Single Event Radiation Testing of LTC2449 24-Bit ADC and LTC6241 OpAmp from Linear Technology

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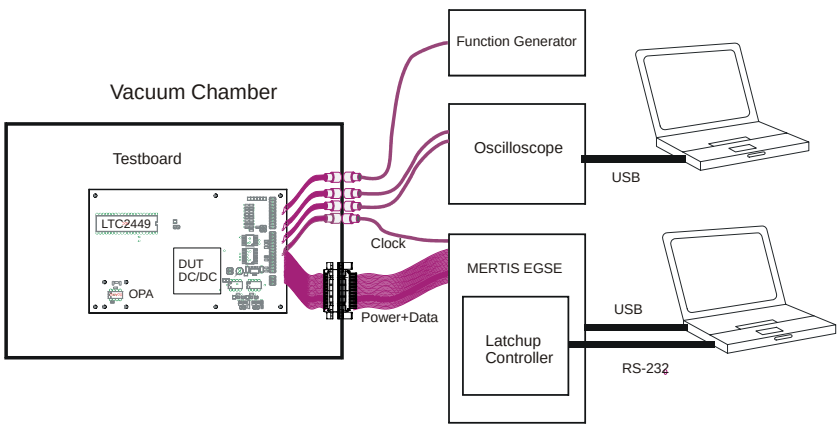
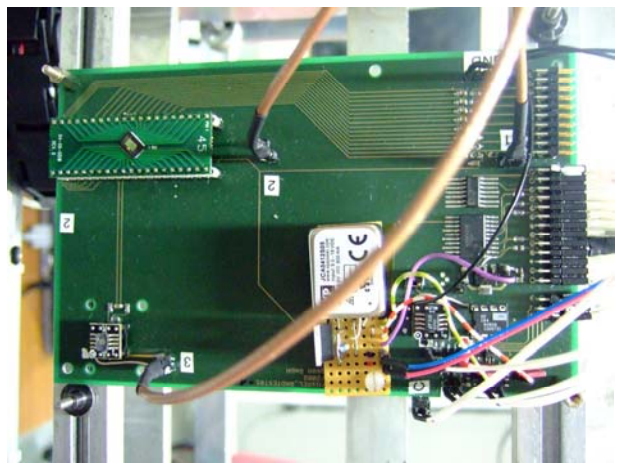
Introduction:

- High resolution ADC required for MERTIS-Radiometer on BepiColombo
  - 2x15 Pixel thermopile line array (R_s=25 kOhms)
  - noise less than 50 nV required for NETD<1K@100 K object temperature (t_{int}< 100 ms)
- Bepicolombo requirements (EID-A)
  - Parts with LET threshold larger 70 MeV cm^2 mg^{-1} considered as latch-up insensitive
  - Parts with LET threshold less than 3.7 MeV cm^2 mg^{-1} shall not be used
- LTC2449 best candidate
  - 24-Bit Sigma-Delta ADC with integrated 8-Channel differential MUX and 8 kSamples/s
  - MUXOUT/ADCIN terminals for separate Buffer/Gain stage
    - Gain required for MERTIS-RAD
    - External AMP inside ADC calibration loop (Chopper input)
  - Plans at Linear Technology for space qualification (=> RH2449)
    - **Succesful TID test to 200 kRad**

Test Setup:

- Test board design
  - enlarged variant of one MERTIS Radiometer channel
  - 1 LTC2449 MUX/ADC + 1 Diff-Amp with G=40 (LTC6241)
  - Parts opened by jet etching
  - Latchup detection circuitry for each DUT
  - MUX inputs shortened by 25 kOhms resistors (except 1 for external stimulus)
- Controlled by MERTIS-EGSE + external Latchup controller





