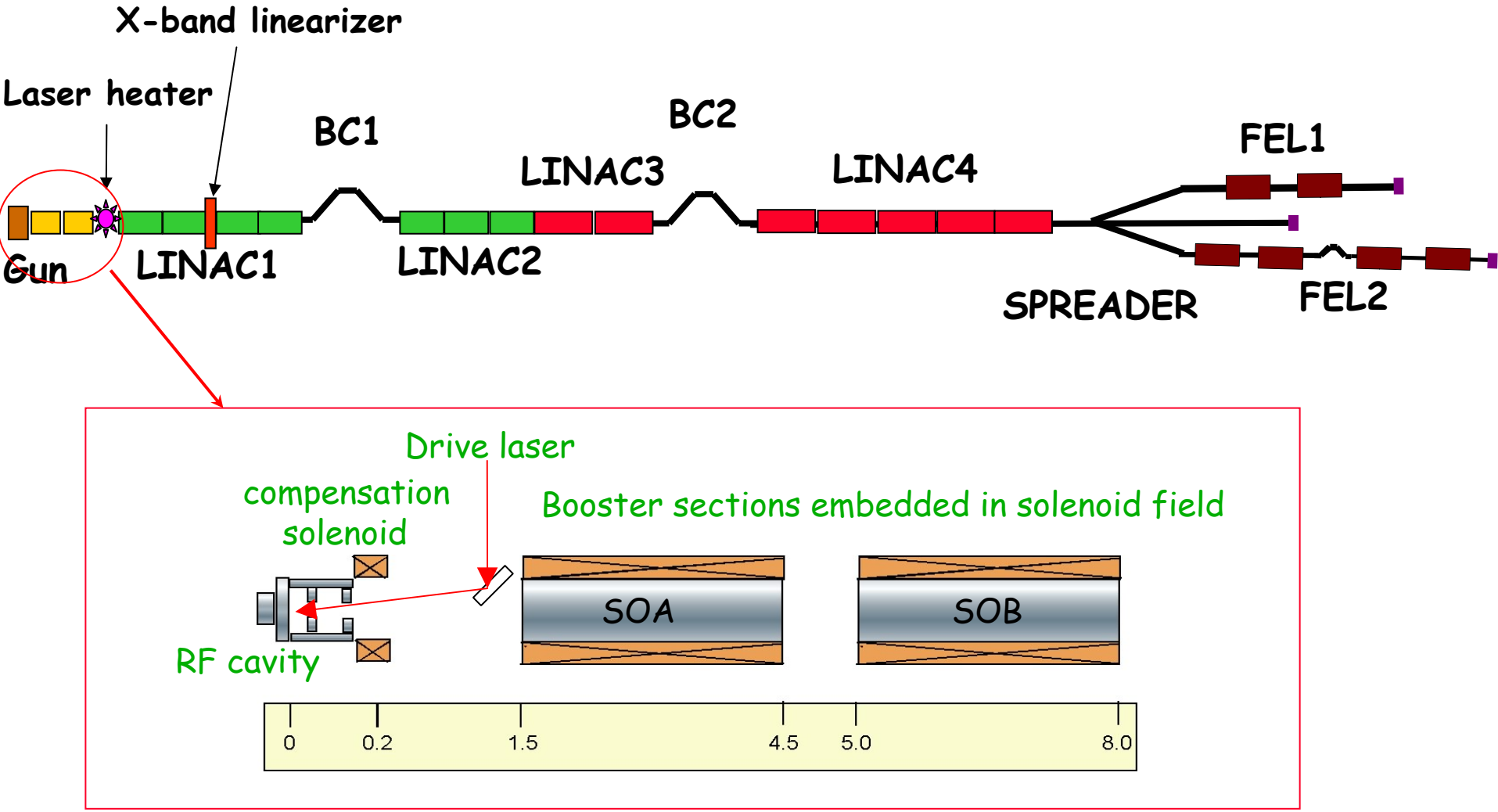
Gun Jitter Study for the FERMI@Elettra photoinjector

