The LINTEL, a system for estimating the effective dose equivalent of the space stations' crew

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Assessment of Radiation Exposure of Astronauts in Space

Draft Report for Consultation, 2012 July 03
ICRP Publication XXX

Absorbed dose, D

$\Downarrow$

Dose equivalent, H

$\Downarrow$

Dose equivalent in an organ or tissue, $H_{T,Q}$

$\Downarrow$

Effective dose equivalent, H_E

Solved tasks

- **Absorbed dose, $D \Rightarrow$ Pille (η ~0.8)**
- **Dose equivalent, $H \Rightarrow$ TRITEL (field value)**

(The dose equivalent at a point in tissue is given by: $H = Q\,D$, where D is the absorbed dose and Q is the quality factor at that point)

Final task:
estimation of
effective dose equivalent, H_E

Step 1

Estimation for all relevant organs or tissues

- **Dose equivalent in an organ or tissue, $H_{T,Q}$**

The product of the mean quality factor, Q_T, and the mean absorbed dose, D_T, in an organ or tissue T:

$$H_{T,Q} = Q_T \, D_T.$$

A quantity introduced by ICRP in Publication 26 and replaced by equivalent dose in an organ or tissue in Publication 60.

Step 2

Calculation of

- **Effective dose equivalent, H_E**

The tissue-weighted sum of dose equivalent in an organ or tissue from all specified organs and tissues of the body, given by the expression:

$$H_E = \sum w_T H_{T,Q}$$

where $H_{T,Q}$ is the dose equivalent in an organ or tissue w_T is the tissue weighting factor.

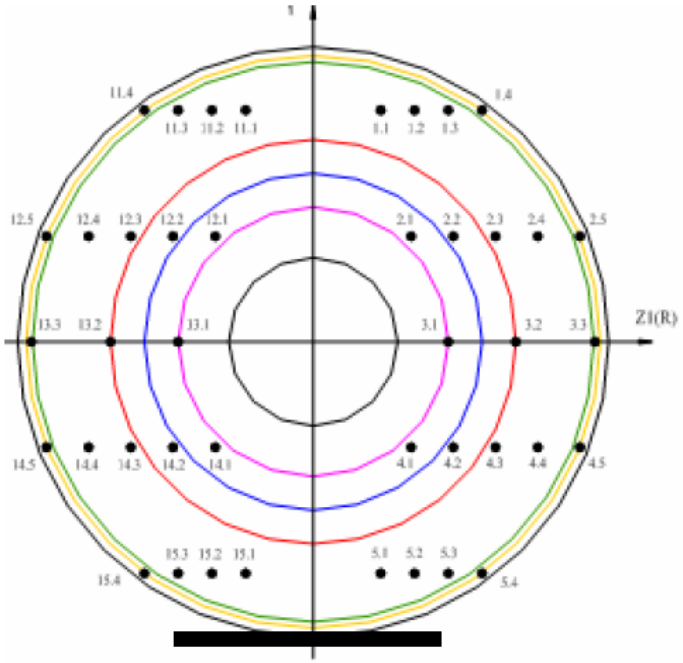
Estimation the dose equivalent by measurement of organ/tissue dose equivalent for all relevant organs/tissues

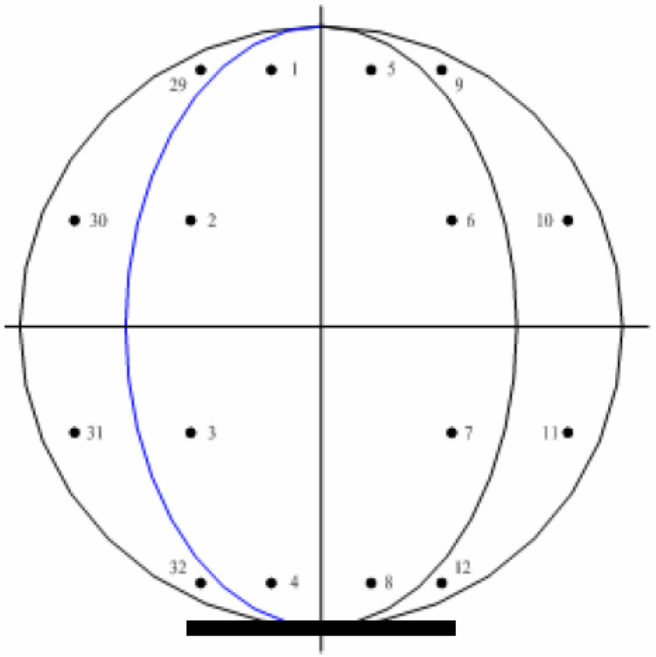
⇓

LINTEL

Measurement of LET spectra at different tissue equivalent depths separately for galactic and trapped radiation

Locations of the containers and jacket pockets with detectors





- 20 containers with the detectors inside the phantom
- 32 pockets with the detectors on the phantom surface
- More than 500 LiF TLD in total and CR-39 type detectors
- *D = D(depth, φ, θ)*

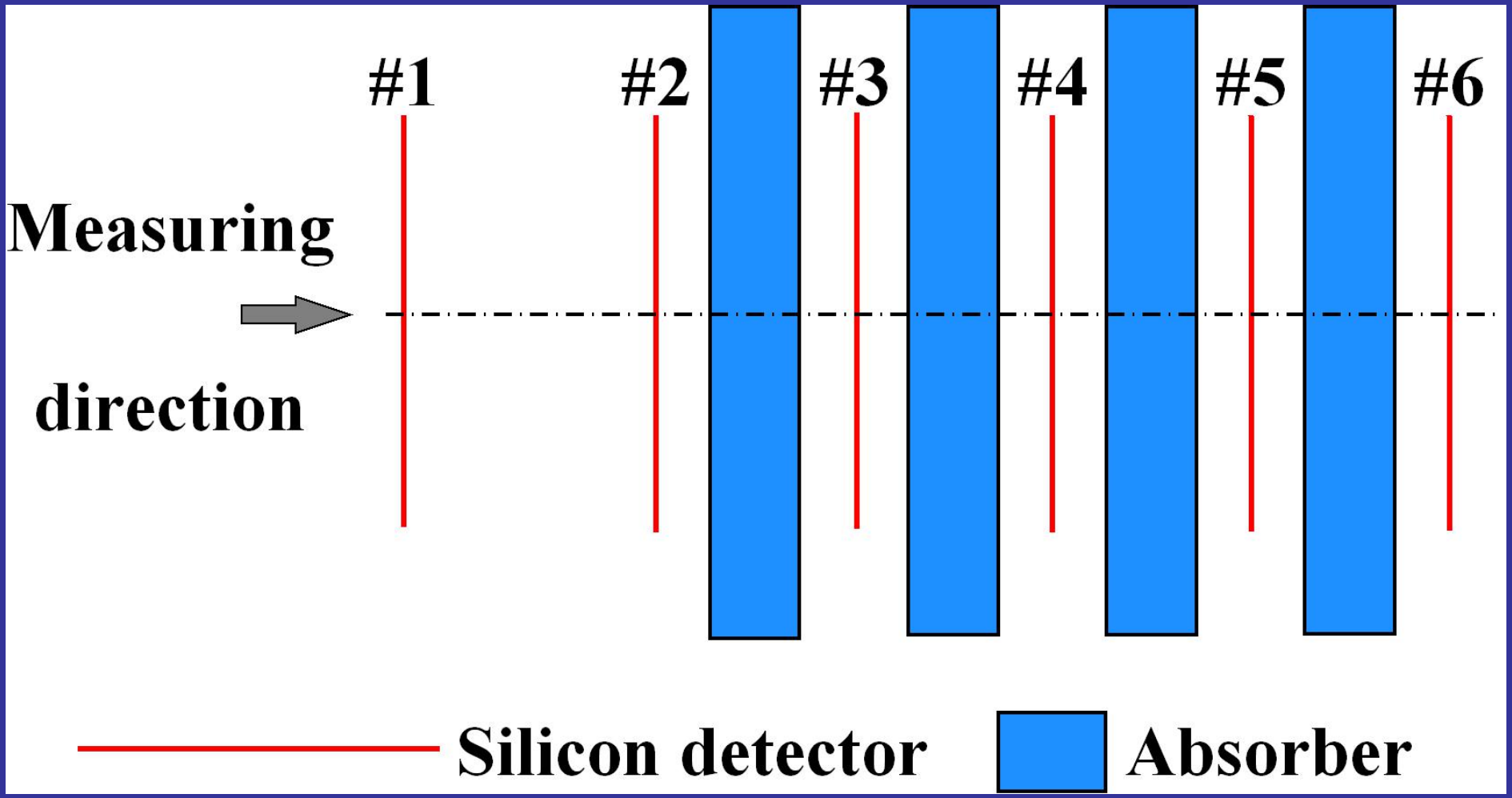
(*V.A. Shurshakov et al. 16th WRMISS, Prague, 2011)

Recent version of LINTEL is dedicated for equivalent dose measurement of the following organs (tissue equivalent depth in cm*)

– Eye lens (0.3)
– Testis (1.8)
– Blood forming organs – BFO (5)
– Central nervous system – CNS (7)
– Gastro-enteric system – GES (9)

