Status Report on the CNGS beam

(previous CNGS reports to SPSC: 27 Jun + 3 Nov 1998)

> Overview of the CNGS facility

> "Guidelines" used since CNGS approval

> Some recent beam studies

> Schedule and Status

> Summary

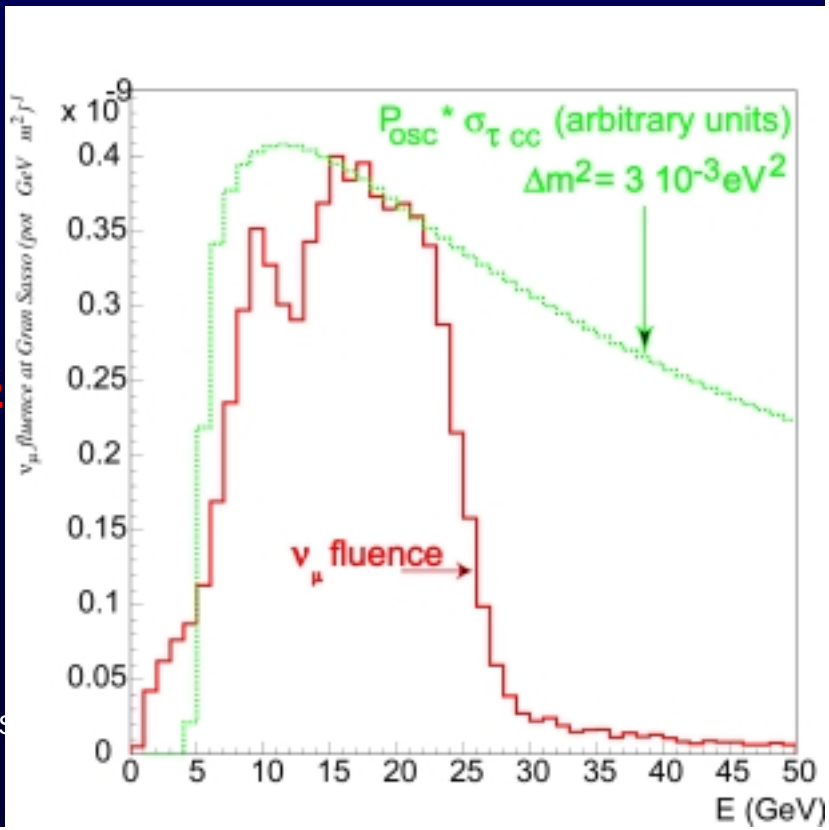
Overview of CNGS

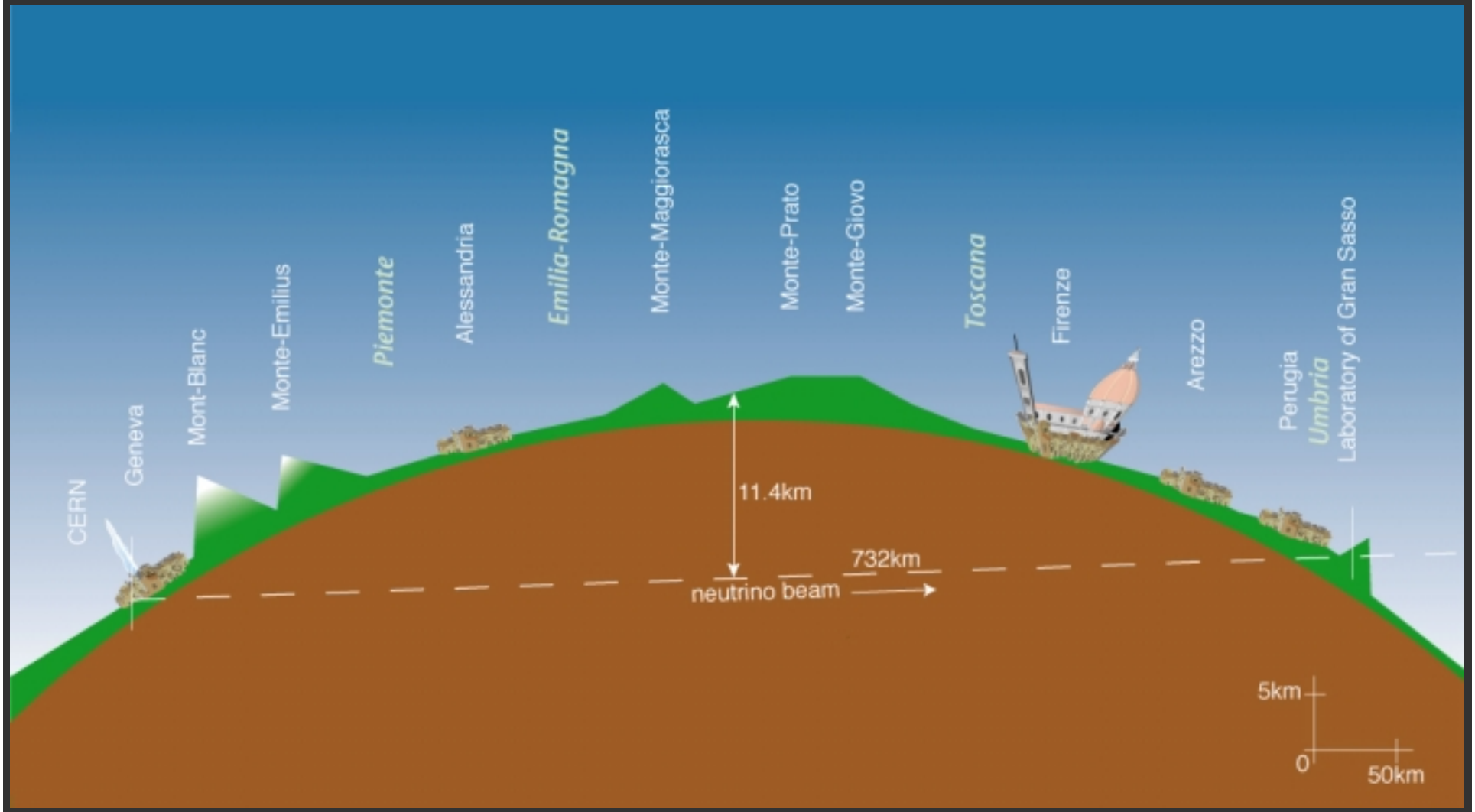
ν_μ neutrino beam from CERN to Gran Sasso:

-> intensity:
as high as possible

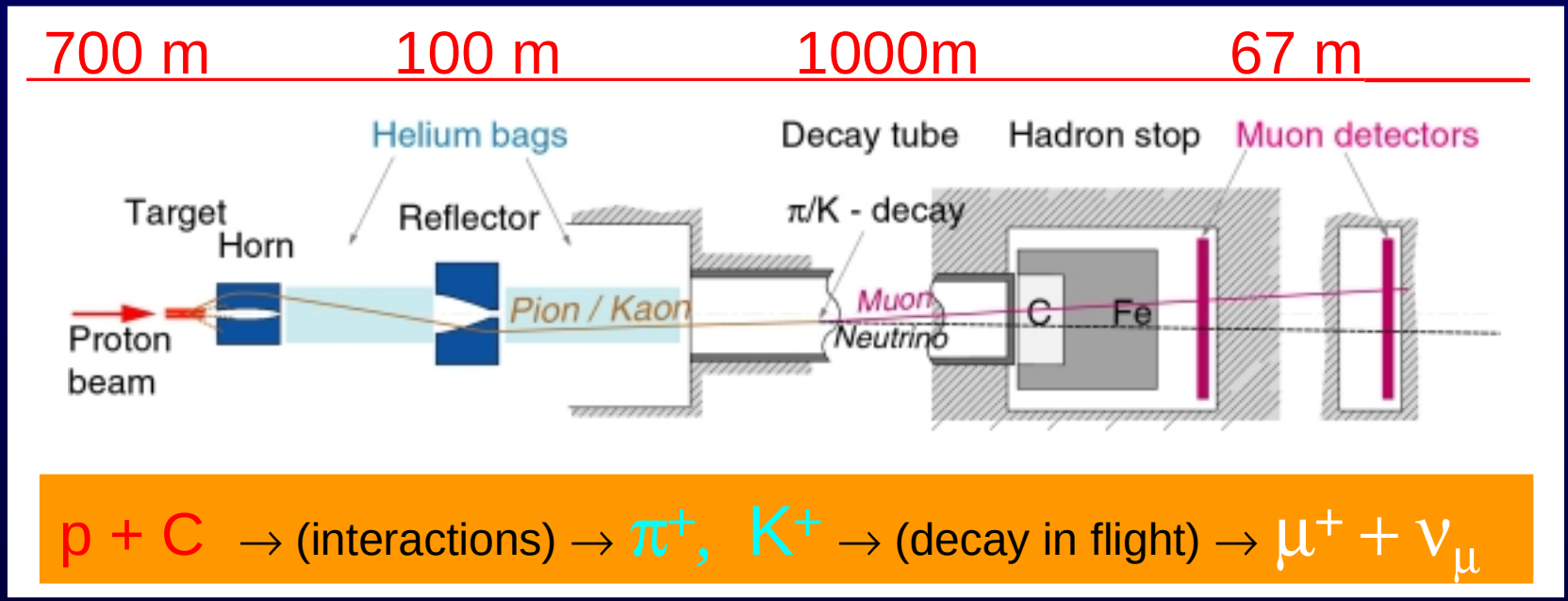
-> energy:
matched for

$\nu_\mu \rightarrow \nu_\tau$ appearance experiments

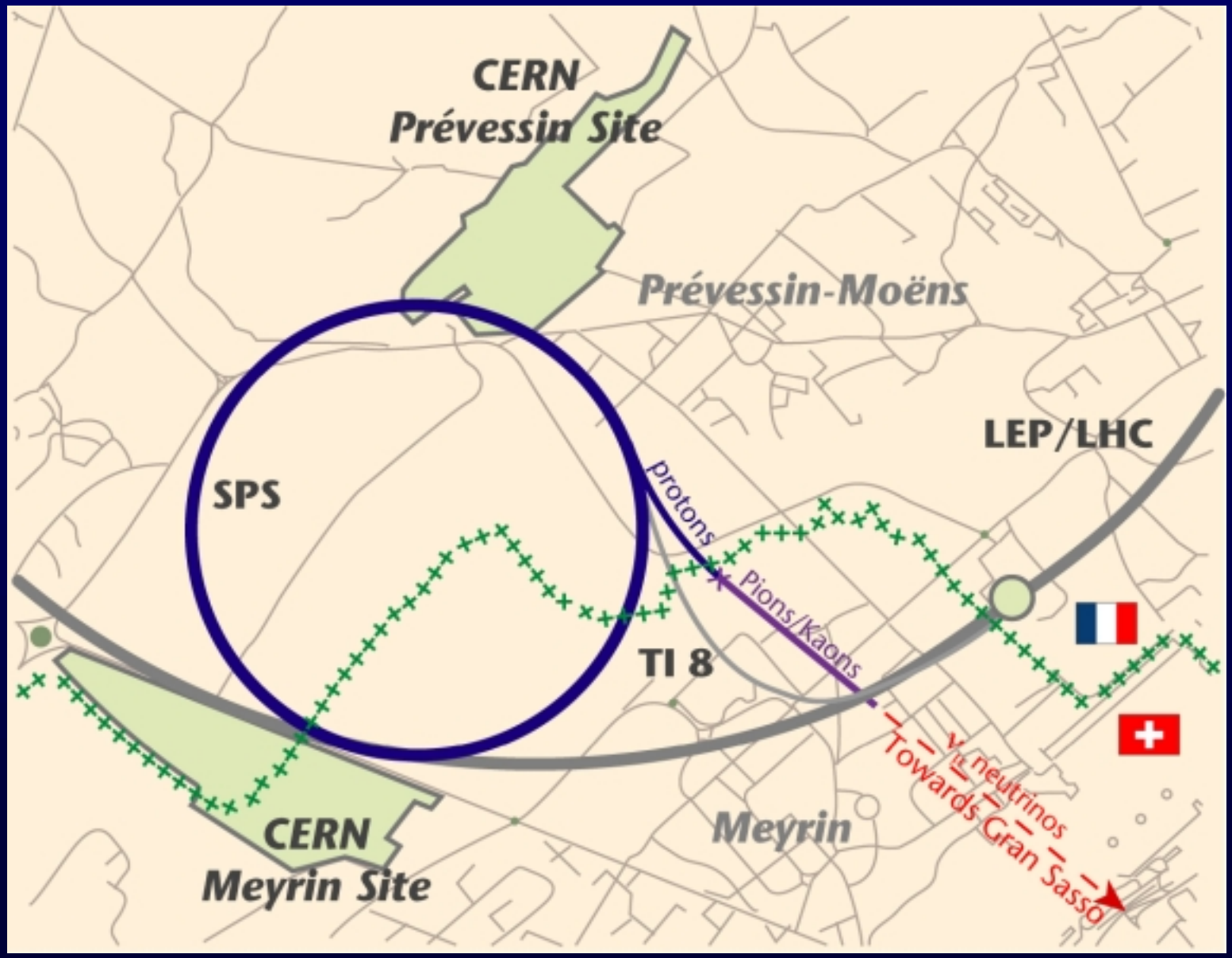


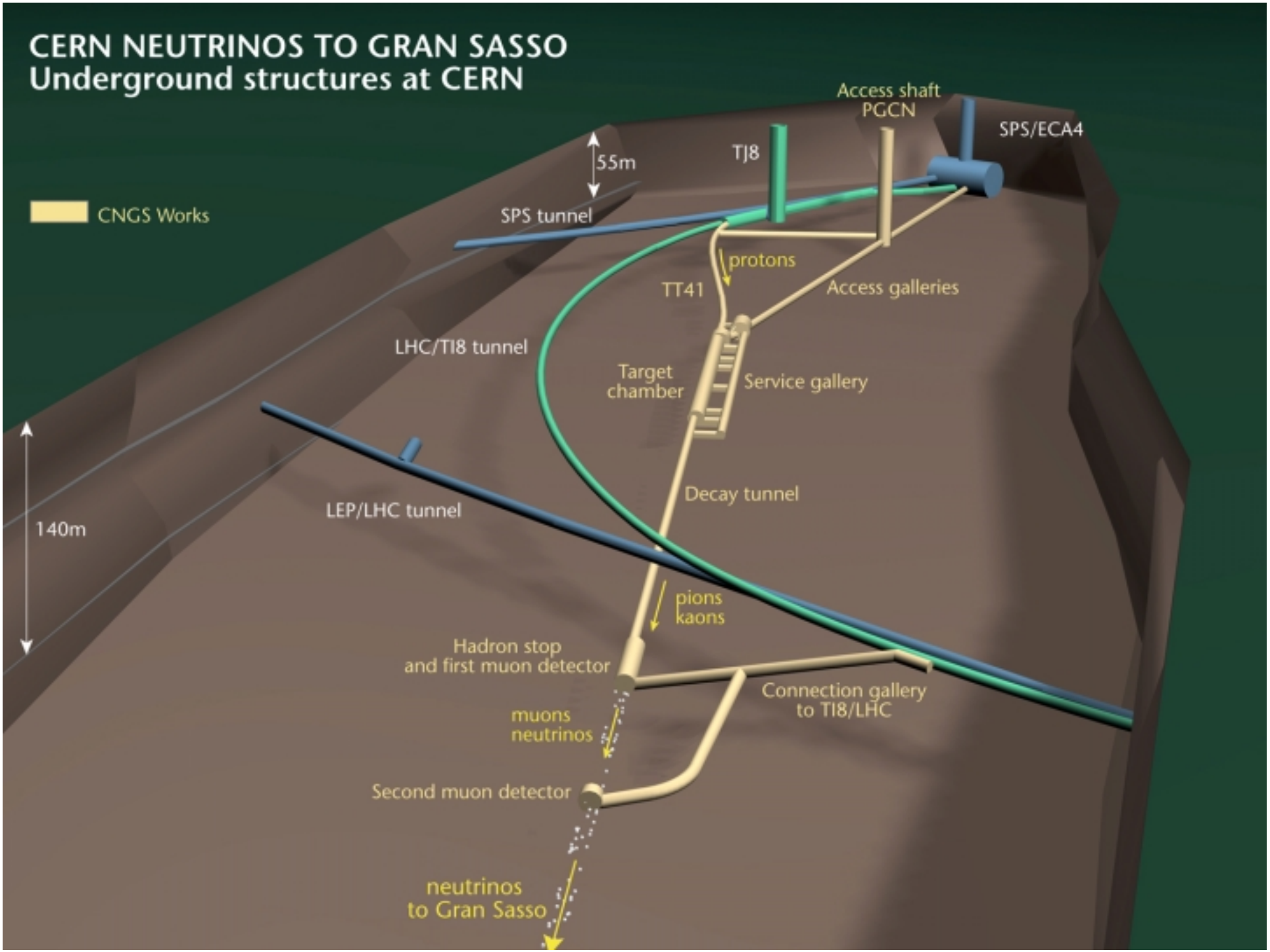

CERN
Geneva
Mont-Blanc
Monte-Emilius
Piemonte
Alessandria
Emilia-Romagna
Monte-Maggiorasca
Monte-Prato
Monte-Giovo
Toscana
Firenze
Arezzo
Perugia
Umbria
Laboratory of Gran Sasso
11.4km
732km
neutrino beam
5km
0
50km

CNGS: the main components



$p + C \rightarrow$ (interactions) $\rightarrow \pi^+, K^+ \rightarrow$ (decay in flight) $\rightarrow \mu^+ + \nu_\mu$


CERN
Prévessin Site
Prévessin-Moëns
LEP/LHC
SPS
protons
Pions/Kaons
TI 8
ν_μ neutrinos
Towards Gran Sasso
CERN
Meyrin Site
Meyrin


CERN NEUTRINOS TO GRAN SASSO
Underground structures at CERN
CNGS Works
55m
SPS tunnel
TJ8
Access shaft
PGCN
SPS/ECA4
protons
TT41
Access galleries
LHC/TI8 tunnel
Target
chamber
Service gallery
140m
LEP/LHC tunnel
Decay tunnel
pions
kaons
Hadron stop
and first muon detector
Connection gallery
to TI8/LHC
muons
neutrinos
Second muon detector
neutrinos
to Gran Sasso

