Fuji Test Beam Line (FTBL)

K. Egawa

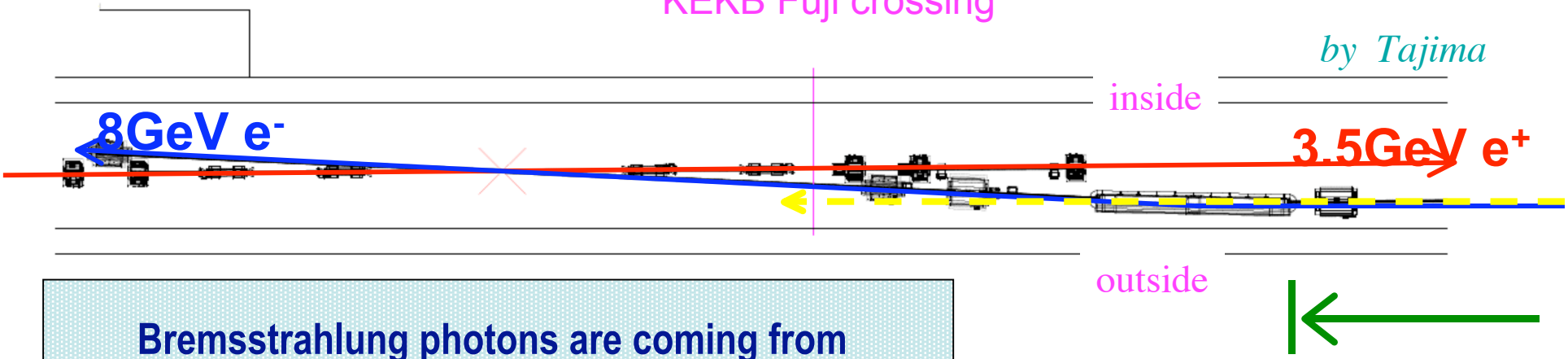
The KEKB **F**uji **T**est **B**eam **L**ine (**FTBL**), which was being built in the Fuji experimental hall of the KEKB accelerator, was completed in September 2007. Soon after the KEKB operation started in October, the first beam was observed to pass through the FTBL successfully.

outline

- After the *KEK 12 GeV PS shutdown*, no GeV class test beam line was available in Japan. *A new GeV class test beam* is strongly desired.
- The feasibility study to construct a test beam line in Fuji experimental hall of the KEKB accelerator started in 2006.
- The *idea* is to use *bremsstrahlung photons* coming from *HER 8 GeV electron vs. residual gas scattering* in *Fuji* straight section. They are *converted to e-/e+ pairs*. The obtained electrons have a sharp forward peak and are sufficient as a test beam at a few GeV/c range.
- The project team was organized and the construction started up.

KEKB Fuji crossing

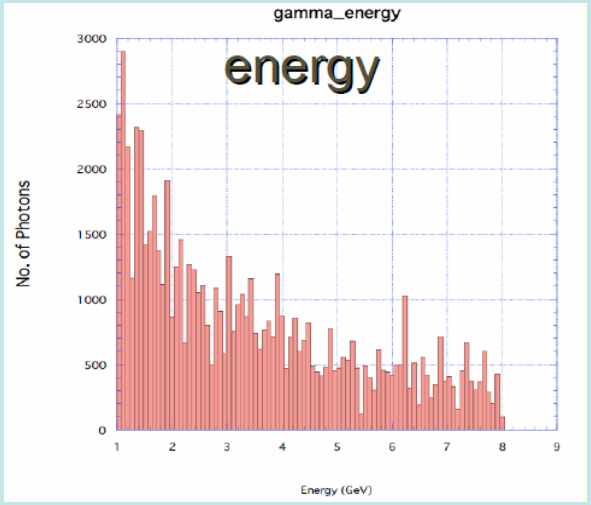
by Tajima

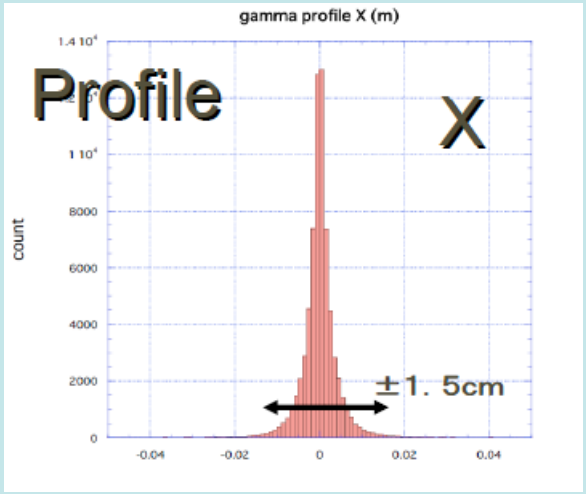


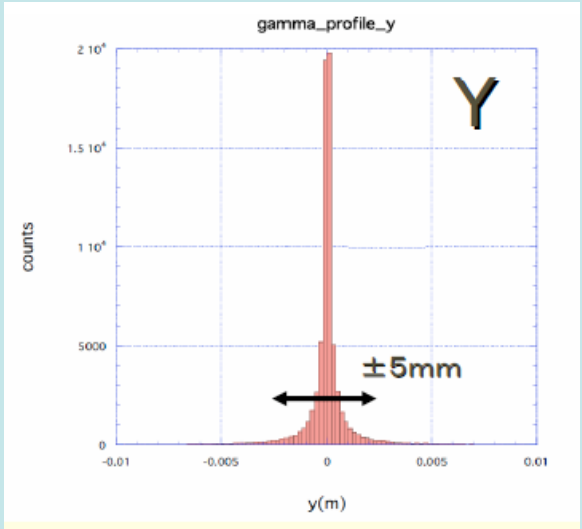
Bremsstrahlung photons are coming from HER 8 GeV e^- beam vs. residual-gas scattering.
1.6×10^5 photons/sec (3×10^{-8}Pa is assumed)

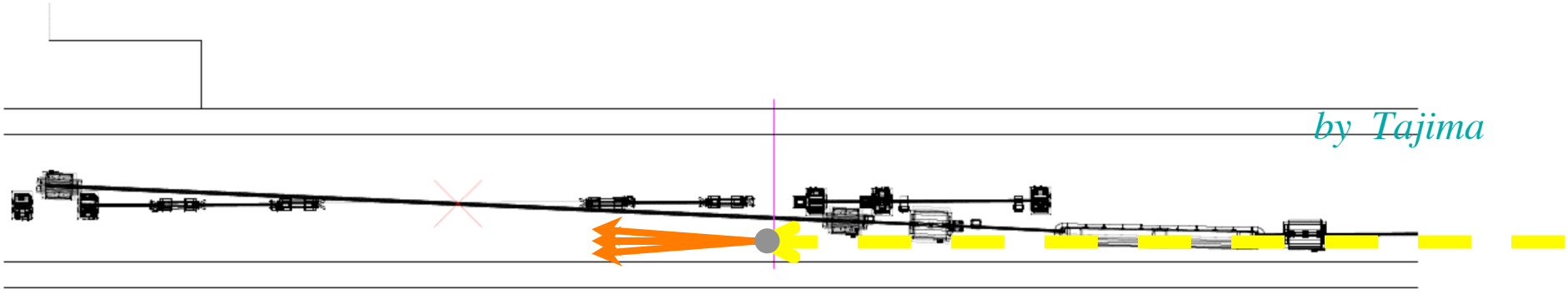
Straight section (100m)