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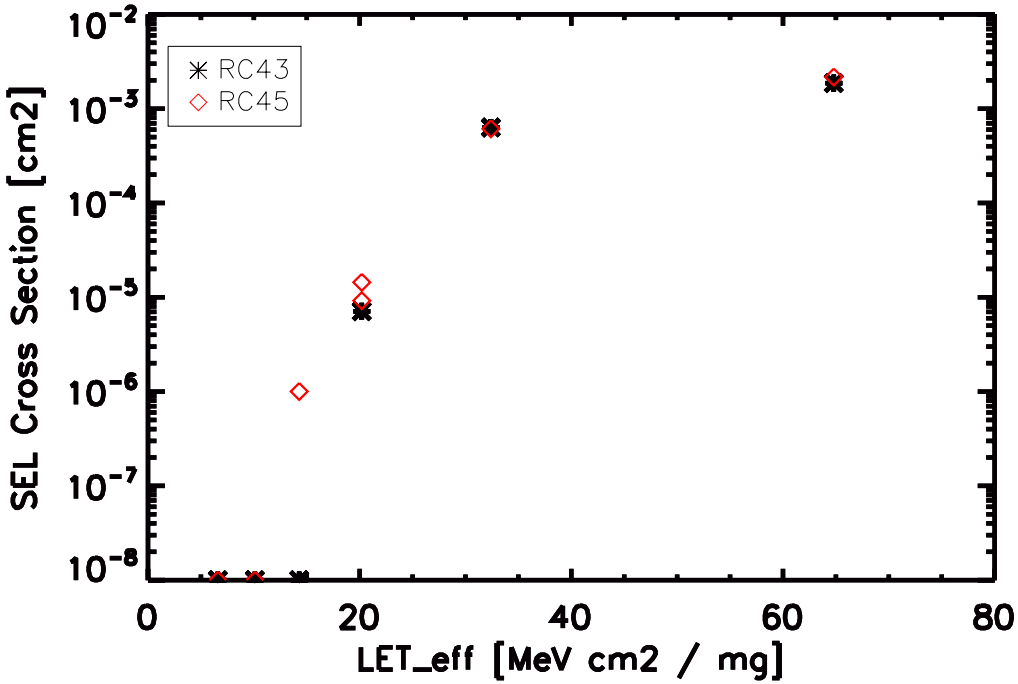
Test Execution:

- Test conducted on 13th Oct 2008 at HIF (Brussels) using Ion Cocktail 2
  - Deep penetration cocktail with range between 90 µm and 200 µm
  - Neon^{7+} , Ar^{12+} , Kr^{25+}
  - Device tilting used to increase LET_{eff} for given ion
  - LET_{eff} range **3.3-64.8 MeV cm^2 mg^{-1}** covered in 7 steps
  - Fluence between 2.5 10^4 to 10^6 cm^{-2}
  - 2 samples of LTC2449 and 1 sample of LTC6241 tested

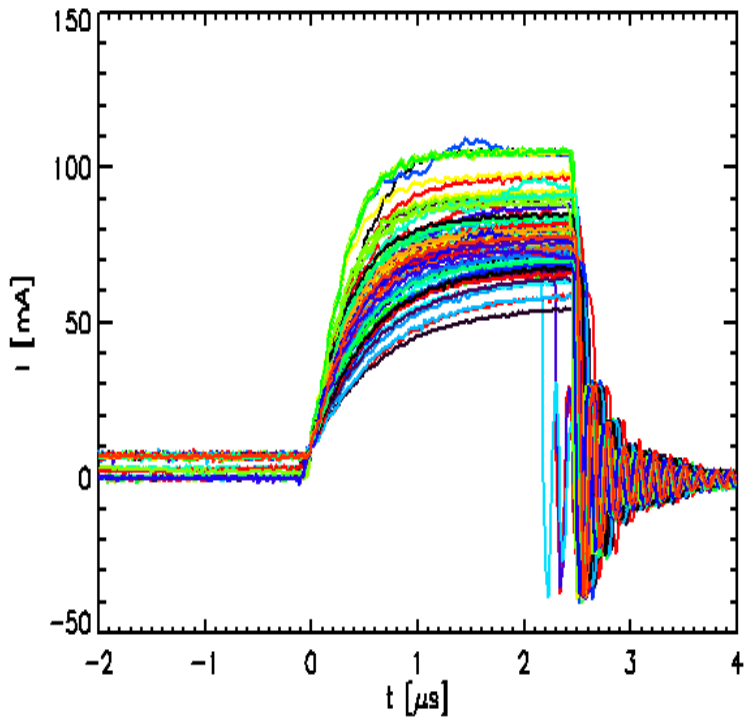
- Operational conditions
  - ADC sampled at 2.78 kHz (highest sampling rate of MERTIS-EGSE)
  - MERTIS-like operational scenario
    - All 8 MUX channels used (taking 192 samples on each channel before switching)
    - Double speed mode (=> 2 data values affected by single event)

