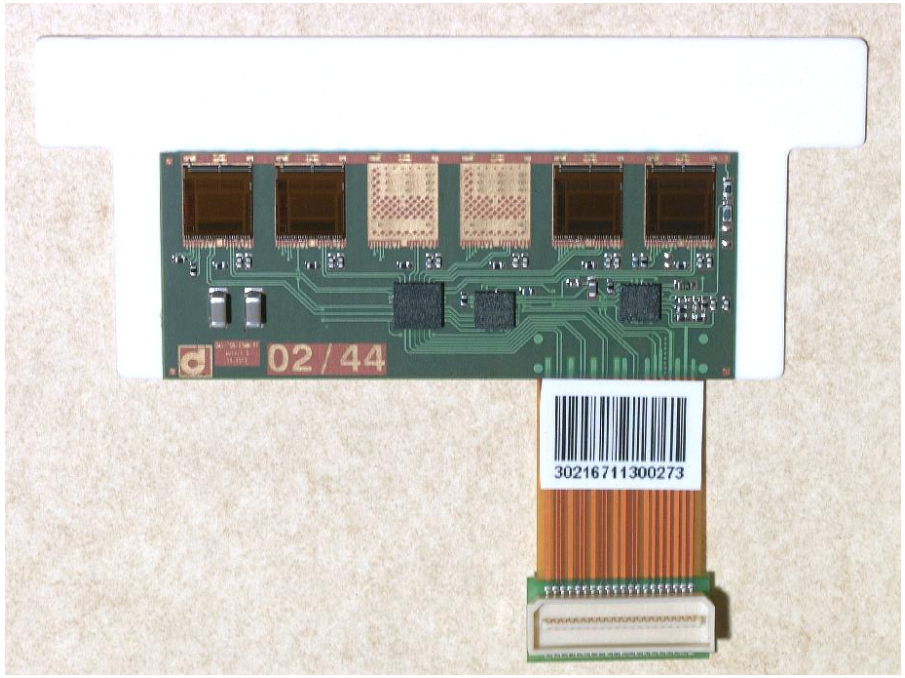
Testing and characterizing CMS tracker front-end hybrids



Luc Bonnet, Vincent Lemaître, Xavier Rouby

LHC and CMS

CMS tracker

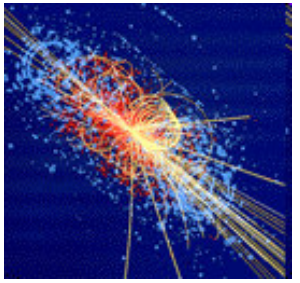
Front-end hybrid

FHIT

Hybrid characterization

LHC & CMS

Large Hadron Collider : pp collider : 7 TeV on 7 TeV
high luminosity $10^{34}cm^{-2}s^{-1}$
bunch crossings every 25ns (40 MHz)



Compact Muon Solenoid : general purpose detector
→ search for Higgs boson, new physics signatures

Different layers :