"Turtle" simulation for Bremsstrahlung photon *by T. Higuchi*









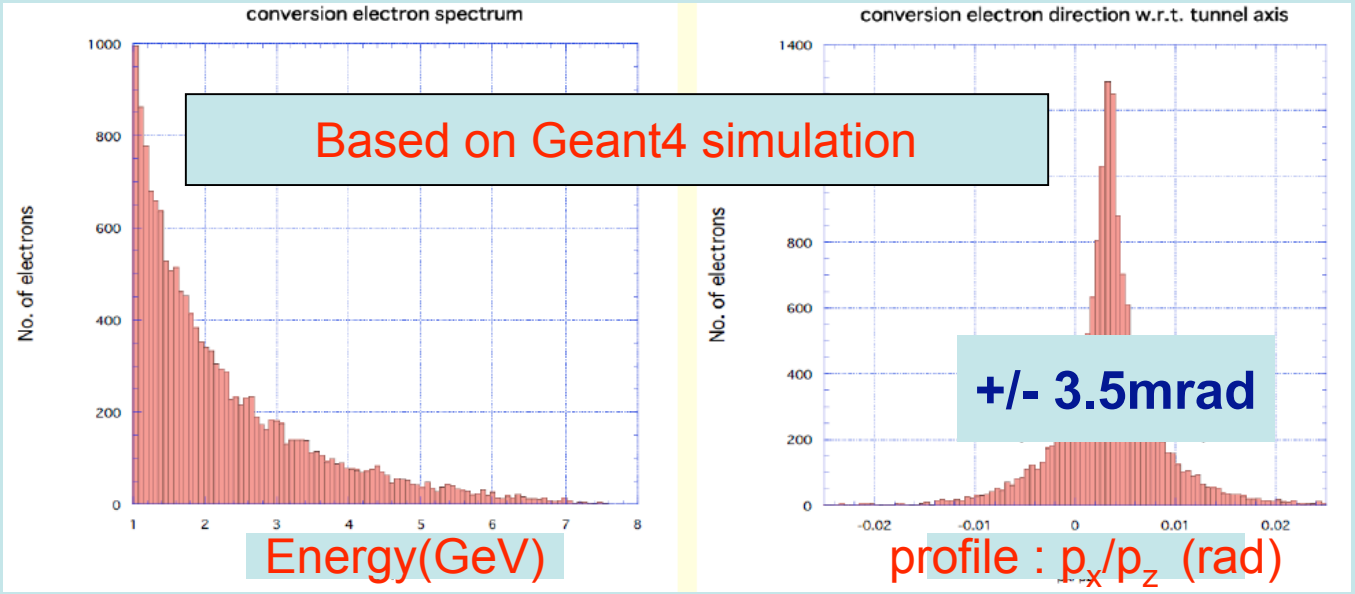
by Tajima

Brem. photons are converted to
e^- / e^+ pairs
by tungsten converter : 5mm (3mm ⇔ ~1X_0)
Sufficient electrons at a few GeV/c
with a sharp forward peak are obtained.

Straight section
(100m)

Generated electron

by T. Higuchi



KEKB Fuji Test Beam Line (FTBL)

by Tajima

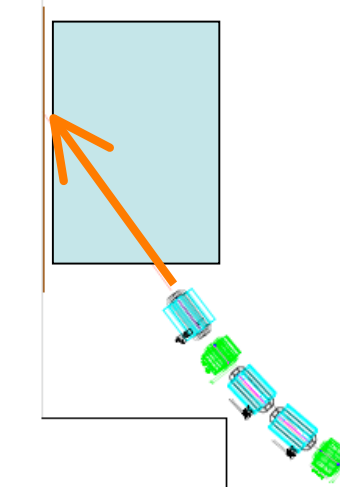
Converted electrons are extracted to outside of KEKB tunnel

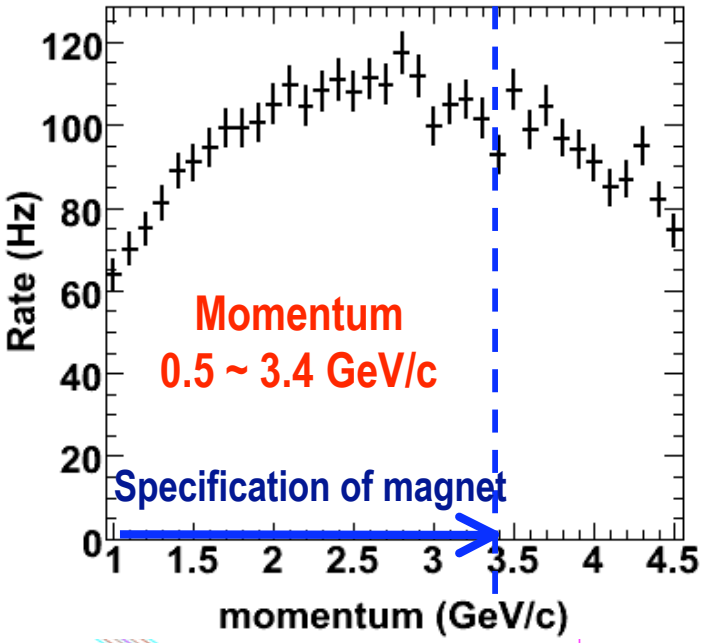
simulation

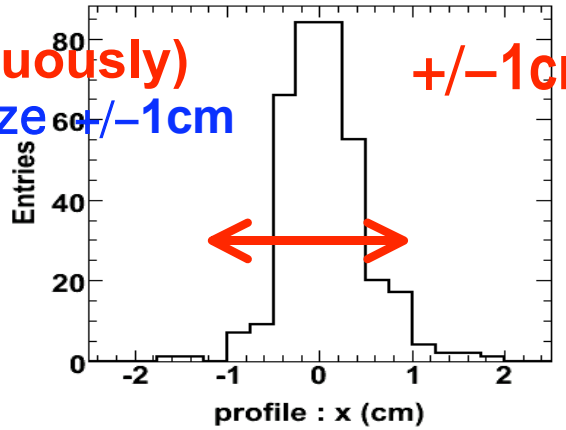
More than 100 electrons/sec (continuously)

p = 0.5 ~ 3.4 GeV/c, σ_p/p ~ 0.4%, spot size +/–1cm

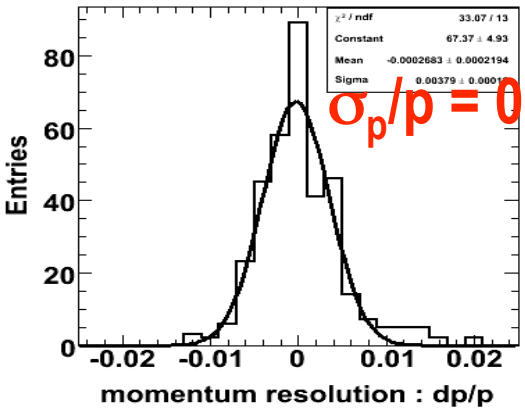
Floor for experiment (7m x 4m)



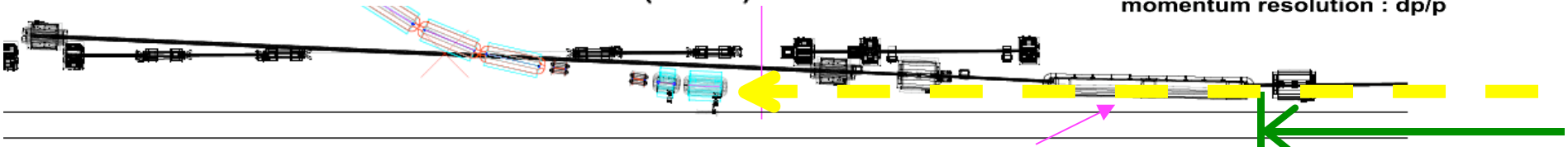




+/–1cm



σ_p/p = 0.4 %



BX1.2

Straight section (100m)

Fuji Test Beam Line : magnet parameter

The lattice was designed to make the most use of the recycled magnets and power converters to save the construction cost.

- Aperture
  - Bend aperture **width 80mm** (including sagitta 40mm)/ **height 40mm**
  - Q[1,2] **ϕ 50 mm** tr BT Q
  - Q[3,4] **ϕ 166 mm** kekB LER_Q.rf
  - hole dia. of the concrete shield **ϕ 100**
- Beam Line Parameters...

Bend	type	Max B(T)	Max I(A)	L(m)_eff	PS	W (kg)
B1L	tr wiggler L	1.2	300	1.00	**A**	3400 * with support
B1S	tr wiggler S	1.2	300	0.513	**A**	1800 *
B2	new	1.2	500	1.64	**B**	2800 ** w/o support
B3	new	1.2	500	1.64	**B**	2800
B4	new	1.2	500	1.64	**B**	2800
B5L	tr wiggler L	1.2	300	1.00	**A**	3400
B6L	tr wiggler L	1.2	300	1.00	**A**	3400
B7L	tr wiggler L	1.2	300	1.00	**A**	3400

Quad	type	Max B'	Max I(A)	L[m]_eff	Bore[m]	PS	W
Q1	tr BT Q	16 T/m	50 A	0.525	0.052	**C**	390 kg
Q2	tr BT Q	16	50	0.525	0.052	**C**	390
Q3	kekB Ler	3.79	300	0.584	0.166	**A**	2070
Q4	kekB Ler	6.32	500	0.584	0.166	**B**	2070

- PC (Power Converter)
  - Type **A**: 12 GeV PS Beam channel **300A_55V**、(WL: 29.6V、WS : 20.06V @ 300A)
  - Type **B**: 12 GeV PS Beam channel **500A_33V**、 (new : 30V @ 500A)
  - Type **C**: KEKB Vac. Group **60A_35V**
- Wall power 400V_300A (Fuji A-side)

The FTBL is like a "*roller coaster*" !

