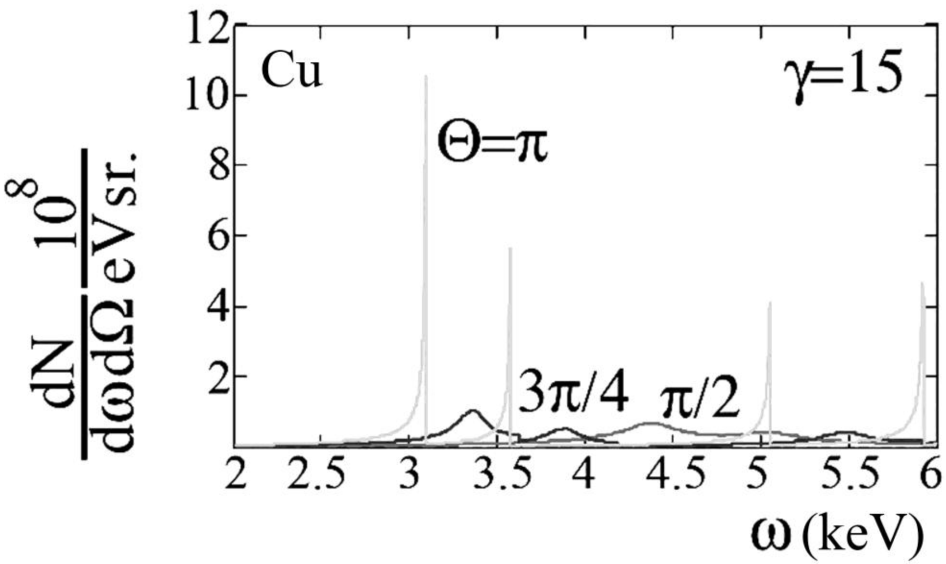
Diagnostics of polycrystals using polarization bremsstrahlung from relativistic electrons in backscattering geometry

V.I. Alexeyev[1,2], A.N. Eliseyev[1,2], E. Irribarra[1], I.A. Kischin[1], A.S. Kubankin[1,2], V.V. Polyansky[2], R.M. Nazhmudinov[1,2], V.I. Sergienko[1,2]

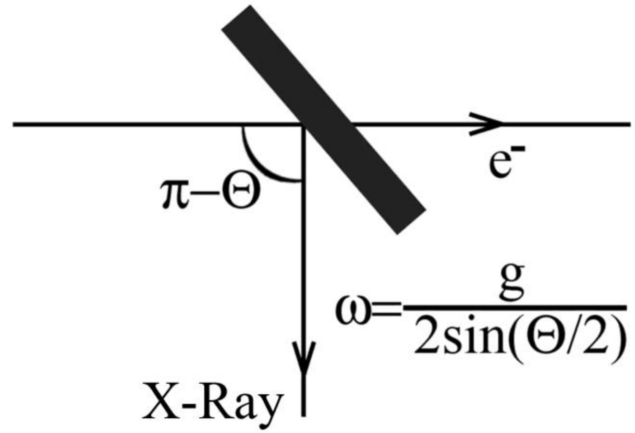
[1] ***Belgorod State University, Belgorod, Russia***

[2] ***P.N. Lebedev Physical Institute RAS, Moscow, Russia***

Capri - 2014



The dependence of PB spectra on observation angle.



