Twisting Wire Scanner

V.Gharibyan, A.Delfs, I.Krouptchenkov, D.Noelle, H.Tiessen, M.Werner, K.Wittenburg

DESY

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HELMHOLTZ ASSOCIATION

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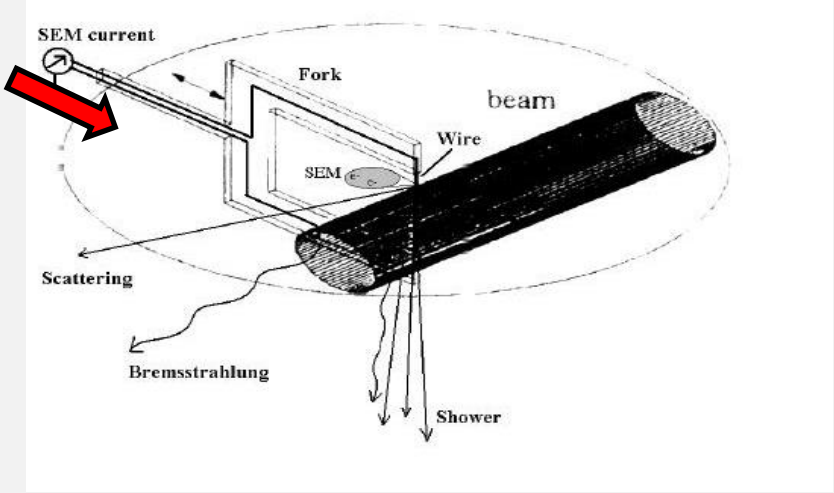
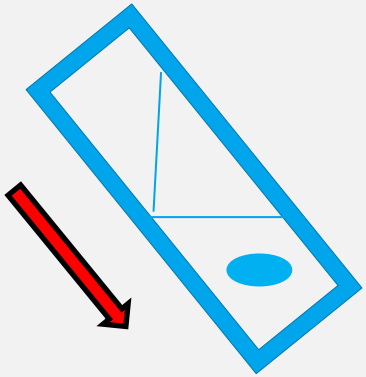
Existing Solutions

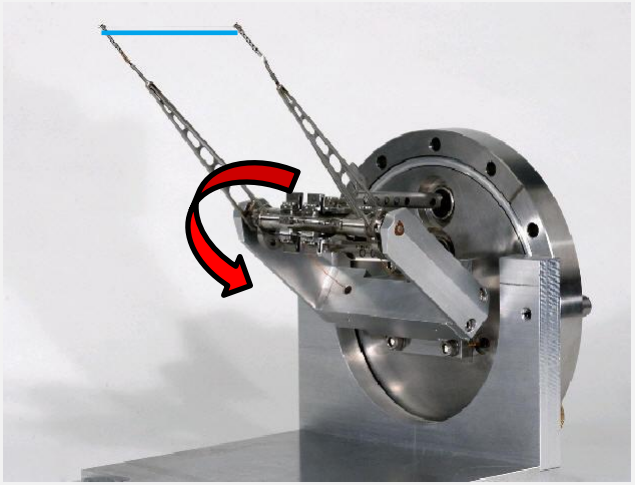
Linear



two in one, 45deg



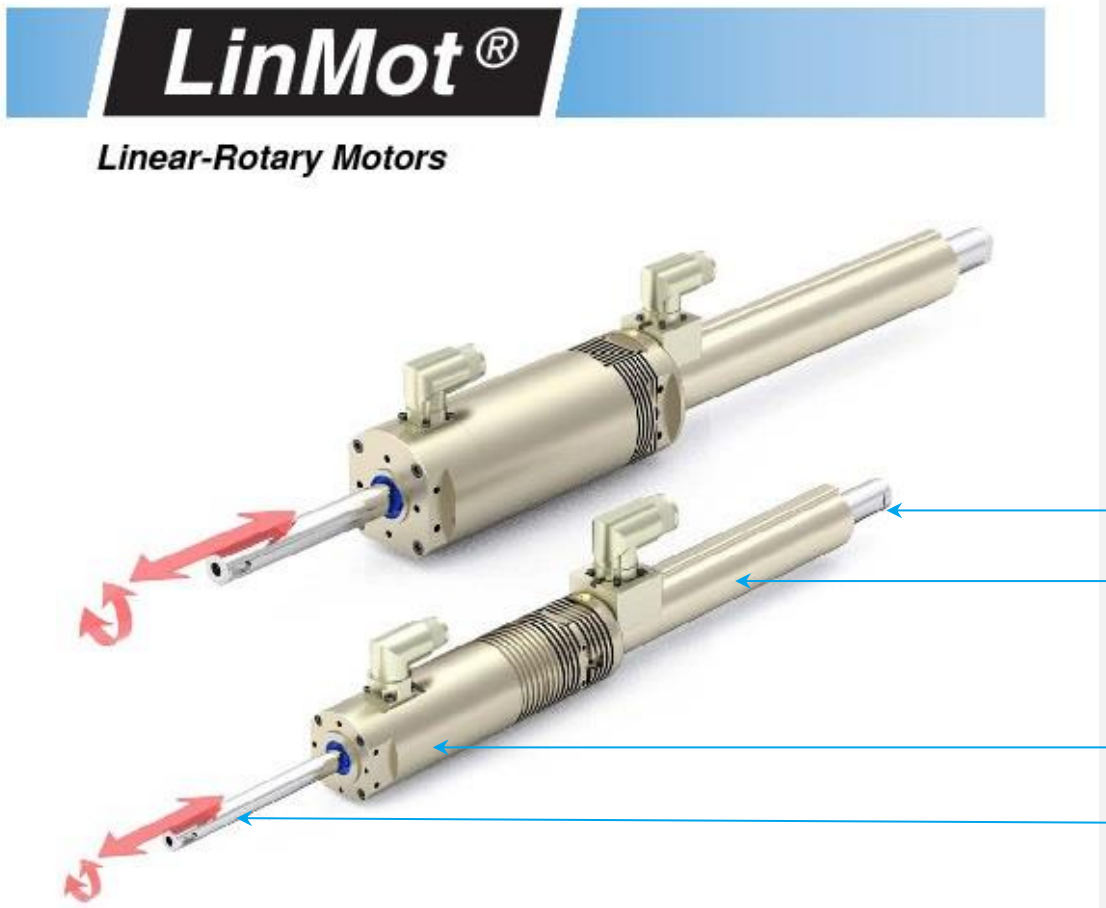
Rotating



Driver Motors

Stepper
Servo Rotating
Linear (R&D)

