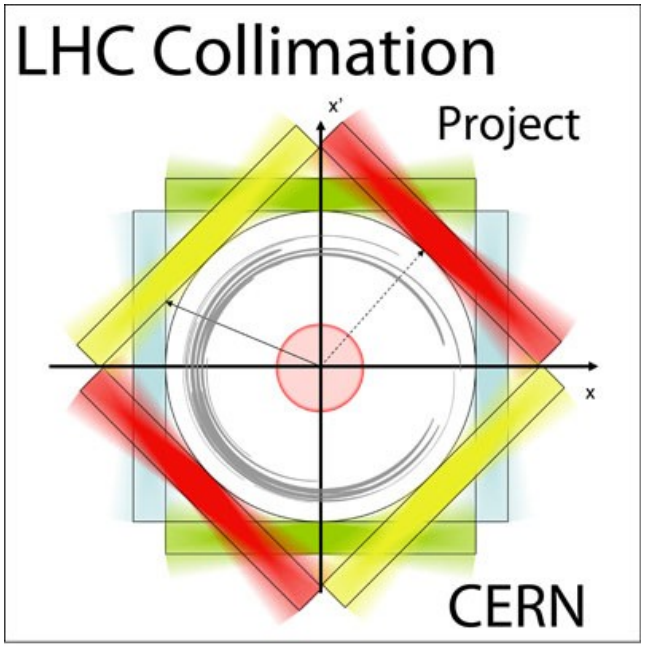
Collimator with Beam Diagnostics Functionality



D. Wollmann, CERN/BE

11.05.2011

EuCARD 2nd Annual Meeting,

CNRS-Paris, France

10-13 May 2011

On behalf of

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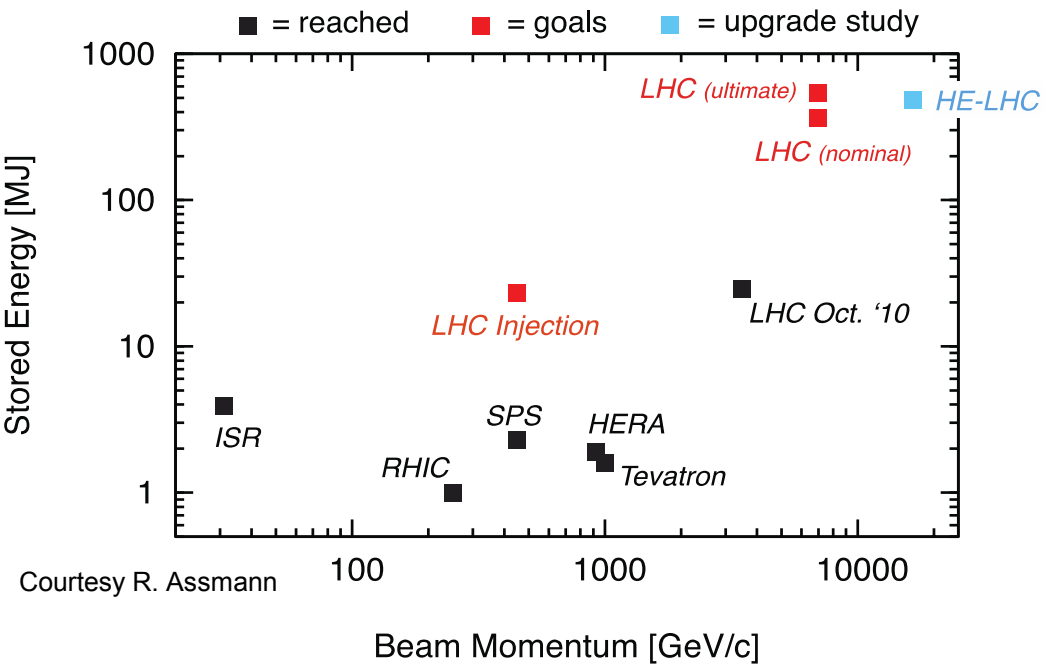
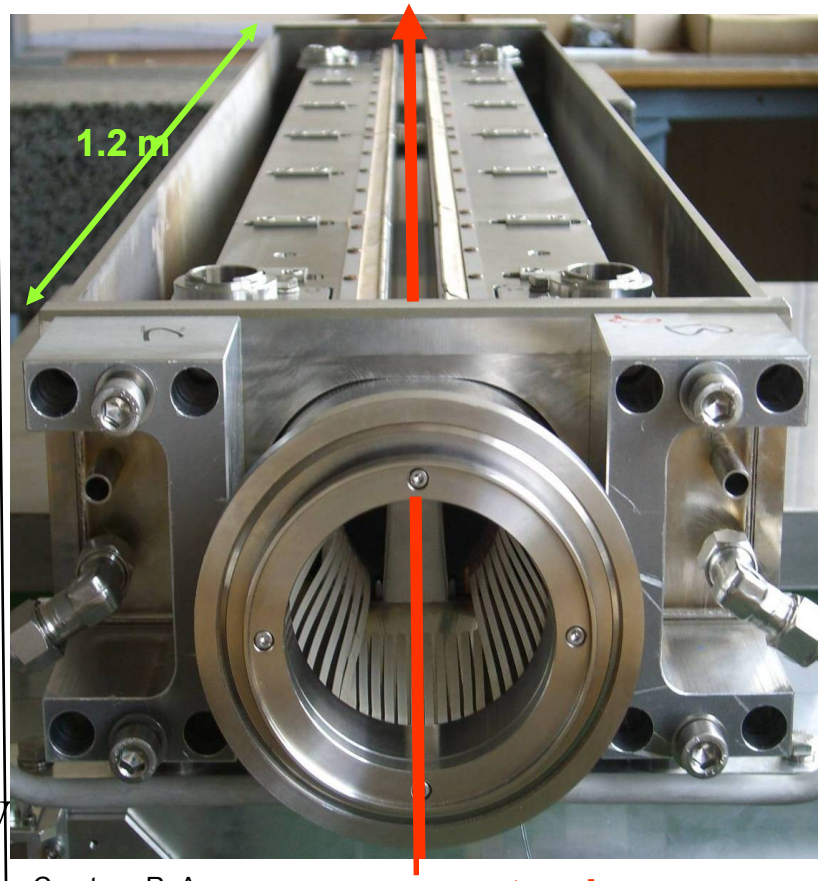
Outline