The width of spectral PB peaks

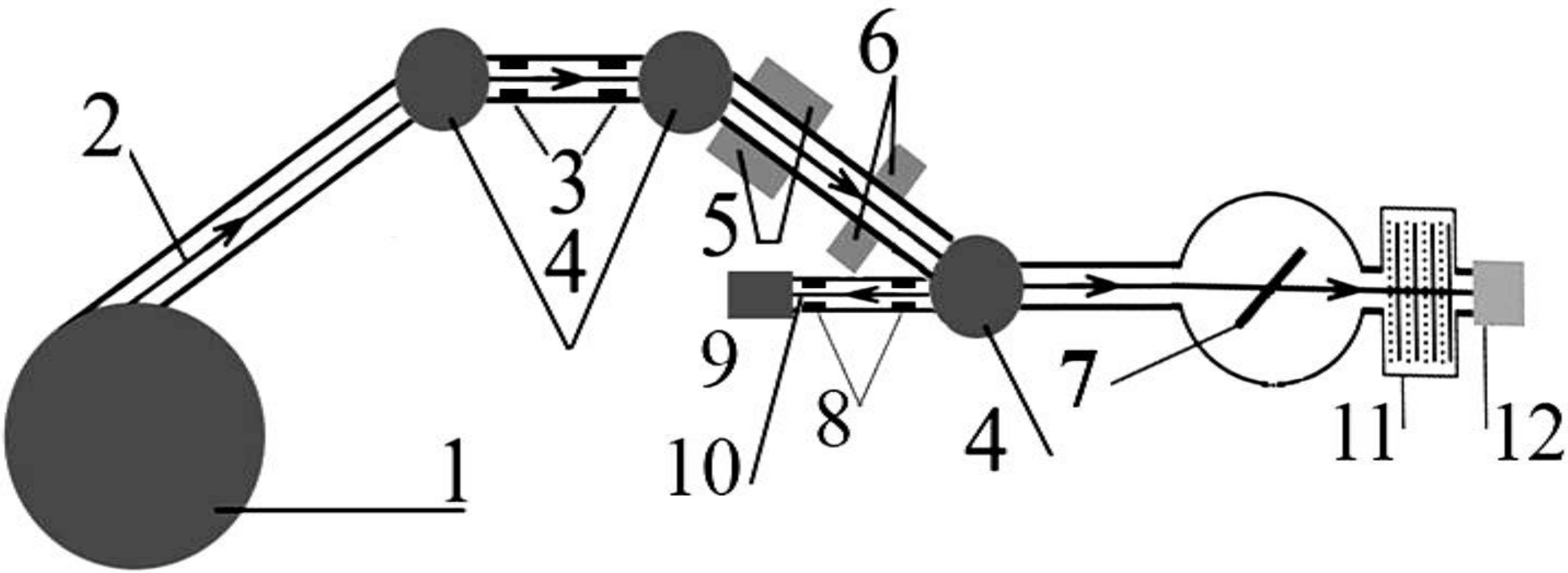
$$\frac{\Delta\omega}{\omega} \approx \frac{\sqrt{\cos^2(\theta/2) - \frac{1}{4}\rho^2\cos(\theta)}}{\rho^{-1}\sin(\theta/2)}$$

$$\rho^2 = \gamma^{-2} + \omega_0^2/\omega^2$$

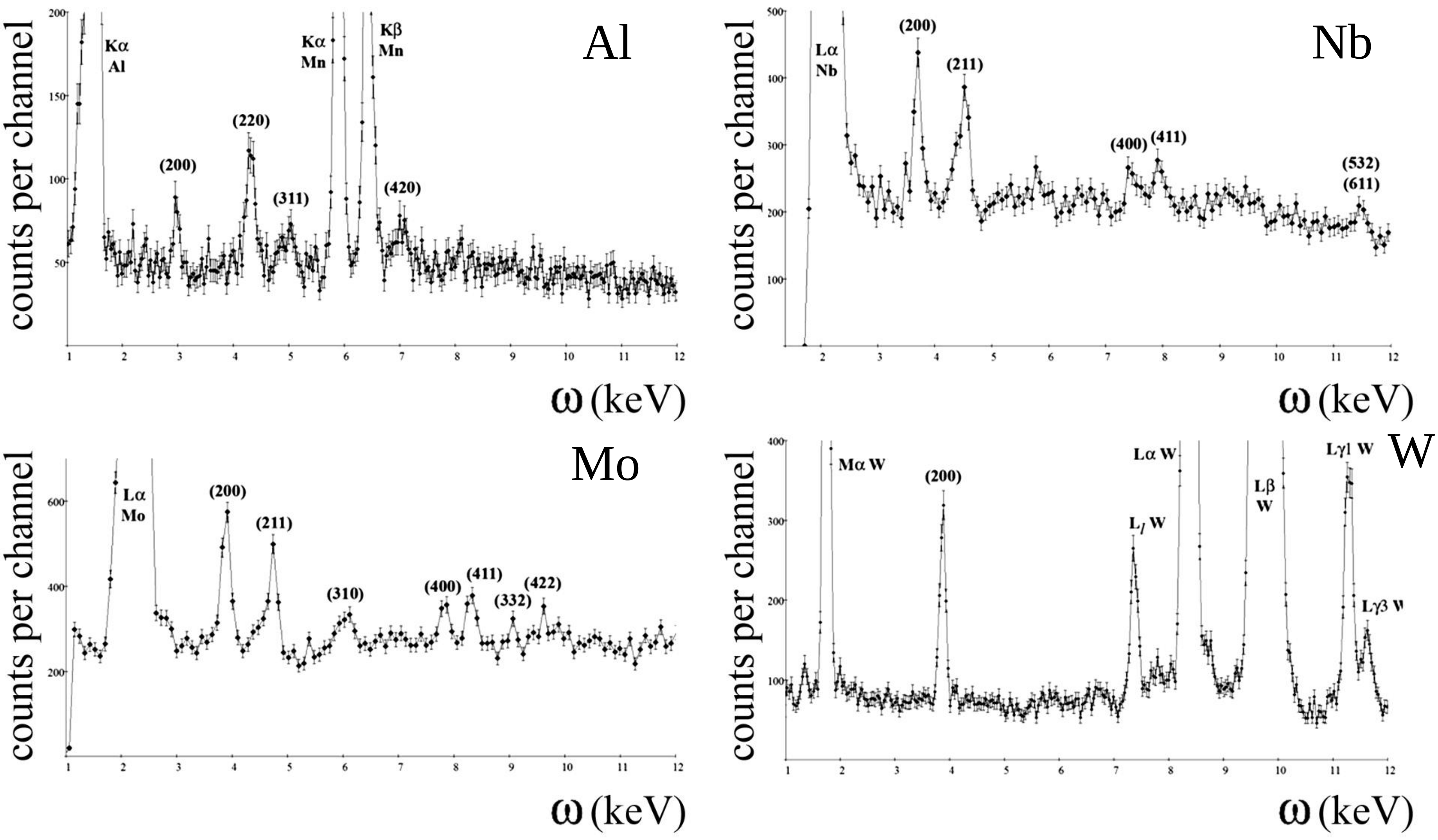
$$\frac{\Delta\omega}{\omega} \approx \gamma^{-1}$$ **- usual geometry**

