Vertical slow drift between Storage Ring & beam position at the secondary source of NANOSCOPIUM at SOLEIL

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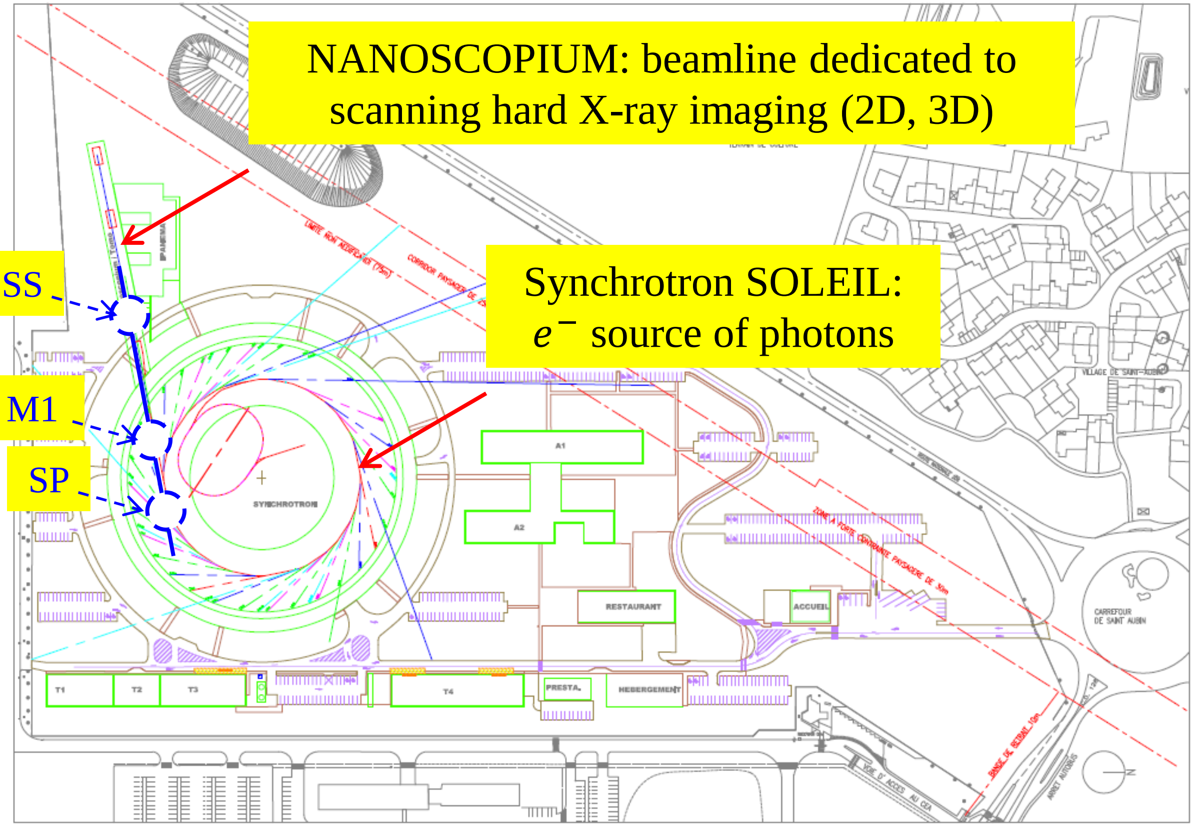
Synchrotron SOLEIL & NANOSCOPIUM

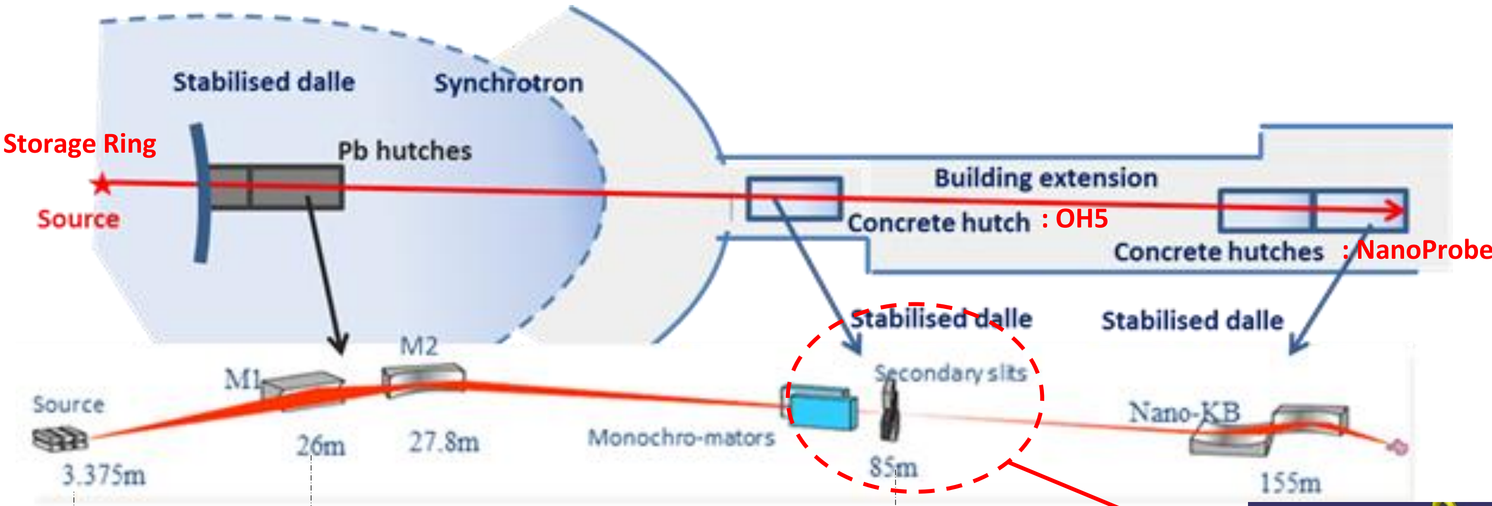


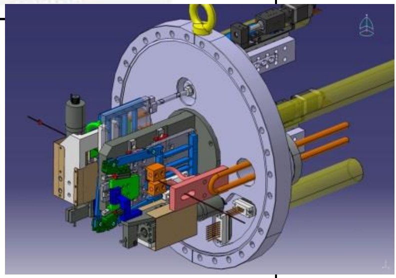
Stability:few µm over 8h

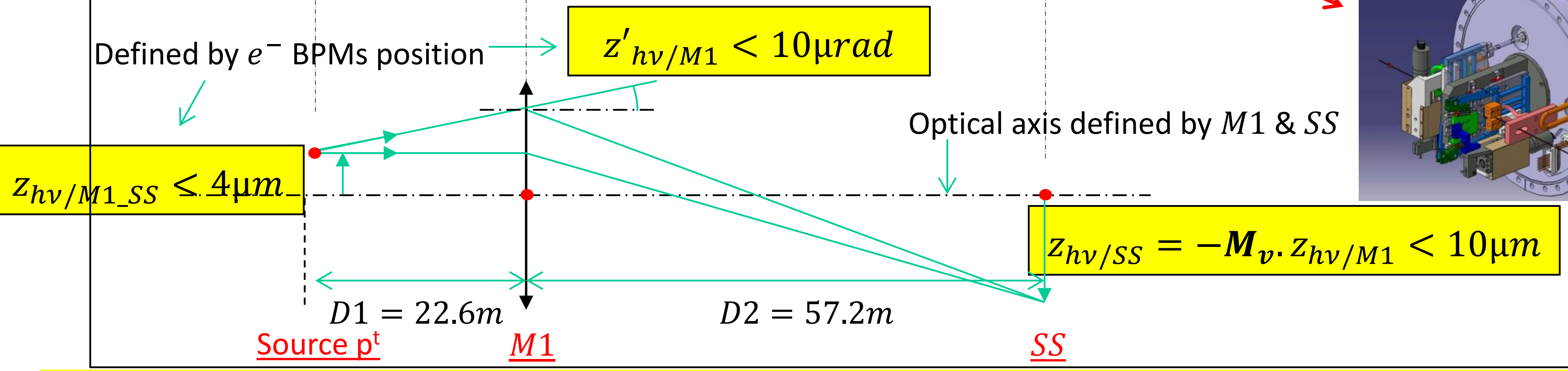
Summary

1) NANOSCOPIUM optics & stability/position requirements
2) HLS, stability issues & data processing
3) HLS & beam monitoring comparison
4) Experimental hall air conditioning variations
5) NANOSCOPIUM stability estimation

NANOSCOPIUM optical design







Stability/positioning criterion: $\frac{\Delta I}{I} < 10\%$ photon beam loss of intensity after SS of 10 x 10 µm opening

NANOSCOPIUM HLS design

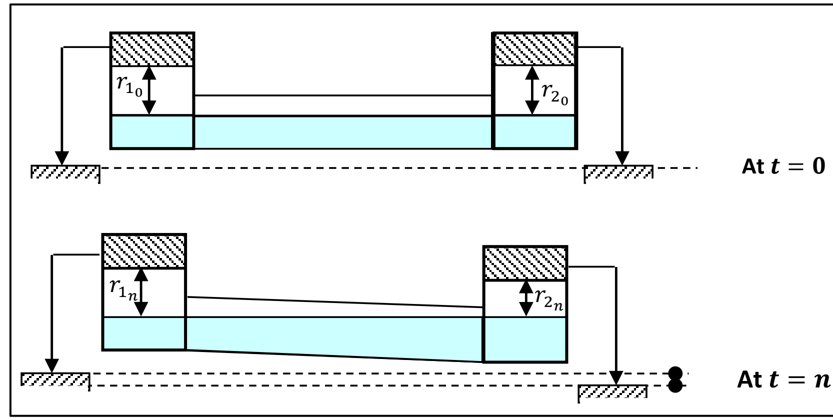
Survey of vertical slow drift of strategic monitors & optics with HLS