- Introduction
- Why Collimators with Beam Diagnostics Functionality?
- Design overview
- Results from First Beam Measurement
- Conclusion & Outlook

Challenges for LHC collimation



Courtesy R. Assmann

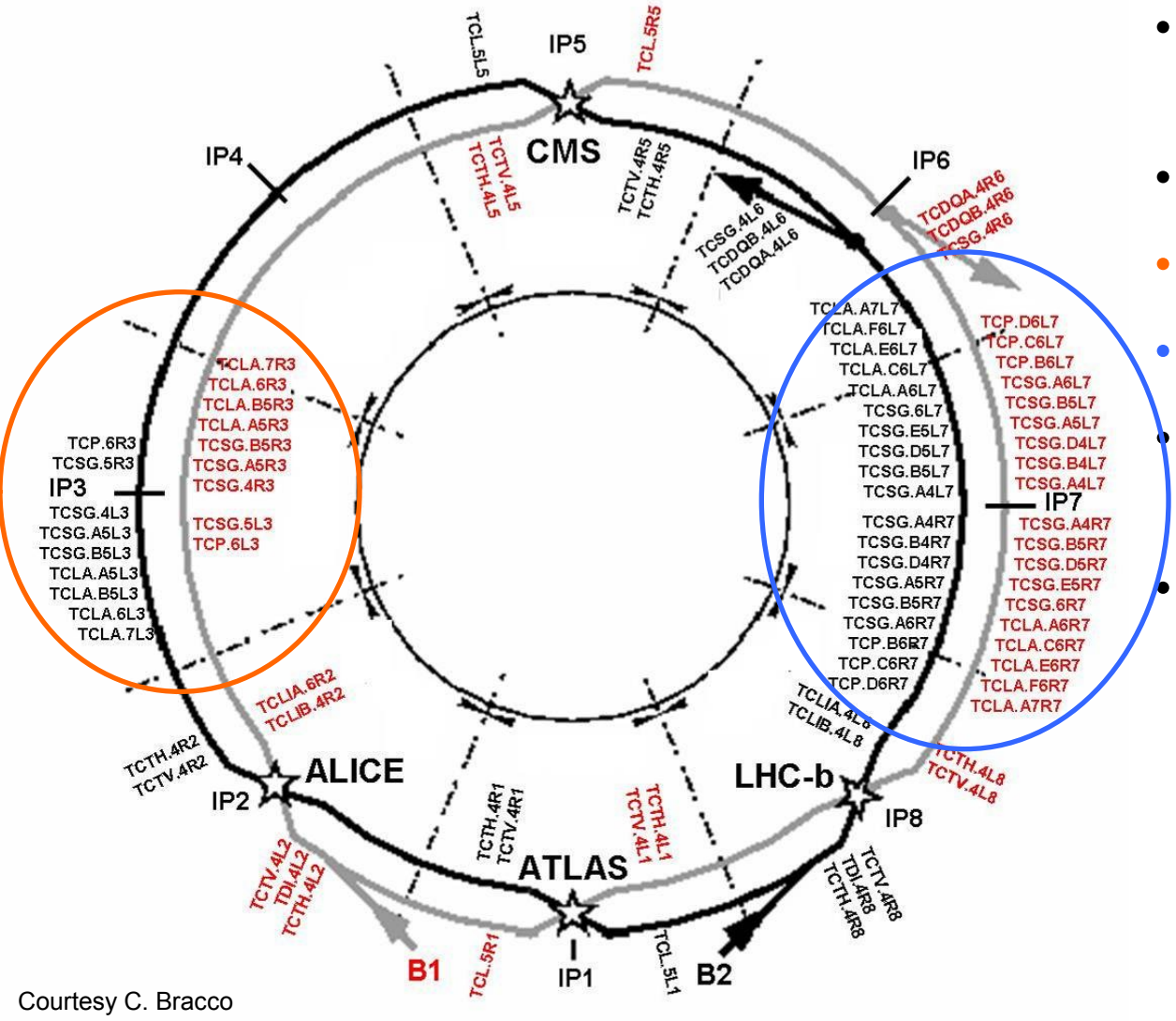


Courtesy R. Assmann

- 362MJ stored energy per beam at 7TeV with 3e14 protons
- Quench limit (7TeV): 7.6e6 $ps^{-1}m^{-1}$

- Phase-I collimator

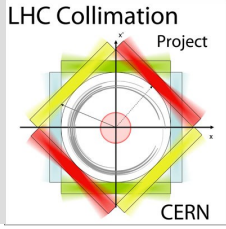
Installed Phase-I Collimation System



Courtesy C. Bracco

- 44/43 collimators per beam installed in the LHC ring
- 4 stage cleaning
- IR3 momentum cleaning
- IR7 betatron cleaning
- Injection and Dump protection
- Protection of Experimental insertions and triplets

Beam based setup and qualification of collimation system

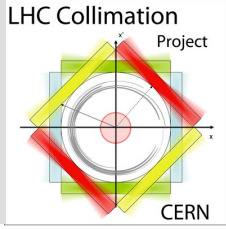


- Centre collimator jaws around beam (by touching the beam halo)
- Determine local beam size at collimators
- Set up system with agreed collimator settings

➔**~15mins per collimator & machine state (two beams in parallel)**

- Qualify system by measuring the cleaning efficiency
  - β-tron losses by crossing a third integer tune resonance (B1-h, B1-v, B2-h, B2-v)
  - Momentum losses by changing the RF frequency (± 1000 Hz, B1+B2). 1000Hz to make sure that full beam is lost with off-momentum error. Could use smaller.

