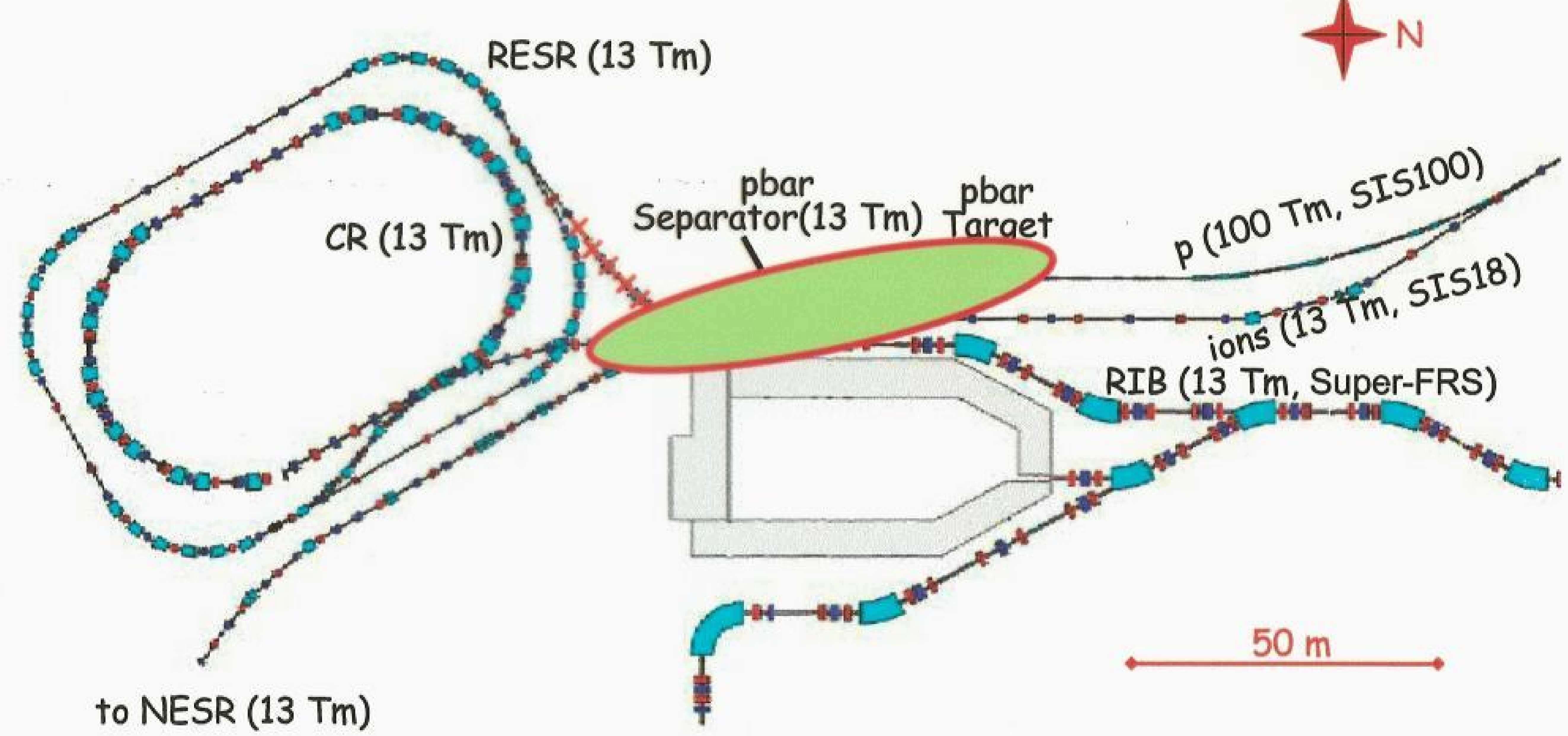
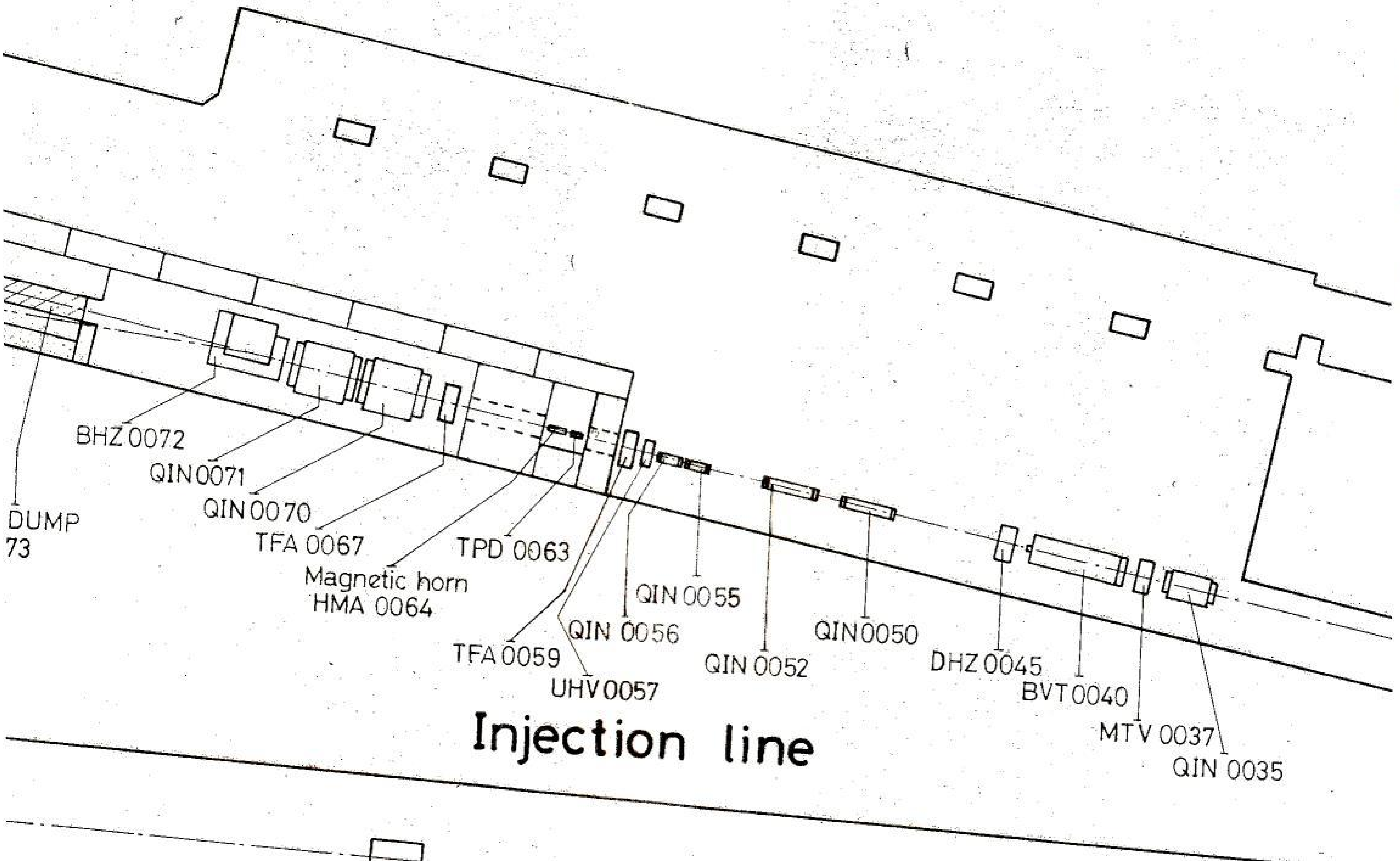
pbar-Source in HEBT of FAIR

(Status 2005, see new layout by S. Ratschow)




BHZ 0072
QIN 0071
QIN 0070
DUMP
73
TFA 0067
TPD 0063
Magnetic horn
HMA 0064
QIN 0055
QIN 0056
TFA 0059
UHV 0057
QIN 0052
QIN 0050
DHZ 0045
BVT 0040
MTV 0037
QIN 0035
Injection line

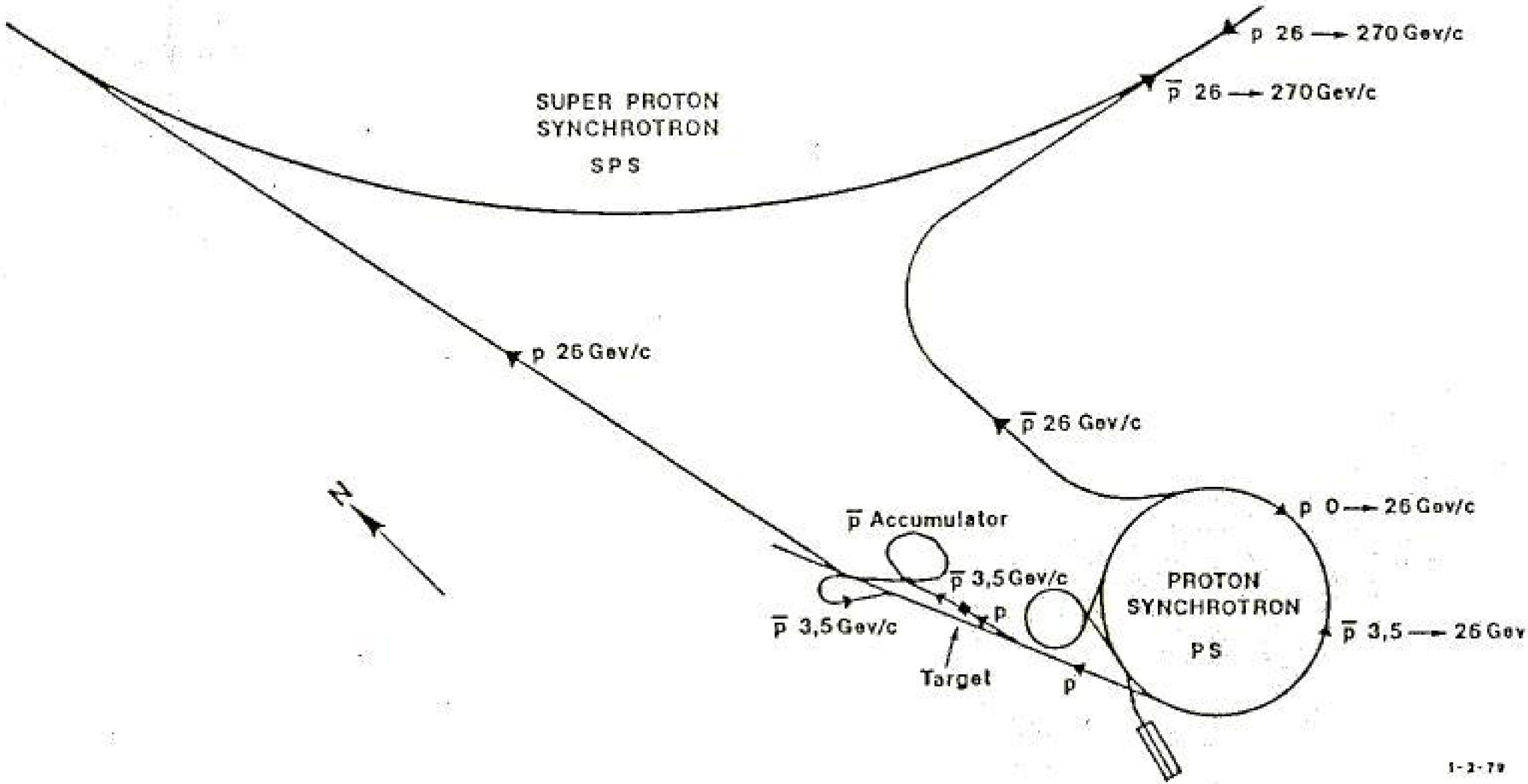
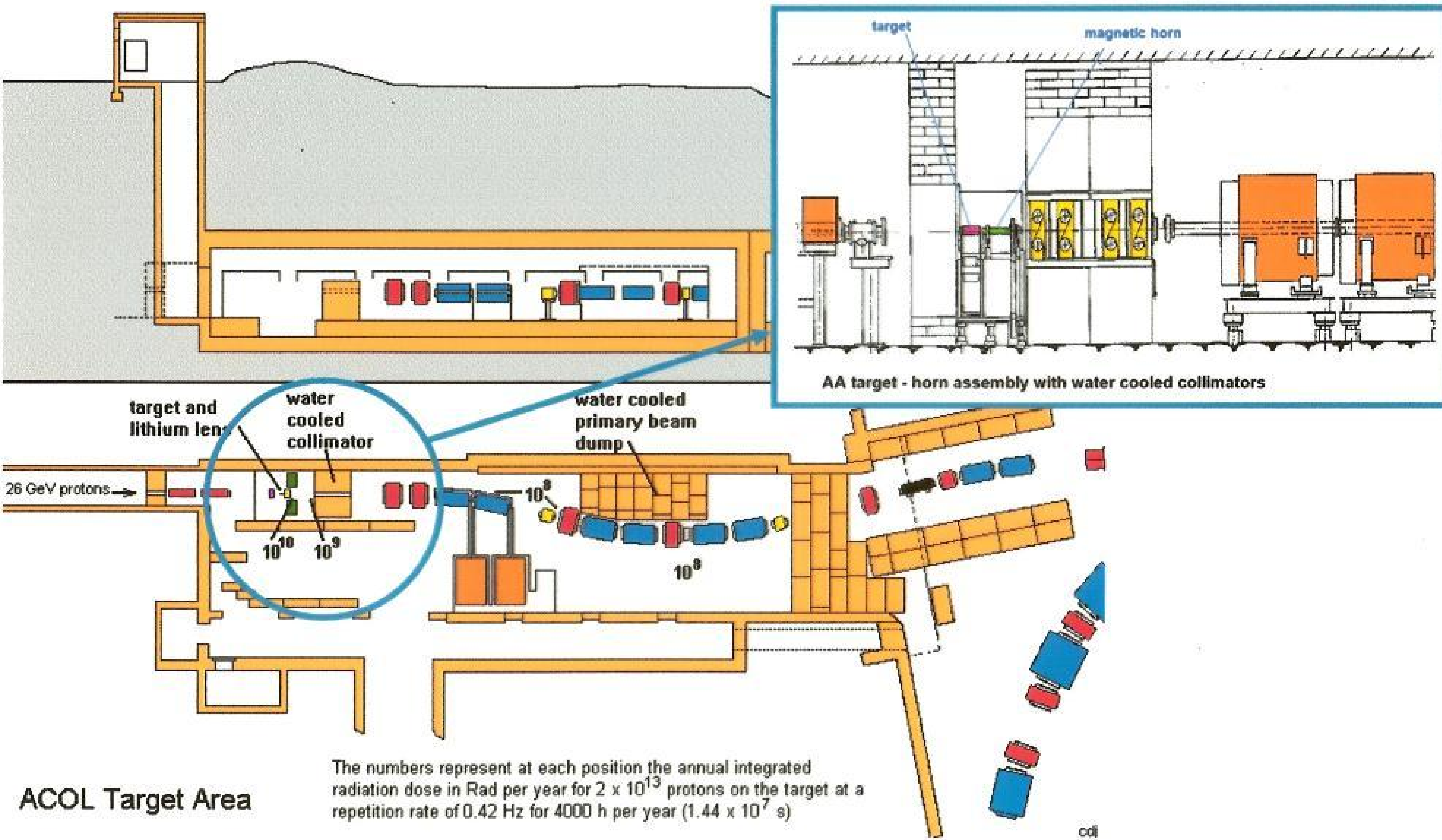
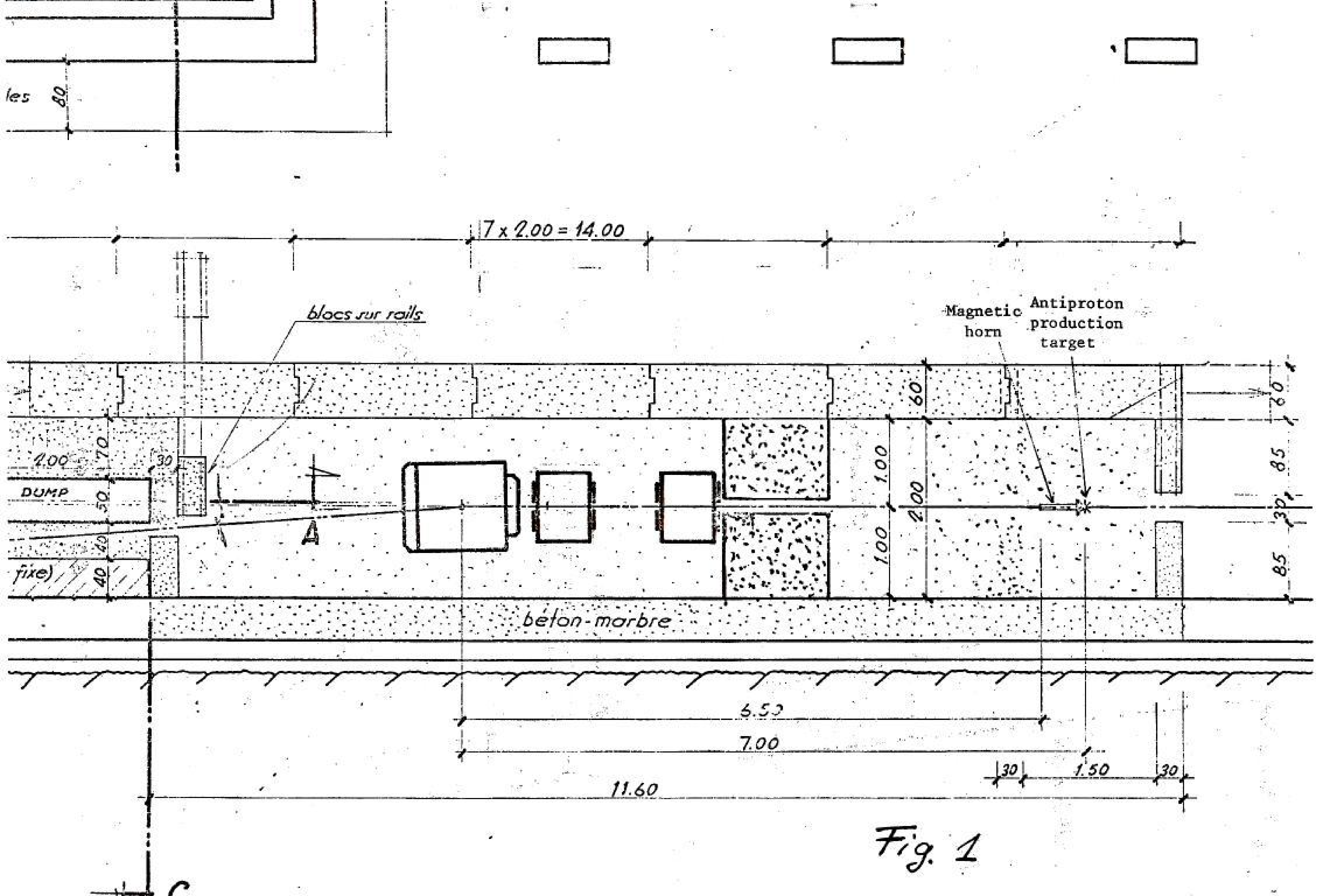


Fig. 1 Overall layout of the $p\bar{p}$ project.

