Optimization of Pbar Bunch Intensity Distribution

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Optimizing the number of pbar at Low Beta.

As pointed by Alvin T….

We know that the total integrated Luminosity is, within measurement error, directly proportional to the number of pbar at low beta.

We know that are loosing pbar at injection due to finite lifetime at 150 GeV, on the Helix.

At high proton intensity, the pbar TeV ramp efficiency strongly depends on the bunch number within a given train, and on the total number of protons. *This efficiency is much worst for the first few bunch, and ~95 to 98% for the last bunches.*

So, why are putting more pbars in the the first few bunches? Given the current TeV performance on the ramp, we should keep most of the pbar we got for the last bunches!

Pbar Lifetime at 150

.. Has increased significantly over the past few months, due to optimization of the helix.

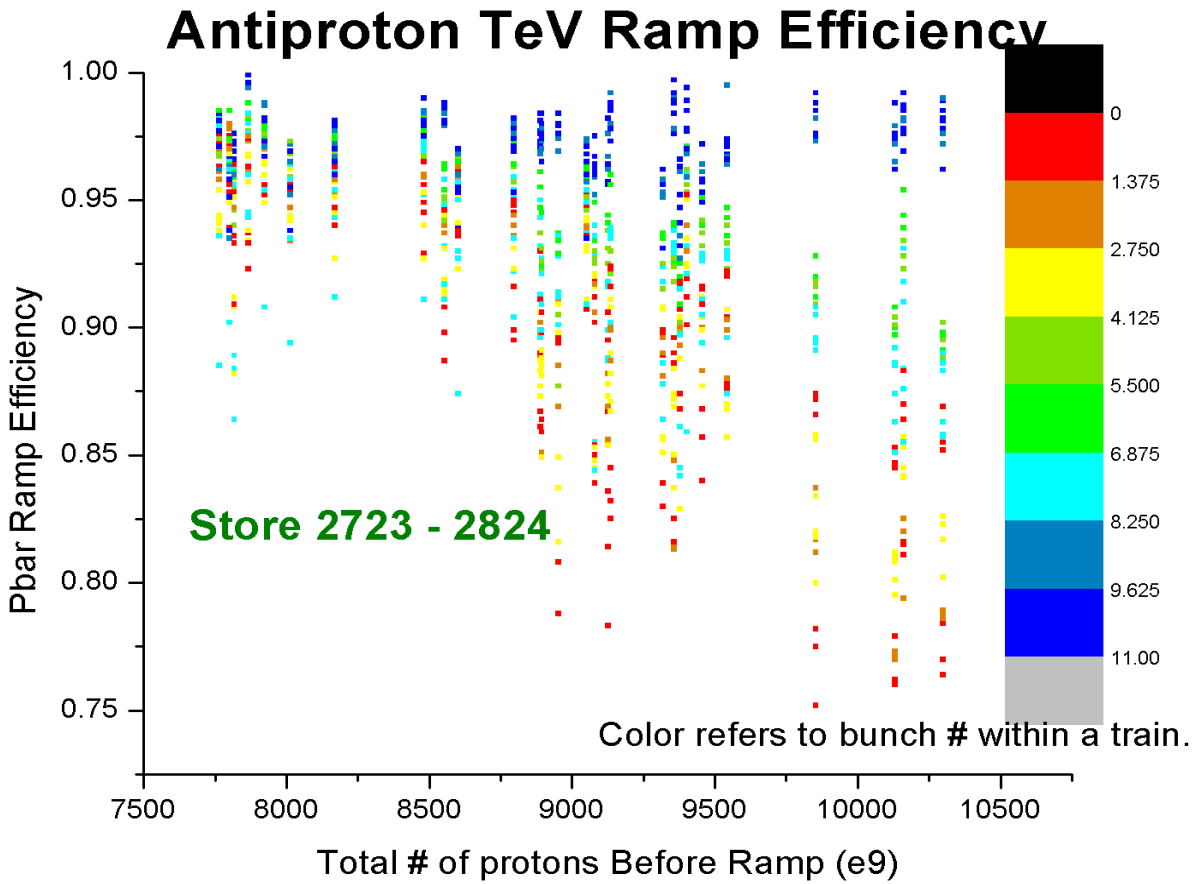
Currently greater than the proton lifetime..

