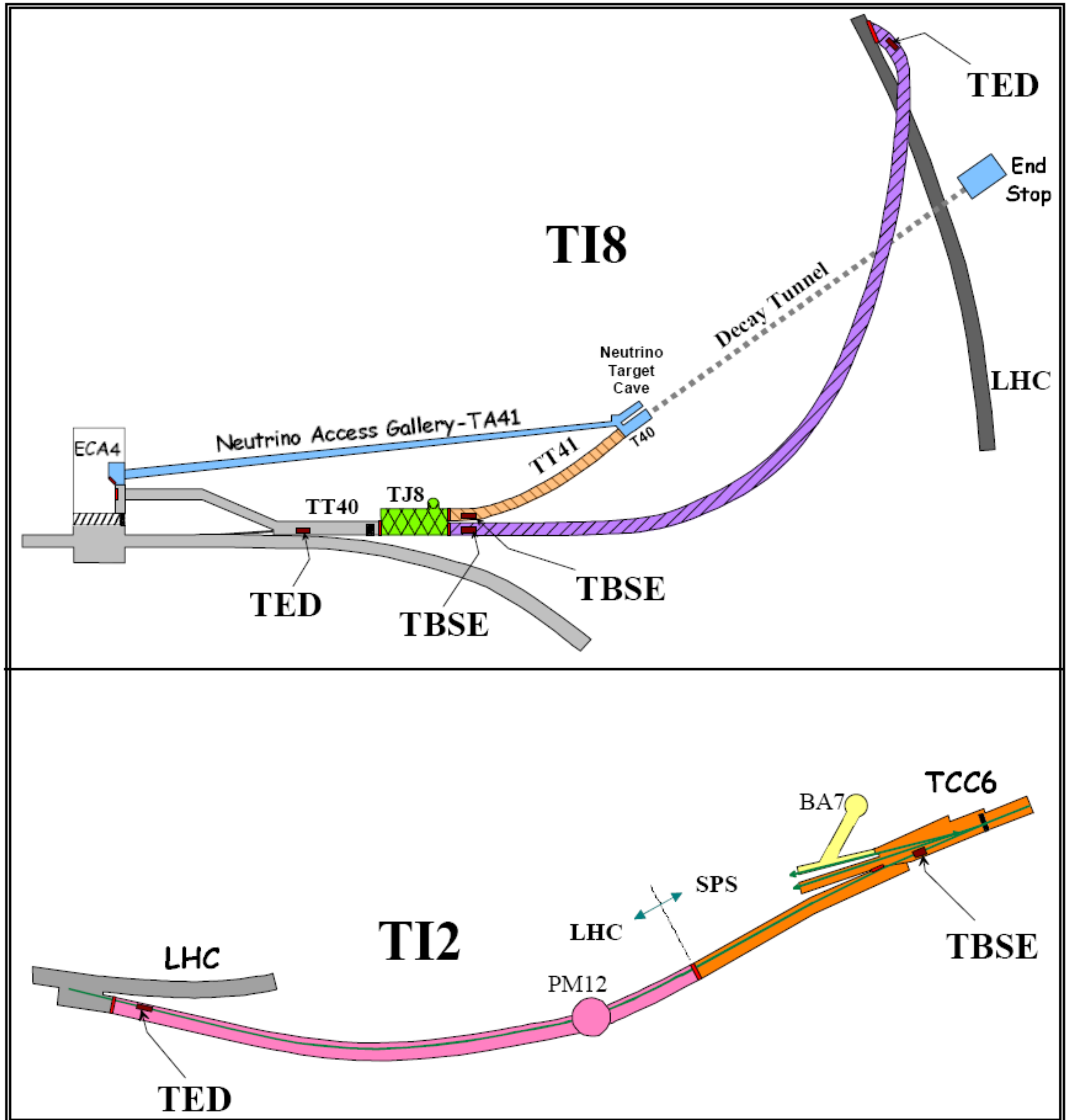
TI8/WIC Incident & UJ87/UA87 Radiation Levels & Analysis

