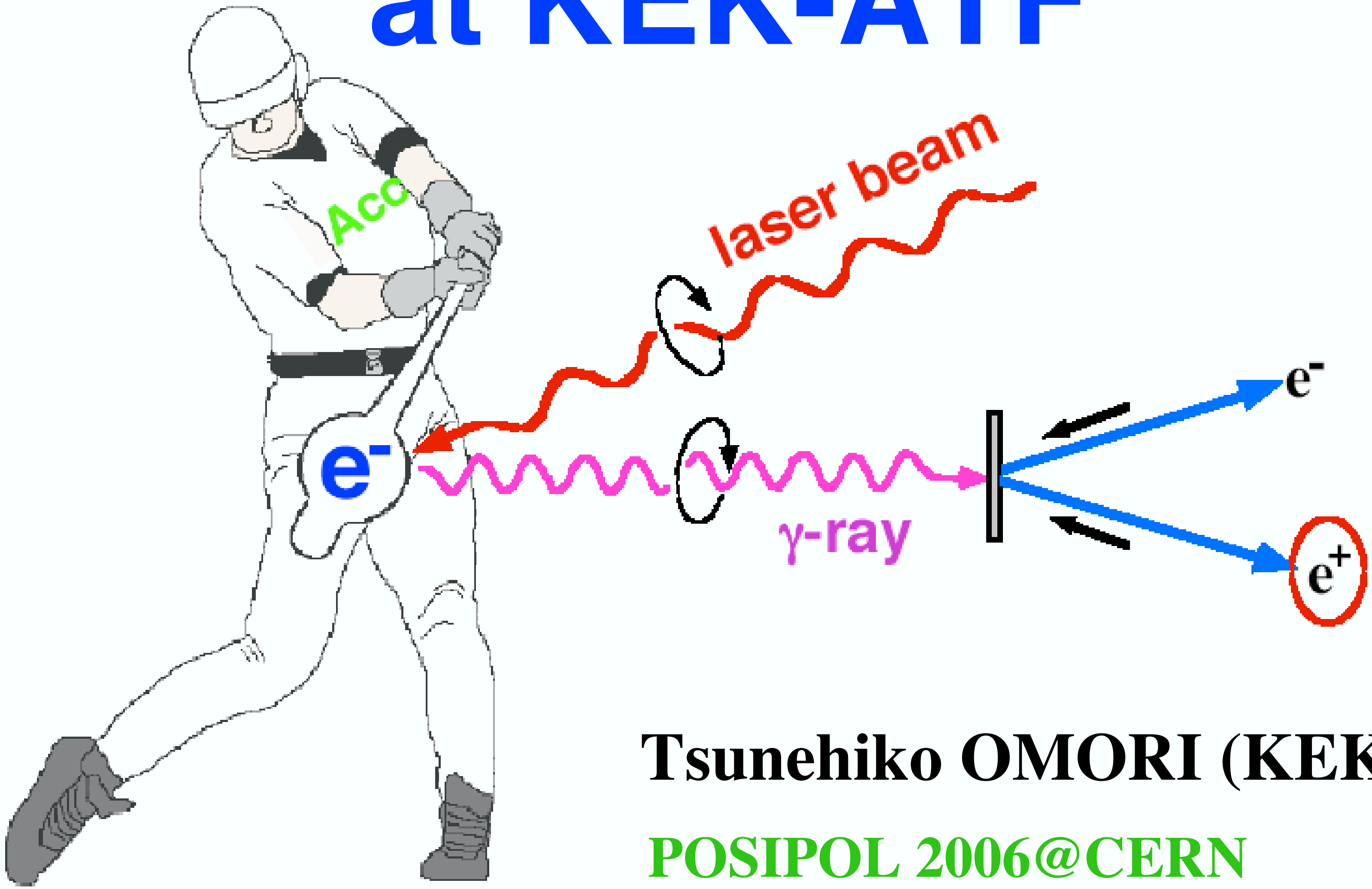
Polarized e^+ generation at KEK-ATF

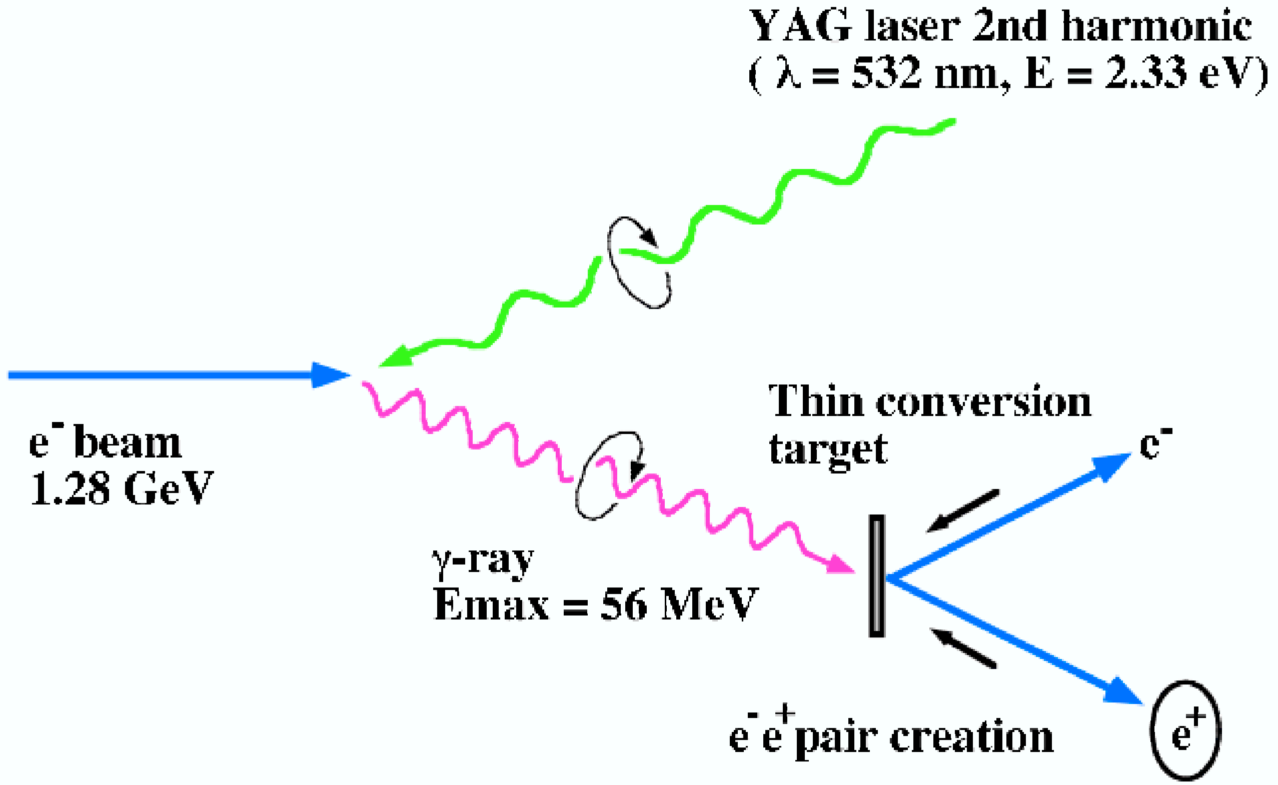


Tsunehiko OMORI (KEK)

POSIPOL 2006@CERN

27/Apr/2006

ATF-Compton Experiment@KEK



i) proof-of-principle demonstration

ii) accumulate technical informations:
polarimetry, beam diagnosis, …

No Optical Cavity at Collision Point

ATF-Compton Collaboration

KEK

Y. Kurihara, T. Okugi, J. Urakawa, T. Omori

Tokyo Metropolitan Univ

A. Ohashi

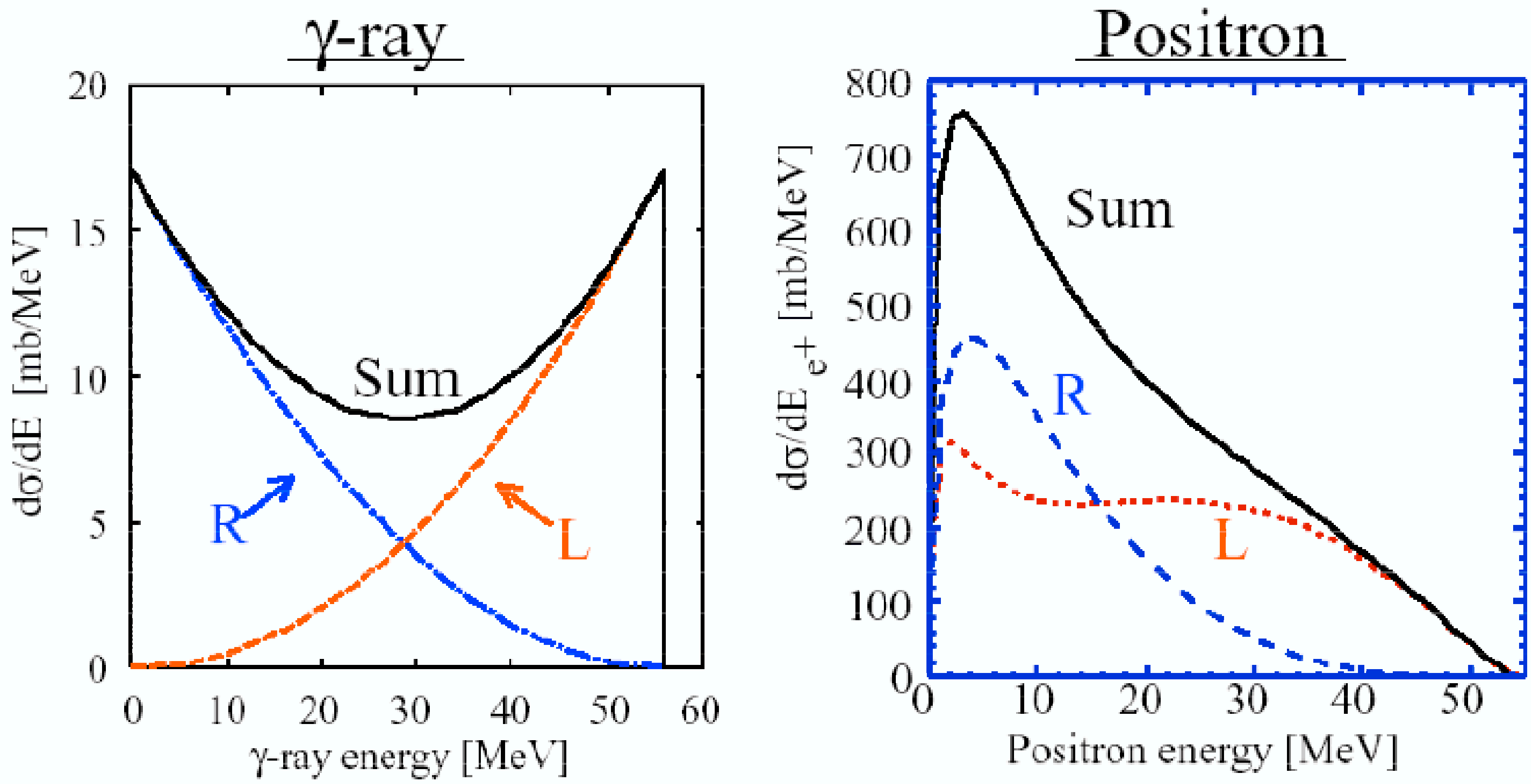
Waseda Univ.

