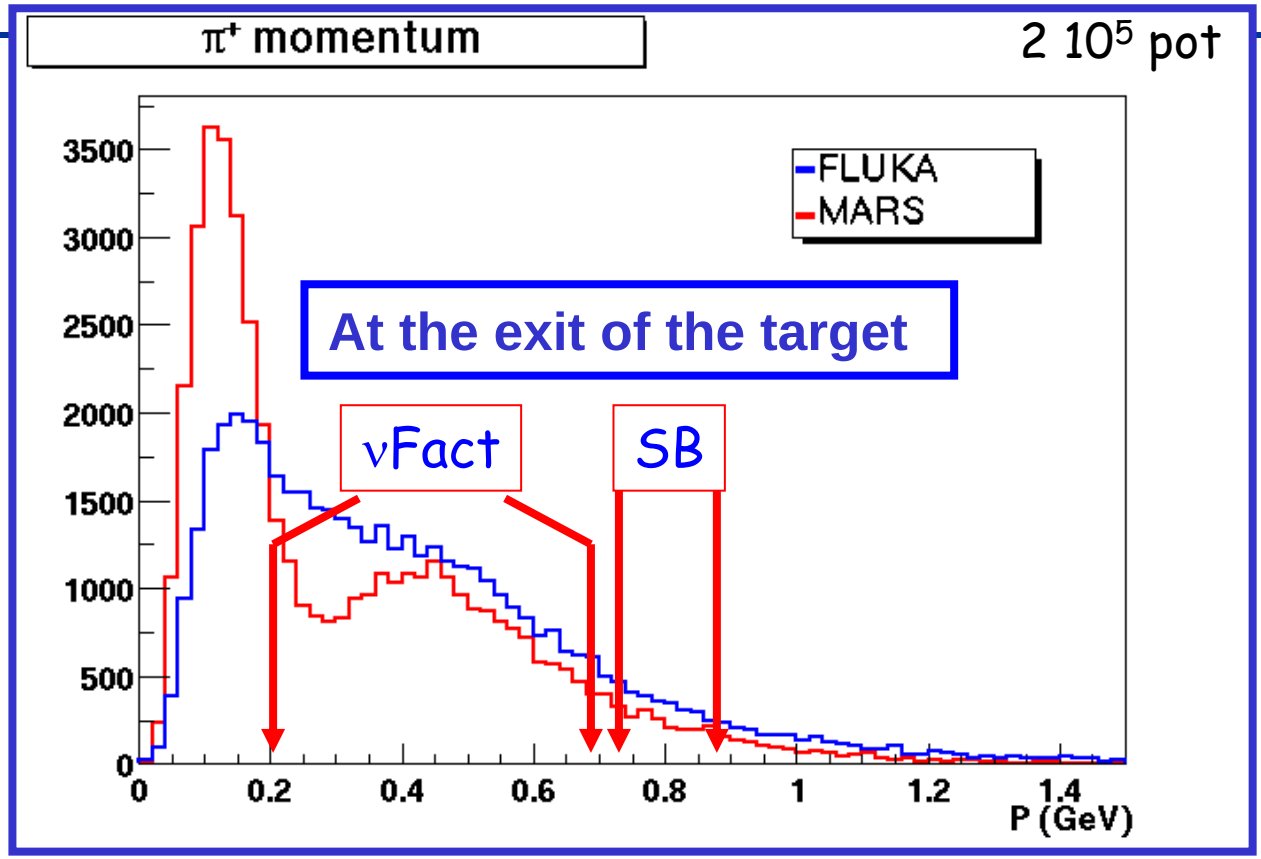
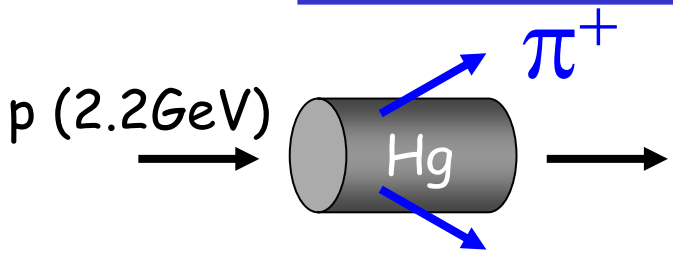
Pion Collection

- Introduction
- CNGS Horn: some LAL realisation
- SuperBeam/νFact Horn: some CERN results + some thinking…

Thanks to S. Gilardoni and A. Cazes

Pion momentum



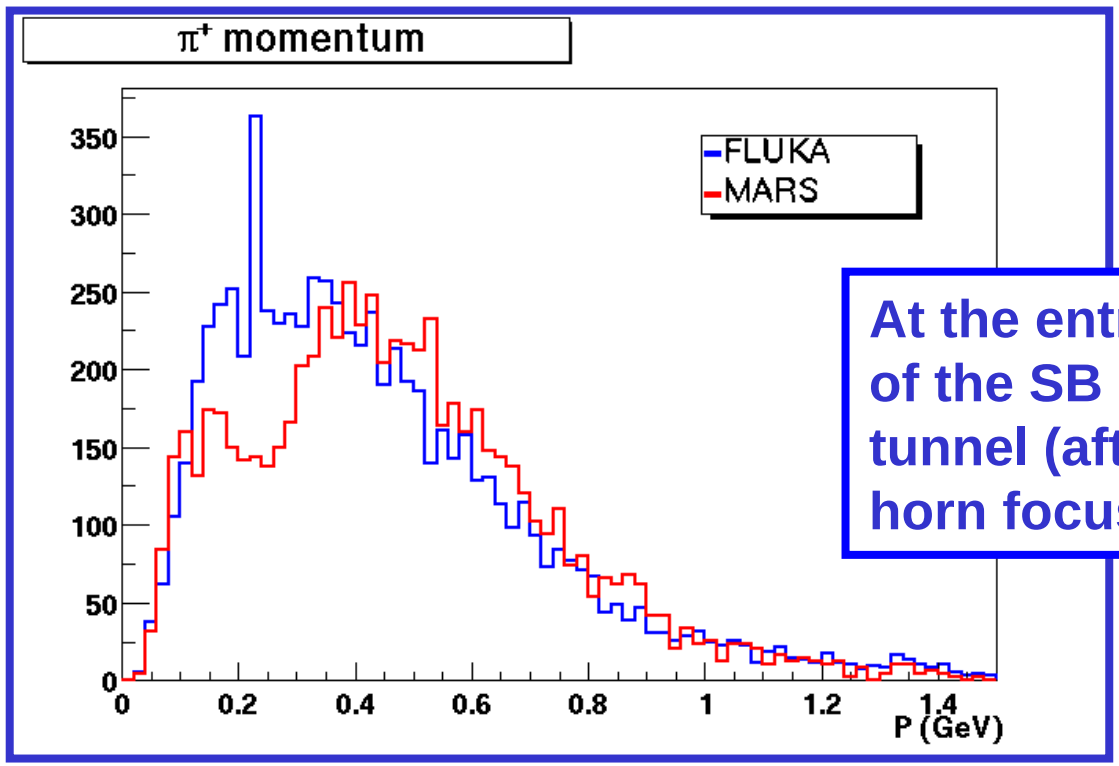


π+(no cut)/p.o.t = 0.24 (FLUKA & MARS)

Ø = 15mm, L = 2.3λ_I =300mm

A. Cazes thesis

MARS vs FLUKA



At the entrance of the SB decay tunnel (after the horn focusing)

