Experiment of Positron Production with W Single Crystal
(Preliminary Results)

Kazuro Furukawa, KEK
<kazuro.furukawa@kek.jp>
for
Collaboration group of
S.Anami, A.Enomoto, K.Furukawa, K.Kakihara, T.Kamitani,
H.Okuno, Y.Ogawa, A.Ohsawa, T.Oogoe, T.Suwada [KEK],
R.Hamatsu, K.Sasahara [Tokyo Metro. Univ.],
T.Fujita, K.Umemori, K.Yoshida [Hiroshima Univ.],
V.Ababiy, A.P.Potylitsin, I.E.Vnukov [Tomsk Polytech.]

<URL:http://www-linac.kek.jp/chan-pos/>

Positron Generation

- To Get Higher Yield --- Thicker Target
  but Broader Momentum Spectrum
  --- Lower Capture Efficiency
  --- Higher Focusing Magnetic Field / Accelerating Field
  --- Discharge Issues, etc

for Linear Colliders

- Higher Incident Energy and thus Higher Positron Yield
- However, Higher Repetition and Larger Number of Bunches
  Heating Issues, There are Many Ideas, but ...
- Also Optimization of Thickness and Post Acceleration

Beam Induced Light

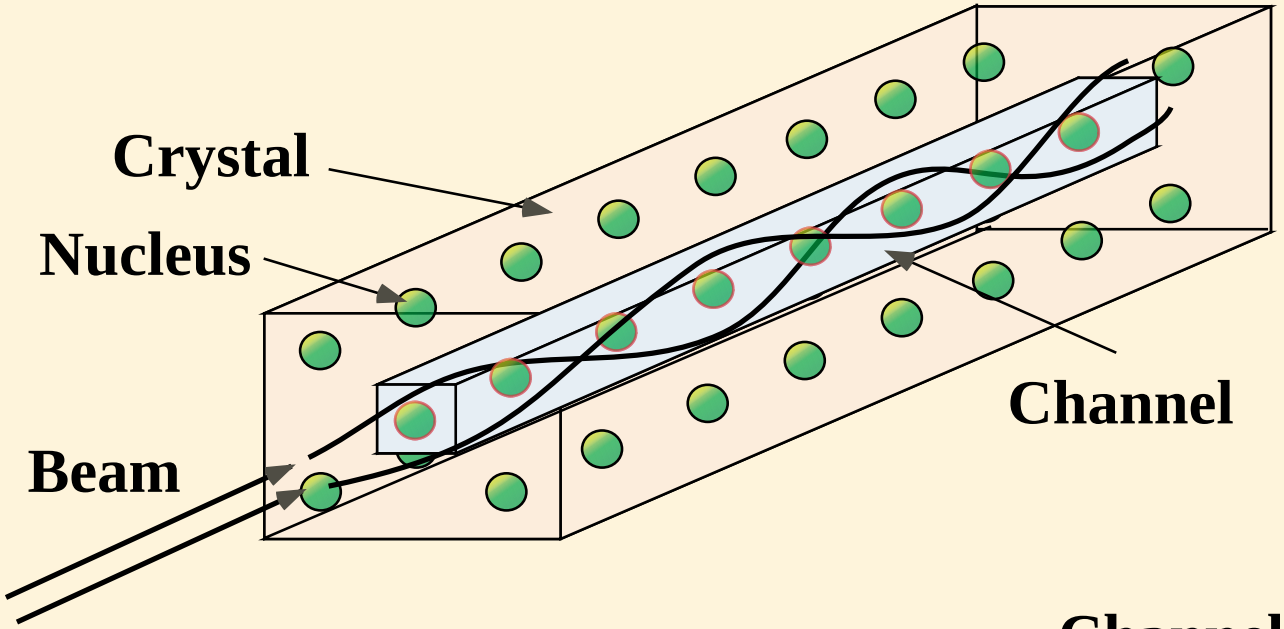
- Bremsstrahlung
- Channeling Radiation
- Cerenkov Radiation
- Optical Transition Radiation (OTR), (ODR)
- Synchrotron Orbit Radiation (SOR)
- Coherent Bremsstrahlung
- etc.

They are used for Beam Instrumentations, etc.

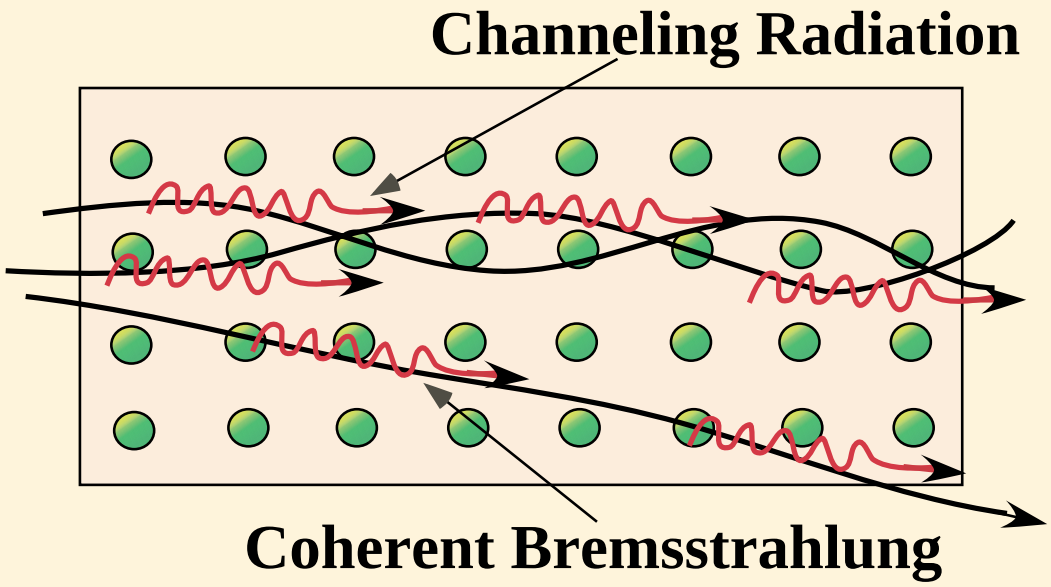
Positron Generation Enhancement by Channeling Radiation and Coherent Bremsstrahlung Using Single Crystal (Tungsten or Tantalum)

- Suggested by R. Chehab et al, (LAL) 1989
- Technical Issues -- Vacuum, Cooling (because of Goniometer)
- Thick Crystal Production
- Thickness Dependence
- Incident Energy Dependence
- Mosaicity
- Instant and Integrated Radiation Hardness of Crystal
- Crystal / Amorphous Combination Ratio
- Simulation Code Development for Positron Generator Design