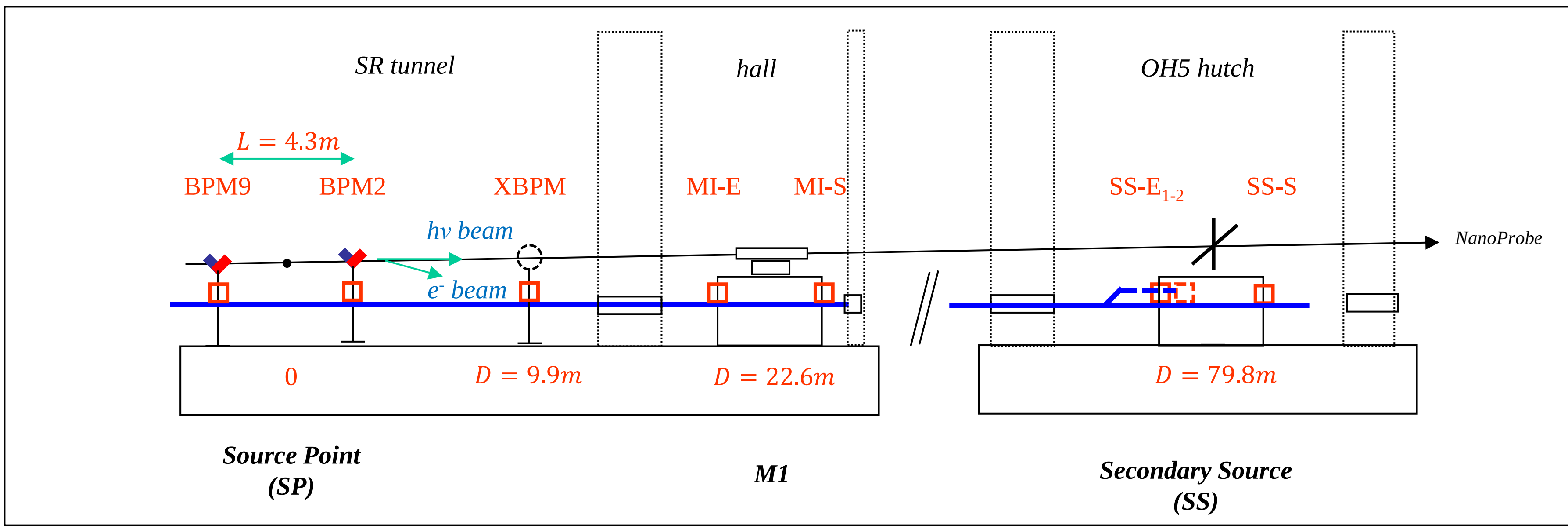
Sensors with 1mm range

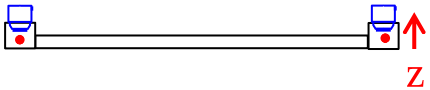
16 bits DAC for 0-10V

Half-filled rigid pipes

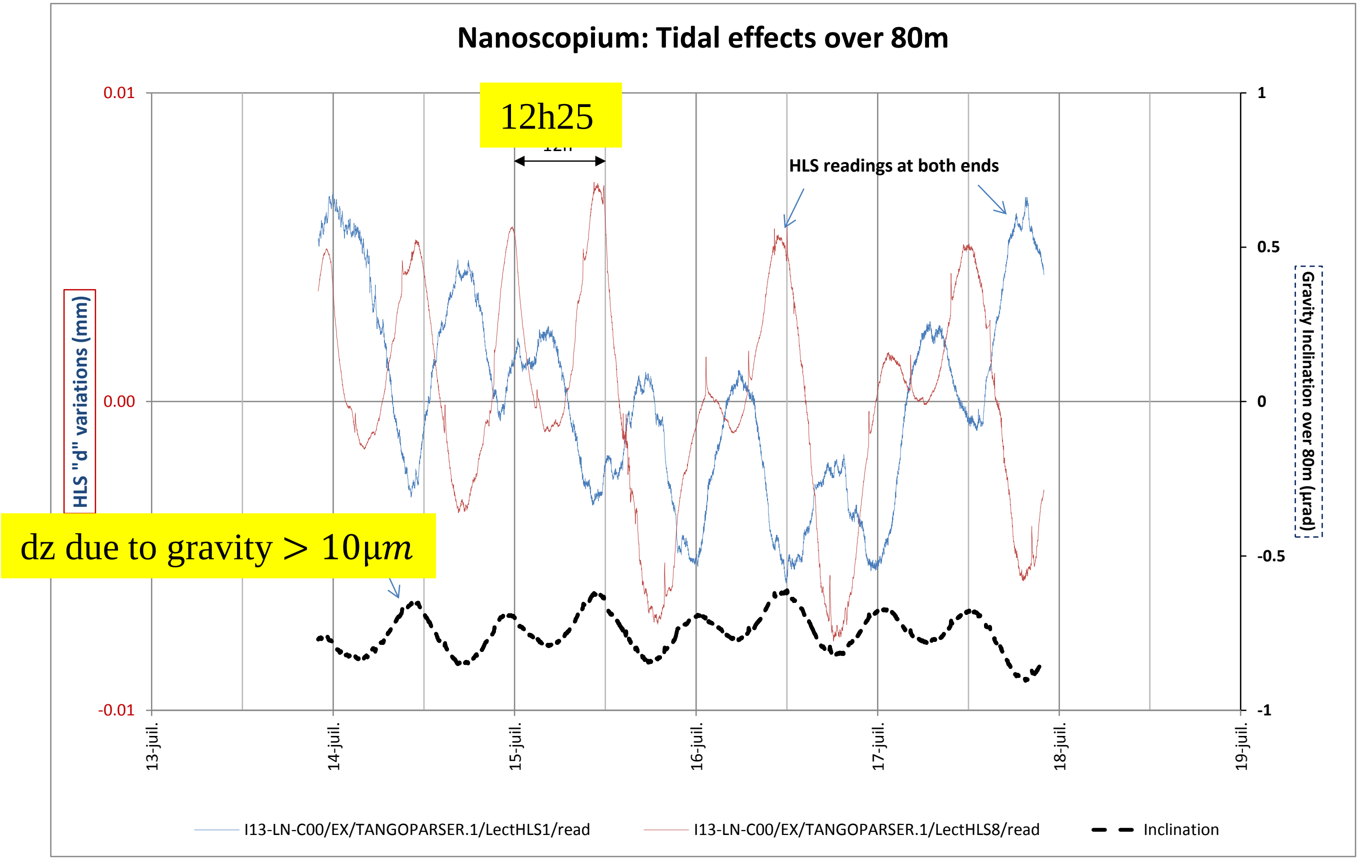
Fogale HLS

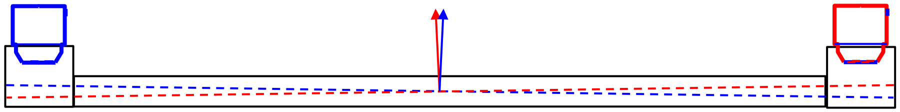


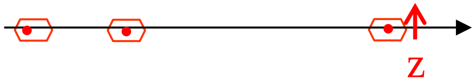




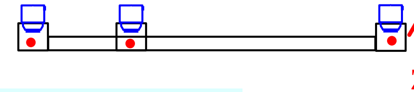
Tidal effects on free surface of water (FSW)





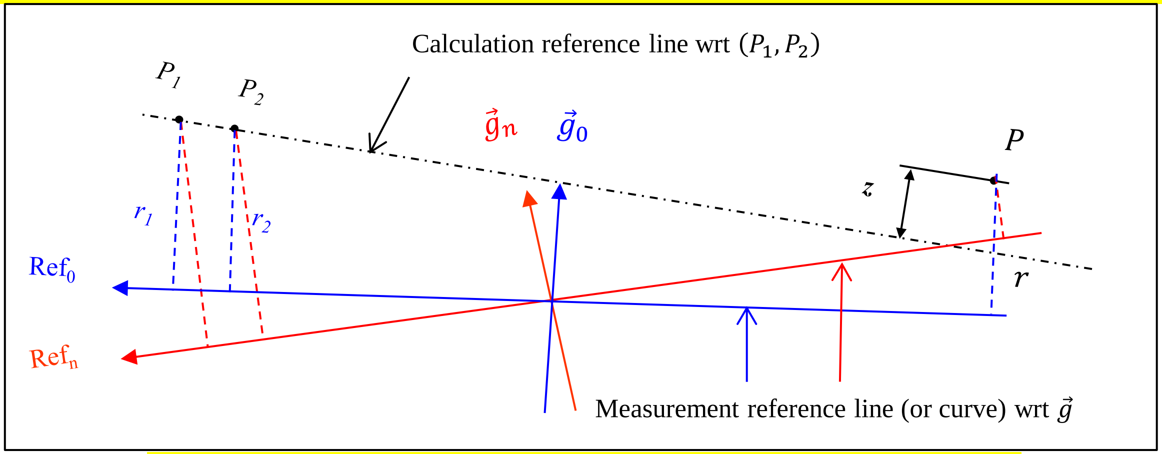


sensors & SDP configuration

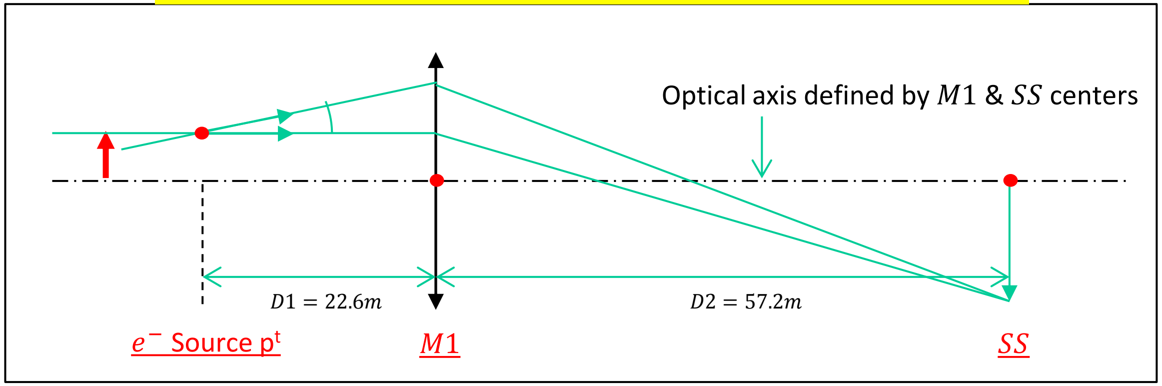


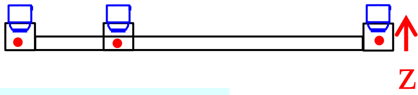
Spatial differential processing (SDP)

