Reliability concerns with the SNS Machine protection Sytem

Doug Curry,

Eric Breeding,

Alan Justice

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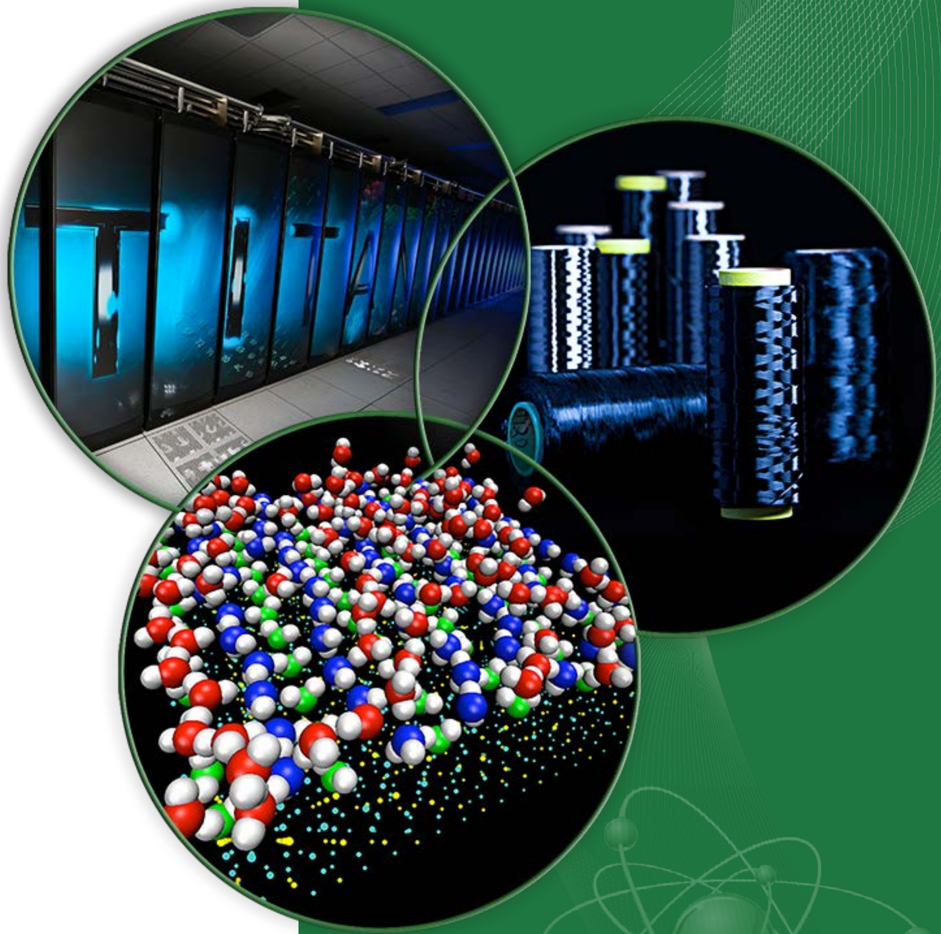

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Overview

- Leading causes of reliability issues at SNS
  - False trip reports
  - Excessive trip delays
  - Fail to deliver fault status
- Additional reliability concerns at SNS
- 2^{nd} Generation Highlights

