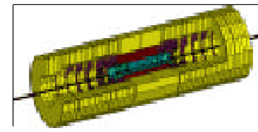
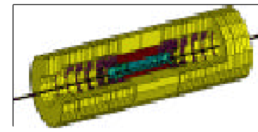
ATLAS inner detector activation studies



Richard Hawkings

IDSG meeting 6/11/02

- Work done by V Hedberg, M Morev, etal
  - ISTC project with MEPHI Moscow
- Sources of activation in ATLAS ID:
  - Thermal neutron capture (n, γ) giving delayed γ or β particle.
  - High energy hadrons $\Rightarrow$'stars' $\Rightarrow$radioactive nuclei
- Radiation limits:
  - **15 mSv/year** maximum allowed at CERN
    - 0.4-4 mSv/year from natural background radiation
    - >1 Sv gives acute radiation sickness
  - Maintenance operations must be designed for maximum of **5 mSv** total dose (safety factor)
  - For example 40 μSv/hour corresponds to maximum of 20 8 hour shifts (one month) per person
- Classification:
  - 2-20 mSv/hour – high radiation area
    - Supervision by radiation group, no outside contractors.
  - >20 mSv/hour – remote handling only

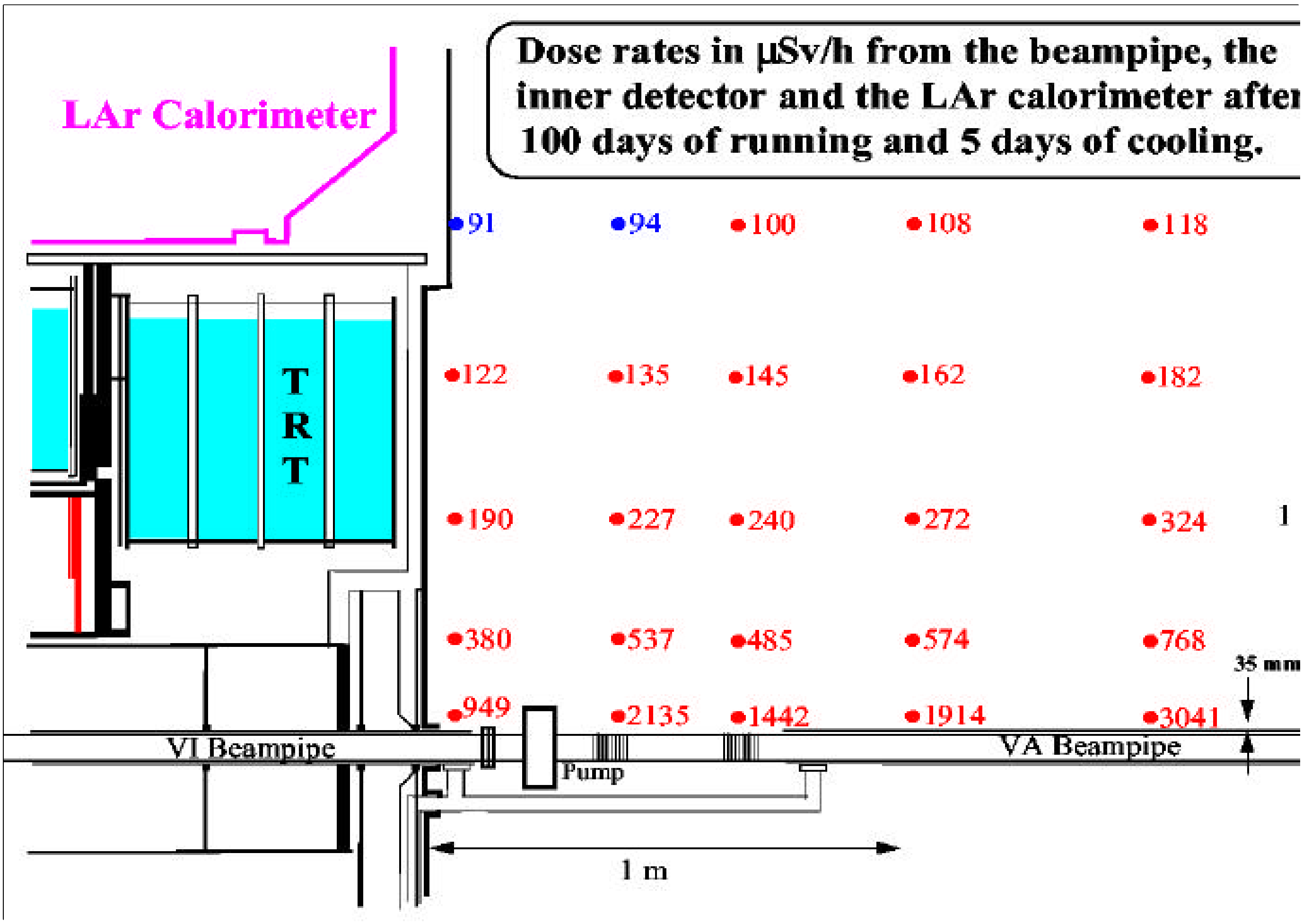


Geometry/material input

- Input to calculations in terms of volumes:
  - Volume dimension and material composition
    - Small amounts of heavy metals (e.g. Au, Ag, Sn) are important – often missed out in estimates…
  - Model of whole of ATLAS detector
    - Inner detector is most complex part
  - Material distributions exist in form of spreadsheets/tables.
