



# Module testing

A.Nomerotski 3/6/2003, Sensor PRR

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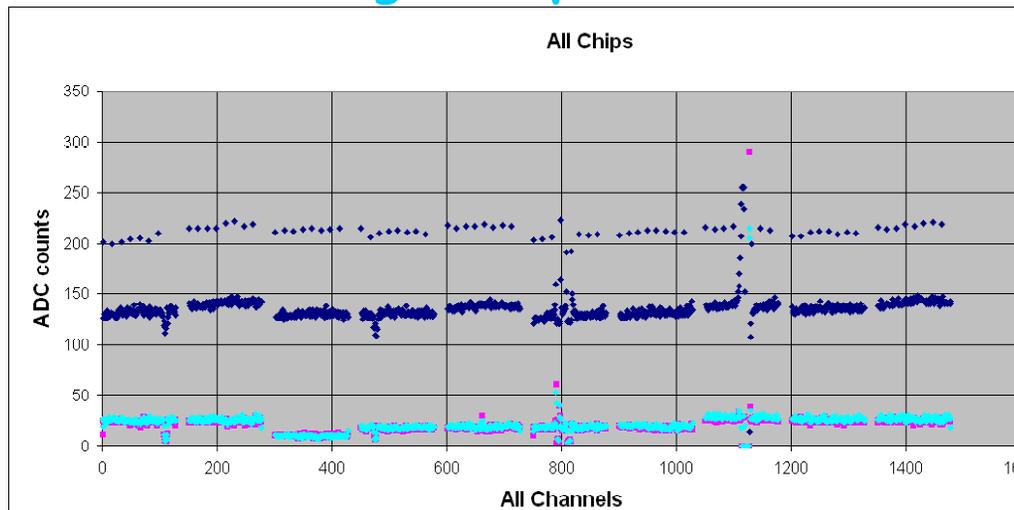
- Status of module production
- Results
  - ◆ Noise performance
  - ◆ Irradiated sensors performance
  - ◆ Pinhole clamping feature of SVX4
  - ◆ Channel-to-channel cross-talk
- Summary



# Status of module production

- L2-5 modules

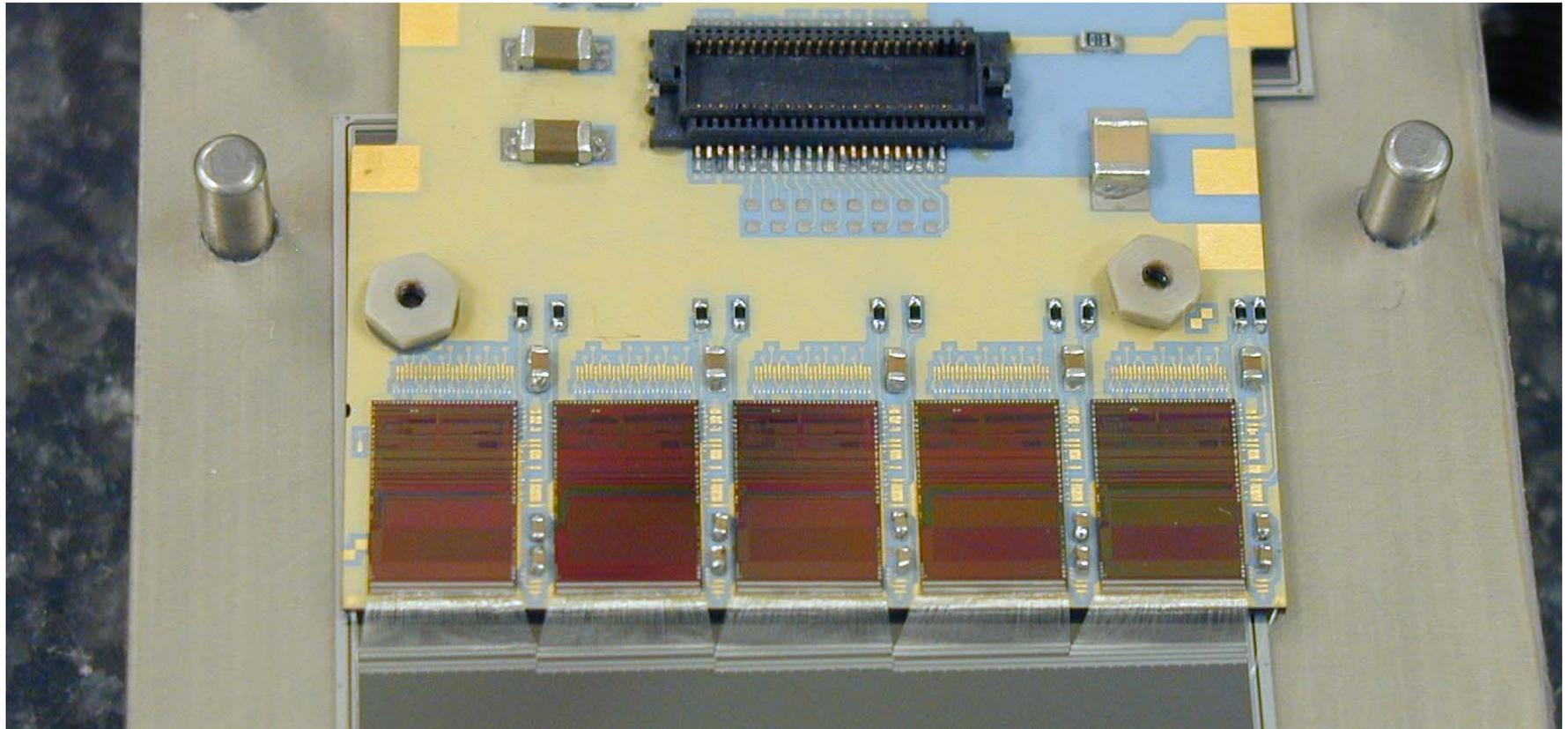
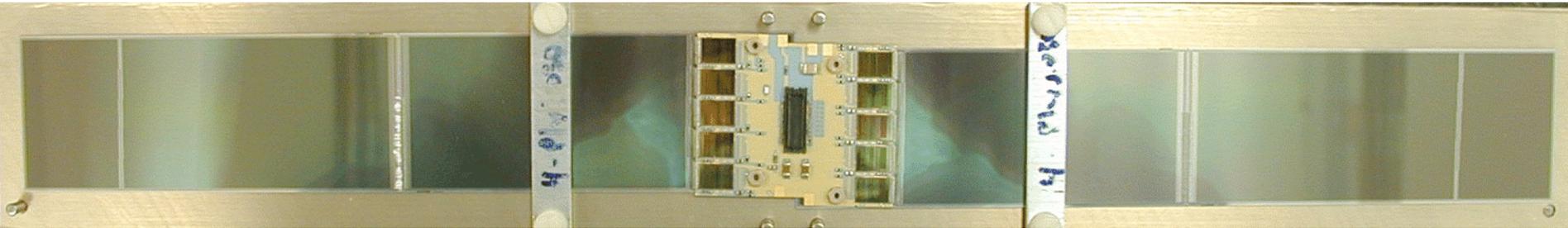
- ◆ Built 4 modules, all use HM sensors
  - ▲ L2 Axial 20-20, uses L2A hybrid from Amitron
  - ▲ L2 Axial 10-10, uses Amitron L2A hybrid and irradiated sensors
  - ▲ L2 Stereo 10-10, L2 Stereo 20-20, use L2S hybrids from CPT
- ◆ 3 modules read out ok, L2S 20-20 has problems
- ◆ Mechanical dimensions of the hybrids and bonding from chips to sensors have been validated for all types of L2-5 modules
  - no changes required



