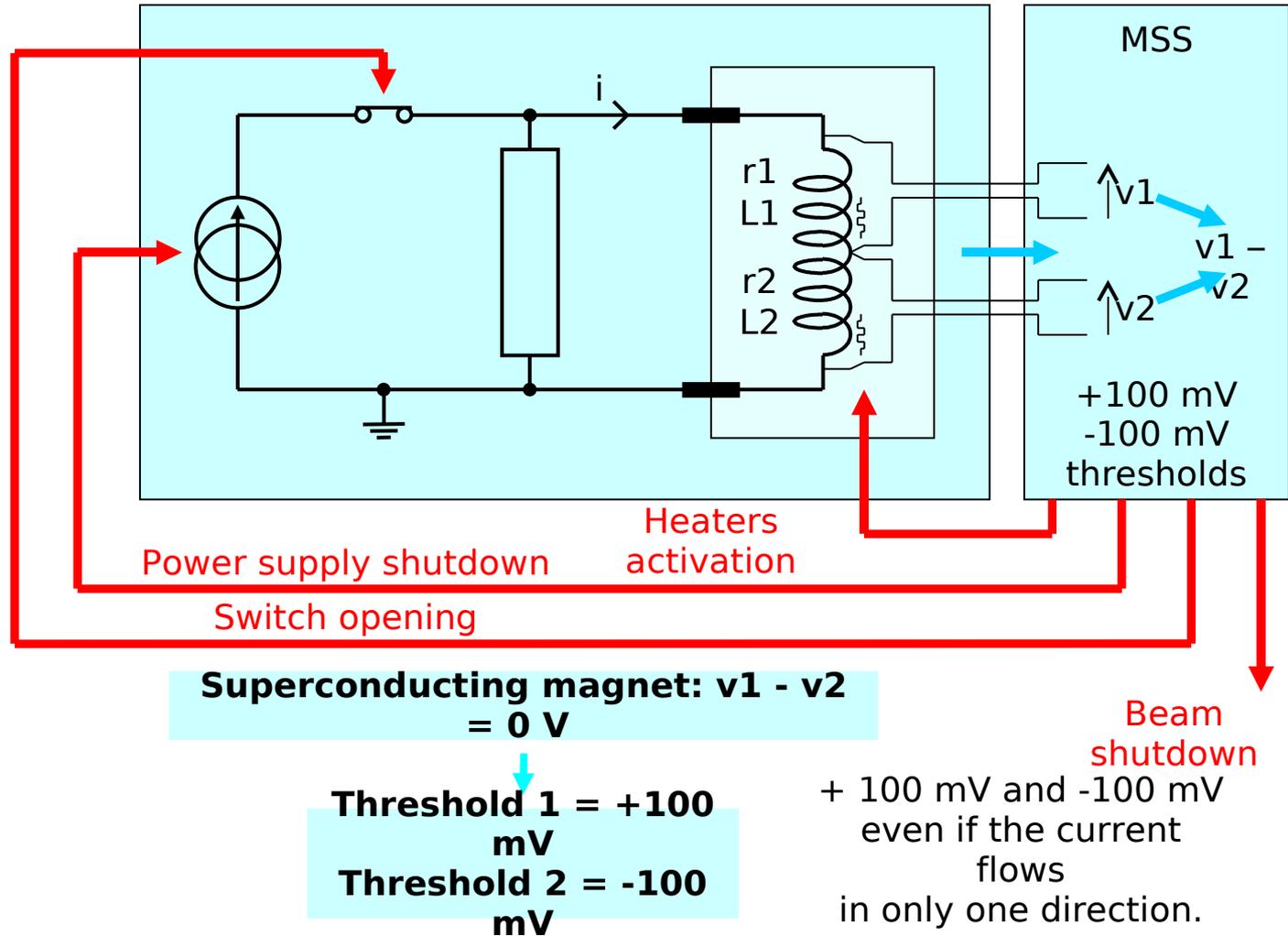


**R&D of neutrino beam production  
for future (Multi-)MW proton facility:**

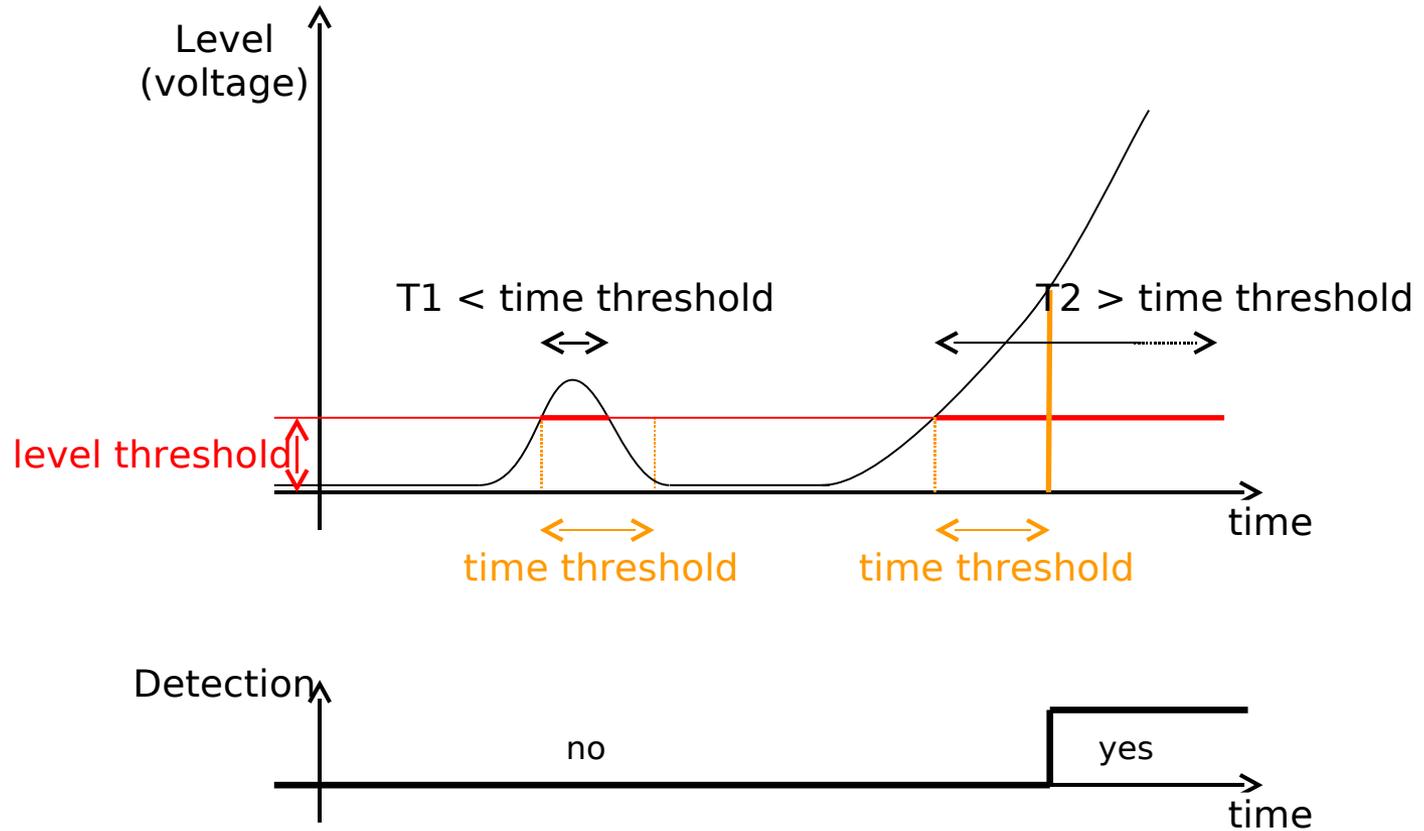
## Superconducting Magnet Safety System (MSS)

