SIXTE implementation of the WFI

T. Dauser, for the WFI e2e team

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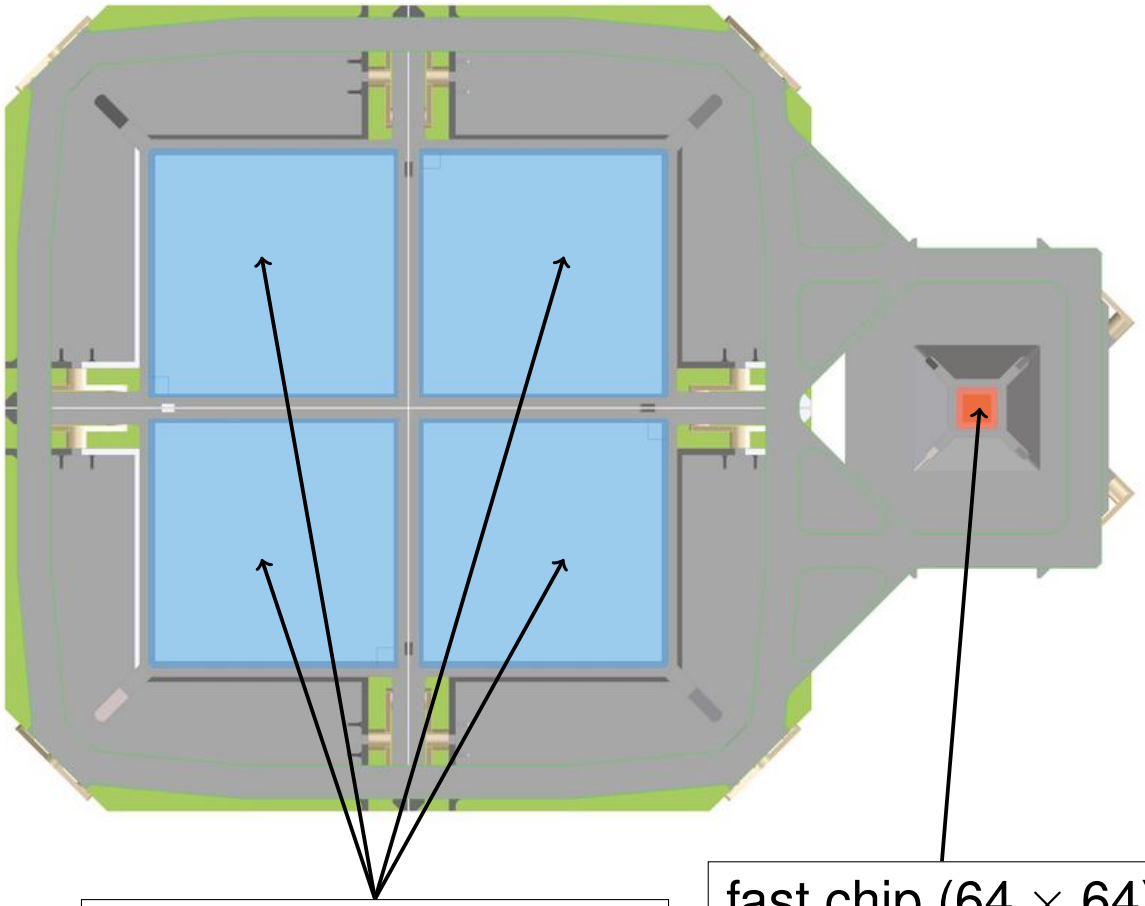
FRIEDRICH-ALEXANDER
UNIVERSITÄT
ERLANGEN-NÜRNBERG

ERLANGEN CENTRE
FOR ASTROPARTICLE
PHYSICS

ATHENA

WFI focal plane



- pixel size 130 μm
- $\Delta E < 150$ eV @6 keV
- large FOV: $40' \times 40'$

fast chip is mounted defocused by **35 mm** and with possible multiple line readout

