

A new 3-axes magnetic field measurement system based on the Hall elements

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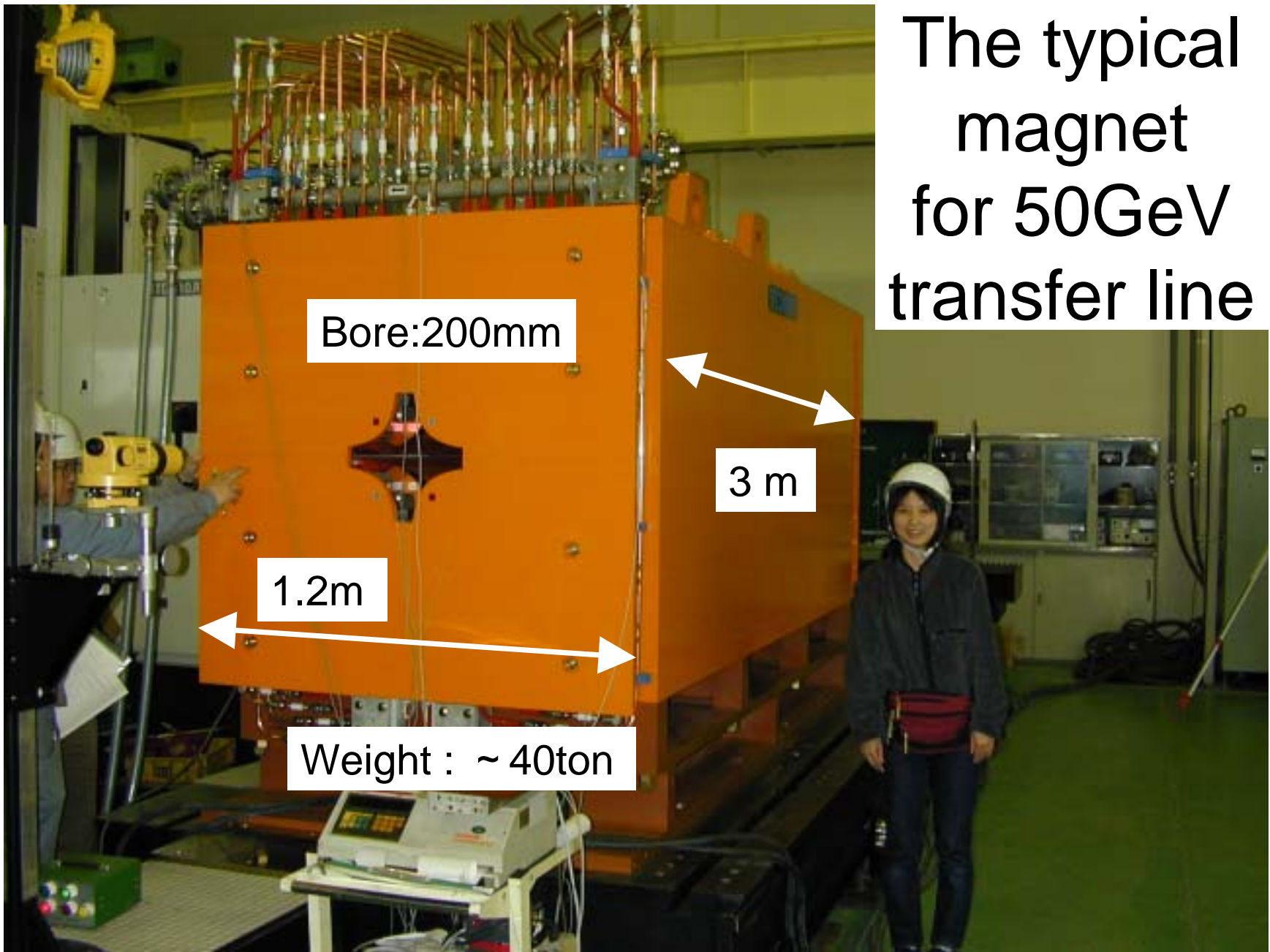
The typical
magnet
for 50GeV
transfer line