$$\frac{\Delta\omega}{\omega} \approx \frac{\rho}{2}\sqrt{\rho^2 + (\Delta\theta)^2} \rightarrow \frac{\rho^2}{2} \approx \frac{\gamma^{-2}}{2}$$ **- backscattering geometry**

$$\frac{\Delta d}{d} \approx \frac{\Delta\omega}{\omega} \approx \frac{\gamma^{-2}}{2}$$



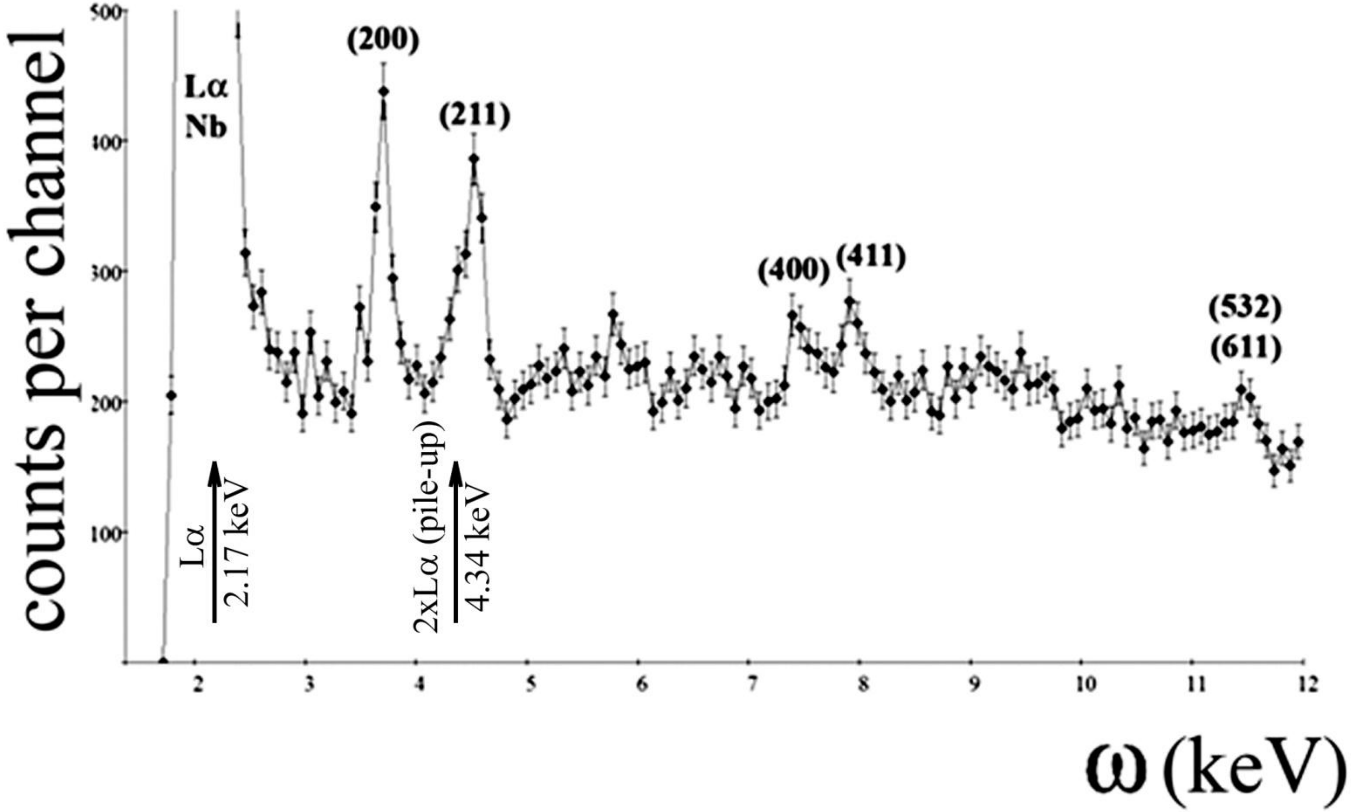
1 – microtron; 2 – electron beam; 3 – carbon collimators; 4 – deflecting magnets;
5 – magnetic quadrupole lenses; 6 – magnetic V-corrector; 7 – target;
8 – X-Ray collimators; 9 – X-Ray detector; 10 – X-Ray signal;
11 – multichannel proportional detector; 12 – Faraday cup.