Yet, it is of the order of 4 to 10 hours. (hard to measure, due to cogging effects and due to limited time to accumulate good statistics).

So we have a small loss of 5 to 10 % for the first few transfer.

Late transfer stay at 150 for only a few minutes!

Recent Ramp Efficiency

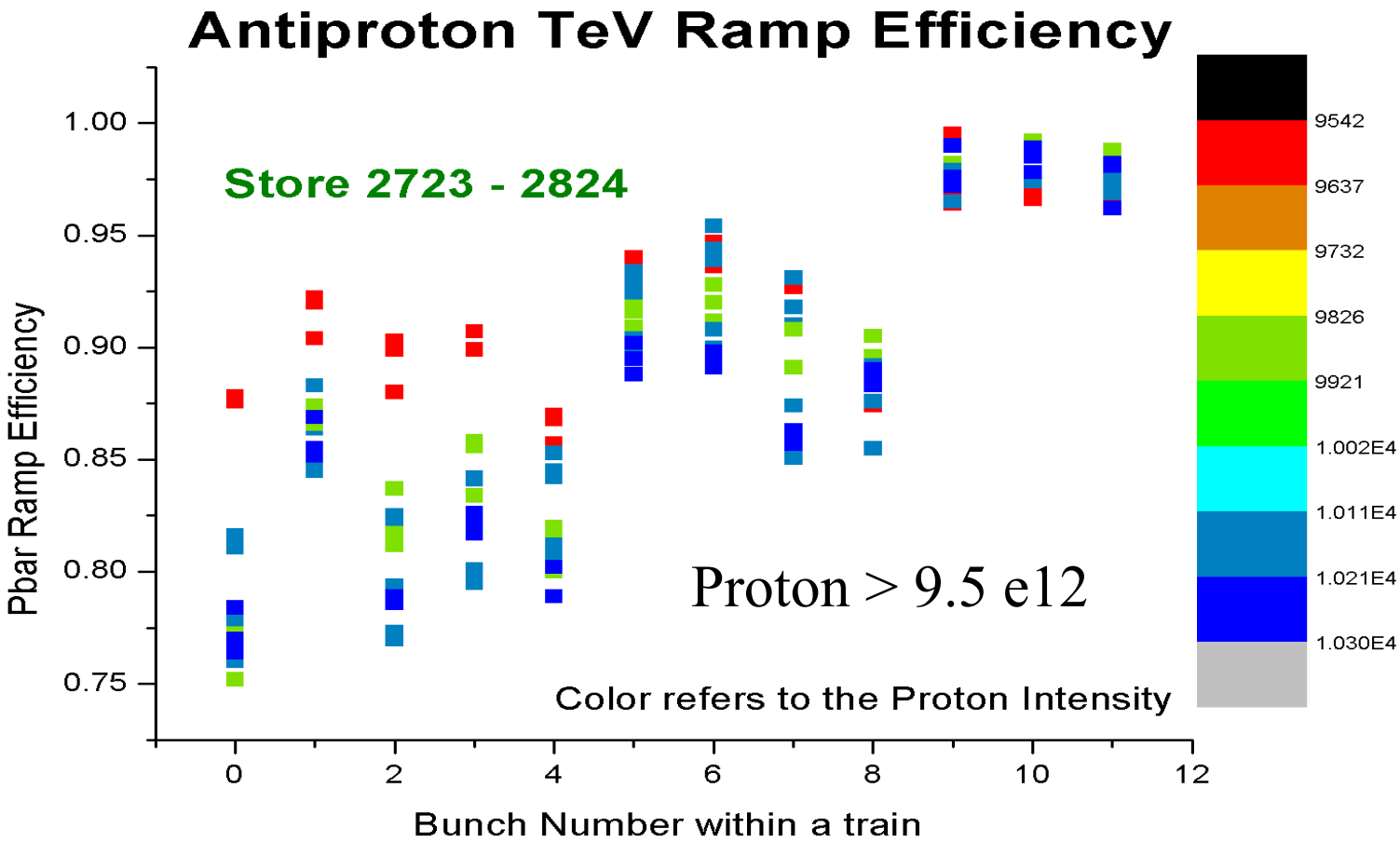


Ramp Efficiency is defined by the ratio of the FBI narrow gates at Flat top and Before Ramp.

