Signal Monitoring at CERN with LXI

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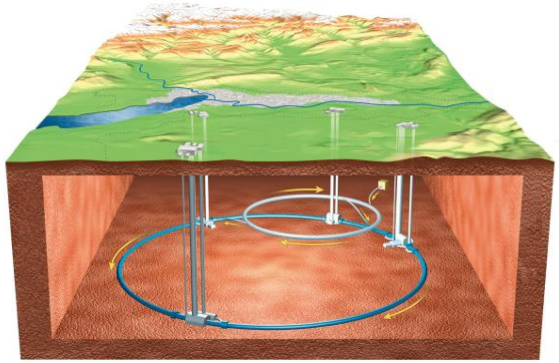
About CERN

- CERN is one of the largest Research Organisations
- Developer of world's largest particle accelerator (LHC)
  - It spreads in a ring over 27 Km circumference
  - 100 m below the surface of Swiss-French border
  - One of the most complex structures ever built



Collider at CERN

- Two high-energy particle beams travel at close to the speed of light before they are made to collide.
- There are four collision sites around the ring
- Provides evidence for particles that makes up dark matter, beauty quark and the Higgs Boson
- Testing the Big Bang Theory - a major effort to explain what happened at the very beginning of our universe.

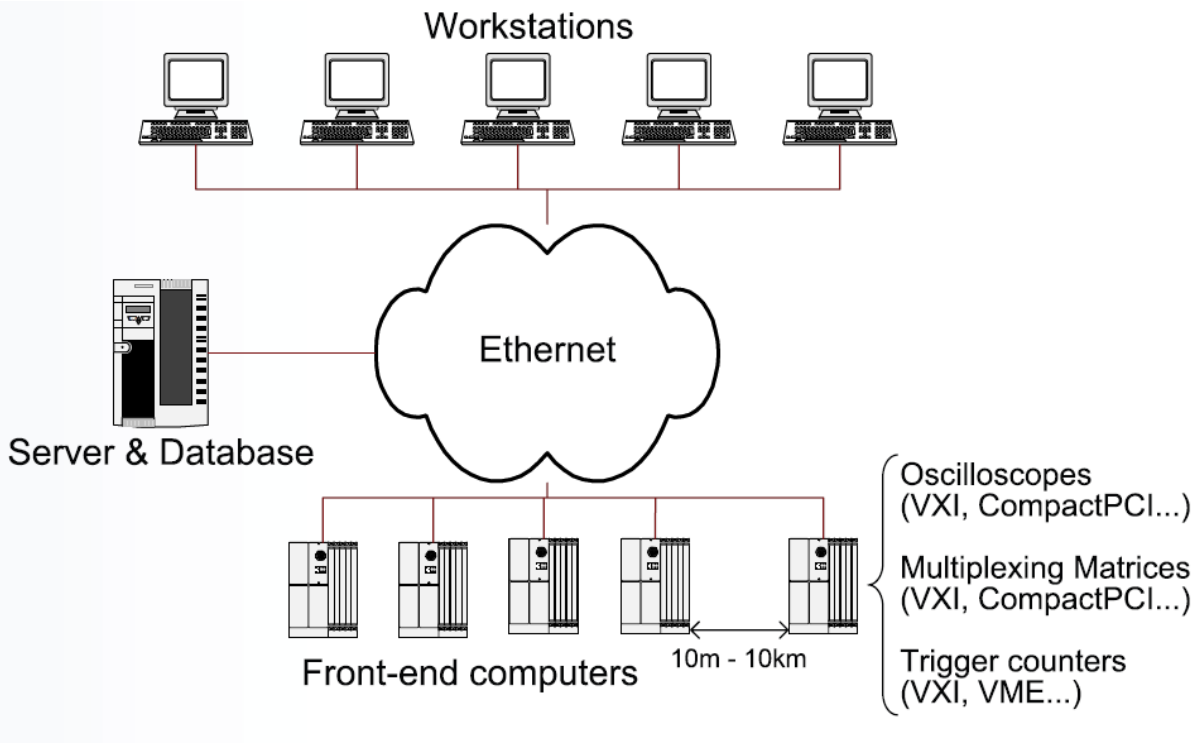
Bikes are used as mode of transportation

Monitoring the Collider

- The collider results grab much of the attention, and the collider itself is a massive feat of engineering
- Monitoring the collider is in itself a difficult task .
  - It is performed by Open Analogue Signal Information System or OASIS .
  - Signals are tapped off around the ring so the status can be checked
  - Getting it wrong has massive impact on the physics experiment
    - Collider time is scarce and expensive

