STATUS REPORT ON BEAM POSITION STABILITY STUDIES AT SOLEIL

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on behalf of the SOLEIL team

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- Storage Ring Slab
- Measurements on the Magnet-Girder Assembly
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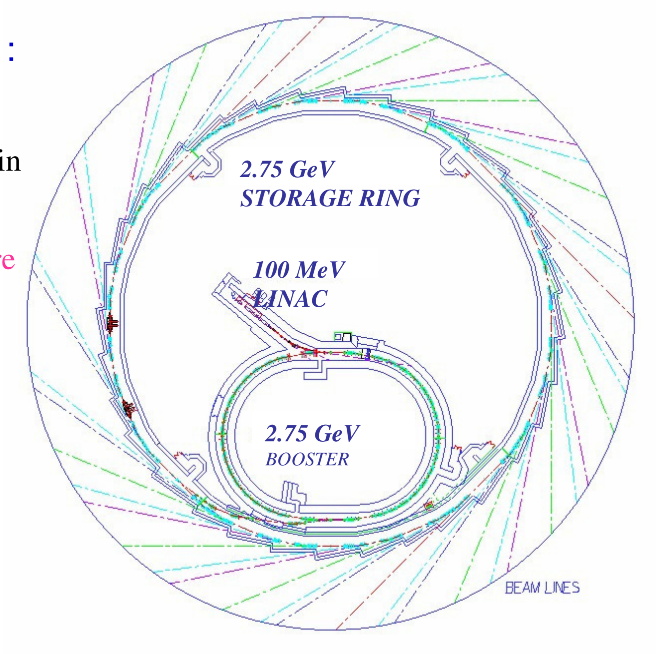
SOLEIL PROJECT : ACCELERATORS

LINAC specification :

• (500 mA in 416 bunches): Output LINAC charge 8 nC in 300 ns

• In temporal structure (100 mA in 8 bunches):

• Output LINAC charge 1.5 nC in 3 bunches



BOOSTER:

2 super periods

36 Dipoles : 0.67 T / 2.17 m

44 Qpoles:

10.3 T/m/0.4 m

Drifts: 3.17 m

Circumference: 157 m

Emittance:

150 nm

Power supplies cycling at 3 Hz

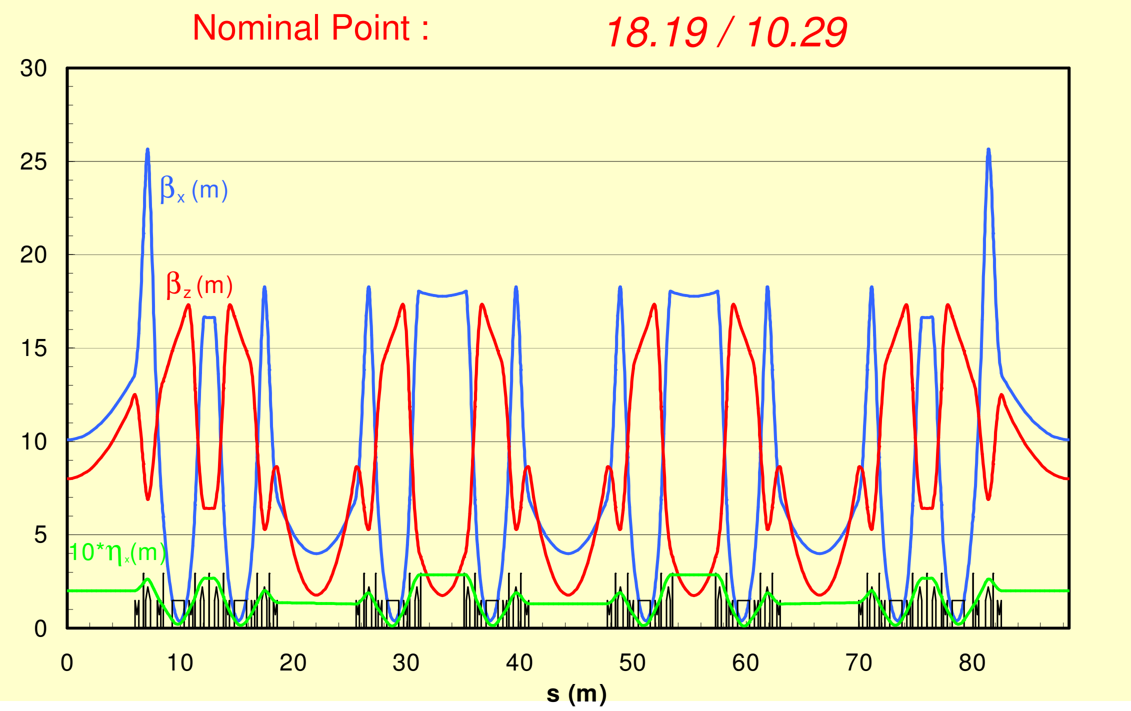
(SLS concept)

TOP UP Injection : injection every 2 min (for a beam lifetime as bas as 4h).

STORAGE RING MAIN PARAMETERS

Energy:	*2.75 GeV*
Circumference:	*354.097 m*
Emittance H / V:	*3.73 nm.rad / 37.3 pm.rad*
Number of cells / super periods:	*16 / 4*
Straight sections:	*12 m x 4 ; 7 m x 12 ; 3.8 m x 8*
Betatron tunes, ν_x/ν_z:	*18.19 / 10.29*
Natural Chromat. ξ_x/ξ_z :	*-52.42 / -22.76*
Momentum compaction:	4.49×10^{-4}
Energy dispersion :	$1.02\ 10^{-3}$
Revolution Frequency :	*0.846 MHz*

OPTICAL FUNCTIONS FOR ONE SUPER PERIOD

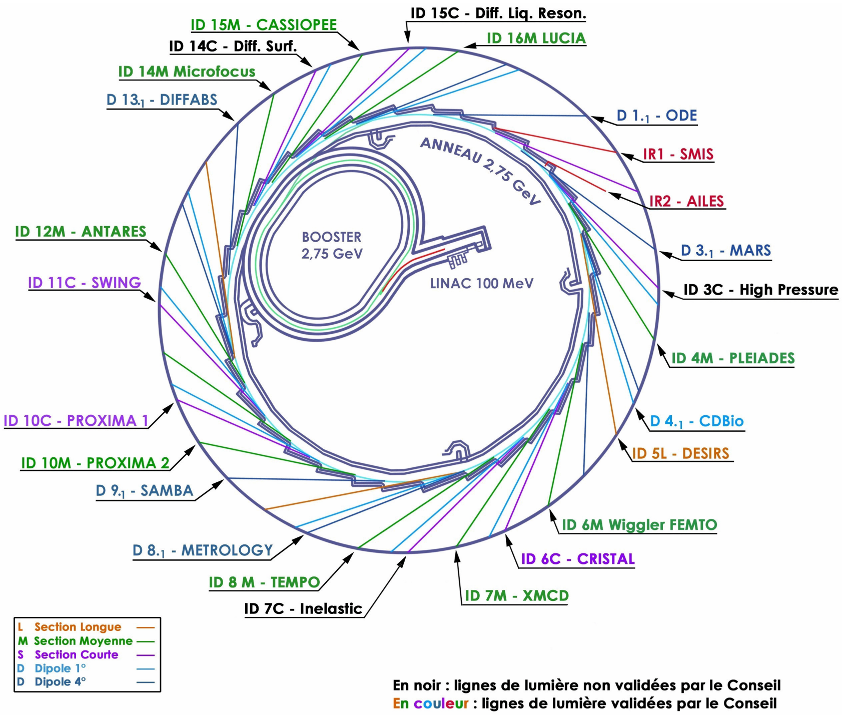


SOLEIL PROJECT : BEAMLINES

2500 users

- **10 beamlines** in spring 2006
- **24 beamlines** in 2009

43 possible beamlines, 21 on undulators



STABILITY CRITERIA

- Long term stability : 100 µm / 10 m / year

  Building foundation, (Piles)
  Alignement, (Girder design)
  HLS survey

- Medium term stability : (24h) ⟷ (reference BPM versus beamlines)

  Storage ring tunnel (and water cooling) : 21 °C ± 0.1 °C
  Experimental hall : 21 °C ± 1 °C
  Slow Orbit FeedBack
  Top-up

