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CERN BE-BI-BL

- Specification
- Limitation of existing scanners
- Goals for new design
- Planning
- Personal

Specifications

Functional Specification

(EDMS n. 772786)

MEASUREMENT OF THE TRANSVERSE BEAM DISTRIBUTION IN THE LHC INJECTORS

Functional Specification

MEASUREMENT OF THE TRANSVERSE BEAM DISTRIBUTION IN THE LHC RINGS

EDMS Document No.

328147

Aim: Common basic layout of design for all CERN rings

5.1.3.1 PROFILE MONITOR FOR EMITTANCE COMPARISON AND CALIBRATION

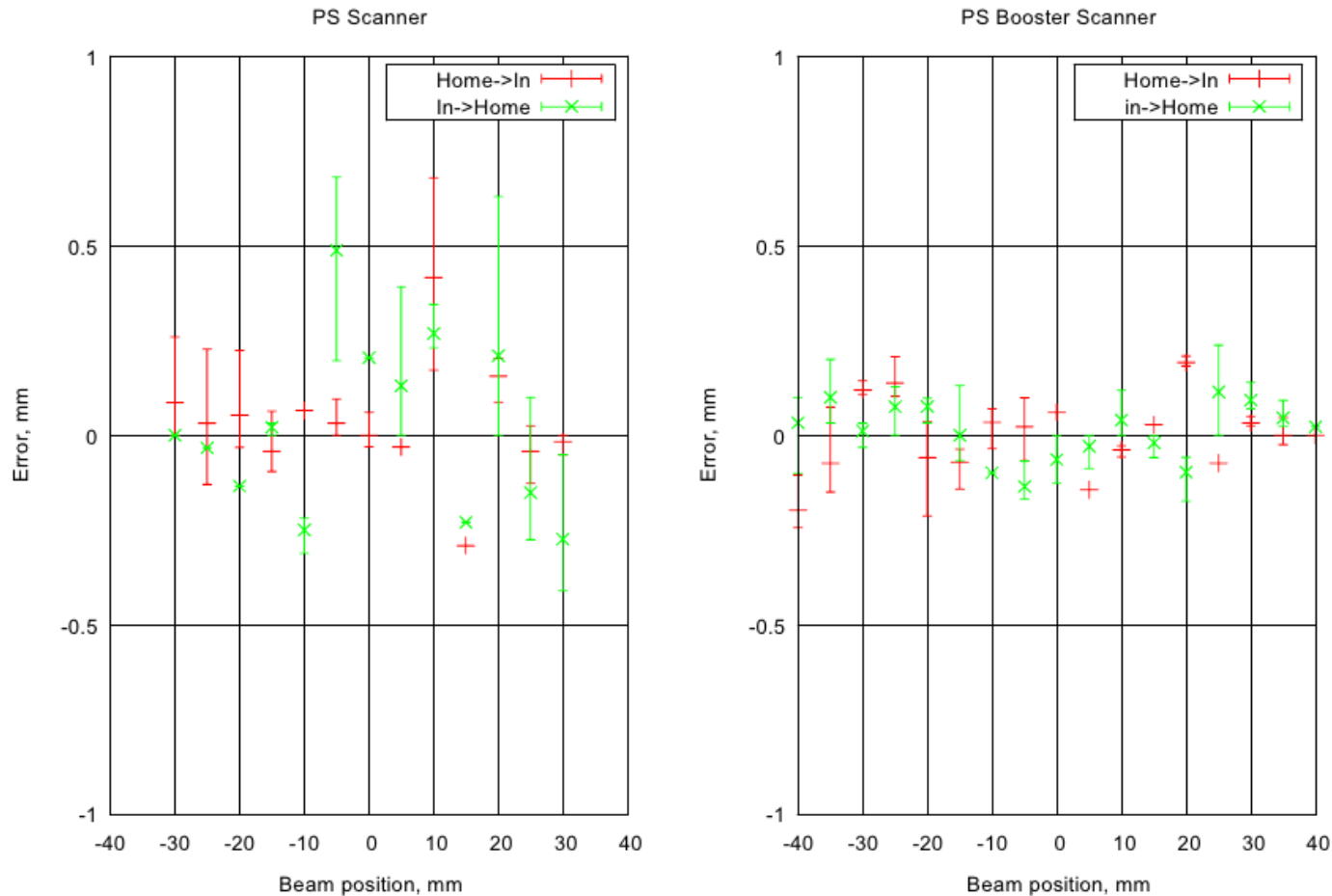
The main use of the circulating beam profile monitors is to provide accurate profile measurements to determine accurately the beam emittance for comparison purposes between different machines to detect possible blow-up during extraction and/or injection.

