An Overview of LLNL's newly developed CT Software package, Livermore Tomography Tools (LTT)

CASIS

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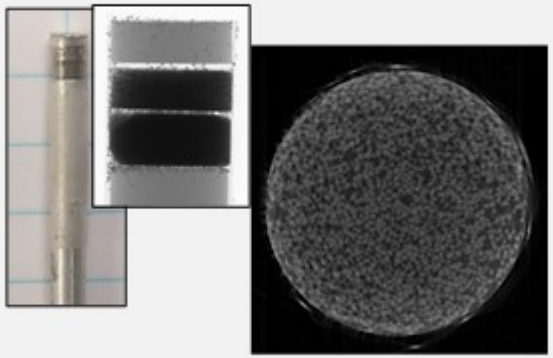
Outline

- Introduction
- Motivation for developing the next-generation CT processing Software
- Livermore Tomography Tools (LTT), LLNL's next-generation CT processing package Project Plan
- LTT design requirements and progress
- LTT Verification
- Summary

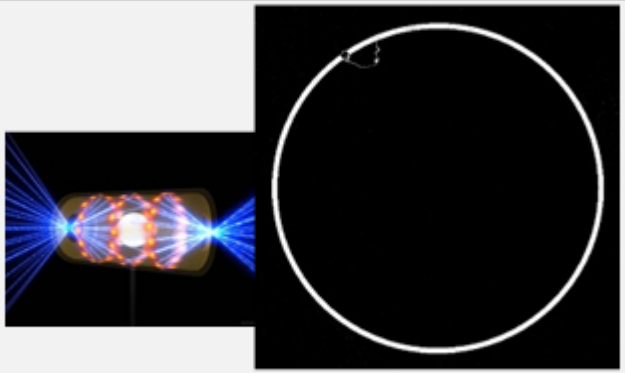
CT is widely used at LLNL for Non-destructive evaluation

Global Security



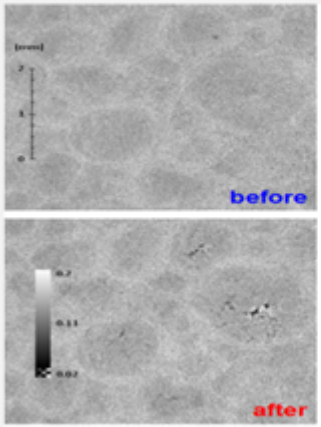
Al\Ni grain distribution & voids in intermetallic pellets. (Courtesy J. Sain)

NIF



Attempts to image aerogel to template DT ice layer in NIF target (Courtesy T. Willey)

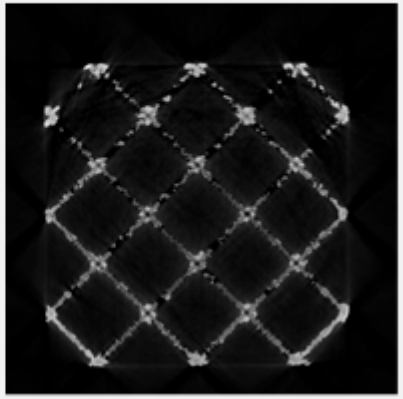
WCI



Microstructure of High Explosives before & after temperature cycling (Courtesy T. Willey)

WCI

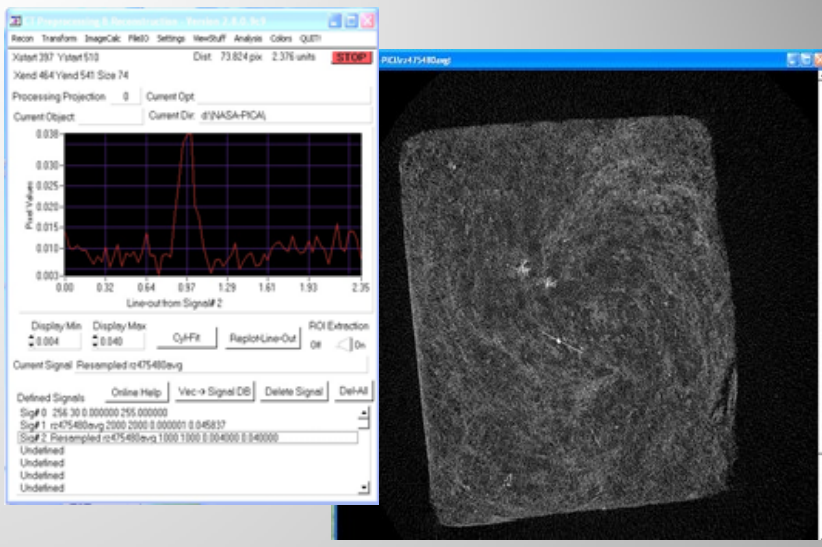
Additive Manufacturing Part (Courtesy C. Divin)



