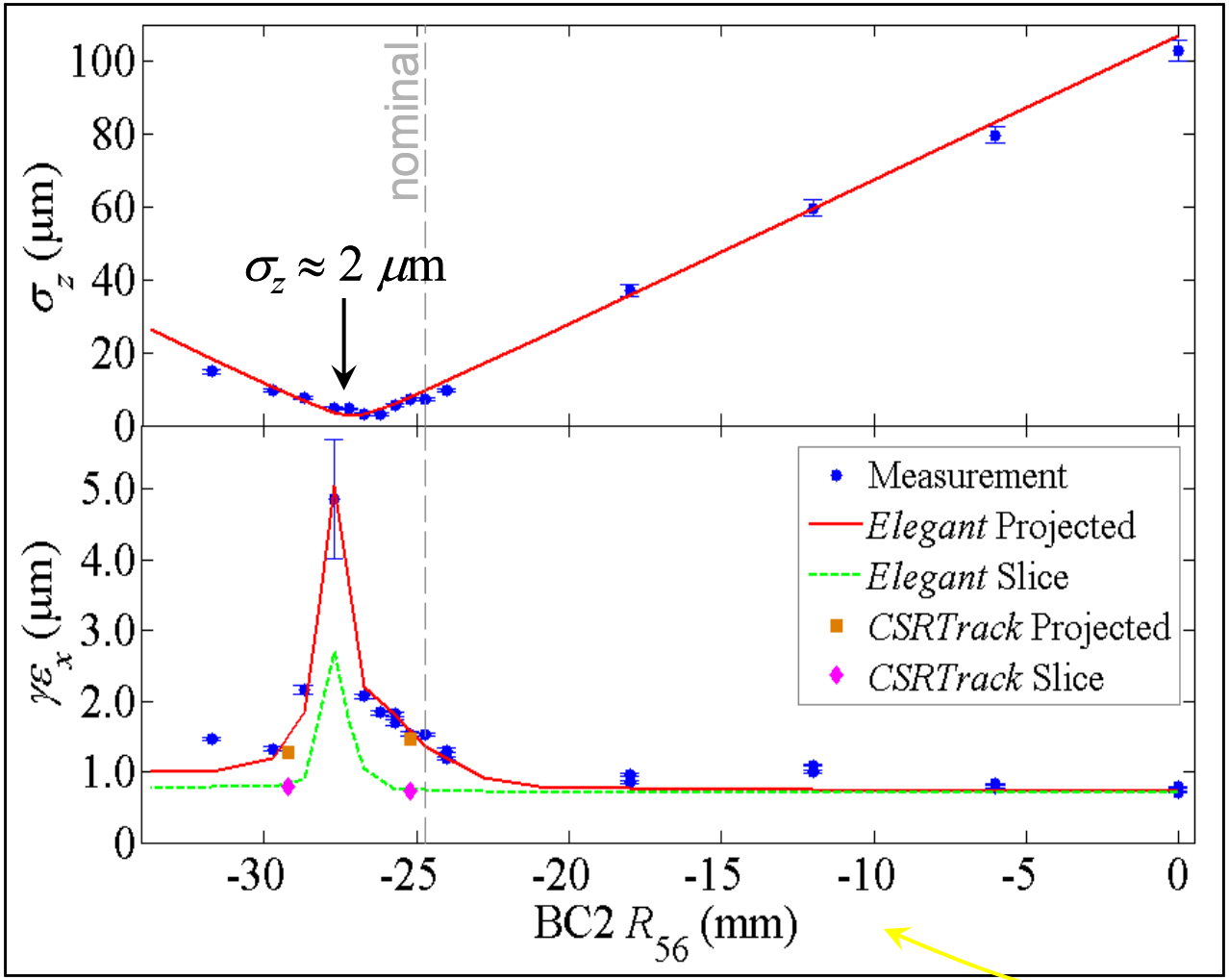
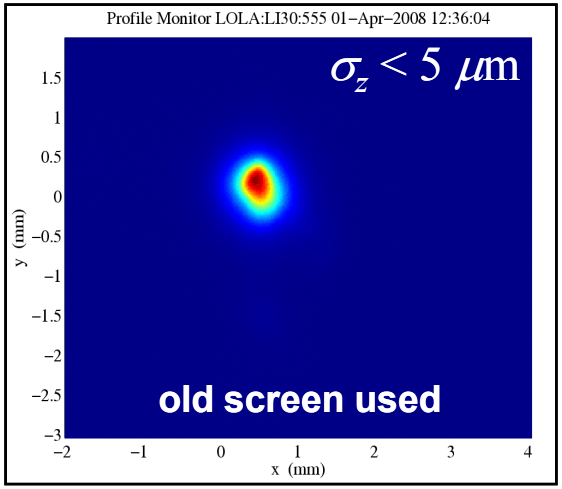
A Skew Quad in the *LCLS* BC1 as a CSR Diagnostic

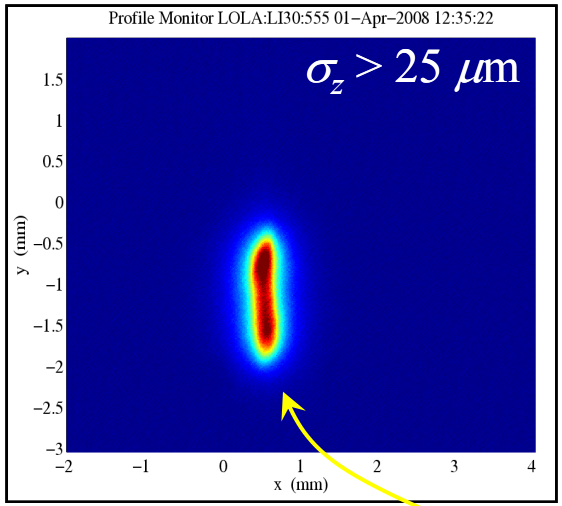
P. Emma *et al.*
SLAC

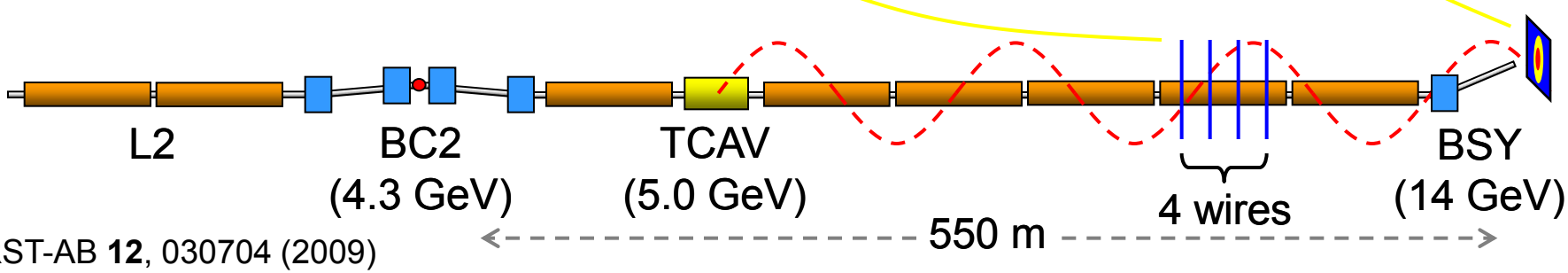
μBI-III Workshop
Frascati, Italy
March 25, 2010

Bunch Compression & CSR Measured after BC2 (0.25 nC)









PRST-AB **12**, 030704 (2009)