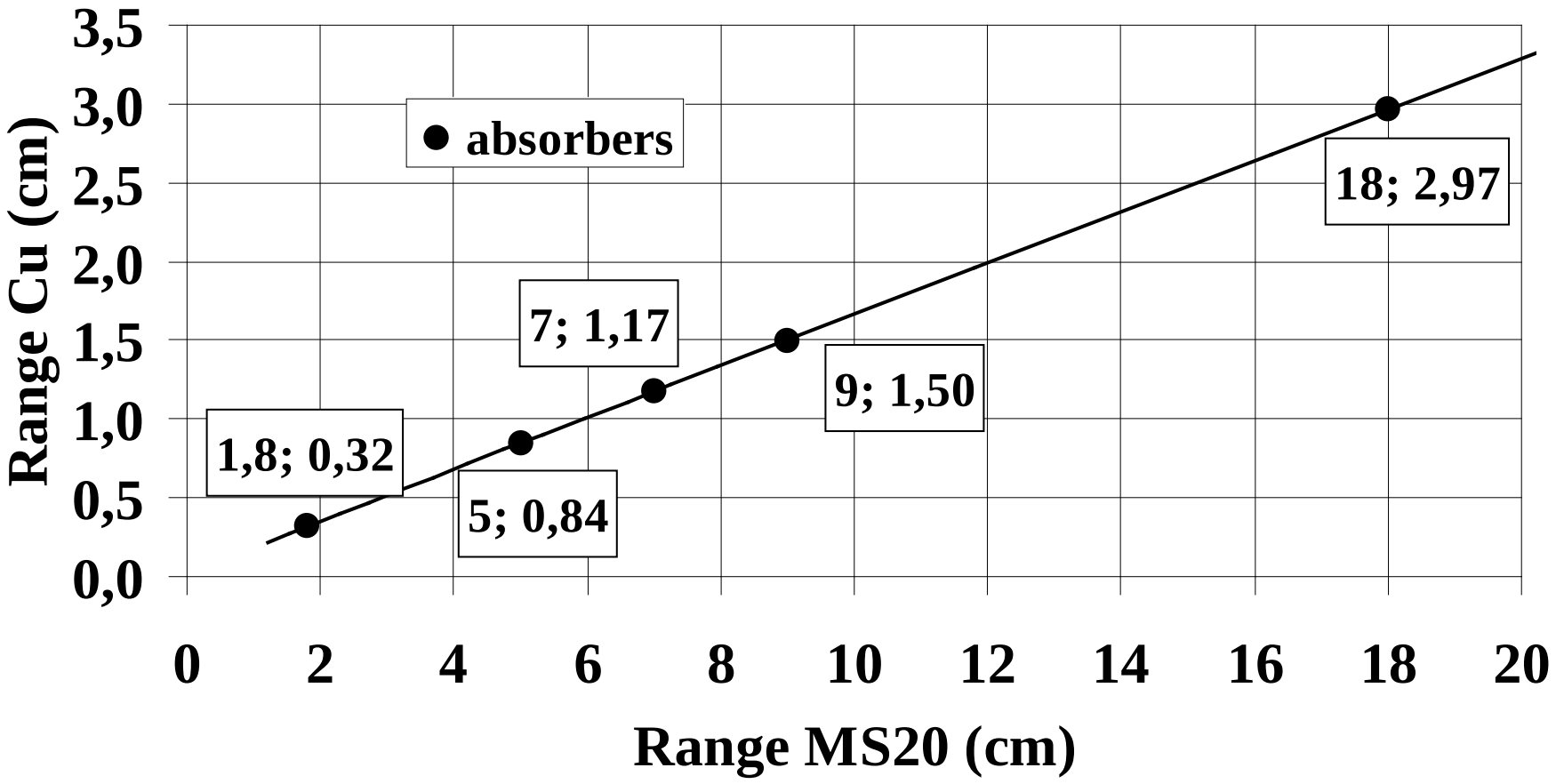
(*V.A. Shurshakov et al. 16th WRMISS, Prague, 2011)