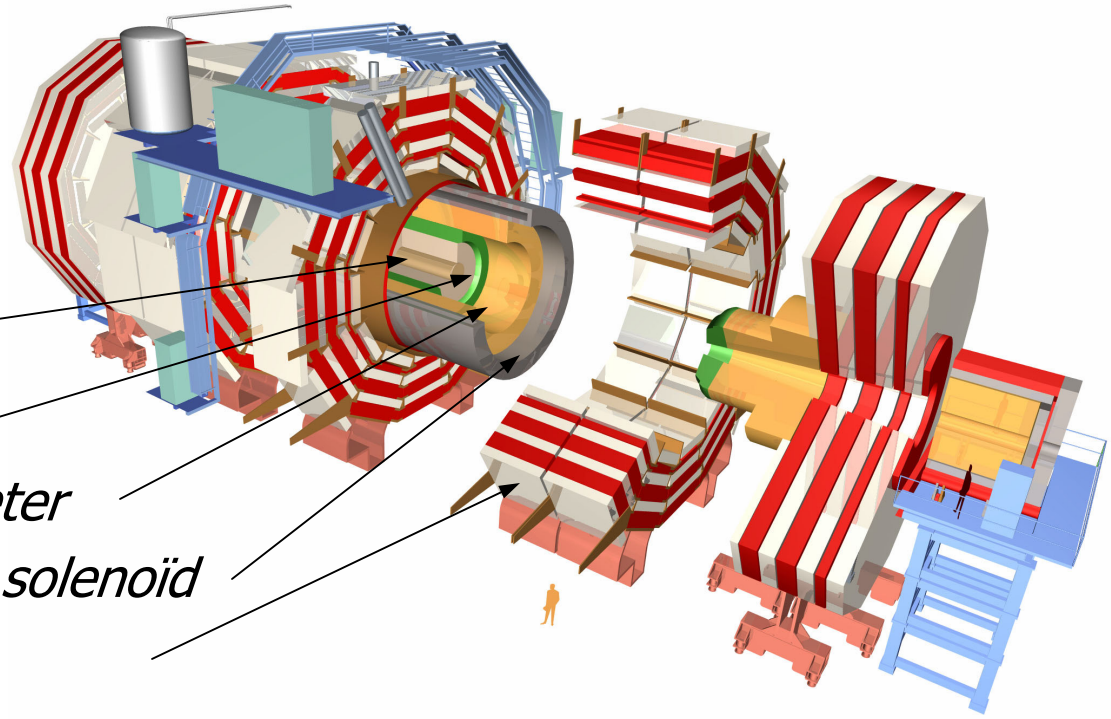
tracker

em calorimeter

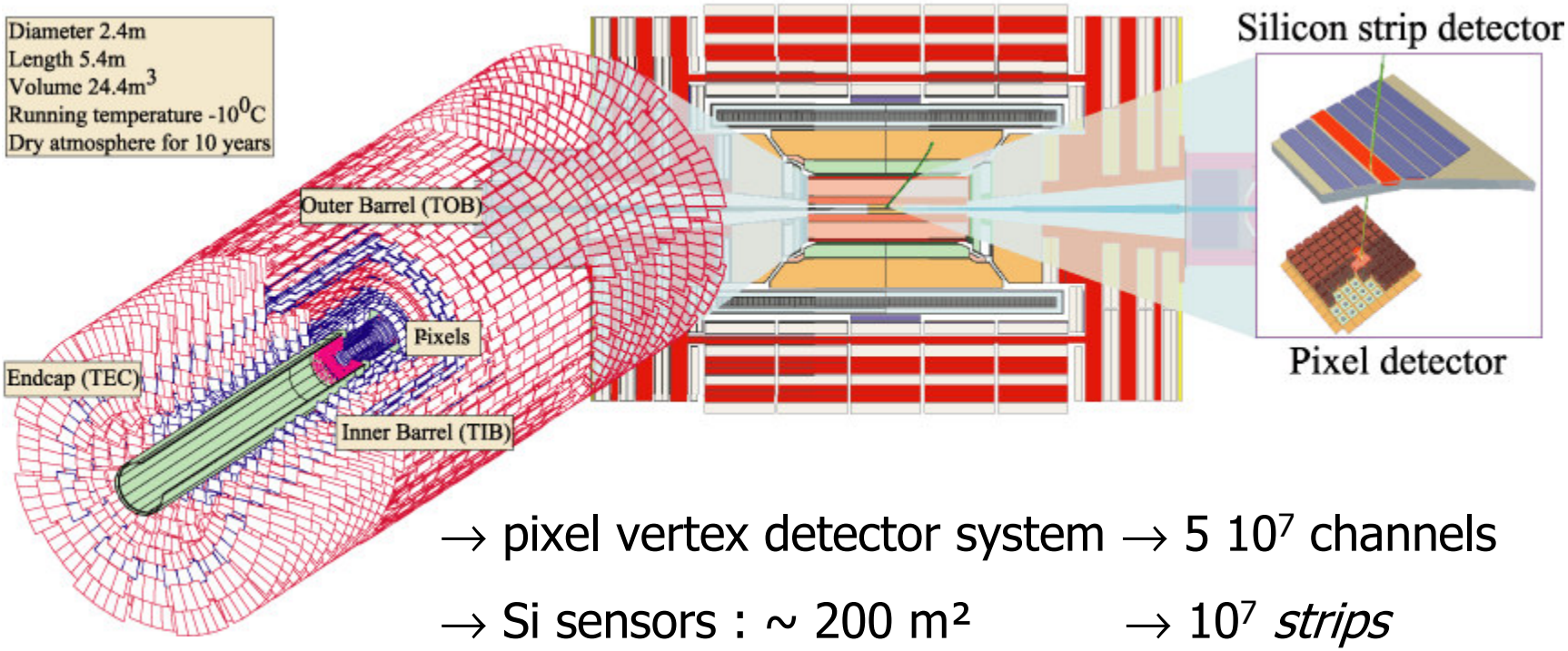
hadronic calorimeter

superconducting solenoïd

muon chambers



Tracker



→ pixel vertex detector system → 5 10^7 channels

→ Si sensors : ~ 200 m² → 10^7 *strips*

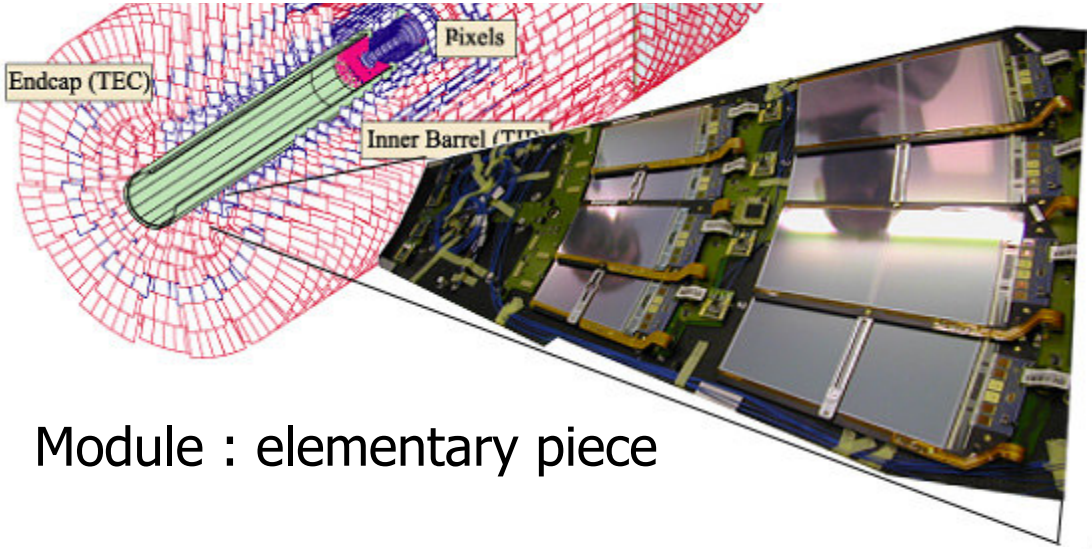
minimum material (ECAL…)

very high radiation doses