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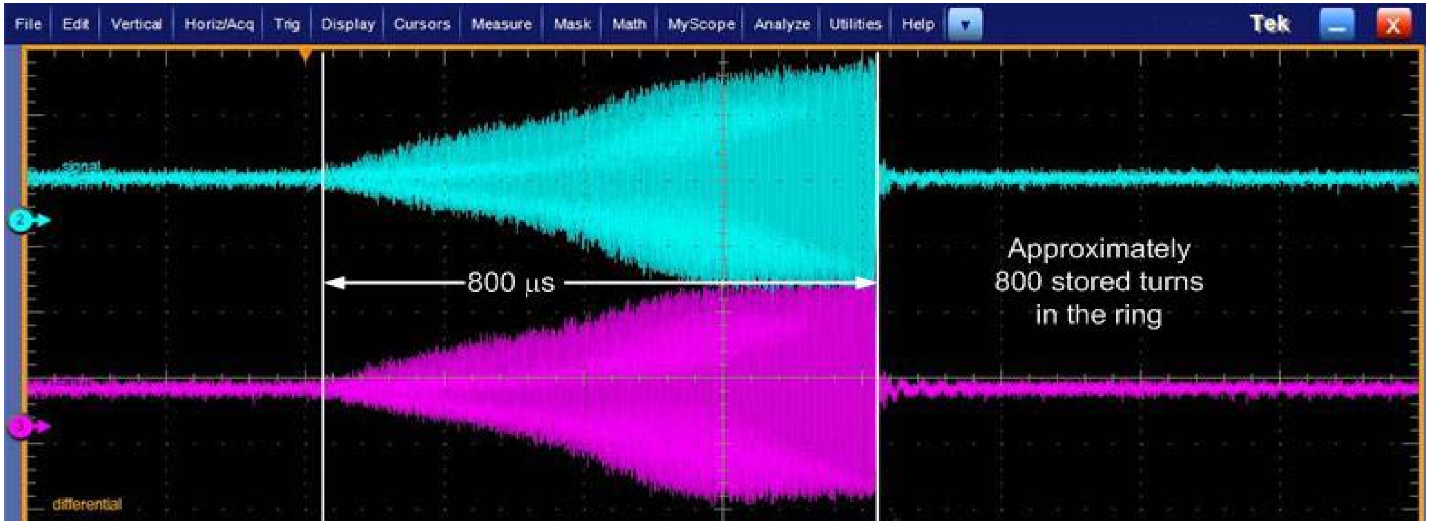
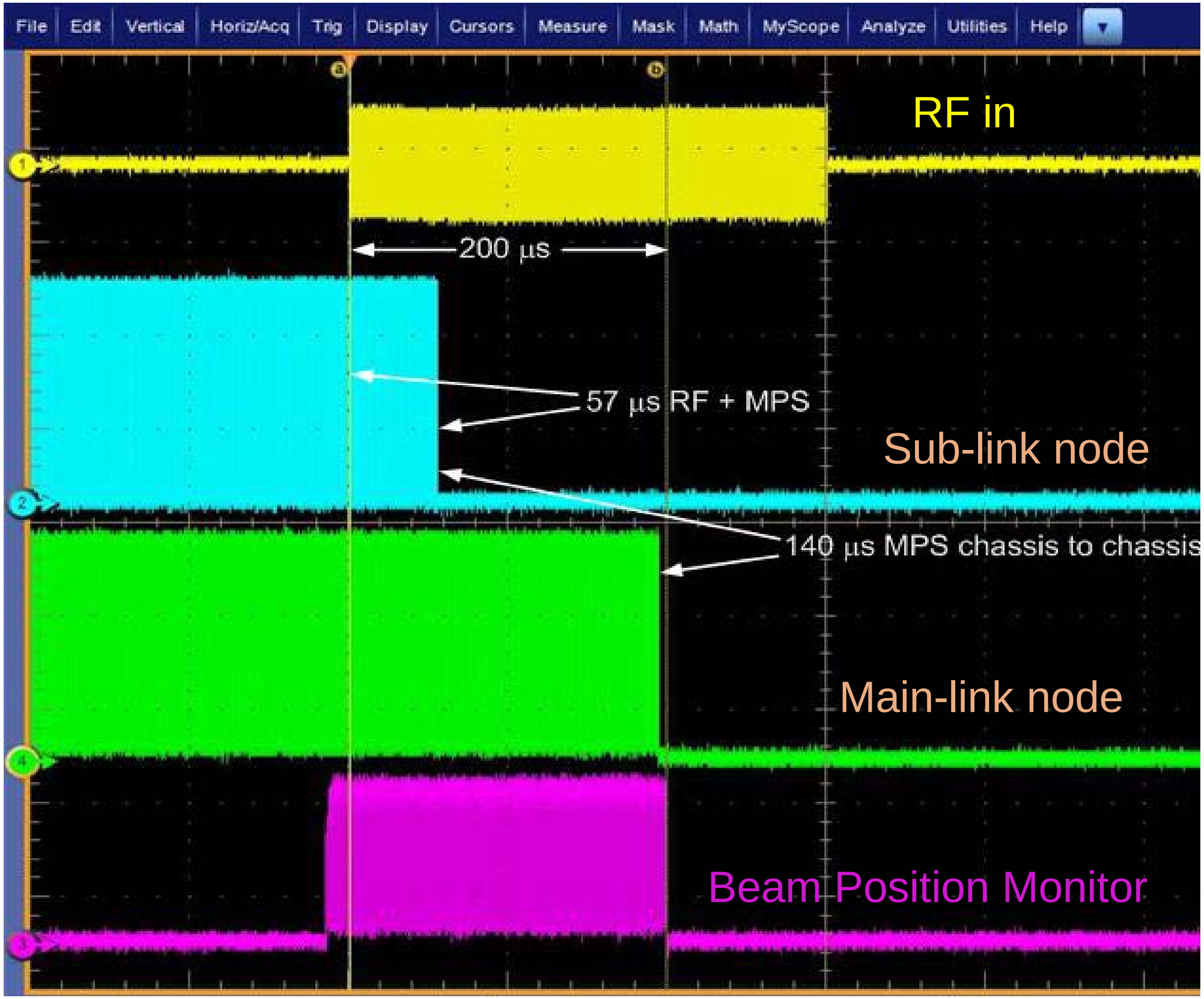
False trip reporting