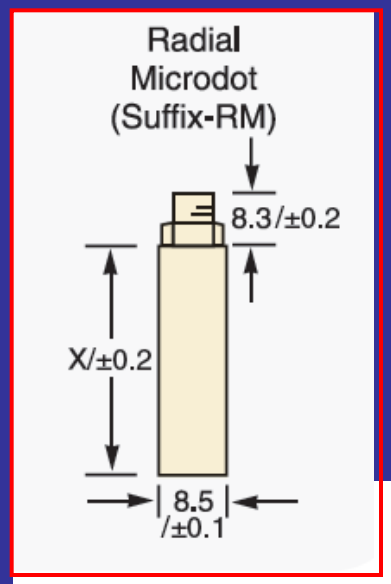
Principle of LINTEL



Detectors #2 – #6 are gated by the signal of detector #1

Cu absorber thicknesses





Detectors and absorbers

Detector number

#1 #2 #3 #4 #5 #6

a b c d e f

34,8

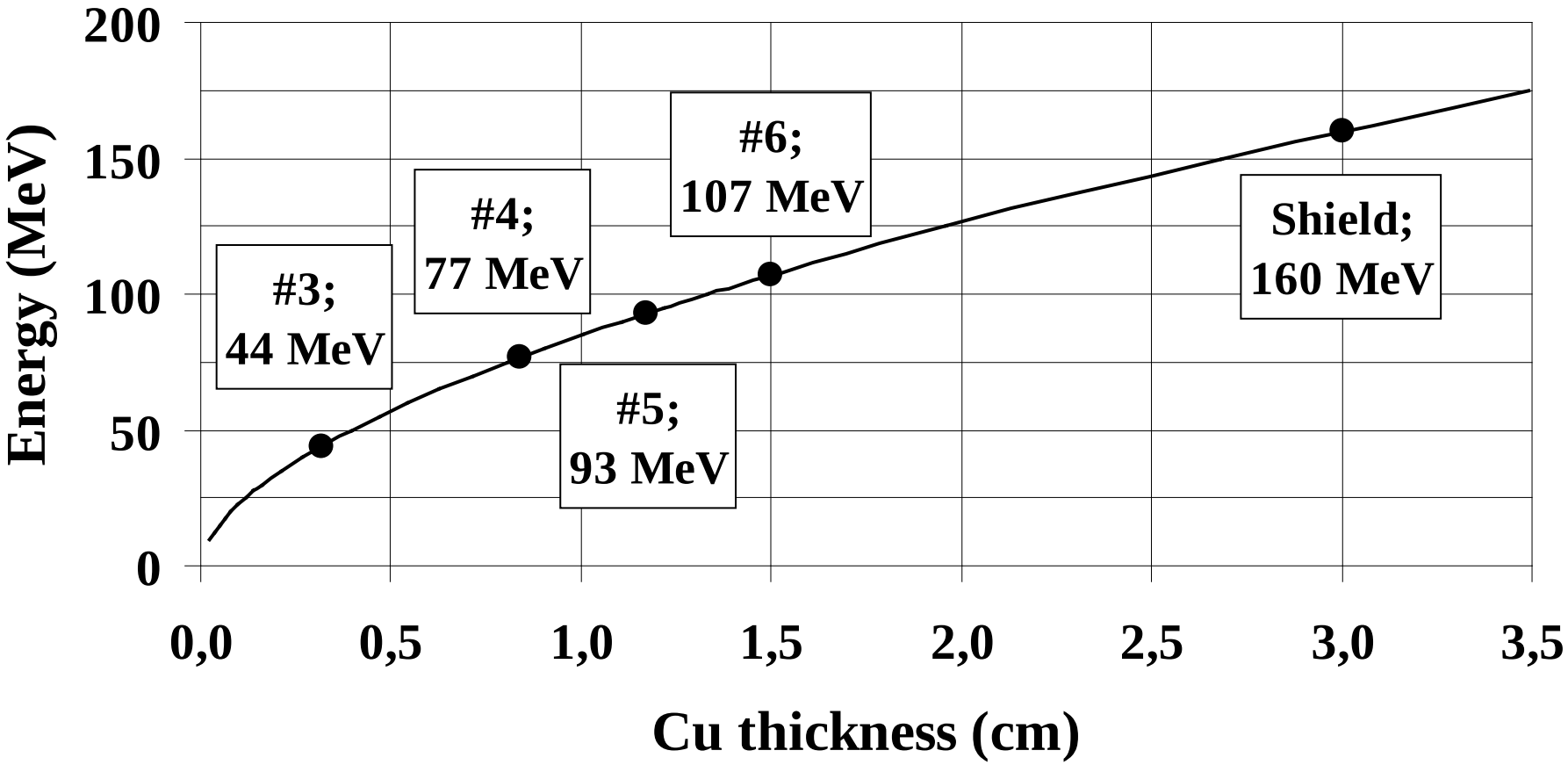
Measuring direction

1

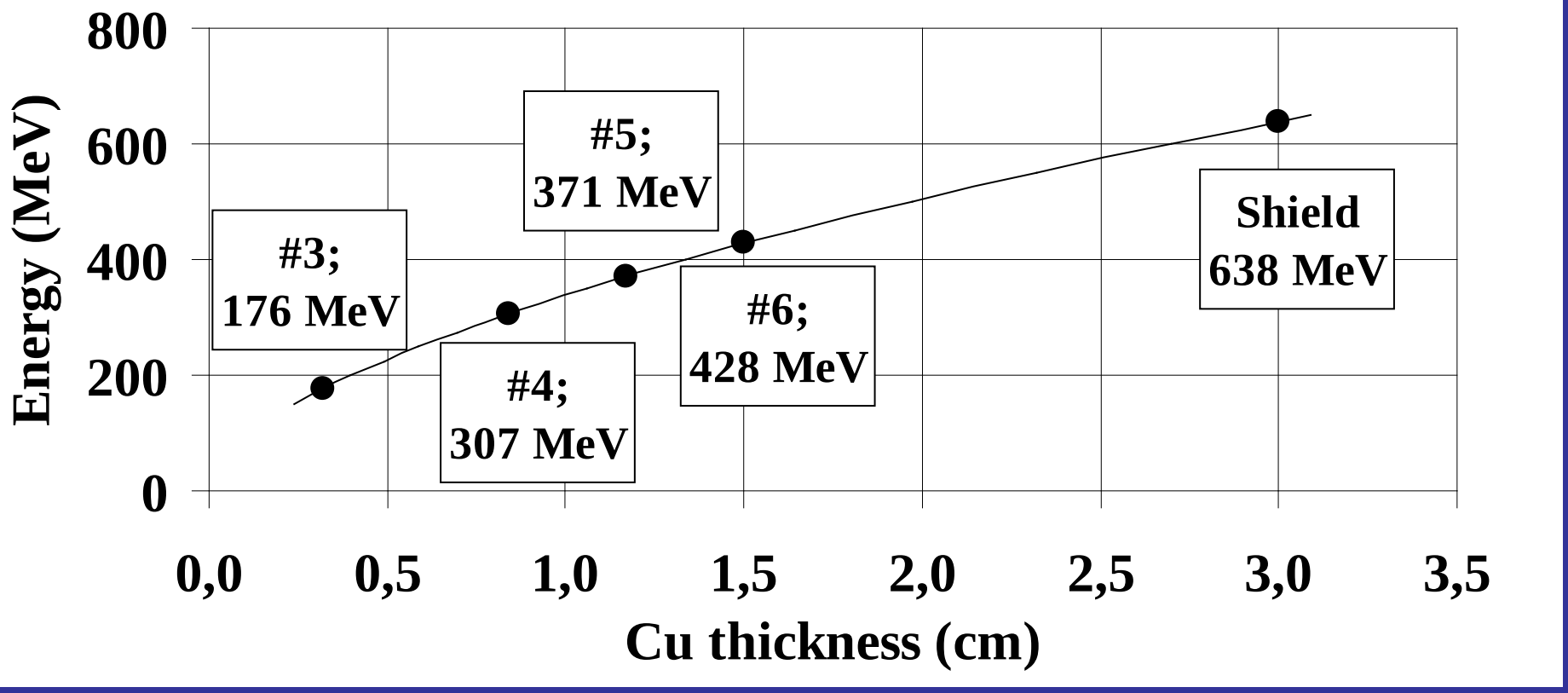
8,5 5,7 3,1 5,1 3,2 3,2 15 mm

PIPS detector Detector house Cu

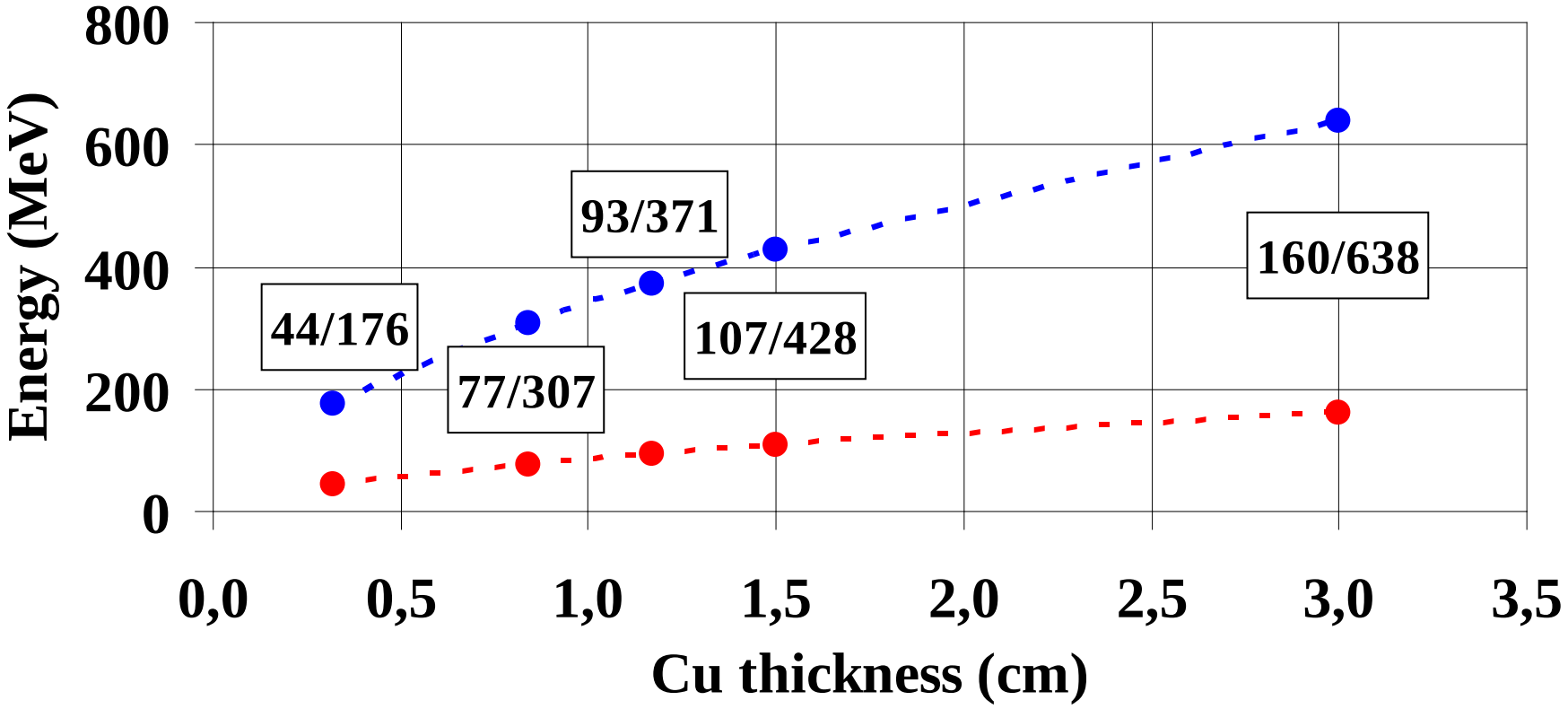
Proton energy limits for detectors #n



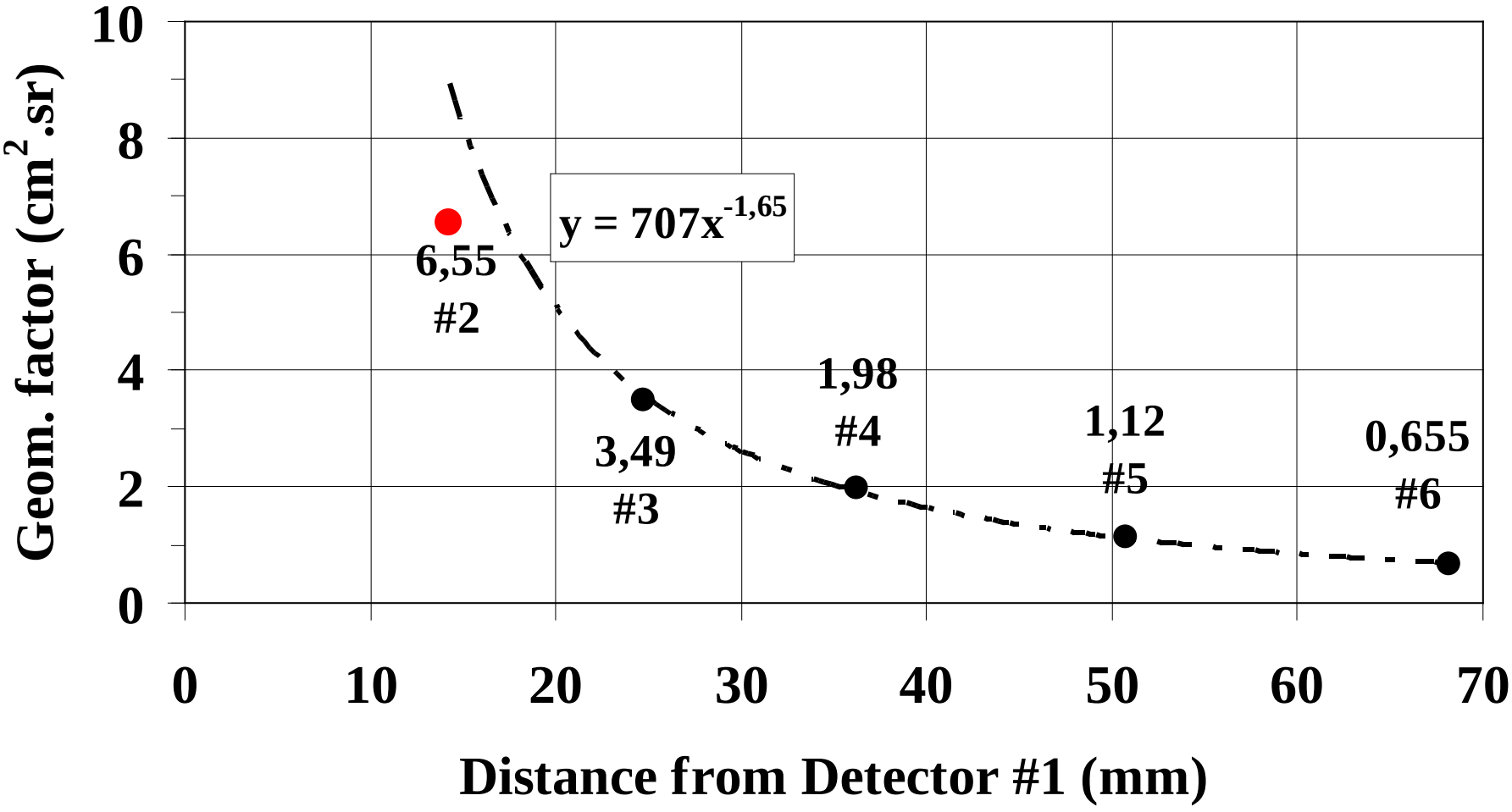
α-energy limits for detectors #n



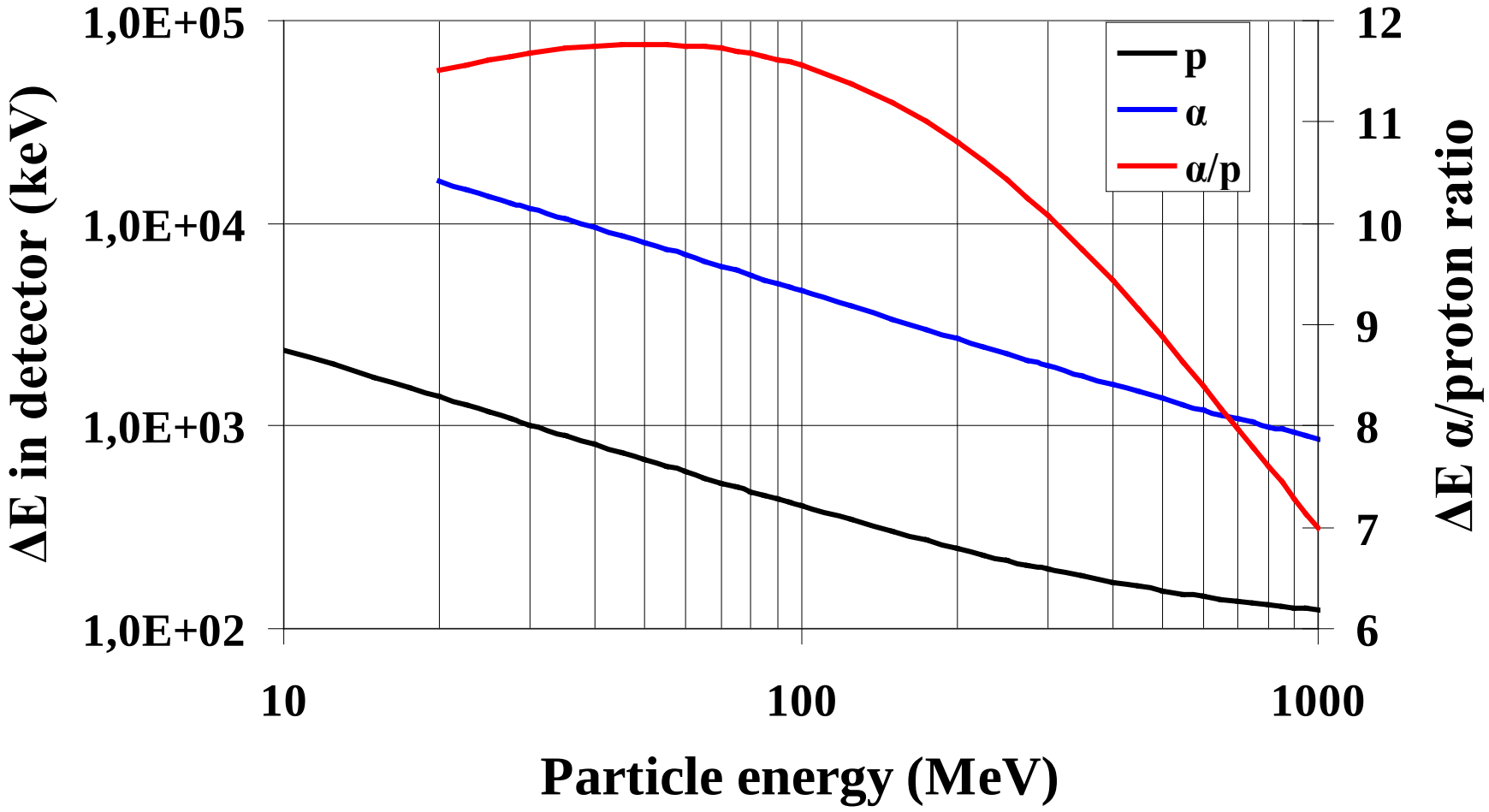
Proton and α-energy limits for detectors #n