low noise after 10 years } → running temperature –10°C

low power consumption

Modules



Module : elementary piece

512 strips

Si sensors

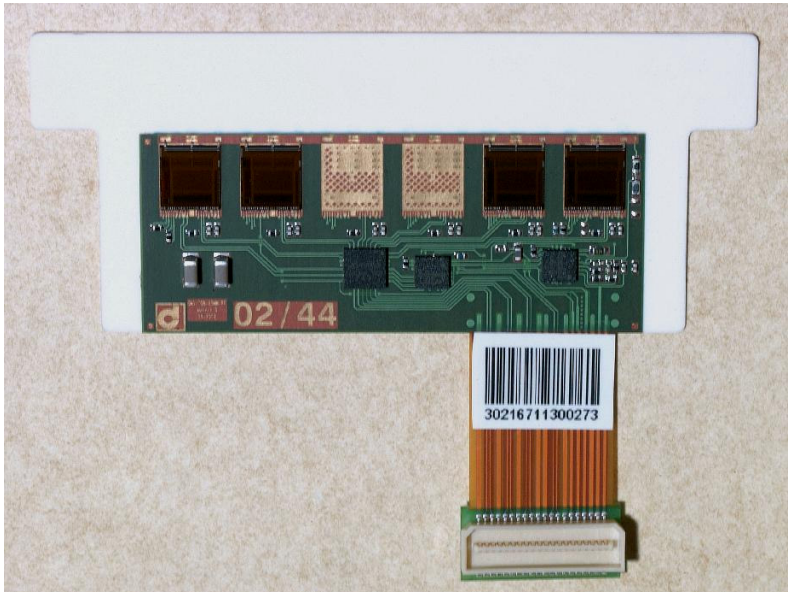
pitch adapter

front-end hybrid

carbon fibre structure

Front End Hybrids

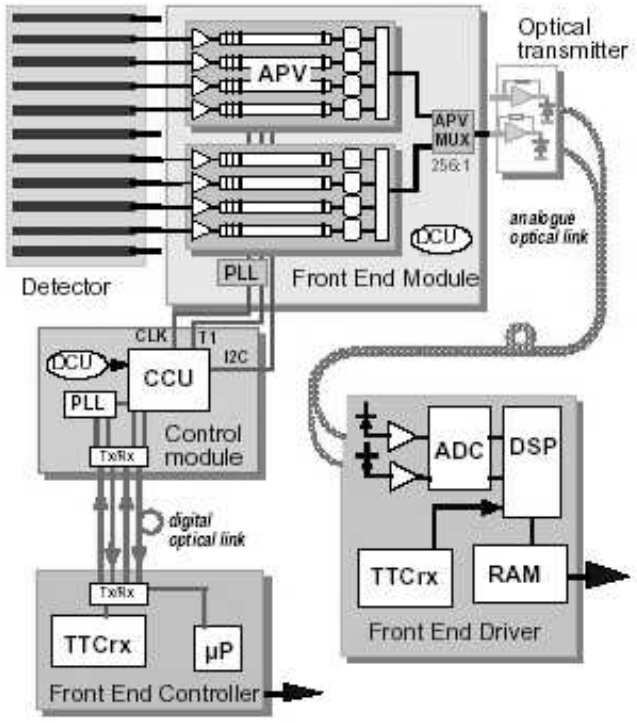
- FEH : critical position in the acquisition chain !
  - module readout
  - waiting for L1 - trigger
- 12 layouts