Monitoring Systems

- Monitoring systems as located around the system and need to be accessed via Ethernet

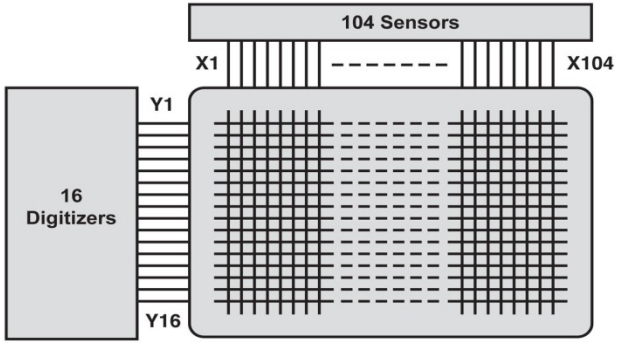


Collider Upgrade

- Planned upgrade at LHC to almost double the collider energy
- Monitoring signals present challenges to the current switching system
  - Time wasted due to no remote debugging facility and limited self test
  - Obsolescence issues on VXI content
  - Limited ability to scale the monitoring system without disruption
  - Increasingly difficult performance requirements
- Like all projects has cost constraints
  - It may be a big science experiment but it has a finite budget and competing demands

Two Competing Approaches

- Use digitisers on each signal to digitise and send over the Ethernet backbone
  - High cost of the high performance digitisers was a major cost driver
  - Controlling large numbers of high performance digitisers created access issues
    - Only a limited number of monitor channels required to be active at any time
- Use a switching system to reduce the number of high performance digitisers
  - Easier to scale the system
  - Required a core 104x16 matrix capability
  - Does what switching systems do – test resources across many access points



Switching System Requirements

- User scalable
  - System had to allow the creation of different matrix sizes in different location to reflect the signals available
- Easy to integrate
  - Had to be easy to configure and manage as a matrix
- Provide excellent bandwidth and crosstalk
  - BW had to be at least 25MHz and crosstalk performance had to be excellent so low level and high level signals on different paths did not create interference
- Accessible remotely
- Remotely controlled self test to ensure the matrix was working before starting the test run

Issues

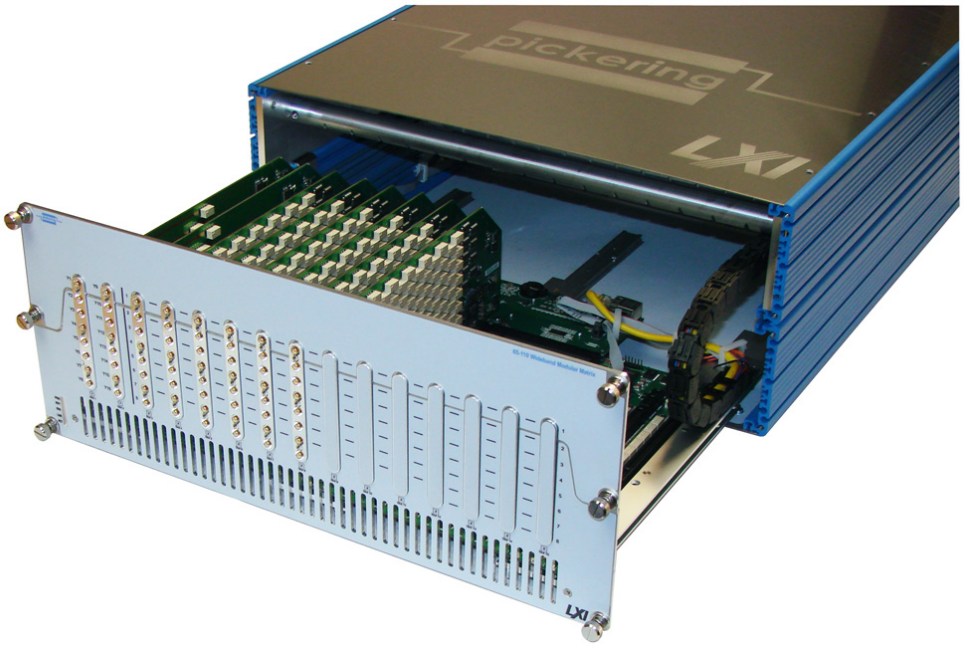
- It had to be a modular system
  - Modular standards not very suited as the system is large
  - Standard modular systems do not have adequately defined inter-module interconnect systems
- It had to be cost effective
  - Ruling out inter-module cabling
- It had to have a compact size
- It had to be designed for at least 100MHz BW to achieve the required crosstalk numbers
- Ability to perform self test on the signal path
  - Implying the switch system had to operate as single entity