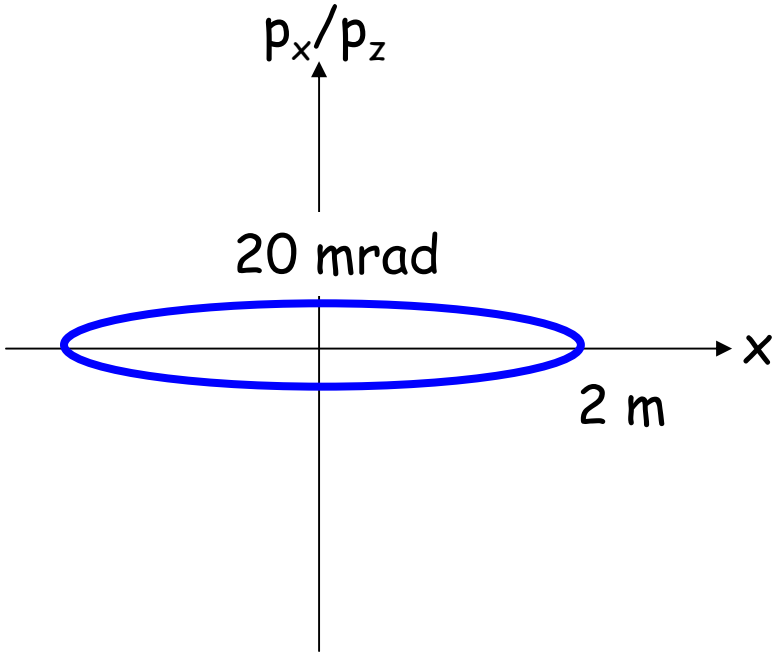
Discrepancies reduced in the beam line

R = 1m
No angular cut

A. Cazes thesis

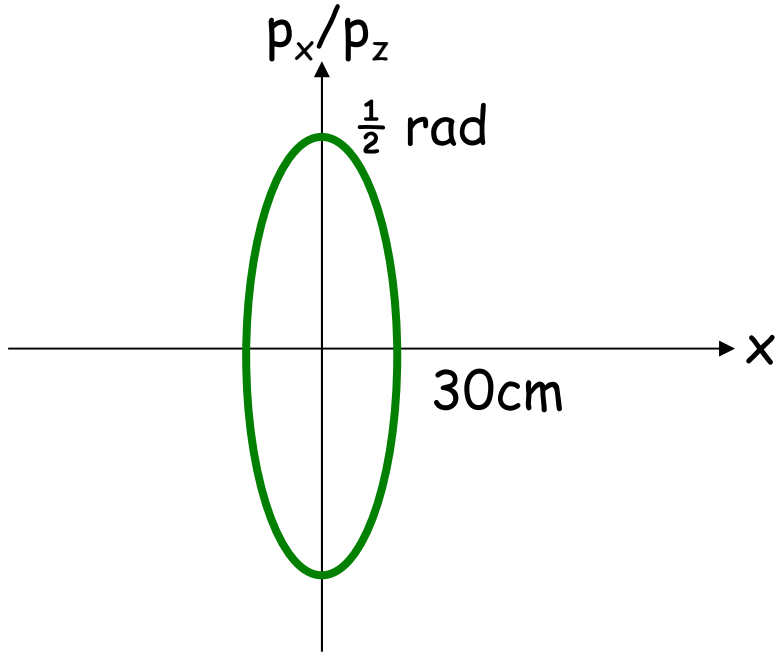
SuperBeam vs νFact Optics

Super Beam



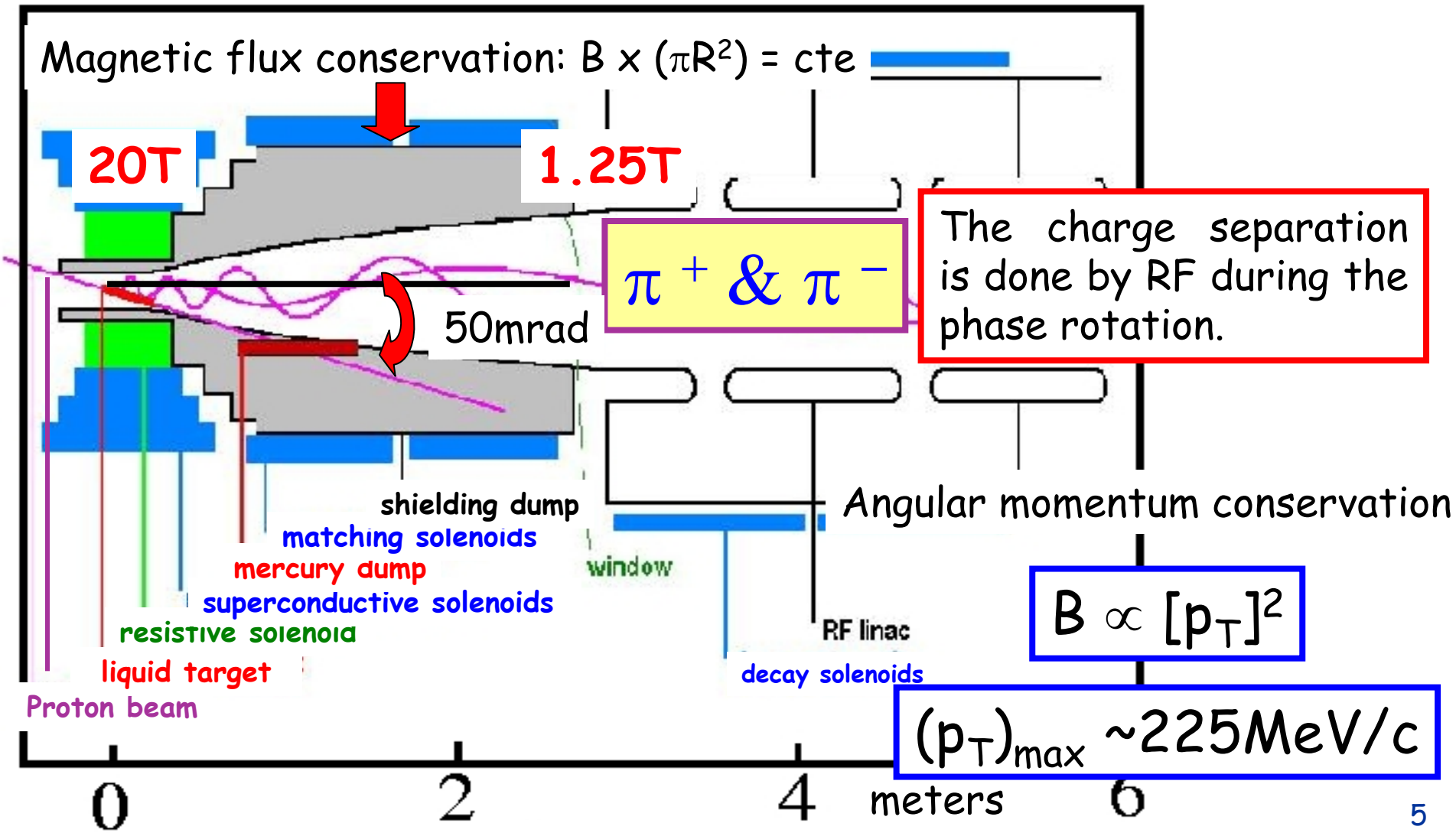
Spot size @ 130km
Decay tunnel size

νFact

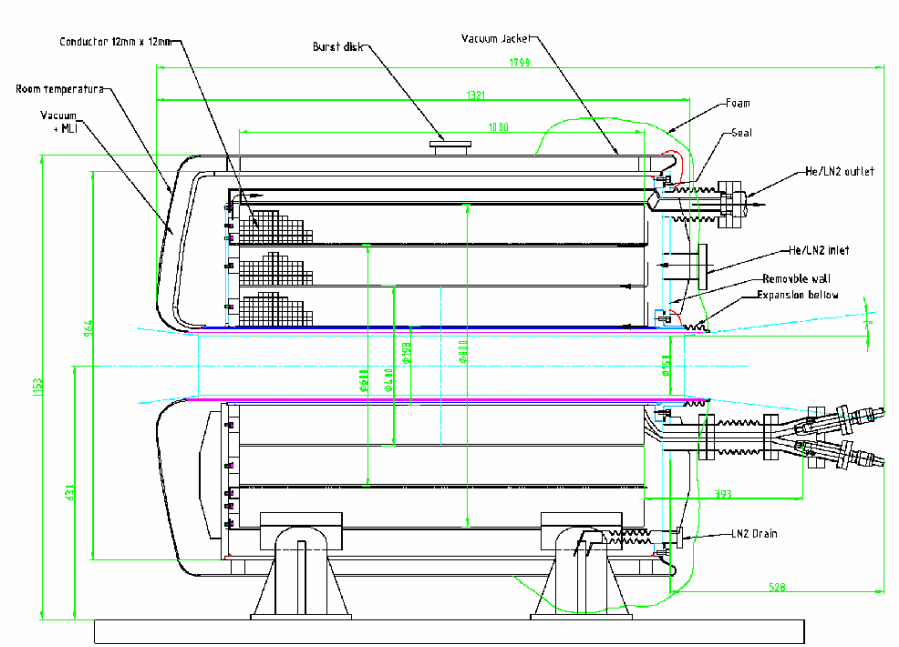


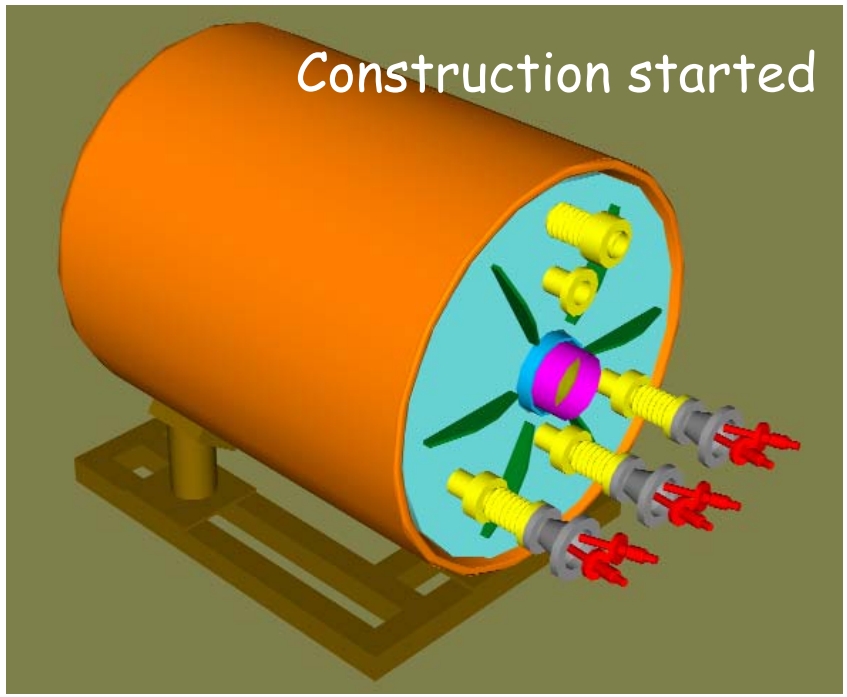
Decay channel solenoids
Aperture and B strength

Solenoid style of collection



High Field Pulsed Solenoid





- 70 K Operation, LN2 cooled
- **15 T** with 4.5 MW Pulsed Power
  - 1 second flat top
- 15 cm warm bore
- 1 m long beam pipe

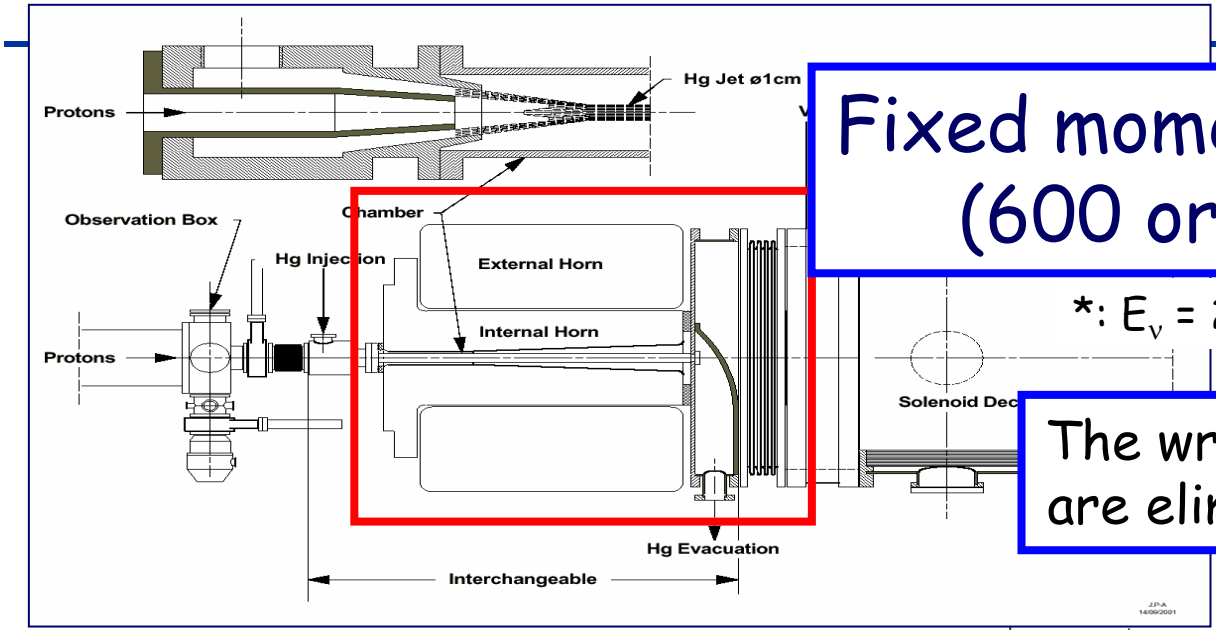
Peter Titus, MIT

~ 1MFCH

For TT2A exp. At CERN

From A. Fabich (CERN)