Antiproton Source at CERN





les
80
7 x 2.00 = 14.00
blocs sur rails
Magnetic horn
Antiproton production target
1.00
DUMP
fixe)
30
70
50
40
40
A
60
1.00
2.00
1.00
85
30
85
béton-marbre
6.50
7.00
11.60
30
1.50
30

Fig. 1

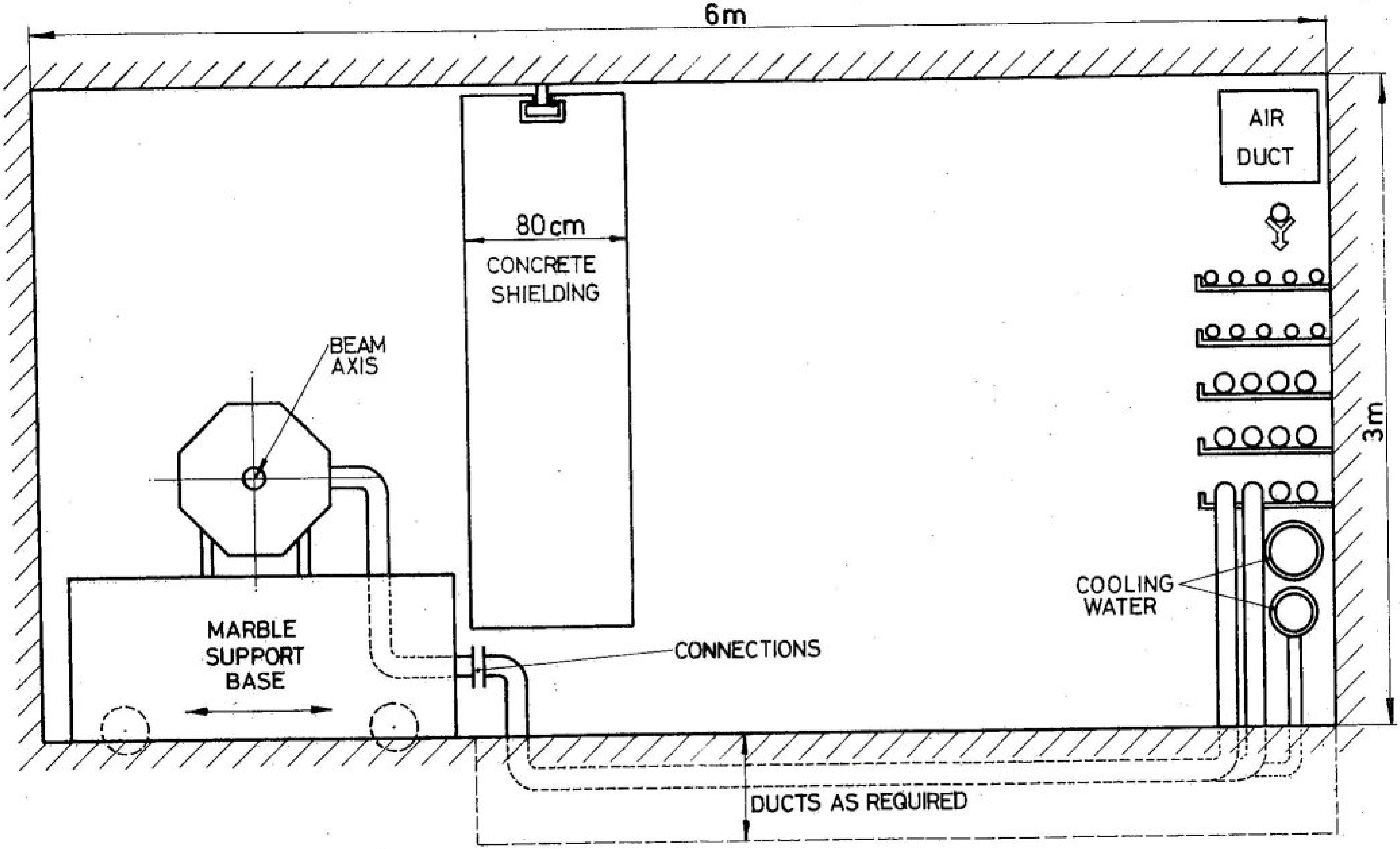


Fig. 9.2 Target area Schematic cross section

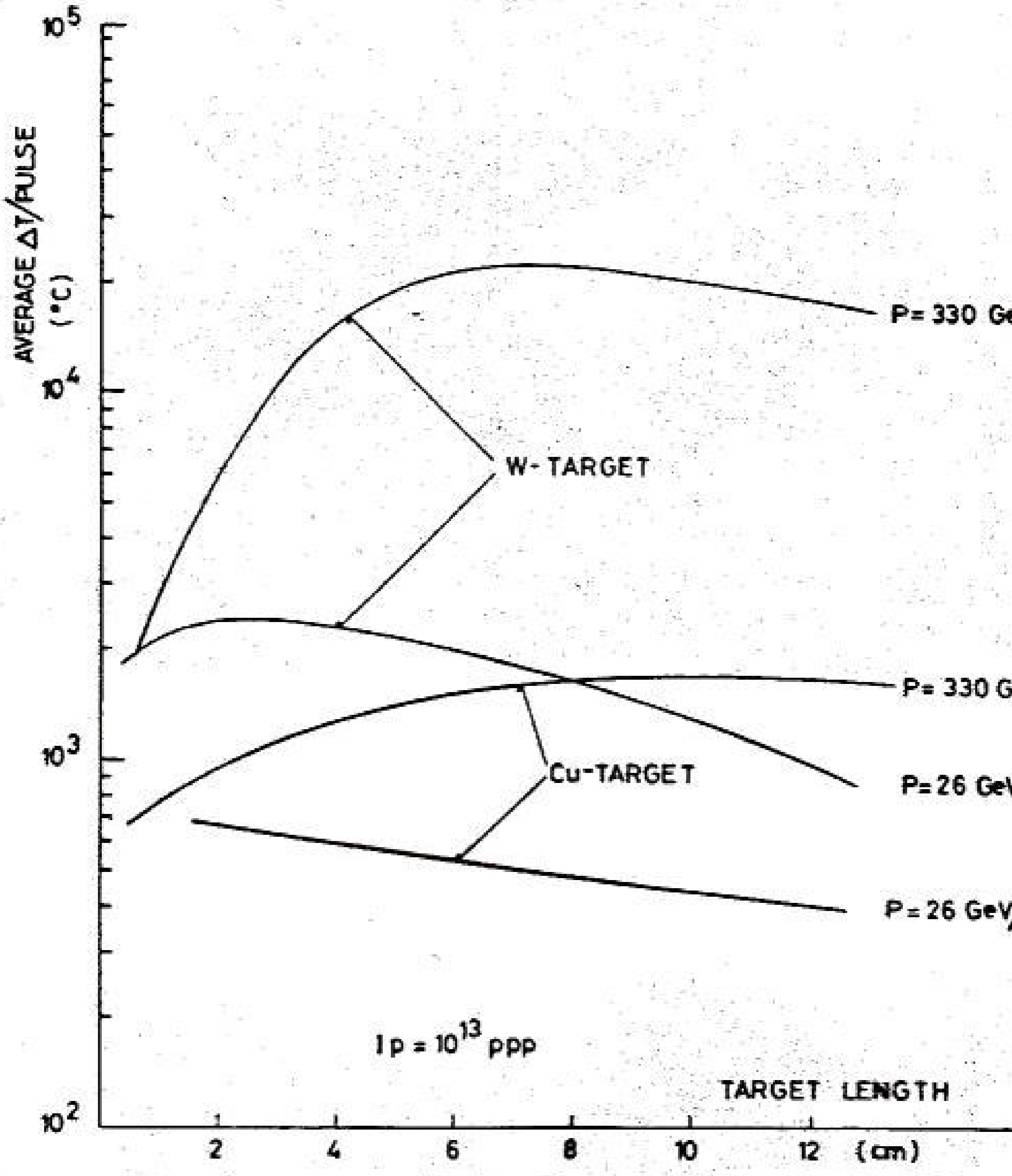


Fig. 3 - Temperatures rises per pulse due to 10^{13} protons of 26 GeV/c and 330 GeV/c in W and Cu targets. ΔT gives the temperature averaged over the target cross-section of 2 mm diameter.

4b = 1.2 mm

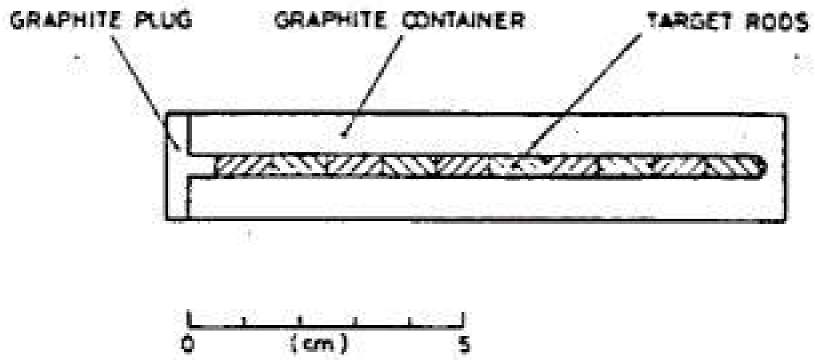


Fig. 1 - Vertical cut through the target graphite ensemble. The individual target rods are inserted into the blind axial hole, drilled into the graphite which is thereafter closed with a graphite plug.

