An instrument for precision magnetic measurements of large magnetic structures

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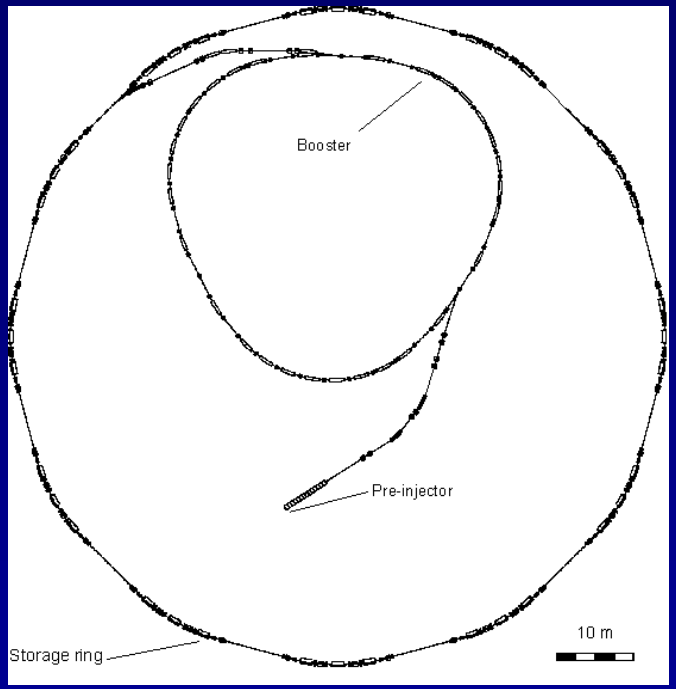
Outline

- Introduction
- Design requirements
- System description
- Performance
- Real examples
- Conclusions

Introduction

LLS (Spanish synchrotron light source) at Barcelona



Characterize B in Bending, Quadrupolar and higher order magnets

Design requirements

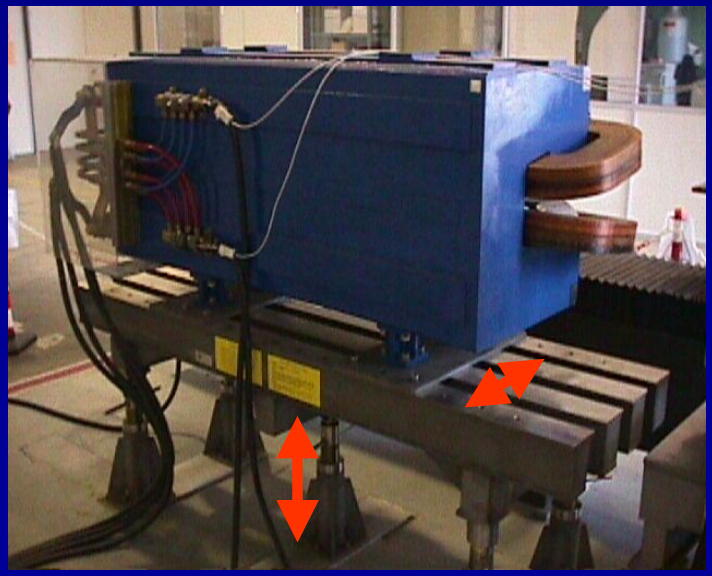
- $\Delta B < \pm 2$ Gauss ($B < 1.4$ T)
- Scan a Volume 500 x 250 x 3000 mm^3
- Position confusion $< \pm 50$ μm
- Hall probe motion re-programmable

System overview

System mechanics (I)

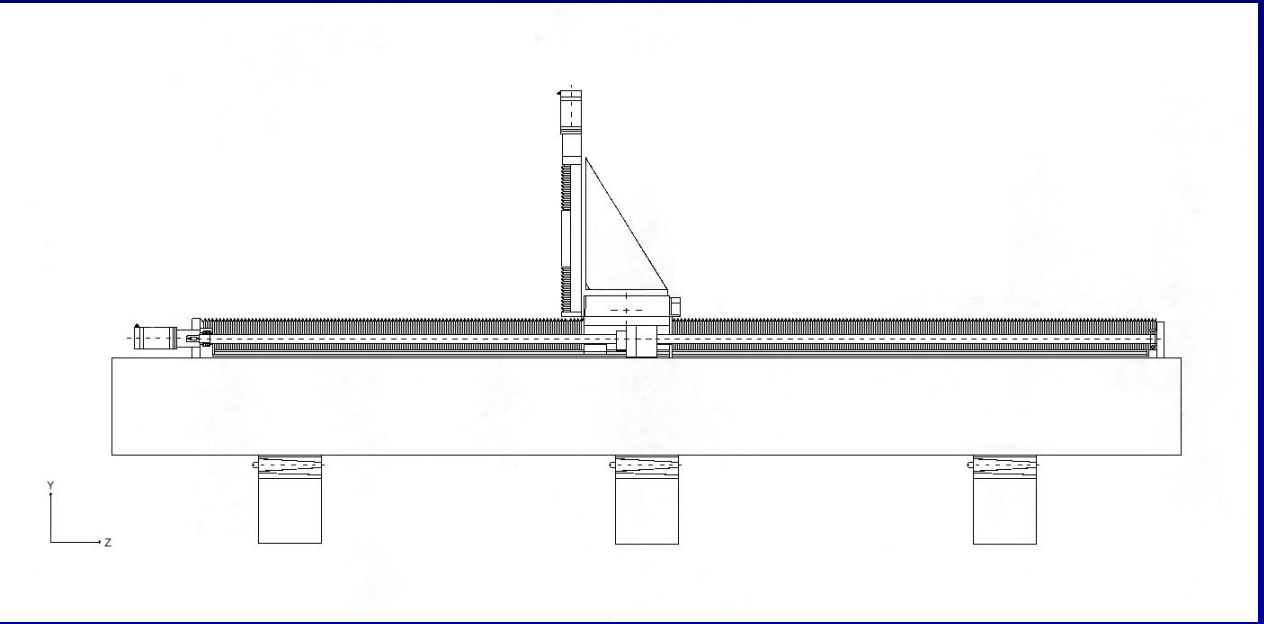
- Anti-vibration floor (50μm)

