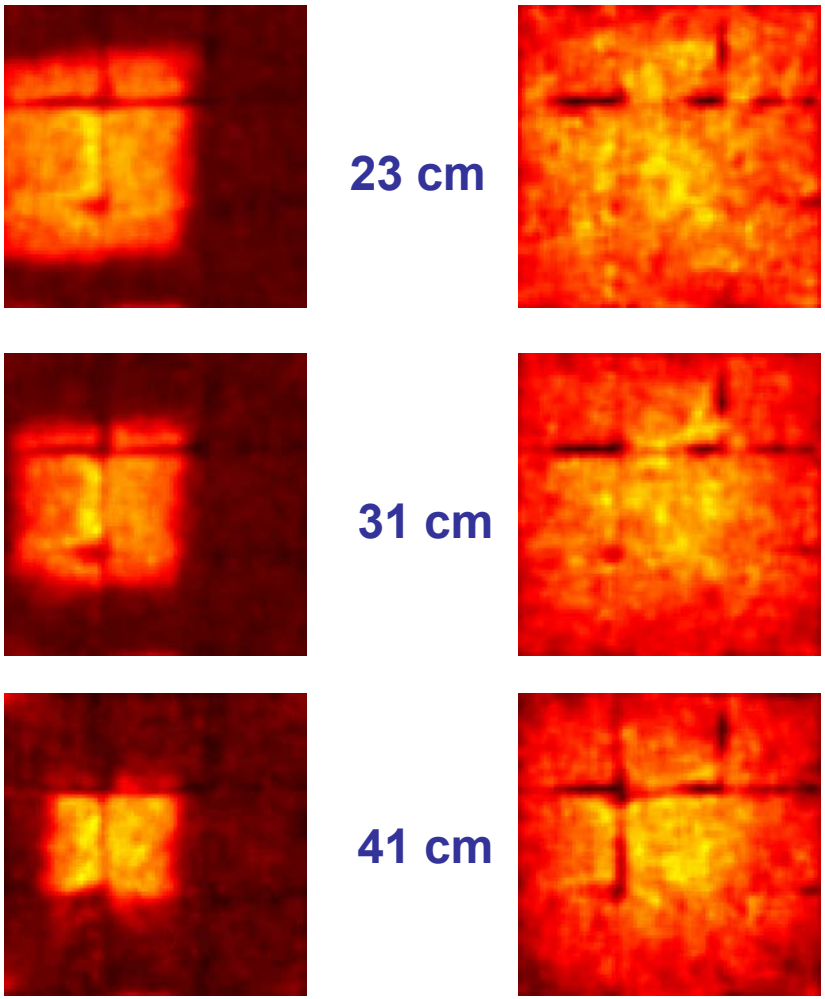
Area segmentation



3D resolution by distance variation

Uncovered
tank mine dummy

Tank mine dummy
below 10 cm soil



23 cm

31 cm

41 cm

Identification by

→ Size change

→ Radial displacement

Distance segmentation

Conclusions

→ The gamma ray backscatter technique is for the first time successfully employed for imaging of buried land mines

→ Low lying APM can be identified with the Verificator

→ For deep lying ATM the 3D resolution needs to be improved

→ New depth algorithms are currently developed

→ The project shall be continued by developing a new light weigth handheld device