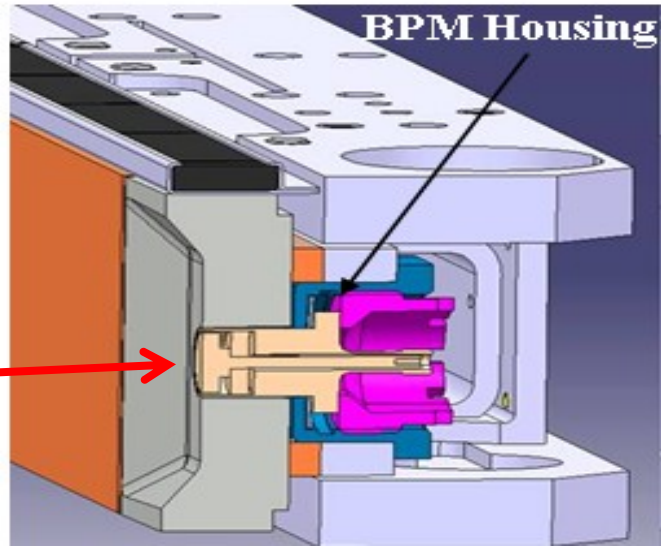
Why Collimators with Beam Diagnostics Functionality?

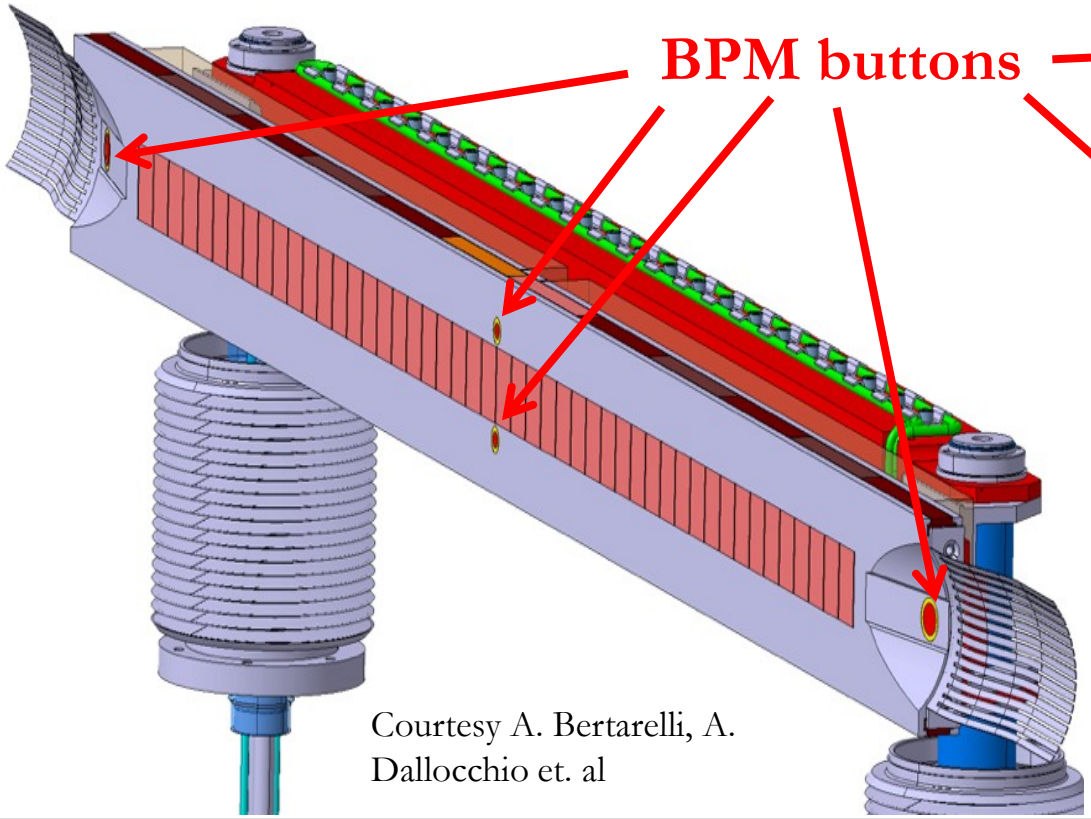


- Drastic reduction of setup time of collimation system (gain time for physics).
- **Continuous monitoring** of beam offsets at collimators.
- Measurement of **jaw angle** w.r.t. the closed orbit.
- Less strict requirements on **long-term orbit stability**.
- More flexibility for local orbit changes in the experimental IPs (crossing angle, separation for luminosity leveling, etc.).
- **Relaxed restrictions** for luminosity optimization in the experimental IPs.
- Increased passive machine protection as collimators can follow slow orbit drifts.
- Allows **reduction of margins** between collimator families, as collimators can follow slow orbit drifts ➔ **tighter collimator settings** possible ➔ better cleaning.

