universitätbonn

Signal resolution and dynamic range

A SHORT REMINDER…

DEPFET

Active Pixel Detector

manuel.koch@uni-bonn.de Valencia 09/2010

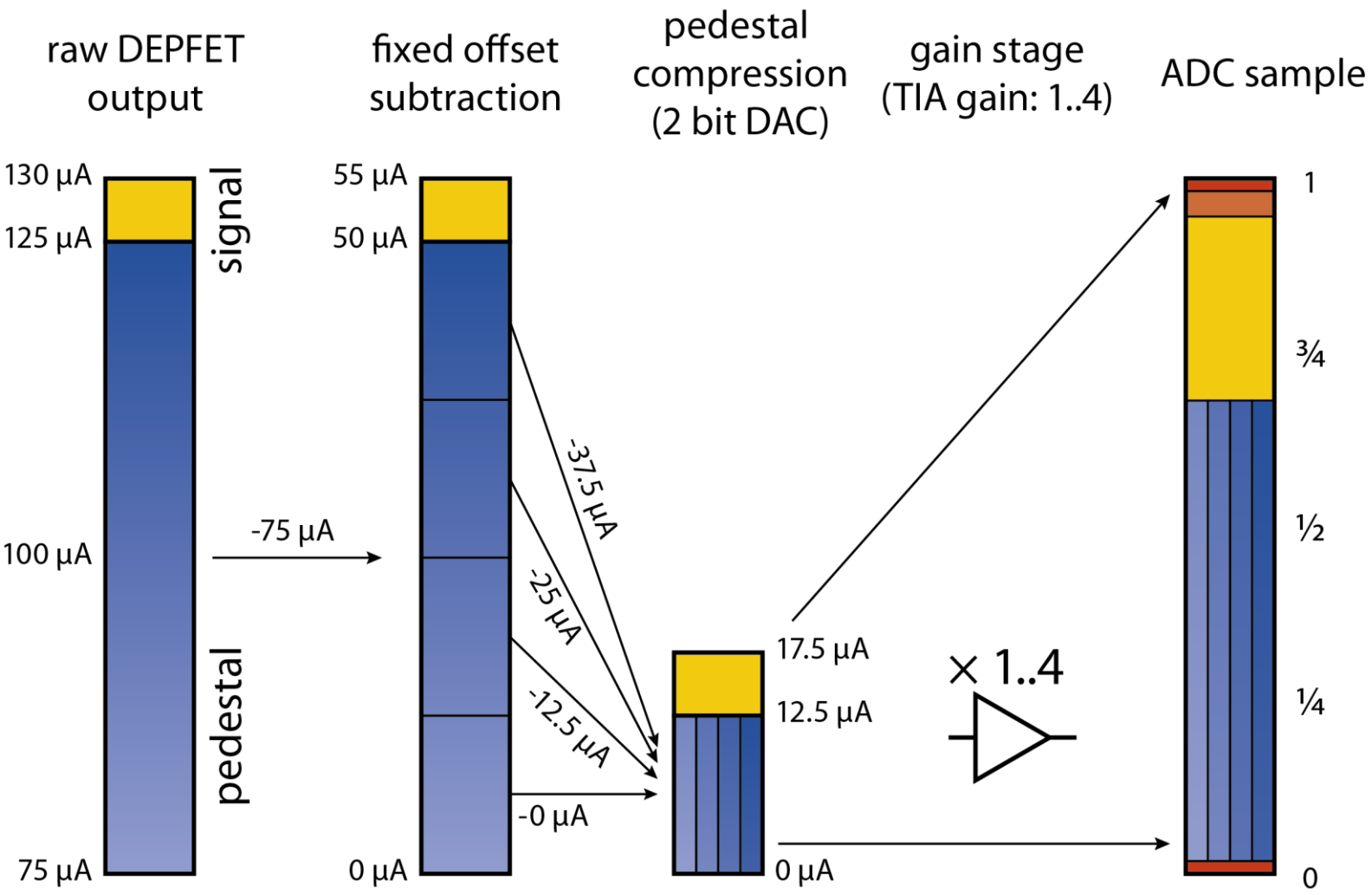
Signal resolution and dynamic range

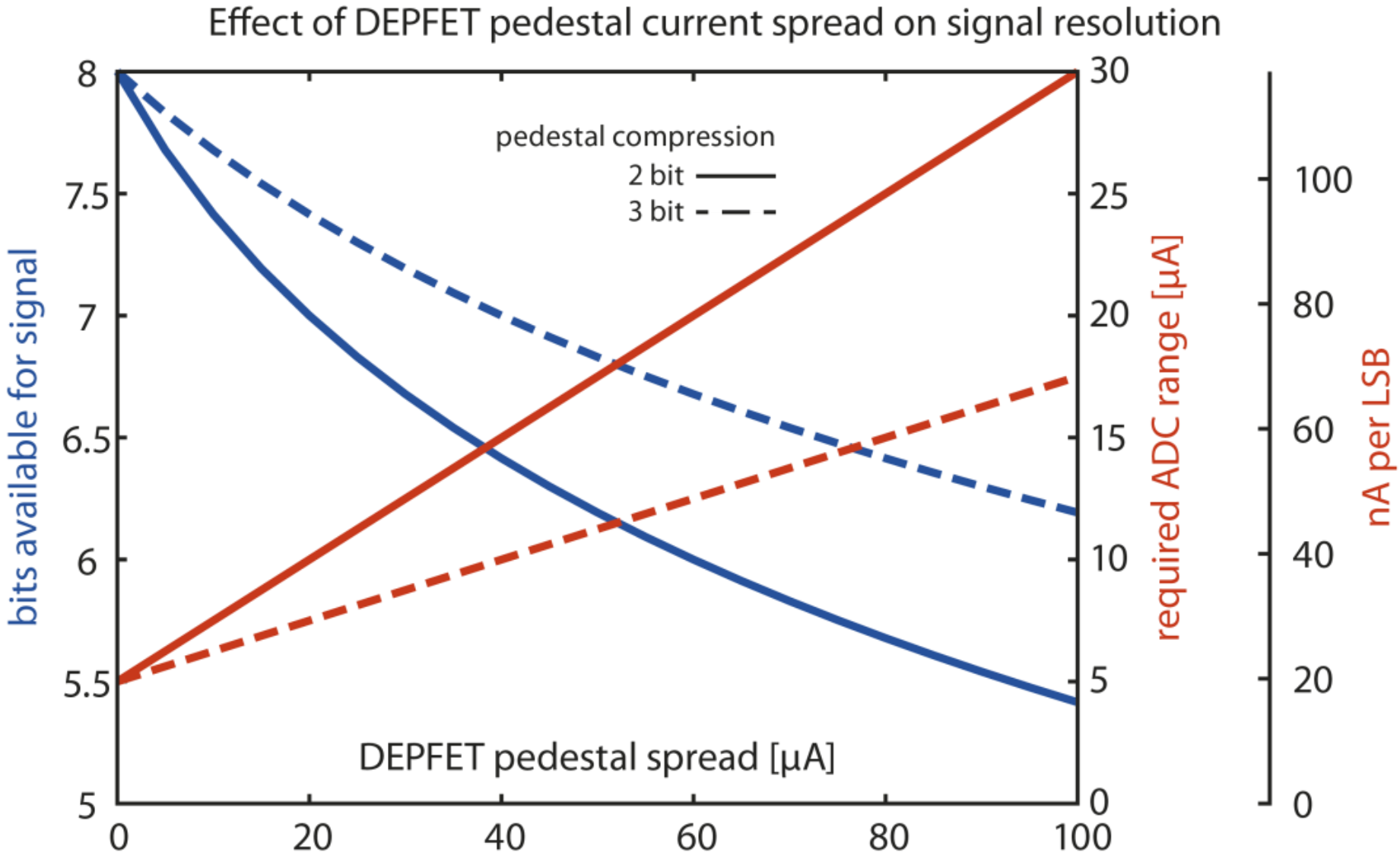
- What signal resolution can we expect just from the ASICs?

