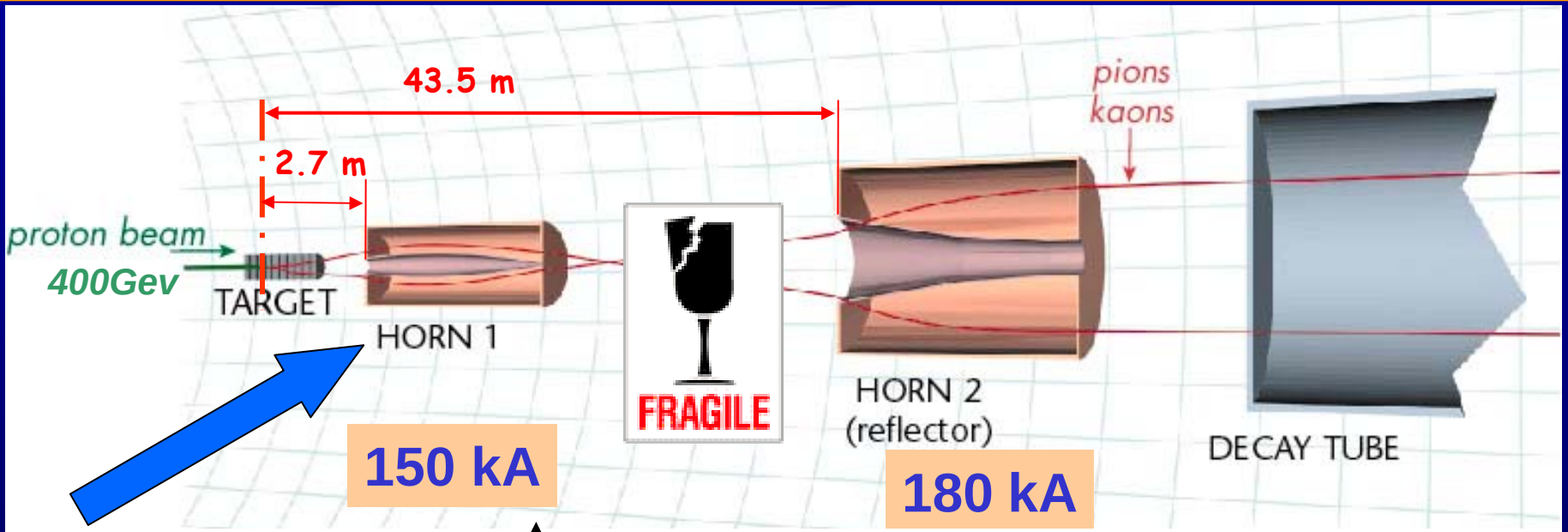
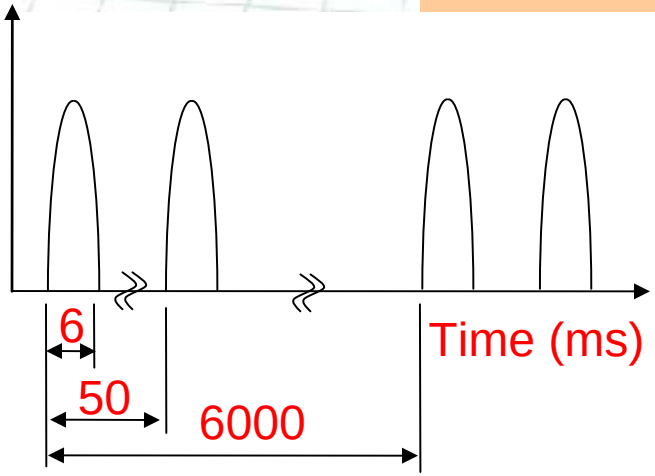
CNGS Horns

- CNGS Horns
  - Introduction
  - Design
  - « Remote »
  - Timing tests
- Horn exchange
  - Striplines
  - Procedure
  - Exchange Exercise

Introduction



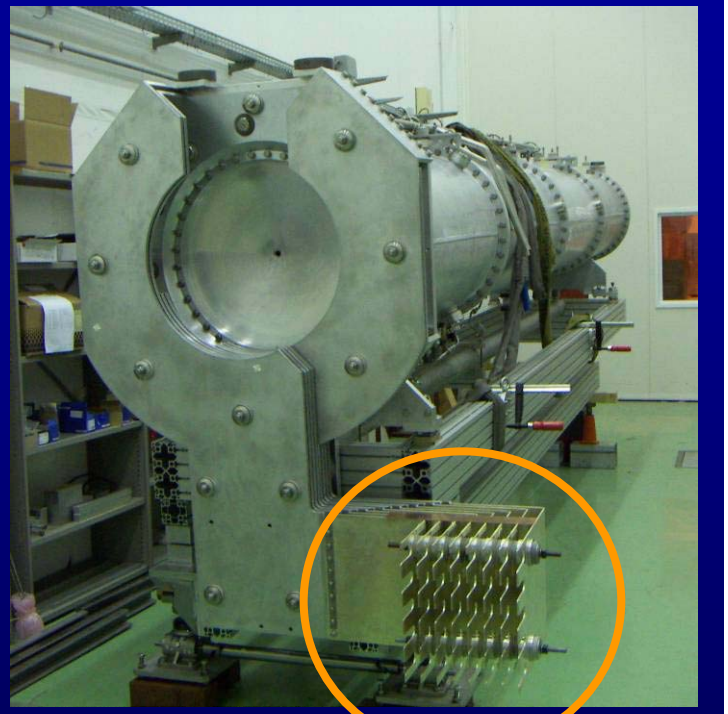
Electrical
Pulse Timing



Beam Extraction
2.4×10^{13} p.p.p.

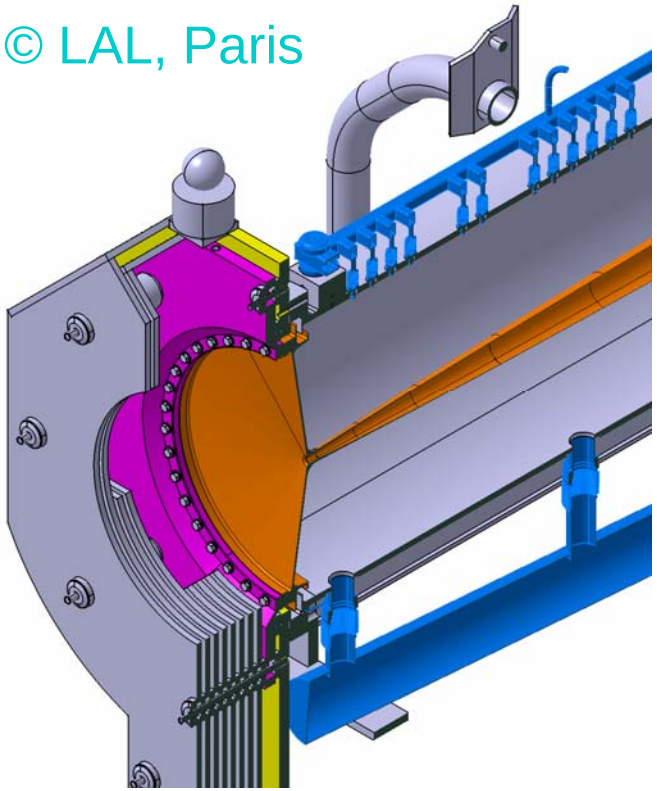
Flat top
0.01ms

Introduction

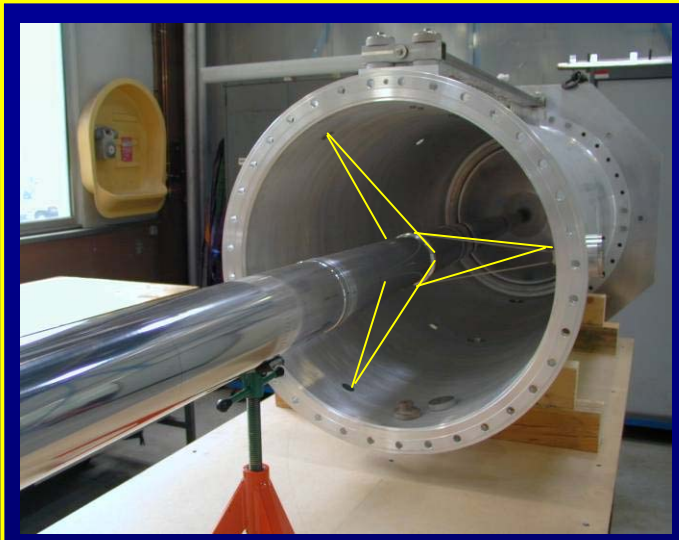


- Weight ~1.2t (Reflector: 1.8t)
- 7 meters long, inner & outer conductor
- Upper frame (exchange) & lower frame (align)
- Electric (manual) & water connections (automatic) at downstream end

