講演番号　29aSL6

Polarization Measurement of Short-Pulse Gamma Rays Produced through Inverse Compton Scattering of Circularly Polarized Laser Beams

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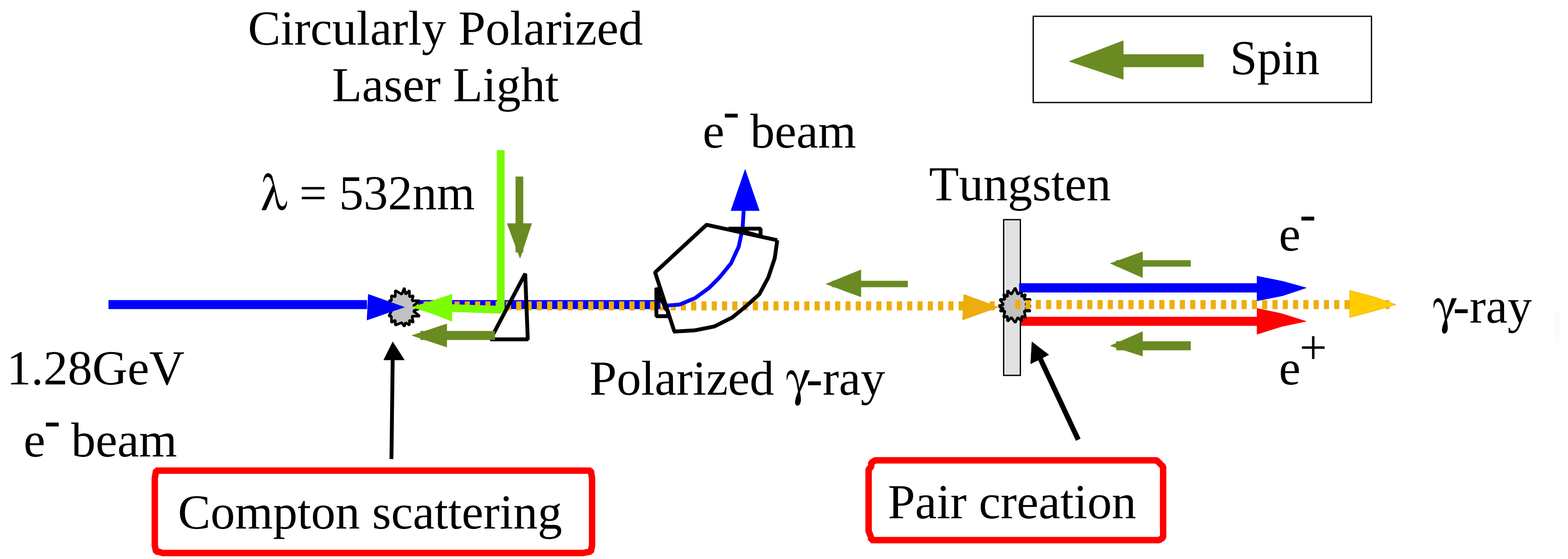
目的

我々は、KEK-ATFにおいて次世代のリニアコライダーのための偏極陽電子源の基礎研究を行っている。

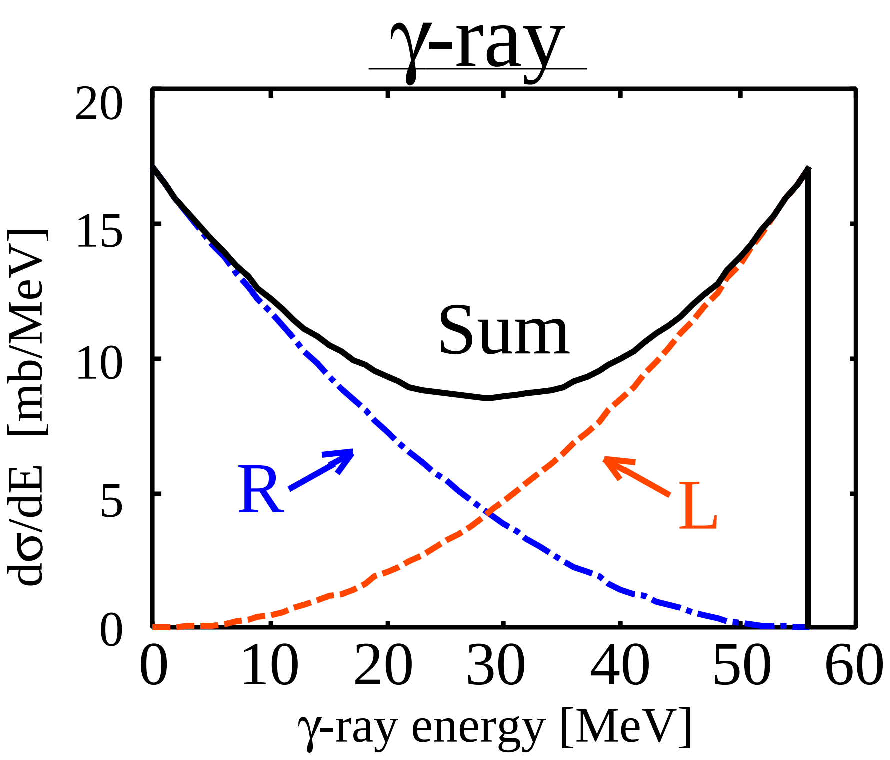
Schematic design for a polarized positron generation

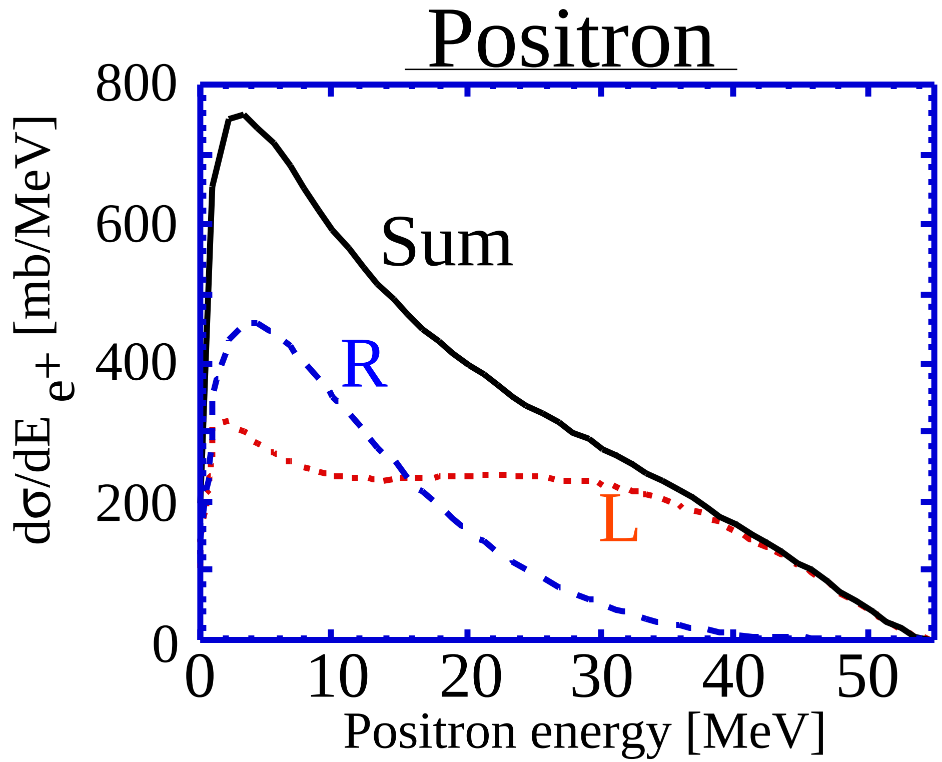


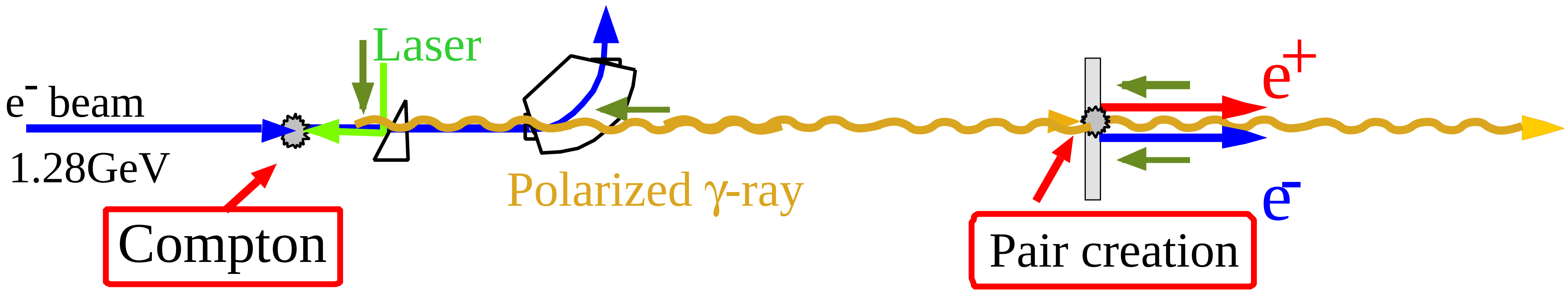
Cross section

高エネルギー側で高い偏極度をもつ。

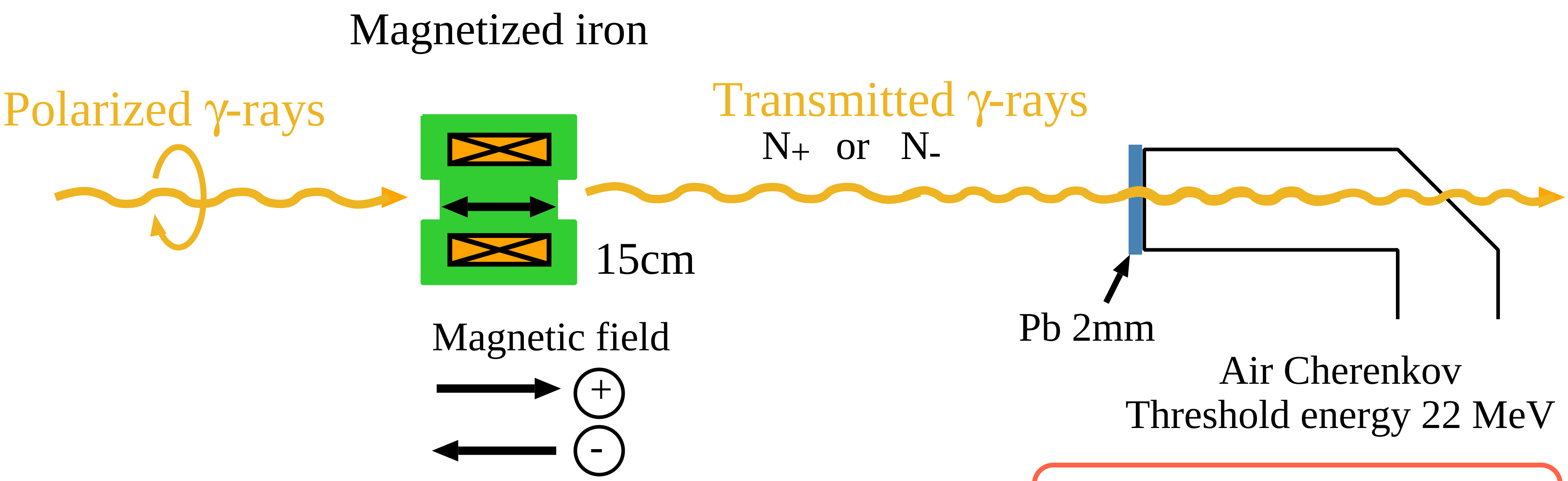
γ 線、陽電子ビームも電子ビームと同じ30ps と短パルス







γ 線の偏極度の測定方法



$$A = \frac{N_+ - N_-}{N_+ + N_-}$$

(~ 1 %)