I. Yamazaki, K. Sakaue, T. Saito, R. Kuroda(Waseda&AIST), M. Washio, T. Hirose

National Institute of Radiological Sciences

M. Nomura, M. Fukuda

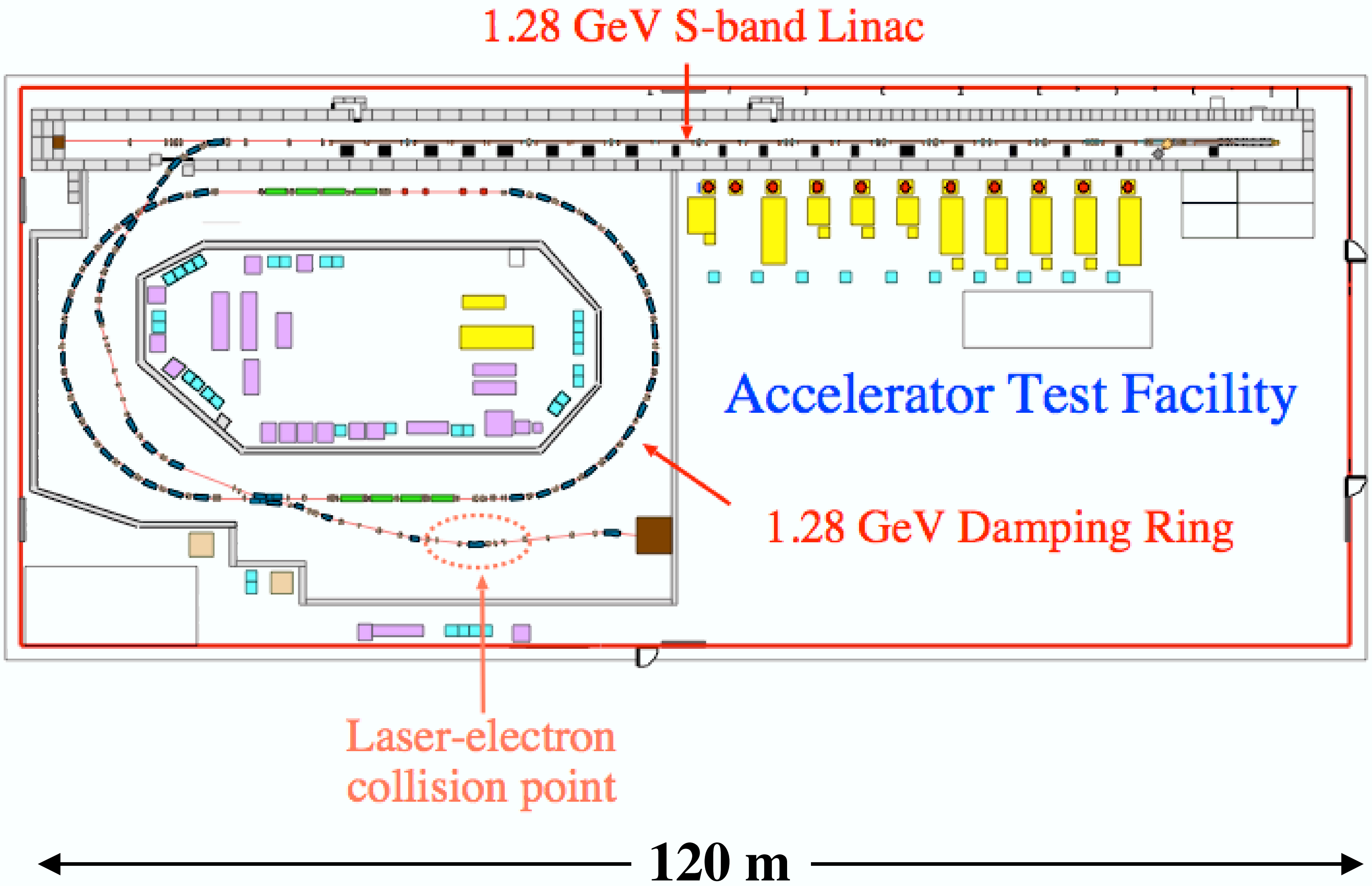
Cross section (calculation)



γ & e^+ : short bunch length 31 psec

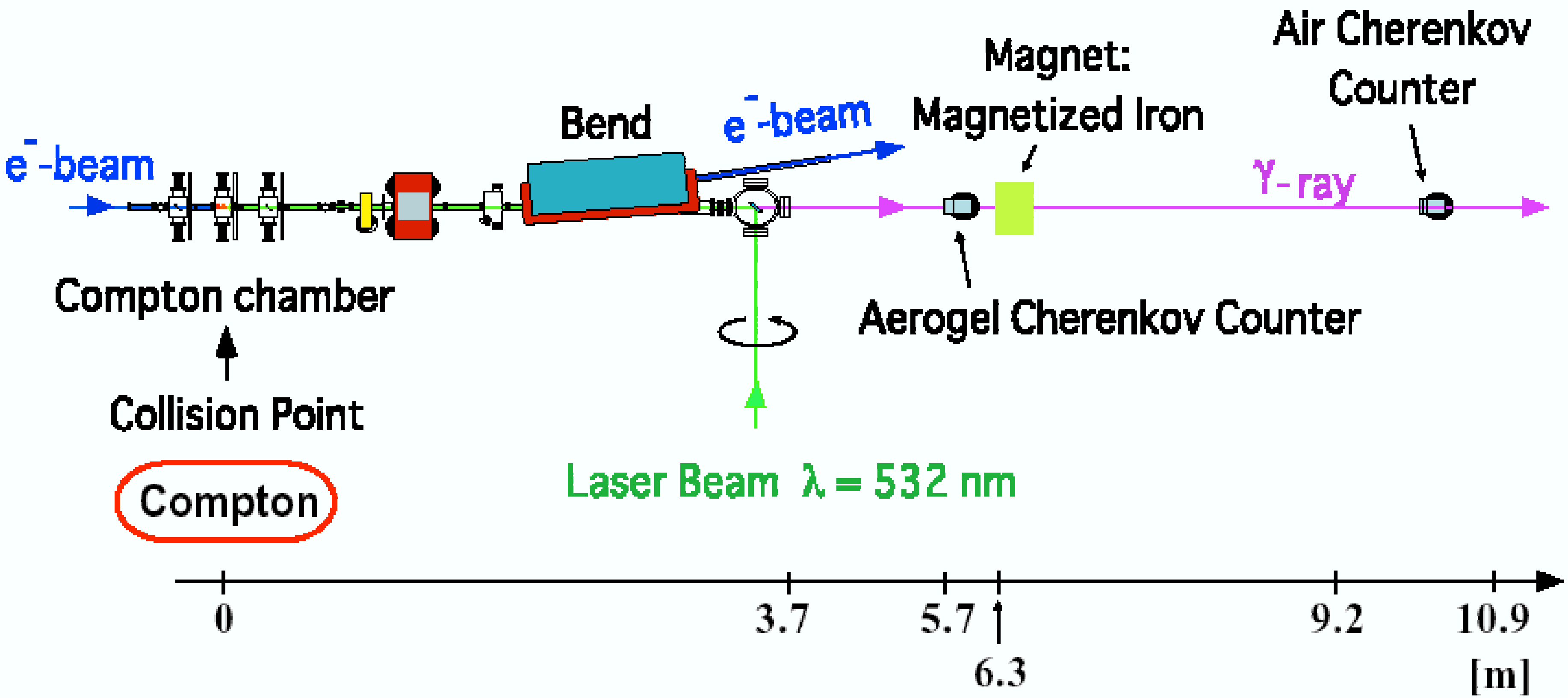
We can easily flip polarization of γ-ray and e^+, by flipping laser polarization.