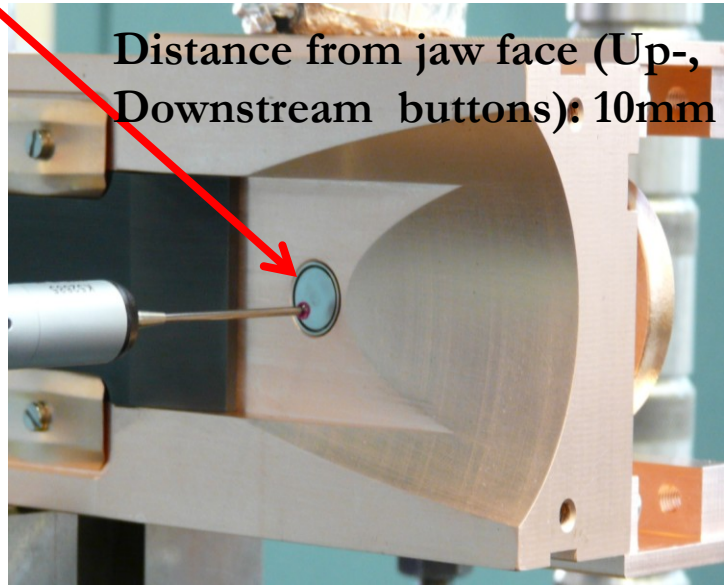
First CERN Phase-II prototype collimator with integrated BPM buttons

- First prototype produced at CERN (EN-MMI, BE-BI, Collimation Team)
- Installed into **SPS in 2010**

