

SNS Ring Collimation Studies

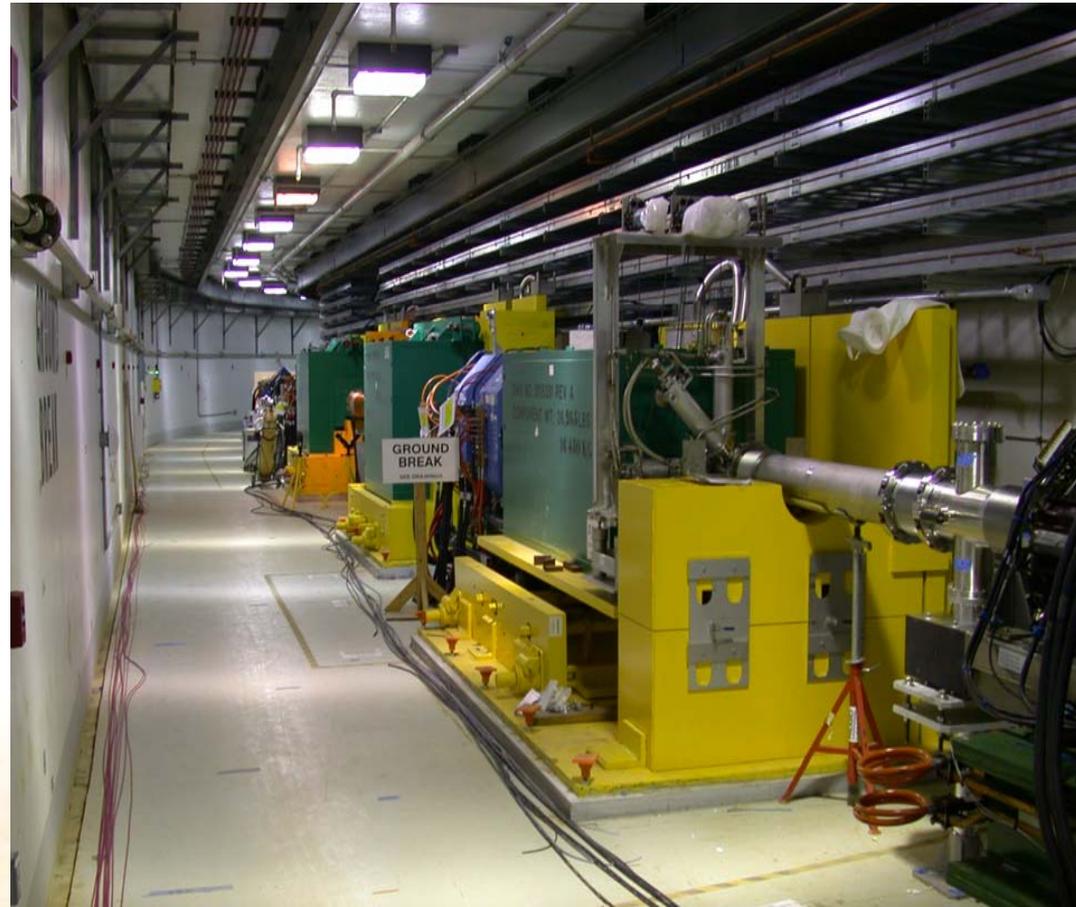
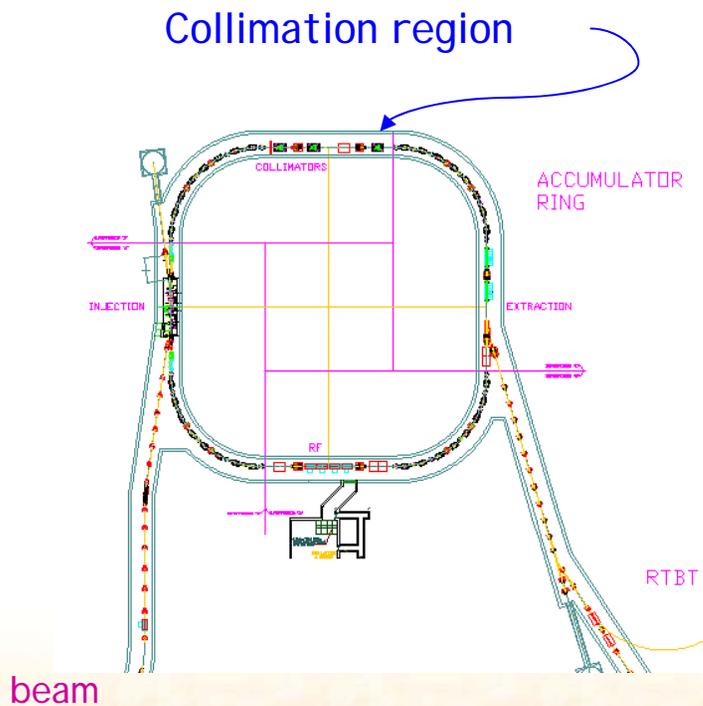
Sarah Cousineau,
Mike Plum, Saeed Assadi, Slava Danilov, J. Holmes, Andrei Shishlo

PAC07
Albuquerque, 2007



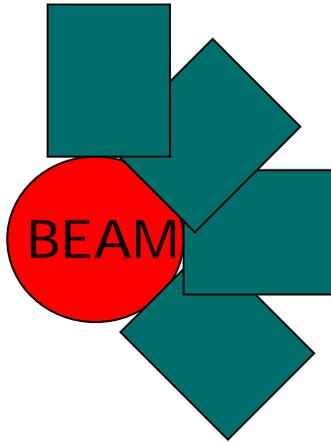
The SNS Ring Collimation System

- One side of our ring is dedicated to collimation.
- The collimators can absorb ~ 2 kW (0.2%) of beam on every accumulation cycle, or two consecutive 2 MW pulses in the event of a hardware failure.
- We have a scraper box, and three large collimators.



