High Power Targets

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1. Some existing targets

2. Design considerations
   Simple thermal principles
   Radiation effects

3. Some possible solutions

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High Power Targets

Target	Beam	Material	Target Power kW	Size cm	Power Density W/cm^3	Cooling
ISIS neutron	protons, 800 MeV, 200 μA, 50 HZ,	**tantalum** slabs	**130**	10x10x30 stopping	**average -- 43 peak --- 340**	**heavy water**
ESS* neutron	*protons, 1.3GeV 4 mA, 50 Hz*	***mercury***	***2240***	*6x20x60 stopping*	***average -- 310 peak --- 2500***	***mercury***
SINQ neutron	*protons,600 MeV 1.5 mA, cw*	***zircalloy lead***	***600***	*30x15 dia. stopping*	***average -- 110 peak --- 300***	***heavy water***
APT* tritium	*protons ~2 GeV,~100 mA*	***tungsten***	***~200000***	***~20x200x100 stopping***	***average --- ~1***	***heavy water***
GANIL RNB	heavy ions, cw e.g.Argon,3456 MeV 1 pμA	**graphite** cone	**2.1**	~3 dia. cone stopping	**5250**	**radiation**
RIST RNB	protons, 800 MeV, 100 μA, ~10Hz	**tantalum** foils	**20 - *40***	20x4 dia. transmission	**average 80-*160* peak 170-*340***	**radiation**
PSI muon	protons, 600 Mev, 1.5 mA, cw	**graphite** rotating wheel	**6**	0.6x5 transmission	**average -- 60 peak --- 280**	**radiation**
Muon Collider muon	*protons, 2 GeV, 1 mA*		***200***	*20x1-2 dia. transmission*	***3000-13000***	

**** Proposed***

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Design Considerations

Need to know

Beam current density profile and target geometry

Power density distribution within the target

Pulsed or continuous

Apply thermal calculations

Cooling Stresses (pulsed)

Temperatures

Radiation Effects

Shielding, Activity, Remote Handling, beam dump

Radiation Damage Maintenance, Target changes. Disposal

Magnet

Magnetic field, sc magnet (heat and radiation)
(Forces, induced currents)

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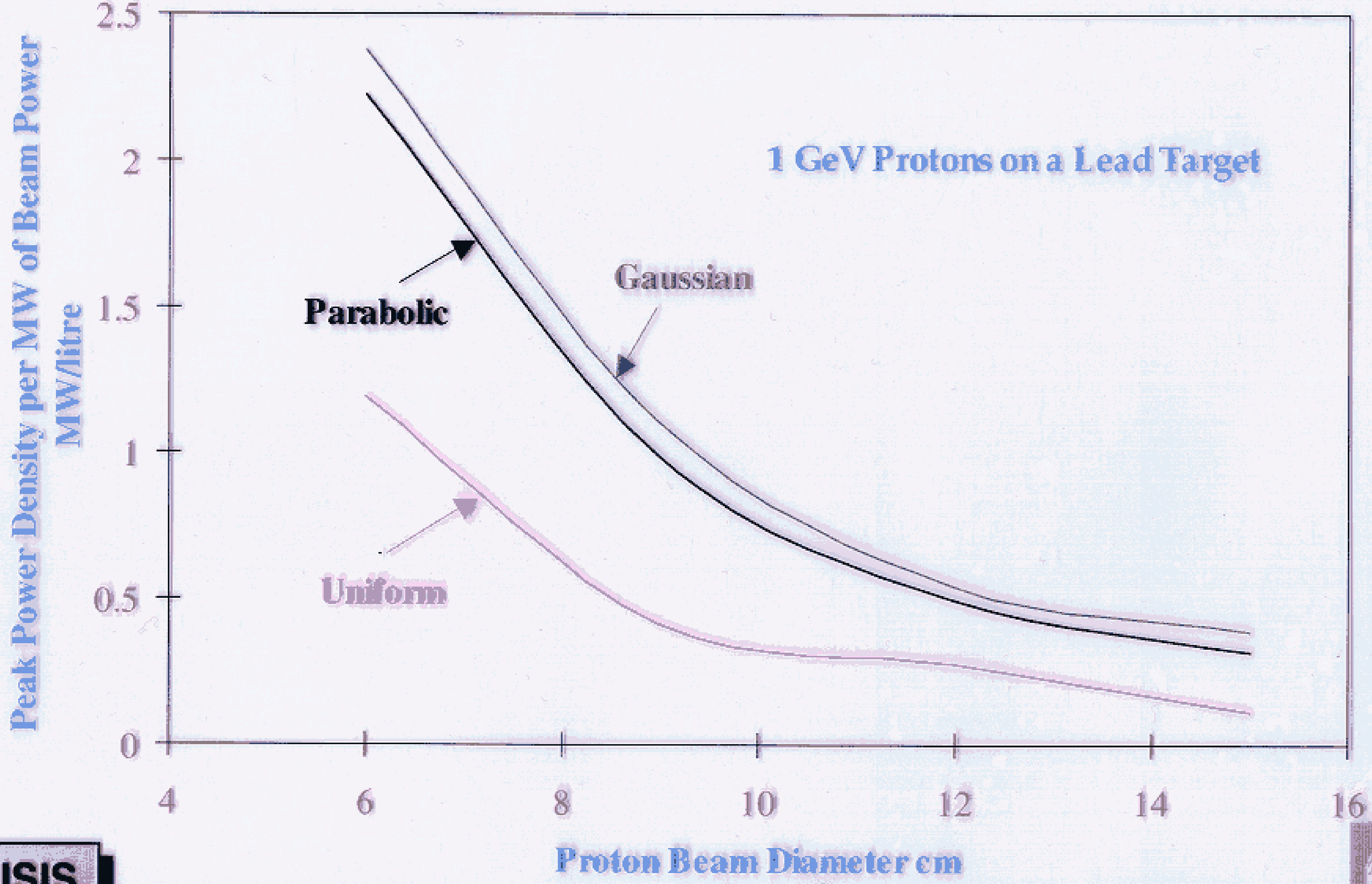
Peak Power density vs beam size and profile



ISIS

Rutherford Appleton Laboratory

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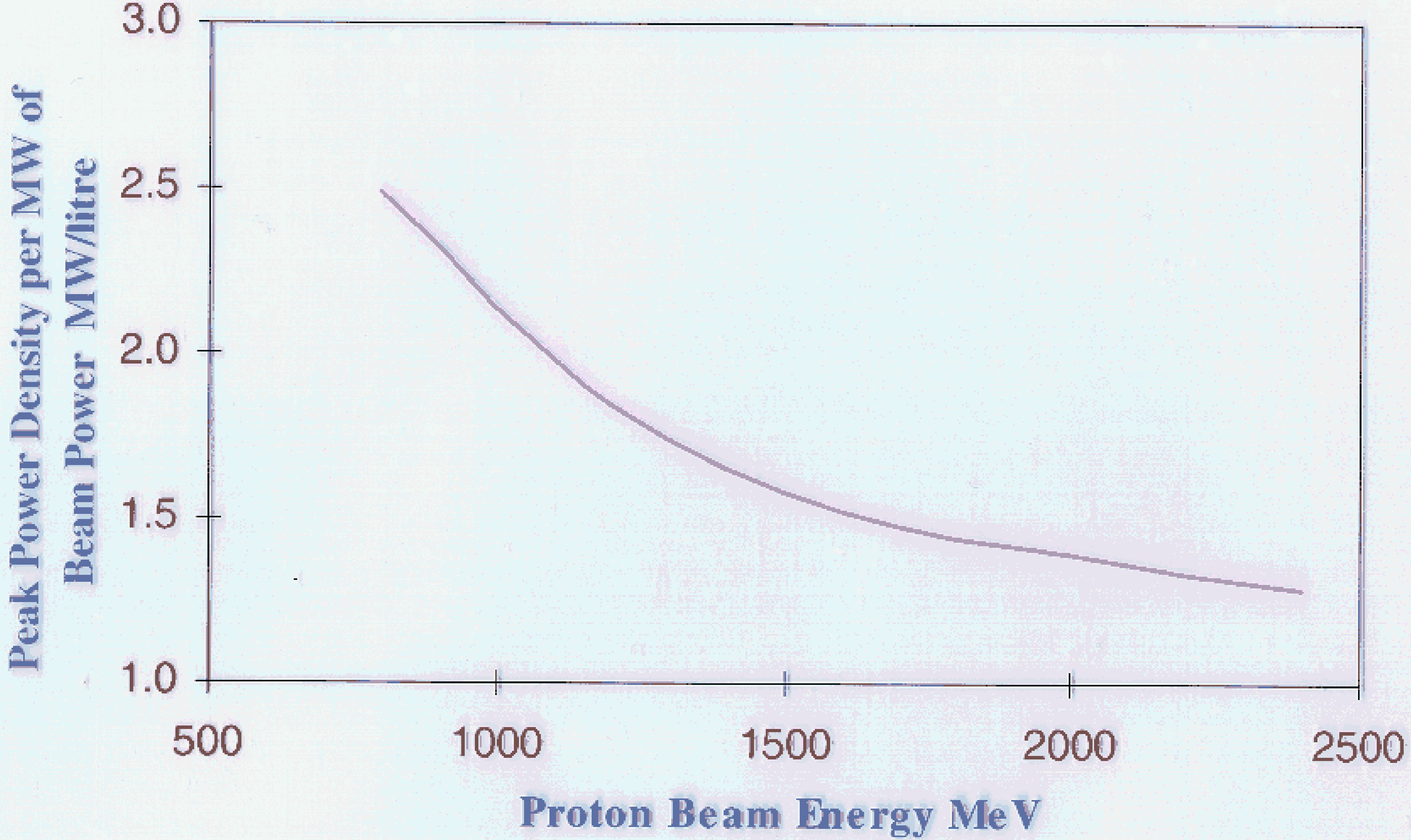
Peak Power density vs beam energy



ISIS

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Cooling

Mainly a problem of power density

1. Fluid Cooling

Water

(limited to ~5-10 kW/cm^3)

Liquid metals

Gas

2. Conduction

3. Radiation

Limited to ~400 W/cm^2

Increase the Effective Volume (also reduces radiation damage)

Larger target- less dense, larger cross-section

Moving target - rotating wheel, moving band

Flowing Target - liquid metal in tube, liquid metal jet, solid powders in fluid (radiation damage no problem)

