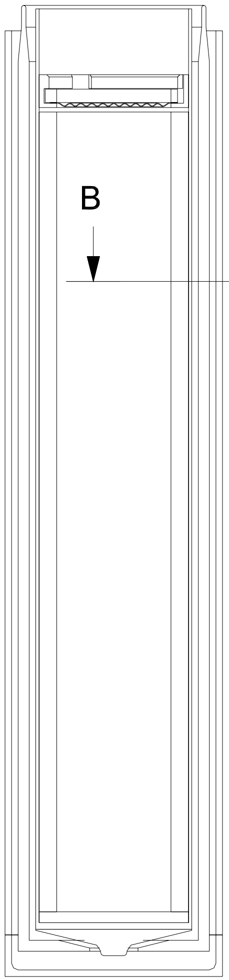
Status of the target reference solution

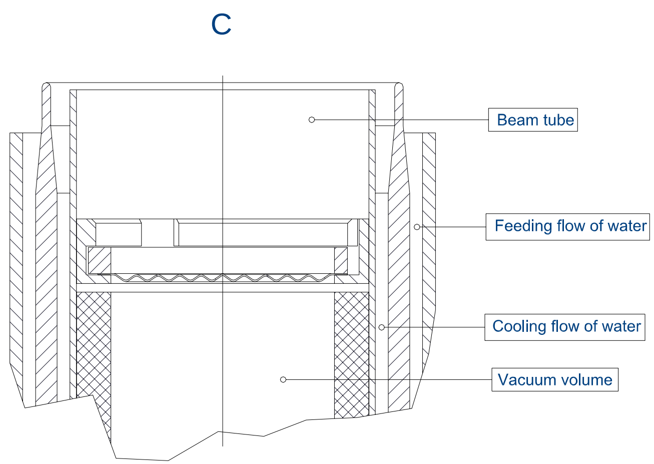
P.Agostini, C.Krakowiak,
L.Sansone, C.Petrovich, M.Ciotti

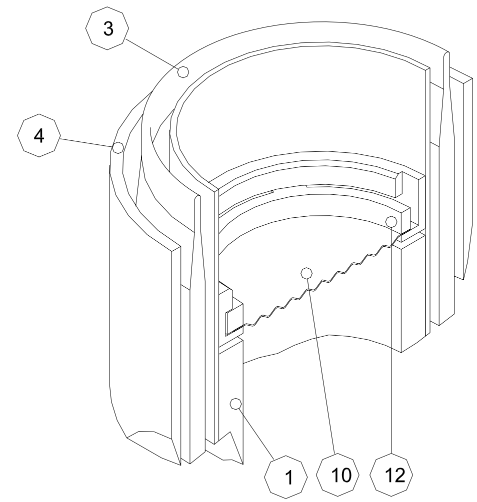
Petrovich table on neutron production

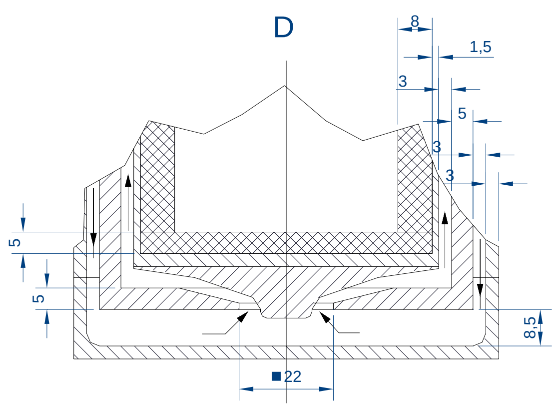
	Neutrons/sec (30 kW, 25 MeV)	Neutrons/sec (20 kW, 25 MeV)	Comments
Infinite uranium	~9.8E13 (tot net prod. including fiss. ~8E13 from (γ,n))	~6.5E13 (tot net prod including fiss. ~5.3E13 from (γ,n))	
Infinite tungsten	~4.0E13 (tot net production)	~2.7E13 (tot net production)	
Uranium cylinder (r=3.25cm, h=8cm)	~8.0E13 (escape n)	~5.3E13 (escape n)	Impossible to cool it
TRADE-13c200 with Ta	~3E13 (escape n)	~2E13 (escape n)	The n-production is too low
TRADE-13c200 with U	~7.4E13 (escape n)	~4.9E13 (escape n)	Difficult to manufacture
Multi-plate target	~5.7E13 (escape n)	~3.8E13 (escape n)	Viable solution (backup)
Hollow uranium cylinder	~7.8E13 (escape n)	~5.2E13 (escape n)	Viable solution (reference)

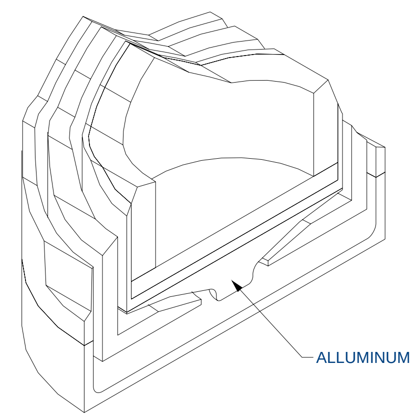
General Assembly of Reference Solution (without rastering)