Linear-Rotary Motor



Slider with Nd magnets

Stator windings

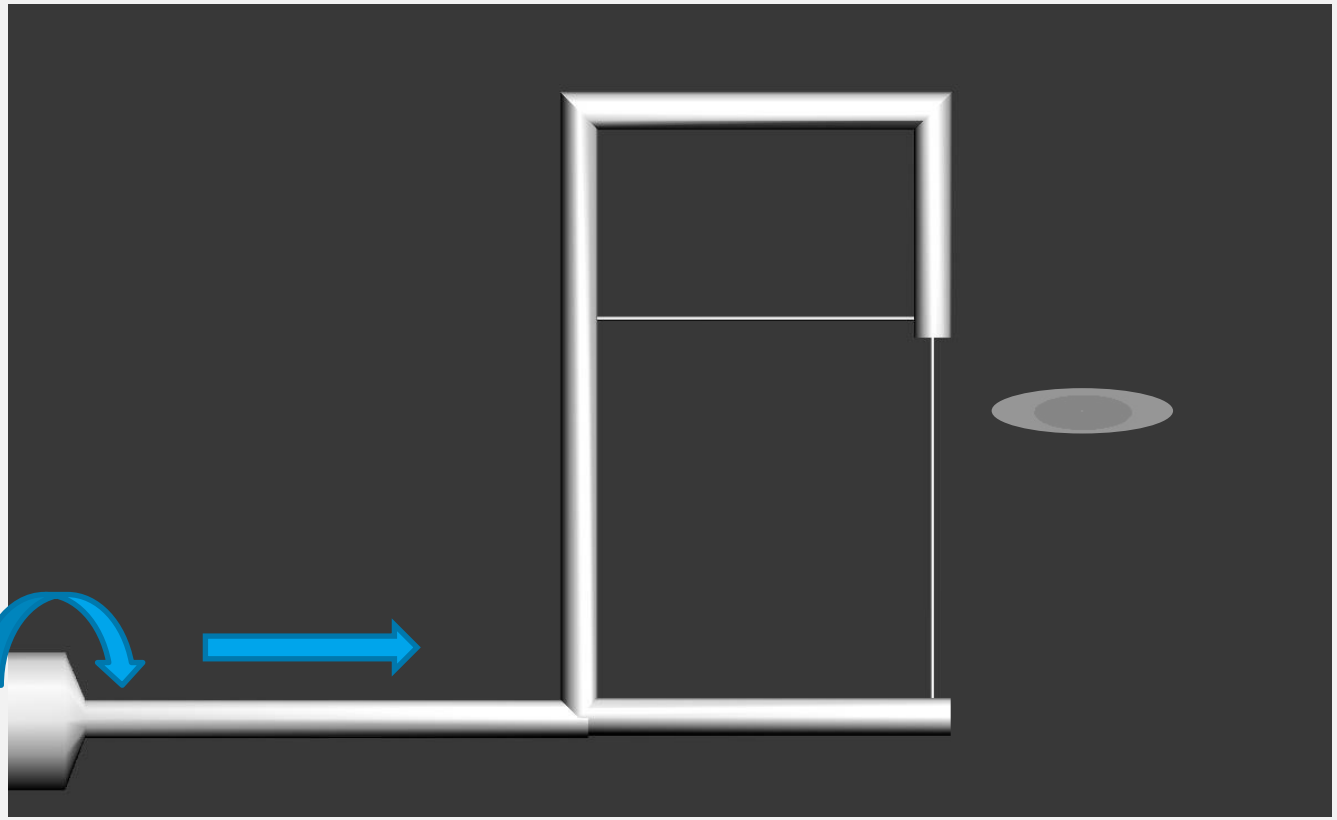
Rotary windings

Rod (shaft)