F.Pierre on behalf of Jean-Paul CHARRIER  
CEA SACLAY – DSM / IRFU / SIS

# T2K MSS : Magnet quench detection

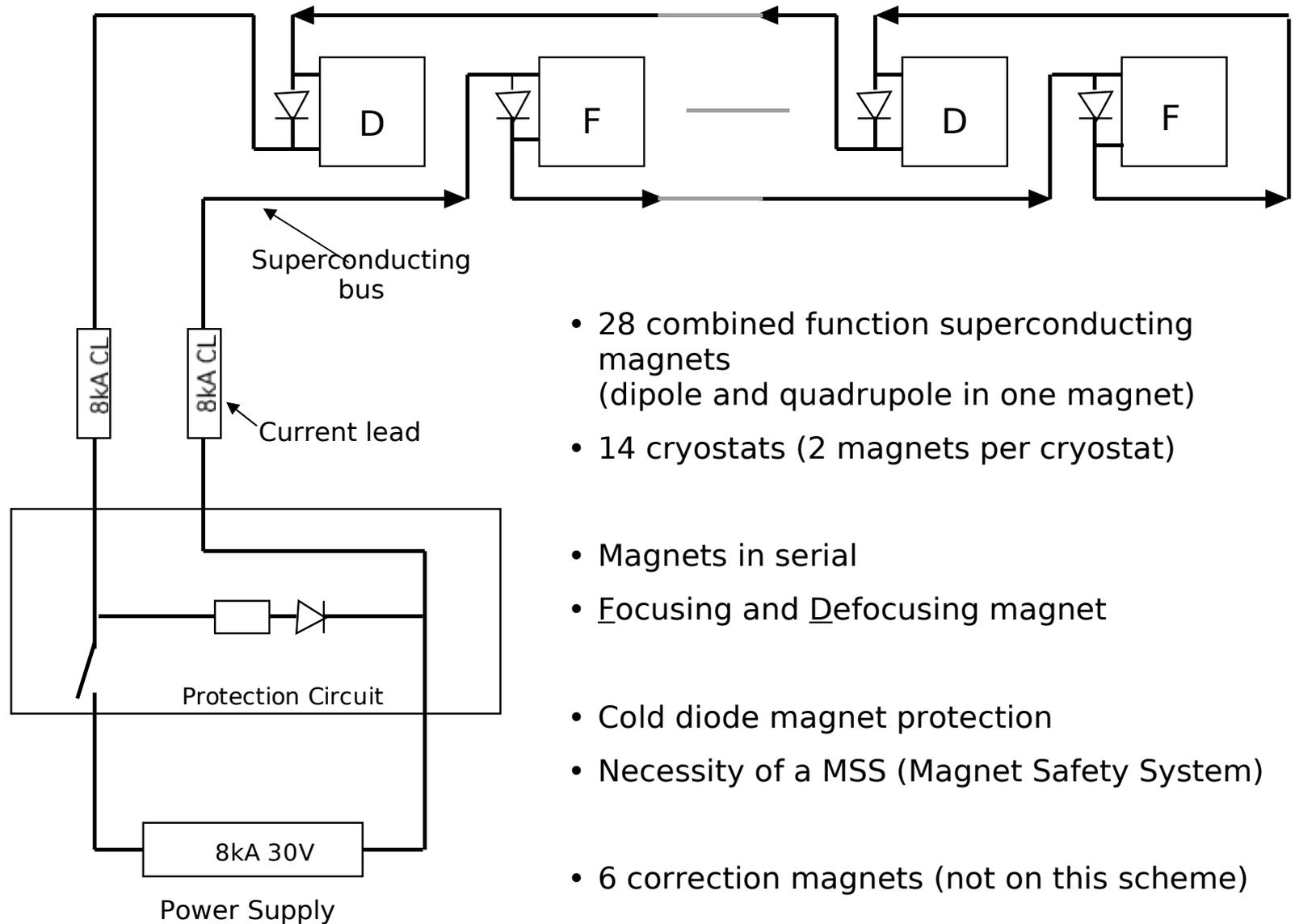


# T2K MSS :



# T2K MSS :

# Electrical circuit



- 28 combined function superconducting magnets (dipole and quadrupole in one magnet)
- 14 cryostats (2 magnets per cryostat)
- Magnets in serial
- Focusing and Defocusing magnet
- Cold diode magnet protection
- Necessity of a MSS (Magnet Safety System)
- 6 correction magnets (not on this scheme)

# T2K MSS : MSS functions / specifications

- Main functions

- Detection

- Main magnets quench detection, 100 mV / 10 ms
- Bus bars quench detection, 100 mV / 10 ms
- Current leads protection, 100 mV / 100 ms
- Corrector magnets quench detection, 400 mV / 10 ms

- Security actions

- Beam shut down,
- Power supplies shut down,
- Heaters activation.

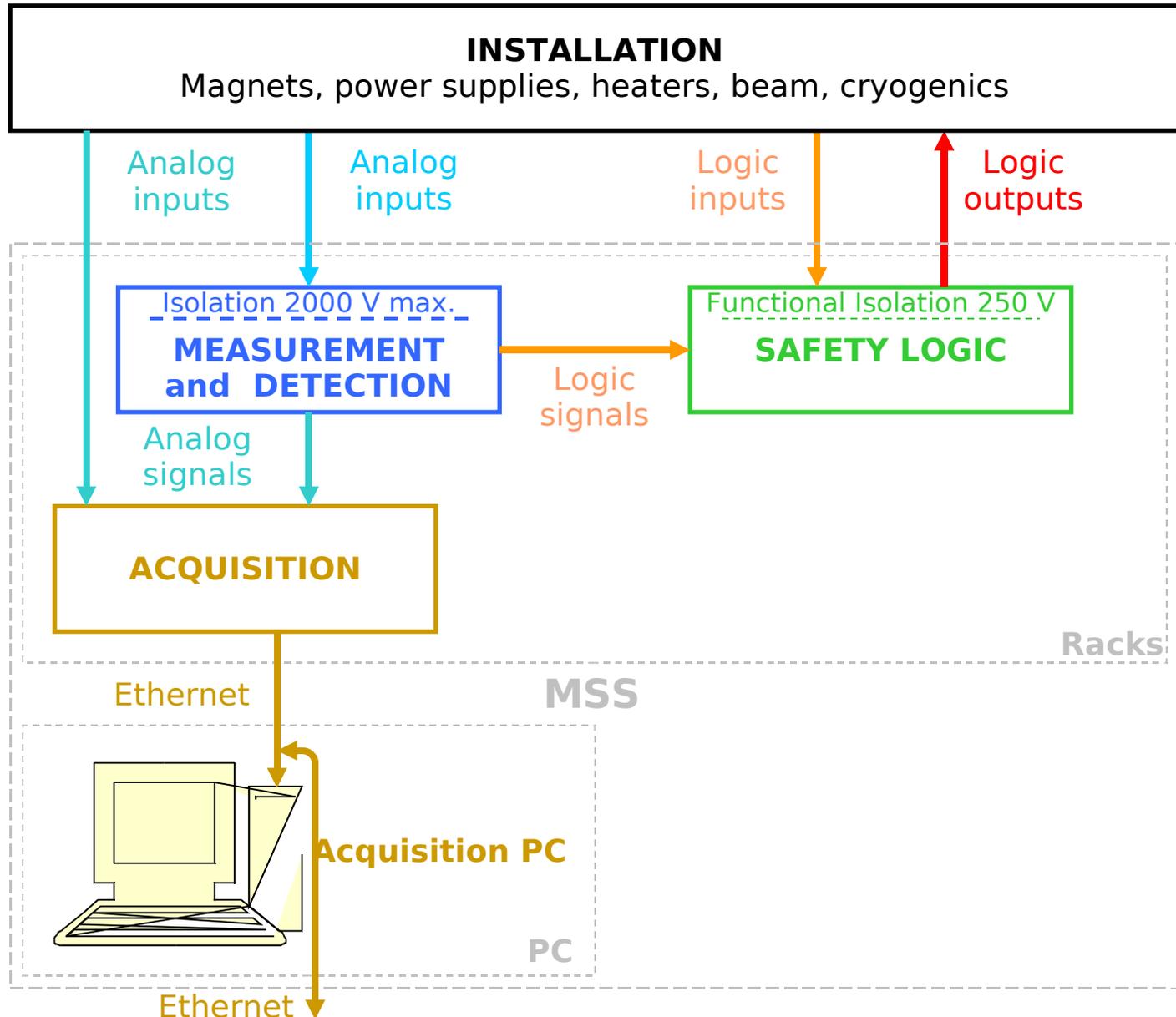
# T2K MSS : MSS functions / specifications

- Complementary function
  - Data acquisition (analog parameters)

