

805 MHz μ -bunch in Booster

- Addressing only question of μ -bunch shape for one or two turns
- Complicated bunch shape argues for fine binning
- Statistics (granularity) a clear problem
- There is more than one source of granularity
 - macroparticle count
 - bin count
- Can use frequency or time domain calculation; techniques are complementary
 - time domain much faster
 - frequency domain gives simple digital filtering of high frequency component

Parameter Choices

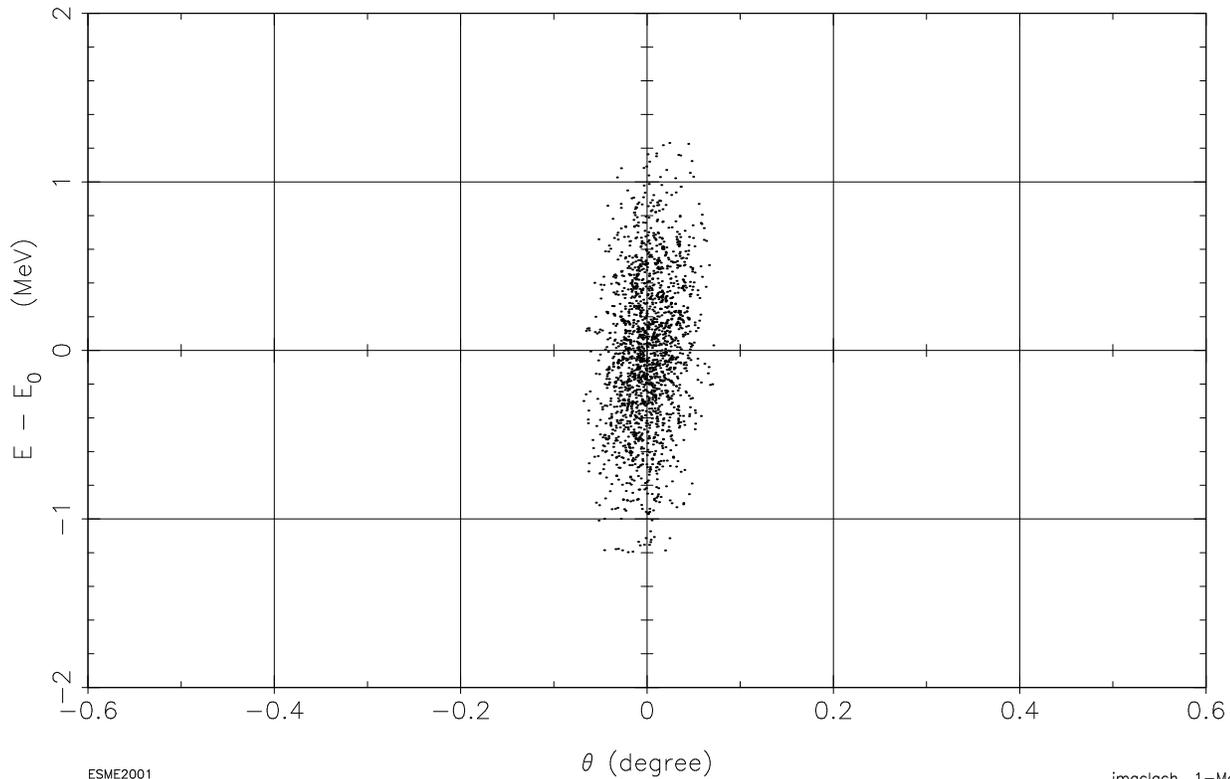
ε_l (end linac)	$8.21 \cdot 10^{-5}$	eVs
ΔE (HW)	1.4	MeV
$\Delta\varphi$ at 805 MHz (HW)	9	deg.
number of protons	$1.25 \cdot 10^9$	
linac-debuncher separation	40.0	m
debuncher-booster separation	20.0	m

Discussion

- linac-debuncher-booster separations convenient, not precise
- bunch length at debuncher about $\pm 90^\circ$
- Booster first turn voltage at wrong azimuthal scale (program artifact, avoidable) Apparently no egregious bunch disruption.
- two turns with correct space charge voltage calculated to show beam charge effects in Booster
- collective voltage puts usfp in center of bunch
- following figures come from tracking of 10^7 macroparticles using 2000 bins for calculating the charge distributions

805 MHz micro bunch (1.25×10^9)

	Iter	50	4.678E-06 sec		
H_B (MeV)	S_B (eV s)	E_S (MeV)	h	V (MV)	ψ (deg)
2.6552E+01	4.2173E-02	1.3383E+03	75	6.000E+01	0.000E+00
ν_s (turn $^{-1}$)	pdot (MeV s $^{-1}$)	η			
7.1929E-01	0.0000E+00	-4.9155E-01			
τ (s)	S_b (eV s)	N			
9.3559E-08	8.6293E-06	10000000			