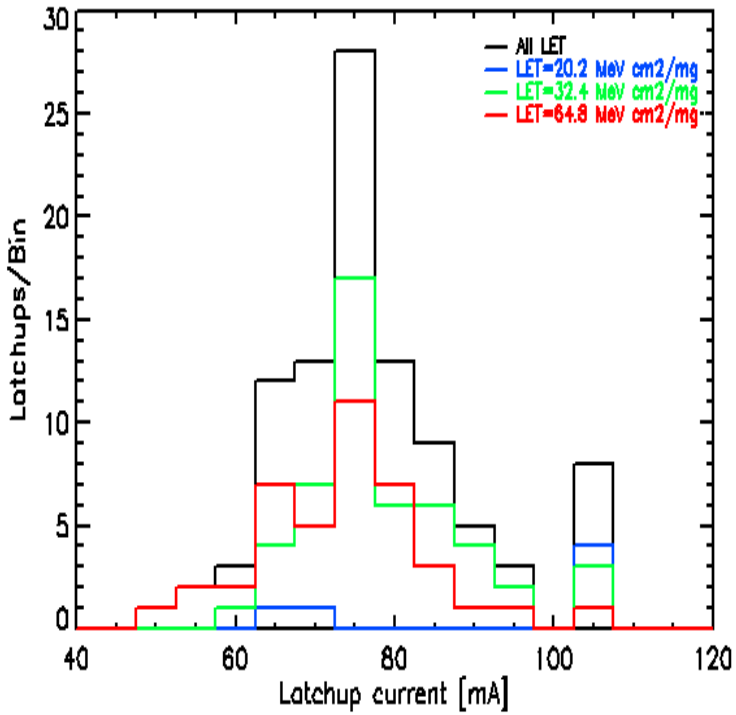
SEL cross section of LTC2449



- Latchup threshold ~ LET_{eff}=14 MeV cm^2 mg^{-1}
- Saturation cross section ~ 2 10^{-3} cm^2/dev

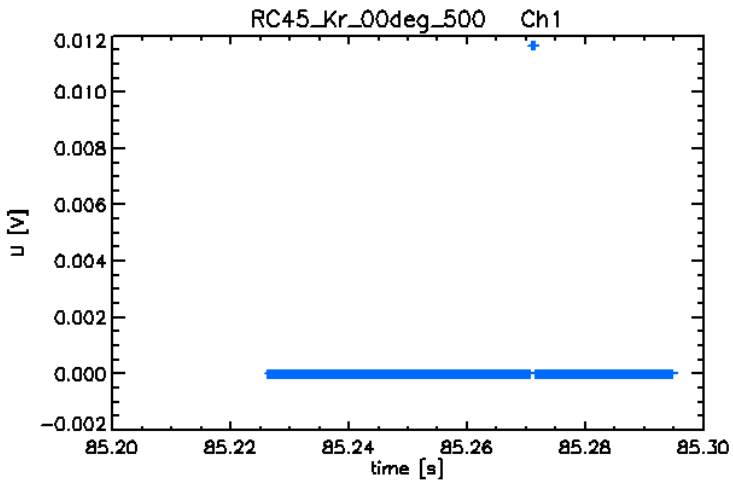
Latch-up Currents of LTC2449



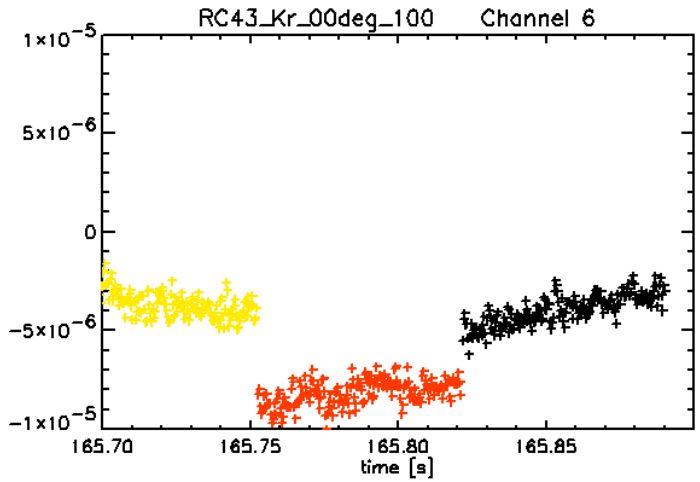


- Latch-up currents between 50 mA and 110 mA (limited to 180 mA by R)
- Latch-up current distribution peaks at 75 mA, second peak at 110 mA
- Latch-up current distribution insensitive to LET

