Positron-Production Experiment Using 8-GeV Channeling Electrons in a Crystal-Tungsten Target

T.Suwada, S.Anami, A.Enomoto, K.Furukawa, K.Kakihara, T.Kamitani,Y.Ogawa, S.Ohsawa, T.Oogoe

***Accelerator Laboratory, High Energy Accelerator Research Organization (KEK),* 1-1 Oho, Tsukuba, Ibaraki 305-0801, Japan**

H.Okuno

***Institute of Particle and Nuclear Studies, High Energy Accelerator Research Organization (KEK),* 1-1 Oho, Tsukuba, Ibaraki 305-0801, Japan**

T.Fujita, K.Umemori, K.Yoshida

***Hiroshima Synchrotron Radiation Center, Hiroshima University,* 2-313 Kagamiyama, Higashi-Hiroshima 739-8526, Japan**

R.Hamatsu, K.Sasahara

***Department of Physics, Tokyo Metropolitan University,* 1-1 Minami-Ohsawa, Hachioji-shi, Tokyo 192-0397, Japan**

V.Ababiy, A.P.Potylitsin, I.E.Vnukov

***Nuclear Physics Institute, Tomsk Polytechnic University,* 634050, P.O.Box 25, Tomsk, Russia**

Motivation

- High-intensity positron sources are required for future linear colliders and B-factories.
- Conventional methods using amorphous heavy metals limit to increase the intensity of primary electron beams due to the heat load on the target.
- New method using the processes of coherent bremsstrahlung (CB) and channeling radiation (CR) is one of the bright schemes for high-intensity e^+ sources.

Motivation (cont.)

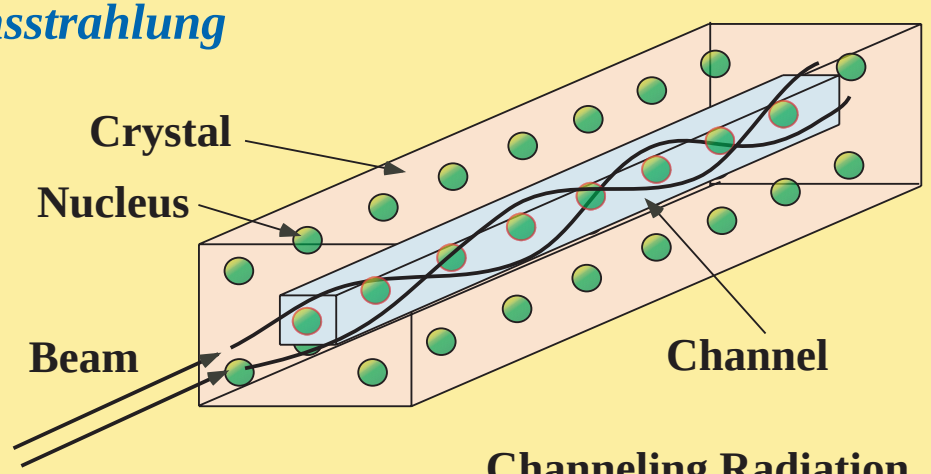
- Theoretically unified treatment taking into account both processes of CR and CB has not yet been established on the simulation.
- More experimental data are expected to clearly understand the elementary physical processes of the CR and CB, and they are also required to develop the design of a real-type positron source.

Historical View of Our Experiment

Month/Year	Accelerator	Energy [GeV]	Positron Target [mm]
May/1997	KEK Tanashi, ES	1.2	Crystal W (W_c) [1.2]
Apr, Jun/1998	KEK Tsukuba, Electron Linac	3	W_c [1.7] + Amor. W (W_a) [7]
Nov/1998	KEK Tanashi, ES	0.6, 0.8, 1	W_c [0.4, 1.2, 2.2], GaAs [0.36], Diamond[1.1]
Sep, Oct/2000	KEK Tsukuba, Electron Linac	8	W_c [2.2], W_c [2.2]+W_a [5, 10, 15]
Apr/2001	KEK Tsukuba, Electron Linac	8	W_c [2.2], W_c [9] W_c [9]+W_a [2, 4]