Calinjects for L2A 20-20

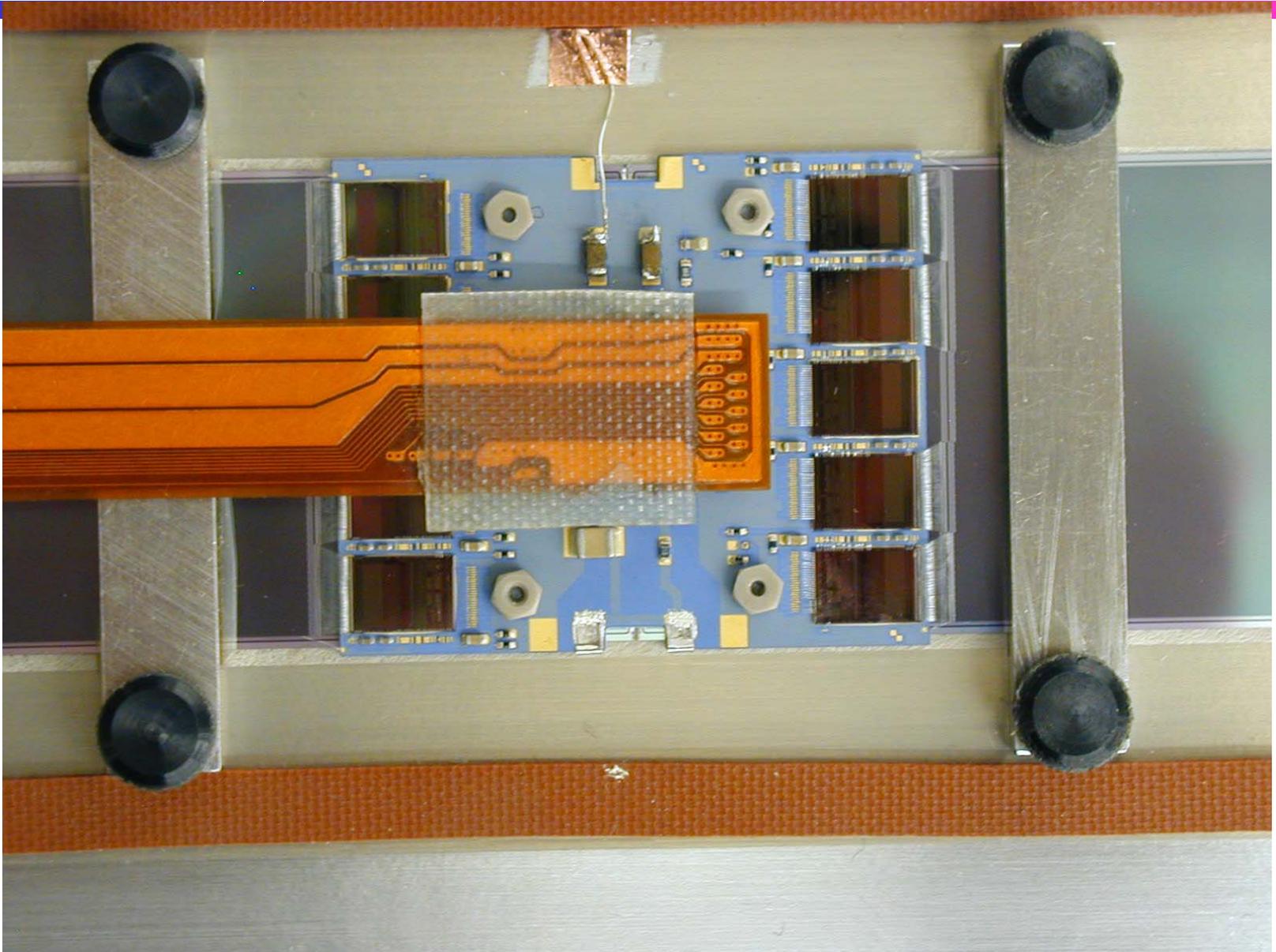


# L2 Stereo 20-20 Module





# L2 Axial 20-20 Module

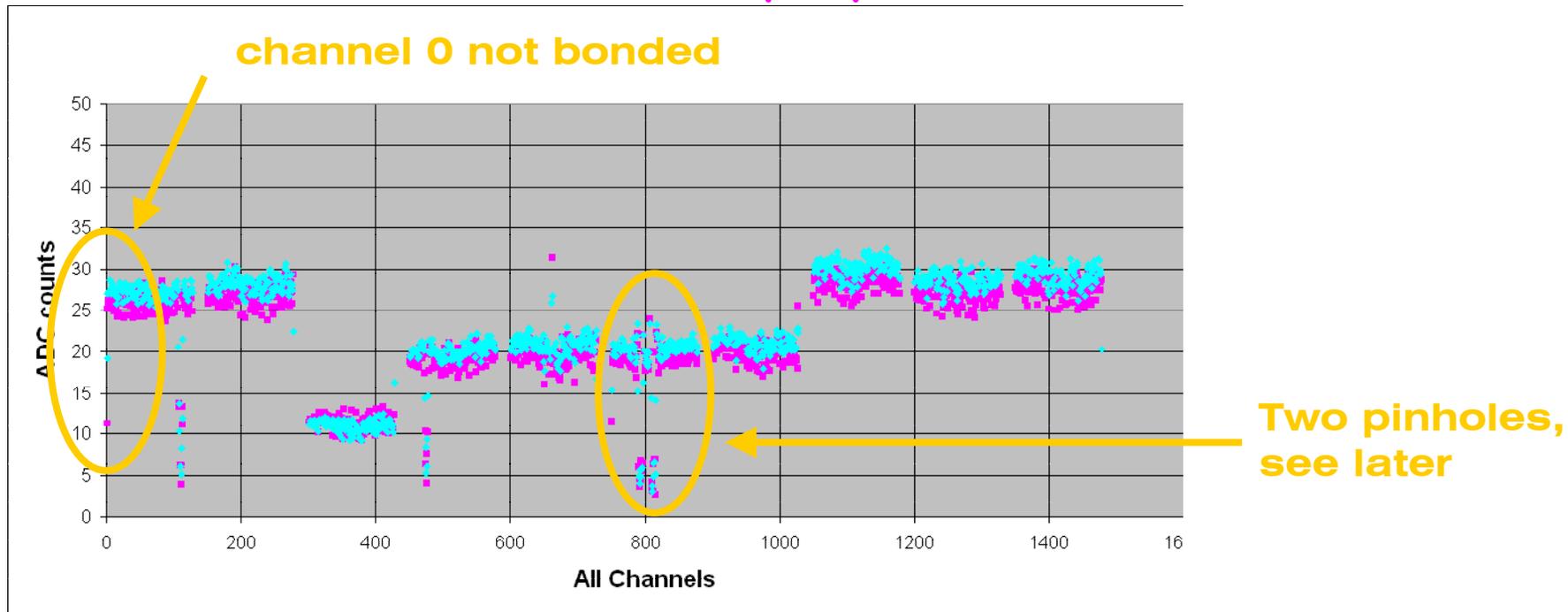




# Noise performance (1)

- L2A 20-20 module

- ◆ 5 chips connected to 20 cm of silicon (## 1,2,8,9,10)
- ◆ 4 chips connected to 10 cm of silicon (## 4,5,6,7)
- ◆ 1 chip left unbonded (# 3)
- ◆ Non irradiated HM sensors fully depleted @ 80 V bias



Differential noise [ADC counts x 10]

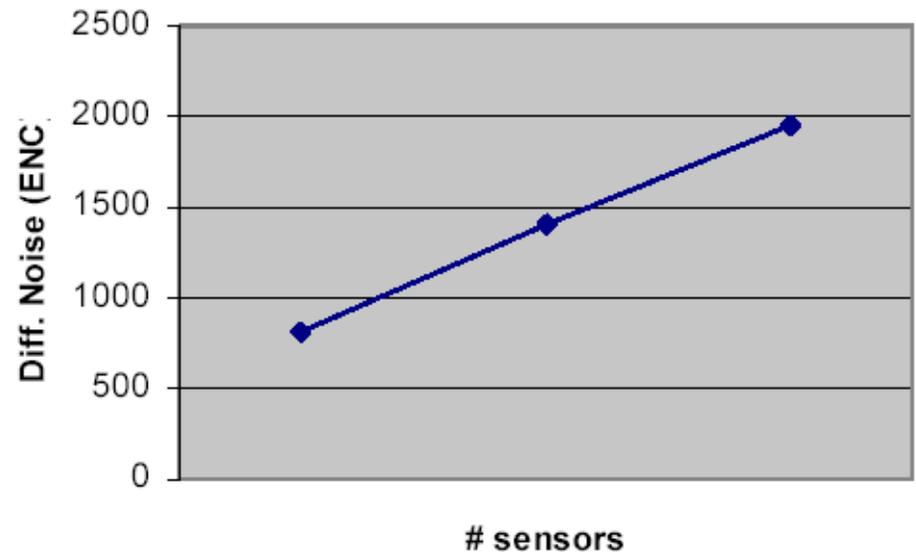
Total noise [ADC counts x 10]



# Noise performance (2)

- Measure  $ENC = 800 e + 600 e / \text{sensor}$
- Expected  $ENC = 500 e + 40 e / \text{pf}$ 
  - ◆ Agrees with measurement assuming
    - ▲ Setup noise of  $600 e$
    - ▲  $1.5 \text{ pf/cm}$  of capacitive load
    - ▲ Negligible contributions from other sources of noise
- Signal/Noise (preliminary)
  - ◆ Assume MIP =  $22000 e$
  - ◆ 20-20 modules  $S/N = 11$ 
    - ▲  $S/N = 12$  in TDR
  - ◆ 10-10 modules  $S/N = 16$