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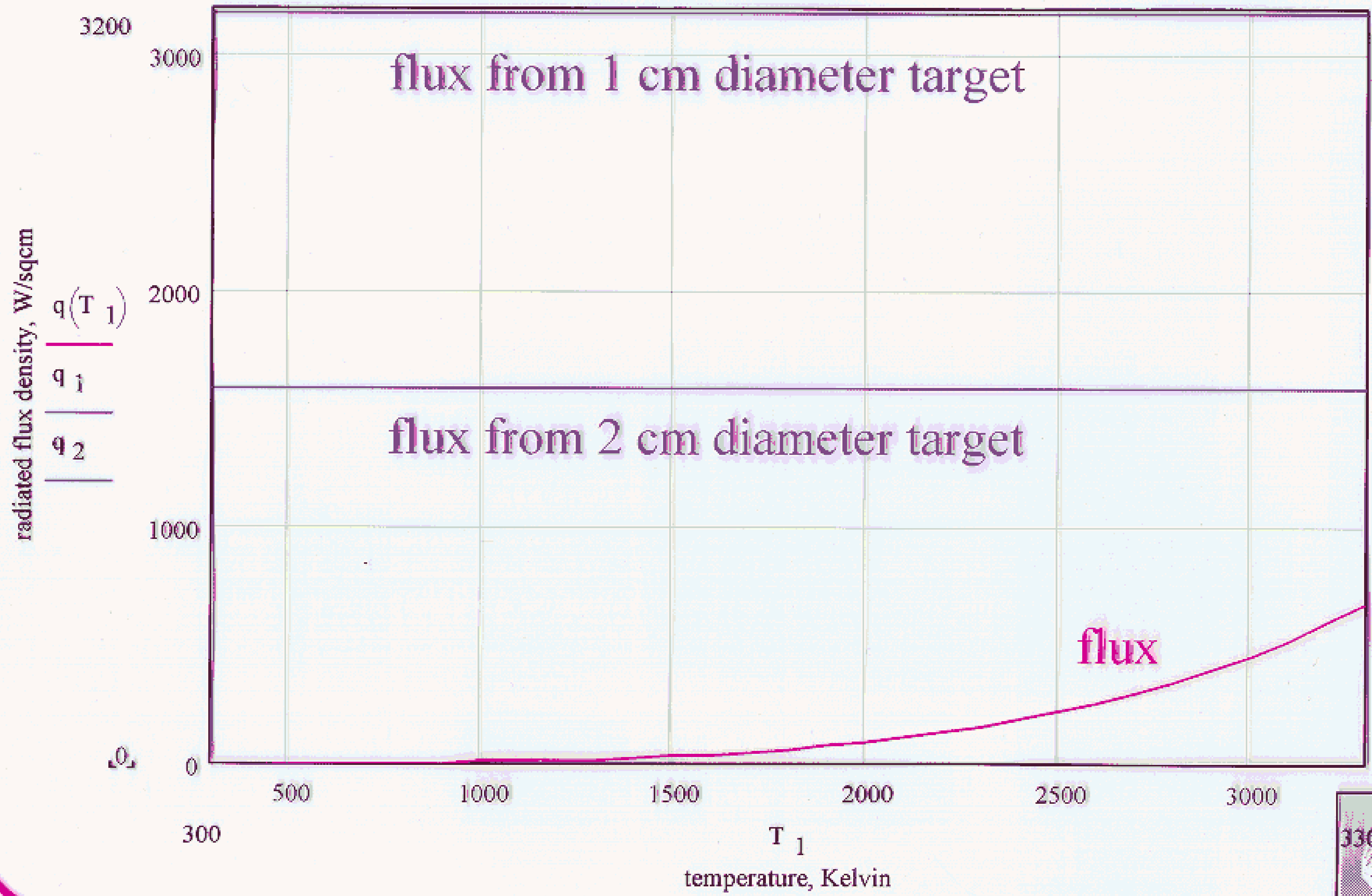
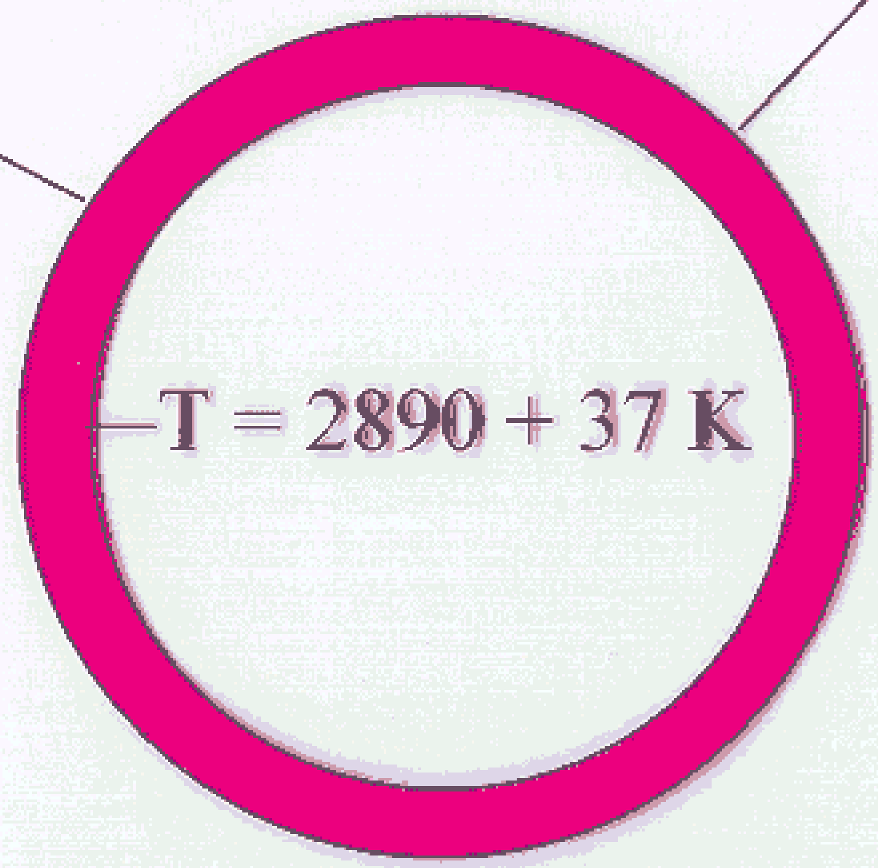
Power/cm² radiated from surface at temperature T_1 with emissivity 0.8



Radiation cooled target

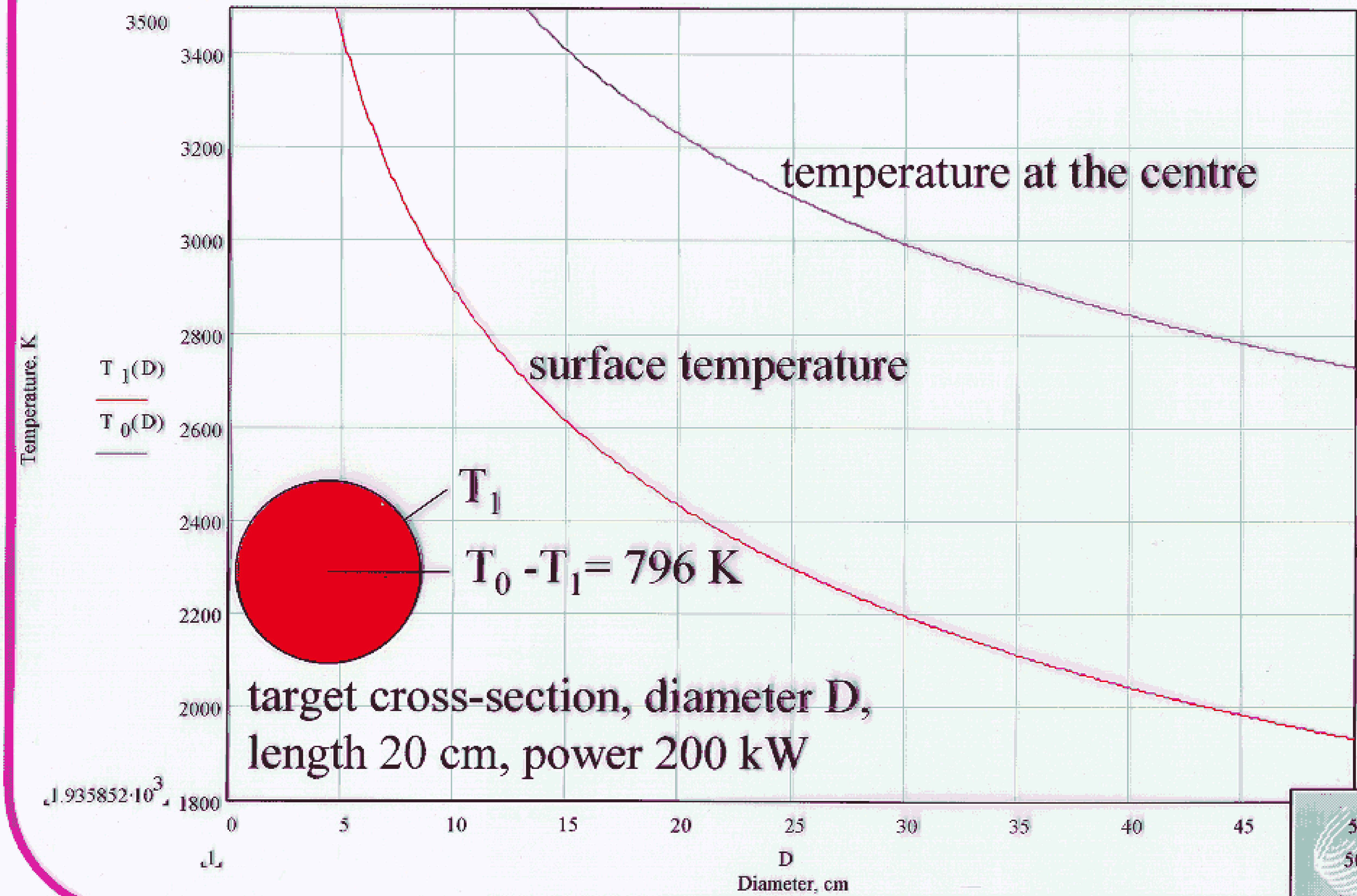


Rotate beamspot or Target

cross-section through the target tube

If diameter increased to 20 cm, T = 2430 K

Radiation Cooled Target

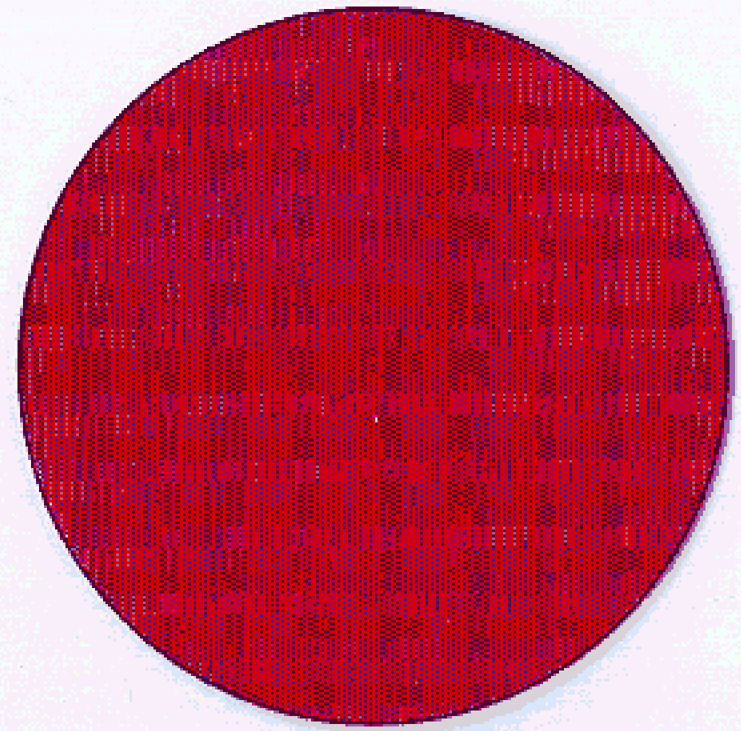


Water Cooled Target

2 cm diameter x 20 cm long

one central water channel

Insufficient heat transfer across the water boundary



2 mm diameter water channels, taking up 50% of the cross sectional area

Just possible (probably)

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USA Muon Collider

Metal Jet Target

Being considered by BNL.

lead or gallium alloys (mercury toxic!)

