Velo Position Control System
MPP – 20/11/2020

EP-DT
Detector Technologies

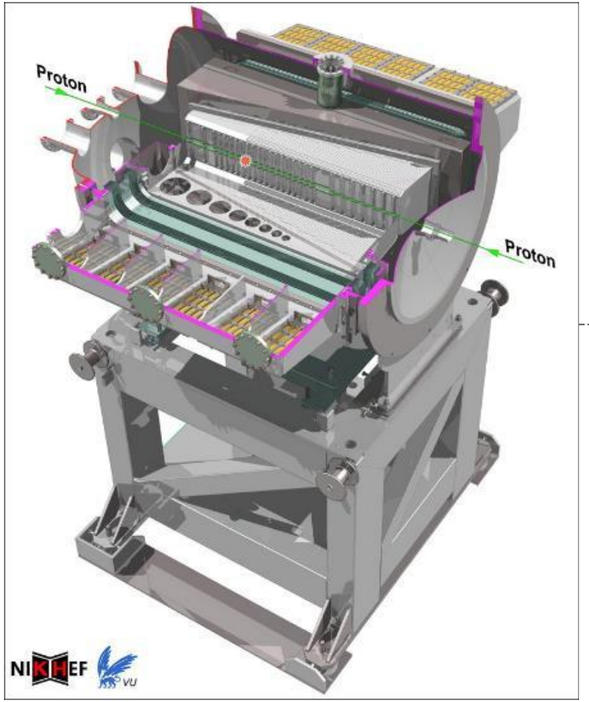
Xavier Pons EP-DT-DI

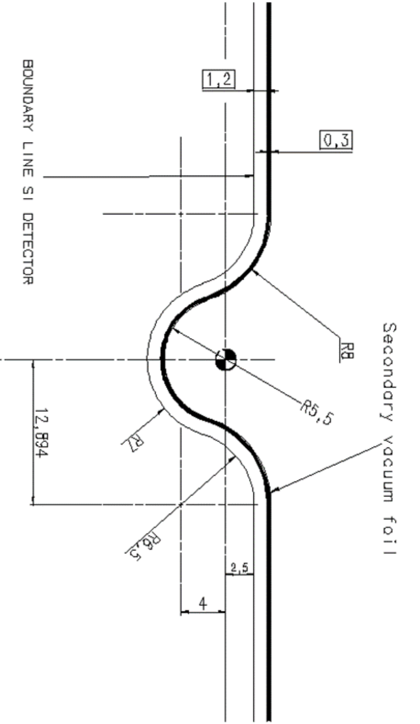
VELO Position Control System

Vacuum tank with 2 movable detector halves

Independent movement in horizontal plane (X)
Range -5..+30 (+5,-30) mm

Common movement in Y
Range -4.7..+4.7 mm





VELO Position Control System

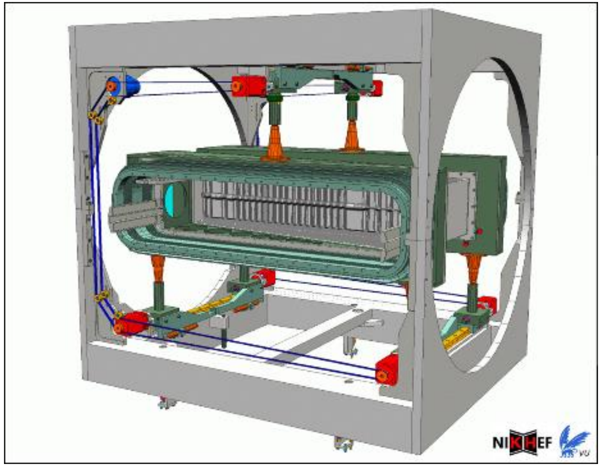
Three independent motion axes, with radiation hard stepper motor

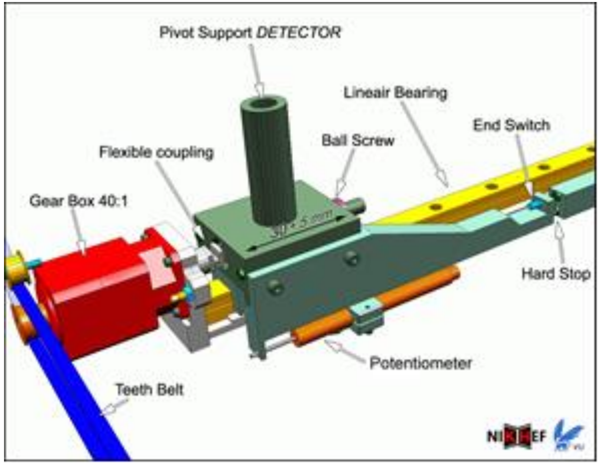
Horizontal XA (outer) and XC (Inner)

Vertical Y

Horizontals (XA, XC) are connected to a teeth belt that runs between the three gear boxes.