IMGREC is LLNL's trusted CT Processing Code

In use over 20 years

- Compatible with LLNL / NNSA scanners
- Algorithms to process varied data
- Peer- reviewed /published Algorithms
- Quantitatively accurate and resulting in physical units



But no longer meets emerging user requirements

Portability
Not released for MacOS and Linux

Extensibility
Not conducive to modern algorithms\hardware like GPUs

Maintainability
Limited documentation with a one developer team

LLNL requires a next-generation CT processing package

Commercial software packages were considered but it was determined that they do not meet LLNL/NNSA needs

- Incompatible with LLNL/NNSA scanners
- Use proprietary algorithms that are not documented in detail
- Are not quantitatively accurate and in arbitrary units

LLNL is investing an in-house CT software package, Livermore Tomography Tools (LTT)

LTT, LLNL's Next-Generation CT processing Code Project Plan

Systems Engineering approach to development of LTT

- Requirements (FY13)
- Design\development (FY14-FY15)
  - Phase 1: command- line tool for basic pre-processing and analytical reconstruction
  - Phase 2: advanced algorithms and GUI development
- Verification

LTT v0.87 was released in FY14

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Livermore Tomography Tools (LTT) is LLNL's Next-Generation Computed Tomography processing Code

LTT Design Requirements

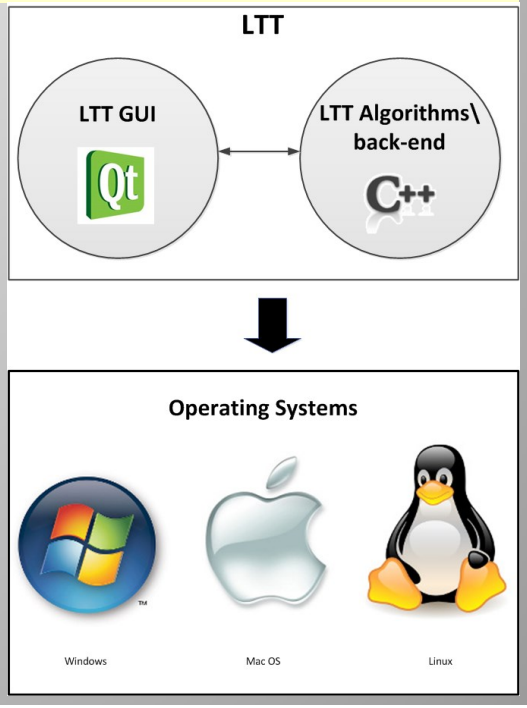
- ***Backwards compatibility with IMGREC***
  Ability to read\write sct parameter file
  Ability to read\write sdt\spr data files

Livermore Tomography Tools (LTT) is LLNL's Next-Generation Computed Tomography processing Code

LTT Design Requirements

- ***Backwards compatibility with IMGREC***

- ***Portability across multiple platforms***
  LTT has been released for Windows and MacOS
  Future LTT releases will include support on Linux



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LTT Design Requirements

- ***Backwards compatibility with IMGREC***
- ***Portability across multiple platforms***
- ***Leveraging modern hardware for Speed***

Leveraging modern hardware for Speed

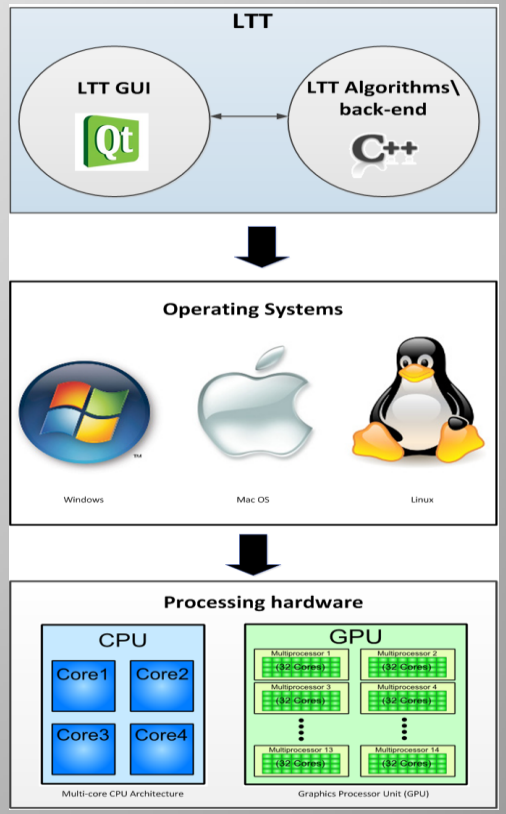
Parallel computing is accomplished while maintaining portability