Channeling and Coherent Bremsstrahlung



- In single crystal these two phenomena enhance e.m. shower then positron yields



Beam Experiment in Japan

- INS ES 1GeV (-1999)
- KEK Linac 3-GeV Experiment (1998)
  Enhancement Confirmation
- KEK Linac 8-GeV Experiment (2000-)
  More Quantitative Considerations

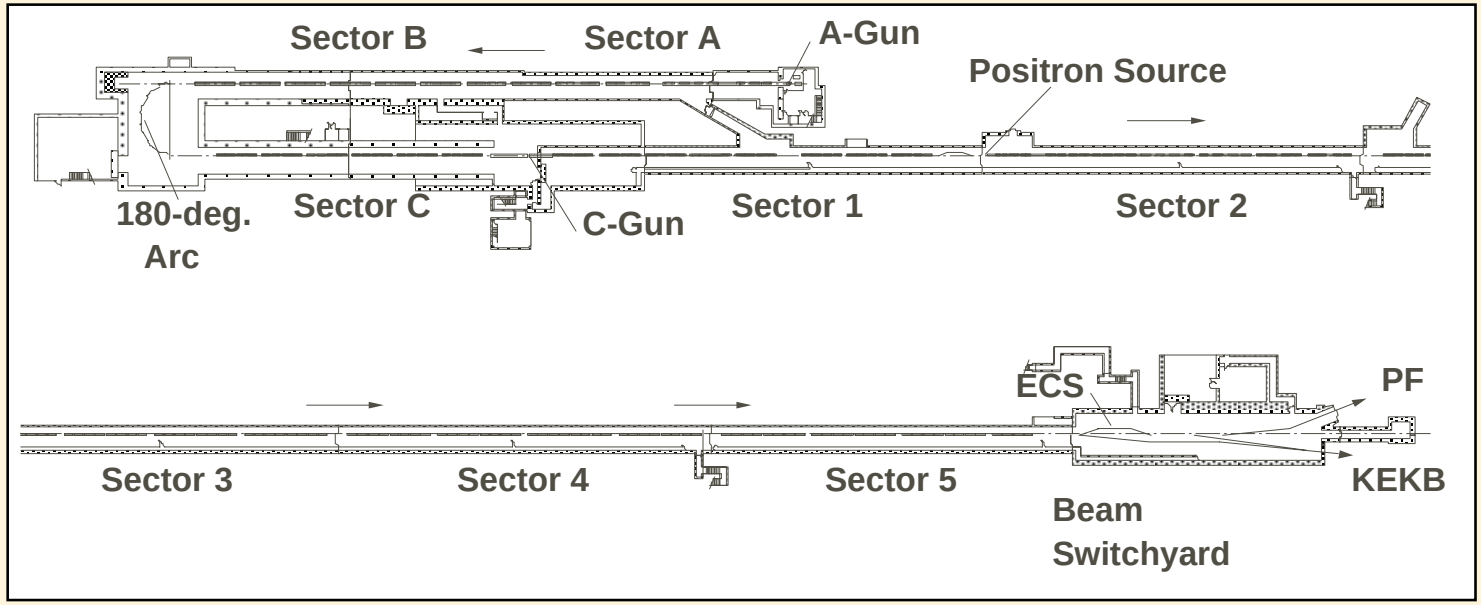
Collaboration

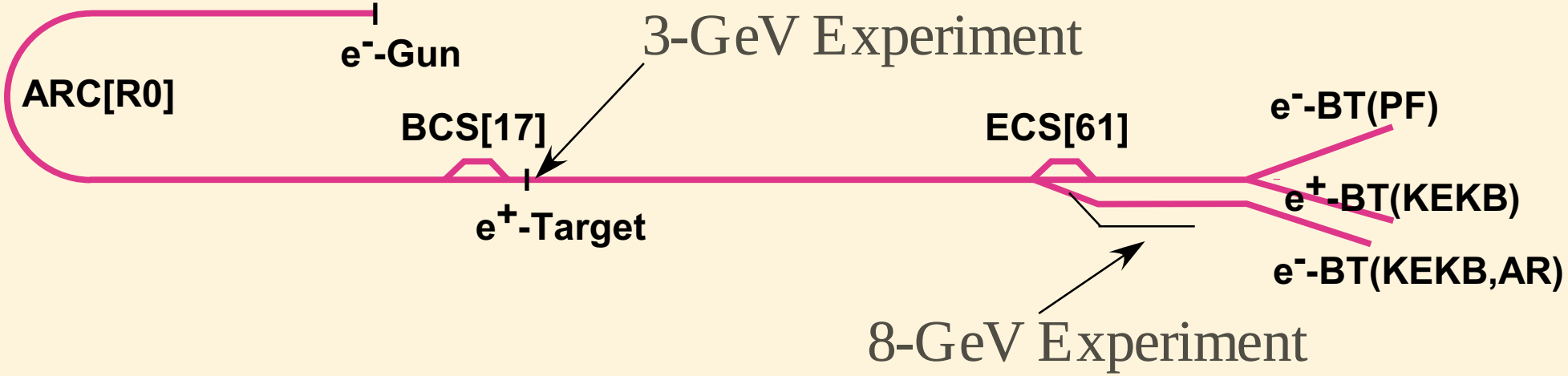
Tomsk Polytech. --- Crystal Production, Simulation Code