CERN Discussion

- Number of routes were discussed
- The only viable route for a switching solution was an LXI based approach
  - but it had to be modular and scalable
    - Not a requirement of the LXI standard but something Pickering Interfaces had done before

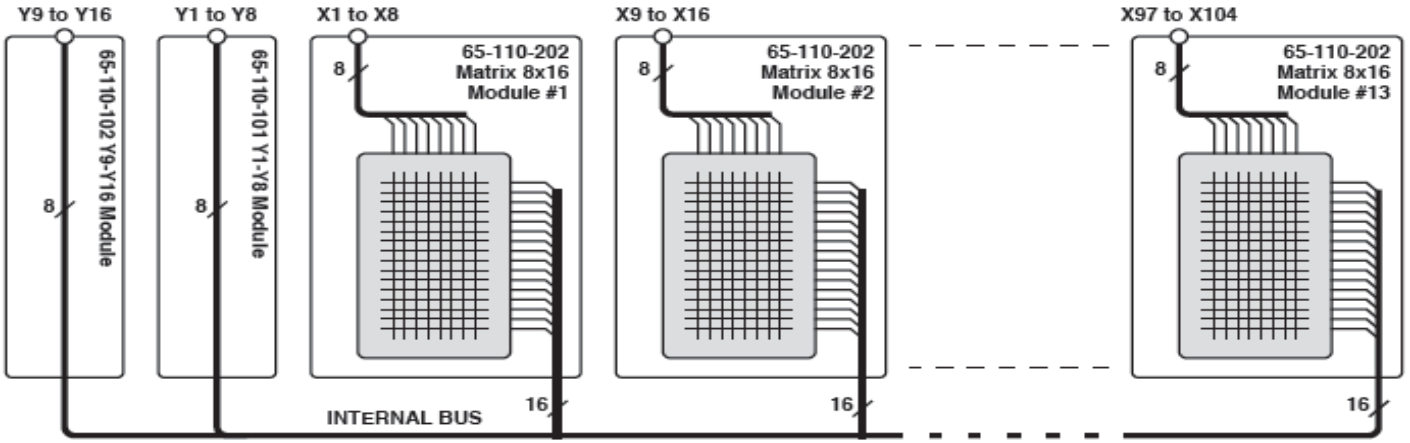
65-110 Proposal

- 1GB Ethernet interface and embedded ARM based controller
- Modular on a proprietary module size
- PCB based signal RF signal interconnect between modules



65-110 Completely User Scalable

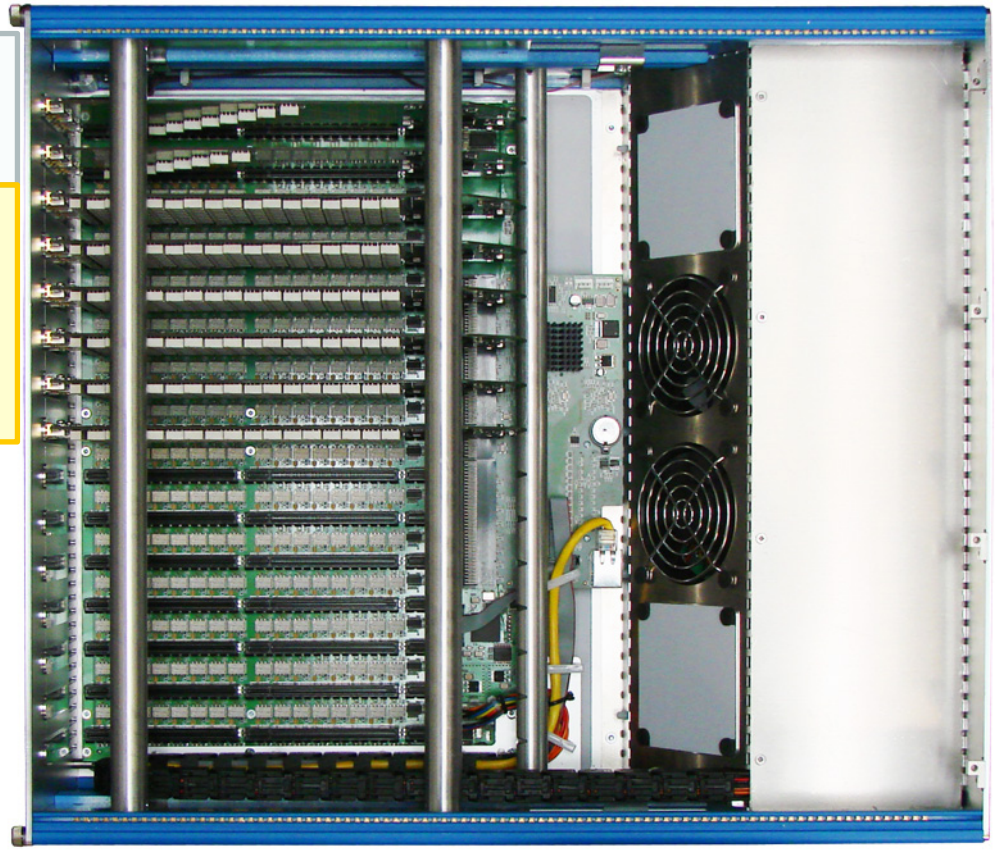
- Set of two Y axis plugins to provide Y=8 or Y=16
- X plugin modules providing 8x8 or 8x16 matrices which can be user inserted in any of 13 slots
  - Embedded software automatically detects the plugins present