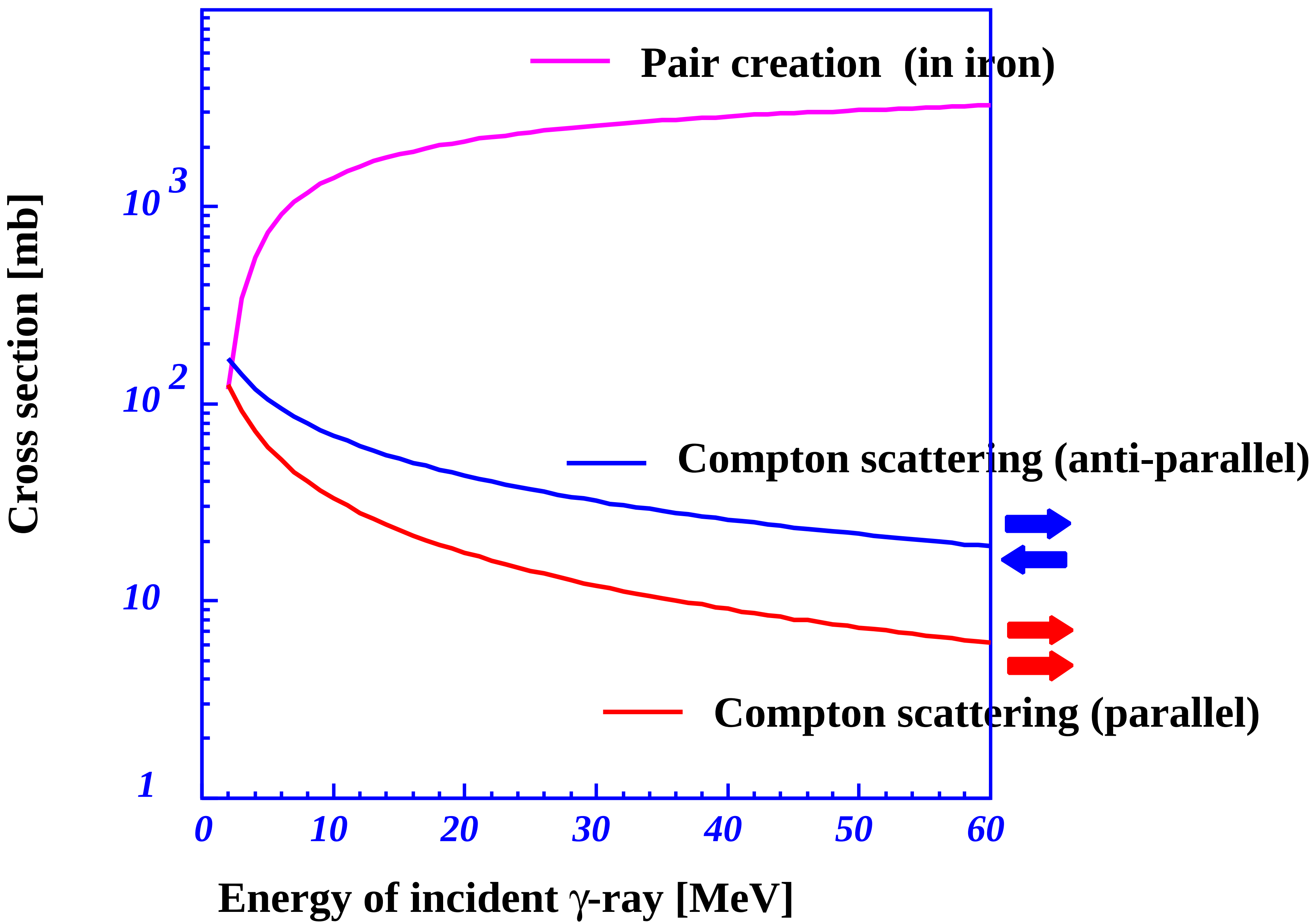
Cross section of Compton scattering

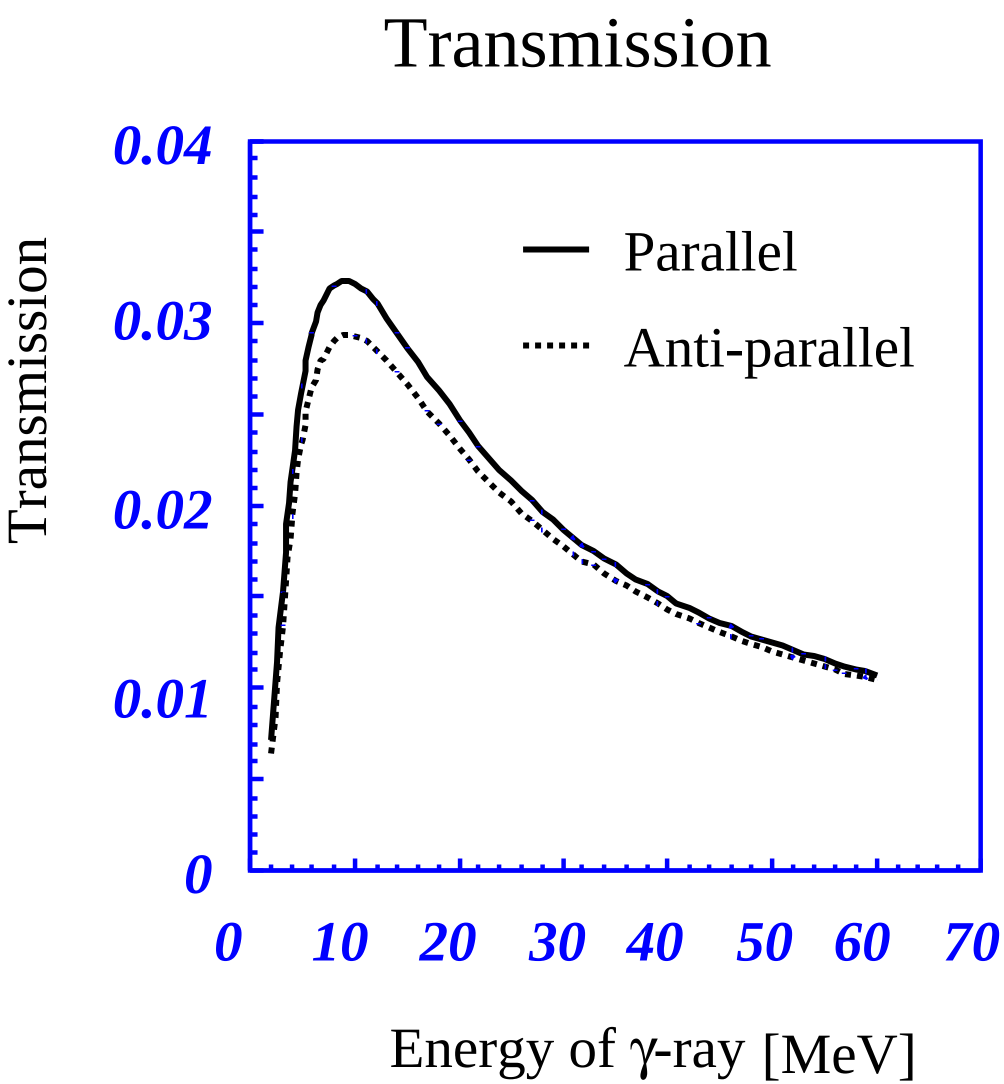
$$(\sigma_{comp}(\uparrow\uparrow) < \sigma_{comp}(\uparrow\downarrow))$$

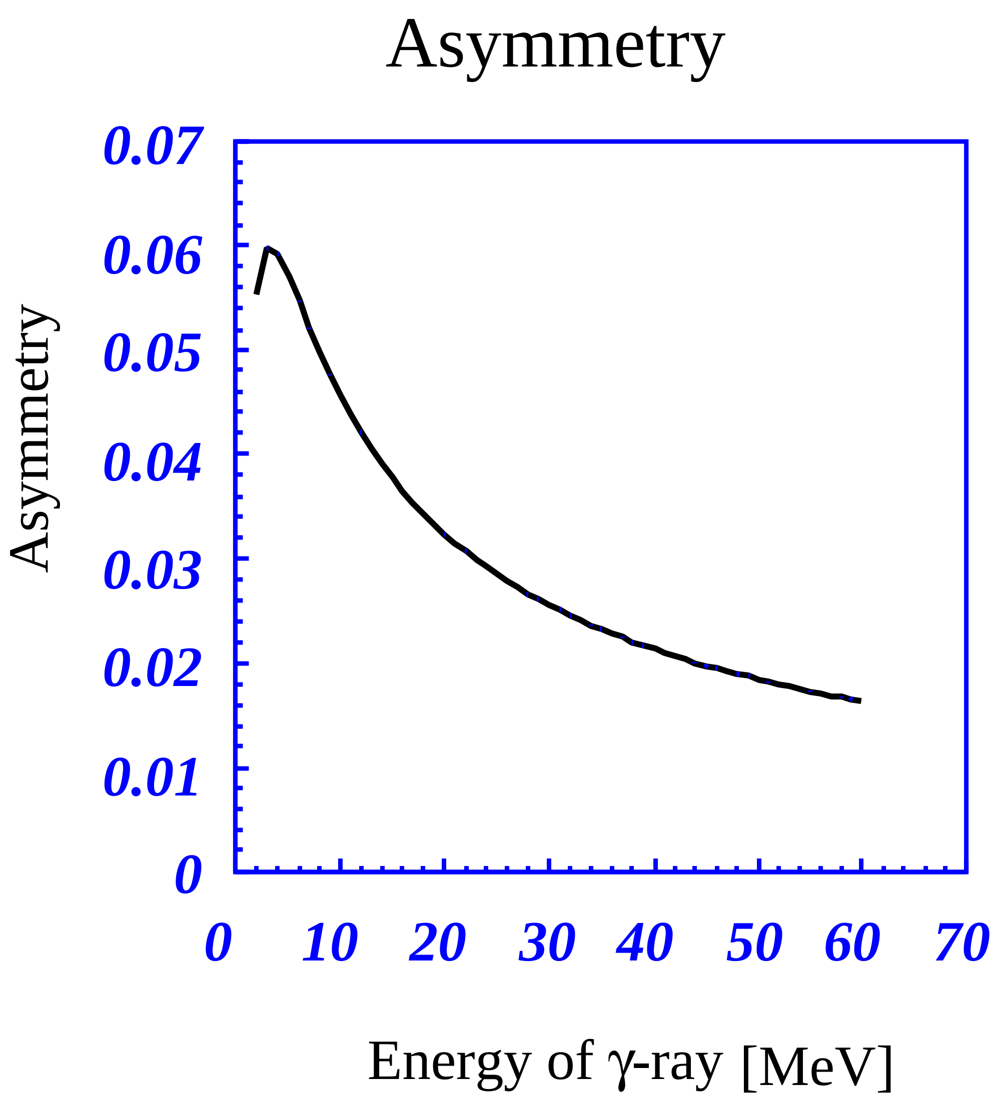
$$\Downarrow$$

透過 γ 線数が磁場の向きによって異なる

Cross section







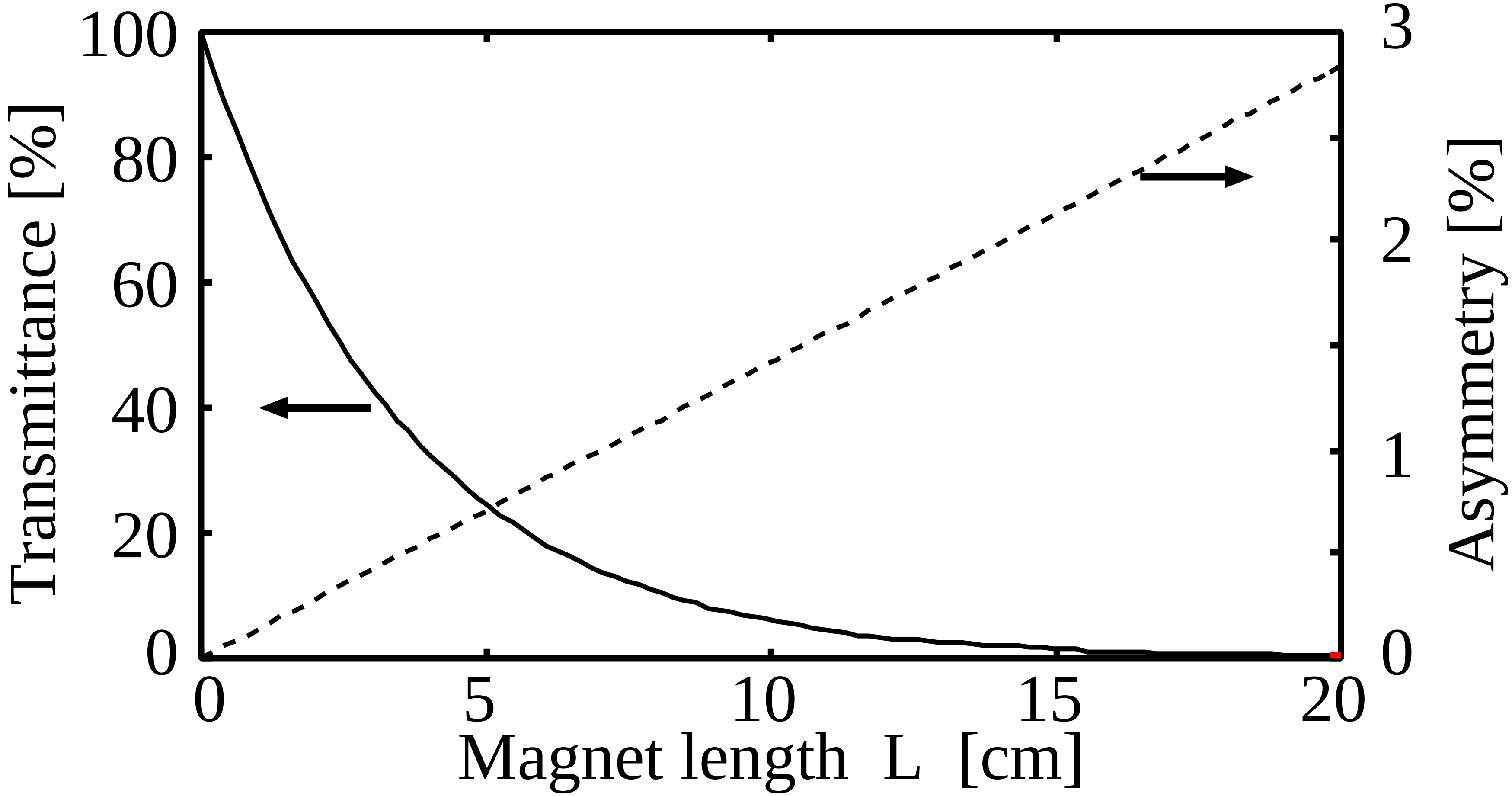
Feの電子、26個のうち2個が100%磁化しているとき

(鉄の厚さ：15cm)

