Shot noise in irradiated sensors

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- L2S 10-10 module with irradiated sensors
  - Total dose is equivalent to 95 inv.fb for L2
    - New depletion voltage 48 V & 62 V (two sensors)
  - Were warm 2 days during assembly
    - Should not change much depletion voltage
    - Since then in the fridge at -9 deg C
    - Warm ~2 more days during measurements
  - All chips bonded to sensors

Shot Noise

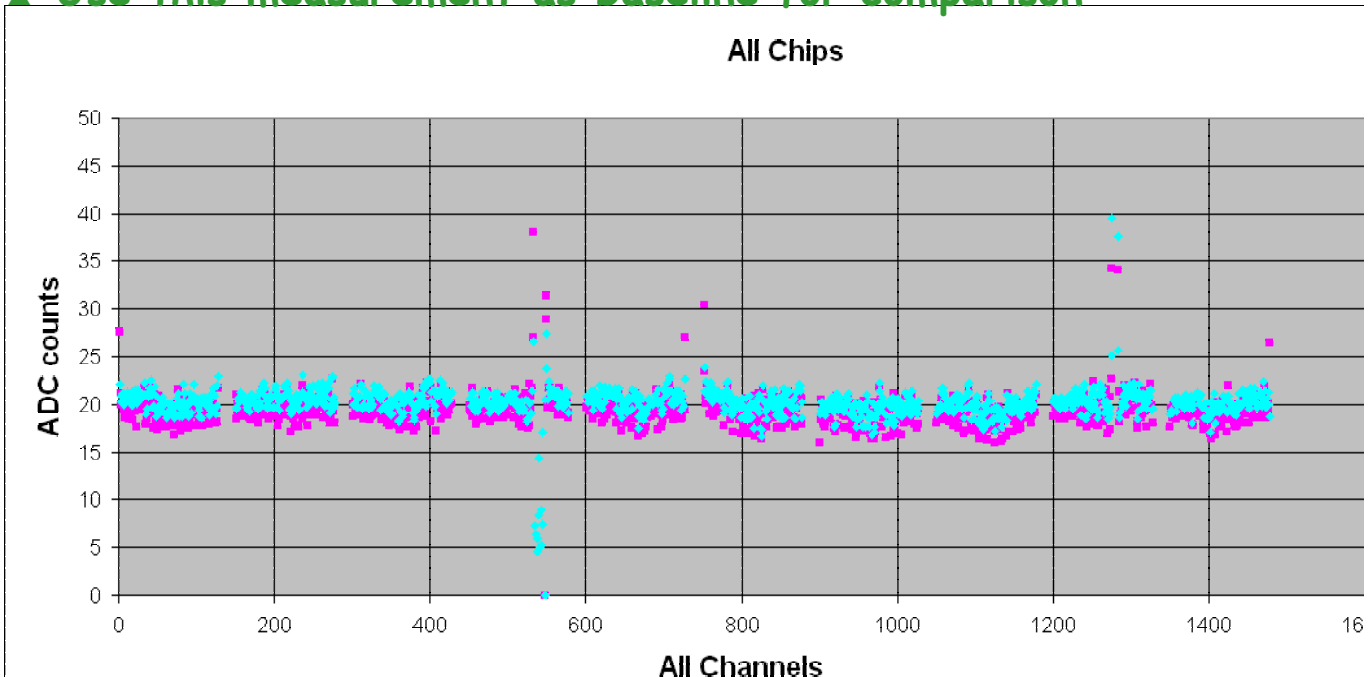
- Caused by fluctuations of leakage current in the detector
  - Note that the sensor is AC coupled to the preamp input
- For integrating preamp with risetime tau, integration time T and double sampling (~ SVX4)

$$Noise[e] = 76 \times \sqrt{I[\mu A]} \times \sqrt{T[ns] + \frac{\tau[ns]}{2}\left(e^{-T/\tau} - e^{-2T/\tau} - 1\right)}$$

  - Time domain calculation following H.Spieler recipes
  - For APV25 (shaping preamp) $Noise[e] = 108 \times \sqrt{I[\mu A]\tau[ns]}$
- Integration time = "low" of acquire clock, currently 108 ns
  - Can be changed from 120 to 60 ns for 132 ns operation
  - Can be switched to 396 ns operation
- Risetime is defined by BW setting and load capacitance
  - For C=10 pF, tau [ns] = 25 + 5 x BW, range 25 – 100 ns
  - For C=40 pF, tau [ns] = 60 + 10 x BW, range 60 – 210 ns