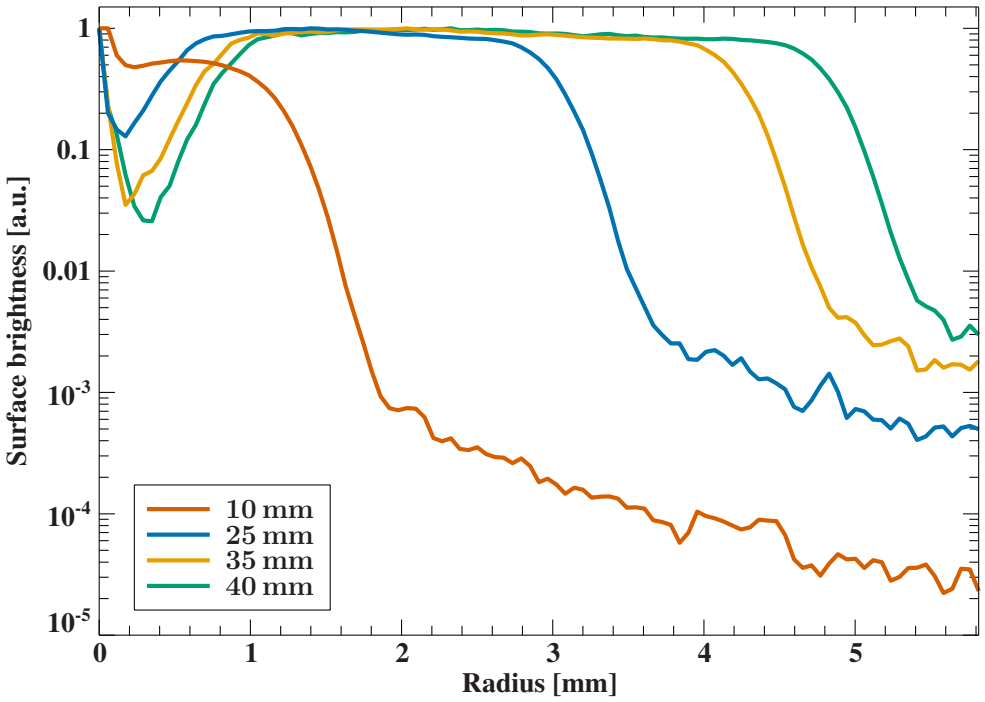
$\Rightarrow$ study bright sources

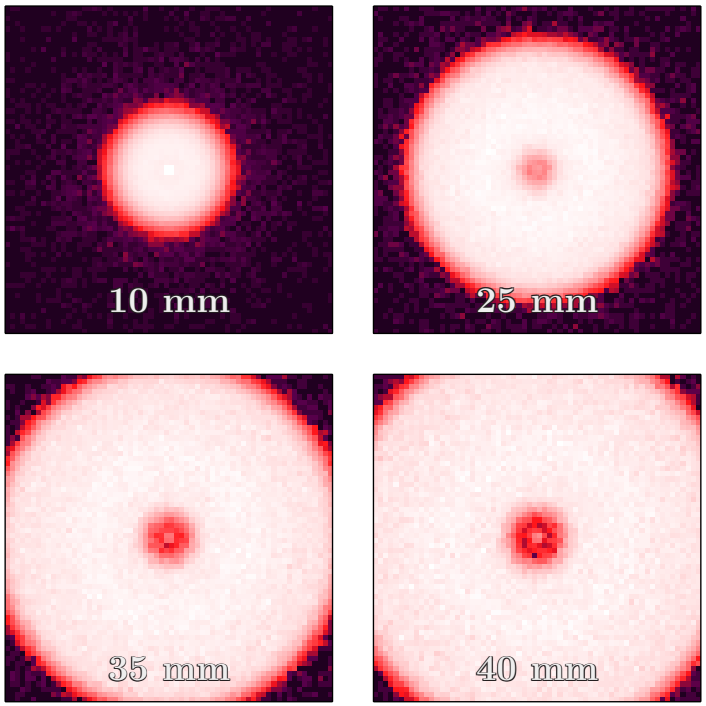
$\Rightarrow$ time res. 80 μsec

Defocusing of the Fast Chip

defocusing necessary to fulfill high count rate science requirements

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





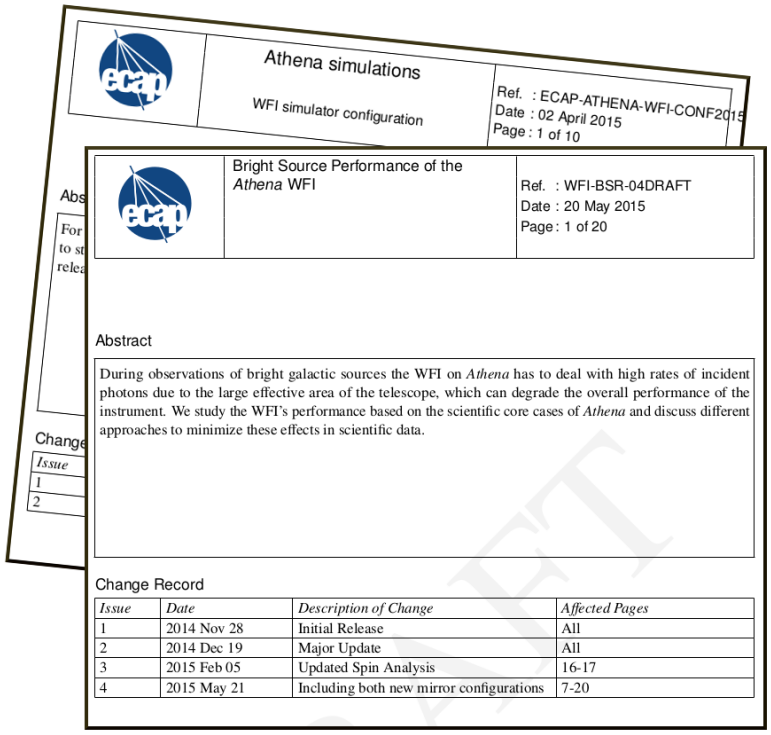
35mm is optimal deplacement for maximal high count rate efficiency

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

Detector Parameters

Practical issues: there were (slightly) inconsistent detector parameters between different simulations

$\Longrightarrow$ documents summarizing *all* relevant WFI parameters (PSF, ARF, RMF, ...), including bright source performance, defocus study, ...


Athena simulations

WFI simulator configuration

Ref. : ECAP-ATHENA-WFI-CONF2015
Date : 02 April 2015
Page : 1 of 10

Bright Source Performance of the *Athena* WFI

Ref. : WFI-BSR-04DRAFT
Date : 20 May 2015
Page : 1 of 20

Abstract

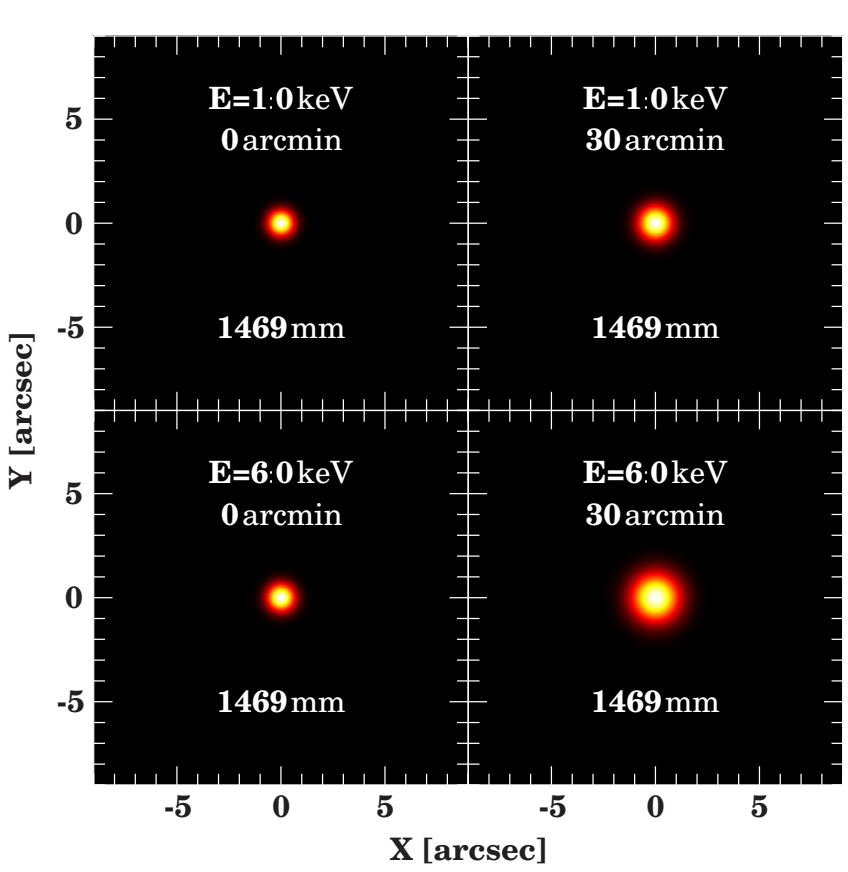
During observations of bright galactic sources the WFI on *Athena* has to deal with high rates of incident photons due to the large effective area of the telescope, which can degrade the overall performance of the instrument. We study the WFI's performance based on the scientific core cases of *Athena* and discuss different approaches to minimize these effects in scientific data.

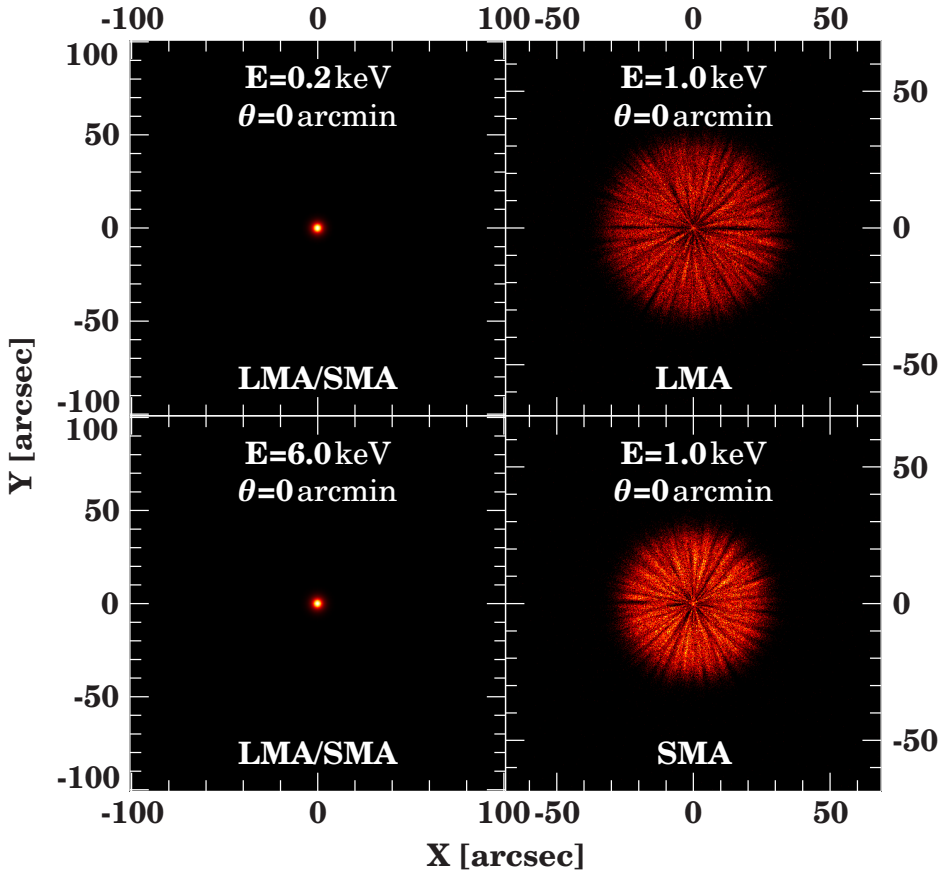
Change Record

Issue	*Date*	*Description of Change*	*Affected Pages*
1	2014 Nov 28	Initial Release	All
2	2014 Dec 19	Major Update	All
3	2015 Feb 05	Updated Spin Analysis	16-17
4	2015 May 21	Including both new mirror configurations	7-20

