Automated Experimental Data Analysis at the National Ignition Facility

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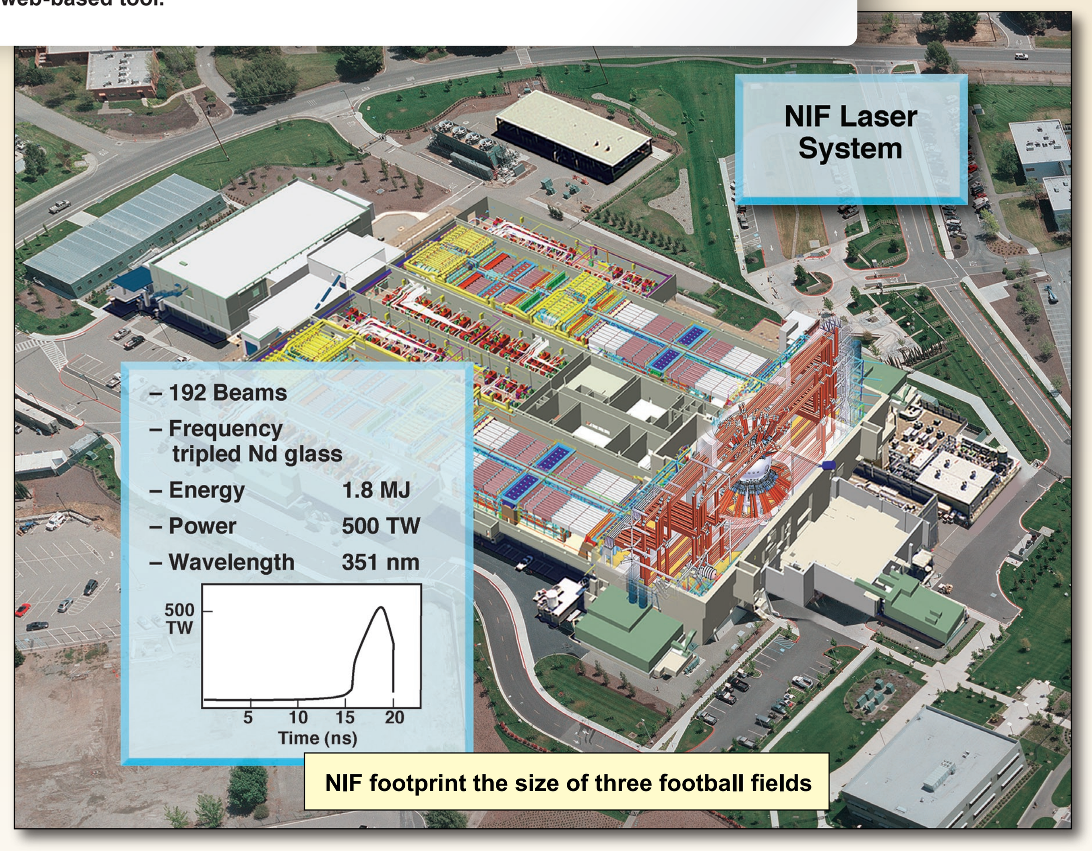
Abstract

The National Ignition Facility (NIF) at the Lawrence Livermore National Laboratory is a 192-beam 1.8 MJ ultraviolet laser system designed to support high-energy-density science, including demonstration of inertial confinement fusion ignition. After each target shot lasting ~20 ns, scientists require data acquisition, analysis and display within 30 minutes from more than 20 specialized high-speed diagnostic instruments. These diagnostics measure critical x-ray, optical and nuclear phenomena during target burn to quantify ignition results and compare to computational models. All diagnostic data (hundreds of Gbytes) are automatically transferred to an Oracle database that triggers the NIF Shot Data Analysis (SDA) Engine, which distributes the signal and image processing tasks to a Linux cluster. The SDA Engine integrates commercial workflow tools and messaging technologies into a scientific software architecture that is highly parallel, scalable, and flexible. Results are archived in the database for scientist approval and display using a web-based tool.