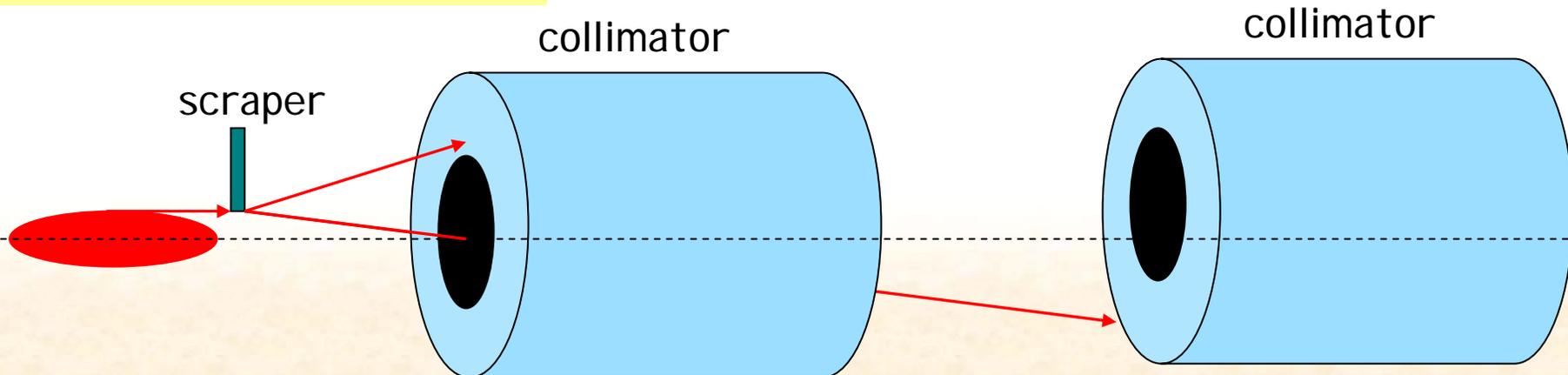
Two Stage Betatron Collimation System

Scraper system

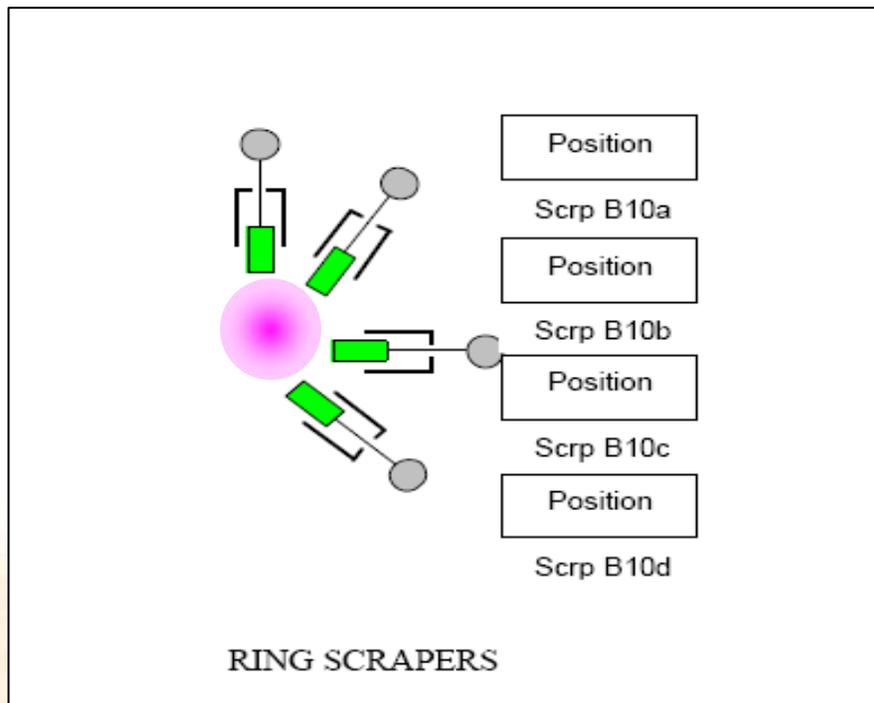
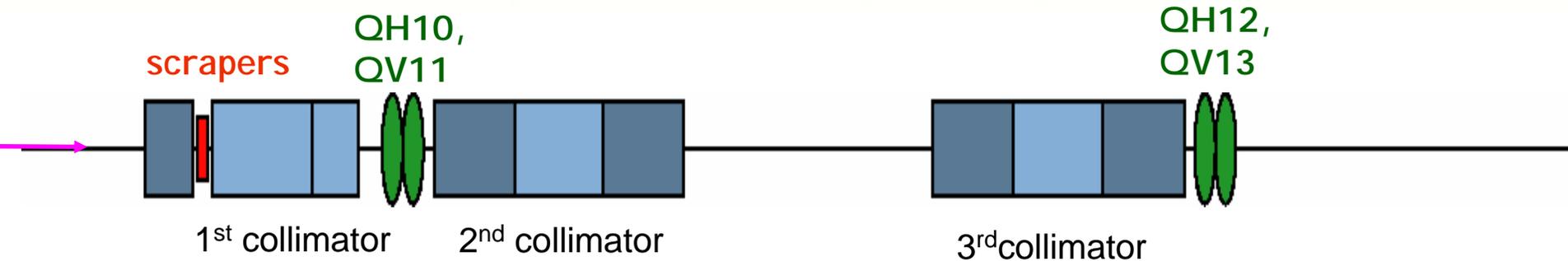


