Horn status review

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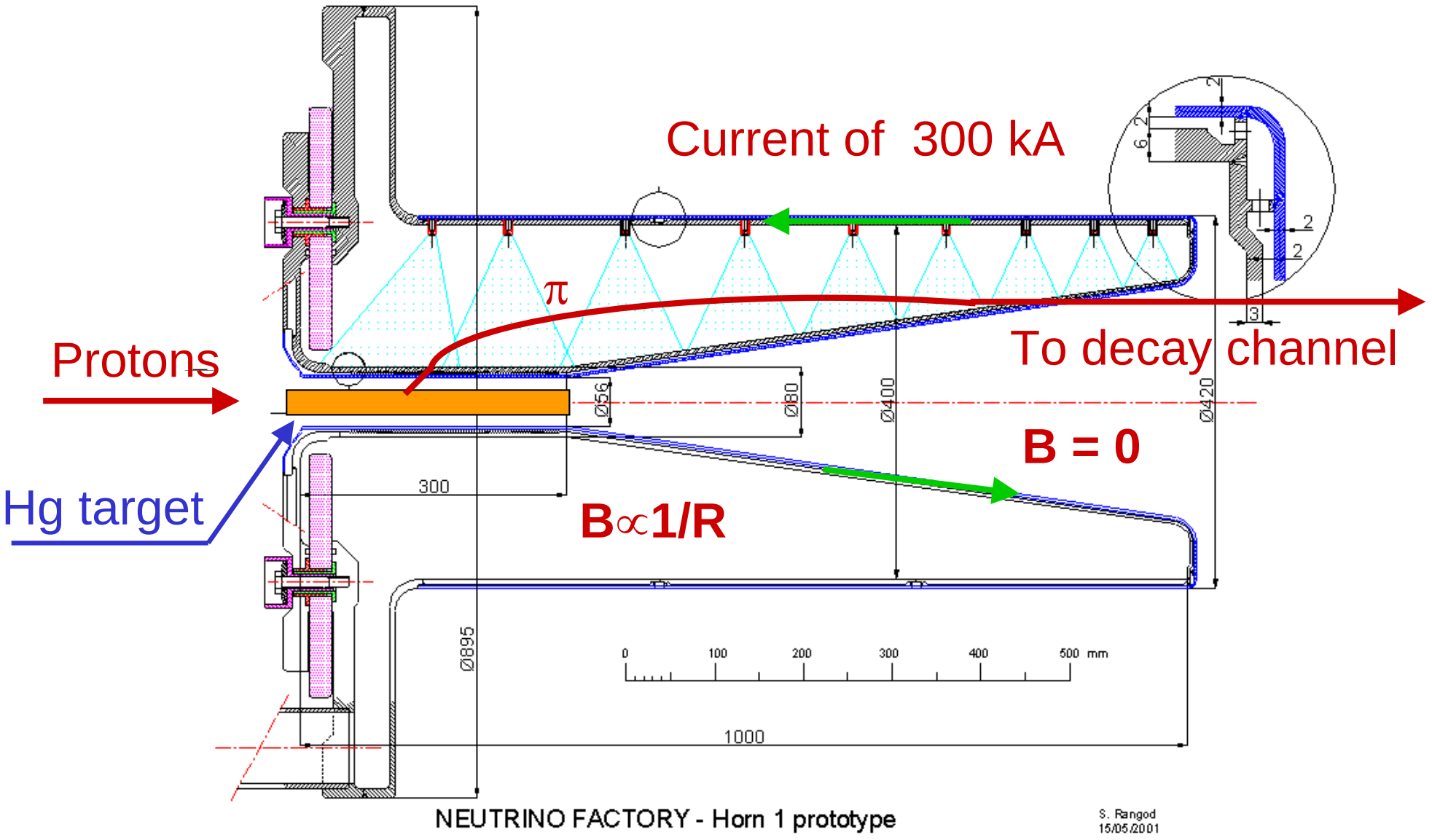
For the CERN Horn working group

