PAUL SCHERRER INSTITUT

PSI

Wir schaffen Wissen – heute für morgen

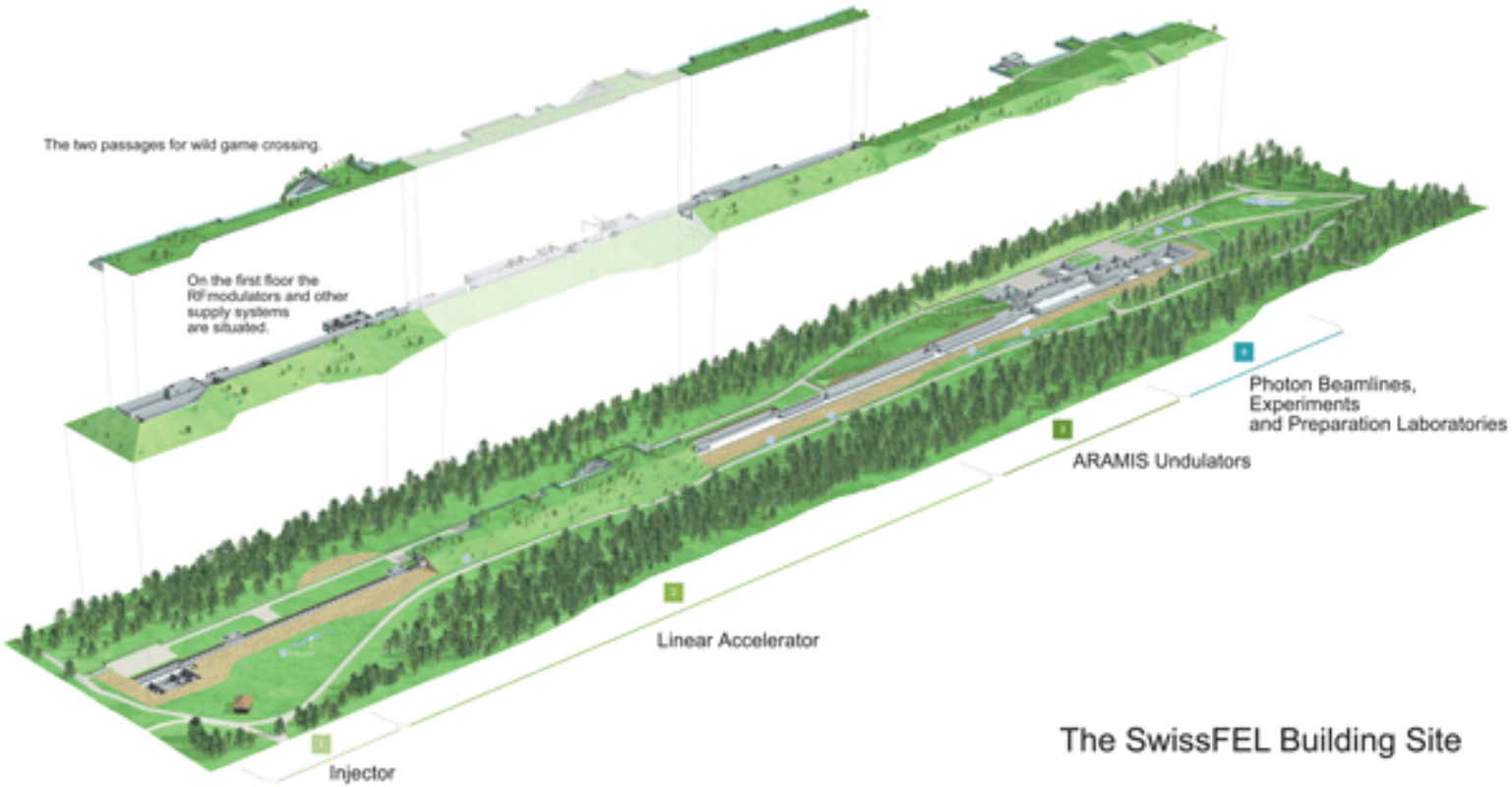
Paul Scherrer Institute, Switzerland

Dragutin Maier-Manojlovic,

Embedded Software and Motion Control Systems

ICALEPCS 2015 - Melbourne, Australia

Paul Scherrer Institute (PSI) - Switzerland

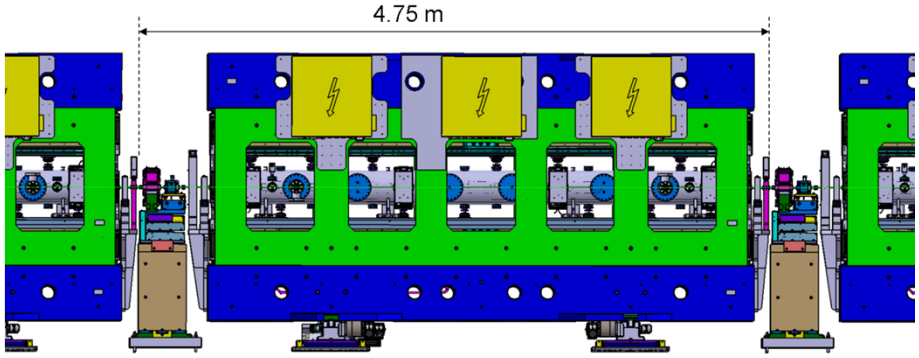


The SwissFEL Building Site

