Channeling 2016

# Cherenkov Radiation from the Target with Predetermined Dielectric Properties, Produced Using 3D-Printer

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# About problem

For verification of new theoretical models of Cherenkov and other radiation (for example **D.V Karlovets, A.P Potylitsyn, PLA**), the experimental results using targets with a simple (rectangular) profile are often required.

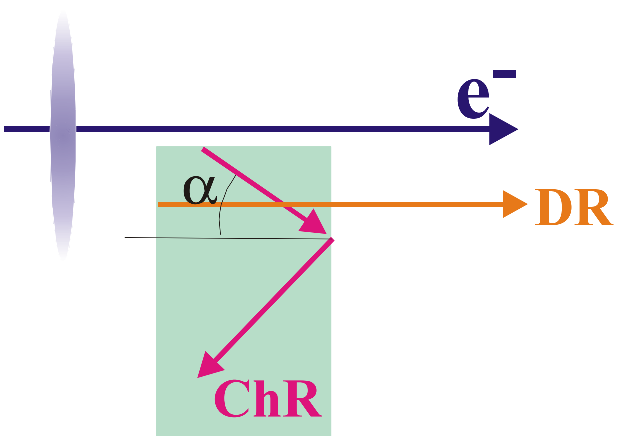



TABLE I

MILLIMETER-WAVE DATA OBTAINED WITH OPEN-RESONATOR SYSTEMS

| Material | λ (mm) | Frequency (GHz) | n | References |
|---|---|---|---|---|
| Alumina | 8.834 | 33.906 | 3.119 ± 0.015 | Lynch (1982) |
| Polyethylene (high density) | 0.87 | 344.83 | | Degenford and Coleman (1966) |
| | 2.1 | 142.86 | | Degenford and Coleman (1966) |
| | 8.57 | 35 | 1.5218 ± 0.0015 | Afsar and Jones (1978) |
| Polyethylebe (Rigidex 2000) | 8.6 | 34.88 | 1.5360 ± 0.0015 | Cook *et al.* (1974) |
| Polypropylene | 8.718 | 34.38 | 1.5858 ± 0.0004 | Lynch (1982) |
| | 8.862 | 34.80 | 1.5012 ± 0.0004 | Lynch (1982) |
| | 8.57 | 35 | 1.5014 ± 0.002 | Afsar and Jones (1978) |
| | 0.87 | 344.83 | | Lynch (1982) |
| Teflon (sintered) | 2.1 | 142.86 | | Lynch (1982) |
| | 6 | 50 | 1.433 ± 0.007 | Culshaw and Anderson (1962) |
| | 8.6 | 34.88 | | Degenford (1968) |
| Teflon (unsintered) | 8.6 | 34.88 | | Cook *et al.* (1974) |
| TPX | 8.677 | 34.57 | 1.4589 ± 0.0013 | Lynch (1982) |
| | 8.508 | 35.26 | 1.458 ± 0.002 | Afsar and Jones (1978) |
| Polystyrene | 0.87 | 344.83 | | Degenford and Coleman (1976) |
| | 2.1 | 142.86 | | Degenford and Coleman (1976) |
| | 6 | 50 | 1.590 ± 0.008 | Culshaw and Anderson (1962) |
| | 8.6 | 34.88 | | Degenford (1968) |
| Plexiglas | 0.87 | 344.83 | | Degenford and Coleman (1976) |
| | 2.1 | 142.86 | | Degenford and Coleman (1976) |
| | 6 | 50 | 1.599 ± 0.008 | Culshaw and Anderson (1962) |
| Crystal Quartz (ordinary ray) | 8.57 | 35 | | Jones (1976a) |
| (extraordinary ray) | 8.57 | 35 | | Jones (1976a) |
| Slip-cast fused silica | 3.18 | 94.34 | 1.812 ± 0.003 | Breeden and Langley (1969) |
| Liquid cyclohexane | 8.436 | 35.56 | | Cook and Jones (1978) |
| | 4.167 | 72 | | Cook and Jones (1978) |
| | 2.083 | 144 | | Cook and Jones (1978) |

