UT TRIGA Control System Upgrade

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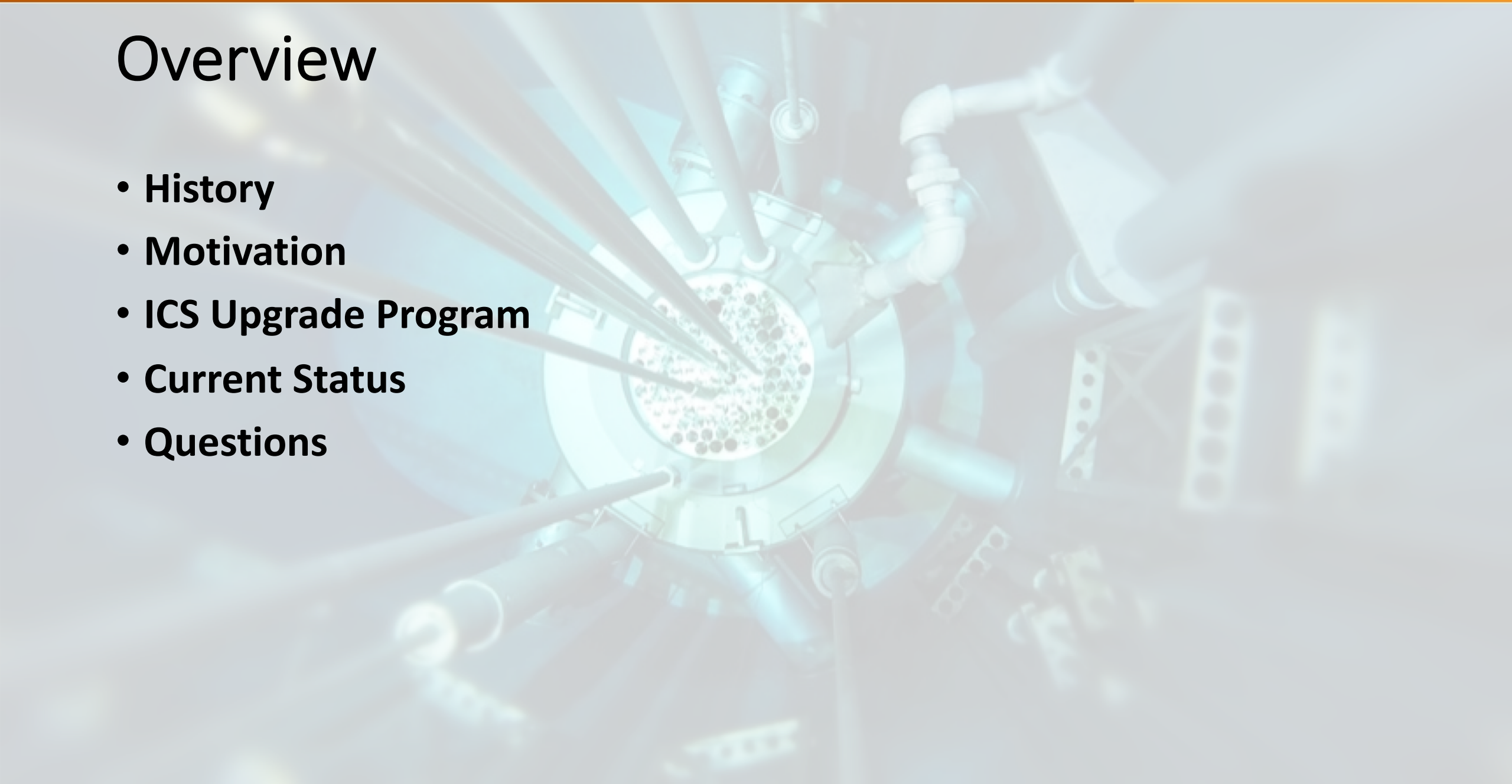
Overview