M. Trovò, *on behalf of FERMI Gun Team*

FERMI @ Elettra layout

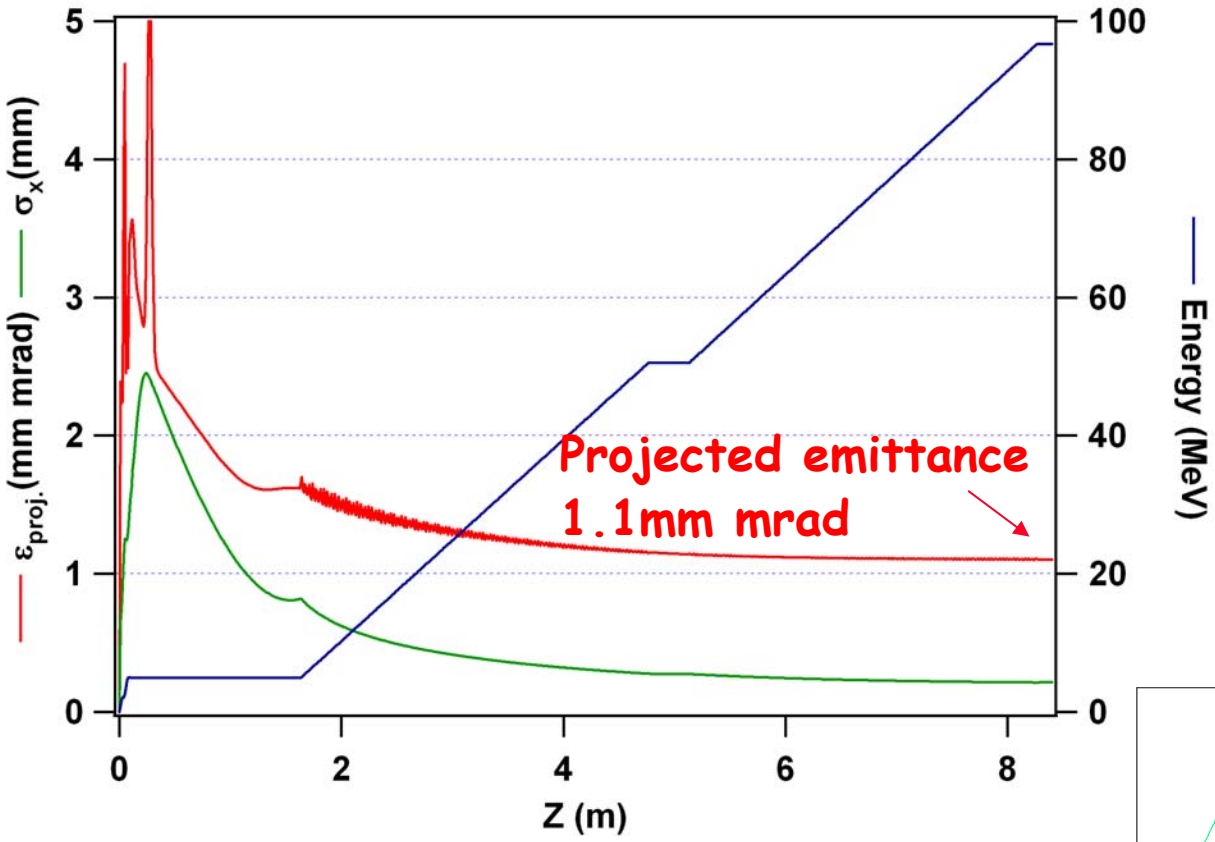


Simulations

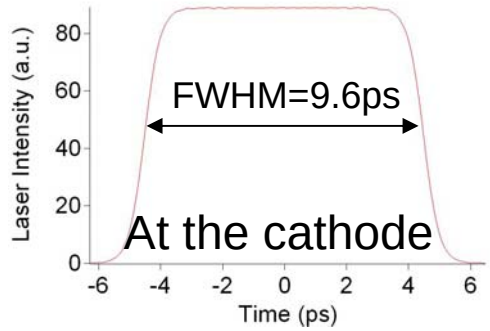
- We study different configurations
  - Different bunch charge [0.2 to 1 nC]
  - Different pulse length at cathode

- We accept constrains
  - Max Gun E field: 110 MV/m (3 GHz)
  - First booster position: 1.6 m
  - First booster energy gain: 45 MeV

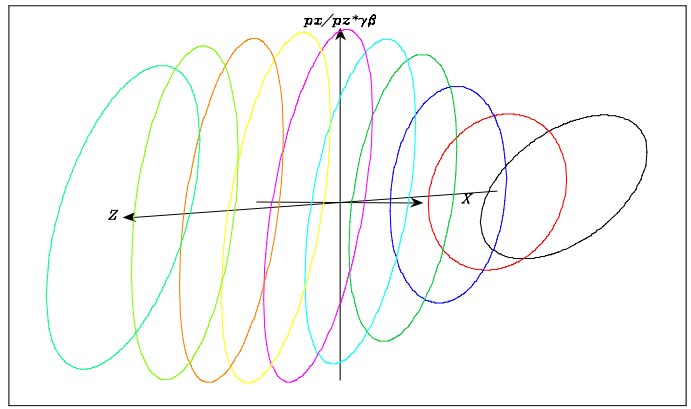
A case: "Long Bunch"



