Horn R&D for 2002-2003

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For the CERN Horn working group
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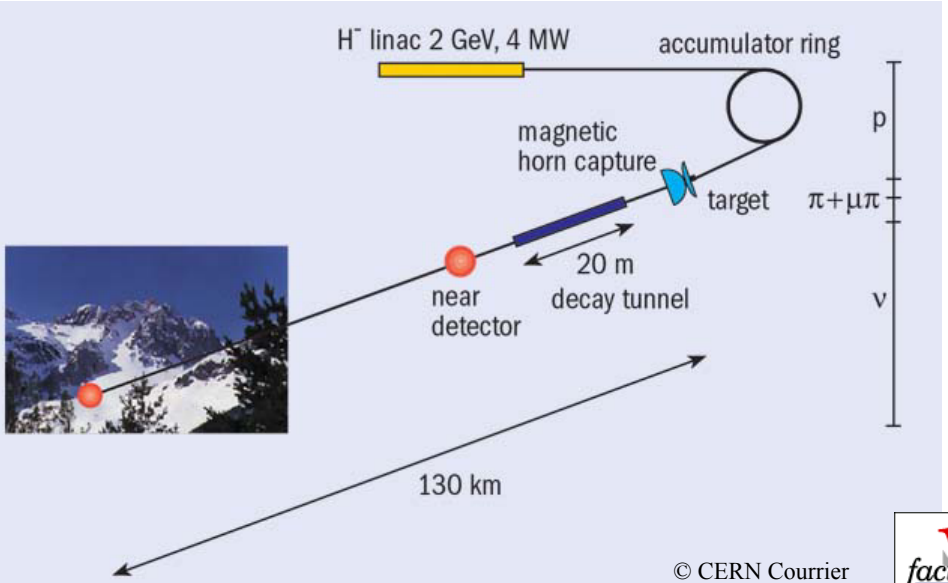
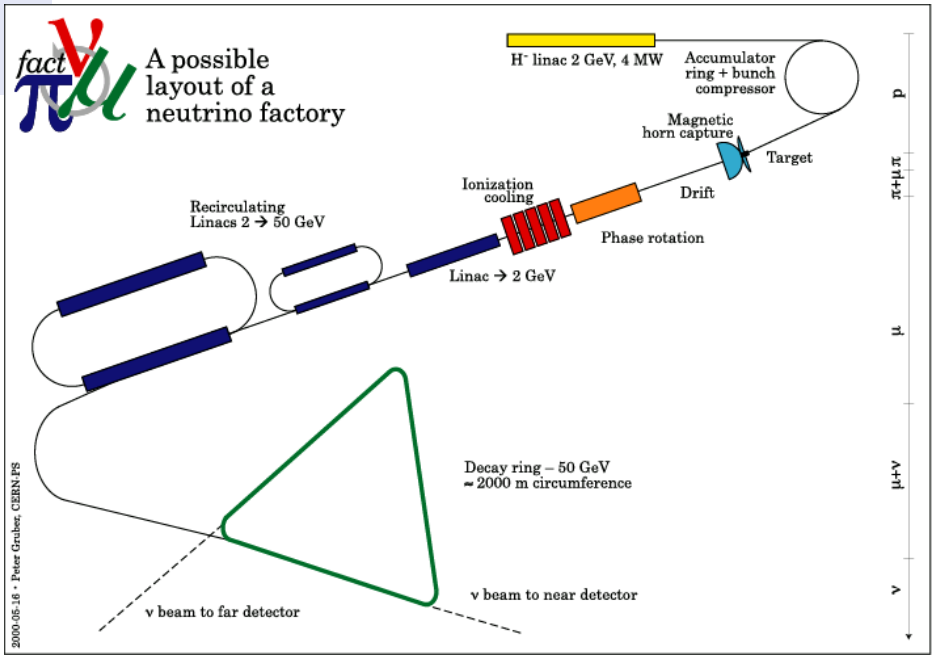
Nufact + SuperBeam



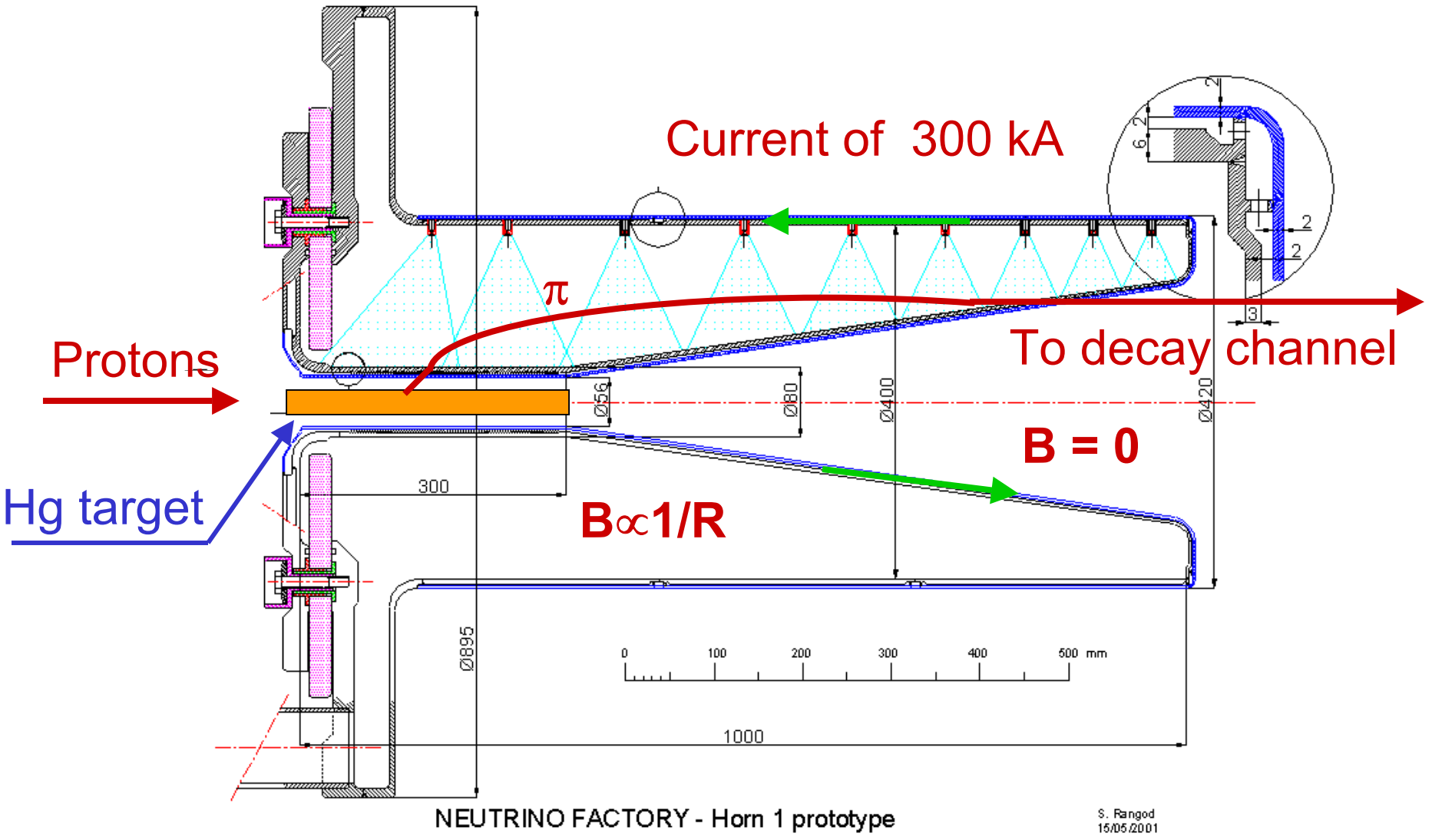
Different horn design&optimisation



Same technological issues:

- Lifetime estimation
- Target-horn integration

Horn focusing system



Horns available from the shelf

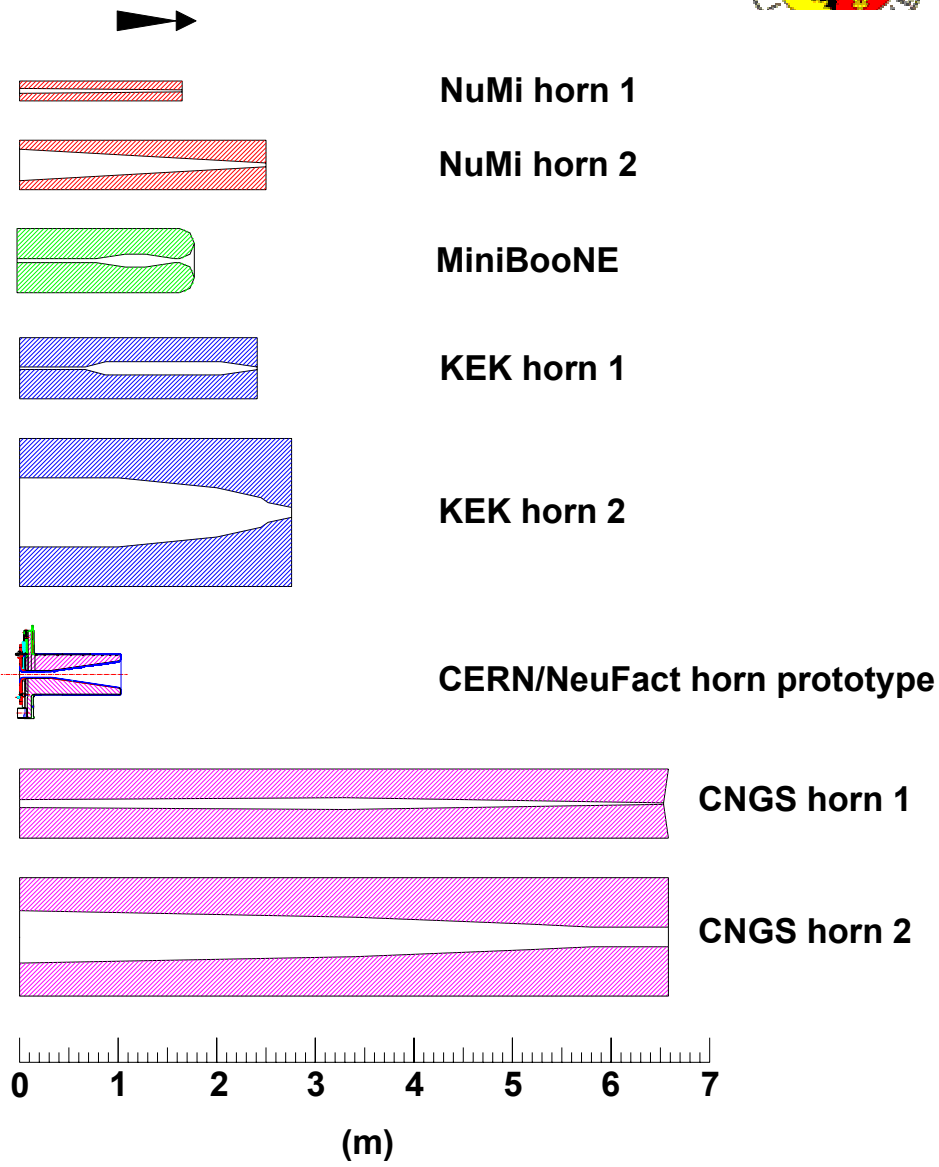
Numi: 200 kA, 0.5 Hz, 6M pulses
1 year

MinibooNe: 170 kA, 5 Hz, 11M pulses
1 year

K2K: 250 kA, 0.5 Hz, 11M pulses
1 year

Nufact: 300 kA, 50 Hz, 200 M pulses
6 weeks

CNGS: 150 kA, 2 pulse/6s, 42 M pulses
4 years



The challenge of low ν-energy

- The target is not point-like:
  - Normally 1-2 interaction lengths
    - Order 20-30 cm for heavy targets (Hg)
- Particle produced with large energy spread
  - Typical transverse momentum 250 MeV/c
  - Typical energy around 1 GeV (even less)
  - **Large divergence**
- In any case, from Van der Meer:
  - Max angle for a given momentum depends only on the square root of the current

$$\theta_{MAX} = \sqrt{\frac{\mu_0 I}{2\pi B\rho}}$$

Target inside or outside ?

