Adapting COTS Technology for Scientific Applications for Global use

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Scientific Research & Big Physics
Senior Program Manager

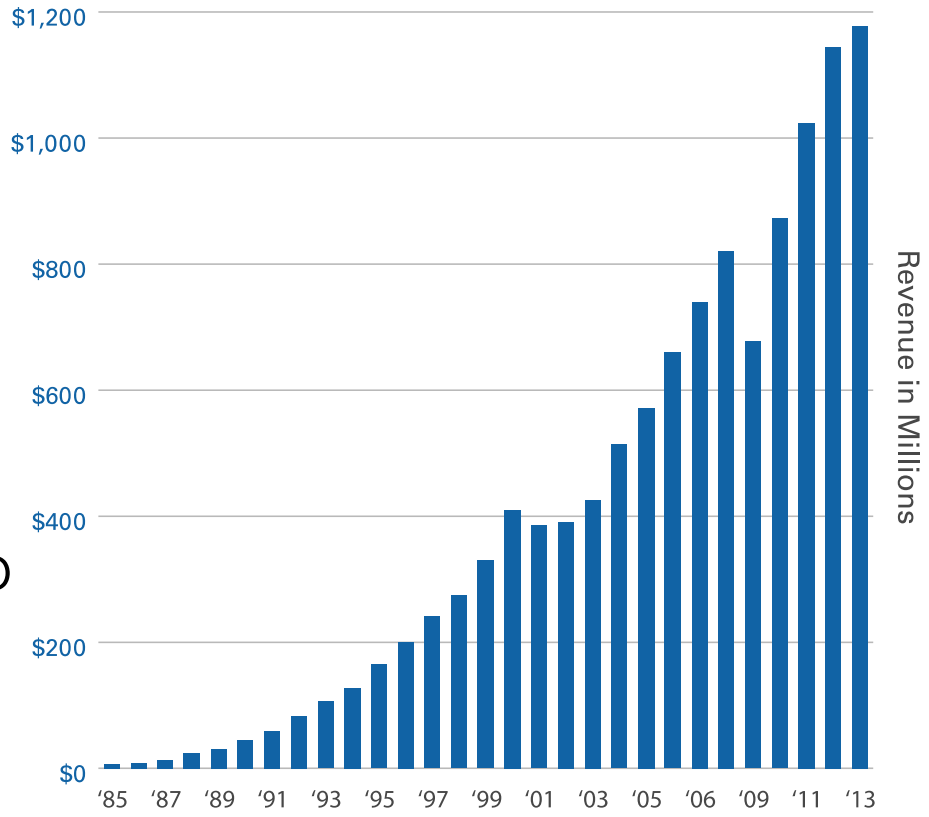
NATIONAL INSTRUMENTS

Agenda

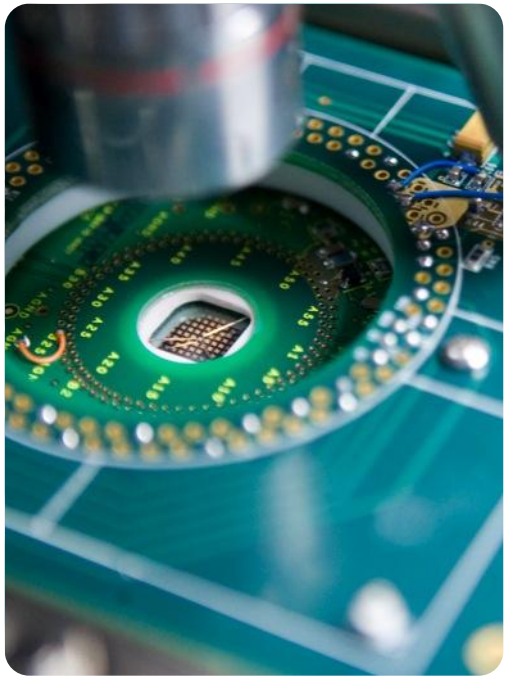
- Introduction to National Instruments (NI)
- Involvement in "Big Physics"
- Addressing Big Physics Application Requirements
  - Linux
  - EPICS
  - Radiation and Magnetic Field Testing
  - RASM
  - Lifecycle Management
  - Global Services
- Conclusions

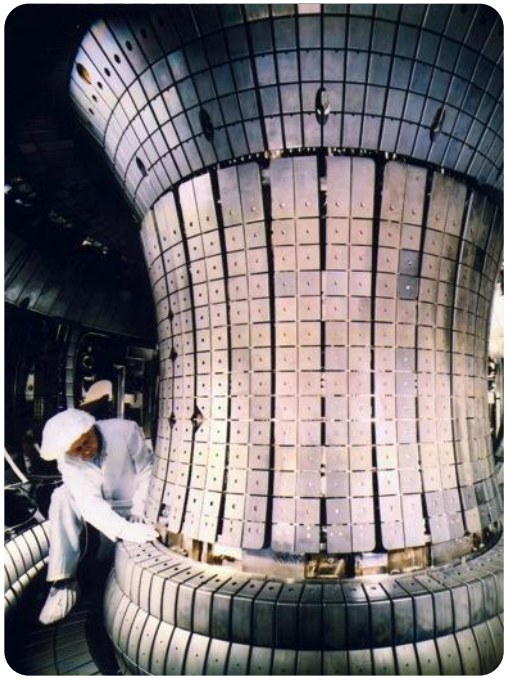
National Instruments Overview

- 35+ years of industry experience
- 1,700+ R&D engineers
- 600+ Field Engineers
- 200+ Application Engineers
- 700+ Alliance Partners
- Broad Customer Base with no industry >15% of revenue



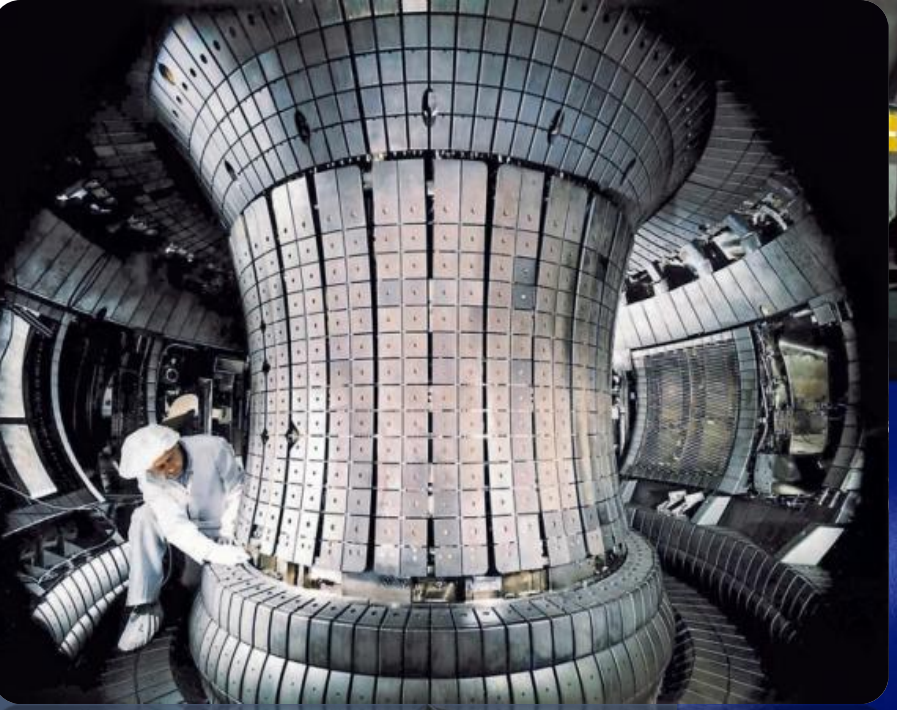
Our Mission



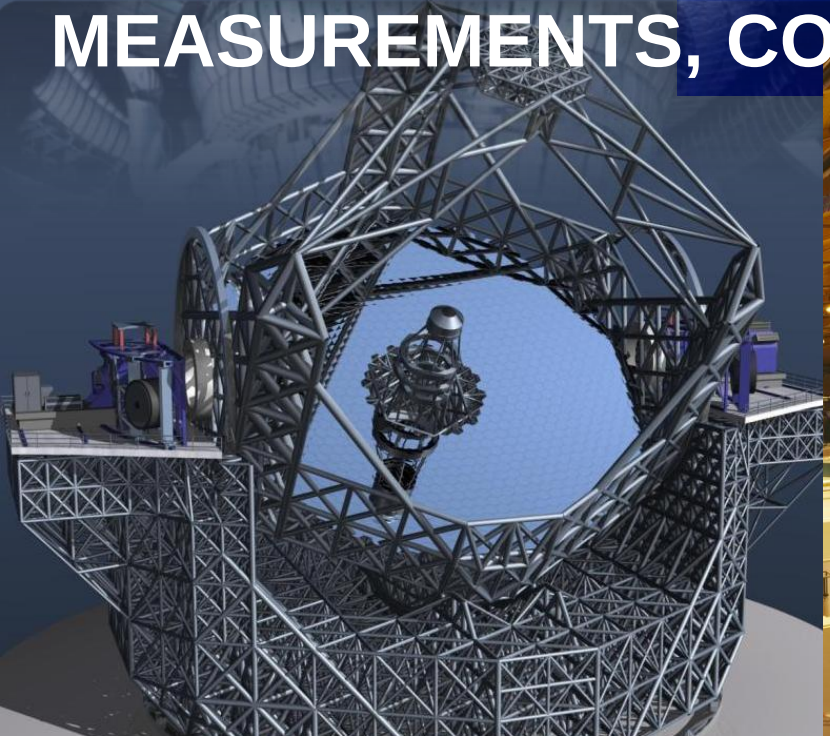


We equip engineers and scientists with tools that accelerate productivity, innovation, and discovery.