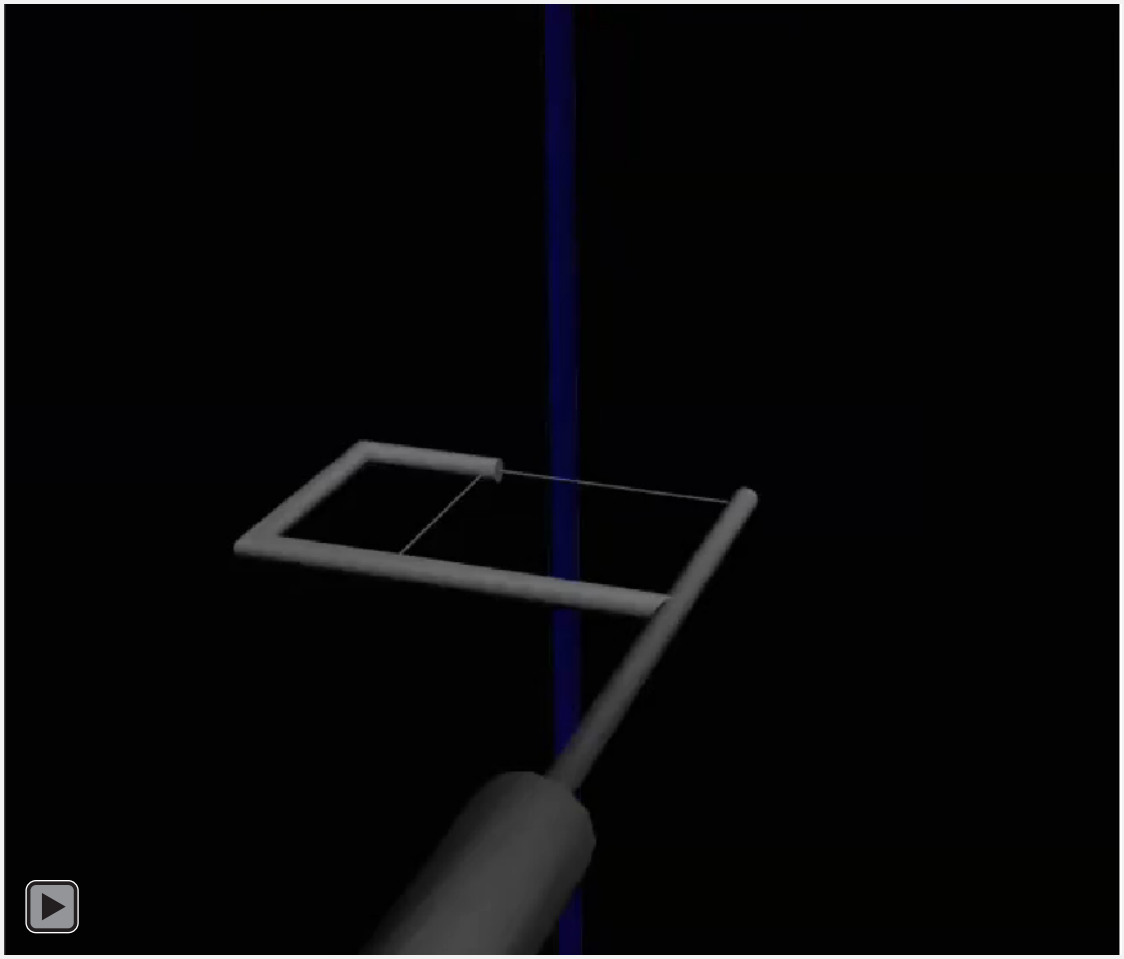
Linear-Rotary Motor Parameters

Parameter	Value
Linear Motion	
Standard Stroke SS mm (in)	100 (3.94)
Peak Force E12x0 - UC N (lbf)	255 (57.3)
Cont. Force N (lbf)	51 (11.5)
Cont. Force Fan cooling N (lbf)	92 (20.7)
Force Constant N/A (lbf/A)	17 (3.8)
Max. Current@ 72VDC A	15
Max. Velocity m/s (in/s)	3.9 (154)
Position Repeatability mm (in)	±0.05 (±0.0020)
Linearity %	±0.10
Rotary Motion	
Peak Torque Nm (lbfin)	2 (17.7)
Constant Torque (Halt) Nm (lbfin)	0.5 (4.4)
Max. Number of revolutions Rpm	1500
Torque Constant Nm/A (lbfin/A)	0.46 (4.07)
Max. Current@ 72VDC A	6.2
Repeatability deg	±0.05

Key bit Scanner



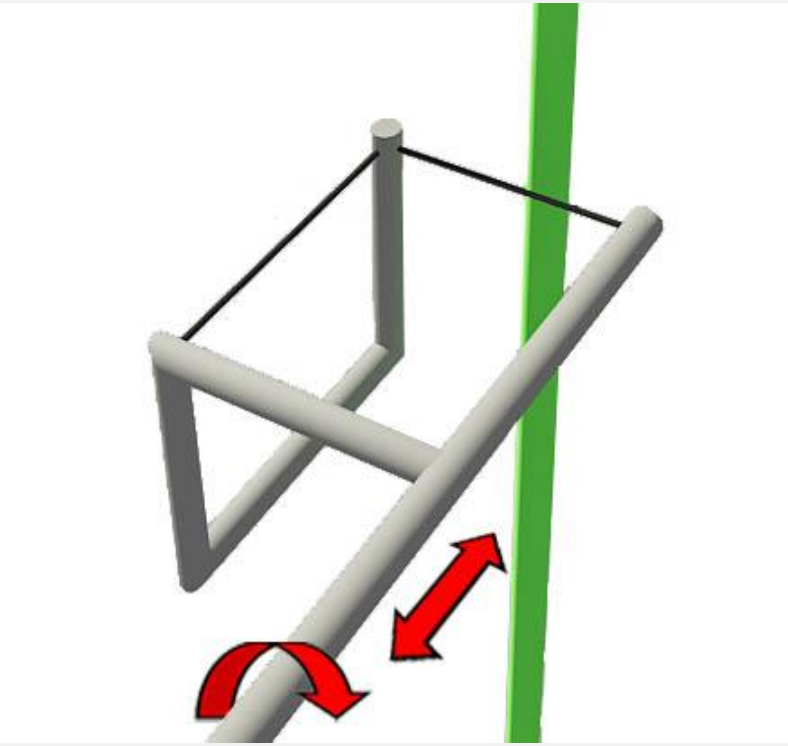
Key bit scanner operation



Distance between beam & frame = $L\left(\arccos\frac{x}{L}-\arccos\frac{x}{l_w}\right)$