Definition: 1 Crab: tbnew(E) $\times AE^{-\Gamma}$ with $A = 9.5\,\mathrm{ph\,keV^{-1}\,cm^{-2}\,s^{-1}}$, $\Gamma = 2.1$, $N_\mathrm{H} = 4 \times 10^{21}\,\mathrm{cm^{-2}}$ using `wilm`(!) abundances
$\Longrightarrow$ 115 kcts/s (large ARF) and 87 kcts/s (small ARF)

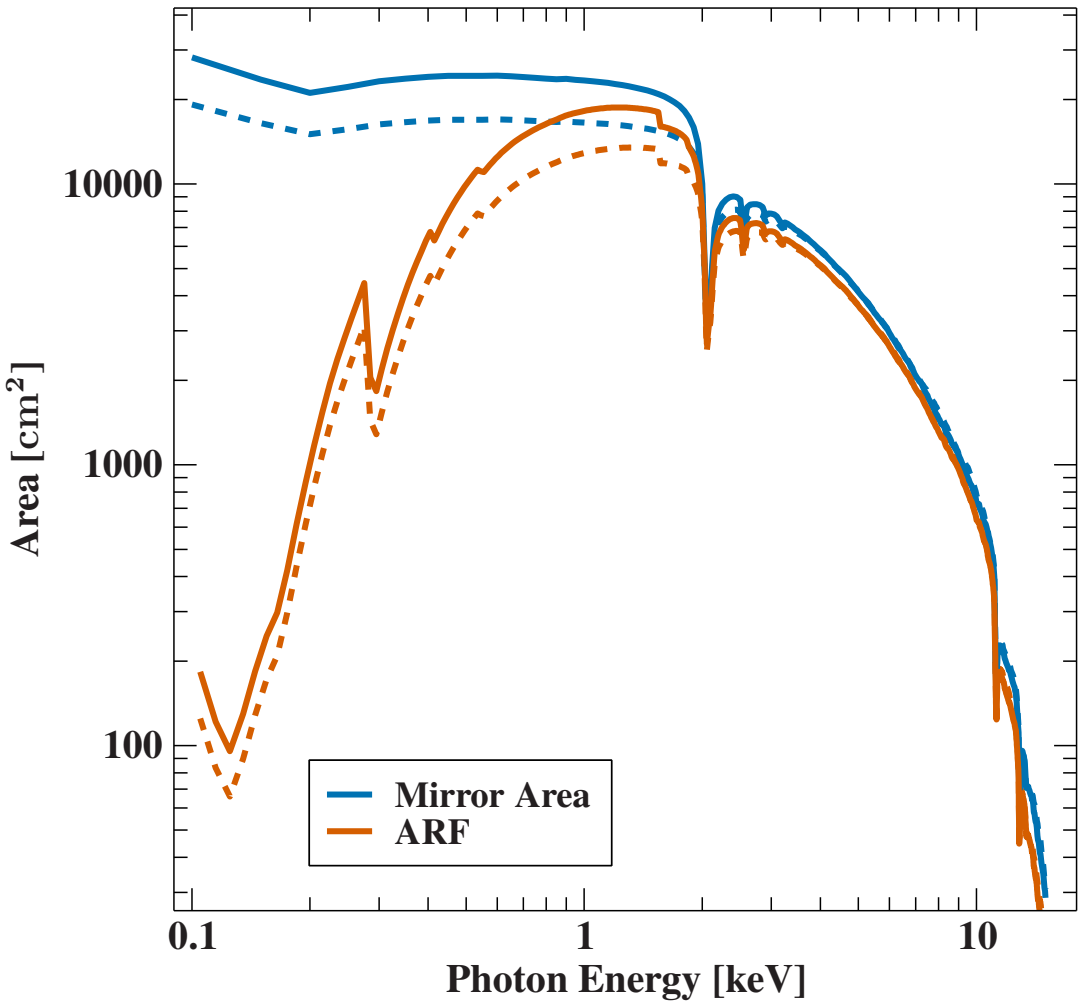
Detector Parameters: PSF





Energy and position dependent PSF (data from Dick Willingale)

Detector Parameters: ARF



Mirror area and ARF for different mirror assemblies

Detector setup

```
<?xml version="1.0"?>
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<telescope>
<arf filename="athena_sixte_wfi_1469_onaxis_w_filter_v20150504.arf"/>
<focallength value="12.0"/>
<fov diameter="1.0"/>
<psf filename="athena_1469_2.3_irb4c_psf.fits"/>
<vignetting filename="athena_1469_2.3_irb4c_vig.fits"/>
</telescope>

<detector>
<dimensions xwidth="512" ywidth="512"/>
<wcs xrpix="256.5" yrpix="256.5" xrval="0.0" yrval="0.0" xdelt="130.e-6" ydelt="130.e-6"/>
<depfet integration="1.0e-6" clear="0.3e-6" settling="0.1e-6" type="normal"/>
<rmf filename="athena_wfi_sixte_v20150504.rmf"/>
<phabackground filename="sixte_wfi_particle_bkg_20150430_large.pha"/>
<split type="GAUSS" par1="11.e-6"/>

<threshold_readout_lo_keV value="50.e-3"/>
<threshold_event_lo_keV value="50.e-3"/>
<threshold_split_lo_keV value="50.e-3"/>
<readout mode="time">
  <loop start="0" end="511" increment="1" variable="$i">
    <wait time="2.5e-6"/>
    <readoutline lineindex="$i" readoutindex="$i"/>
```
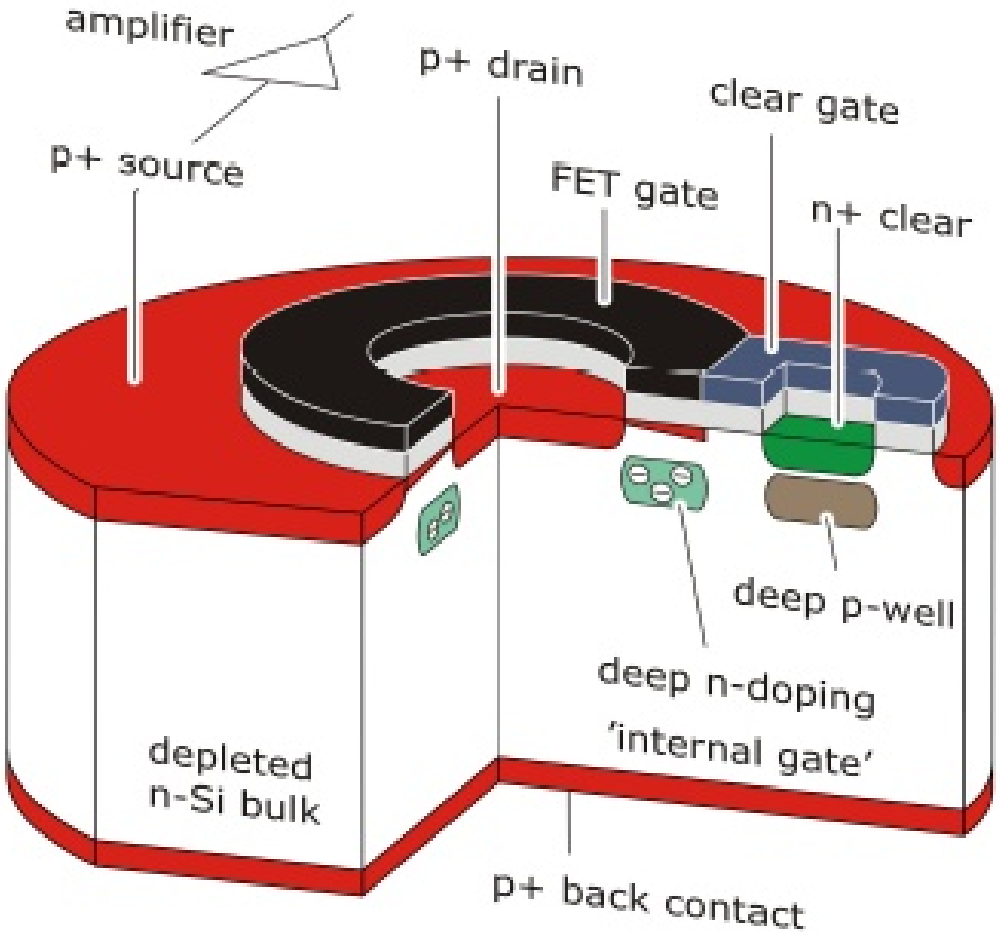
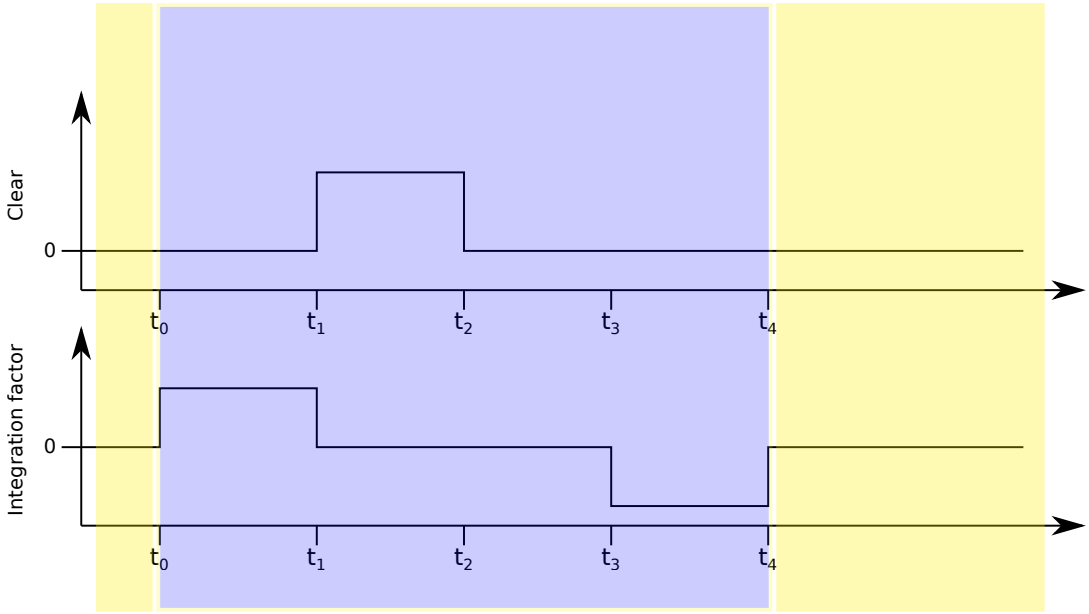