Swiss Free Electron Laser

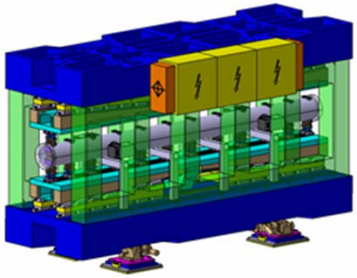
SwissFEL

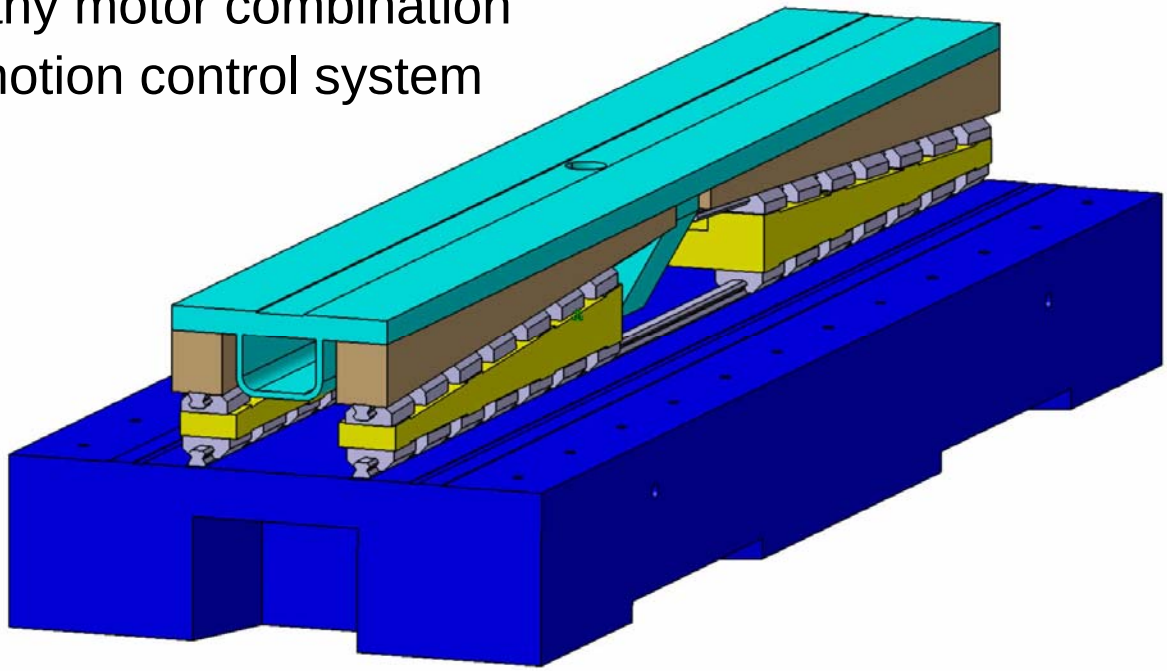
Undulator Positioning Systems



Local Synchronization

- Gap drive system with two wedges
- 1 Servomotor and absolute encoder per wedge
- Synchronisation of any motor combination
- Beckhoff PLC and motion control system
- EtherCAT fieldbus

