Simulating the Detector Performance

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PHYSICS

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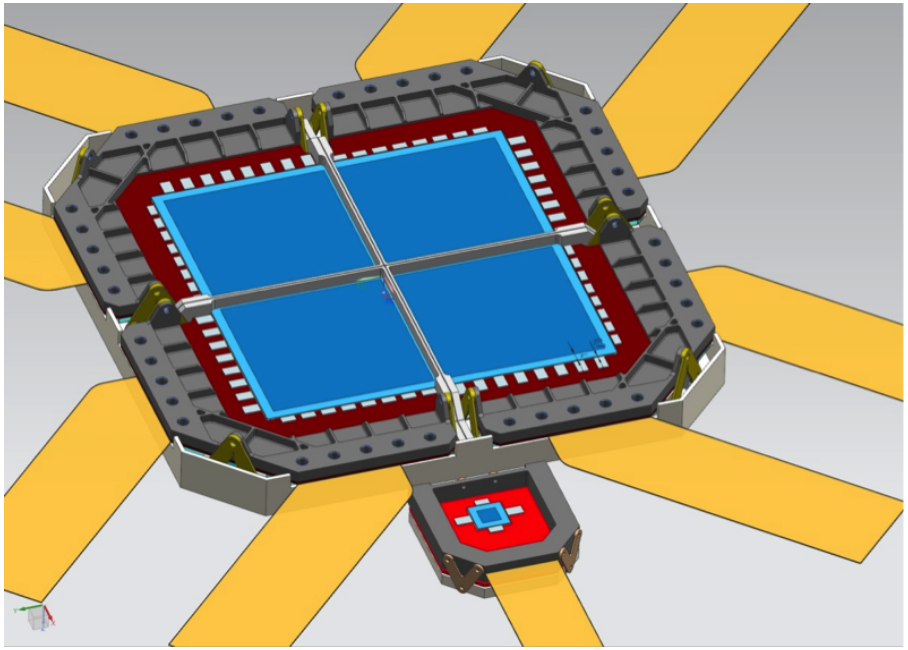
Detector Performance: High Count Rate Capabilities

focus on fast chip for high count rate science requirements

- 80% throughput @1 Crab
- $<$ 1% pile-up fraction @1 Crab



studied options:

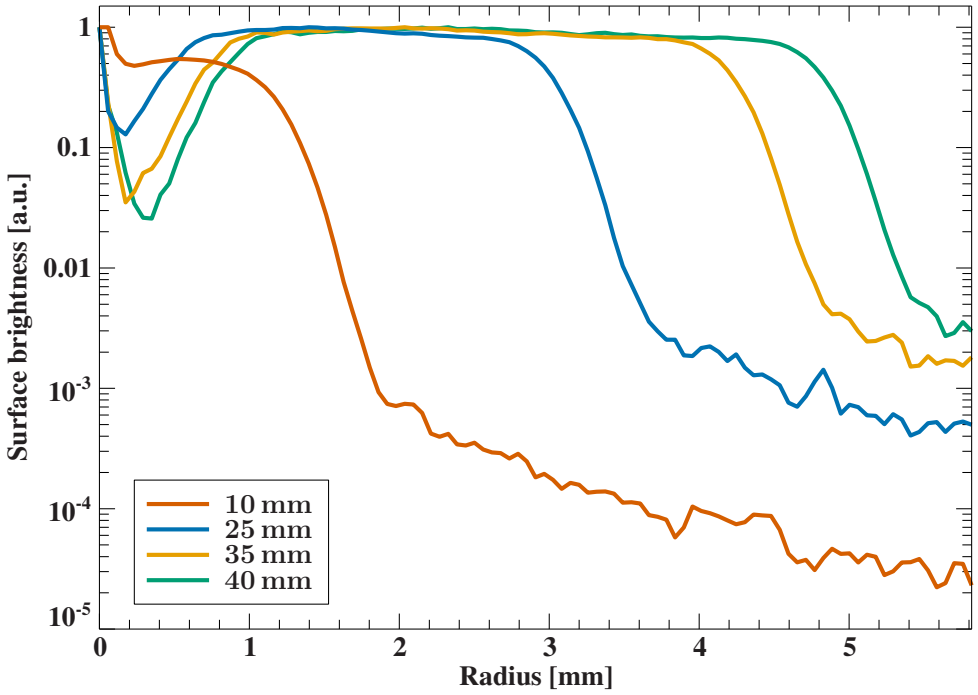
- defocusing
- *gateable* DEPFET
- multi line readout
- macro pixel array

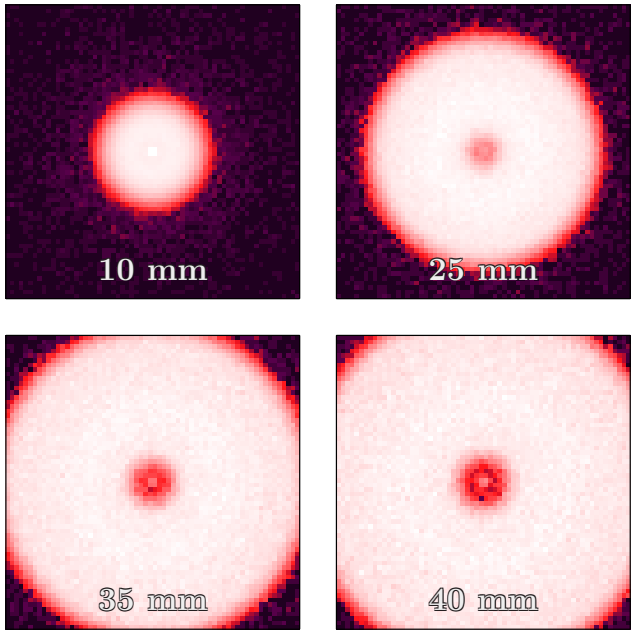
$\rightarrow$ *full SIXTE e2e simulations of the fast chip*

Previous Results: Defocusing of the Fast Chip

defocusing necessary to fulfill high count rate science requirements

(see bright source report ECAP-WFI-BSR-04)

