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New sorting monitors at NPP A1, Slovakia

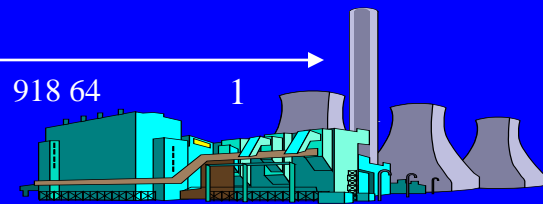
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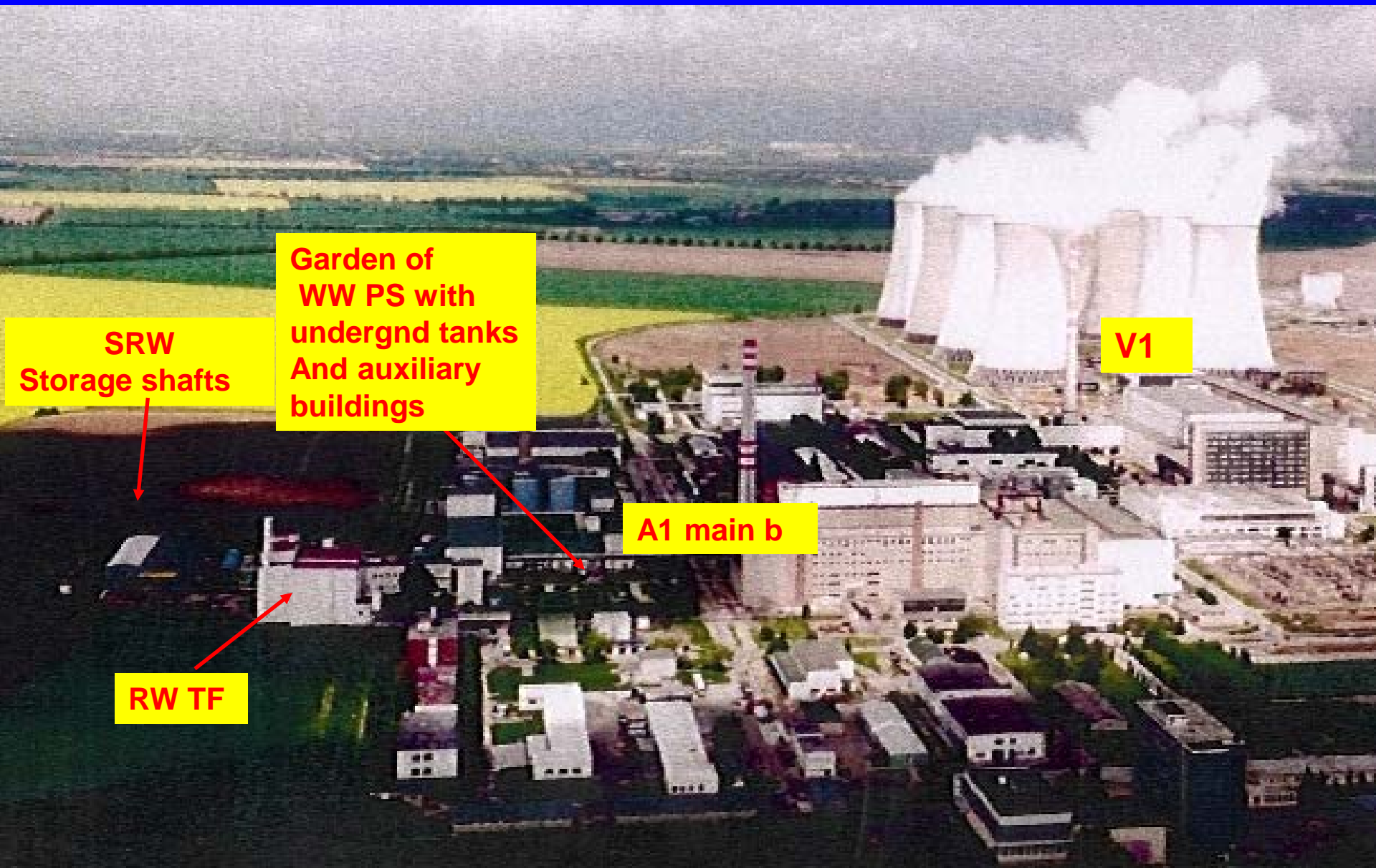
Content

1. NPP A1 site, decommissioning status, moving of large volumes of contaminated soil
2. Operative loader shovel monitor for soil sorting
 - a. Concept
 - b. Design
 - c. Prototype
3. Conclusions

NPP A1 Present day status of D&D

- NPP A1 is under decommissioning more then 12 years
 - I.stage: 1999 - 2007
 - II. stage from 2009
- Specific radiological conditions due to an accident shutdown after partial core melting, in 1977
 - Cs-137 is dominant RN
 - HDRNs vector is known, cca in the most caases
 $\text{Sr/Cs} = 0.1$, $\text{Pu/Cs} = 0.01$