Tokyo Metro. Univ., Hiroshima Univ., KEK

Beam Line Construction, Detector Design, Simulation

Experiment Stations

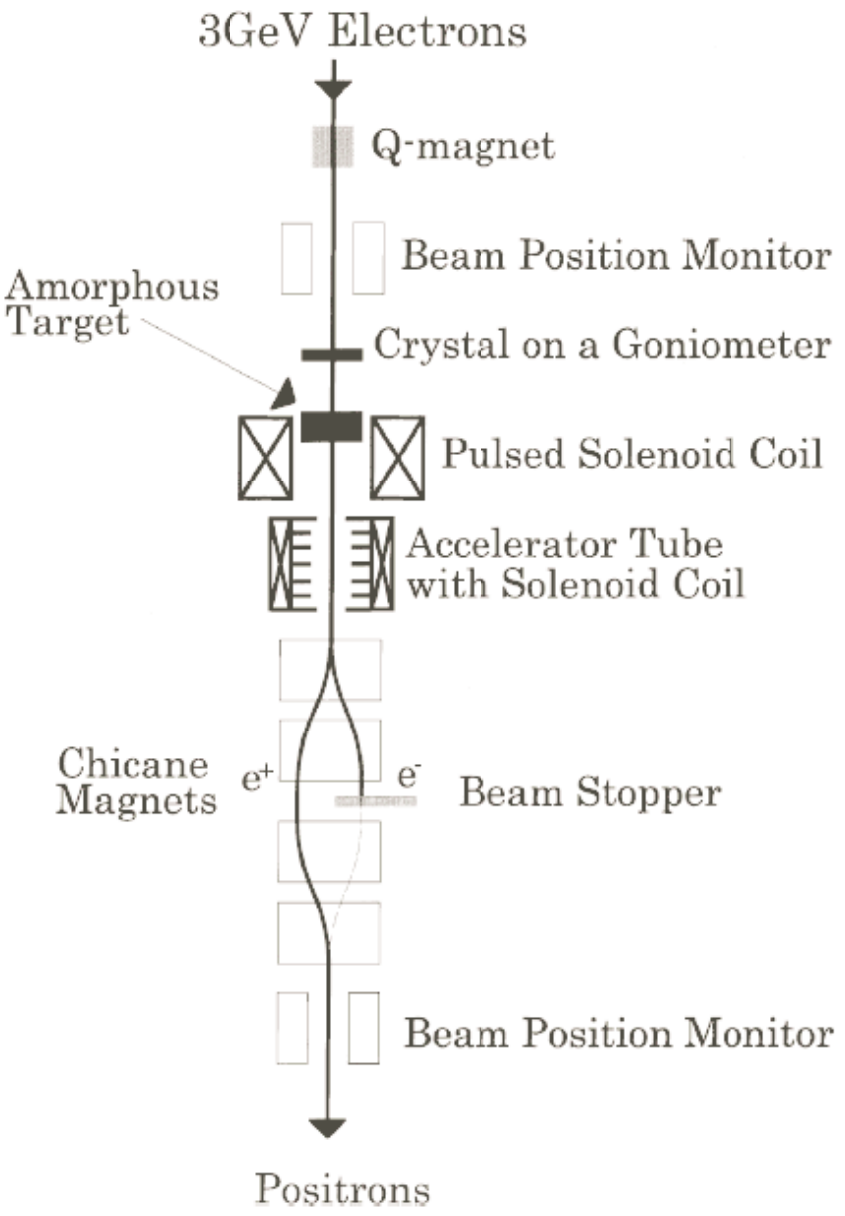


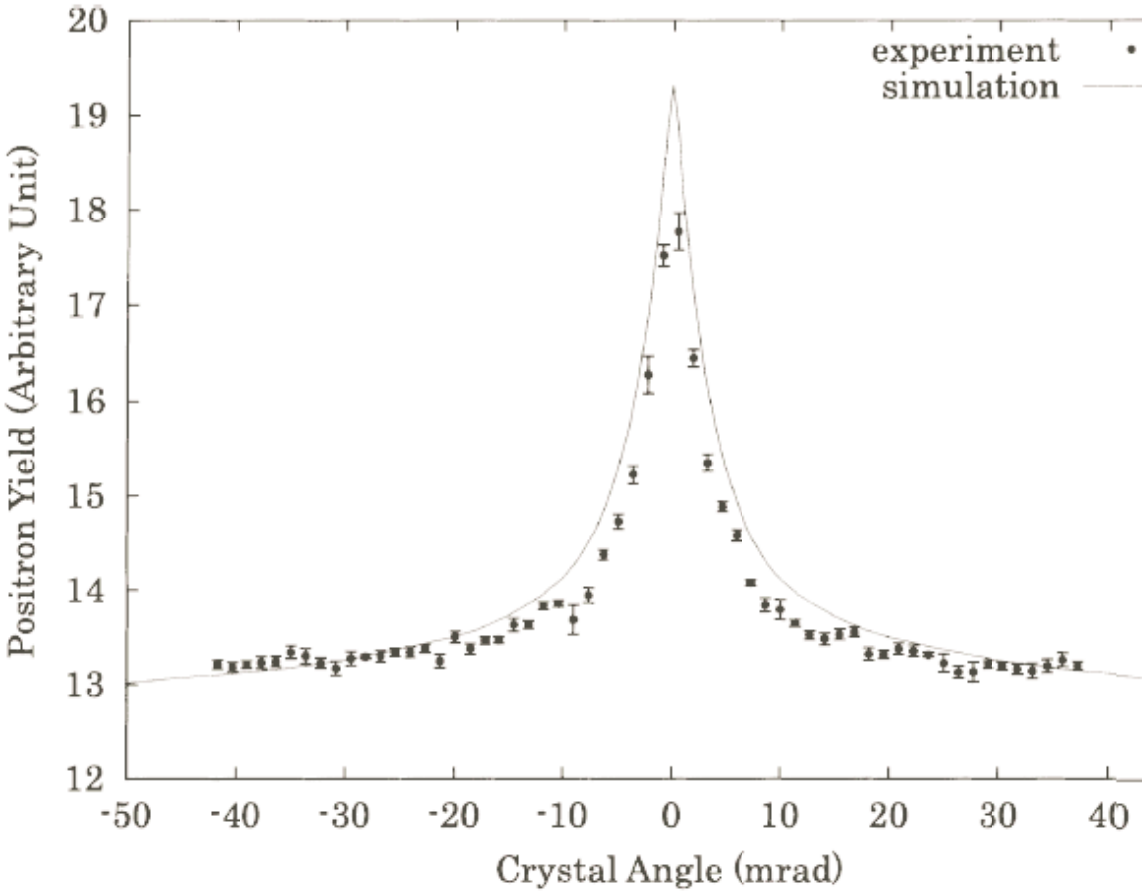


3-GeV Experiment at KEK Linac

- Enhancement Measurement (1999)
  with 3-GeV 6nC 10ps Beam
- 0.5 Radiation Length (r.l.) Crystal
  + 2.0 r.l. Amorphous (r.l. = 3.4mm for Tungsten)
  Measured x1.4 Enhancement
- No Short-bunch Radiation/Heating Degradation Observed
- Goniometer Radiation Hardness and Vacuum Issues

3-GeV Experiment Apparatus





FWHM~6.9mrad is much Larger than Channeling-only Lindhard Angle (0.7) thus Coherent Brems. and Mosaicity