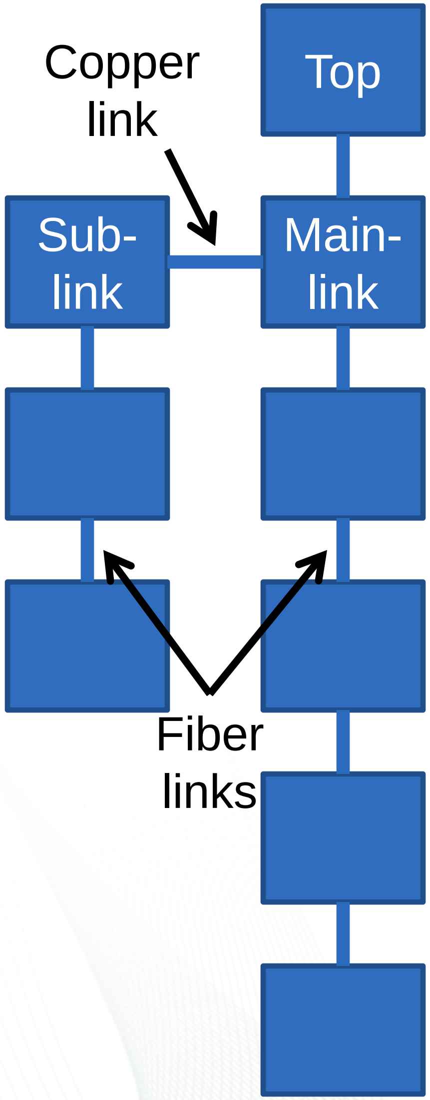
- Excessive Common Mode currents on input channels



- Mitigation techniques
  - Redesigned interface module with integrated ferrites that cover broad frequency range
  - Replaced Power Supply opto-couples with lower dynamic range but higher CMRR