Channeling Radiation & Coherent Bremsstrahlung

Physical processes for the channeling radiation and coherent bremsstrahlung



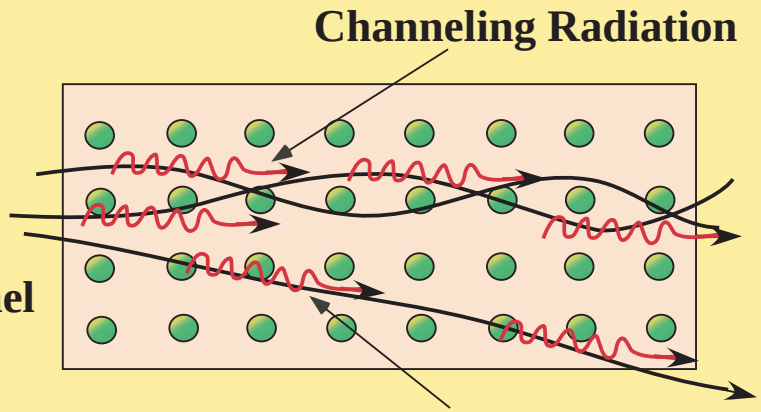
Critical Angle of Channeling Radiation

$F_c=(2U_0/E_b)^{1/2}$

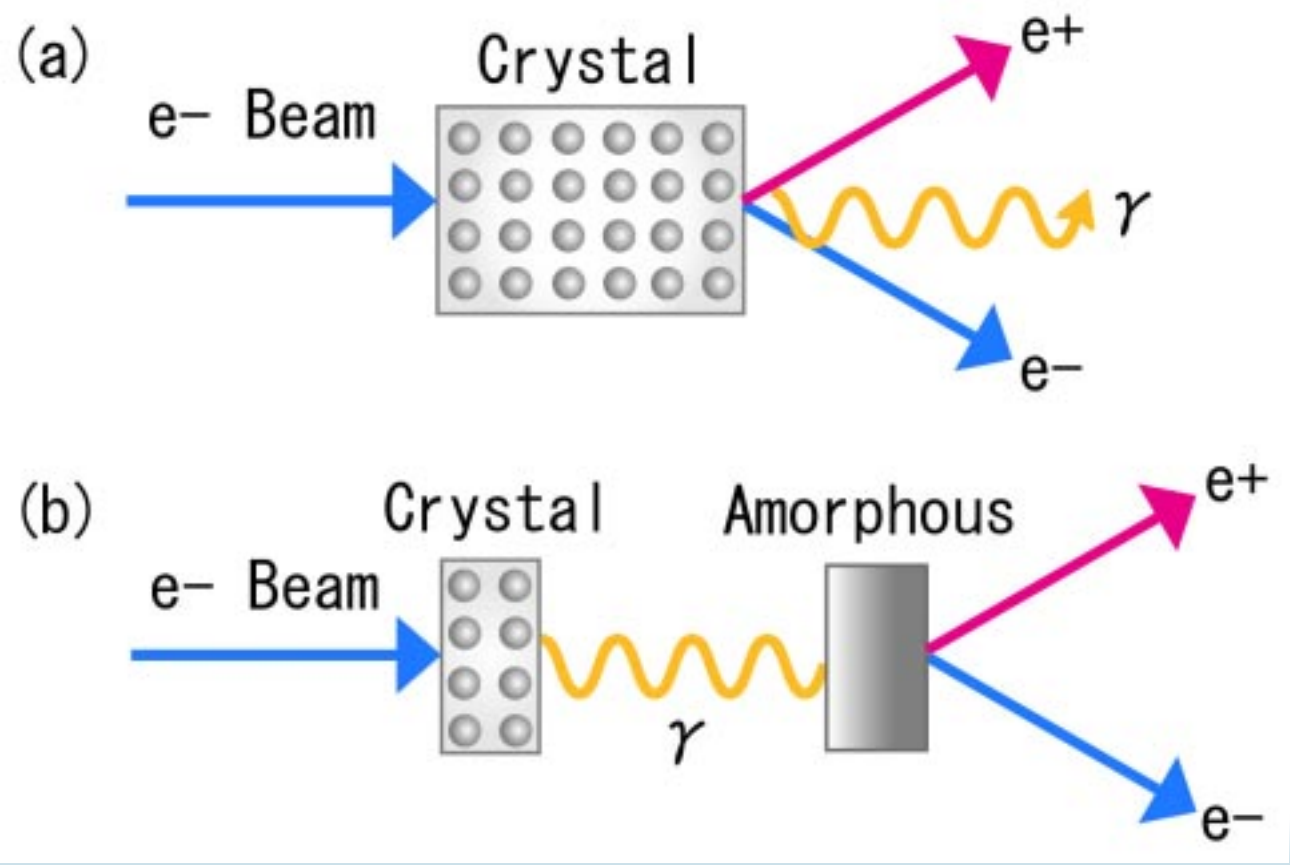
$\sim 0.43\text{mrad}@E_b=8GeV$

U_0:**Potential Energy of a Channel**

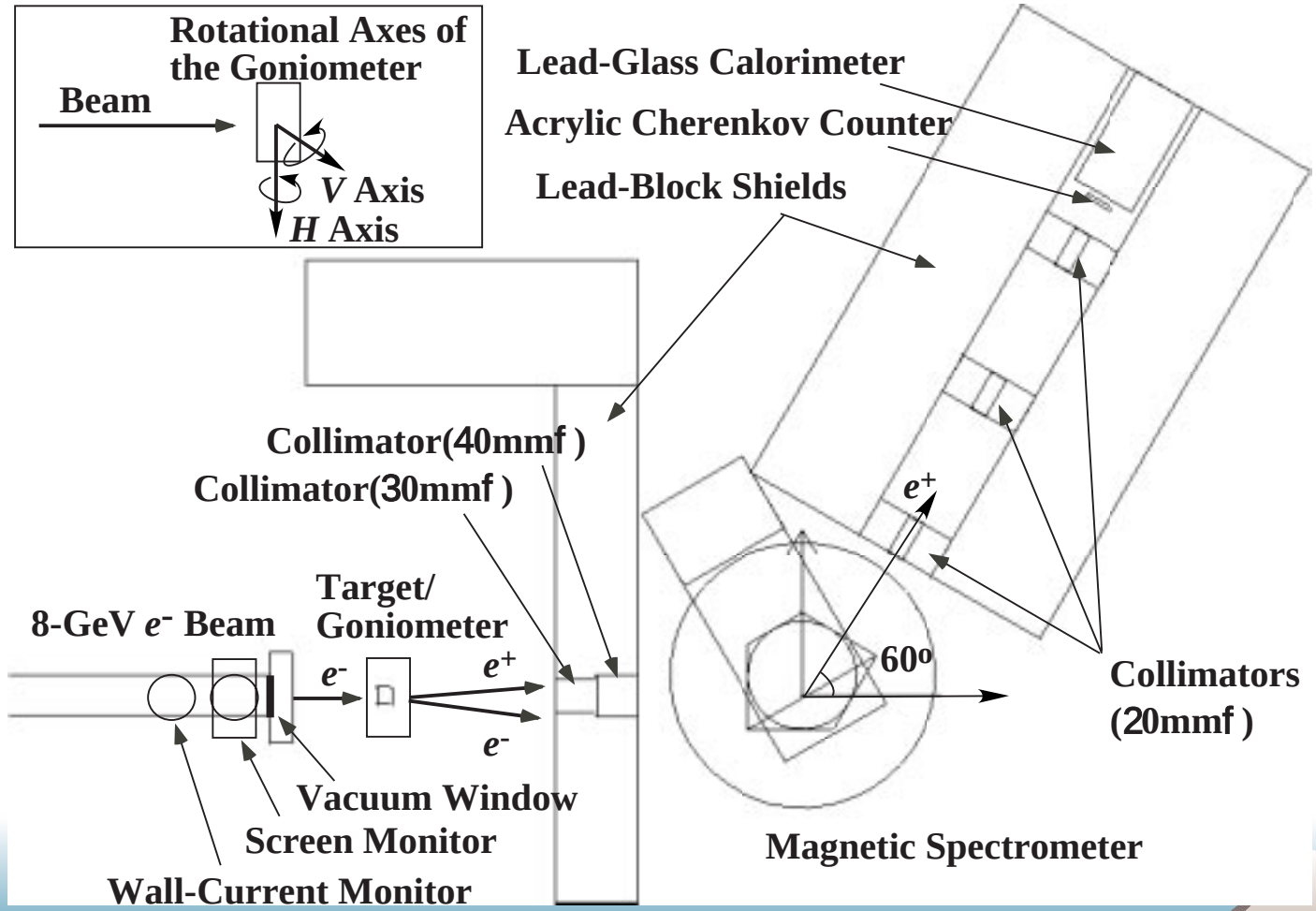
E_b:**Beam Energy**



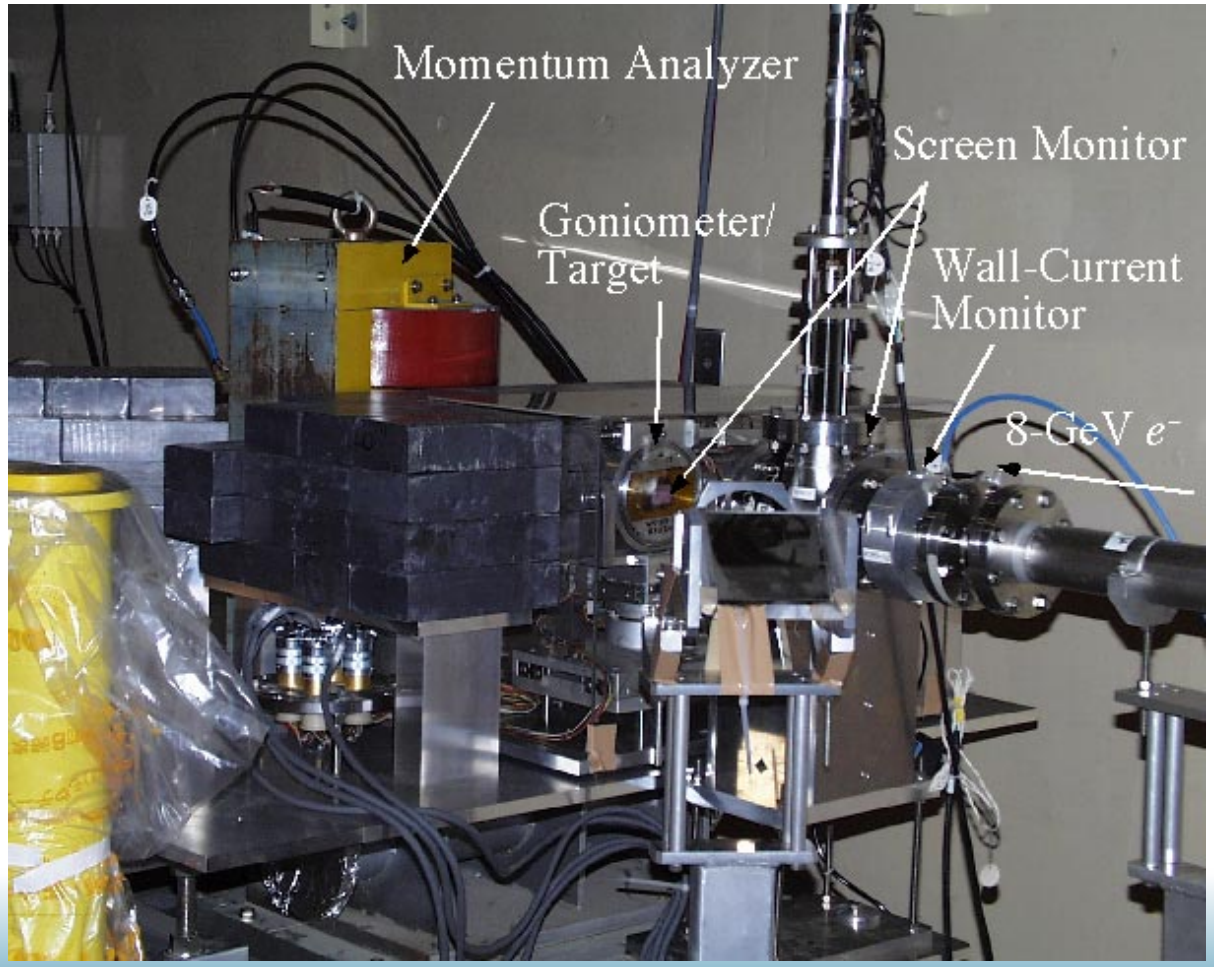
New Positron Production Scheme



Experimental Setup



