Orbit stability in the IRs during intensity ramp-up

Joint LHC CWG-MPP meeting

June 3rd, 2016

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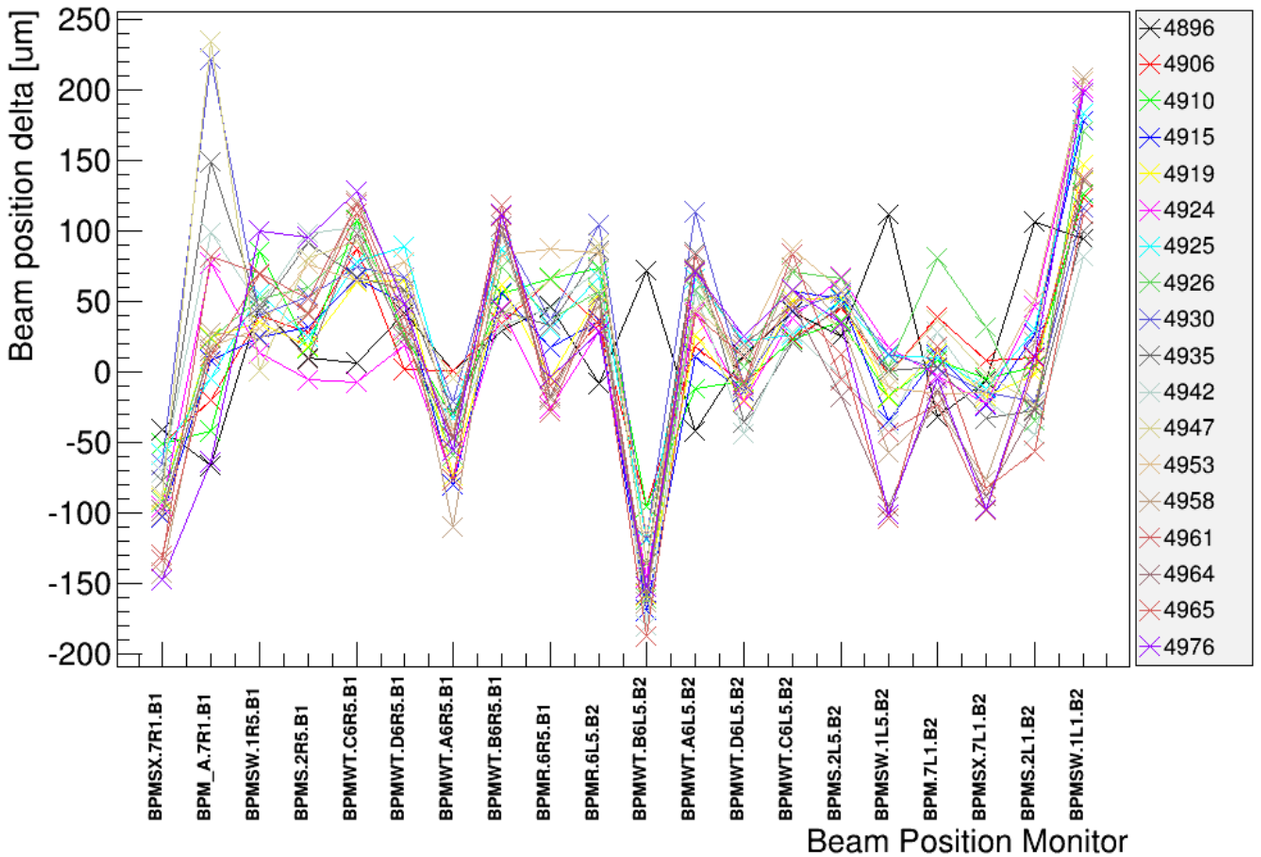
with input from R. Bruce, S. Redaelli, A. Valloni, J. Wenninger

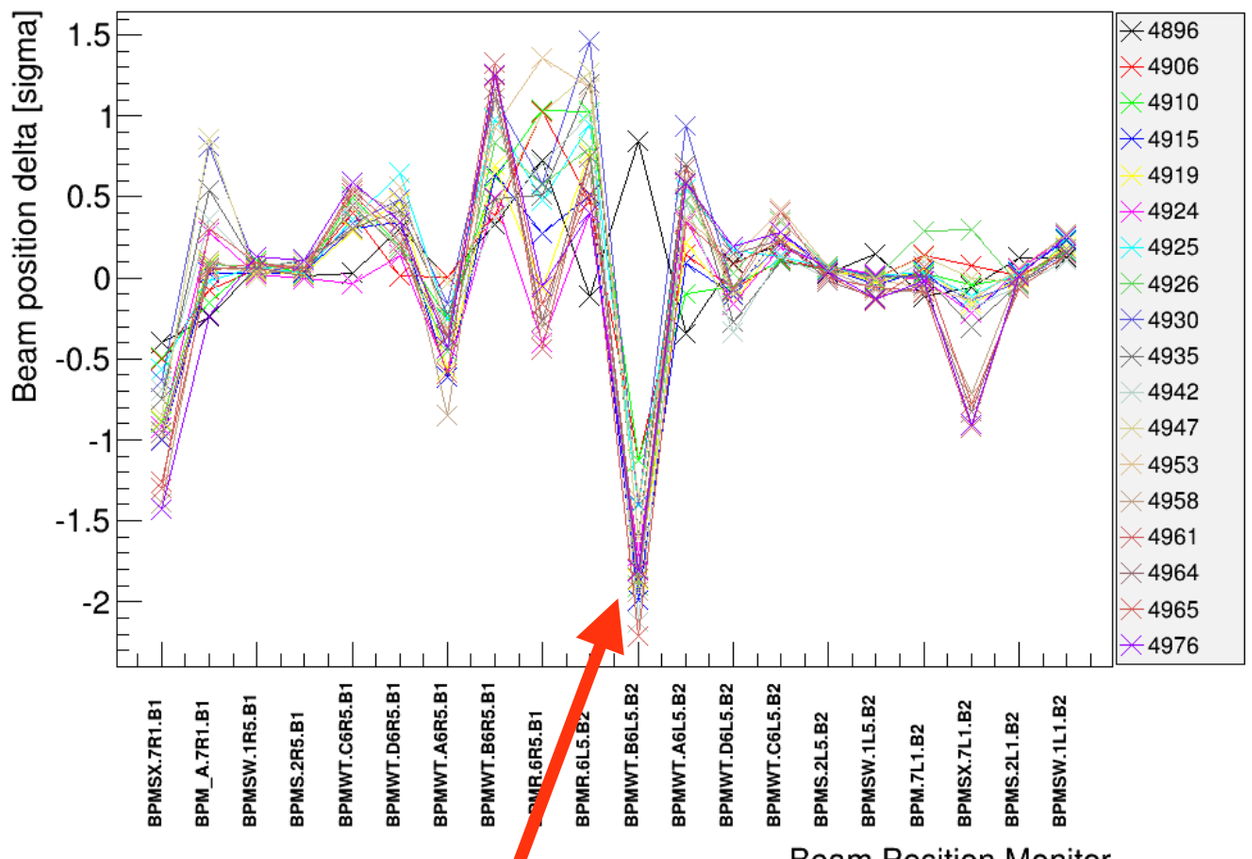
Outline

- Orbit stability near IR5 TCLs and TOTEM pots
- Analysis of interlocks for BPM collimators

Orbit stability in IR5

- Fill-to-fill analysis to determine orbit reproducibility in BPMs near triplet, TCLs and XRP and evaluate suitability of current 0.5 mm margin
- Reference: first 313b fill (# 4895)
- Orbit within +/- 200 um (+/- 1.5 sigma) in Horizontal:

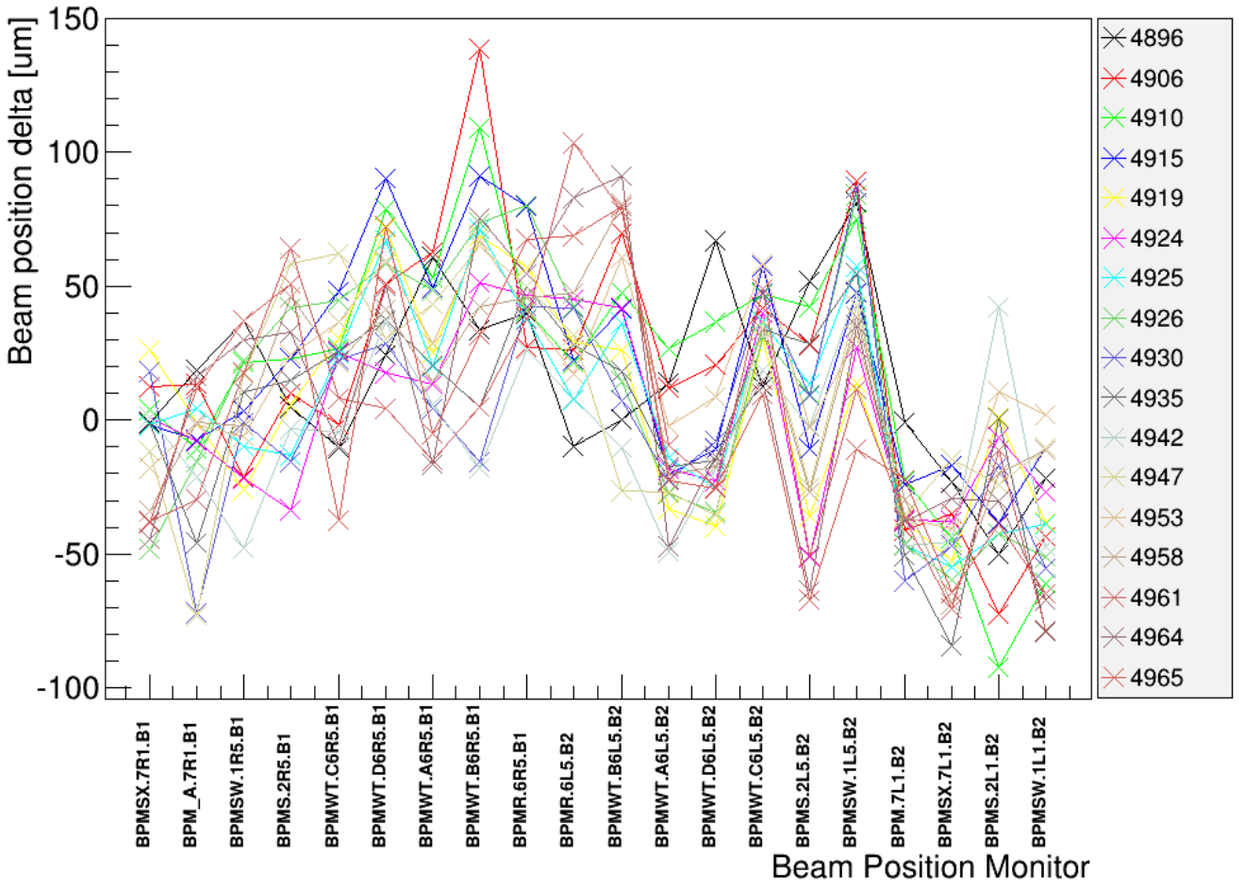


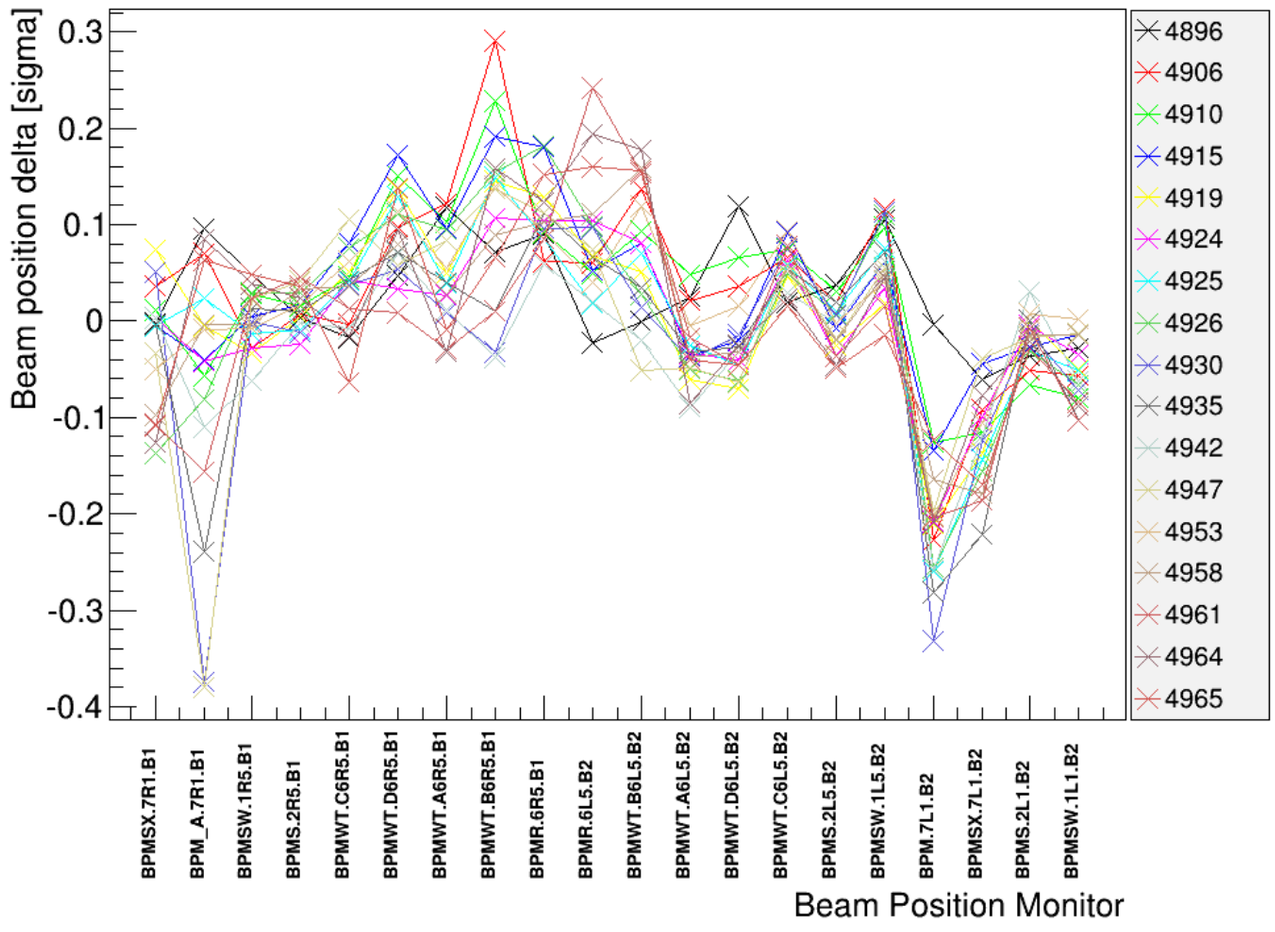


Removed from OF due to reliability issues

Orbit stability in IR5

- Orbit within +/- 100 um (+/- 0.3 sigma) in Vertical:





