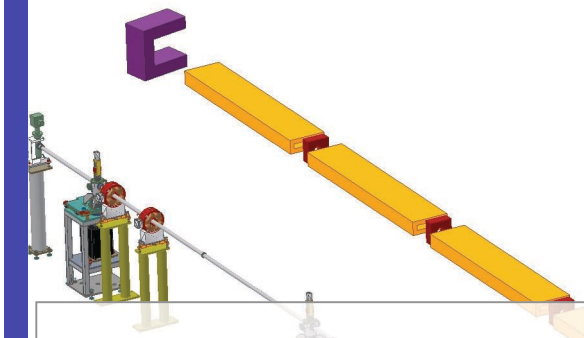
Experimental results with the SPARC emittance-meter

Massimo Ferrario

INFN - LNF



GUN PARAMETERS

Frequency: 2856 MHz

Peak Field: 120 MV/m

Beam Energy: 5.6 MeV

Charge: 1 nC

Emittance < 2 mm-mrad

Laser: 10 ps (Flat Top with <2 ps rise time)

LINAC PARAMETERS

Frequency: 2856 MHz

Accelerating Field: 25 MV/m

Beam Energy: 155 MeV

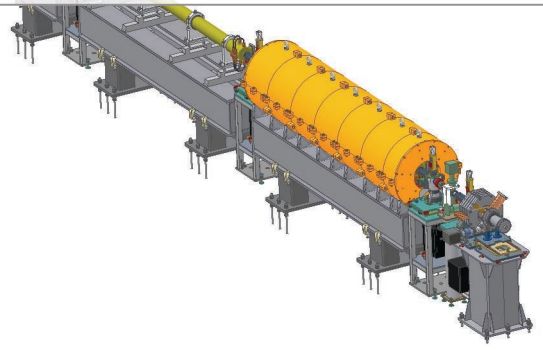
Energy Spread 10^{-3}

Peak Current 100 A

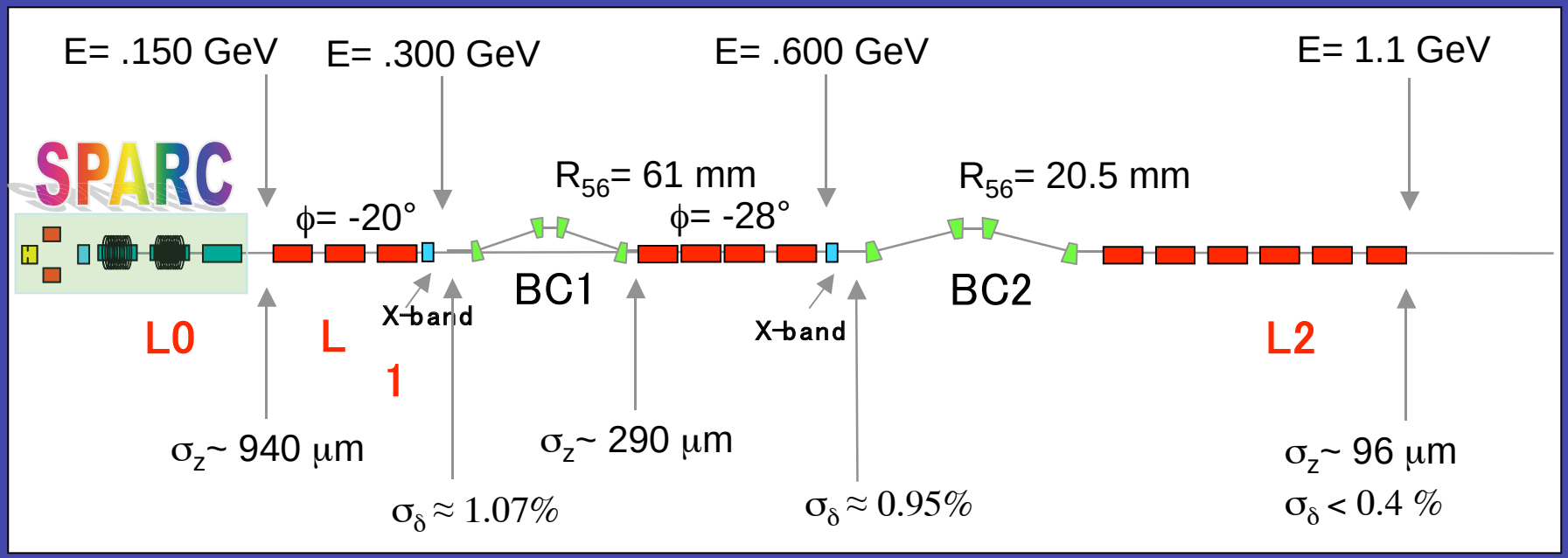
FEL PARAMETERS

Wavelength: 530 nm

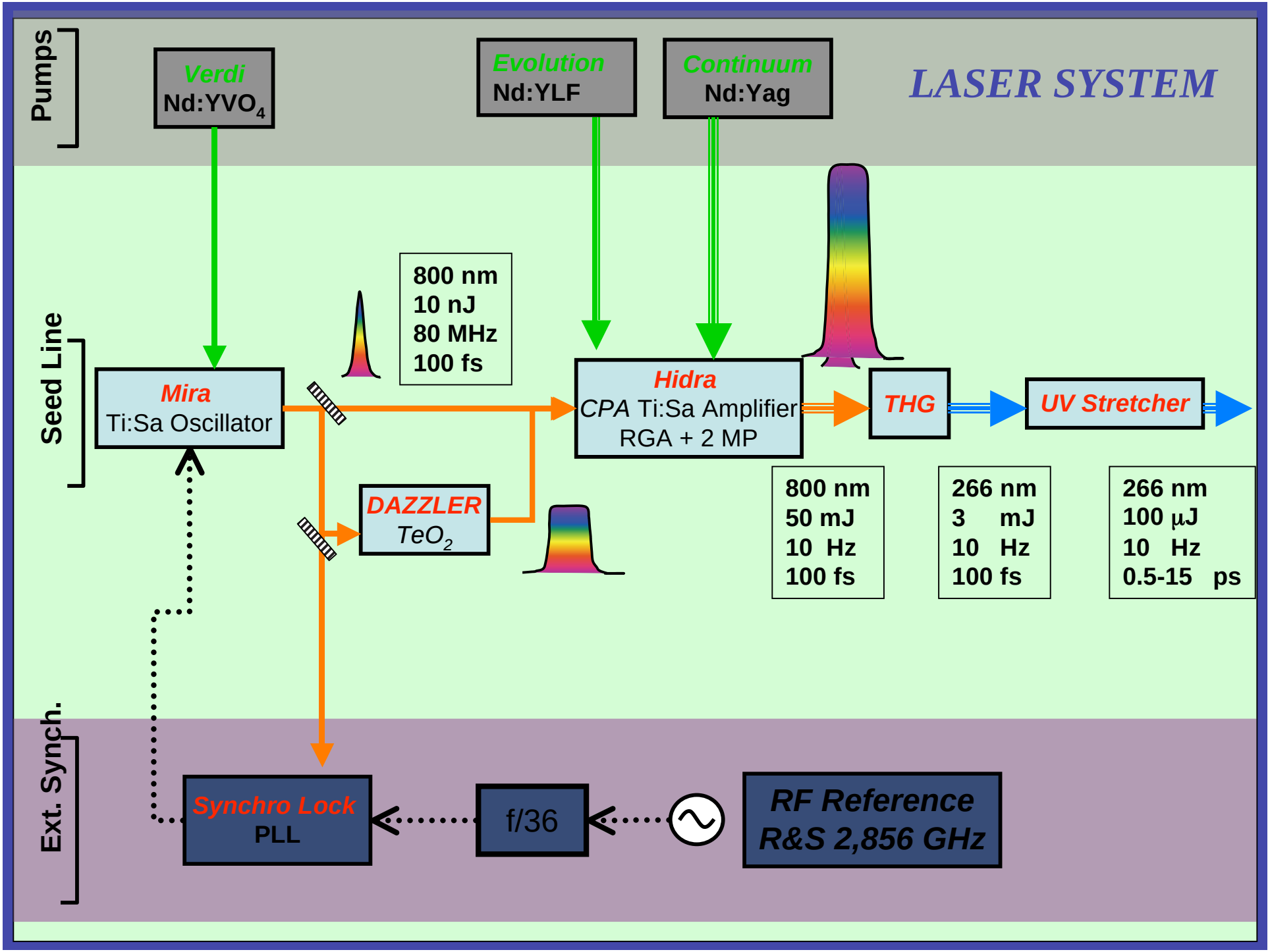
Undulator period 2.8 cm



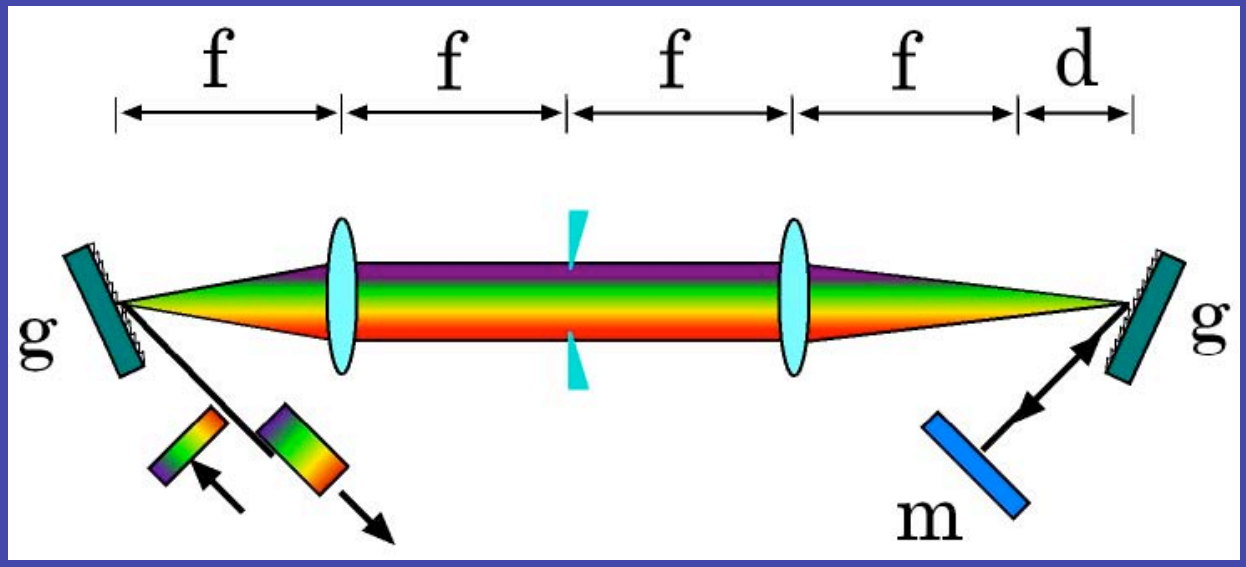
Recently Approved Project
SPARX
1-2 GeV ==> 10 - 1 nm FEL