Bore:200mm

3 m

1.2m

Weight : ~ 40ton



The new 3-axes magnetic field measurement system

The Auto-level unit

The mechanics for moving rod

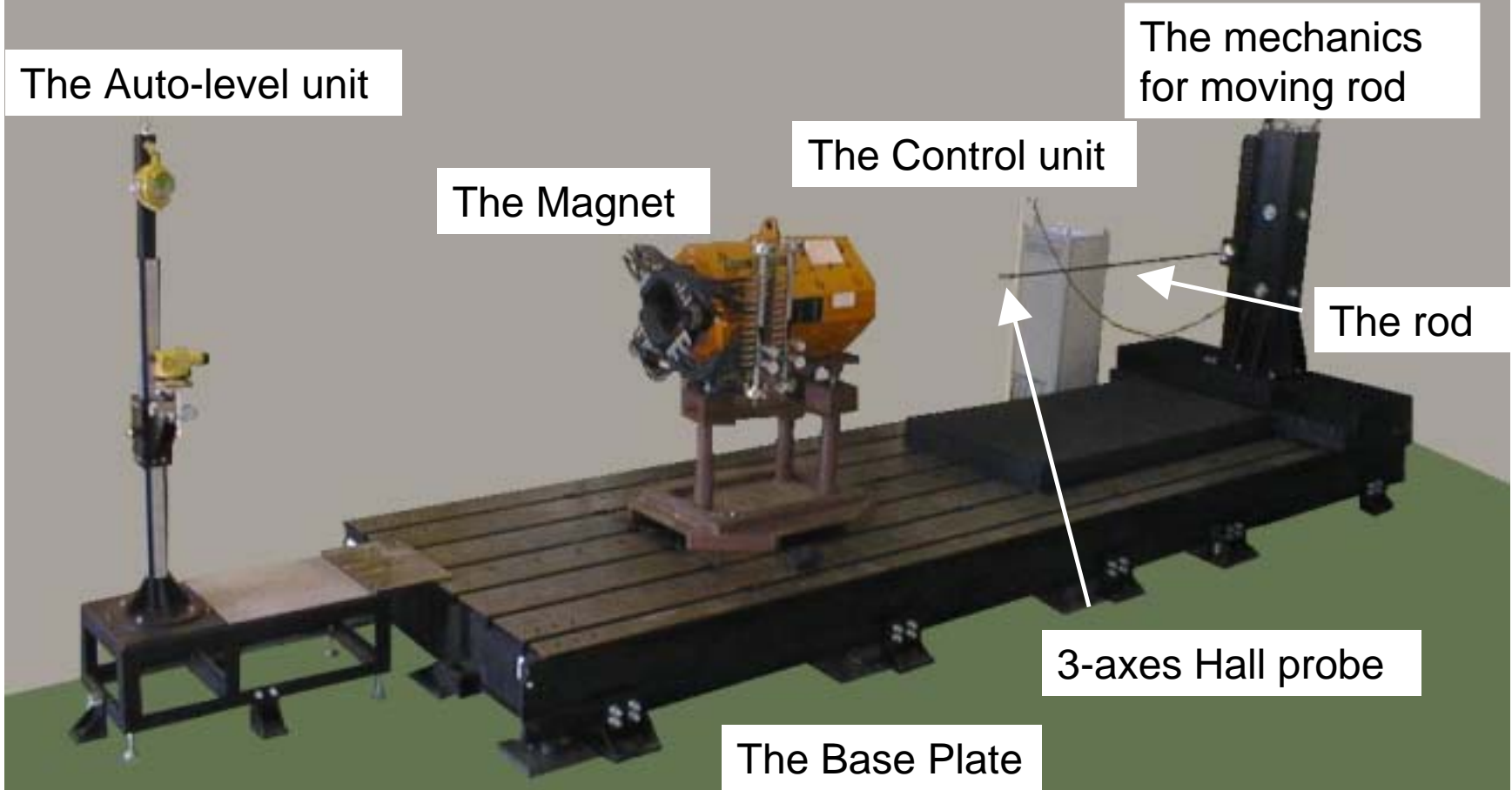
The Control unit

The Magnet

The rod

3-axes Hall probe

The Base Plate



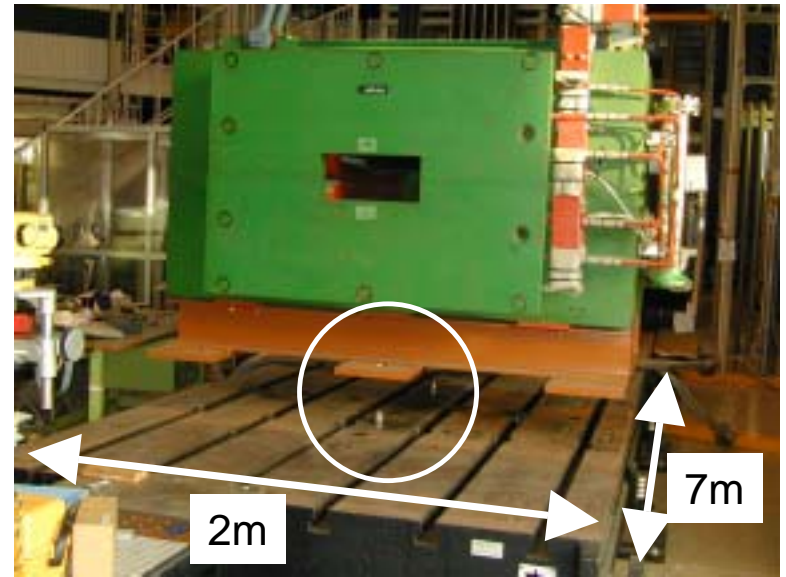
The Base Plate