Bohunice NPP complex –auxiliary buildings on left side



SRW
Storage shafts

Garden of
WW PS with
undergnd tanks
And auxiliary
buildings

V1

A1 main b

RW TF

Removing of large volume of contaminated soils



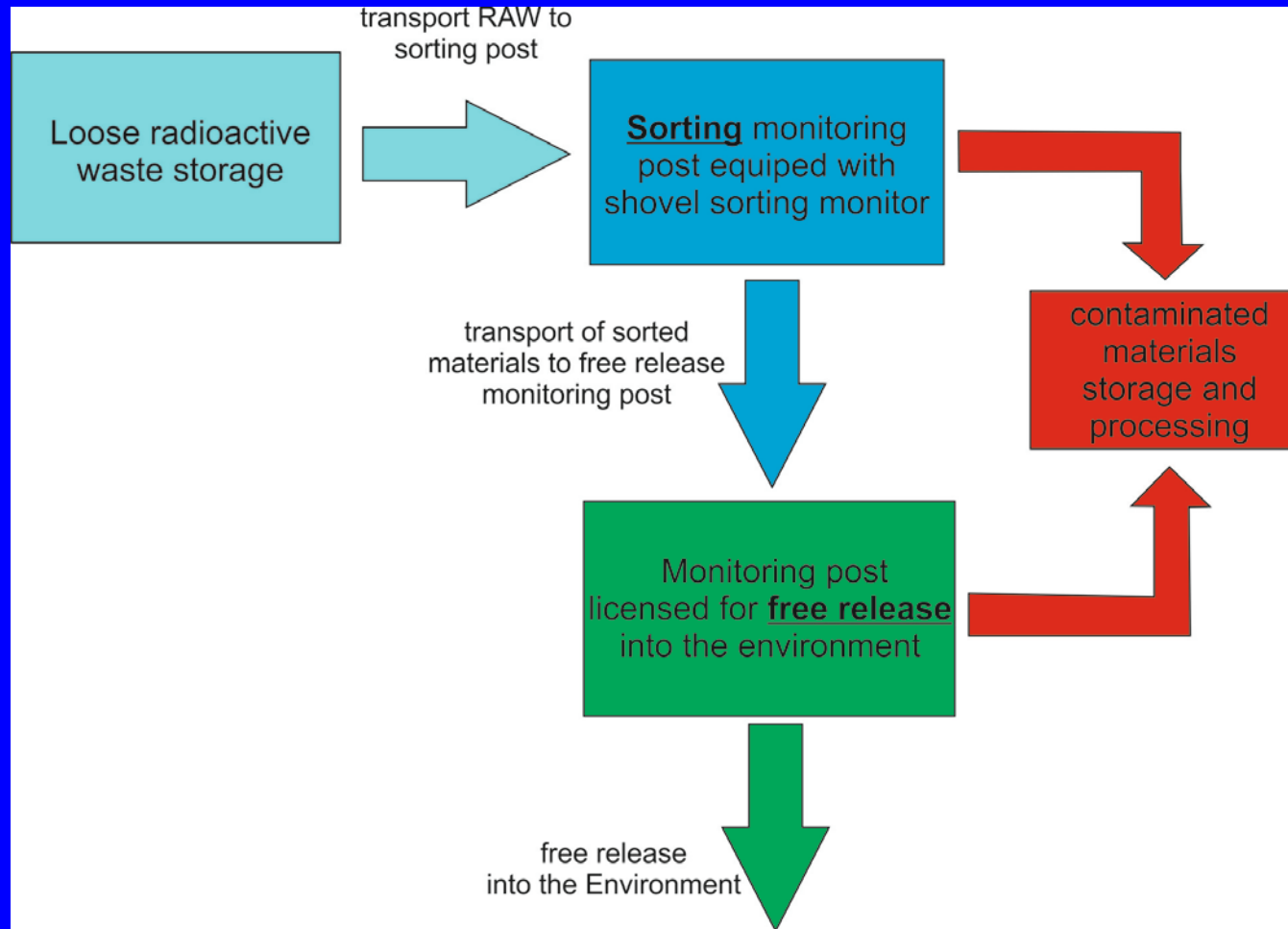
Means sorting and transport of soil to manipulation place for VLLW and to free release post

It needs:

- Application of heavy techniques like excavator, trucks, etc.
- Establishment of manipulation place for excavated soil
- Sorting of soil to contaminated and potentially free releasable parts by suitable sorting monitor and so:
 - to reduce volume of soil to be monitored by costly free release techniques (belt or container monitor)
 - to minimize volume of VLL CS



CS stream diagram at sorting and free release monitoring process



Operative CS sorting monitor

- It should have
 - short measurement time but
 - Sufficiently low MDA, e.g. 100 Bq/kg (limit 300 Bq/kg)
 - low manipulation time for measurement!!,
 - Light, wireless signalling of measured data at the sorting post,
e.g. > 500 or < 500 Bq/kg (FR limit – 300 Bq/kg of pure ^{137}Cs)



Shovel of an UNC loader

- was selected as part of sorting monitor (far counting geometry)
- slab source geometry cca 30 cm thick was used



for MCNP peak eff. calculation



Shovel width x depth:

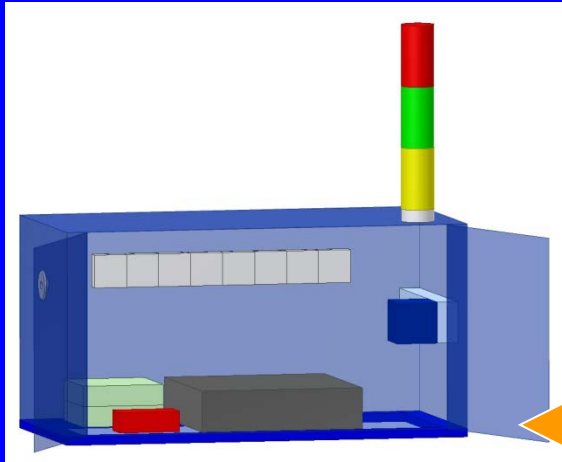
180 x 75 cm,

$V = \text{cca } 400 \text{ dm}^3$

Supposed density $= 1.2 \text{ g.cm}^{-3}$

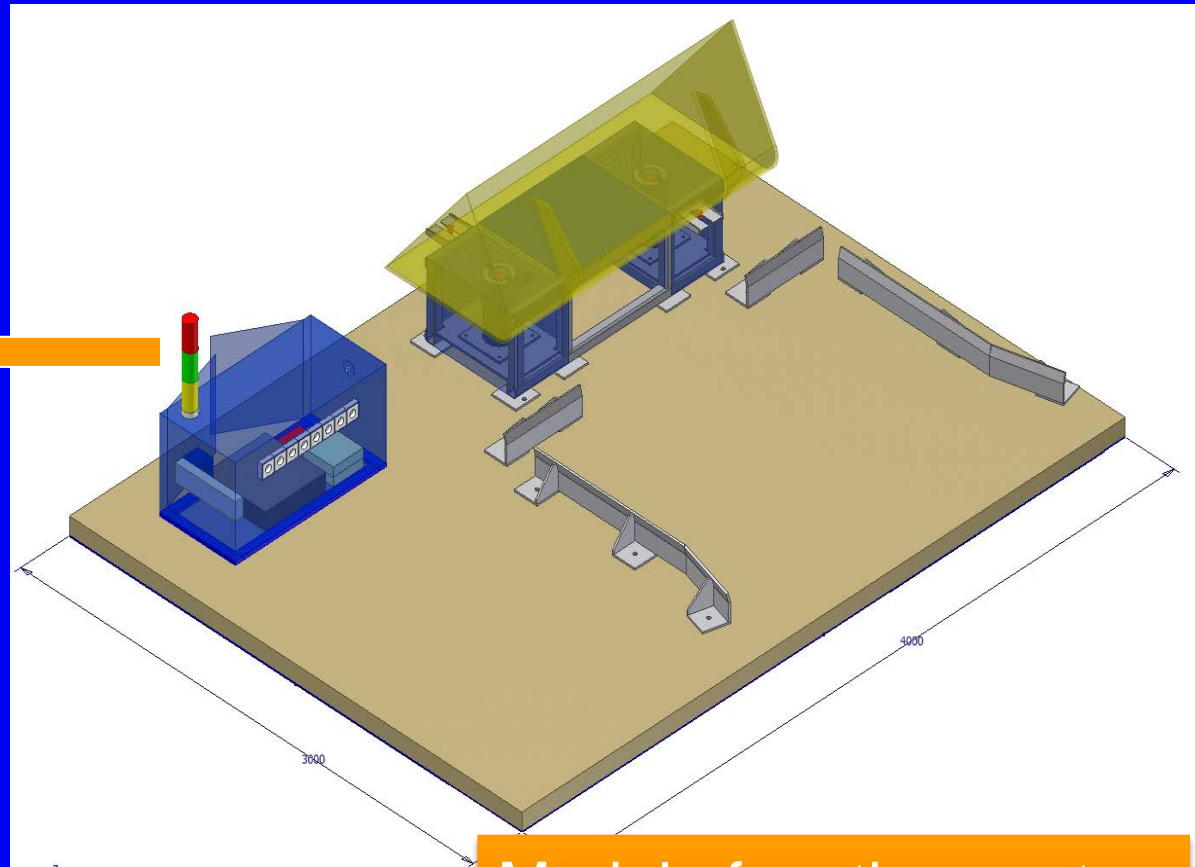
No weighting

Concept of operative CS sorting shovel monitor



Limited accuracy of measurement, so sorting only, but with

high capacity: 10 – 50 t per working shift



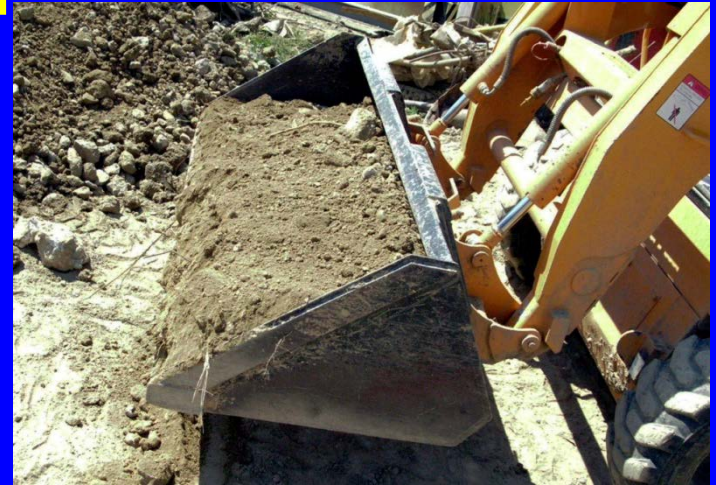
Model of sorting post

Loader Shovel sorting monitoring system - prototype

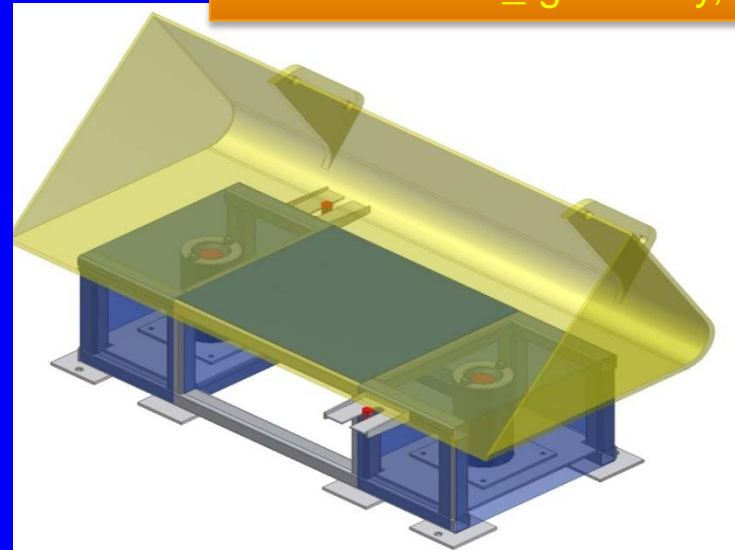