The required accuracy in the beam size measurement is of few percents if accuracies in the range of 5% have to be achieved for the emittance measurement as required for the LHC proton and ion beams with nominal intensity. This level of accuracy requires a very good measurement of the optics properties at the beam profile monitor which might demand the

Monitor type/mode		Beam scenario	Observation mode	Precision mode/value
Single-pass to Few-pass	Beam spot	1 pilot to 1 nominal SPS batch	Turn-by-turn	Accuracy: <ul style="list-style-type: none"> • 20% rms on σ • average position: $\approx 300 \mu\text{m rms}$
	matching	1 intermediate bunch to SPS batch	Turn-by-turn over 20 turns	Resolution: $\pm 20\%$ on σ
Intermediate to ultimate SPS batch				
Circulating	beam size and profile	Pilot to intermediate beam	10^3 turns	Resolution: 10% rms on beam σ
		intermediate to ultimate beam		Resolution: <ul style="list-style-type: none"> • 1% rms on beam σ • 5% rms on bunch σ • 10% rms on transv. distribution points • ($\pm \sigma/10$ in beam position)
		10^2 turns	Resolution: 5% rms on beam σ	
	Beam emittance		10^3 turns	Accuracy: $\pm 5\%$ on beam σ
	tail	intermediate to ultimate beam	10^4 turns	Resolution: 10% rms on transv. distribution points

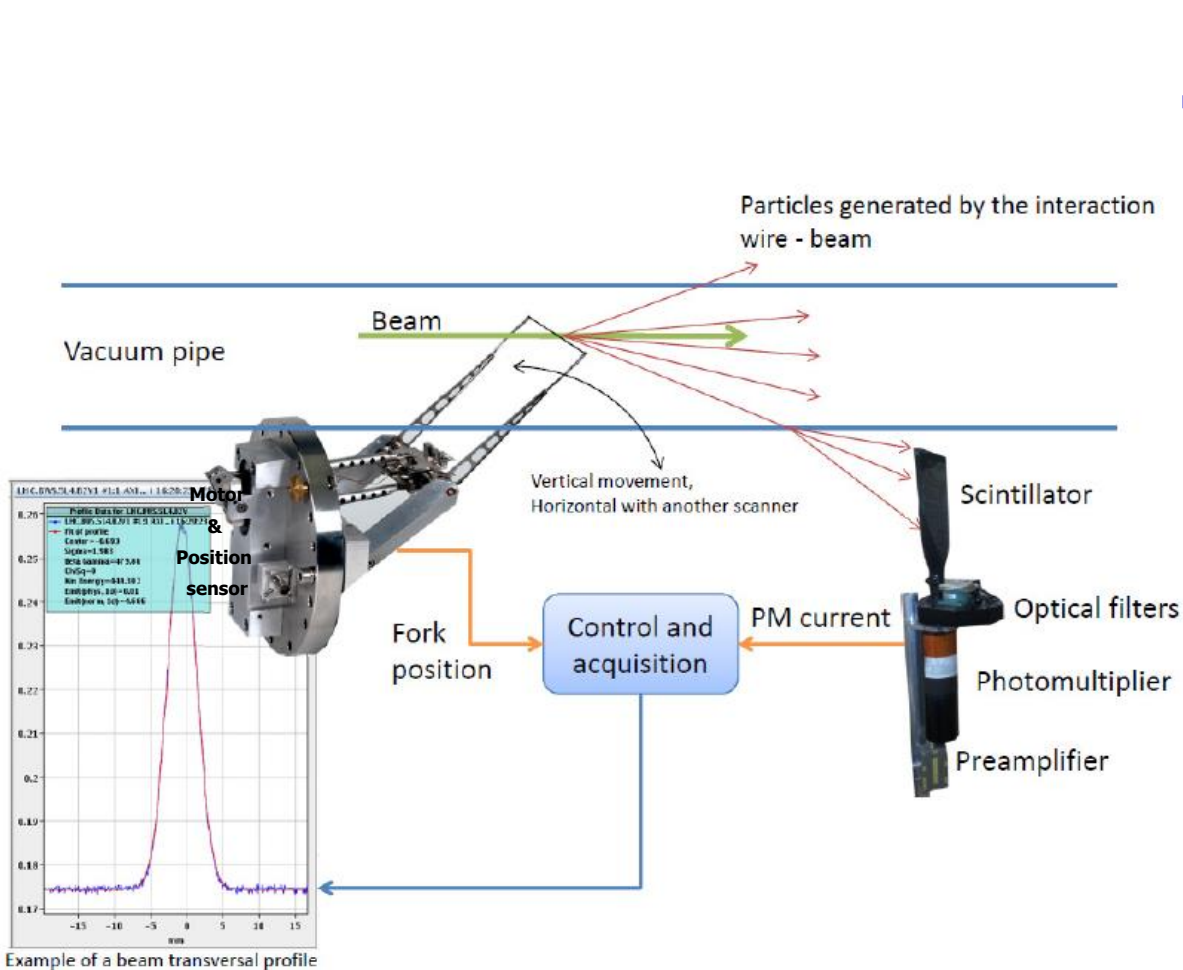
LASER beam reproducibility test measurements

