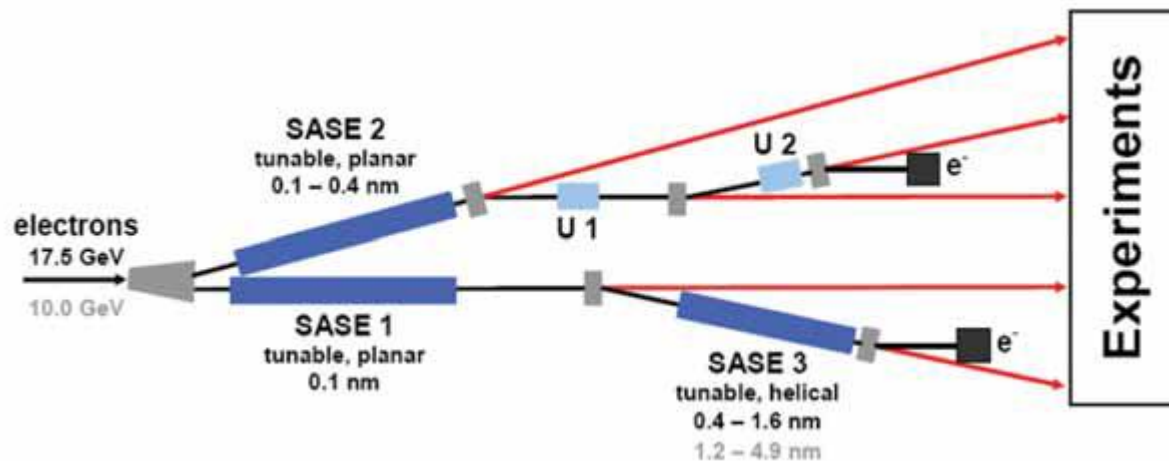


Högprecisionssystem för temperaturkompensation av XFEL:s undulatorer

Anders Hedqvist & Fredrik Hellberg

Varför temperaturkompensering?

- Stabil temperatur avgörande för fas- och våglängdsmatchning
- Potentiell stor temperaturvariation längs hela undulatorn – dyrt att hålla temperaturen konstant
- Justera undulatorgapet efter lokal temperatur
- Krav på upplösning: 0.03 °C

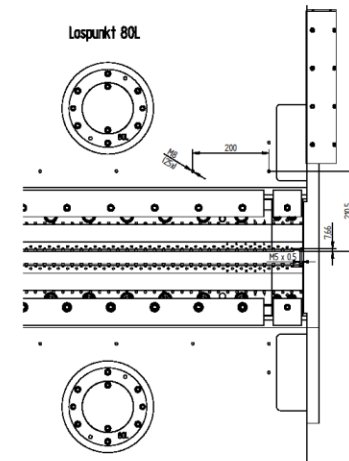
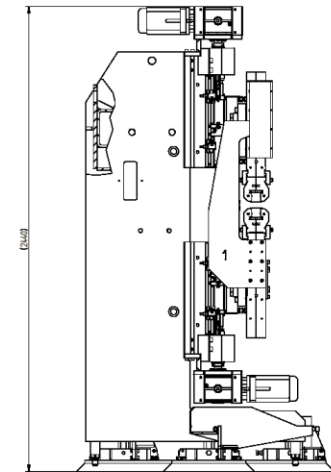
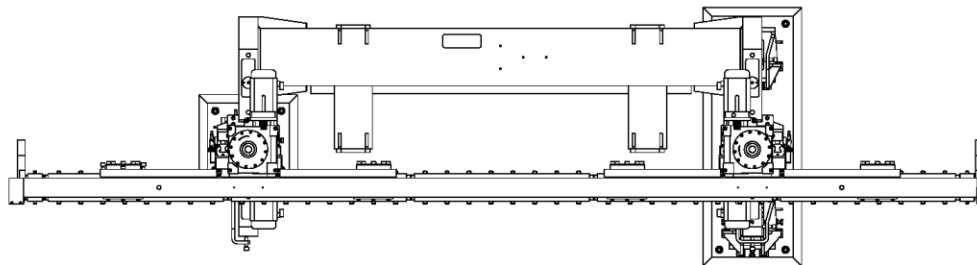
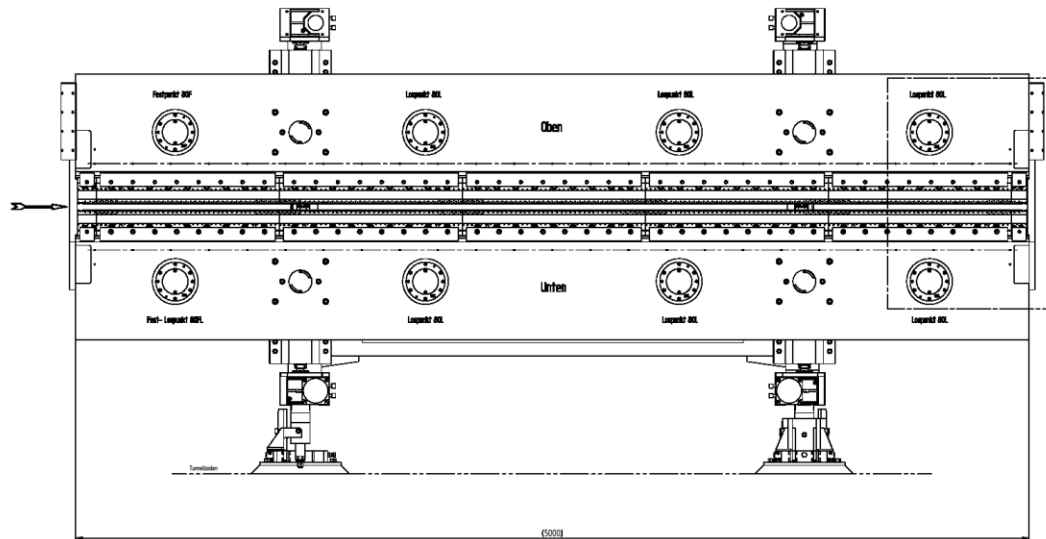