- NIF is a stadium-sized facility containing a 192-beam, 1.8 MJ, 500-TW, 351-nm laser system
- The target is enclosed in a 10-meter diameter target chamber with room for nearly 100 target diagnostics
- Diagnostics acquire many Gbytes of data for each NIF "shot" lasting ~20 ns; typical time between shots is 4 hours
- Shot data and processed results are required within 30 minutes

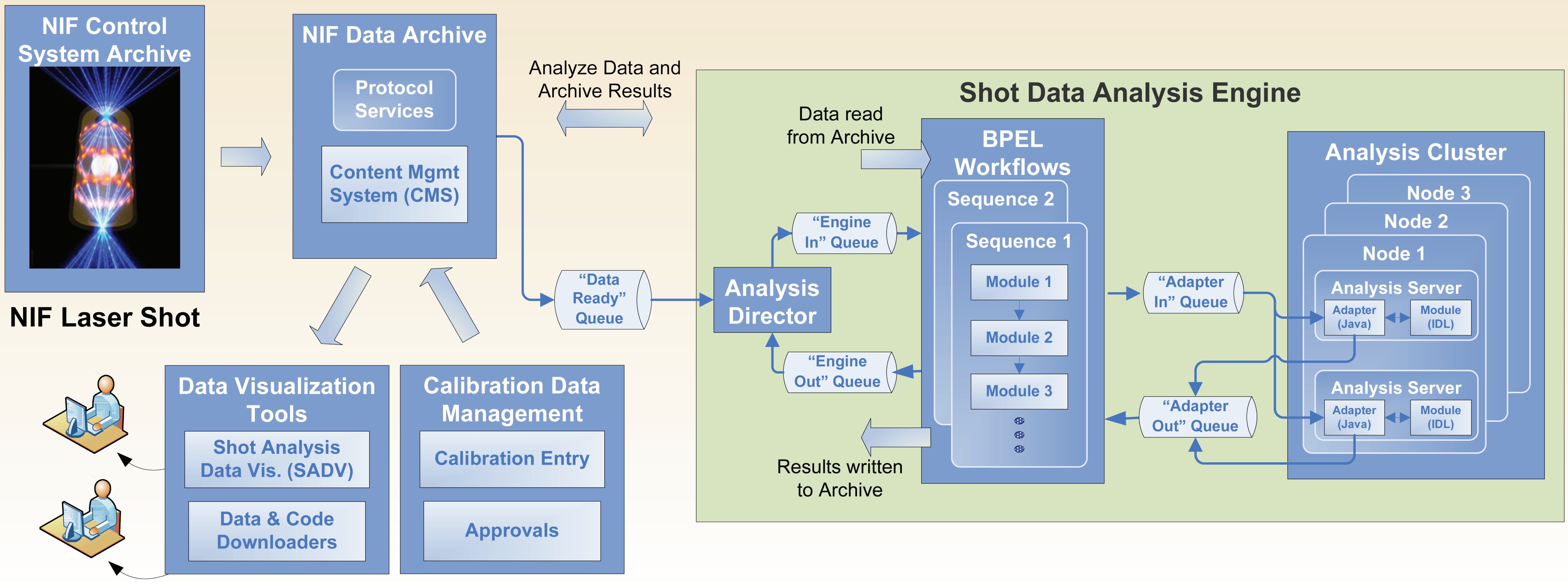
Shot Data Analysis requirements

High-level requirements are that the data must be

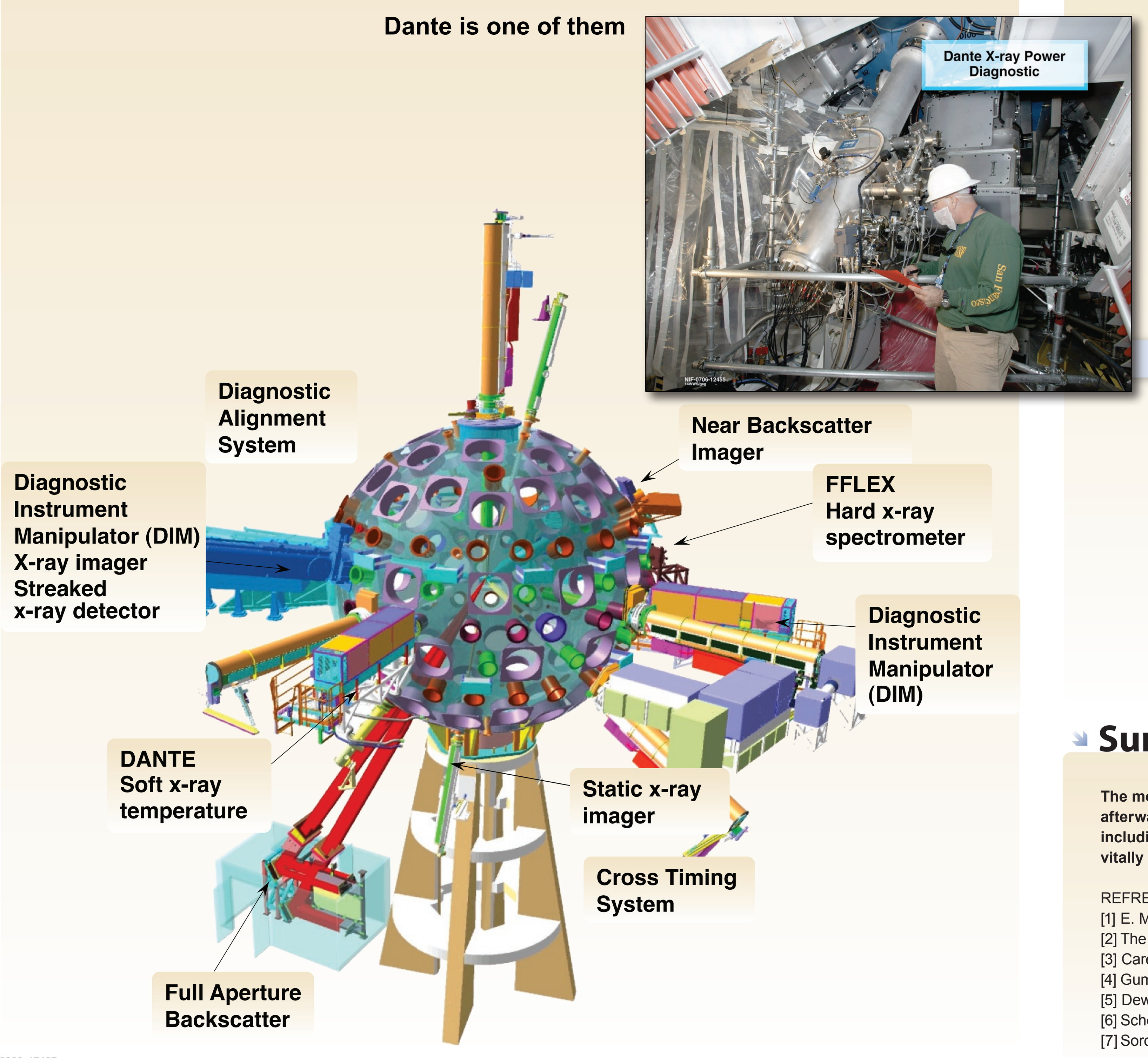
- **Secure –** stored in a safe data repository
- **Accurate –** with error bounds and quality metrics
- **Visible –** to stakeholders, on the NIF web, in ~30 min.
- **Available –** to be downloaded at all processing steps
- **Pedigreed –** with a known history of algorithms, versions, calibration, configuration, raw data, etc.
- **Reviewable –** to be approved by responsible party

To meet these requirements, the SDA software must be published and transparent, with design reviews, revision control and results validation.