BPM Collimator interlocks

- Data from 32 standard physics fills during intensity ramp up
- Same analysis as done for Evian'15, determine #dumps vs threshold:
  - **Mesh in mm:** 0.1 - 1 mm, steps of 0.05 mm
  - **Mesh in sigma:** 0.2 - 2 sigma, steps of 0.1 sigma

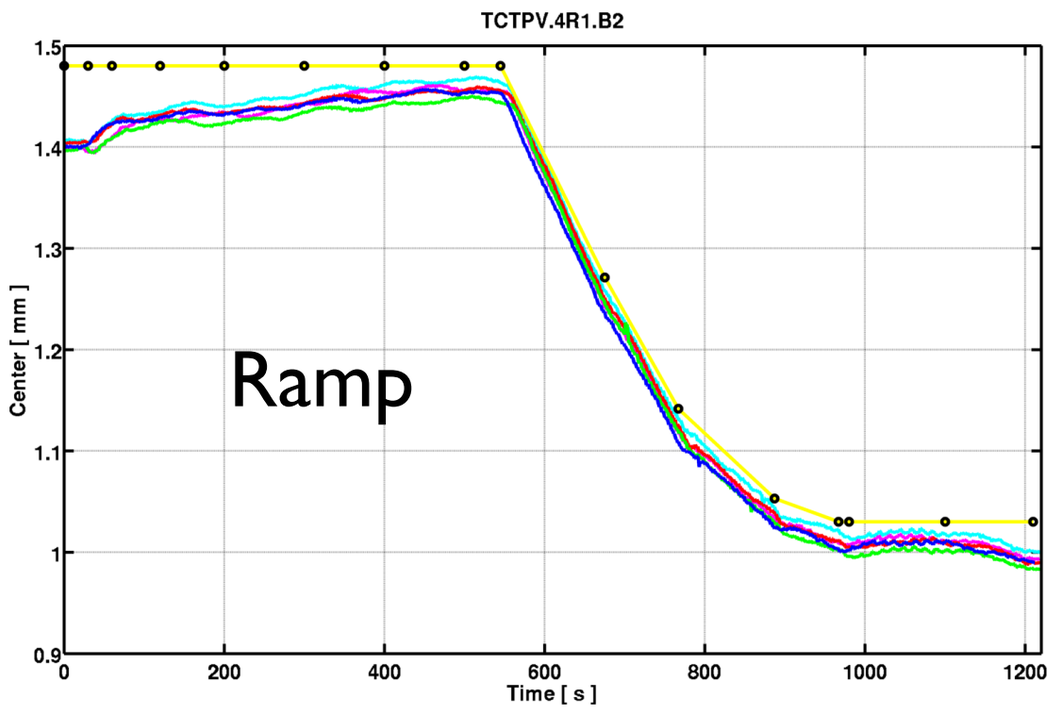
Current SIS implementation:

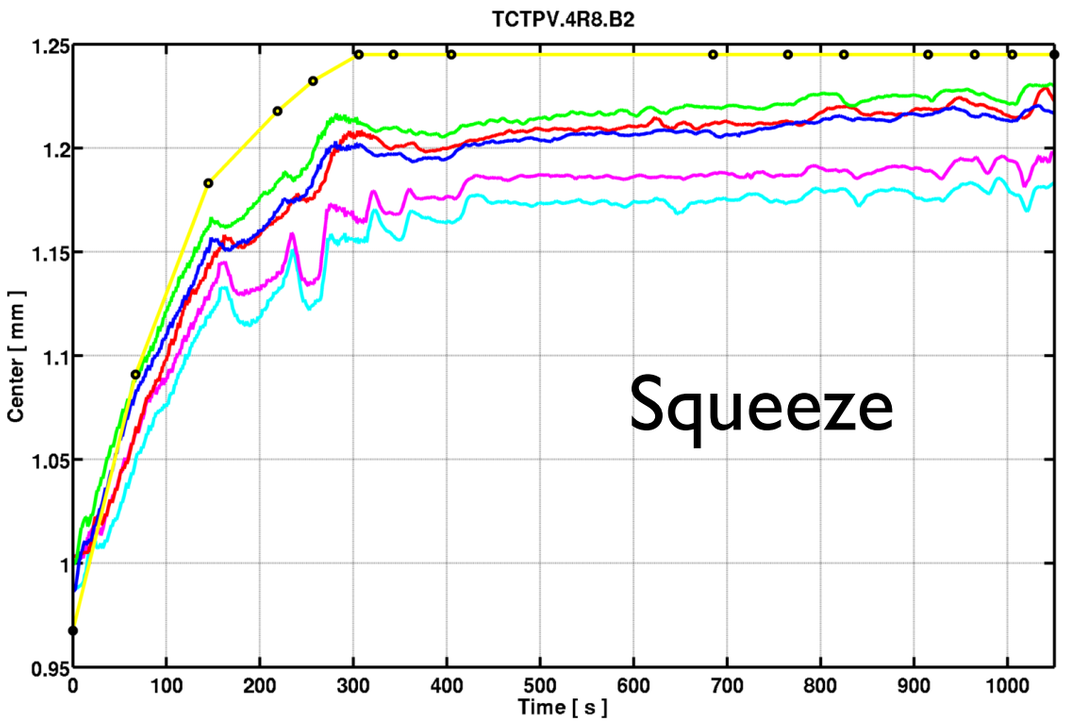
- The interlock settings consist of:
  - *A table of β^* versus collimator β and interlock tolerance in σ.*
  - *A reference emittance (3.5 μm) to define the beam size.*
- SIS logic:
  - *Reads back the appropriate β^* and the energy,*
  - *Interpolates the collimator β and tolerance for that β^*,*
  - *Calculates the beam size at the BPM,*
  - *Normalizes the two BPM readings by the beam size,*
  - *Finally applies the tolerance → interlock if both BPMs are out of tolerance*

J.Wenninger, 127th MPP meeting

BPM Collimator interlocks

- Small reminder on TCT function generation:
  - Up to 2015: TCT functions for collimator centres during ramp & squeeze generated linearly with energy and β*, using BLM-based alignment.
  - In 2016: centres follow orbit predicted by MADX, scaled to average of Up and Down BPM-based alignment centres at start and end.





A. Mereghetti, 204th CWG meeting

- Therefore for interlocks analysis, consider also the average of the two BPMs per collimator.

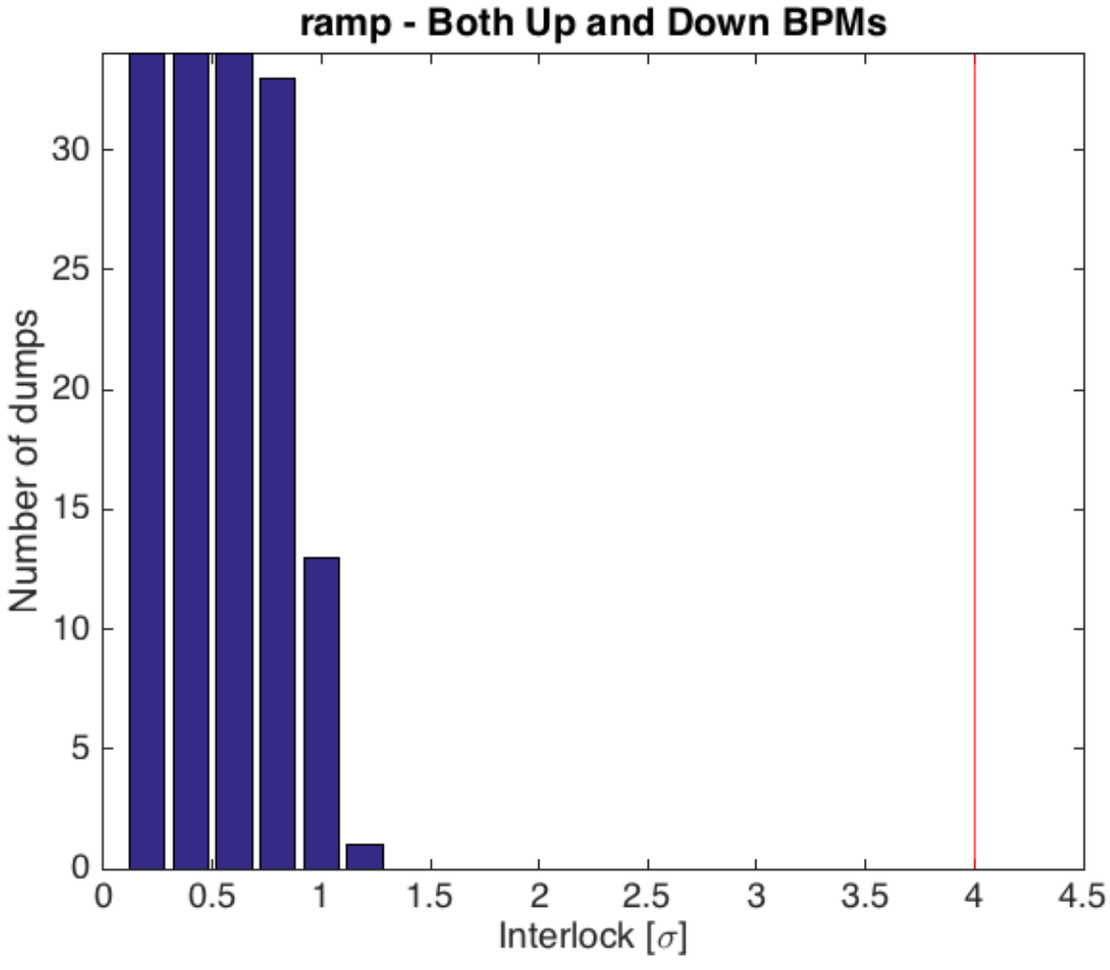
BPM Collimator interlocks

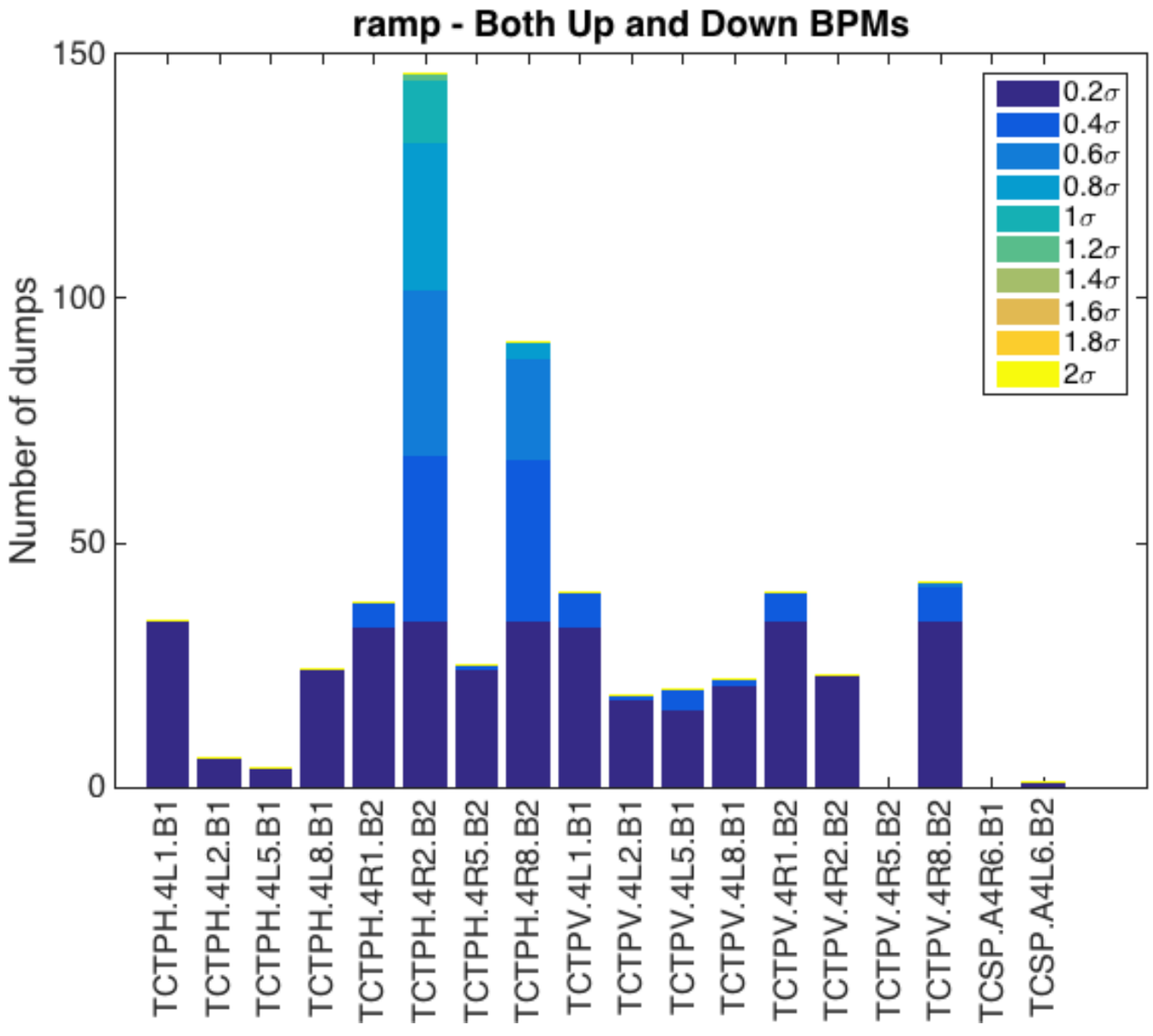
Current SIS implementation:

- All collimator BPM interlocks are running reliably (at least on the SIS side).
- All interlocks are in the interlock tree, but are currently masked.
- The interlock limits are currently set to 4σ except for:
  - ***1σ*** *in IR1 and IR5 at β*= 40 cm,*
  - ***1.5σ*** *in IR6 at β*= 40 cm (linked to IR5 β*),*
  - ***2.5σ*** *in IR8 at β*= 3 m.*