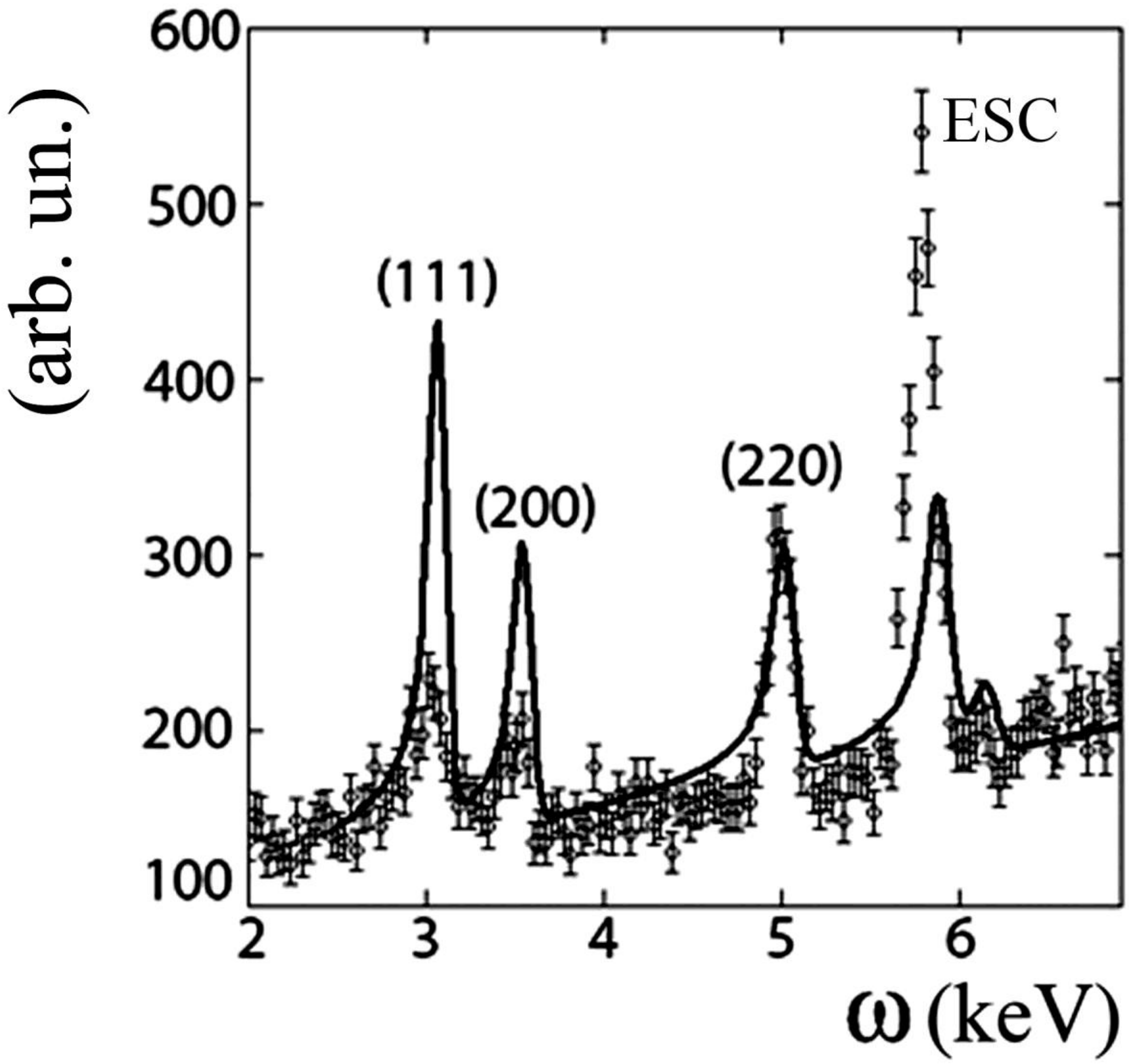


PBBS from different polycrystalline targets.