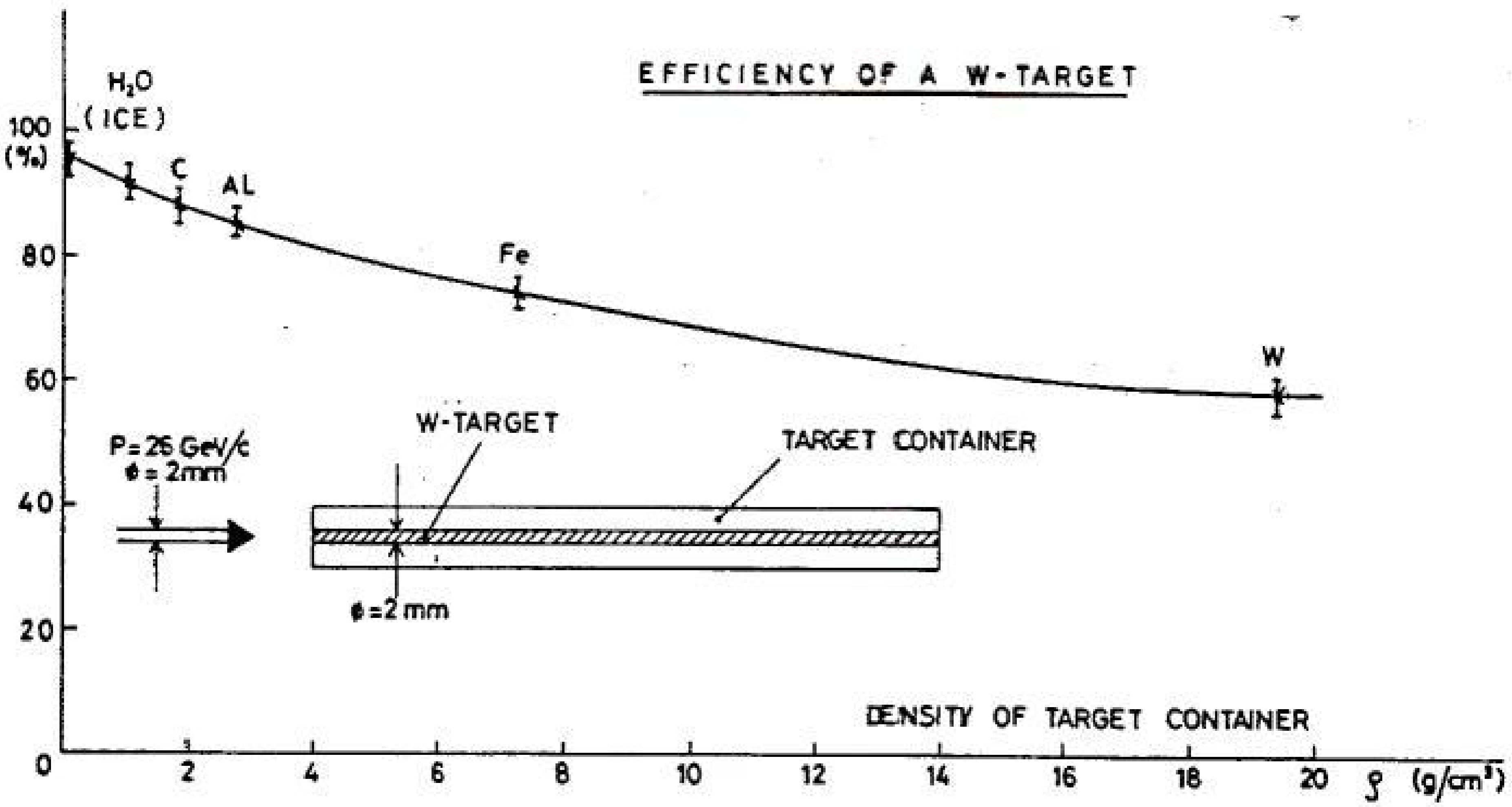
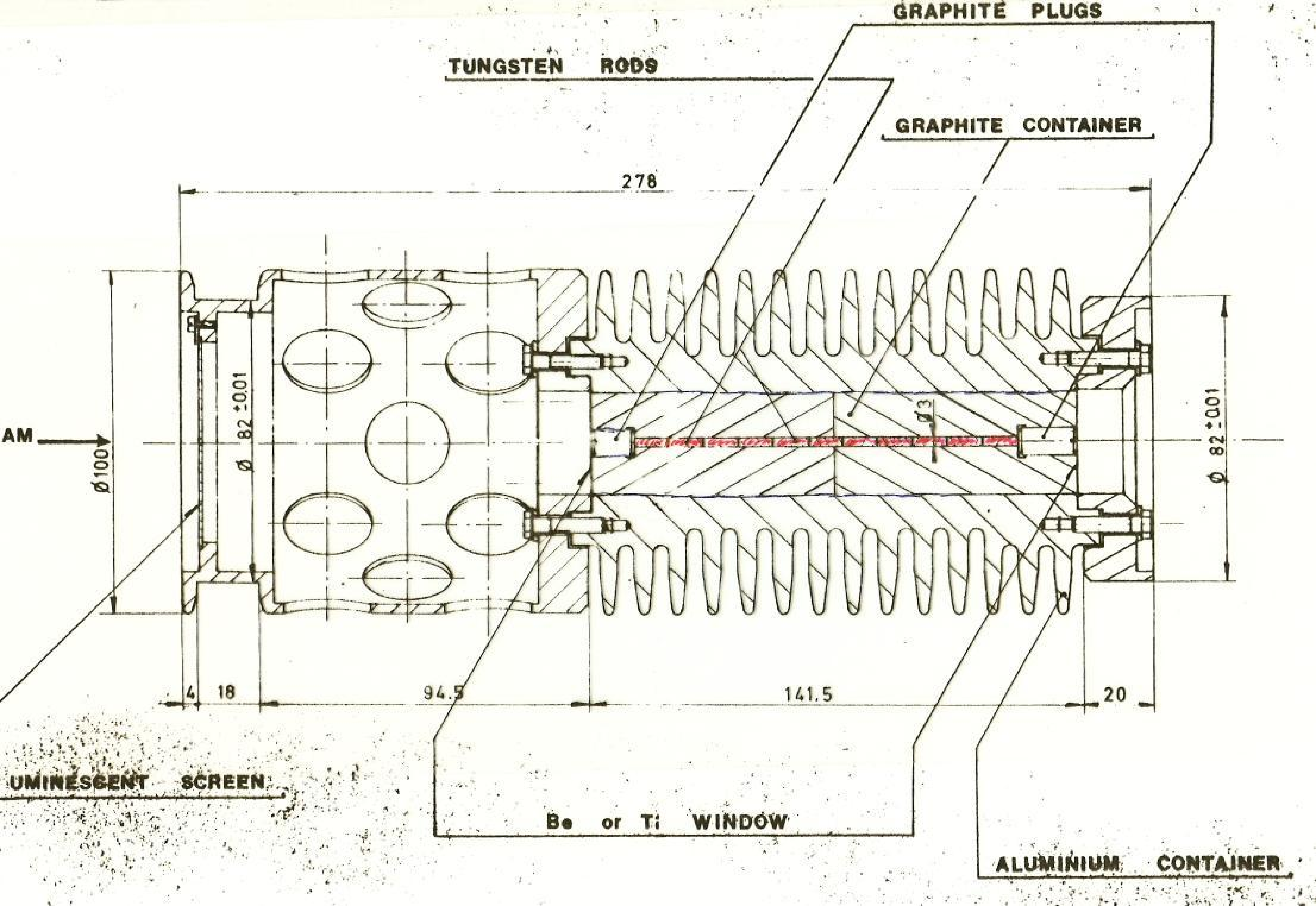
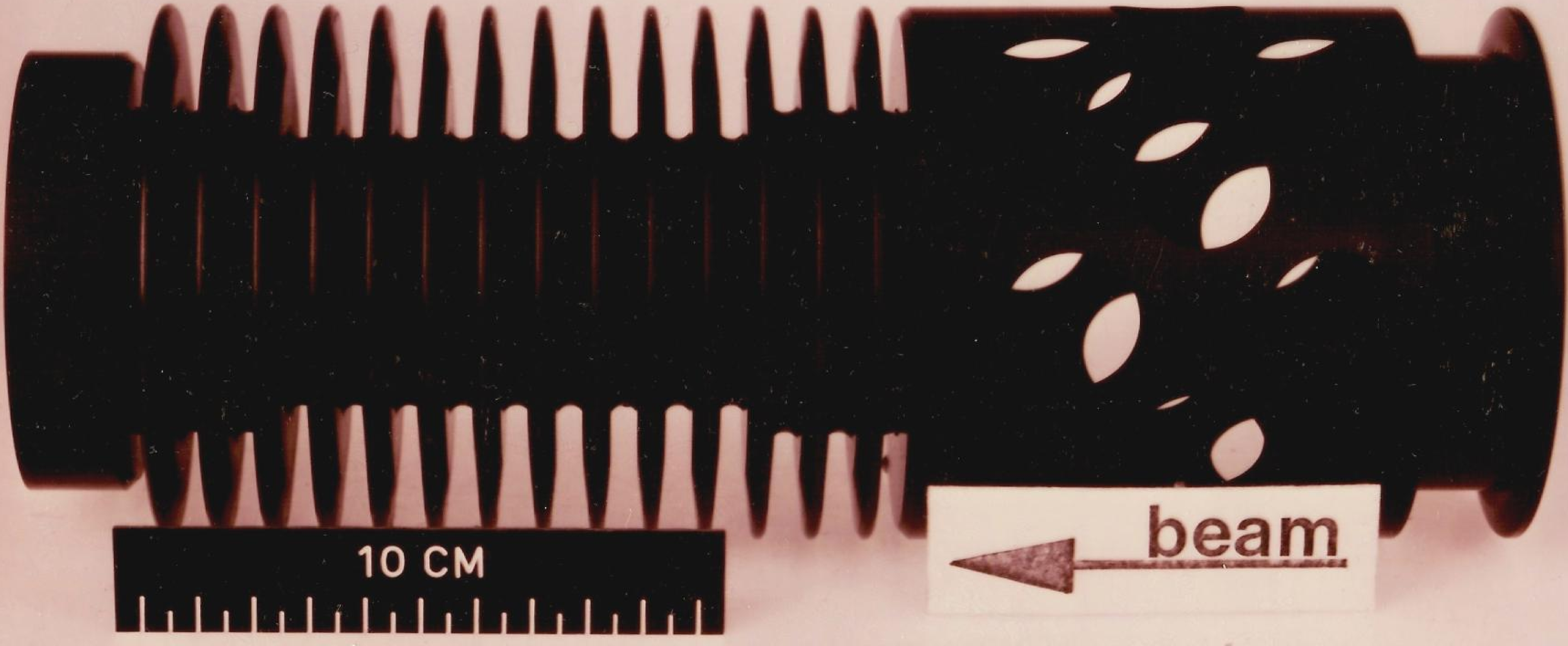
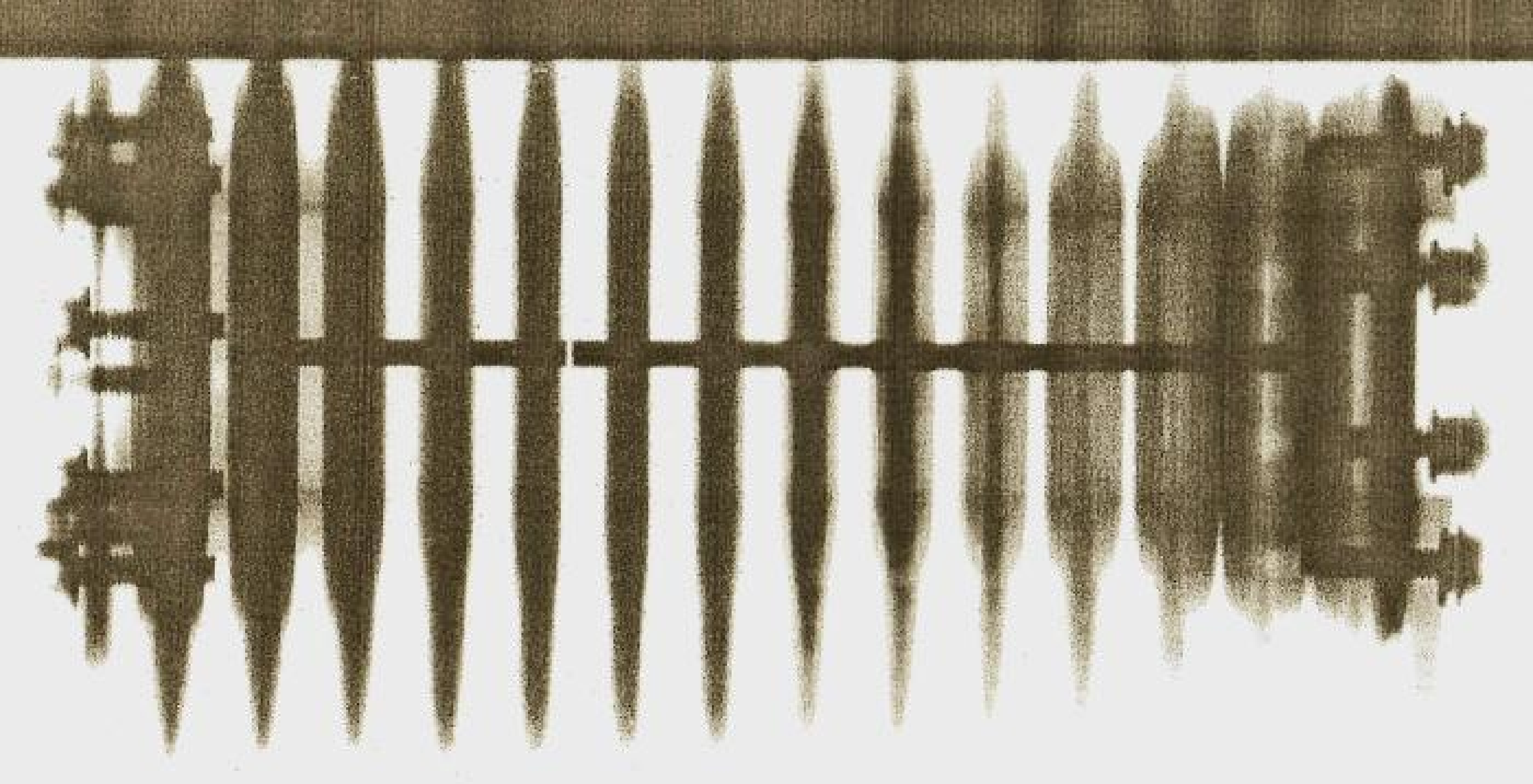


Fig. 2 - Target efficiency (escaping $\bar{p}$'s over created $\bar{p}$'s) of a 2 mm thick W target embedded in various materials. $\bar{p}$'s of 3.7 GeV/c produced within a cone of ± 50 mrad are considered.



GRAPHITE PLUGS
TUNGSTEN RODS
GRAPHITE CONTAINER
278
AM
Ø100
Ø 82 ± 0.01
Ø3
Ø 82 ± 0.01
4
18
94.5
141.5
20
UMINESCENT SCREEN
Be or Ti WINDOW
ALUMINIUM CONTAINER


10 CM
beam



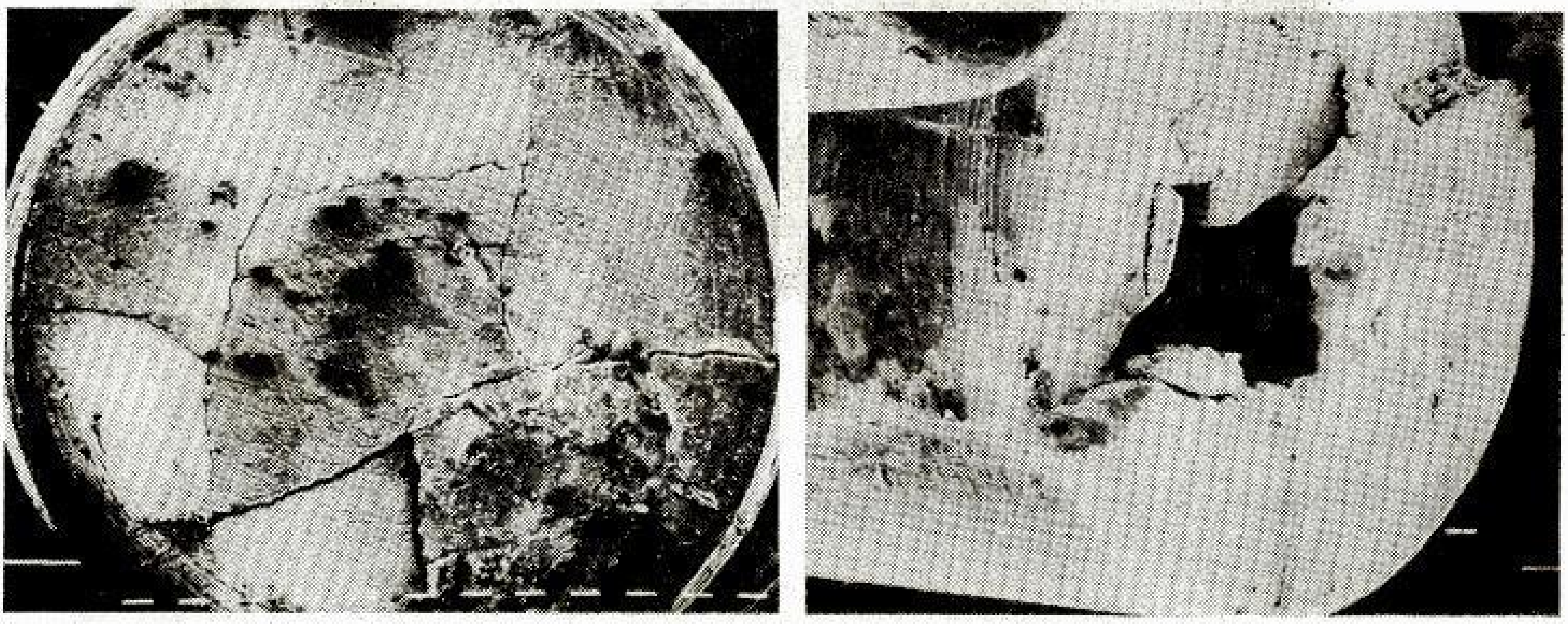


Fig. 7 - Front view of the W-rods after irradiation. The longitudinal craks and a pit of about 1 mm depth can clearly be seen.

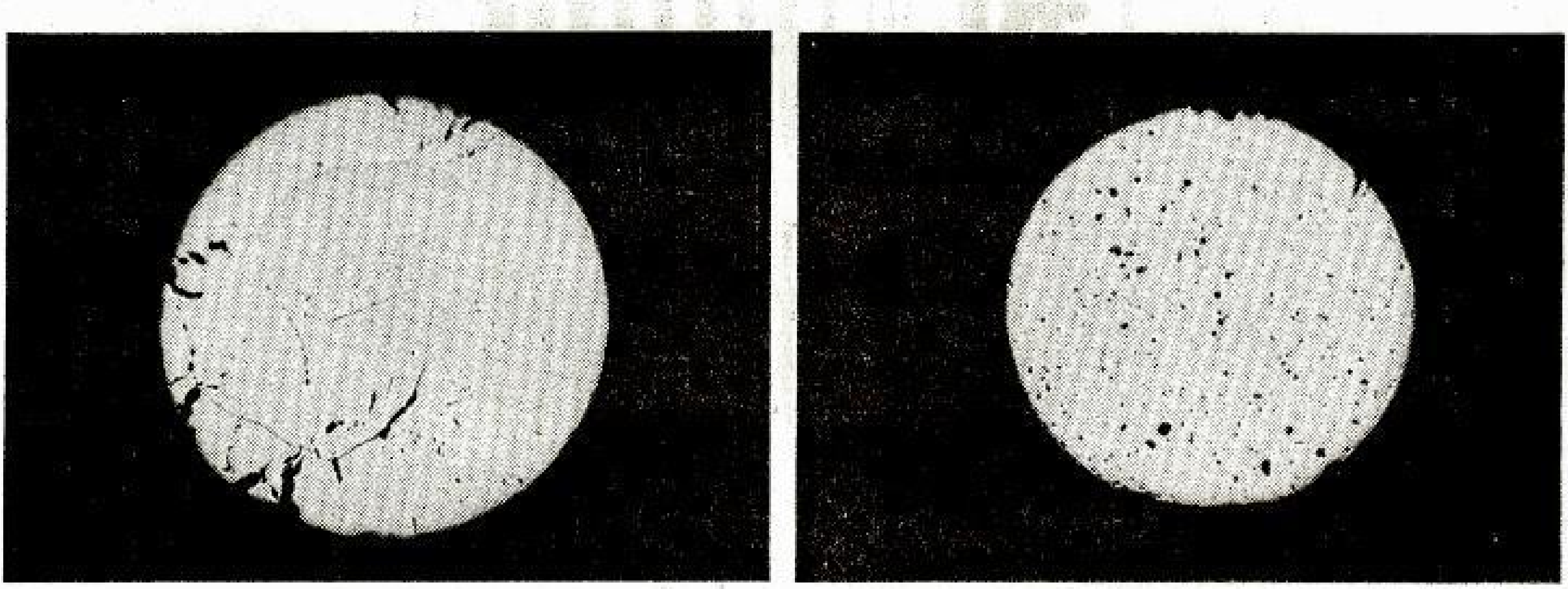
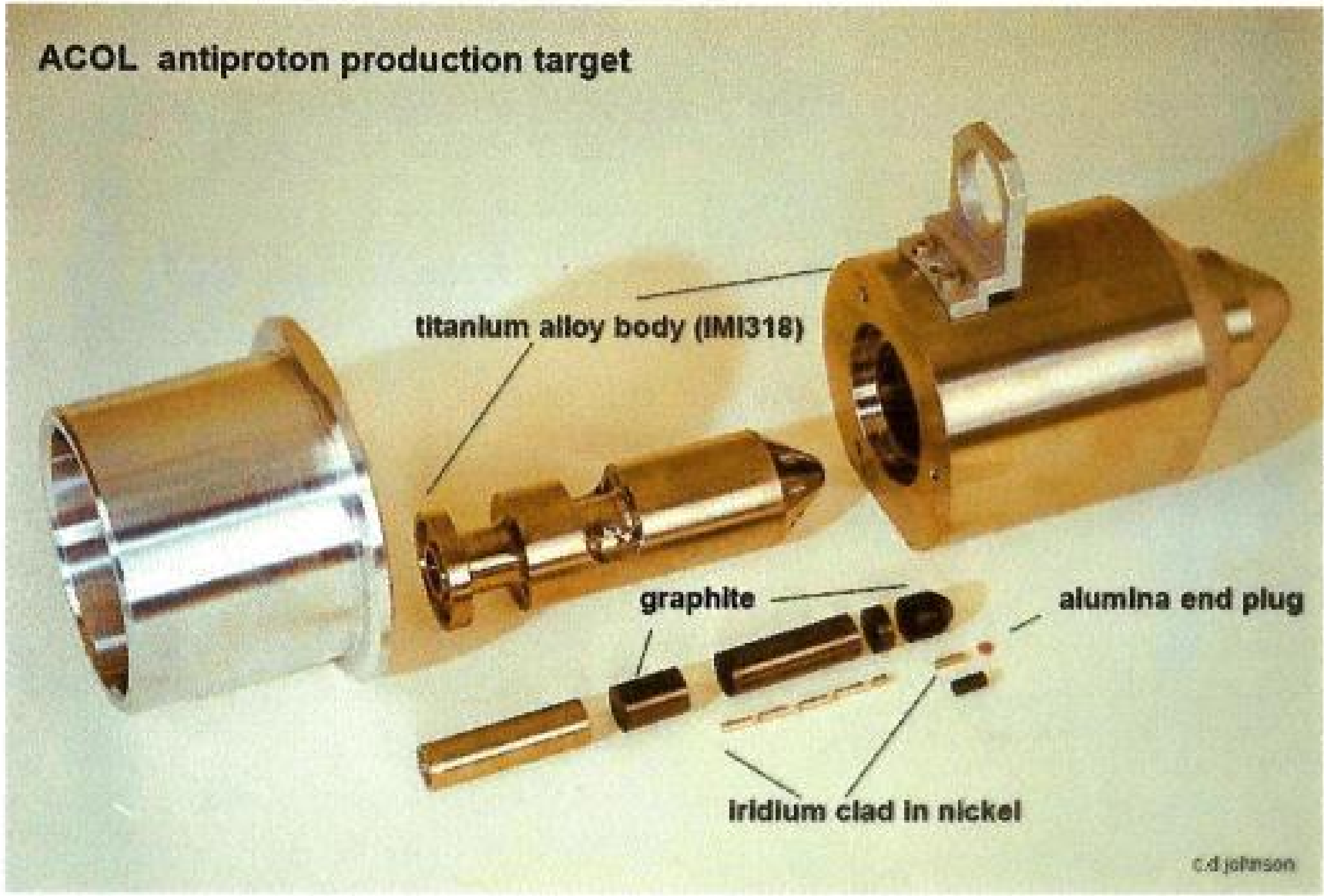


Fig. 8 - Tungsten (left) and rhenium (right) rods after bake-out in graphite at 2000^{o} C over 48 hours. In the tungsten a considerable amount of tungsten carbide was formed. In the otherwise stable rhenium, a slight graphite precipitation occurred at the grain boundaries.