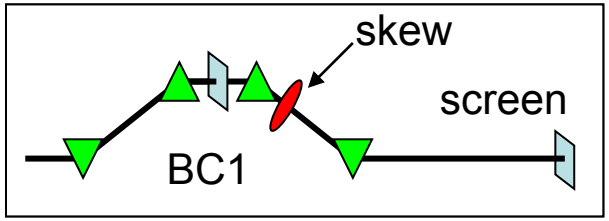
Skew Quad Motivations, History, etc…

- We all agree that transverse RF deflectors are great as a temporal diagnostic (time-slicing), however…
- …they are expensive, require high power RF, and are not so readily available.
- In Oct. 2008, at ***LBNL FEL Workshop***, Joe Bisognano asks, "How can we resolve the time-dependent CSR kicks along the bunch… I want to see it!"
- Same day, Oleg Shevchenko asks me (PE) if a skew quad might help… (note, the correct answer is **YES**)
- After ~1 yr (way too slow!), we install a small skew quad in BC1, and on the ~last day of the 2009 *LCLS* run (Dec. 15, 2009) we get first (only) skew quad CSR data…
- Concept and results follow…

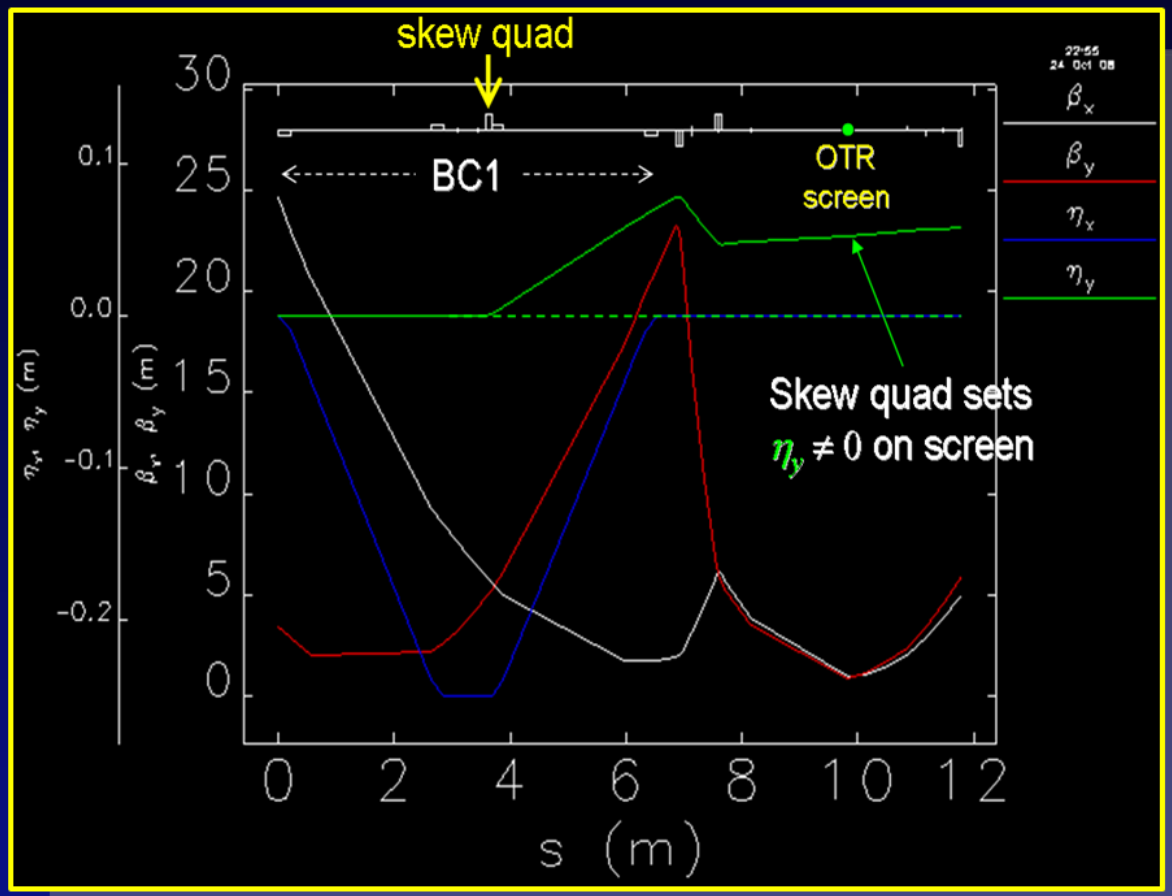
A CSR-Diagnostic Skew Quad in BC1

K. Bertsche,
P. Emma,
O. Shevchenko
(see PAC'09)

A skew quad in BC1 creates vertical dispersion after the chicane revealing x vs t space and CSR effects

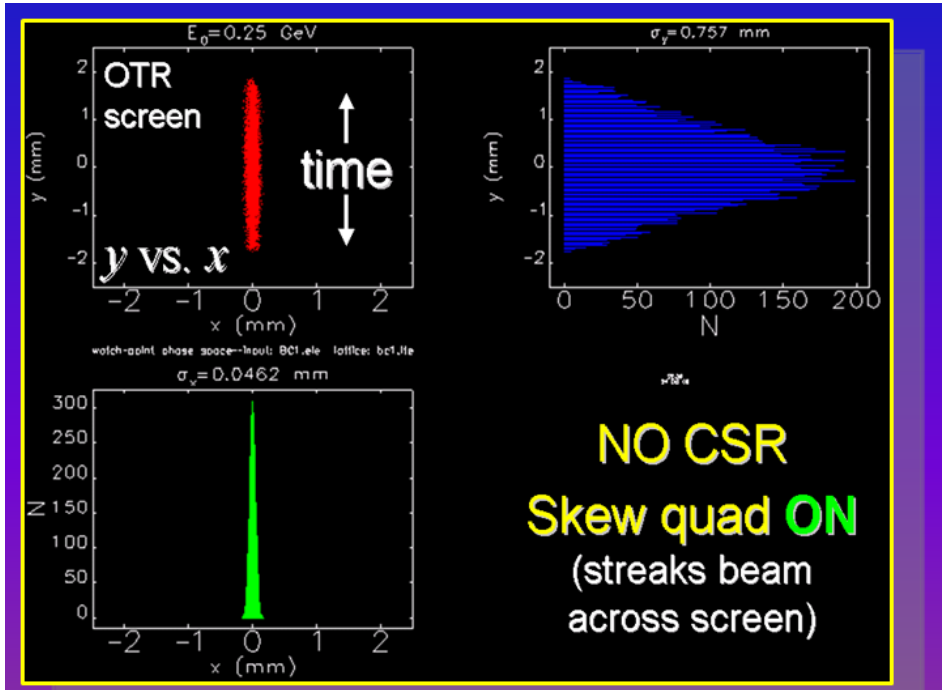


Slides from LBNL FEL Workshop: Oct. 2008

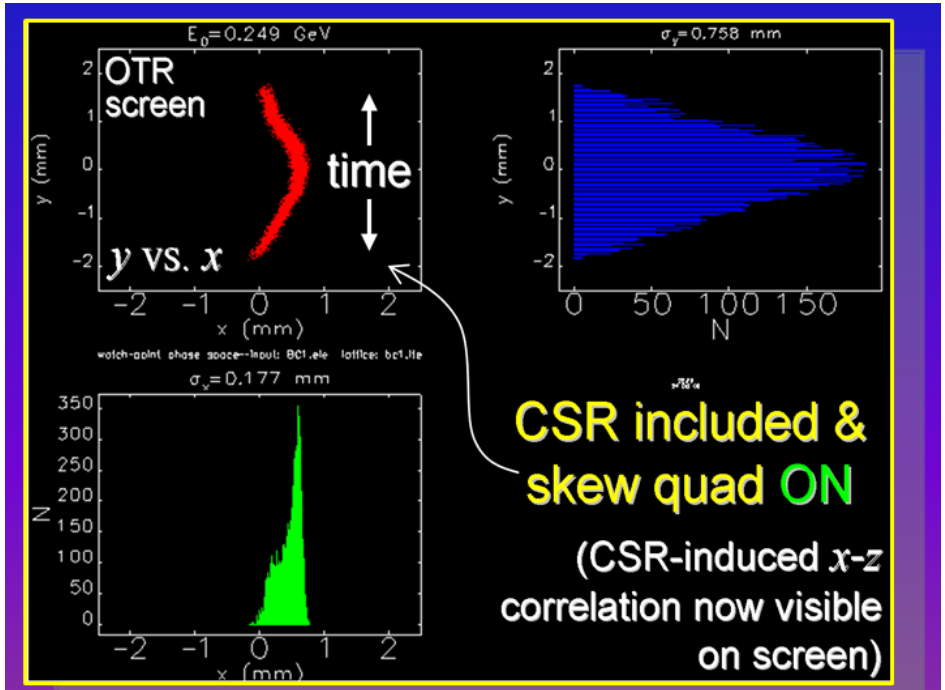


Chicane and OTR screen layout with skew quad switched on near center of chicane.

