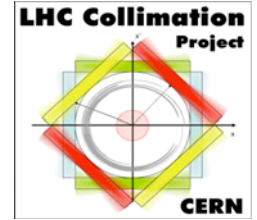




Geneva, 31 January 2005  
50th LHC Collimation Working Group meeting



# Measuring the Beam Size by Scraping the Beam with the Collimator?

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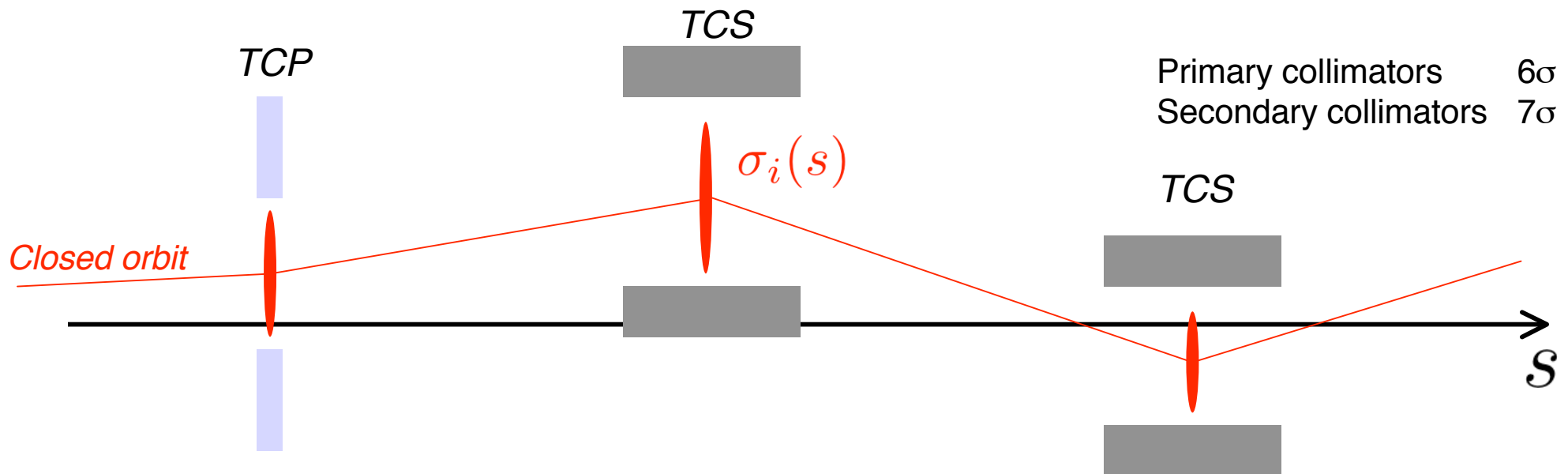
## *Contents:*

1. Motivation
2. How to measure the beam size
3. Data from the SPS test
4. Conclusions

# 1. Motivation: why do we need the beam size at the collimator?

For *commission the LHC collimation system*, we need to:

1. Centre the collimator jaws around the local closed-orbit →  $\leq 50 \mu\text{m}$  at the SPS
2. Set the collimator depth to the *local beam size* → How do we measure it?



Beam size:


$$\sigma_i(s) = \sqrt{\beta_i(s)\epsilon_i + D(s)^2\delta^2}$$

Rely on nominal optics? ( $\delta\beta/\beta < 10\%$ !)

Measure optical functions at each collimator?

**Measure the local beam size?**

## 2. What happens if we scrape the beam with the collimator



**Fermilab**

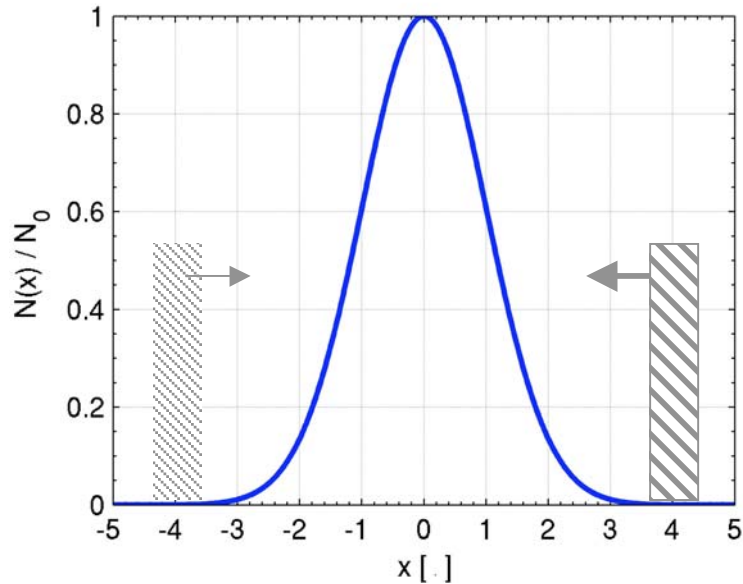
**Tevatron beam study report**  
1.21.2003  
A. Jansson *et al*