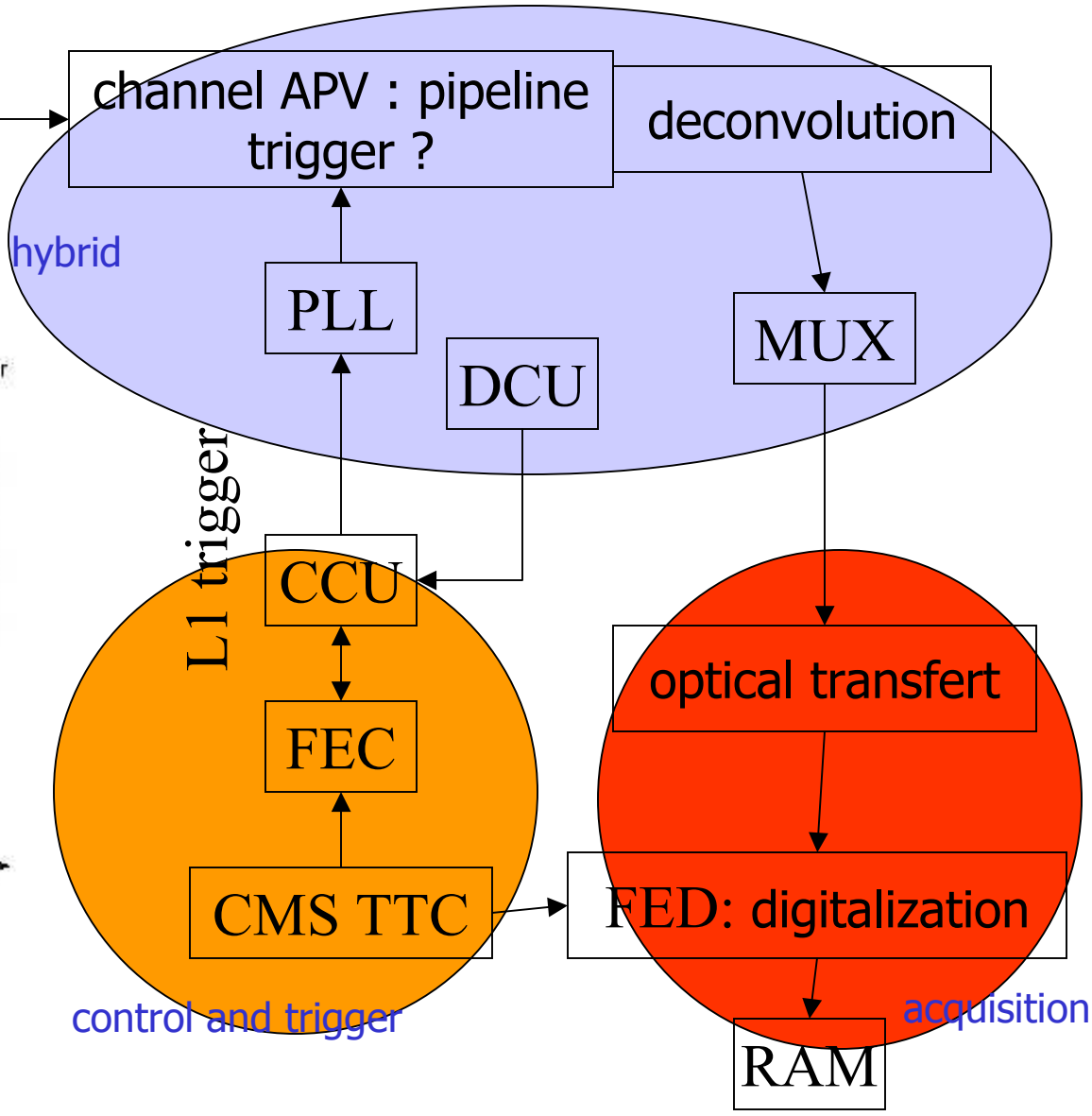


~ 16 000 hybrids to be produced … and tested → FHIT

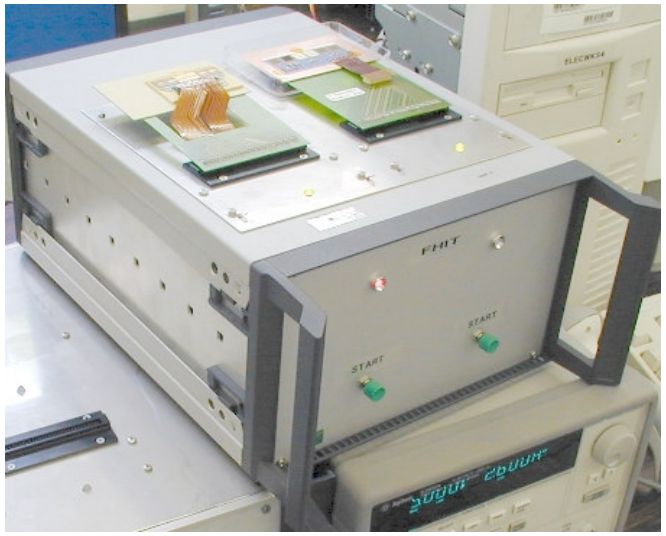
CMS acquisition chain

Si sensor
charge → microstrip



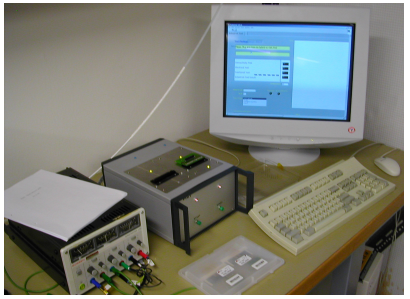


Front end Hybrid Industrial Tester



~ 16 000 hybrids needed