Charge = 1 nC
Spot radius = 1.0mm
ε_x = 0.6 μm

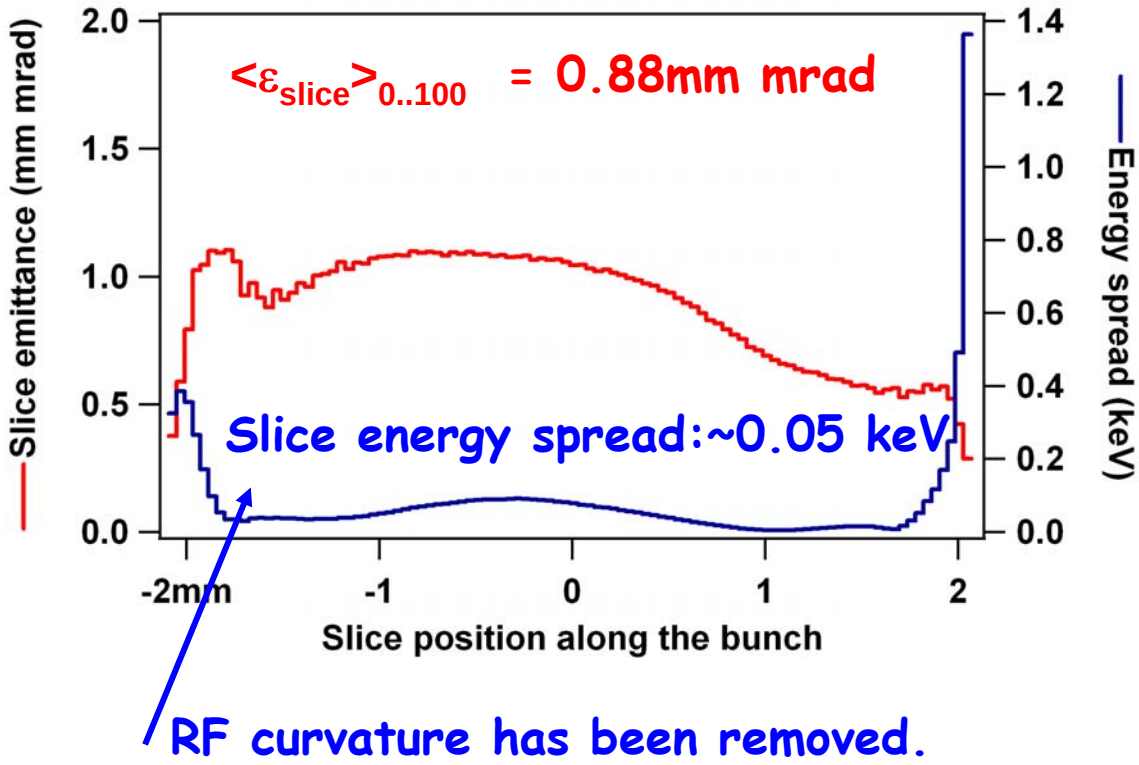


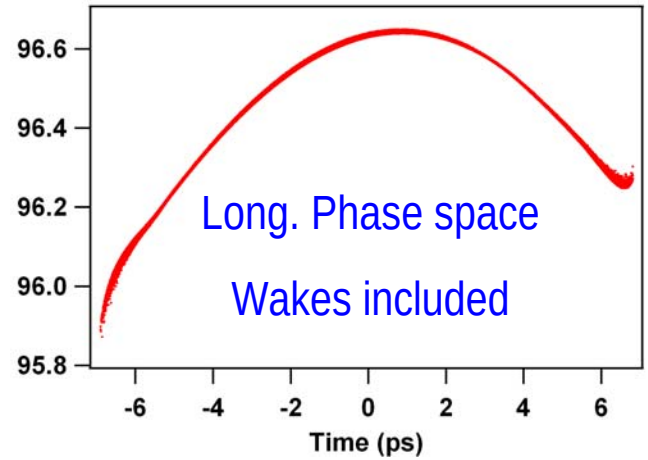
Emittance compensation result =>

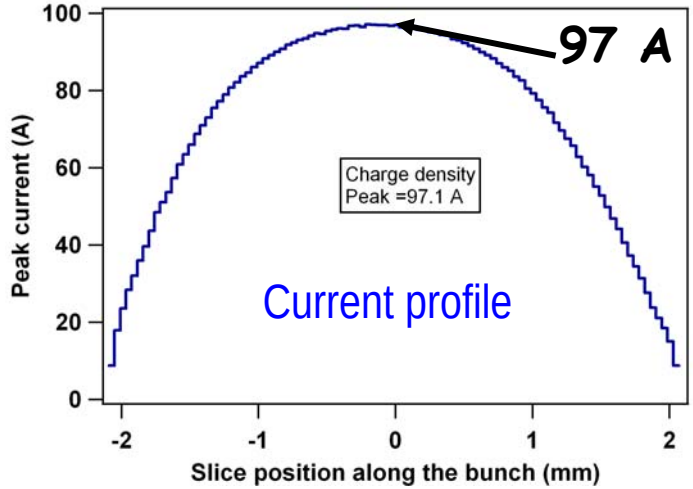


"Long Bunch" Optimization

Bunch at the SOB exit







(100 slices over 1M particle bunch)

"Long Bunch" Sensitivity Study

Parameters (variation)	ΔI (+ 1%)	ΔT (+ 100fs)	σ_E (10keV)	ΔE/E (+ 0.1%)	ε_{proj} (5%)	$\langle\varepsilon_{slice}\rangle_{80\%}$ (5%)
Gun Solenoid (±3%)	2.3 %	5 %	n/s	n/s	0.7 %	0.3 %
Gun Eacc (±1%)	0.6 %	0.15 %	0.2 %	2.7 %	0.4 %	0.7 %
Gun RF phase (±0.3°)	1.4°	1°	0.3°	1.8°	3° *	2.7°
Bunch Charge (±12%)	1.5 %	20 %	40 %	n/s	6 %	7 %
Laser pulse length (FWHM) (±10%)	4 %	2.5 %	5 %	n/s	6 %	9 %
Laser time jitter (±0.9ps)	1 ps	150 fs	230 fs	1.5 ps	2 ps	2.5 ps *
SOA Eacc (±7%)	40 %	1.8 %	1.4 %	0.25 %	14 %	n/s
SOA RF phase (±0.3°)	6°	0.12°	0.27°	0.8°	27° *	n/s