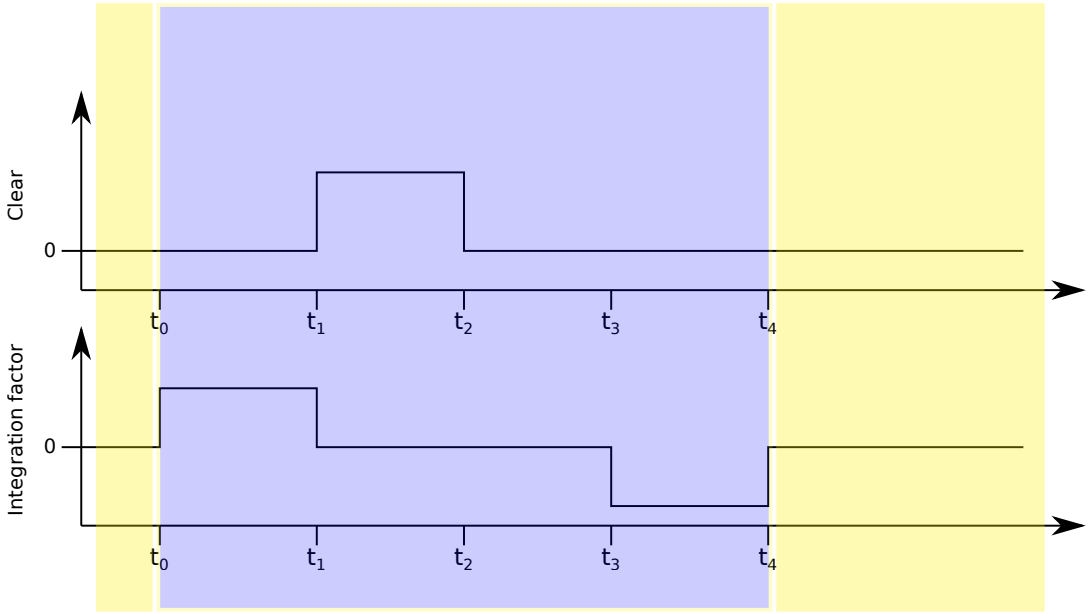


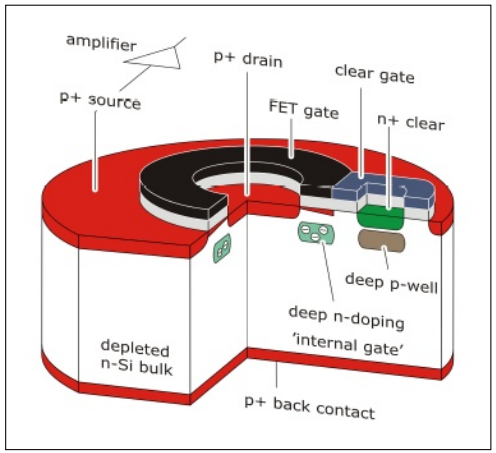


35mm is optimal deplacement for maximal high count rate efficiency

(see defocusing report ECAP-WFI-DEFOC-20150727)

The DEPFET Readout





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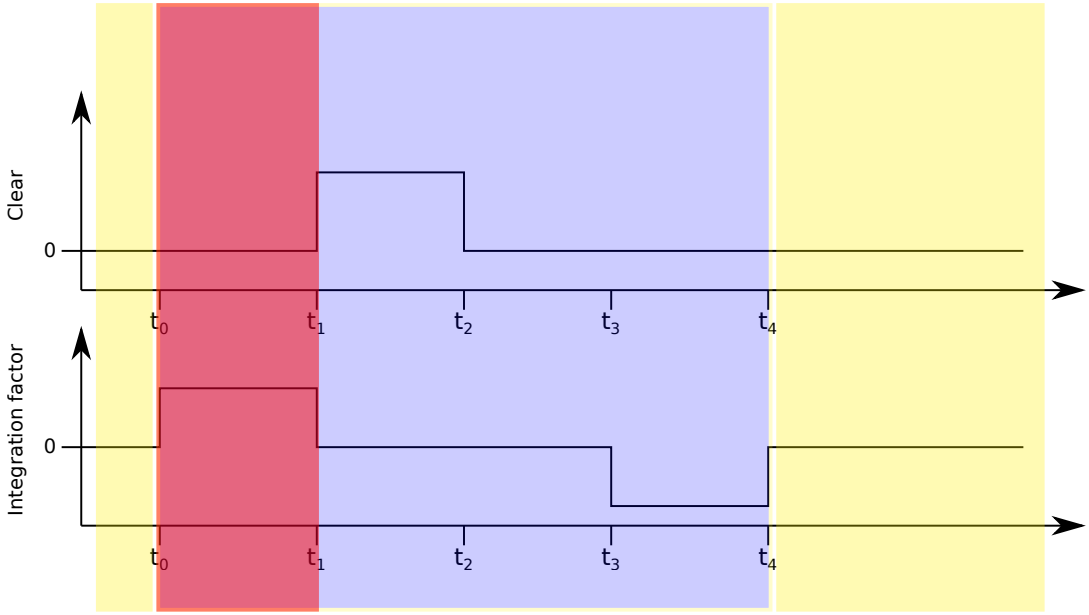