Target INSIDE for low energy

- Max p_t more or less independent from the energy
  - p_t = 250 MeV/c

p_{tot}= 600 MeV/c

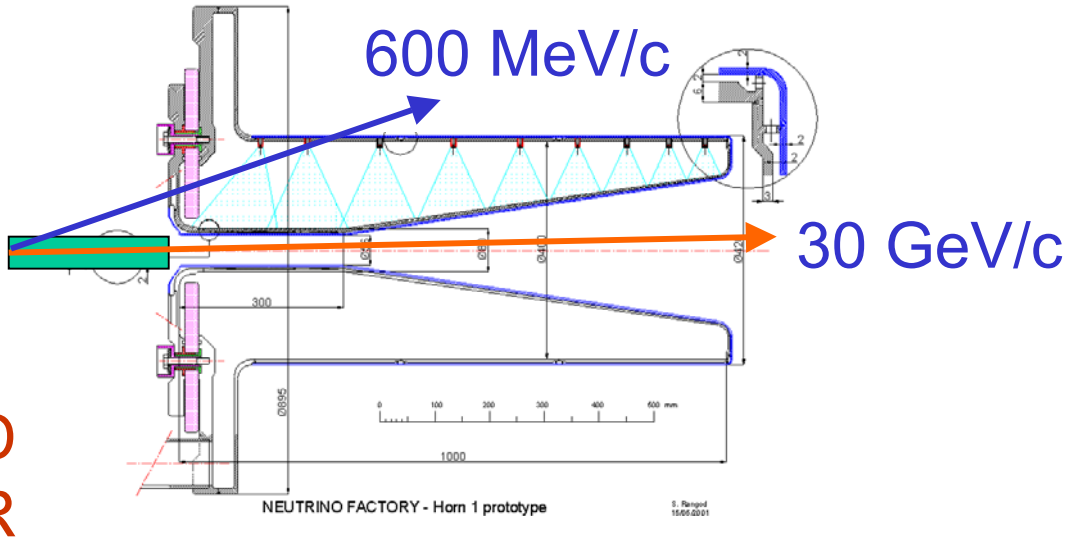
θ = 24°

R(z=30 cm)= 13 cm

p_{tot}= 30 GeV/c

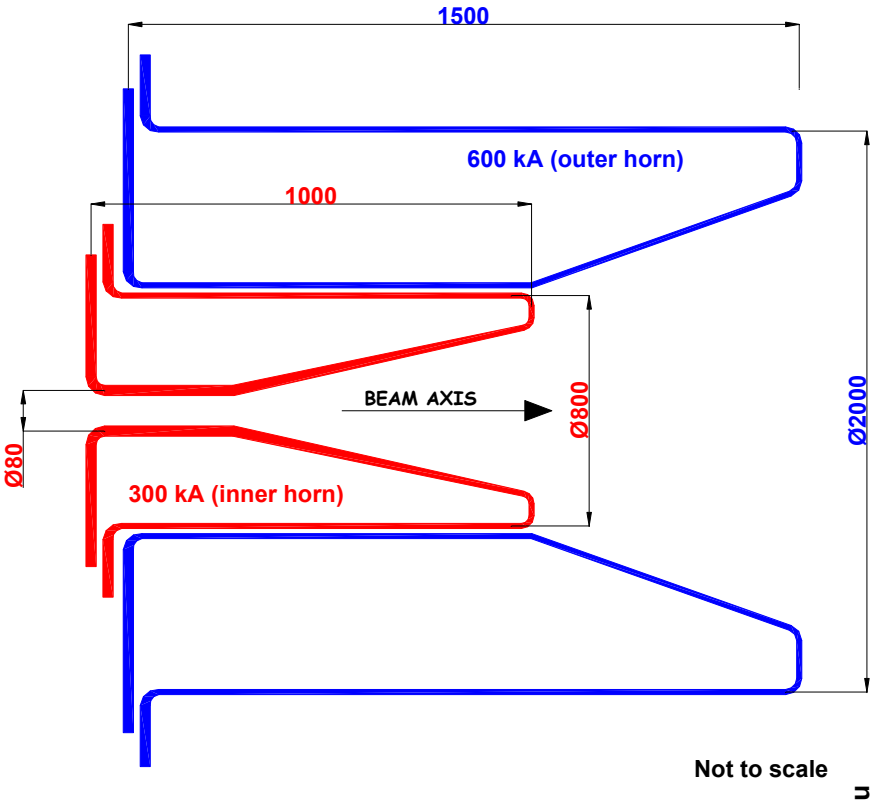
θ = 0.47°

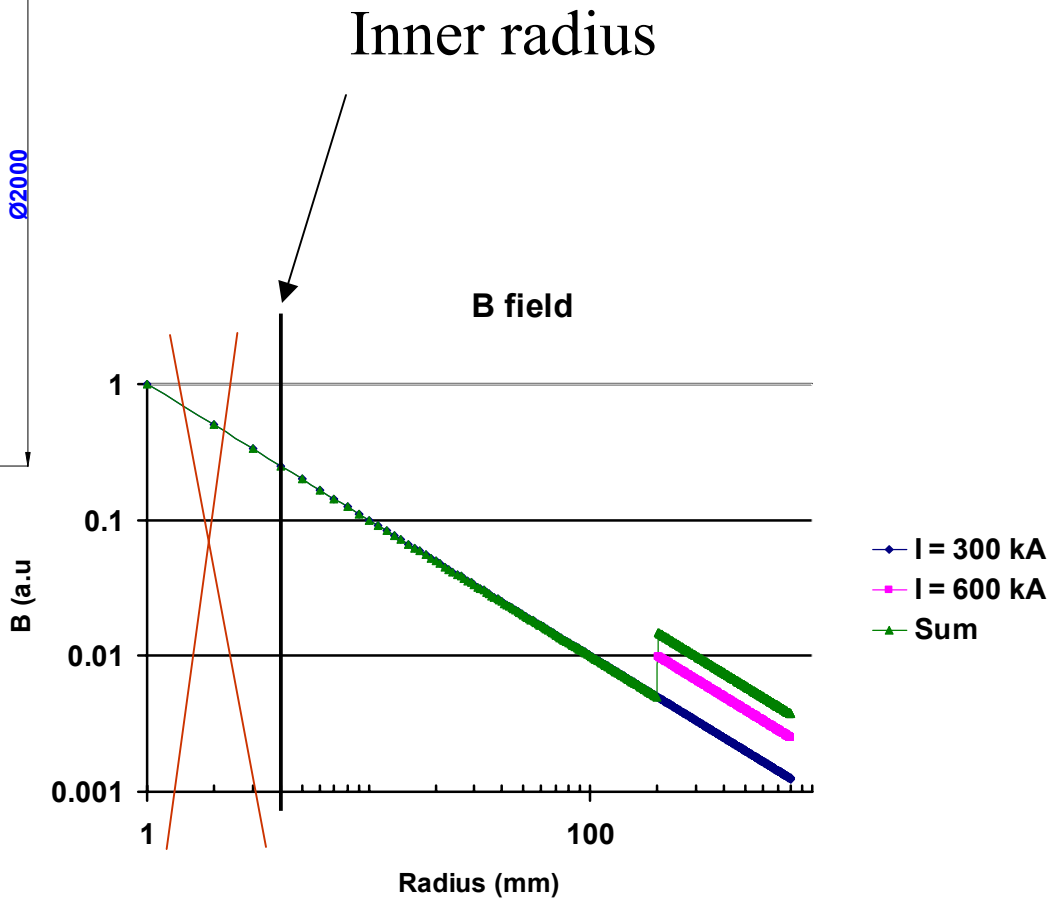
R(z=30 cm)= 0.25 cm



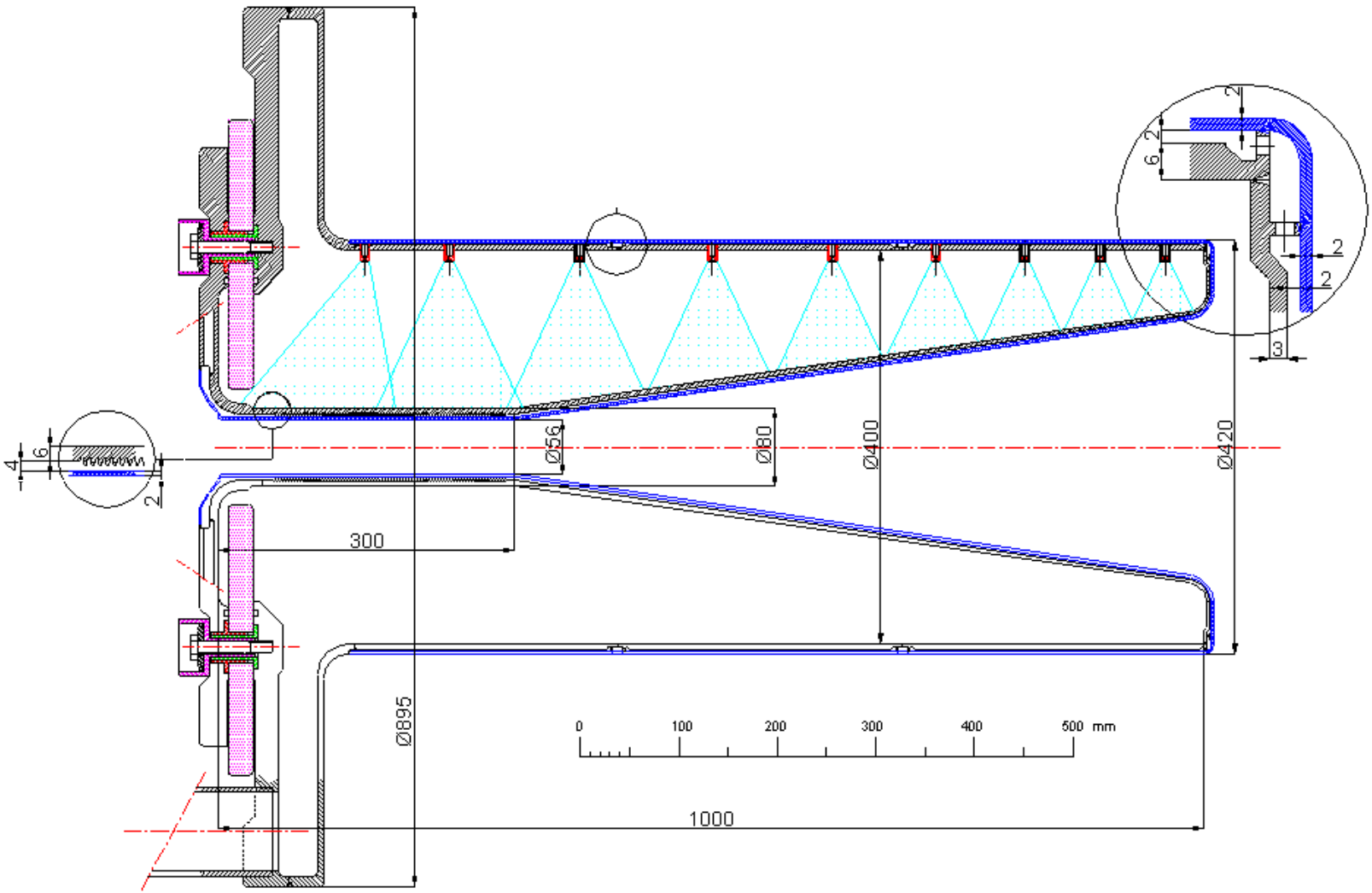
TARGET AND HORN R&D
HAVE TO GO TOGETHER

Double horn concept





Horn first prototype



What we planned to do

- First “inner” horn 1:1 prototype
- Power supply for Test One:

  30 kA and 1 Hz, pulse 100 μs long