x = distance beam to rotational axis,
L and Lw are vertical frame and wire sizes

3D tilted Key bit

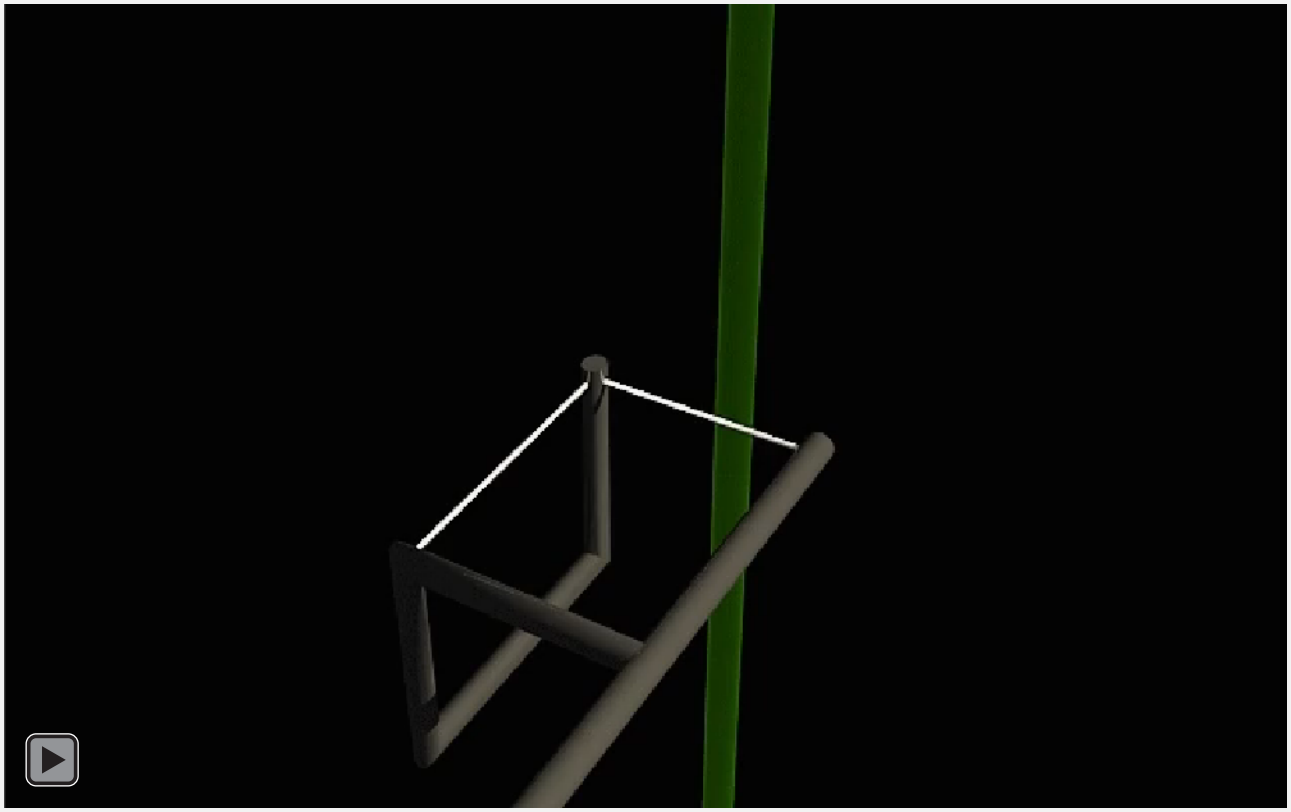


For fast scans.

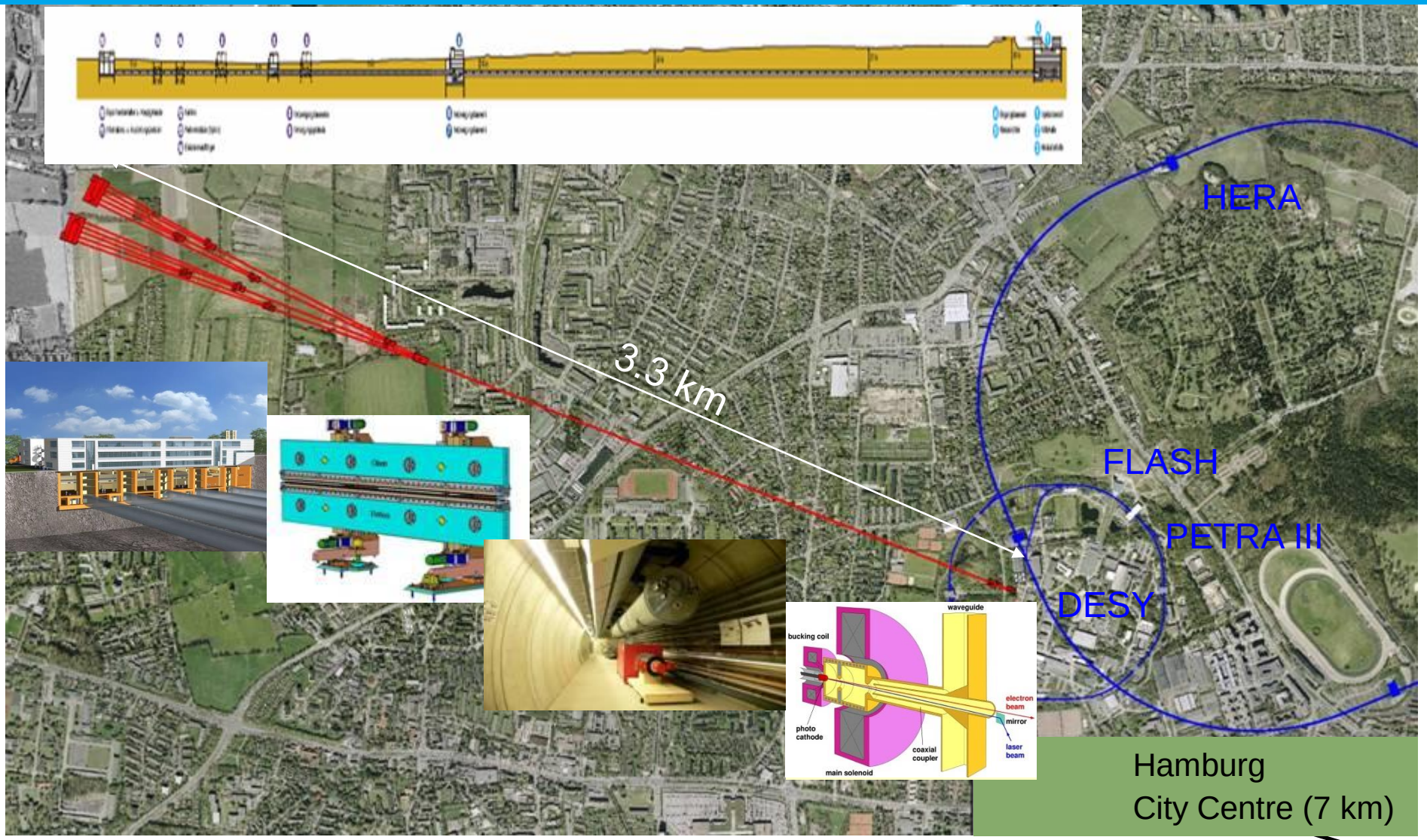
Improved space management.