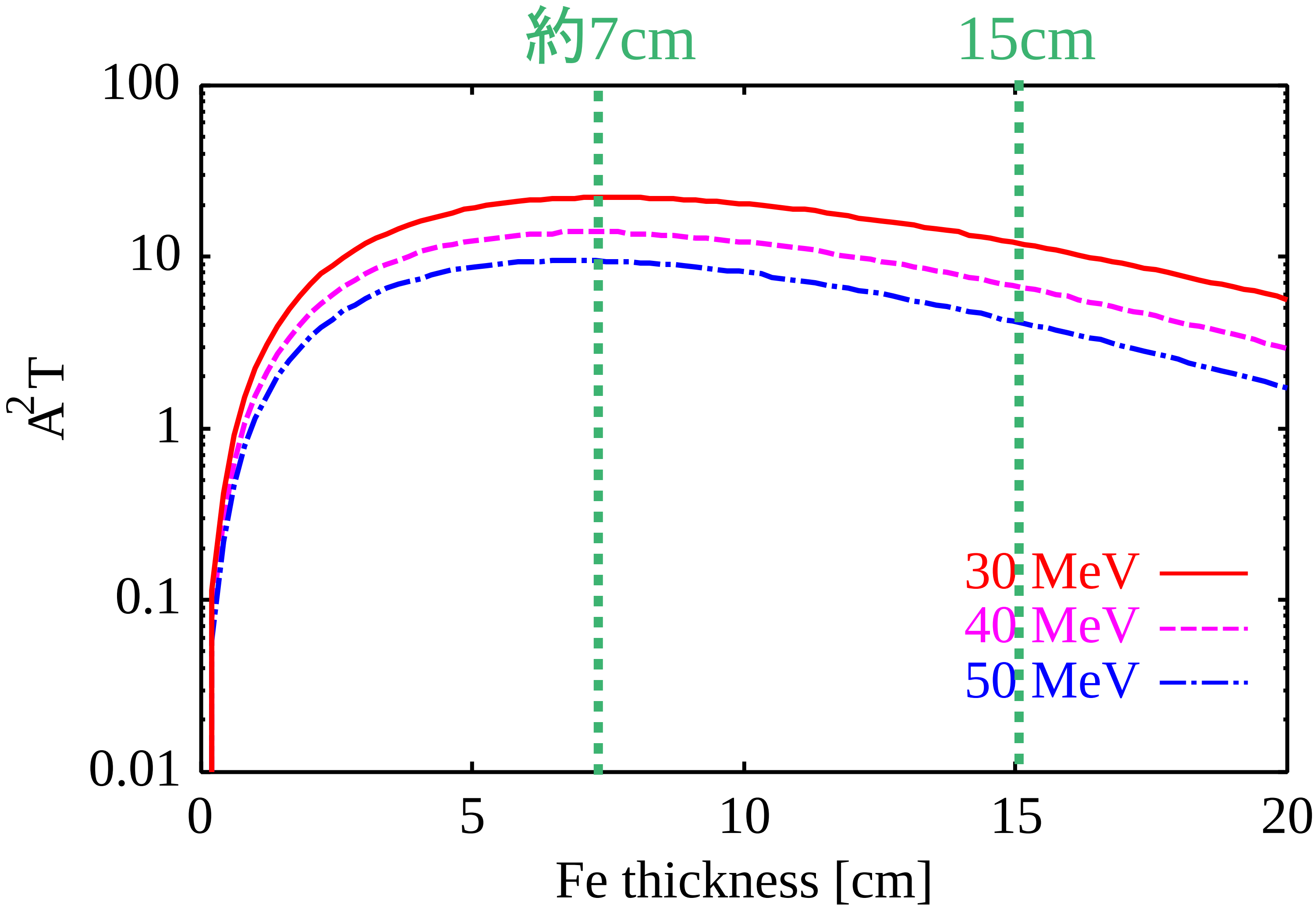
鉄が薄い → 透過率 大

鉄が厚い → Asymmtry 大

⇨ 最適な厚さがある

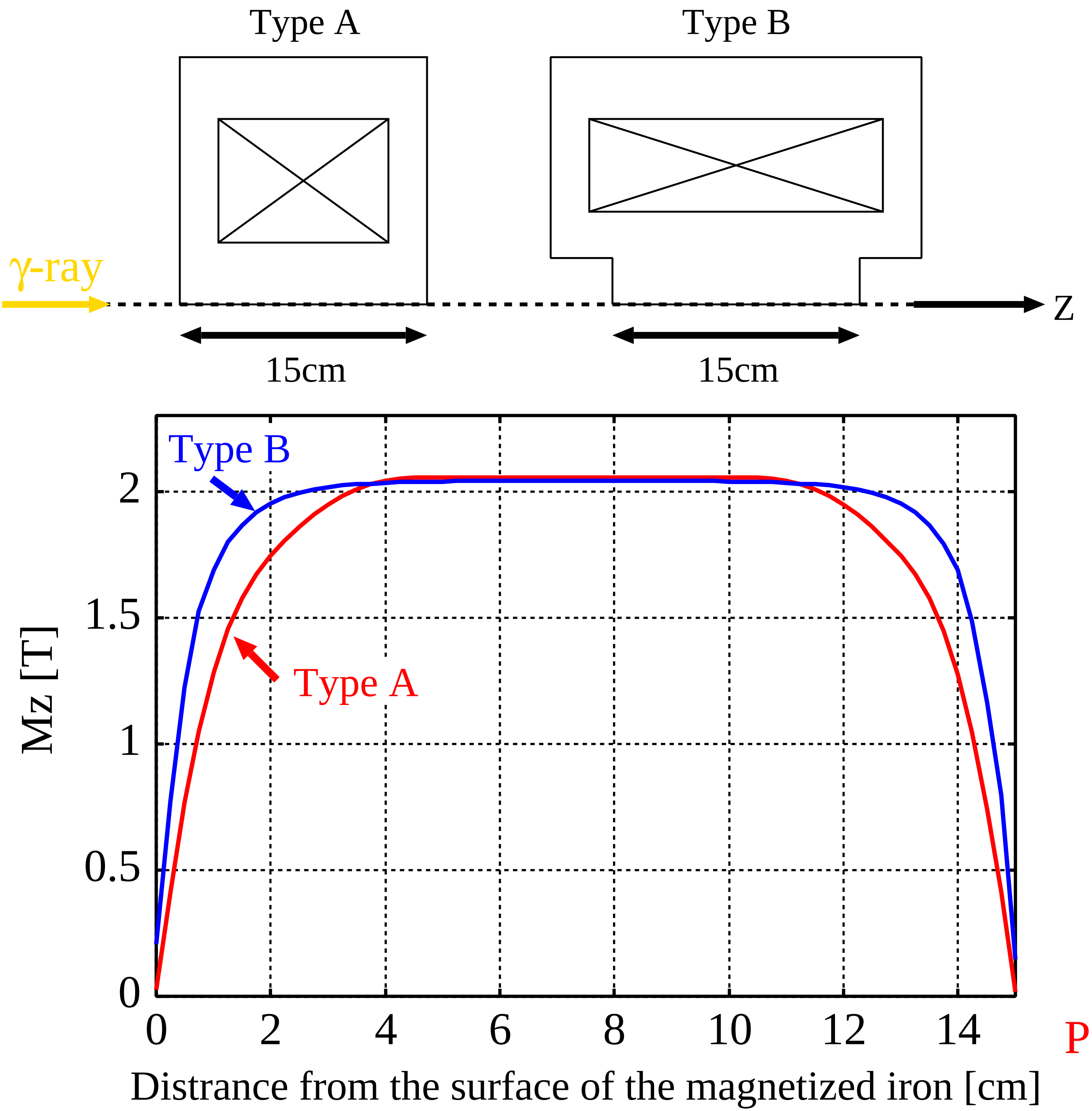


最適な厚さ → A^2T が最大



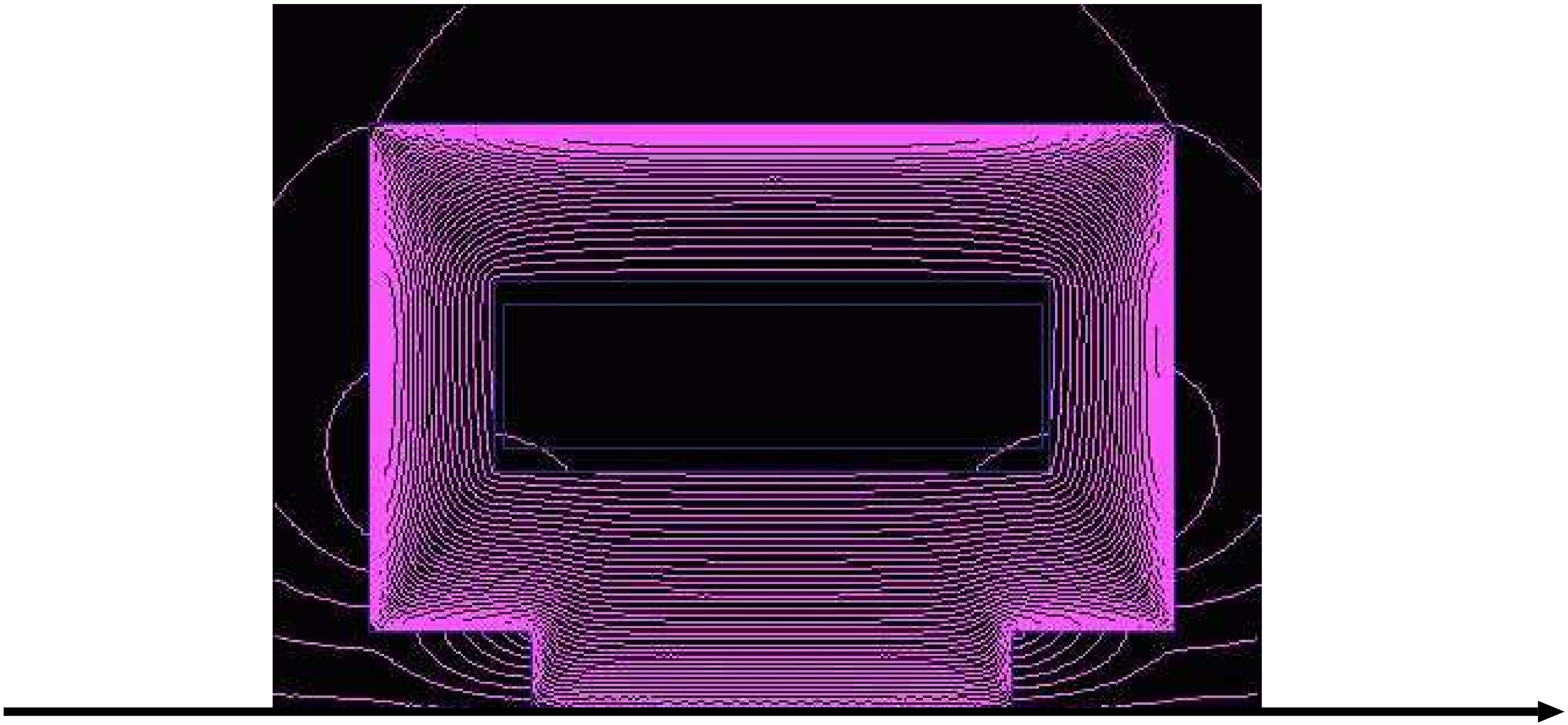
Asymmetry を大きくして、BGに強くなるように

厚さを15cmに決定

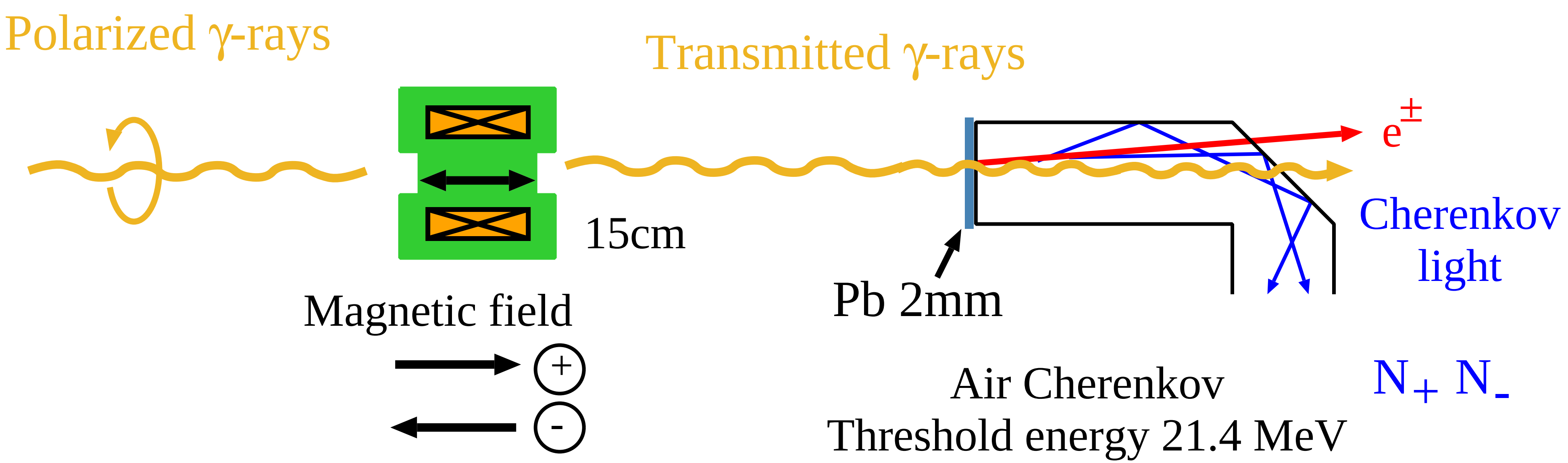

Type A
Type B
γ-ray
Z
15cm
15cm
Type B
Type A
Mz [T]
2
1.5
1
0.5
0
0
2
4
6
8
10
12
14
Distrance from the surface of the magnetized iron [cm]

POISSONで計算

磁力線の様子



Expected Asymmetry

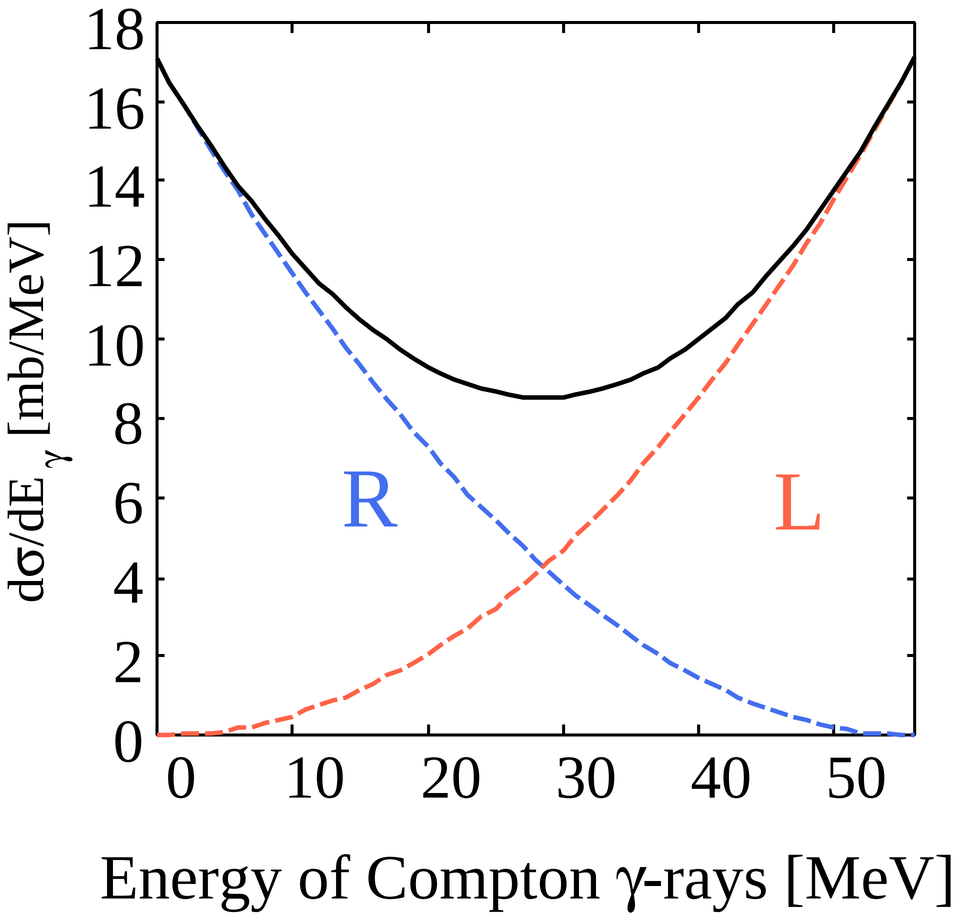


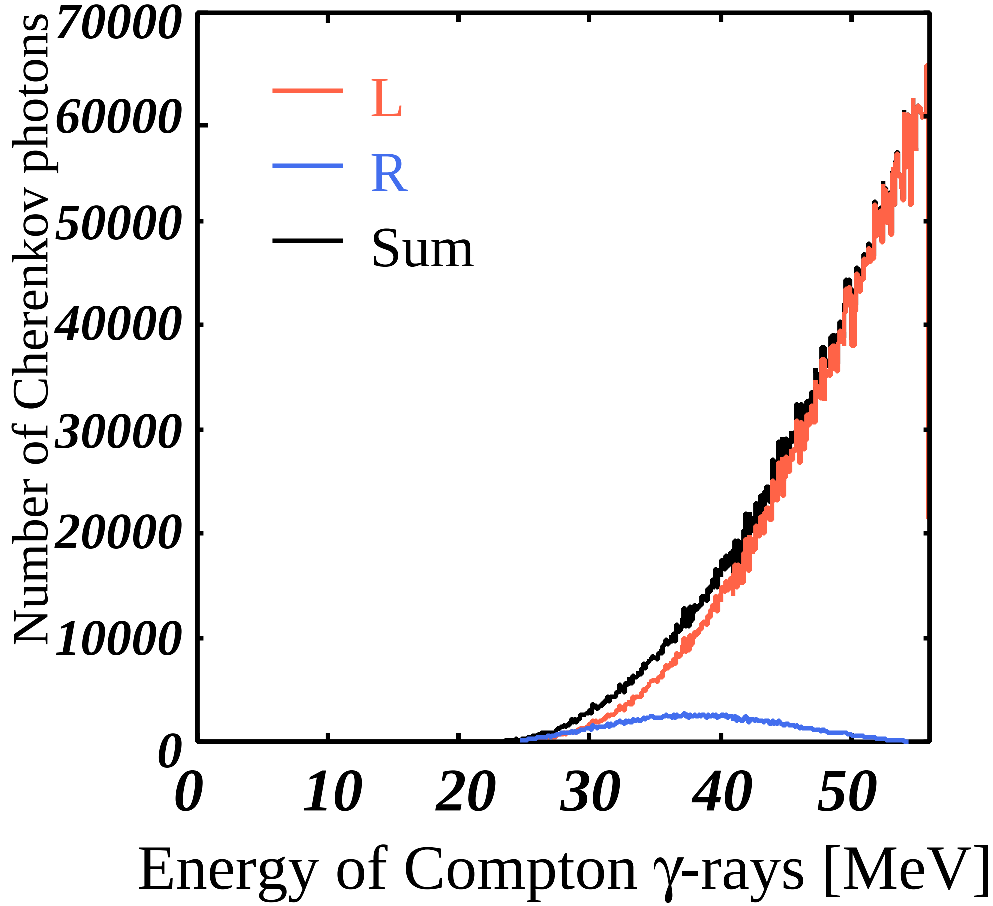
(Calculated by GEANT and GRACE)