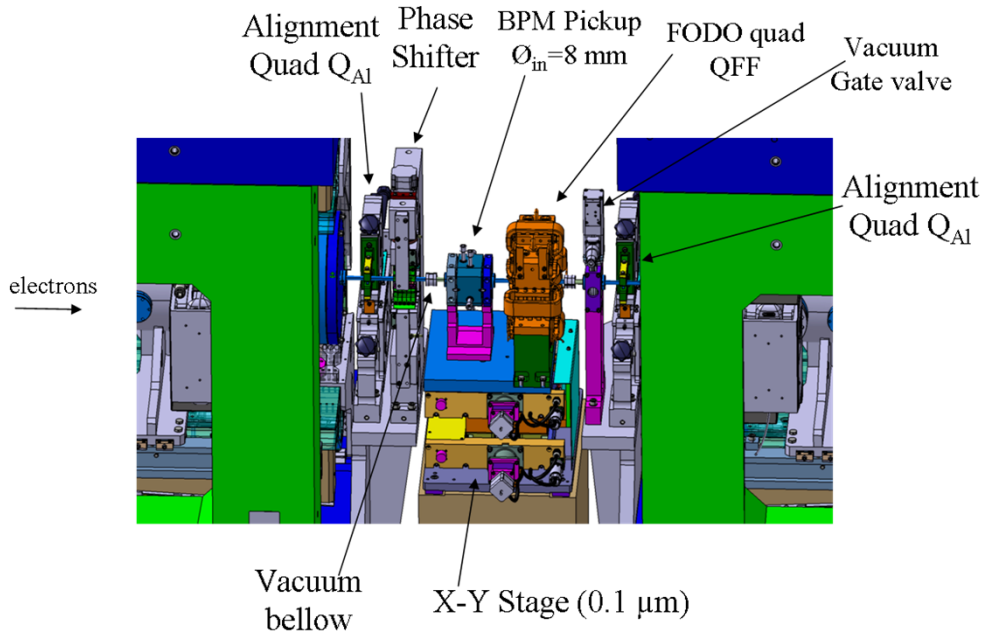


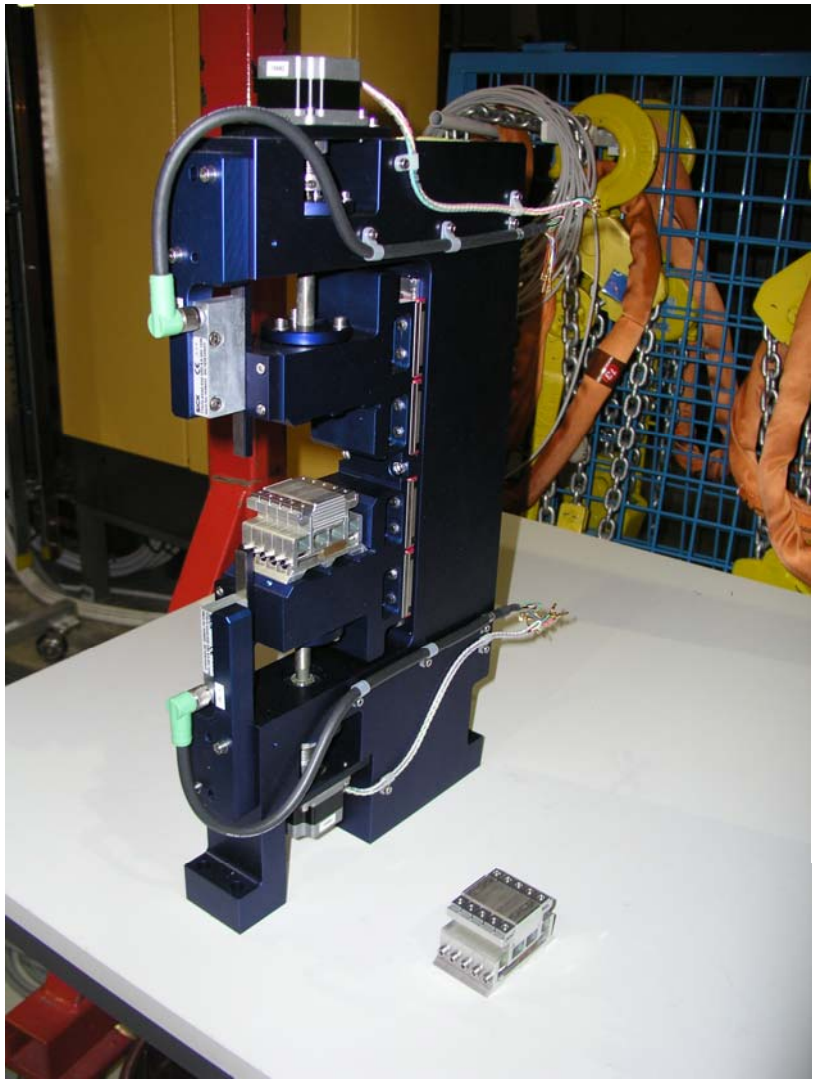


Positioning Systems

Phasematcher/Phaseshifter

- 2 Steppermotors
- 2 Linear absolute encoders
- Local synchronisation of both motors
- Beckhoff PLC and motion control system
- Integrated in the Gap controler box





