

Radiation Hardened Imaging Systems For Fusion Diagnostics

2025 INFUSE Workshop

Matthew Dayton, Marcos Sanchez

Advanced hCMOS Systems

matthew@hcmos.com, marcos@hcmos.com

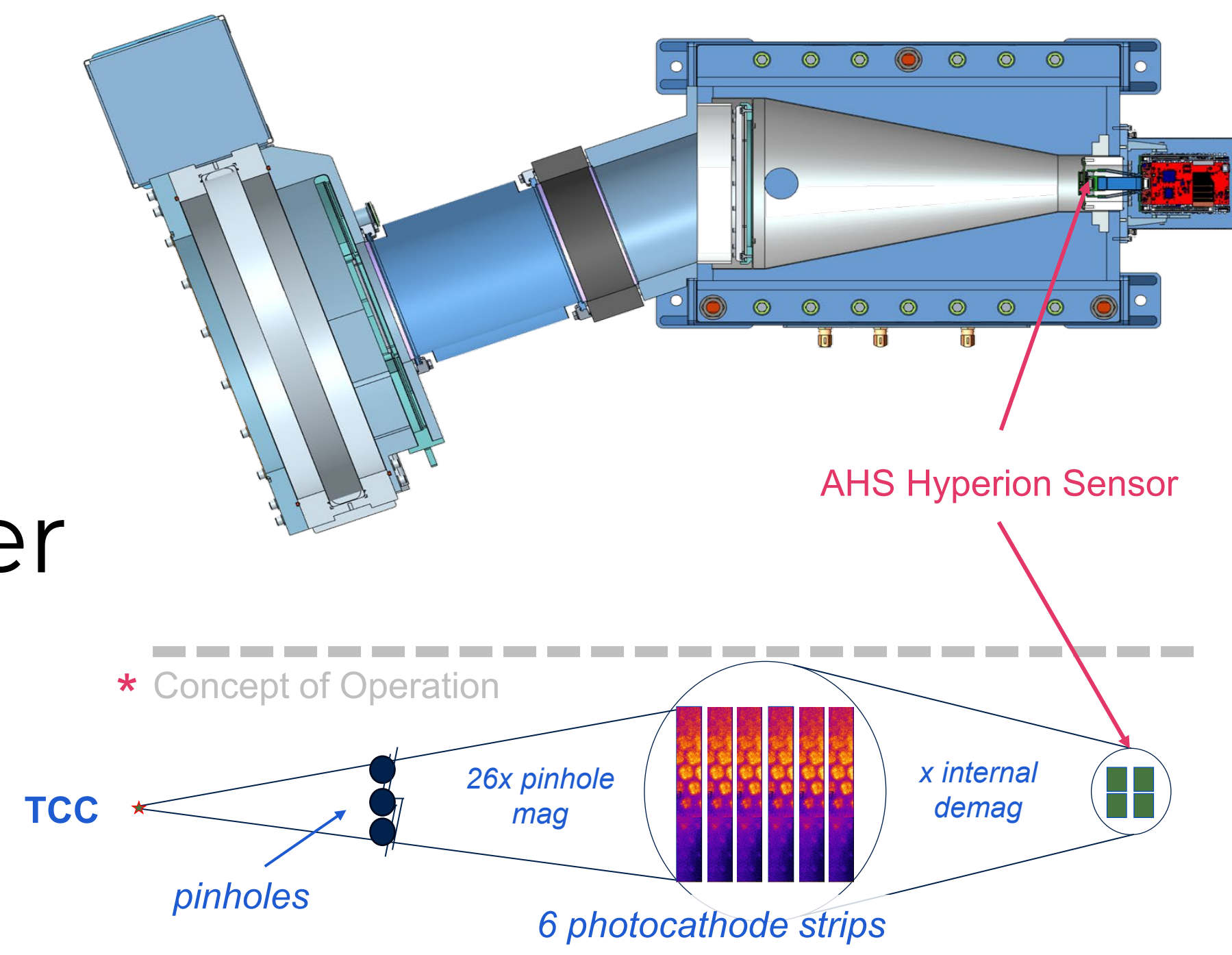
The Radiation Challenge For Fusion Diagnostics