Production Target : ACOL-Target for FAIR?



Proposed:

ACOL target for FAIR up to 50% p-intensity

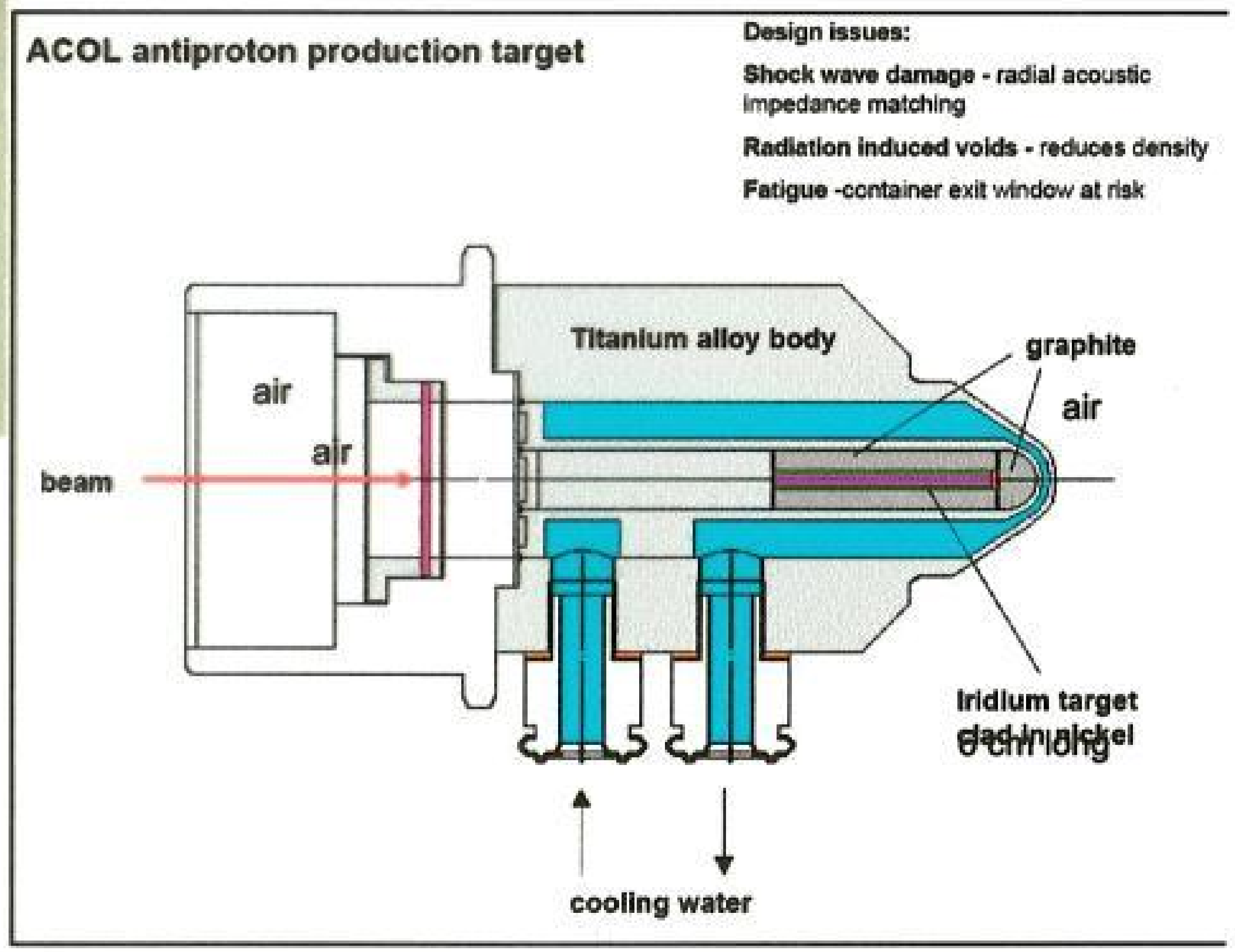
Arguments:

Should withstand beam period of 2-3 months

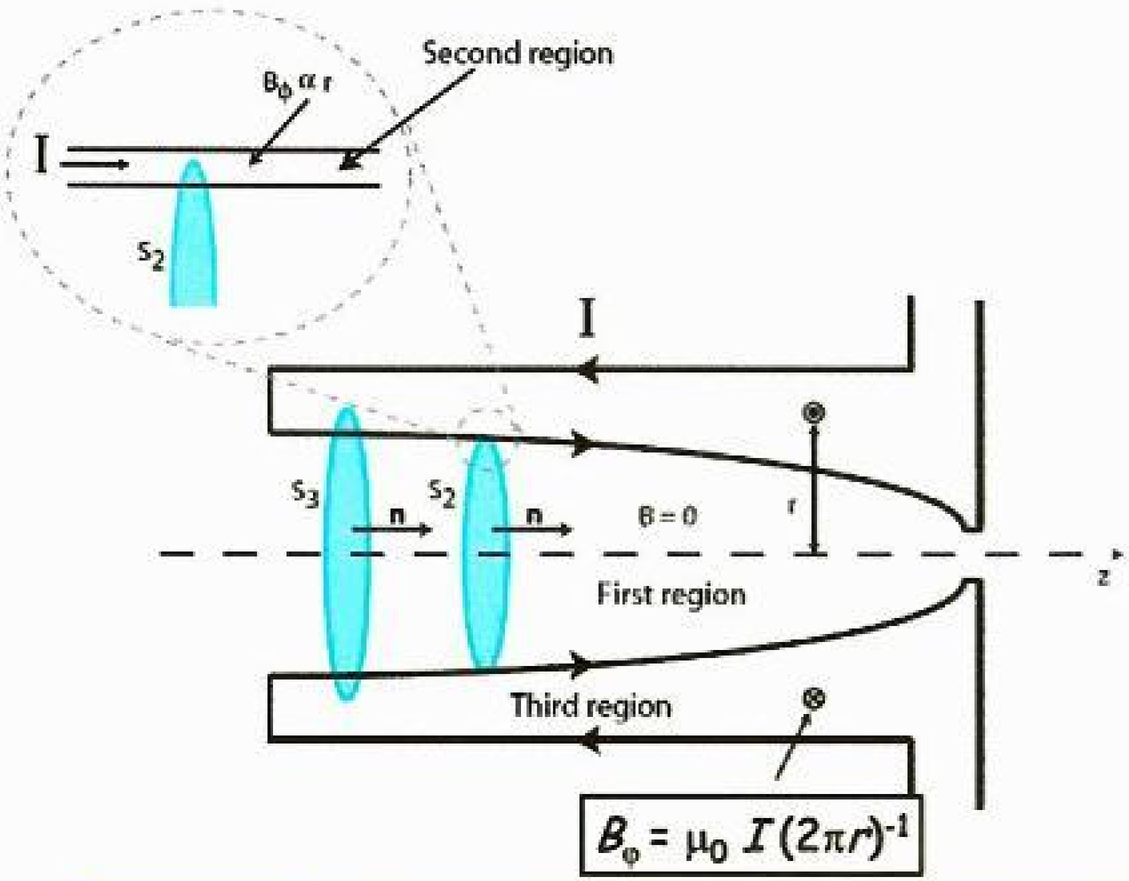
Simple construction

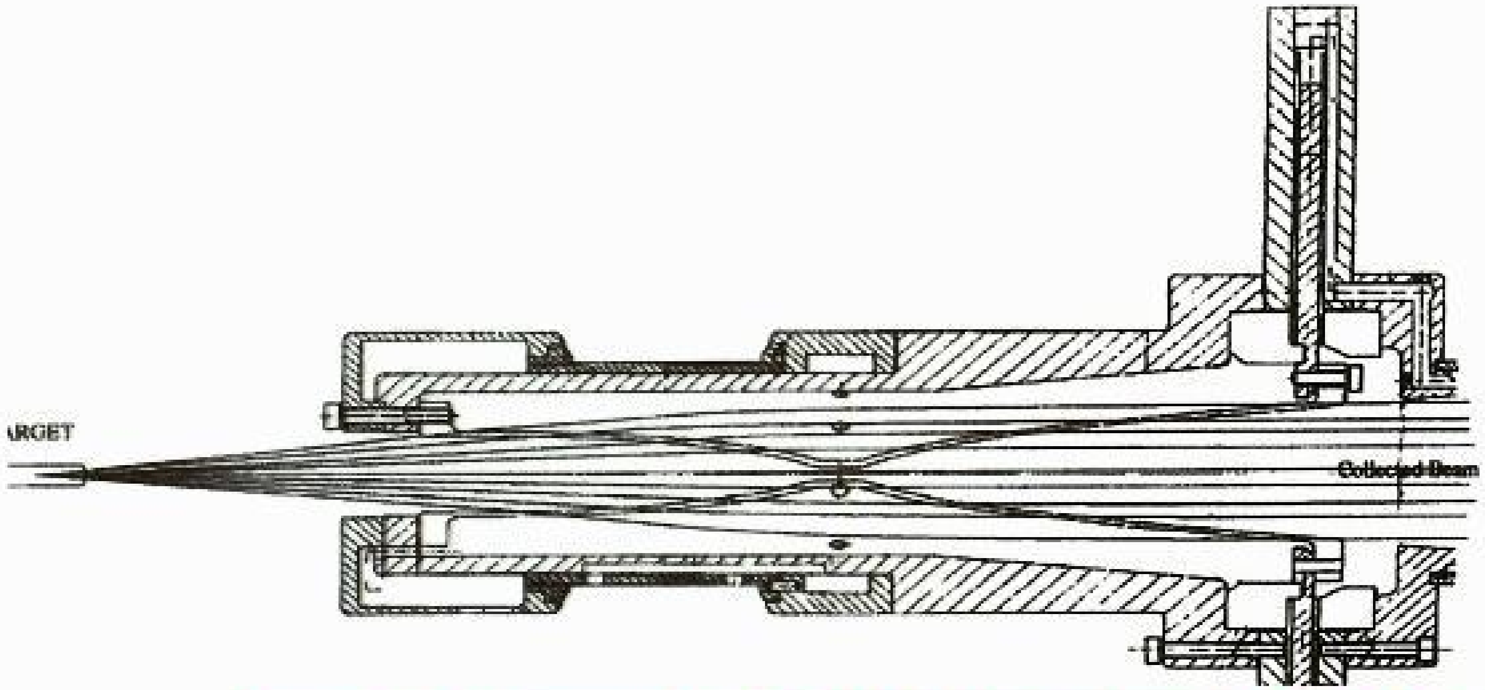
Not too expensive

Easy exchange (coolant connections only)



Collector: Magnetic Horn or Li-Lens





Proposed

Bi-conical ACOL-horn for FAIR (assembly drawing)

Operational parameters

Horn current	400 kA
Rise time	15 µs
Acceptance angle for pbars	82 mrad
Manufacturing costs per unit:	30 000 €

5 units recommended

(R. Maccaferri, CERN, private communication, July 2005)

Proposed upgrade for 100% proton intensity:

3cm Ø Li-lens with 1 MA pulser

Operational parameters

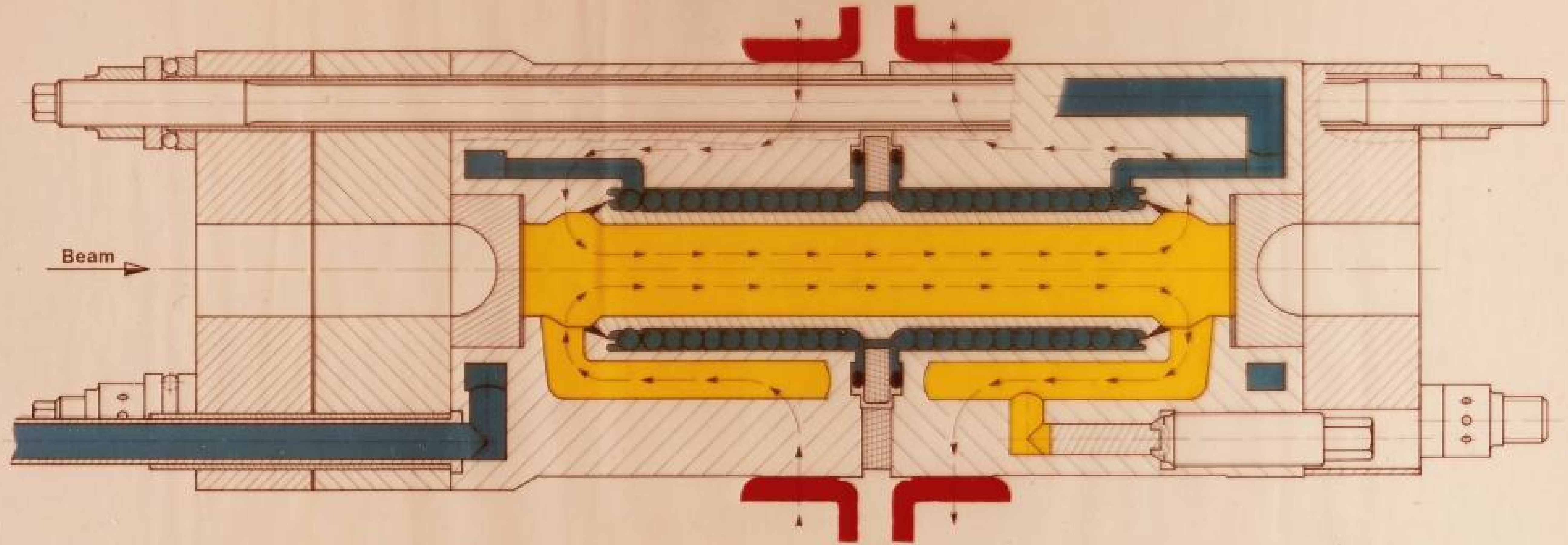
Current	1 MA
Rise time	1 ms
Acceptance angle for pbars	95 mrad
Manufacturing costs per lens:	80 000 €

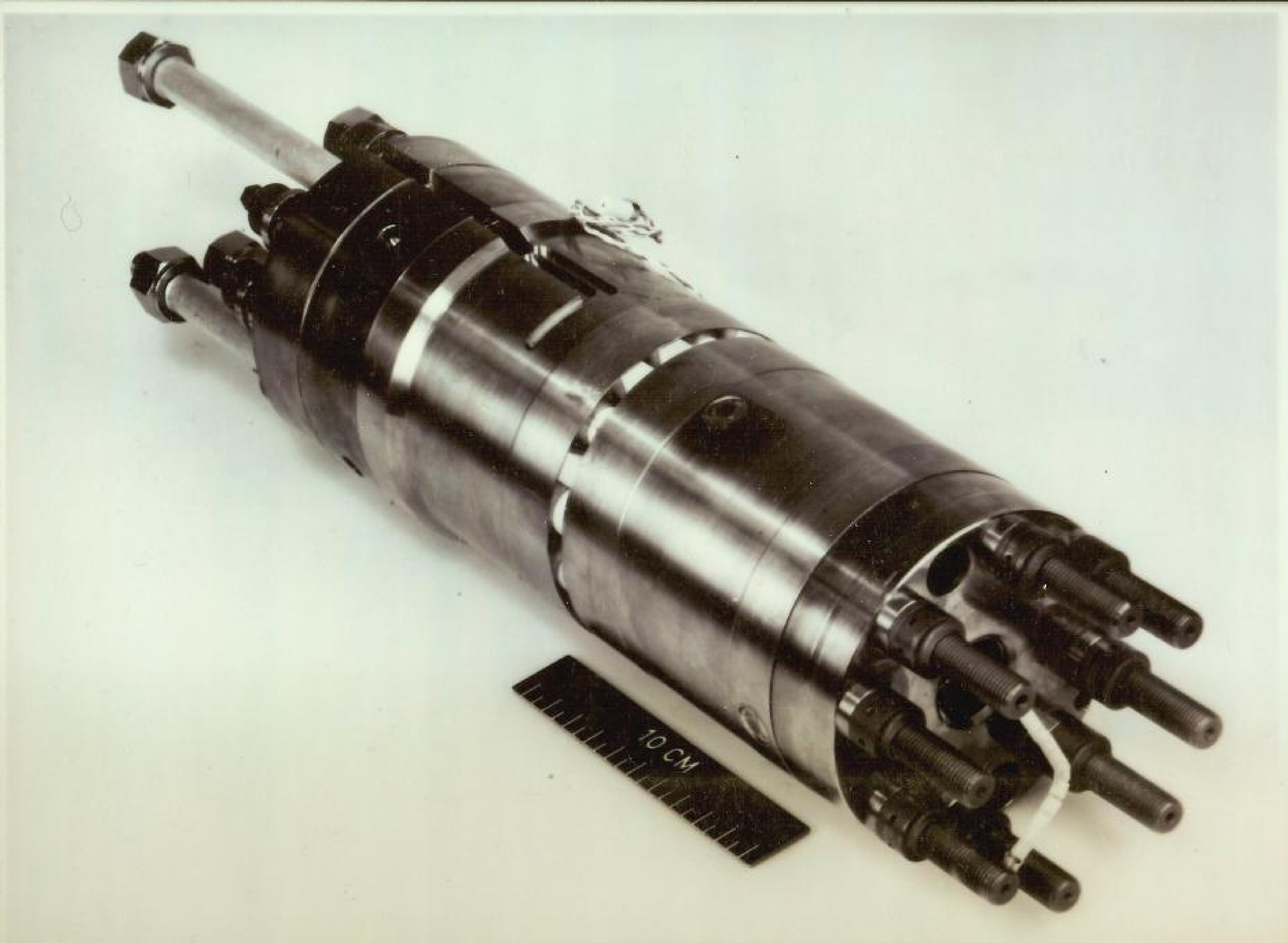
5 spare lenses recommended

(P. Sievers, CERN, private communication, July 2005)

1 MA pulser & transformer:	300 000 €

My own estimate!