CERN-AB-2004-032 (ABP)  
CERN-AB-Note-2004-054 (ABP)

**COLLIMATOR SCANS TO MEASURE TEVATRON EMITTANCE**

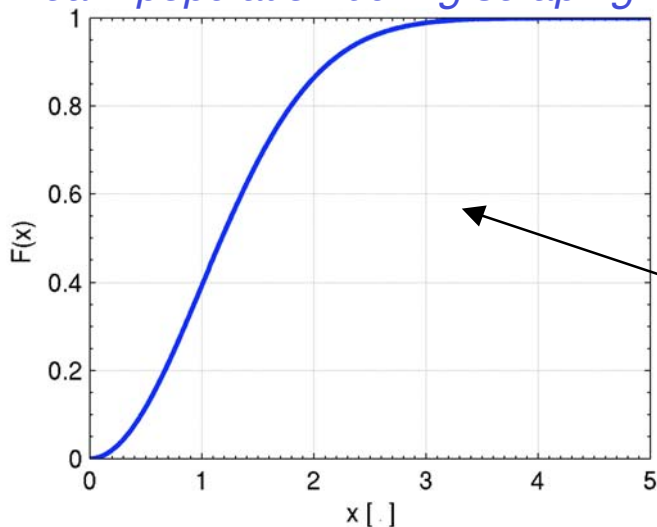
**INTENSITY AND LUMINOSITY AFTER BEAM SCRAPING**