Inner conductor



- Thickness1.8 mm
- Aluminum grade 6082
- 9 machined sections
- Electron beam welds



Support Points (3)

3x3 grooves in inner conductor

↓

S.Steel cables

↓

Insulator

↓

Outer conductor

Heat load horn:
15 kW (Joule)
+ 6 kW (beam)

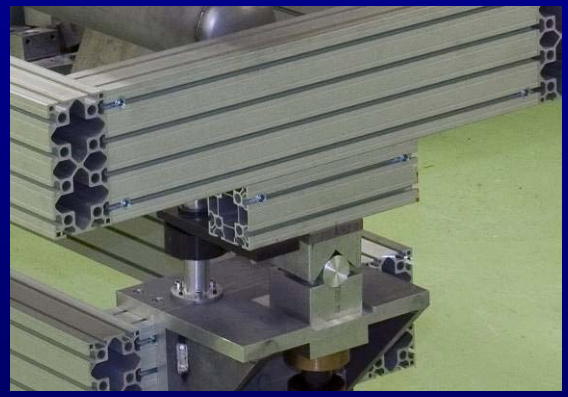
Cooling through top sprayers, 1.2 bar

Magnetic field: Max.1.5 Tesla

Designed for remote handling

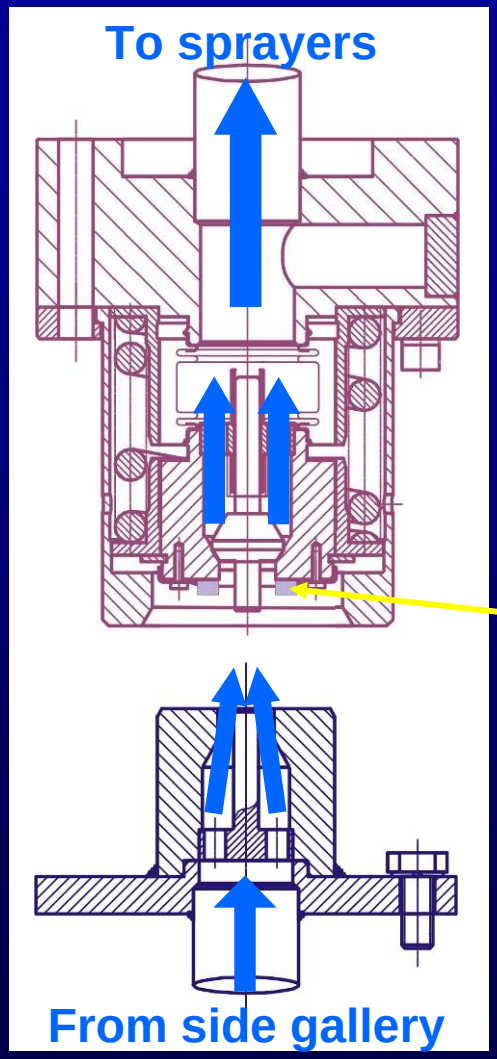
Pre-guiding elements, cameras, remotely steered crane, cameras, plug-in water connection…

