Using Neutron Generator with APT/NNA for Detection of Explosives

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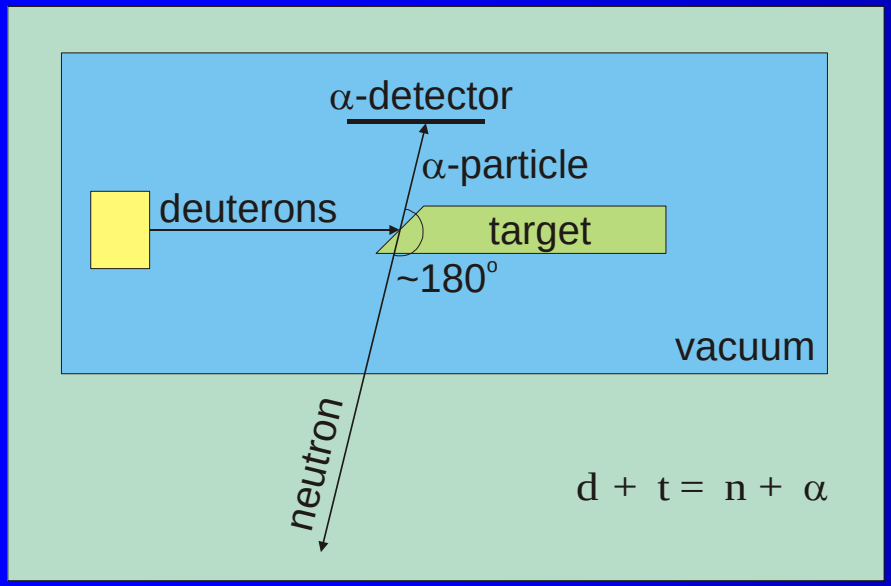
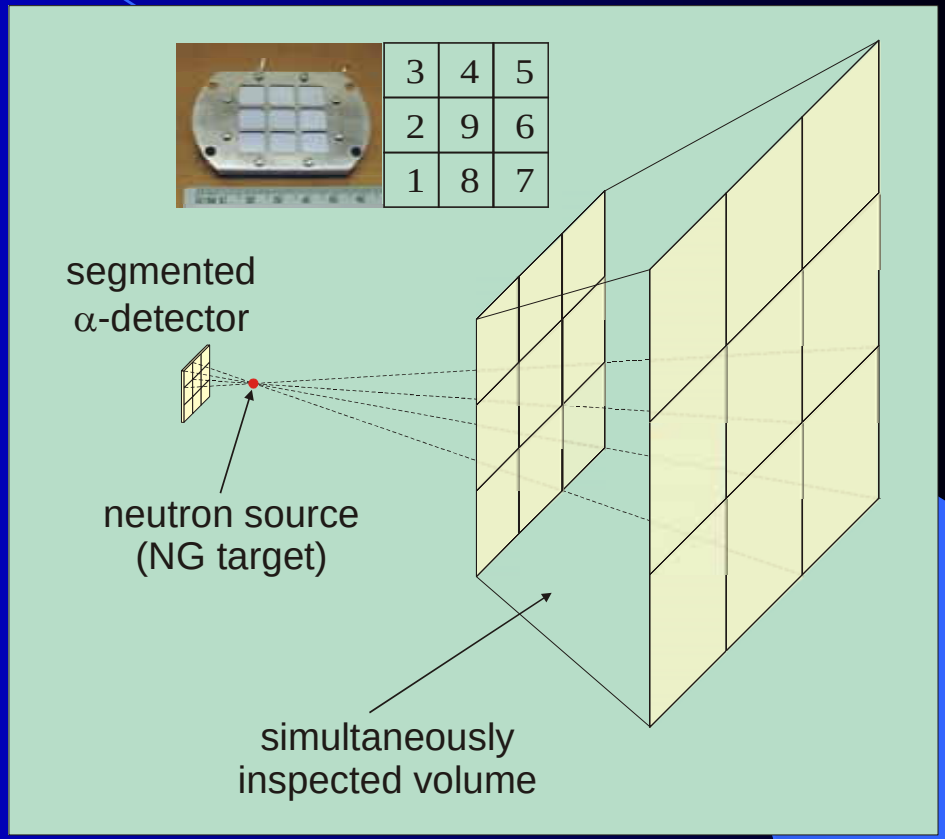
Presentation Layout

- Nanosecond Neutron Analysis/ Associated Particles Technique (NNA/APT)
- Prototype NNA/APT device
- Data Analysis
- Experimental Results
  - Measurements with small objects
  - Measurements with luggage
  - Measurements with containers
- Conclusions

NNA/APT

NNA / APT allows one to obtain a 3D image in terms of elemental composition of the inspected volume.