- Short term stability : $\sigma_{COD} < 0.1\,\sigma_{Beam}$ and $\sigma'_{COD} < 0.1\,\sigma'_{Beam}$

  Girder design
  Fast Orbit FeedBack

	σ_{COD} (µm)	σ'_{COD} (µrad)
Horizontal	18	3
Vertical	0.8	0.5

(medium straight section)

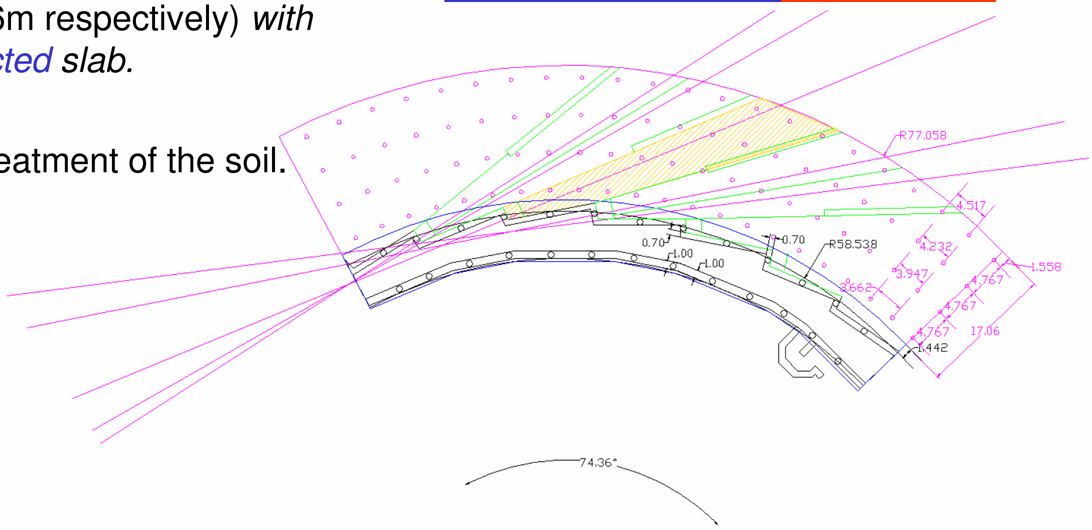
!Sub-micron tolerances!

BUILDING FOUNDATION

Slab (*0.8m thick*) of the ring tunnel and experimental hall on simple bored piles (diameter 0.8 and 0.6m respectively) *with connected slab.*

No treatment of the soil.

Chosen solution : Bored Piles



SOLEIL SYNCHROTRON

First Pile

Date : Oct 13th 2003
Length : 16 m
Weight : 38 t

SOLEIL SYNCHROTRON

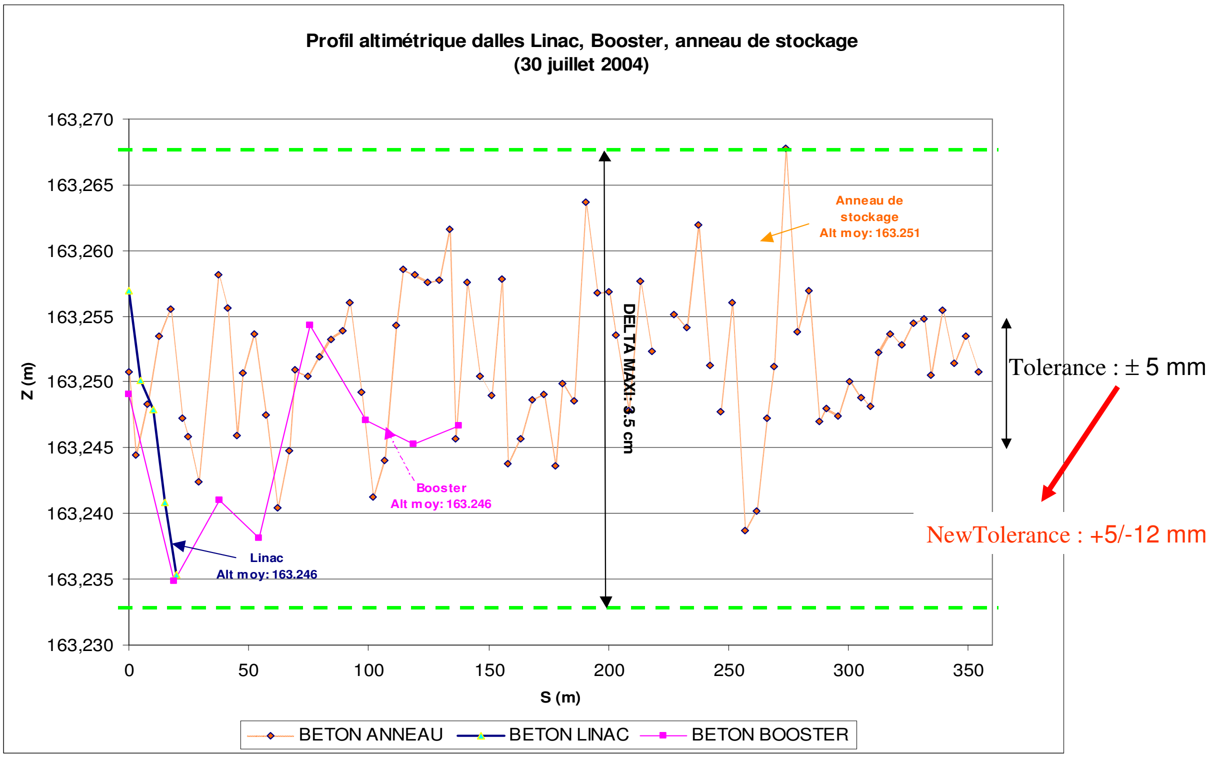
Bored Piles

128 under the ring tunnel

420 under the experimental hall (4*105)

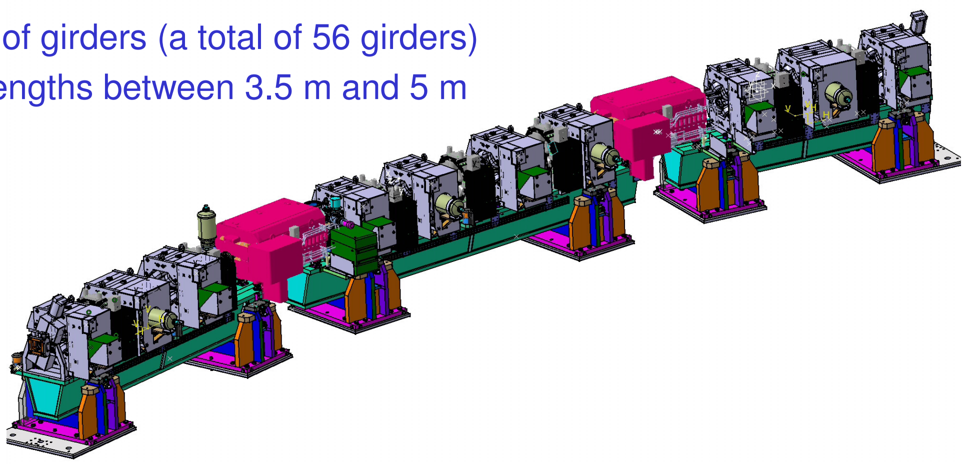
64 under linac and booster with a slab unconnected

STORAGE RING SLAB PLANARITY



STORAGE RING CELLS

- 2 Configurations :
  - 2 adjacent girders supporting 1 dipole
  - 3 adjacent girders supporting 2 dipoles
- 4 types of girders (a total of 56 girders)
- girder lengths between 3.5 m and 5 m



