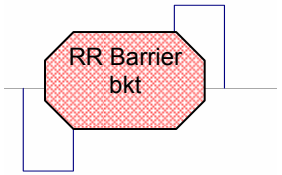
Improvements in Momentum Mining for Tevatron Shots



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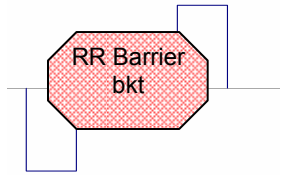
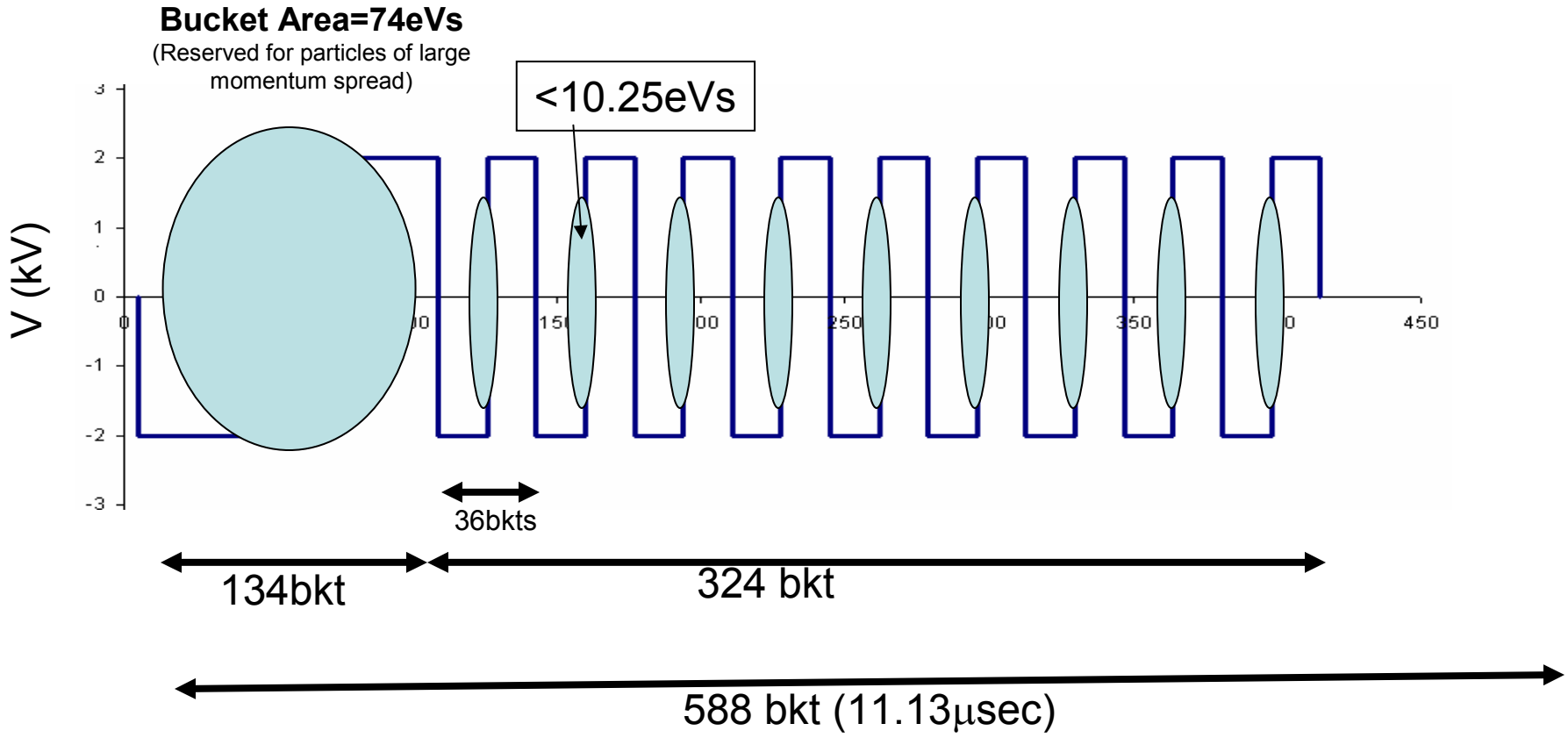
RR Meeting
November 15, 2006

- Issues related to current MM scheme
- Improvements
  - New RF waveforms for MM and gain
  - Changes involved in R6 states
  - Changes in sequencer
  - Future plans

Schematics of Current Momentum Mining





These RF manipulations take ~170 sec.