Beam


10 CM

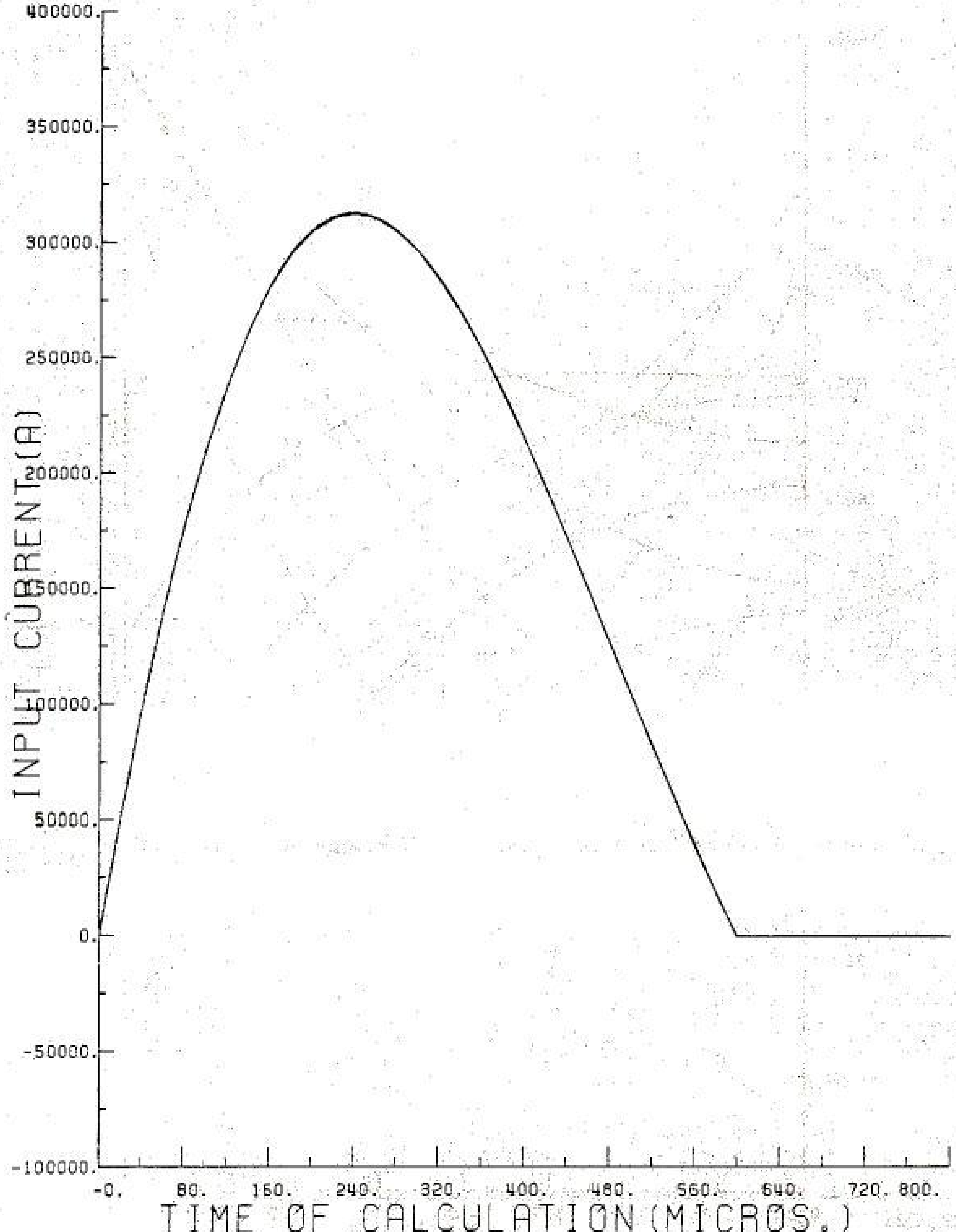


Fig.1. The current pulse.

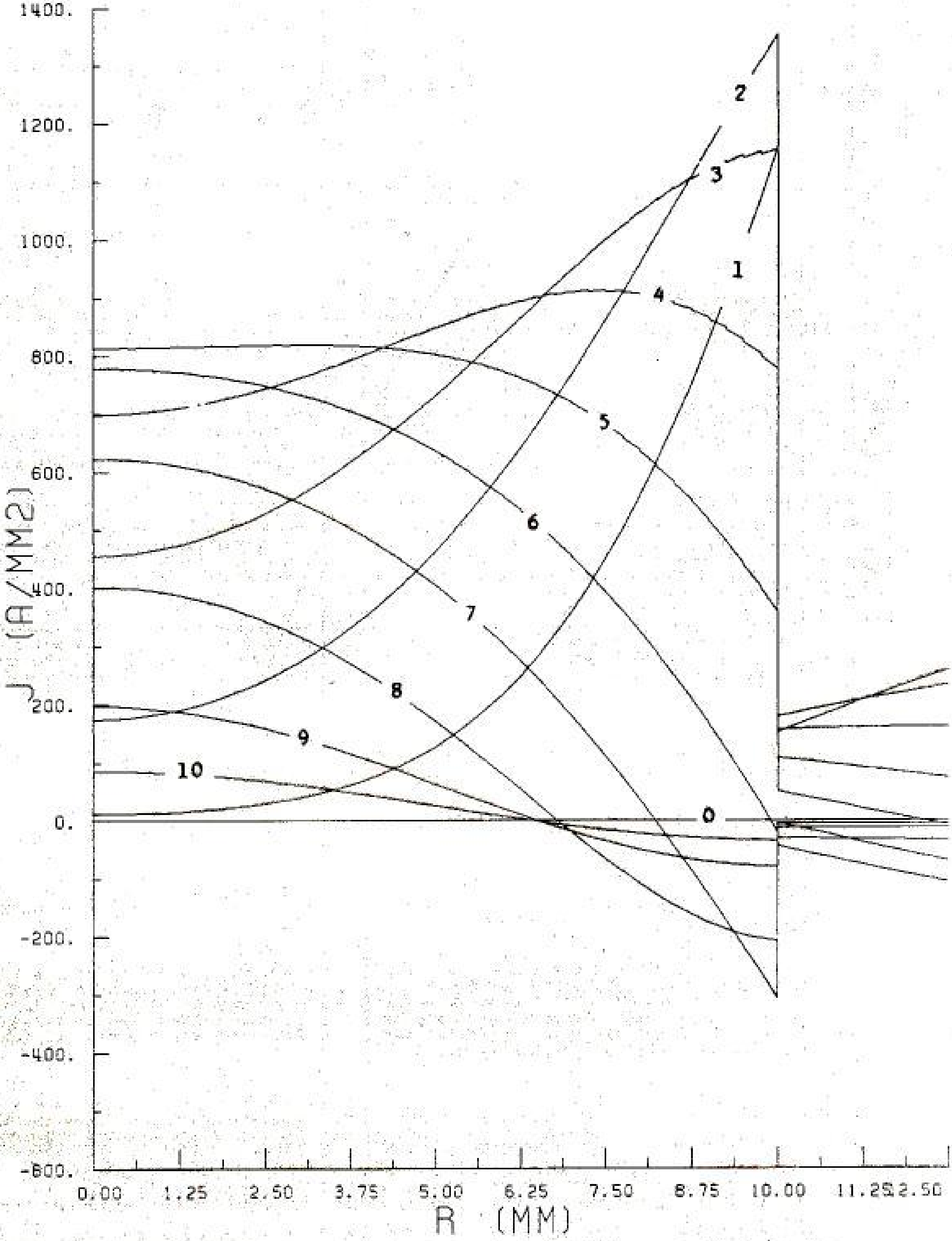


Fig.2. The current density distribution at various instants.
The curves are marked with the number of time increments of 80 microseconds each.
The driving current pulse is shown in fig.1.

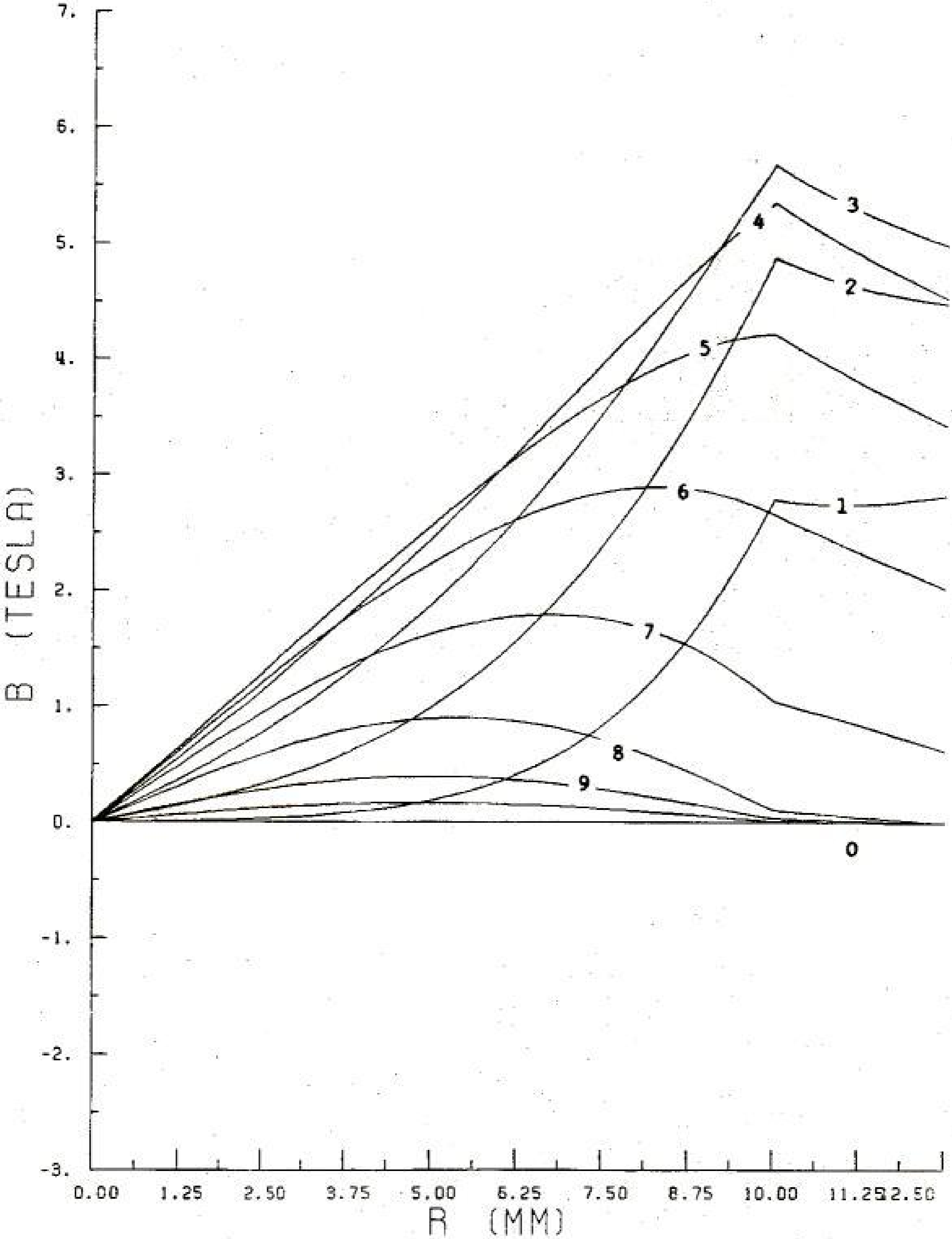


Fig.3. The field distribution at various instants.
The curves are marked with the number of time increments of 80 microseconds each.
The driving current pulse is shown in fig.1.