Accelerator Test Facility@KEK

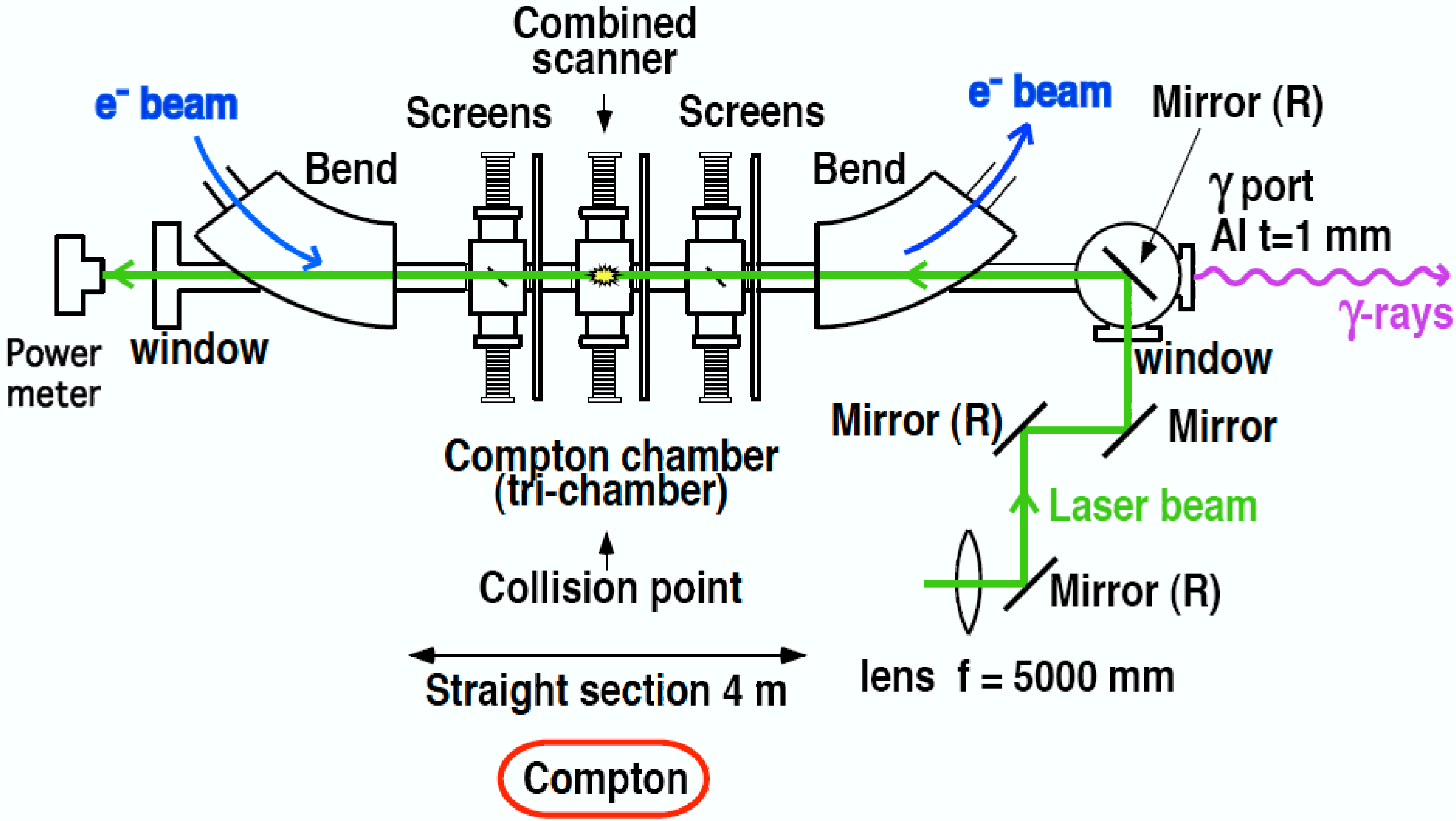


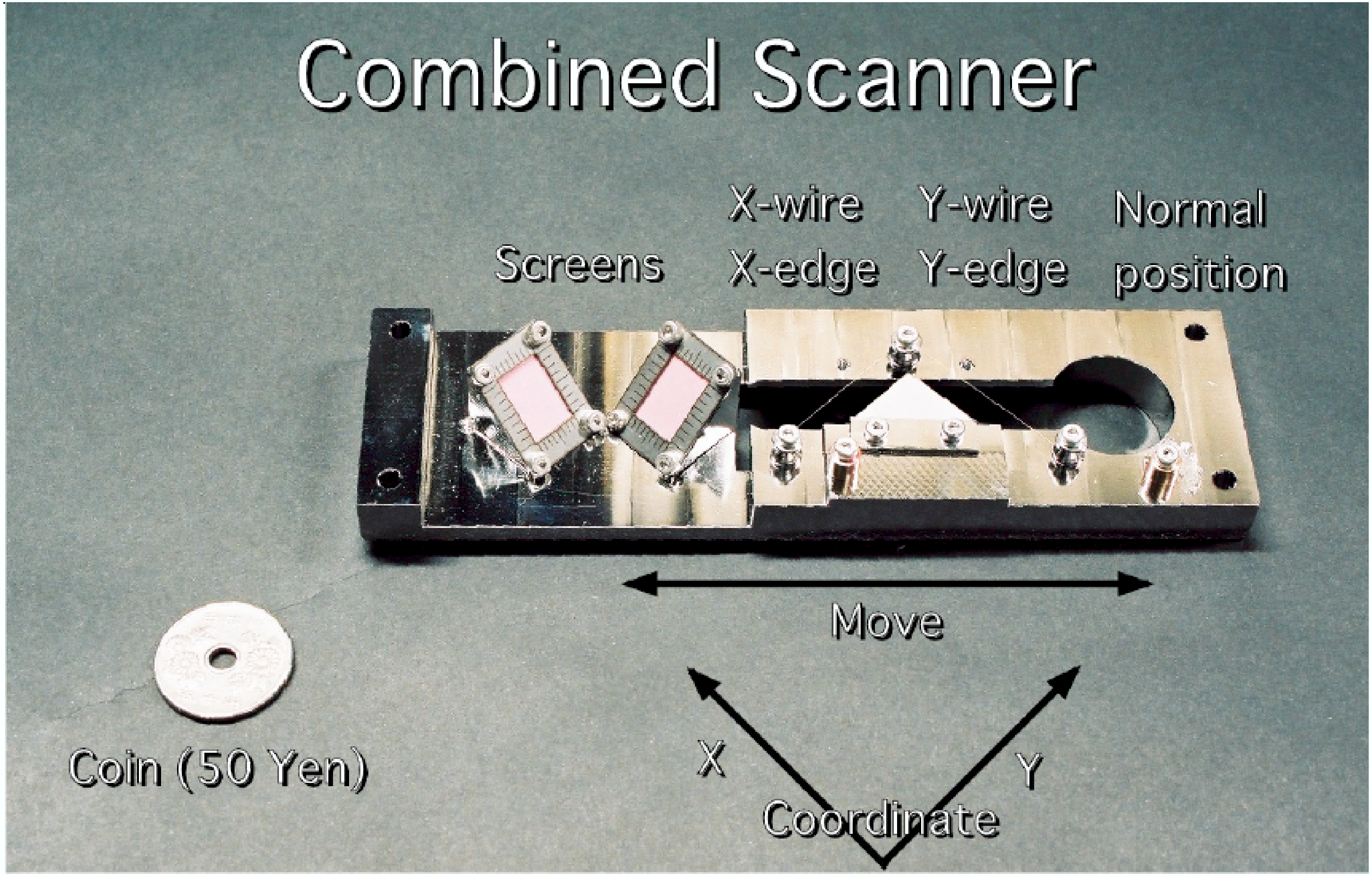
γ-ray: production, detection, and polarimetry

at ATF Extraction line



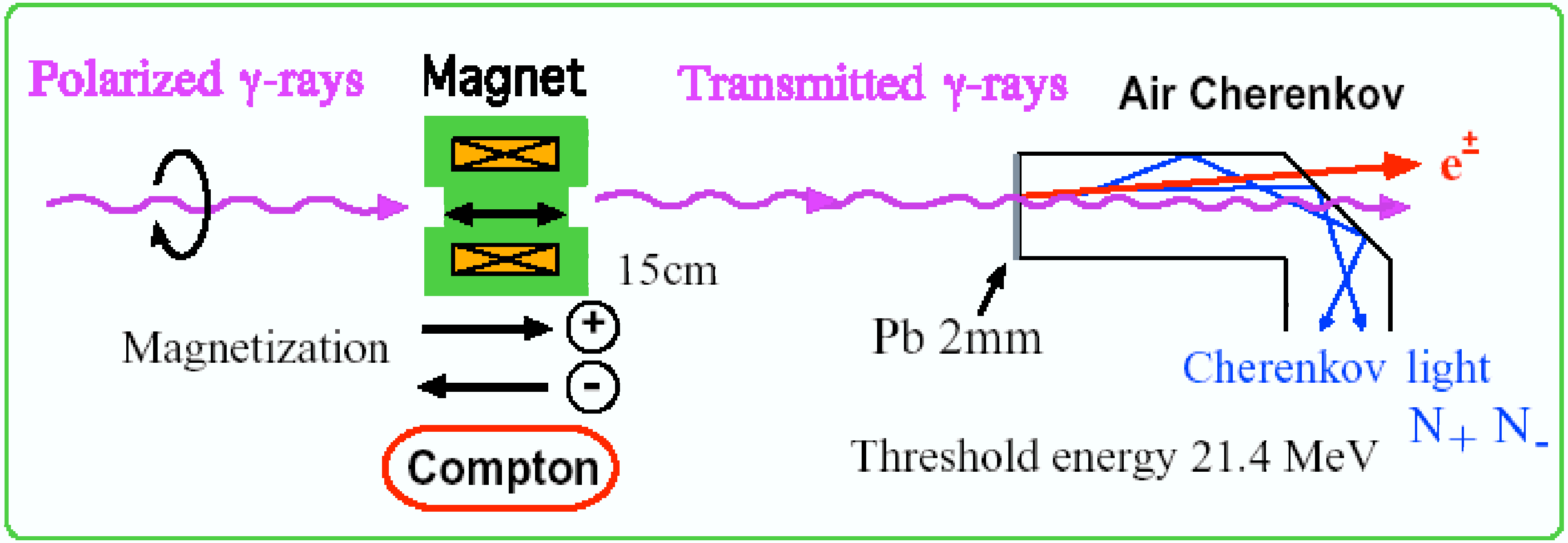
Compton Chamber




Combined Scanner
X-wire
X-edge
Y-wire
Y-edge
Normal
position
Screens
Move
X
Y
Coordinate
Coin (50 Yen)