- Checks of material estimates:
  - TRT: very comprehensive description including straws, radiators, supports, services, cables, patch panels, fluids, gas.
  - SCT comprehensive description for barrel, less so for endcap (modules assumed as barrel).
    - Cross checks with Ian Dawson et al. work for barrel modules -> some differences found and understood -> OK.
    - Further checks of missing patch panels and cables -> OK.
  - Comprehensive description for pixels, spreadsheets and input from Marco Olcese.
  - Most important for calculations are services and beampipe.

Short access scenario

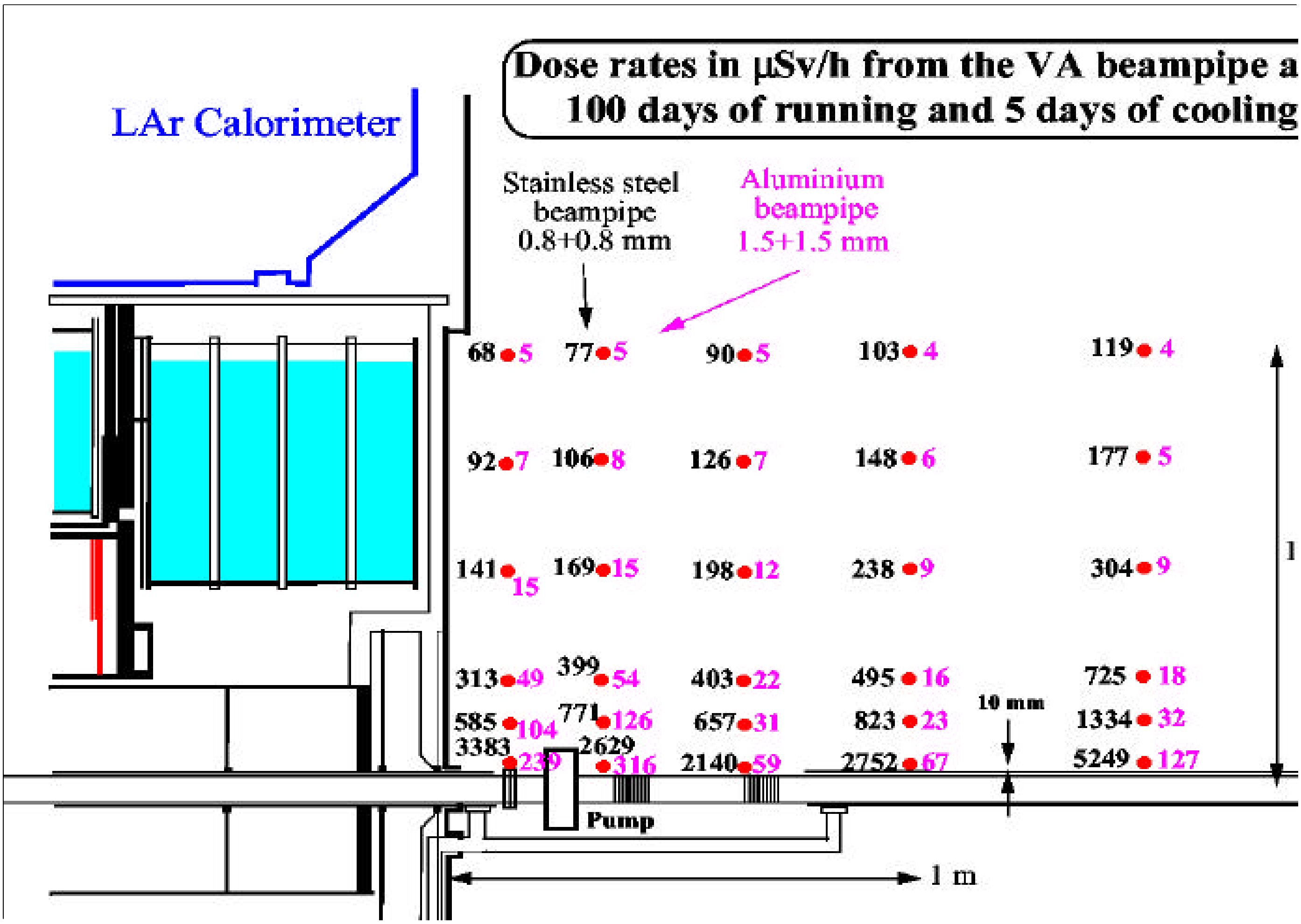
- Endcap calorimeters withdrawn:



- Several hundred µSv/hour around ID endplate
  - Only a few shifts of work here per person
- Around 3 mSv/hour close to VA beampipe
  - =1 hour dose, difficult to remove beampipe !
  - Avoid coming too close to pipe during ID operations (but difficult – elevated working)
- 10-20% higher radiation after 10 year running
- Factor 5 less after 100 days cooling off

VA beampipe material

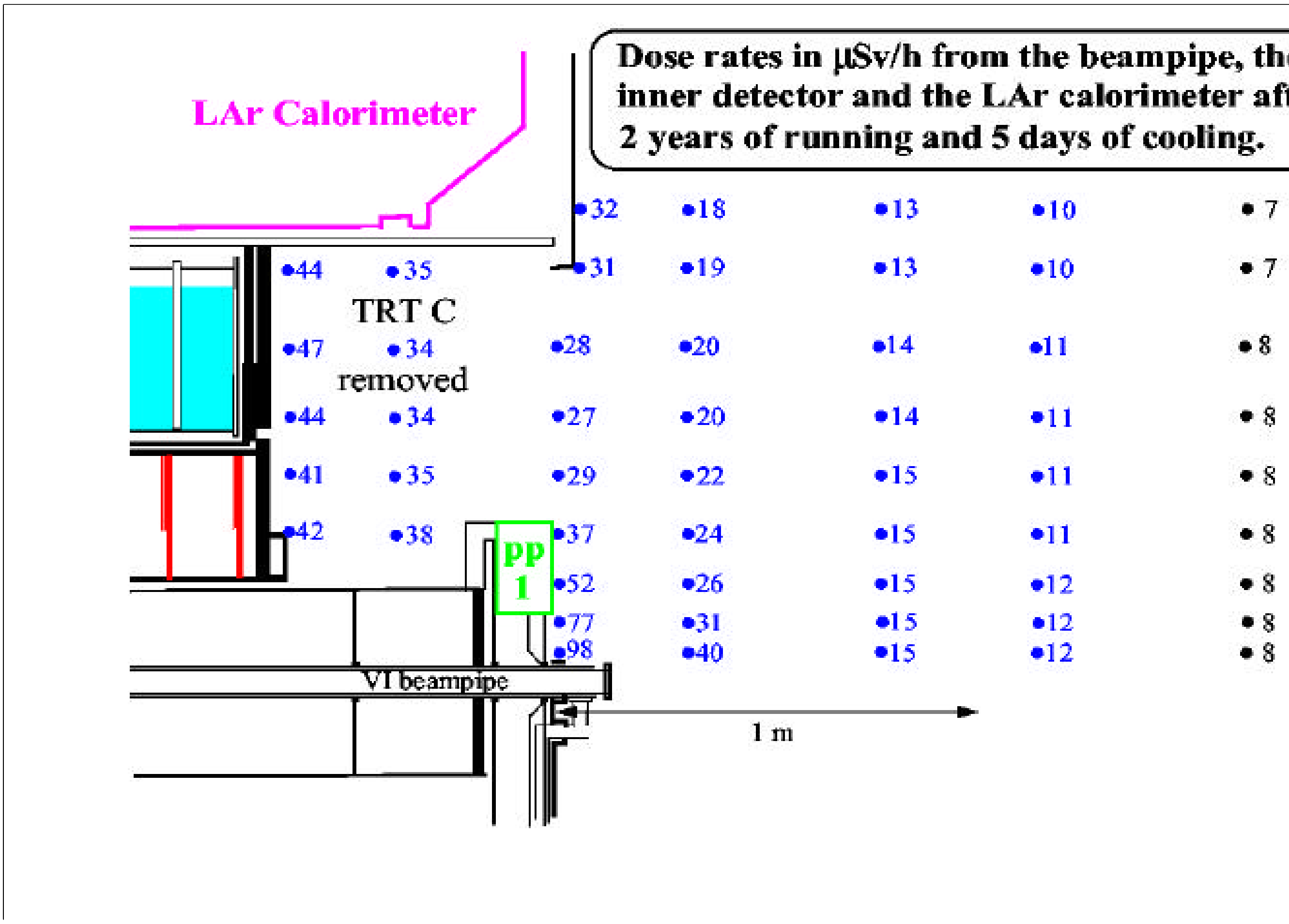
- Stainless steel (0.8+0.8mm) vs aluminium (1.5+1.5mm)



- Reduction in dose from VA beampipe of > factor 10
  - Good for vacuum group, ID and muon background.
- Technical problems to be solved:
  - Bellows in aluminium or steel->aluminium transition
  - Special alloy, low bakeout temperature.
- ID should support request for this beampipe.

