

# CERN update on measurements

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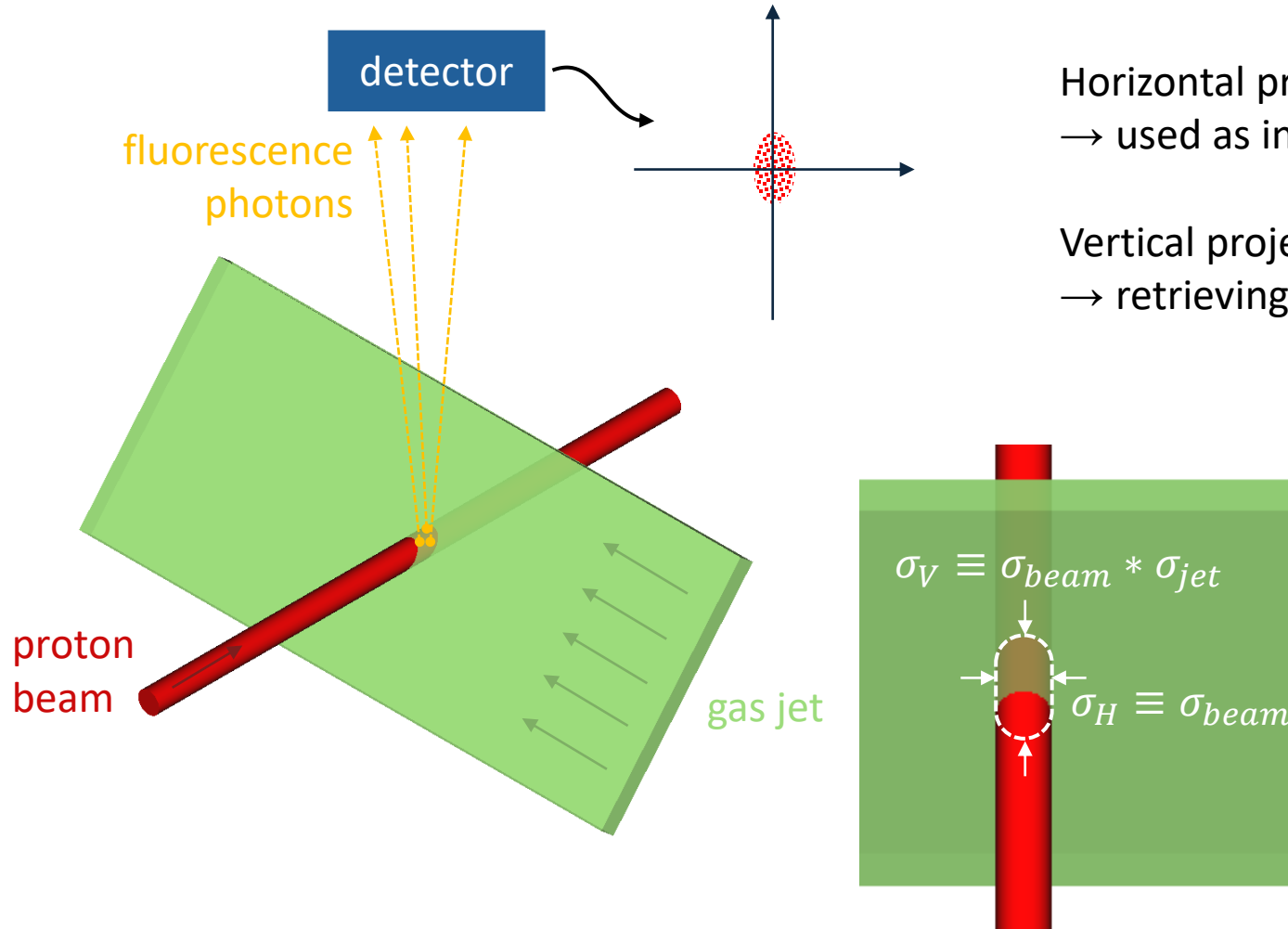
26/07/2024

# BGC as beam size monitor

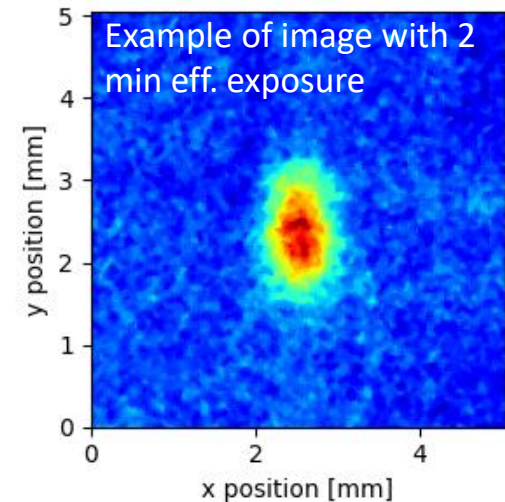
Because of the gas jet finite thickness, the **BGC output is different in the two directions**