Not achievable with current tolerances

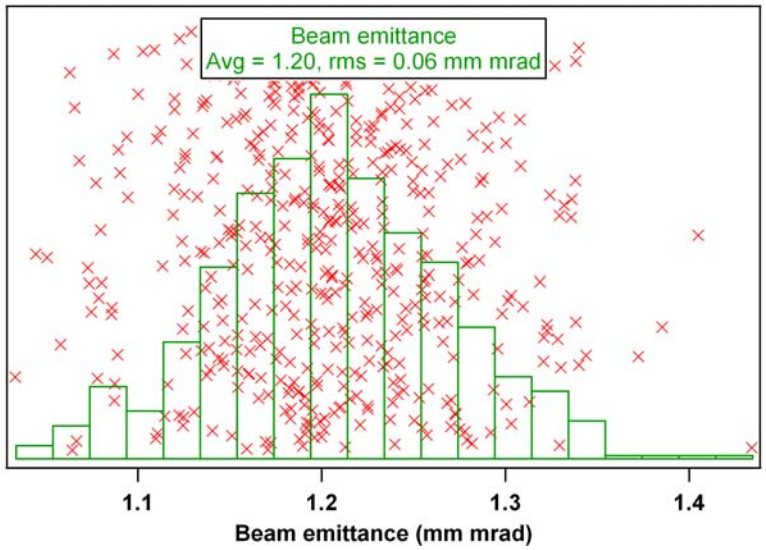
Achievable with current tolerances

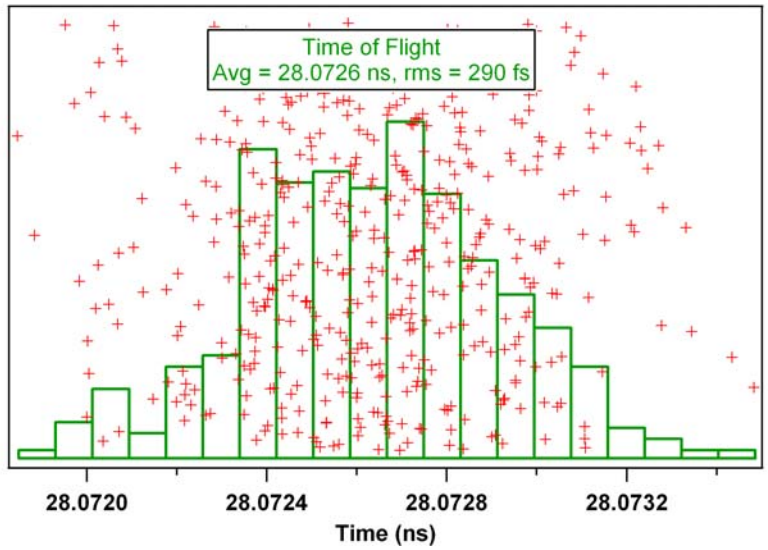
*: extrapolated
n/s: not sensitive

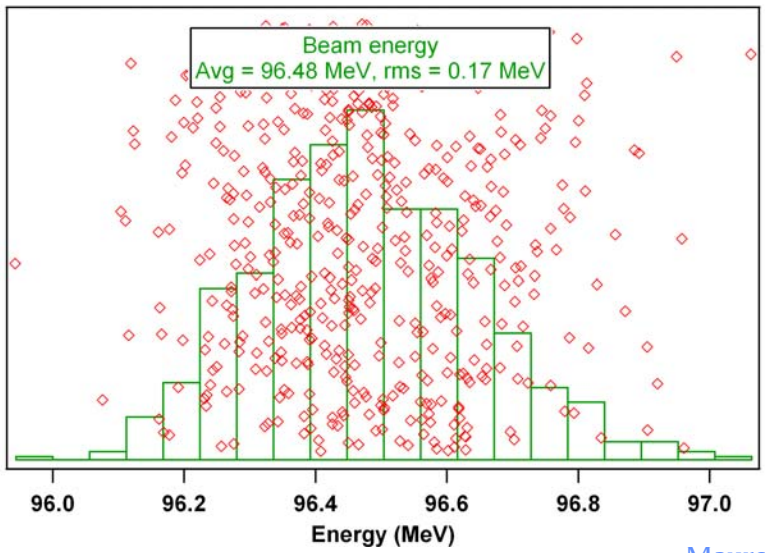
Anticipated Tolerances Budget

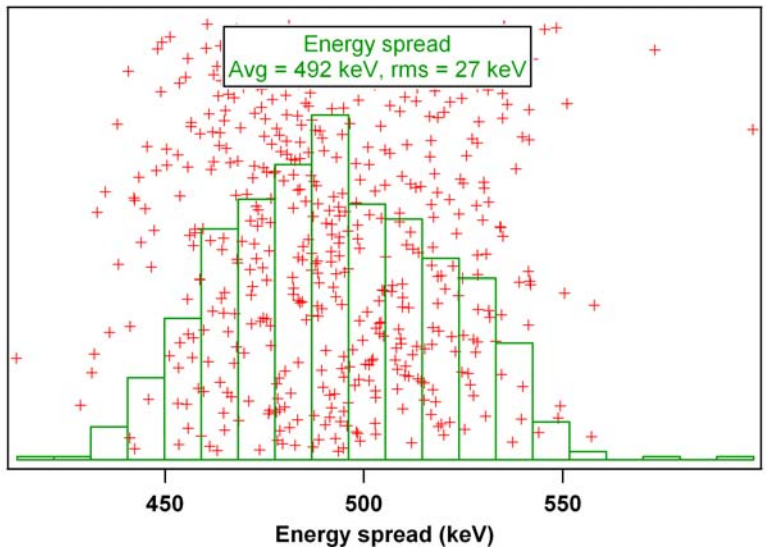
Parameter	Expected RMS Variation
RF injection phase	0.1 deg
Laser arrival time	100-300 fs
Gun E_{acc}	0.25 %
SOA-SOB E_{acc}	0.25 %
SOA-SOB RF phase	0.1 deg
Charge (laser pulse energy)	4 %
Laser spot size	4 %
Laser pulse length (FWHM)	5 %

