Path to High-Z on NIF – A Working Group Summary

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Management declared it a priority to execute a High-Z experiment on NIF in FY15

- Five working groups were established on March 8th 2012 to assess technical readiness establish a path forward a High-Z experiment
  - RT-Strength Platform, Ramp EOS Platform, Diffraction Platform, Target Fabrication, and Facility
  - Briefed on current readiness and program needs at a kickoff meeting
- Internal membership included subject matter experts from WCI, NIF, PLS, and Engrg.
- Working groups were chartered to define the outstanding issues and how to overcome them, but not when and how much
  - Platforms groups defined notional target specs and assumed that targets could be built and caught
  - Platform groups defined a shot list with dependencies and gates
  - Infrastructure groups defined a ranked priority list of experiments, development and facilitization efforts
External community was engaged to build consensus plans

- A two day working group meeting was held on May 1\(^{st}\) and 2\(^{nd}\) 2013 to engage the external community
  - Included SME’s from LANL, SNL, AWE, LLE, and other academic institutions

- Purpose was to brief internal plans, amend them with external comment, and get buy-in from the external community
  - Agenda: readiness and program needs briefing, five parallel working group breakout sessions, ending with out briefs of the updated paths forward

- By all accounts the meeting was a success and accomplished its objectives
  - Meeting report is currently being edited and will be available by June 21\(^{st}\), 2013
Assessment of RT strength platform readiness

- Successful platform experience at Omega
- Platform has been able to differentiate between different strength models
- Strength needs to be measured to within 50%
- Limited number of materials investigated (Ta, V, Fe, Al)
- No comparable experience at NIF to date (first TaRT experiments in FY13Q4)
- High confidence in team
High level issues identified for the RT strength platform

- Definition of a design that doesn’t require the use of ARC
- Feasibility and acceptance of the multilayer foam reservoir
- Feasibility of imparting desired ripple pattern on High-Z specimen
- Community buy-in will be established by demonstrating platform on Ta, U, and liquid
## Proposed list of experiments needed to lead to a High-Z RT strength experiment

<table>
<thead>
<tr>
<th>Shot Group ID</th>
<th># of Shots</th>
<th>Purpose / Objective</th>
<th>PE&amp;S Issue</th>
<th>Prerequisite Shots</th>
<th>Success Likelihood</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>Demonstrate the high-P drive - Low density foam behavior (8)</td>
<td>1.a</td>
<td>None</td>
<td>Medium</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>Heat shield performance (4)</td>
<td>1.b</td>
<td>None</td>
<td>Medium</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
<td>Integrated Experiments: - Stacked reservoir (4) - Ta-RT Expts at 5 Mb (8) - Leading shock (4) - Integrated DU-RT (8)</td>
<td>1.a, 1.d</td>
<td>Group 1</td>
<td>Medium</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>17 keV Backlighter Test (2)</td>
<td>2.a</td>
<td>None</td>
<td>High</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>Evaluate performance of catcher</td>
<td>3.b</td>
<td>Group 1</td>
<td>Medium</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>5 Mbar low opacity design: - Low density foil (Al) (2) - Low opacity shield (CHI) (2)</td>
<td>1.a, 2.a, 3.a</td>
<td>None</td>
<td>Medium</td>
</tr>
</tbody>
</table>
Assessment of diffraction platform readiness

- A history of platform improvement and success at Omega (PXRDP)
- A wide range of materials have been investigated (Ta, Sn, Fe, Ta, C, Mo, FeO, MgSiO$_3$)
- Need to be able to identify complex crystal structures
- Stretch goal to determine density
- No experience at NIF (first shots in FY13Q4)
High level issues identified for the diffraction platform

- High-Energy backlighter needed to filter background and maximize number of lines for structure identification
- Forward modeling and robust physics design capability needed
- Direct drive dynamic range and quality is uncertain
- Dependence on initial sample microstructure is uncertain
- Must be able to isolate target diffraction from spurious diffraction
## Proposed list of experiments needed to lead to a High-Z diffraction experiment