Includes own designed components:

- protective casing with
 - measurement table for shovel fixation checking position sensors
 - 2 shielding towers (+ standard NaI)
- components for loader navigation to fixed measurement place
- control SW for monitoring and signaling
- color lights box for indication of monitoring data, and monitor statuses

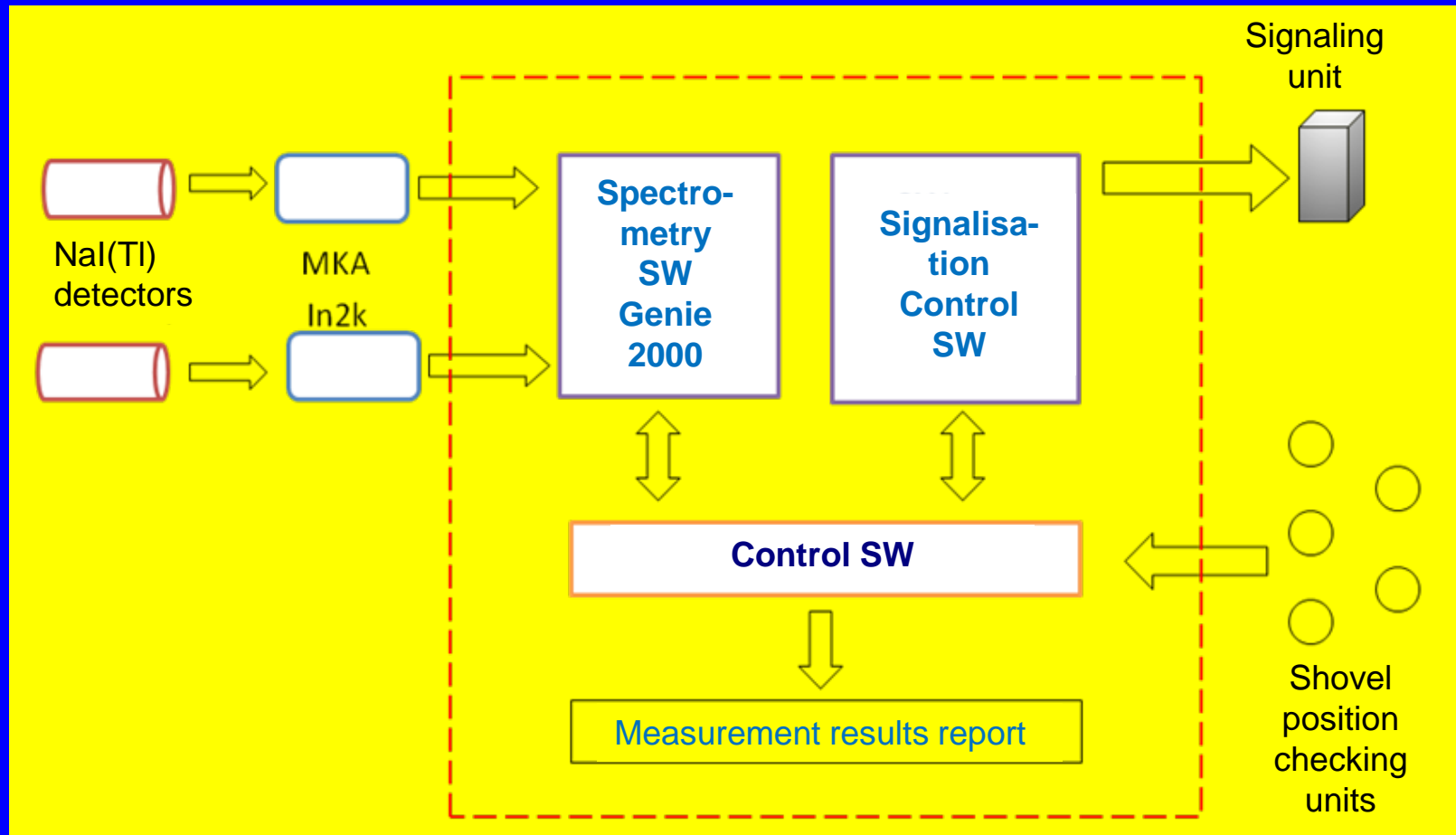
and a case with standard gama spectrometry electronics (MCA, DSP, PC, GSP SW – Canberra Packard)