Reduced inertia moment

Twisting scanner operation

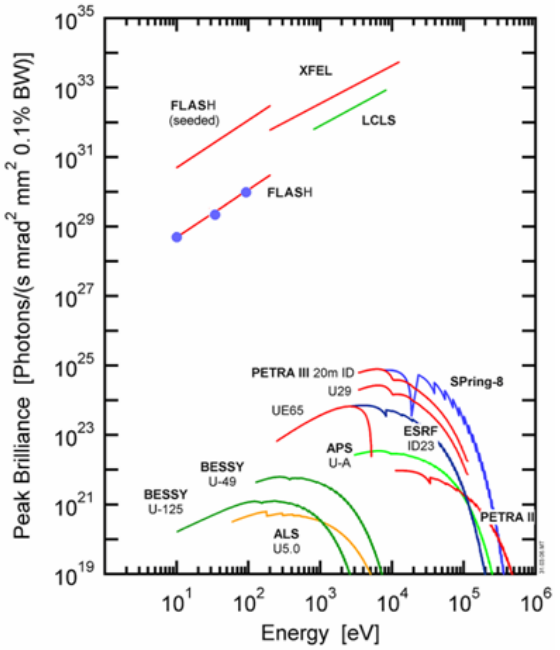


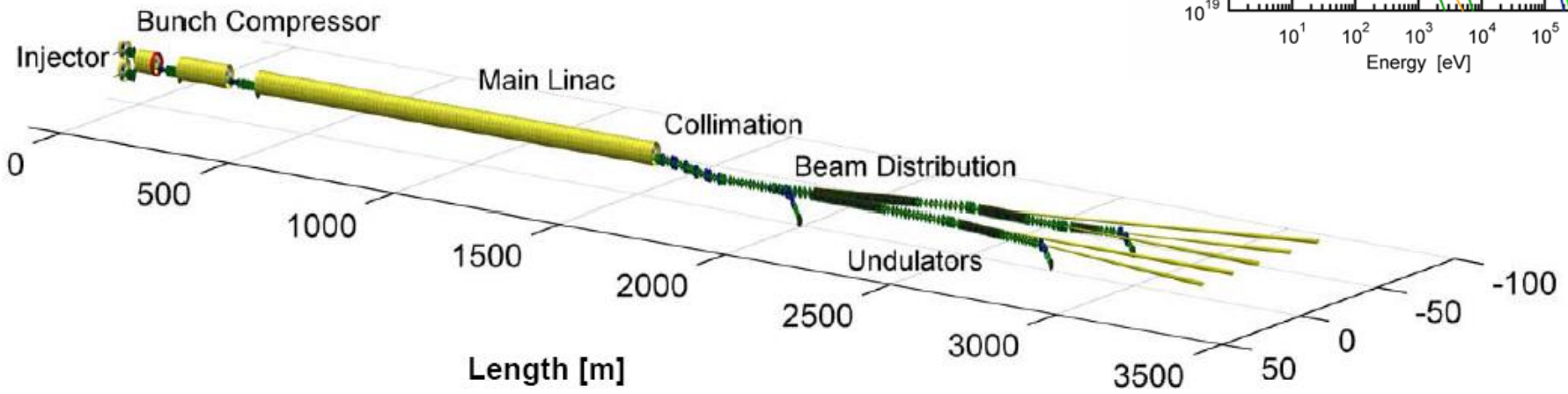
The European XFEL: Birds View



E-XFEL accelerator Layout

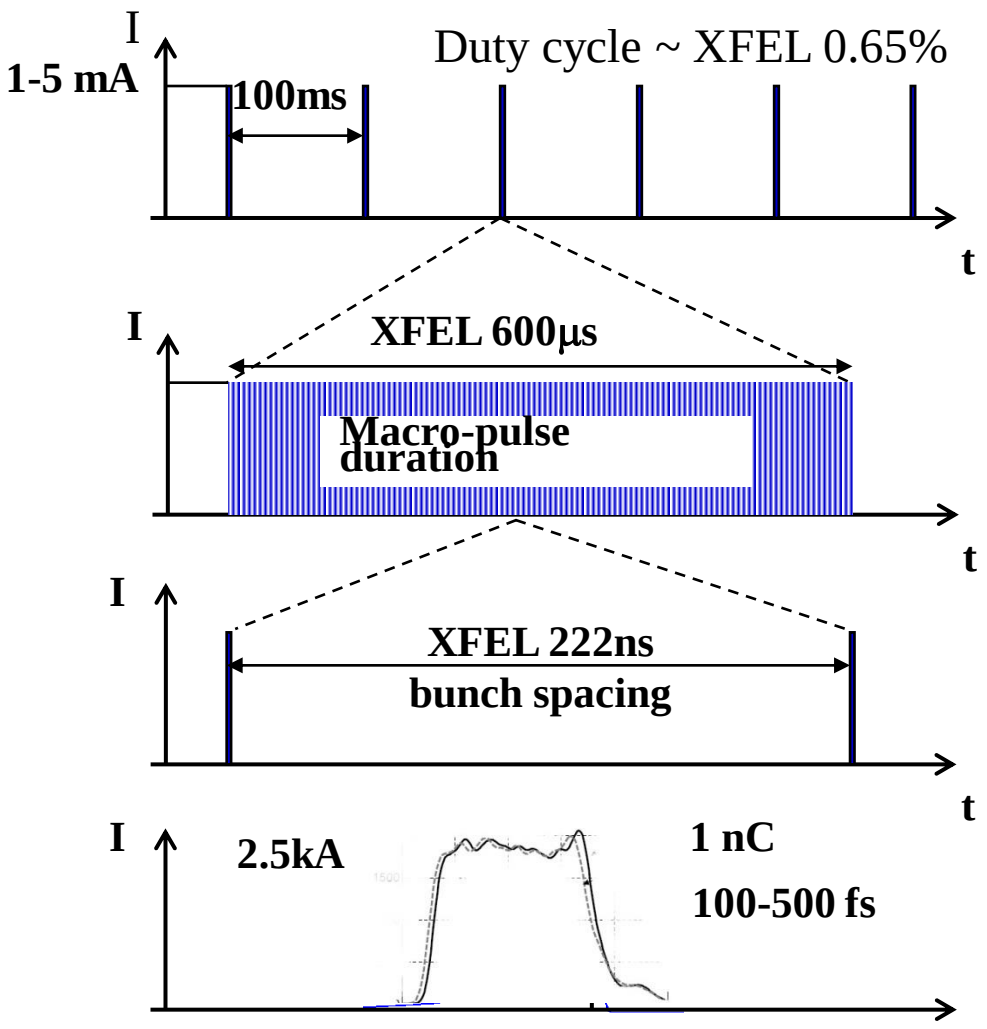
17.5 GeV superconducting LINAC
RF photoinjector, two bunch compression stages
3 SASE undulators plus 1 spontaneous source, extension possible
5 experimental stations to be extended to 10
potential extension with a second experimental hall