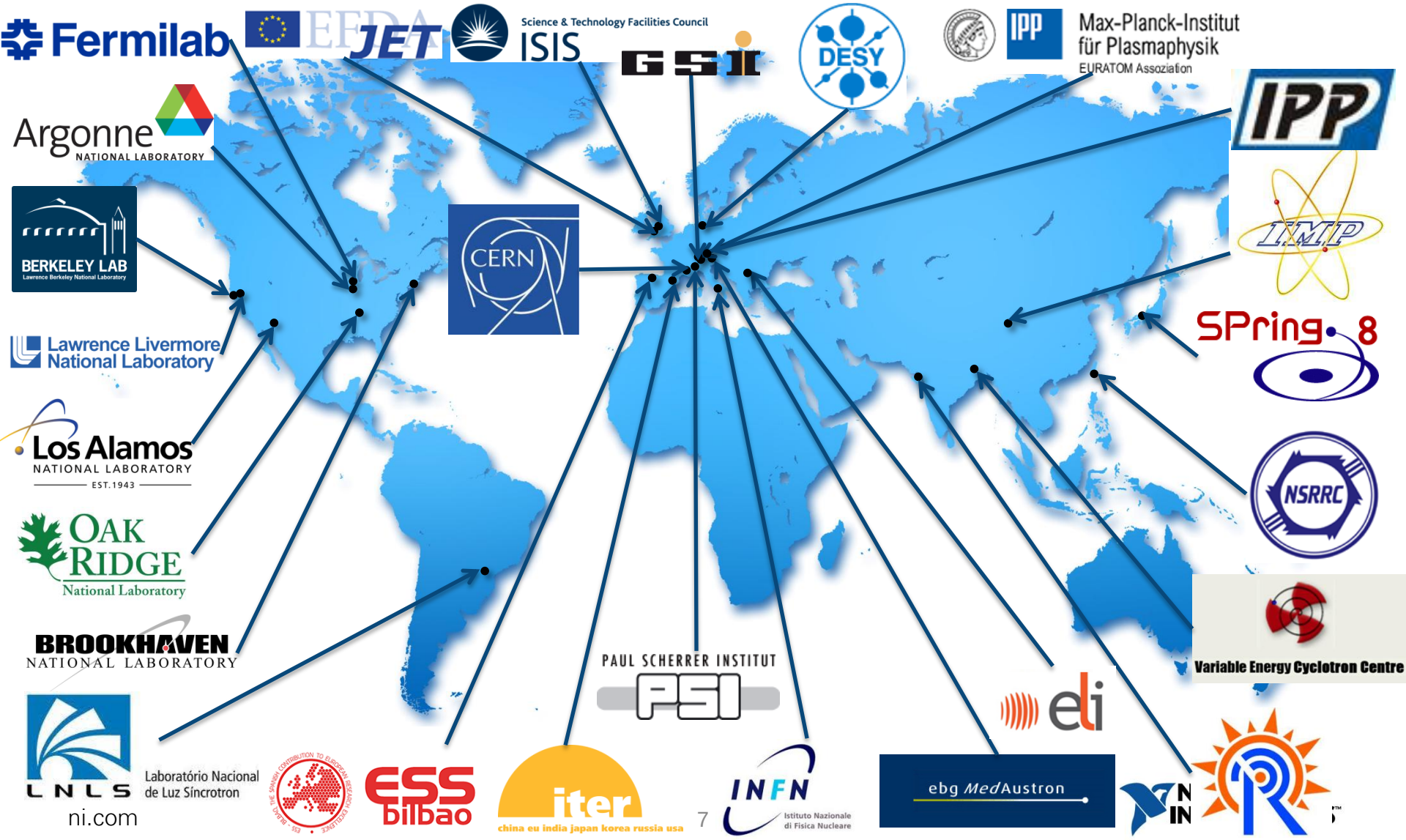
Diversity of Applications – Multitude of Benefits



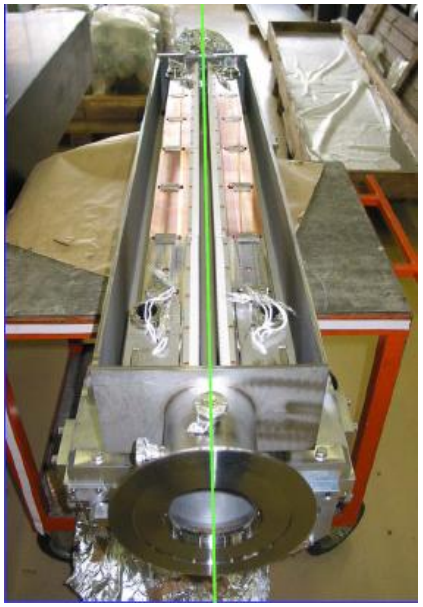
MEASUREMENTS, CONTROL AND DIAGNOSTICS



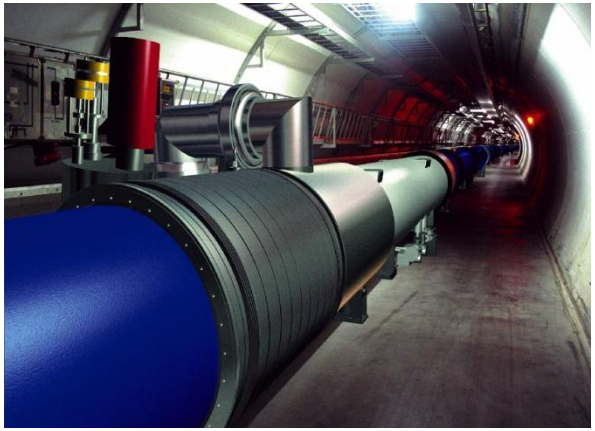
Worldwide Customers



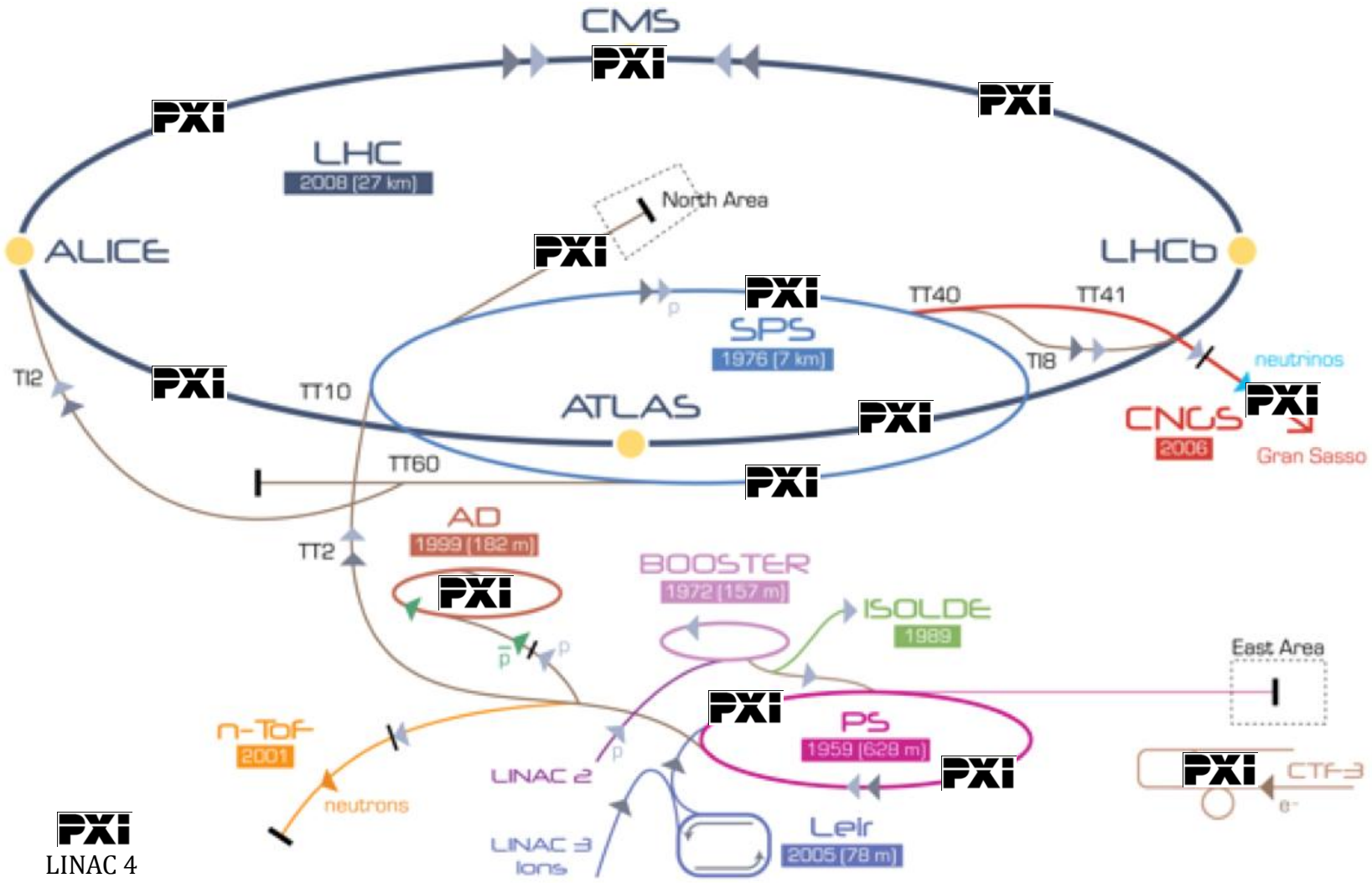
LHC Collimator Control



- 550+ axes of motion
- Across 27 km distance
- The jaws have to be positioned with an accuracy which is a fraction of the beam size (200µm)
- Synchronized to
  - < 5ms drift over 15 minutes
  - Maximum jitter in µs



PXI in CERN Accelerator Complex



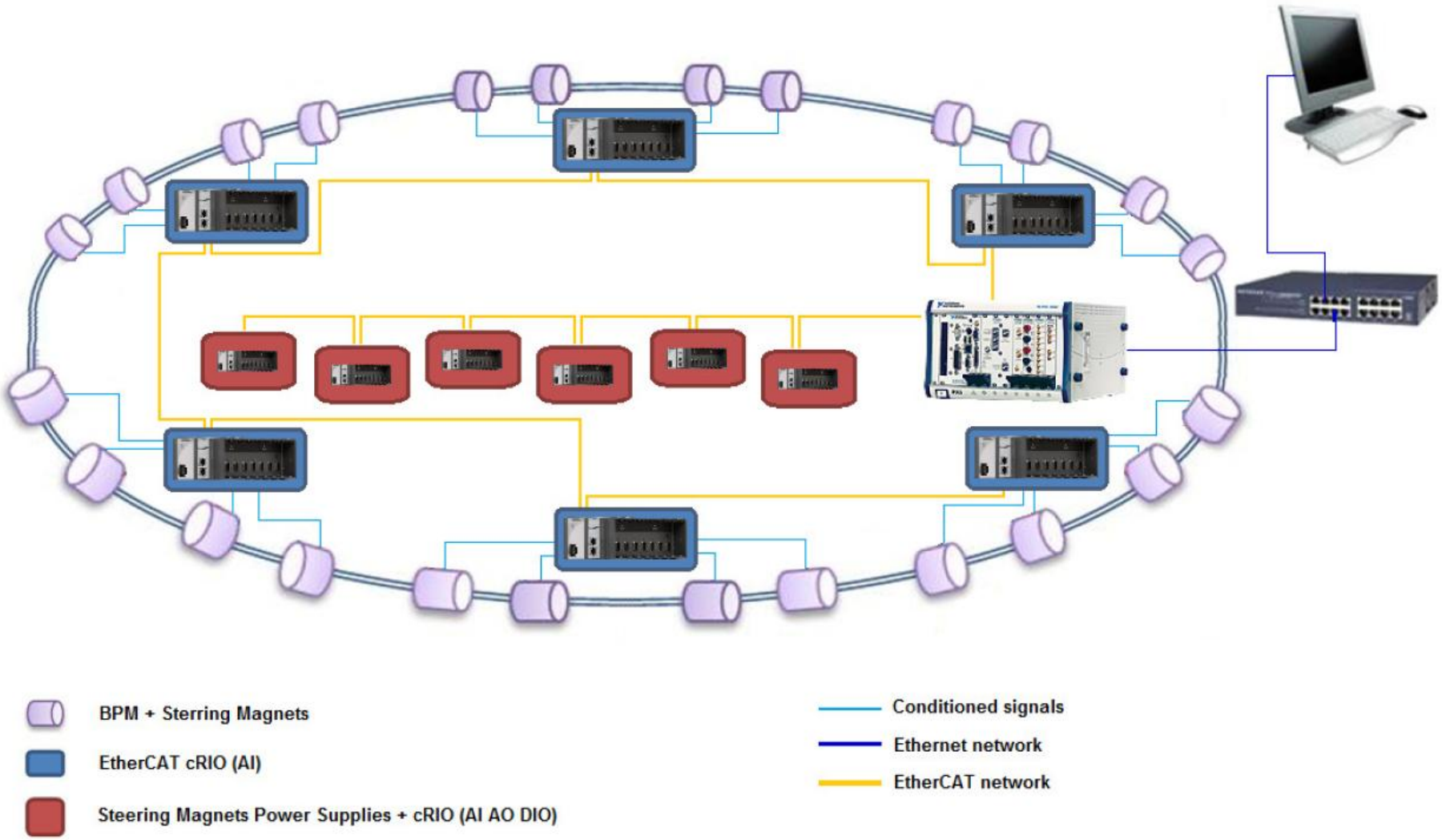
Control & Monitoring SuperKEKB Vacuum System