Horizontal projection is unaffected  
→ used as indicator of data quality

Vertical projection includes jet distribution  
→ retrieving accurate beam size is more challenging

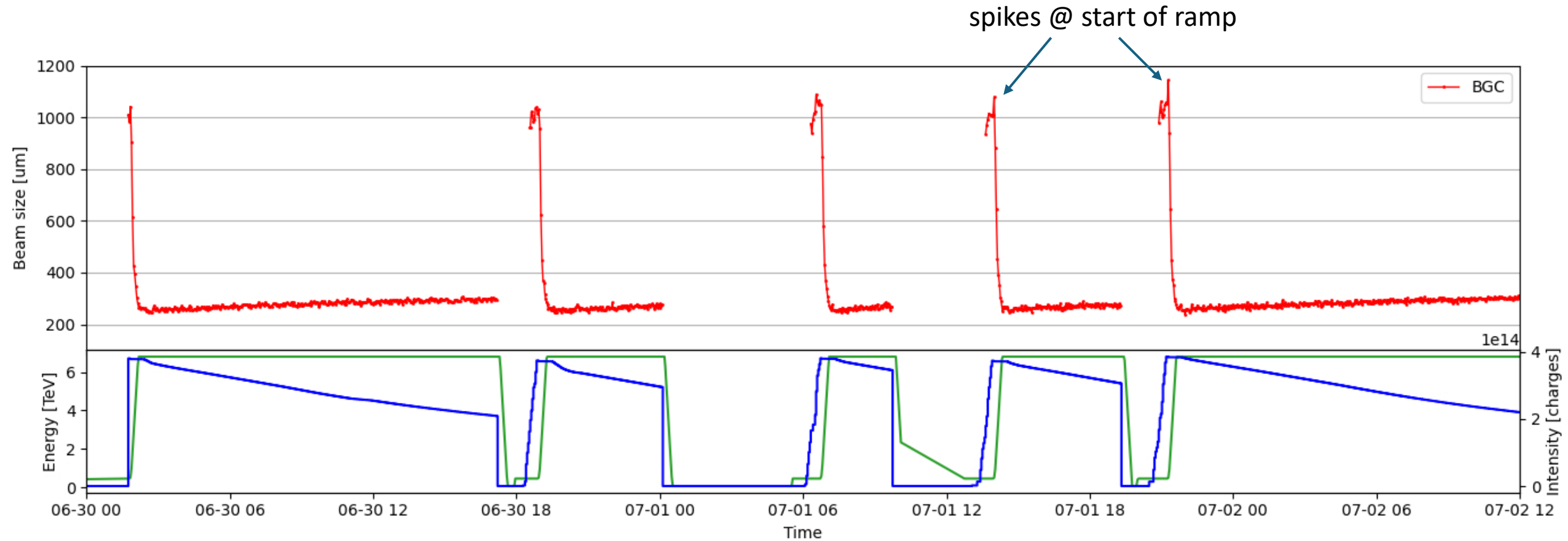


Top view:  
horizontal size coincides with the horizontal beam size whereas the vertical needs to be convolved over the jet thickness.