Some magnets are tilted at more than 30° to the horizontal plane.

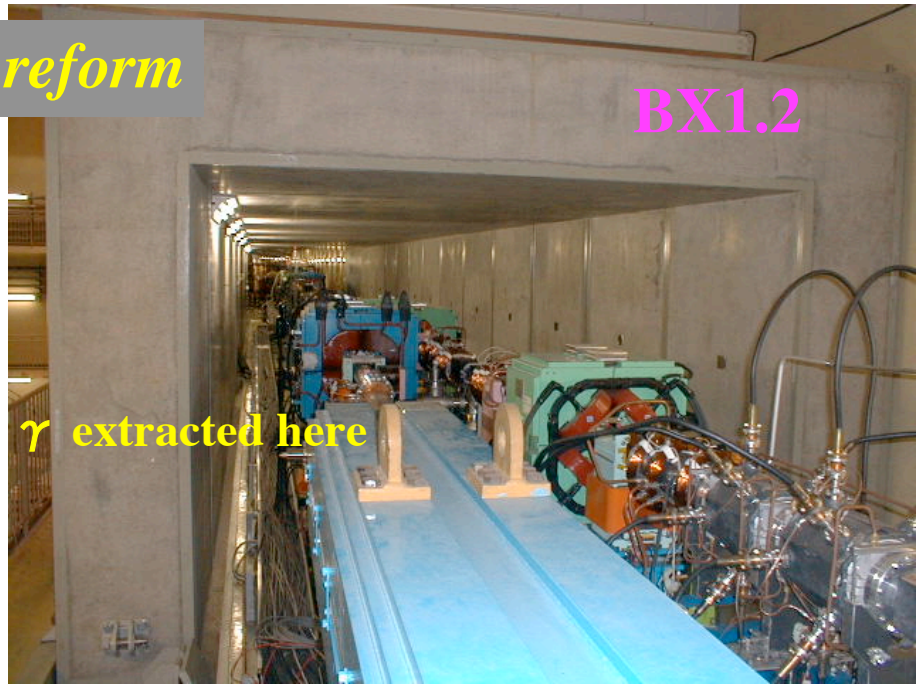
magnet rotation : θ_{rot} @ G_{xyz} = Rotate + Chi3

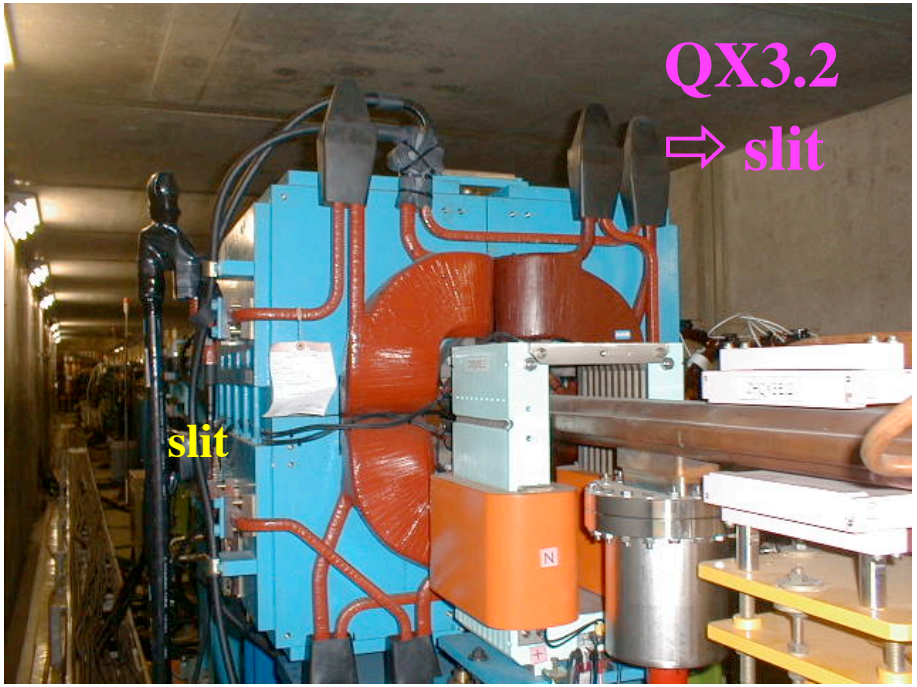
Beam Line Parameters...

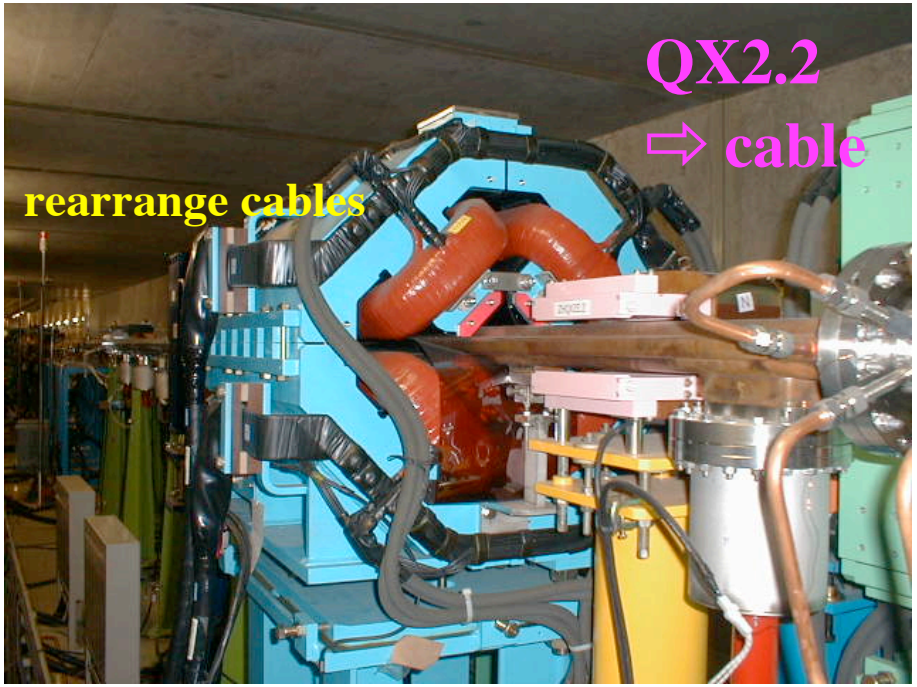
Bend	Rotate	Angle	Edge1	Edge2	Chi3
B1L	-30.246	-6.050	0.000	0.000	0.
B1S	-30.246	-3.048	0.000	0.000	0.13908
B2	-0.315	-9.706	0.000	0.000	0.3147
B3	-1.087	-9.706	0.000	0.000	1.0865
B4	-1.847	-9.706	0.000	0.000	1.8473
B5L	-2.597	-6.471	0.000	0.000	2.5970
B6L	-3.091	-6.471	0.000	0.000	3.0910
B7L	38.173	-6.471	0.000	0.000	3.5818

Quad	Rotate	K1[m^-1]	L[m]	Bore[m]	
Q1	-59.511	-0.515	0.525	0.050	0.3147
Q2	-54.202	0.365	0.525	0.050	0.3147
Q3	-59.712	-0.194	0.584	0.166	2.5970
Q4	-31.486	0.222	0.584	0.166	3.5818