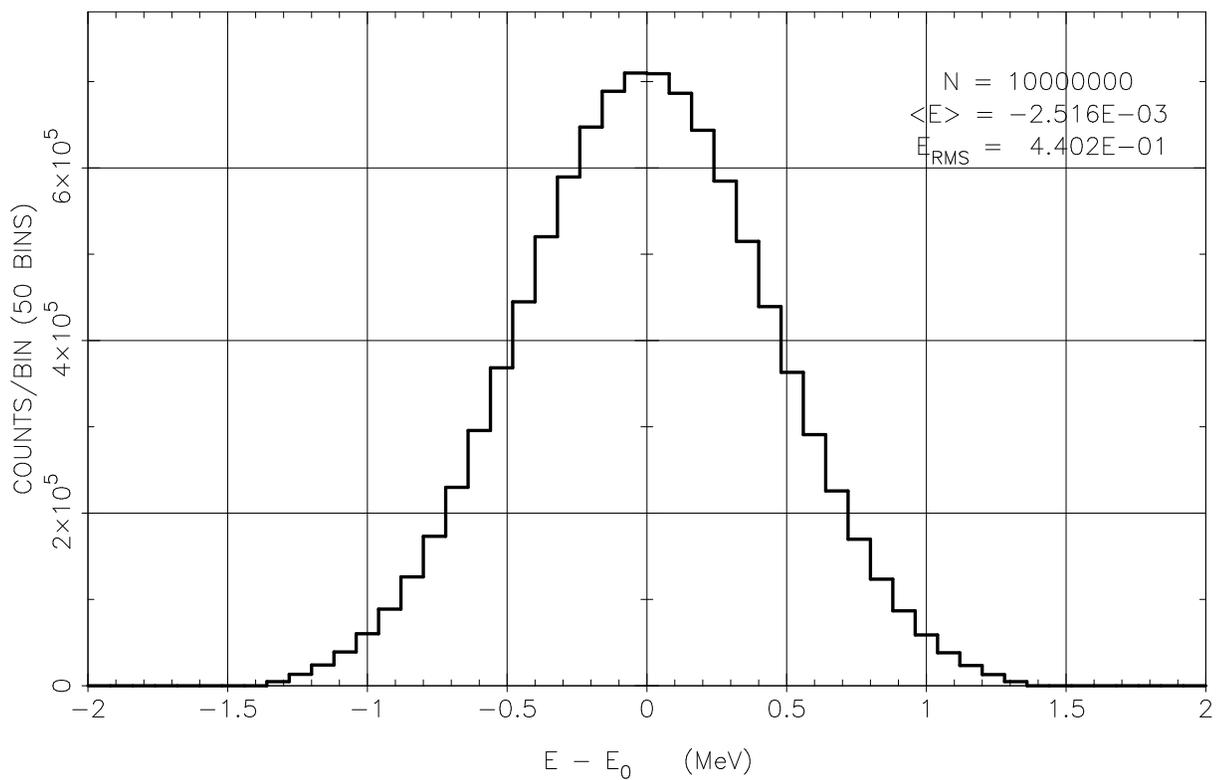
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Longitudinal phase space plot of nominal bunch at end of 400 MeV linac, the starting distribution for results following The phase axis spans 45° of 805 MHz phase; energy axis is in MeV.

