PAUL SCHERRER INSTITUT

SWISS LIGHT SOURCE SLS

Dynamic Alignment at SLS

IWBS 2004, Grindelwald, December 7th, 2004

Andreas Streun, PSI, Villigen, Switzerland

PSI:

M. Rohrer, P. Wiegand[+], S. Zelenika	Mechanical Engineering
K. Dreyer, H.Umbricht, F. Wei	Survey & Alignment
A. Jaggi, R. Kramert, V. Schlott	Diagnostics
S. Hunt	Control system
M. Böge, L. Rivkin, A. Streun	Beam Dynamics

External:

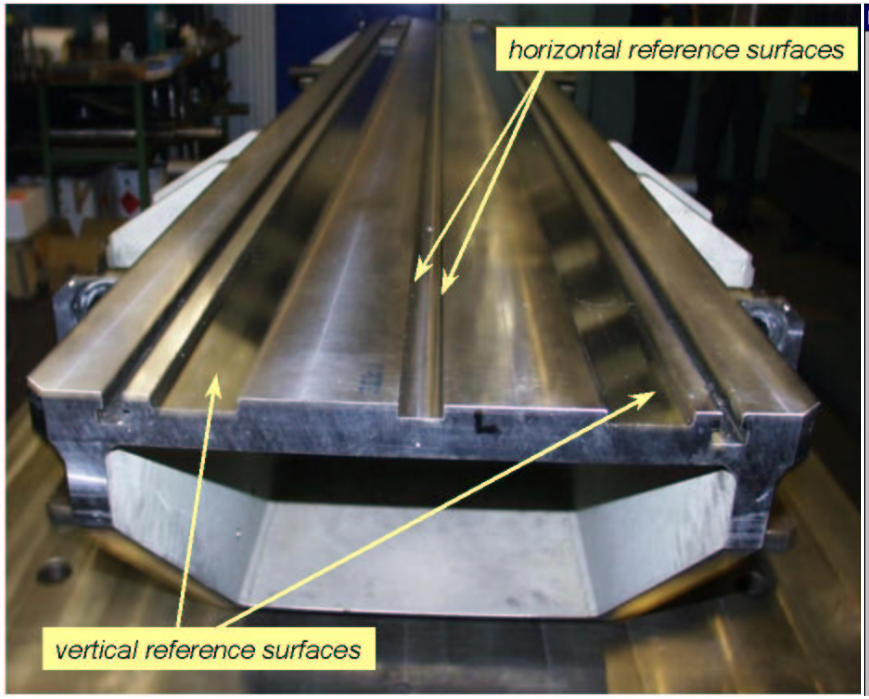
R. Ruland, SLAC, Menlo Park, USA	Concept
E. Meier, Ingenieurbüro Meier, Winterthur, Switzerland	Hydrostatic Levelling System
B. Fiechter, Eltromatic AG, Winterthur, Switzerland	Girder Mover Control
R. Sabjan, CosyLab, Ljubljana, Slovenia	Control system

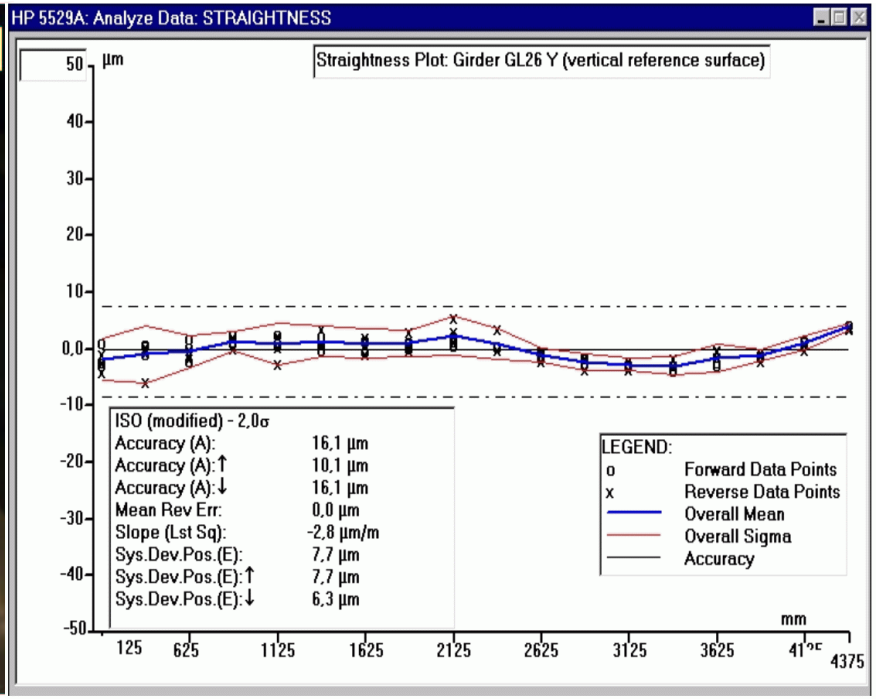
[+]*now UGS, Schlieren, Switzerland*

Dynamic Alignment

Concept

Magnet mounted rigidly onto girders



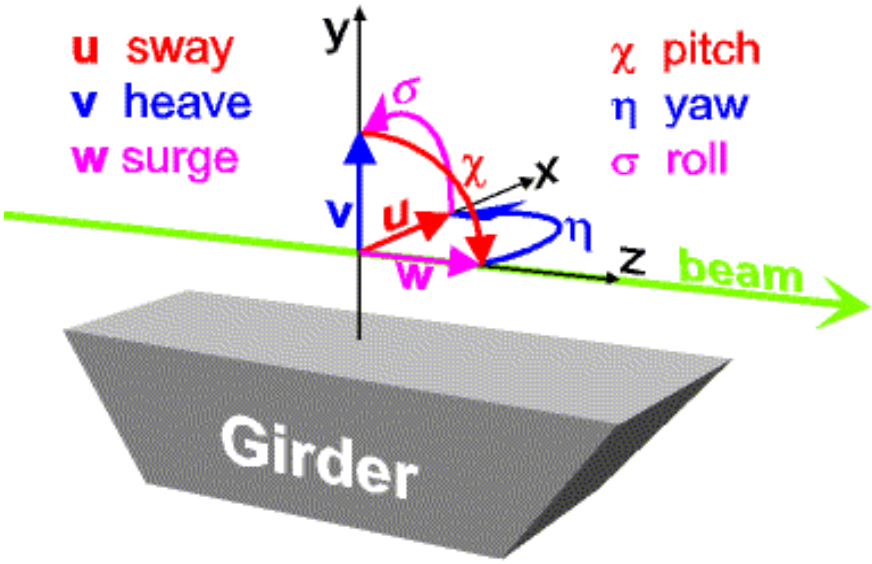


Girder rail precision 15 µm , Magnet axis calibration 30 µm

Girders movable in 5 degrees of freedom

Position monitoring systems on girders

Girder motion control



Initial survey

read u, v, w, χ, η, σ

GM & GME:

5 movers & encoders / girder

set & readback u, v, χ, η, σ

HLS: hydrostatic levelling system:
4 pots / girder

read v, χ, σ

HPS: horizontal positioning system: 2 arms /girder

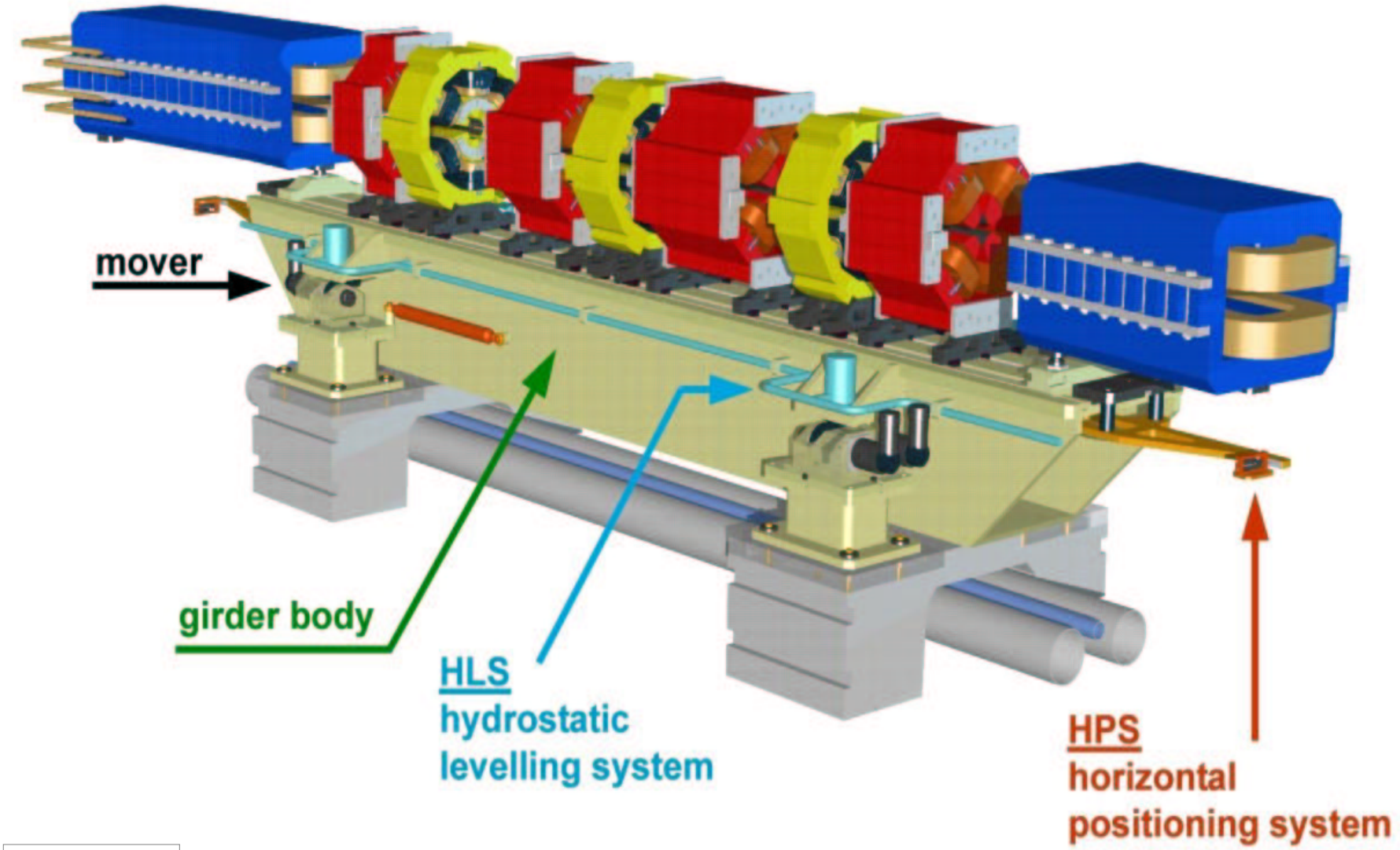
read u, η (requires HLS data for evaluation)

BPM & POMS: beam position monitors & position monitoring system
(BPM ↔ girder): 1 or 2 /girder

reconstruction of u, v, χ, η ("beam based girder alignment")