Measure Asymmetry

ΔT=31 psec → can NOT measure each γ-ray



Cross section of Compton scattering

$$\sigma(\uparrow\uparrow) < \sigma(\uparrow\downarrow)$$

$$\Downarrow$$

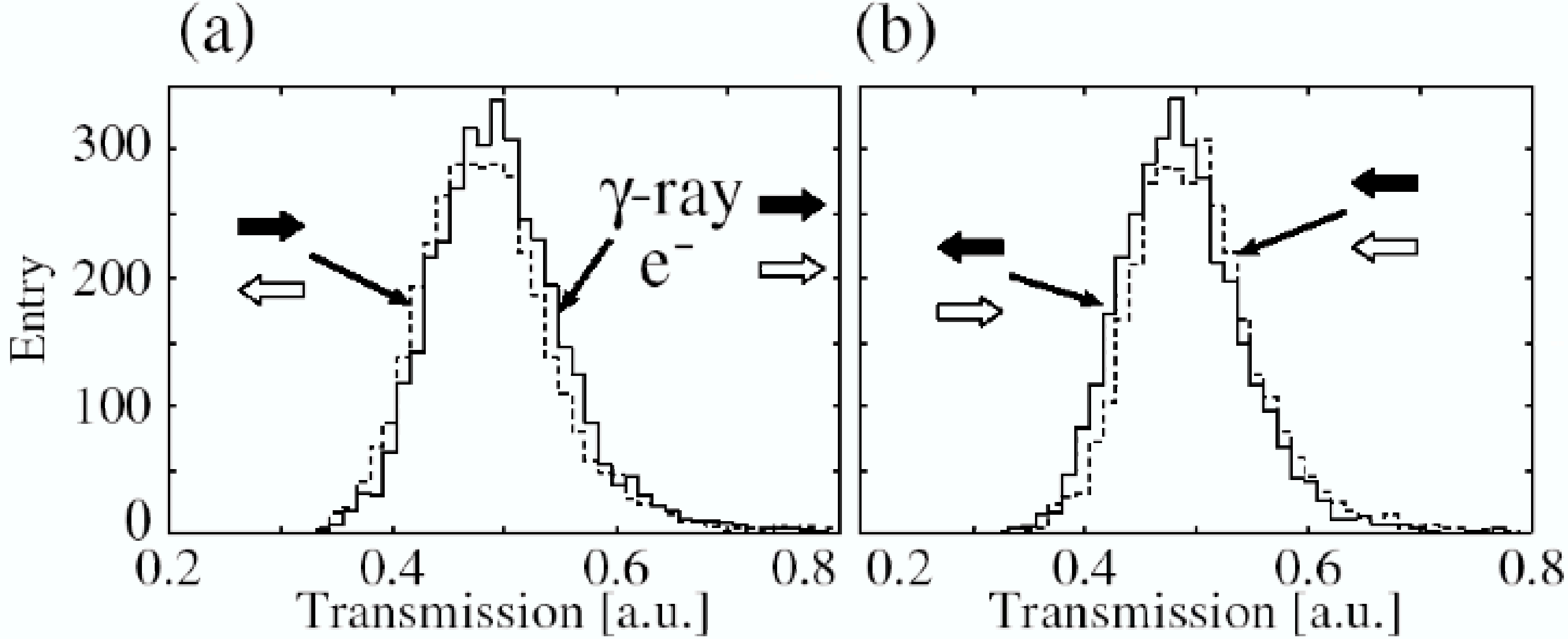
Transmission depends on
the direction of the magnetization

Expected asymmetry

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

$A = 1.3\ \%$ (Pol.=88%)
($E_{th} = 21.4$MeV)

γ-ray Measured Asymmetry (4 years ago)



A= -0.93± 0.15 % **A= 1.18± 0.15 %**

laser pol. = - 79 % **laser pol. = + 79 %**

M. Fukuda et al., PRL 91(2003)164801

Pol. γ-ray Production

Done: Mar. 2002

$N\gamma \approx 1 \times 10^6$ /bunch

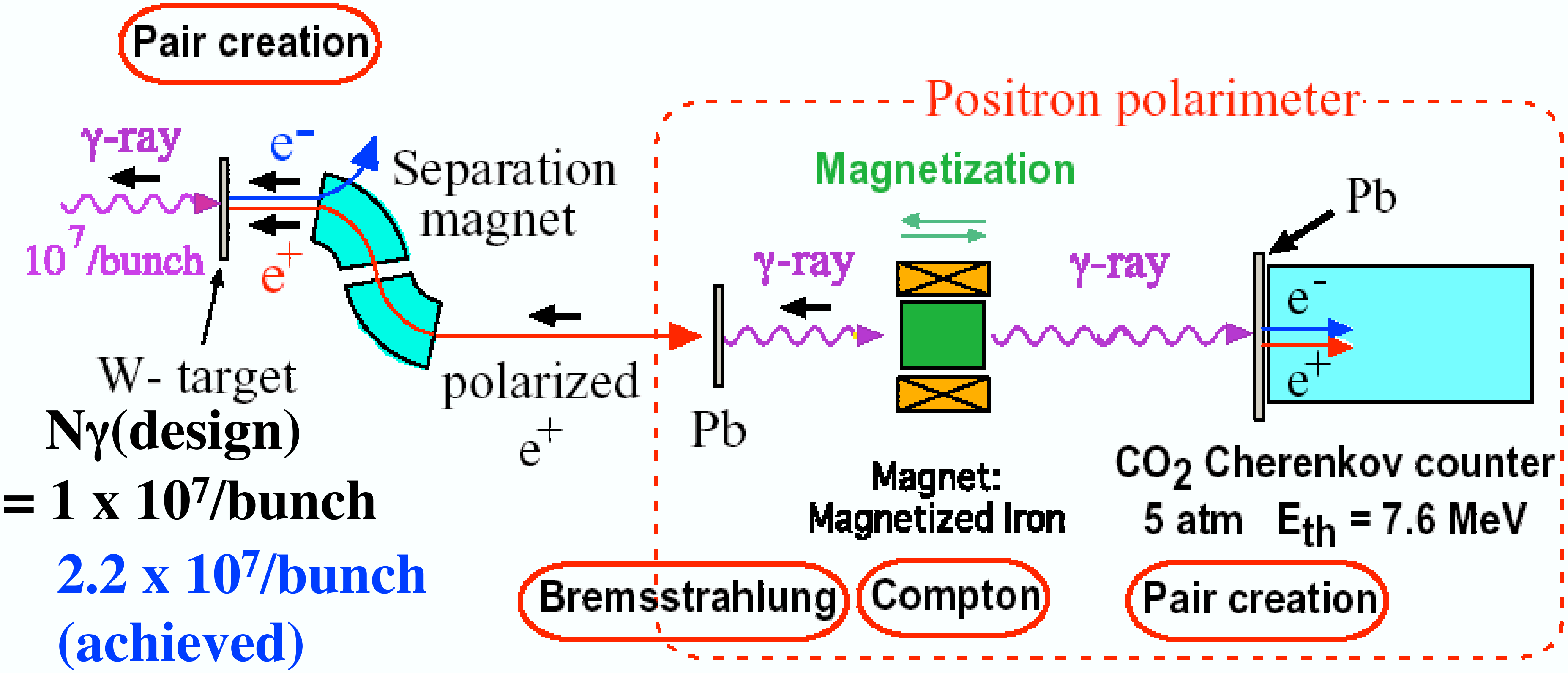
$\Delta T(\mathrm{rms}) = 31$ psec

Pol. : $\gamma = 88$ % (if laser pol. = 100 %)

(measure $E\gamma > 21$ MeV)

M. Fukuda et al., PRL 91(2003)164801

Positron: production, selection, and polarimetry



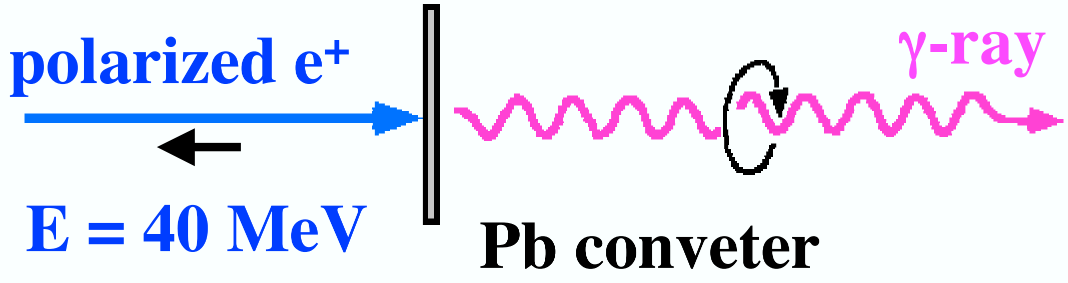
Nγ(design) = 1 x 10^7/bunch

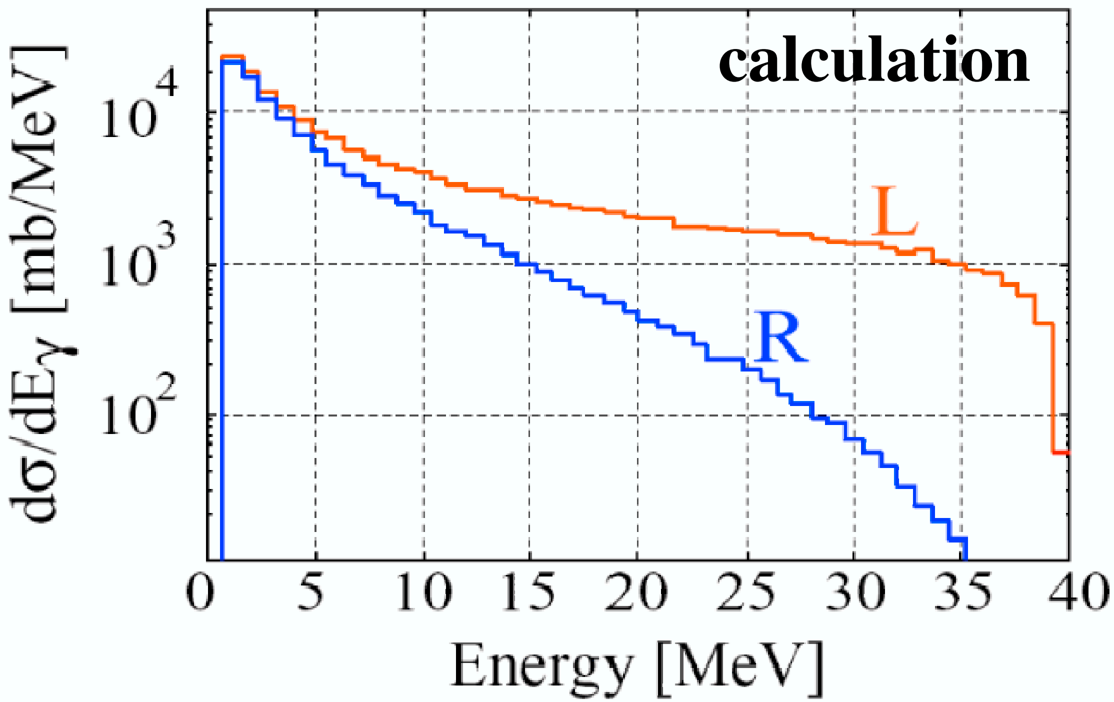
2.2 x 10^7/bunch (achieved)