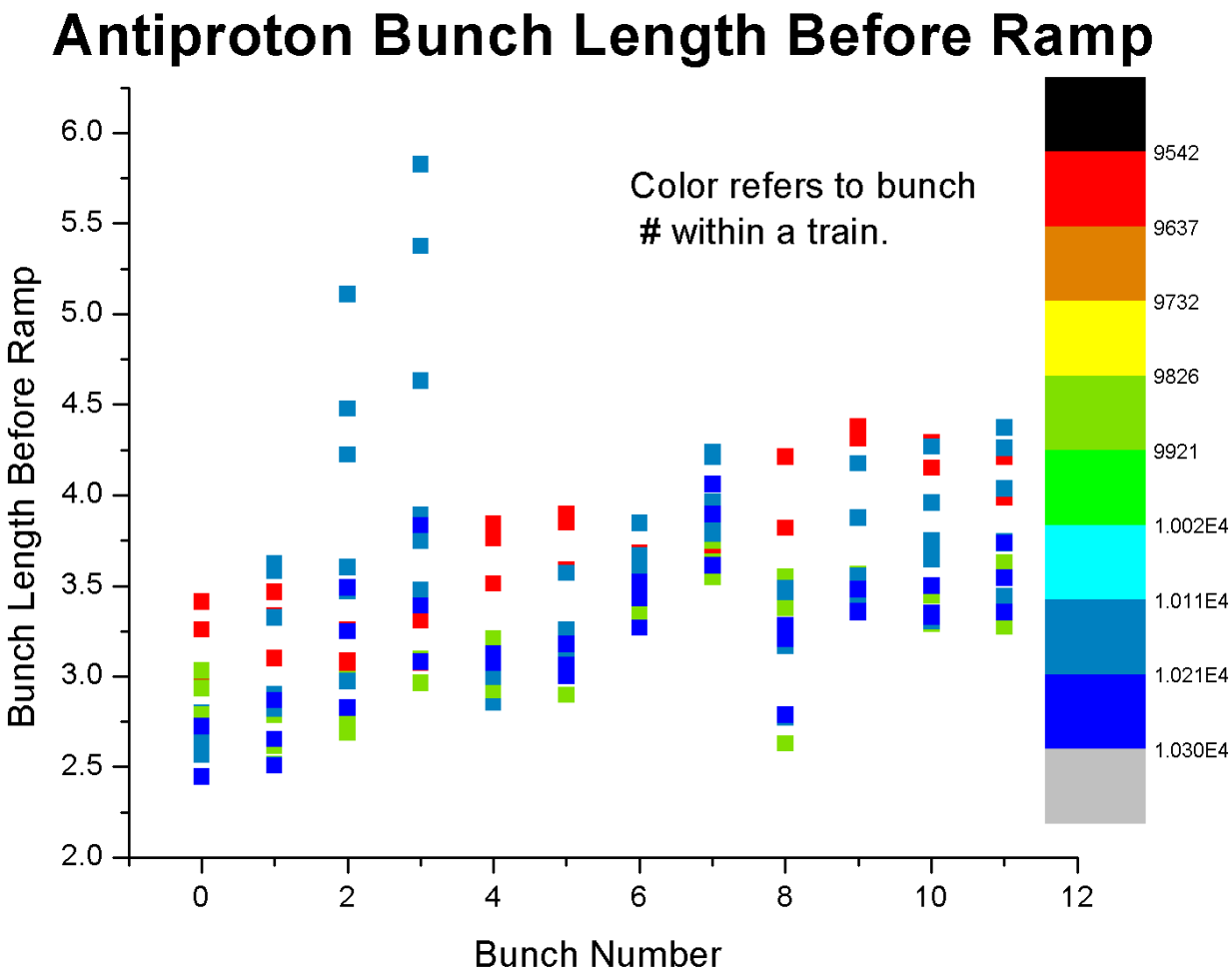
For some bunch, there is clear correlation between bunch number and this efficiency.

Bunch late in the train are spared..