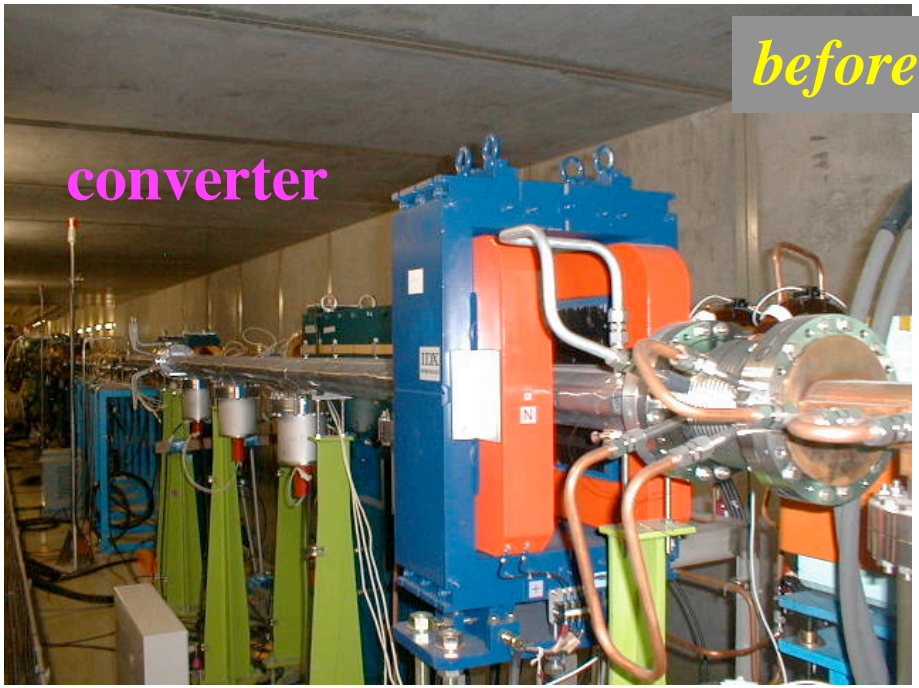
before reform

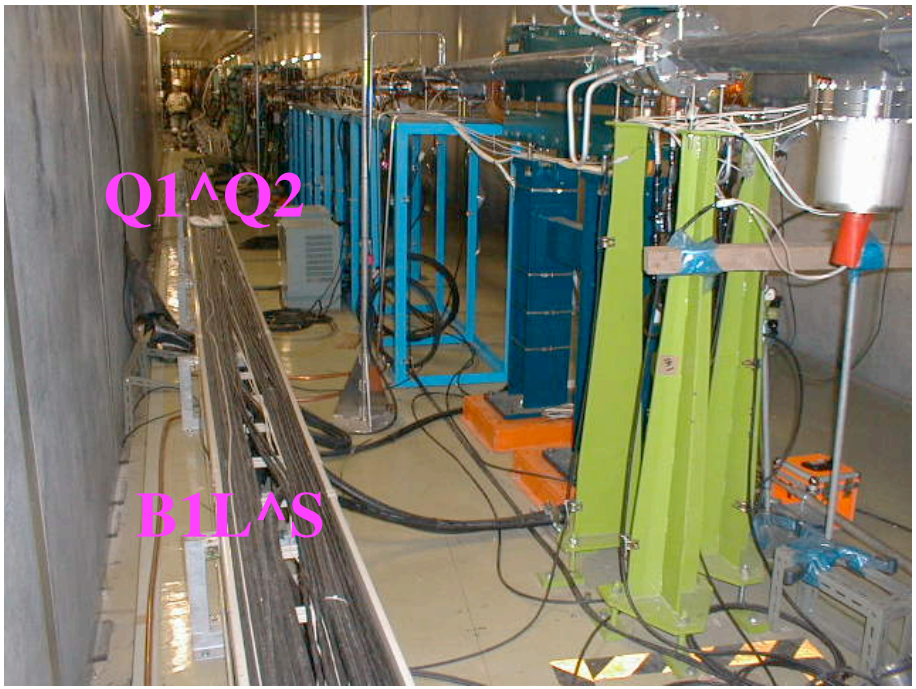




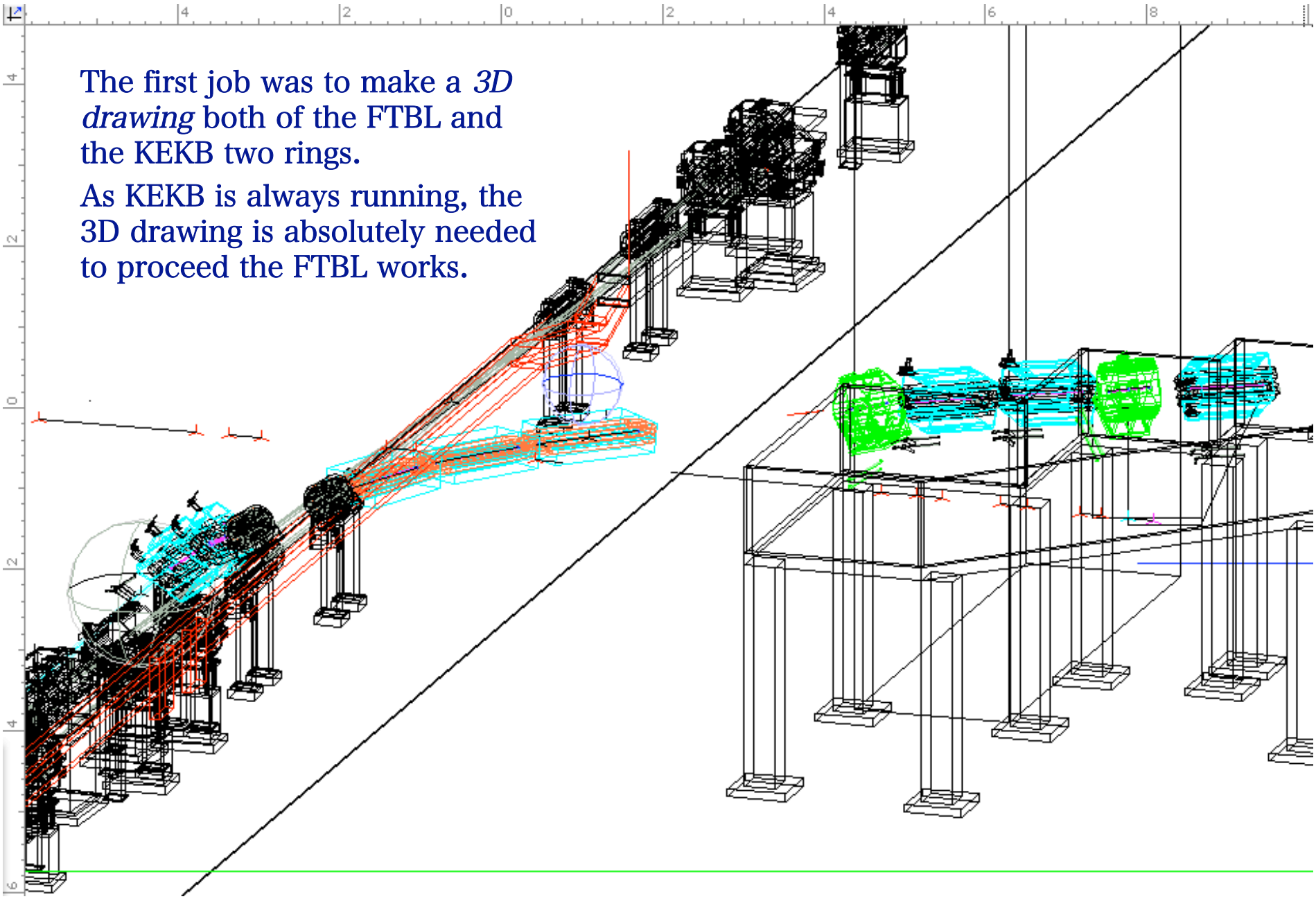


before reform





vw_3d


The first job was to make a *3D drawing* both of the FTBL and the KEKB two rings.
As KEKB is always running, the 3D drawing is absolutely needed to proceed the FTBL works.