Excessive system delays

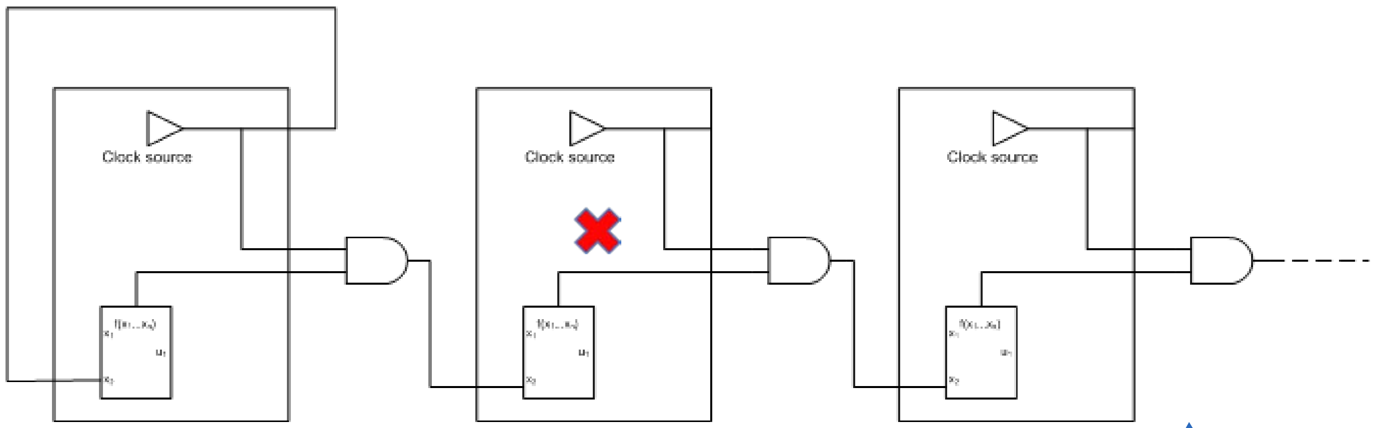




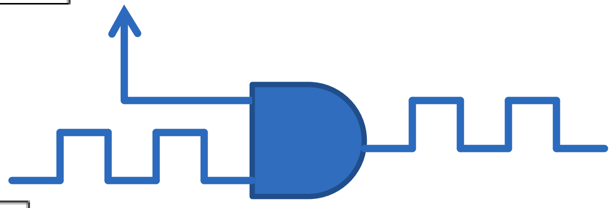
Failure to deliver fault status

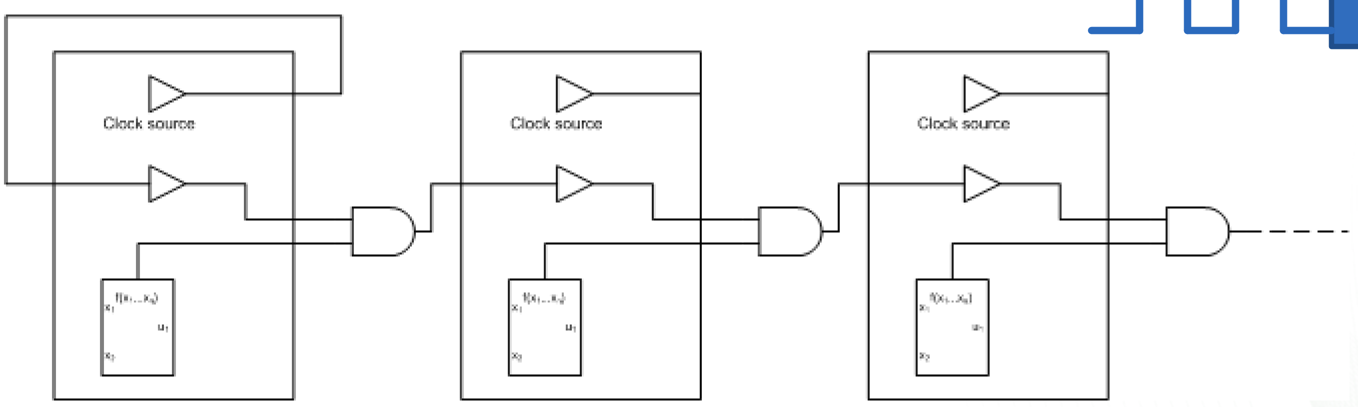
- Output enable stuck high
  - Provides a false MPS status to the top level node and permits continued beam production
- Firmware implementation did not match the architecture approved by the review committee
  - Single clock source generated at the lowest node in the chain
    - Each node simply grants or prevents the passing of the permissive signal
  - Passed local clock reference instead of original clock source

Reporting false positive MPS status



What got installed





What was approved

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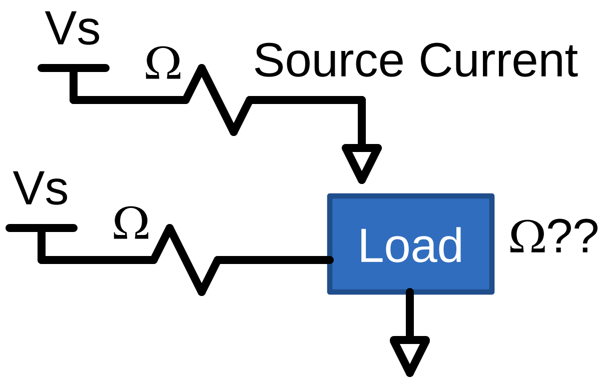
Additional reliability issues at SNS



- Low current drivers
  - Increased complexity
    - Non-standard configuration
- High density connectors
  - Bent pins "stuck high" status shorted to power pin
- PLC interfaces
  - Single digital output interface "solid state output"
- Operating System errors
  - Software interlocks
- Hardware Assembly inconsistencies

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Methods for improving system reliability

- Power measurement checks performed every 6 months
  - Plot the output power of fiber transmitters over time to identify degrading components
- 100% system verification checks performed after every extended outage
- Standardized testing procedures for improved consistency
- Equipment status tags
  - Red, yellow, and green tags

Modernization is imperative to achieve high reliability and maintainability

- Aging hardware increases the probability of failures within the MPS.
- Failures must be mitigated quickly to achieve the high availability goals of the SNS.
- Unfortunately, the MPS is comprised of several obsolete components. Component obsolescence prevents the acquisition and maintenance of a safe supply of spare parts.
- As failures become more likely, the existing inventory of spare parts will become depleted.

