# CNGS proton beam

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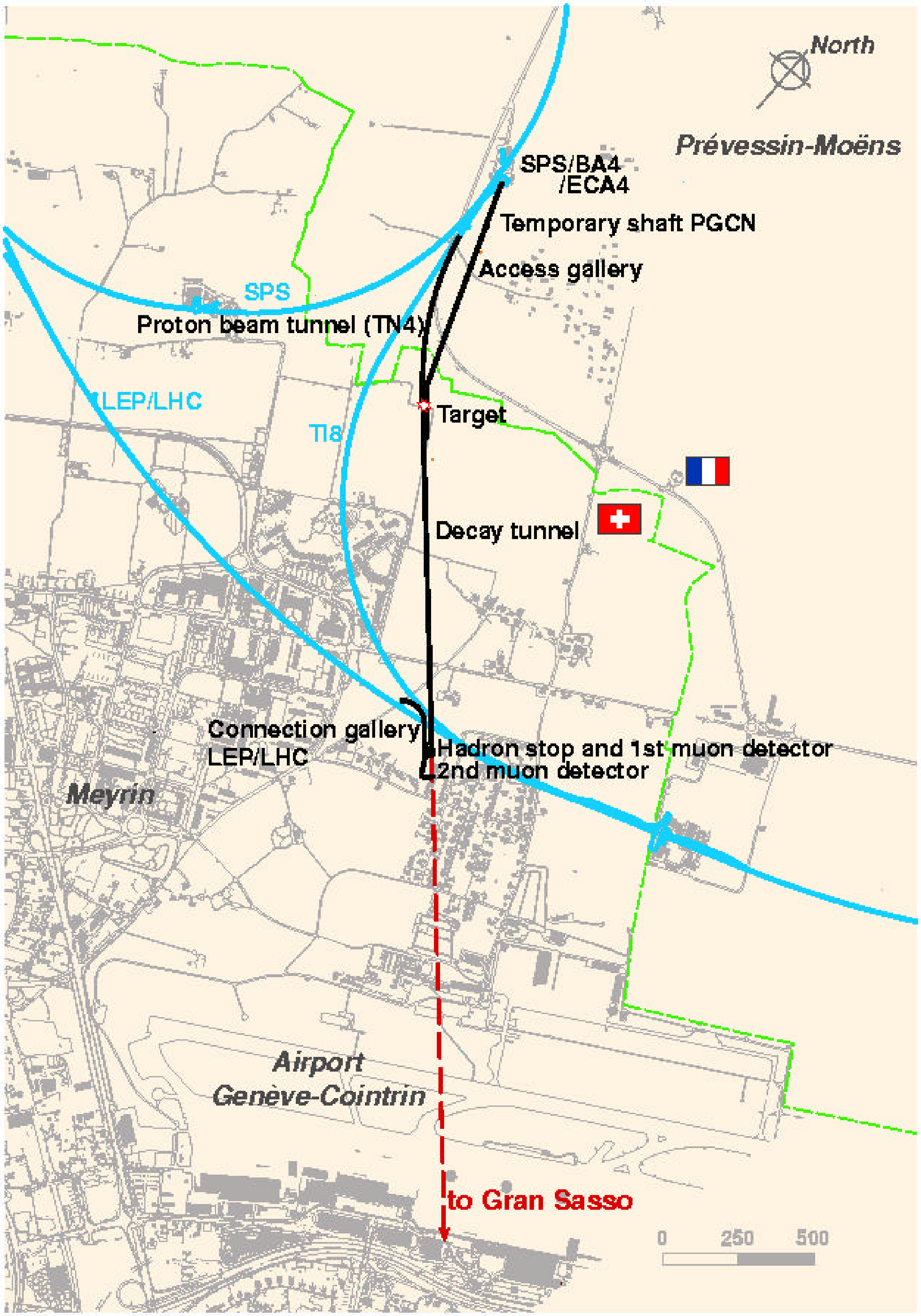
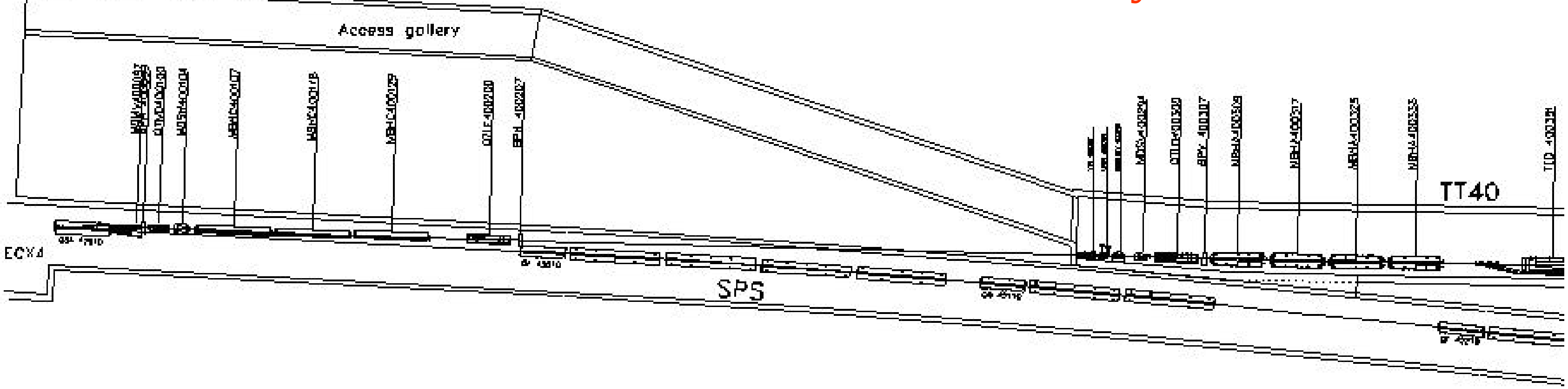
**for SL/BT group**
**CERN**

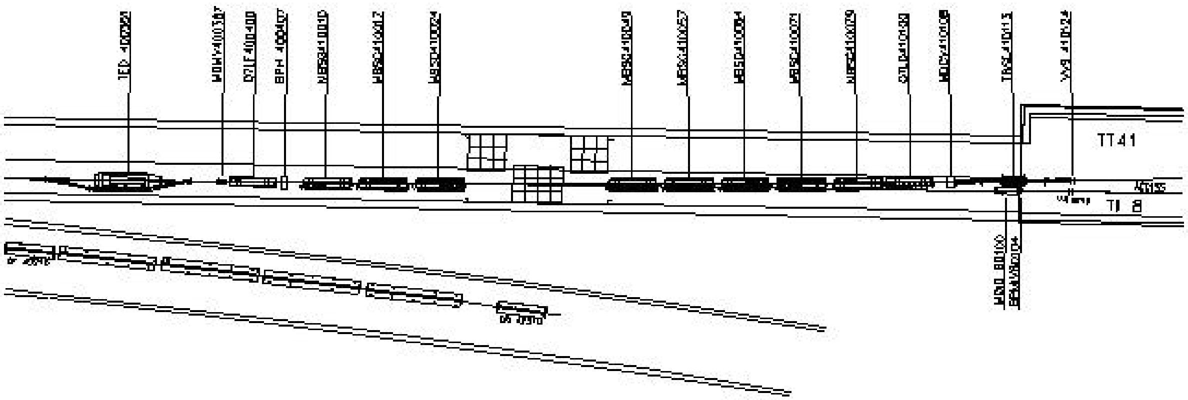
# CNGS proton beam

- Layout of the proton line
- Beam parameters
- Extraction channel
- New magnets
- Intensity limitations
- Requirements for beam instrumentation

