Radiation damage of video device in a fusion stellarator

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Introduction (1)

- ***D*** + ***T*** → ***4He***(3.52 MeV) + ***n***(14.1 MeV)
- ***D*** + ***D*** → ***3He***(0.82 MeV) + ***n***(2.45 MeV)
- ***D*** + ***D*** → ***T***(1.01 MeV) + ***p***(3.02 MeV)
- ***D*** + 3***He*** → ***4He***(3.66 MeV) + ***p***(14.6 MeV)

Introduction(2)

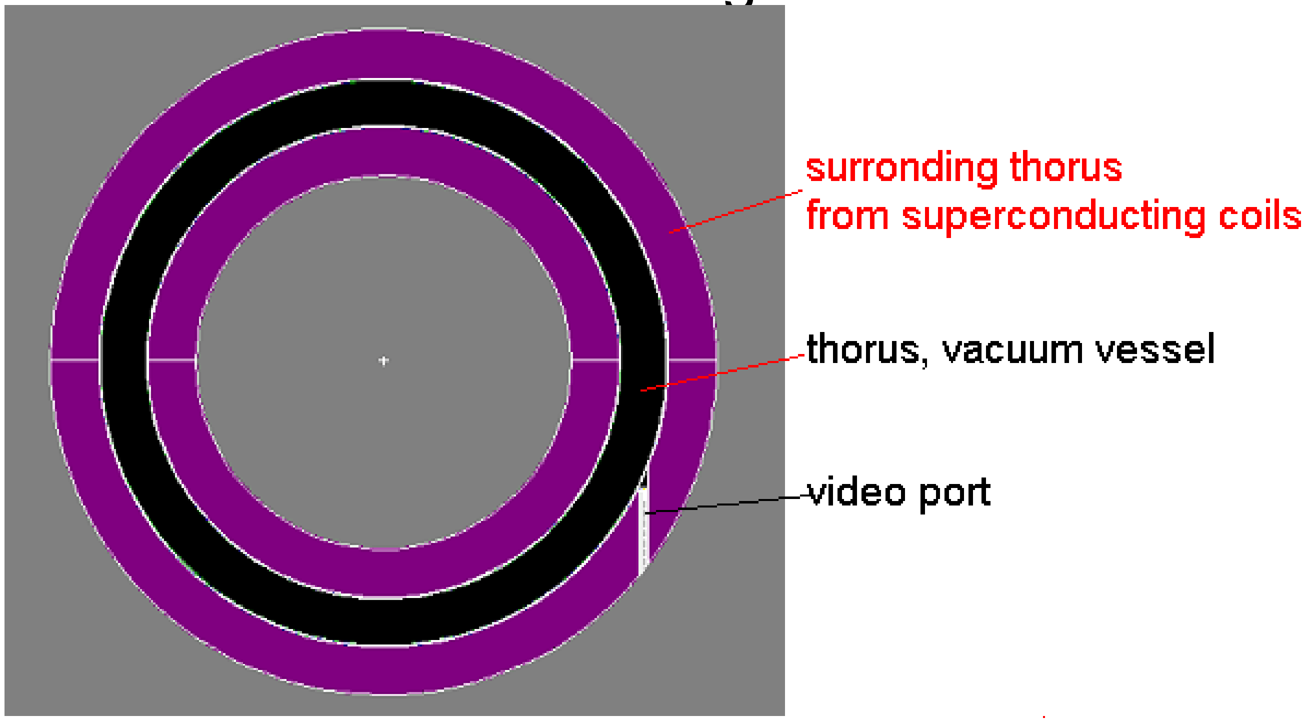
- Gamma radiation from (n,γ) reaction
- Neutron radiation from fusion
- Bremstahlung from the acceleration of the electrons and ions
- Thermal radiation
- X-ray from Electron capture
- Gamma, X-ray form de-excitation
- …

Introduction(3)

- EDICAM (Event Detecting Inteligent CAMera)
- CMOS sensor (LUPA-1300)
- 1.3 Mega pixel
- 1280x1024 pixels
- 16 channels ADCs (12bits, 444 full frame/s)
- Black and white
- Operates in visible light region
- …

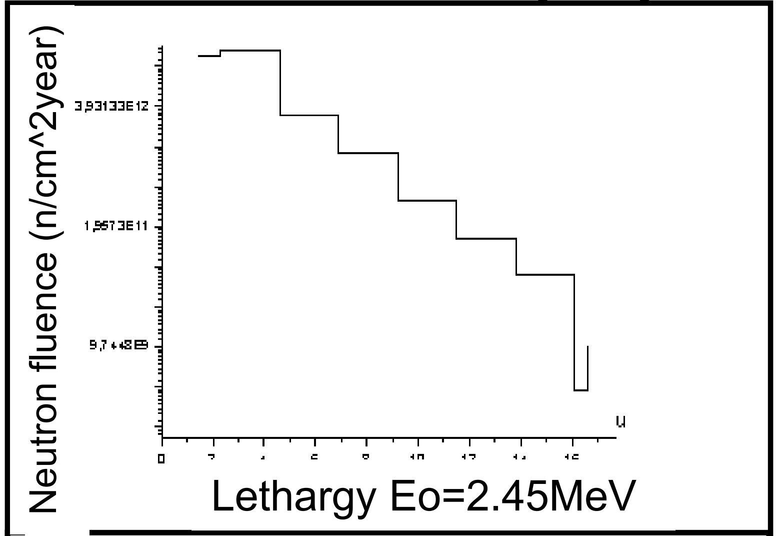
Monte Carlo calculations(1)

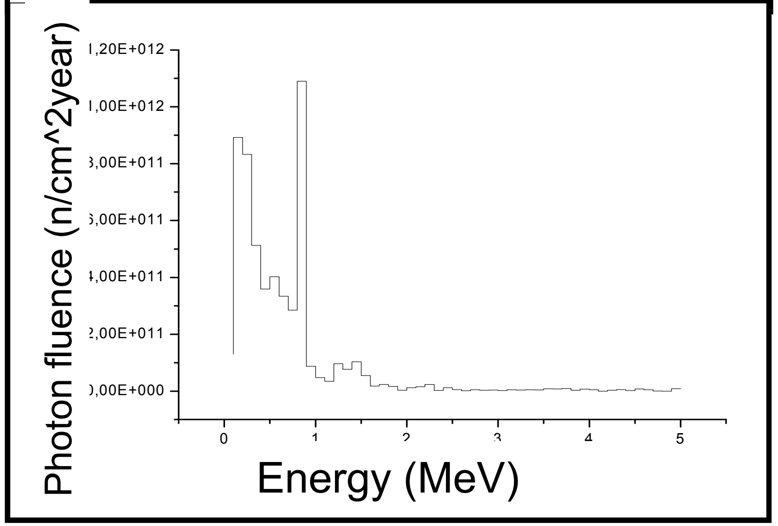
- Monoenergetic, homogeneous 2.45 MeV neutron source
- real vacuum, no slow down
- Fe-Ti-Ni-air surrounding thorus



Monte Carlo calculations(2)

- The neutron spectrum is rather hard, half of it from fast neutrons (~2.45MeV) the other half from epithermal energy region (0.2 eV-1MeV).
- 17.4 Gy Neutron dose in Si target
- 16.7 Gy Gamma dose in Si target





