Investigations of the LSC Microbunching Instability and Beam Characterization at the Advanced Photon Source Linac

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LSC μBI and beam characterization outline

- upgraded laser, diode pumped regen amplifier
- linac beam measurements
- diagnostic mitigation of COTR
- simulations with ASTRA
- discussion
Laser

regen ampl. folded 1.8-m cavity with new diode-pumped heads

Overall quantum efficiency

$$\eta = \frac{Q \ h \nu}{e \ E} = 1.3 \times 10^{-5}$$

virtual cathode image

fluorescence image from photocathode

61 µJ

significant transverse uniformity — not optimized

195 µJ

fluorescence image rotated 90° and flipped vertically (periscope out-of-plane transport)

gun charge and laser output over several days

600 pC

0.22 mJ
39 μJ on flipper screen (saturated) in front of laser port.

PC Gun

L1 solenoid

Solenoid

L1

L1

L5

pc gun

L1

L1

L4

L1

pc gun

YAG/mirror cube

Linac schematic
Diagnostics

three-screen emittance section—following quad matching section after chicane
FIR coherent transition radiation autocorrelator
electron spectrometers
OTR and scintillator screens—OTR, YAG:Ce, and LSO:Ce
cameras (STA5)
  VICON CCD
  SCO QUIK-05A gated intensified
  Pulnix MCP-Intensified CCD (GaAs)

Beam size—entrance to and midway through L2

several types of cameras and screens are used with different calibrations

L1:FS1 screen

L1:FS1cal screen

S3:C2 screen

S3:C2 cal screen

240 hlines = 3.6 cm
320 vlines = 3.6 cm

305 hlines = 12.7 mm
388 vlines = 12.7 mm
FIR coherent transition radiation autocorrelator

Gaussian spect. dist. \( \sigma = \frac{l_{\text{fwhm}}}{2\sqrt{2\ln(2)}} = 84.9 \, \mu m \), \( \Delta t = \frac{2\sigma}{\sqrt{2}c} = 401 \, fs \)

Counts

L3:CTR:scanDataWF

\( l_{\text{fwhm}} = 200 \, \mu m \)

\( \Delta t = 173 \, fs \)

\( \sigma = 36.7 \, \mu m \)

\( l_{\text{fwhm}} = 86.5 \, \mu m \)

\( \mu m \)

Time starting Thu Jul 14 21:51:00 2011

L3:CTR:AutoCorr_1000um.sdds was recorded at 23:25 according to the time stamp in the file. The time stamp in L3:CTR:AutoCorr_1000um.sdds is 23:35.
OTR screen images in Station 5—COTR present

450 pC, -22°
Diagnostic mitigation—use of a BW or narrow band interference (NBI) filters

**GaAs ICCD, COTR observed**

*Data from SDDS file /tmp/test3.sdds, table 1*

**GaAs ICCD, COTR suppressed**

*Data from SDDS file /tmp/test3.sdds, table 1*

Imaging s/w centers frame on the location of maximum intensity
Diagnostic mitigation—use of a BW or narrow band interference (NBI) filter with LSO:Ce scintillator

VICON CCD, COTR observed

VICON CCD, COTR suppressed

500 micron thick crystal 500x OTR

emission wavelength of LSO:Ce centered at 415 nm
Diagnostic mitigation—use of a BW filter with LSO:Ce scintillator, con’t

~ 2.5 x weaker than 400 nm

LSO

ND0.5

450 nm x 10 nm

ND1.0

LSO

VICON CCD, COTR observed

VICON CCD, COTR suppressed

Sigma = 31.19 (0.87 mm)

Sigma = 33.54 (0.94 mm)

y_{slice} = 1.68 mm

500 micron thick crystal

500x OTR

emission wavelength of LSO:Ce centered at 415 nm
temporal suppression using delayed the gated camera past the prompt emission of COTR from scintillators

20 ns gate, phase shift ~-12°
gain significantly higher for LSO—900 V vs. 725 V for YAG
LSO data generally noisier
Zero-Phase measurement at L5 and ASTRA simulation

rms laser pulsewidth = 1.5 ps
diameter = 1 mm
Q = 450 pC

L2KlyPhaseReadbackMean1 (deg)
Error/Value<0.5
Preliminary ASTRA simulations—compared with 3-screen emittance measurements

measurements:
- $x$ - horizontal
- $y$ - vertical

emittance vs. charge
$I_s = 115 \, \text{A} (120 \, \text{A} @ 450 \, \text{pC})$

emittance vs. solenoid current
70 pC, comparing with earlier meas.*

ASTRA:
- * - h
- * - v

*J. Lewellan and M. Borland, PAC 2001
Discussion and Summary

Upgraded laser (regen) helps with reliability, but nonuniform transverse spatial distribution on cathode diagnostic mitigation of COTR explored with spectral and temporal techniques good beginning with ASTRA simulations of the linac ASTRA and elegant simulations around the chicane Testing with thermionic guns still possible

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L3 Energy spectrometer (after the chicane) {backup slide}

-9.1° expanded views

Δp/p (%)

Region expanded on right

Δp/p (%)

Region expanded on right

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