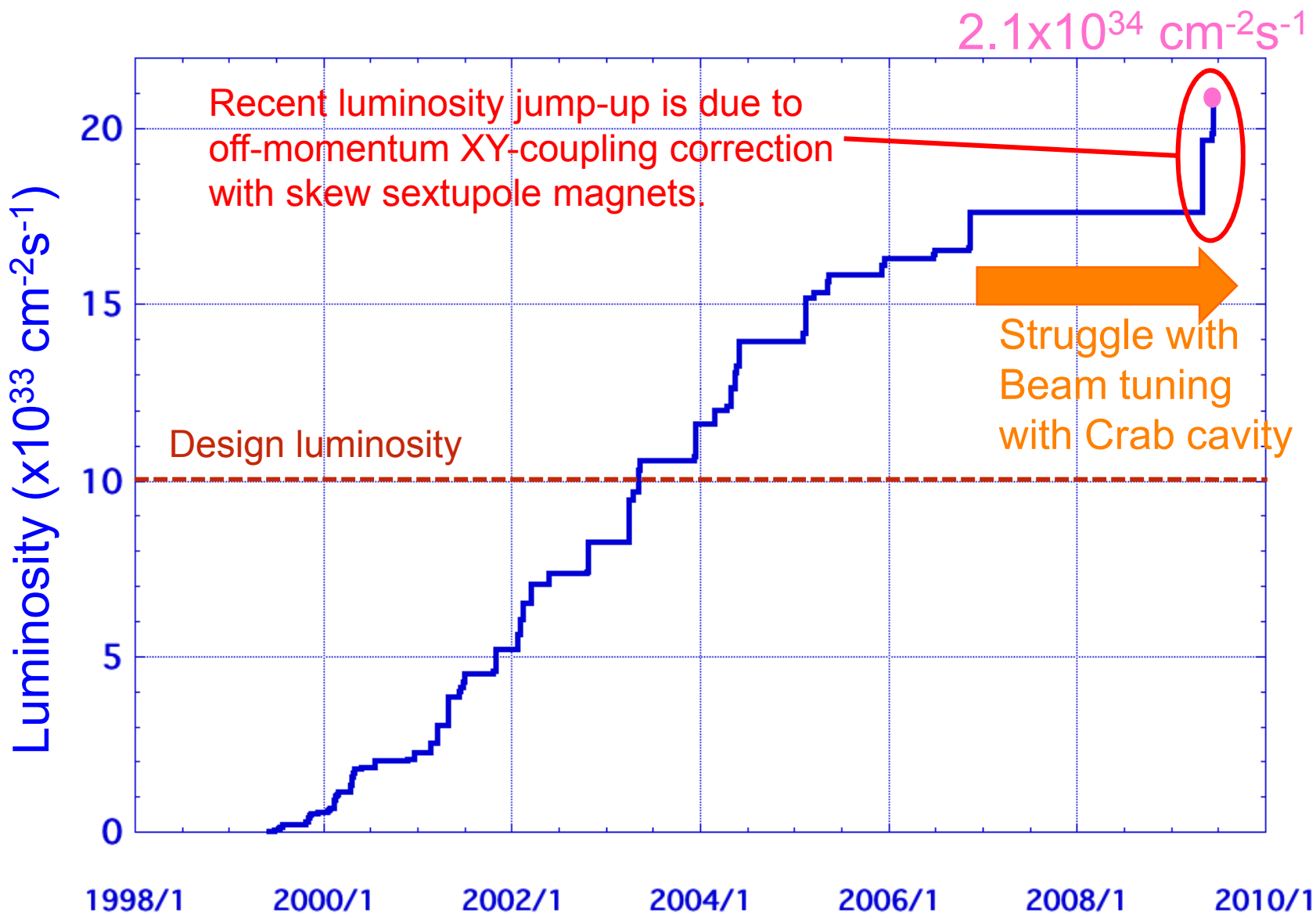
Posipol-2009 (Lyon) 2009.June.26

Flux concentrator R&D for KEKB upgrade (collaboration with BINP)