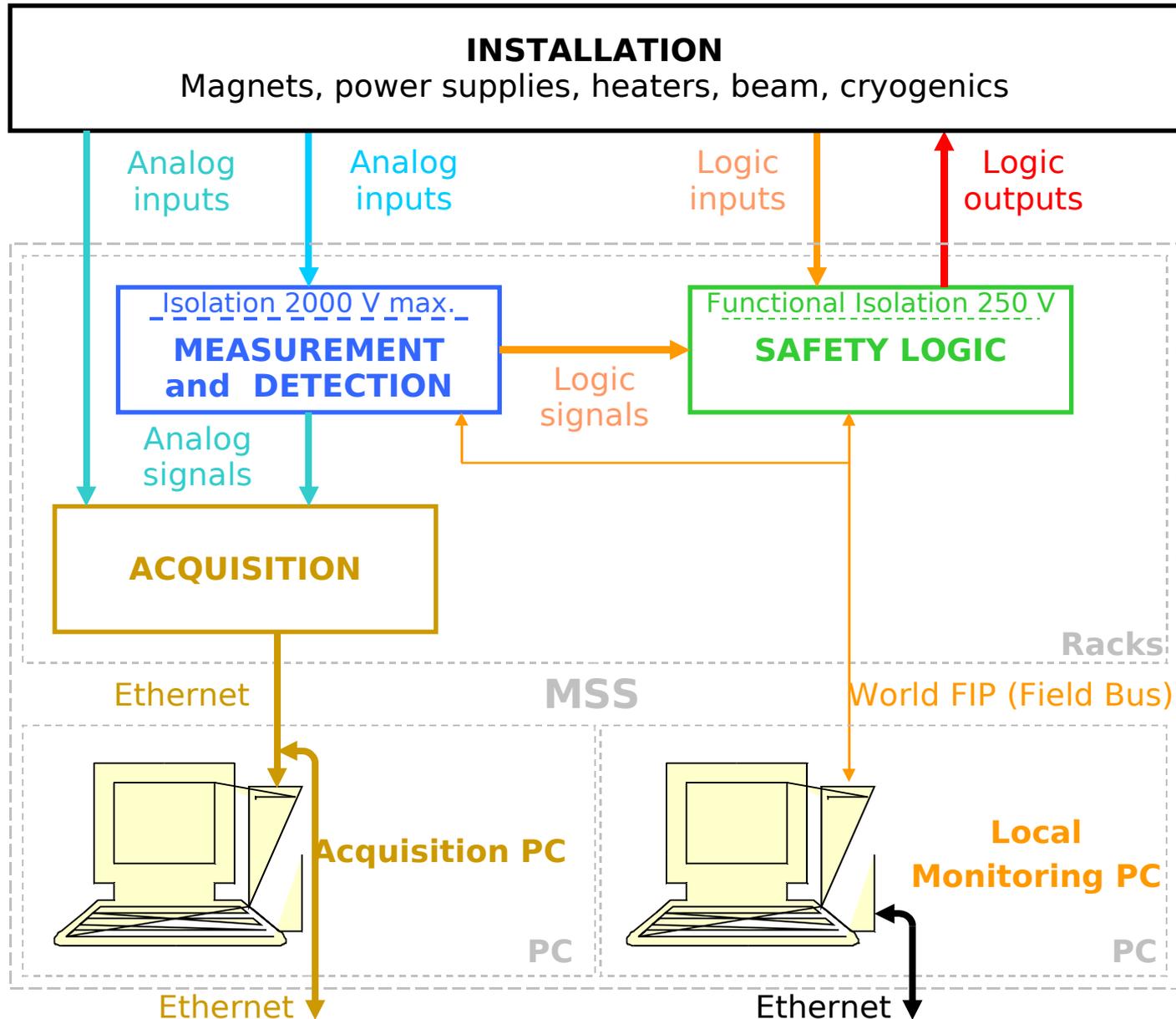
	<b>DAQ1</b>	<b>DAQ2</b>
Origin of measurements	Magnet system	Corrector magnets
Number of channels	61	32
Acquisition frequency	10 kHz	
Total record length	100 s	
Input range	+/- 10 V	

- High voltage
  - Withstand voltage : 500 V DC
  - (Cables, connectors and detection board inputs)

# T2K MSS : Synoptic overview of the MSS



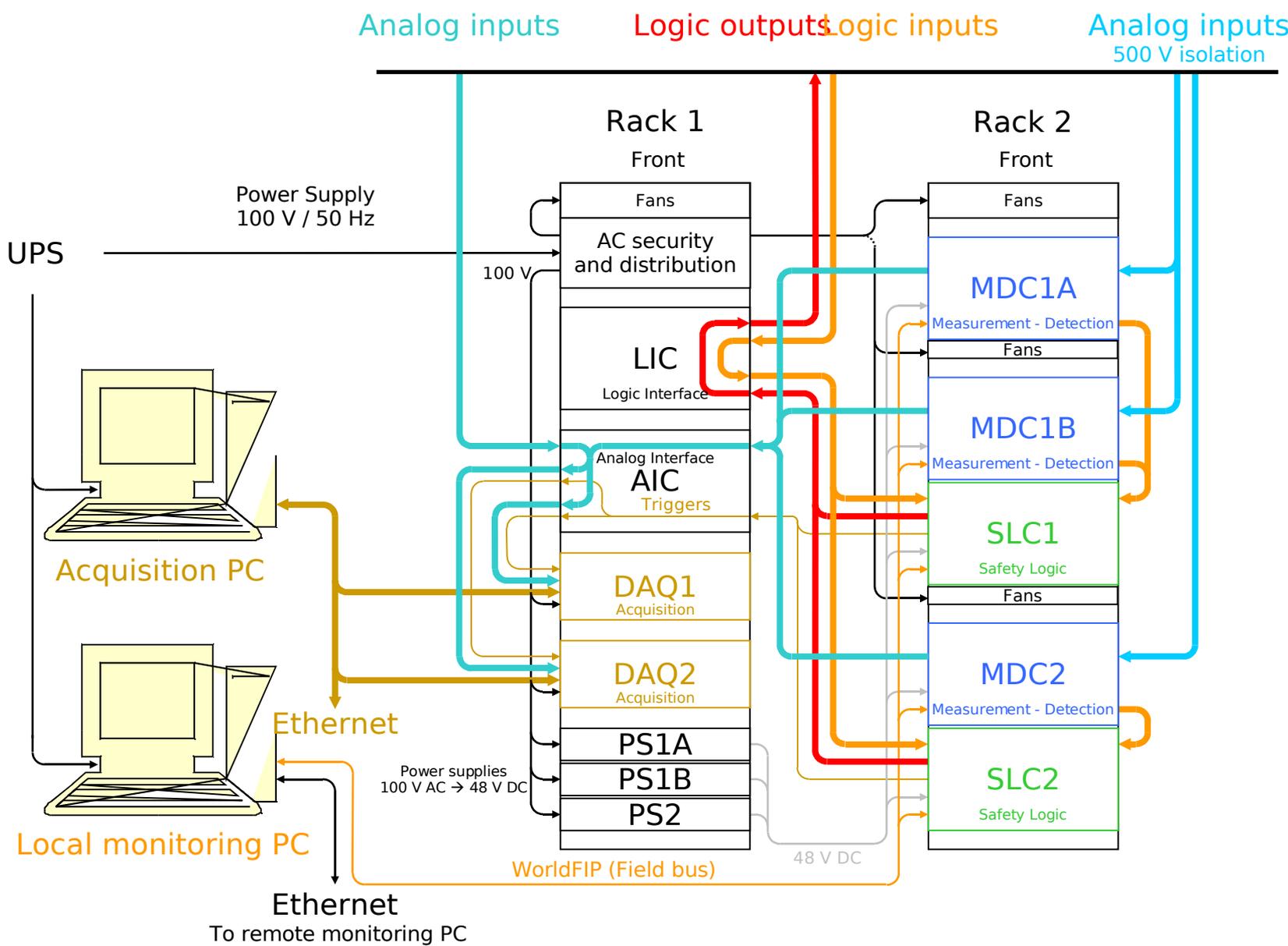
# T2K MSS : Synoptic overview of the MSS



# T2K MSS :

# MSS Architecture

## Magnet System



# T2K MSS : Quench detection boards (MD200)

- Measurement

- Analog inputs
  - Voltage scaling, filtering and isolation (2000 V)
- Analog outputs
  - For copying to the acquisition system

- Detection

- Fault detection with :
  - Level thresholds,
  - Time thresholds

**35 MD200 boards realized  
(17 tested and other ones to be tested)**



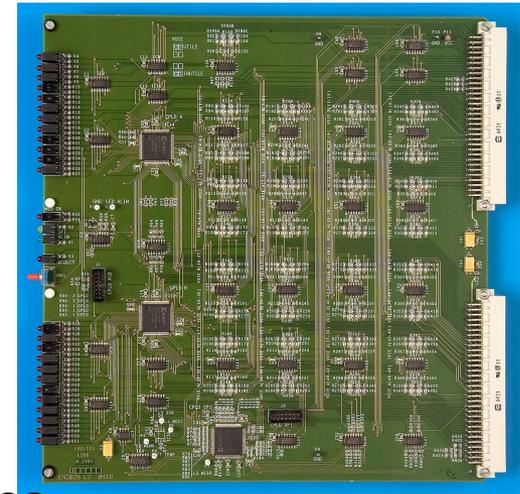
← 22 cm →

- Treatment board : DX96
  - Receive and memorize the faults of the installation especially : magnet quenches
  
  - Command the main security action
    - Beam shut down.