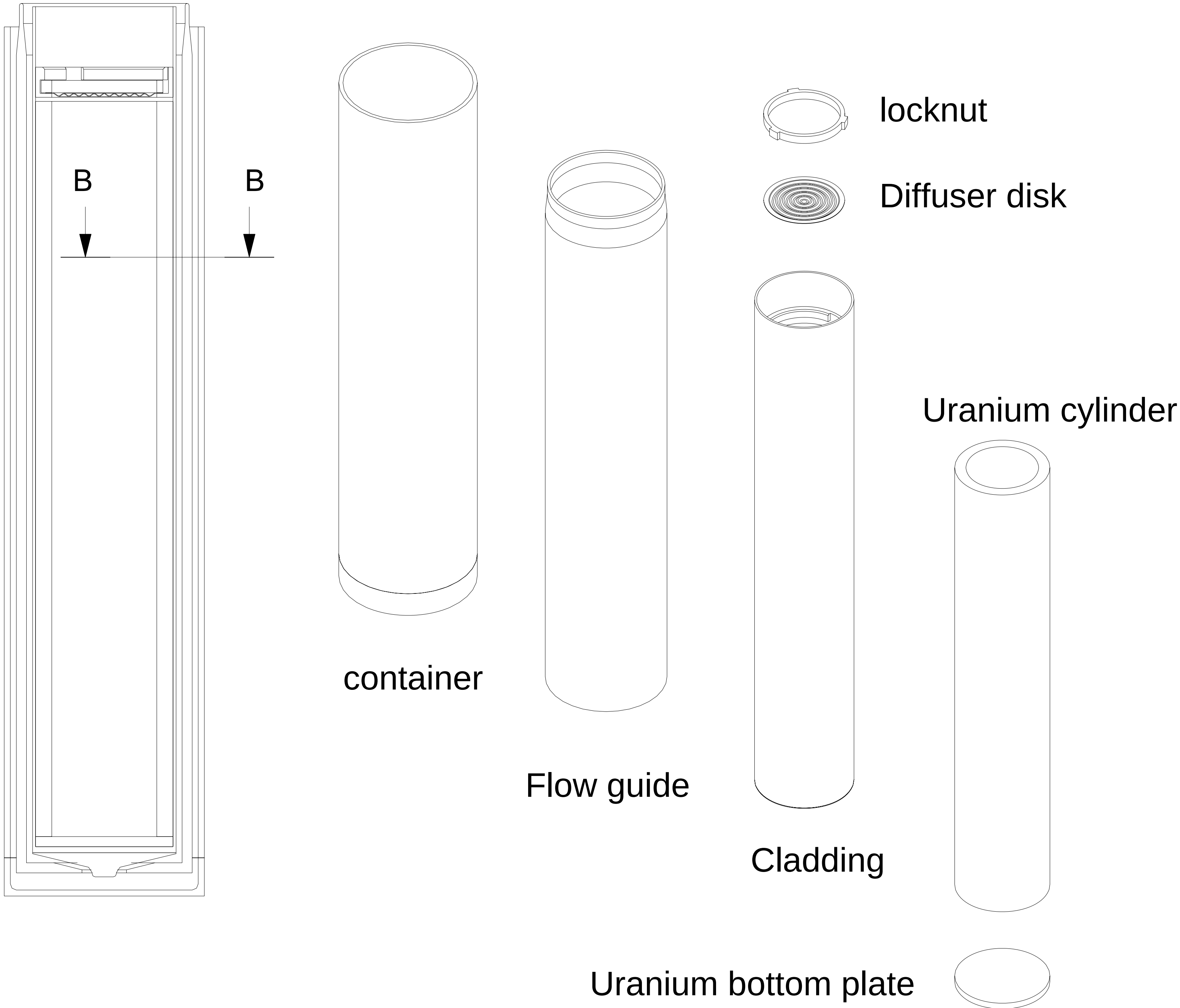








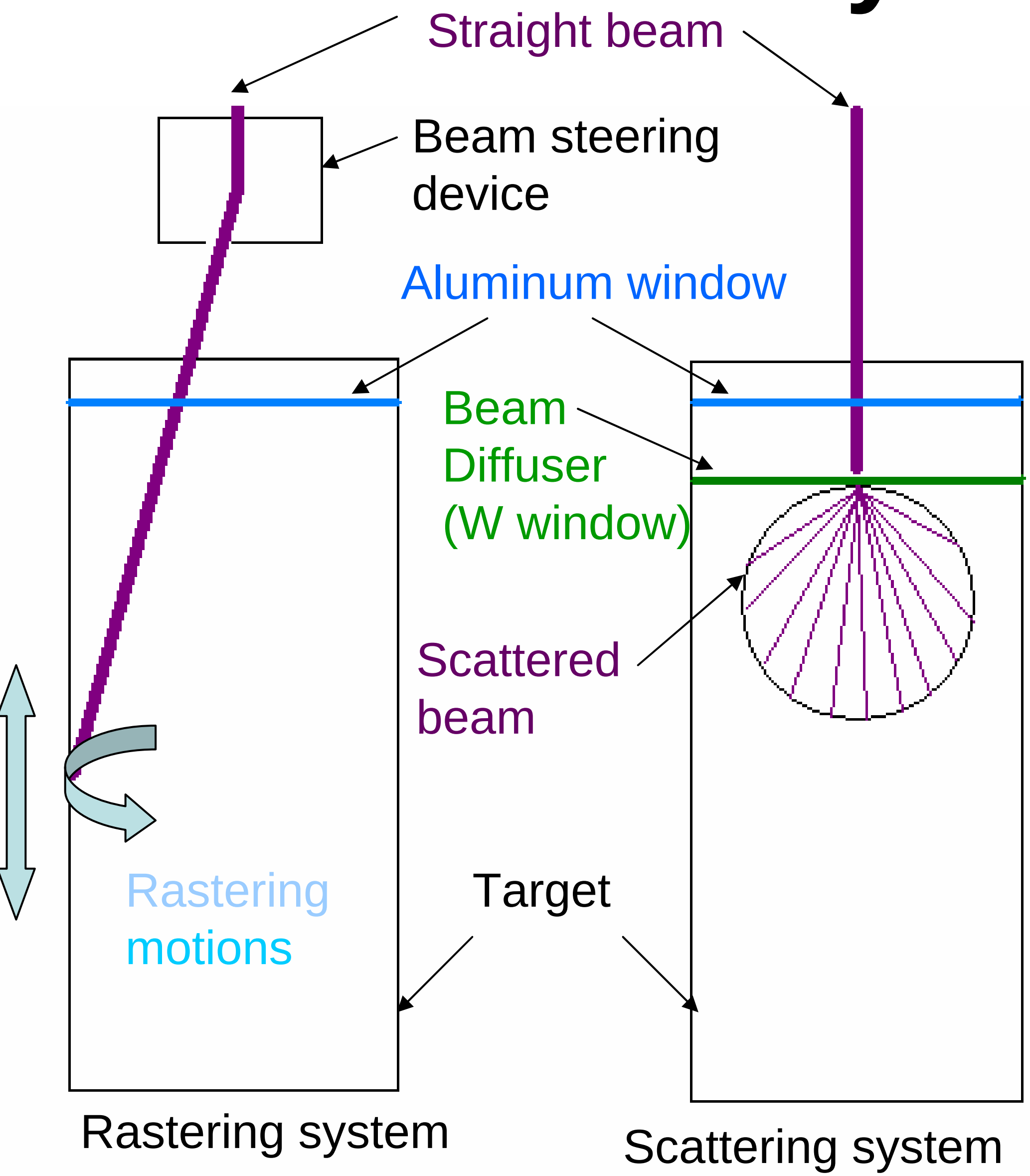



B
B
container
Flow guide
locknut
Diffuser disk
Cladding
Uranium cylinder
Uranium bottom plate

Motivations for the Target selection

- a high neutron production (more than 7E13 n/s)
- a large and suitable surface for water cooling (a vertical cylinder of 370 mm height and 71mm diameter),
- homogeneous power distribution along the walls
  - Beam steering option: possibility to engineer the power distribution functions
  - Beam diffusion option: Acceptable homogeneity
- Possibility to obtain the function of best coupling to the core in case of beam steering option
- Possibility to perform thermal hydraulic tests in full scale and full power

PROs and CONs of the rastering system



PROs

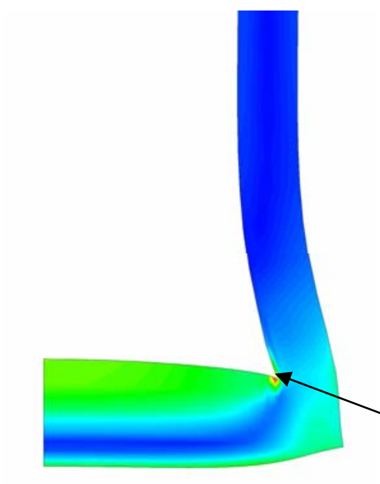
- The technology is very easy
- allows to optimize the power deposition inside the target.