+ Crystal target break-up issue

Kamitani Takuya

KEKB peak Luminosity trend

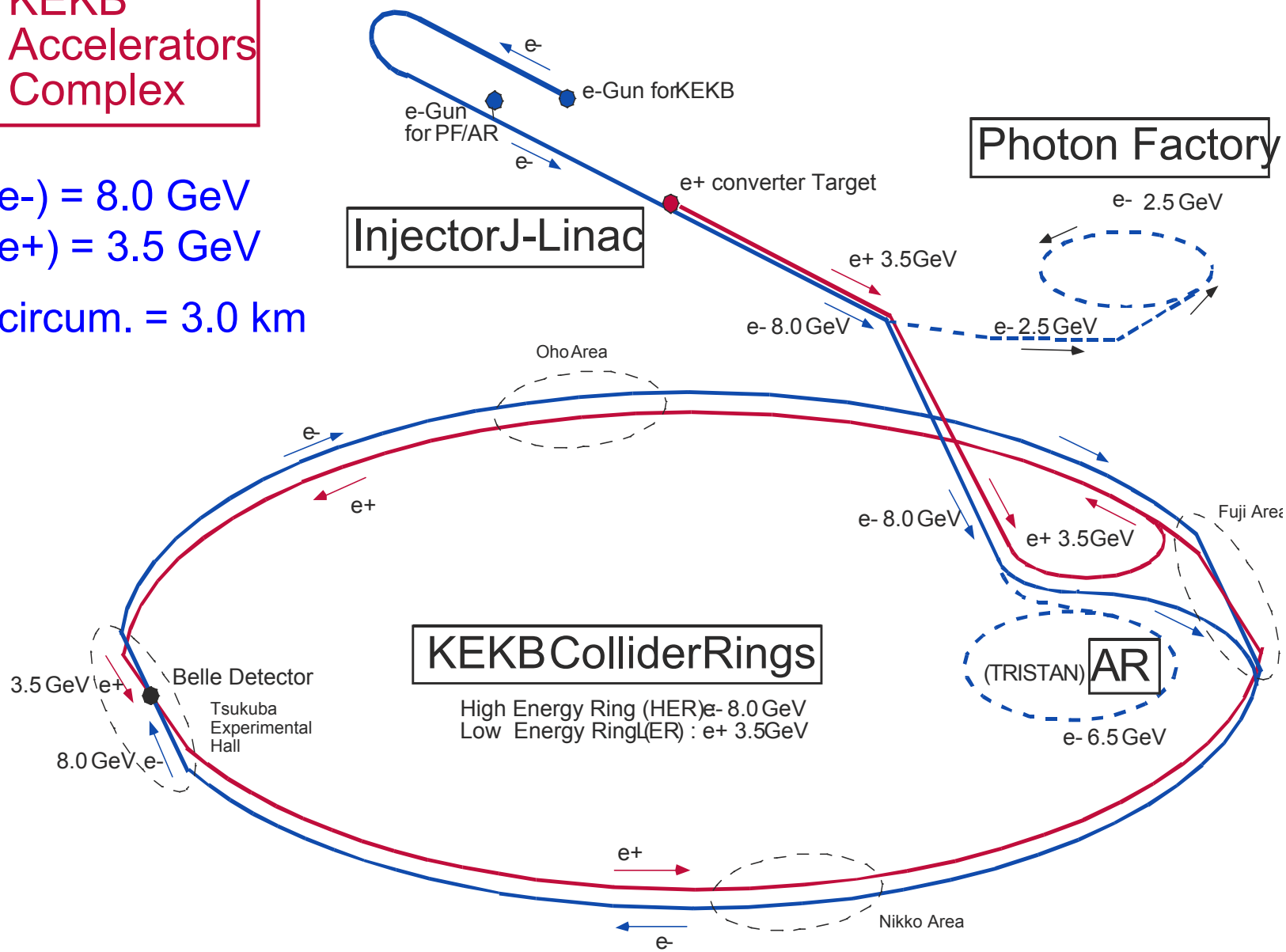


KEK B-factory

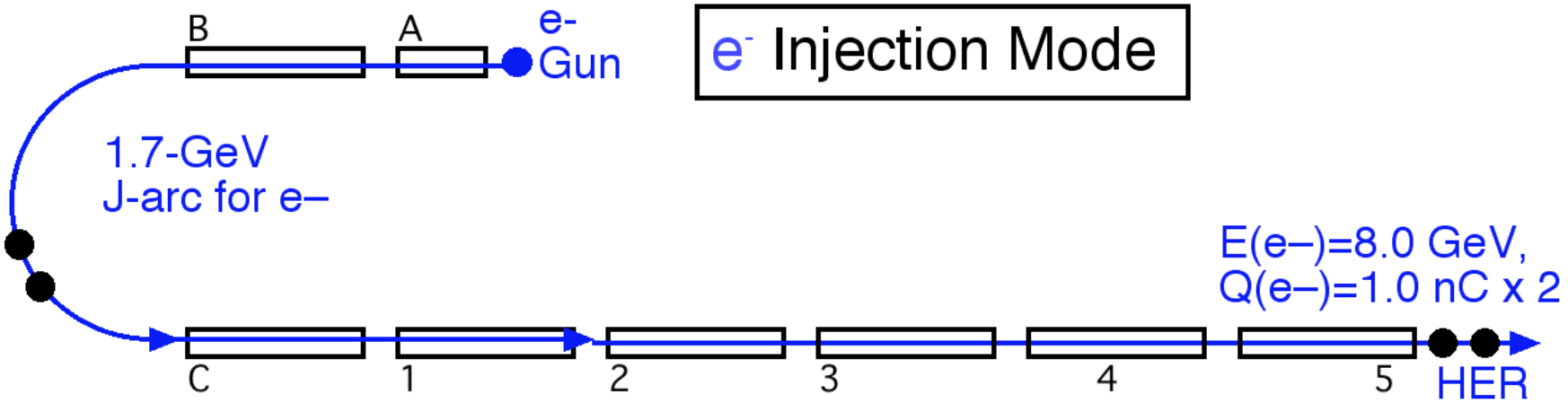
KEKB Accelerators Complex

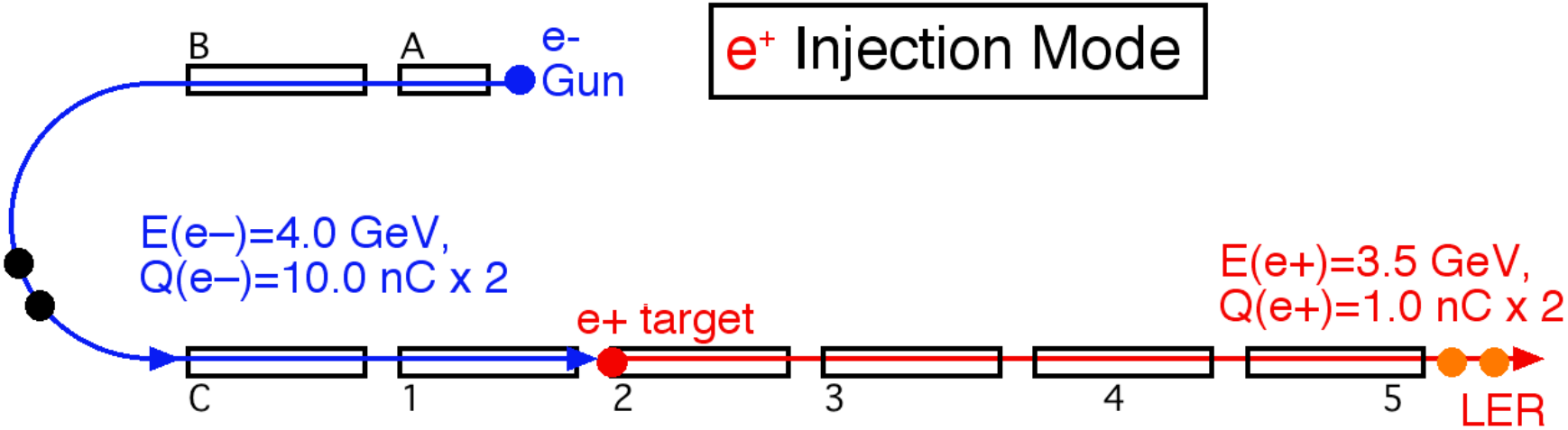
E(e-) = 8.0 GeV
E(e+) = 3.5 GeV

L-circum. = 3.0 km



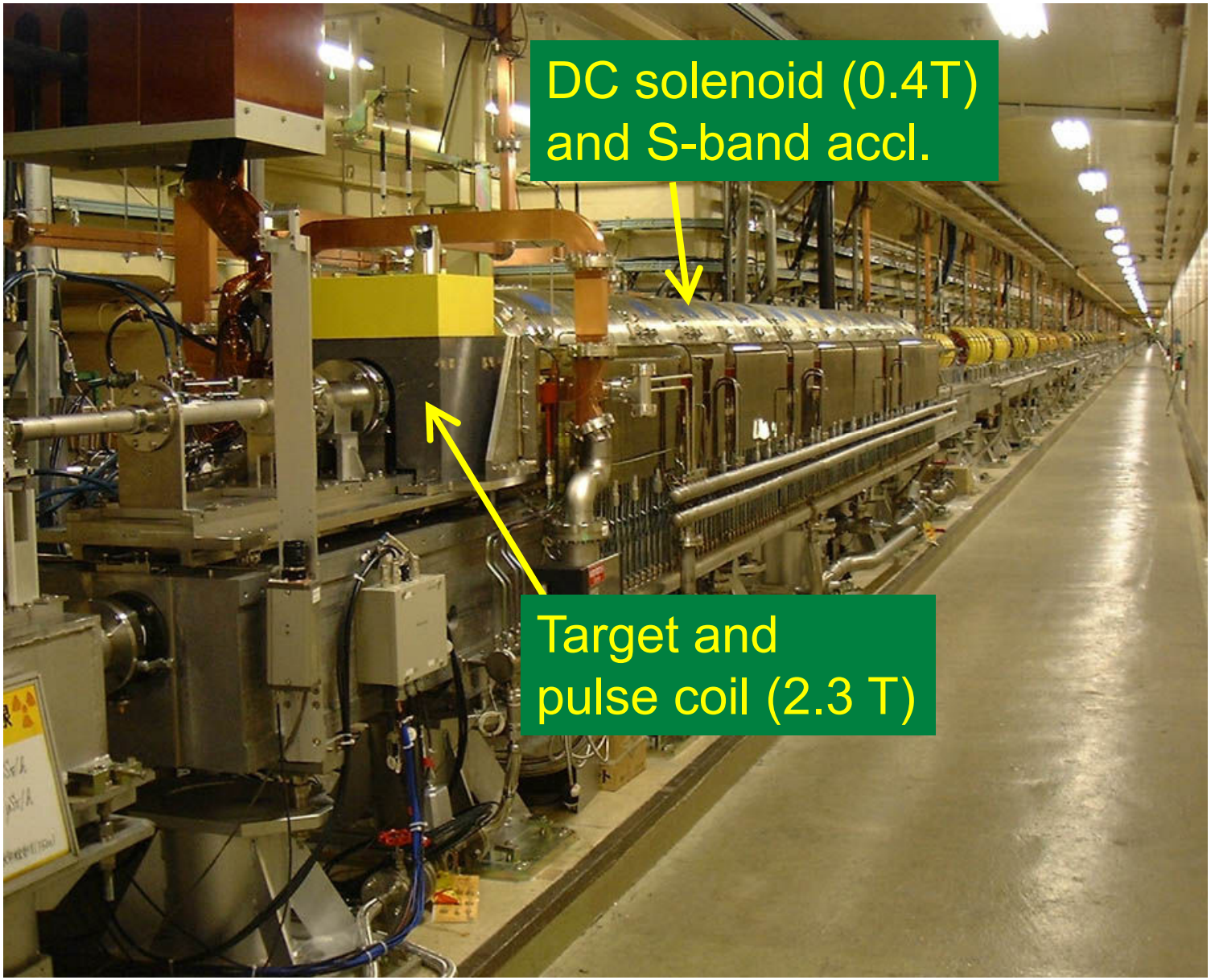
KEKB Injector Linac



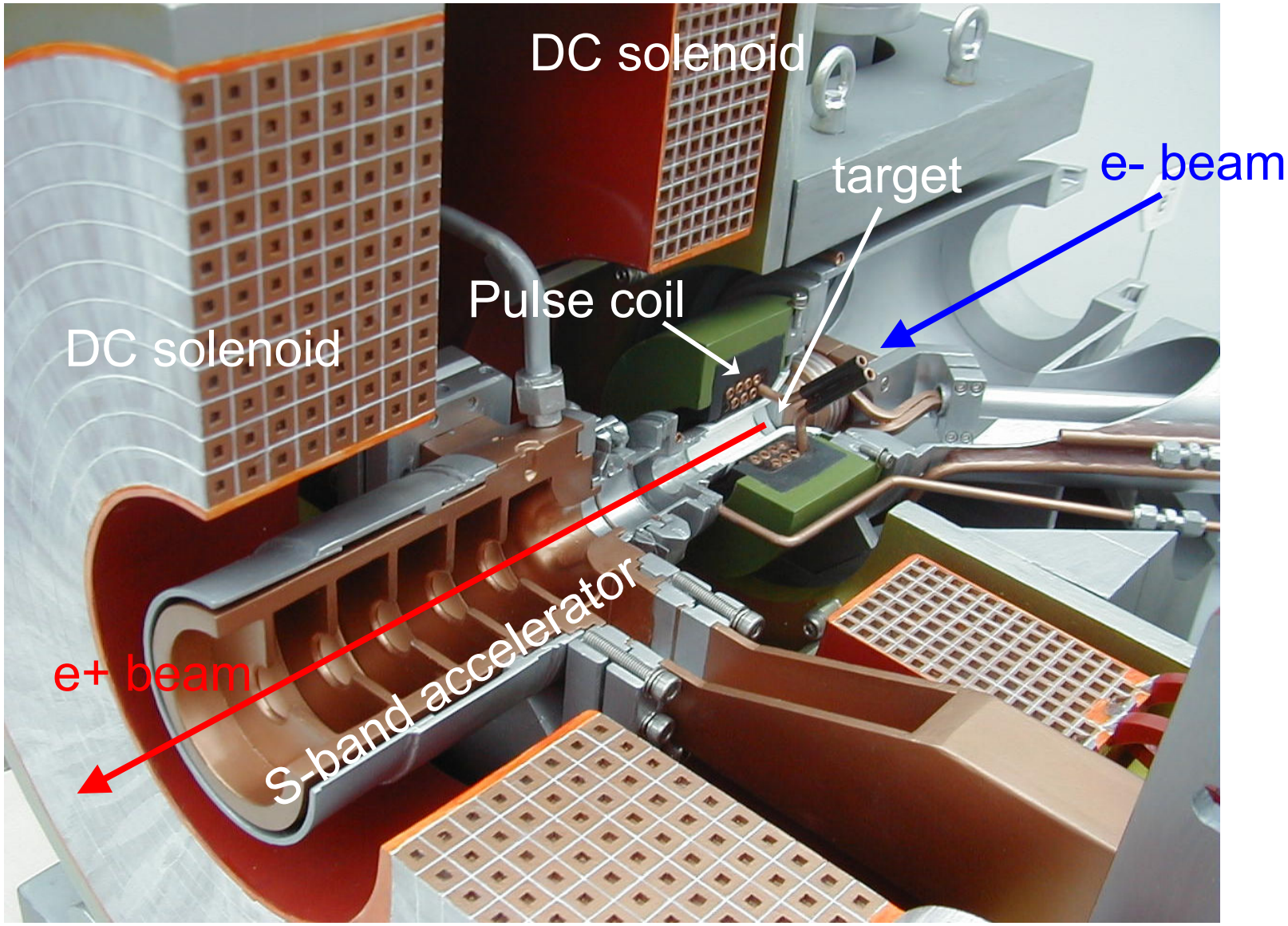


Since 2009 April, the beam modes can be switched pulse-to-pulse !!

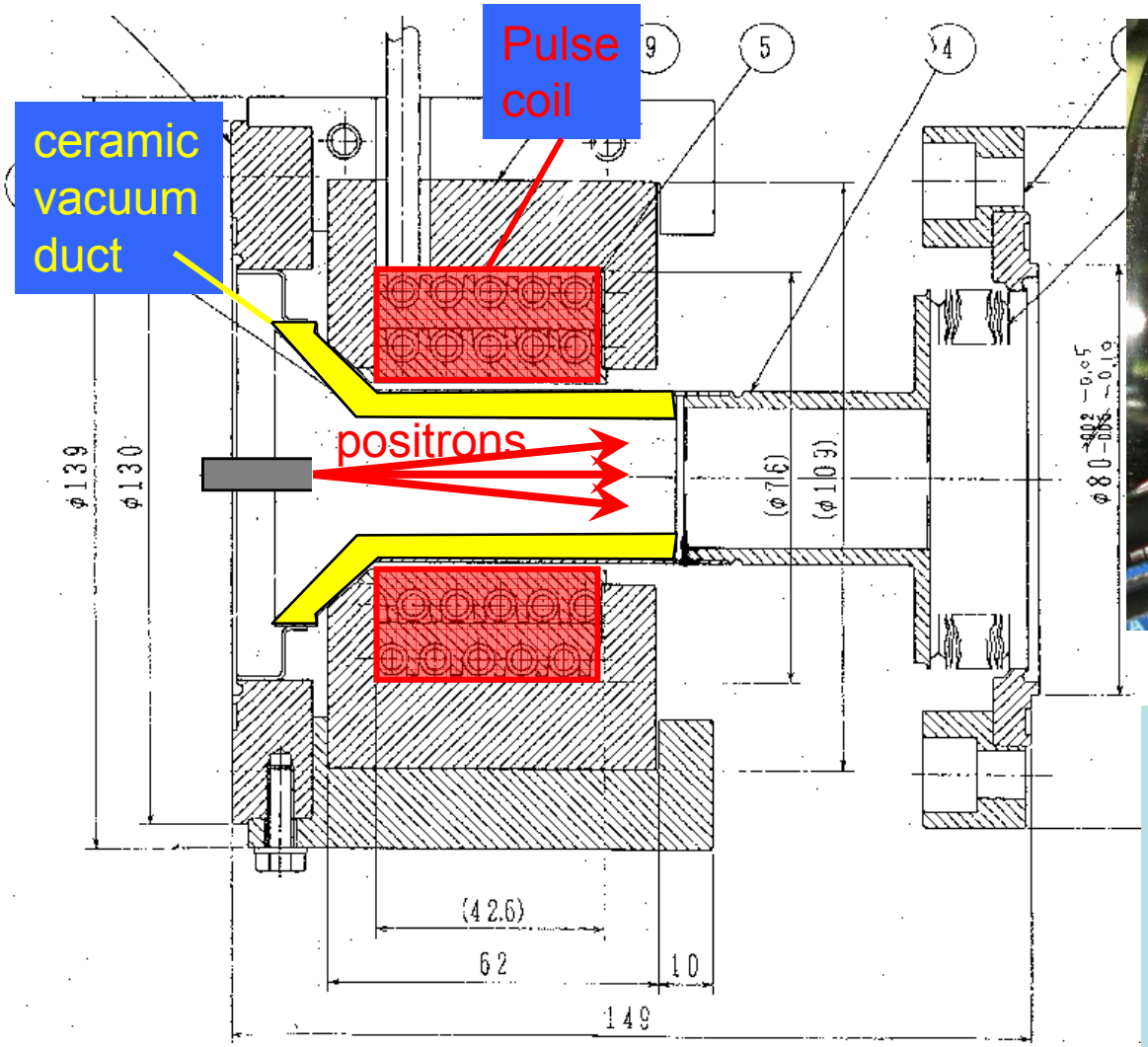
Positron source in the Linac

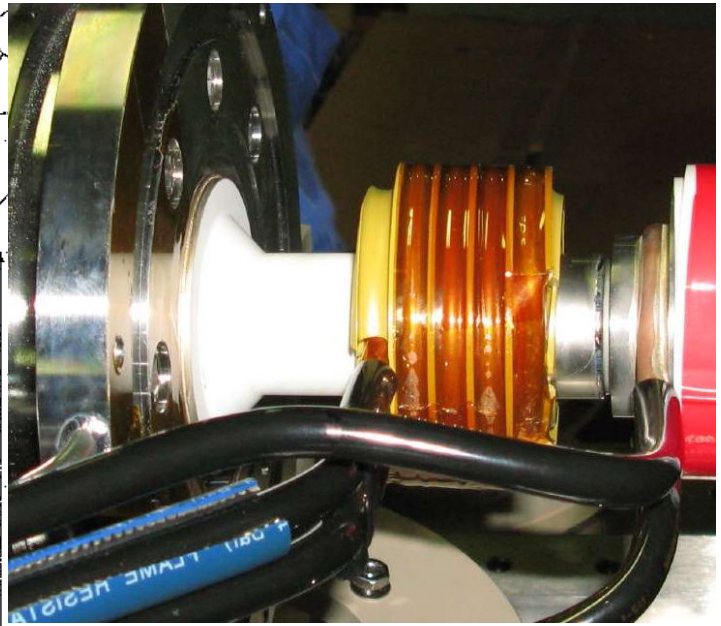


Positron source (cut model)



Pulse coil

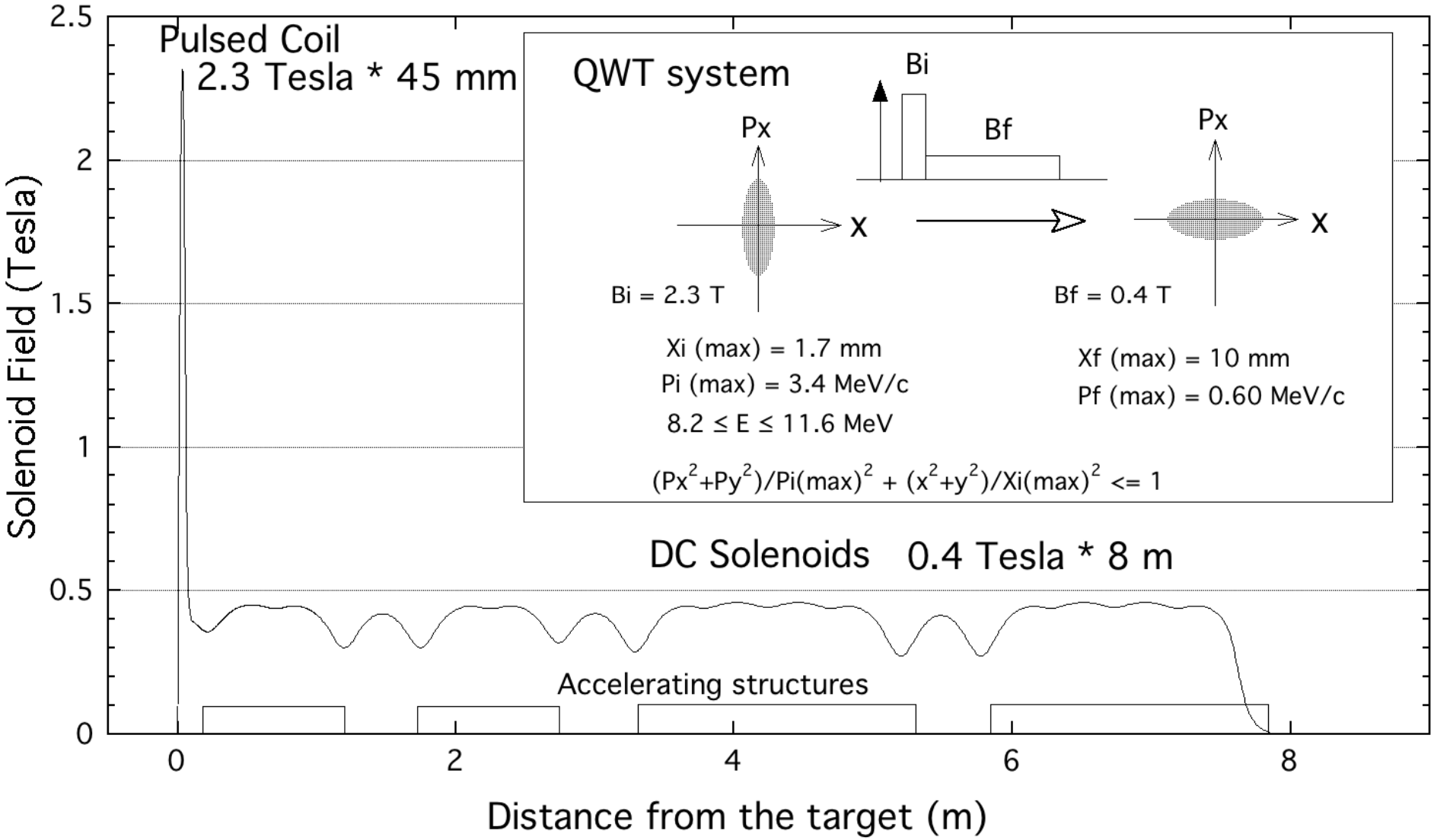




- Peak Voltage 2.0 kV
- Peak current 10 kA
- Pulse duration 100 μs
- Magnetic field 2.3 T
- Effective length 45 mm
- Repetition rate 50 Hz