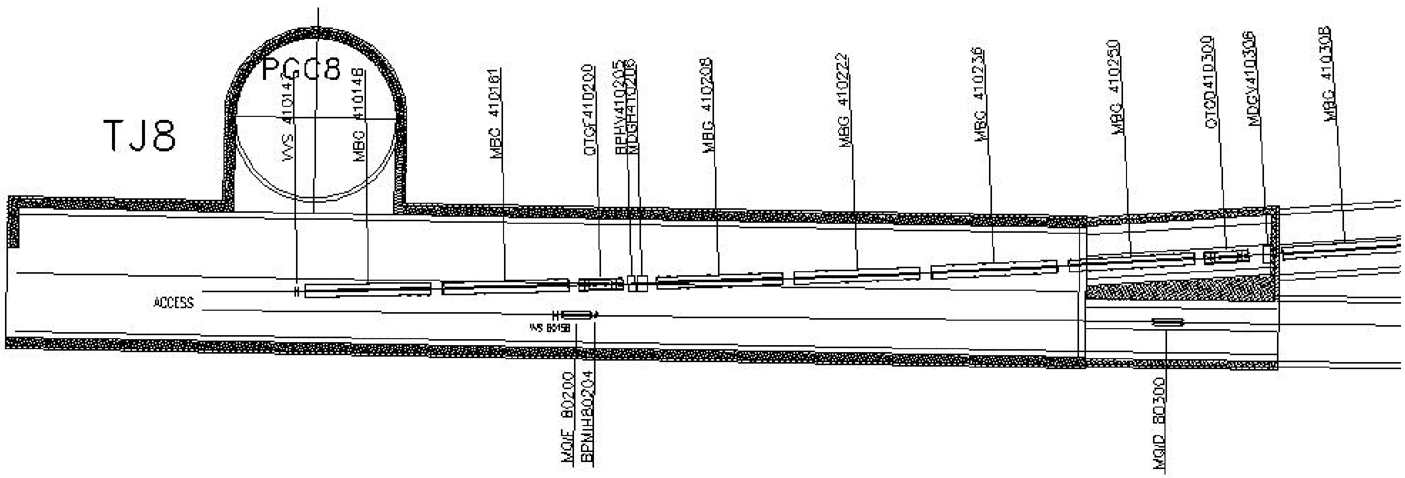

North
Prévessin-Moëns
SPS/BA4
/ECA4
Temporary shaft PGCN
Access gallery
SPS
Proton beam tunnel (TN4)
LEP/LHC
TI8
Target
Decay tunnel
Connection gallery
LEP/LHC
Hadron stop and 1st muon detector
2nd muon detector
Meyrin
Airport
Genève-Cointrin
to Gran Sasso
0
250
500