- A differential processing is necessary:
- The relative position of points does not depend on the referential

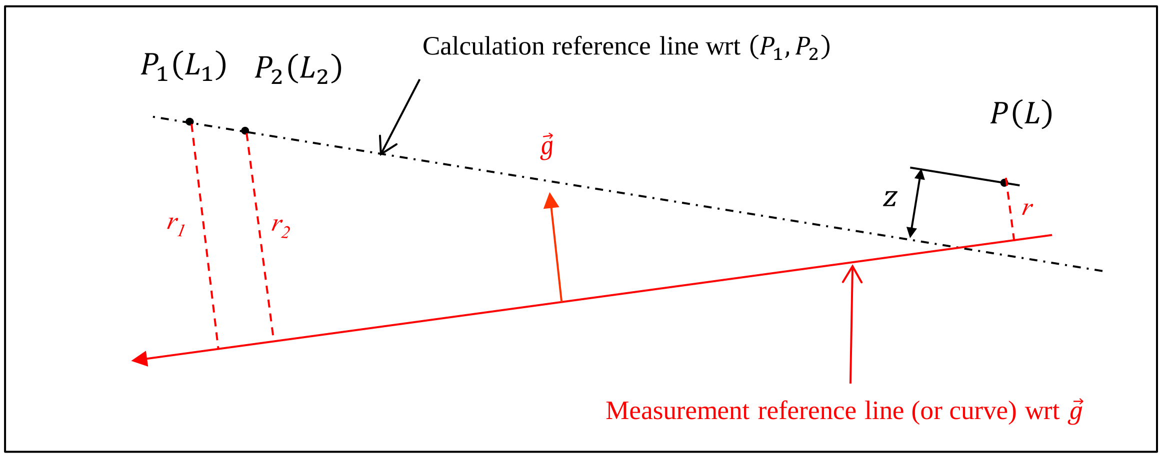


- Optical design defines relative z variations

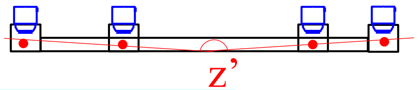




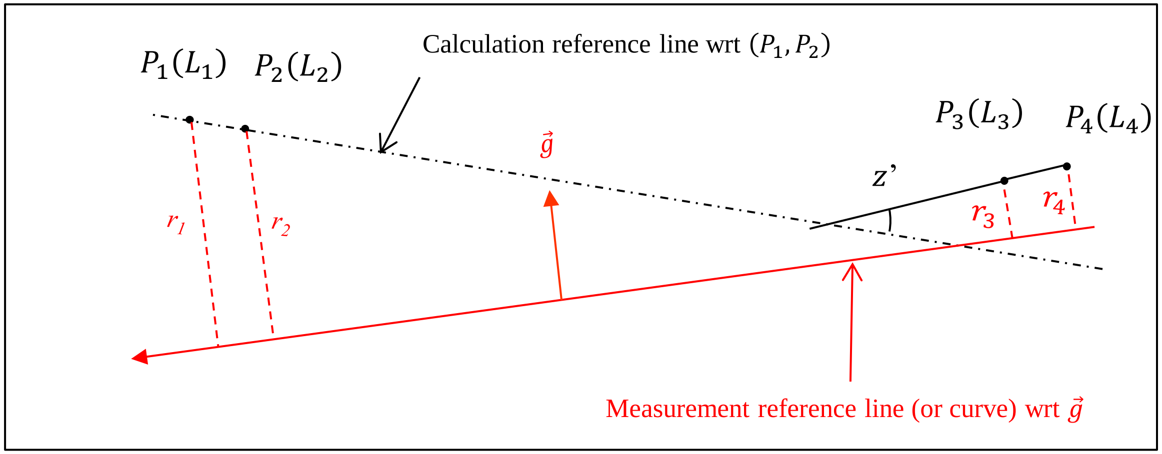
Spatial differential processing (SDP)



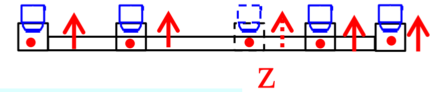
- $z_n \sim r_n - \left(r_{1_n} + \frac{(r_{2n} - r_{1n})}{(L_2 - L_1)} * (L - L_1) \right)$
- $z_{0n} = z_n - z_0$ (temporal differential processing)



Spatial differential processing (SDP)

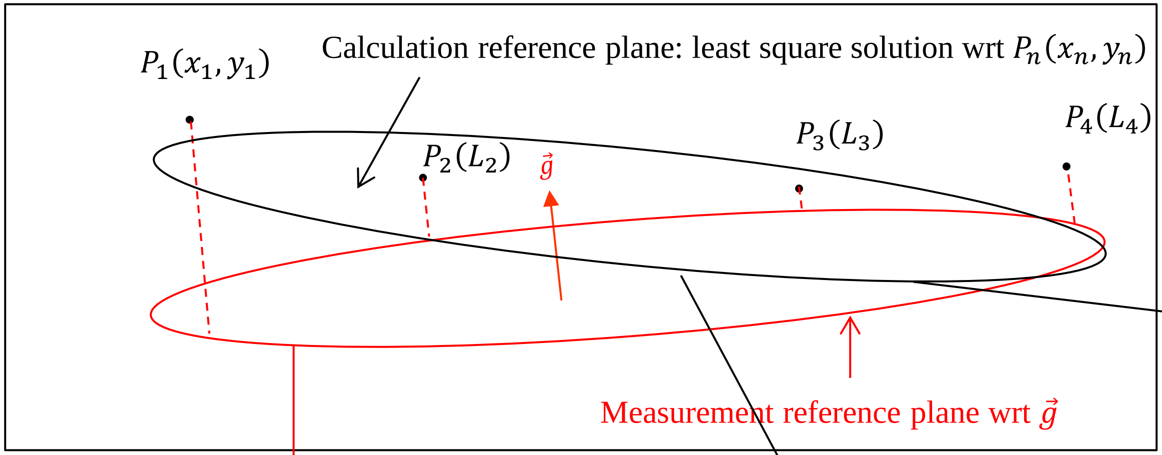


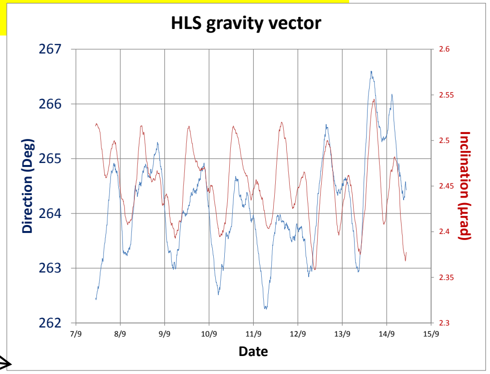
- $z'_n = \frac{r_{4n} - r_{3n}}{L_4 - L_3} - \frac{r_{2n} - r_{1n}}{L_2 - L_1}$
- $z'_{0n} = z'_n - z'_0$ (temporal differential processing)



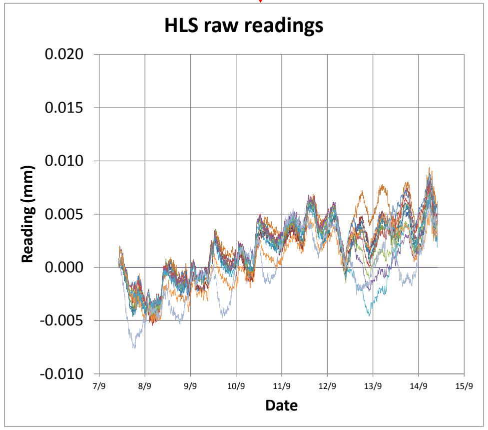
Spatial differential processing (SDP)

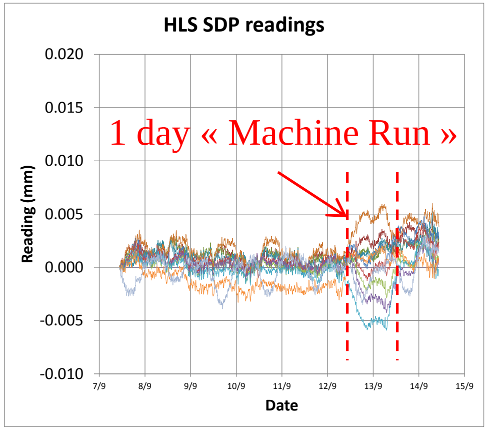
- Process for Storage Ring 168 HLS at SOLEIL: least square plane of the $P_n(x_n, y_n)$