7m long 2m wide iron base.

The base level stability is within 0.1mm against the magnet weight 40 ton.



The base plate supports prepared on the floor, which were fixed by anchor bolts.



Pivots fitting on the base

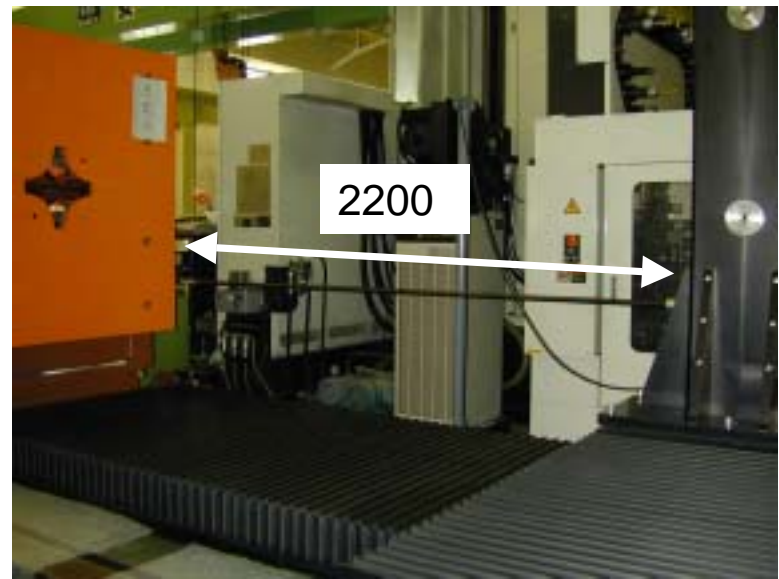
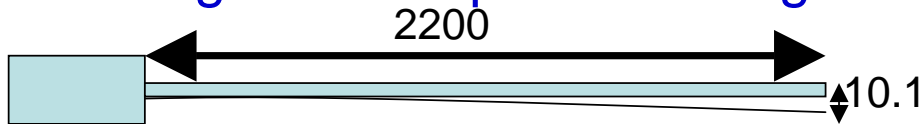
The rod