Pbar Ramp Efficiency, II



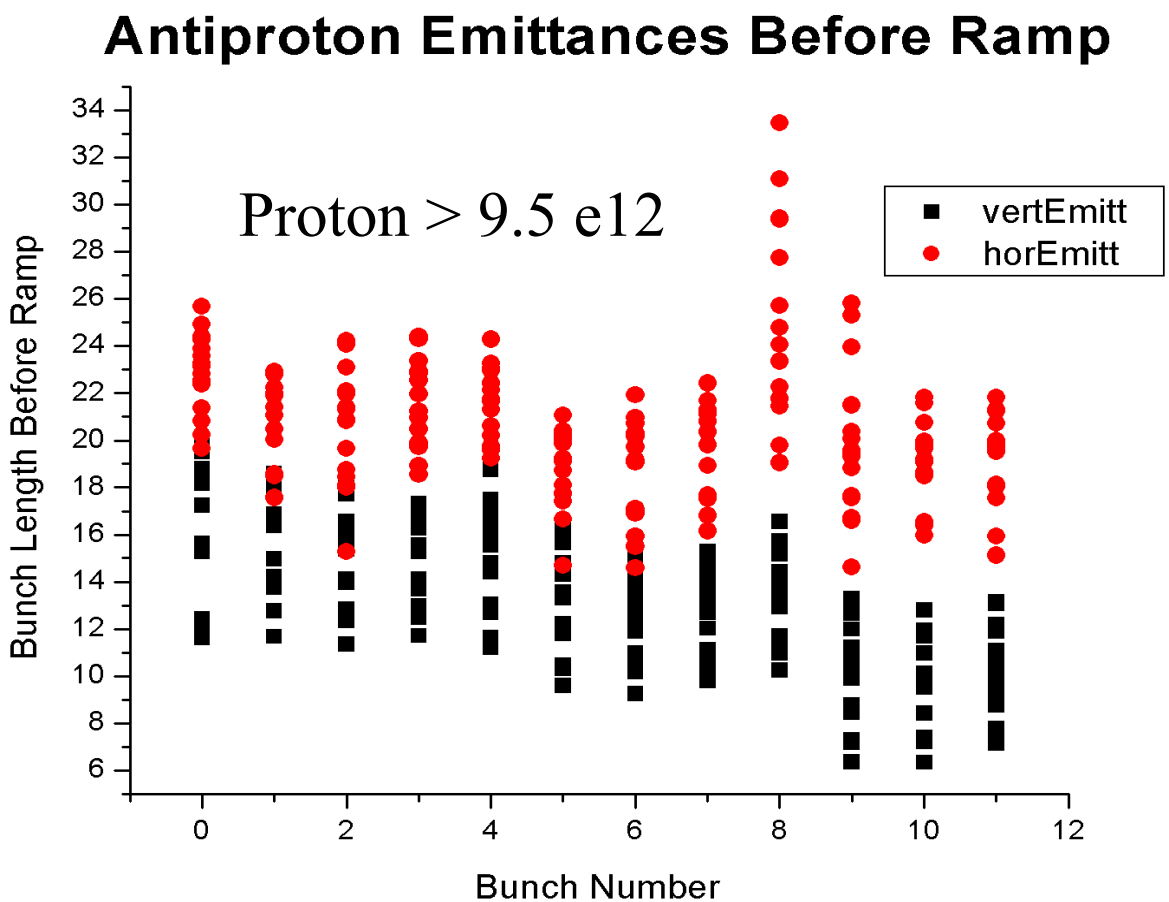
What is different for these pbar bunches ?



- A bit paradoxal : long bunches (at the end of Pbar injection) have a higher ramp efficiency. .