- 300 cold cathode gauges
- Residual gas analyzers
- Vacuum switches
- 300 wheel type flow meters
- 6000 Platinum resistance thermometer sensors
- All measurements every 1 or 2 seconds and data recorded (several minutes) - All above data controlled by EPICS
- All of the above controlled and measured using LabVIEW-FPGA, cRIO & EPICS (in cRIO)
  - Controlled remotely from control room
  - Highly reliable control and alarm system

CAMAC Systems replaced with by cRIO+EPICS+LabVIEW FPGA

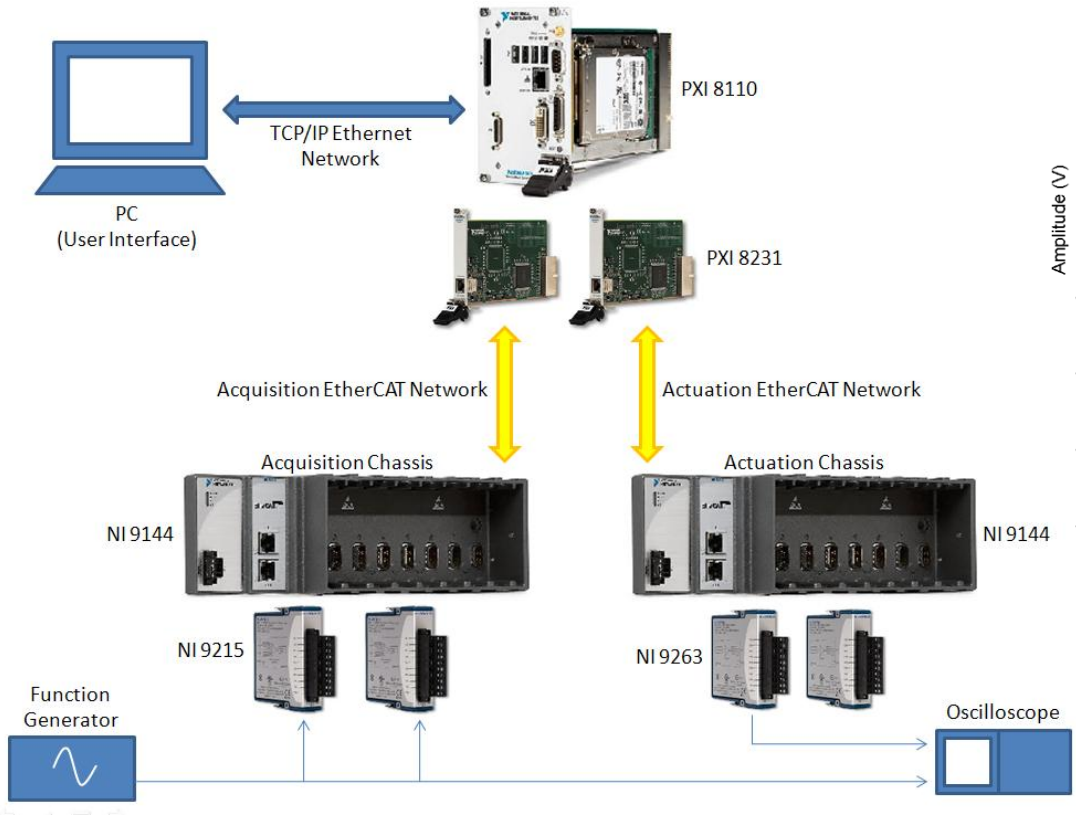
NATIONAL INSTRUMENTS

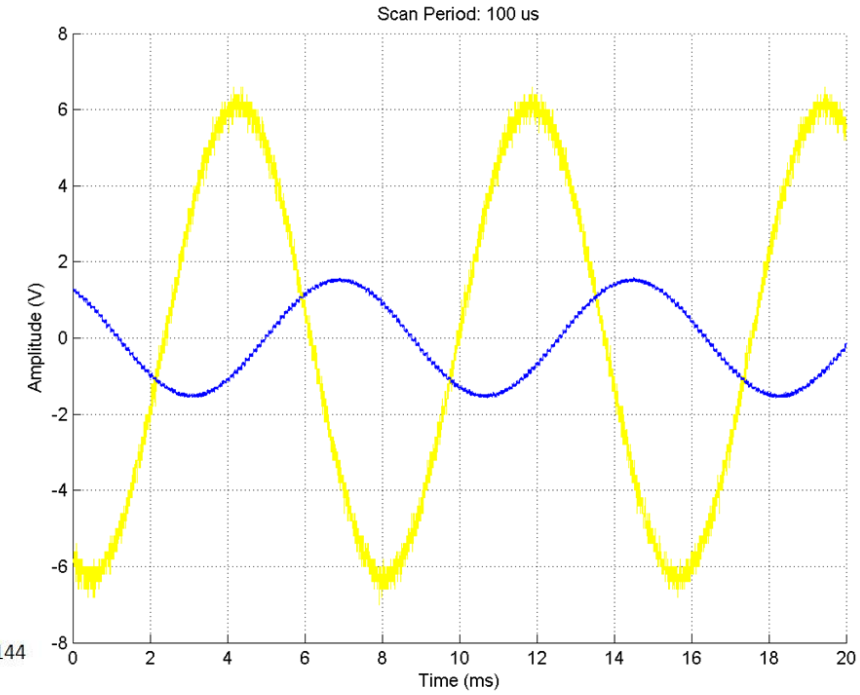
LNLS (Brazil): FOFB Control System



FOFB Control System

System Validation: Speed





MIMO system @ 5KHz

15x improvement !

Addressing Big Physics Application Requirements

Platforms and Standards

More than 1,500 PXI Products from More than 70 Vendors

DAQ and Control:

- Multifunction I/O
- FPGA/Reconfigurable I/O
- Digital I/O
- Analog Input/Output
- Vision and Motion
- Counter/Timers

Instruments:

- Oscilloscopes
- Digital Waveform Generator/Analyzers
- Digital Multimeters
- Signal Generators
- Switching
- RF Signal Generation and Analysis

Interfaces:

- GPIB, USB, LAN
- SCSI + Enet
- Boundary Scan/JTAG
- CAN + DeviceNet
- RS232/RS485
- VXI/VME

Features and Specifications

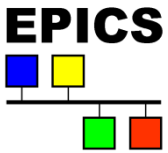
- Analog Input
  - Up to 250 kS/s, simultaneous sampling
  - 4, 8, 16, and 32-ch options
  - Built-in signal condition for sensors
    - Strain gages, accelerometers, thermocouples, RTDs
  - Up to ± 60 V, ±20 mA
  - 12, 16 and 24-bit resolution
  - Available ch-to-ch isolation
- Analog Output
  - Up to100 kS/s simultaneous updating
  - Up to 16-ch per module
  - ±10 V, ±20 mA
  - Isolation

- **Digital I/O**
  - Up to 10 MHz timing
  - Counter/timer, PWM
  - 8 and 32-channel options
  - 5V/TTL, 12/24/48 V logic levels
- **Specialty**
  - 2-port CAN modules
  - Brushed DC servo motor drive
- **Third Party Modules**
  - LIN, Profibus, WLAN 802.11, MIL-1553, ARINC-429, GPS, and more