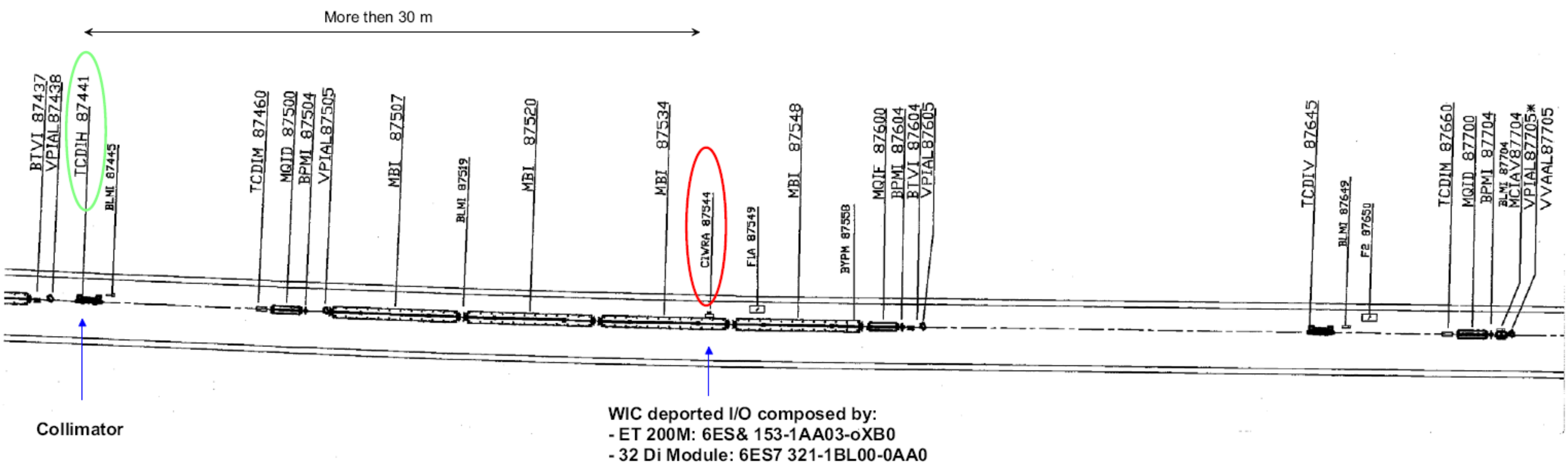
M. Brugger for the R2E Study Group

The Injection Lines



Observations TI8/WIC

- **~2x10^{12} protons** were ‘dumped’ on an injection line collimator (TCDIH 87441), *i.e.*, ~1.2x10^{11} protons per shot [J. Wenninger, S. Redaelli]
  - how many protons have been lost on this collimator before during earlier operations (scaled BLMI 87445)?
- a **WIC crate installed ~30m downstream** (below MBIs) got stuck and this is most probable due to an SEE [P. Dahlen]



Beam Loss & Normalisation

- how do the ~$2x10^{12}$ (and ~$1.2x10^{11}$) protons compare **to 'normal' operation**
  [based on an old loss analysis by B. Goddard]:
  - **full injected batch: ~$3x10^{13}$**
    (such a loss could arise through a steering error or a converter trip during the interlock dead time prior to extraction -> this was estimated to happen once every few years)
  - **regular loss** (depending on sigma and beam): between **$1.5x10^{10}$ and $2.6x10^{11}$ per injection and collimator**
    (this fits to the estimated 1% of full injected batch)
  - $2.5x10^{10}$ per injection and collimator was at that time the given 'work estimate'
- the possible number of annual WIC **failures will however scale with the integrated fluence**, *i.e.,* one has to consider *e.g.*, the annual number of injections, thus about 400!
  (in case the operational scenario of one full injected batch per LHC fill is kept)

