New nTOF target: Design Issues

Abstract: Following the radiation safety requirement that nTOF lead target shall not be in contact with the cooling water, an entirely new target assembly must be developed. The concept of a clad target is described.

Preliminary designs of target geometry and target integration in the existing cooling loop are shown, as well as structures for positioning and installation.

Outline

- Introduction
  - Old Target versus New
- Design issues
  - Radiation Safety → Target Cladding
  - Cooling → Geometry of Target Assembly
  - Integration → Supports & Installation
- Summary
- Estimated cost, manpower, time

Introduction

- Satisfy the safety requirements of SC/RP
  - Clad lead target cooled by existing system

- Guidelines for the new target design
  - Keep the neutron flux characteristics
  - Reduce radioactive waste (target mass)
  - Reduce overall activation

From ABMB meeting, 12 June 2006

Remark

This presentation shows:

- First studies to identify design issues
- First simulations (thermal, mechanical) give preliminary results to guide design
- Estimations for cost, manpower & time

- Work and results from:
  SBM Ingénierie & AB/ATB & TS/MME

Introduction

Old Target

- Lead blocks directly in contact with cooling water
- Target mass > 4 tons
- Support structure entirely stainless steel (water basin in aluminium → corrosion risk)

New Target

- No direct contact between target lead & water circuit
- Smaller target (~1 ton)
- Optimised support structure (corrosion, activation, etc.)

Design issues: Radiation Safety

➢ Target Cladding

Metal(*) clad lead target with lead core

Consequences of cladding:

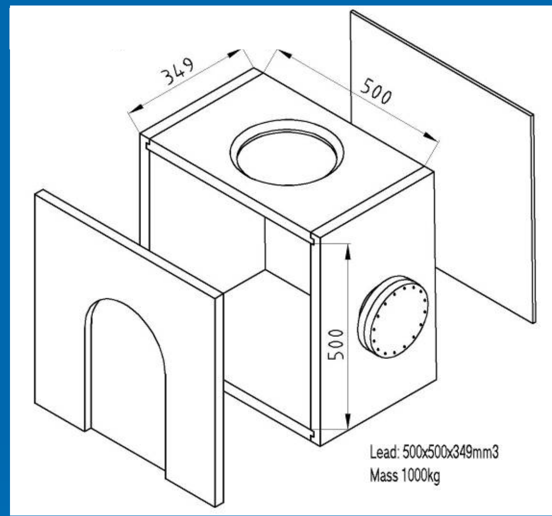
1. Thermal contact resistance between lead and cladding. Need for good contact pressure between core and shell.

2. Core and shell will have different temperatures → different expansion → large forces on shell

Proposal: Introduce initial core-shell gap, to have contact at nominal working temperature. Needs to be studied!

Challenge

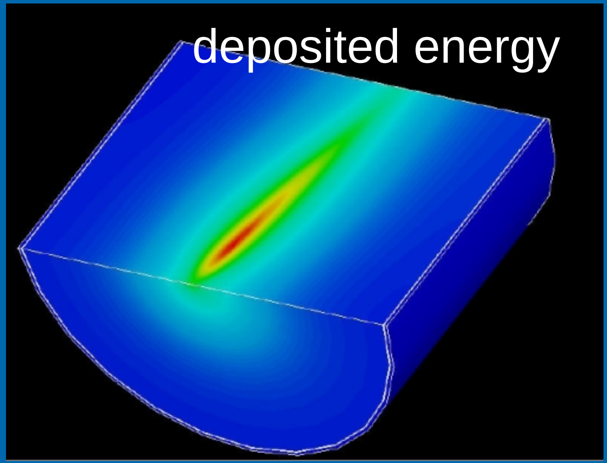
Possible production method



(*) Aluminium is used in the calculations. Material may have to change for reasons of radioactive waste disposal (see talk Luisa ULRICI, today at 12:00)