Horn style of collection



Fixed momentum focalisation (600 or 800)* MeV/c

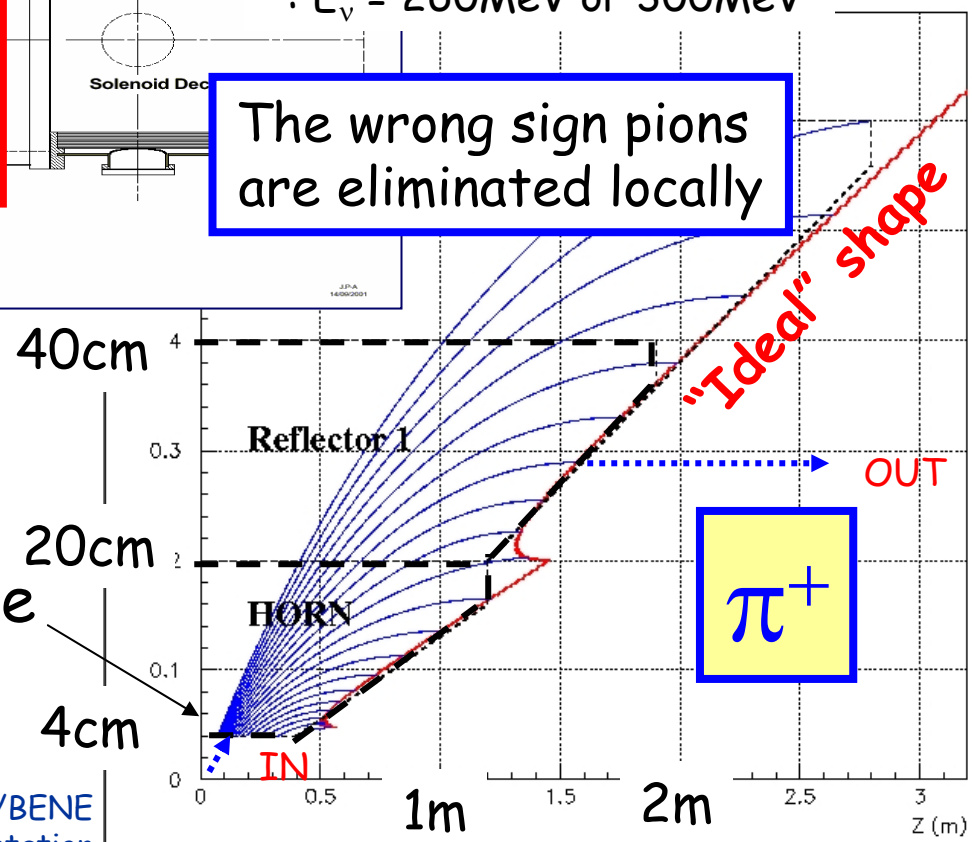
*: E_ν = 260MeV or 300MeV

The wrong sign pions are eliminated locally

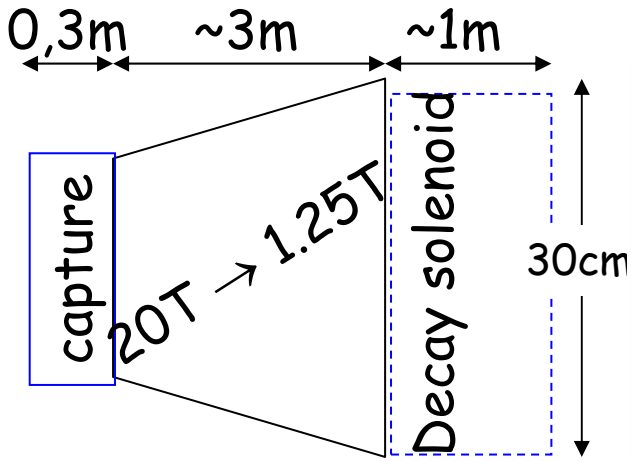
$$B_\phi(r) \propto I_{cur}/r$$

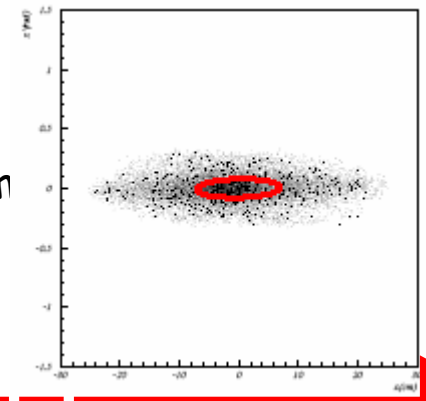
I_{cur} ~ (300 ÷ 600) kA

r_{min} limited by Target size

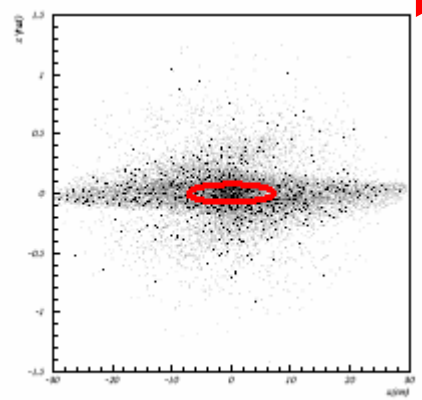


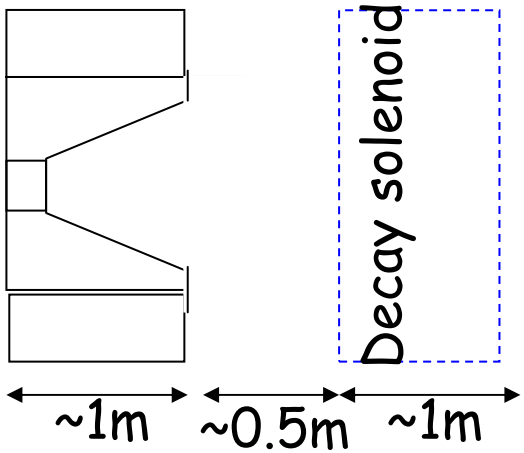
Comparison Solenoid vs Horn



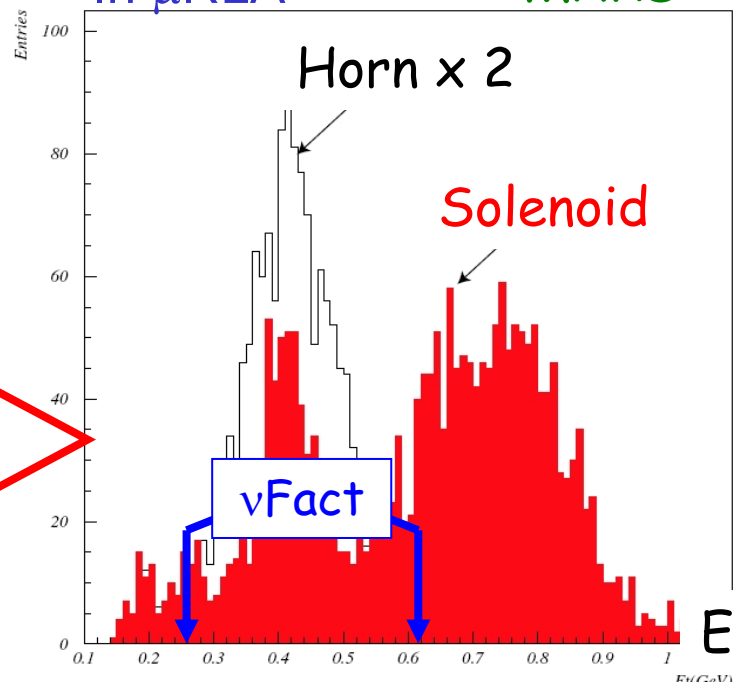


Cut : 1.5 cm.rad



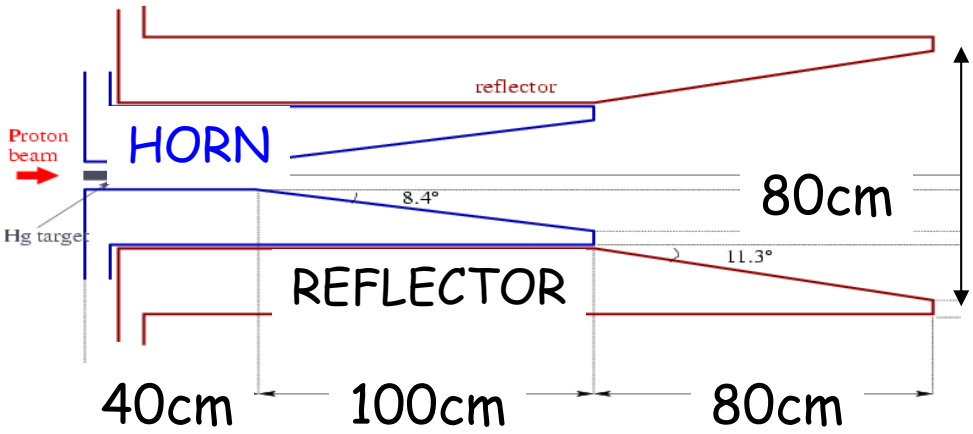


In μRLA MARS



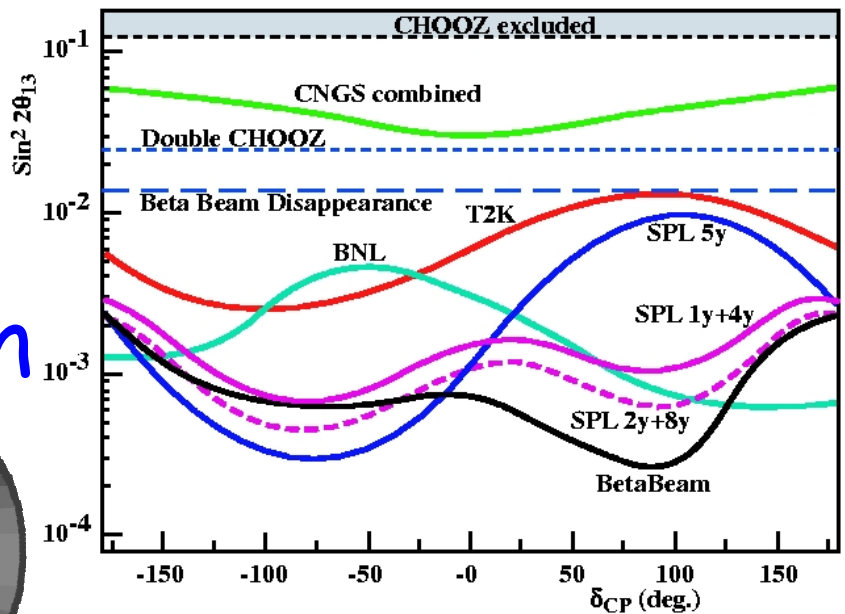
The collection yield is identical ~1.4 10^{-3} π/pot

Optimisation of the focusing for SuperBeam



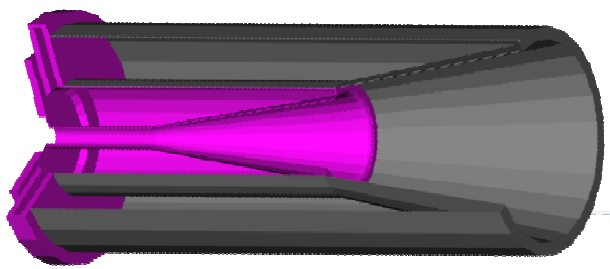
SPL: 2.2GeV →3.5GeV
Decay tunnel: L = 40m, R = 2m
SPL-Fréjus 130km + UNO-like

A.Cazes + JEC (submitted to EPJ C)



Horn is mandatory for charge separation

E_ν ~ 300MeV
P_π~ 800MeV/c



See WP1 &2 parallel session
(Room 2, 3/11/04 @11am)

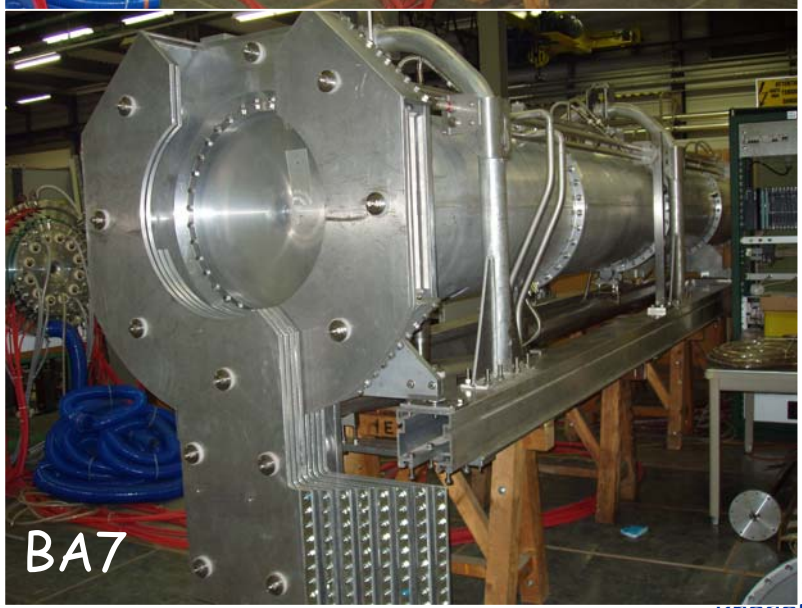
2-3 ν See also S. Gilardoni thesis

CNGS Horns

Project Leader: J.E C
Responsible Engineer : J.L Borne
+ 1,5 Engineers
+ 2 Draftsmen
+ 3Technicians

Present LAL FT team

First Horn at CERN 7th April 04



The 1st Horn had successfully passed a 65,000 double nominal pulses test early may 04.

Metrology at CERN of the Horn I.C

(2 10^7 double-pulses in 5 years)

CNGS Horn construction

A more detailed presentation on what we have learned will be given in the TARGET & COLLECTOR WP4

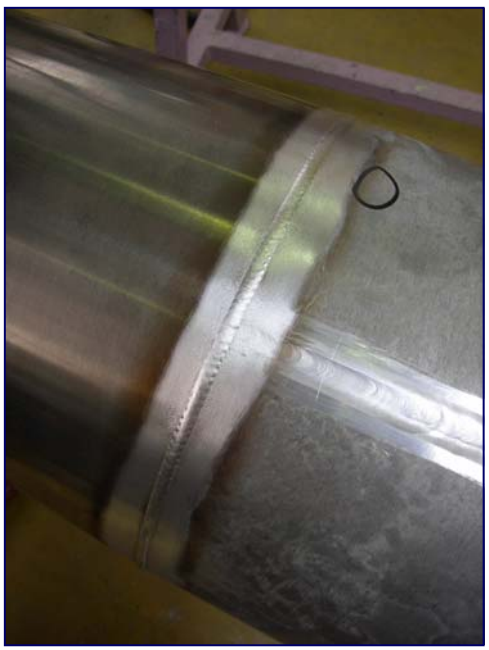
(Room 1, 3/11/04 @11am)

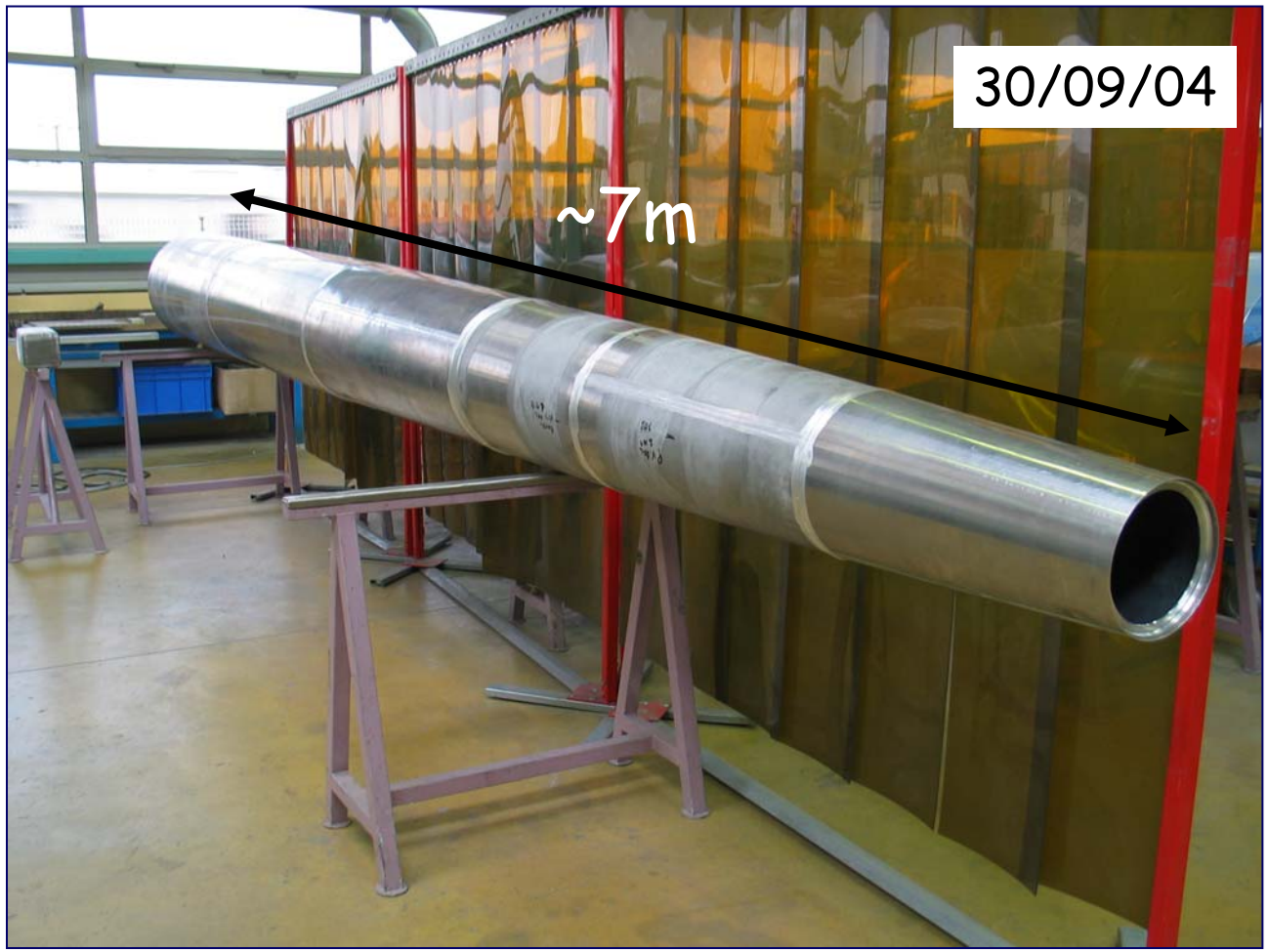
Inner Conductor of the Reflector (RIC)