- Current LTT release utilize Multi – core processor hardware using OpenMP

Upwards of a factor of 5 speed improvement over IMGRECv17

- Future LTT releases utilize GPUs using OpenCL

Expected improved reconstruction time by a factor of 100 over IMGRECv17



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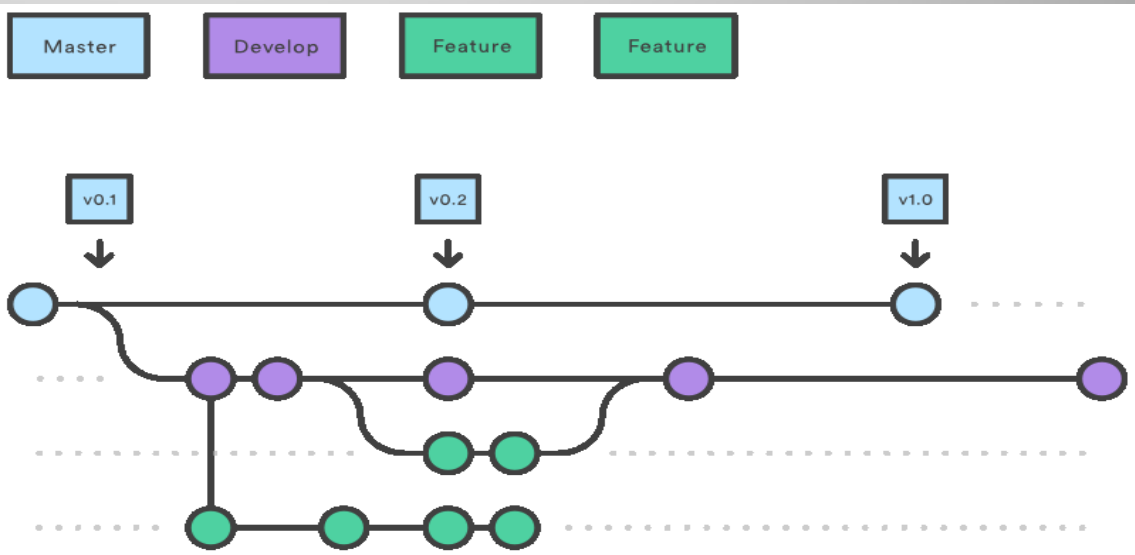
LTT Design Requirements

- ***Backwards compatibility with IMGREC***
- ***Portability across multiple platforms***
- ***Leveraging modern hardware for Speed***
- ***Use software engineering best practices***

LTT uses software engineering best practices

- **Multiple developers for peer review and redundancy**
- **Source Code is in Revision Control (Git)**
  Enables code development by multiple developers
  Code is backed up
  Releases are tagged
- **Issues are logged \tracked using a bug tracker (JIRA)**