Cladding: Thermal equilibrium

Cylindrical target (R=26.5cm)
with 5mm aluminium cladding



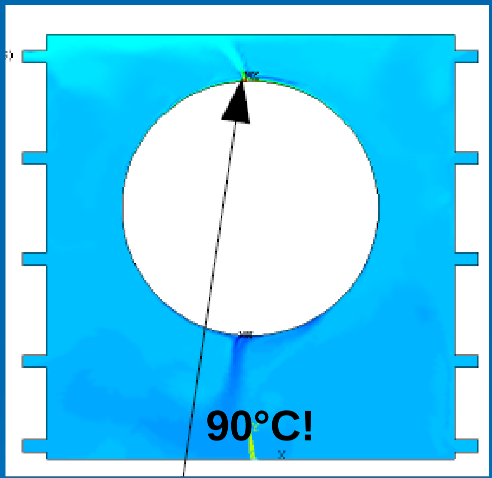
- 3.4kW(*) to be evacuated
- Assume adequate cooling
- Results from thermal calculations:
  - Temperature rise from lead to aluminium ~ 75K
  - Estimated temperature rise of 130K between start-up and equilibrium → Target temperature reaches 150 °C which is acceptable (45% of lead melting temperature)
  - Cylindrical shape better cooled and generally easier for production

(*)Load case = 5 pulses/16.8s supercycle

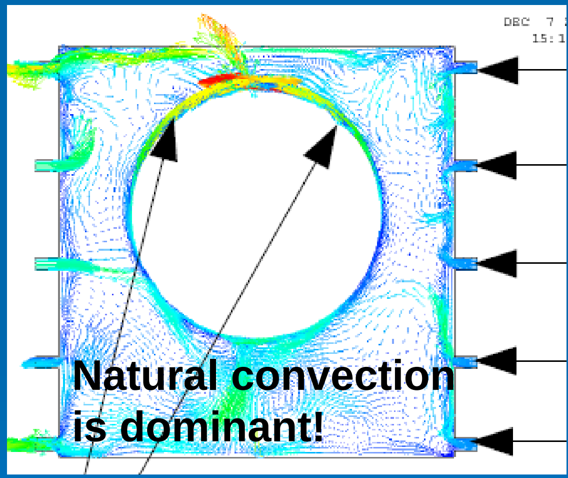
Design issues: Cooling

➢ Cooling → Target Assembly Geometry

Maximum temperature:
Target: 150°C Water: 90°C

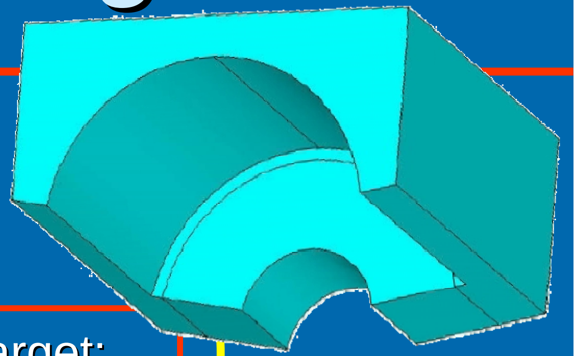


Water Inlet Nozzles:
Flow=6l/s Velocity=0.01m/s



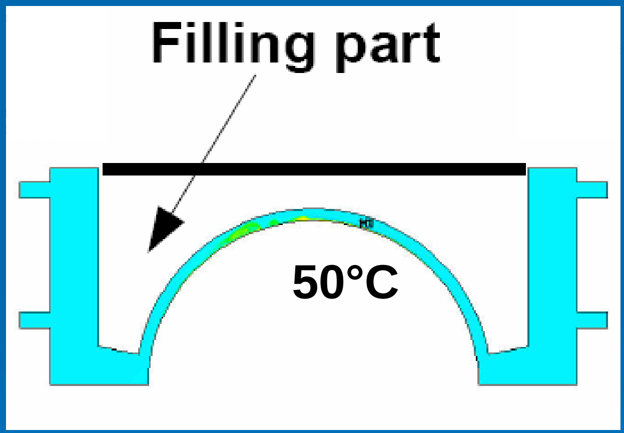
Existing water flow not adapted to size of new target
Target is sufficiently cooled, but water temperature locally high
→ Need to redirect / concentrate / guide the water flow around the target

