Title: Summary of E214 at FACET, May 2014: Monochromatic 10 MeV Gammas by a Miniature Undulator

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Intended for: SLAC Accelerator Research Experimental Program Committee Meeting, Experiment Reivew, 2014-09-15 (Menlo Park, California, United States)

Issued: 2014-09-11 (Draft)
Summary of E214 at FACET, May 2014

Monochromatic 10 MeV Gammas by a Miniature Undulator

Experimental Team

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Univ. of Florida  Alexandra Garraud (Prof. David Arnold)
Univ. of Pennsylvania  Brock Peterson (Prof. Mark Allen)
FACET  Mark Hogan, Christine Clarke et al.
Anticipated Performance of Mini-Undulator in 20-GeV/3-nC FACET beam

Fabricated, Assembled and Measured Mini Undulator (λ_u = 400 μm)

Laser-machined SmCo undulator array

Assembly (End View)

<table>
<thead>
<tr>
<th>Gap</th>
<th>Peak Undulator Field</th>
<th>10 MeV γ’s / bunch</th>
</tr>
</thead>
<tbody>
<tr>
<td>200 μm</td>
<td>0.25 T</td>
<td>2×10^6</td>
</tr>
<tr>
<td>400 μm</td>
<td>0.063 T</td>
<td>5×10^5</td>
</tr>
</tbody>
</table>
Installed Undulators

- Undulator 1 = 200 micron gap, 2\textsuperscript{nd} generation
- Undulator 2 = 200 micron gap, 1\textsuperscript{st} generation
- Undulator 3 = 400 micron gap
- Dummy = 400 micron gap, no magnet

Dummy (during assembly)
General Layout

Mini-Undulator in IP Area

(Dielectric Wakefield Chamber)

Instruments/Experiments on Beam-Dump Optical Table

dipole deflects e-beam 10 cm from gammas at optical table

approx. 6 ft × 3 ft
Crowded optical table and beam-dump area
But enough room for detectors and instruments
and shielding

Mach-Zehnder interferometer encased neatly in lead beneath the beamline
## Favorable Prospects for gamma-Detection by GCD

<table>
<thead>
<tr>
<th>Date</th>
<th>HlgS (Duke)</th>
<th>FITAS (Idaho)</th>
<th>Omega</th>
<th>FACET</th>
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<tr>
<td>Date</td>
<td>2010 April</td>
<td>2012 July</td>
<td>1999-present</td>
<td>2014 May</td>
</tr>
<tr>
<td>Spectrum</td>
<td>$\Delta E/E = 5%$</td>
<td>Exponential</td>
<td>Near mono</td>
<td>$\Delta E/E = 3%$</td>
</tr>
<tr>
<td>Peak energy</td>
<td>10, 4, 17</td>
<td>End point of 20 MeV</td>
<td>16.75, 4.44</td>
<td>10</td>
</tr>
<tr>
<td>MeV</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flux at source</td>
<td>$1E+7 \gamma/s$</td>
<td>?</td>
<td>$&gt; 2E+6 \gamma/shot$</td>
<td>$\sim 1E+7 \gamma/s$</td>
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<tr>
<td>frequency</td>
<td>5.6 MHz</td>
<td>10 Hz</td>
<td>Single shot</td>
<td>10 Hz</td>
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<tr>
<td>Incident</td>
<td>1 – 2 $\gamma$/pulse</td>
<td>5E+8 $\gamma$/pulse (&gt; 6 MeV)</td>
<td>$&gt; 2E+4 \gamma/shot$</td>
<td>$\sim 1E+6 \gamma$/pulse</td>
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<tr>
<td>gamma- flux per pulse</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulse width</td>
<td>$&lt; 0.1 \text{ ns }$</td>
<td>60 ns</td>
<td>0.1 ns</td>
<td>$&lt; 1 \text{ ps}$</td>
</tr>
<tr>
<td>Detection</td>
<td>- electrometer ($\sim 250 \text{ pA}$) - Single count</td>
<td>- DPO 400 mV - Fast frame</td>
<td>- SCD - MZ</td>
<td>MZ with DPO fast-frame mode</td>
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Diagnose overall system performance by remaining tools

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Compton-Diode Signal from “Dummy” Indicates Brem for even an Optimized and Centered e-Beam

Green Line = nothing inserted

Dummy at +100 μm

Dummy at +50 μm

Dummy (400 μm gap) aligned to beam center

(e-beam minor-diameter ~45–70 μm)
Also Indicates that Brem will Dominate Total Flux

Signal ($\Delta$) in dummy case is $\sim 500X$ more than expected from gammas.
No Discernible Detection of $\gamma$’s by VCD (not unexpectedly)

![Graph showing VCD Signal over Time](image-url)
Lanex Images: “Blank” Case

Brem spot apparent with no device (undulator or dummy) inserted
Lanex Images: Dummy, 400-μm Gap

Centerline Counts Increase ~2X with Dummy Inserted and Centered
Lanex Images: 400-μm Undulator

Spot-size and signal with centered 400-μm undulator much like dummy case.
Lanex Images: 400-μm Undulator, 100 μm Offset

~5X signal increase from Brem, consistent with VCD results
Conclusions / Future Plans

- Can’t quite thread the needle — Bremsstrahlung generated by the present combination of mini-undulator and e-beam overwhelms produced gammas.

- Spectral and spatial filtering (e.g., collimation) will help isolate gammas from background.

- Intensive modeling of Brem generation, collimation, spectral filtering (by W and plastic, e.g.), and detection must precede a second try.

- Compare the GCD against a Compton spectrometer, which detects gammas with spectral resolution and will likely be a future option.