SOLEIL SYNCHROTRON

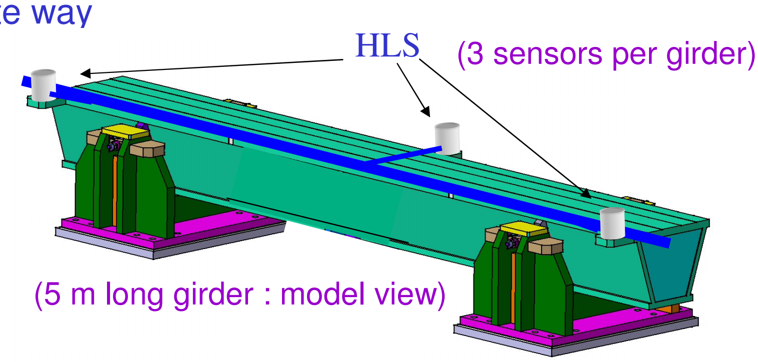
STORAGE RING SURVEYING

- Planimetric survey (s,x) by optical means :
  theodolite (*long scale)*
  wire ecartometre (*short scale*) designed especially for SOLEIL by a french company, Symétrie :

  rms measured accuracy ~ 5 µm with a 15 m long Kevlar wire

- Altimetry survey (z) : HLS (*Hydrostatic Levelling System*) network used in absolute way

Fogale HLS (Nîmes, France)



SOLEIL SYNCHROTRON

HLS : Requirements for storage ring positioning

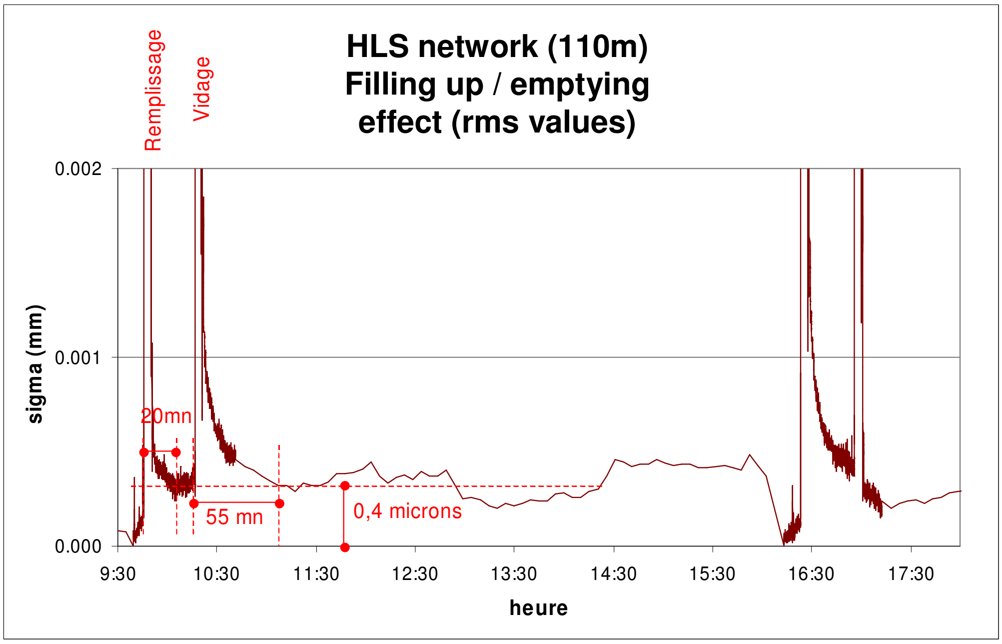
- In terms of bandwidth:
  - Detection of the variations on an hour scale
  - Maintenance of the system once a year (ex: slow drift elimination)

- The origin of the main physical parameters to be taken into consideration :

  - Thermics : fluid & mechanics dilation,
  - Mechanics : fluid movements, stability of the sensor
  - Electronics : capacitive measurement & signal conditioning

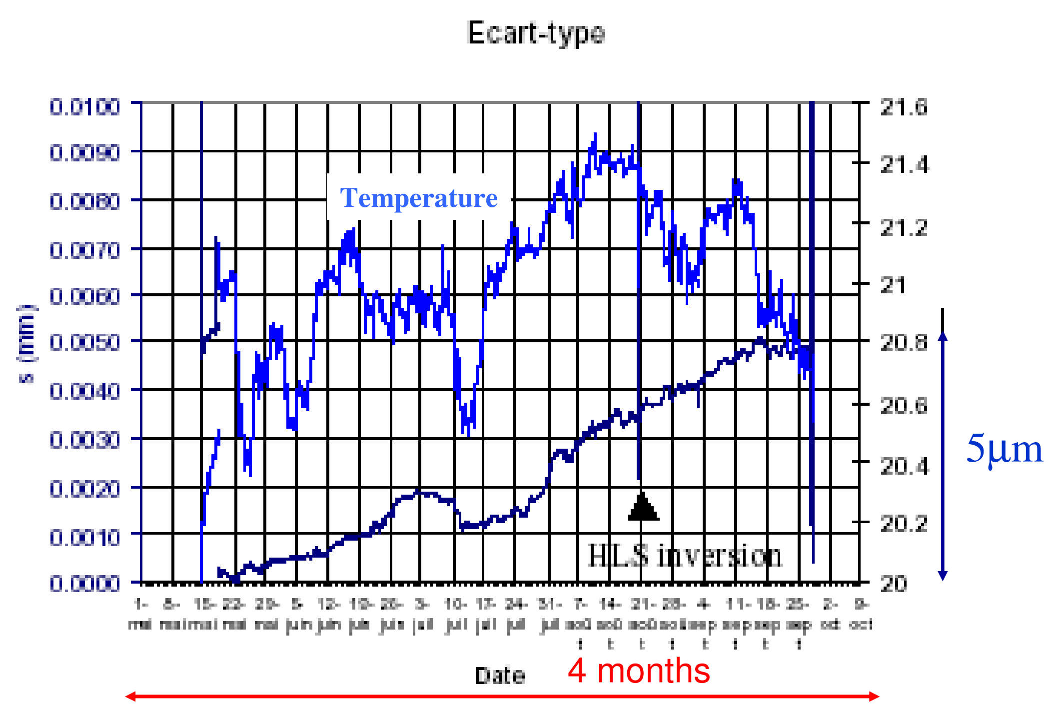
QUALIFICATION TESTS OF THE HLS

(short term stability : 0.4 µm after 1 hour)

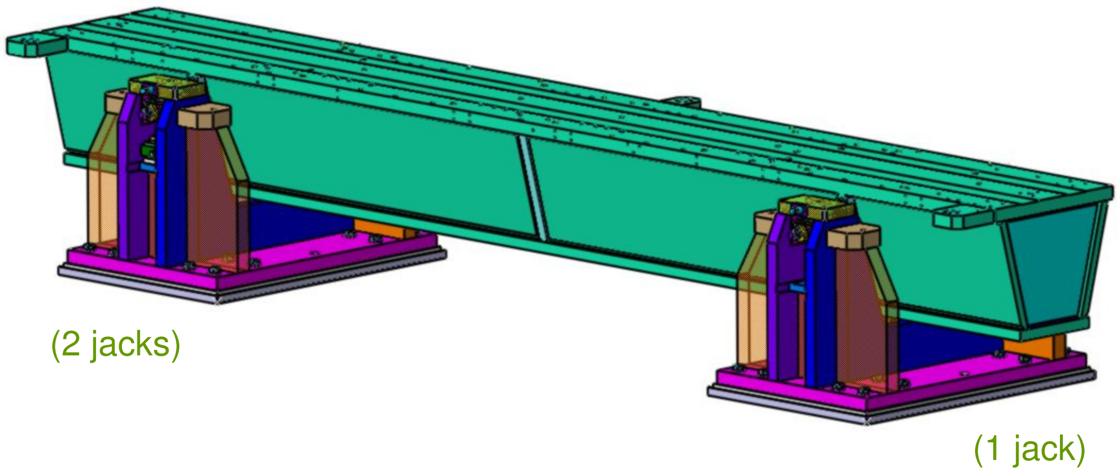


QUALIFICATION TESTS OF THE HLS

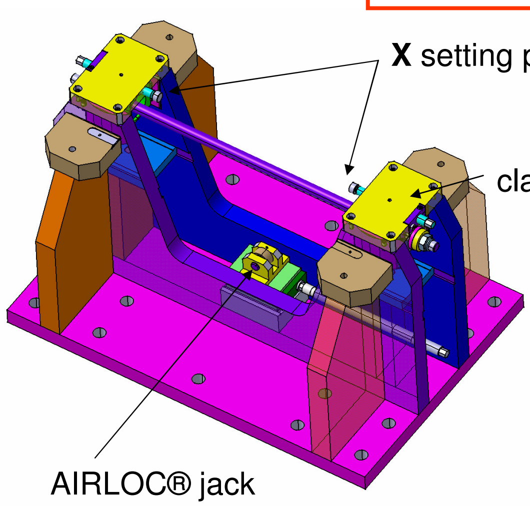
(Long term stability)