2 cm diameter, 30 cm long, 1000 cm/s, 400 kW

Rotating Cu-Ni Band Target

Considered by BNL

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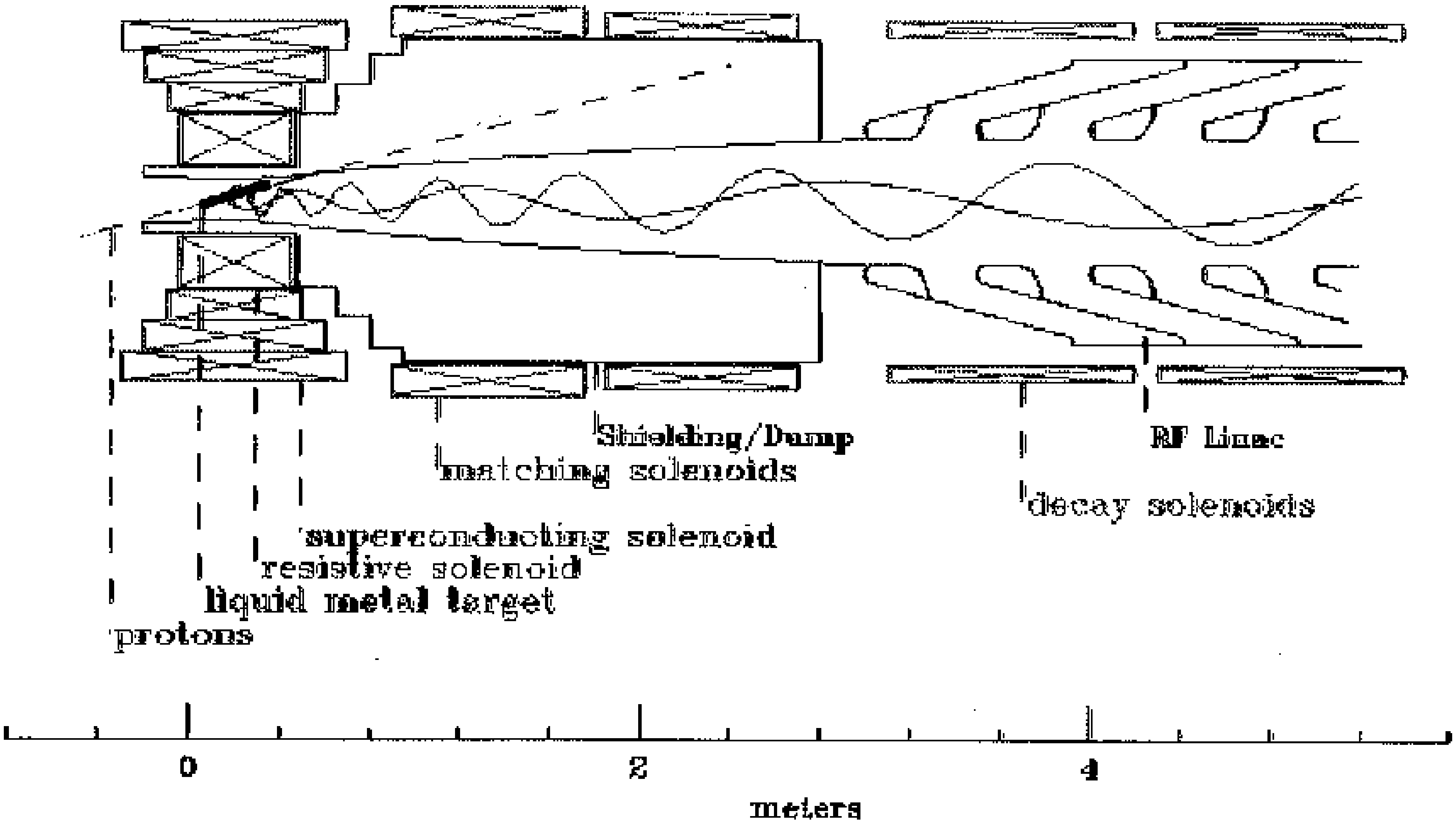


Muon Collider Targetry and Phase Rotation

See Links at end.

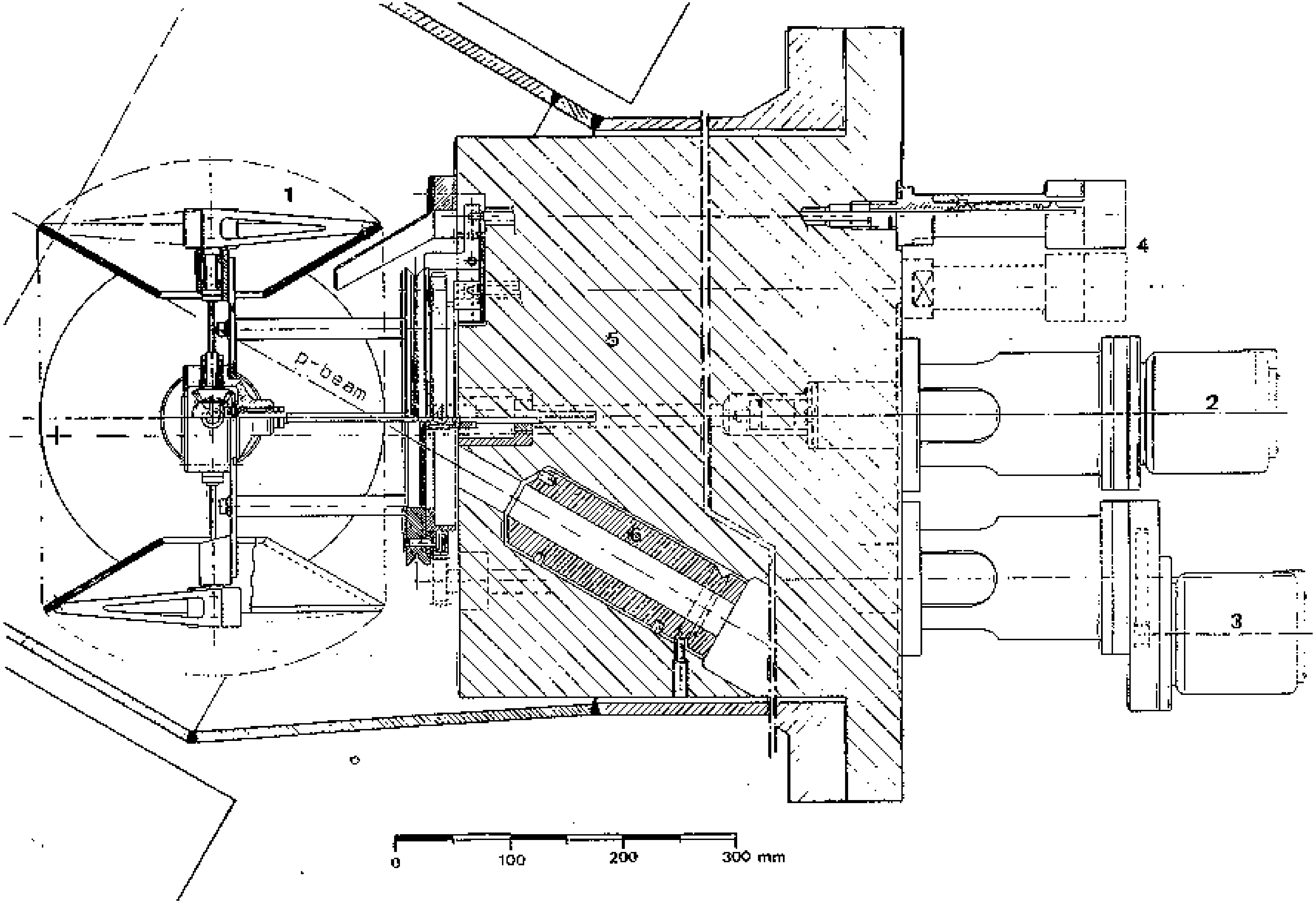
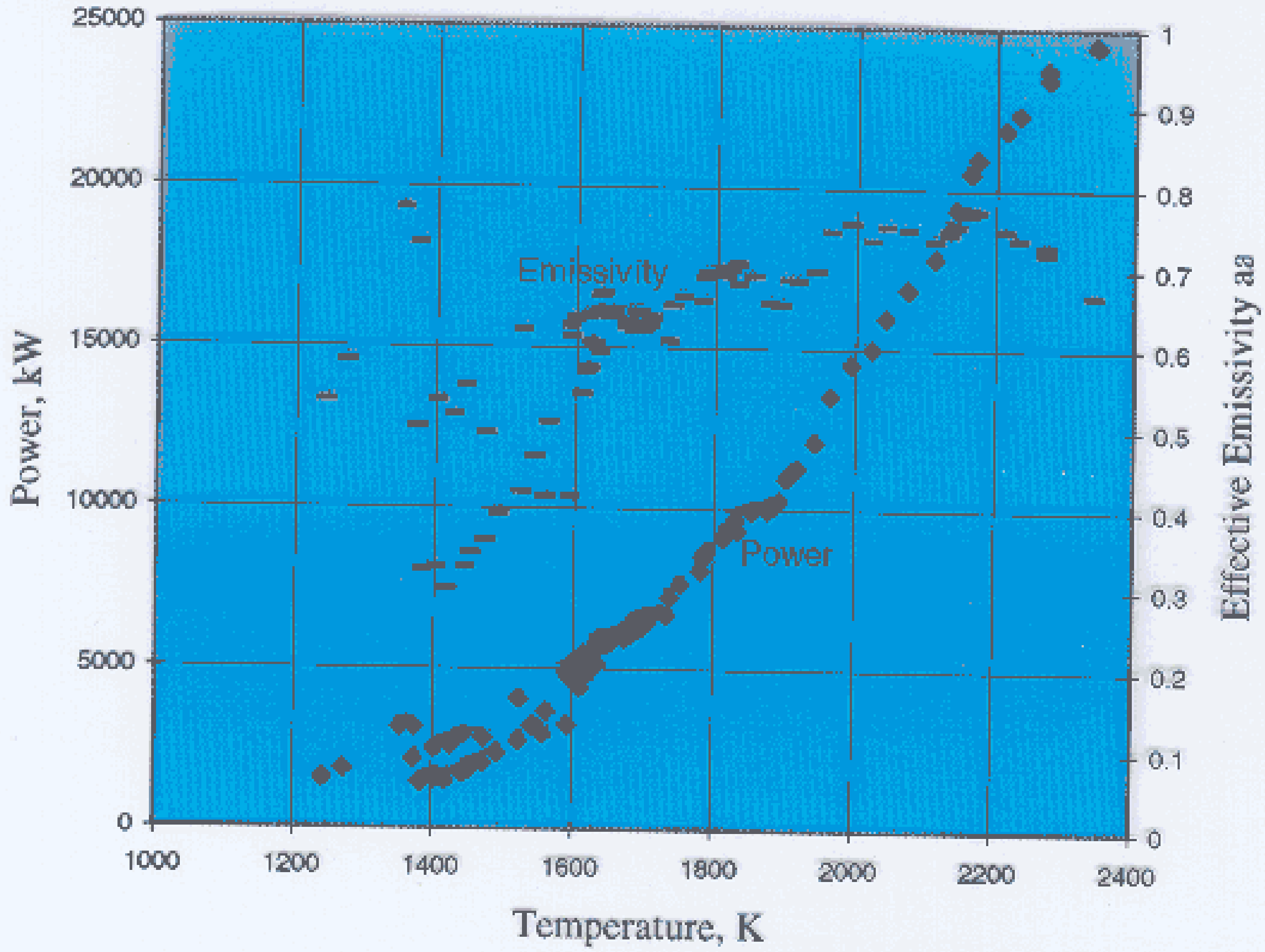