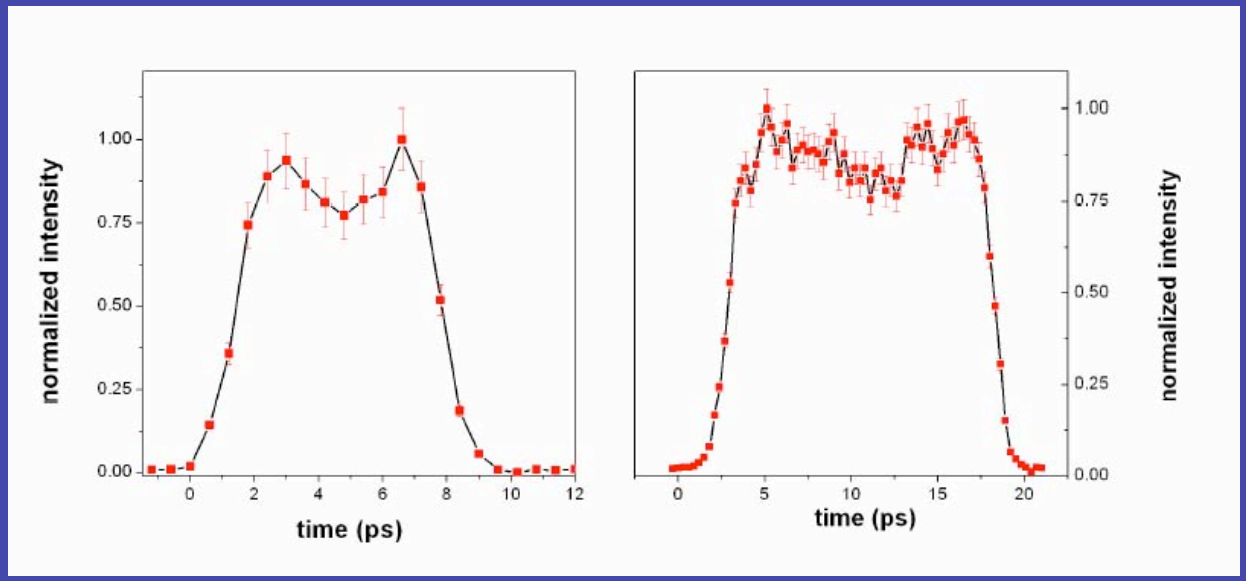


C. Vaccarezza et al., Status of the SPARC - SPARX project TUPMN039


LASER SYSTEM
Pumps
Verdi
Nd:YVO4
Evolution
Nd:YLF
Continuum
Nd:Yag
Seed Line
Mira
Ti:Sa Oscillator
800 nm
10 nJ
80 MHz
100 fs
Hidra
CPA Ti:Sa Amplifier
RGA + 2 MP
THG
UV Stretcher
DAZZLER
TeO2
800 nm
50 mJ
10 Hz
100 fs
266 nm
3 mJ
10 Hz
100 fs
266 nm
100 µJ
10 Hz
0.5-15 ps
Ext. Synch.
Synchro Lock
PLL
f/36
RF Reference
R&S 2,856 GHz

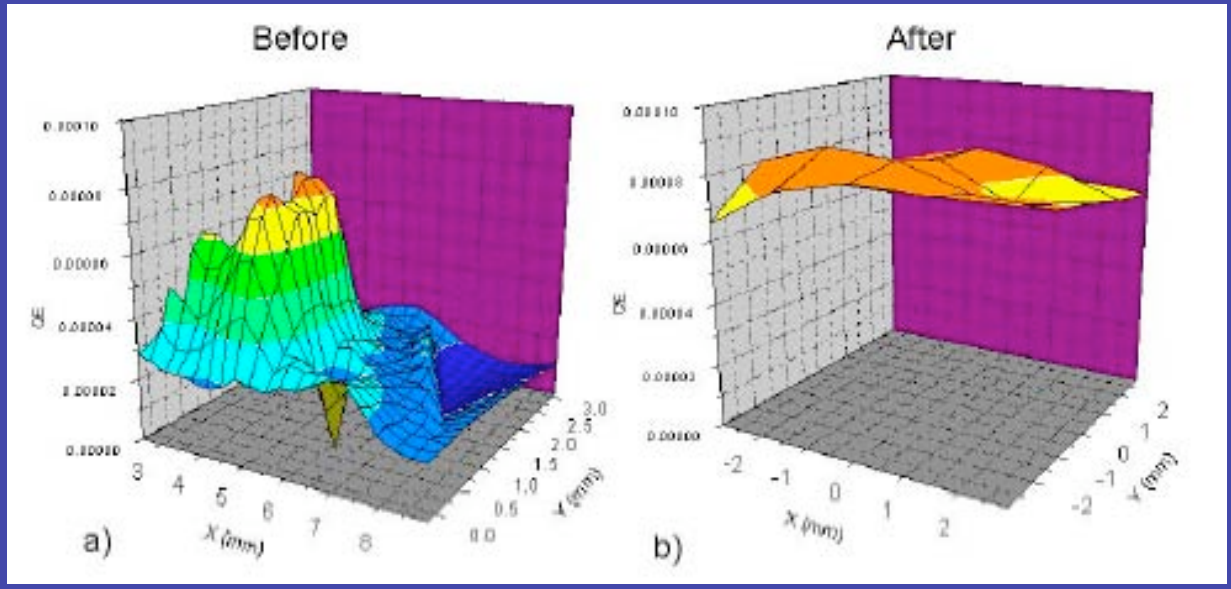
Modified UV stretcher to obtain shorter rise time



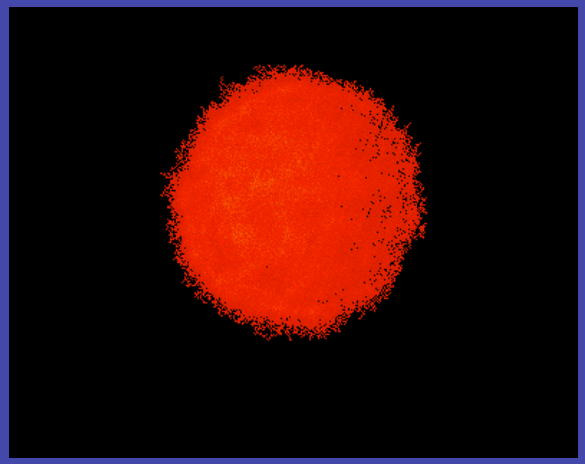


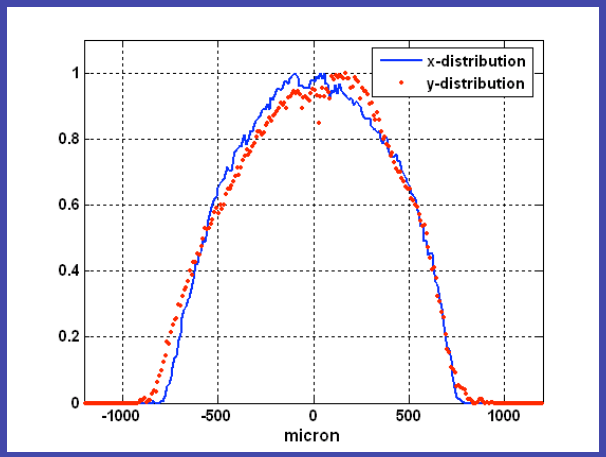
C. Vicario et al., Drive Laser System For Sparc Photoinjector TUPMN040

Cu Cathode QE ~ 10-4 improved by laser cleaning



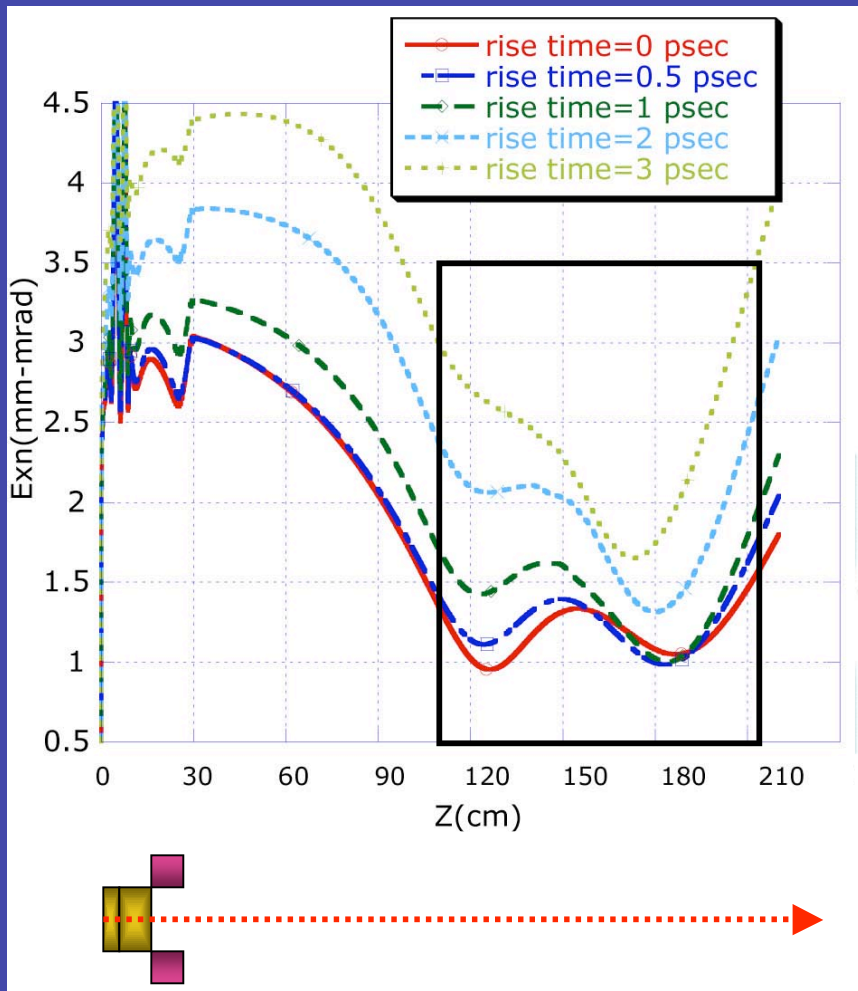
1 nc with 50 μJ laser pulse energy at 120 MV/m peak field on the cathode with a time jitter standard deviation of 350 fs