# Transfer line layout

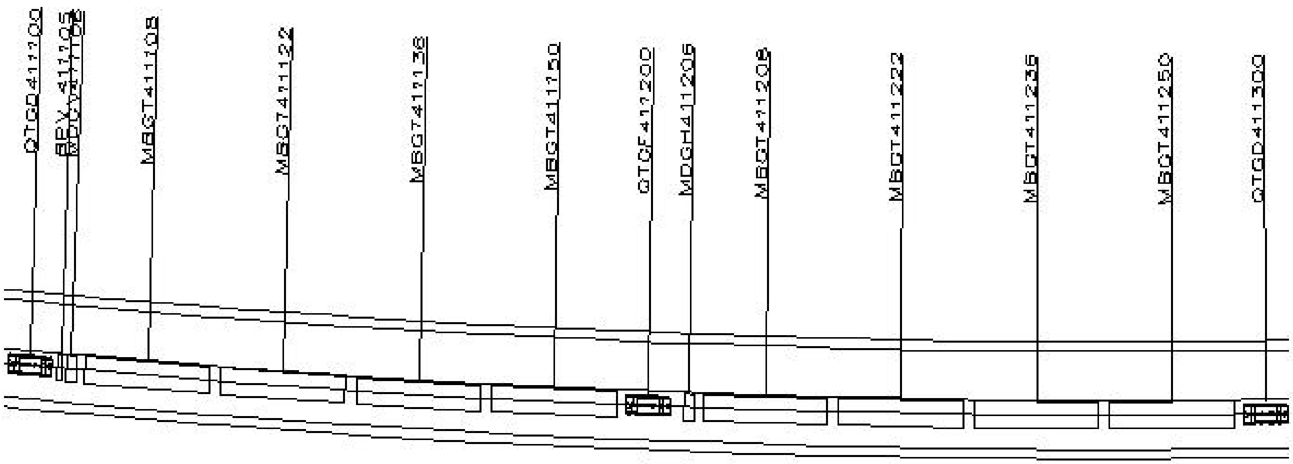


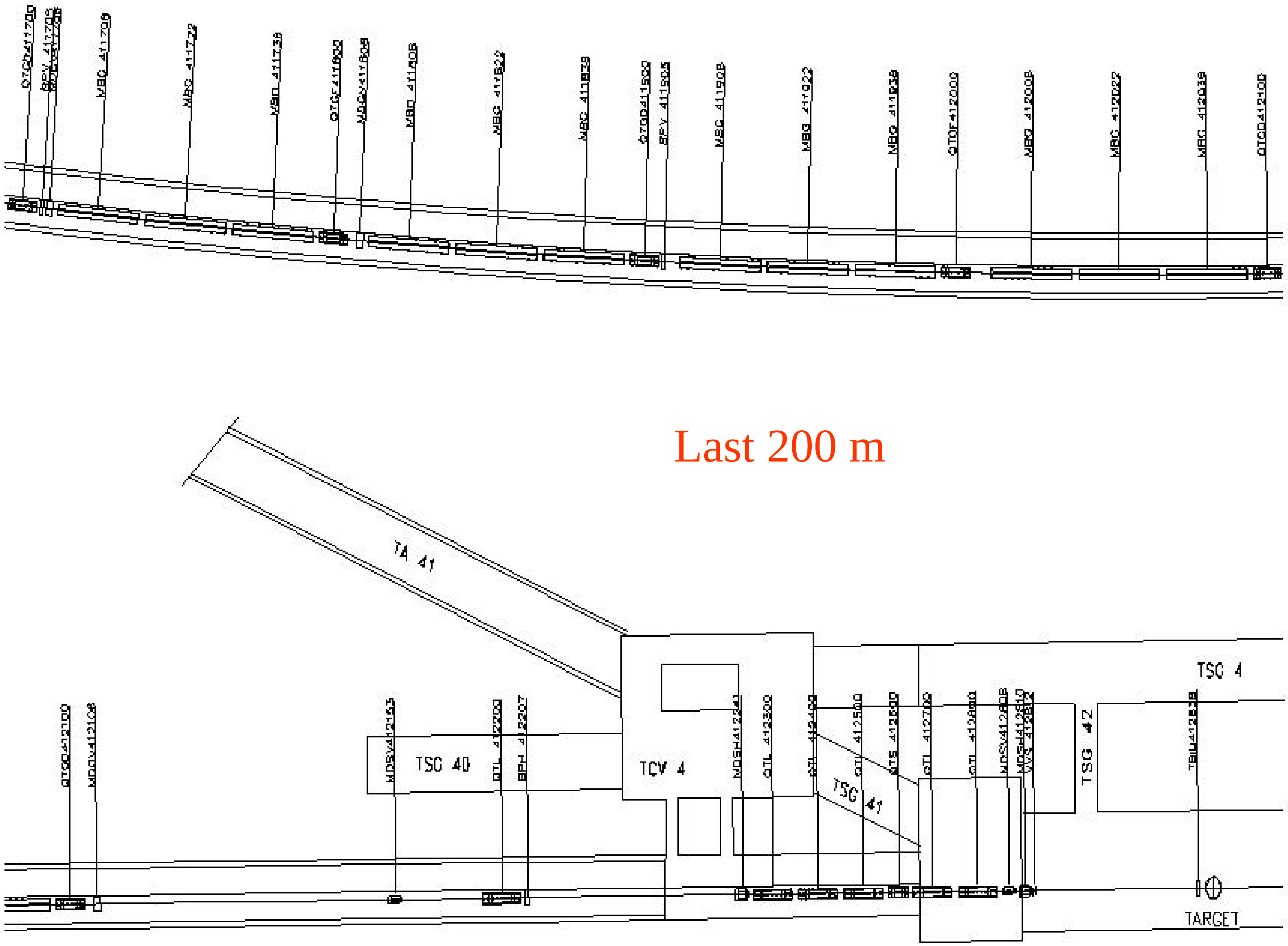
# Transfer line layout : branching Off



# Transfer line layout : half cell



## Last 200 m

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# Beam parameters

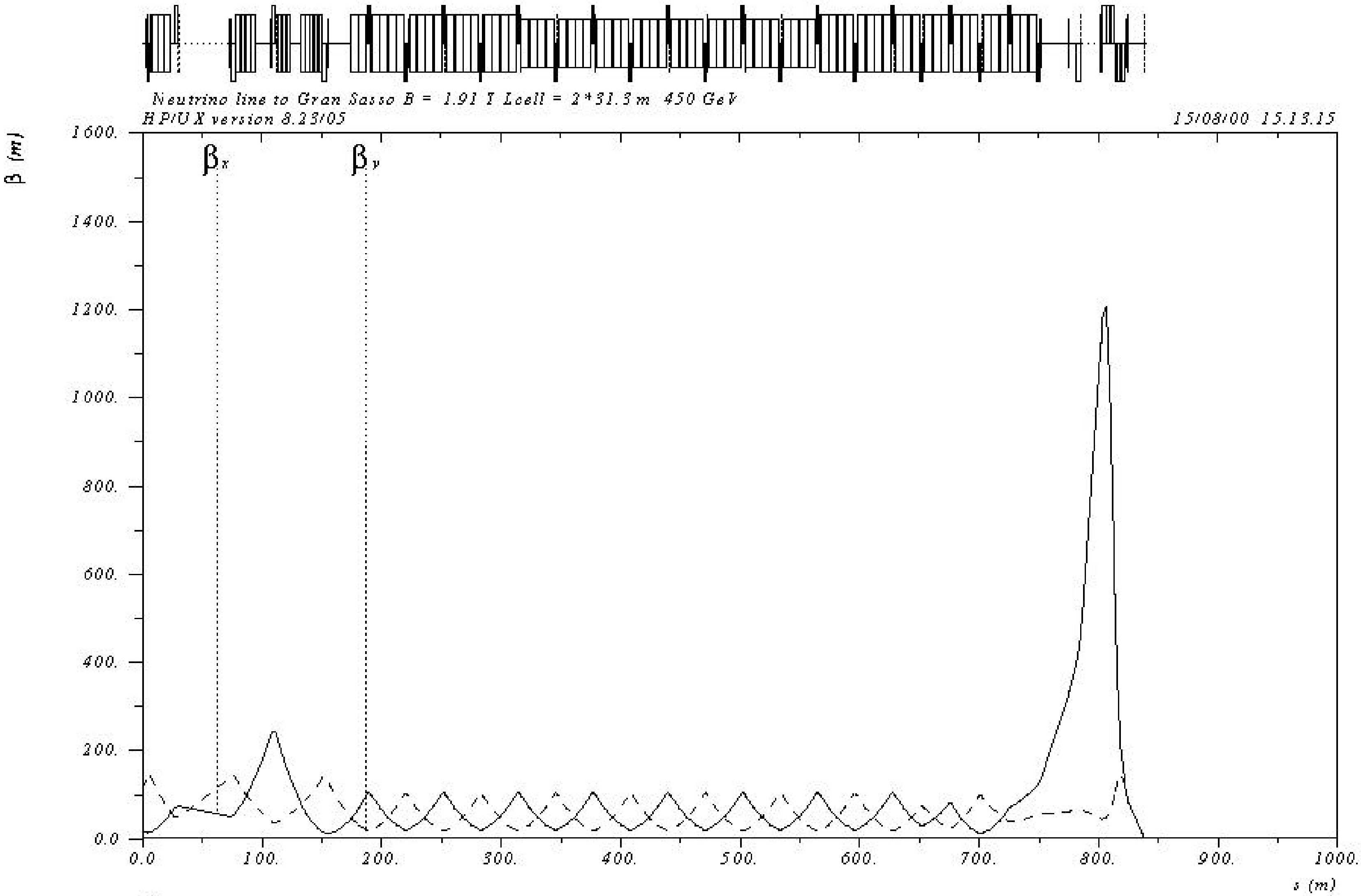
| Beam parameters | CNGS beam |
|---|---|
| Nominal energy | 400 GeV |
| Normalized emittance | 12 ❍m |
| Emittance | 0.028 ❍m |
| # of extractions per cycle | 2 separated by 50 ms |
| # of train per extraction | 1 |
| # of bunches per train | 2090 |
| Intensity per extraction | 2.4 $10^{13}$ p |
| Bunch length (4s) | 2 ns |
| r.m.s. bunch length | 15 cm |
| Bunch spacing | 5 ns |
| Train length | 10.5 ❍s |

# Optics at target

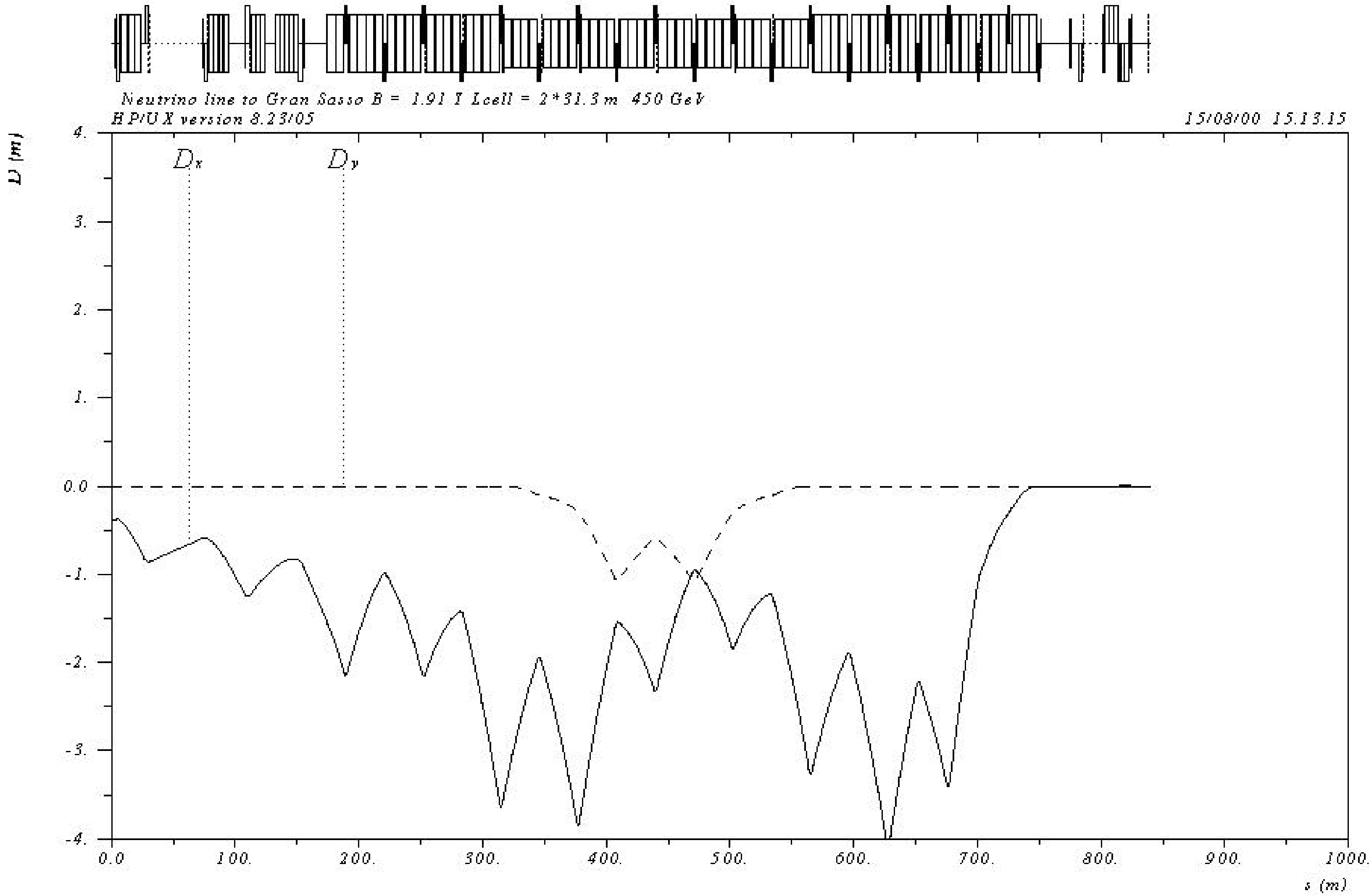
**Flexibility of the optics**

| | |
|---|---|
| $\beta^*$ at the focus (h/v) | 20 m to 2.5 m |
| → minimum beam size/maximum divergence | 0.27 mm, 0.1 mrad |
| $\Delta p/p$ | 0.12 % |