Material : carbon fiber composite

Diameter : 20mm

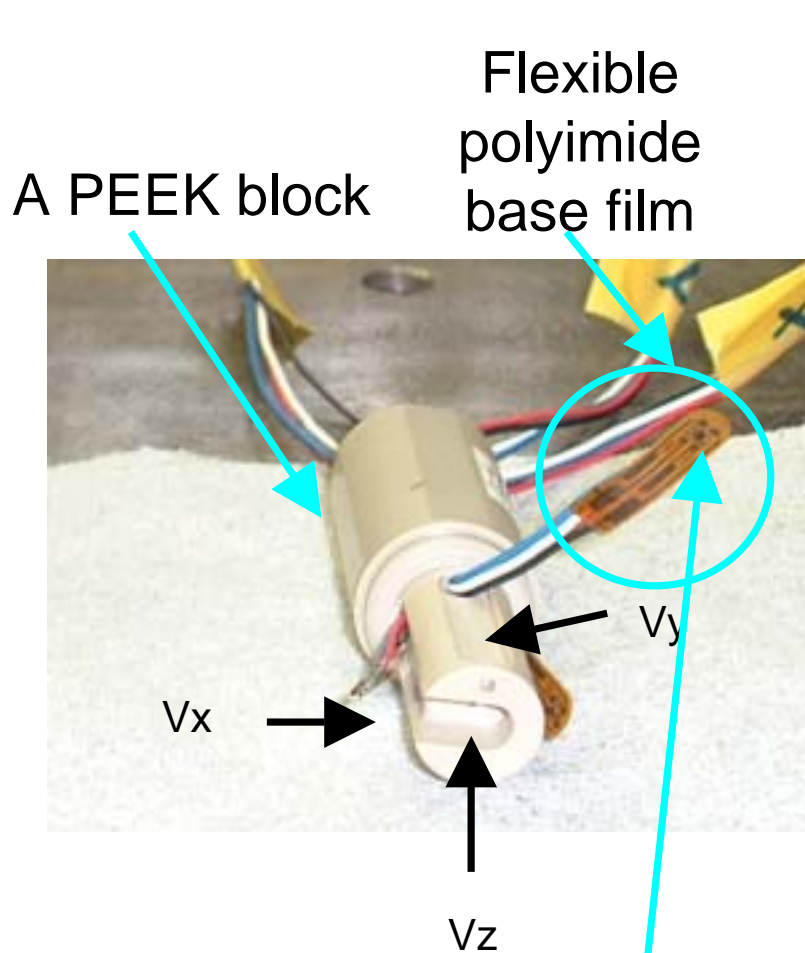
Thickness : 2mm

The weight of Hall probe : < 50g

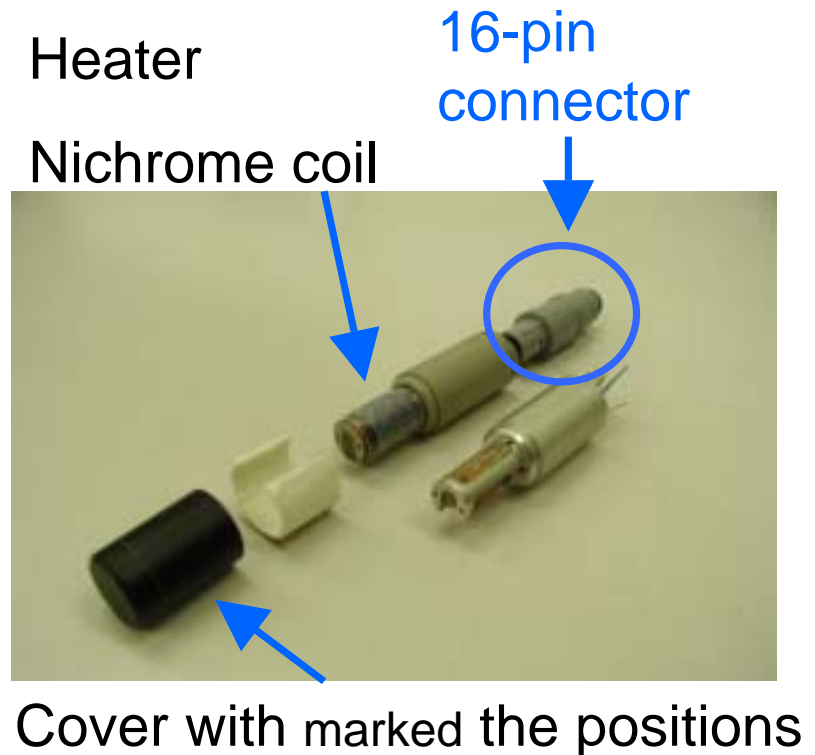


Quantity of deflection [mm]		Measuring position from the part of support [mm]			
		700	1200	1700	2200
The rod length [mm]	1200	0.7	1.9		
	1700	1.0	2.4	3.8	
	2200	1.8	4.4	7.2	10.1