8-GeV Experiment at KEK Linac

- Analyzer Line at the End of Linac

  No Interference against KEKB, PF, PFAR Operation

- 8-GeV 0.2nC (~1×10^9) 10ps

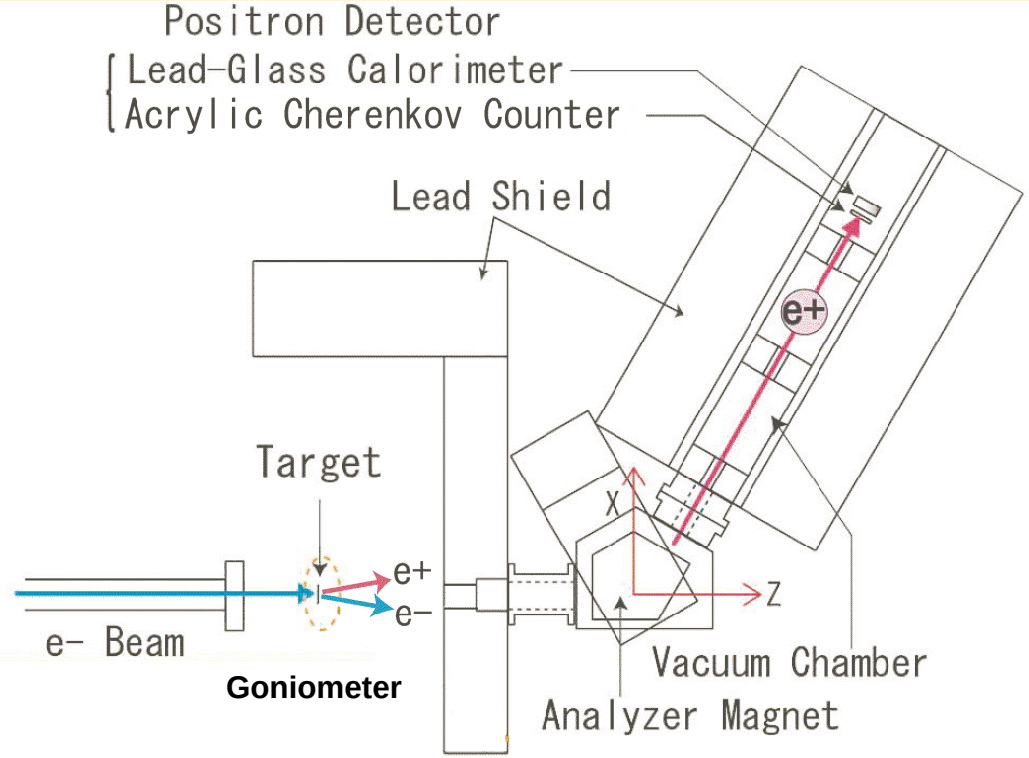
- 2.2mm (=0.63 Radiation Length (r.l.)) Crystal

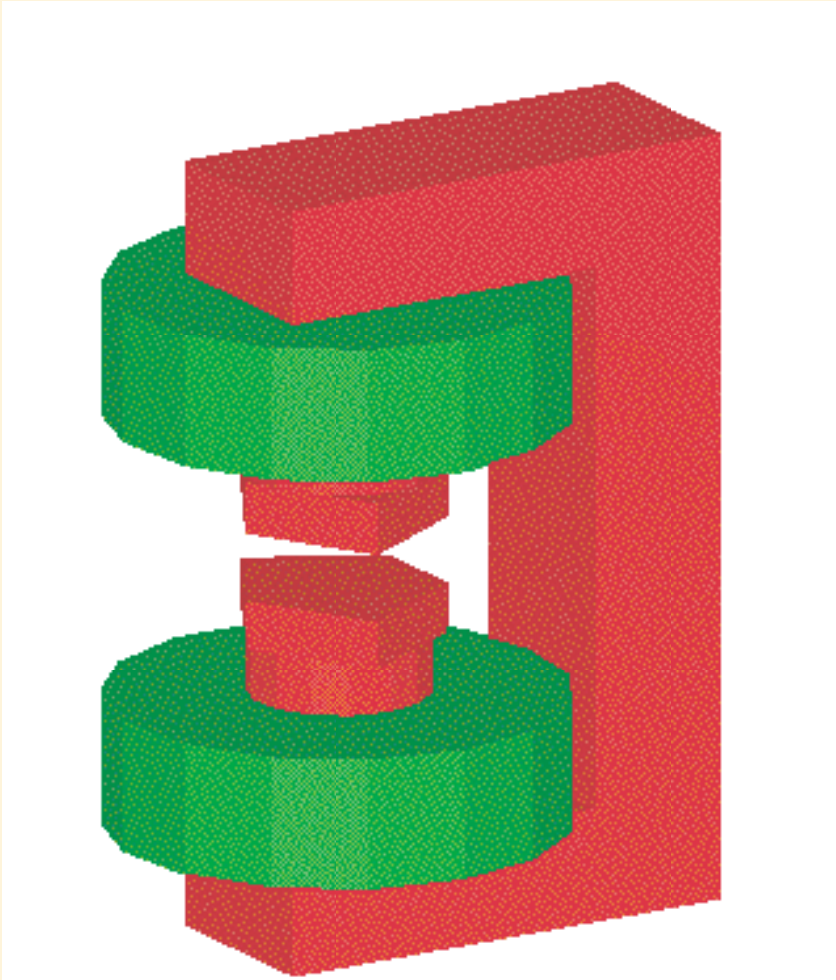
  (r.l. = 3.4mm for Tungsten)

