Beetle 1.3 - Silicon Tracker Lab Tests

- PolyCMS vs. LCMS(TELL1)
- High/Low trigger rate
- Non-/consecutive readout
- Channel crosstalk
- Analogue output
- other ‘features’
- Conclusion

Changing the hardware..

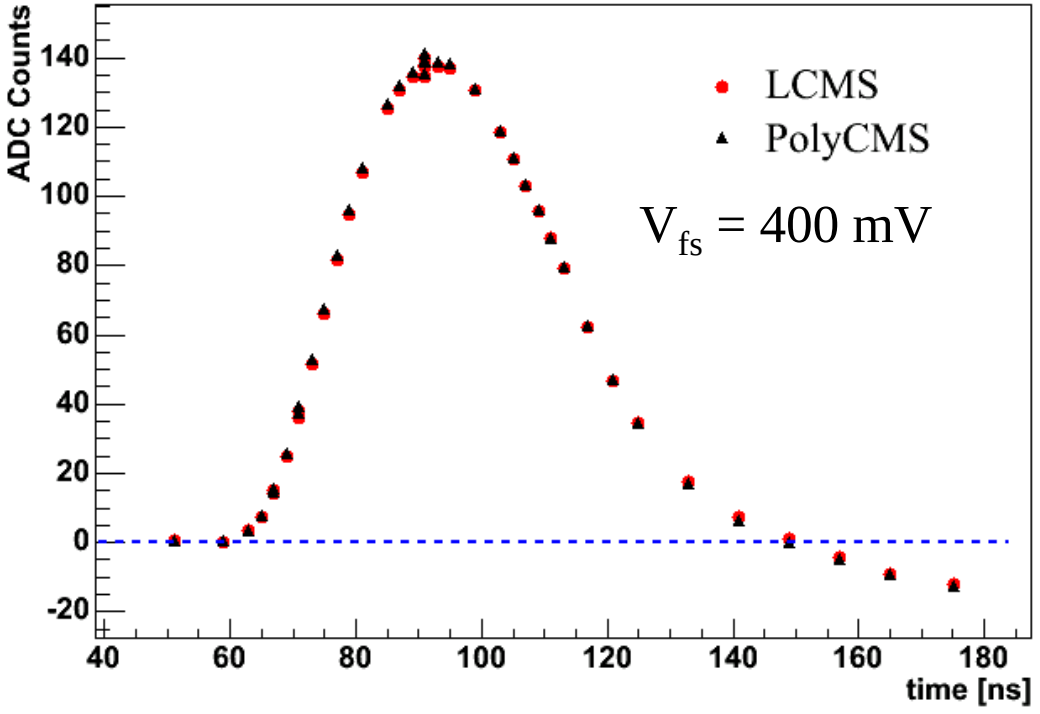
- During failure-induced downtime (PC PSU), some changes in setup:
  - 4-port readout of single Beetle now possible
  - single 2.5 V regulator for VDDA+VDDD (separated on hybrid)
  - amplifier interface in front of RB2 upgraded to 4 ports, equivalent to planned ST circuit (AC-coupling + line receiver)

- measurements done on 3 CMS sensors (500 um thick) + kapton flexcable (C_{tot} ca. 56 pF, 67 cm long)

Poly-CMS vs. LCMS (TELL1)

- laser spot near strip
- analysis performed for 1-port mode
- baseline splitted in groups of 32 for LCMS use