Detector is defined through XML file $\Longrightarrow$ allows **fast changes of design and background** (format can be easily extended)

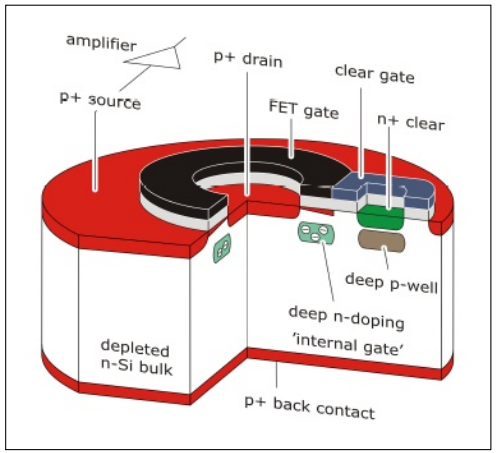
$\rightarrow$ ***extra session tomorrow***

The DEPFET Active Pixel Sensor

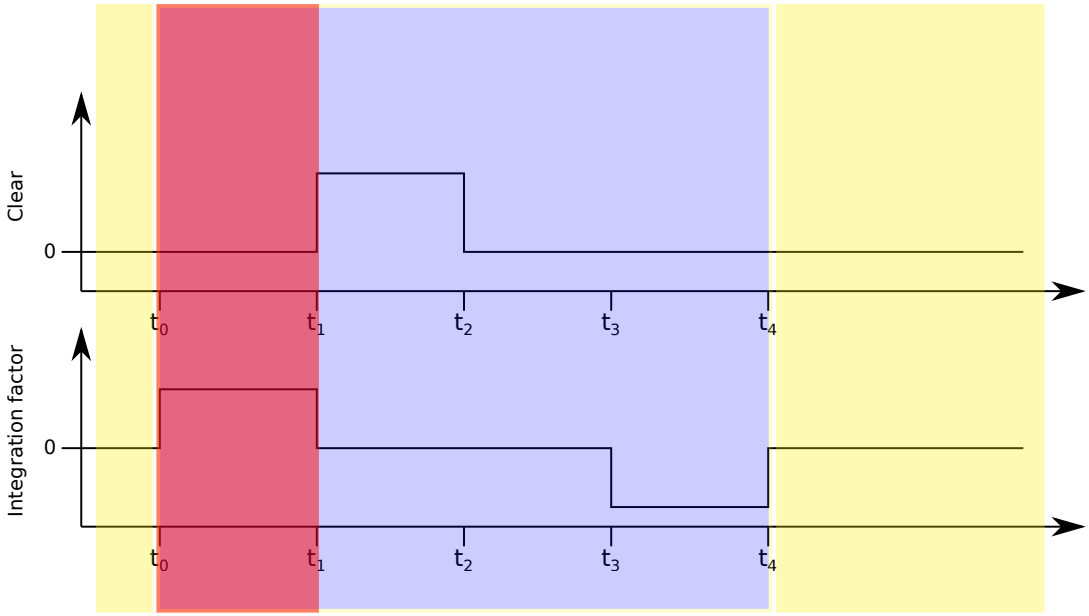


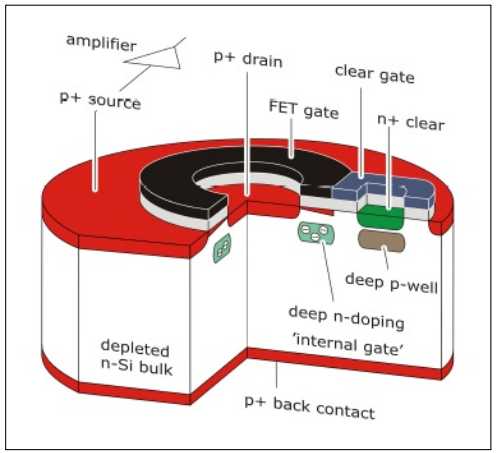
The DEPFET Readout





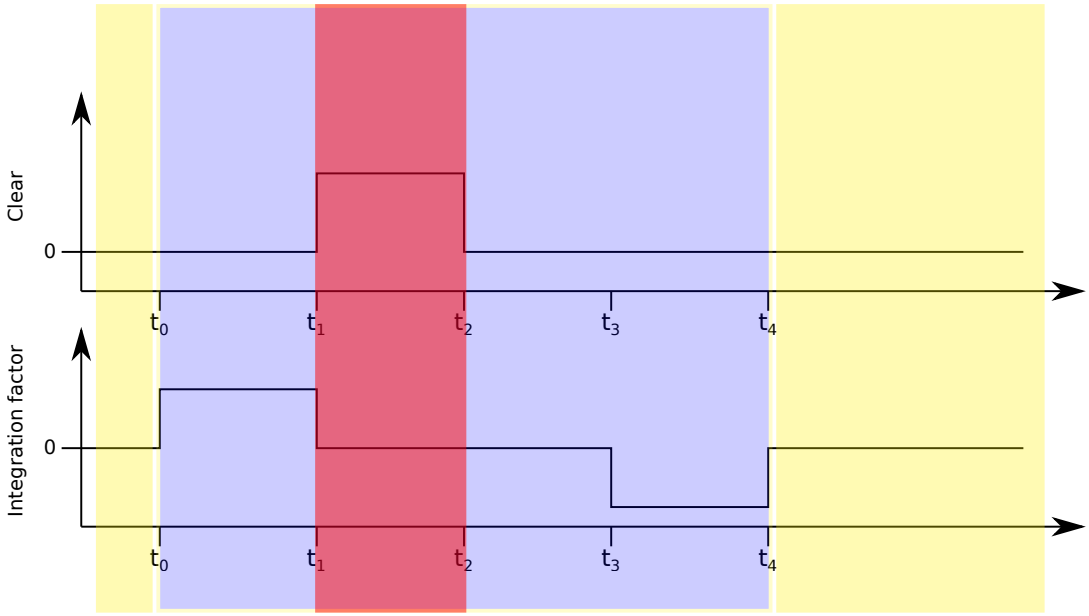
The DEPFET Readout