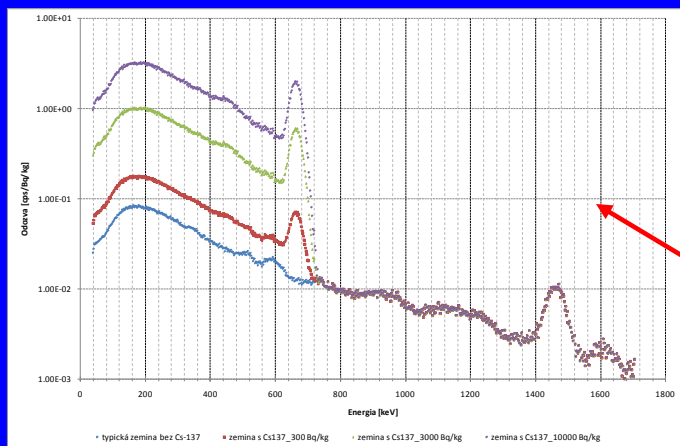
2xNaI count._ geometry,



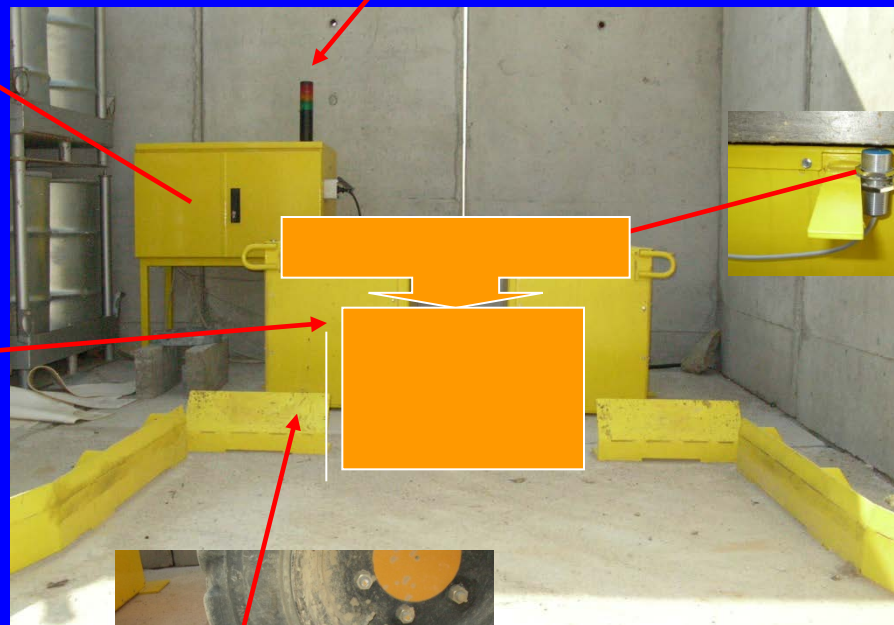
Control diagram of the shovel monitor



Details of sorting shovel monitor

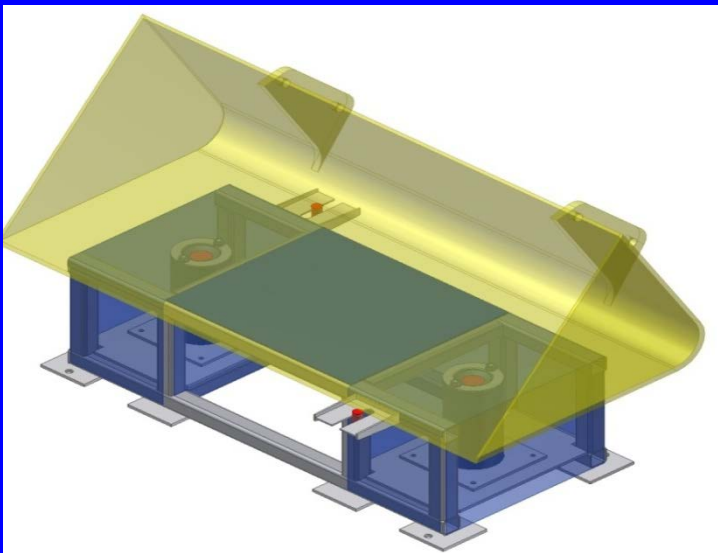


Lightning signal
of sorting result



Characteristics of the shovel monitor

- 1800 x 750 mm (width x depth), $V \approx 400 \text{ dm}^3$



- Background subtraction before measurement evaluation
- No weighing at measurement
Supposed soil density $= 1.2 \text{ g.cm}^{-3}$
- Estimated sensitivity:
 $0.009 (2'')$, $0.027 (3'')$ $\text{s}^{-1}/(\text{Bq/kg})$
by MCNP simulation:
- Sorting result light indication
- Uncertainty – high, typical cca 30%