Modernization affords a unique opportunity to improve MPS reliability and functionality

- Failure points are reduced through simplification of the Fast Protect System (FPS) architecture.
- Functionality required for second target station (STS) may be fully implemented with the new FPS hardware .
- Lessons learned over years of operating the accelerator may be applied with new FPS hardware.
- Development of better in-system diagnostics will be feasible with modern components and devices.

Proposed Architecture Achieves a Significant Reduction in Hardware

	Current System	Proposed System
MPS Chassis	102	60
Interface Chassis	20	0
Programmable Interface Chassis	5	0
VME Chassis	8	0
VME Computer	8	0
Rear Transition Board	102	0
VME PMC Expansion Boards	24	0
Field Node Cards **FPGA	102	60
MPS Master Chassis	1	1
MPS Trigger Control Chassis	1	0
MicroTCA Cards	0	4
Linux Workstation/uTCA IOC	0	1
VME Computer	1	0
Total Hardware Count	382	126

Legacy data courtesy of Alan Justice

67% Reduction in Failure Points

Consolidation of Hardware Into Fewer Entities Mitigates Cable-Induced Failures

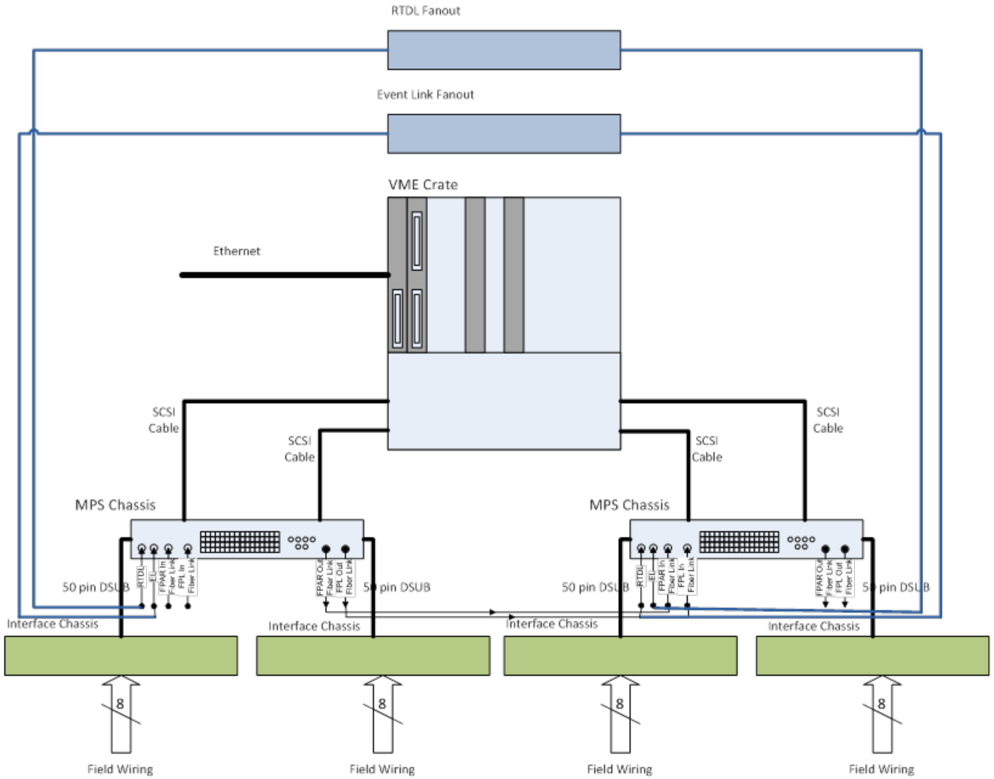
	Current System	Proposed System
SCSI Cables	206	0
Fiber Links	204	65
Timing Links	226	2
Miscellaneous MPS Links	14	7
Total # of Interconnects	***650***	***74***

