# The Advanced Radiographic Capability, A Major Upgrade of the Computer Controls for the National Ignition Facility

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The ARC will provide a dynamic x-ray radiography of ICF implosions, a core requirement of NIF

NIF Hohlraum

X-ray movie of target compression

0   20 ps   40 ps

NIF laser beams
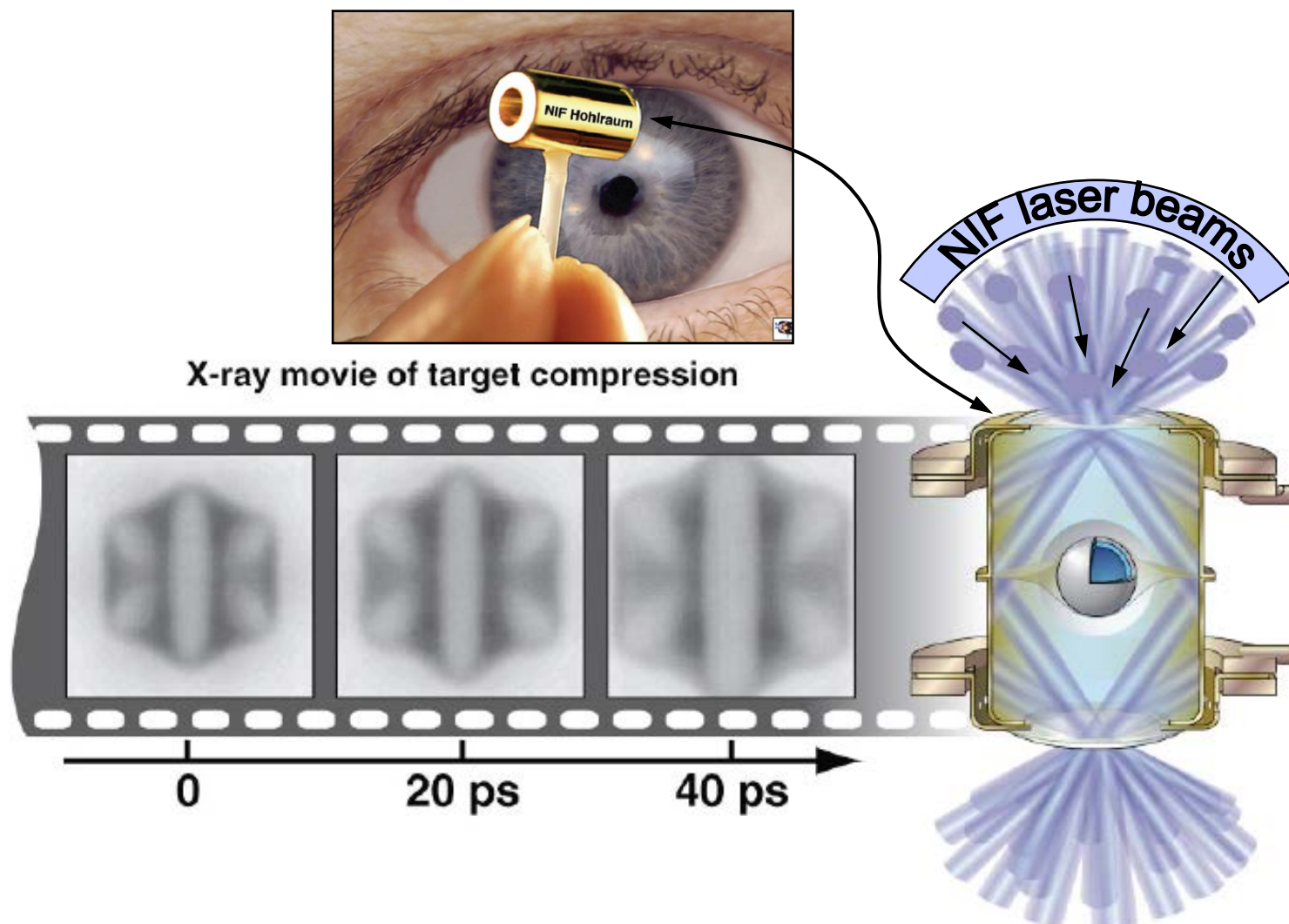
Full scale ARC will provide NIF with 8 Petawatt-class pulses capable of generating multi-frame hard X-ray backlighting images
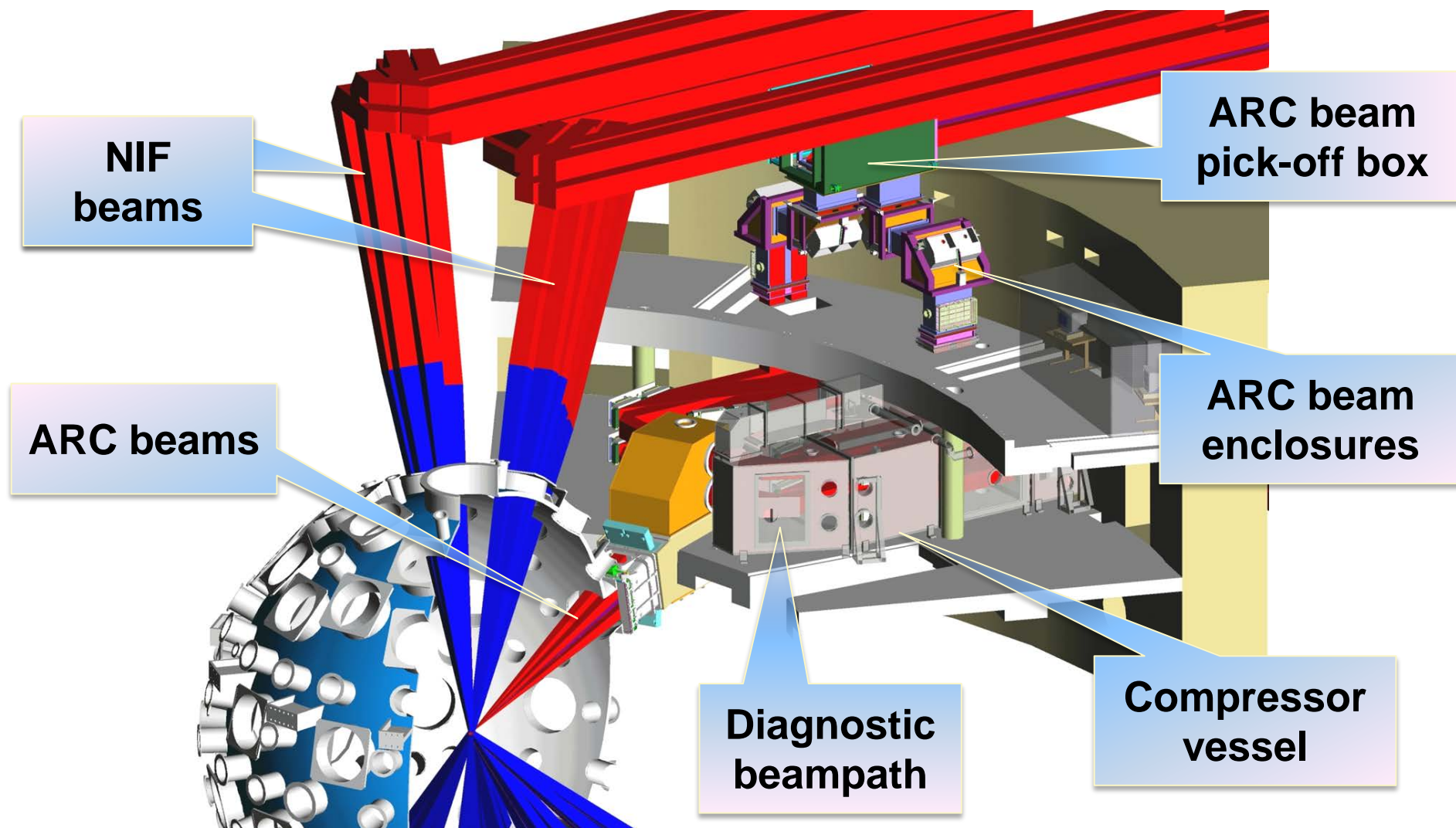
ARC chirped-pulse technology is used to produce short (1-50ps) laser pulses on NIF