Installation of TRT C wheels

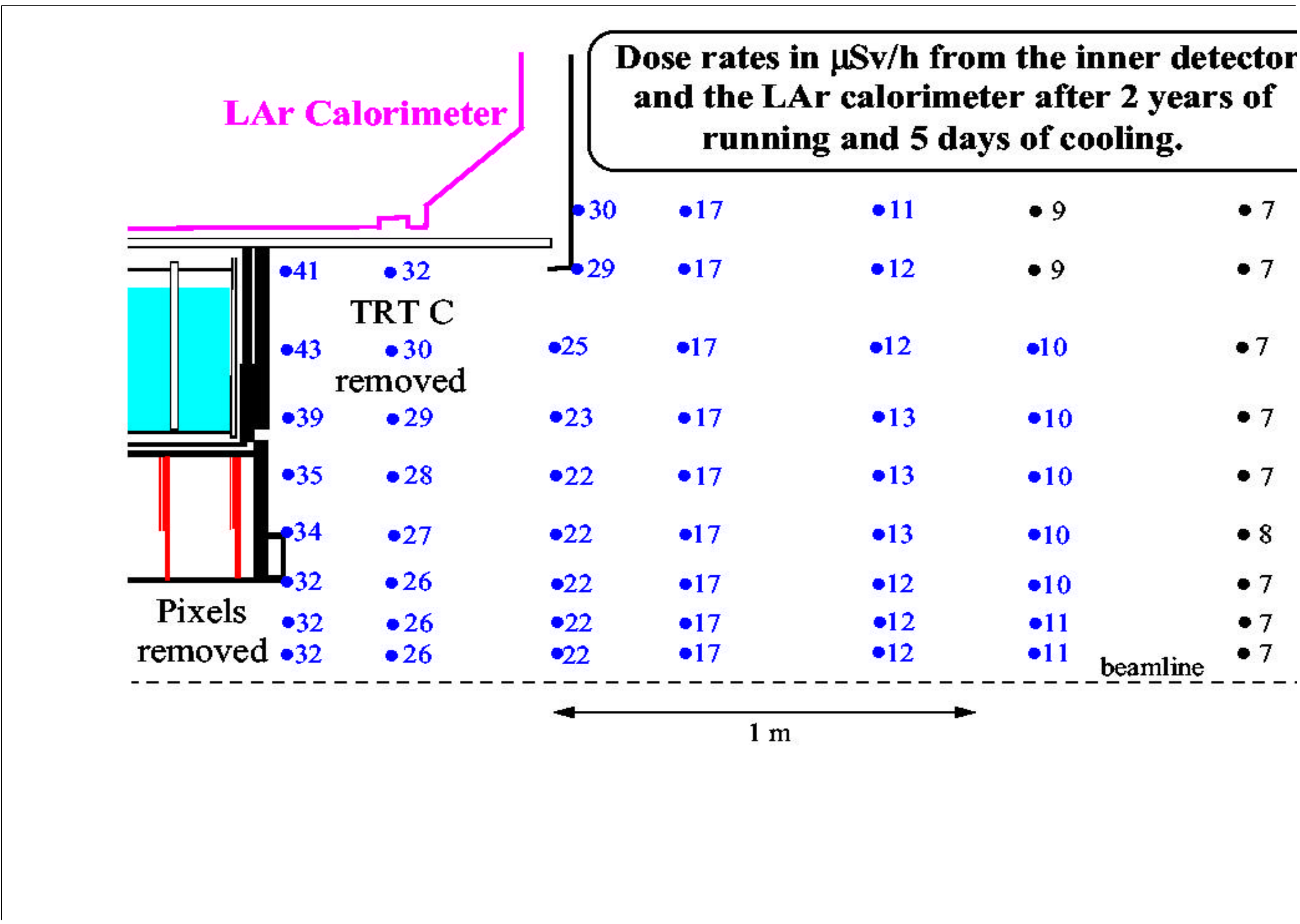
- Dose near end of ID:



- Doses around 30-40 µSv/hour at end of ID
  - Even at high radius close to PPF1
  - Around 5 weeks per person work time.
  - Only small decrease after 100 days cooling
- Upto 100 µSv/hour close to pixel PPF1
  - Due to Al part of VI beampipe
  - Could install some temporary lead brick shielding

Installation of TRT C ctd.

