Safety Issues for the n-TOF target

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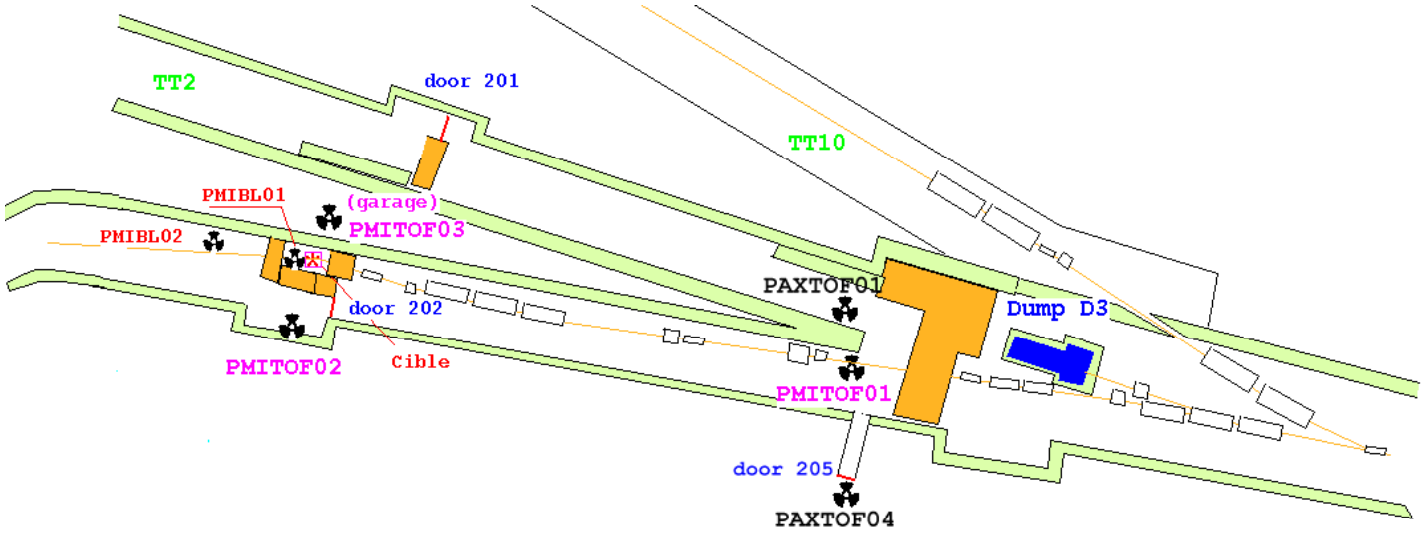
Installation of n-TOF at CERN



- The n-TOF spallation target has been installed in a former transfer tunnel between the PS and the West Area.
- No ventilation nor water retention facilities
- Radioactive air is moving and escaping uncontrolled
- Radioactive water spillage can go unhindered into surface waters (environment)

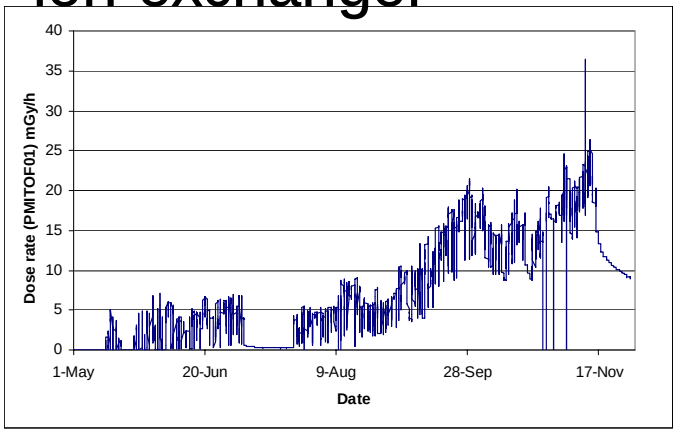
n-TOF spallation target

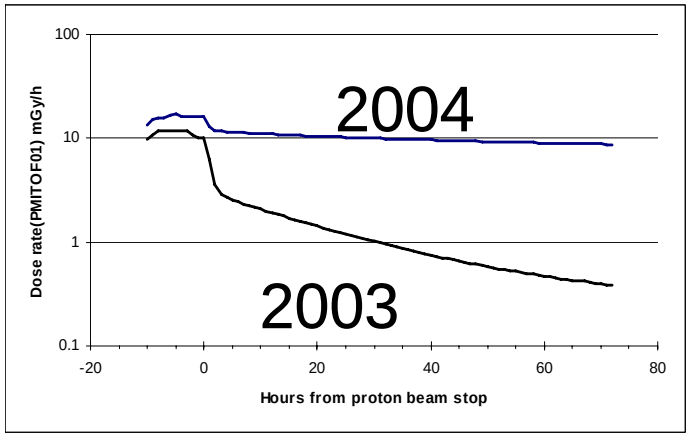
- Lead target
- in direct contact with cooling water