  ✓ First mechanical measurements

  ➢ Test of numerical results for vibration

  ✓ Test of cooling system

done

- Test Two: 100 kA and 0.5 Hz
  - Testing during this week
- Last test: 300 kA and 50 Hz

Unknown schedule

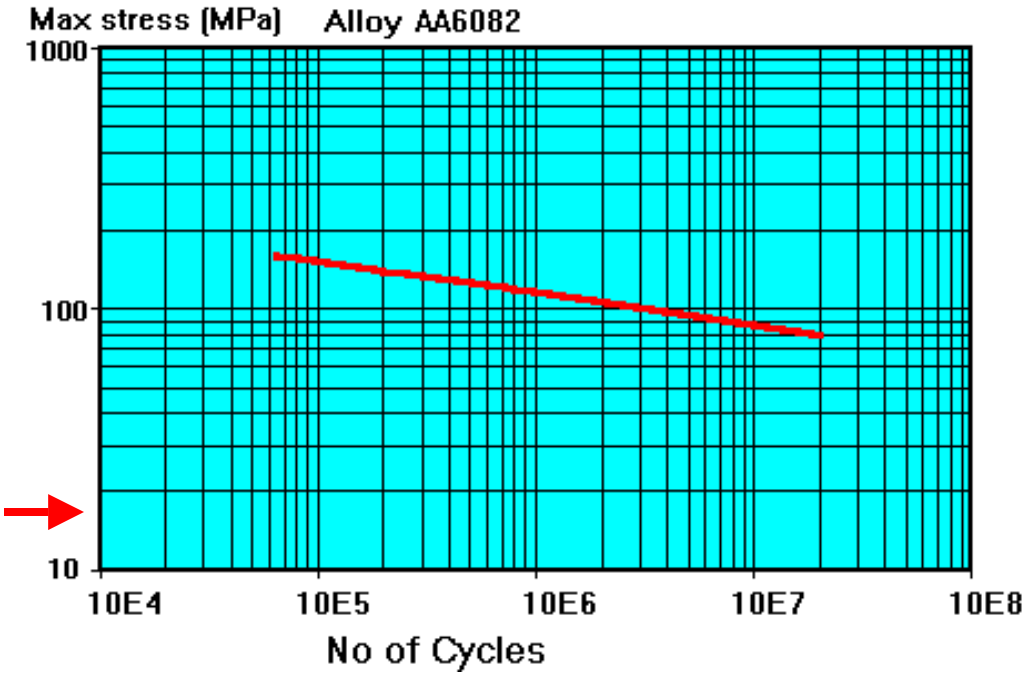
Goal: Horn Life-Time 6 weeks ($2*10^8$ pulses)

First prototype ready

Material choices

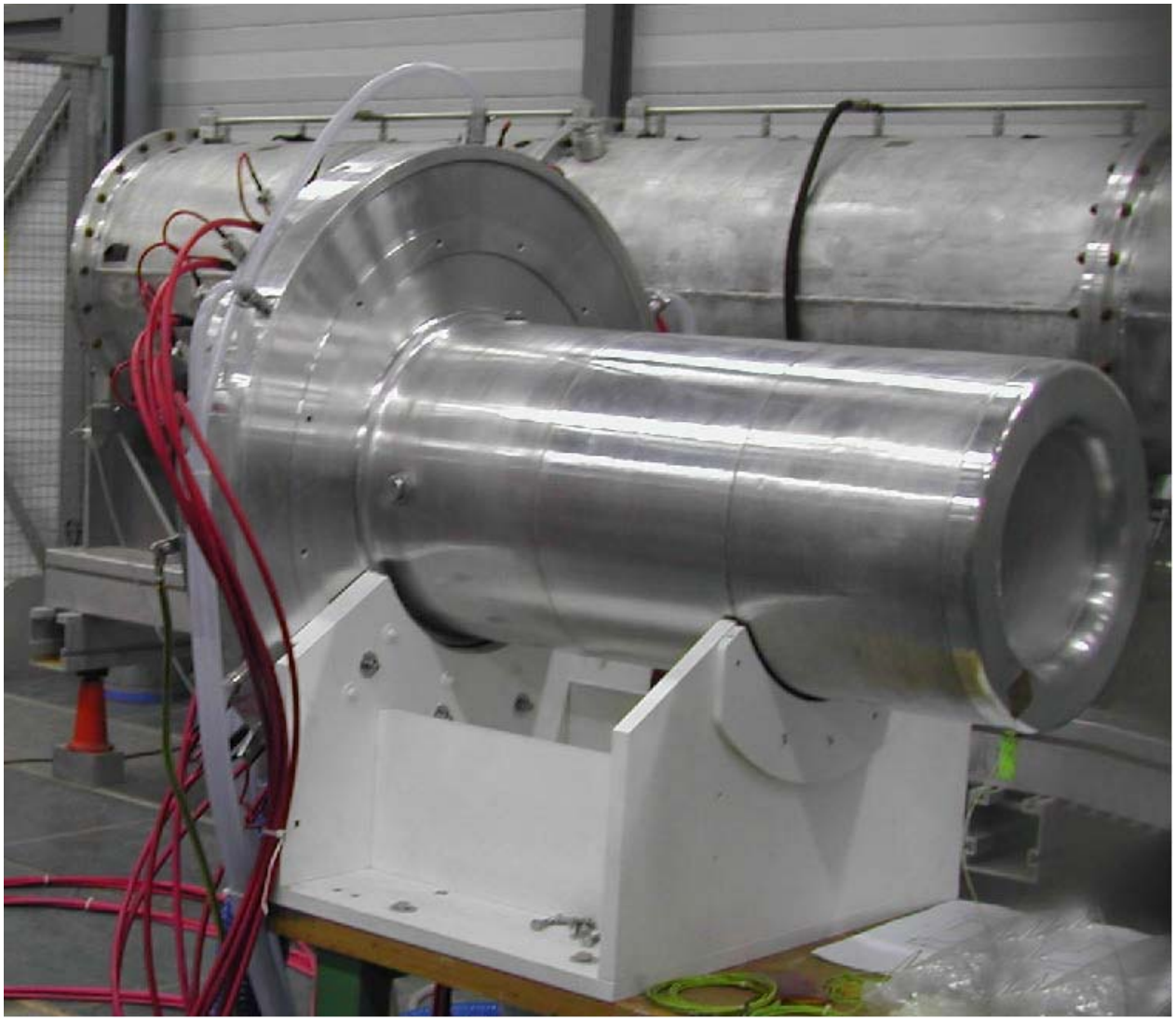
- **AA 6082-T6 / (AlMgSi1) is an acceptable compromise between the 4 main characteristics:**
  - Mechanical properties
  - Welding abilities
  - Electrical properties
  - Resistance to corrosion
  - Same for CNGS