Optimized for cooling

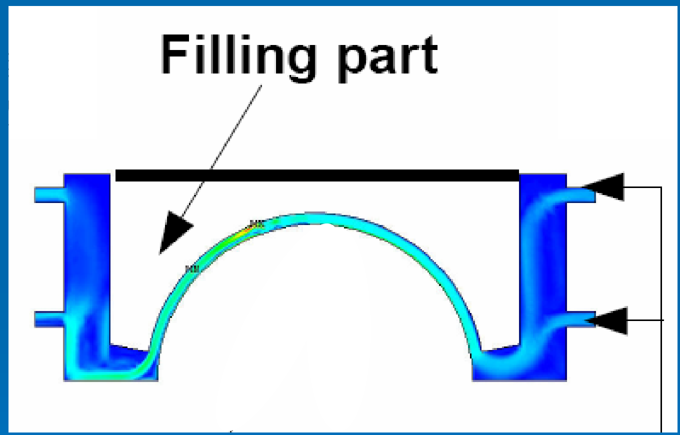


Proposal: Filling part to help guide the water and increase local velocity

Water temperature:
Average: 22°C - Local:50°C



Water velocity around target:
Average: 0.02 m/s - Local: 0.1m/s



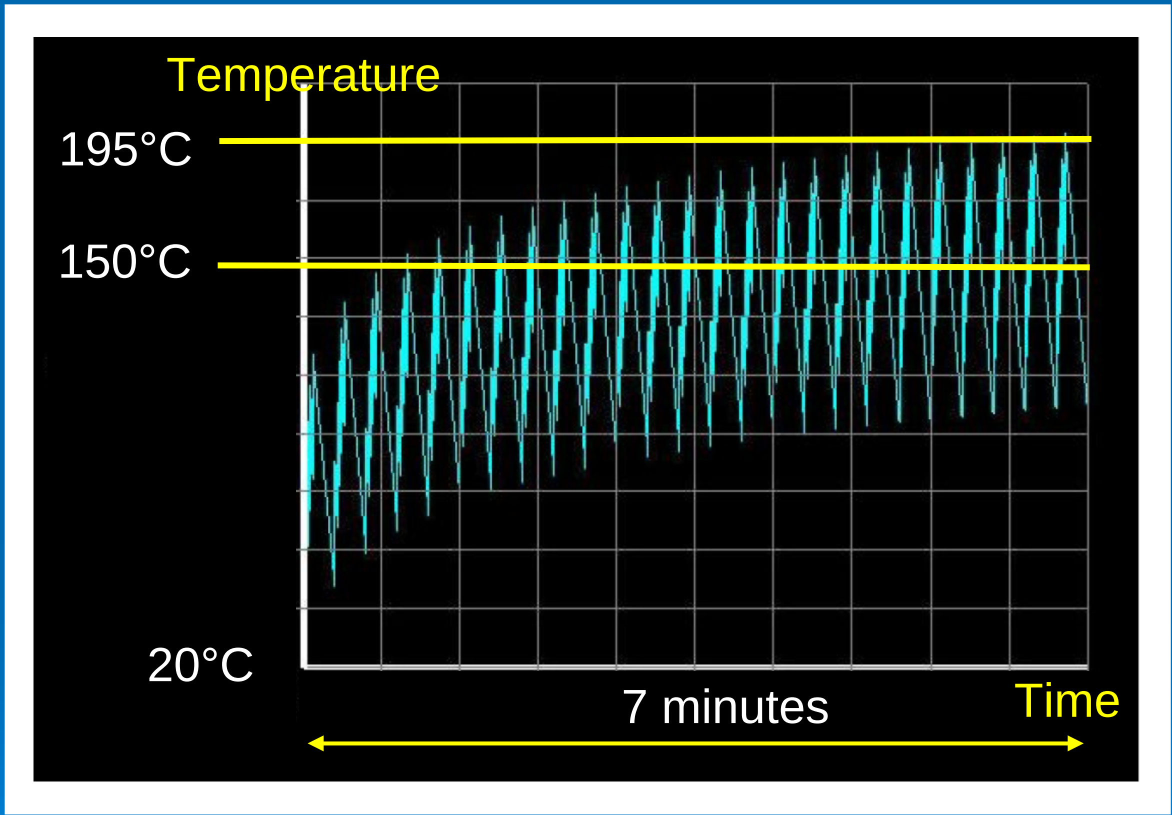
Filling parts are efficient

- Filling parts: complex geometry, minimize mass
- Support structure to be adapted
- Impact on target integration to be evaluated

Challenge

Transient behaviour