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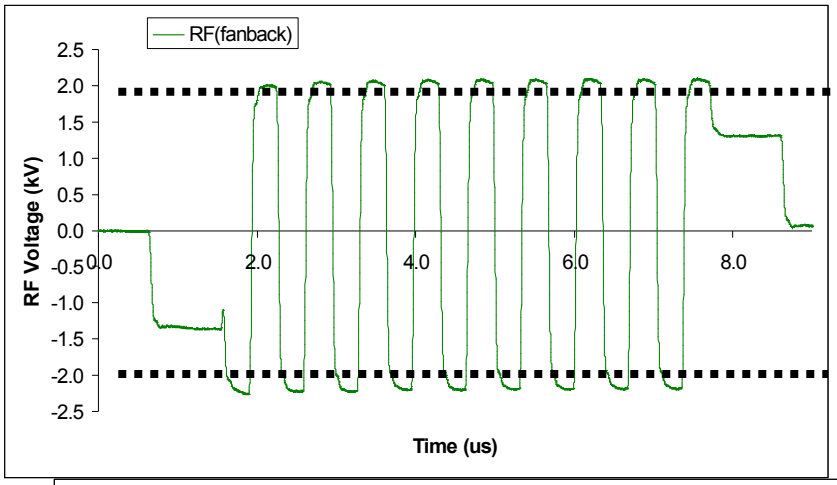
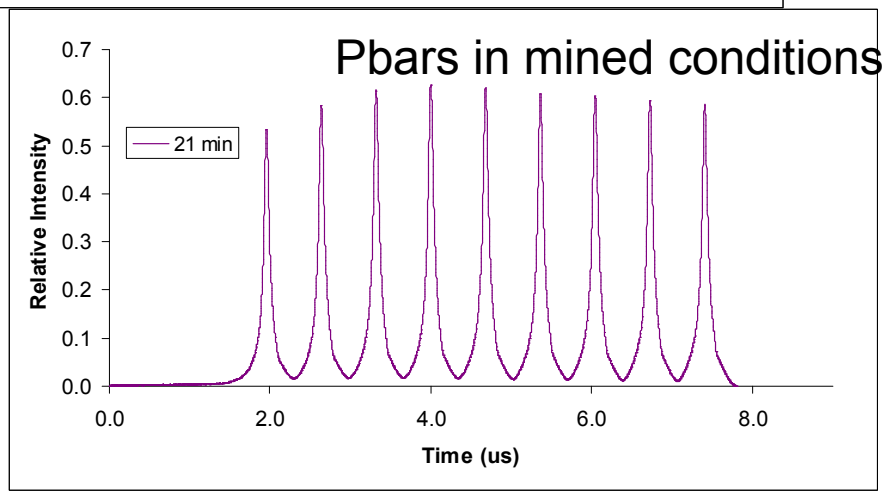
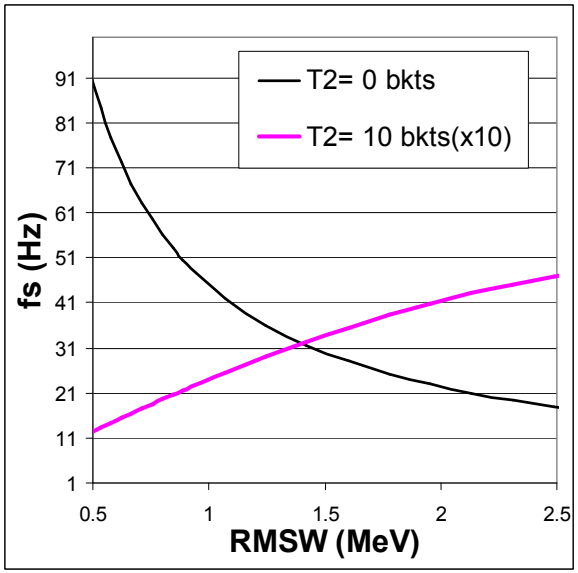
Momentum Mining (Hard edges)
Mini-barrier Buckets
(current)



$$\left[\int V\,dt\right]_{Negative\,Pulse} \approx 1.1\left[\int V\,dt\right]_{Positive\,Pulse}$$

Is this discrepancy due to beam-loading?





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Issues with Back-to-back Barriers

RR Barrier bkt

Theoretical Studies

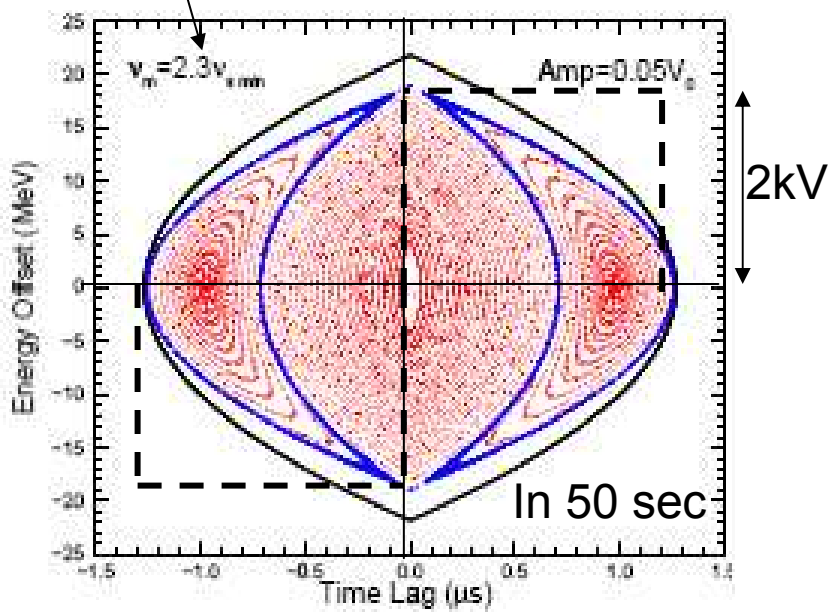
by K. Y. Ng, PRST Accel. and Beams, V9, 064001 (2006)

- Voltage modulation

$$V_0 \rightarrow V_0\{1 + a\cos(\nu_m \theta)\}$$

- Phase-modulation → phase modulation can coherently perturb the particle motion.