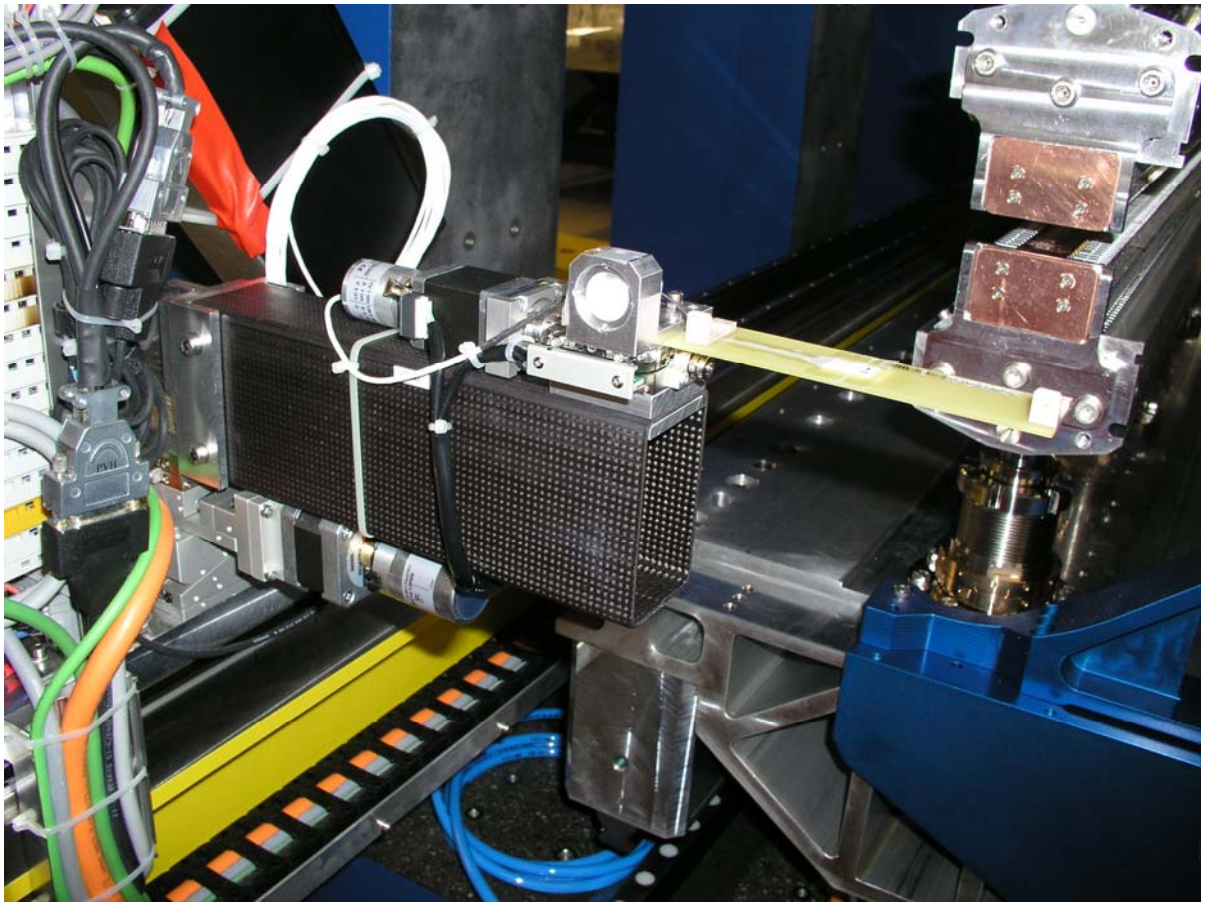
Undulator Positioning Systems

Hallsensor stabilising system

- 2 Laserbeams, 2 Pinholes and 2 PSDs (Position Sensitive Detectors)