<table>
<thead>
<tr>
<th>Shot Group ID</th>
<th># of NIF, OMEGA Shots</th>
<th>Purpose / Objective</th>
<th>PE&amp;S Issues Addressed</th>
<th>Prerequisite Shots</th>
<th>Likelihood of Success</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>TARDIS PQ (Sn, Ta w Ge, Zn probe) Coalignment and cotiming</td>
<td>2.1</td>
<td>None</td>
<td>High</td>
</tr>
<tr>
<td>2</td>
<td>5 + 4</td>
<td>16 keV Diffraction PQ (Ta w Zr probe) SNR, Contrast, λ, Δλ, Δθ</td>
<td>1.1</td>
<td>1</td>
<td>High</td>
</tr>
<tr>
<td>3</td>
<td>10 + 6</td>
<td>Drive PQ (w and w/o Ta) Planarity, Profile, Fidelity, Self-emission</td>
<td>1.2</td>
<td>2</td>
<td>High</td>
</tr>
<tr>
<td>4</td>
<td>10 + 2</td>
<td>Melt/Preheat Detection (Sn or Bi w Zr probe)</td>
<td>1.3</td>
<td>None or 2</td>
<td>High</td>
</tr>
<tr>
<td>5</td>
<td>10 + 6</td>
<td>DU Diffraction (DU w Zr probe) Prototype Repeatability, Classified Ops</td>
<td>3.1</td>
<td>4</td>
<td>High</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>TARDIS as Catcher (Ir or DU)</td>
<td>3.2</td>
<td>3</td>
<td>Medium</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>Preheat Check (High Z w Zr probe)</td>
<td>1.3</td>
<td>5</td>
<td>High</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>High Z Diffraction (High Z w Zr probe) Structure vs Pressure</td>
<td>2.2</td>
<td>6, 7 + Off-line diffraction</td>
<td>High</td>
</tr>
</tbody>
</table>
Assessment of ramp EOS platform readiness

- Omega shots rely on a halfraum while NIF has employed a hohlraum
- Omega data on stiff materials
- Need to be able to measure density to within 5% in a single experiment
- Design simulations are not predictive
- Diamond has failed as an ablator/pusher at NIF
- Platform doesn’t have sufficient documentation history for community acceptance of results
High level issues identified for the Ramp EOS platform

- A forward modeling and robust physics design capability
  - Improve design capability with information from previous shots
- Identify a new ablator/pusher
- Lack of a simultaneous drive measurement
- Understanding of reverberation in thin ablators
- Platform robustness on compressible materials
- Documentation of analysis techniques and error budget
### Proposed list of experiments needed to lead to a High-Z Ramp EOS experiment

<table>
<thead>
<tr>
<th>Shot Group</th>
<th># Shots</th>
<th>Objective</th>
<th>Prereq Shots</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9</td>
<td>Define ablators, optimize pulse shaping</td>
<td>FY13 ablator shots (Al, Cu)</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>Halfraum qualification</td>
<td>None</td>
</tr>
<tr>
<td>3</td>
<td>9</td>
<td>EOS of Stiff Material; Data validation (Ta), X-platform</td>
<td>Groups 1-2</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>EOS of Compressible Material; Data validation (Au, Pt), X-platform</td>
<td>Groups 1-3</td>
</tr>
<tr>
<td>5</td>
<td>9</td>
<td>EOS of Compressible Material with Phase Transition (Pb, Ce)</td>
<td>Groups 1-4</td>
</tr>
<tr>
<td>6</td>
<td>3</td>
<td>Catcher</td>
<td>Group 2</td>
</tr>
<tr>
<td>7</td>
<td>12 (continuing)</td>
<td>HighZ EOS</td>
<td>Groups 1-6</td>
</tr>
<tr>
<td>8</td>
<td>6</td>
<td>EXAFS development (not on critical path)</td>
<td>None</td>
</tr>
</tbody>
</table>
Target Fabrication Status and Plan

- We have never field a High-Z target
- Plan is to use a low-activity 242 isotope material and build targets in 239 contaminated gloveboxes if contamination level is found to be acceptable
- 242 isotope is currently in solution and needs to be converted to metal
- Preferred paths for fabrication identified
  - Polishing and coining Strength targets
  - Polishing (and pressing) a diffraction target
  - Diamond turning a ramp EOS target
- Diamond turning could be potentially used to field every target but we don’t have a High-Z diamond turning capability at LLNL
High Priority Target Fab Experiments