Verification measurement accuracy after having introduced calibration data



- Fluctuation up to several 100 μm
- Fluctuation due to principle of scanner hardware

Limitations

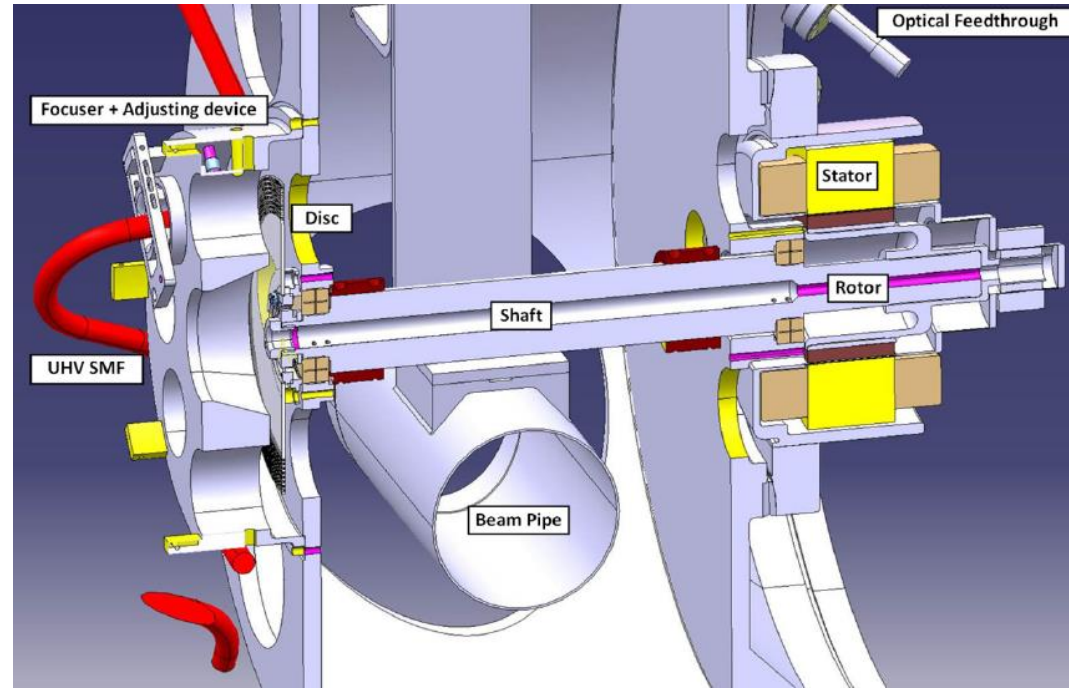
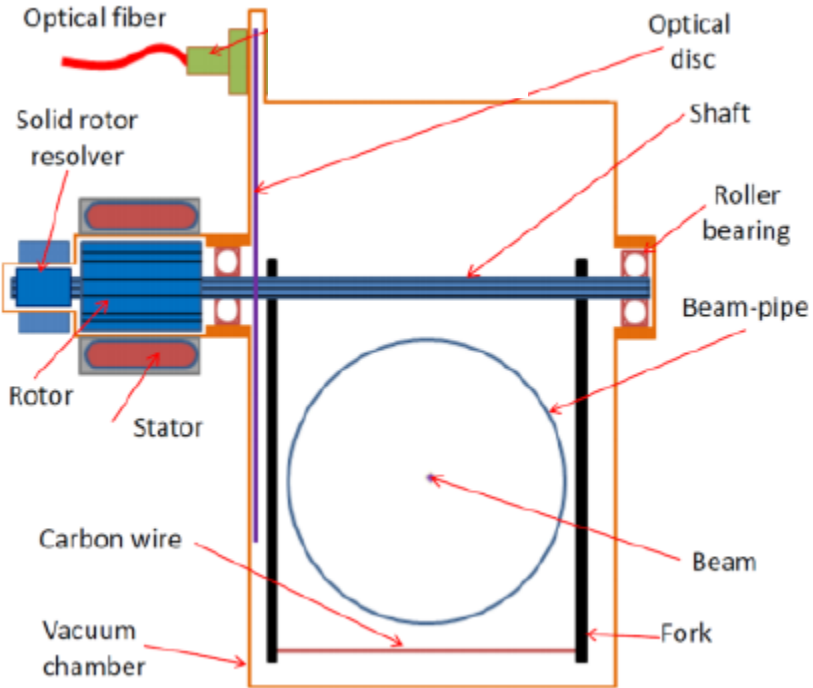