Y-CARDS (Y1-Y16)

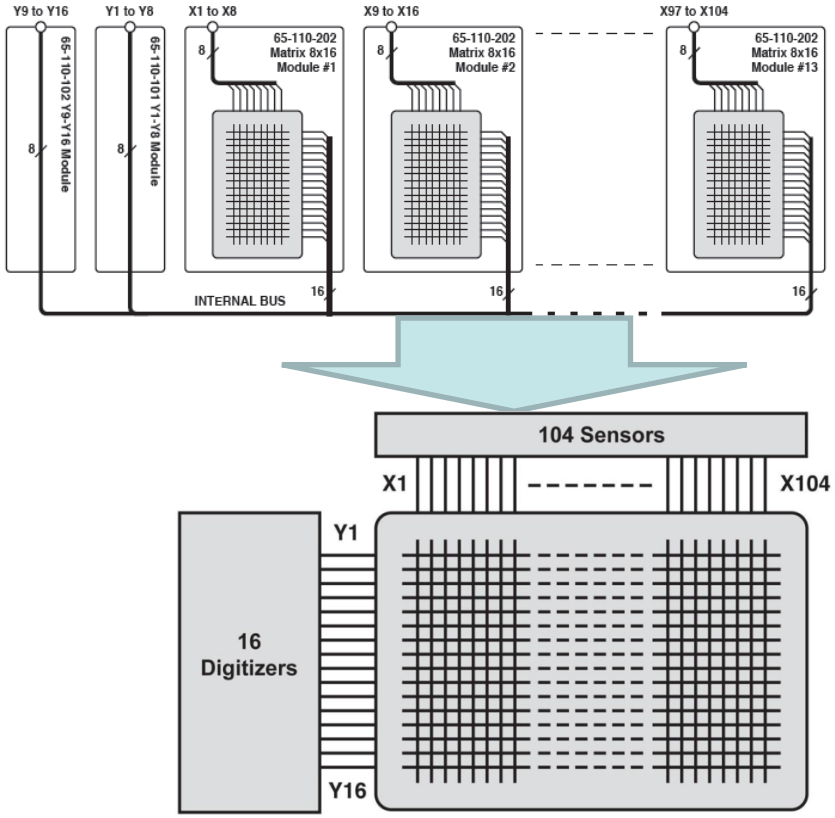
X-CARDS (X1-X48)

MATRIX SIZE (48x16)