Measured asymmetry

$$A = \frac{N_+ - N_-}{N_+ + N_-}$$

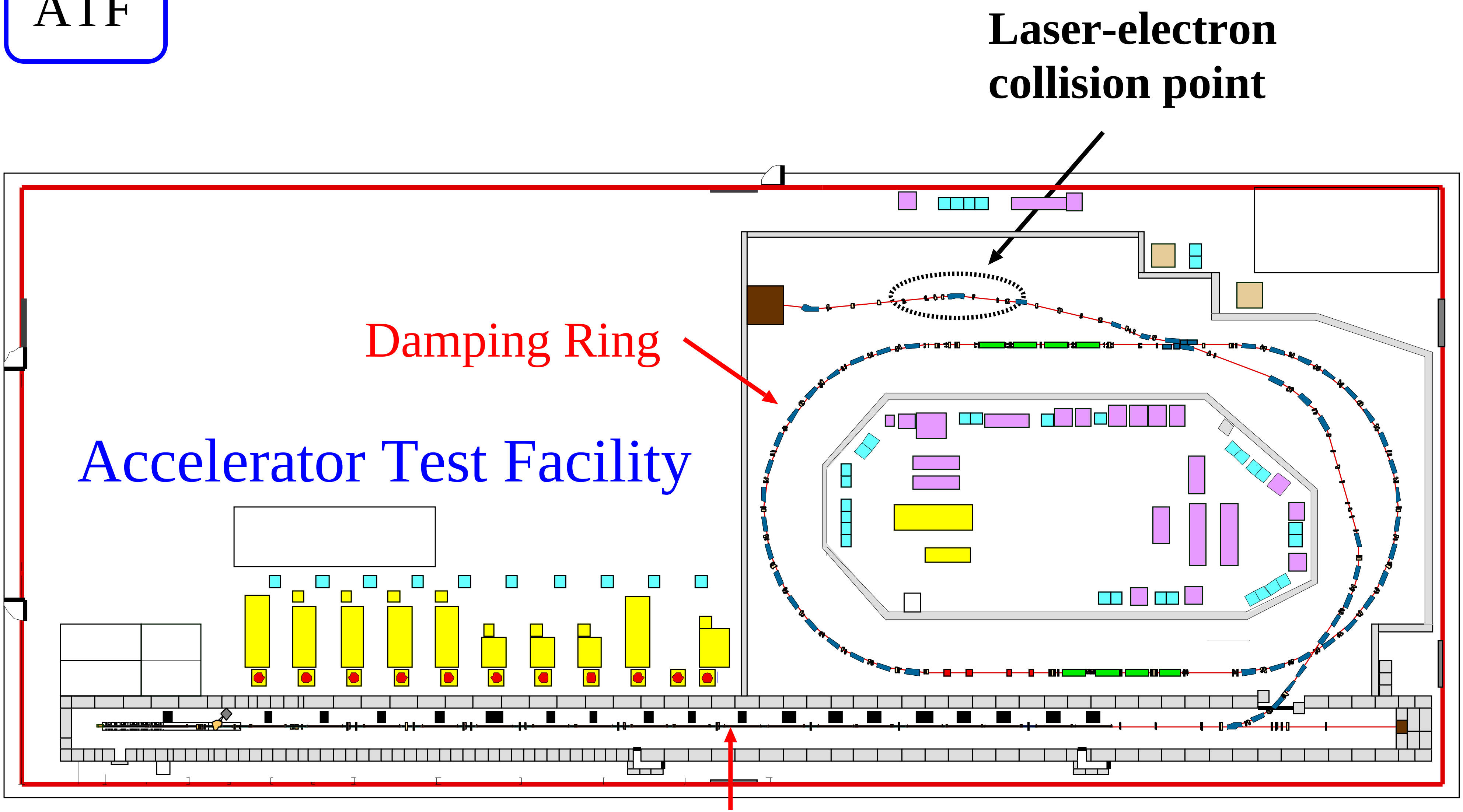
Expected asymmetry
A = 1.3 %   (Pol.: 88%)
(Threshold energy 21.4MeV)





Expected polarization of γ-rays: 88 %

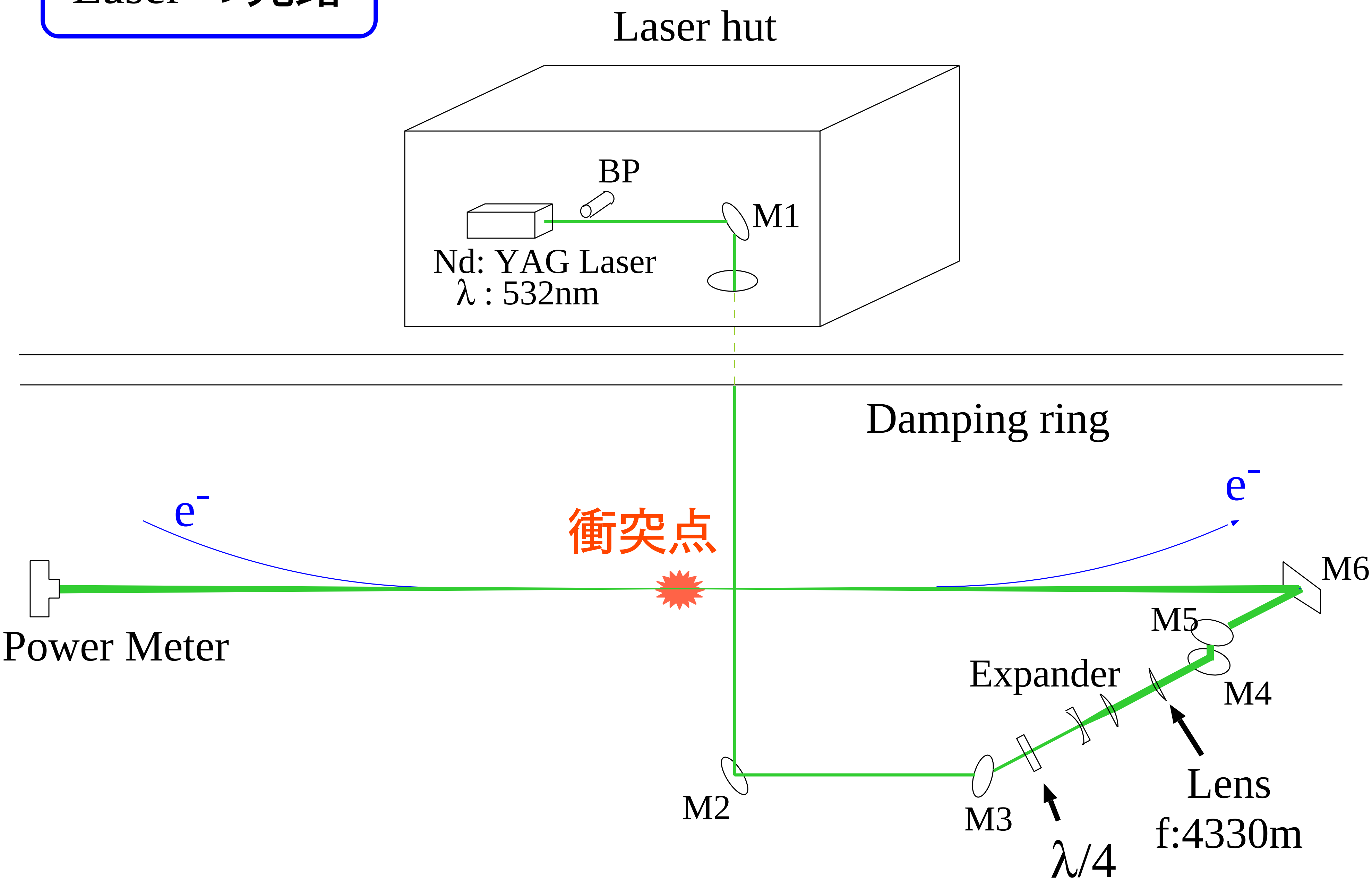
ATF

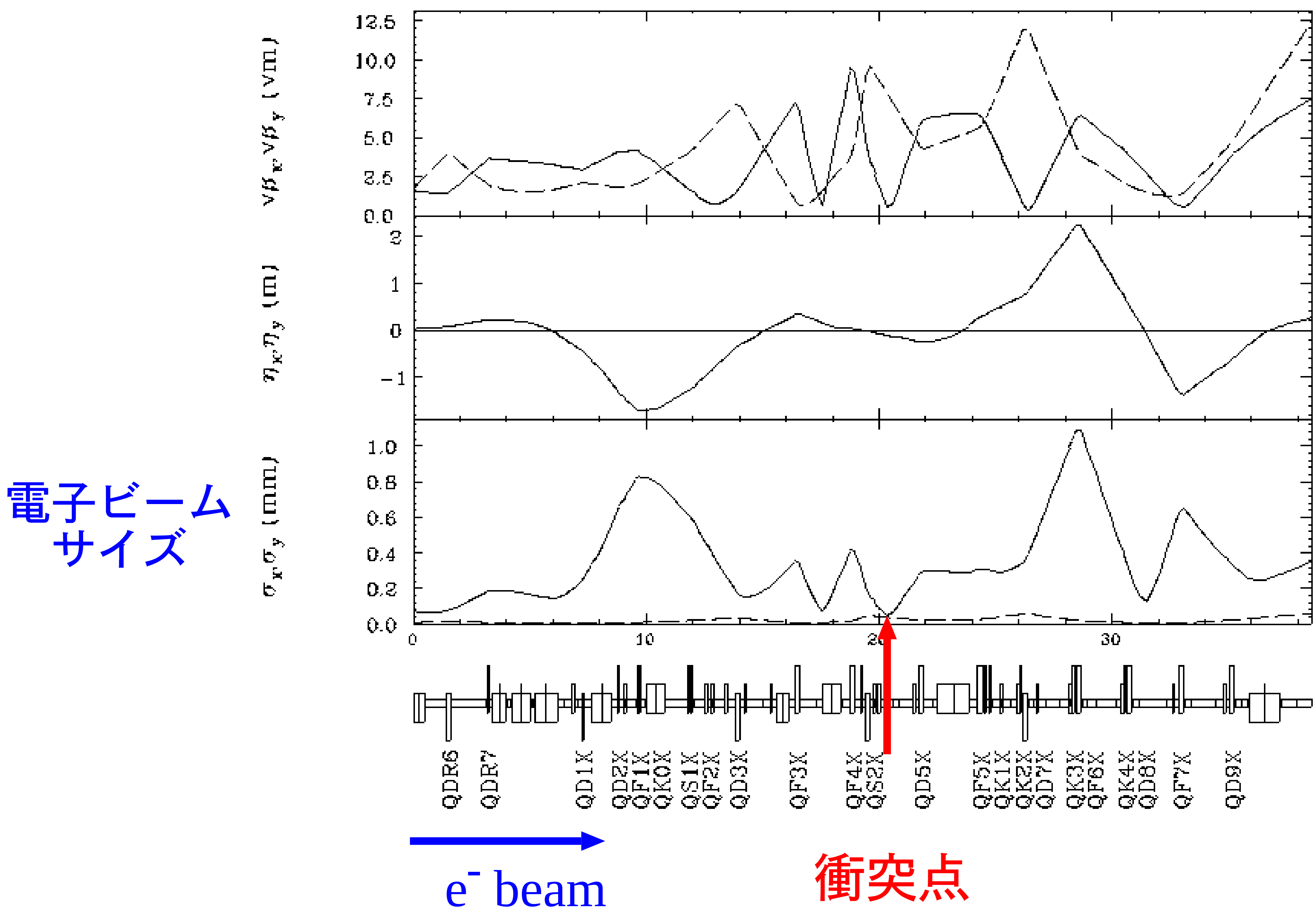


E_e: 1.28 GeV

Rep.Rate: 3.12 Hz

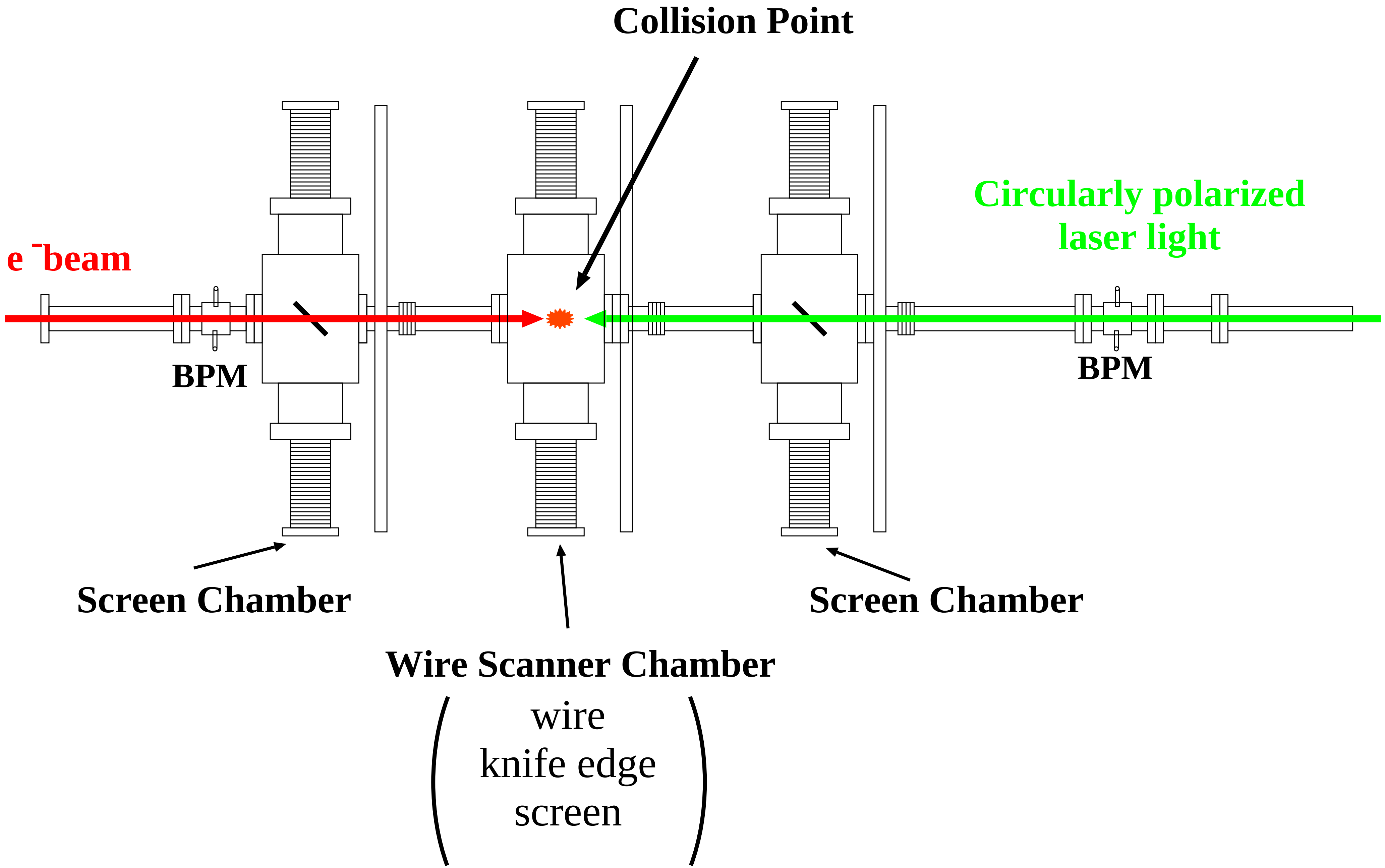
Laser の光路


Laser hut
BP
M1
Nd: YAG Laser
λ : 532nm
Damping ring
e-
e-
衝突点
M6
Power Meter
M5
Expander
M4
Lens
f:4330m
M2
M3
λ/4



