

# The CNGS facility: Status and Outlook

- > Overview of the CNGS facility
- > **Schedule and status of works**
  - CNGS Review 2004
- > Performance "nominal"
- > Performance "upgrade"
  - measures taken / preparation (since 2001)
  - possible problems (as seen today)
- > **Some comments**
- > **Summary**

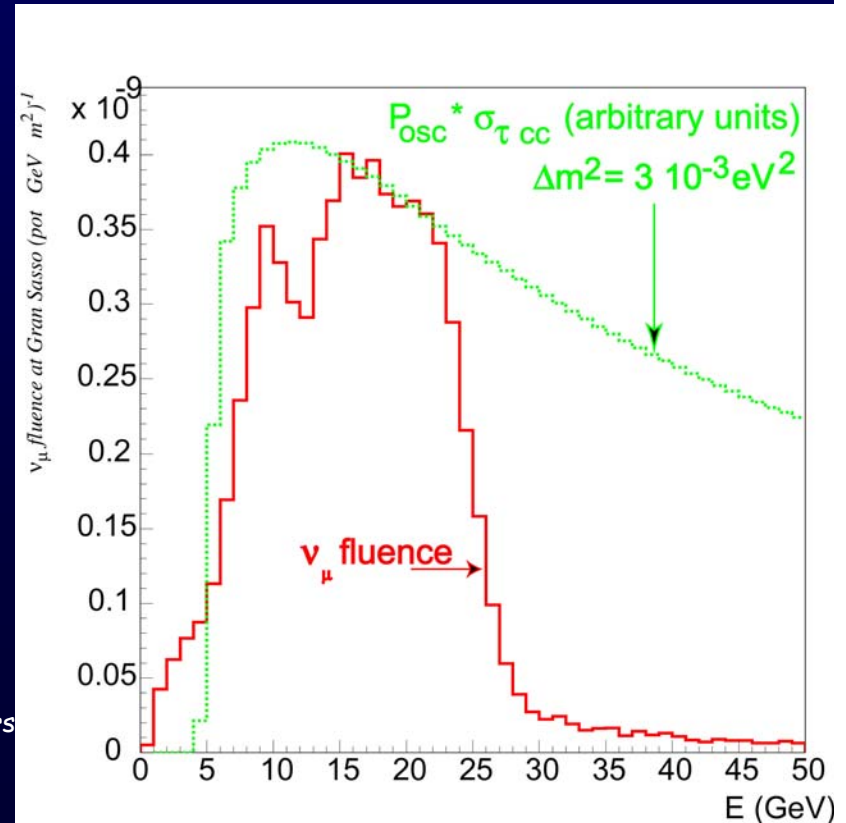
# Overview of the CNGS facility

$\nu_{\mu}$  neutrino beam from CERN to Gran Sasso:

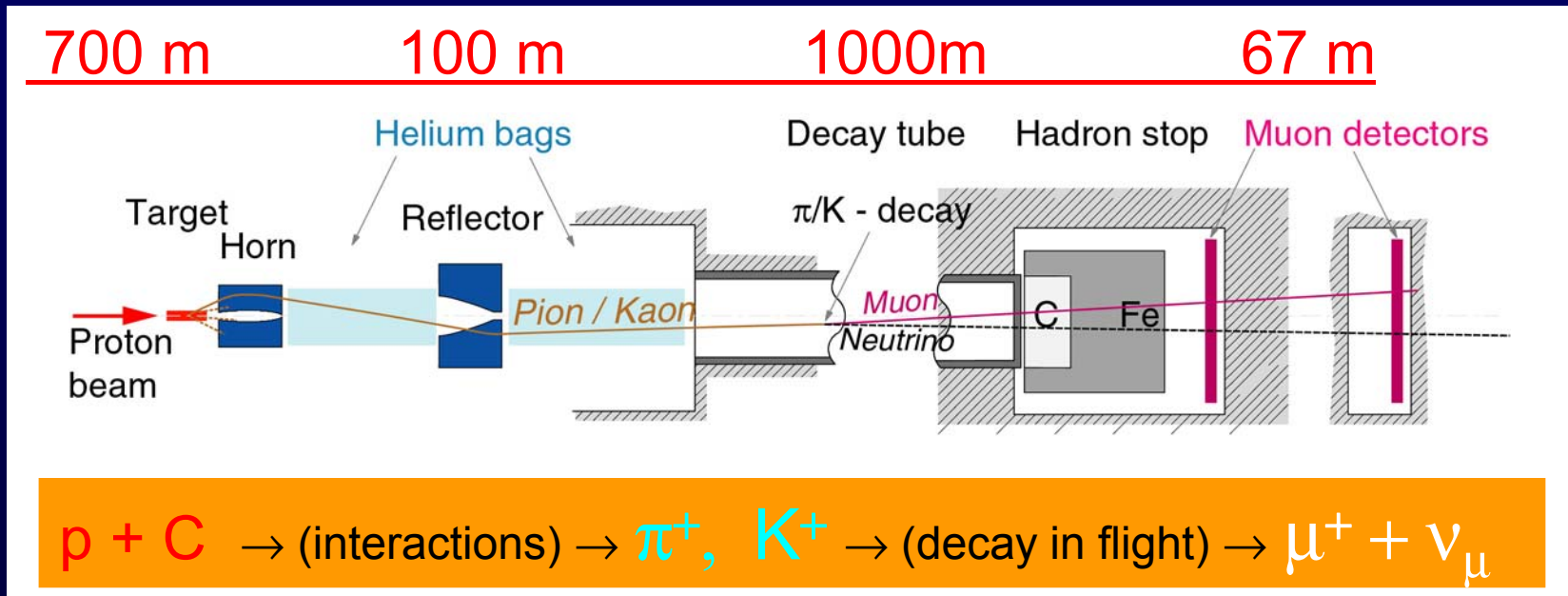
-> intensity:  
as high as possible

-> neutrino energy:  
matched for

$\nu_{\mu} - \nu_{\tau}$  appearance experiments

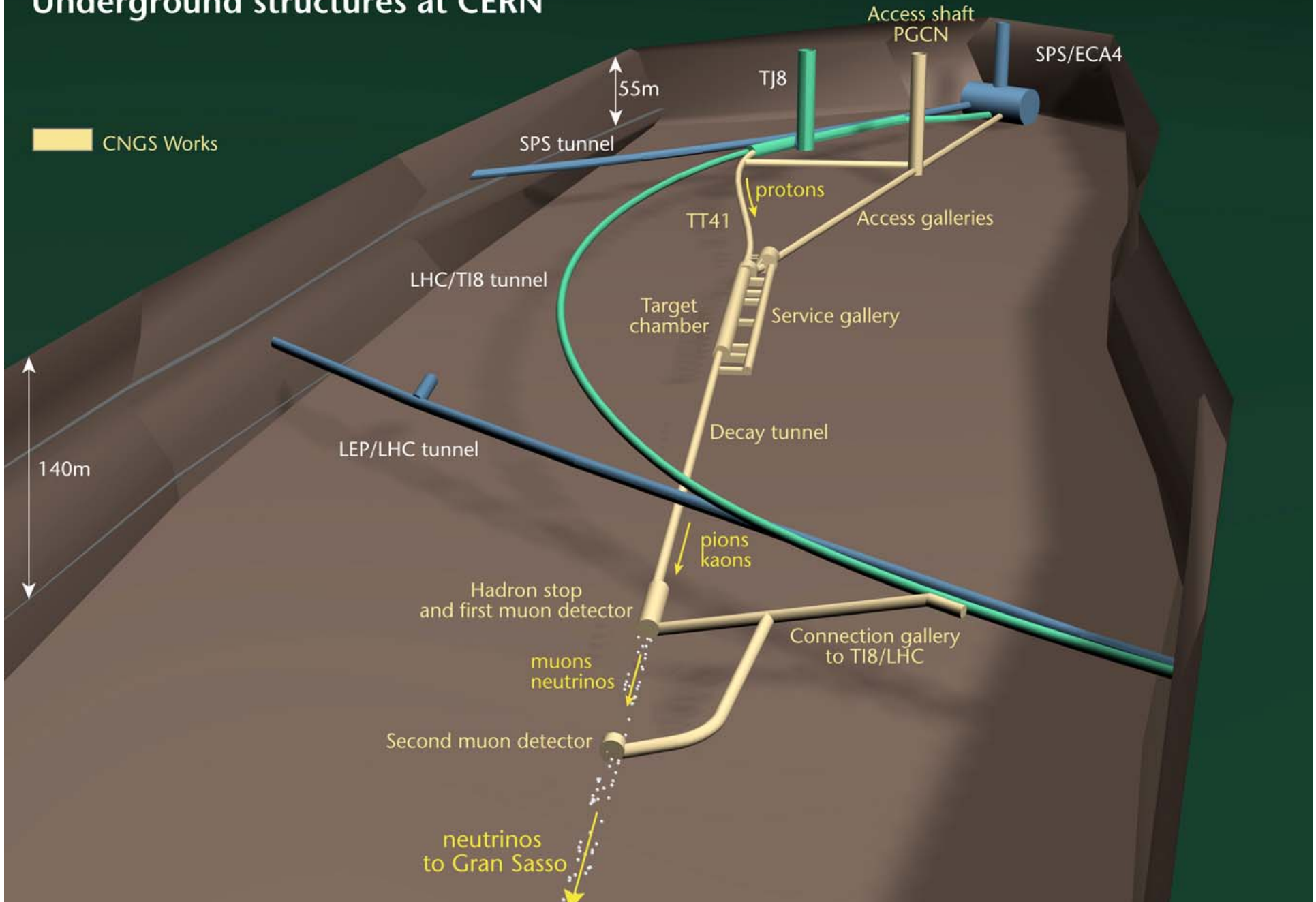


# Overview of the CNGS facility

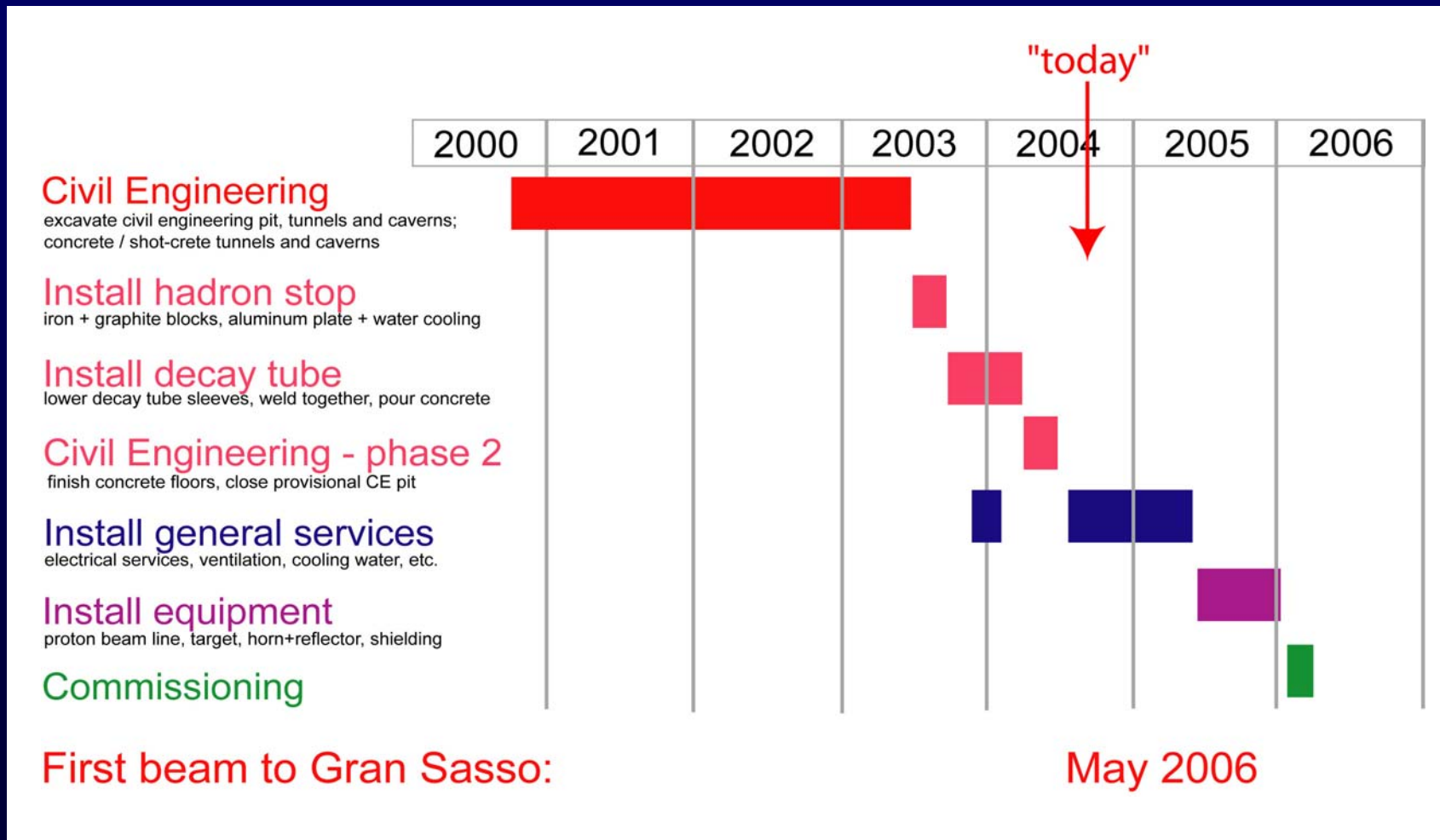


# CERN NEUTRINOS TO GRAN SASSO

## Underground structures at CERN



# Schedule and status of works





Schedule and status of works



# Civil engineering completed



Proton beam tunnel



## Schedule and status of works



# Civil engineering completed



Target Chamber



Schedule and status of works



# Civil engineering completed



Decay tunnel



# Civil engineering completed



Hadron stop chamber

# Civil engineering completed



surface (former CE shaft)