- Generate a short laser pulse at low energy that has bandwidth
- Stretch the pulse in time and amplify using the existing NIF laser chain
- Recompress the pulse in the target area
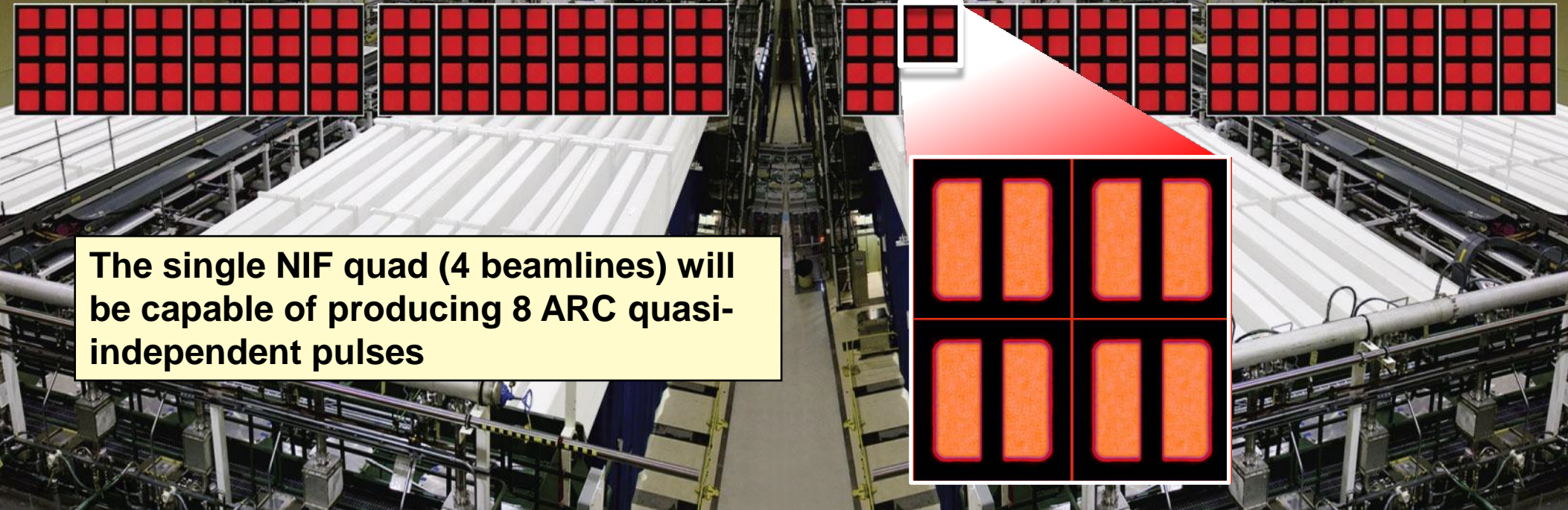- Focus onto targets with a parabolic mirror

New ARC Front End

Modified NIF Laser Bay

New ARC Target Area
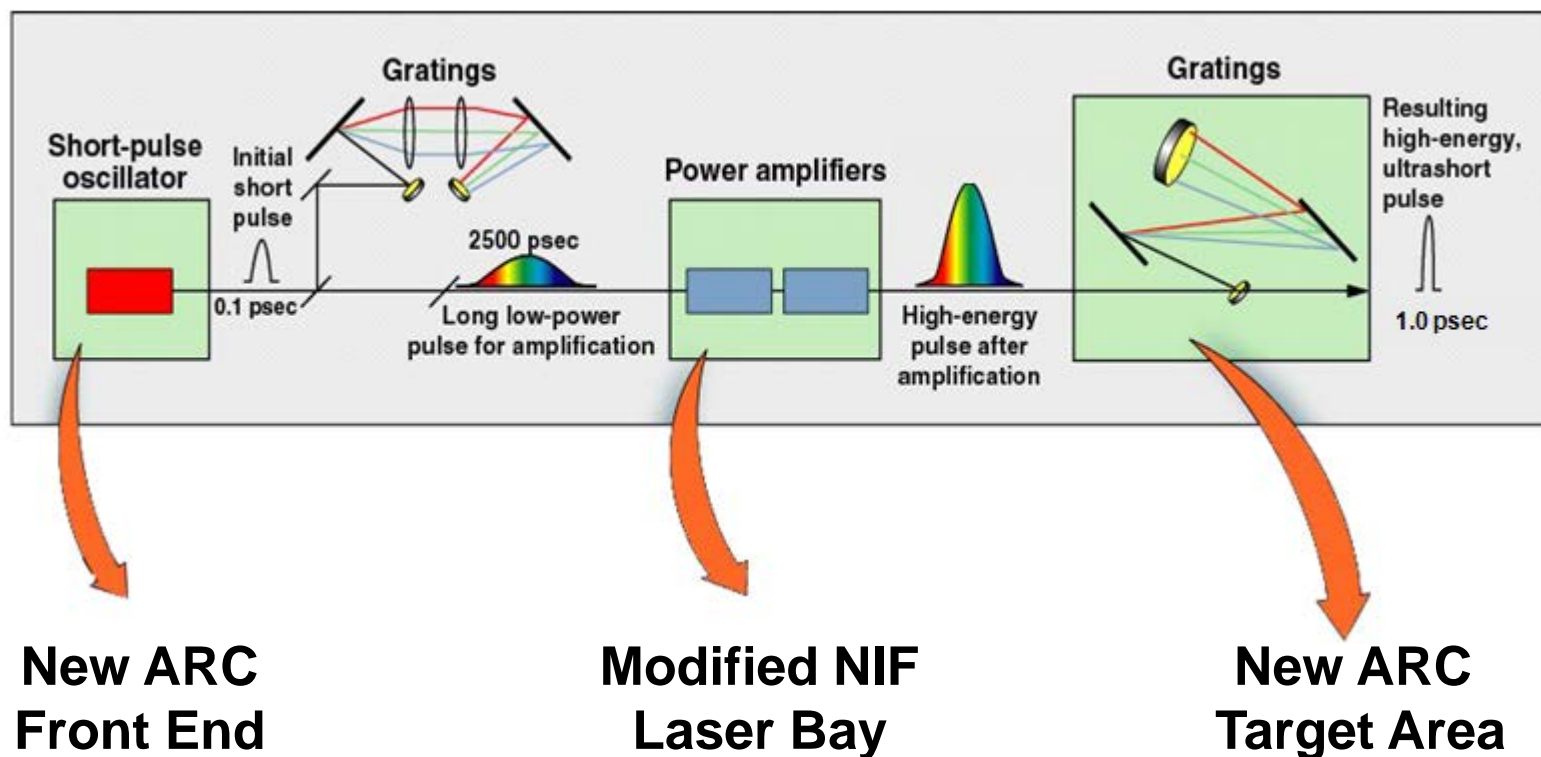
Stretching the pulse lowers the overall peak power allowing ARC to safely utilize NIFs main amplification chain