--> LCMS used for all following lab results

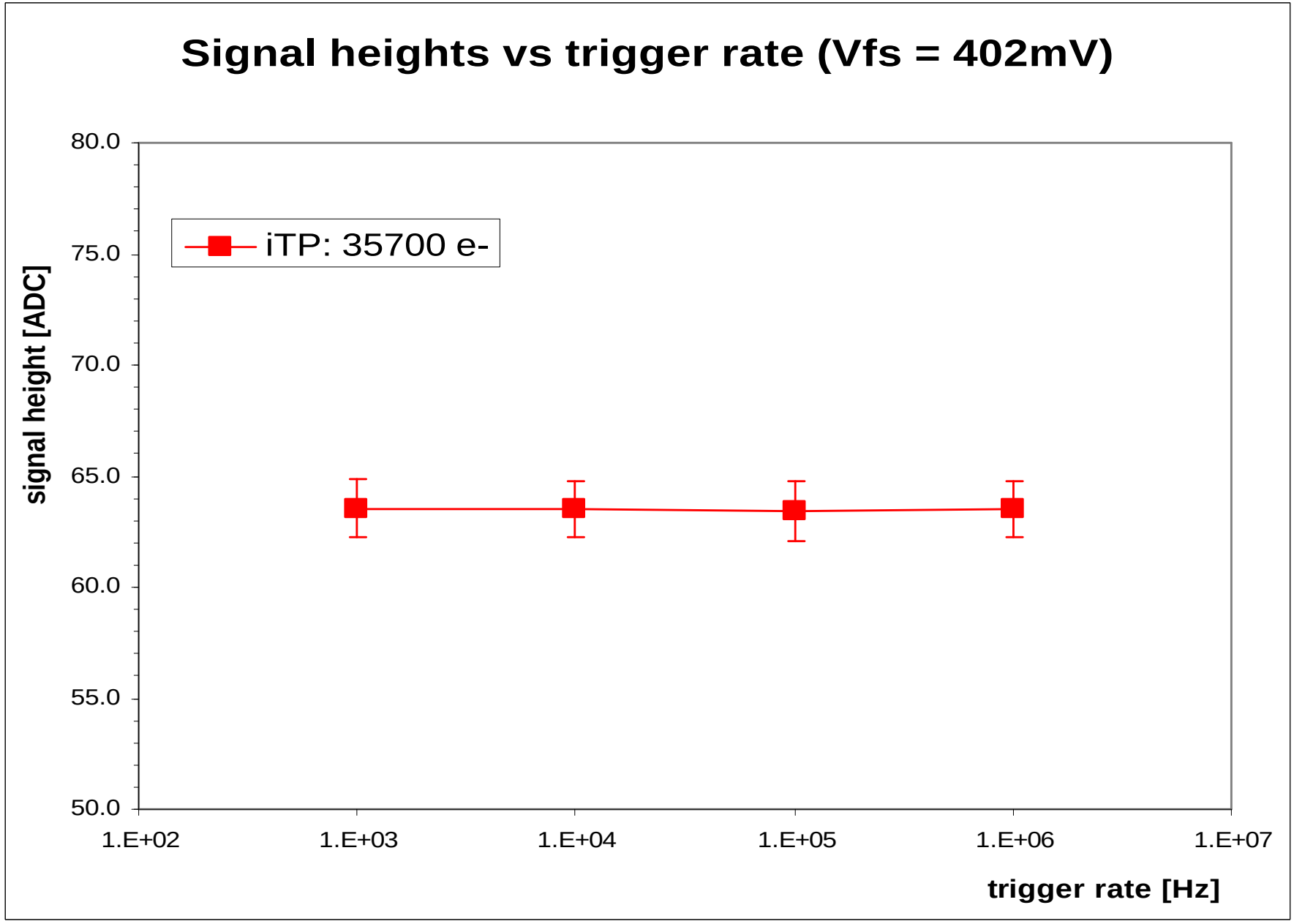


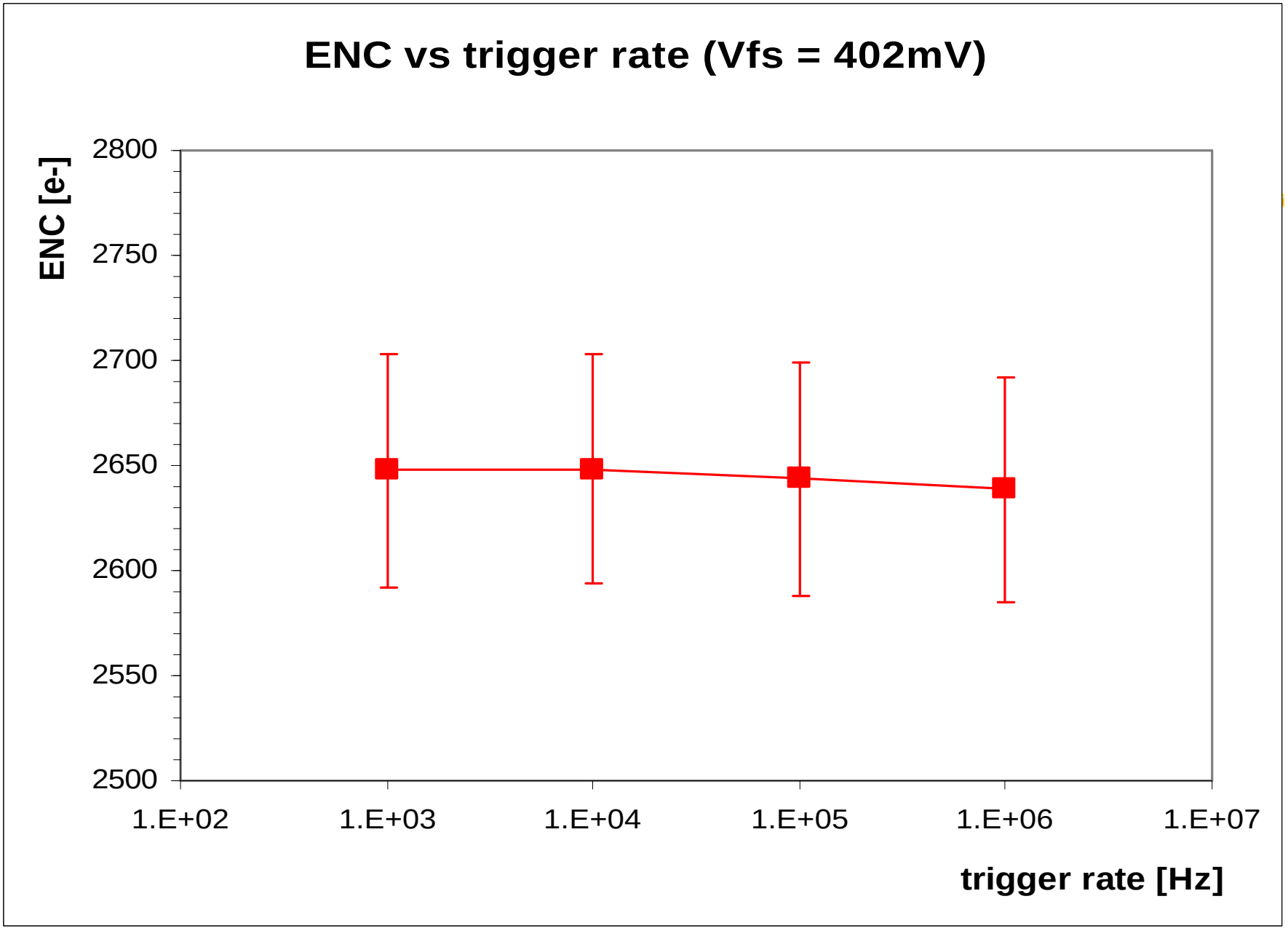
High/Low trigger rate

- Strip noise (raw noise - CMS) was determined for 4-port mode and trigger rates between 1 kHz and 1 MHz ('just' non-consecutive)
  --> No effect for high trigger rates on strip noise

- Signal amplitude was determined with internal testpulse
  --> No effect for high trigger rates on signal

--> SNR independent of trigger rate


Signal heights vs trigger rate (Vfs = 402mV)
iTP: 35700 e-
signal height [ADC]
80.0
75.0
70.0
65.0
60.0
55.0
50.0
1.E+02
1.E+03
1.E+04
1.E+05
1.E+06
1.E+07
trigger rate [Hz]


ENC vs trigger rate (Vfs = 402mV)
ENC [e-]
2800
2750
2700
2650
2600
2550
2500
1.E+02
1.E+03
1.E+04
1.E+05
1.E+06
1.E+07
trigger rate [Hz]