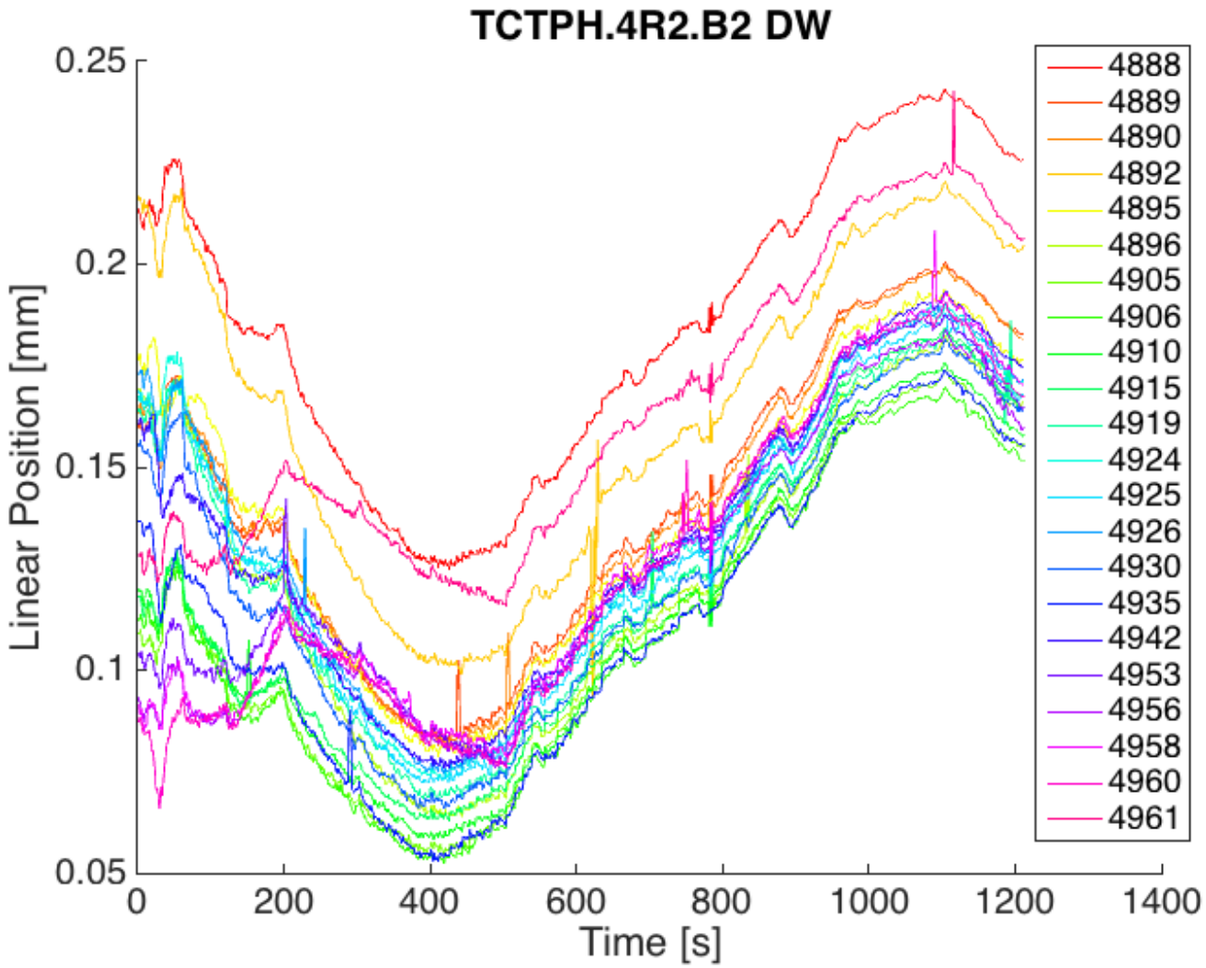
J.Wenninger, 127th MPP meeting

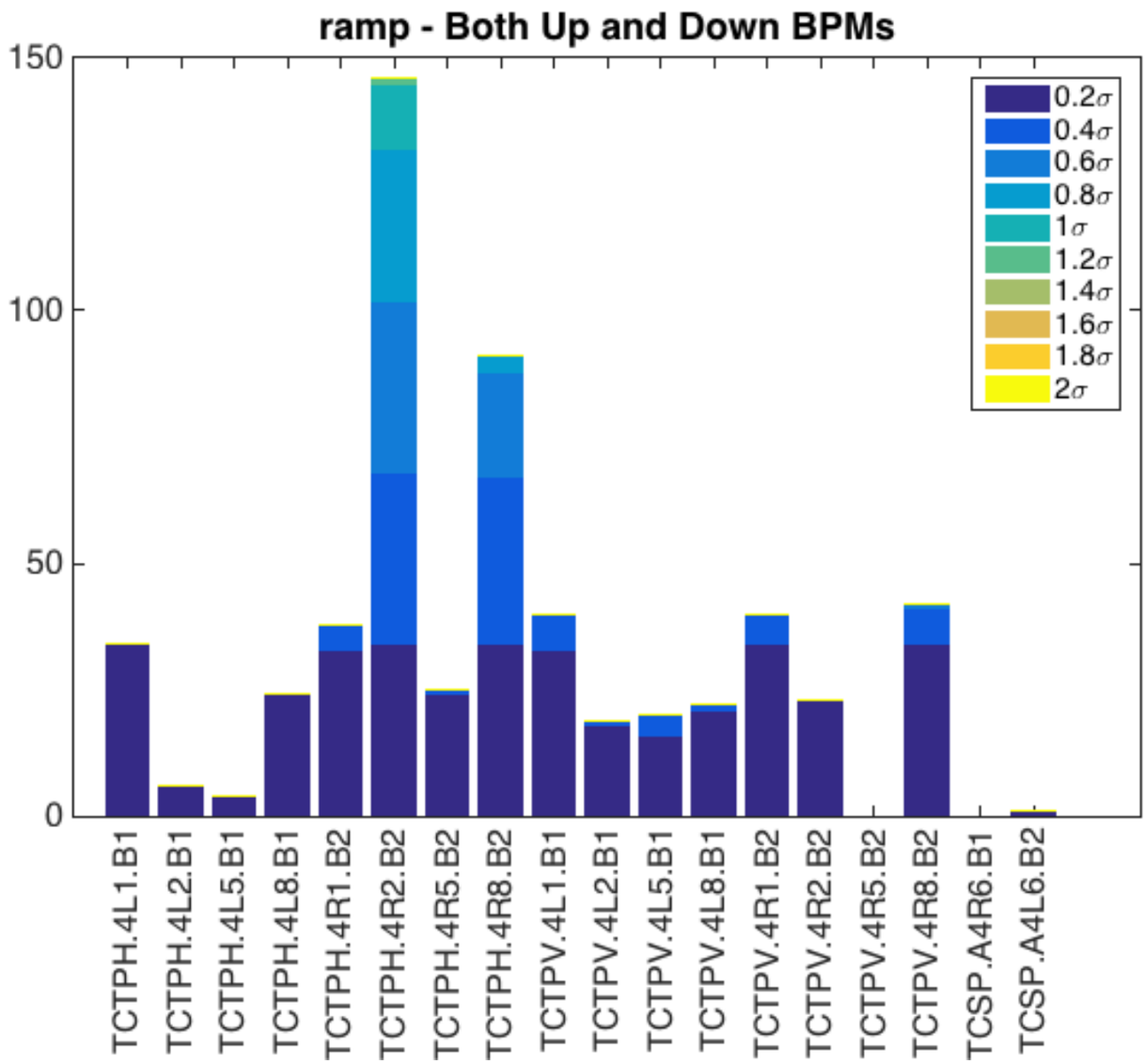
BPM Interlocks - RAMP



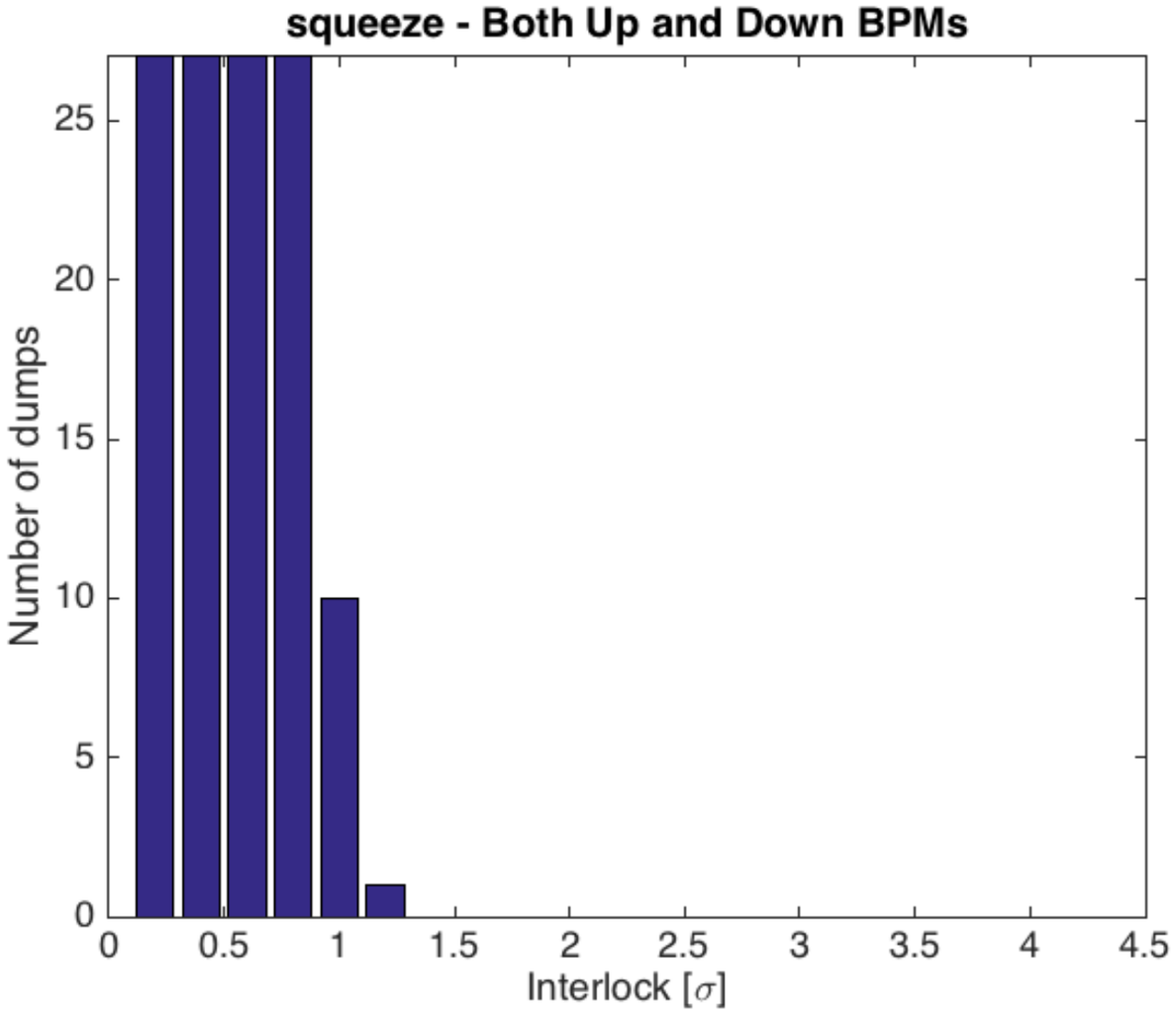


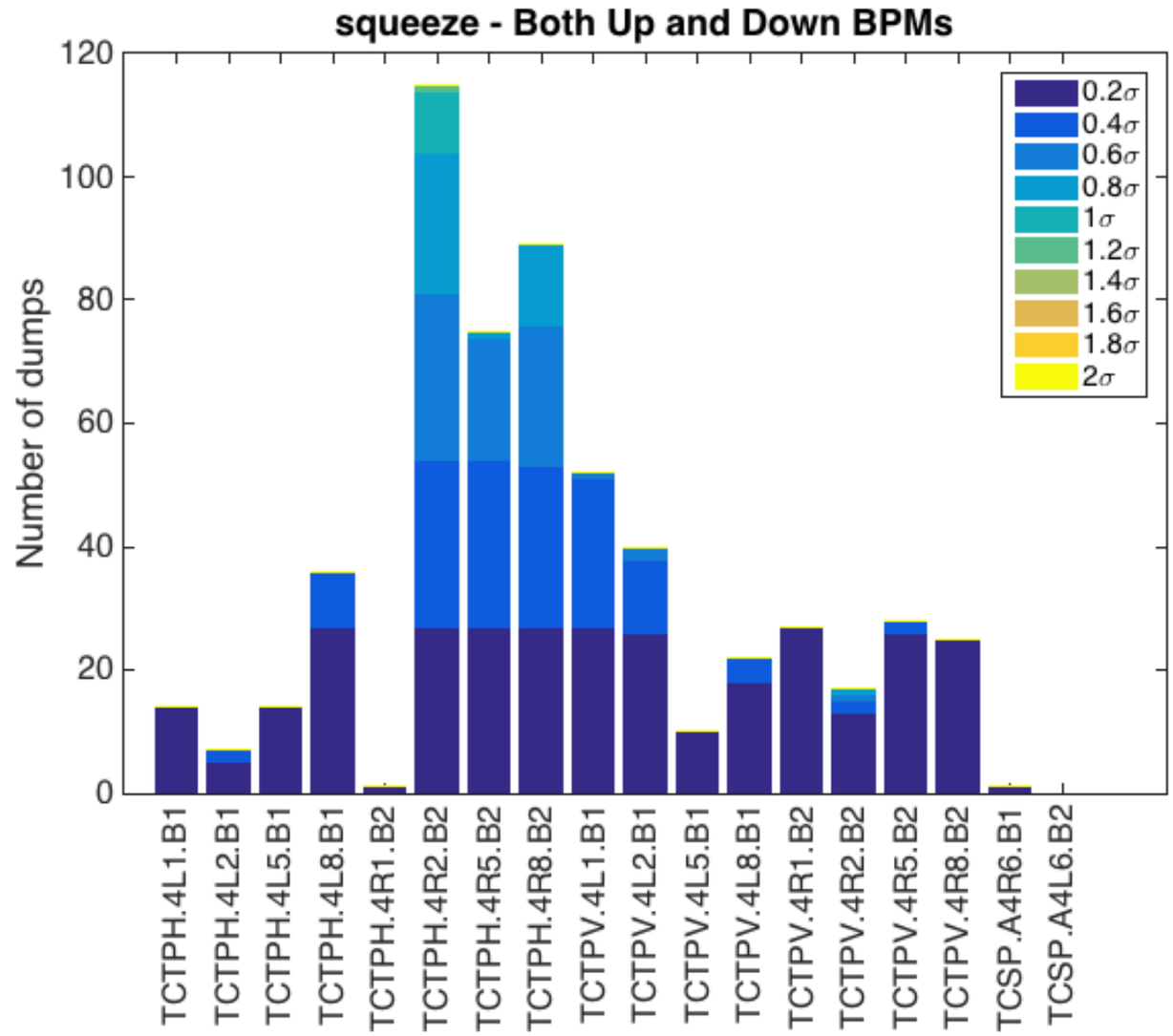
BPM Interlocks - RAMP