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- ***Backwards compatibility with IMGREC***
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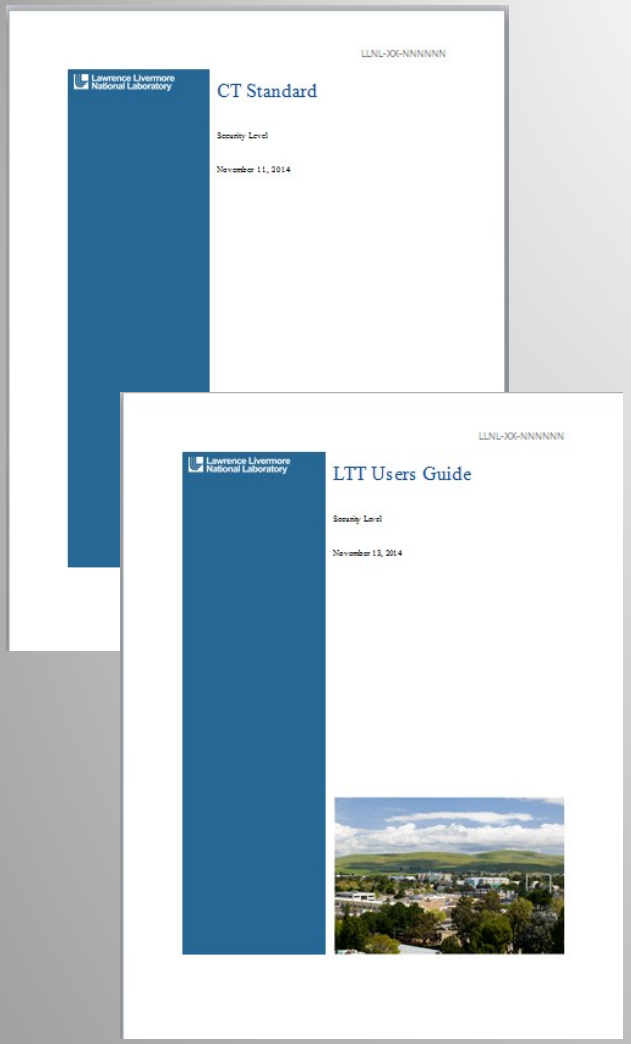
- ***Documentation***

LTT Documentation



- **CT Standards**
  Description of scanner geometry\data processing
- **LTT User's Guide**
  Description of the commands\use procedures.
- **LTT Algorithms**
  Description of implemented algorithms.
- **LTT Software Design**
  Description of software architecture
- **LTT Verification**
  Verification tests and results

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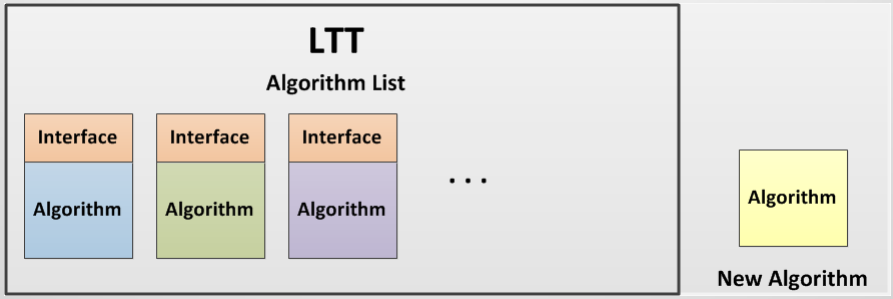
- ***Documentation***
- ***Extendibility to modern algorithms***

Extensibility to modern algorithms

Well-defined and documented algorithm interface

Easy addition of new algorithms



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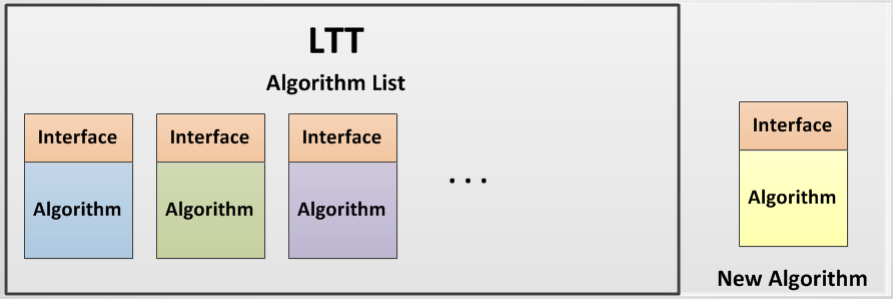

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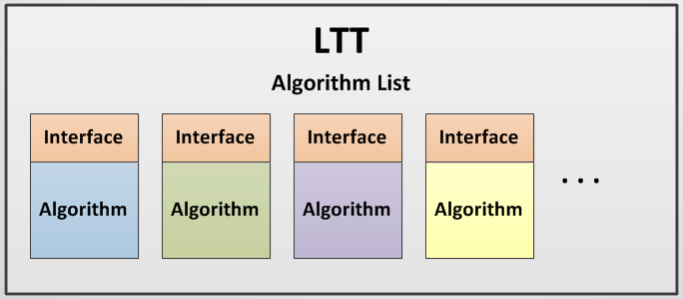