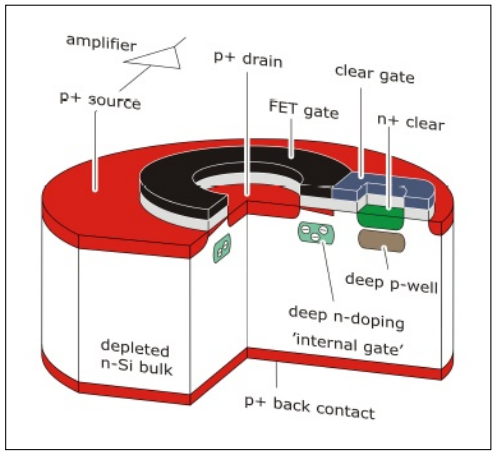

- 1st integration

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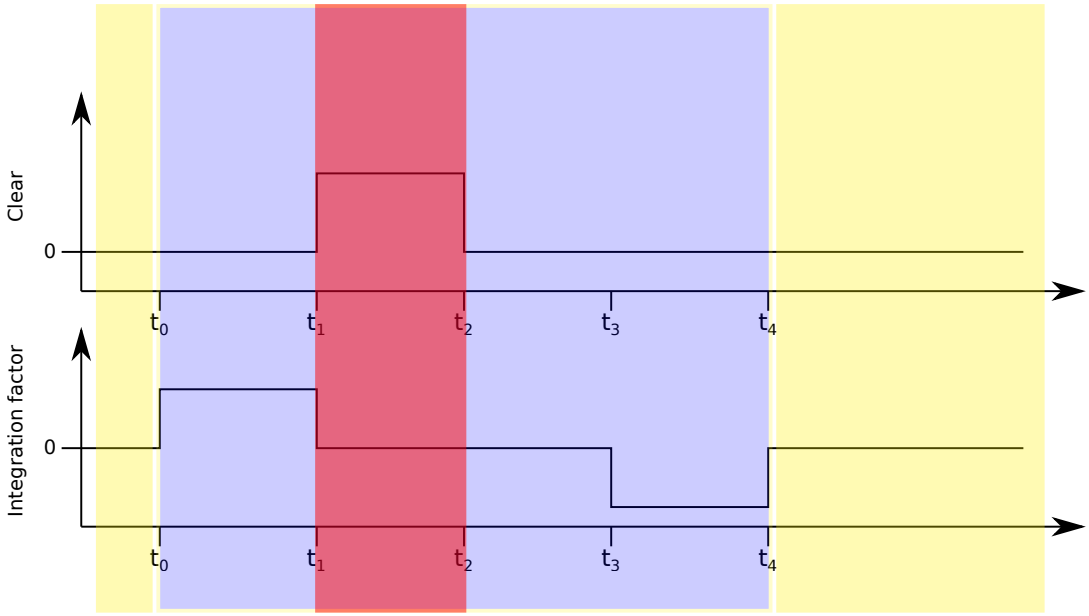
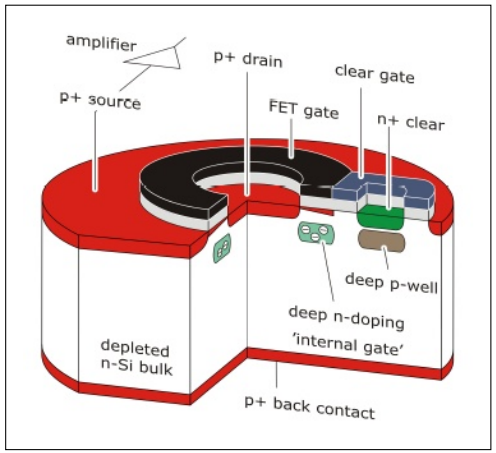
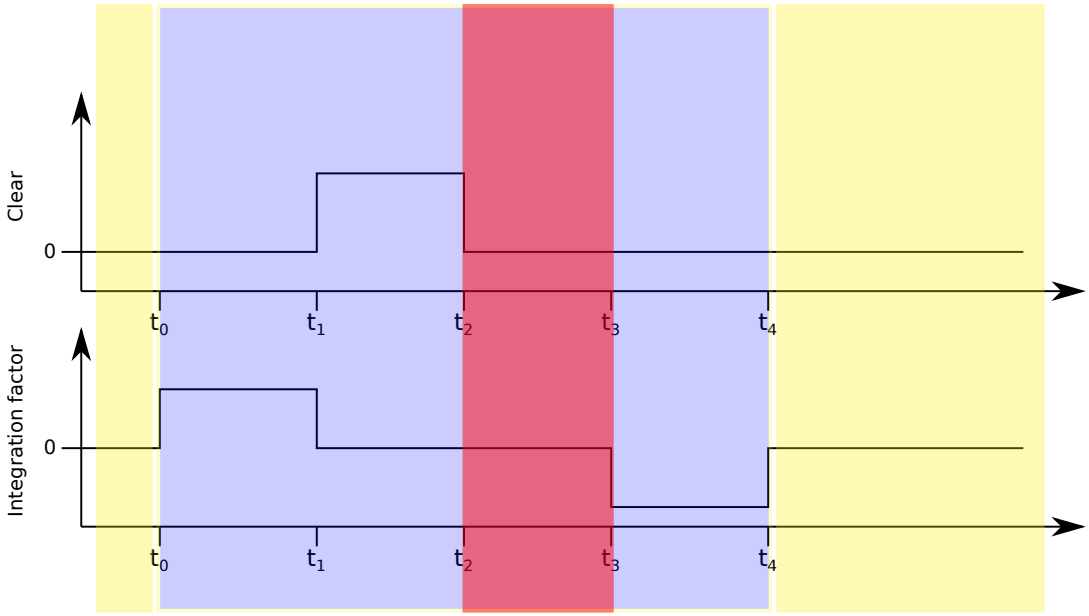
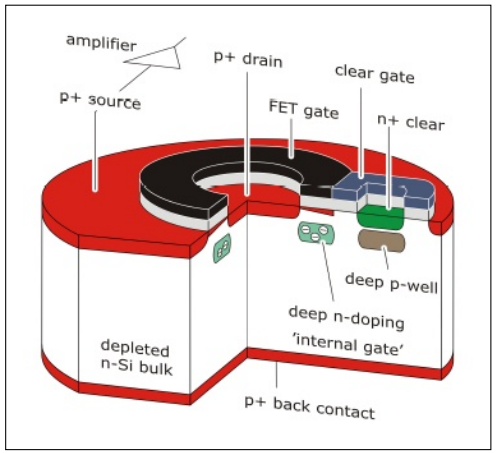