SASE 2: 42 undulatorer á 5 m + 1.1 m mellan sektioner

Längd: 256 m

SASE 1, 2 och 3 totalt 96 undulatorsektioner

Undulatorn och sensorpositioner

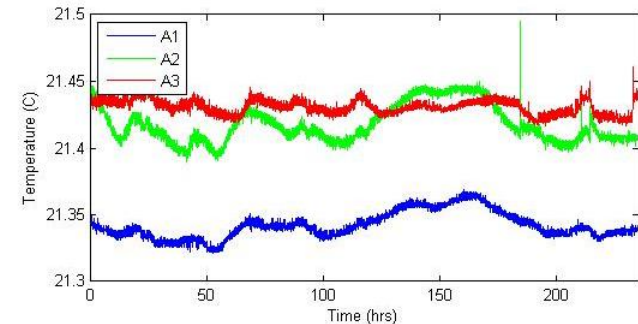
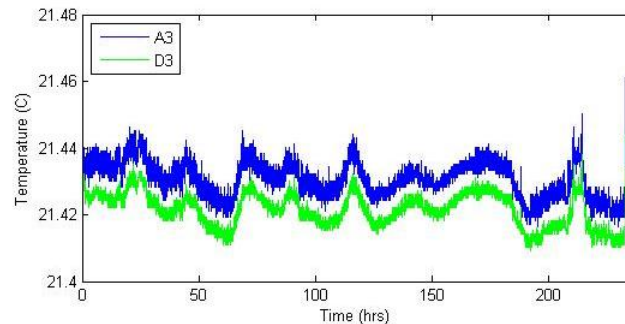
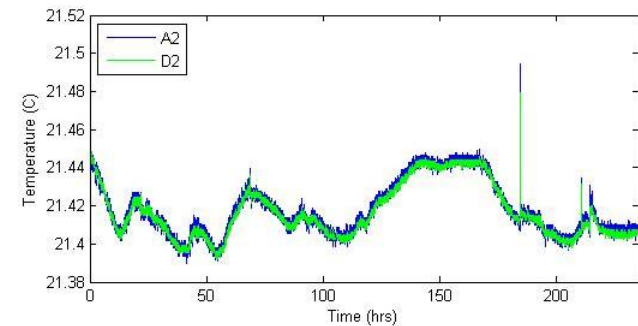
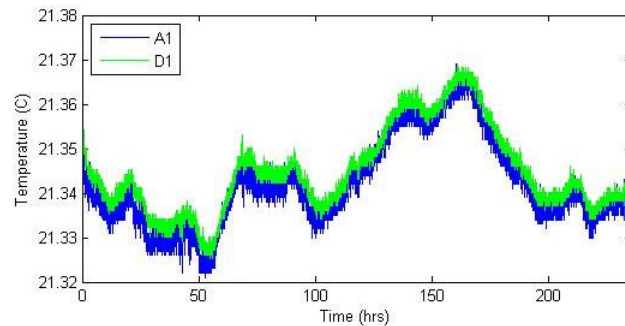


Kalibrering och typ av sensor

Mätsystem: 9-kanals Almemo med Pt-100 sensorer
Noggrannhet och precision: 0.2 °C respektive 0.001 °C
Kalibrering av sensor+elektronik nödvändig

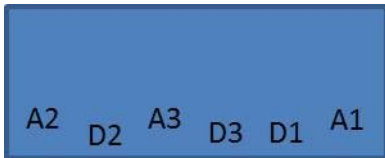
A2	A1	A3
D2	D1	D3

$$\begin{aligned} \langle |A1-D1| \rangle &= 0.0012 \\ \langle |A2-D2| \rangle &= 0.0014 \\ \langle |A3-D3| \rangle &= 0.0087 \\ \text{corr}(A1,D1) &= 0.99 \end{aligned}$$