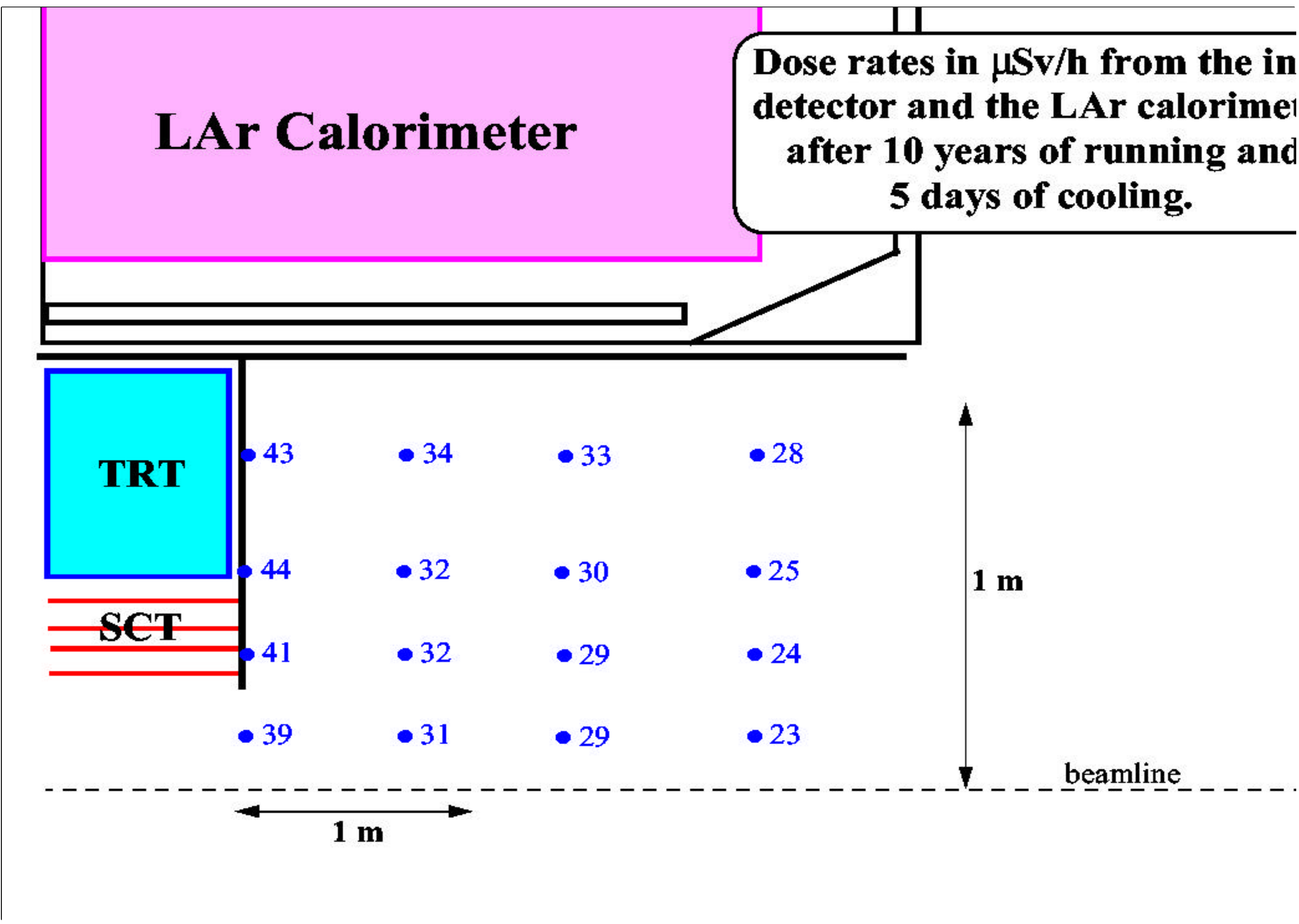
- Doses without pixel detector:



- Reduction at low radius cf previous scenario
  - NB: PST is missing in this calculation
- At high radius, radiation dominated by ID and calorimeter.