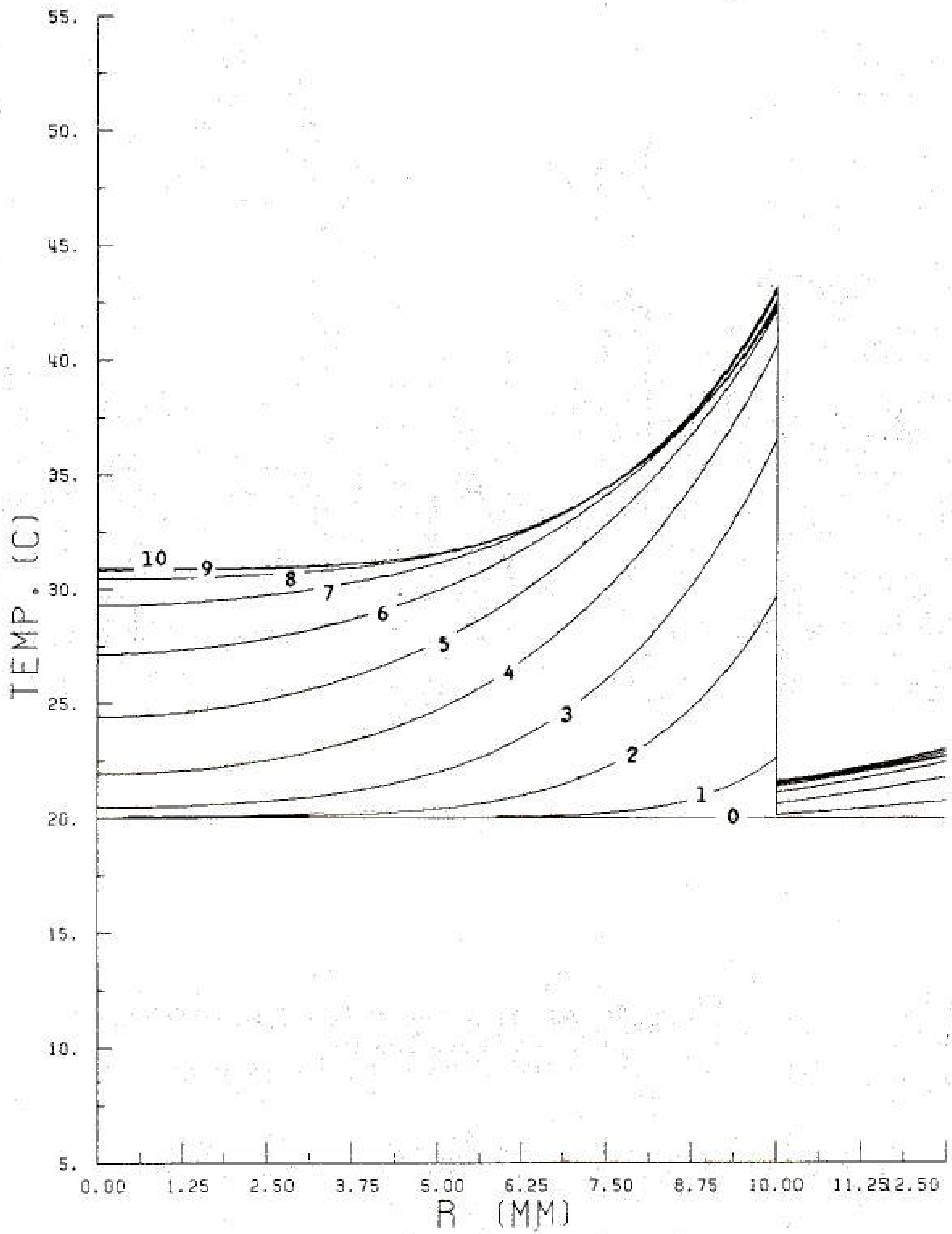
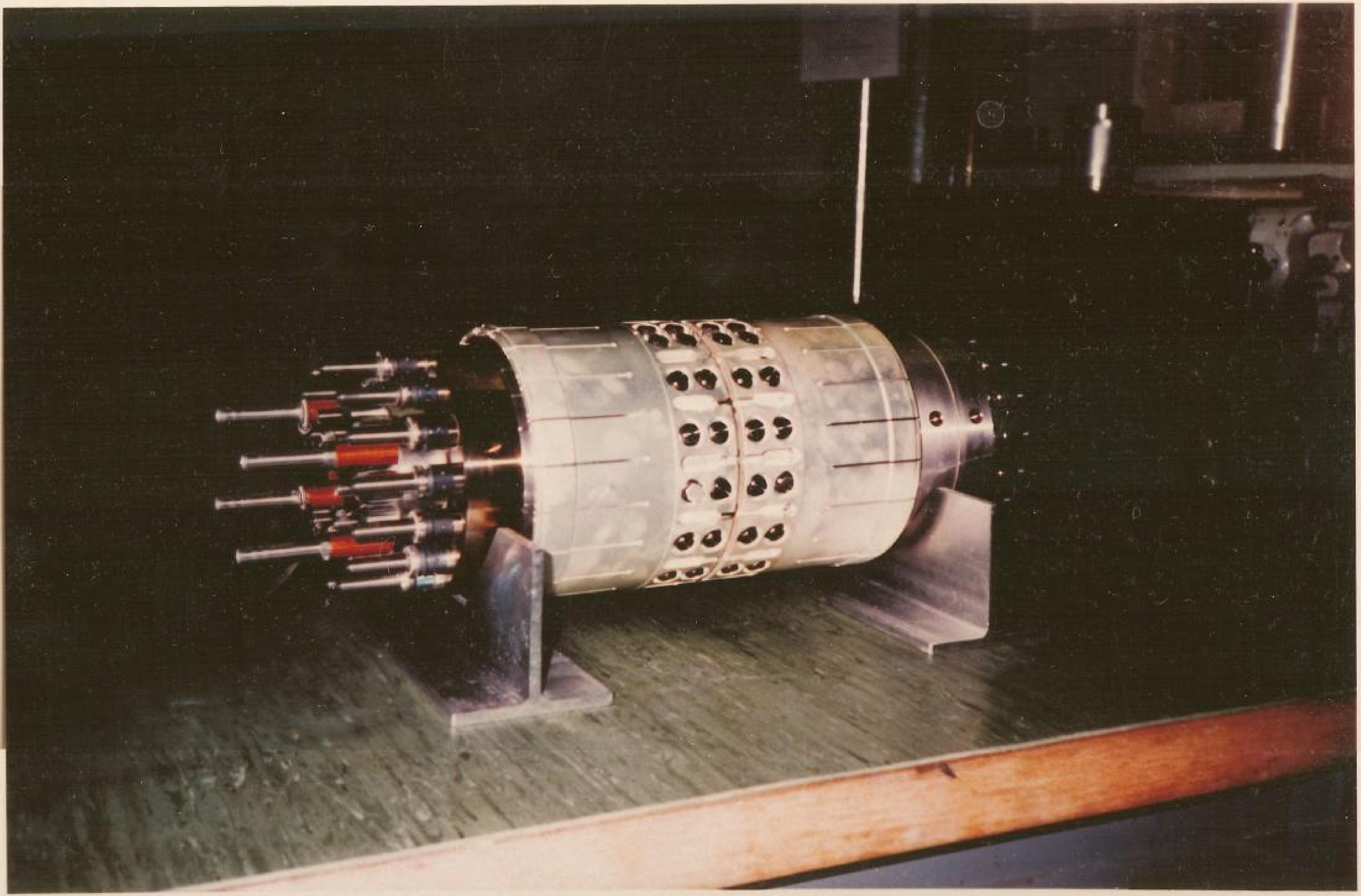
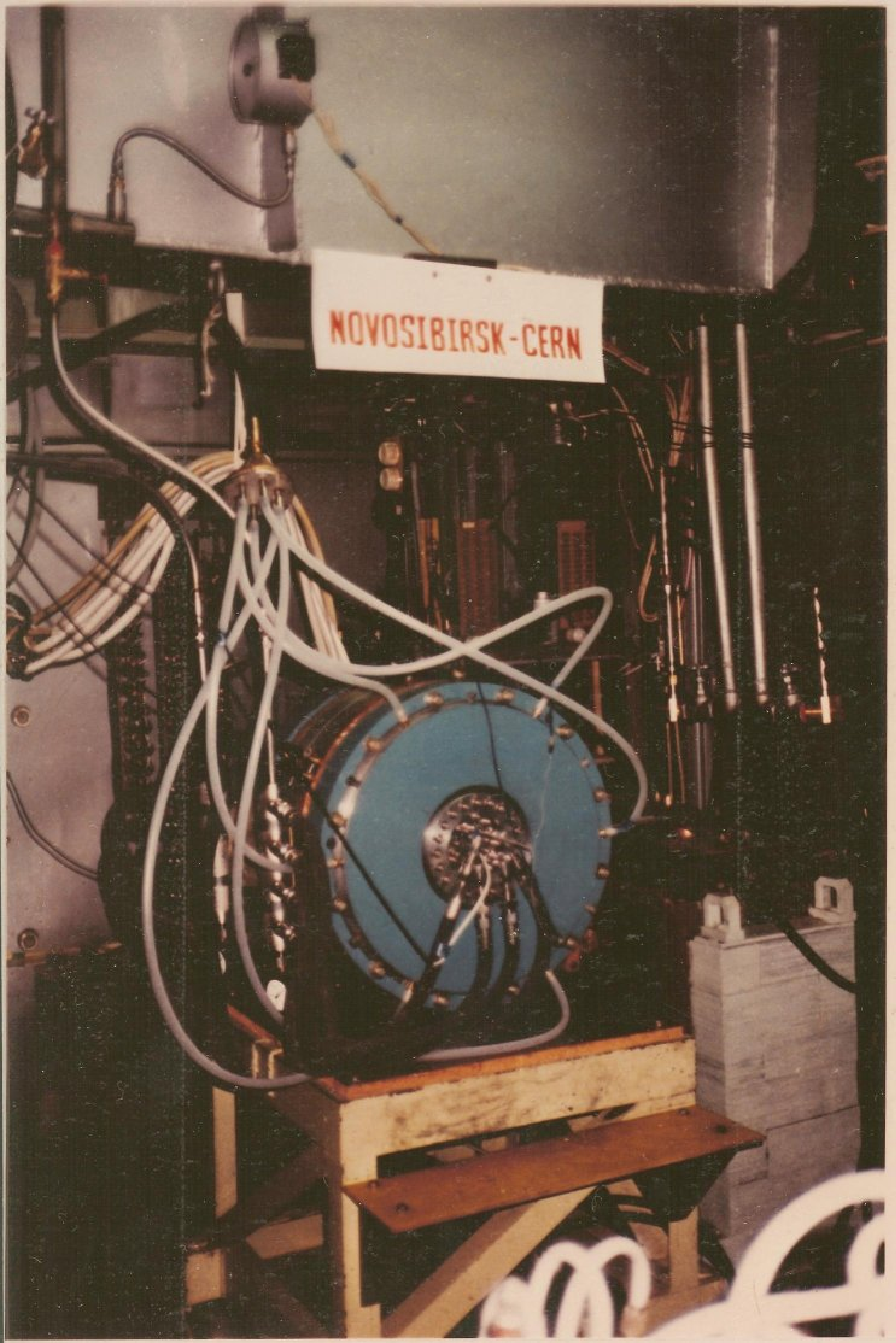


Fig.5. The temperature distribution at various instants during a single pulse.
The curves are marked with the number of time increments
of 80 microseconds each.
The driving current pulse is shown in fig.1.

x846 .9.86




306.1.89


NOVOSIBIRSK-CERN

1986

ANTIPROTON ACCUMULATOR

Performance to date - Spring 1982

	Operational	Best	Design Goal
1. Yield = $\frac{\text{No. of } \bar{p}\text{'s circulating on injection orbits}}{\text{No. of p's colliding with target}}$	6×10^{-7}	7.8×10^{-7}	25×10^{-7}*
2. Acceptance on injection orbits: Horizontal E_H	60π	89π	100π (mm.mrad)
Vertical E_V	70π	75π	100π (mm.mrad)
Longitudinal Δp/p	$>1.5 \times 10^{-2}$	$>1.5 \times 10^{-2}$	1.5×10^{-2}
3. Precooling Efficiency = $\frac{\text{No. of } \bar{p}\text{'s captured and transferred by RF}}{\text{No. of p's circulating on injection orbits}}$	67%	75%	80%
4. Stacking Efficiency = $\frac{\text{No. of p's circulating in the stack}}{\text{No. of p's captured and transferred by RF}}$	60%	67%	84%
5. Accumulator efficiency = (#3 × #4)	40%	50%	67%
6. Accumulation Rate: ($\bar{p}$'s per hour; *normalized to AA receiving 6 PS cycles out of 6, each cycle delivering ~10^{13} protons)	3.5×10^{9}/h	~5×10^{9}/h	25×10^{9}/h*
7. Missing Factor: MF = $\frac{\text{Design Goal \#6 (optimistic value)}}{\text{Operational or Best \#6}}$	7.1	~5	1
8. Stack Density (after ~30 min cooling without accumulation)	2.4×10^{10} $\bar{p}$/eVs	5.4×10^{10} $\bar{p}$/eVs	12×10^{10} $\bar{p}$/eVs
9. A maximum circulating current of	10^{11} $\bar{p}$'s	1.9×10^{11} $\bar{p}$'s	~10^{12} $\bar{p}$'s
10. "Cooled" emittances: Horizon. E_H	1.2π	1π	1.4π (mm.mrad)
(after 30 min without accumul.) 95% values Vertical E_V	1.6π	0.9π	1π (mm.mrad)
Longit. Δp/p	3×10^{-3}	3×10^{-3}	3×10^{-3}
11. Eject. Efficiency = $\frac{\text{No. of } \bar{p}\text{'s arriving at PS at 3.5 GeV/c}}{\text{No. of } \bar{p}\text{'s leaving AA at 3.5 GeV/c}}$	>85%	>95%	100%

focused and matched into the injection transport line by a collector lens. Different collecto have been successfully used:

- a lithium lens of 20 mm diameter, pulsed with 480 kA excitation current,
- a lithium lens of 34 mm diameter, pulsed at 1.0 MA,
- a magnetic horn of 60 mm diameter, pulsed at 400 kA.

Two other types of collectors were tested in situ:

- a lithium lens of 36 mm diameter, pulsed at 1.2 MA [6],
- a plasma lens of 40 mm diameter, pulsed at 400 kA [7].

The performance of the different devices is illustrated in Fig. 1. For routine operati the magnetic horn is the preferred solution, as it seems to be very reliable and less expensi to build. These advantages largely override the slightly smaller yield.

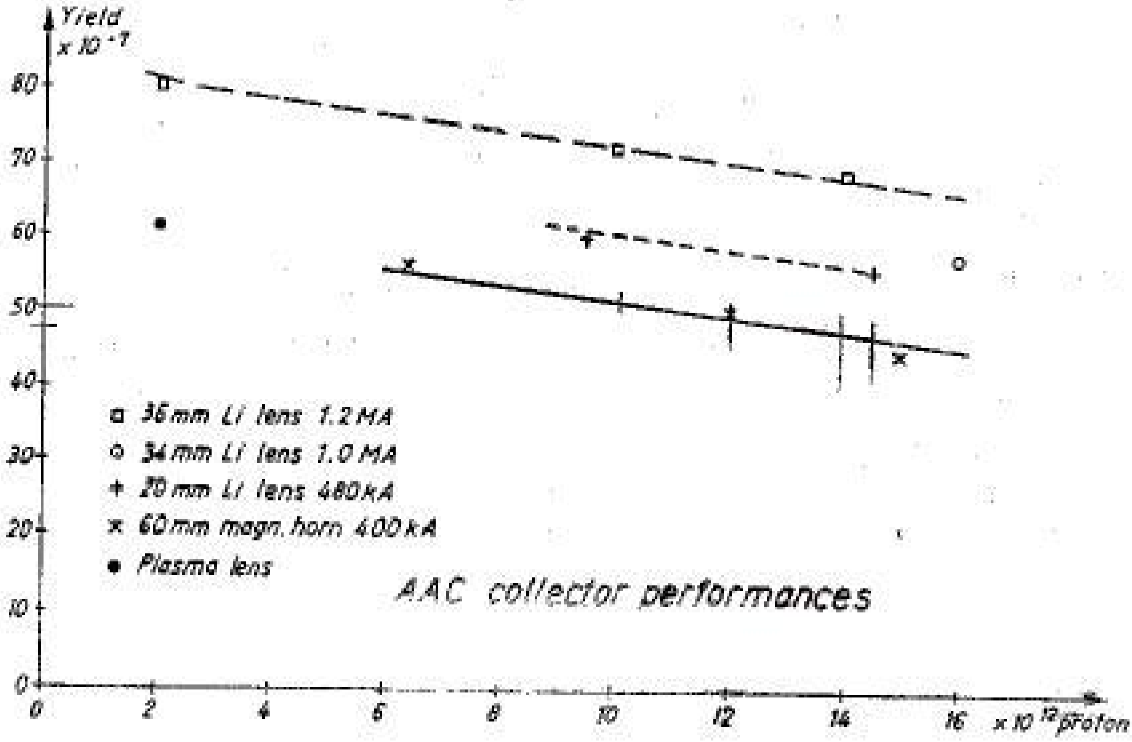


Fig. 1.

4. AC injection yield

With careful adjustment, the AC reaches (and even exceeds) the design acceptances (Table 1 This leads to efficient capture of the incoming beam.

Table 1

		Design values	Reached values
A_h	(π mm·mrad)	200	220
A_v	(π mm·mrad)	200	210
$\Delta p/p$	(%)	6	6

2.6	80.0	+38
10.0	72.1	+24
14.0	69.1	+19

In the last column we see the yield increase compared to t 20 mm lithium lens ($Y_0 = 58 \times 10^{-7}\ \bar{p}/p$). The yield measureme comparison between 20 mm and 36 mm Li lens is plotted in Fig. 4

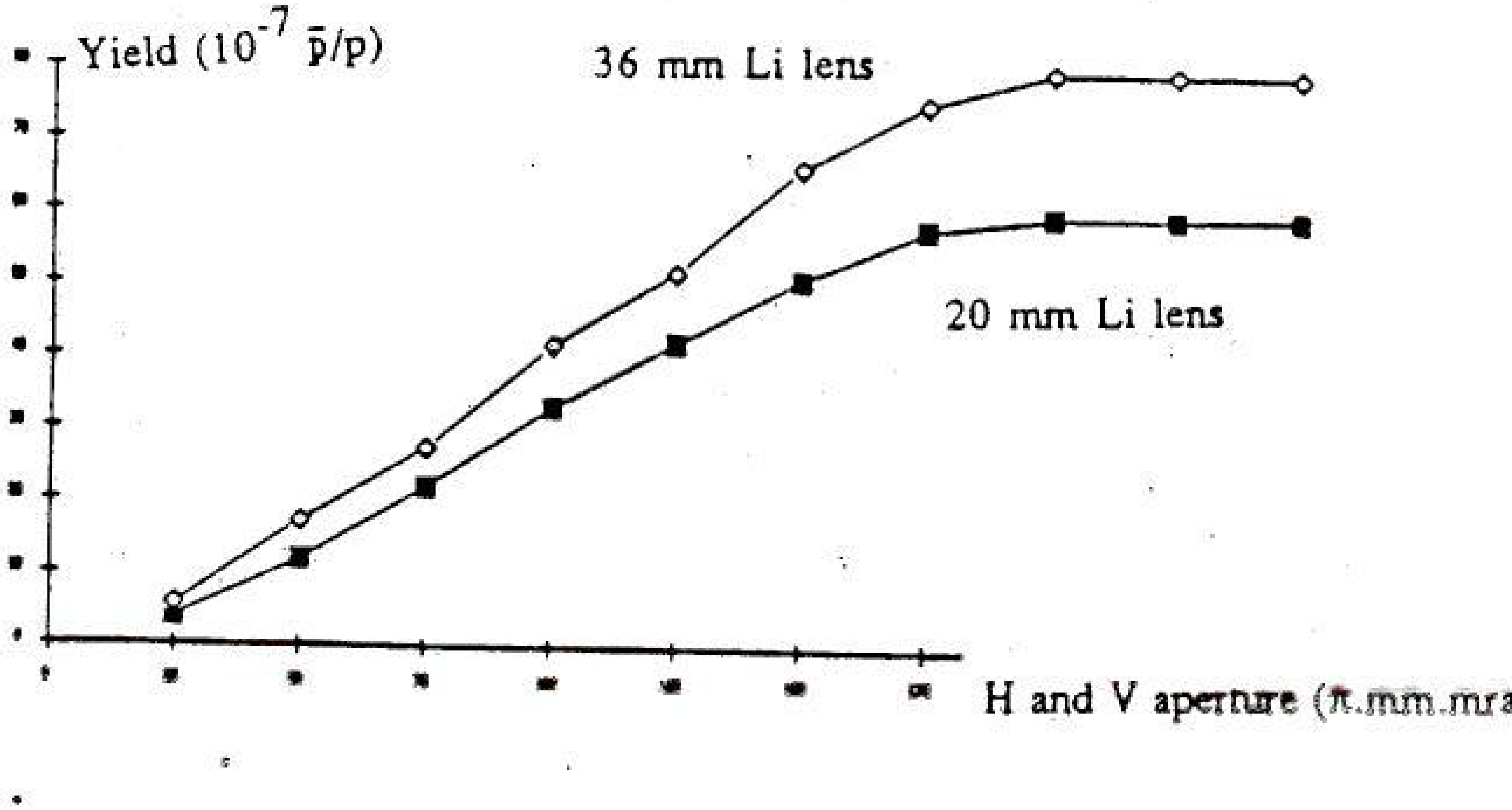


Fig. 4 - Yield comparison between 20 and 36 mm lighium lens.