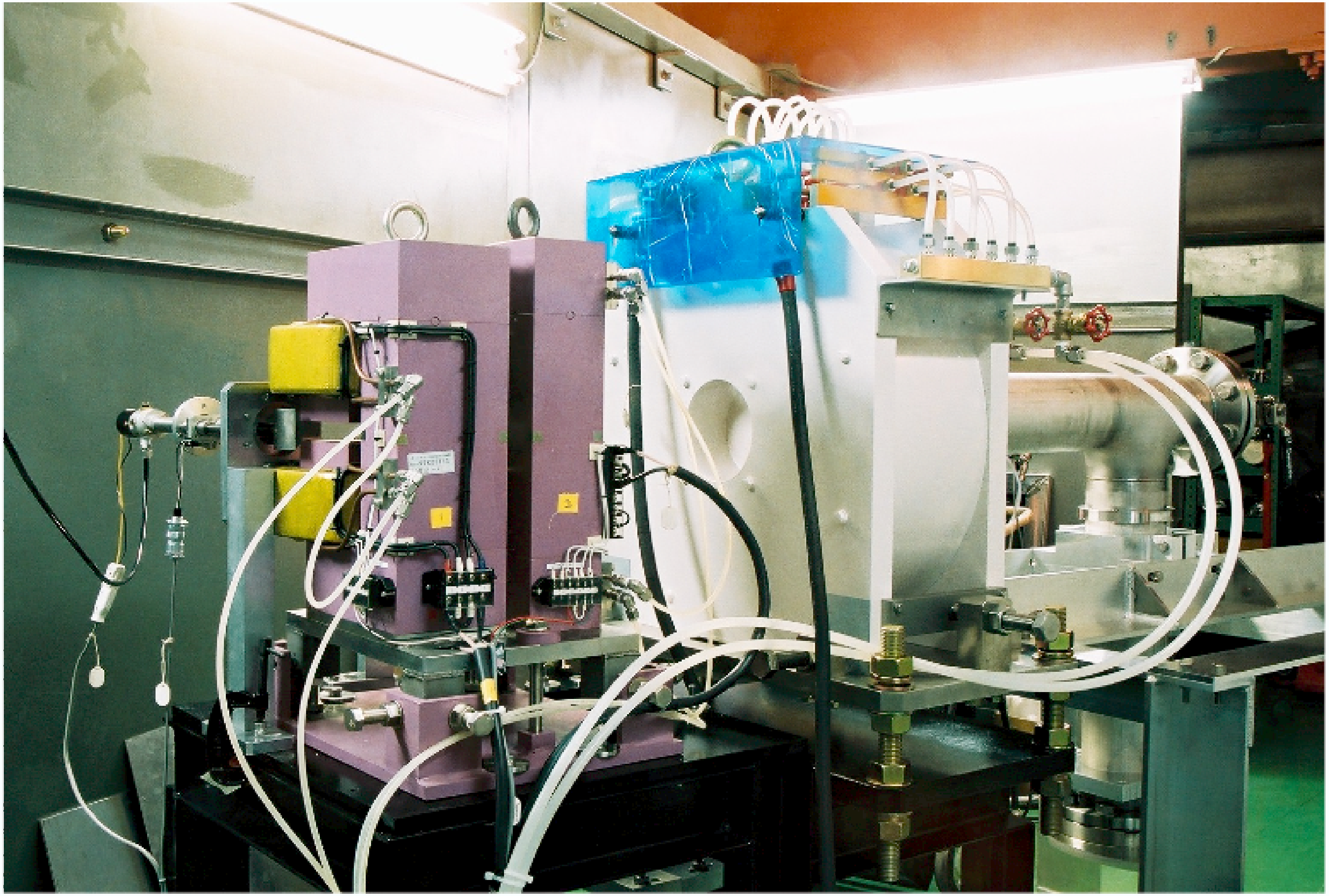
Ne+(design) = 3 x 10^4/bunch

Pol(expected) = 80% **Asym (expected) = 0.95%**

Measure e⁺ polarization :
use Bremsstrahlung γ-ray







Measurement and Cross-Check

Measurement

e^+ beam pol. (laser pol)	e^- spin in iron (magnet pol.)		expected value (MC)
R →	⇄	Calculate A	A(R) : A(R) ~ + 0.95 %
L ←	⇄	Calculate A	A(L) : A(L) ~ - 0.95 %
0 non (Liner)	⇄	Calculate A	A(0) : A(0) = 0

Cross-Check

e^+ beam pol.	magnet pol.		
⇄	P →	Calculate A	A(P) : A(P) ~ + 0.95 %
⇄	N ←	Calculate A	A(N) : A(N) ~ - 0.95 %

Zero magnet current Not Equal No-polarization, due to residual magnetism

e^+ polarization (e^+ run): results

Measurement

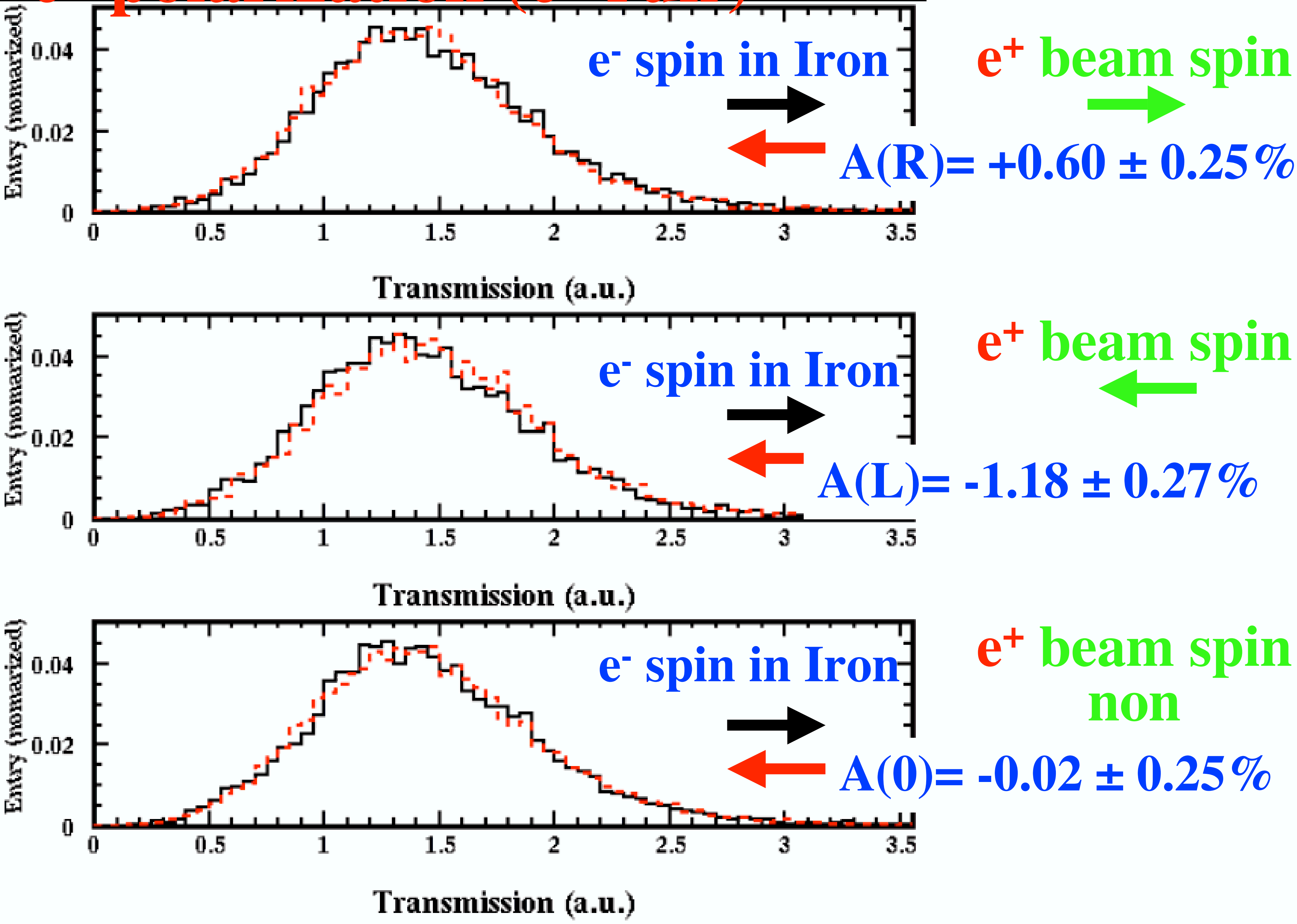
e^+ beam pol. (laser pol)	e^- spin in iron (magnet pol.)	
R		A(R)= +0.60 ± 0.25%
L		A(L)= -1.18 ± 0.27%
0 non (Liner)		A(0)= -0.02 ± 0.25%