- History
- Motivation
- ICS Upgrade Program
- Current Status
- Questions

NETL ICS History

- 1st Generation GA Digital I&C integrated with analog safety system
- TRIGA Mark II construction 1989-1992, initial crit March 1992
- Compiled operating systems:
  - Operator interface: General Atomics software on a windows platform
  - Hardware interface: QNX
- Current system is original with a few peripheral upgrades
  - Tektronix recorder display relaced with a PC based emulator
  - RMS II & area monitors replaced with Ludlum, networked display
  - GA effluent monitor replaced with Canberra, networked display

Motivation

- Compiled drivers can't be updated
  - Windows XP
  - 250 MB max hard drive
  - OEM drivers for 1992 do not support current generation hardware
  - Additional operator computers & interfaces support networked displays
- Equipment is obsolete, critical components irreplaceable
  - Rod controls
  - Safety System
- We are a single failure away from a long shutdown
- Multiple annual requests for DOE NEUP support unsuccessful

Strategic Planning with AI

- **A popular AI**

- **Just Kidding**

Strategic Planning

- **Search for Tech Support to rewrite software for changing drivers**
  - **QNX not interested**
  - **Austin's system integrators**
    - **On-site discussions**
    - **Declined to respond to request for proposal**
- **Continue requests for DOE NEUP support**
- **Develop a strategy to accommodate an alternate funding profile**

Strategy for Alternate Funding Profile

- **Develop an ICS upgrade program based on phased implementation**
  - **Implement phases as funds become available**
  - **Replace original GA software with configurable GA software**
  - **Replace obsolete GA equipment with current generation equipment**
  - **Address identified needs for improvements**
- **Identify potential funding sources**

ICS Upgrade Program

- **Overview**
- **Equipment Replacement**
- **Design for Optimization**

Overview

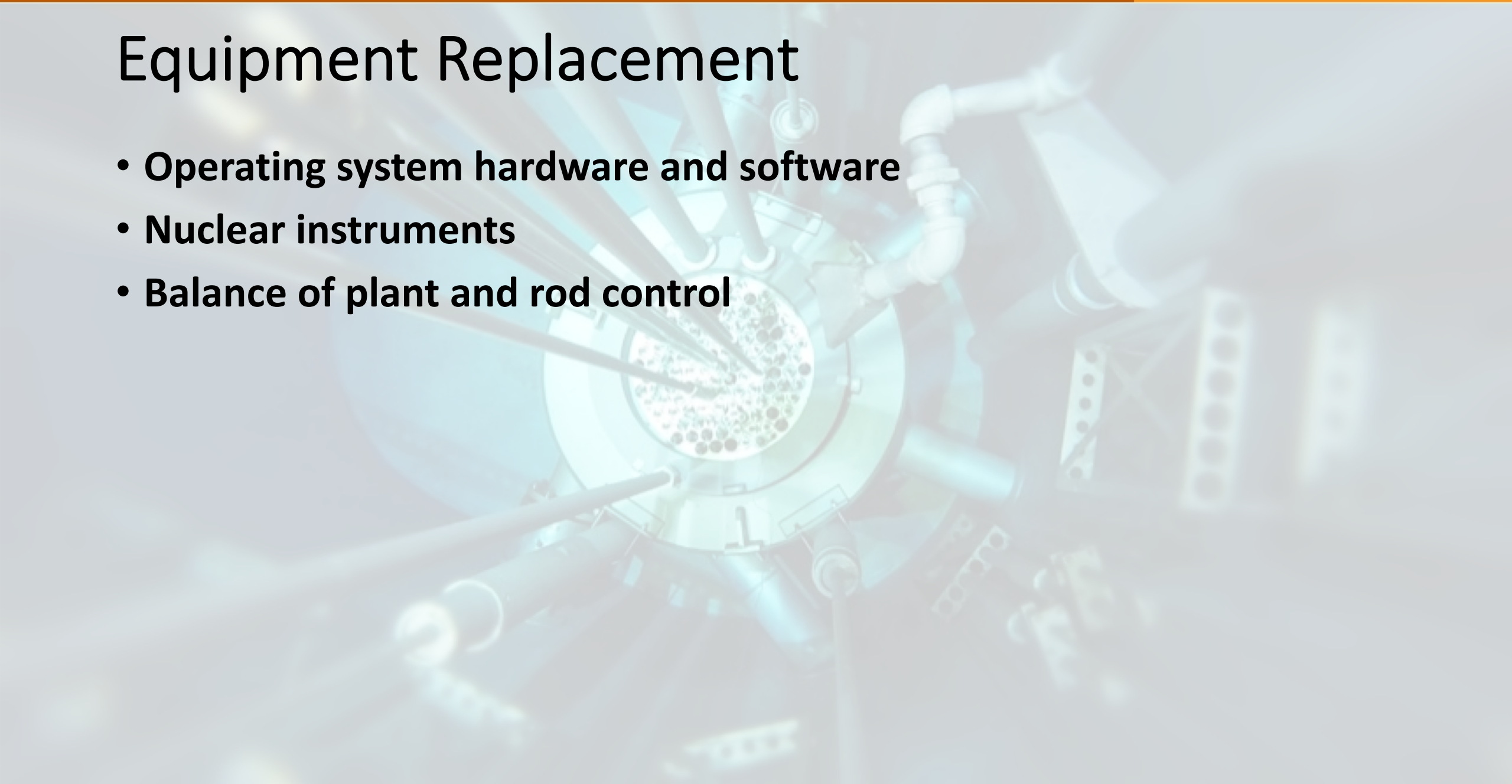
- **Fundamental goals:**
  1. **Control costs**
  2. **Improve long term viability (configurable software, COTS equipment)**
  3. **Minimize single channel failures that impact reactor operability**
  4. **Leverage experience at other facilities to support NRC approval (USGS, INL, AFFRI and BAEC [Bangladesh], and DOW)**
- **On request, Plantation Productions, Inc. submitted a proposal**
  - **Fleshed out a proposed phased-project**
  - **Accepted and initiated**
- **Initial intent for 10CFR50.59 route, but an LAR is required**
  - **Implementing SCRAM logic to prevent spurious shutdown**
  - **Opened consideration for optimization**

