CNGS Horns

- CNGS Horns
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  - Design
  - «Remote»
  - Timing tests

- Horn exchange
  - Striplines
  - Procedure
  - Exchange Exercise
Introduction

Electrical Pulse Timing

Beam Extraction
2.4x10^{13} p.p.p.

Flat top
0.01 ms
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

- Thickness 1.8 mm
- Aluminum grade 6082
- 9 machined sections
- Electron beam welds

Support Points (3)
3x3 grooves in inner conductor
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

To sprayers

Fixed to horn

Leak

Seal

From side gallery

Fixed to lower frame

From water collector

To side gallery
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
Decoupled Frames

Seal contact force (from spring) = 2000N

To absorb force

→ Need for rigid lower frame
→ Fix collector tube to rigid upper frame

In case of horn exchange

Goes away with horn
Stays in place

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Installation

Fast Coupling Connection
(horn exchange)

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Timing: Vibration tests
(courtesy of R. Wilfinger CERN/TU Vienna)

Natural frequency horn: 149Hz (reflector: 73Hz)
Data collected for future study of effect of
- Cooling water temperature
- Glass disk assembly

In target chamber
(new horn)
In test stand
(old horn & new horn)
Vibration tests
(courtesy of R. Wilfinger CERN/TU Vienna)

→ Optimum of 50ms gap for horn
(less fragile reflector: optimum @48ms, +20%@50ms)

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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

TARGET CHAMBER
HORN
Beam Axis

SERVICE GALLERY
TRANSFO

500V/150kA

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Horn exchange procedure

- 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

Target Chamber: Top View

Beam direction

Fast Coupling Connection

Stripline Link Section

SL Horn
Disconnect Fast Coupling

Fast Coupling

Stripline Link
(rigid plates)
(with shielding in place)

before after

Move stripline down
(open)

→ Fast Coupling is disconnected

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Open shielding

100% Remote

before

after

« mushrooms » as guide

Overhead crane with coordinates

Cameras

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Remove old horn & Install new

100% Remote (radioactive)

from: target chamber
to: radioactive storage

50% Remote (clean)

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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

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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

Conclusion of successful horn exchange:
CNGS Horn exchange procedure validated
Through documentation, tools, mock-up → knowledge remains