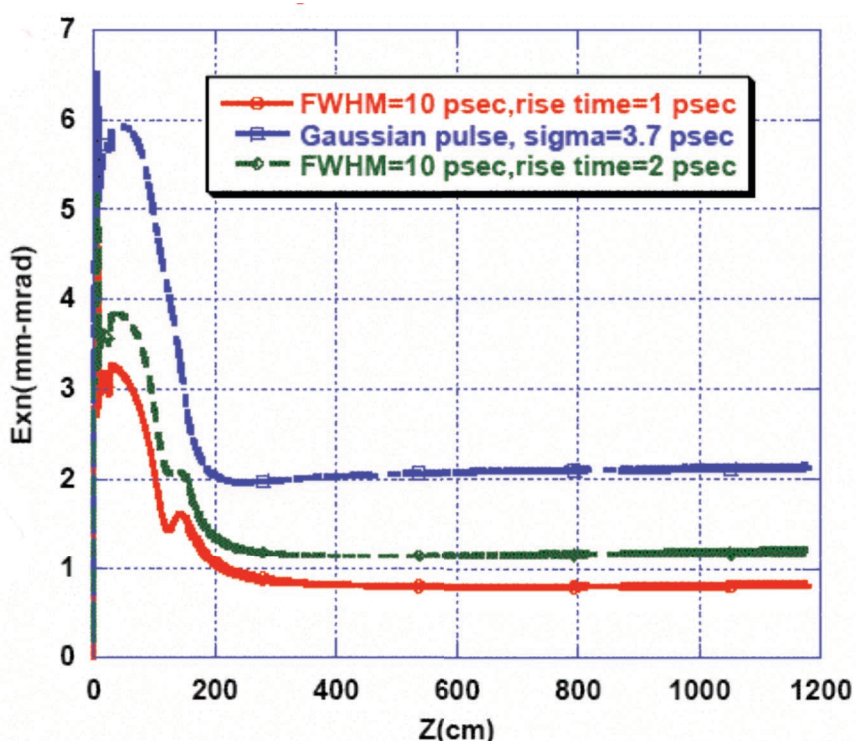


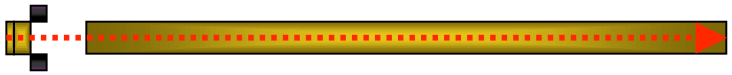


A. Gallo et al., Laser and RF Synchronization Measurements at SPARC TUPMN036

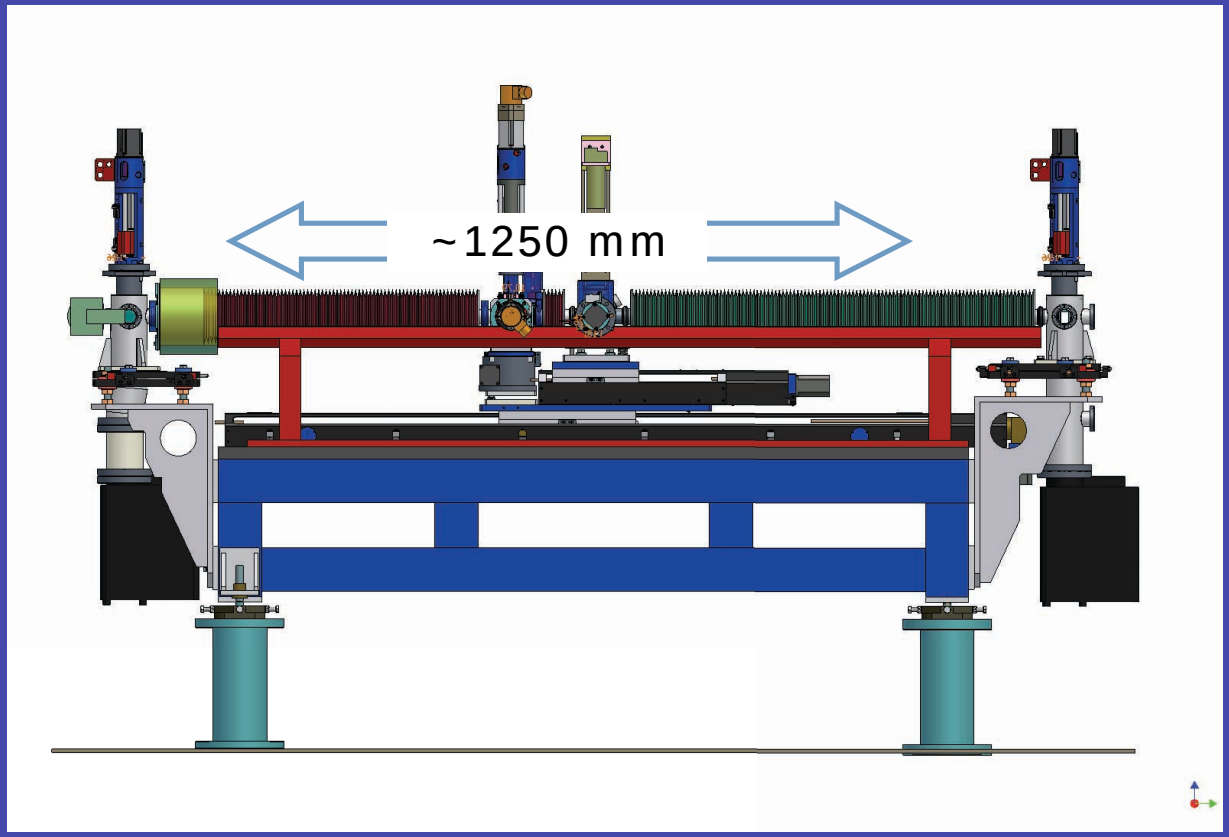
Emittance evolution for different pulse shapes