Game Changer 1

With upgrade in progress, proposal to support the program accepted by DOE

Equipment Replacement

- **Operating system hardware and software**
- **Nuclear instruments**
- **Balance of plant and rod control**



Operating System Hardware & Software

- Next Unit of Computing (NUC) computers replacing 286 PCs
- Ethernet based data acquisition hardware replacing the Digital and Analog I/O running on an IBM-PC AT bus
- New LINUX & General Atomics software
  - Windows 3.0 replaced with Windows 10
  - QNX 4.25 replaced with a version of LINUX
- Replace Tektronics graphic and text display emulator with HD displays

Nuclear Instruments

- **NM 1000 does not have a direct replacement, requires**
  - **NLW - Wide range log channel with a compensated ion chamber**
  - **NLW will be configured to add multirange data display**
  - **NMP - Multirange linear channel with a fission chamber (OBE)**
  - **NMP will be configured to add wide range log display (OBE)**
- **NP-1000, direct replacement with current generation (OBE)**
- **NPP-1000, direct replacement with current generation (OBE)**
  - **Integral pulse recording**
  - **LabMaster high speed recorder not necessary**

Balance of Plant and Rod Control

- **Replace Action Pak with COTS signal processing modules**
  - **Fuel temperature modules using current generation instruments**
  - **Water temperature modules with Ethernet based RTD module**
  - **New ‘Magnet power ground’ module**
  - **Isolation/converter modules for analog bar graph display**
- **Ethernet single-board computer for rod control**

Design Optimization

- **SCRAM**
- **Auto Flow (power level) Control**
- **Startup Channel(s)**
- **Process Instruments**
- **Data Capabilities**

SCRAM Logic - 2 Channel Power Level Trip

- ***This will require a Technical Specification change***
- **Up to four channels will have SCRAM capability**
- **Prevent spurious SCRAMs**
- **Permit online calibration, testing and maintenance**