Linac Beam Line & Experimental Setup



Experimental Condition

Electron Beam:

- Beam Energy = 8 GeV
- Angular Spread ~72 mrad (Horizontal), ~15 mrad (Vertical)
- Transverse Beam Size ~1 mm (FWHM) in diameter
- Beam Charge = 0.2 nC/bunch
- Bunch Length (Single Bunch) ~10 ps (FWHM)
- Beam Repetition = 2Hz

Angular Spread of the Electron Beam at the Positron Target

- θ ~ 0.1 mrad < θ_c (due to multiple scattering by a vacuum window(100mm-thick SUS))

Critical Angle for the Channeling Condition at the Positron Target

- θ_c ~ 0.43 mrad @8GeV (Linhard Angle)

Experimental Condition (cont.)

Positron-Production Targets:

- Crystal Tungsten Target : 2.2mm and 9mm thickness
- Amorphous Tungsten Target : 2mm and 4mm thick (for the purpose of hybrid targets)
- Amorphous Tungsten Target: 3-18mm (3mm step) thickness (for the e^+ production yield calibration)

Detected Momentum Range

- Pe^+ <30 MeV/c

Positron Detectors

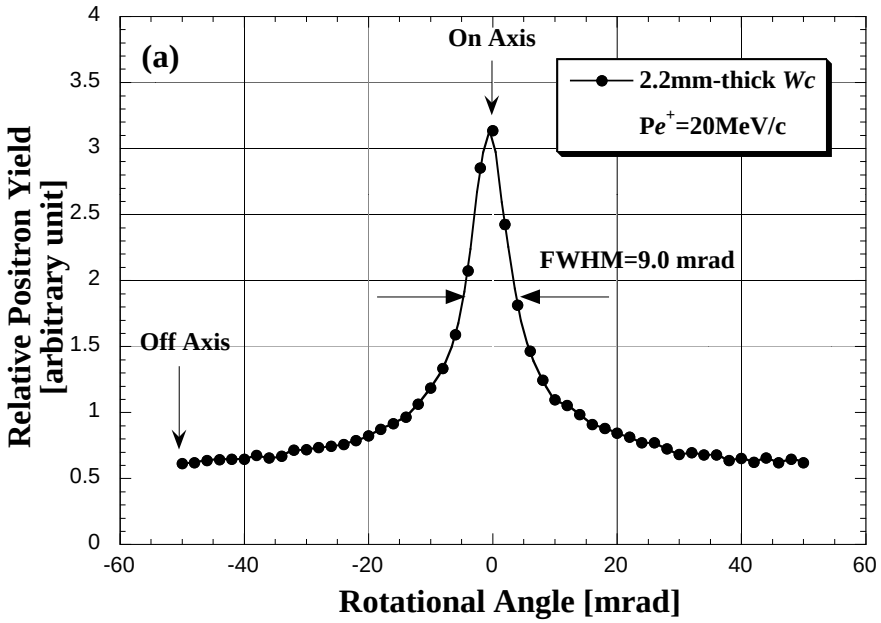
- *Lead-Glass Calorimeter* and *Acrylic Cherenkov Counter*