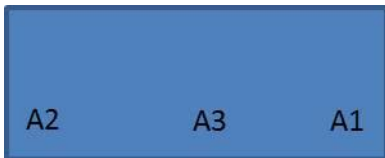
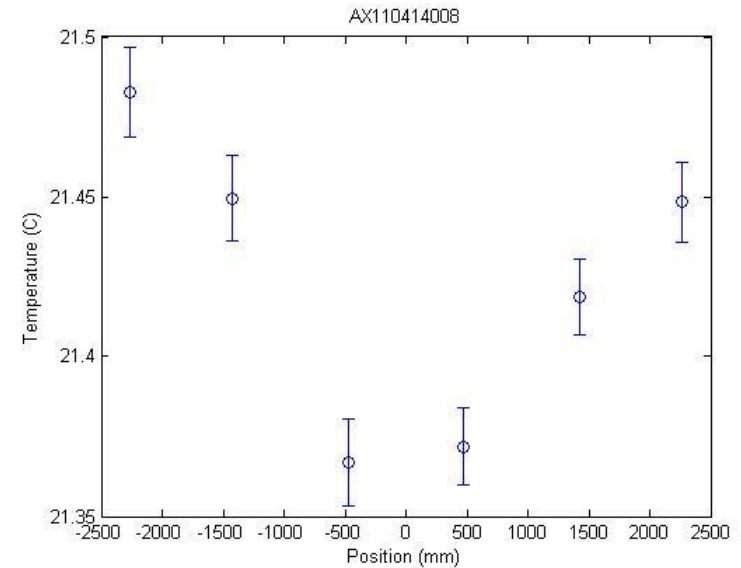


Sensorer och kalibrering ok!

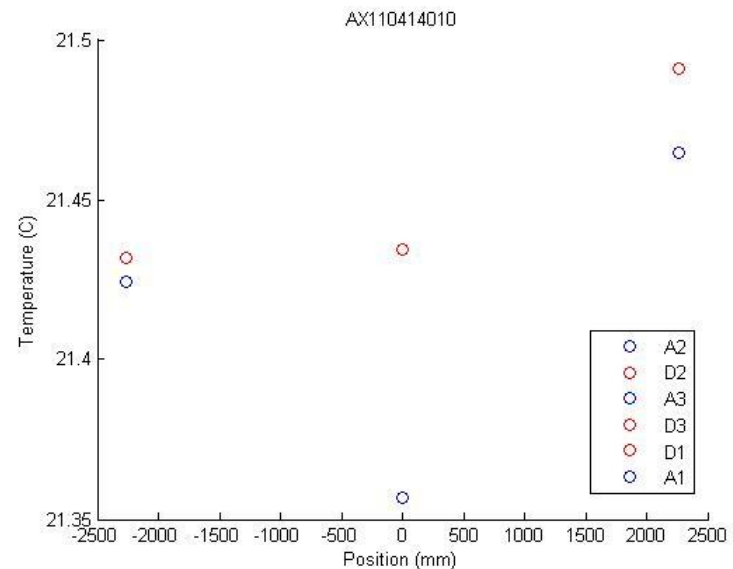
Temperaturgradient och sensorposition



$\langle A2 \rangle = 21.48 \pm 0.01$ $\langle D3 \rangle = 21.37 \pm 0.01$
 $\langle D2 \rangle = 21.45 \pm 0.01$ $\langle D1 \rangle = 21.42 \pm 0.01$
 $\langle A3 \rangle = 21.36 \pm 0.01$ $\langle A1 \rangle = 21.45 \pm 0.01$



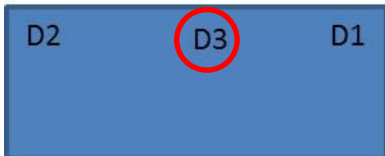
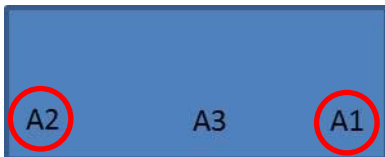
$\langle A2 \rangle = 21.42 \pm 0.05$ $\langle D2 \rangle = 21.43 \pm 0.04$
 $\langle A3 \rangle = 21.36 \pm 0.05$ $\langle D3 \rangle = 21.43 \pm 0.04$
 $\langle A1 \rangle = 21.46 \pm 0.03$ $\langle D1 \rangle = 21.49 \pm 0.04$



Temperaturgradient och sensorposition



$\langle A2 \rangle = 21.48 \pm 0.01$ $\langle D3 \rangle = 21.37 \pm 0.01$
 $\langle D2 \rangle = 21.45 \pm 0.01$ $\langle D1 \rangle = 21.42 \pm 0.01$
 $\langle A3 \rangle = 21.36 \pm 0.01$ $\langle A1 \rangle = 21.45 \pm 0.01$



$\langle A2 \rangle = 21.42 \pm 0.05$ $\langle D2 \rangle = 21.43 \pm 0.04$
 $\langle A3 \rangle = 21.36 \pm 0.05$ $\langle D3 \rangle = 21.43 \pm 0.04$
 $\langle A1 \rangle = 21.46 \pm 0.03$ $\langle D1 \rangle = 21.49 \pm 0.04$