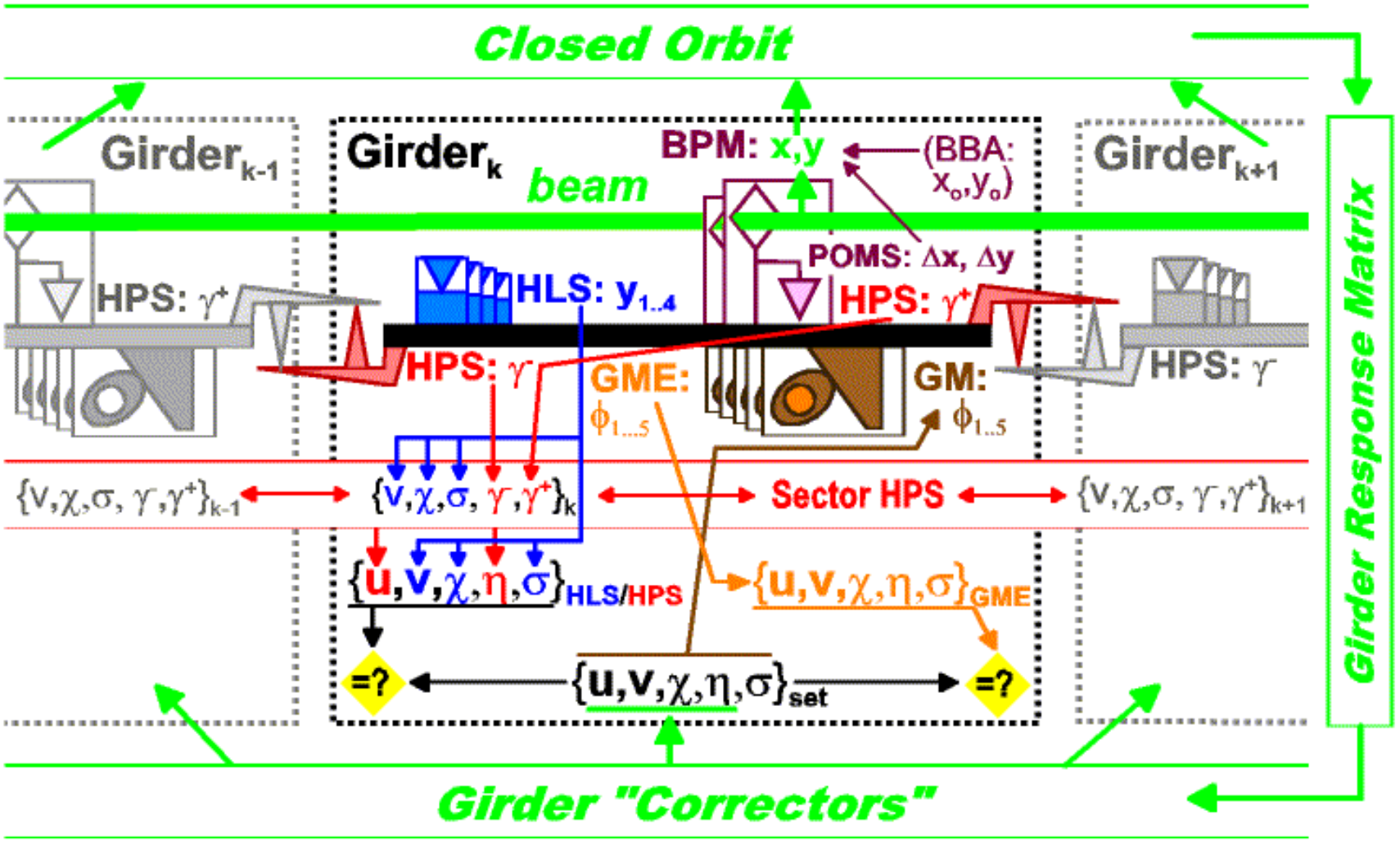
no control: w

Girder motion control: Layout

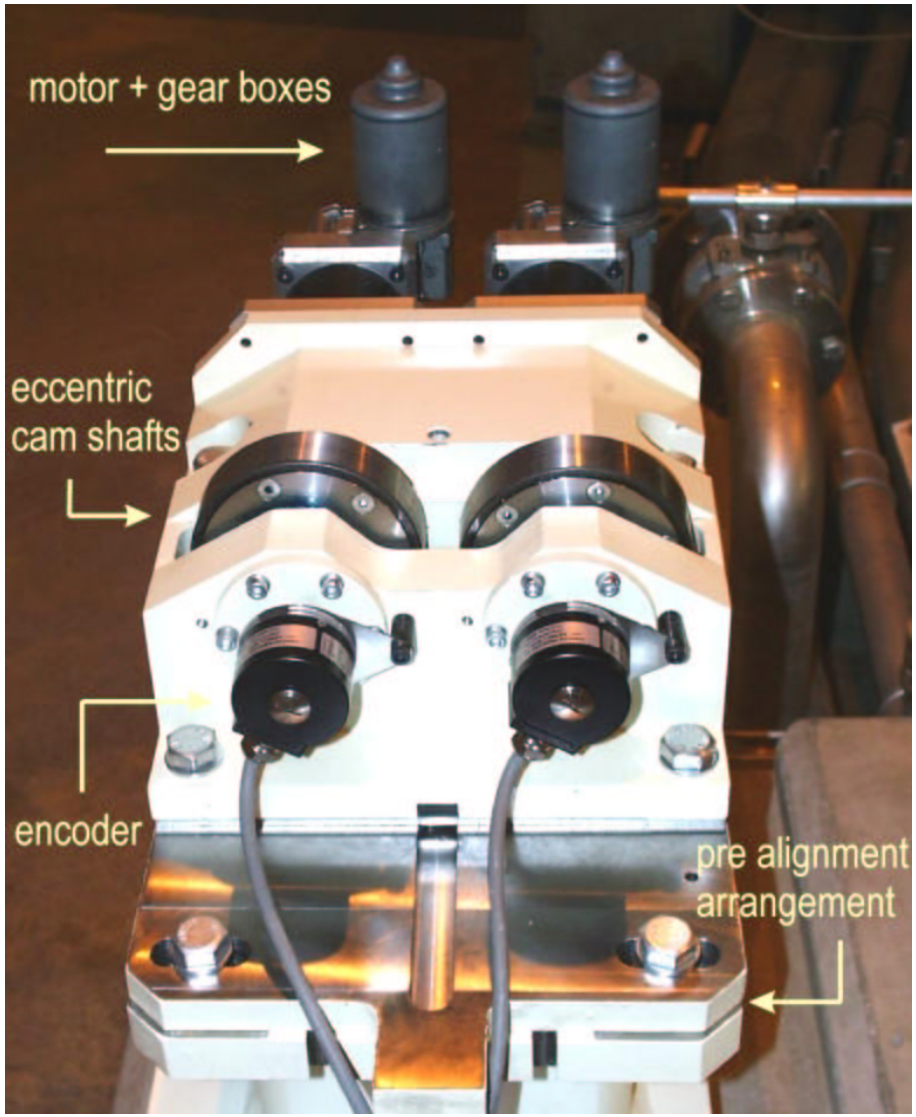


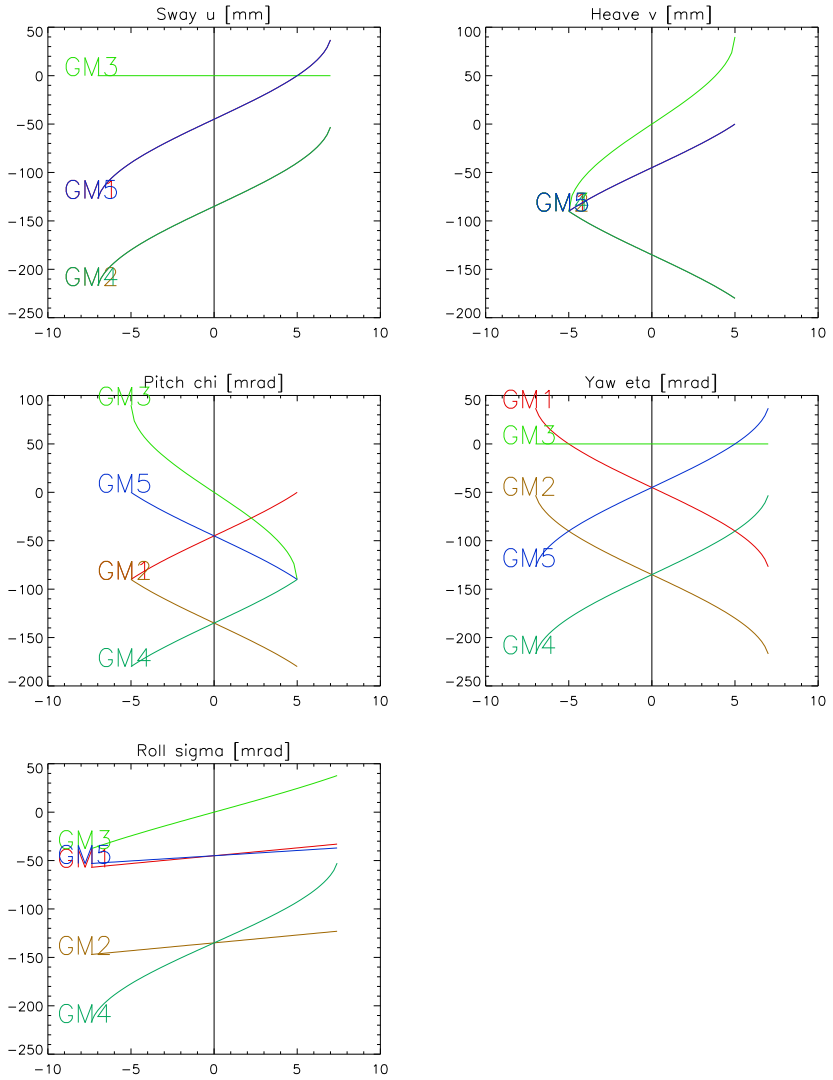
P.Wiegand

Girder motion control: signal flow



Girder Movers & Girder Mover Encoders





GM excenter working windows

Hydrostatic Levelling System

4 pots per girder

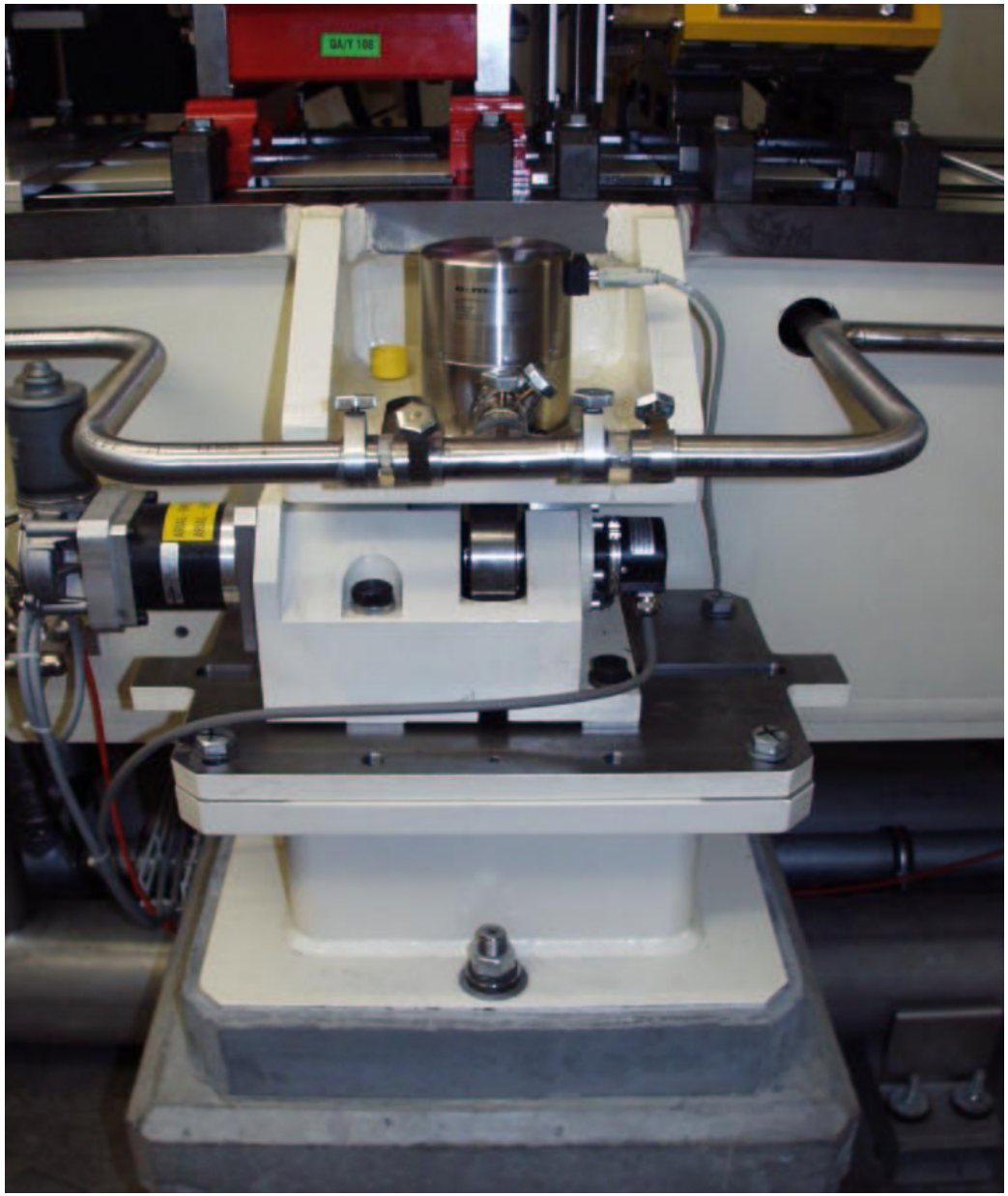