- Determine which targets can and cannot be built with current specs
  - Assess contamination during fabrication of components in existing isotopically contaminated gloveboxes
  - Polish a sample to the best surface finish achievable (goal: better than 0.02 µm $R_A$)
  - Polish and coin a rippled high-Z sample with 0.1 µm amplitude sine waves
  - Diamond turn ripples and/or steps at LANL in a High-Z sample
  - Bring metal winning capability online and demonstrate ability to produce metal
  - Establish methods for counting material pre- and post-shot
  - Purchase remaining 242 material from Oak Ridge

Produce a full up 239 High-Z NIF target in FY14 that meets specs
Facility mostly concerned about pre- and post shot handling

- Chamber Contamination
  - Handling procedures for inserting and removing targets
    - Both High-Z and all shots following first High-Z shot
  - Evaluate impact on optics and diagnostics loops
- Formal High-Z procedures have to be developed
- Development of a catcher is required
- Chamber inventory evaluated by subtracting what was removed from what entered the chamber
Catching

- Catcher necessary to reduce inventory and to reduce impact on long-term operational efficiency and worker exposure potential

- Use of high-purity 242, and limiting target masses yielded a result that >100 shots could be fielded with a minimal design catcher within the safety basis

- Catcher design should initially be specified as a best effort with a plan for continuous improvement
Executive decisions following Working group meeting

- Diffraction and RT strength platforms should be considered for accelerated development
  - Path should feature parallel development on outstanding issues

- Ramp EOS platform is not at a technical readiness level to consider for acceleration
  - Open ended ablator search
  - Simultaneous drive measurement design needed

- High-Z target R&D should begin immediately and identify feasibility by the end of the FY13

- Catcher development must begin immediately
  - Led by NIF with strong experimental group involvement
Executing the plan

- Planning scenarios with one week resolution
- Accelerate strength now

- High-Z shot date: June 2015
  - Schedule based on successes can tolerate a couple of failed experiments and meet September 2015 deadline
Executing the plan

- Planning scenarios with one week resolution
- Accelerate diffraction now

- High-Z shot date: February 2015
  - Schedule based on successes can tolerate a multiple failed experiments and meet September 2015 deadline
## Executing the Plan

- Planning scenarios with one week resolution
- Delay platform selection until the second week in January and script FY14Q1/Q2 shots

### Results in a modest delay of the High-Z diffraction date but not in the RT Strength date

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<tbody>
<tr>
<td>HighZ-L edge</td>
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<td>2</td>
<td>2</td>
<td>2</td>
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<tr>
<td>LD foam Rsvr</td>
<td></td>
<td>2</td>
<td>2</td>
<td>2</td>
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<tr>
<td>5 Mb Rsvr</td>
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<td>2</td>
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<tr>
<td>Full 5 Mb</td>
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<tr>
<td>DU-RT</td>
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<tr>
<td>TaRT ripple</td>
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<td>TaRT drive</td>
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<td>HighZ KB BL</td>
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<td>HighZ 5Mb</td>
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### Diffraction

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<tbody>
<tr>
<td>Drive PQ (Dir Drive, Ta, Pb)</td>
<td>2</td>
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<tr>
<td>16 KeV (Ta)</td>
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<td>2</td>
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<tr>
<td>16 KeV (Pb)</td>
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<tr>
<td>Complex Structure (Pr/Bi)</td>
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<tr>
<td>Complex Structure (DU)</td>
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<tr>
<td>Catcher PQ</td>
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<tr>
<td>Preheat</td>
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<tr>
<td>High Z diffraction</td>
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</table>
Regardless of what platform is chosen there is a multiyear plan to obtain materials properties data from all three platforms

- First RT Strength or Diffraction data in FY15
- First Diffraction or RT Strength data in FY16
- First Ramp EOS data in FY18
- Desire to obtain data by FY18 from all platforms has been stated
- Drives the need to execute 40 shots per year for the next three years and sets budget
Working Group Leadership

Integration – (b)(6)

RT strength Platform – (b)(6)

Diffraction Platform – (b)(6)

Ramp EOS Platform – (b)(6)

Facility – (b)(6)

Target Fabrication – (b)(6)