
# Velo Position Control & Velo Safety System Implementation


EP-DT
Detector Technologies

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# INTRODUCTION

- EP-DT-DI is committed to upgrading the Velo Position Control and implementing the new Velo Safety System by two Workpackages between DT-DI and the VELO collaboration.

- DT-DI accepted upgrading the VELO Position Control System used on LHC Run 1 and Run 2 developed by Nikehf due to the similarities and compatibilities with the Roman Pots Position Control System and consequently similar to Collimators Position Control System (EN-SMM).

# OUTLINE

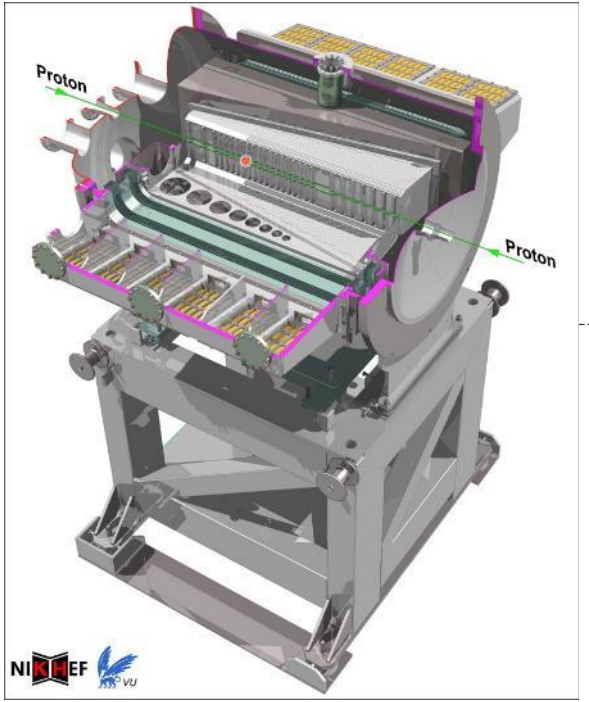
- Nikehf VELO Position Control System . → Velo Position Control System Upgrade Implementation
- New VELO Safety System Implementation.

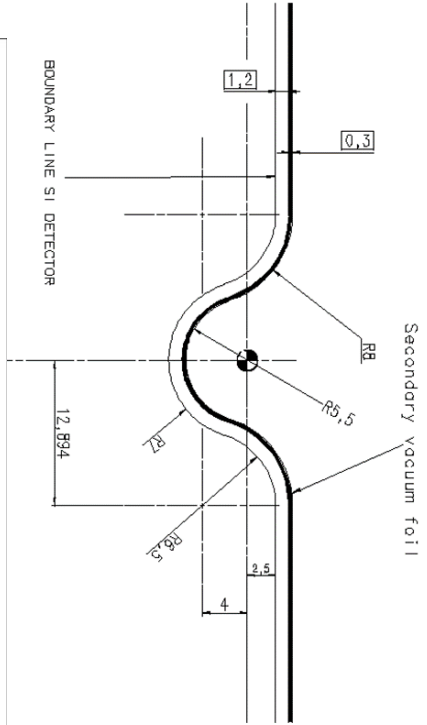
# NIKHEF VELO Position Control System

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



# NIKHEF VELO Position Control System

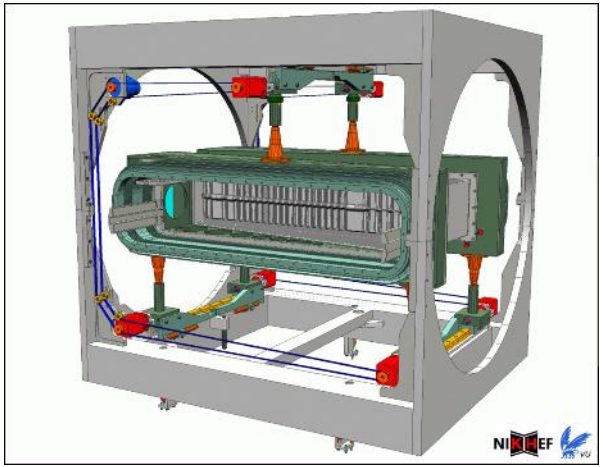
Three independent motion axes, with radiation hard motor

