# STRIPPING FOIL DISPLACEMENT UNIT CONTROL FOR H⁻ INJECTION IN PSB AT CERN

P. Van Trappen*, R. Noulibos, W.J.M Weterings, CERN, Geneva, Switzerland

* pieter.van.trappen@cern.ch

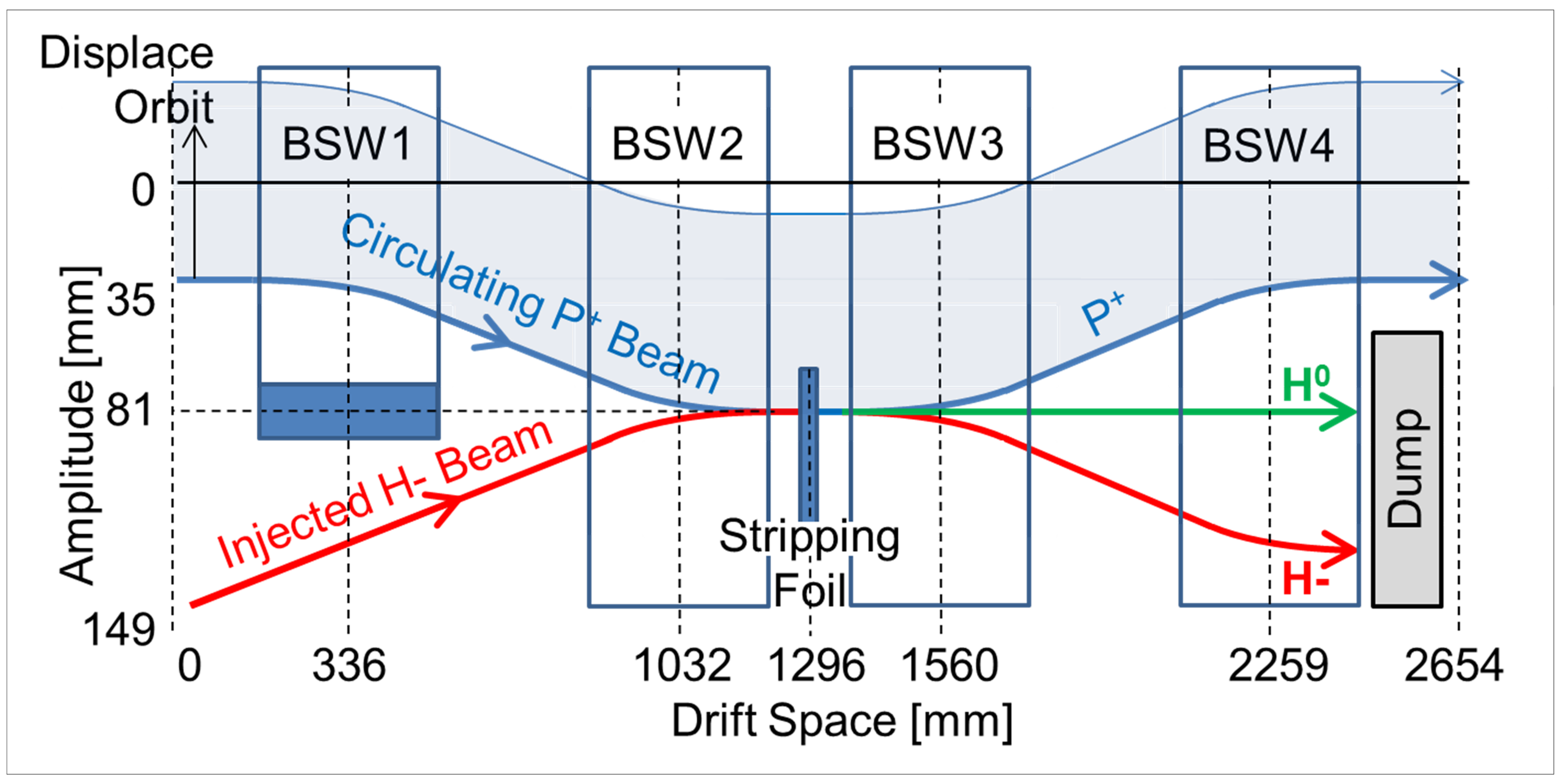
ICALEPCS 2015 International Conference on Accelerator & Large Experimental Physics Control Systems
17-23 OCTOBER 2015 MCEC MELBOURNE

