ECL background

BELLE collaboration
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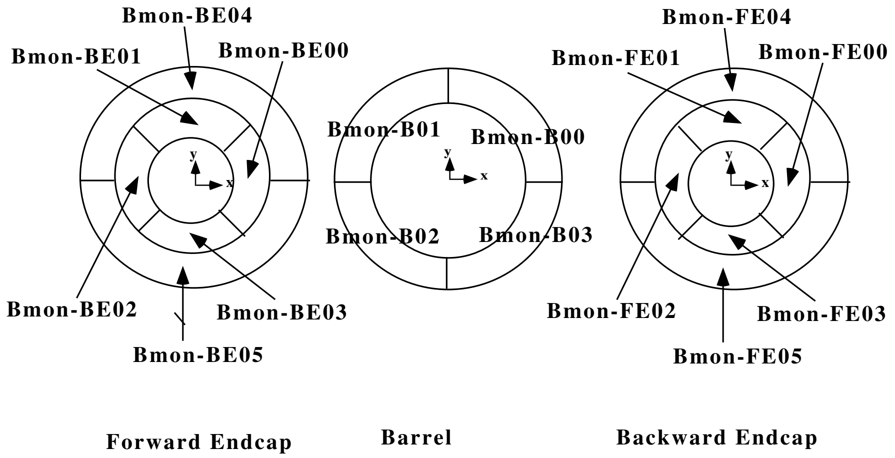
- Radiation dose measurement
- Lightoutput degradation
- Dark current increasing
- Pile-up effect