# Hadron stopper



# Hadron stopper



# Hadron stopper installed



# Decay Tube



# Decay Tube

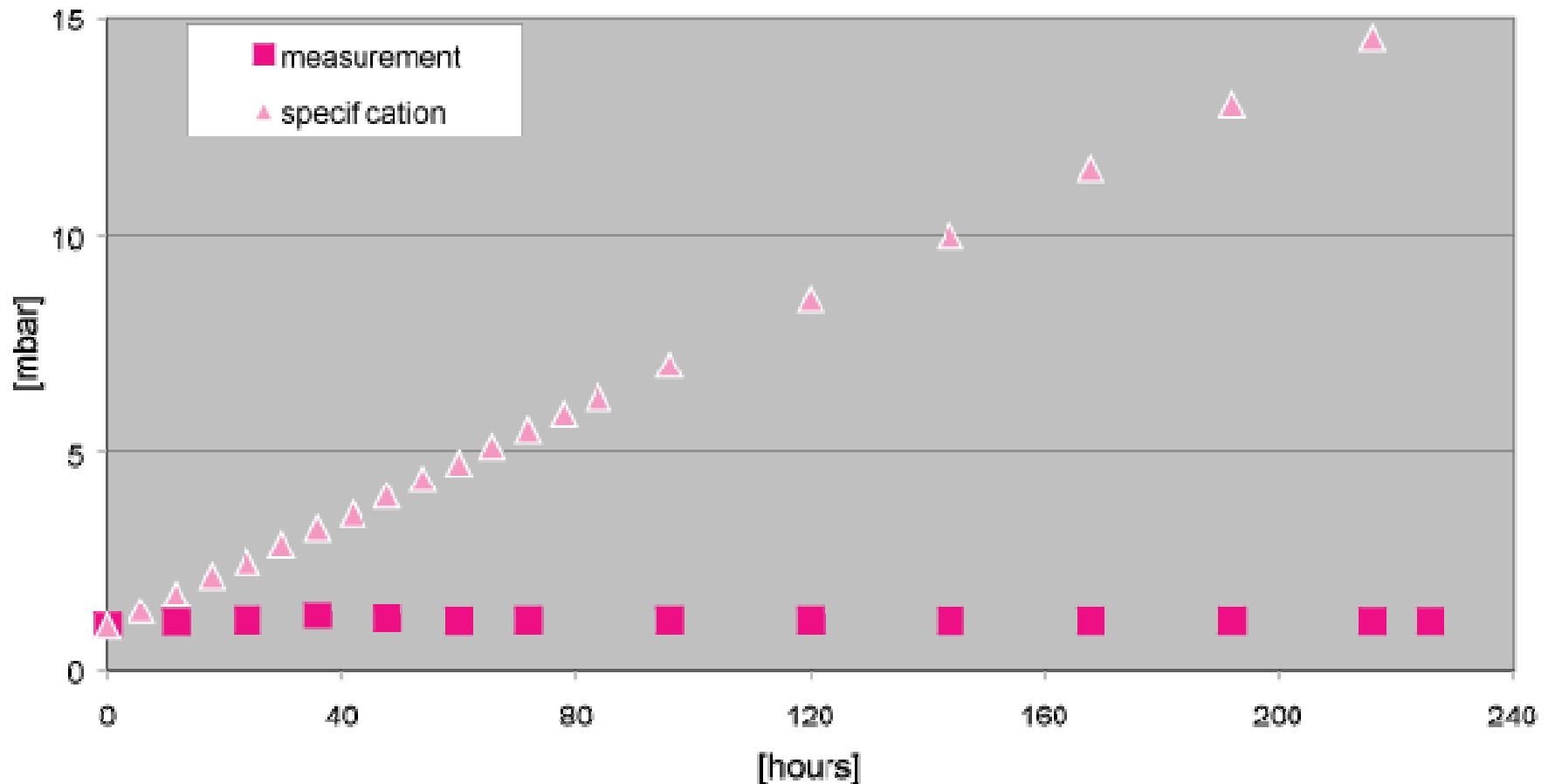






# Decay Tube completed

Decay tube: pressure increase vs. time



- the feasibility of dismantling the decay tube has been studied (required by authorities)  
(assume 10 years of operation + 10 years of "cooling")
- [www.nuclear.co.uk](http://www.nuclear.co.uk) have demonstrated feasibility;  
estimated cost 95 MCHF (incl. 25 MCHF storage Preveessin)  
(N.B. construction cost was 8 MCHF)