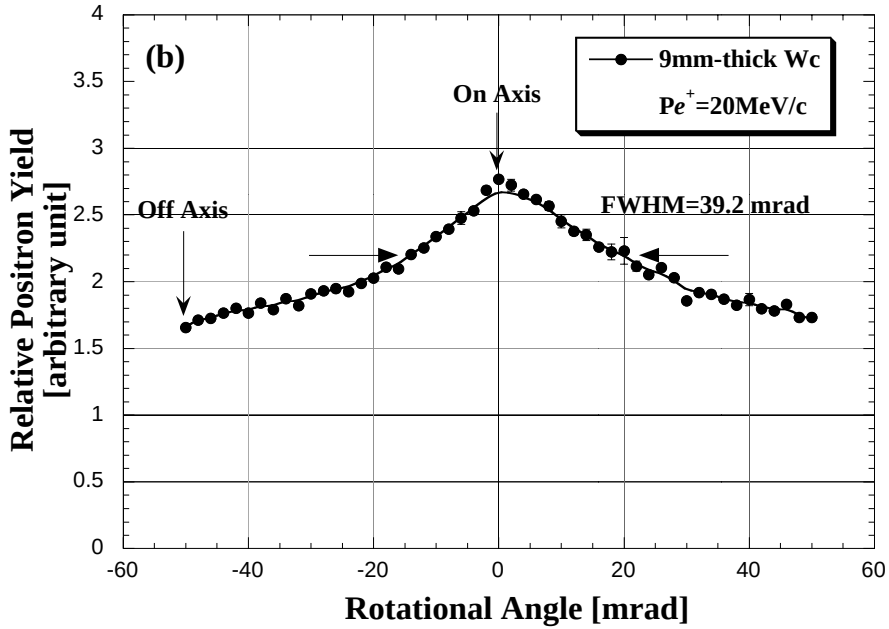
Beam Monitors

- *Wall-current monitor* for the beam-charge measurement

and *screen monitor* for the beam-profile measurement

Experimental Results: Rocking Curves (Crystal Axis <111>) for 2.2mmt and 9mmt Wcs