The Hall Sensor unit

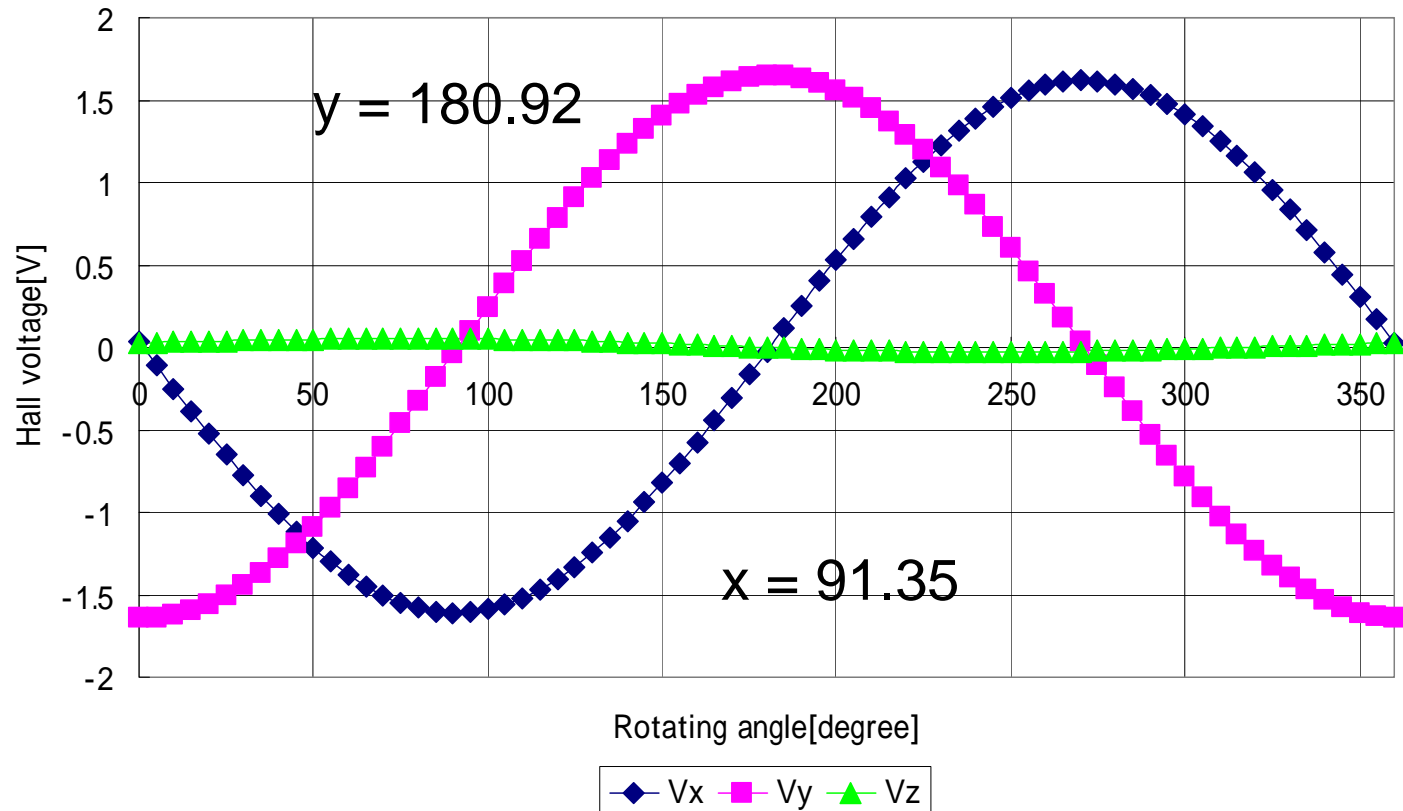


1-axis Hall elements : National OH008



The measured temperature coefficient of Hall elements :
-0.075%/degree

The angler resolution of a 3-axes Hall probe



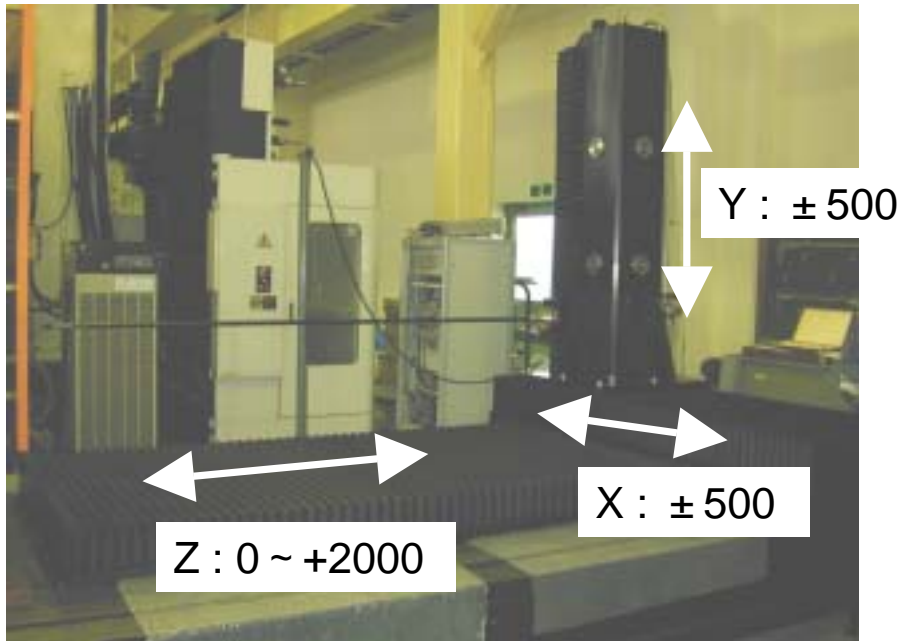
Measured angle between X and Y Hall elements : 89'34''

Operating the Hall elements and data taking



- Current supply
 - Operating current : 6mA
 - Stability : $\pm 0.02\%$
- Temperature controller
 - 60 ± 0.01
 - The error by temperature : about 0.15mTesla for 2Tesla
- Heater power supply