The Dilemma

- Increased fusion gain results in increased prompt dose radiation
- Diagnostics must operate through prompt dose radiation

LLNL Initial Solution

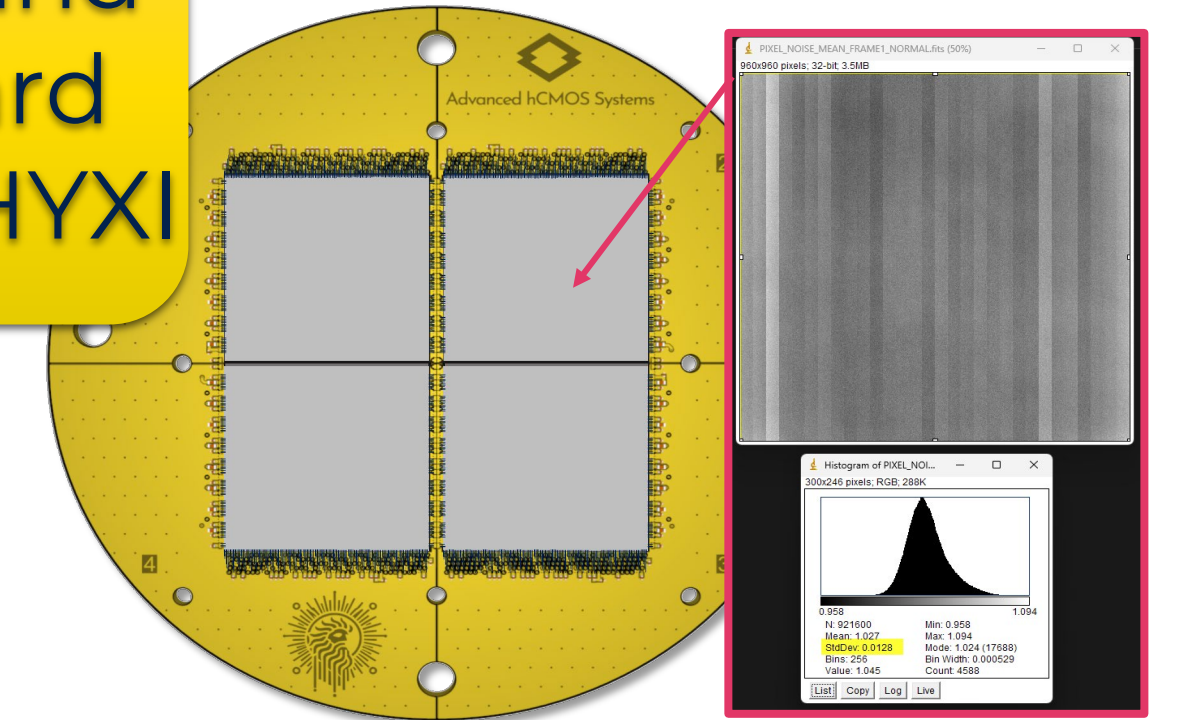
High
Yield
X-Ray
Imager



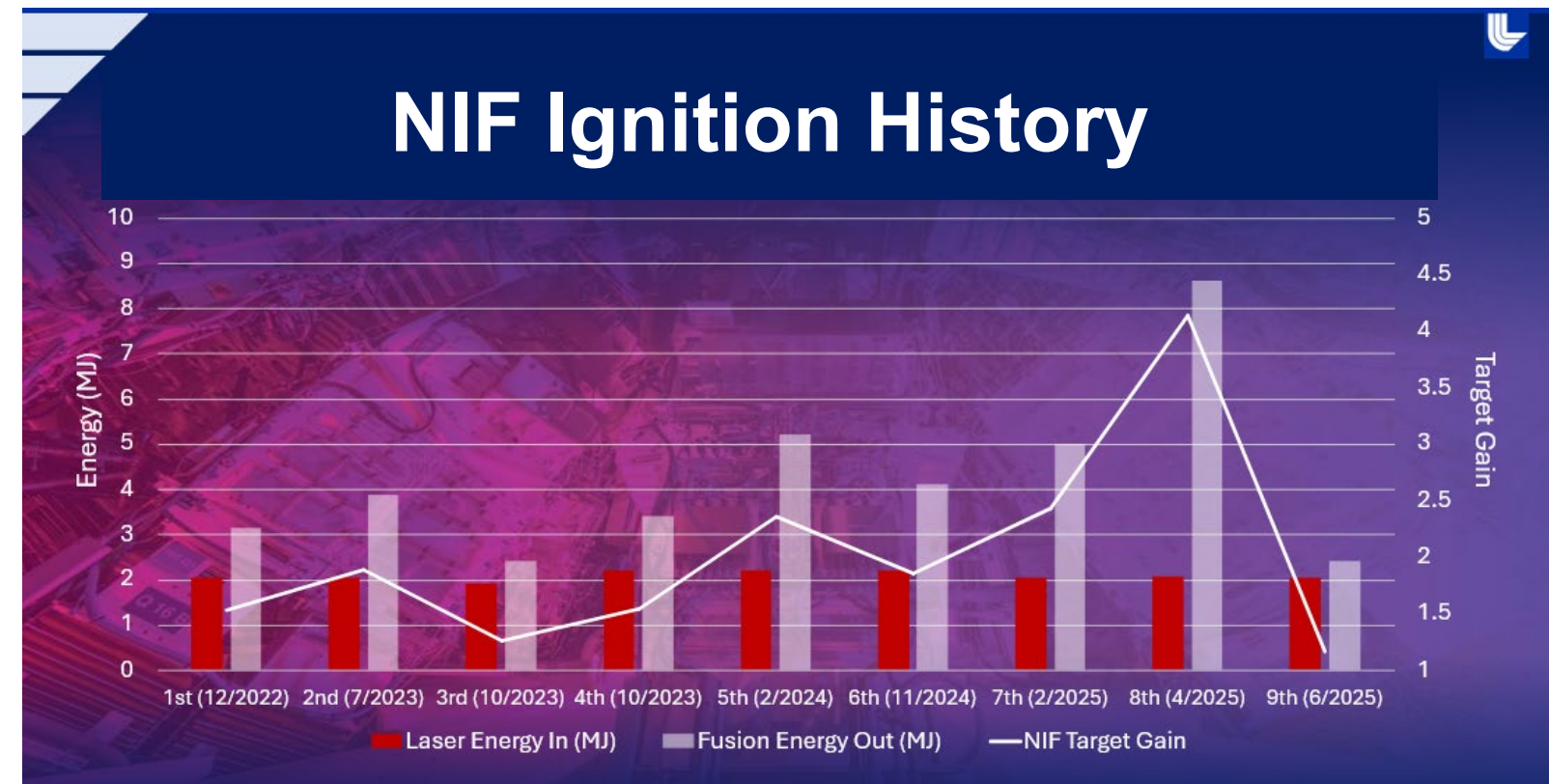
• HYXI Diagnostic

- Pinholes project onto 6 photocathode strips
- Strips projected on 4 custom rad-hard sensors
- Six, 400ps temporal records captured (time dilation)
- Rad qualified components used in system
- Reduced radiation induced noise vs film
- Higher image quality due fast shutters

AHS has designed and fabricated a rad-hard imaging sensor for HYXI



HYPERION Package and Readout



* Information provided by Terry Helsabeck
Lawrence Livermore National Laboratory

Fusion diagnostics will require sensors and electronics that are hardened to prompt dose radiation