Fig. 15

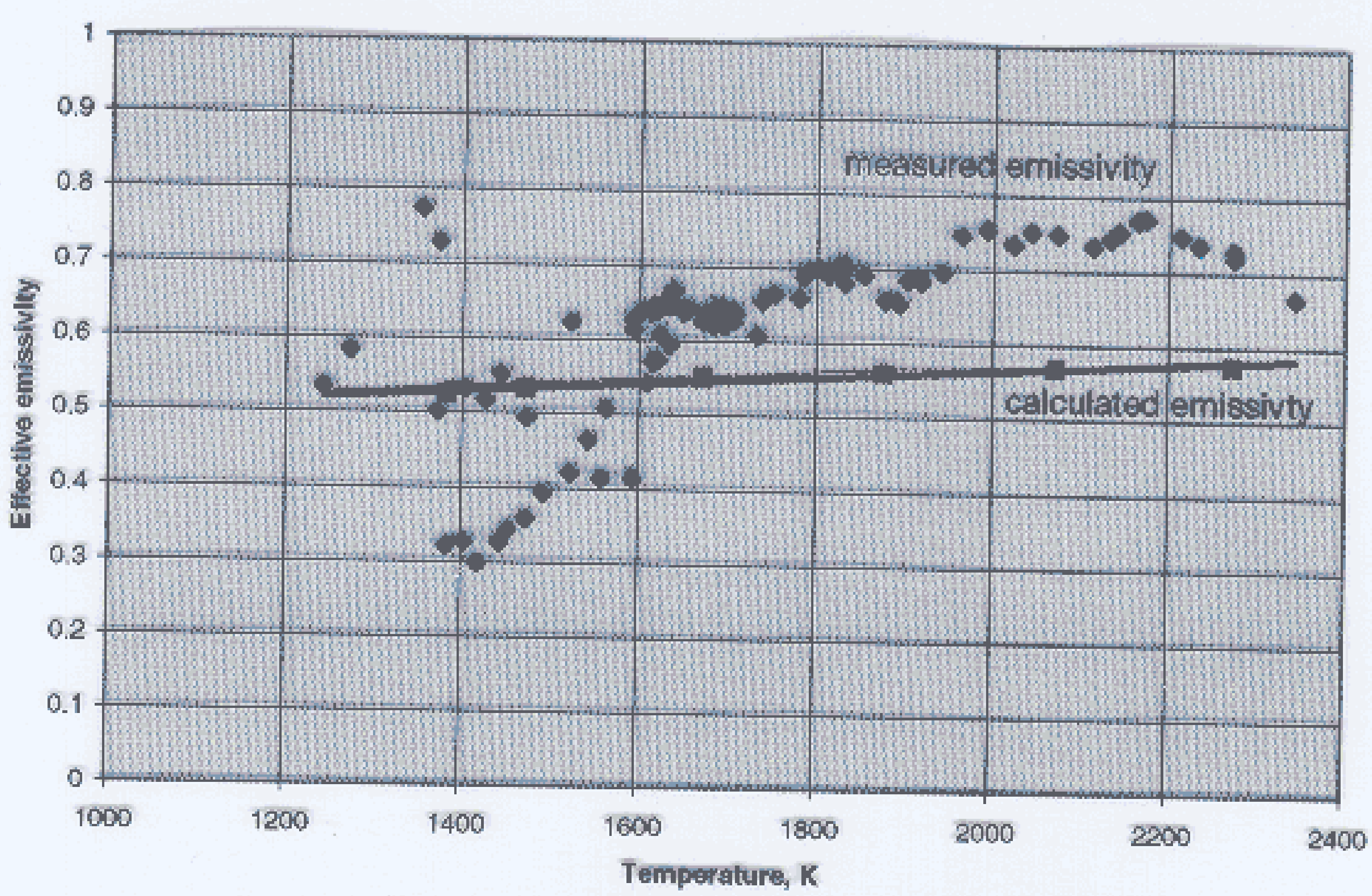
Schematic view of a typical target station

1 Carbon wheel
2 Wheel rotation drive motor
3 Target change drive motor
4 Target position indicators
5 Shielding
6 Collimator

Measured power and effective emissivity versus temperature of the RIST Target



Measured and calculated emissivities versus temperature



95Fc 5279

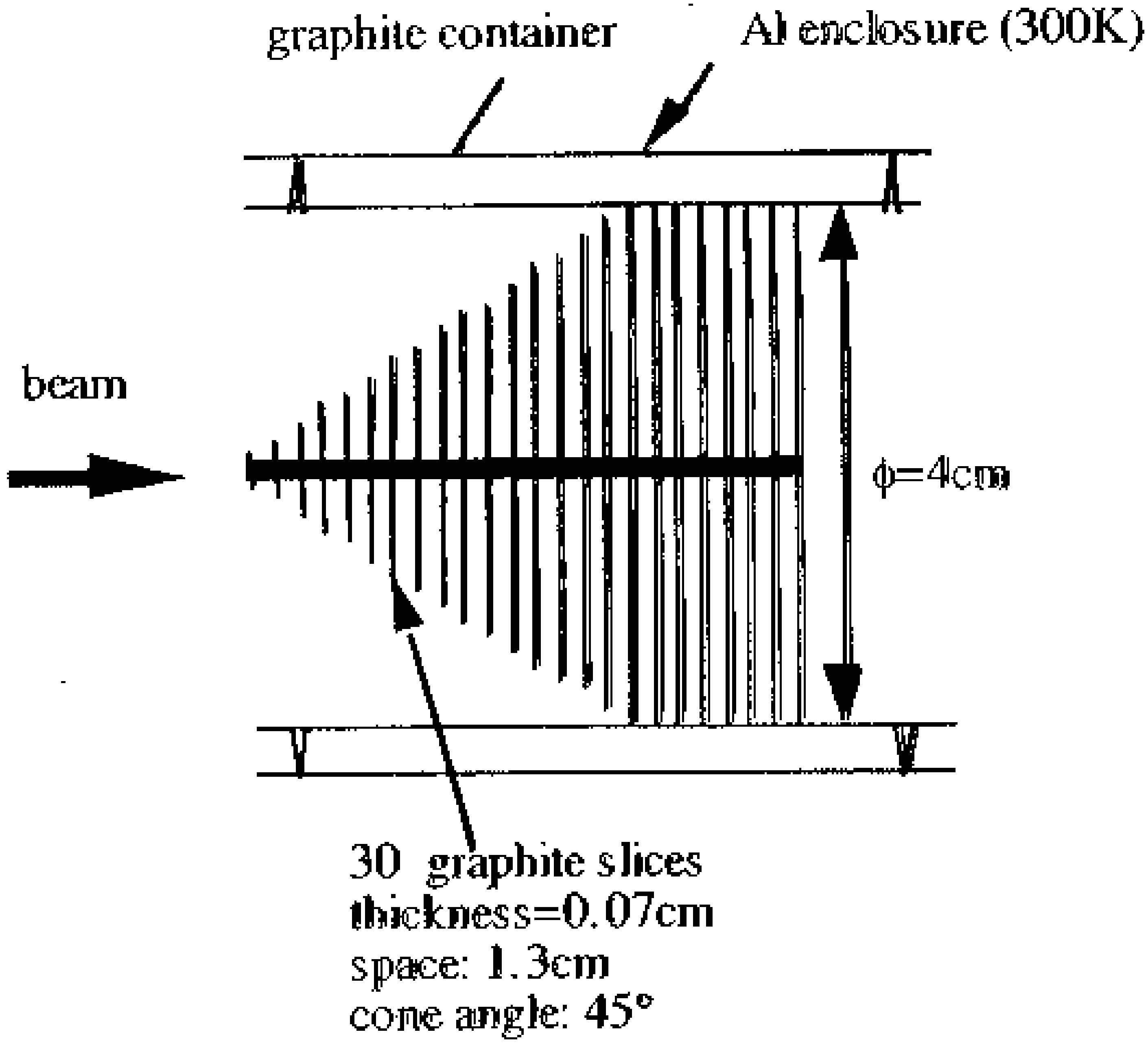


Fig. 1. Schematic representation of the conical target.