Pre-guiding upper frame vs. lower frame



Crane with coordinates

Plug-in Water Connection

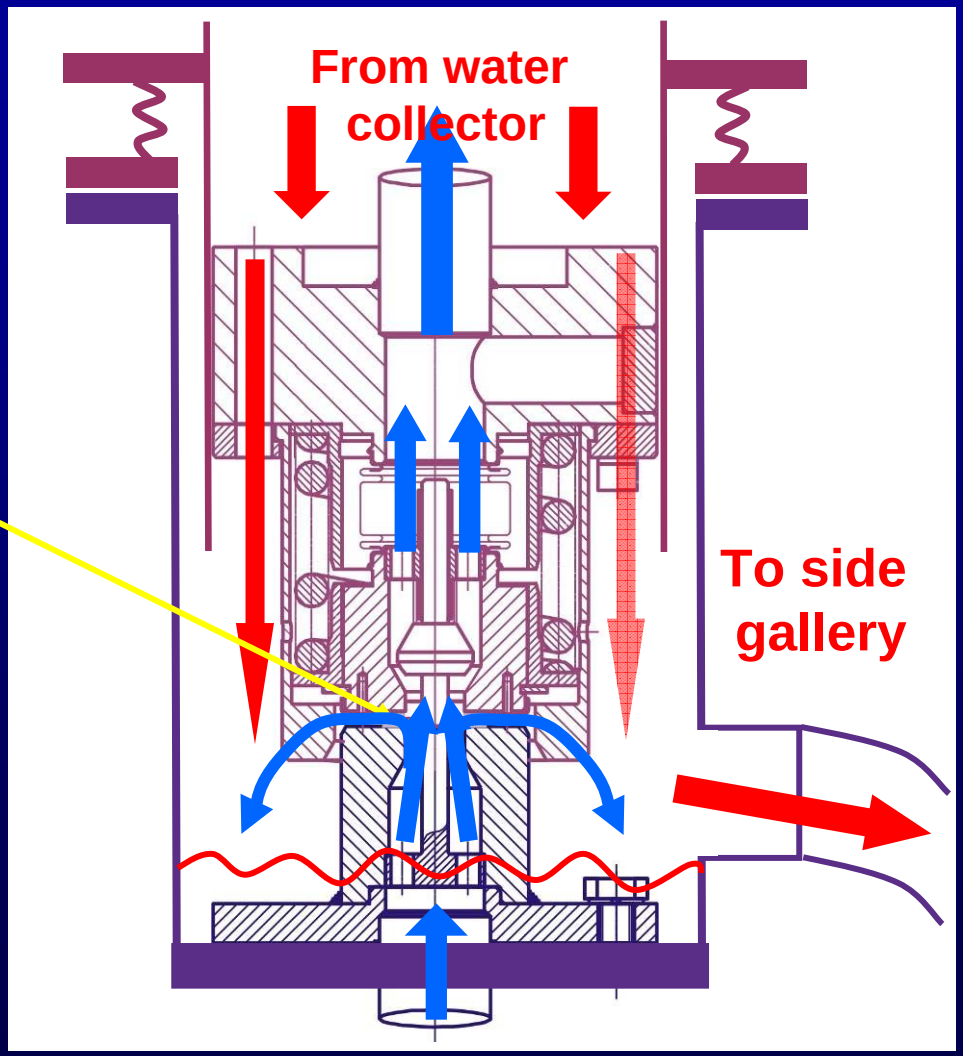


Fixed to horn

Leak

Seal

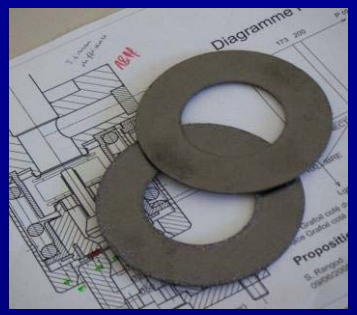
Fixed to lower frame

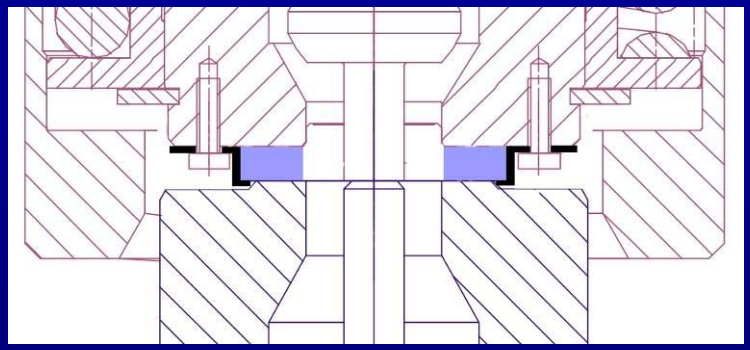


Grafoil seals

Grafoil seal

- 98% pure graphite
  → Resists high radiation
- Needs only ~5MPa
  contact pressure

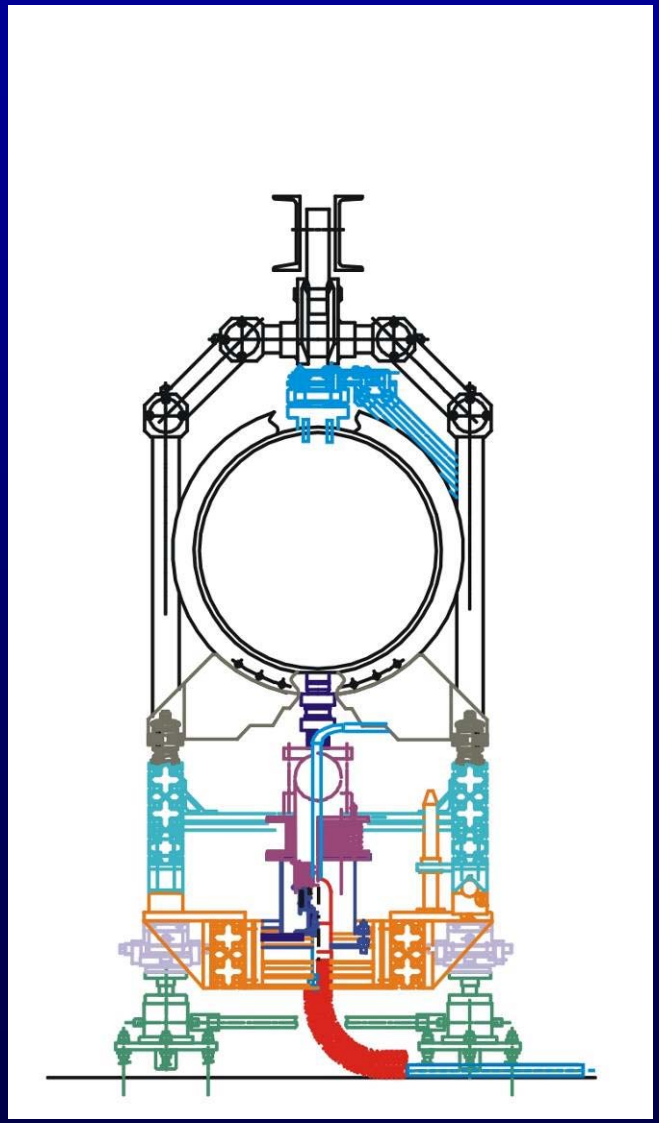




Other applications:

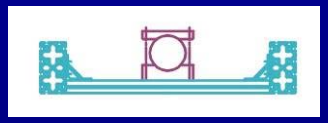
- Two way-valve with spherical graphite seal (switching between water feed circuits)
- Seal between insulating glass disk and plates of electrical connection
  ("glass disk assembly")

Decoupled Frames



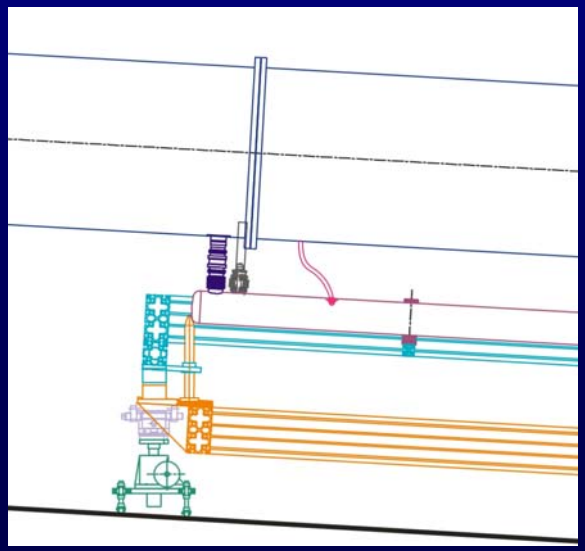
Seal contact force (from spring) = 2000N

To absorb force



→ Need for rigid frames

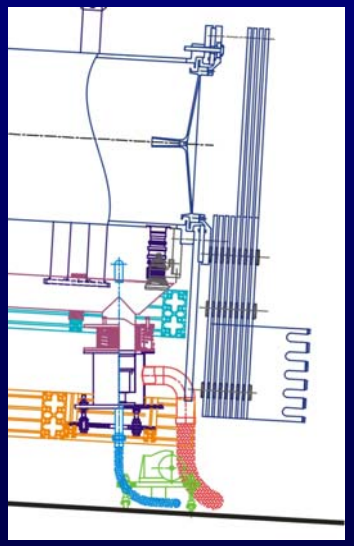
→ Fix collector tube to rigid upper frame