Long term access to barrel

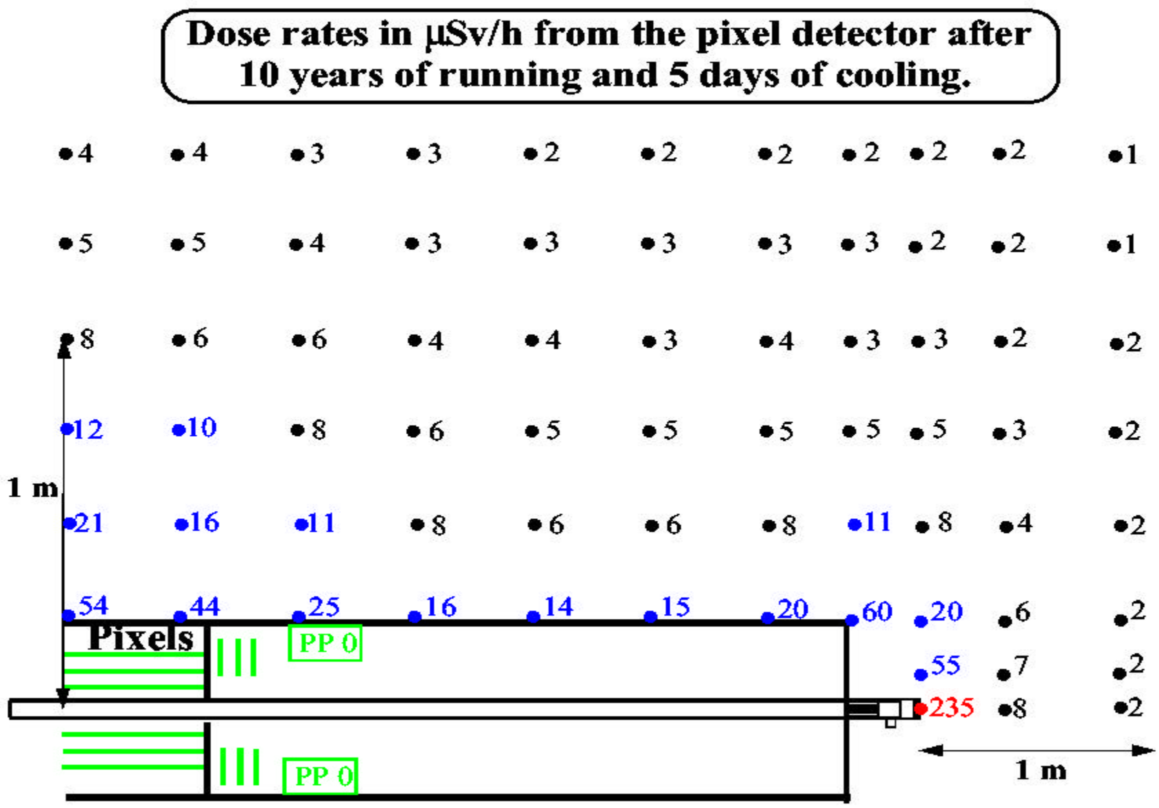
- Endcaps and pixels removed:



- 20-50 µSv/hour after 5 days cooling
- Decrease by only 25% after 100 days cooling
  - Dominated by materials other than steel
- Fairly uniform over working region
- ~1 month of shift per person