- Correction with 3 Steppermotors in X / Z / roll angle

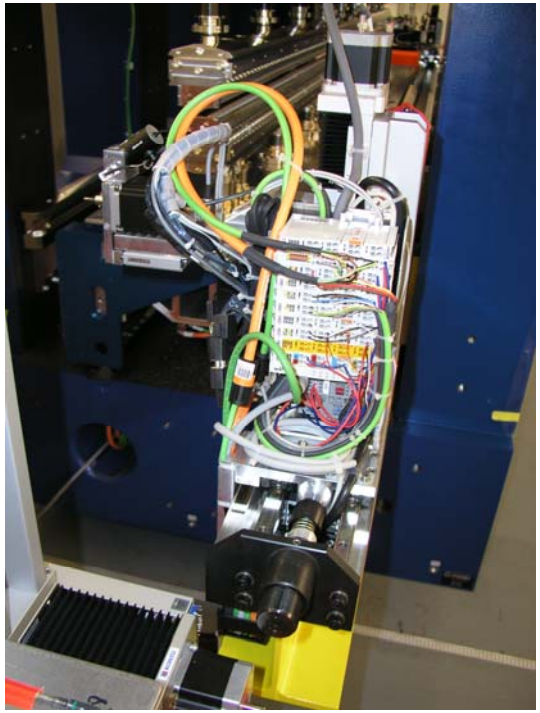
- Manual adjustment of pitch



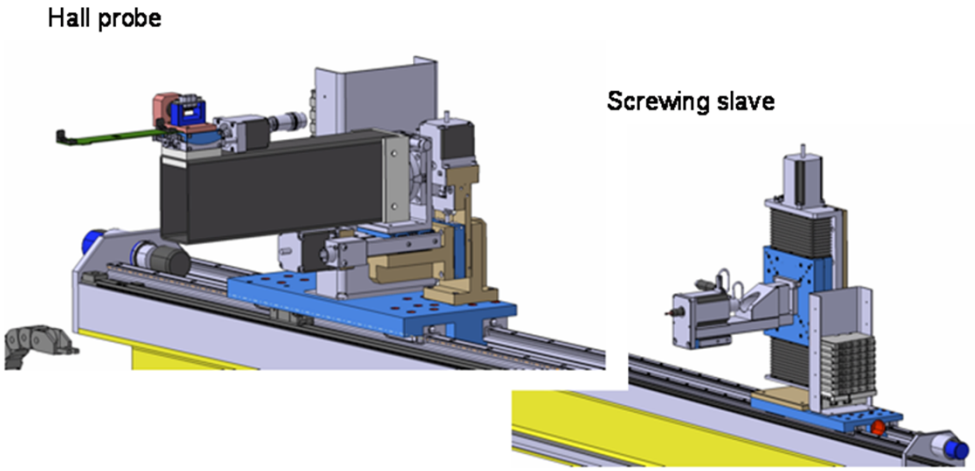
Undulator Positioning Systems

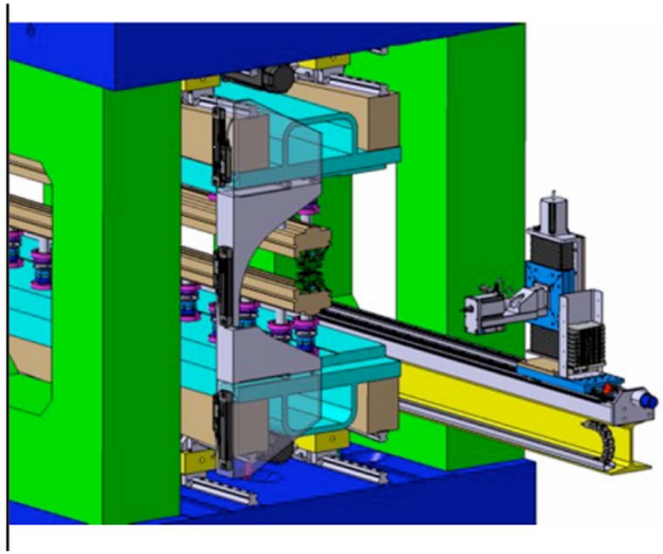
Robot screwdriver

- Automatized correction
- Using linear- and stepper motors
- Shared platform



Hall probe and screwer on common linear motor

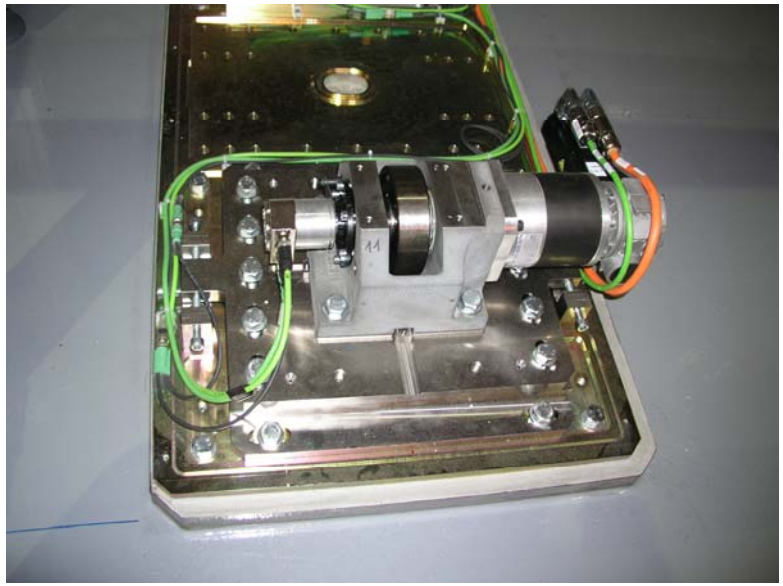