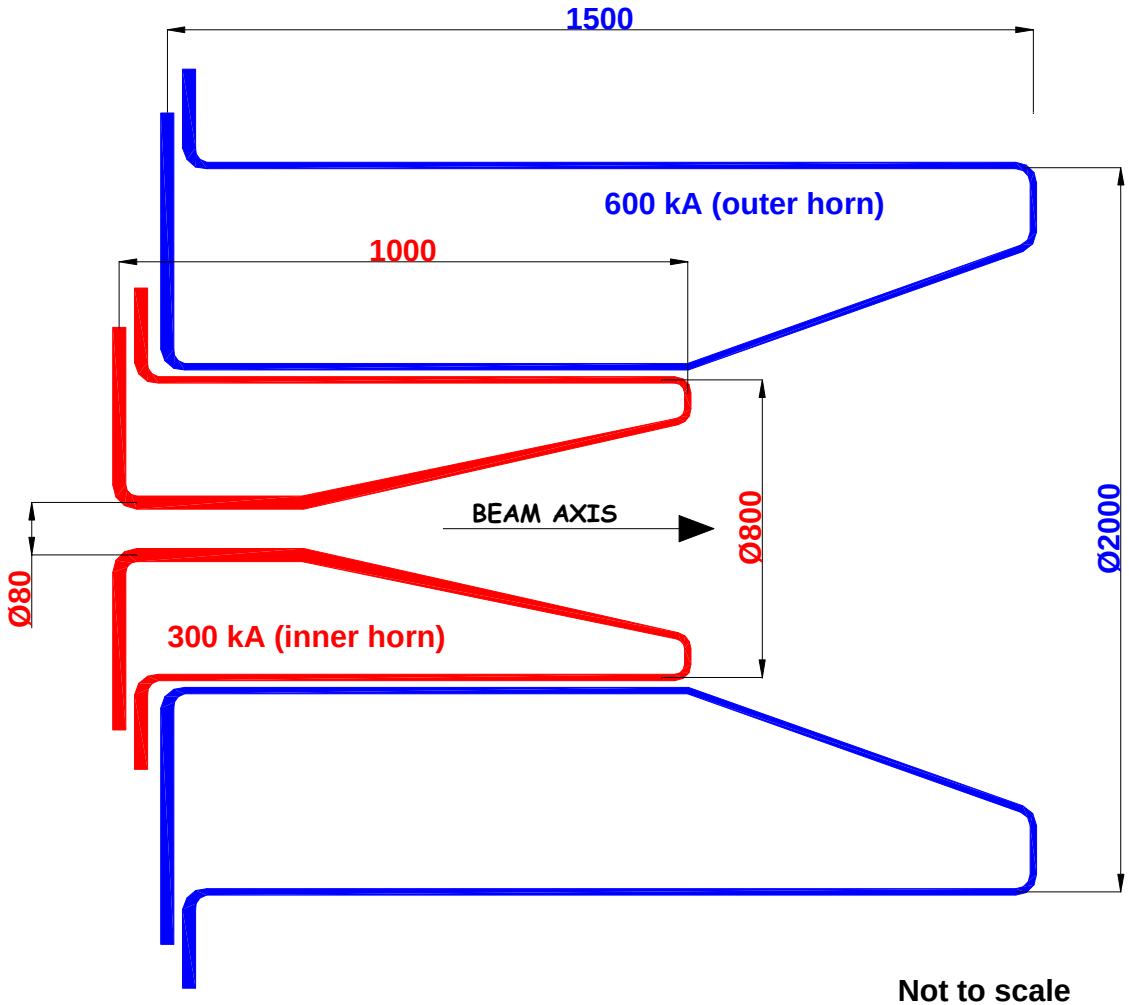
Work in progress

- Horn beam dynamics study
- Horn building and testing
- Horn life-time determination
- Integration between target and horn