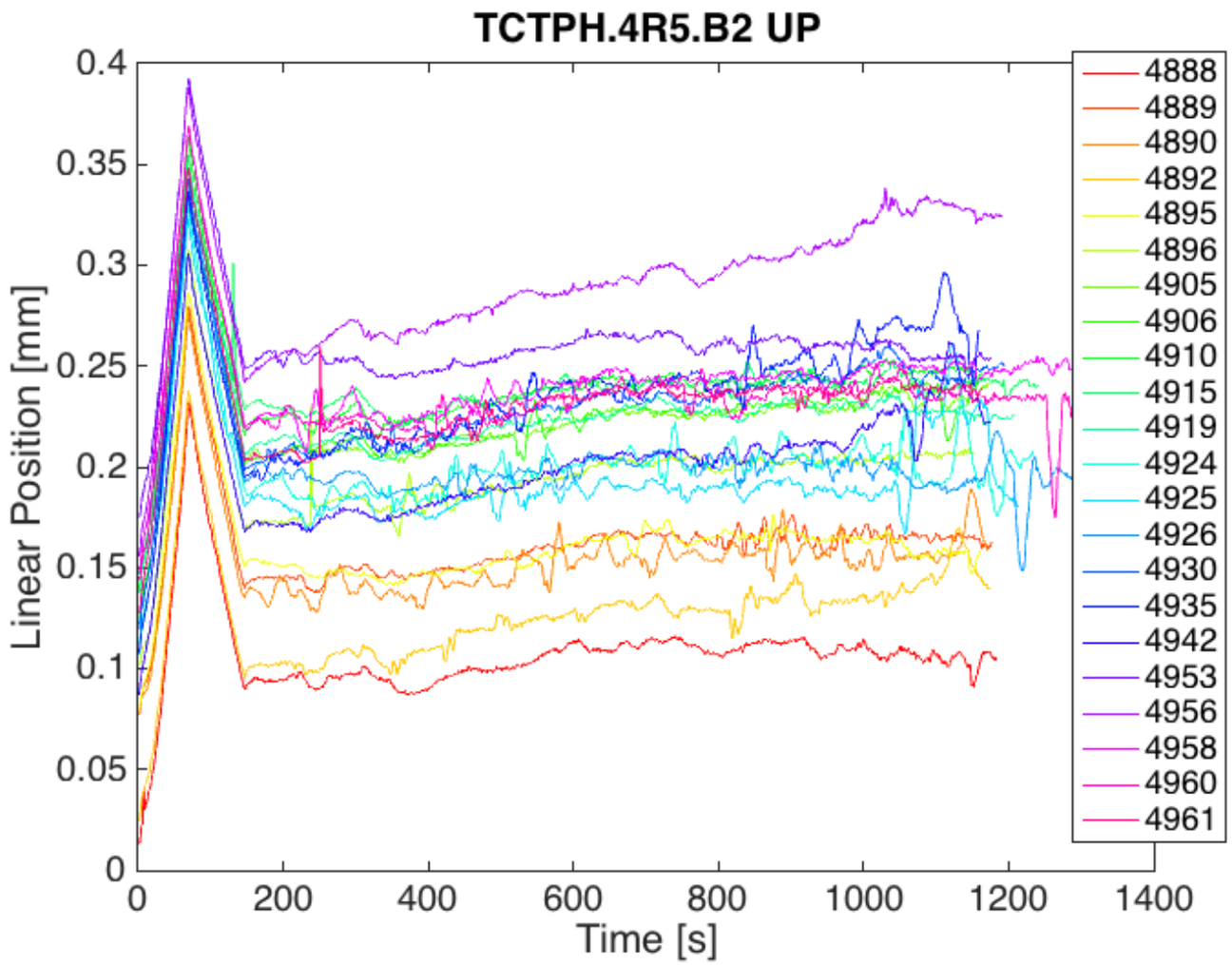


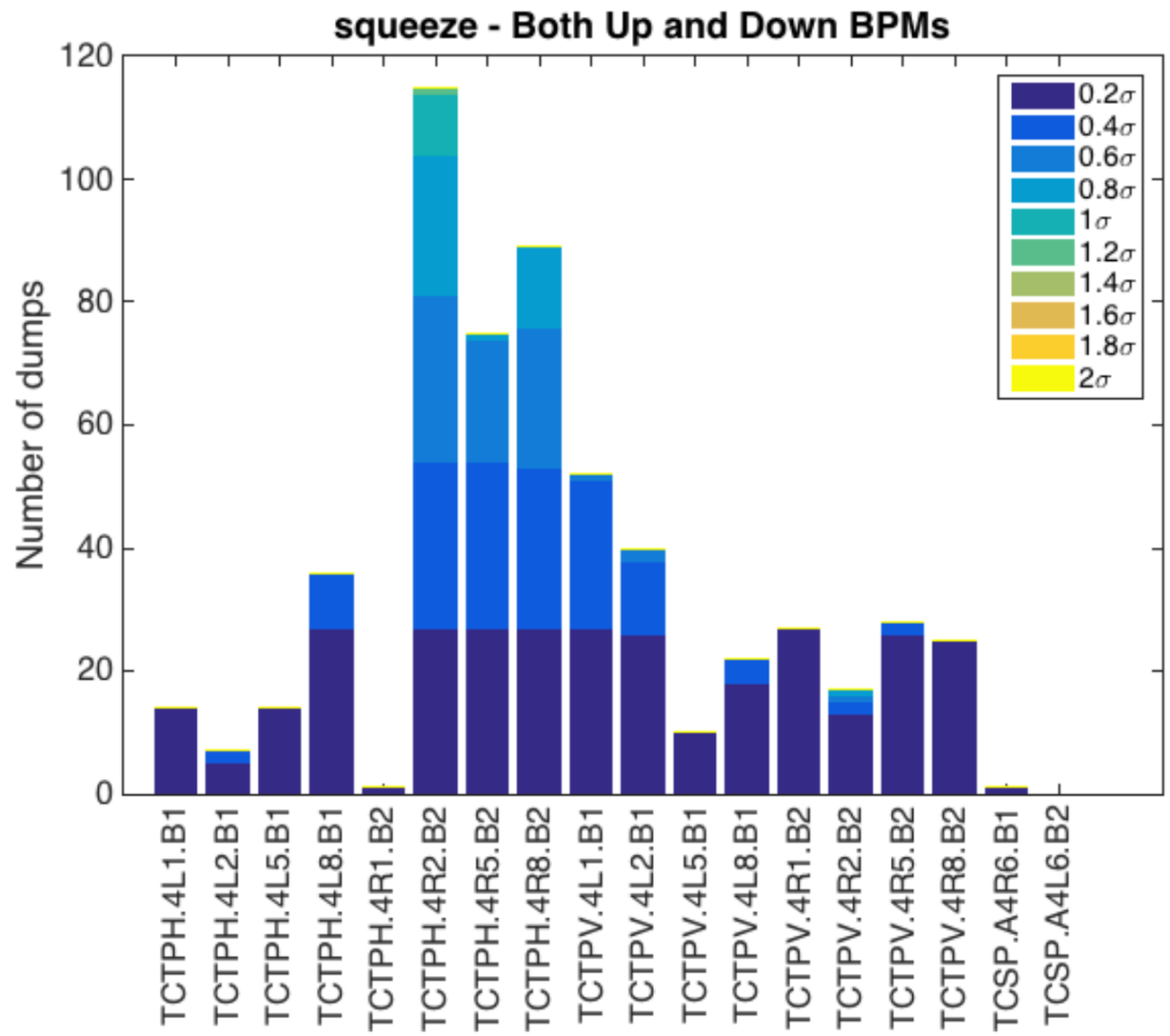
BPM Interlocks - SQUEEZE



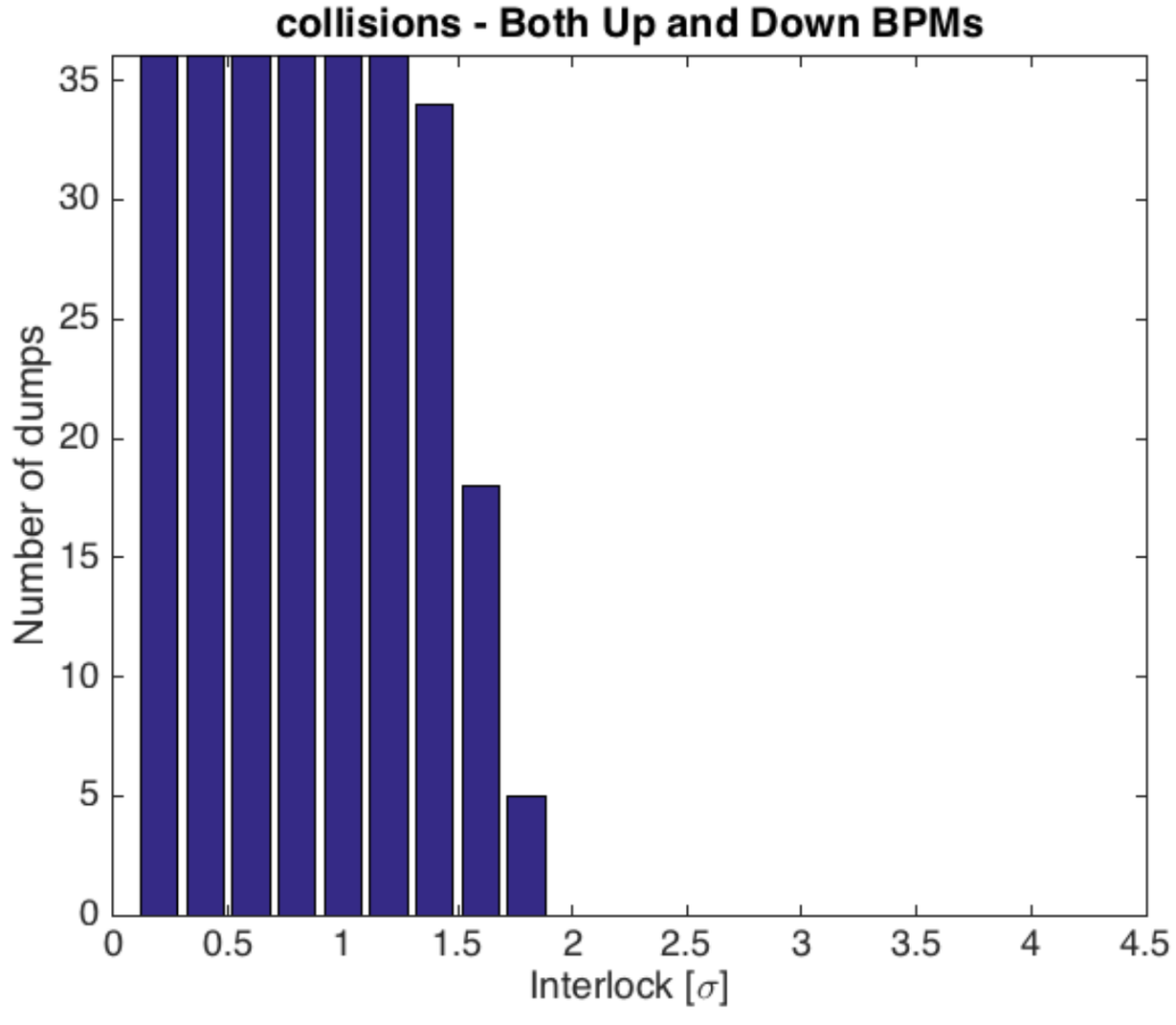


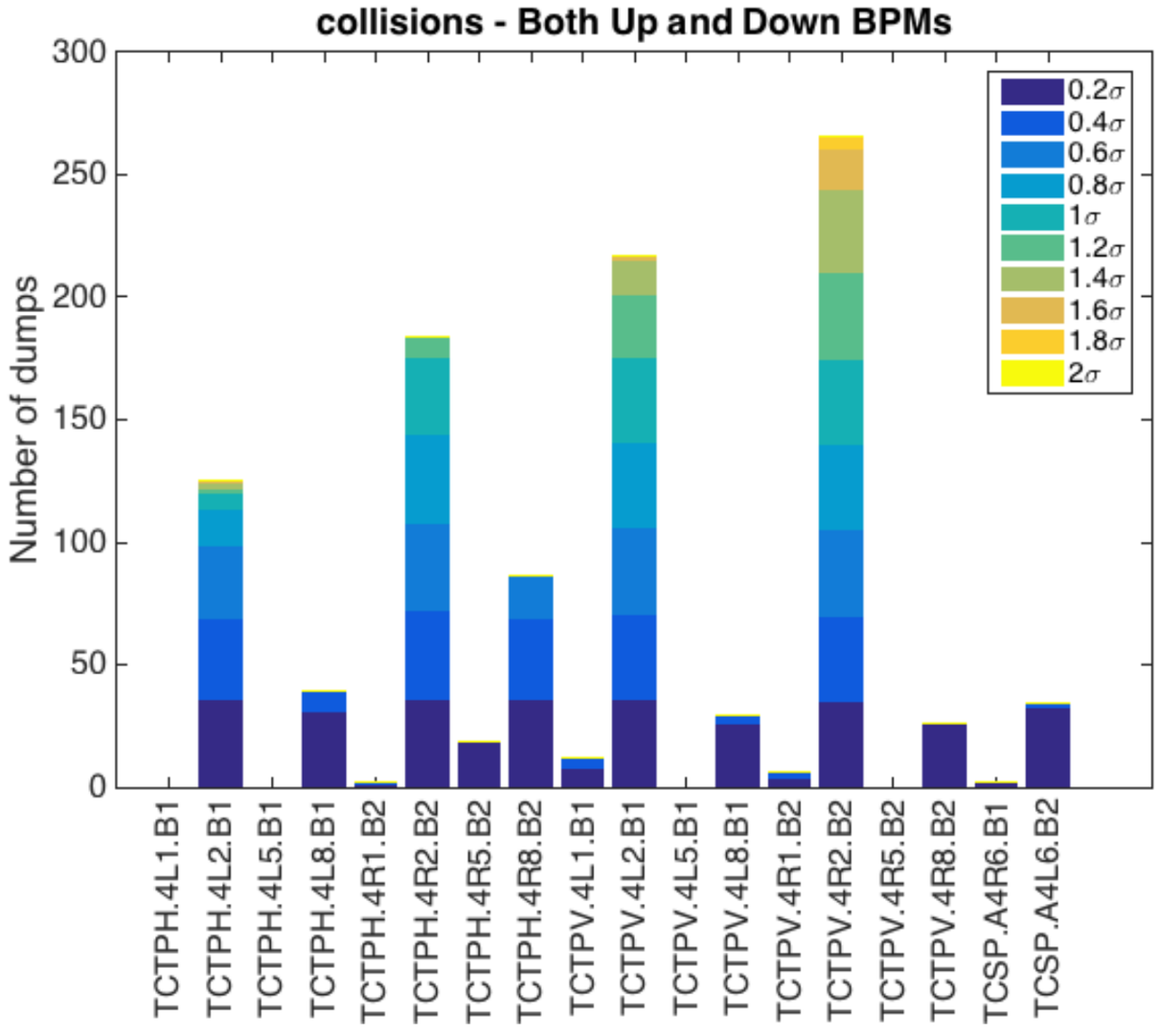
BPM Interlocks - SQUEEZE



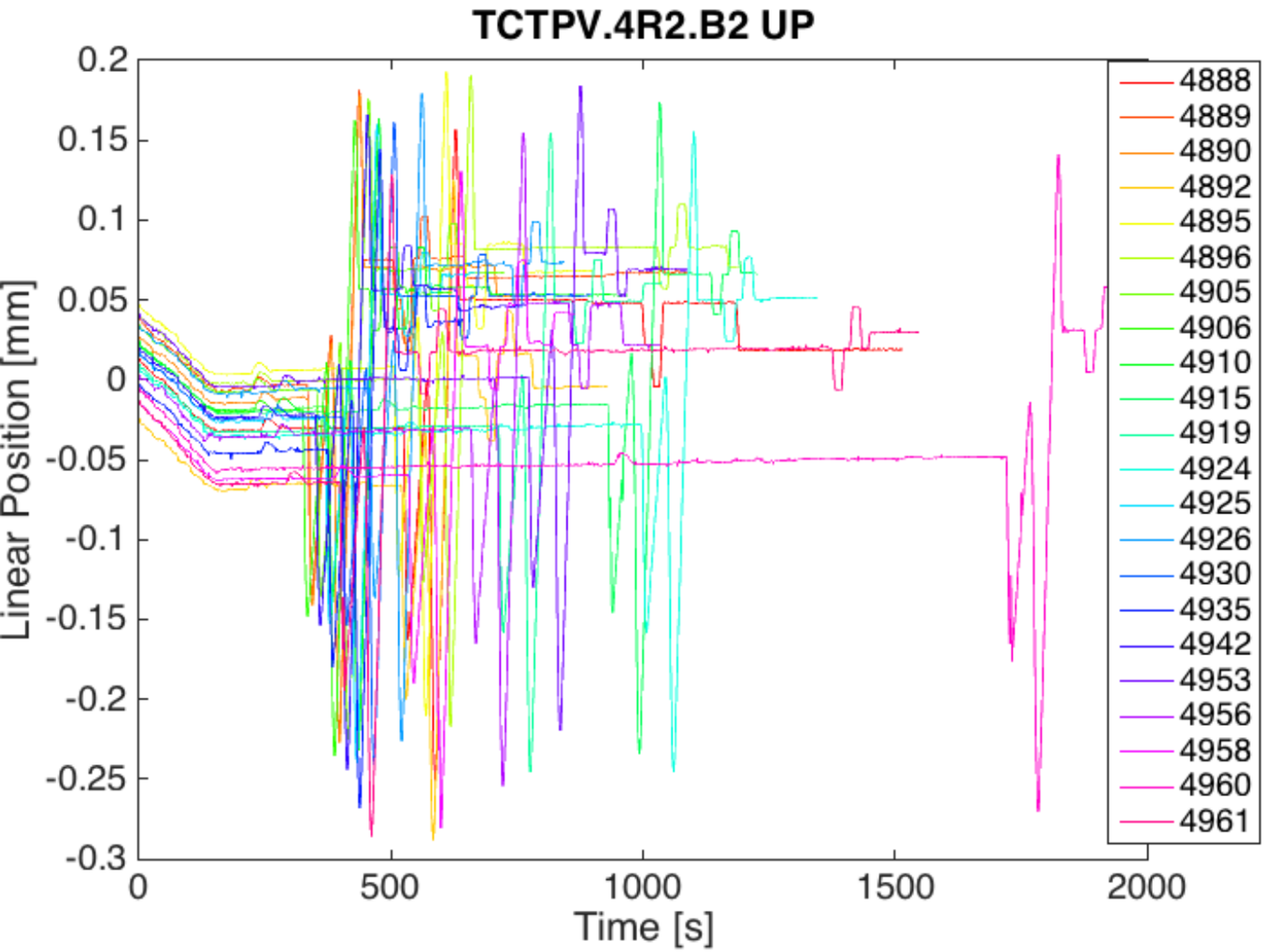