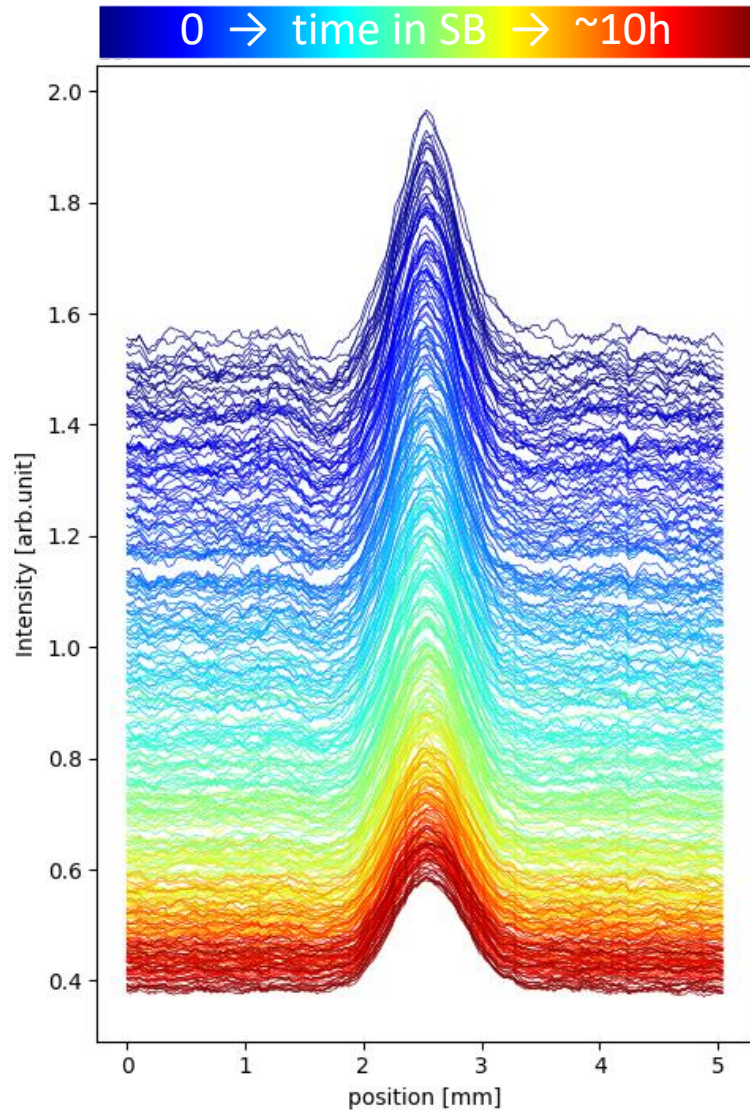


# Horizontal measurements over some fills

- horizontal size measurement looks qualitatively ok at injection and flat-top
- beam size growth resolvable during stable beams (SB)
- ramp shows some unexpected behaviour (e.g. spikes at start of ramp)

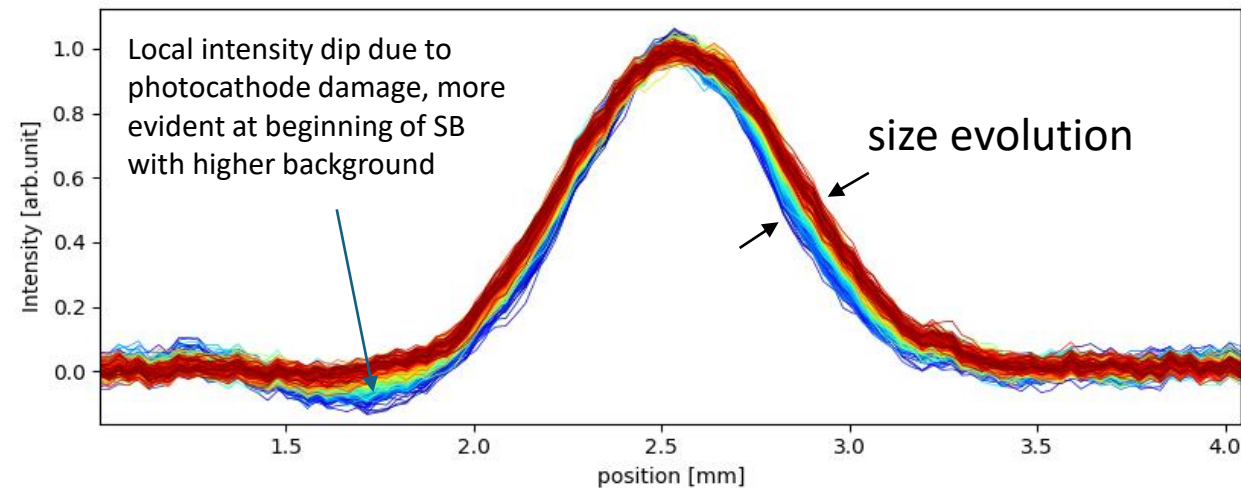


# Horizontal measurements of proton beams in SB



Example of horizontal profiles recorded over a physics fill

- peak decrease follows intensity depletion
- background decrease follows reduction of losses
- (slight) width increase follows emittance growth

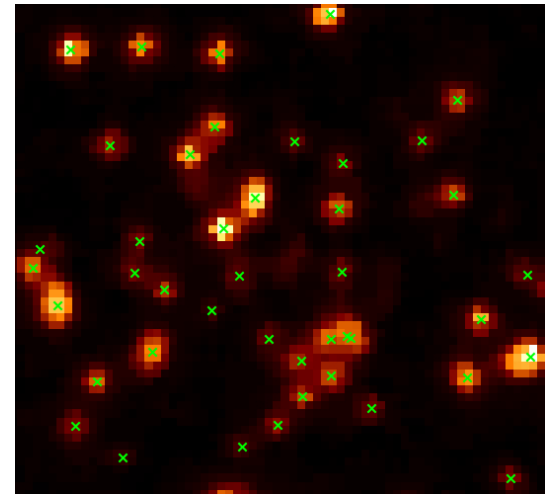


Profile evolution in SB, subtracting constant background and normalizing by fit amplitude