  Then 5.3mm, 9.0mm Thick Crystal

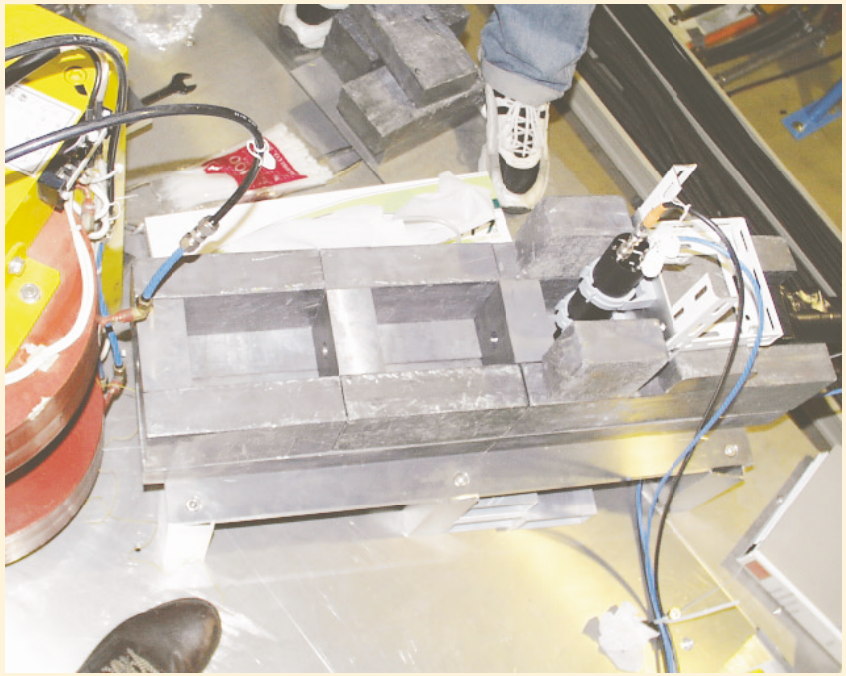
  Measured Enhancement

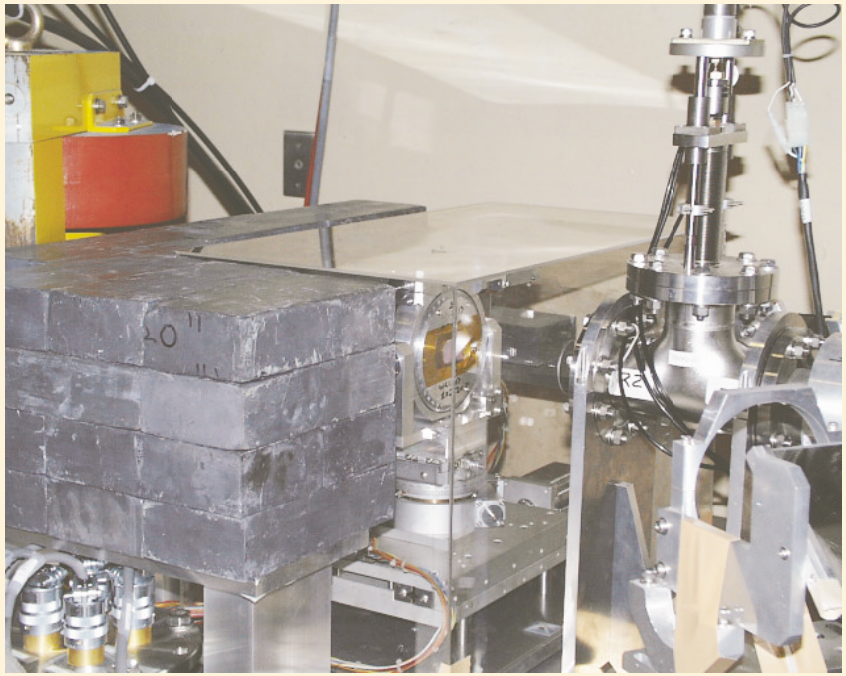
8-GeV Experiment Apparatus

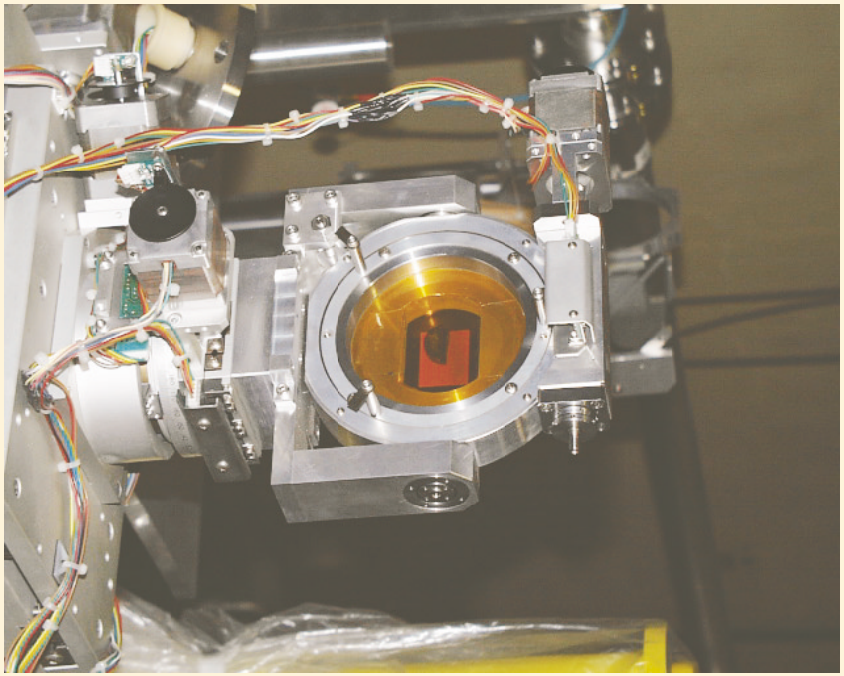


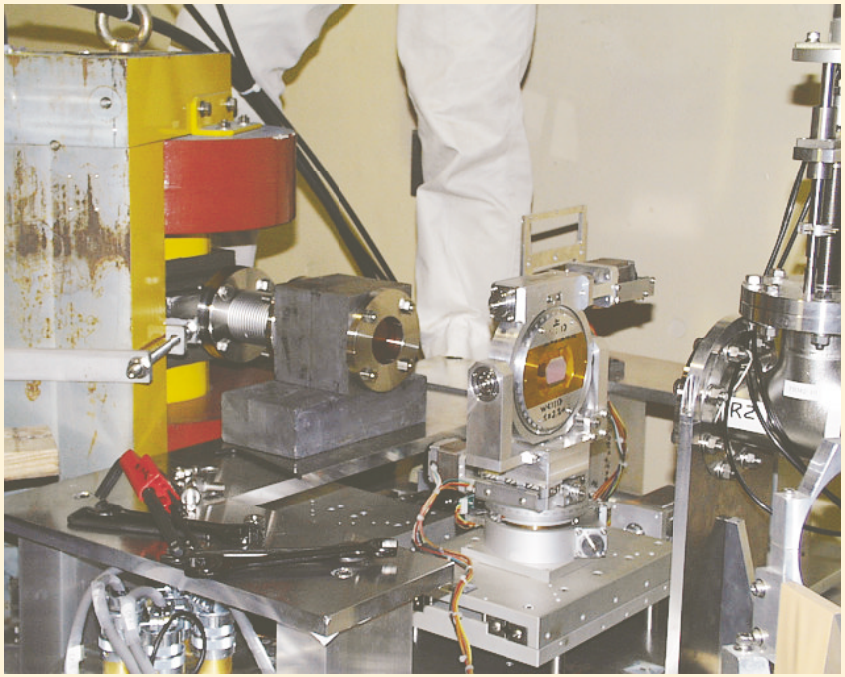