3D position resolution:
segmented α-detector: in-plane (XY)
time-of-flight: in-depth (Z)

Prototype NNA/APT device

- Neutron generator with 9-segment α-detector.
- One or two BGO-based γ-ray detectors.
- Electronics in a single 3U-high crate.
- RF connection to a remote Notebook PC.

Prototype NNA/APT device

Characteristics of the existing APT/NNA device

Explosives detection limit	100 g in tens of seconds
Detection method	Nanosecond neutron analysis (NNA) with spatial resolution (APT technology)
Decision-taking algorithm	Automatic
Simultaneously inspected area	$30\times30\times30$ cm^3
Spatial resolution	7-8 cm in-plane, 8-10 cm in-depth
Total mass of the device	not more than 20 kg
Dimensions	$70\times45\times20$ cm^3
Radiation safety	Safe when switched-off

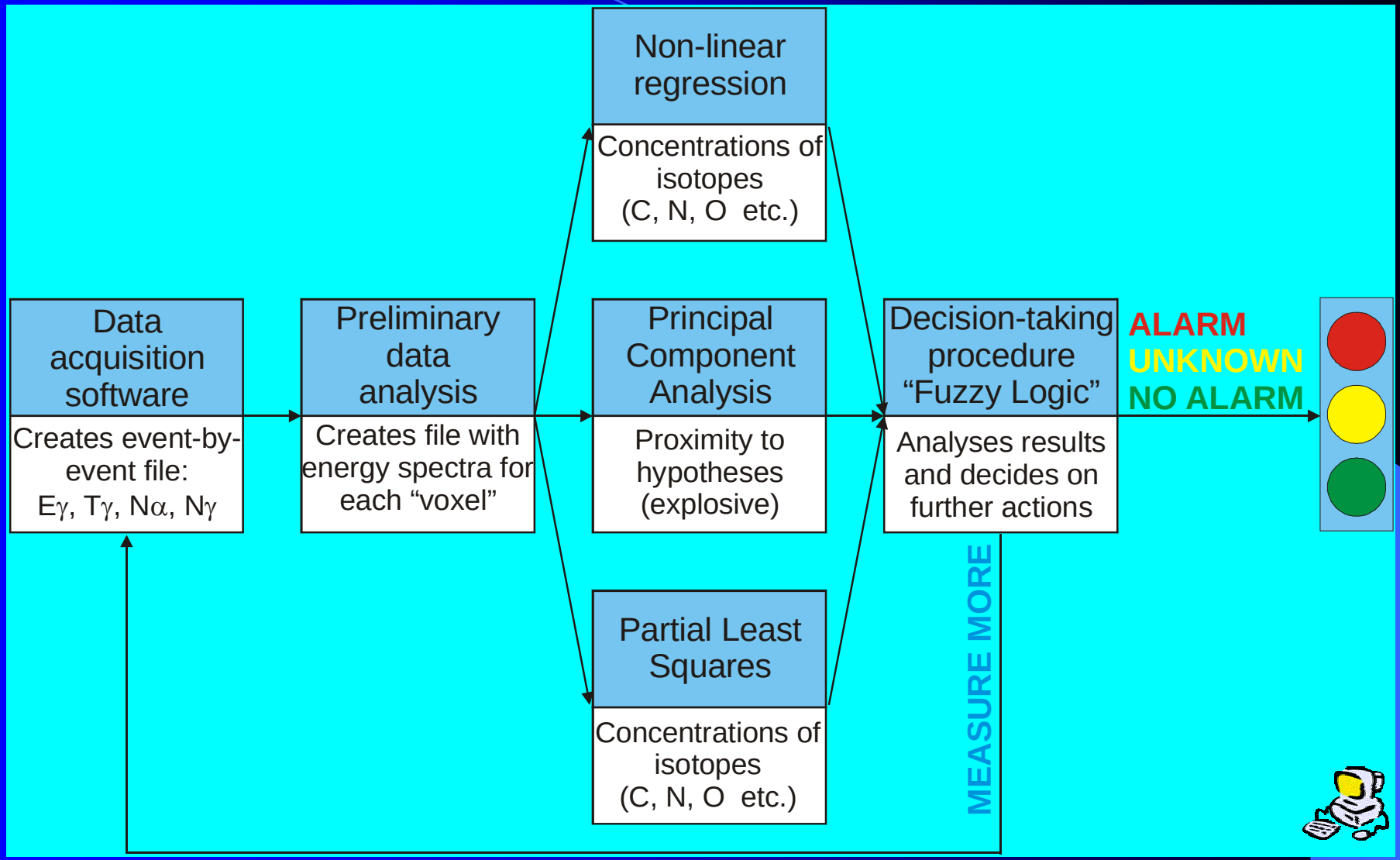
Portable Electronics

Digital: pulses from BGO are digitized, and full analysis (energy, time, pileup…) is done by a dedicated DSP on-line.

Scalable: many γ-detectors can be serviced, each by a fully independent gamma-detection module (up to 12 fit into a single crate).

- Alpha-detection module can handle count rates up to 10^7 α/s with dead time depending only on signal's length.
- Gamma-detection modules can handle count rates up to 10^6 γ/s per second from BGO- or NaI-based gamma-ray detector each.