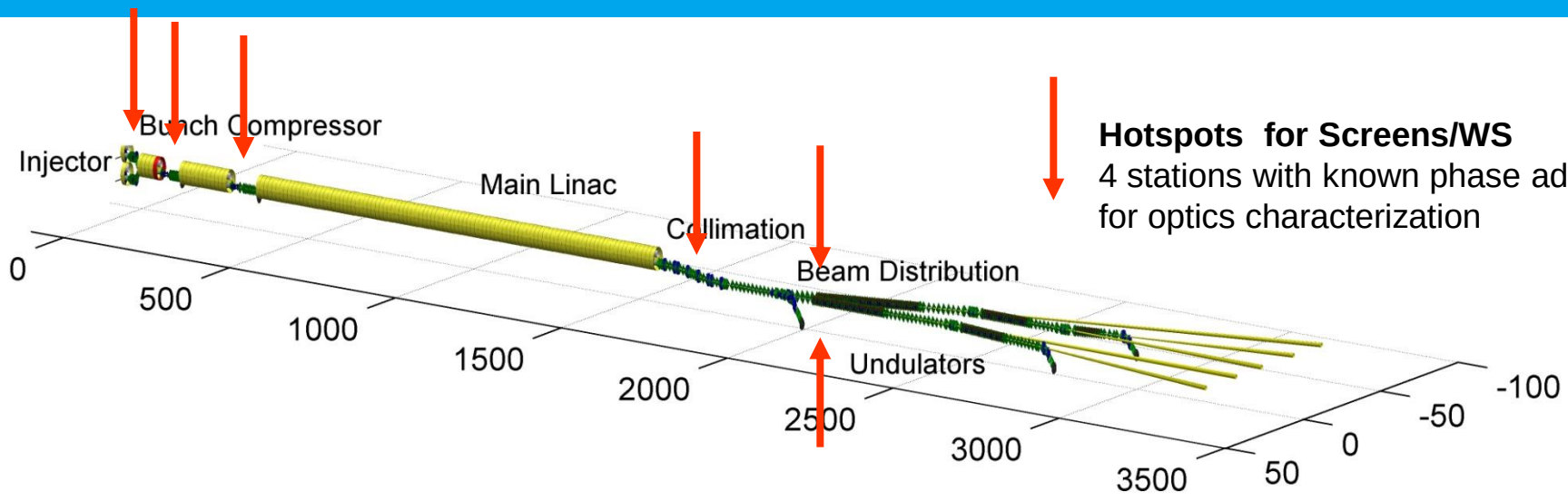
E-XFEL Time Structure

- Repetition rate
- Macro-pulse
- Bunch
- Slice



Up to 27000 Bunches/s

E-XFEL beam size measurement



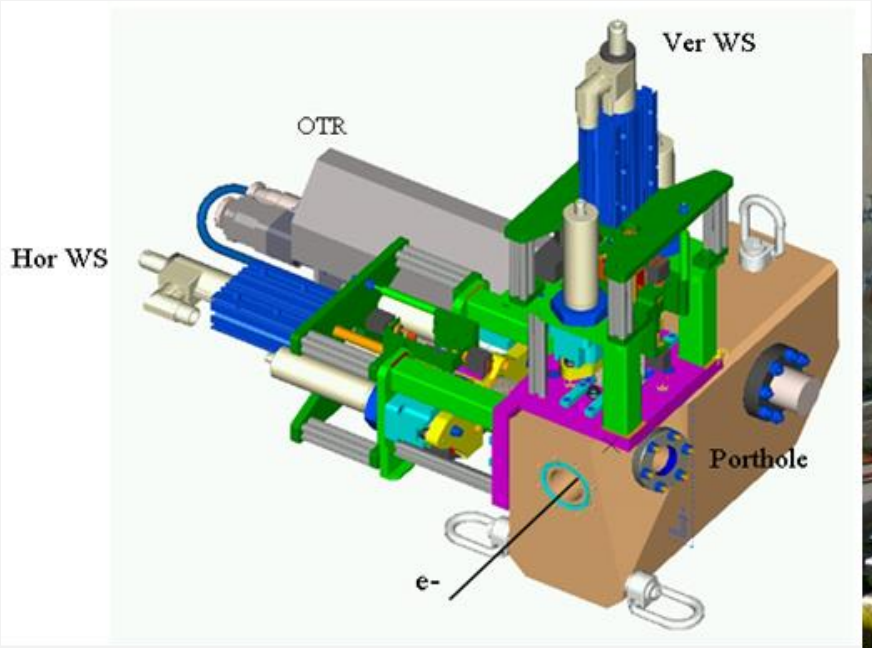
XFEL uses OTR and fast Wire Scanners

- to check and detect beam at critical places
- to match the optics and to measure Emittance at
  - Injector (OTR)
  - Bunch Compressor B1 and B2 (OTR)
  - in the Collimator (OTR/WS)
  - before the Undulator (WS)
- to measure slice parameters in combination with a
- transverse mode structure in Injector and Bunch Compressors B1 and B2