5 m LONG GIRDER : MODEL VIEW



THE GIRDER STAND



X setting pushing screws

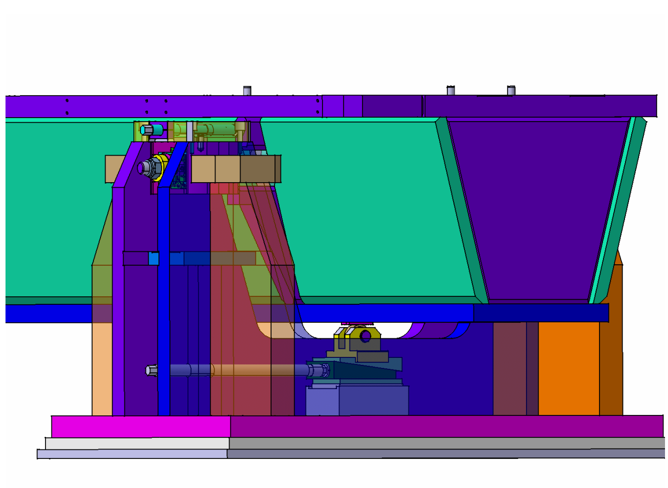
(no loss of the setting after clamping)

clamping on the 4 binding points (increases stiffness)

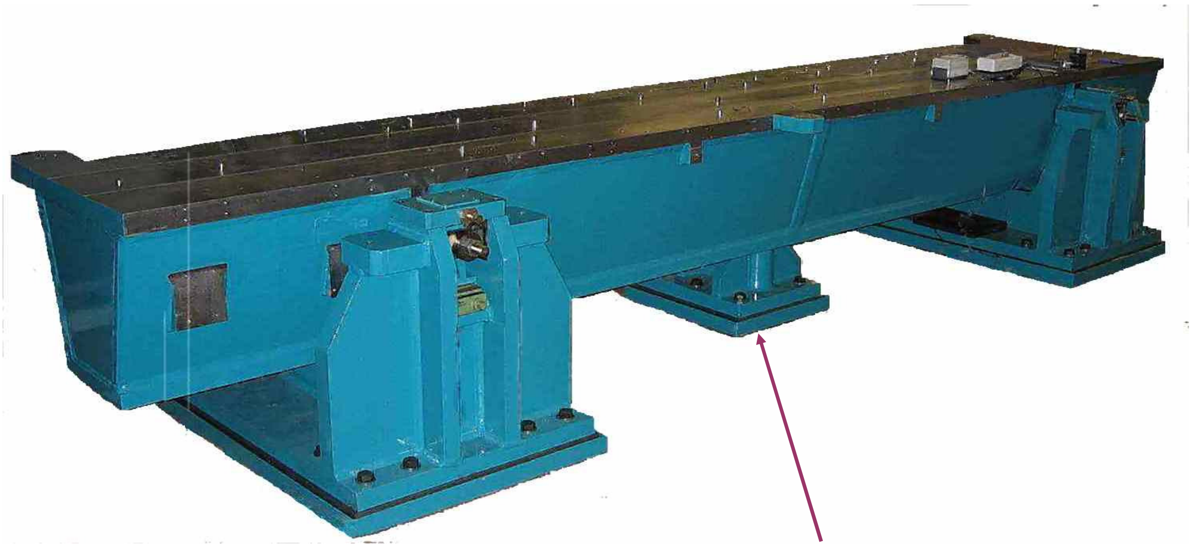
AIRLOC® jack

travel **Z**= +8/-6 mm

(one jack configuration)

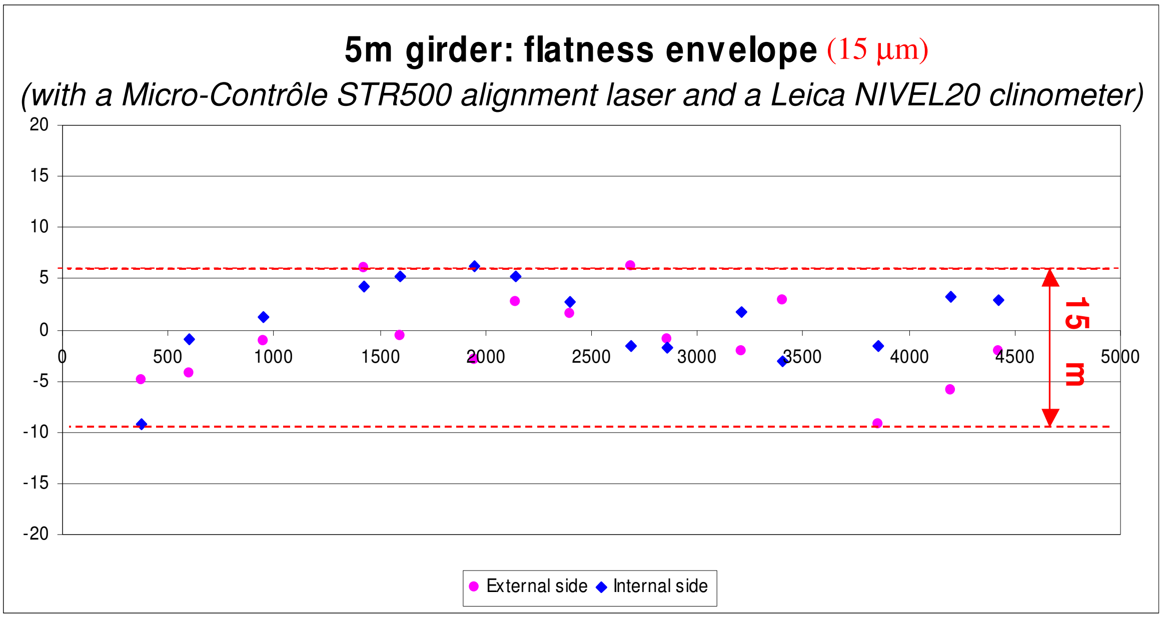


5 m LONG GIRDER : PROTOTYPE REAL VIEW



(This central stand is suppressed in the final version)