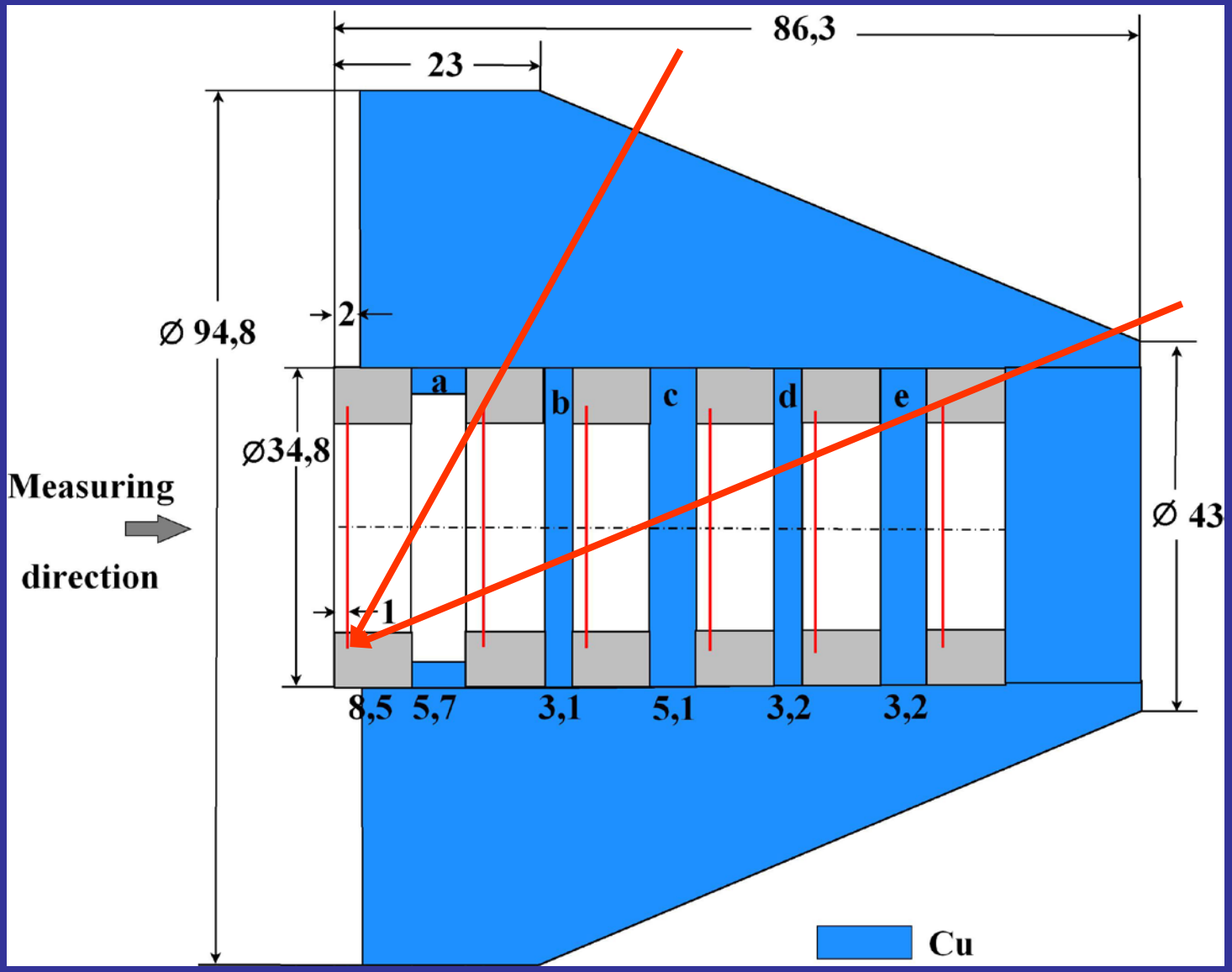
Geometrical efficiencies



Energy deposition in 0,3 mm thick Si detector for protons and α-particles



30 mm Cu shielding against reverse direction particles (penetration: protons >160 MeV, α-particles >638 MeV)



Electronics

Fully based on TRITEL electronics, uses two TRITEL detector units with 3+3 preamplifier cards.

Registers 12 spectra (2 spectra for each detectors):

- One ungated spectrum inside SAA and one spectrum outside SAA (detector #1)

- Five gated by detector #1 spectra, detectors #2...#6) (each inside and outside SAA)

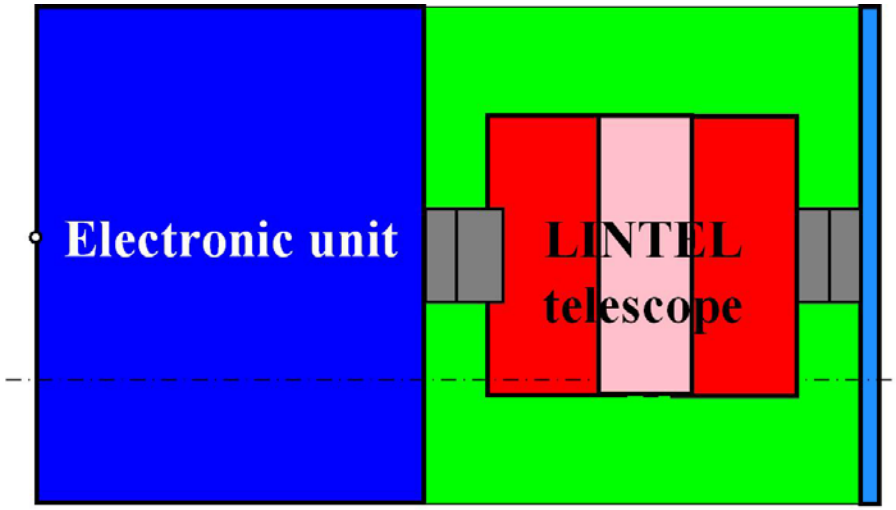
Central (interface) unit is the same one as for TRITELs

