Framing Camera Sensitivities

November 2016

POC: Joe Holder, Robin Benedetti
### Available GXD Framing Cameras at NIF

<table>
<thead>
<tr>
<th>Camera</th>
<th># strips</th>
<th>DIM</th>
<th>Add’l INFO</th>
<th>Gain Rel$^2$</th>
<th>Pulse Vel (mm/ns)</th>
<th>Gate width (ps)@(bias V)</th>
<th>Actual Interstrip Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>RGXD1F</td>
<td>4</td>
<td>00-00</td>
<td></td>
<td>31</td>
<td>150</td>
<td>104 (150V)</td>
<td></td>
</tr>
<tr>
<td>RGXD2T</td>
<td>2</td>
<td>90-78 &amp; 90-315</td>
<td>ERASER$^1$</td>
<td>.4</td>
<td>131</td>
<td>110(100V) 106(150V)</td>
<td>0/97 0/206 0/252</td>
</tr>
<tr>
<td>GXD3F &amp; RGXD3F</td>
<td>4</td>
<td>90-78</td>
<td></td>
<td>5</td>
<td>142</td>
<td>115 (50V) 90 (300V)</td>
<td></td>
</tr>
<tr>
<td>RGXD4F-200</td>
<td>4</td>
<td>0-0 &amp; 90-78</td>
<td>200 ps electrical</td>
<td>11</td>
<td>137</td>
<td>100 (100V)</td>
<td></td>
</tr>
<tr>
<td>RGXD4F-600 extended integration</td>
<td>4</td>
<td>0-0 &amp; 90-78</td>
<td>600 ps electrical</td>
<td>176 $(16x$of $-200$ config)</td>
<td>139</td>
<td>228 (100V)</td>
<td></td>
</tr>
</tbody>
</table>

**RGXD4** - Door Added to allow Pulse Forming modules to be changed in field in R configuration

1 Early Radiation Artifact Suppression Electrode Rig, see slide 4
2 Relative gains are extrapolated to 100V and compared to HGXD1 strip2 with average CCD counts/ CCD pixel compared to PDS film exposure counts / scan pixels

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J.P. Holder, L. R. Benedetti & the framing camera team
## Current HGXDs

<table>
<thead>
<tr>
<th>Camera</th>
<th># Strips</th>
<th>DIM</th>
<th>Add’l INFO</th>
<th>Gain Rel</th>
<th>Pulse Vel (mm/ns)</th>
<th>Gate width (ps)@ (bias V)</th>
<th>Actual Interstrip Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>HGXD1T</td>
<td>2</td>
<td>0-0 &amp; 90-78</td>
<td>ERASER(^1) reduced phosphor(^4) <strong>1800V</strong></td>
<td>0.8*</td>
<td>154</td>
<td>106 (50V) 95 (150V)</td>
<td></td>
</tr>
<tr>
<td>HGXD2F</td>
<td>4</td>
<td>90-78</td>
<td>ERASER; New head &amp; PFM design; phosphor at 1800V setting</td>
<td>2</td>
<td>132</td>
<td>~92(50V)/~82(200V)</td>
<td>0/250/514/743@200V</td>
</tr>
<tr>
<td>HGXD3T</td>
<td>2</td>
<td>TBD</td>
<td>ERASER Run w/ phosphor at 1800V setting</td>
<td>~0.8</td>
<td>137</td>
<td>~105(50V)/94(150V)</td>
<td>0/248</td>
</tr>
<tr>
<td>HGXD6F</td>
<td>4</td>
<td>90-78</td>
<td>ERASER; New head &amp; PFM design; phosphor at 1800V setting</td>
<td>2</td>
<td>135</td>
<td>~80(50V)/~72(250V)</td>
<td></td>
</tr>
</tbody>
</table>

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\( ^{1}\)HGXD3T pulser replaced (March 2015), Head(MCP/Phosphor) and PFMs nominally the same. Timing expected to change (next use unscheduled, expect ± 200 ps certainty). Similar sensitivity to previous build expected.

\( ^{2}\)HGXD6F is four strip framing camera first used in April using new taper transformer drive head design

\( ^{3}\)HGXD2F was rebuilt Aug 2015 to be like HGXD6, new MCP, new timings and sensitivity

1 Early Radiation Artifact Suppression Electrode Rig, see slide 4

2 Relative gains/sensitivity are extrapolated to 100V and compared to HGXD1T strip2 with 2300V phosphor setting

3 All HGXDs are “R” or “vertical” orientation for film recovery

- *Strip 1 on HGXD1T 20-30% less sensitive than Strip2(check flat field for specific delays/bias)

4. Engineering decision, Aug 2015, to reduce phosphor pulser charge voltage to 1800V *on all HGXDs* (~7kV to imager)

HGXD4 and HGXD5 for pulsers currently being rebuilt
Relative Gain & Saturation Values

- 1 on the graph means: 1 percent saturated per TW when MCP is 1280 mm from TCC
- I extrapolated saturation values to 100V using 3x/50 Volts as the gain factor
- Dashes are 3x/50V guidelines
- GXD1 may have changed (reduced) sensitivity sometime in 2012

Saturation levels are uncertain
Framing Camera Operational Issues

• GXDs: strip 1 must be first
  – Bias voltage minimum = 60V (no alarms)
  – Bias voltages can be set in increments of 10 V –
    • prefer users use 60,100,150,200,250V etc to “lump” calibration and FF efforts
  – Maximum interstrip delay = 50 ns, in units of 25 ps

• HGXD1 has higher gain on strip 2 due to cross talk (gain variation reduced after 1/2015 reclamp)

• HGXDs
  – Strip 1 is not required to be first
    • Need to verify/calculate timing requests with TDOs/RSs –
      – most NIF software does not account for strip1 delay
  – Bias voltage minimum = 50V
  – Bias voltages can be set in increments of 50V
  – Maximum interstrip delay = 10.4 ns, in units of 25 ps
  (10400 ps)

• HGXD2F rebuilt head after October 2015 has relatively slow strips fed by tapered transformers
  – Do not operate with interstrip timing < 250 ps
  – Observed delays with 0/250/500/750 settings 0/250/514/743@ 200V
  – Strip length on film ~35mm/(0.132 mm /ps) = ~265 ps

• HGXD6F has relatively slow strips fed by tapered transformers
  – showed strong cross talk effects in calibration at 0/200/400/600 set
    • observed (1/3.8/3.2/2.4 x) with measured delays 0/189/402/590
  – Do not operate with interstrip timing < 250 ps
ERASER mitigates the effect of early x-rays

ERASER | Early Radiation Artifact Suppression Electrode Rig

ERASER suppresses artifacts by attracting electrons before the camera is triggered. High-voltage surface installed ~1cm above framing camera active area (microstrips) Changes E-field to attract electrons that arrive before amplifying voltage

ERASER Schematic

HGXI1 without ERASER

Artifacts due to x-rays that arrive before camera is triggered

HGXD2F with ERASER

No apparent artifacts

Update Jan2014
Estimates at best 20% (normalization), for ~8keV x-rays
Strip to Strip, Droop and dependence on Timing and bias details

Looking to “average correction” produced by FF correction (looking at check graphs produced by Shahab) I
Get that HGXD2 (sequential) is 0.825 of HGXD6F (Con A timing) on average…but looks like strip to strip variations with particular timing larger