Ratio of the contributions real and virtual photons diffraction in thin perfect crystals. Comparison of calculation and experiment.

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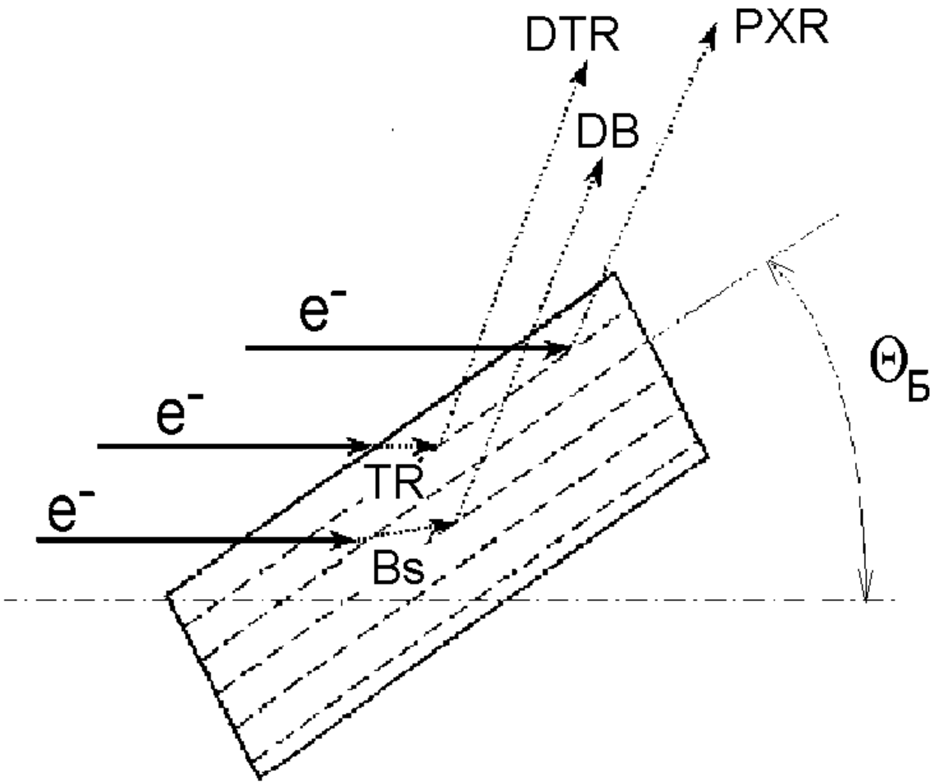
Aim –careful comparison of the experimental data for thin crystals with calculation taking into account all experimental condition and different types of photons emissions.

Checking and improvement the previous developed calculation method: S.A. Laktionova, O.O. Pligina, M.A. Sidnin, I.E. Vnukov // J. Phys. Conf. Ser. **517** (2014) 012020

Contribution of different radiation types into photon yield measured

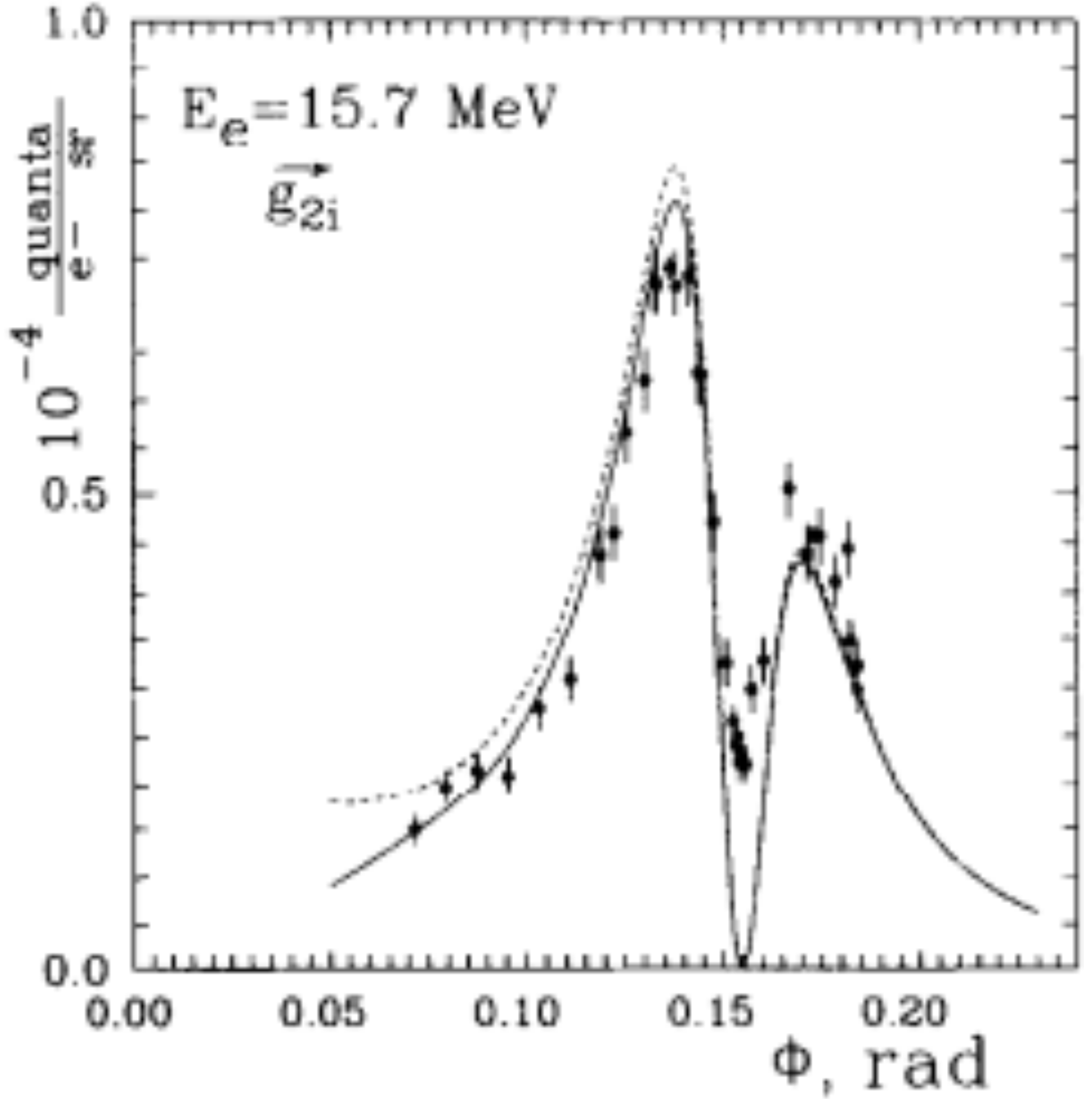


$\omega > \gamma\omega_p$ PXR+DB;
$\omega < \gamma\omega_p$ - PXR+DTR;
$\omega \sim \gamma\omega_p$ - PXR+DB+DTR