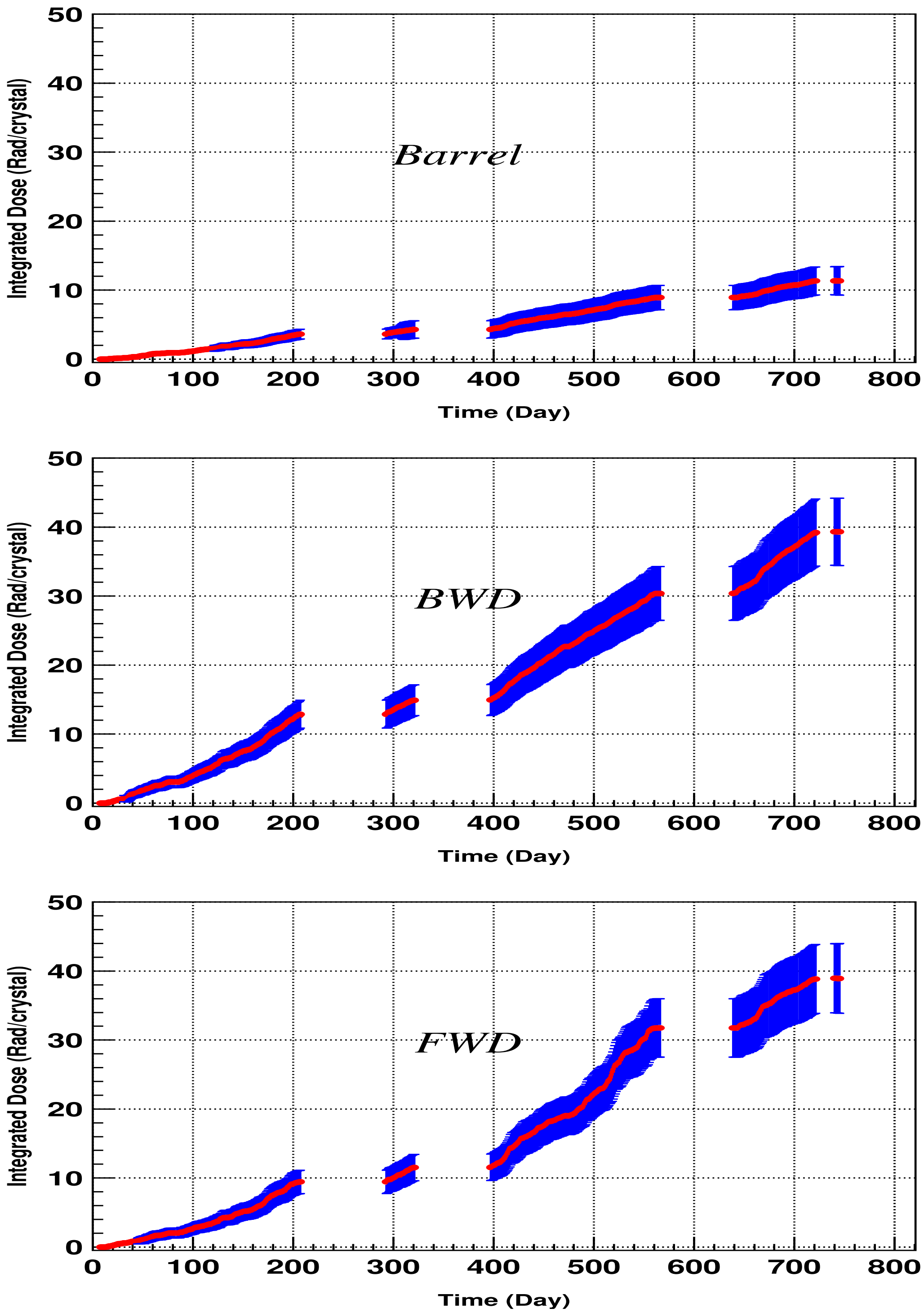
Radiation dose

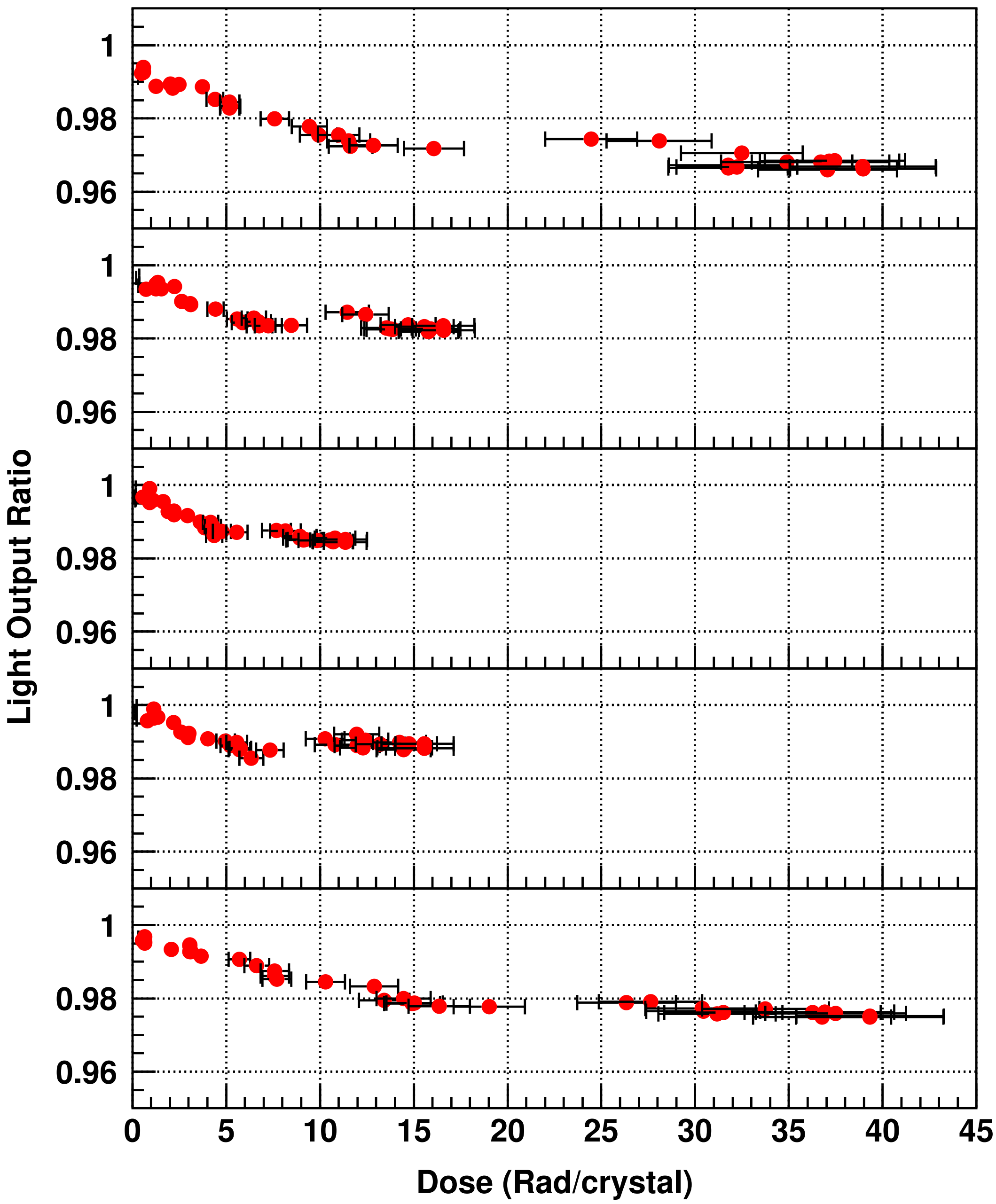
- **The instantaneous radiation dose is proportional to the energy deposited in the crystal in unit of time.**

