LHC Machine Protection System Review

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with input from R. Assmann and R. Losito

Ensuring required collimator settings

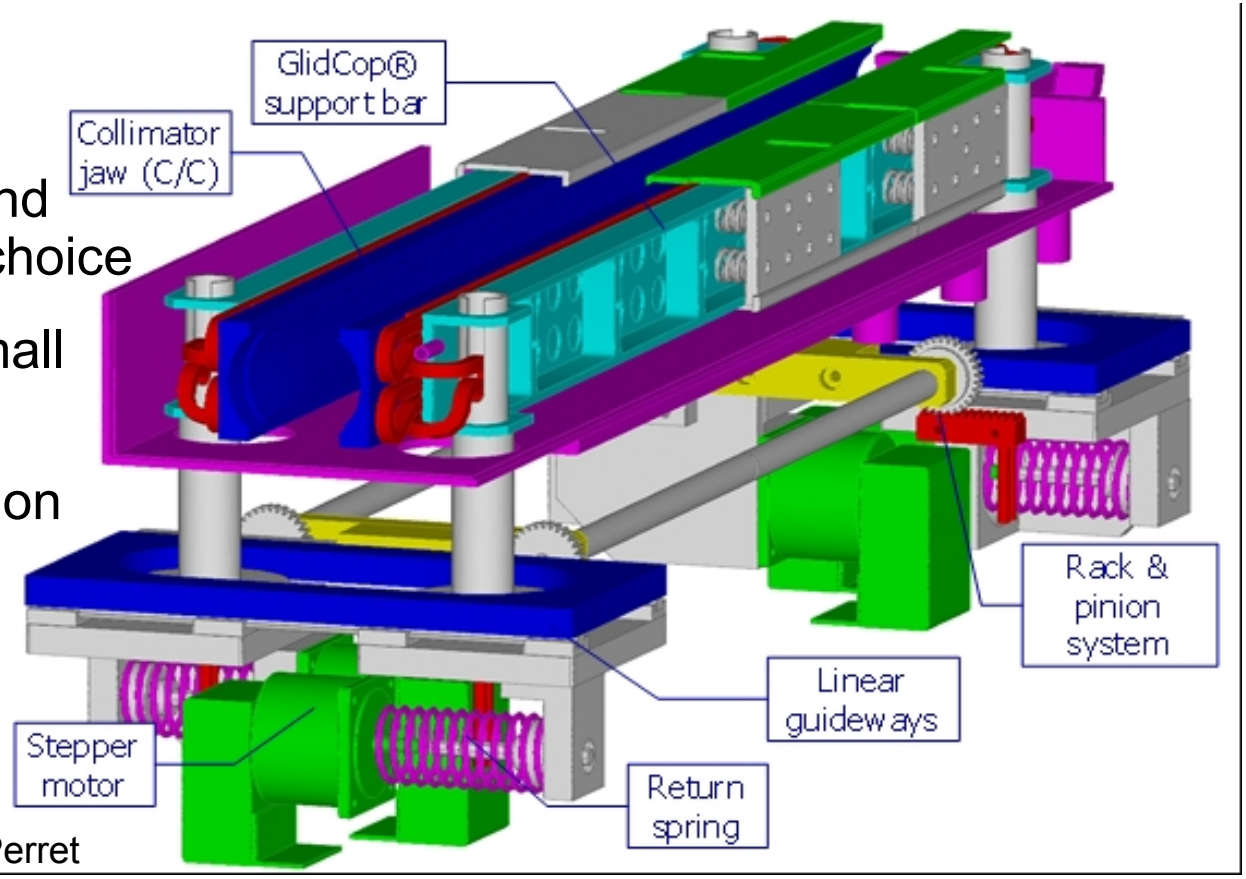
Overview

- Design features
- Movements
- Position control
- Electronics, control and interlocks
- Summary

Design features

Three major design criteria to assure a precise jaw position:

- Tight tolerances and adapted material choice
- Movement with small step size
- Independent position measurement



Courtesy of A. Bertarelli and R. Perret

Design features

Side view at one end

+ switches for IN, OUT, ANTI-COLLISION

Design features

- **Two opposite jaws per collimator** provides enhanced safety for settings if compared to TEVATRON and RHIC!
- **Position and angle control** for jaws.
  Automatic retraction and play elimination.
- **Independent position read back** and end position switches.
- Independent & **direct monitoring of the collimator gap**.
- **Survey** of temperature, vacuum and shock impact.

Movements

Collimators will be moved by Stepper motors:

- δL is defined by the geometry of the motor
- That makes “easy” to implement a given ΔL
- The movement can be implemented in open loop position:
  - sensors are not necessarily needed
  - the system is more robust.
- After a power-cut, or single-event, we need to reset the step counter to a home position

Movements

We use

- 2-phase hybrid motors, 200 step/revolution
- Angle resolution 1.8°±0.1°
- 2mm pitch lead screw
- Pull-out torque sufficiently higher than load

And we have:

- 2mm/200 step = (10 ±0.5) μm !!!!
- Static Error due to load negligible if
- pull-out torque >> load torque
- With Ministep Driver we can do 400, 800, 1600, steps/revolution (5, 2.5, 1.25, 0.75 μm)

Position controls

LVDT and Resolvers:

Radiation hardness:

If the motor survives, the LVDT and the Resolvers can survive.

