GEANT4 Simulation of background radiation study for APEX

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- Simulated Real Compton Scattering experiment
- Study how dose rates differ within HRS electronics area
Real Compton Scattering (RCS)

- **Target**: 0.81 mm thick Copper radiator
  15 cm LH$_2$ target
- **Beam**: 3.481 GeV
- **Left HRS**: positioned at 19.47°
RCS experiment

- **Target:** 0.81 mm thick Copper radiator
  15 LH2 target
- **Beam:** 3.481 GeV
- **Left HRS:** positioned at 19.47°
- No photon arm.

Extension box and Septum magnet are removed. A pipe with Aluminum walls is put in place.
Origins of particles entering Upstream detector, 6% Cu, 15 cm LH₂

Origins of n entering Upstream detector

Origins of n entering Left HRS electronics area

A

B

C

D
# RCS Radiation Evaluation Results

<table>
<thead>
<tr>
<th>RCS E, Current GeV, μA</th>
<th>Target $X_0$, t % r.l, mg/cm²</th>
<th>Dose Rates: Upstream Detector (rem/h)</th>
<th>Dose Rates: Left HRS electronics area detector (rem/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.481 GeV, 100 μA</td>
<td>Cu radiator 6% r.l. $LH_2$ target 15 cm</td>
<td>$e$: under study $\gamma$: 1.08 $n$: 1.10</td>
<td>$e$: under study $\gamma$: 3.62 $n$: 0.98</td>
</tr>
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# APEX and RCS Radiation

<table>
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<tr>
<th>APEX E, Current GeV, μA</th>
<th>Target X₀, t % r.l, mg/cm²</th>
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<th>Dose Rates: Left HRS electronics area detector (rem/h)</th>
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<tr>
<td>1.1 GeV, 100 μA</td>
<td>Carbon 0.7 % r.l. 298.9 mg/cm²</td>
<td>e: under study γ: 0.12 n: 0.20</td>
<td>e: under study γ: 0.53 n: 0.11</td>
</tr>
<tr>
<td>2.2 GeV, 100 μA</td>
<td>Tungsten 4.0 % r.l. 270.4 mg/cm²</td>
<td>e: under study γ: 0.34 n: 0.82</td>
<td>e: under study γ: 1.88 n: 0.41</td>
</tr>
<tr>
<td>3.3 GeV, 100 μA</td>
<td>Tungsten 8.0 % r.l. 540.8 mg/cm²</td>
<td>e: under study γ: 0.76 n: 1.77</td>
<td>e: under study γ: 4.11 n: 0.97</td>
</tr>
<tr>
<td>4.4 GeV, 100 μA</td>
<td>Tungsten 8.0 % r.l. 540.8 mg/cm²</td>
<td>e: under study γ: 0.65 n: 1.57</td>
<td>e: under study γ: 2.93 n: 0.72</td>
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**RCS – Real Compton Scattering**

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</table>
Comparison of upstream detector dose rates

Neutron dose rates produced from APEX $<$ Neutron dose rates produced from PREX. Good

factor of 3.5 less

Neutron dose rates produced from APEX $>$ Neutron dose rates produced from RCS. Need additional shielding

factor of 1.6 higher
My result with roughly a factor of 2.5 higher.

RCS - Feb. 2002: $E_{e^-} = 3.48$ GeV

Dose Rate (mR/hr) @100 µA

Target thickness = 637 mg/cm² (Cu) + 1040 mg/cm² (H)

Average Dose Rate = 440 mR/hr at 100 µA

J. Boyce, 2011
PREX – June 2010: $E_{e^-} = 1.06$ GeV

My result with roughly a factor of 3 higher.

Target thickness = 637 mg/cm$^2$ (Pb)

Average Dose Rate = 2080 mR/hr at 100 μA
APEX (test) – July 2010: $E_{e^-} = 2.26$ GeV

J. Boyce, 2011

My result with roughly a factor of 2 higher.

Target thickness = 22 mg/cm$^2$ (Ta)
Average Dose Rate = 24 mR/hr at 100 $\mu$A
HRS electronics area detector assembly

10 blocks in x direction

10 blocks in x direction

Z Layer 1

Z Layer 2

Z Layer 3
Neutron Dose rate in HRS electronics area

Neutron Dose Rate (in layer 1 in z direction)

- Closer to Beam line
- 4% rad length W target
- 2.2 GeV beam energy
Neutron Dose rate in HRS electronics area

Neutron Dose Rate (in layer 2 in z direction)

Closer to Beam line

4% rad length W target
2.2 GeV beam energy
Neutron Dose rate in HRS electronics area

**Neutron Dose Rate (in layer 3 in z direction)**

- Neutron dose rate (mrem/hr) normalized to 100 µA
- Located closer to the beam line
- 4% rad length W target
- 2.2 GeV beam energy
Neutron Dose rate in HRS electronics area

Closer to Beam line

4% rad length W target
2.2 GeV beam energy