Max. allowed stress →

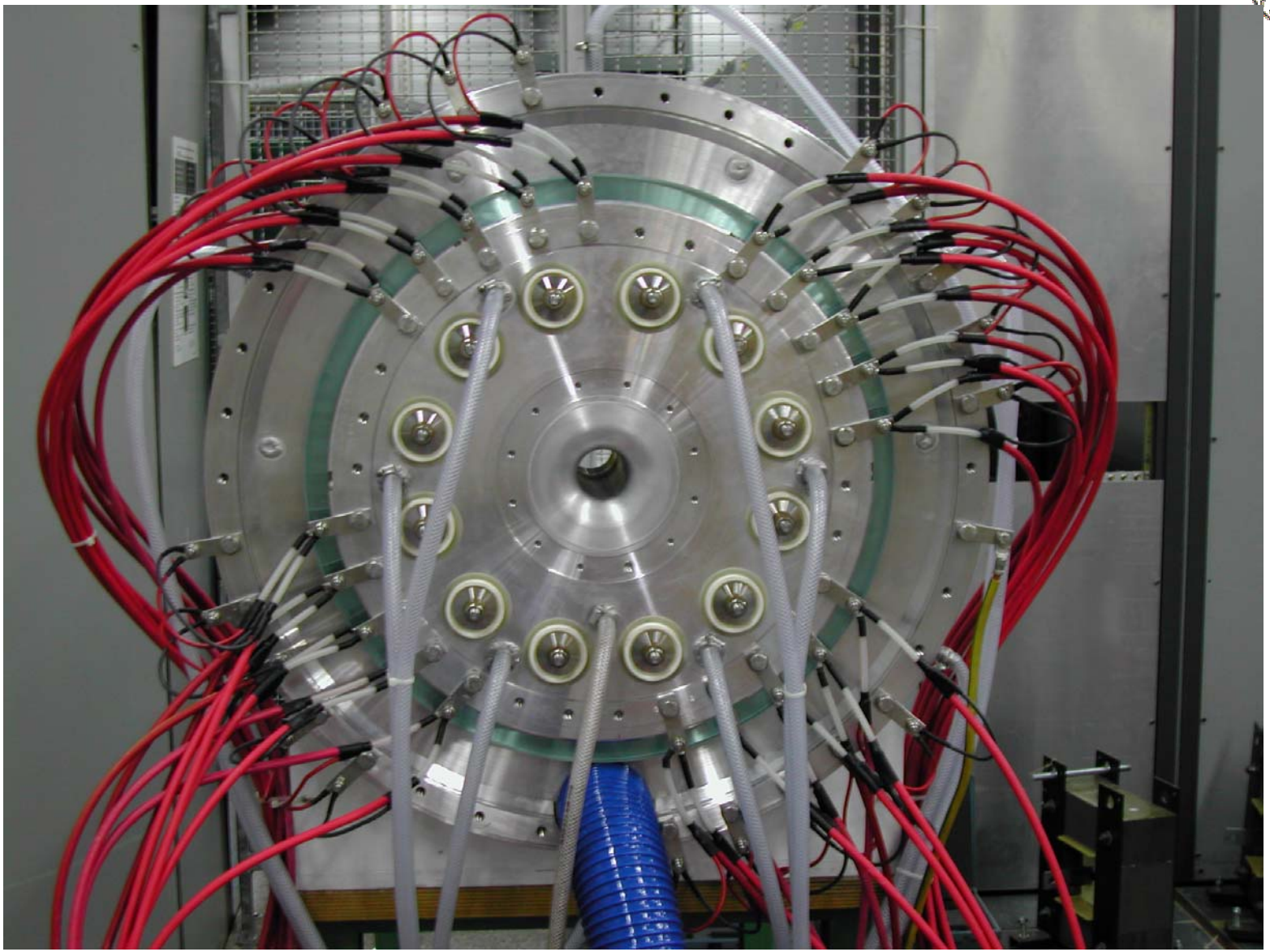


Not compatible with Mercury

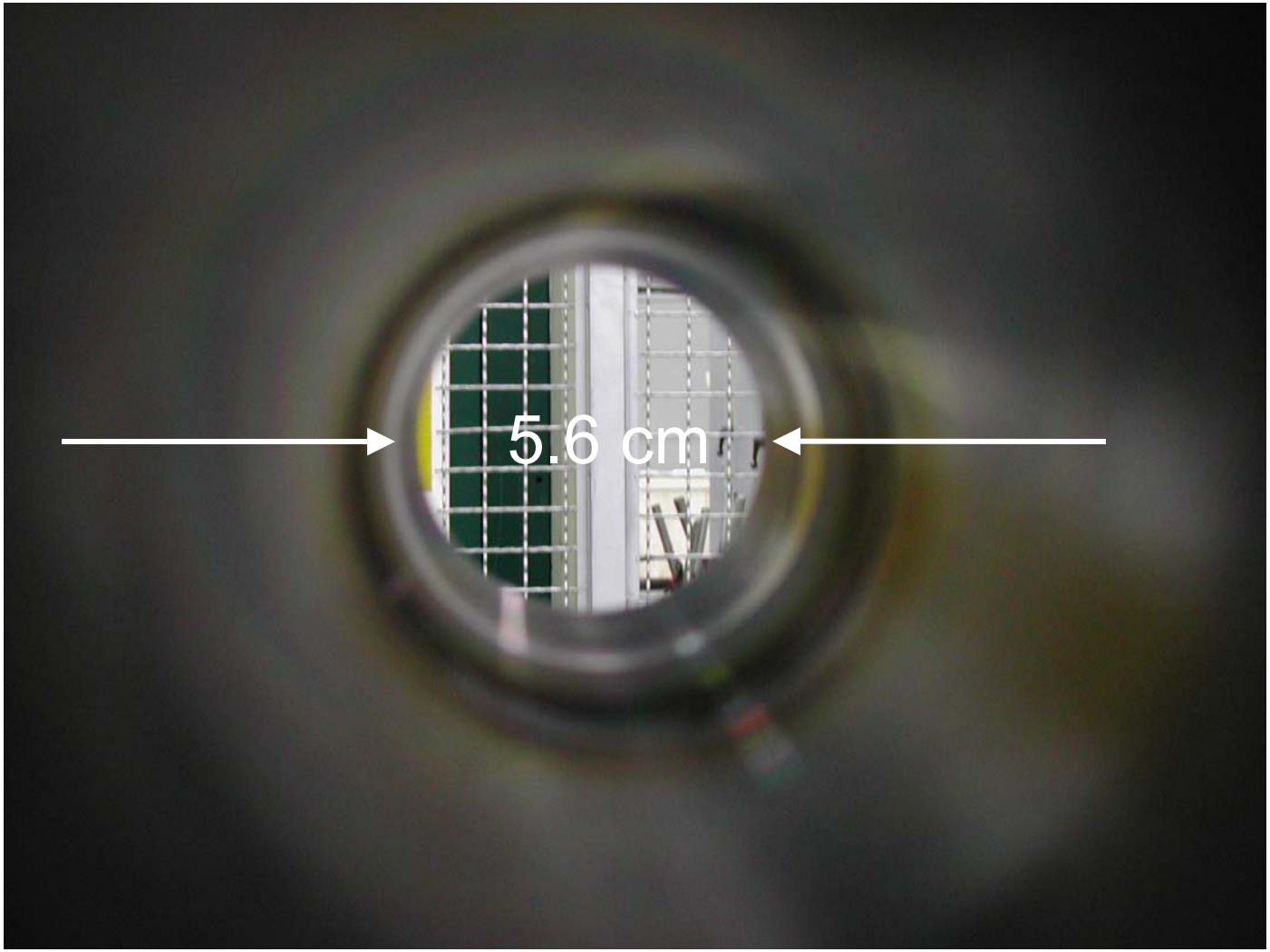
Horn prototype ready for tests



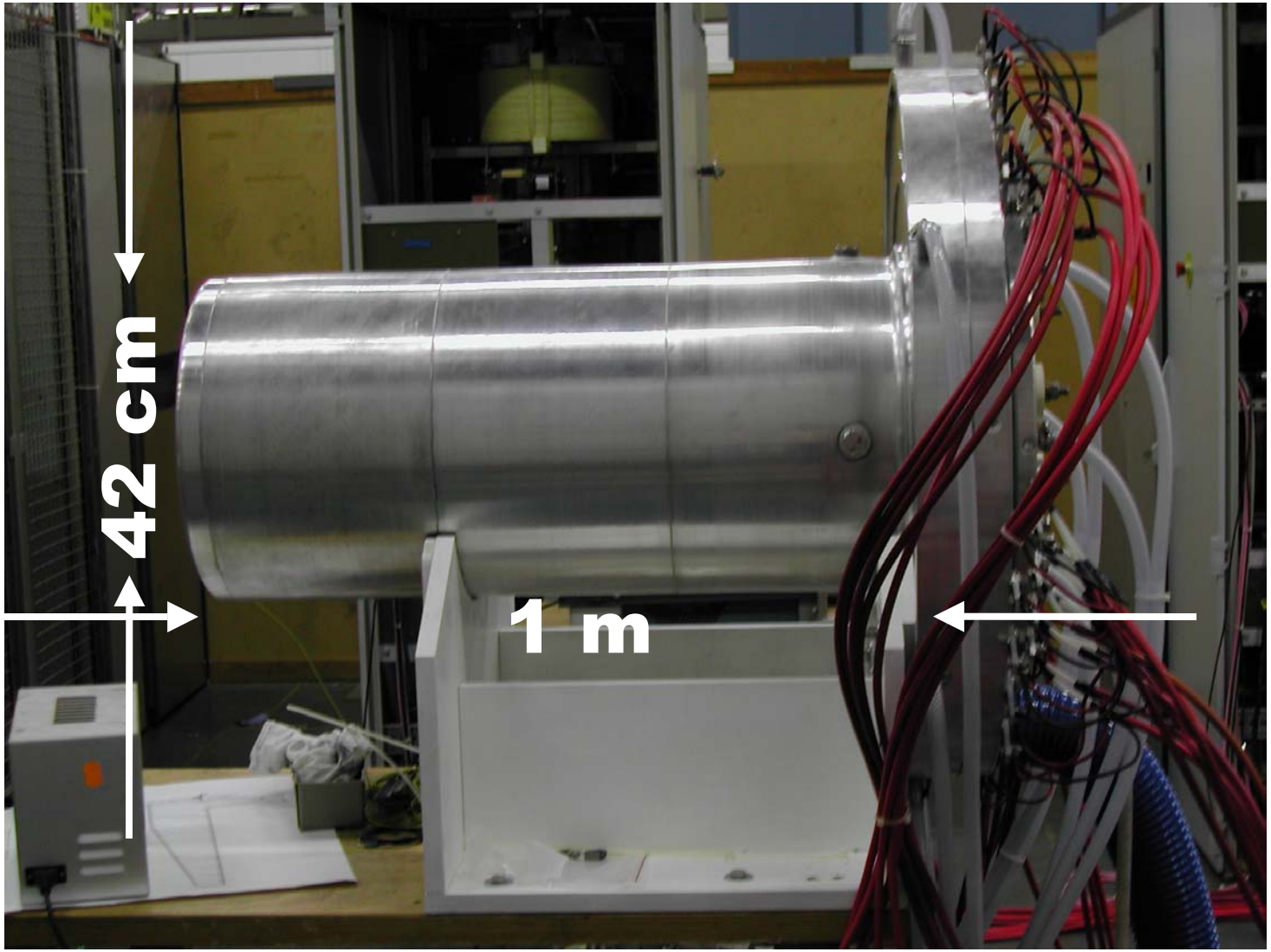
Electrical and water connections



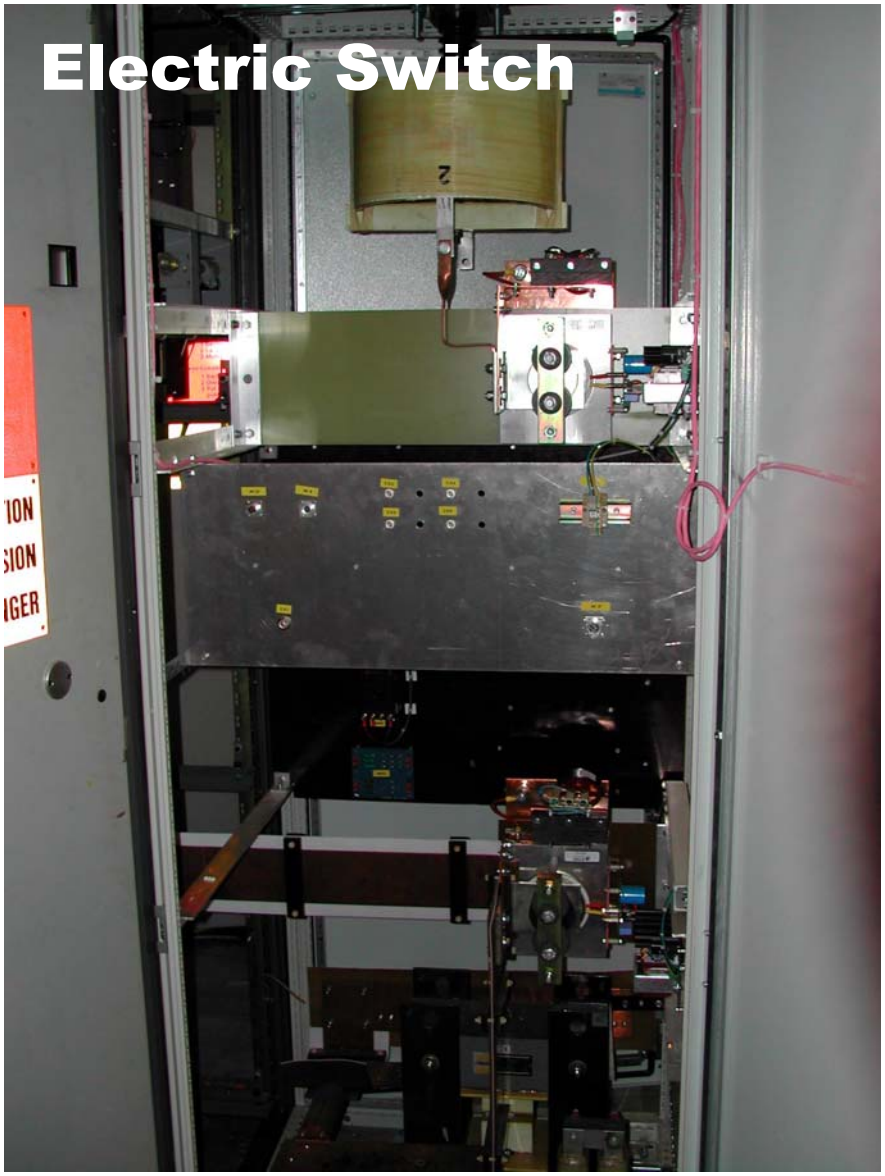
Inside the neck



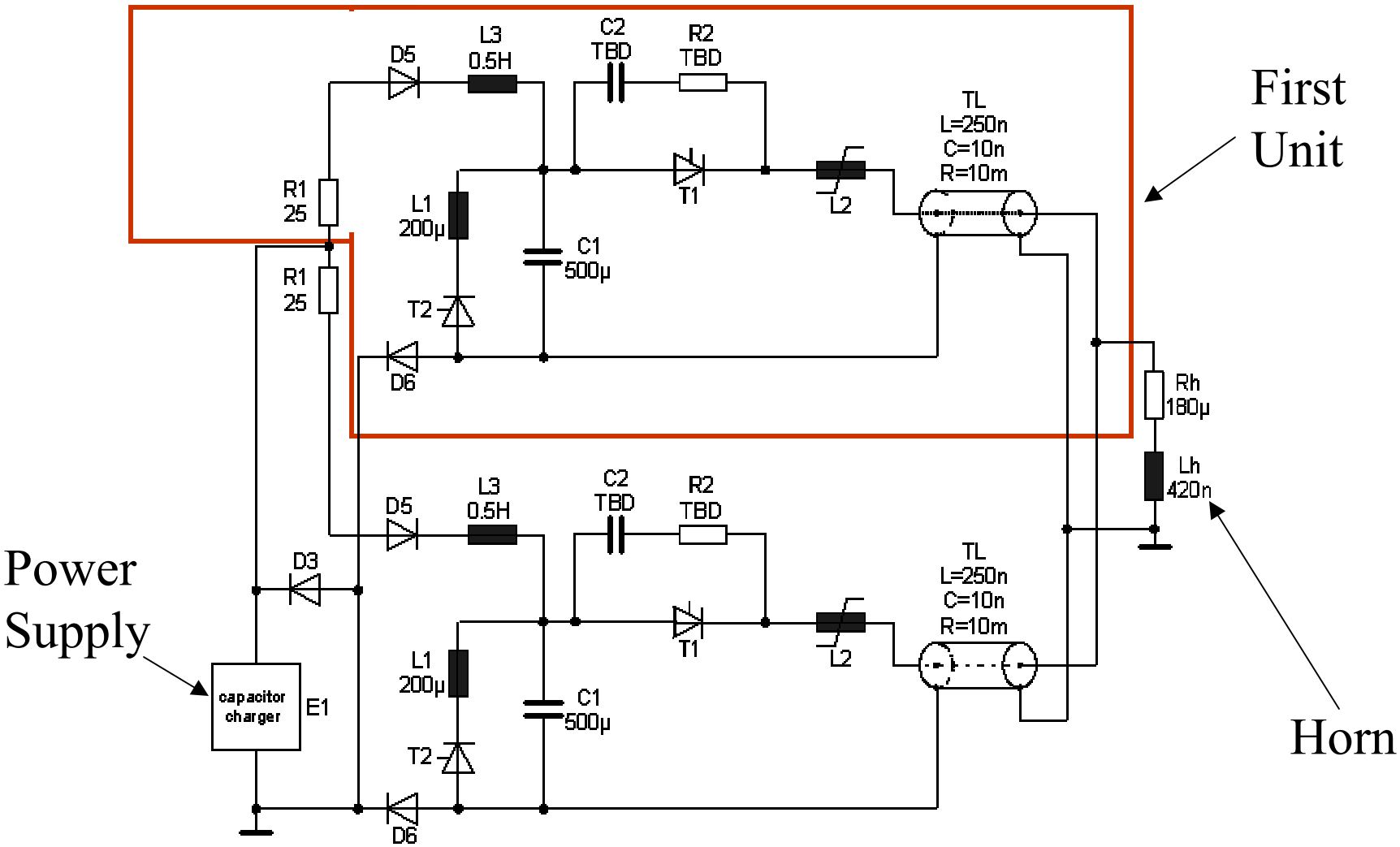
Lateral view



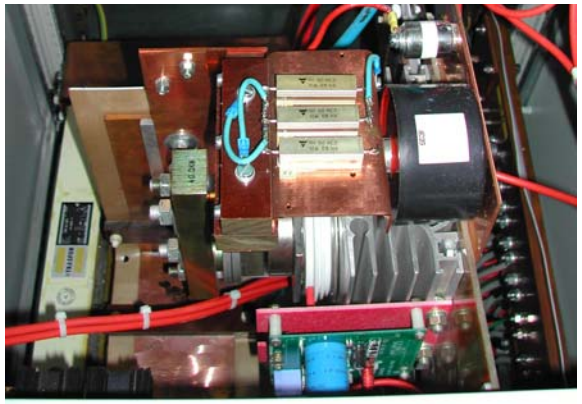
First discharger unit : 2 units in parallel