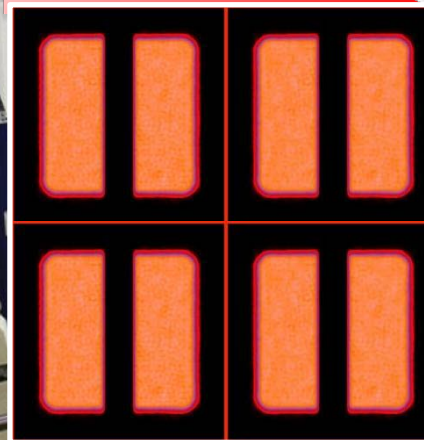# ARC will utilize up to a quad of NIF beams in the target bay for short-pulse use on target

NIF beams

ARC beams

ARC beam pick-off box

ARC beam enclosures

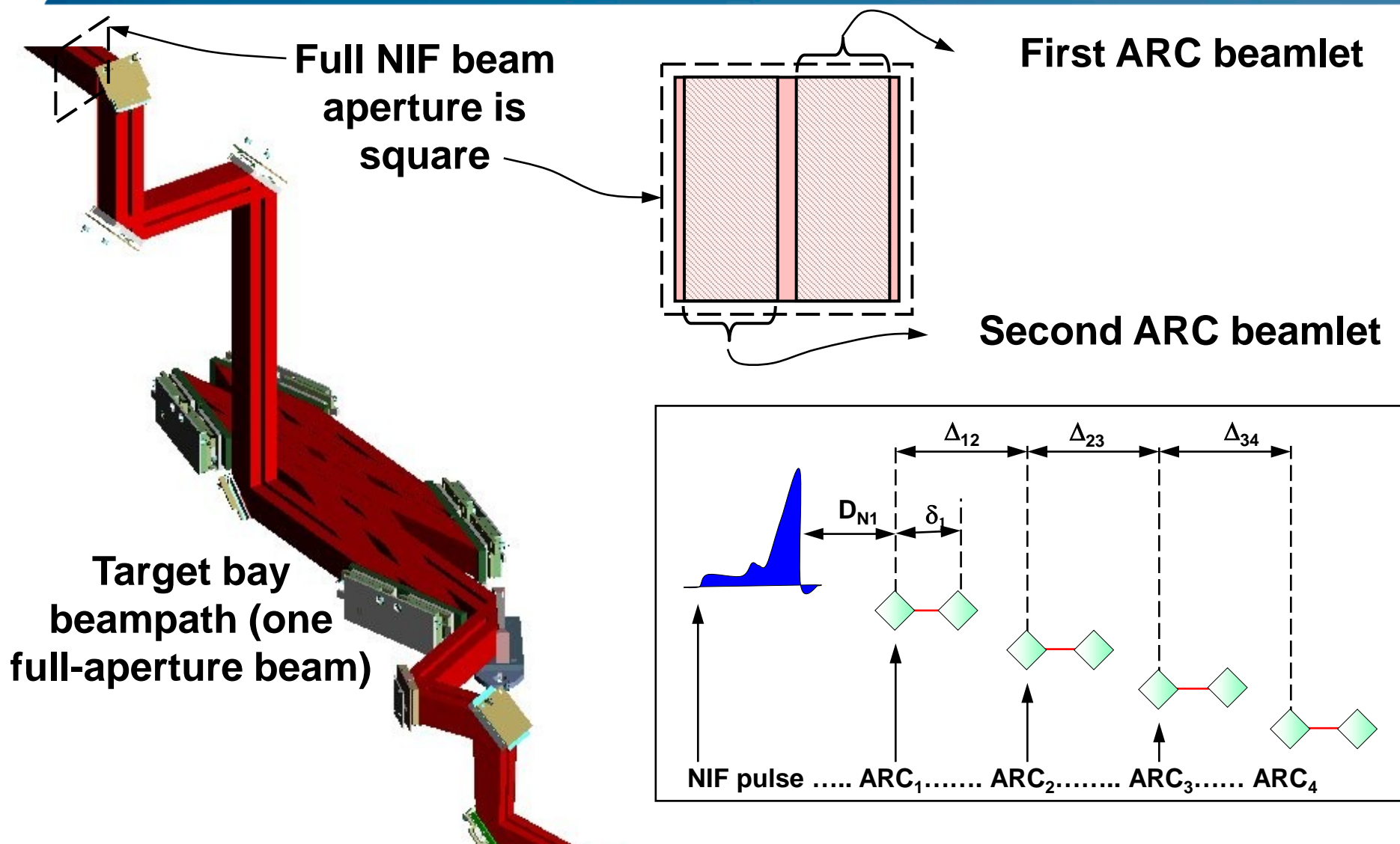Diagnostic beampath

Compressor vessel

The modified quad will allow for either short pulse (ARC) or long pulse (NIF) operations

The single NIF quad (4 beamlines) will be capable of producing 8 ARC quasi-independent pulses
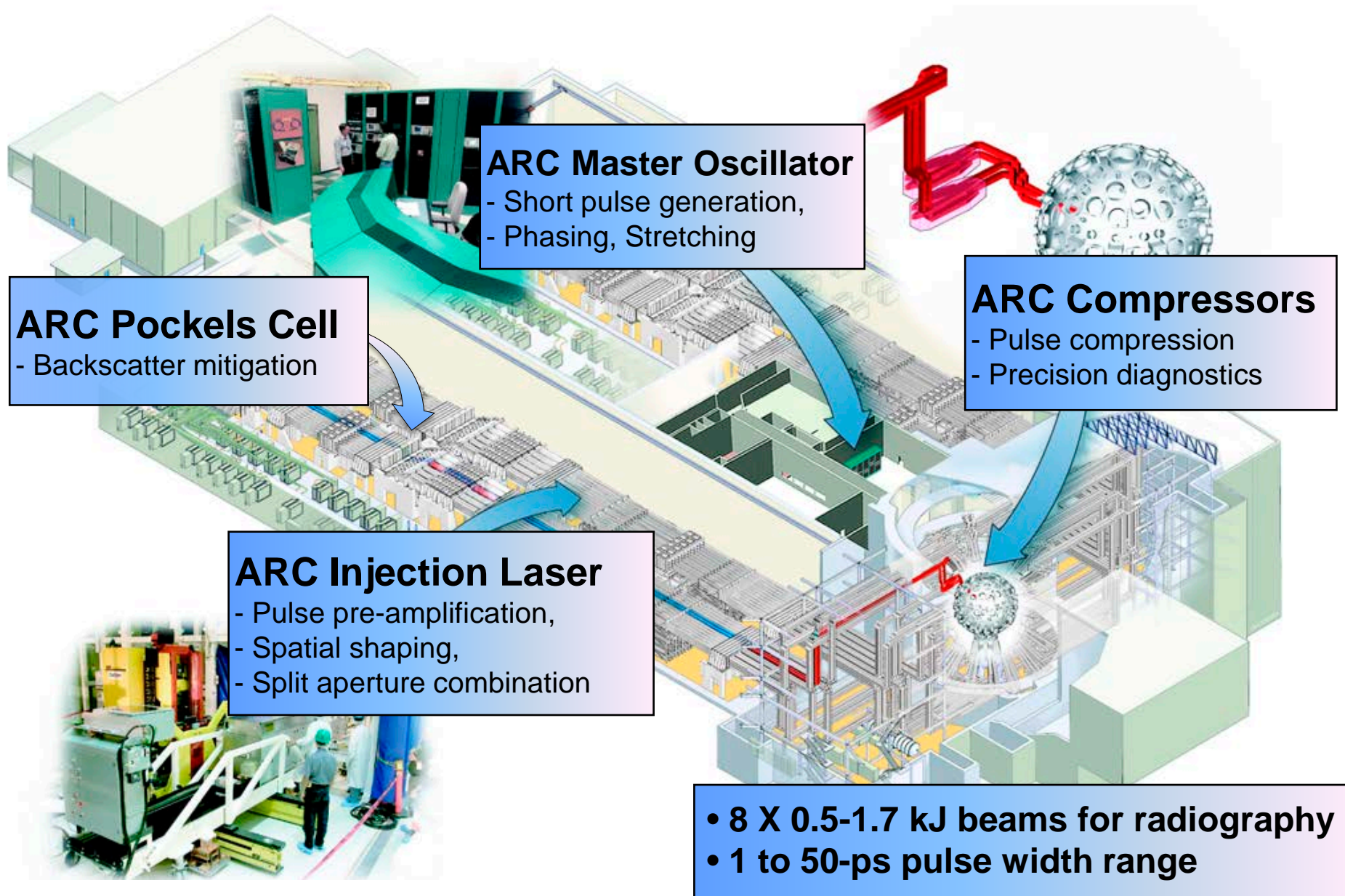
Each ARC beamline will be divided into two sub-apertures to double backlighting capabilities