QWT system

KEKB e+ generator Solenoidal field profile



KEKB upgrade

1. Luminosity upgrade

   $L = 2.1 \times 10^{34}$ -> 8×10^{35}

2. Stored current

   1.2 A (e-) x 2.0 A (e+)

   -> 4.1 A x 9.4 A (High current option)

   -> 1.2 A x 2.0 A (Low emittance option)

   But, beam lifetime is very short 600 sec

3. Charge switch

   -> Almost abandoned !!

For both cases, linac beam intensity upgrade needed !

Collaboration with BINP

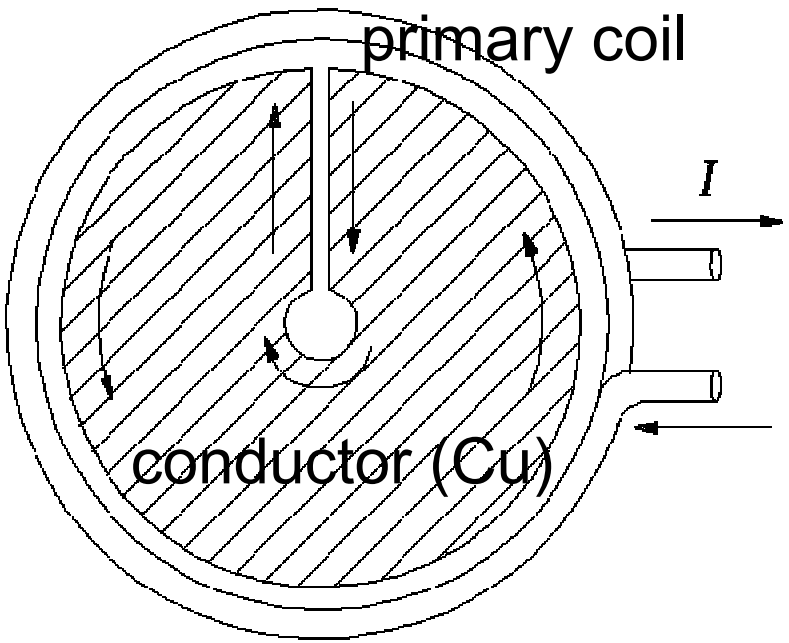
1. BINP has been working on R&D of flux concentrator for the VEPP5 linac and for Linear colliders.

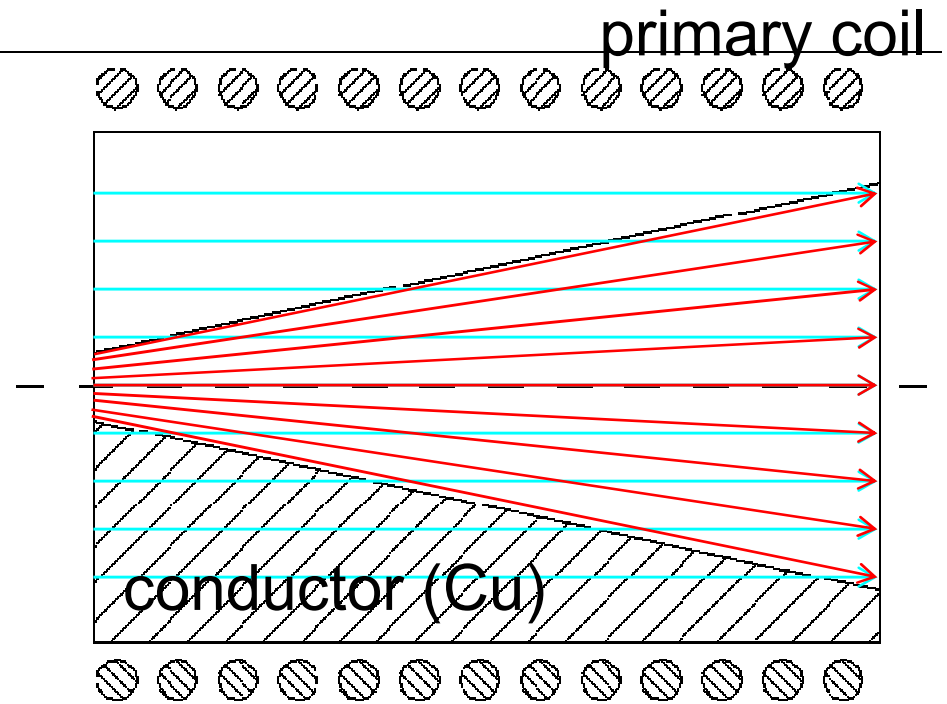
2. Pavel Logatchev suggested the possibility to use BINP type of flux concentrator for the KEKB injector linac.

3. KEK and BINP started a collaboration on flux concentrator from 2004.

4. Nikolay Dikansky is responsible for the R&D work at BINP.

Flux Concentrator

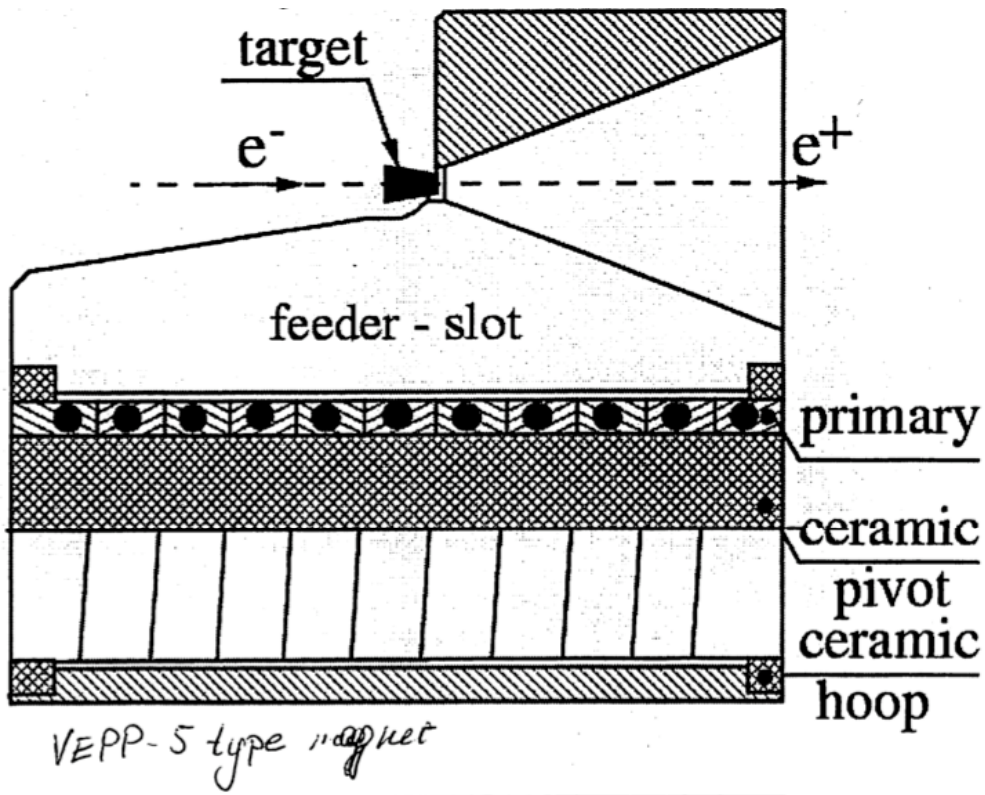


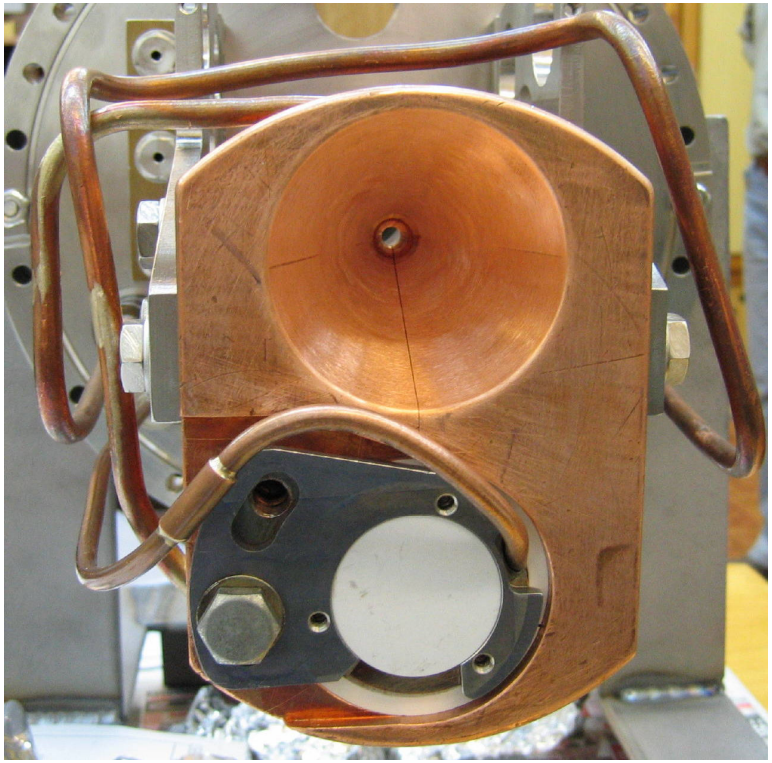


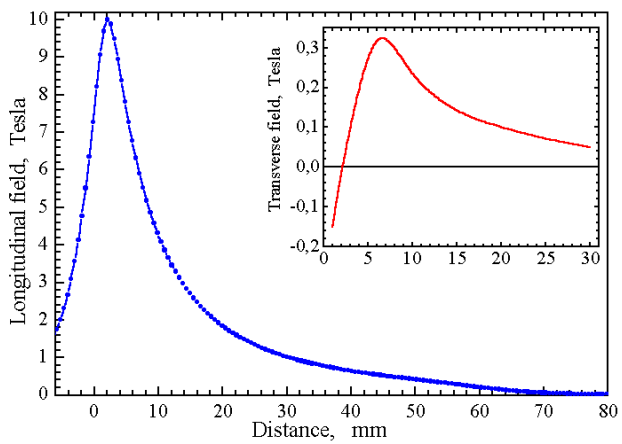
Magnetic flux is concentrated into a space inside a conductor by induced current.