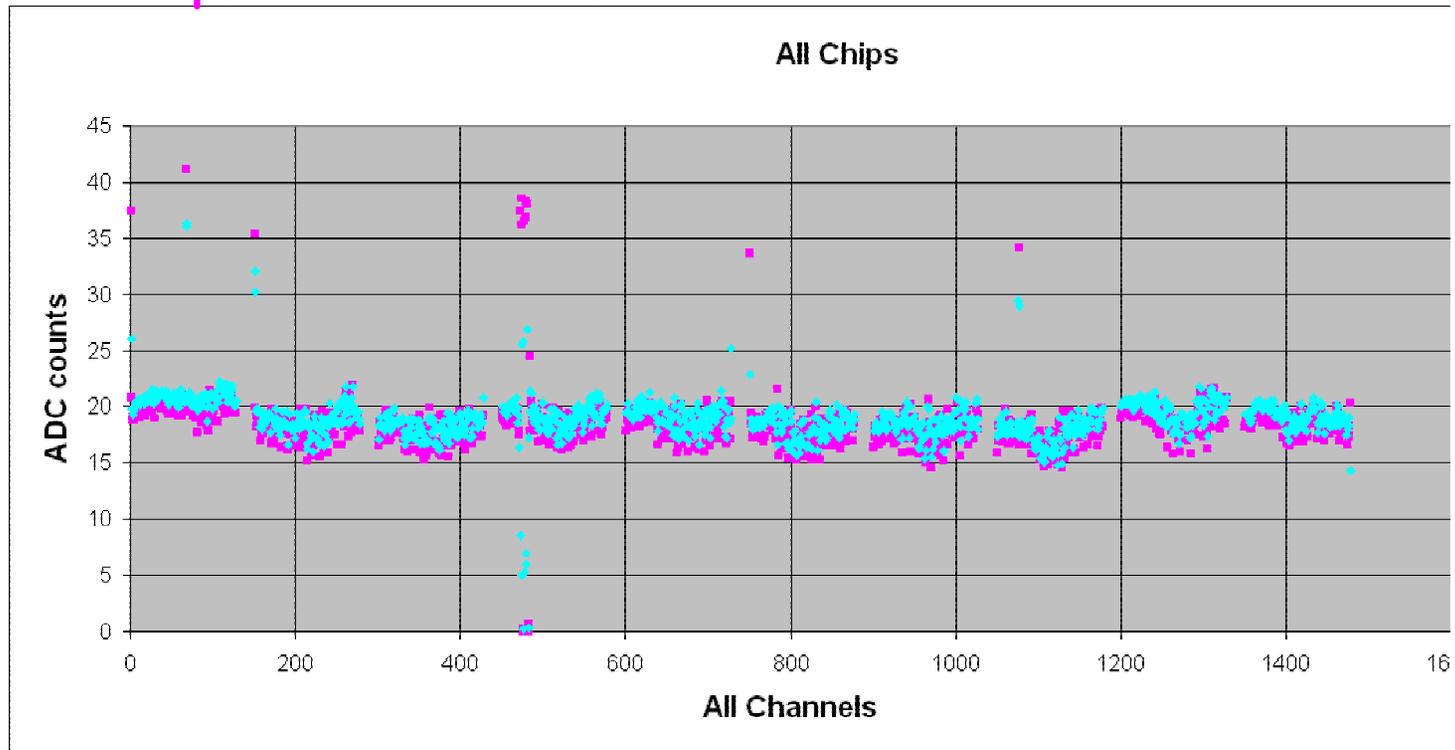
Differential noise vs # sensors





# Noise performance (3)

- L2S 10-10 module
  - ◆ Non irradiated sensors fully depleted @ 80 V bias
  - ◆ All chips bonded to sensor



**Differential noise [ADC counts x 10]**  
**Total noise [ADC counts x 10]**



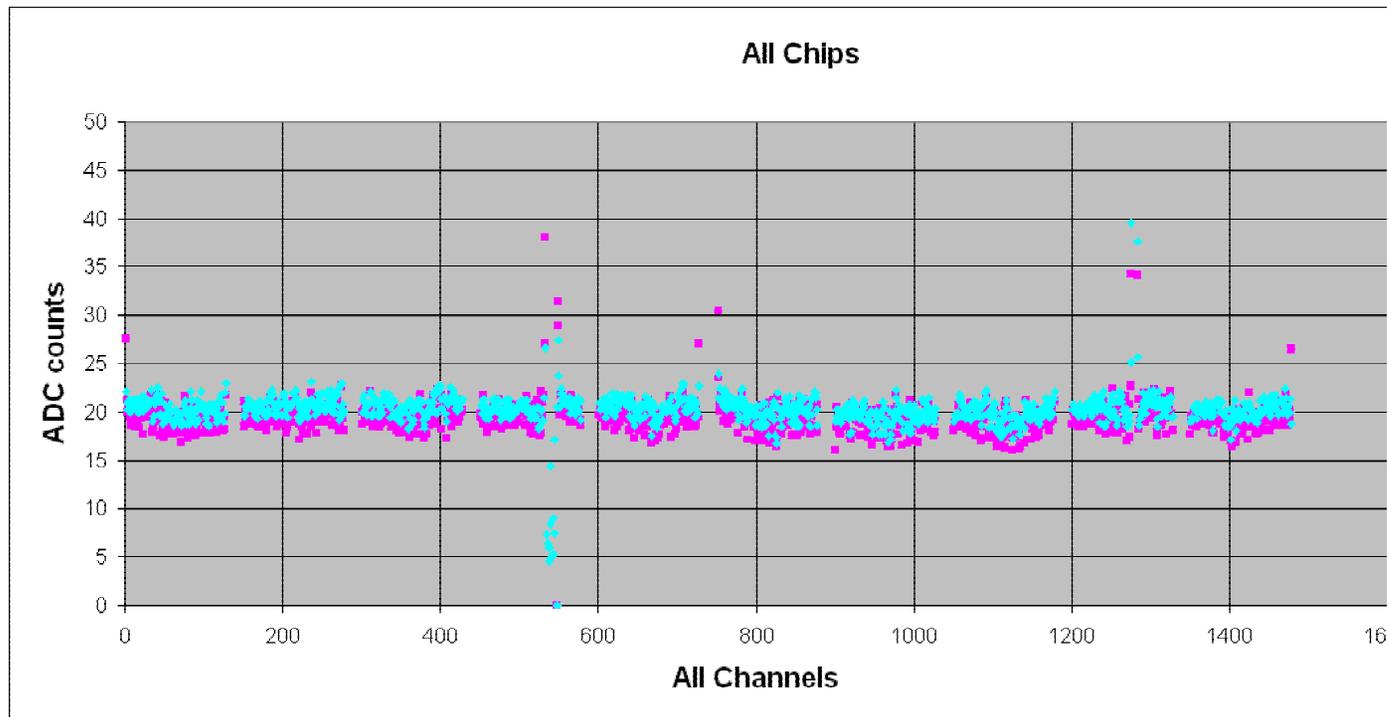
# Irradiated sensors

- Built L2S 10-10 module with irradiated sensors
  - ◆ Total dose equivalent 1.2 E14 n
  - ◆ 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
  - ◆ All chips bonded to sensors