- Magnet support (6000 Kg)



System mechanics (II)

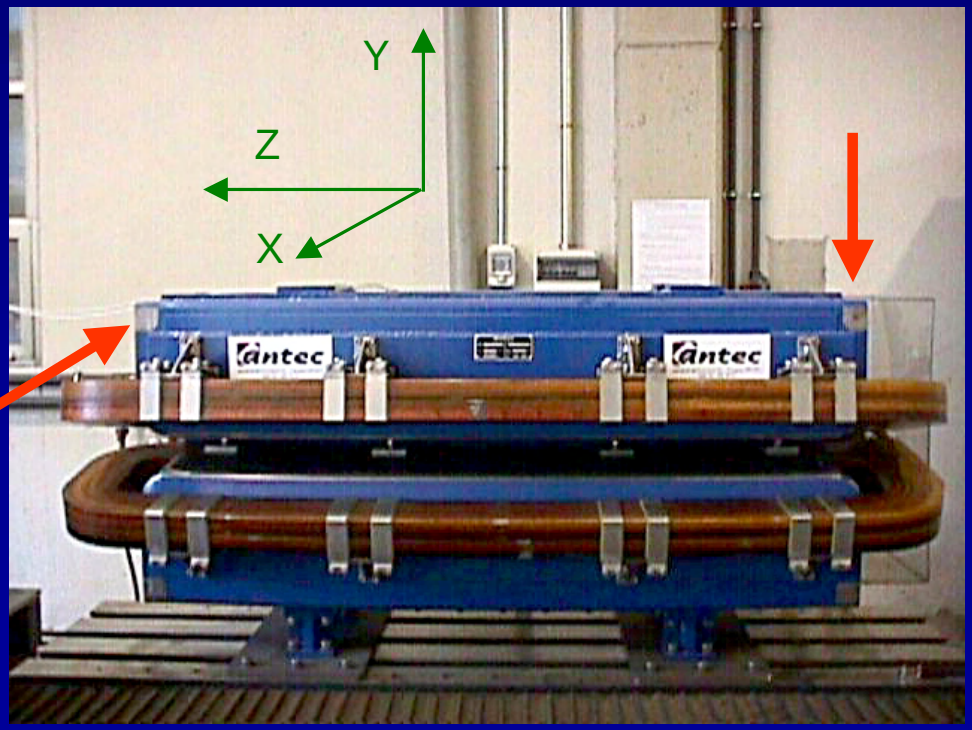
- **Hall probe bench (500x250x3000 mm^3)**



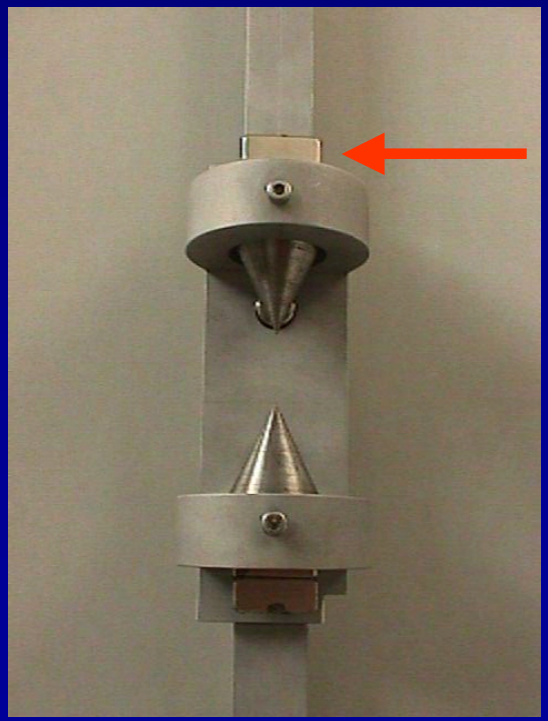
Mechanical alignment

Reference magnet mechanical center to arm coordinate system

1. Parallelism magnet-bench



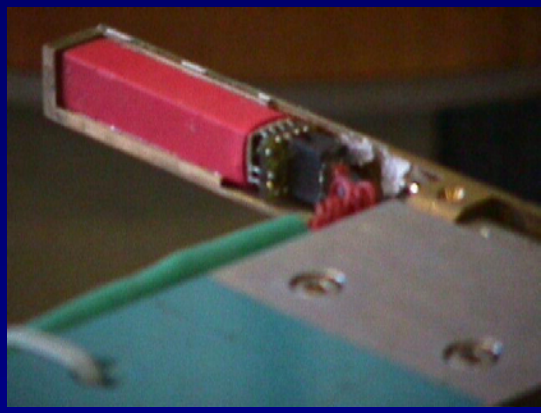
2. Translation vector magnetic struc.-bench