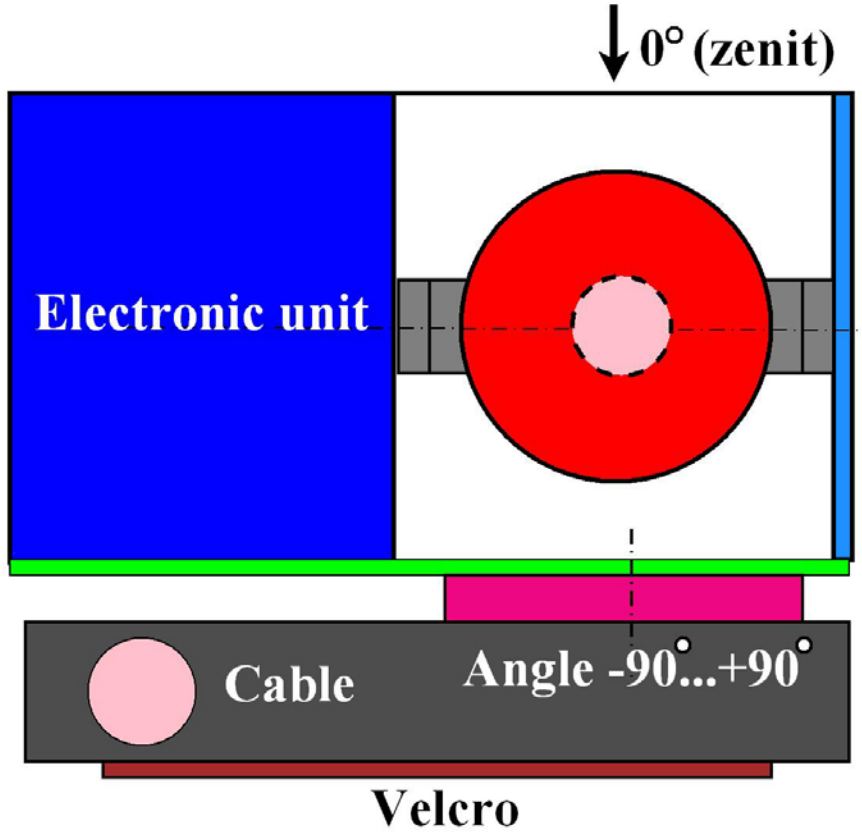
Mechanical construction

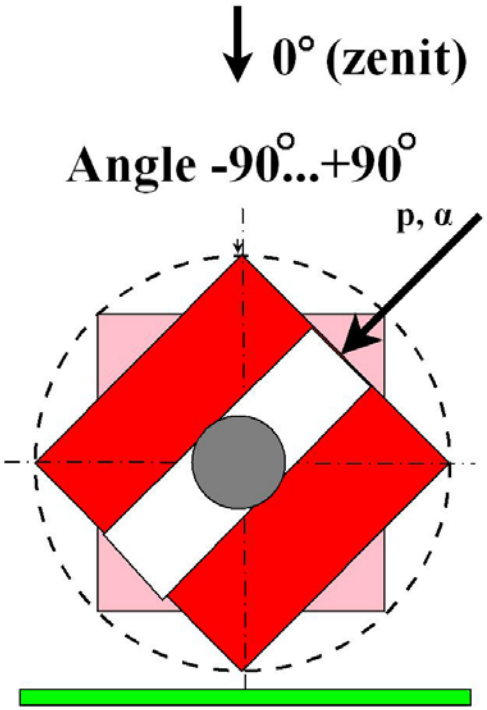
LINTEL detector unit includes electronics of two TRITEL detector units and one LINTEL telescope in a common housing

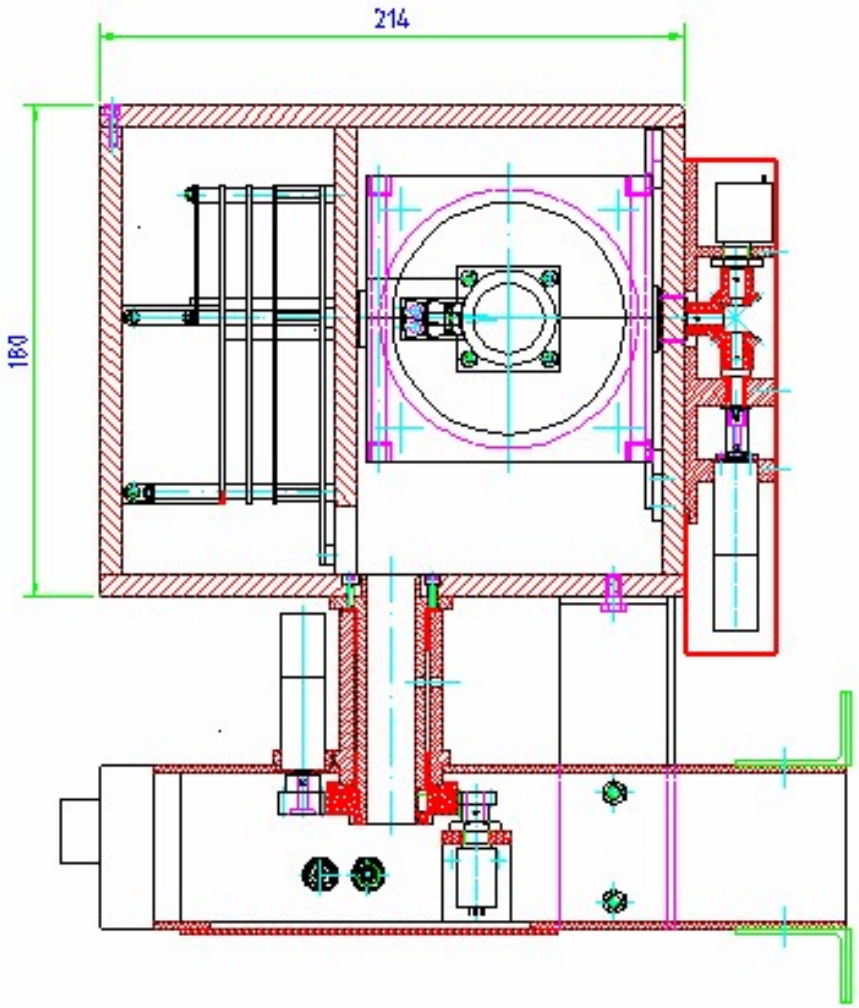
Additional mechanism provides possibility to set in any direction the telescope axis in full 2π solid angle.