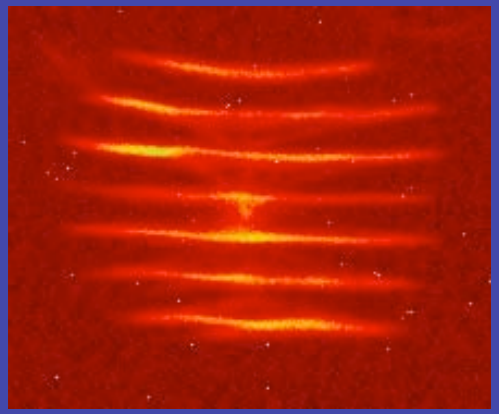


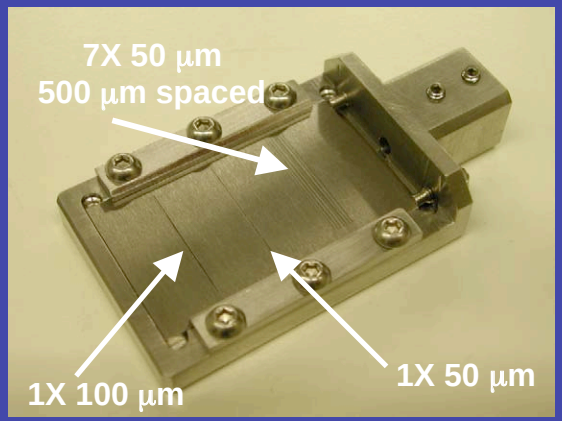




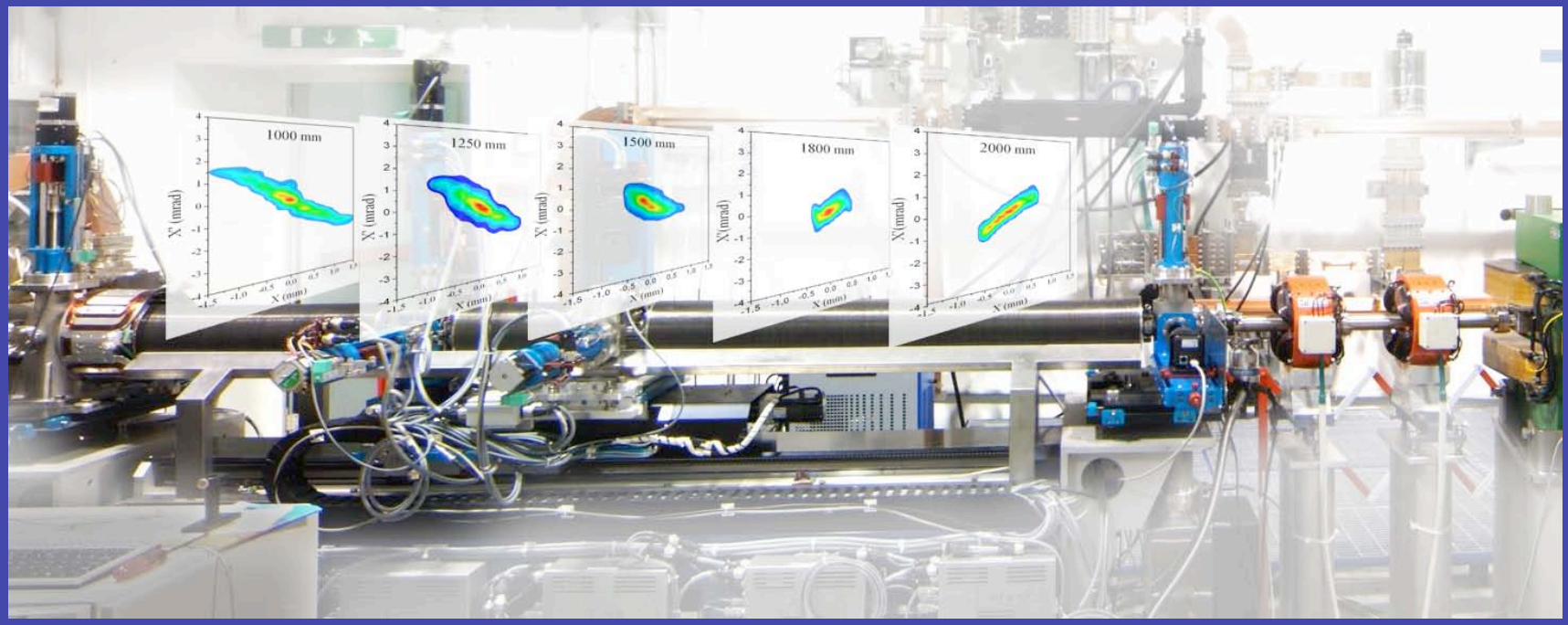
The SPARC Emittance Meter

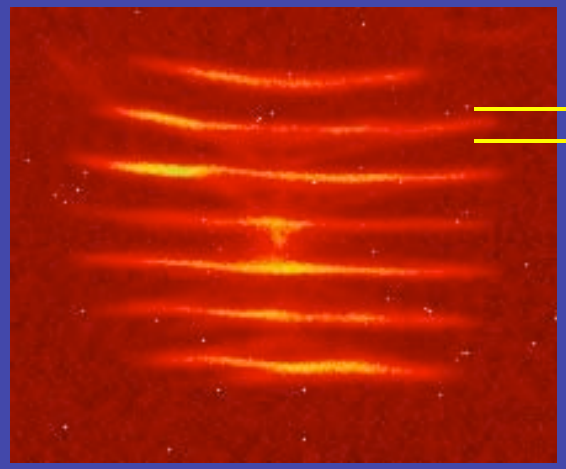


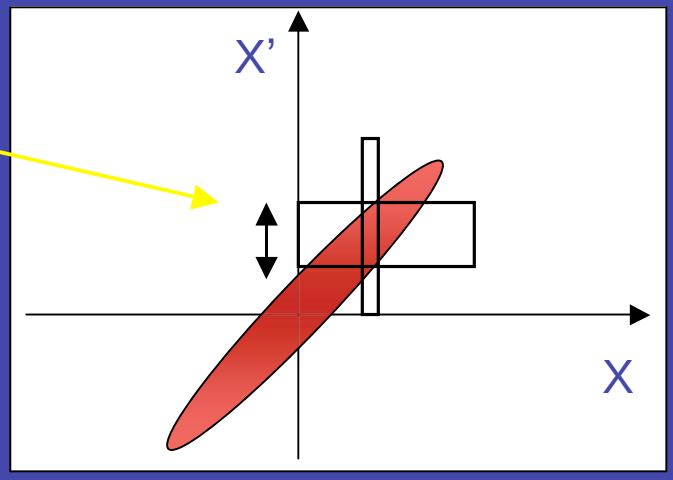




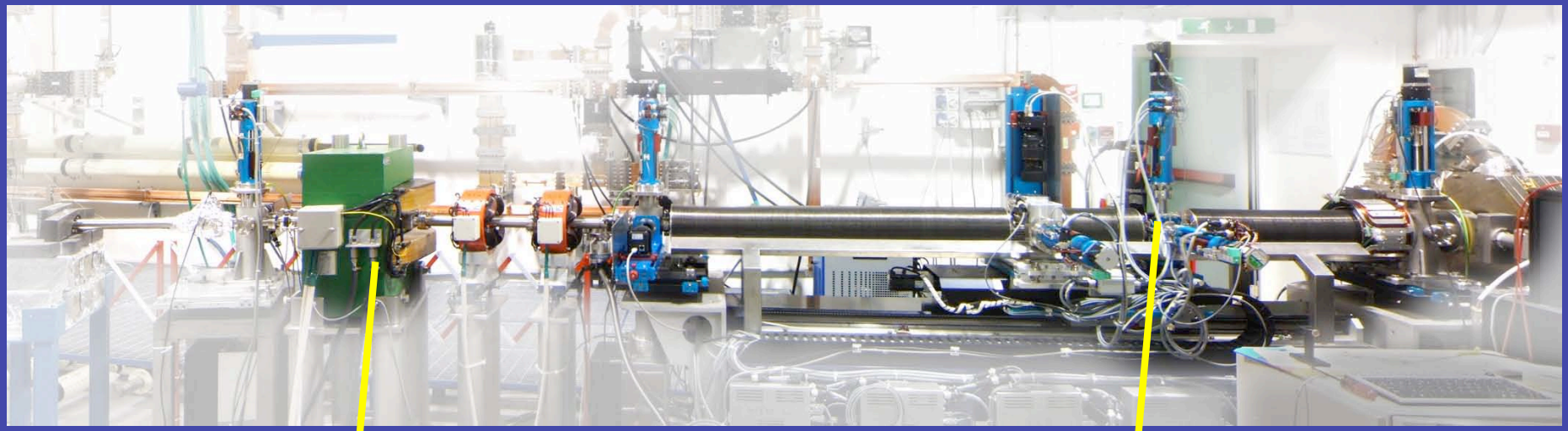
Phase space reconstruction

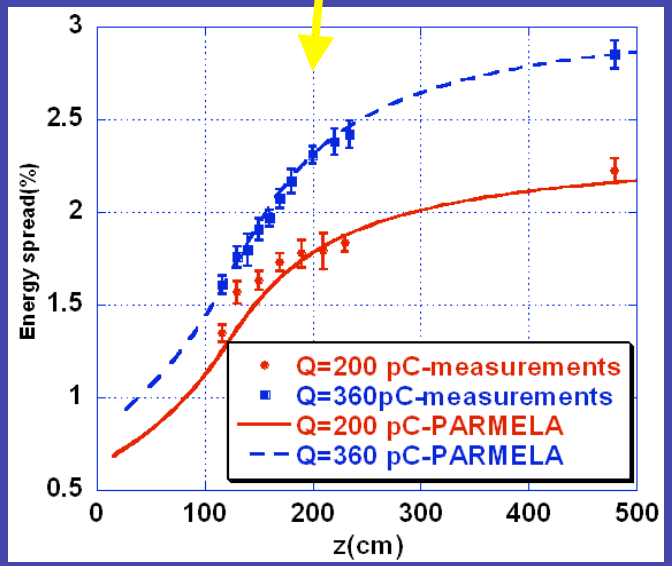


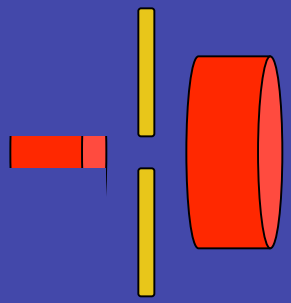




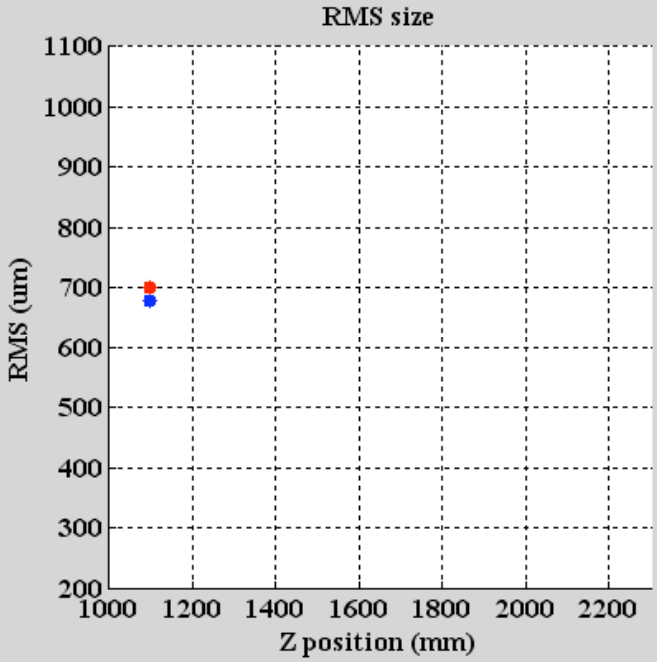
Energy spread evolution along the drift

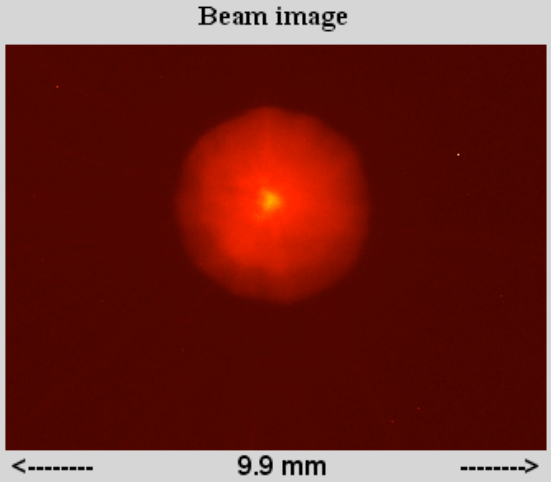




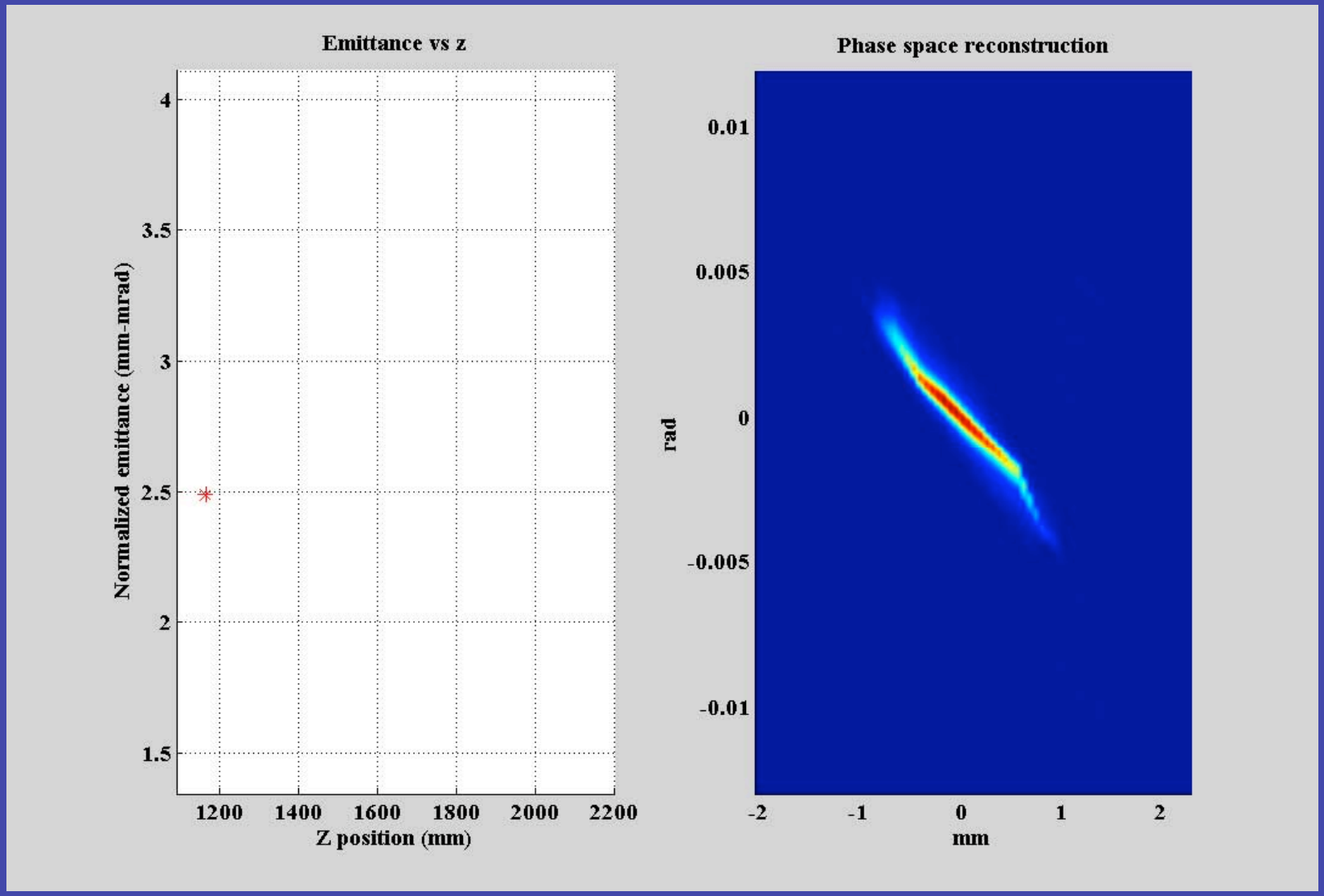


Beam Envelope automatic measurement