$$n > 1.42 \longrightarrow \alpha > \alpha_{REFL}$$

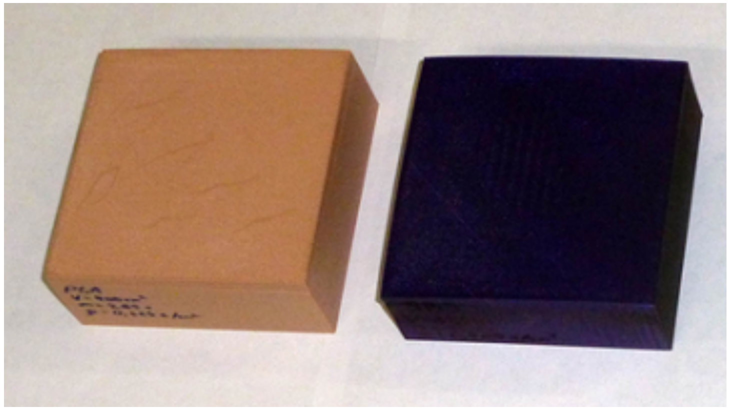
**So,we need for this purpose targets with $n < 1.4$**

# How to obtain n < 1.4 ?

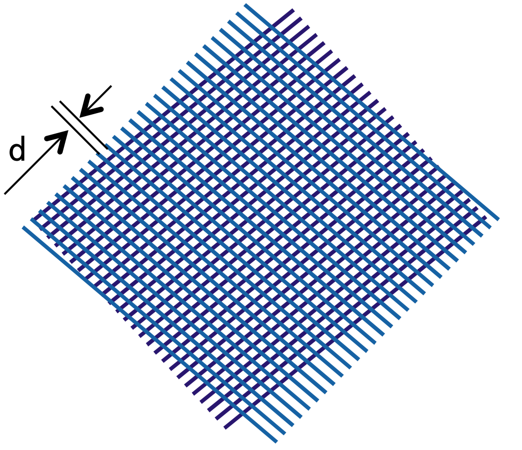
One of the solution of this problem are the targets produced using 3D - printer

$100 \times 100 \times 40\, mm$

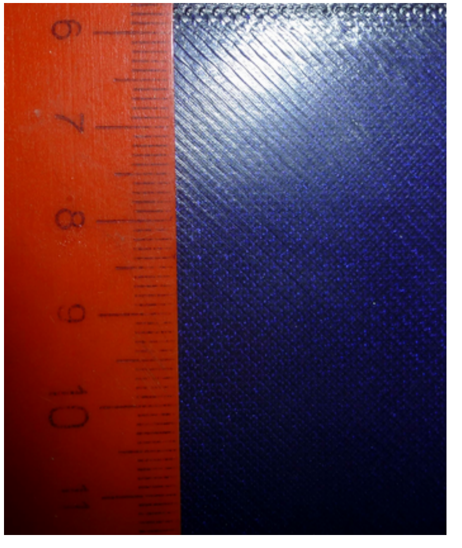
n=1.4 n=1.37



Target structure



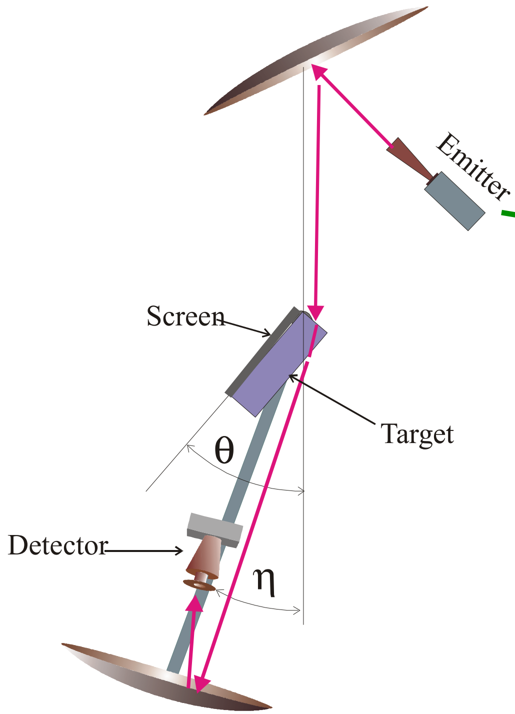

Target material: styrene-butadiene-styrene plastic



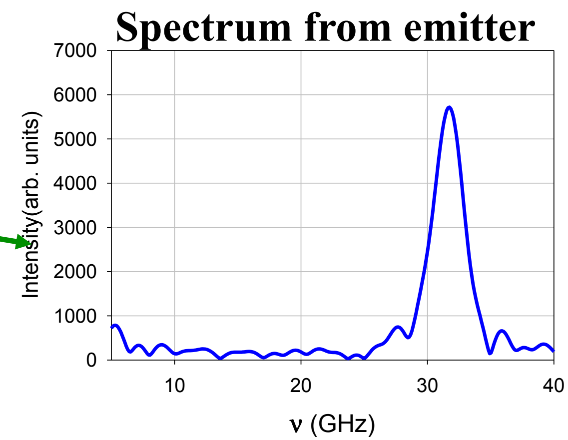
$$For \quad \lambda > 10\, mm \qquad \delta \approx 1 mm \quad << \lambda$$