Simulation with *Elegant* showing CSR x-kicks vs time (exaggerated here with 1 nC and 50 μm bunch length)

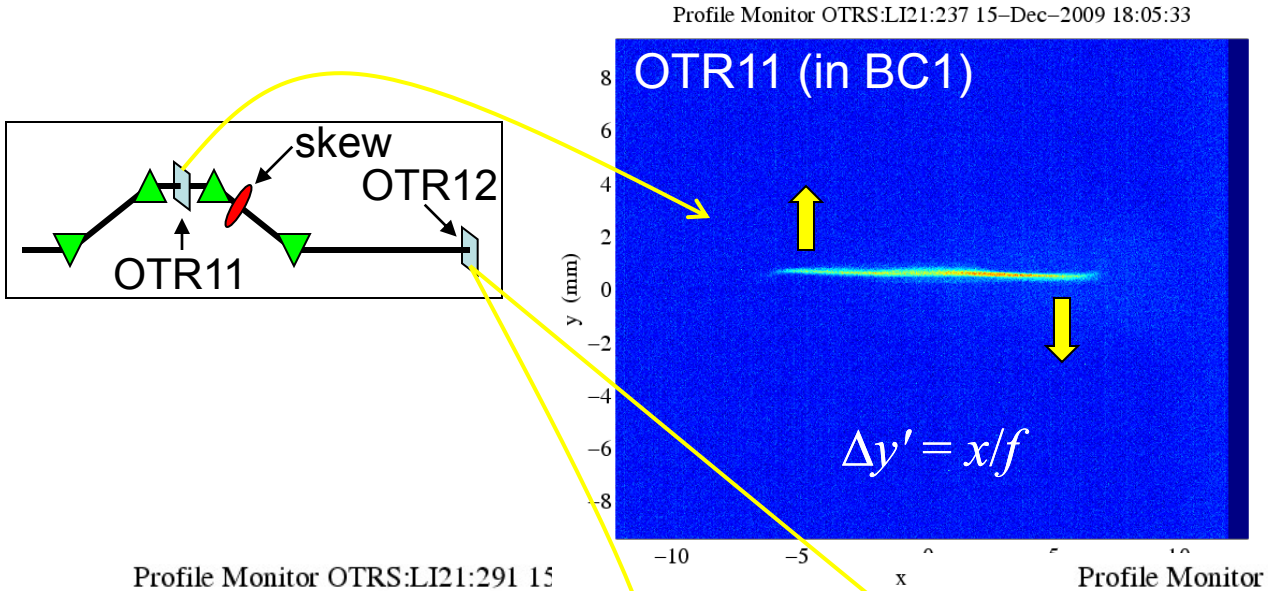


Beam on screen with no CSR & skew quad ON.



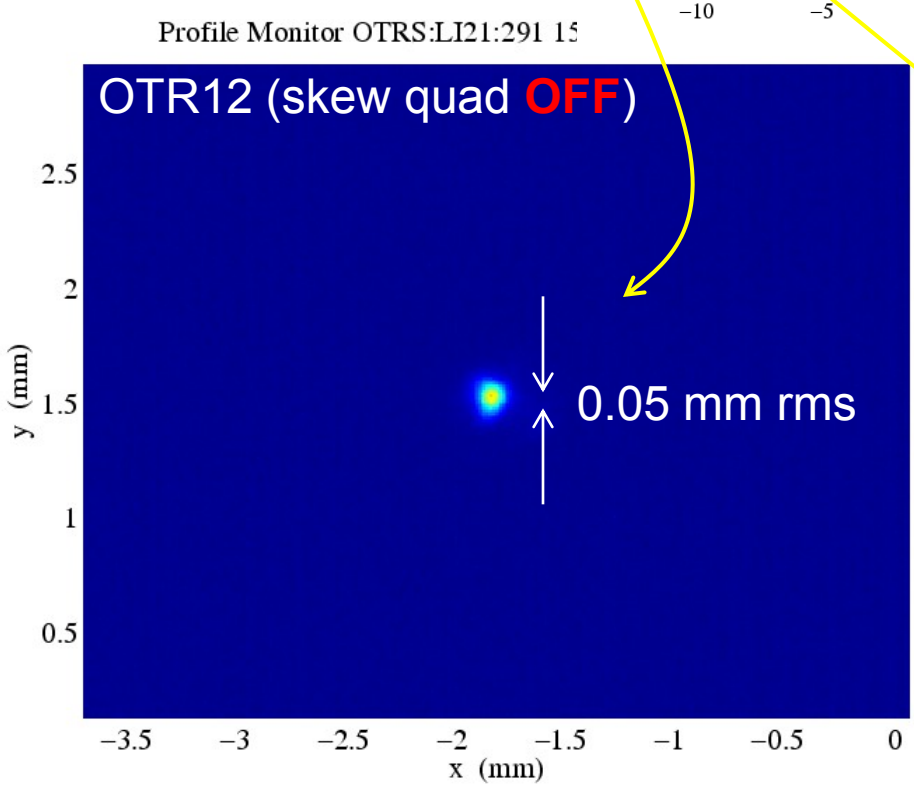
Beam on screen with CSR & skew quad ON.

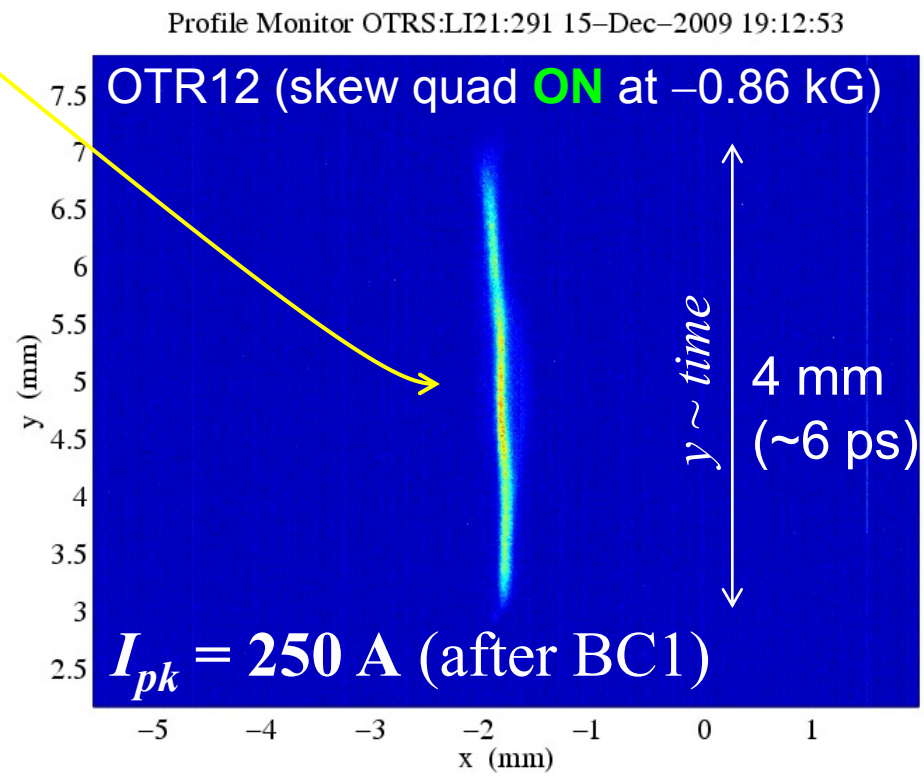
First (only) Measurements on Dec. 15, 2009 (250 pC)