# Irradiated sensors

- ◆ Noise @ 70 V bias ( $T = -9 \text{ degC}$ ,  $I=200 \text{ uA}$ )
  - ▲ ~ same as for non irradiated module
  - ▲ noise is uniform
- ◆ Expect 400 e from shot noise
  - ▲ Compared to 1400 e for non irradiated module
  - ▲ Negligible contribution to total noise

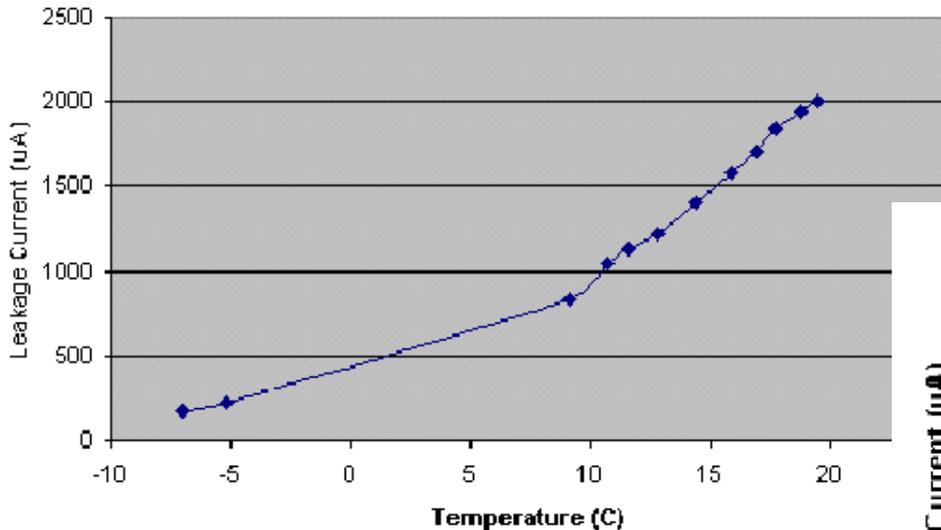




# Irradiated sensors (2)

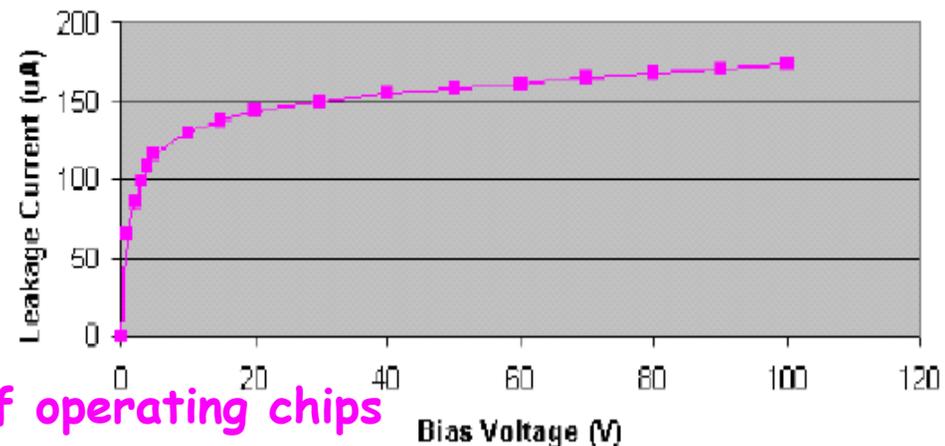
- Warm them up!
- Current vs. Temperature dependence
  - ◆ In agreement with sum of two bare sensors currents at  $V_{depletion}$

Leakage current as func. of T



- Current vs. Voltage

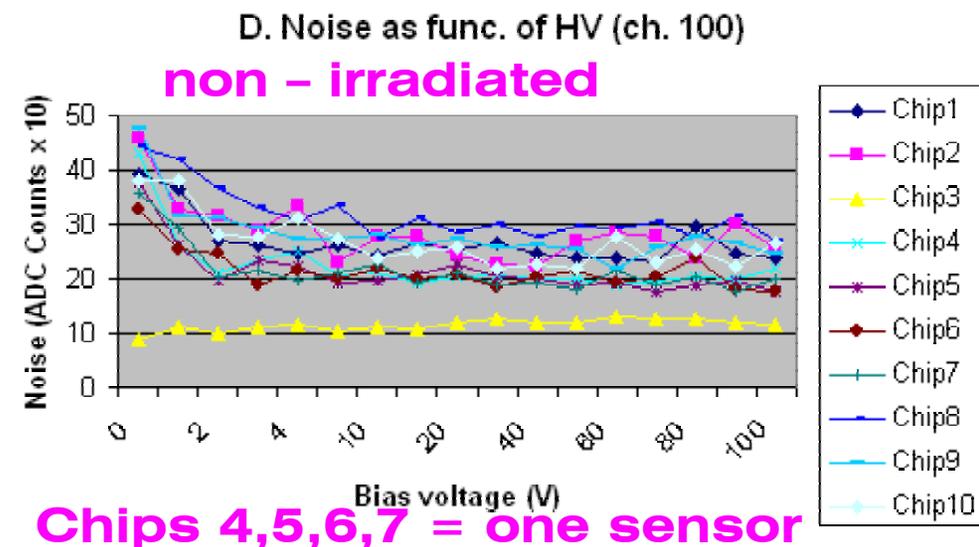
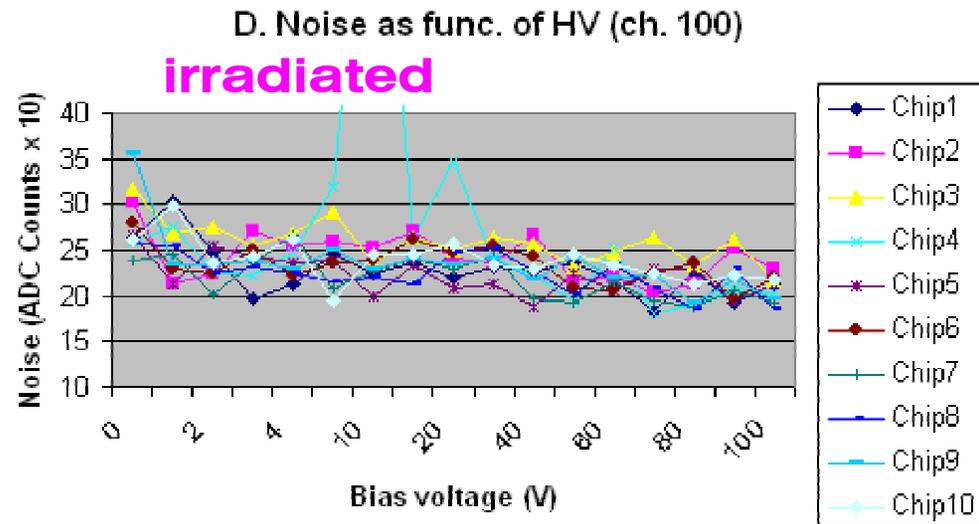
- ◆ @ -9 deg C
- ◆ Current is drifting because of operating chips
- ◆ All later measurements @ 70 V