Without scrapers, we would have poor collimation efficiency.

- SNS has a two-stage collimation system.
- Job of the scrapers is to intercept the halo beam and project it to very high amplitude onto the collimators. High impact on the collimators decreases likelihood of outscatter.
- In a single-stage system, there are no scrapers. Particles directly hit collimators and have higher probability of outscatter. Outscattered particles are usually outside of the dynamic aperture, will be lost.



The Ring Collimation Layout



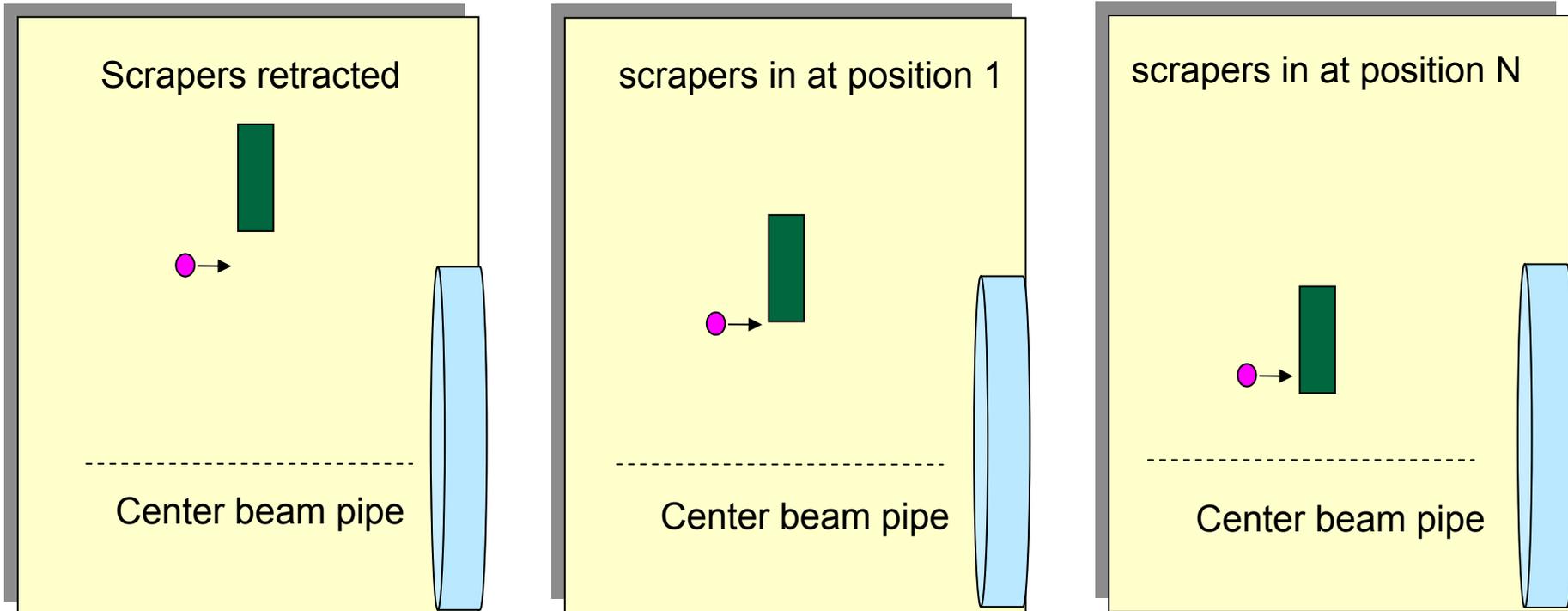
The 4 scrapers cover roughly $\frac{1}{2}$ of the beam aperture.

Therefore, multiple-turns are necessary for particles to intercept the scrapers.

If emittance growth happens on a one-turn time-span (e.g., foil scattering), many particles will bypass scrapers and do single-stage collimation.