<u>Problem</u> : Transverse component of magnetic field
-> beam loss by transverse kick

VEPP5-type FC developed at BINP

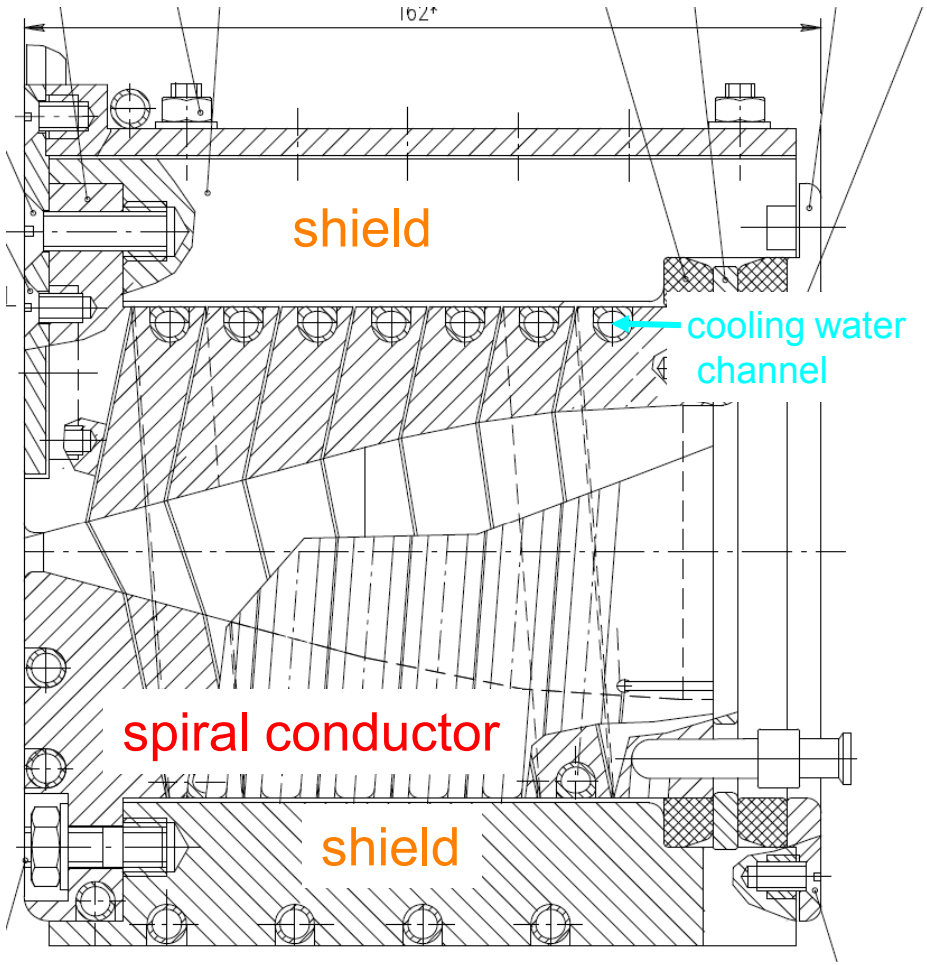


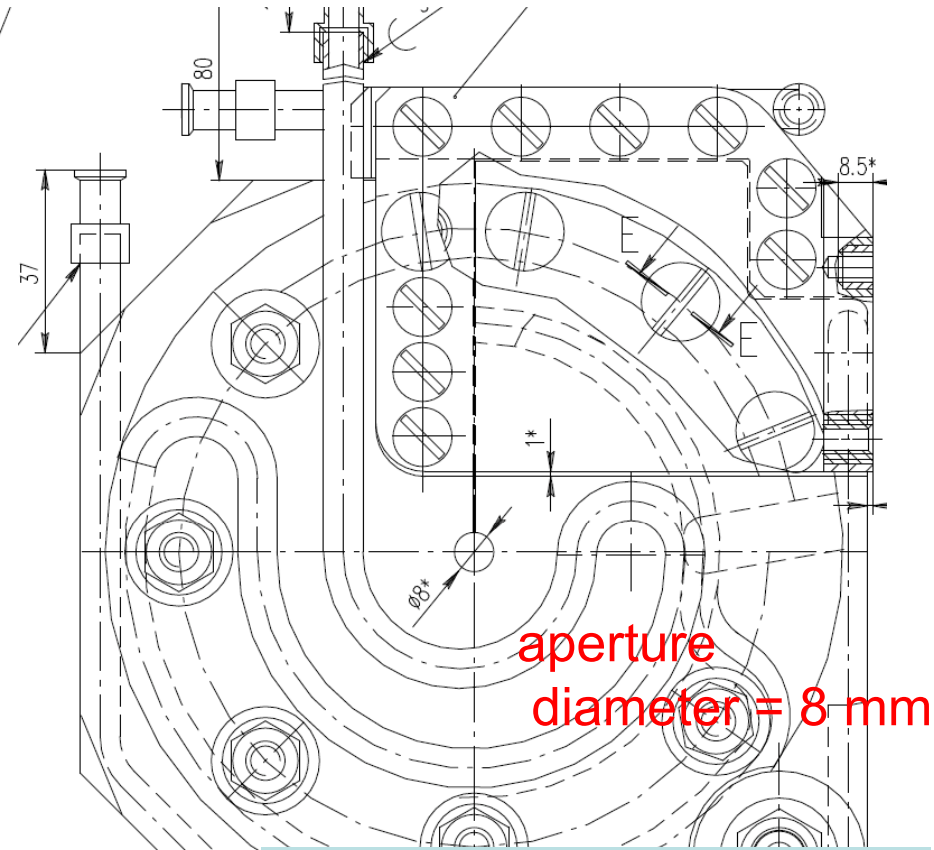




10-T field achieved with tolerable transverse component, but space for target is too small for KEKB e+ source.

flat-face FC developed at BINP

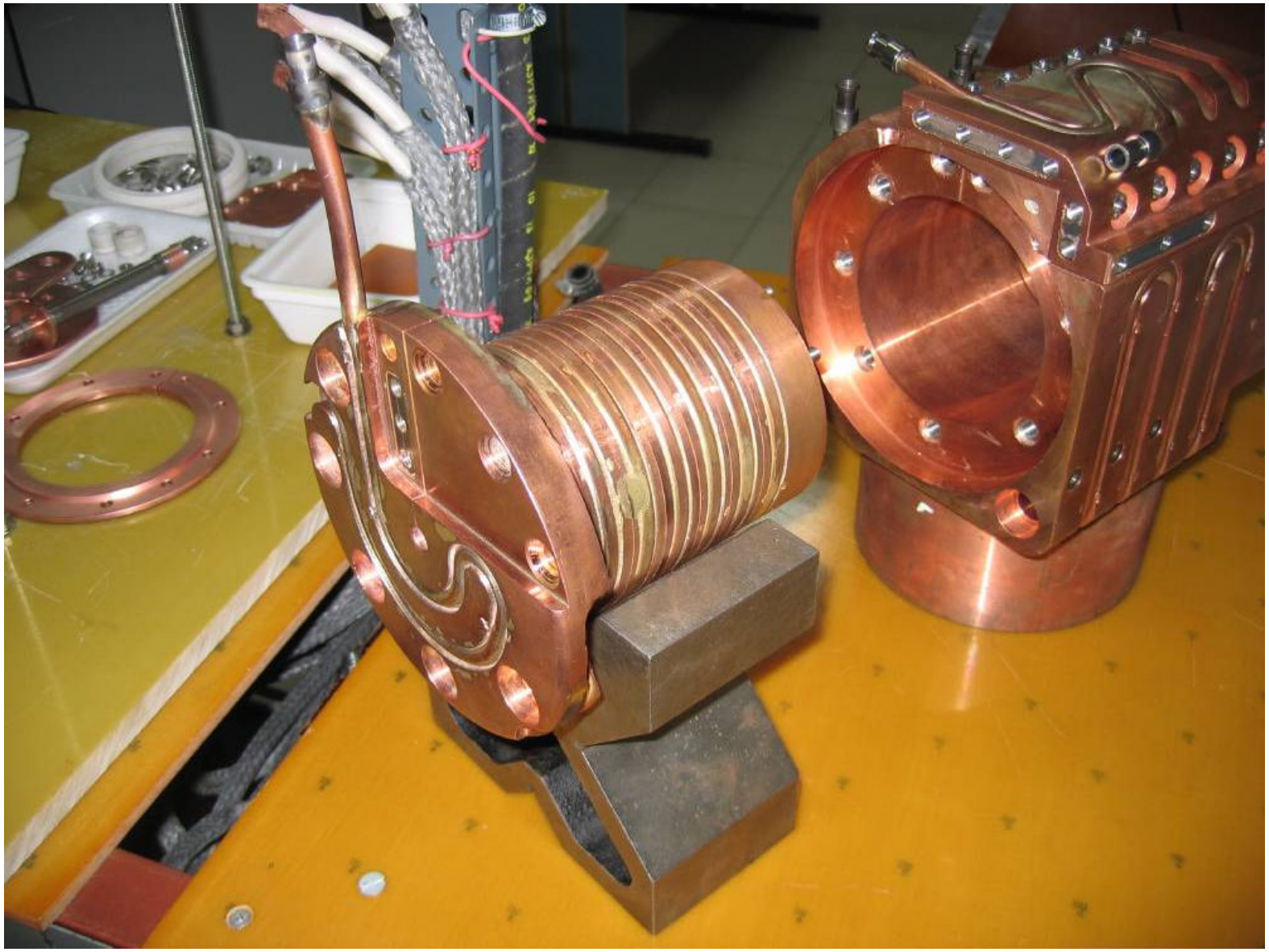




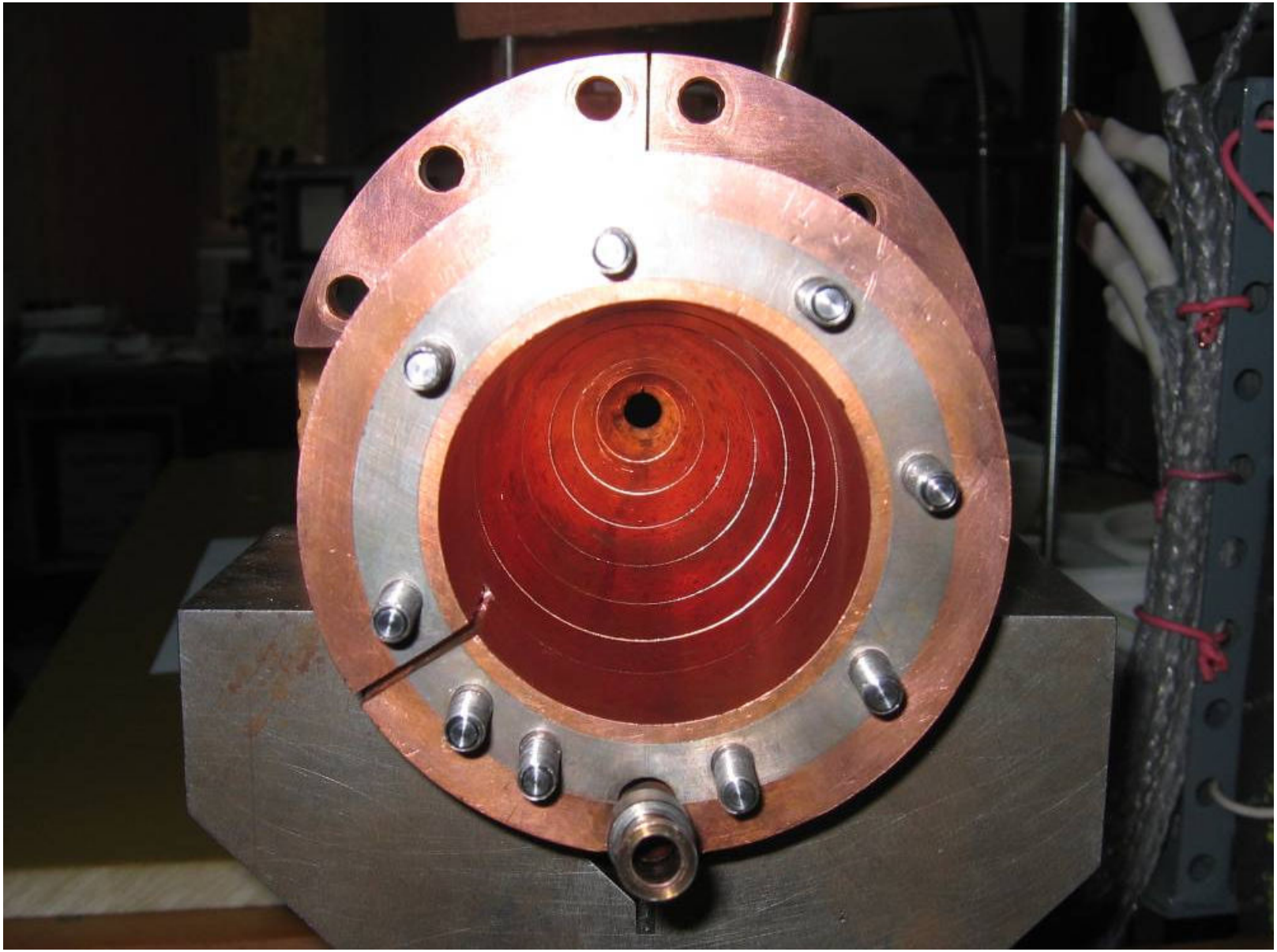
•Voltage	2.5 kV
•Peak current	30 kA
•Pulse duration	25 μs
•Magnetic field	10 Tesla
•Power dissipation	18 kW
•Repetition rate	50 Hz

This type can be compatible with the target of KEKB e+ source.