$$Dose \sim E \sim \int I dt$$

- **Leakage current $\approx$ 5 nA/crystal**
- **Increase of 2.5 nA/crystal $\sim$ 100 Rad/(10^7sec)**
- **Detector subdivided in 16 groups. Total current of each group is monitored and radiation dose accumulated is estimated.**




Barrel
BWD
FWD
Integrated Dose (Rad/crystal)
Time (Day)
0
10
20
30
40
50
0
100
200
300
400
500
600
700
800

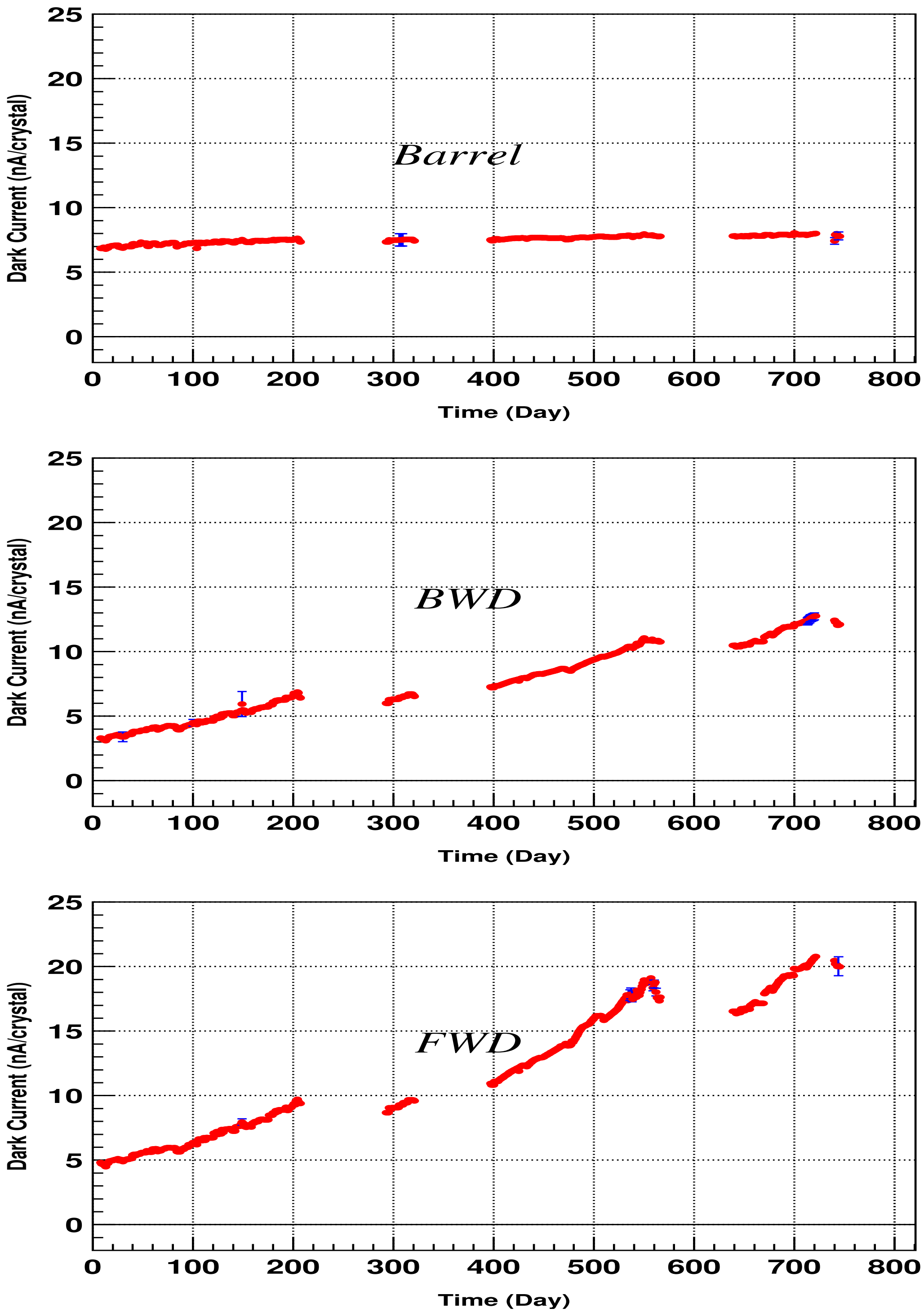

Light Output Ratio
1
0.98
0.96
0
5
10
15
20
25
30
35
40
45
Dose (Rad/crystal)

Effect of increasing PIN diode dark current

The PIN dark current continuously increases during accelerator work.

The increasing is not proportional to the total dose.

Neutrons?


Barrel
BWD
FWD
Dark Current (nA/crystal)
Time (Day)
0
5
10
15
20
25
0
100
200
300
400
500
600
700
800

Occupancy ECL for random trigger.

