# Experimental investigation of Smith-Purcell radiation focusing by using the parabolic periodical targets

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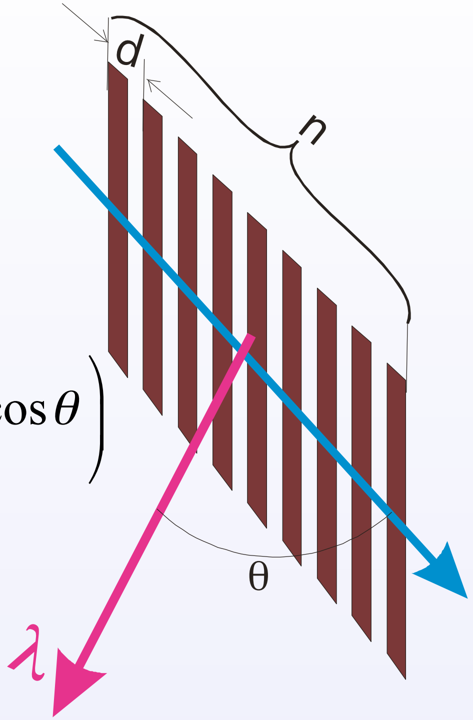
**Microtron 12 MeV, NPI, Tomsk, Russia, 2008**

# Smith-Purcell radiation




$$\lambda = \frac{d}{m}\left(\frac{1}{\beta} - \cos\theta\right)$$

**A.P. Potylitsyn, Phys. Lett. A 238 (1998) 112.**

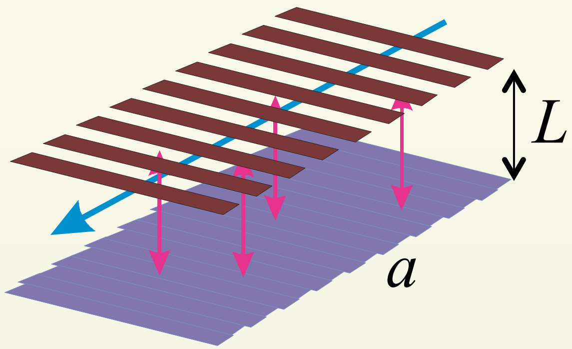
## *Far field zone*

## Pre-wave zone

***For* TR** $R \leq \gamma^2 \lambda$ → **Spectral and angular distribution distortion**

**M. Castellano and V. Verzilov. Phys. Rev. E 67, 015501(R) (2003)**
**S.N. Dobrovolsky, N.F. Shul'ga, EPAC 2002, Paris, France**

**But what about Smith-Purcell radiation?**




$L \leq a$ **?**

**We may expect the similar SPR characteristic distortion**

# Estimations

**The classical Kirhoff method was modified to take into account the fact that in case of TR and SPR one have inhomogeneous Maxwell equations.**

(D.V. Karlovets, A.P. Potylitsyn. ZhETPh, 134, 5 (2008) p. 887
A. G. Shkvarunets and R. B. Fiorito, Phys. Rev. ST AB, 11, 012801 (2008))

*Normal to a target*

*Electron field*

*Grin function*

$$\vec{E}(\vec{r}) = 2\int_{S} \left(\vec{n} \times \vec{E}_0\right) \times \text{grad}' G \, d\vec{r}',$$