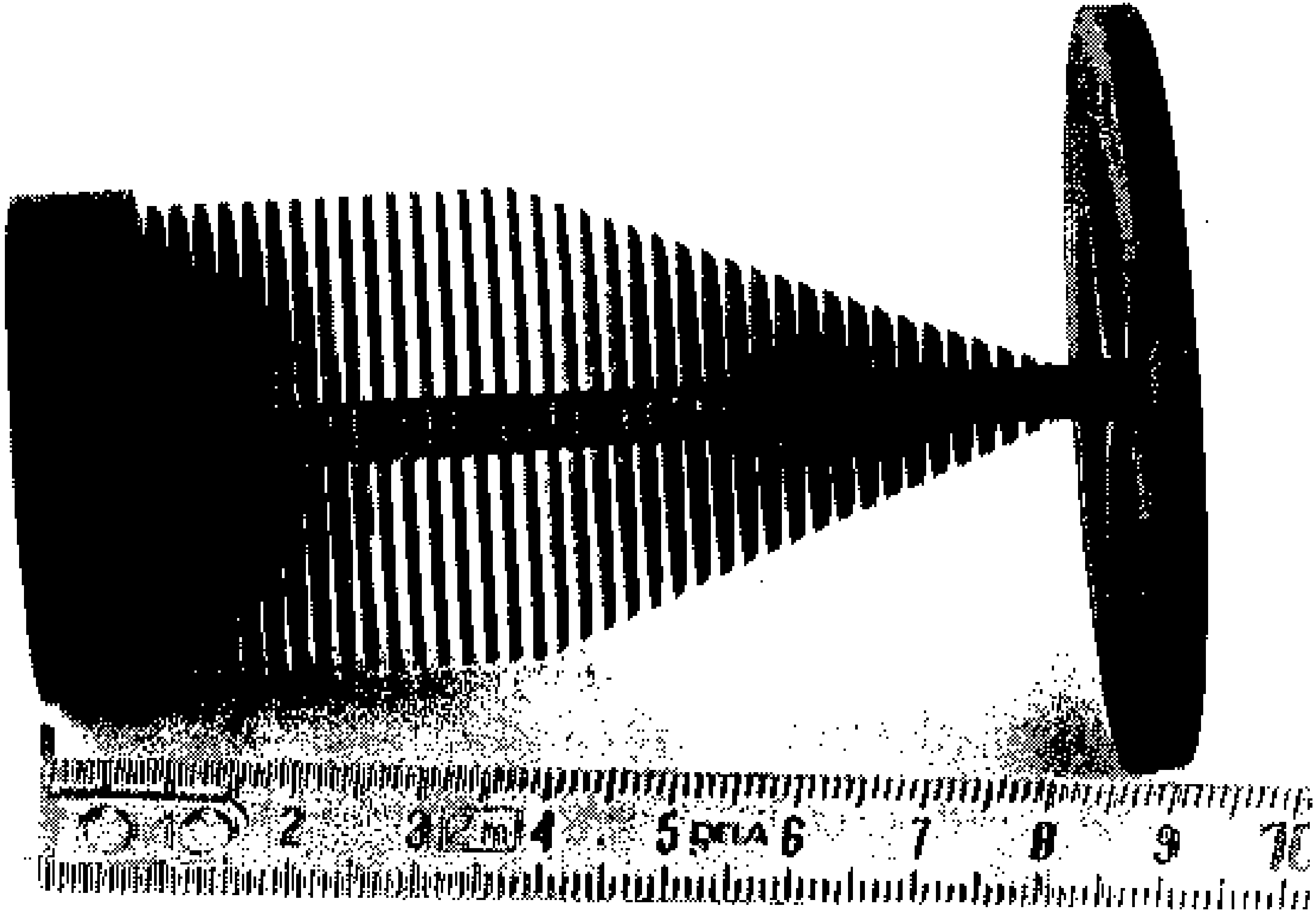


Fig. 4. Conical graphite target.

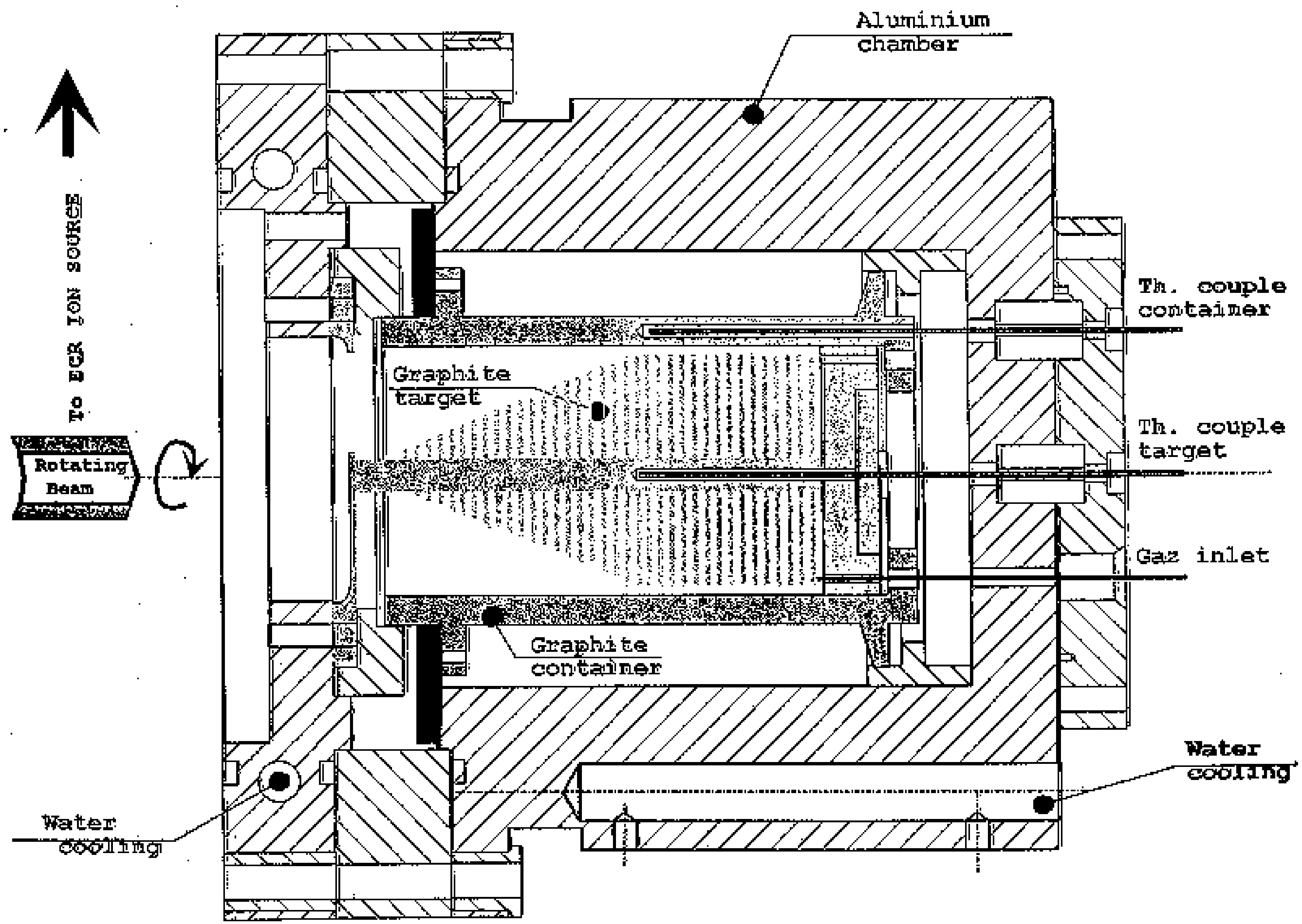
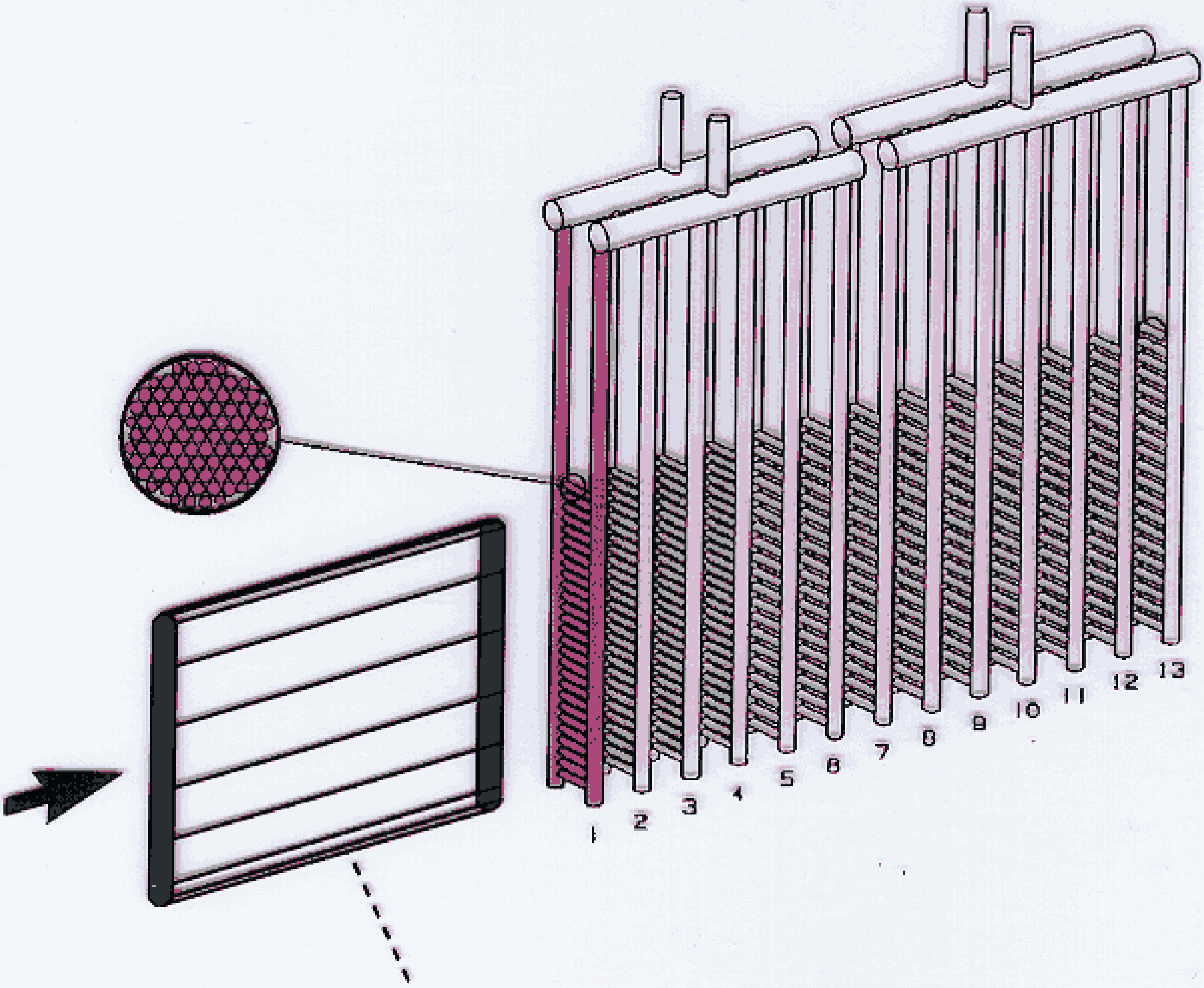


Fig. 5. Target set-up for SPIRAL.