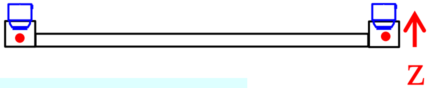




$SDP168$



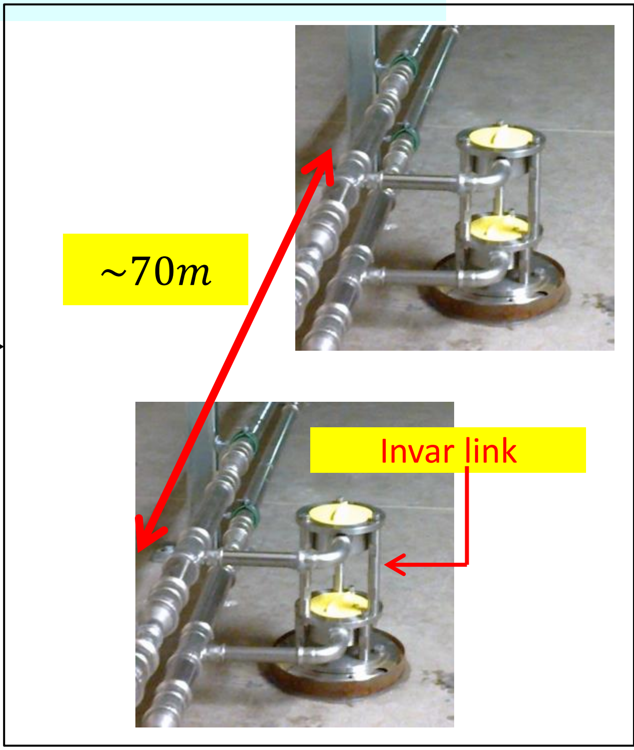




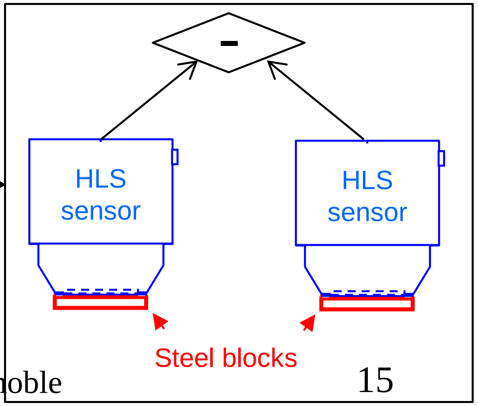
Stability test of HLS sensors

(Preliminary test (IWAA 2006) : 10 µ*m over* 1 *year)*

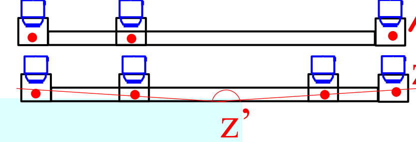
2 parallel networks : 0,14 µm over 8 h

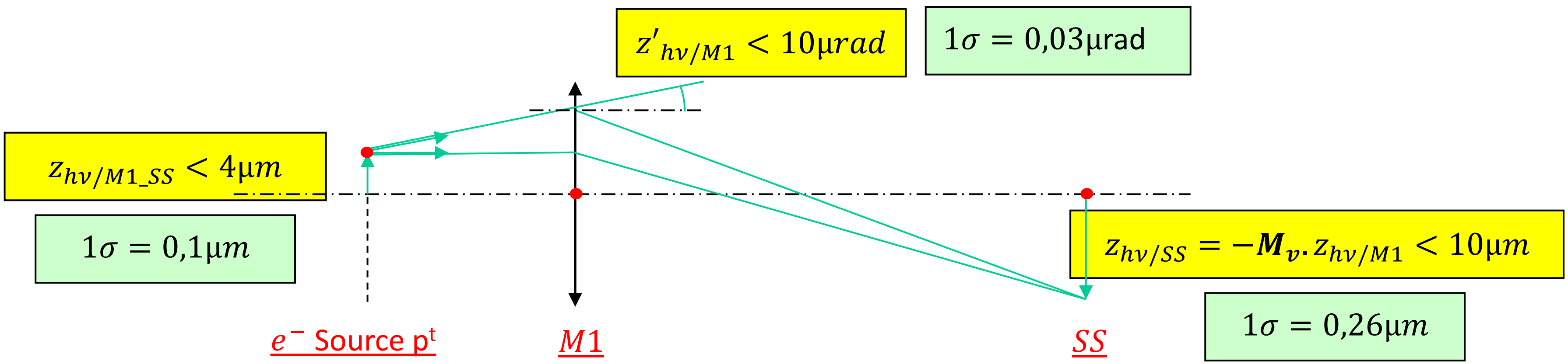


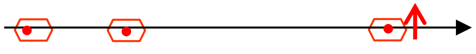
Steel blocks : 0,07 µm over 8 h



Approximate estimation of HLS sensors stability

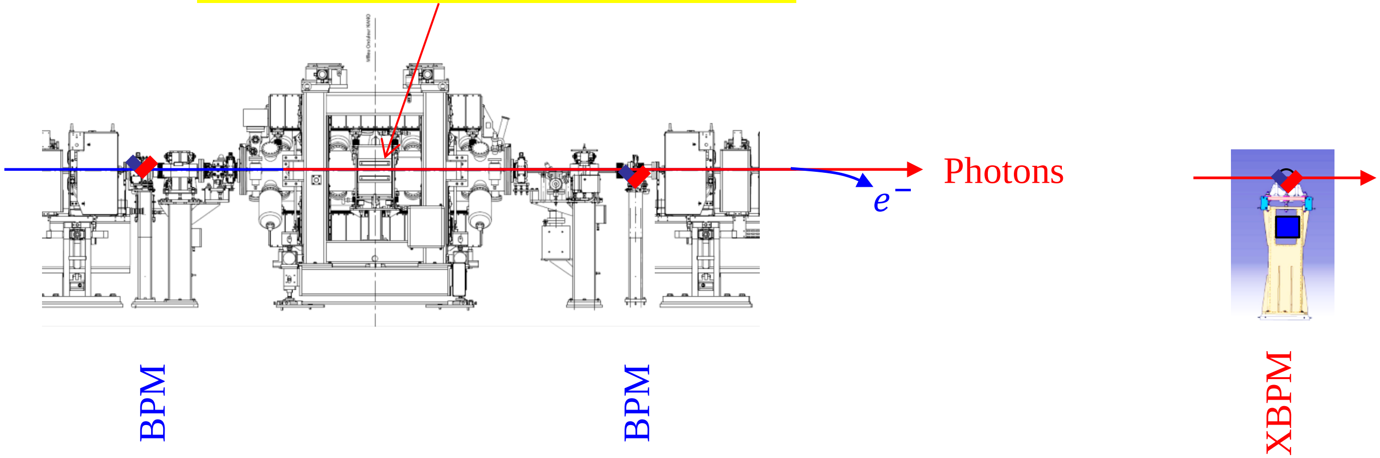






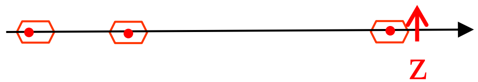
Beam monitoring

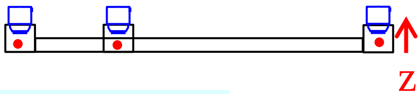
Photon beam linked to e^- beam
(physics for a constant gap)



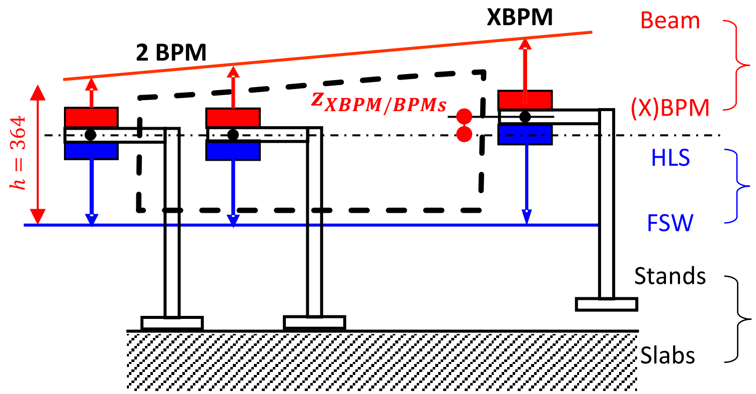
Mixing BPM & XBPM measurements in terms of displacements is relevant at constant gap