Horn focusing system

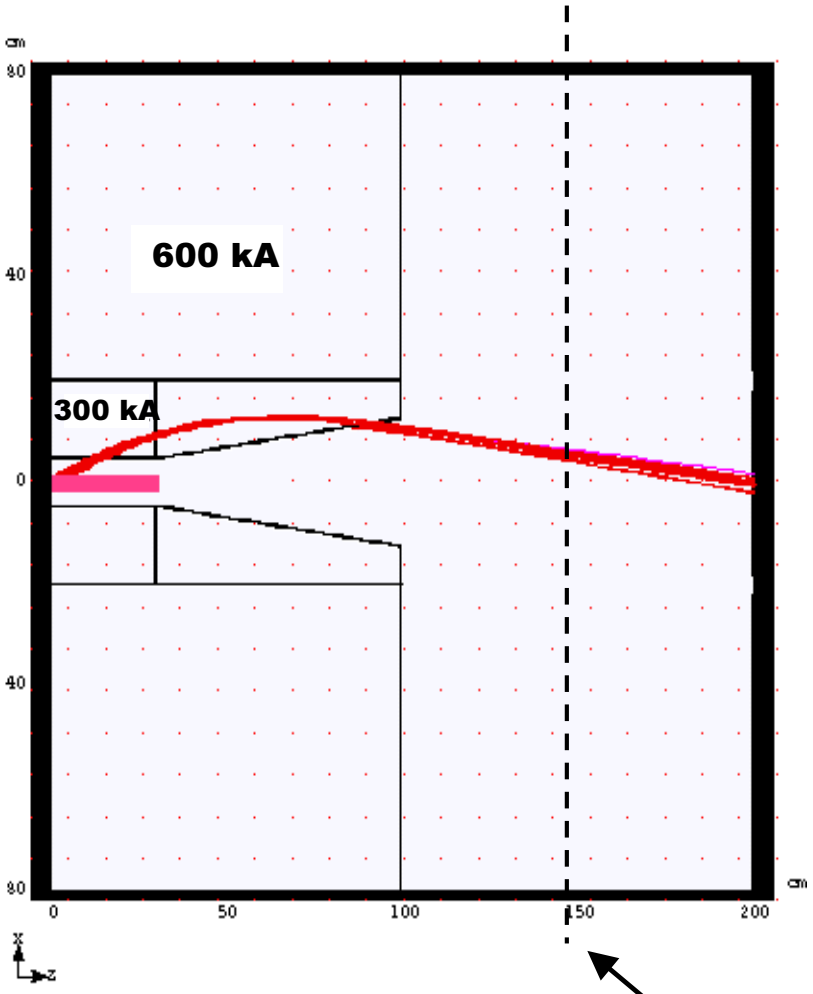


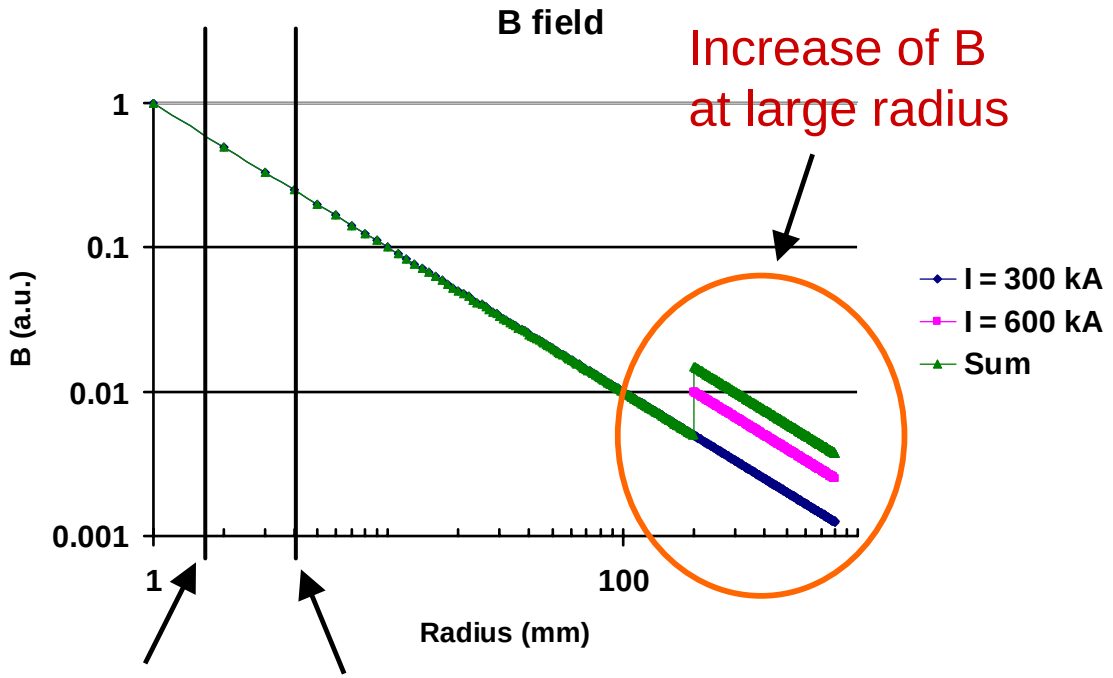
Double horn concept



Not to scale

Double Horn





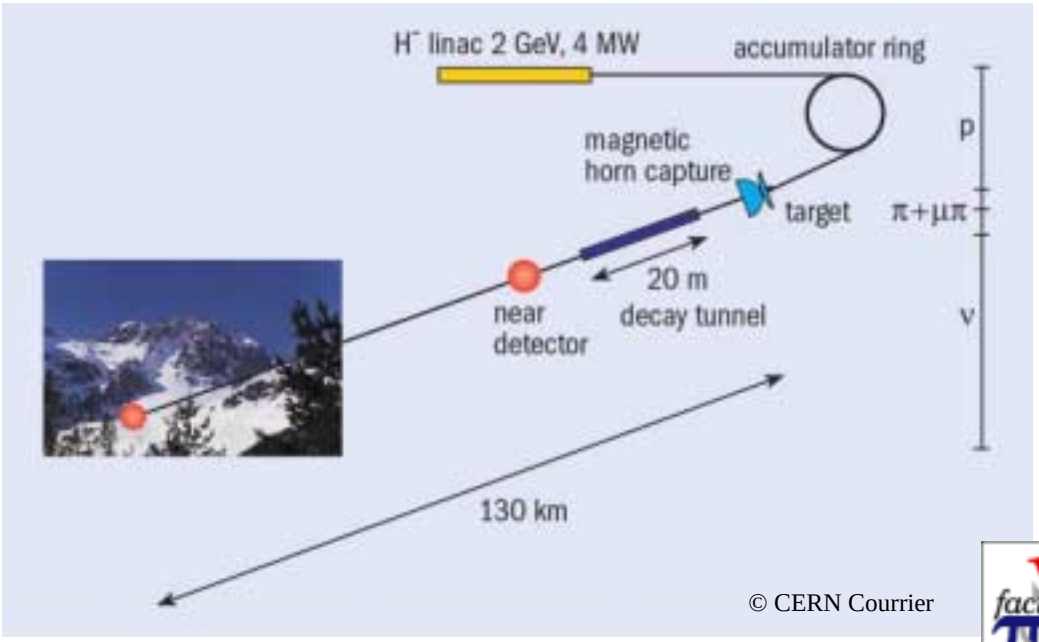
Increase of B
at large radius

Old horn neck
R = 1.6 cm

New horn neck
R = 4 cm
B field is 2.5 times smaller !

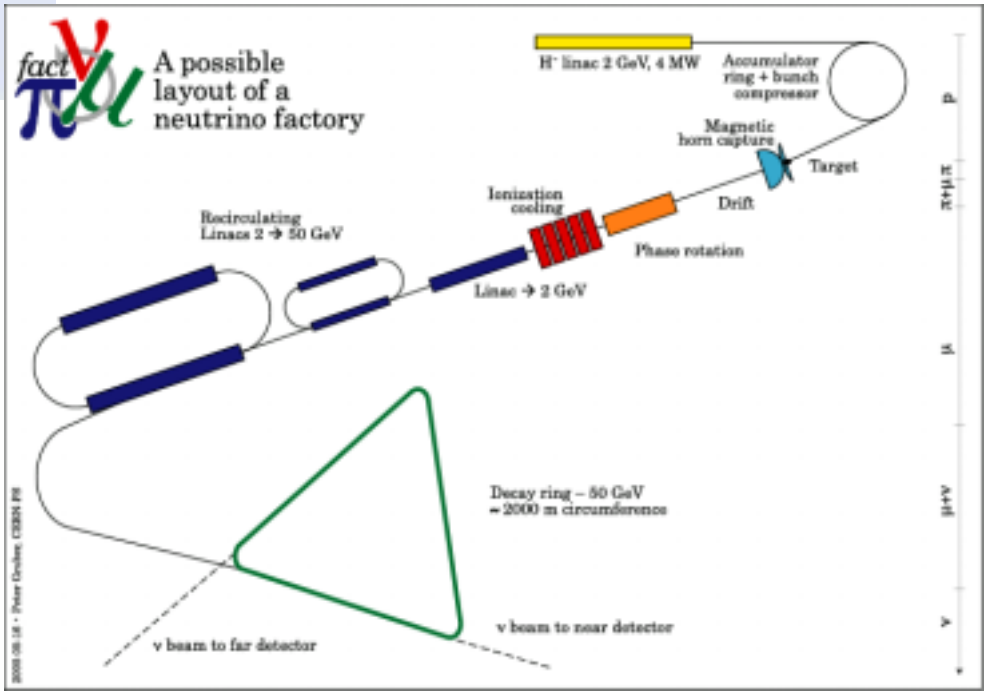
First decay
channel solenoid

Nufact + SuperBeam



Same Inner horn for SuperBeam & Nufact

Different optimisation of the outer horn for the two cases



Beam dynamics study

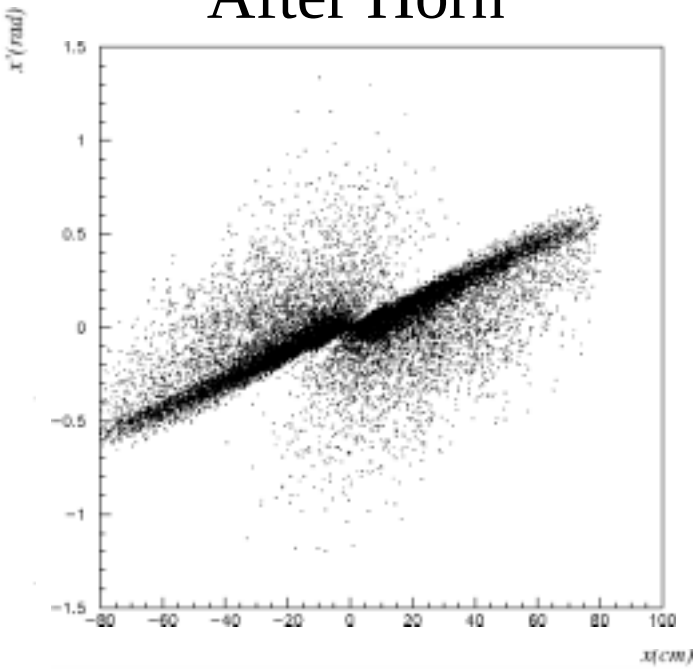
Transverse phase space:

•Simulation and tracking by MARS

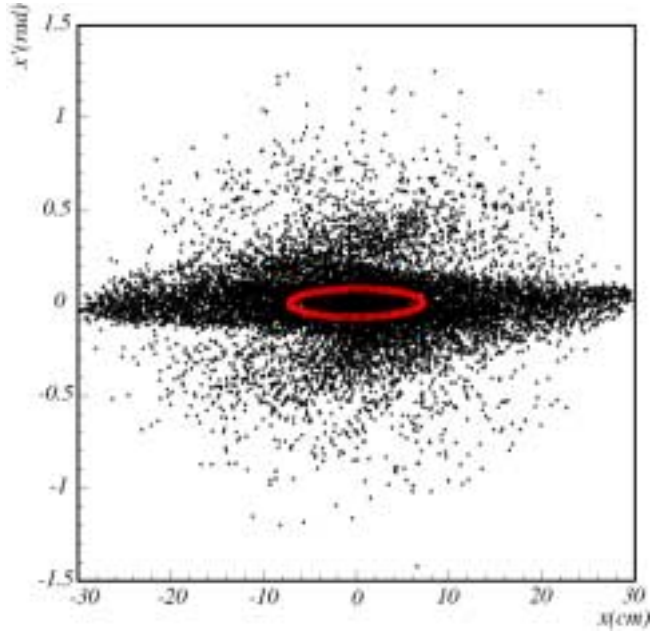
Pion Yield: 0.0013 π/POT with CUT ε_n =1.5 cm rad

0.3 GeV < Et <0.6 GeV

After Horn



In 1.8 T solenoid



Work in progress

- Optimization of the outer horn shape
- “Clever” injection in the solenoid
  - Matching to be optimized
- Waiting for HARP results

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 and thermal stresses measurements
  - Test of numerical results for vibration
  - Test of cooling system

Delay due to budget restriction

- Test Two: 300 kA and 1 Hz
- Last test: 300 kA and 50 Hz

Unknown schedule

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

Main Parameters

•Radius of the waist	40 mm
•Peak current	300 kA
•Repetition rate	50 Hz
•Pulse length	93 μs
•Voltage on the horn	4200 V
•rms current in the horn	14.5 kA
•Power dissipation (by current)	39 kW
•Skin depth	1.25 mm

•Total length	1030 mm
•Outer diameter	420 mm
•Max diameter (electrical connection flange)	895 mm
•Free waist aperture	56 mm
•Waist outer diameter	80 mm
•Average waist wall thickness	6 mm
•Double skin thickness	2 mm

Very good news

Horn conductor

Inner conductor

Horn neck

Discharger Unit

What we are doing

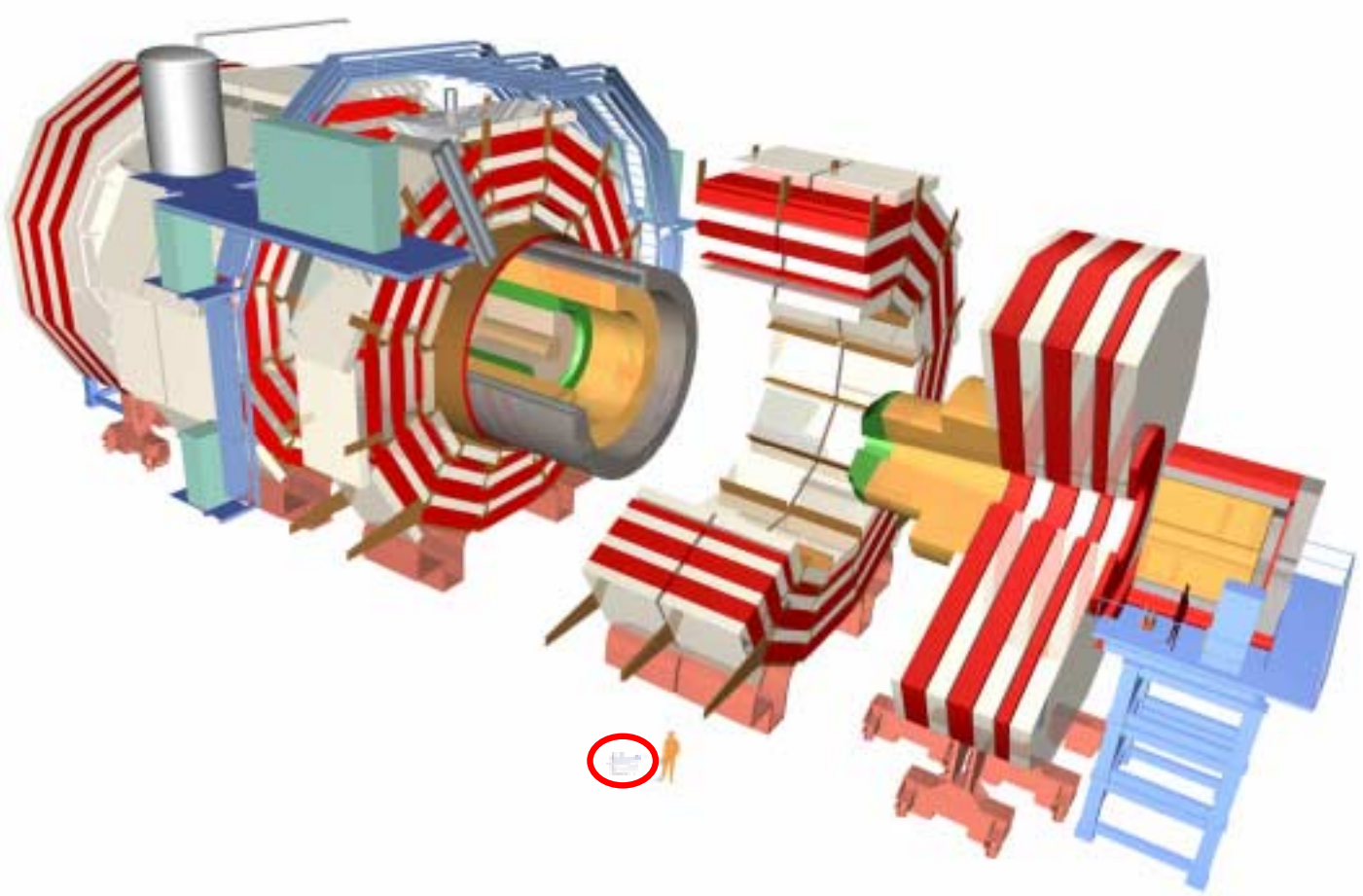
- Finishing the power supply for Test One
  - Cabling finished one week ago, tests this week
  - Test One as soon as possible (summer)