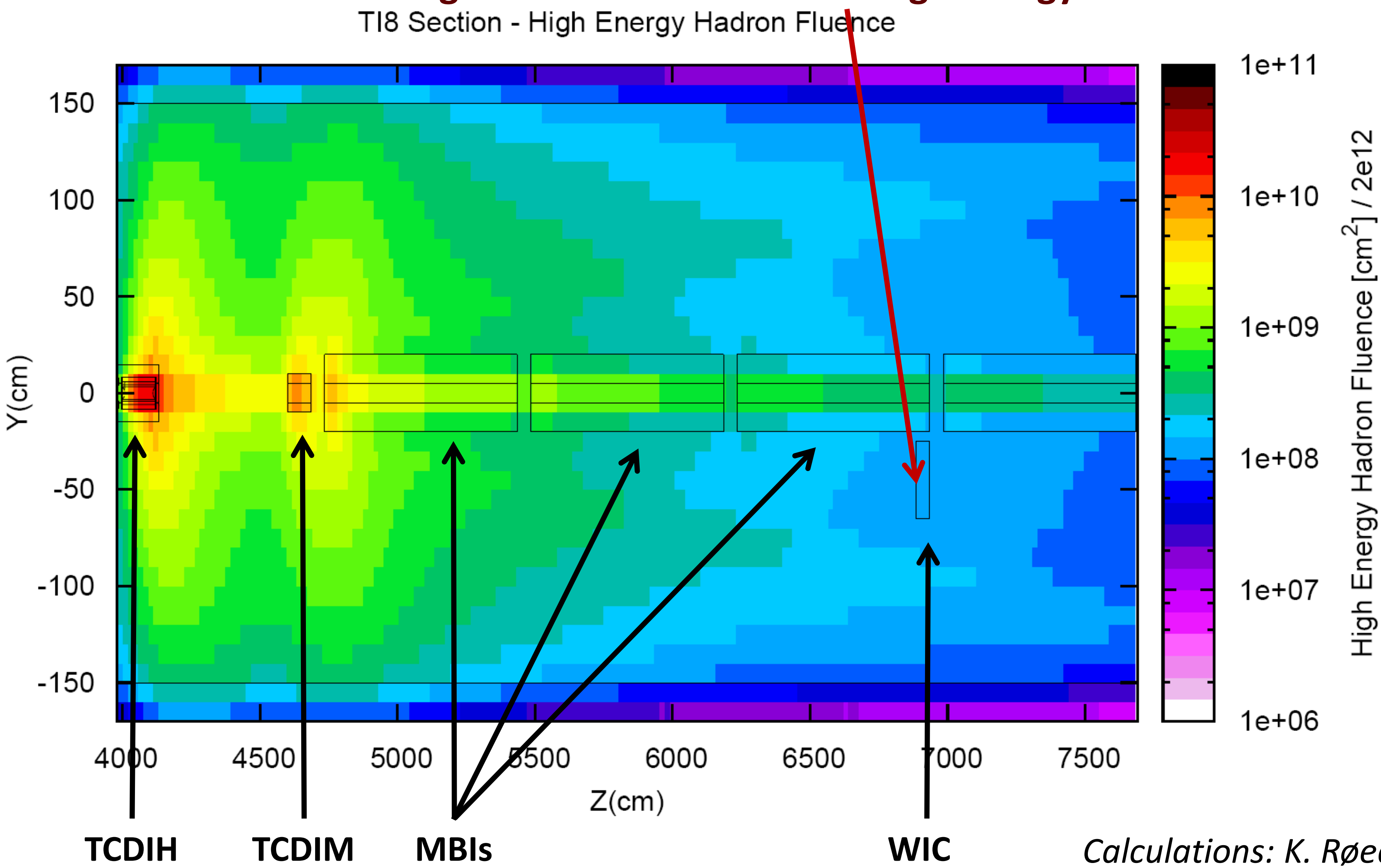
Radiation Levels

- a **FLUKA simulation** (collimator + downstream magnets) was put in place **to have a quick check on the radiation and particle energy spectra at the location of the electronics** (see following slides)
  - 1.2×10^{11} 450 GeV protons on collimator
  - radiation map downstream looking at the rack location below the magnet
  - analysing:
    - high-energy hadron fluence
    - particle energy spectra
    - possible low-energy neutron component
- an **over-the-thumb (very rough) estimate** based on available calculations at IR7 currently gave the following conservative estimate:
  - **a few 10^8 to 10^9 high-energy hadron fluence (per 1×10^{11} protons dumped on the collimator)**

Radiation Levels per $2x10^{12}$ protons lost

!!! SIMPLIFIED CALCULATION !!!

- **At the WIC location one gets about: $2x10^8$ cm^{-2} of High Energy Hadron Fluence**