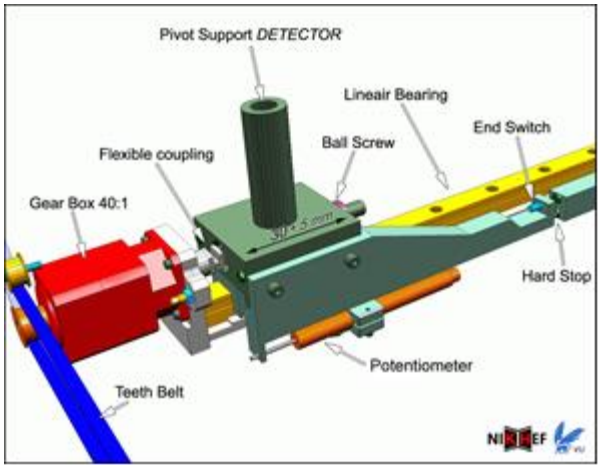
- Horitzontal XA (outer) and XC (Inner)
- Vertical Y

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

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

The components include linear bearings, end switches, hard stop, gear boxes, potentiometers,… all radiation hard





# NIKHEF VELO Position Control System

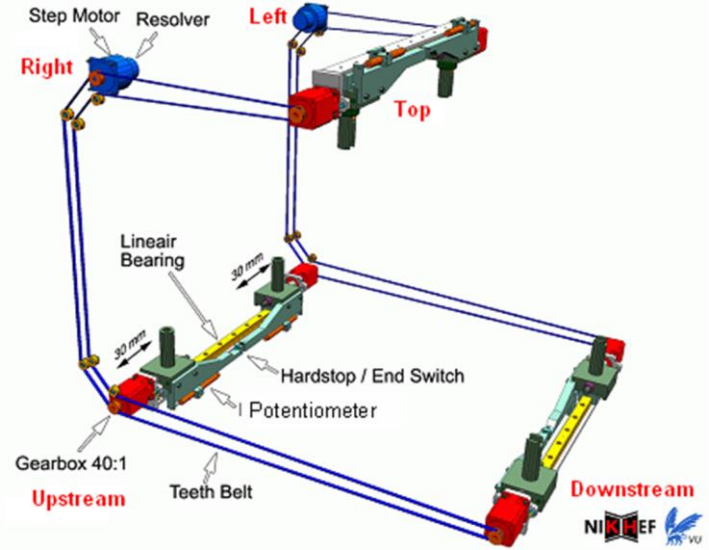
## Instrumentation Components

**Actuator** – Radiation hard Stepper motor Empire Magnetics

**Linear Position Sensor** – Potentiometer Maurey

**Angular Position Sensor** – Precision resolver Empire Magnetics. (High accuracy)

**Absolute Position Sensor** – Precise Baumer Microswitches




Same layout as the Roman Pots Position Control System, just replacing the potentiometer by LVDT's and the Roman Pot are spring retracted to the HOME position in case of motor OFF

- 1 stepper motor / side =>2000 steps/revolution
- Resolver on motor axis=>1024 steps / revolution
- 3 gear boxes (40:1) on teeth belt
- Effectively 50 um / revolution
- Velocity 0.2 mm/sec

# NIKHEF VELO Position Control System

The control is performed in a dedicated rack by a Siemens S7-300 PLC which includes a set of custom interfaces between field and the PLC.

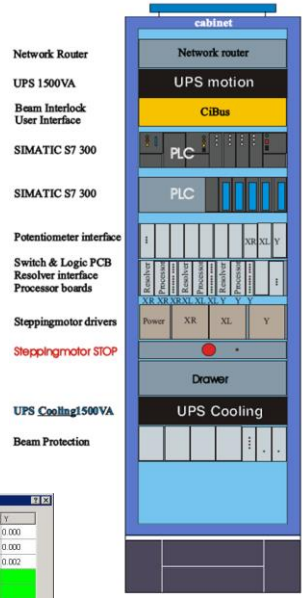
The PLC is connected by an Ethernet connection to LHCb-VELO WINCC DCS application for supervision and operation.

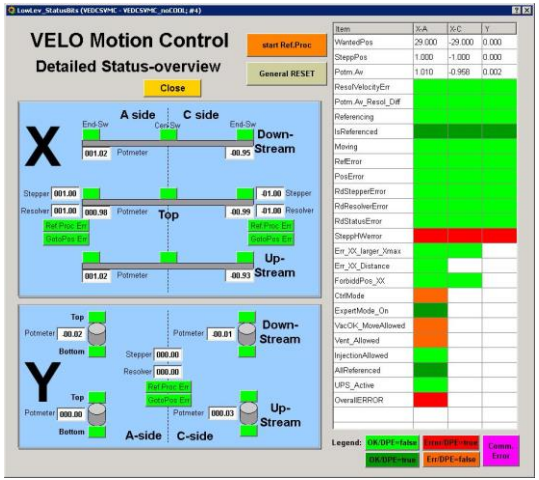
Safety Interlocks are triggered by PLC DO