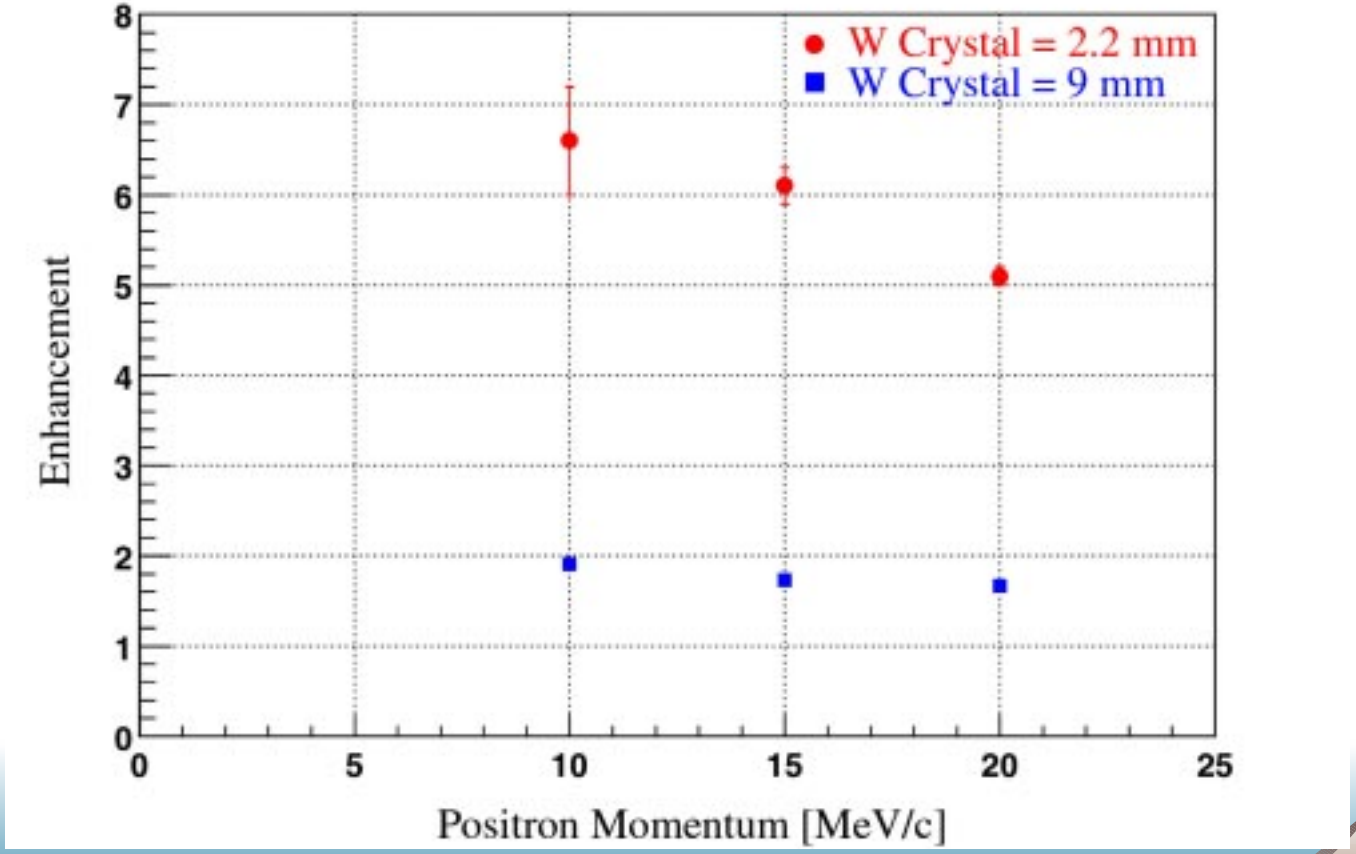




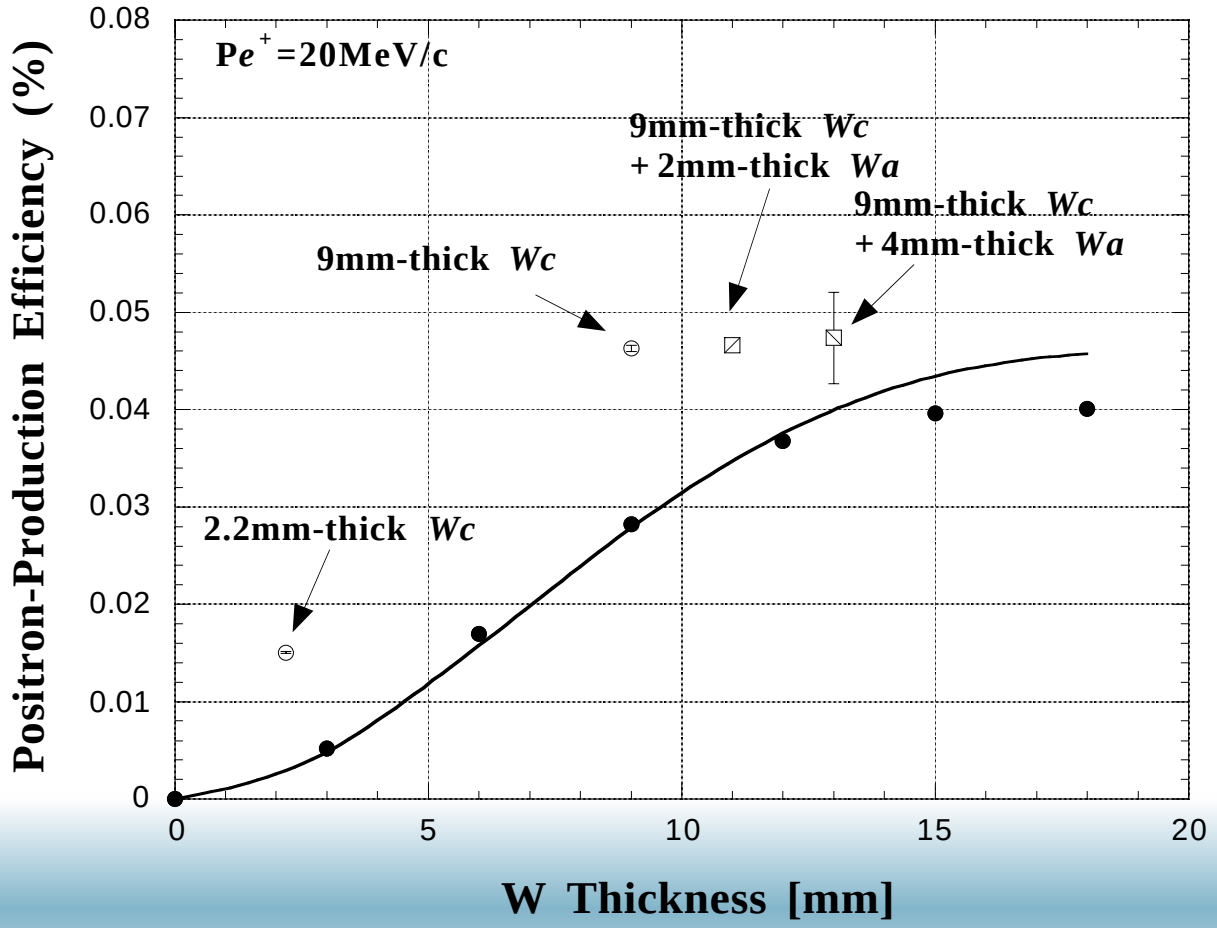
Experimental Results: Momentum dependence of the Positron-Yield Enhancement (=$PY_{on\text{-}axis}$/ $PY_{off\text{-}axis}$)