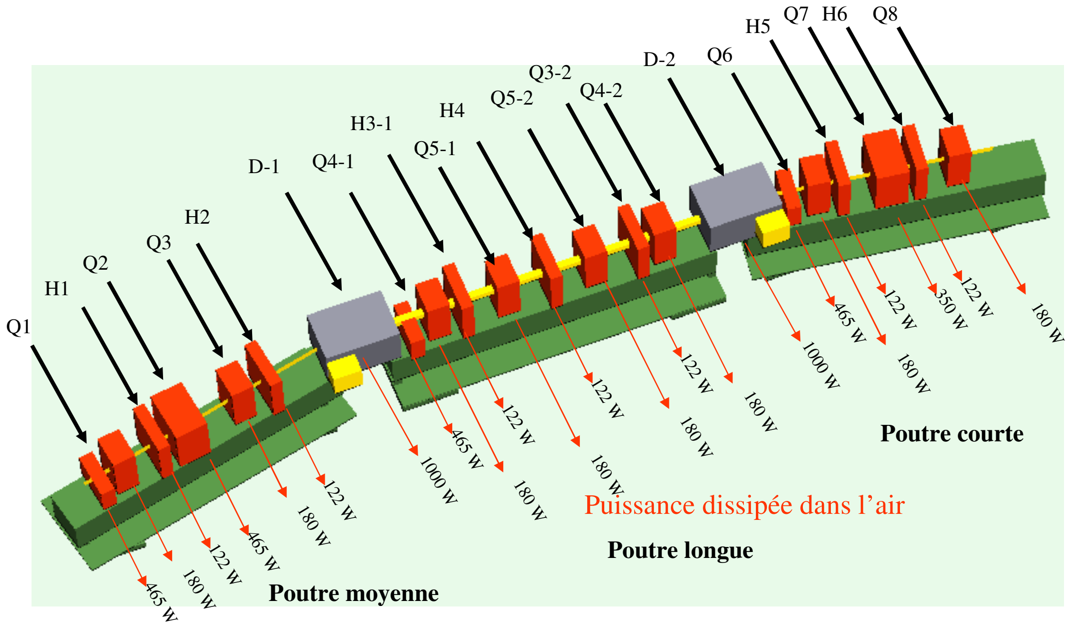
STATIC GIRDER MEASUREMENTS



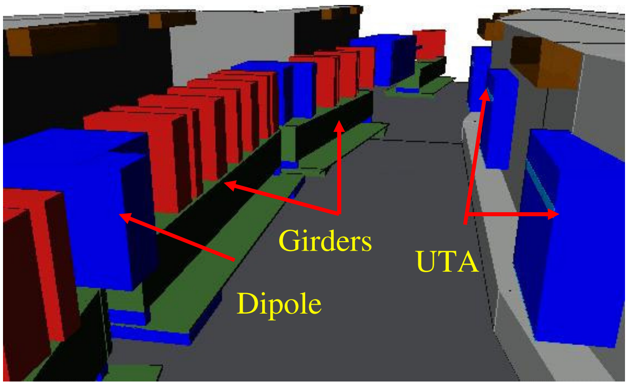
- Deflexion with full load: ≈ 10µm

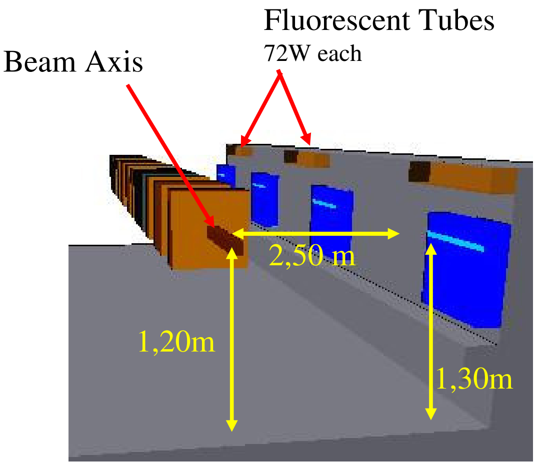
AIR CONDITIONING : CELL01 MODELING

Hypothesis : 15% of the power is dissipated in air (pessimistic)

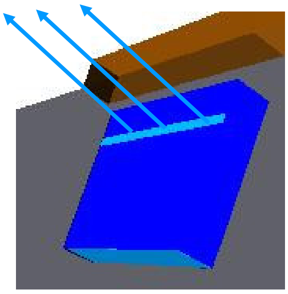


STORAGE RING AIR CONDITIONING





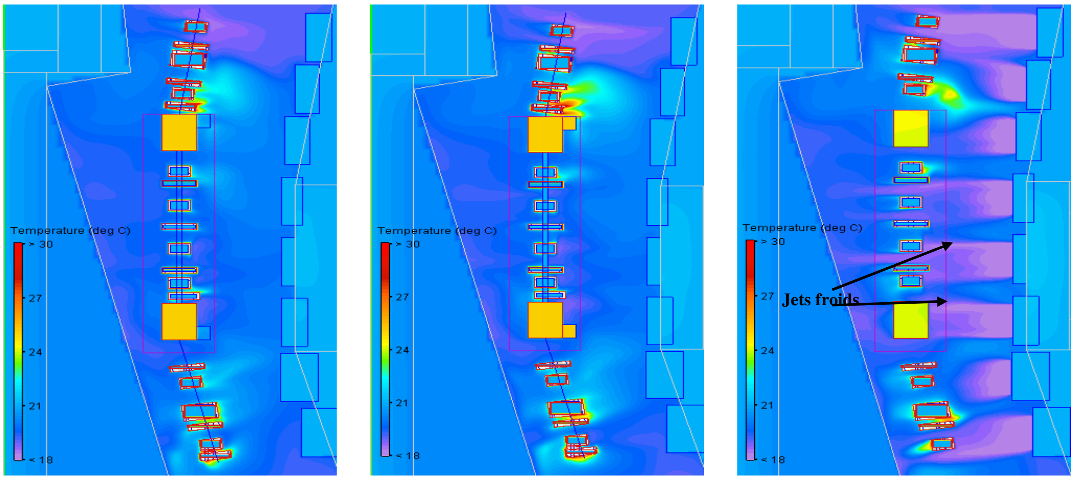
UTA
(blowing unit)



UTA blowing temperature = 18°C
horizontal widening angle 5°
vertical deflection angle +10°

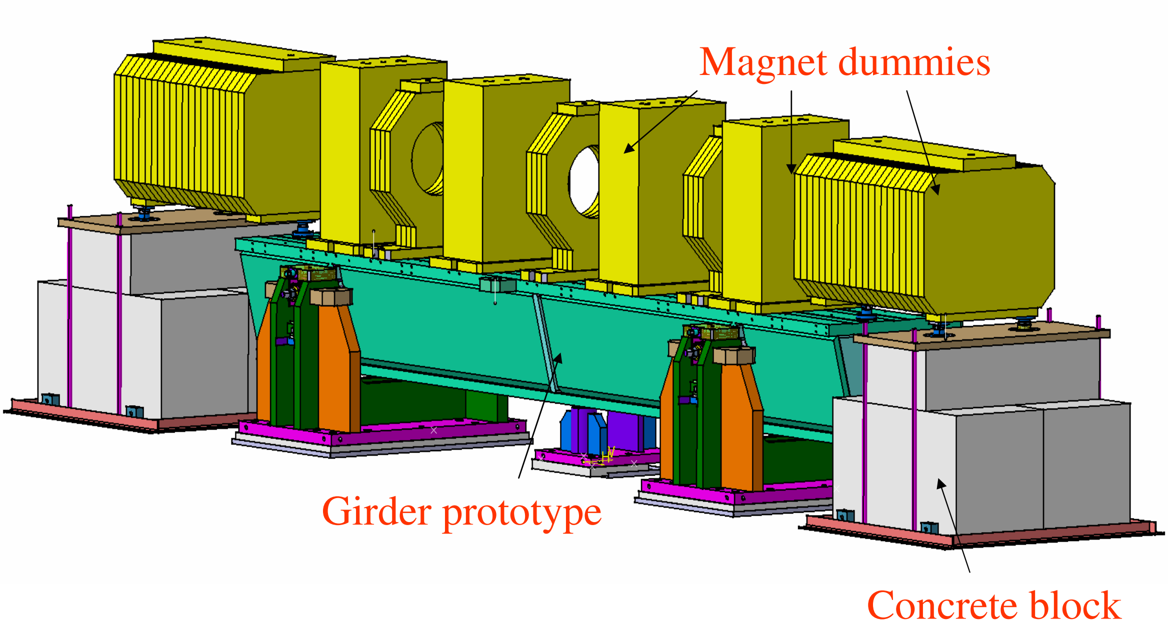
TEMPERATURE DISTRIBUTION :
Horizontal Plane

- The achieved static (average) air temperature in the area of the girders is of 19.5 ± 0.3 °C in the longitudinal direction. UTA regulation should insure the temporal stability within ± 0.1 °C.