## ABSTRACT

For CERN's Linac4 (L4) Proton Synchrotron Booster (PSB) injection scheme, slices of the 160 MeV $H^-$ beam will be distributed to the 4 superposed synchrotron rings of the PSB. The beam will then be injected horizontally into the PSB by means of an $H^-$ charge-exchange injection system using a graphite stripping foil to strip the electrons from the $H^-$ ions. The foil and its positioning mechanism will be housed under vacuum inside a stripping foil unit, containing a set of six foils that can be mechanically rotated into the beam aperture. The band with foils is controlled by a stepping motor while a resolver, micro-switches and a membrane potentiometer provide foil position feedback. The vicinity of the ionizing beam and vacuum requirements have constrained the selection of the above mentioned control system parts. The positioning and interlocking logic is implemented in an industrial Programmable Logic Controller (PLC). This poster presents the design of the stripping foil unit electronics and controls and presents the first results obtained from a test bench unit which will be installed in the Linac4 transfer line by the end of the year for foil tests with beam.

## PSB INJECTION SCHEME

1. A combination of bending, kicker and septum magnets will **distribute** the 160 MeV H- ions to the four superposed PSB synchrotron rings. The image below shows the injection region in a separate ring after distribution.
2. The beam will subsequently be **injected horizontally** into the PSB. The orbit of the circulating beam is horizontally displaced by four pulsed dipole magnets (BSW) to meet the incoming beam.
3. The injected beam will be **stripped** by a $H^-$ charge exchange injection system where the ions will be converted to protons. Partially stripped $H^-$ and unstripped ions will be directed to an internal dump.




*Linac4 to PSB injection scheme*

## CONTROL SYSTEM

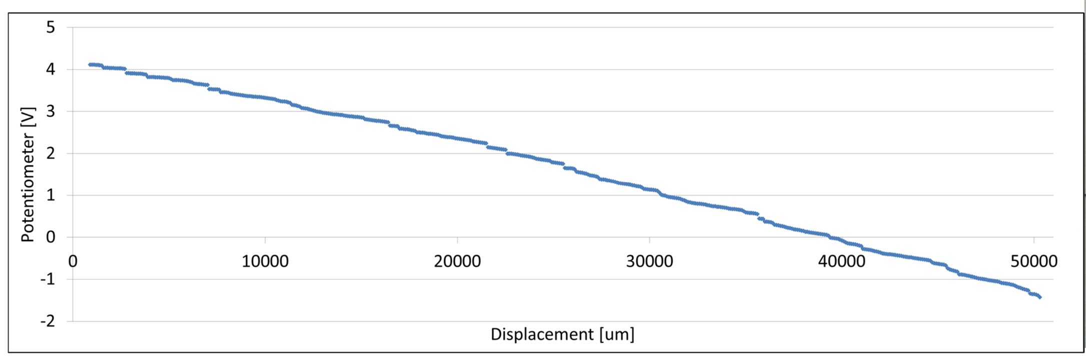
**Hardware**: Siemens 1515F CPU with decentralised IO over PROFINET (one crate for the CPU & HMI and one per stripping foil unit). A safety PLC was chosen for machine safety i.e. reducing machine downtime.

**Positioning algorithm:** Using the system's precise resolution (1 step = ~5 µm) a zero-point calibration occurs with every full band turn to avoid accumulative positioning errors. Two calibration methods can be used for full calibration redundancy: microswitch or potentiometer calibration.

