Project-X Beam Transfer to Booster

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Parameters for Transfers

- *We wish to do bucket to bucket transfers between the Linac and Booster, but the RF frequencies are not harmonically related*
  - *RFQ frequency = 162.5 MHz*
  - *Booster frequency at 1GeV kinetic=46.46 MHz*
- *Linac beam current ~ 1mA for 1ms*
  - *For 4 mA from RFQ 75% of beam is chopped out*

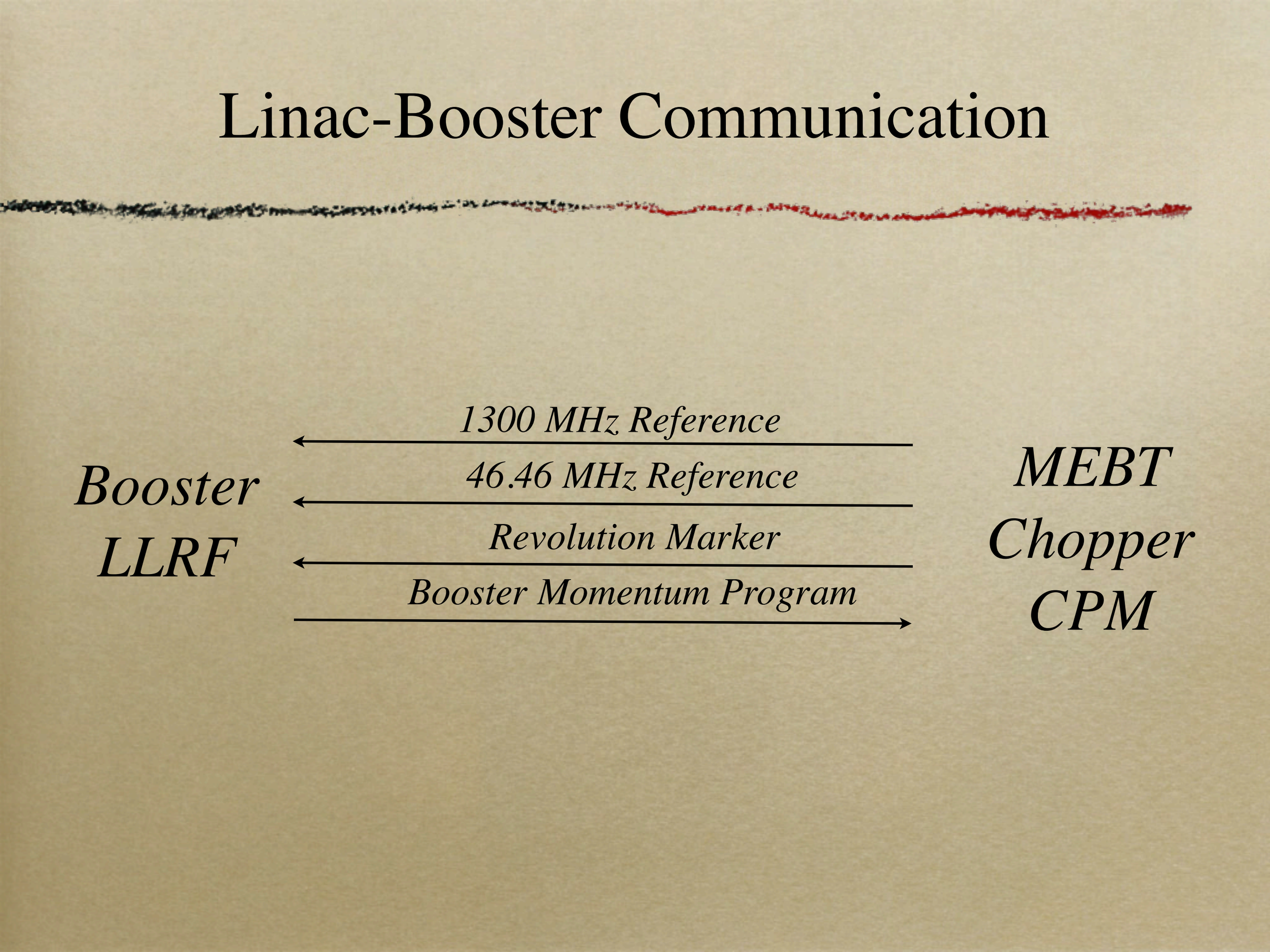
Chopper Program Module(CPM)

- *The CPM*
  - *generates chopper pattern to distribute beam to multiple experiment beam lines*
  - *generate chopper pattern to load beam into Booster or RR RF buckets*
  - *pre-distort the pattern to correct for amplifier and chopper structure distortion*
- *The original concept of generating a chop pattern in real time based on Booster RF does not allow time to "learn in" the pre-distortion waveform*