Electronics and controls (I)

- Hall probe → Manufactured by Sentron

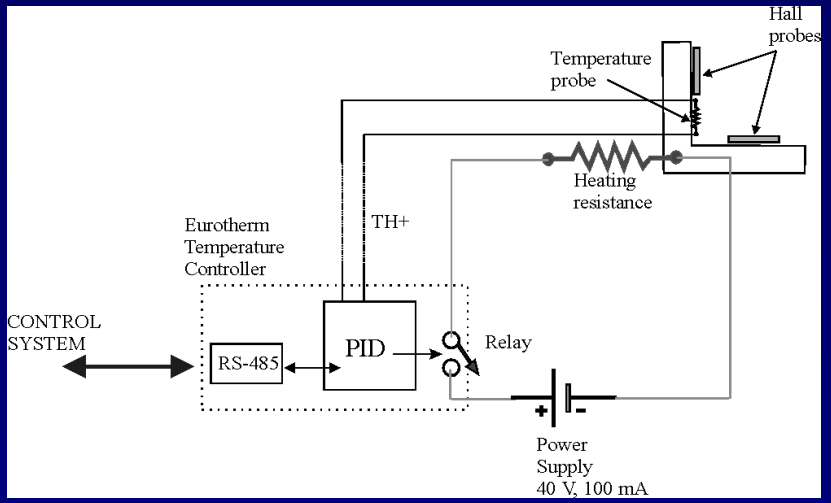
  450 mV/T ±10%



- Hall probe power supply
- Voltmeter
- Calibration system
  - Reference Magnet $\Delta B/B < 15$ ppm
  - DC Power converter $\Delta I/I < 2$ ppm
  - Magnetometer $\Delta B < 0.02$ G

Electronics and controls (II)

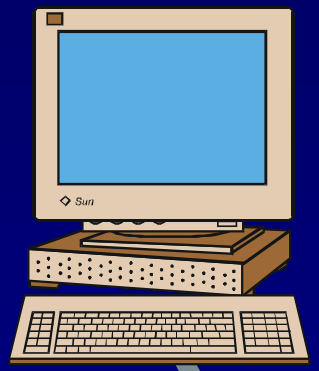
- **Temperature controller**



- **Magnet power converter**

- **Cooling system**

DAQ (HW architecture)