# Irradiated sensors (3)

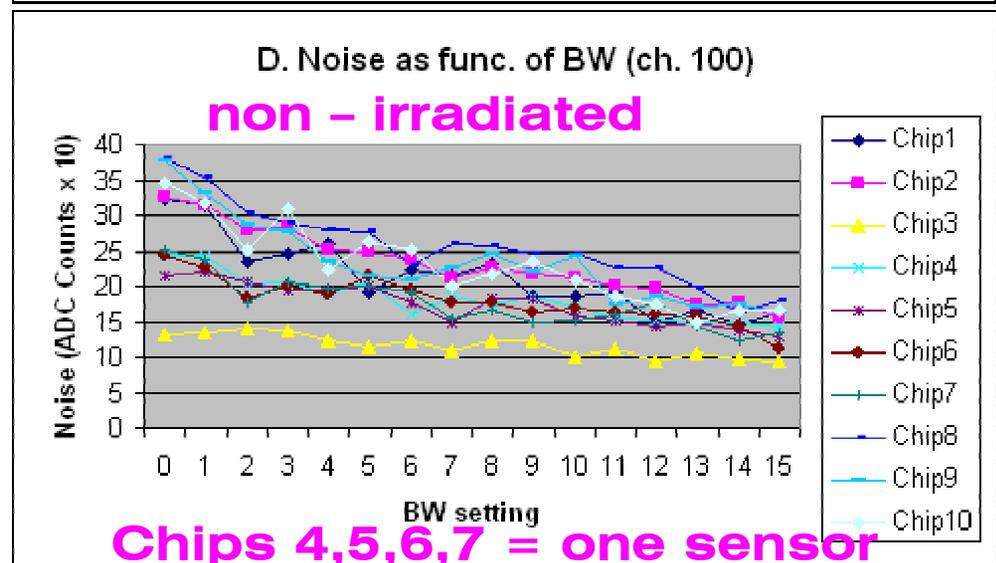
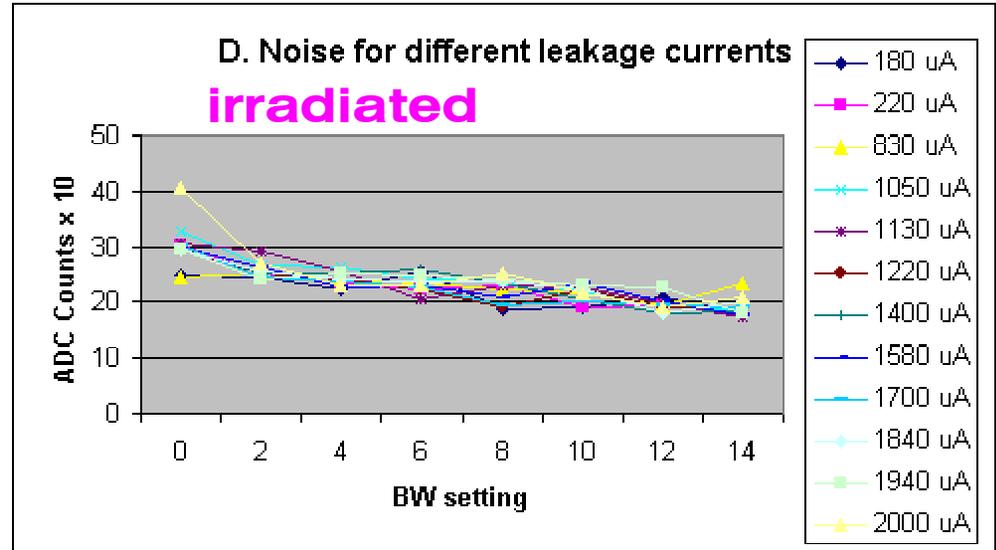
- Noise vs. Bias Voltage
  - ◆ No surprises