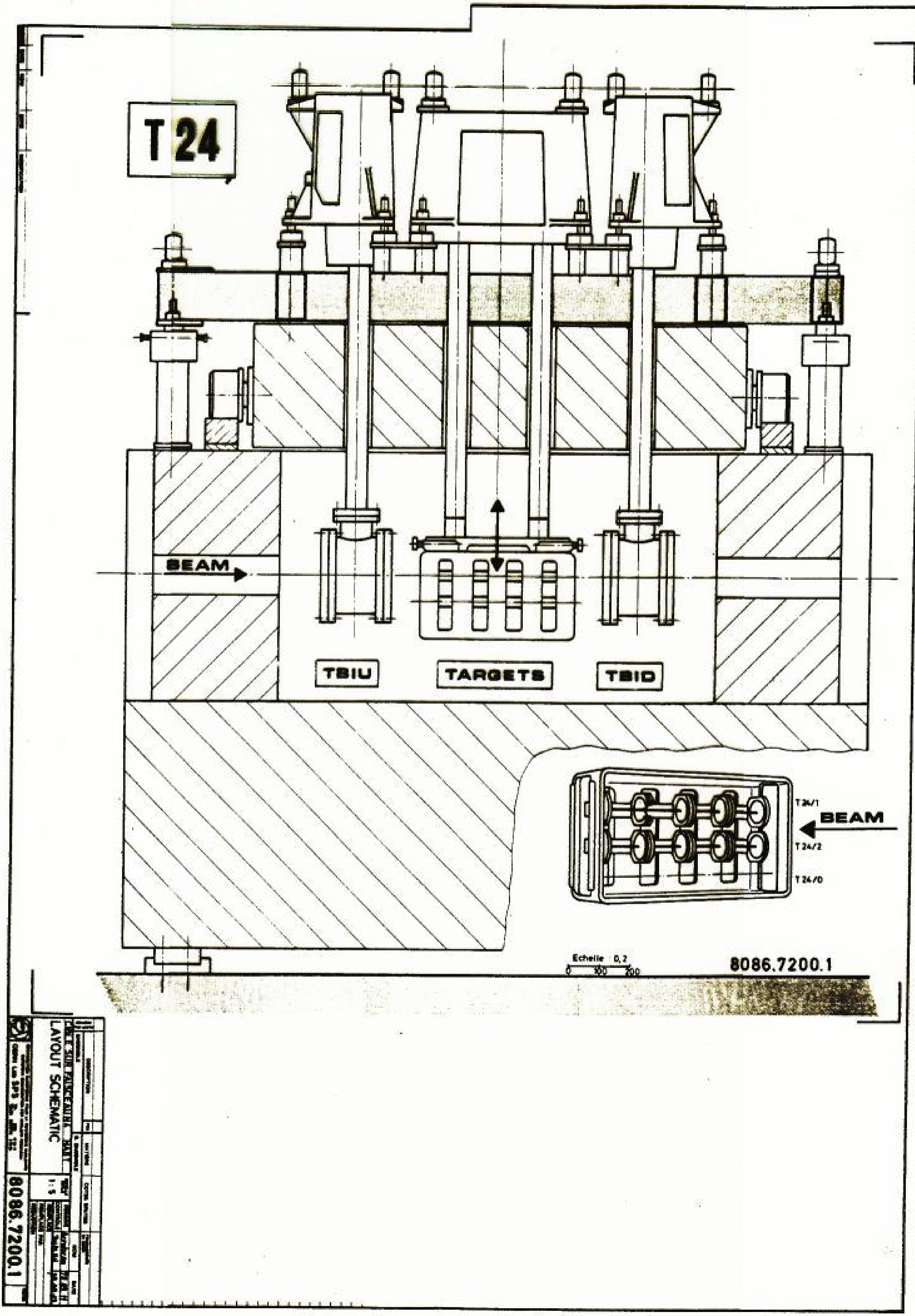
The maximum number of antiprotons injected into the AC was 9.5×10^7 (mean value over ten pulses). It should be fairly eas to reach a value of 10^8 antiprotons after further adjustment.

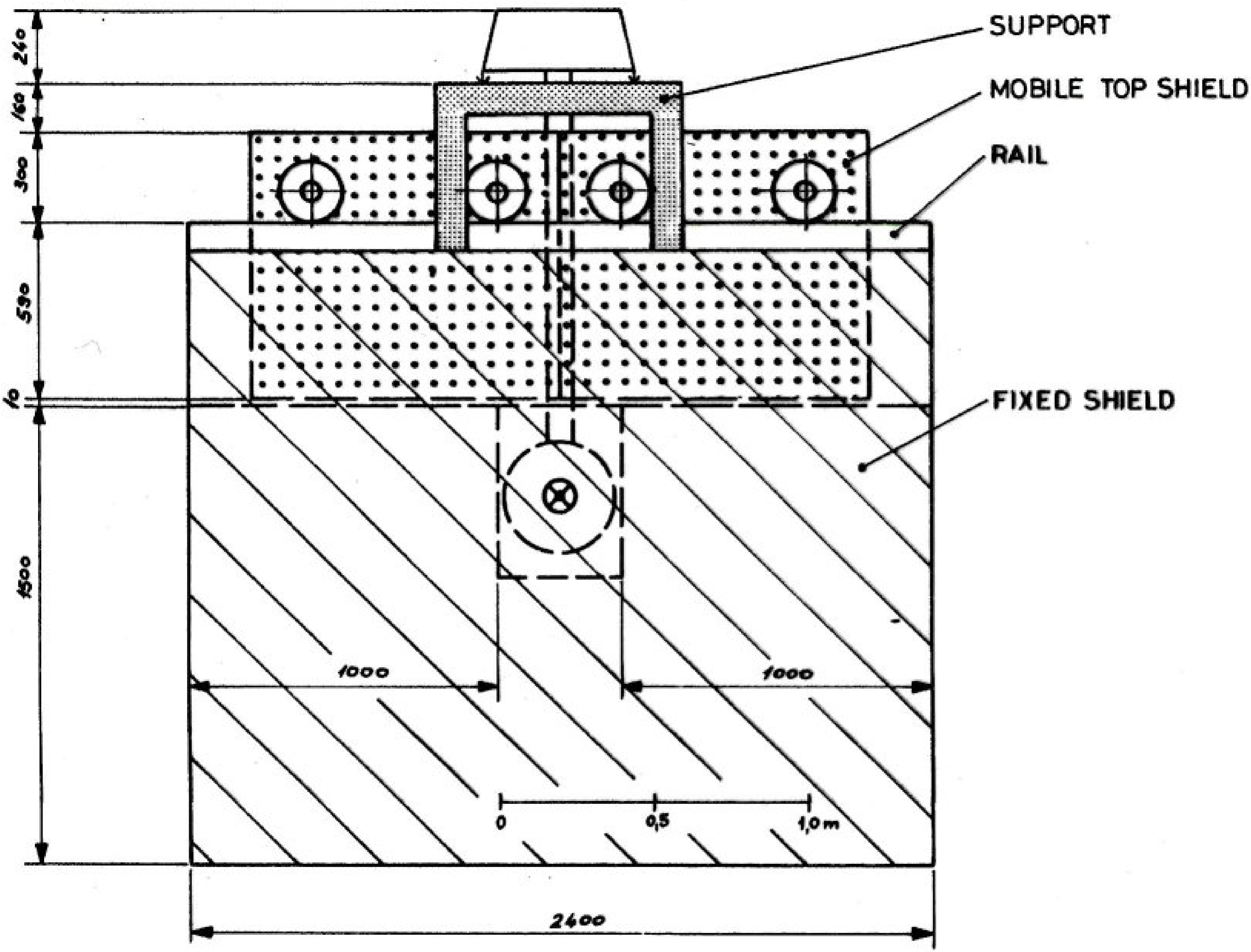
Lithium Lens Lifetime and Improvement

During subsequent life tests in the laboratory, the stainles steel container of the lithium lens failed after half a million pulses a 1.1 MA. A substantial increase in wall thickness is obtained by reducing the lithium diameter from 36 mm to 34 mm. The resulting loss of yield is only about 3 to 4% according to the Monte Carlo program used in ref. [8]. It should be noted that the prototype 36 mm lens was originally designed for a peak current of 800 kA. Two new 34 mm lithium lenses are being built and should be tested and ready for operation in August 1990.

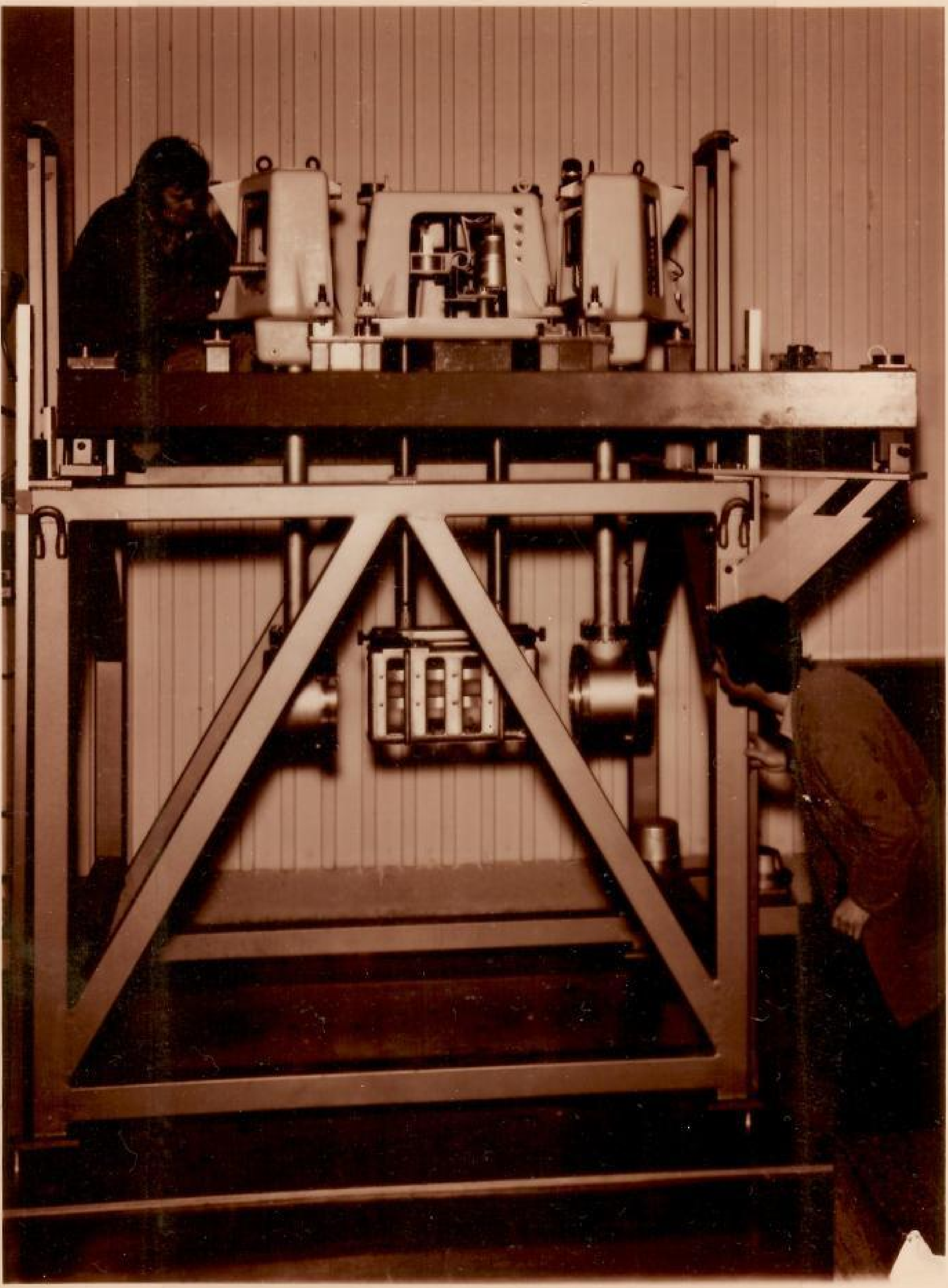
References

[1] R. Bellone. A. Iispeert and P. Sievers in

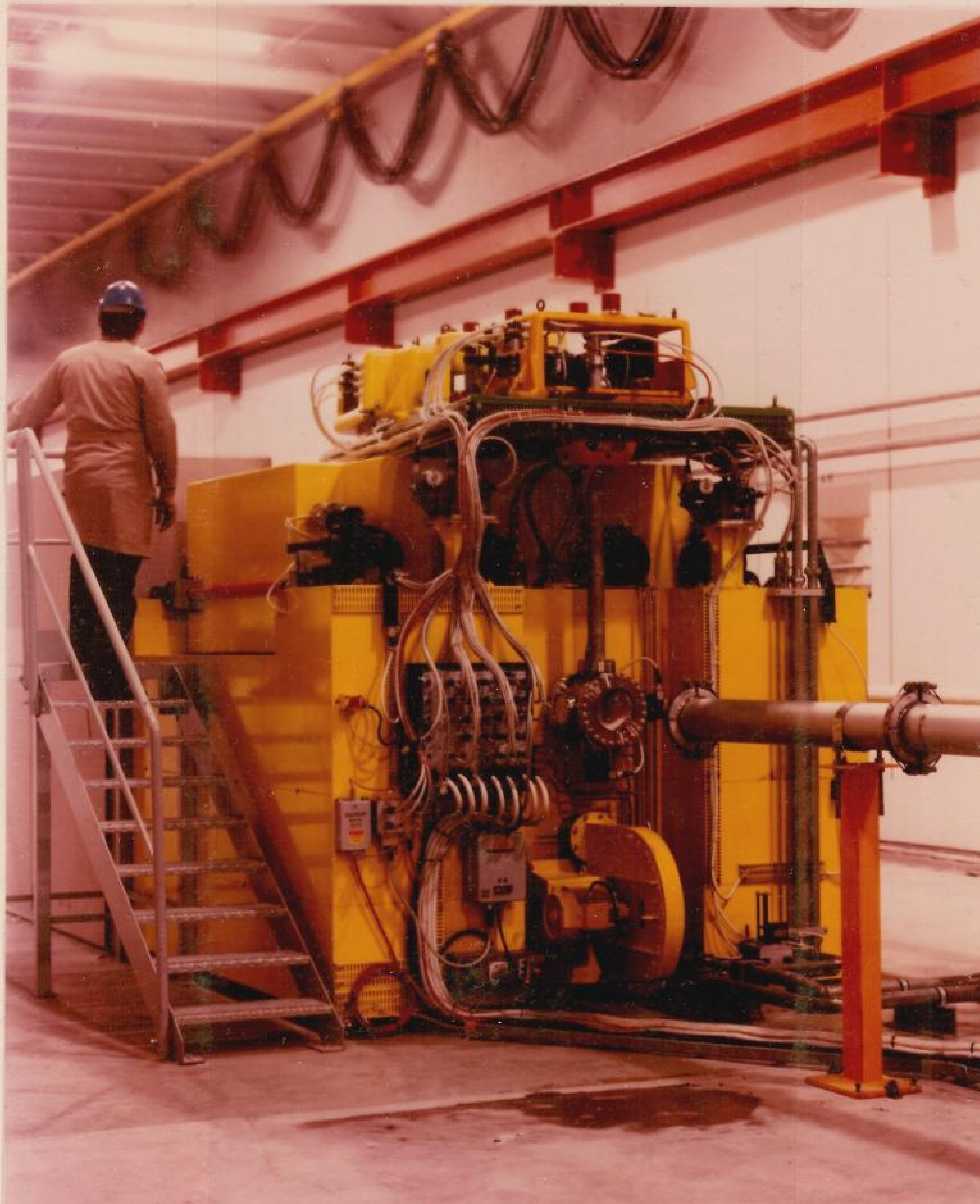

T 24
BEAM
TBIU
TARGETS
TBID
T 24/1
BEAM
T 24/2
T 24/0
Echelle 0,2
0 100 200
8086.7200.1
LAYOUT SCHEMATIC
1 : 5
8086.7200.1