Single Minipulse Collimation Experiment

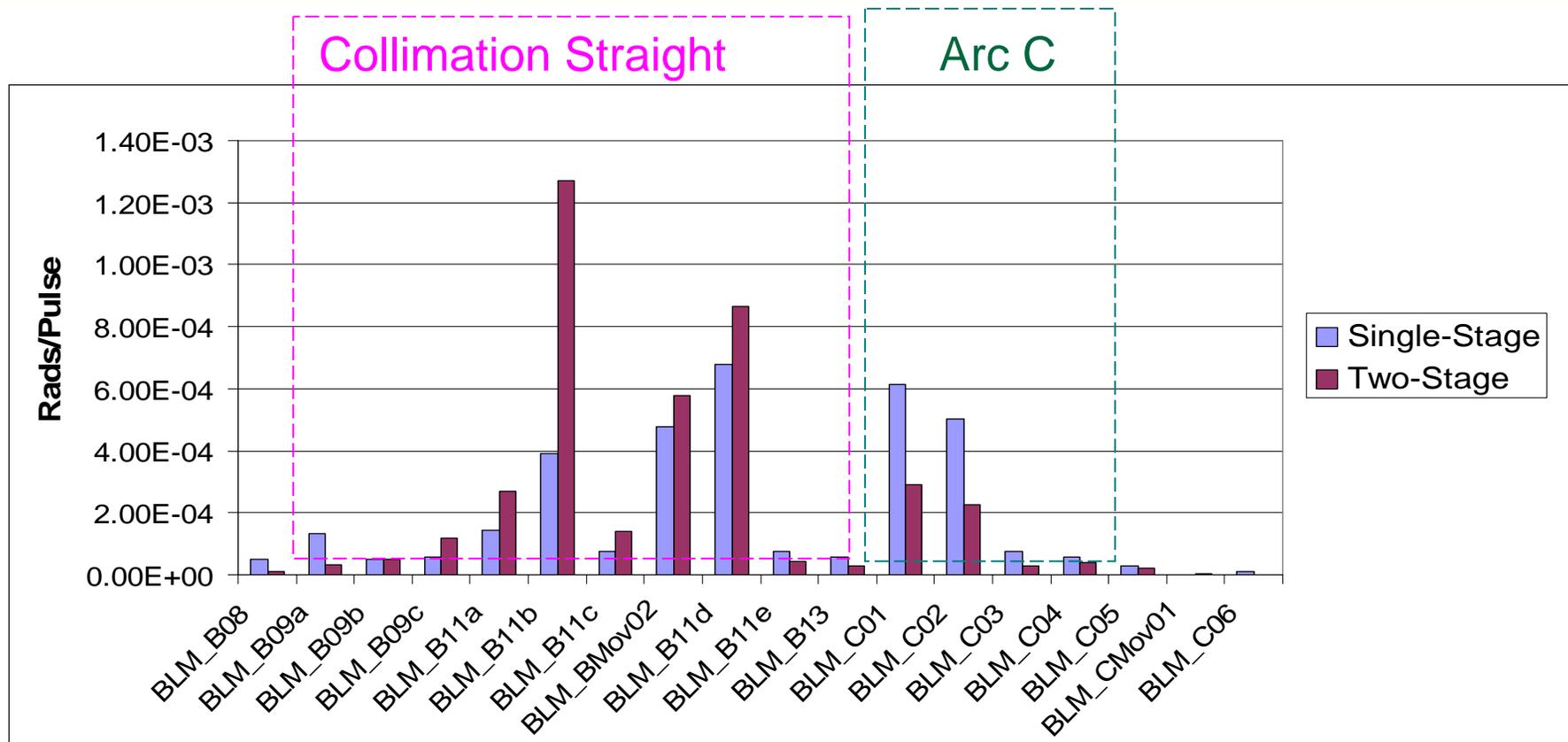
We adjusted the scraper setting and varied the amplitude of the injected beam pulse until the minipulse intercepted the scraper.



Three goals for this study:

- Compare single-stage versus two-stage collimation system.
- Check the dependence of the loss distribution versus scraper setting
- Benchmark a dataset with the ORBIT simulation code.