# Irradiated sensors (4)

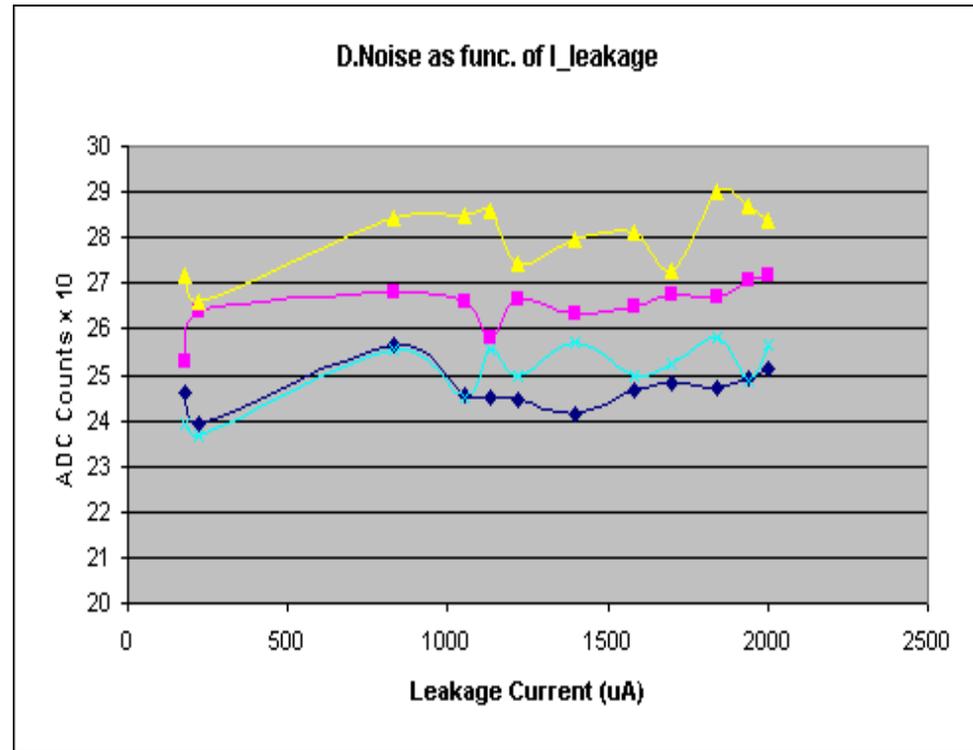
- Noise vs. BW
  - ◆  $BW = \text{preamp rise time } (\tau)$
  - ◆ Integration time always 132 ns
  - ◆ Preamp noise falls with  $\tau$
  - ◆ Shot noise rises as  $\text{sqrt}(\tau)$
- At high leakage currents should see shot noise contribution
  - ◆ Expect 1200 e @ 2000  $\mu\text{A}$
  - ◆ Don't see it
  - ◆ Don't see right BW dependence for high current
  - ◆ Why?





# Irradiated sensors (5)

- Noise vs. Leakage current
  - ◆ May be see some increase
    - ▲ 2.5 -> 2.7 counts
    - ▲ Corresponds to 700 e shot noise contribution
  - ◆ Why not 1200 e?
  - ◆ Possible explanations
    - ▲ Spent too little time on it, difficult measurements require time
    - ▲ Use APV25 formula for shot noise
      - SVX4 formula is not known
      - SVX4 has two time constants : rise time and integration time - very different preamp than AVP25
      - Plan to vary integration time : 132 -> 396 ns
    - ▲ Currents are surface and don't contribute to shot noise
    - ▲ Something else

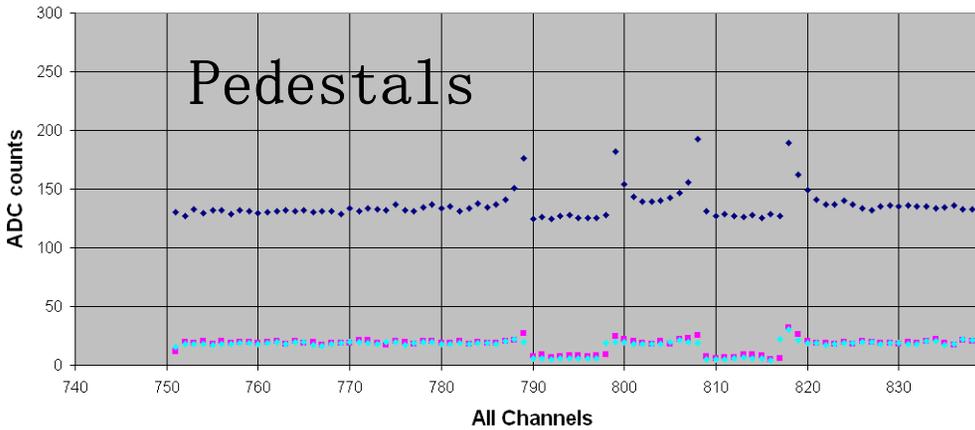




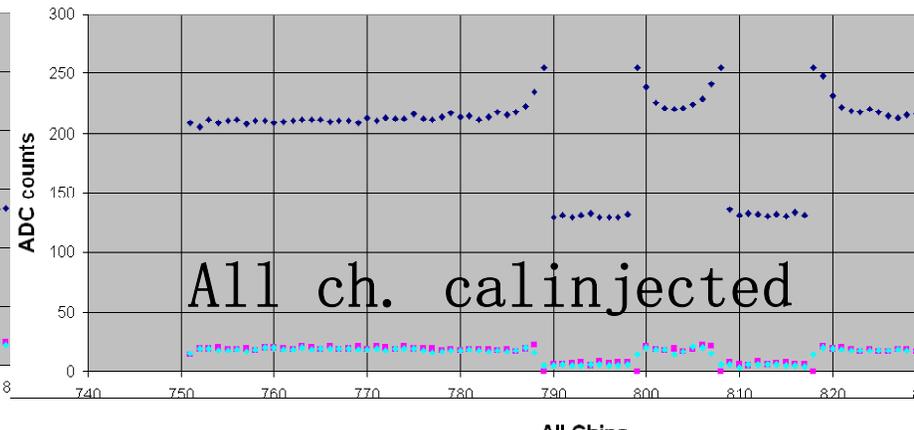
# Pinhole Clamping

- Chip 6 : pinholes (broken AC) in ch.44 and 63
- Masking recovers all but broken channels
  - ◆ New feature of SVX4