DX96 board

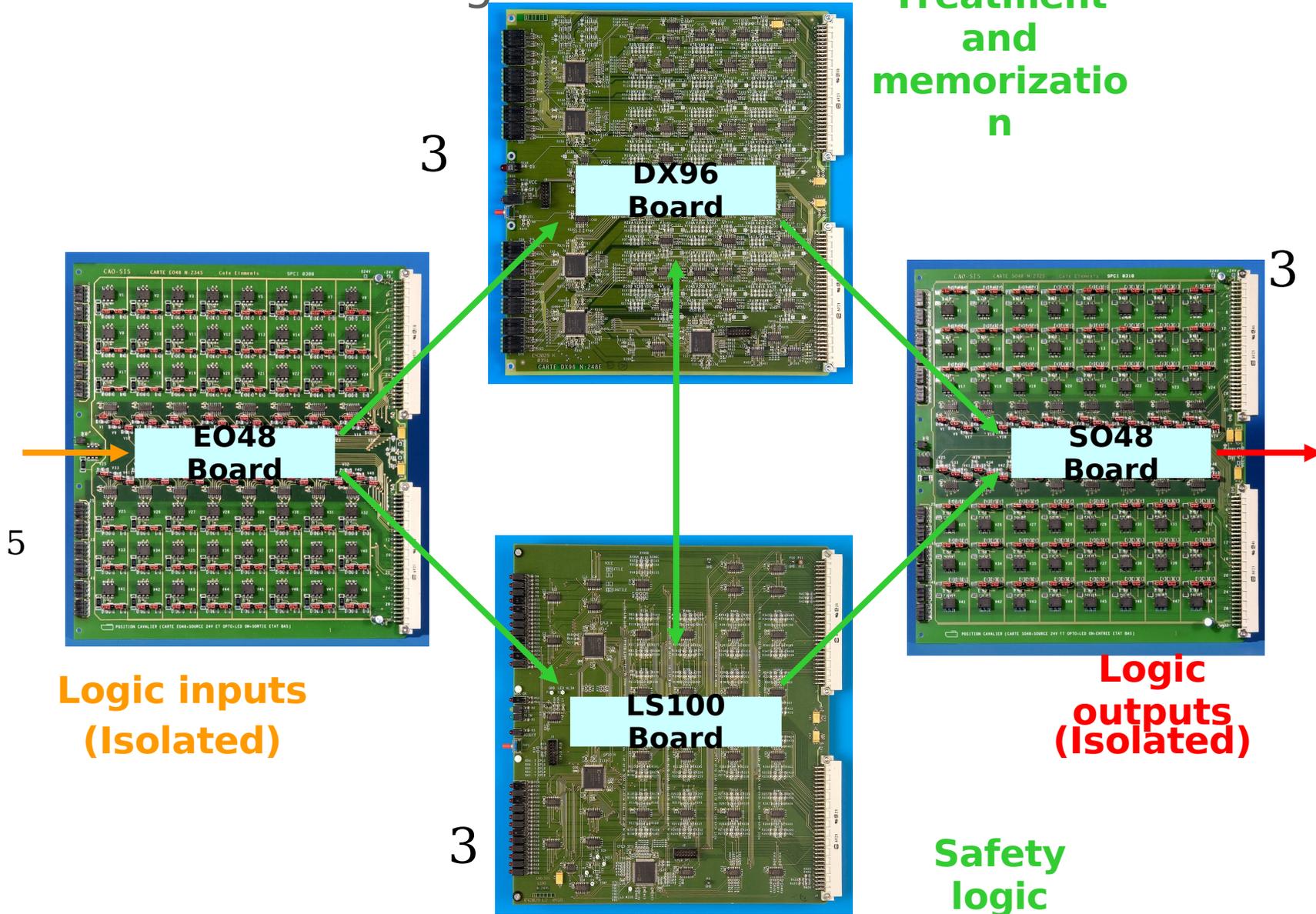
- Safety logic board : LS100
  - Receive the faults of the installation
  - Command the security actions
    - Power supplies shut down,
    - Heaters activation.
  - Send information to the Cryogenics
    - Quench Detection,
    - Fast Discharge.
  - Send information to the Power Supplies
    - Fast Discharge.
  - Triggers the Acquisition systems
  - Determine the status of the MSS (OK or not)
  - Gather and display important information
  - Manage the MSS acknowledge



Example : LS96 board

Updated into LS100  
for T2K MSS

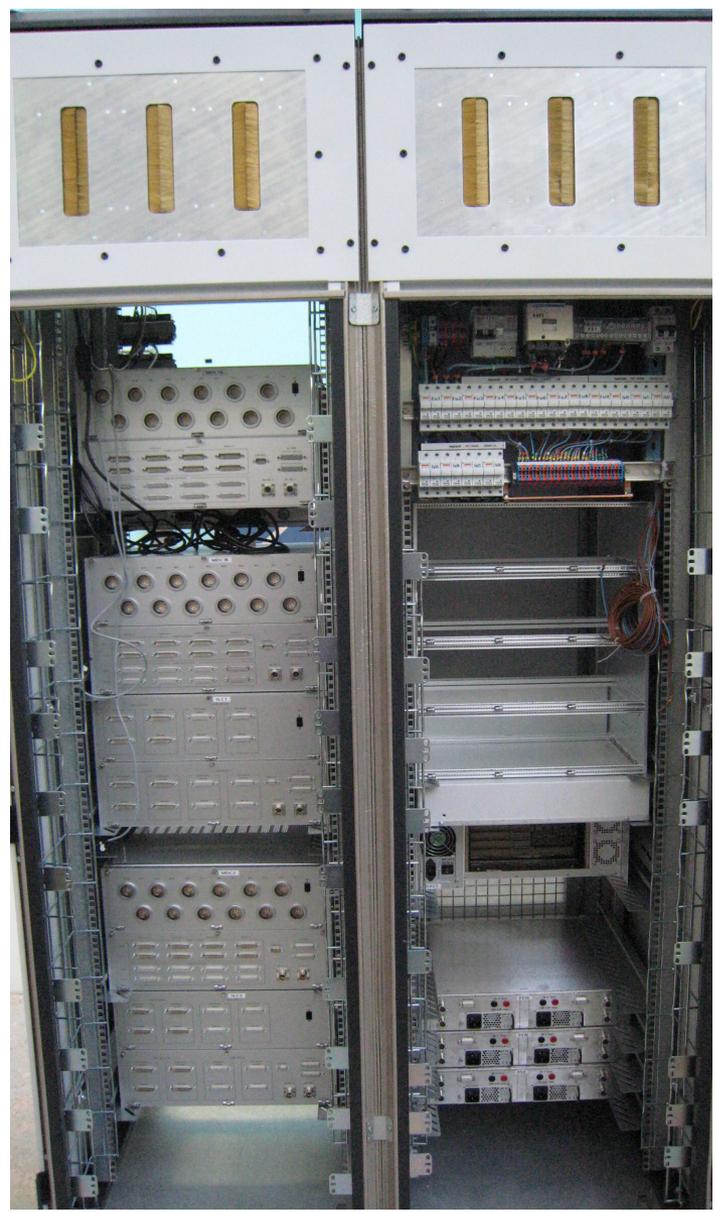
Treatment  
and  
memorization



**All logic boards are realized and tested, Integration and tests in progress.**

On this scheme, configuration boards and backplanes are not drawn

# Front



# Back

# Monitoring, Settings, Control

# Monitoring

Human-Machine interface : Labview

analog(input voltages, balance voltages,  
temperatures, low voltages ...