805 MHz micro bunch (1.25×10^9)

Iter 50
4.678E-06 SEC

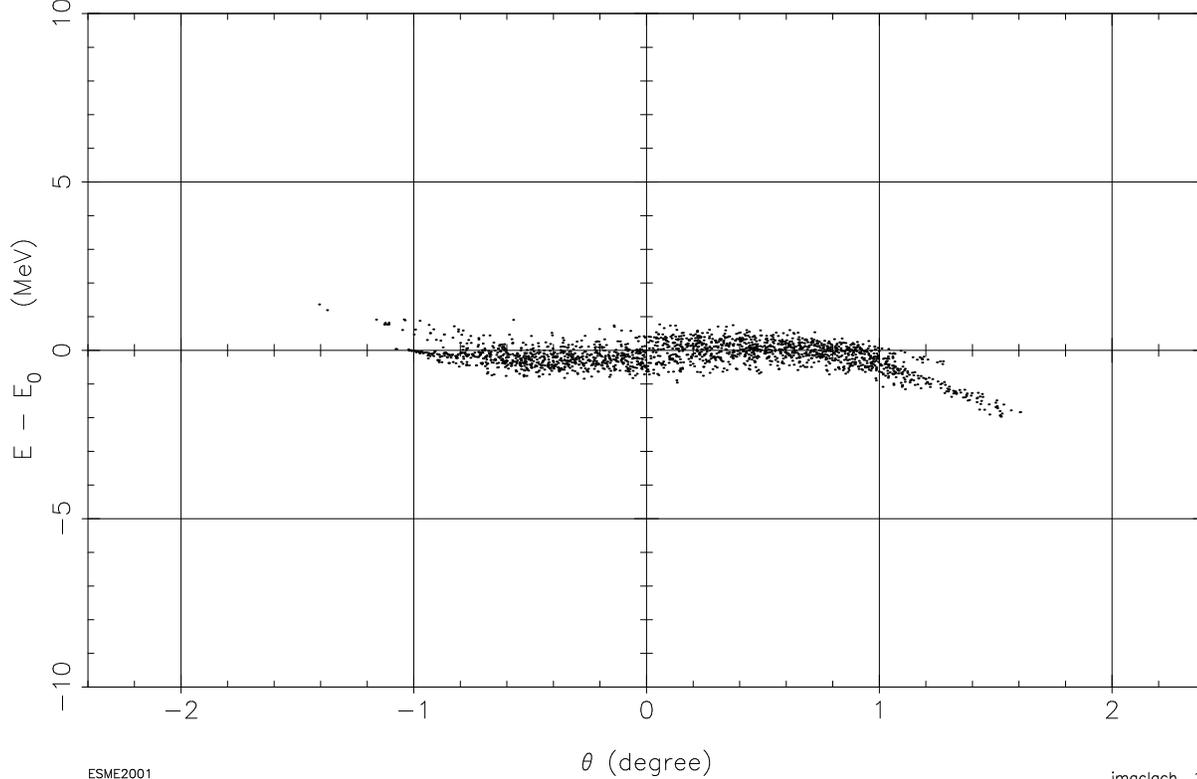


The energy projection of the linac bunch, truncated gaussian extending ± 1.4 MeV. The extremes of the phase projection (also gaussian) are $\pm 9^\circ$ of 805 MHz phase.

805 MHz micro bunch (1.25×10^9)

Iter 90 $4.865E-06$ sec

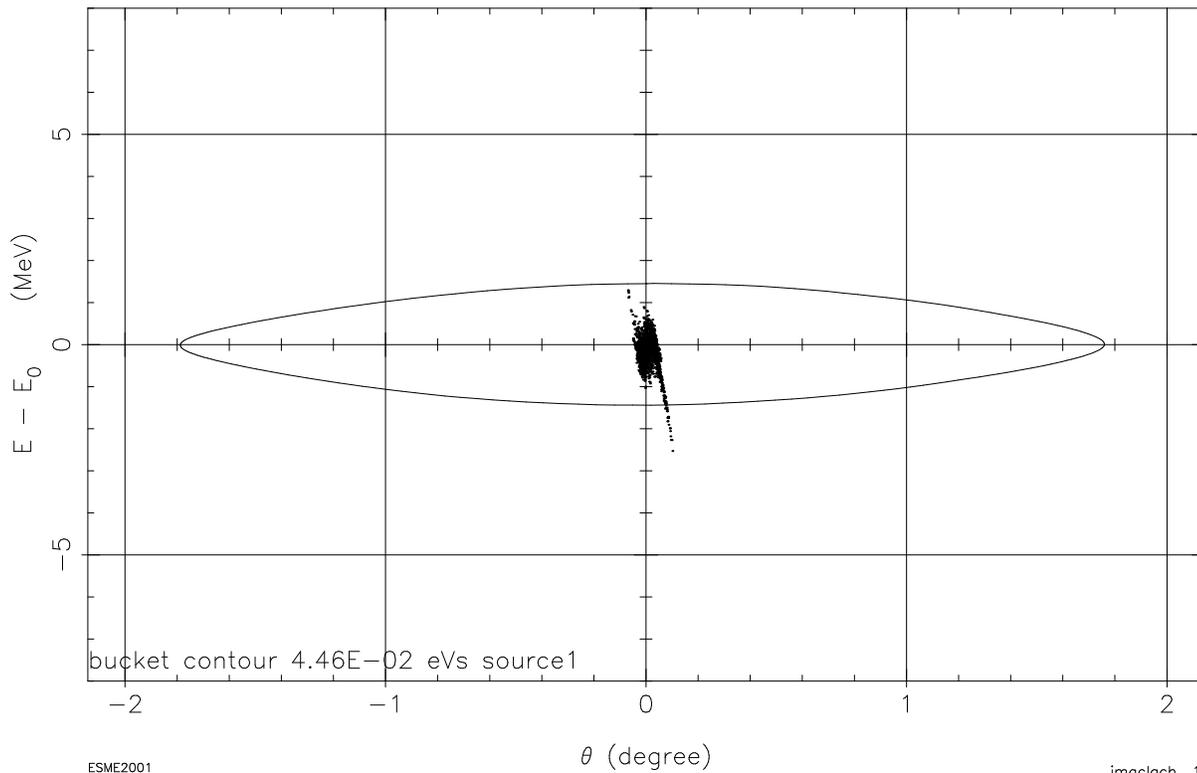
H _B (MeV)	S _B (eV s)	E _S (MeV)	h	V (MV)	ψ (deg)
5.9372E+00	9.4301E-03	1.3383E+03	75	3.000E+00	0.000E+00
ν _S (turn ⁻¹)	pdot (MeV s ⁻¹)	η			
1.6084E-01	0.0000E+00	-4.9155E-01			
τ (s)	S _b (eV s)	N			
9.3559E-08	1.9109E-04	10000000			