Momentum [MeV/c]	**Enhancement** (2.2mm W_c)	**Enhancement** (9mm W_c)
10	6.6 ± 0.1	1.9 ± 0.1
15	6.1 ± 0.1	1.7 ± 0.1
20	5.1 ± 0.1	1.7 ± 0.1

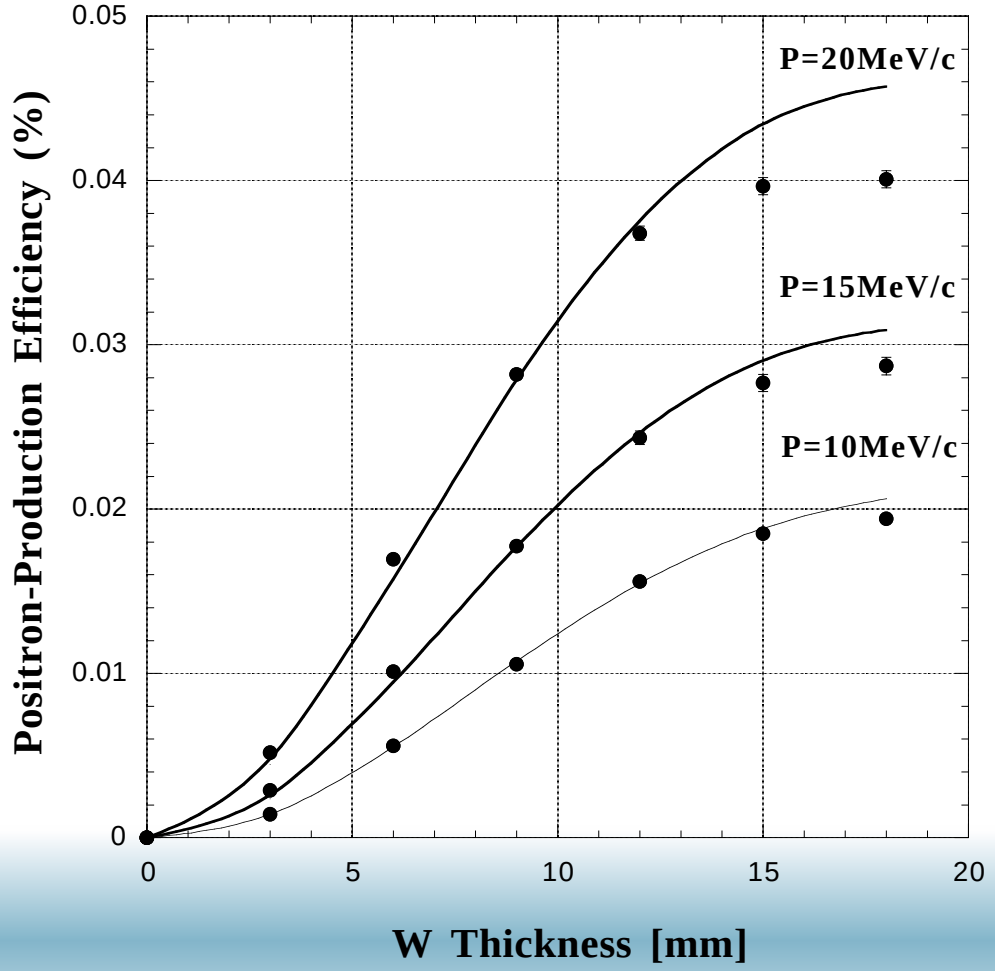
Experimental Results: Momentum dependence of the Positron-Yield Enhancement (=$PY_{on\text{-}axis}$/ $PY_{off\text{-}axis}$)