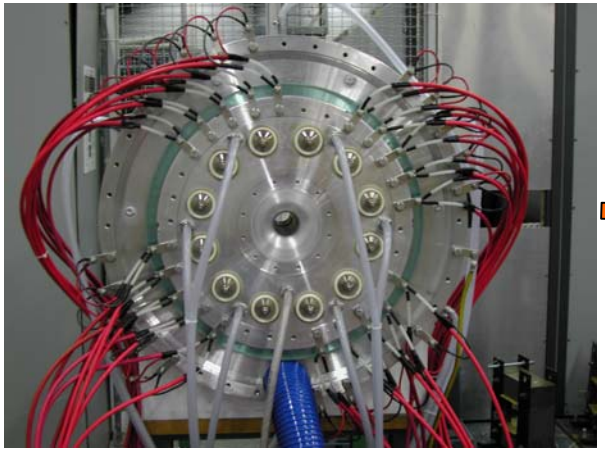


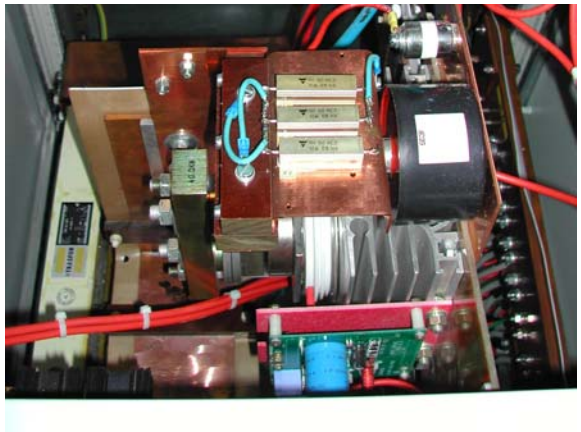
Power supply scheme



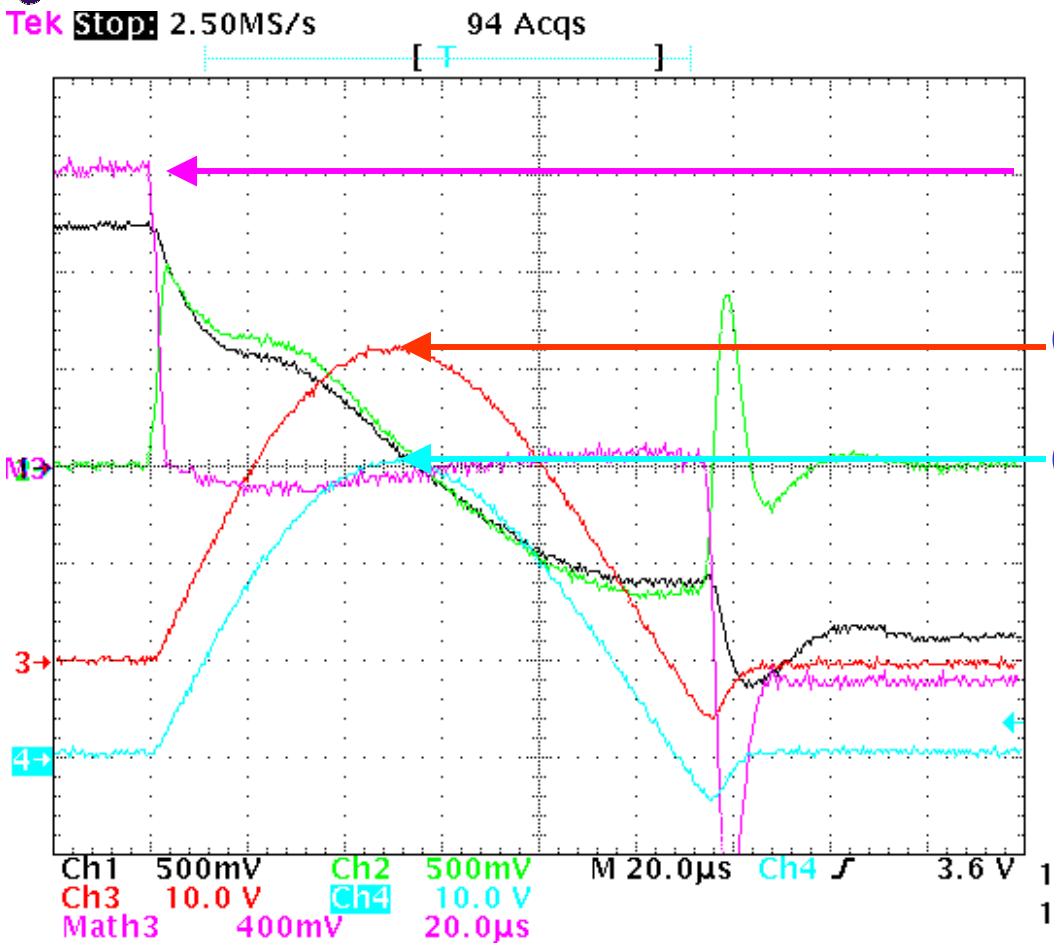
From scheme to reality







P.S. test on dummy load

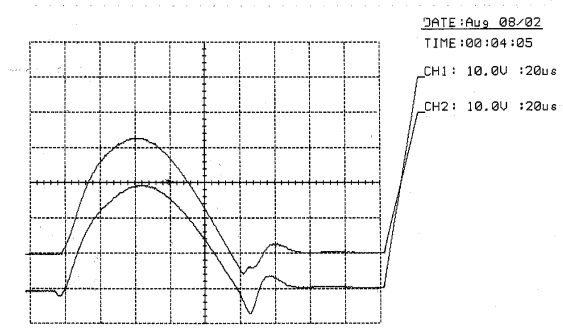


Voltage on horn/tyristor: 1.5 kV

Current first unit =16kA

Current second unit =15kA

Horn current



Channel 1: Voltage at anode of T_1 of first unit to ground (500V/div)