# The Beam Envelope



# Dispersion



Neutrino line to Gran Sasso B = 1.91 T Lcell = 2*31.3 m 450 GeV
HP/UX version 8.23/05
15/08/00 15.13.15
D (m)
Dx
Dy
4.
3.
2.
1.
0.0
-1.
-2.
-3.
-4.
0.0
100.
200.
300.
400.
500.
600.
700.
800.
900.
1000.
s (m)

# Trajectory correction scheme

Usual trajectory optimization criteria plus cost and space constraints

Optimized scheme two possible trajectory corrections:

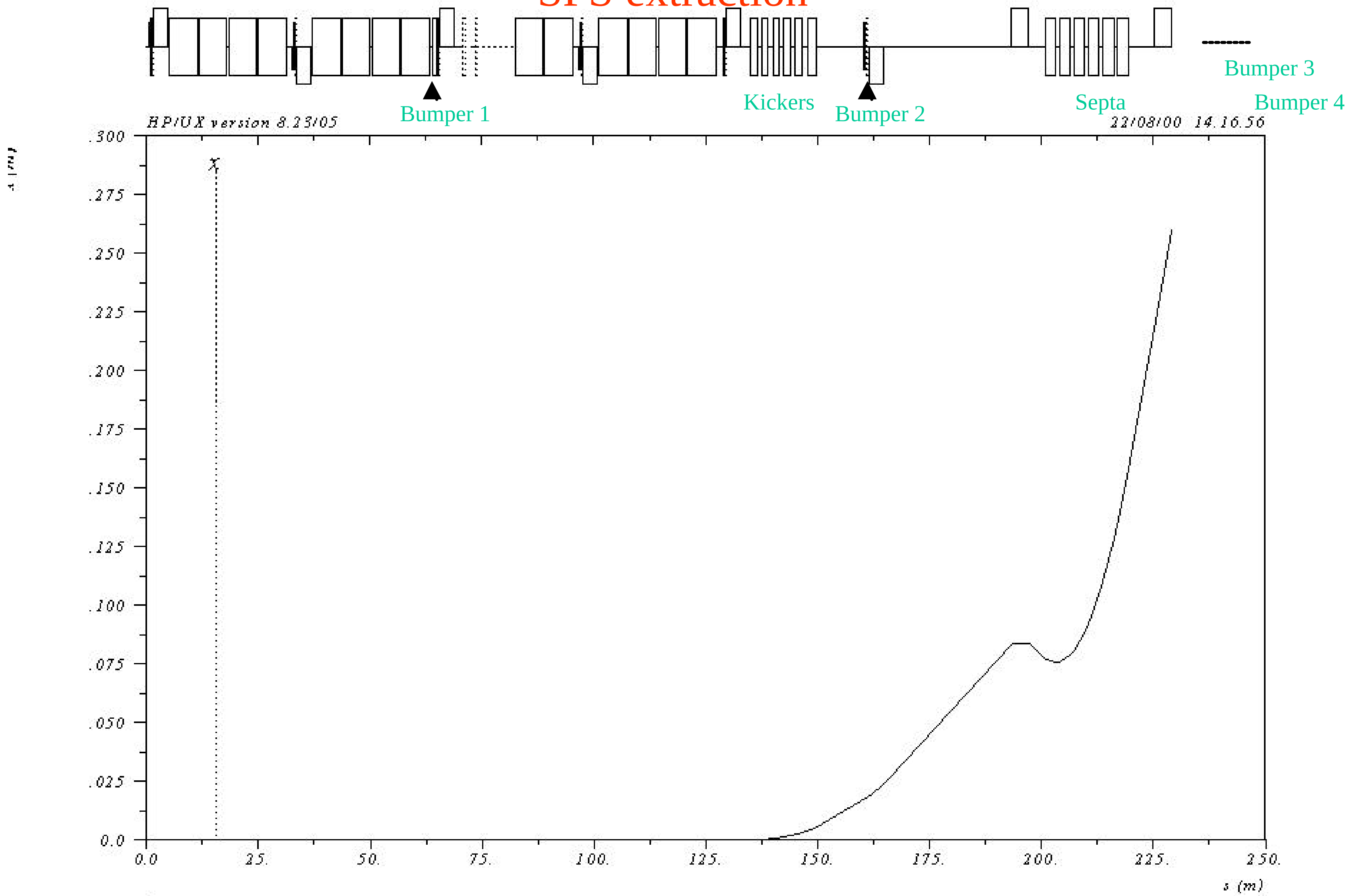
| **Mode** | **Peaks of 3 s orbit (mm)** | **3 s exit angle (mrad)** | **Monitor/Corrector counts** |
|---|---|---|---|
| 1-to-1 | X: 2 peaks @ 3.1<br>Y: 2 peaks @ 3.2 | X: 0.05<br>Y: 0.085 | X: 10 / 10<br>Y: 10 / 10 |
| Over-constrained | X: 1 peak @ 2.7<br>Y: 2 peaks @2.7&2.9 | X: 0.05<br>Y: 0.085 | X: 10 / 7<br>Y: 10 / 8 |