Maximum target temperature vs. time → effect of each pulse and supercycle(*)



Dynamic effect
will cause shockwaves
and cyclic stresses.
(time-scale = msec)

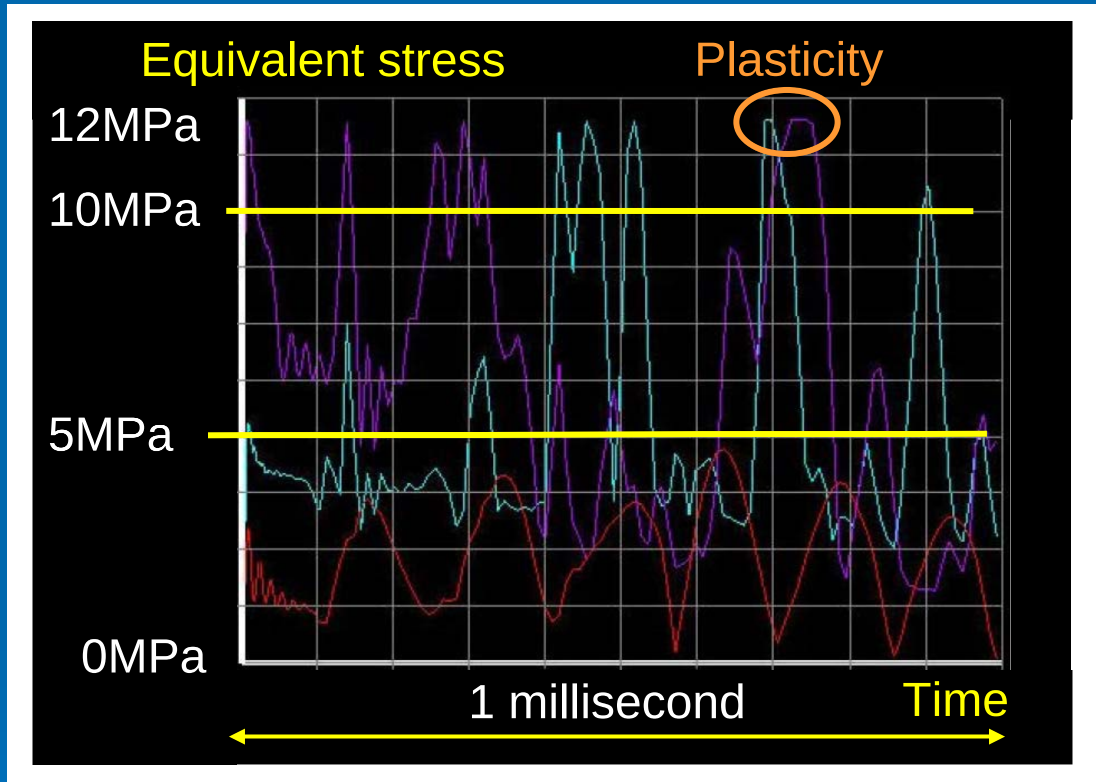
Fatigue?
Cracks?
Lifetime?

(*)Load case = 7ns burst, 1.2s pulse,
5 pulses/16.8s supercycle

Transient elasto-plastic behaviour

First results:

- Presence of plasticity
- Fatigue driven failure of the material will occur in central region (number of cycles to be determined).