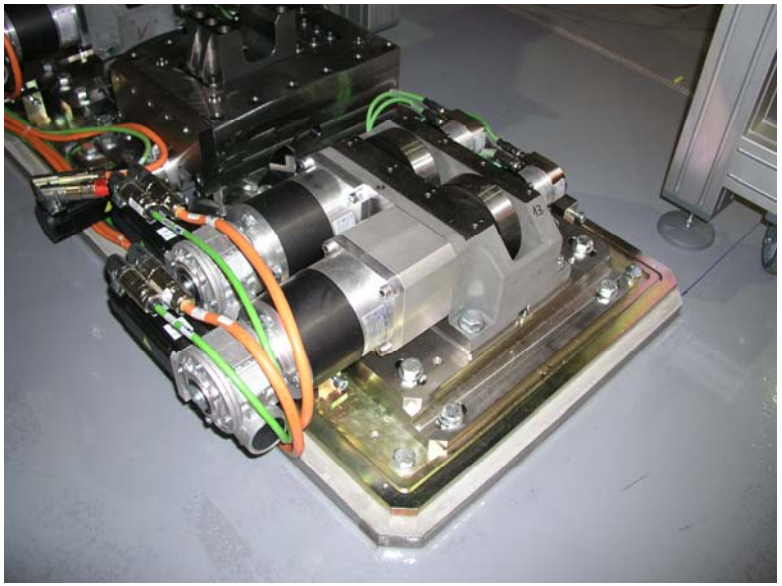


Undulator Positioning Systems

Movers

- Alignment of each undulator with respect to the electron beam
- 5 rotating camshafts with prisms
- 5 Servomotors and absolute encoders
- 5 possible directions: **vertical**, **transverse**, **pitch**, **yaw**, **roll**
- Calculation of each camshaft angle for the 5 possible movements
- Beckhoff PLC and motion control system