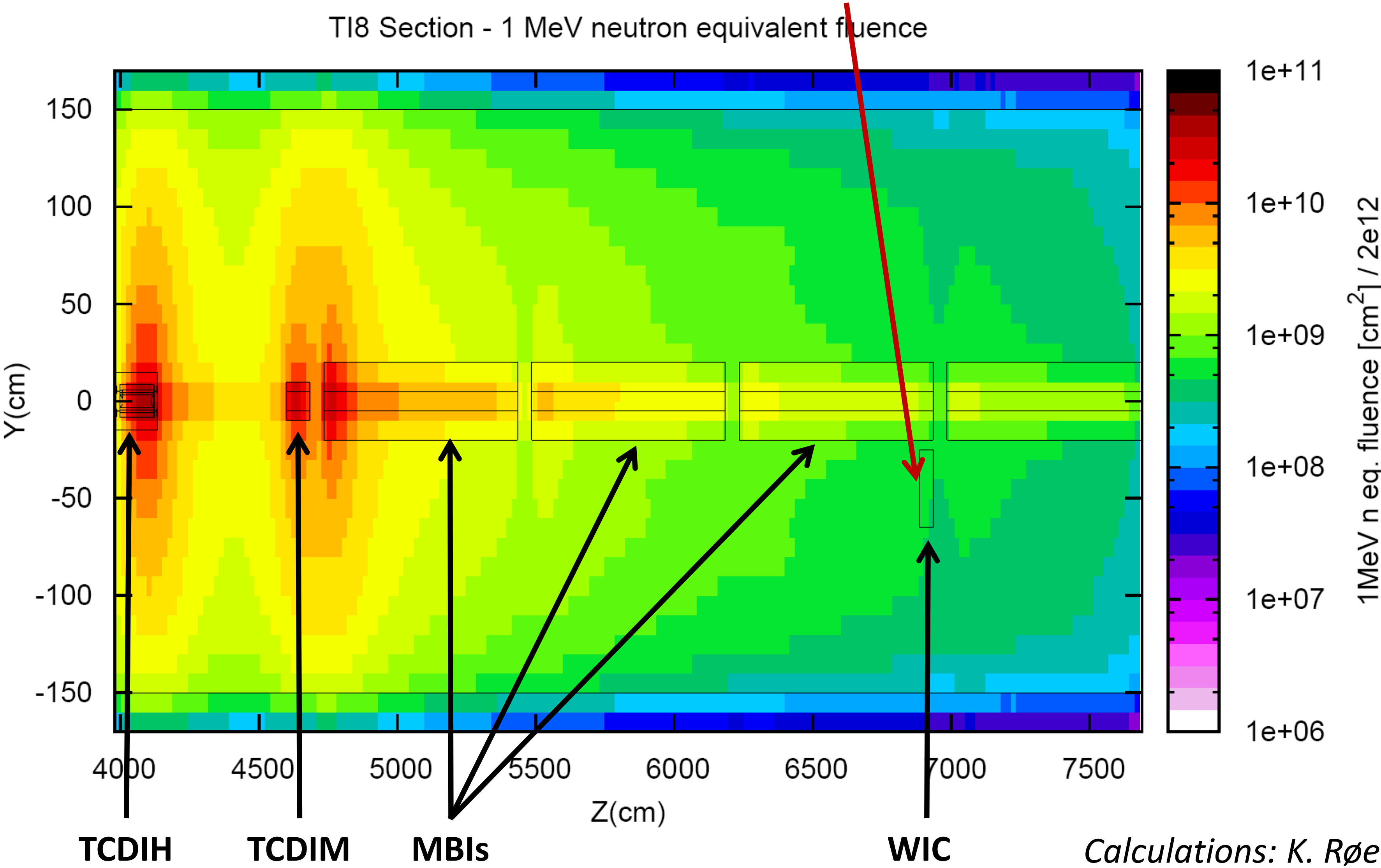


Calculations: K. Røed

Radiation Levels per $2x10^{12}$ protons lost

!!! SIMPLIFIED CALCULATION !!!

- **At the WIC location one gets about: : $6x10^{8}$ cm^{-2} of 1MeV Neutron Equivalent**