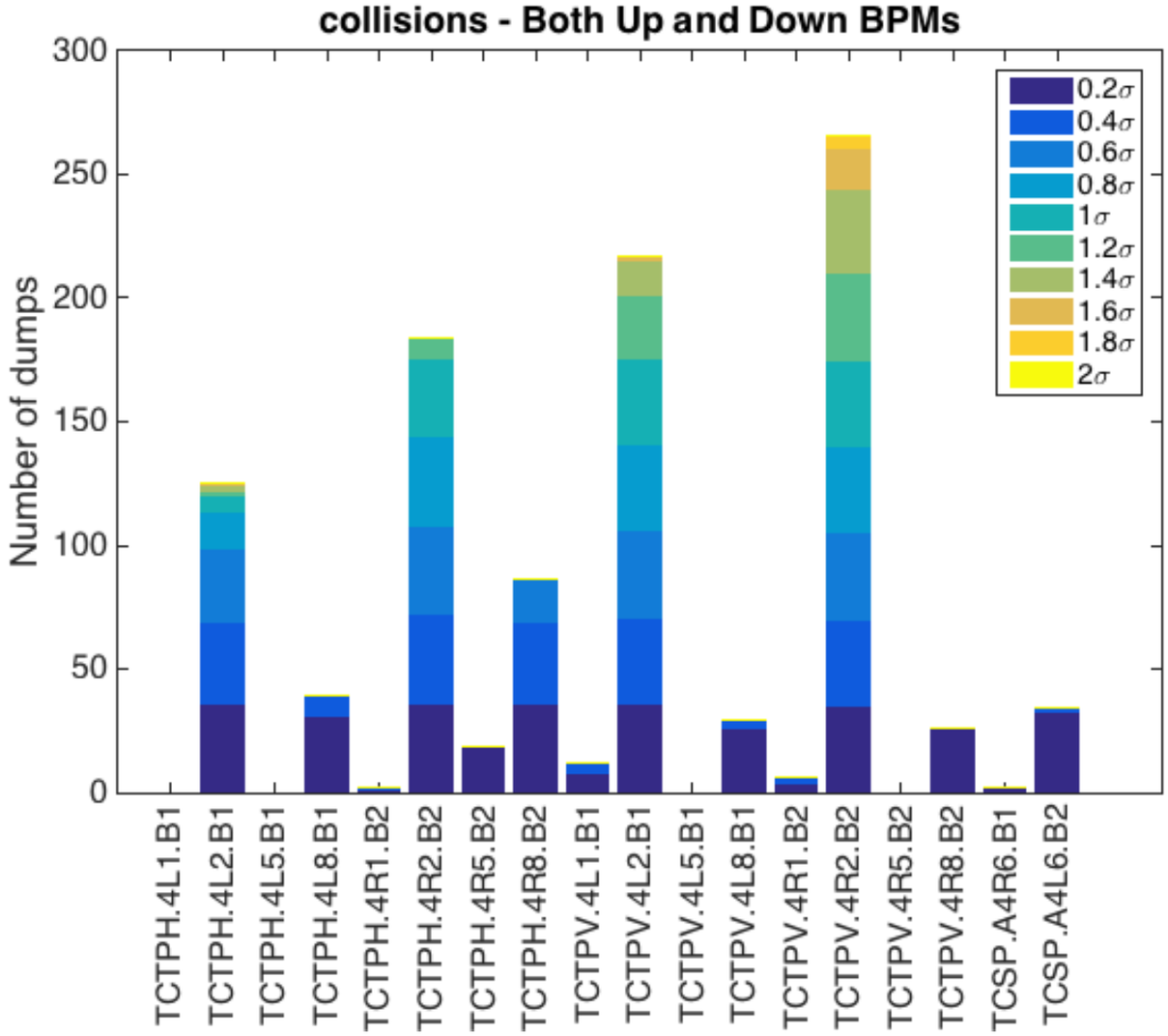
BPM Interlocks - ADJUST



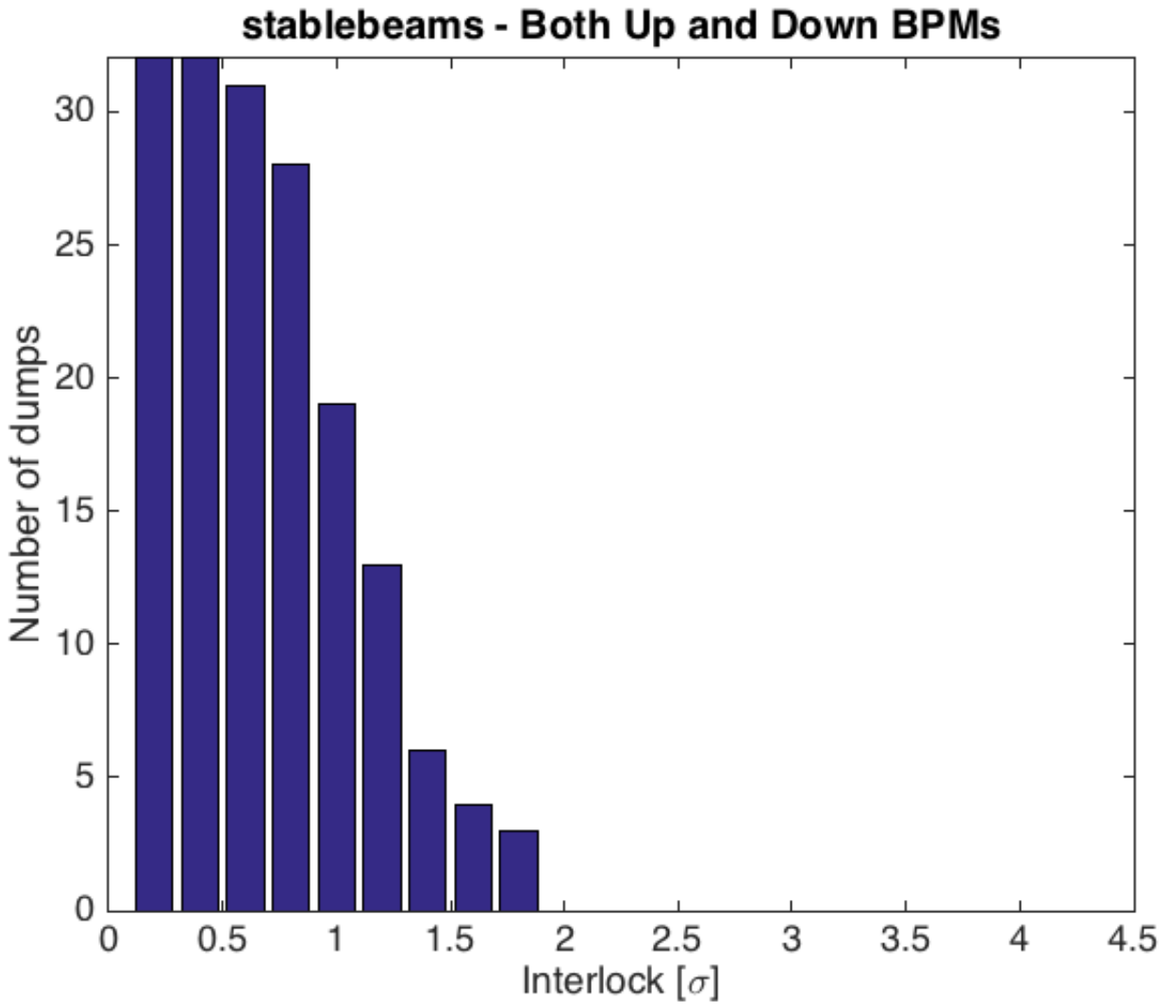


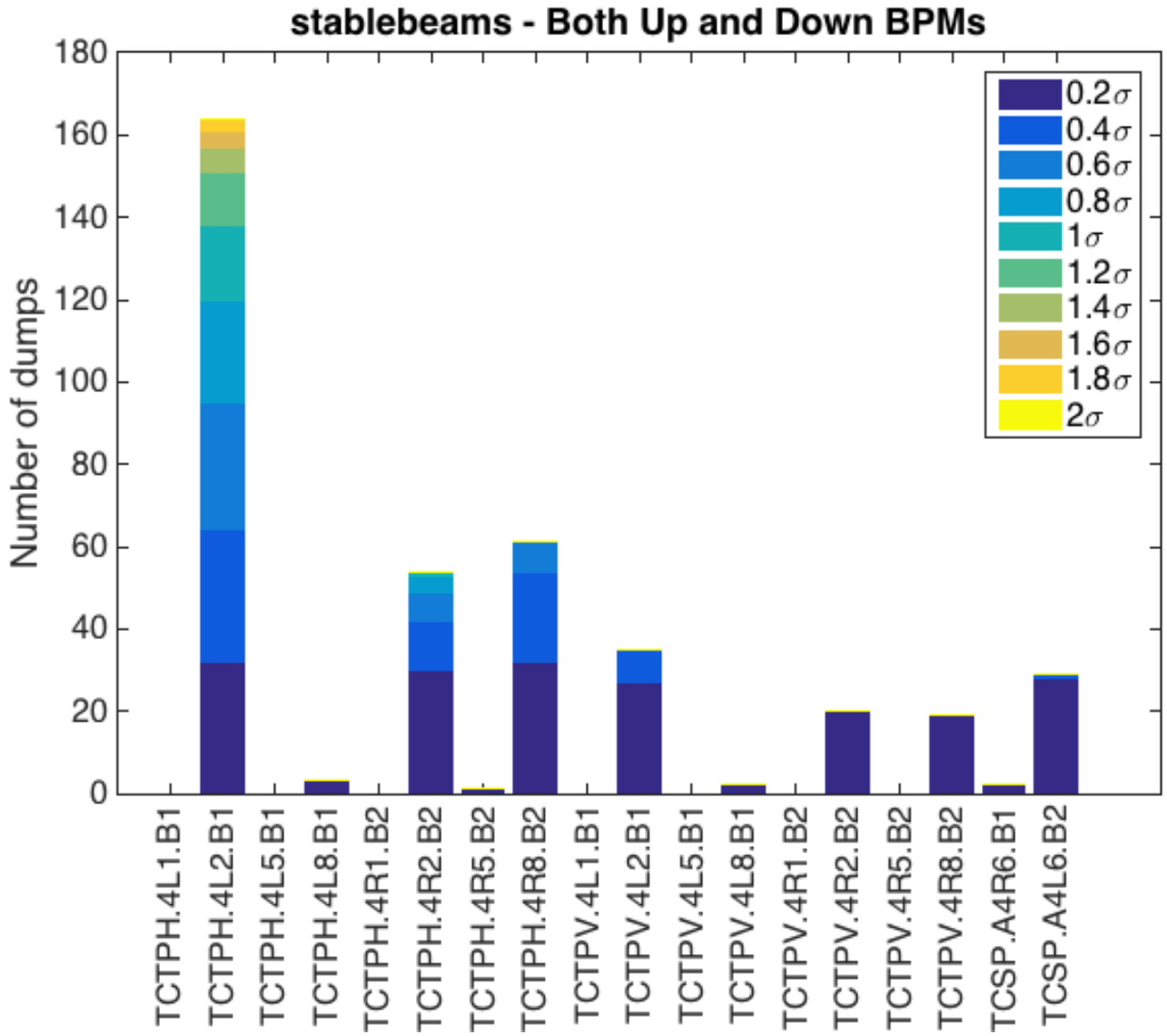
BPM Interlocks - ADJUST



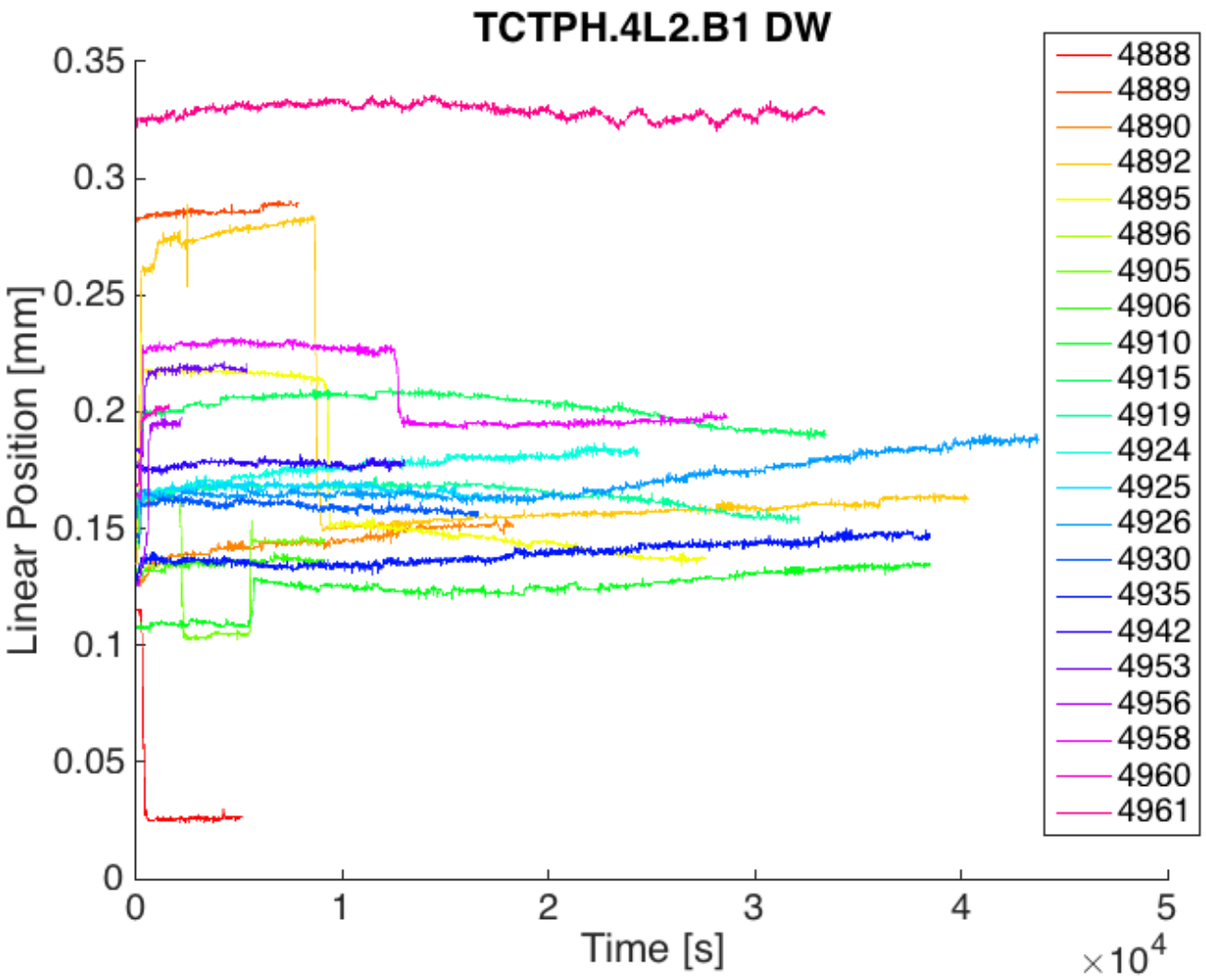


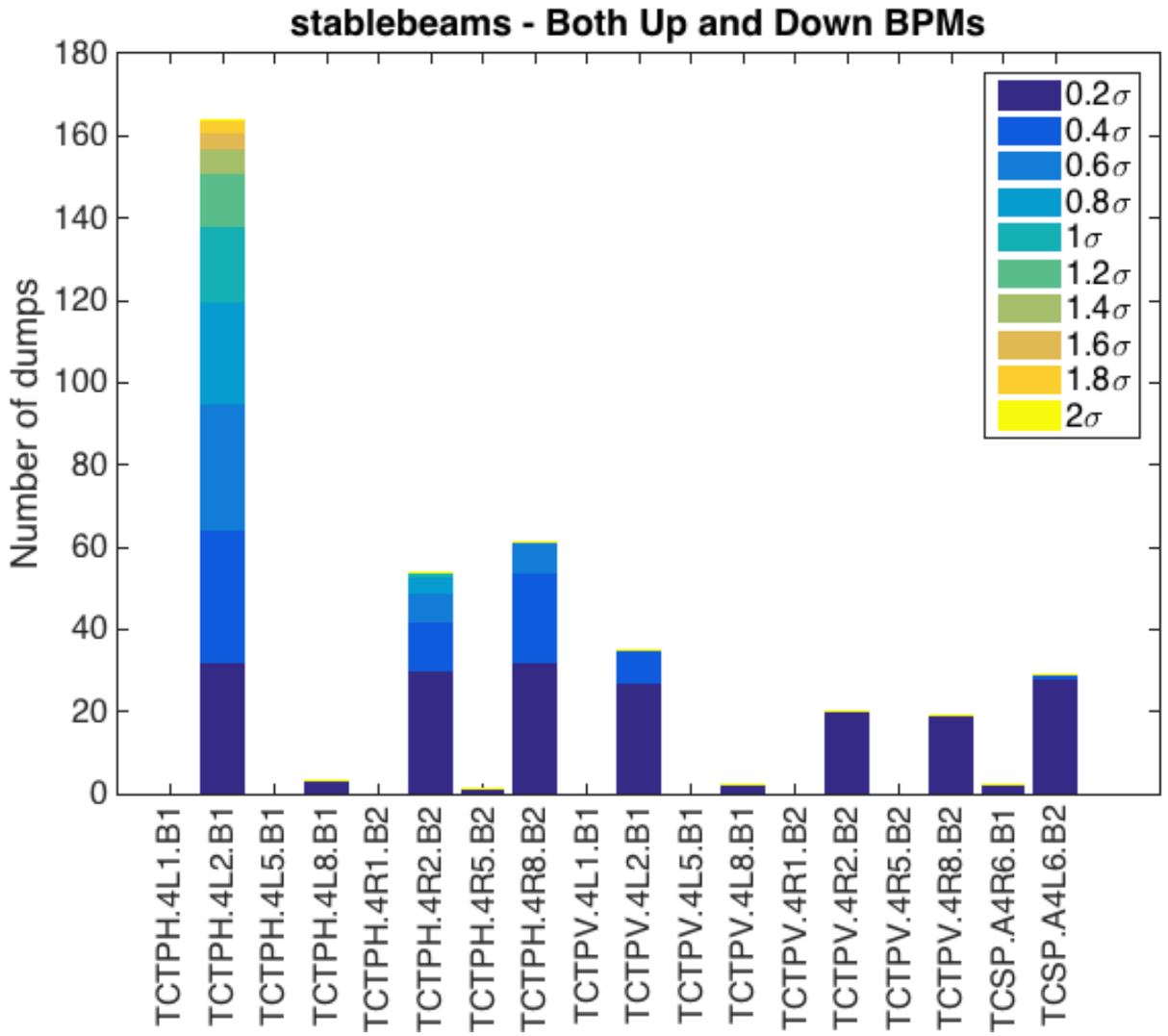