Gamma irradiation(1)

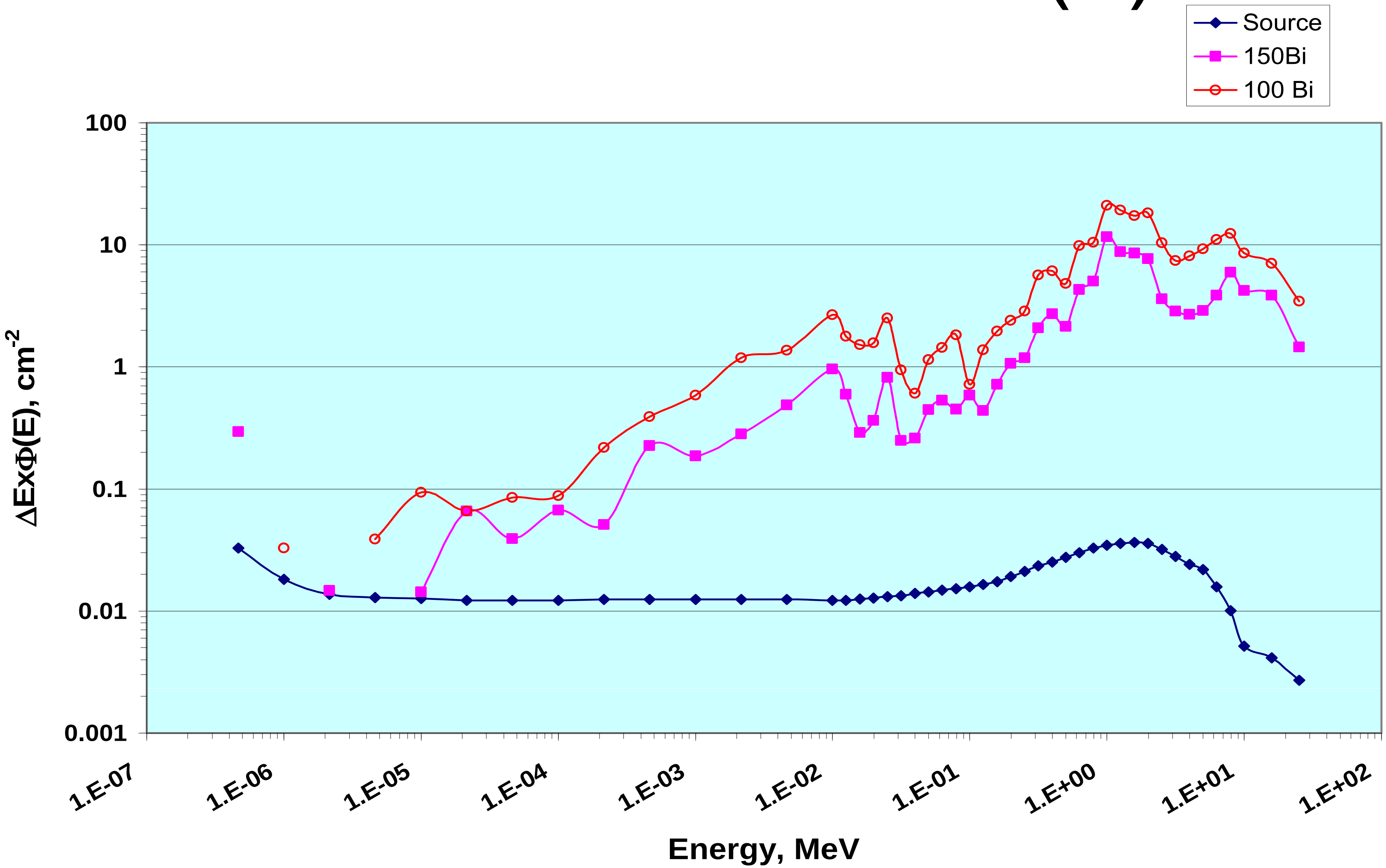
- BUTE Training reactor
- Pure gamma radiation environment
- Mistakes during irradiation (few useful picture)

Neutron Irradiation(1)

- Budapest Neutron Centre, Budapest Research reactor
- 5. horizontal channel

	Fluence $1/cm^2$	Dose (Gy) (water)
E_n >1Mev	1.7*10^12	63.7
Gamma	-	3.5
Sum	1.7*10^12	67.2

Neutron Irradiation(2)



Evaluation methods and results(1)

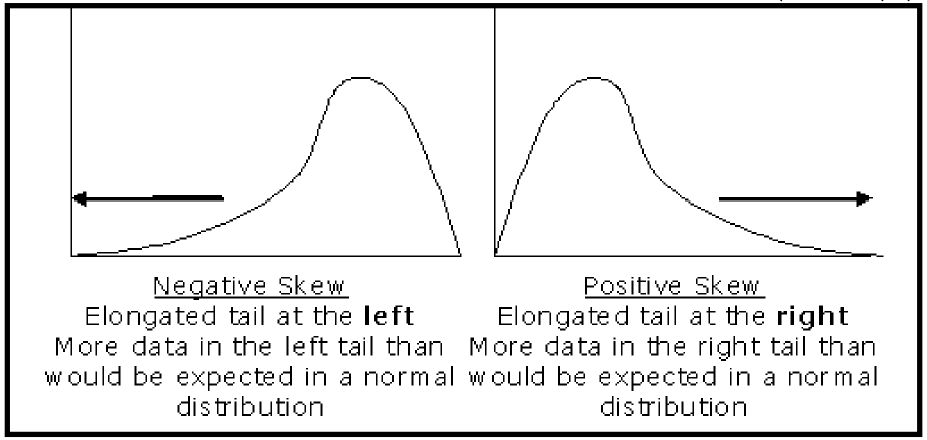
- Empirical mean $\bar{x}$
- Standard deviation s
- Skewness γ_1
- Kurtosis γ_2

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

$$s = \frac{\sqrt{\sum_i (x_i - \bar{x})^2}}{n-1}$$

$$\gamma_1 = \frac{n}{(n-1)(n-2)} \sum_{i=1}^{n} \left(\frac{x_i - \bar{x}}{s} \right)^3$$

$$\gamma_2 = \frac{n(n-1)}{(n-1)(n-2)(n-3)} \sum_{i=1}^{n} \left(\frac{x_i - \bar{x}}{s} \right)^4 - 3\frac{(n-1)^2}{(n-2)(n-3)}$$