- 1st integration
- clear

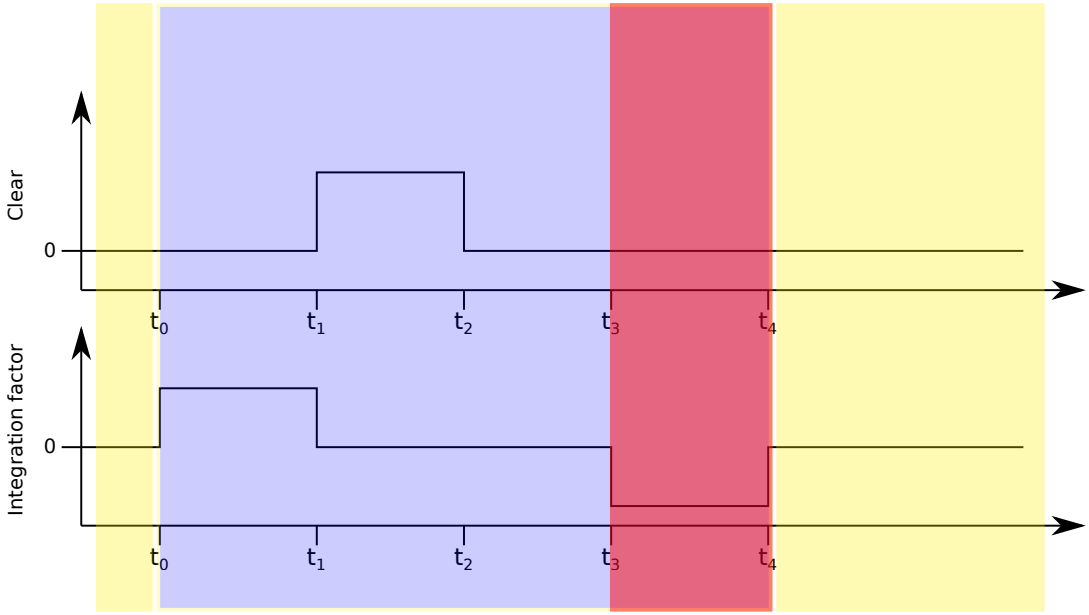
The DEPFET Readout

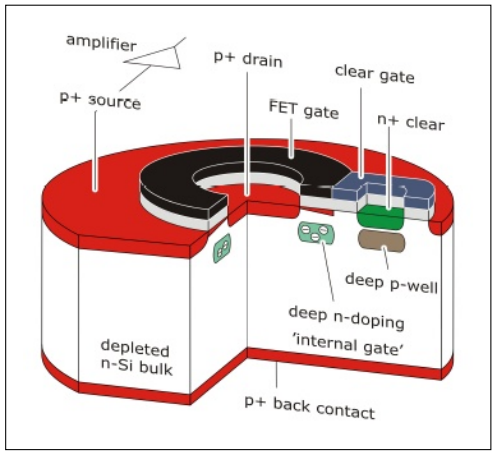




- 1st integration
- clear
- settling

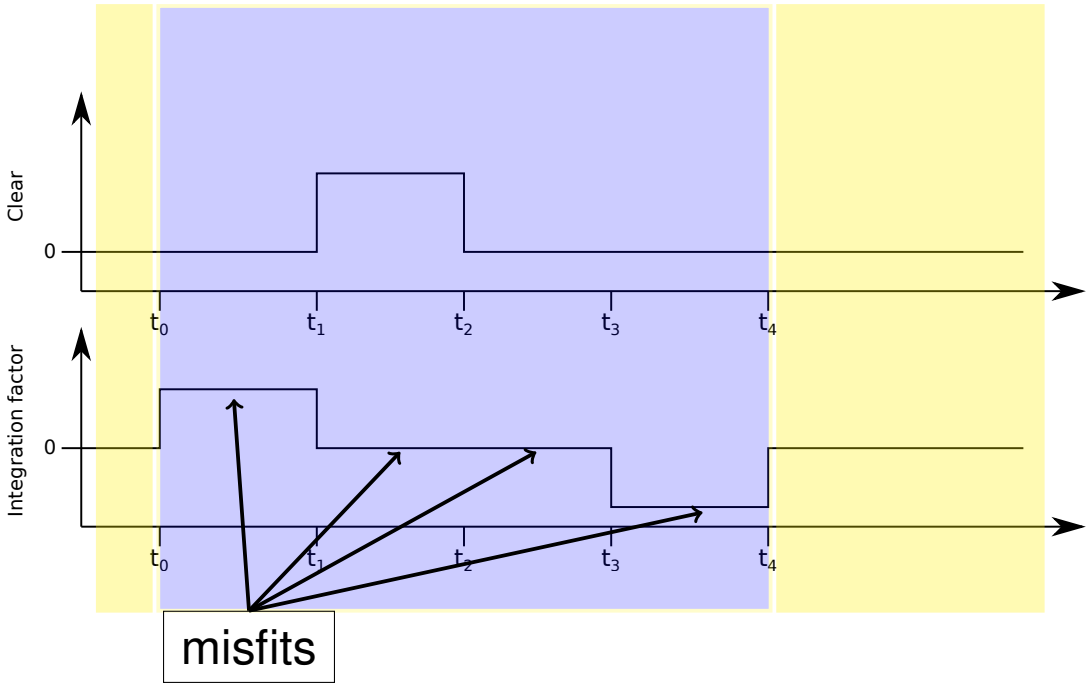
The DEPFET Readout

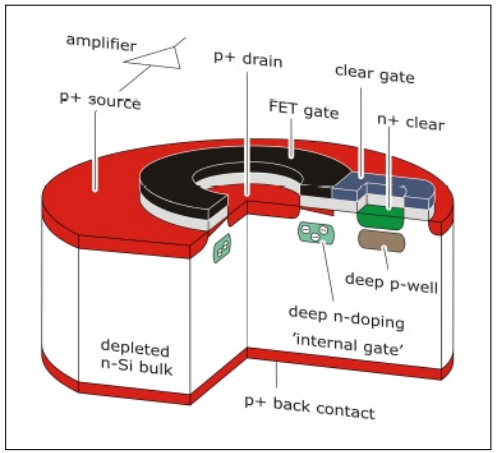




- 1st integration
- clear
- settling
- 2nd integration

The DEPFET Readout





- 1st integration
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- 2nd integration

misfits: photon hit during readout ⇒ wrong energy or invalid event

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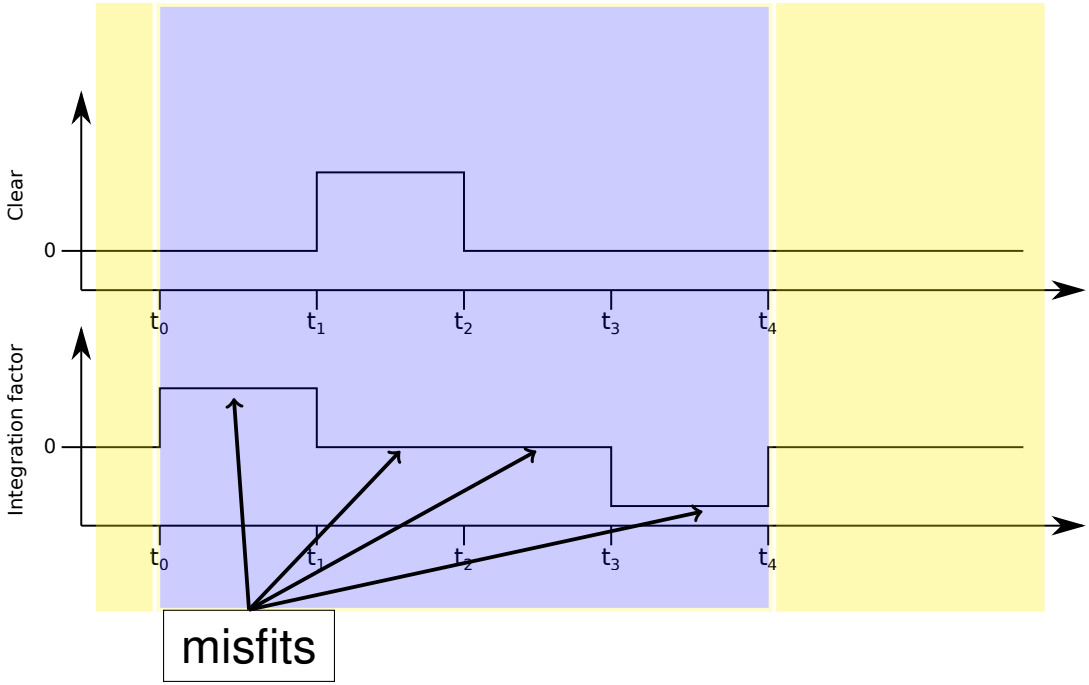
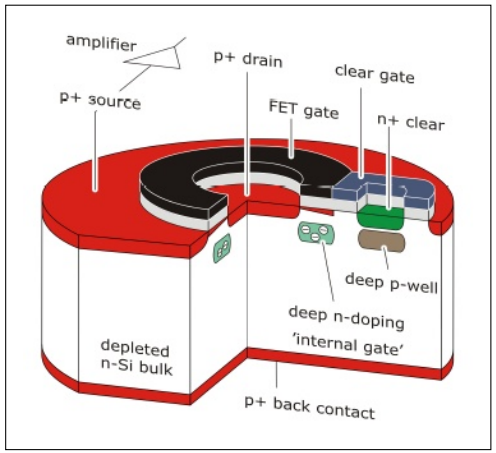




solution: ***gateable*** **DEPFET** (global charge transfer to shield the readout)

misfits: photon hit during readout ⇒ wrong energy or invalid event

The DEPFET Readout: resulting events

non-gateable DEPFET

	Δt	1st frame	2nd frame
transfer (global)	—	—	—
1st settling	0.1 μs	E_p	0
1st integ	1.0 μs	$\Delta t_{1,p} E_p$	0
clear	0.3 μs	< 0	$\Delta t_{0,p} E_p$
2nd settling	0.1 μs	< 0	E_p
2nd integ	1.0 μs	< 0	E_p