- Switching digital voltmeter
 - Hall voltage of each axis
 - Current of Magnet power supply
 - Interfaced to the PC via GP-IB

The mechanics for moving rod

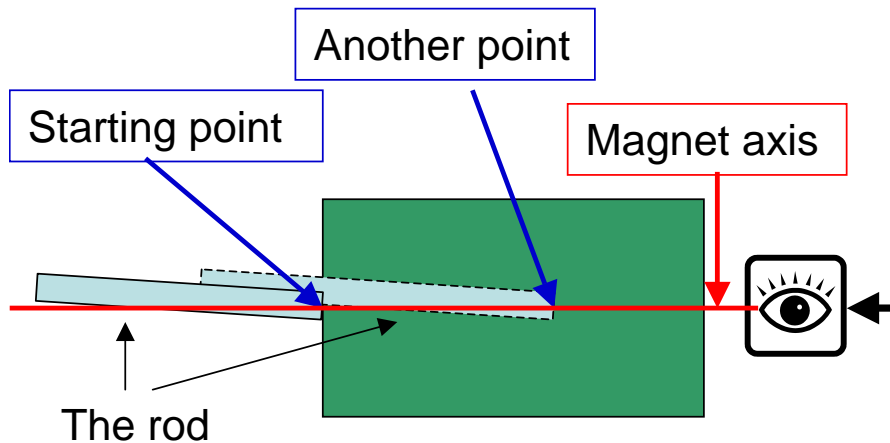


The control unit



- They moved by servo motors via PCI motor control board
- The accuracy of the positions : within 0.1mm
- The rod can be moved through the axis step by step
- The motion speed is controlled to be slow start/slow stop manner
- interval distance=5mm (movement time:2.3sec, waiting time for stopping the rod oscillation :1sec)