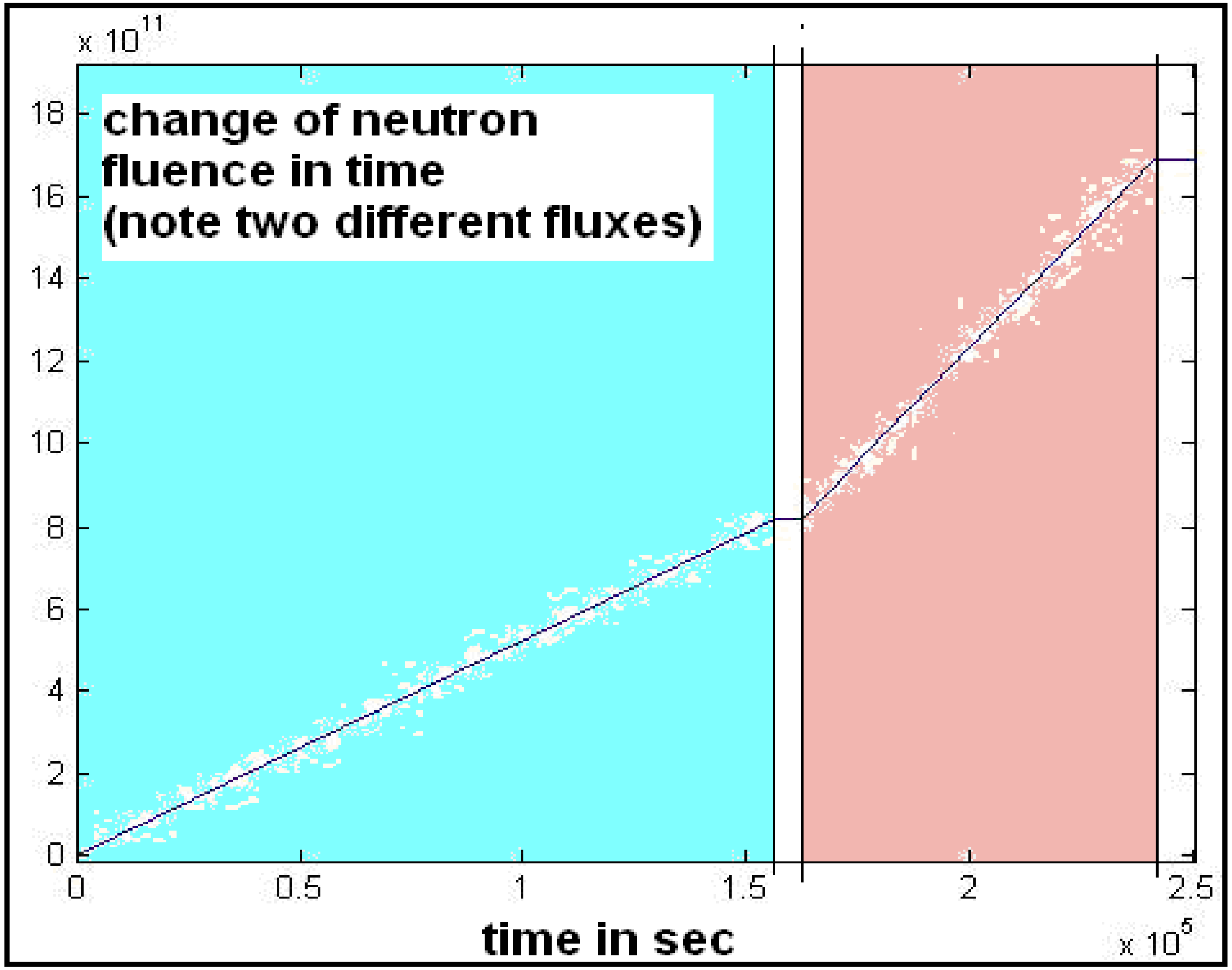


For Gaussian distribution γ_2=0

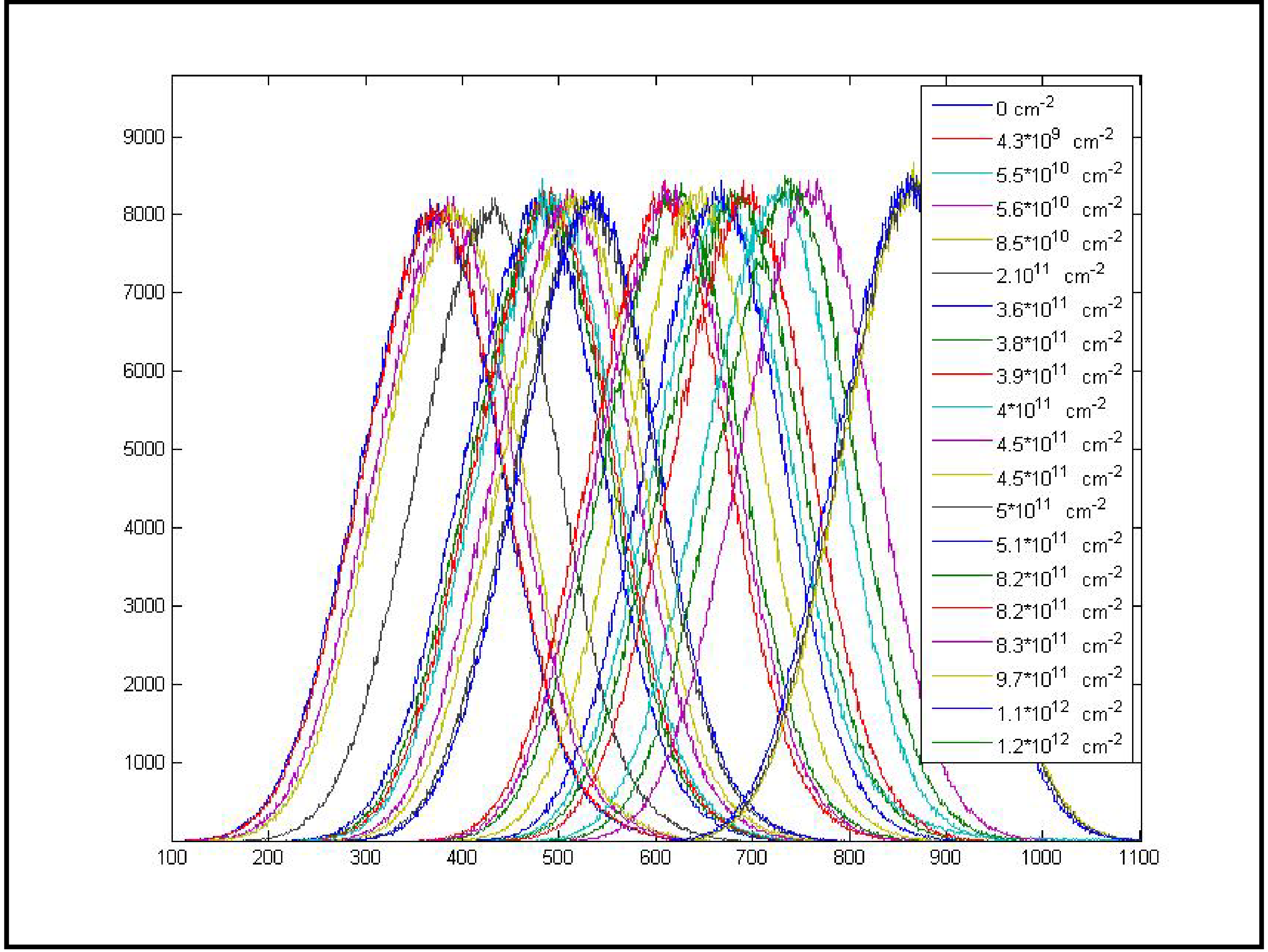
If γ_2<0 the histogram is flatter