Matrix, not a set of modules

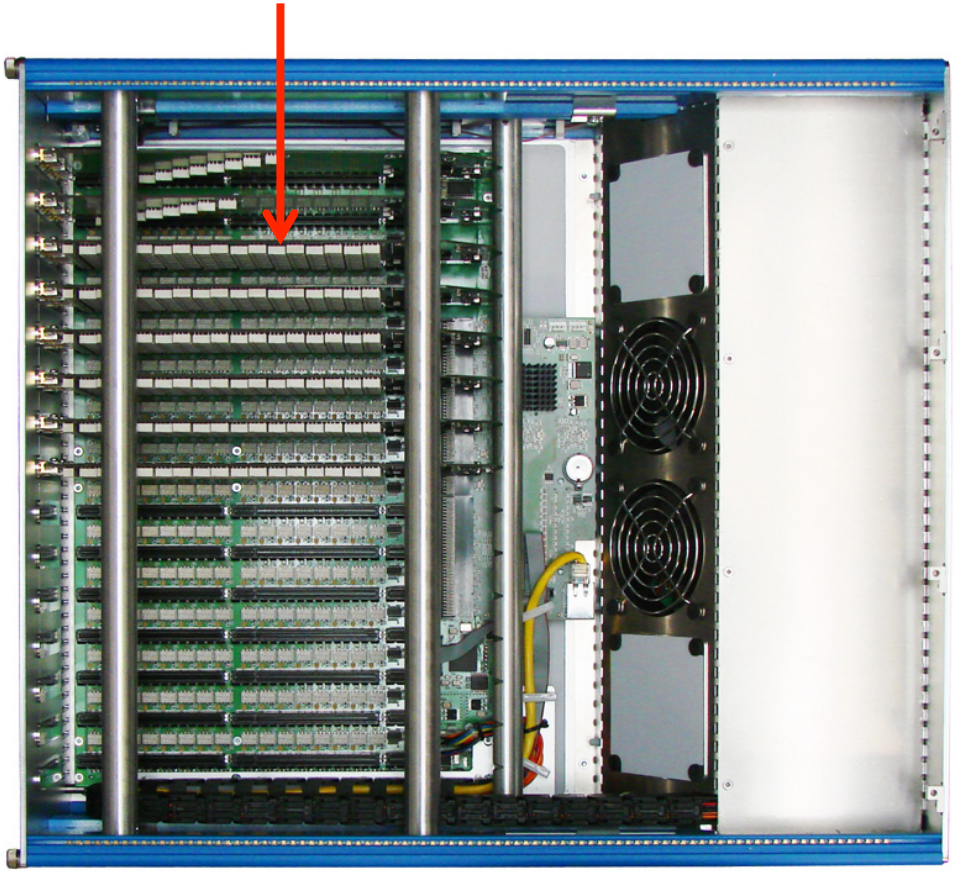
- The ARM controller that provides the LXI interface configures the matrix to the installed size without user intervention
  - User deals with a matrix, NOT a set of modules



High performance with no module interconnect cables

- Usable BW to 500MHz
- Plugin modules sized to allow layout to be optimised for low crosstalk
- Module interconnect through a motherboard with controlled impedance tracking and defined crosstalk performance

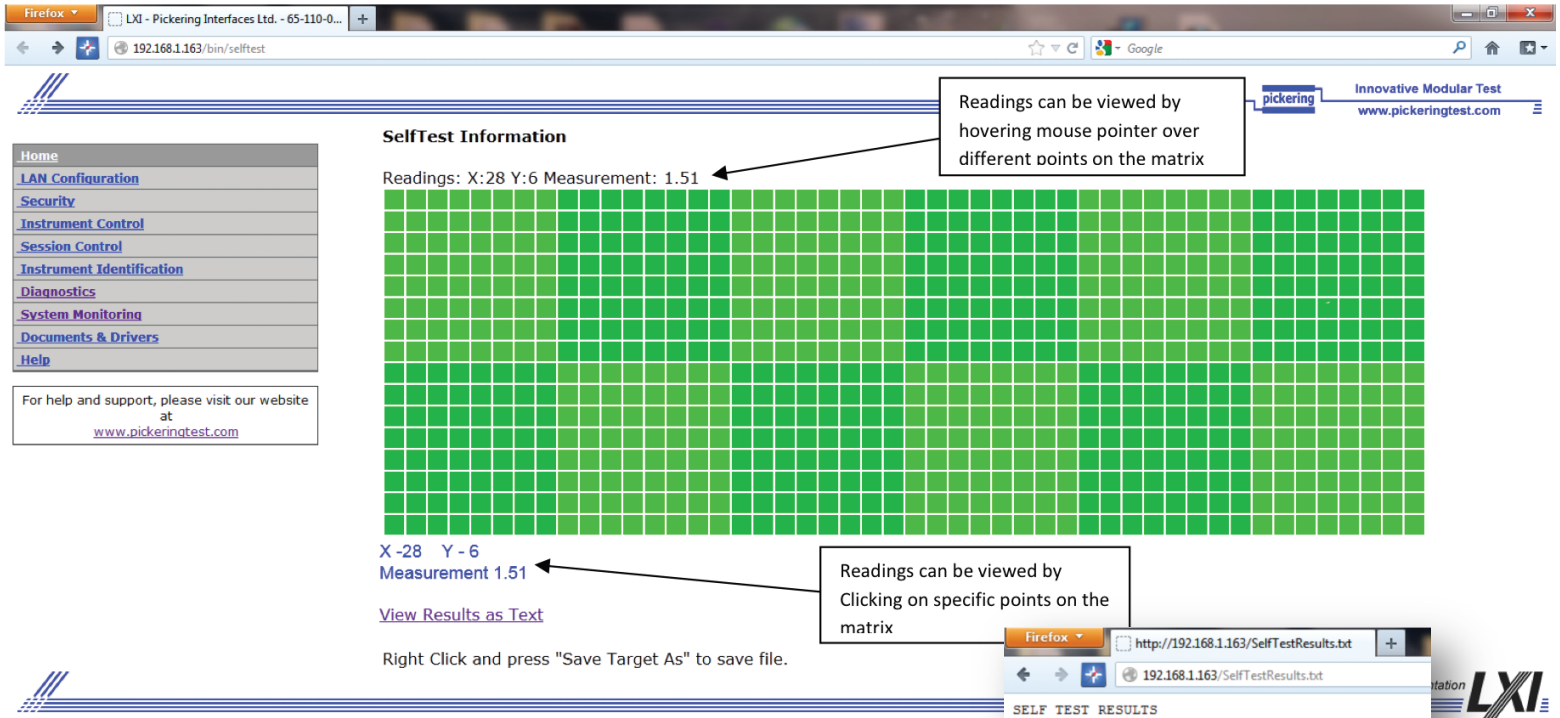
Motherboard provides the RF interconnect between the modules and at right angles to the X connection to ensure good matrix performance