Adjusting the rod axis and magnet axis



Remote control unit and Auto-level unit

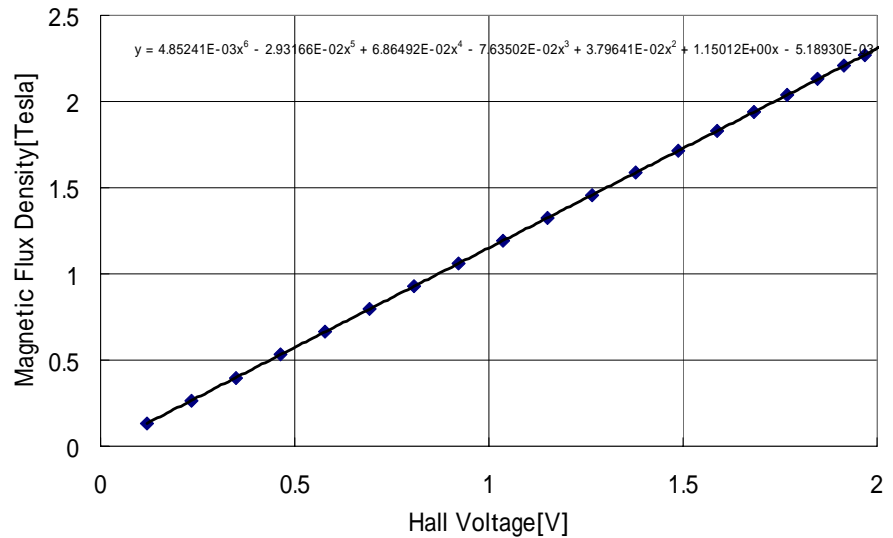
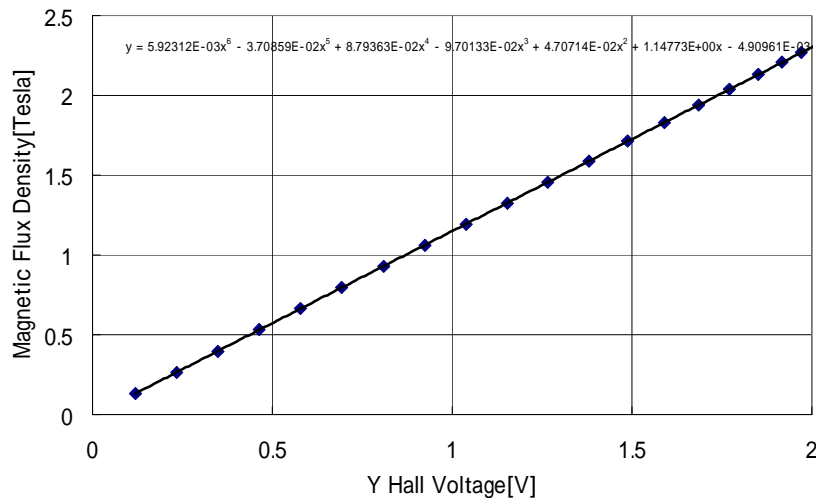
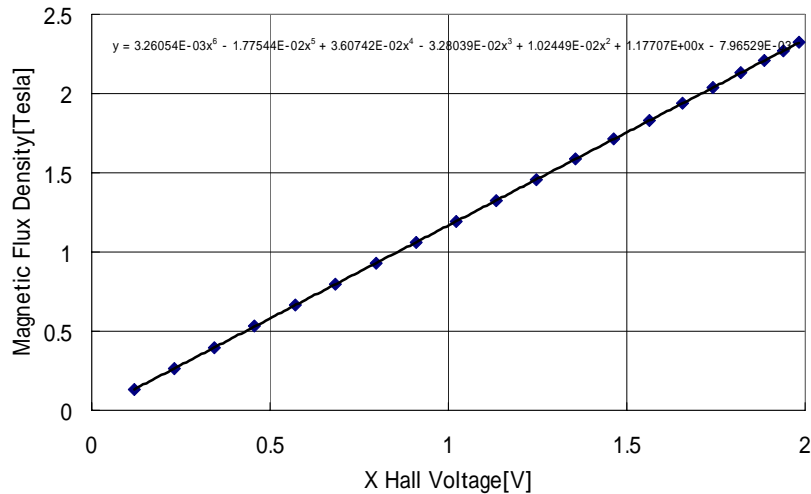
Given the starting point and another point on the magnet axis, the field measurement points on the magnet coordinate can automatically be calculated and positioned in software way.