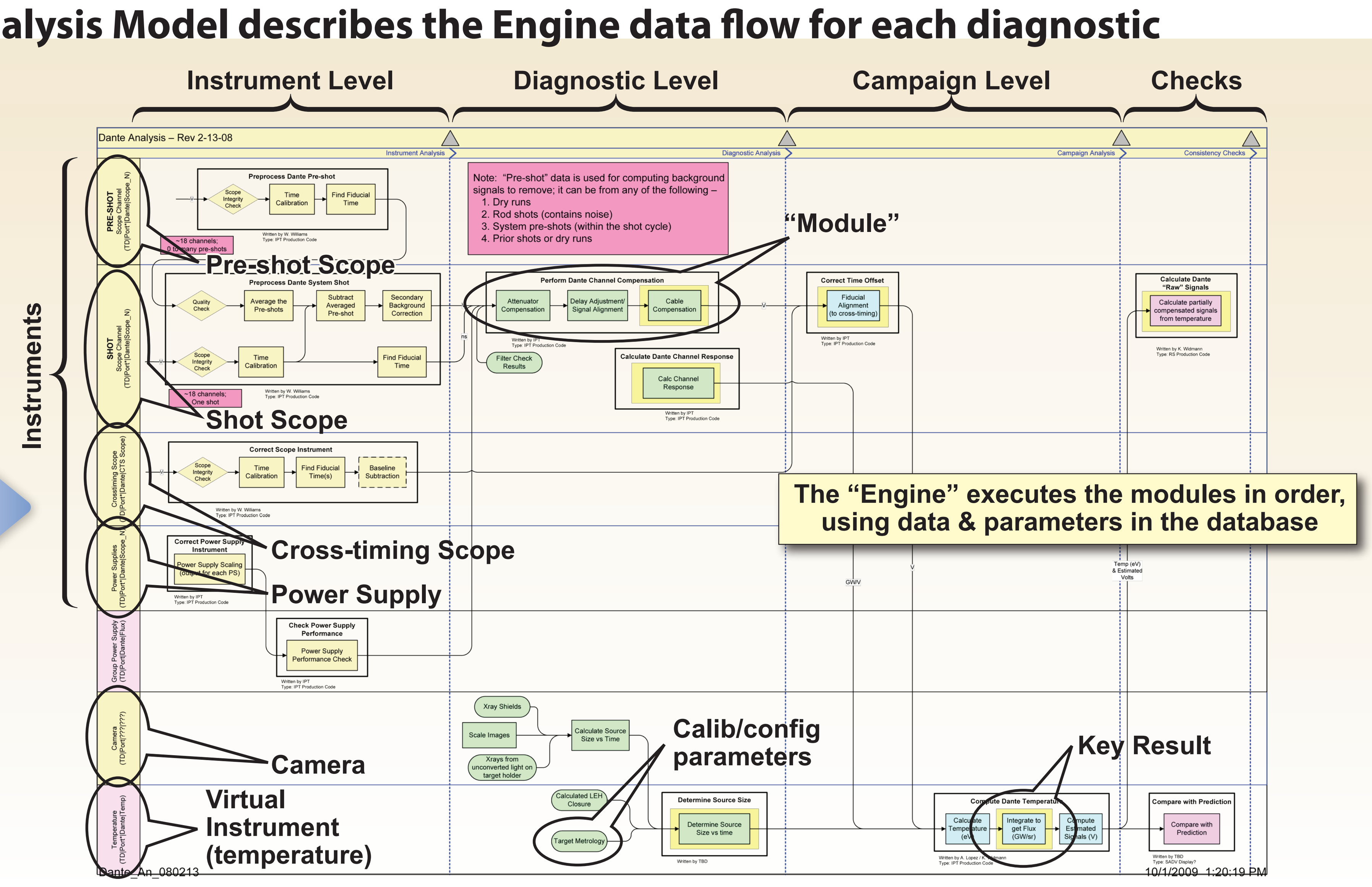
Workflow for Target Diagnostic Data



Over twenty types of diagnostic systems are planned for the National Ignition Campaign



An Analysis Model describes the Engine data flow for each diagnostic



Summary

The most common expected use of this software will be that an experimentalist or the responsible campaign scientist will want to know the results of a NIF shot as soon as possible afterward with the least time delay and the most confidence that the data received is ready for release. In the years to come, however, there will be many more use-cases for the software, including the diagnostic developers, laser scientists and others, so that as NIF evolves into a user facility, the SDA tools are expected to be employed in a variety of different ways. It is vitally important to the future of NIF that all shot-related data be processed and analyzed with a consistent method that is reviewed by scientific and engineering experts.

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NIF National Ignition Facility