- Stress calculation via a numerical model

- Test two: Looking around for a 200 – 300 kA power supply plus discharger

P.S.: *If you have one spare power supply we are happy to come and visit you with our horn.*

CMS Magnets Power supply



- Total RMS current for CMS magnets: 19 kA DC
- Ramping in 5h
- Horn RMS current: 14.5 kA

Horns available from the shelf

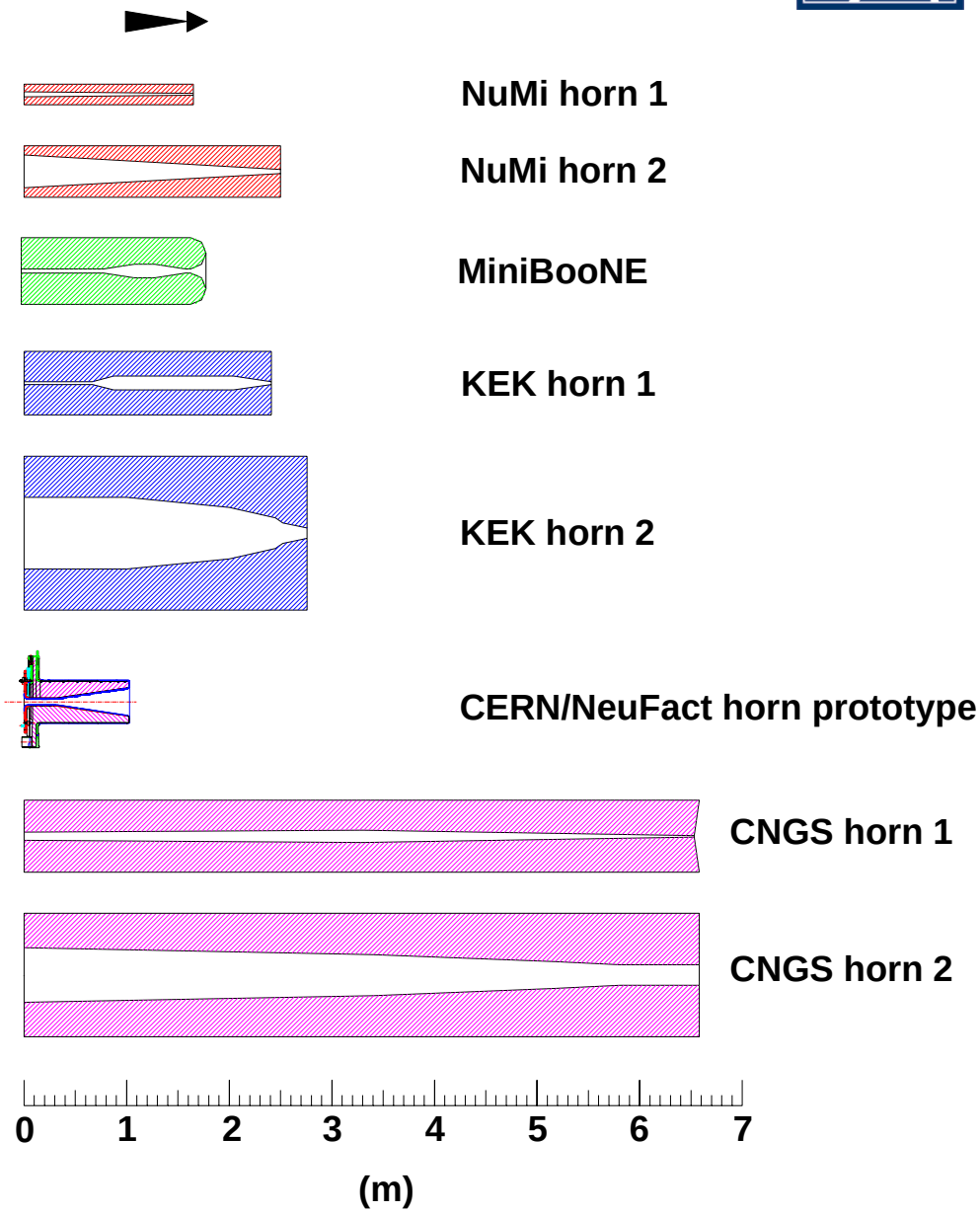
Numi: 200 kA, 0.5 Hz, 6M pulses
1 year

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

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

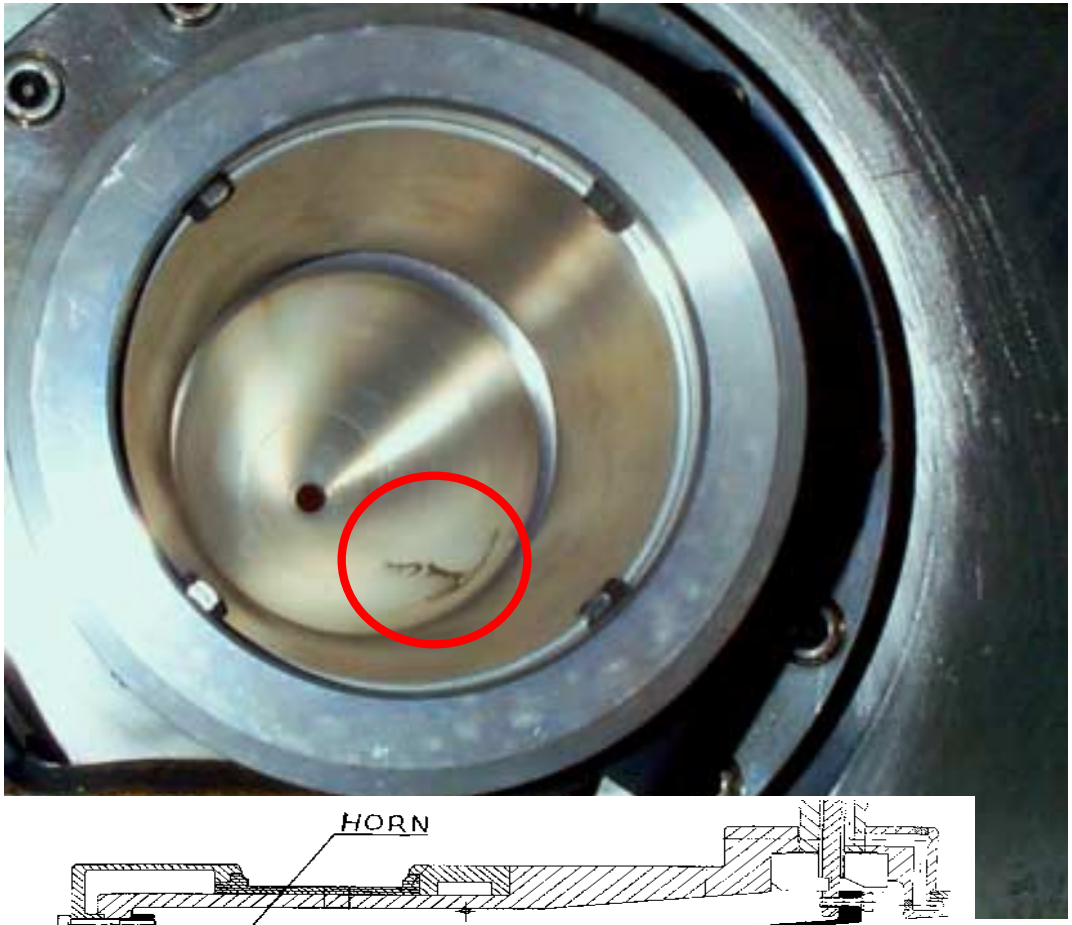
Nufact: 300 kA, 50 Hz, 200 M pulses
6 weeks