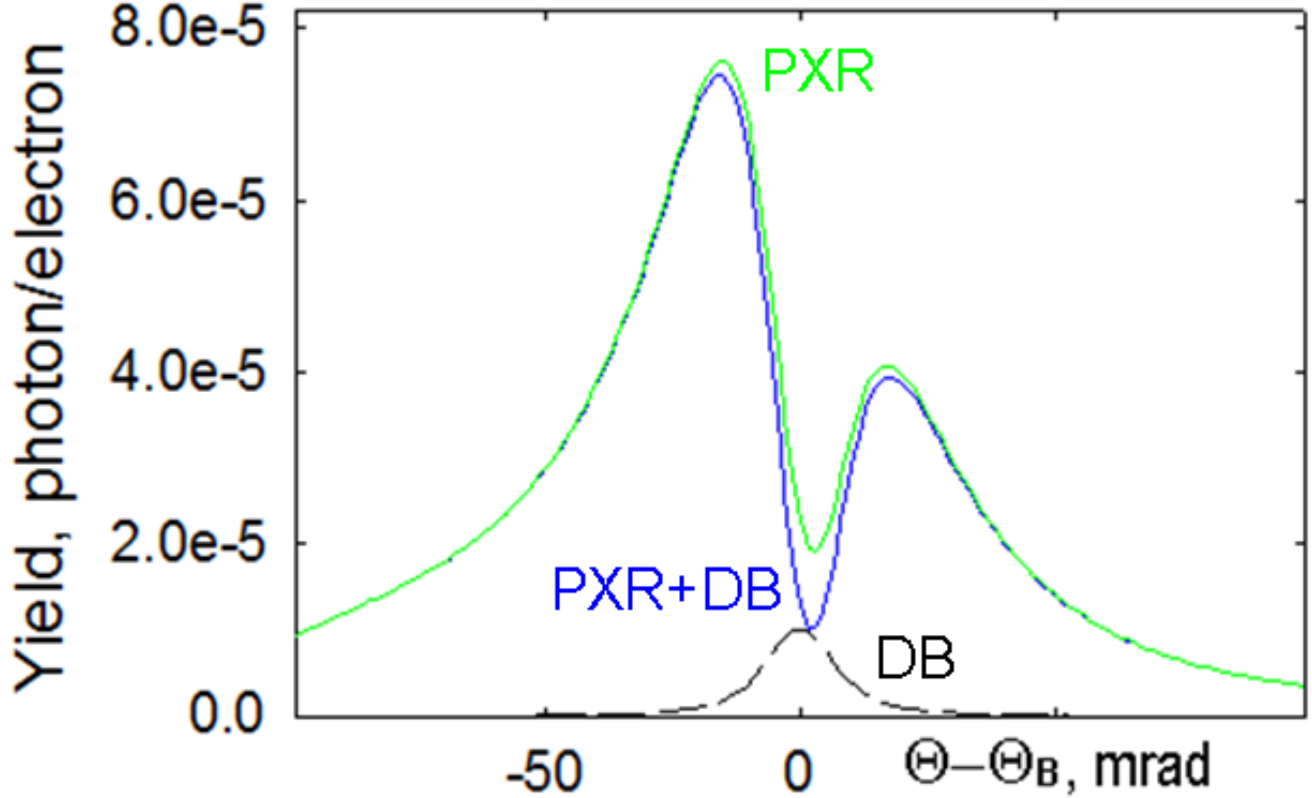
PXR - Nitta's formula
DTR – Garibian's formula
DB – Nasonov's formula

PXR – polarized; Bs – polarized (for thin target) and large emission angles; TR –polarized. Polarization of radiation changes measured emission yield because of the different reflectivity's for emission with the different direction of polarization vector.

Theta-scan, silicon (111), E=15.7 MeV, T= 0.017 mm
Shchagin A. V.,Pristupa V. I., Khizhnyak N. A.
//Phys. Lett. A. 1990. V.148. P.485.



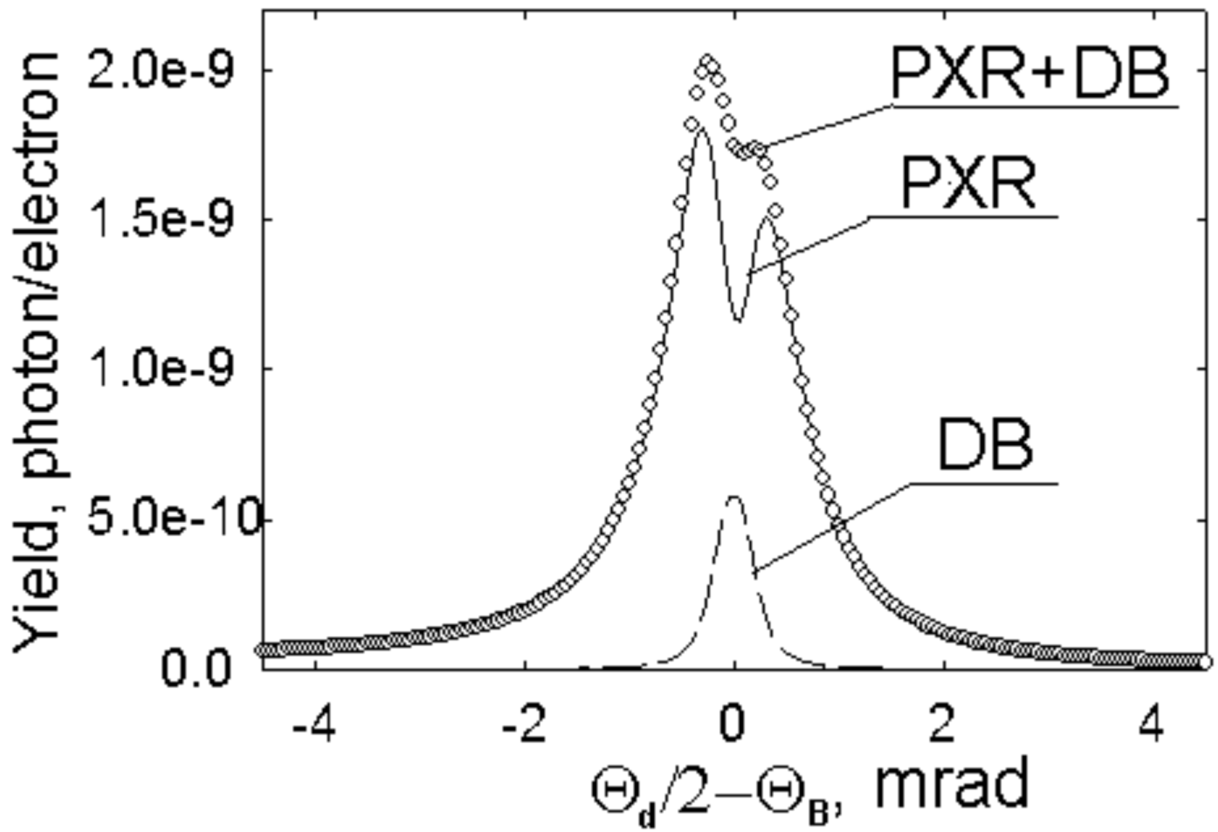
Calculation results



	Calc	Exp	Exp/calc
left peak	$7.64*10^{-5}$	$7.5*10^{-5}$	0.98
Centre	$2.29*10^{-5}$	$2.3 *10^{-5}$	1
right peak	$4.07*10^{-5}$	$4.3*10^{-5}$	1.07

For electron energy 25 MeV agreement is worse (experimental yield is greater than calculated one), but ratio of measured and calculated photon yields differs less than 10%.