Comparison of Loss Distribution for Single-Stage Versus Two-Stage Collimation

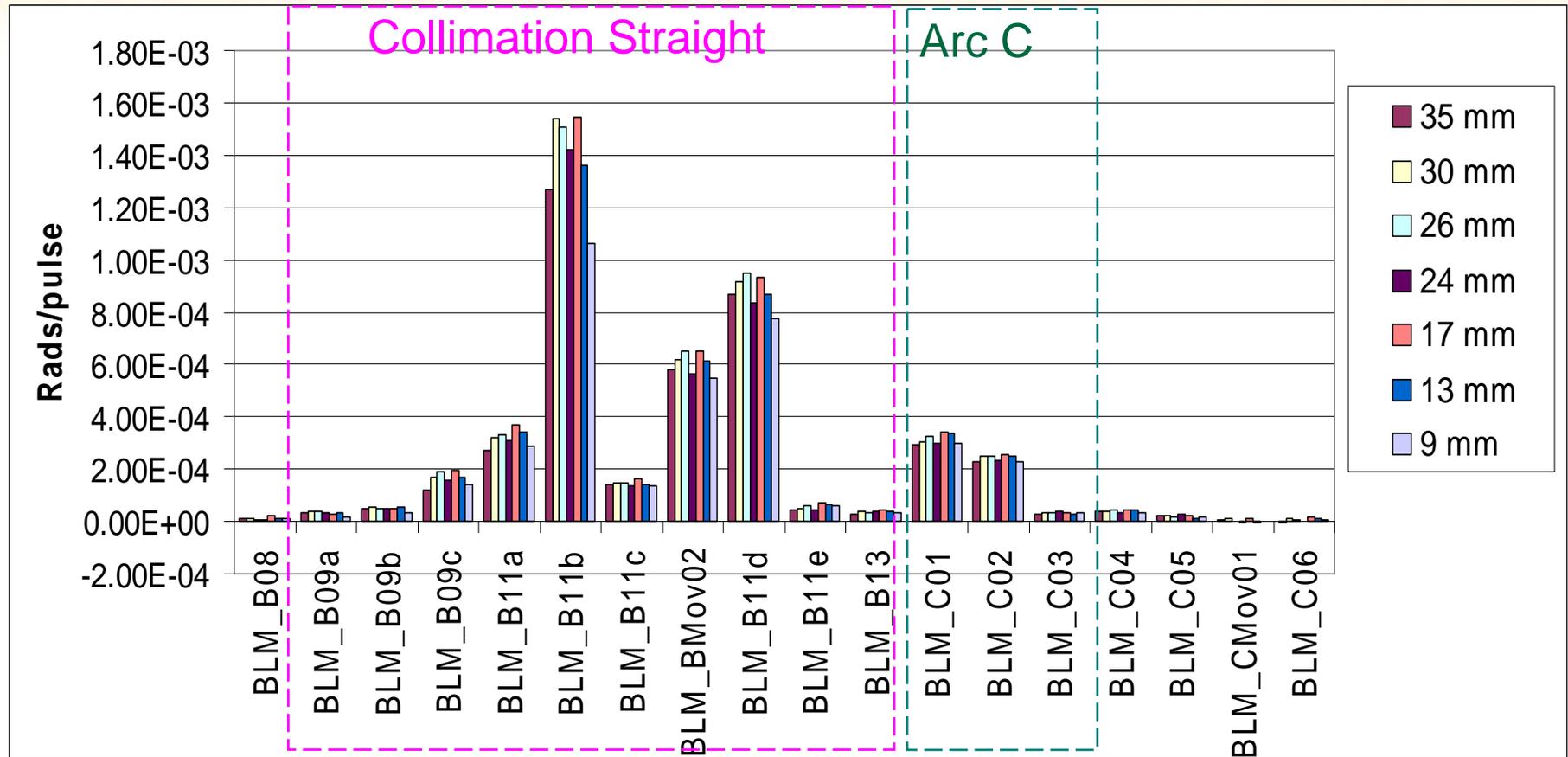


Observations:

More out-scattering from collimation system in the single stage system.

Collimating beam without scraping it first leads to poor efficiency, large beam loss in downstream arc.