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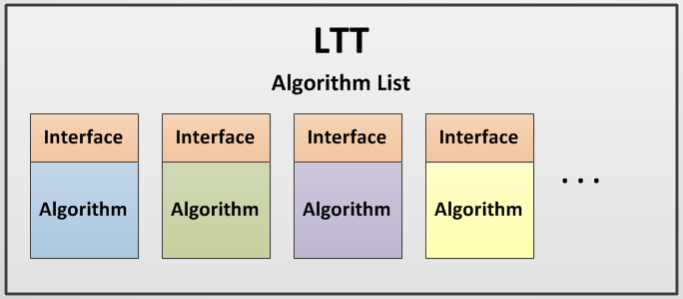
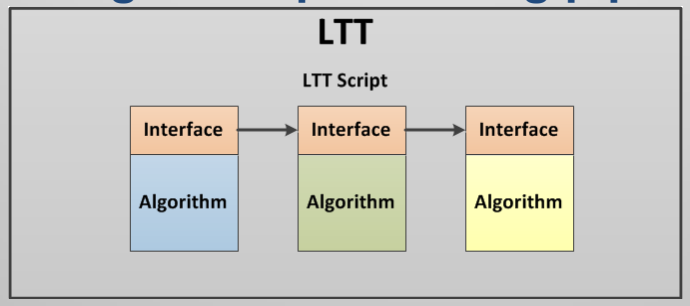


Configurable processing pipeline



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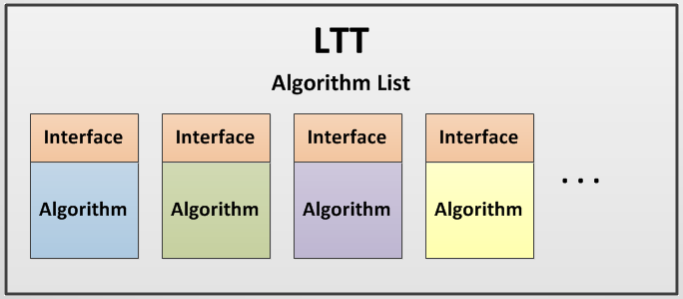

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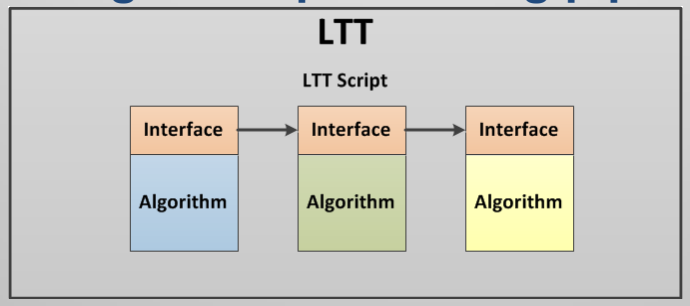

Common Memory Management Infrastructure

- Chunking
- In- place processing
- In – RAM processing

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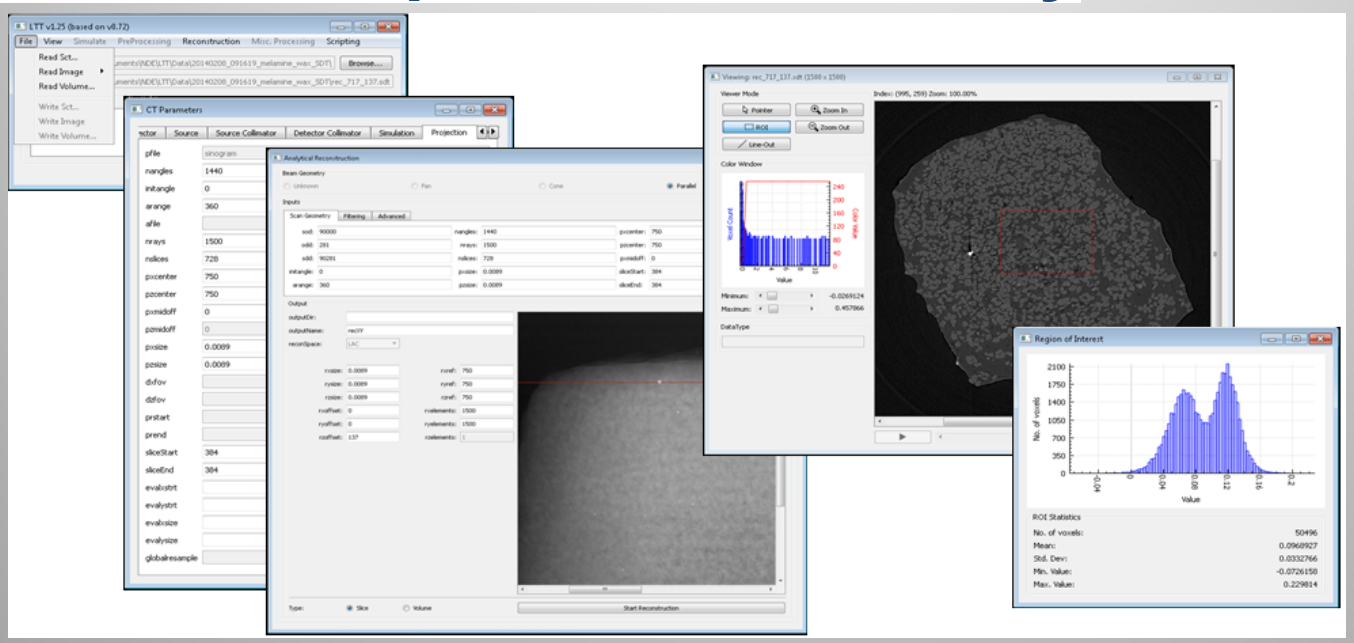
- ***Documentation***
- ***Extendibility to modern algorithms***
- ***Command – line scripting and GUI***