*So, the target may be considered as the continuous target (like metamaterial)*

# Refractive index measurement



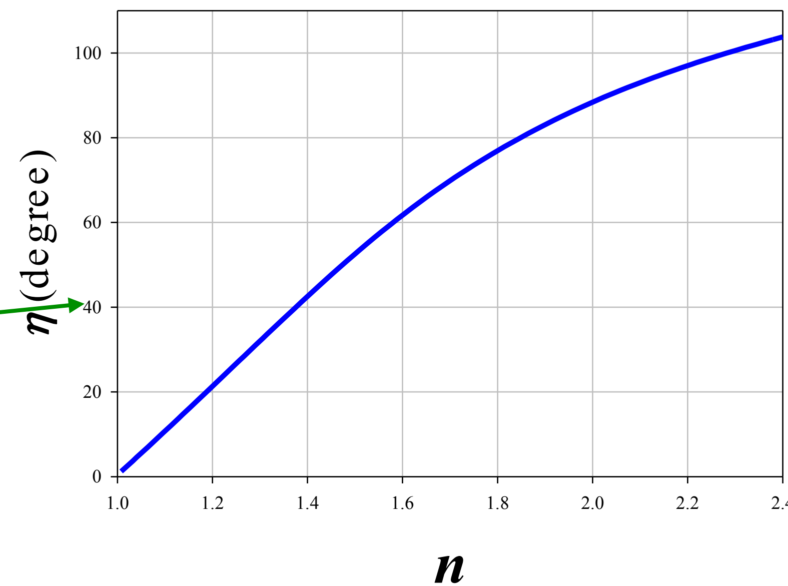

Parabolic telescope




*Refraction on the input and output surface according the Snellius low*

$$\eta = f\left(n,\theta\right)$$

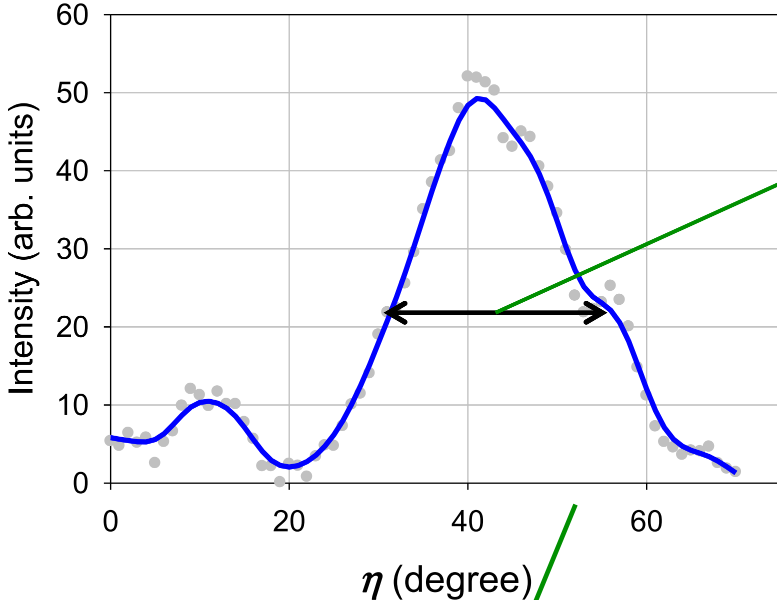
$$\theta = 60^0$$



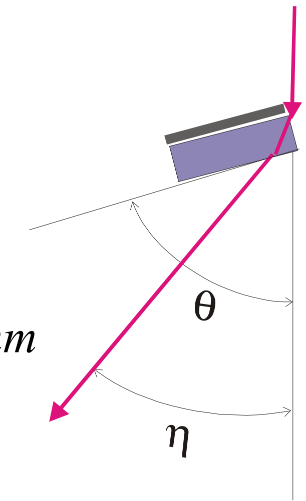

The measurements are performed in approach of far field zone

$$\theta = 60^0$$

Measured angular dependence

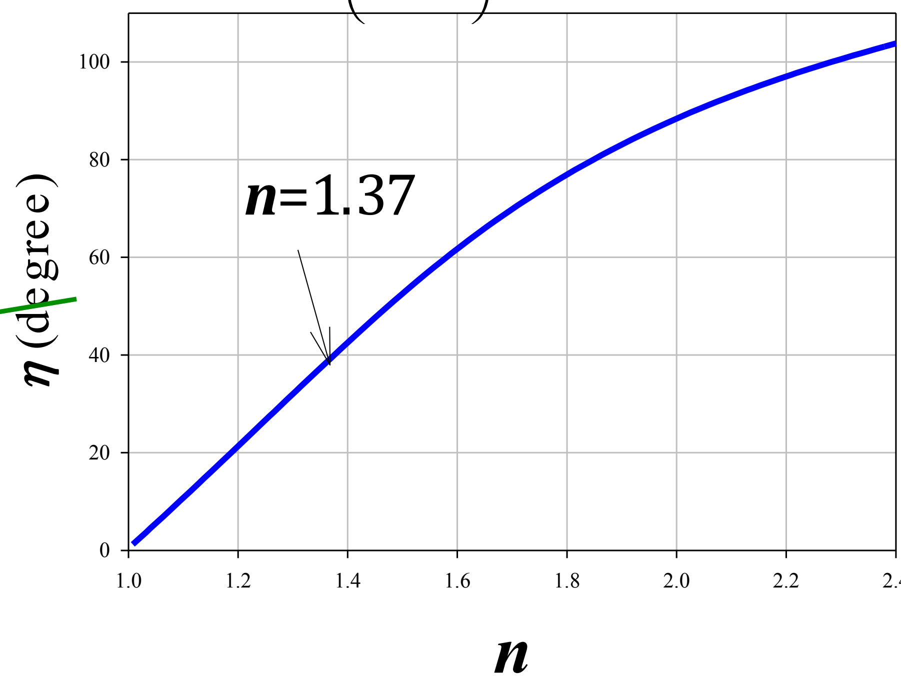







$a$=40 $mm$
is comparable to $\lambda = 9.5\ mm$

$$\eta = f\left(n, \theta\right)$$



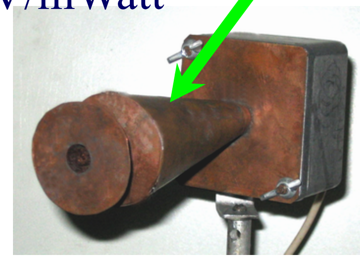

$$n = 1.37 \pm 0.015$$

# Cherenkov radiation measurement

## Detector parameters :

wavelength range: = 3 ~ 35 mm, ***Horn***

sensitivity = 0.3 V/mWatt



Broad bend detector

The detector efficiency is declared by the manufacturer in the wavelength region ?=3?35

mm as a constant with accuracy ? 15%

## Electron beam

**Tomsk polytechnic university microtron**

| Beam parameters | |
|---|---|
| Electron energy | 6.1 MeV |
| Macro-pulse duration | 2~6 ms |
| Pulse repetition rate | 1~8 Hz |
| Micro-pulse length | ≈ 6 mm |
| Electrons number per micro-pulse | ≈ $10^8$ |
| Micro-pulses number per macro-pulse | ≈ $10^4$ |
| Beam size at the output | 4×2 $mm^2$ |
| Emittance: horizontal | $3 \cdot 10^{-2}$ mm ×rad |
| vertical | $1.5 \cdot 10^{-2}$ mm ×rad |