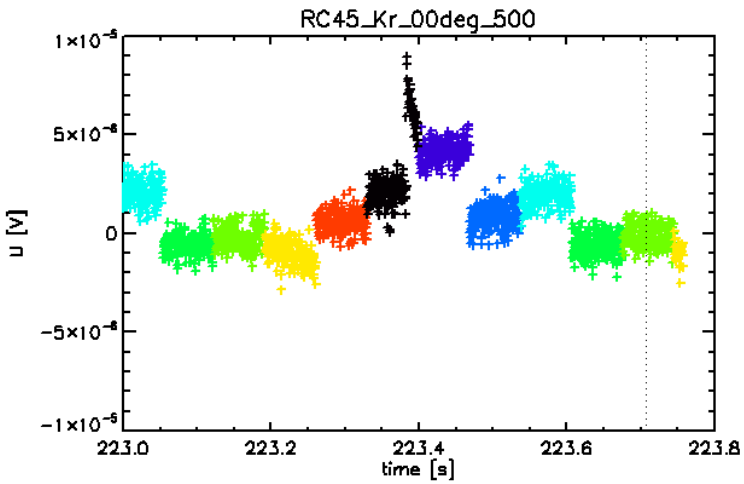
Single Event Soft Error Types of LTC2449



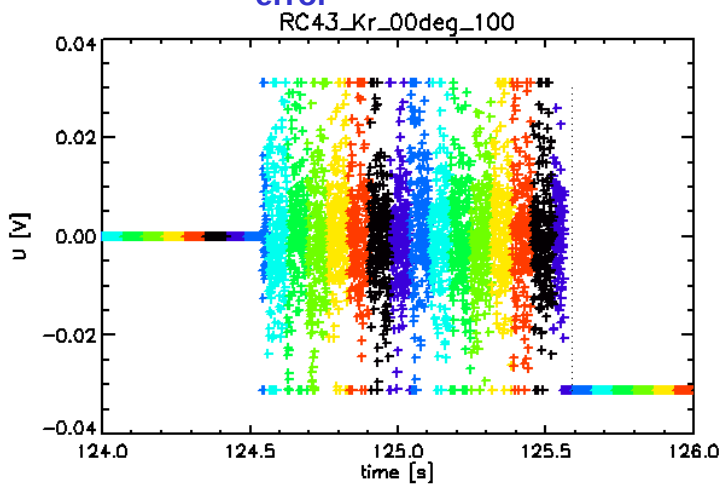
Type 1: SEU (Bit flip)