- redundancy
- get v, χ, σ with error bars

Valves

- 1 $\times$ ring
- 12 $\times$ single sector
- [48 $\times$ girder]

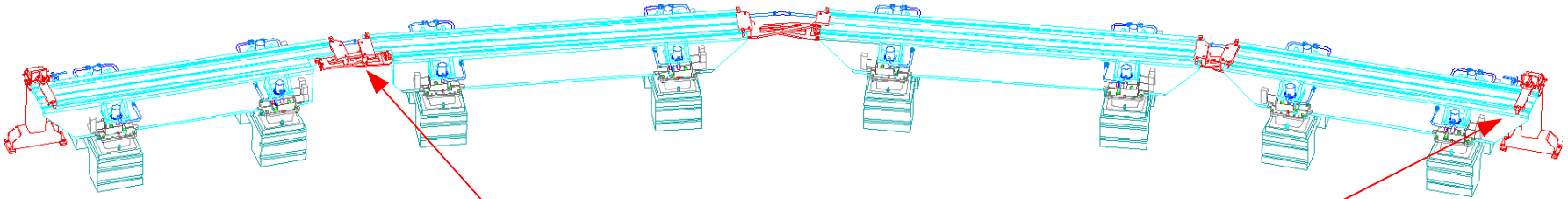
Performance

- resolution: 1 μm
- range: 14 mm



Horizontal Positioning System

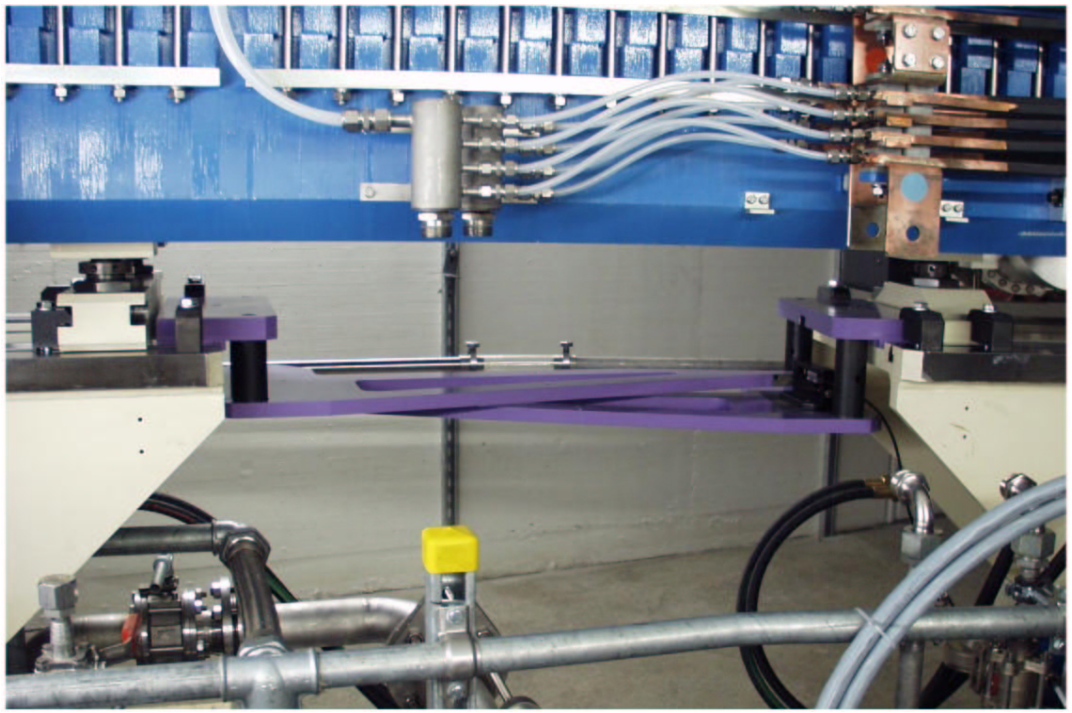
Readout: digital encoders ±2.5 mm range, 0.5 μm resolution