Full NIF beam aperture is square

First ARC beamlet

Second ARC beamlet

Target bay beampath (one full-aperture beam)

Δ_{12} Δ_{23} Δ_{34}

D_{N1} δ_1

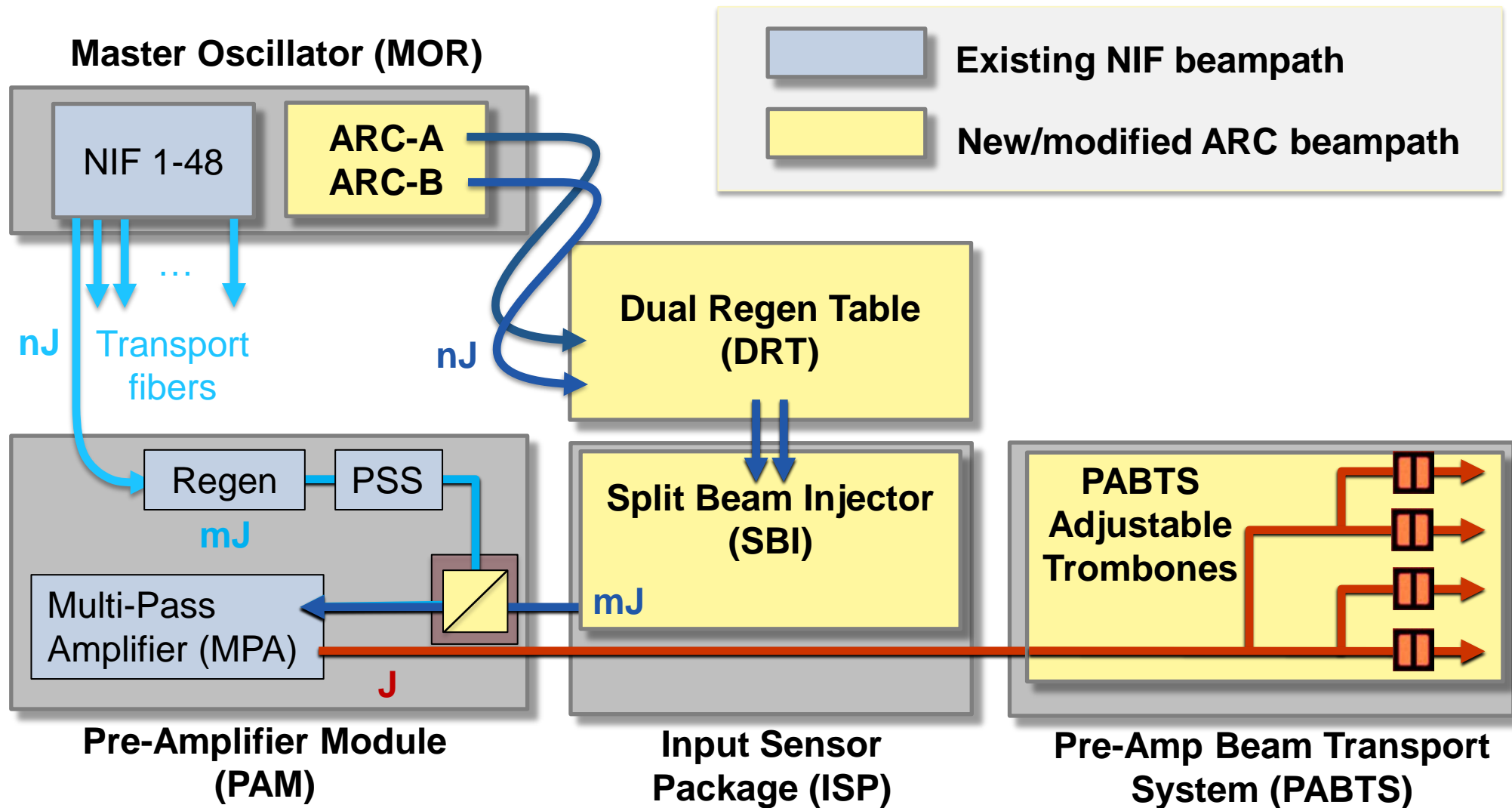NIF pulse ….. ARC$_1$……. ARC$_2$…….. ARC$_3$…… ARC$_4$

Each of the 8 beamlets can be independently focused and separated in time, to produce a pulsed-backlighter source