$\gamma = 12,$

$\lambda = 9 - 35\ mm$

## Coherency

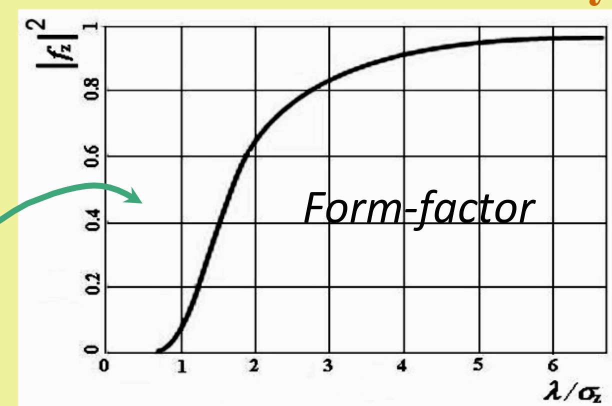
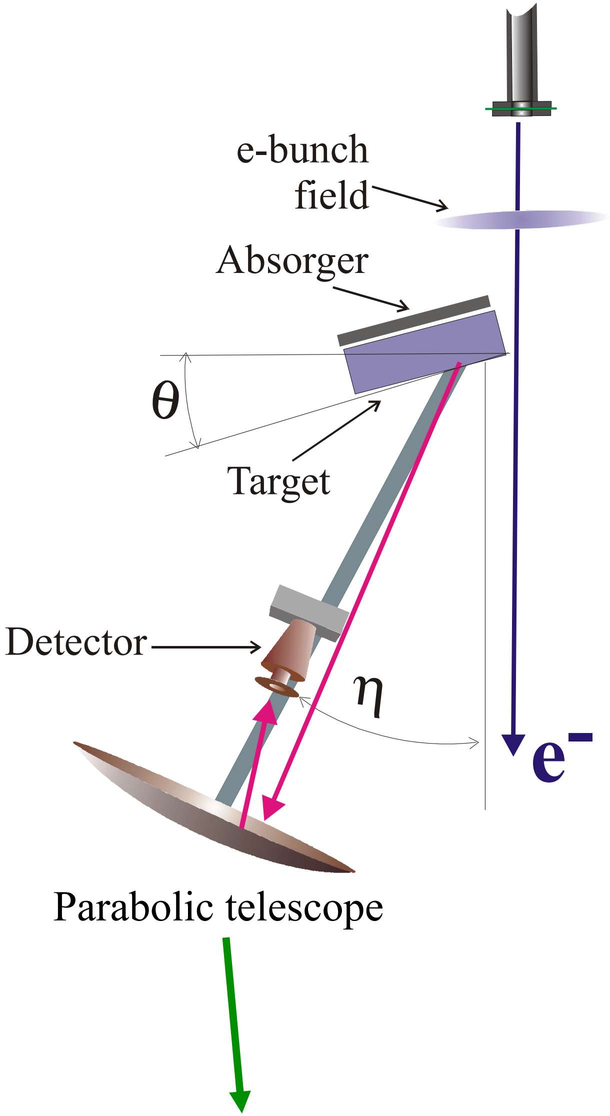


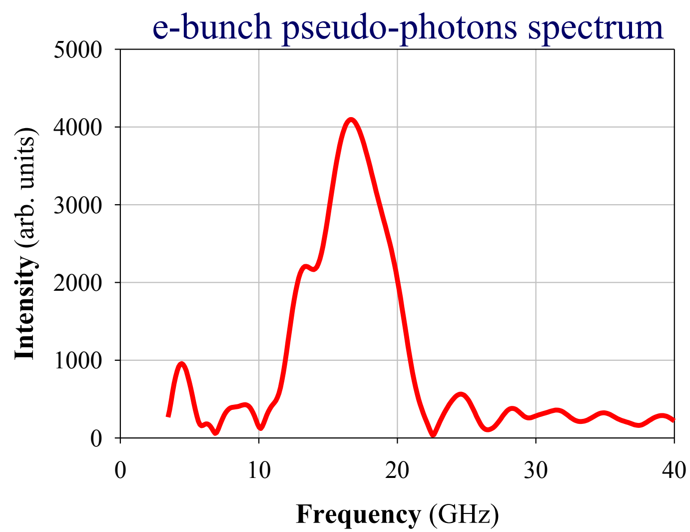

Fig.4 Dependence of the squared form-factor module on the radiation wavelength for the gaussian longitudinal distribution of electrons in a bunch.