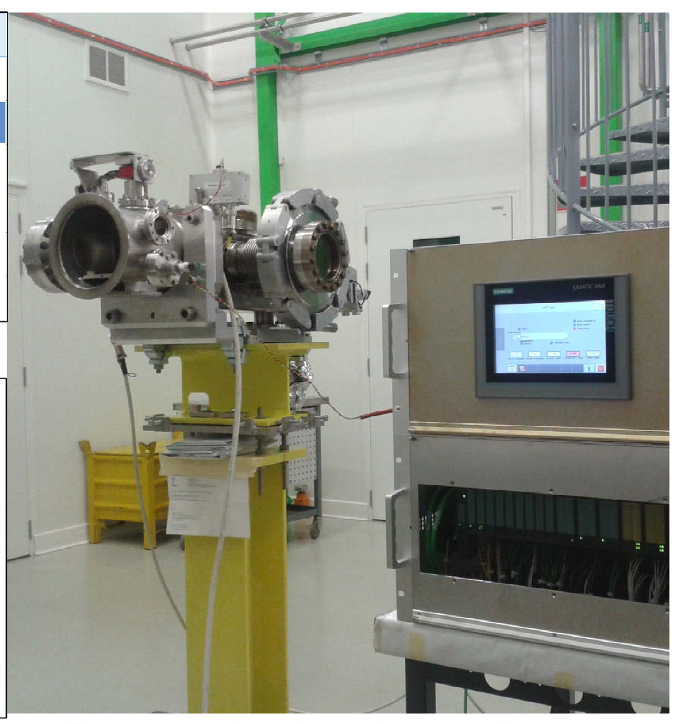
**Test results:** Data from test runs with more than 1k measurement points shows a calibration within the required precision but with positioning differences that are due to the feed-through's mechanical slack and probably band construction. Will be verified with a second unit and band.

| Row Labels [um] | Average of laserMeas [mm] | StdDev of laserMeas [mm] |
|---|---|---|
| 1000 | 2.683 | 0.021 |
| 45000 | 3.993 | 0.543 |
| 135000 | 3.952 | 0.398 |
| 227000 | 2.277 | 0.090 |
| 317000 | 2.393 | 0.324 |
| 405000 | 4.539 | 0.511 |