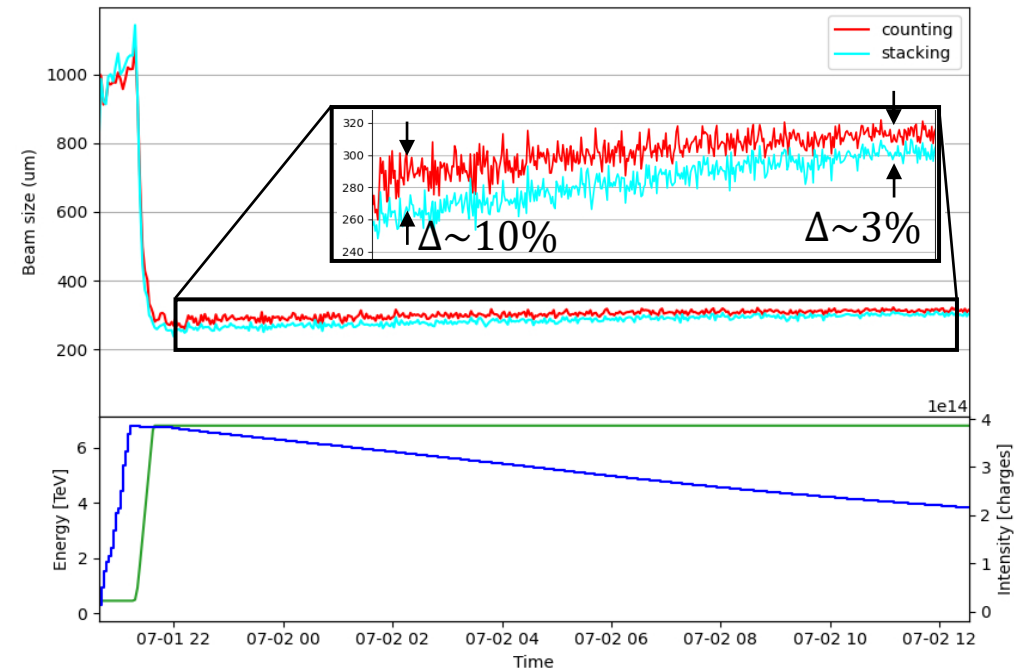
# Photon counting vs intensity stacking

Given the long exposure time required, two possible strategies to create image

- **photon counting:** necessary for fluorescence cross-section measurements and, in principle, less affected by noise
- **intensity stacking:** straightforward implementation but more susceptible to noise



Example of photon detection in a single frame of 50ms exposure



**Counting and stacking coincide for large beams**  
(e.g. at injection energy)

**For small beams, counting is systematically larger,** and the delta decreases with time at flat-top.  
Likely due to a failure of photon counting at high photon density (small beams and beginning of SB with high losses).