# Infrastructure started

- Ventilation ducts in proton beam tunnel installed
- Common supports (for cable trays, ducts and pipes) in access gallery installed
- October / November:
  - electrical services in access gallery
  - pipe work in proton beam tunnel
  - ventilation equipment in ventilation chamber
  - ...



Schedule and status of works



# Infrastructure started





# Equipment

GOAL: all equipment ready and tested in July 2005, to start installation in proton beam and target chamber

## STATUS:

- this goal is still achievable
- some "bumps in the road" (in-kind contributions)
- main issues today:      QTG quadrupole magnets  
  horn / reflector / striplines  
  target station



# CNGS Review - Summary

[http://proj-cngs.web.cern.ch/proj-cngs/PDF\\_files/CNGS-2004-Review-Report.pdf](http://proj-cngs.web.cern.ch/proj-cngs/PDF_files/CNGS-2004-Review-Report.pdf)

- **no technical obstacle**  
(SPS MD' in Sept.'04 to demonstrate double-batch extraction)
- **a lot of work remains to be done !!!!**
- horn / reflector and accessories now very critical -  
immediate action strongly recommended - **DONE (enough?)**  
(problems at LAL/IN2P3 have led to delays)
- urgent need for radioprotection expert "full-time"
- matters of general safety to be reviewed end 2004

**lack of manpower !!!!**



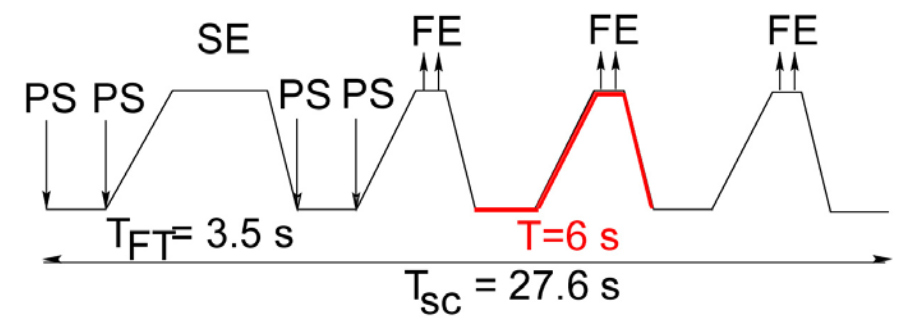
# Performance "nominal"

reminder: CNGS protons: 400 GeV from SPS

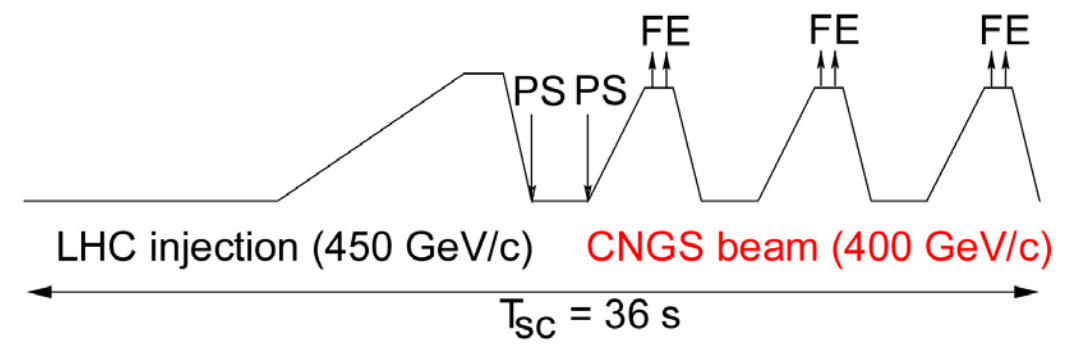
SPS cycles for CNGS:  $2 \times 10.5 \mu\text{s}$  extr.,  $\Delta t = 50\text{ms}$  / 6 s cycle

examples of SPS supercycles (out of date?):

CNGS + fixed target



CNGS + LHC



## Performance "nominal"

### CNGS proton beam (p.o.t.)

Project Proposal (1999):

per extraction:  $2.4 \times 10^{13}$

per cycle:  $4.4 \times 10^{13}$

per year  $4.5 \times 10^{19}$

(200 days run  $60\%$  efficiency, mixed with LHC MD,  
LHC filling, other fixed target users, etc.)

combination of these  
two is what matters  
"the art of operating  
an accelerator complex"



# Performance "nominal"

## CNGS proton beam (p.o.t.)

Project Proposal (report of 1999):

per extraction:  $2.4 \times 10^{13}$

per cycle:  $4.8 \times 10^{13}$

per year  $4.5 \times 10^{19}$

(200 days run 55% efficiency, mixed with LHC MD,  
LHC filling, other fixed target users)

discussed at this  
SPSC meeting ...