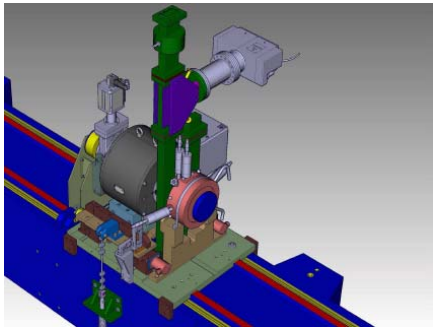
Gun Solenoid Positioning System

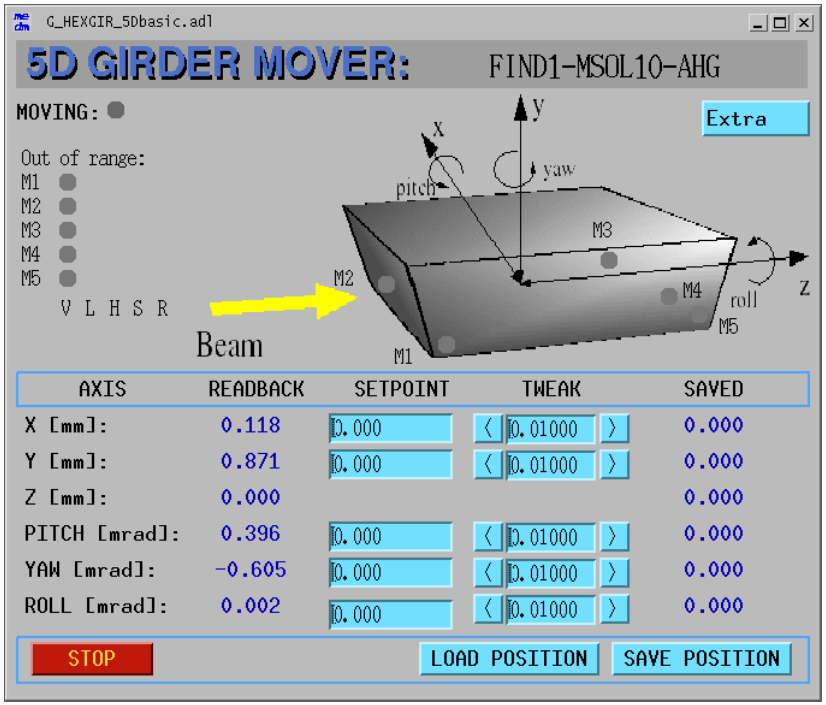
5D Mover

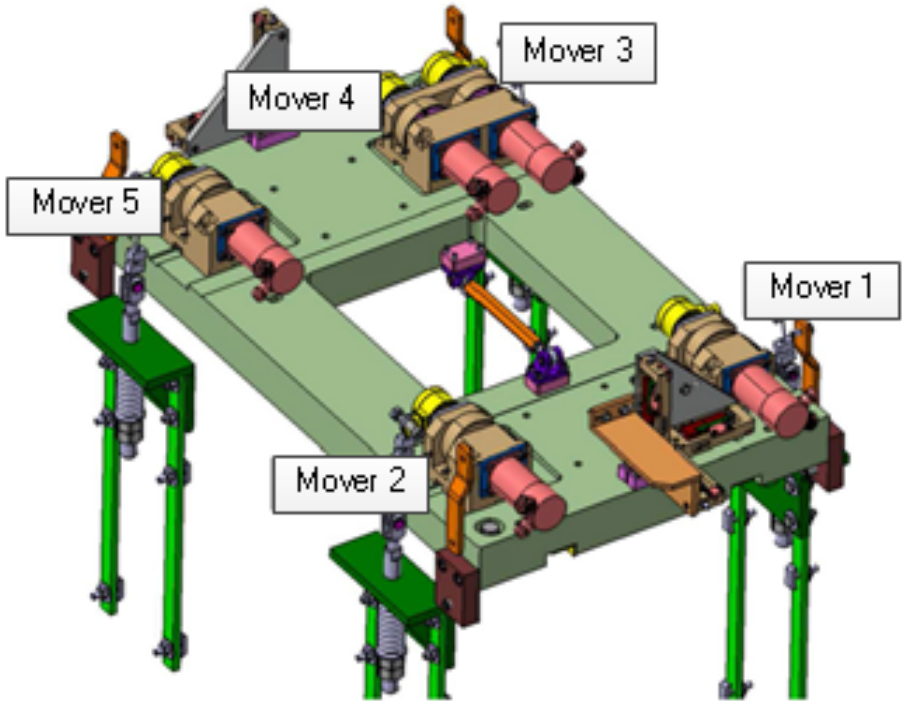
- 5 possible directions:

vertical, **transverse**, **pitch**, **yaw**, **roll**

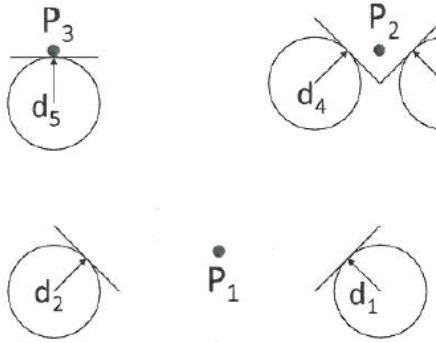
- 5 excentric rotating camshafts
- 5 Servomotors and absolute encoders





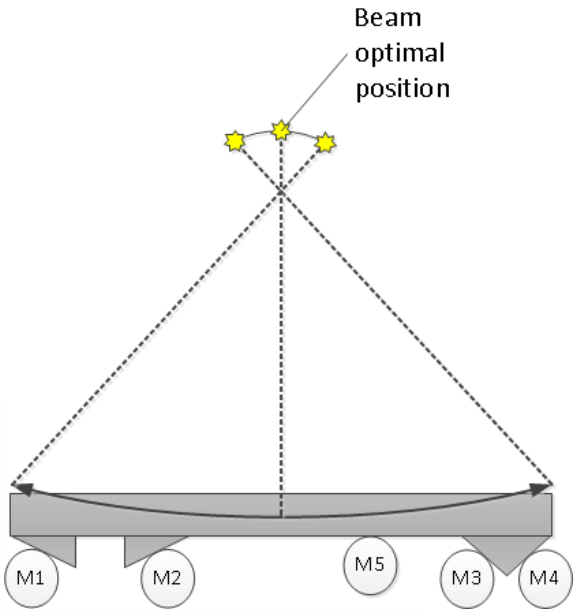


5D Positioning System



$P_\xi=(x_\xi,y_\xi)$

Figure 1



$$\begin{cases} \underline{X} = \underline{\underline{M}} \cdot \underline{P} \\ \underline{P} = \underline{\underline{A}} \cdot \underline{S} + \underline{\underline{B}} \cdot \underline{X} \end{cases}$$