Jitter study results

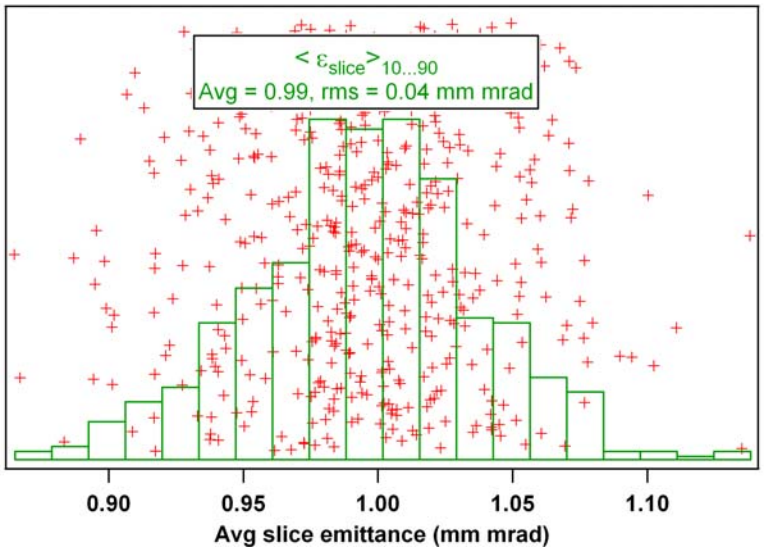


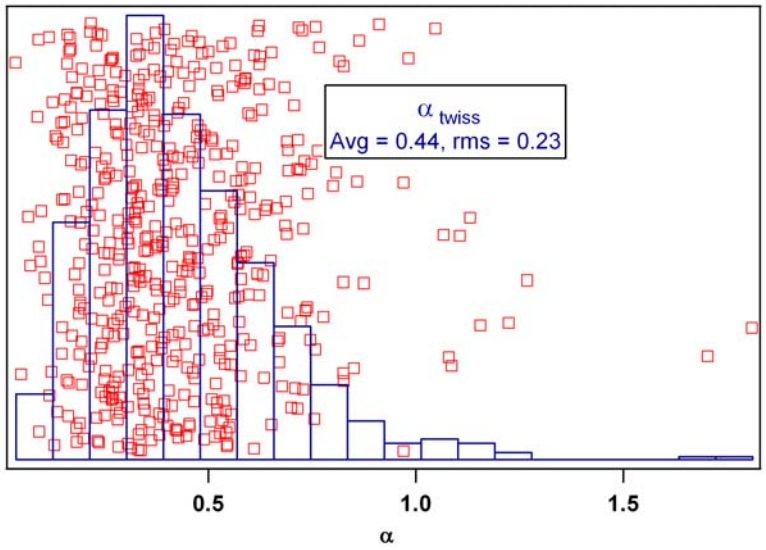


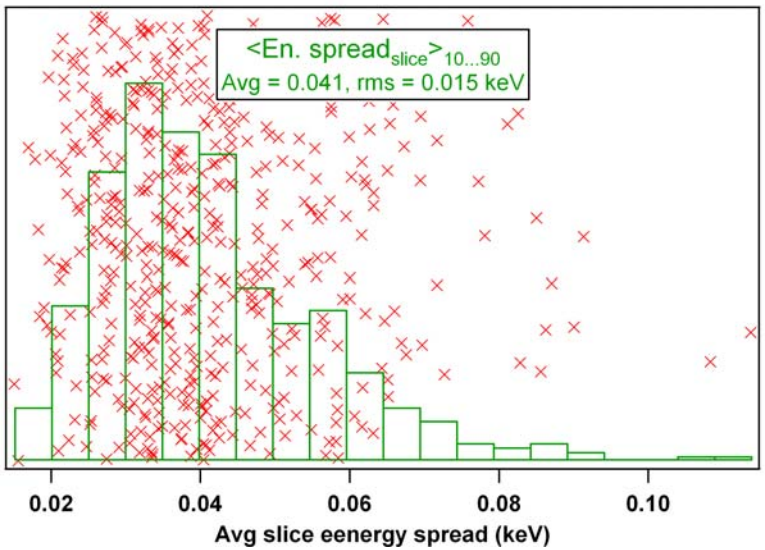


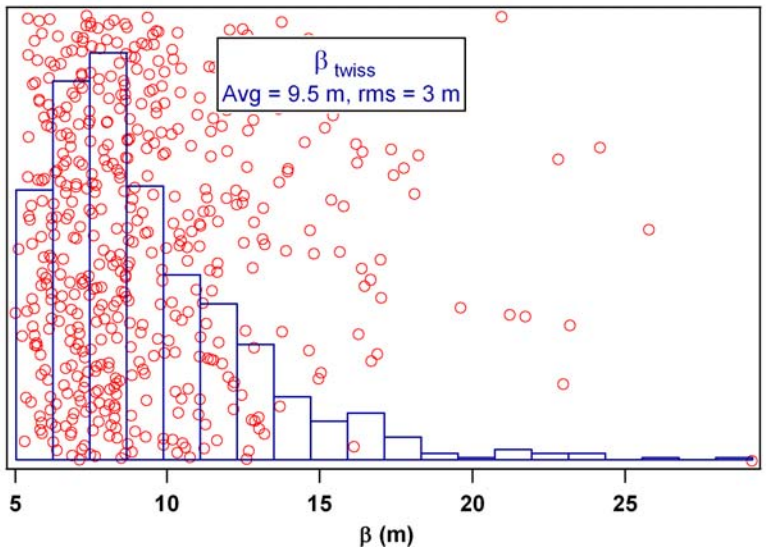


Jitter study results



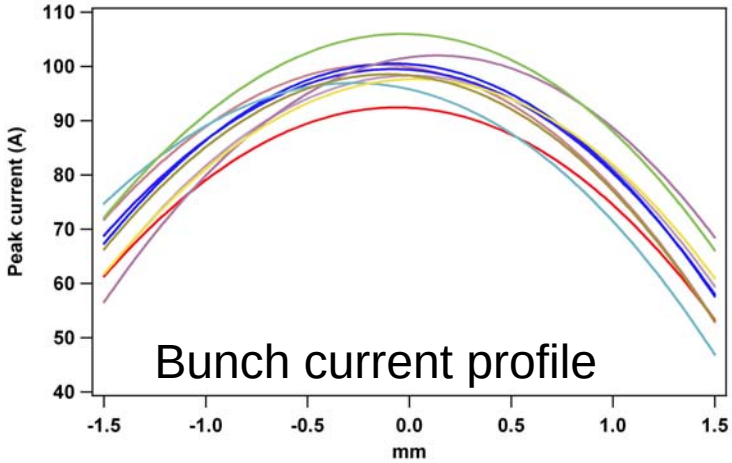


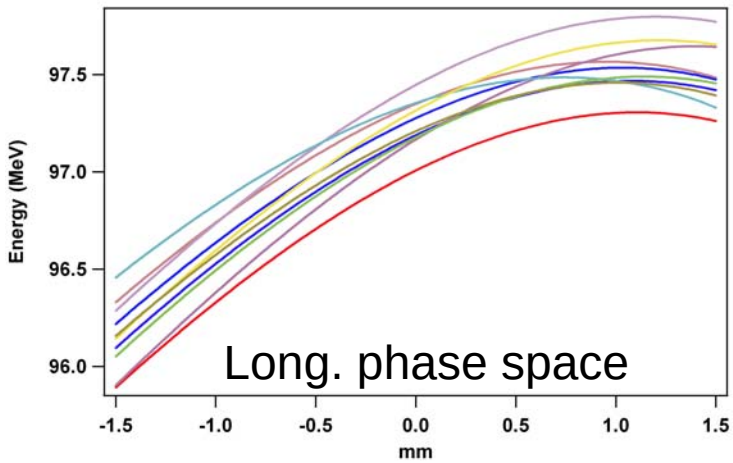


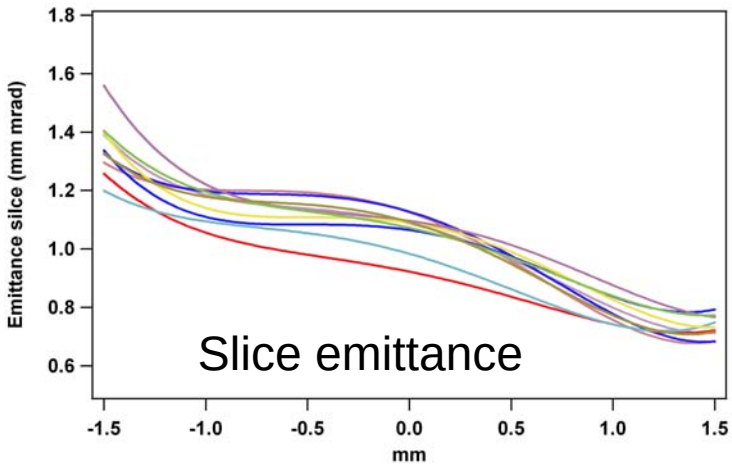


'Slice' fits

samples of 10 randomly chosen out of 500 fits *(polynomial)*







	Current	Ph.space	Slice emit.
<c0>	98	97.18	1.03
$c0_{sdv}$	3	0.19	0.07
<c1>	-1924	5e2	-160
$c1_{sdv}$	3e3	70	53
…			

Summary table

Varying the laser time jitter:

RMS Jitter	300 fs	100 fs
Time [fs]	290	224
Energy [%]	0.17	0.17
Peak current [%]	3.1	3.1
Correlated energy spread [keV]	17	18
ε_{proj} [%]	5.4	5.1
$\langle\varepsilon_{slice}\rangle$ [%]	4.2	4.1
$\langle\sigma_{E,slice}\rangle$ [eV]	15	10

Summary on Injector Jitter Case Studies

- Extensive simulations and data output analysis have been performed
- Sensitivity and jitter studies are (for the most part) commensurate with the expected parameter tolerances.
  - Some expected parameter variation tolerances may need to be tightened.
- For the seeded FELs time jitter remains a critical limiting parameter
- In progress S2E simulations: Gun SDDS Output files are ready to be propagated through the linac and delivered to the fel system