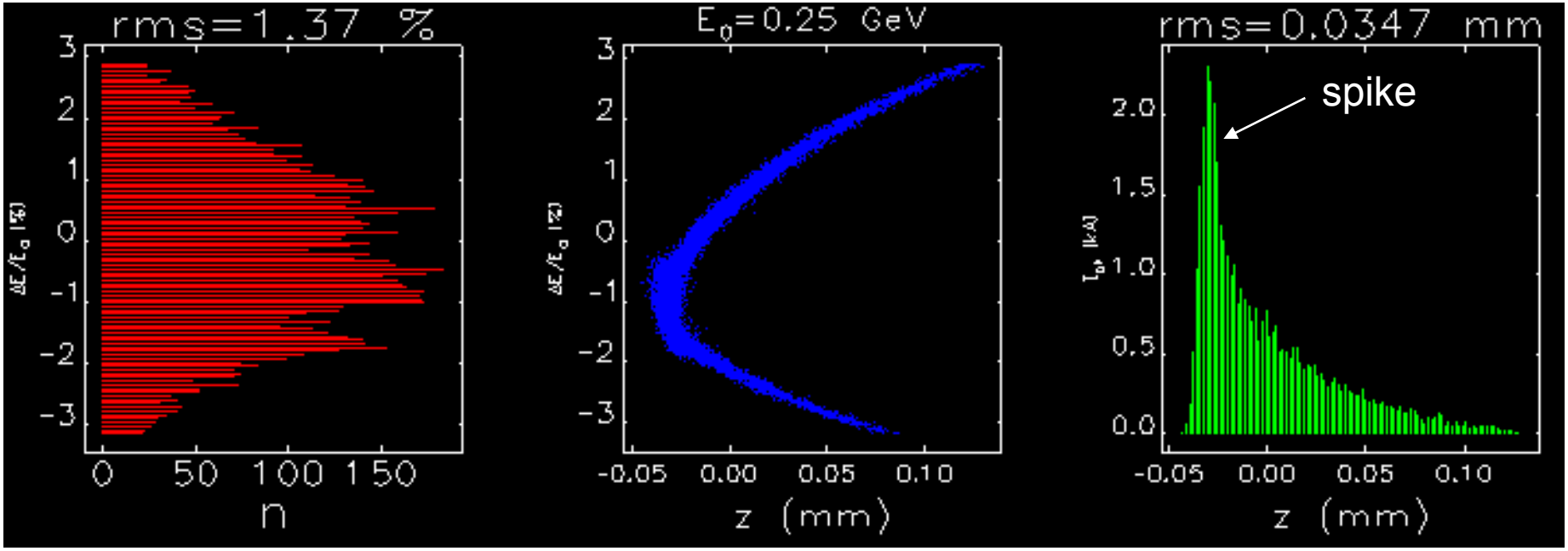
1.3% rms relative energy spread at 250 MeV and 230 mm horizontal dispersion

Skew quad generates y' from x: $\Delta y' = x/f$

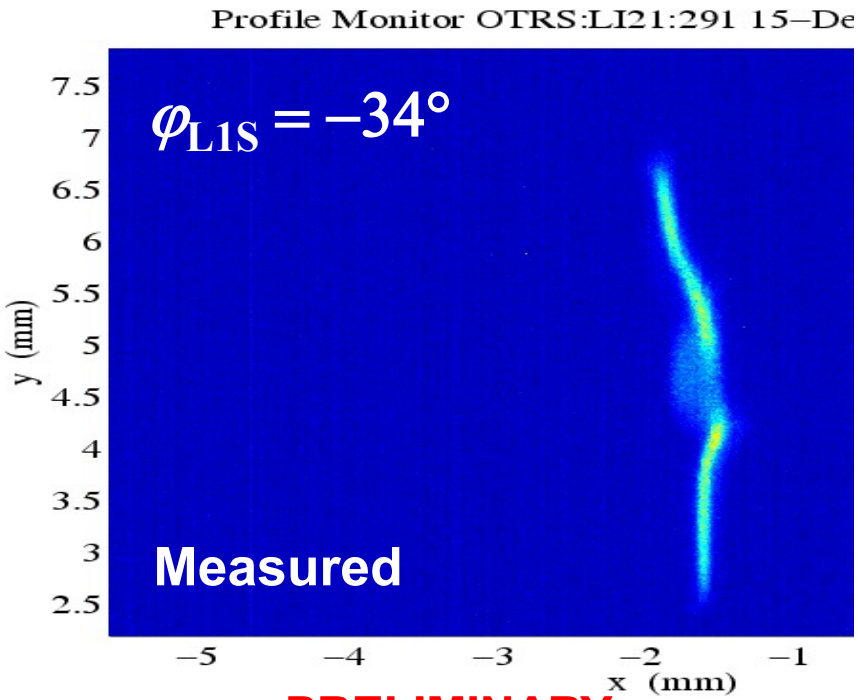




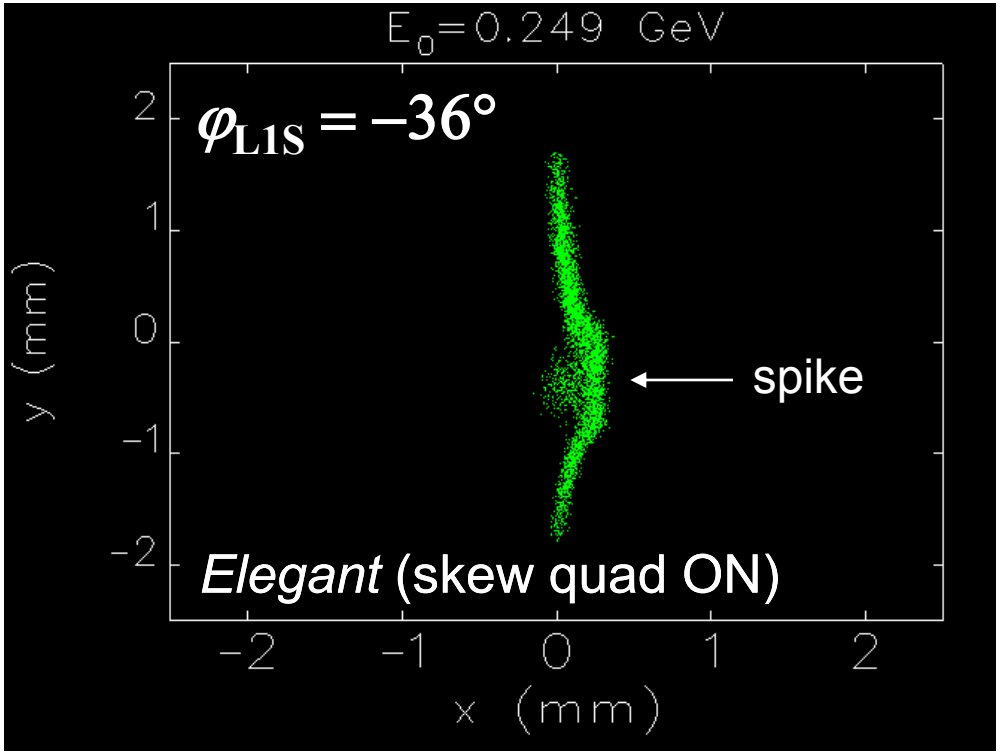
Now turn off X-band RF to generate a high peak current spike at the head of the bunch (as at *FLASH*)