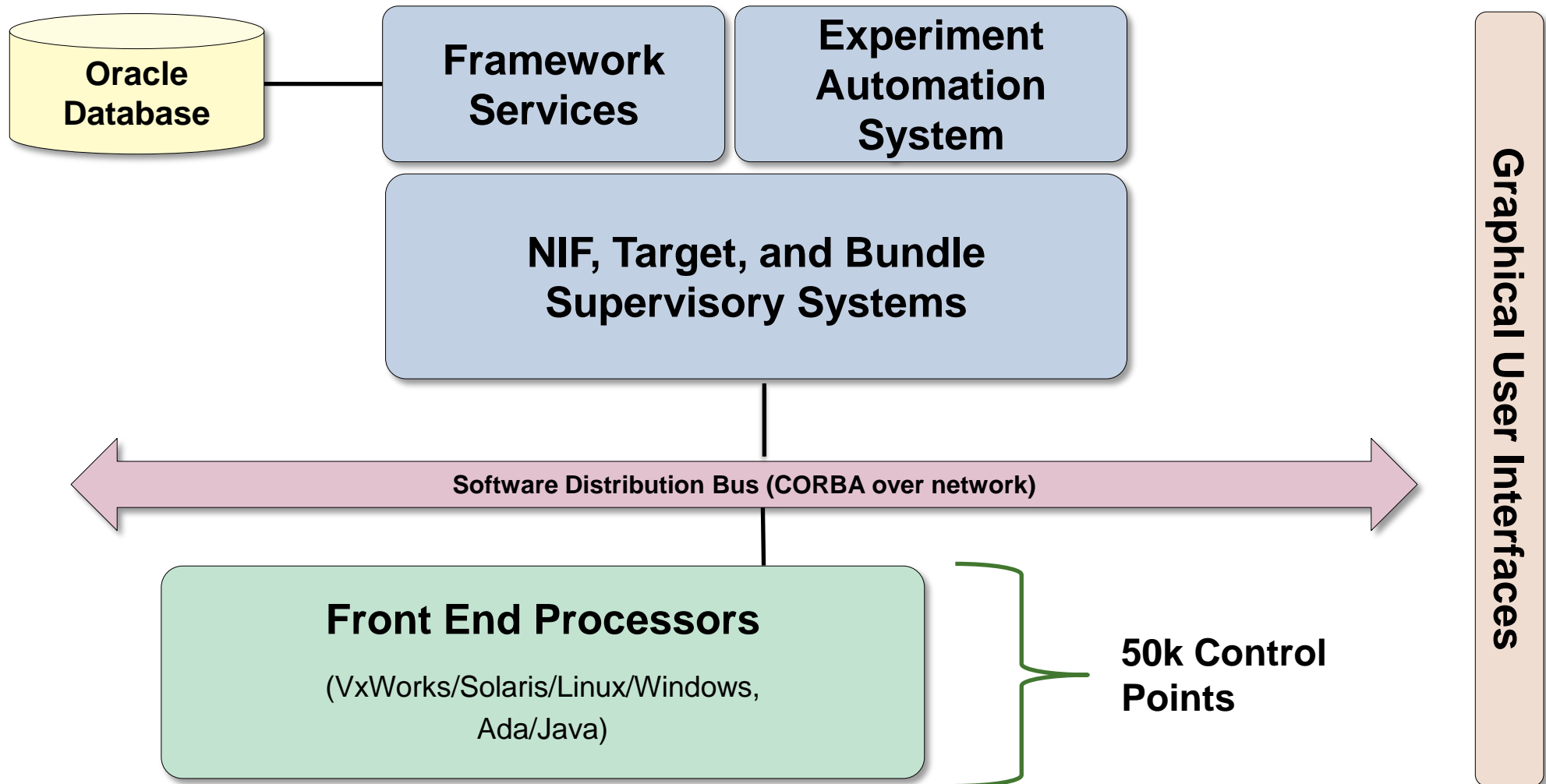# High-energy, short pulse generation requires four modifications to NIF's laser and controls architecture

ARC Master Oscillator
- Short pulse generation,
- Phasing, Stretching

ARC Compressors
- Pulse compression
- Precision diagnostics

ARC Pockels Cell
- Backscatter mitigation

ARC Injection Laser
- Pulse pre-amplification,
- Spatial shaping,
- Split aperture combination

- 8 X 0.5-1.7 kJ beams for radiography
- 1 to 50-ps pulse width range

New ARC injection laser system provides independent control of short pulse characteristics

Master Oscillator (MOR)

NIF 1-48

ARC-A
ARC-B

Existing NIF beampath

New/modified ARC beampath

nJ   Transport fibers

nJ

Dual Regen Table (DRT)

Regen   PSS

mJ

Multi-Pass Amplifier (MPA)

J

Pre-Amplifier Module (PAM)

Split Beam Injector (SBI)

mJ

Input Sensor Package (ISP)

PABTS Adjustable Trombones

Pre-Amp Beam Transport System (PABTS)

Propagation of either NIF or ARC pulse is controlled autonomously by shuttering either ARC or NIF dependent on experimental goals

# The segmented and layered software architecture allows rapid integration of ARC to existing controls

Oracle Database

Framework Services

Experiment Automation System

NIF, Target, and Bundle Supervisory Systems

Software Distribution Bus (CORBA over network)

Graphical User Interfaces

Front End Processors

(VxWorks/Solaris/Linux/Windows, Ada/Java)

50k Control Points

Minimizing impact to existing NIF controls significantly reduces the integration qualification duration

ICCS ARC controls integration is a large scale development but is well underway

- ARC will add 70% additional control points (850) to existing NIF quad
- Heavily leveraging existing controls (80% reuse of NIF controls SW)
- 13 new or modified control types required for ARC
- >60% controls already deployed and undergoing commissioning

ARC Control Point Additions/Modifications
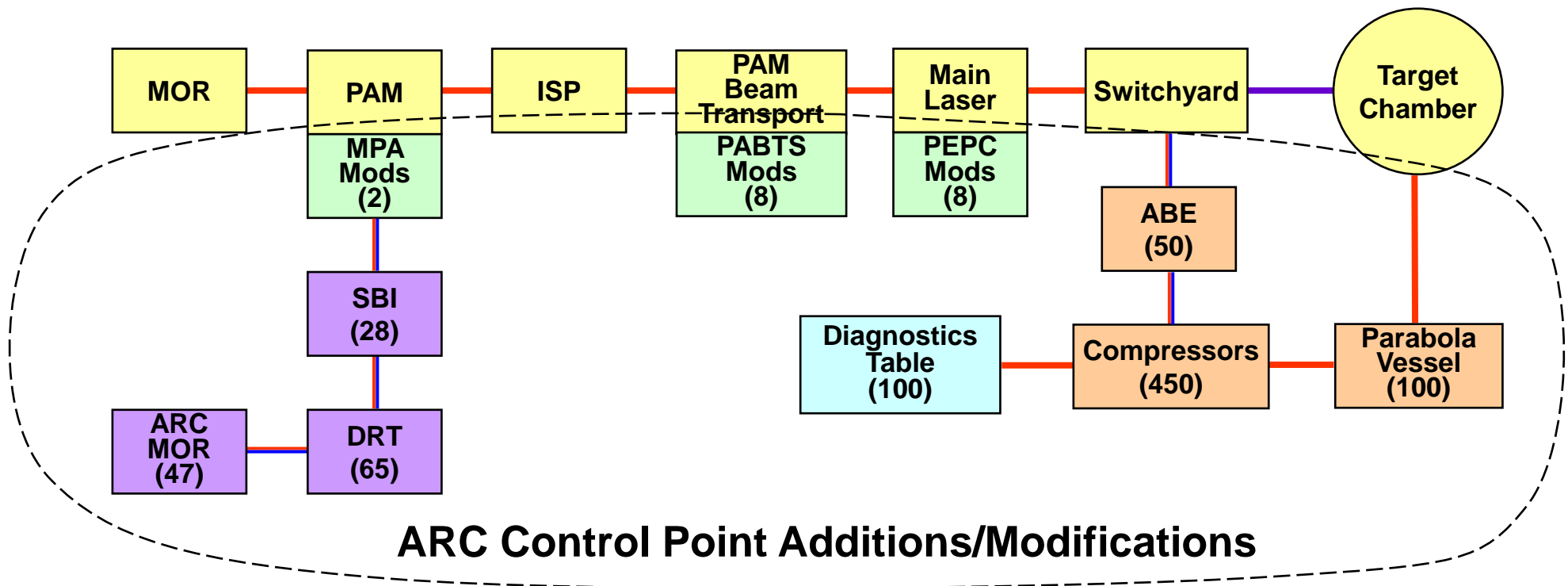
ICCS's flexible, object oriented architecture is designed to rapidly integrate ARC's new control points into automated shot framework