$$G(\vec{r}, \vec{r}\,') = \frac{1}{4\pi} \cdot \frac{e^{ikR}}{R},$$

*Radiation field*

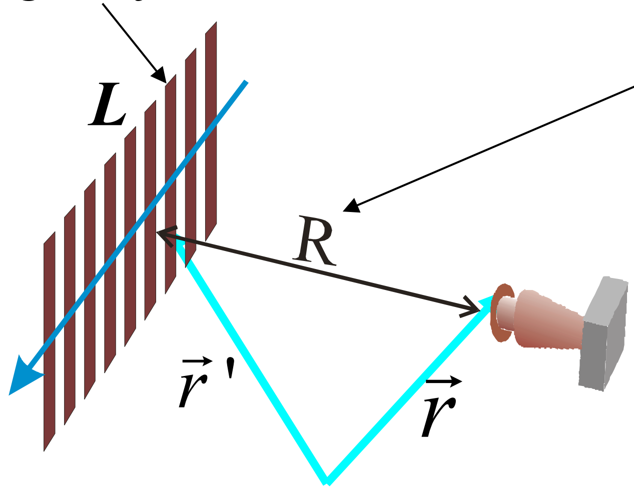
*Target surface*

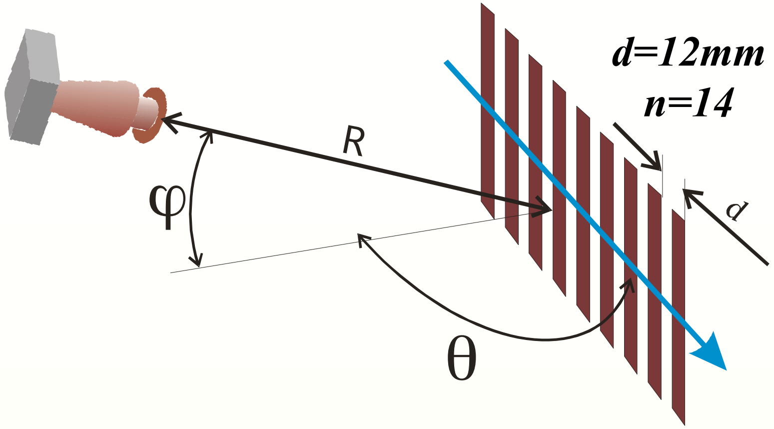
$$R = \left|\vec{r} - \vec{r}\,'\right|$$

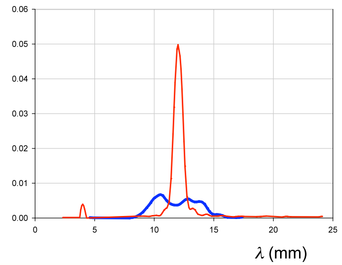
**Far field zone:**

$$R \gg \gamma^2 \lambda$$

$$R \gg L\sqrt{\frac{L}{\lambda}}$$

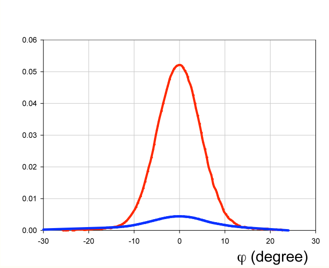





*Far field zone*

*Spectra ($\theta=90^0$, $\varphi=0$)*




*Pre-wave zone*

**R=300 mm**

# May be a focused periodic target will be useful?

*Azimuthal angular density distribution*

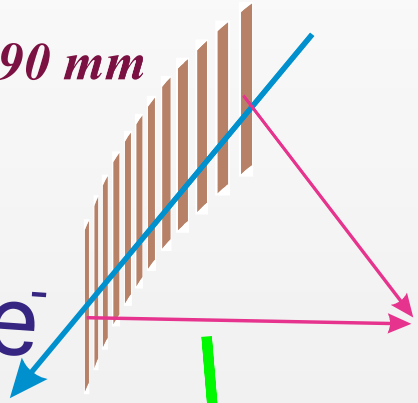
*($\theta=90^0$, $\lambda=12$ mm)*

# Focusing by parabolic targets

The idea of a focusing was suggested also by A. Schagin (RREPS-2007, Prag), but in this report were presented simple estimations using data from the **far field zone theory**.