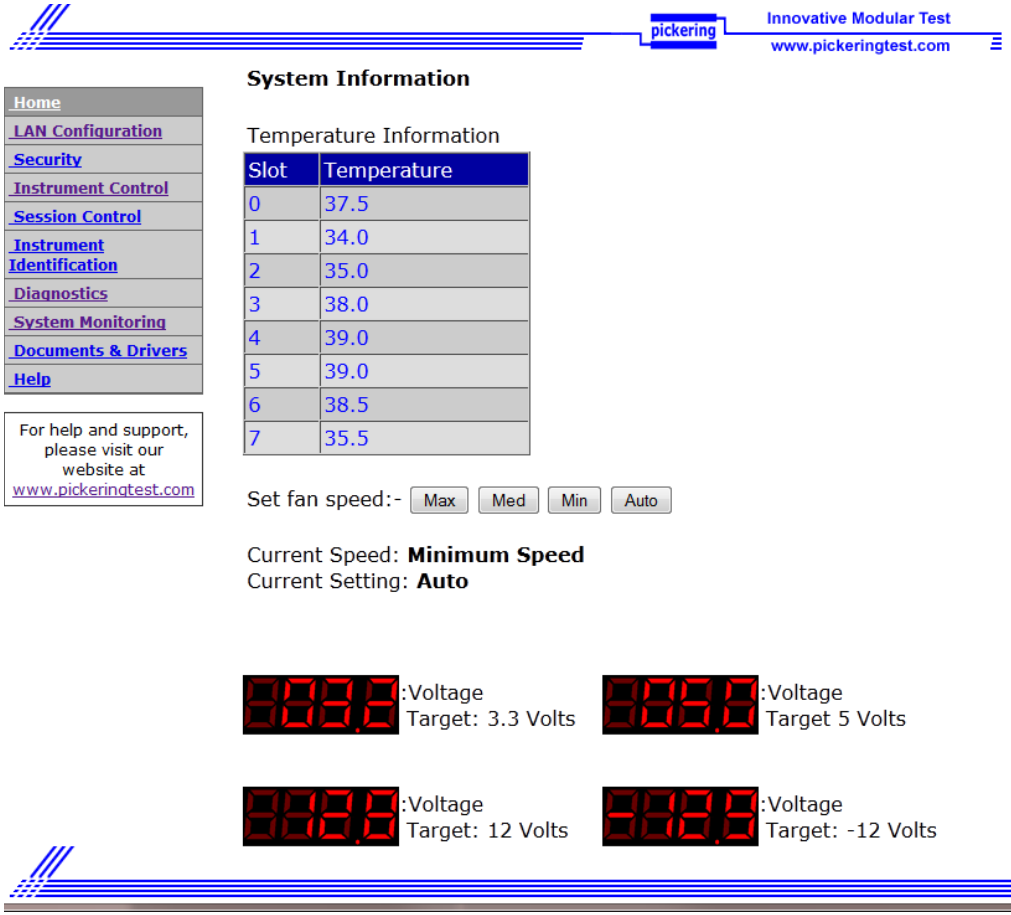
Built in Self Test

- Hardware system built in to inject test signals to check for matrix continuity
  - External connections remain connected but not powered
- Self test run independently by the controller
- Self test can be initiated through the web interface provided by the LXI interface
  - Progress can be viewed through the web browser, results displayed and can be downloaded as a text file