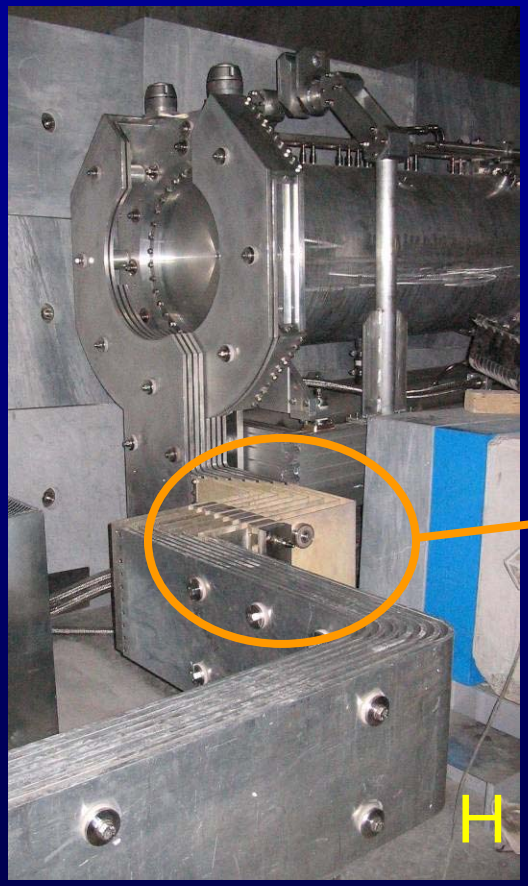
In case of horn exchange

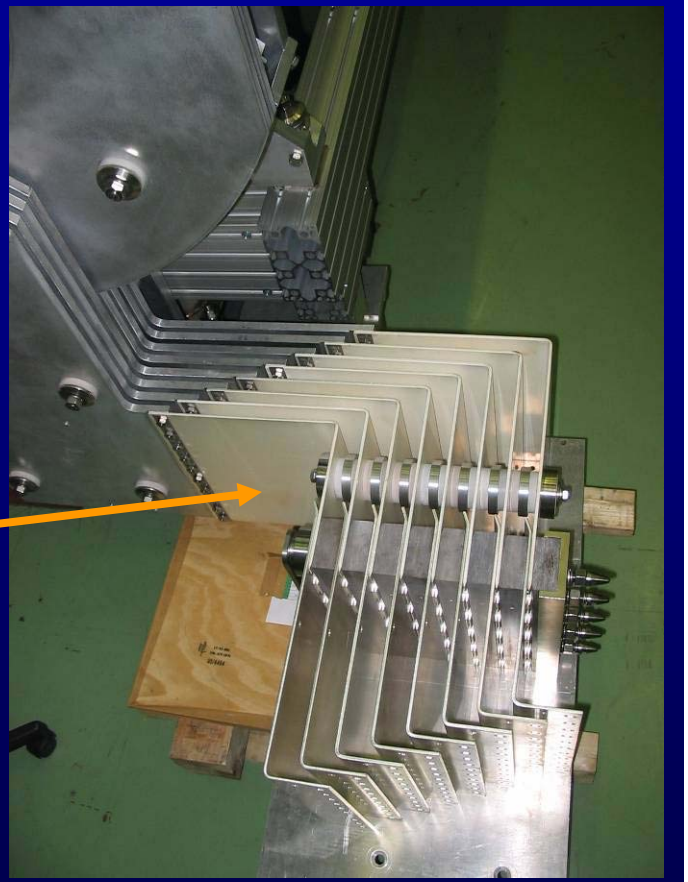
Goes away with horn

Stays in place



Installation

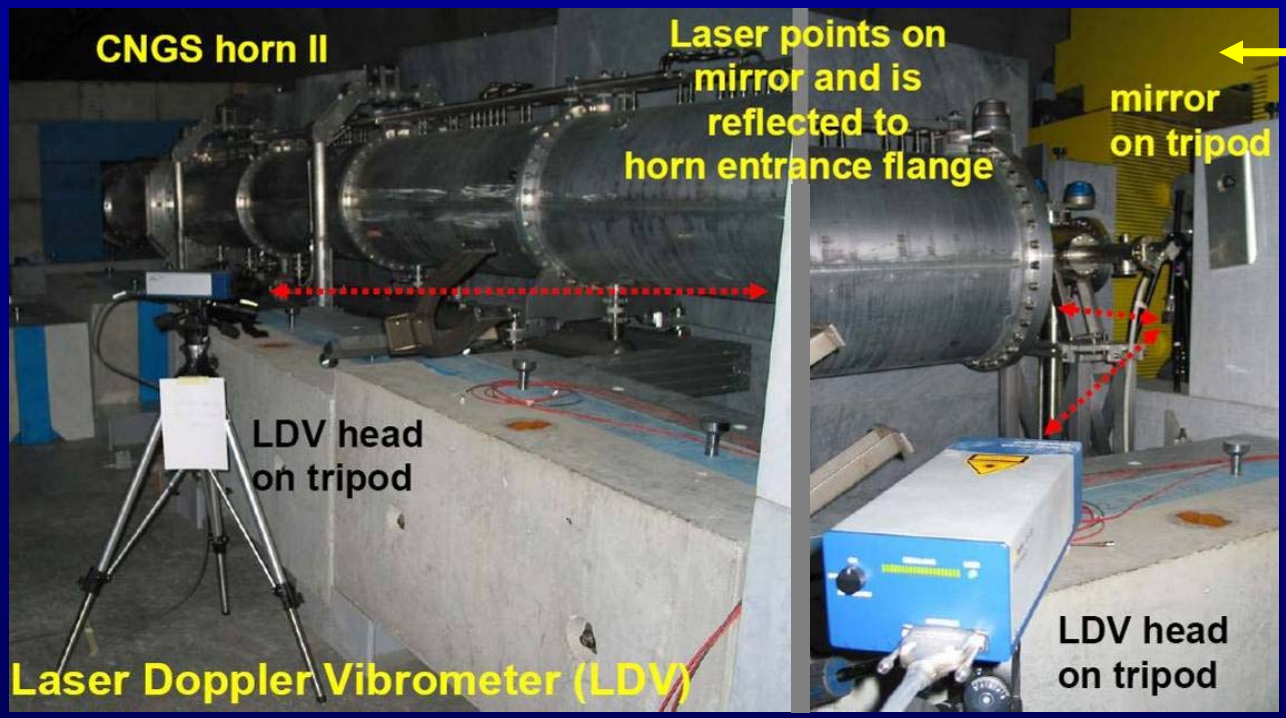




Fast Coupling Connection (horn exchange)

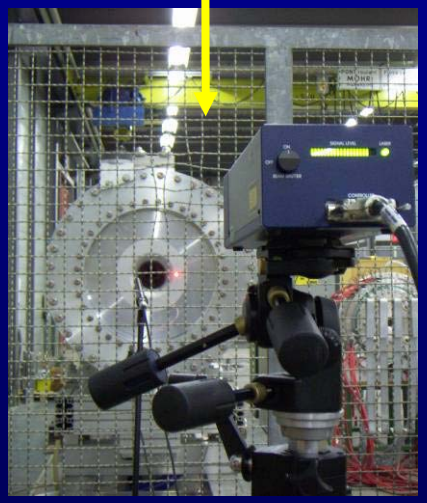
Timing: Vibration tests

(courtesy of R. Wilfinger CERN/TU Vienna)



In target chamber
(new horn)

In test stand
(old horn & new horn)