## Let’s consider two schemes of focusing:

***f=190 mm***




***R=300 mm***

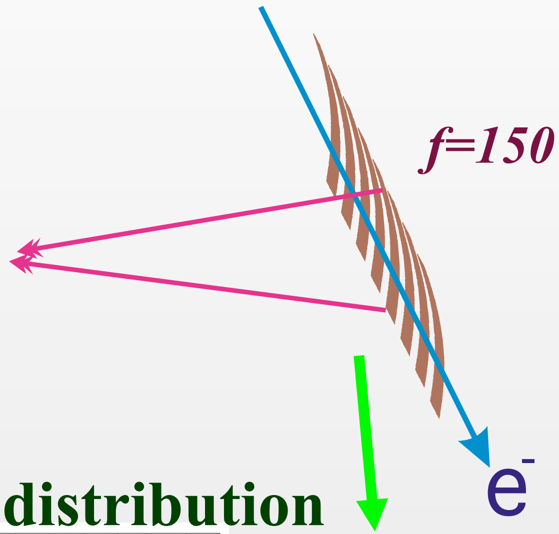
***d=12 mm***

***n=14***

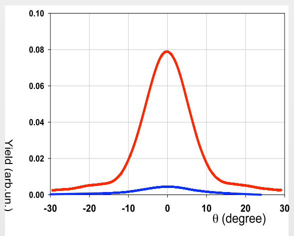
***$\theta$=90$^0$***

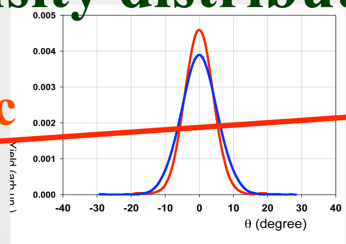
***$\lambda$=12 mm***

***f=150 mm***




**Azimuthal angular density distribution**




**Parabolic target**

**Flat target**

# Experiment

## 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 | $\approx 10^8$ |
| Micro-pulses number per macro-pulse | $\approx 10^4$ |
| Beam size at the output | $4\times2$ mm$^2$ |
| Emittance: horizontal | $3\cdot10^{-2}$ mm ×rad |
| vertical | $1.5\cdot10^{-2}$ mm ×rad |

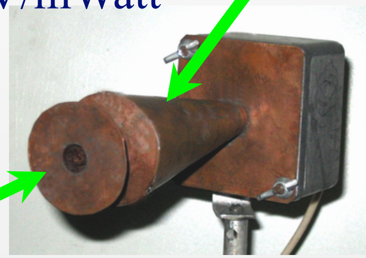
## Detector parameters :

wavelength range: = 3 ~ 16 mm, ***Horn***

sensitivity = 0.3 V/mWatt

**$\lambda_{cut}$=17 mm**

***Beyond-cutoff wave-guide***



Broad bend detector

$\gamma$=12; $\lambda$=9~17 mm

**The detector efficiency is declared by the manufacturer in the wavelength region λ=3~16 mm as a constant with accuracy ± 15%**