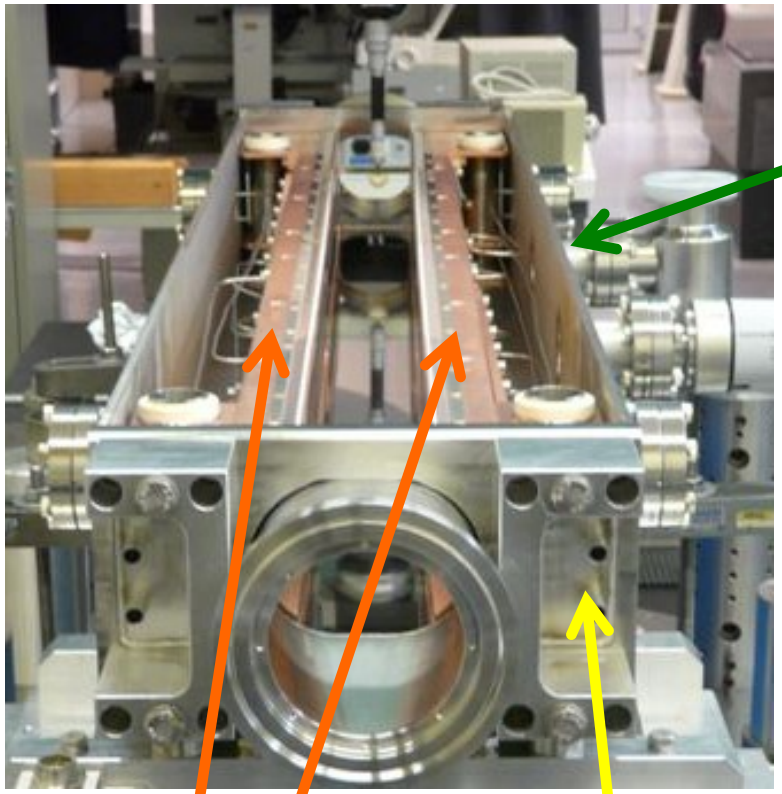




Courtesy A. Bertarelli, A. Dallocchio et. al

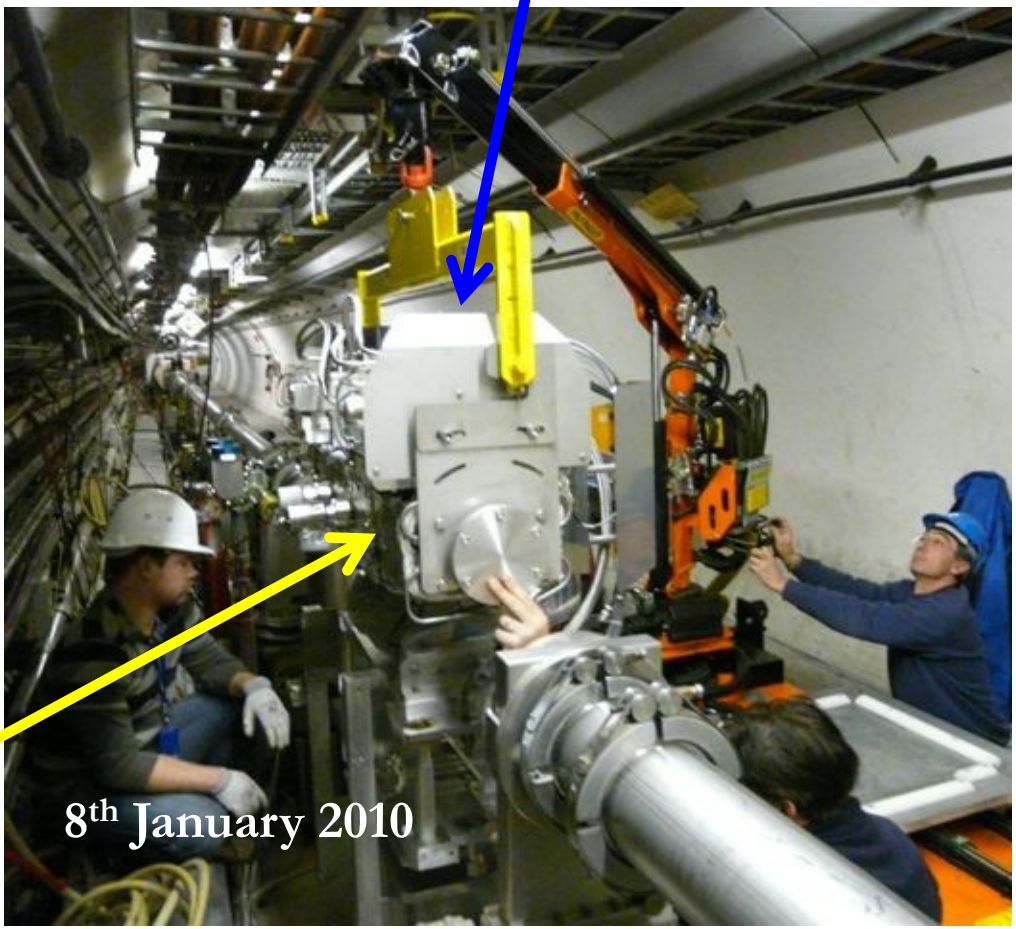


First CERN Phase-II prototype collimator with integrated BPM buttons



Courtesy A. Bertarelli, A. Dallocchio et. al

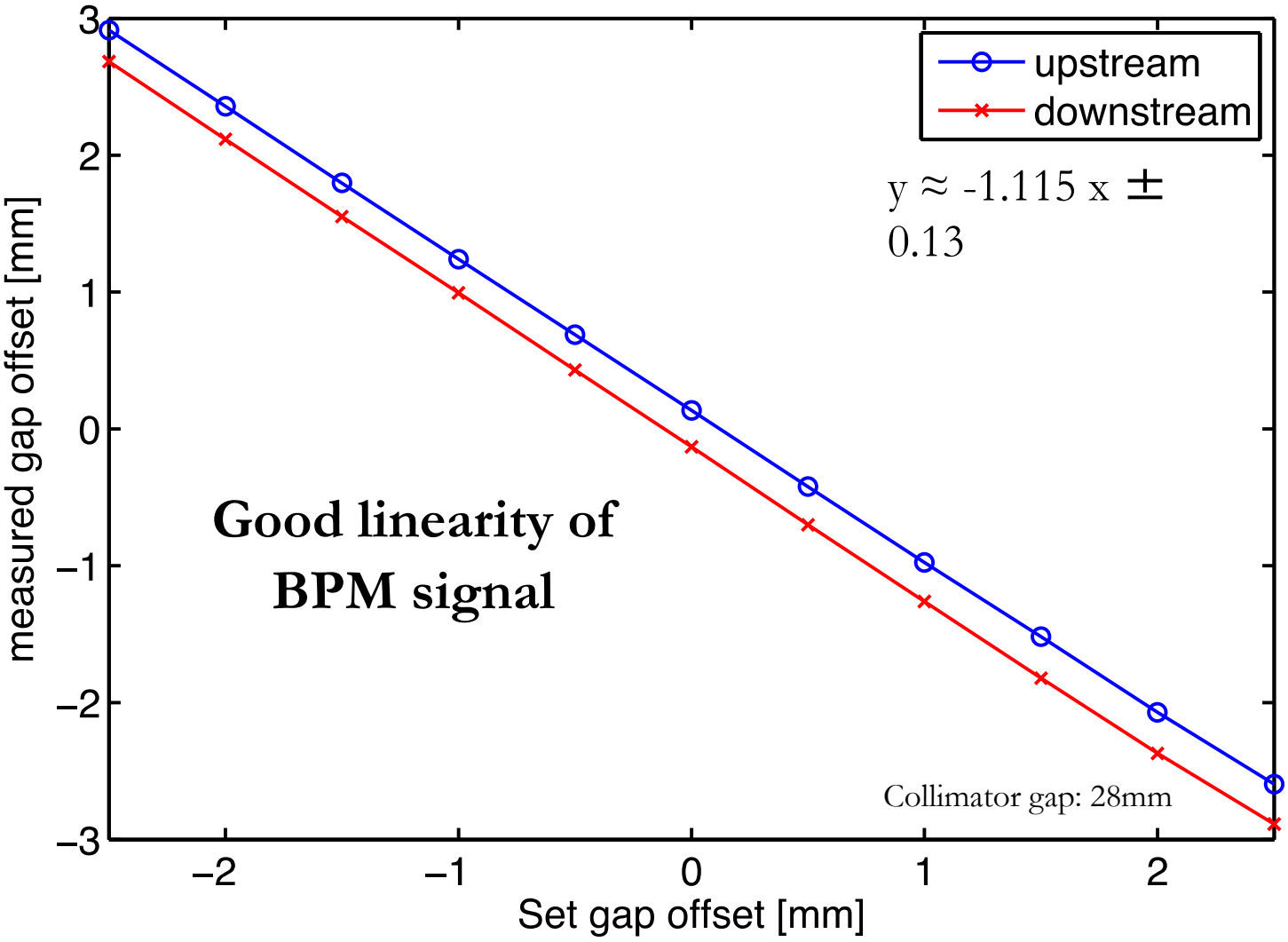
From the lab into the SPS tunnel



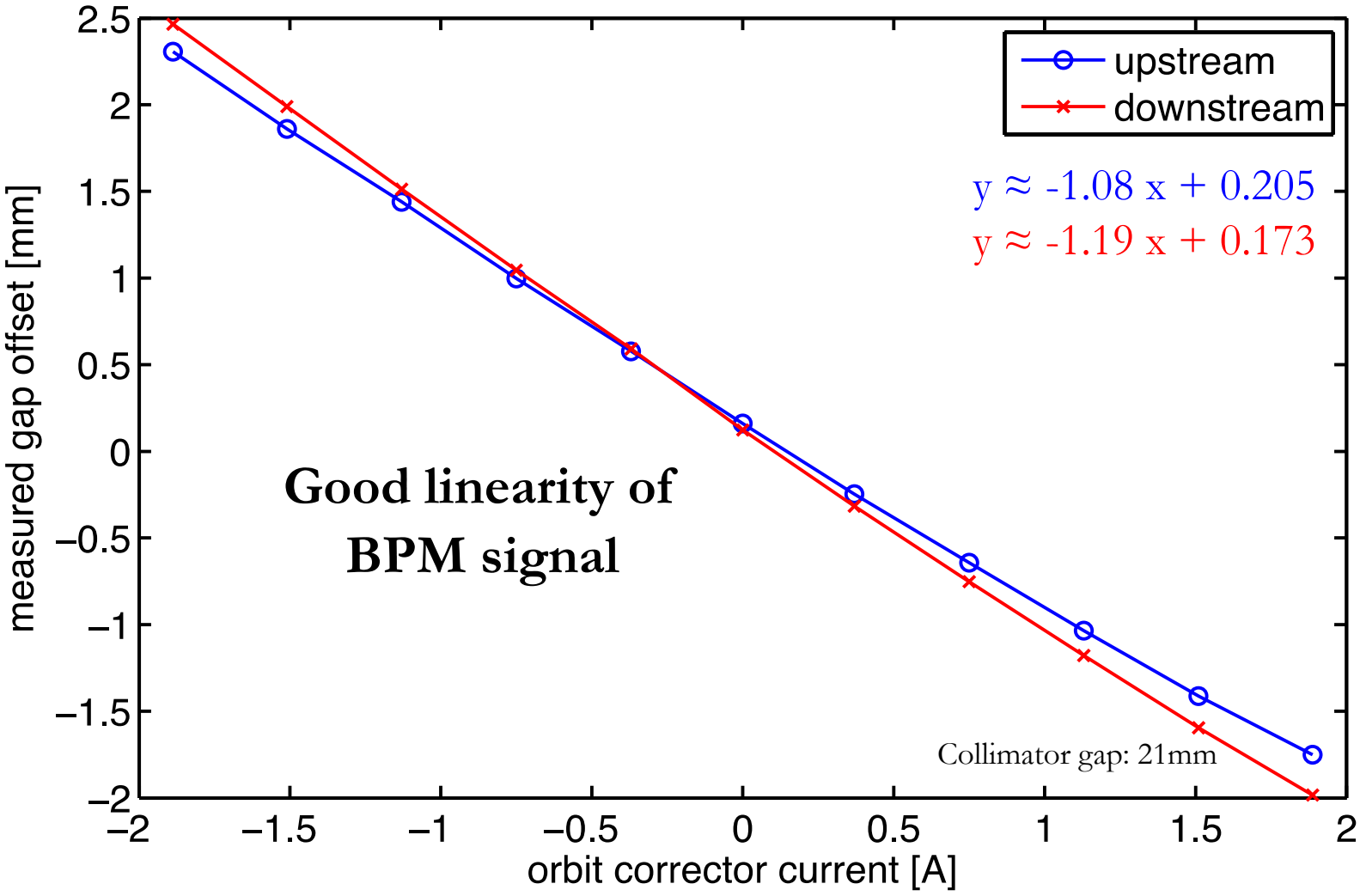
Jaws

Tank

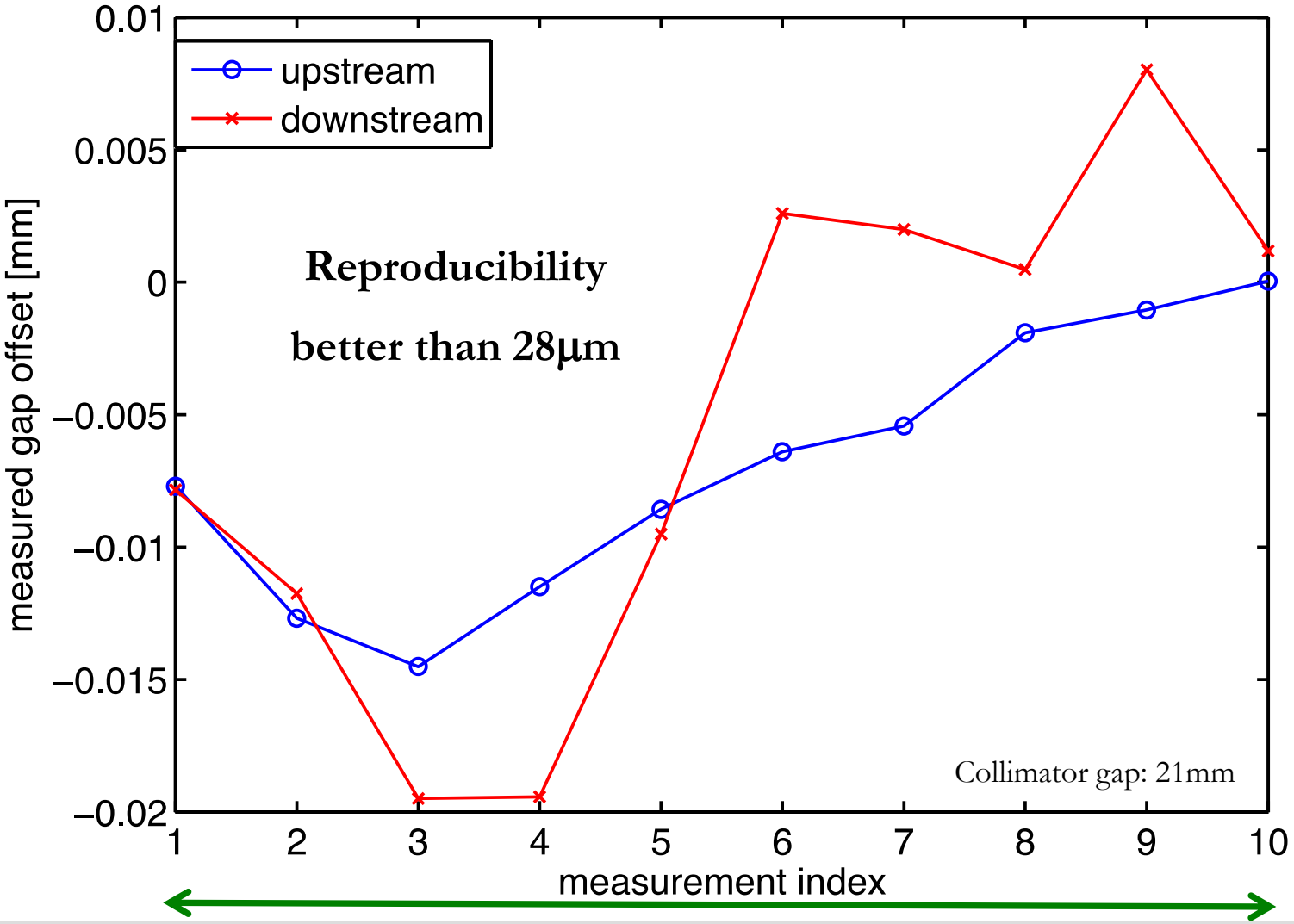
Measurement: Shift of collimator gap



Measurement with a local orbit bump



Measurement of reproducibility (no changes, 3 mins, 10 measurements)