Target	Peak	Position experiment	Spectral width	Position theory
Al	(220)	4.351 кeV ± 6 eV	140 eV ± 13 eV	4.329 кeV
Nb	(200)	3.796 кeV ± 9 eV	130 eV ± 20 eV	3.756 кeV
Nb	(211)	4.605 кeV ± 13 eV	211 eV ± 30 eV	4.600 кeV
Mo	(200)	4.002 кeV ± 5 eV	150 eV ± 10 eV	3.940 кeV
Mo	(211)	4.851 кeV ± 8 eV	130 eV ± 18 eV	4.825 кeV
W	(200)	3.962 кeV ± 3 eV	106 eV ± 5 eV	3.924 кeV

Target	Peak	Position experiment	Spectral width	Position theory
Al	(220)	4.351 keV ± 6 eV	140 eV ± 13 eV	4.329 keV
Nb	(200)	3.796 keV ± 9 eV	130 eV ± 20 eV	3.756 keV
Nb	(211)	4.605 keV ± 13 eV	211 eV ± 30 eV	4.600 keV
Mo	(200)	4.002 keV ± 5 eV	150 eV ± 10 eV	3.940 keV
Mo	(211)	4.851 keV ± 8 eV	130 eV ± 18 eV	4.825 keV
W	(200)	3.962 keV ± 3 eV	106 eV ± 5 eV	3.924 keV





PBBS (220)

Position:

experiment – 4.94 keV;

theory – 4.98 keV.

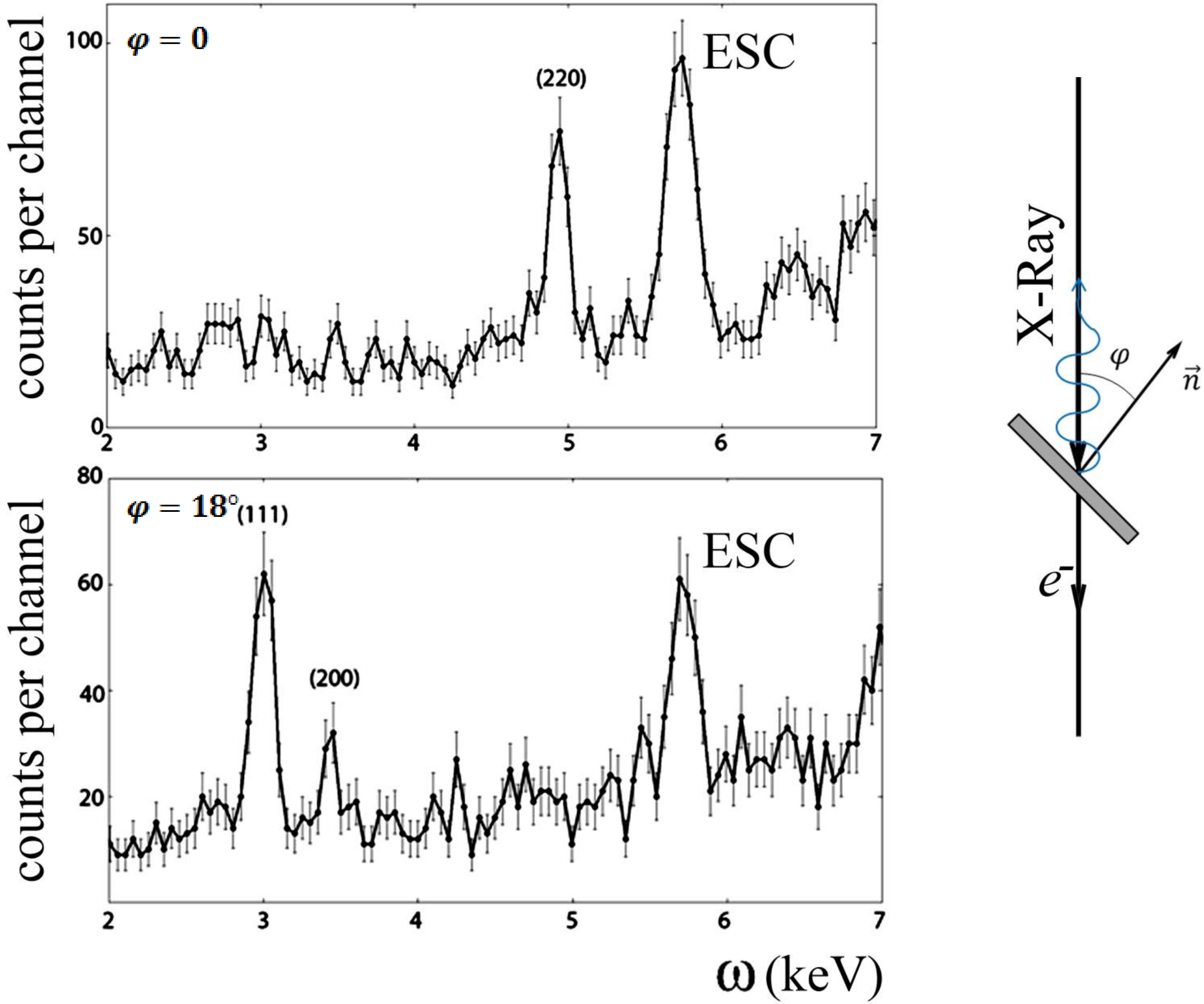
Width:

experiment – 159 keV;

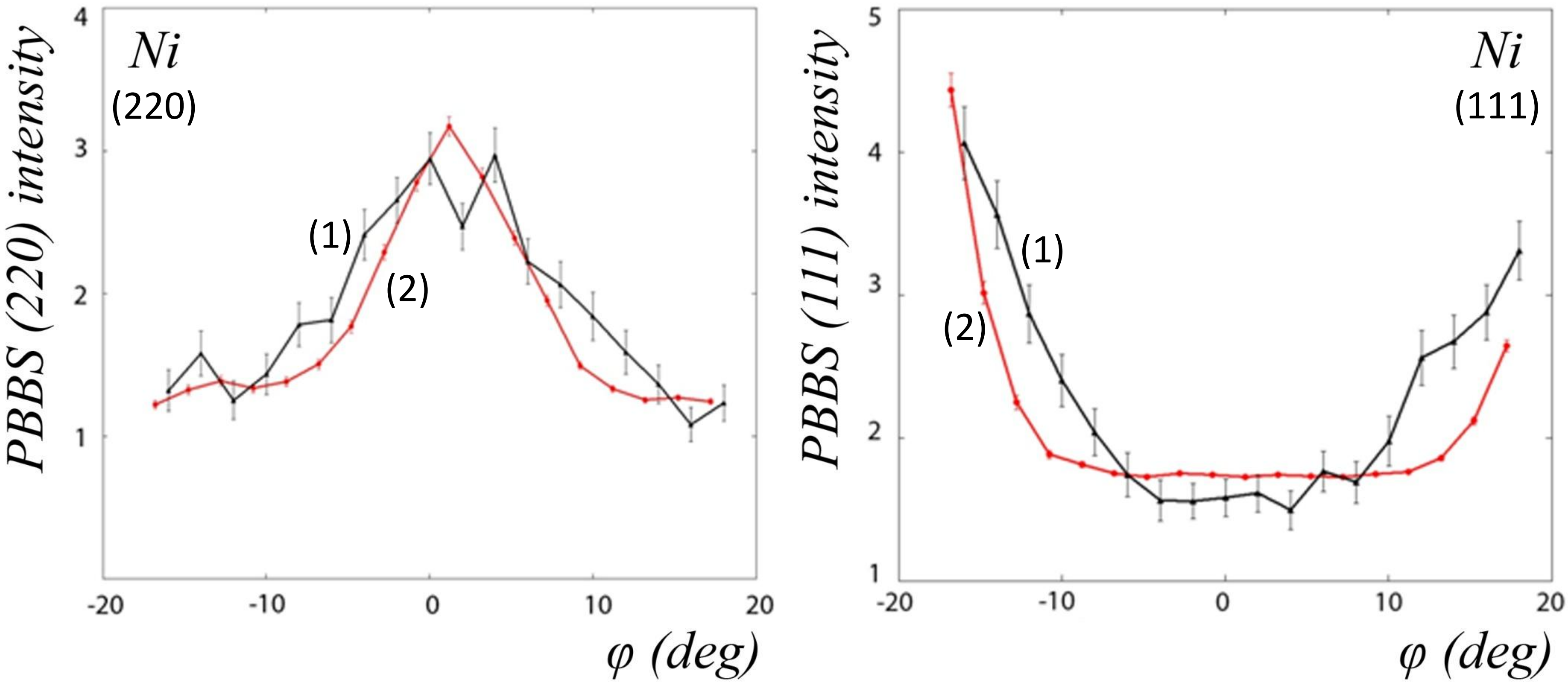
detector resolution – 160 eV

(measured for K_{β}^{Ti} 4.93 keV).