H. Burkhardt, R. Schmidt



$$N(x) = \frac{1}{2\pi} \exp\left(\frac{-x^2 - x'^2}{2\sigma^2}\right)$$

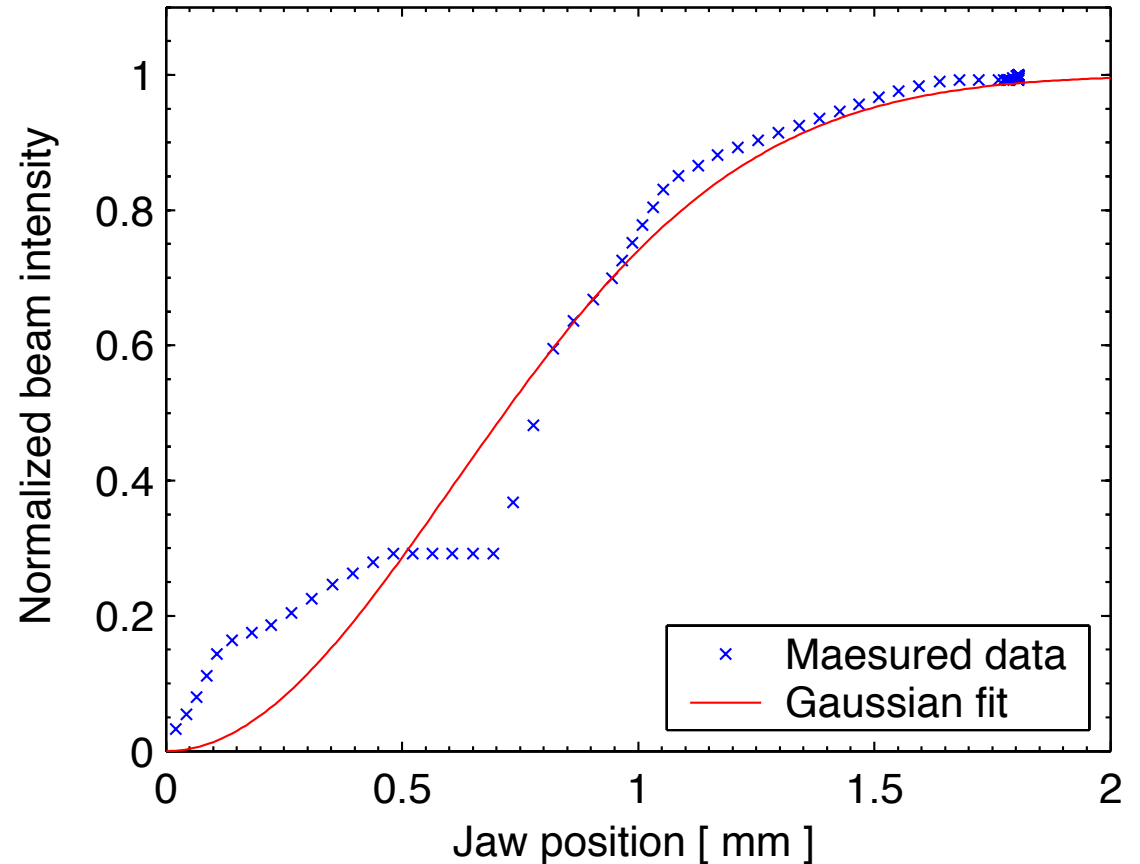
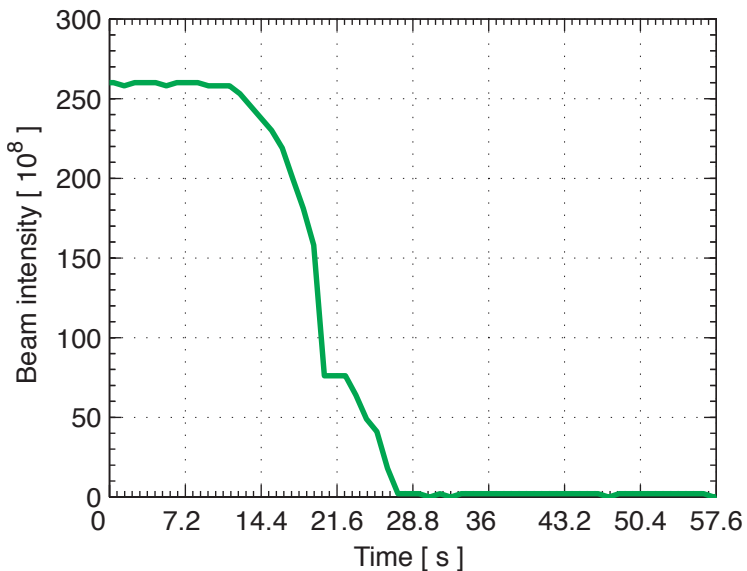
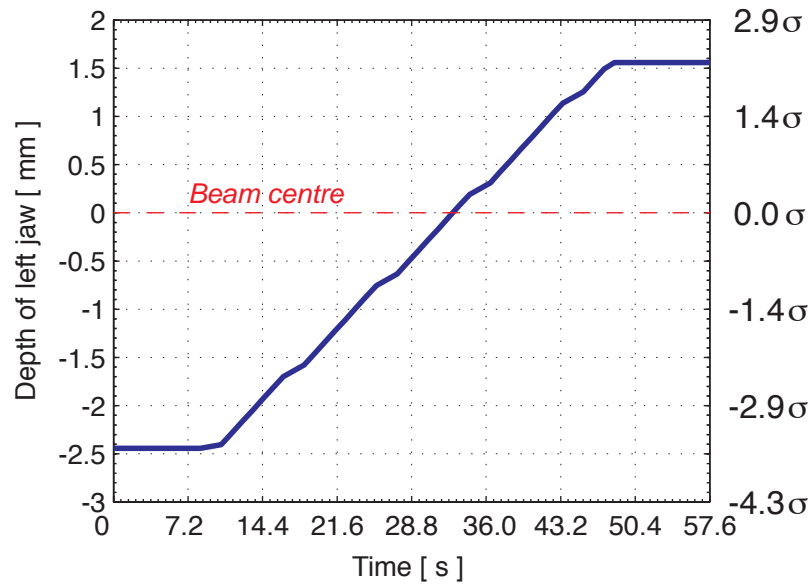
*Beam population during scraping*