$$\nu_{s,\min} = \frac{eV_0}{4\Delta E_{pk}} = 2.29 \times 10^{-5}$$

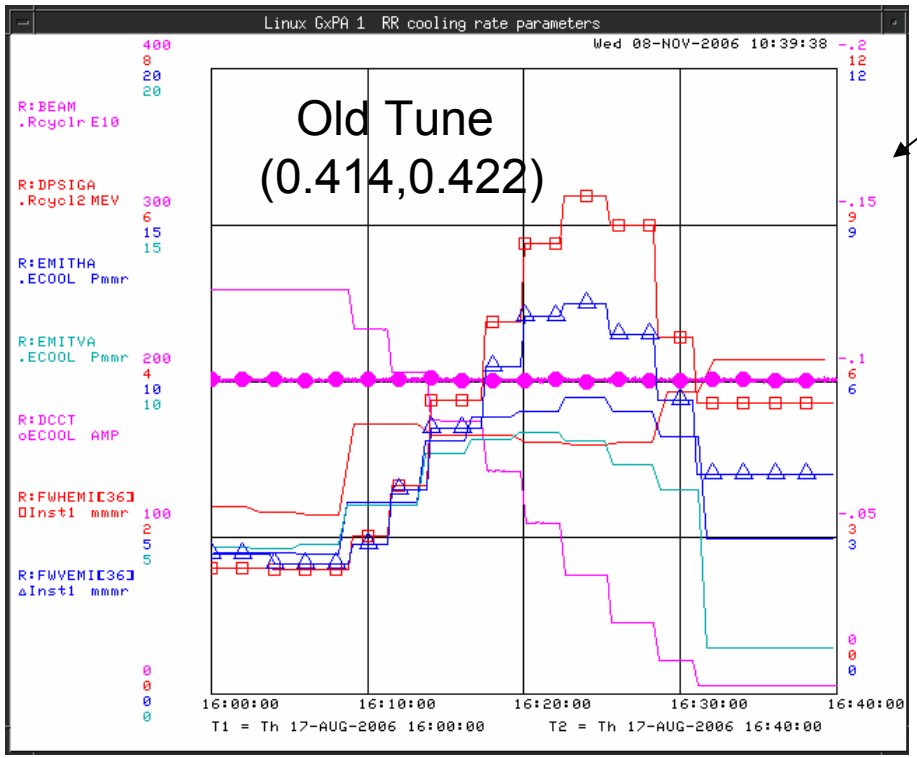


Conclusions from this study:
The rf phase modulation is more devastating than voltage modulation in the buckets of this type. In any case, effort should be made to avoid to use this type of barrier buckets

Observed Emittance Growth During Shots

Past and Present

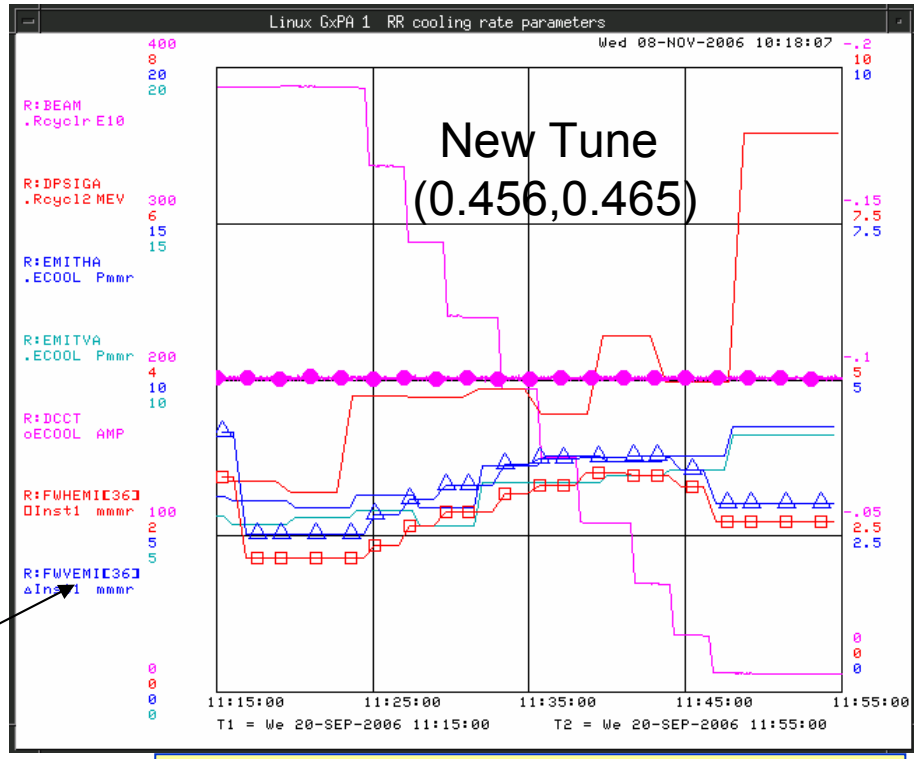
RR Barrier bkt



Old Tune (0.414,0.422)

$$\frac{N}{\varepsilon_T \varepsilon_L} = [1.01]_{Schottky} = [1.89]_{FW}$$

LT =94 hr



New Tune (0.456,0.465)