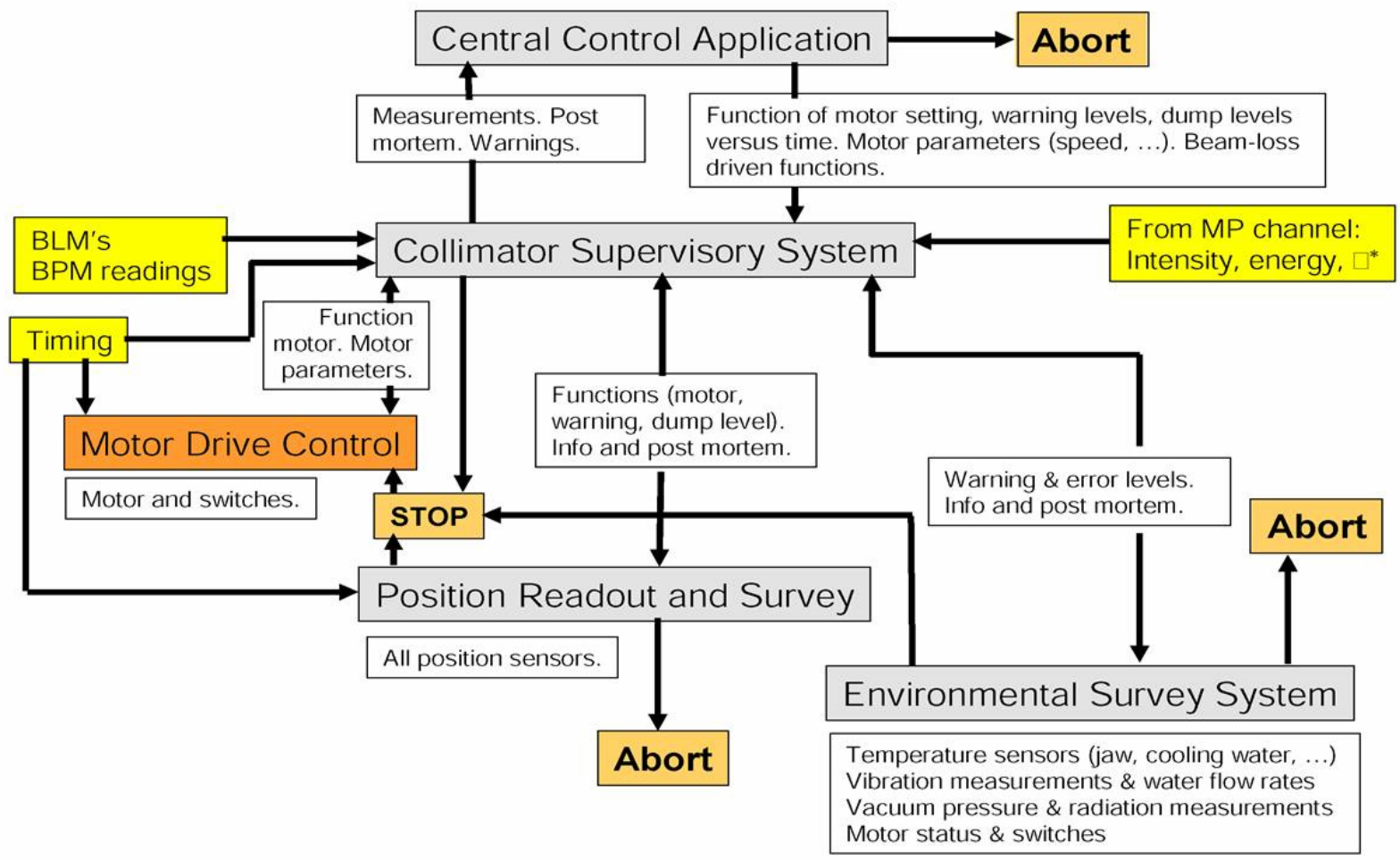
Lifetime:

“infinite” since contact less (no mechanical stresses).

Resolution is determined by ADC in conditioning electronics.

16 bits on ±40 mm= 1.2µm resolution

Electronics, control and interlock



Interface to interlock system

- Preliminary thinking. Details being worked out.
- Collimation control system has several paths to interlock system. Beam dump could be requested if:
  - Jaw temperatures exceed tolerance, abnormal motor and/or sensor status, shock beam impact detected, ….
  - In, out or anti-collision switches are activated.
  - Jaw positions and/or gap deviate from requested value for the considered time (setting function). Depends on tolerance. Monitor with 40 μm accuracy.
  - Inconsistency detected between:
    - requested settings and machine mode, energy, … (to be defined).
    - among requested settings (e.g. protection gaps < cleaning gaps).
    - measured orbit and collimator reference orbit (or track orbit with coll.?)
- Crucial connection to interlock system: Collimator design and extensive monitoring should prevent “wrong” and “unsafe” settings!

Summary

- Two jaws per collimator provide important enhancement for safety of collimator setting control.
- Very tight mechanical tolerances and play minimization with spring system.
- Stepping motor for precise positioning.
- Two additional, independent devices for direct measurement of jaw positions and collimator gap (redundancy).
- Several possible links to interlock system from low through high level controls ➔ control system being attacked now.
- We feel confident that jaw positions and gaps can be controlled by hardware to significantly better than 100 μm during all times (~ 40 μm).