電子ビーム
サイズ
e- beam
衝突点
QDR6
QDR7
QD1X
QD2X
QF1X
QK0X
QS1X
QF2X
QD3X
QF3X
QF4X
QS2X
QD5X
QF5X
QK1X
QK2X
QD7X
QK3X
QF6X
QK4X
QD8X
QF7X
QD9X

Collision System



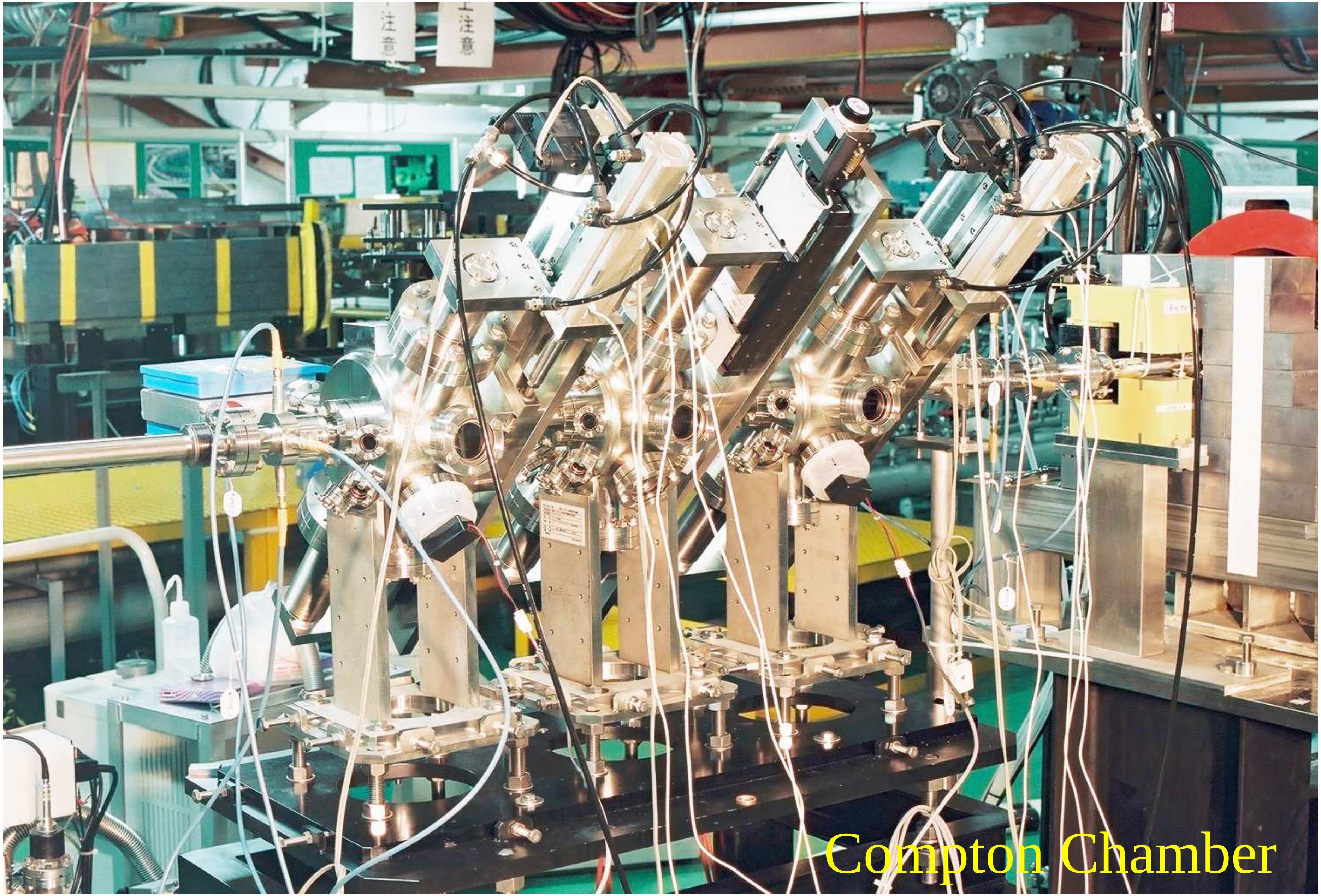


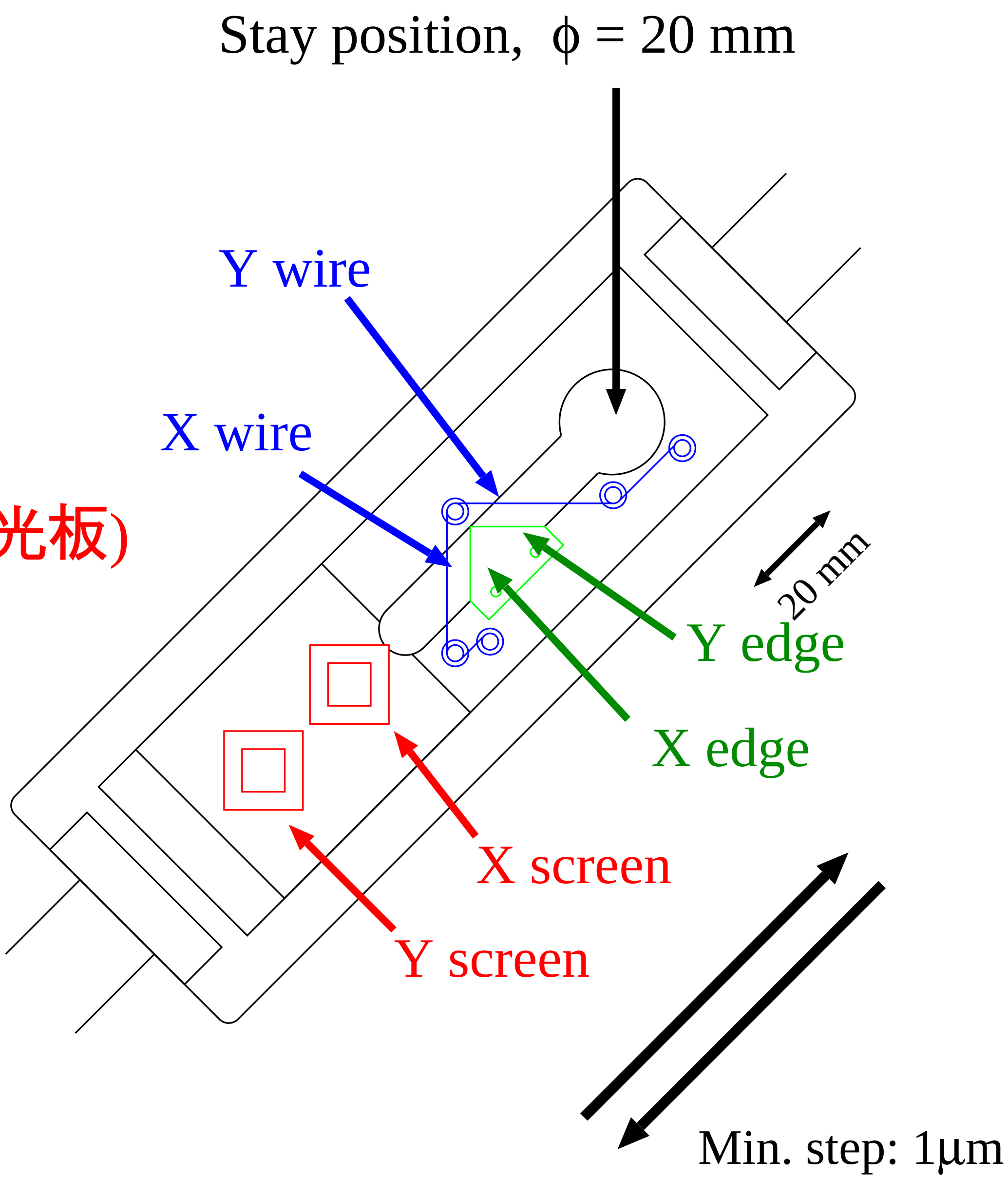
Photo: T. Omori

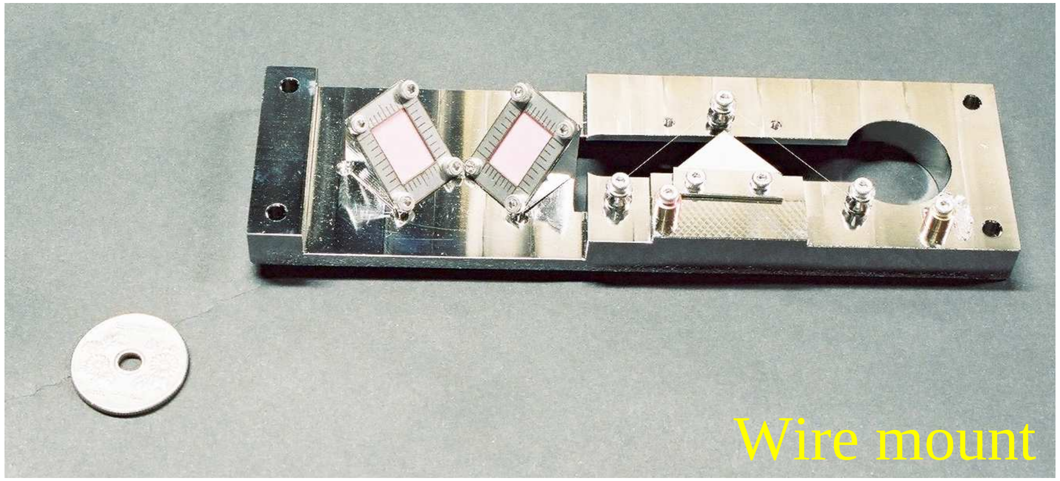
Wire Mount

Wire: Tungsten, ϕ = 10μm

Knife edge: stainless steel plate,
t = 500μm

Screen: Almina(Cr doped) plate (蛍光板)
8mm x 8mm, t = 100μm
CCDカメラでモニタ





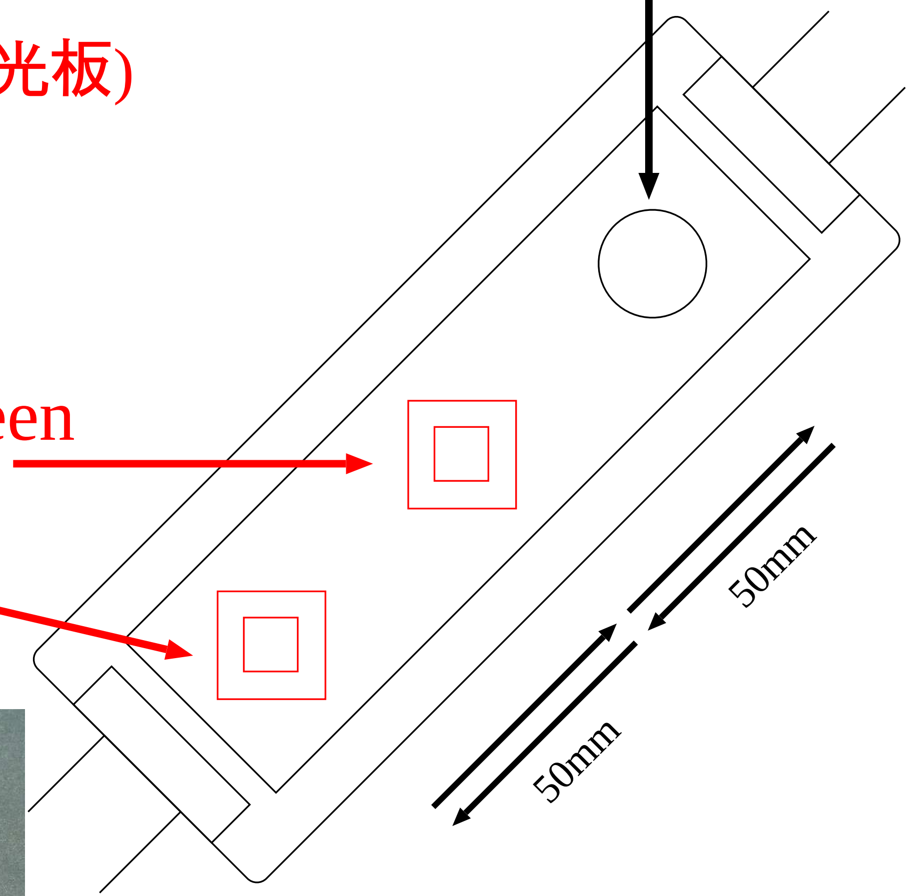
Screen Mount

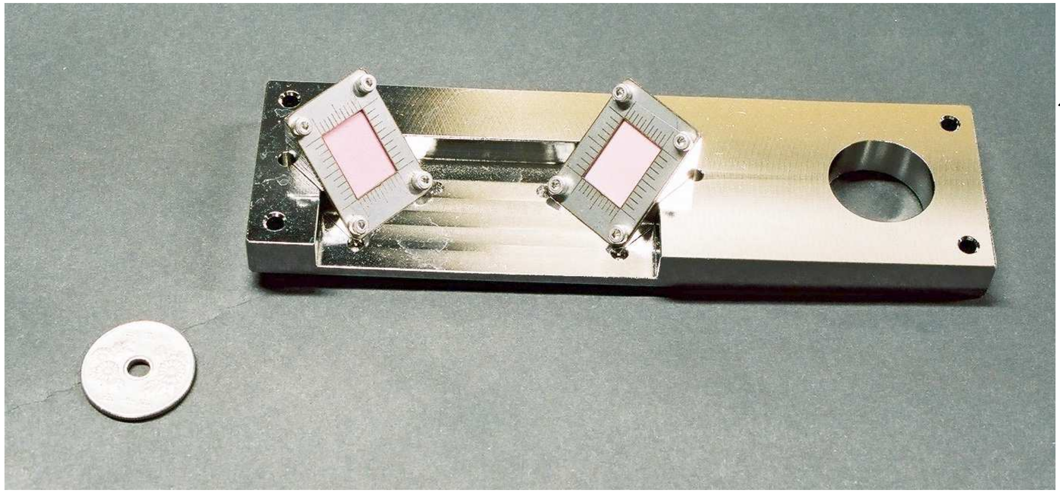
Screen: Almina(Cr doped) plate (蛍光板)
10mm x 10mm, t = 100μm
CCDカメラでモニタ