$$\frac{N}{\varepsilon_T \varepsilon_L} = [1.07]_{Schottky} = [2.61]_{FW}$$

LT =163 hr

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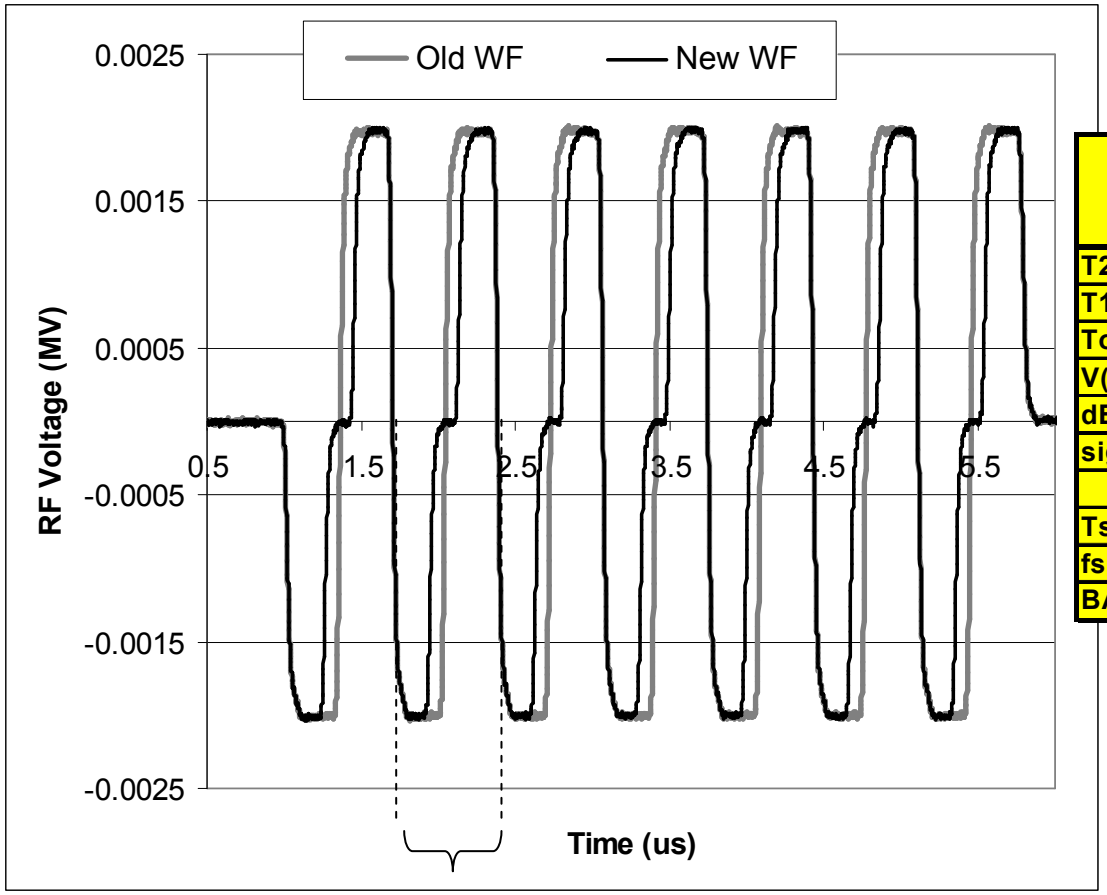
However, reducing **BEAM ENERGY SPREAD** and **PEAK PBAR DENSITY** is better from the point of view of beam stability

New RF waveforms



Mini-bucket

	TRUE -based on the Fanout data		
	Old WF	New WF	% gain
T2 (53MHz bkt)	0	10	
T1 (53MHz bkt)	18	13	
Total-W(53MHz bkt)	36	36	
V(MV)	0.002	0.002	
dE(1/2) (MeV)	10.6	8.9	18.9
sigma(MeV)	5.3	4.5	18.9
Tsmin(sec)	0.236	0.243	
fsmax(Hz)	4.24	4.12	3.0
BA(eVs)(Estimate)	8.55	8.48	– 0.8