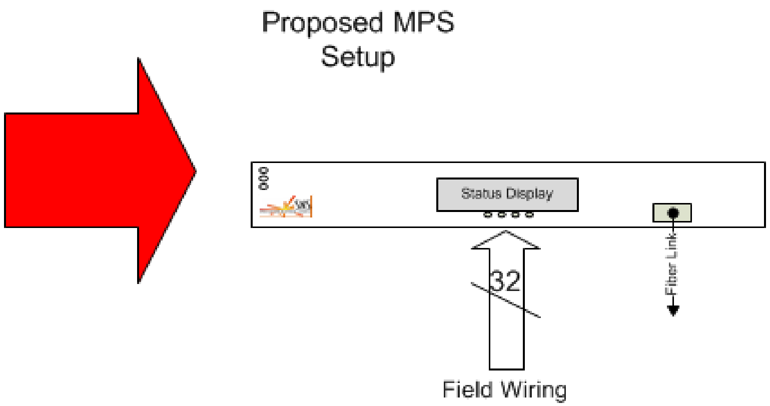
Data courtesy of Alan Justice

89% Reduction in Failure Points

The Field Node Has Significantly Fewer Components and Interconnects

Hardware assembly





- No software interfacing to EPICS at field nodes
- No RTDL/Event Link
- No VME SBC