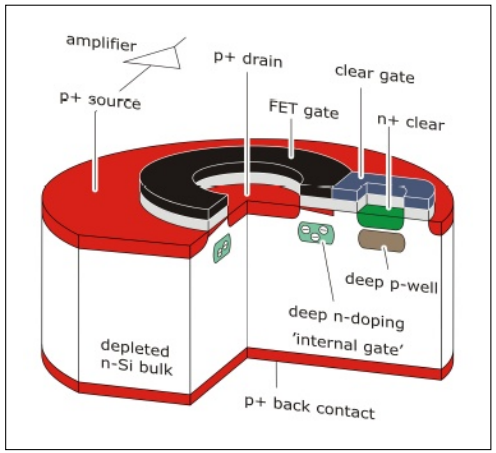




- 1st integration

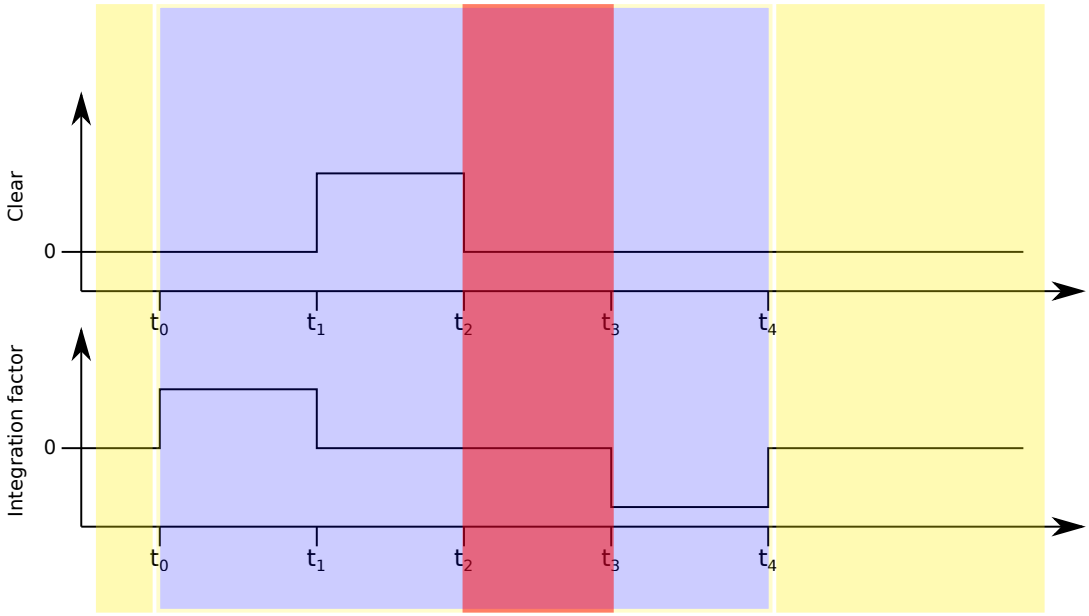
The DEPFET Readout

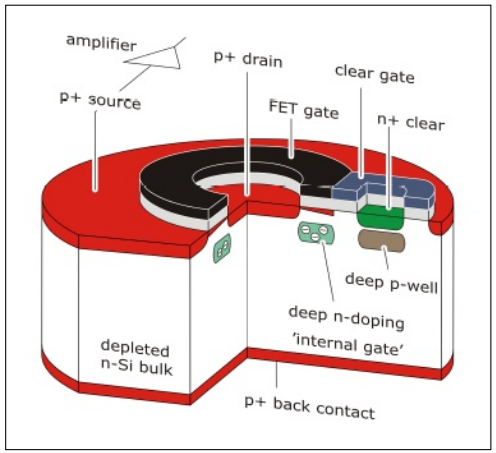




- 1st integration
- clear

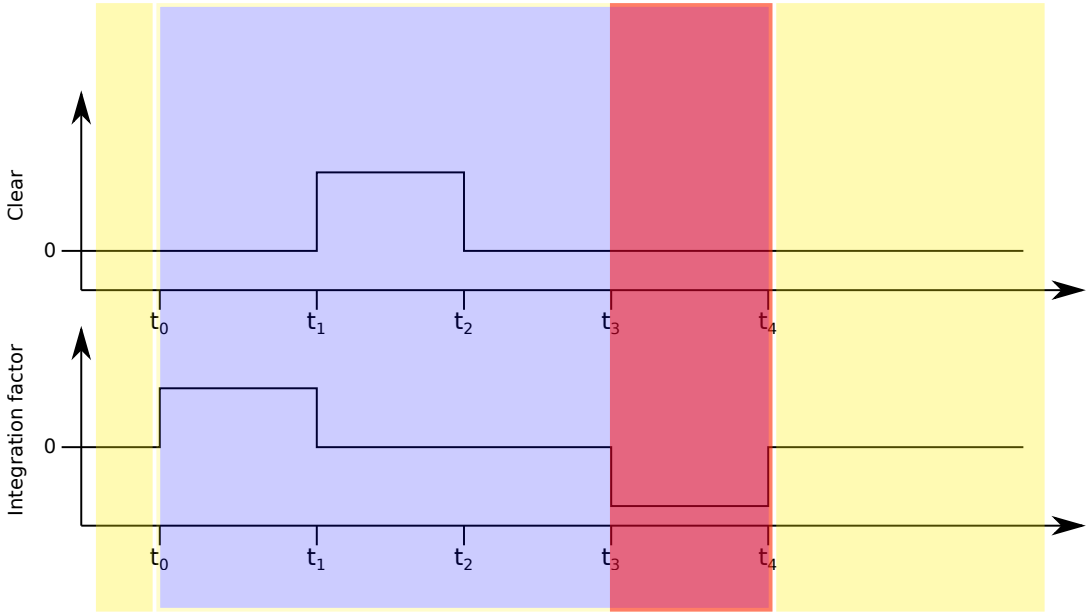
The DEPFET Readout

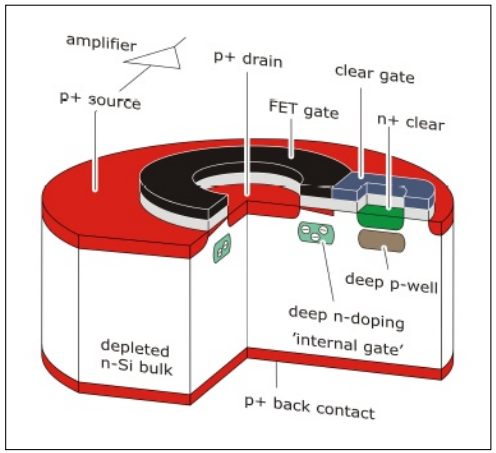




- 1st integration
- clear
- settling

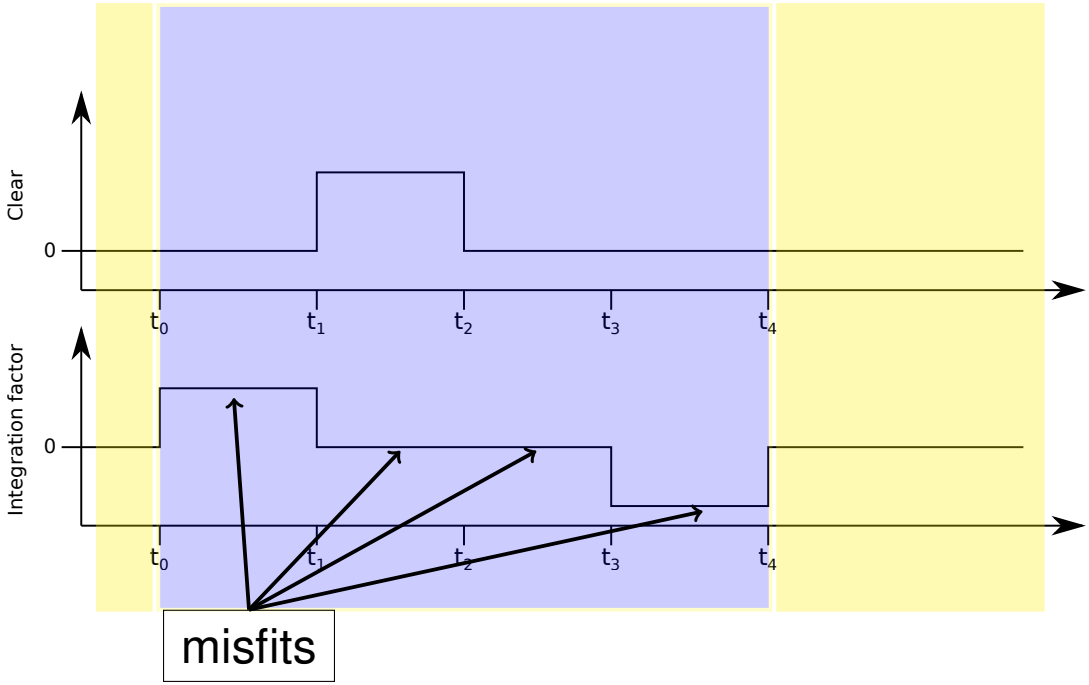
The DEPFET Readout

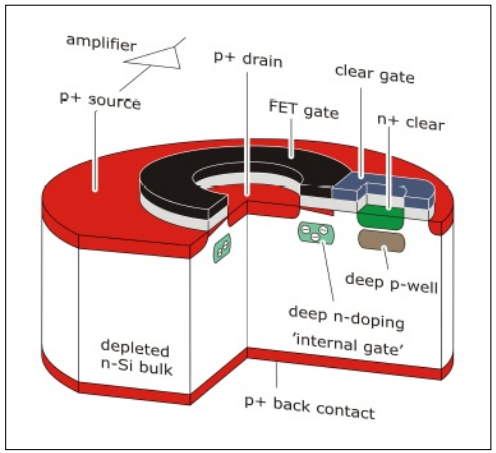