→ 1 fast and specific tester : FHIT



Three different kinds of tests

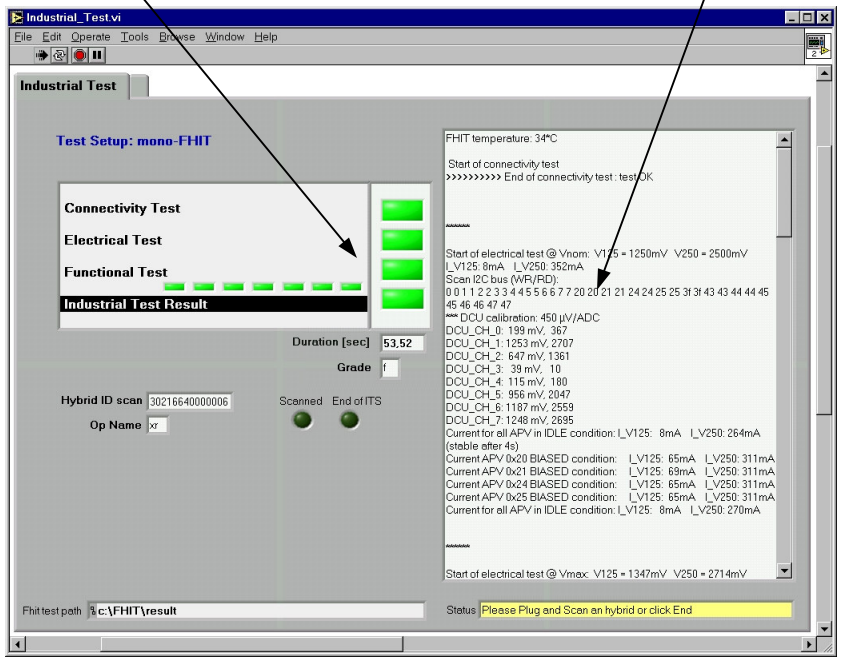
- *connectivity* : open-, short- circuits ⟶ most of hybrid failures !
- *electrical* : hybrid powered on, current measurements
- *functional* : pedestal, noise, gain ⟶ hybrid characterization