*Precision test run data results*



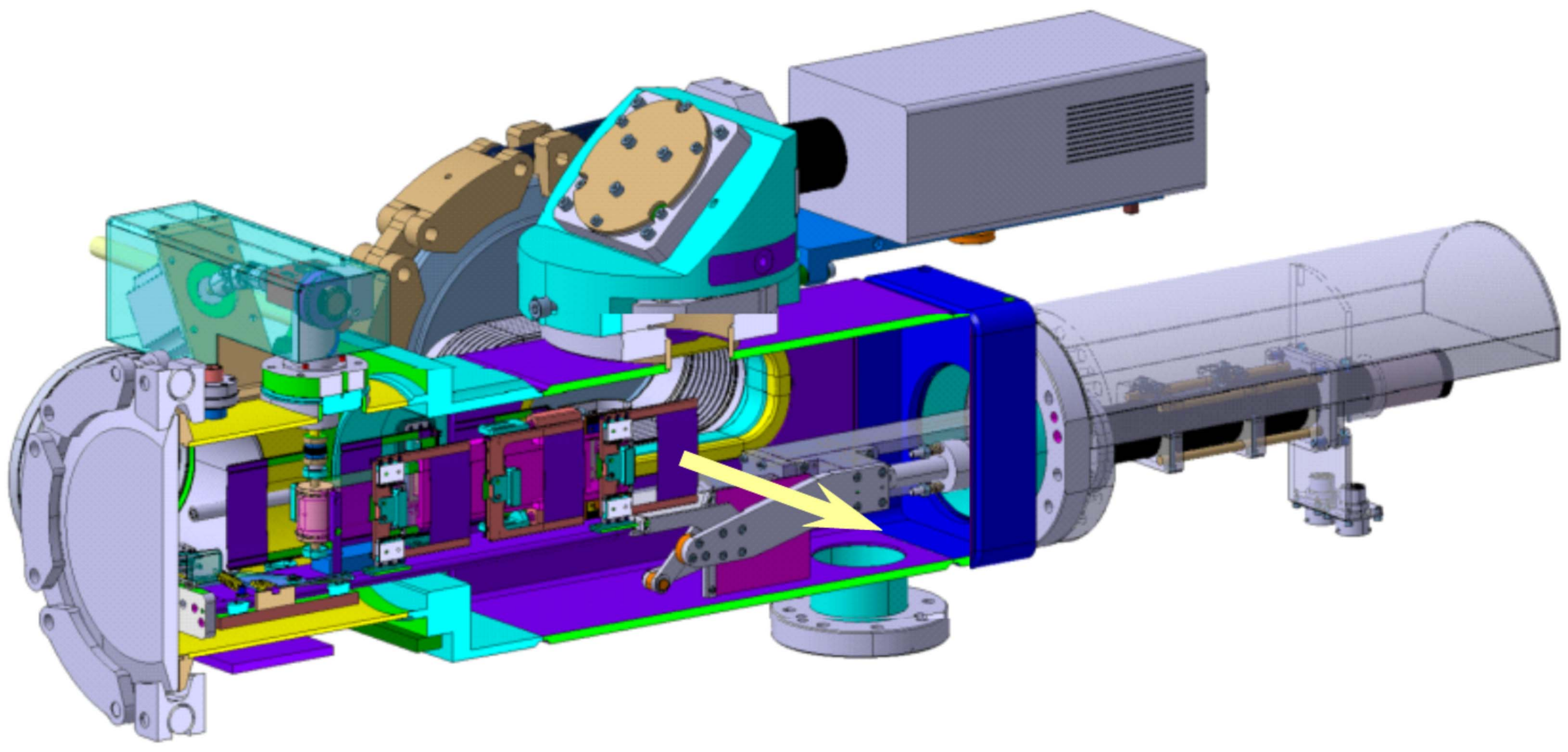

*Potentiometer linearity test run data results*



*Test-stand unit and control crates*

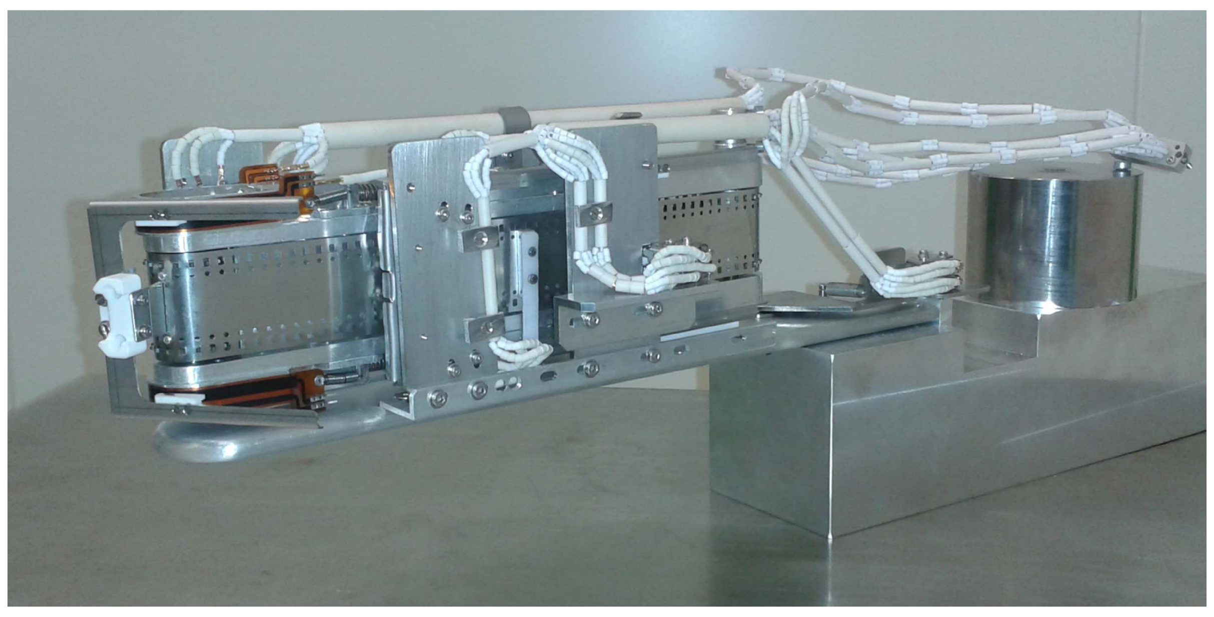
## FOIL INTERCHANGE MECHANISM (FIM)

The six carbon foils can be interchanged by rotating a band with a stepping motor using a closed resolver feedback loop. The rotating band and sensors are in a vacuum chamber with a mechanical axis feedthrough connecting the band to the motor.