Multi-turn scraping slow w.r. to betatron frequency (both sides+x!)  
Neglect dispersion and coupling

$$F(x) = \frac{1}{N_0} \int_0^{x-x_0} N(t) dt = 1 - \exp\left(\frac{-(x-x_0)^2}{2\sigma^2}\right)$$

### 3. SPS measurements - LHC beam (1x72 bunches) (I)

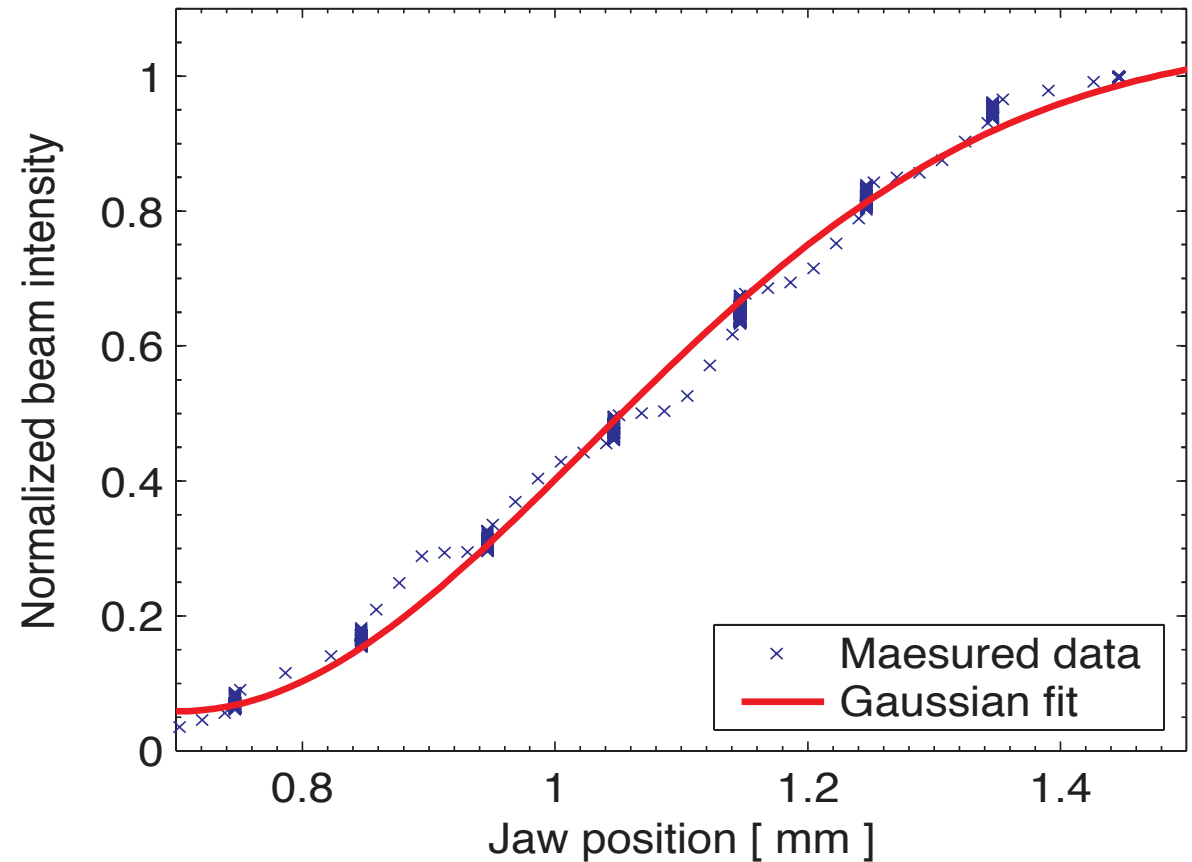
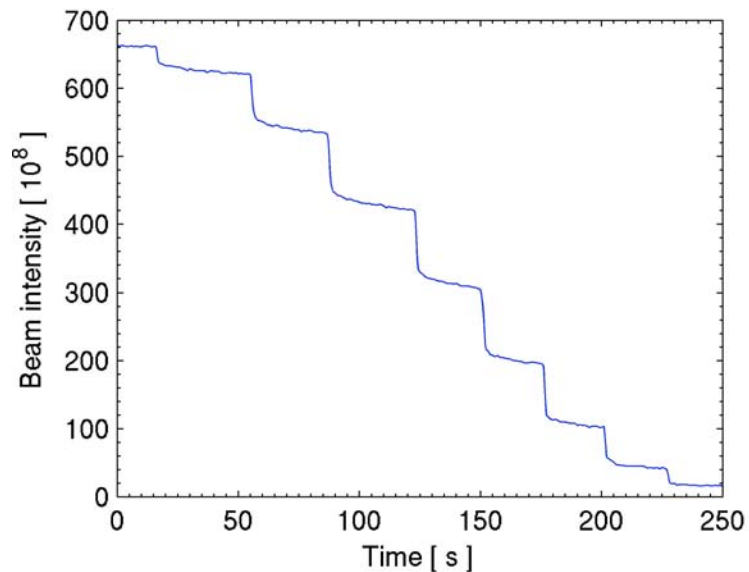
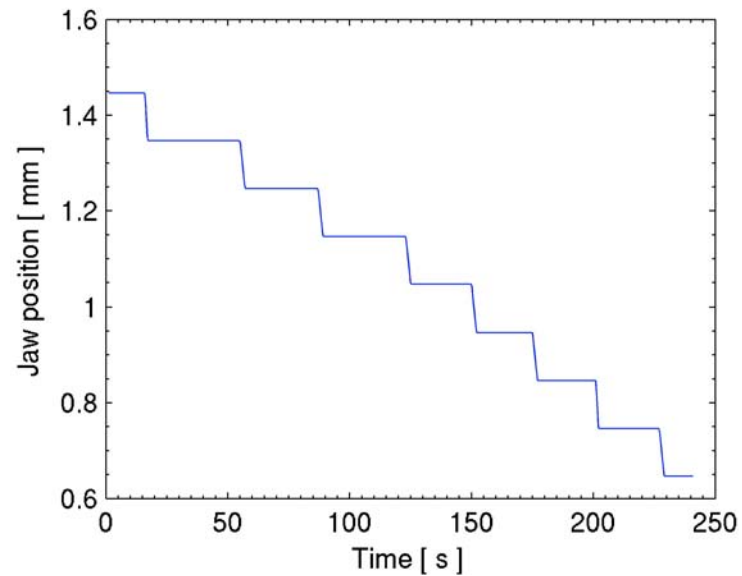