CONs

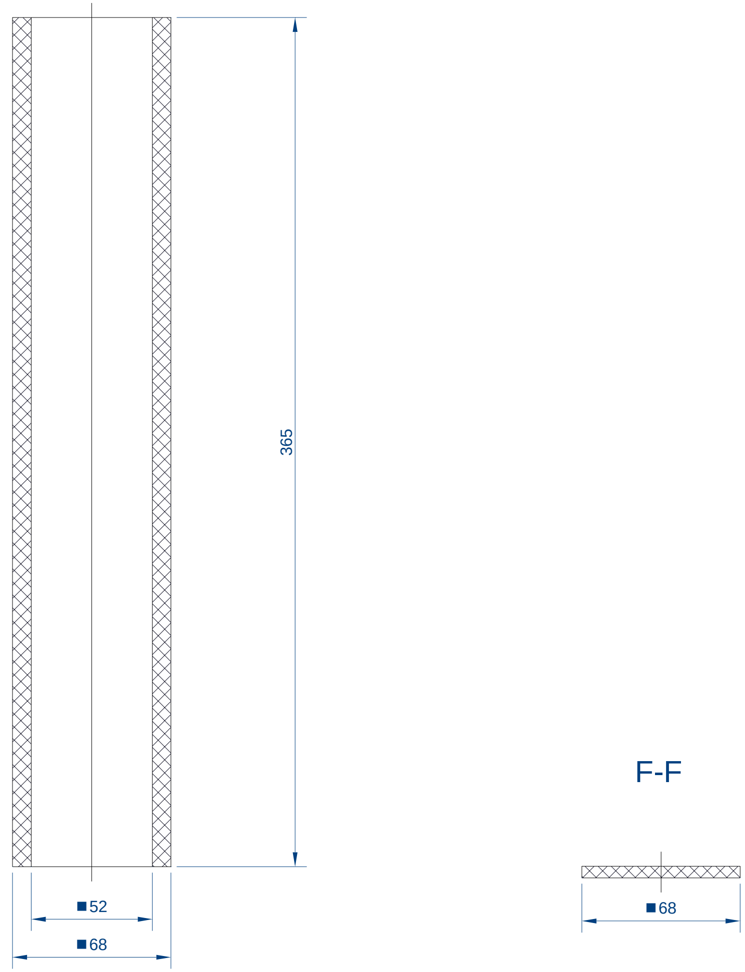
- The rastering magnets will occupy a certain volume, but some driving magnets are necessary in any case.
- The rastering magnets need to be placed below the water level, close to the core

Uranium Cylinder and Bottom Plate

- Uranium has the highest neutron production
- The inner diameter (52 mm) is the better compromise between high lateral surface (for heat removal) and small base surface (for small neutron loss at the bottom)
- The thickness (8 mm) is the maximum allowed to withstand the thermo-mechanical stresses
- The cylinder and the bottom plate are decoupled to reduce the stresses

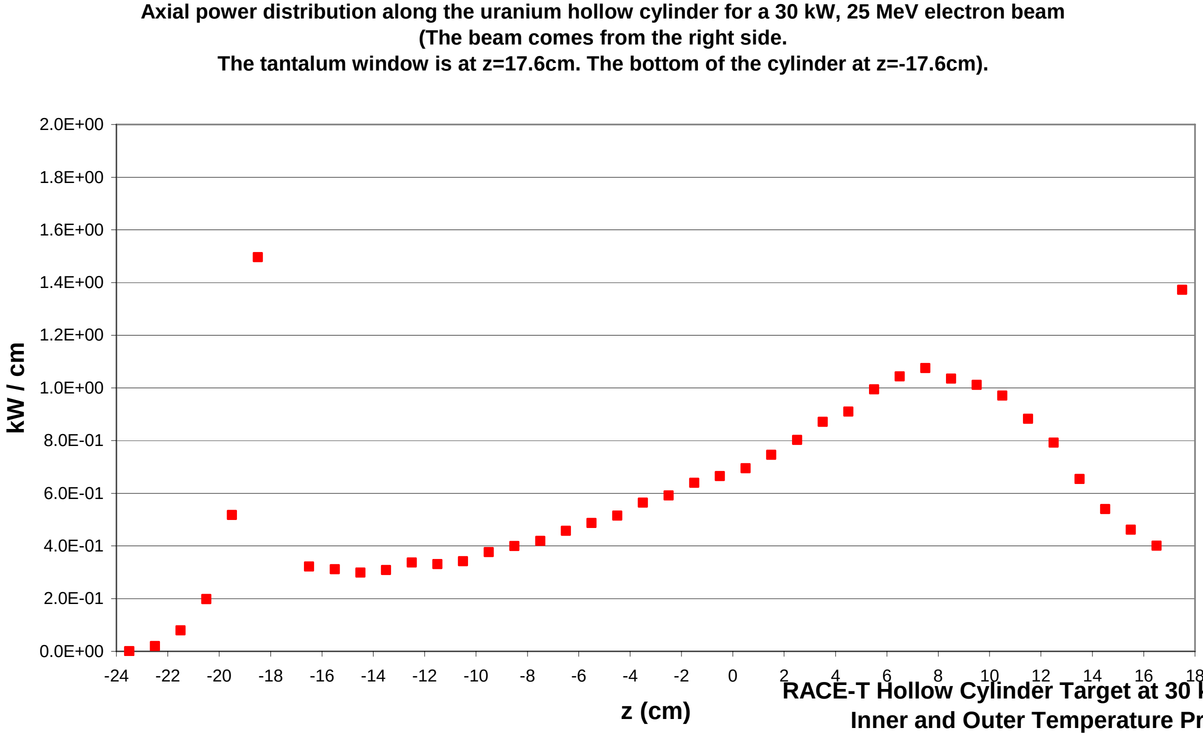


The junction between the plate and the cylinder will induce very high thermo-mechanical stresses (about 1100 MPa)