E-XFEL Wire Scanner

First Scanners with Linear Motors

@ development stage



E-XFEL Wire Scanner Specifications

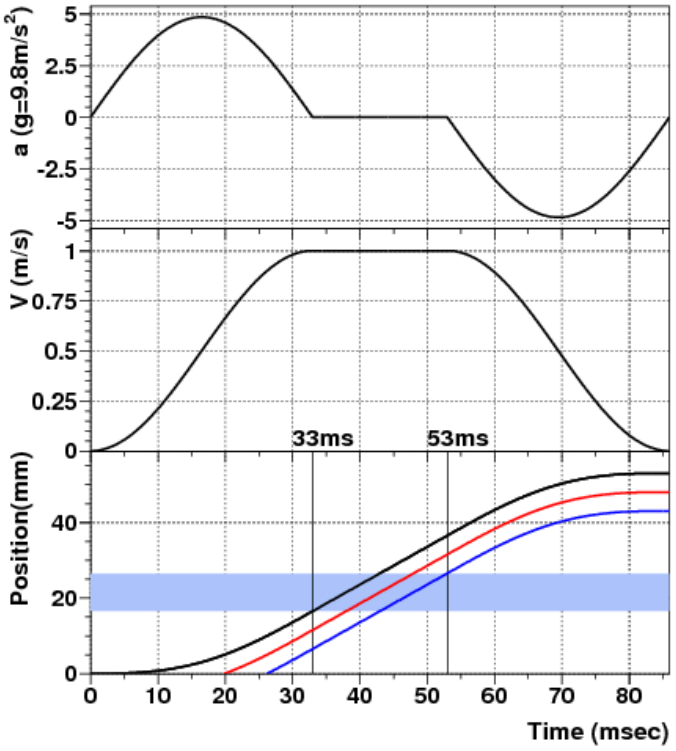
Stroke	53mm
Measurement duration	5 sec / 4 scanners
Scanning modes	Fast (1m/s, <100ms/scan), Slow
Motor to pulse synchronization	<10 μs (RMS)
Position accuracy in a cycle	2 μm (RMS)
Width accuracy per cycle	2 % (RMS)
Wire positioning error	1 μm
Number of wires per fork	3 + 2 (3x90deg, +/-60 deg)
Wire material	Tungsten
Fork gap	15mm
Wire-wire distance (0deg)	5mm

20 – 200μm beam sizes will be measured in a fast, triggered mode to scan bunch trains in a quasi-noninvasive way.

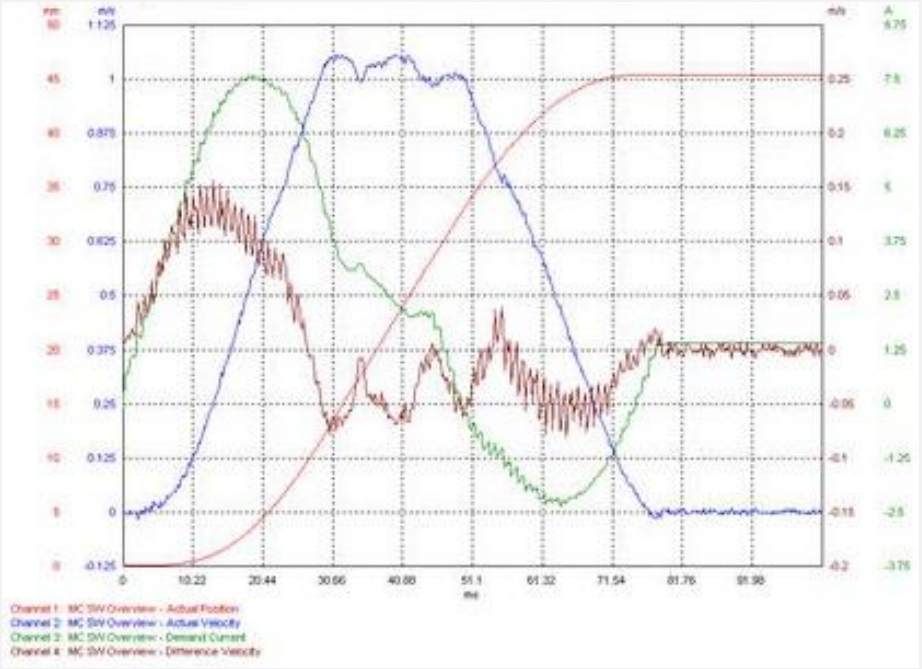
(Positive) Experience with Linear Motors