2mm Al thick plates rolled

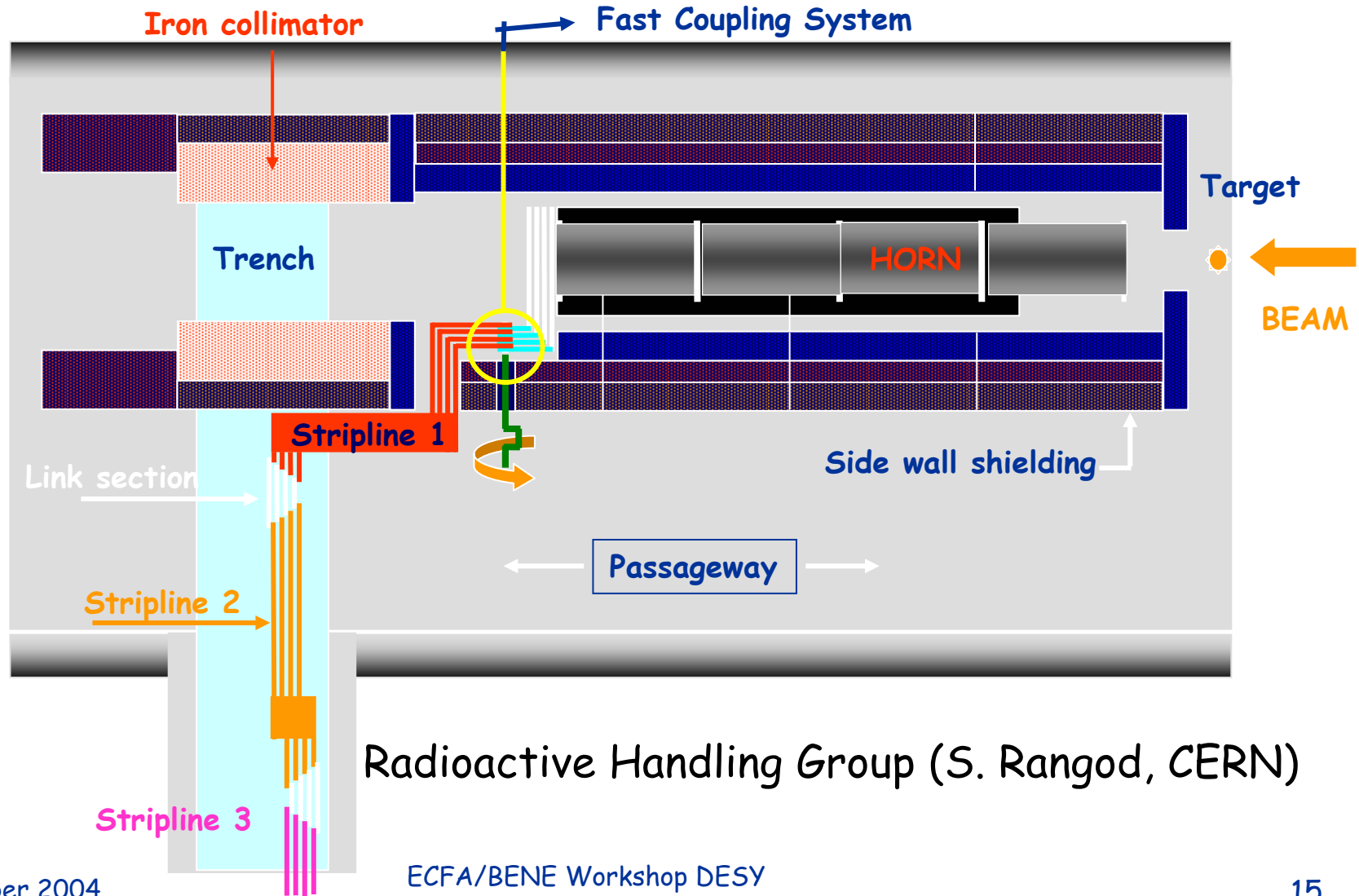
R.I.C : continued

Orbital
&
Longitudinal
TIG welding





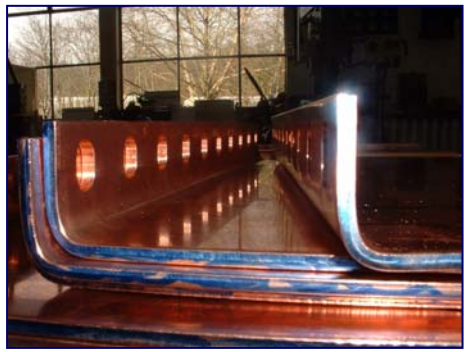
Fast Coupling System (F.C.S)

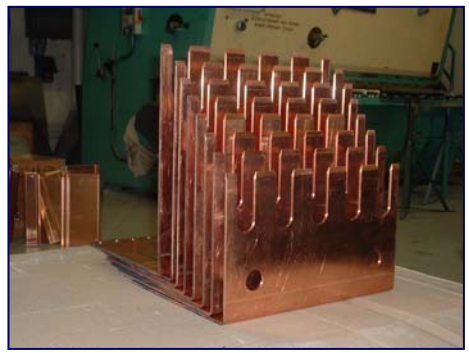


Radioactive Handling Group (S. Rangod, CERN)

F.C.S : 1st realisation at LAL

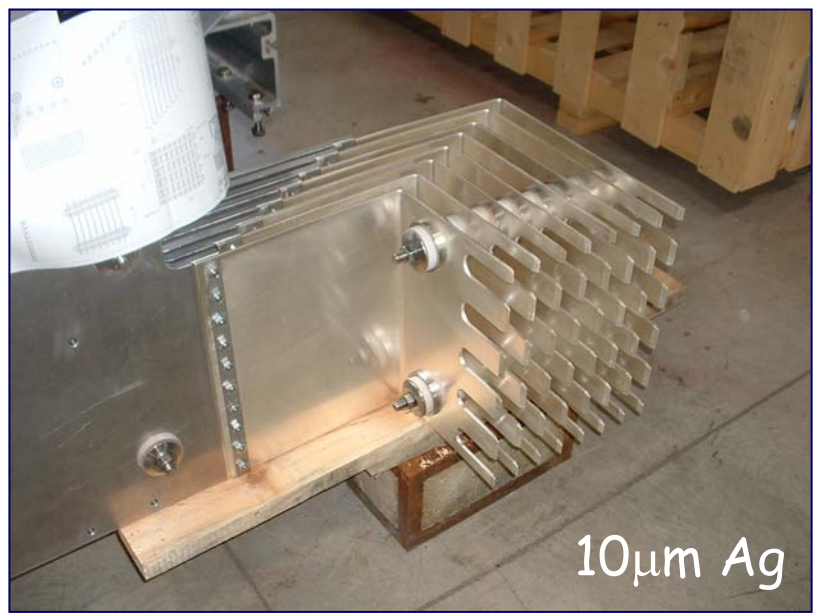
at LAL





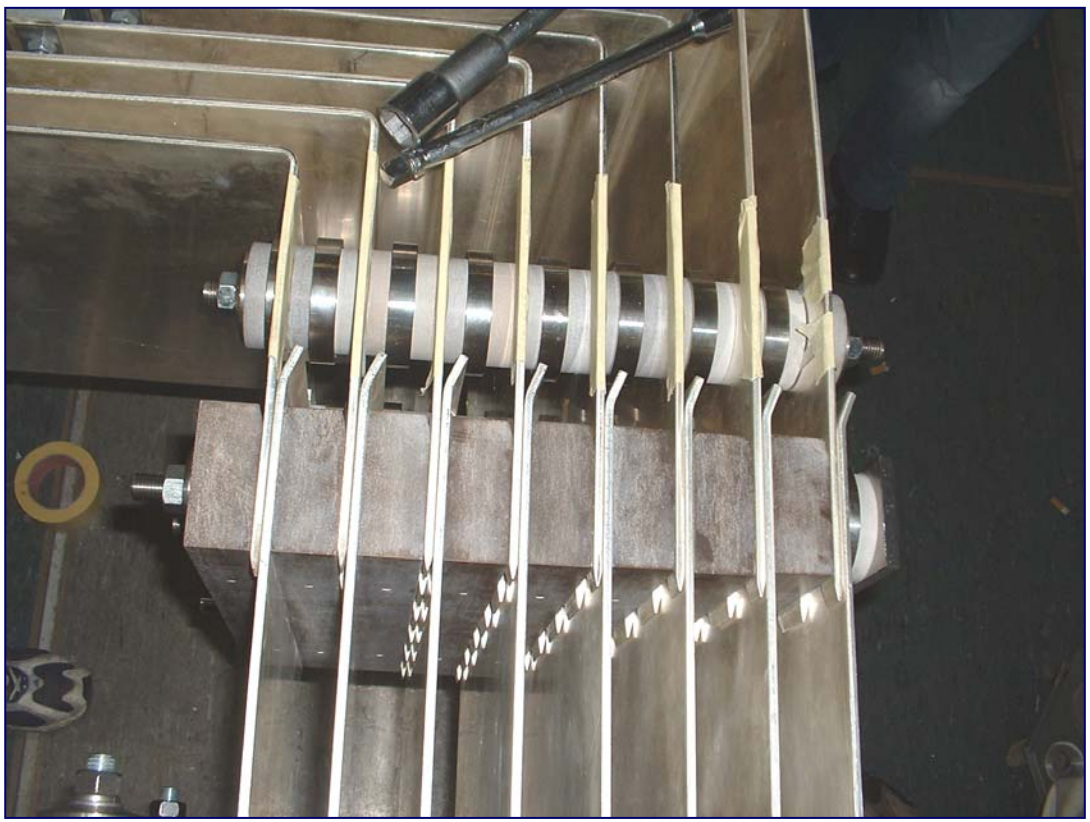
Feb.-Mar. 04

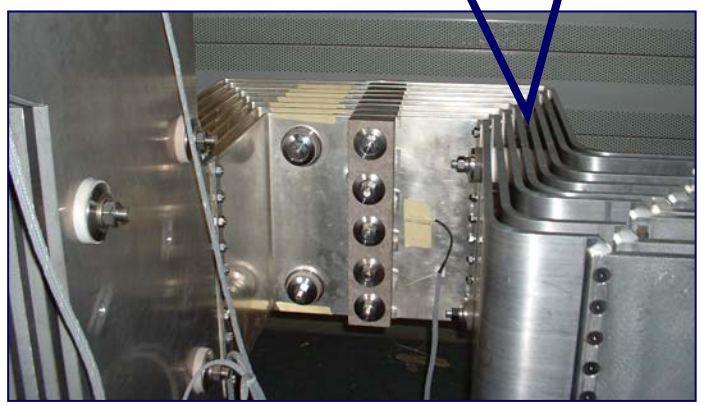
M10 "La Clusienne" bolts



F.C.S : mounting at CERN BA7

With some difficulties, we have managed to work out and proceed to the Horn tests.