BP Application Special Requirements

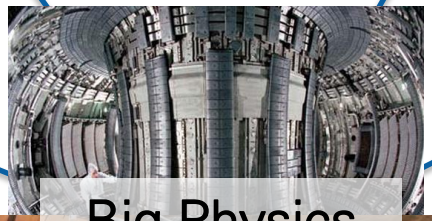
Linux Support

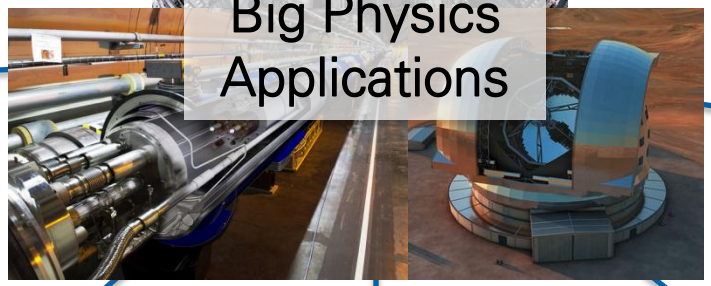
RASM

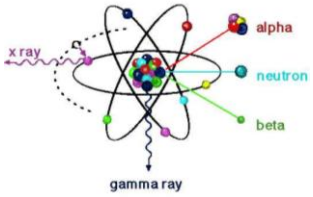


EPICS Support

Lifecycle Management







Radiation and Magnetic Field Testing

Safety : EMI, UL, CE, SIL

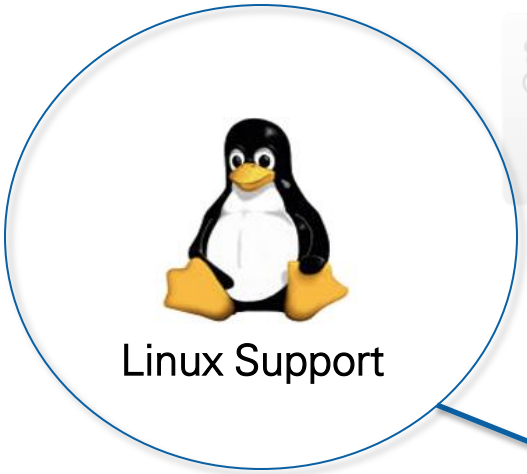
Environmental: ROHS, ChinaROHS, WEEE

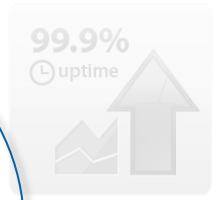
Global Technical Support

Global Calibration And Repair

NATIONAL INSTRUMENTS

Linux Support

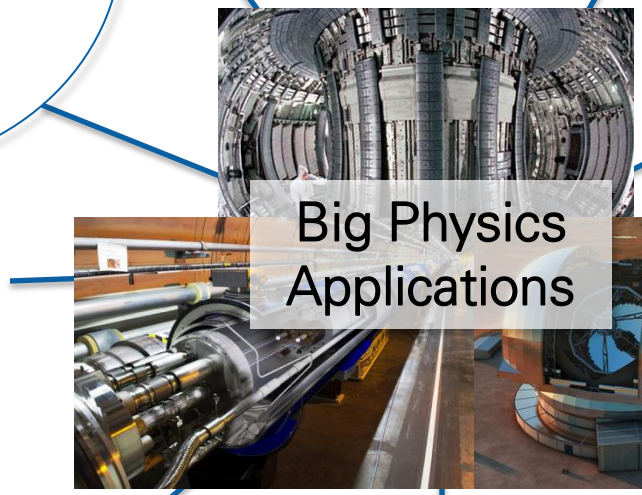




RASM

EPICS Support

Lifecycle Management



Radiation and Magnetic Field Testing

Safety : EMI, UL, CE, SIL

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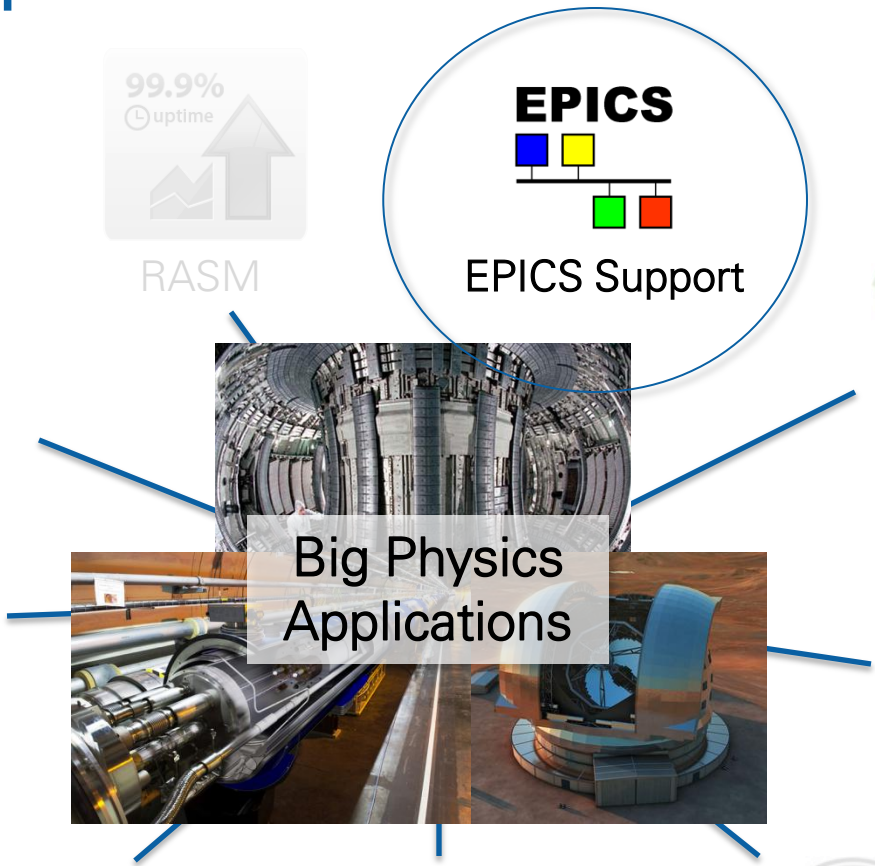
Global Technical Support

Global Calibration And Repair

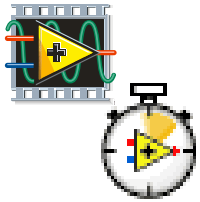
Linux Integration - Summary

Hardware	Customer Custom Driver Development	NI Custom Open Source Driver	Platform Integrated
Measurement HW	MHDDK	ITER	DAQmx Linux, Hypervisor
RIO	FPGA interface C API	ITER	API, Hypervisor

EPICS Support



EPICS Integration

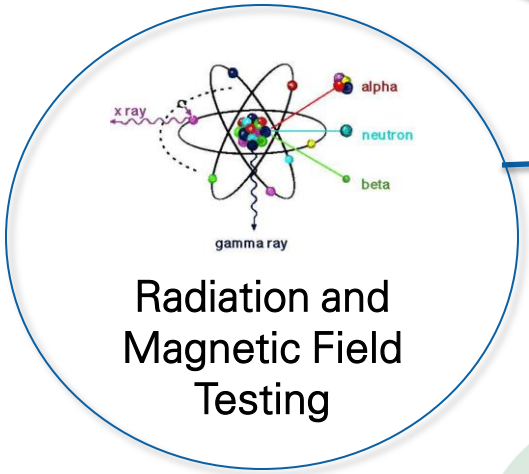


LabVIEW	I/O Server	EPICS CA Client or Server

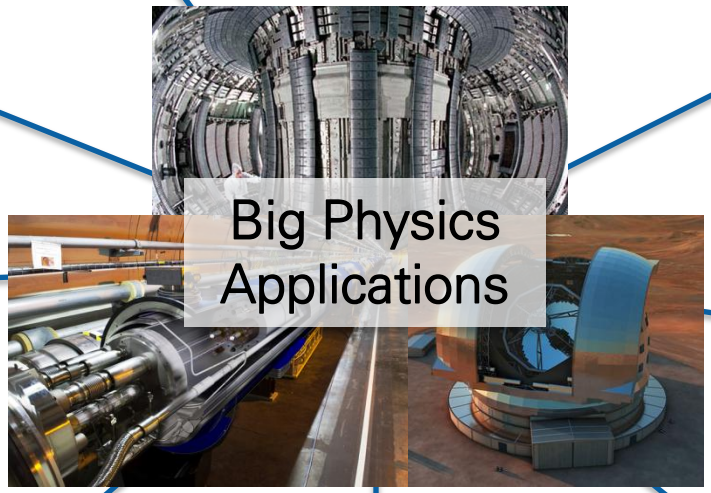
NI Linux RT on cRIO	Standard Implementation	EPICS IOC
LabVIEW RT on PXI	Hypervisor Shared MemoryS	EPICS IOC on Linux

PXI (No LabVIEW)	Linux Driver Device Support	EPICS IOC on Linux

Radiation and Magnetic Field Testing



Radiation and Magnetic Field Testing



Big Physics Applications

RASM

EPICS Support

Linux Support

Lifecycle Management

Safety : EMI, UL, CE, SIL

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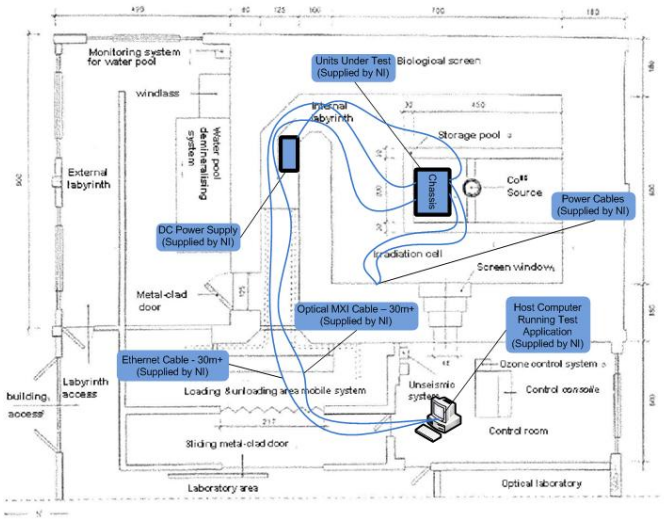
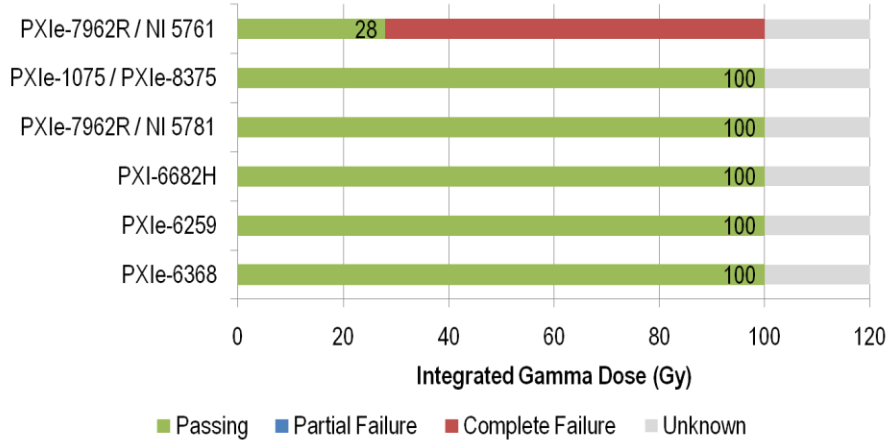
Global Technical Support

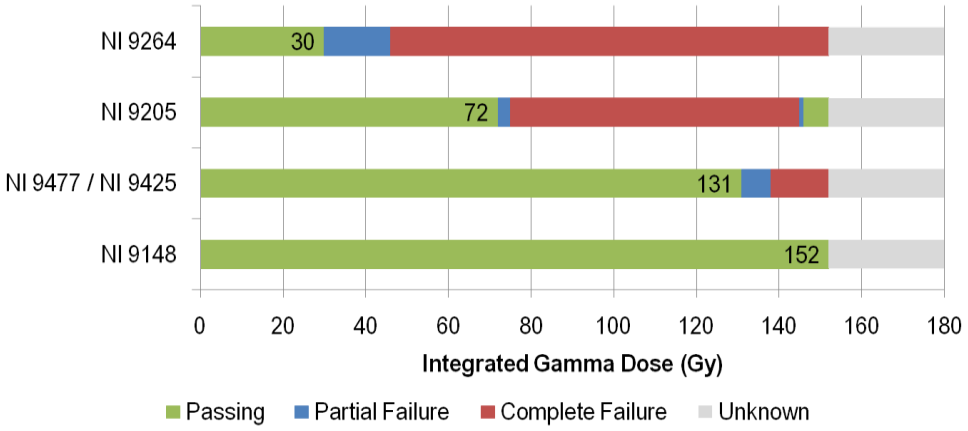
Global Calibration And Repair

Calliope Gamma Research Lab at ENEA Casaccia



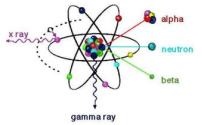
PXIe and cRIO Gamma Testing





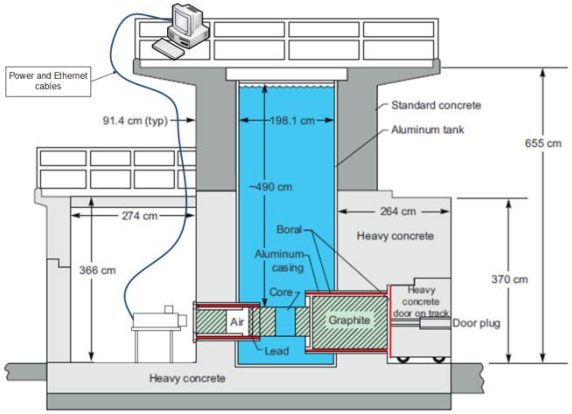
- Cumulative effects are evident in the gamma testing
- Most (1 PXI / 1cRIO) failed devices exceeded expected failure dose of 50Gy
- More than half of the devices exceeded the maximum expected failure dose of 100 Gy