PBBS from 40μm Ni polycrystal. The average grain size is 300nm.

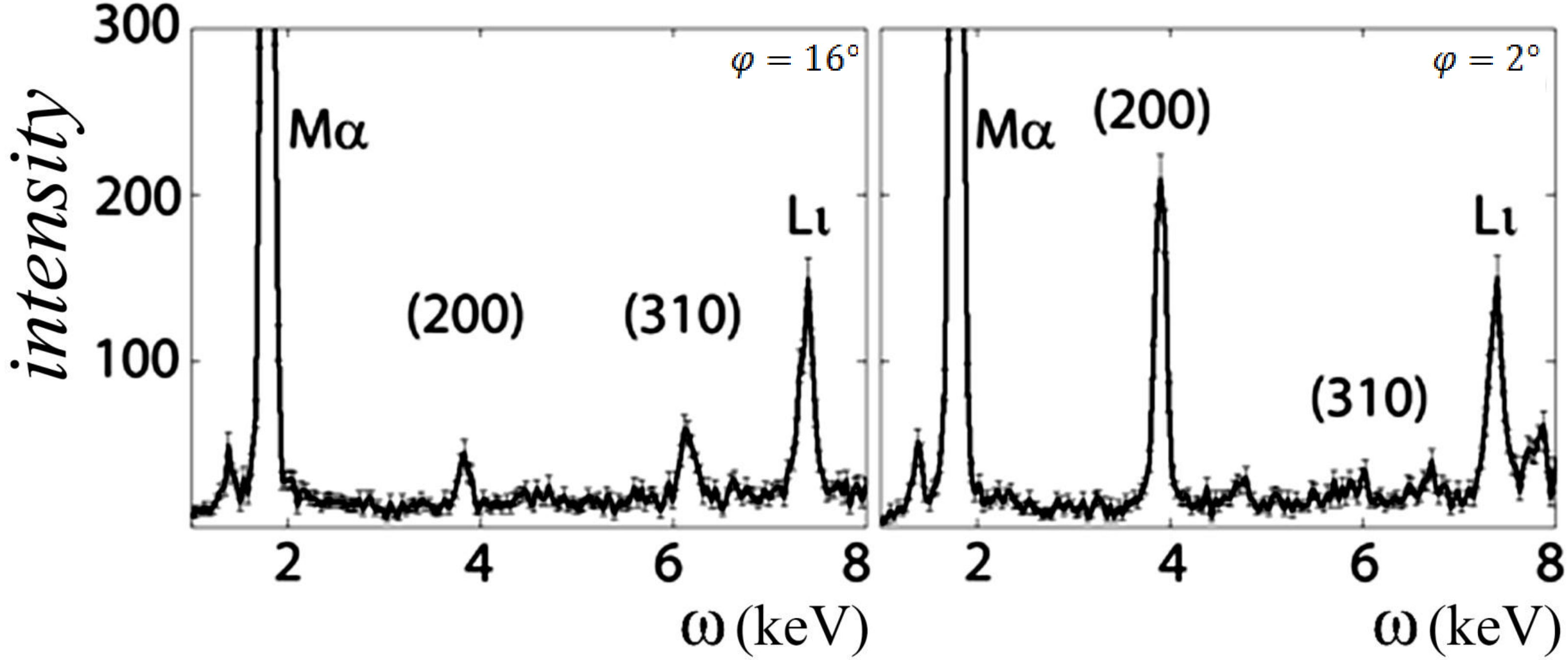


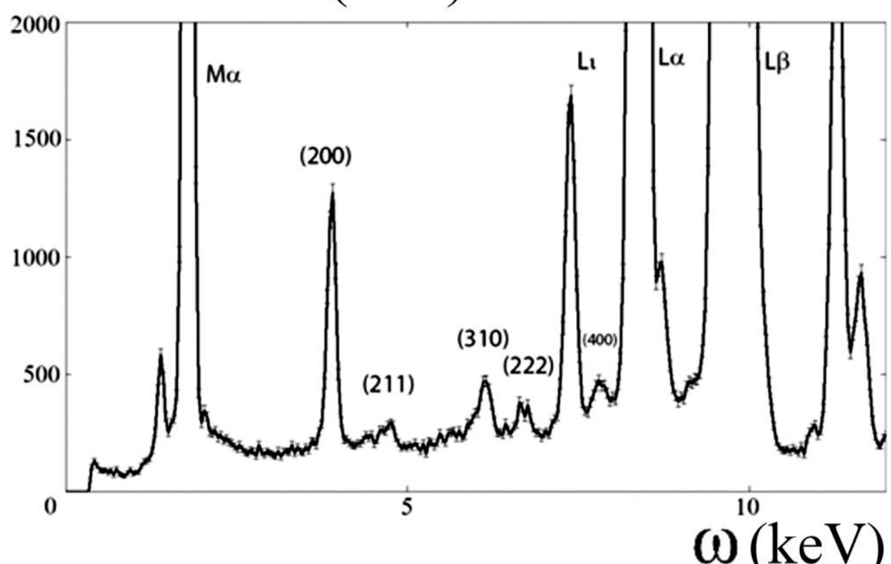
PBBS from 30μm Ni polycrystalline foil. The average grain size is 50nm. Different orientation angles.