# Performance "upgrade"

## CNGS proton beam (p.o.t.) - SPSC Sept. 2001

(cf. R. Garoby)

per extraction:  $3.5 \times 10^{13}$

per cycle:  $7 \times 10^{13}$

per year  $?? \times 10^{19}$

### Design of CNGS Facility (2001):

per extraction:  $3.5 \times 10^{13}$  (+ safety)

per cycle:  $7 \times 10^{13}$  (+ safety)  
(shock phenomena: target rods,  
decay tube windows, etc.)

per year  $13.8 \times 10^{19}$

cf. heating/cooling of target, horn,  
hadron stop; TCC4 shielding; etc.



# Preparations for "upgrade" beam (since 2001)



examples:

(a) Cooling capacity in Target Chamber (air cooling)  
and Hadron Stop (water cooling)  
(+ sensors to check temperature evolution)

(b) Dimensioning of decay tube -> 18 mm  
(+ temperature sensors to check model)

(c) Cooling of horn/reflector inner and outer conductor

...



## Possible problems with "upgrade" beam



N.B. : CNGS beam line components only -  
other problems occur in the accelerator complex

- (1) non-centred beam hitting the target rods (-> next)
- (2) thermal expansion of target downstream support (x)
- (3) Ti windows of target downstream monitor (SEM) (x)

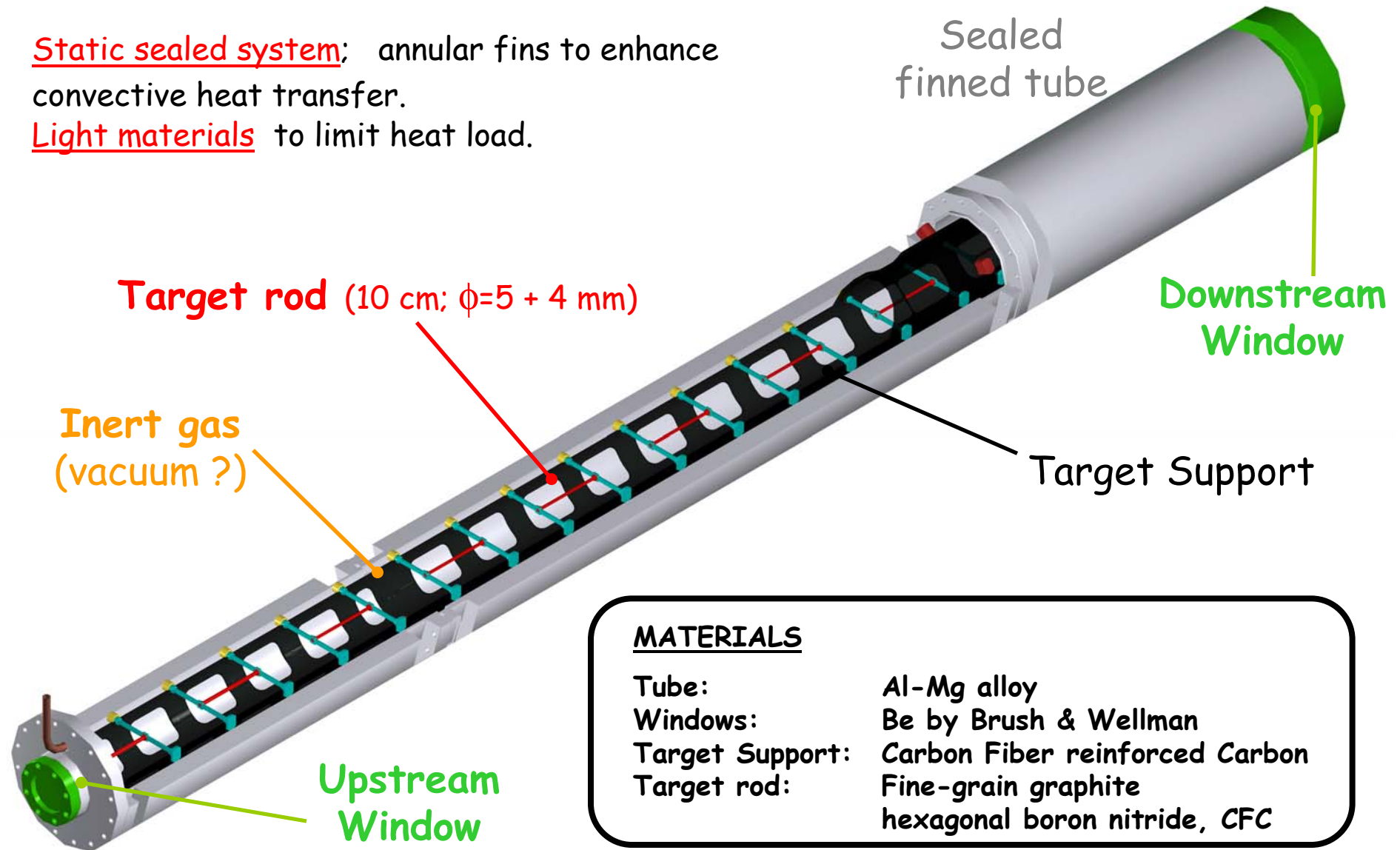
... ..