Loss Distribution for Different Vertical Betatron Amplitudes

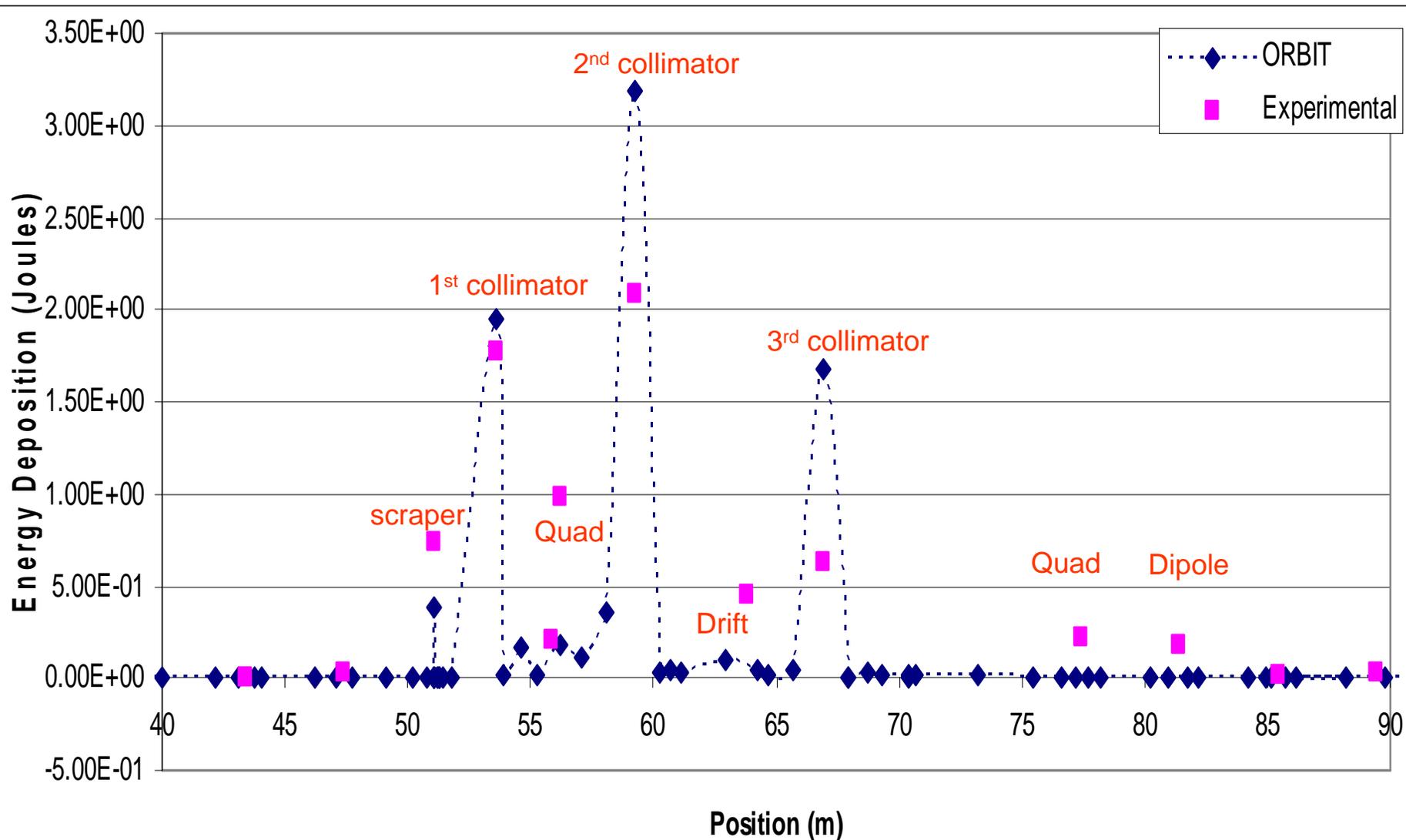


Observations:

- See more losses than expected in first part of the arc than we expected.
- Once two-stage collimation is used, loss pattern is fairly independent of scraper setting, at least to within our ability to collimate exact same amount of beam on every shot (~20% spread in joules of beam collimated).

Benchmark of simulated versus measured beam loss

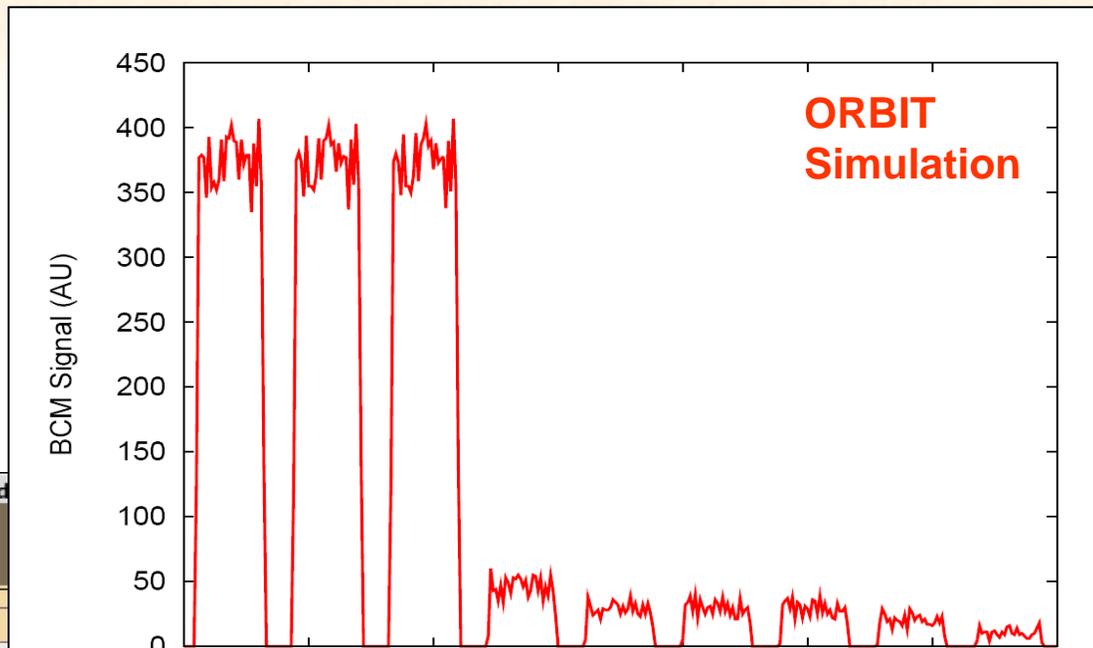
* To perform the benchmark we had to convert BLM rads/pulse to Joules/pulse. This required some additional beam loss measurements, and a few first order approximations.