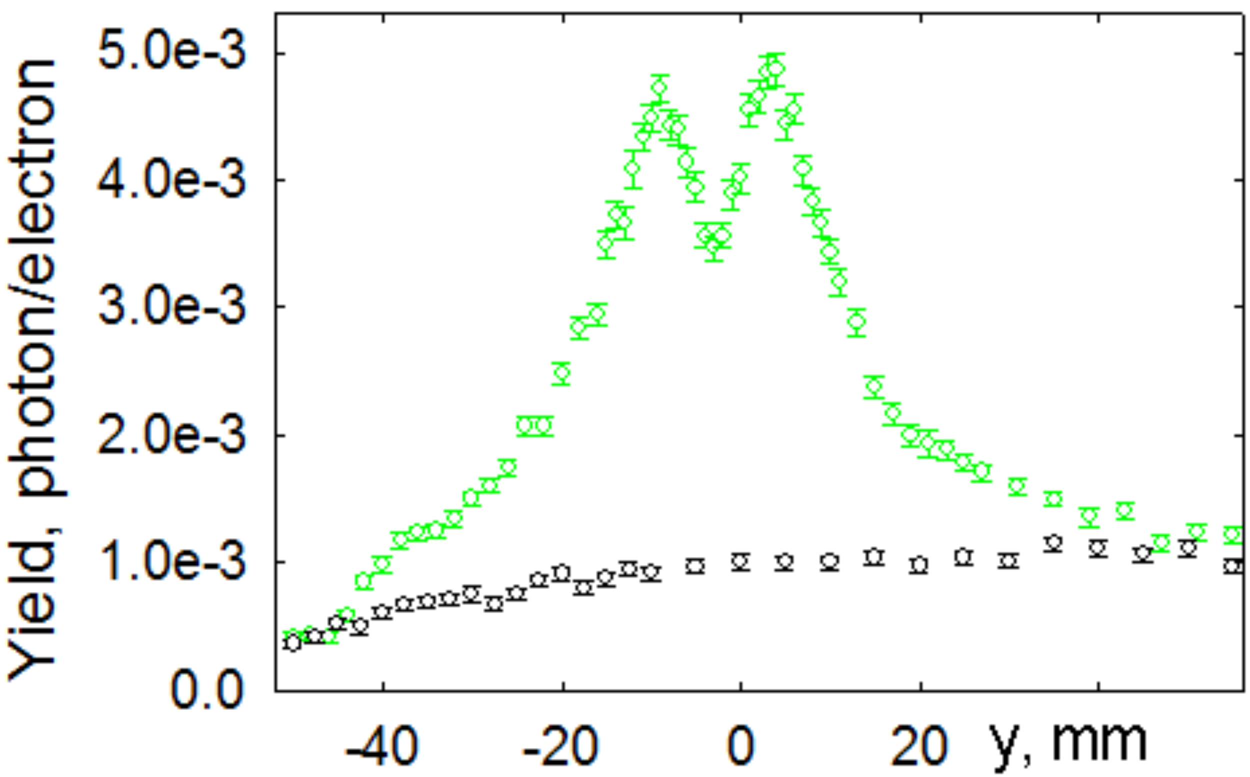
Kharkov, LUE, E=900 MeV, observation angle 17.8 мрад.
Laue geometry
D.I. Adeishvili et al. // DAN USSR, 1988, **298**, P. 84



Exp. ~ 0.3 phot./(MeV*electron/sr.)
Calc. - 0.314 phot./(MeV*electron/sr.)

DBR contribution ~10-15% from total intensity

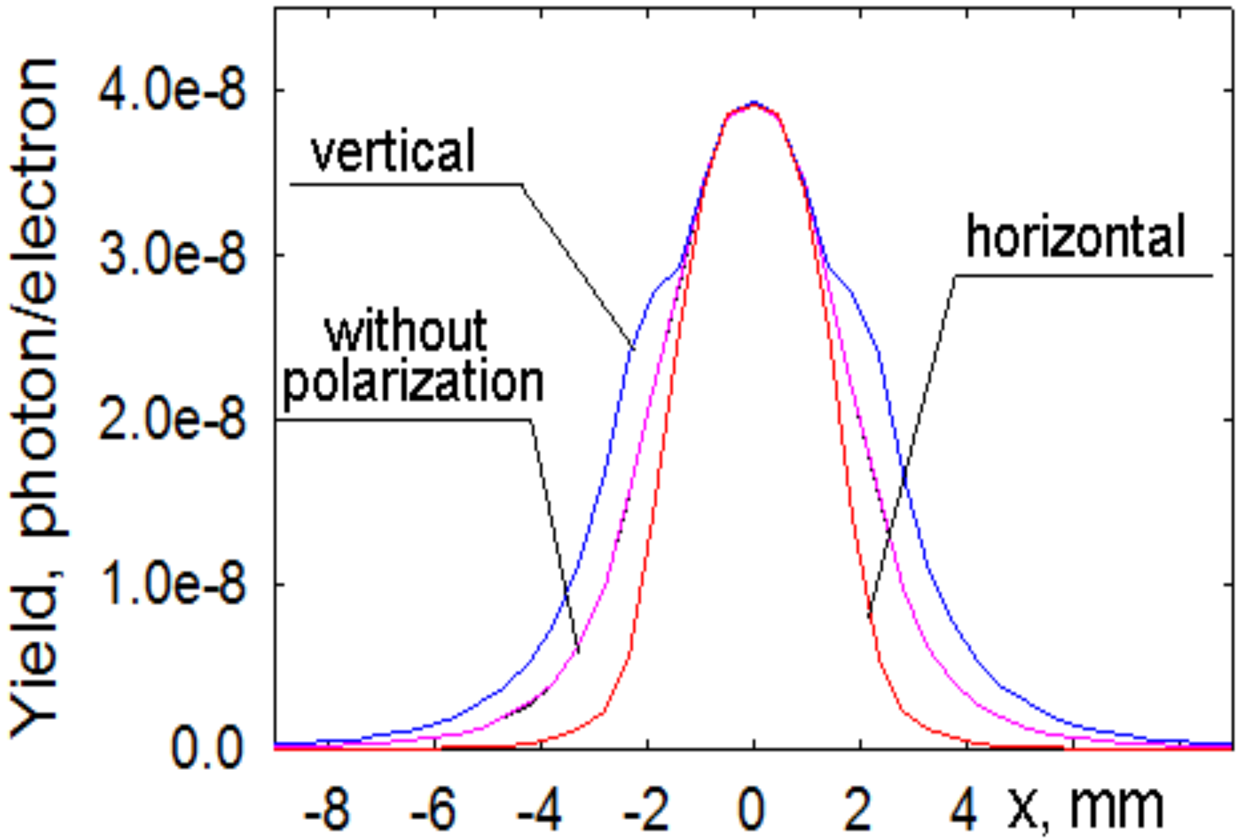
Tomsk experiments, E=900 MeV, Θ_D=90°, Θ_B = 45°, (220) reflection , diamond, T=0.35 mm, Bragg and Laue geometry for the same crystal and experimental condition. Both orientations were obtained by the crystal rotation on 45°. Distance 1.067 m, collimator aperture -4 mm The main features: multiple passing of electrons through the target. Path of some electrons and photons in the crystal is less than its thickness