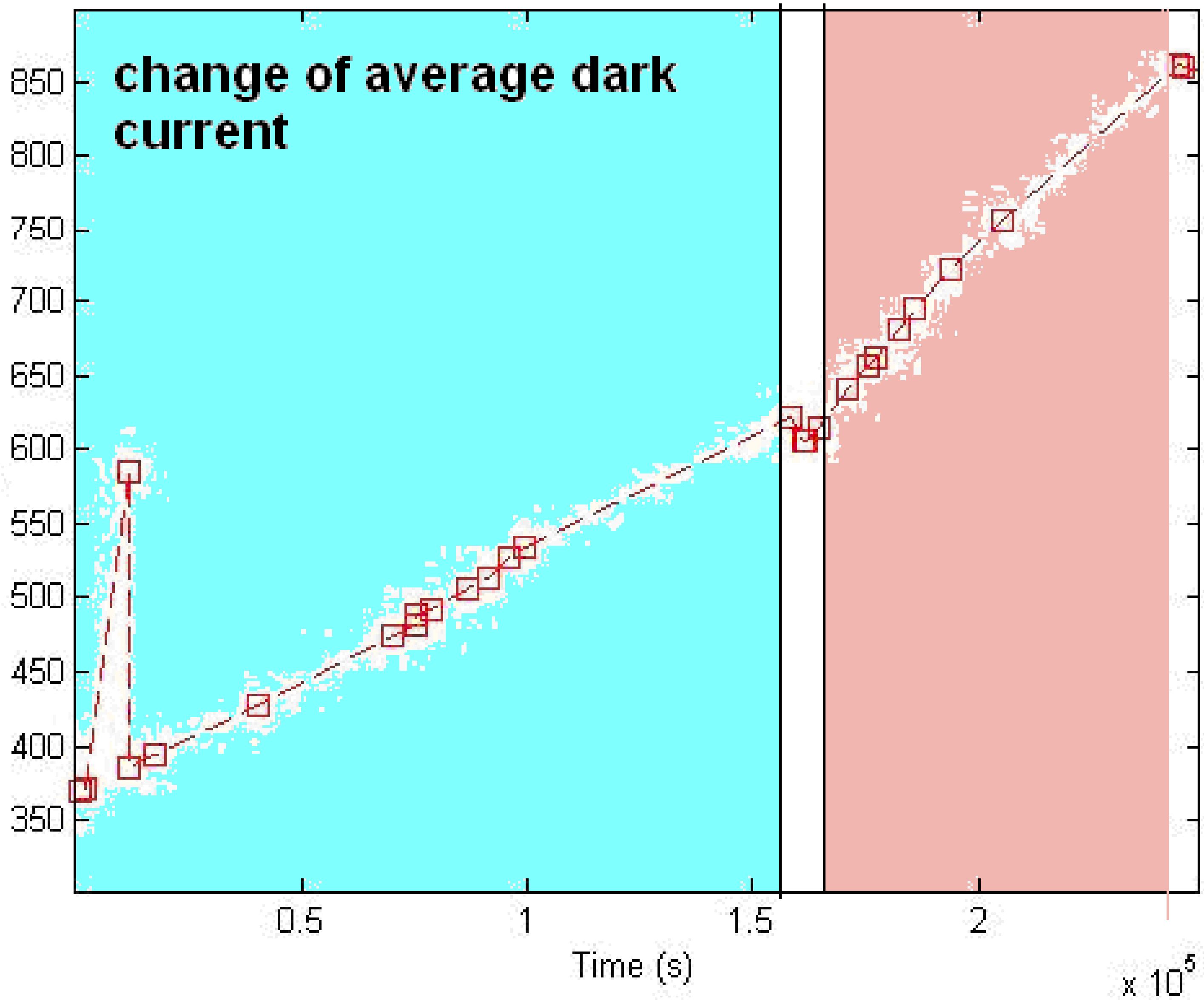
If γ_2>0 histogram is pointed

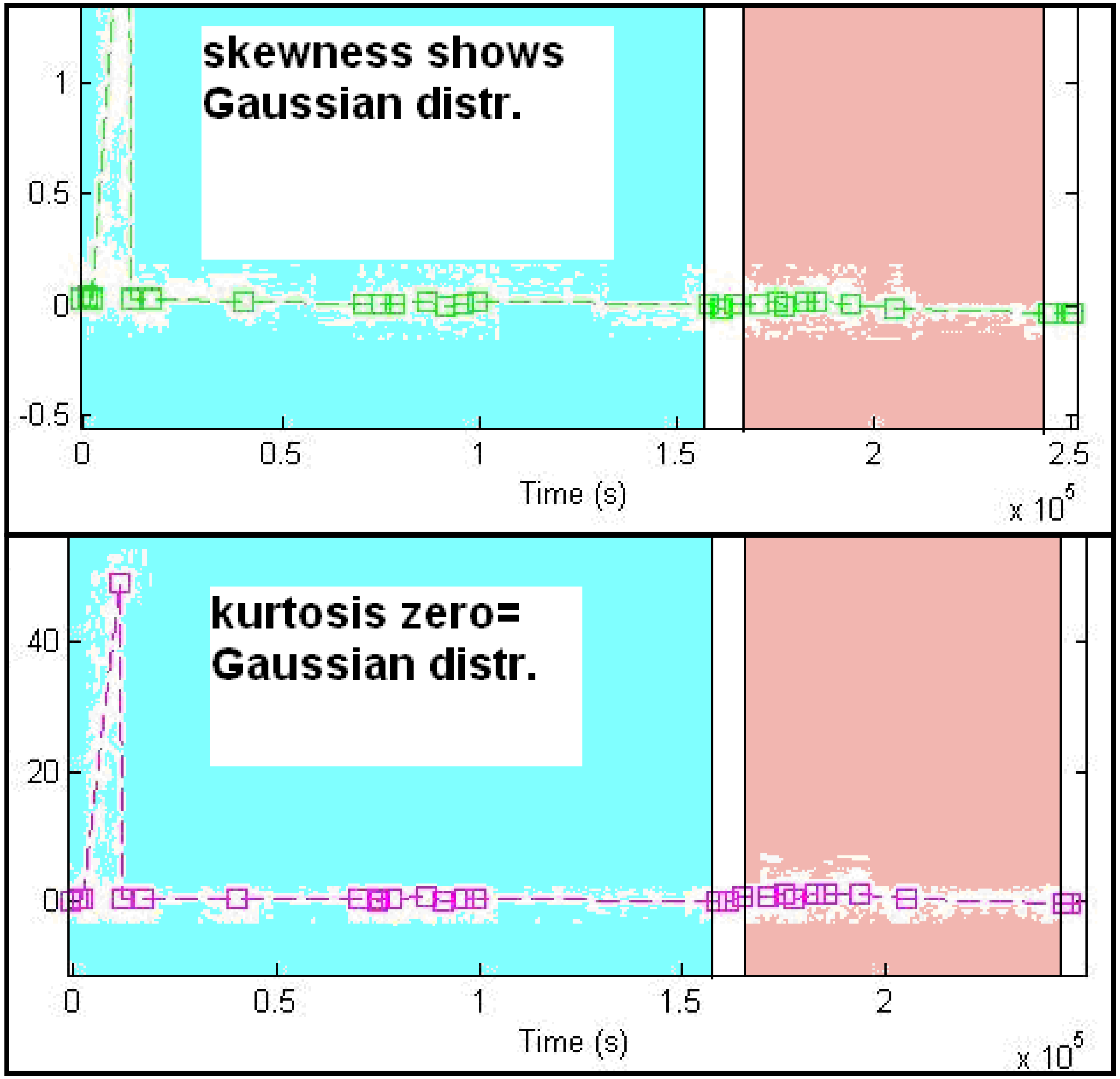
Evaluation methods and results(2)