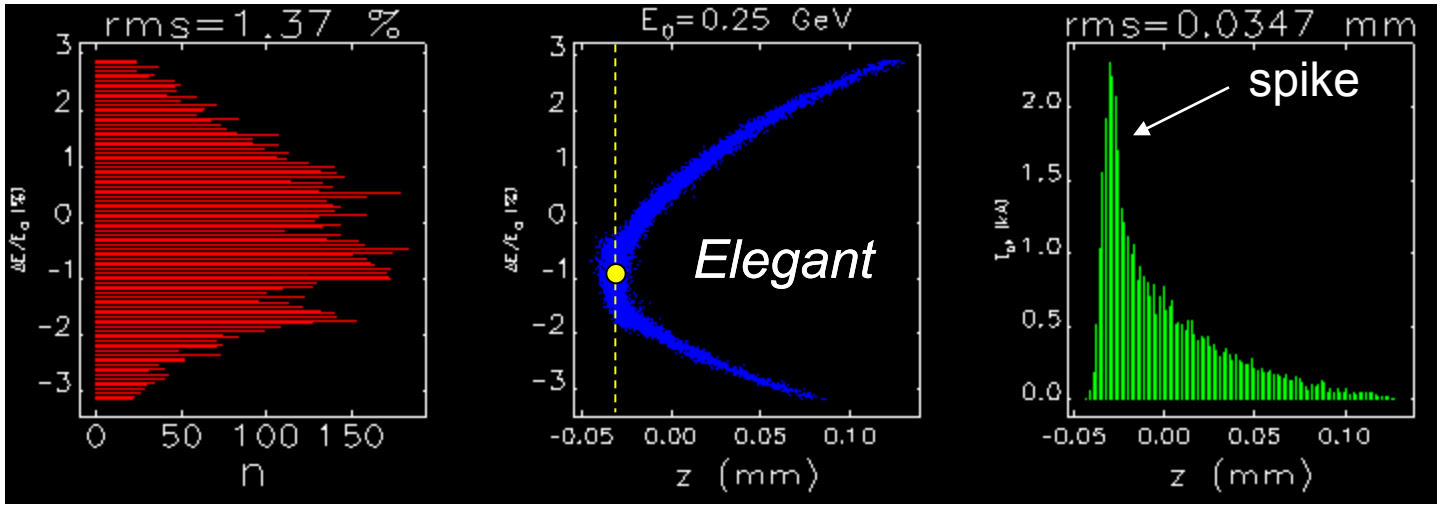


Elegant Comparison (250 pC, X-band RF OFF)