## Coherency

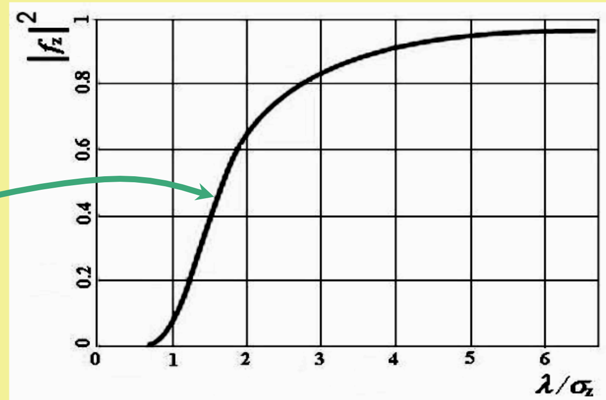
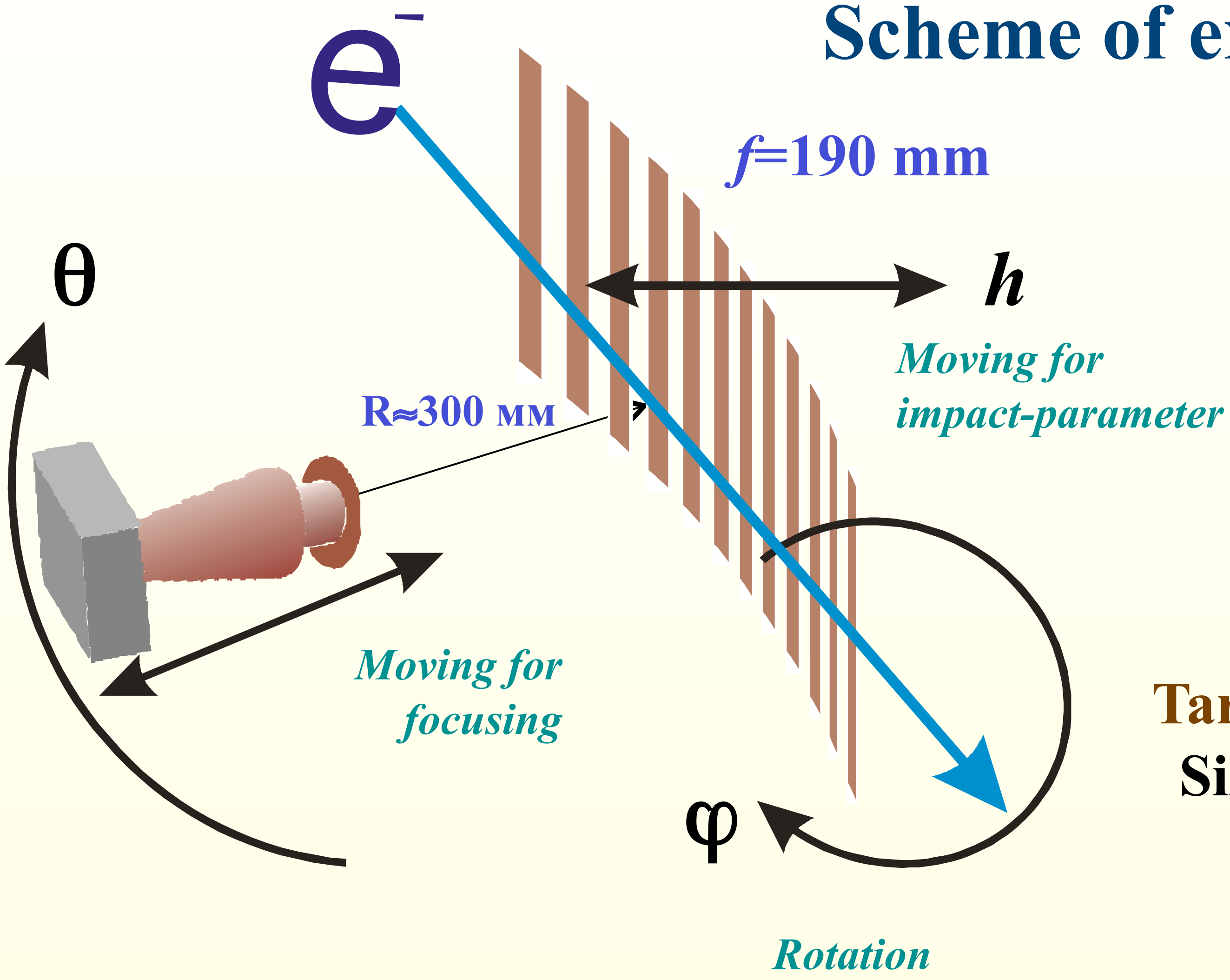



Fig.4 Dependence of the squared form-factor module on the radiation wavelength for the gaussian longitudinal distribution of electrons in a bunch.