MDA = $200 \text{ Bq/kg } ^{137}\text{Cs}$ (NaI(Tl) $2'' \times 2''$),
= 100 Bq/kg (NaI(Tl) $3'' \times 3''$)



Conclusions

- Acceptable deviations were found with laboratory measurements using samples from the shovel
- Monitor for loader shovel is extensively explored within CS handling at NPP A1 (Bohunice, Slovakia)
- Approximately 50% of CS was assorted as free releasable soil
- The most of assorted soil has been free released into the environment (metrologically certified FR monitors)

Thanks for attention



Free release licences at the site

- **200 L WM2001 drum monitor** – since 2004, has very limited capacity, 2 t/shift
- **Soil Sorting Conveyor Monitor** – part of FR post since 2010, 10 t/shift
- **600 L Container Monitor** - part of FR post for CS and CCR – under licencing (Pub. Health auth-y), 10 t / shift
- **Loader Shovel operative monitor** - part of CS handling and characteris. post – is under testing, 50 t/ shift, for sorting only

Central free release post with WM 2001 3xHpGe drum monitor



Central Free release post with handy crane manipulation (very slow)



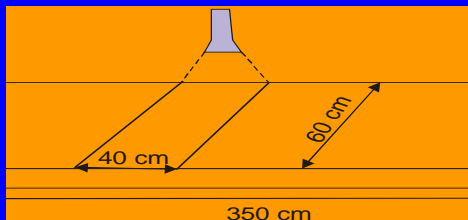
limited
capacity!! –
cca 2.5t / shift

T=15 min,
MDA =5 Bq/kg

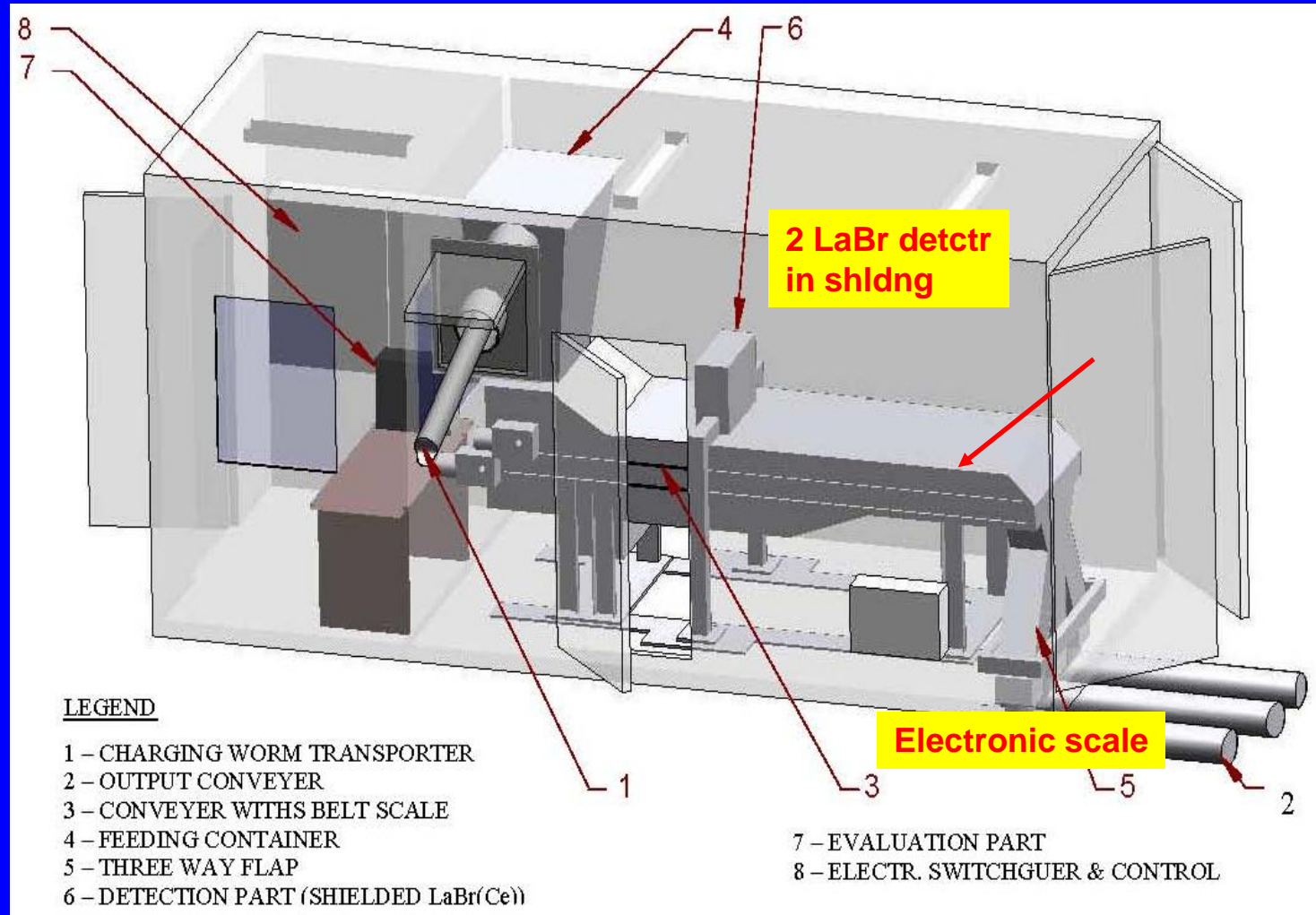
Belt monitoring system for FR and sorting of contaminated soil