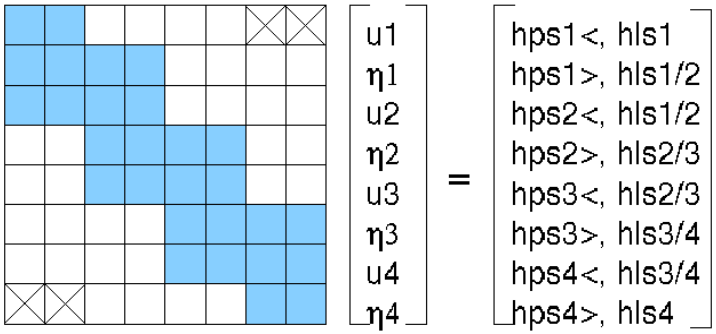
Lever arms to adjacent girders, resp. sector terminating monuments ➘

$$u + m_z \eta - C\,u - (C\,a_z + S\,a_x)\,\eta = \gamma\,(C\,c_x - S\,c_z) + m_y\,\sigma - C\,a_y\,\sigma - S\,a_y\,\chi - S\,w$$

unknowns, HPS readout, HLS evaluation, constants, adjacent girder's quantities, out of control (set to 0)



➘ Linear system (4 girders/sector):



needs HLS data as input !

Girder movement: Comparison to Survey and HLS/HPS data

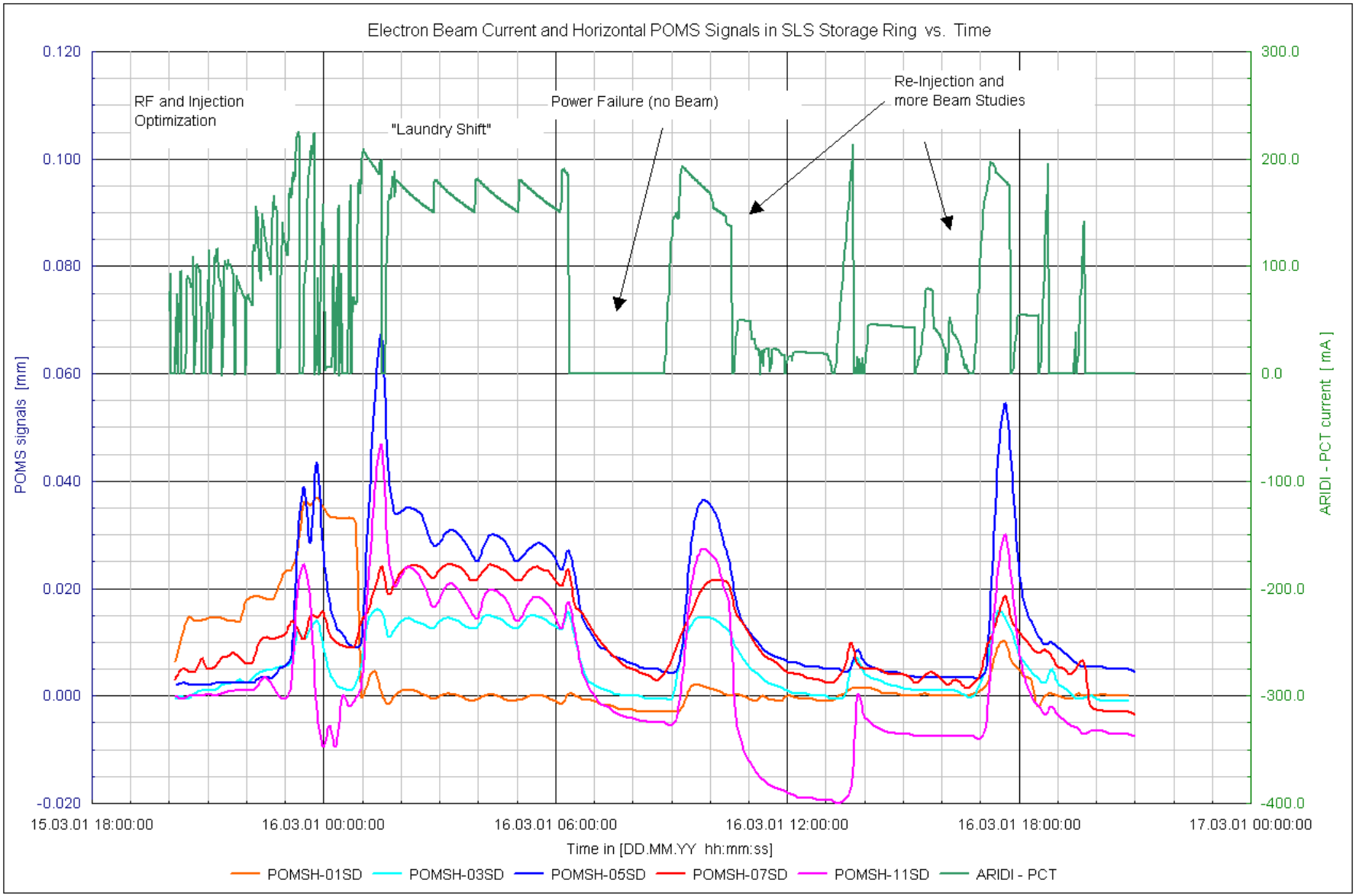
K. Dreyer, S.Hunt, A.Streun, H. Umbricht, F. Wei, S. Zelenika

Set Movers of Girder	02G1	
Survey of Girder	02G1	(18 reference marks)
HLS/HPS readouts of girders	02G1..4	(sector 02 evaluation)

		Set	Survey	HPS/HLS	comment
Single motions:					
Sway	[µm]	**+100**	**89 ± 9**	**100**	02G**2** sway = 14 micron
Heave	[µm]	**+100**	**93 ± 6**	**6**	HLS too slow
Roll	[µrad]	**+100**	**103 ± 24**	**100**	
Yaw	[µrad]	**+100**	**85 ± 7**	**80**	surge 7 ± 6 instead of 35 expected
Pitch	[µrad]	**+100**	**99 ± 6**	**99**	surge 63 ± 6 instead of 81 expected
Combined motion:					
Sway	[µm]	**+50**	**33 ± 9**	**35**	
Heave	[µm]	**+50**	**50 ± 6**	**30**	
Roll	[µrad]	**+50**	**89 ± 24**	**55**	
Yaw	[µrad]	**+50**	**41 ± 7**	**31**	
Pitch	[µrad]	**+50**	**51 ± 6**	**49**	

+ **HPS/HLS evaluation works**
– **HLS very slow (τ > 15 min)**
– **Yaw too small**
– **Coupling to adjacent girder ?**