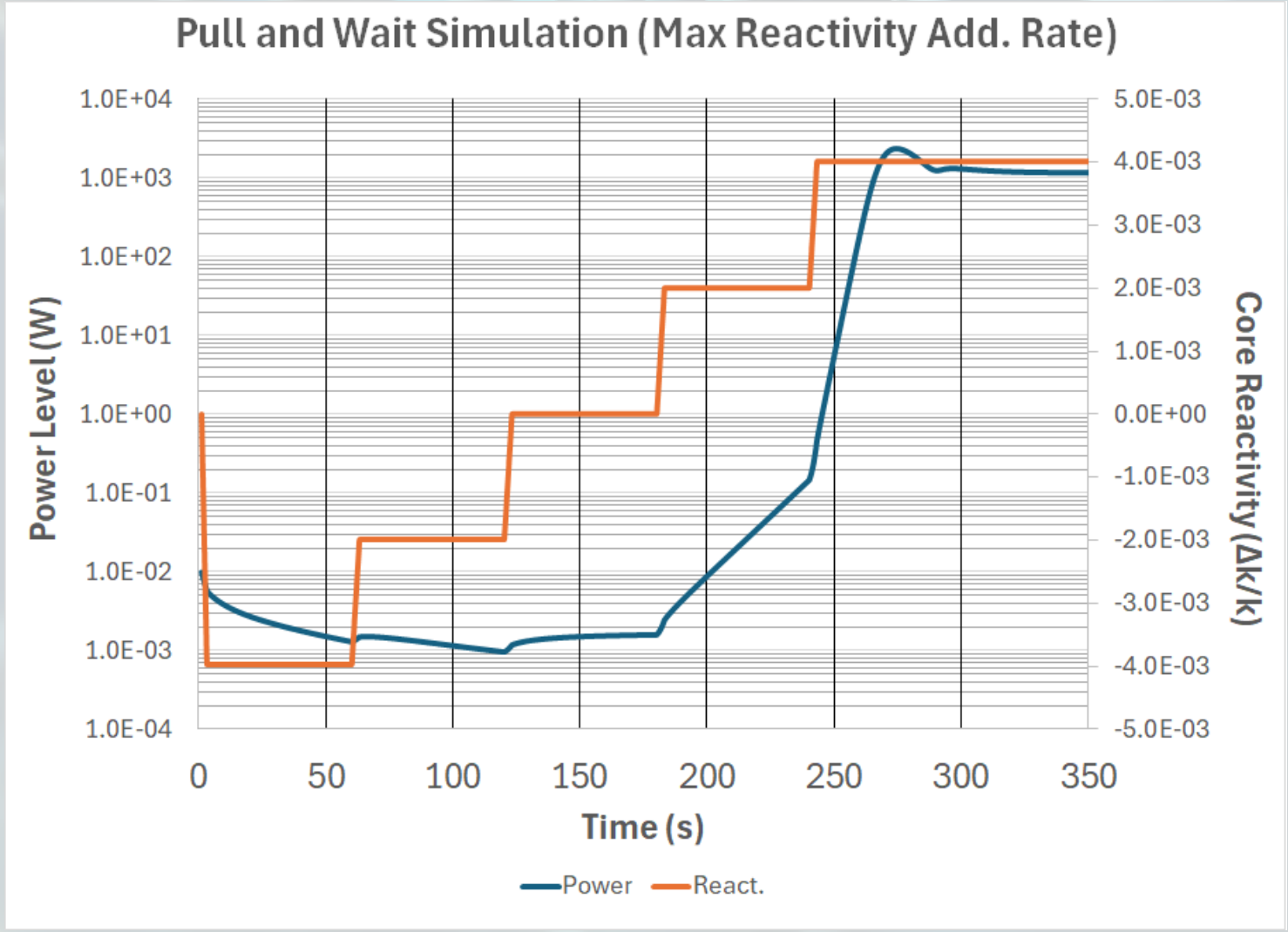
Auto Flux Control

- **GA & QNX scan at 0.1 second intervals**
  - **Reactor power can change significantly in less than 0.1 second**
  - **NM at 0.2 sec., QNX scan 0.1 sec., delay in display and control**
  - **Discontinuous jumps in power indication, lower operating power**
  - **Time dependent power level for control rod calibration**
- **Options under consideration to improve response:**
  - **Exploit Linux capabilities for 25 ms scan time**
  - **Adjust controller time constants in new system, or**
  - **Develop single board computer using 40 ms rod drop timer, or**
  - **Develop an embedded system using analog signals**