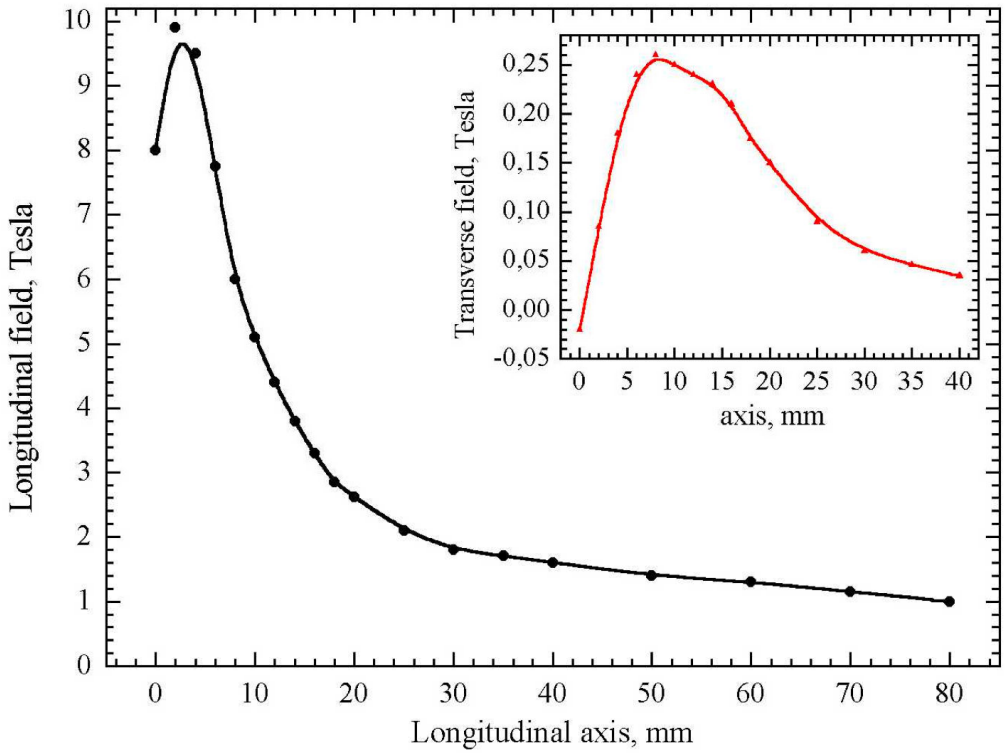
FC prototype

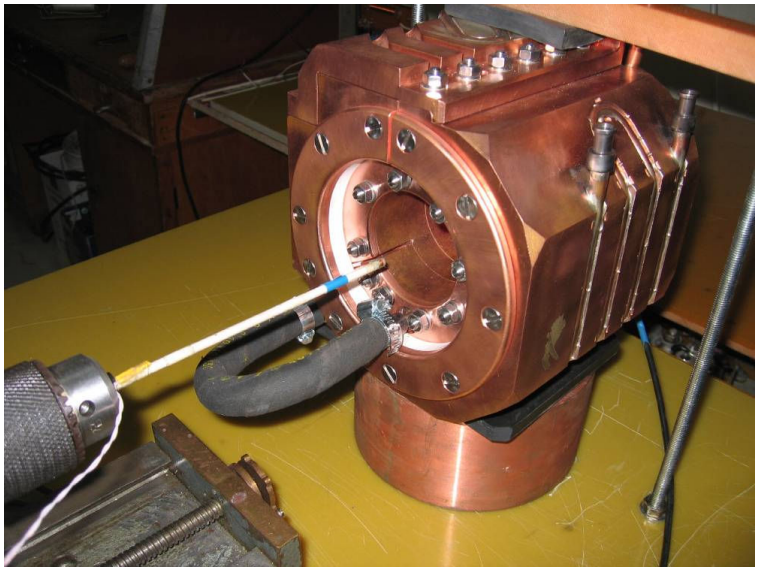


FC prototype



Field distribution

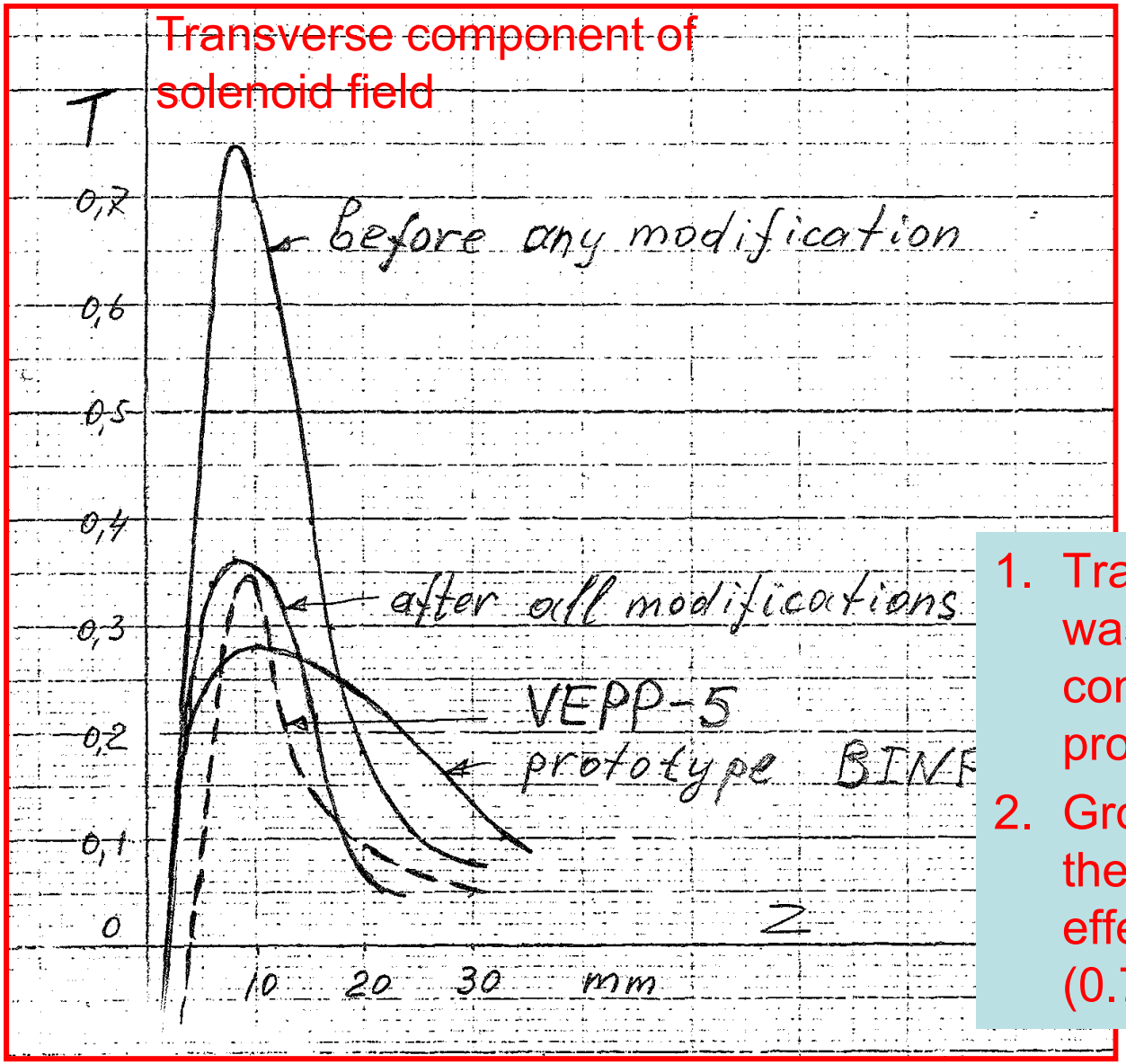




Low-power Prototype

1. 10-T field can be achieved.
2. Design efforts performed with some prototypes to minimize transverse field component.
3. Field axis offsets 1 ~ 2 mm.

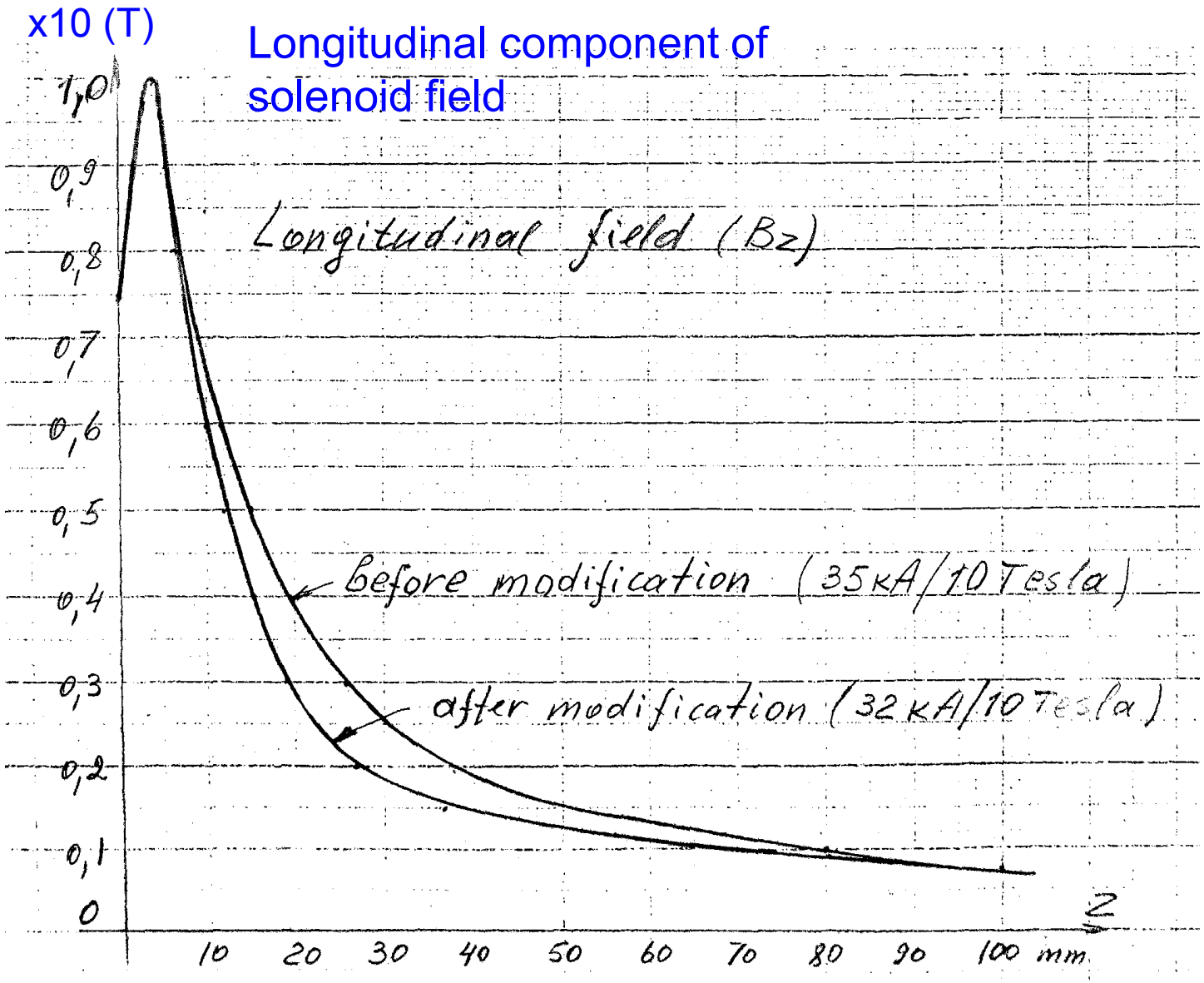
Larger B_T in high-power prototype



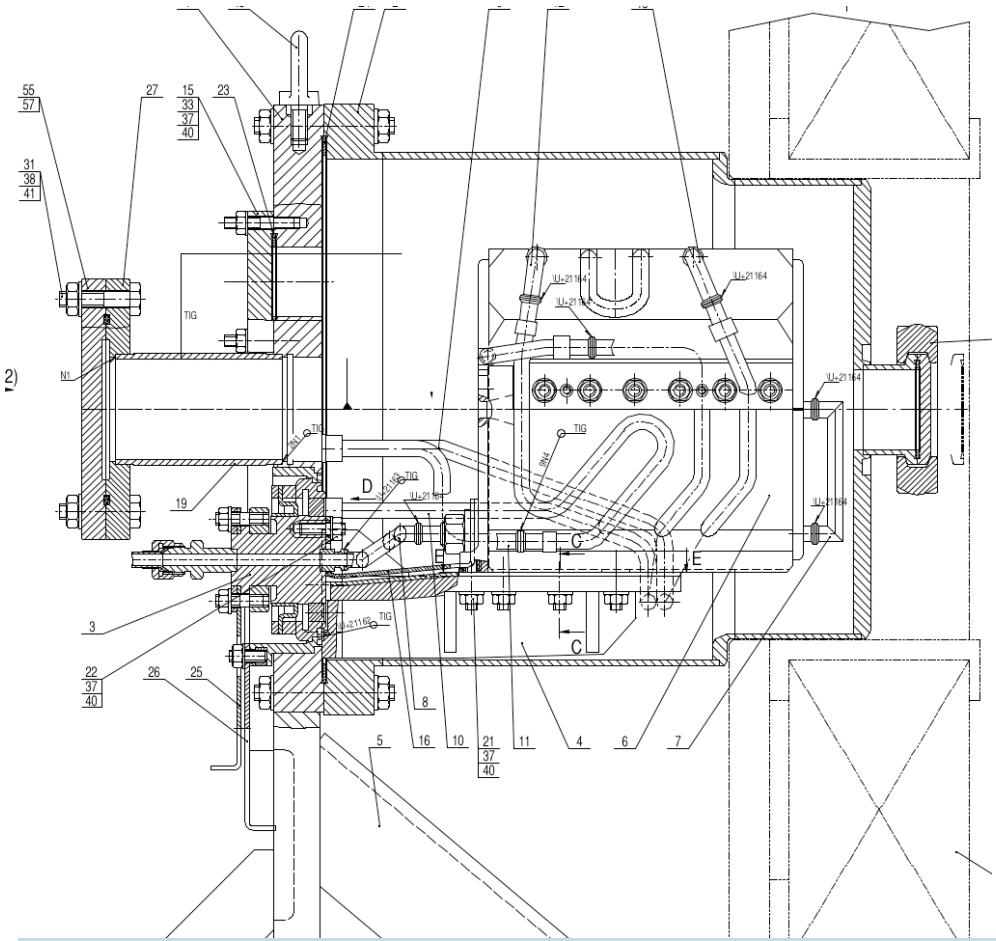
1. Transverse component was larger (0.75T) compared with low-power prototype (0.3T).
2. Grooving at inner side of the conductor was effective for improvement. (0.75 -> 0.35 T)

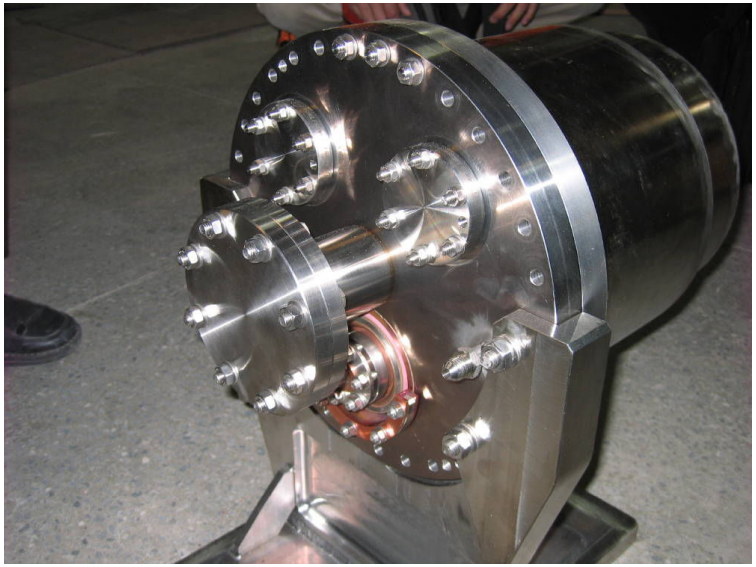
Groove to improve B_T

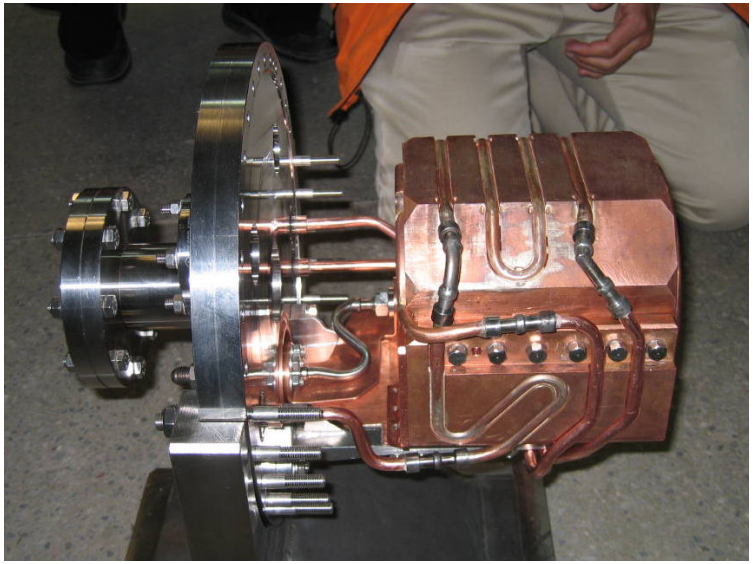
Field distribution is steep (QWT?)