POsition Monitoring System: BPM ↔ Girder *(Quadrupole)*



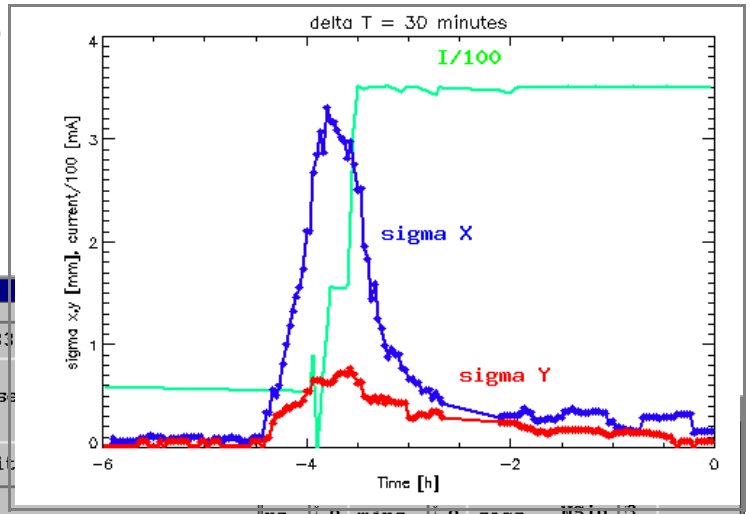
V.Schlott

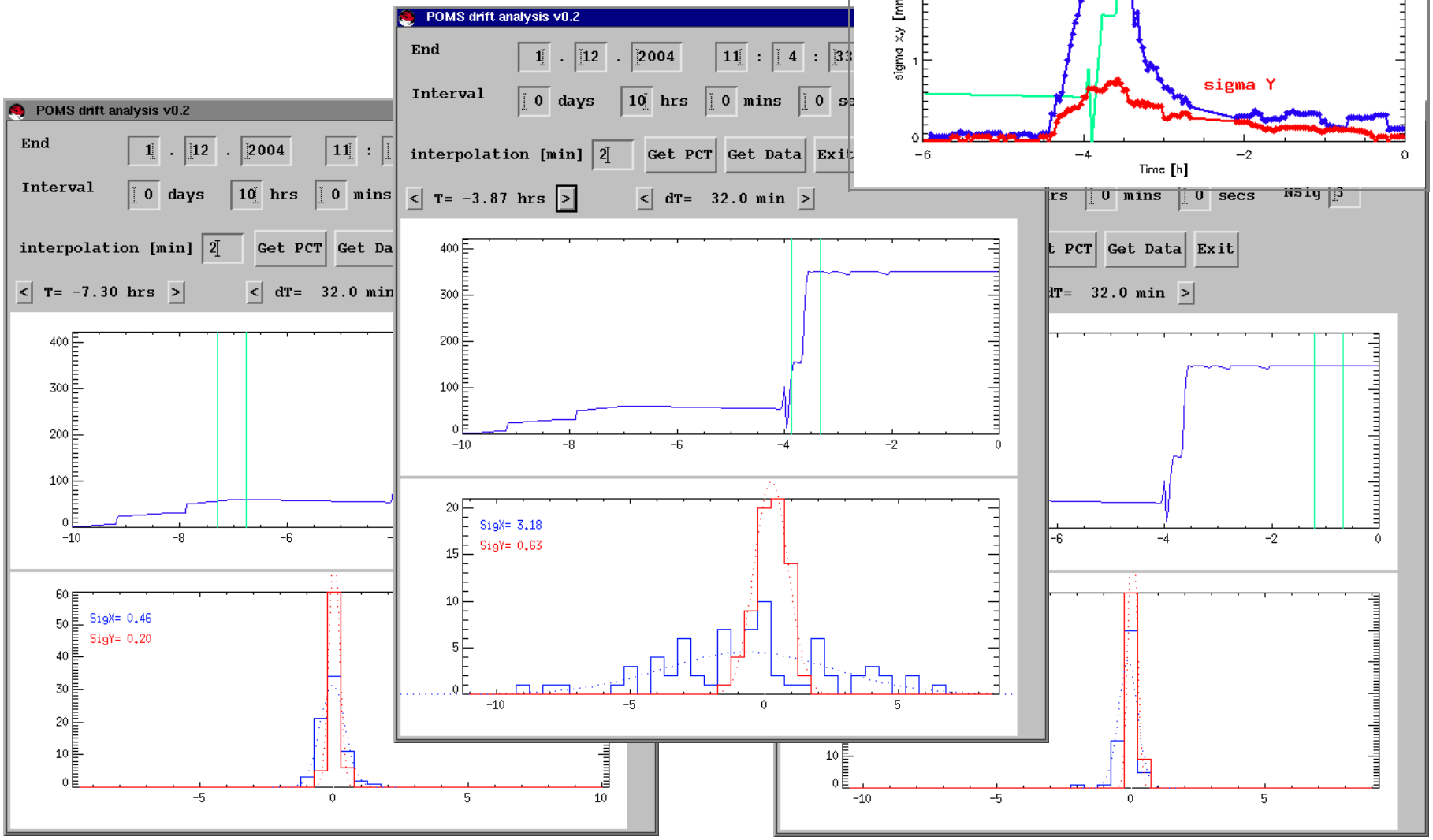
POMS for monitoring of machine warm-up

User request:

Measure for movement going on

$\rightarrow \sigma_x(t) = \langle \Sigma_k [x_k (t) - x_k (t - \Delta t)]^2 \rangle$