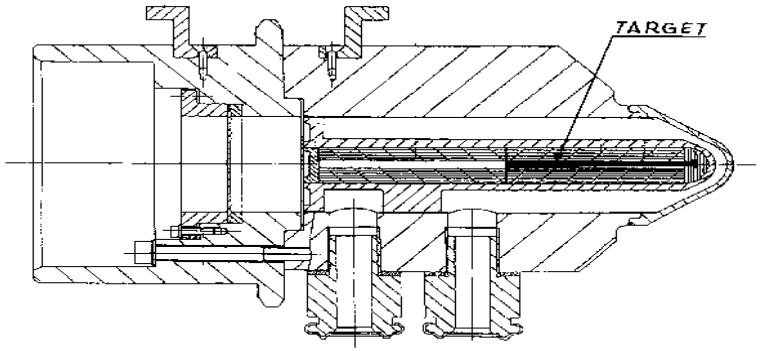
CNGS: 150 kA, 2 pulse/6s, 42 M pulses
4 years

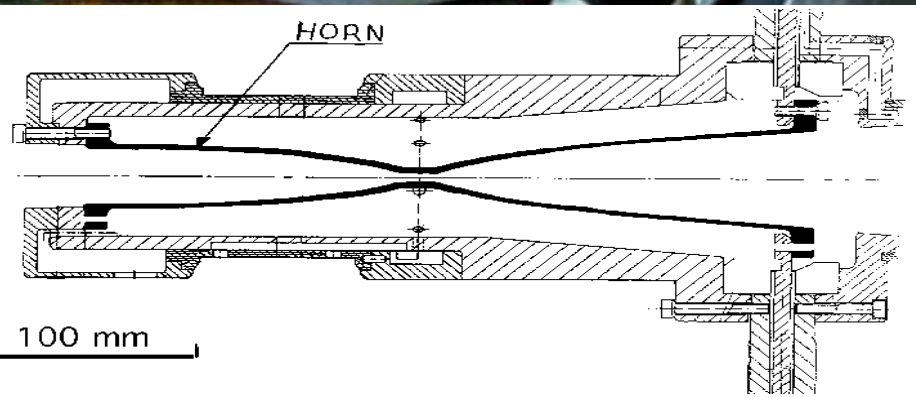


Horn failures ...When? Why?

AD horn (see Microcosm)
300 kA, 0.5 Hz, 1M pulses





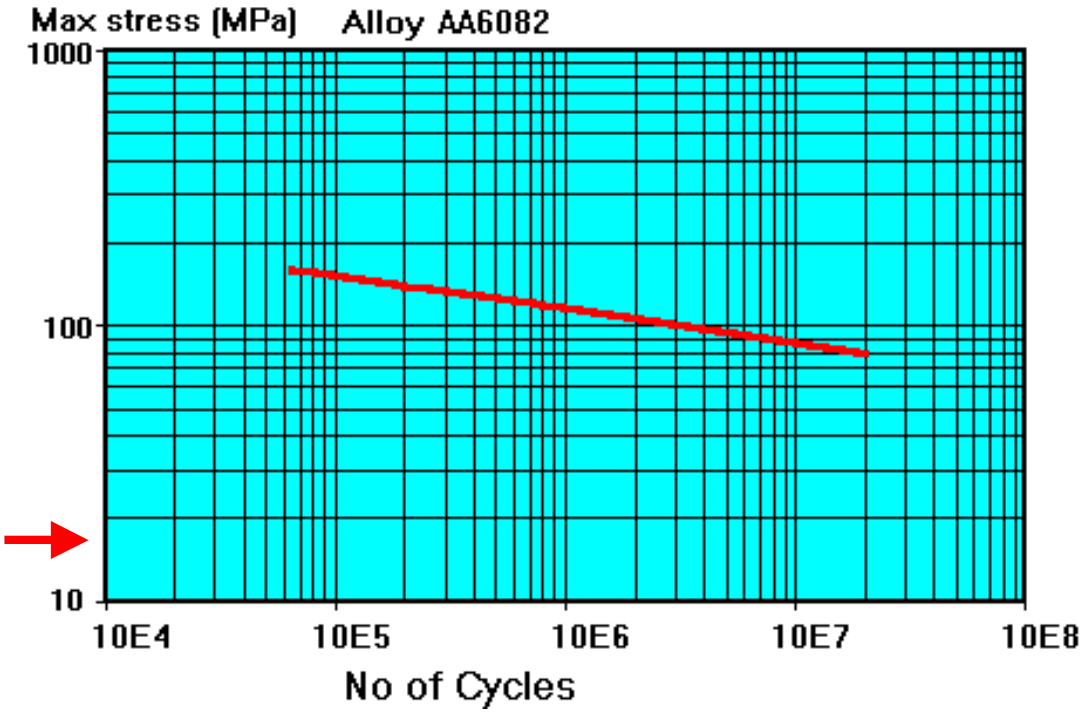


Reasons for horn failure

- Fatigue limit
  - stress due to electro-magnetic forces
  - Max pressure: ≈14 MPa (140 kg/cm^2)
  - Operation always in material elastic regime
- Thermal stresses
  - joule losses: 39 kW
  - particle energy deposition (still to be evaluated)
- Neutron irradiation
  - Swelling
  - Mechanical properties variation