Hardware Preparation

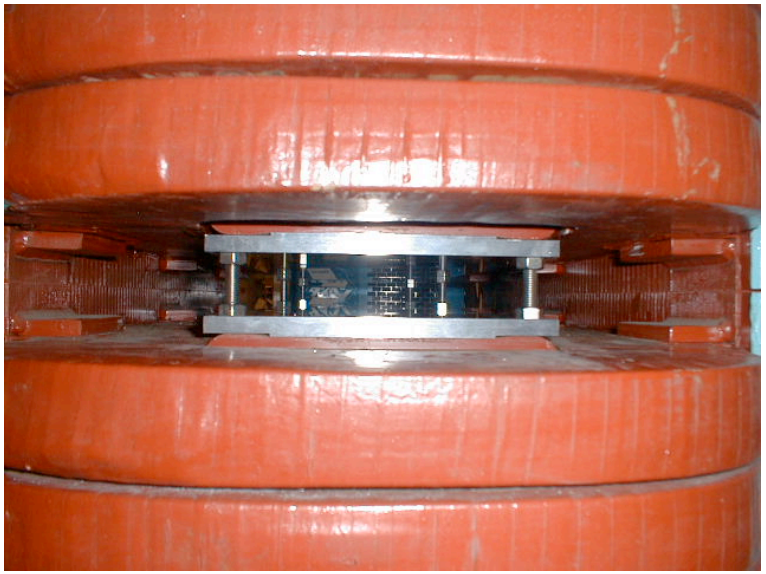
Vacuum Duct

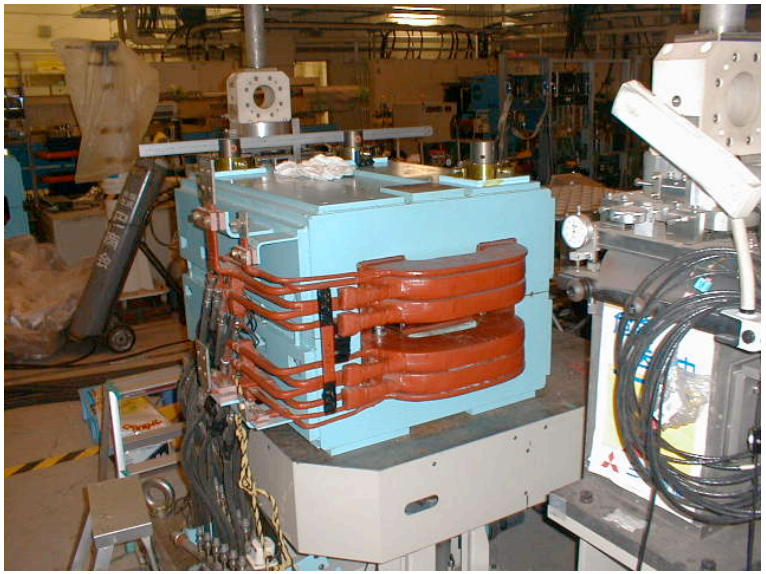
- The **new vacuum duct** was fabricated for the **extraction**.

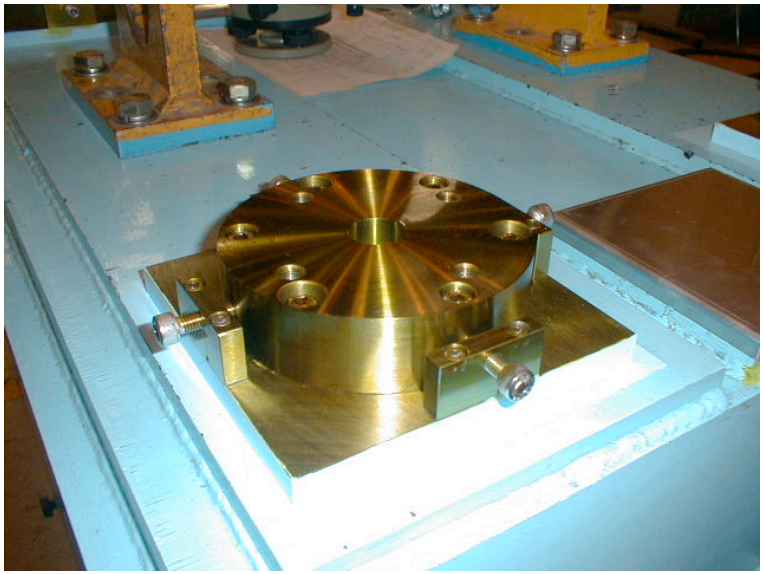
Magnets

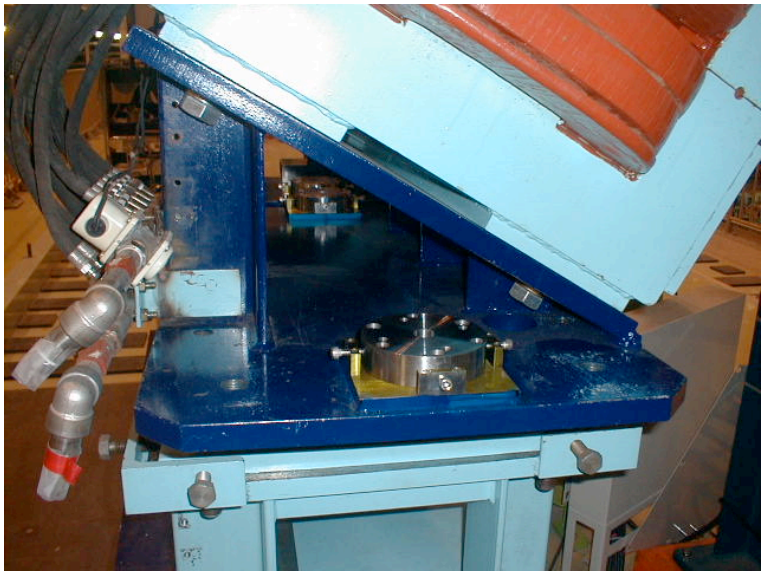
- The lattice was designed to make the most use of *the **retired Tristan magnets and KEKB spairs*** to save the construction cost.
- The FTBL design, like a ***"roller coaster"***, was fixed.
- Design and fabricate the **new 3 dipoles** (**B2, 3 and 4**)
- Reform the TRISTAN magnets and the KEKB spares
  - TR Wiggler （WL：4、 WS：1）
  - TR BT Q ： Q1, Q2
  - KEKB LER Q.rf ： Q3, Q4
  - reduce the gap of the TR wigglers **64mm → 40mm**
  - add **new surveying bases for the laser tracker**
  - design and fabricate **a tilted and sloped support** for each magnet
  - put the surveying bases on the supports
- Power converter： reuse the old power converters used at 12 GeV PS beam channel.
- Power cabling, cooling water