Automatic Data Analysis

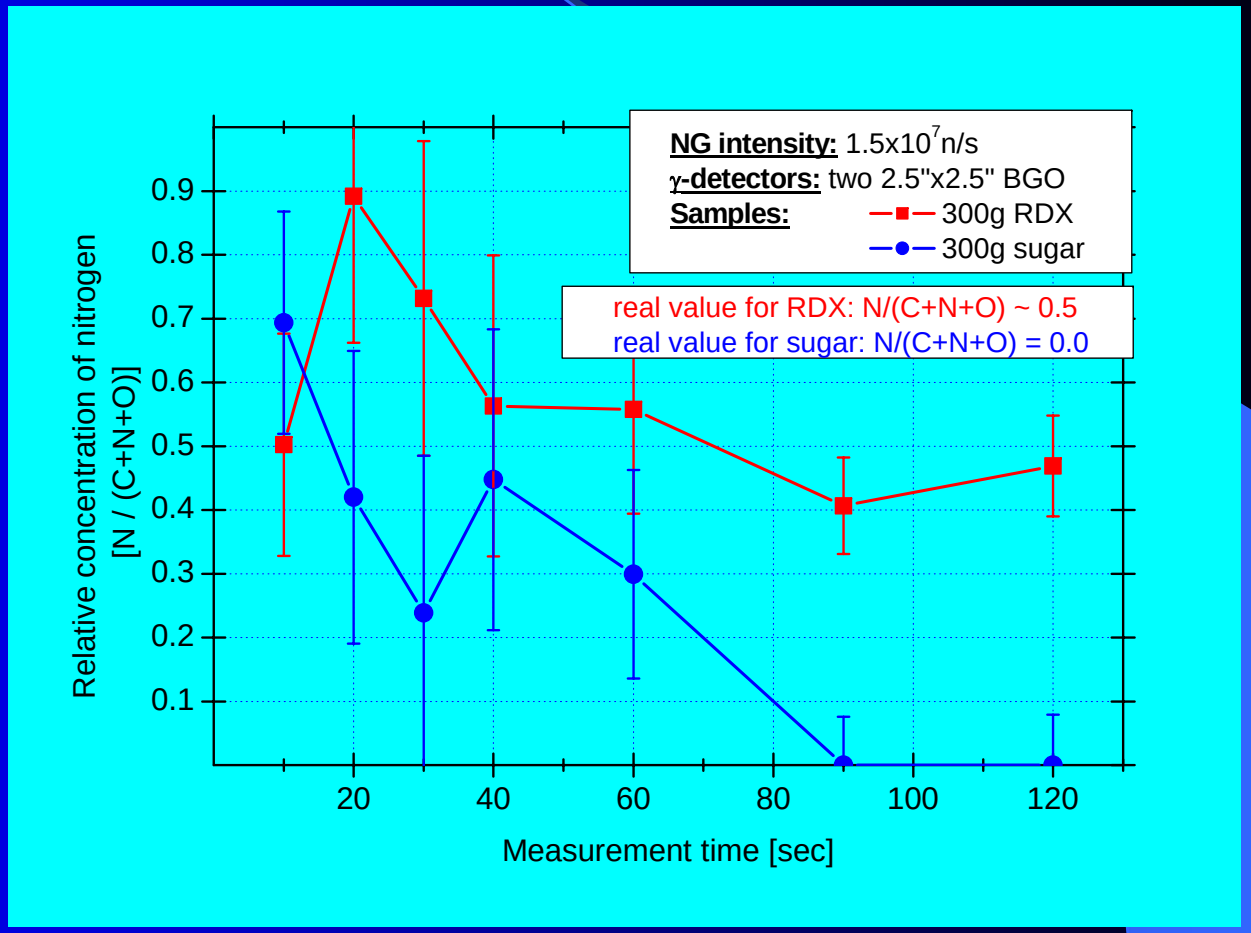


Experimental Results

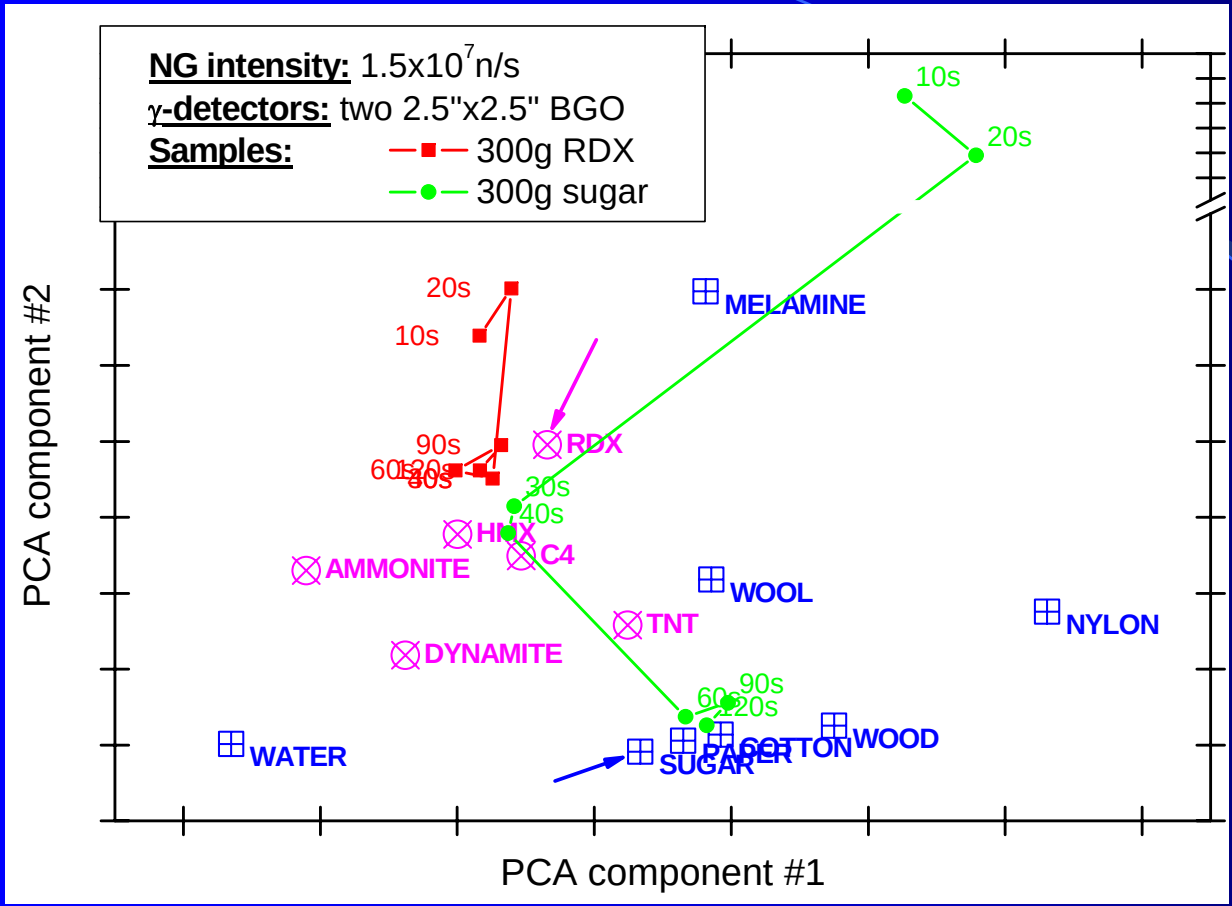
- Measurements with imitators of explosives (RDX, TNT, C4, nitroglycerine, PETN);
  weight of mixture 300g, packed in 24g “Cola” cans.
- Measurements with common objects and explosives’ imitators in passenger luggage.
- Measurements with multiple luggage items in containers.