Evaluation methods and results(3) 2ms exposure time (dark current):

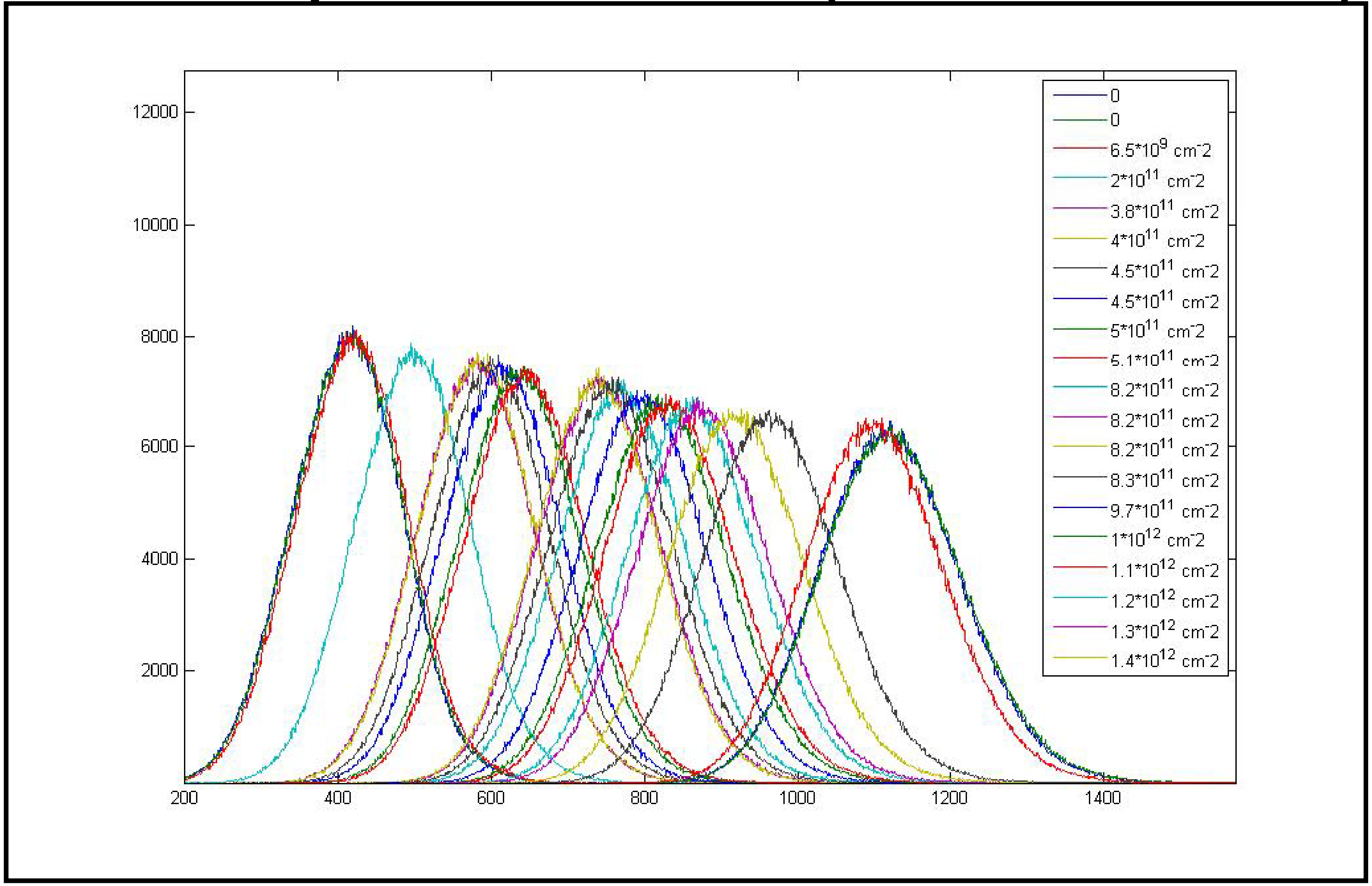


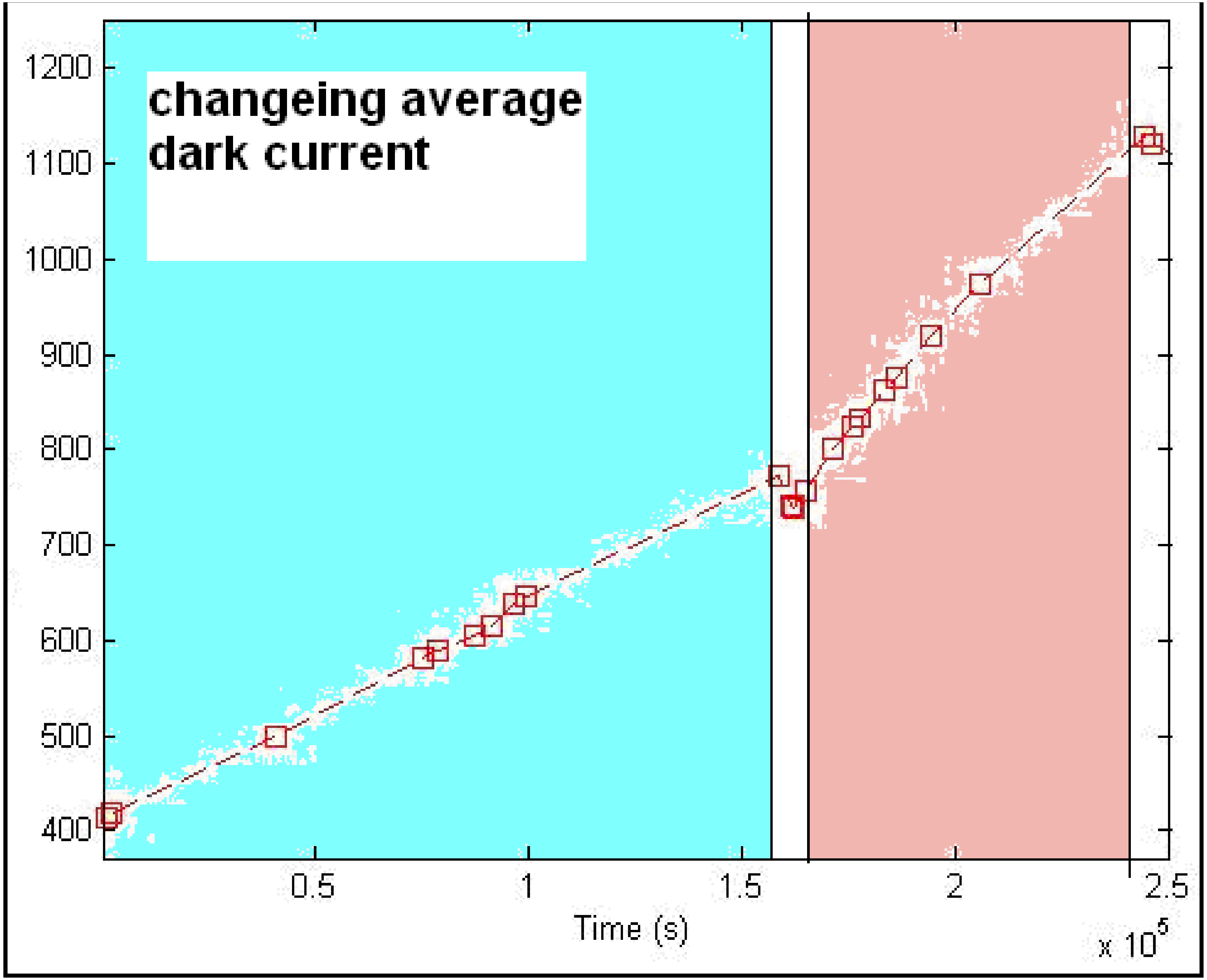

change of average dark current
850
800
750
700
650
600
550
500
450
400
350
0.5
1
1.5
2
Time (s)
x 10^5