- Try realistic scenario and include (most) error sources
  - DEPFET pedestal spread
  - DCD nonlinearities
  - Electronic Noise
  - Numerical errors

- We have
  - Signal: ≈ max 10000 e^- → gq ≈ 0.5nA/e^- → 5µA maximum Signal
  - Pedestals: @100µA average; large area, irradiation
    → 50µA variation (+/- 25µA)
  - DCDb with 2bit DAC for “pedestal range compression”
  - DCD**2** ADC range up to 24µA (from my own measurements)
  - … multiple sources of errors…

DCDb dynamic range concept




Effect of DEPFET pedestal current spread on signal resolution
pedestal compression
2 bit
3 bit
bits available for signal
required ADC range [µA]
nA per LSB
DEPFET pedestal spread [µA]
8
7.5
7
6.5
6
5.5
5
30
25
20
15
10
5
0
100
80
60
40
20
0
0
20
40
60
80
100

To consider…

- common mode noise needs to fit in too!

- ganged pixels? → double range!

Common mode noise

- … is mostly a system aspect
- can be avoided/reduced by careful design

- As an example:

  ← from our previous scenario
  1LSB ≈ 70nA

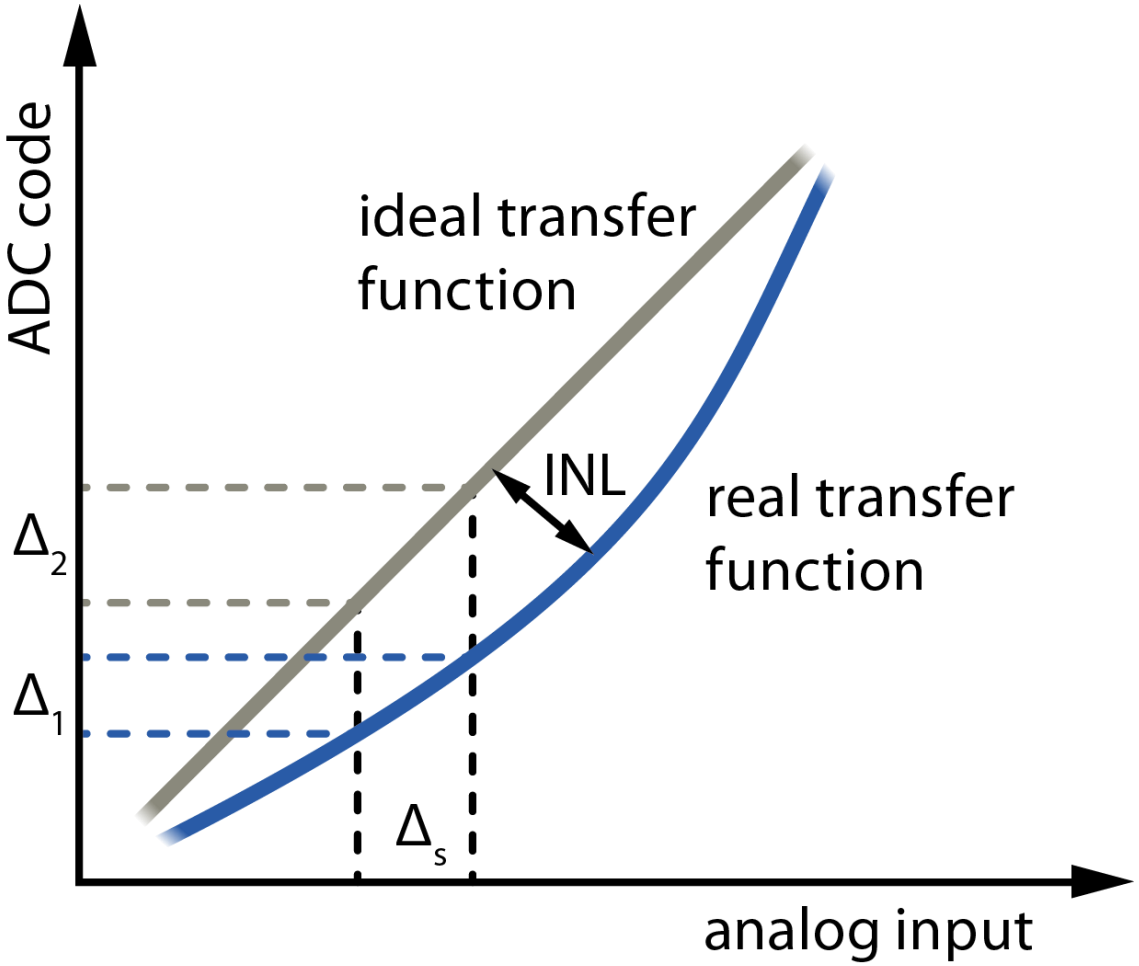
  DEPFET's $g_m \approx 50\mu S = \frac{\partial I_{out}}{\partial V_{in}}$