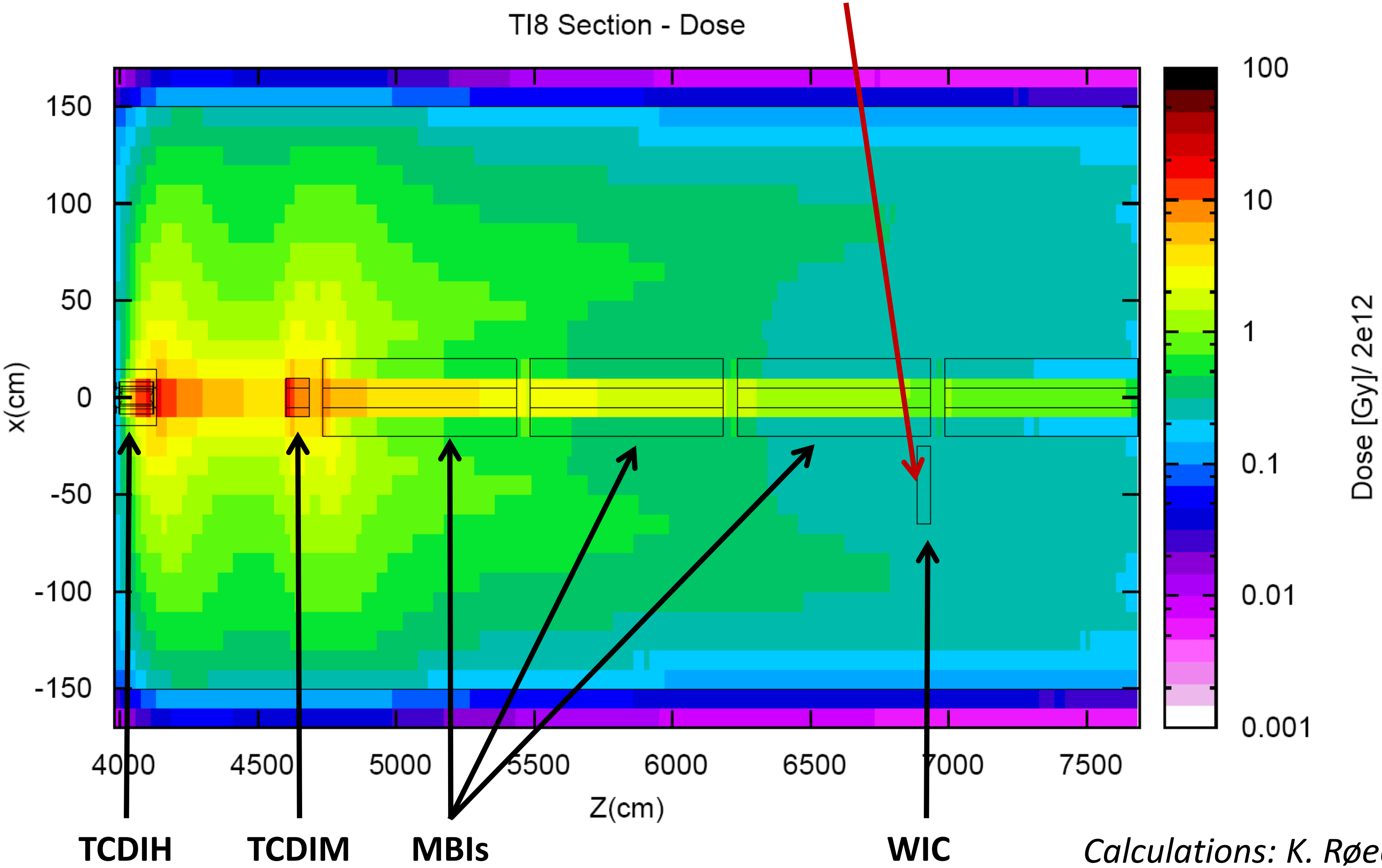


Calculations: K. Røed

Radiation Levels per $2x10^{12}$ protons lost

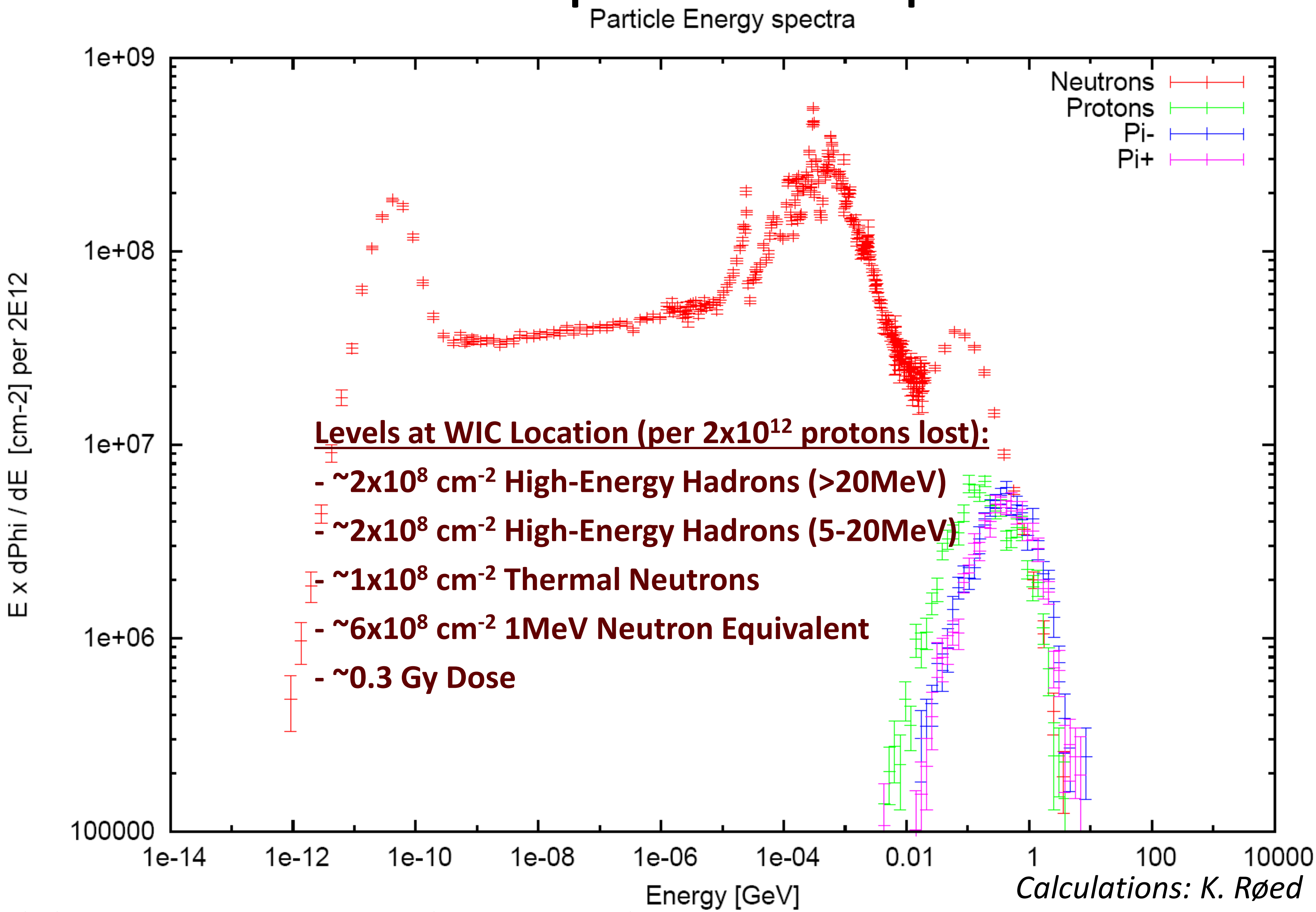
!!! SIMPLIFIED CALCULATION !!!

- **At the WIC location one gets about: 0.3 Gy of Dose**



Calculations: K. Røed

Radiation Levels per 2×10^{12} protons lost



Levels at WIC Location (per 2×10^{12} protons lost):

- **~2×10^{8} cm^{-2} High-Energy Hadrons (>20MeV)**
- **~2×10^{8} cm^{-2} High-Energy Hadrons (5-20MeV)**
- **~1×10^{8} cm^{-2} Thermal Neutrons**
- **~6×10^{8} cm^{-2} 1MeV Neutron Equivalent**
- **~0.3 Gy Dose**

Calculations: K. Røed

WIC: Affected Module – ET200M

P. Dahlen, T. Wijnands

- **This module allows the communication of the data from the I/O modules over the Profibus Fieldbus connection**
- **Radiation tests:**
  - with a flux of **~10^8 p/cm^2/s this module shows bus errors** but the module manages to recover without external intervention provided the beam was stopped
  - **reproducible (six times) up to a total fluence of 1.8x10^{11} p/cm2**
  - giving a (very rough estimated!) **cross section of 3.3x10-11 cm^{-2}** (an identical module gave ~6 x10^{-11} cm^{-2})
- **Reason of failure ('hanging'):**
  - most probably the **Profibus address of the module is changed**, thus by reinitializing the module, the correct hardware address is loaded back into the SRAM and the device works normally again
- **Consequence:**
  - **In case of failure (module 'hangs'), the device needs to be reset (by distance), thus the beam needs to be dumped**
  - **In TI8 this also leads to a beam-dump for CNGS**

WIC Locations & Consequences

- Locations and Number:
  - racks locations where (for TI8) decided without knowing the collimator locations
  - **18 racks in TI8 (**one of them downstream of collimators)
  - **~20 racks in TI2** (also one of them downstream of collimators)
  - a relocation of these racks was already discussed in the past
- We have **one event only**, *i.e.*, a single measurement of a Gaussian distribution (around an tested cross section of ~3x10^{-11}), still the integral number of protons for the full operation time (2008/2009) should be checked
- A possible contribution due **to low-energy neutron fluence** would require a significantly higher respective cross-section at these energies (**unlikely**)
- If the failure is confirmed to be related to SEEs then the affected rack(s) **could be relocated** (at least upstream the collimator locations), or **local shielding could be discussed** (easier and significant reduction possible due to 40-80cm iron block upstream)
- Independently, **as a precaution** the **foreseen early WIC relocations** from critical LHC areas (*e.g.,* US85) could become even more urgent and we need to understand further what happened (future tests, CNGS tests)