Includes a crate with the stepper motor drive from STOEGRA

The rack includes the Beam Interlock Interface CIBU

The Rack is sunder UPS power



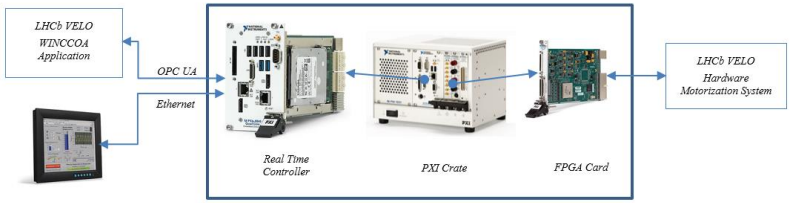
# VELO POSITION CONTROL SYSTEM UPGRADE

The Position Control System developed by Nikhef has been successfully operated since the operation of the LHC. It doesn't make sense to make changes in the hardware layout.

Basically the upgrade will consist only in the replacement of the Siemens S7-300 PLC by National Instruments PXI-FPGA. Commonly used at CERN for the TOTEM, ALFA and AFP Roman Pot Position Control System developed by DT-DI

Several lab integration tests have been performed in order check the compatibility of the current hardware components: motor drive, resolver, potentiometer and switches with the PXI-FPGA control system and the developed software.

The upgrade doesn't includes the hardware sensors/actuators replacement




New LHCb Velo Control System

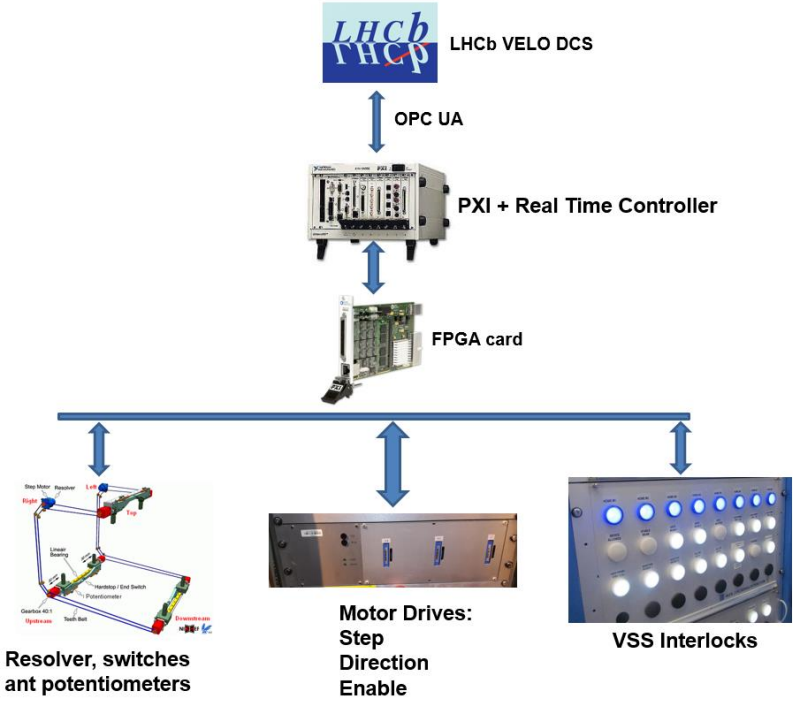
Velo Detector

# VELO POSITION CONTROL SYSTEM UPGRADE

Major Changes.

- The resolver position will be integrated an calculated directly at the FPGA level.
- The STEP, DIRECTION, ENABLE signal of the motor drives also generated at the FPGA level directly.
- The Potentiometer and Microswitches interface still needed.
- Communication with the VELO DCS straightforward with OPC UA server integrated in the PXI-Controller.
- Interlock Signals including the ones to the CIBU connected to VSS
- The CIBU will be removed from the Position Control Rack and it will be installed in the VSS rack.

- THE MOVEMENT LOGIC, INTERLOCKS,… REMAINS THE UNCHANGED. It's well documented by Nikhef.