SUPPORT
MOBILE TOP SHIELD
RAIL
FIXED SHIELD
240
160
300
590
10
1500
1000
1000
2400
0
0,5
1,0 m

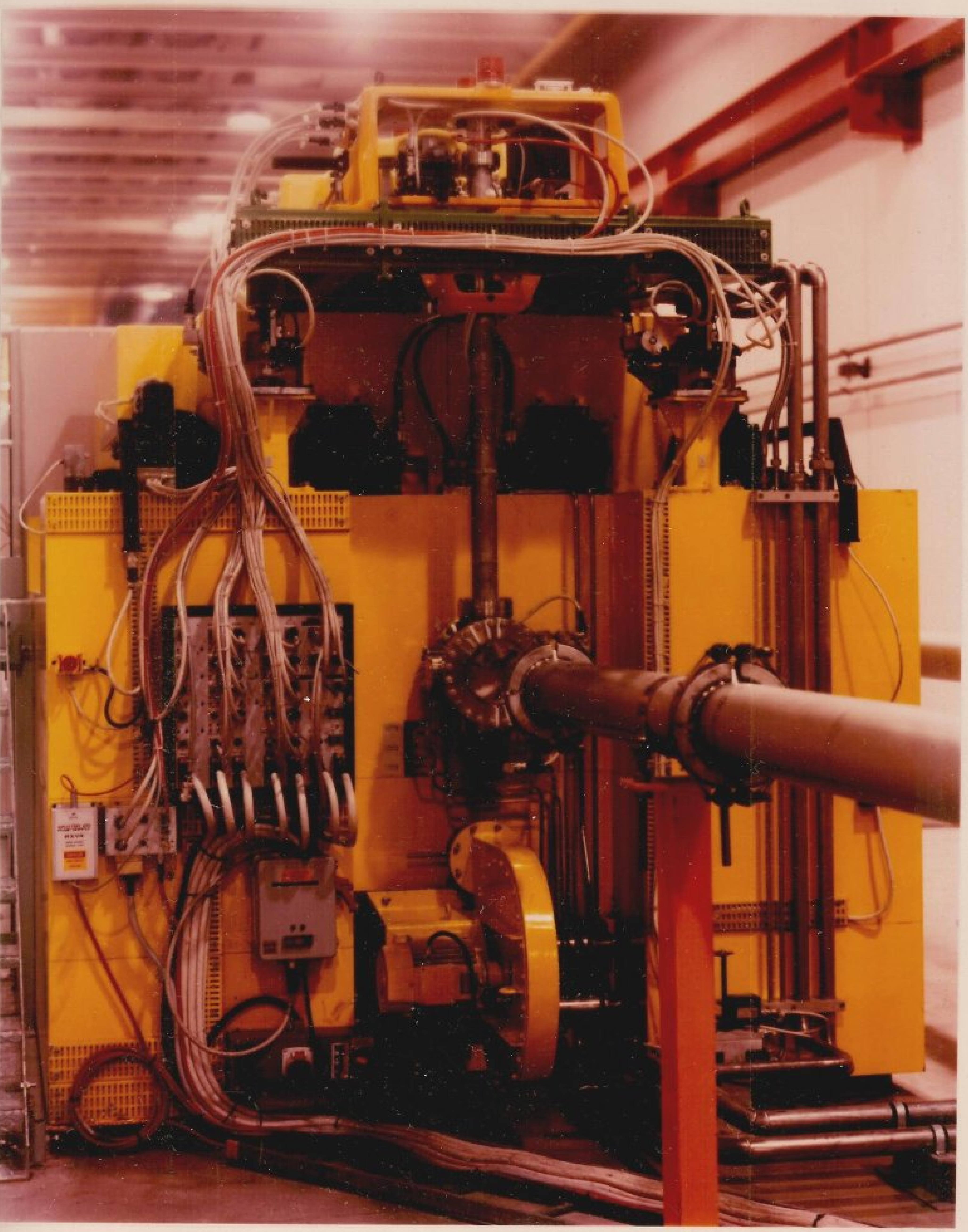


T8_T10



Réf: X 695 11-79

T8 _ T10

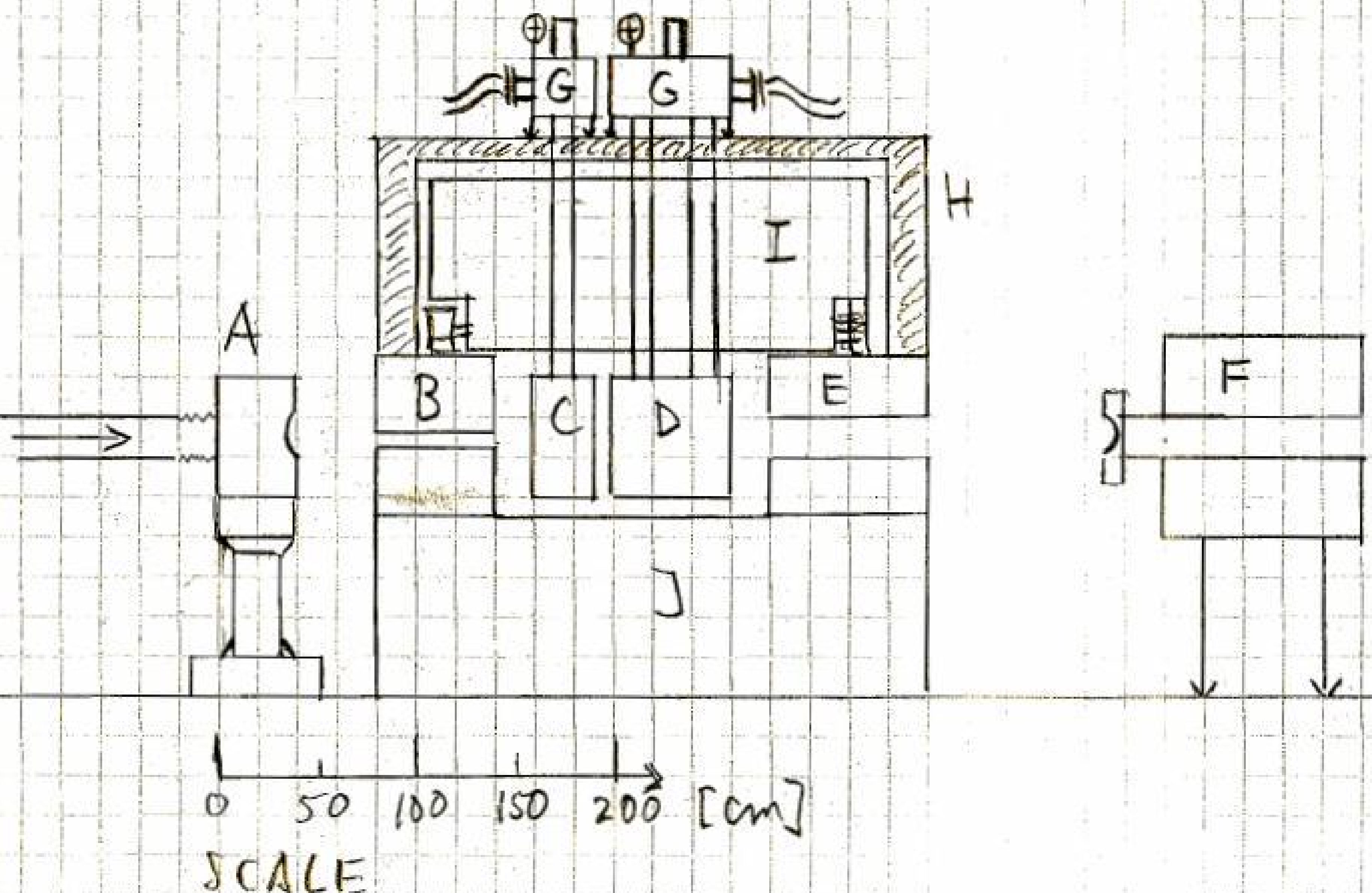


Réf: X 694 11-79

P. SIEVERS
25/7/06

TARGET STATION "0"

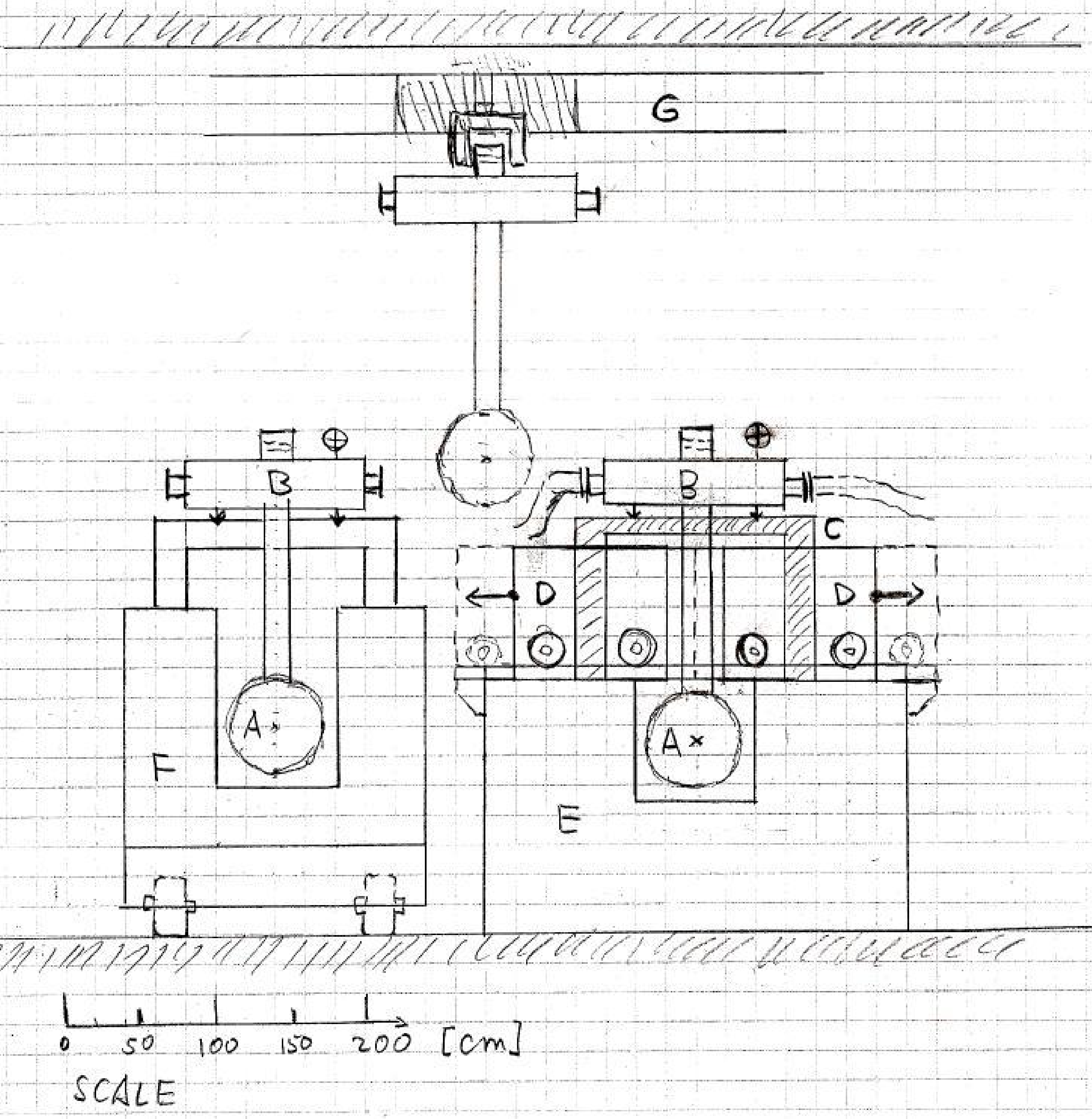
SIDE VIEW



TARGET STATION "0"

FRONT VIEW

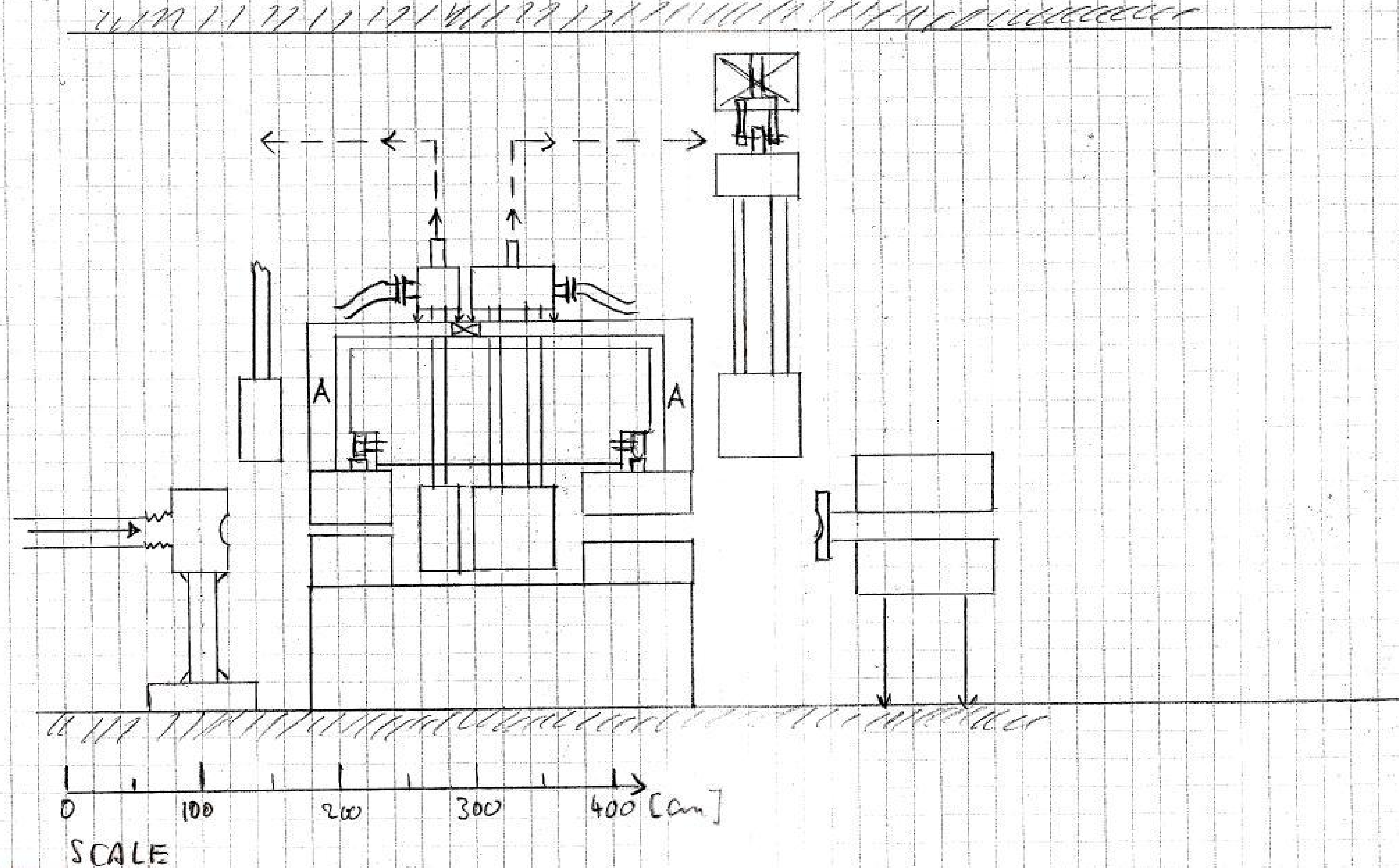
P. SIEVERS
25/7/06



TARGET STATION "1"

SIDE VIEW

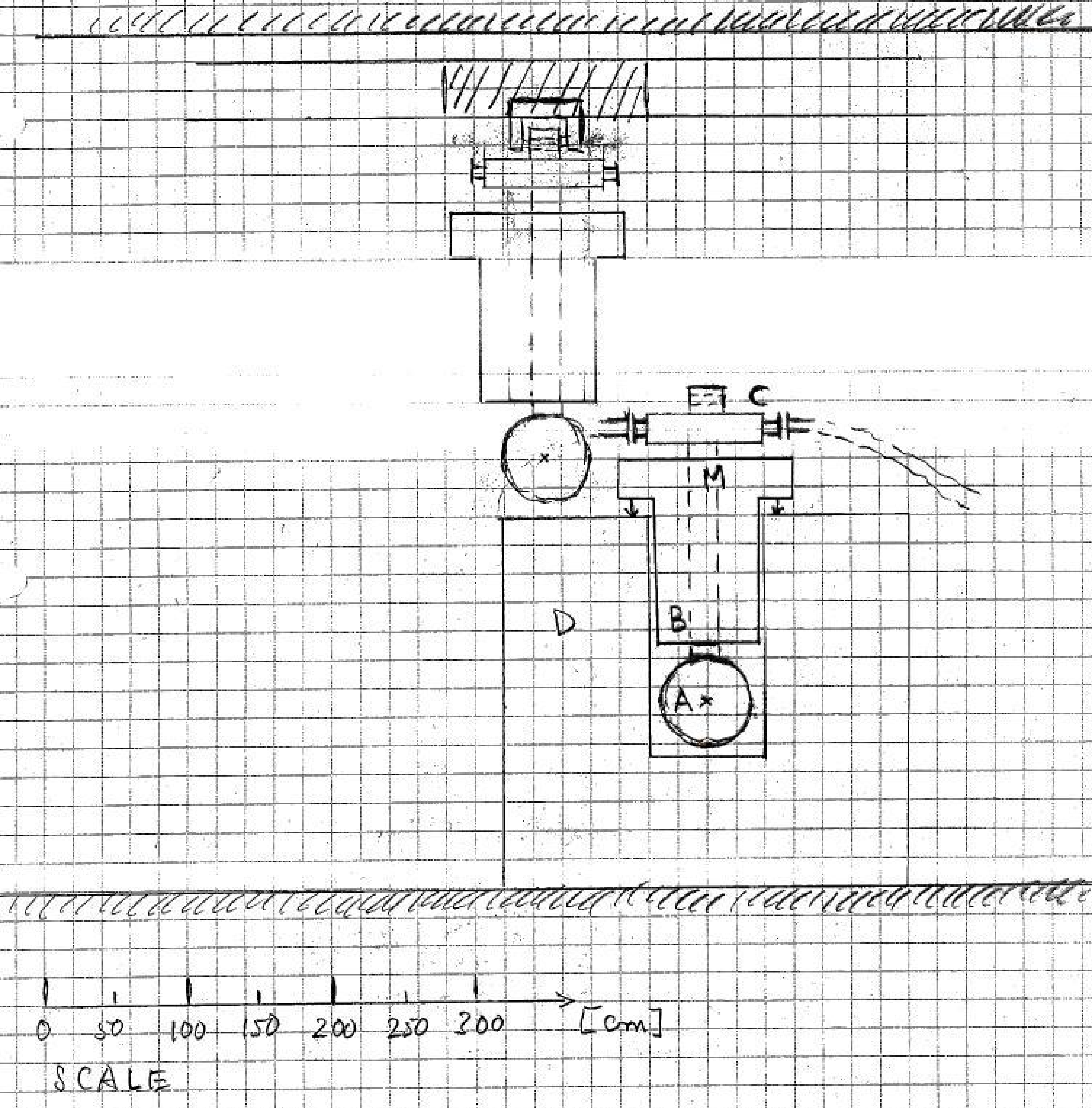
P. SIEVERS
27/7/06



P. SIEVERS
7/8/06

TARGET STATION "3"

FRONT VIEW



TARGET STAION "2"

FRONT VIEW

P. SIEVERS
3/8/06