Generalized INFUSE Supported Solution

Potential INFUSE Project



- Development of Rad Hard Camera System

INFUSE NEEDS

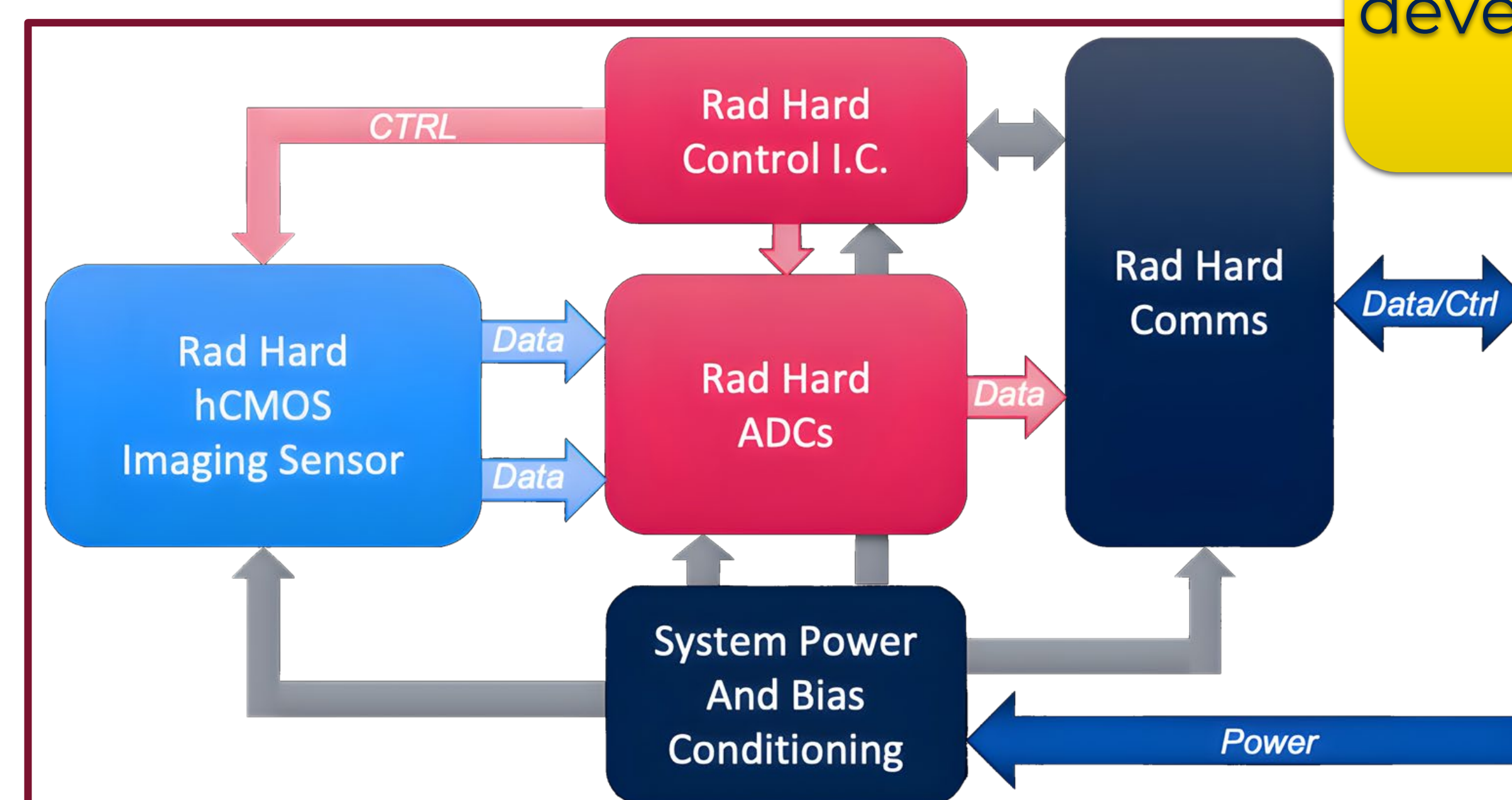
Access to Rad Source

Radiation Effects Simulation

Access to Rad Source

Primary Project Efforts

- Rad-test AHS prototype circuits and COTS electronics
 - Sensor readout chip
 - Rad-hard ADC
- Proto-type design iteration + system design
 - Modify designs based on sim/test results
 - System architecture definition and component selection
- Proto-type/system fabrication and rad-testing
 - Fabricate designs in rad-hard process
 - Fabricate system electronics and firmware
 - Rad test camera system



