Overview of the X-band Photoinjector Laser System

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Concept Overview

Table-Top High Power Laser

Collimated Intense X-Ray Beam

Laser-Like Tunable X-Rays

Tagged Agents Imaged by Noninvasive X-Ray Absorption or Diffraction Spectroscopy

Intensity Increased to Deliver Localized Radiation Dose

X-Ray Intensity

X-Ray Energy
Photoinjector Design Parameters*

- $Q = 500$ pC
- $\varepsilon_{n,x} = 0.74 \pi$ mm-mrad
- $\varepsilon_{n,y} = 0.76 \pi$ mm-mrad
- $\Delta z/c = 800$ fs
- $\Delta \gamma/\gamma < 1\%$
- Focus (50 MeV): $\sigma_x = 16.6$ µm, $\sigma_y = 10.4$ µm
- Peak Brightness $= 2I/\varepsilon^2 = 2000$ A/mm²/mrad²

*Using PARMELA
Laser Requirements

- UV energy exceeding 120 µJ/shot at 266 nm
- Energy stability < 5%
- 180 Hz
- Compact
- Timing jitter < 0.5 ps
- 1mm beam diameter at cathode (uniform profile)
- 800 fs temporal flattop at cathode
- TW amplifier must not be impaired by cathode laser considerations
• $Q_o = 7,000$; $\text{Field Imbalance} < 5\%$; $\beta = 1.8$ (per design)

• Peak Surface Gradient of $185 \text{ MV/m}$ in $200 \text{ ns}$ pulse (7 MeV)

• Operates at 60 Hz (120 – 180 Hz possible)
UV Laser Feedthru Chamber

- Three distinct removable electron beam diagnostics
- Viewport as close as possible to diagnostics
- Dielectric rectangular $45^\circ$ UV mirrors
- Remote operated mechanical feedthru
- Direction of electron travel
- Extra vacuum pumpout
Diagnostics and laser feedthru incorporated into a single component

High resolution and prompt electron beam diagnostic using a thin foil to create Optical Transition Radiation

Tantalum plate pepper pot for emittance measurement

Low resolution electron beam diagnostic using a scintillating material (Ce:YAG)

Space to recess diagnostics
Mirror Dispersion Controlled Laser Oscillator

Designer’s Claim: No Prisms $\rightarrow$ Low Jitter
FemtoLaser Oscillator Output

Large Bandwidth Overfills Stretcher
“Spitfire” Regenerative Amplifier Used As Intended…

All Diode Pumped: 1 mJ, 50 fs, 1 kHz
...Except for Timing

- Laser Oscillator 79.33 MHz
- Pulse Picker 1 - 60 Hz
- SLAC Synch 1 - 60 Hz
- Phase Locked Dielectric Resonance Oscillator 11.424 GHz
- Evolution DPSSL
- Regen. Pockels Cells
- Final Amp Flashlamps
- Traveling Wave Tube
- Test Stand 8 Klystron
- LINAC
- Test Stand 6 Klystron
- Photoinjector
Proposed Electron Beam Timing Diagnostic

- Monitors laser phase by deriving a transient X-band signal
- Originally built for use as a pre-accelerator at ASTA
- Will be inserted after the Interaction Point

Figure 6.15  Timing stabilization schematic.
UV Production

- 50 fs, 1 mJ, 800 nm input $\rightarrow$ 120 $\mu$J, 266 nm output (Evolution Diodes at 100%)
- 0.5 mJ input $\rightarrow$ 40 $\mu$J output (Evolution Diodes at 80%)
- As advertised, easy to align and optimize
- UV energy stability $\sim$ 2% rms
X-Band Photoinjector Laser Summary

- Mirror dispersion controlled 12 fs oscillator leaves no ambiguity about the spectrum, and the frequency can be controlled via the output coupler.
- All-diode pumping is wonderful for amplitude stability, pointing stability, and ease of operation, and high repetition rates are no problem.
- Built-in triggers for the Evolution / Spitfire lasers are very poor.
- Optics in the vacuum beamline are compatible with $10^{-9}$ torr operation, but alignment can be difficult.
- Use of the commercial UV Tripler “Timeplate” system makes UV generation much easier at short pulsewidths.
- “Environmental Control” : No one is in the laser room when the photoinjector is running!