(altimetry) **1 m** **1.20 m (Beam axis)** **1,48 m (UTA axis)**

DYNAMIC MEASUREMENTS
TEST BENCH : MODEL VIEW



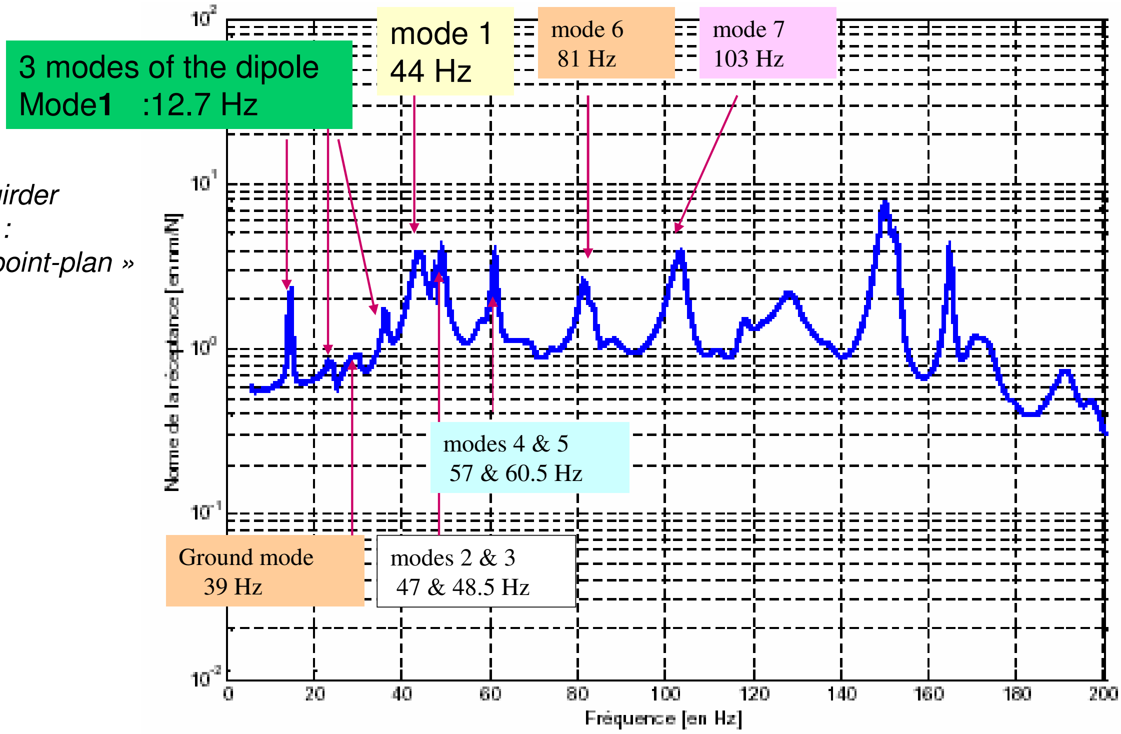
SOLEIL SYNCHROTRON

TEST BENCH : REAL VIEW

SOLEIL SYNCHROTRON

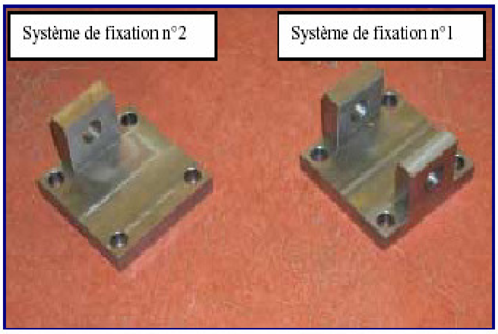
LOADED GIRDER RESULTS

dipole/girder contact : « Line-point-plan » support

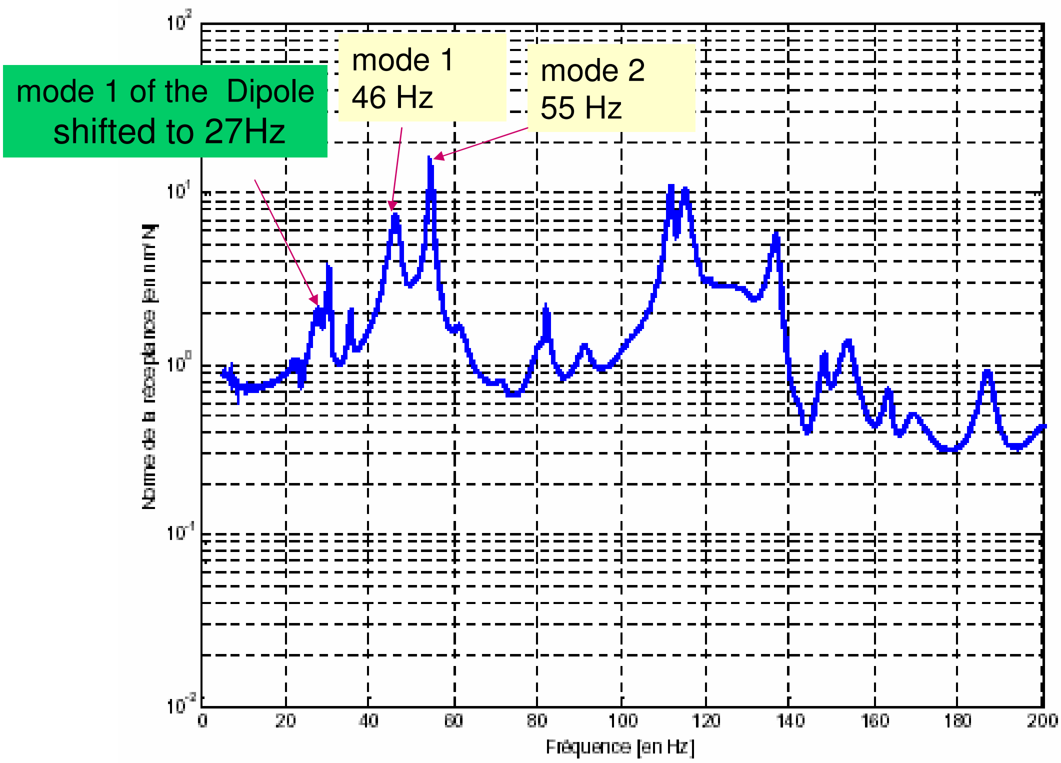


NEW MODE OF DIPOLE SUPPORT

(MORE) RIGID FIXATION



LOADED GIRDER RESULTS WITH RIGID FIXATION



BPM Electronics Requirements

	SOFB	FOFB
Absolute accuracy	≤ 20 µm	≤ 20 µm
rms Resolution @ rep. rate	≤ 0.2 µm @ 10 Hz	≤ 0.2 µm in 100 Hz BW
Measurement rate	10 Hz	≥ 8 kHz
Dynamic range	20 - 600 mA	20 - 600 mA
Current dependence	≤ 1 µm	≤ 1 µm
8-h drift	≤ 1 µm	≤ 1 µm
1-month drift	≤ 3 µm	≤ 3 µm
bunch pattern	≤ 1 µm	≤ 1 µm

Instrumentation **T**echnologies
+ SOLEIL developments

BPM Electronic Module :
***Libera** from **I**nstrumentation **T**echnologies*

Acceptance Tests of Prototype Unit

- Goal : validate the hardware design before series production
- Acceptance test measurements :
  - Electronics offsets ≤ 180 µm (easily subtracted via software)
  - Stability during one night ≈ 1.5 µm in 12 hours (ΔT = 1.5 °C)
  - Stability due to Temperature variation ≈ 10 µm from 10 to 35 °C
  - Check first turn lowest measurable current (Booster and Storage ring)
  - Bunch pattern dependence (416 B; 8 B; 1 B) ≤ 2.5 µm (to be suppressed by software subtraction, being developed by I -T)
  - *Beam Current Dependence* ≤ 8 µm *(not a problem if Top-up,* to be suppressed by software subtraction *)*
  - *Resolution at 700 Hz rate*
- There is no real issue, we have good confident that these requirements can be achieved.
- Tests on table (at SOLEIL, this month) and with beam (at ESRF) are foreseen at the beginning of next year.

GLOBAL BEAM POSITION FEEDBACKS

- Slow Orbit FeedBack (SOFB) 0 to ~ 0.01 Hz : to be ready for the commissioning

  Secondary coils in sextupoles
  120 BPM → SVD algorithm → 56 H correctors and 56 V correctors and Δf_{RF}
  Aluminium vacuum chamber (eddy current, f_{cut} ~ few Hz)

- Fast Orbit FeedBack (FOFB) 0.01 to ~100 Hz : few months after the commissioning

  Dedicated FOFB network provides position data to all BPM modules

  Each BPM module (in its FPGA) computes one line of the correction matrix and sends the results to the correctors (**8 kHz** rate in Horizontal and Vertical)

  Fast air correctors are installed over the bellows (stainless steel vacuum chamber, f_{cut} ~ few kHz)