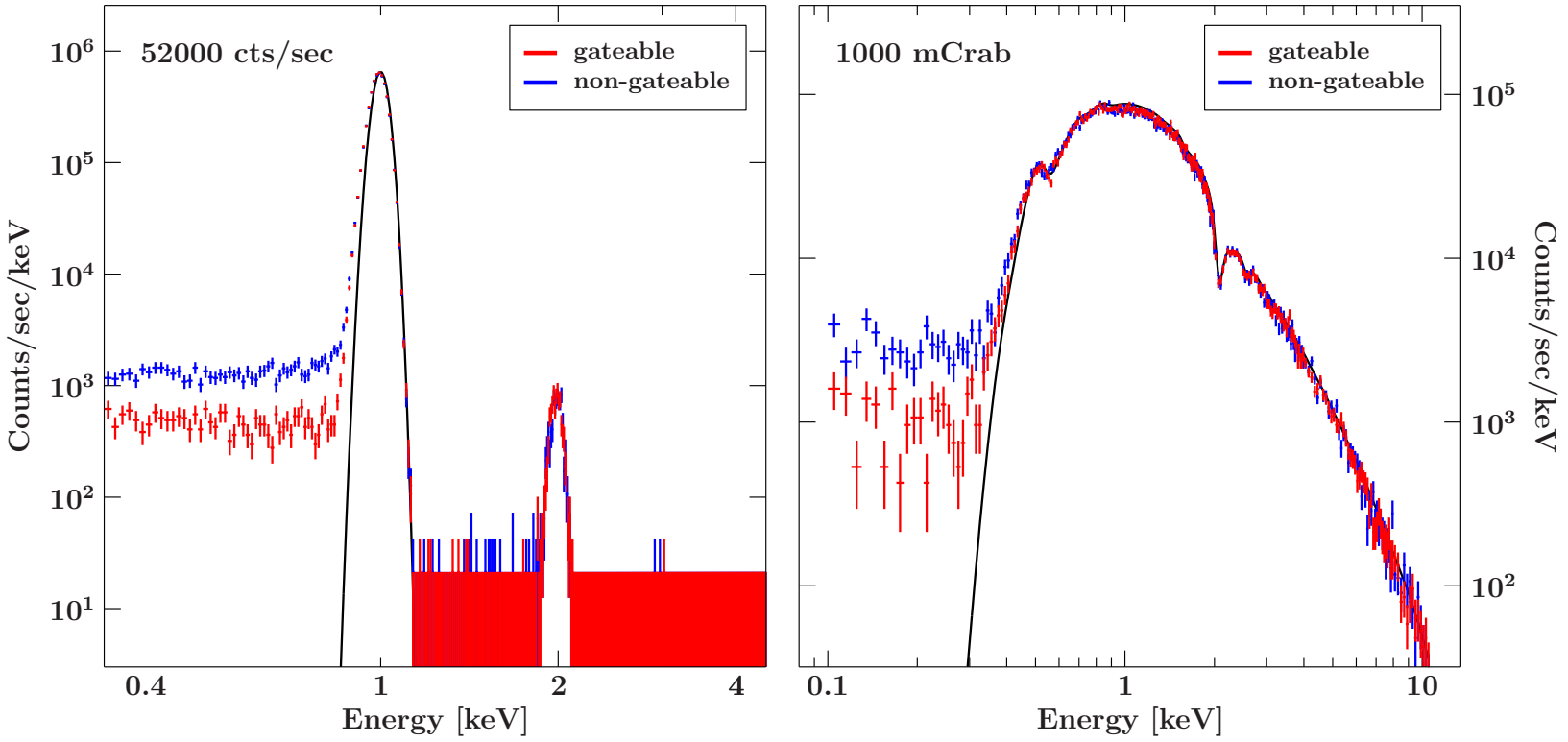
gateable DEPFET

	Δt	1st frame	2nd frame<
transfer (global)	0.2 μs	$\Delta t_{p,0} E_p$	$\Delta t_{1,p} E_p$
1st settling	0.1 μs	E_p	0
1st integ	1.0 μs	E_p	0
clear	0.2 μs	0	$\Delta t_{p,0} E_p$
2nd settling	0.1 μs	E_p	0
2nd integ	1.0 μs	E_p	0

time of the photon hit determines the measured event energy

fraction of ***misfits*** increased by more frequent readout (negligible for large chip)

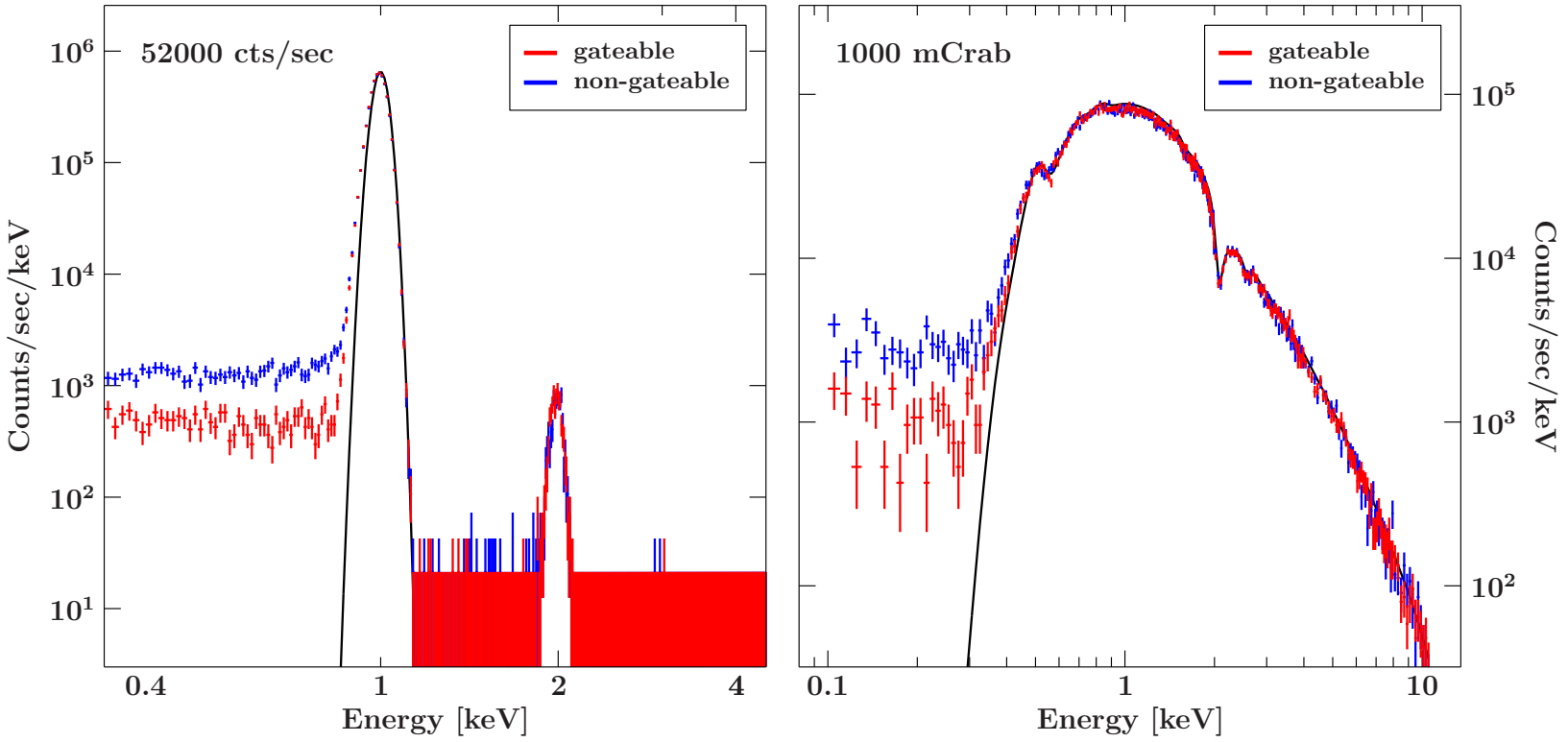
Comparing gateable vs. non-gateable DEPFET