BPM Interlocks - SB





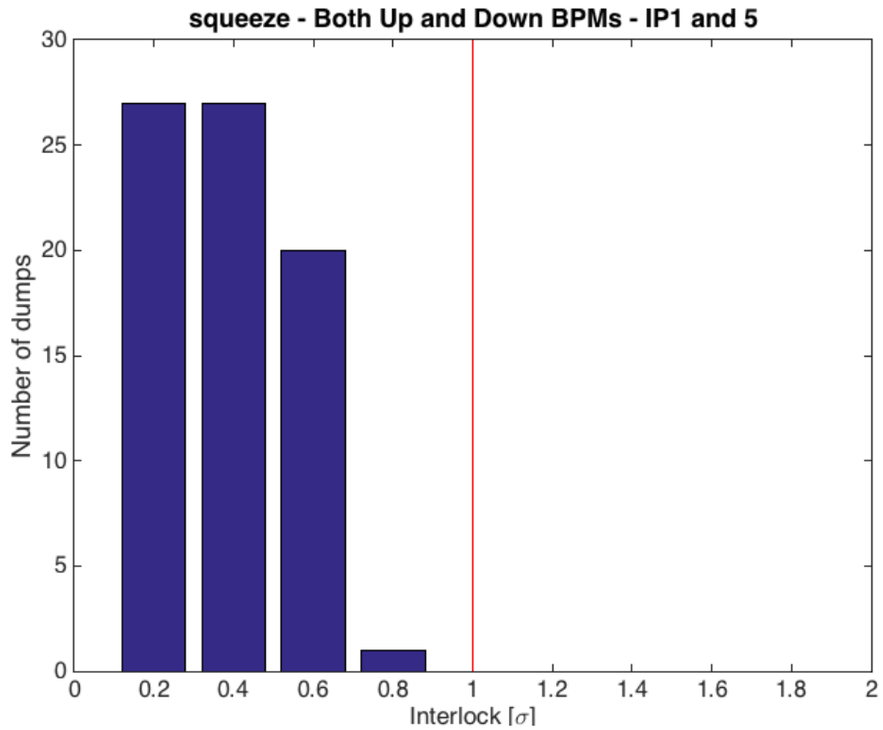
BPM Interlocks - SB

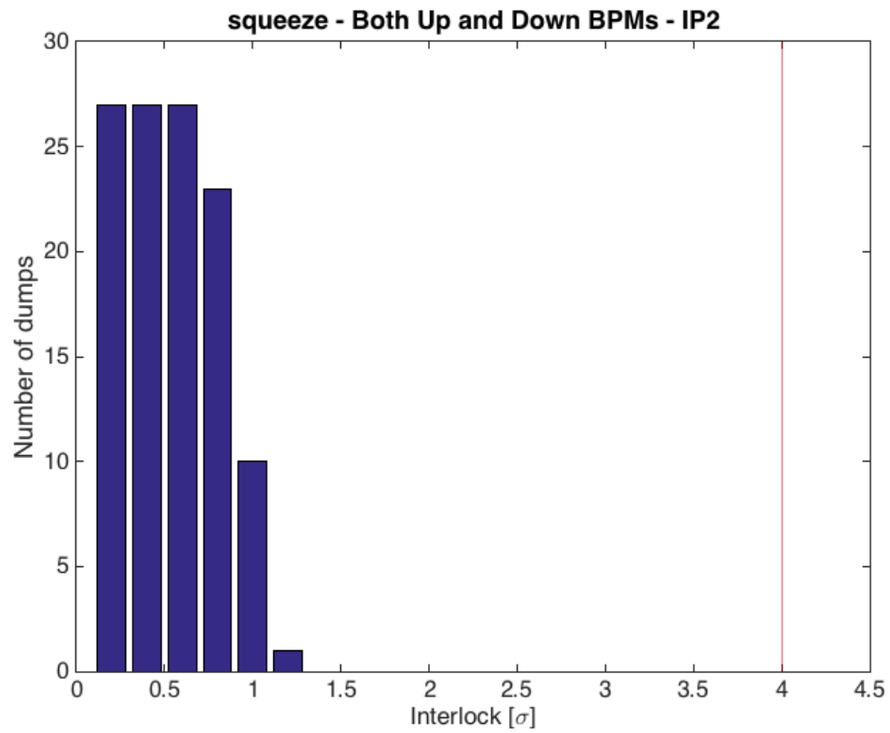


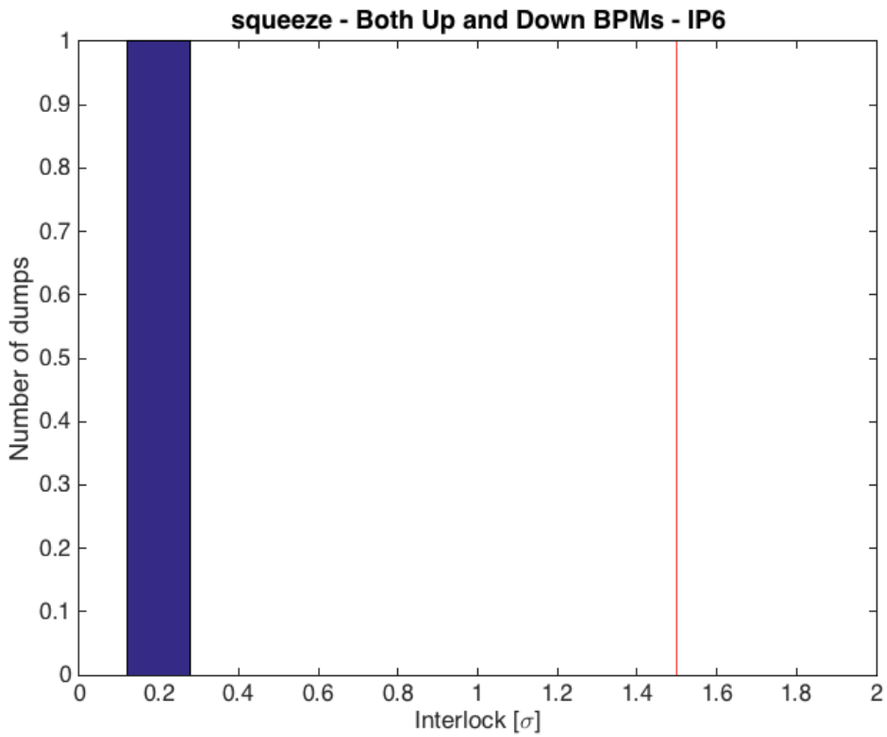


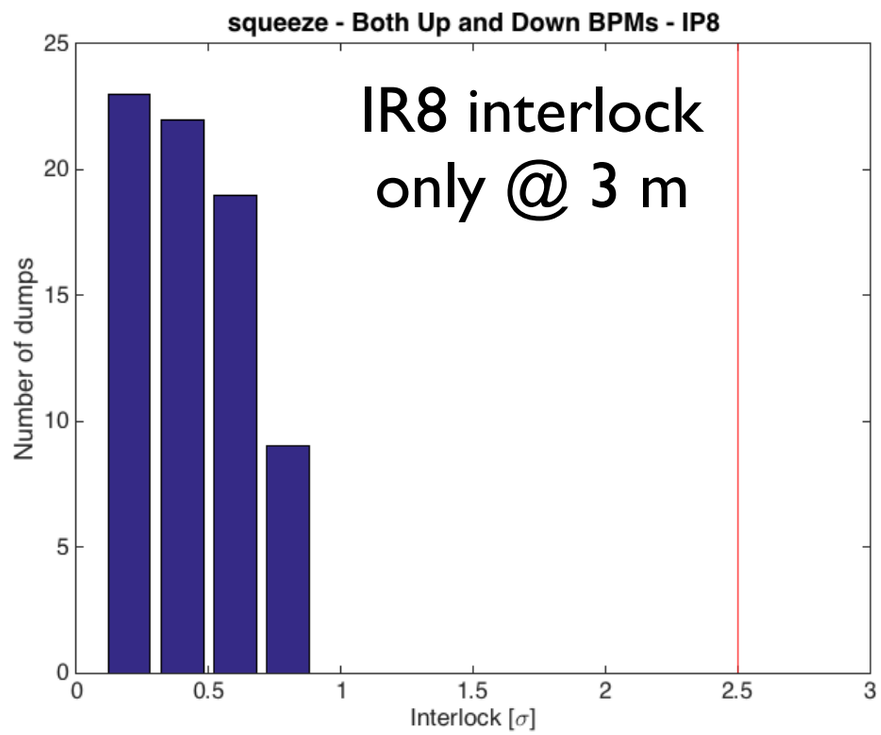
BPM Interlocks - by IR (squeeze)