Command line interface : LTT script

- Is a simple text file
- Allows custom processing pipeline
- Used for batch processing

LTT GUI development is underway



Qt GUI is portable to Windows, MacOS and Linux

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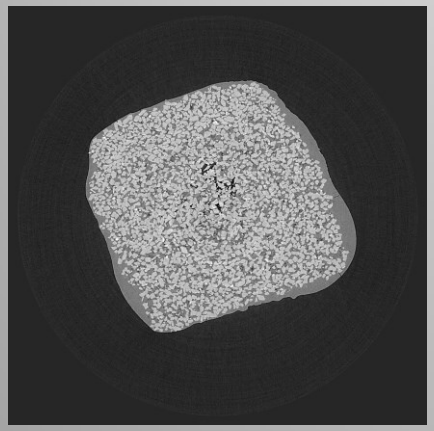
LTT Verification

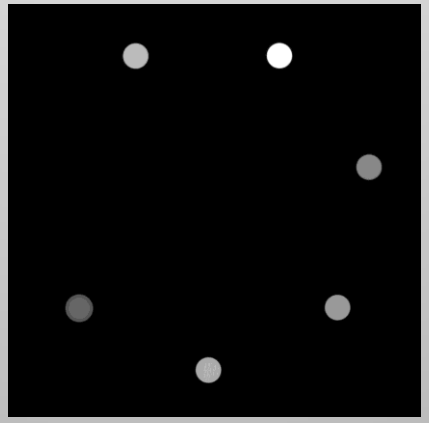
Reconstruction algorithm Verification using simulated data (HADES)

- A simple 2-spheroid (Aluminum \ Graphite) scene was simulated for
  - Various scanner geometries
  - Reconstruction volume definitions
  - Reconstruction algorithm parameters
- Suite of Metrics calculated versus ground truth

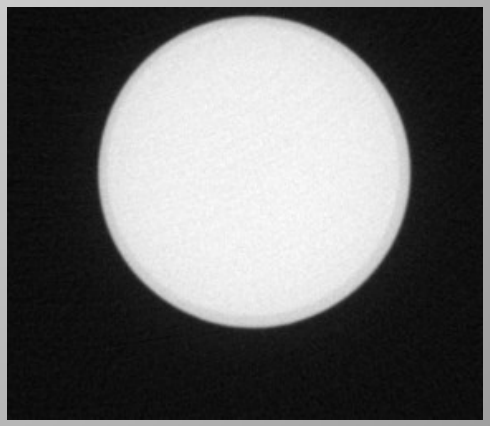
End–to–end Verification using Experimental Data



Melamine Wax part, ALS LBL (Parallel beam)



Reference Materials, Micro CT Test bed (Fan Beam)



Water sample, Micro CT Test bed (cone beam)

Summary

- LTT v0.87 was released
  - used at LLNL by NDE engineers at HEAF
  - Used externally at Tyndall Air force base
- Excellent progress towards upcoming LTT releases.
- On – track to reach proposed goals by the end of FY15.