Figures courtesy of Alan Justice

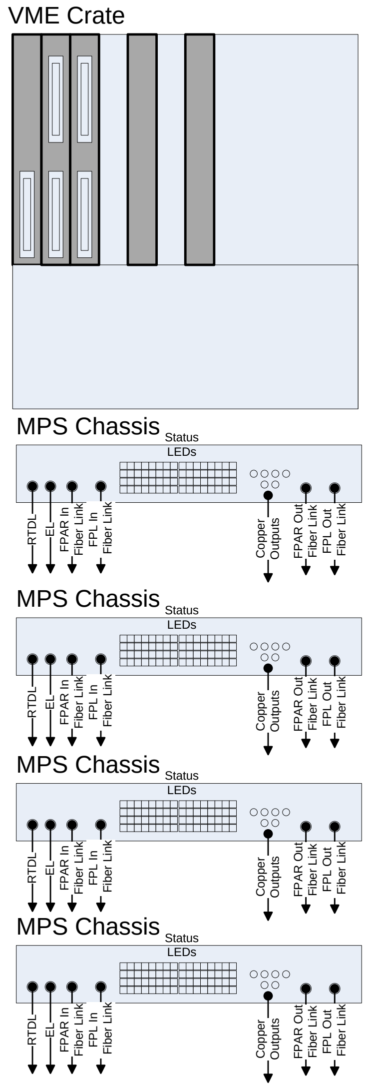
Current configuration

High density connections

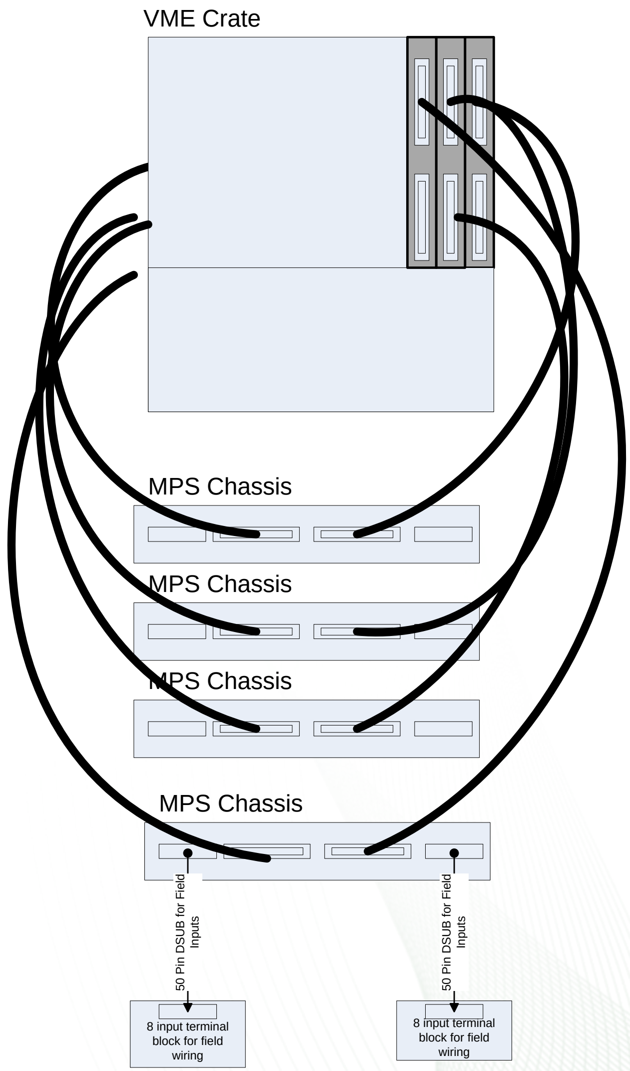
Required hardware for Deployment

- VME Crate
- VME IOC
- MPS chassis
- Teknobox PMC card
- **VME PMC Span
- SCSI Cables
- RTDL and Event Link cables
- Rear Transition Card

Front



Rear



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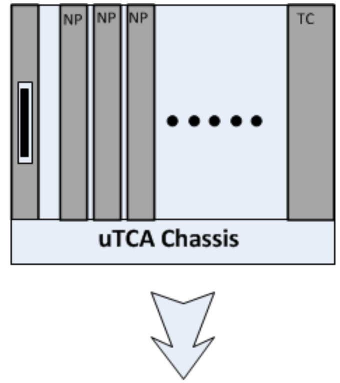
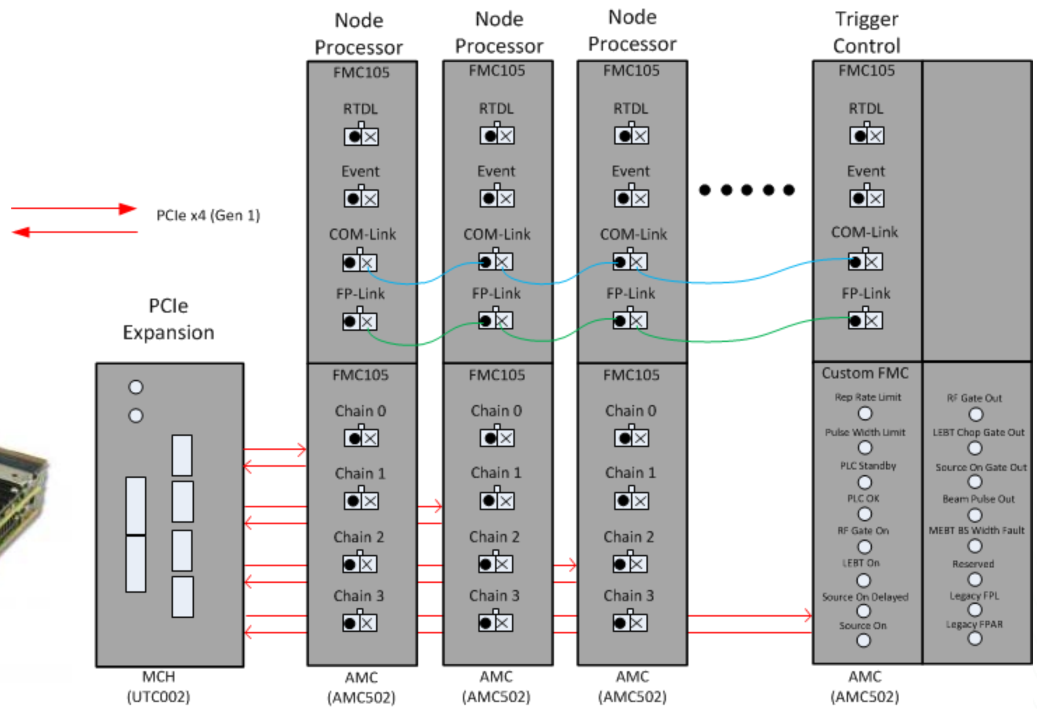
Leverage Readily Available COTS Hardware To Expedite Deployment



Software interlocks
“chatter faults”



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SNS 2nd Generation System

- System integrity checks prior to the production of each beam pulse
  - Verify one channel per machine cycle
  - Full MPS system verification checks competed every 30 seconds for 1800 input channels
  - 100% status reports from all interface modules required prior to cycle production
  - SFP “fiber” status
- Standardized modules
  - Hot swappable for increased interface flexibility and maintainability “leave chassis in place”
- Increase Timing System coupling Interface to provide improved post mortem analysis event