- 1st integration
- clear
- settling
- 2nd integration

The DEPFET Readout

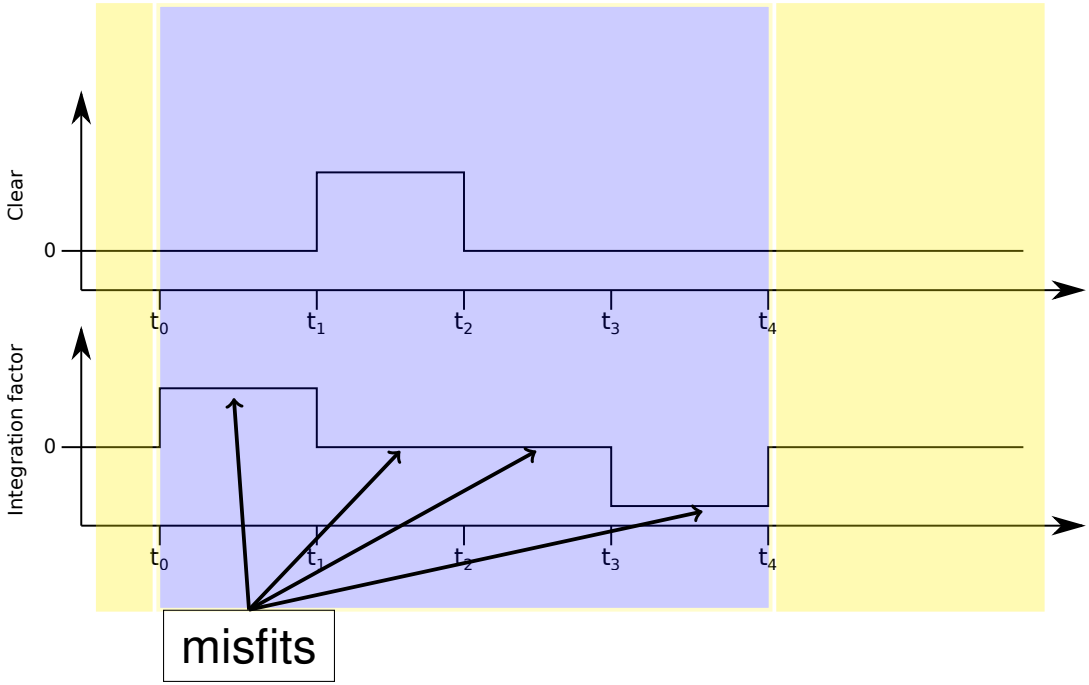


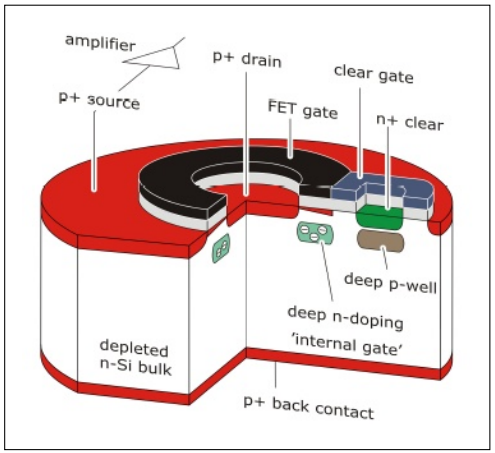


- 1st integration
- clear
- settling
- 2nd integration

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

The DEPFET Readout

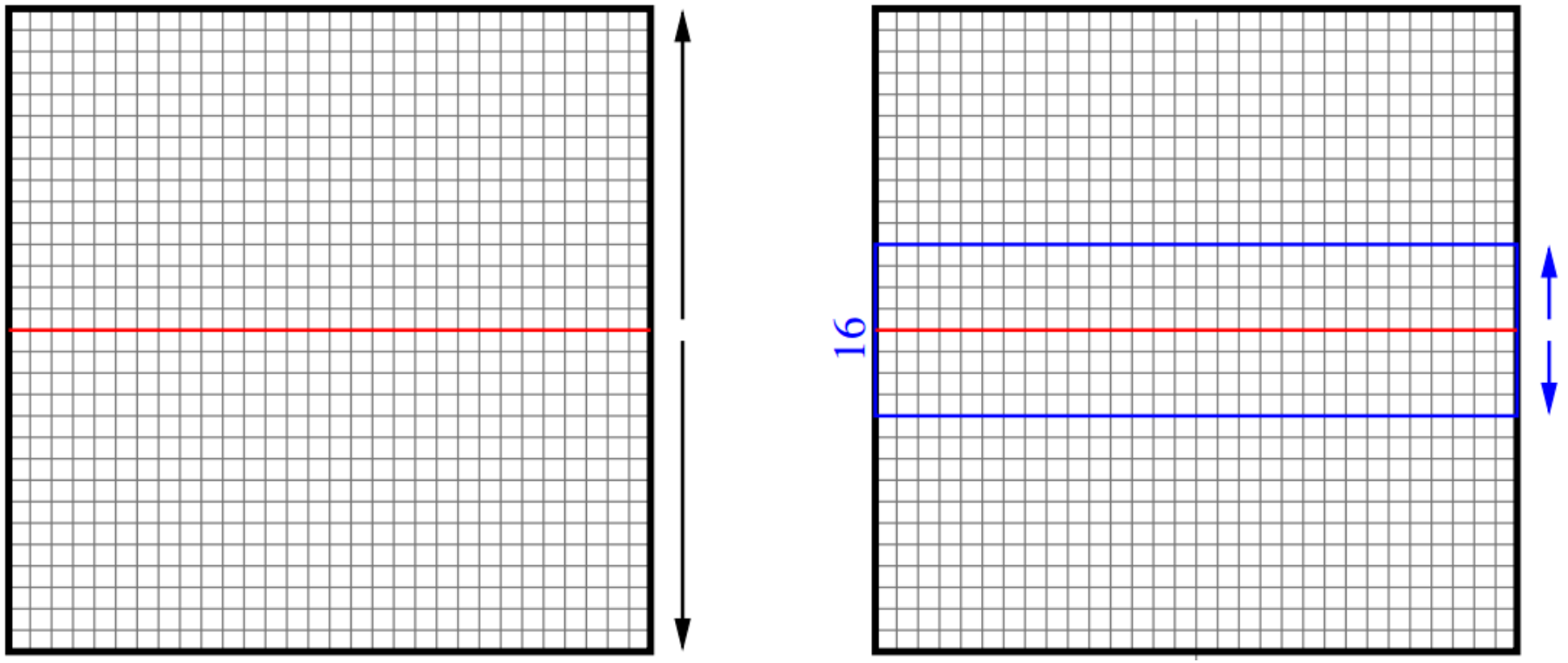




solution: ***gateable*** **DEPFET** (global charge transfer to shield the readout)