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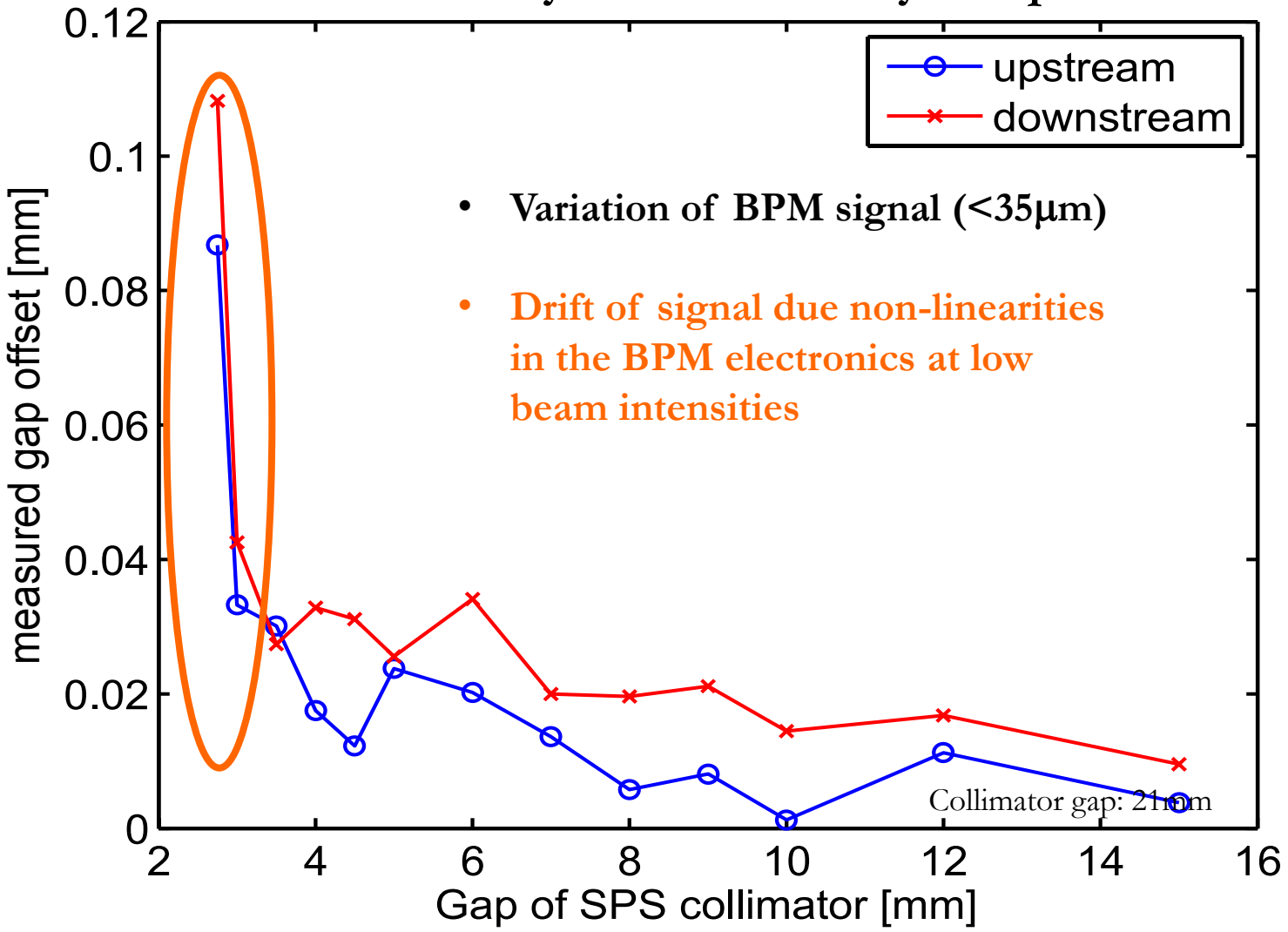
Measure the influence of radiation on BPM signals

Measurement with secondary halo created by an upstream SPS collimator



- **Variation of BPM signal (<35µm)**
- **Drift of signal due non-linearities in the BPM electronics at low beam intensities**

Conclusion & Outlook I

- Collimators with integrated BPMs have the potential to:
  - Drastically **decrease setup time**.
  - Increase **passive machine protection**.
  - Allow for **better cleaning** due to tighter collimator settings.
- First CERN prototype was installed into the SPS in 2010.
- First measurements showed:
  - Good **linearity of BPM signals** even at big gaps.
  - Reproducibility of BPM signals better than 28µm.
  - No disturbance in BPM signal due to primary protons impacting on collimator jaws seen so far.
  - No disturbance of BPM signal due to secondary showers from upstream seen so far (variation of BPM signals < 35µm) .
  - Drift of BPM signals for low beam intensities (due to electronics).