→ frame rate faster than current 20Hz probably needed

# Size and emittance size during ramp

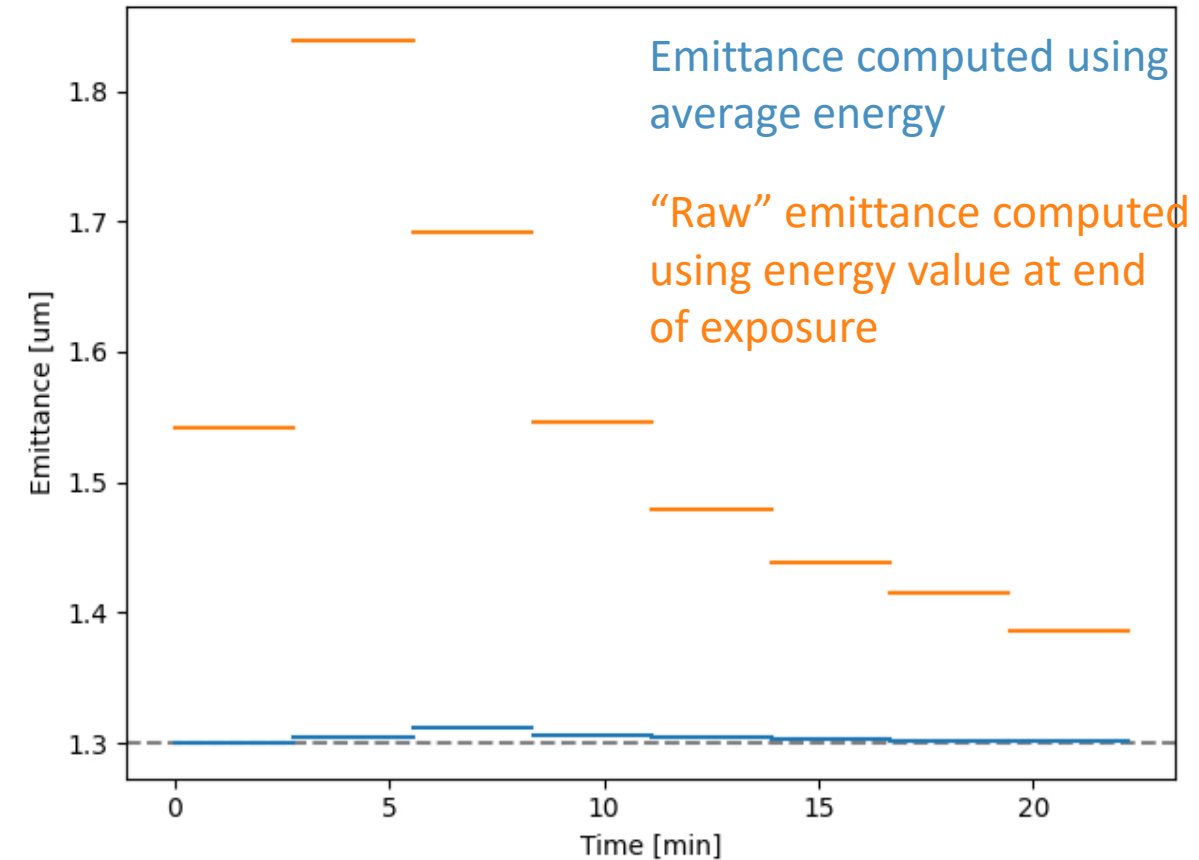
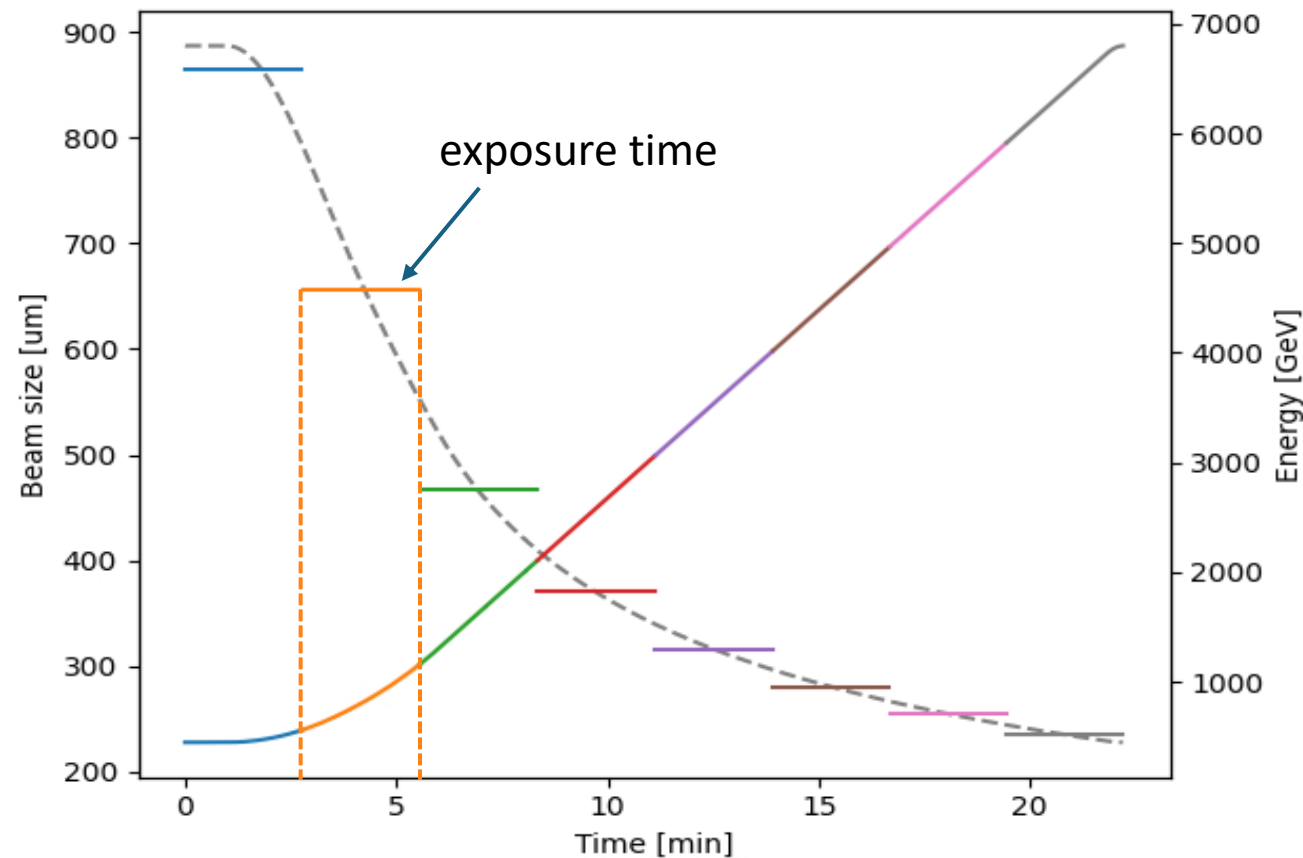
$$\varepsilon = \gamma \frac{\sigma^2}{\beta}$$

Within the exposure time of  $\sim 3$  min, the BGC measure the integrated beam size.

During the ramp, the machine optics ( $\beta$ ) is almost constant but the energy ( $\gamma$ ) changes.

Can we use the average energy of each integration period to obtain the emittance?

