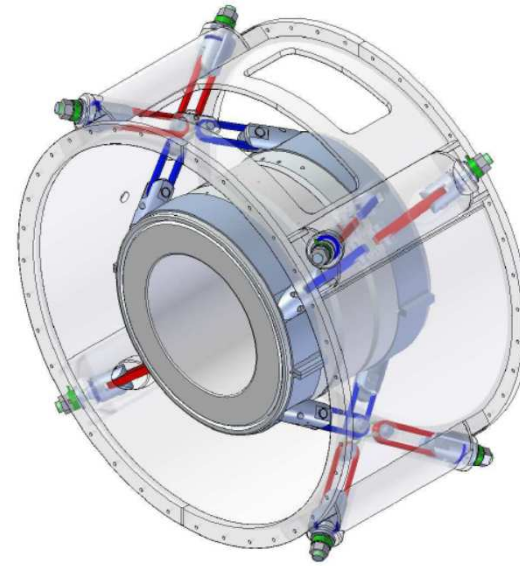


**FOCUS COIL  
QUENCH DETECTION  
&  
QUENCH PROTECTION  
SYSTEM**

# FOCUS COIL MODULE



- **Two 'Gradient Coils' on common aluminium bobbin within cryostat**
- **Absorber contained in warm bore**

- **Module focuses the beam**
- **Two coils operated in:**
  - **‘Solenoid mode’ = same polarity**
  - **‘Flip mode’ = opposite polarity**
    - **More demanding:**
      - ~ 2 x higher currents
      - ~ 2 x higher fields at conductors
      - ~ 4 x higher internal forces
        - » 300 (+) tons
    - **Coils repel**
- **Coils powered in series from one PSU**
  - **Currents ~ 50 – 225 Amps**
  - **$L = 130$  H (Flip mode) ;  $185$  H (Solenoid mode)**

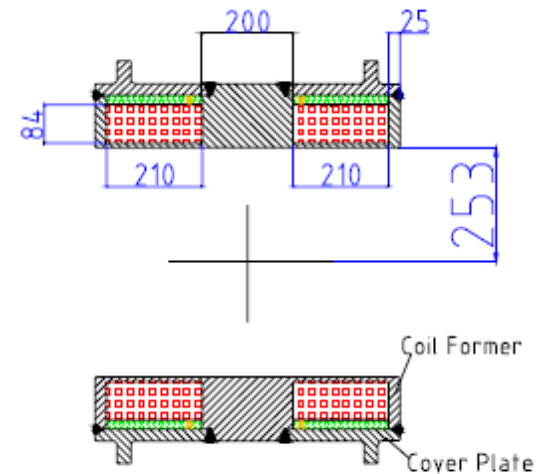
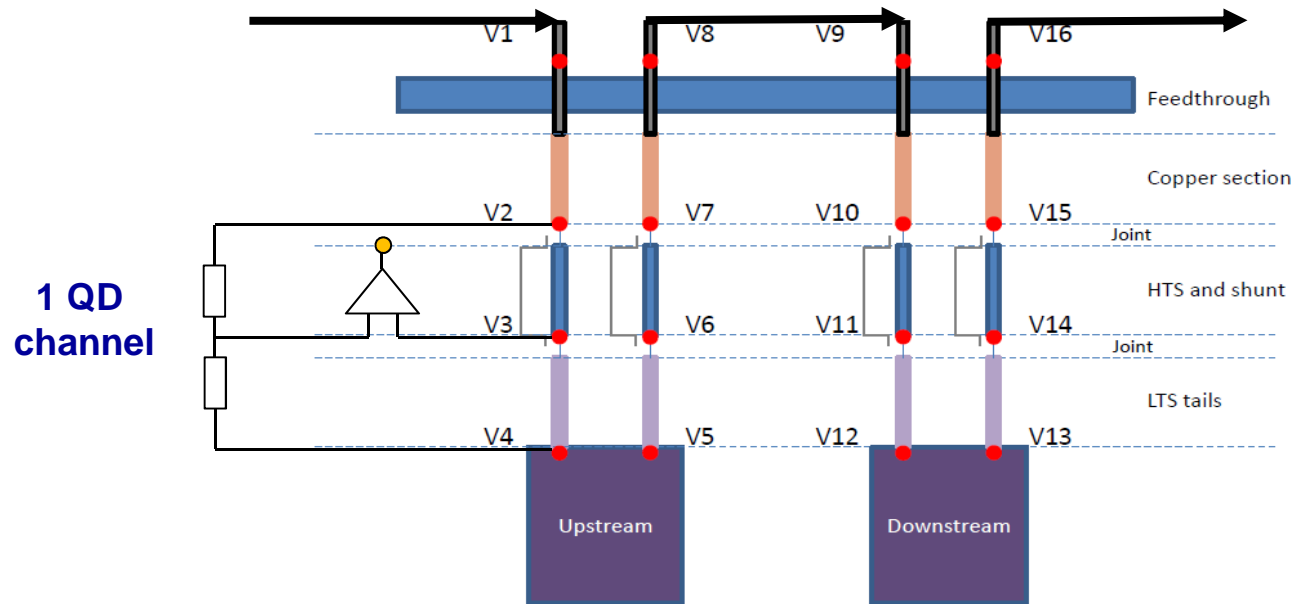