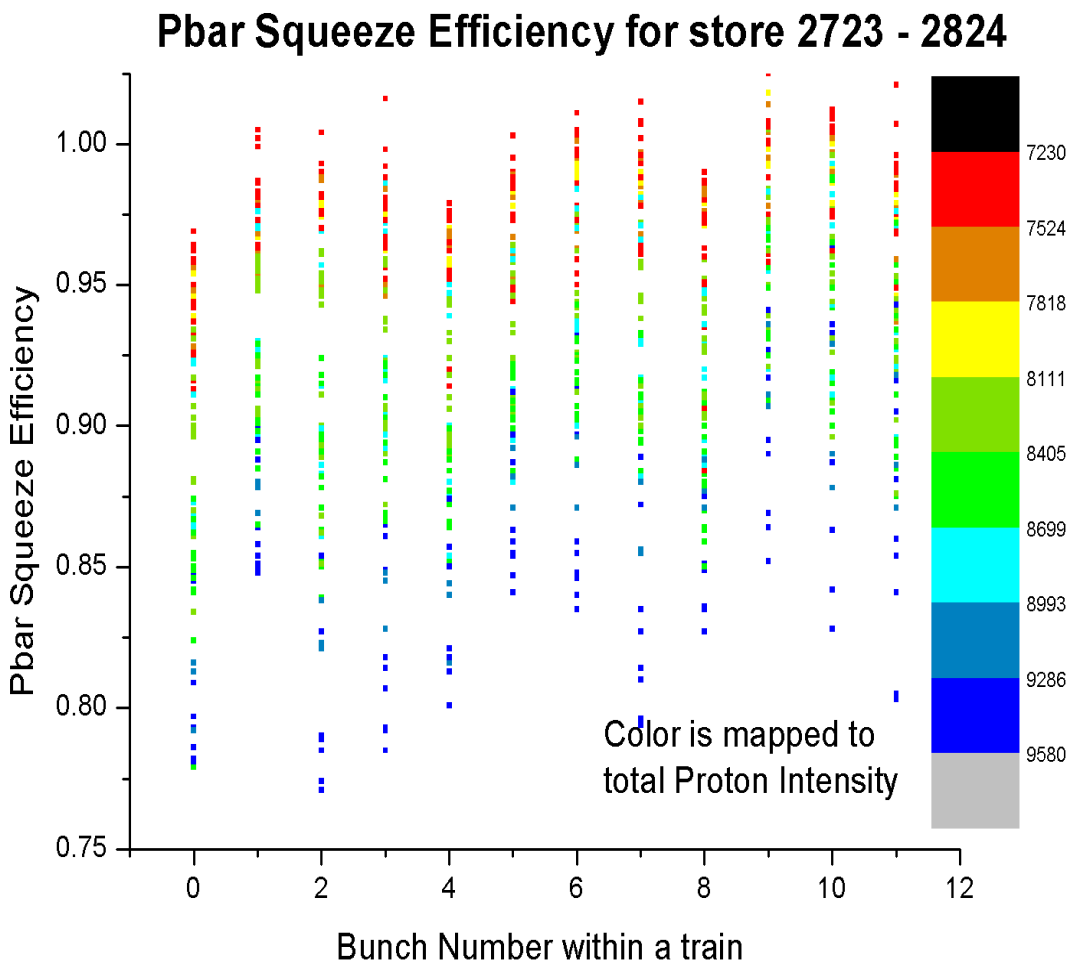
Proton > 9.5 e12

What is different for these pbar bunches, II

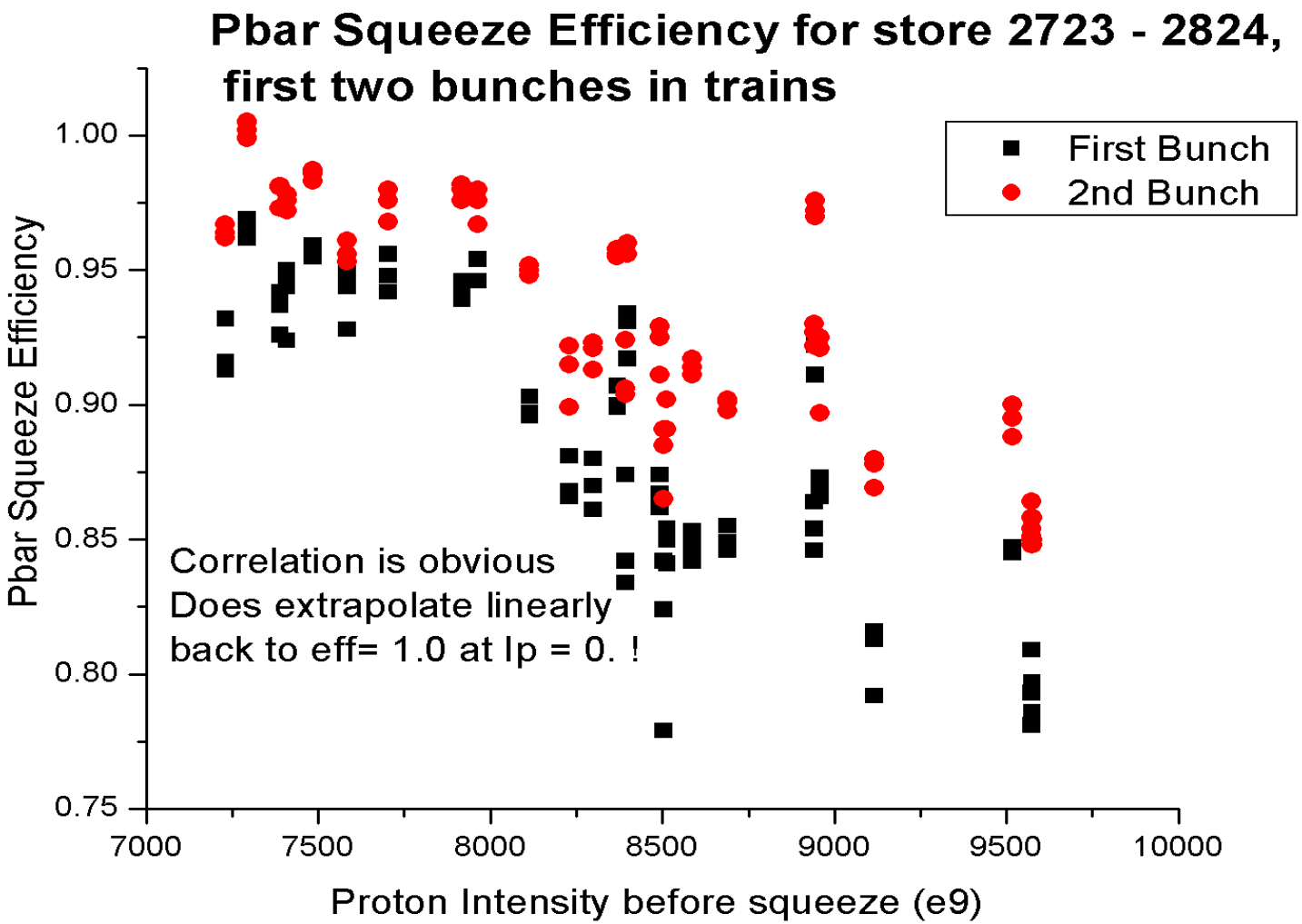


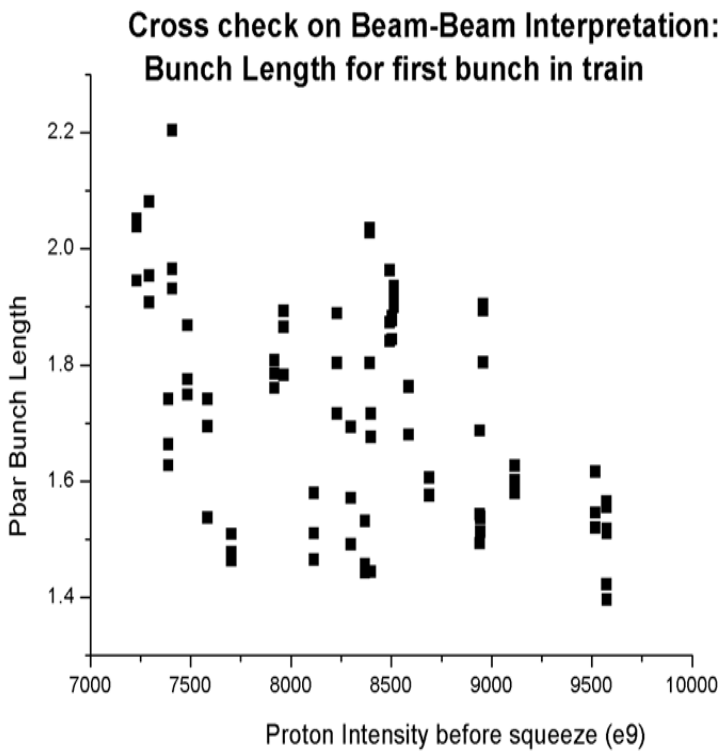
- Late bunch have a slightly smaller pbar emittance.
- However, nothing distinguishes bunch 0 from bunch 1 in terms of emittance. Yet, bunch 1 has a better efficiency than bunch 0
- *We need to increase helix seperation at ~800 GeV where losses are greatest!*