Line and Crab spectrum show only **small differences**

→ 2.1% (non-gateable) and 0.75% (gateable) misfits expected for the *defocused 64x64 mode*

Comparing gateable vs. non-gateable DEPFET



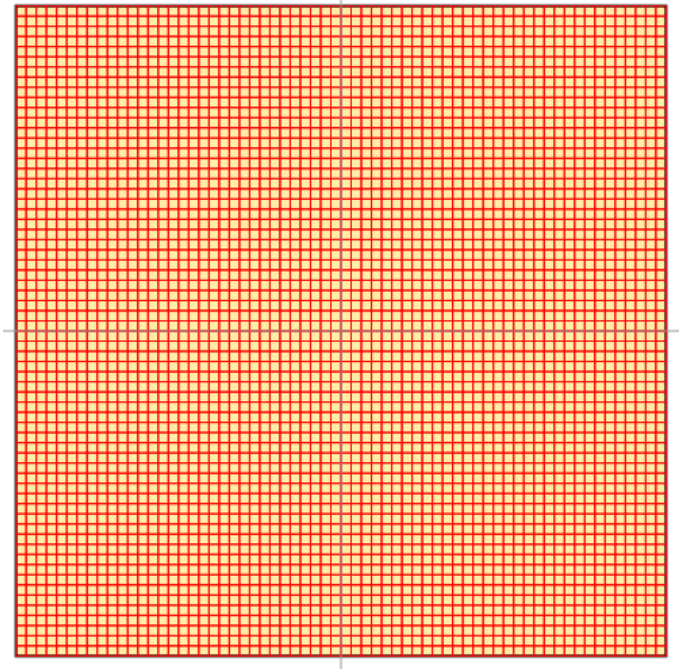
Line and Crab spectrum show only **small differences**

→ 2.1% (non-gateable) and 0.75% (gateable) misfits expected for the *defocused 64x64 mode*

misfit fraction does **not** depend on count rate → possible calibration?

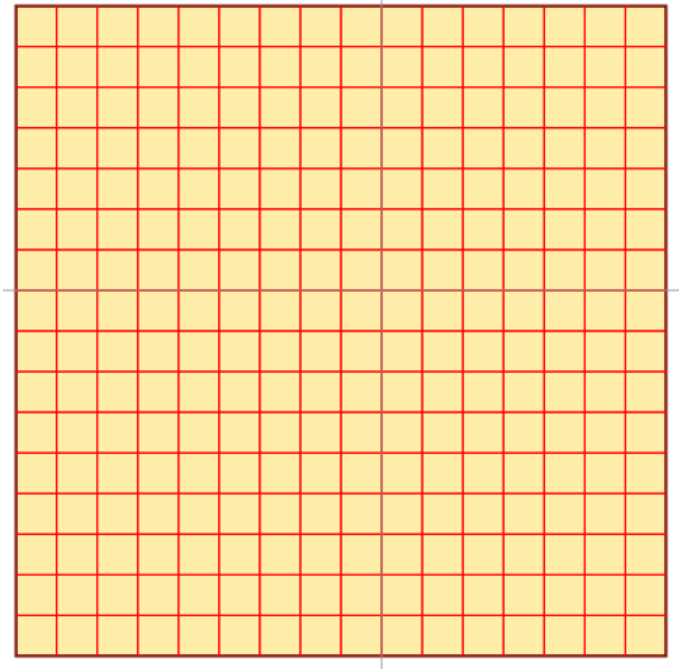
The WFI Bright Source Performance

fast array (64x64)



- 130 μm pixel size
- 2 halves of 32x64 pixels
- frame time: 80μs

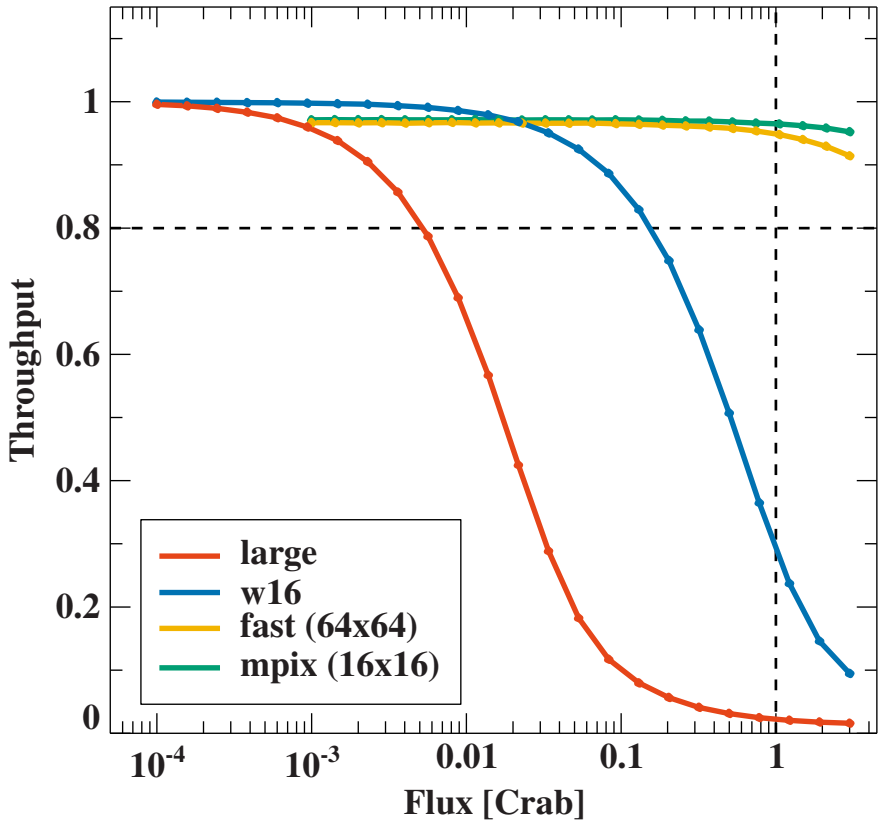
macro pixel array (16x16)