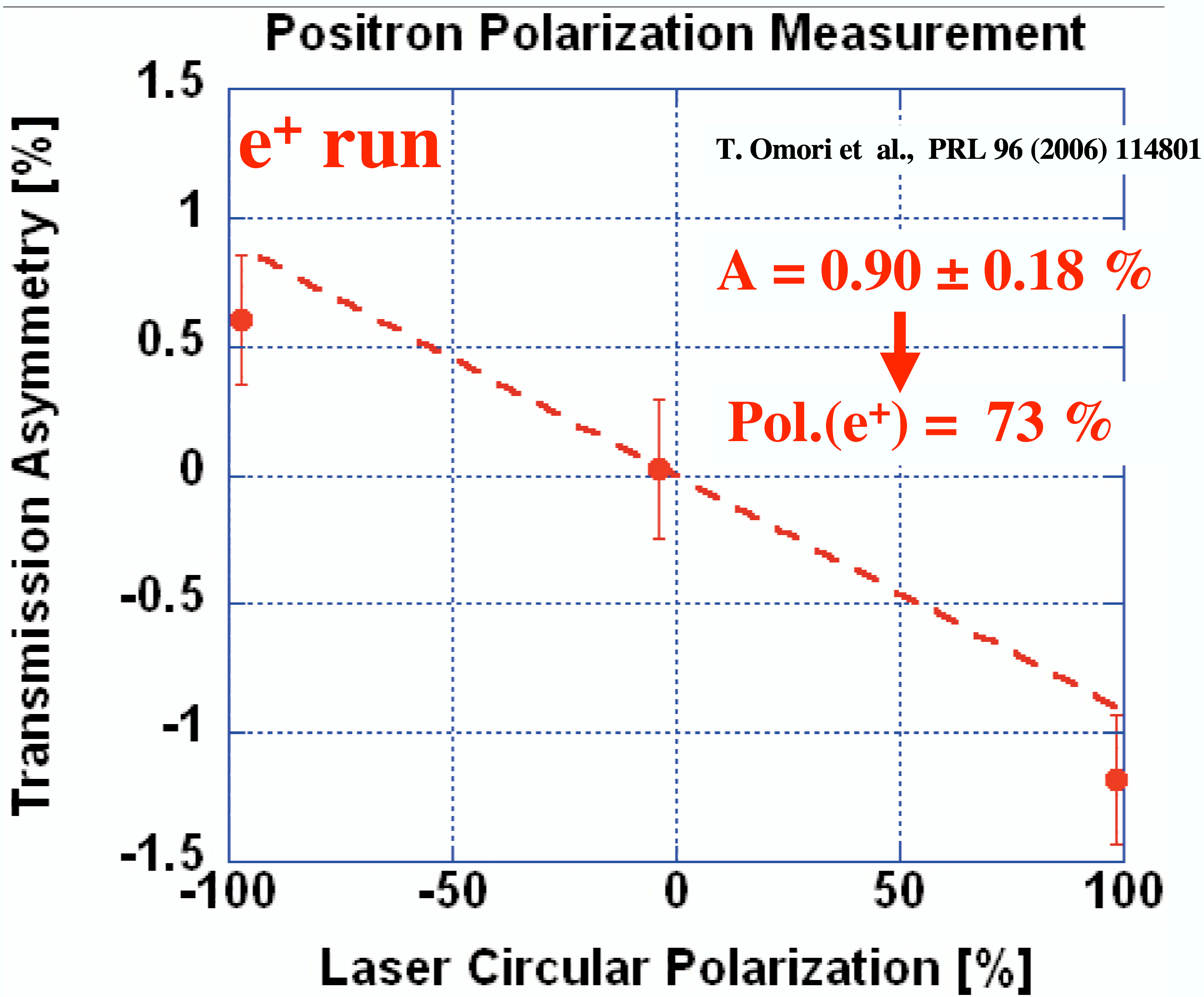
Cross-Check

e^+ beam pol.	magnet pol.	
	P	A(P)= +0.81 ± 0.26%
	N	A(N)= -0.97 ± 0.26%

e^+ polarization (e^+ run)

T. Omori et al., PRL 96 (2006) 114801

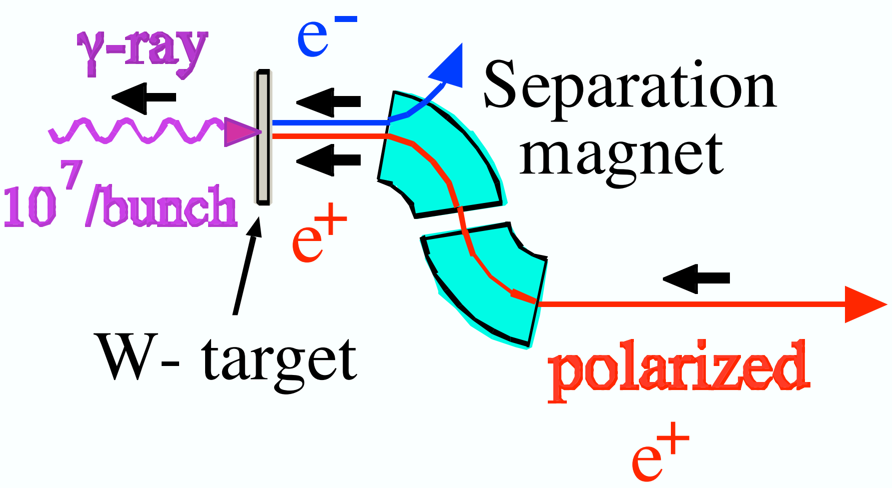




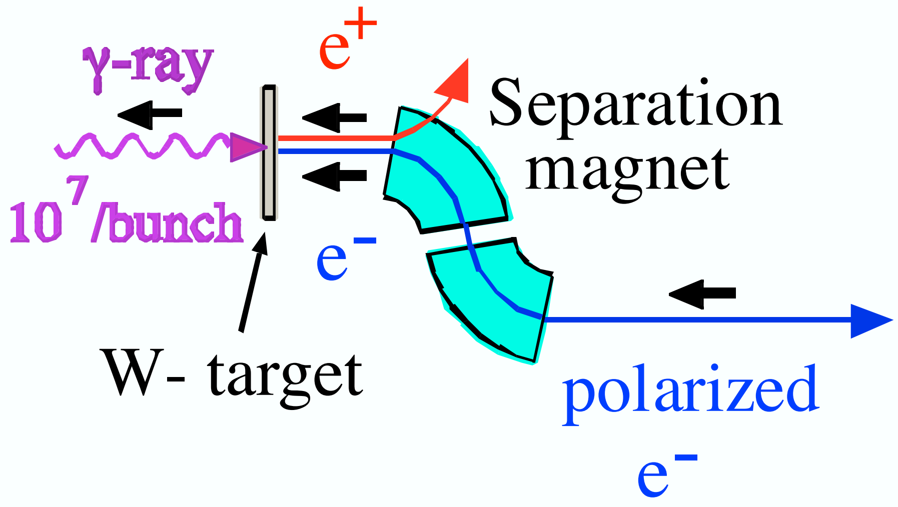
Positron Polarization Measurement
e+ run
T. Omori et al., PRL 96 (2006) 114801
A = 0.90 ± 0.18 %
Pol.(e+) = 73 %
Transmission Asymmetry [%]
Laser Circular Polarization [%]
1.5
1
0.5
0
-0.5
-1
-1.5
-100
-50
0
50
100

We did e^- run, also.

e^+ run



e^- run



e^- polarization (e^- run): results

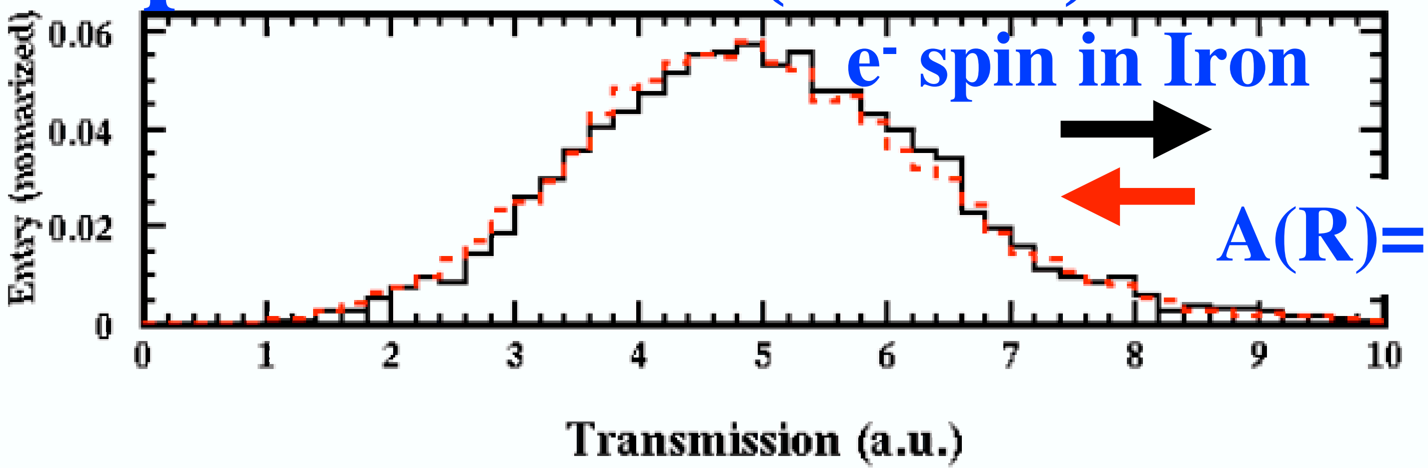
Measurement

e^- beam pol. (laser pol)	e^- spin in iron (magnet pol.)	
R →	⇄)	A(R)= +0.78 ± 0.27%
L ←	⇄)	A(L)= -0.97 ± 0.27%
0 non (Liner)	⇄)	A(0)= -0.23 ± 0.27%