n-TOF target

- 2004: observation of activity transfer target -> water
- Activity concentration of water $A >> 100 * L_E$: must not be released to environment
- At CERN, no facilities to handle or store large quantities (700 litres) of contaminated water

Dose rate measured at ion exchanger





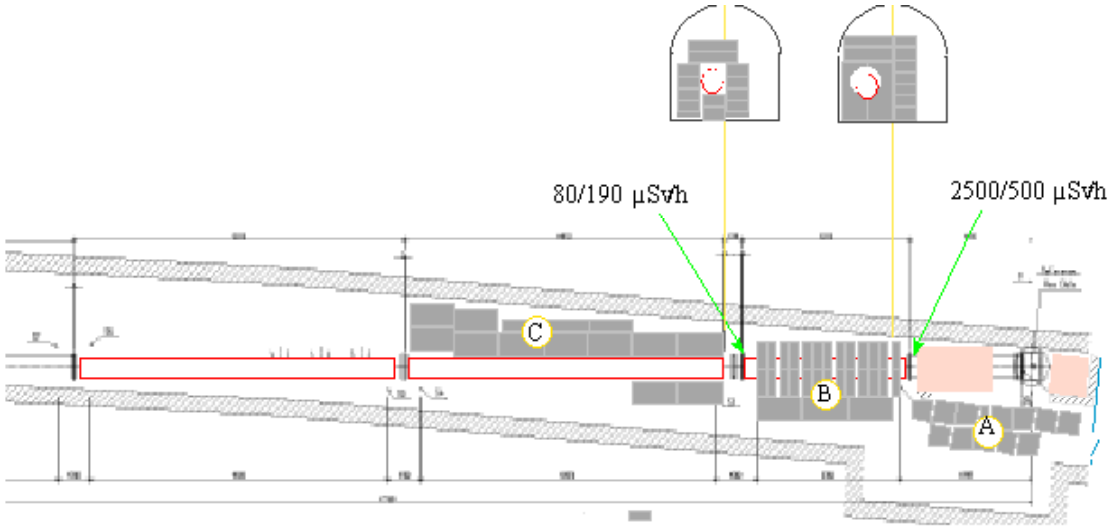
Cooling water system

- The cooling water system is internally contaminated with Pb spallation products (qualitative measurements: dose rate of water pipes and gamma spectrometry of wipe test)
- A quantitative analysis in the target tank and in a section of pipe is required
- Options for the cooling water system:
  - No intervention needed if contamination low enough
  - Cleaning with water and weak acid, collection in ion exchanger resins
  - Replace cooling water system

Requirement 1: Cladded spallation target

- Cladded spallation target is required, to prevent radioactive contamination of cooling water.
- Cladding with aluminum is not favoured (radioactive waste separation, see below)
- The cooling water circuitry must be inspected for contamination (fixed or mobile) before deciding on its potential re-use

Air activation in target area



- N-TOF target dimension approx. one interaction length, no dump
- Intense hadronic cascade leaving target and shielding
- Consequence: Air activation

Air activation in target area

- Aerosol concentration during operation:

	Door 203 (40 m f. target)	Door 204
^{7}Be	860 Bq/m^3	27 Bq/m^3
^{24}Na	290 Bq/m^3	4 Bq/m^3

- Estimated annual release:

	n-TOF (est.)	ISOLDE
^{7}Be	300 MBq	121 MBq
^{24}Na	100 MBq	1.16 MBq
Short-lived gases	?? (small)	6 TBq

- Ventilation must be refitted.
  - Improve atmospheric conditions during operation (temperature, humidity, O_3)
  - Improve working conditions after access
  - Account for releases to environment

Requirement 2: Ventilated Target Area

- The n-TOF spallation target area must be equipped with a filtered and monitored Ventilation, such as target areas in the PS, SPS and ISOLDE.