and

logic monitorings

Thresholds

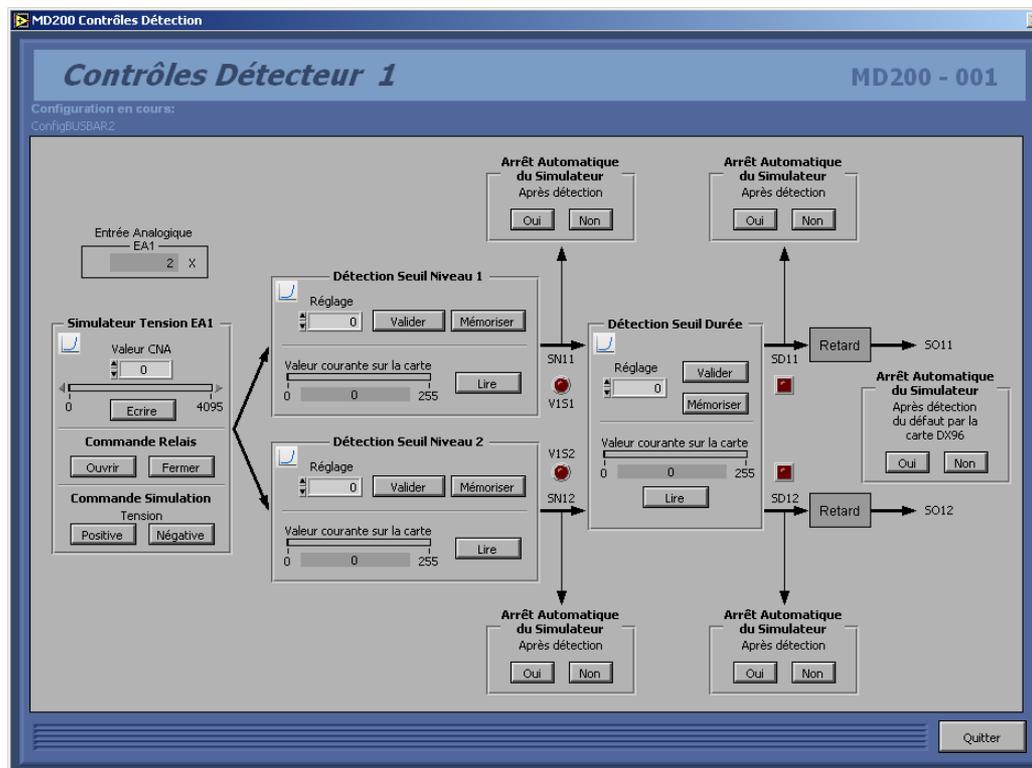
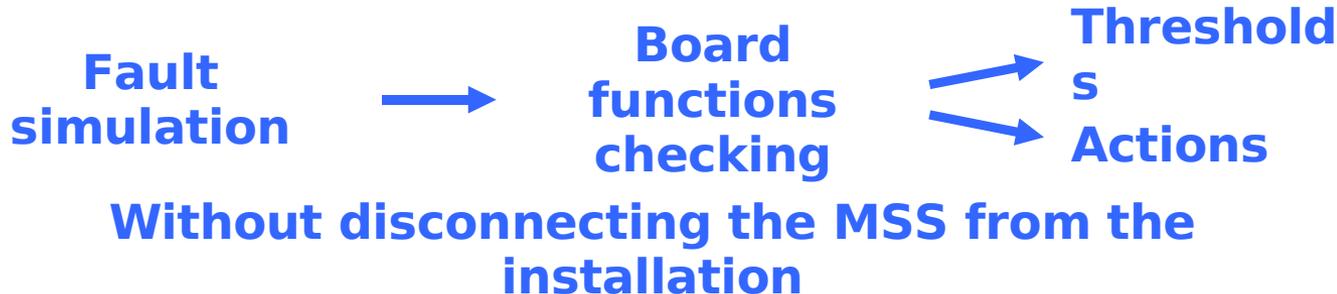
Balance

Analog output offsets and gains

The image displays three screenshots of the MD200 software interface, each with blue arrows pointing to specific settings:

- Réglage Détection: 1 (MD200 - 001):** This window shows detection configuration. It includes two threshold levels (Seuil Niveau 1 and Seuil Niveau 2) and a duration threshold (Seuil Durée). Each level has a 'Réglage' (setpoint) and 'Valeur courante sur la carte' (current value) field. Blue arrows point from the 'Thresholds' text to the 'Réglage' fields and from the 'Balance' text to the 'Valeur courante sur la carte' field.
- Réglage Compensation (MD200 - 001):** This window shows compensation settings. It features two analog inputs (EA1 and EA2) and a 'Compensation' section with a 'Réglage' and 'Valeur courante sur la carte' field. Blue arrows point from the 'Balance' text to the 'Réglage' field and to the 'Valeur courante sur la carte' field.
- Réglage Sortie Analogique: 1 (MD200 - 001):** This window shows analog output settings. It includes two channels (A and B), each with an 'Offset' and a 'Gain' section. Each section has a 'Réglage' and 'Valeur courante sur la carte' field. Blue arrows point from the 'Analog output offsets and gains' text to the 'Réglage' fields of the Offset and Gain sections.

**For T2K MSS, thresholds and balance settings will not use software settings, but hardware settings with a screwdriver.**



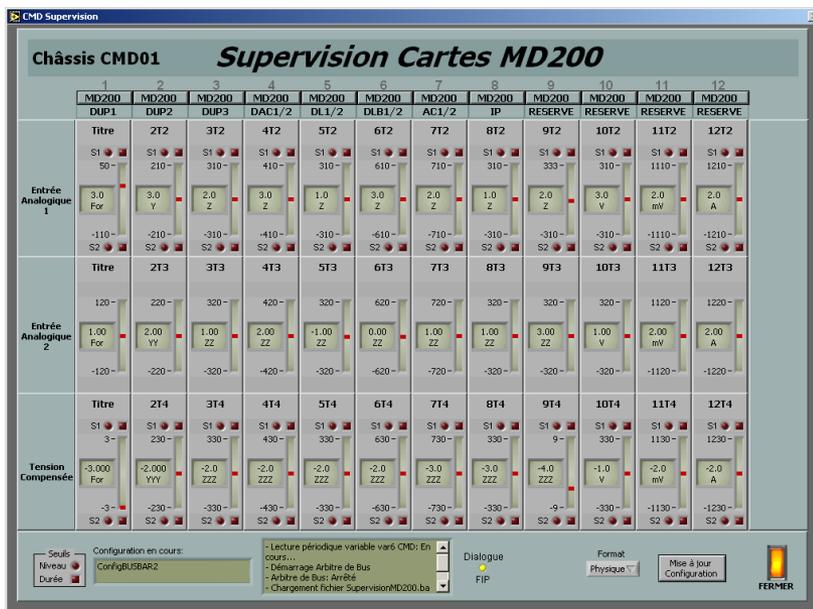
**Possible without really triggering security actions**

# Cost, Manpower, Schedule

## T2K MSS :

- Cost
  - 204 k€ (hardware)
- Manpower
  - 8 man-year
  - + a lot of work (specification, software, previous realization, tests)  
already done for other Magnet Safety Systems, by many people in  
CEA SACLAY – DSM / DAPNIA / SIS
- Schedule
  - 2004: First preliminary specification
  - 2005-2006: Requirements specification / Preliminary definition
  - 2007: Detailed definition / Realization in CEA - Saclay
  - 2008: Shipment / Tests at J-PARC
  - 2009: Commissioning

# RESERVE

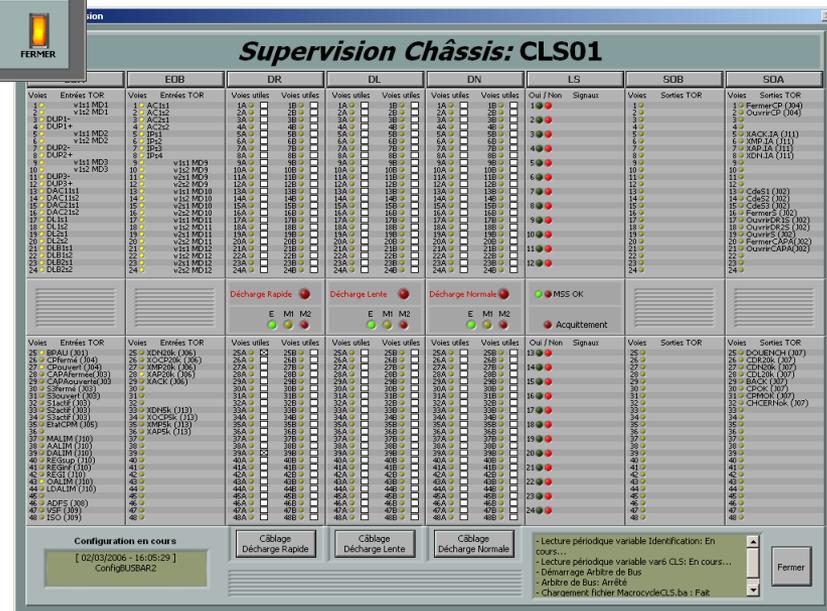
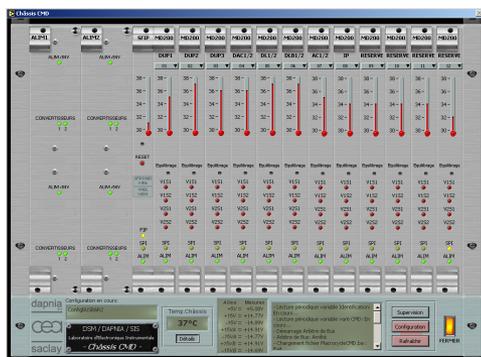