- 2 GSP LaBr detectors above moving belt (reported at ICEM 2009)
- control SW and 3 way sorting flaps
- FR and sorting of 30 kg batches above Release Limit, capacity = 10 t/shift



Scheme of the belt conveyer monitoring and sorting system



FR belt monitoring system for FR and sorting of contaminated soil

is based on

- feeding mechanics and 60 cm belt conveyer
- 2 GSP LaBr detectors above moving belt (Canberra HW, SW)
- control SW and 3 way sorting flaps

It has sorting capability as well (30 kg portions > 300 Bq/kg)

- !! works with **dried** soil, only
- Monitoring capacity, dried soil: cca 10 t / shift,



Input bin with charging helical conveyor

New 600L container monitor

- Was recently designed and commissioned at VUJE

it increases the free release monitoring capacity

- for contaminated bulk material (soil, concrete)

- Use lift truck for manipulation with
 - 600 L containers / 200 l drums

- Is reconfigurable (container/drum)– horizontal and vertical configuration

- Productivity, container: 10 t /shift (has dischargeable bottom – lower manipulation time)

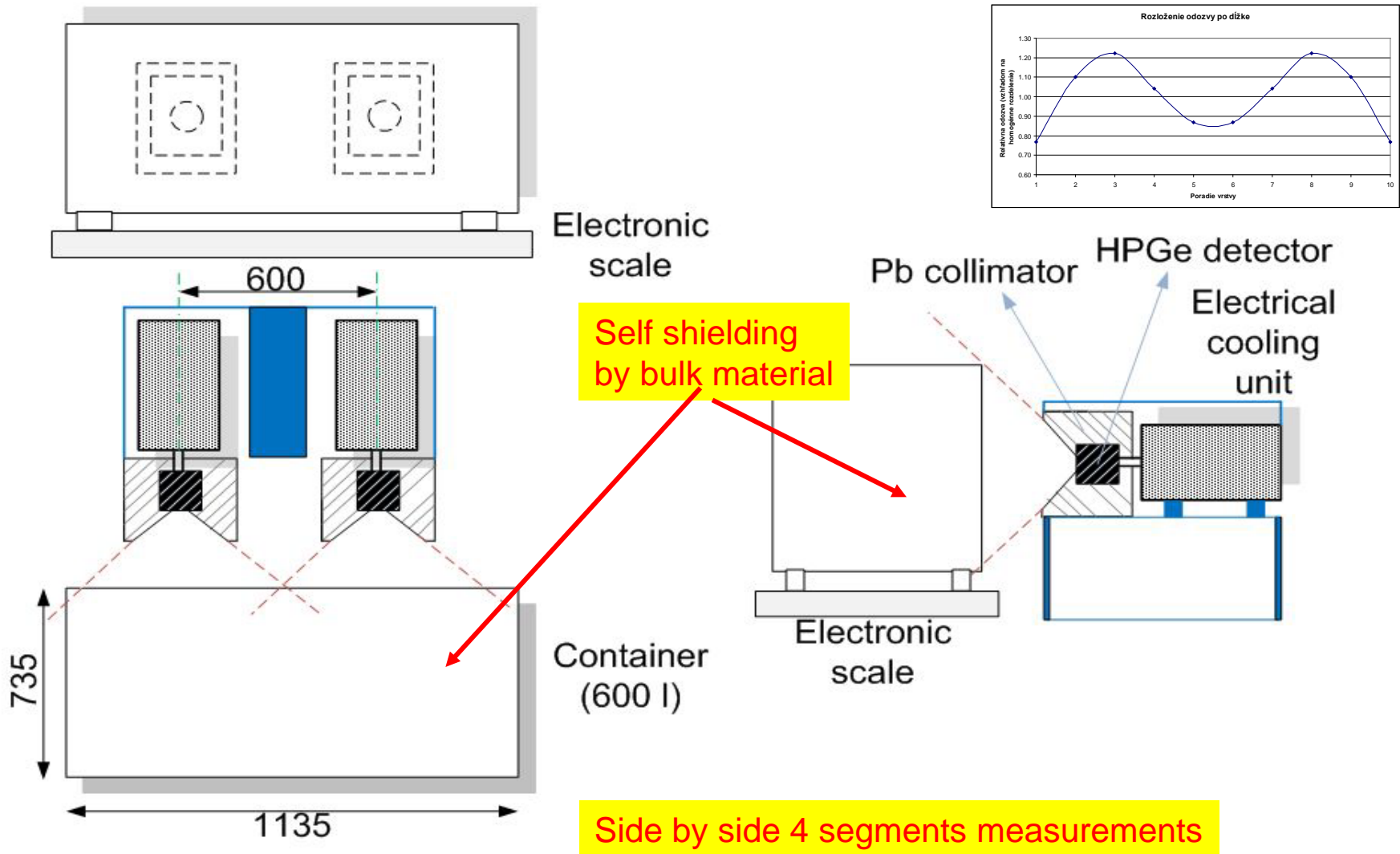


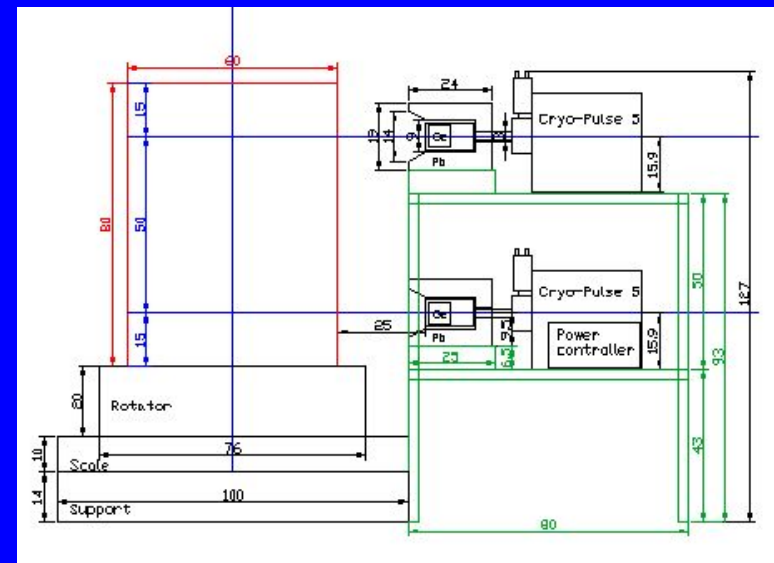
Self absorption

Rectangular
Pb colimator shielding



600 l container monitor – (lift truck manipulation)





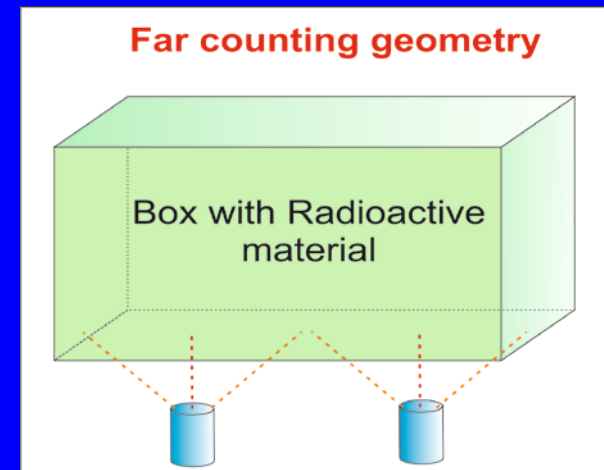
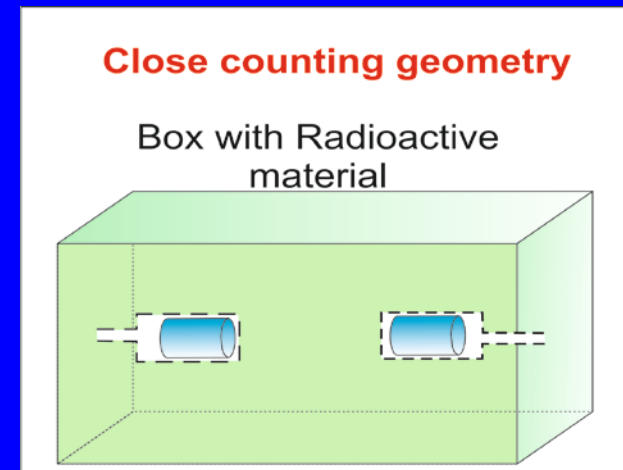