# Target Unit

(NOTE: target magazine contains 5 units)

Static sealed system; annular fins to enhance convective heat transfer.

Light materials to limit heat load.



## MATERIALS

Tube:	Al-Mg alloy
Windows:	Be by Brush & Wellman
Target Support:	Carbon Fiber reinforced Carbon
Target rod:	Fine-grain graphite hexagonal boron nitride, CFC



## Possible problems with "upgrade" beam



Non-centred proton beam hitting the target rods

---> PROBLEM of a SINGLE CYCLE <---

- > exc. beam introduces stresses / shock wave
- > (2<sup>nd</sup> or 3<sup>rd</sup>) rod may break
- > others may follow

NOTE: very little is known experimentally - engineers tend to use conservative safety factors - tests are under way:

- > fatigue tests in laboratory (graphite properties)
- > single shot beam tests in TT40 (SPS)

Resulting stresses in MPa for beam  $\Delta x=1.5\text{mm}$ , ultimate intensity:

Rod radius \ beam size	$\sigma = 0.53$	$\sigma = 0.75$	$\sigma = 0.80$
2 mm	38	27	
2.5 mm	34		22
3 mm	28		20

NOTE: < 18 MPa is considered to be "safe"  
 > 28 MPa is considered "unsafe"

→→ make the beam spot larger and increase the target rod diameter ! ?

(A) Beam spot: can be enlarged to about 0.7 mm → tails missing target ?

(B) Target rod diameter: can be increased, but... loss of  $\nu_{\mu}$  / proton !!

**COMBINED EFFECT:** loss of about 7% in performance **per proton**;  
**easily compensated by** safer operation at higher  
intensity

TARGET MAGAZINE with five units  
is a very important design feature.



# CNGS target magazine (proposal - 2004 Review)

1. Graphite target with baseline geometry under helium;
2. C-C target with baseline geometry under helium;
3. Graphite target with baseline geometry under vacuum;
4. Graphite target with all  $\varnothing 5\text{mm}$  rods under helium  
(possibility to increase the beam size);
5. *"Safe" target based on the knowledge available in 2005.*

+ 1 SPARE TARGET MAGAZINE (equip.: not yet decided)



## Comment on future CNGS beams



Published ideas all imply to change the target / horn configuration.

All equipment in the target chamber (target, shielding, Horn+reflector, etc.) can be removed

- after a LONG shutdown -

It would be good (but is probably impossible !) if the next target/horn configuration to be installed in CNGS would be known "today"



# Comment on CNGS - $\nu_{\tau}$ (my personal view)



"Hot" debates and "spicy" comments were plentiful before and after the approval of CNGS, e.g due to the small number of interesting events.

-- no doubt: CNGS is a difficult, risky enterprise --

Whatever one might think about decisions taken in 1999...

- ❑ a trickle of protons is enough to irradiate CNGS equipment, without any hope for a physics result.
- ❑ deciding to do the CNGS  $\nu_{\mu} \rightarrow \nu_{\tau}$  experiment  
== priority at PS - SPS to run at the highest possible number of protons per year, for several years



before the summary:



many THANKS ...

... to all the colleagues working on the CNGS project  
(special thanks: Malika Meddahi, deputy PL)

... to the equipment and controls experts + to the AB accelerator  
physics and operations groups - "right NOW" working on beam tests  
(double-batch extraction, high intensity in SPS, novel multi-turn  
extraction from the PS, etc.)