Analog monitoring

Input voltages

Balanced voltages

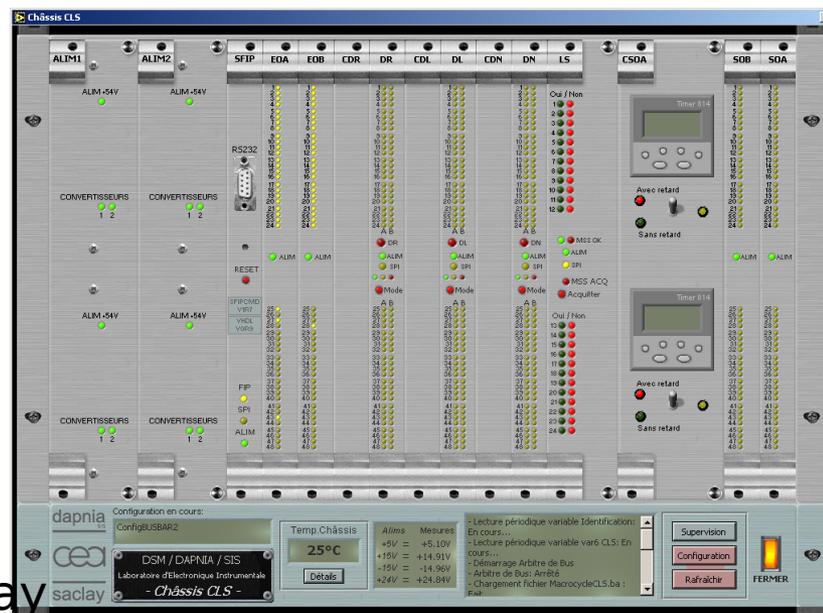
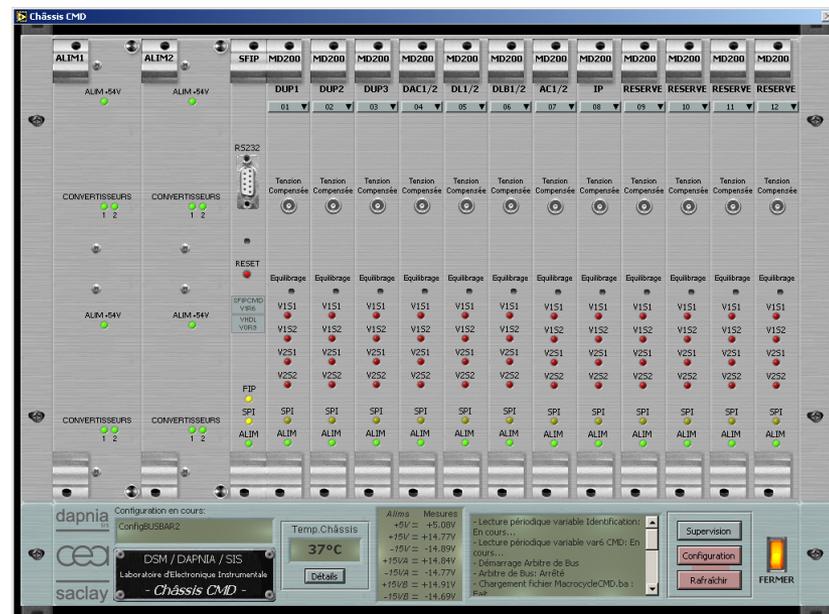
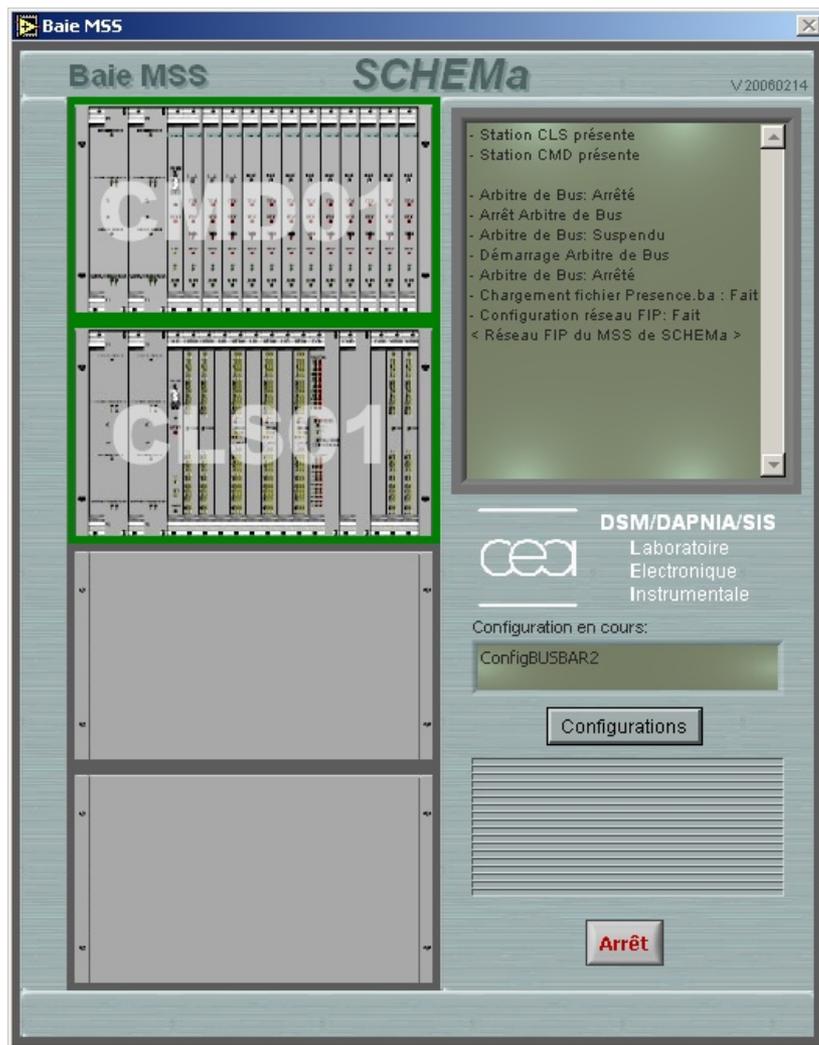
## Temperatures



+ Crates Power Supplies  
(+ 5 V, +/-15 V, etc...)