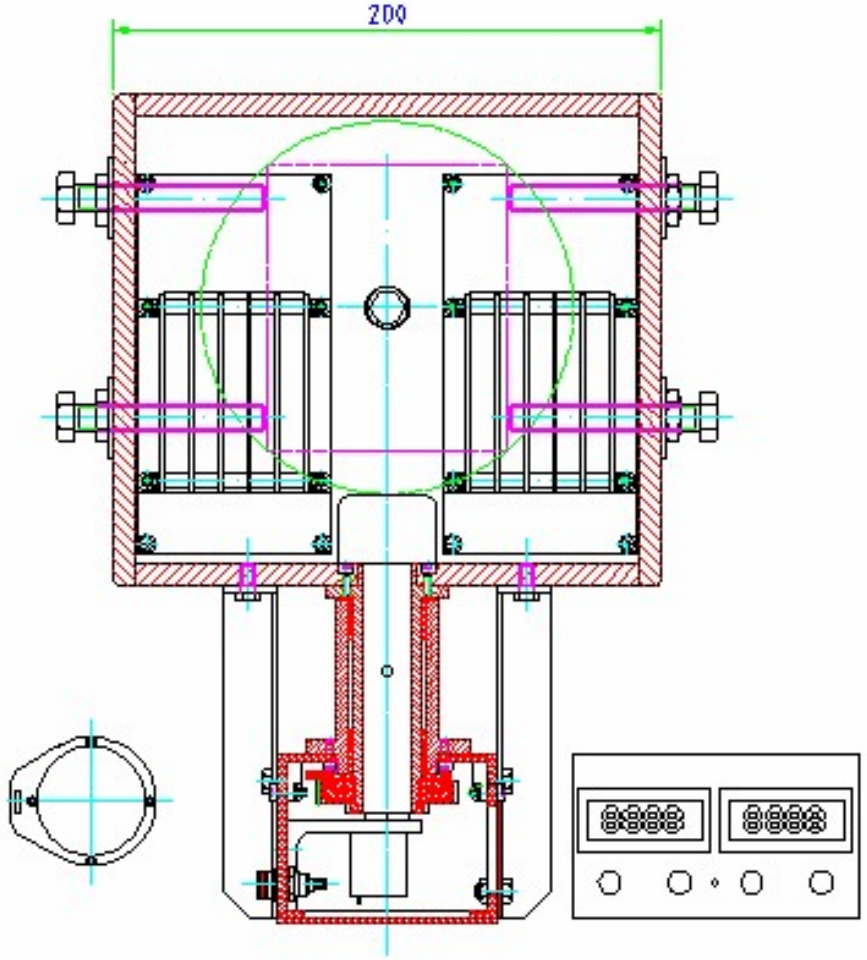
Principle


Electronic unit
LINTEL
telescope


0° (zenit)
Electronic unit
Cable
Angle -90°...+90°
Velcro


0° (zenit)
Angle -90°...+90°
p, α


214
180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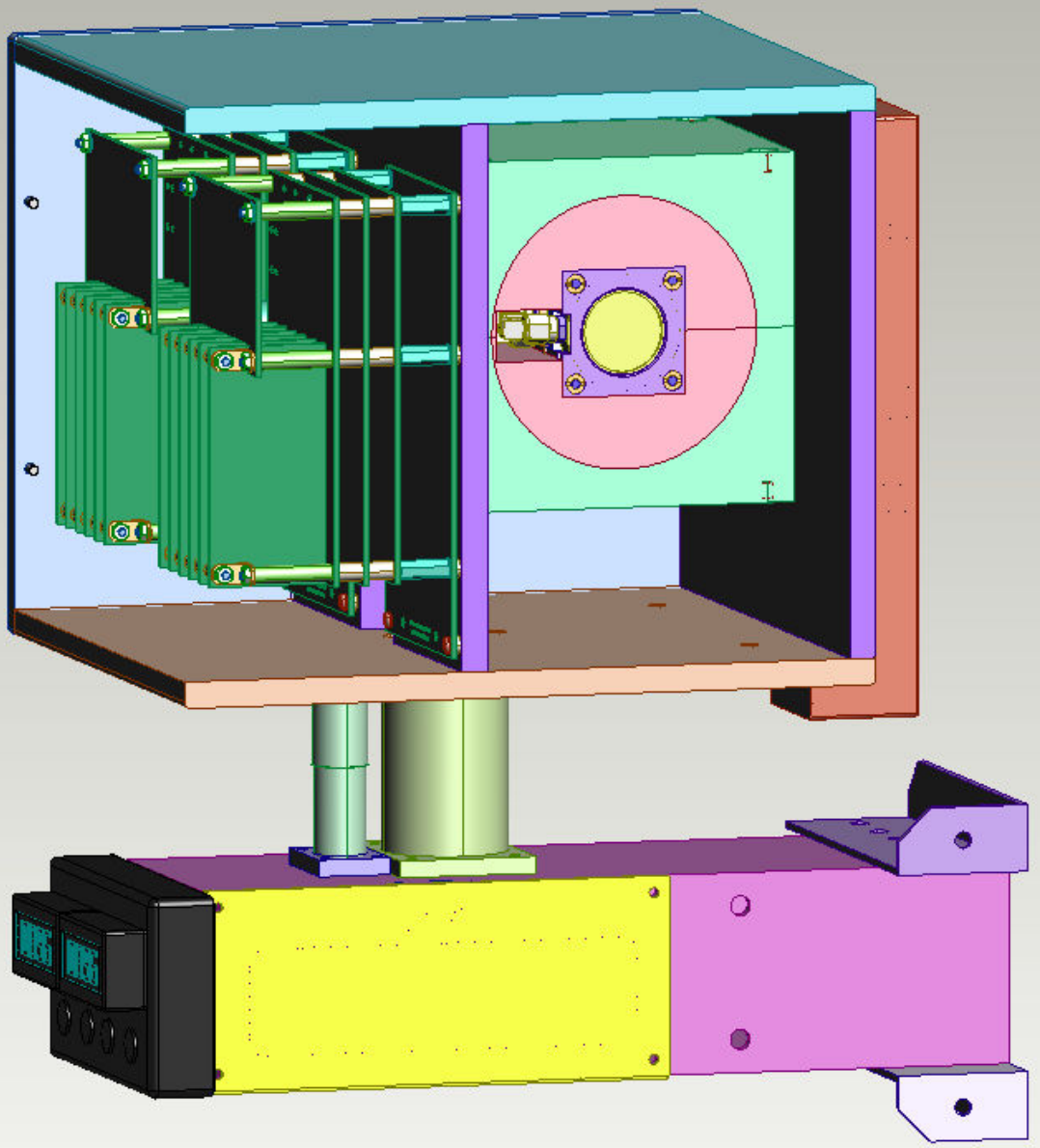
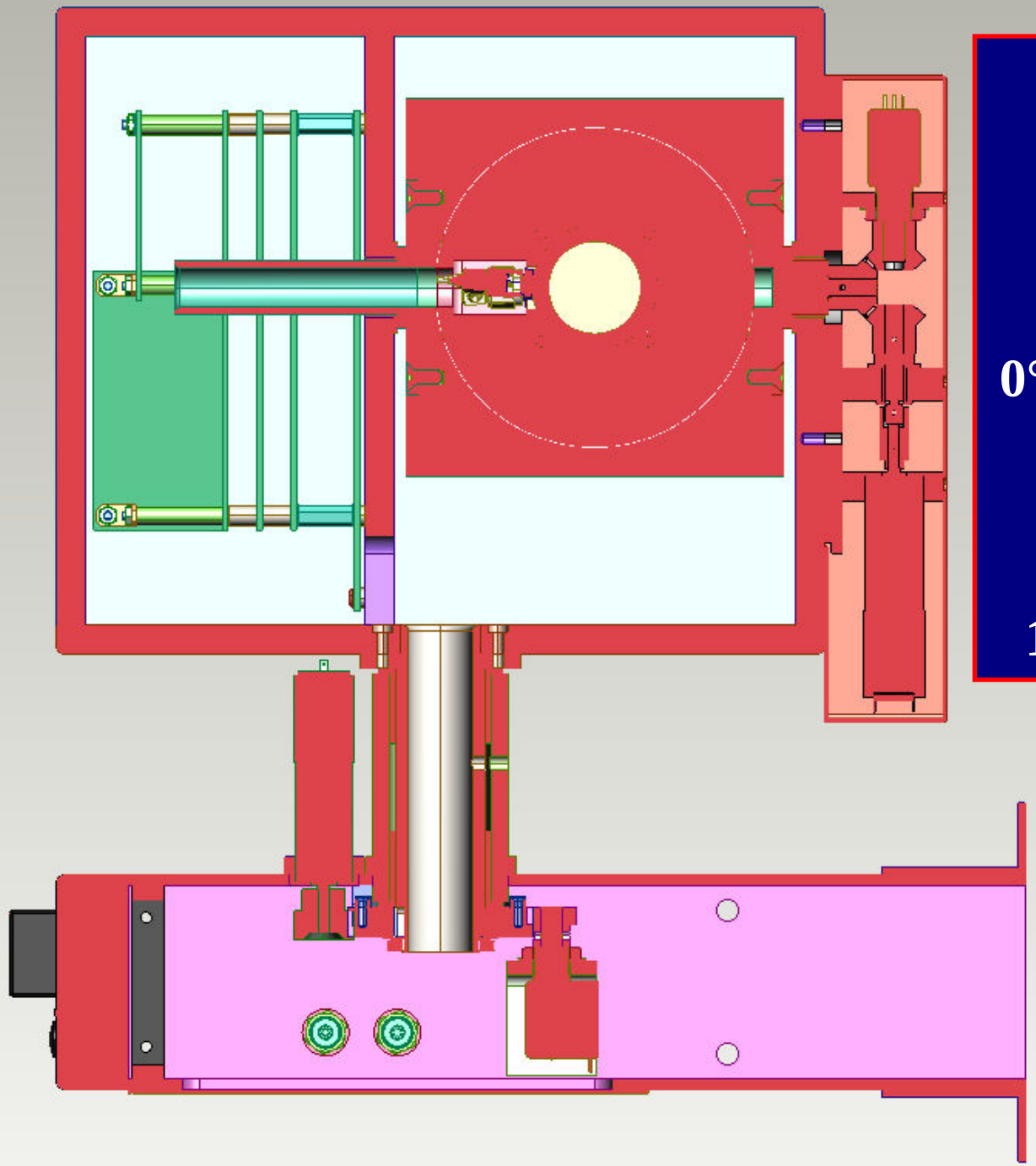