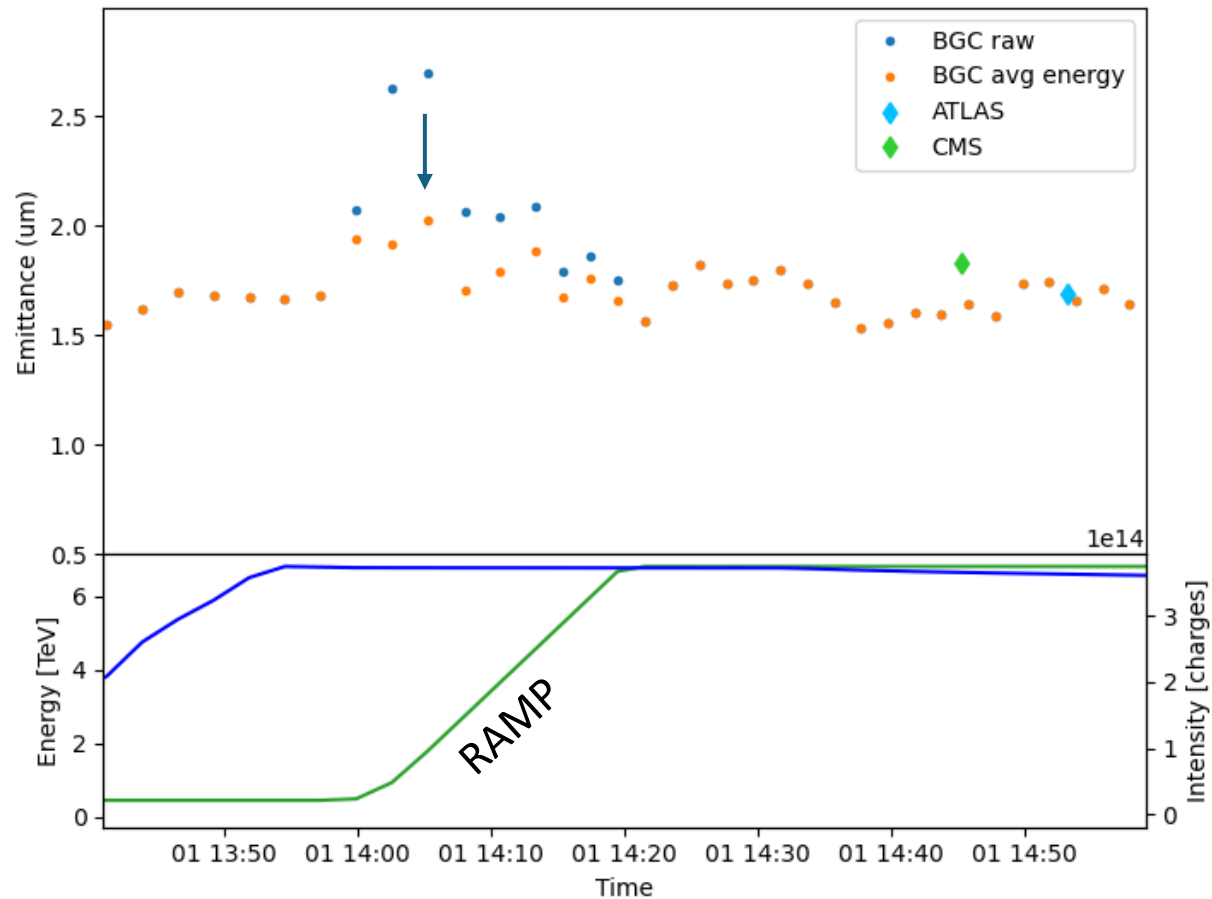
→ from a quick numerical check, it seems OK



# Horizontal emittance during ramp

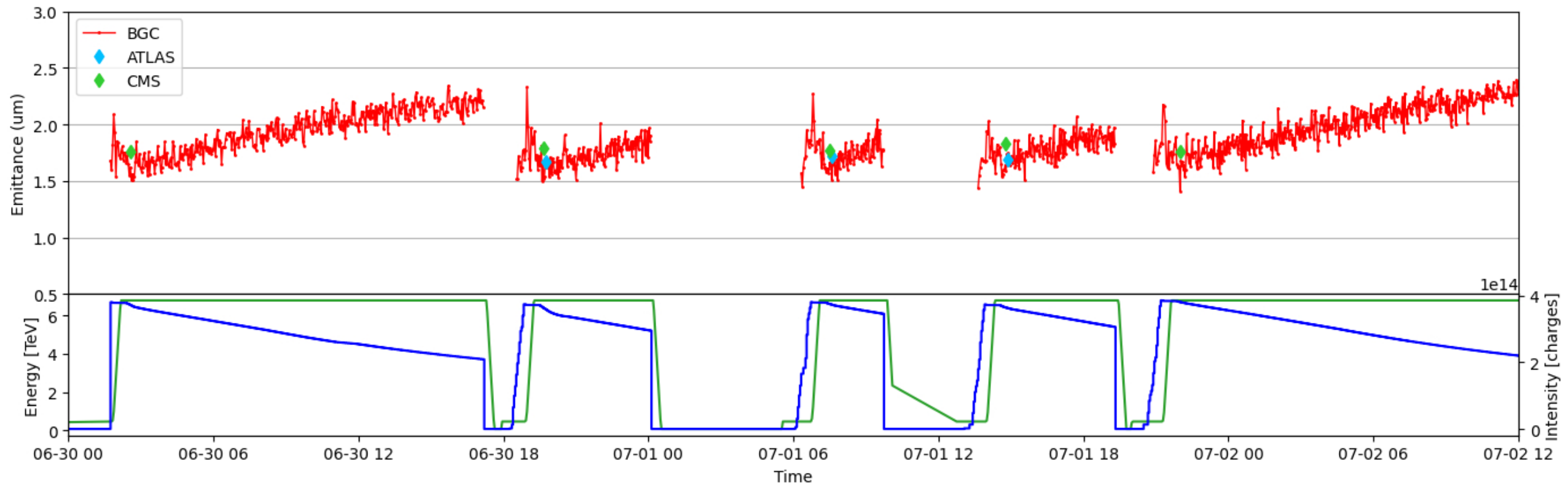
Using the average energy value on real data, the retrieved emittance during the ramp remains confined within the fluctuation of the BGC measurement