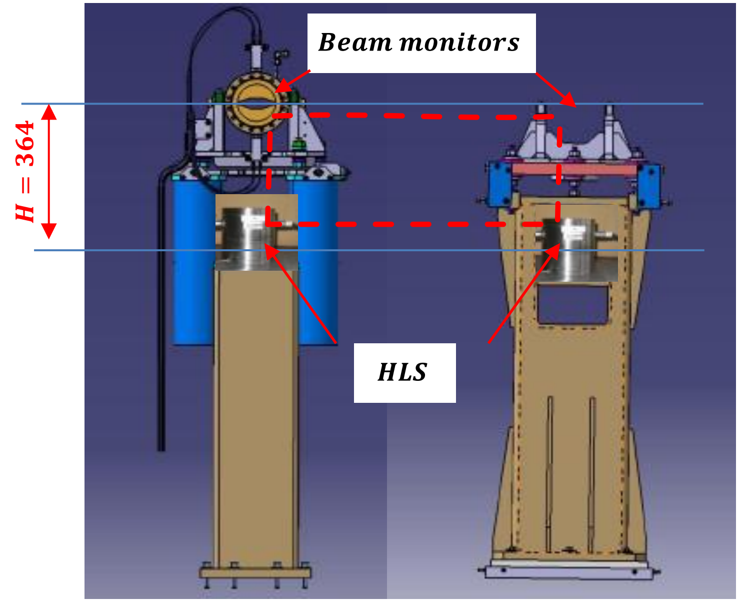
⇔ beam measurement
or monitoring



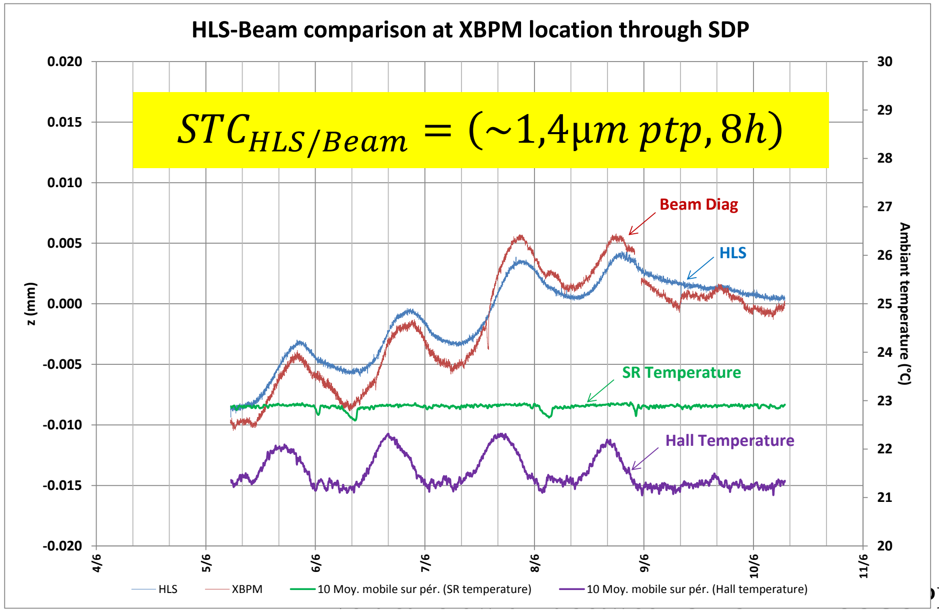


HLS & (X)BPM sensors through SDP





BPM *XBPM (only stand)*



Use of SDP with HLS & beam monitors

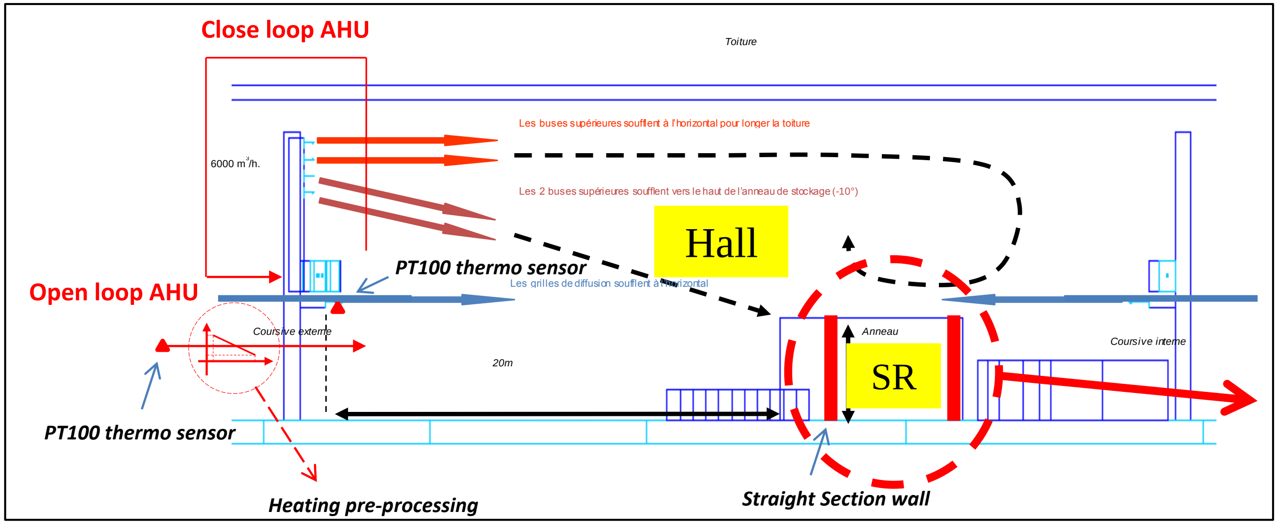
↓

Slab deformation

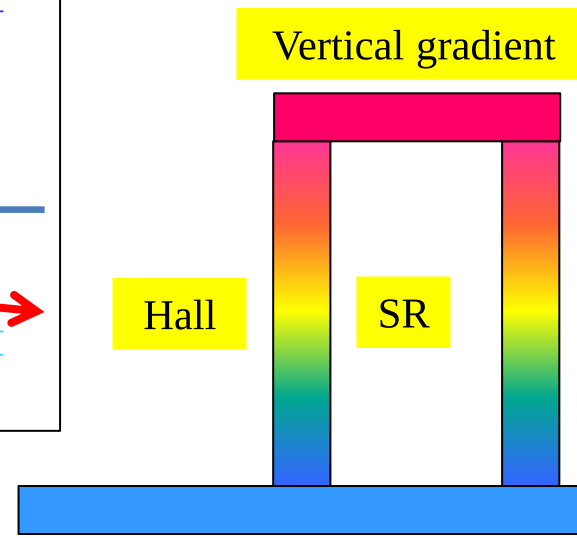
↓

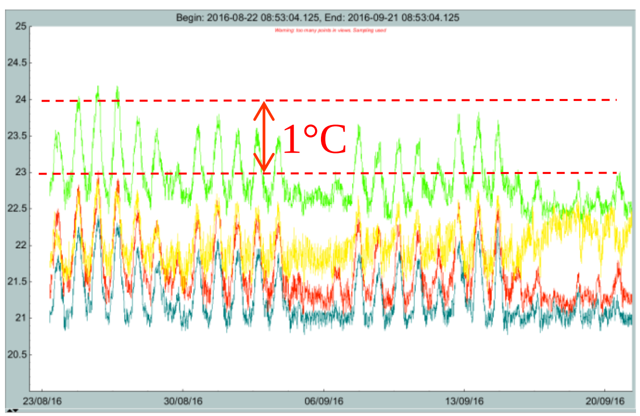
Strongly correlated to hall temperature

Air conditioning of the hall



Side view of the synchrotron building



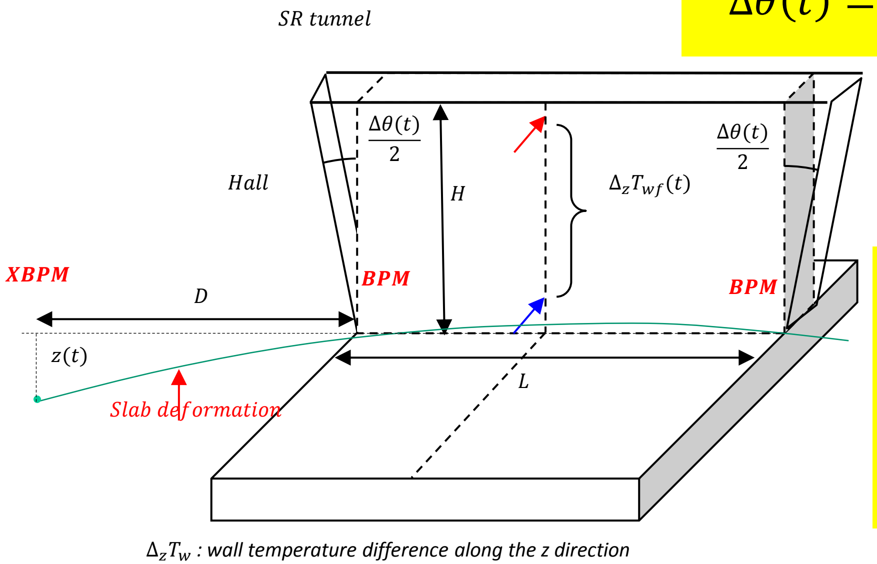


<u>Superimposition of:</u>

- vertical gradient
- 1°C appr. 24h period

Heat diffusion through the SR wall

$$\Delta\theta(t) = \frac{\alpha L \Delta_z T_w(t)}{H}$$



α : Thermal expansion

$\Delta_z T_w(t)$: Vertical thermal gradient through H

$$\Delta_z T_w(t) = T_{w,top}(t) - T_{w,bottom}(t)$$

1D heat equation for harmonic response $\omega = \frac{2\pi}{P}$, $P = 24h$:

$$T_w(x,t) = T_{wf} . e^{-\sqrt{\frac{\omega}{2a}}x} . \cos\left(\omega t - \sqrt{\frac{\omega}{2a}}x\right)$$

Heat diffusion through the SR wall

Angular variation of the straight section wall (SP) :

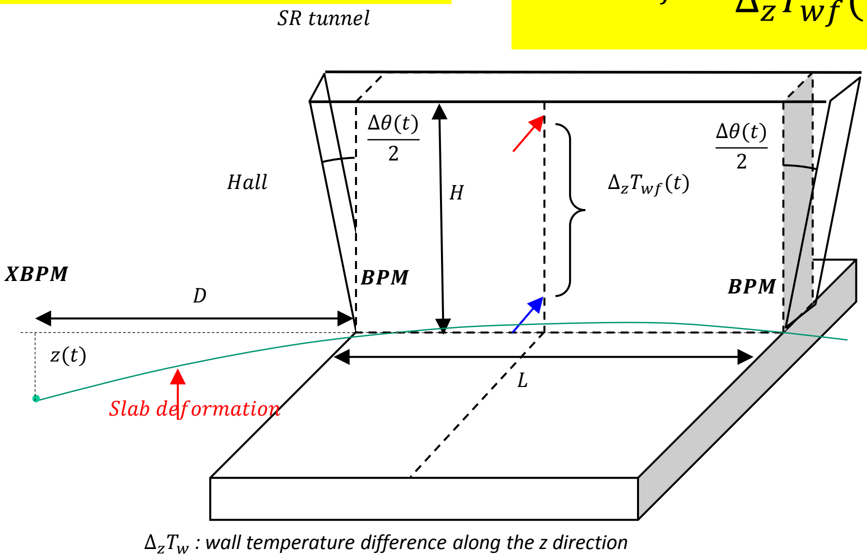
XBPM Z variation :