$l_a \gg l_{ext} \sim l_{form}$

Effect – without thin Ti plate; Background with thin Ti plate

Influence of the emission polarization
Angular distribution in vertical and horizontal plane

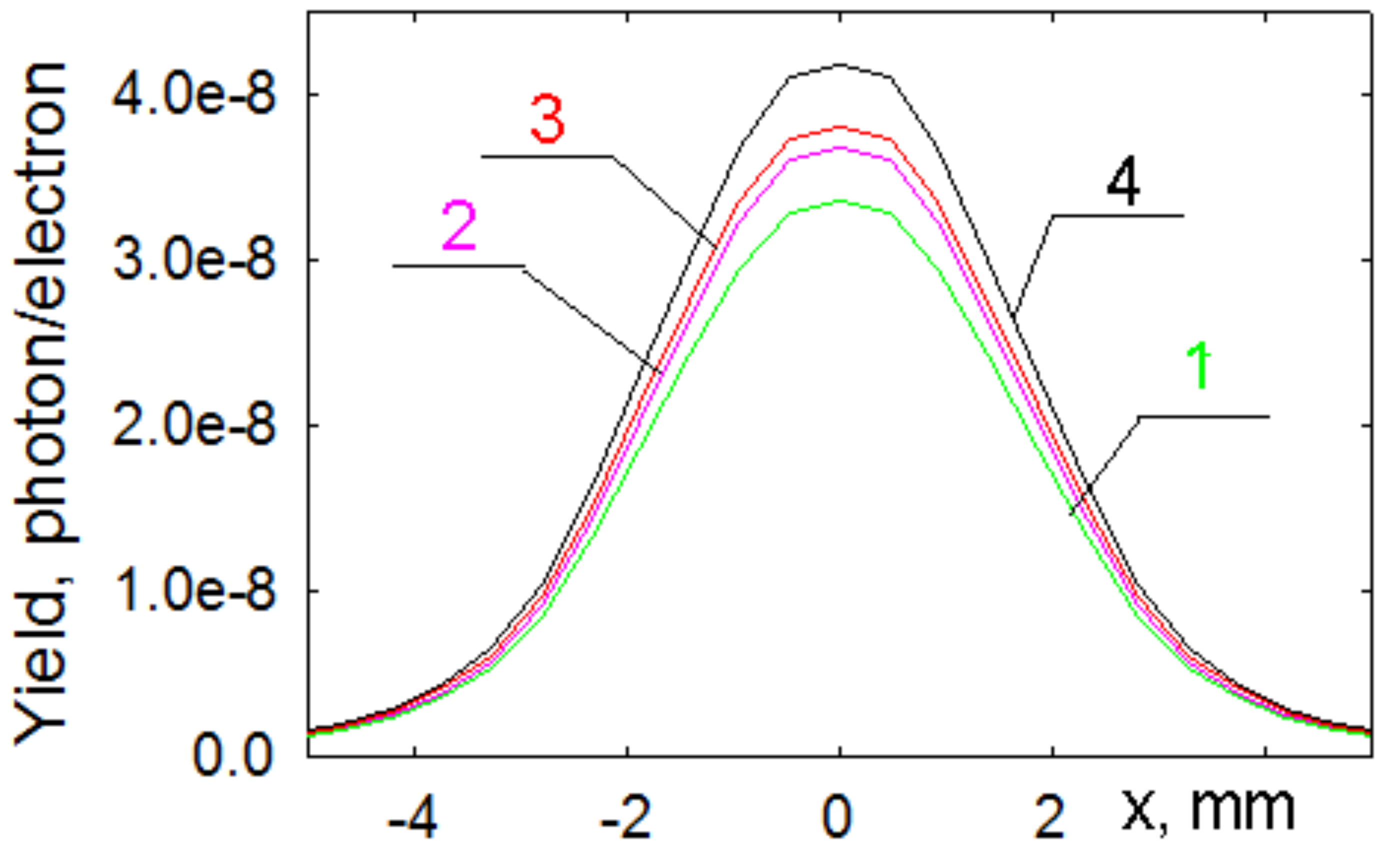


$Y \sim I \sin^2(\phi) + I\cos^2(\phi)\cos(\Theta_D)$, where Θ_D - observation angle, ϕ –azimuthal angle , I – the emission intensity.

Where are the TR and DTR born?