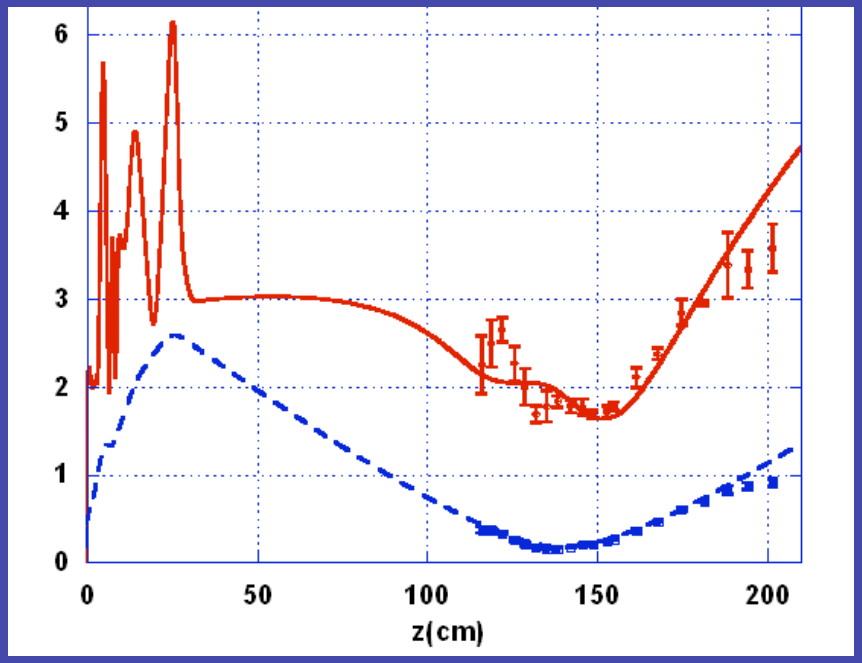


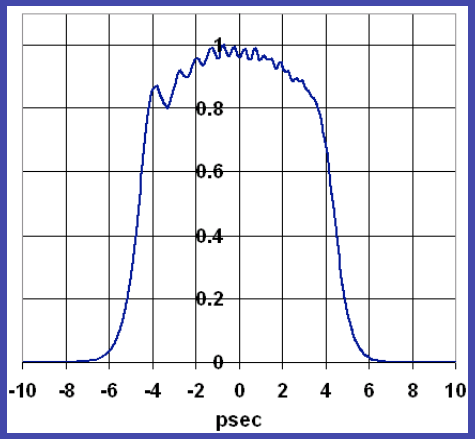
Beam Emittance automatic measurement



Result highlights

T= 5.6 MeV, I= 92 A, ε_n = 1.6 μm ==> B= 7x10^{13} A/m^2

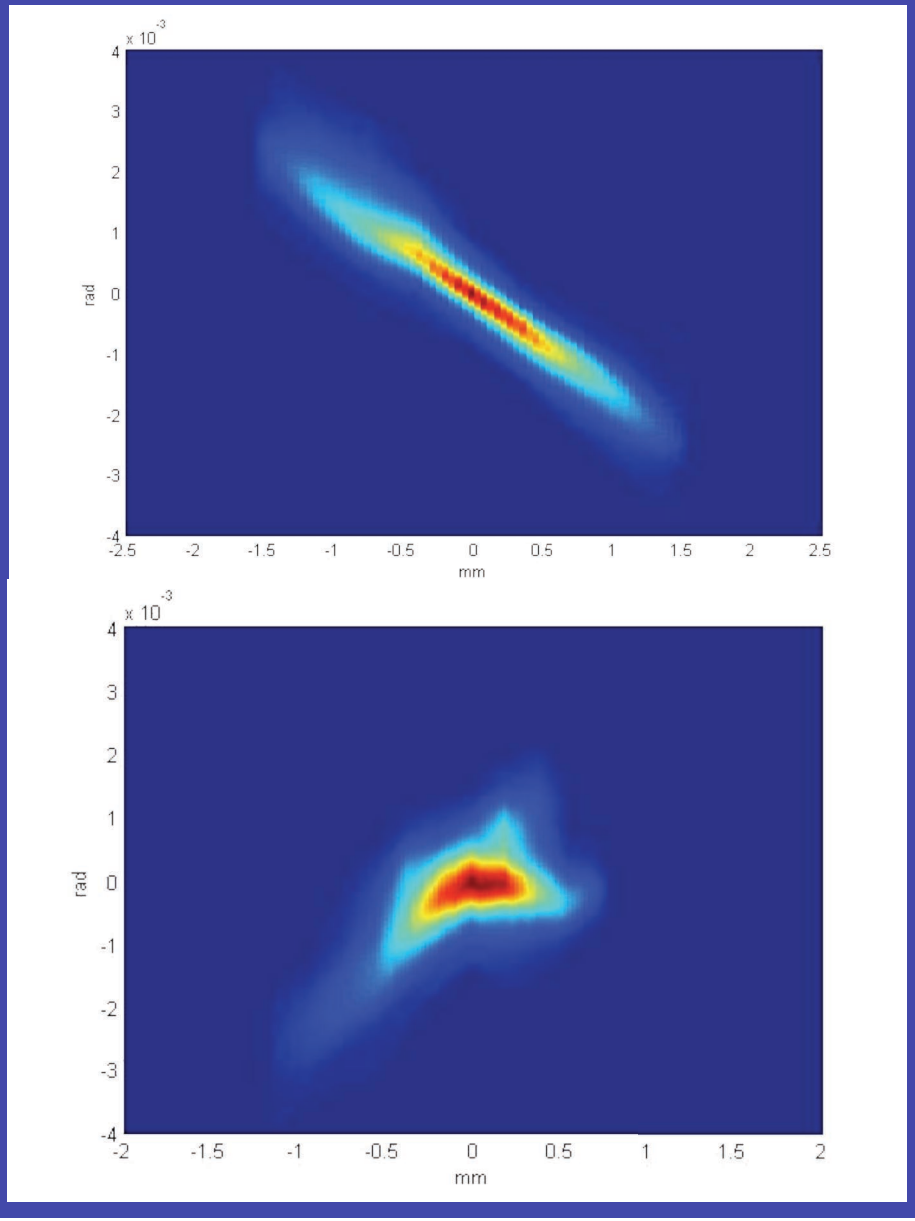


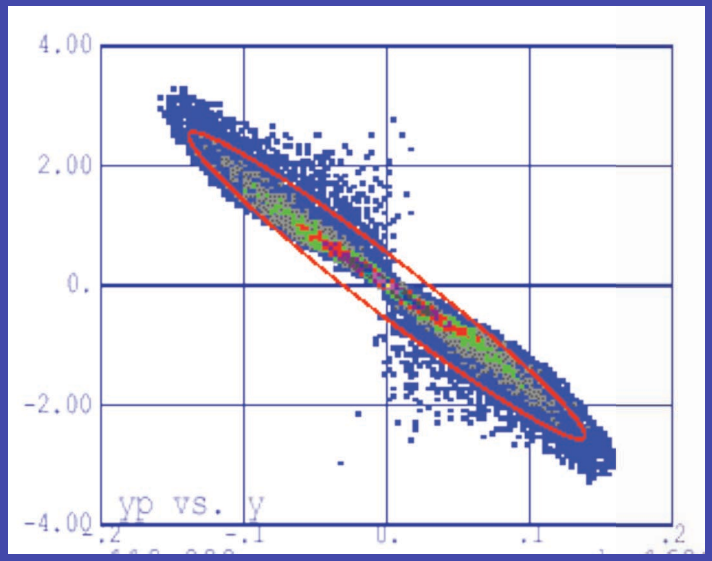


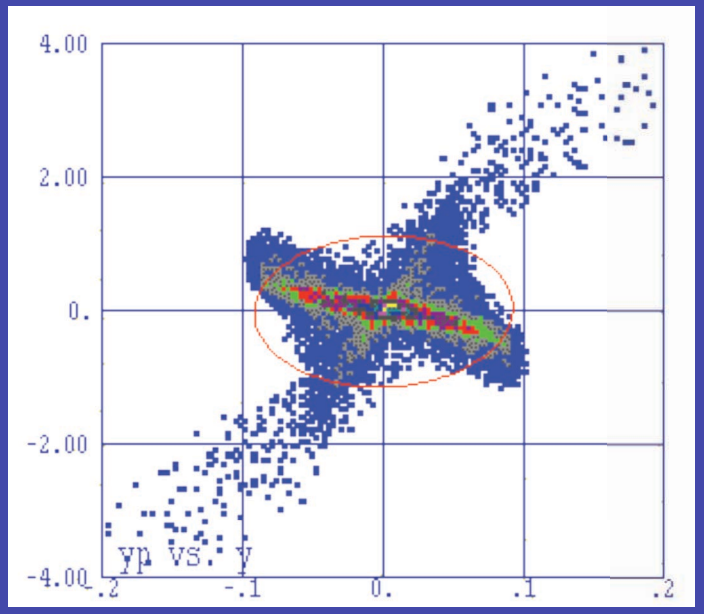
charge	0.83 nC
pulse length (FWHM)	8.9 ps
rise time	2.6 ps
rms spot size	0.36 mm
RF phase (φ-φ_{max})	-8°

C. Ronsivalle, Comparison E-meter Measurements and Simulations TUPMN034

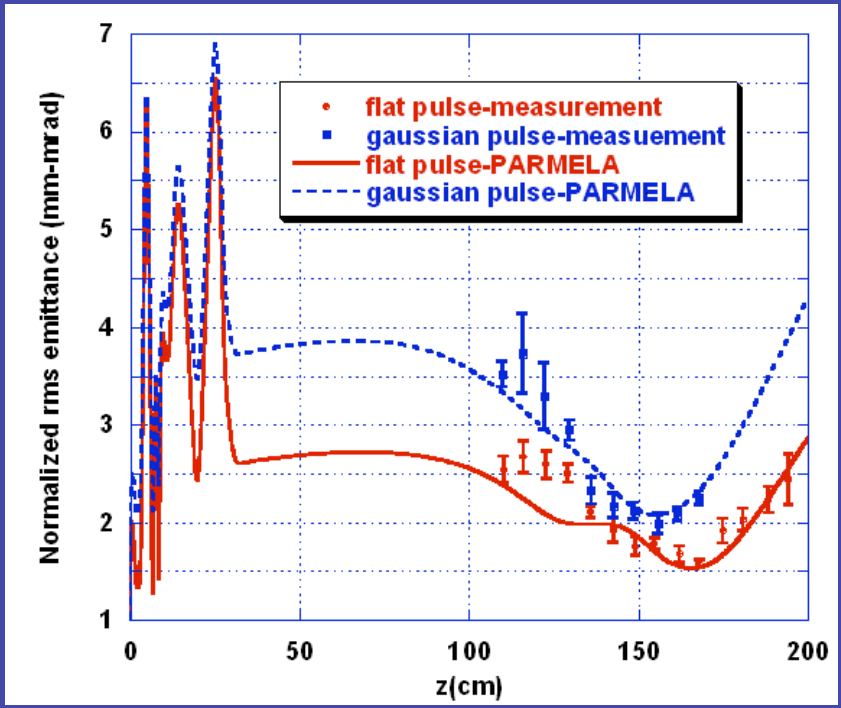
phase space - simulation and measurements