- Reproducibility much larger as required by specification
 - Beam size min LHC 130, PSB 2000 μm
 - Flexible design of wire fork
 - Deformation of fork are not measured
 - Angular position measurement outside of vacuum system
 - Lever arm play is not measured
- Speed regulation circuit
 - Analog feedback loop difficult to optimize
- Secondary particle acquisition system
 - Requires accurate adjustment of working range
 - Saturation effect of PM
 - Dynamic of working range small < 200
 - Tail measurement limited by noise
 - High intensity beams cause an increase of background signal
 - Dynamic of working range reduced
- Aging of bellows

Goals

- Scan at least as fast as the existing system (20 m/s needed to avoid wire damage)
=> Rotational system (power \sim inertia $\sim m * r^2$)
- Absolute accuracy of beam width determination of about 5 μ m
 - Reduction of play in mechanical system
=> all elements mounted on same axis
 - Position measurement
=> high accuracy angular position sensor
 - Overcome bellow limitations:
 - Low lifetime
 - Friction
=> Locate all moveable parts in the vacuum
 - Minimize fork and wire deformations
=> Study of dynamic behavior of fork/wire system
=> Vibration mode optimized acceleration profile
- Large dynamic range for secondary particle detection
=> Usage of sensor with large dynamic (diamond)
=> Automatic electronic switching of gain ranges (**range dynamic 1E4**)
- Increase MTBF compared with existing systems

Schematic and First Design



Planning

- Finished first mechanical design begin 2013
- Produce first prototype Q3 2013
- Produce second prototype Q1 2013
- Installation of second prototype in SPS before startup 2014 (cell 517)
- Commission system up to 2015/16
- Production of system for installation in 2018

People involved

- BE-BI-BL
 - Jose Sirvent Blasco (Master: past: optical angular position sensor, future: PhD on diamond acquisition electronics)
 - Bernd Dehning (scanner system)
 - Jonathan Emery (electronic system)
 - Juan Herranz Alvarez (PhD: accuracy of mechanical system)
 - Carlos Pereira (electronic designed)
- BE-BI-ML
 - Raymond Veness (mechanical system)
 - Sebastian Samuelsson (Master: mechanical design)
- EN-MME
 - Nicola Chritin (design office)

Calibration

- Table used to calculate projected position from measured angular position
- Calibration: Difference of LASER position and projected measured position by scanner results in correction table (error)
- After correction: repeat previous step to check correction

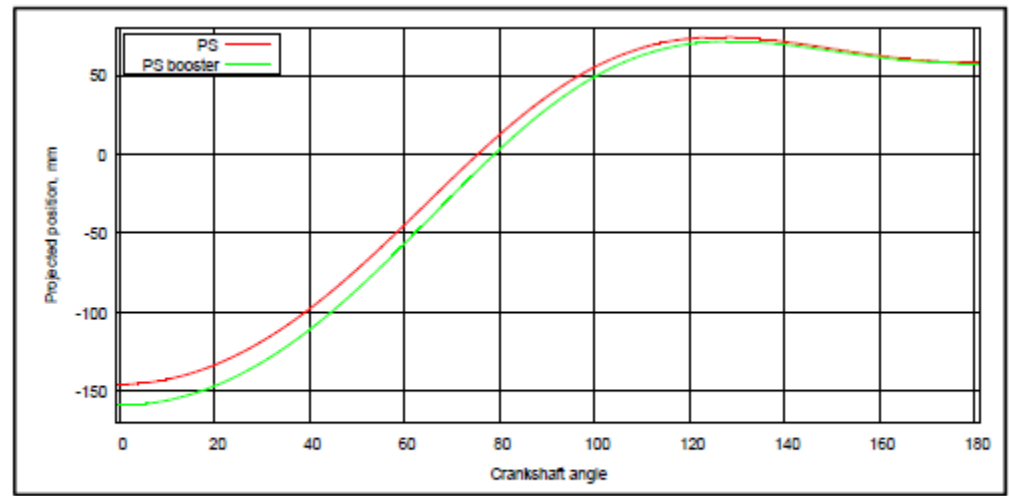


Figure 5: Lookup tables of theoretical projected positions.