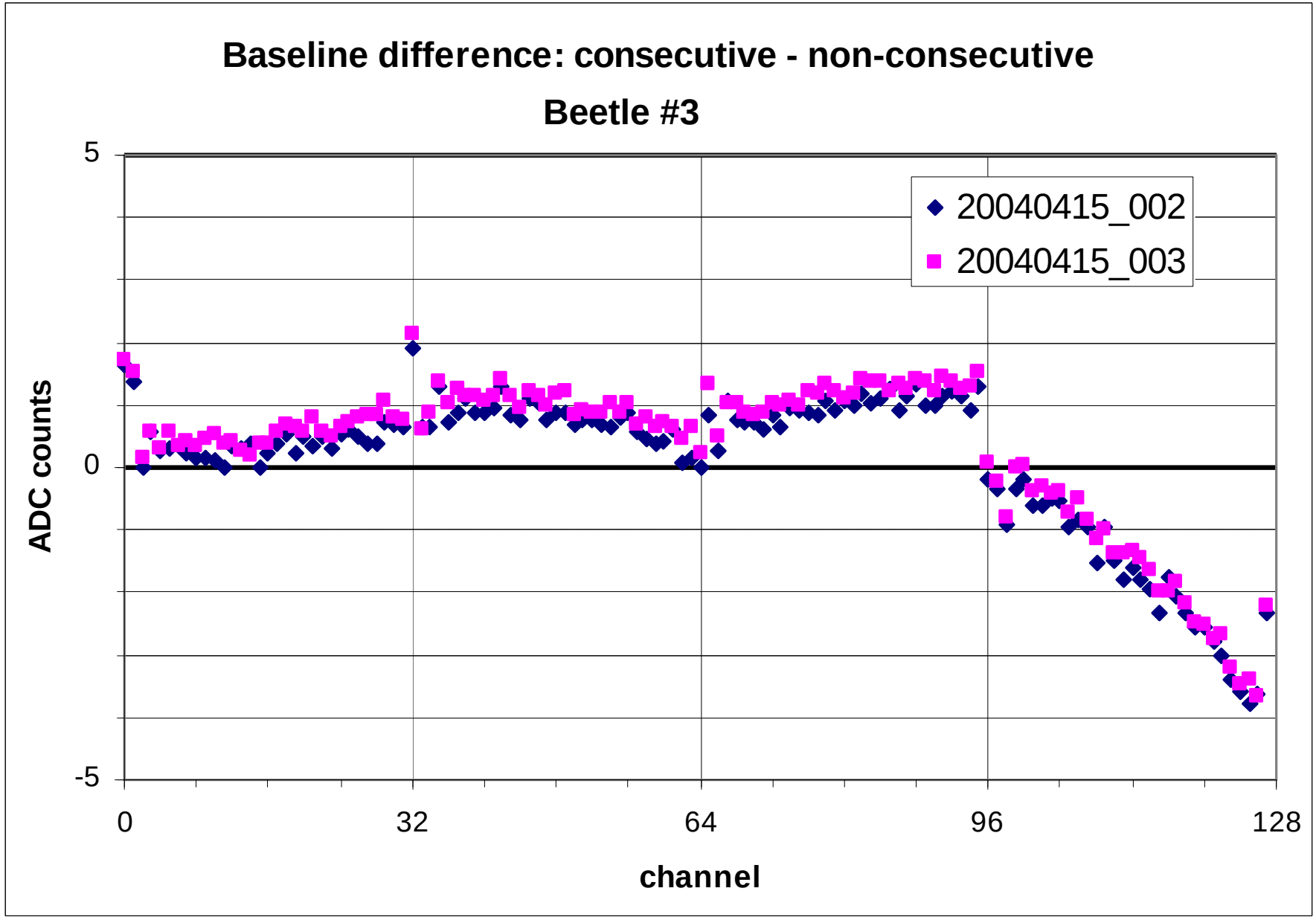
Non-/consecutive readout

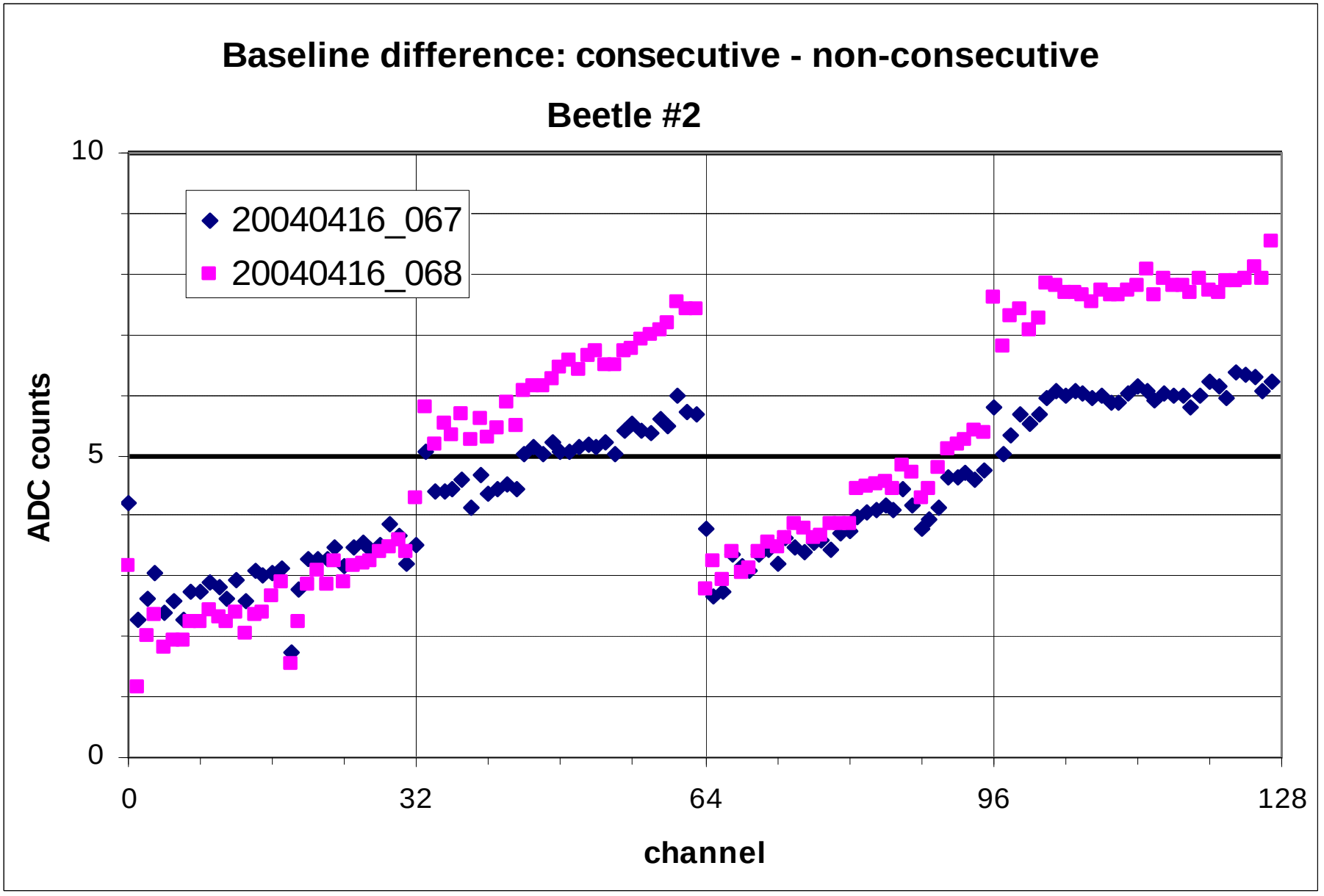
- Beetle 1.3 has slightly differing pedestals for consecutive and non-consecutive readout.
- Consecutive readout baseline is not unique

