Double-pulse generation with the injector laser for pump/probe experiments

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Motivation: Pump-probe experiments with VUV and FIR (from new undulator in 2007)
Optical path length about 80 cm longer for infrared radiation due to construction constraints

Concept: Generate double laser pulses separated by several cycles of 1.3 GHz

1. Splitting, delaying and recombining in the UV
2. Allowing 2 pulses to leave the 27 MHz oscillator by modification of Pockels cell gating

Need finally to generate SASE with second bunch!

These measurements: Method 1, separation of 10 RF periods (7.69 ns)
Setup on laser table

- $\lambda/2$ plate to rotate polarization
- Brewster-angle beam splitter and recombiner
- Arbitrary relative intensity of direct and delayed pulse

No lateral offset of direct beam
**Image on virtual cathode**

**Direct pulse**

**Delayed pulse**

**LASER**

- horizontal profile: $\sigma(x) = 0.71$ mm center(x) = 6.60 mm

- vertical profile: $\sigma(y) = 1.01$ mm center(y) = 3.85 mm

- horizontal profile: $\sigma(x) = 0.62$ mm center(x) = 6.60 mm

- vertical profile: $\sigma(y) = 0.93$ mm center(y) = 3.49 mm
Delay adjustment, phase scan with Gun

- Rough delay adjusted with fast photodiode to about 0.1 ns ($\approx 45^\circ$ RF)
- Fine delay to better than 1° with phase scans ($1^\circ \leftrightarrow 641 \mu m$ path length).

**Direct pulse**
Start of charge 259 deg

**Delayed pulse**
Start of charge 257 deg
Toroid 3GUN response

Direct

Delayed

Both

Cursors spaced 7.7 ns
BPM 1GUN/X response
(self-triggered button)

Problem at large charge:

Almost insensitive to double pulse
(except 7.7 ns delay)
BPM 9ACC1/X response
(reentrant cavity)

Final calculated signal in DOOCS somewhat sensitive to double pulse

-1.45 mm

-1.14 mm

-1.75 mm
BPM 1UBC2/X response
(externally-triggered button)

Direct pulse only

Delayed pulse only

Direct and delayed pulse

Does not see second pulse
BPM 2DBC2/X response
(strip-line)

Direct pulse only

Delayed pulse only

Direct and delayed pulse

Insensitive to double pulse
Screen 3BC2

- Direct pulse
- Delayed pulse
- ACC1 on-crest
- ACC1 10° off-crest
Screen 4DBC2

Direct pulse

Delayed pulse
Next steps
(the difficult ones...)

- Insert compensation optics into delayed path
- Check and improve quality of second bunch
  Emittance, longitudinal profile
- Lasing with second bunch only
- Lasing with second bunch of double bunch
  Wake fields might determine optimum delay, beam loading
- Measure time delay jitter of the two bunches
- Investigate generation of double pulses with Pockels cell gating