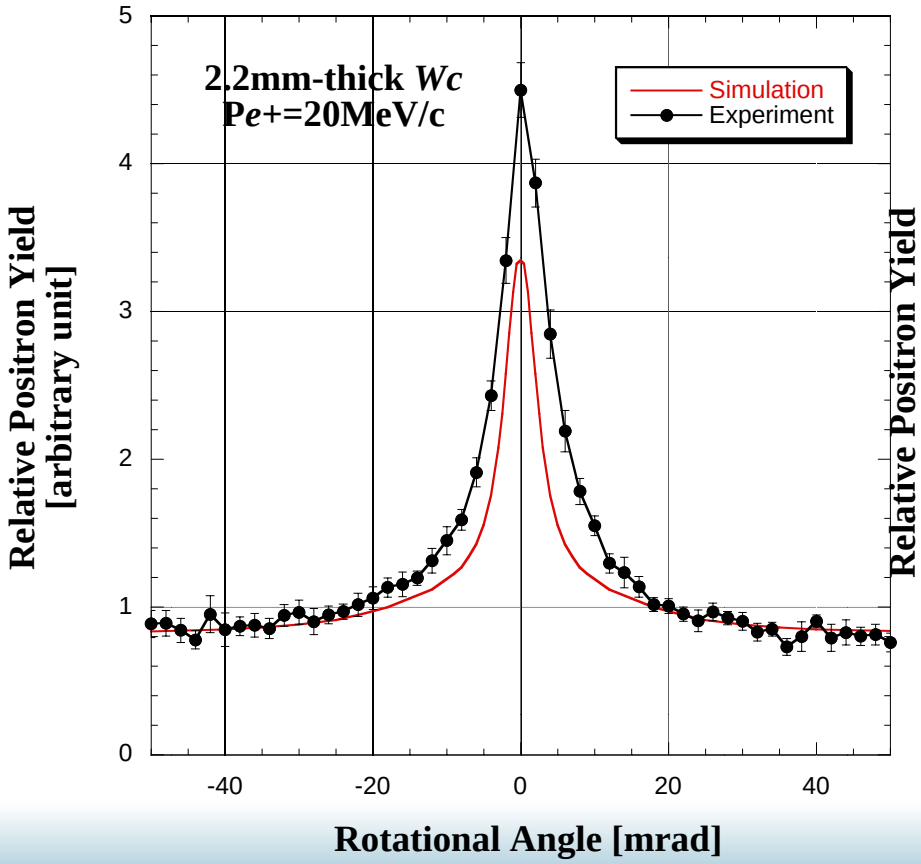
Experimental Results: Positron Yields vs. Target Thickness

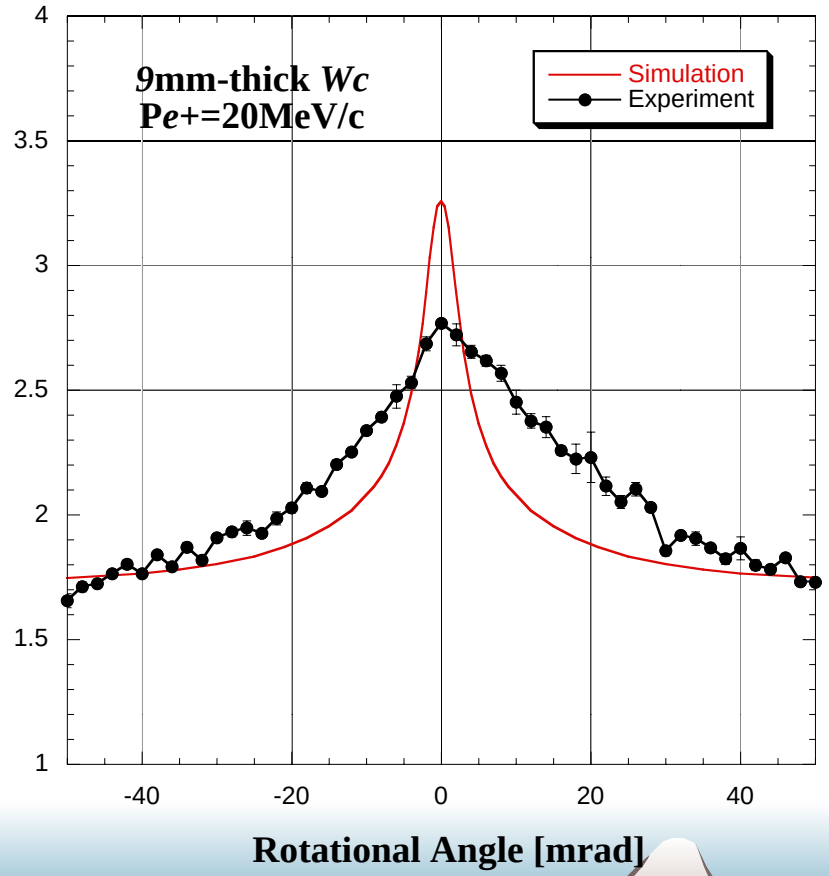


Experimental Results: Simulation check for amorphous W targets using the EGS4 code



Experimental Results: Experiment vs. Simulation





Conclusions

- ***Positron production experiment has been successfully performed at the KEKB 8-GeV electron linac.***
- ***Enhancement (En) and momentum dependence of the e^+ yield from 8-GeV channeling electrons***
  - *En*=5.1 ±0.1 (2.2mmt W_c), 1.7 ±0.1 (9mmt W_c)@Pe^+=20MeV/c
  - the enhancement decreases as the target thickness increases.
  - the positron yield of the 9mmt crystal *W* is slightly larger than that of a 15mmt amorphous *W*.
  - the result of the momentum dependence indicates that as the momentum becomes low, the enhancement is getting larger.
- ***The present simulation results can not agree with the experiment. More sophisticated simulation code is under development.***