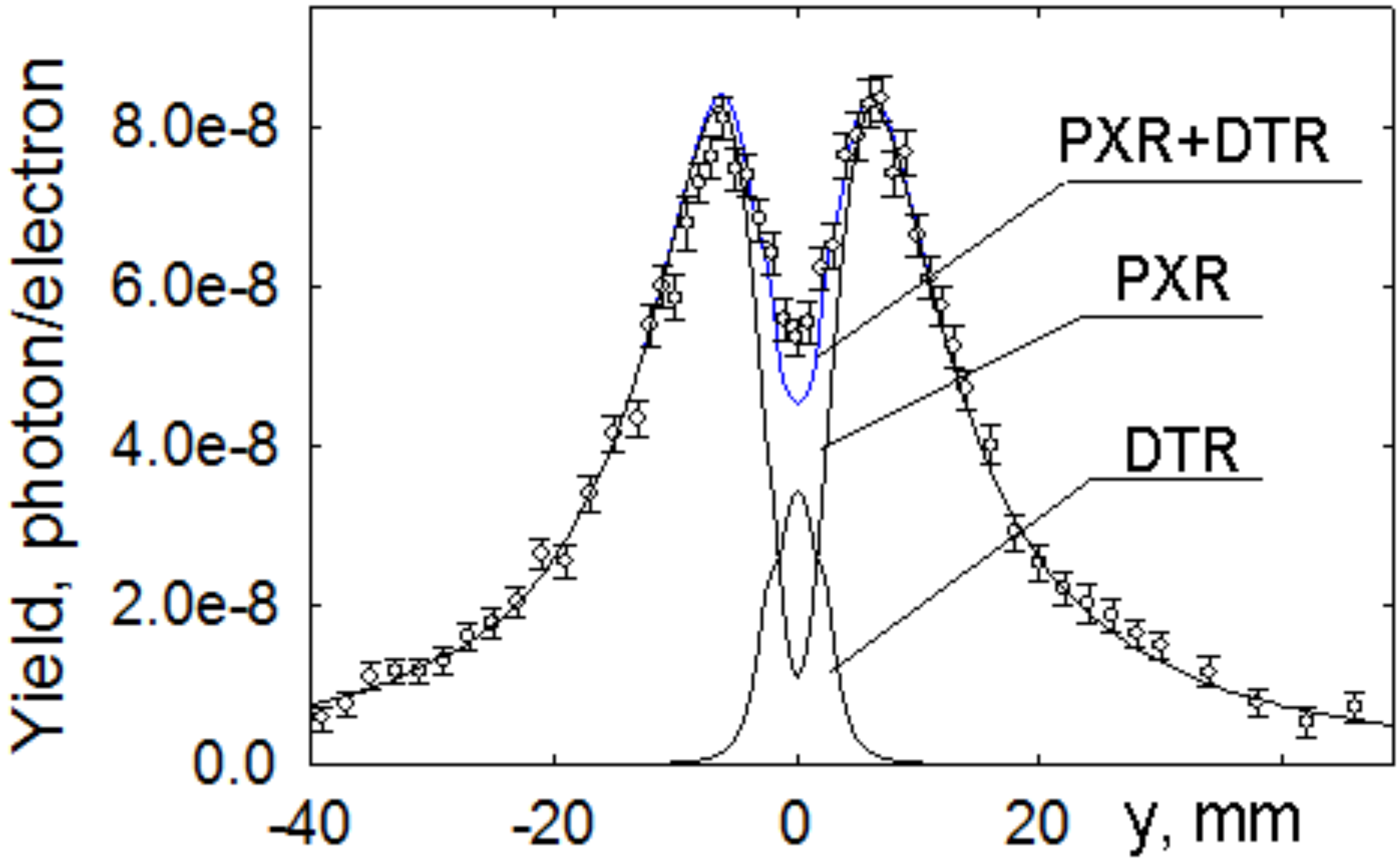
$$l_{form}=4c/(\omega(\gamma^{-2}+(\omega_p/\omega)^2+\theta^2))$$

For $\gamma \gg 1$ formation length don't become from the electron energy and is determined by the medium parameters and the photon energy.



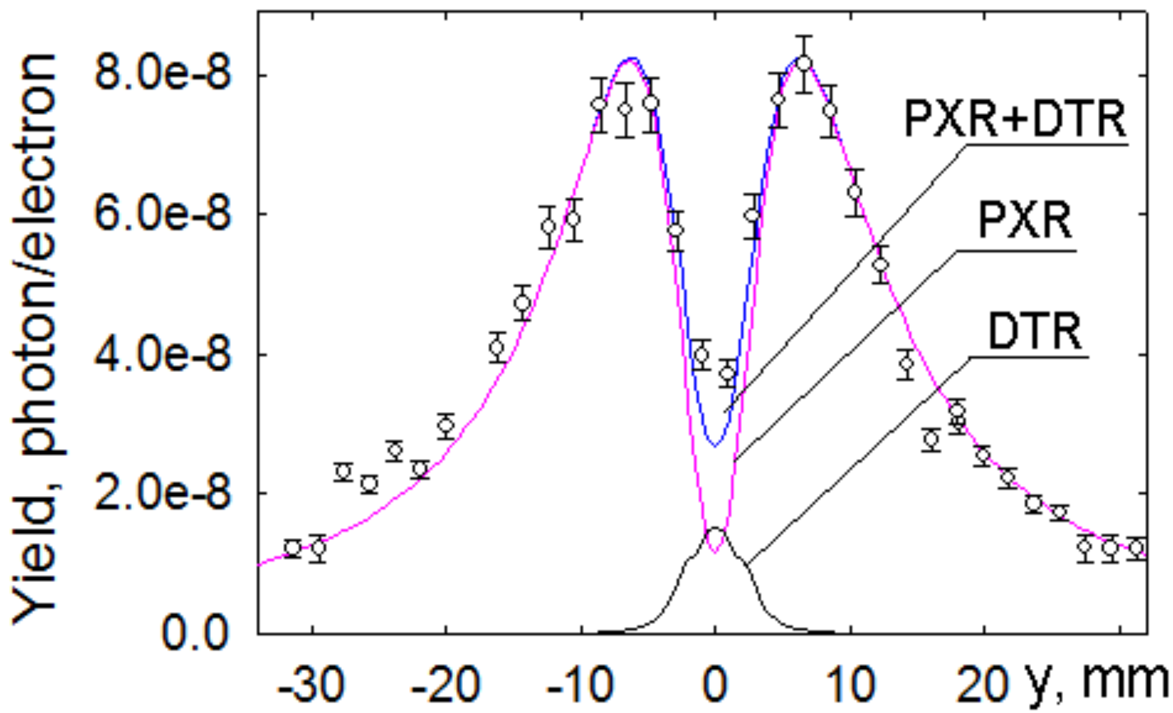
1 – after formation length; 2 – along path; 3 – on the surface; 4 -without absorption;

Comparison of the calculated and the experimental results for Bragg geometry, taking into account all experimental features



Experimental DTR yield is slihtly greater than calculated one.
The difference is about 15-20%

Comparison of the calculated and the experimental results for Laue geometry, taking into account all experimental features too.



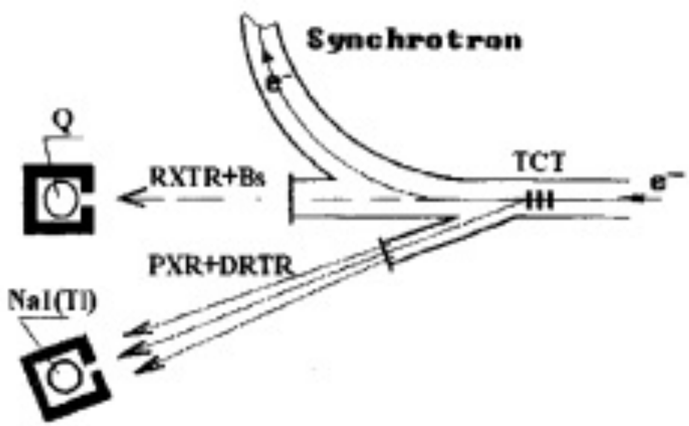
The DTR yield for Laue geometry is less than for Bragg one because of longer photon path in the crystal.