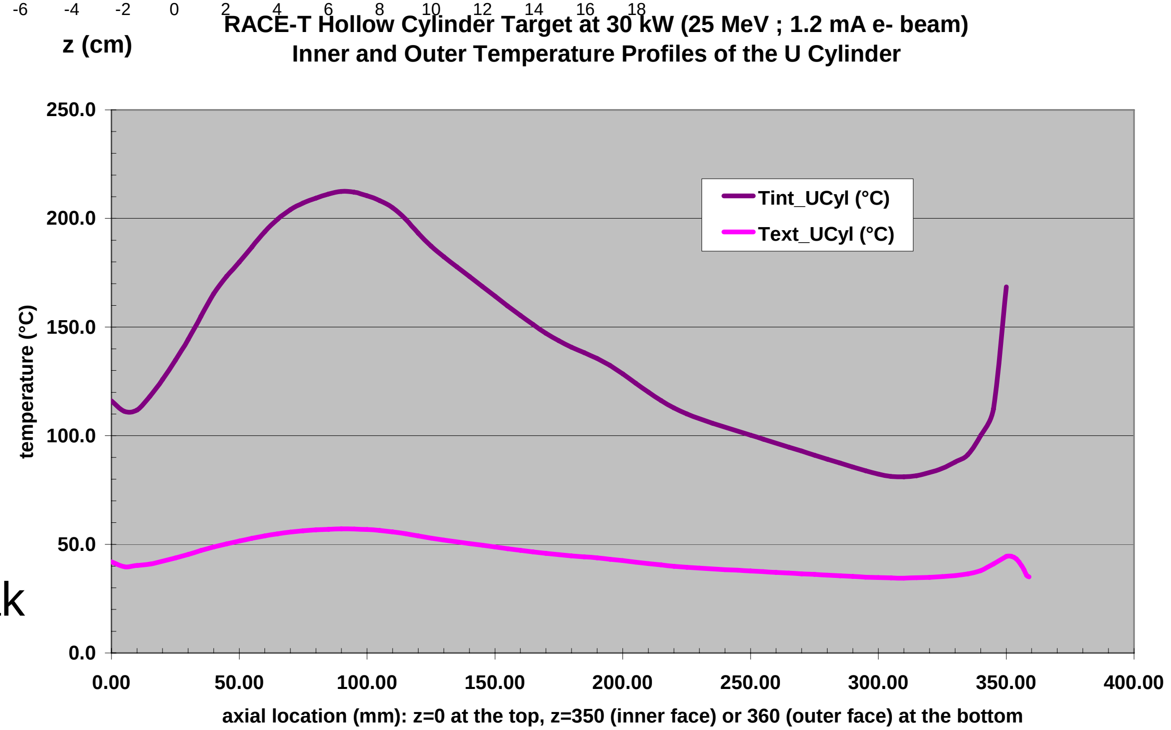


Calculations by C.Krakowiak

Power distribution
In the Uranium inner wall

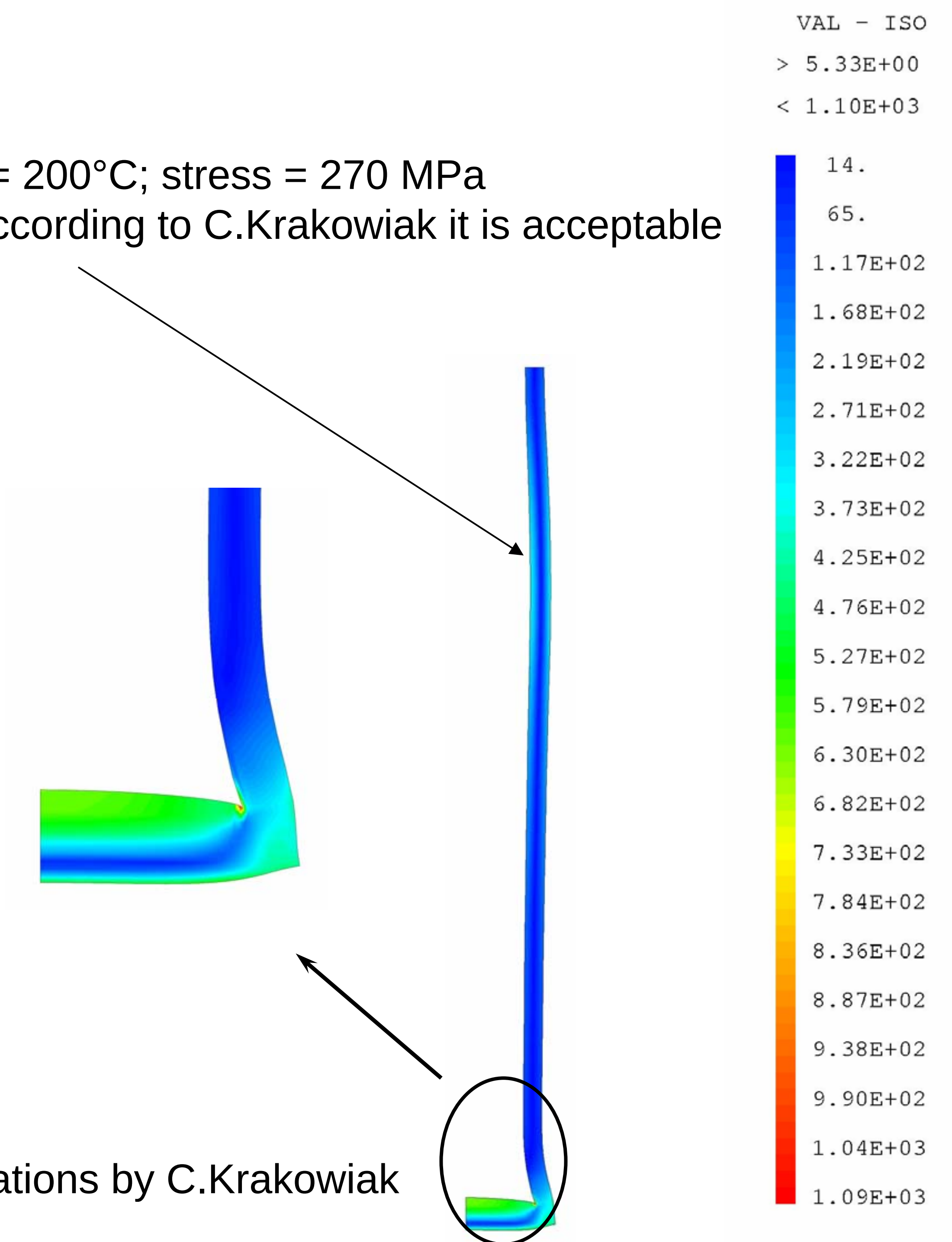


Temperature of Uranium
inner and outer walls



Calculations by C.Krakowiak

T= 200°C; stress = 270 MPa
According to C.Krakowiak it is acceptable



Calculations by C.Krakowiak

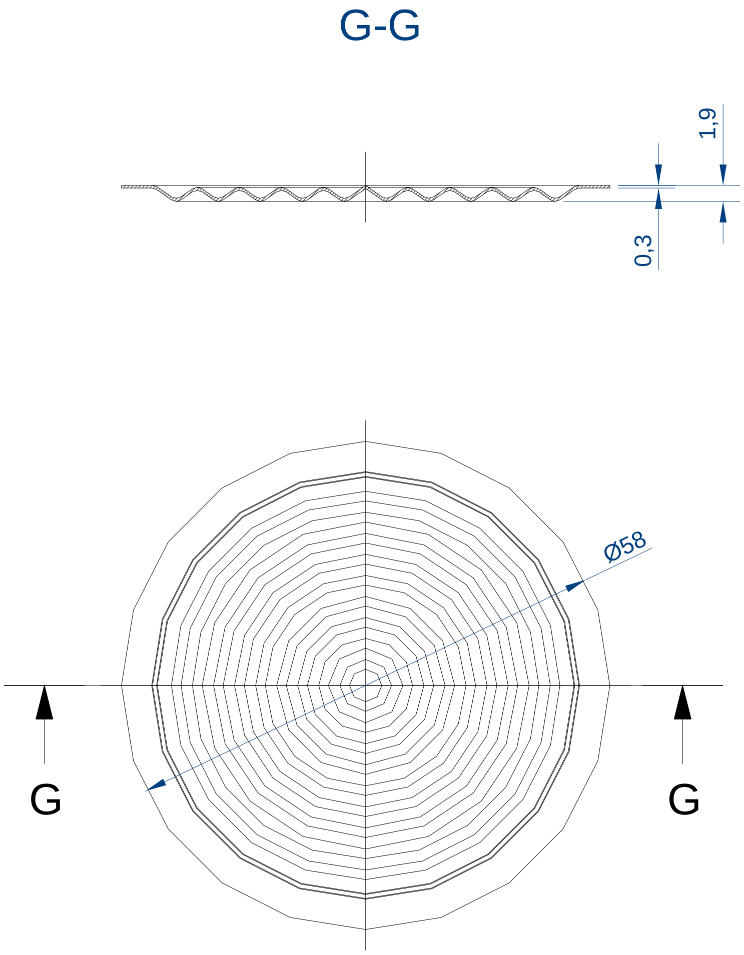
Bellow Type Diffusion Disk

The beam diffusion option relies on the diffusion disk.
The material is W-23.4Re-0.27HfC which associates:

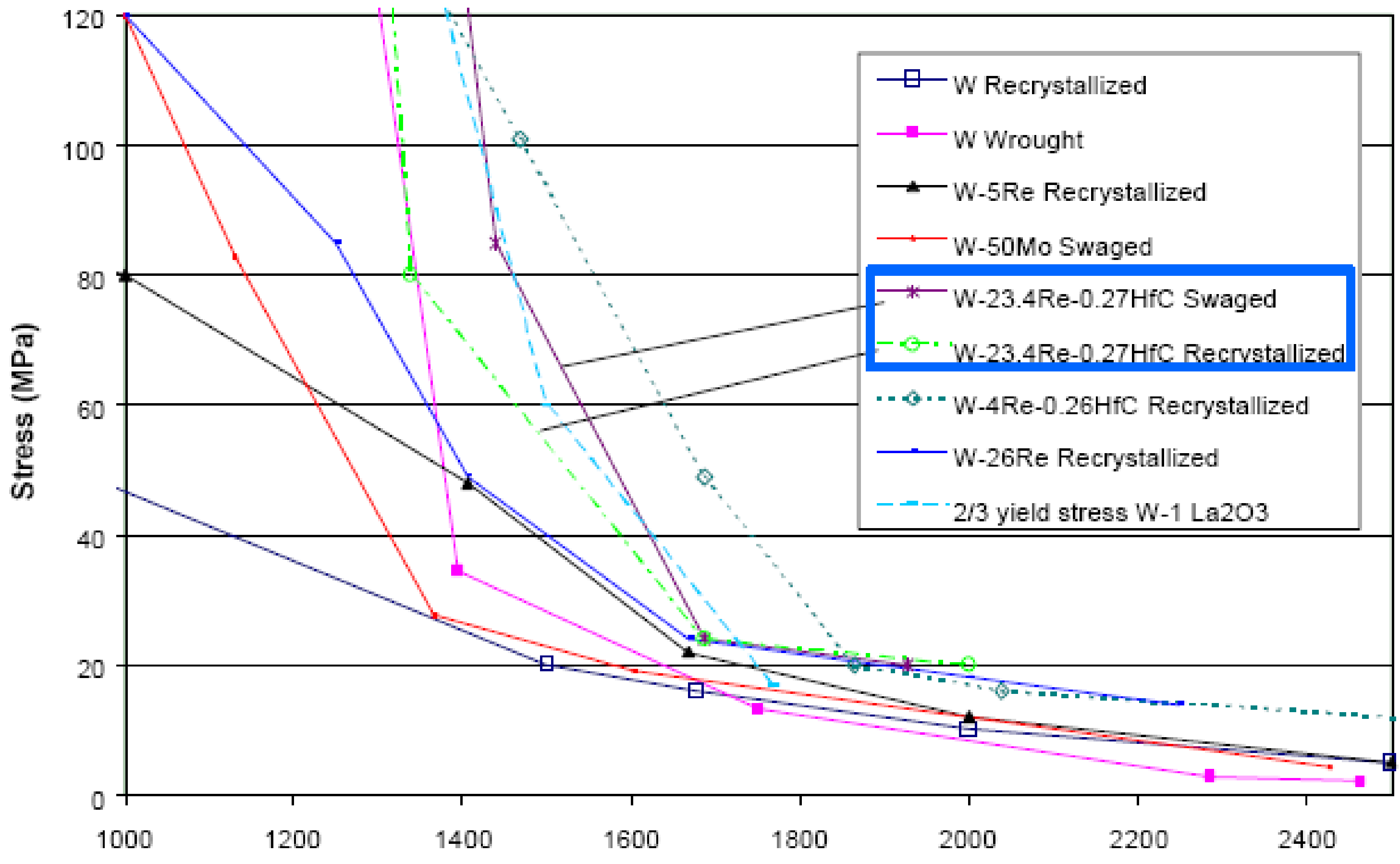
- -High operating temperature
- -Good resistence to the irradiation embrittlement
- -Good neutron production rate
- -Good diffusion of electrons

Two possible shapes are envisaged:

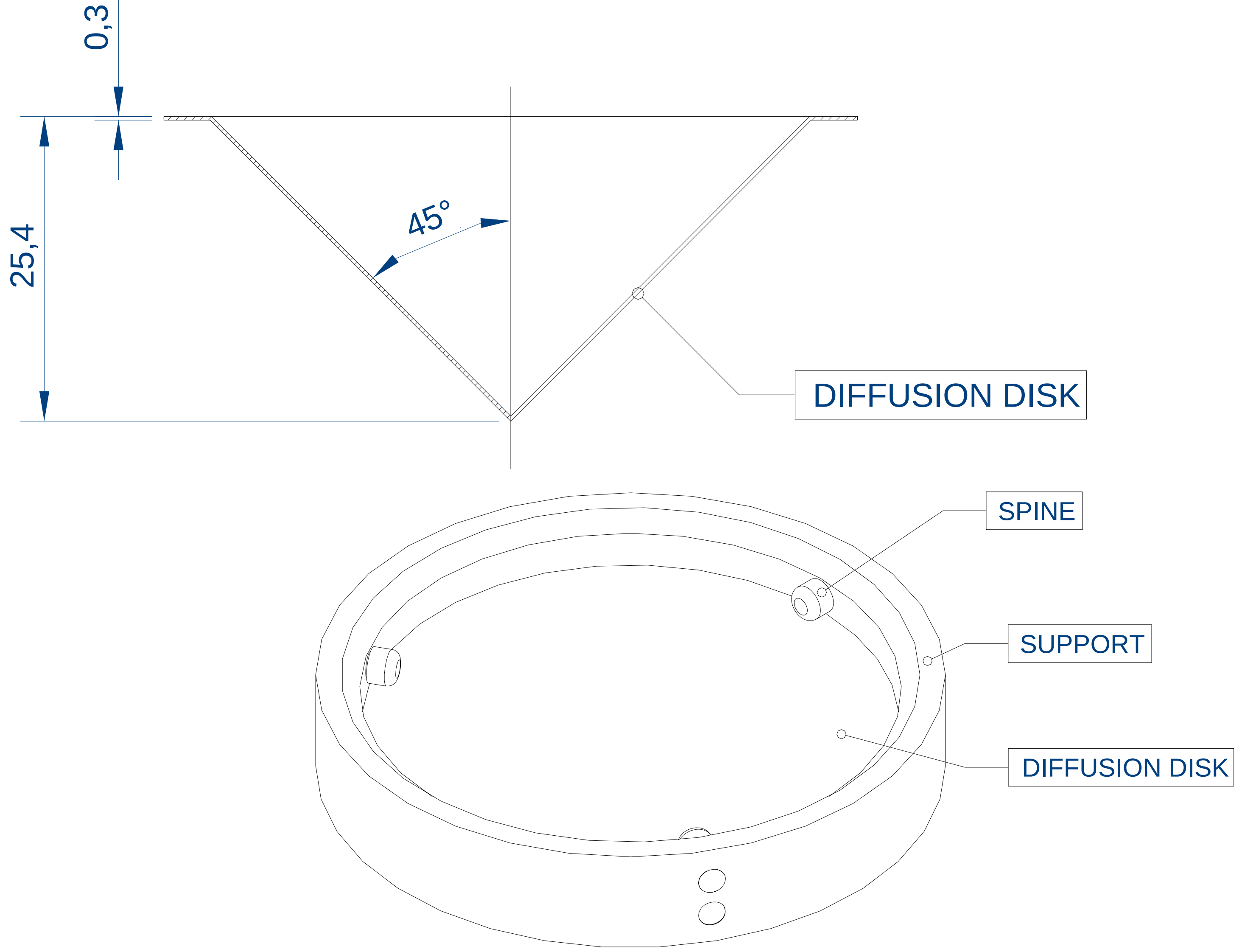
- •Bellow type
- •Flat radiating disk



Comparison of High Temperature Design Stress Limits of W-Alloys



Taken from DESIGN WINDOW FOR
TUNGSTEN ALLOYS
S. Sharafat , R. Martinez
N. M. Ghoniem
The University of California at Los Angeles (UCLA)
Los Angeles, CA. 90095-1597, USA
APEX STUDY GROUP MEETING
PPPL
May 12-14, 1999