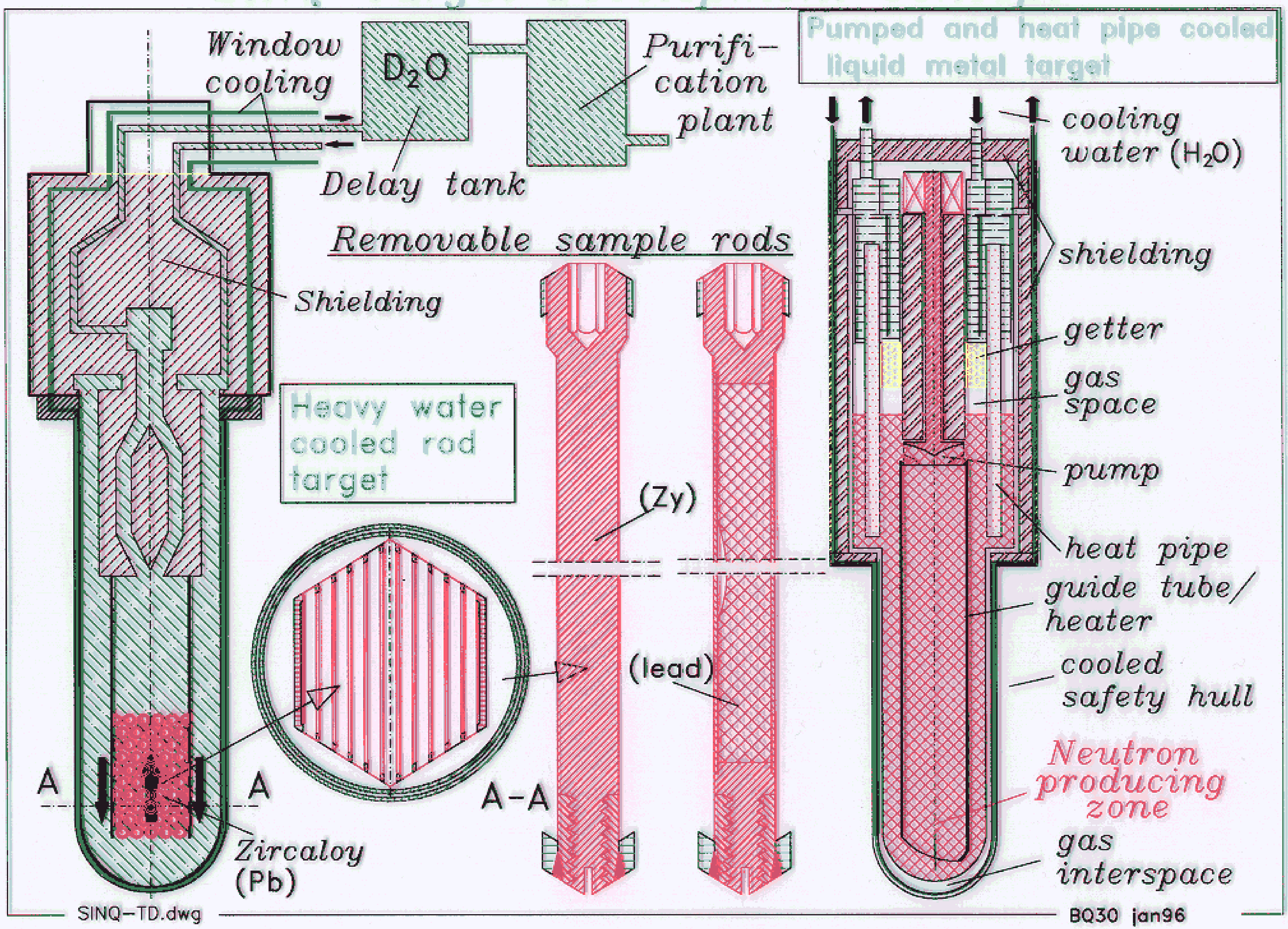
The Los Alamos APT Target

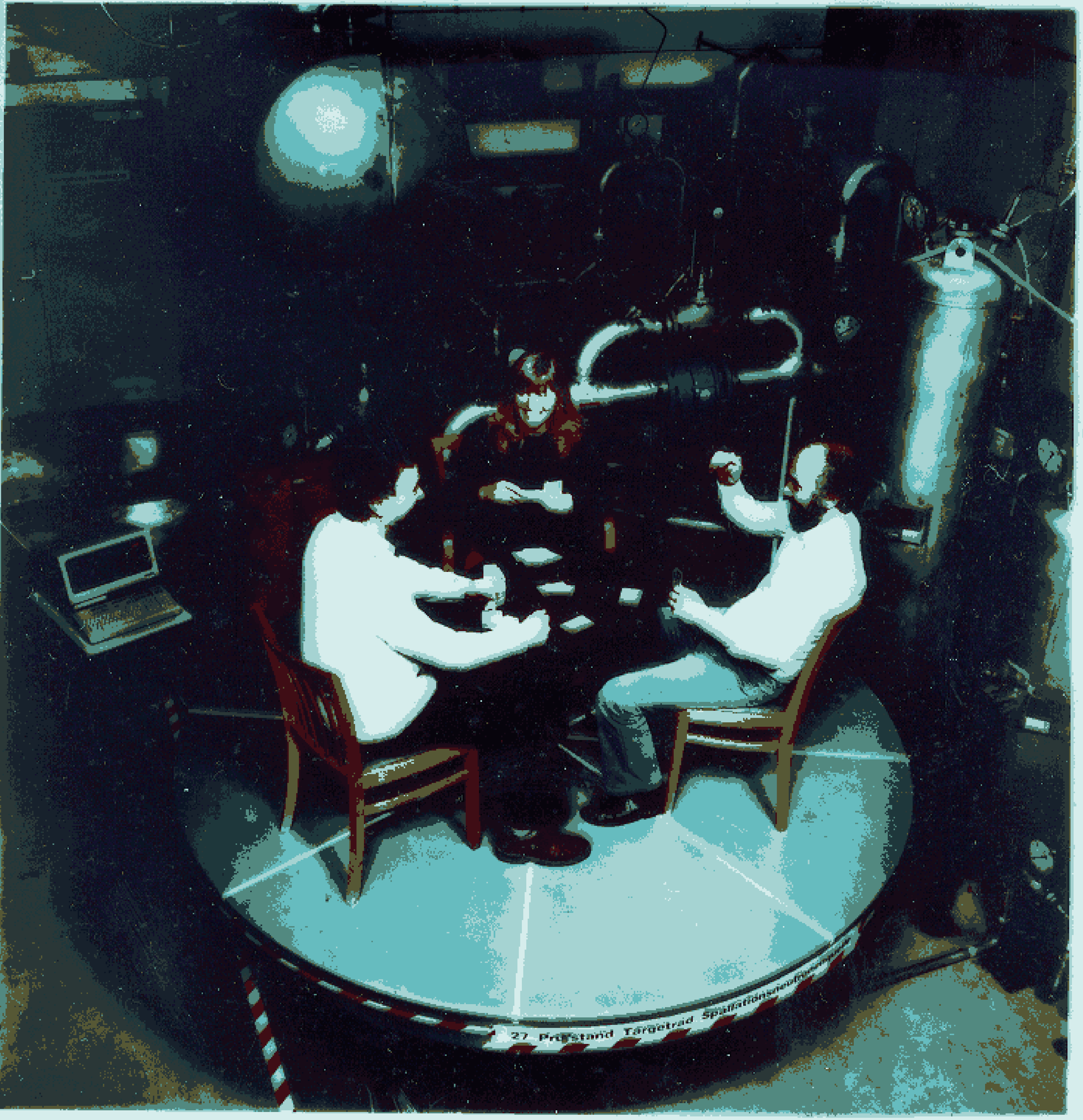
- Water cooled tungsten rod bundles
- Rod size 0.3175 cm
- Power density 1.8 - 2.4 MW/l