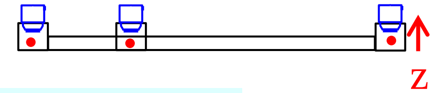
Thermal susceptibility of the straight section slab :

$$\Delta\theta(t) = \frac{\sqrt{\frac{aP}{2\pi}}\sin(\omega t + \pi/4)}{wall_{thick}} \frac{\alpha L \Delta_z T_{wf}(t)}{H}$$

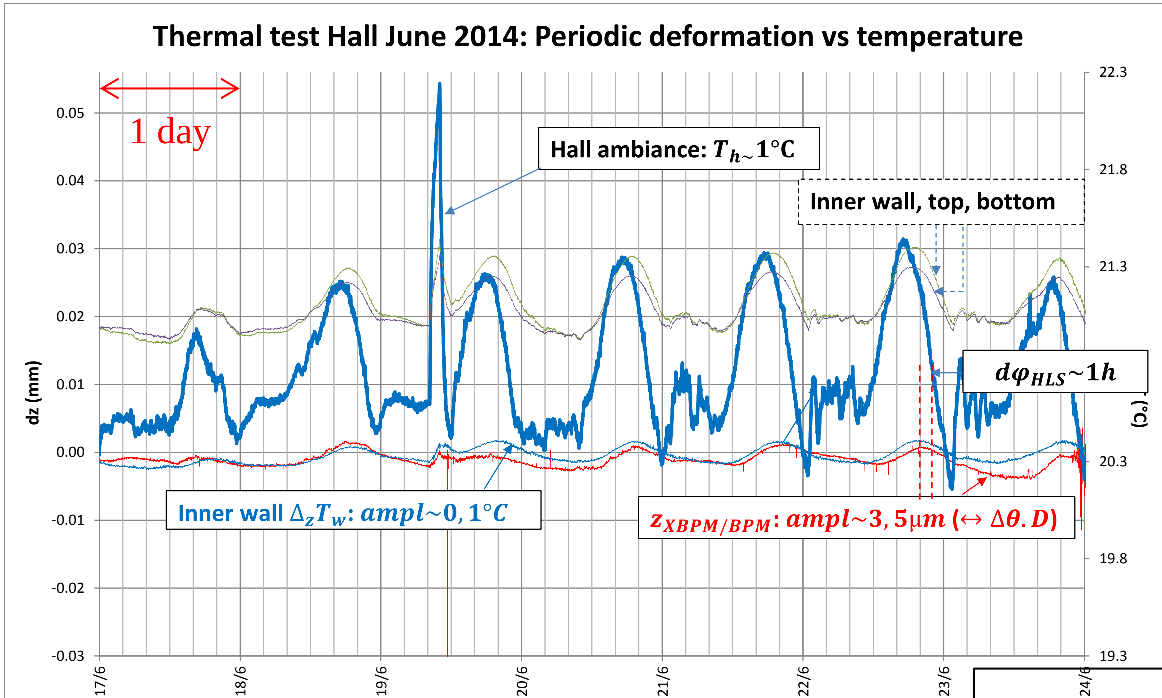
$$z(t) \sim \frac{\sqrt{\frac{aP}{2\pi}}\sin(\omega t + \pi/4)}{wall_{thick}} \frac{\alpha L D}{2H} \Delta_z T_{wf}(t)$$

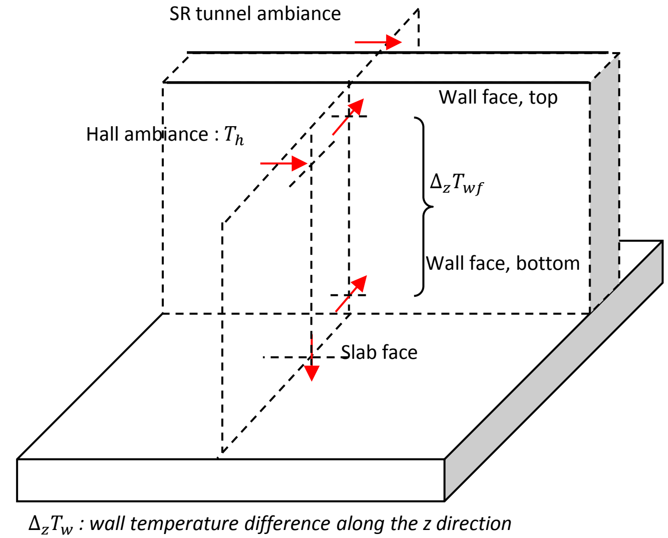
$$S_{z/\Delta_z T_{wf}} = \frac{z(t)}{\Delta_z T_{wf}(t)} = \frac{\sqrt{\frac{aP}{2\pi}}\sin(\omega t + \pi/4)}{wall_{thick}} \frac{\alpha L D}{2H}$$



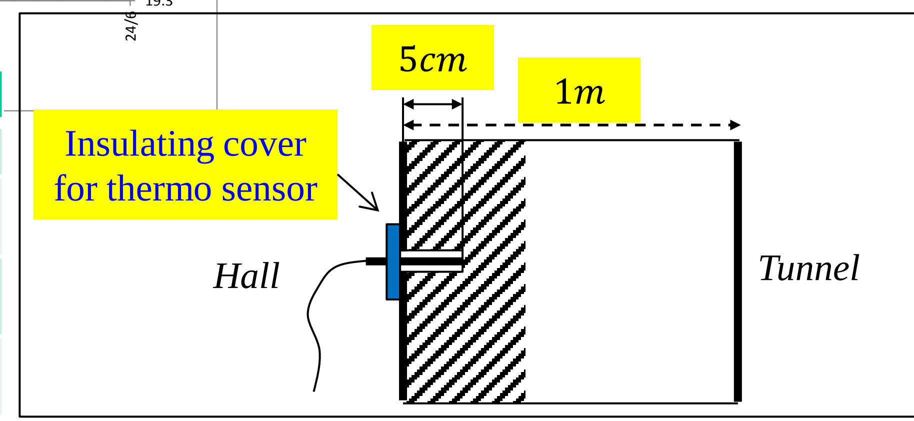


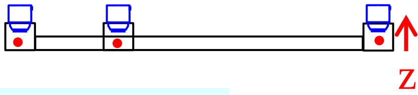
Heat diffusion, experimental results: June 2014





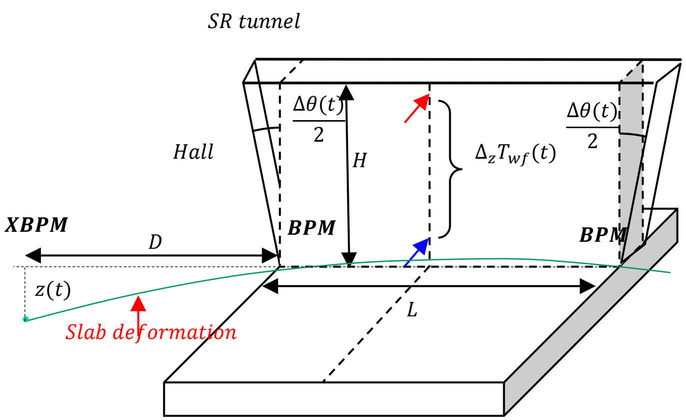
Parameter	Theoretical	Measured
time shift (h)	4	<1
$z_{XBPM/BPM}$ (μm)	1.2	3
$S_{BPM_{\Delta_z T_{wf}}}$ (μm/K)	12	30
$S_{BPM_{T_h}}$ (μm/K)	N/A	3



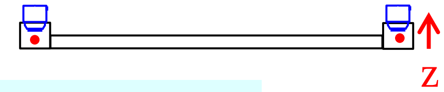


Heat diffusion, experimental results : conclusion

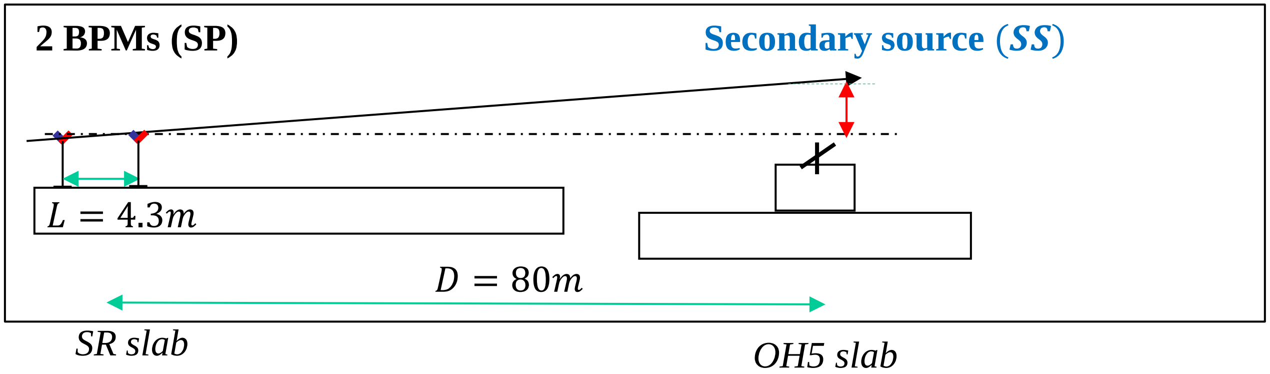
- Heat diffusion modelization have given not perfect results.
- The main question has been solved: a vertical temperature gradient variation has been identified into the wall and $Z_{XBPM/BPM}$ through HLS & beam diagnostic sensors is clearly correlated with both, T_{hall} and $\Delta_z T_h$,