  120 BPM → SVD algorithm → 46 H and 46 V fast correctors (20 bits)

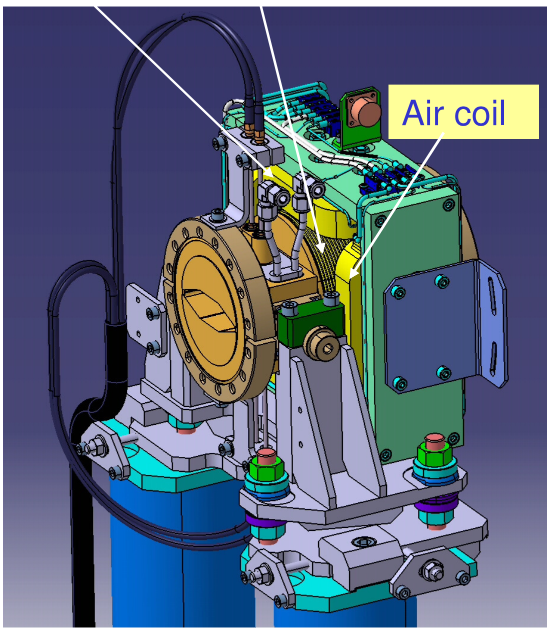
Interaction between both FBs :

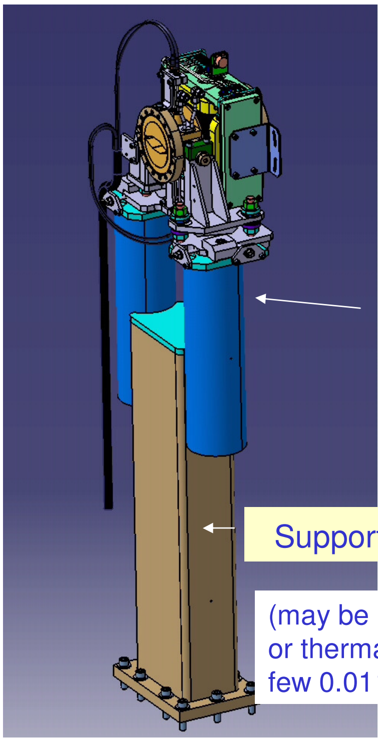
- no frequency dead zone (à la ALS)
- To avoid FBs fighting : SOFB communicates with FOFB

Straight Section BPM Support

BPM

Bellows



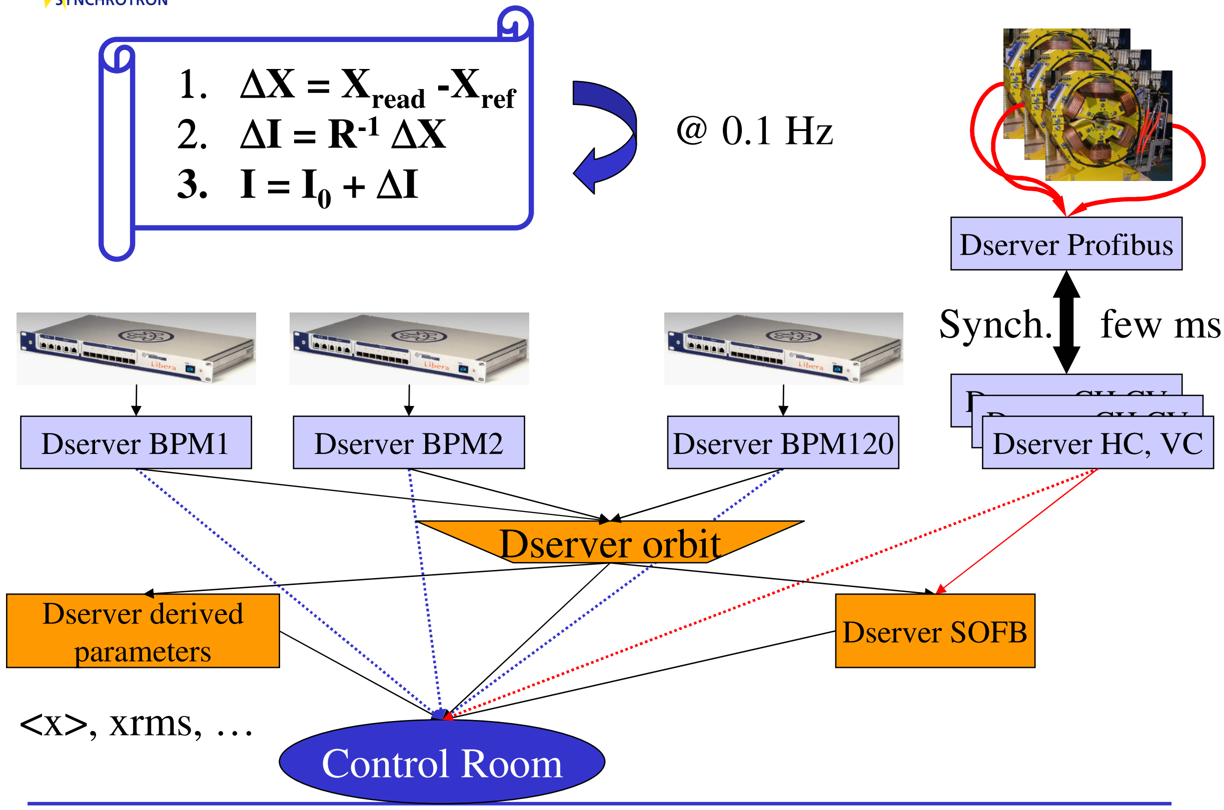


Stainless steel

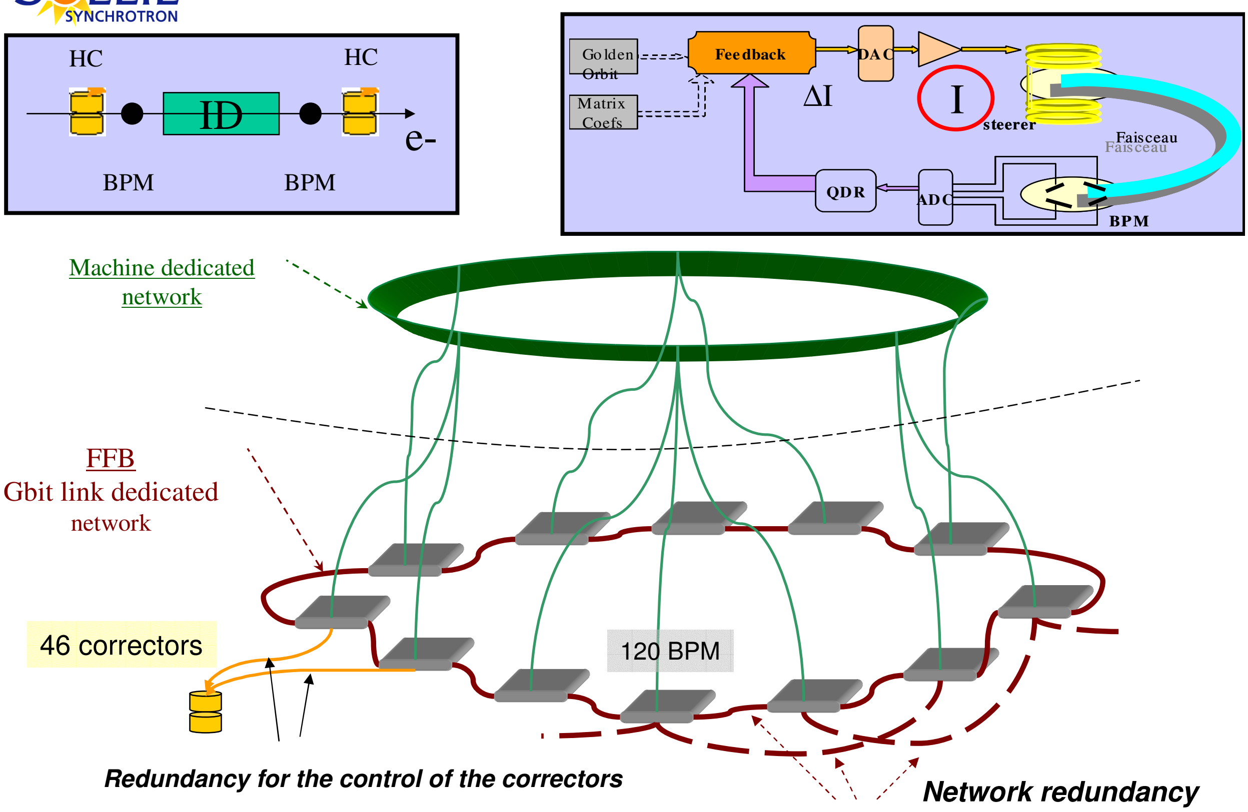
Supporting post in steel

(may be later built in invar or thermally stabilized to a few 0.01 ℃)