Installed in vacuum chamber



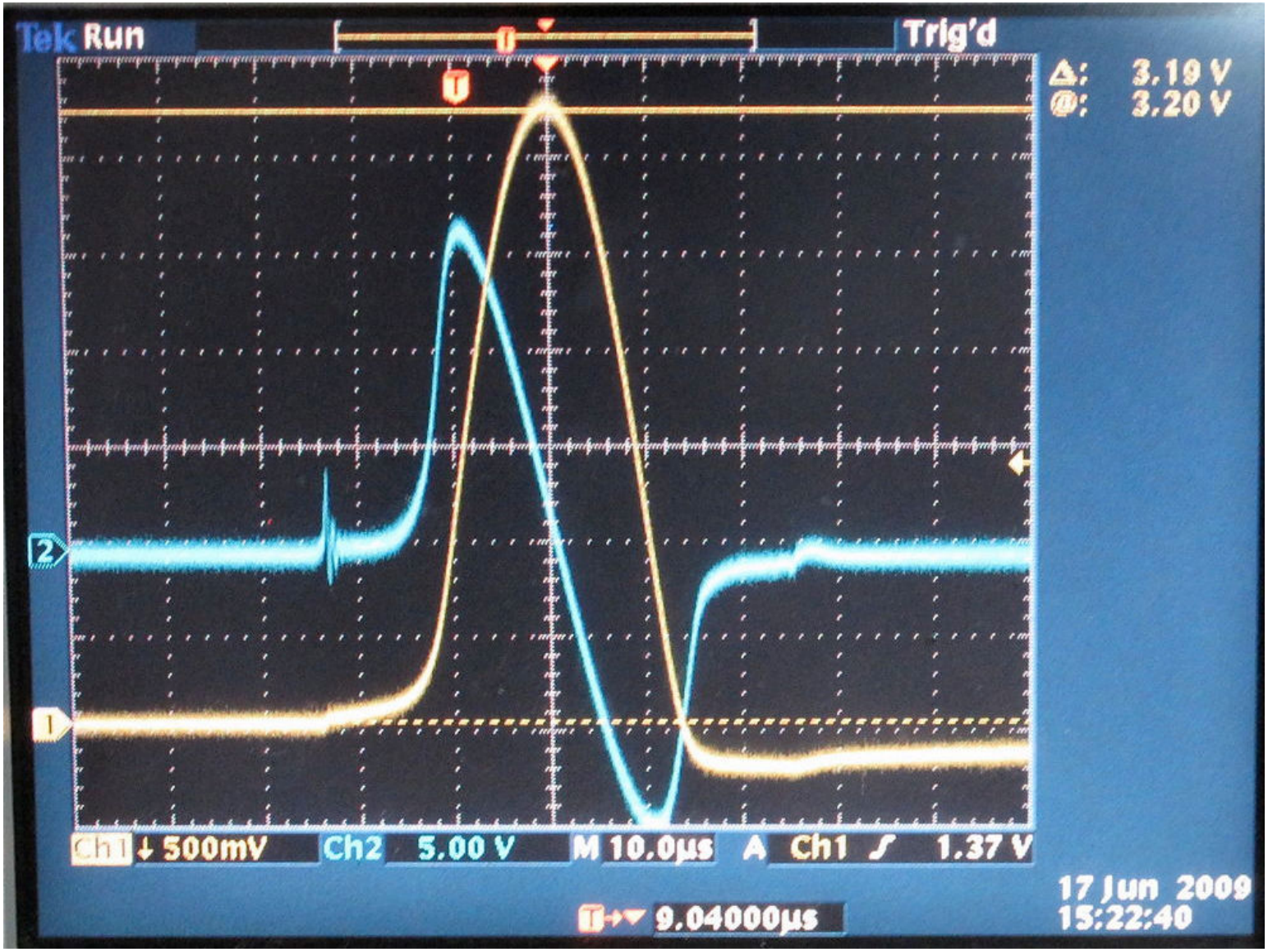




Modified vacuum chamber was fabricated at BINP to fit for KEKB linac.

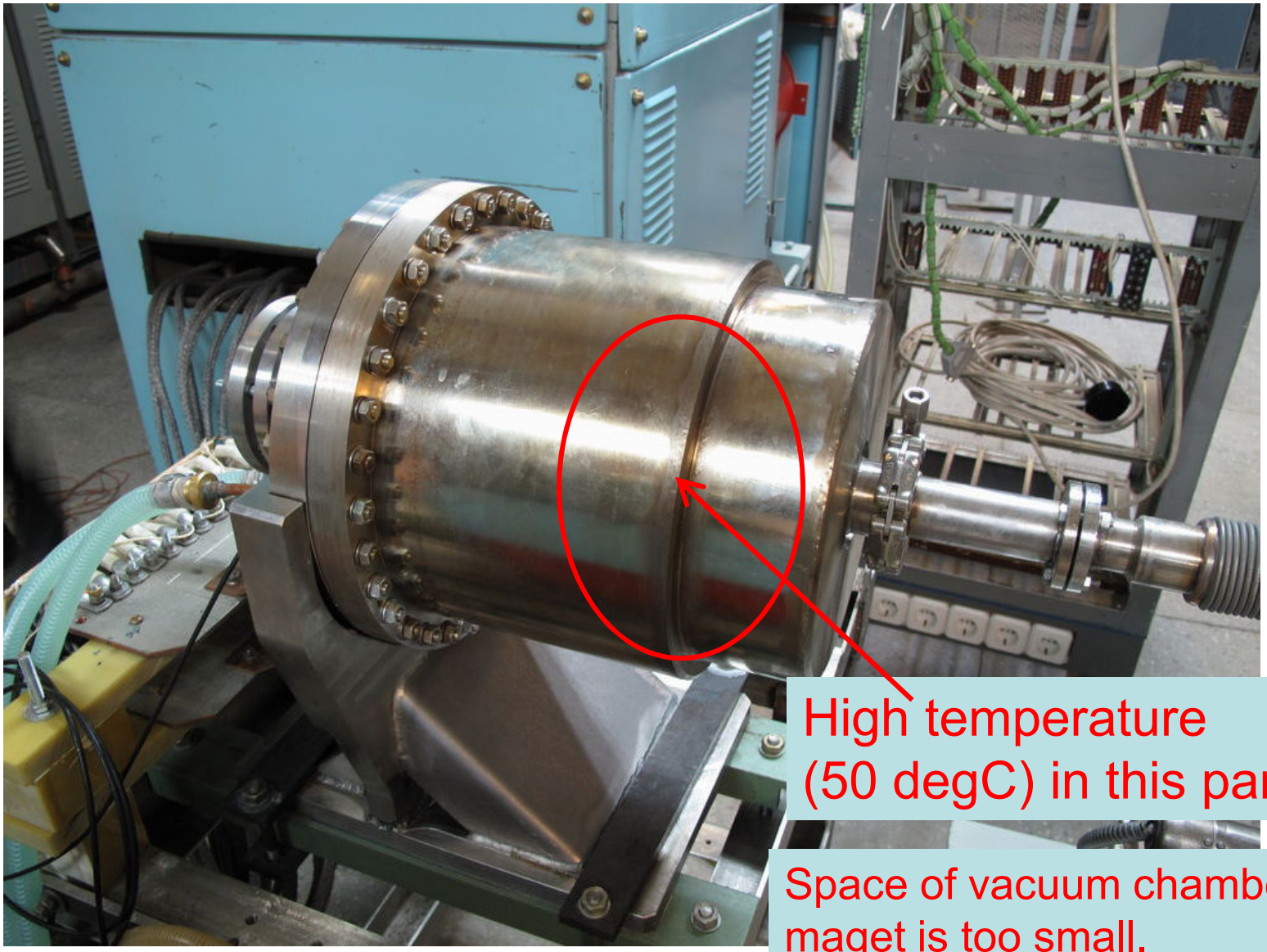
Full-power test (10 Tesla, 50Hz)

Big Noise from the power supply


Tek Run
Trig'd
Δ: 3.19 V
@: 3.20 V
Ch1 ↓ 500mV
Ch2 5.00 V
M 10.0µs
A Ch1 ∫ 1.37 V
9.04000µs
17 Jun 2009
15:22:40

Pulse Power Supply

Heating on the vacuum chamber

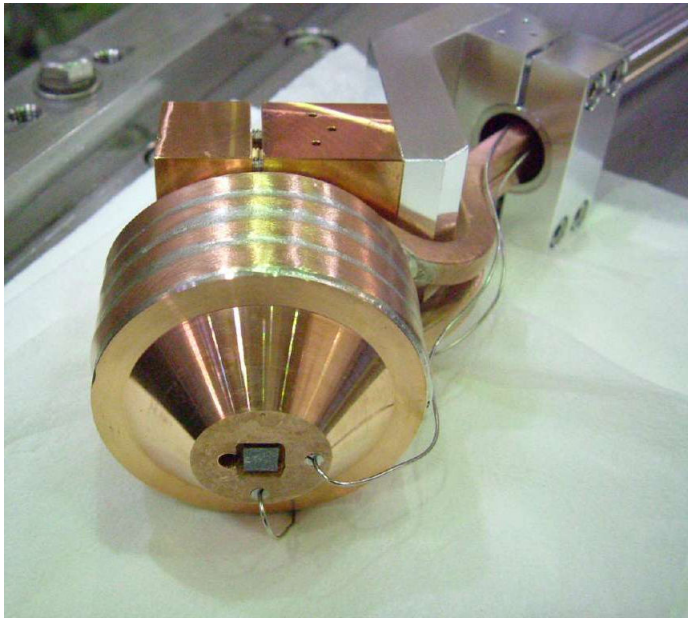


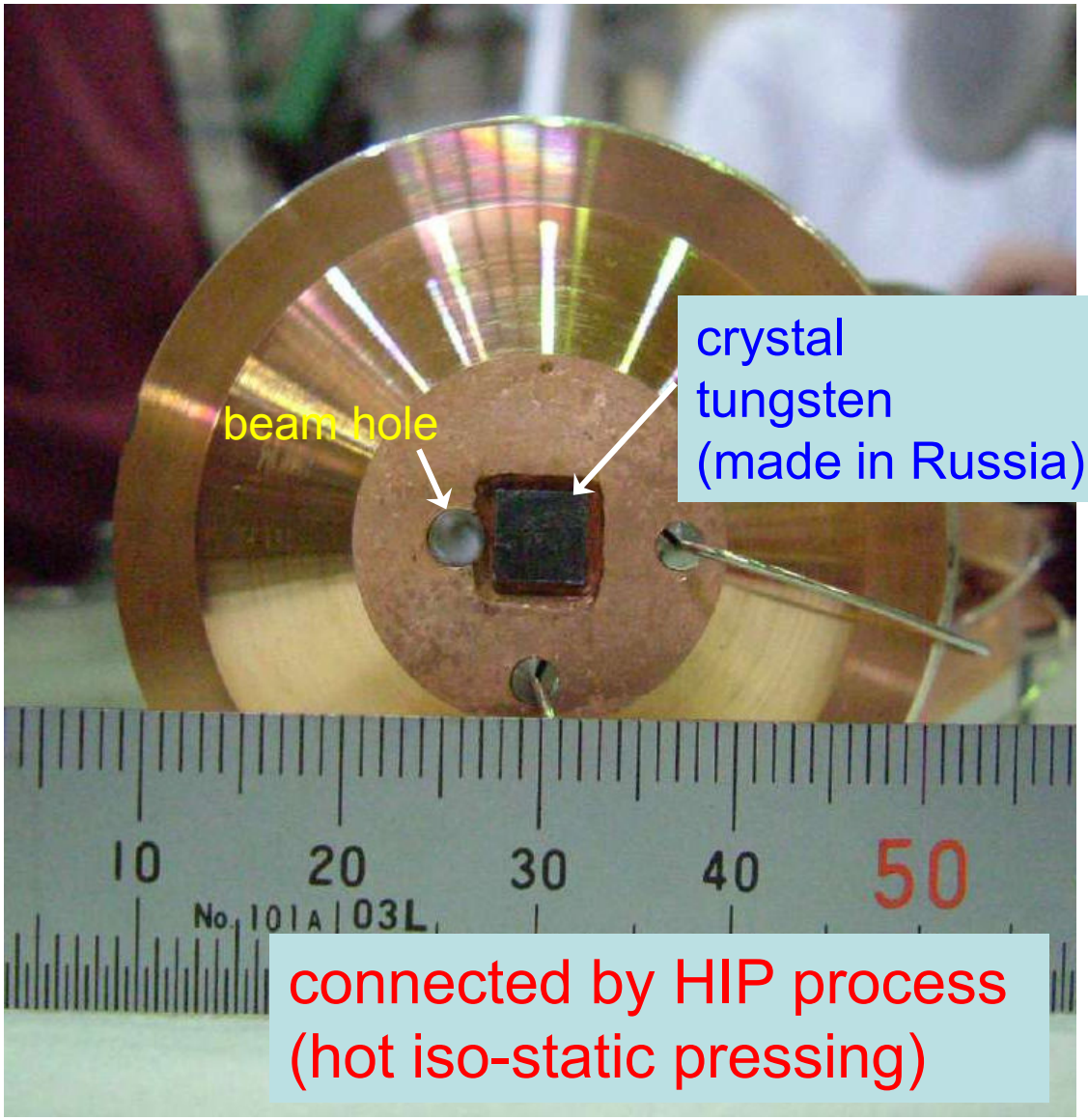
Present status & Next steps

- **BINP & KEK are collaborating on flux concentrator R&D for upgrade of KEKB injector linac**
- **Considering to replace**
  2.3-T pulse coil --> 10-T Flux Concentrator
- **After the improvement B_T is 0.35T at B_Z = 10T**
- **Preliminary full-power operation test of the first high-power prototype has been performed at BINP.**
  - **Magnet and the Power supply works fine.**
  - **Vacuum chamber need to be modified. (and Big noise)**
- **After 2-week operation test in 2009 September at BINP, they will be sent to KEK and installed in the KEKB positron source for performance test in 2010 May.**
- **Particle tracking simulation including the transverse component is needed to evaluate the e^+ yield.**