Operationally –

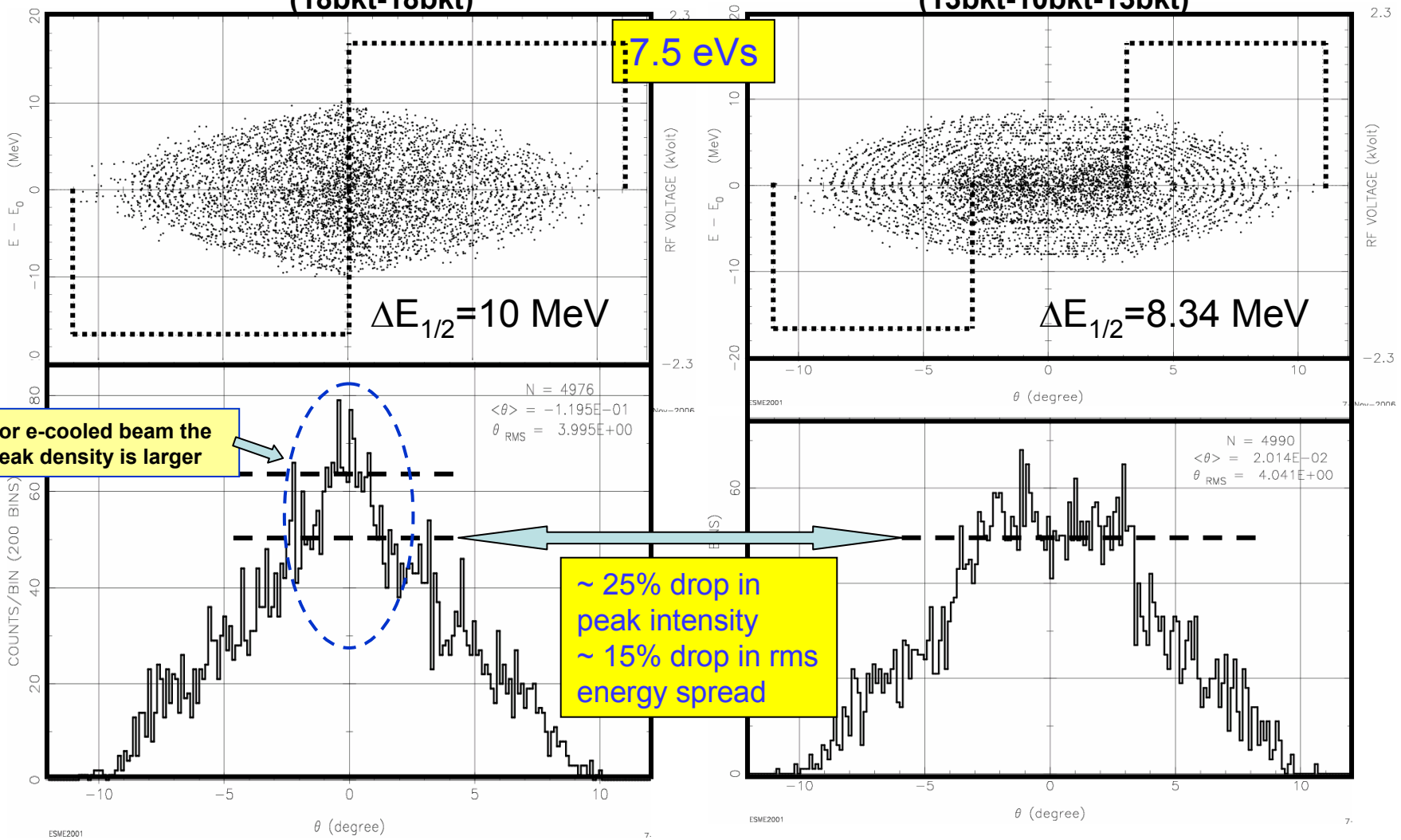
WF 15 → 3 mini-buckets
WF 14 → 2 mini-buckets
WF 13 → 1 mini-buckets
WF 6 → 1 mini-barrier pulse (-ve)
WF 7 → 1 mini-barrier pulse (+ve)

Comparison between Hard and Soft Mini-barrier buckets for Momentum Mining (ESME simulations)

RR Barrier bkt

Current Mini-barrier bucket (18bkt-18bkt)

Proposed Mini-barrier buckets (13bkt-10bkt-13bkt)



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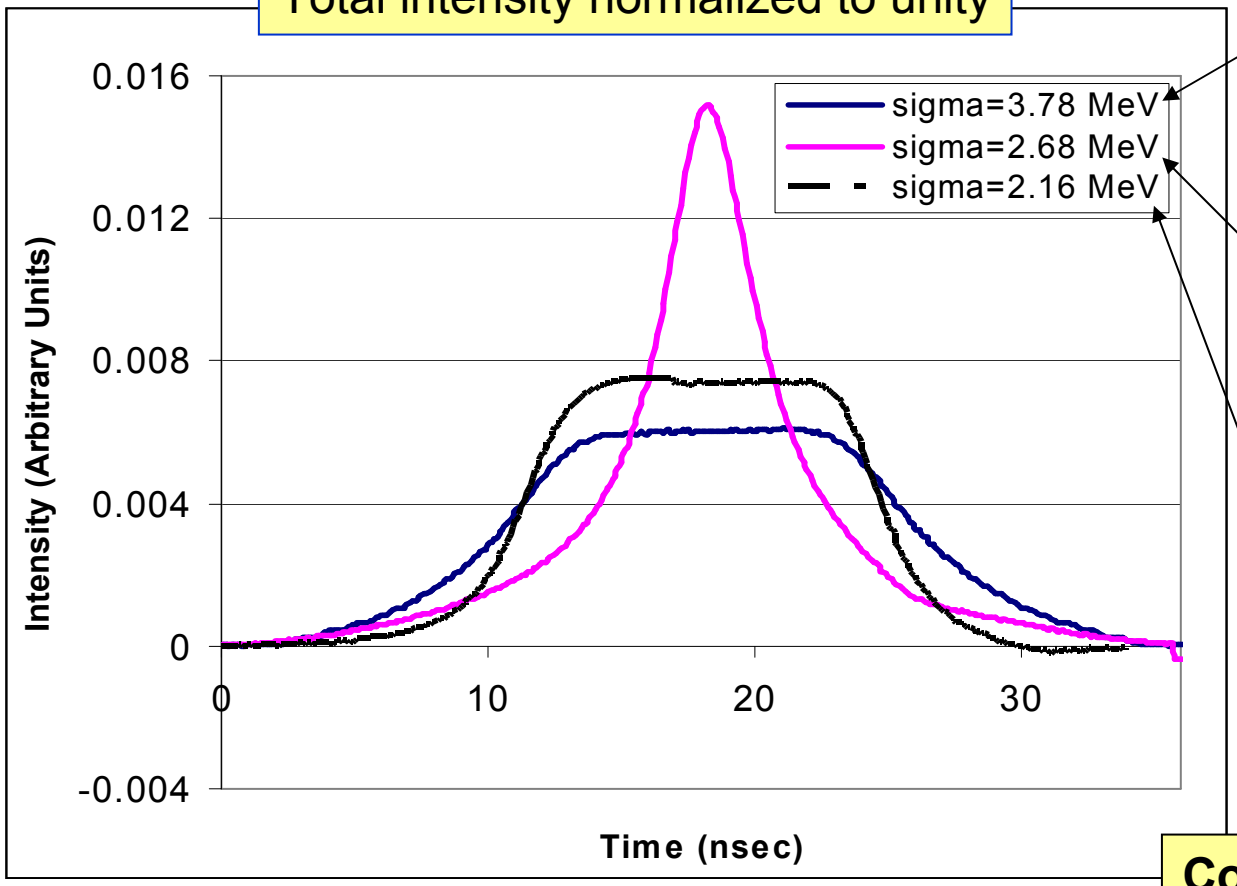
Measurements