Channel 2: Voltage at cathode of T_1 of first unit to ground (500V/div)

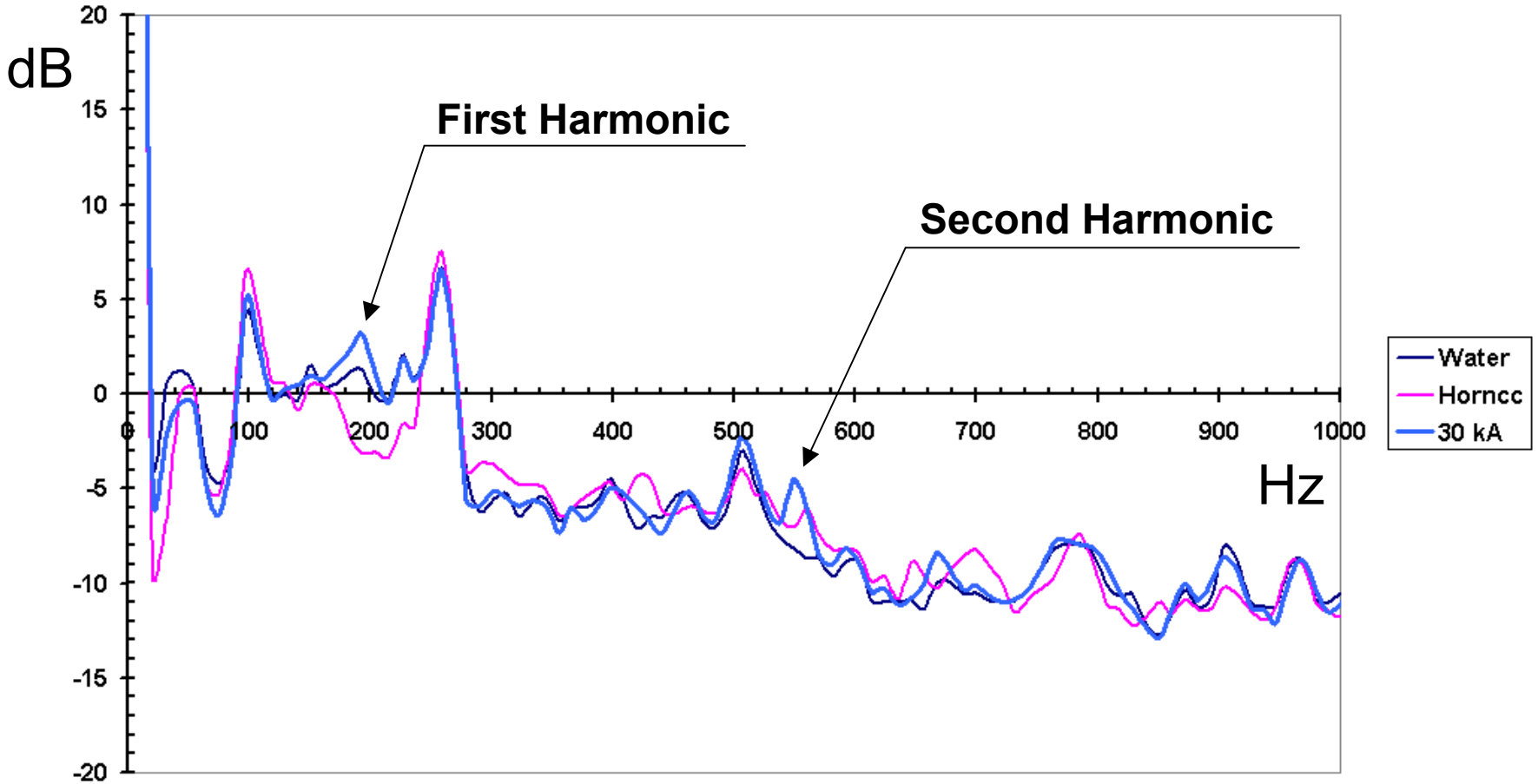
Channel 3: Pulse current of second unit measured with CT1 (5000A/div)

Channel 4: Pulse current of first unit measured with CT1 (5000A/div)

Math 3: Channel 1 – Channel 2, Voltage across T_1 (400V/div)

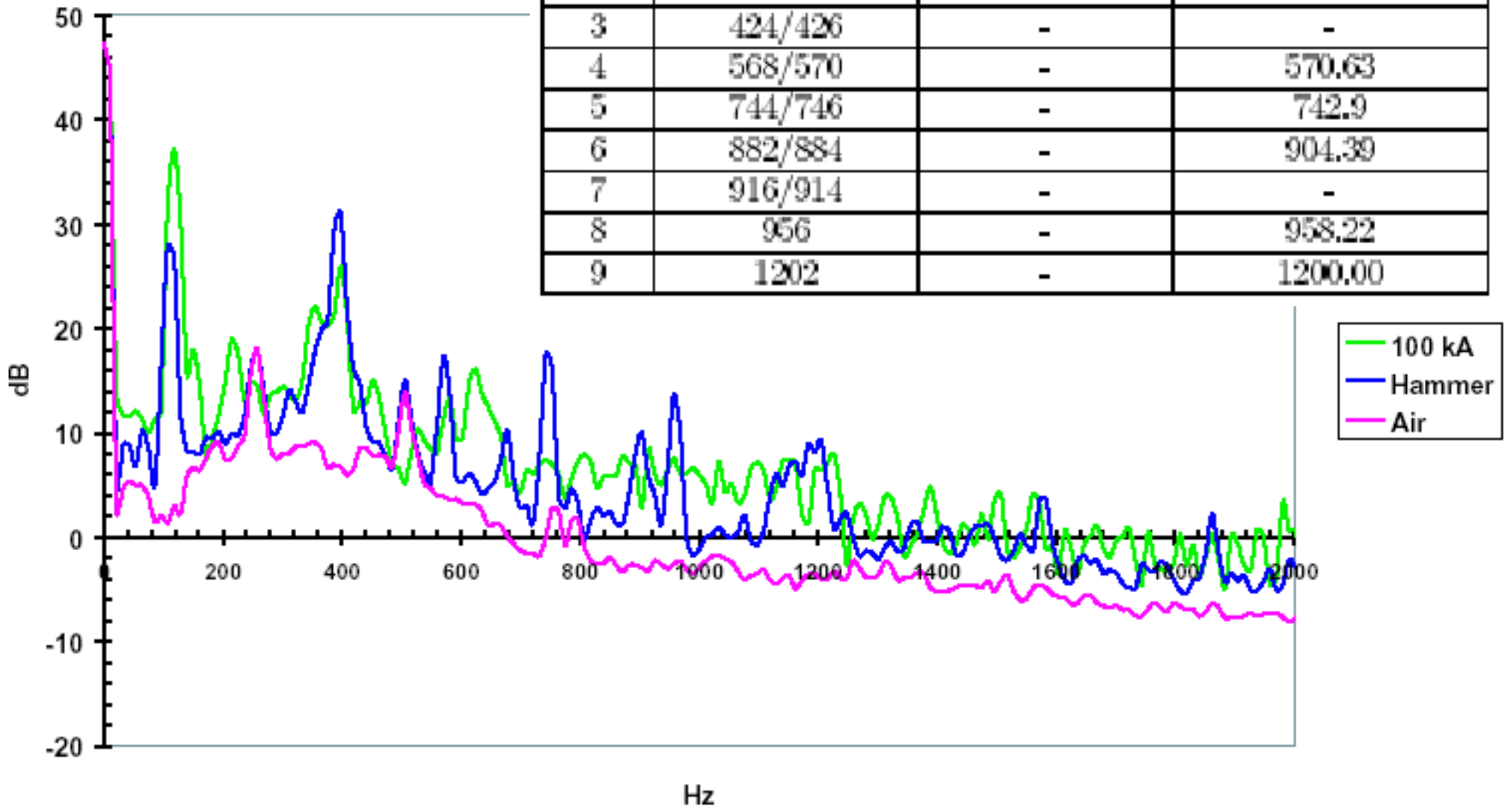
Acoustic frequency meas.

Horn eigenfrequencies from horn “sound”