Measurements with small objects

Dependence of the experimentally determined concentration of nitrogen in 300g RDX and sugar samples in 24g cans on measurement time



Measurements with small objects



Each point represents result of analysis of one spectrum.

Points converge to correct hypotheses after T_{meas} = 30÷60s.

Further increase of the measurement time does not change to location of points.

Arrows indicate correct hypotheses: RDX and sugar.

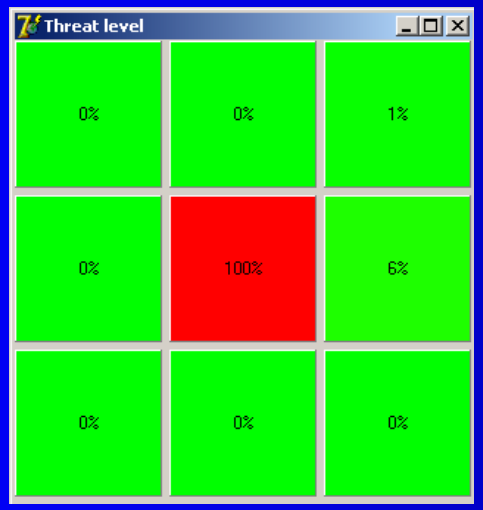
Location of points corresponding to 300g RDX and sugar samples in the space defined by the first two components of the PCA for different measurement times

Measurements with Luggage

Filling of the suitcase, for which measurements were done: cotton and wool clothes, CDs, book, water, wax, soap, vodka, and 1kg TNT imitator under soap (mostly in segment #9).

Measurement time: 60 s

Decision-taking procedure automatically shows the threat level for all nine segments