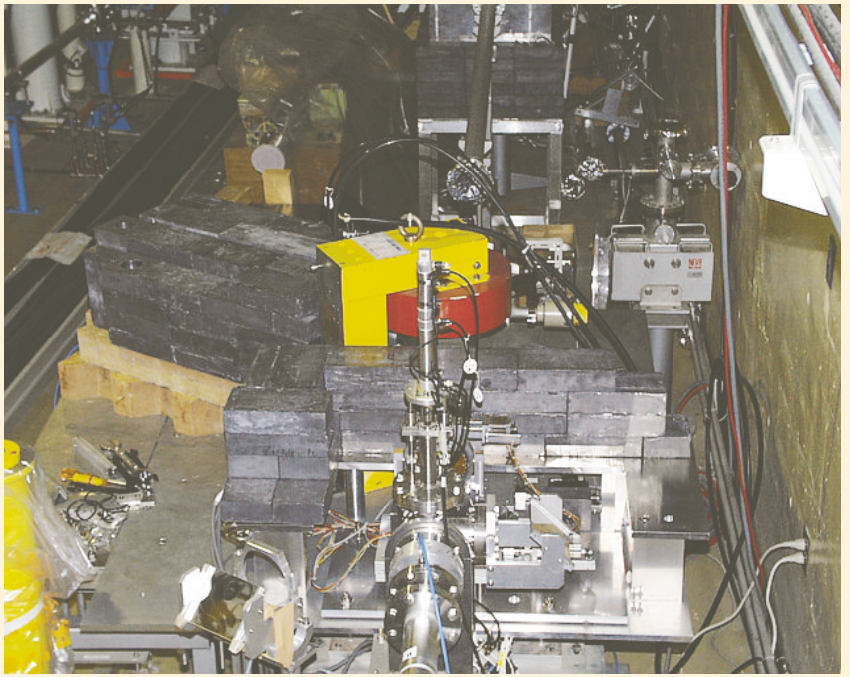
Goniometer
Lucite Cerenkov Counter
Lead Glass Cerenkov Counter

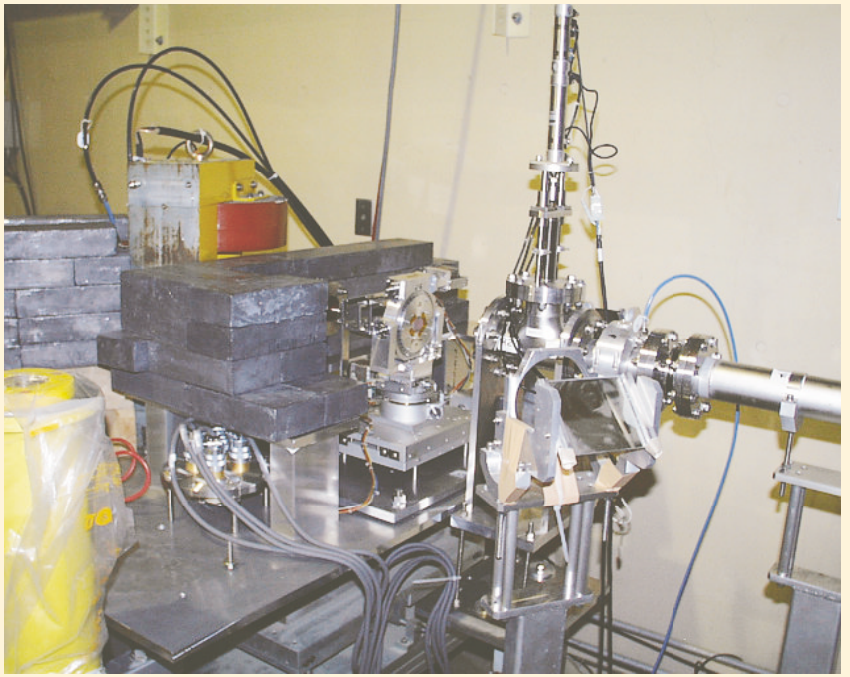










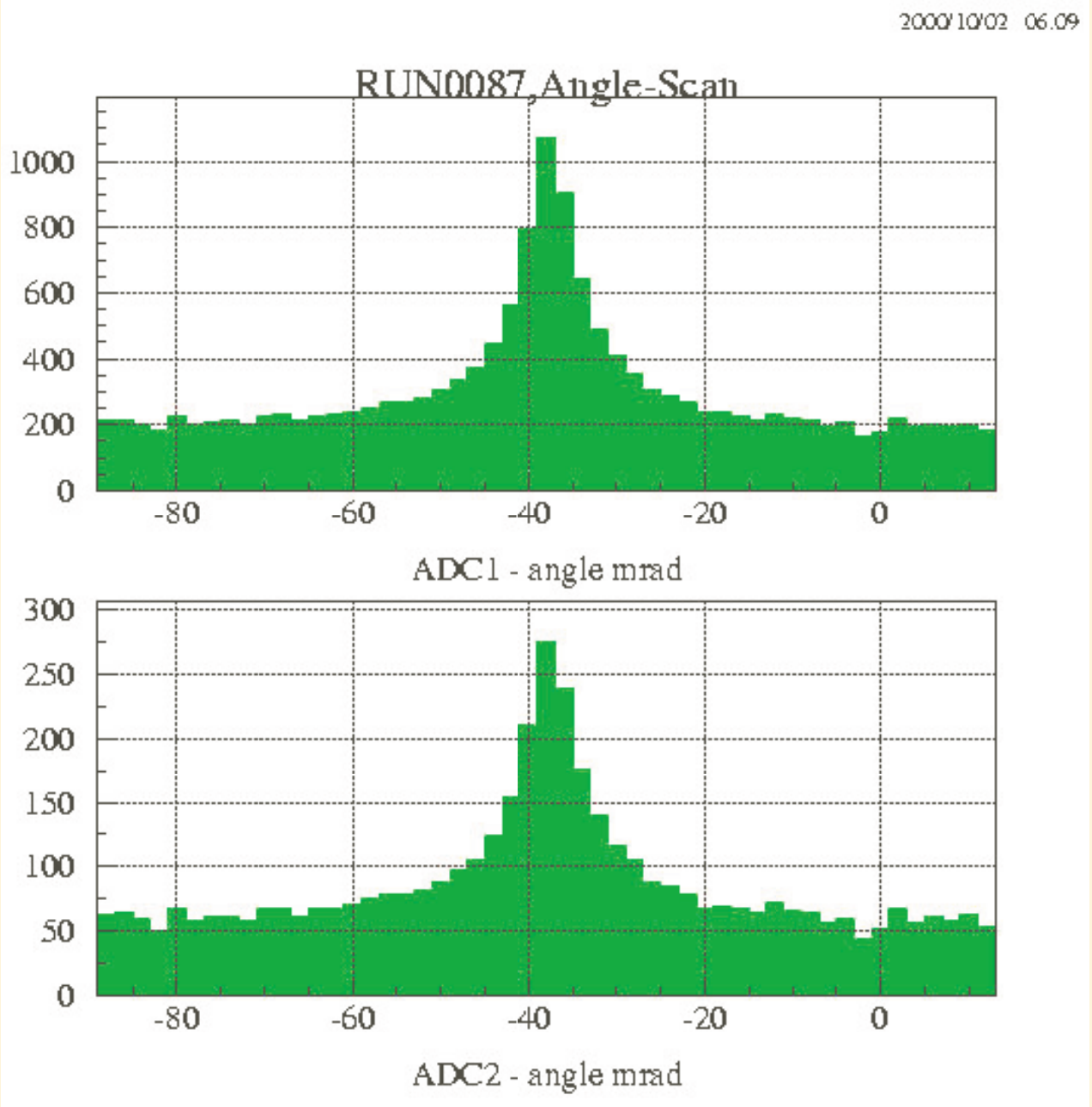


Thin Target Scan

0.63 r.l. (2.2mm) Crystal
without Amorphous
x5 Enhancement
(for 20MeV e+)