$\bar{L} = 3.5 10^{33} cm^{-2} s^{-1}$

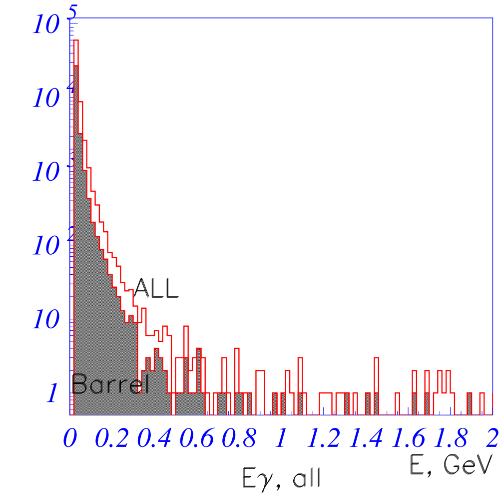
$\bar{I}_{+} = 750 mA$

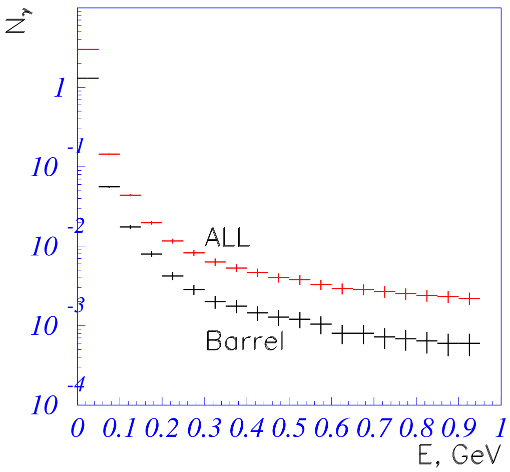
$\bar{I}_{-} = 650 mA$

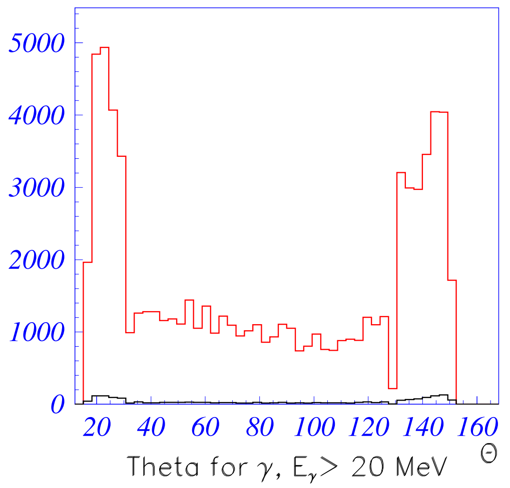
$\bar{E}_{\gamma} = 35 MeV$

$\bar{N}_{\gamma}(> 20 MeV) \approx 3$

$\bar{N}_{\gamma}^{barrel}(> 20 MeV) \approx 1.2$







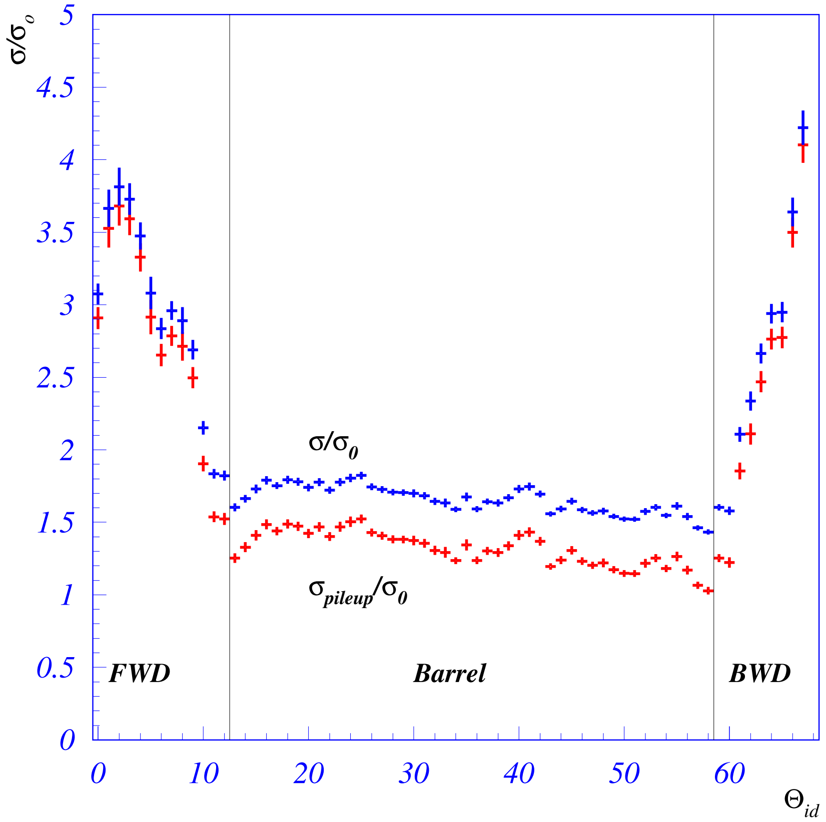
Pile-up effect

Signal overlapping with randomly distributed signals of background photons.