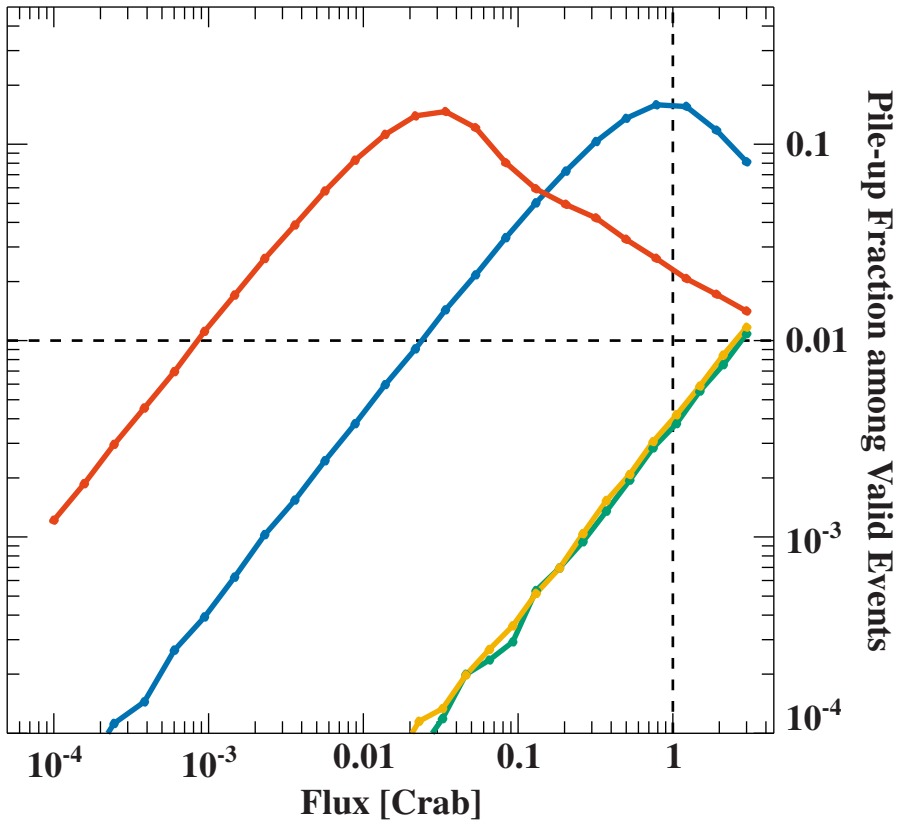


- 550 μm pixel size
- single pixel readout
- frame time: 2.5μs

(both configurations are defocused by 35 mm)

The WFI Bright Source Performance

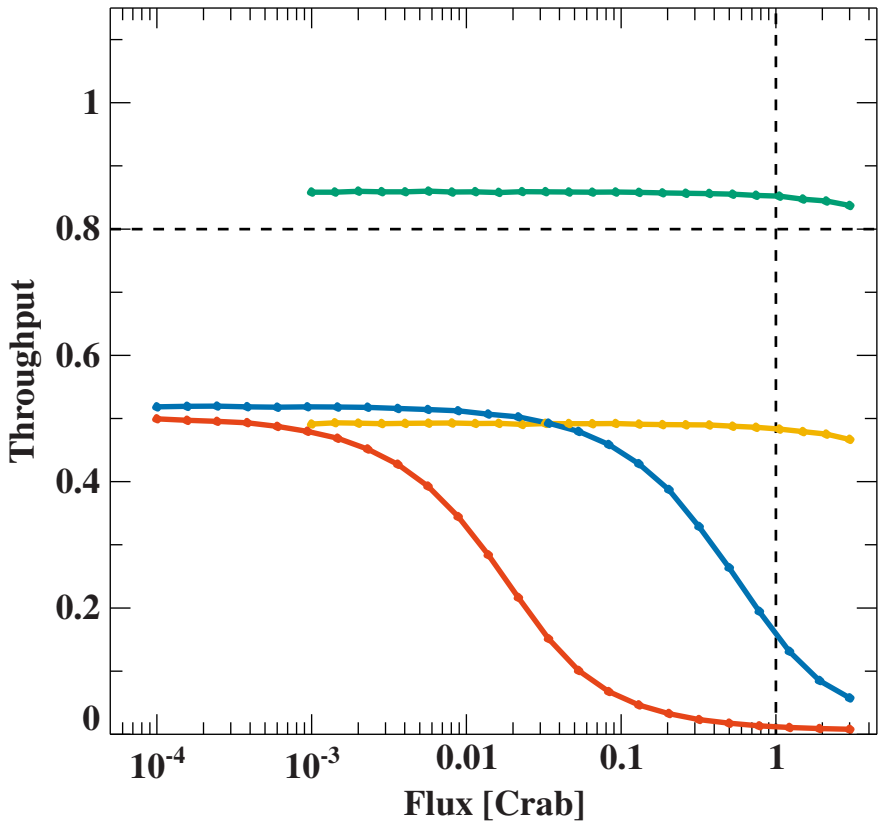


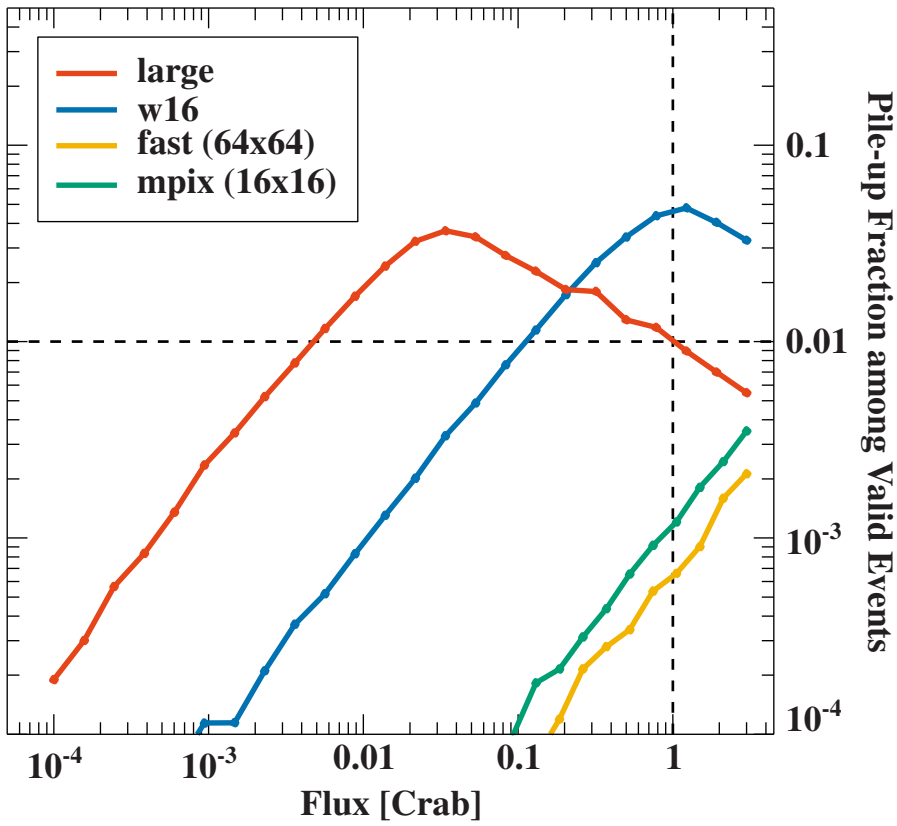


Characterize the performance: **Throughput** and **Pile-up Fraction**

(throughput is the ratio between valid events and incident photons)