Y. Chao

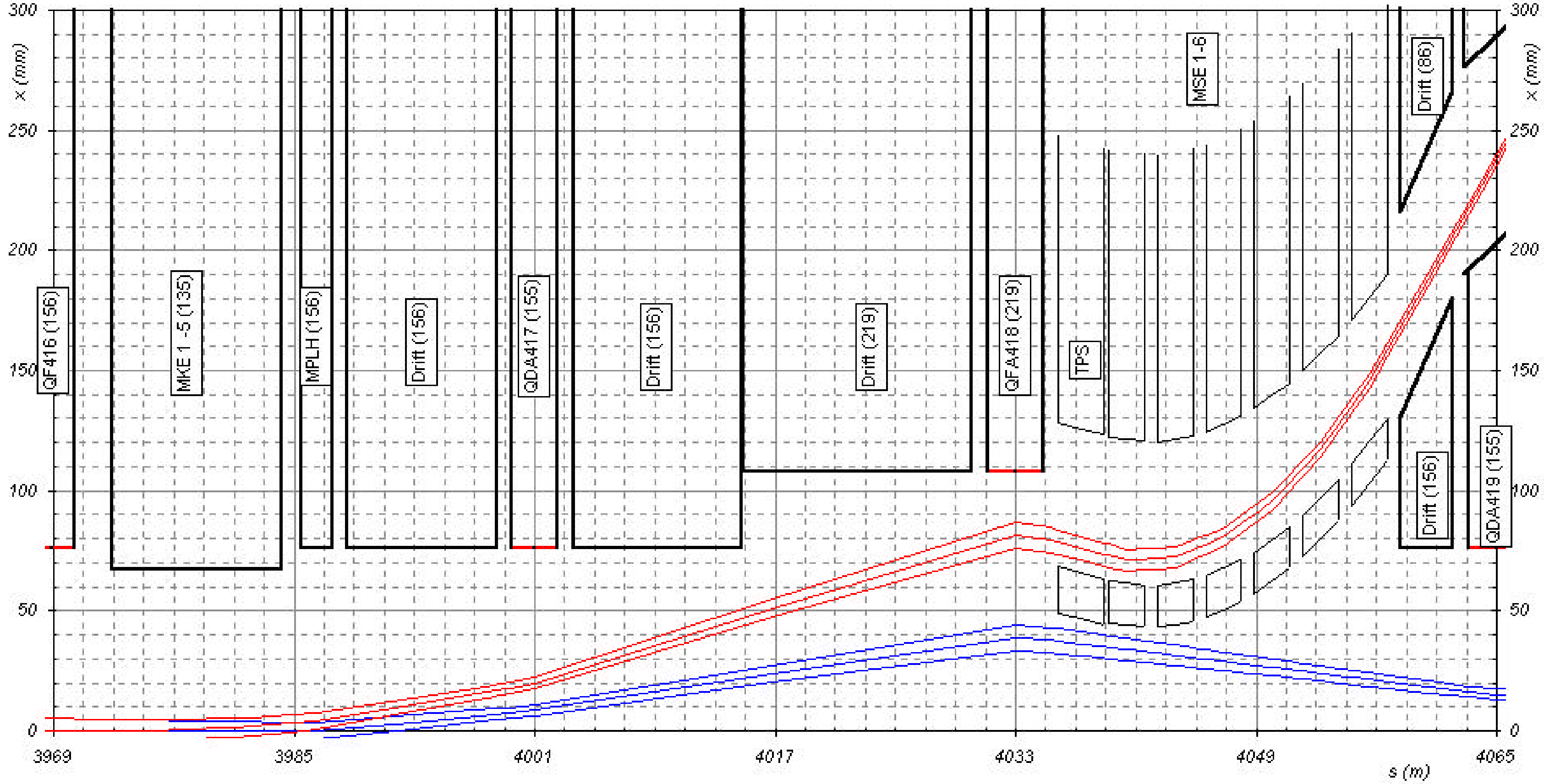
Analysis includes injection, alignment, field errors and monitor offsets.

Orbit and angle errors correspond to the values at 3 ♦ of the orbit error distribution

# SPS extraction

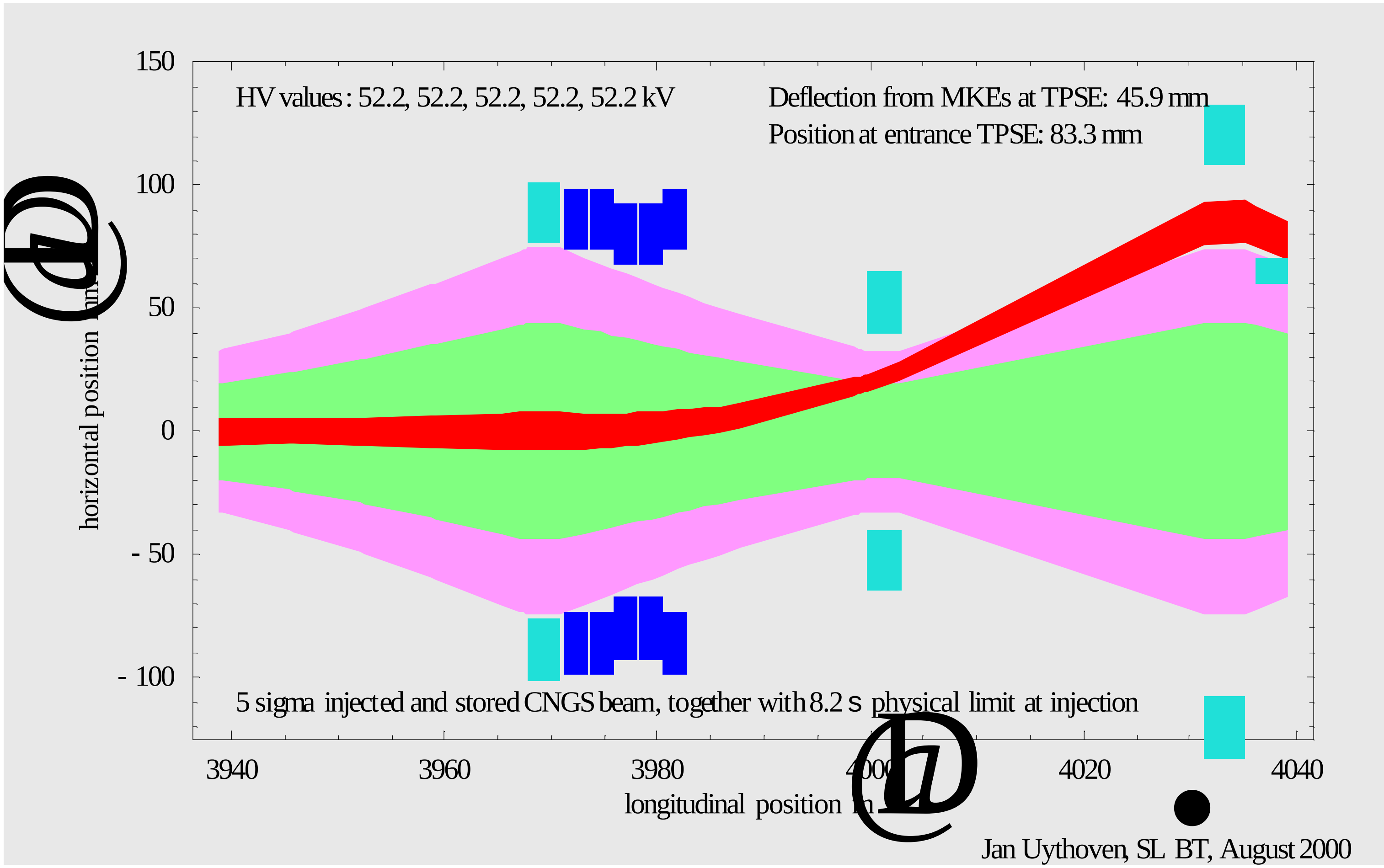


# Trajectories into the extraction channel




B. Goddard SL/BT

# MKE Kickers



HV values : 52.2, 52.2, 52.2, 52.2, 52.2 kV
Deflection from MKEs at TPSE: 45.9 mm
Position at entrance TPSE: 83.3 mm
150
100
50
0
- 50
- 100
horizontal position
5 sigma injected and stored CNGS beam, together with 8.2 s physical limit at injection
3940
3960
3980
4000
4020
4040
longitudinal position
Jan Uythoven, SL BT, August 2000

# MKE kicker parameters, LSS4 SPS extraction

| Mode | proton energy [GeV/c] | Rise time [μs] | Flat top [μs] | Fall time [μs] | Flat top ripple |
|---|---|---|---|---|---|
| CNGS protons | 400 | <1.1 | 10.5 | <1.1 | <2 % |