upper: Lucite
lower: Lead Glass

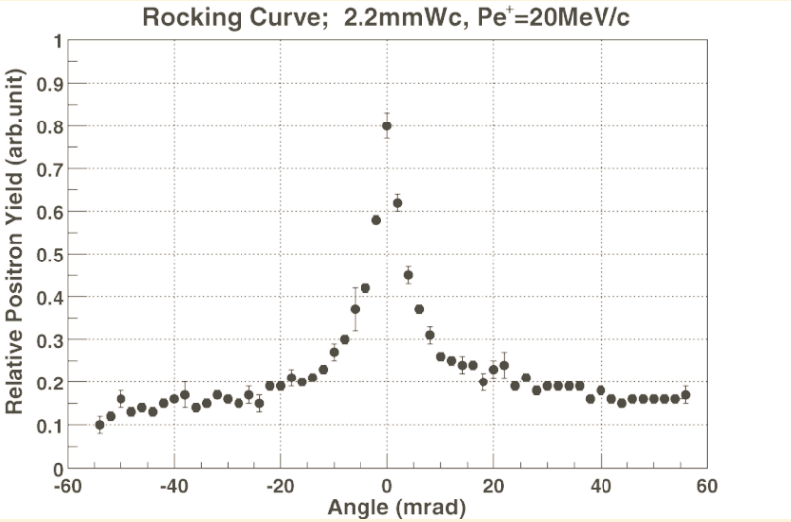
~9mrad FWHM
Mostly Coherent Brems.

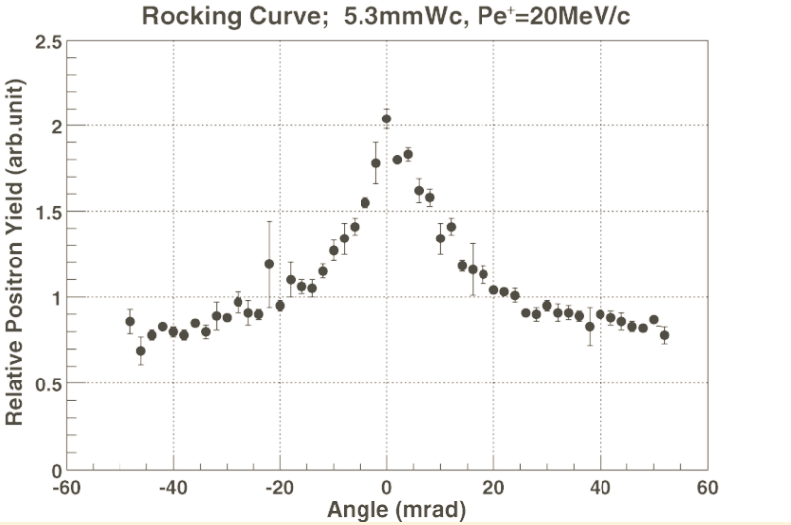


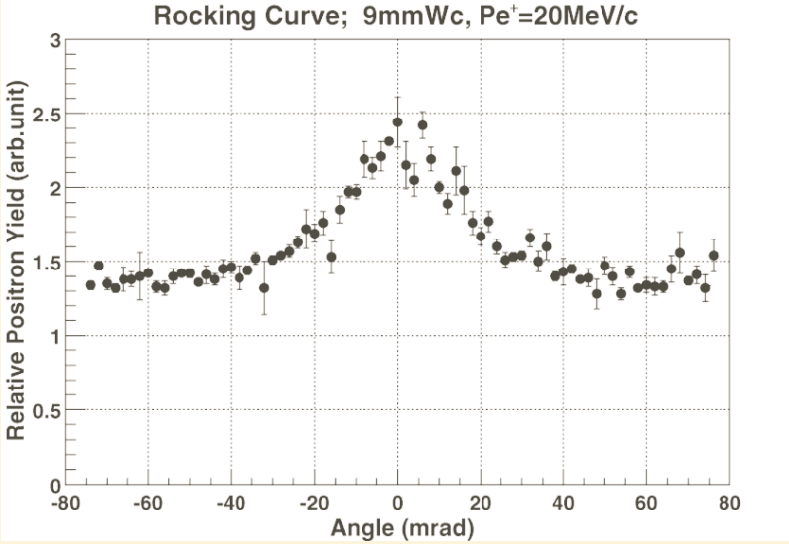
Analysis

- ADC Linearity Study
  - Small Dynamic Range, Need Careful Gain Control
- Background Analysis
  - Beam Hitting Upstream Ducts, etc
  - Lead Shield was Good
- Positron Energy Dependence was Measured
  - but Positron Loss in Air was not Negligible
  - Lower Energy e+ Showed Larger Enhancement
- Thickness (Amorphous) Dependence
- Crystal Mosaicity Measured with Position Scan of Target