Material choices

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



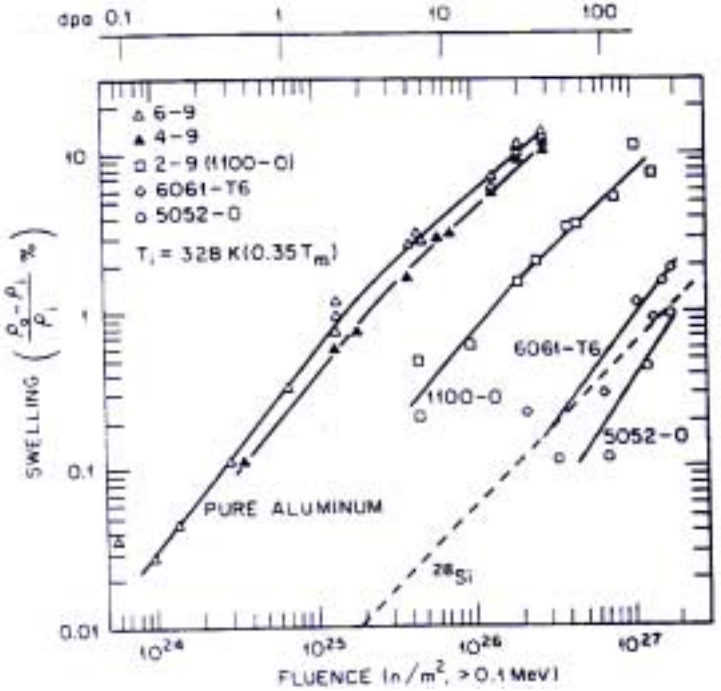
Max. allowed stress →

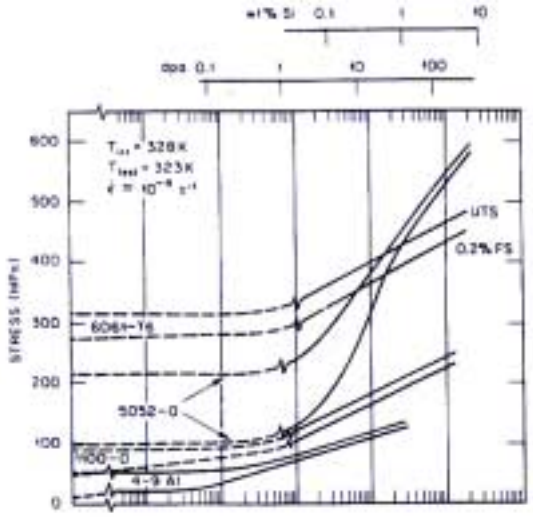
Not compatible with Mercury

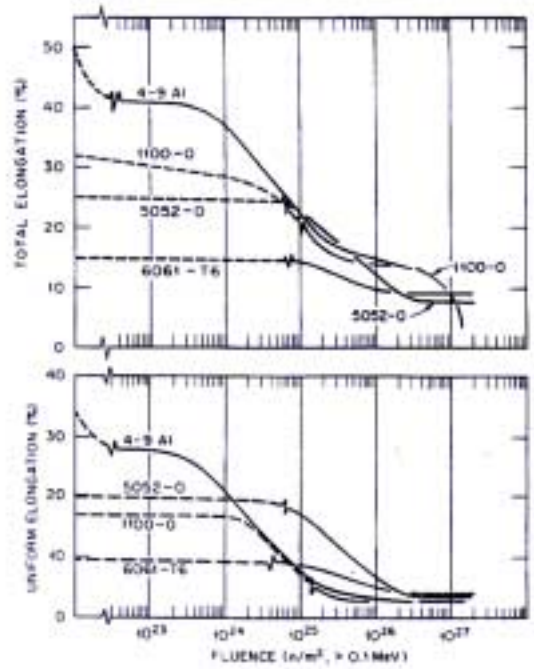
Ductility variation and swelling

Neutron flux from Hg
typical of a
Neutron Spallation Source
(ESS, SNS)