RR Barrier bkt

Total intensity normalized to unity



27.2E10 pbars
εT(H,V)~(8,8)pi
LT~700 hrs
(061113)

20.5E10 pbars
εT(H,V)~(6, 7)pi
(~5% reduction during cooling for about 30 min)
LT~600hrs
(060828)

15.5E10 pbars
εT(H,V)~(3.1,2.9)pi
LT~1400 hrs
(061010)*

Conclusions:
For the same bunch intensity the peak density can be reduced by a factor of ~ 2 by using (13-10-13) type bucket

* During the (061010) expt. beam area was 5.58 eVs, dE1/= 2.16*2MeV ≈ 4.32MeV with (11+28+11) type soft bucket & # of pbar=35.5E10/bunch. The # of beam particles in (3-10-13) type bucket are estimated as follows,

$$I = \frac{(\text{Beam LE})_{\text{T2=10}}}{(\text{Beam LE})_{\text{T2=28}}} I_{\text{bkt with T2=28}} = \frac{2.44}{5.58} 35.5E10$$

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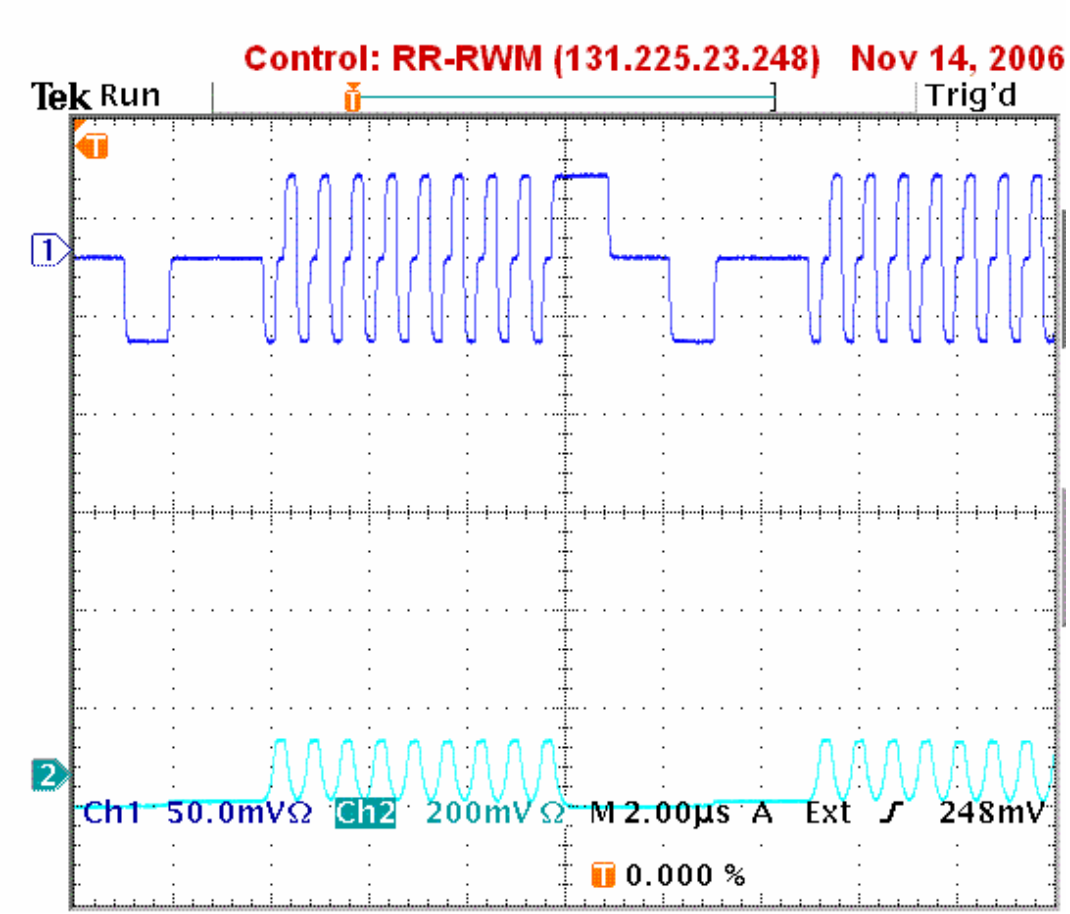
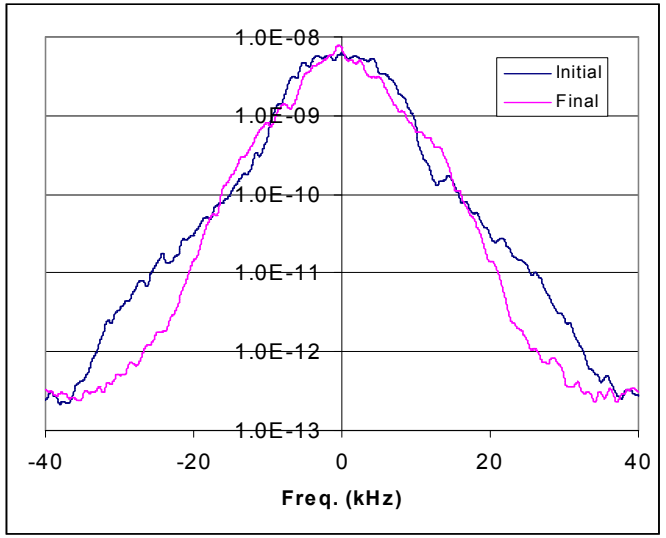
e-cooling and Stochastic cooling on 245E10 pbar