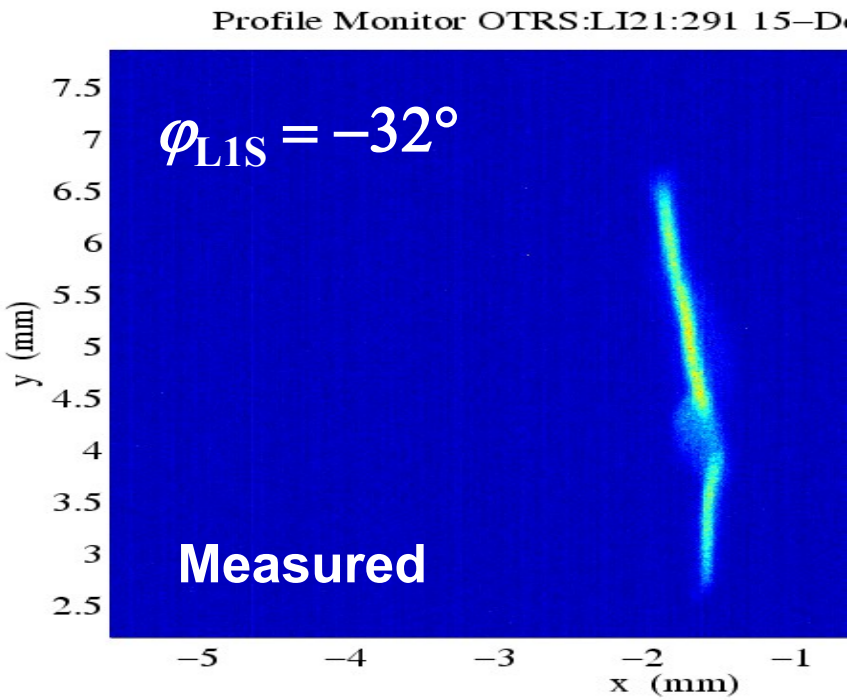


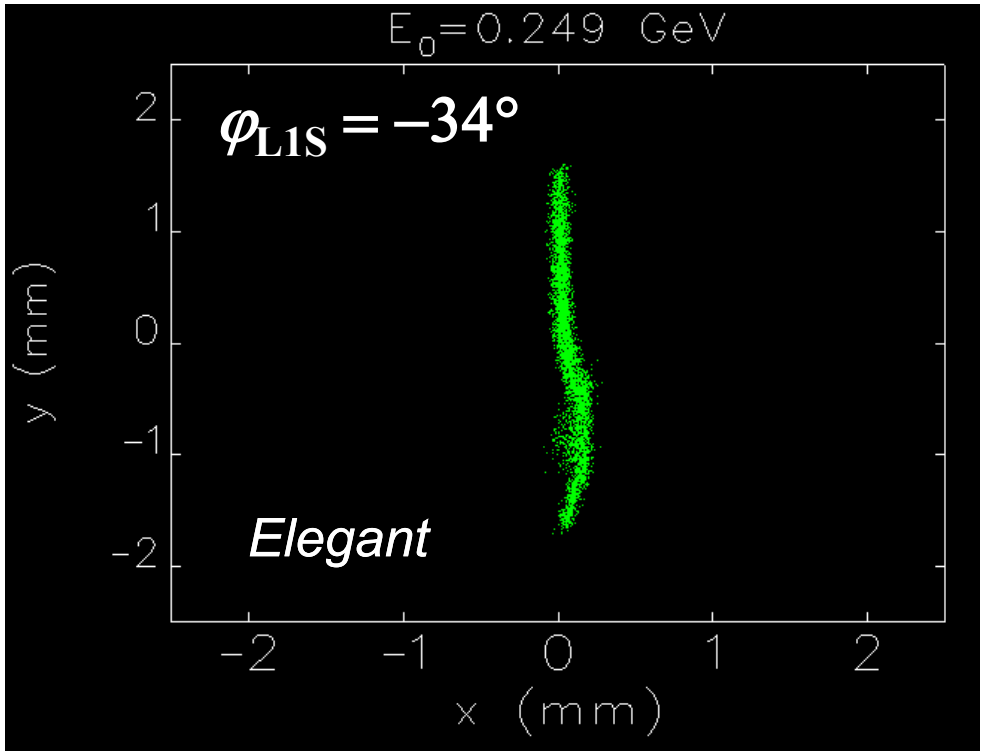
PRELIMINARY

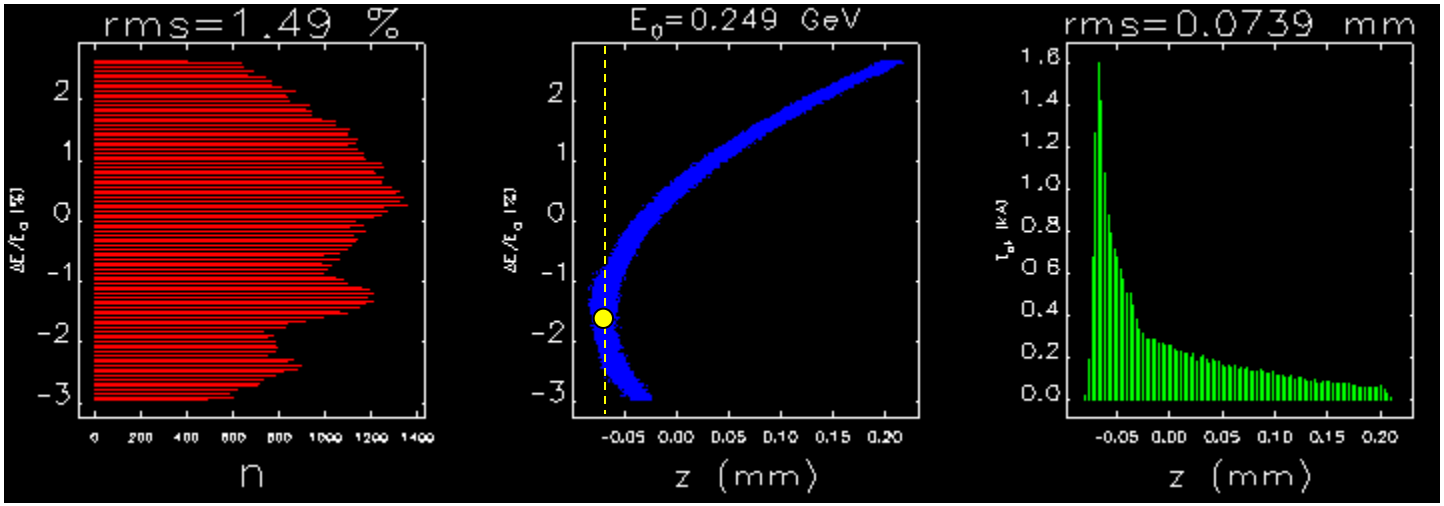




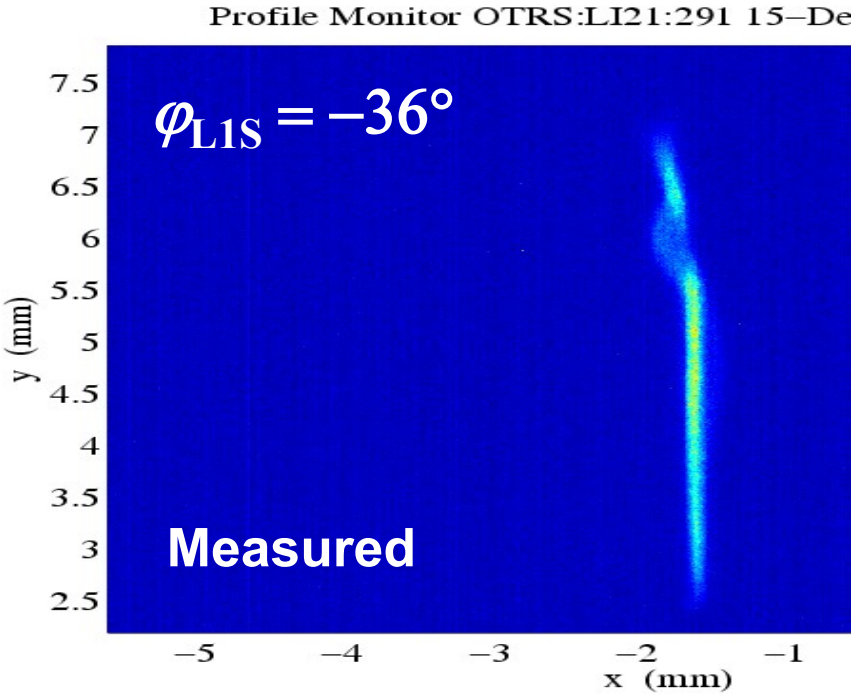
Elegant Comparison (preliminary)

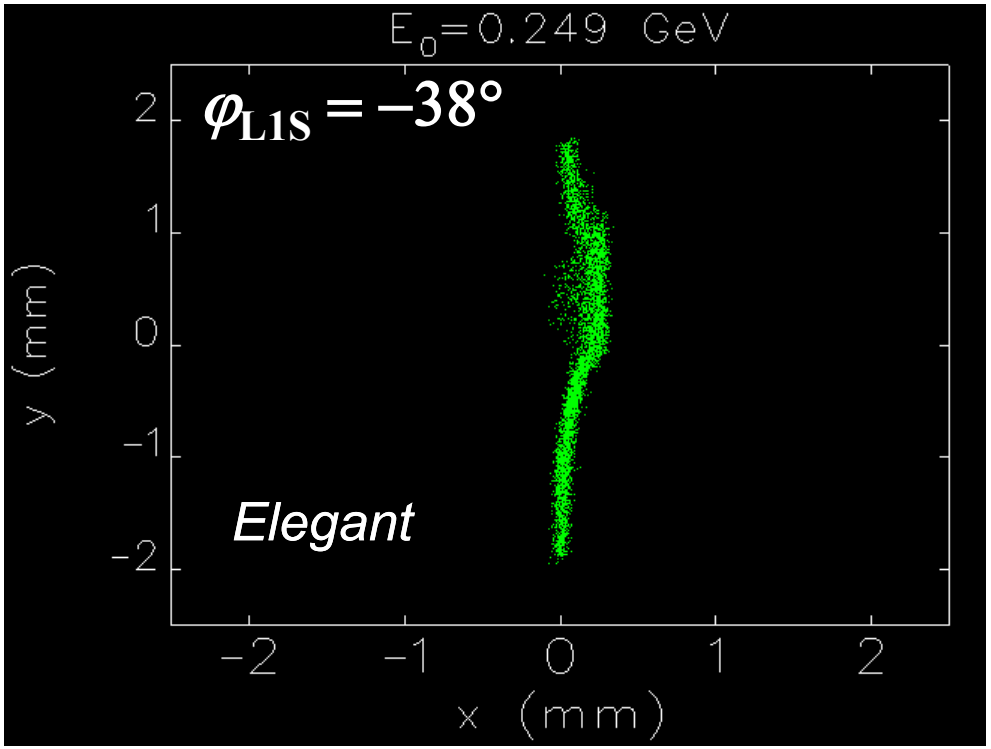


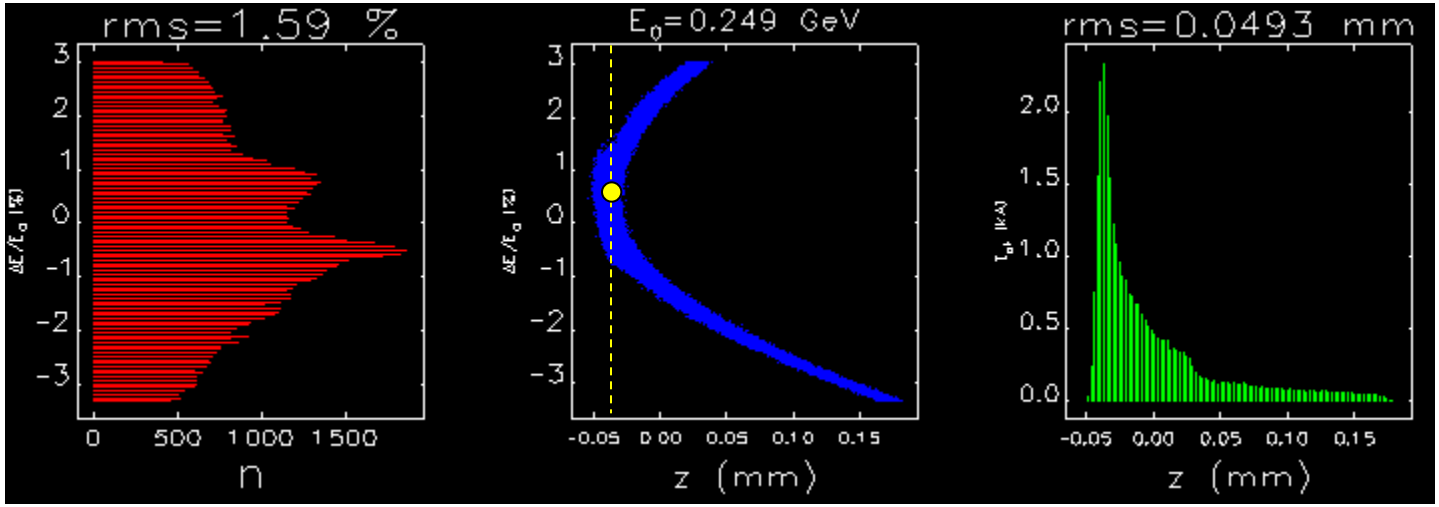




Elegant Comparison (preliminary)