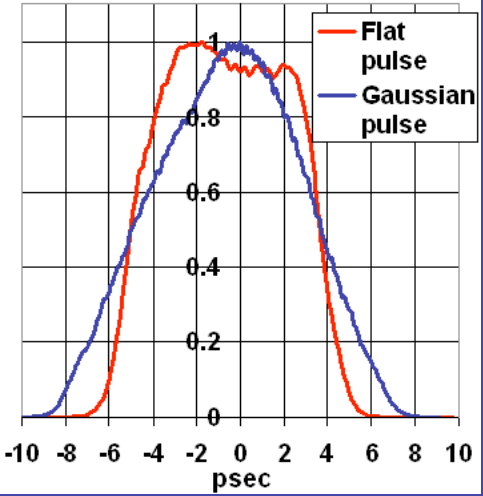






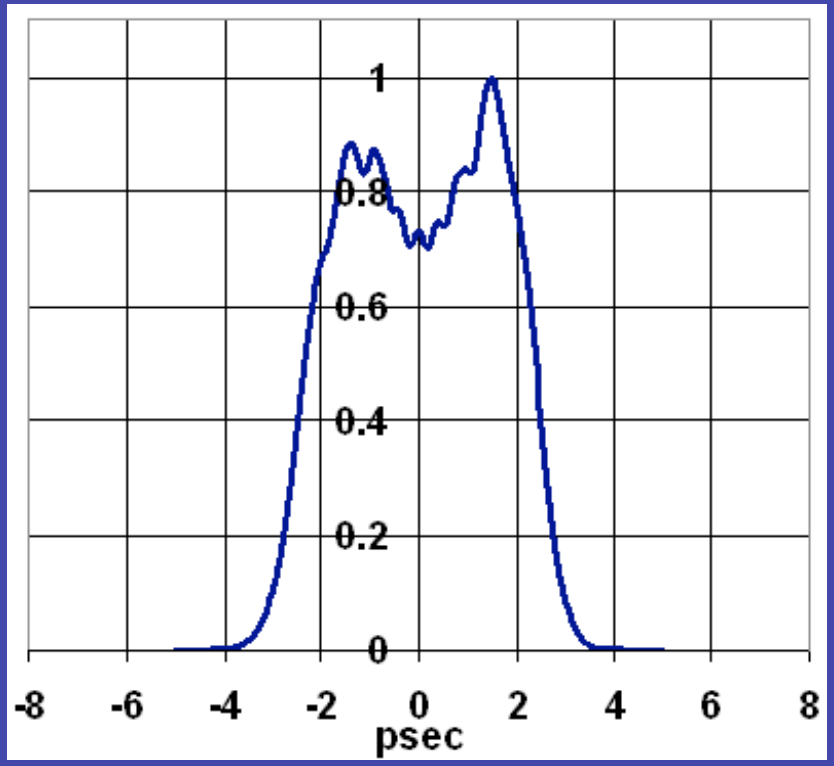
Flat top vs gaussian pulse shape





charge	0.74 nC
pulse length (FWHM)	8.7 ps
rise time	2.6 ps
rms spot size	0.31 mm
RF phase (φ-φ_{max})	-8°

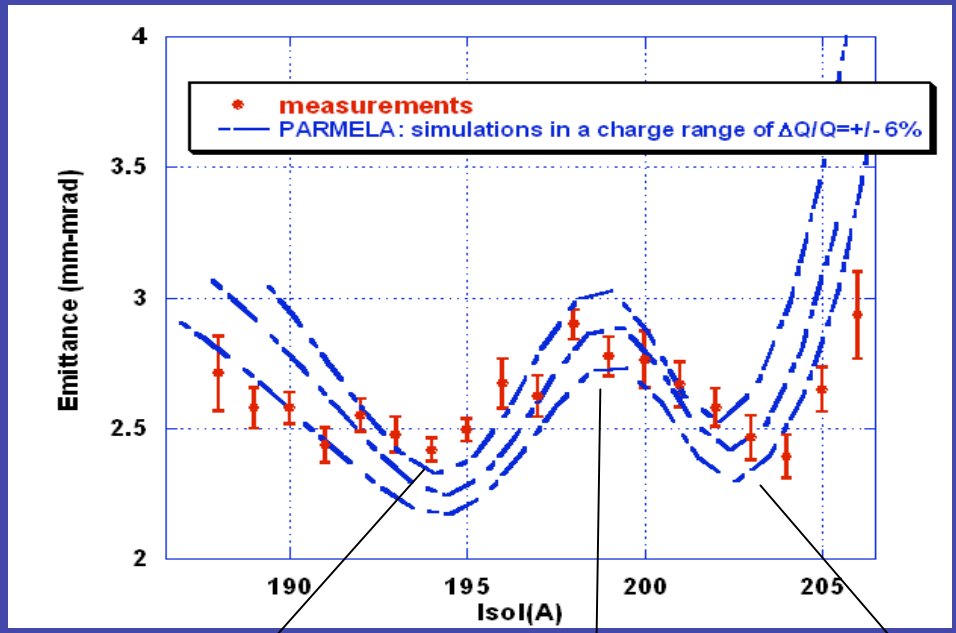
Looking for the double minimum

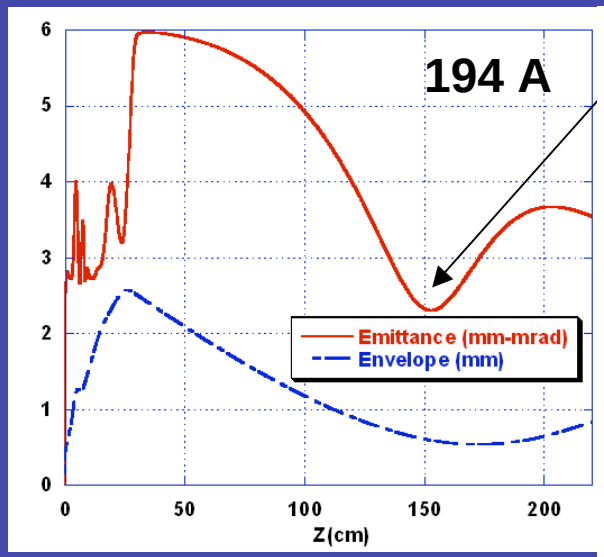


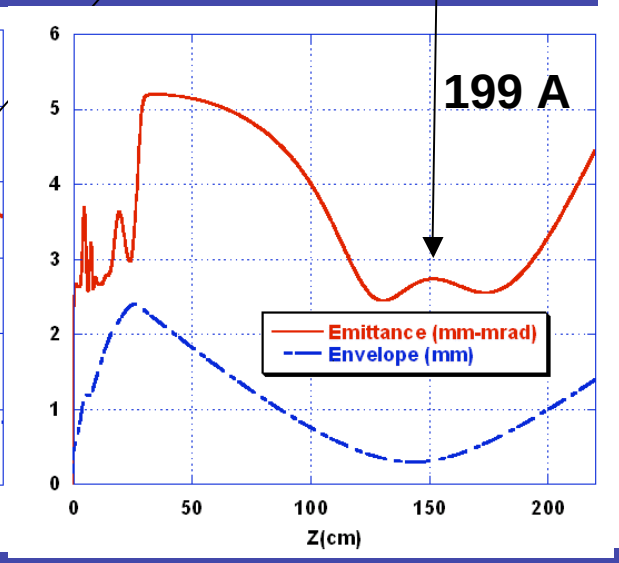
charge	0.5 nC
pulse length (FWHM)	5 ps
rise time	1.5 ps
rms spot size	0.45 mm
RF phase (φ-φ_{max})	+12°

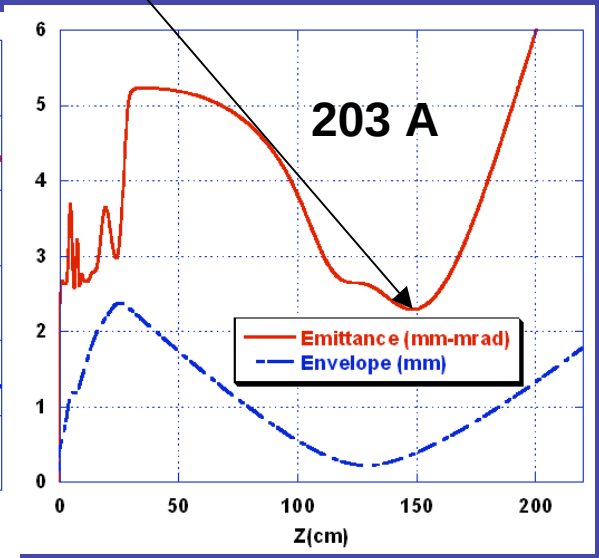
C. Wang et al., Criteria for Emittance Compensation in HB Photoinjectors TUPMN103