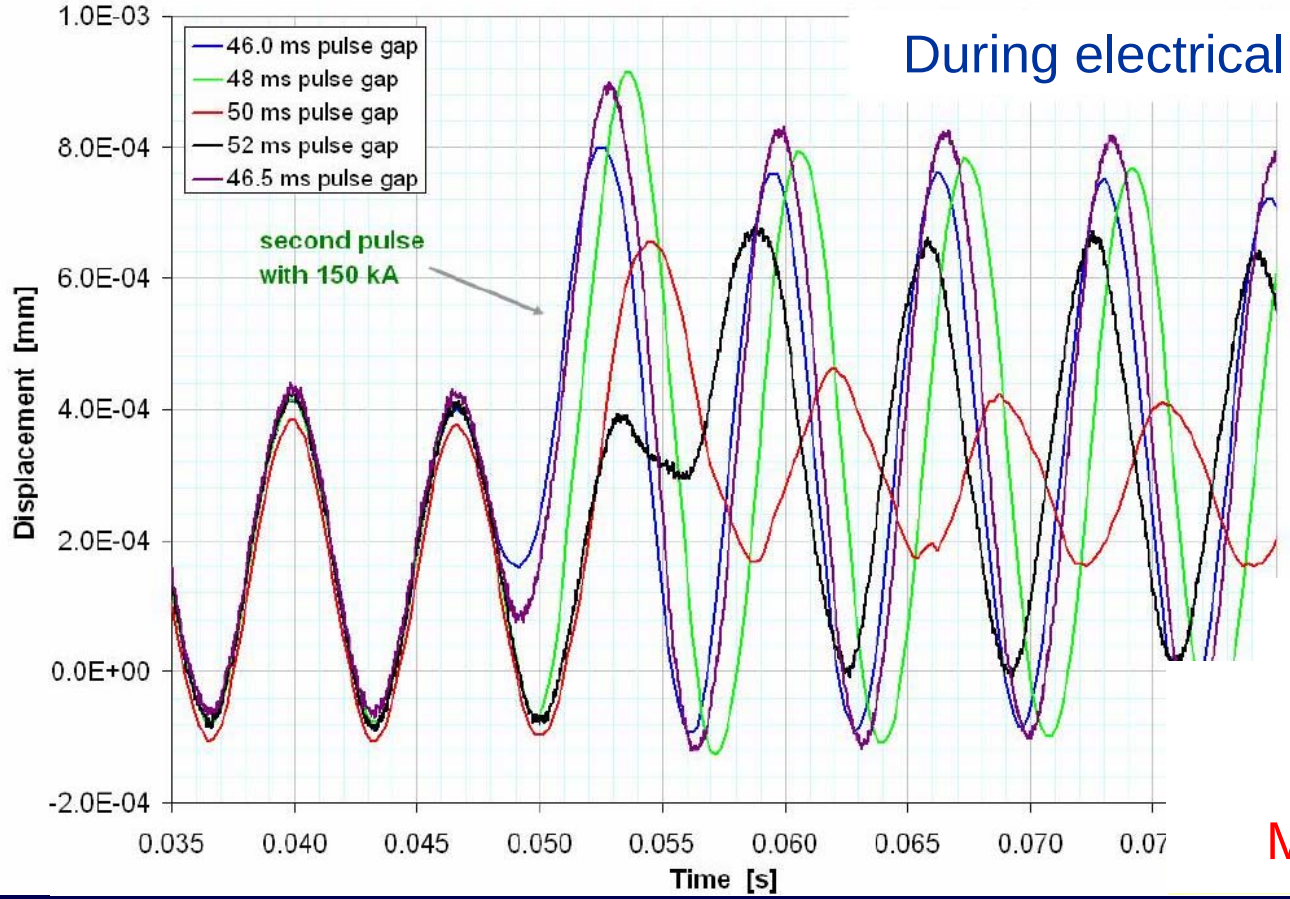


→Natural frequency horn: 149Hz (reflector: 73Hz)

→Data collected for future study of effect of
- Cooling water temperature
- Glass disk assembly

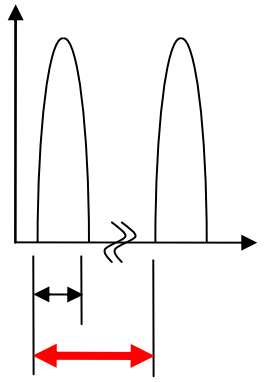
Vibration tests

(courtesy of R. Wilfinger CERN/TU Vienna)



During electrical tests:

Electrical Pulse Timing



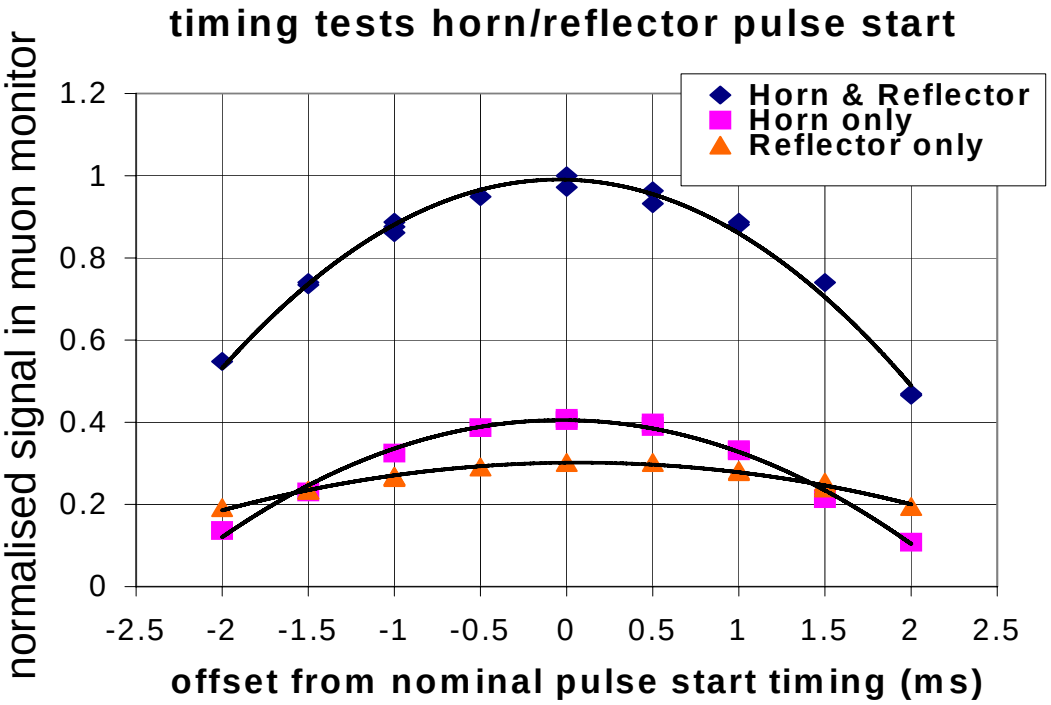
Vary from 46ms to 52ms, Measure response

→ Optimum of 50ms gap for horn

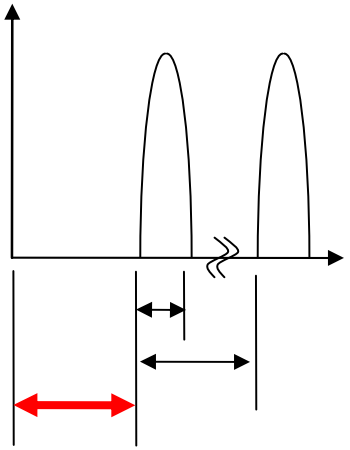
(less fragile reflector: optimum @48ms, +20%@50ms)

Timing: pulse start

During commissioning:



Electrical Pulse Timing



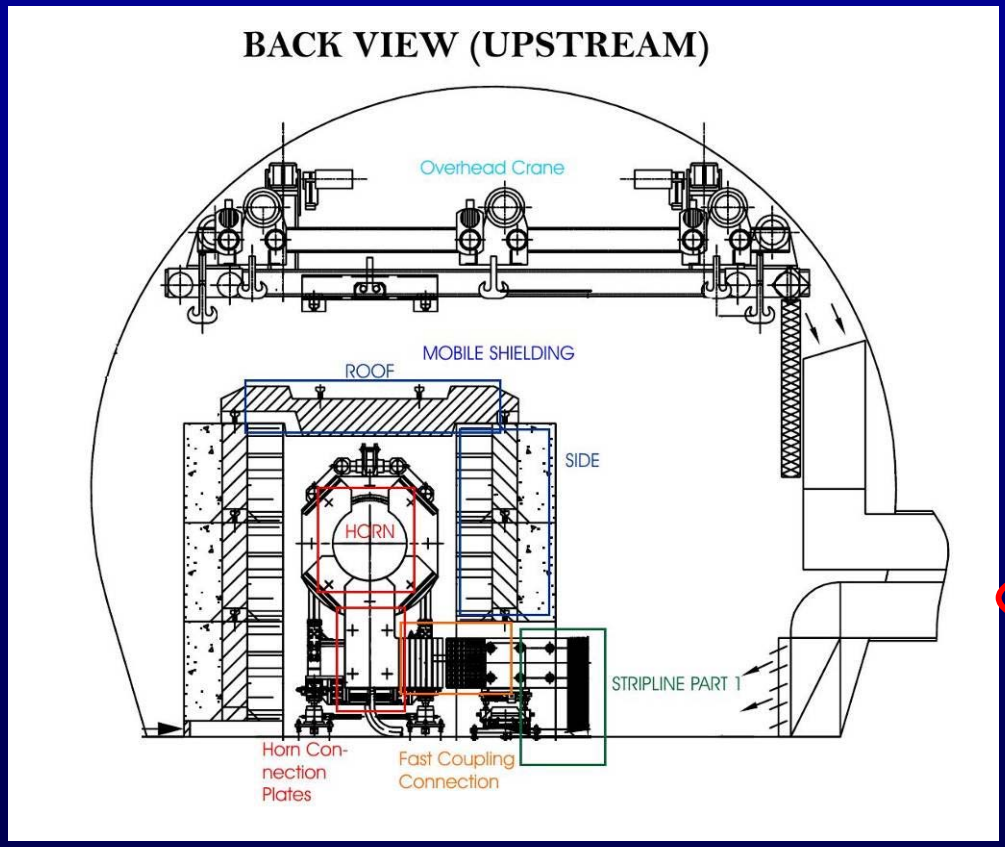
Vary from -2ms to 2ms w.r.t. nominal, Measure muons