- Study in AB-ATB,TS-CV and SC-IE:
  - Minimize dose to critical group of public
  - Potentially recirculation during operation
  - Monitored release

n-TOF Experimental Area

- As the target area, the experimental area EAR-1 is installed in a former transfer tunnel
  - No ventilation
  - No water management
- For nuclear fuel cycle related experiments with radioactive targets (actinides, trans-uranium elements)
  - In 2002-2004, exceptional authorisations for detectors with mechanical and thermal resistance similar to “sealed radioactive sources” (ISO 2919) were obtained
  - One of the detectors was loaded in PSI (no appropriate work sector available at CERN)
  - Numerous actinide targets still at CERN: problems with re-expedition to owner
- EAR 1 in its present form can only receive experiments with inactive targets (astrophysics, nuclear physics)

Requirement 3a: Use sealed radioactive sources

- Wherever possible, sealed radioactive sources with ISO 2919-certification by officially authorised bodies must be used as targets
- The activity is limited by an auxiliary criterion: dose to the public in case of complete dispersion of the source (fire, sabotage) must not exceed 1 mSv
- Binding re-exportation arrangements for the sources should be made before they enter CERN

Requirement 3b: Work Sector

- Construction of a work sector for handling unsealed radioactive samples in the experimental area
  - filtered and monitored ventilation,
  - retention of contamination (multiple barriers),
  - decontamination facility,
  - application of work procedures
  - continuous monitoring by radiation protection

- Examples for work sectors for nuclear fuel-cycle related research at accelerator facilities are available at Synchrotron Light Sources (e.g. ESS, ANKA, SOLEIL)

RP-Resources for n-TOF operation

- Presently available manpower:
  - For ISOLDE, MERIT and n-TOF
    - < 1.5 FTE RP techn. engineers for monitoring
    - 0.2 FTE RP physicist for studies and authorisations
- Additional manpower required for the n-TOF research programme :
  - 0.5 FTE physicist/ senior engineer for studies and authorisations
  - 0.5 FTE technician/ techn. engineer for monitoring work with potentially dangerous radioactive targets
- Can be combined with requests in other areas of radiation protection at CERN

Summary

- In case of restart, n-TOF must be equipped with
  - A new, improved, cladded target
  - A target area ventilation system
- A decision on the reuse of the cooling water system can be taken after measurements have been taken.
- For experiments with actinides and other radioactive samples
  - Sealed sources (certified by authorised bodies) must be used whenever possible
  - A work sector for handling unsealed sources must be built in the experimental area
  - Additional human resources in RP must be made available

Conditioning and Elimination of radioactive waste from n-TOF

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nTOF RADIOACTIVE WASTE

- TARGETS
  - Present (activation + contamination)
  - Future (cladding to avoid contamination of cooling water)
- Other
  - water (if not suitable for free release in environment)
  - heavy water (limited quantities accepted by PSI)
  - Solid metallic waste (maintenance, upgrade, dismantling etc.)

Elimination of old target

- The old n-TOF target can be eliminated towards a Swiss repository, subject to technical requirements
  - No volatile contamination during transport (Type A container needed, probably single use (lost))
  - Maximum dose rate at the surface of the waste container 2 mSv/h (shielding must be fitted)
  - Dimensions adapted to fit in the waste conditioning container for at PSI

DESIGN OF THE NEXT TARGET

- Recommendations for the design of the next target:
  - Cladding => minimize contamination of the water in the cooling system
  - If aluminum is chosen for the cladding, the design shall foresee the possibility to remotely dismantle the cladding
  - Knowledge of the chemical composition of all materials used in the target (for the calculation of the nuclide inventory).

RESOURCES

- Studies on nuclide inventory : 2 man months per target
- Availability of sufficient CPU
- Organisation of waste elimination: 0.2 FTE

COSTS

- Elimination of Targets
  - Transport container ~10kCHF
  - Transport ~10kCHF
  - Elimination container (PSI) ~7kCHF
  - Elimination fees to be defined (meeting with PSI)
  - Shielding for transport depends on type, needs etc.

- Elimination of other waste (pipes, supports, shielding etc.)
  - Transport depends on volumes
  - Elimination 103 kCHF/cubic meter

N.B. No elimination pathway is currently available for activated and/or contaminated deuterium (quantities above 10 liters)

CONCLUSION

- An elimination pathway for the targets of nTOF exists and the disposal can be carried out according to the Host-States regulation
- The disposal of the old target soon after its removal from the irradiation position has the double advantage of
  - Comply with the legislation requirements
  - Eliminate the need of the construction of a second storage place for the future target
- The P & M resources needed to perform the disposal will be confirmed after deciding with PSI on exact method of conditioning of the target