"Guidelines" followed since CNGS approval

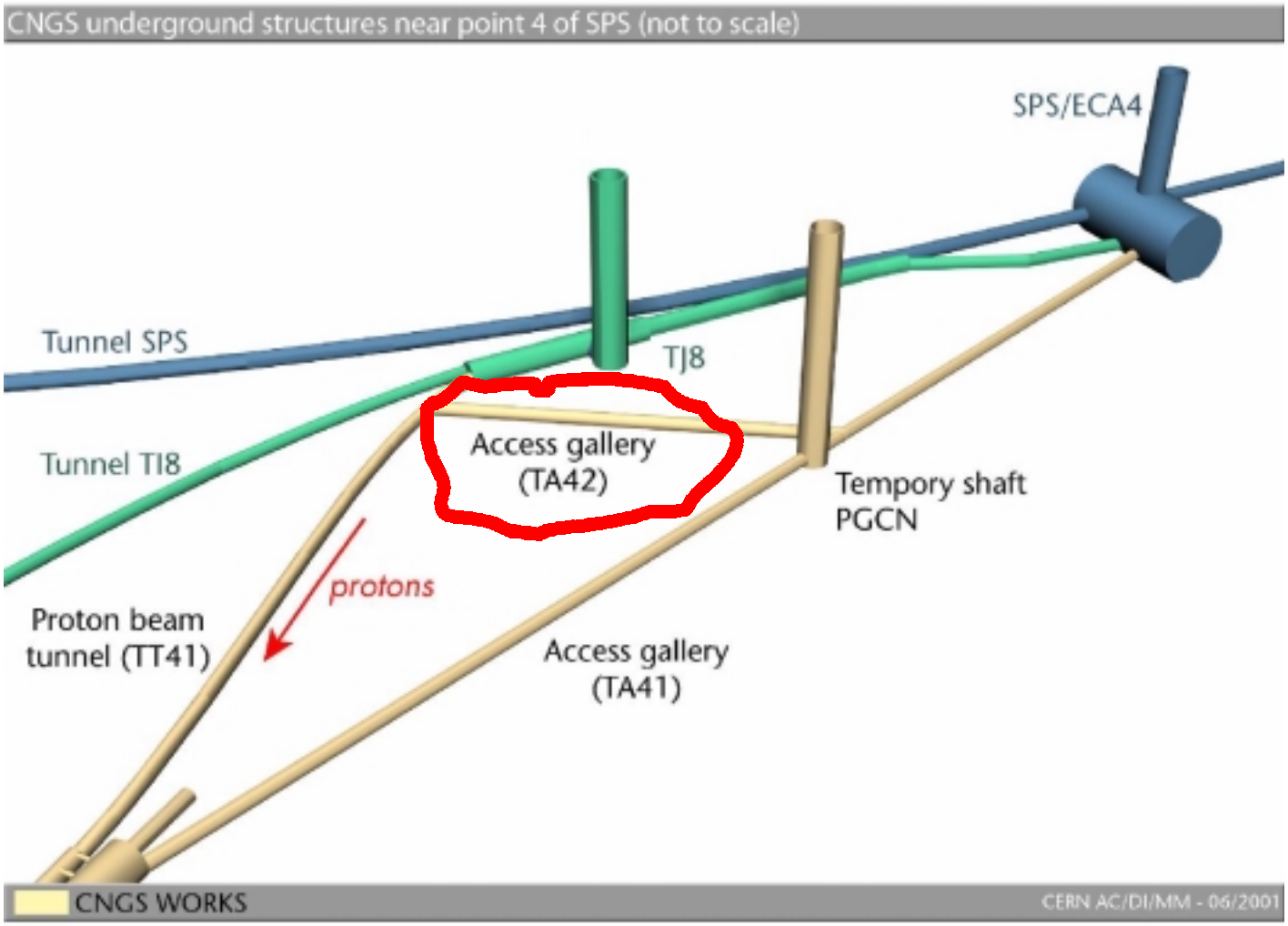
1) make all effort to stay "on schedule"

2) prepare
for future higher beam intensities

3) keep space/flexibility
for future beam options

1) make all effort to stay “on schedule”

New tunnel: “TA42” (L=116 m)



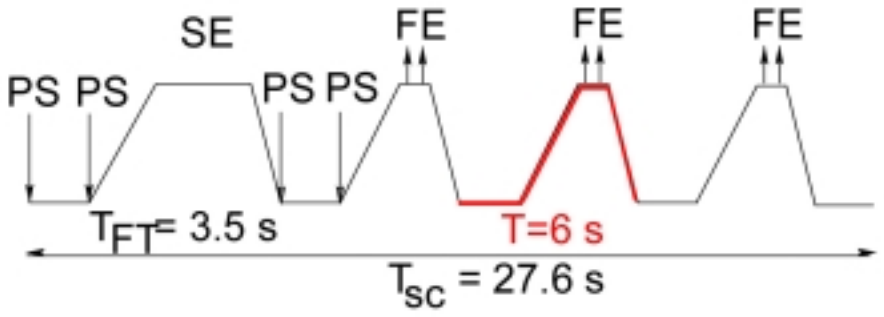
2a) prepare for future higher beam intensities

reminder: CNGS protons: 400 GeV from SPS

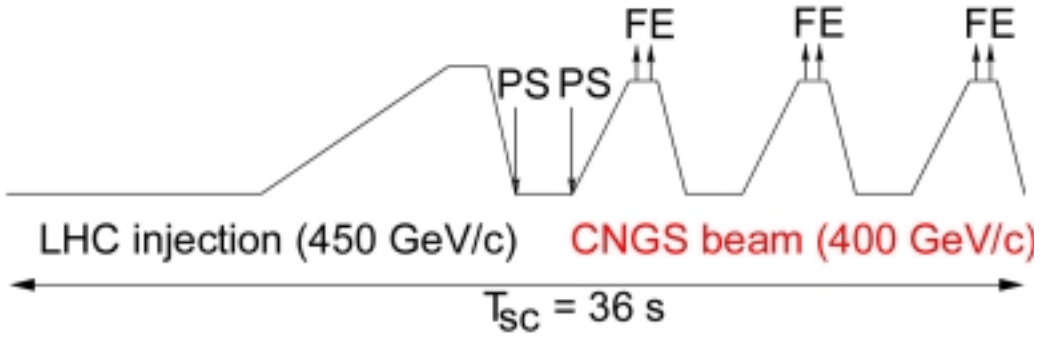
SPS cycles for CNGS: 2 x 10.5 μs extractions / 6 s cycle

Possible SPS supercycles:

CNGS + fixed target



CNGS + LHC



CNGS proton beam (p.o.t.)

Project Proposal:		Design of CNGS Facility for:	
per extraction:	2.4×10^{13}	per extraction:	3.5×10^{13} (+ safety) (shock phenomena: target rods, decay tube windows, etc.)
per cycle:	4.8×10^{13}		
per year	**4.5×10^{19}**	per year	13.8×10^{19} radiological issues, heating/cooling of hadron stop, TCC4 shielding, etc.

NOTE: there are limits - it's not a "game with numbers" !

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one type of limits:

Accelerator Performance - Upgrades

cf. R. Cappi et al.,
"Increasing the Proton Intensity of PS and SPS",
CERN/PS 2001-041(AE) + CERN/SL 2001-32

e.g.	scheme 1.1:	gain: x 1.34	cost: ~1 MCHF
	scheme 1.2:	gain: x 1.49	cost: ~2 MCHF
	...		
	scheme 2.1:	gain: x 1.79	cost: ~70 MCHF
	...		