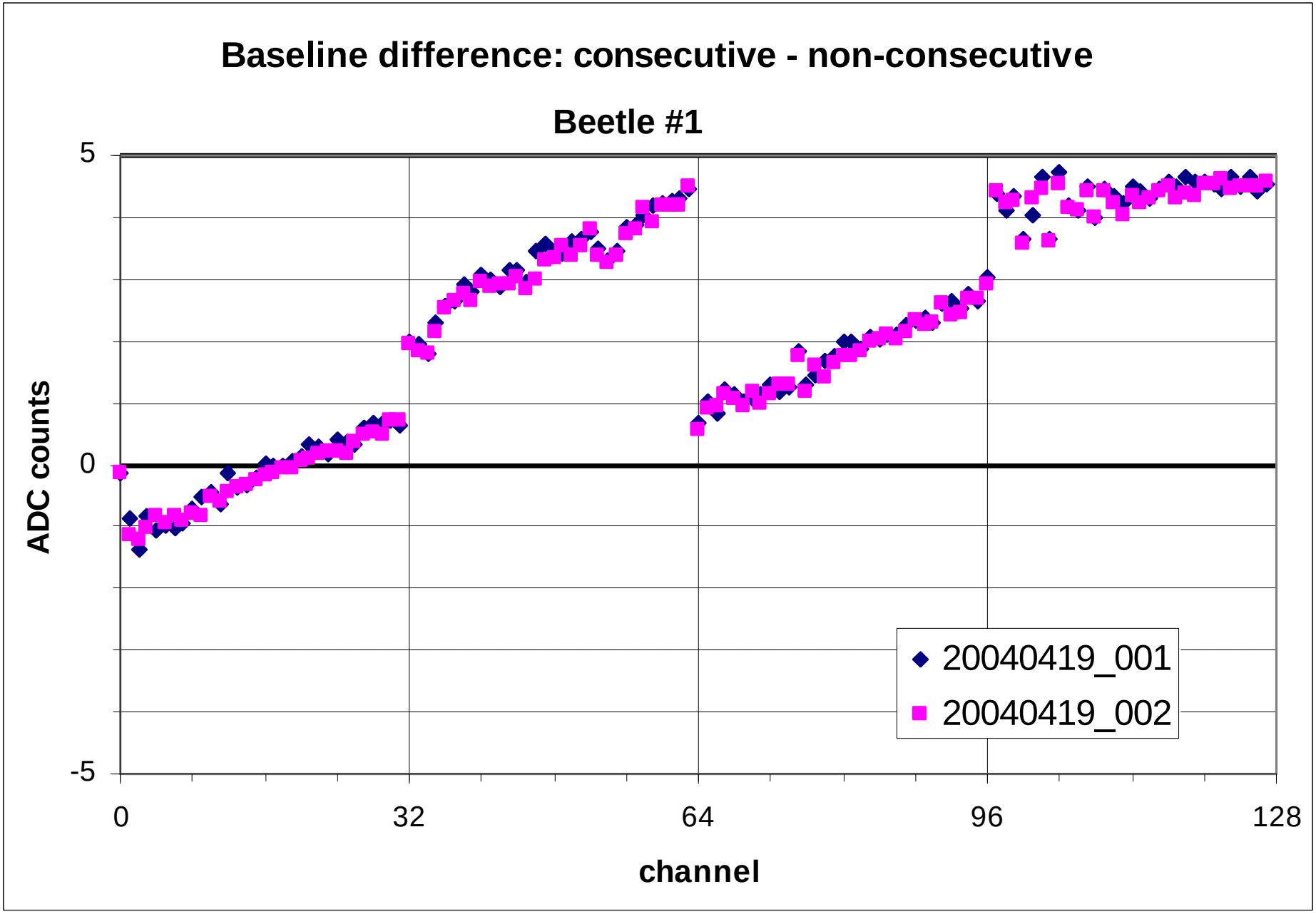
- effect compensated for by LCMS algorithm, even when applying non-consecutive pedestal to consecutive readout

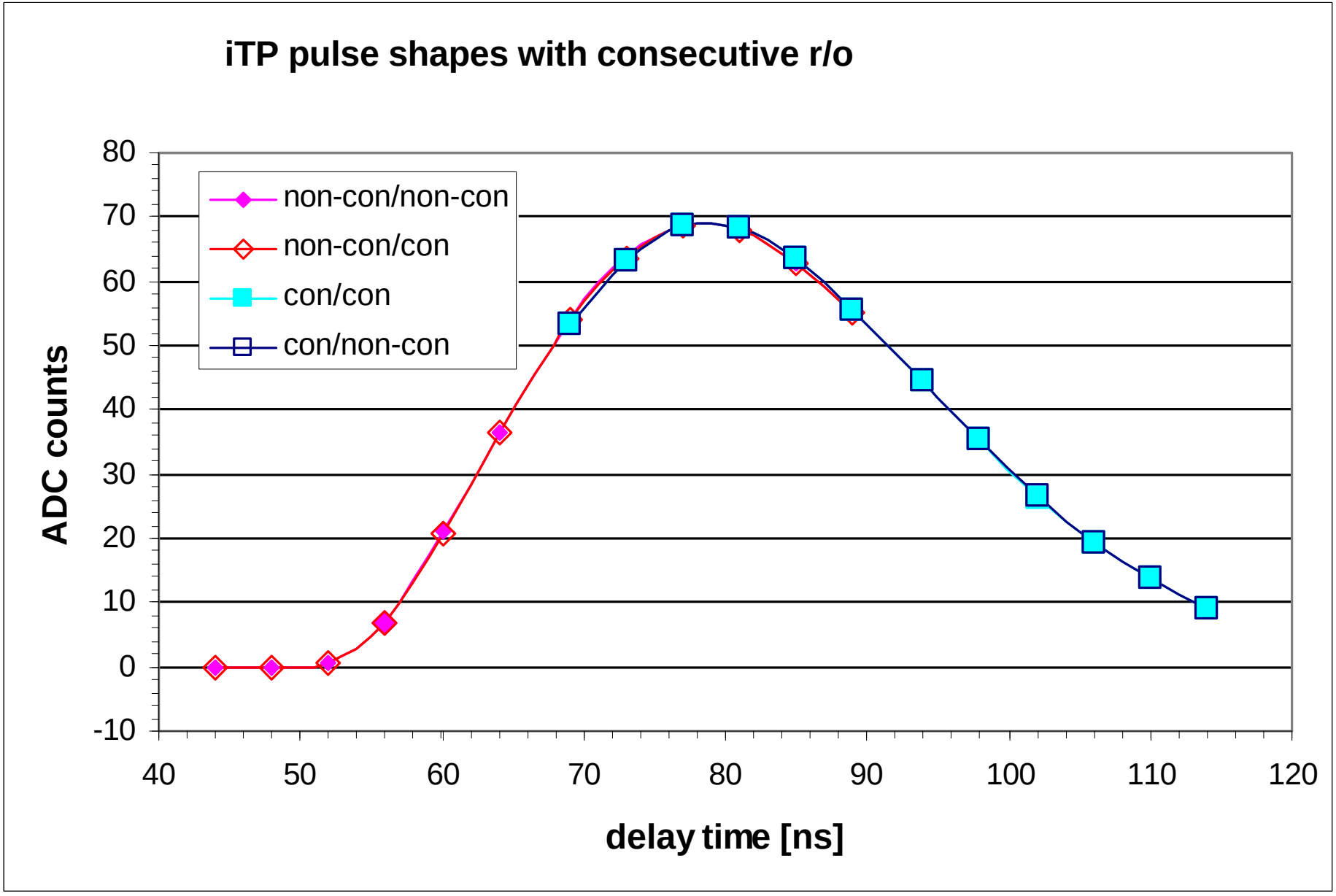
- signal amplitude not affected
  strip noise not affected → SNR constant