Figure 4 Solenoid cold mass with dimensions

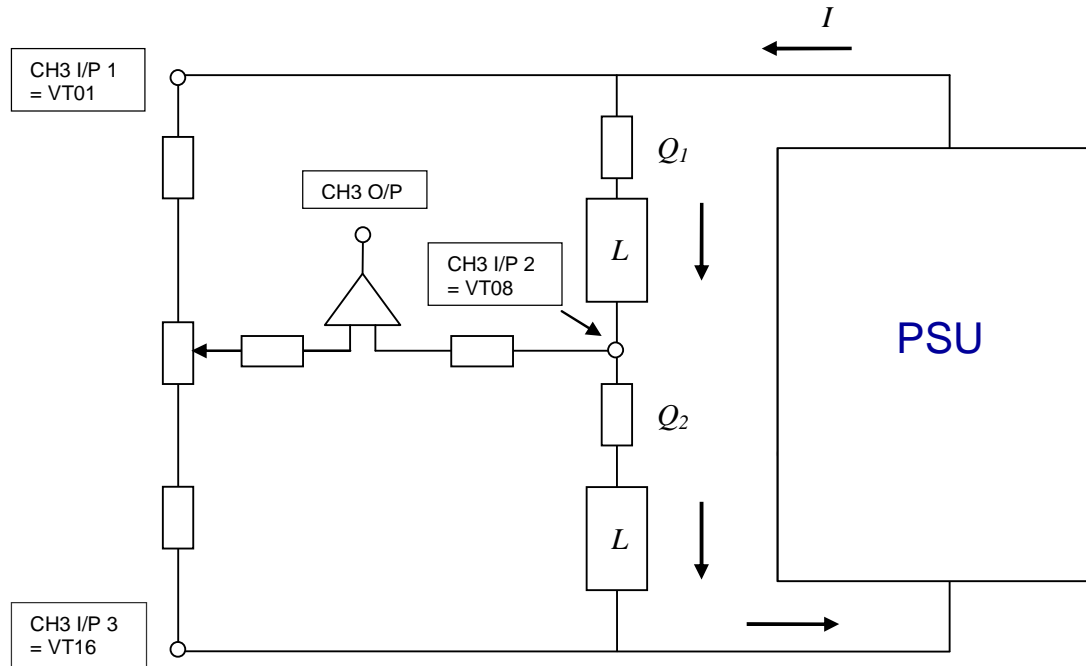
Indirect cooling  
Two cryocoolers

# VOLTAGE TAPS



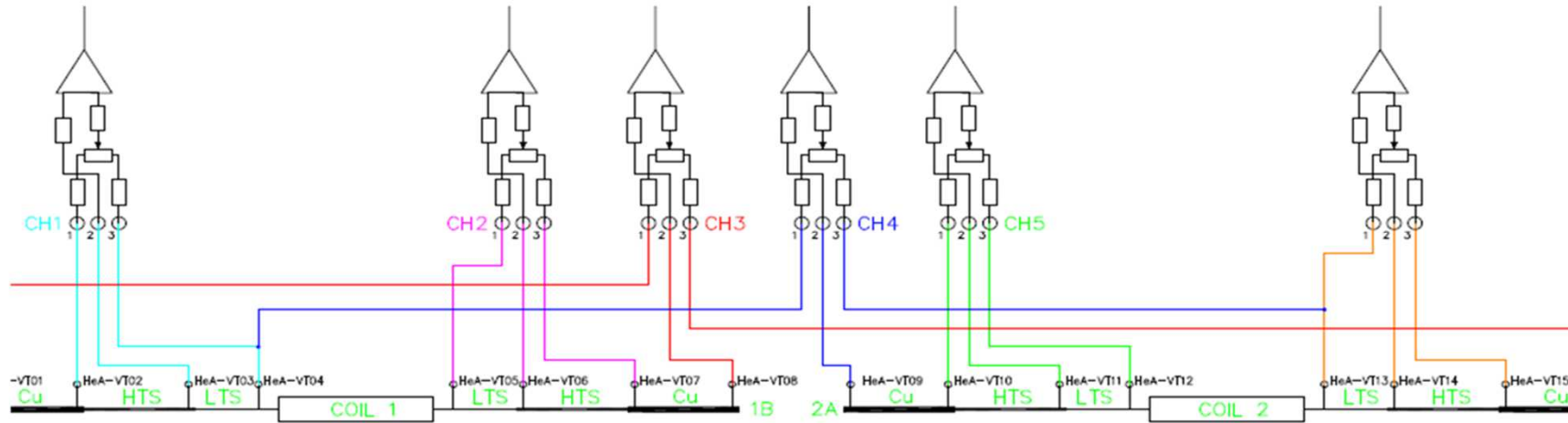
- 8 Voltage taps per coil
- QD system compares:
  - Voltages between adjacent pairs of VTs
    - Protects HTS and LTS tails, e.g. V2 – V3 and V3 – V4
    - Threshold ~ 20 mV
  - and voltages across coils →

# COIL VOLTAGE COMPARISON



- **Voltages across coils compared**
  - **Threshold ~ 0.6 Volts**
  - **Duplicated for redundancy**