A Deterministic Approach

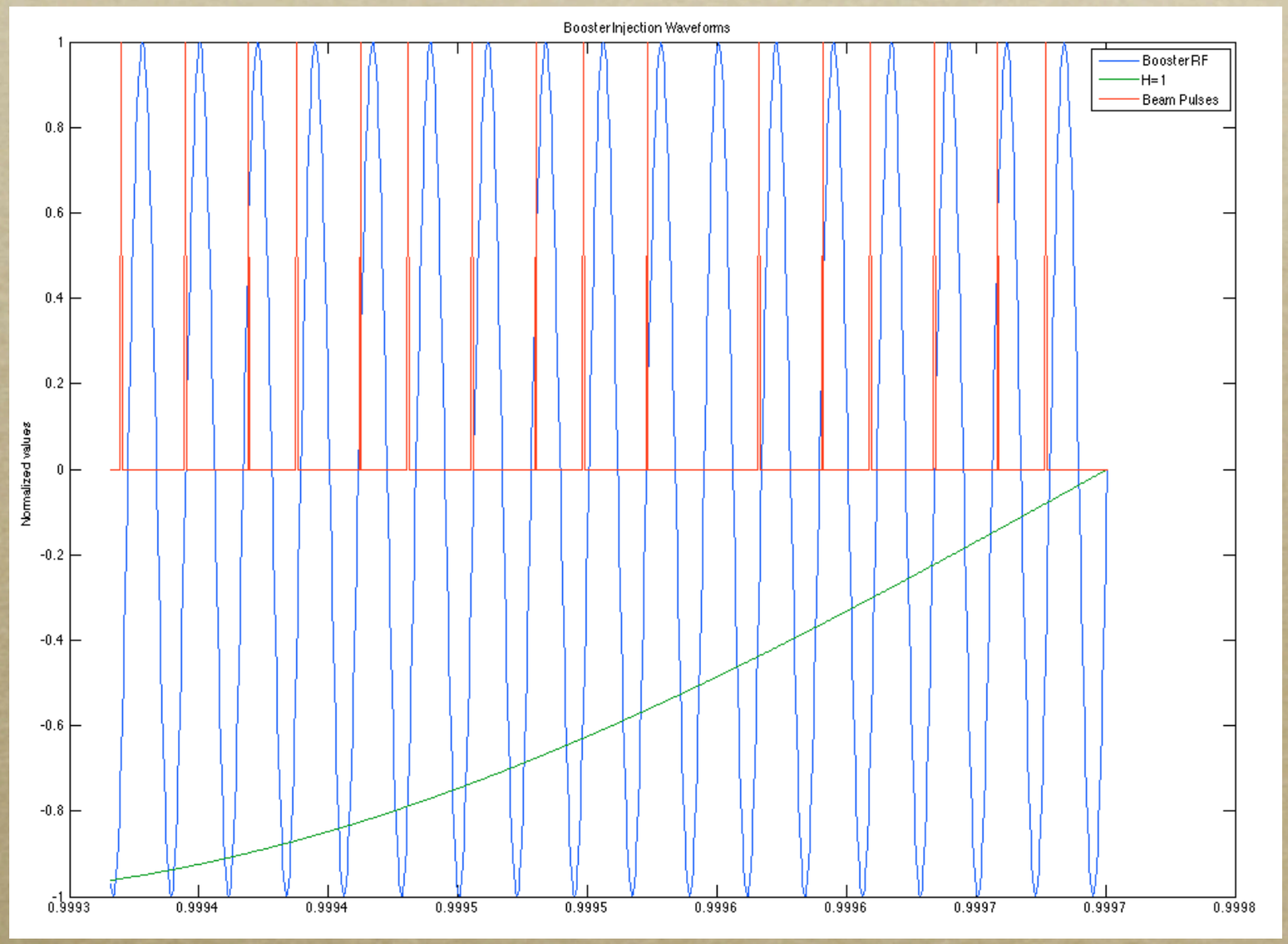
- *Instead of having the linac bunch pattern follow the target machine (Booster) RF, lock the Booster to the linac - allowing the Linac beam pattern and CPM waveform to be pre-calculated and pre-distorted*
- *The CPM generate the target machine's RF signal and revolution marker in sync with the chopper pattern*
- *The Booster phase and marker locks (clock lock) to these CPM signals just before injection*
- *These RF and marker signals will be generated in two new 2.6 GSPS ARB channels with a memory depth equal to the injection period (1 msec for Booster, 4ms for Recycler)*