LE~ 700 hrs
TE~ 6-7 pi (remained the same)
LE = 98 eVs→ 72 eVs



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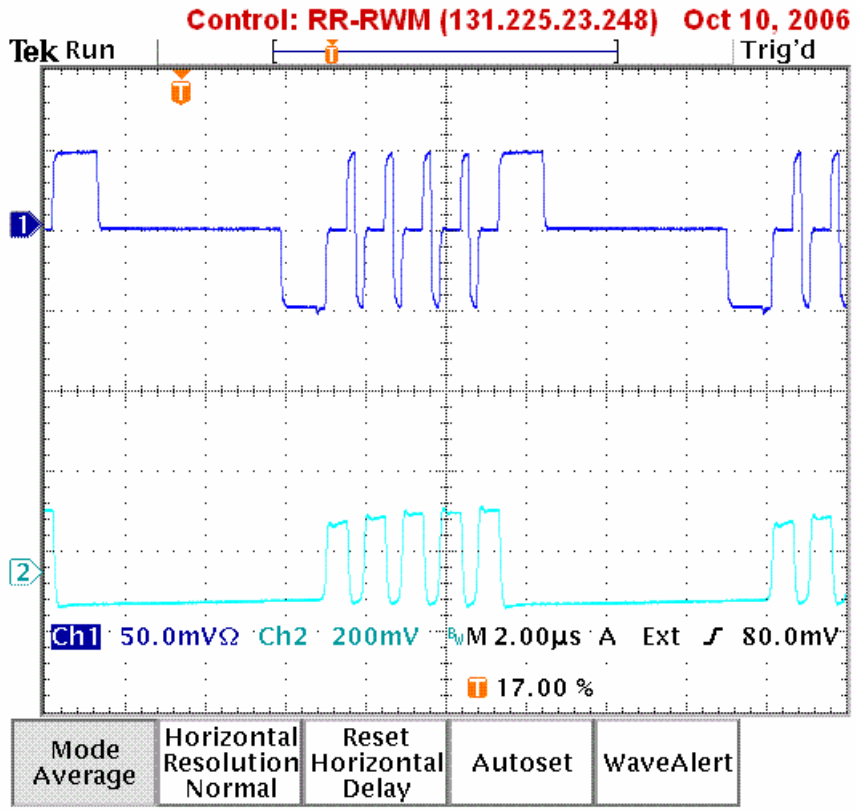
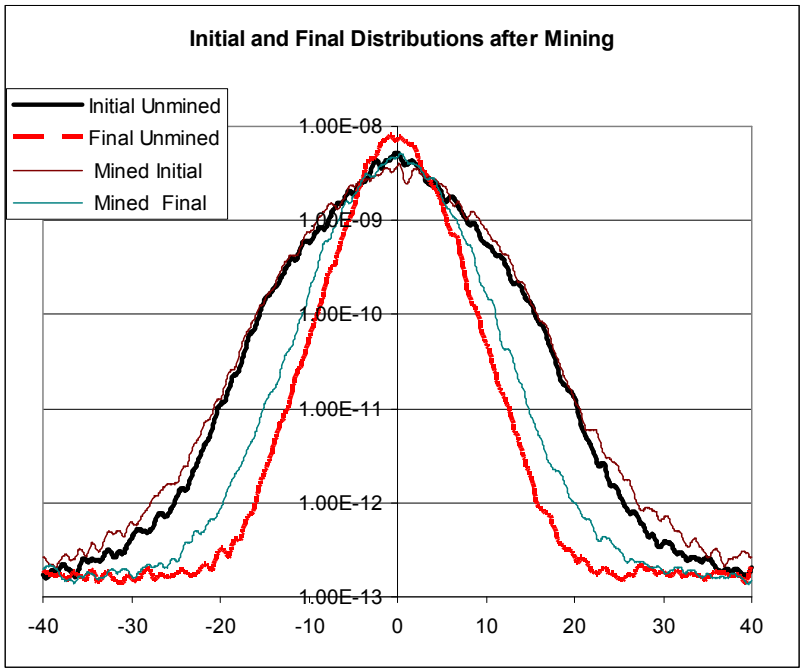
e-cooling and Stochastic cooling on with mined bucket (177E10 pbar)



LE~ 1400 hrs (throughout the mined state)
TE~ 3 pi (remained the same)
LE = 59 eVs→ 31 eVs in 1hr 20min