Approx 10^{26} n/m^2





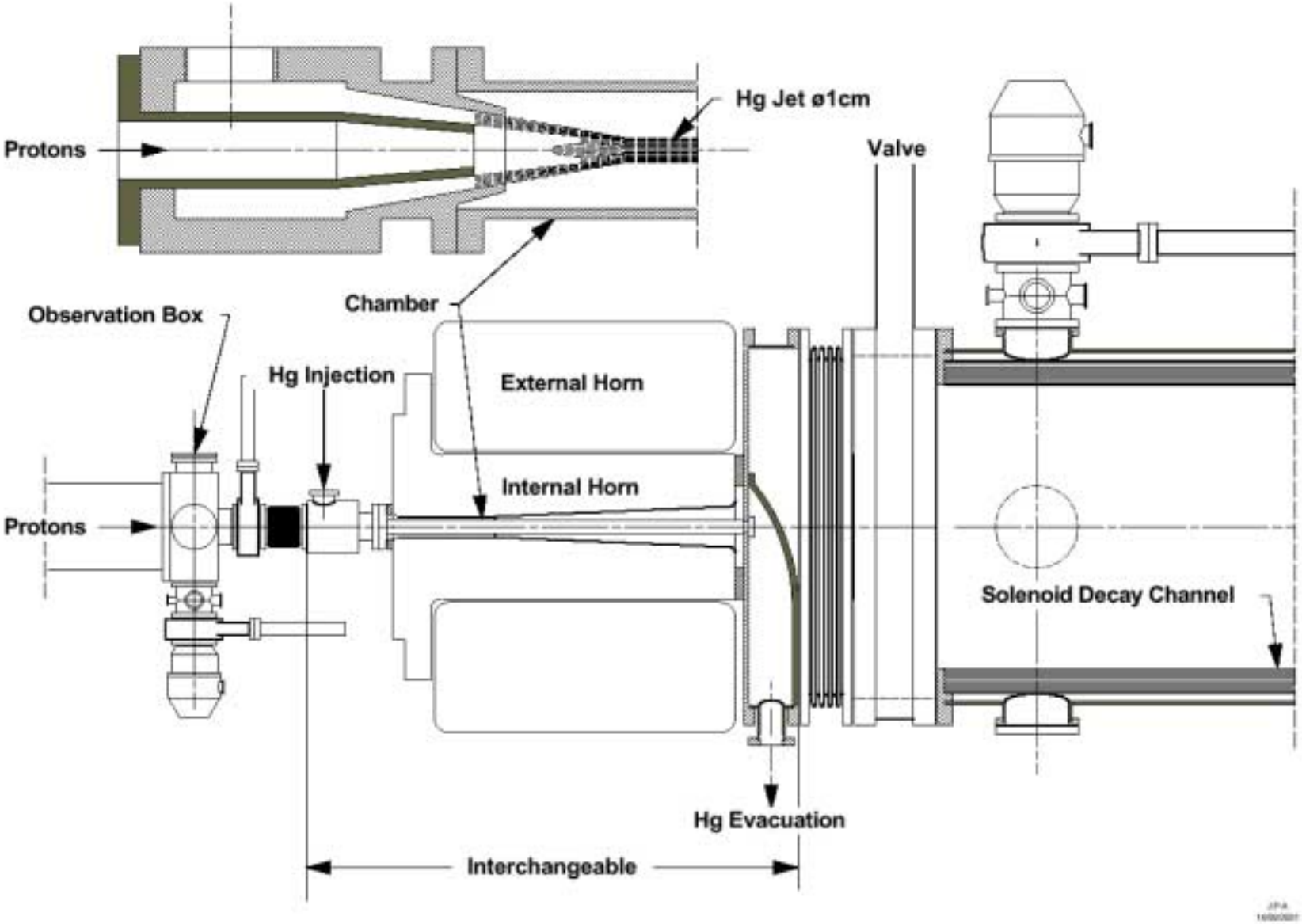


Material development

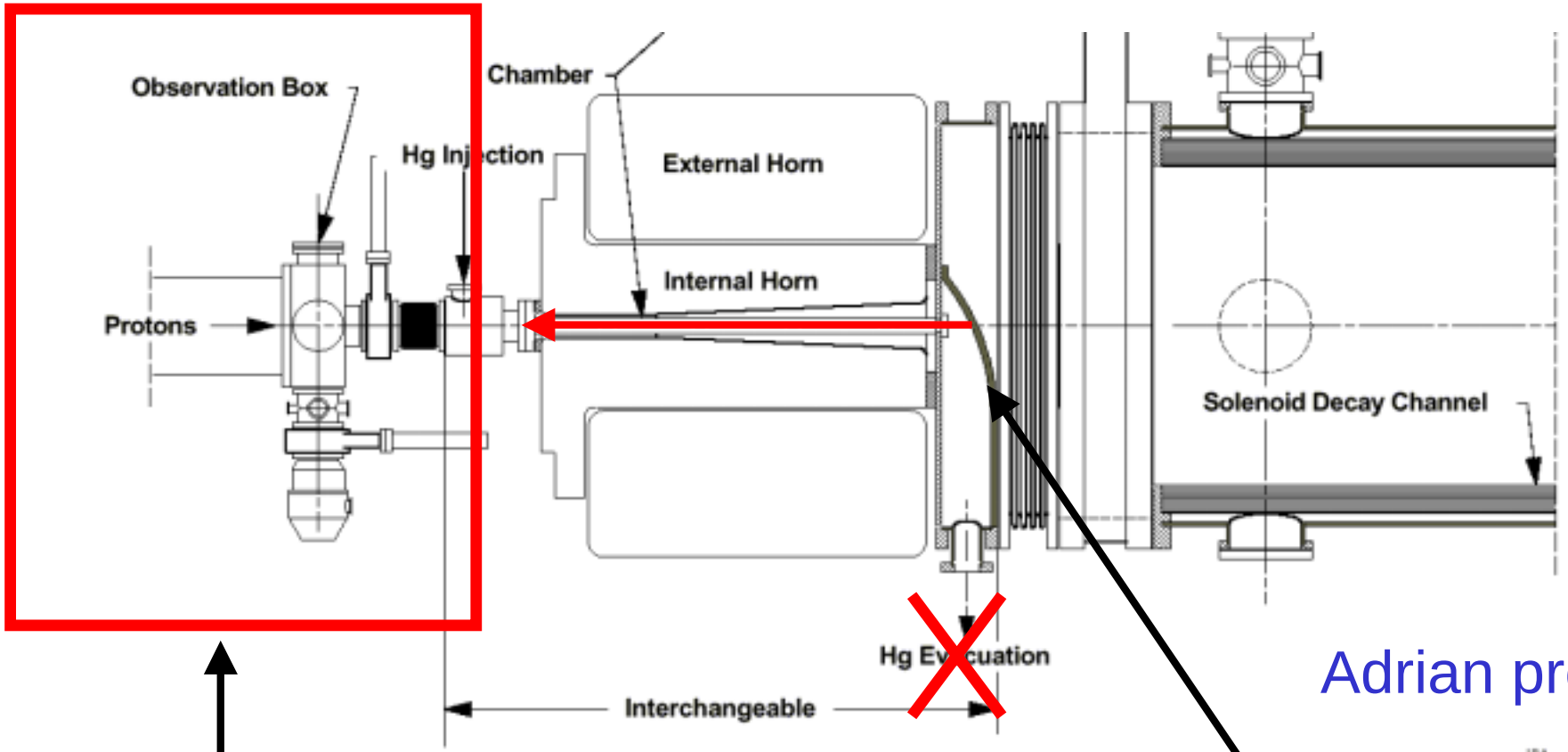
- Mechanical tests of Aluminum-Alloys before and after irradiation
  - Variation of the mechanical parameters
  - CERN is not equipped for such measurements
    - Isolde as irradiation facility but somewhere else for tests

- Test for define material as a wall between Aluminum and Hg
  - Highly “active” environment:
    - Mercury splashing around (See Jacques talk)
    - Minimum thickness but high mechanical resistance (Ti-Alloys? Stainless Steel? See ESS, SNS target)

Target and Horn integration



Target and Horn integration



Adrian proposal

Chamber for Mercury Evacuation

New Nozzle position

Life-Time of Nozzle?

Conclusions

- Inner horn finished and ready for test
- Horn mechanical test:
  - 30 kA, 1 Hz, 100 μs during the summer
  - Power supply tests in progress
- Material study at first stage
- New nice idea how to put horn and mercury together