Self Test



Chassis monitoring capability via the web interface



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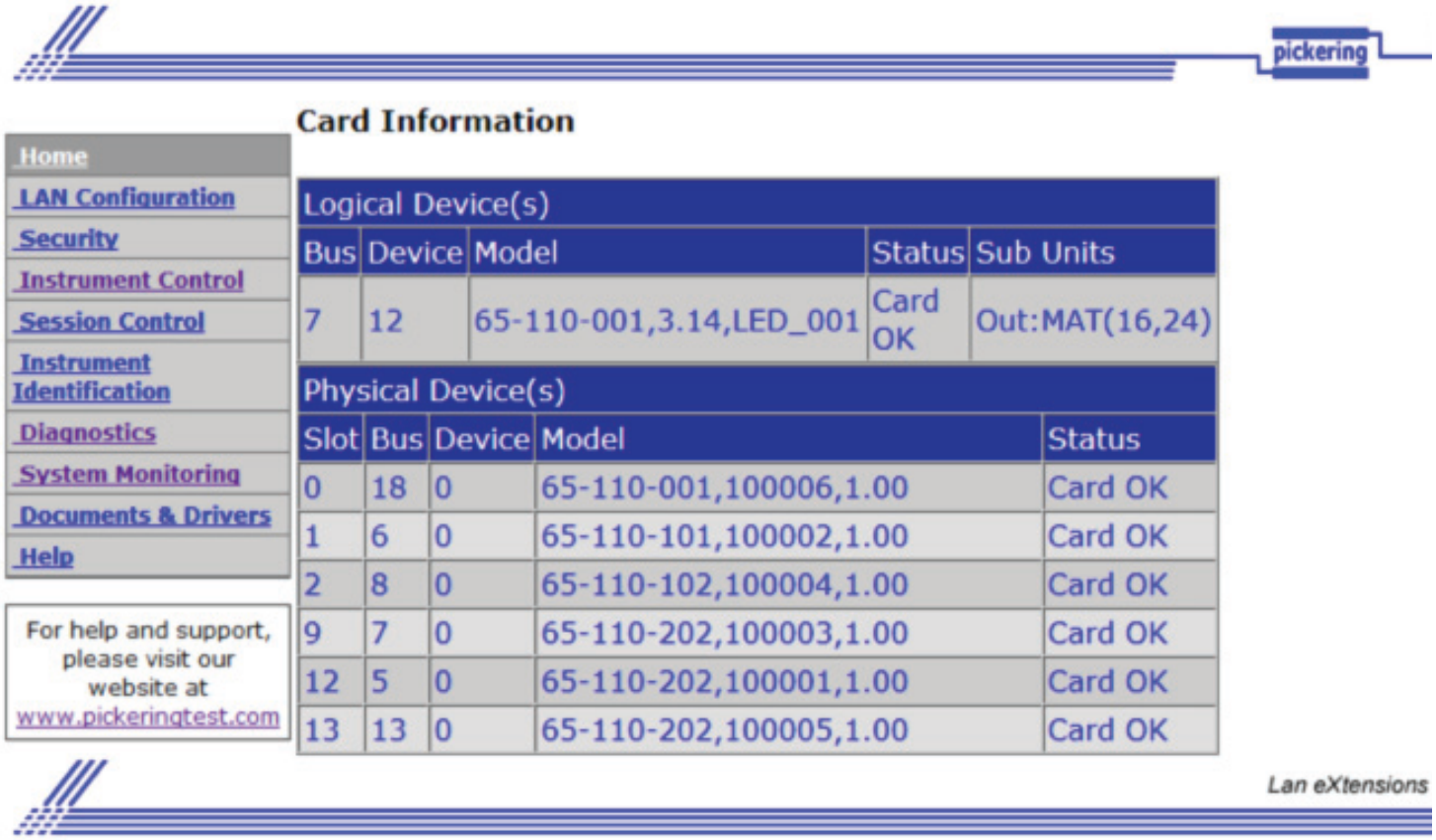
Checking the status of each plugin module via the web interface