*Cross section of the full design, showing the FIM in the vacuum chamber*

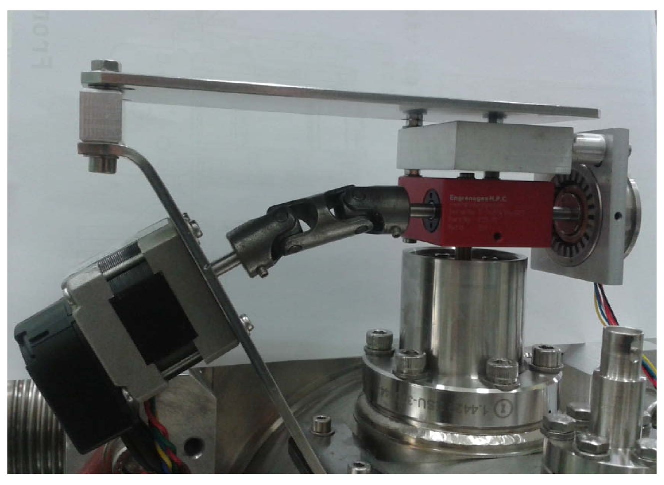
*Carbon stripping foil*



*Cabled mechanism, showing an empty frame*

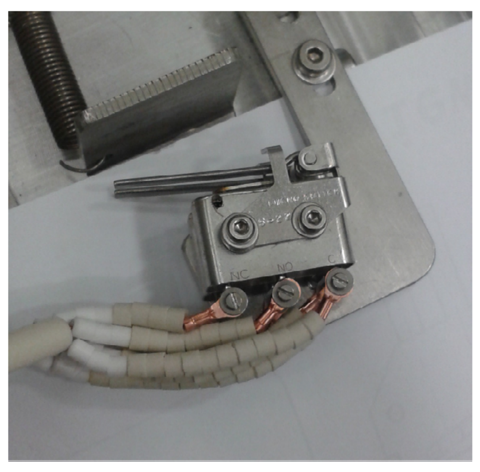
## COMPONENTS

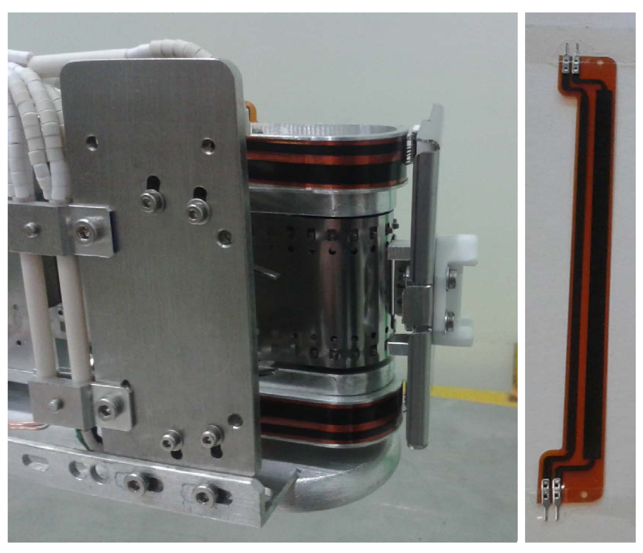
The choice of sensors and actuators is driven by obtaining the frame position with a 200 µm precision and furthermore deal with the stringent vacuum pressure and radiation dose constraints.



Stepping motor, 1:10 gearbox, resolver and mechanical feed-through outside of the vacuum chamber. A radiation hardened motor-resolver combo will be ordered for the first unit installation.

Honeywell 17HM6 microswitches installed for foil_in, foil_out and zero-point position indication. Chosen for low vacuum outgassing and switching precision. Successfully tested to calibrate the band with a precision < 50 µm.





Kapton® with conductive ink membrane potentiometer to follow the frame's rotation. Each frame has wipers that connect the resistive lane with the conducting lane. A absolute position can be deducted by measuring the voltage drop and counting the frames. Manufactured by Hoffmann+ Krippner for this application.