Solenoid scan at a fixed position z = 150 cm

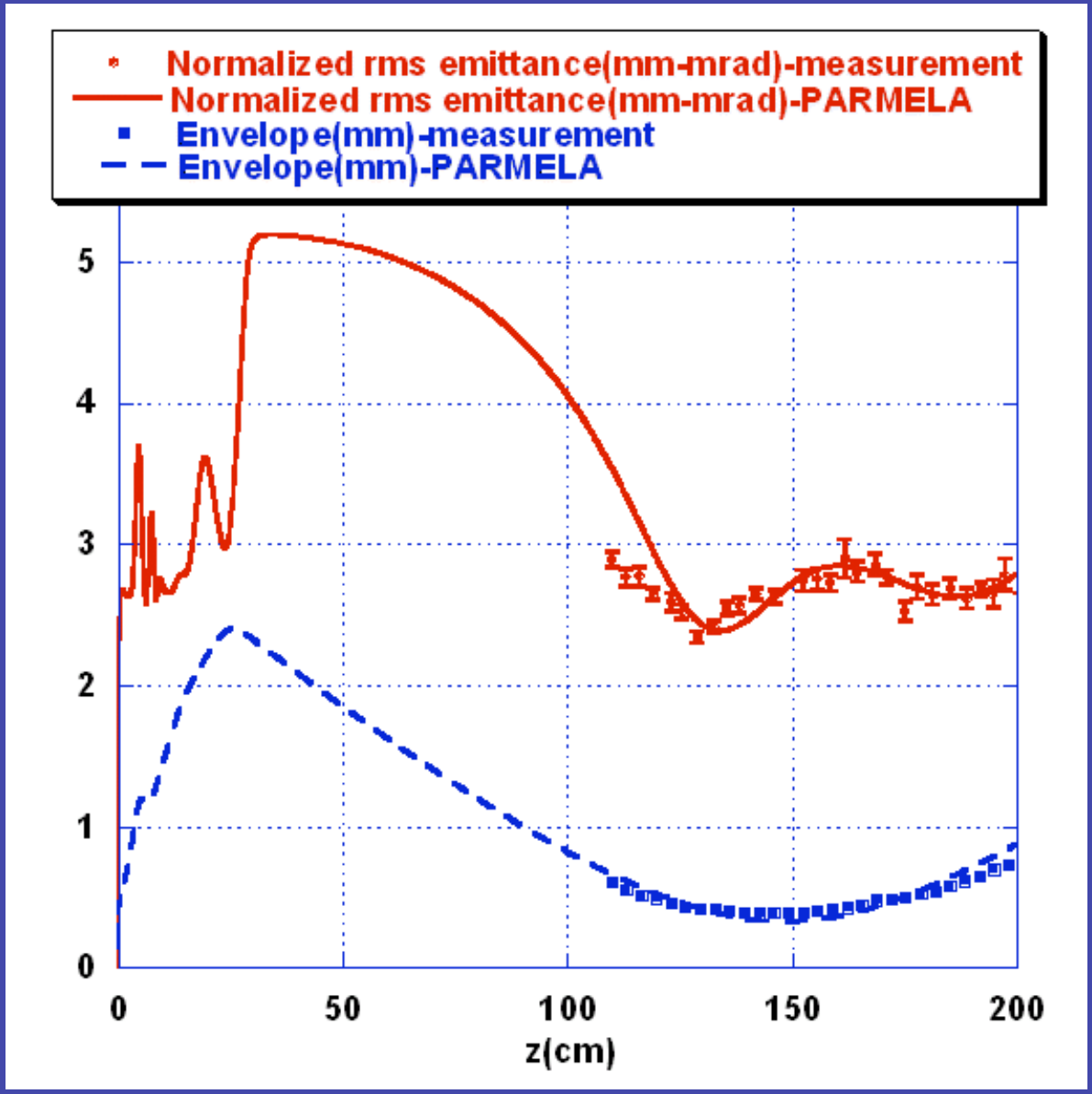




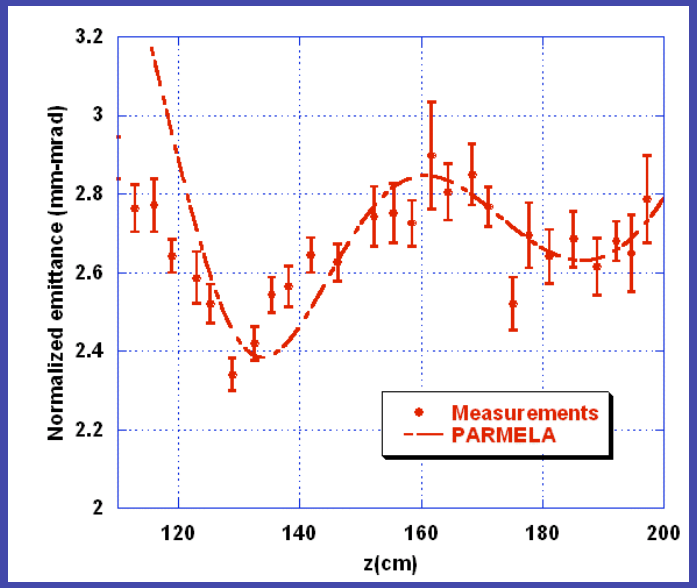


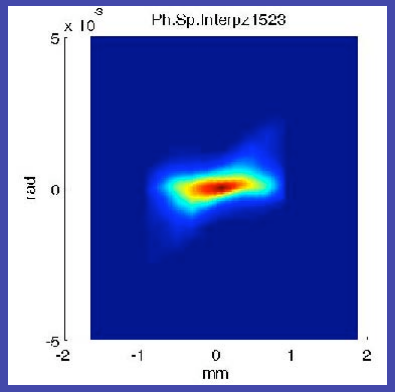


Emittance measurements with the selected solenoid current I=198 A



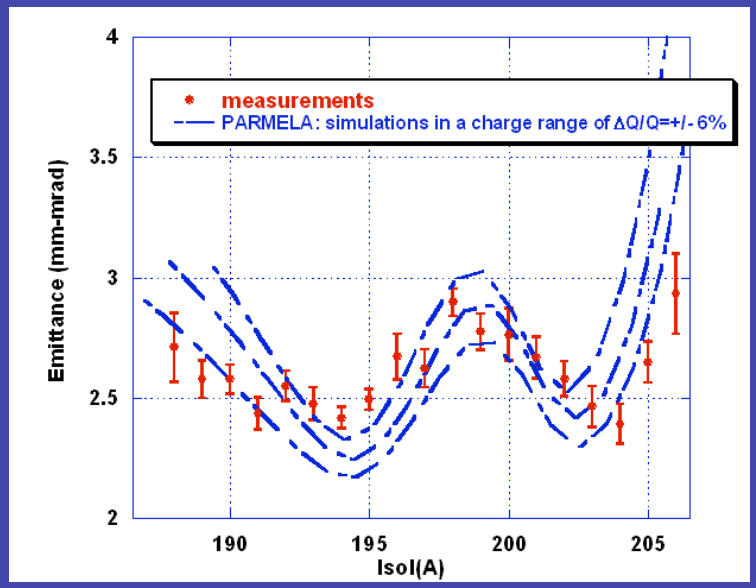
Z-Scan

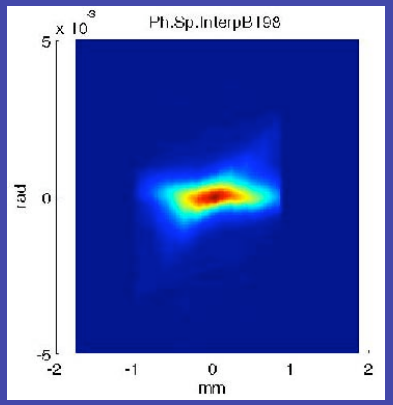




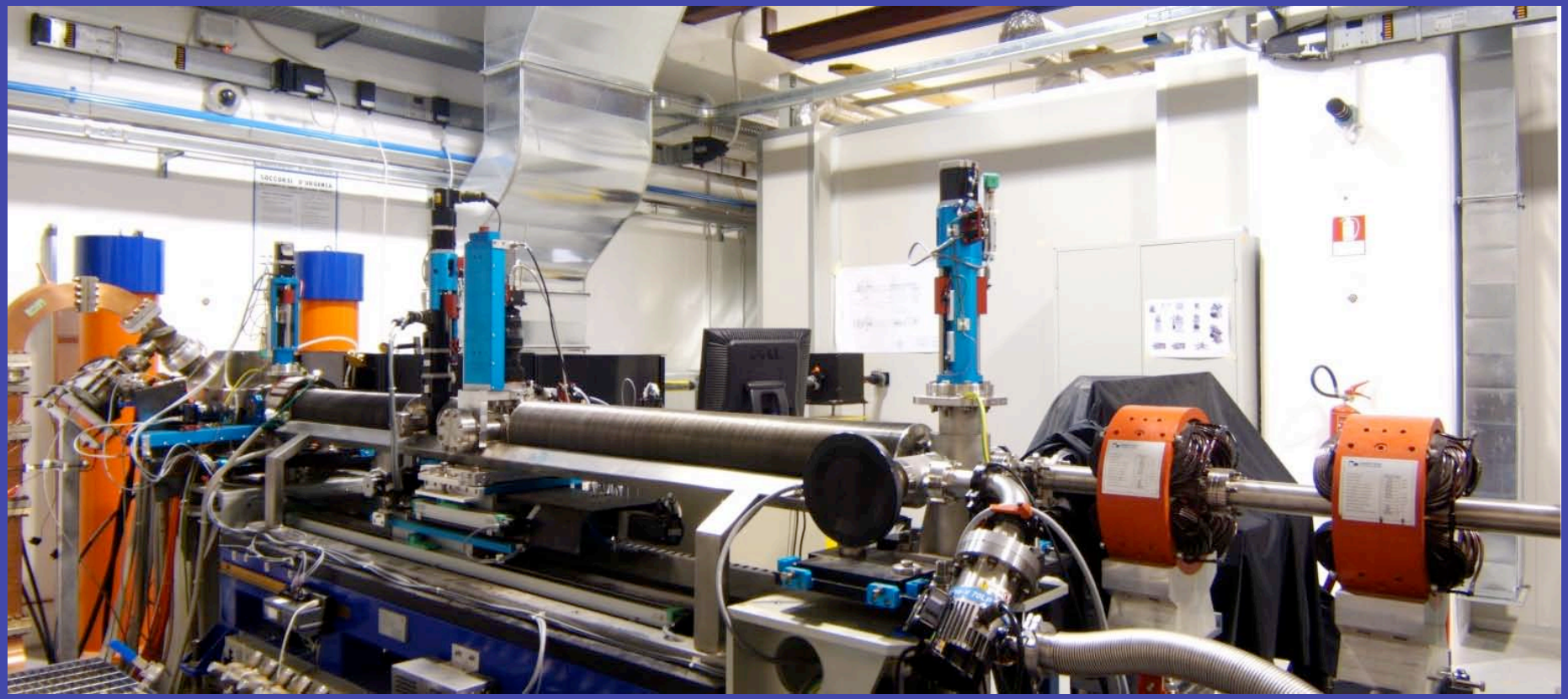
Z~1500 mm, I_{sol}=198 A

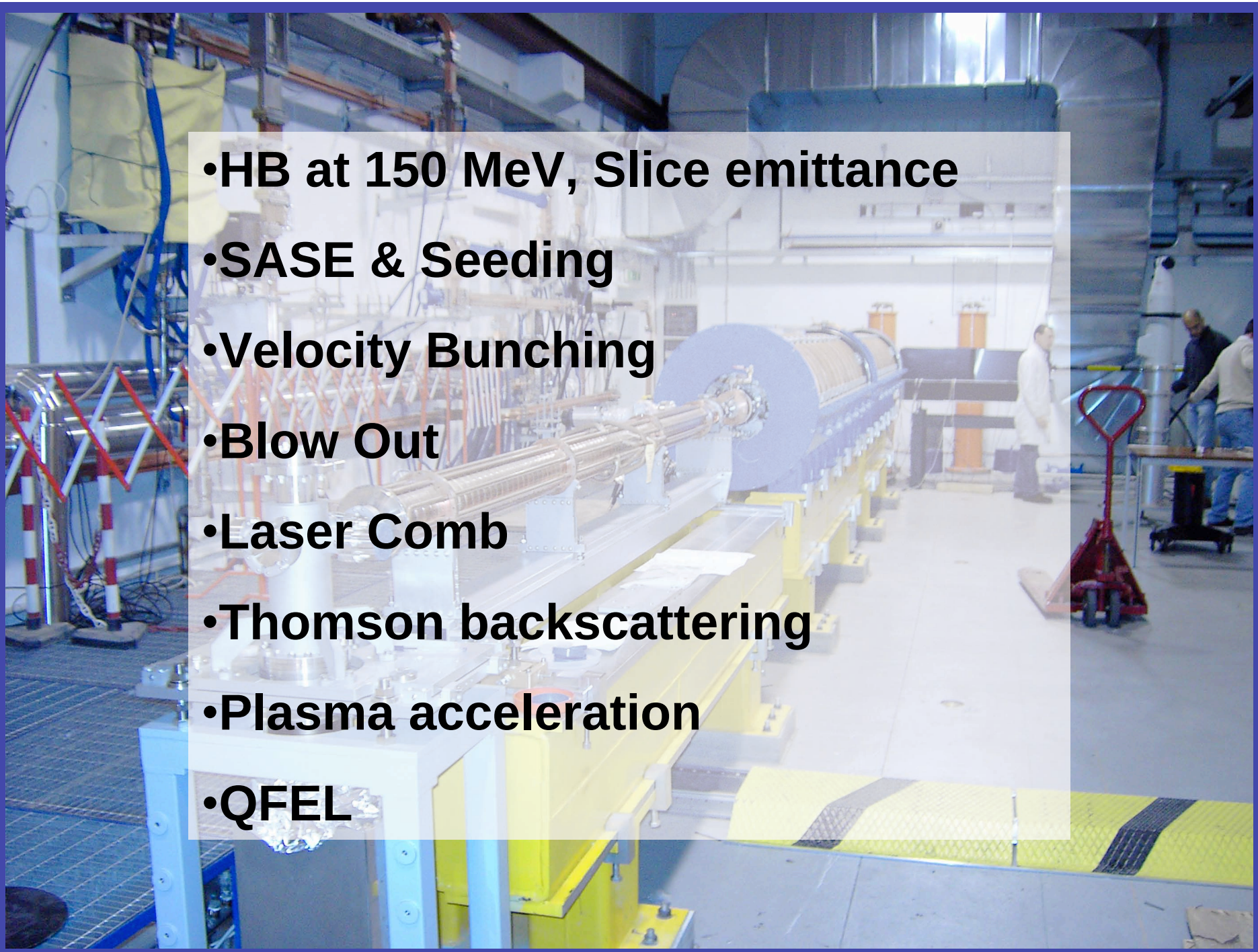
B-Scan



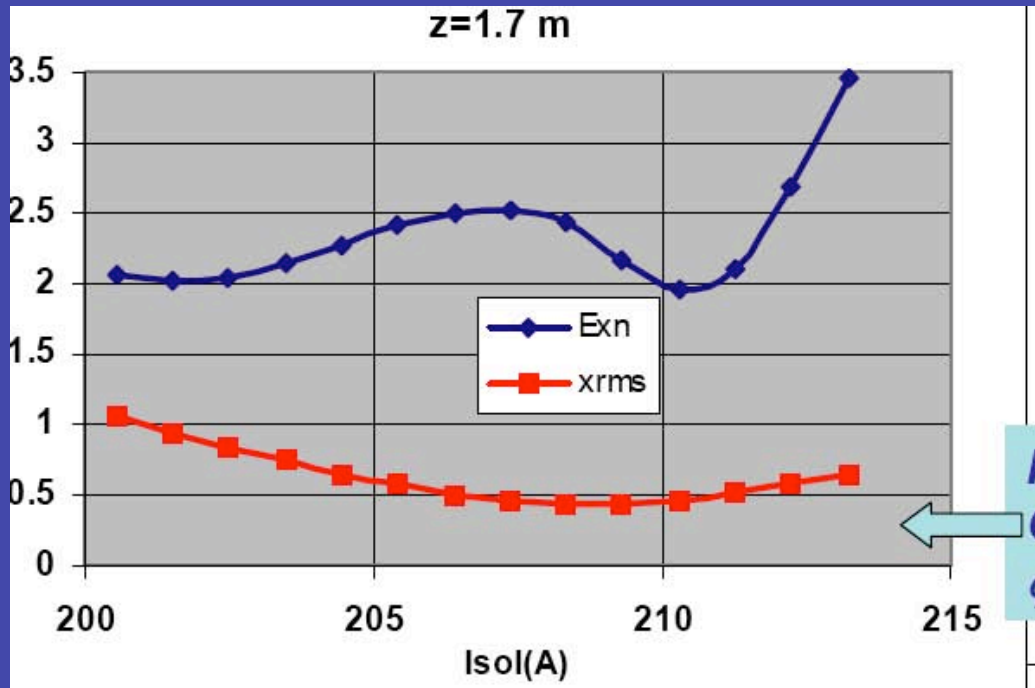


Z~1500 mm, I_{sol}=198 A




•HB at 150 MeV, Slice emittance
•SASE & Seeding
•Velocity Bunching
•Blow Out
•Laser Comb
•Thomson backscattering
•Plasma acceleration
•QFEL

Thank you

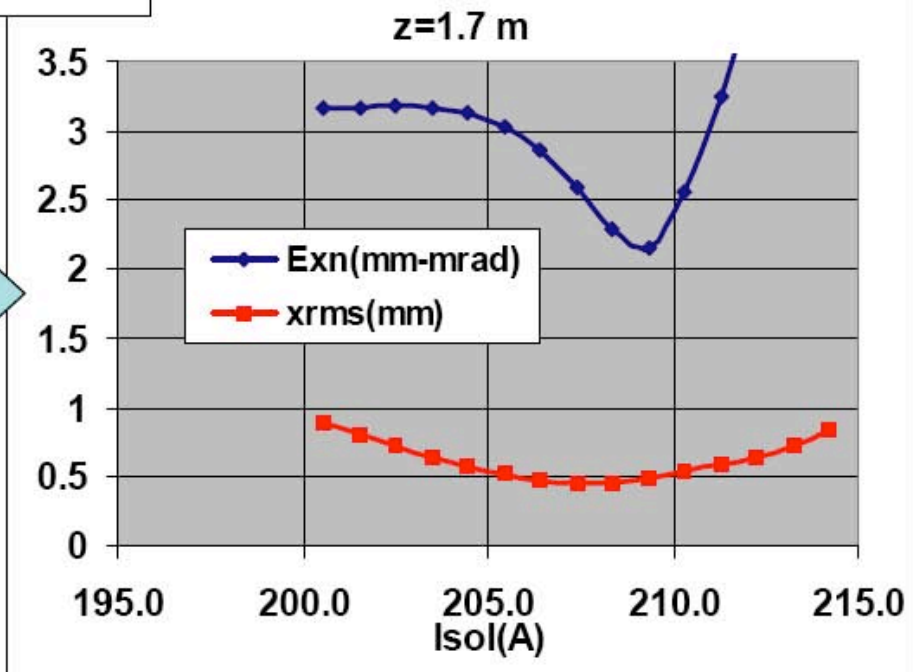


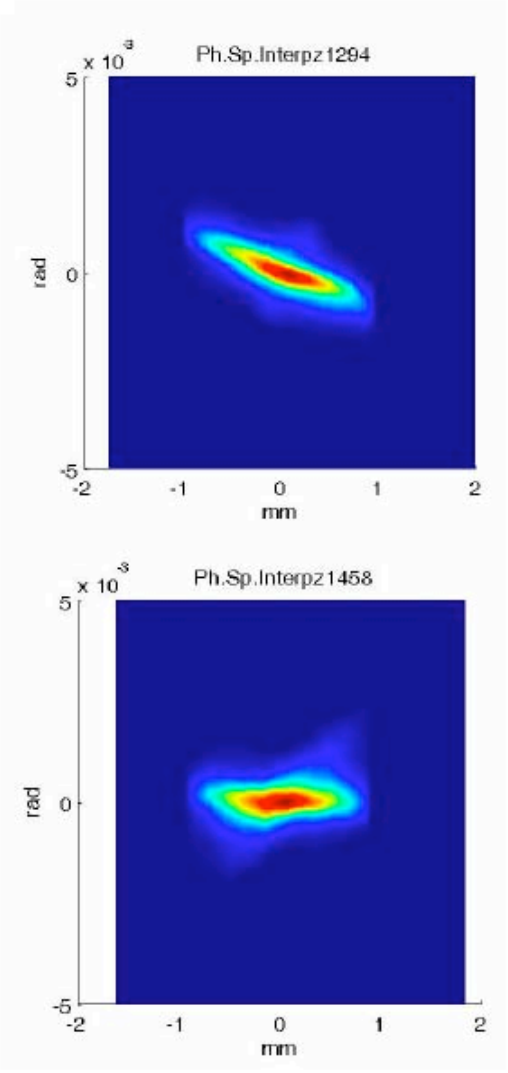