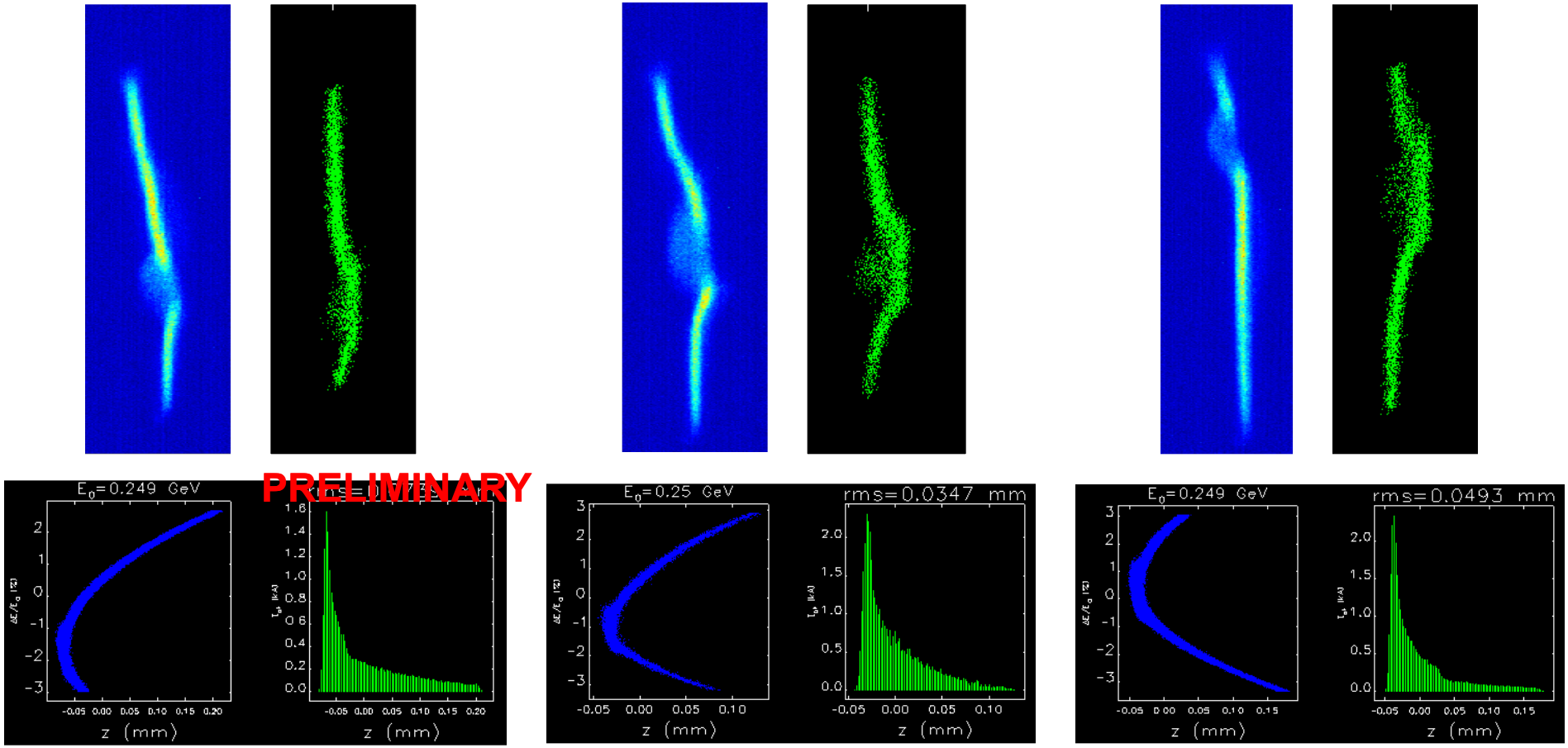






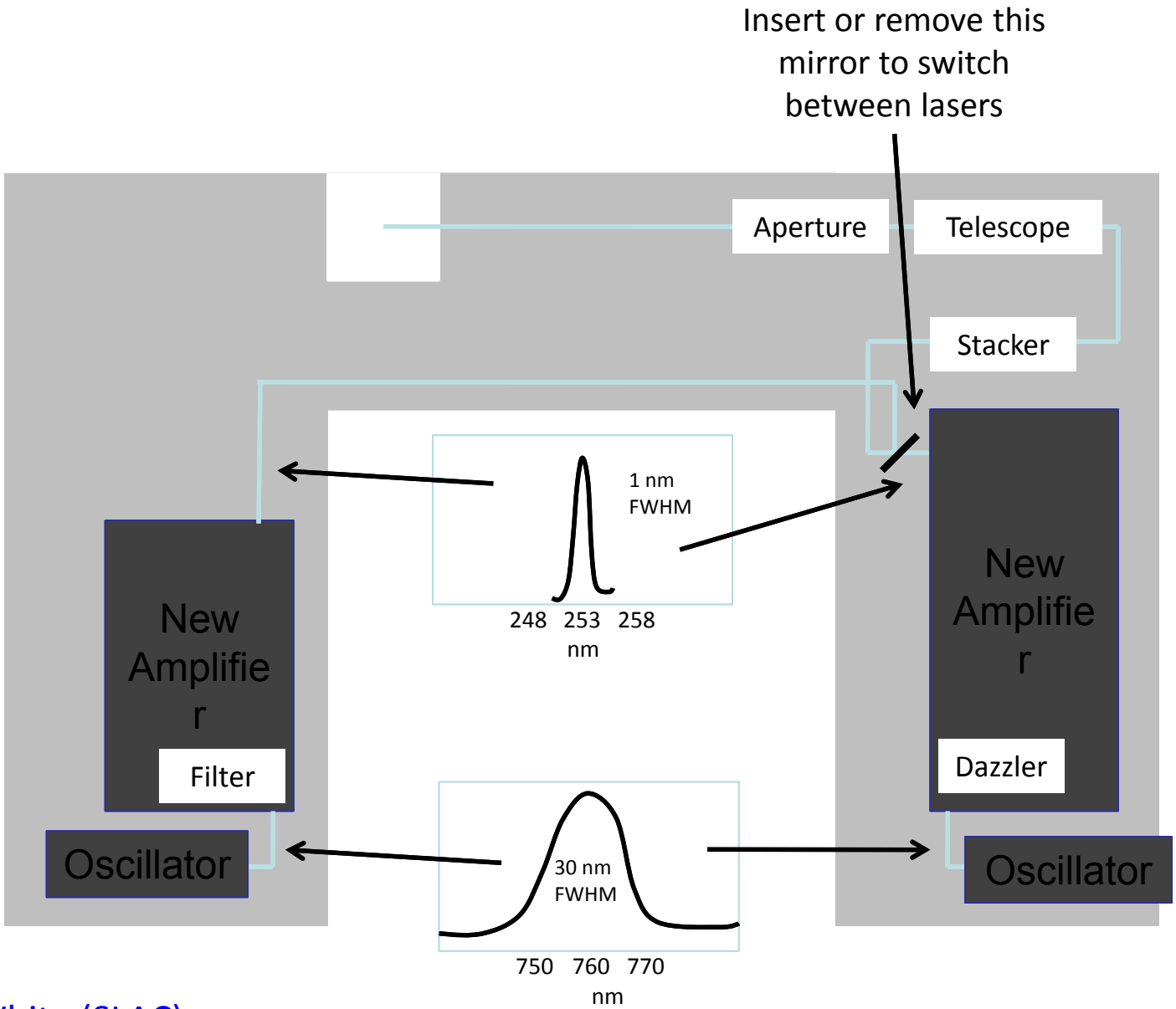
Measured vs *Elegant* on OTR12 (250 pC, X-band RF OFF)