Jan Uythoven, SL/BT August 2000

# Transfer line : transport of primary protons

Compact magnets, re-use existing power supplies

MBG 73 magnets

Gap height 37 mm

Nominal field : 1.7 T @ 400 GeV

Magnetic length : 6.3 m

K. Schirm

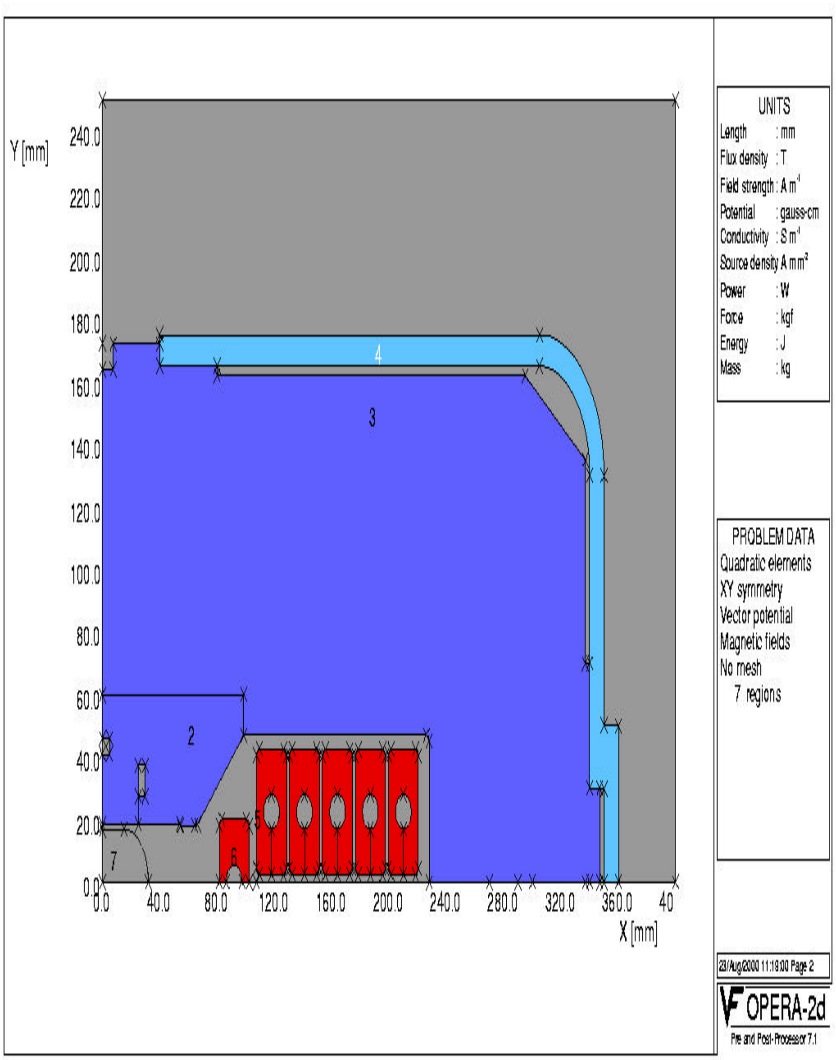
QTG 21 magnets

Magnetic aperture : 45 mm

Nominal gradient 40 T/m, 2.2 m long

T. Zickler

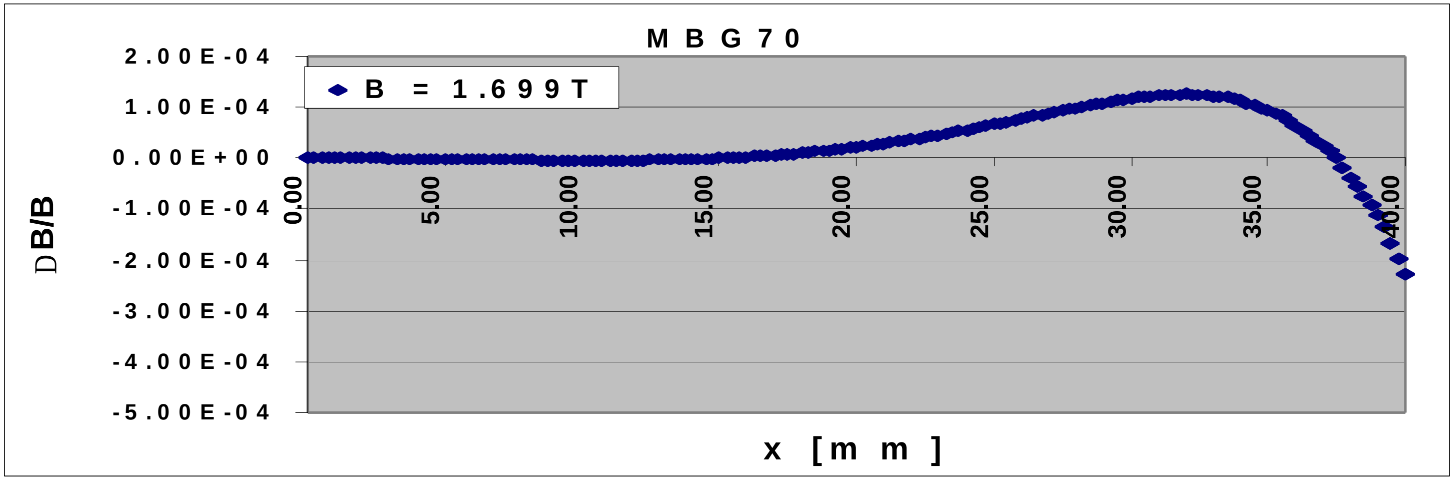
# MBG cross section




K. Schirm SL/MS 08/2000

# MBG 2D field profile

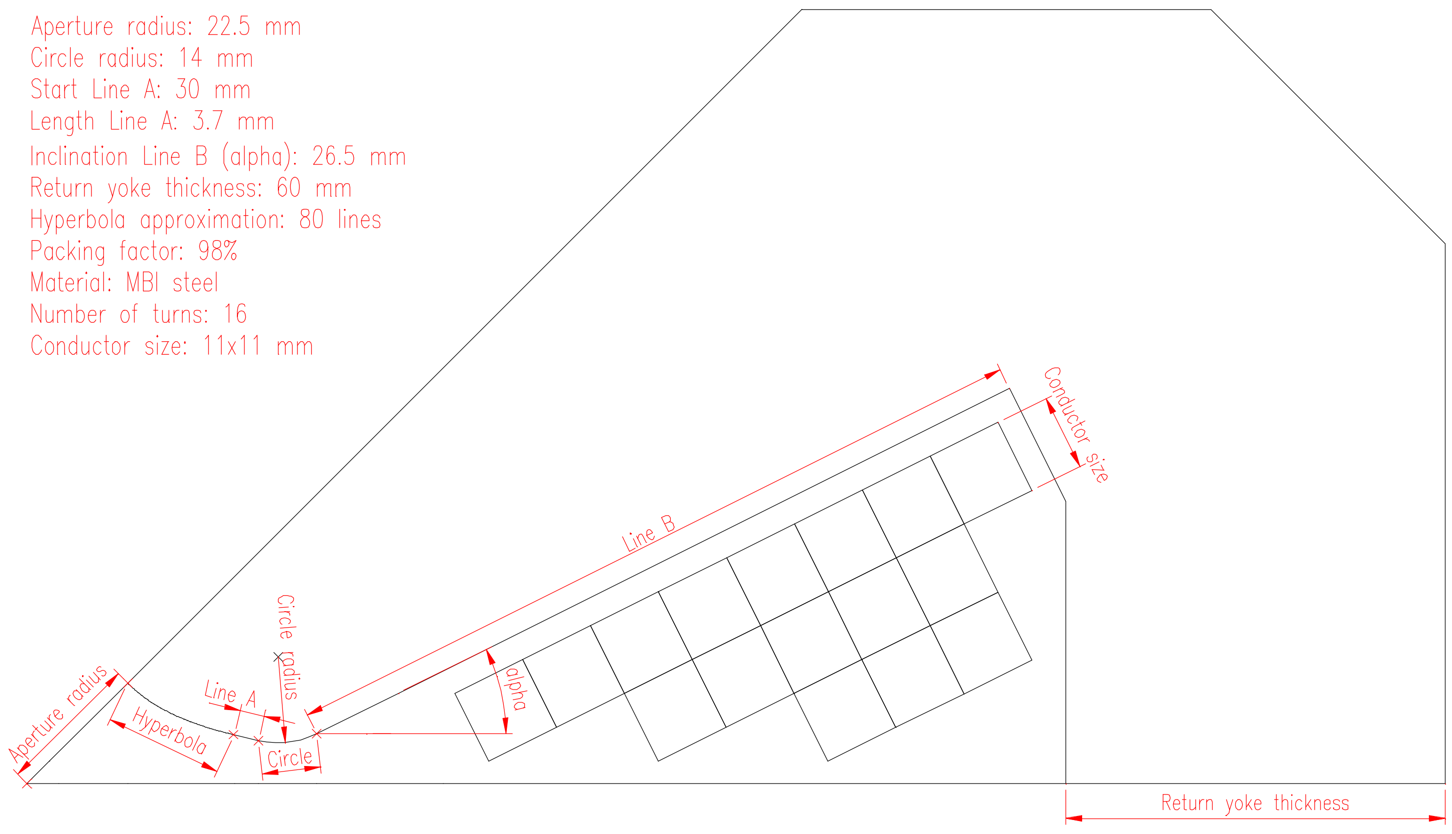
(OPERA2D; Θ=0.985)