B-scan: Comparison between gaussian pulse - flat pulse

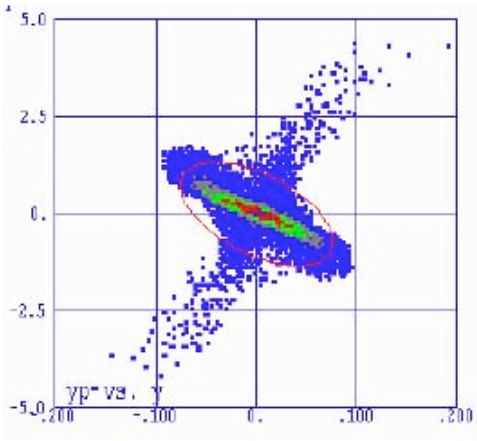
Flat pulse: FWHM=6 psec
Q=650 pC r.t.=1.2 psec σ=0.45 mm
φ - φmax=8,E=120 MV/m*

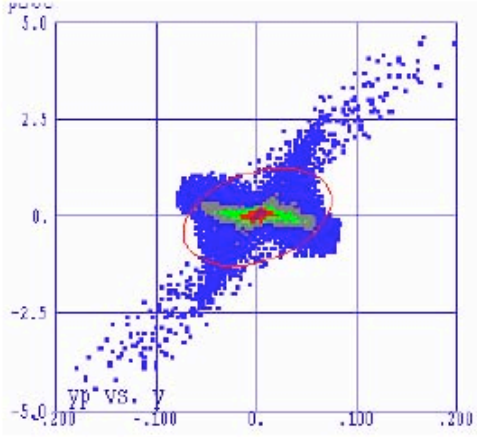
Gaussian pulse: FWHM=6 psec
Q=650 pC, σ=0.45 mm
φ - φ_{max}=8, E=120 MV/m*

Emittance double minimum=flat pulse signature




Ph.Sp.Interpz1294
x 10^-3
5
0
-5
rad
-2
-1
0
1
2
mm
Ph.Sp.Interpz1458
x 10^-3
5
0
-5
rad
-2
-1
0
1
2
mm


5.0
2.5
0.
-2.5
-5.0
yp' vs. y
-.200
-.100
0.
.100
.200


5.0
2.5
0.
-2.5
-5.0
yp' vs. y
-.200
-.100
0.
.100
.200

TOLERANCES

Phase jitter	±3°
Charge fluctuation	+10%
Gun magnetic field	±0.4%
Gun electric field	± 0.5%
Spot radius dimension	±10%
Spot ellipticity	3.5% *(xmax/ymax=1-1.035)*

Minimum variation of the single parameters value for an emittance increase=10%