SB &νFact Horn

LAL Physicists: J.E Campagne, A. Cazes (Ph.D)

Introduction

No R&D has been pushed up to now at LAL due to the CNGS project difficulties encountered.

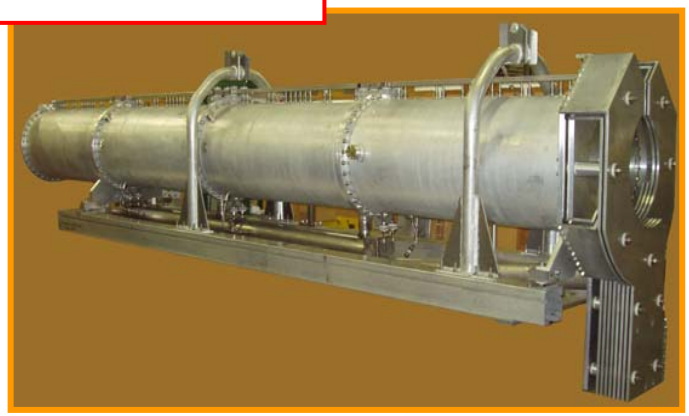
Only CERN had developed a prototype and made a lot of studies (see NUFACT-NOTEs):

1. Power supply
2. Vibration measurements

Beyond that program only thinking may be presented here…

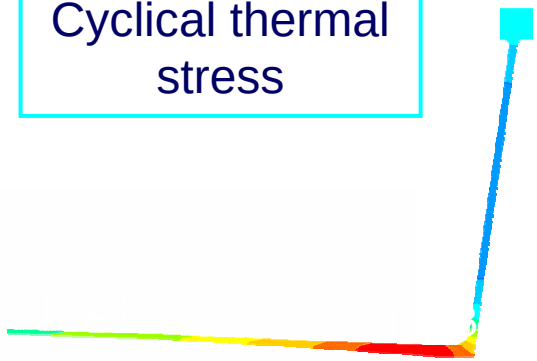
From CNGS experience

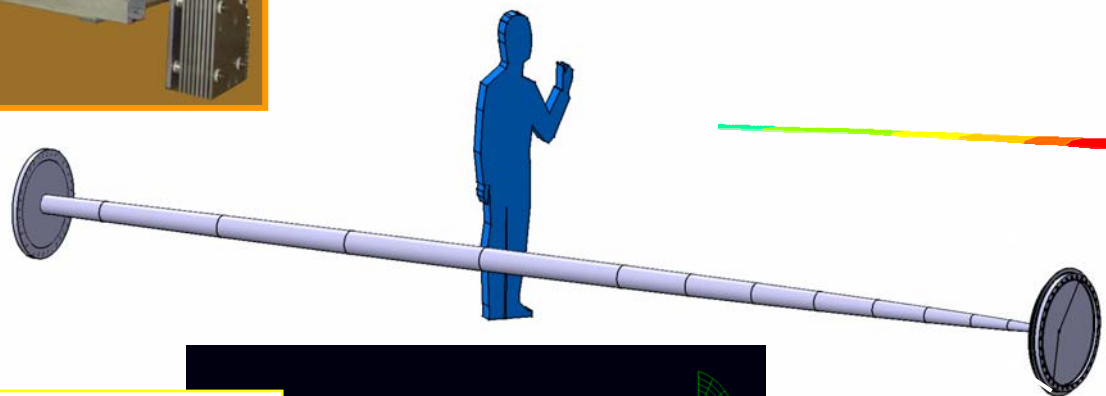
Realisation



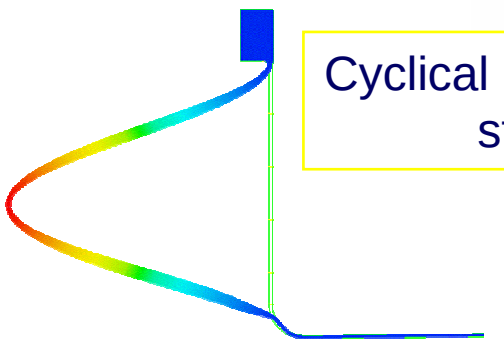
Thermal study

Cyclical thermal stress

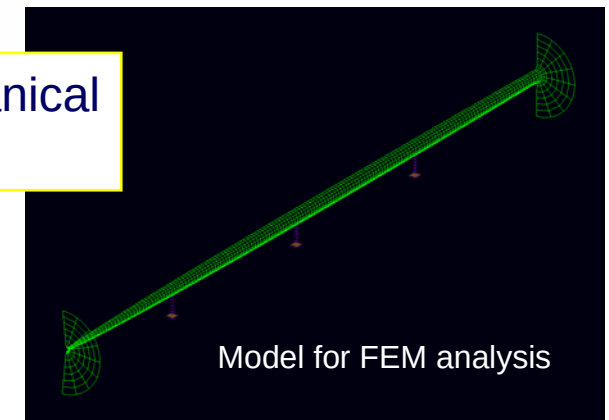


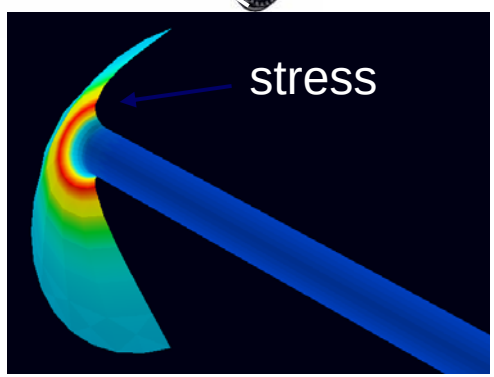


Dynamic study

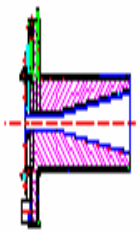


Cyclical mechanical stress



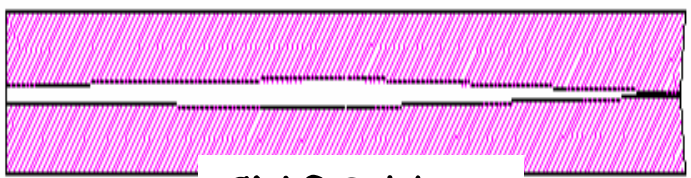


CNGS vs SB/νFact HORN

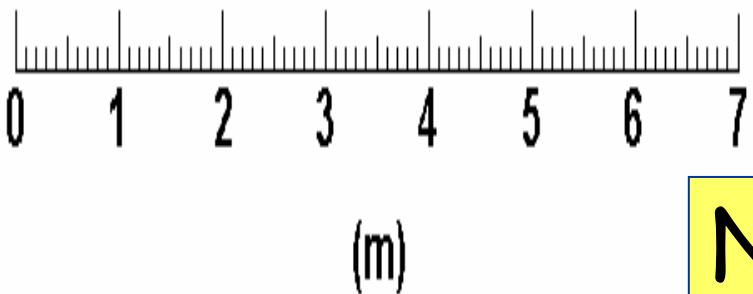


SB/νFact CERN proto

P_{beam} = **4MW** / 2÷3GeV, **Target inside**
300kA/50Hz/100μs
200 M pulses/6 weeks
Neck: P_J = 7kW, P_B = **63kW** (8mm eq. Alu)
10^{22} fast neutron/cm²/6 months



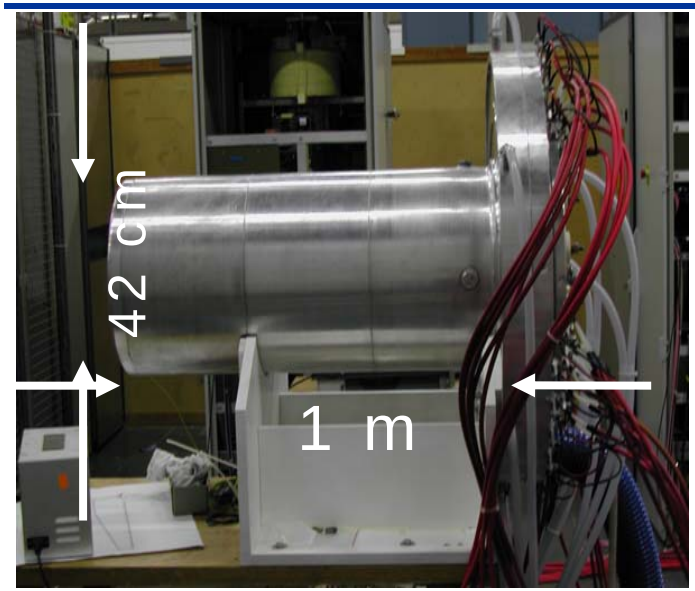
CNGS Horn

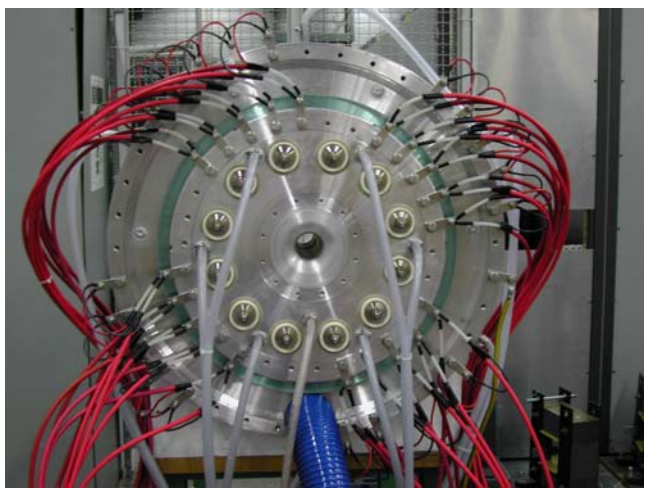


P_{beam} = **0,4MW** / 400GeV, **Target outside**
150kA/2pulses 10μs-6s
20 M 2pulses/5 years
IC: P_J = **13kW**, P_B = 5kW (2mm Alu)

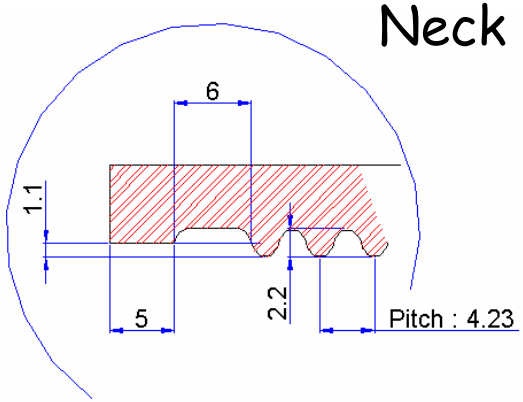
New R&D are required !

CERN prototype (2001-2002)





Neck



Water cooling

(NUFACT-NOTE : 4, 28, 42, 80, 81, 126, 129)

Stress computation road map

1. Define a geometry via the physics requirements, *eg. CERN proto + adaptations*
2. Compute the magnetic pressure on the different pieces
3. Compute the stress, static + dynamic
4. And so on

Rather generic…

Horn vibration measurements

~ Longitudinal modes

~ Radial mode of I.C

Laser vibrometer measurements:

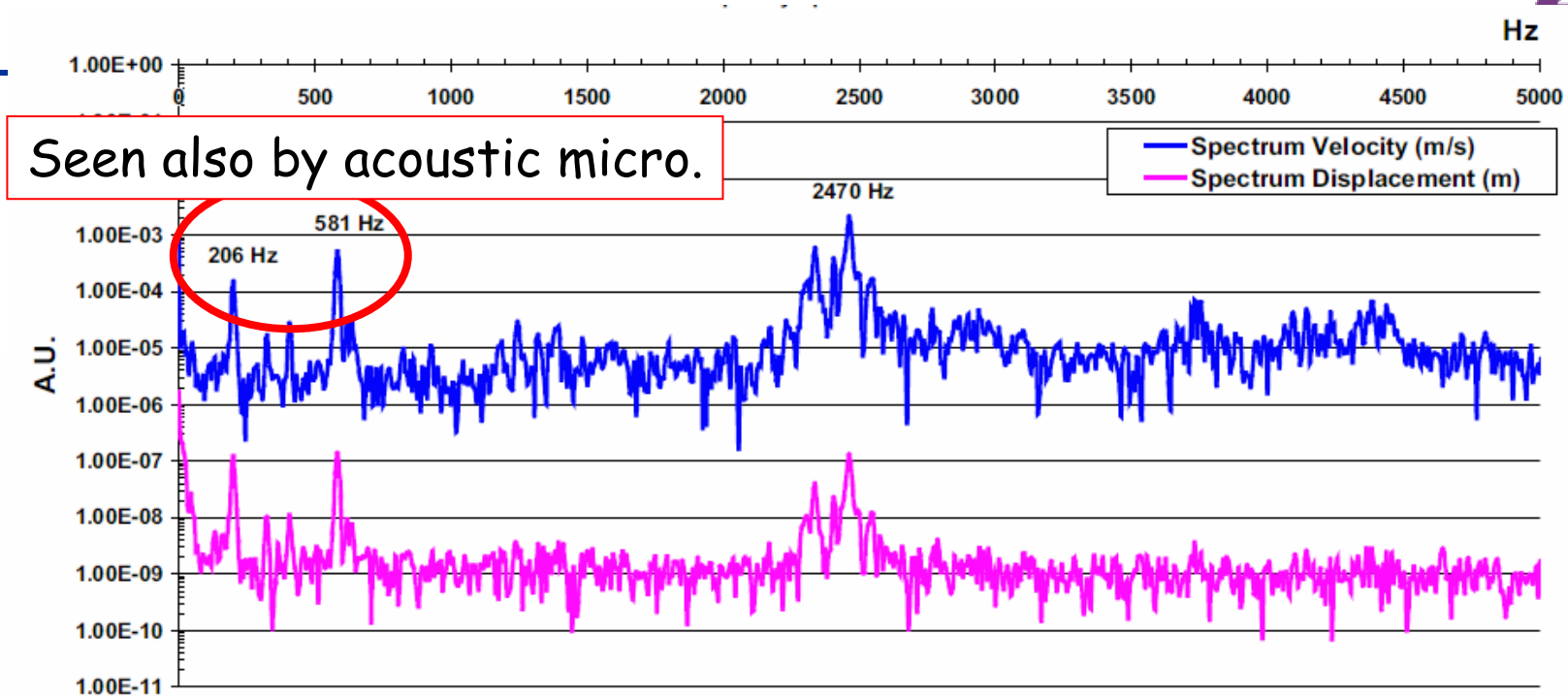
- displacements via phase difference
- velocity via Doppler shift