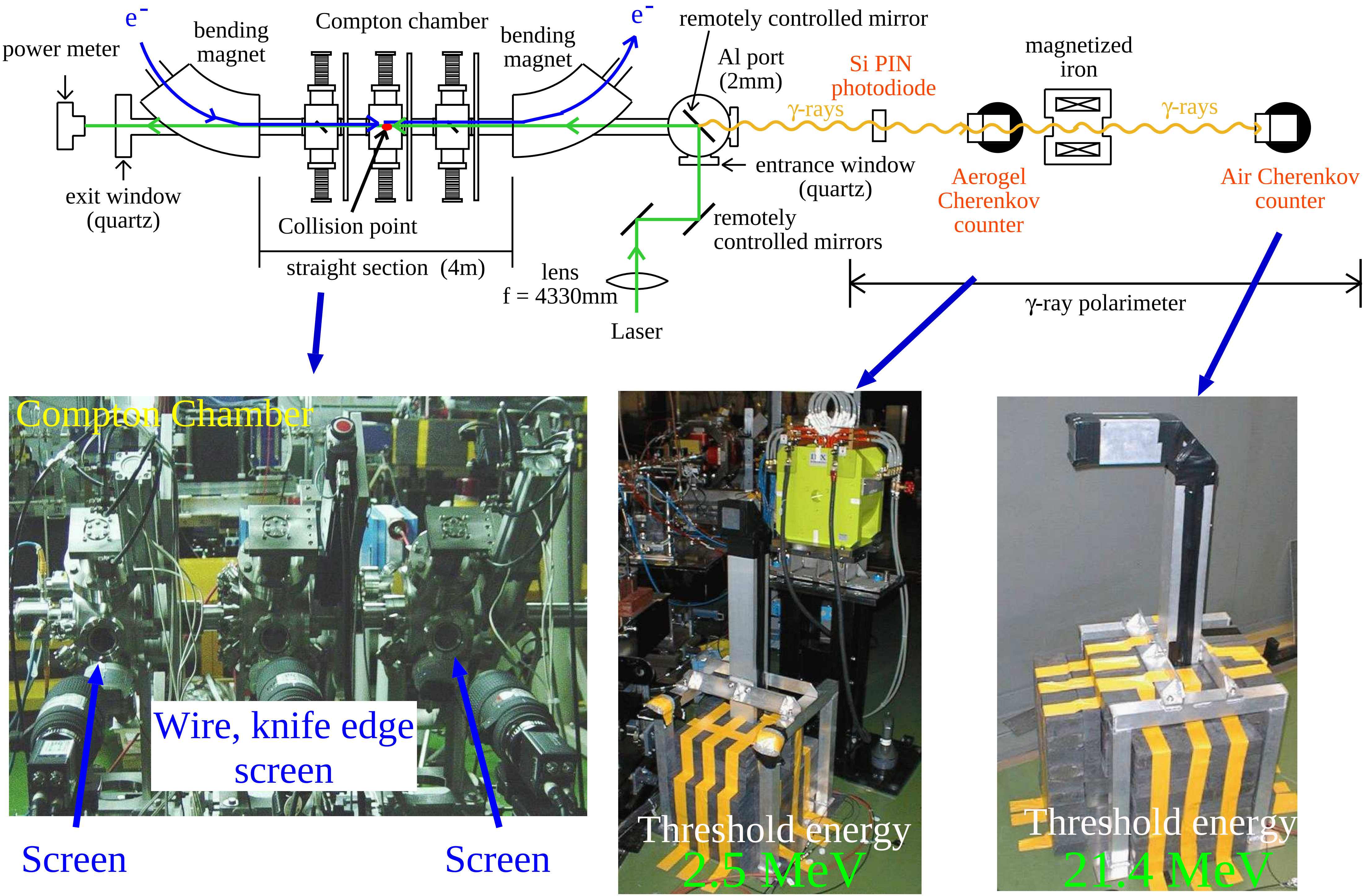
Stay position, ϕ = 20 mm

X screen

Y screen

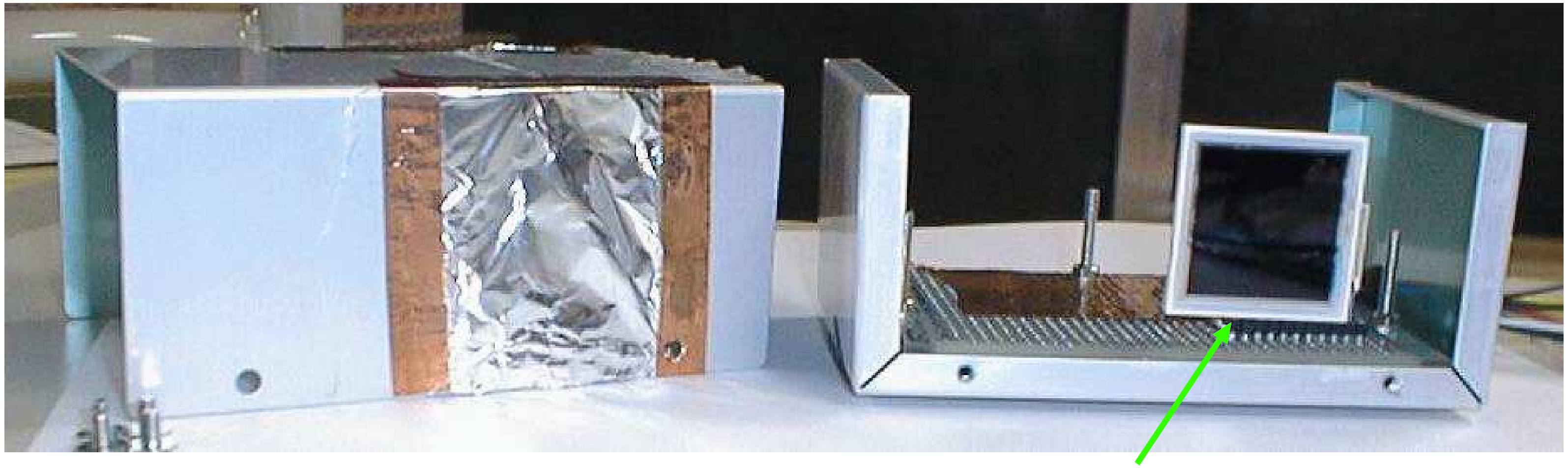






e-
bending magnet
Compton chamber
bending magnet
e-
remotely controlled mirror
power meter
Al port (2mm)
Si PIN photodiode
magnetized iron
γ-rays
γ-rays
entrance window (quartz)
exit window (quartz)
Collision point
Aerogel Cherenkov counter
Air Cherenkov counter
remotely controlled mirrors
straight section (4m)
lens f = 4330mm
γ-ray polarimeter
Laser
Compton Chamber
Wire, knife edge screen
Screen
Screen
Threshold energy 2.5 MeV
Threshold energy 21.4 MeV

Si PIN photodiode



Si photo-diode

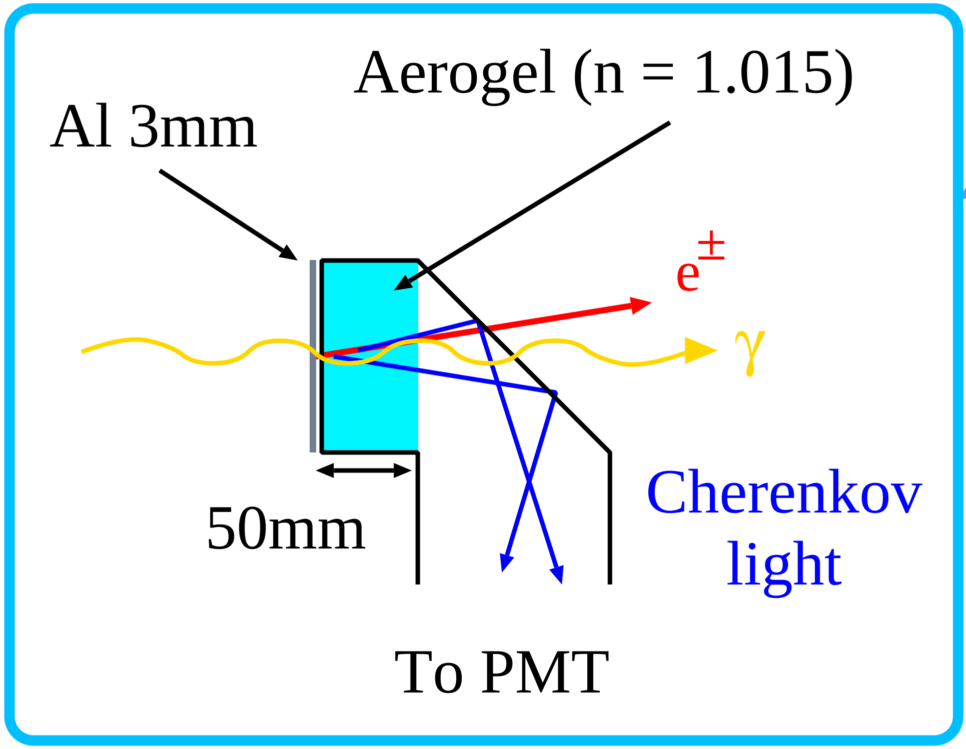
Active area 2.8cm x 2.8cm

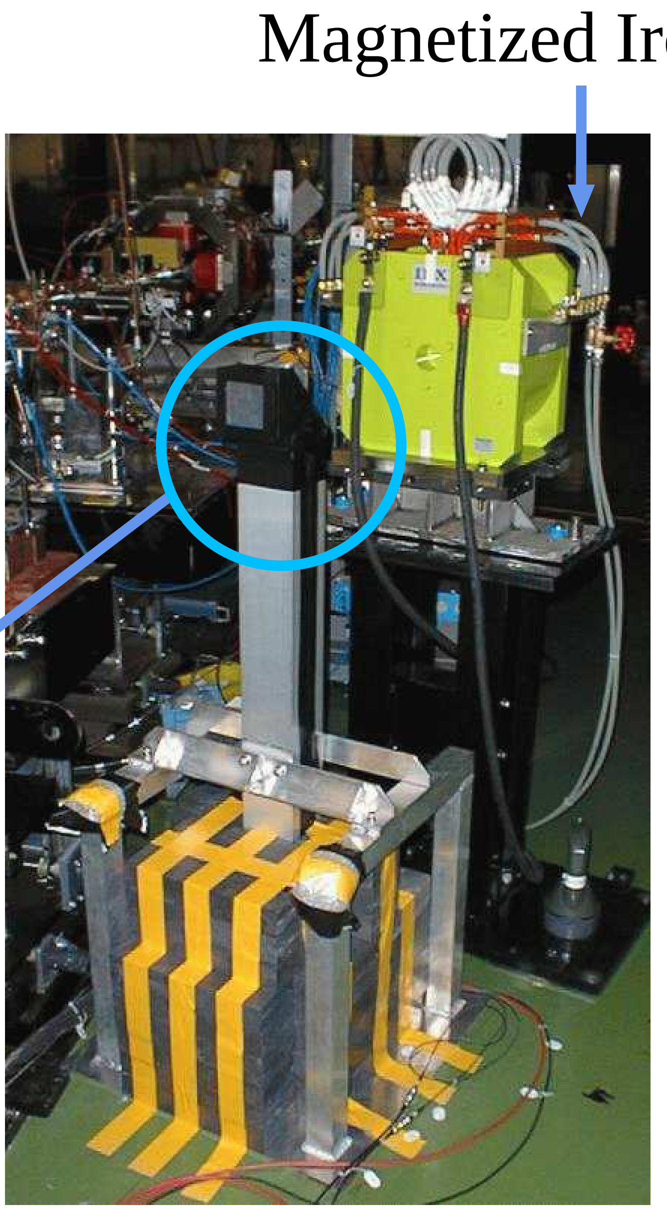
Thickness 300 µm

生成γ線数の測定に使用

Aerogel Cherenkov Counter

Threshold energy: 2.5 MeV ($e^{\pm}$)
(β = 0.9852)

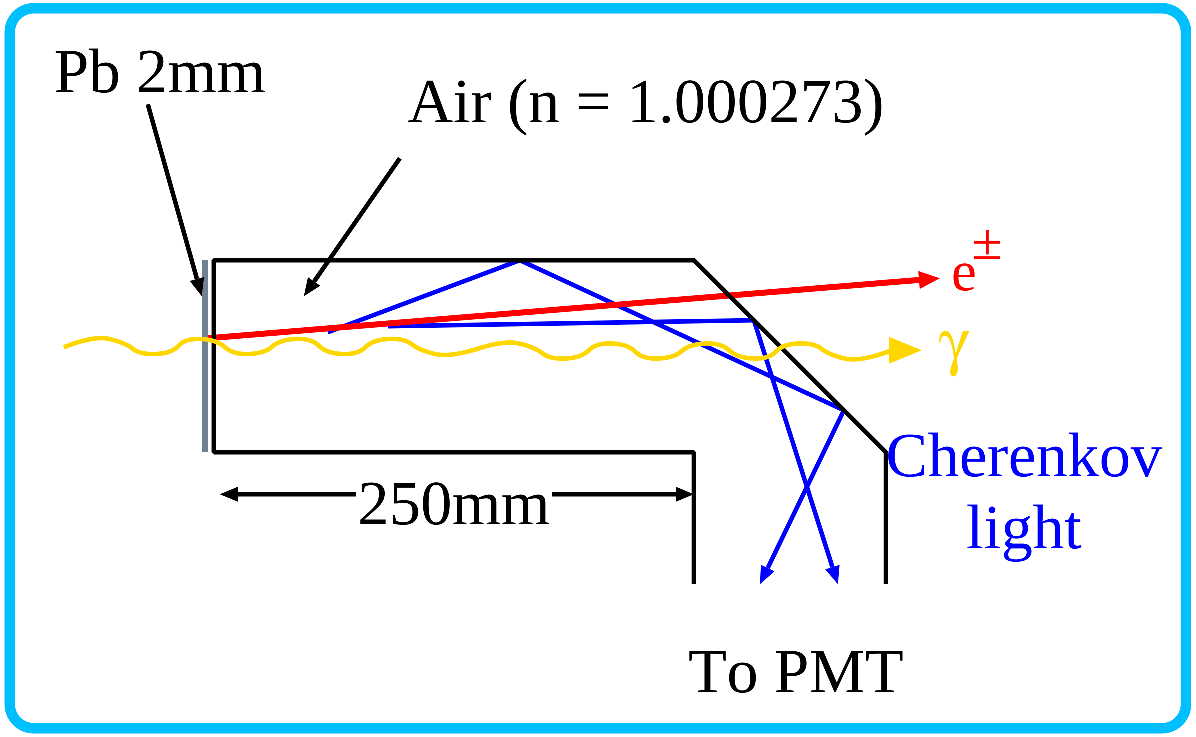




生成γ線数の測定に使用

Air Cherenkov Counter

Threshold energy: **21.4 MeV** ($e^{\pm}$)
(β = 0.9997)