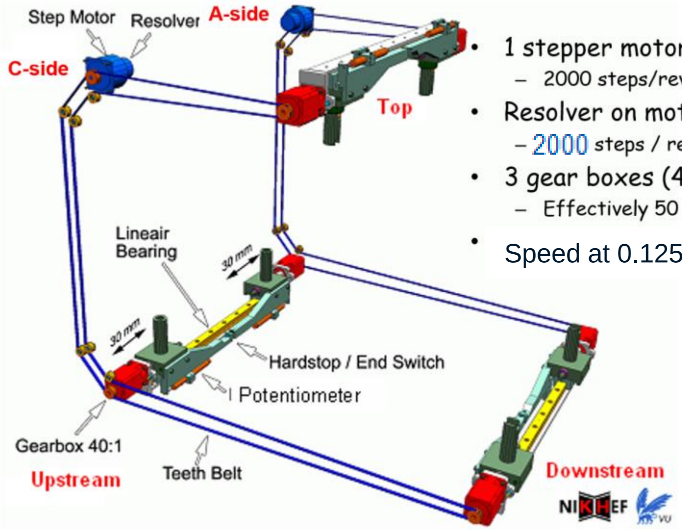
Vertical Y, the stepper motor is directly coupled to the frame.





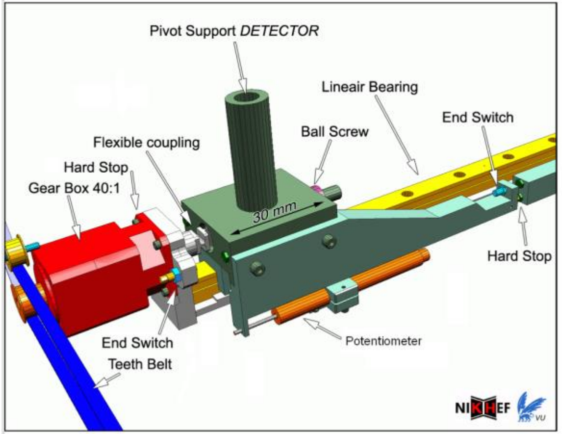
VELO Position Control System

Horizontal movement hardware



- 1 stepper motor / side
  - 2000 steps/revolution
- Resolver on motor axis
  - 2000 steps / revolution
- 3 gear boxes (40:1) on teeth belt
  - Effectively 50 um / revolution
- Speed at 0.125 mm/sec

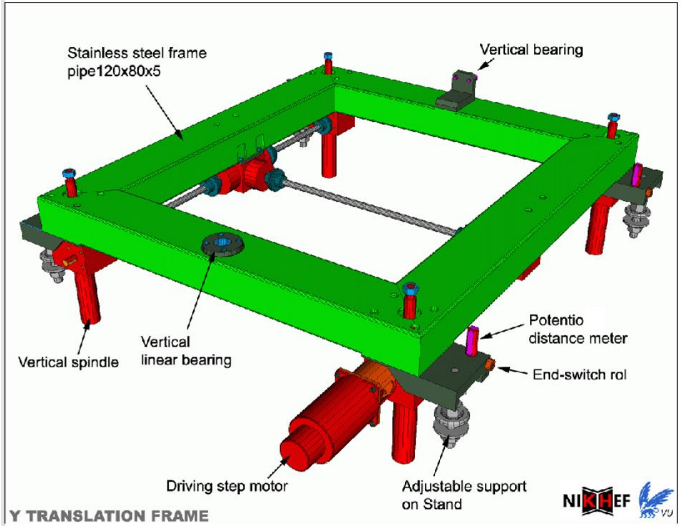
horizontal movement detail



- Switches at 'out' position
  - ~ 2 um accuracy
  - 1 per 'corner', 3 in total
  - 1 (of 3) used as position reference
    - 29.8 mm from x=0
  - 2 (of 3) are end-switches
    - 30.0 mm from x=0
- Switches at 'in' position
  - ~ 2um accuracy
  - No absolute position!, only distance between A and C-side
- **3 Potentiometers X Side**
- Potentiometer accuracy ~100 um