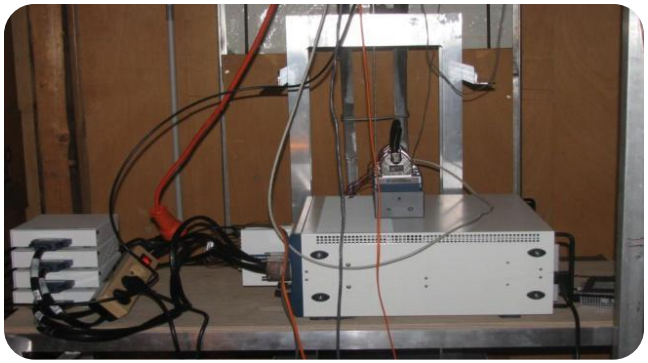
Fast and Thermal Neutron Testing



Frascati Neutron Generator, ENEA, Italy (**Fast**)

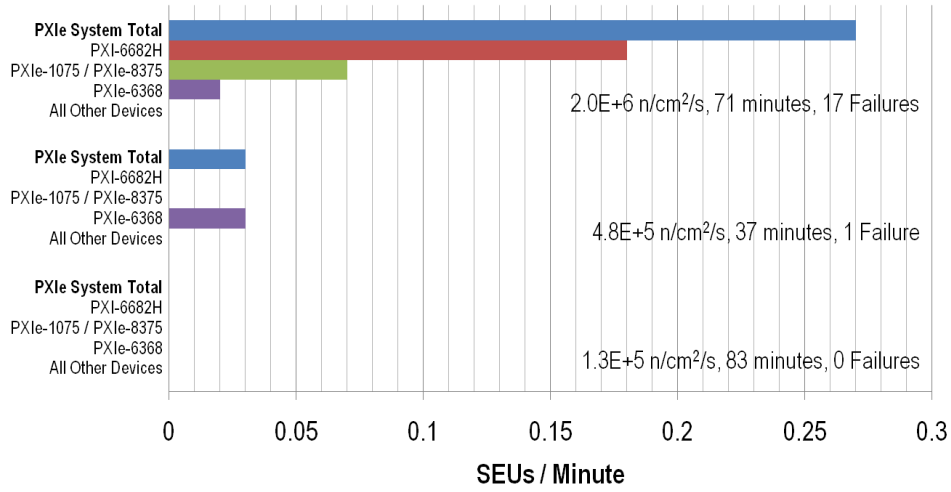
TRIGA Reactor, JSI, Slovenia (**Thermal**)

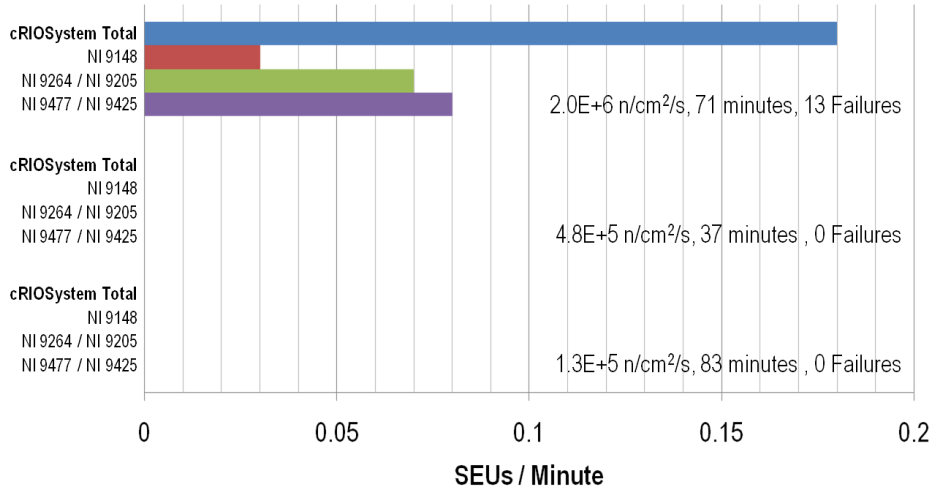




NATIONAL INSTRUMENTS

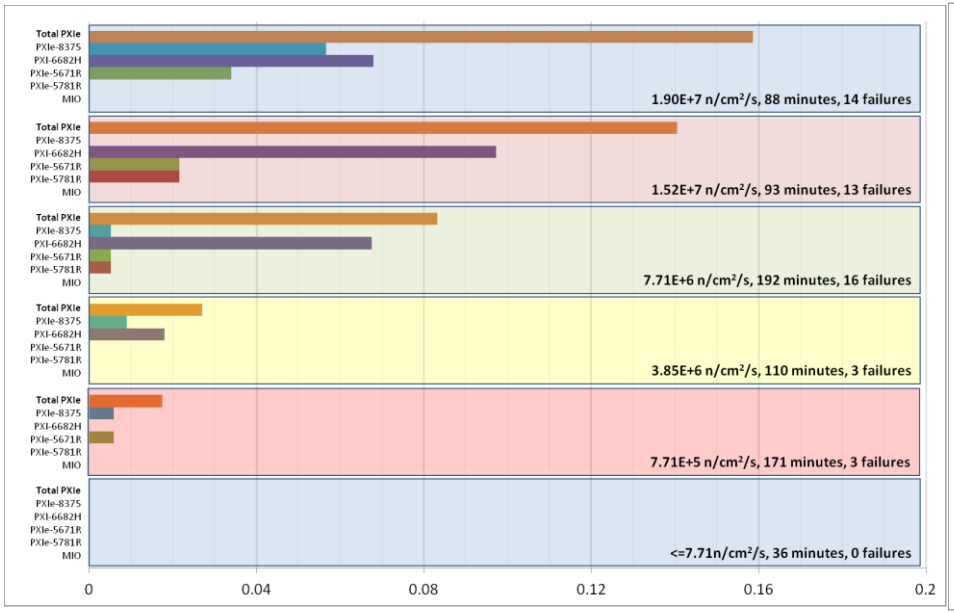
Fast Neutron Results (SEUs/Min)

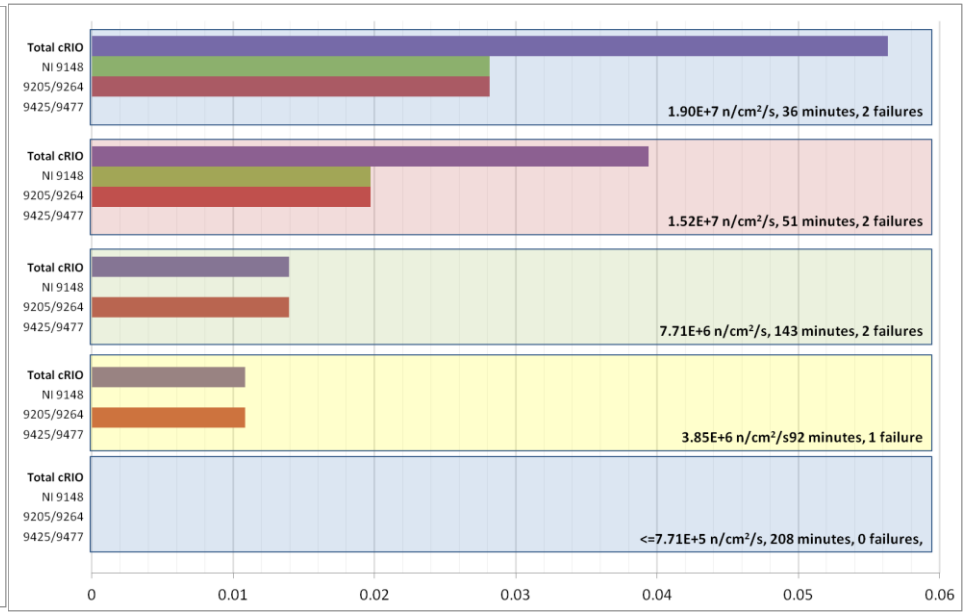




- Single Event Upsets dominated the neutron results generally meeting ITER requirements
- Did not see permanent damage

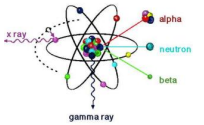
Thermal Neutron Results (SEUs/Min)





- Where able to test, are almost 1 order of magnitude more flux compared to fast neutrons
- Failure rates were less than or equal to what was seen with fast neutron testing
- MIO hardware handled thermal much better than fast (0 failures)

Radiation Testing Conclusions



- Gamma Testing
  - Most devices exceeded expected failure dose of 50Gy
  - Cumulative effects are evident in the gamma testing
- Fast Neutron Testing
  - Single Event Upsets dominated the neutron results generally meeting ITER requirements
  - Did not see permanent damage
- Thermal Neutron Testing
  - Were able to test are almost 1 order of magnitude more flux compared to fast neutrons
  - Failure rates were less than or equal to what was seen with fast neutron testing
  - MIO hardware handled thermal much better than fast (0 failures)

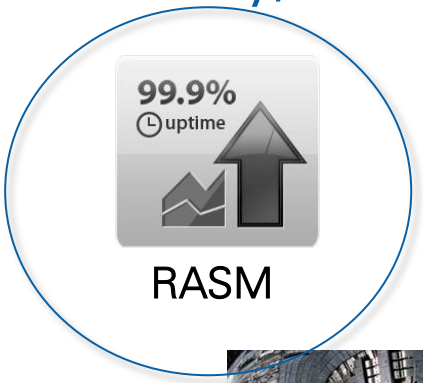
Magnetic Field Testing at DESY: Phase 1

PXI Chassis
- Fans fail between 15mT - 25 mT
- Investigation to find fans tolerant to higher field continues

NI 9148 (cRIO Ethernet Chassis)
- Chassis works well up to 60 mT
- Permanent HW damage at 230 mT

cRIO-9205 & cRIO-9263
- Works well up to 40 mT
- Data error between 40 and 50 mT
- Permanent HW failure after several minutes at 50 mT