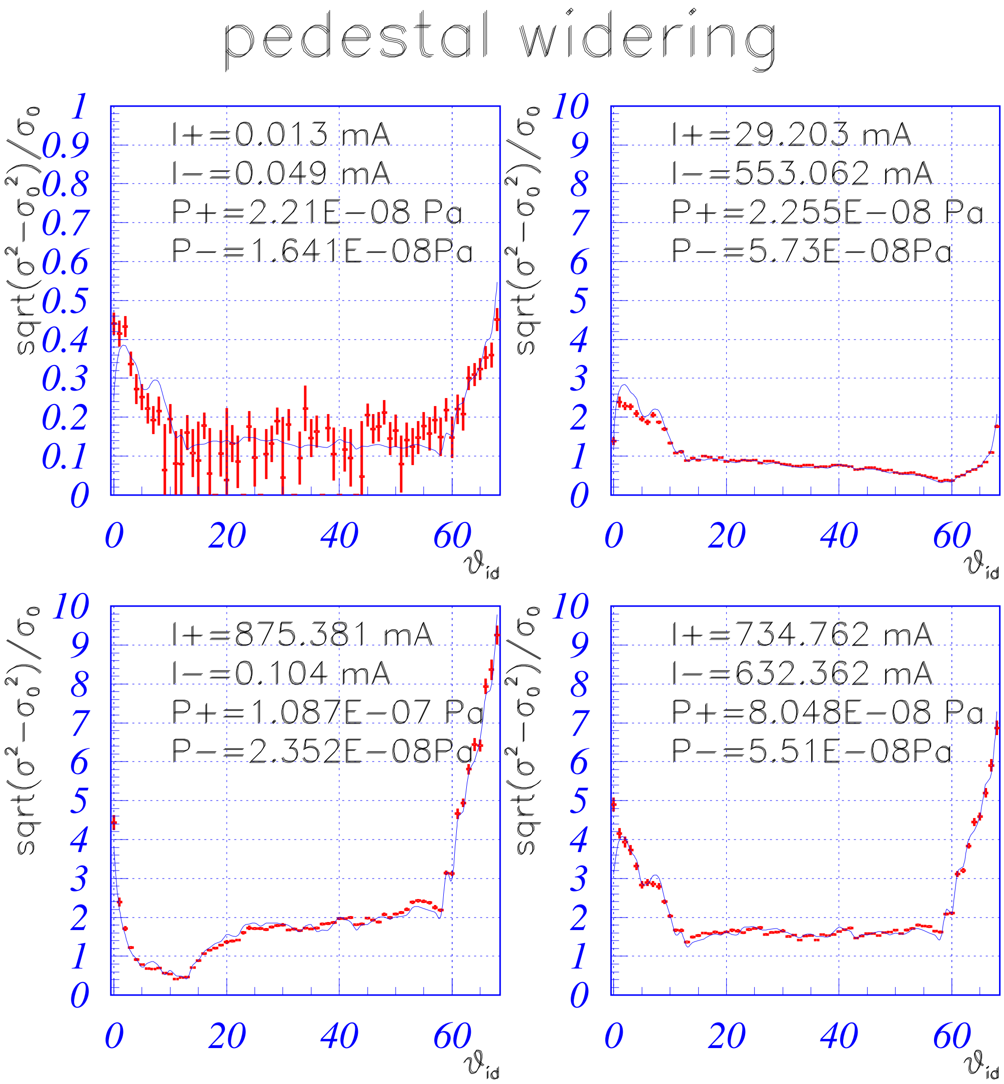
Can be estimated from pedestal width.

$$\sigma \sim \sqrt{N_{bg\gamma}} \sim \sqrt{Dose} \sim \sqrt{IP}$$

$$\sigma_0 \approx 200 \ \mathbf{keV;}\ \sigma_{pileup} = \sqrt{\sigma^2 - \sigma_0^2}$$