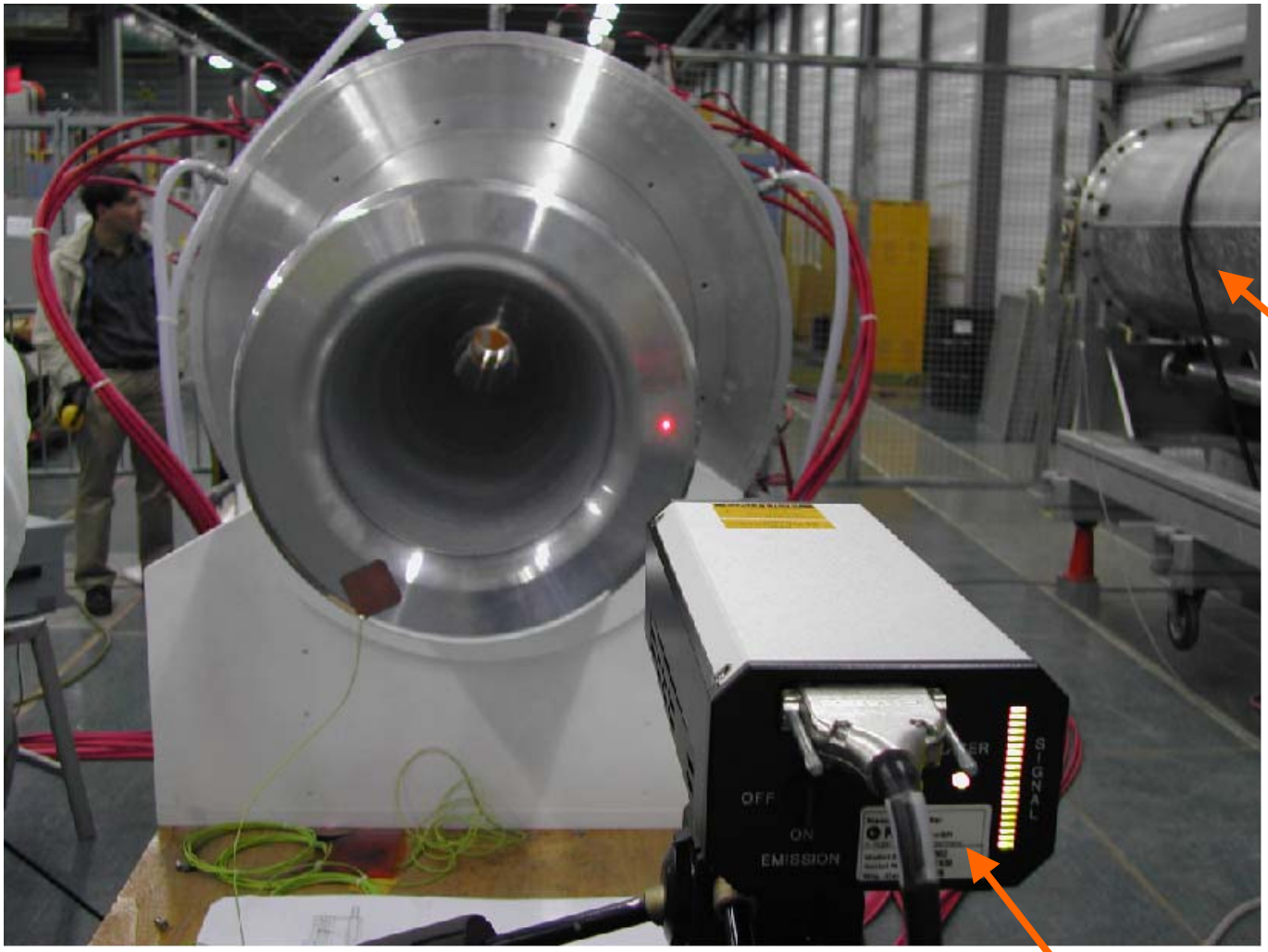


Method validation: CNGS

Mode	Meas. Ref. (Hz)	Calc. Ref. (Hz)	Meas. Microp. (Hz)
1	111	139	107.66
2	392	364	398.36
3	424/426	-	-
4	568/570	-	570.63
5	744/746	-	742.9
6	882/884	-	904.39
7	916/914	-	-
8	956	-	958.22
9	1202	-	1200.00



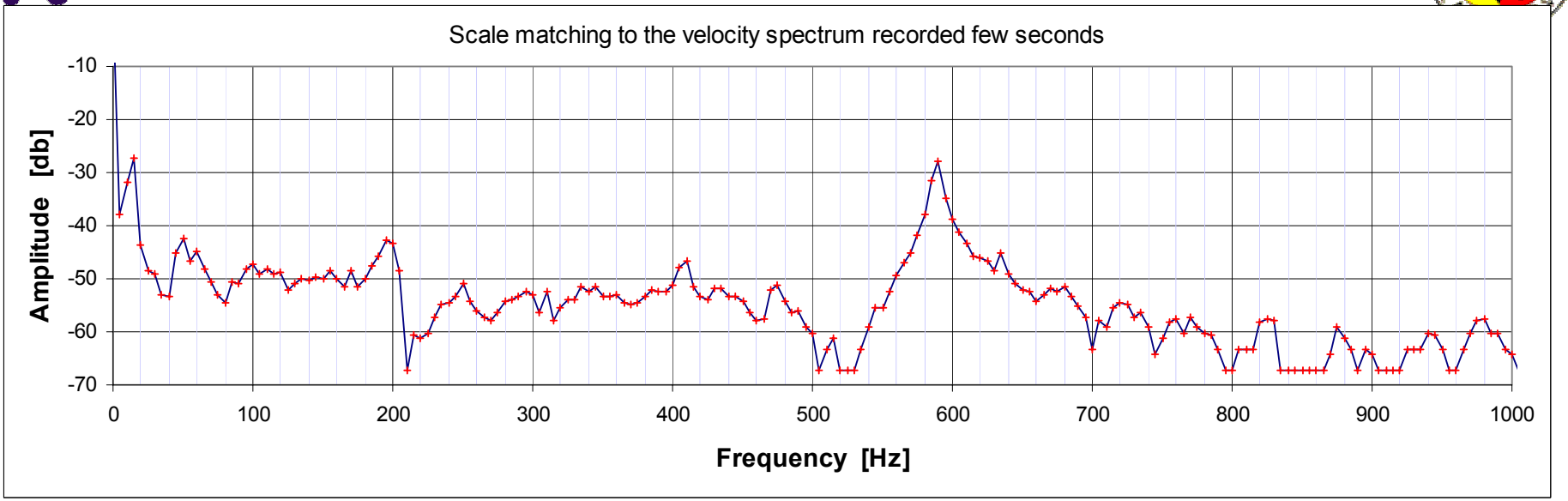
Laser Measurements (prel.)



CNGS horn

Laser vibrometer

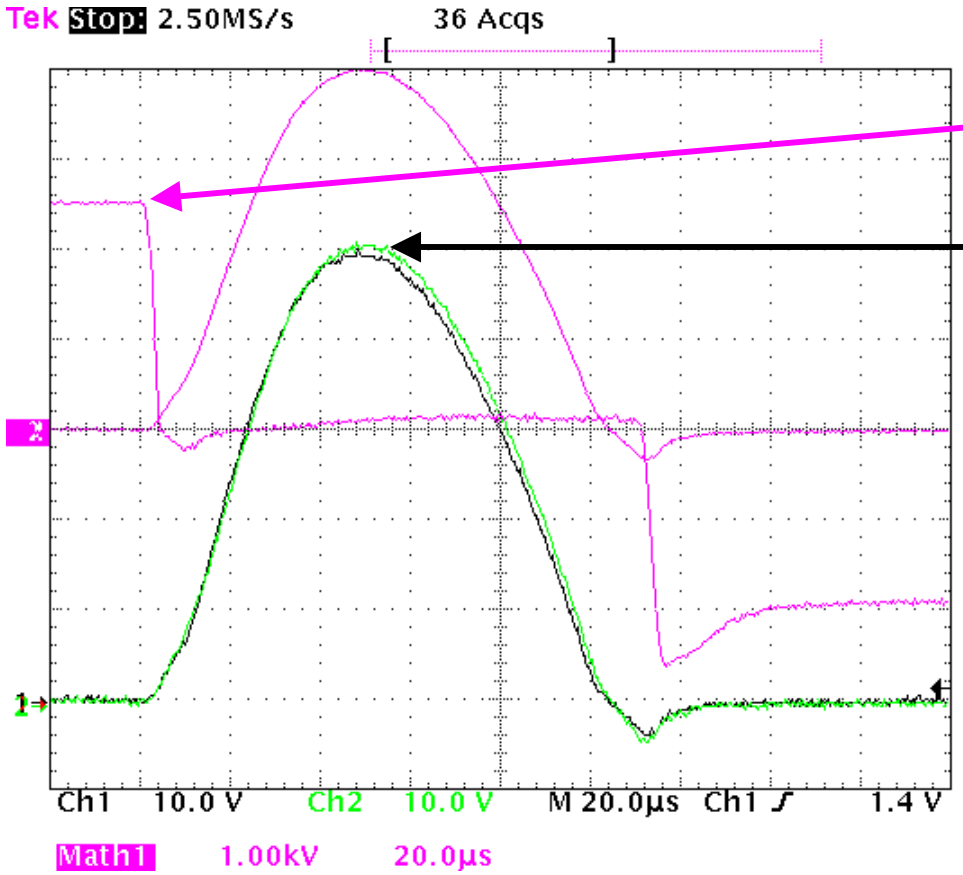
Preliminary vibration meas.



New campaigns of measurements with laser vibrometer and microphone with new power supply.

Any suggestions how to measure a surface that you cannot touch and with water flowing, the INNER conductor ?

Next step: 100 kA – 0.5 Hz



Voltage on horn/thyristor: 2.5 kV

Current first/second unit 50 kA

This is the Limit for the existing equipment:

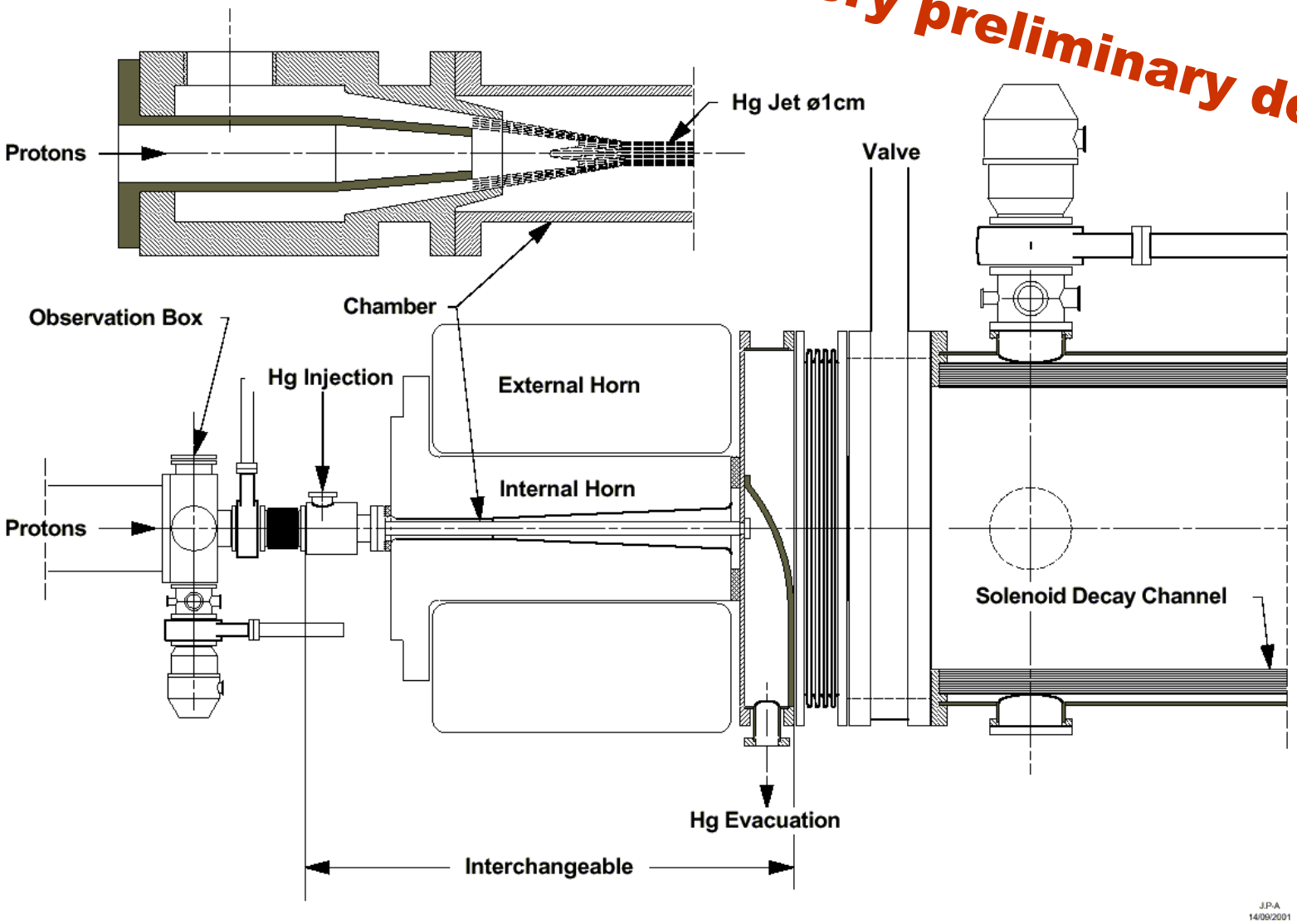
– Max voltage on thyristor

– Max rep rate for resistors

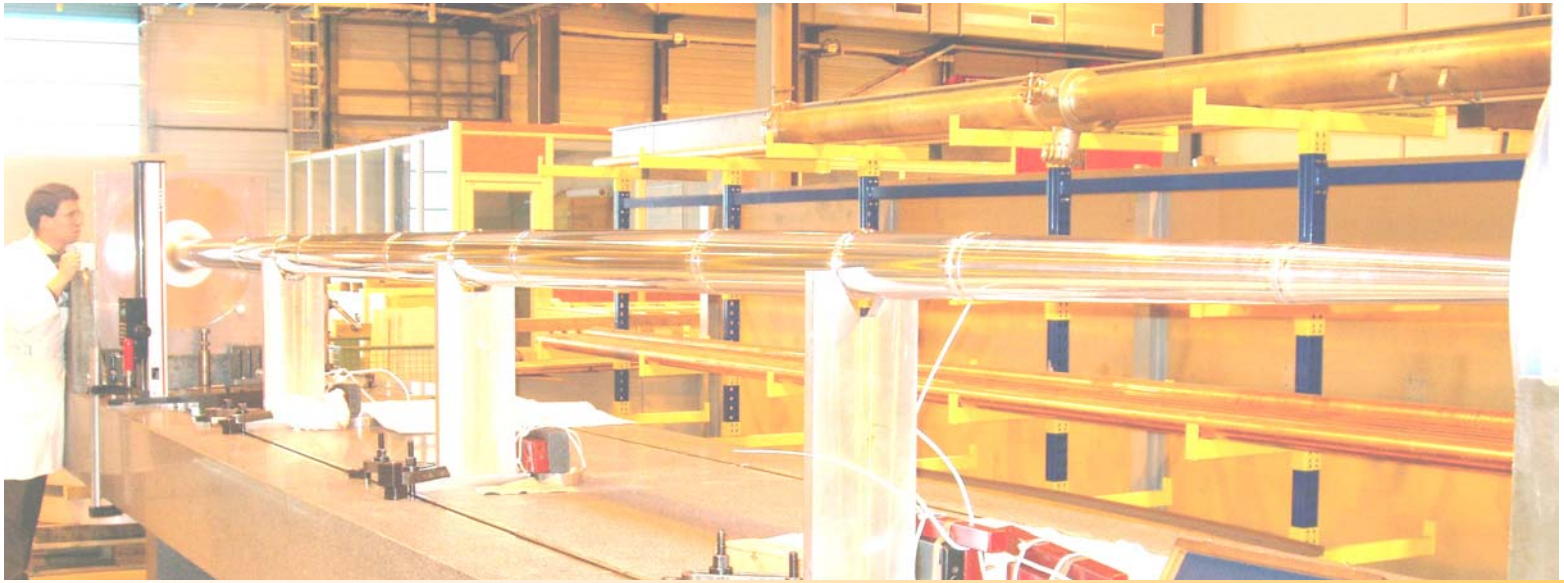
Ch1: Current of unit one measured with current transformer. (10kA/div)
Ch2: Current of unit two measured with current transformer. (10kA/div)
M1: Voltage across thyristor. (1kV/div)
M2: Sum of both currents. (25kA/div)

Target and Horn integration

Very preliminary design



LAL Horn R&D

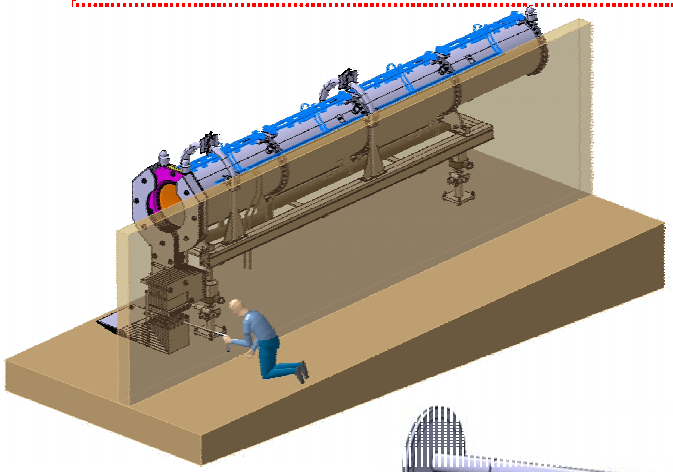


- Physicists: J.E Campagne, A. Cazes (Ph. D),
- Engineers: G. Macé, S. Wallon & J. Bonis, M. Omesh,…
- Previous experience: the CNGS Horn/Reflector

Other IN2P3 members:
J. Dumarchez (LPNHE), D. Autiero (IPNL), S.Katsanevas(IN2P3-adm)

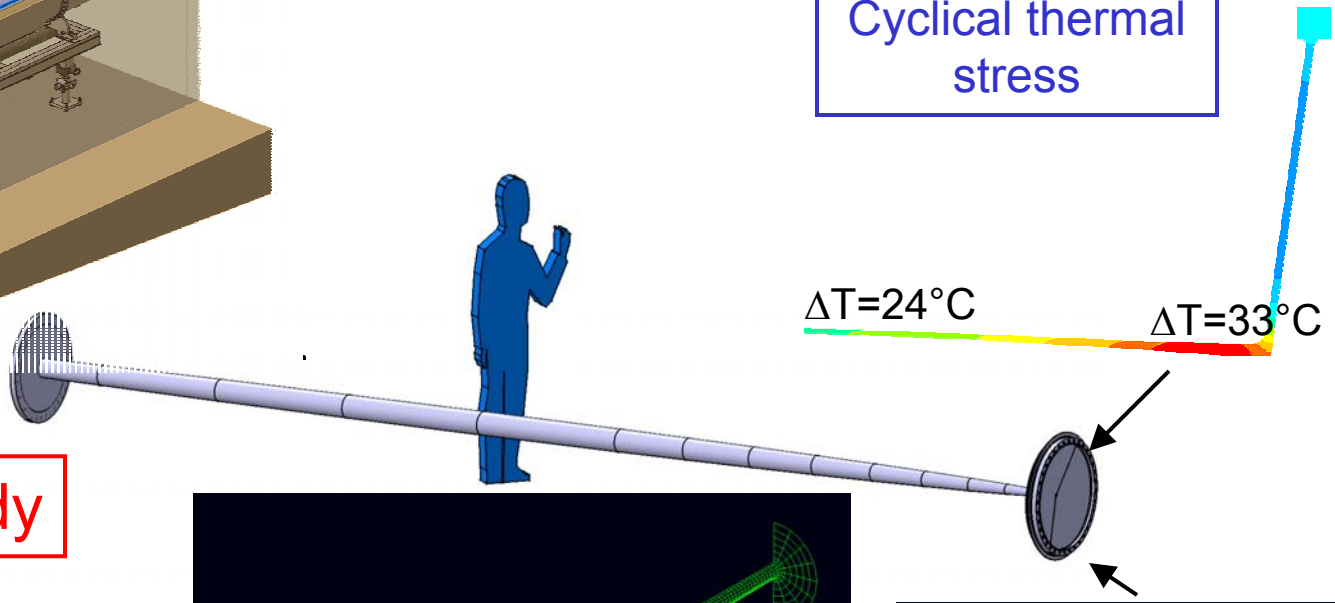
Competence examples for CNGS

Installation/Replacement



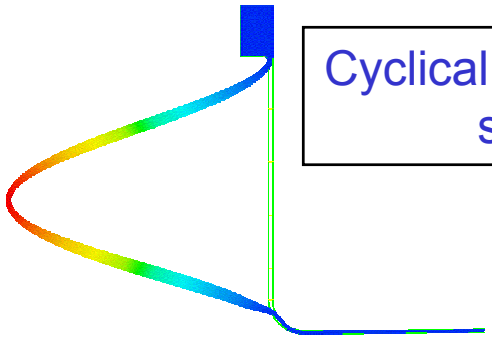
Thermal study

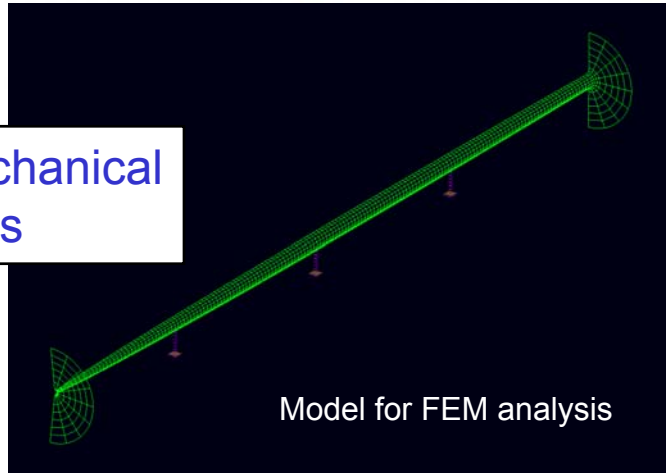
Cyclical thermal stress

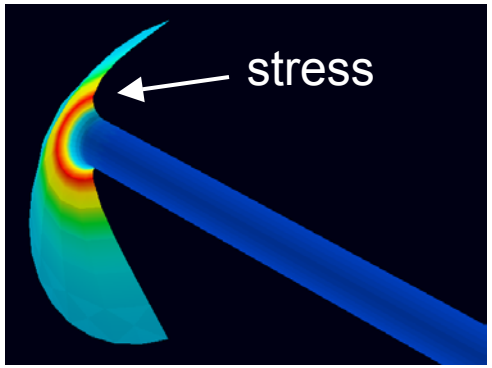


Dynamic study

Cyclical mechanical stress







Conclusions

- Results of last year for horn+power supply
  - Construction and test at 30 kA – 1 Hz – 100 μs
  - First evaluation of horn eigenfrequencies
- Horn CERN program for this year:
  - Measurement with new power supply
  - “Working point” with CNGS power supply
- New friends in the game, LAL draft program:
  - Secondary particles collection simulation
  - Electrical power supply studies
  - Mechanical Simulation
  - Thermal Simulation
  - Ready to be the manager of the project