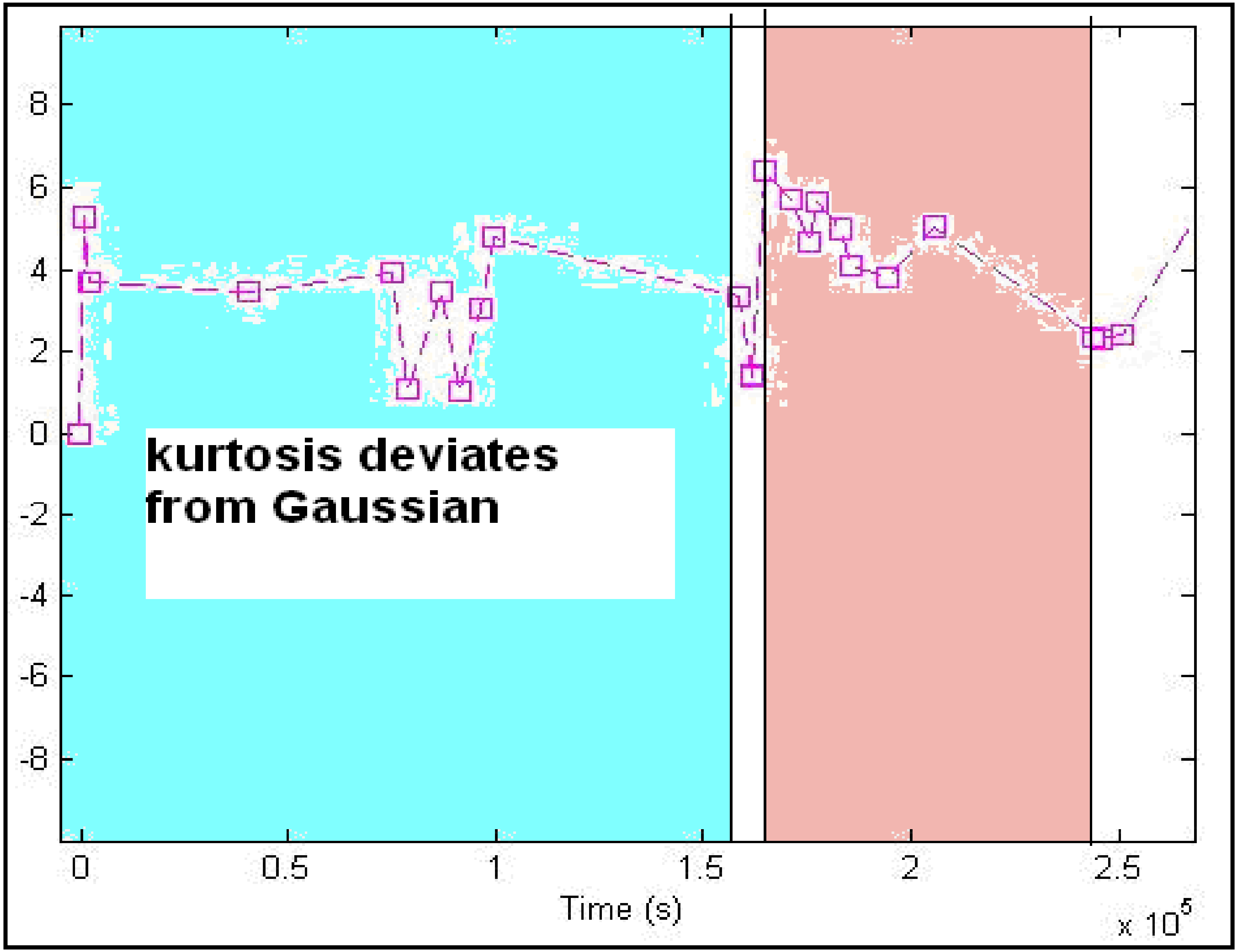


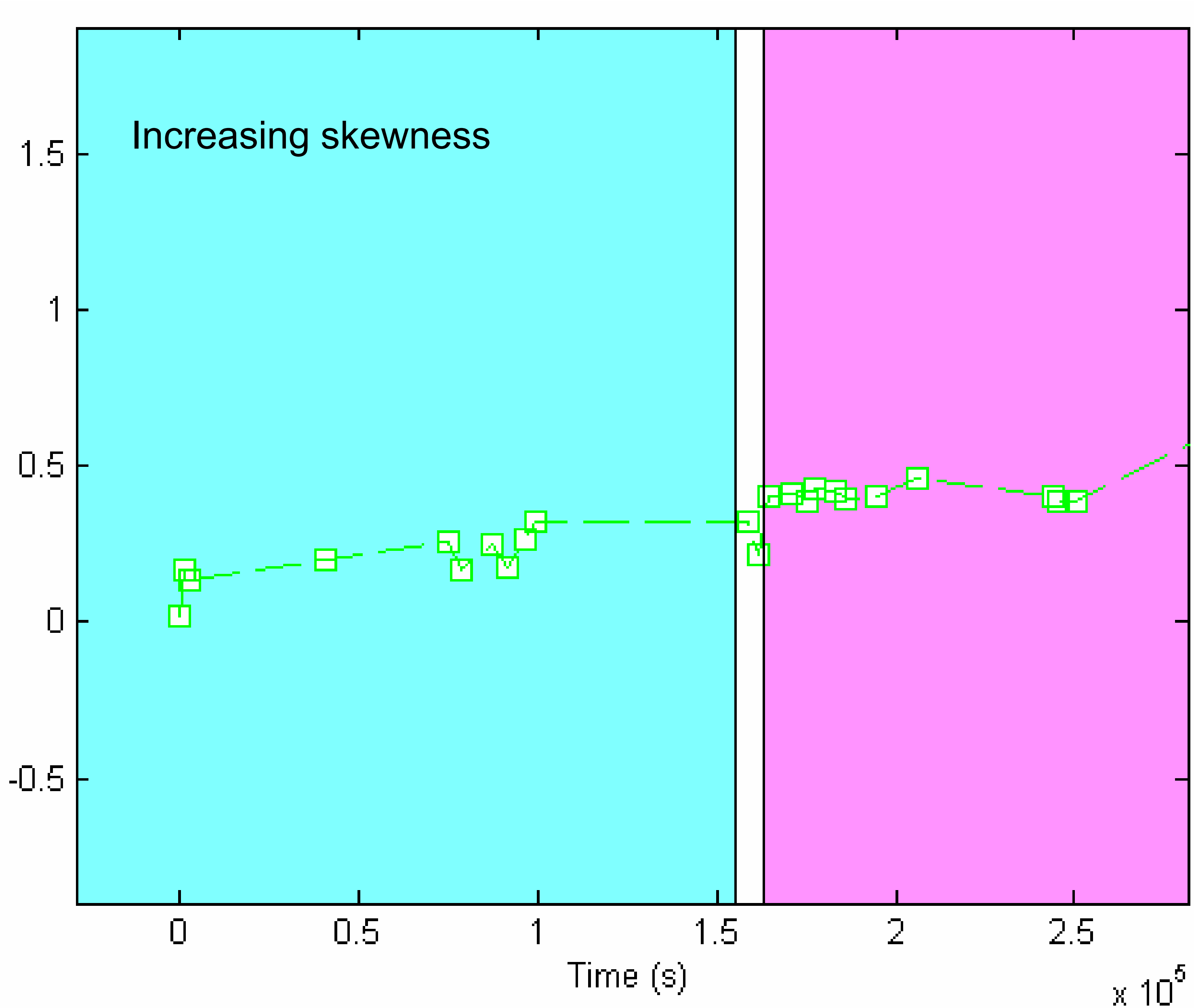
skewness shows
Gaussian distr.
1
0.5
0
-0.5
0
0.5
1
1.5
2
2.5
Time (s)
x 10^5
kurtosis zero=
Gaussian distr.
40
20
0
0
0.5
1
1.5
2
Time (s)
x 10^5