→ ***more informantion tomorrow in the "bright sources" session***

Different WFI Readout Modes



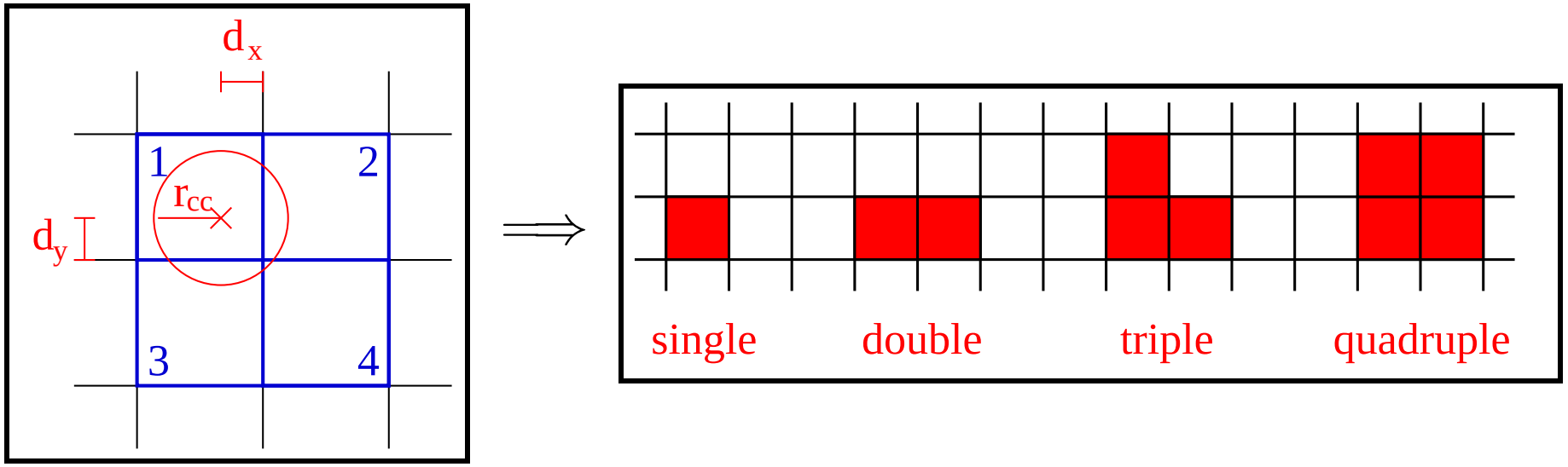
fast chip: full frame mode and window mode

Different DEPFET Readout Modes

Name	Size (rows × columns)	time resolution	XML name
fullframe	$4 \times (512 \times 512)$	$1280\,\mu s$	`depfet_b_1l_ff_chip[0,1,2,3].xml`
large	512×512	$1280\,\mu s$	`depfet_b_1l_ff_large.xml`
w16	16×512	$40\,\mu s$	`depfet_b_1l_ff_w16.xml`
fastdf	64×64	$80\,\mu s$	`depfet_b_1lph_ff_df35mm.xml`

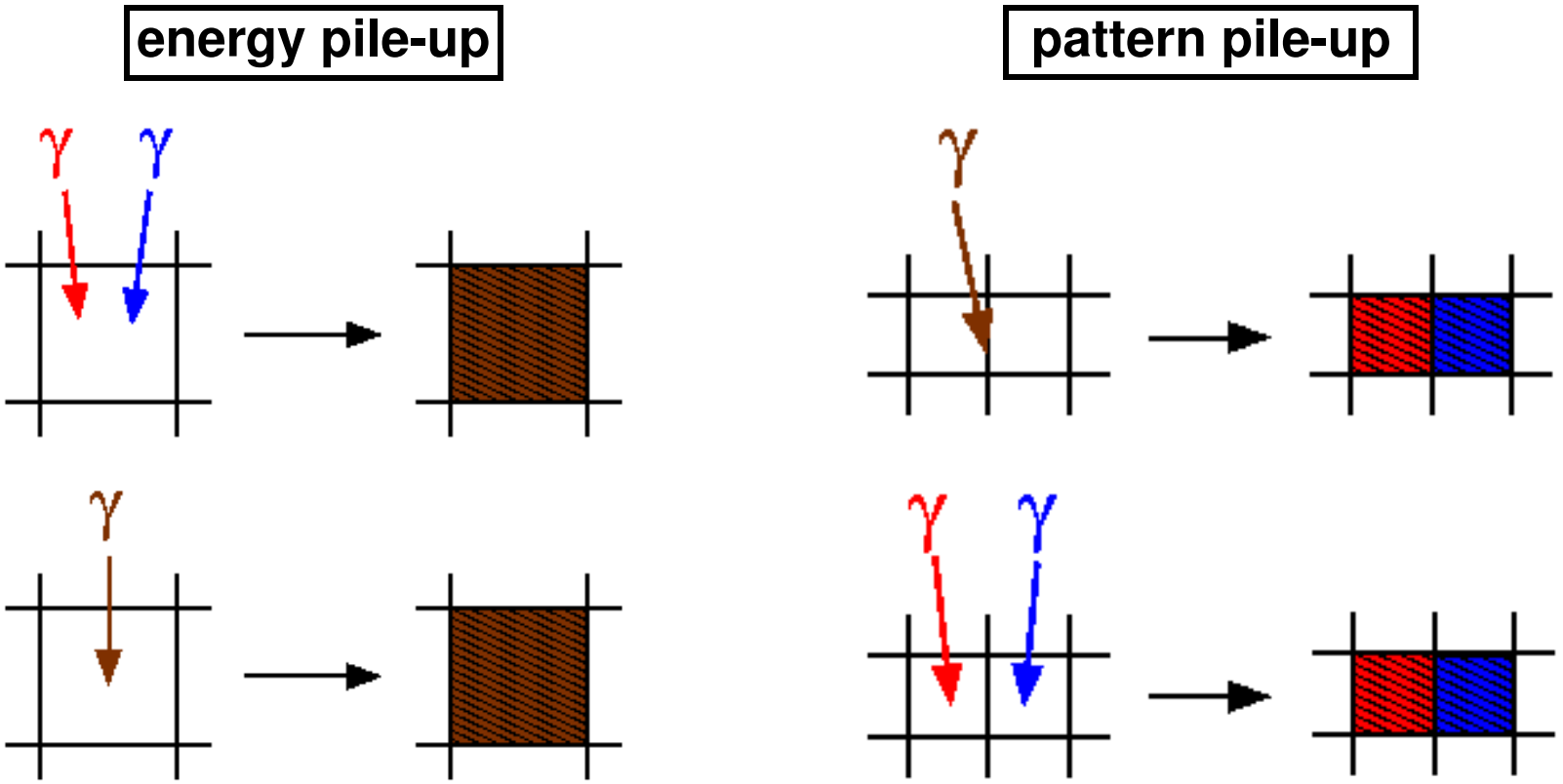
different modes for full frame (**ff**), window (**w**), and defocusing (**df**)

Event Detection in SIXTE for the WFI



patterns are recombined for each frame in the pattern analysis
$\Rightarrow$ invalid patterns rejected