Rocking Curves



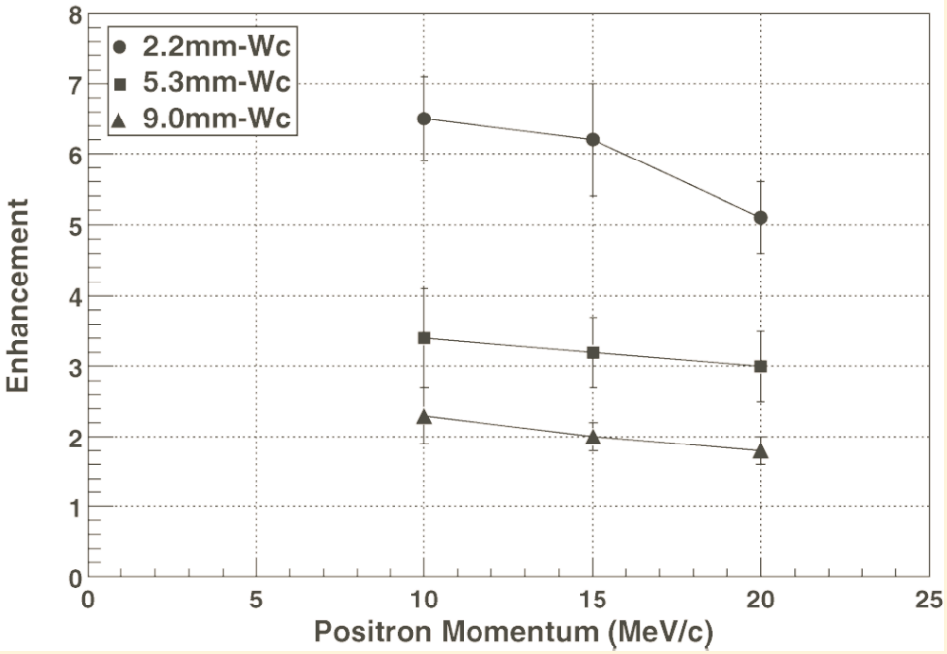




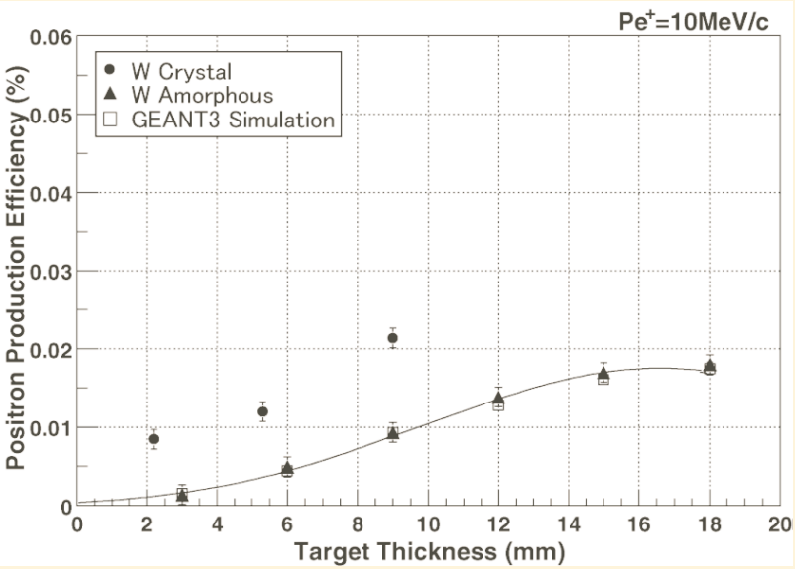
FWHM
~9mrad, ~20mrad, ~39mrad
--> Mostly Coherent Brems.
Need precise sim. codes

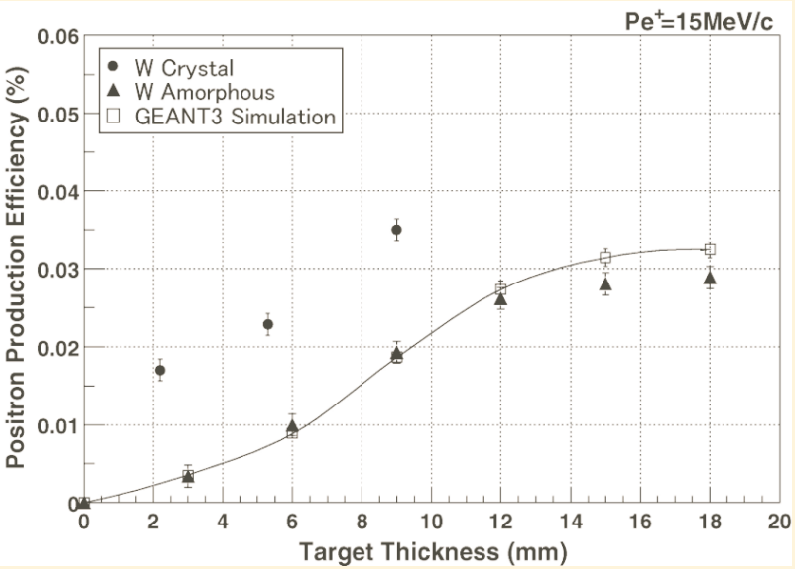
Enhancement Factors

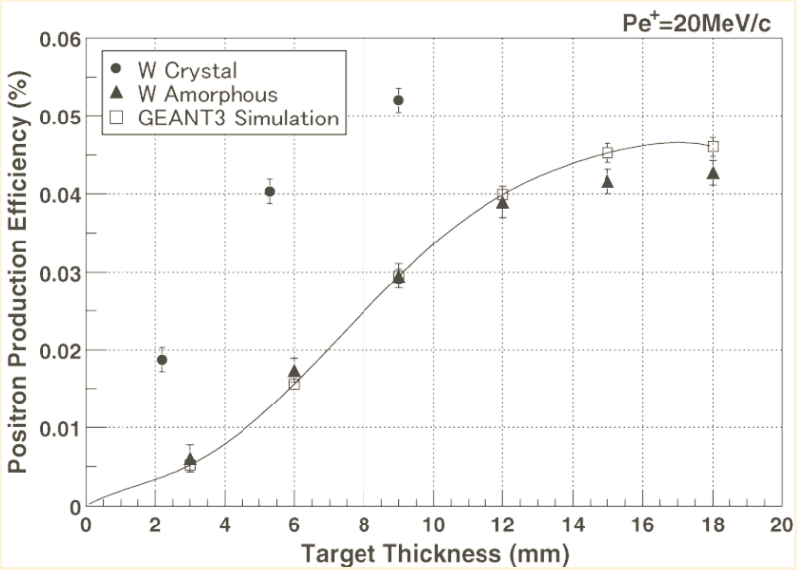
Momentum [MeV/c]	Enhancement (2.2-mm-thick)	Enhancement (5.3-mm-thick)	Enhancement (9.0-mm-thick)
10	6.5±0.6	3.4±0.7	2.3±0.4
15	6.2±0.8	3.2±0.5	2.0±0.2
20	5.1±0.5	3.0±0.5	1.8±0.2



Positron Yields Enhancement







(Preliminary) Conclusion

- The Results will be published in NIM **soon**
- Beam Line and Detector Systems Worked Fine
- With Thin (2.2 mm) and Thick (9mm) Crystal
  5-Times and 1.7-Times Enhancements were Observed
- Yield from 9mm Crystal was Larger than 15-28mm Amorphous
  ---> Lower Heat Deposit at Target
- Thickness and Out-going Energy Dependence
- With Lower Positron Momentum, Higher Enhancement
- Need Good Simulation Code
- Collaboration with Orsay (Chehab san) Group

<URL:http:/ / www-linac.kek.jp/ chan-pos/ >