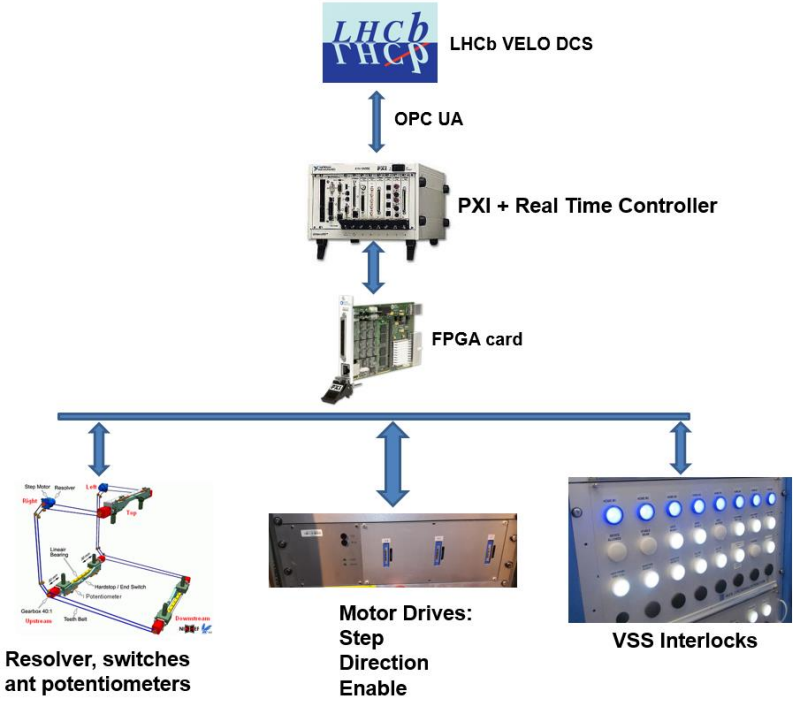



Velo Position Control System Upgrade Layout

# VELO POSITION CONTROL SYSTEM UPGRADE

Planning.

- February 2019, procurement
- March 2019, installation and commissioning
- April 2019, test and commissioning
- End of VELO LS2, replace the hardware components by new ones if needed test and recommissioning




Velo Position Control System Upgrade Layout

# Velo Safety System Implementation

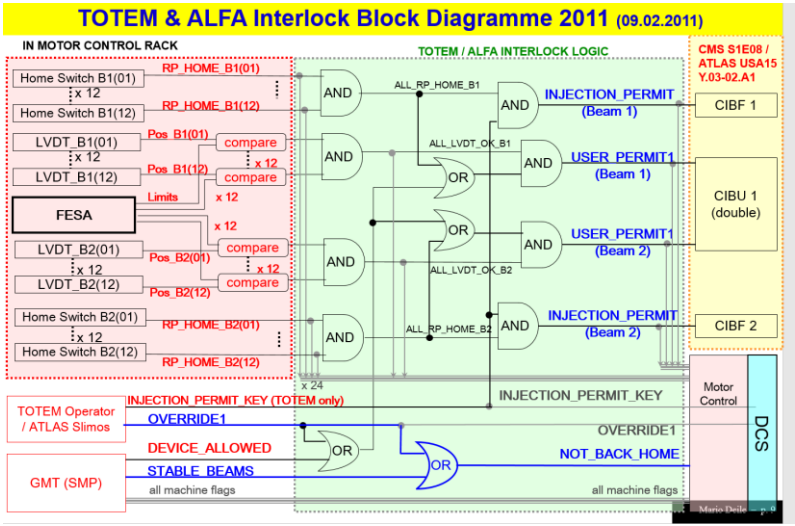
# VELO SAFETY SYSTEM IMPLEMENTATION

Again, comparing with the Roman Pot Position Control Systems; the VSS is equivalent to the existing system called INTERLOCK BOX.

The technology used for those system is based on FPGA:

- Custom EP-ESE development for TOTEM
- National Instrument Compact RIO-FPGA technology for ALFA and AFP Roman Pots

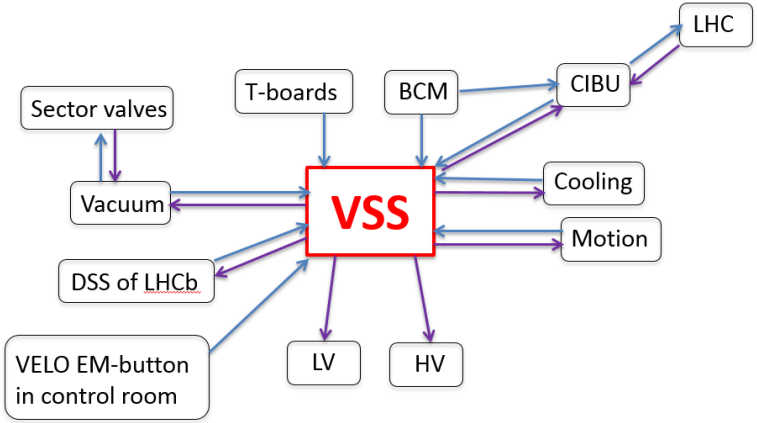
Also this system are similar to Magnet Safety System developed by DT-DI of the LHC Experimental Magnet Protection, based also in FPGA technology from National Instruments.