- However, Z & Z’ of source point are not known through this modelization
- We only can try to correlate hall temperature & HLS measurement along the beamline



Estimation of slabs displacements through SDP_2



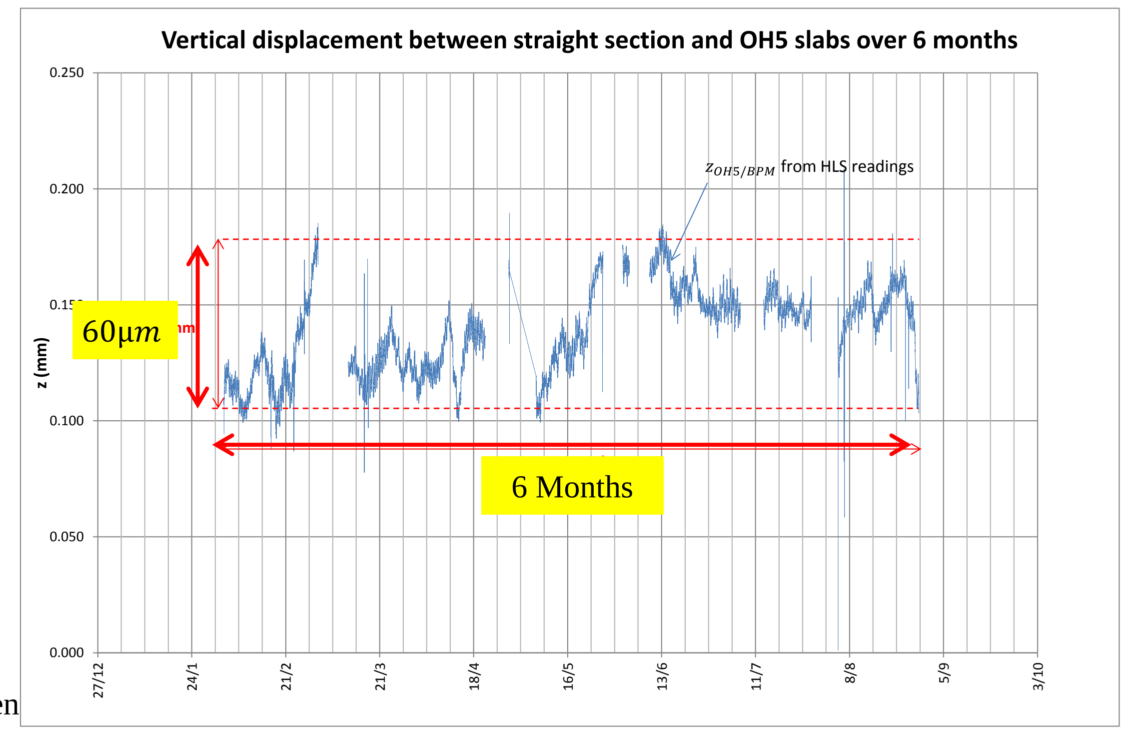
Unfavorable ratio

⇔

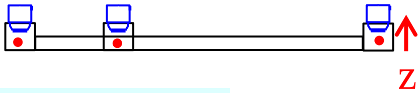
Raw HLS readings

$60\mu m$ over 6 month

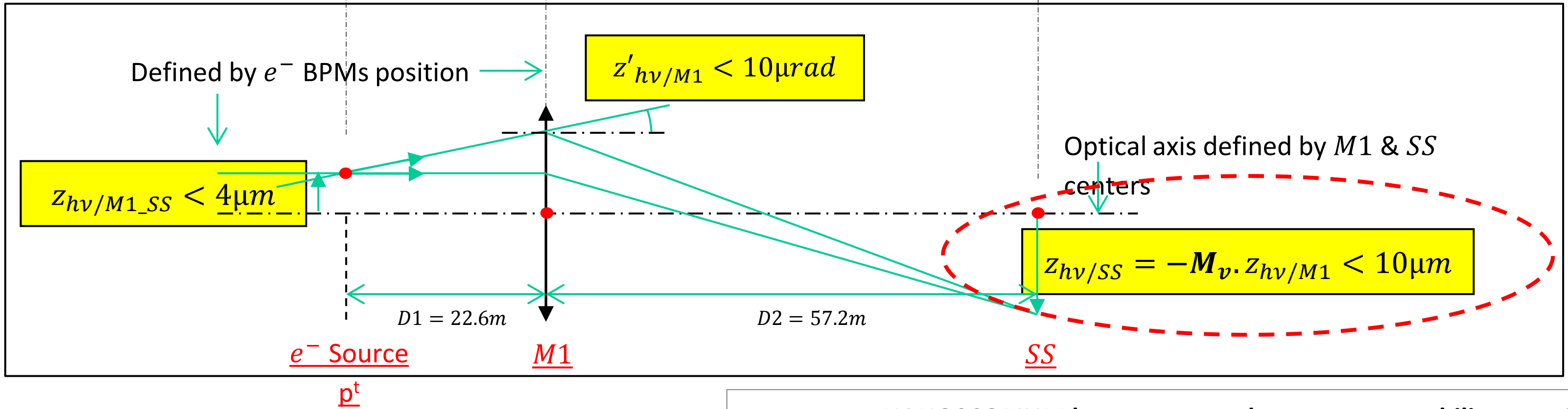
a good infrastructure design



Vertical slow drift between



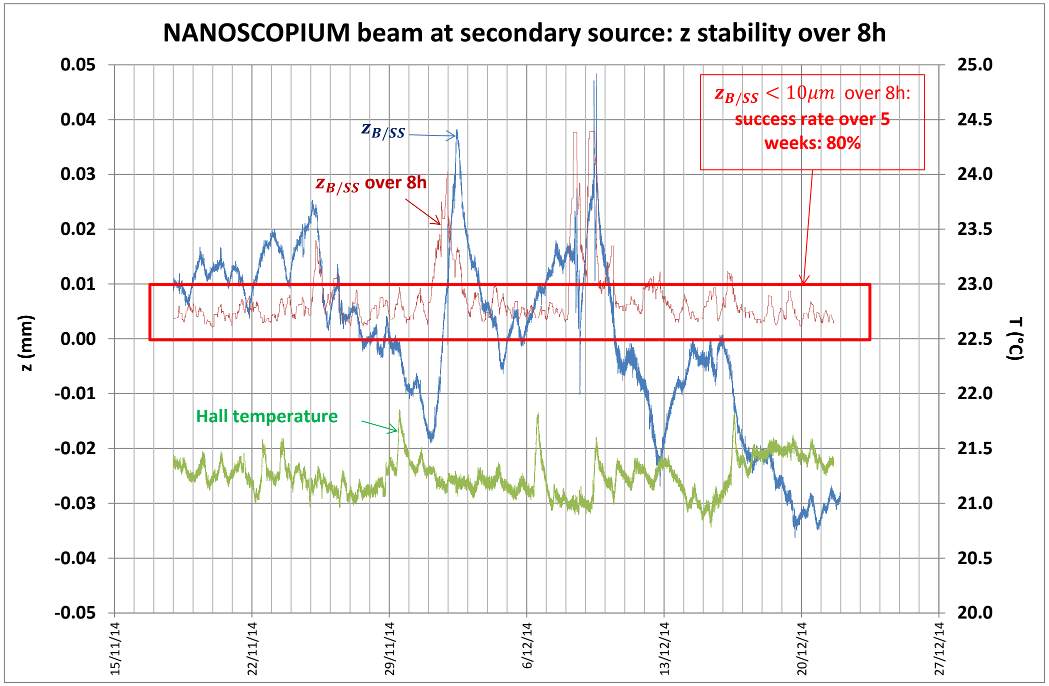
Z Beam stability through NANOSCOPIUM optics

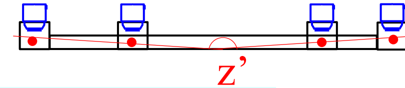


Extrapolated z variations of the beam on SS as a function of HLS variations

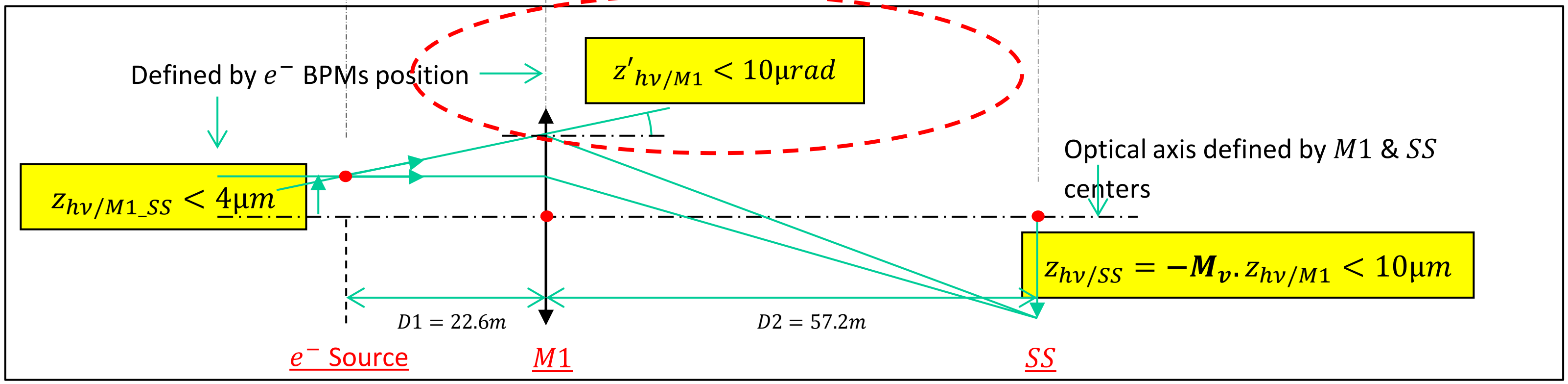
Sucess rate over 5 weeks: 80%

No strong correlation between hall temperature and beam vertical position at the SS location