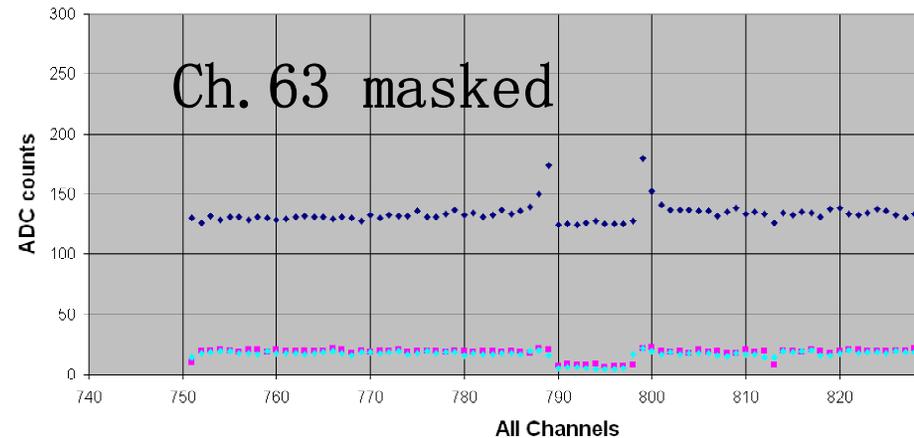
All Chips



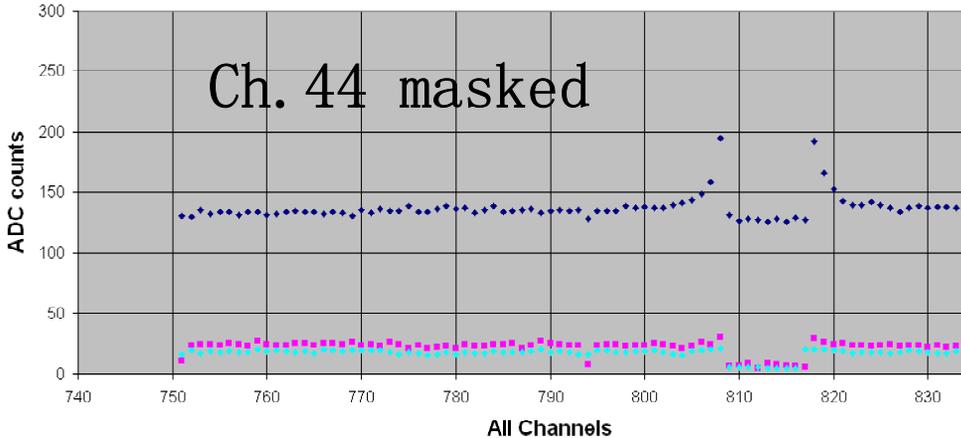
All Chips



All Chips



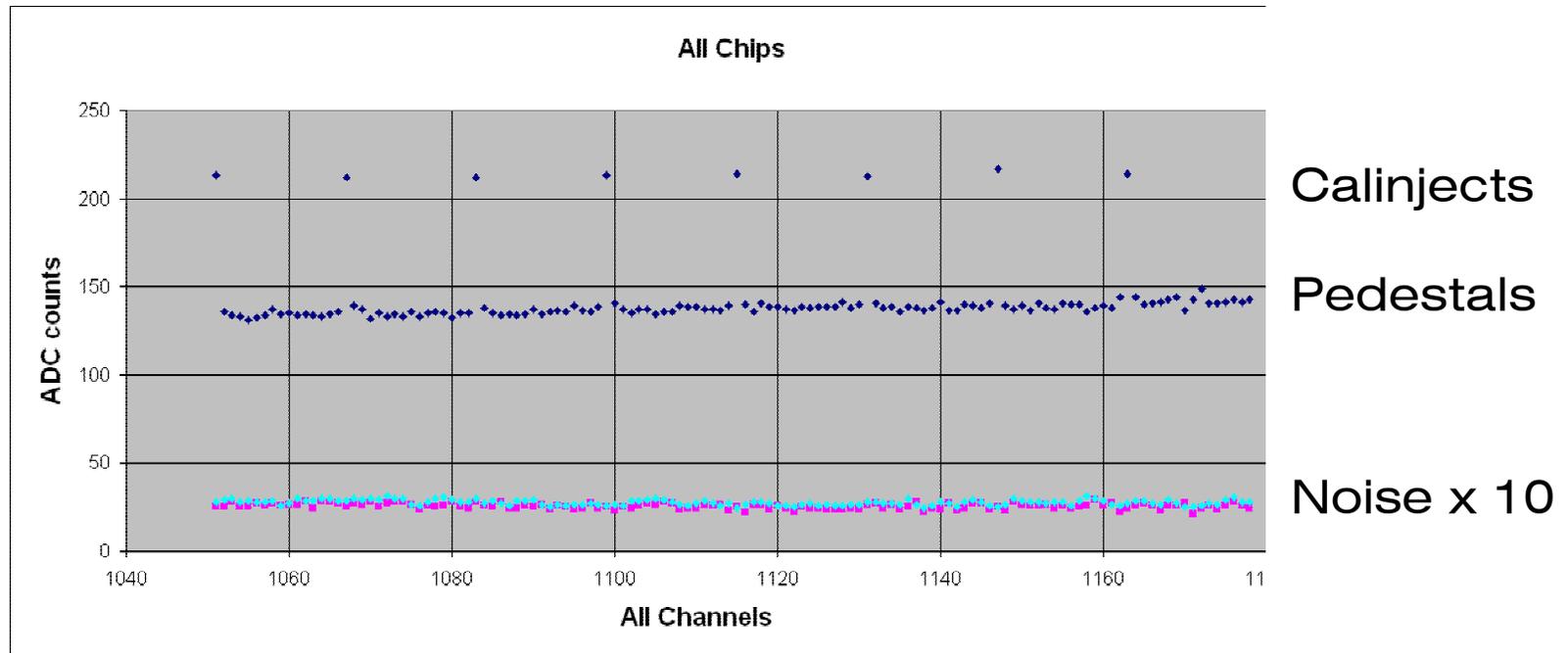
Ch. 44 masked





# Cross-talk between channels

- Preliminary measured with 20 cm silicon gang
  - ◆ Used calinjects, see plot
  - ◆ See a few % cross-talk - looks better than in Run2A
  - ◆ Effect is smaller for 10 cm sensor
  - ◆ Need more studies





# In plans for L2 modules

- Laser scans
  - ◆ Done for L1 module with ELMA sensors
  - ◆ Modifying setup to better focus the beam
- Bare sensors to sensors-in-modules detailed comparison
  - ◆ How sensor defects behave in modules (broken lines, shorts etc.)
- Pinholes analysis
  - ◆ Pinhole accounting
    - ▲ Do we create new pinholes during bonding or assembly?
  - ◆ Spread in behavior of pinholes
- Burn-in of modules
- Module behavior in staves
  - ◆ Don't expect any issues since one module is independent readout unit



# Summary

- Have a number of prototype modules, performed a number of tests
- Performance is good
  - ◆ Signal to noise as expected
  - ◆ Noise is uniform
  - ◆ Pinhole clamping in SVX4 works very well
  - ◆ Cross talk is small
- Irradiated modules have better than expected shot noise
  - ◆ Don't believe it - investigating
- Moving ahead to full stave prototype