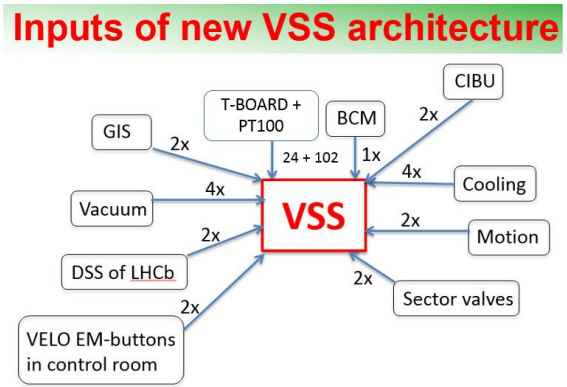
# VELO SAFETY SYSTEM IMPLEMENTATION

The VELO Safety System must include all the conditions and equations generated from the detector subsystem, assuring and keeping the LHC beam and the detector always in safe state.

The complexity of the VSS is determined by the large number different detector subsystems involved in the conditions and in particular the considerable number of temperature sensors




LHCb VELO VSS LAYOUT

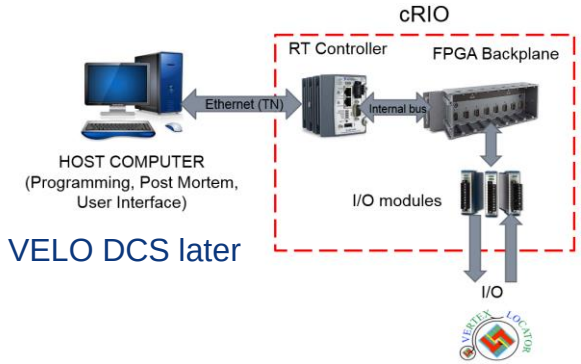


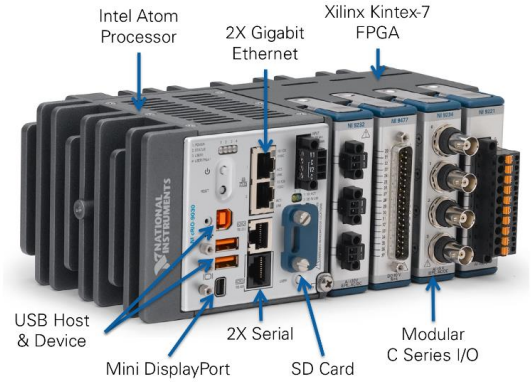
# VELO SAFETY SYSTEM IMPLEMENTATION

The proposed solution VSS will be based in the National instruments Compact Rio FPGA Technology;

Which is made of several components:

- VELO instrumentation connected to the I/O interface modules (DI, DO, AI, AO, PT100, others)
- FPGA containing the safety matrix and where I/O modules are plugged, programmed with LabView FPGA.
- RT Controller, basically a PC running with Real Time Labview OS, for advanced programming functions
- VELO WINCC DCS connected to the Ethernet port with OPC UA server. (Also LabView Programming PC)



# VELO SAFETY SYSTEM IMPLEMENTATION

Implementation of the 102 PT100 sensors. Integration in the Compact Rio


By using 2 Expansion NI-9144 modules

- High-performance deterministic (Real Time) distributed I/O over EtherCAT
- Interlocks Hardware distributed
- Modular slave with 8 slots for C Series I/O modules
- Integrated 2M gate FPGA for custom timing, inline processing, and closed-loop control
- 2 Ethernet ports for daisy chaining additional EtherCAT slaves

http://www.ni.com/white-paper/7299/en/#toc1

# VELO SAFETY SYSTEM IMPLEMENTATION

## VSS Rack

The VSS System will be installed in a single rack D3E01 at Point.

The Rack will be powered 220 Vac from UPS source from LHCb.

The CIBU crate will be moved from Position Control Rack to VSS rack


Totem Position Control Racks

# VELO POSITION CONTROL SYSTEM UPGRADE

Planning.

- 2019, Collecting information, mapping
- 2019, Rack design Procurement
- 2019-2020 Logic implementation. MPP review
- 2020 Commissioning