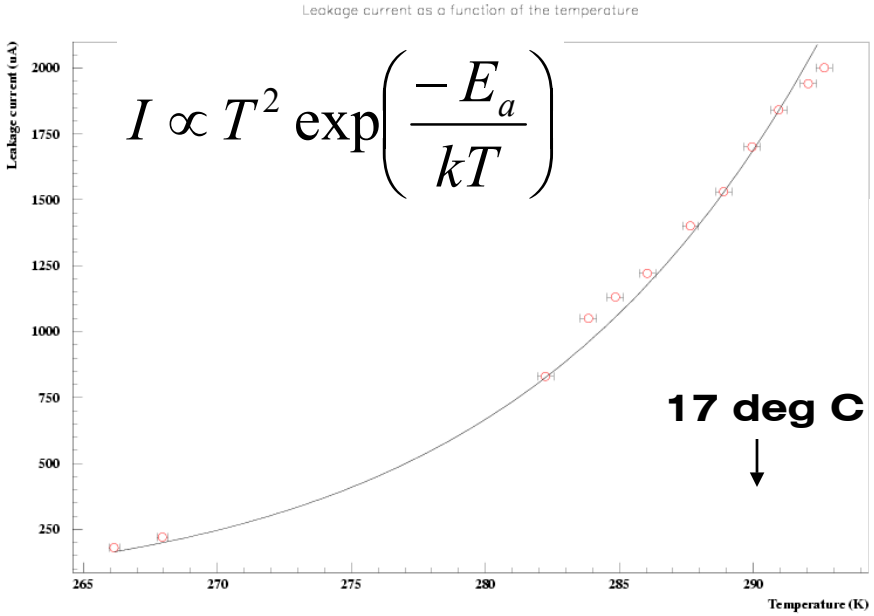
Shot noise measured

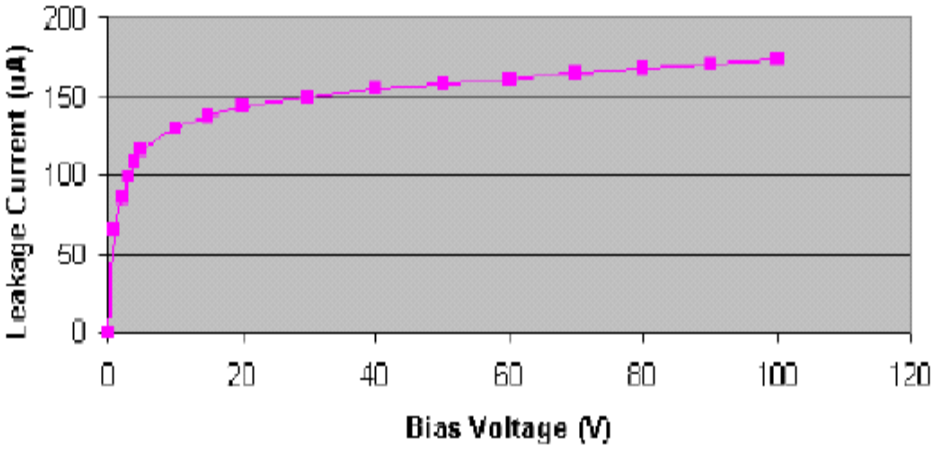
- Noise @ 70 V bias
  - T = -9 degC (away from hybrid), 0 degC at hybrid, I=200 uA
  - ~ same as for non irradiated module
  - noise is uniform (good!)
- Expect ~300 e from shot noise
  - Summed in quadrature with 1400 e for non irradiated module
  - Negligible contribution to total noise
  - Use this measurement as baseline for comparison



Current versus Temperature

- Warmed up the module to increase current
- Current vs. Temperature dependence
  - In agreement with sum of two bare sensors currents at V_depletion
  - In agreement with theory (E_a = 0.6 eV), fit by S.Lager