Dynamic parameters during the stroke

desired

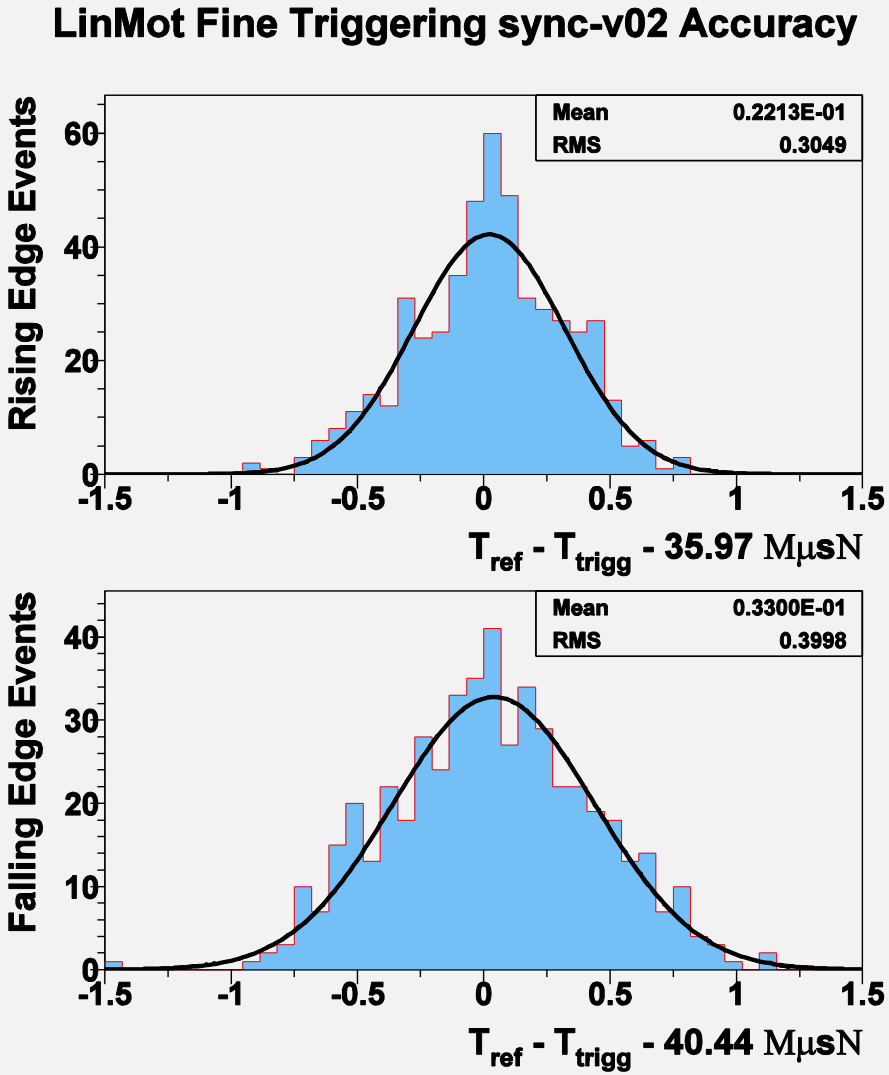


measured



(Positive) Experience with Linear Motors

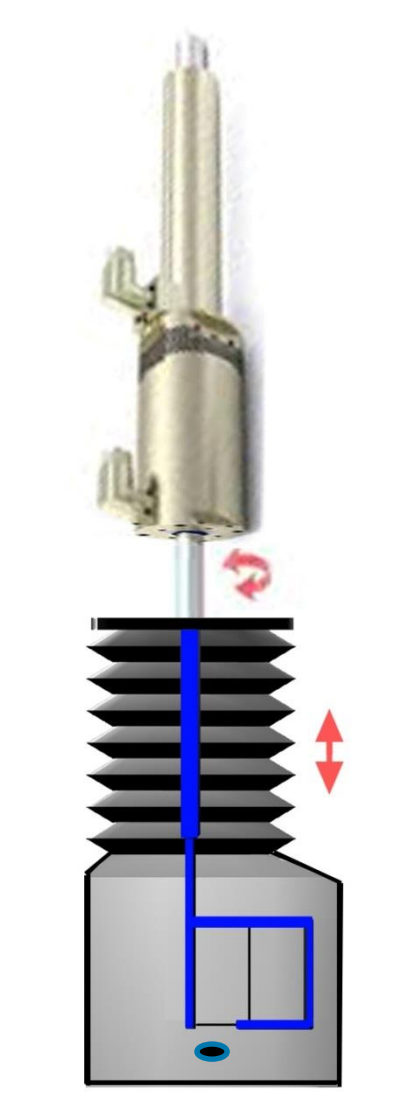
Triggered fast scan jittering magnitude



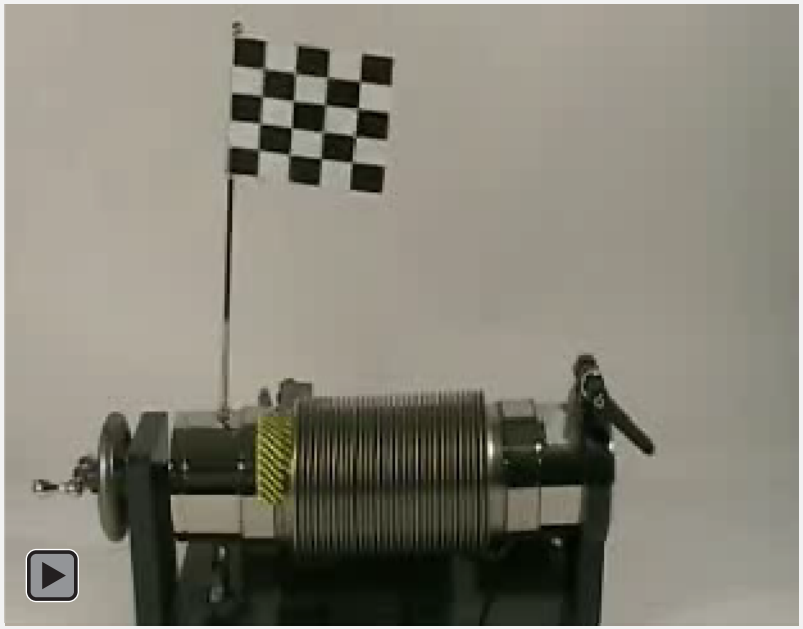
LinMot intrinsic accuracy
100μm by Hall sensor

with External optical sensor
1μm (Heidenhain)

Vacuum / Bellows



Torsional Bellows



http://www.youtube.com/watch?v=C3WTtMCU3lE

alternative: Wobble Bellows

DESY

Summary

- New type of “2 in 1” Wire-Scanner is proposed
- It combines translation and rotation for vertical and horizontal scans
- Fast triggered scans (1m/s) are possible in both directions (linear jitter < 1ms RMS)
- Linear-Rotary motors and software (drivers) are available commercially
- Combined translational & rotational (twisting) bellows need R&D