Startup Channel(s)

- **Selectable startup channel (e.g., AFFRI)**
  - **Configurable for NLW or NMP**
  - **Limit single failure associate with startup channel**
  - **Channel sensitivity may require Technical Specification change**
- **Low count rate rod withdrawal interlock (RWI)**
  - **Automatic or manual channel selection for NLW or NMP**
  - **Explore integration with “pull and wait” option vice standard RWI**

Pull and Wait Concept
(not considering interlock clear at adequate count rate)



Process Instruments

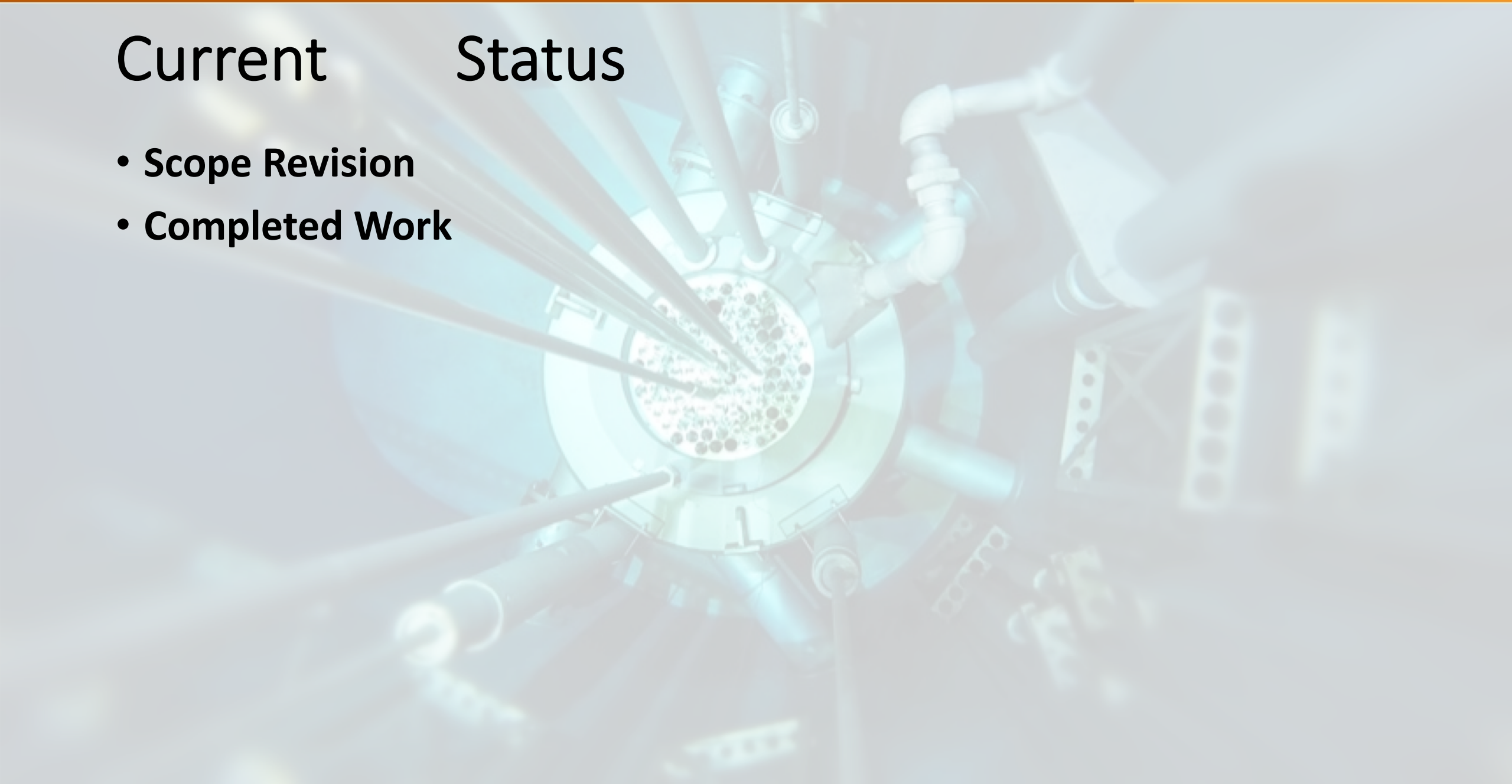
- **Pool level measurement**
- **Conductivity continuous display**
- **Fuel temperature monitors for all available sensors**