Rad-Hard Camera System Concept Block Diagram

AHS has started the development of rad-hard camera system

- - Fully developed
- - In development
- - Development pending

Government and commercial fusion efforts require a commercial rad hard imaging solution for diagnostics

Experience and Enabling Technology

Advanced hCMOS Systems

Founded by national laboratory staff members seminal in the development of hCMOS imaging technology

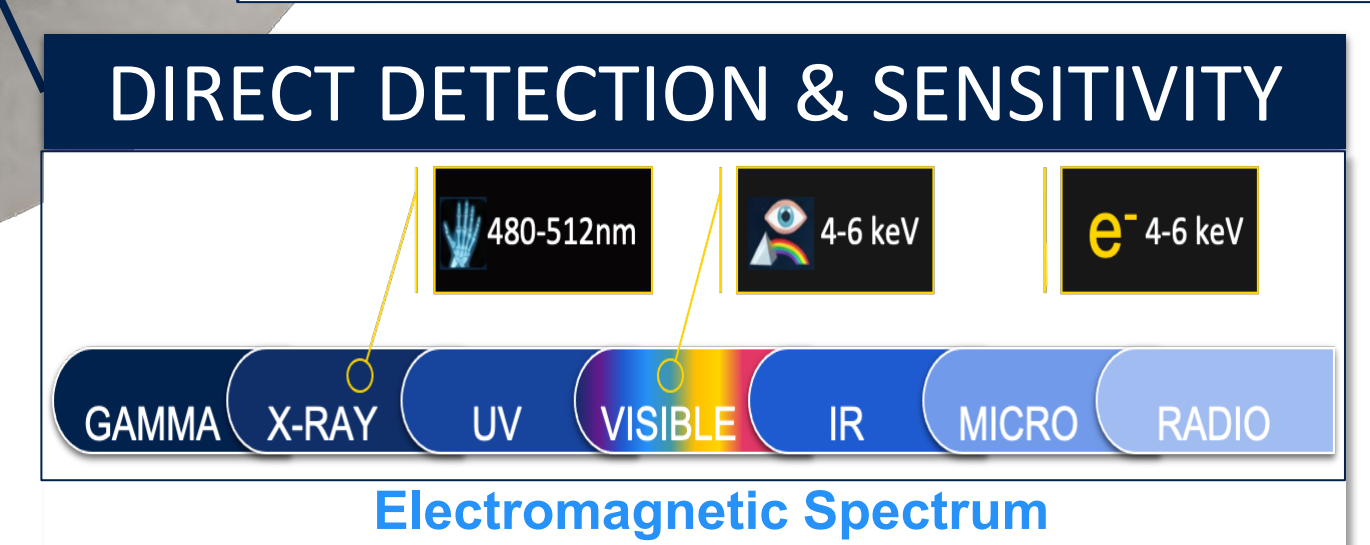
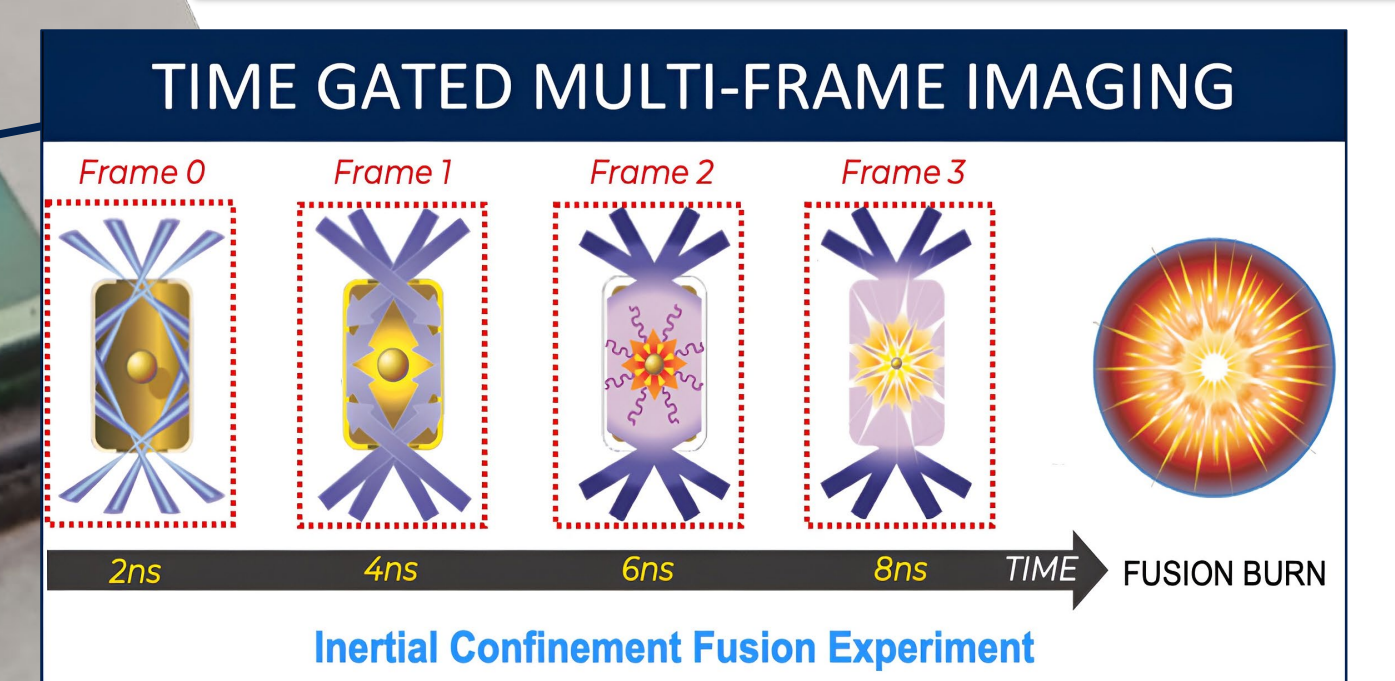
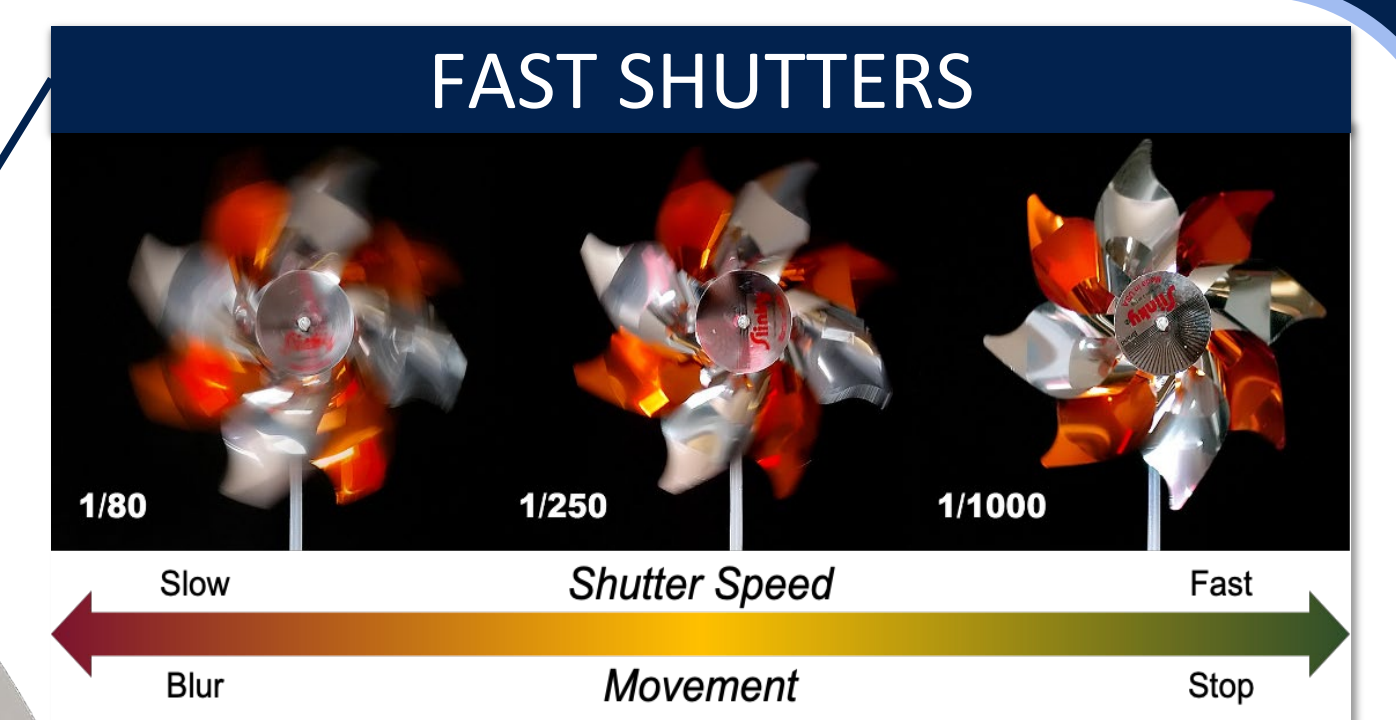
Core Competencies and Focus