Laser Vibrometer	OFV-3001-22/303
Laser Type	He-Ne
Laser Class	2
Light wavelength	632.8 nm
Power	1 mW
Frequency range	1 Hz - 1.5 MHz
Min. displacement	1 nm

Validated with the CNGS horn

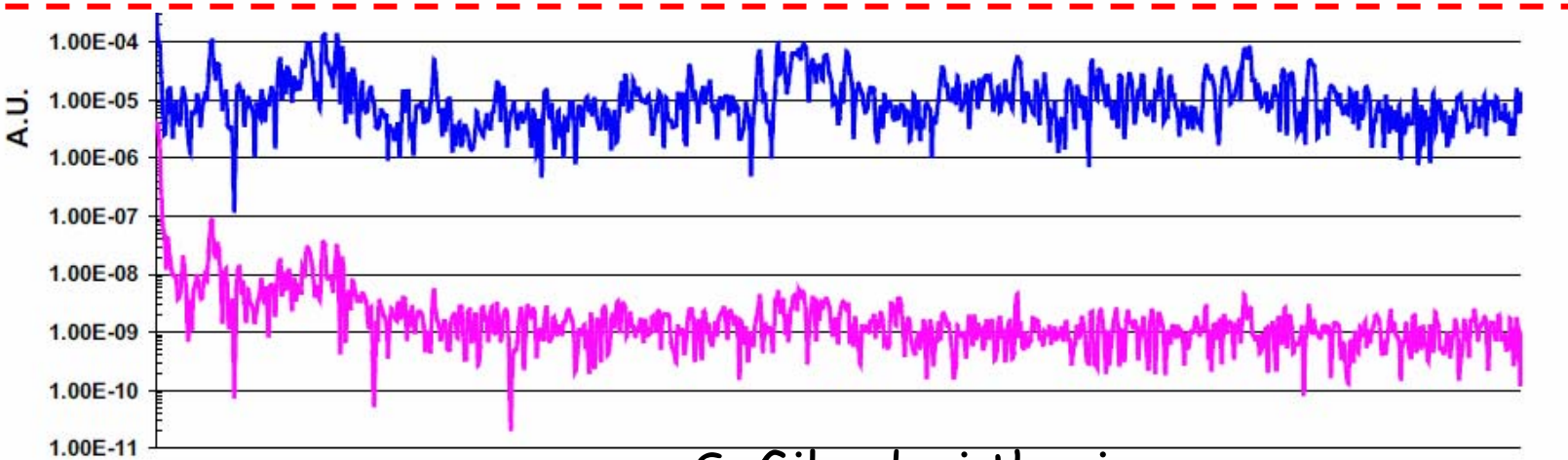
S. Gilardoni thesis

Dumping by the water cooling



Seen also by acoustic micro.

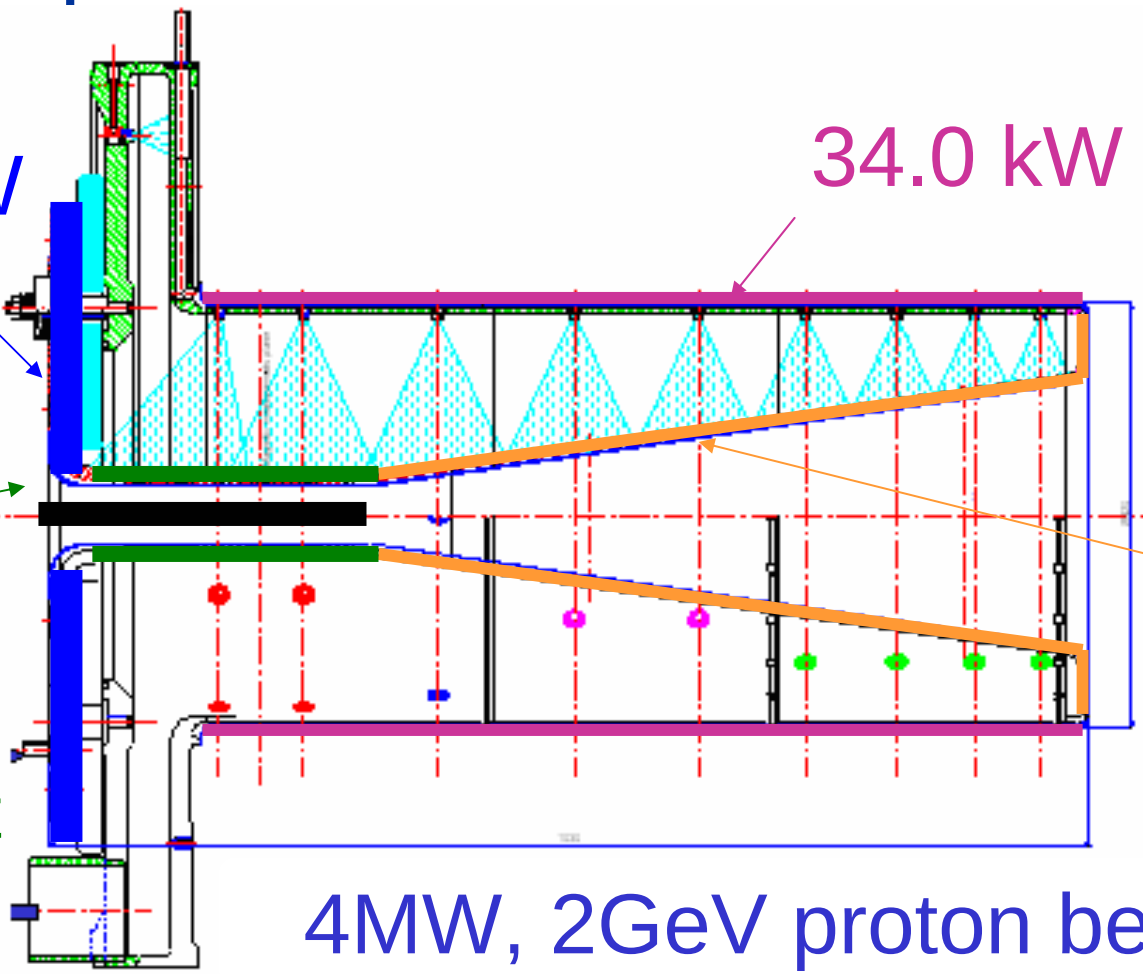
Without water cooling



With water cooling

S. Gilardoni thesis

Energy deposition in the horn



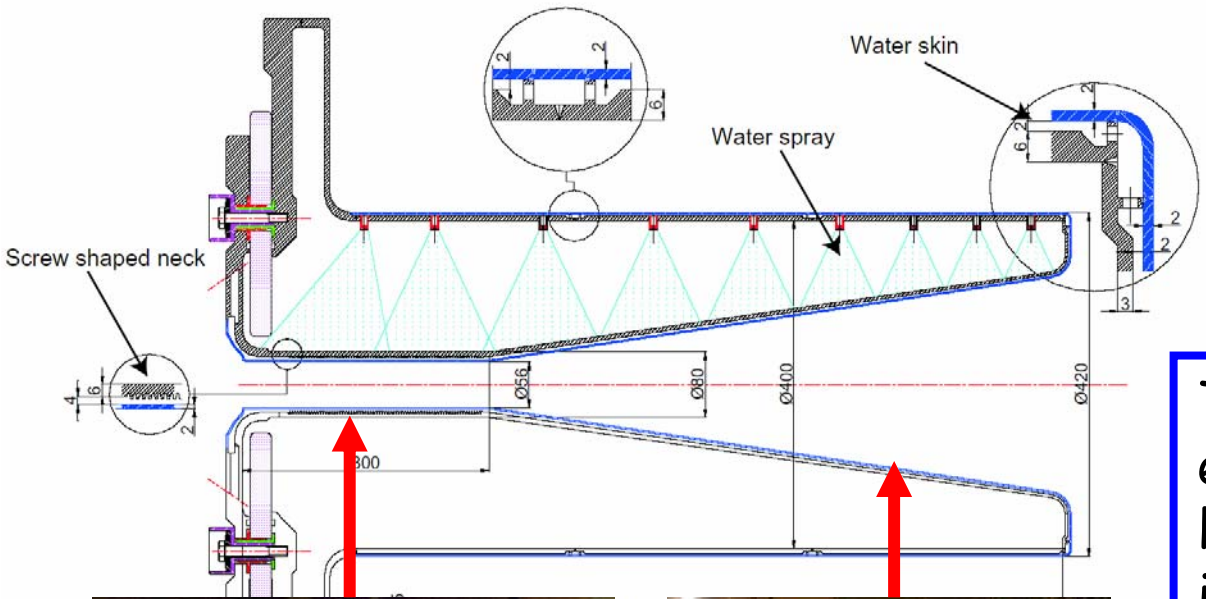
4MW, 2GeV proton beam

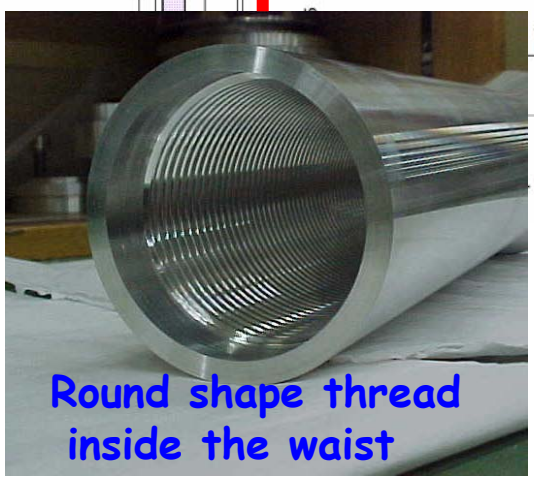
Solution under investigation : reduced Al thickness (3mm Al) + strength rings

A. Cazes + JEC

Nufact-Note-134

Horn cooling (CERN schema)

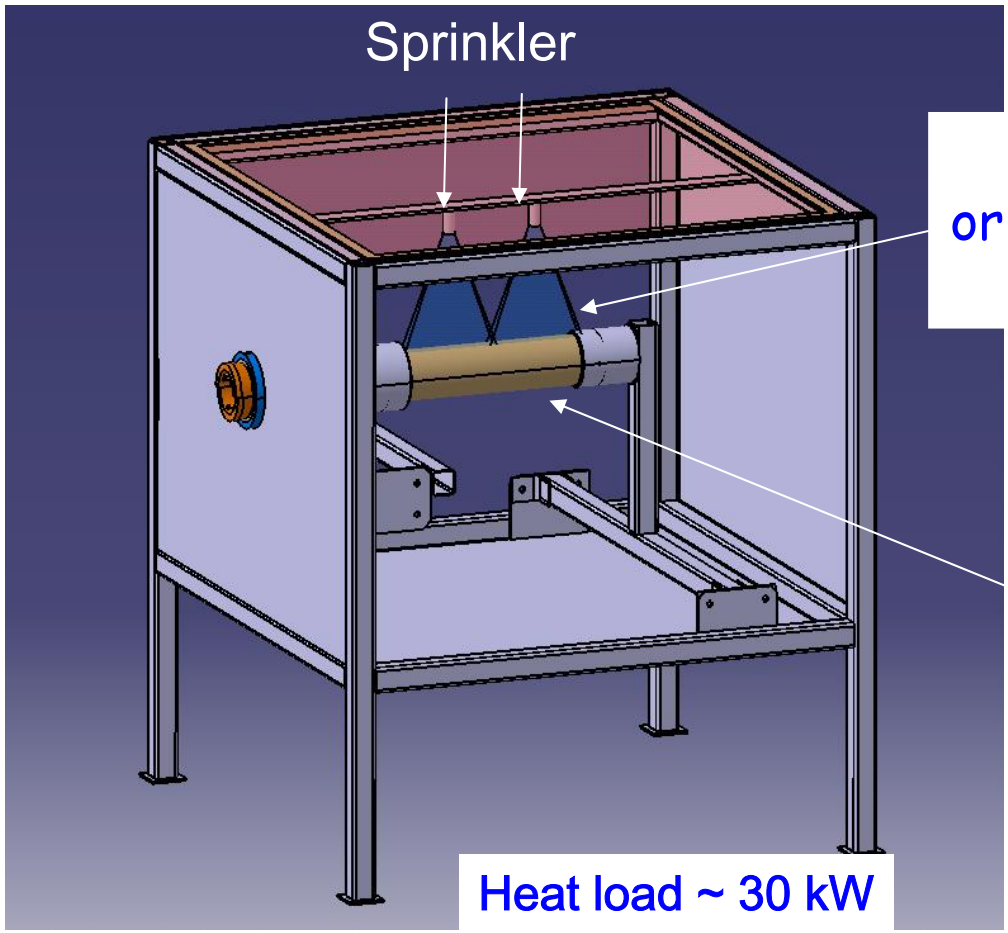




The gain in surface exchange is somewhat lost by the thickness increase and then the heat load increase…

20kW/surface exchange
275kW/m²

R&D: water cooling ok?