  a change of **1.4mV on Gate-ON** will cause 1LSB of 'common mode'

- … and that's why we need low output impedance of the PDN …

DCD nonlinearities

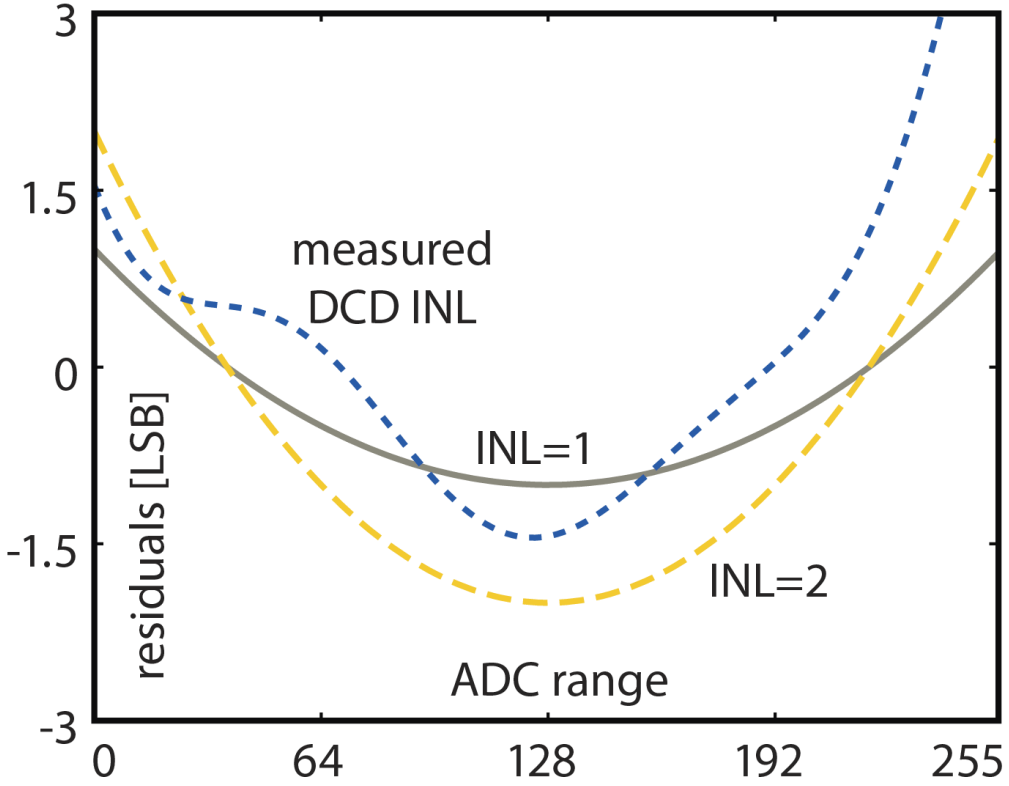
- Do we need to correct for these?
- Can we even correct after DHP calculations? Original values needed!