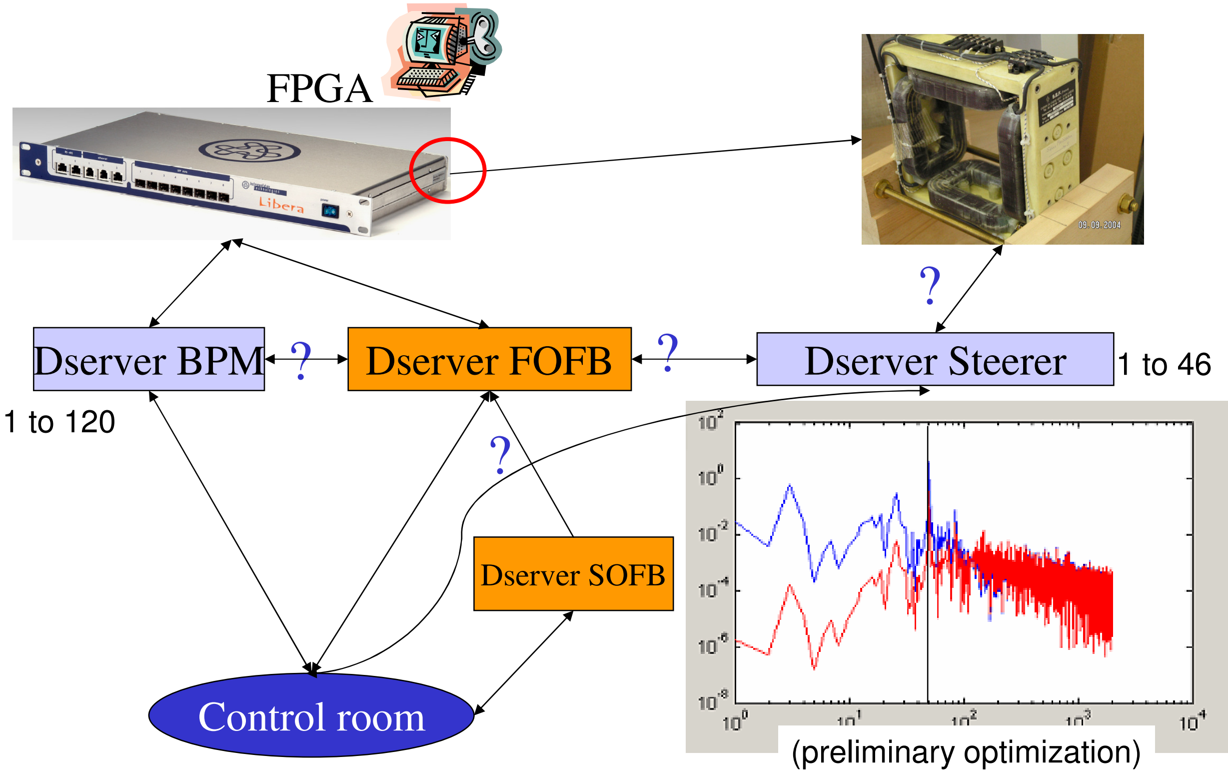
Slow Orbit FeedBack



Fast Orbit FeedBack



FOFB : Command Control Scheme



ACKNOWLEDMENTS

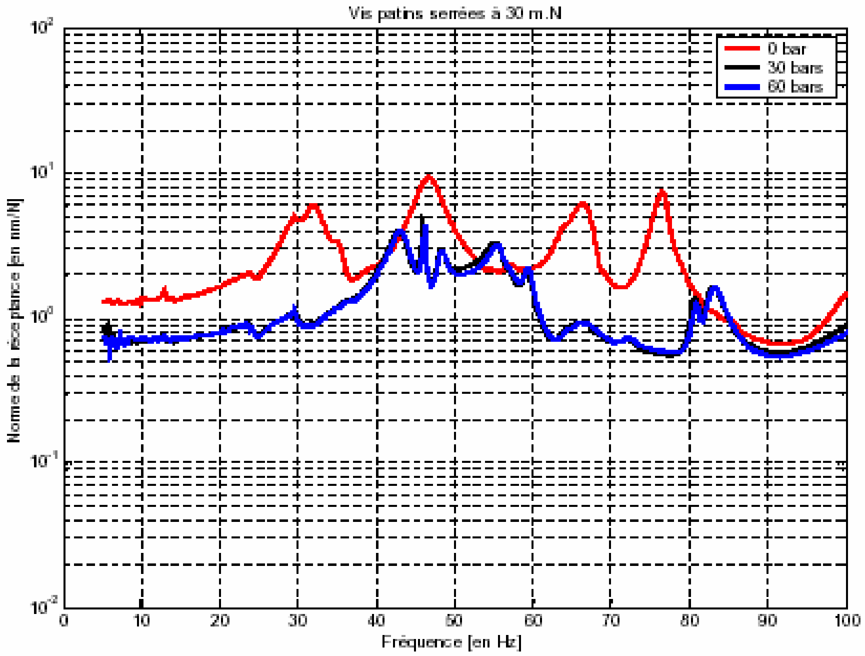
I would like to thank many of my colleagues for many valuable and helpful discussions especially :

Jean Claude DENARD : BPM system
Xavier GLARDON : Air conditioning
Jean-Luc Giorgetta : Measurements on Girders
Nicolas HUBERT : Fast Orbit FeedBack
Alain Lestrade : Alignment, HLS system

Marie-Paule Level and the Machine Physics Group for general discussion.

ANNEXE

INFLUENCE OF THE CLAMPING SYSTEM



Frequency response for 3 values of the clamping force

MILESTONES

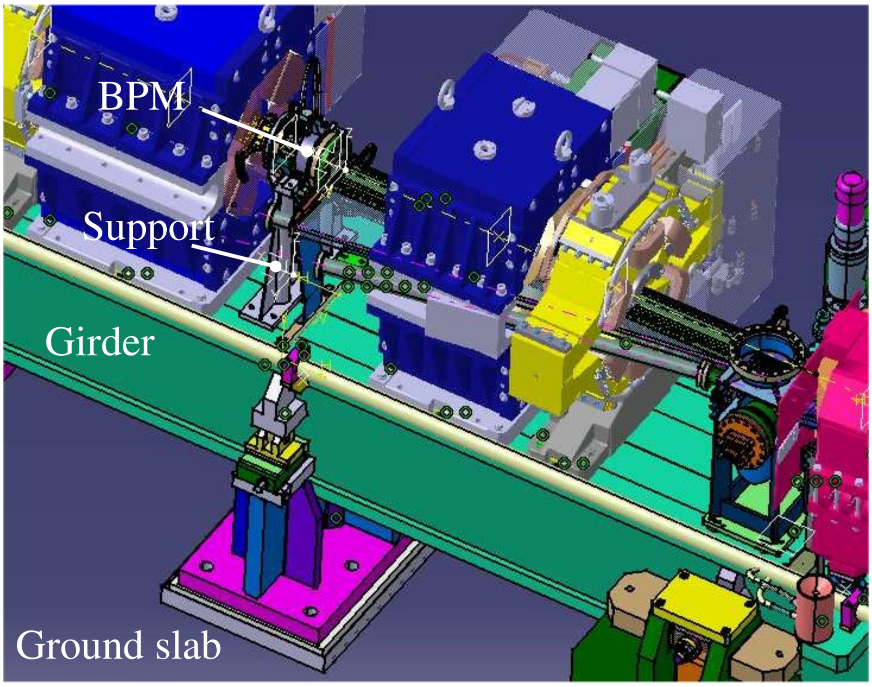
Key issue : beneficial occupancy of the synchrotron building

- LINAC installation 20 September 2004
- Commissioning: February 2005
- Booster installation 15 December 2004
- S.R. installation March 2005
- Booster commissioning: April 2005
- S.R. commissioning: September 2005

•Phase 1 beamlines (11) opened to Users : Spring 2006

SOLEIL in July 2004

BPM in the Arcs



CORRECTORS FOR THE SLOW ORBIT FEEDBACK