$\varphi_{L1S} = -32°$ $\varphi_{L1S} = -34°$ $\varphi_{L1S} = -36°$



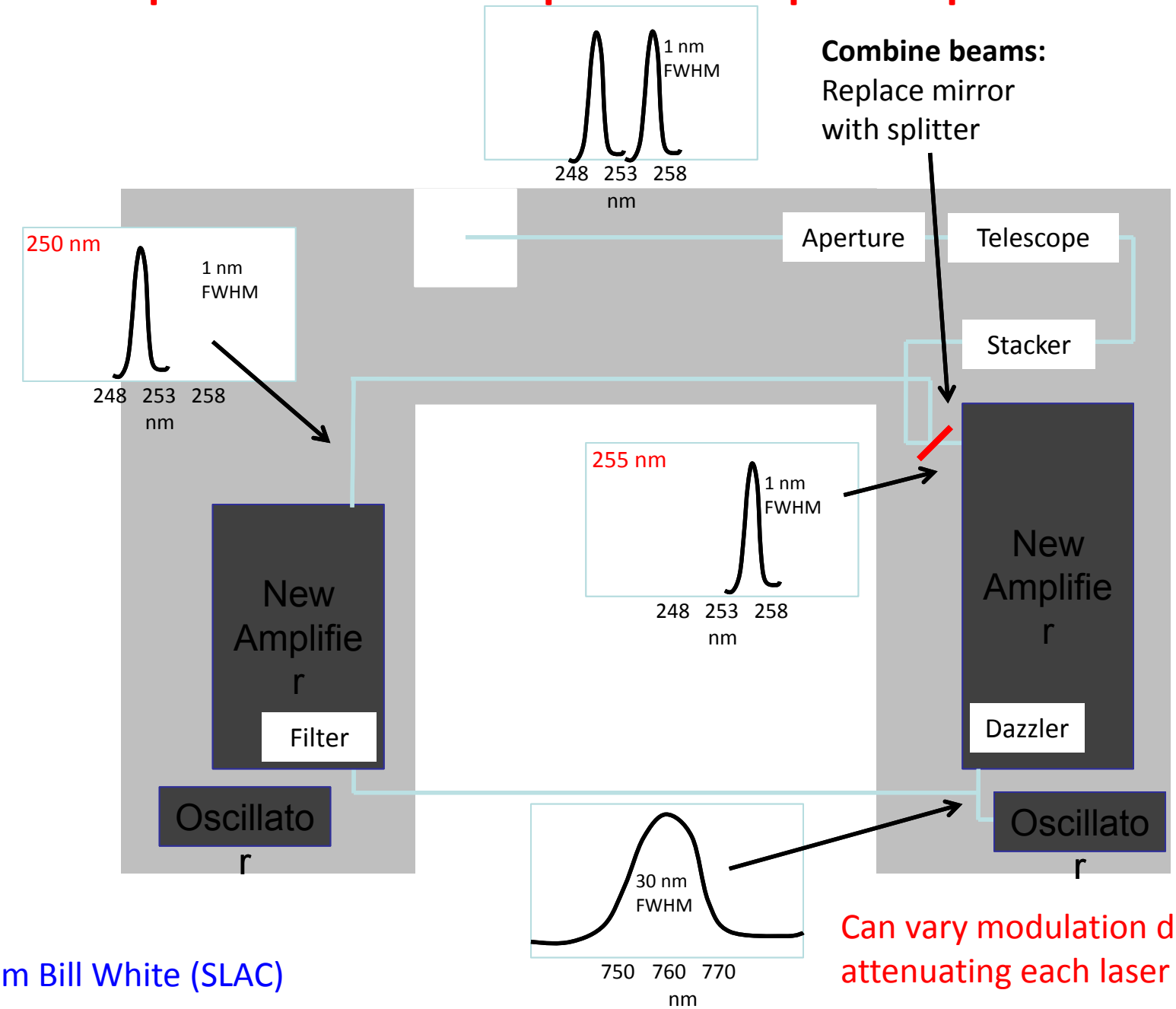
PRELIMINARY: 1-hr of rushed beam time at end of 2009 LCLS run (next run starts April 3)

Present LCLS Drive Laser Layout (with new laser added in March 2010)



From Bill White (SLAC)

5-nm separation at 253 nm provides 13 µm temporal modulation



Can vary modulation depth by attenuating each laser separately

From Bill White (SLAC)

November 15, 1997 / Vol. 22, No. 22 / OPTICS LETTERS 1713

Bill's example from 1997

Tunable short-pulse beat-wave laser source operating at 1 μm

A. K. Hankla

Positive Light, Inc., 103 Cooper Court, Los Gatos, California 95030

A. B. Bullock and W. E. White

Lawrence Livermore National Laboratory, L-251, 7000 East Avenue, Livermore, California 94550

J. A. Squier and C. P. J. Barty

University of California, San Diego, Mail Code 0339, La Jolla, California 92093-0339

(1997) 6.7-nm separation at 1055 nm provides 166 µm temporal modulation

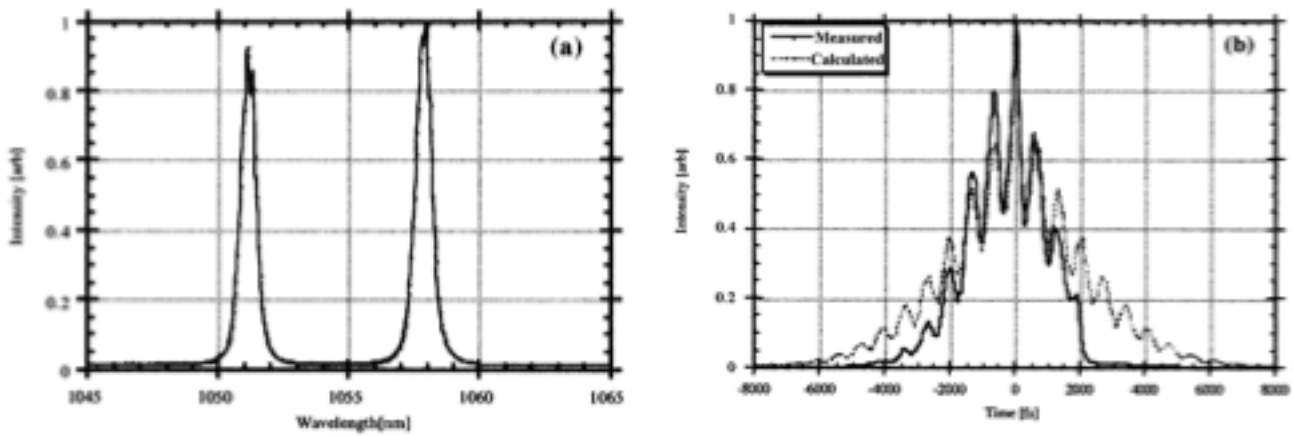


Fig. 3. (a) Spectrum with peaks at 1051.2 and 1057.9 nm and (b) resulting autocorrelation, showing the measured and the calculated 1.8-THz beat frequencies. The calculated autocorrelation was obtained as in Fig. 1(a).

This may allow us to modulate the drive laser at 10-100 µm period with variable modulation depth (~10-50%?)

From Bill White (SLAC)