# Horizontal focusing

## Scheme of experiment




**Target parameters**

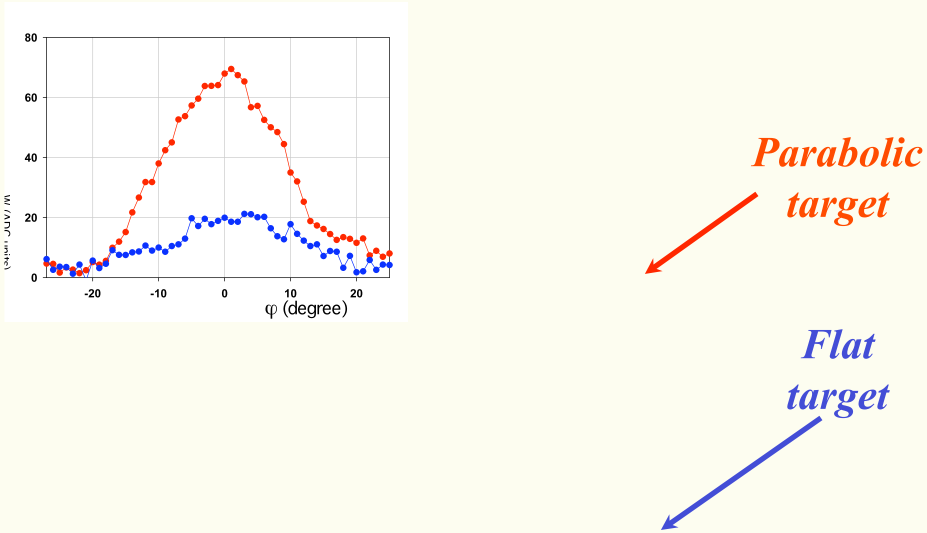
**Size** 106×168 mm

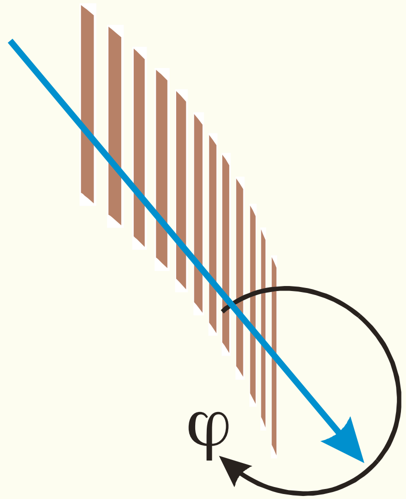
***d***=12 mm

***n***=14

***f***=190 mm

# Azimuthal radiation density distribution

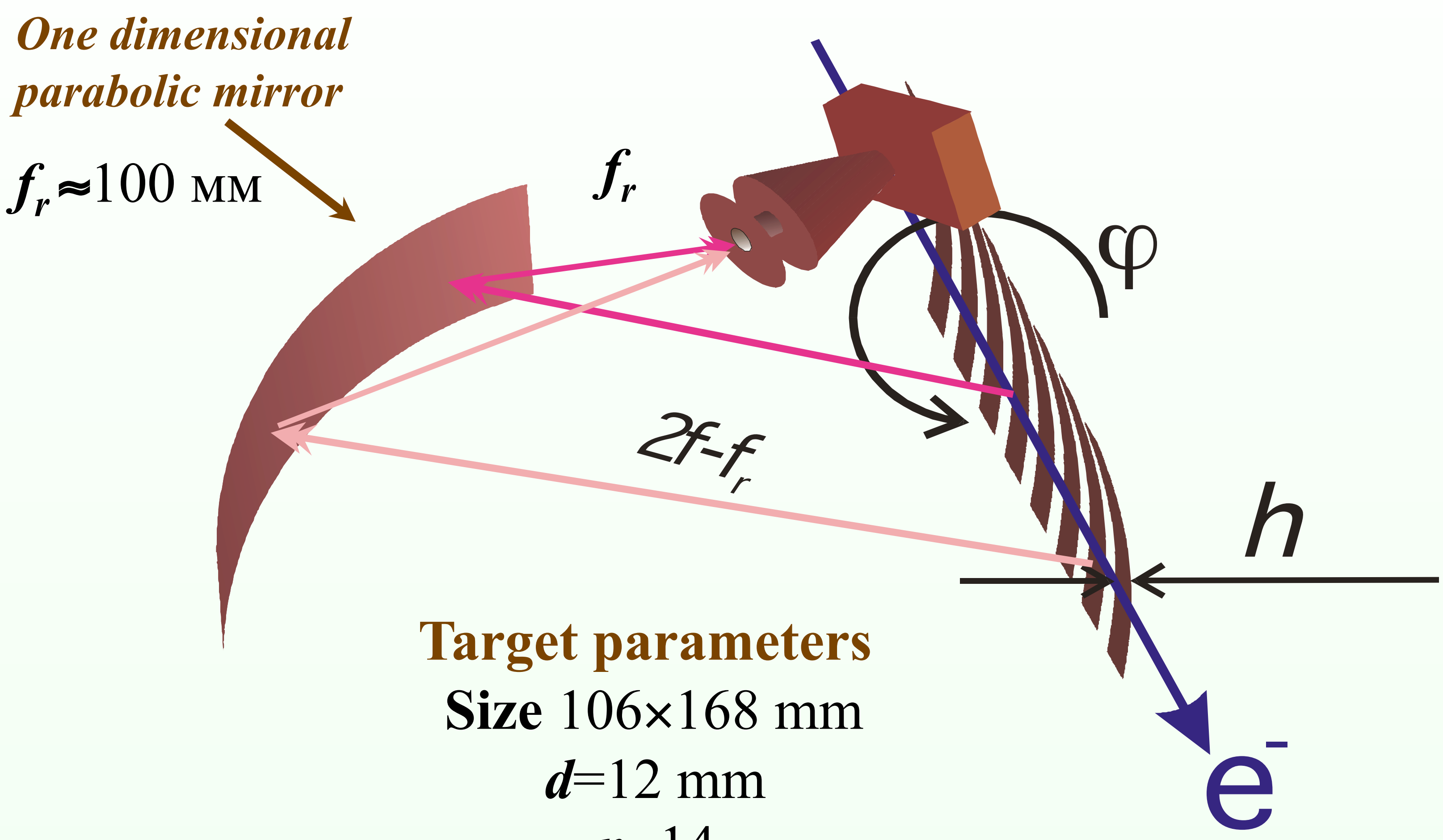



***3.5 times radiation density amplification was observed***

# Vertical focusing

## Scheme of experiment




**Target parameters**

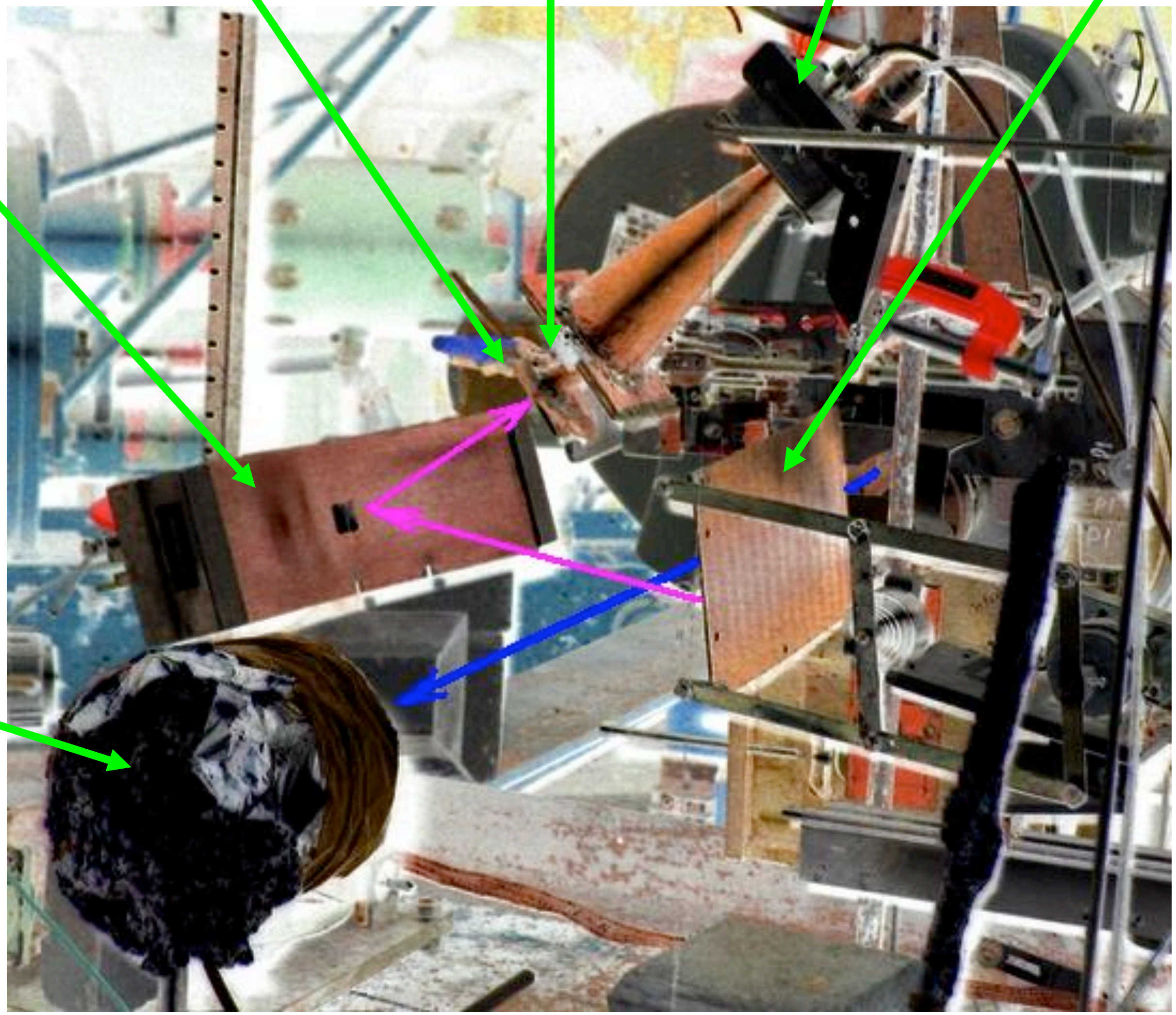