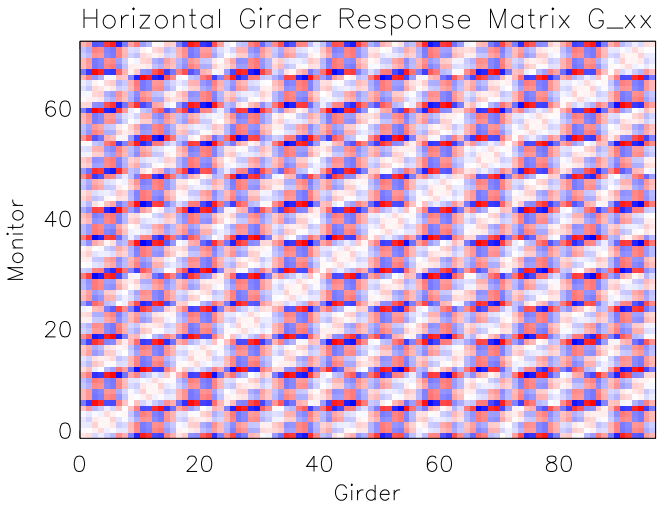


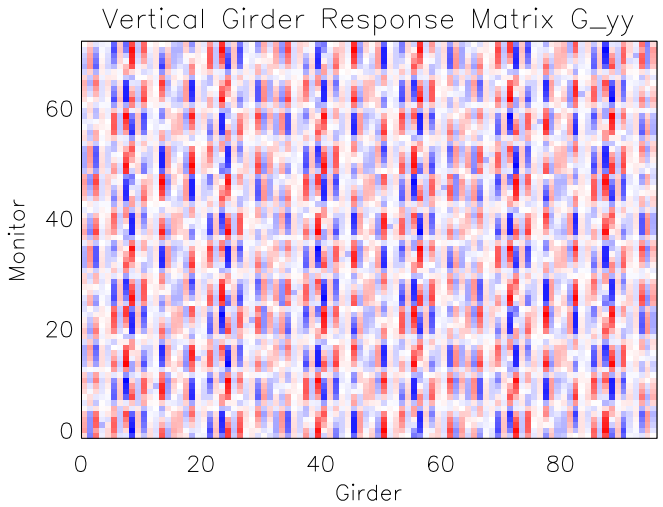


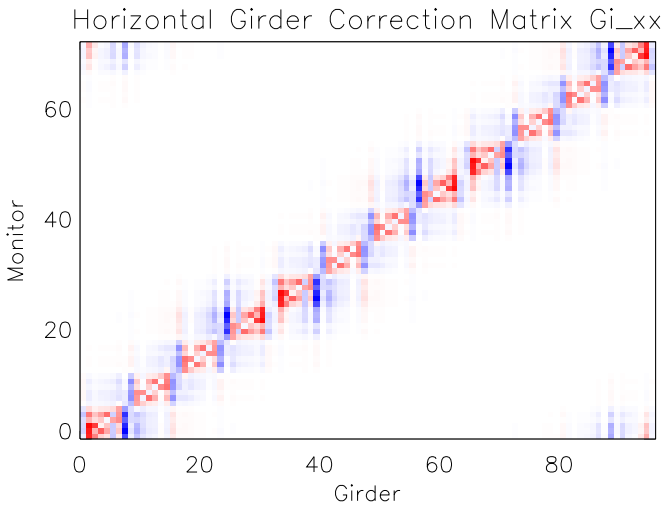
Beam Based Girder Alignment....

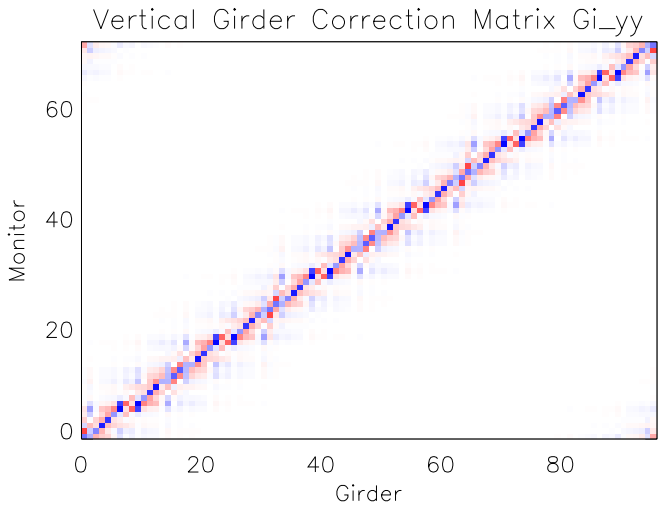
48 girders = 96 hor. & 96 vert. "correctors" ($x_{2n/2n+1} = u_n \pm L\chi_n$)

Response and correction matrices:

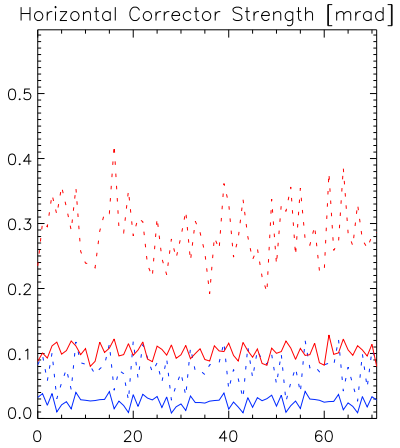


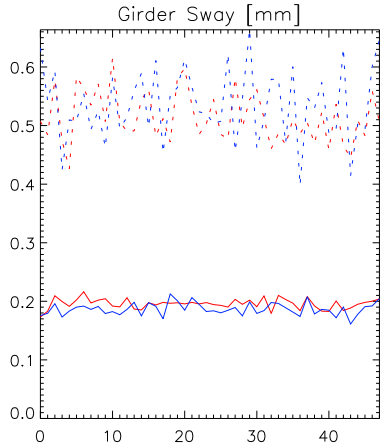


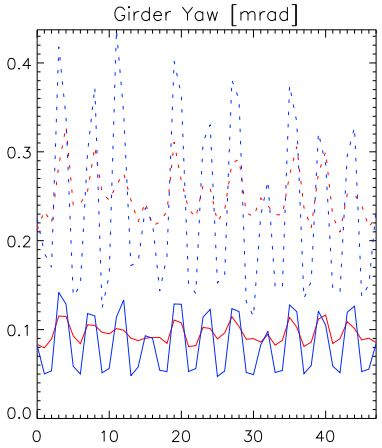


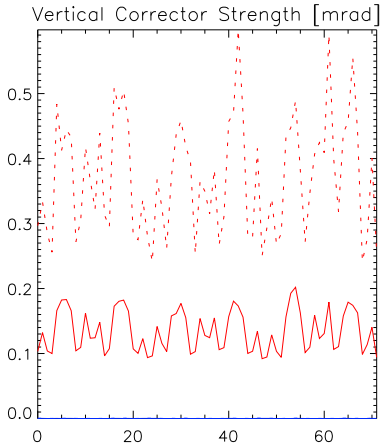


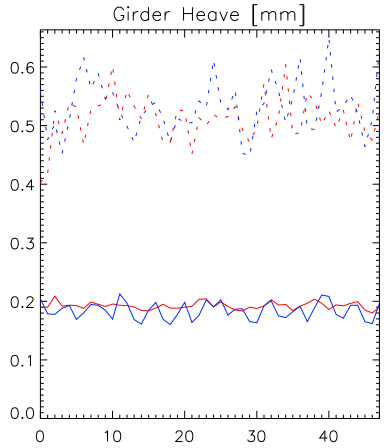
Orbit Correction by means of girder movements (Simulation)

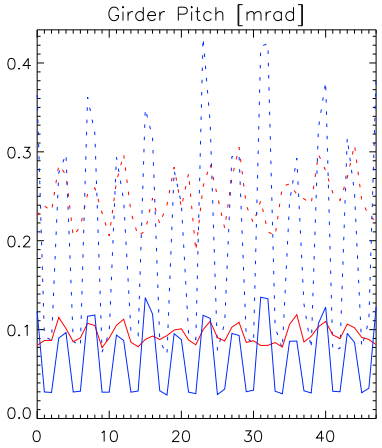












rms

max

OCO only

BBGA + OCO

SLS/D0 mode

200 seeds
(12 rejected).

error settings
(rms, cut 2s):