磁化鉄からの透過γ線の測定に使用

Parameters

○ e^- beam

$\sigma_x = 87$ [μm]

$\sigma_y = 72$ [μm]

(Wire)

$\sigma_z = 30$ [ps]

0.7×10^{10} [e^-/bunch]

○ Laser

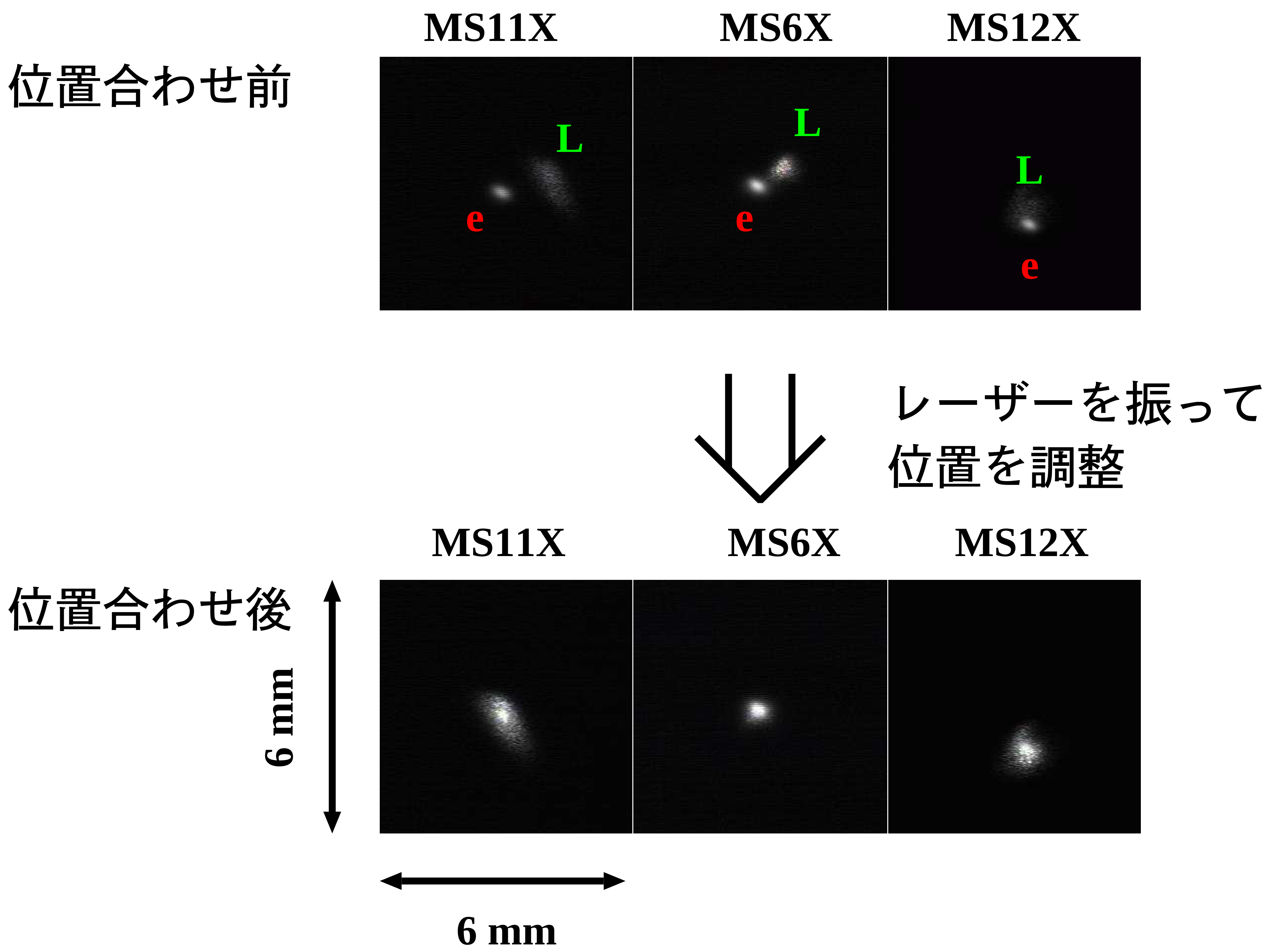
$\sigma_x = 131$ [μm]

$\sigma_y = 134$ [μm]

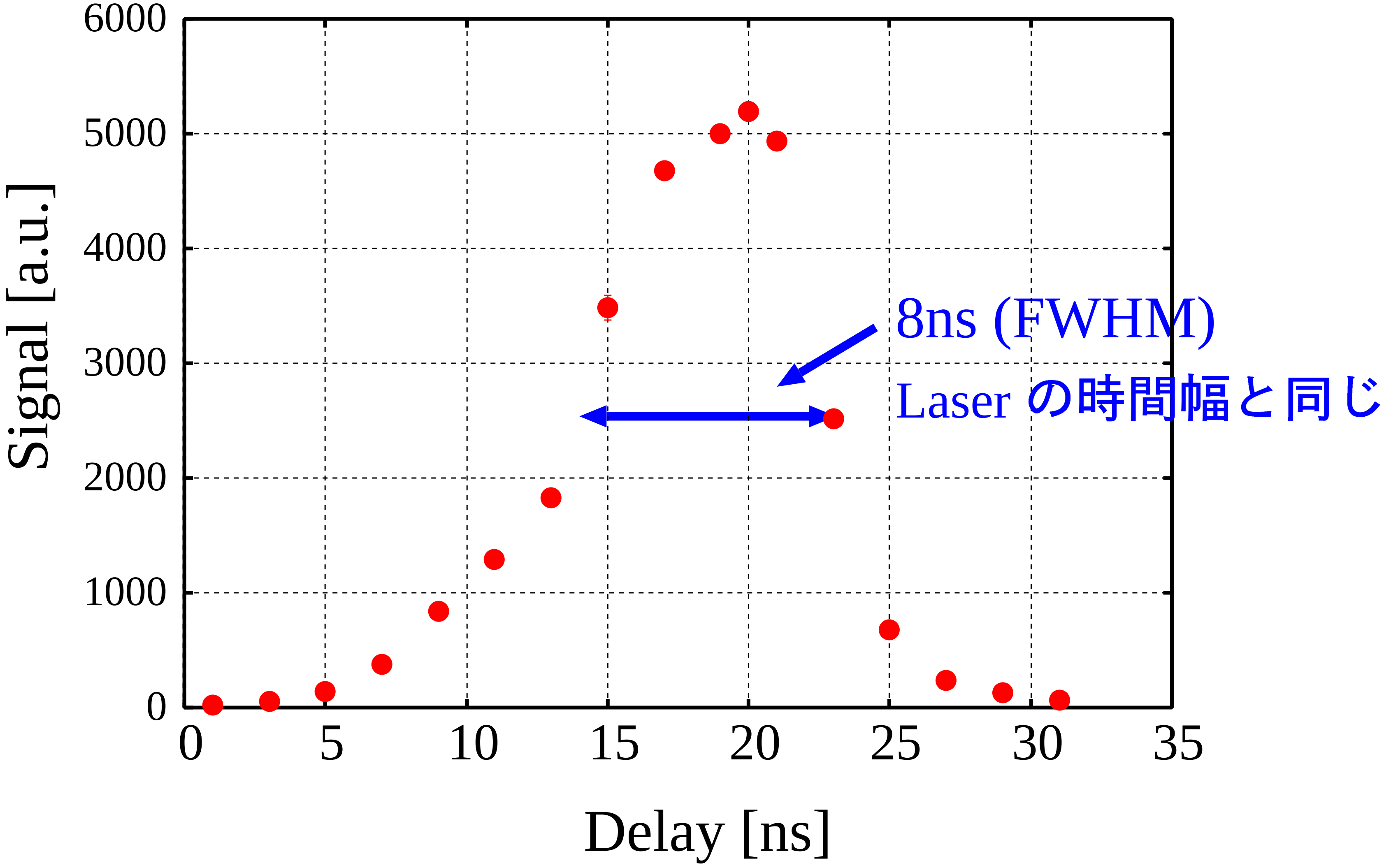
(Knife edge)

$\sigma_z = 3.6$ [ns]

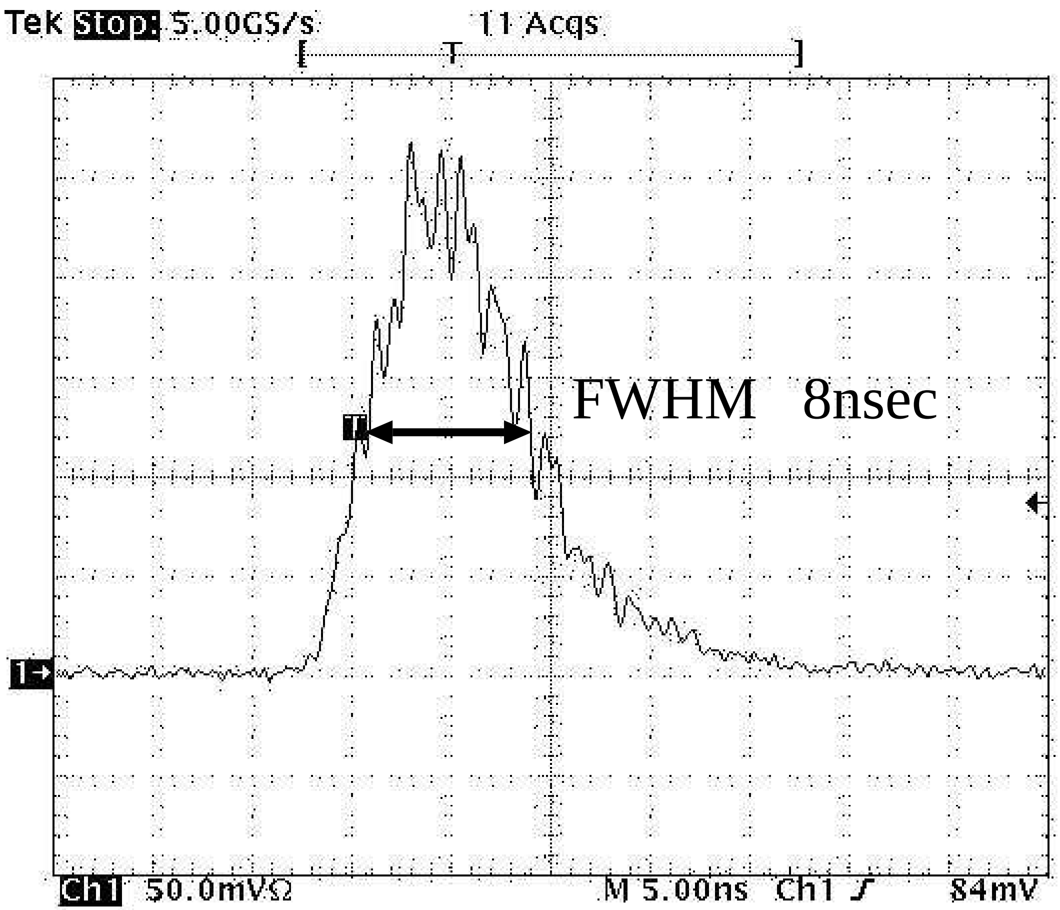
400 [mJ/pulse]


MS11X
MS6X
MS12X
位置合わせ前
L
e
レーザーを振って
位置を調整
位置合わせ後
6 mm
6 mm

Timing scan

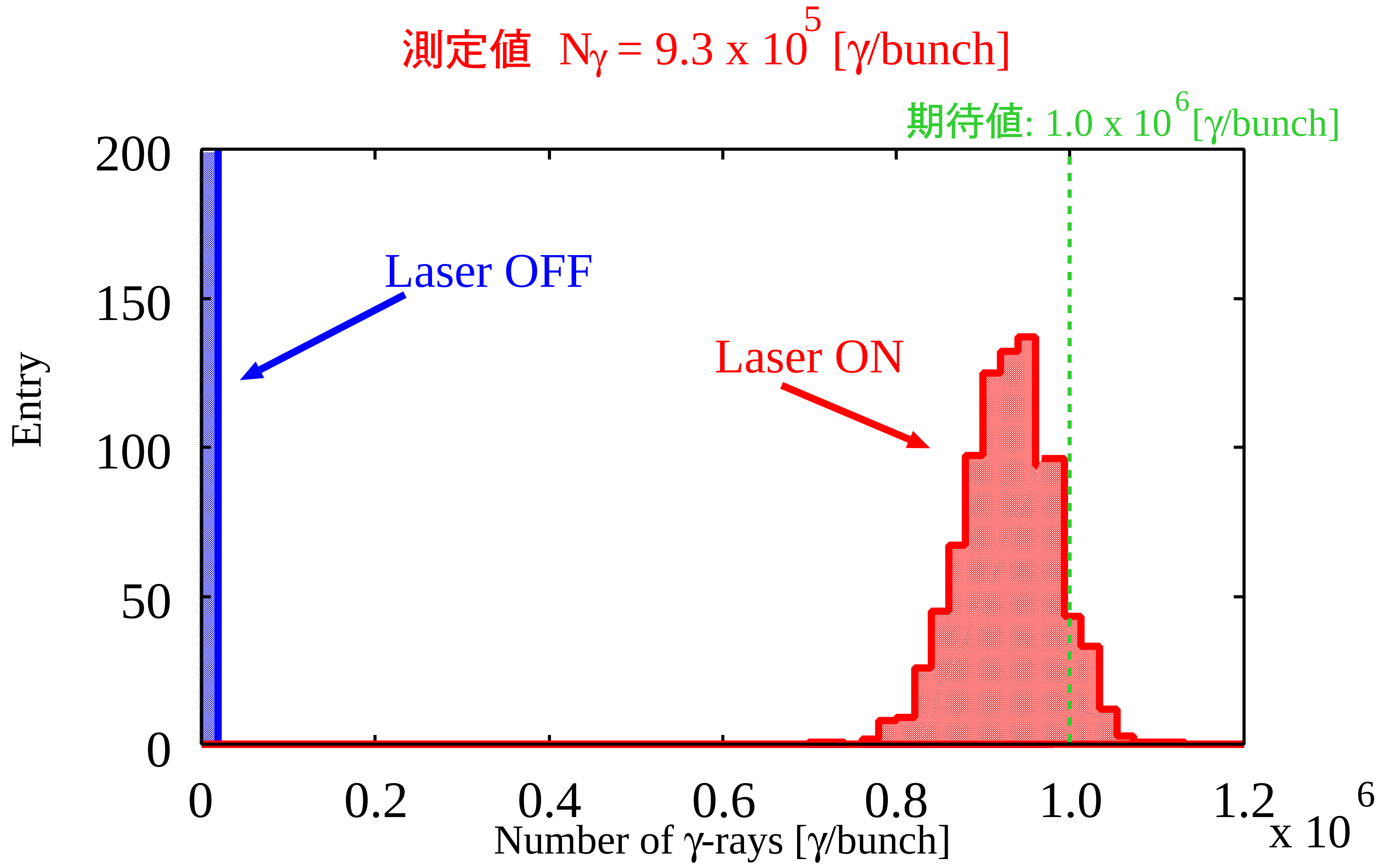

8ns (FWHM)
Laser の時間幅と同じ
Signal [a.u.]
Delay [ns]
0
1000
2000
3000
4000
5000
6000
0
5
10
15
20
25
30
35