**Size** 106×168 mm

$d$=12 mm

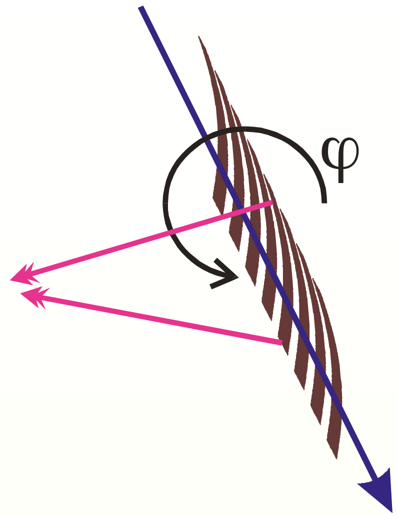
$n$=14

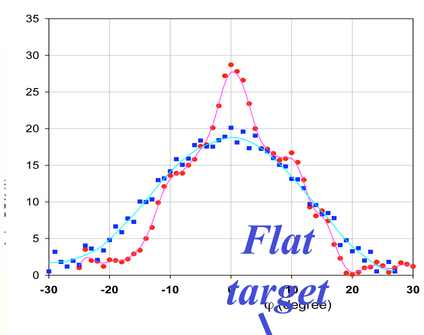
$f$=150 mm

# Experimental setup



# Azimuthal radiation density distribution

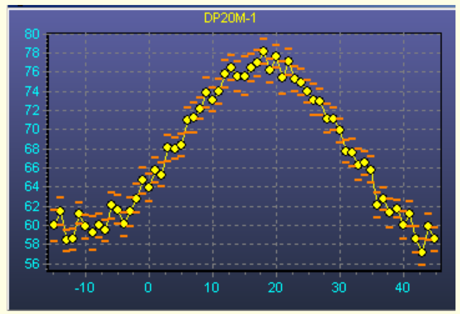


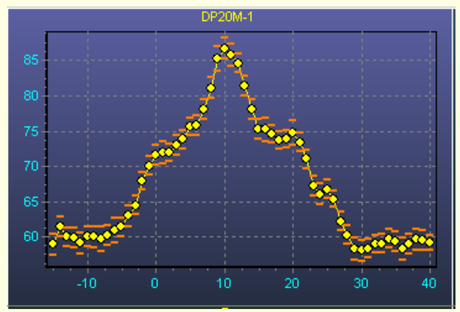




*Flat target*

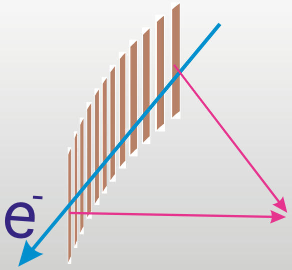
*Parabolic target*

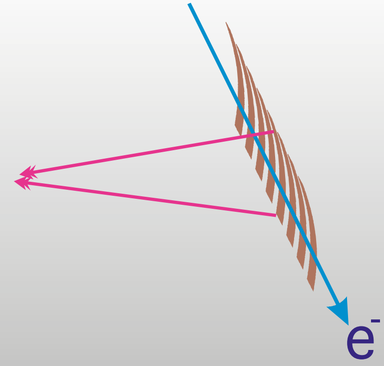
*Directly from the experiment*

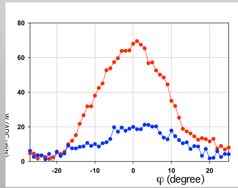


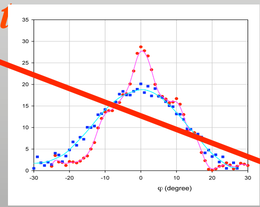
# Summary



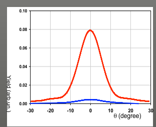




*Parabolic target*




*Flat target*

*λ=9~17 mm*



*λ=12 mm*

*Theory*

**Discrepancy between the predicted and experimental relation is due to the finite wavelength region in experiment *λ=9~17 mm***

**The horizontal focusing is preferable and provides the enhancement of the radiation density by factor ~3.5 over the one from a flat target.**

Thank you
for
your attention