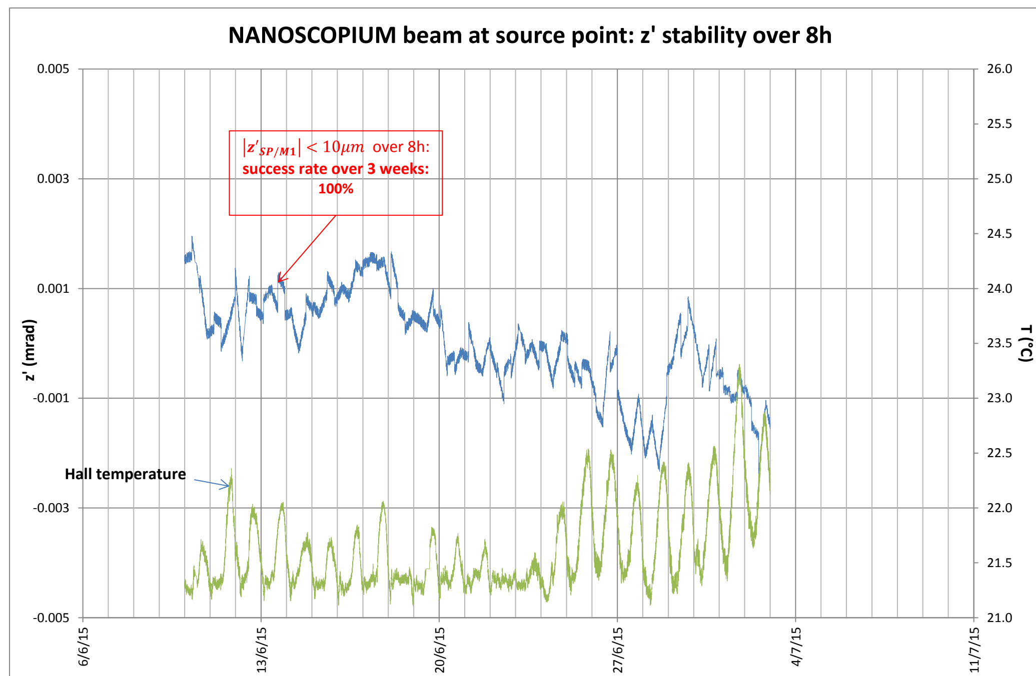
Z’ Beam stability through NANOSCOPIUM optics

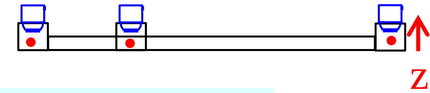


z’ variations of the beam on M1 as a function of HLS variations

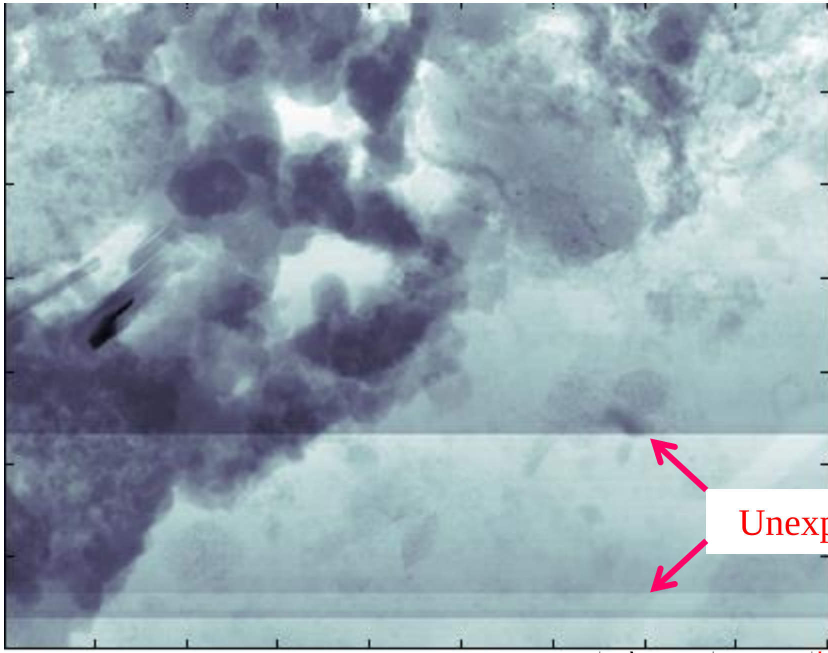
Sucess rate over 3 weeks: 100%

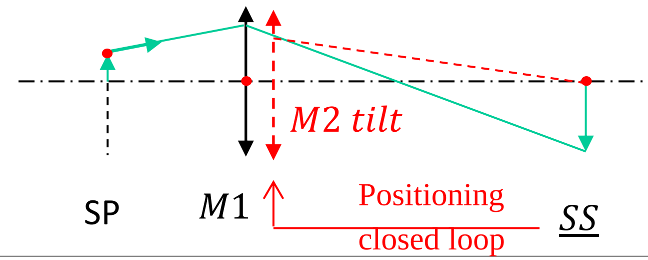
No strong correlation between hall temperature and beam vertical position at the SS location

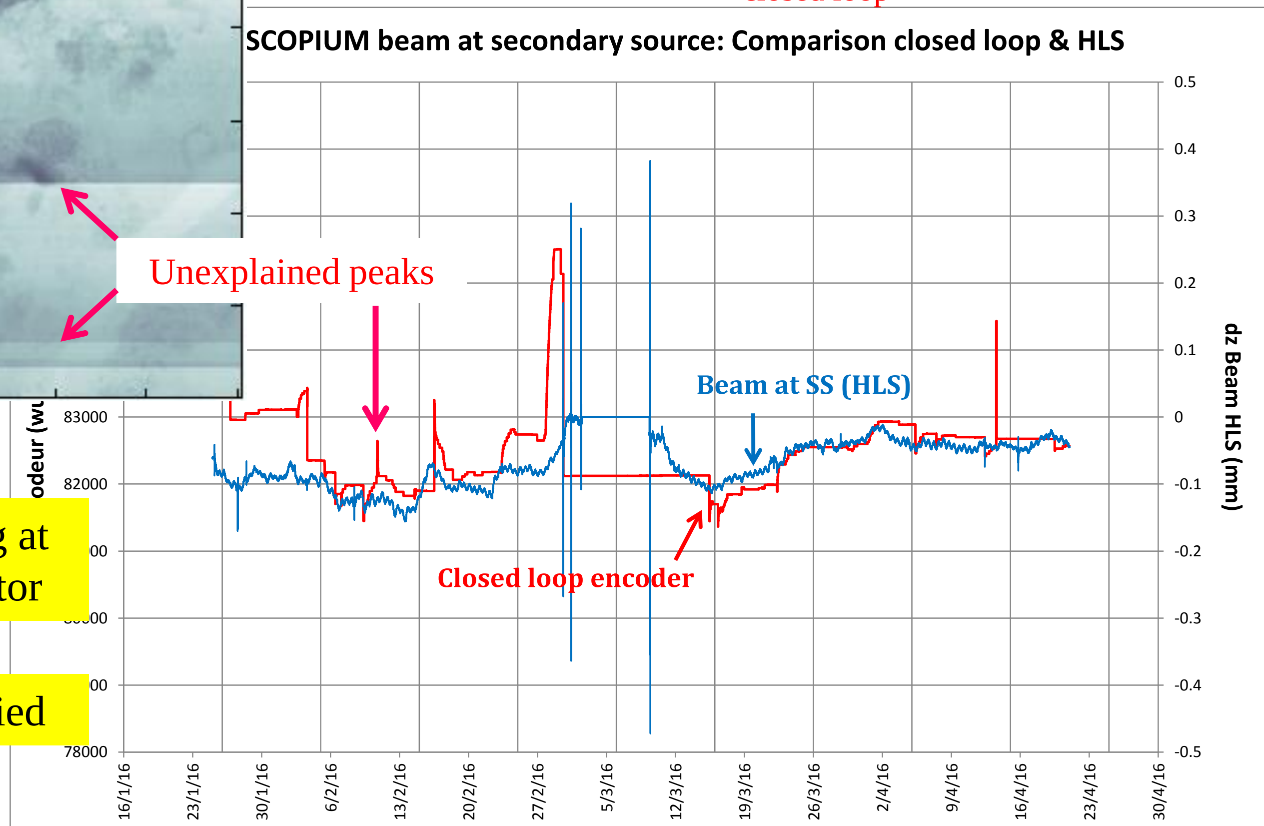




Z Beam stability through positioning closed loop







Slow closed loop with beam diag at SS location : M2 tilt is the actuator

Long term correlation to be studied

Conclusions

Beam monitors & HLS comparison:

- Micrometric accuracy for slow drift measurements.

Thermal daily variations of the Experimental Hall:

- Induces the straight section slab deformations

Slab z variation:

between straight section and OH5 is about 60µm over the 6 last months.

Beam stability over 8h at the secondary source:

- Reaches the 10µm stability requirement with in average a success rate of 70% but position closed loop corrects it.
- Better than the 10µrad of z' requirement in 100% cases

Have a good lunch!!!