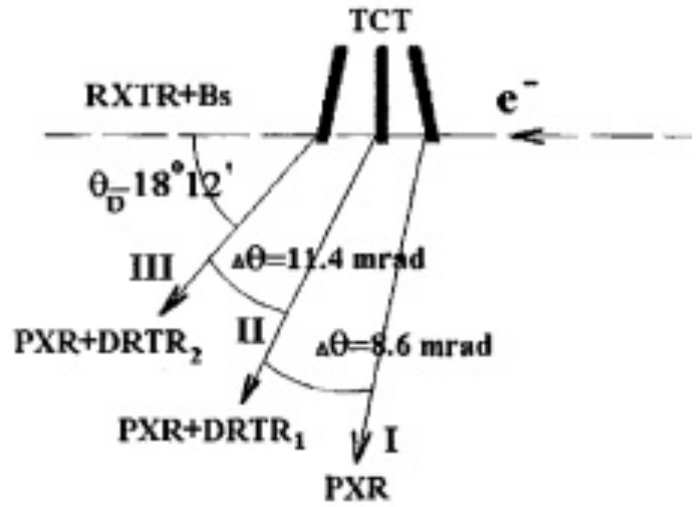
Experimental DTR yield is greater than calculated one too.

The difference is about 15-20% as for Bragg geometry.

Place of photon generation don’t influence on the observed DTR yield.

Multy-crystal target, E=800 MeV, t=0.016 mm and 0.048 mm
Collimator – vertical slit 2x40 mm, base ~ 2 m
Aim of the experiment –DRTR observation
M.Yu. Andreyashkin et al. // JETP Lett., 1997, **65**, P. 625



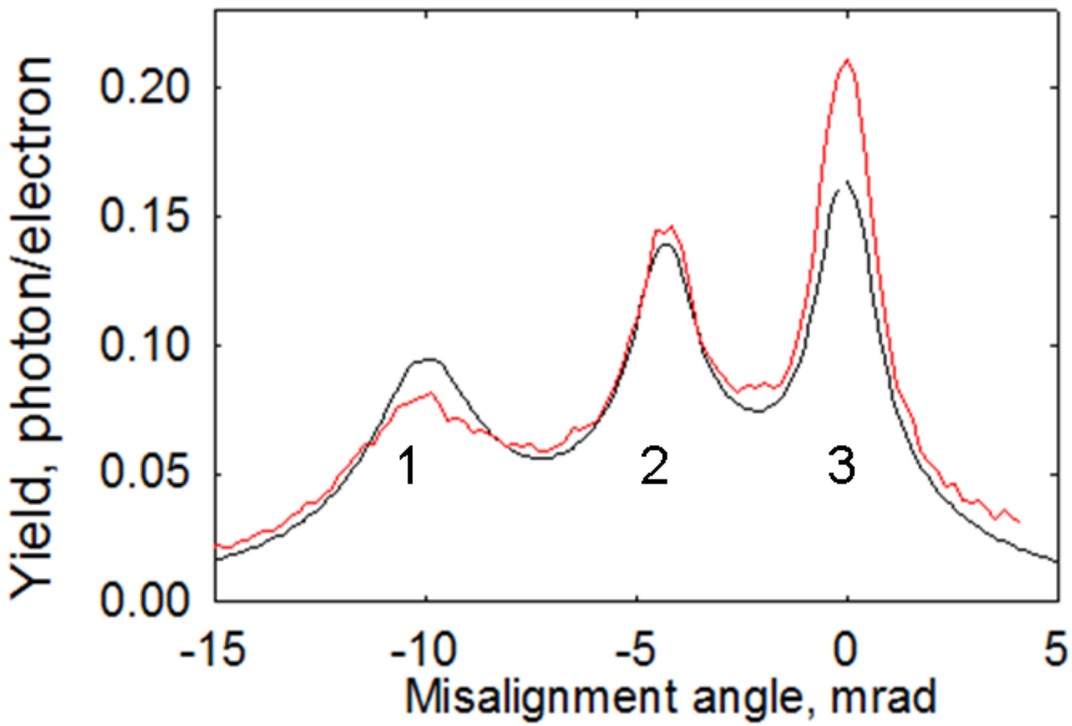


The main feature of the experiment, from our point of view –
two thin crystals with different thickness
for the same experimental condition.

Comparison of the measured and calculated theta-scans for the multy-crystal target.

We compare the shape of the theta-scans scans only.

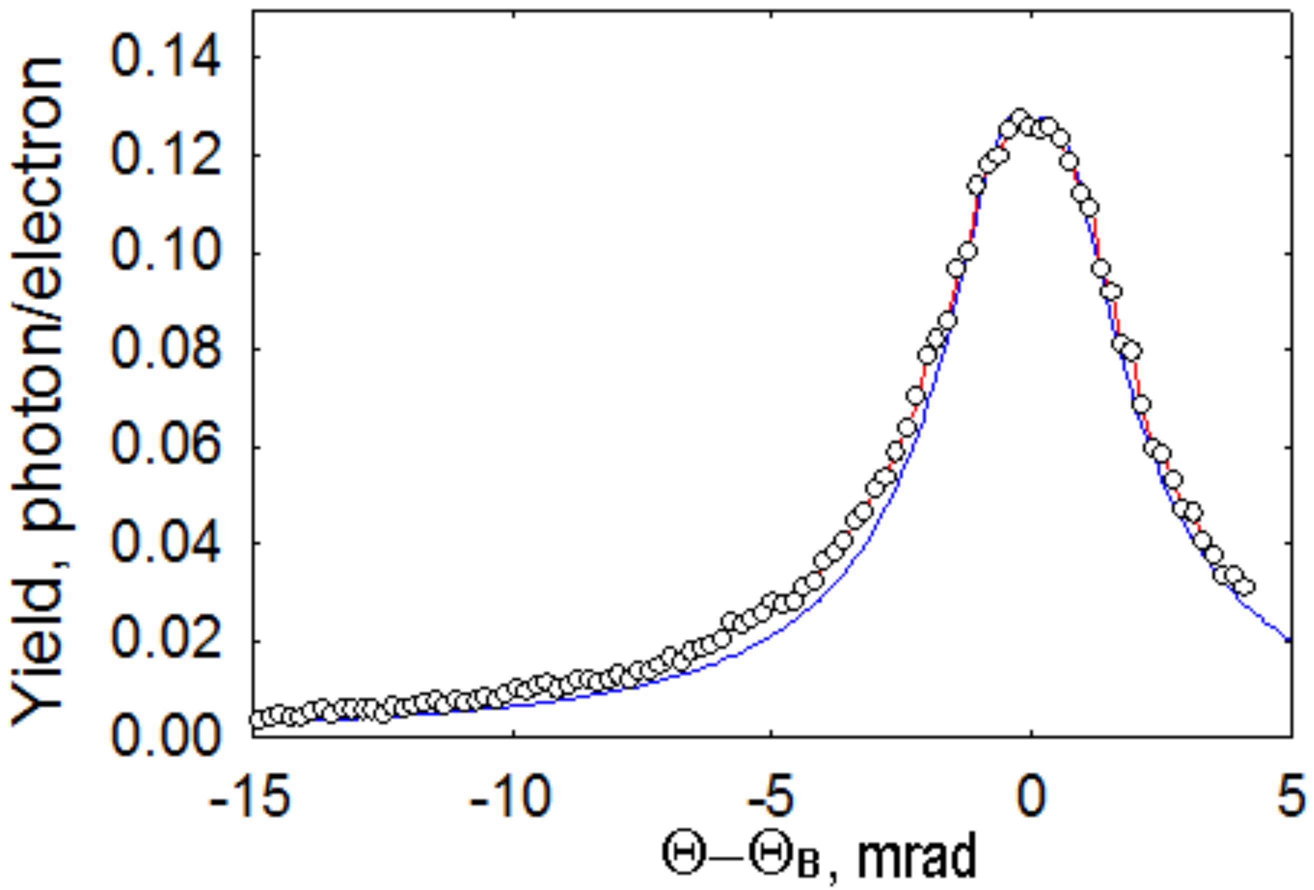
1- PXR+DTR; 2 ~ PXR+3DTR; 3 ~ PXR +5 DTR