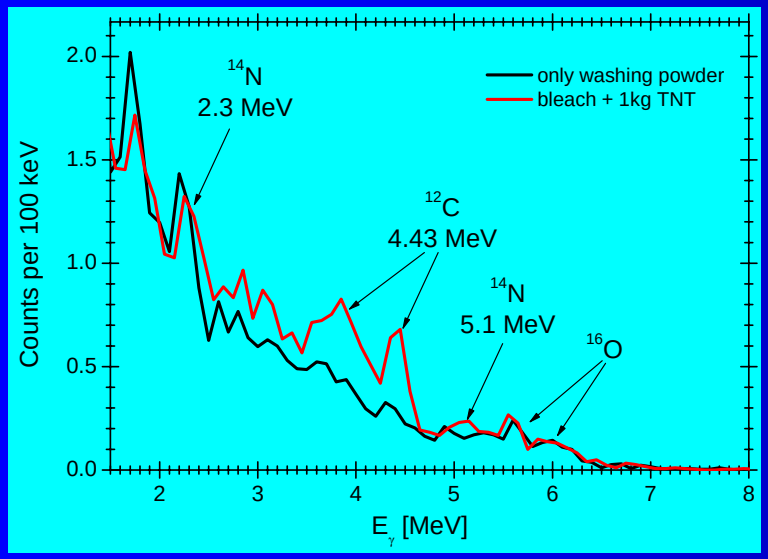


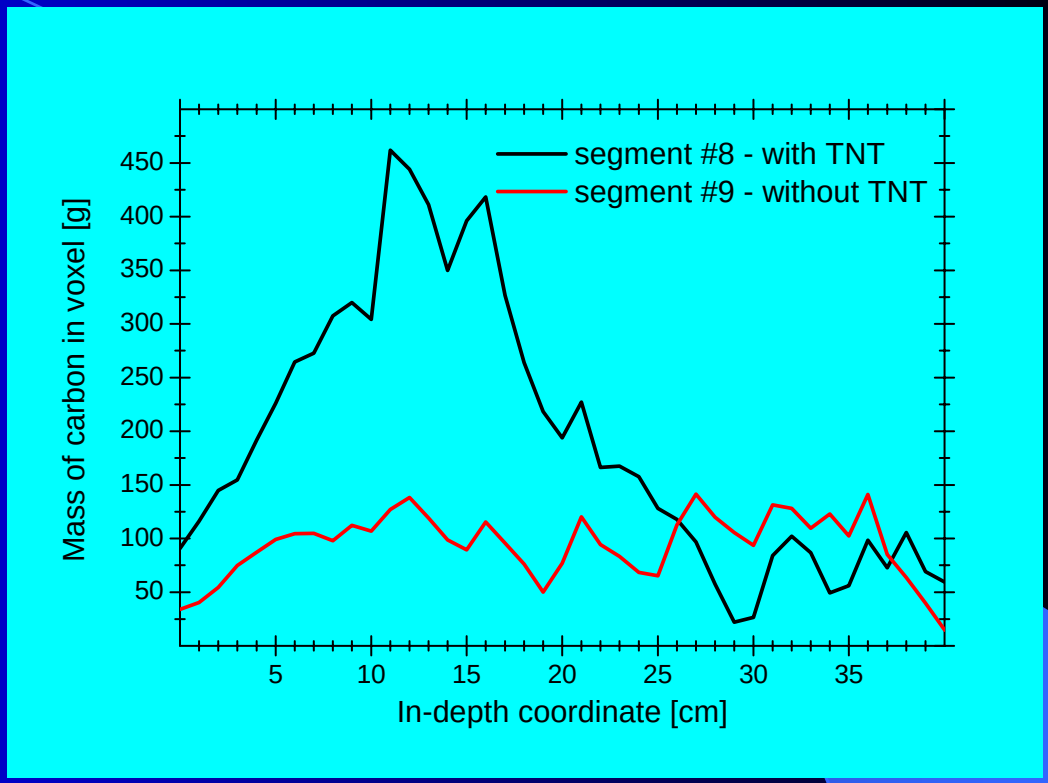
Measurements with containers

Two boxes, each with 0.5kg TNT imitator, were hidden among similar boxes with washing powder (a total of 36 boxes).

Measurements with containers

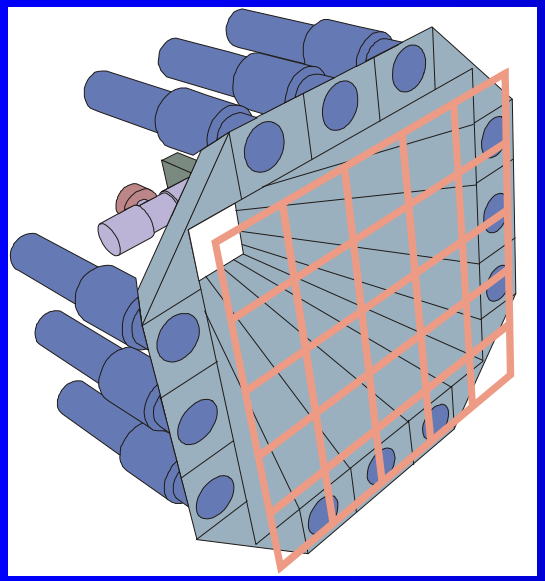
No contrast on oxygen.
A lot of extra carbon.
Some extra nitrogen.

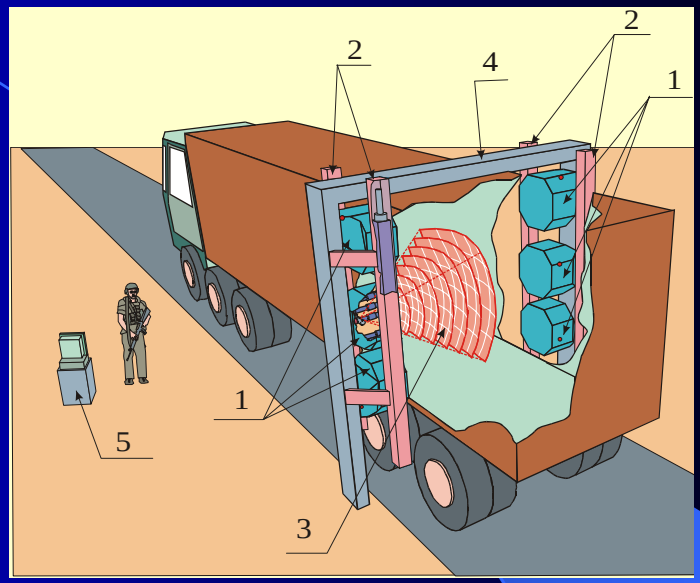




Distribution of carbon mass along the in-depth coordinate for “voxels”, corresponding to two segments of the α-detector: one containing only washing powder (red) and another containing TNT at “depth” about 10 cm behind two boxes of washing powder