Size expected from  $\beta, \epsilon$ :  $\approx 700 \mu\text{m}$

Result from fit:  **$(665 \pm 52) \mu\text{m}$**

*Dispersion neglected*

### 3. SPS measurements - TOTEM beam (1 bunch) (II)

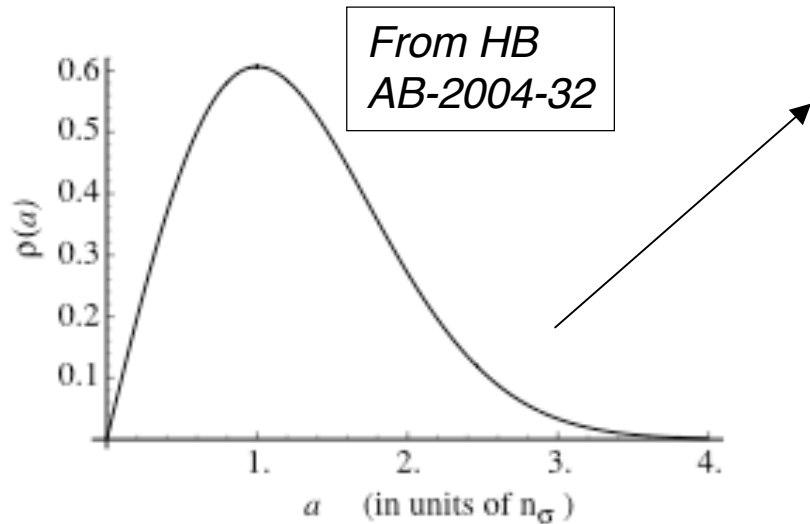


Size expected from  $\beta, \epsilon$ :  $\approx 400 \mu\text{m}$

Result from fit:  **$(325 \pm 3) \mu\text{m}$**

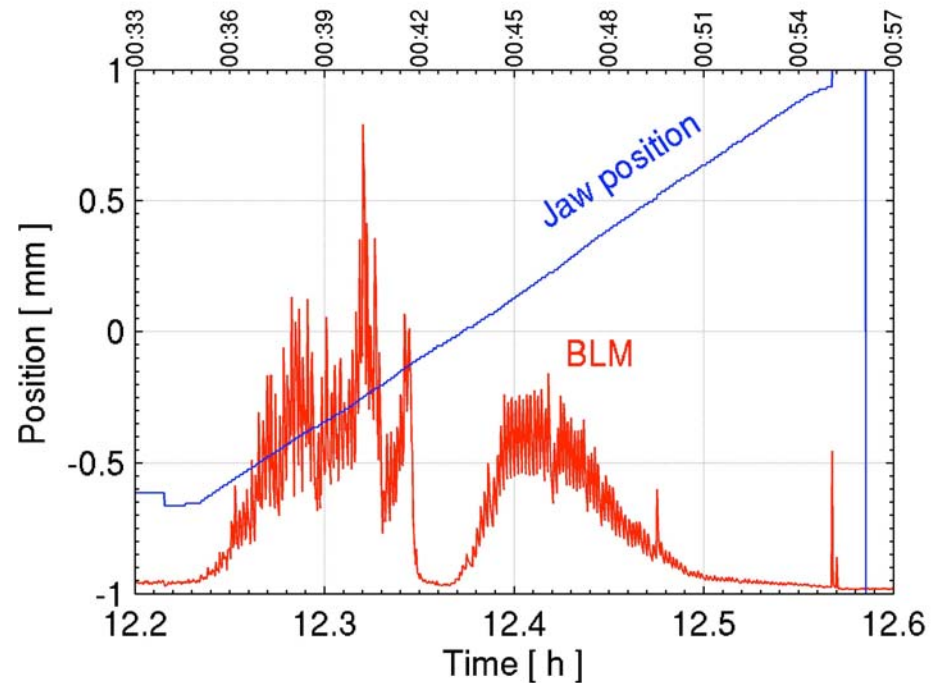
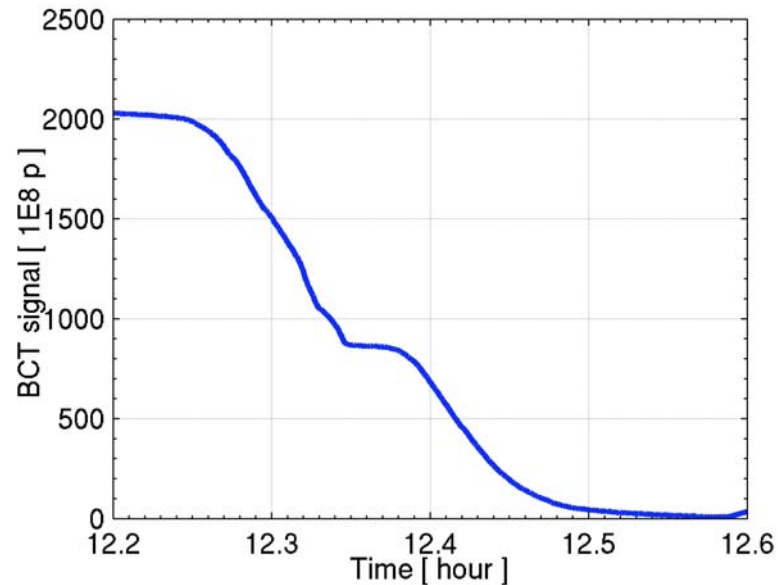
*Dispersion neglected*

# Measuring the beam sigma with the BLM?



Expected losses during beam scraping.  
Can we see this pattern with the **BLM's**?

Only one try. BLM's saturated in the other cases  
Jaw manually moved ( $\Delta x=10\mu\text{m}$ !) - too slow.  
Beam moved...



## Conclusions

- ✓ Even if no dedicated measurements were carried out, it seems that the **local beam size** at the collimator can be measured by **scraping the beam!**

  - Good agreement with theory for Gaussian beams

  - Good agreement with expected sizes from emittance measurements

  - More detailed comparisons are required

  - Effect of dispersion or coupling?

- ✓ Could this method be used for commissioning the LHC collimators?

  - Ok for pilot bunches!

  - How do we extrapolate to high intensity beams?

  - More systematic studies are required the answer these questions