modify *the recycled TR wigglers*

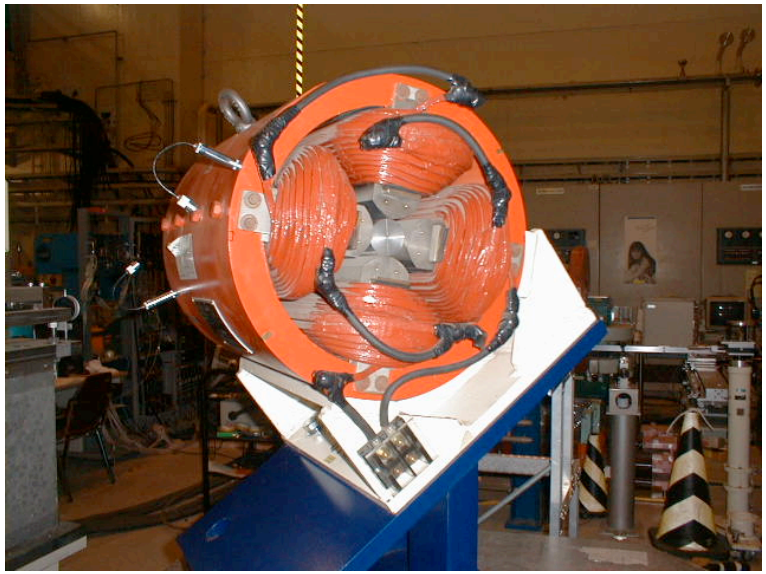




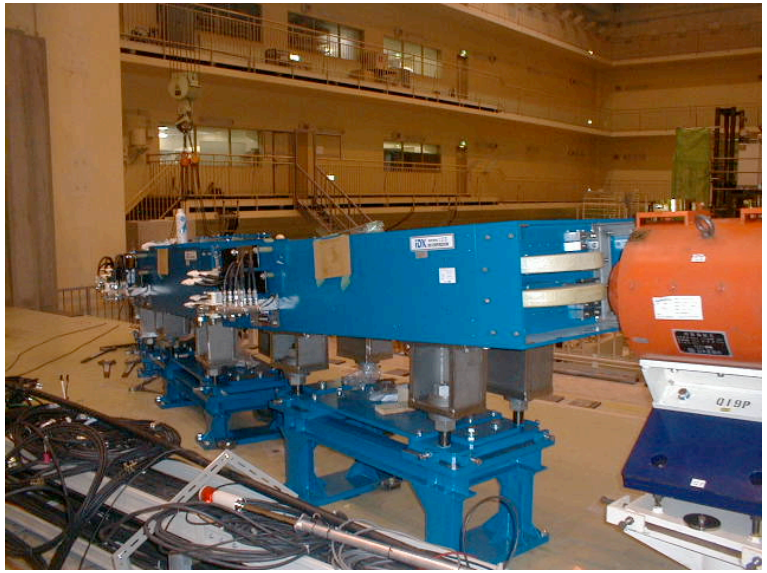


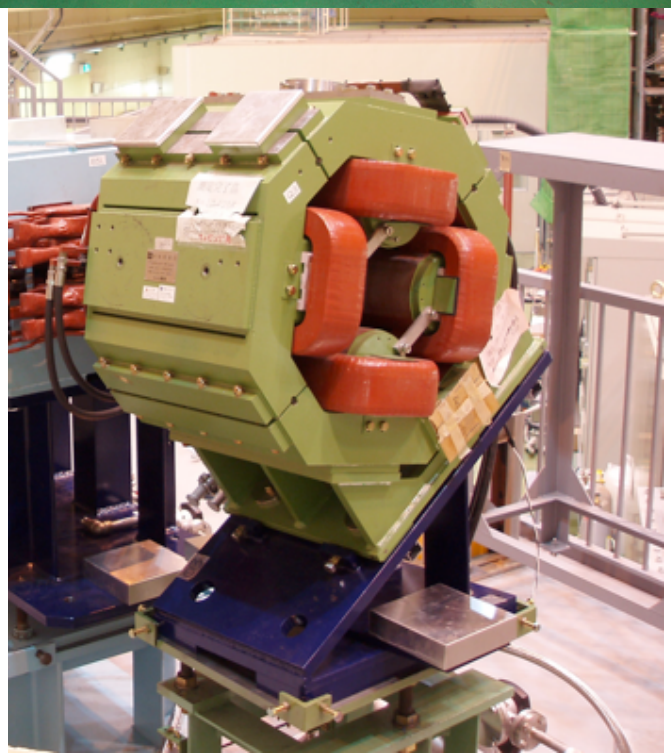


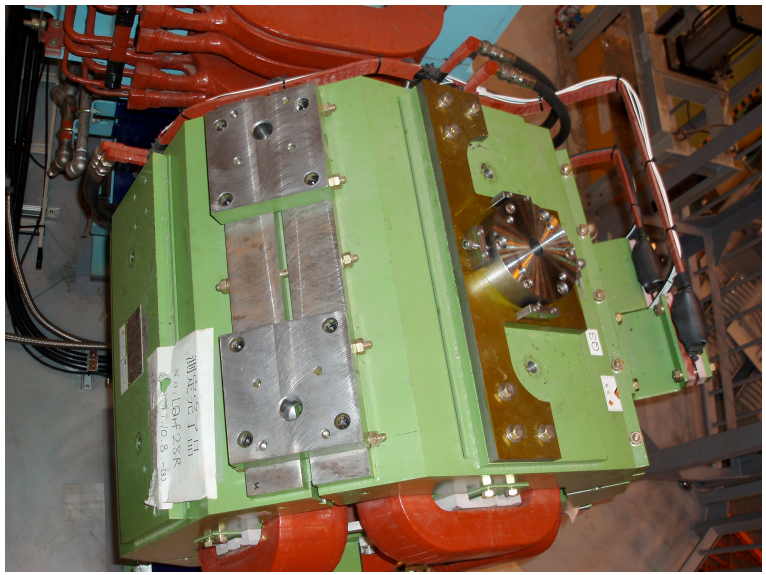
On the new supports



new dipoles & LER Q.rf





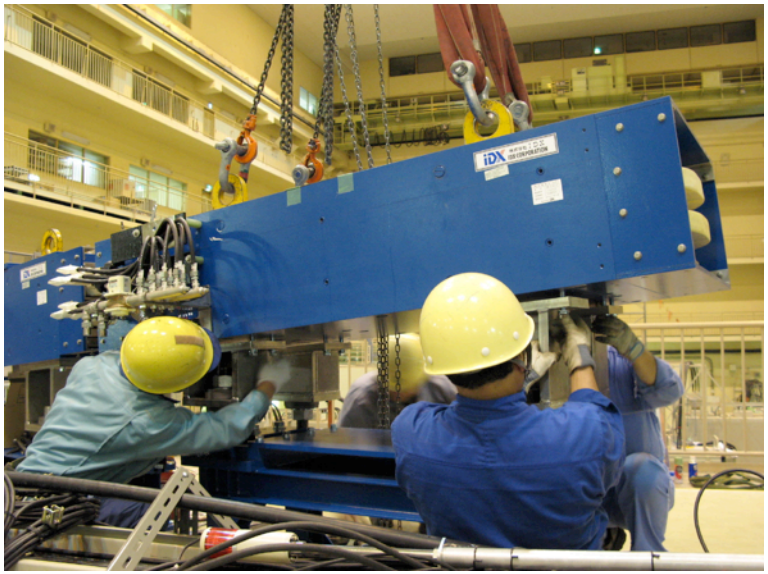


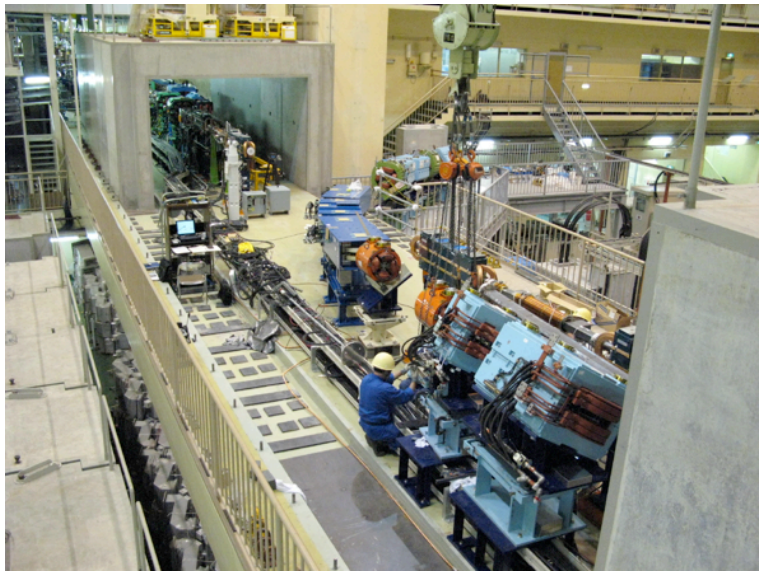
The old power converters were fixed and returned to work.

Installation & Alignment

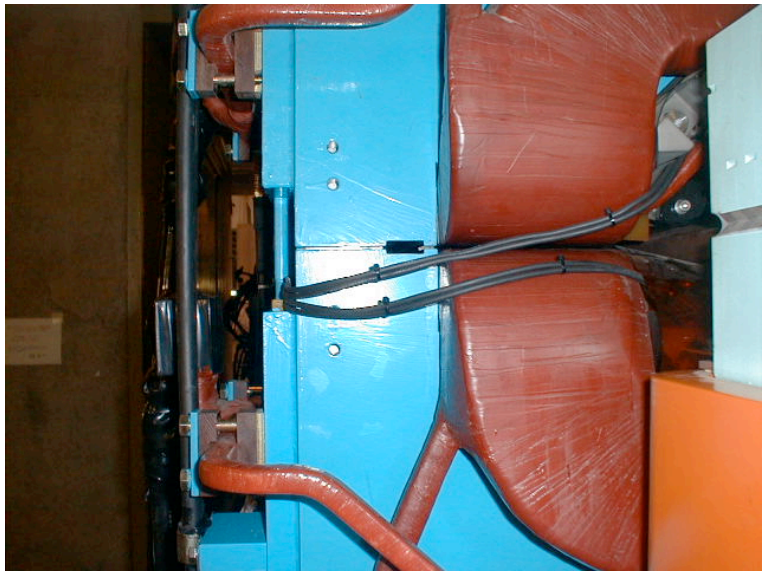
- 3D drawing of the FTBL with the KEKB two rings
- 3D alignment is absolutely needed.
- → Laser tracker is used.
- coordinate system
  - KEKB coordinate
  - laser tracker coordinate
  - magnet coordinate
- process
  - mark off the FTBL beam line on the tunnel floor
  - pre-alignment
    - ✓ 3D measure of the newly added surveying bases
    - ✓ confirm each magnet can be adjusted as the FTBL lattice specification
  - installation
  - survey several KEKB ring magnets to configure the coordinate system
  - survey the FTBL magnets