Reliability, Availability, Serviceability, Maintainability



RASM

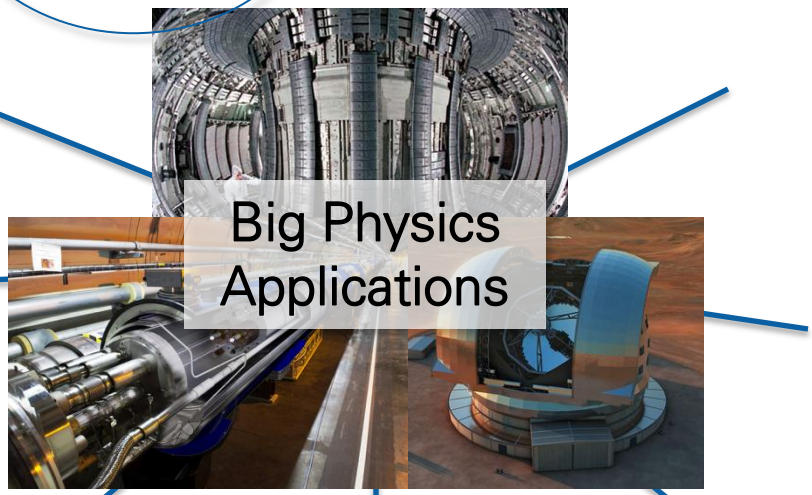
EPICS

EPICS Support

Linux Support

Lifecycle Management

Radiation and Magnetic Field Testing



Big Physics Applications

Safety : EMI, UL, CE, SIL

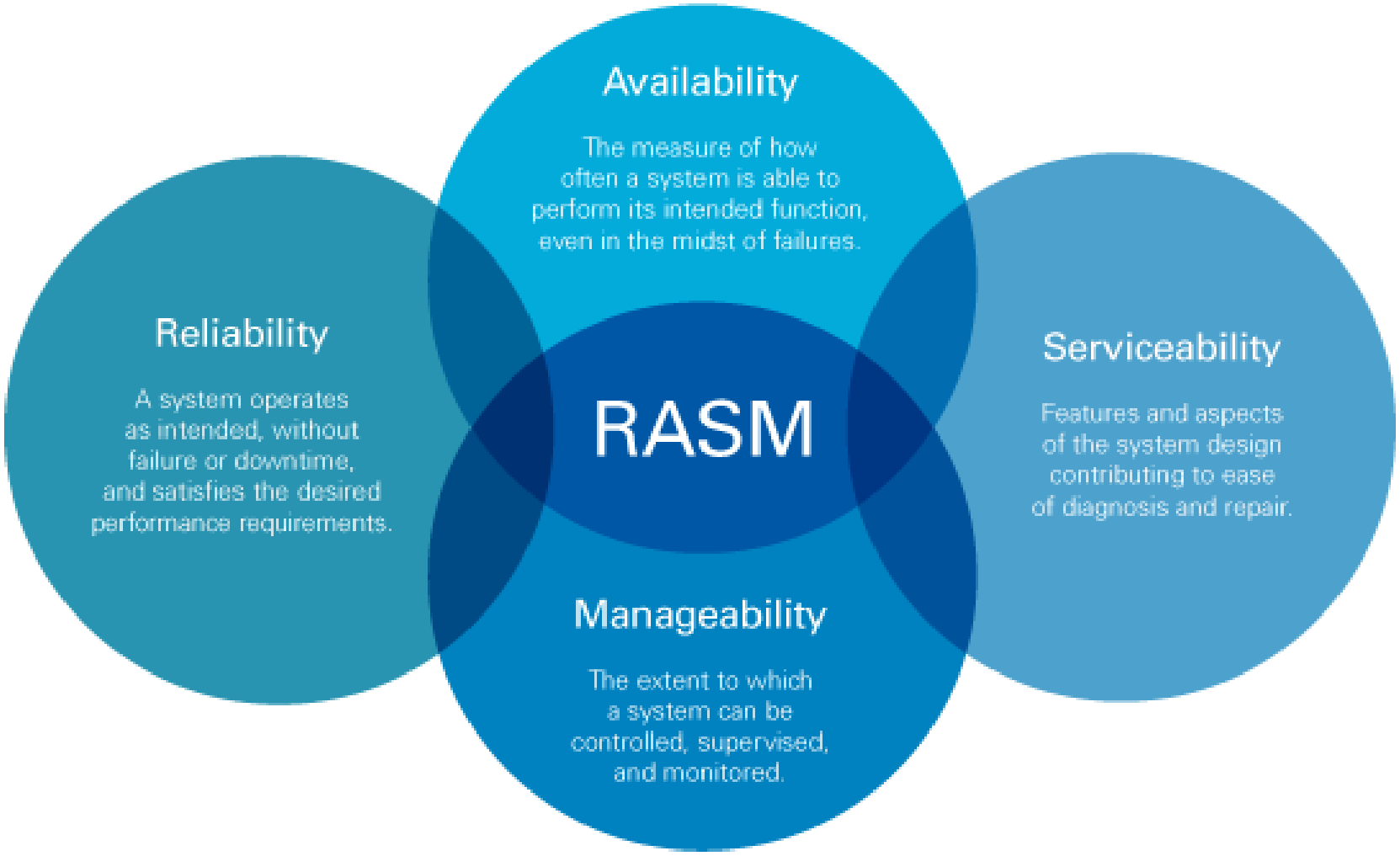
RoHS

Environmental: ROHS, ChinaROHS, WEEE

Global Technical Support

Global Calibration And Repair

RASM


Availability
The measure of how often a system is able to perform its intended function, even in the midst of failures.
Reliability
A system operates as intended, without failure or downtime, and satisfies the desired performance requirements.
RASM
Serviceability
Features and aspects of the system design contributing to ease of diagnosis and repair.
Manageability
The extent to which a system can be controlled, supervised, and monitored.

System Reliability Lab (SRL)

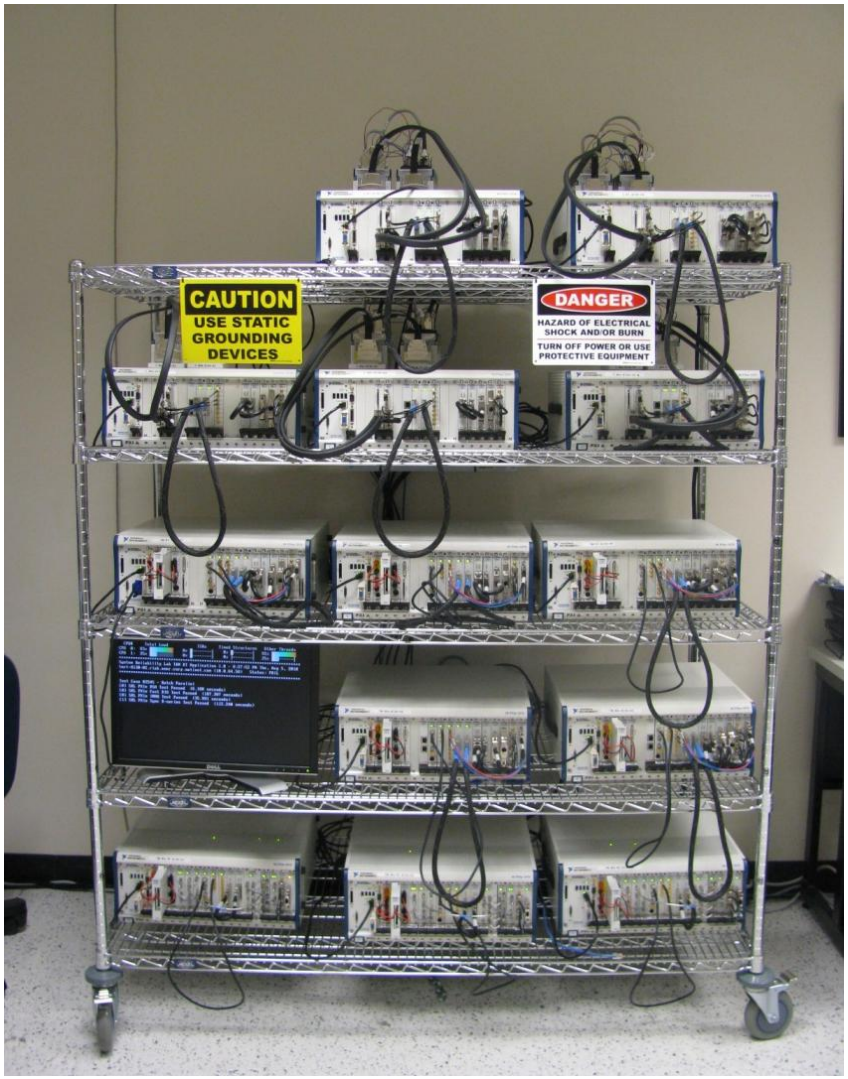
Mission:

Assess the reliability of National Instruments product-based systems and drive product improvements

- Created to focus on system reliability for the:
  - Compact RIO and PXI / PXIe hardware platforms
  - LabVIEW software platform

SRL PXI/PXIe Testing

- 20 systems
  - 18 systems at room temperature
  - 2 systems in temperature chamber (cycles between 5°C and 5°C)
  - 5 systems running on dirty power
- 3 different hardware configurations
- 32 test applications
- 24/7 execution during missions



SRL cRIO Testing

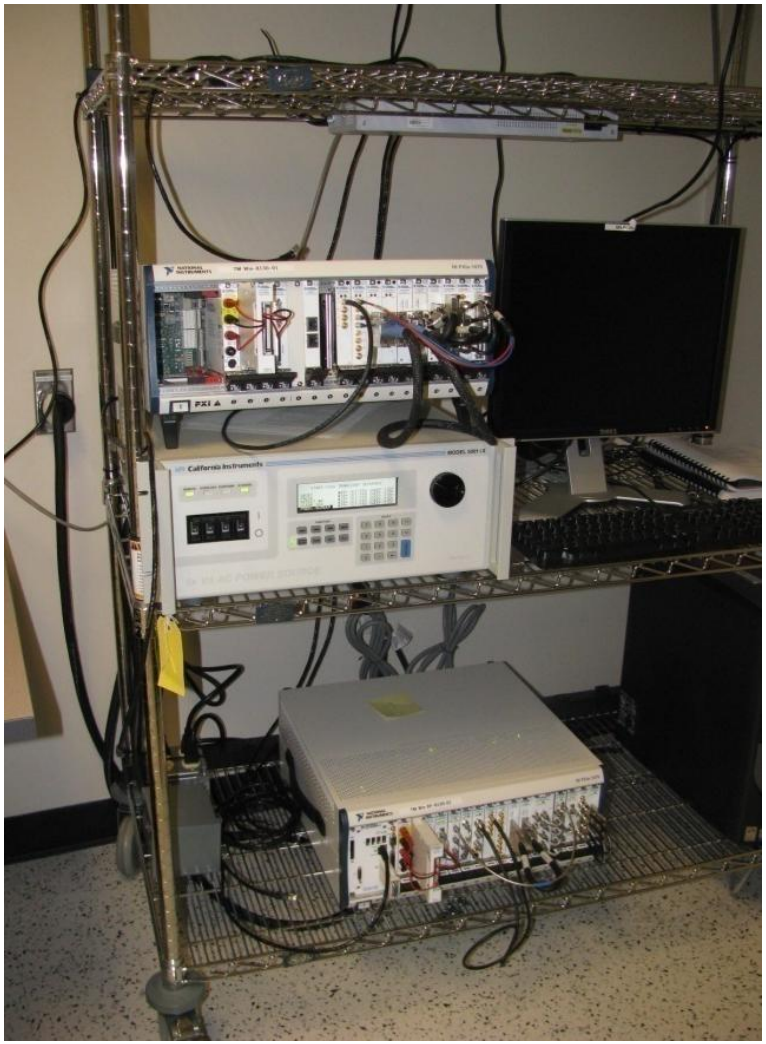
- 40 systems
  - 32 systems at room temperature
  - 8 systems in temperature chamber (cycles between -40 and 70°C three times per day)
  - 8 systems running on dirty power
- 4 unique cRIO applications
- 24/7 execution during mission