# Time synchronization of ARC to NIF pulses required a complex series of feedback controls loops
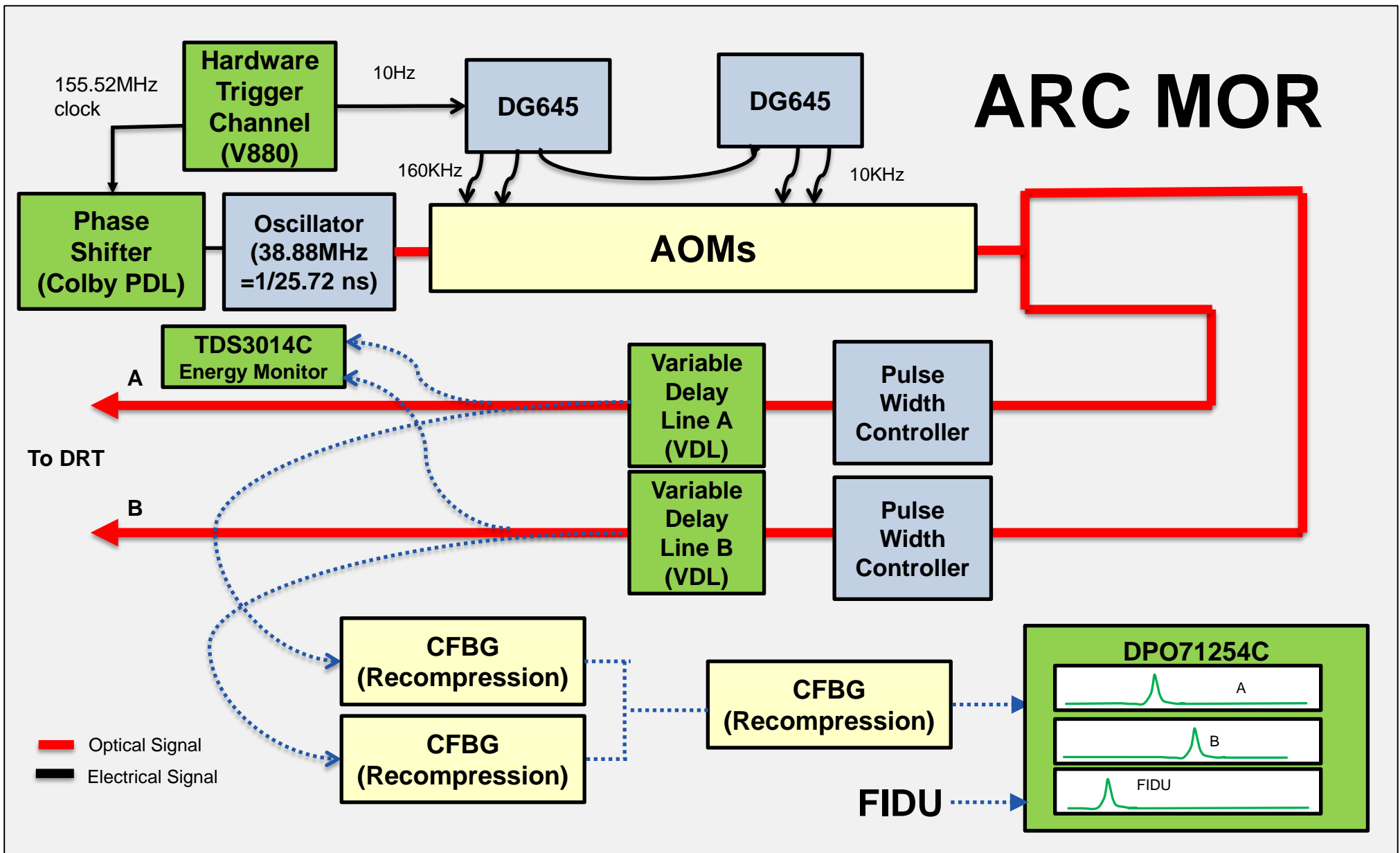
Significant new software development is focused in the complex short-pulse laser diagnostic suite


- Pulse width
- Pulse shape
- Pulse contrast
- Pulse energy
- Pulse spectrum
- Wavefront
- Inter beam coherence
- Relative pulse delay
- Near field
- Far field

New controls development

Several new software controls being developed for diagnostics to allow verification of ARC experiments in NIF automated shot cycle
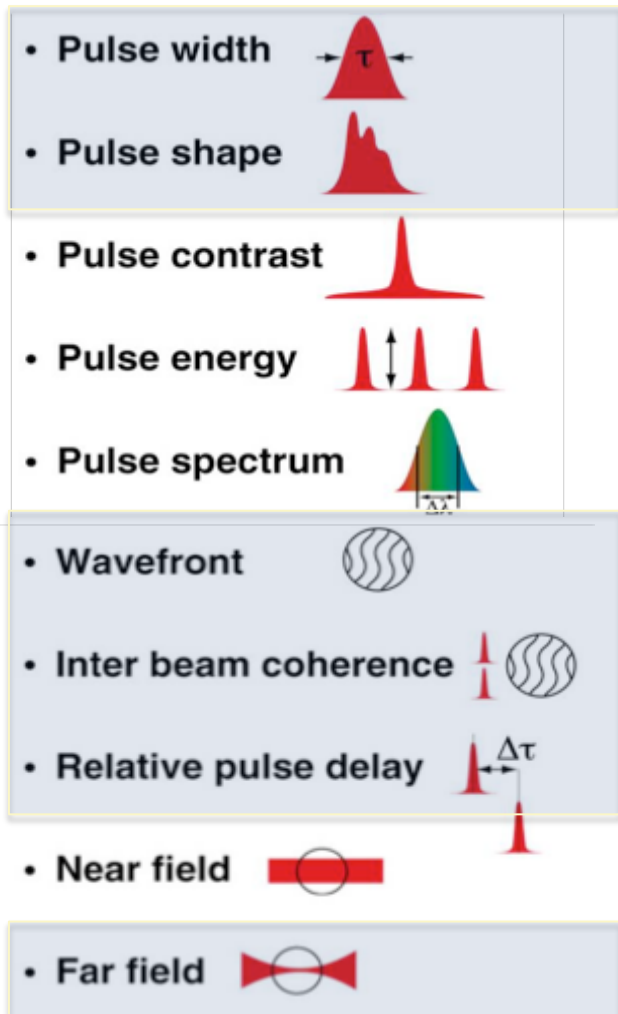
Beam alignment of the ARC laser is automated from origin to target