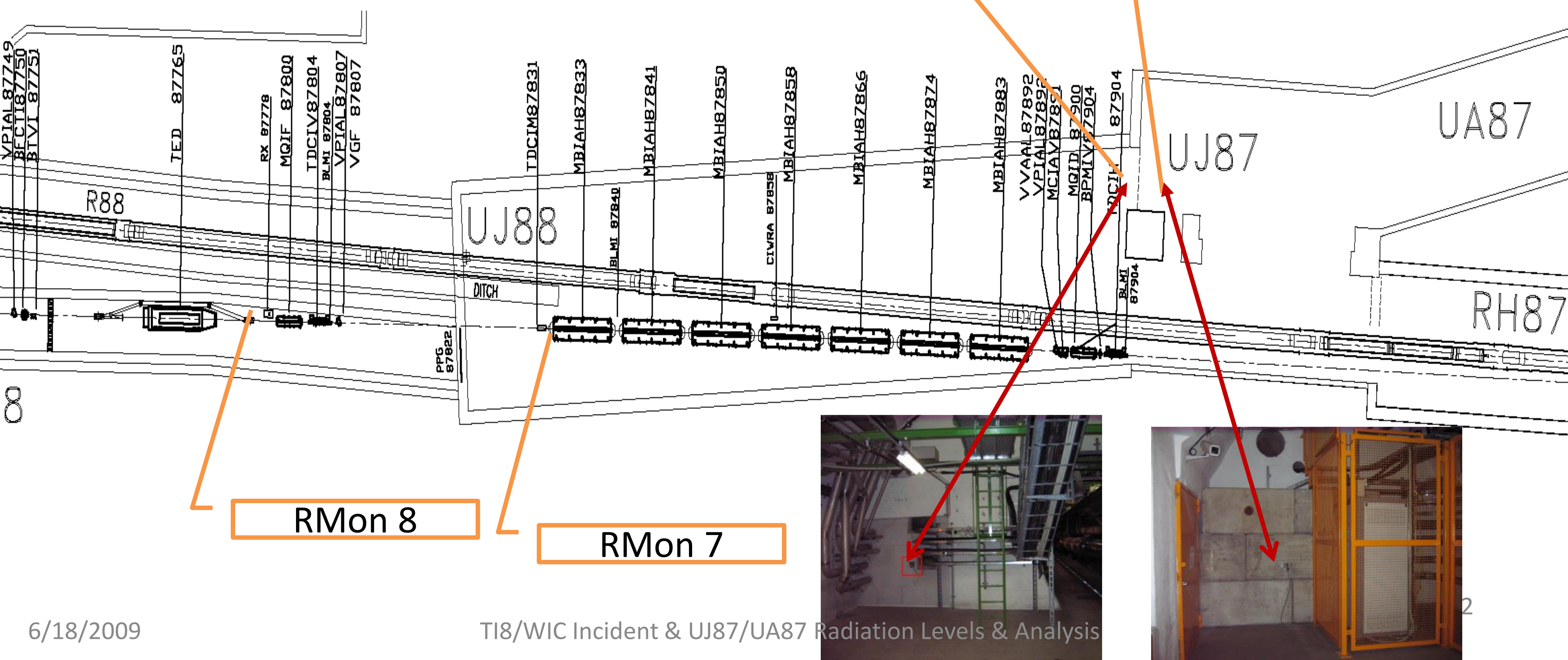
UJ88/UJ87/UA87 Observations

- **RadMon Positions and Settings (some are set to 3V)!**
- Integrated values Hadrons>20MeV:
  - UJ88 – 8: 6.96e+9 cm^{-2}
  - UJ88 – 7: 2.68e+8 cm^{-2}
  - UJ88 – 6: 9.32e+6 cm^{-2}
  - **UJ87 – 1: 1.69e+6cm^{-2}** (two counts only!)