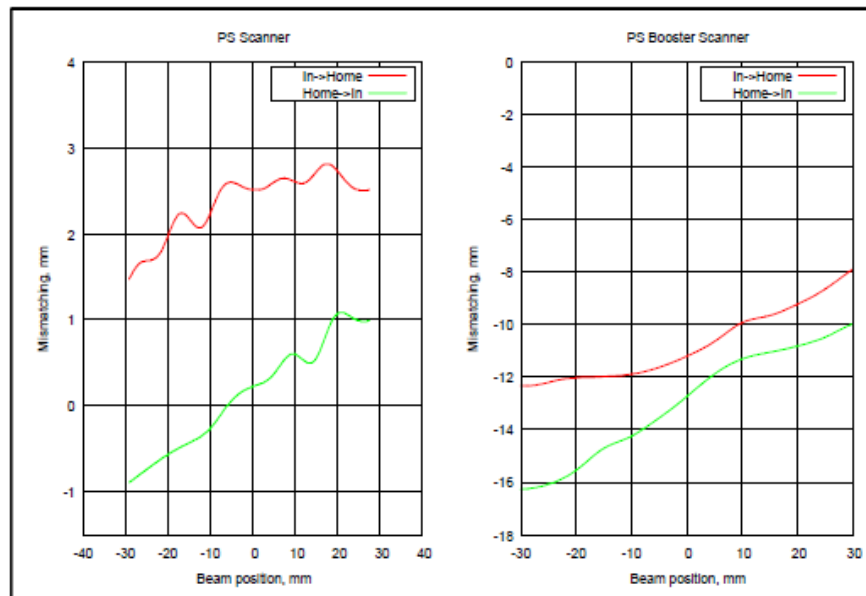


Figure 6: Mismatching between measured and theoretical projected positions of a scanner in PS domain and a scanner in PS booster domain. The wire speed is 15 m/s.