Conclusion of successful commissioning (400000 pulses):

CNGS Horn design validated

(glass disk, water circuit, inner conductor,…)

Horn exchange



Fatigue → Life time of horn
(95% confidence):
20 million pulses = 5 years

Highly radioactive zone:
→Maximize remote & automatic
→ Minimize dose

→Define detailed procedure
(interaction with RP(*) experts)
→ Do complete exercise
(realistic conditions)
→ Documentation (photo, film)
is extremely important!

(*) Radio Protection

Define procedure

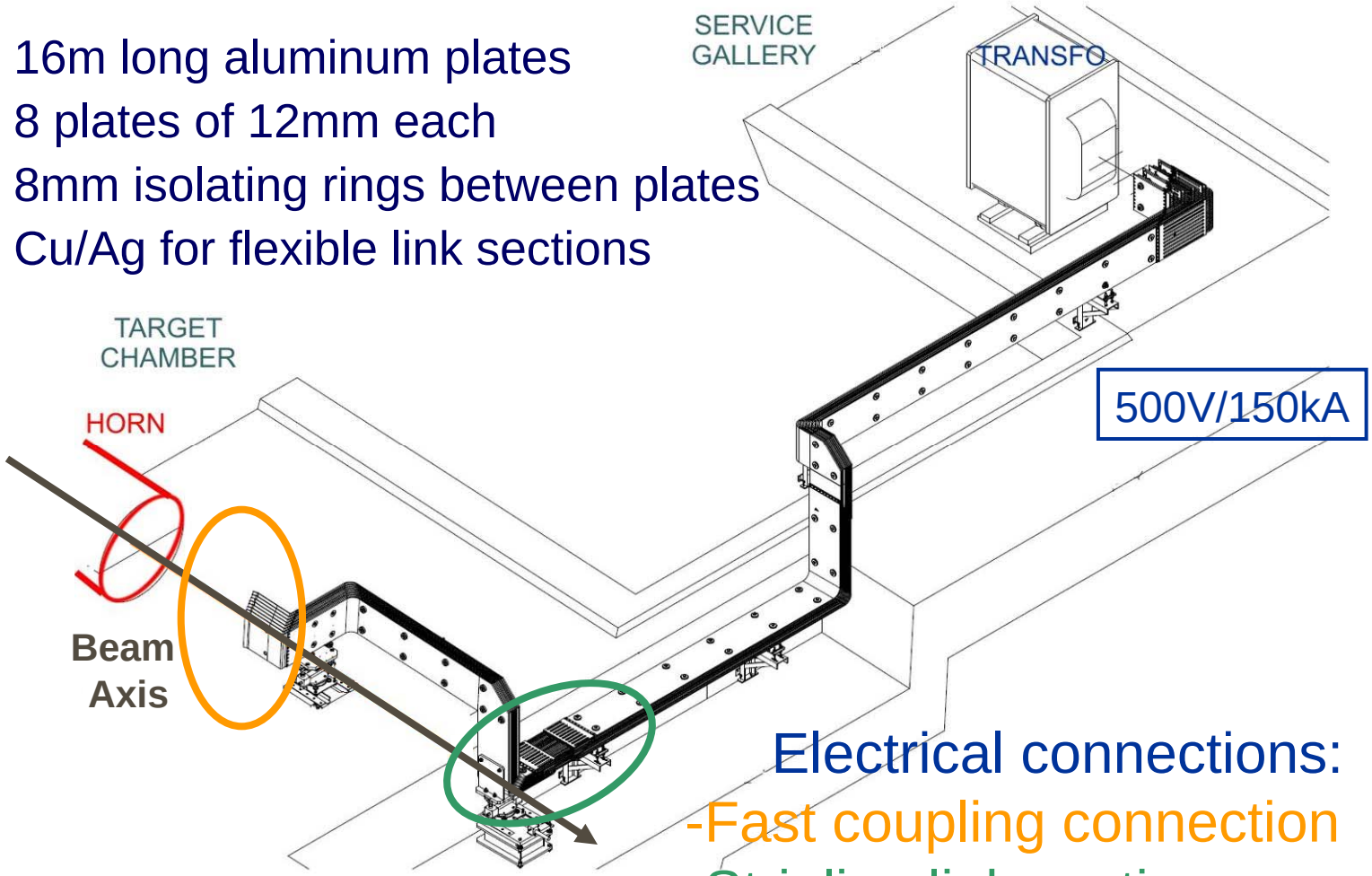
- Design phase: Optimization with respect to dose
- Experience → First draft of procedure
- Input to HAZOP study (*)
  → main remaining risks identified
- New version written with input from study & experts
  (radioprotection, handling, transport, …)
- Tools designed, produced & tested
- Steps were tested & timed → optimisation
- 100% remote handling (shielding):
  Tested → coordinates noted down in worksheets

→ Updated procedure = script for exercise

(*) Hazard & Operability study

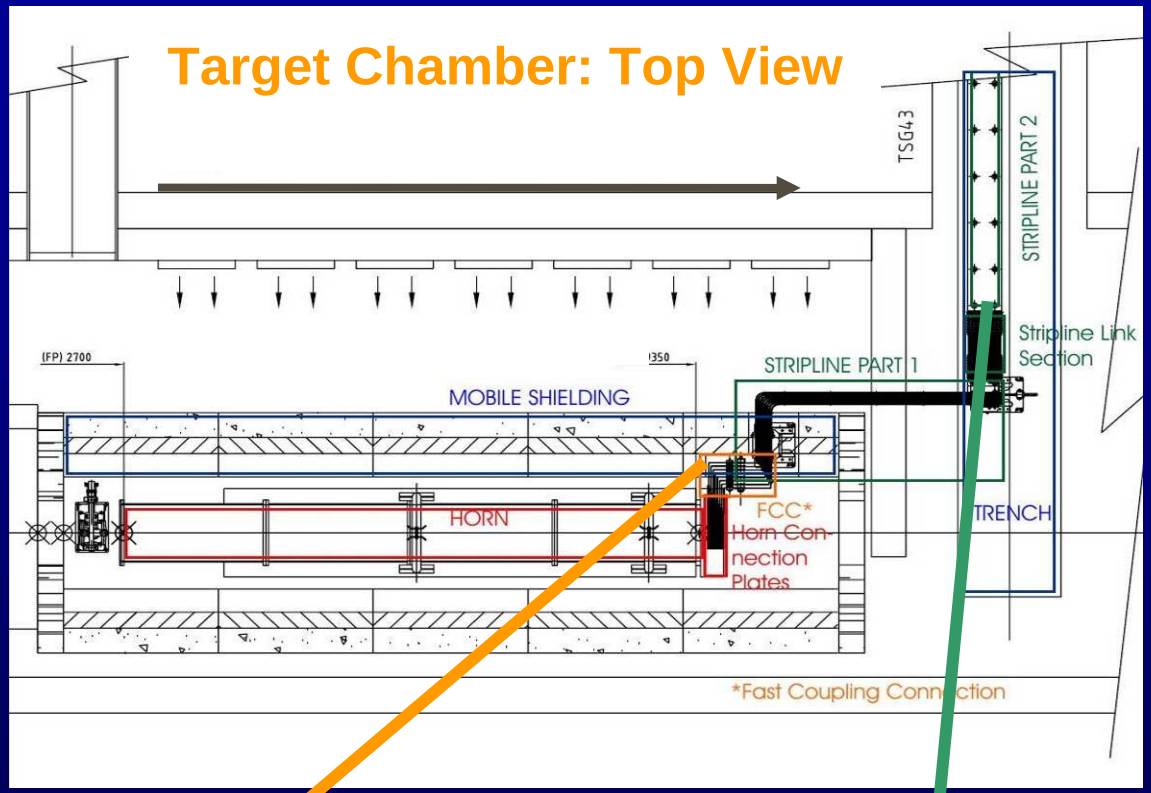
Striplines

- 16m long aluminum plates
- 8 plates of 12mm each
- 8mm isolating rings between plates
- Cu/Ag for flexible link sections