Operator interface

I/O controller

Devices

CPU MVME147

GPIB

PMAC

RS-485

CPU CM-cpu40

ETHERNET SWITCH

PS Danfysik

Calibration Magnet

Metrolab PT 205

NMR Probe

Motor, drivers, encoders

Mechanical arm

HP3631A

Keithley 2010

Hall probe

Eurotherm 2408

Philips Digital 280

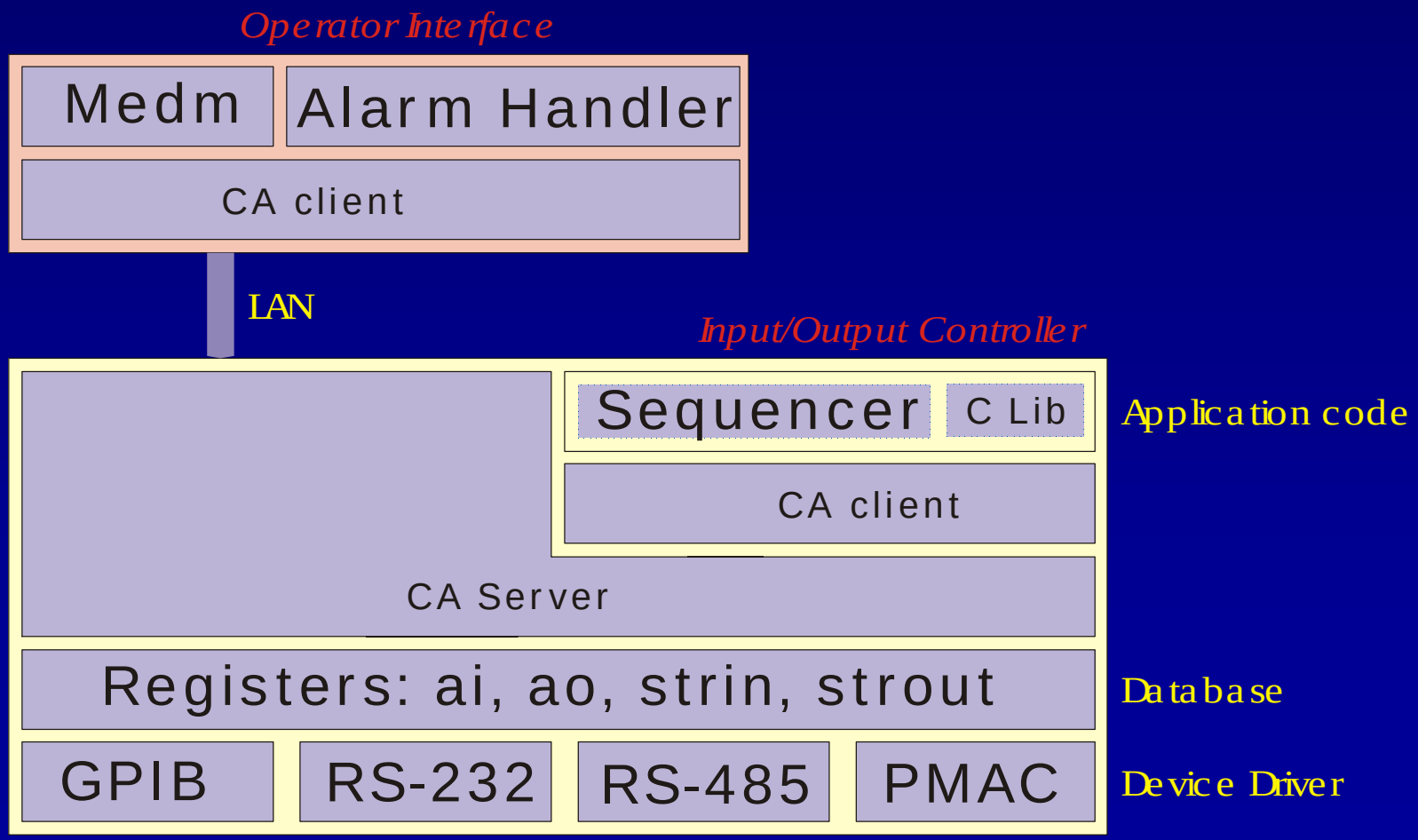
PS Enertrón

Magnet under test

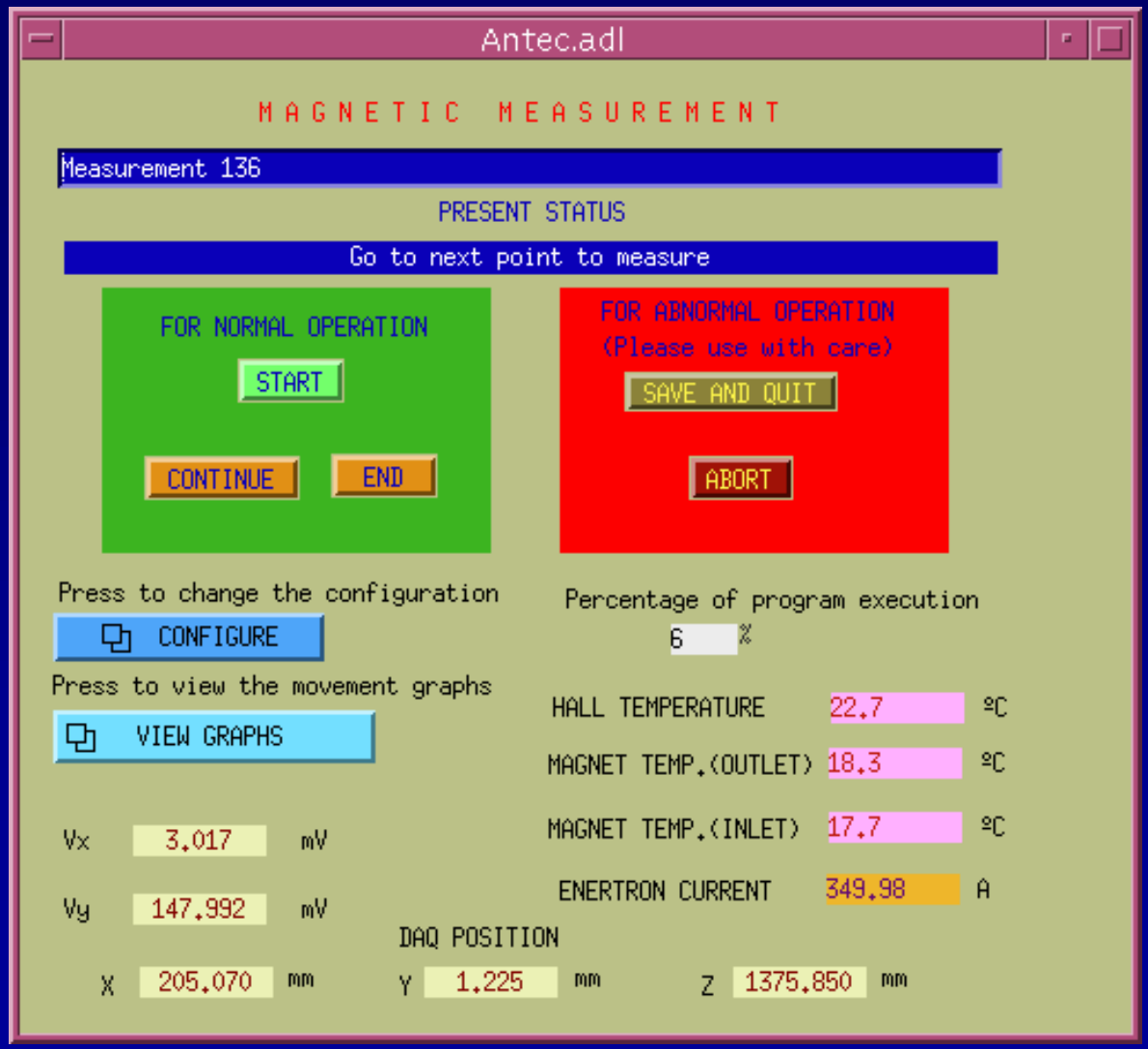
ETHERNET
VME
GPIB
RS-232
RS-485

DAQ (SW architecture)