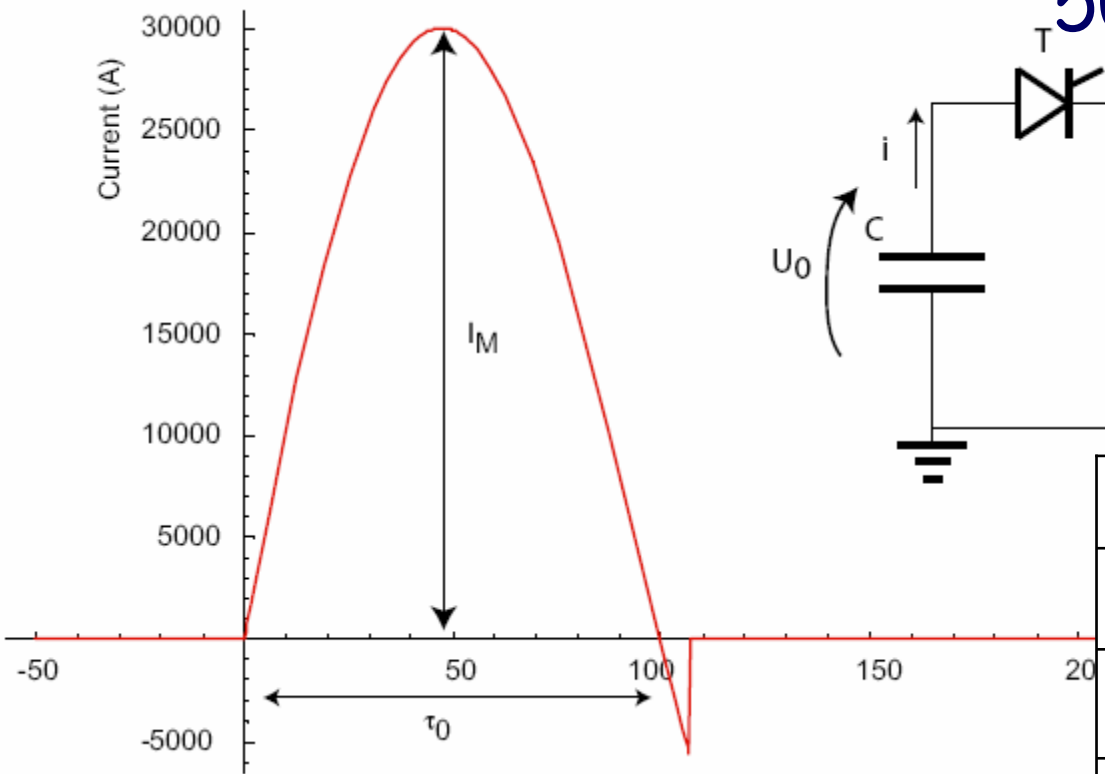
Water curtain
or other water jets
configuration

Aluminum alloy cylinder
80 mm ext. diameter
300 mm length

No green light to continue at LAL…

Power Supply (basic)

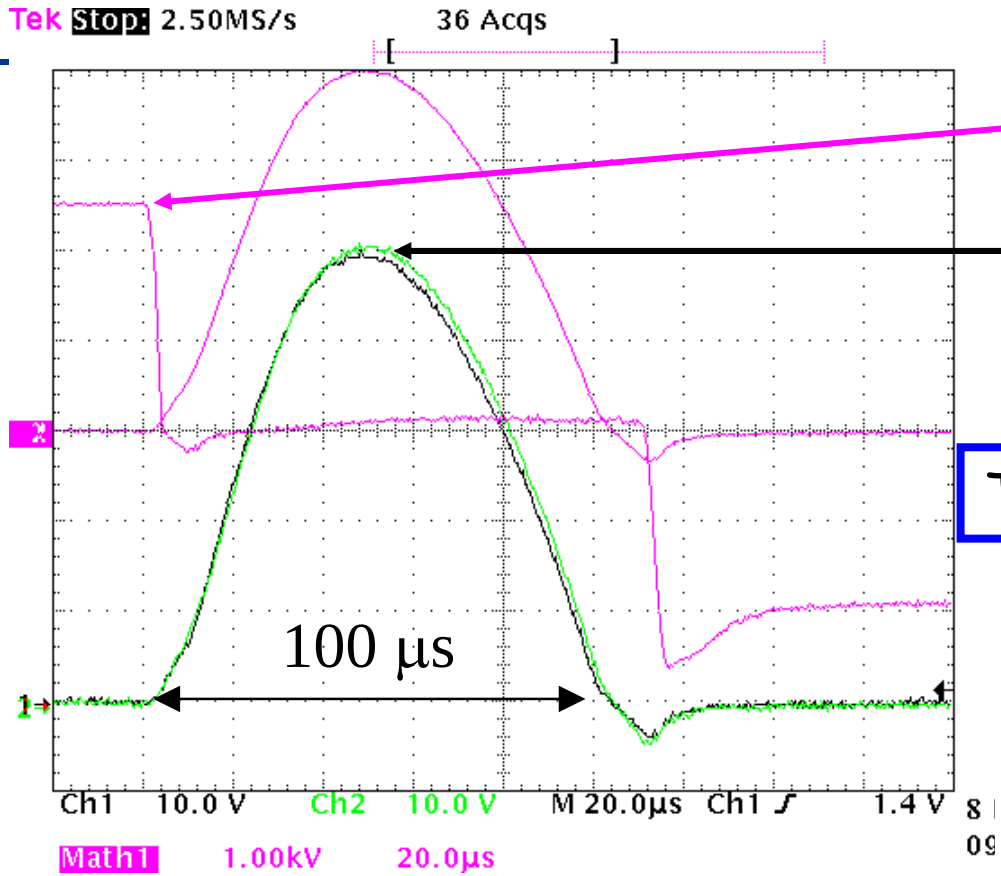
50Hz thyristors



U_o	7kV
I_M	300kA (14,5 rms)
τ_o	100μs
L	0.6 (0.4 Horn)μH
R	500 (180 Horn) μΩ
C	1500μF

50Hz: 20 x « μ life time »

Power supply last CERN prototype: 100 kA – 0.5 Hz



Voltage on horn/thyristor: 2.5 kV

Current first/second unit 50 kA

Total current on the Horn: 100kA

This is the Limit for the existing equipment:

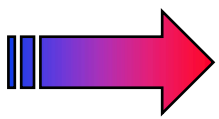
– Max voltage on thyristor

– Max rep rate for resistors

S.Gilardoni thesis

Power Supply

- CERN had successfully tested the Horn at 100kA/(0.5)Hz
- mid-June 03: a schedule of conditions have been written by LAL (13p) for a (300kA/100μs/50Hz) power supply.
- 1st industrial price feed back:
  1. Main power supply (7kV/130A): HAZEMEYER co.: ~ 160k€
  2. Switches (300kA/100μs/50Hz): ABB co: ~ 3x2x50k€* = 300k€

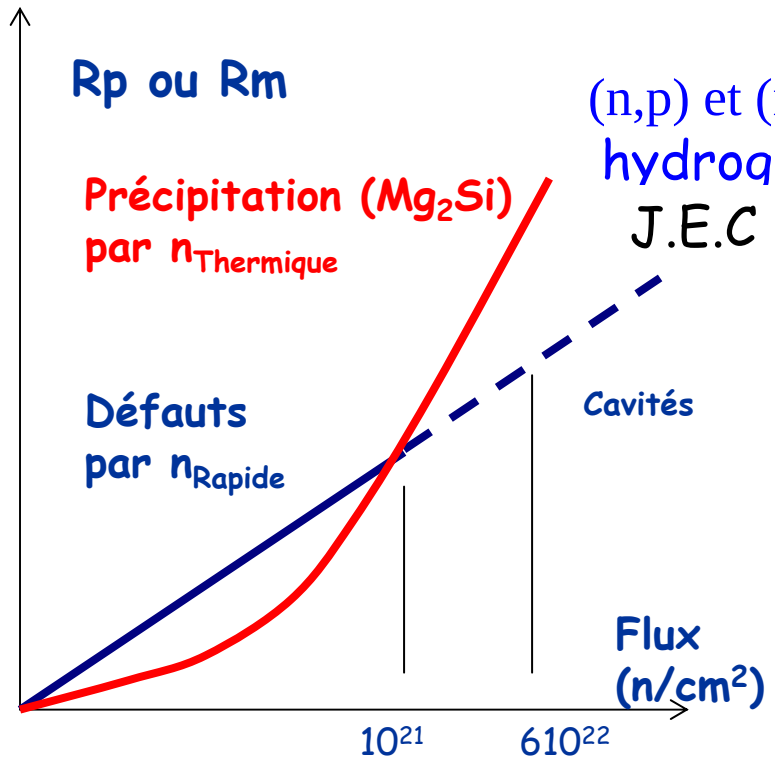


A solution exists for ~ 460k€ (700kCH)

But we think that a 300kA/1Hz may be a good next step to push the present CERN power supply prototype..

*: factor 2 for # of switches, factor 3 for 1Hz -> 50Hz

Al alloy property modifications



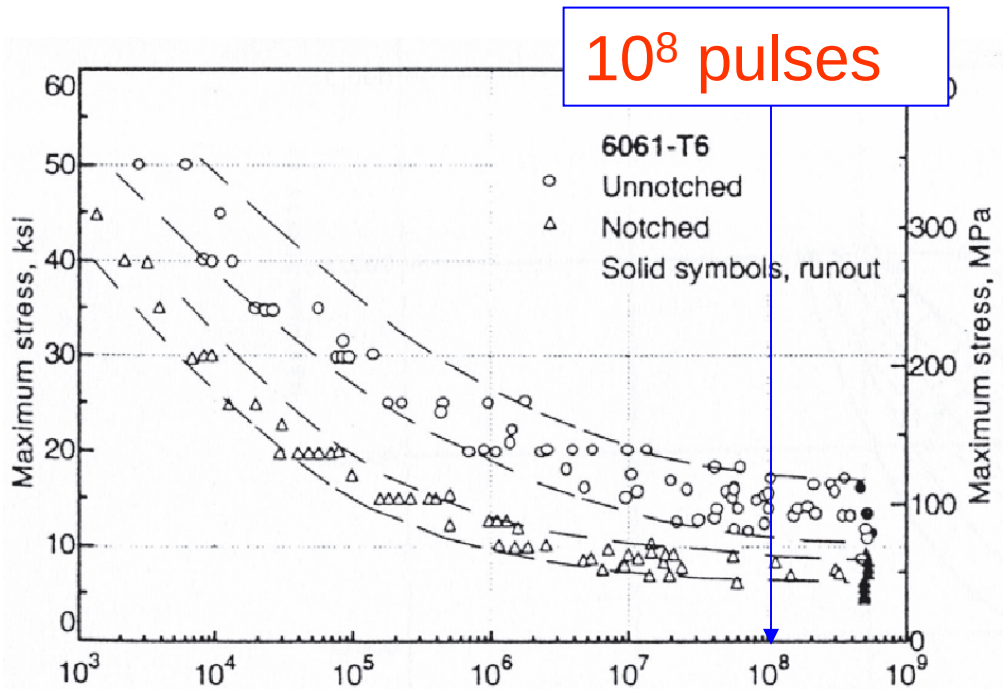
(n,p) et (n,α) reactions produce hydrogen and helium cavities

J.E.C NuFact-Note-130

6082 (CNGS) or 6061 (MiniBOONE)

Non irradiated Al can stand more than 10^8 pulses

And also MiniBOONE…



Max. stress ~ 14MPa to be confirmed

Other problems…

- Integration of the Target
- Compatibility with Hg
- Radioactive water cooling treatment
- Water Cooled Striplines
- Fabrication cost issues if the life time of a horn is < 1y
- Fast Coupling (cooling & electric) remotely controlled
- Nuclear waste management

…

Some costing

For a electrical test at 300kA/1Hz : >150k€

Striplines	Not yet estimated
Cooling (Horn + Striplines)	20k€ (from CNGS)
H.V.	~10k€
switches (300kA/1Hz/100ms)	2 x 50k€ (ABB)
Capacity (1500 mF)	24k€ Atesys)

Horn	100k€ (CERN prototype cost)
H.V. + switches 300kA/50Hz/100ms	460k€ (ABB & Hazemeyer)
Cooling Test	5k€
Fatigue curves (non irradiated)	5k€ (CNAM)

LAL SC has just decided to stop any new R&D (8/10/04) New comers are urgently welcome!