Pixels on surface

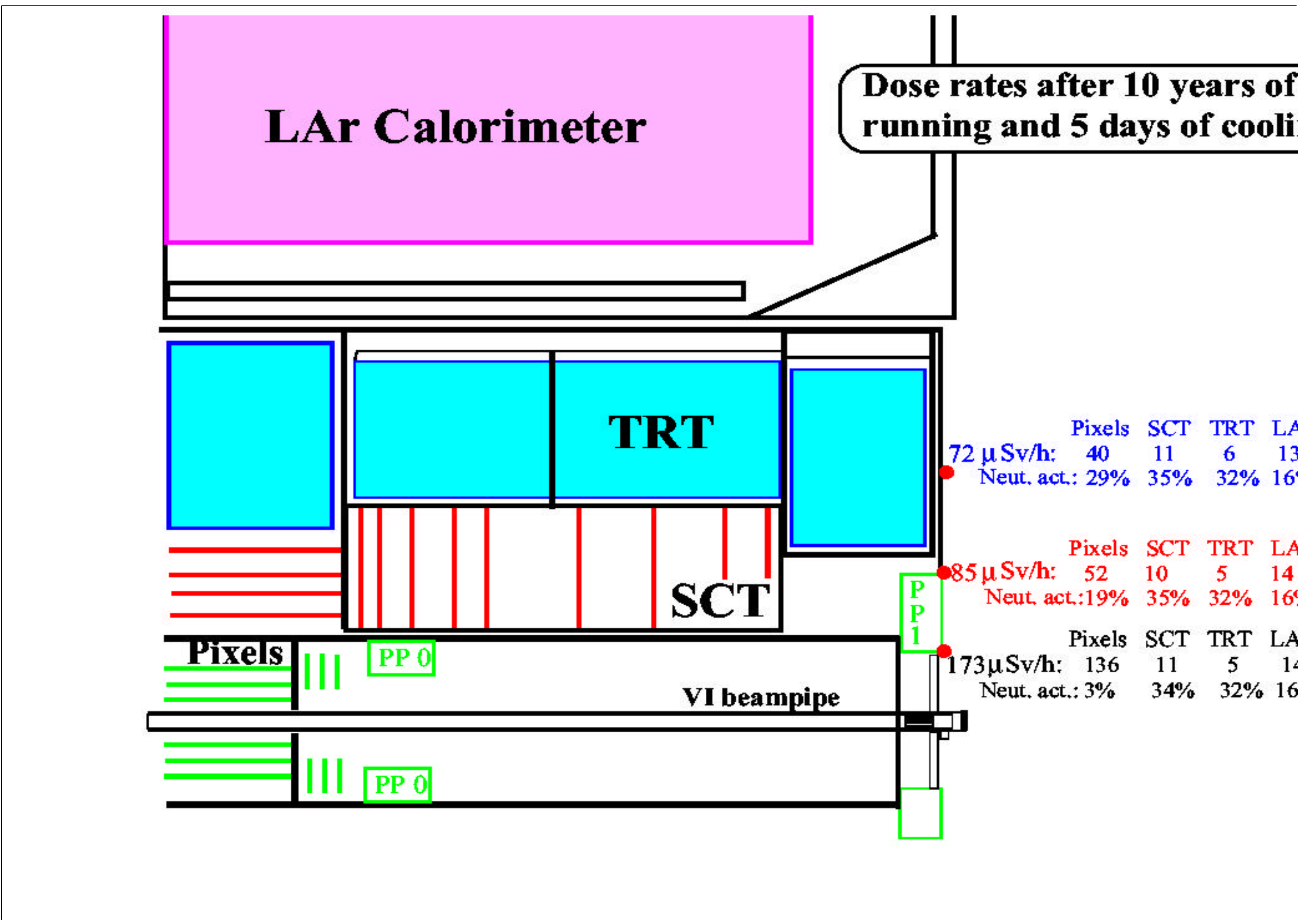
- Complete package (including support tube!):



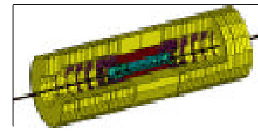
- Dose rates 50-60 μSv/hour close to tube
  - Hot spot around endflange – shield with lead
  - Dropping to <10 40cm away from it
  - Area around pixels a `simple controlled area'
    - Film badges, warning signs, no special access control
  - Additional calculations performed for insides of dismantled detector
    - Similar results O(1-20) μSv/hour
    - Not a big problem for (dis) assembly operations

Moderator dopant: Li vs B

- Breakdown activation: h.e. hadrons vs neutrons:



- Lithium is default. Using boron gives:
    - 10% more high energy neutrons ⇒radiation damage
    - 10% more photons ⇒detector occupancy
  - 50% reduction in thermal neutron activation
- n activation is small (<35%, less near pixel PPF1)
  - ⇒not a strong argument to switch to boron



Conclusions

- Studies from MEPHI now complete (end of project)
- No major nasty surprises
  - Short access: dominated by VA beampipe
    - High doses close to beam pipe – limited working time
    - Changing from stainless steel to aluminium would greatly help here.
  - Radiation dose during installation of TRT C wheels/pixels will be significant, but not excessive
    - ~1 month working per person allowed.
    - Not much change after 10 years.
  - Similar for long-term access to barrel.
  - Transport of pixel to surface and disassembly should be OK – simple ‘film badge’ area.
  - No big advantage in going from Lithium to Boron for moderator dopant.