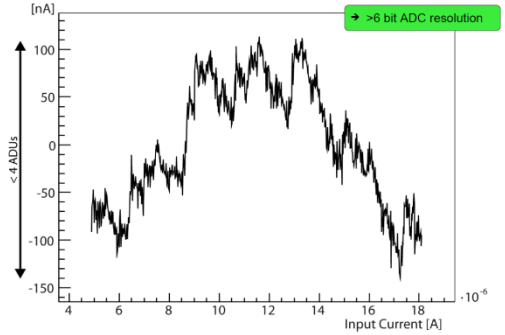
Nonlinearities…

- Typical picture:

- Measured INL smoothed! (DCD2)

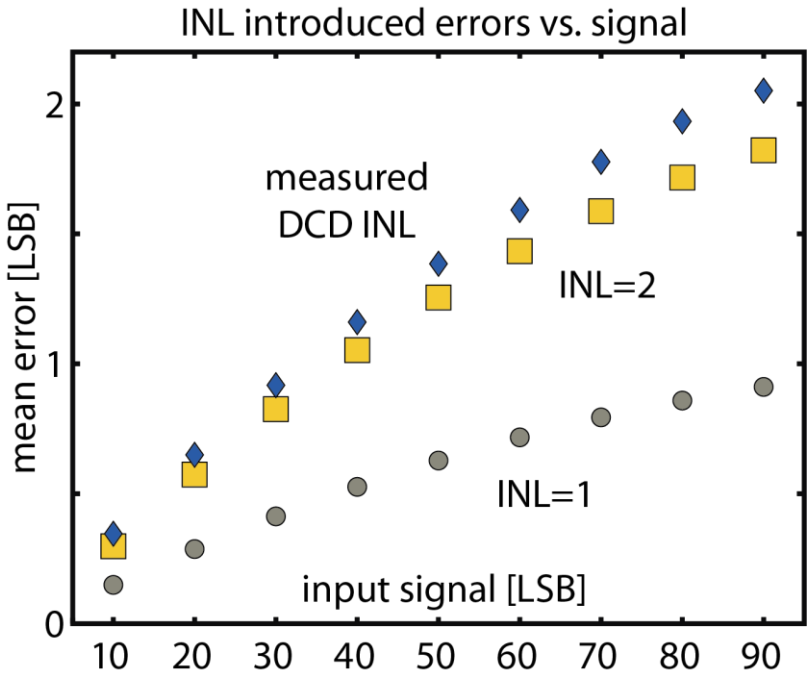


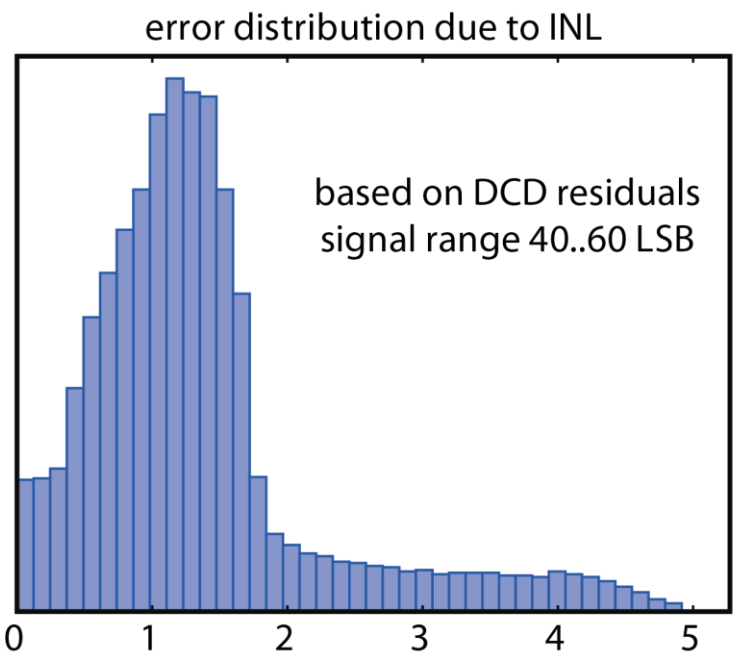
- The real picture (see Jochen's talk)



Nonlinearities…
… and their effect

- Introduced errors depend on INL shape and signal range





- Expect 1LSB of additional systematic error
- Correctable?
  Only if you calibrate and common mode is low

To summarize…

- We effectively digitize signals with 6bit resolution
- Minus… $\Big[$
  (electronic noise ≈ 0.7 LSB)² +
  (nonlinearities ≈ 1 LSB)² +
  (DHP numerical errors ≈ 0.14 .. 0.28 .. 0.5 LSB)²
  $\Big]^{1/2}$
- **This leaves us 4.5 bits of real information!**