Crystal target break-up issue

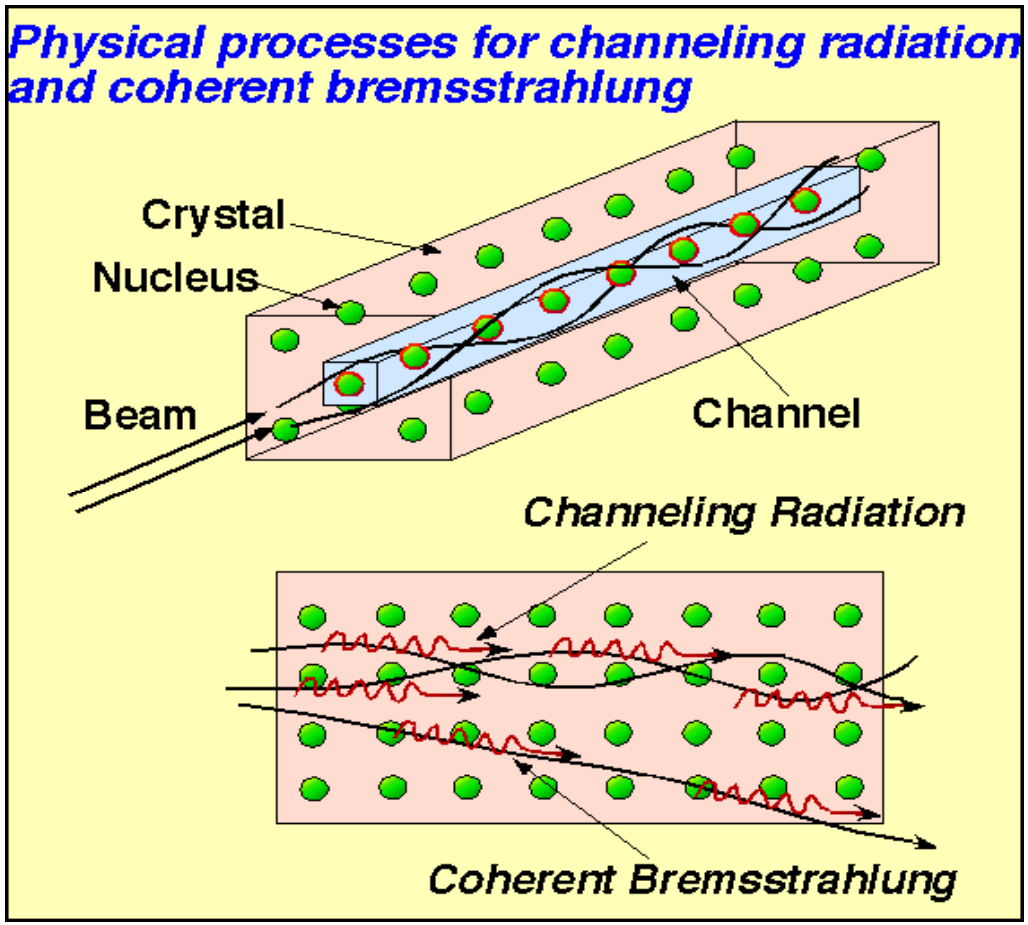
Crystal tungsten target No.1



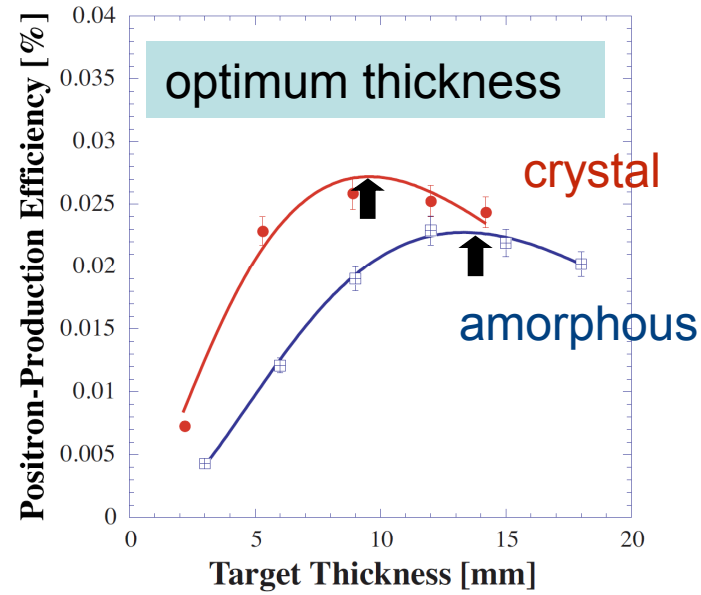


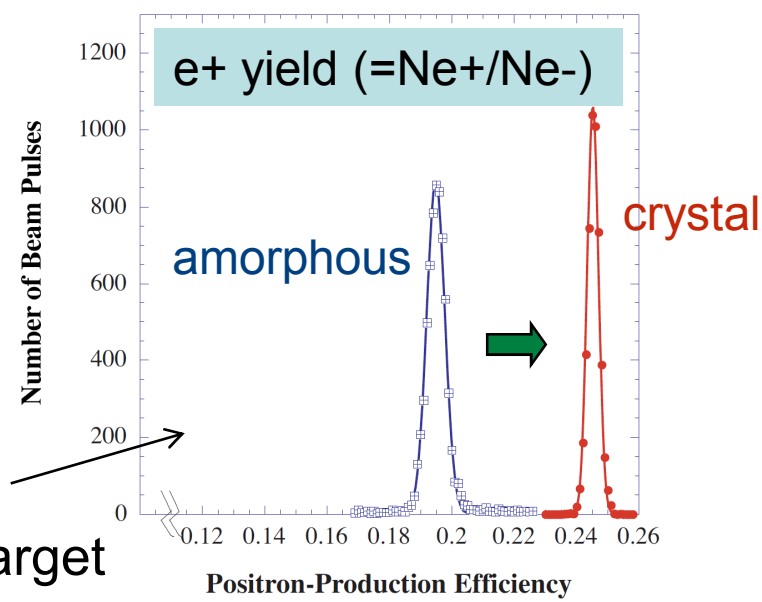
crystal thickness
= 10 mm
(~ 3.0 X_0)

e^+ yield increase with crystal tungsten



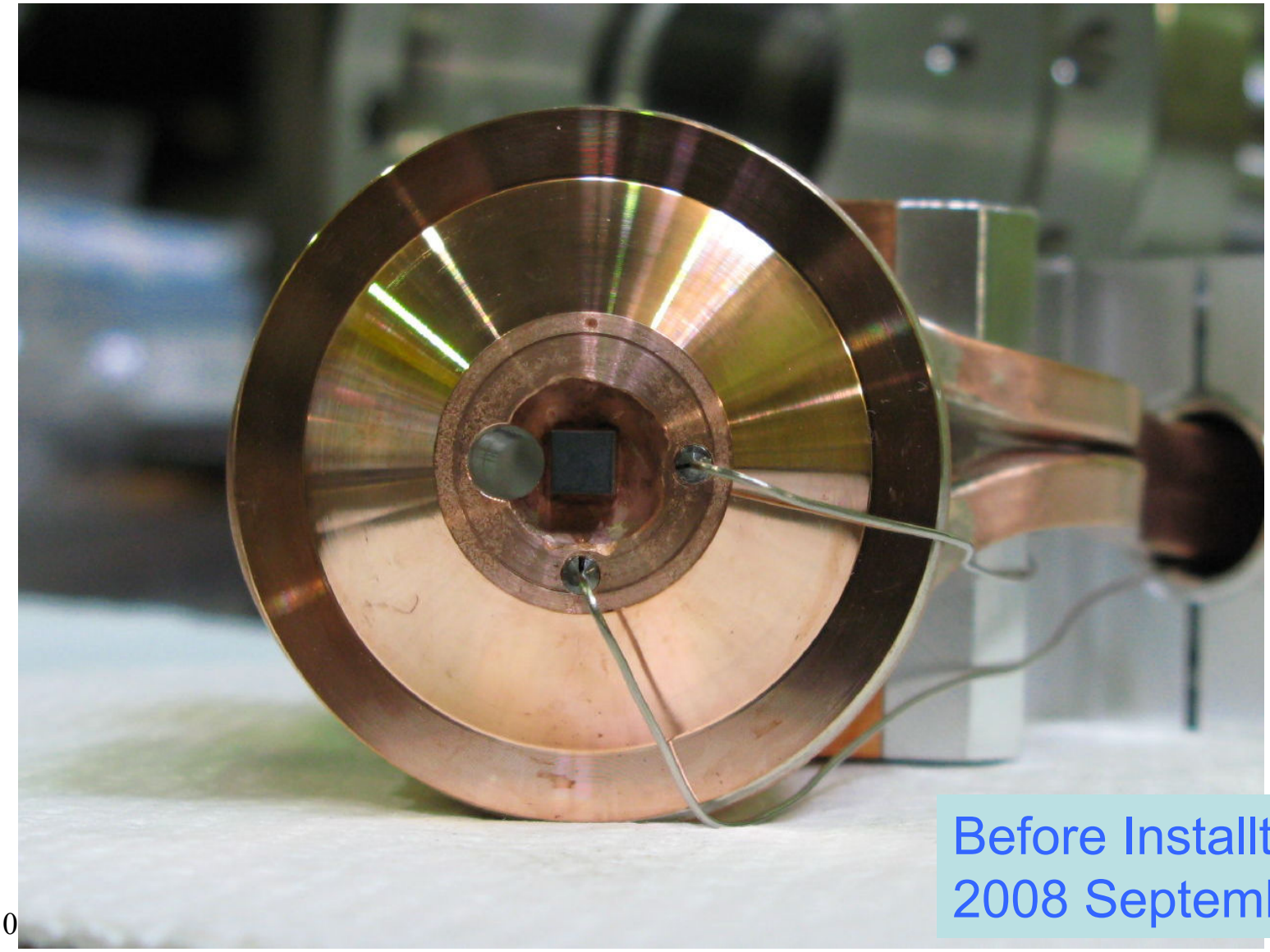
(Thanks to T. Suwada)