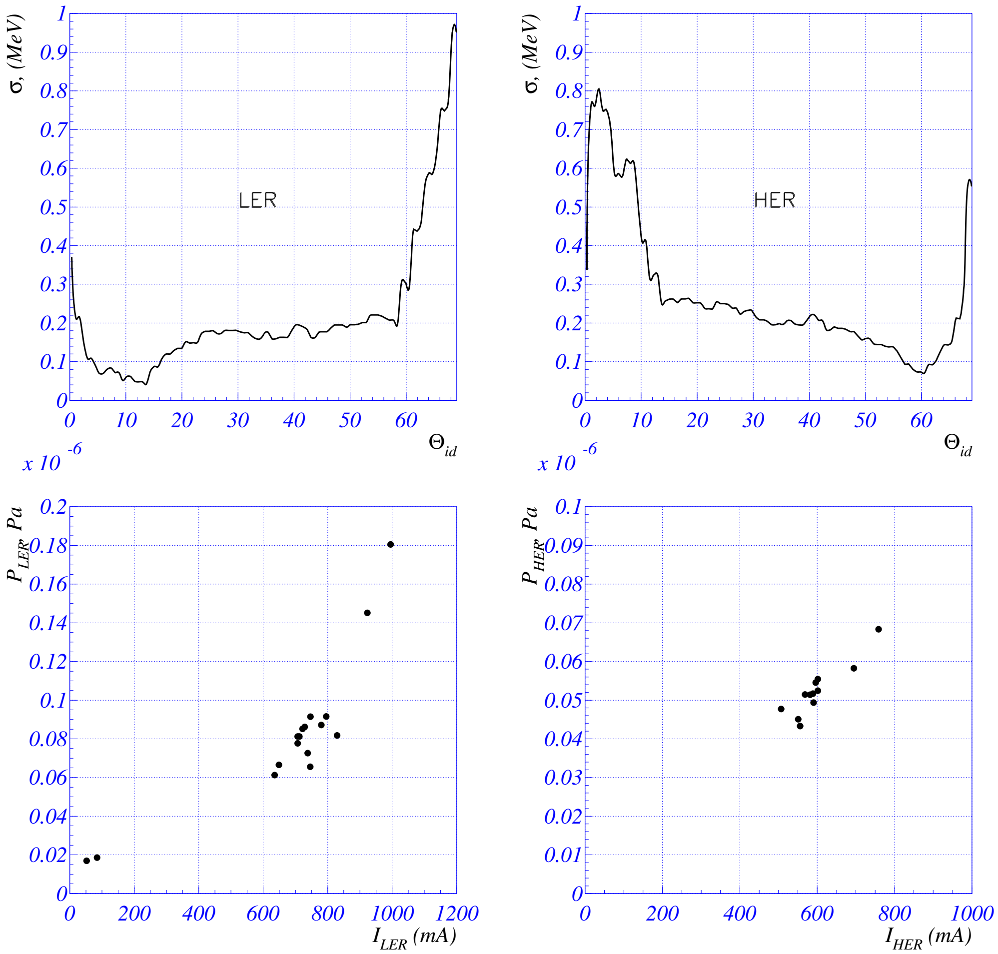


$$I_+ = 360 \ \mathbf{mA,}\ I_- = 360 \ \mathbf{mA}$$

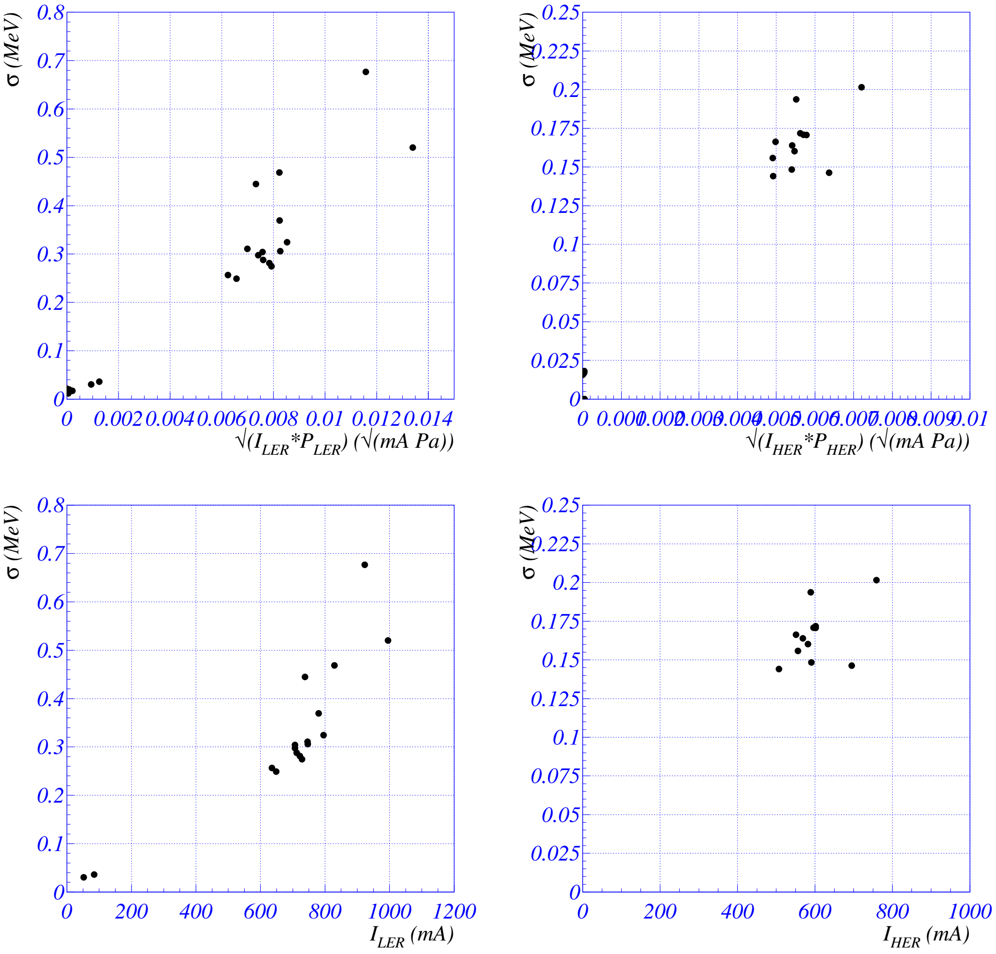

pedestal widering
I+=0.013 mA
I−=0.049 mA
P+=2.21E−08 Pa
P−=1.641E−08Pa
I+=29.203 mA
I−=553.062 mA
P+=2.255E−08 Pa
P−=5.73E−08Pa
I+=875.381 mA
I−=0.104 mA
P+=1.087E−07 Pa
P−=2.352E−08Pa
I+=734.762 mA
I−=632.362 mA
P+=8.048E−08 Pa
P−=5.51E−08Pa
sqrt(σ²−σ₀²)/σ₀
ϑ_id

Total background contribution can be expressed as sum of LER and HER background:

$$\sigma(\theta) = \sqrt{(s_L\sigma_{LER}(\theta))^2 + (s_H\sigma_{HER}(\theta))^2}$$



Vacuum pressure increases with beam current


σ (MeV)
√(I_LER*P_LER) (√(mA Pa))
σ (MeV)
√(I_HER*P_HER) (√(mA Pa))
σ (MeV)
I_LER (mA)
σ (MeV)
I_HER (mA)

Conclusion

- **The radiation dose obtained by the crystals during one year is 10 – 40 Rads. Lightoutput degradation is about 1-2 % for barrel crystals and about 2-4 % for most inner crystals of endcaps which is consistent with degradation expected from radiation dose.**
- **There is effect of increasing of the PIN diode dark current. This effect essential for endcaps.**
- **Pile-up noise is factor 2-3 higher then electronics noise in barrel and 3-6 times larger in endcaps for present background conditions.**