The operating monitor

The screenshot displays the 'Magnetic Field Measurement Machine Operation Screen' (磁場測定機 操作画面). The interface includes several sections for user input and machine status:

- Power supply:** Controls for '電磁石電源制御' (Electromagnet power control), including '電流指令値' (Current command value) in [A], 'フィードバック' (Feedback) in [A], and [V], with '電源ON' (Power ON) and '電源OFF' (Power OFF) buttons.
- Position:** A section for '実測座標' (Actual coordinates) and '機械座標' (Mechanical coordinates) for X, Y, and Z axes, with values in mm.
- Hall Voltage:** Input fields for 'X方向' (X direction), 'Y方向' (Y direction), and 'Z方向' (Z direction) in [V] and [Gauss].
- Define the starting point:** Input fields for 'X軸 開始点' (X-axis start point), 'Y軸 開始点' (Y-axis start point), and 'Z軸 開始点' (Z-axis start point) in mm.
- Waiting time:** A field for '待ち時間' (Waiting time) in sec, with a value of 1.
- Interval distance > 1mm:** A field for 'ピッチ送り量' (Pitch feed amount) in mm, with a value of 5.
- Define the final point:** Input fields for 'X軸 終了点' (X-axis end point), 'Y軸 終了点' (Y-axis end point), and 'Z軸 終了点' (Z-axis end point) in mm, with a '終了点決定' (End point decision) button.
- Date:** A field showing '2003年10月12日' (October 12, 2003).
- Filename:** A field for the filename, currently empty.
- Machine Status:** Fields for '現在動作' (Current operation) and 'リミット' (Limit) with '状態表示' (Status display) buttons.
- User Settings Parameters:** A section for 'ユーザー設定パラメータ' (User setting parameters) including '全長' (Total length) in mm, '現在値' (Current value) in mm, and 'pulse' settings for X, Y, and Z axes.
- 3-axis Measurement Control:** A section for '3軸計測制御' (3-axis measurement control) with buttons for 'X, Y, Z方向' (X, Y, Z direction), 'ピッチ送り測定開始' (Pitch feed measurement start), '励磁特性測定開始' (Magnetization characteristic measurement start), and '励磁特性測定停止' (Magnetization characteristic measurement stop).
- Operation Modes:** Buttons for 'JOG運転モード' (JOG operation mode) and 'PTP運転モード' (PTP operation mode), with '有効' (Valid) and '無効' (Invalid) status indicators.
- Stop Operation:** A 'ストップ' (Stop) button.

Calibration



- A dipole magnet (max flux density = 2.2 Tesla) was used for calibration of Hall probe
- Absolute flux density was measured by NMR at the same time
- The error of fitting is estimated within 3 Gauss at whole measurement range.

Conclusion

- A new 3-axes magnetic field measurement system based on the Hall elements has been constructed at KEK
- We can align the measuring machine and the magnet at the accuracy within 0.1 in total by simply putting the magnet on the base
- The field measurement points on the magnet coordinates can automatically be calculated and positioned in software way
- 3 Hall elements could be mounted in one sensor unit and the angle between X and Y Hall elements is 89'34''
- The temperature of Hall elements can be controlled within 60 \pm 0.1 degree
- The deflection of rod was less than 10mm for 2200 mm carbon rod length
- We have successfully measured the field of the Q-magnet, whose bore diameter and length are 200mm and 3m