K. Schirm SL/MS 08/2000

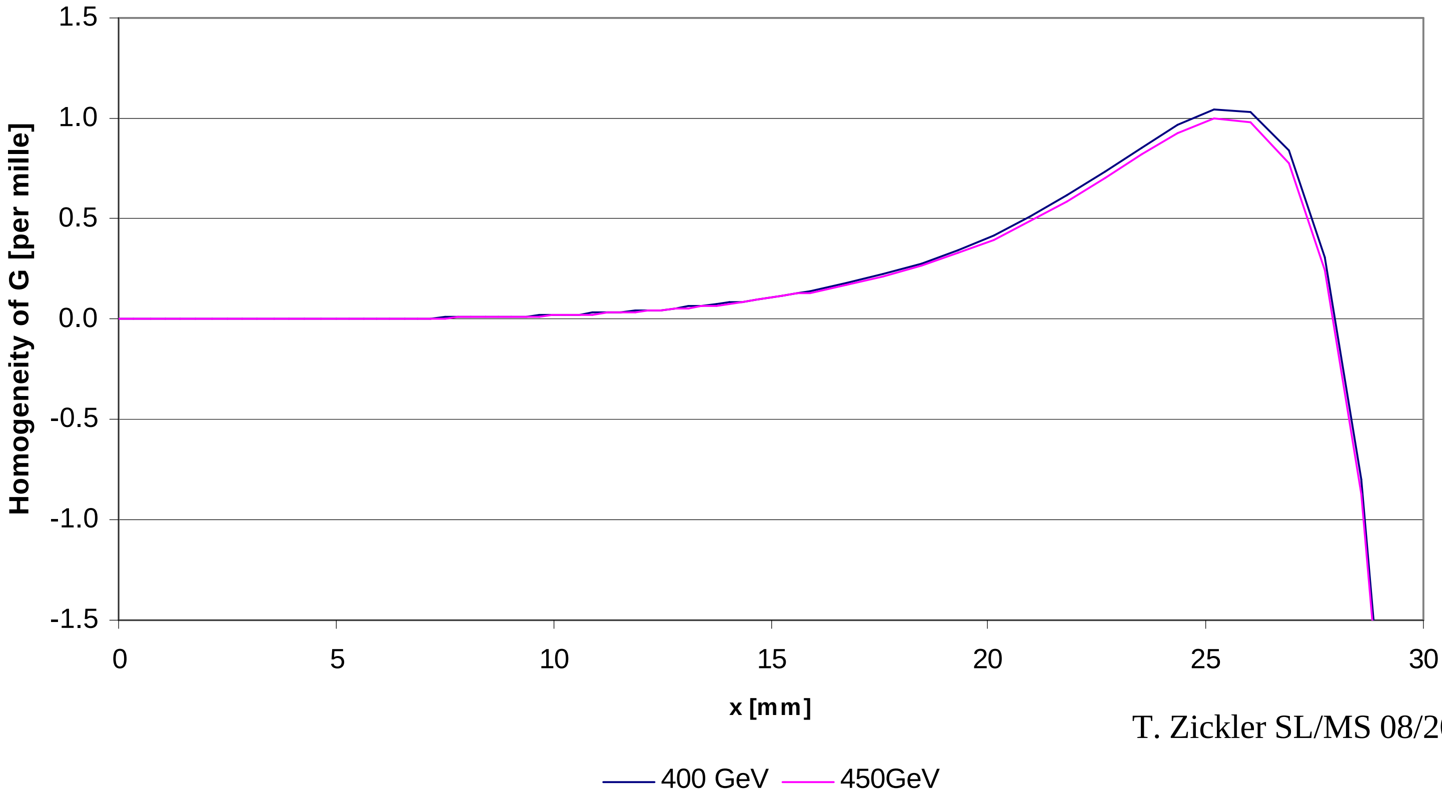
# QTG Pole Shape (1/8)

T. Zickler SL/MS 08/2000



# QTG Gradient Homogeneity

| QTNF | Requested G [T/m] | I[A] | G[T/m] | ΔG/Gmax | ΔG/G at 21mm | ∫Gdl [Tm/m] | Bmax [T] |
|---|---|---|---|---|---|---|---|
| **400GeV** | 26.7 | 339.24 | 26.70 | 1.04 | 0.51 | 59.28 | 1.37 |
| **450GeV** | 30 | 381.16 | 29.96 | 1.00 | 0.49 | 66.53 | 1.45 |




T. Zickler SL/MS 08/2000

# Increasing the intensity

Increasing total number of protons per year onto the target

2 ways to increase the SPS intensity :

a) increase number of injection from CPS into SPS (2 $\rightarrow$ 3)

b) increase intensity per injection from CPS.

b) is preferred (20 % less intensity than with a) but shorter cycle, and much easier operation).

ACHIEVED

- CPS 3 $10^{13}$ p
- SPS 4.8 $10^{13}$ p

ULTIMATE

- CPS >3.5 $10^{13}$ p
- SPS 7 $10^{13}$ p

CPS side : Booster injection energy into CPS : 1 to 1.4 GeV

Reduced CPS ♏$_h$ into SPS

Equalize 4 booster ring intensities

Electrostatic septum upgrade/replacement

SPS side : Hardware limitation solved by LHC upgrade program

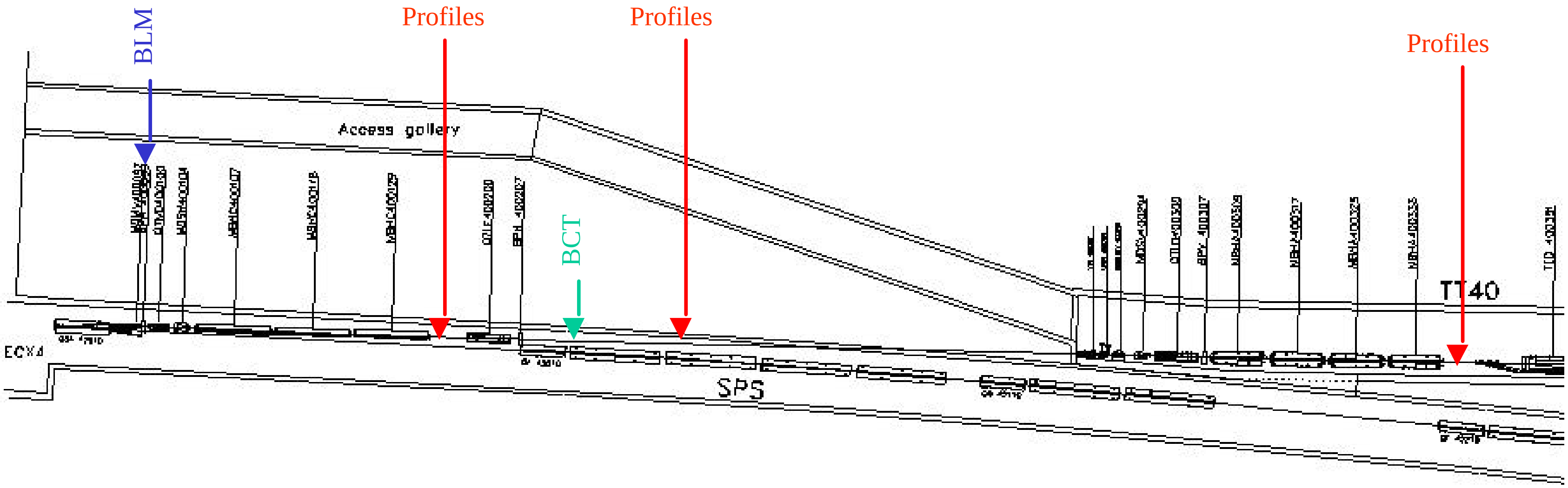
(RF system, damper system, impedance budget)