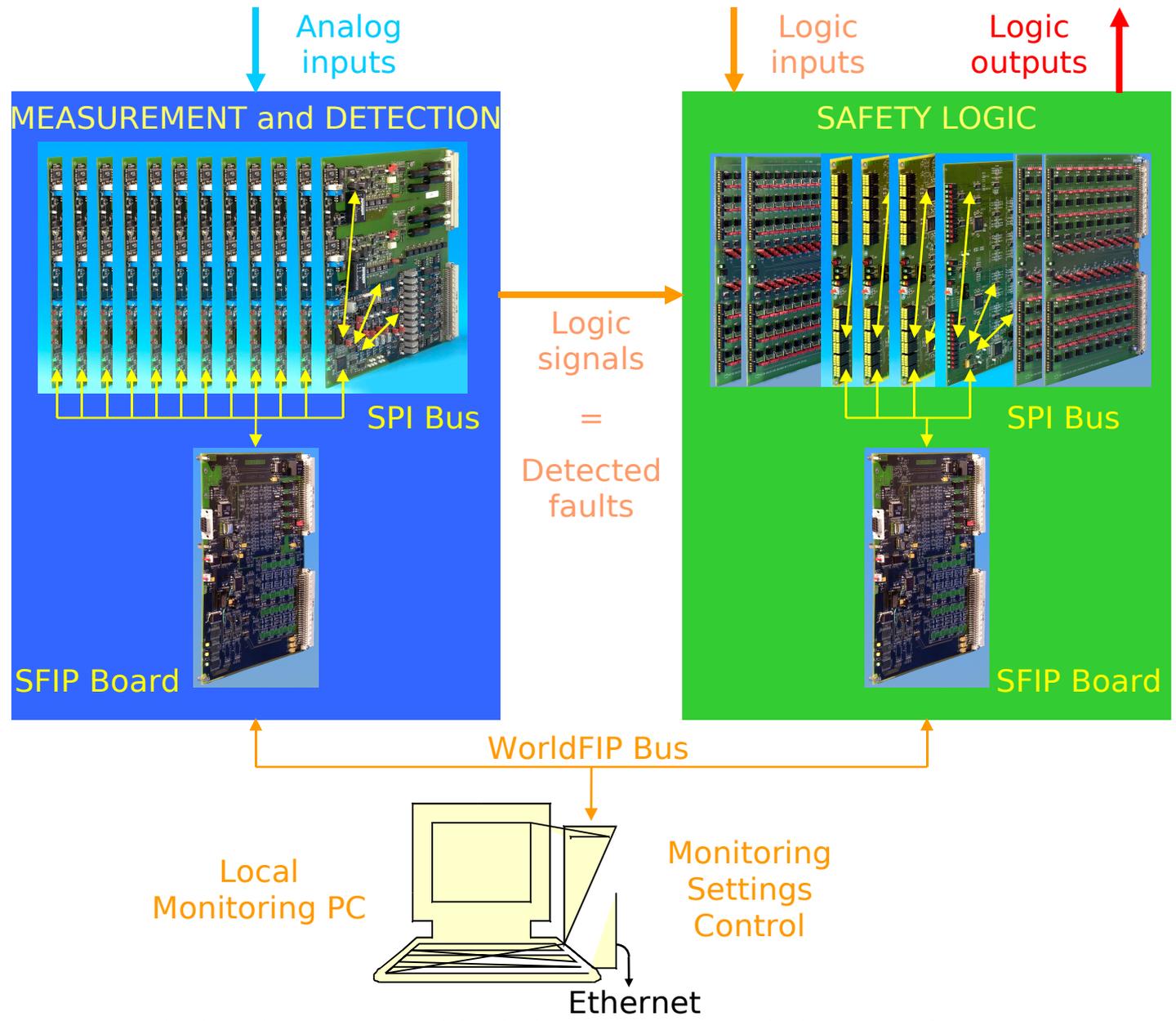
Logic monitoring

# T2K MSS : Human-Machine Interface (Labview)



Example for a test facility in Saclay

# T2K MSS : Communication : FIP and SPI



# T2K MSS : Transition of a superconductor

**Transition from the superconducting to the resistive (or normal) state**

or

**quench**



**$R \neq 0$**



**Joule heating,  
local, then global (if  
propagation)**



**Conductor and magnet  
destruction**

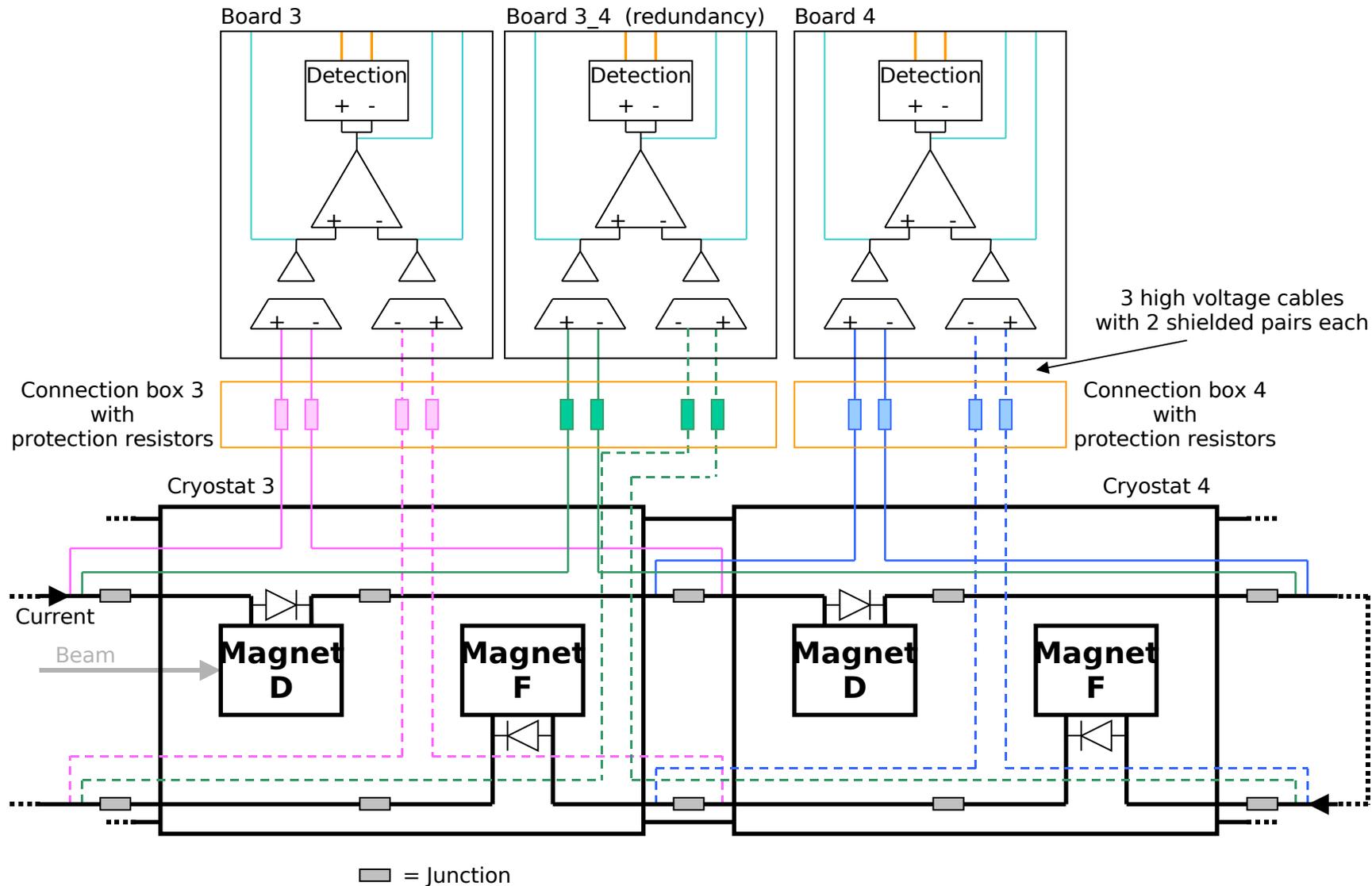


**Unusable experiment  
Repair sometimes  
impossible**

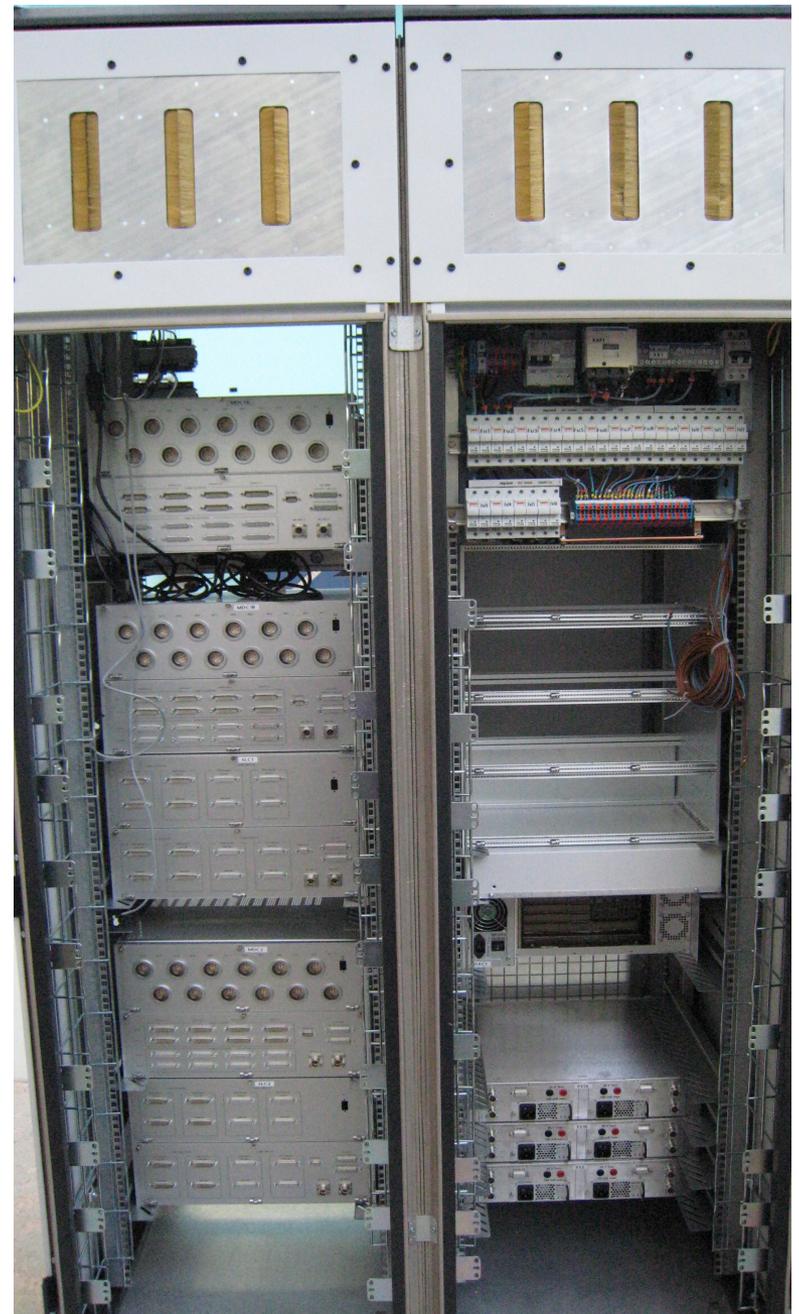
# T2K MSS :Detail of the principle for 2 cryostats