FHIT software

- automatic sequence of tests
- data acquisition during tests

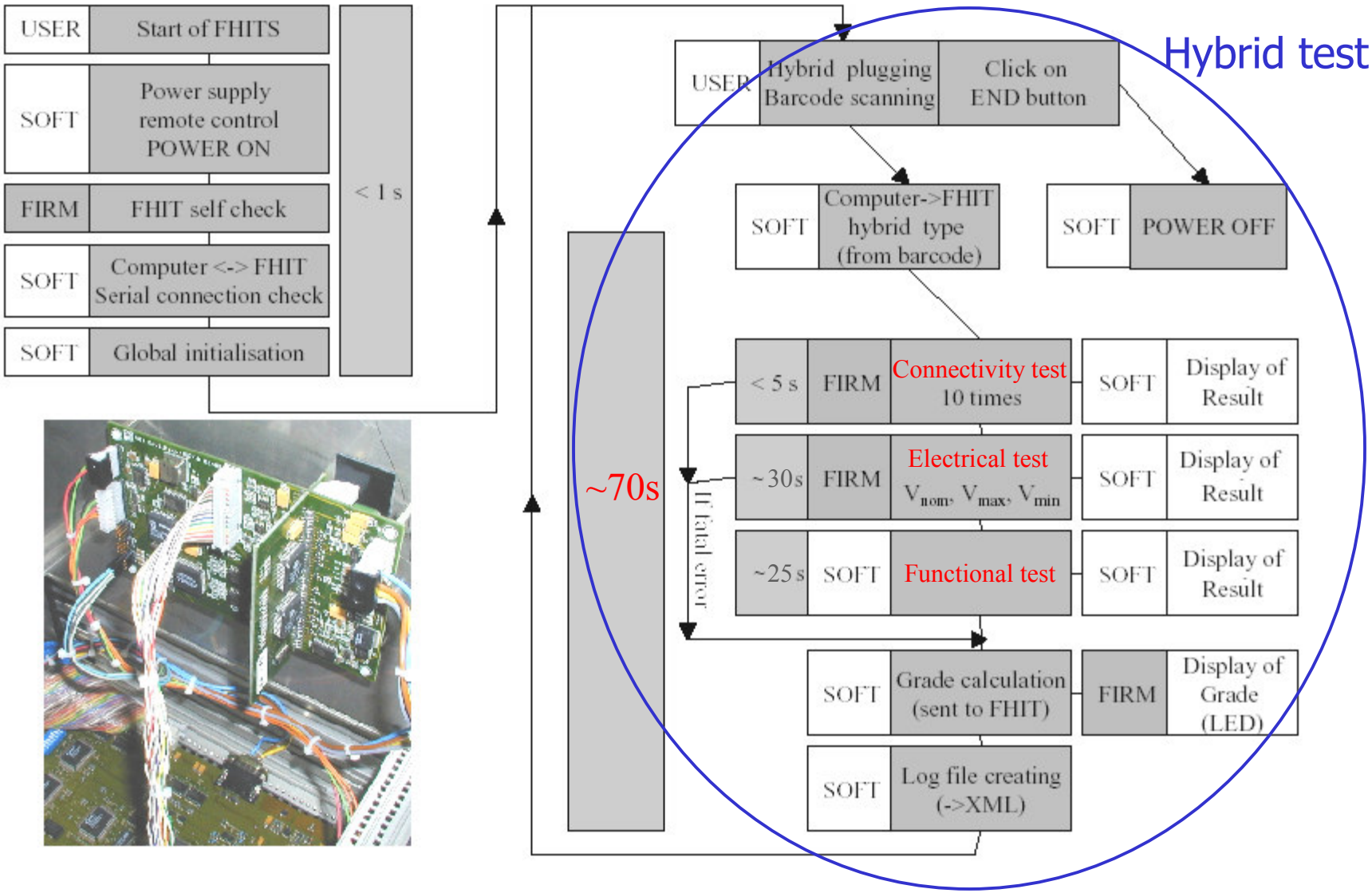
test result

details



...in collaboration with
Aachen, Strasbourg and CERN

Working diagram



Data analysis

data acquisition in real (industrial like) conditions

62 FEH tested

FHIT setup proved to be reliable

dual-FHIT used

test ~ 70 seconds > time needed to handle FEH

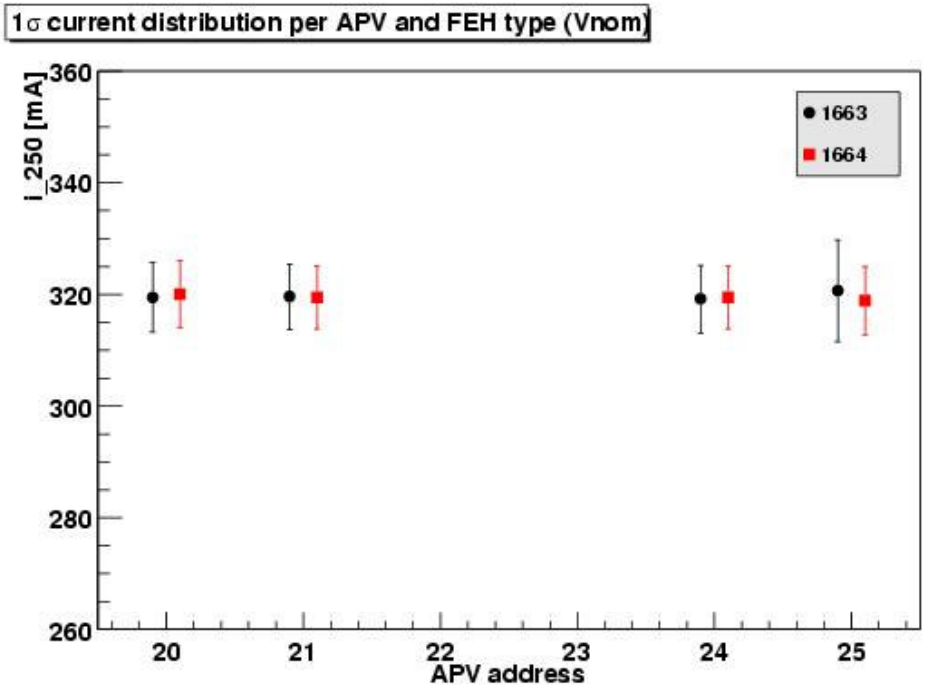
analysis and characterization :

APV25s currents, DCU calibration, APVMUX resistors,

pedestal, noise and gain measurements.