NOTE: there are limits - it's not a "game with numbers" !

approaching the limits:

"Radiological Considerations"

--> beam losses in PS / SPS accelerators

--> damage to equipment --> repair

(or: produce waste)

--> induced radioactivity in the target chamber air

(Note: we need permission to operate CNGS)

"Damage to CNGS equipment"

--> lifetime of the target, the horn etc.

NOTE: while some of these limits can be reliably calculated today, others will be known when CNGS starts operating (measure !)

3) keep options open for future beams

NOTE: in radiation areas, work has to be done “NOW” !

a) length of target chamber
(allows for different target/horn/reflector configurations)

b) two muon detector chambers
(may be important if better understanding of the neutrino beam and backgrounds is crucial)

c) “third fast extraction” (third pulse): space reserved
(may be important to increase CNGS p.o.t.)

Some recent beam studies

by the CNGS Secondary Beam Working Group

Sept. 2000: Workshop on Neutrino Beam Instrumentation
(K2K, NuMI, MiniBoone and CNGS presentations)

Dec. 2000: "CNGS: Update on secondary beam layout"
SL-Note 2000-063 EA

May 2001: "CNGS: effects of possible alignment errors"

Dec. 2000:

"CNGS 2000"

mostly work on details of technical components and on improvements of the layout;

--> safer design for horn inner conductor,
space for monitor downstream of target,
etc. etc.

"BONUS":

4 % increase of expected ν_τ cc events per p.o.t.
(2 % increase for OPERA)

Sept. 2000/ May 2001:

CNGS: effects of alignment errors

Examples:	effect on ν_τ cc events
horn off axis by 6 mm	< 3%
reflector off axis by 30 mm	3%
proton beam on target off axis by 1 mm	< 3%
CNGS facility misaligned by 0.5 mrad (beam 360 m off)	< 3%

"A world of differences" between **APPEARANCE** (CNGS) and **DISAPPEARANCE** experiments !

Conclusion: For CNGS performance, the main issues are
(a) the geodesic alignment wrt. LNGS
(b) the beam must hit the target
--> (e.g.) horn and reflector NOT motorised

May 2001:

beam monitor at Gran Sasso ("veto" in OPERA)

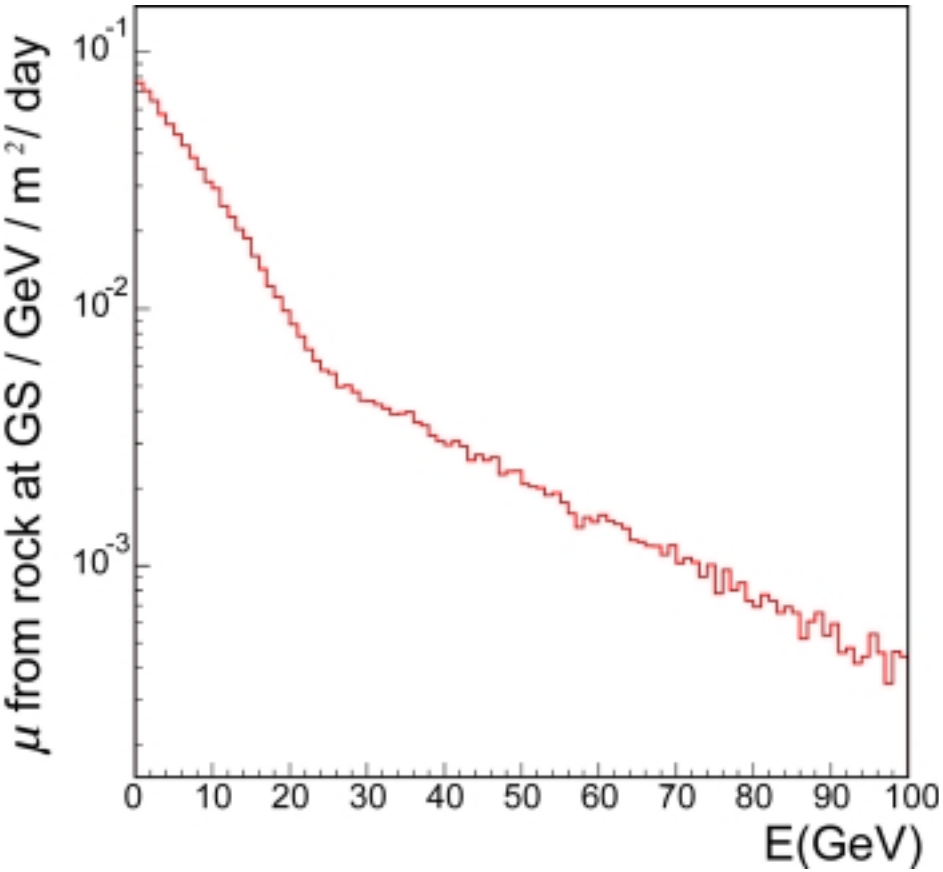
Idea:

use muons induced by CNGS neutrinos
in the rock upstream of the LNGS halls

Rates:

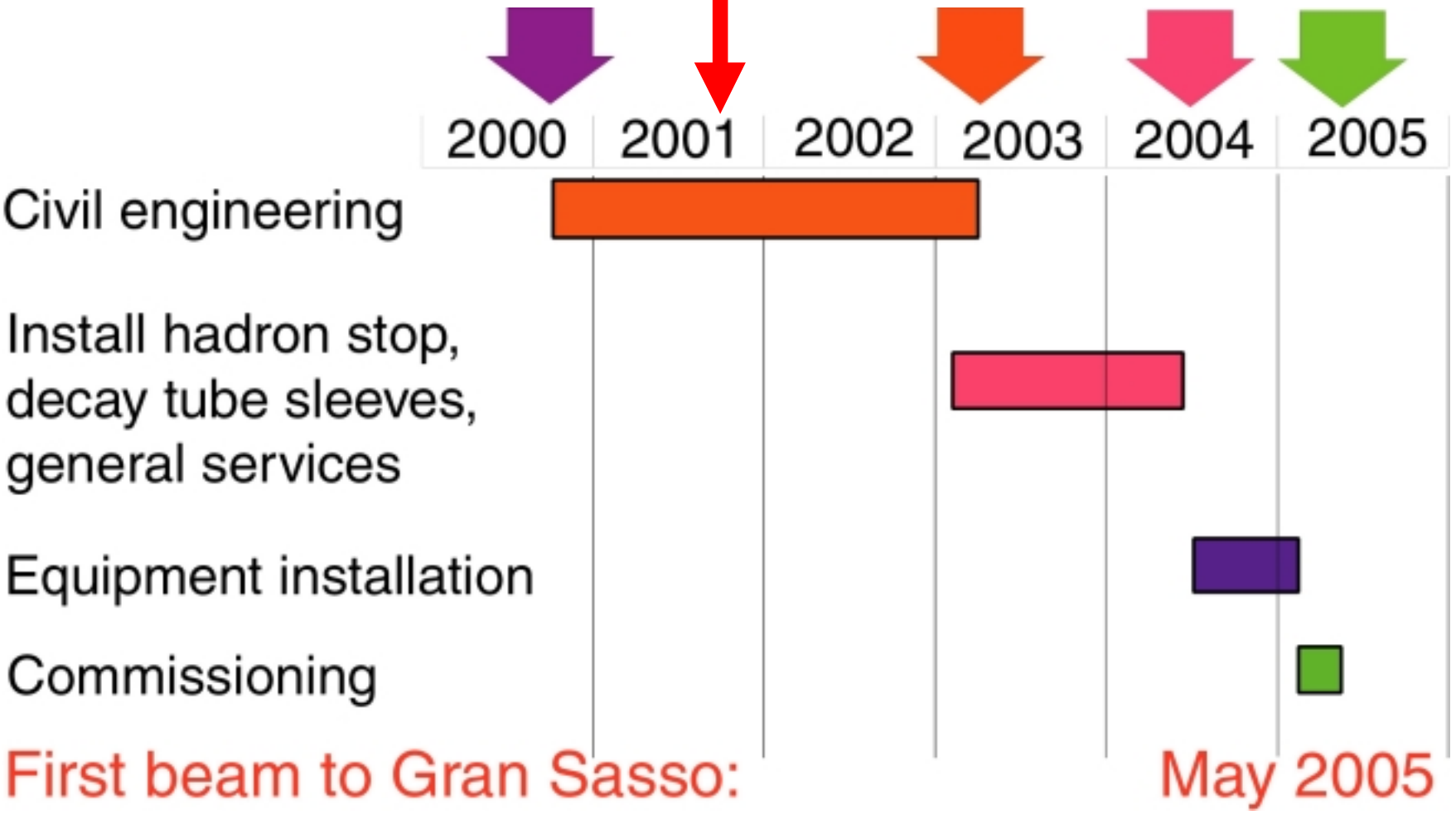
about 150 muons per day
in 13 x 13 m^2

Request made to LNGS
to study such a beam monitor



CNGS schedule

(project approved in Dec. 1999)



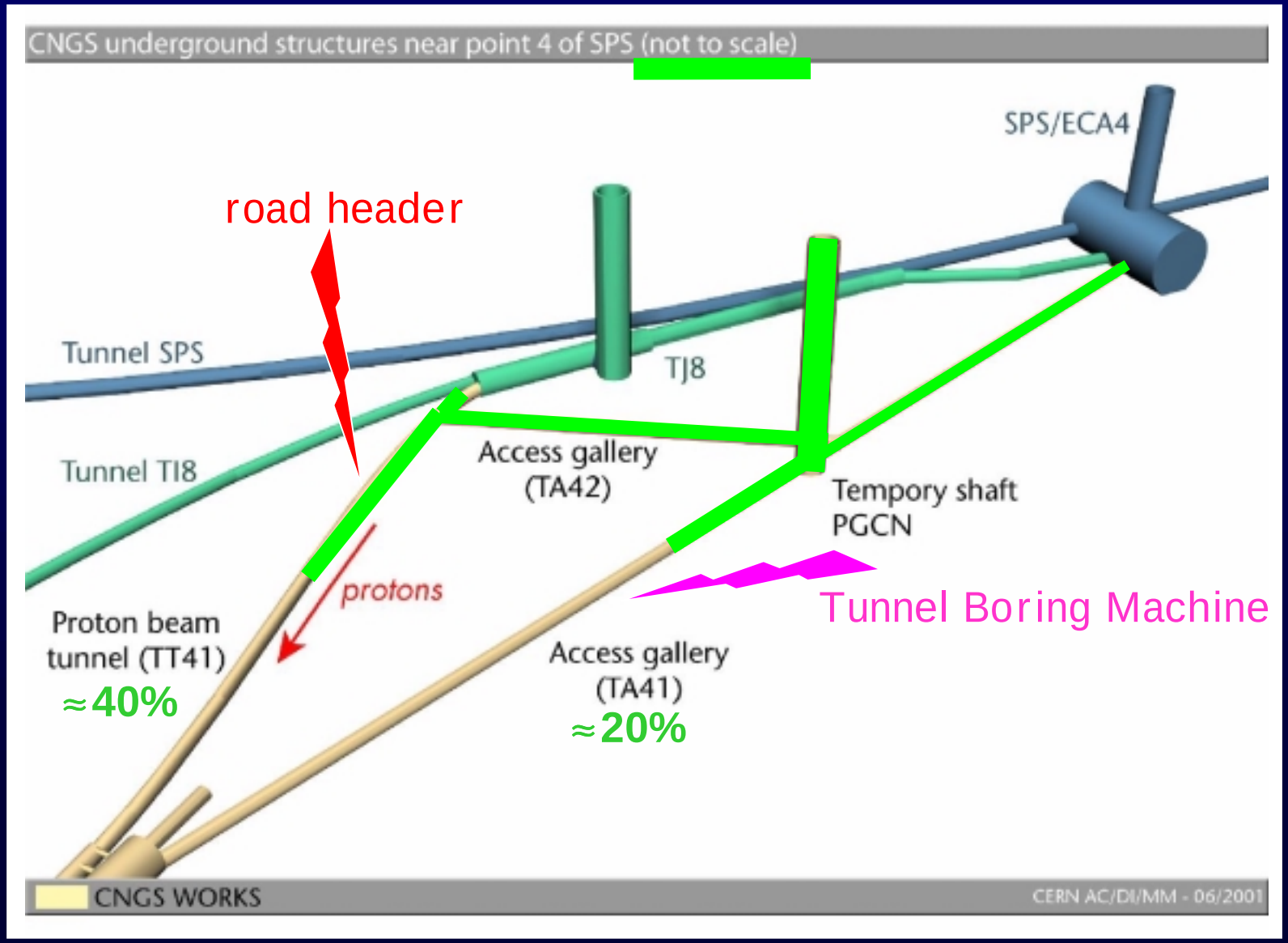
CNGS status -- Civil Engineering (1)

- ground breaking ceremony:
  12 October 2000

CNGS status -- Civil Engineering (2)

CNGS status -- Civil Engineering (3)

CNGS status -- Civil Engineering (4)