Evaluation methods and results(3) 20ms exposure time (dark current):

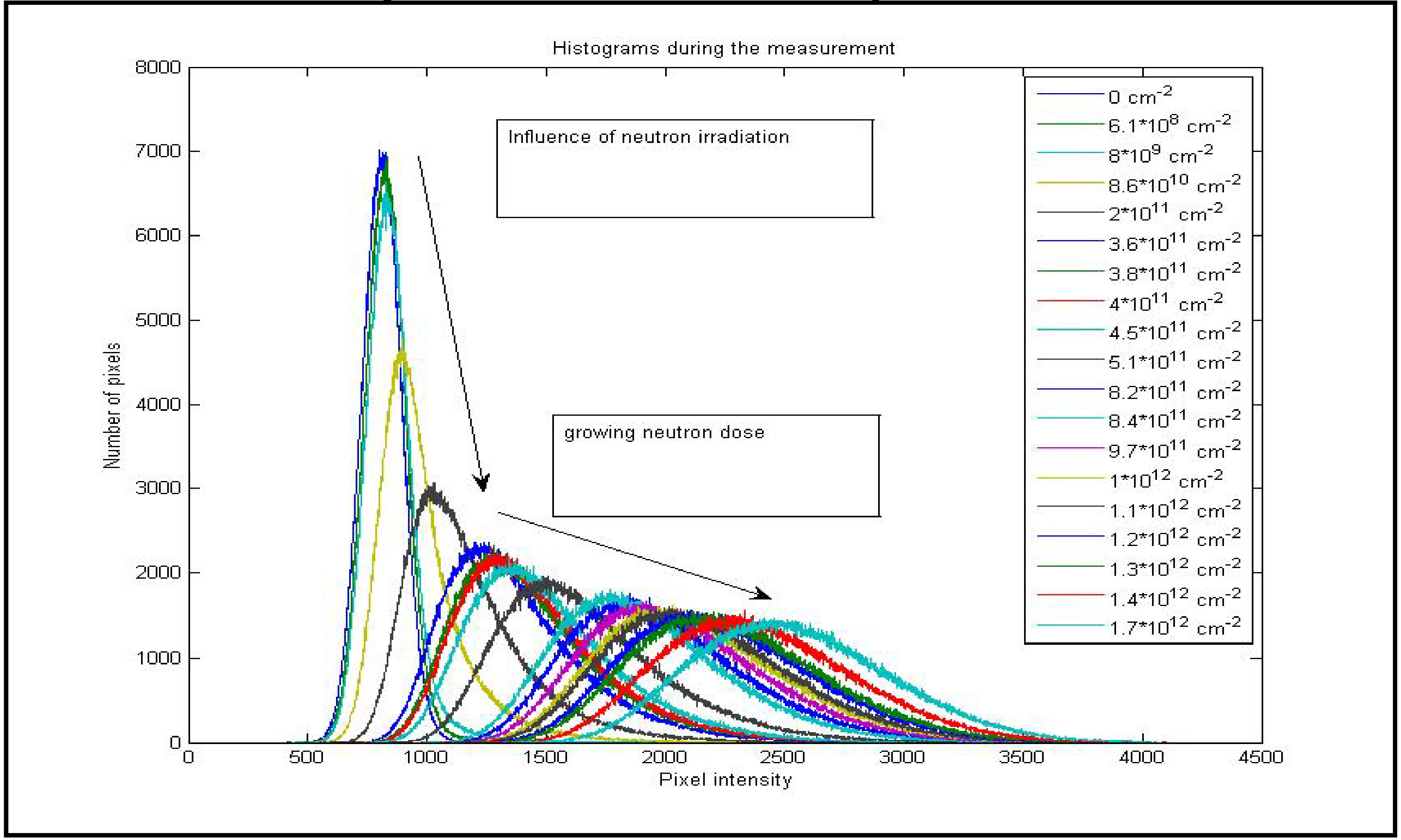


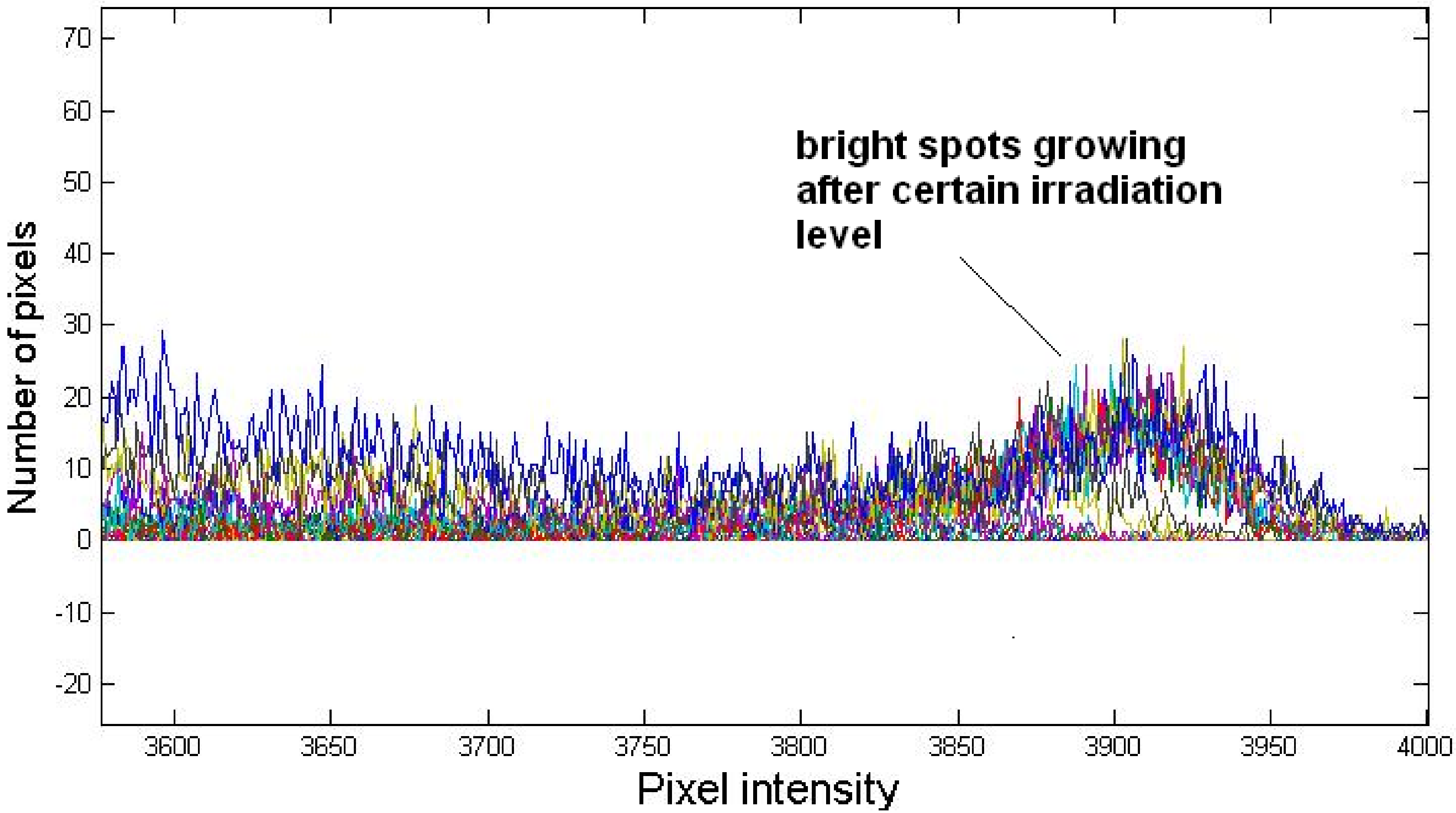

changeing average
dark current
1200
1100
1000
900
800
700
600
500
400
0.5
1
1.5
2
2.5
Time (s)
x 10^5

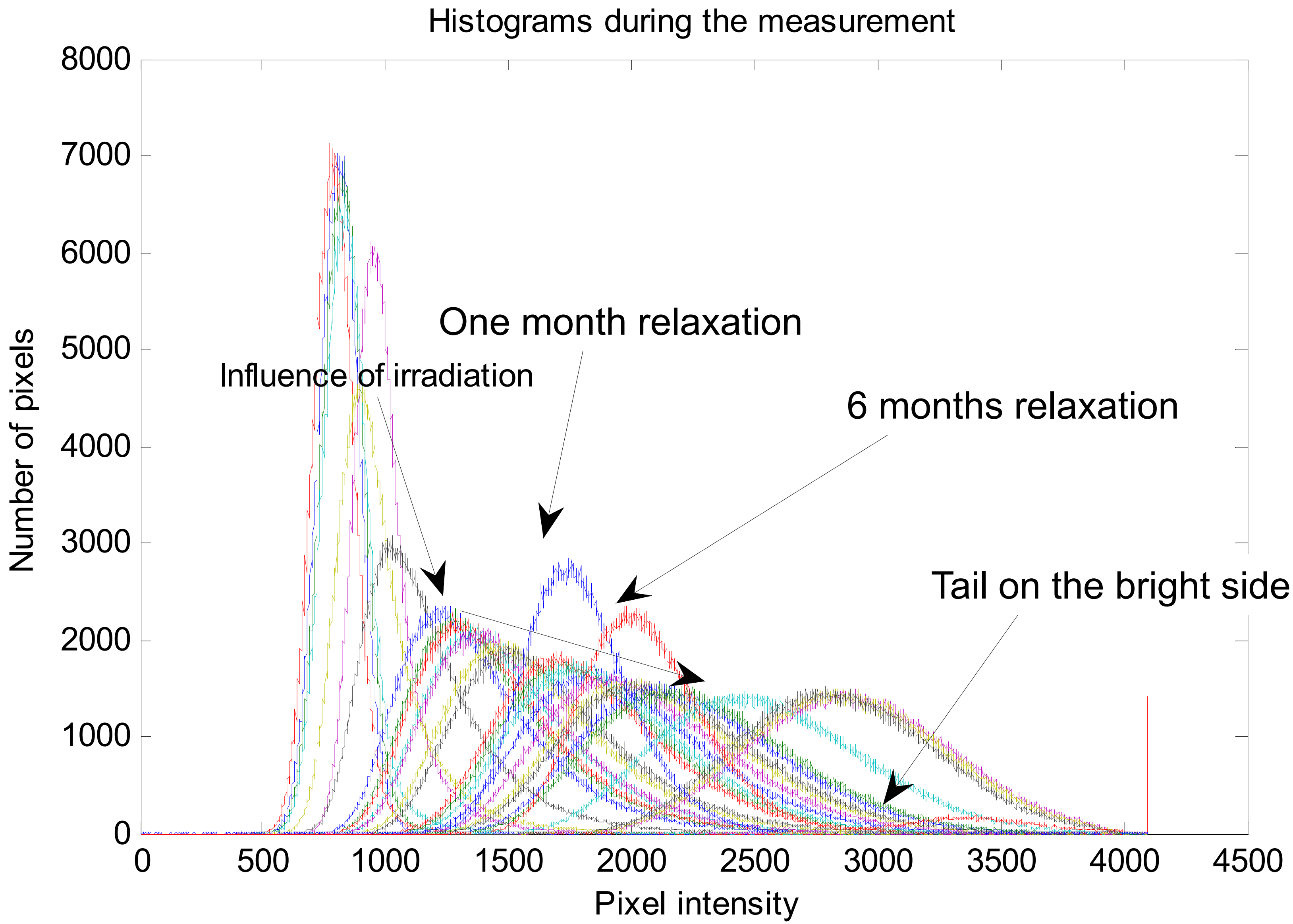

kurtosis deviates
from Gaussian
8
6
4
2
0
-2
-4
-6
-8
0
0.5
1
1.5
2
2.5
Time (s)
x 10^5


Increasing skewness
1.5
1
0.5
0
-0.5
0
0.5
1
1.5
2
2.5
Time (s)
x 10^5

Evaluation methods and results(3)
200ms exposure time (dark current:




bright spots growing
after certain irradiation
level
Number of pixels
Pixel intensity
70
60
50
40
30
20
10
0
-10
-20
3600
3650
3700
3750
3800
3850
3900
3950
4000


Histograms during the measurement
8000
7000
6000
5000
4000
3000
2000
1000
0
Number of pixels
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Pixel intensity
One month relaxation
Influence of irradiation
6 months relaxation
Tail on the bright side

Future plans

- Correct the mistakes
- Specify our model
- Build a neutron irradiation site with good gamma shielding and big flux if it is possiple in the Training reactor
- Measurements with neutron pulser
- Optical system irradiations (glass)

Thank you for your attention

Co-authors

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