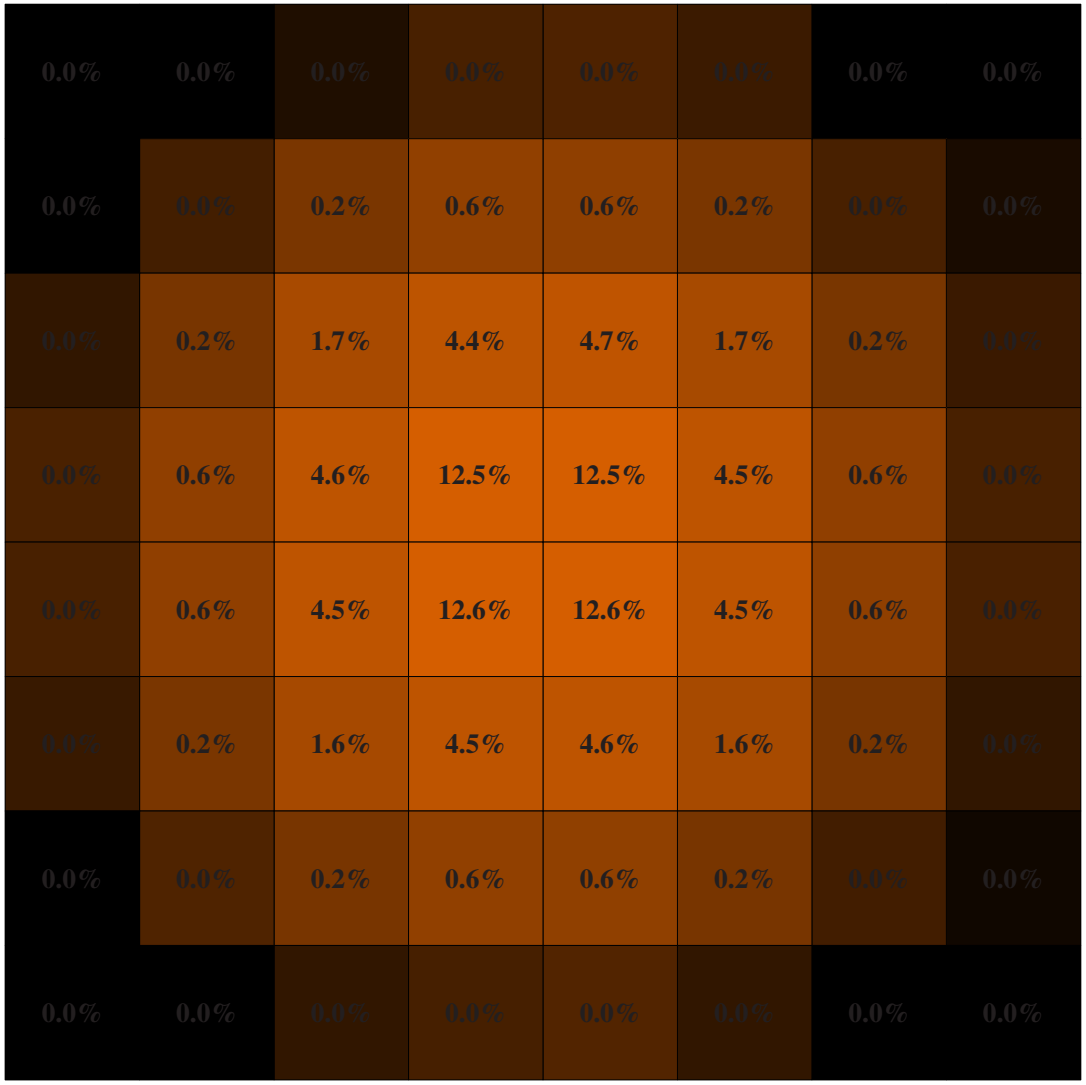
The different Pile-up Events



remove pattern pile-up by only selecting singles, however, energy pile-up still present

pile-up events distort spectral shape

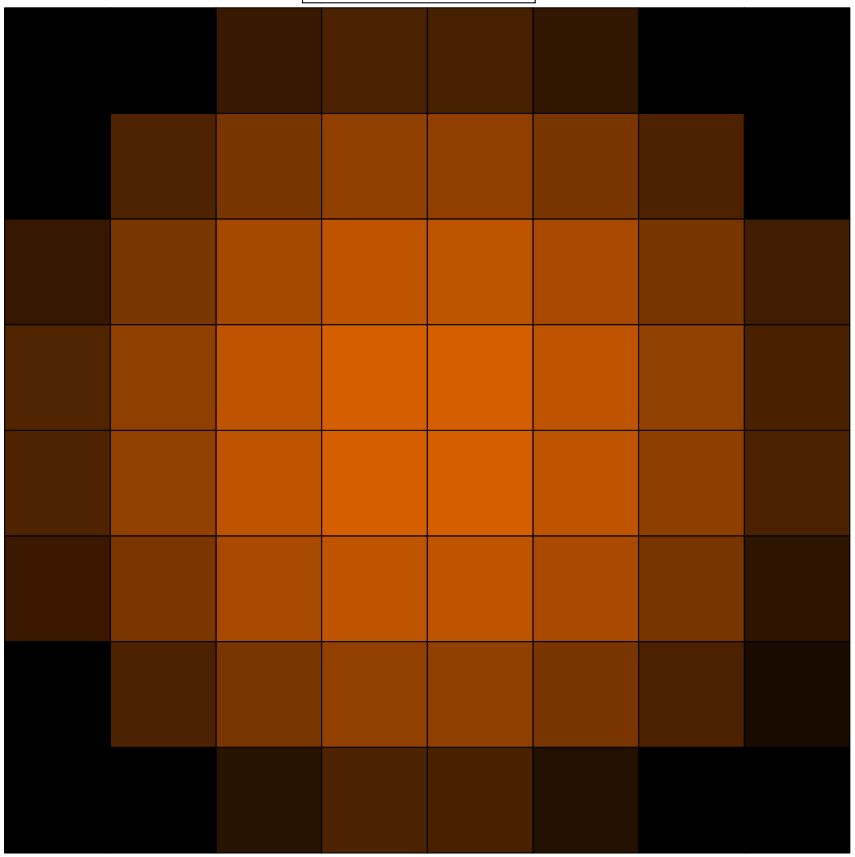
Valid Events on the Detector



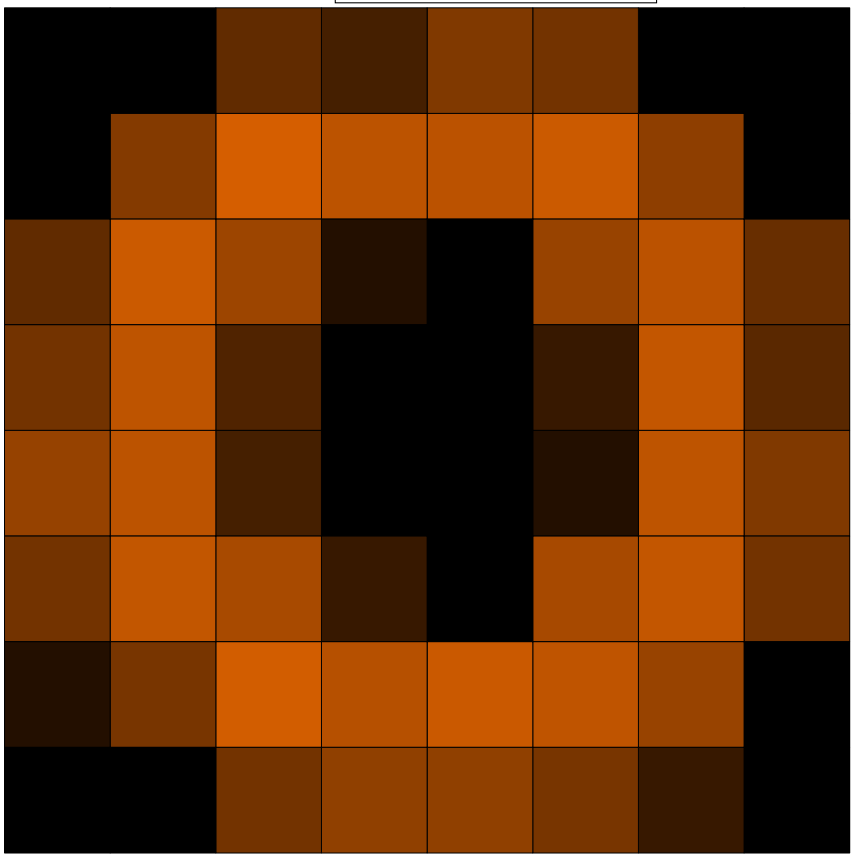
PSF spreads events over multiple pixels

Valid Events on the Detector

1 mCrab



1000 mCrab



strong pile-up creates many invalid patterns

Summary

- different WFI chips and readout modes implemented
  - four large chips ($40' \times 40'$ FOV)
  - small and fast chip with 64×64 pixels
- detector information stored in XML format
- defocusing implemented ($\Delta x = 35\,\mathrm{mm}$) for the fast chip
  $\rightarrow$ increases bright source capabilities
- incident photon create patterns on the chip
- detailed DEPFET readout implemnted