Improved Data Collection

- Isolated analog power level signal display and/or processing
- Auto-log records timestamped data changes (text file) 25 ms scan
- Post SCRAM data 25 ms
- Pulse data recorder
  - Increased sample rate by 10
  - Playback available on console
  - Record data in CSV file
- High speed recording (via pulse data recorder) on demand
- All files playback on TINA
- Pulse calculations include variable for fuel mass

Current Status

- **Scope Revision**
- **Completed Work**

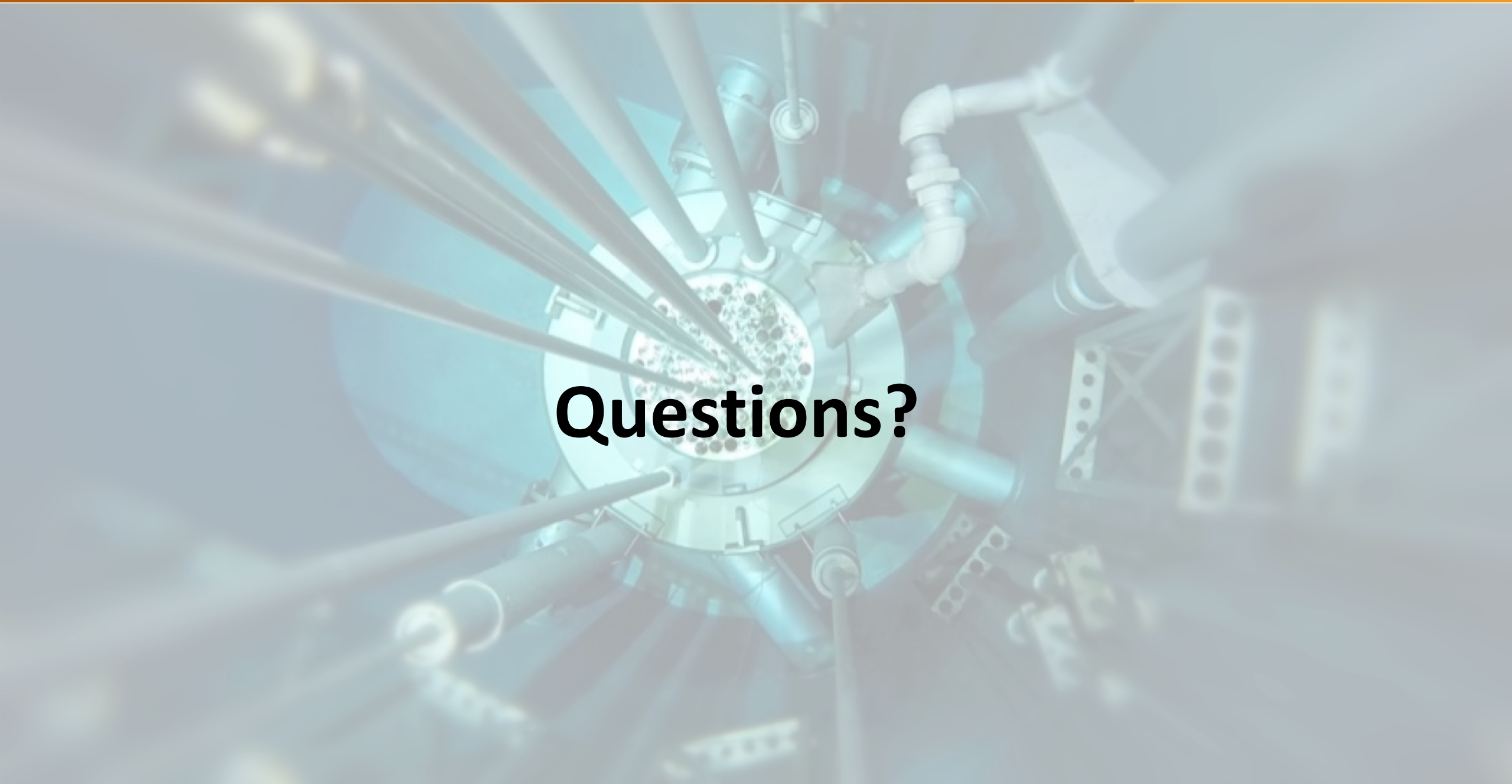


Scope Revision

- **UT Support had a hard expiration date**
  - **Negotiations with GA drove purchase past deadline**
  - **Funding for new NP, NPP and detectors was lost**
- **Add NLW to existing power level channels**
  - **NP/NPP need an interface ('Backpack')for ethernet connectivity: Digital signals and controls sampling 40 Hz**
  - **Backpack channel test lines compatible with current generation NP, NPP (*Current generation NP & NPP will essentially be plug and play*)**
- **NM-1000**
  - **Unfavorable 200 ms sample rate**
  - **Backpack configured to emulate NMP signals**
  - **'Plug & Play' NMP when funds become available**

Completed Work

- Phase 0 Public Meeting Complete
- GA Software license acquired
- Purchase initiated for Plantation Productions, Inc.
- Site Survey complete
- Initial design requirements complete
  (QA draft but fundamentally in use)
- TINA hardware installed
- Order placed for:
  - NMP-1000
  - Compensated Ion Chamber



Questions?

Phase 1: Overall System Requirements/Design

- **System Requirements modeled on IEEE 830-1998 software requirements**