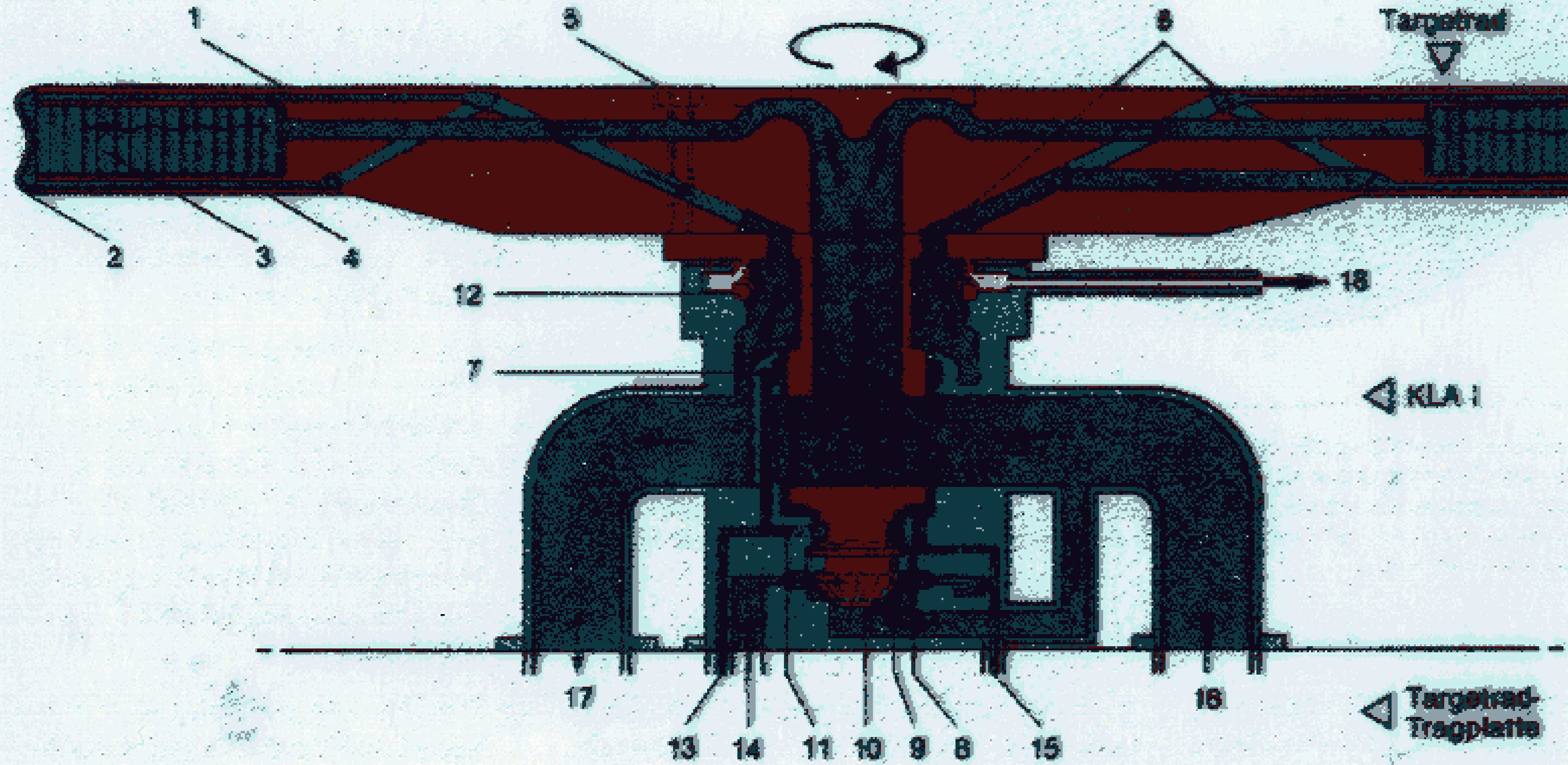


- Proton beam 150 MW
- Size 160 cm high by 16 cm wide

SINQ–Target Development Concept




27 Prüfstand Targetrad



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Targetrad
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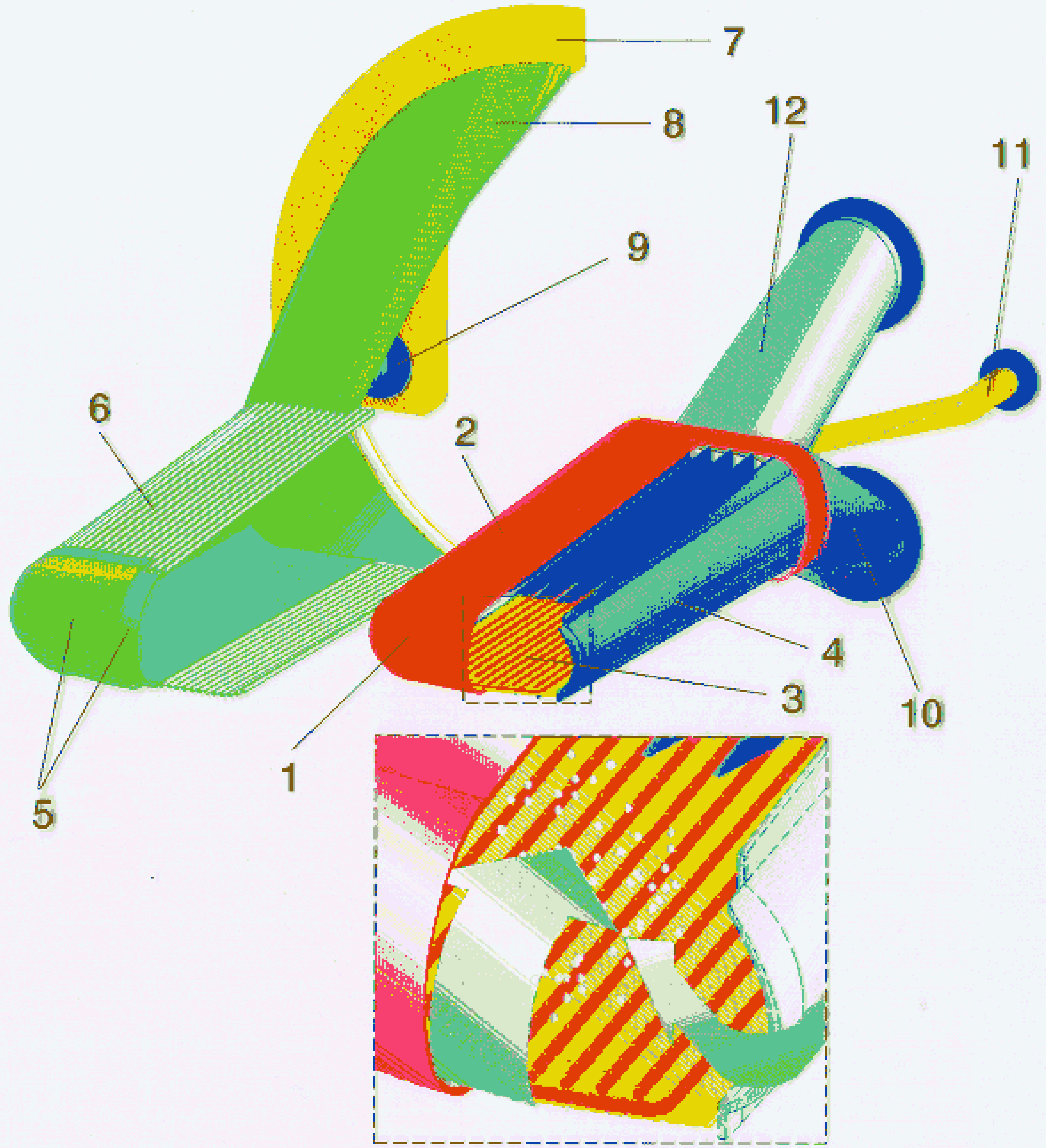