Type 2: lingering error

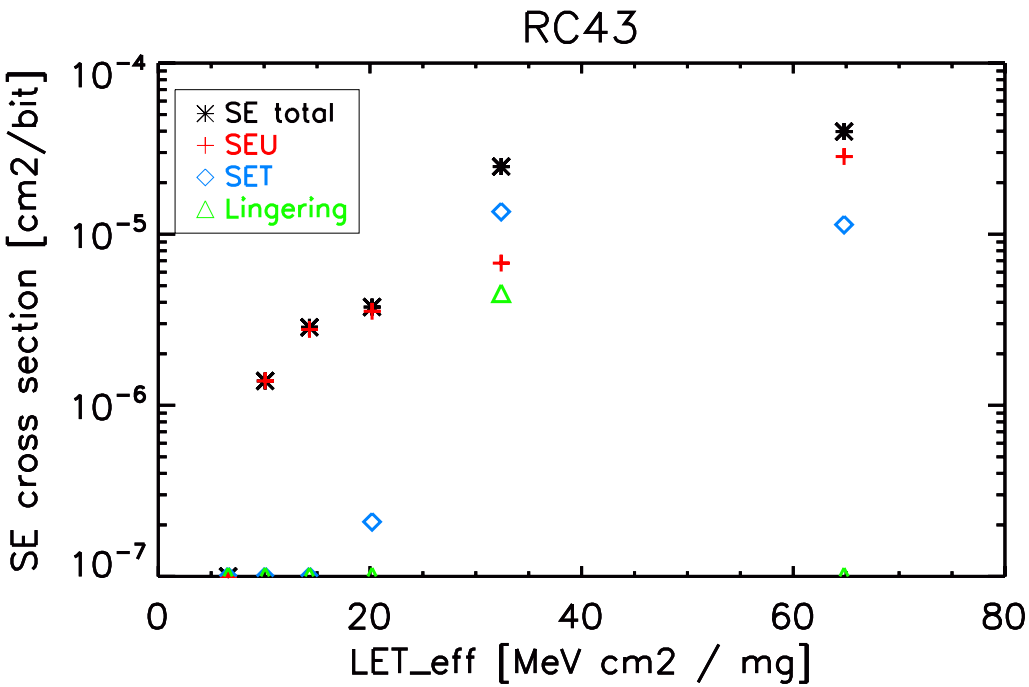


Type 3: transient error



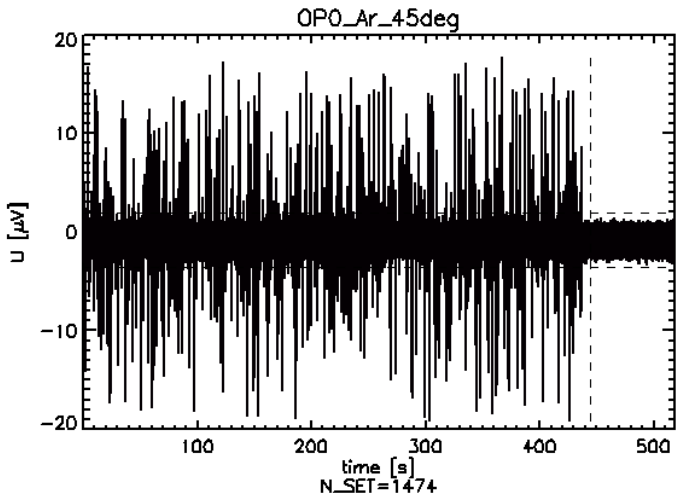
Type 4: SEFI

SE cross section of LTC2449

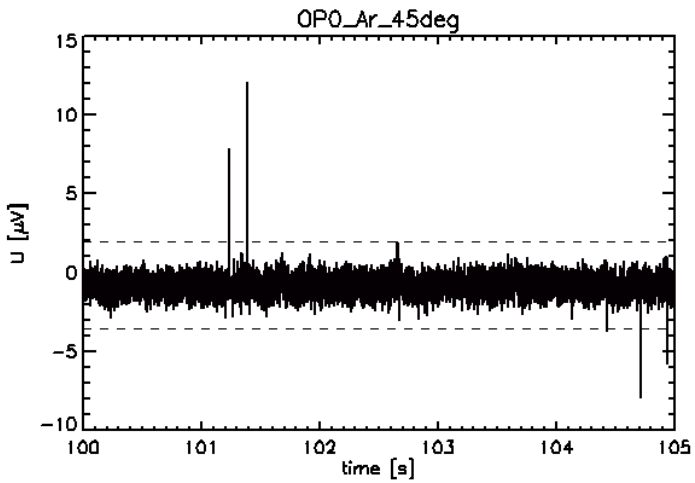


- SEU threshold ~ LET_{eff}=6.6-10 MeV cm^2 mg^{-1}
- Saturation cross section ~ 4 10^{-5} cm^2/bit