Linac bunch after debunching at 805 MHz 40 m downstream of the linac

805 MHz micro bunch (1.25×10^9)

	Iter	110	4.959E-06 sec		
H_B (MeV)	S_B (eV s)	E_S (MeV)	h	V (MV)	ψ (deg)
1.4473E+00	4.4645E-02	1.3383E+03	84	2.000E-01	-2.881E-01
ν_S (turn ⁻¹)	pdot (MeV s ⁻¹)	η			
4.2415E-02	-6.3587E+02	-4.5784E-01			
τ (s)	S_b (eV s)	N			
2.2183E-06	1.9361E-04	9998588			



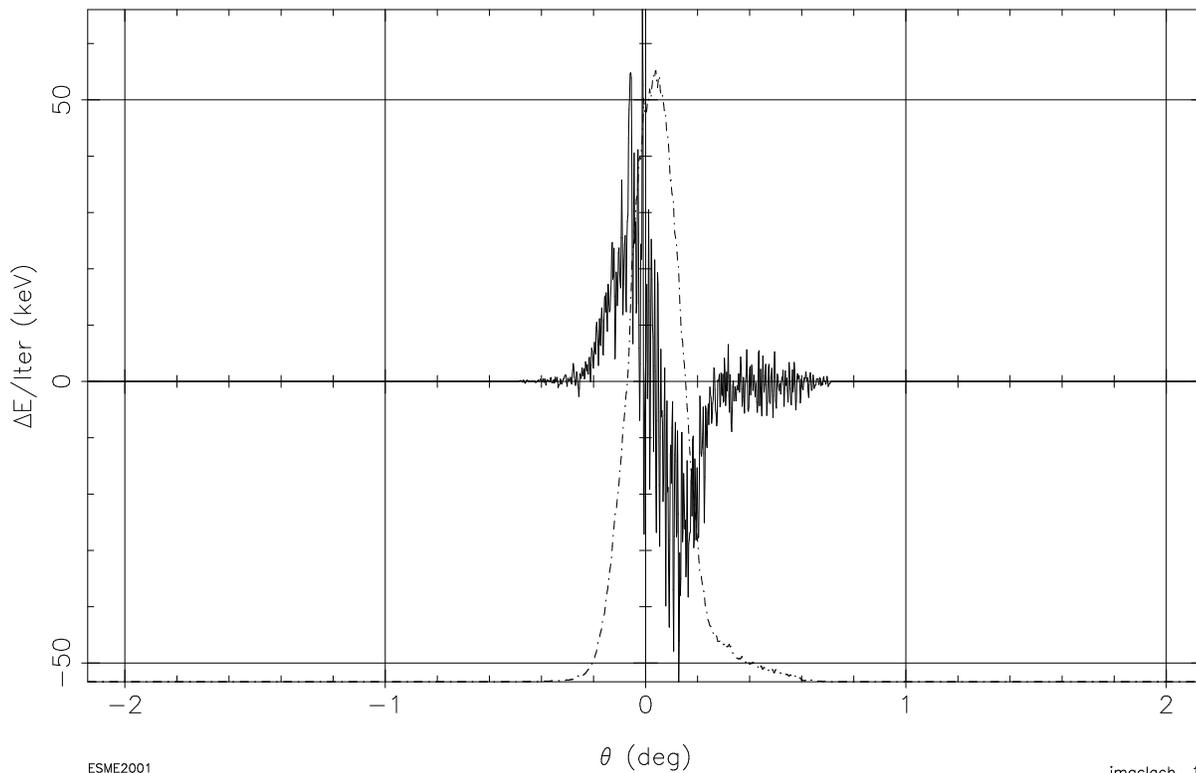
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μ -bunch in booster after 20 m drift from debuncher
 The phase axis is now in degrees of