**For ?? 8 mm the radiation is coherent**

# Experimental setup



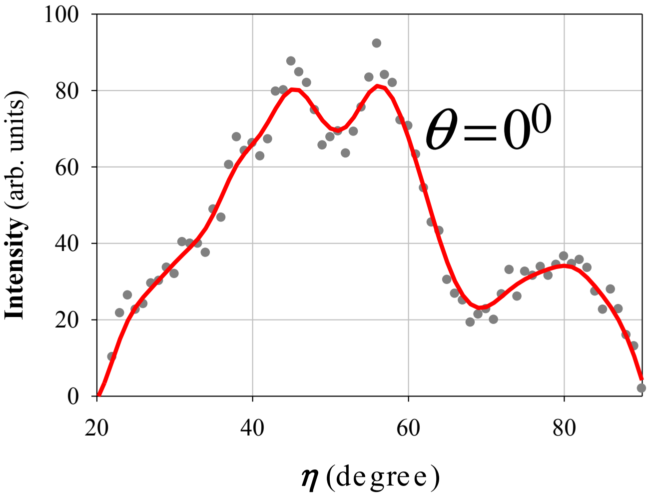


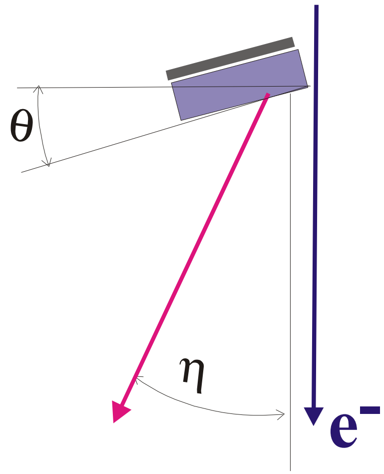


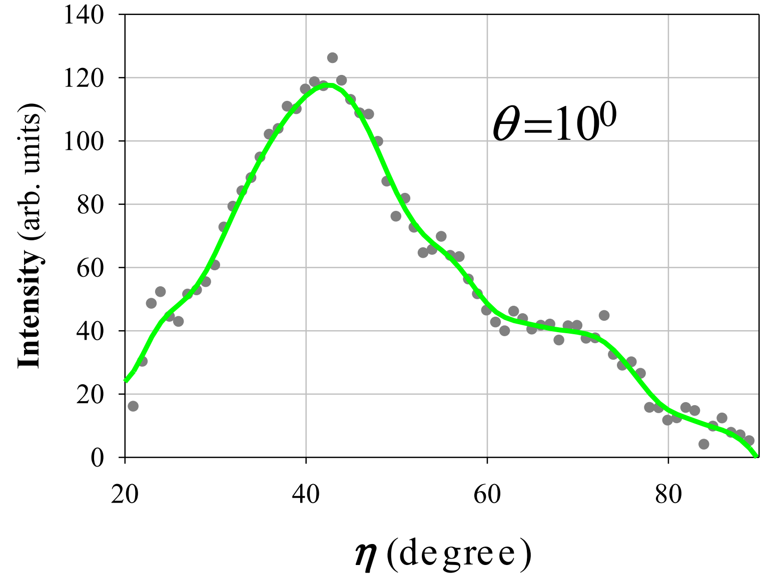

**The measurements are performed in approach of far field zone**

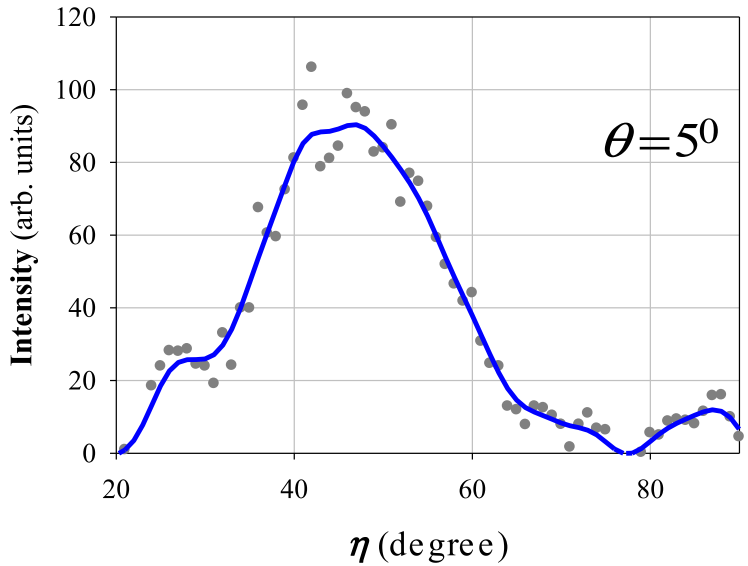
# Results

## Cherenkov radiation angular dependences




***Now we can verify a theoretical model using these results***

# Summary

- 3D-printer technique allows us to prepare targets with a refractive index which provides generation of Cerenkov radiation from rectangle targets in downstream semi-space.

- Suggested technique allows us to verify a new theoretical models using a simple targets geometry, by comparison with experimental results.

- Such viewpoint is useful for the development of new theoretical models of Cherenkov radiation, when electrons do not cross the target but move near its edge.

# Thank you for your attention