SRL Temperature Chamber

- Cycle Temperature three times per day for months
- 2 to 8 Systems run for months at time in this environment
- PXI / PXIe: 5°C to 50°C
- cRIO: - 40°C to 70°C

SRL Dirty Power Test Station

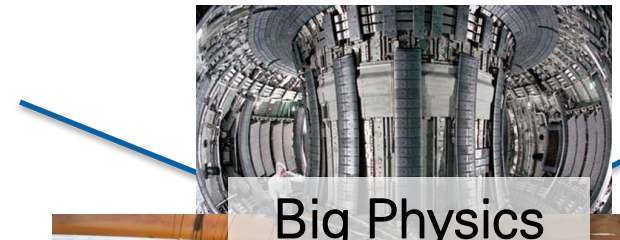
- Simulates a bad power grid
- 5 to 8 Systems run for months at time in this environment
- Vary frequency from 47 to 63 Hz
- Vary voltage level from 90 to 264 V



CERN High Availability Chassis

- Redesigned to mechanically fit into a custom rack
- Independently powered, redundant hot swap power supplies and fans
- Remote Monitoring : Chassis Temperature, Fan Status, Power Supplies

Lifecycle Management



Big Physics Applications

Linux Support

RASM

EPICS Support

Lifecycle Management

Radiation and Magnetic Field Testing

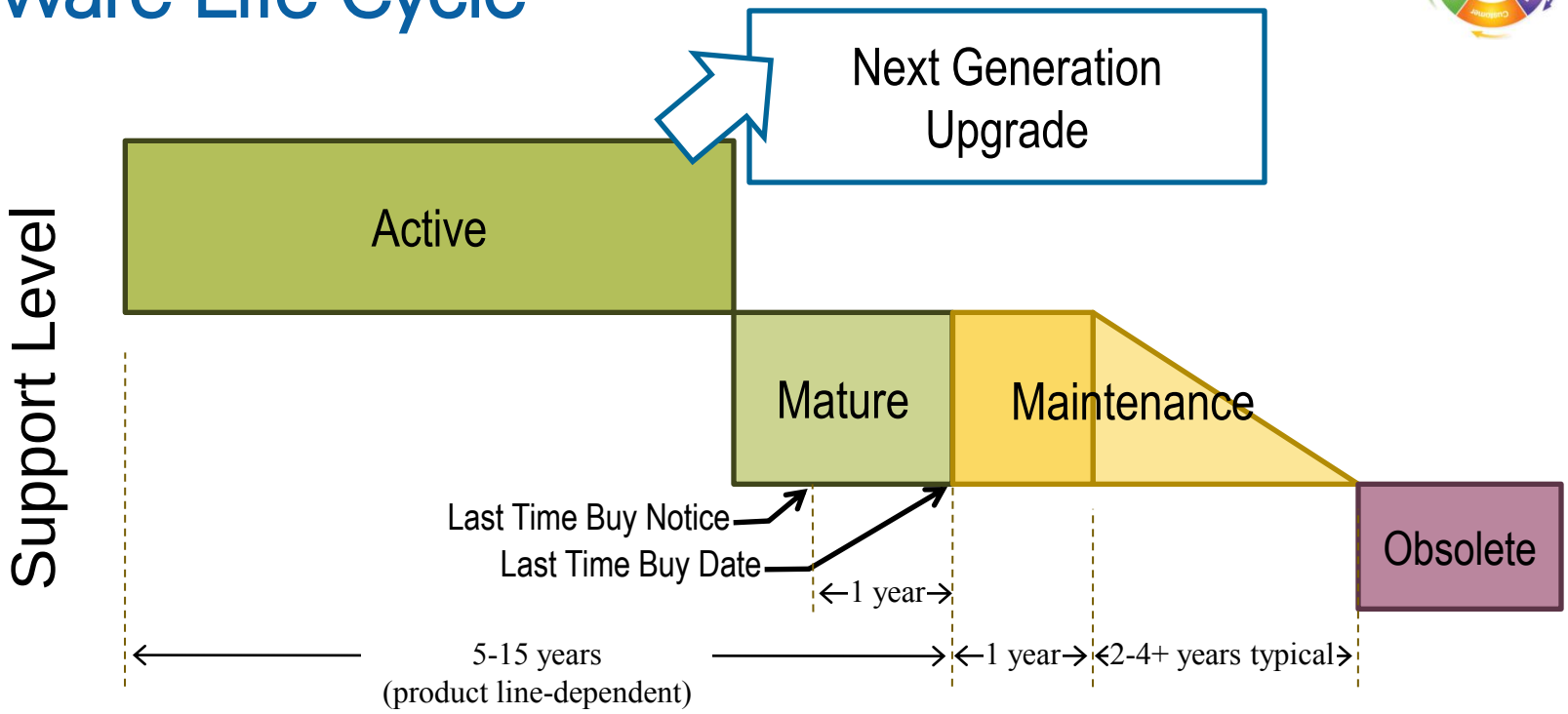
Safety : EMI, UL, CE, SIL

Environmental: ROHS, ChinaROHS, WEEE

Global Technical Support

Global Calibration And Repair

Hardware Life Cycle



	Active	Mature	Maintenance		Obsolete
Purchase new	Yes	Yes	No	No	No
Repair	Yes	Yes	Yes	Reasonable effort	No
Calibration	Yes	Yes	Yes	Reasonable effort	No
Service Agreements	Yes	Yes	Yes	Yes	Yes

Lifecycle Planning: Examples

Product	Part Number	Released	Active	Mature	Maintenance	Obsolete
cRIO-9072	779998-01	Nov-2007	Nov 2007 - Nov 2012	Nov 2012 - Nov 2017	Nov 2017 - Nov 2022	Nov-2022
cRIO-9073	780471-01	Nov-2007	Nov 2007 - Nov 2012	Nov 2012 - Nov 2017	Nov 2017 - Nov 2022	Nov-2022
cRIO-9074	779999-01	Nov-2007	Nov 2007 - Nov 2012	Nov 2012 - Nov 2017	Nov 2017 - Nov 2022	Nov-2022
cRIO-9002	779000-01	Aug-2004	Aug 2004 - Aug 2010	Aug 2010 - Aug 2014	Aug 2014 - Aug 2019	Aug-2019
cRIO-9004	779055-01	Aug-2004	Aug 2004 - Aug 2010	Aug 2010 - Aug 2014	Aug 2014 - Aug 2019	Aug-2019
cRIO-9012	779563-01	Nov-2006	Nov 2006 - Nov 2011	Nov 2011 - Nov 2016	Nov 2016 - Nov 2021	Nov-2021
cRIO-9014	779564-01	May-2007	May 2007 - May 2012	May 2012 - May 2017	May 2017 - May 2022	May-2022
cRIO-9022	780718-01	Feb-2009	Feb 2009 - Feb 2014	Feb 2014 - Feb 2019	Feb 2019 - Feb 2024	Feb-2024
cRIO-9023	781173-01	Feb-2010	Feb 2010 - Feb 2015	Feb 2015 - Feb 2020	Feb 2019 - Feb 2024	Feb-2024
cRIO-9024	781174-01	Aug-2009	Aug 2009 - Aug 2014	Aug 2014 - Aug 2019	Aug 2019 - Feb 2024	Feb-2024
cRIO-9025	781313-01	Jan-2010	Jan 2010 - Jan 2015	Jan 2015 - Jan 2020	Jan 2020 - Jan 2025	Jan-2025

Product	Part Number	Released	Active	Mature	Maintenance	Obsolete
cRIO-9101	779052-01	Aug-2004	Aug 2004 - Aug 2010	Aug 2010 - Aug 2014	Aug 2014 - Aug 2019	Aug-2019
cRIO-9102	779007-01	Aug-2004	Aug 2004 - Aug 2010	Aug 2010 - Aug 2014	Aug 2014 - Aug 2019	Aug-2019
cRIO-9103	779053-01	Aug-2004	Aug 2004 - Aug 2010	Aug 2010 - Aug 2014	Aug 2014 - Aug 2019	Aug-2019
cRIO-9104	779054-01	Aug-2004	Aug 2004 - Aug 2010	Aug 2010 - Aug 2014	Aug 2014 - Aug 2019	Aug-2019
cRIO-9111	780915-01	Feb-2009	Feb 2009 - Feb 2014	Feb 2014 - Feb 2019	Feb 2019 - Feb 2024	Feb-2024
cRIO-9112	780916-01	Feb-2009	Feb 2009 - Feb 2014	Feb 2014 - Feb 2019	Feb 2019 - Feb 2024	Feb-2024
cRIO-9113	780917-01	Feb-2009	Feb 2009 - Feb 2014	Feb 2014 - Feb 2019	Feb 2019 - Feb 2024	Feb-2024
cRIO-9114	780918-01	Feb-2009	Feb 2009 - Feb 2014	Feb 2014 - Feb 2019	Feb 2019 - Feb 2024	Feb-2024
cRIO-9116	780919-01	Feb-2009	Feb 2009 - Feb 2014	Feb 2014 - Feb 2019	Feb 2019 - Feb 2024	Feb-2024
cRIO-9118	780920-01	Aug-2009	Aug 2009 - Aug 2014	Aug 2014 - Aug 2019	Aug 2019 - Feb 2024	Feb-2024