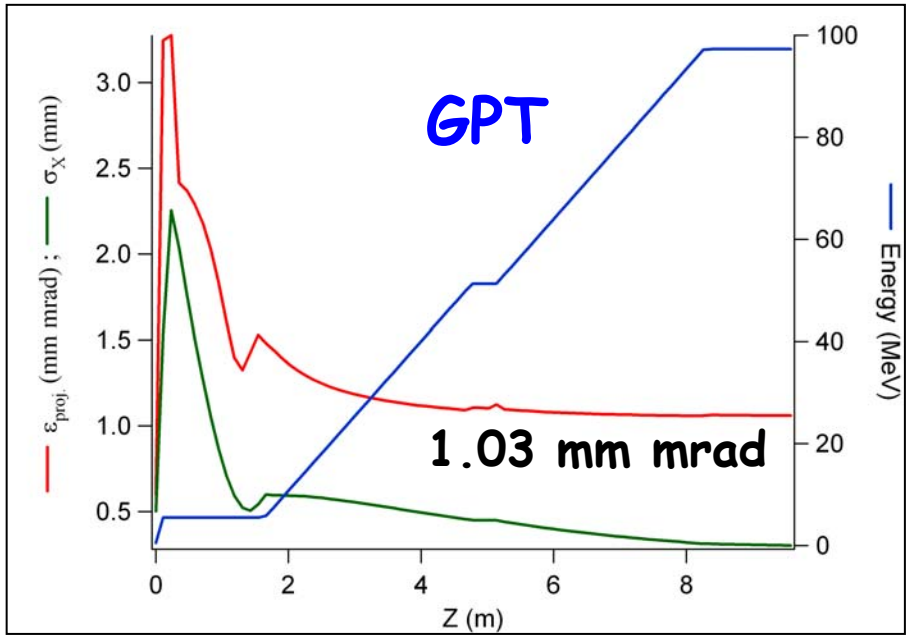
Medium Bunch Case

At the cathode:

Q=800 pC

FWHM=9ps

ε_{th}=0.6 mm mrad



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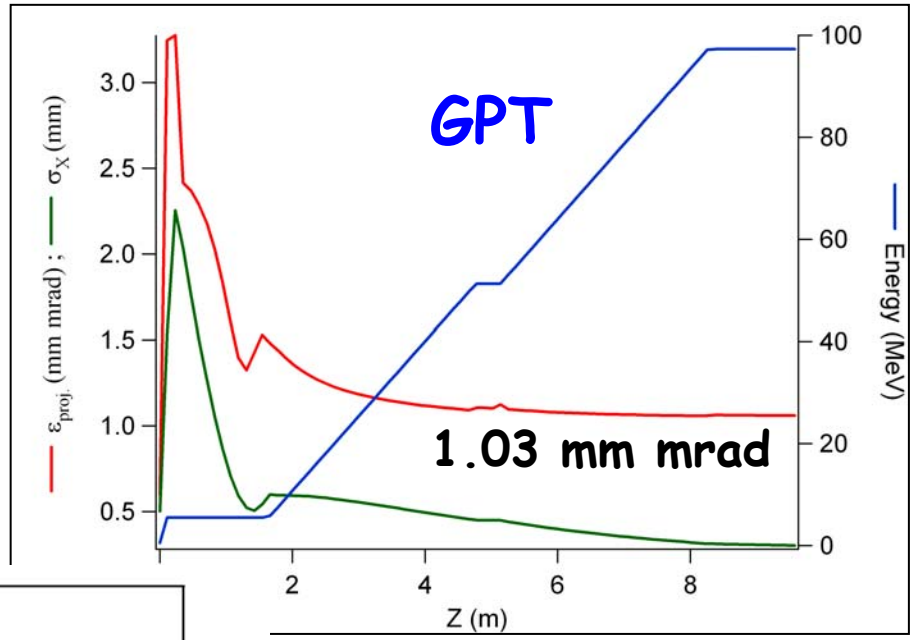

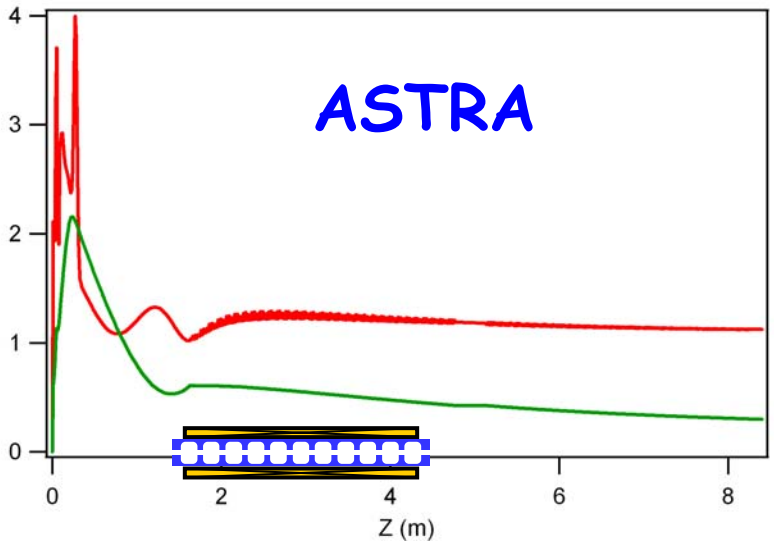

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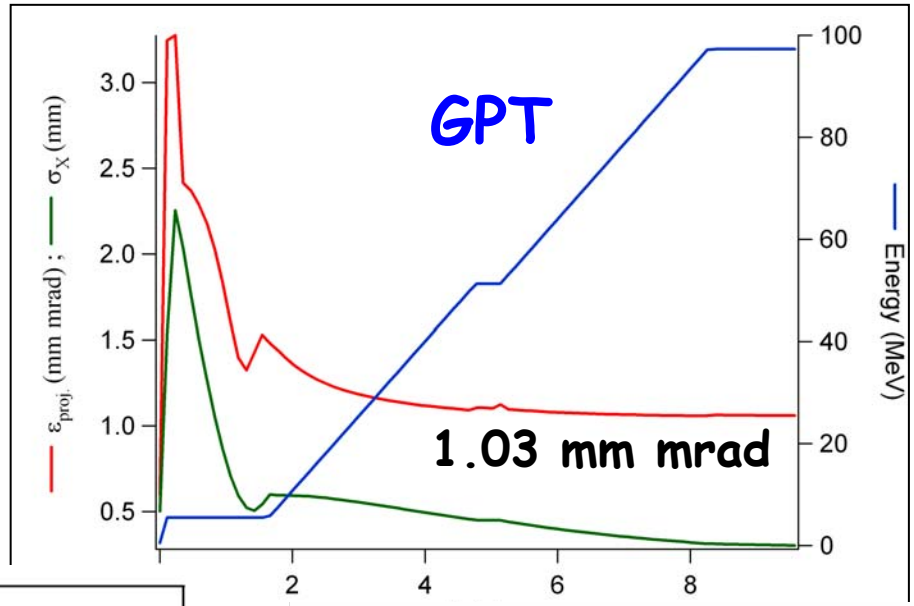