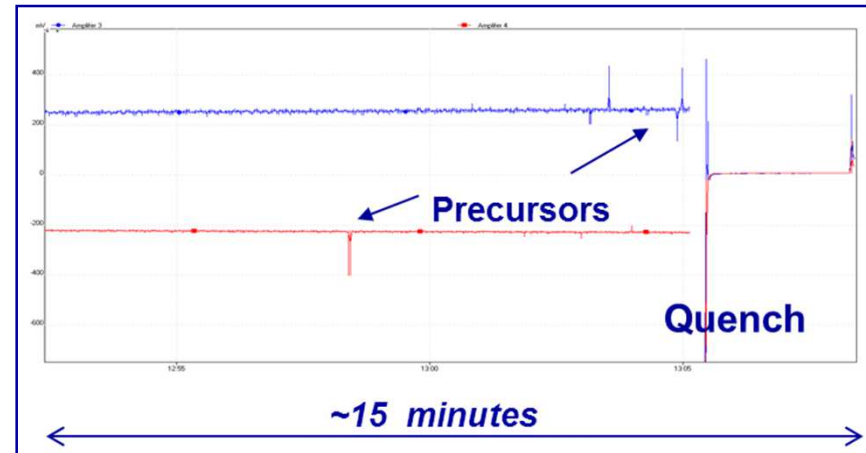
# QD SYSTEM – SUMMARY



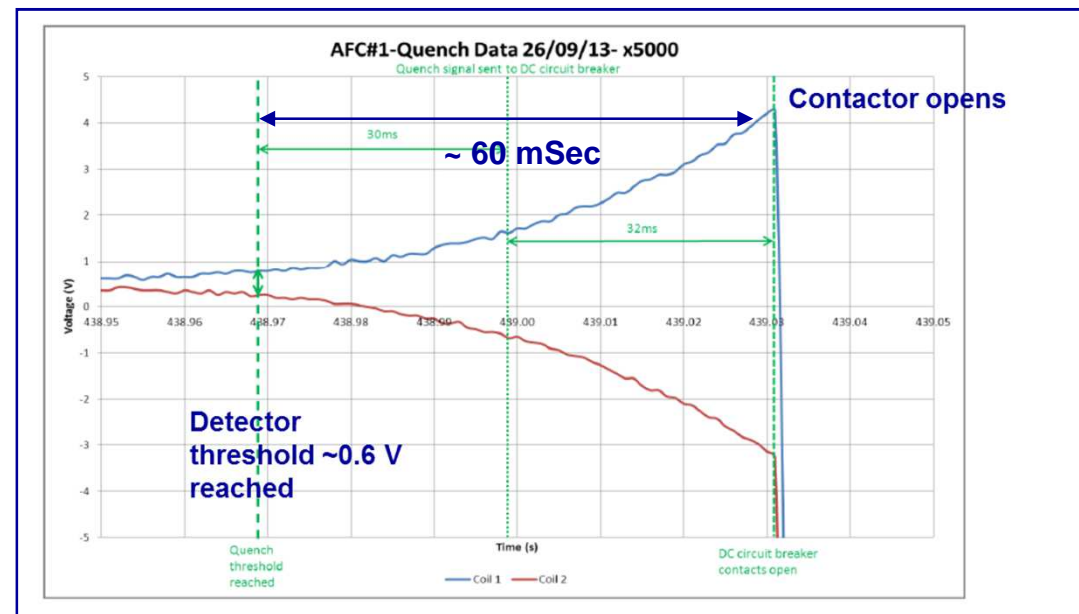
- **6 channels in all**
- **Channels 1,2, 5 and 6 protect HTS and LTS tails**
- **Channels 3 and 4 detect quenches in coils**
- **Amplified outputs available for logging →**

# LOGGING SYSTEMS

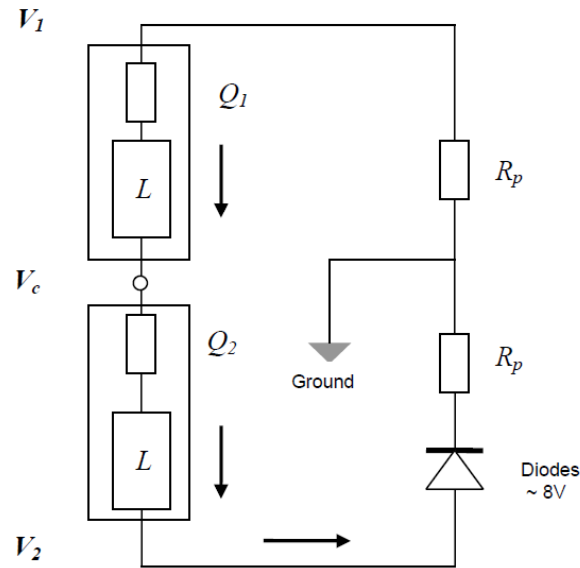
- **SLOW**
  - Uses ‘Picologger’
- Amplified QD outputs (differences) recorded



- **FAST**
  - NI ADCs record VT signals directly



# AFTER QUENCH



- **QD system detects quench:**
  - **Contactor opens**
    - **Current flows through diodes & 2 x 1.5 ohm dump resistors**
      - **Voltage across (fraction of) dump resistors powers heaters on each coil (not shown)**
        - » **Forces other coil to quench**
  - **Quench all over in 10 – 15 seconds**
    - **80 – 90 % of stored energy dumped inside module**