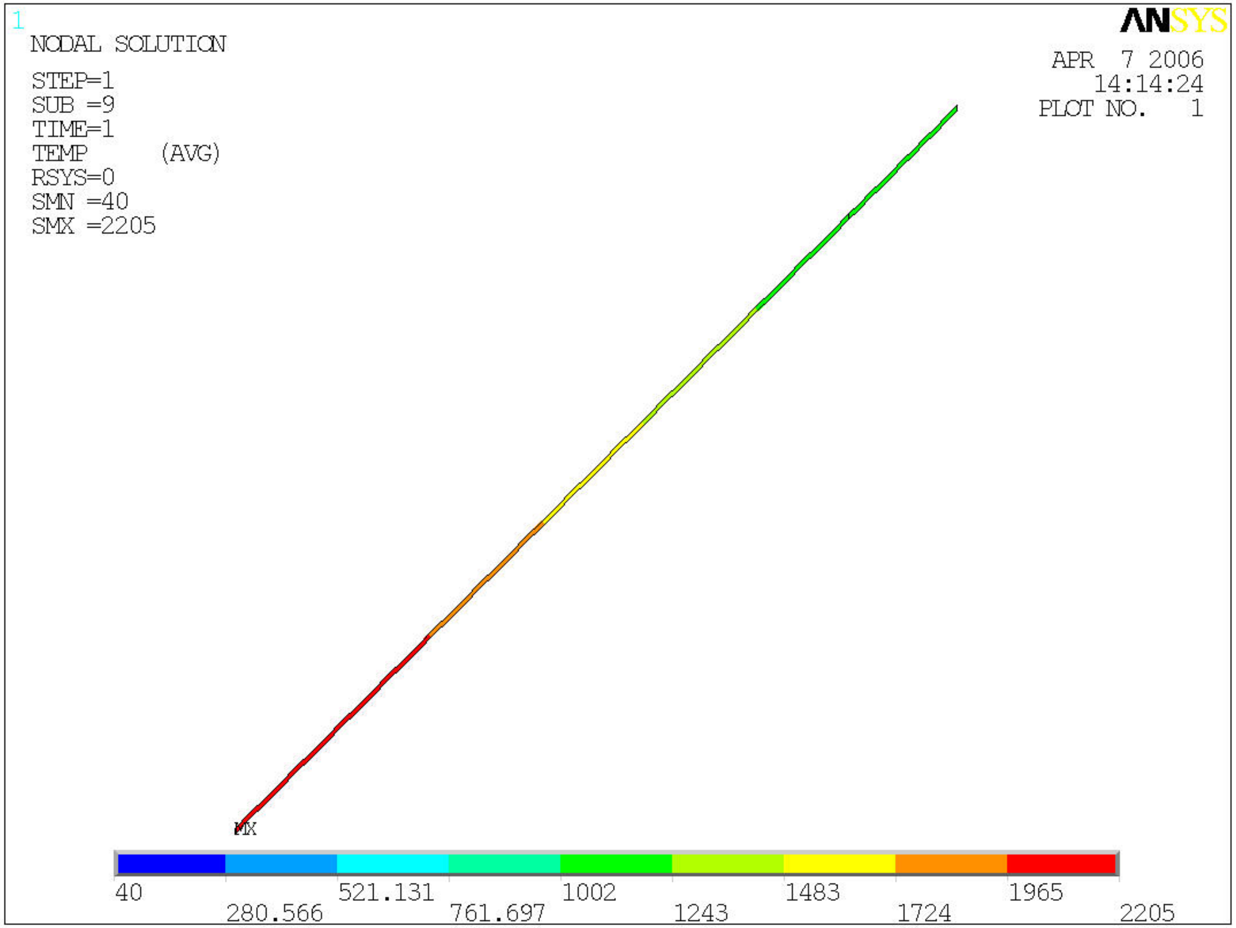


Conical type Diffuser

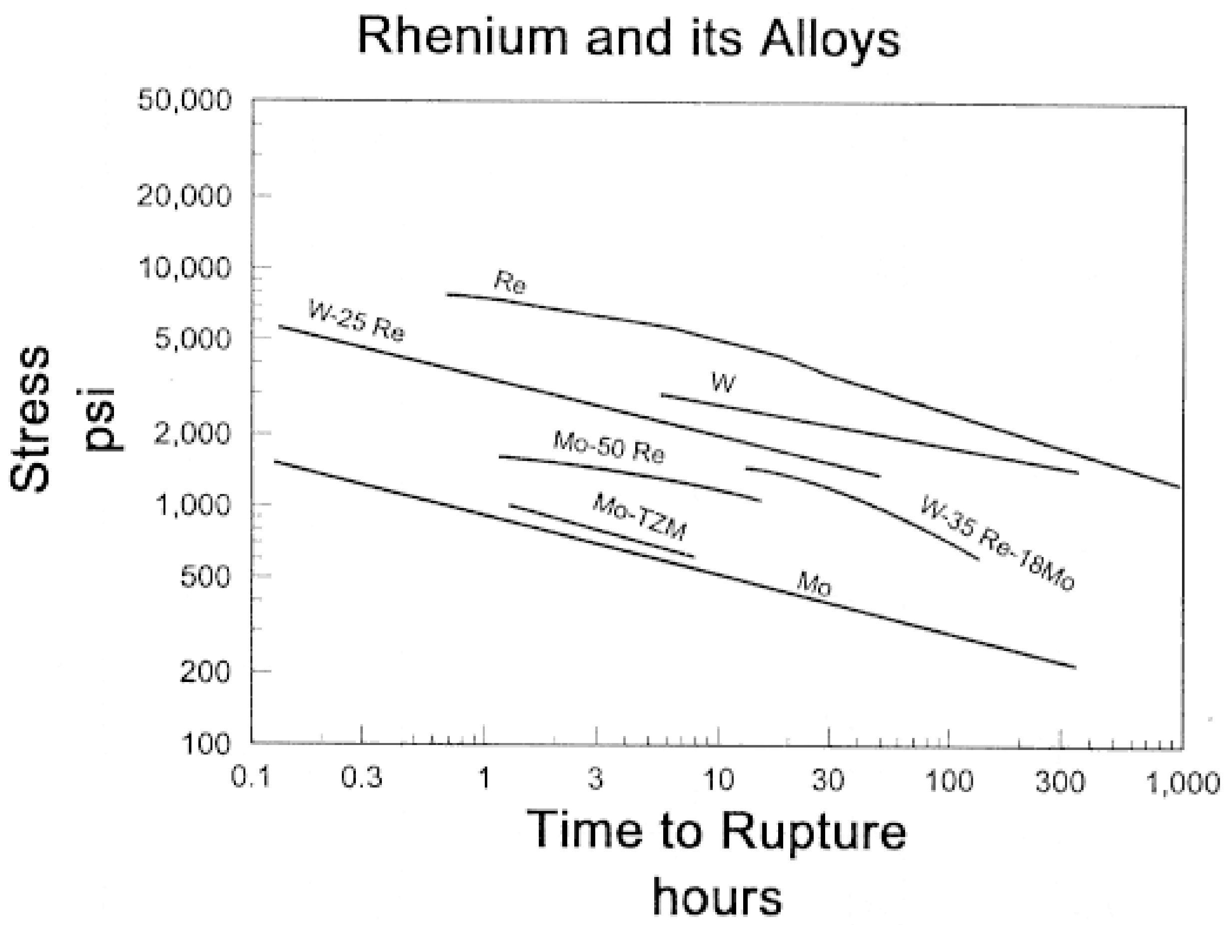
Materials:

- DIFFUSION DISK (W-Re)
- SUPPORT (AISI 316)
- SPINE (W)

Temperatures of the Conical Diffuser



Creep Resistance of W-Re alloys
At 2200°C



The final design will consider the expected lifetime

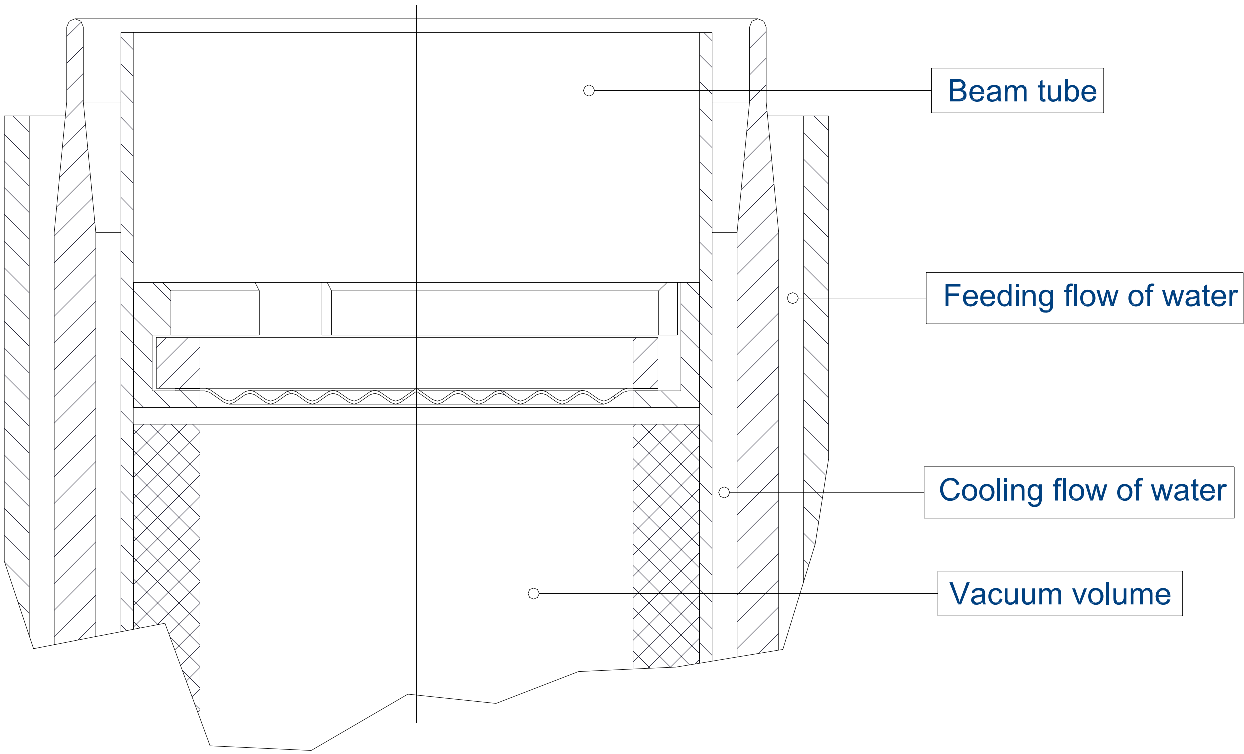
Cladding

Cladding is necessary to avoid direct contact between Uranium and cooling water

In this case has also structural functions, therefore AISI 316 would be the best choice.

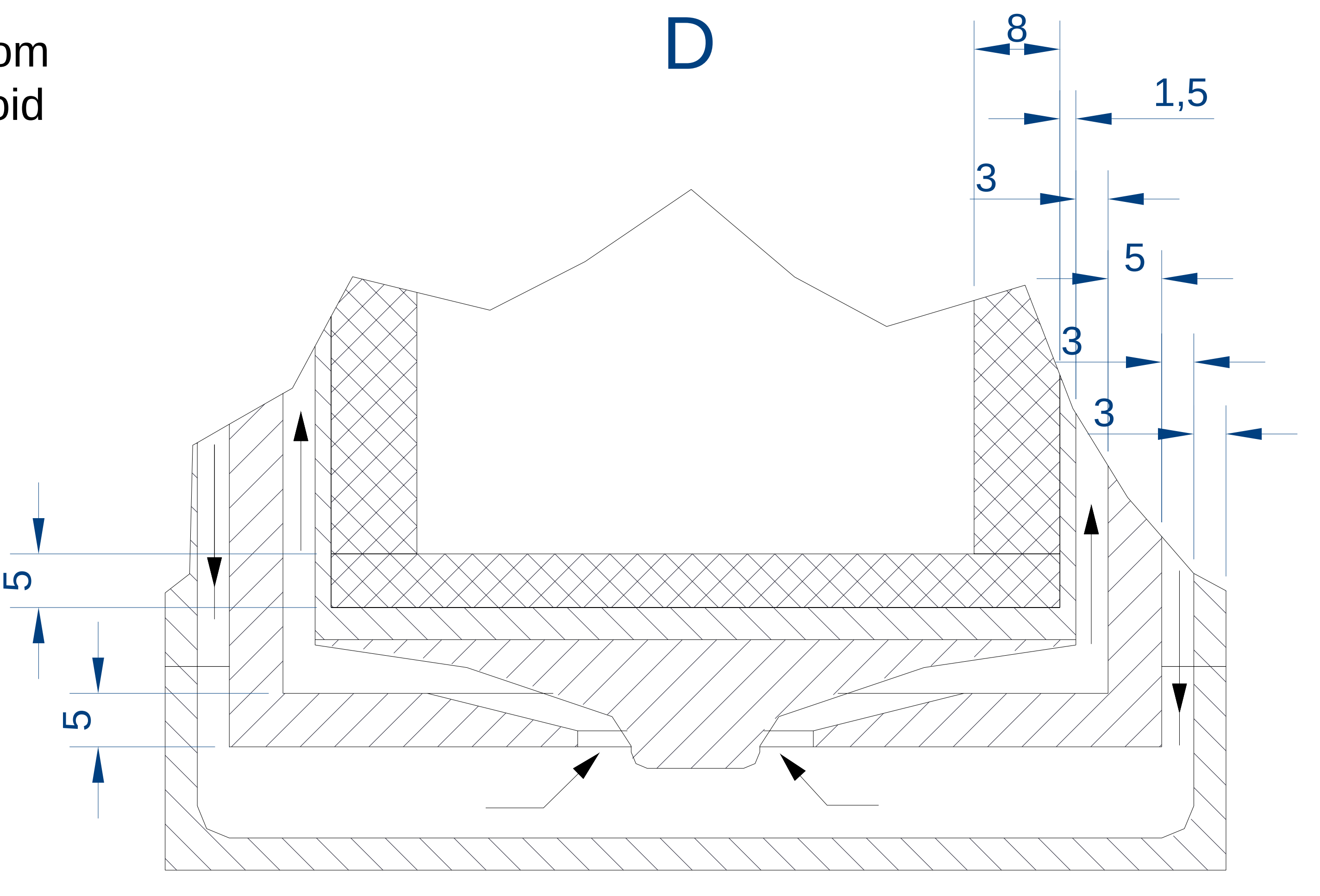
This item has to be discussed with the manufacturer

The inner cladding would reduce the neutron conversion efficiency due to the low grazing angle and long path of electrons inside it.