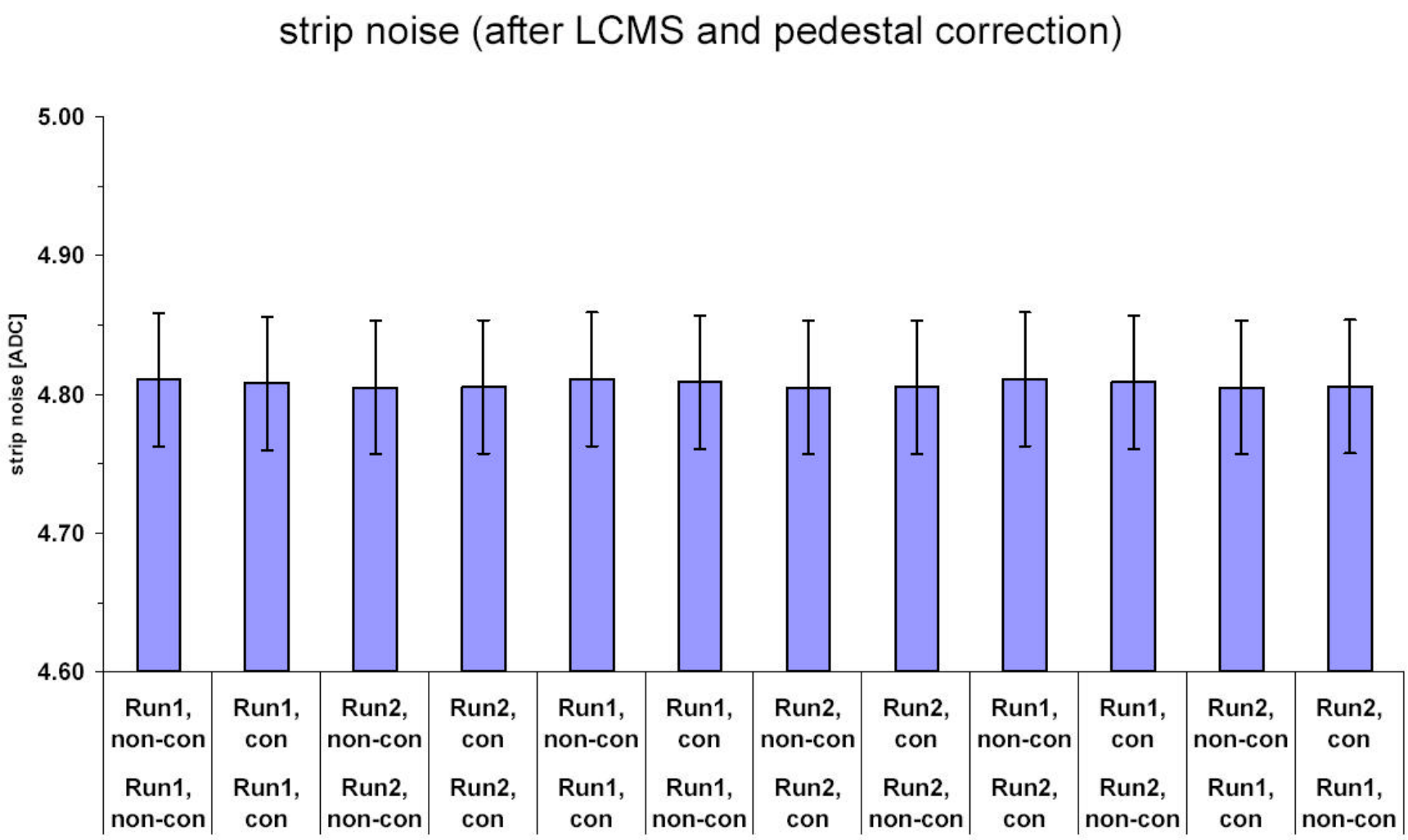
--> no influence on ST operation


Baseline difference: consecutive - non-consecutive
Beetle #3
5
0
-5
ADC counts
0
32
64
96
128
channel
20040415_002
20040415_003