Agreement between calculation and experiment is not well not only for the second and the third crystal, but for the first crystal too, where the authors observeed usual PXR and DTR in the crystal only .

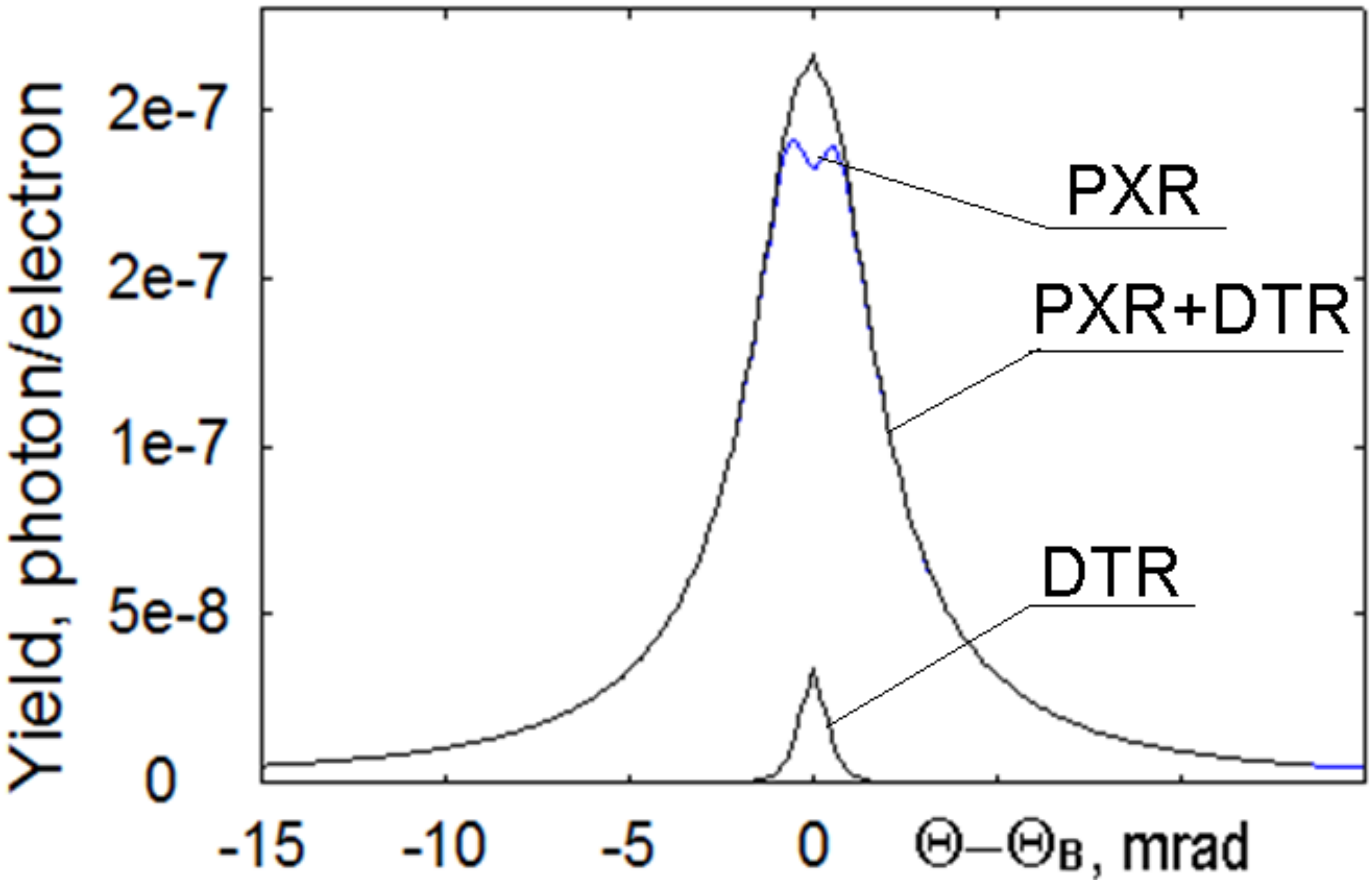
What is the reason?

Comparison of the experimental and calculated theta-scan for the crystal thickness of 0.048 mm.