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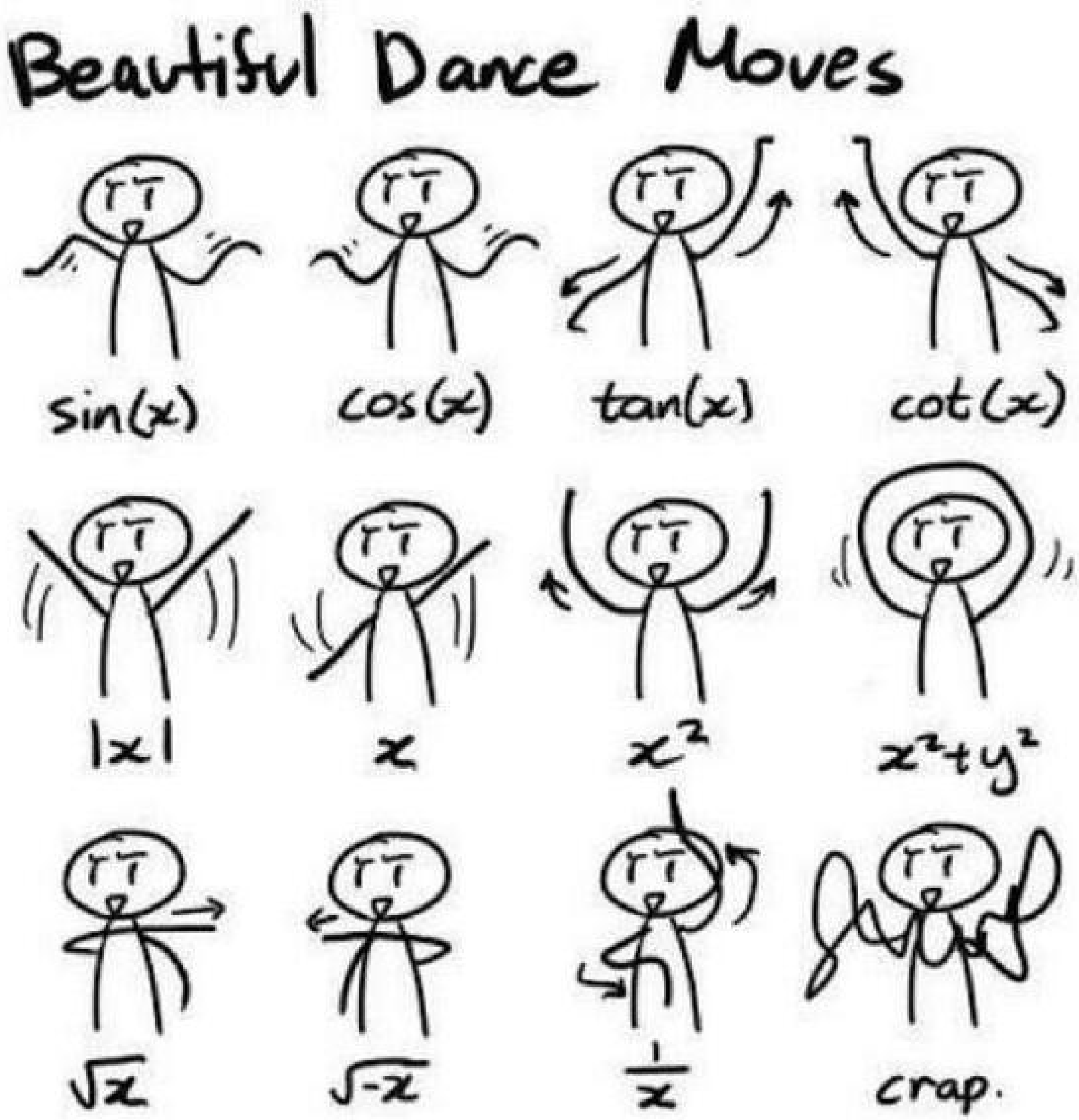
The new architecture Shall Reside Within Legacy Infrastructure

- The proposed FPS will be “form, fit and function compatible” with the legacy system to the greatest extent possible.
- The new FPS hardware shall reside in equipment racks that house the legacy FPS.
- Each FPS node shall accept existing input field wiring.
- All modules shall be compatible down to the pin level with the legacy FPS chassis and all field inputs.

Questions???



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