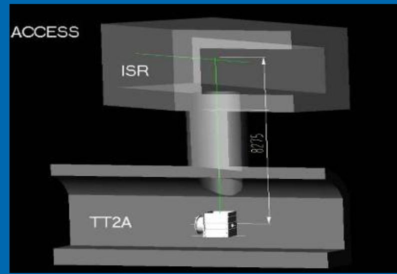
Next steps:

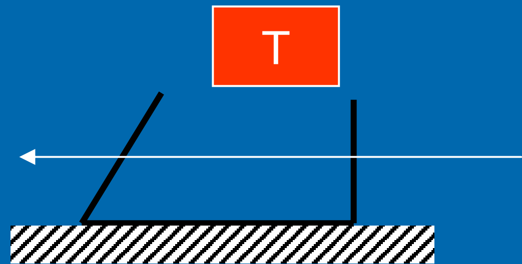
- Get detailed material properties (literature / experiment)
- Take into account the initial gap and the cladding material
- Fatigue analysis of both lead and cladding material

Challenge

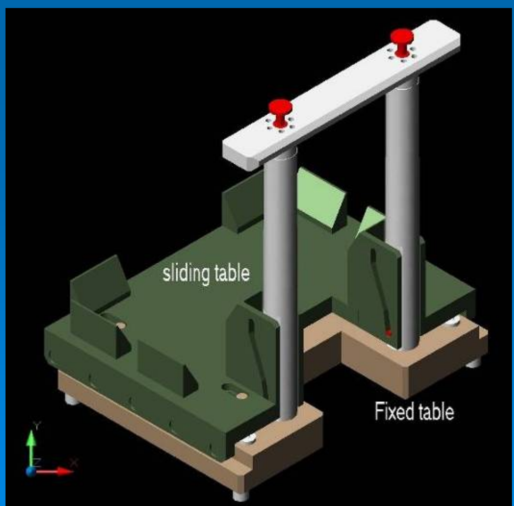
Design issues: Integration

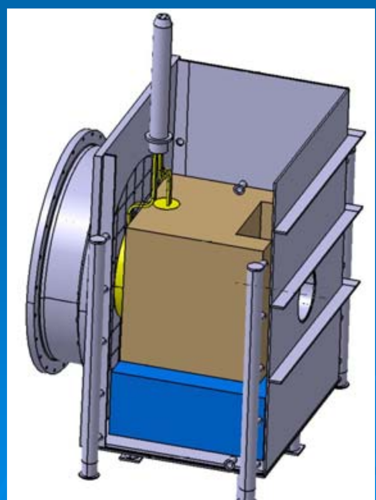
- Supports and guiding system
  - Need for precise positioning (access!)
  - Limited space available
  - Integrate “filling parts”
  - Installation vertical + horizontal (moderator)

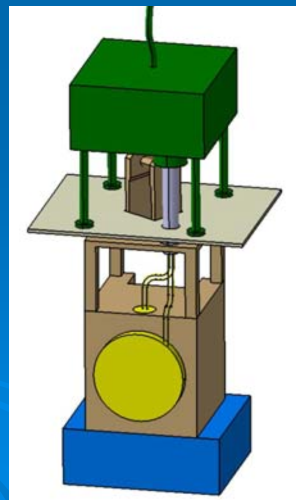




First ideas: remotely actuated sliding table, tubes for moderator







To do:

- Design
- Prototypes
- Production

Challenge

Summary: Remaining design work

- Cladding & gap
  (define material, geometry, production method)
- Optimise cooling circuit
  (define geometry, link to target support)
- Simulate dynamic behaviour
  (perform material tests & calculations)
- Integration of components
  (define supports, guides)

Estimated Cost, Manpower &Time

- Cost target & supports:
  240 kCHF
- Manpower
  AB/ATB: 1.5 FTE - SC/RP: 0.5 FTE - TS/MME: ?
- Time for design (internal)
  4 – 6 months
- Time for target production (external)
  6 – 9 months