But some jumps still appear at the beginning of the ramp, physical or just a BGC artefact?



# Horizontal emittance over some fills

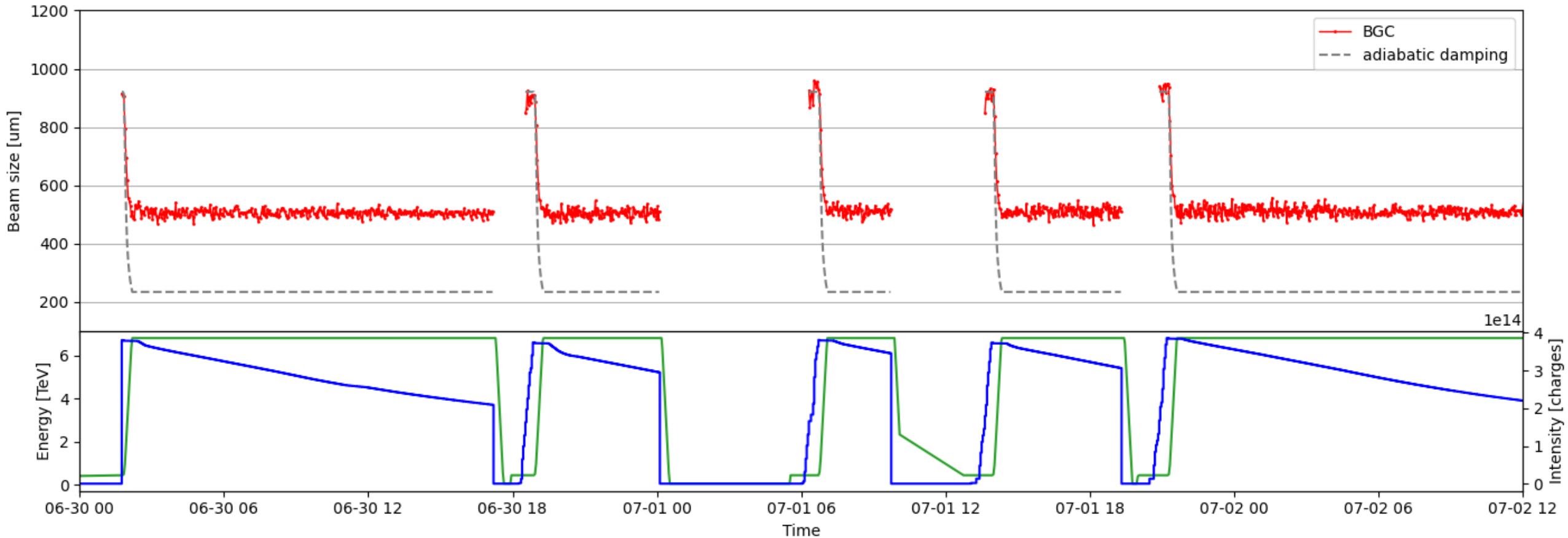
- horizontal emittance is quantitatively ok compared to emittance scans (de facto LHC reference)
- emittance growth resolvable during stable beams (SB)
- emittance measurement in ramp shows residual spikes. Investigations needed to check if instrumental artefact or physical