Cross-Check

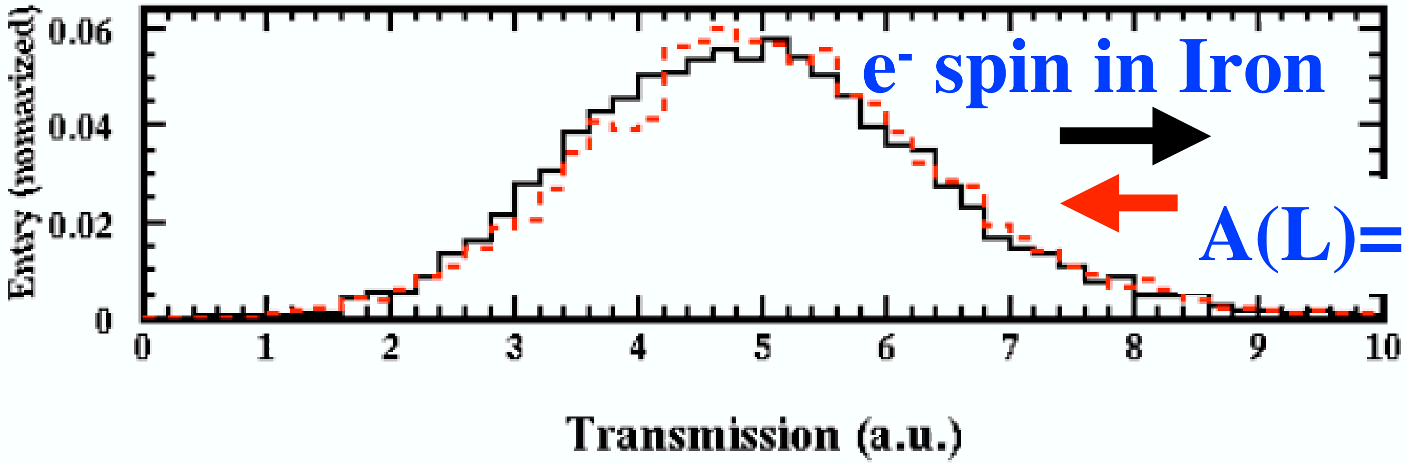
e^- beam pol.	magnet pol.	
⇄)	P →	A(P)= +0.72 ± 0.27%
⇄)	N ←	A(N)= -1.03 ± 0.27%

e^- polarization (e^- run)



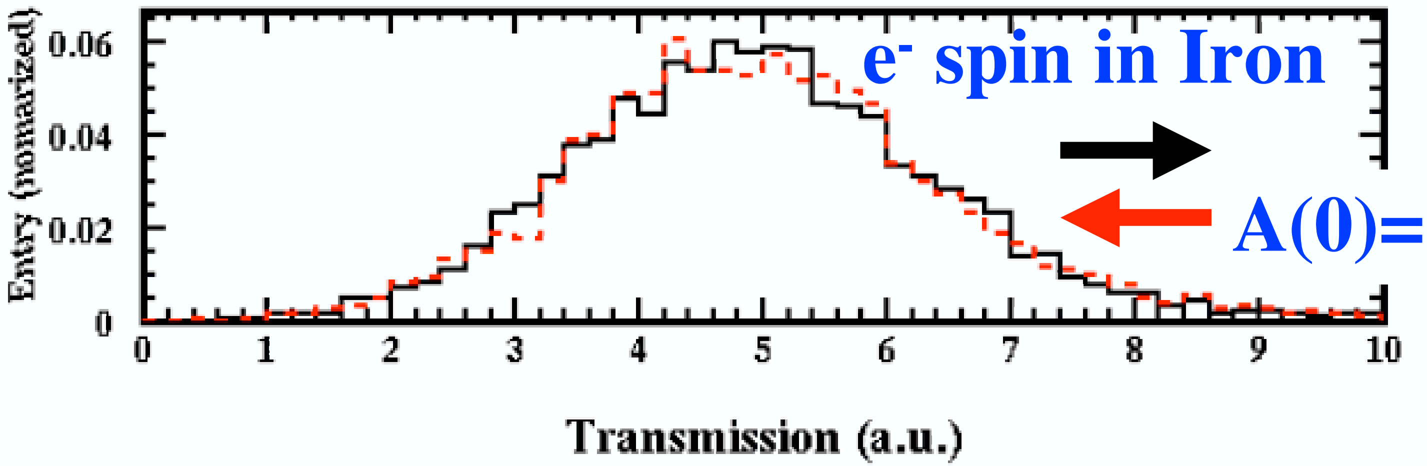
e^- beam spin

A(R)= +0.78 ± 0.27%



e^- beam spin

A(L)= -0.97 ± 0.27%

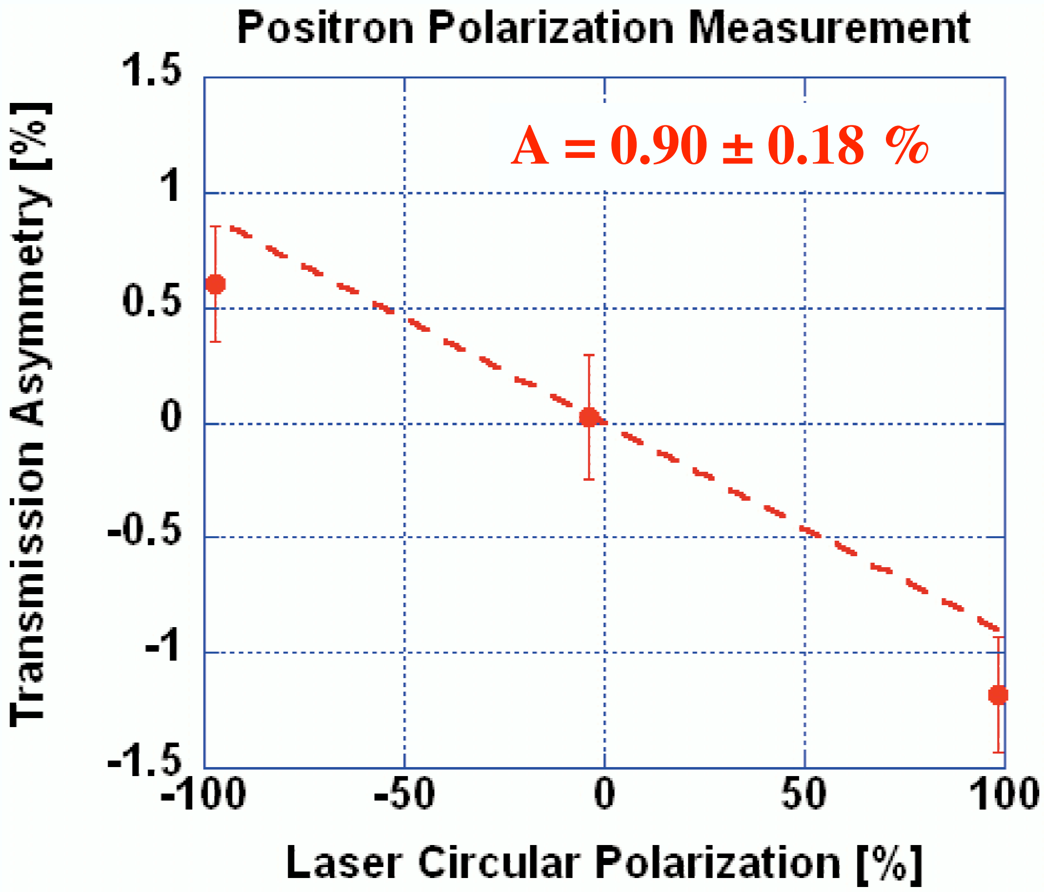


e^- beam spin non

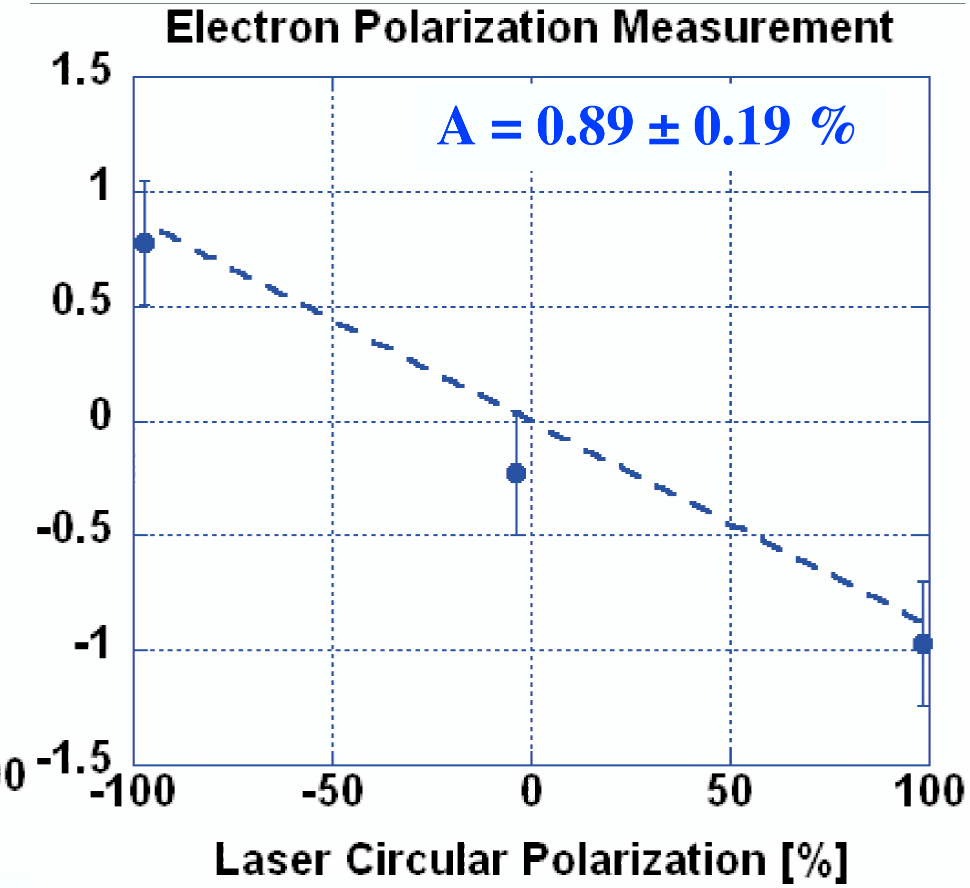
A(0)= -0.23 ± 0.27%

Asymmetry Measurements

e+ run



e- run



T. Omori et al., PRL 96 (2006) 114801

Summary of Experiment

1) The experiment was successful.
High intensity short pulse polarized e^+ beam was firstly produced.
Pol. =73 ± 15(sta) ± 19(sys) %

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2) We confirmed propagation of the polarization from laser photons -> γ-rays -> and pair created e^+s & e^-s.