- 50 μm magnet + BPM vs. girder,
- 300 μm girder abs.
- 100 μm girder vs. girder

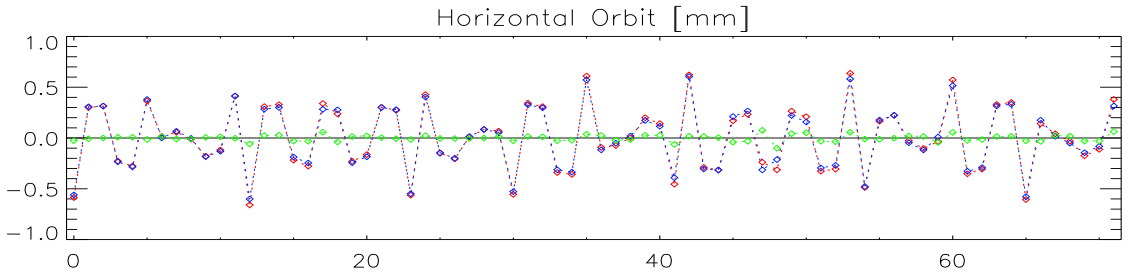
	horizontal	vertical
SVD weighting factor filter ω_i/ω_o >	0.001	0
SVD weighting factors used (from 96)	60	96
saved magnetic corrector strength (rms)	**75 %**	**100 %**

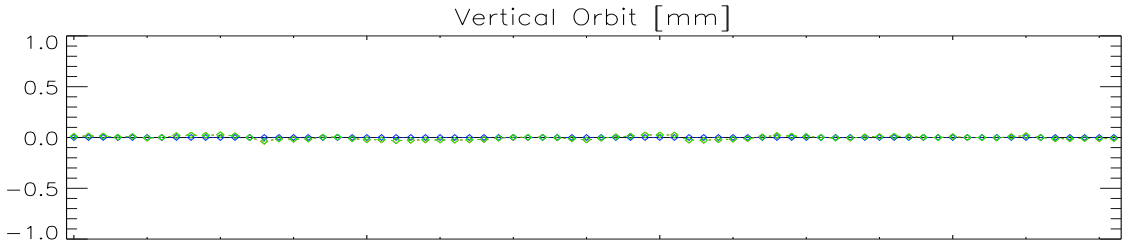
Real Test

M.Böge, R.Sabjan, A.Streun, F.Wei

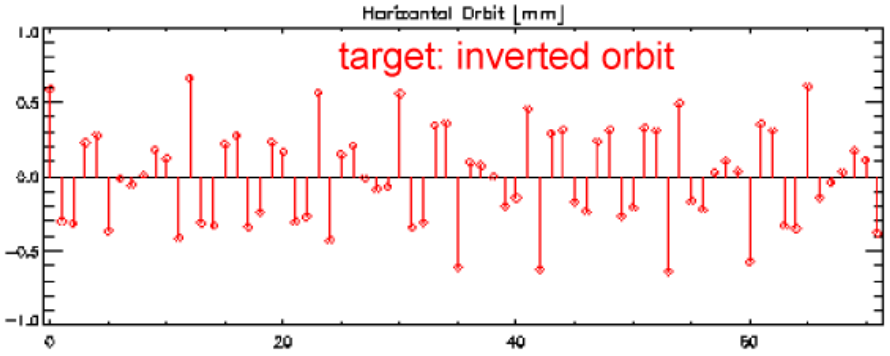
Girder 5: set 100 μm sway (Δx)

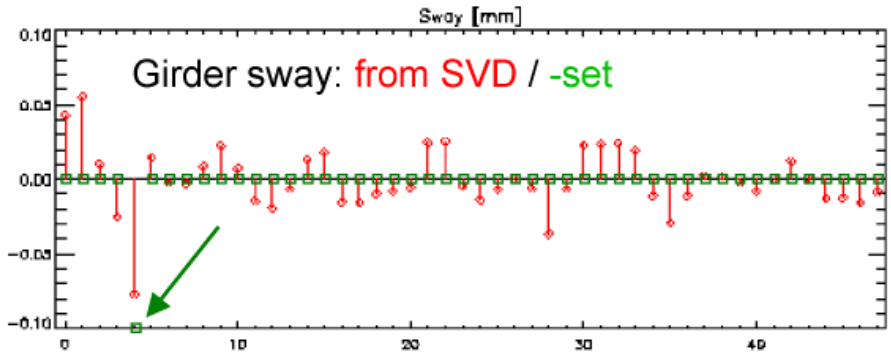
orbit: measured
simulated
difference

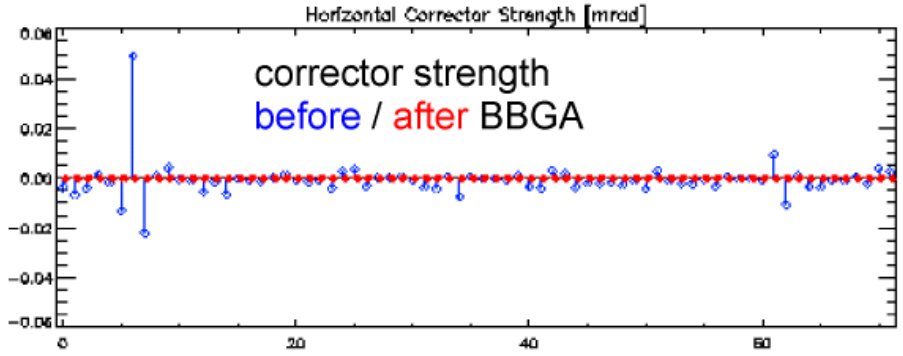


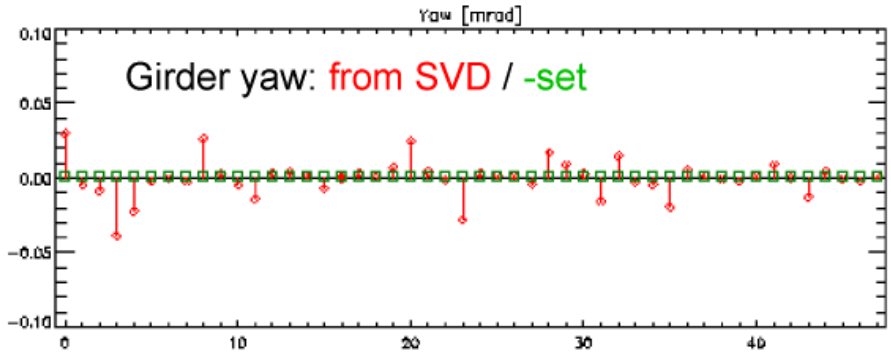


SVD orbit correction
with 48 girders:









Dynamic Alignment - a critical review

POMS (BPM Position Monitoring System)

- ✔ useful to observe drifts and correlations, warm-up
- ✘ sensors radiation sensitive → local shielding ✔

HLS (Hydrostatic Levelling System)

- ✔ monitoring of long term settlements
- ✘ too slow for interactive use
- ✘ technical problems (drifts, waves, biology, fluid mixing) → ✔

HPS (Horizontal Positioning System)

- ✘ depends on HLS → no interactive use

⇒ **"VPS"** is missing !

GM / GME(Girder Movers / Encoders)

- ✘ complex system (240 motors...) / manpower intensive
- ✘ dangerous operation (vacuum chamber stress, potential irreversibility)
- ✘ reduced eigenfrequencies (coupled girder oscillations)
- ✔ Potential of "Girder–OCO" (no true BBGA)- not needed ✘
- ✔ Convenient girder realignment

"spin off":

6D positioning for experiments

Mover types: rod mover
cylinder mover
wheel mover