- **Software Requirements for GA software on CCS/UIT units**
- **Block diagrams**
- **External components list (to be supplied by UT)**
- **Preliminary list of hardware components**
- **Validation by UT NETL staff**

Strategy for Alternate Funding Profile

The initial phase was in-progress, supported by other funds, at notification of a 2022-2023 NEUP award

Phase 2 : Design Test Platform

- **Custom TINA (Testing, Instruction, No Atomics module)**
- **Simulation platform for software testing**
- **Playback system for operating system**

Phase 3: Digital Data Acquisition Design/ Construction

- **Fabricate 2 computer systems (one for TINA, one for console)**
  - **UIT**
  - **CCS systems**
- **TINA system build**
- **Integrate (watchdog and networking)**
- **Design DAC backplane & build DAC**
- **Fabricate single board computers**

Phase 4: Software Porting

- **Customize GA digital console software system for NETL**
- **Testing using the TINA platform**

Phase 5: Installation

- Assemble hardware for parallel operation
- Assemble auxiliary rack
- Connect/Disconnect cables for:
  - Rod drive controllers
  - Analog circuits
  - Digital circuits
- Perform wiring
- Integrate and test
- Acceptance testing
  - Part I: Reactor secured, simulating signals
  - Part II: Reactor operating

Principle Quality Assurance Components

- **VDD-2726, NETL Reactor Control Console Software and Hardware Update, Version Description Document**
- **RTM-2726, Requirements Traceability Matrix**
- **SQAP-2726, Software Quality Assurance Plan**
- **CM-2726, Configuration Management Plan**
- **etc.**