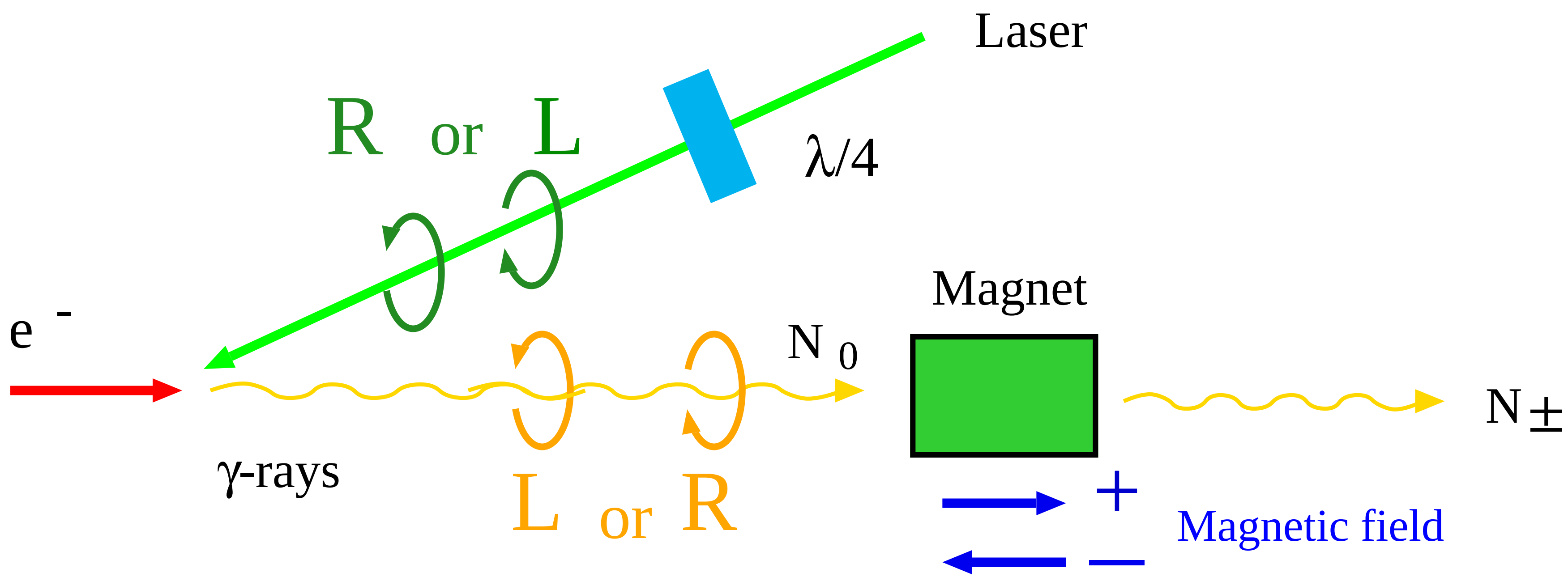
Laser の時間幅



Tek Stop: 5.00GS/s
11 Acqs
FWHM 8nsec
Ch1 50.0mVΩ
M 5.00ns Ch1 ∫ 84mV

Measured number of γ-rays





λ /4 : -45°、-22.5°、0.0°、22.5°、45°

$$L \longleftrightarrow R$$

Asymmetry

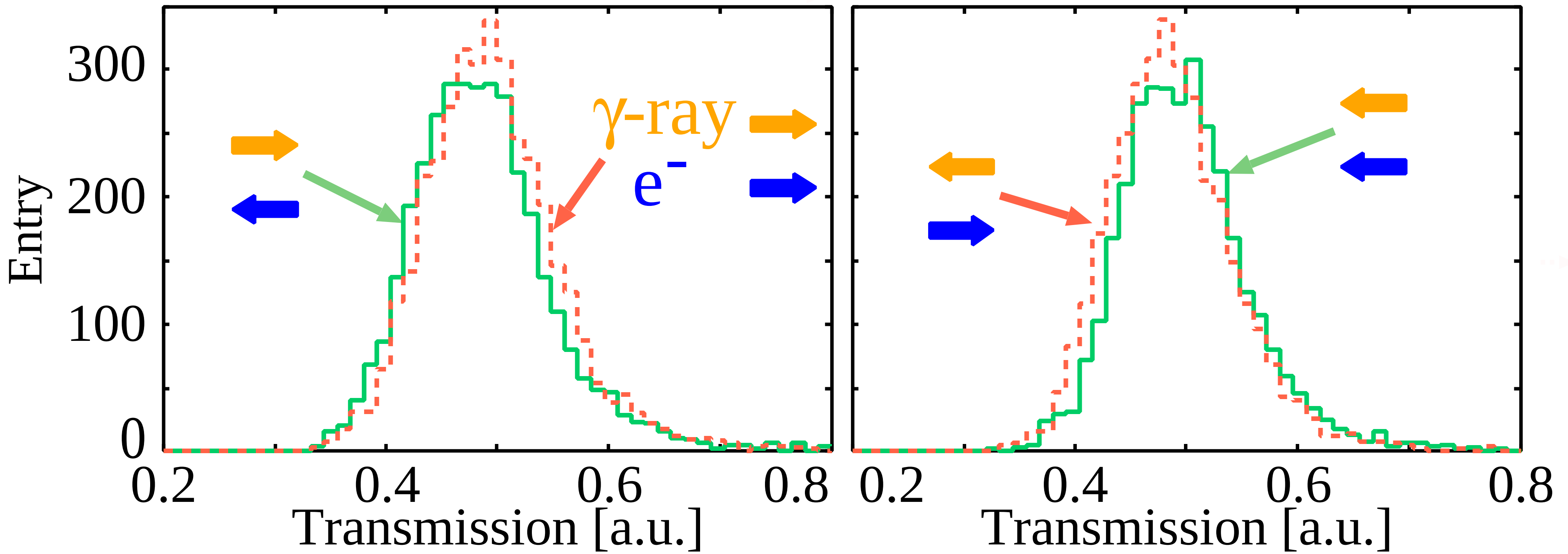
$$A = \frac{T_{+} - T_{-}}{T_{+} + T_{-}}$$

$$T_{\pm} = \frac{N_{\pm}}{N_{0}}$$: Transmission

レーザーの円偏光度測定結果

$\lambda/4$	円偏光度
-45°	76 % (L)
-22.5°	79 % (L)
0.0°	24 % (R)
22.5°	94 % (R)
45°	79 % (R)

Measured Asymmetry

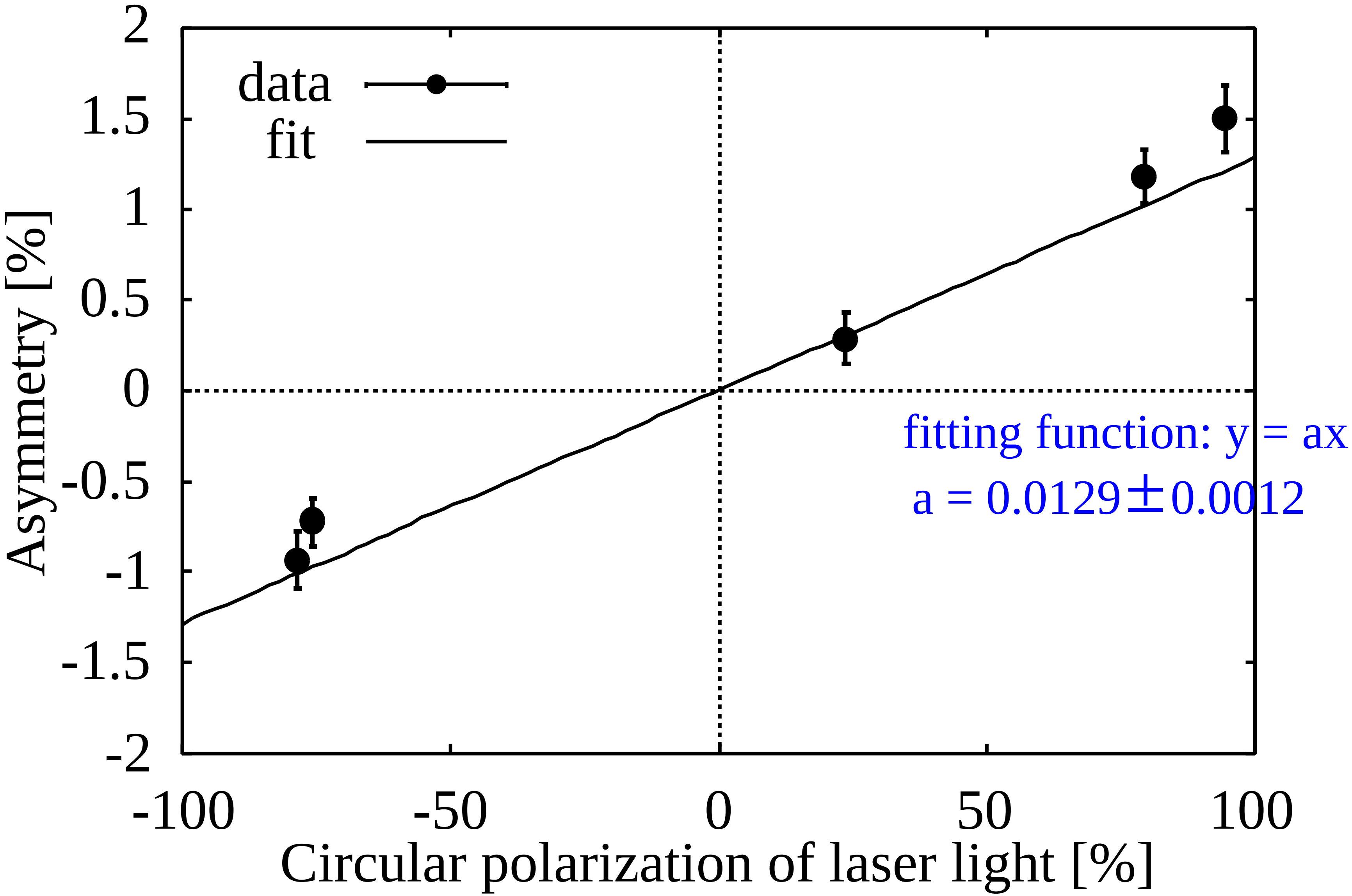


$A = -0.9 \pm 0.2$ %

$A = 1.2 \pm 0.2$ %

(Error: statistical)

Measured Asymmetry



円偏光度 100% のとき、Asymmetry は 1.29 ± 0.12 % (期待値 1.3 %)

Summary

磁化鉄の透過率を測定する方法により

世界で初めて短パルスのバンチ化されたγ線の偏極度測定に成功。

期待値と一致した結果が得られた。

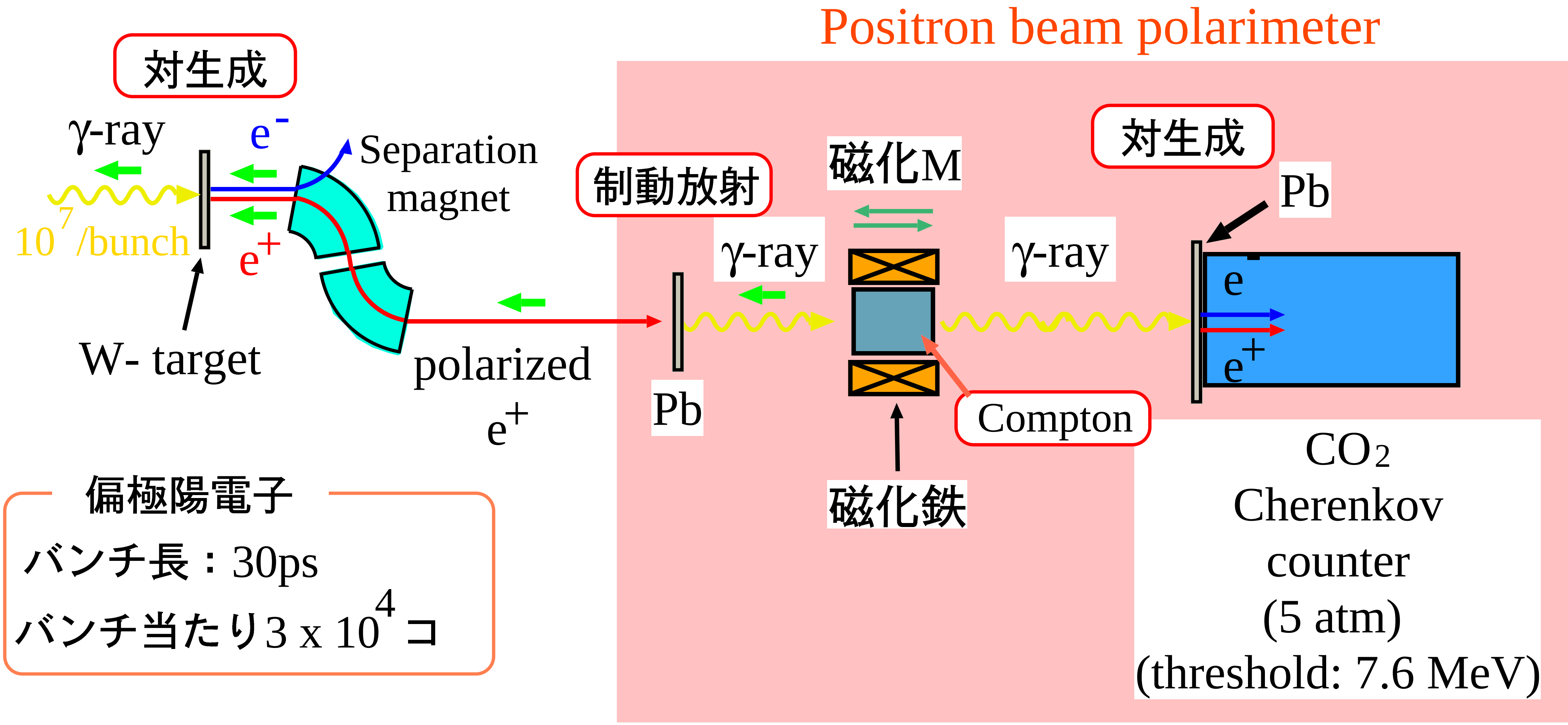
円偏光度 100% のとき、

Asymmetry : 1.29 ± 0.12 % (期待値 1.3 %)

偏極度：87 ± 8 % (期待値 88 %)

この方法は、陽電子の偏極度測定にも応用可能。

Schematic design for positron polarization measurement



偏極陽電子

バンチ長：30ps

バンチ当たり3 x 10^4 コ

透過率を測定する方法なので、陽電子の時間構造に依らず測定可能