Hard radiation from long spark discharges

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• Experimental setup
• Results measurements
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  • Negative polarity discharges
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Motivation

- Satellite detection of TGF’s
- X-ray from lightning
- X-ray from long laboratory spark discharges
- X-ray from diffuse discharges

What is the mechanism behind this high energy process?
Experimental setup

- 12 stage 2.4MV Marx generator
- properly shielded instruments
- 8m distance from Marx generator
- measurement of electrical properties in combination with energetic photons
Schematic of experimental setup
X-ray detector properties (662keV)

<table>
<thead>
<tr>
<th></th>
<th>NaI(Tl)</th>
<th>LaBr₃(Ce)</th>
<th>BaF₂</th>
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</thead>
<tbody>
<tr>
<td>a) # Photons/keV</td>
<td>38</td>
<td>63</td>
<td>1.8</td>
</tr>
<tr>
<td>b) Rise/fall [ns]</td>
<td>40/230</td>
<td>11/23</td>
<td>–</td>
</tr>
<tr>
<td>c) FWHM [ns]</td>
<td>270</td>
<td>38</td>
<td>4</td>
</tr>
</tbody>
</table>

LaBr₃(Ce) response to $^{137}$Cs

- 2.5% energy spectrum for 662keV photon (FWHM)
- 165% photoelectron yield with respect to NaI(Tl)
- good energy resolution
Difference between CZT- and scintillation detectors

• CZT-detectors converts photon or electron energies to number of electron-hole pairs. → possible to discreet photon or electron energies

• Scintillation detectors converts photon or electron energies to visible light. → no difference in electron or photon detection!
Results measurements

Positive discharges

86cm, point-point electrodes

$V_{\text{Gap}}$ [MV]
$I_{\text{GND}}$ [500A]
$I_{\text{HV}}$ [500A]
$LaBr_3$ [MeV]

$980$ kV
$6.5$ kA

$400$ keV

X-ray burst correlated with initialization of negative leader, near cathode
Negative discharges

- More complicated process
- X-ray burst at initialization negative streamer/leader and stepping?
Larger electrode distance
Conclusions

- Only X-ray bursts during streamer/leader development
- Strong correlation with negative streamers/leader
- Positive HV polarity
  - near cathode
  - X-rays in 45% of discharges
- Negative HV polarity
  - near cathode and possibly during stepping
  - X-rays in 75% of discharges
  - More intense X-ray bursts (pile-up)
  - High-energetic electrons cannot be ruled out!
- Photon energies up to several 100keV
- Bremsstrahlung process
Thank You!