... to our "sponsors": Belgium, France, Germany, Italy, Spain, Switzerland

## SUMMARY

- > CNGS approved in Dec. 1999, started Sept. 2000
- > CNGS project is well under way  
... some worries... ...a lot of work... lack of manpower
- > ready for "upgrade" intensities  
(target rod choice - performance loss per proton < 10%)
- > first beam expected in May 2006



## Spare Slides

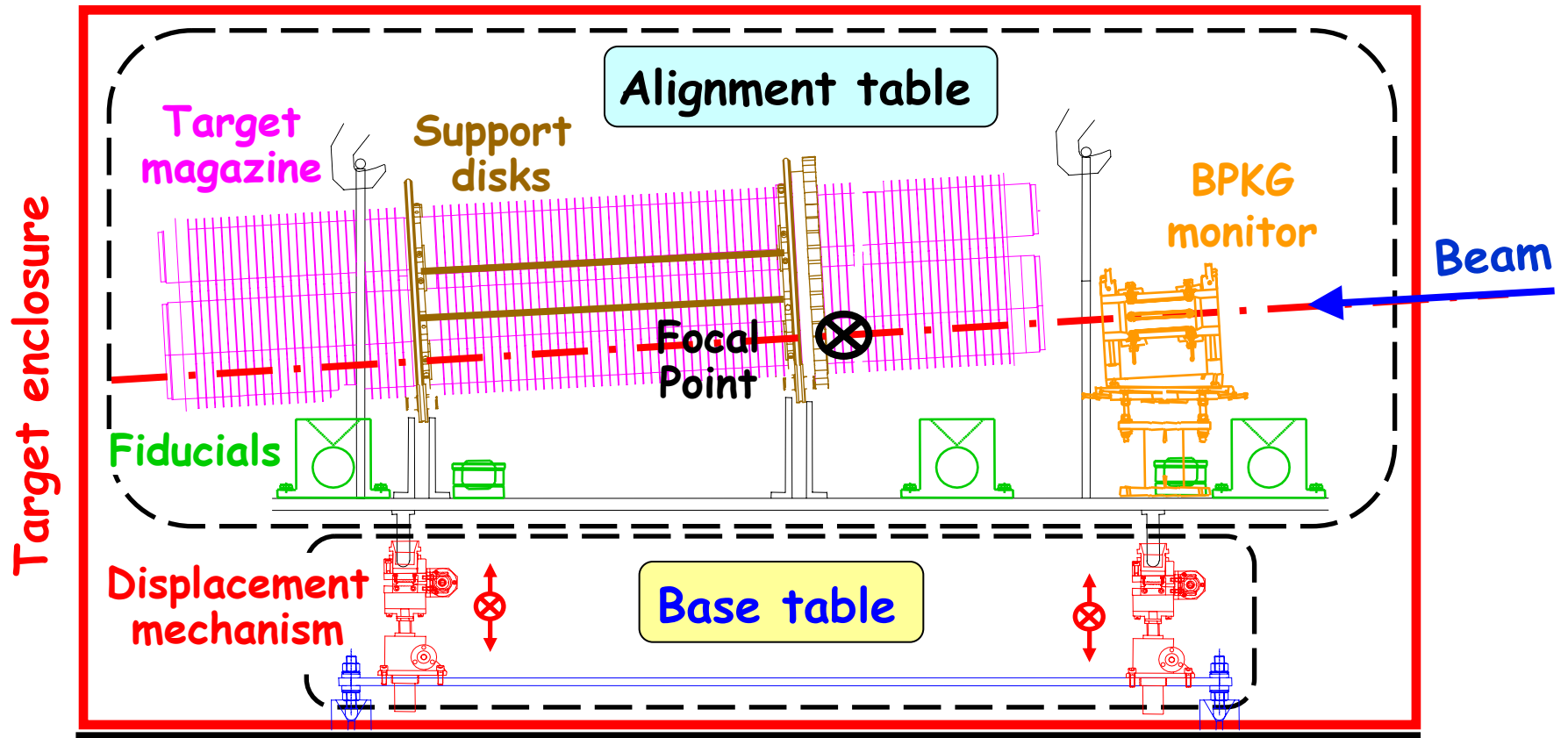
Examples: effect on  $V_{\tau}$  cc events

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

# Target Assembly



## Shielding

The target magazine is **mechanically coupled** to the BPKG monitor. They are aligned in the lab and are remotely handled as a single component (the « **alignment table** »). They rest on the « **base table** », bearing the displacement mechanisms. The cooling manifold are not shown.