3) We established polarimetry of short pulse & high intensity γ-rays, positrons, and electrons.

What's Next ?

What's Next ?

↓

Optical Cavity at Collision Point
Placed in Storage Ring

What's Next ?

↓

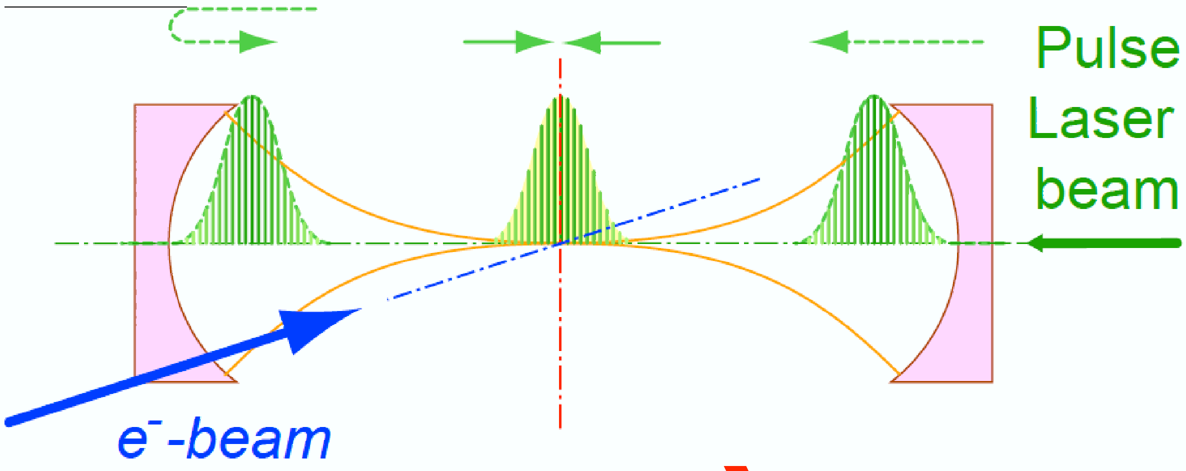
Optical Cavity at Collision Point
Placed in Storage Ring

↓

Cavity-Compton Collaboration

Cavity-Compton at ATF

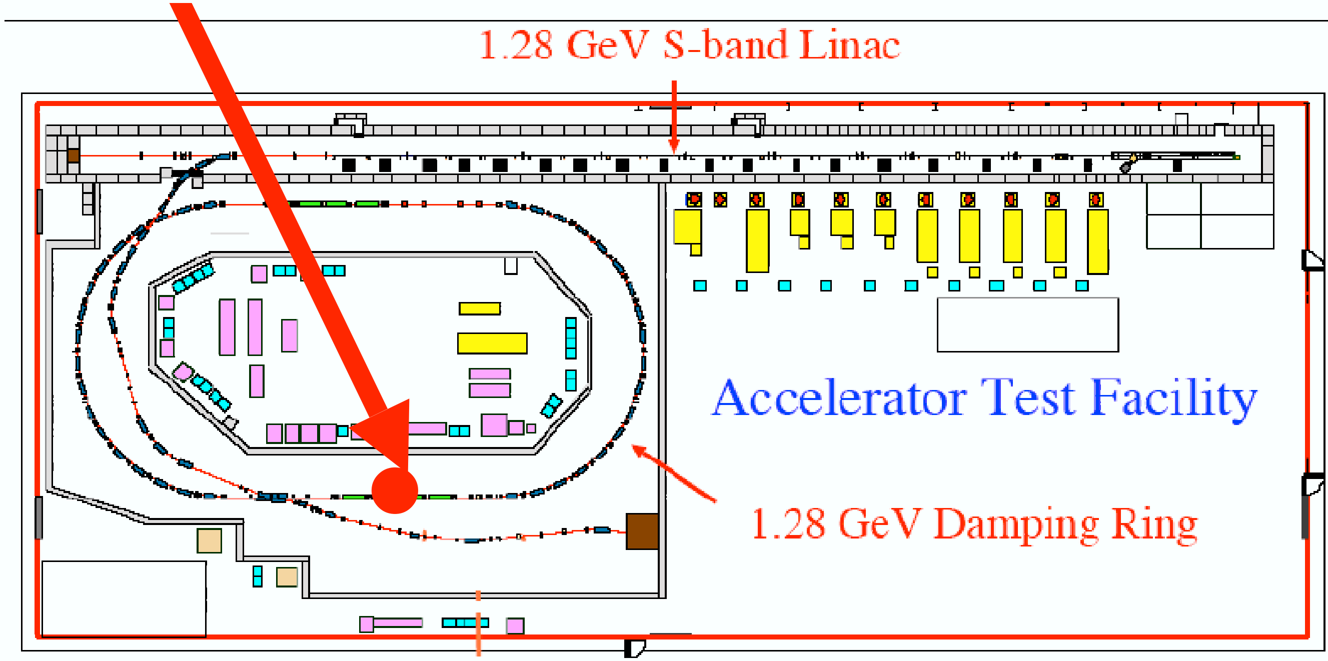
Hiroshima-Waseda-LAL-Kyoto-CERN-KEK Collaboration

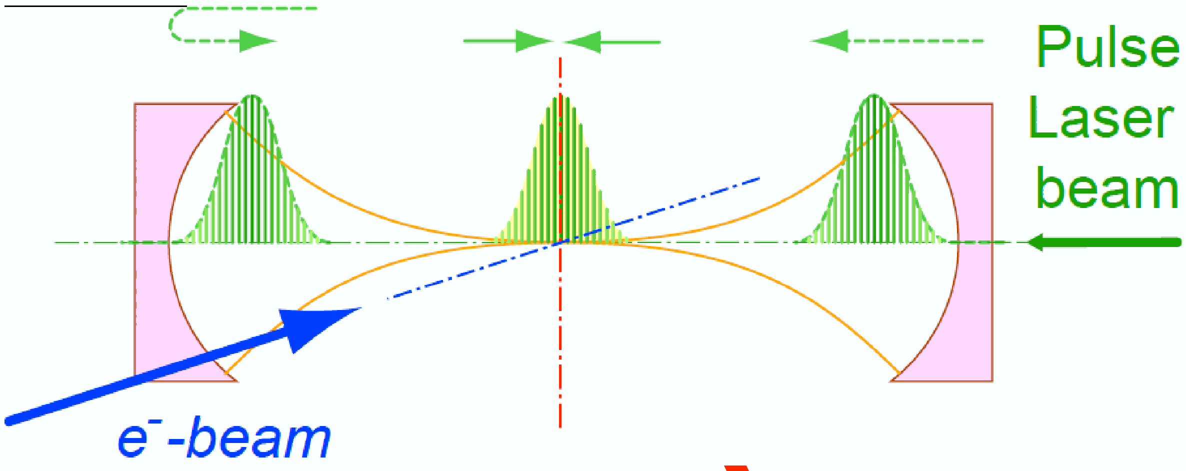


Make a fist prototype single cavity

L_{cav} = 420 mm

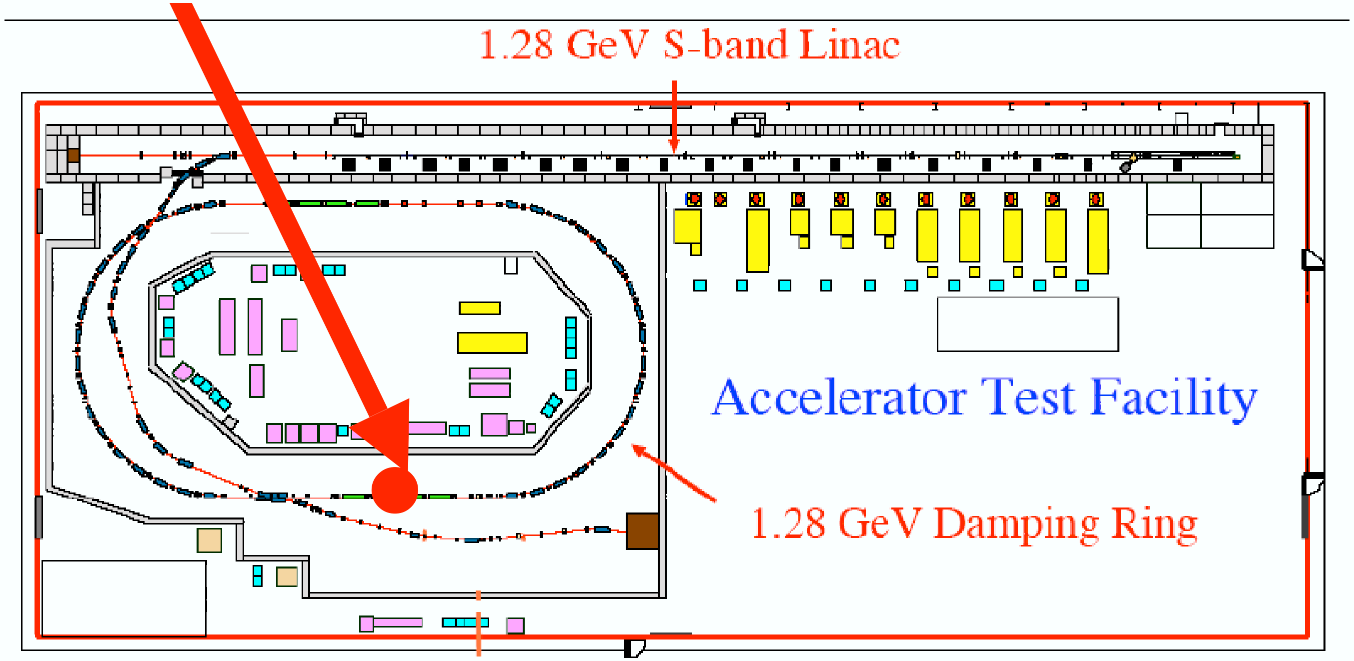
Put it in ATF ring Oct. 2006





Make a fist prototype single cavity

L_{cav} = 420 mm



Put it in ATF ring

Oct. 2006

detail → Sato's talk Tomorrow