VELO Position Control System

Vertical movement hardware



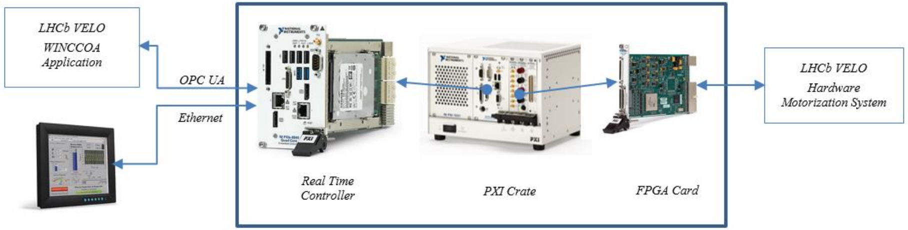
- 'translation frame'
- 1 stepper motor
  - 2000 steps/rev
- 1 resolver on motor axis
  - 2000 steps /rev
- Gearbox 1:16
  - Effectively 250um/rev
- Velocity **0.25 mm/sec**
- **4 Potentiometers**
- Accurate switch 'up' per corner
  - 1 position ref. (y=4.8 mm)
  - 3 end-switches (y=5.0 mm)
- normal microswitch 'down' per corner
  - 4 end-switches (y=-5.0 mm)

VELO Position Control System

The Motion control system will be based in the National Instruments PXI-FPGA. Commonly used at CERN for the TOTEM, ALFA and AFP Roman Pot Position Control System developed by DT-DI and LHC collimators.
The system will consists:

- 1 chassis NI PXIe-1082
- 1 NI PXIe-8840 Real Time controller
- 2 PXIe-7861 FPGA Kintex-7 reconfigurable I/O

- One PXIe-7861 FPGA performs the motion control for XR and XL movements
- Second FPGA controls the Y movement



New LHCb Velo Control System

National Instruments PXIe-1082 PXI Chassis

National Instruments PXIe-8840 Quad-Core, LabVIEW RT

National Instruments PXIe-7861 FPGA Reconfigurable I/O

XR & XL

National Instruments PXIe-7861 FPGA Reconfigurable I/O

Y

VELO Position Control System

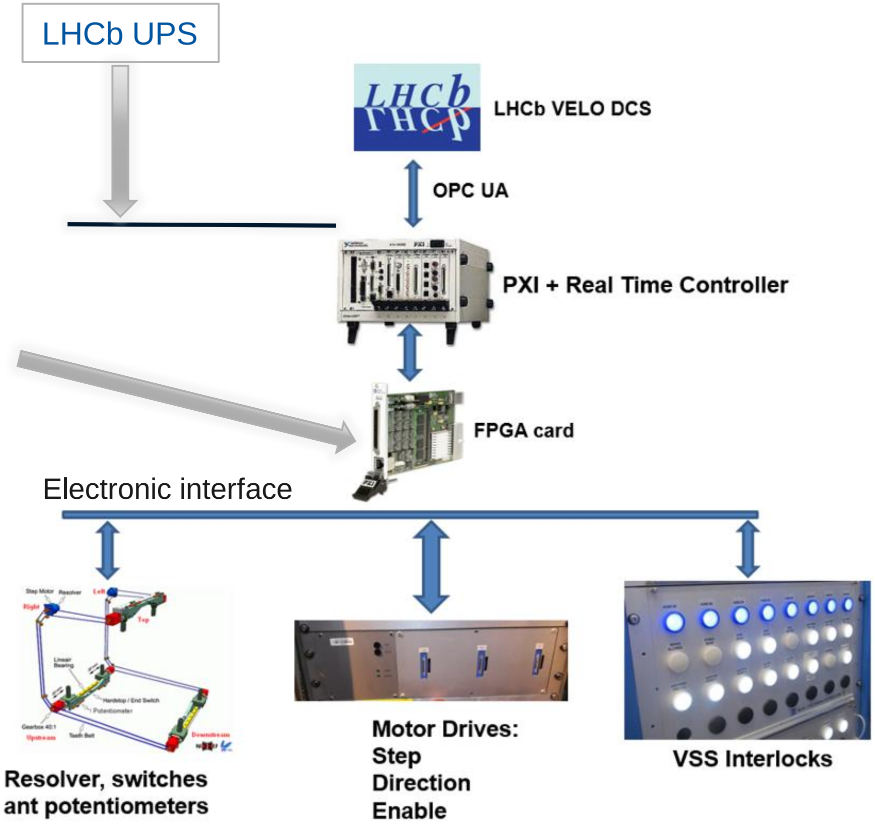
Major change in the control system hardware

- The resolver position calculation.
- The motor STEP, DIRECTION, ENABLE signal of the motor drives also generated at the FPGA level directly.
- The Potentiometer signals
- Microswitches logic
- Interlocks processed at the FPGA LEVEL.

