#### Lab Characterization Results Matrix biasing and depletion, gain and efficiency homogeneity

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Signal and noise homogeneity (Pablo)

2 DCD gains and  $g_q$  (Pablo)



3 Measurement of doping variations

#### Sensor response/homogeneity and gain measurements

- measurements and analysis by Pablo
  - $\rightarrow$  How to optimize matrix biasing?
  - $\rightarrow$  Variations of signal and noise over sensor?
  - $\rightarrow$  DCD gain and  $g_q$  determination
- data from module W46\_OF2
  - mass testing/characterization: grade A

Signal and noise homogeneity (Pablo)

#### hitmaps at different biasing conditions



P. Wieduwilt (Uni Göttingen)

#### biasing optimization: procedure



#### biasing optimization: results



 $\Delta V_{clear-drift} = 6, 7 V$ 

#### signal variation in DCD/Switcher regions



#### noise variation in DCD/Switcher regions



#### SNR variation in DCD/Switcher regions



P. Wieduwilt (Uni Göttingen)

#### DCD gains



#### energy calibration



## DEPFET $g_q$



#### WHEN CORRECTED BY THE DCD GAIN THE 4 CURVES OVERLAP

THE CURVE SHOWN IS THE MEAN OF THE 4 ASIC CURVES

#### Measuring bulk doping variations

• Can we measure bulk doping variations on PXD9 sensors?

- $\rightarrow$  resolve (ring) structures?
- $\rightarrow$  measure amplitude of variation?
- ightarrow choose biasing not sensitive to doping variations?
- data from modules
  - W40\_IF (Göttingen guinea pig)
  - W03\_OB1 (grade A)
- lab measurements on final PXD9 modules with Sr90  $\beta$ -source
  - correlate charge collection efficiency to measured signal MPV
  - $\bullet\,$  varying HV  $\leftrightarrow$  varying varies sensor depletion
  - varying biasing conditions (drift, clear-off)

### Single DEPFET pixel simulations (Rainer)



### Measuring MPV per DCD/Switcher region

- Sr90  $\beta$ -source
- cluster charge histograms per DCD/Switcher region
- fit Landau distribution
- MPV per region  $\rightarrow$



#### MPV evolution with HV



#### Correcting for Switcher gradient and DCD gain



#### Simulation $\leftrightarrow$ measurement



#### Under- and over-depletion



#### under-depletion

- HV too low for depleting bulk with doping concentration Nbulk
- $\rightarrow\,$  charges recombine with remaining charge carriers

#### over-depletion for DEPFET

- high HV fully depletes bulk, but charges are pushed into clear structures
- $\rightarrow$  charges lost

#### Changing the matrix biasing



#### Finer HV stepping and smaller macro pixels



### Quantifying the HV shift



for each macro pixel

#### HV shift maps

- relative HV shift w.r.t. median of all HV values at falling edge
- ring structures clearly visible
- HV shifts in the order of 1100mV
- $\Rightarrow$  measuring doping variations at an arbitrary scale



#### HV shift maps - independent of biasing



#### HV shift maps - W03\_OB1



#### **Biasing optimization**



#### Conclusion and next steps

- check MPV fitting error estimation ( $\rightarrow$  ROOT/RooFit)
- map to physical distances (µm instead of pixels)
- add information on postion on wafer
  - (concentric) rings around wafer center?
  - agreement between modules from same wafer?
- translate HV shifts to absolute doping variations  $\rightarrow$  ?
- $\bullet$  collect statistics  $\rightarrow$  mass testing
- detailed TB studies about impact on absolute and sub-pixel efficencies

# Backup