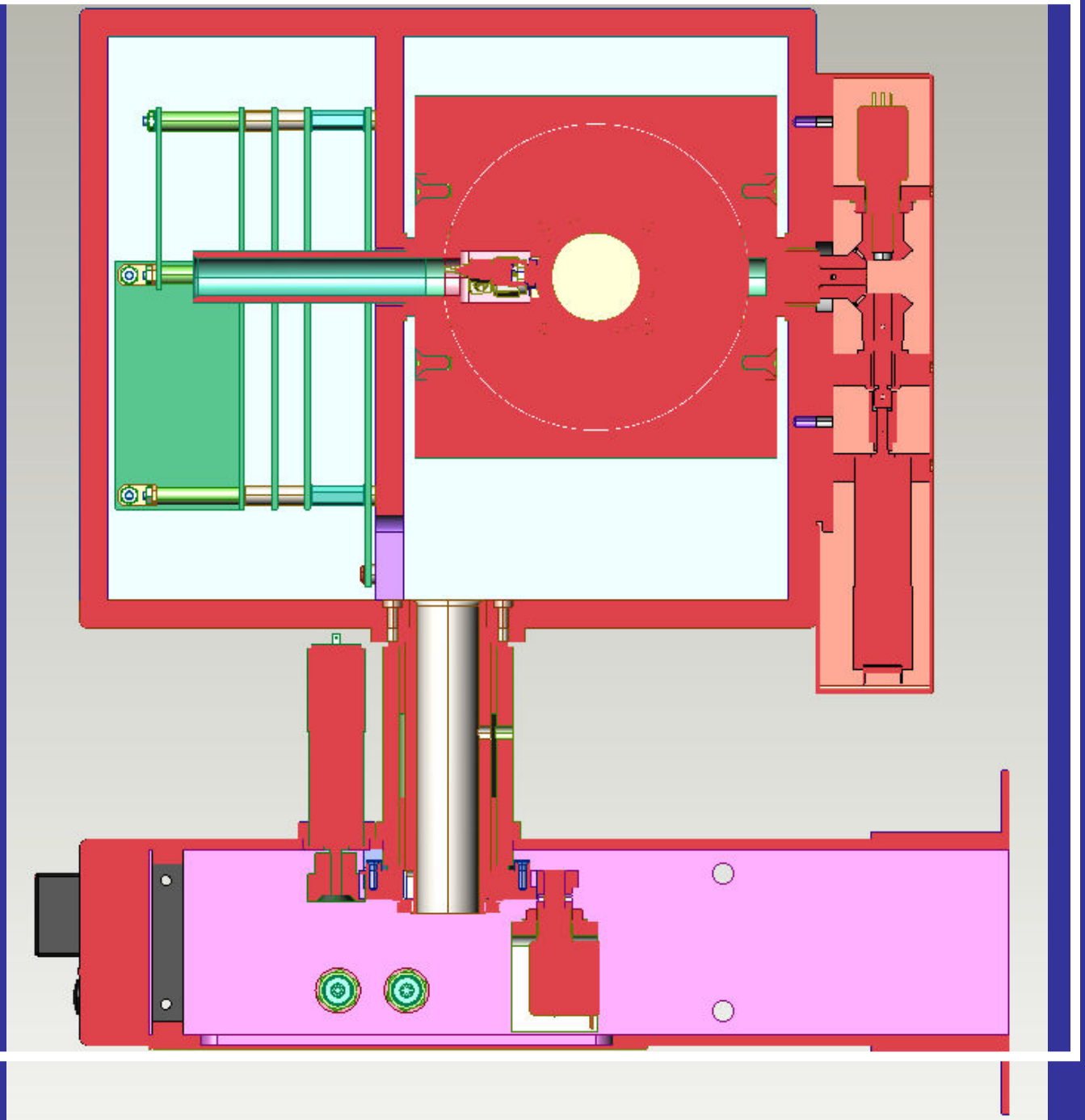
Automatic scanning

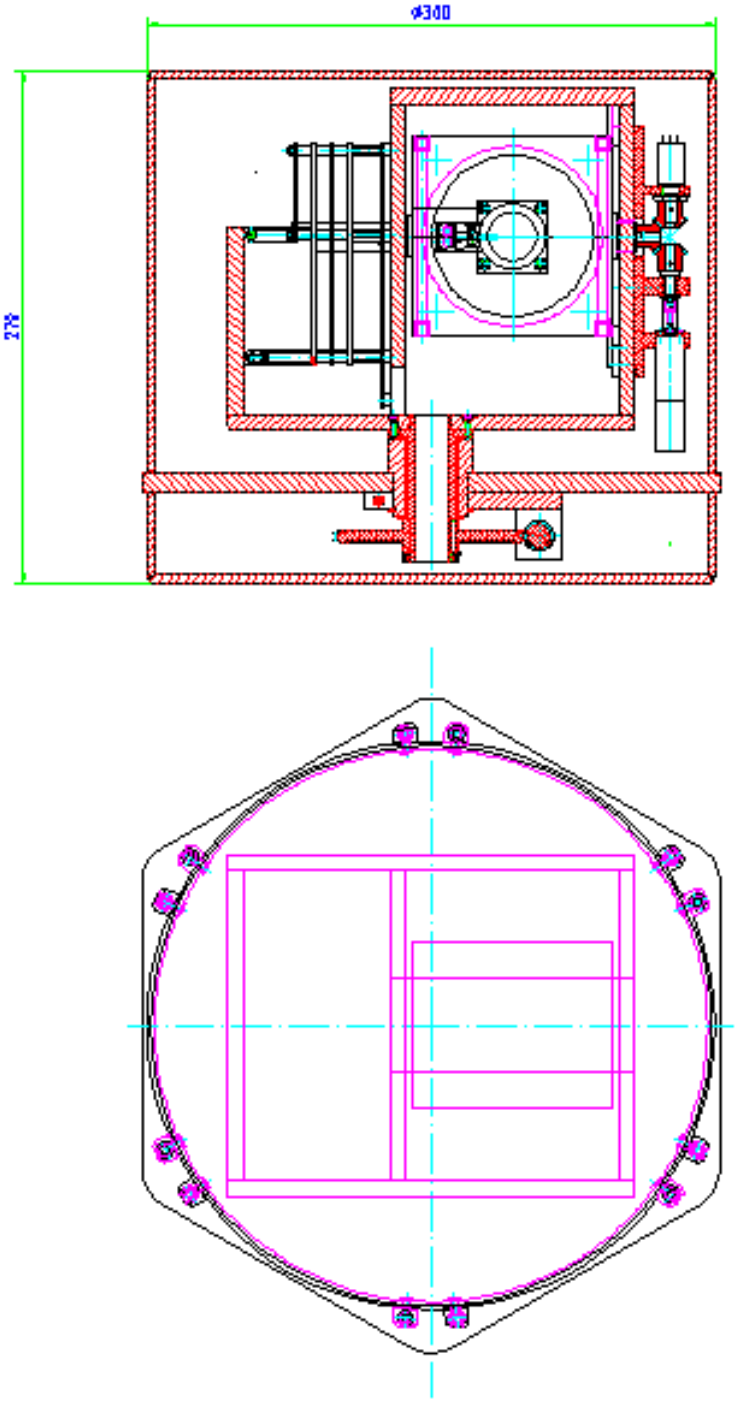
-90° – +90°/15° =
12 points

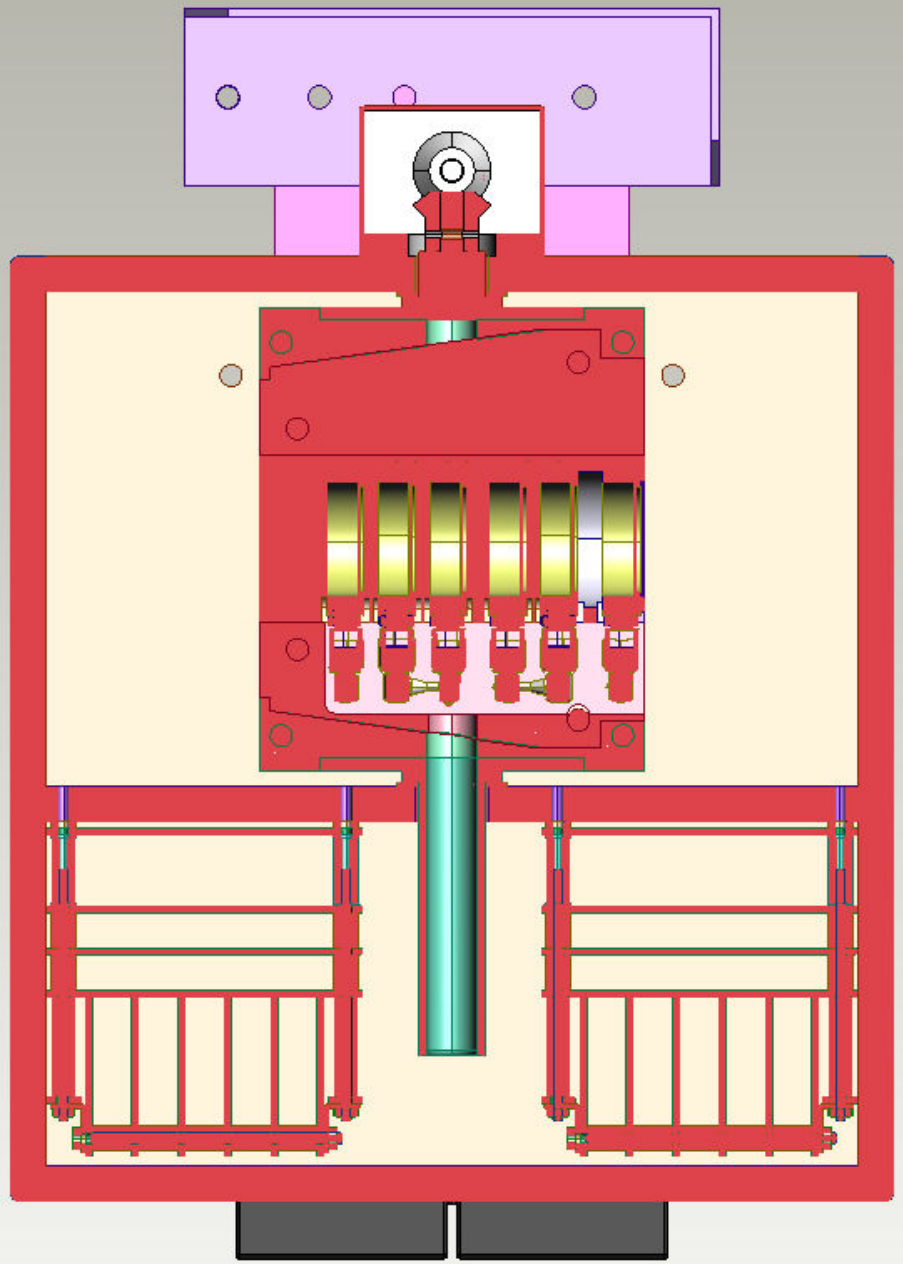
0° – 180°/15° = 12 points

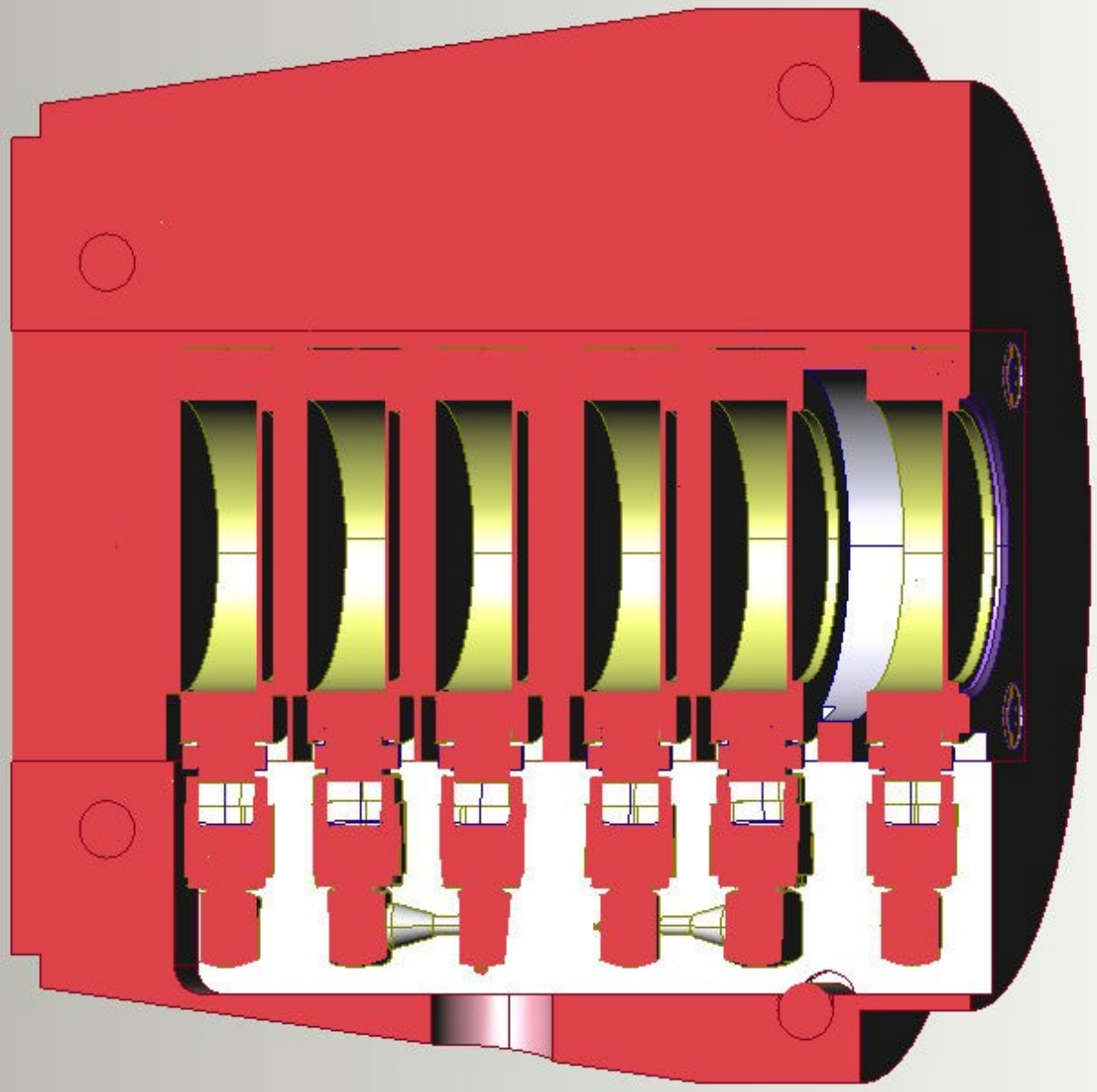
12 x 12 = 144 points

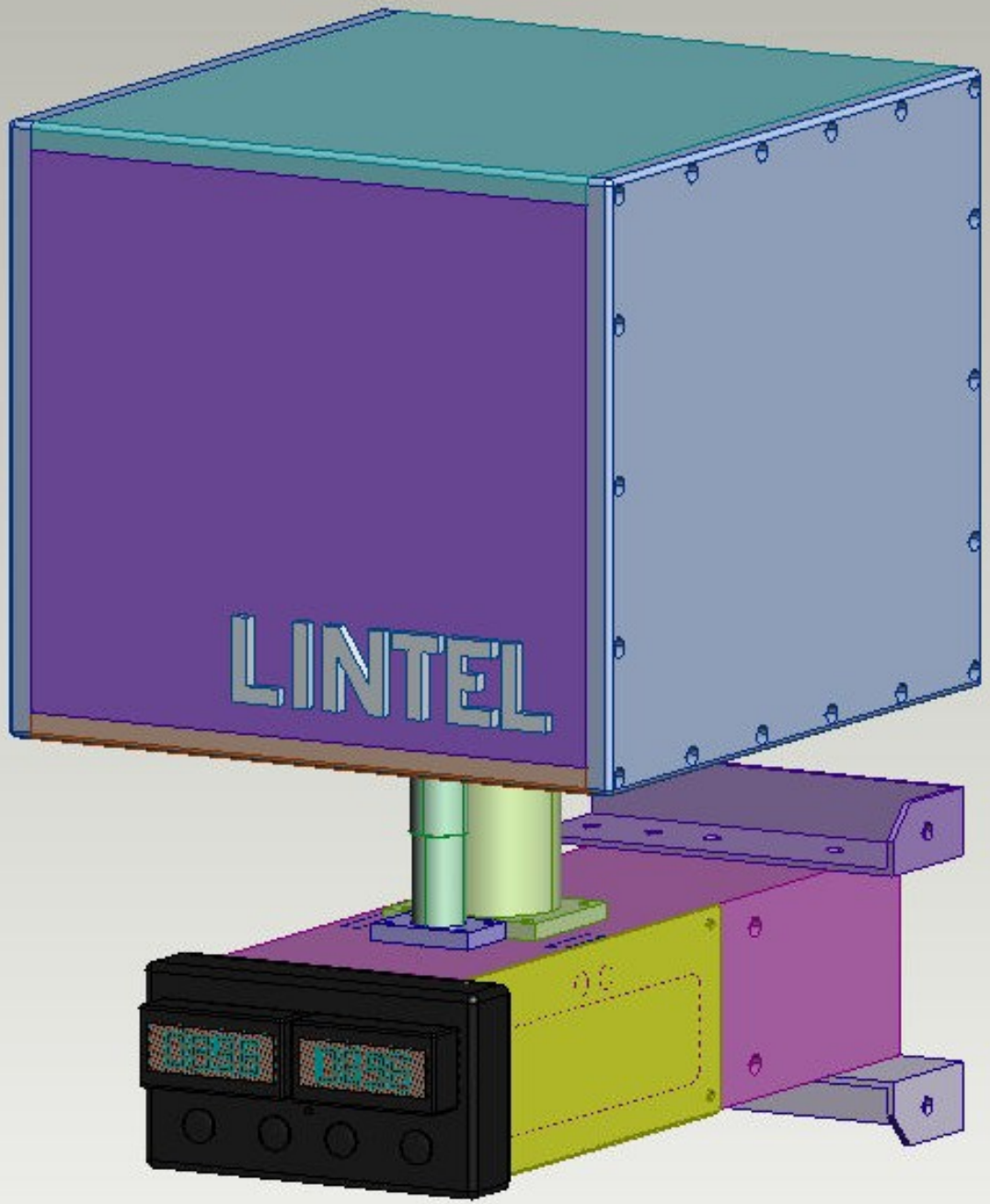
144 days = ~ 5 months

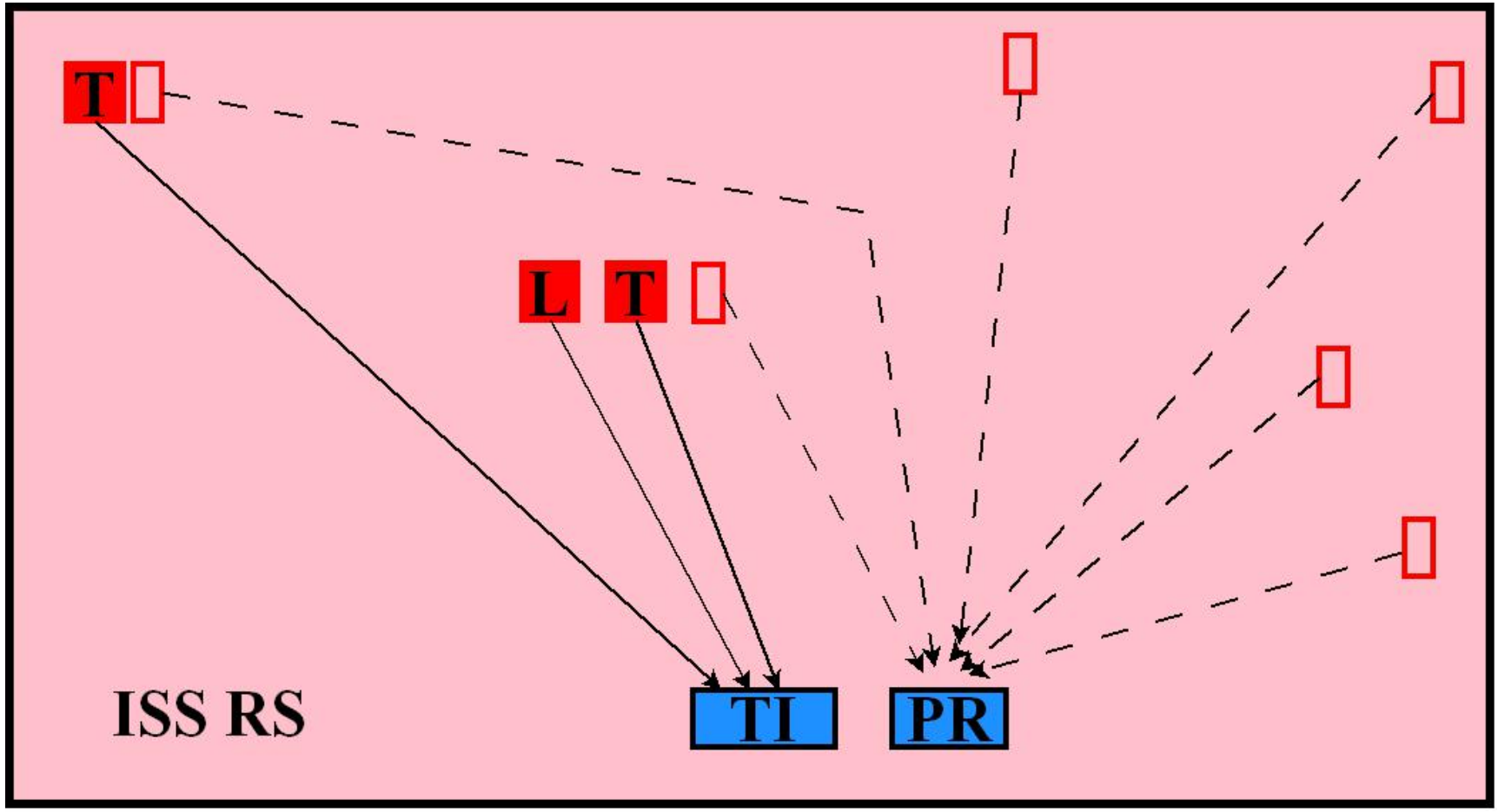



Φ300
278






LINTEL



Marking: ▯ - Pille dosimeter, PR - Pille reader

T - TRITEL Detector Unit

L - LINTEL Detector Unit

TI - TRITEL Interface Unit

Conclusions

Absorbed dose, $D \Rightarrow \surd$ Pille

Dose equivalent, $H \Rightarrow \surd$ TRITEL

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- Dose equivalent in 5 organs $H_{T,Q} \Rightarrow \surd$ LINTEL

- Effective dose equivalent, $H_E \Rightarrow \surd$ to be calculated from LINTEL data

- Radiation field to effective dose equivalent conversion coefficients for galactic and trapped radiation separately

Thank you for your attention!