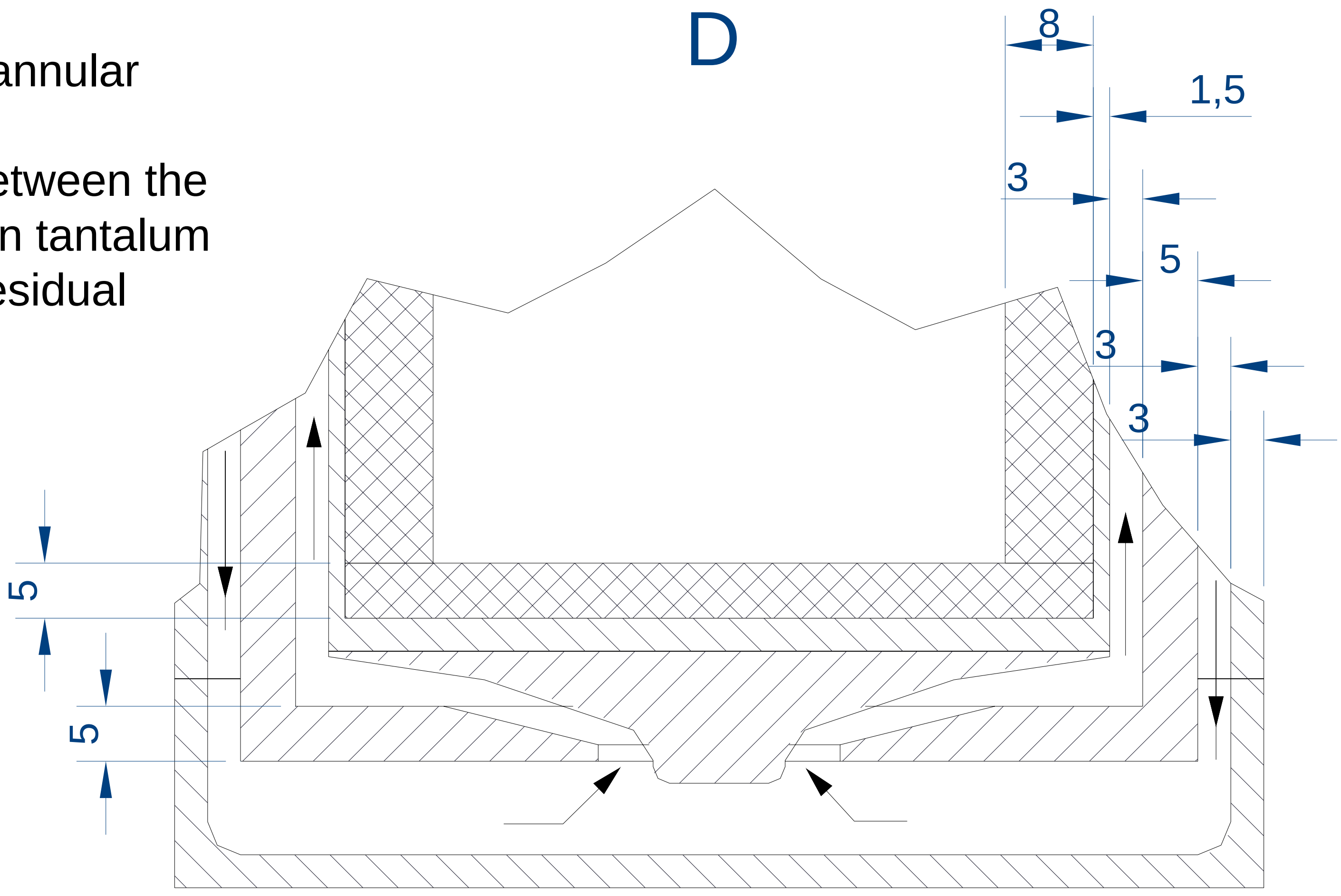
Cladding

A suitably shaped Aluminum body will be placed below the bottom cladding to avoid stagnation of vapor bubbles.



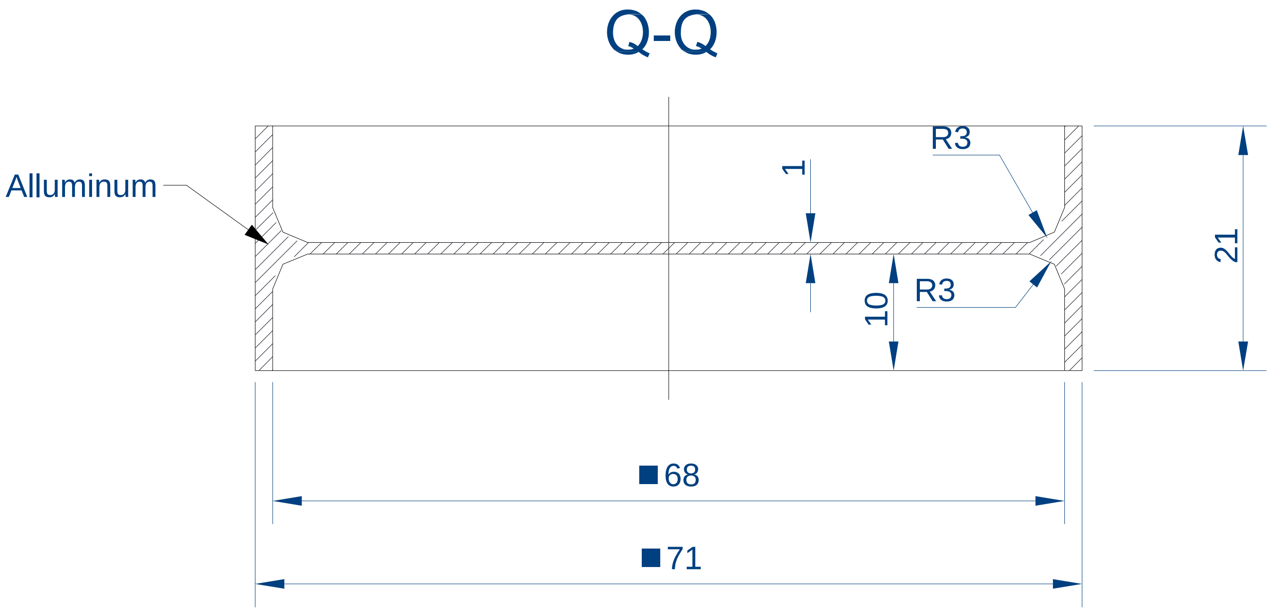
Concentric flow channels

In order to minimize the radial space, the feeding water
Comes from an annular external channel
The separator between the two channels is in tantalum
To convert the residual electrons



Aluminum window

An Aluminum window will separate the uranium region and its vapours and/or particles from the beam line
The aluminum window is cooled by convection
It is about 1 mm thick to reduce the electrons absorption



Conclusions

- The feasibility studies evidenced some viable solutions and provided information for their evaluation
- We reached an agreement to identify the hollow cylinder as the reference solution
- More detailed studies of the reference solution are under way
- At this stage, in order to proceed, it is necessary a close interfacing with the reactor people (safety issues) and with the target manufacturer (fabrication issues).
- We can produce first drawings in June if the former conditions are respected.