The orientation dependence of PBBS peaks (111) and (220)
from Ni textured polycrystalline foil (1). The comparison with XRD (2).

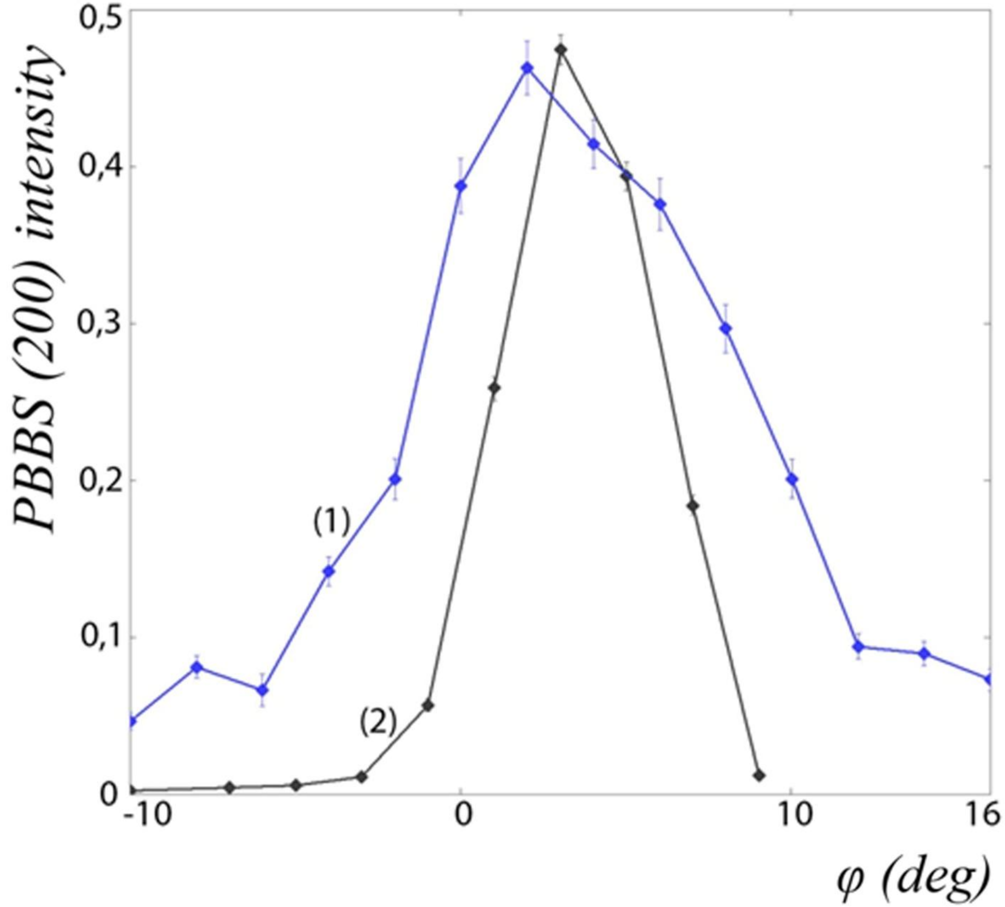
PBBS (220) distribution width	**XRD distribution width**	**Difference**
13.7°	**9.2°**	**4.5°**





Tungsten polycrystalline foil 20μm thickness.

Sum of spectra in range $-10° \leq \varphi \leq 16°$ with step $\Delta\varphi = 2°$.



The orientation dependence of PBBS peak (200)
from W textured polycrystalline foil (1). The comparison with XRD (2).

PBBS (220) distribution width	**XRD distribution width**	**Difference**
10.2°	**5.6°**	**4.6°**

Summary

Narrow PBBS coherent peaks are reliably fixed from polycrystalline foils of Al, Ni, Nb, Mo, W.

The possibility to detect PBBS peaks from nanodispersive polycrystals is confirmed.

The orientation dependences of PBBS peaks from textured polycrystalline foils are measured and compared with analogous XRD results.

The results present interest for the further development of a new energy-dispersive method for diagnostics of atomic structures of polycrystals.

Thank you for attention!