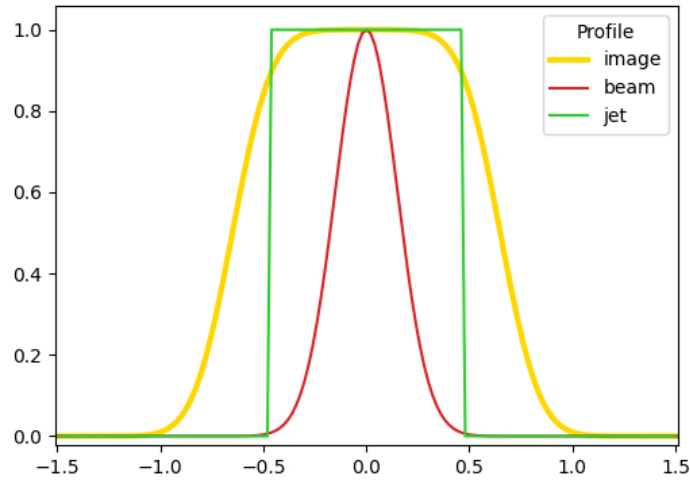


# Vertical measurements over some fills

- vertical size measurement looks qualitatively ok at injection and start of ramp (no spikes!)
- fitted size “saturates” at mid ramp because of jet thickness, with no change detectable

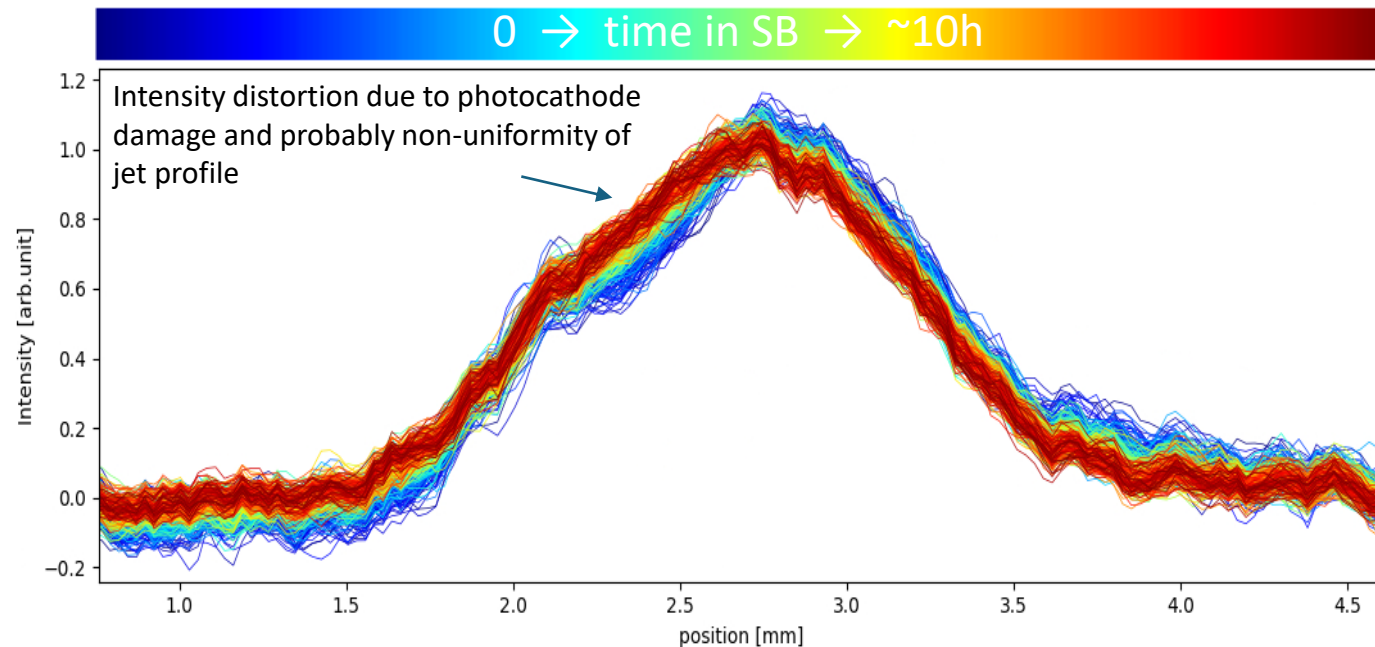


# Vertical measurements throughout SB



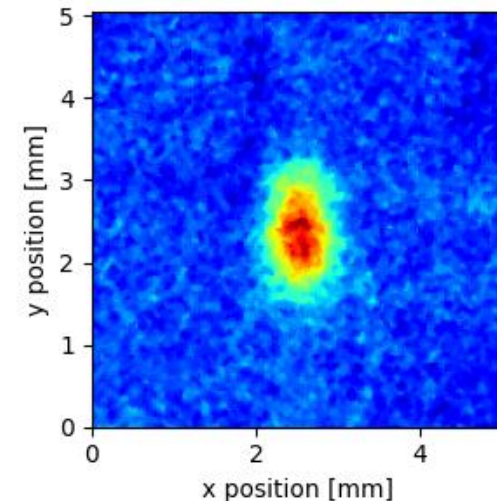
Ideally, the vertical profile of the image should have

- intensity plateau determined by uniform jet distribution
  - Gaussian edges determined by beam distribution
- the beam size information is only encoded in the edges and a **deconvolution should suffice**



In reality, profiles are not as straightforward and no general method to retrieve beam size found so far

Work in progress...



# Neon bottle consumption

For reference, as of today 26/07/2024

