Precision of collimator jaw positioning and gap values

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R. Losito, G. Robert-Demolaize, M. Sobczak, T. Weiler
Topics

1. Introduction
   Jaw position measurements
   Philosophy of collimator settings controls

2. Mechanical reproducibility

3. Performance of jaw position monitoring

4. Gap values

5. Conclusions
Introduction

SPS prototype

- 4 LEP stepping motors used to move the jaw corners
- 4 resolvers count the motor steps
- 4 potentiometers measure the actual jaw position
- 2 LVDT’s provide direct gap measurements
- 10 switches prevent breaking the mechanics (full-IN + full-OUT per each corner + 2 anti-collision)

See SR, LCWG of 20/09/2004

- Extensive measurement campaigns at the metrology
- Reproducibility of switches: $\sim 30-50$ $\mu$m (going IN)
- Resolvers and motors worked reliably
  Motors more precise: error $< 15$ $\mu$m vs $\sim 70-100$ $\mu$m of resolvers
- Direct position measurements (potentiometers, LVDT’s) did not work
- Jaw position measurements relied on counting the motor steps
  from the full-OUT switches
  - Motors were reset at the full-out position (step count restarted)
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The collimator was not re-calibrated, nor the sensors were revised, since Aug. 2004
2004 performance \textit{(LCWG, 20/09/2004)}

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Settings control philosophy

- ABSOLUTE settings in the beam coordinate (compatibility with LSA TRIM)
- Middle- and high-level controls only use absolute settings
- Motor step counter is INDEPENDENT of the measured positions (no feedback)
- Operator can update the motor settings if he thinks they are wrong (e.g. if steps are lost - inferred from position measurements)
- Automatic update of settings when the switches are activated
Mechanical reproducibility

We must rely on the old switch metrology data to get a reference! Precision will only be as good as the mechanical reproducibility...
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<td>34.038 ± 0.020</td>
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**Conclusions**
- Mechanics behaves like in 2004
- Motors provide the most accurate position measure
- Resolver are less precise (seen differences up to 100μm)
- Direct position measurements basically cannot be used!
Accuracy: resolvers vs motors

Jaw position [mm]

Motor
Resolver

Difference [mm]

Right Downstream
Accuracy: resolvers vs motors

Transient differences from timing errors (see next slide)

S. Redaelli, LCWG 04/12/2006
Accuracy: resolvers vs motors

Transient differences from timing errors (see next slide)

Δ = 200 μm

Right Downstream
Accuracy: resolvers vs motors

Transient differences from timing errors (see next slide)

Left upstream

Δ = < 10 μm
Accuracy: resolvers vs motors

Transient differences from timing errors (see next slide)

Motors or resolvers are correct??

Δ = 200 μm

Δ = < 10 μm
Accuracy: resolvers vs motors

Transient differences from timing errors (see next slide)

Motors or resolvers are correct??
2004: resolvers were found to be less reliable than the motors
We assume that this is still the case and we base the position measurements on the count of motor steps from the OUT switches
Time delay in the acquisition

Error during movements cause by ~1s delay in the acquisition

Static values are better

Offsets from time delay changes during the MD

Source of these delays needs to be understood!
Example of potentiometer data

-30
-30.2
-30.4
-30.6
-30.8
-31
-31.2

Motor
Resolver
Potentiometer
Switch activated

Jaw positions [mm]

Time [h]
Example of potentiometer data

Noise in the signal!
Example of potentiometer data

![Graph showing motor, resolver, and potentiometer positions over time with noise and offset annotations.]

-30.2
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Time [h]

Jaw positions [mm]

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Resolver
Potentiometer
Switch activated

Noise in the signal!

Offset
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Noise in the signal!

Is it worth re-calibrating these sensors and understand the data we have!?!
Example of potentiometer data

Noise in the signal!

Is it worth re-calibrating these sensors and understand the data we have!?!?

Use motor step count from driver for the moment
Settings errors from loss steps

Problem of motor measurements: they are “upstream” of the mechanical structure and do not “see” mechanical plays!
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Source of loss steps not yet understood...
Settings errors from loss steps

Problem of motor measurements: they are “upstream” of the mechanical structure and do not “see” mechanical plays!

... This is the reason why at the LHC we MUST HAVE direct jaw position measurement!
This example: gap versus time during impedance measurements, MD1 (see Chiara’s and Elias’s talks)

Anti-collision switch is consistent with 2004!

Data is being provided to the impedance colleagues

More cumbersome than 2004 because motor data have to be manually set to switches...
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Nevertheless, we believe that we could achieve a measurement accuracy of about $\sim 100 \, \mu \text{m} [\text{preliminary!!}]$

- Based (1) on indications that the mechanics did not deteriorate in 2 years and (2) on the reliability of motor step size
- Position of the switches did not change?
- Motivations take out the collimator and perform new calibrations?
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More detailed results at the upcoming controls review
TT40: LVDT position measurements

![Graph showing LVDT jaw position measurements over time.](image)