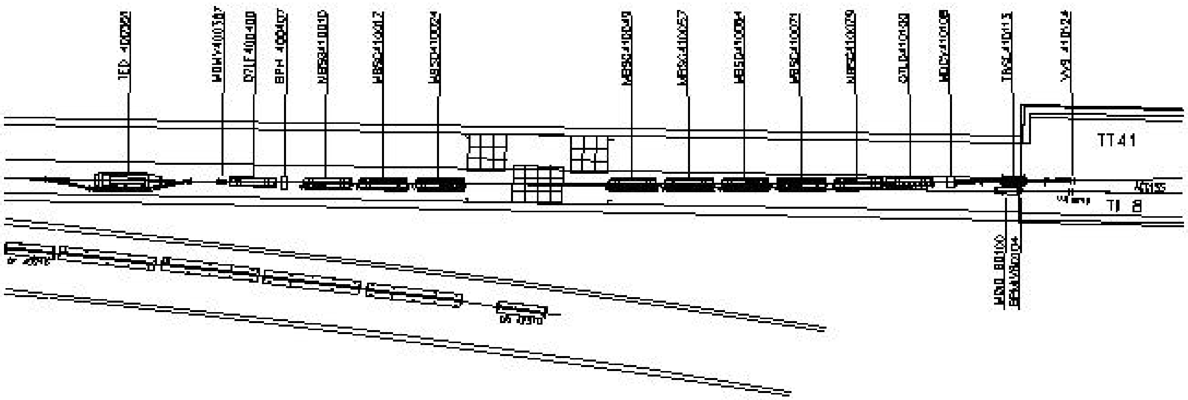
Heating of the ferrite of the kicker system

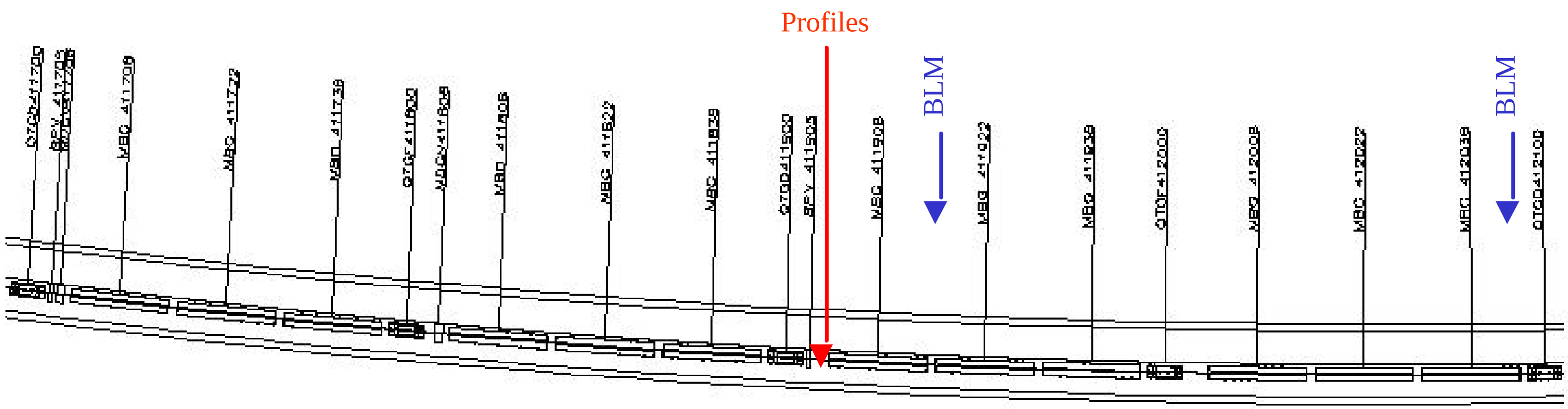
# Requirements for Instrumentation

**Mesure :**

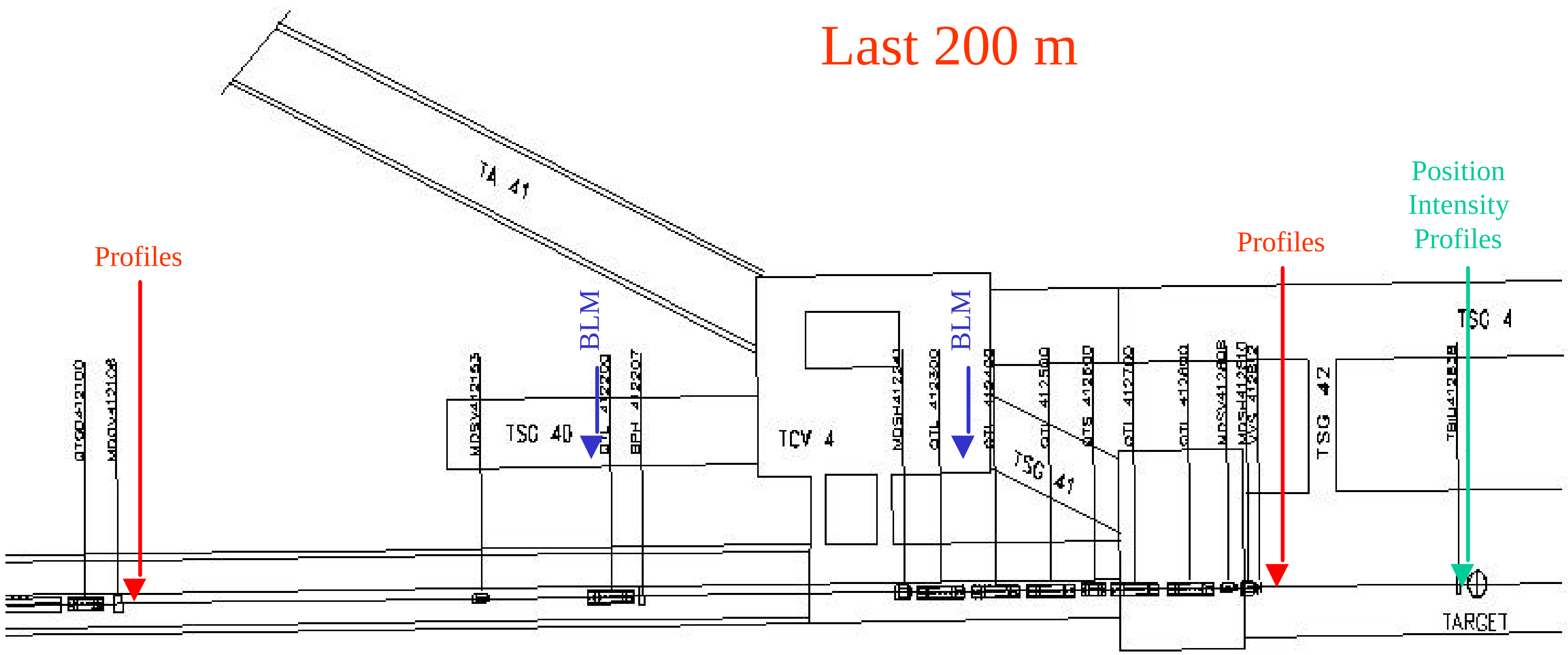
- Proton beam intensity to 1 %
- Proton beam position with an accuracy of 0.1 mm and beam angle with 0.1 mrad
- Beam loss monitors
- Right upstream of the target : intensity, positions, profiles
- Beam position and angle at target cycle to cycle


BLM
Profiles
Profiles
Profiles
BCT
Access gallery
TT40
SPS
ECX4


TT41
TI 8




# Last 200 m

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# STATUS

- Layout and concept of primary proton line
- vacuum
- magnet design
- extraction channel
- instrumentation
- ...