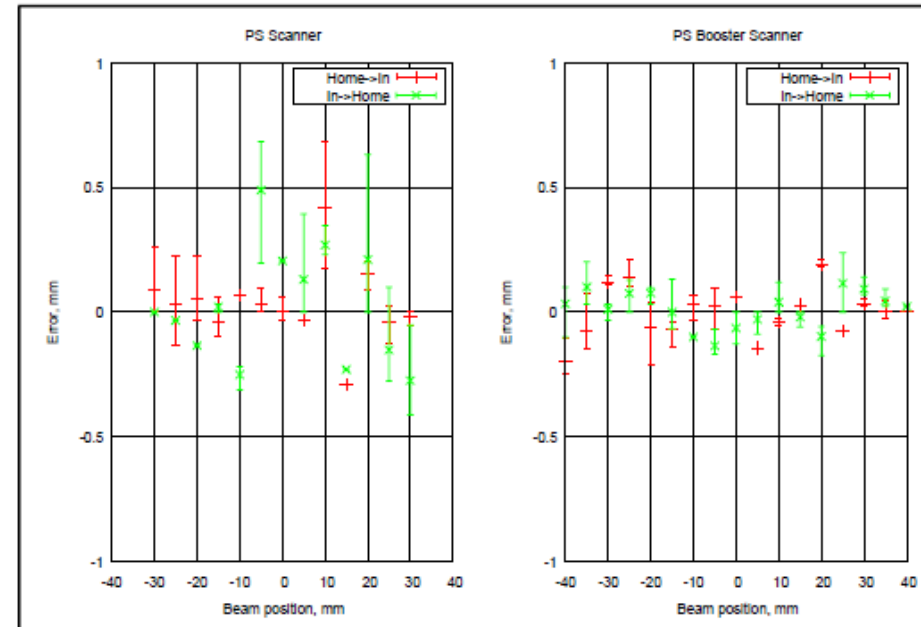
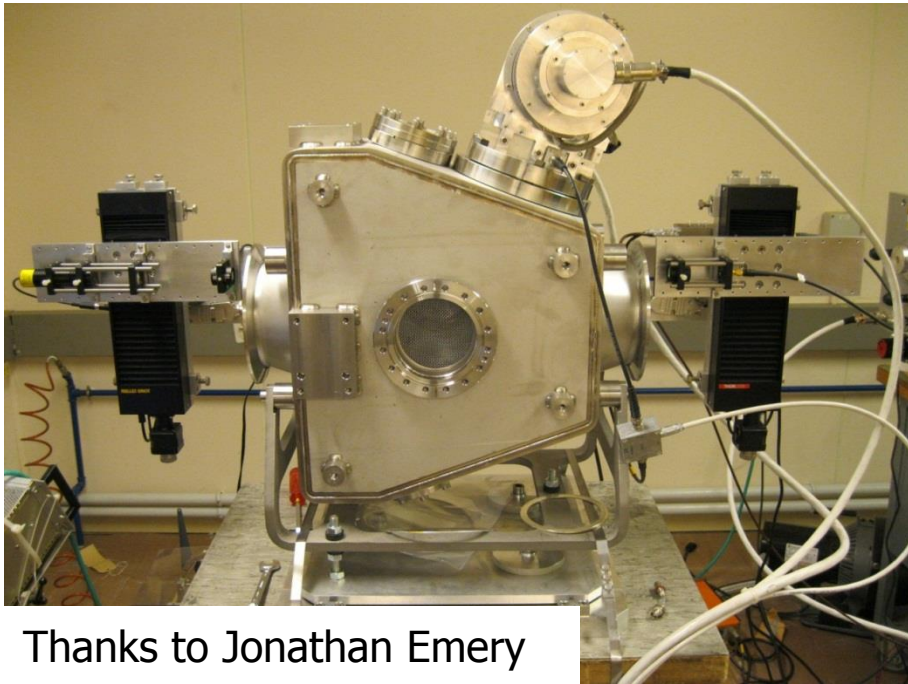
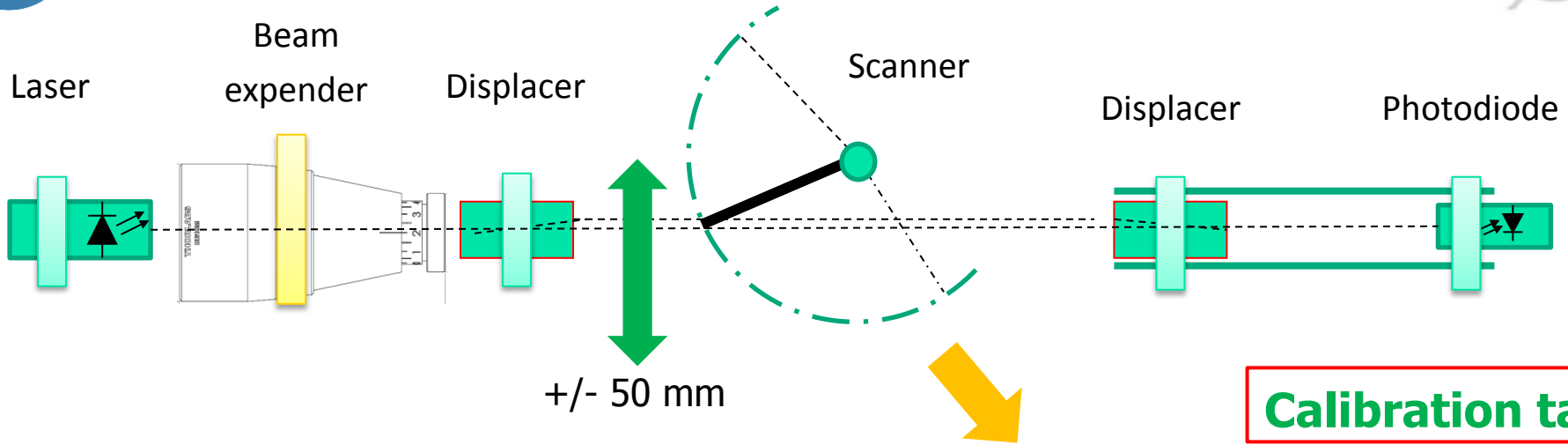


Figure 7: Check results of a scanner in PS domain and a scanner in PS booster domain. The wire speed is 15 m/s.



Thanks to Jonathan Emery