First 1/3 of phase
Second 1/3 of phase
Third 1/3 of phase

Global Services

Big Physics Applications

Global Technical Support

Global Calibration And Repair

Committed to Your Success

Technical sales engineers in more than 40 countries

Systems engineers to assist

Local technical support worldwide

Global manufacturing

World-class NI services

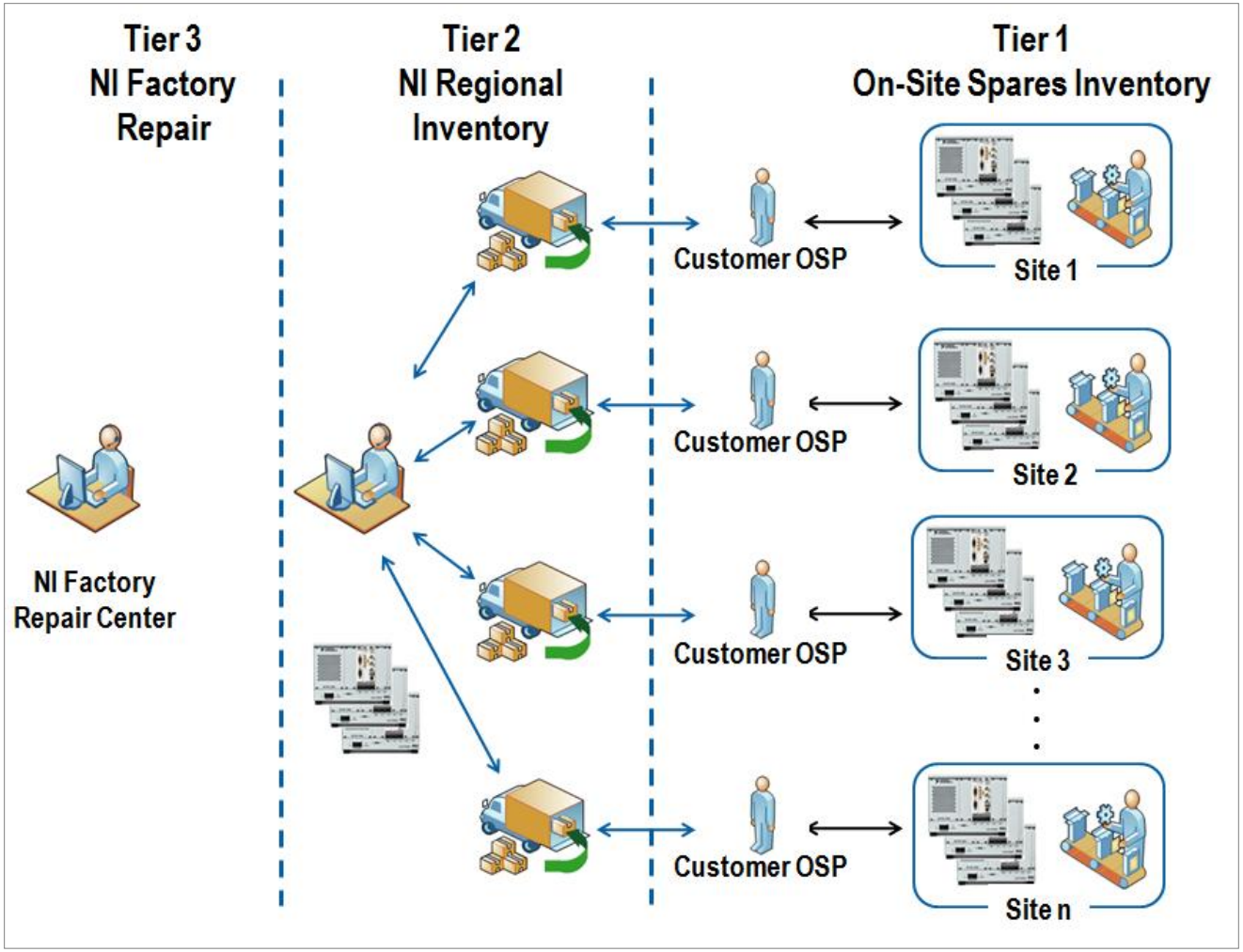
700+ NI Alliance Partners worldwide

Calibration Services

NI Flexible Calibration Options Reduce Maintenance Expenses

Perform verification and adjustment of NI products in your own metrology lab	Your existing service providers can verify and adjust NI products	NI can calibrate your device at the NI service center in your region	NI can provide calibration service at your facility
			
NI Calibration Executive	**Calibration Support**	**Regional Calibration**	**Onsite Calibration**

Global Sparing and Rapid Replacement for High Availability Requirements



Safety Certifications

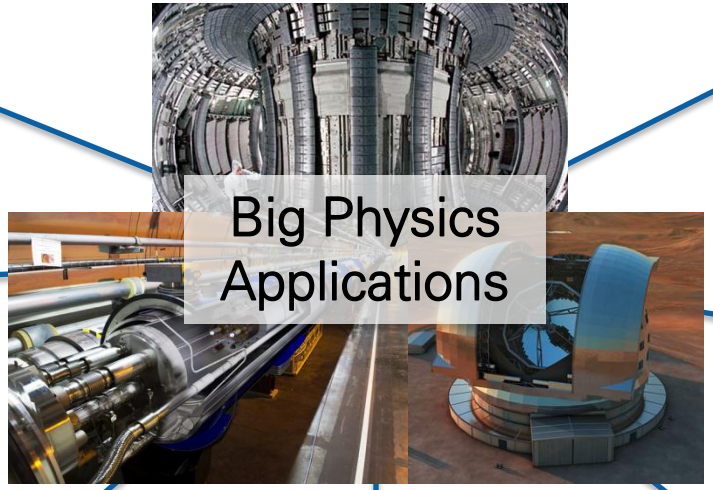
Linux Support

RASM

EPICS Support

Lifecycle Management

Radiation and Magnetic Field Testing



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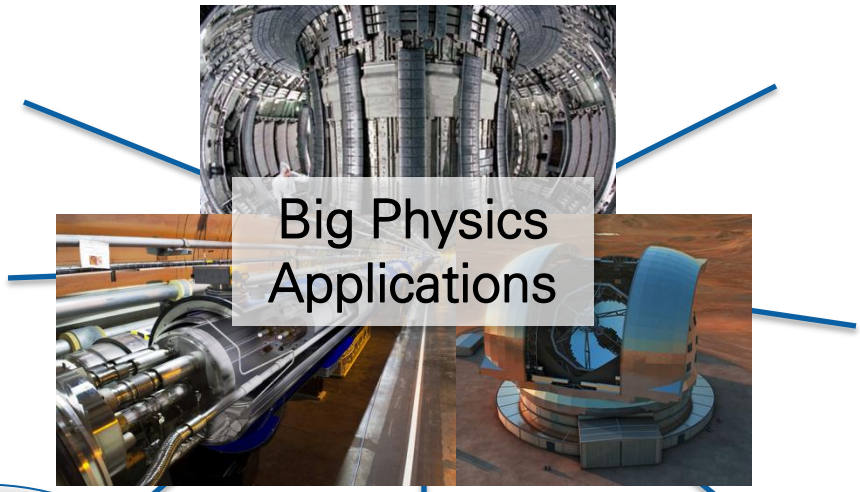
Global Technical Support

Global Calibration And Repair

Environmental Certifications



RASM

EPICS Support

Linux Support

Lifecycle Management

Radiation and Magnetic Field Testing

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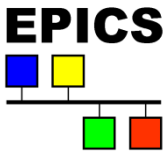
RoHS

Environmental: ROHS, ChinaROHS, WEEE

Addressing Big Physics Requirements: Recap

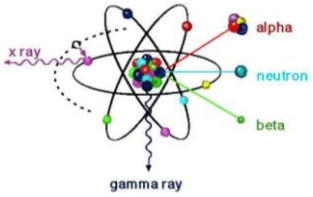
Linux Support

RASM

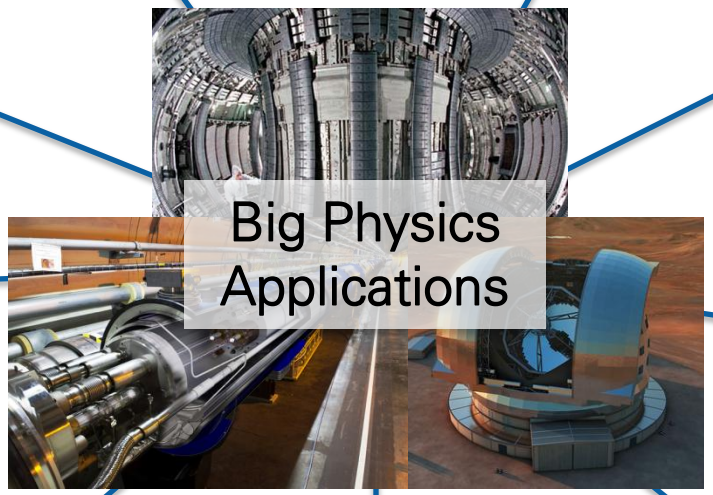


EPICS Support

Lifecycle Management



Radiation and Magnetic Field Testing



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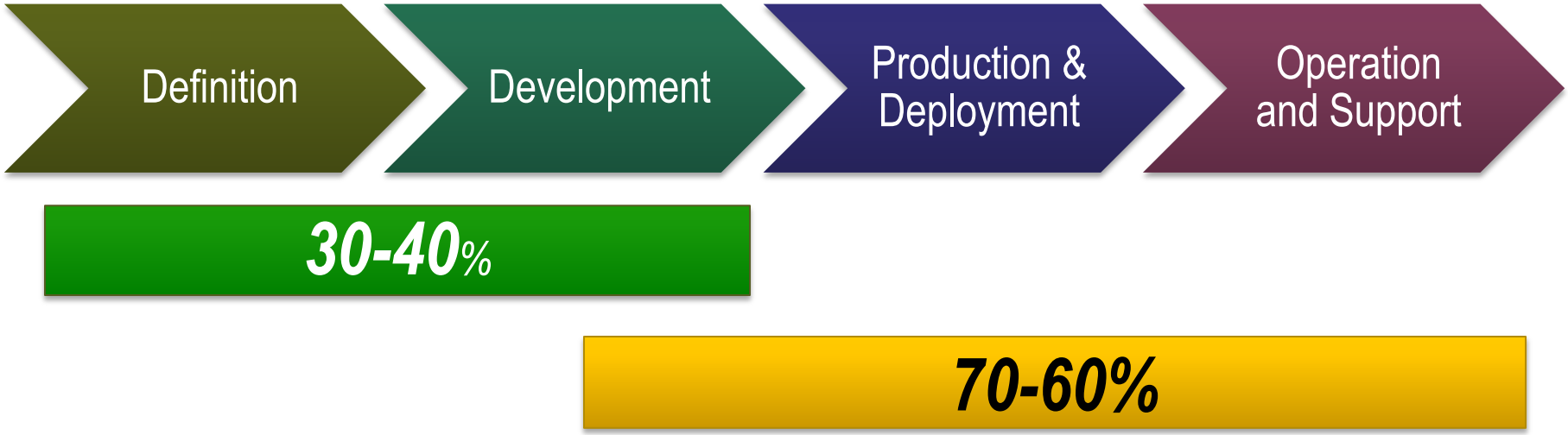
Global Technical Support

Global Calibration And Repair

NATIONAL INSTRUMENTS

Prototype to Product Investment



Conclusions

- Measurement and Control products must meet technical specifications and features requirements
- Big Physics applications have additional requirements
- NI adapts COTS products to meet such requirements
- NI globally offers accompanying services to be successful over long term

Contact

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