END

New Protocol CERN-IN2P3-LAL

LAL Responsibility:

1) Horn & Reflector Supports
2) Fast Coupling System
3) Reflector Inner Conductor
4) Reflector and Horn-2 assembly/modifications
5) Horn & Reflector + FCS + Supports drawings

IN2P3 contribution
650k€ material
+
20 men.years

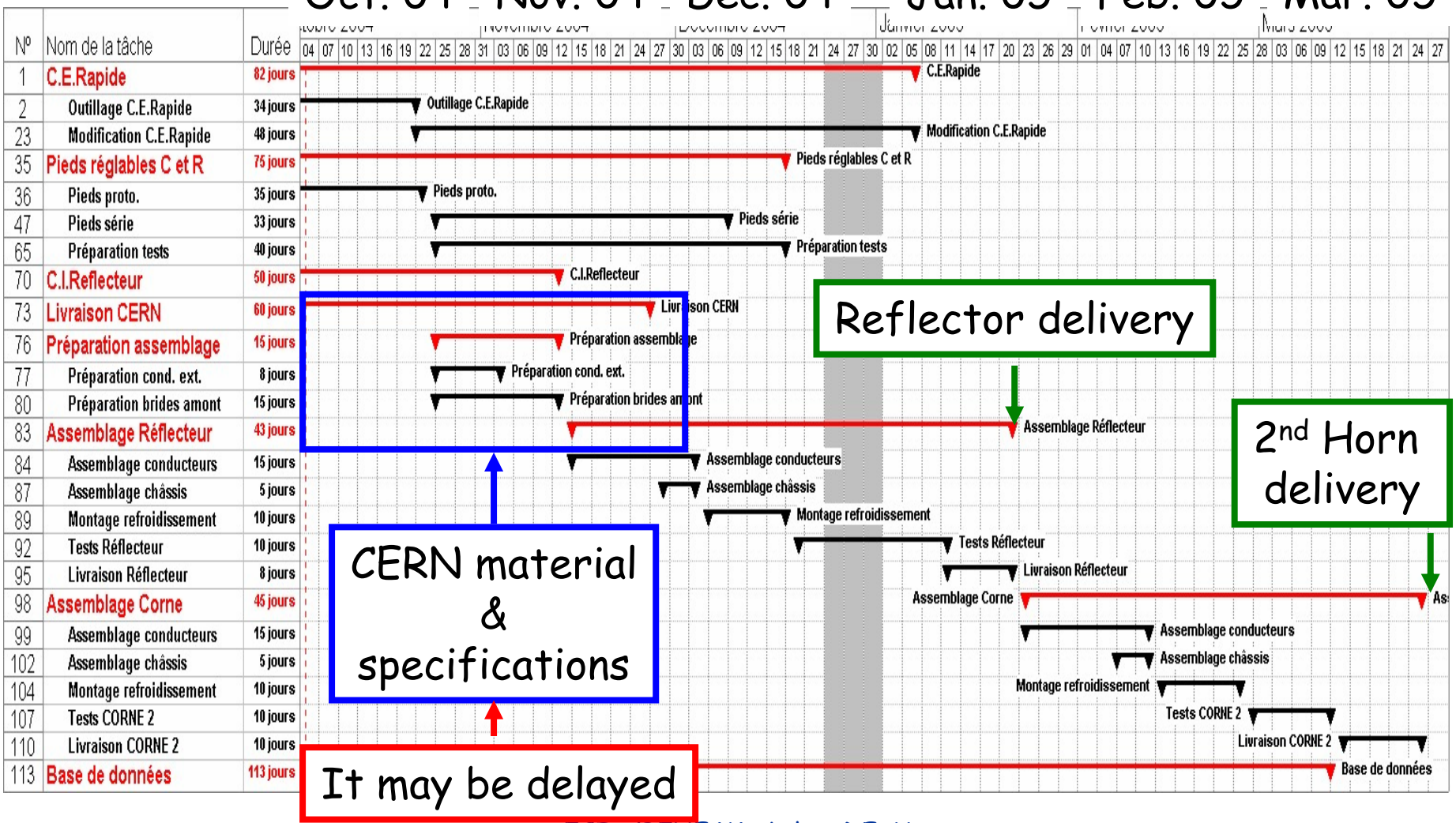
CERN Responsibility:

1) Striplines
2) Water cooling systems
3) Horn-1 modifications and the specifications for Horn-2 & Reflectors

Estimate at
> 300k€
+
manpower

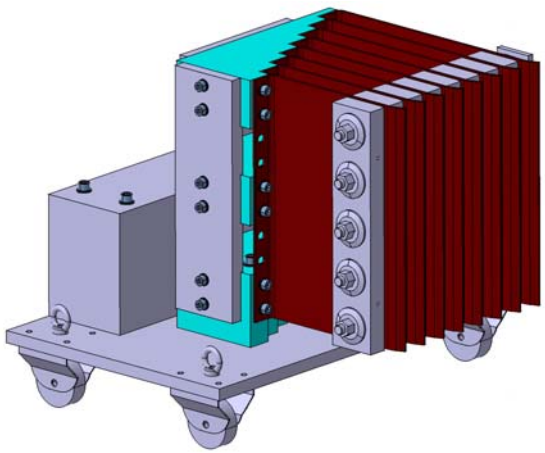
More or less a factor 2 in human and money resources w.r.t 2000

Planning (preliminary)

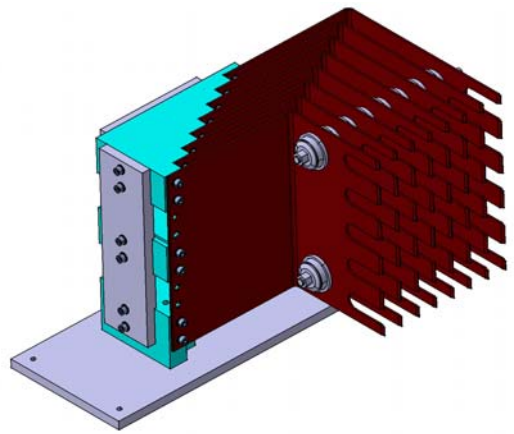


F.C.S : new prototype at LAL

We are now engaged in a full scale prototype test bench at LAL



Start test early
October 04



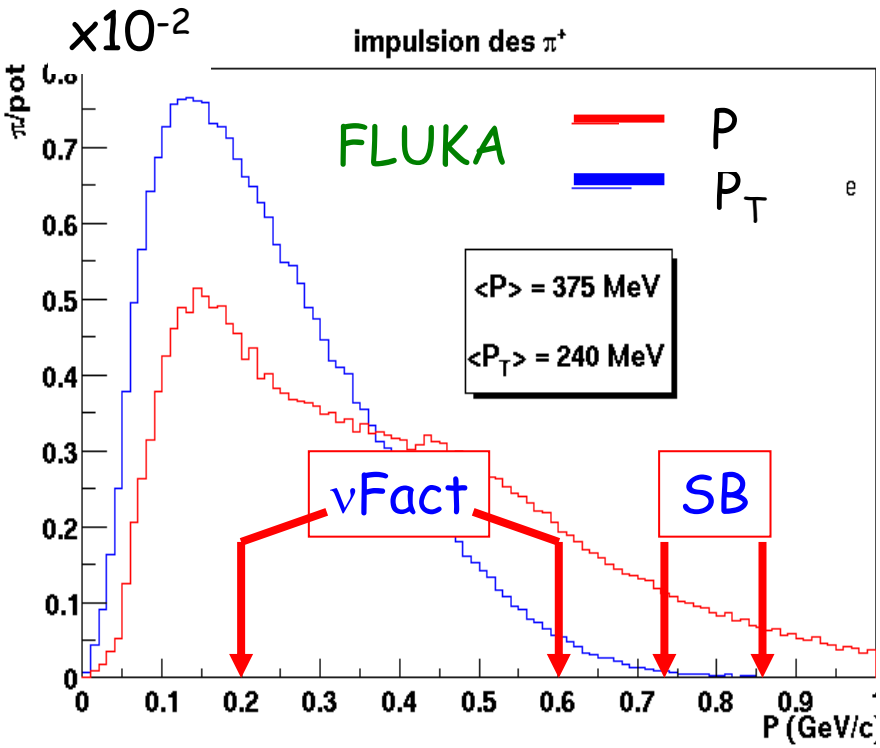
Strip-line "simulation"

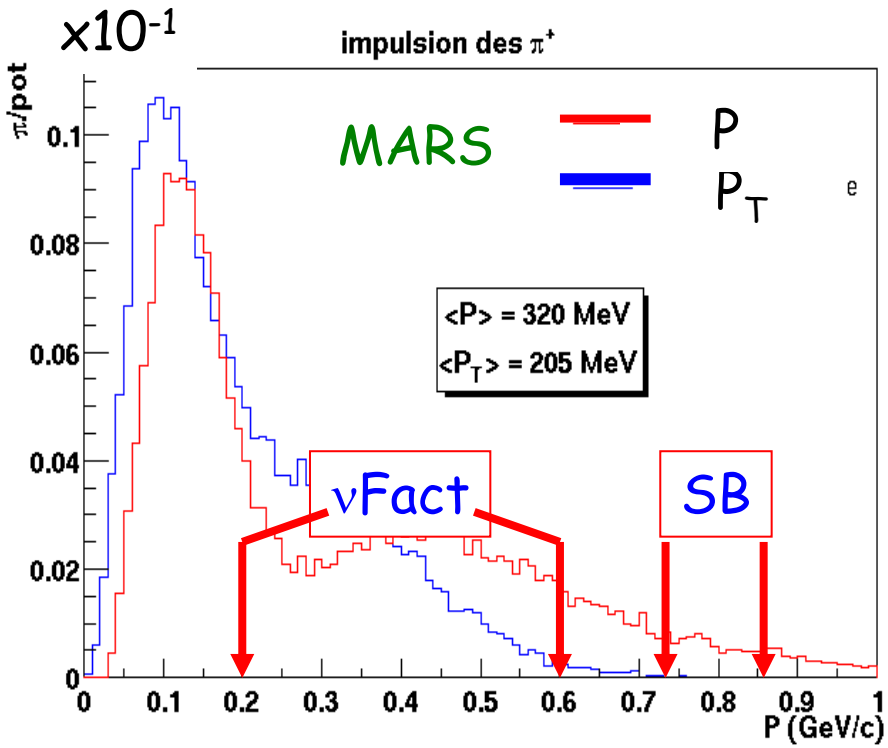
Test the ARCLEX bar fixing, the spacing operation as well as the F.C.S plug in.

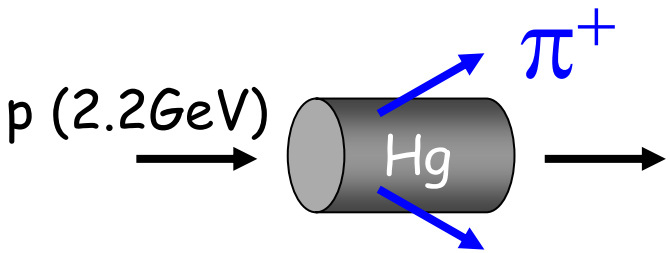
Horn "simulation"

This should answer to: How to design a mounting tool and a mounting scenario to guaranty the geometry ?

Pion momentum







π+(no cut)/p.o.t = 0.24 (FLUKA & MARS)

Ø = 15mm, L = 2λ =300mm