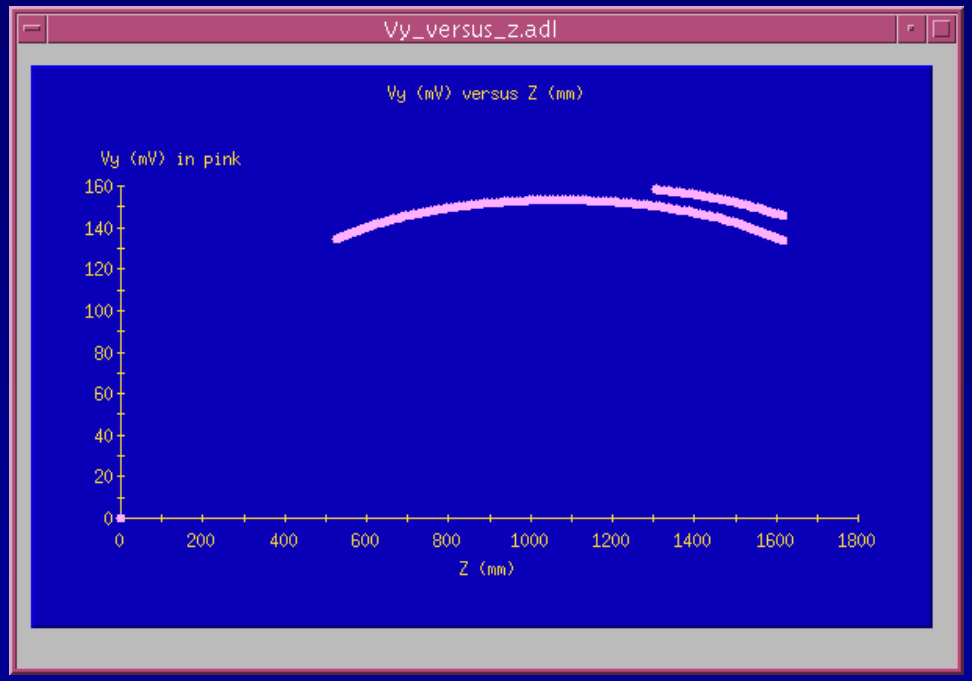
Toolkit EPICS

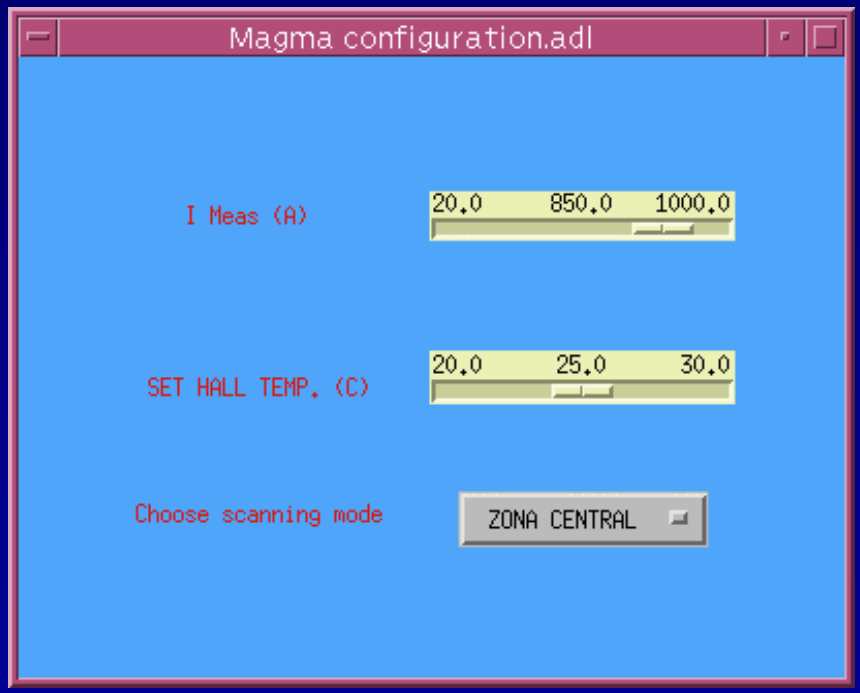


DAQ (User interface) I

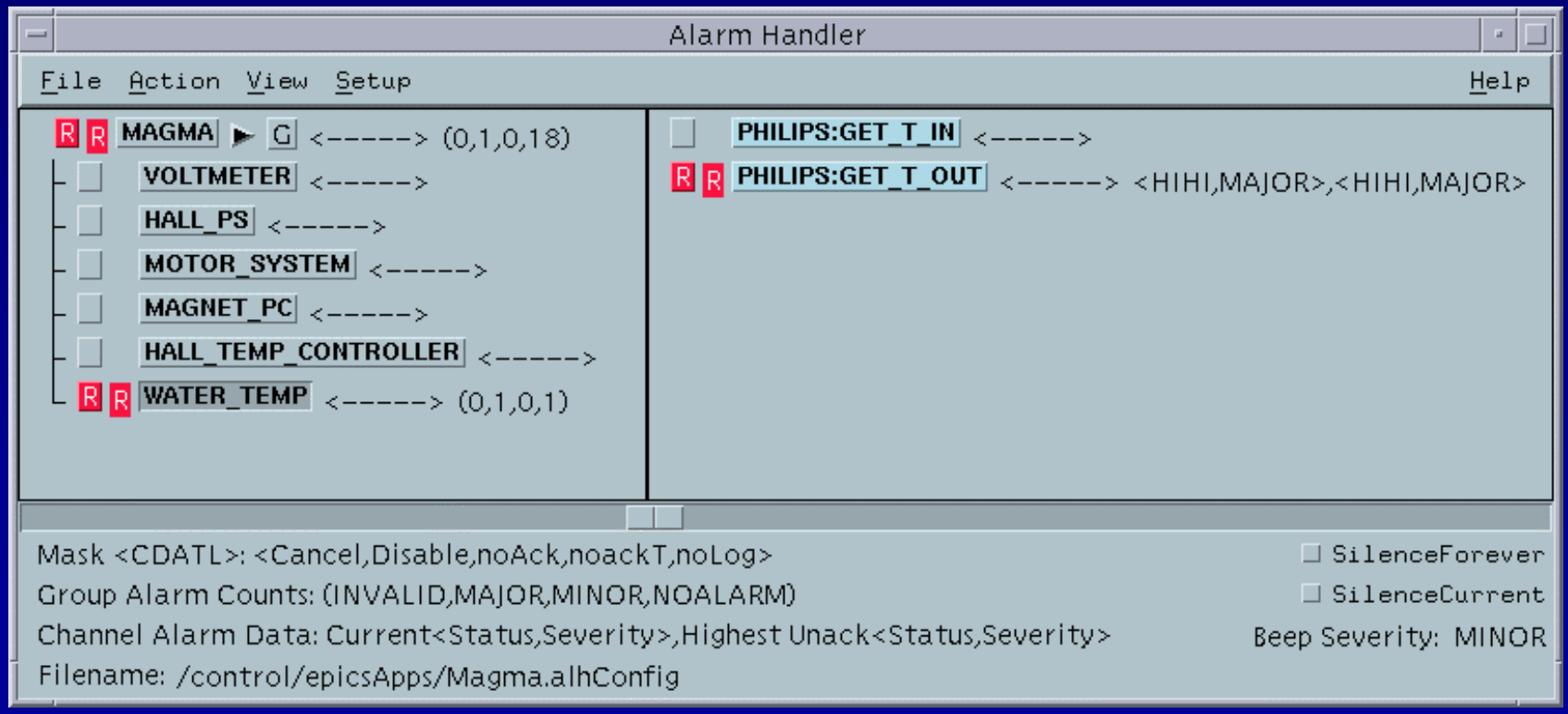


DAQ (User interface) II





DAQ (User interface) III



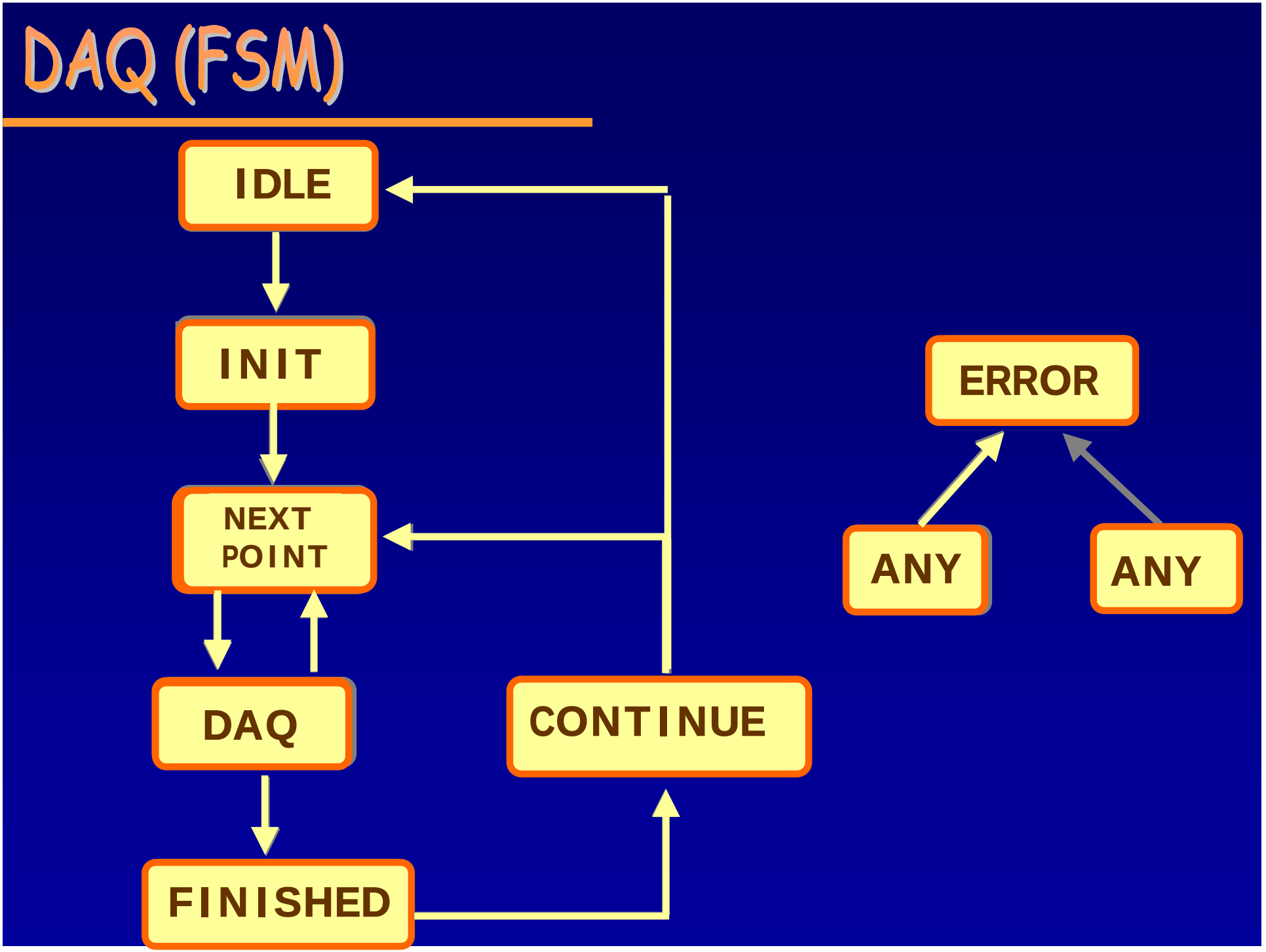
DAQ (User interface) IV