- Ultra-high speed sensor design and realization
- Camera systems development
- Radiation hardened integrated circuit design and realization
- Commercialization of hCMOS technology



AHS is establishing a supply chain for ultra-high speed imaging sensors for the fusion community

hCMOS sensors are the worlds fastest burst-mode imaging sensors



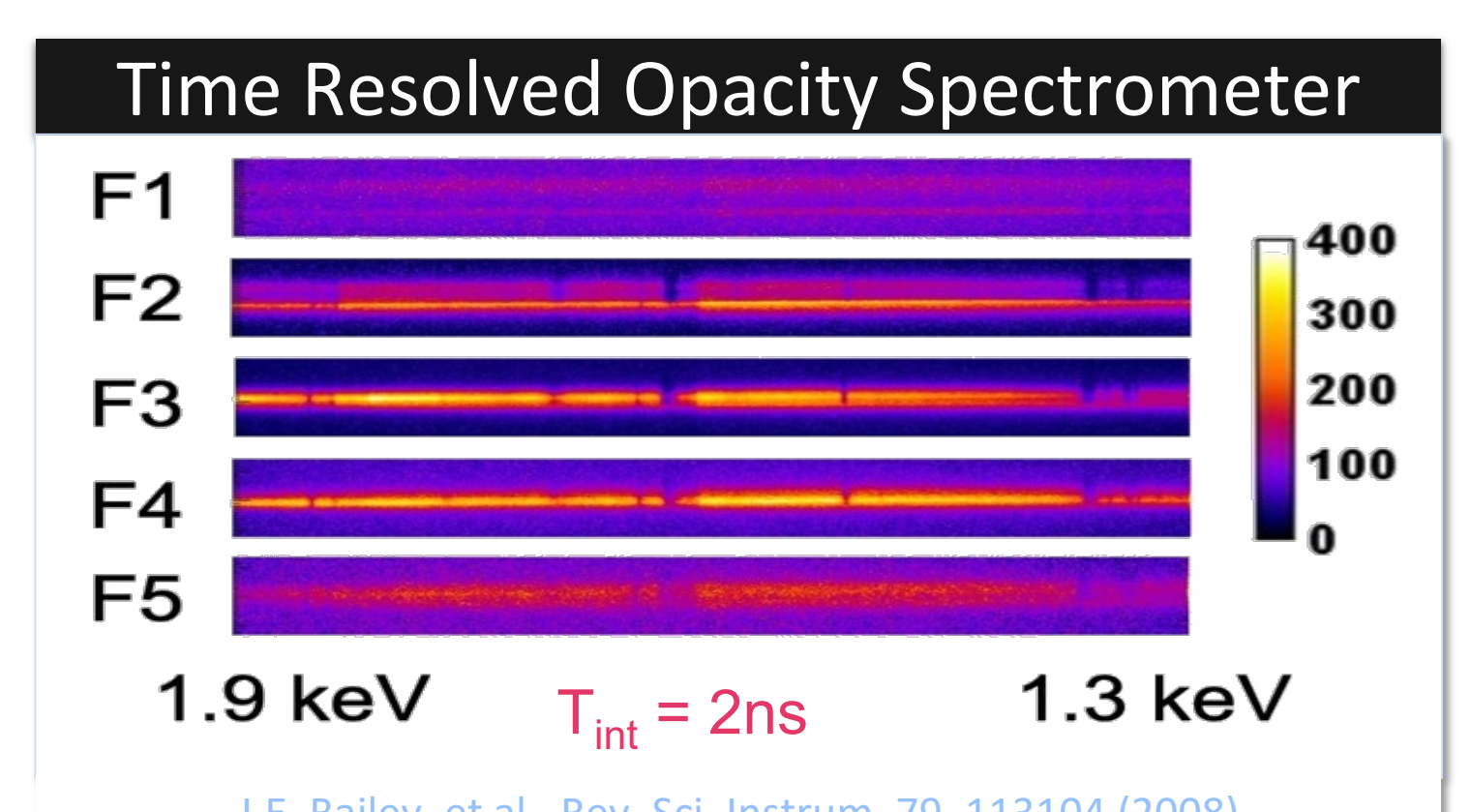
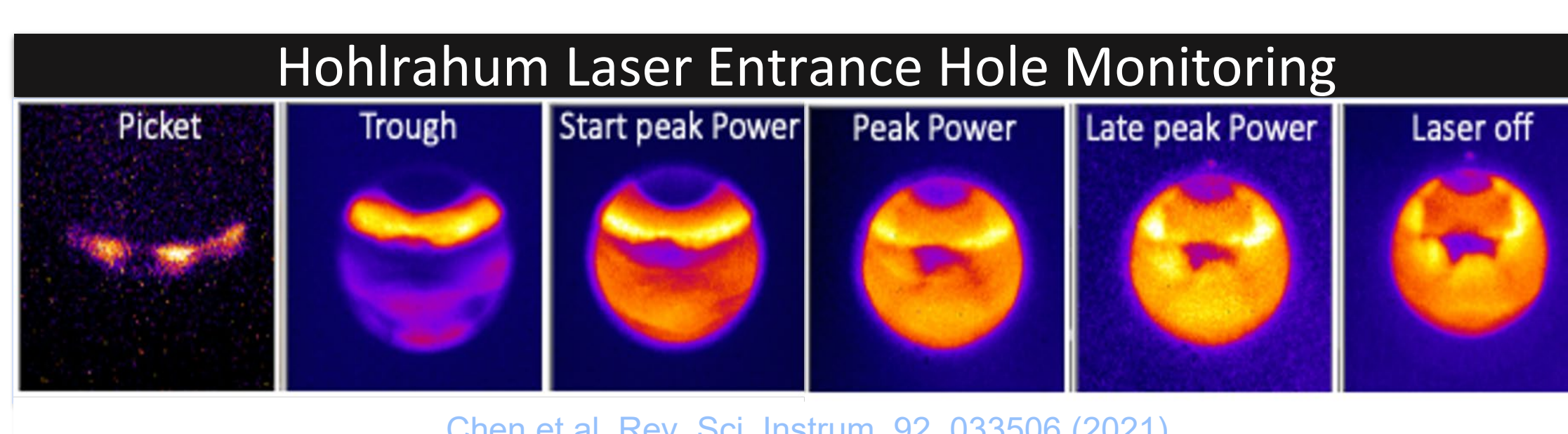
Icarus Sensor

- 4 frames per-pixel
- 500 k e- full well
- 300 e- noise floor
- > 60 dB dynamic range
- 1.5 ns integration time
- 2 ns inter-frame time
- 1024 x 512 pixels @ 25 um pitch

Versatile, solid-state, option for HEDP/fusion diagnostics

hCMOS Diagnostics/Applications

- Time Resolved Spectroscopy
- X-Ray Shadography
- Laser Generated Plasma Dynamics
- Material Shockwave/Void Interaction Physics



Results From Diagnostics Using Icarus Sensor