IR1,5&6 interlock only @ 40 cm

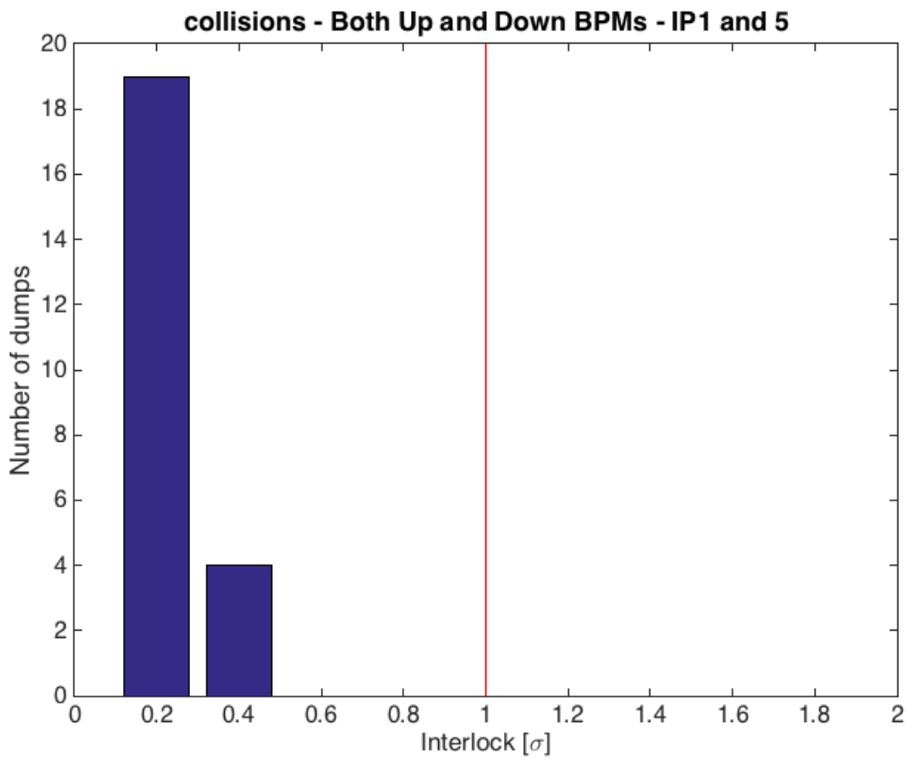


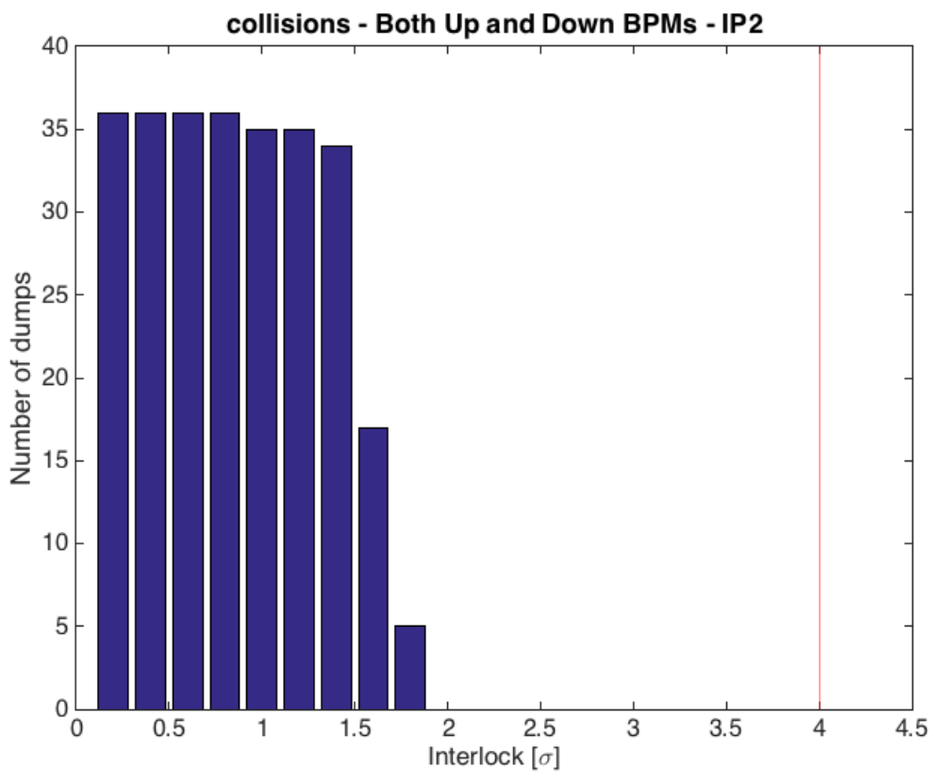


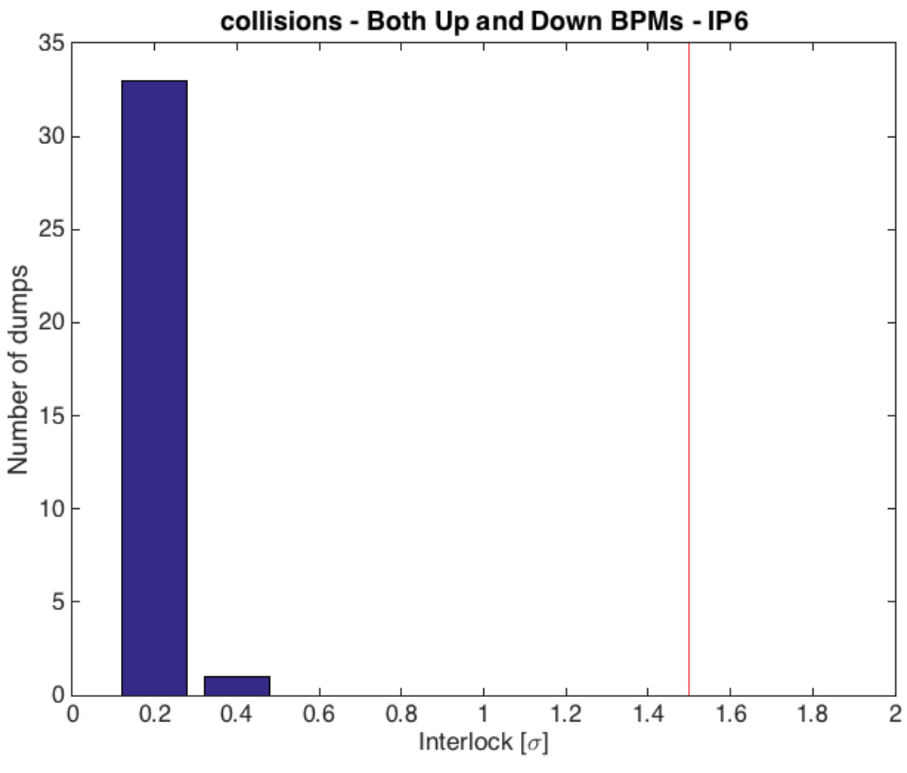


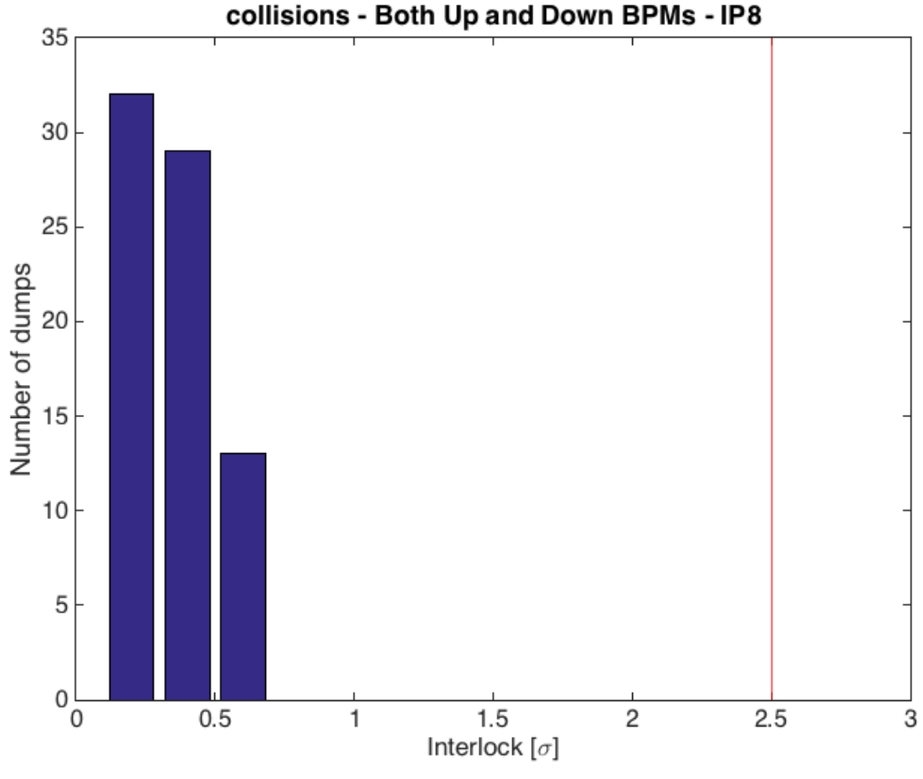


BPM Interlocks - by IR (adjust)