29/7/99
17:45
magma990729-1745.bin
Normal
Measurement
2000
Magnet #9

Hour	minute	second	TH	Tin	Tout	X(mm)	Y(mm)	Z(mm)	Vx(mV)	Vy(mV)	I(A)
16	9	20	0.0	0.0	0.0	200.000	0.000	1000.000	4.567	352.848	0.00
16	9	22	0.0	0.0	0.0	200.000	0.000	1010.001	4.581	353.016	0.00
16	9	25	0.0	0.0	0.0	200.000	0.000	1020.000	4.234	352.826	0.00
16	9	28	0.0	0.0	0.0	200.000	0.000	1030.000	4.590	353.002	0.00
16	9	30	24.0	18.0	32.9	200.000	0.000	1040.000	4.621	352.832	849.96
16	9	33	0.0	0.0	0.0	200.000	0.000	1049.999	4.432	352.999	0.00

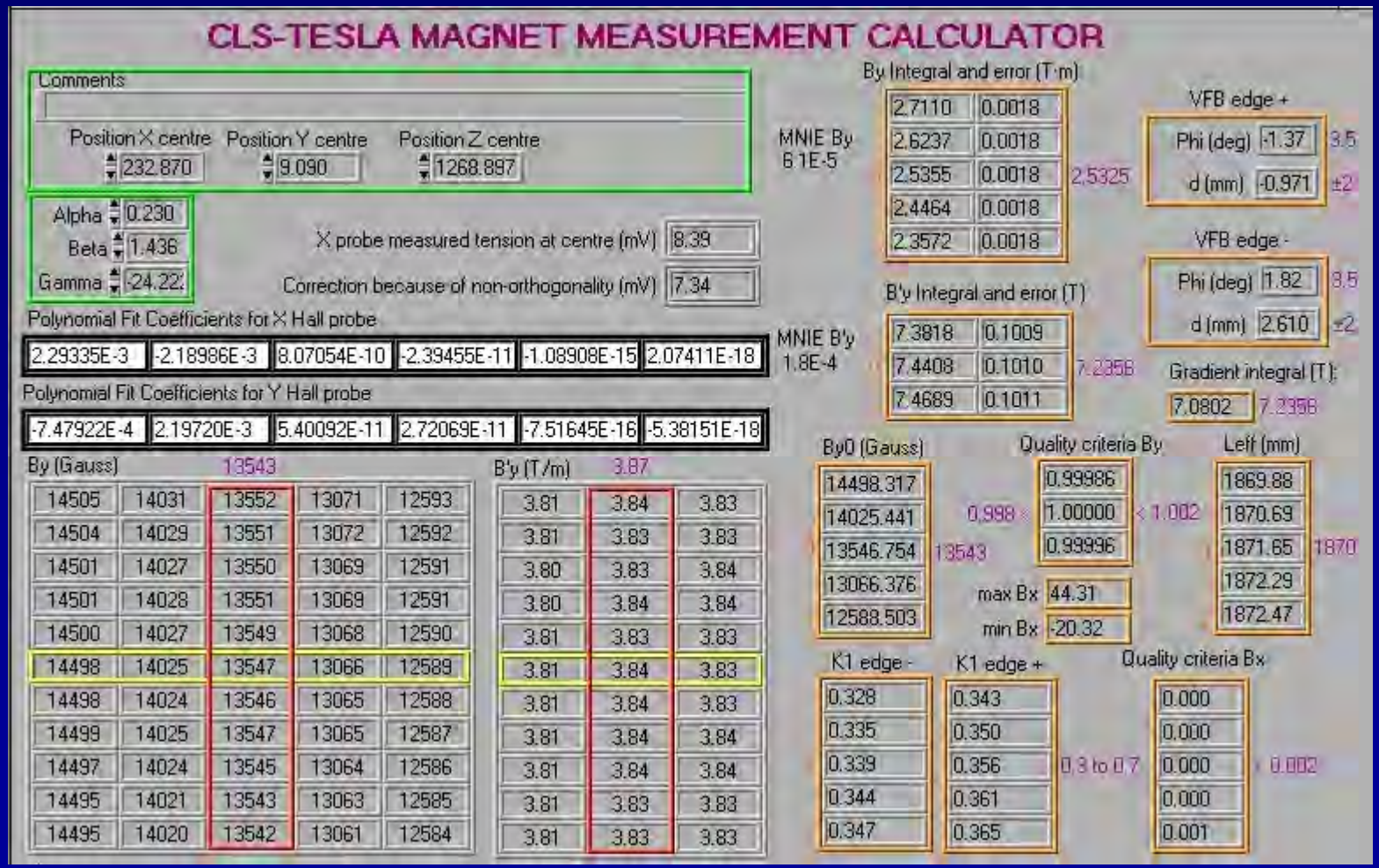
...