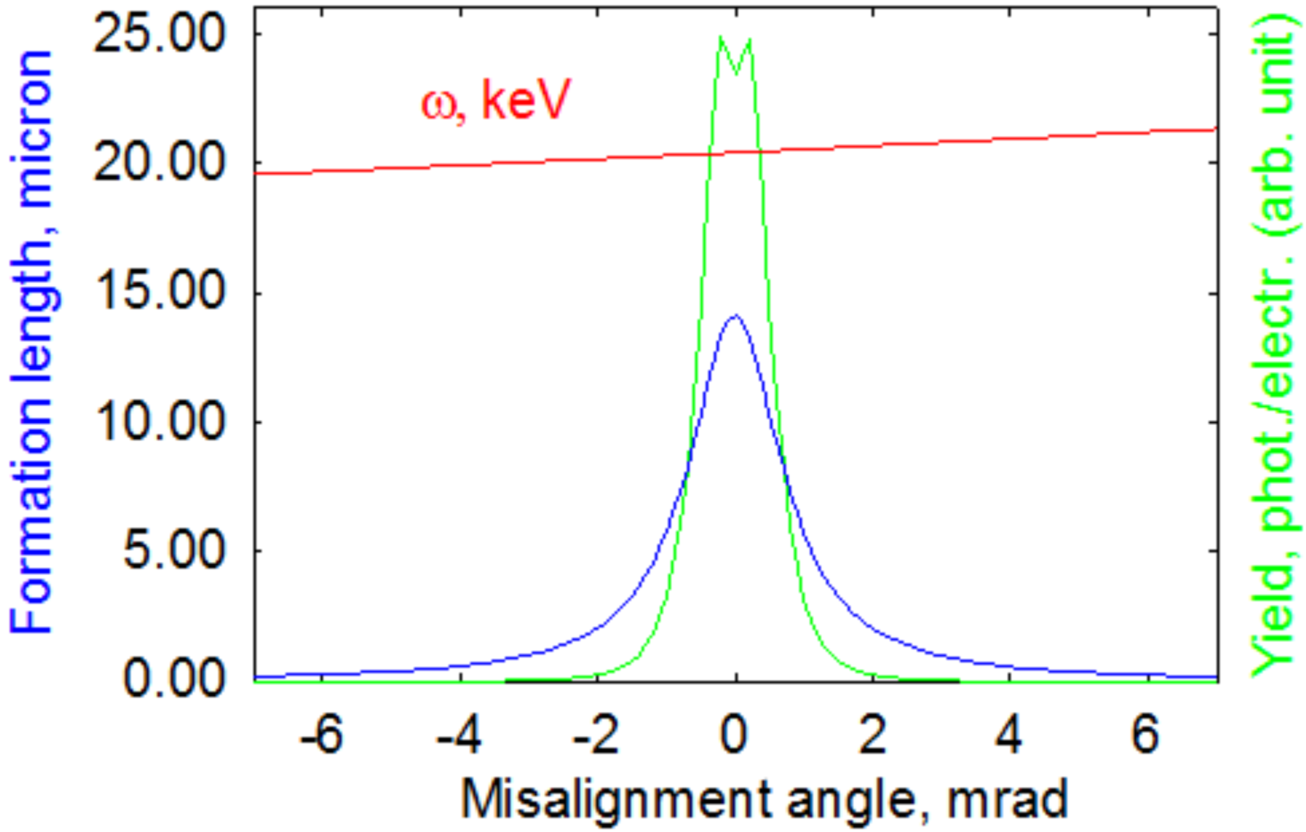
Agreement between calculation and experiment is a rather well.
Why we observe bad agreement for the thin crystal and good one for the thicker crystal? May be it is the influence of the crystal thickness?

Calculation results for the thicker silicon crystal



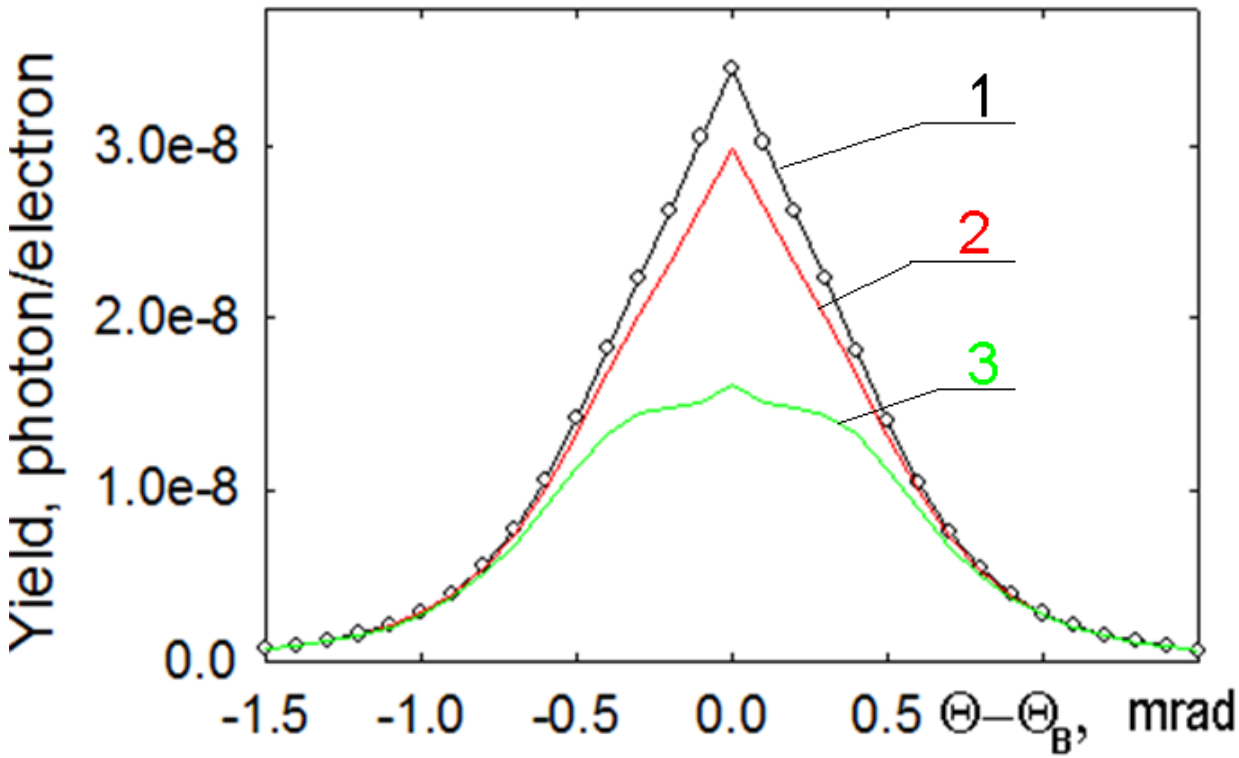
DTR contribution is about 10-15% from the PXR one. For thinner crystal it is about a half of the PXR yield.

Dependence of the formation length size for the detector displacement region from the crystal orientation. DTR theta-scan for less collimation angle



The formation length is closed to the thin crystal thickness, therefore its influence may be very strong.

Dependence of the theta-scan characteristic from region where the TR generation and its diffraction take place.



1 – on the crystal surface; 2 – along electron path in the crystal; 3 – after formation length. For this situation the discrepancy will be less

This experiment needs more careful data treatment. It is a very important, because here the authors have absolute value of the photon yield for both targets: multi-foil one and equivalent silicon crystal.

Other experiments with relatively thin crystals:

J. Freudenberger et al. // Phys. Rev. Let., 2000, **84**, P.270

PXR+DTR for a thin silicon crystal and observation angle 360°.
Adischev Y.N. et al. // NIM, 2003, V.B201, P.114

PXR+DTR for a tungsten crystal and observation angle 90°
In both cases we didn't obtain good agreement between calculation and experiments. In both case the experimental yield is about twice larger than calculated one. We suppose that this discrepancy is connected with strong X-ray absorption. Here l_a is about 5 $l_{ext.}$ Therefore we can't consider photon scattering and absorption as independent processes.

Conclusion

1) Previous proposed method of calculation of real photon diffraction contribution in thin crystal was checked and improved.
2) The method works well for bremsstrahlung diffraction and transition radiation diffraction for Laue geometry and crystals with a thickness greater than some formation length.
3) Problem where the transition radiation arises and its diffraction process is taken place needs more accurate investigation.
4) For relatively strong photon absorption when absorption length is about some extinction one the diffraction and absorption processes shouldn’t consider separately.