Choose of counting geometry for operative large capacity on site monitor

Feasibility of implementation of various counting **geometry** with **selective NaI det.** showed:

- **close geometry** with highest eff was found problematic due to:

- too complex machine structure, needed
- high manipulation time with bulk material (fill in, moveout)
- need of multi detector syst. (short mean free path for cs-137 in soil)

- **loader shovel monit.** in far geometry showed to be as the most feasible - next



Evaluation algorithm for signaling lighting tower

Contaminated side: both NAI results > 500 Bq/kg

Free releasable side (Conveyor or container monitor):

- Average soil cont < 500 Bq/kg
- One of shovel half < 500 Bq/kg (one Nal data)
- Goal is
 1. to avoid costly free release measurements
 2. to leave as much as is possible at free release side -
- sorting of 30 kg batches by the conveyor monitor



Main characteristics of the Bohunice NPP-A1 which is now under decommissioning

- **Reactor:** pilot, channel type **HWGCR** (HW Gas (CO₂) colled)
- **Spent fuel:** nat U (with Mg-Be cladding)
- **Gross power output:** 143 MWe
- **Comissioned:** 1972
- **Operation period:** 5 year
- **Shutdown:** **1977** - fuel integrity accident.
- **Decommisioning -I phase** **1999 -2006**
- The shovel monitor explores far counting geometry and SW control of shovel fixation and gammaspecrometry measurements at soil monitoring,