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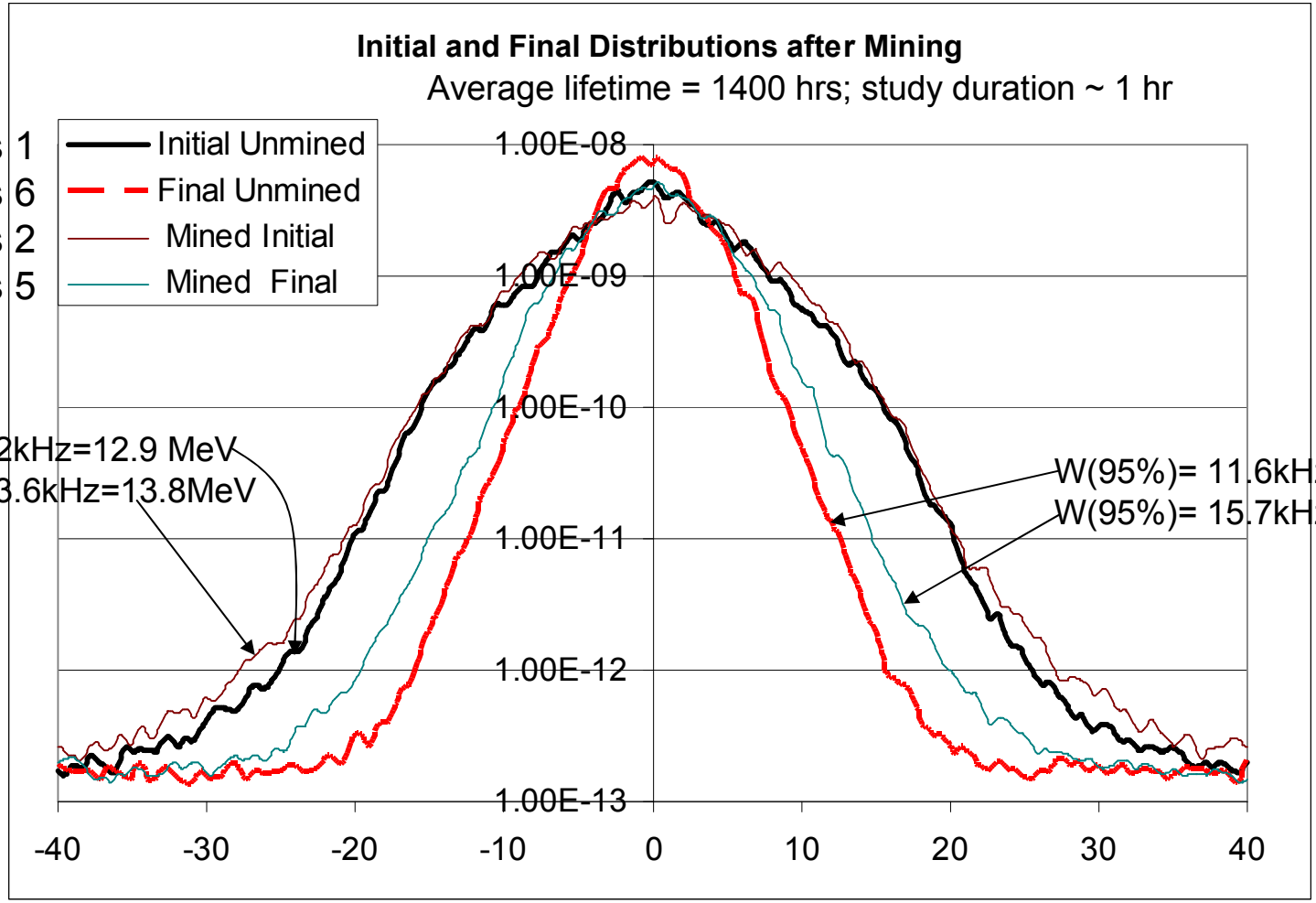
Mining Improve EXPT2 177E10pbars

MM-improve-dataset-2-061010.xls



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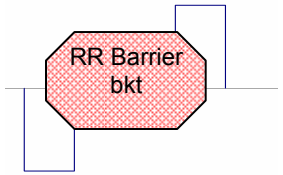
Development of R6 states & Implementation in Operation

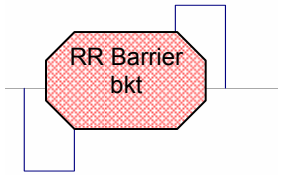


- R6 states have been developed on RRLLD and tested
- Implementation for Tev shots
  - 53 for Mining
  - 45,46,47 for transfers
  - 48 and 49 for 1st and 2nd cogging
  - 50 for grow 2.5 MHz buckets and antibuckets
  - 52 for recovery at the end of Tev shots

  } Replace by new states

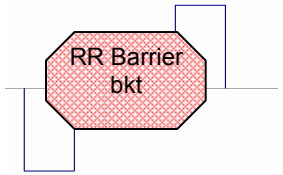
  - WF 15, 14, 13, 6, 7 will be replaced by new WFs

Changes in sequencer



- No changes are required
  - No additional efforts needed to train MCR Operators

Future Plans



- With the approval from the Operation Department (Brian and Cons) and RR department we can replace with the appropriate new r6 states
- Follow the same procedure for the Tevatron shots and recovery
- Try during one of the Tev shots ←**Enjoy the benefits of lowered peak intensity and σ (better lifetime, lower LE)**