Conclusion & Outlook II

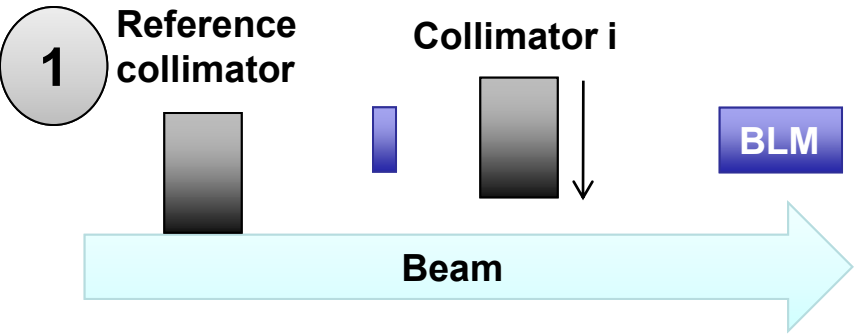
- Ongoing work to **improve the acquisition** electronics to achieve a better
  - Signal quality (linearity, etc).
  - Accuracy and Reproducibility.
  - Increase speed of signal acquisition.
- Several **experiments** with the prototype in the SPS are scheduled within this year.
- **Design work on phase-II** collimators with integrated BPM buttons is ongoing at CERN.
- **Tertiary collimators** (around experimental IPs) are most probably the **first candidates** to be replaced.

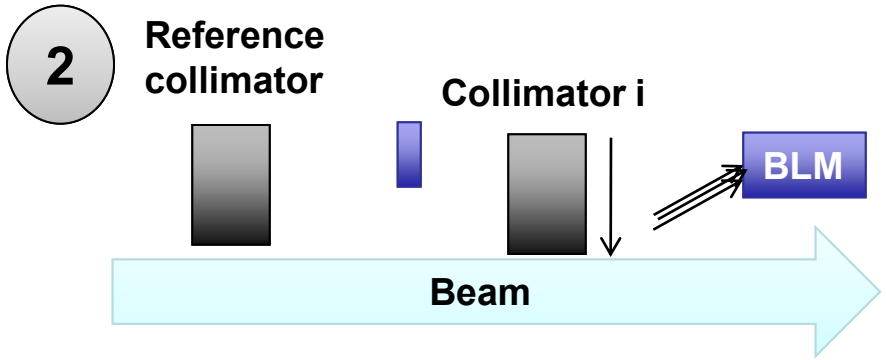
END

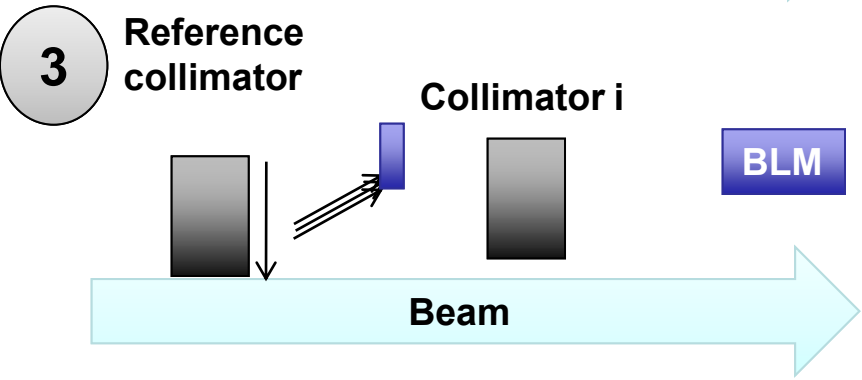
Thank you for your attention!

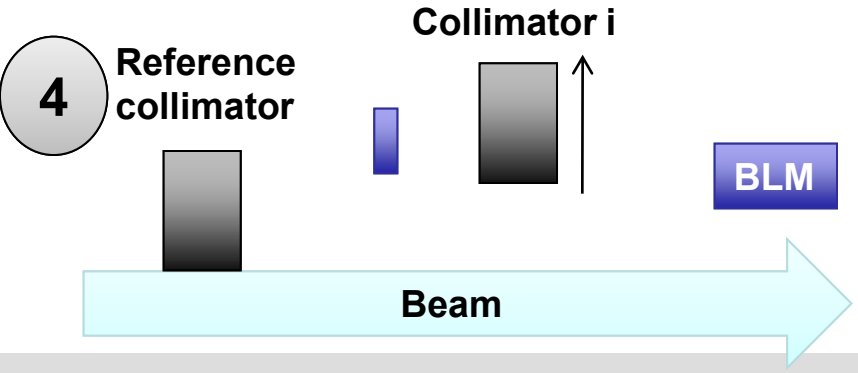
Backup slides

Beam based setup procedure for LHC collimators









- Define beam edge by hor, ver or skew reference collimator
- Center collimator i
- Re-center reference collimator
- Beam size: $\sigma_i = \frac{x_i^{L,m} - x_i^{R,m}}{(N_0^{k-1} + N_0^{k+1})/2}$
- Open collimator to $N_i \cdot \sigma_i$