BCM Benchmark

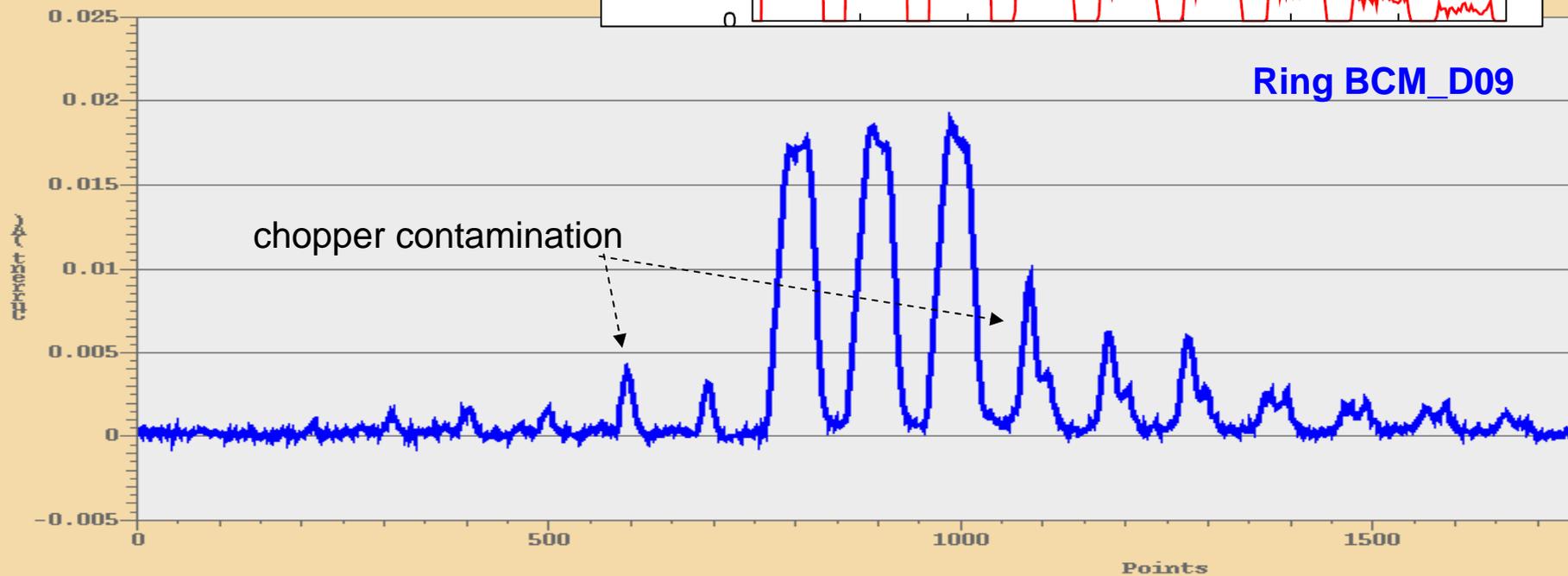
Phasing is correct.

Both simulation and experiment show that ~80% of beam is lost on turn 4.

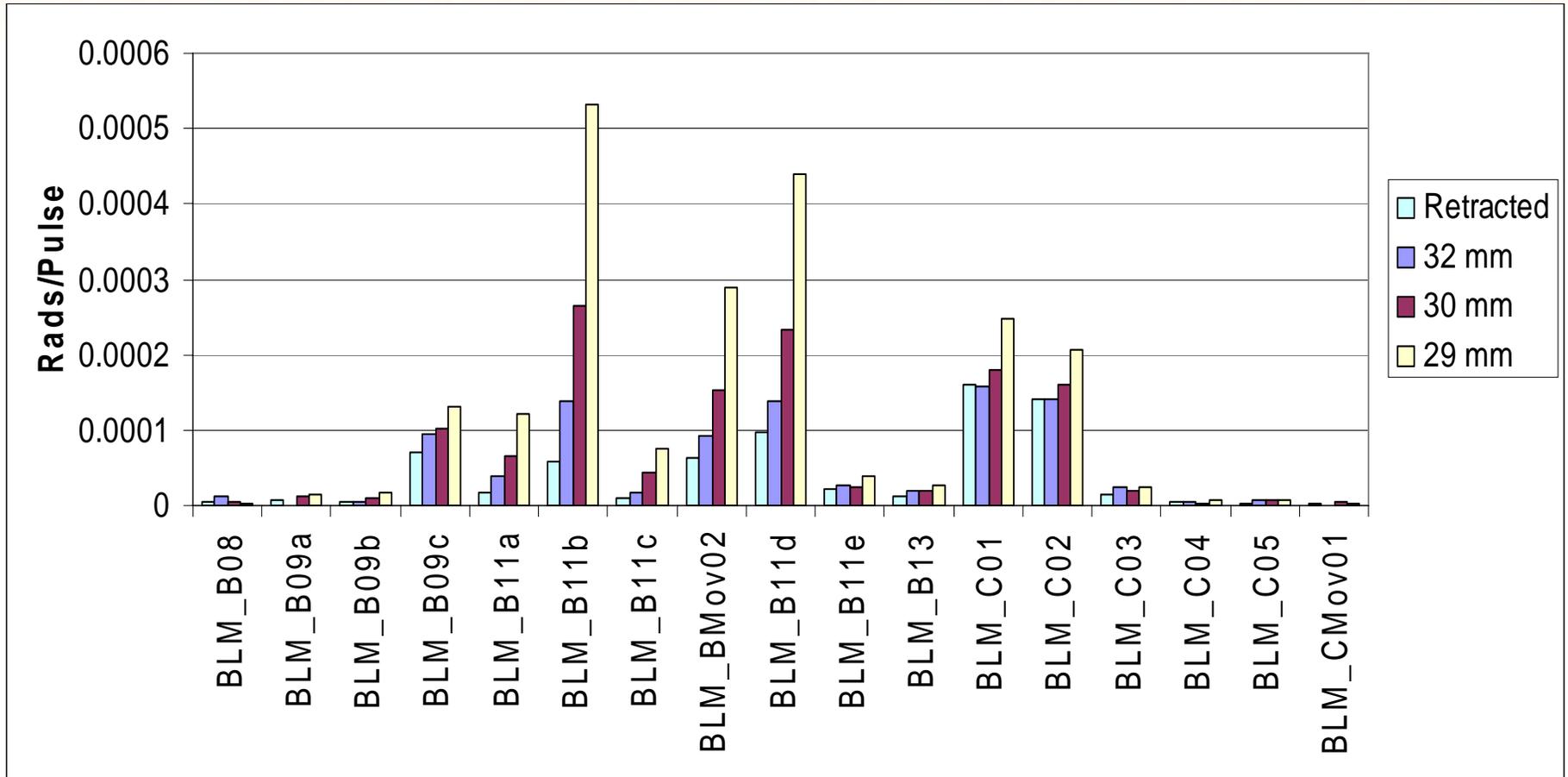


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Diagnostics
Ring_Diag:BCM_D09