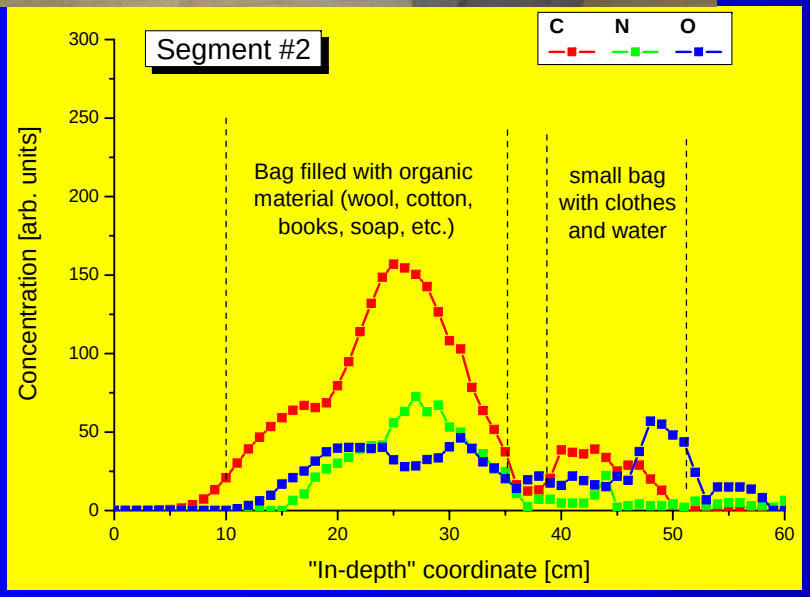
3D NNA Scanner

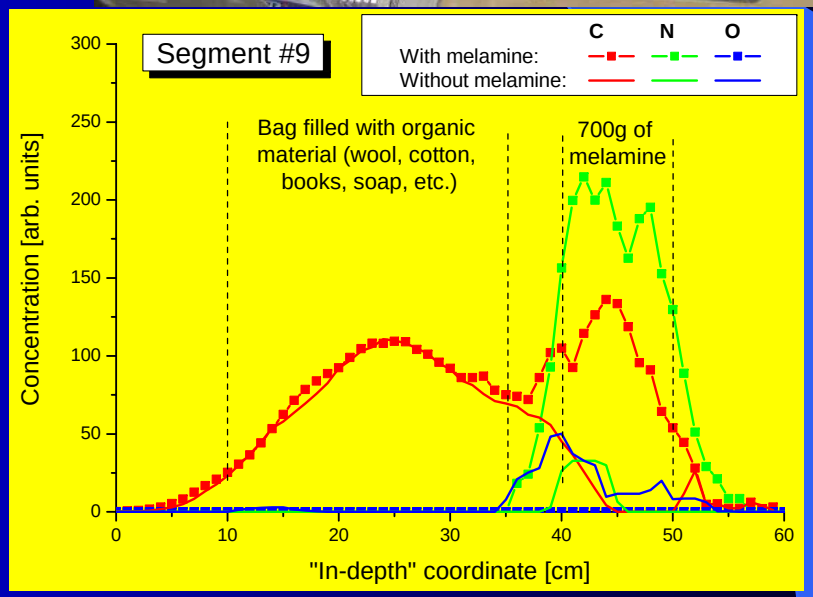




Left: one NNA/APT basic module consisting of one APT neutron generator and 12 gamma-ray detectors. ***Right:*** "3D NNA Scanner" for Inspection of Sea Containers. 1 – NNA/APT basic modules. 2 – neutron detectors. 3 – volume inside the 40'-high sea container screened by one "measurement module". 4 – construction frame. 5 – remote control and data analysis module

3D NNA Scanner





Conclusions

- The existing portable device can automatically identify 300g of organic substance in 30÷60 seconds.
- The existing portable device can automatically detect explosives hidden inside midsize suitcase filled with various organic materials.
- The existing portable device can detect several hundred grams of concealed explosives within tens of seconds at distances about 50cm and within several minutes at distances around 1 meter from the NG target.
- Work is under way to create a full-scale NNA/APT basic module, which can serve as a component for large-scale devices for inspection of cargo containers and luggage.

Acknowledgements

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