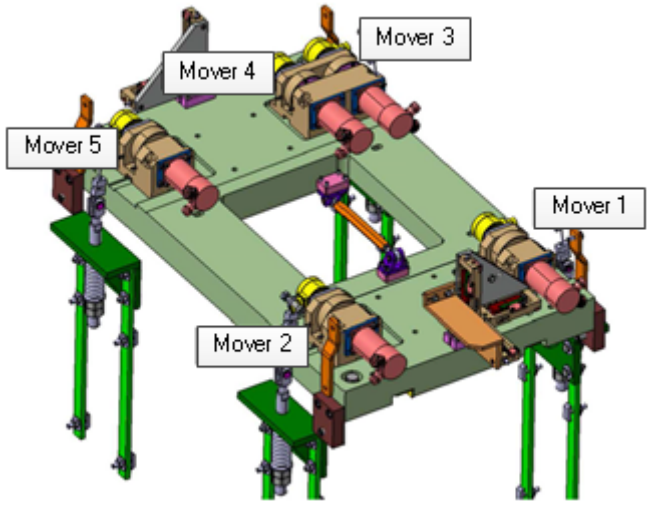
$$\underline{S} = \underbrace{(\underline{\underline{M}} \cdot \underline{\underline{A}})^{-1}(\underline{\underline{1}} - \underline{\underline{M}} \cdot \underline{\underline{B}})}_{\underline{\underline{D}}} \underline{X}$$

$$\underline{X} = \underline{\underline{D}}^{-1} \cdot \underline{S}$$

$$\underline{\underline{D}} = \begin{bmatrix} \frac{1}{2} & \frac{1}{2} & -\frac{r}{2}+\frac{1}{4} & -\frac{1}{4} & -\frac{1}{4} \\ -\frac{1}{2} & \frac{1}{2} & \frac{r}{2}-\frac{1}{4} & \frac{1}{4} & -\frac{1}{4} \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{4}-\frac{r}{2} & \frac{1}{4} & \frac{1}{4} \\ -\frac{1}{2} & \frac{1}{2} & \frac{1}{4}+\frac{r}{2} & -\frac{1}{4} & \frac{1}{4} \\ 0 & \frac{1}{\sqrt{2}} & -\frac{1}{2\sqrt{2}} & 0 & \frac{1}{2\sqrt{2}} \end{bmatrix} \quad \underline{\underline{D}}^{-1} = \begin{bmatrix} \frac{1}{2} & -\frac{1}{2} & r+\frac{1}{4} & r-\frac{3}{4} & \frac{1-4r}{2\sqrt{2}} \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{4} & \frac{1}{4} & \frac{1}{2\sqrt{2}} \\ 0 & 0 & 1 & 1 & -\sqrt{2} \\ -1 & 1 & \frac{3}{2} & -\frac{1}{2} & -\frac{1}{\sqrt{2}} \\ -1 & -1 & \frac{1}{2} & \frac{1}{2} & \frac{1}{\sqrt{2}} \end{bmatrix}$$

$$\underbrace{\begin{bmatrix} x \\ y \\ \rho \\ \omega \\ \phi \end{bmatrix}}_{\underline{X}} = \underbrace{\begin{bmatrix} \frac{1}{2} & \frac{1}{2} & 0 & 0 & 0 \\ 0 & 0 & \frac{1}{2} & \frac{1}{4} & \frac{1}{4} \\ 0 & 0 & 0 & 1 & -1 \\ -1 & 1 & 0 & 0 & 0 \\ 0 & 0 & -1 & \frac{1}{2} & \frac{1}{2} \end{bmatrix}}_{\underline{\underline{M}}} \cdot \underbrace{\begin{bmatrix} x_1 \\ x_2 \\ y_1 \\ y_2 \\ y_3 \end{bmatrix}}_{\underline{P}}$$

$$\underbrace{\begin{bmatrix} x_1 \\ x_2 \\ y_1 \\ y_2 \\ y_3 \end{bmatrix}}_{\underline{P}} = \underbrace{\begin{bmatrix} 1 & -1 & 0 & 0 & 0 \\ 0 & 0 & 1 & -1 & 0 \\ 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & \sqrt{2} \end{bmatrix}}_{\underline{\underline{A}}} \cdot \underbrace{\begin{bmatrix} s_1 \\ s_2 \\ s_3 \\ s_4 \\ s_5 \end{bmatrix}}_{\underline{S}} + \underbrace{\begin{bmatrix} 0 & 0 & r-\frac{1}{2} & 0 & 0 \\ 0 & 0 & r & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}}_{\underline{\underline{B}}} \cdot \underbrace{\begin{bmatrix} x \\ y \\ \rho \\ \omega \\ \phi \end{bmatrix}}_{\underline{X}}$$



Paul Scherrer Institute (PSI) - Switzerland

Author especially wishes to thank people involved in PSI GFA, Controls and other departments, who (among others) contributed to the development of these systems and this presentation:
Marc Brügger, Peter Heimgartner, Dr. Dirk Zimoch, Dr. Elke Zimoch, Dr. Markus Janousch

Paul Scherrer Institute (PSI), Switzerland

Dragutin Maier-Manojlovic, Embedded Software and Motion Control Systems, Large Research Facilities