DAQ (FSM)



Data analysis

Labview

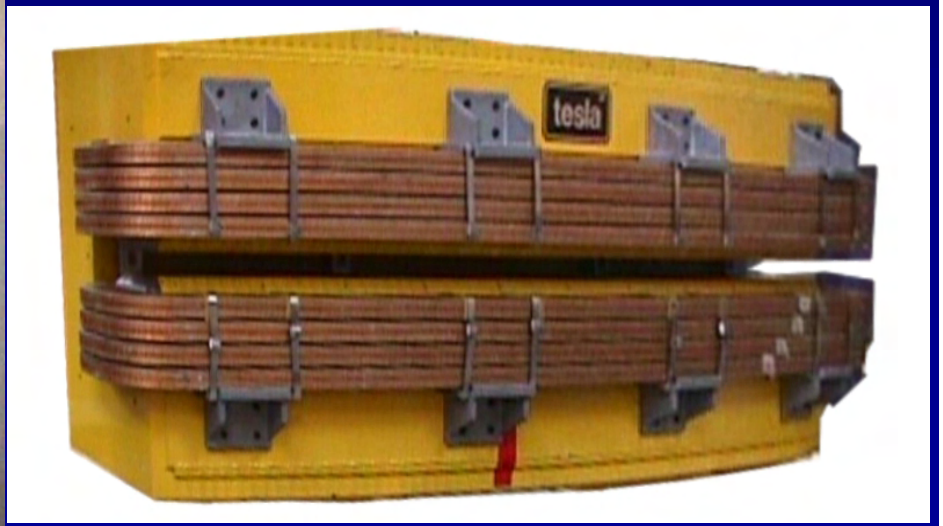


Performance

Error source	Rnd/Syst	Relation with B	Worst case
Magnet power supply (ΔI_1)	Syst	$\Delta B/B = \Delta I_1/I$	± 0.28 Gauss
Hall probe power supply (ΔV_1)	Syst	$\Delta B = B/V \times \Delta V_1$	± 0.25 Gauss
Multimeter (ΔV_2)	Syst	$\Delta B = Gain \times \Delta V_2$	± 0.12 Gauss
Calibration Error (ΔB_1)	Syst	$\Delta B = \Delta B_1$	± 0.9 Gauss
Total systematic			± 1.6 Gauss
Temperature (ΔT_1)	Rnd	$\Delta B = (0.5 + 10^{-4} B) \times \Delta T_1$	± 0.15 Gauss
Hall probe power supply (ΔV_3)	Rnd	$\Delta B = B/V \times \Delta V_3$	± 0.02 Gauss
Multimeter (ΔV_4)	Rnd	$\Delta B = Gain \times \Delta V_4$	± 0.03 Gauss
Hall probe noise (ΔV_5)	Rnd	$\Delta B = Gain \times \Delta V_5$	± 0.4 Gauss
Cable noise (ΔV_6)	Rnd	$\Delta B = Gain \times \Delta V_6$	± 0.04 Gauss
Total random			± 0.4 Gauss

Real examples

- ✓ LLS Bending magnet prototype
- ✓ ANKA storage ring bending magnets
- ✓ CLS combined magnets



Conclusions

- High precision measurement system (±2 Gauss)
- Large volume (250x20x300 mm^3) with high precision (±50μm)
- Easily adapted of a wide range of magnets
- Movement + acquisition: 2.5 s per point
- In situ data analysis
- Proved: LLS prot., Anka bending, CLS prototype