Multiple controller access

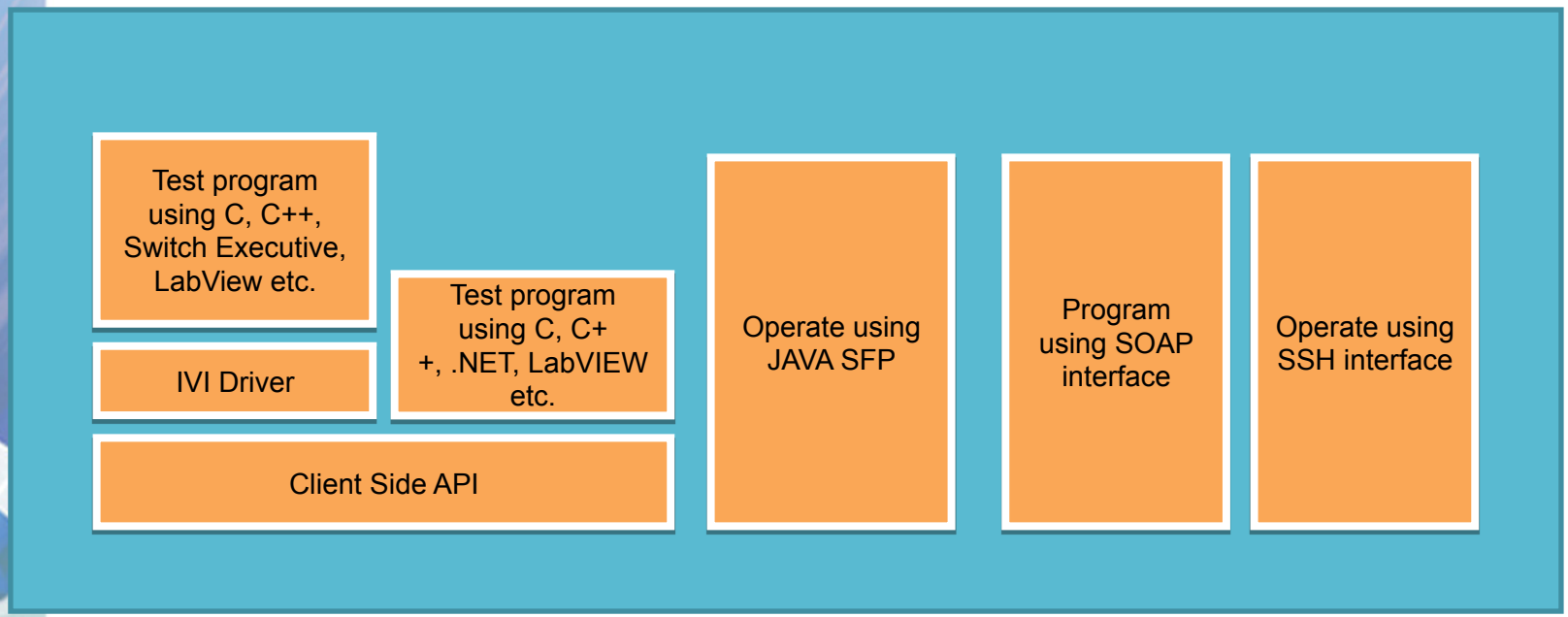
- Single controller can lock the 65-110 settings to restrict changes
- Other users can be allowed to access what it is doing without changing settings
  - A very useful feature for any system with remote access

Other features

- Other Features include
  - Remote Firmware Upgrades
  - Store/Recall switch state
  - IP address display

Control in different ways

- There are various modes of operations used to control Pickering's LXI product.
- All drivers are provided with examples to get user started in different programming environments (e.g. C, C++, .NET, LabVIEW, CVI, MATLAB, Python)
- Driverless interface is also available to control the LXI using SSH, SOAP and Java SFP.



What LXI made possible

- Standardised Ethernet interface made it easy to manage
- Being able to change the module size to suit the application made it possible to optimise the design performance
- Having local controller allowed for ways to virtualise the matrix
- Allowed the introduction of monitoring systems and self test
  - with web based access and initialisation
- Ethernet allowed direct mounting on the network for easy installation in the CERN infrastructure

Many features are not requirements of the LXI standard, but once you go down this route they become easy to add to suite market requirements

More information links on CERN

- http://home.web.cern.ch/about/updates/2013/04/animation-shows-lhc-data-processing
- http://home.web.cern.ch/about/engineering
- http://home.web.cern.ch/about/accelerators
- https://project-oasis.web.cern.ch/project-oasis/

- Thank you for time