805 MHz micro bunch (1.25×10^9)

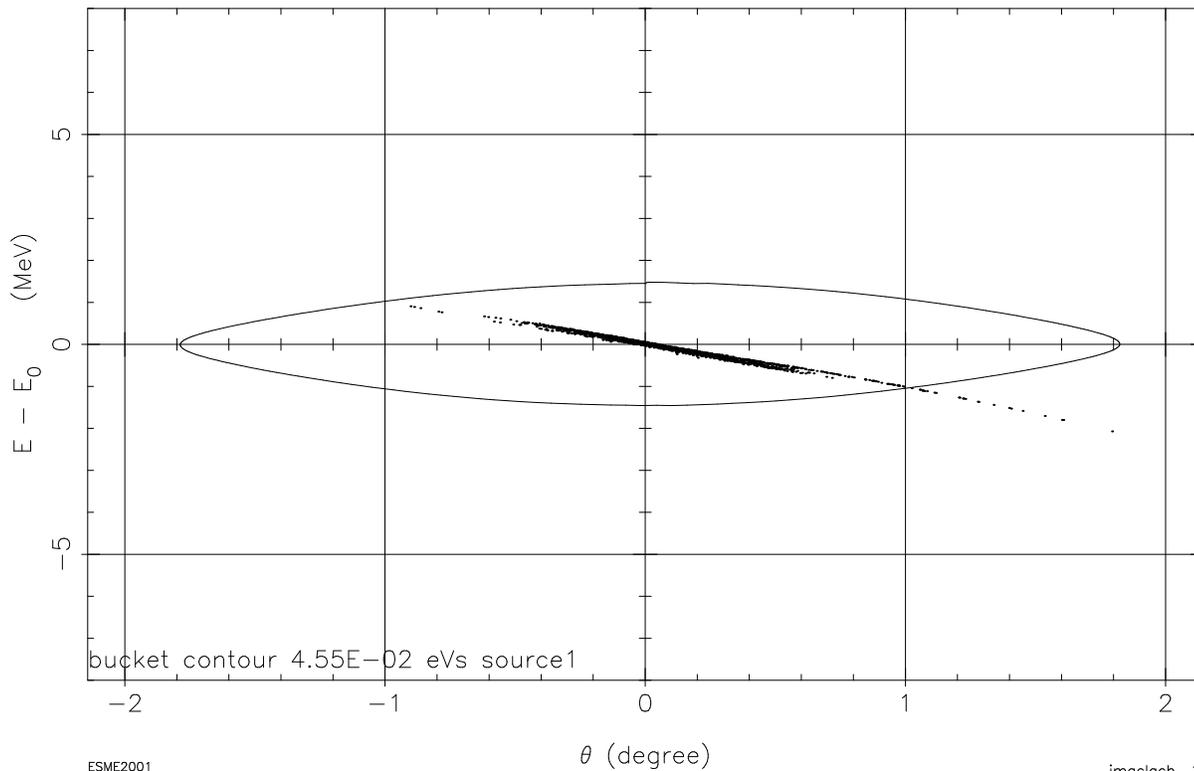
Iter 130
7.177E-06 SEC



The perfectly conducting wall voltage expressed as the energy loss or gain for 1/20 of a booster turn. Thus the voltage values are 20 times the values on the $\Delta E/\text{iter}$ axis.

805 MHz micro bunch (1.25 × 10⁹)

	Iter	170	1.161E-05 sec		
H _B (MeV)	S _B (eV s)	E _S (MeV)	h	V (MV)	ψ (deg)
1.4689E+00	4.5453E-02	1.3383E+03	84	2.000E-01	-1.818E-01
ν _S (turn ⁻¹)	pdot (MeV s ⁻¹)	η			
4.2416E-02	-4.0127E+02	-4.5784E-01			
τ (s)	S _b (eV s)	N			
2.2183E-06	1.9525E-04	9998588			



The μ -bunch after 3 turns in the booster without additional beam injection

Results

- μ -bunch maintains integrity
- voltage developed by one μ -bunch \sim peak rf voltage at injection
- fast increase in rf necessary to stay ahead of growth arising from collective voltage (little to do with “adiabatic capture”)
- present result unlikely to effect conclusions drawn from existing (PWL) multi-turn injection calculations with lower statistics