RMon 1 — 3V

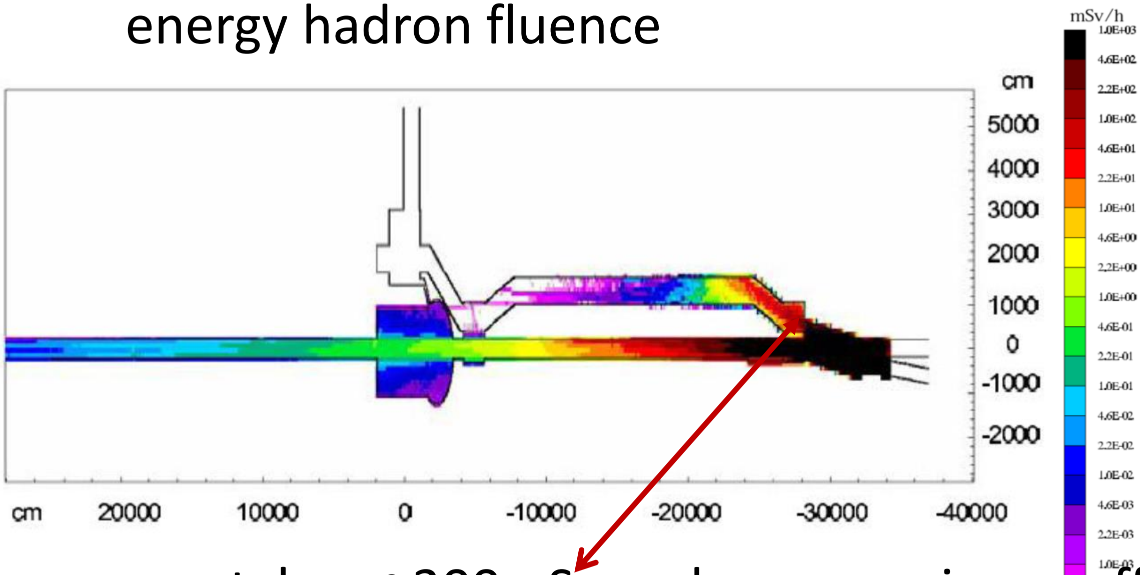
RMon 6 — 3V

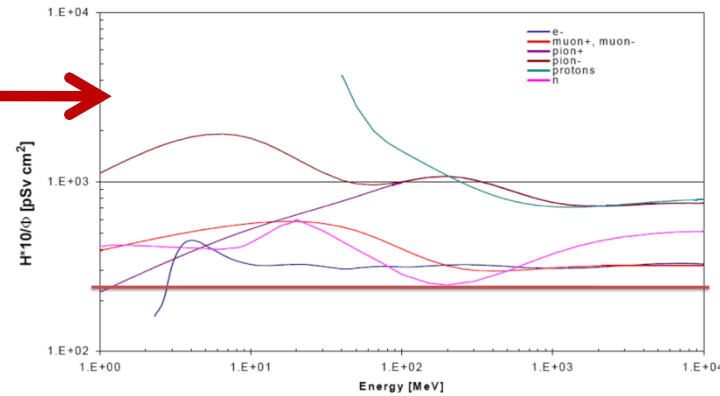
Refers to total losses of this weekend, *i.e.*, ~5.6x10^{13} !!!



UJ88/UJ87/UA87 Analysis

- Estimate **based on RP Calculations** [H. Vincke et al.] as already **analysed through R2E** end of 2008, where estimates for prompt dose equivalent can be used to get a rough estimate of a maximum equivalent high-energy hadron fluence





- one takes: ~300mSv and a conversion coefficient of ~200pSvcm^2
- this referred to 1.44x10^{16} protons on the TED (maximum annual estimate)
- this gave an estimated maximum **high-energy hadron fluence of ~10^8-10^9/cm^2/year**, however not including the 80cm of concrete and some other conservative assumptions
- **fully consistent to the current RadMon reading: ~2x10^6 (@3V), thus ~some 10^5 (@5V) high-energy hadrons, which would give ~10^8/year**

UJ88/UJ87/UA87 Conclusions

- The situation was **identified through R2E already in 2008**
- The observed (and estimated radiation levels) refer to the **worst case location** just behind the shielding wall (levels in the UA are lower!)
- The **shielding wall** between the UJ88 and UJ87 **can be improved** and this area is in the list of suggested actions
- The final radiation levels in the UJ87 and especially in the UA87 will strongly depend on the **chosen operation scheme** (how many full intensity batches are dumped on the TED), thus any action was so far put on hold
- This TI8 test **measurements are fully consistent with the expectations and the simulation estimates** are confirmed within the given uncertainties
- **Later tests this year (ideally with high-intensity), as well as a decision on the operational scenario shall trigger the decision if and when to improve the concerned shielding wall**