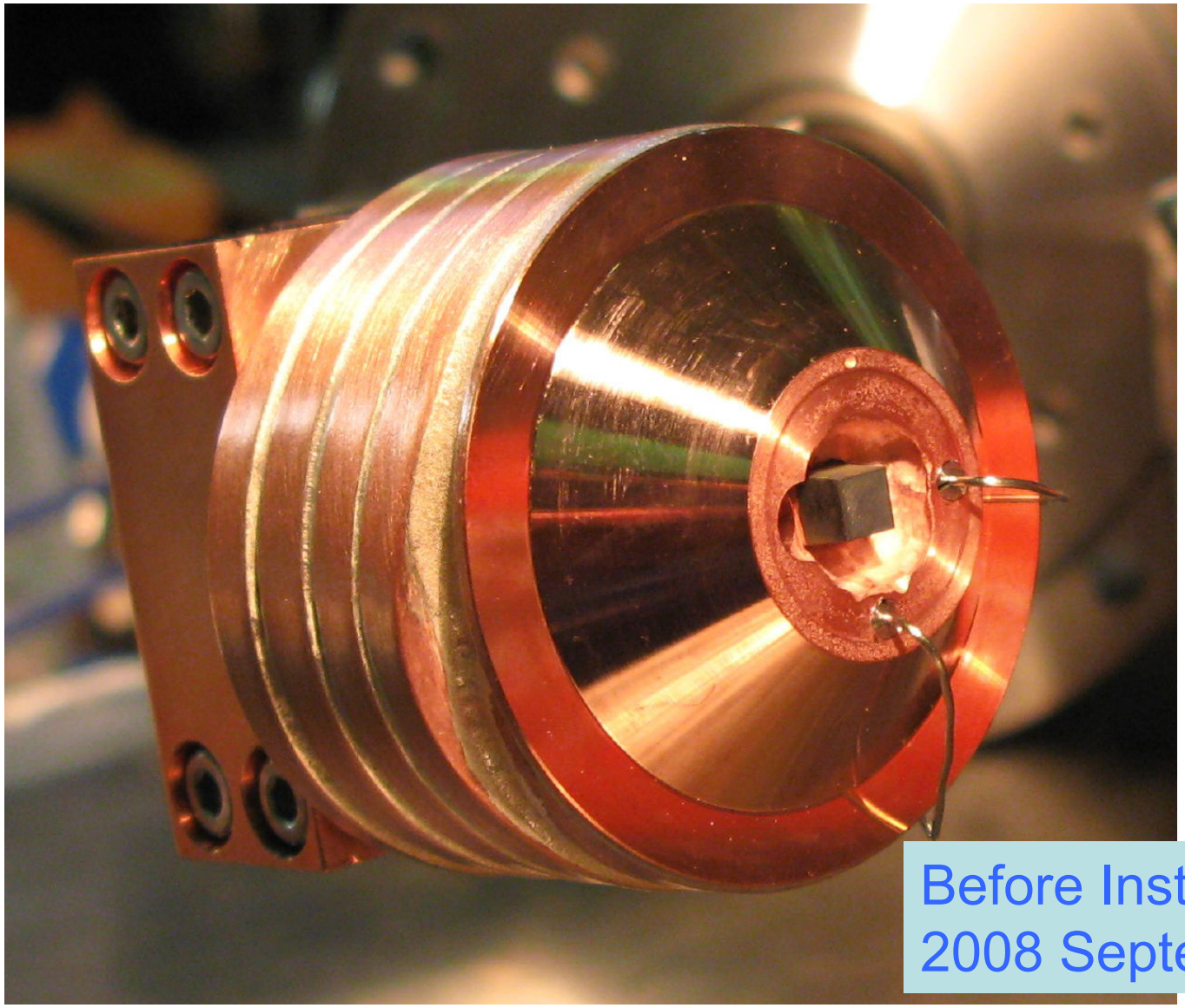


e+ yield is improved 25 %
with crystal tungsten (W) target

Crystal tungsten target No.2

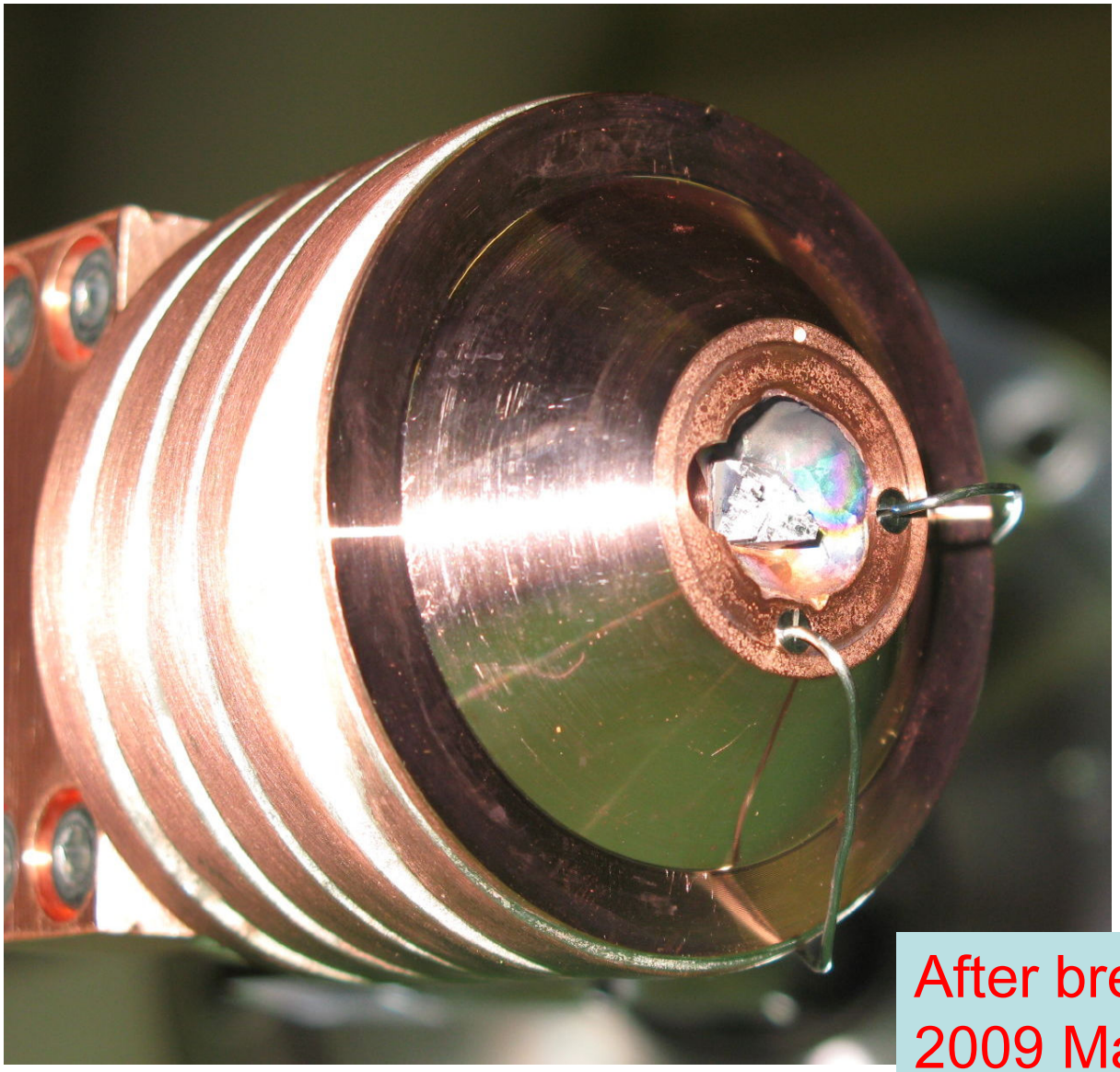


Before Installtion
2008 September



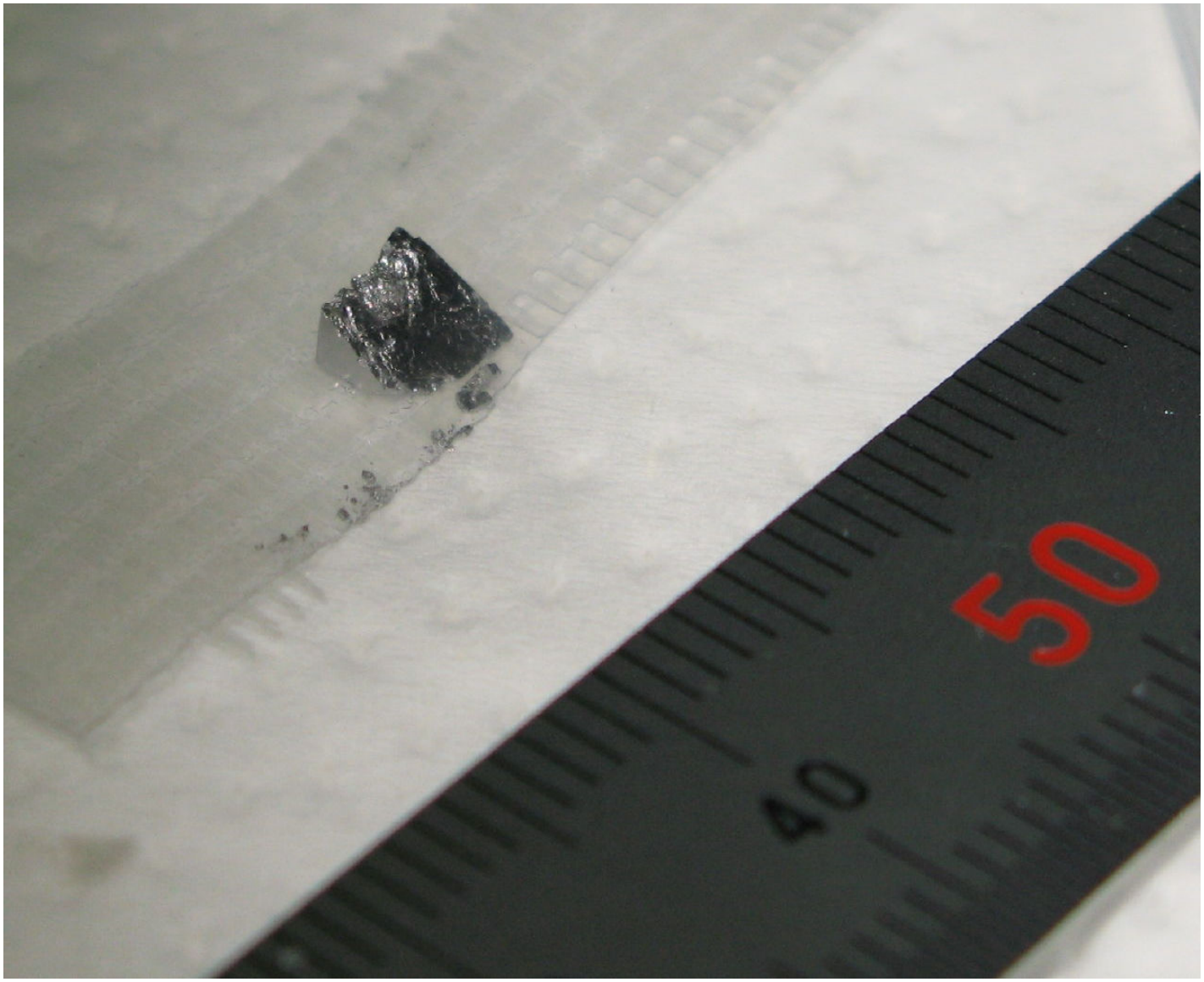
Before Installtion
2008 September

Crystal tungsten target No.2

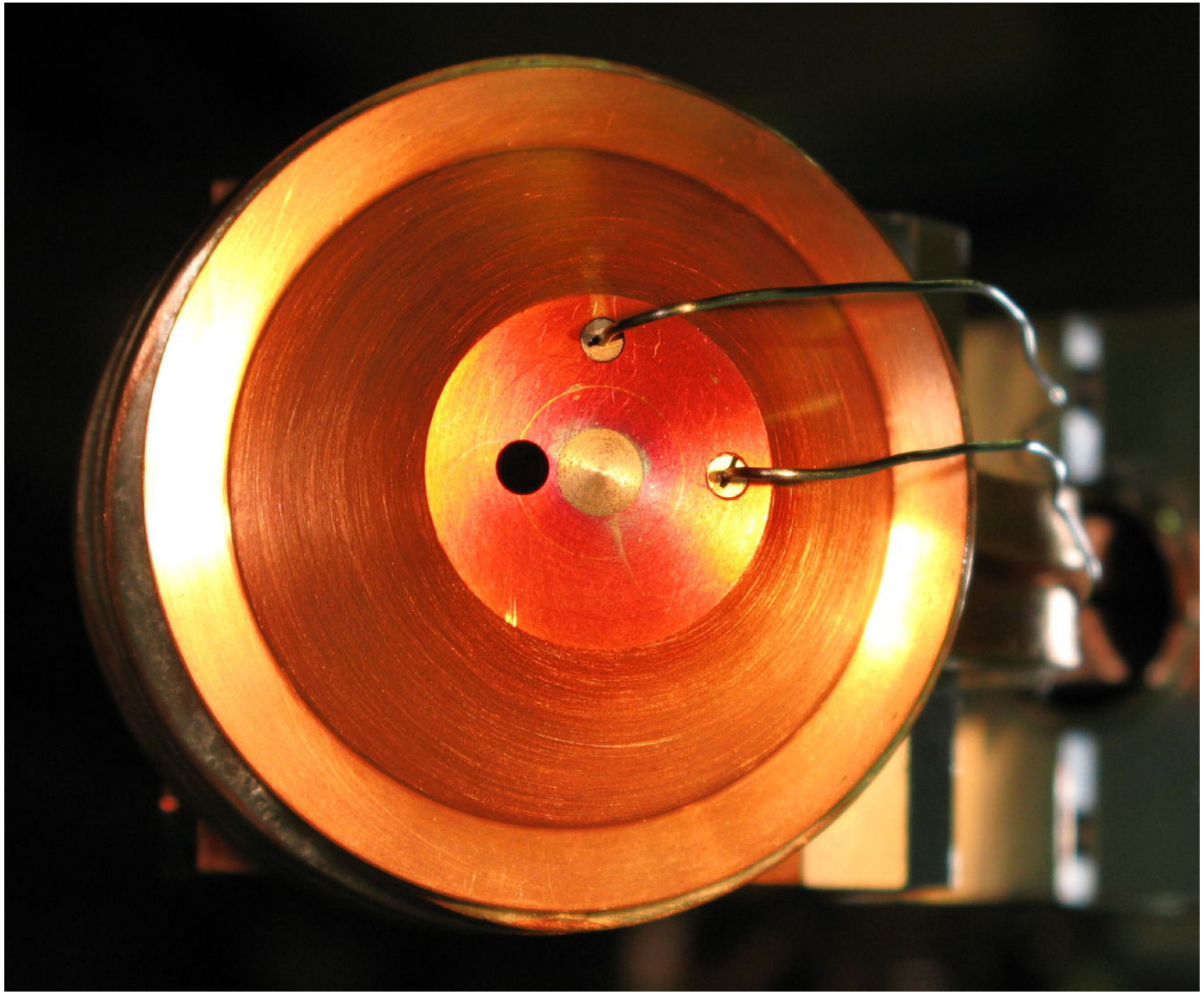


After break-up
2009 March 27

A tip of broken target



Amorphous tungsten target



Target break-up

1. Second crystal target of KEKB e+ source had wide and deep gap between the tungsten and the copper support.
   It is due to imperfect masking in the etching process.
2. Cooling of the target tail was not effective.
3. Severe beam operation condition gave excessive heat-up of the target.
4. Target has broken and tail has tipped off.

Even below the expected destruction limit, sufficient care should be taken for target cooling.