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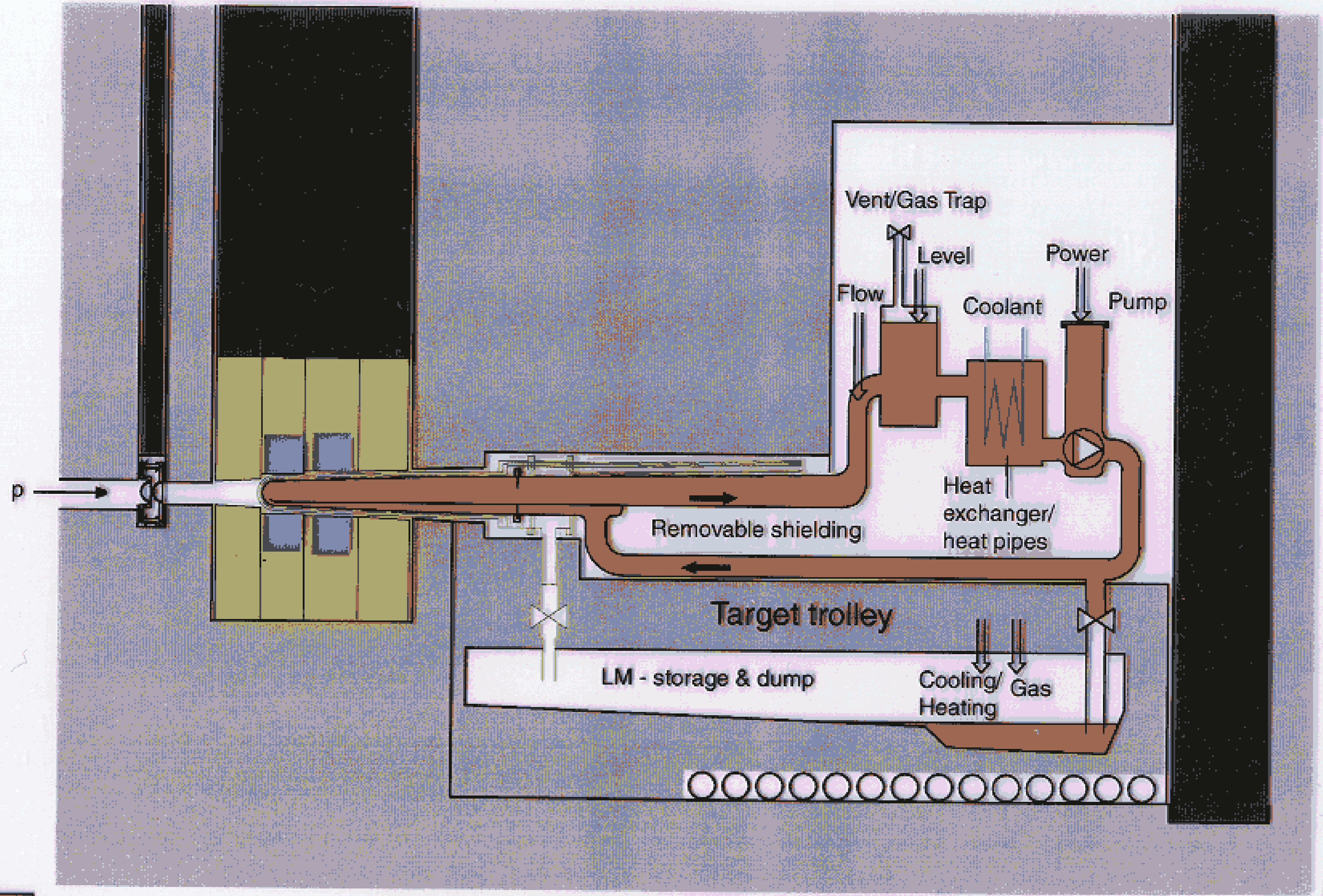
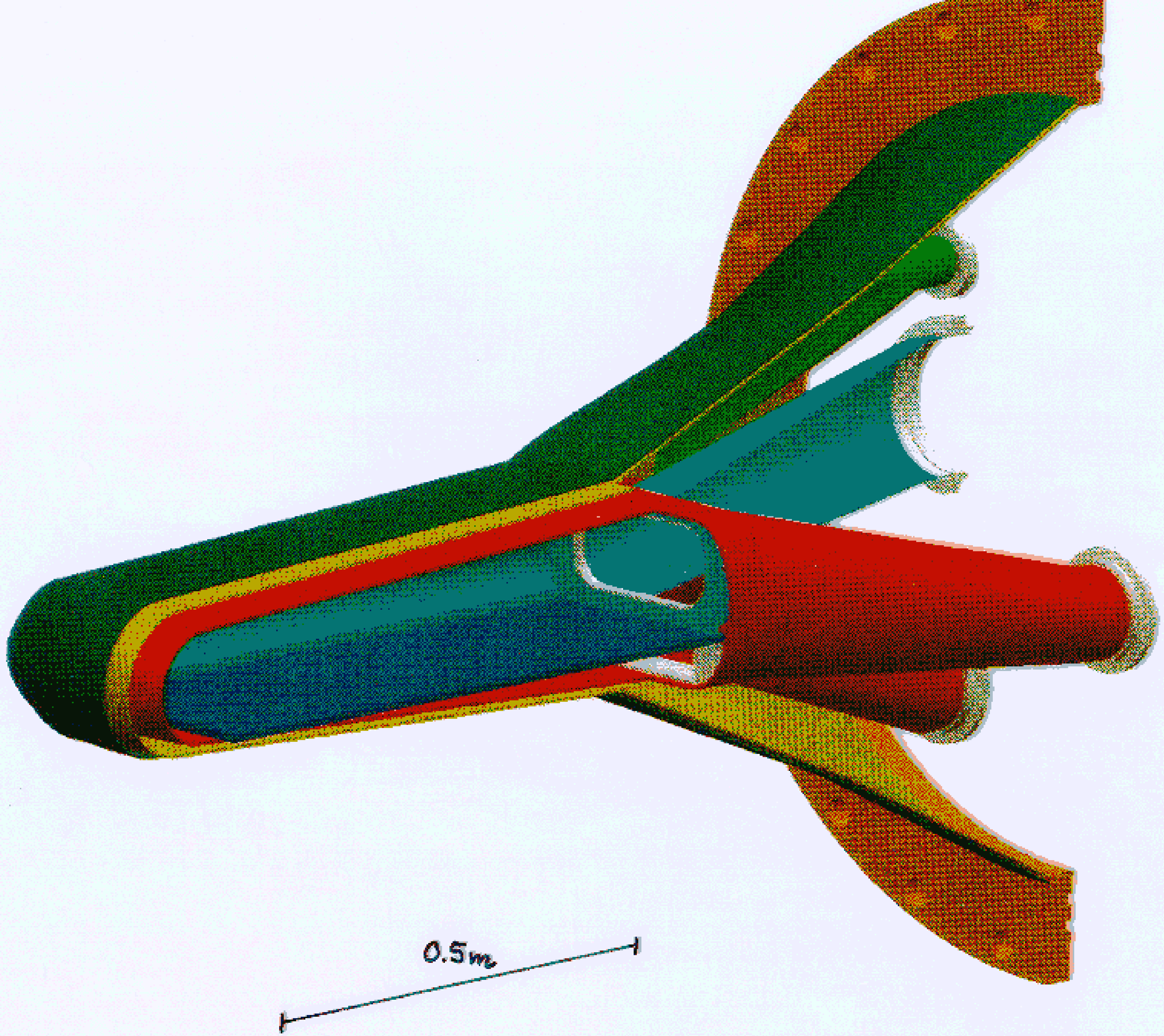
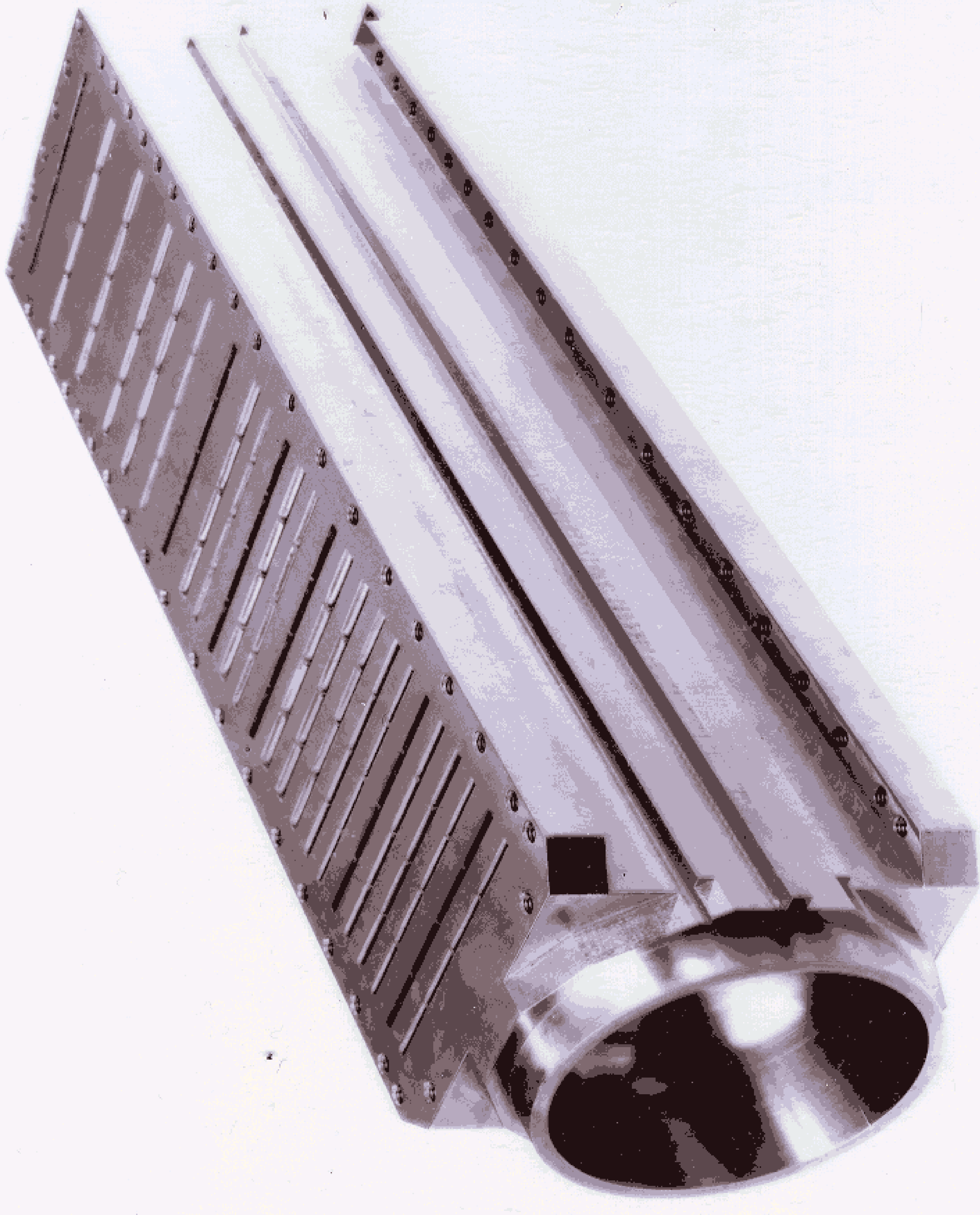
The ESS Mercury Target System

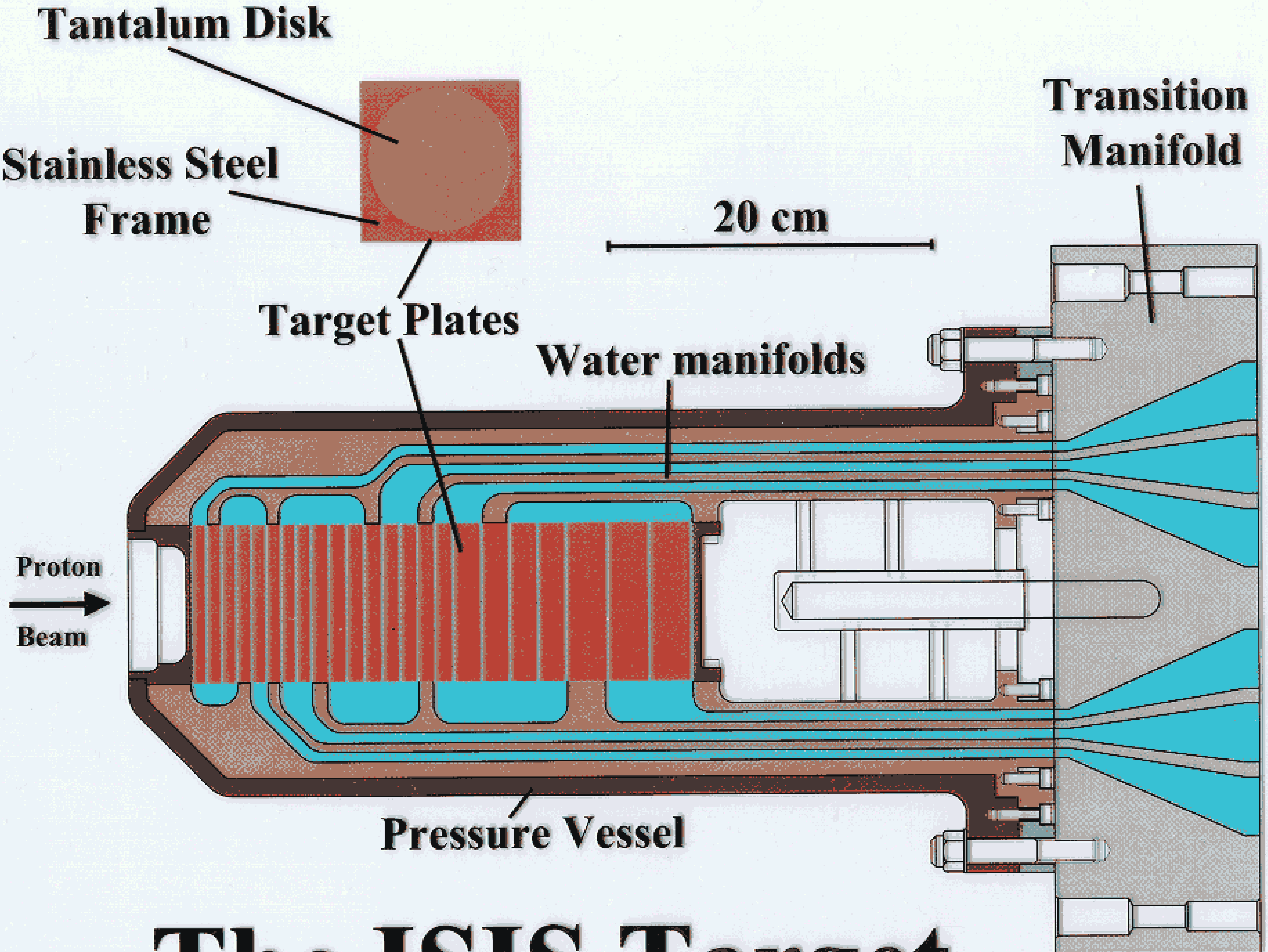



0.5m

Photograph number **84FB4765**



An ISIS target module after assembly awaiting fitting of the water manifolds



The ISIS Target

The Muon Target

assumed parameters

Proton beam

Energy	2 GeV
Current	1 mA
Power	2 MW

Target

Dimensions	20 cm long, 1-2 cm diameter
Power Dissipation	200 kW
Power Density	3.2-12.7 kW/cm^3 (average)
	20-80 kW/cm^3 (peak Gaussian)