CNGS status -- Civil Engineering (5)

progress is good on the proton beam tunnel (> 220 m exc.)
(we benefit from the added TA42 tunnel...
the roadheader is moving ahead towards the target)

progress is not satisfactory on the access gallery (TBM)
(delay: approx. 6 weeks)

Summary:

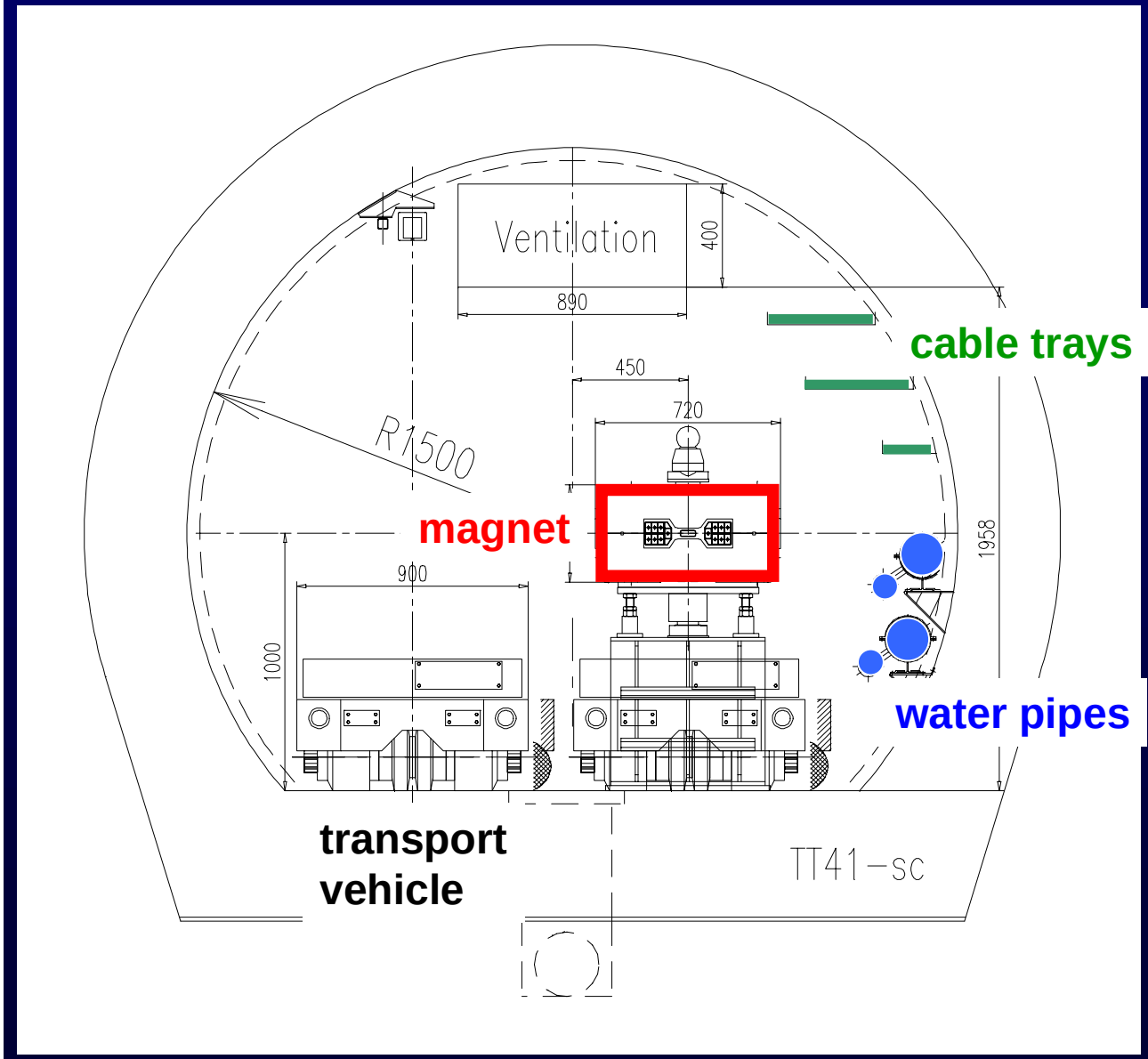
worry! schedule and cost of CE works

CNGS status -- Proton beam TT41

- 400 GeV/c protons, fast extracted from SPS in point 4
  (extraction system has to cope with LHC and CNGS beam)

- TT41 (700 m of transfer line):
  conceptual design / layout finished
  magnets: pre-series under construction
  vacuum: design finished / under construction
  beam monitoring: well advanced
  ...

No problem: CNGS proton beam is well under way



proton transfer line
cross section
(preliminary)

warning:
there is “no space”

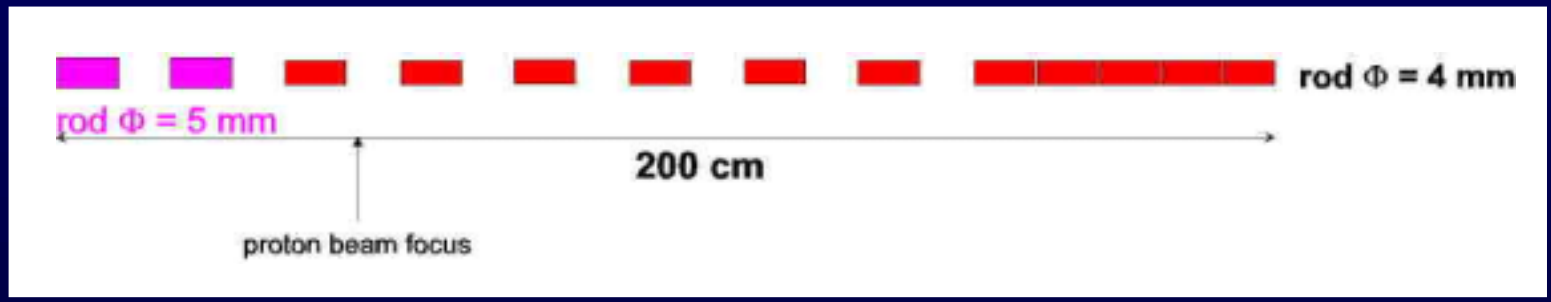
CNGS status -- target station T40

-> target rod optimisation:

- first step: symmetric beam impact - done

10 cm long graphite rods, Ø = 5mm and/or 4mm

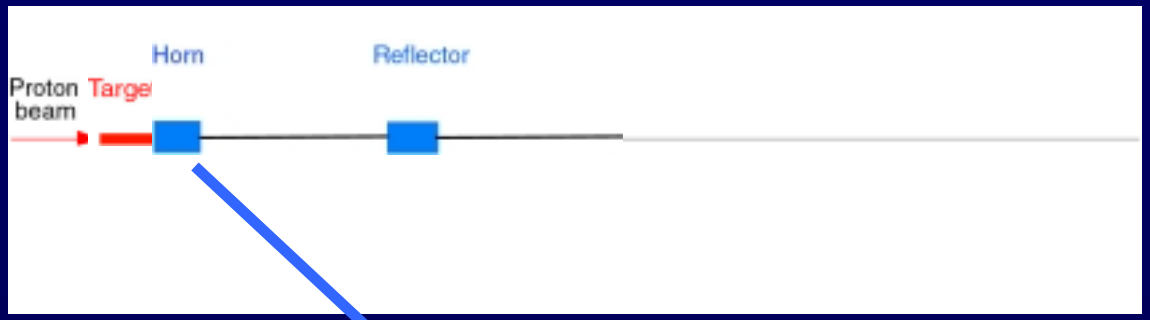
--> target o.k. even for CNGS-II, 3.5×10^{13} p.o.t / 10µs



- second step: asymmetric beam impact - in preparation

worry: target station overall design -
still in its very early stages

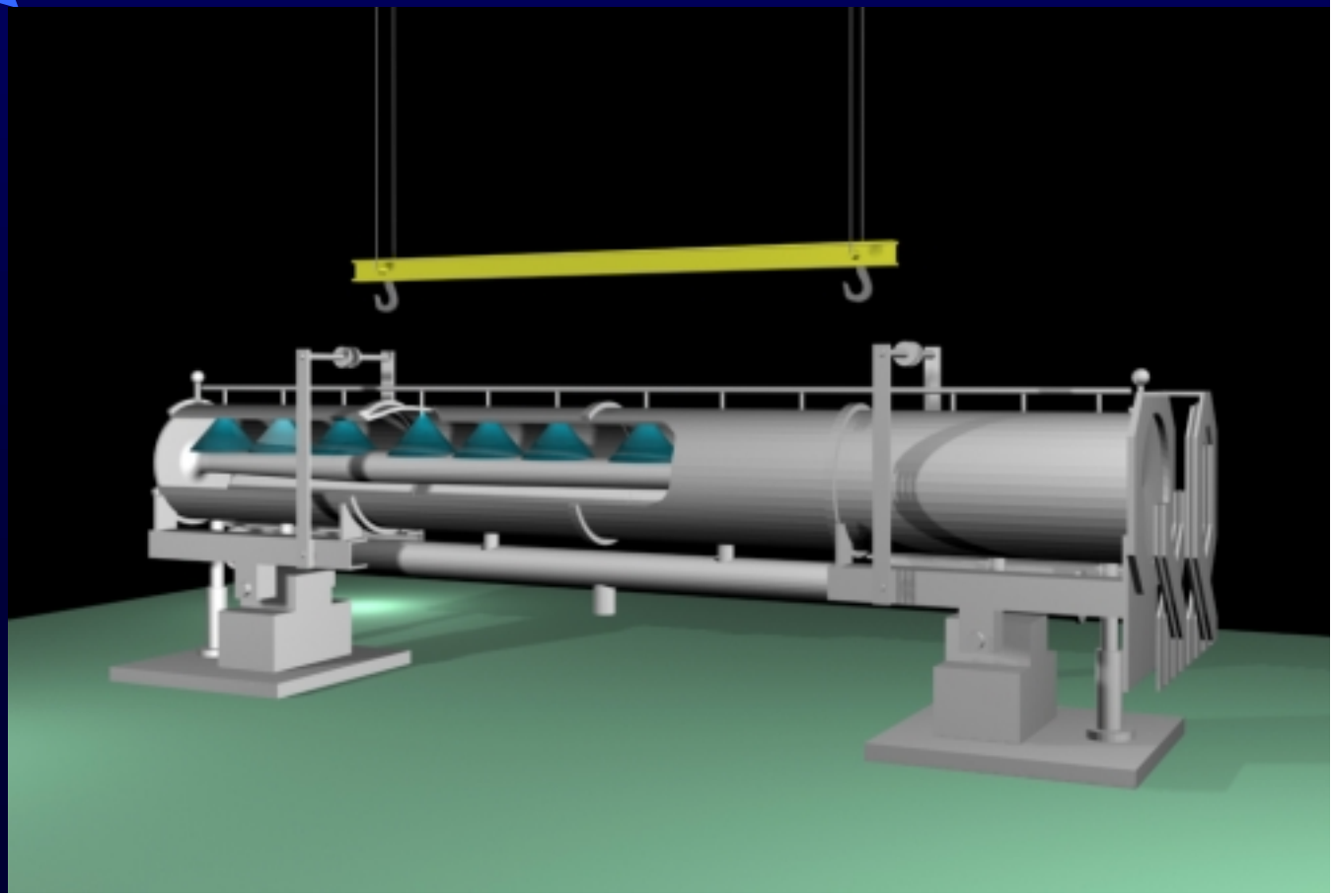
CNGS status -- focusing devices (1)



length: 6.5 m
diameter: 70 cm
weight: 1500 kg

Pulsed devices:
150kA / 180 kA, 1 ms

water-cooled:
distributed nozzles



CNGS status -- focusing devices

No problem:

horn and reflector are well under way

Horn prototype tests in BA7 (1.5 Mio pulses in 2000)

CNGS status -- decay tube

- detailed design "has just started" (consultant)
  - 2.45 m diameter steel tubes, 6 m long each, 1 km total
  - welded together in-situ
  - vacuum: ~ 1 mbar
  - tube embedded in concrete

- worries:
  - how to check for leaks during construction
  - heating by particles -> cooling needed ?

CNGS status -- decay tube windows

- decay tube entrance window: 2 mm Ti, 1.4 m diameter

  - design / mechanical / thermal studies finished (EST/ME)
    shock by beam impact -> no problem

  - test window in Nov. 2001 (spare WANF window)

  safety issues in case of a rupture of this window:
  -> tech. Student now starting study

- decay tube exit window: thick, steel

  detailed design in preparation

"before the summary" slide:

My Apologies

to all colleagues (at CERN, BINP, IN2P3, INFN,...)
whose work has not been mentioned today

A sincere " THANK YOU ! "

for their contribution to the CNGS project

SUMMARY

-> CNGS approved in December 1999
-> Civil Engineering construction started Sept 2000

-> CNGS project is well under way
(...there are some worries...)

-> first beam expected in May 2005