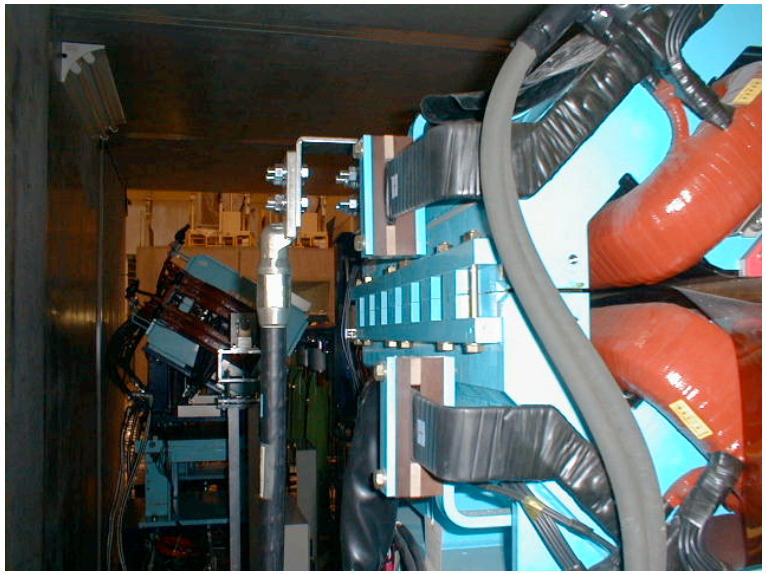
installation

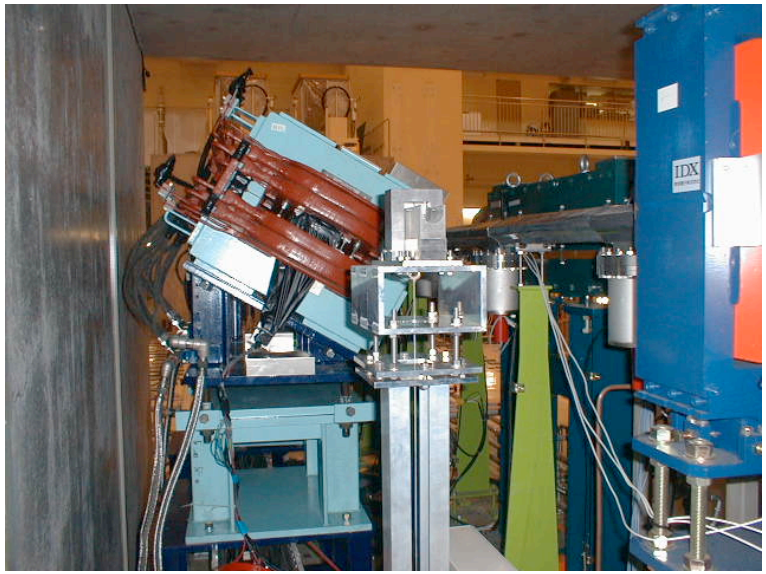


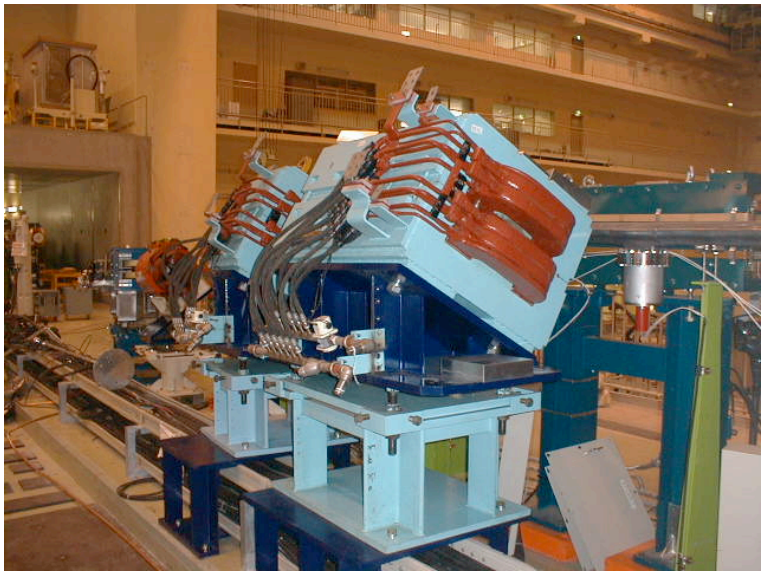


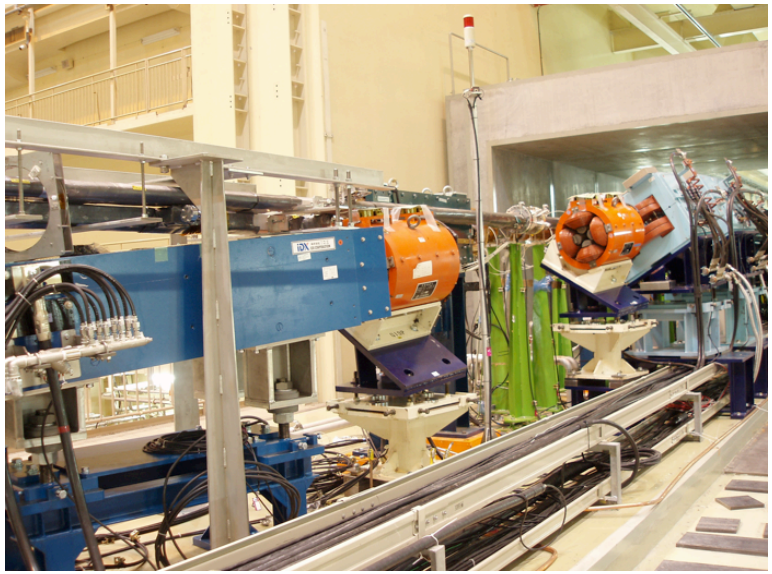
after reform

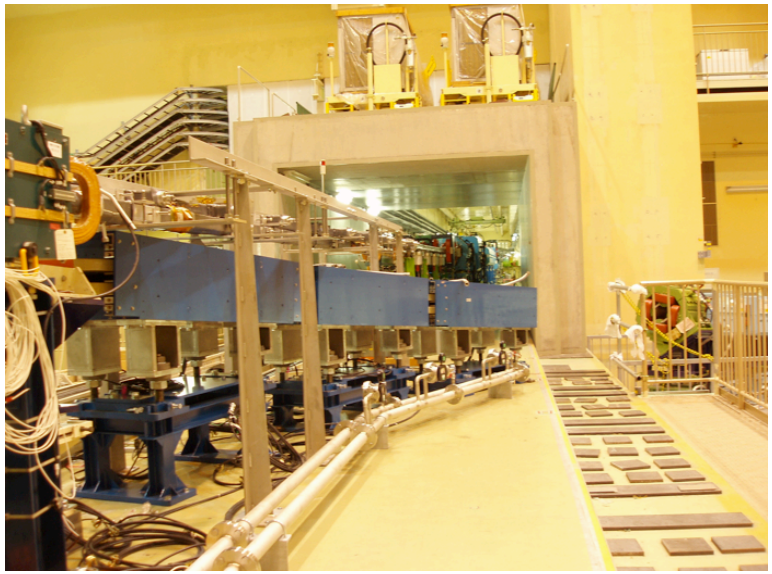




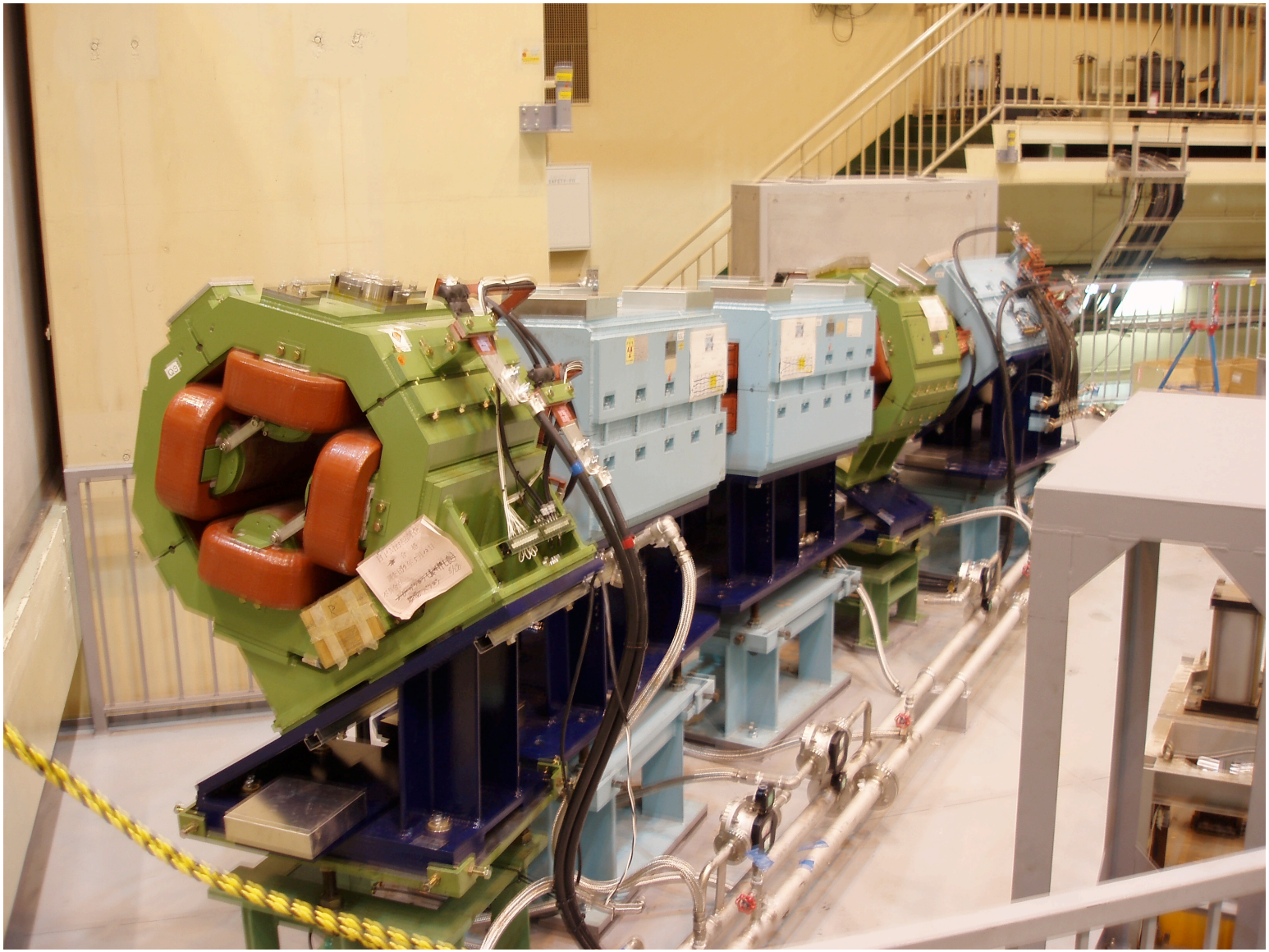








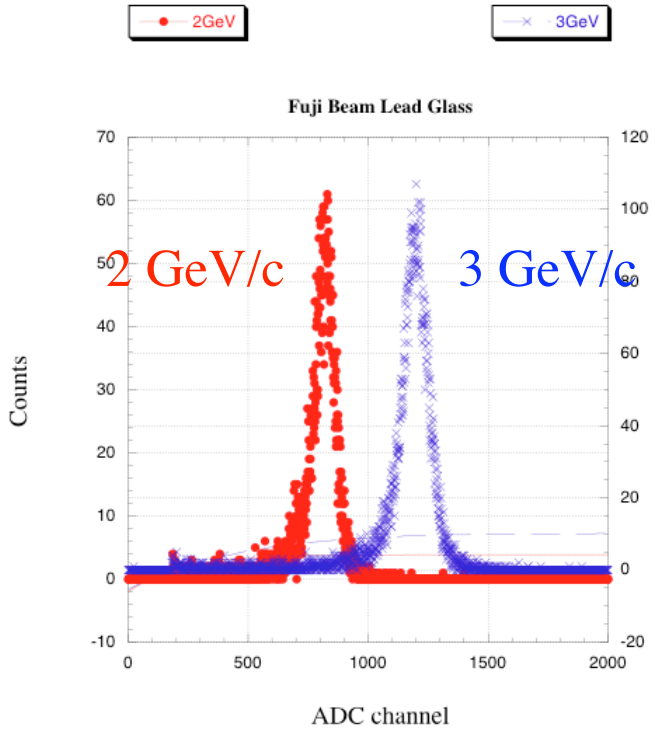
On the stage

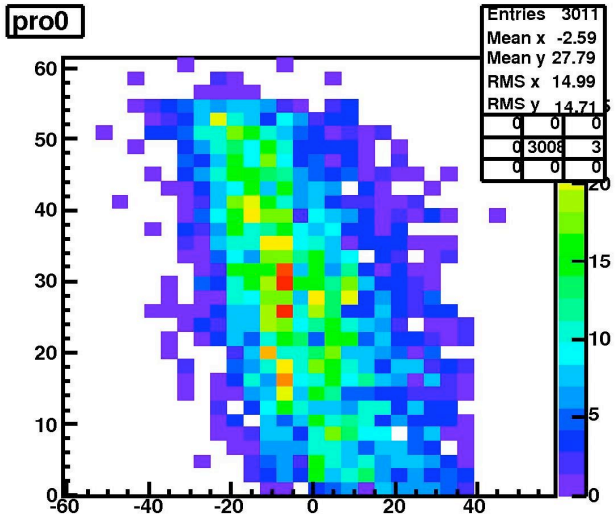


The FTBL overall view

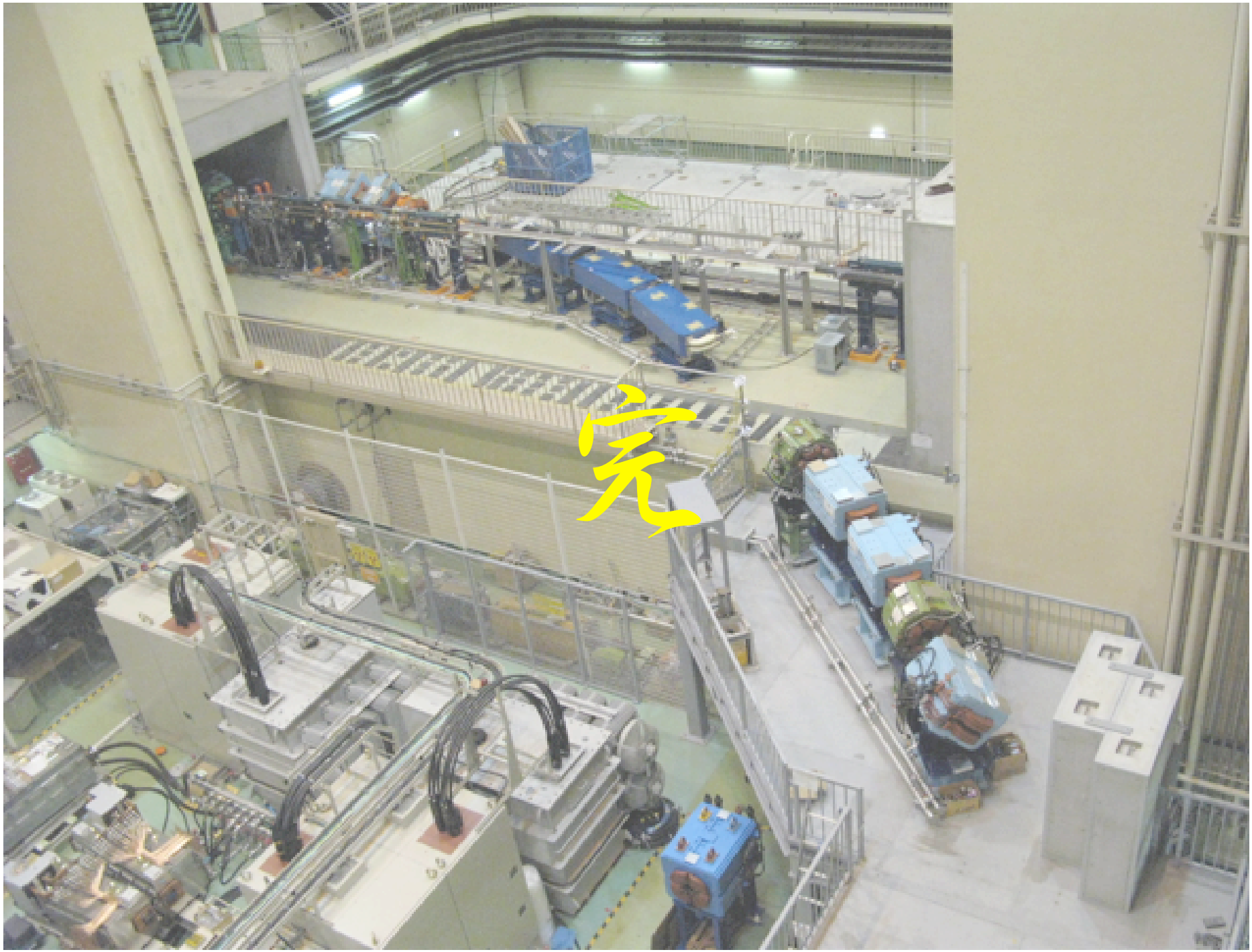
Commissioning

- Soon after the KEKB operation started in October 2007, the first test beam was observed to pass through the FTBL successfully on October 12th.
- The FTBL magnet leakage field affects the KEKB operation. → The shields against the leakage field have been improved.
- The test use of FTBL has started. Further FTBL commissioning will be continued.





beam profile @ the target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