- A series of automated alignment loops align the entire ARC beampath
- Each feedback control loop uses image analysis measurements to adjust a series of mirrors to align the ARC beams with very high accuracy
- A total of 20 new control loops are required to align the entire ARC beampath
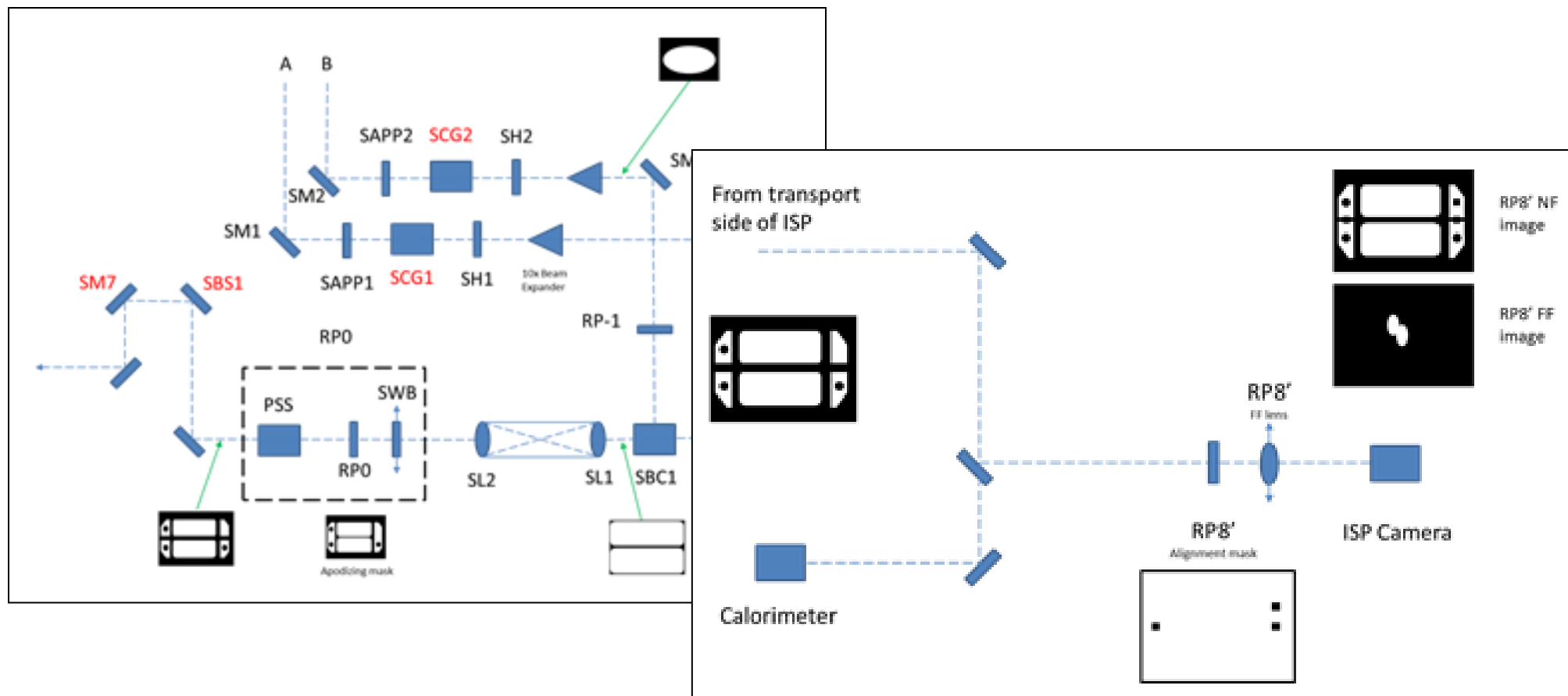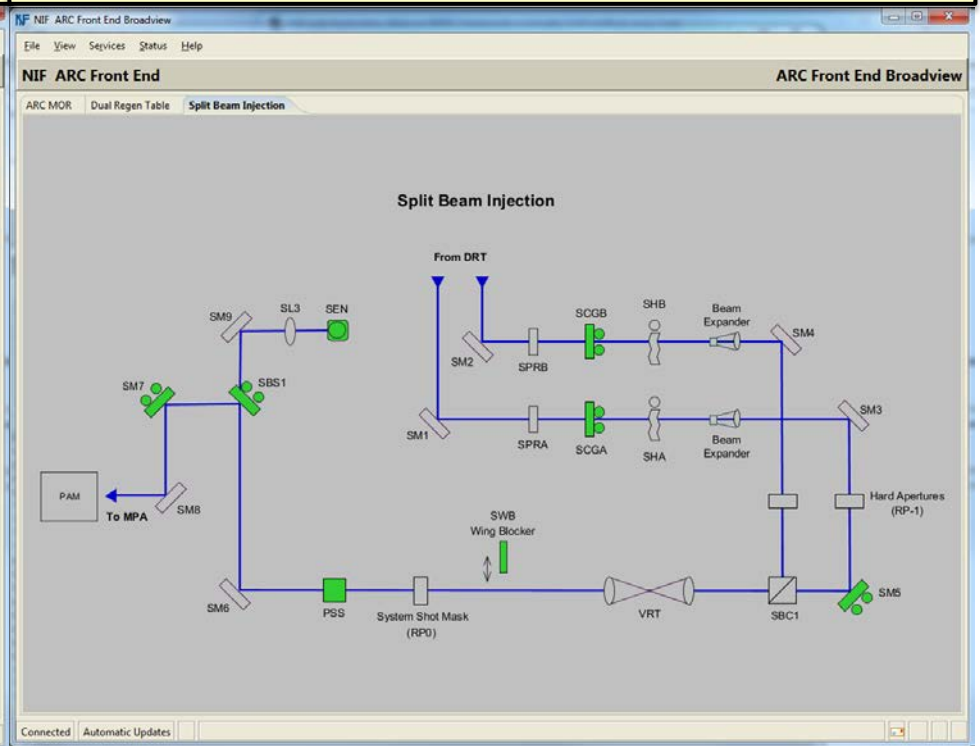
ARC graphical interfaces developed to provide operations with continuous feedback of device state
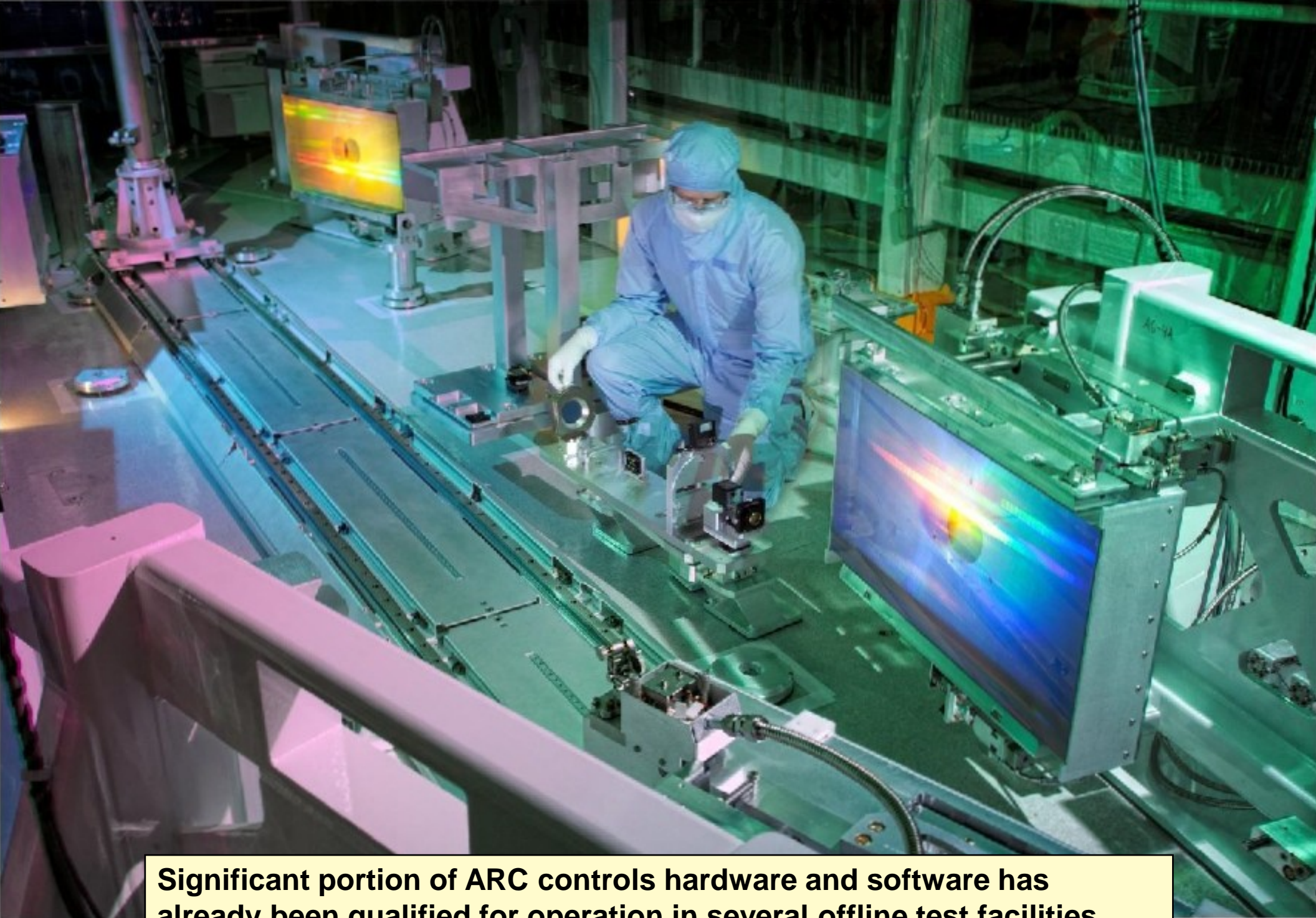