Baseline difference: consecutive - non-consecutive
Beetle #2
20040416_067
20040416_068
ADC counts
10
5
0
0
32
64
96
128
channel

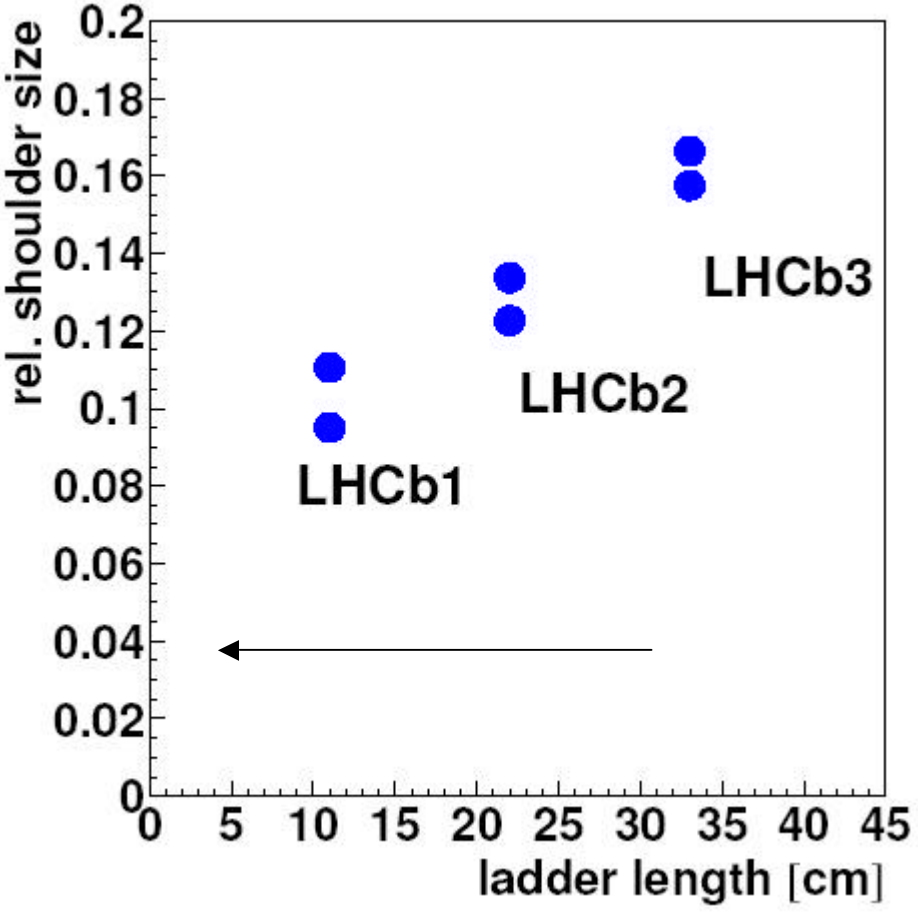

Baseline difference: consecutive - non-consecutive
Beetle #1
ADC counts
5
0
-5
0
32
64
96
128
channel
20040419_001
20040419_002


iTP pulse shapes with consecutive r/o
ADC counts
delay time [ns]
non-con/non-con
non-con/con
con/con
con/non-con
80
70
60
50
40
30
20
10
0
-10
40
50
60
70
80
90
100
110
120


strip noise (after LCMS and pedestal correction)
strip noise [ADC]
5.00
4.90
4.80
4.70
4.60
Run1, non-con
Run1, con
Run2, non-con
Run2, con
Run1, non-con
Run1, con
Run2, non-con
Run2, con
Run1, non-con
Run1, con
Run2, non-con
Run2, con
Run1, non-con
Run1, con
Run2, non-con
Run2, con
Run1, non-con
Run1, con
Run2, non-con
Run2, con
Run1, non-con
Run1, con
Run2, non-con
Run2, con