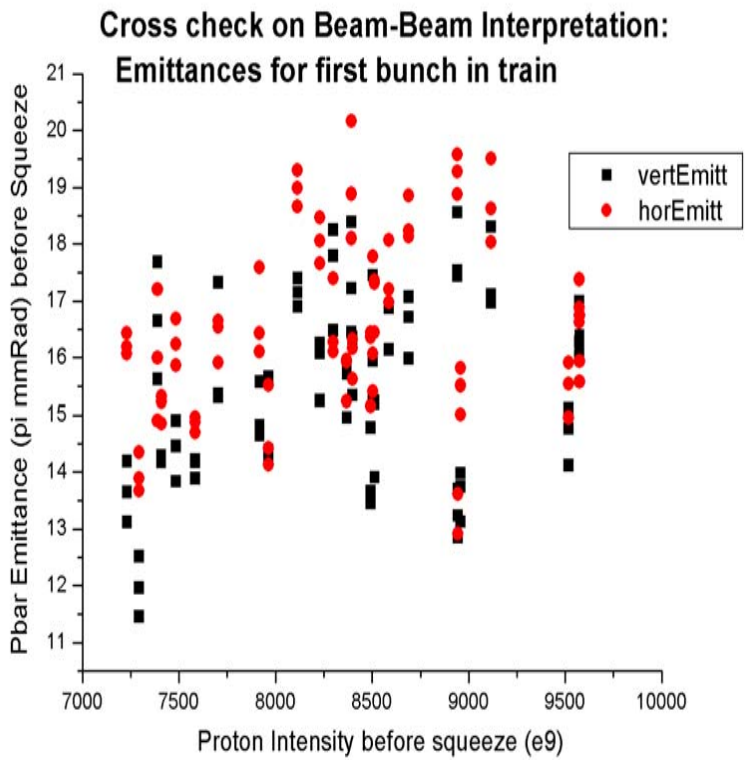
Similar Effects are observed during the Squeeze



- Correlation between efficiency and proton current for all bunches! .
- *Much weaker bunch dependence*


Pbar Squeeze Efficiency for store 2723 - 2824,
first two bunches in trains
First Bunch
2nd Bunch
Correlation is obvious
Does extrapolate linearly
back to eff= 1.0 at Ip = 0. !
Pbar Squeeze Efficiency
1.00
0.95
0.90
0.85
0.80
0.75
7000
7500
8000
8500
9000
9500
10000
Proton Intensity before squeeze (e9)


Cross check on Beam-Beam Interpretation:
Bunch Length for first bunch in train
Pbar Bunch Length
2.2
2.0
1.8
1.6
1.4
7000
7500
8000
8500
9000
9500
10000
Proton Intensity before squeeze (e9)


Cross check on Beam-Beam Interpretation:
Emittances for first bunch in train
Pbar Emittance (pi mmRad) before Squeeze
21
20
19
18
17
16
15
14
13
12
11
vertEmitt
horEmitt
7000
7500
8000
8500
9000
9500
10000
Proton Intensity before squeeze (e9)

Tentative Conclusion

- Beam – Beam Effects on the ramp confirmed at our relatively high proton intensity.
- This established dependency on bunch number could help us determine where we need more helix separation
- Significantly increase the helix separation will not happen anytime soon!.
- Meanwhile, we could optimize the luminosity by not loading that much the first 3 transfers, reserving more pbar for the late bunches in the trains, allowing us to :
  - Save pbar during injection (they have a longer lifetime in the source than in the TeV !
  - Let the BLM do his job, getting better efficiency after a few “pilot” transfers.
  - Save pbar up the ramp.