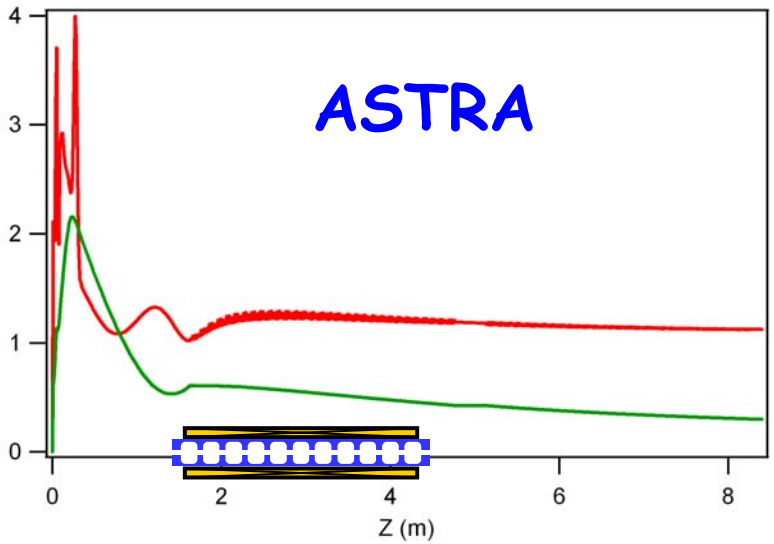

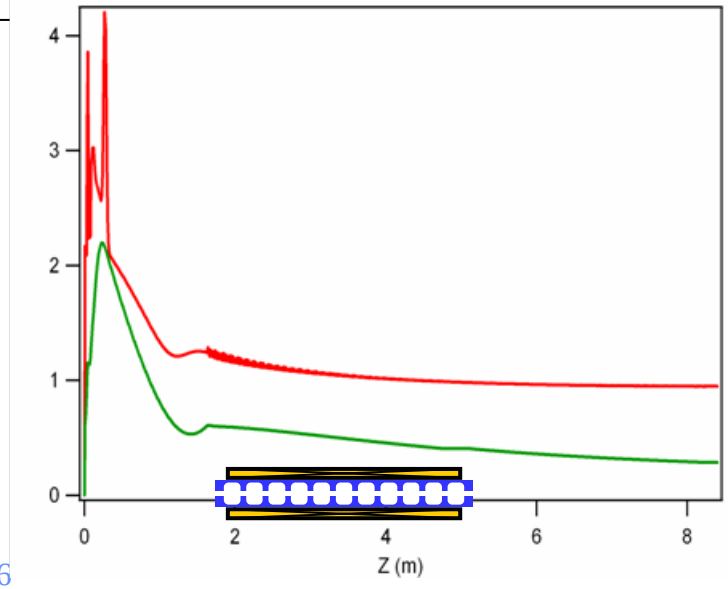

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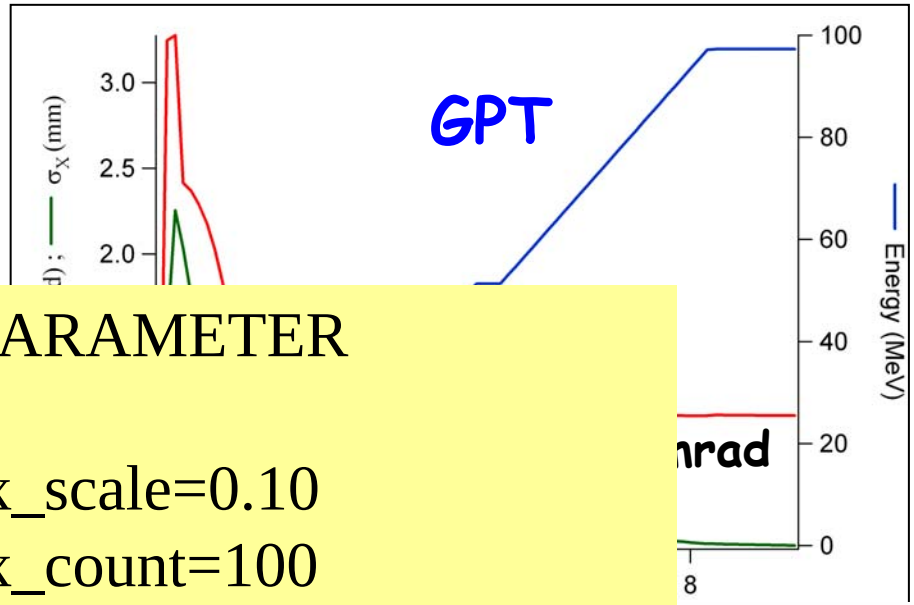


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