Data analysis : currents

electrical test

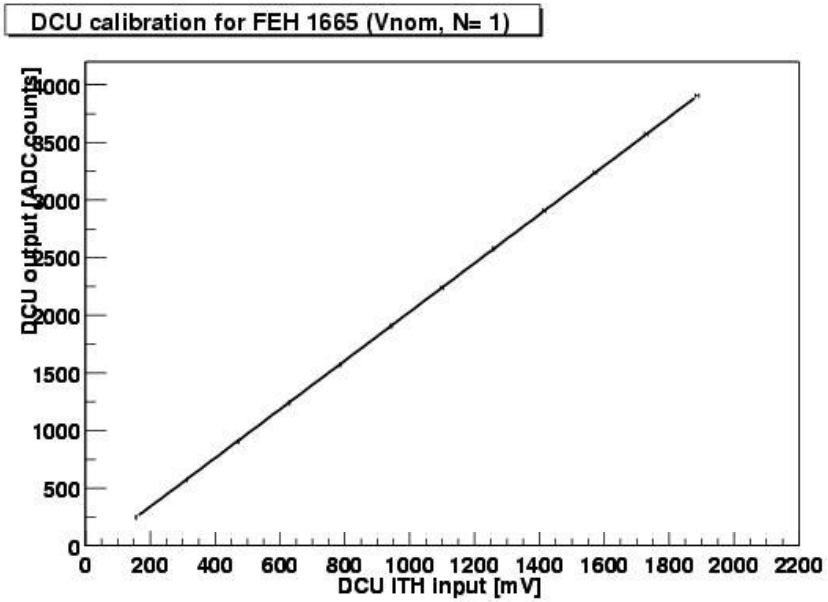


APV current consumption distribution

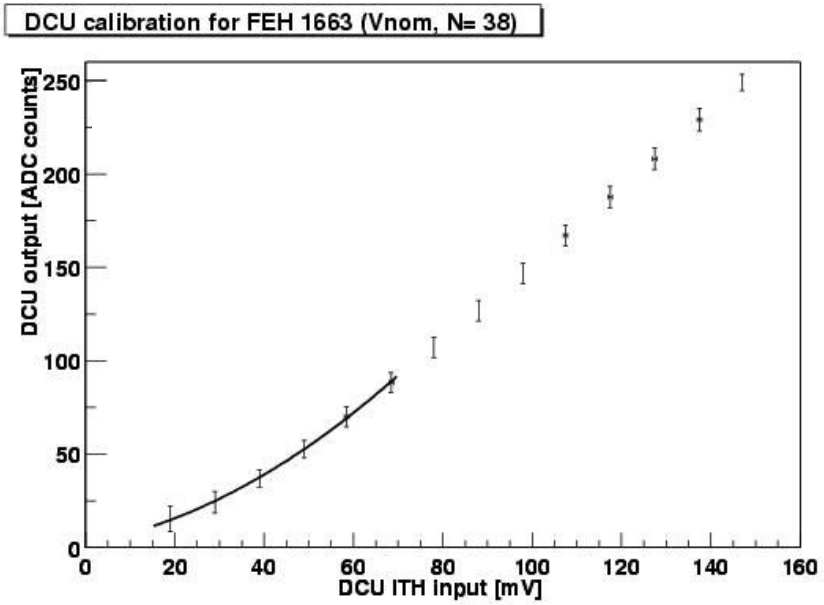
for an APV address and a sample of a given FEH type

- independent on hybrid type or APV position
- dependent on trigger rate !

Data analysis : DCU calibration (ET)



electrical test
DCU = 12bit ADC



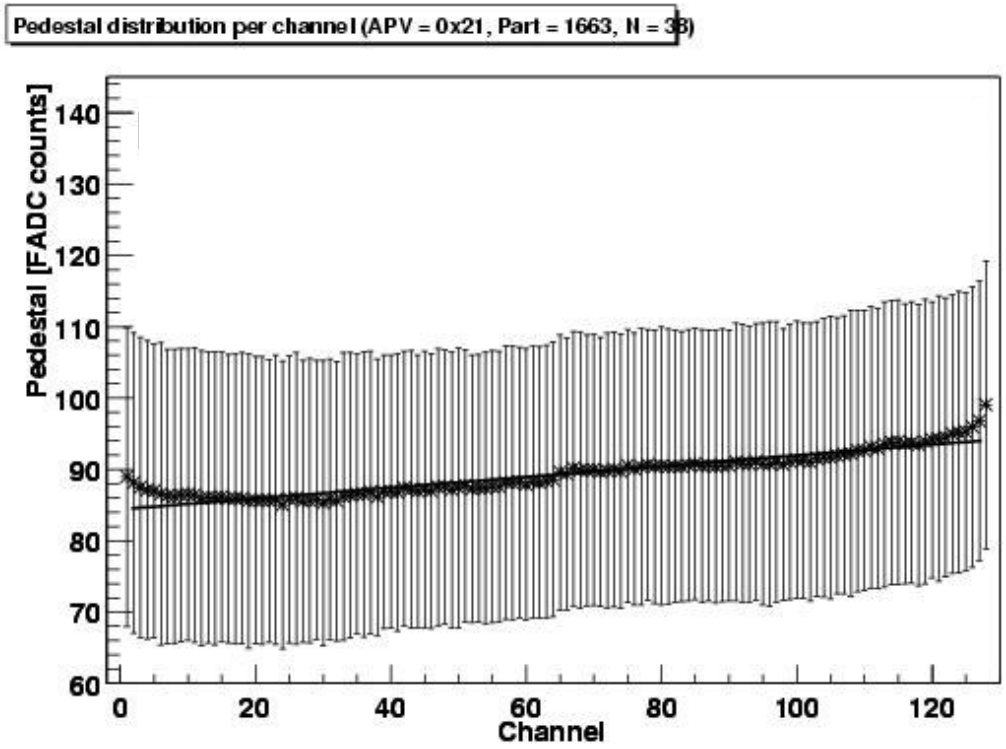
DCU calibration for an APV address and a given FEH