  In 1 msec loop

Real time Controller.

- Performs the communication with the VELO WINCC OA DCS by means of OPC UA server programmed in the PXI-Controller.



Velo Position Control System Upgrade Layout

VELO Position Control System

A set of electronic interface circuit have been implemented in order to translate the physical signal to the FPGA levels ad connectors

It consist:

1 PCB – connector adapter-FPGA signal distribution

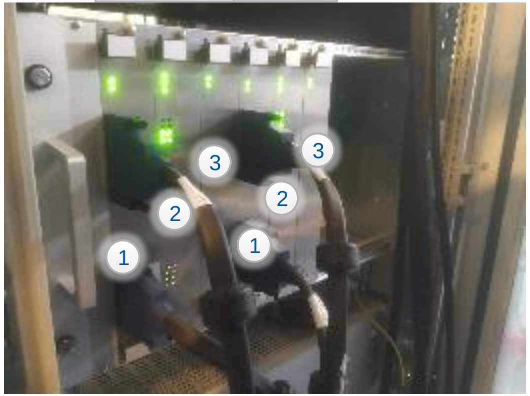
1 PCB – Digital interface: motor control signals, switches,…

1 PCB – Analogue interface: Resolver, potentiometers

The signals are distributed in the rear side backplane PCB

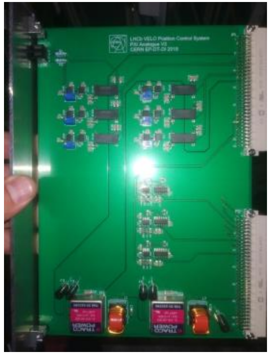
The interface circuits reproduce the same circuits developed by NIKHEF in the previous motion control

XL&XR FPGA | Y FPGA



1-Signal Distribution

2 – Digital interface



3 – Analogue interface

VELO Motion System – CIBU Interlock Layout

- The VELO motion interlock signals are exchanged with the VSS
- The CIBU interlocks signals are processed by the Velo Safety System VSS

VELO Motion & Safety System Interlocks

- From VELO VSS Safety Matrix EDMS 2051570

1. VELO_IN_ALLOWED ==

   Stable Beam Flag SSB **AND**

   VELO_OUT_NO_EMERGENCY AND

   DSS_NO_EMERGENCY

2. BEAM_INJECTION_PERMIT ==

   C_SIDE_OPEN AND

   A_SIDE_OPEN

3. BEAM_A/B_PERMIT ==

   BCM_OK AND

   (SSB | (C_SIDE_OPEN AND A_SIDE_OPEN) AND

   A/C_RFOIL_TEMP_X_NOT_HIGH

VELO Position Control - Failure Case

Failure case of one component of the Motion Control hardware:

- Microswitches
  - 1st Request intervention, try to repair
  - 2nd Override by software

- Potentiometers
  - 1st Disable by software
  - 2nd Repair when access

- Stepper Motor-Resolver
  - (Freek's presentation)

- Motor power drives, Electronic interface, NI PXI-FPGA
  - 1st Request intervention and replace the failing component
  - 2nd Move the VELO to OUT position to allow the BEAM_PERMIT

VELO Motion - Status

- The VELO Motion System has been successfully installed, tested and hardware commissioned on June with a local control software from the PXI

Pending:

  - To implement the control from DCS detector with the advanced movement procedures

  - To implement hardware/software interlocks between Motion and VSS

Backup

VELO Motion - Failure Case → “Holiday Mode”

Implemented in the Roman Pots position control

It allows VSS providing the BEAM_PERMIT with disabled Motion Control

The disabling is made by a key-switch that removes the power of the motor drives.

The operation consist:

1- Move VELO to OUT (or safe) position

2- Turn on the key-switch (remove motor power)

3- VSS knows that VELO is OUT position (copy signal of microswitches)

4- The key of the key-switch is stored at the CCC-Control room