Linac-Booster Communication



Chopper and RF Waveforms

- The RF waveform tables are calculated from the target machine parameters:
  - injection frequency
  - harmonic number
  - Bucket target phase
  - Linac average and peak beam current
  - Beam bunch frequency after any RF separators (162.5,81.25)
- The waveform is generated to contain an integer number of RF and H=1 cycles so that it can loop and generate seamless waveforms

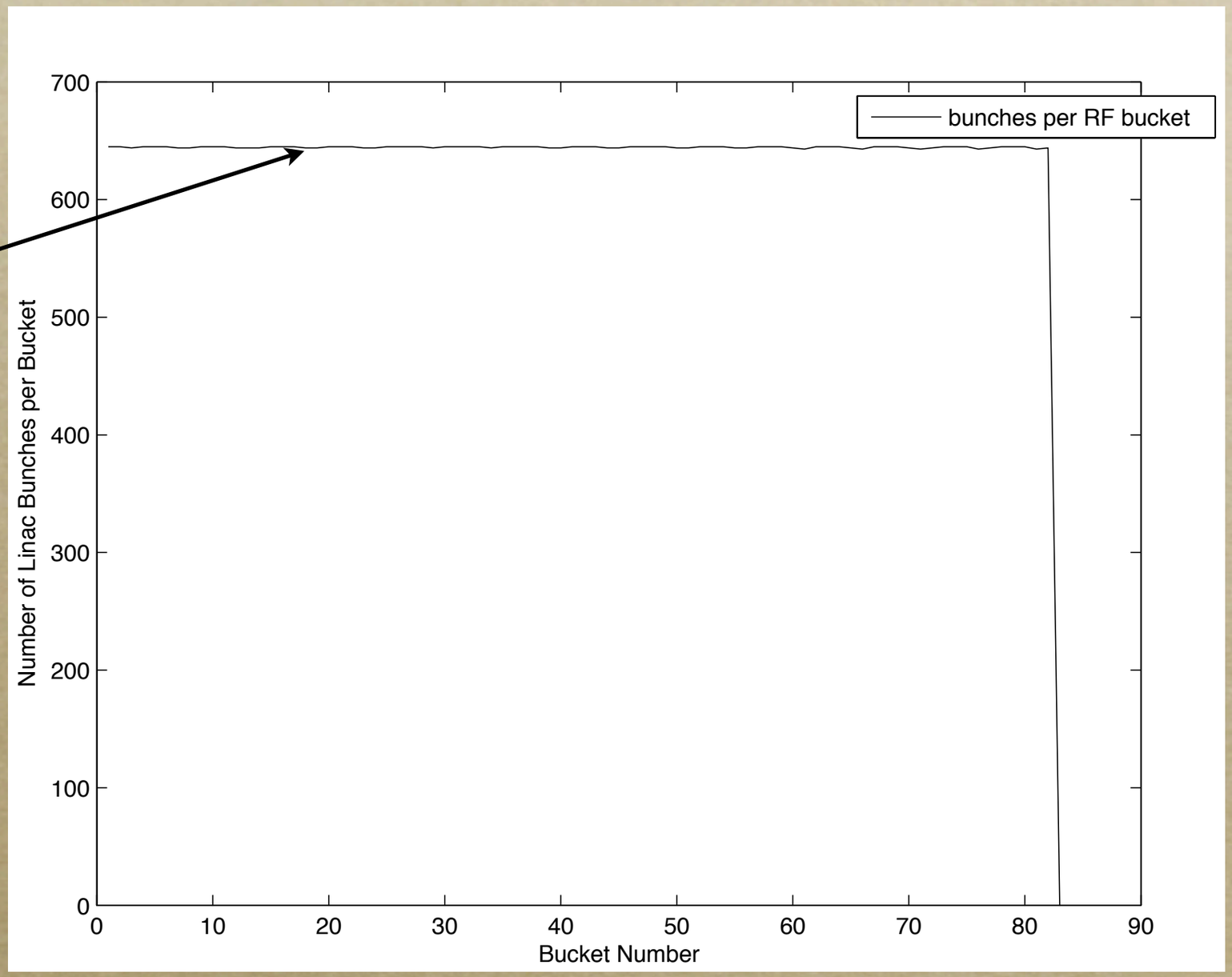


Beam Intensity per Bucket

H=84

1 ms injection with 2 bucket kicker gap

Generated with 162.5 MHz beam available to the CPM



Linac Turbo Mode

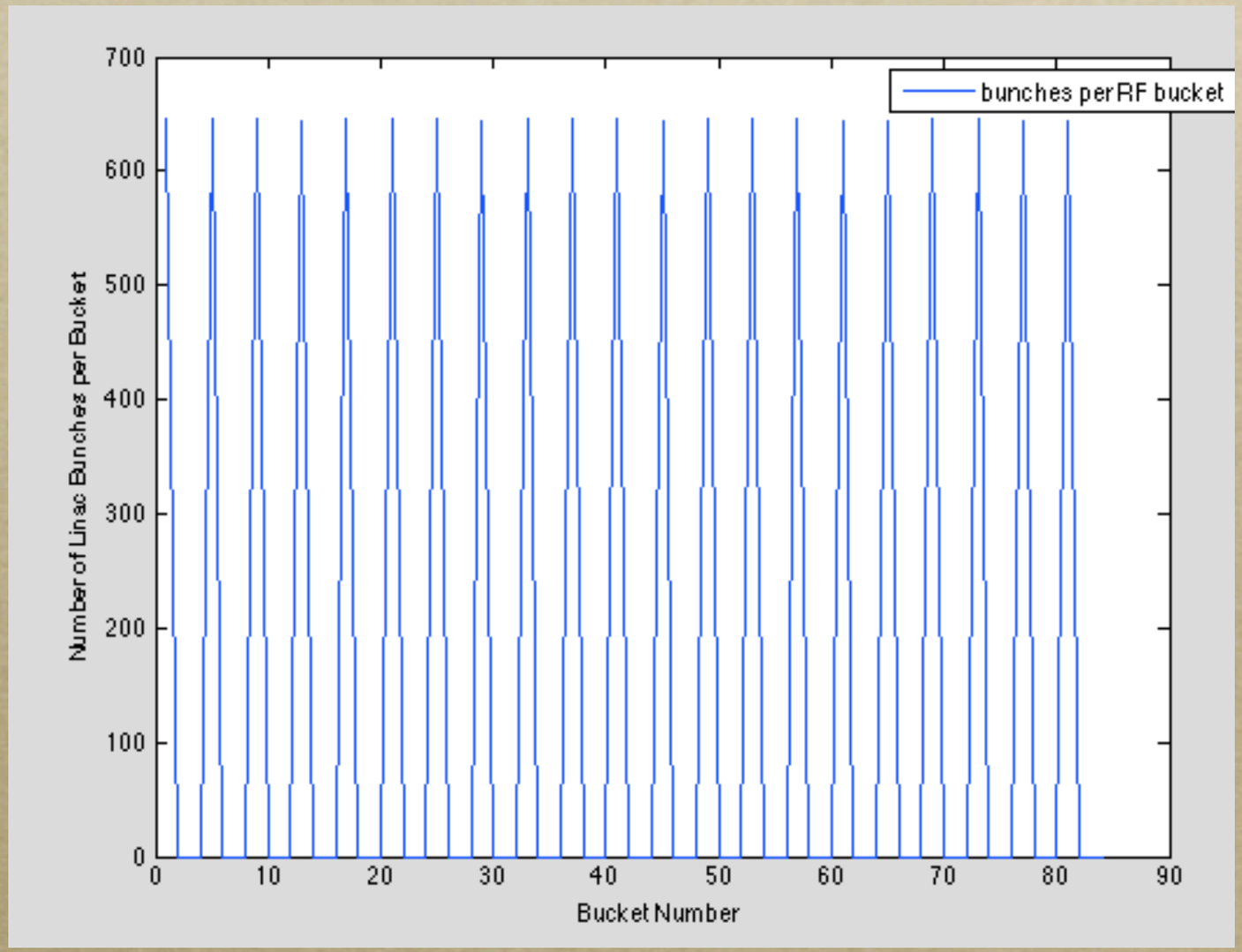
- *The shorter the Booster injection time the better*
  - *Less field change during injection*
  - *Less beam loss and emittance blow up from the stripping foil*
- *If designed from the start, solid state RF amplifiers can put out higher power for sub millisecond pulses*
  - *Therefore we could consider increasing the beam current during Booster injection and reducing the injection time*

Other Ideas Considered

- *Hormonic injection from Linac to Booster*
  - *Let H=83, Booster RF = 162.5/3.5 MHz*
  - *Phase paint buckets*
  - *Increased complexity with no physics gain*
- *Sweep Linac energy over 4 MeV range*
  - *this may work but may be more complex as it touches many systems (LLRF, beamline correctors, etc)*

40.625 MHz Beam Structure

- *A 40.625 MHz beam structure does not lend itself to Booster injection*
  - *4 ms injection time*
  - *Poor bucket filling*



Conclusions about transfers (2)

- *We have a scenario to produce the proper chopper pattern to inject beam into Booster (and Recycler) RF buckets*
  - *It "looks" like we can inject into stationary buckets in the Booster by using correctors to compensate the Booster dipole swing NEEDS SIMULATION!*
- *A 162.5 MHz beam structure is best and most flexible*
- *A 81.25 MHz beam structure will work*
- *A 40.625 MHz beam structure does not appear to work*