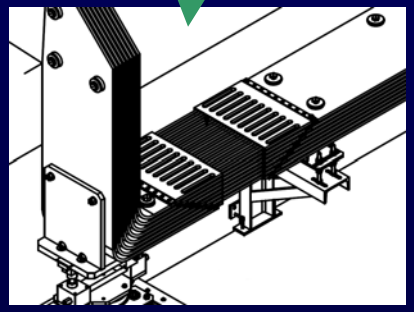
Electrical connections:
-Fast coupling connection
-Stripline link section

Horn exchange procedure



Fast Coupling Connection

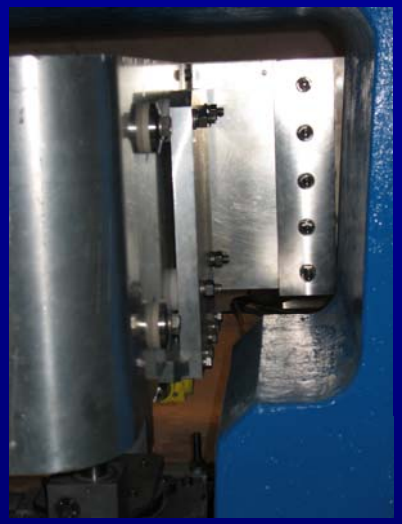
Stripline Link Section



- Disconnect Fast Coupling
- Take out Stripline Link
- Move stripline (open)
- →horn disconnected
- Open shielding (roof & side wall)
- Exchange horn remotely
- Close shielding

- Move stripline (close) →horn reconnected
- Put Stripline Link back
- Connect Fast Coupling

Disconnect Fast Coupling



Fast Coupling

Stripline Link
(rigid plates)

(with shielding in place)

before

after

Move stripline down
(open)

→ Fast Coupling is disconnected

Open shielding

before

after

100% Remote

« mushrooms »
as guide

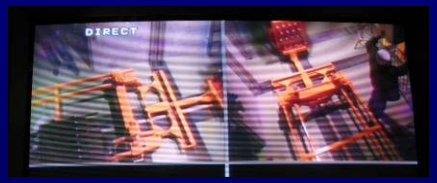
Overhead crane
with coordinates

Cameras

Remove old horn & Install new

100% Remote (radioactive)





from: target chamber
to : radioactive storage



50% Remote (clean)


Close shielding

before

100% Remote

Storage blocks

after

Crane coordinates recorded during exercise

Connect Fast Coupling

Move stripline up

Fix 5 bolts, install 8 plates

→ Fast Coupling is closed

Horn exchange exercise

Final test = complete exchange

- Realistic conditions:
  - Suits, gloves, masks
  - Lighting, location

- Locations photographed (storage, intervention)
- Every step filmed (except if 100% remote)
- Every step timed and observed by RP experts
- With last inputs → final documents

Detailed procedure | **Worksheets (crane/human)** | **Tools description** | **Photos** | **Film** | **Mock-up for training**

Conclusion of successful horn exchange:

CNGS Horn exchange procedure validated

Through documentation, tools, mock-up → knowledge remains

Info (26/8) from J. Hylen on Numi horns ceramic failure (leak)

"For both ceramics that we have replaced, the ceramic that leaks is mostly hidden behind a shroud, and we have not yet done an autopsy to look directly at what failed.

For what it is worth, we are guessing that the braze joint is corroding or otherwise failing, and are thinking of switching to shrink-fit connection to the ceramics.

The ceramics that we can see directly (the one between horn inner and outer conductors, the ones mounting the stripline, the ones holding the shrouds) look fine other than color changes.

The ceramics were both on water cooling circuits.
There is a flex-hose between the ceramic and the water header mounted directly on the horn, so the ceramic is somewhat insulated from the horn vibration, although vibration can still travel through the horn mounting to the hanger bracket and back to the ceramic."

extra slide

Short movies

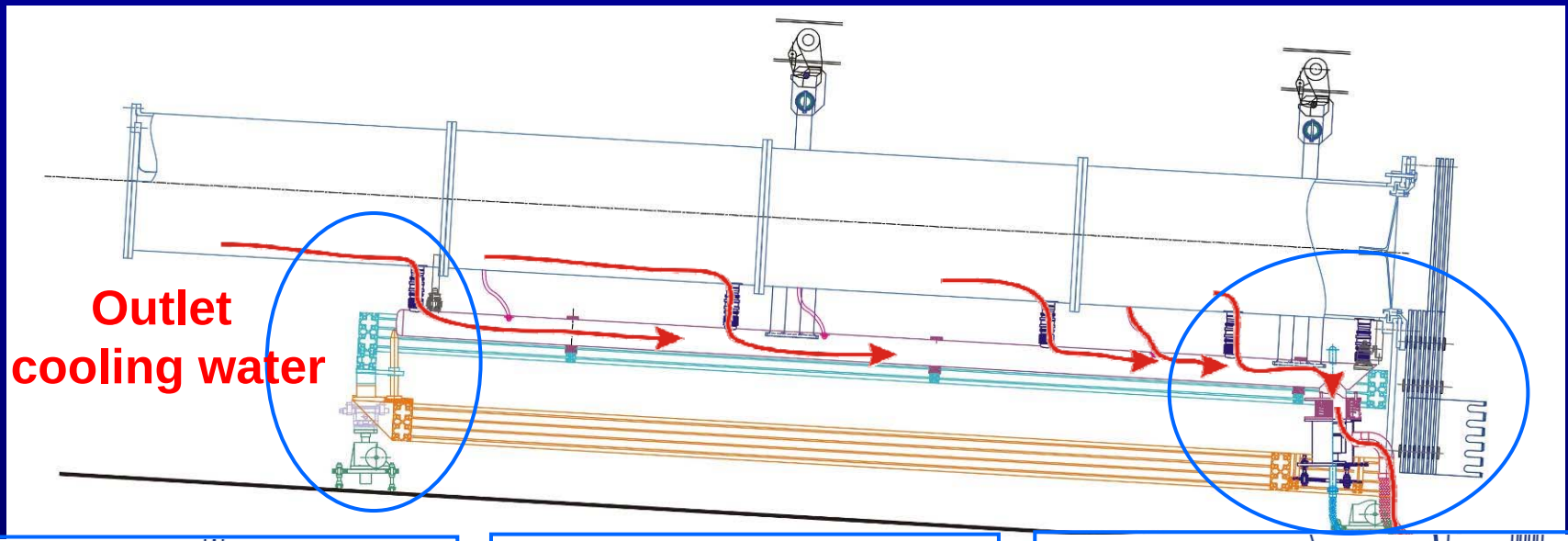
Preview:

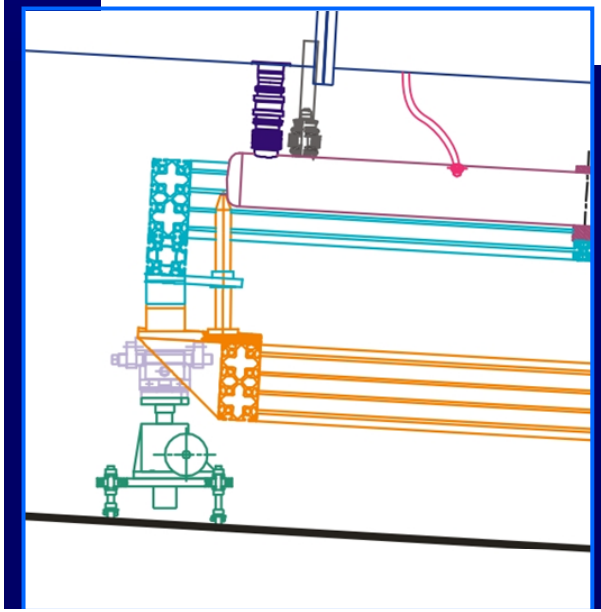
Move the Stripline Link (upstream) (2’40’’)

Starring Victor De Jésus

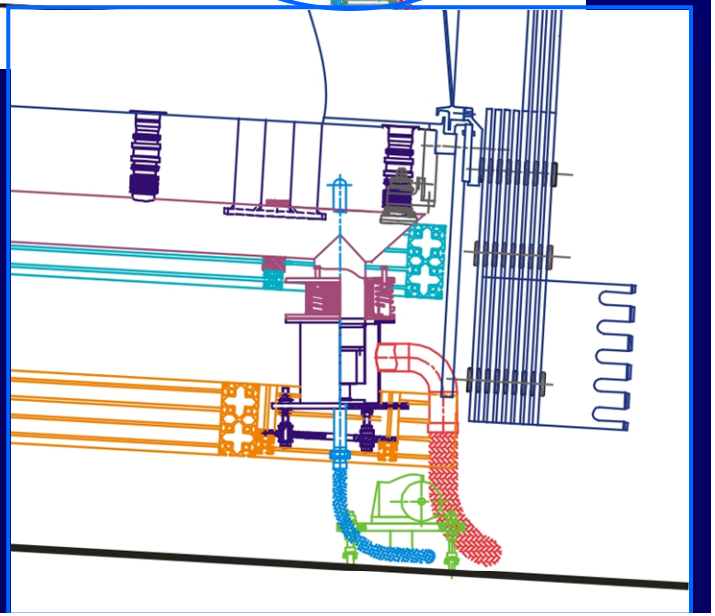
extra slide

Horn Design





Isolated Link
Cradles
Water Collector
Upper / Lower frame
Alignment & Feet
Coaxial Plug-in
Water Connection (*)
Water in / out
(*) remark review 2004



extra slide

Horn exchange: HAZOP

Hazard & Operability study for horn exchange

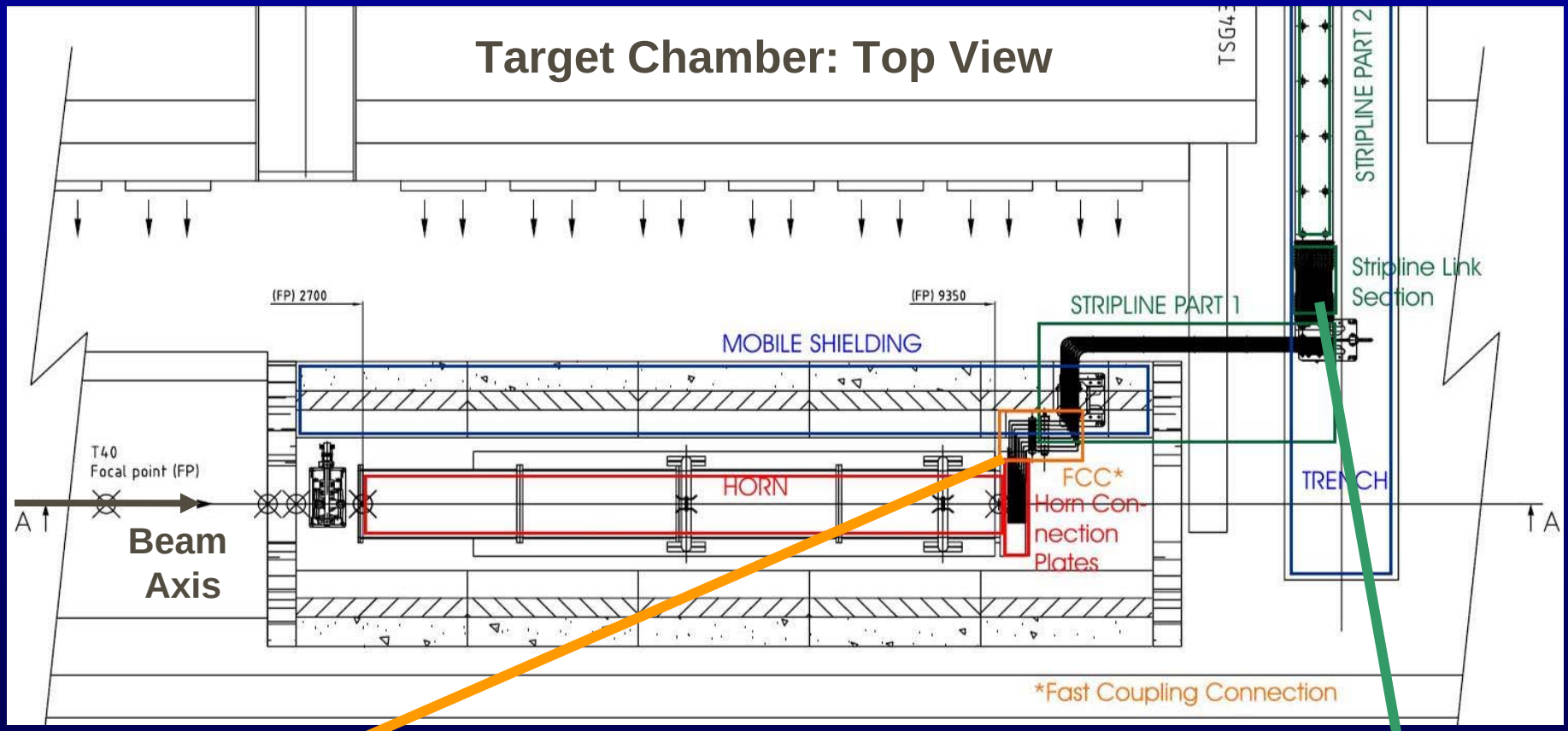
1) write specification
   (incl. Horn exchange procedure)
2) make call for tender (at least 5 companies)
3) choose company, agree on dates

-> agree on sequences in horn exchange procedure
-> agree on keywords

-> HAZOP meeting (2.5 days) 15-17 June 2005
-> approve minutes
-> follow-up on “actions”
-> review actions (phone conference)
-> presentation of HAZOP report 2 Sept. 2005

extra slide

Horn Exchange: Stripline

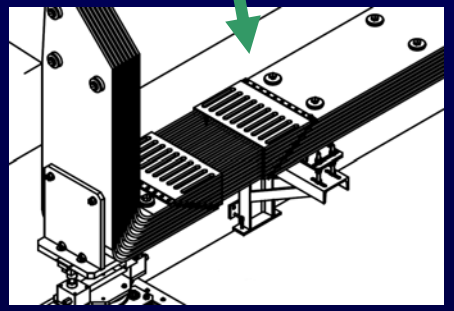


Fast Coupling:

5 nuts (manual, through shielding)

Stripline Link:

8x10x2 screws (pneumatic in trench)



Ans PARDONS