**DRT Broadview**
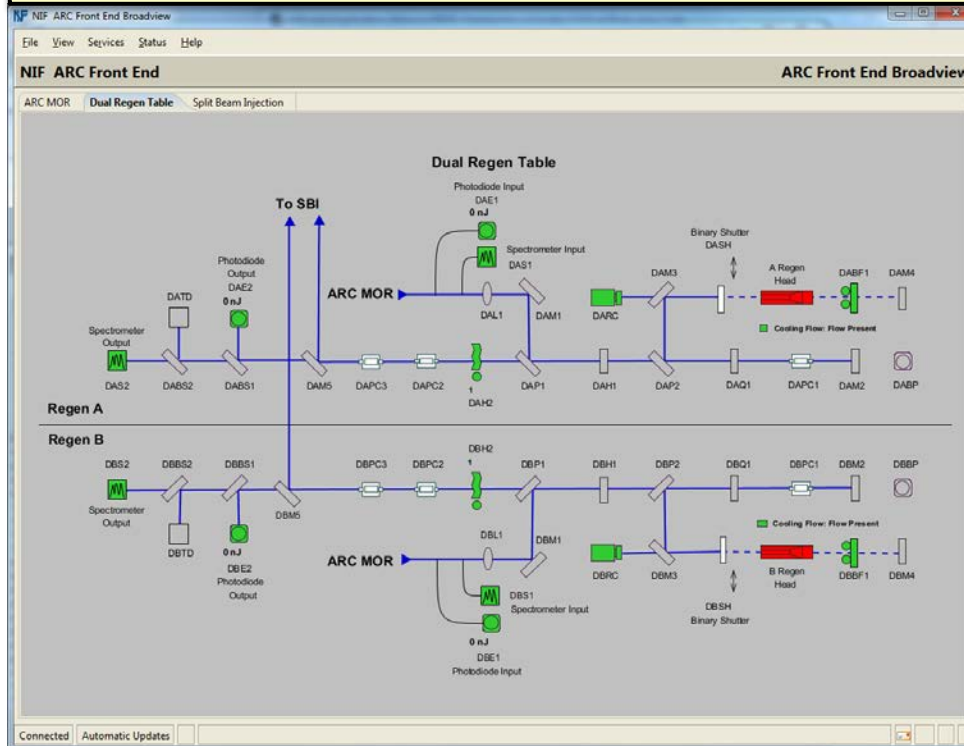
SBI Broadview

Schematic interfaces provide operation staff with a high level system overview and provide a realistic reference for maintenance activities

Significant portion of ARC controls hardware and software has already been qualified for operation in several offline test facilities

Significant progress to ARC controls qualification has already been accomplished
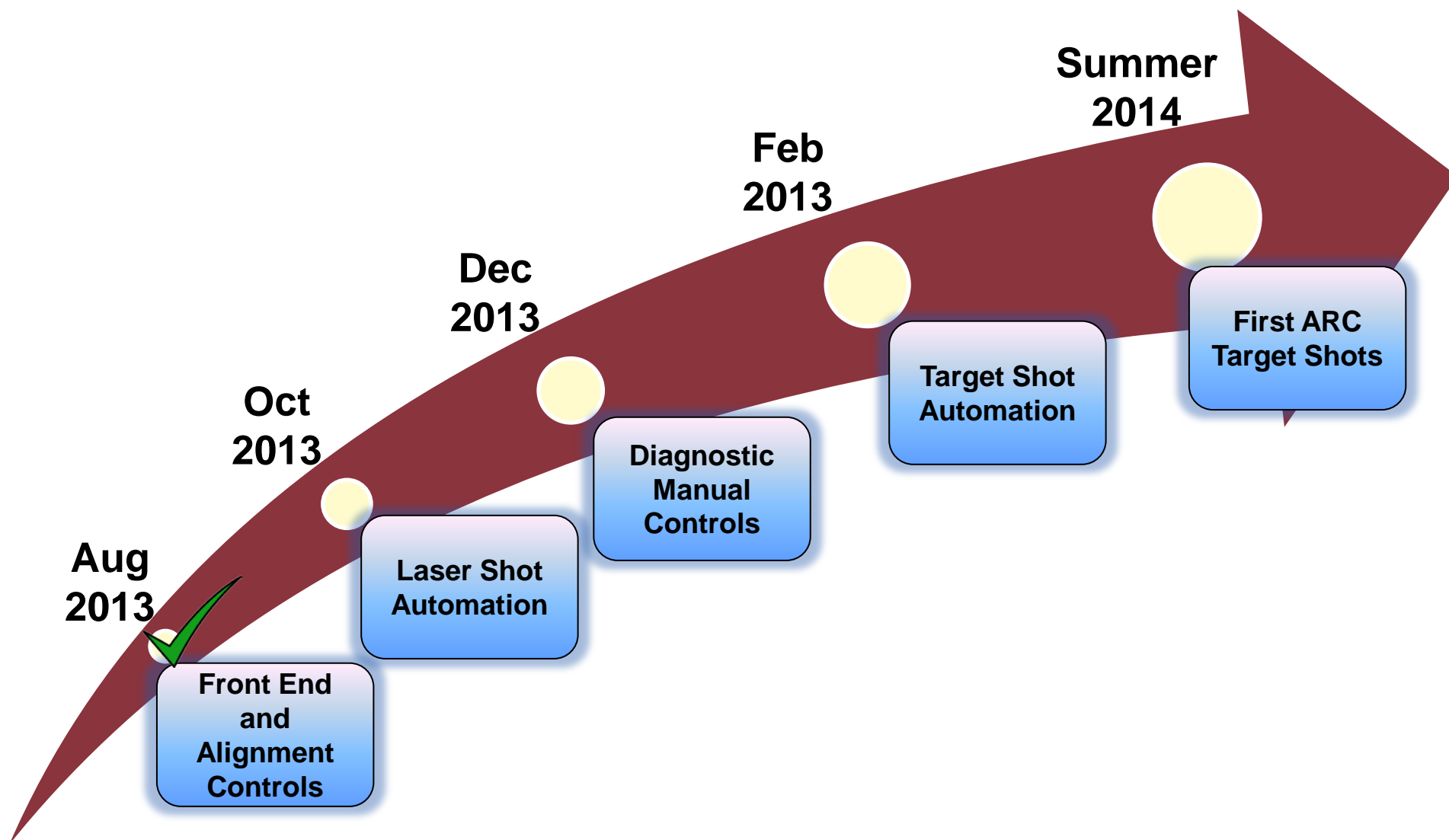
Phased deployment of ARC capabilities reduces overall project deployment and commissioning risks