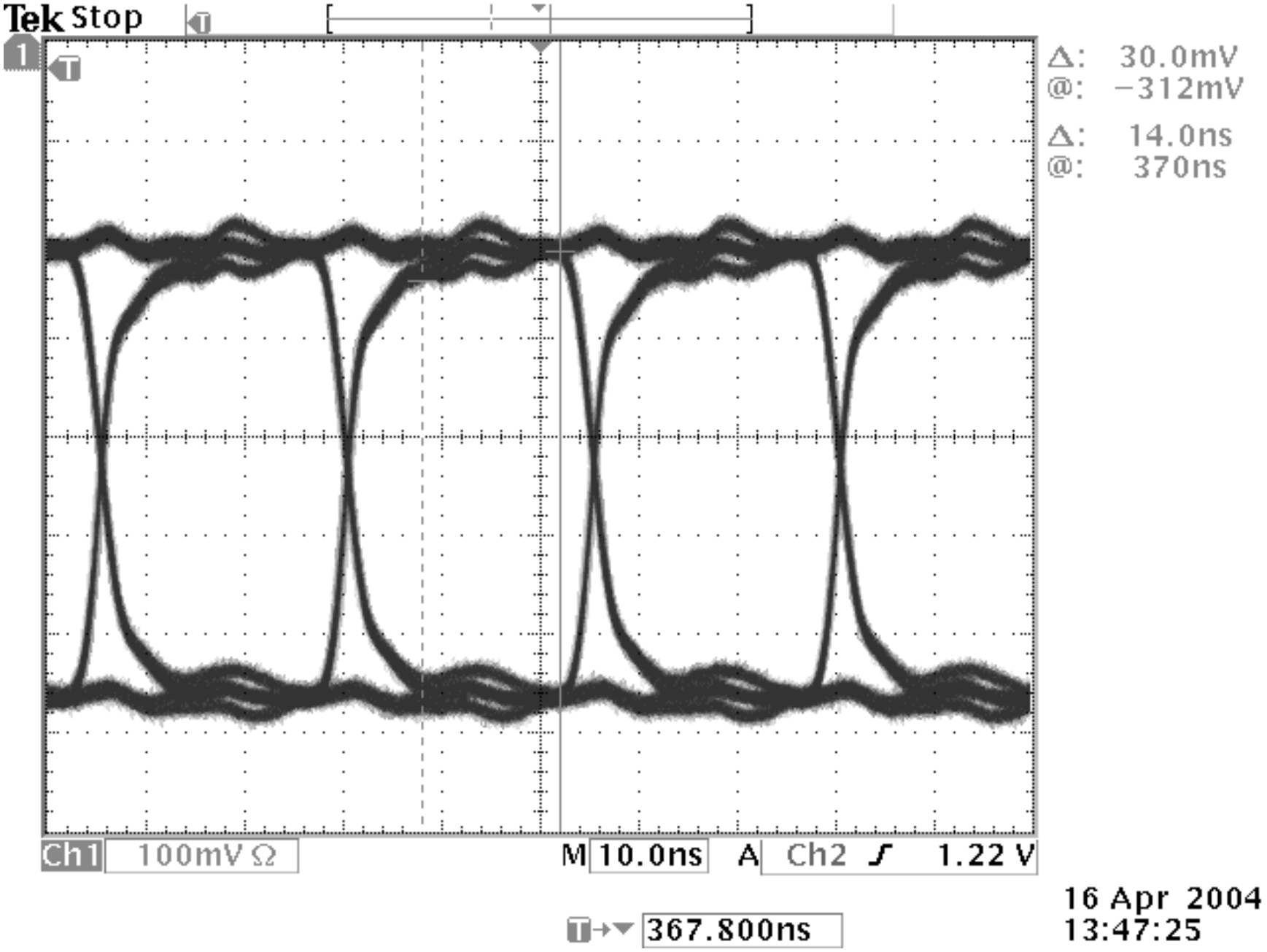
Channel crosstalk: 'Shoulders'

- Capacitive strip-to-strip coupling to neighbouring detector channels
- larger than Beetle internal crosstalk -->Beetle internal crosstalk negligible for ST needs



Analogue output

- Laser setup connects to 5 m twisted pair cable
- AC-coupled amplifier (ST schematics) + interface to RB2 board
- AD8129: optimized for G=+10
  (AD8130 for lower gain but not rad-qualified)
- gain of 10 used, but followed by 1:4 voltage divider
  (HUGE signals from Beetle 1.3)
- 'flat top' of header ca. 14 ns wide --> large enough to adjust for proper ADC sampling time
- enhanced gain for higher frequencies (cable compensation like VELO) not used


Tek Stop
Δ: 30.0mV
@: −312mV
Δ: 14.0ns
@: 370ns
Ch1 100mV Ω
M 10.0ns A Ch2 1.22 V
16 Apr 2004
13:47:25
367.800ns

FE Performance for IT+TT

- Extensive measurements done with Beetle 1.2 (incl. testbeam) with (IT+TT)-similar setups
- Frontends 1.2 <--> 1.3 identical (see S. Loechner's talk from Nov '03 LHCb week)

Sensor	Thickness	SNR on-strip	SNR mid-strip
IT 1-sensor	320 um	15.8	12.0
IT 2-sensor	410 um	16.9	13.9
TT 3-sensor+ flex	500 um	14.6	12.8

- All SNR scaled to 1 MIP (V_{fs}= 402 mV), published in LHCb2003-140
- 2003 Testbeam SNR in agreement with Beetle ENC from lab (LHCb2003-082)
- ST requirement: SNR >= 12 pre-irradiation
  --> Beetle 1.3 frontend sufficient for ST operation

other ‘features’

- Parity bit encoded wrongly:
  no concern for ST, as pipeline column number will be cross-checked to other Beetle chips and FEM-Beetle on TELL1

- RCLK-divider, last channel issue:
  not needed in ST, operation at full speed

- Daisy chain:
  not used in ST

Conclusion

- The Beetle 1.3 satisfies the needs of the LHCb Silicon Tracker
- Need to go to production ASAP to maintain ST production schedule:
  - 290 Beetle chips delivered by Jun 04
  - 900 Beetle chips delivered by Oct 04
  - 2900 Beetle chips delivered by Feb 05
- Estimate in addition 3 months for assembly and testing
- ST would like to go with production lot of 100% Beetle 1.3
  --> no Beetle 1.4

Questions:

- Do we get enough Beetle1.3 in time?