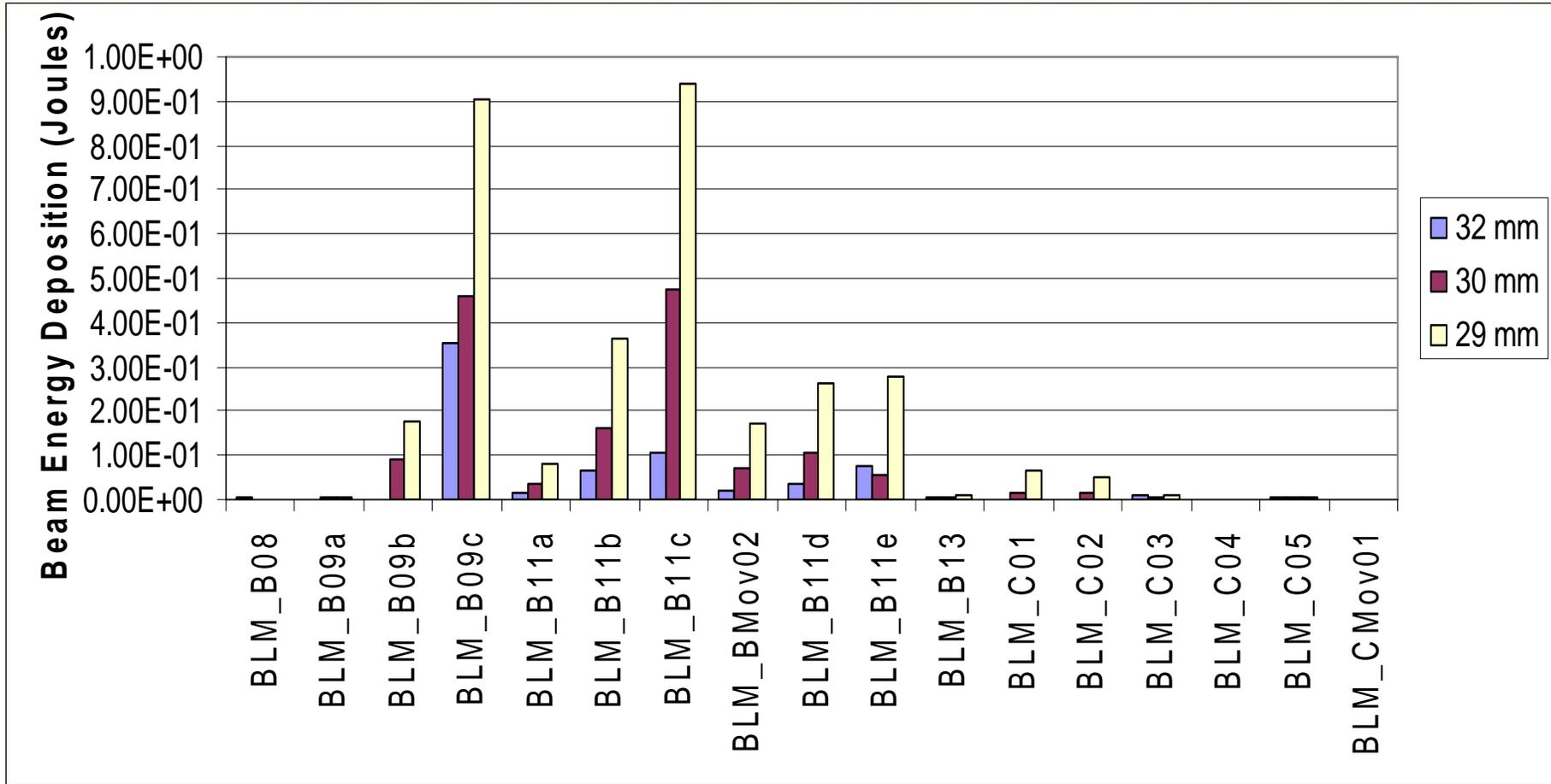
Scraping different amounts of a 150 Turn Painted Beam



Observations:

- Loss distribution same pattern as single minipulse.
- Some collimation losses present for retracted scrapers.
- C01, C02 increase much less than collimation BLMs as scrapers are inserted.

Two-Stage Collimation Loss Pattern



- If we subtract off the “background”, which we believe is due to 1st turn, single-stage collimation losses, then we get the loss pattern for two-stage collimation.
- Losses on C01, C02 in the arc aren't quite as bad now.

Conclusions and Open Questions

- A big difference is observed between single-stage and two-stage loss distribution
- For two-stage collimation, the loss distribution is fairly independent of scraper setting, amount of beam lost.
- ORBIT simulations agree reasonably well with data. Biggest discrepancy is at quad between first and second collimator.
- We see single-stage collimation of foil hits, leading to collimation inefficiency.
- Two-stage collimation of high emittance beam seems to have good efficiency.