calibration of linear and non linear regions

Data analysis : pedestal (FT)

data from 1000 triggers

functional test



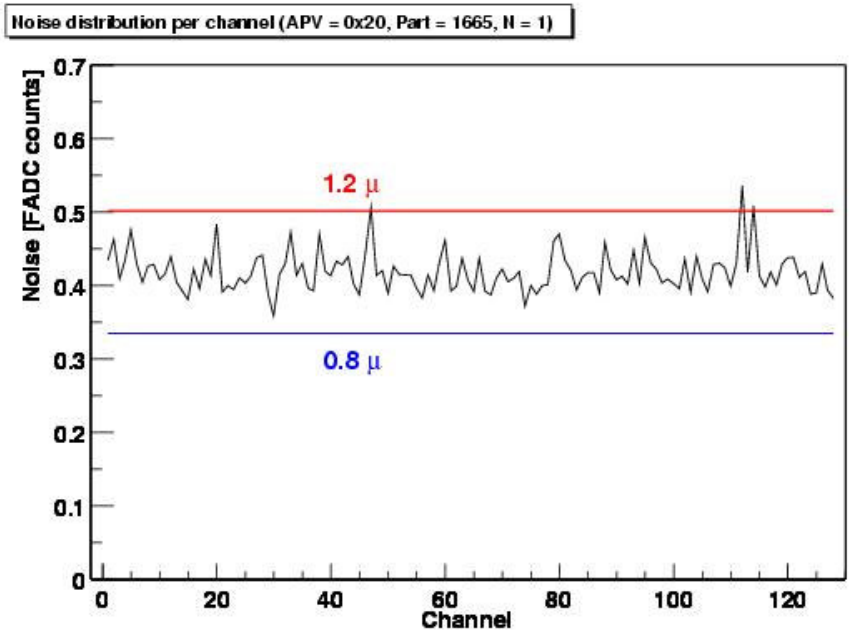
Pedestal distribution per channel for an APV address and for the sample of a given FEH type

visible structures :
- linear increase
- border effects

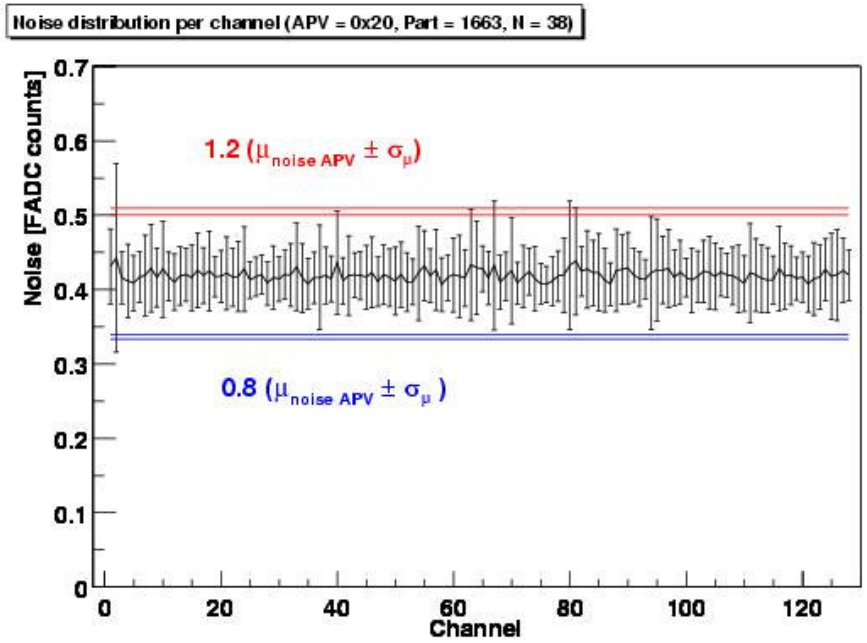
for each FEH :
strong correlation between channels

common mode noise !

Data analysis : noise (FT)



noise per channel for an APV of one FEH



distribution of noise per channel
for an APV address and for the sample of a given FEH type

good/bad channels selection criterion :

$0.8\ \mu < N_i < 1.2\ \mu$

- less correlated *(common mode noise substrated)*
- criterion too restrictive

functional test
from same data as pedestal

Conclusions

- Industrial tester for CMS tracker front-end hybrid
  - has been designed and built at UCL
  - is working
- First characterization of hybrids
  - characterization table is available
- Full production of hybrids
  - characterization could evolve with more statistics