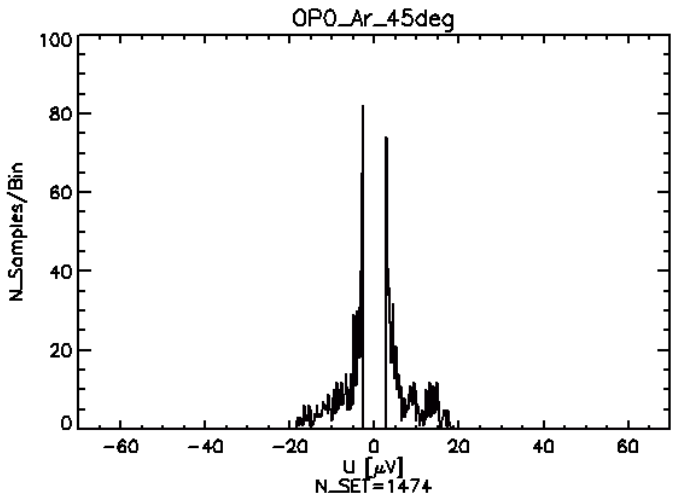
LTC6241 Single Event Transients



Time series at LET_{eff}=14.2 MeV cm^2 mg^{-1}

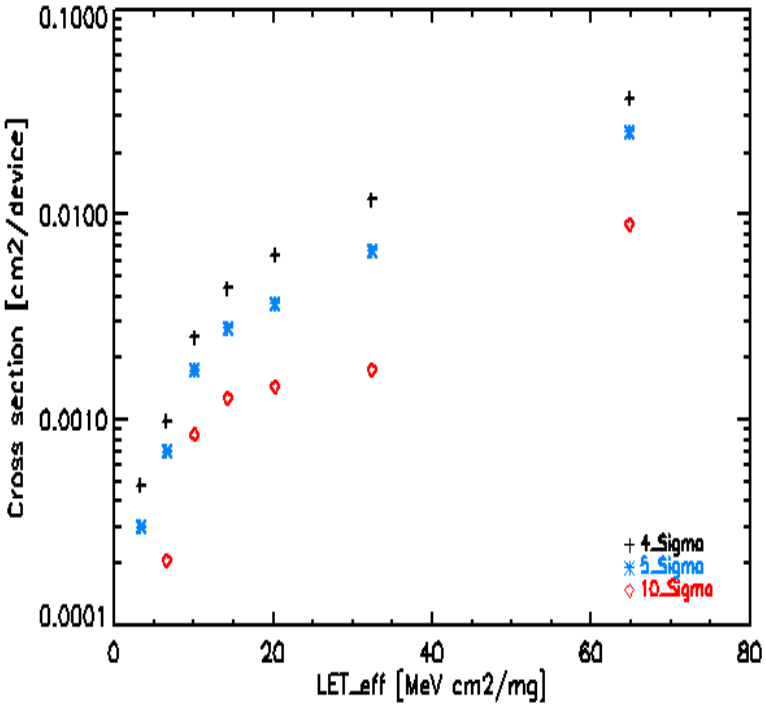


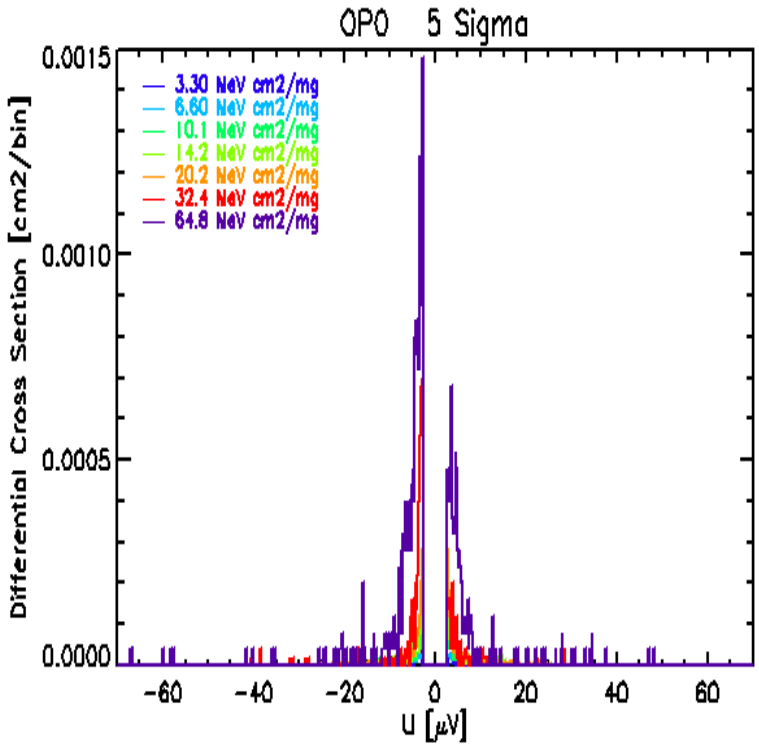
Zoom into plot above



Resulting histogram

SET cross section of LTC6241





- SET's observed over the whole range of LET=3.3-64.8 MeV cm^2 mg^{-1}
- SET amplitudes increase with increasing LET (U_{max}=70 µV)
- SET distribution broadens with increasing LET

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Summary of Results:

- LTC2449 ADC latch-up sensitive for LET_{eff} > 14 MeV cm^2 mg^{-1}
  - CREME-96 predicts ~ 2 SEL for worst week Solar Particle Event at Mercury
  - Latchup protection required (=> no problem for usage in BepiColombo)
- LTC2449 sensitive to SEU for LET_{eff} > 6.6 MeV cm^2 mg^{-1}
- SEFI observed for LET_{eff} > 14 MeV cm^2 mg^{-1}
- LTC6241 OPAMP insensitive to latch-up for LET_{eff} < 65 MeV cm^2 mg^{-1}
- LTC6241 sensitive to SET over full range of tested LET_{eff}
  - rather small amplitudes (mostly a few µV)
  - no problem for usage in BepiColombo (CREME-96)