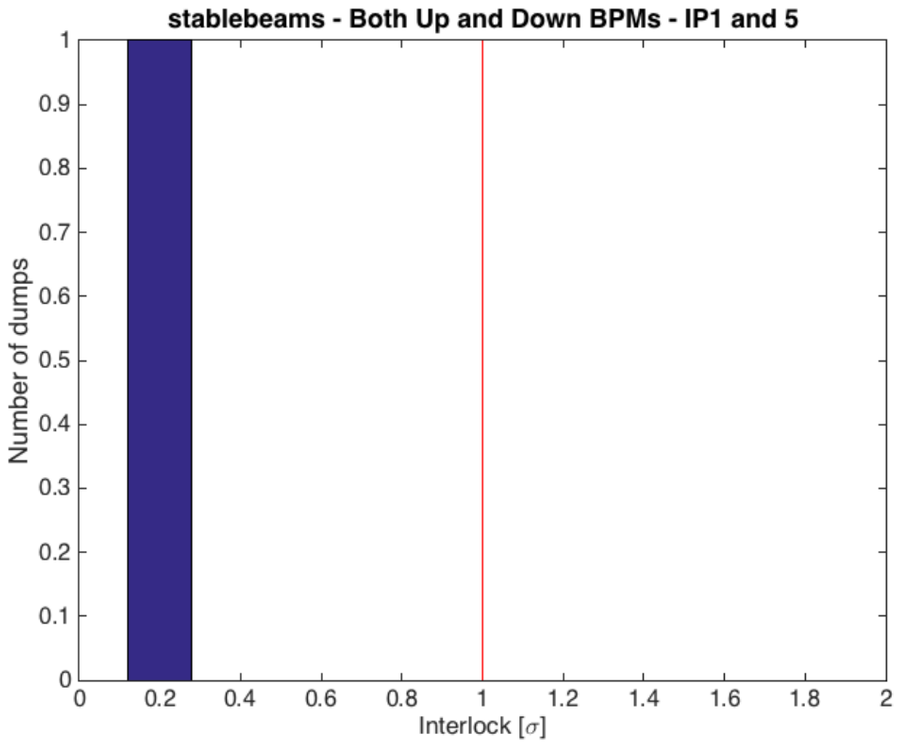


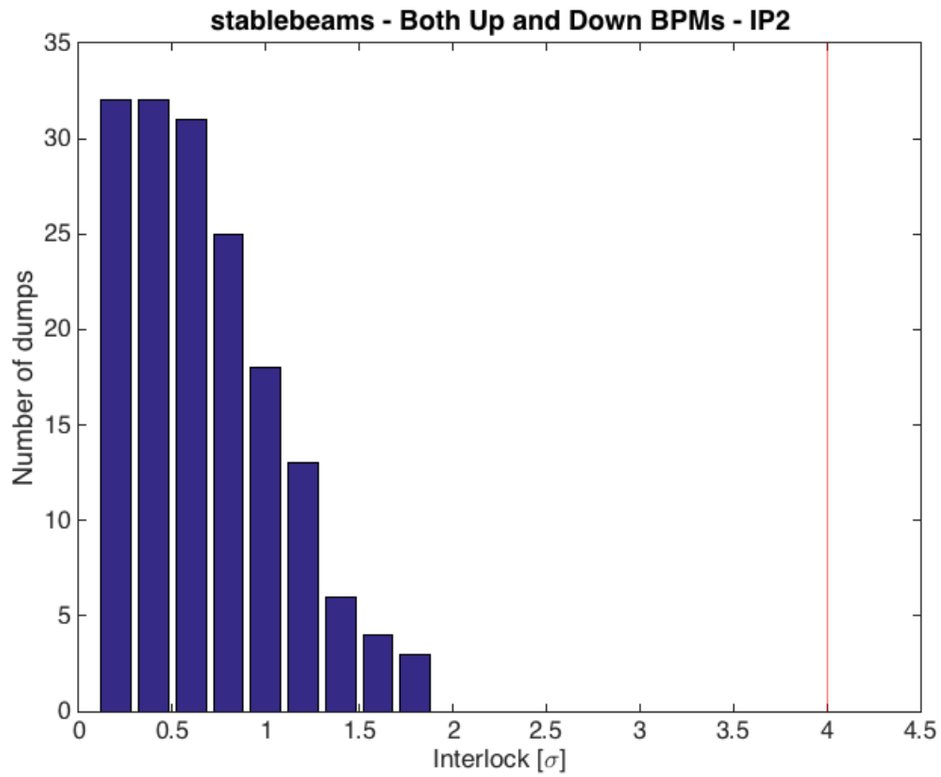


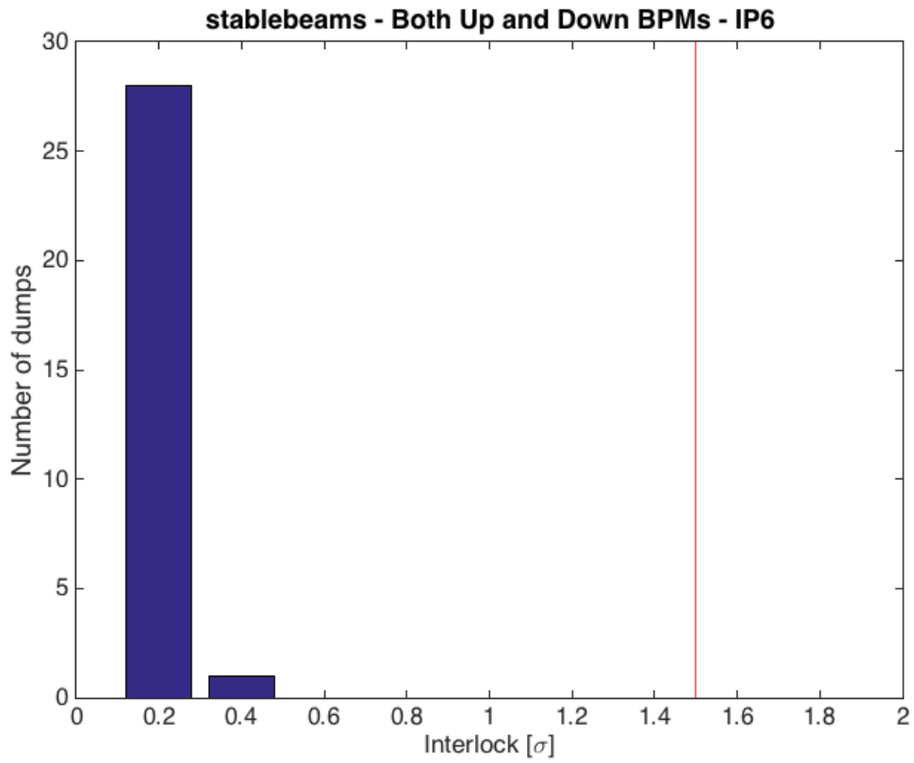


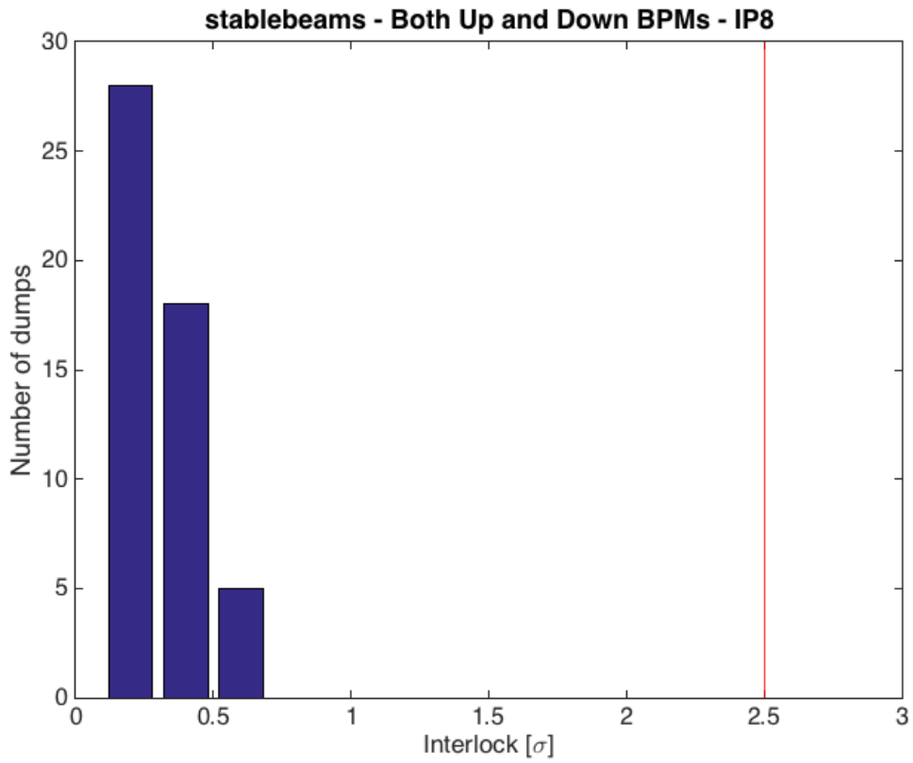


BPM Interlocks - by IR (SB)





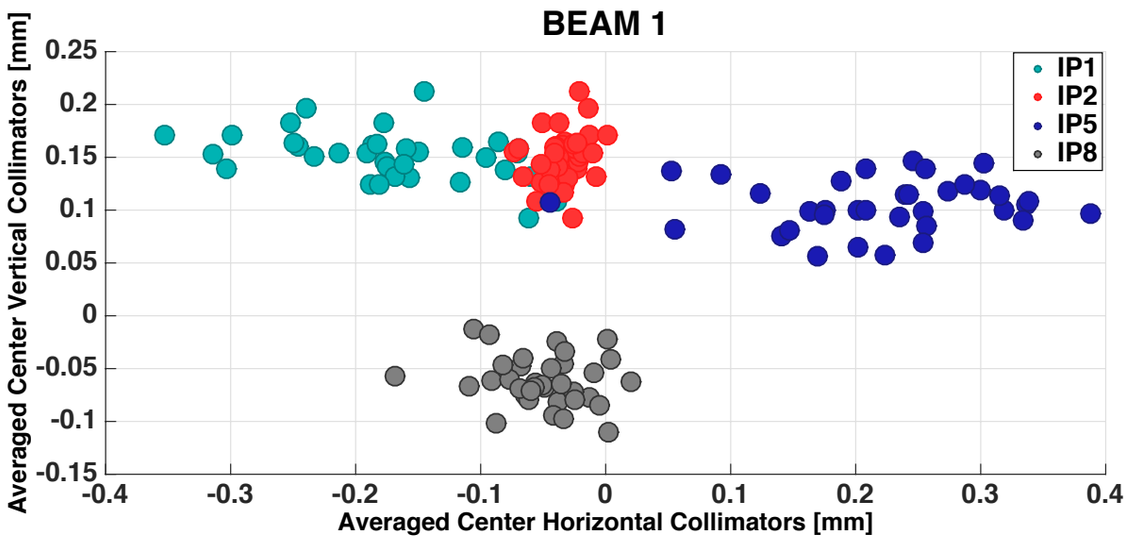


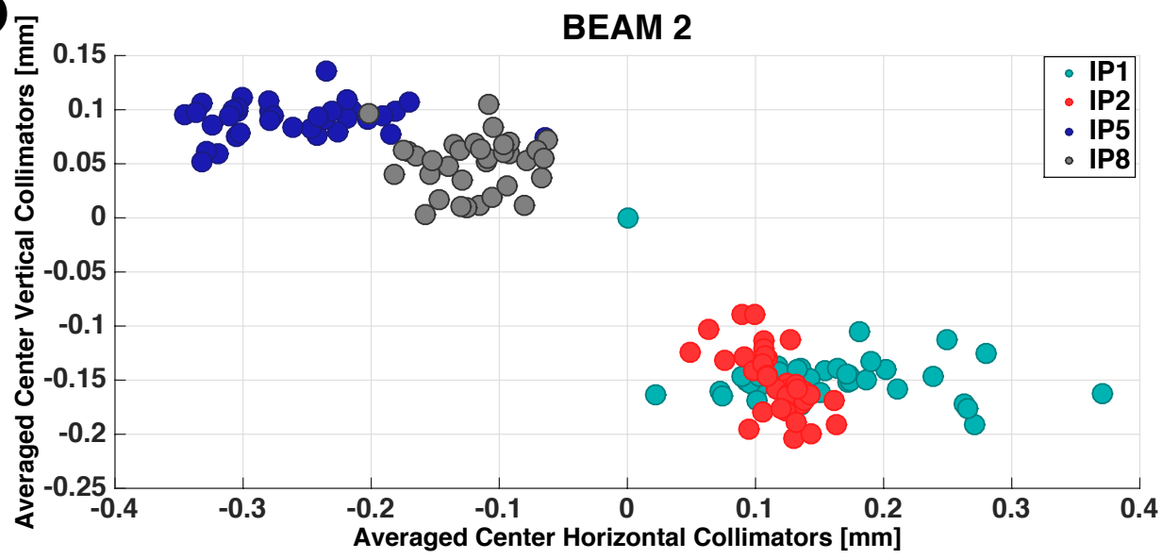


BPM Collimator interlocks

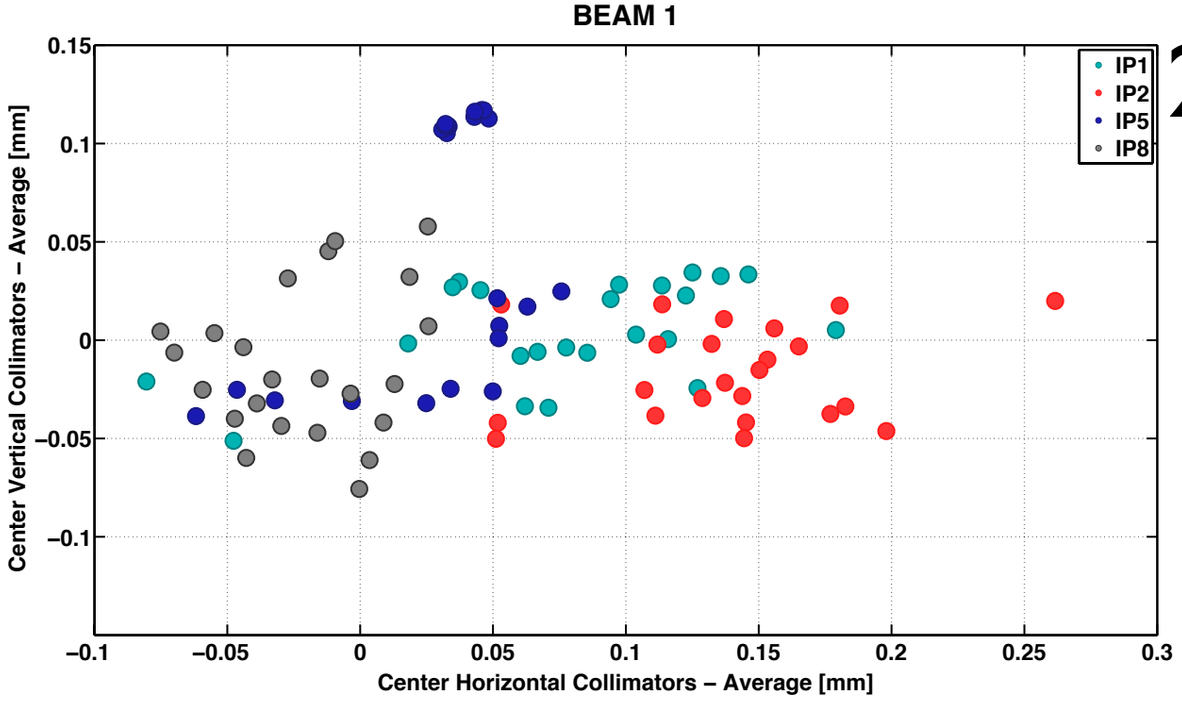
- In general, the orbit spread appears to be much less than in 2015, also thanks to more accurate collimator settings based on BPM measurements.

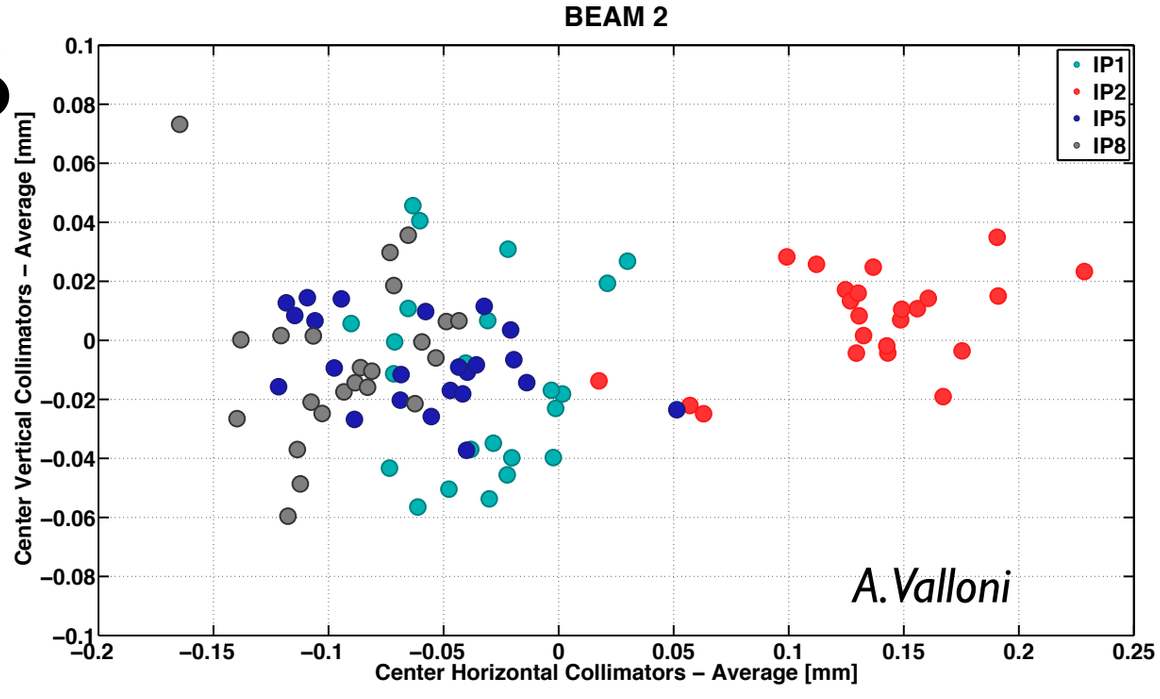
2015





2016





Conclusions

- **TOTEM XRP:** drifts of up to 200 μm (1.5 sigma) in H and 100 μm (0.3 sigma) in V.
- **Collimator BPMs:** much better orbit stability seen so far in during intensity ramp-up than in 2015.
- Confirm that suggested BPM collimator interlocks are **mostly twice** the maximum observed drifts in sigma (squeeze IR1 & 5 -> see jump at the start when limit still 4 sigma).
- Not much difference between taking both BPMs crossing threshold or average in terms of #dumps.
  - also should never have a case where e.g. Up BPM gives random values and the other gives correct position.
- From async dump measurements, the losses on the TCTs in IR1 and 5 does not increase for orbit drifts up to 3.5 sigma wrt IR6 with good phase advance @ 40 cm β* (R. Bruce, LMC #259).
  - Therefore worst combination of 1 sigma in one direction for IR1 & 5 and 1.5 sigma in the opposite direction for IR6 still gives 1 sigma more than previously qualified position with 3.5 sigma margin.