3 MD200 boards for 2 cryostats  
→21 boards for 14 cryostats

Measurement : analog outputs  
Detection : logical outputs



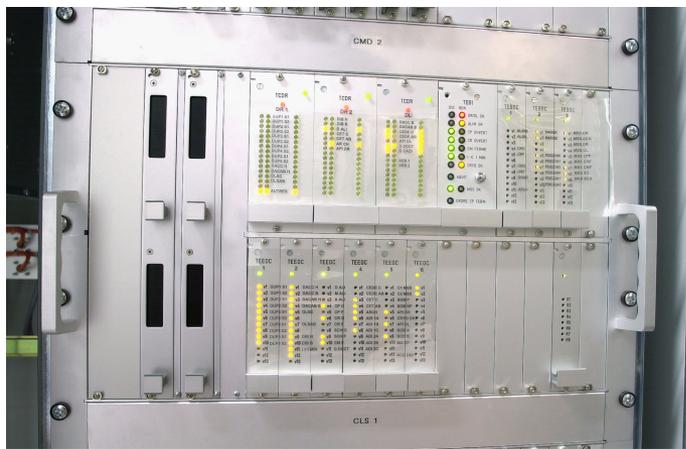




# T2K MSS :Example of MSS : W7X test facility

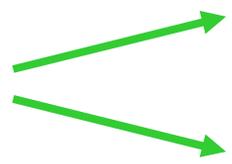
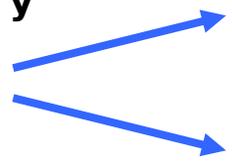


**Measurement and Detection**



**Safety Logic**

**Redundancy**

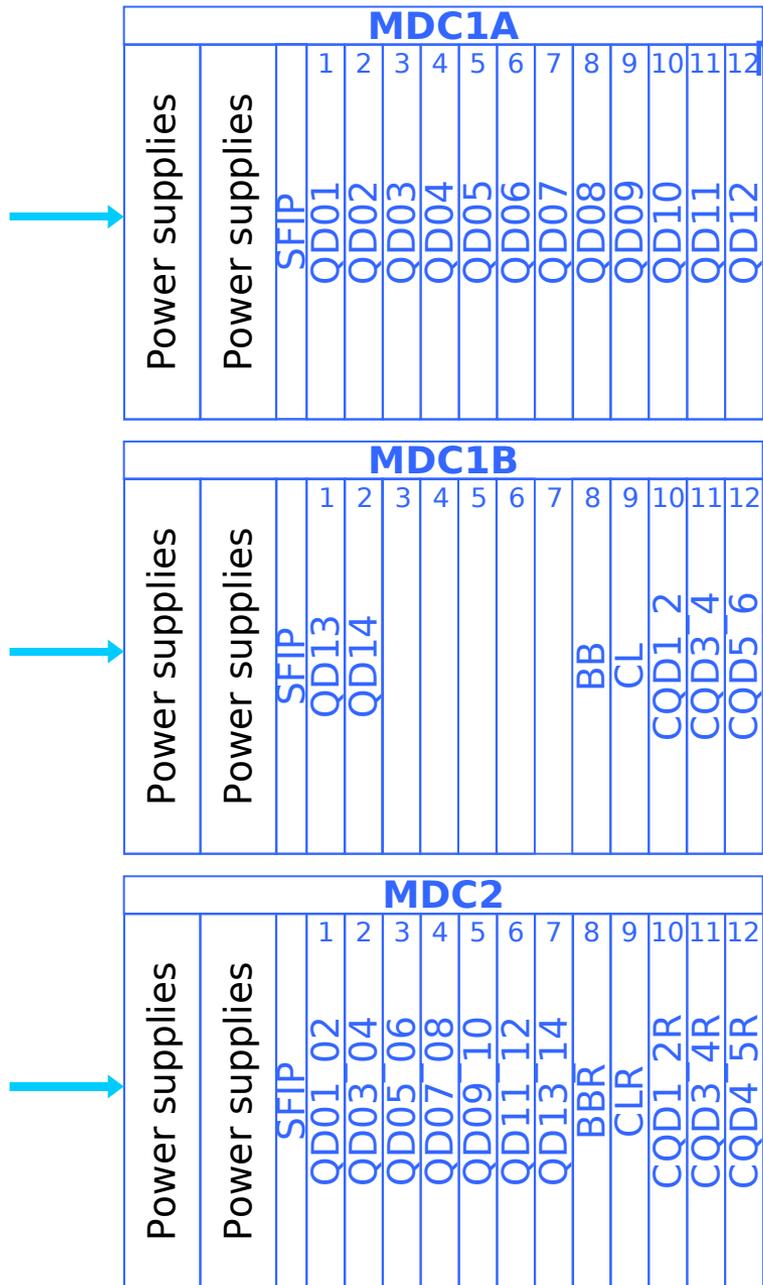


(Example with the previous generation of electronic boards)

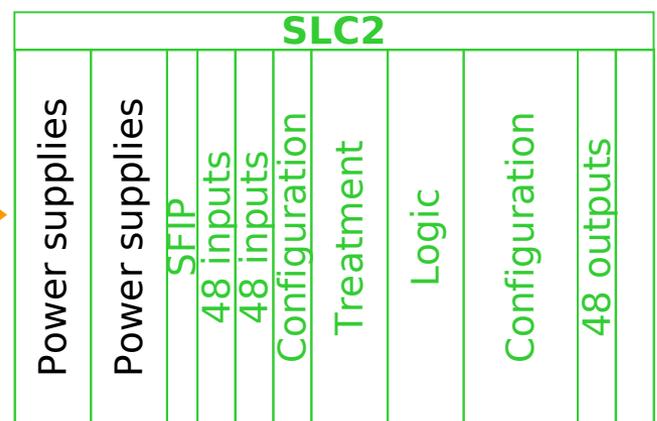
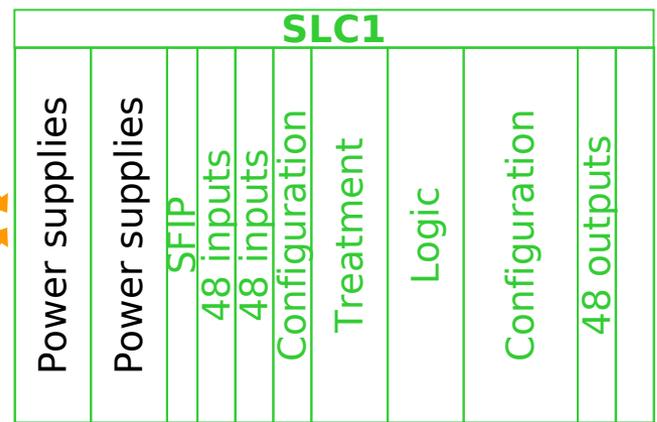
# T2K MSS :

# Protection crates

## Measurement and Detection Crates



## Safety Logic Crates



Redundancy