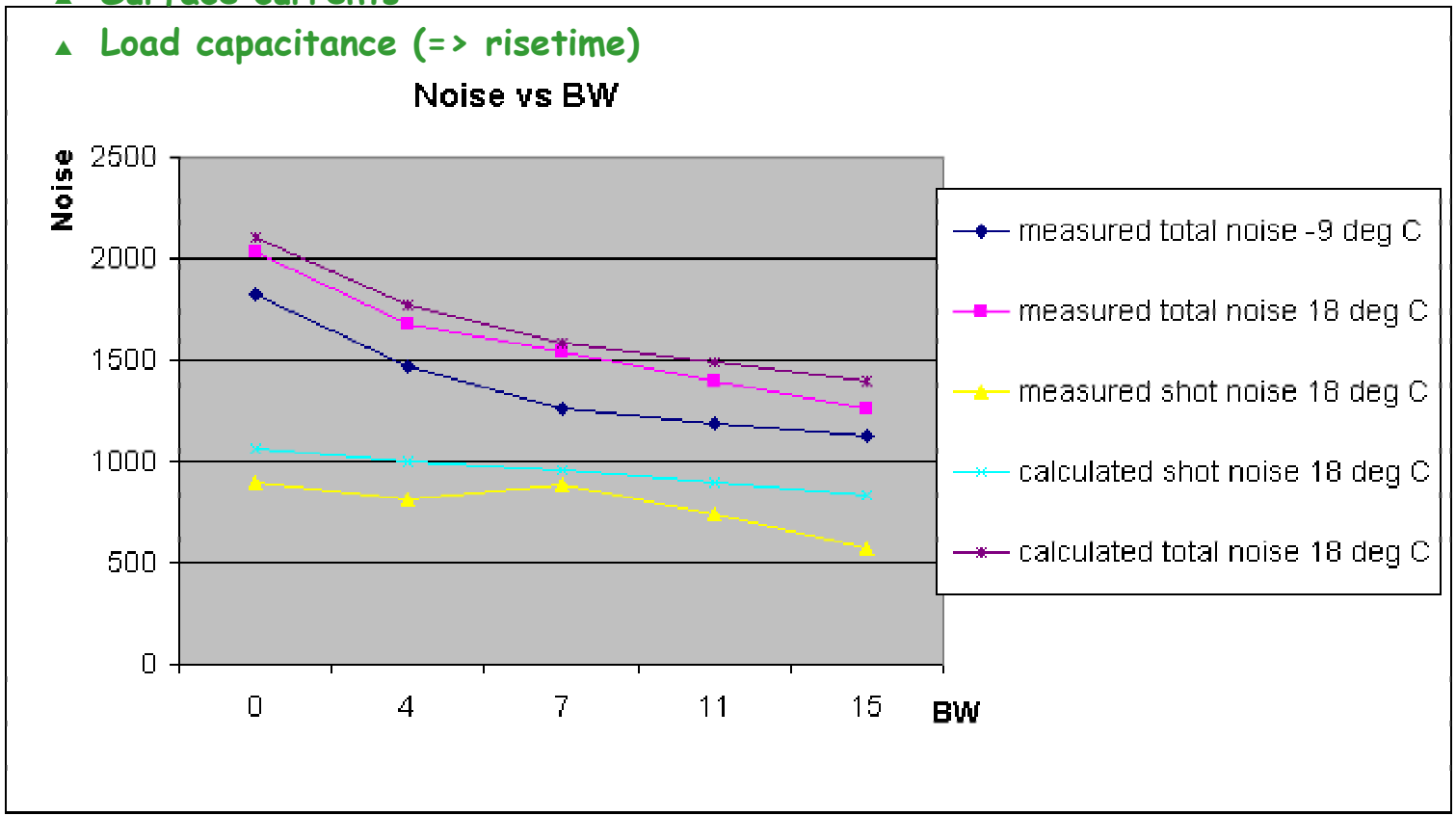




- Current vs. Voltage
  - @ -9 deg C
  - Current is drifting because of operating chips, ~10% error
  - All later measurements @ 70 V

Noise versus BandWidth

- Noise vs. BW for –9 C and +18 C
  - Integration time always 108 ns
  - See reasonable agreement with calculation, correct BW dependence
  - Possible systematics
    - Calibration
    - Surface currents
    - Load capacitance (=> risetime)



Noise versus HV

- Measured noise at 70 V and 210 V
- Nice behavior @ 210 V
- Noise decreased
  - 2.5 -> 2.3 counts
  - Current 2.6 -> 3.2 mA
- Possible explanation
  - Smaller interstrip C for higher bias, known effect for irradiated sensors
  - Need to check non-irradiated sensors