The WFI Bright Source Performance: Only Single Events

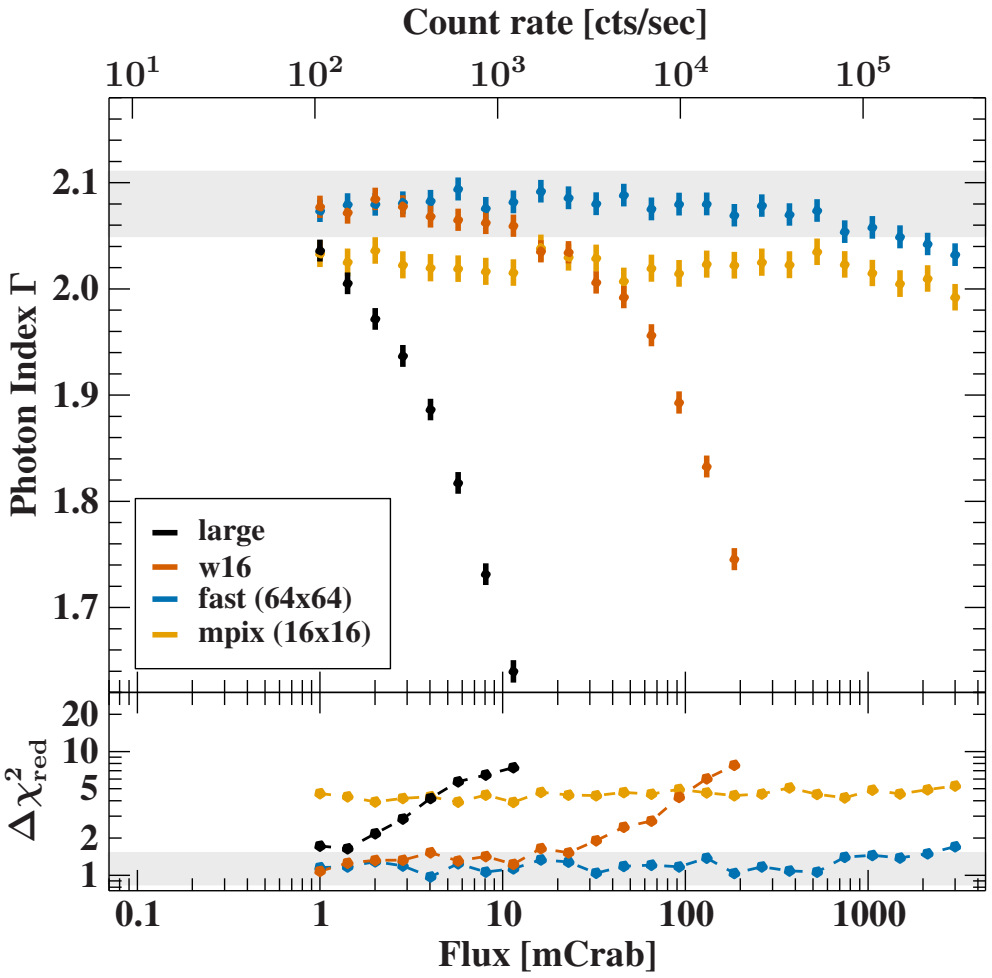




selecting only **single patterns reduce pile-up**, but also throughput

due to the large pixels mainly singles for the `mpix` → much larger throughput at low pile-up fraction

The WFI Bright Source Performance: Spectral Stability



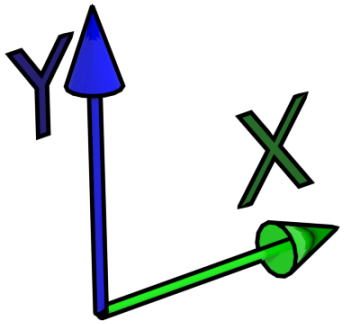
Crab-like spectra with fixed number of counts

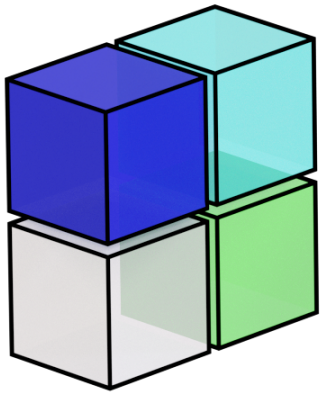
good performance at high count rates

mpix has larger problems with DEPFET misfits → calibration?

Pattern Recombination: Intra-Frame Splits

line-wise readout can split doubles and higher order patterns
$\rightarrow$ not taken into account in the pattern analysis





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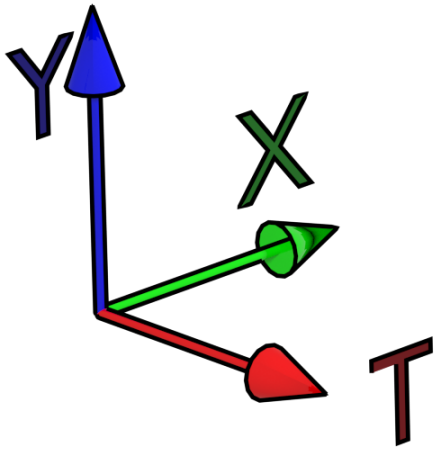
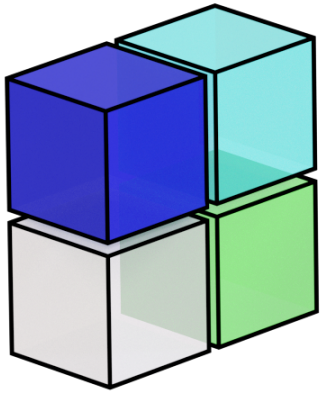
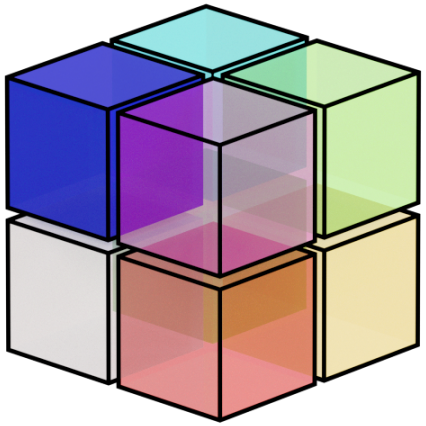


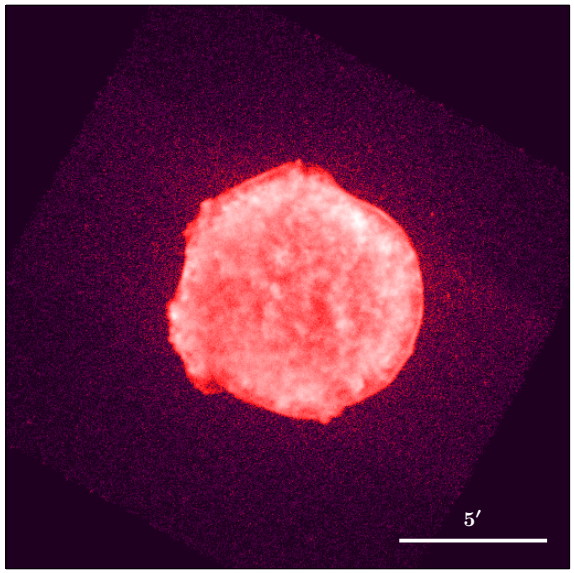




combining intra-frame split events results in increased pile-up

Summary

- full e2e simulations of fast chip
- defocusing needed for bright source capabilities
- misfits in DEPFET readout:
  $\rightarrow$ gateable version marginally better
  $\rightarrow$ linear effect (calibration?)
- 64x64 fast and 16x16 macro pixel array
  $\rightarrow$ **fulfill science requirements**



Next Steps

- **user documentation**
- study DEPFET calibration for macro pixel configuration
- construct new RMFs with MC approach (geant not sufficient $\Rightarrow$ better cross sections, charge diffusion, . . .)
- simulation of calibration uncertainties (ARF, energy resolution, . . .)