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Title: IMPULSE Highlights for recent experiments at the Advanced Photon Source (2/9-2/18 2014)

Author(s): Jensen, Brian J.

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IMPULSE Highlights for recent experiments at the Advanced Photon Source (2/9-2/18 2014)

Prepared by: B.J. Jensen

WX-9 Shock and Detonation Physics

Los Alamos National Laboratory, Los Alamos, NM 87545, USA

Distributed to the IMPULSE working group, participants, and collaborators
March 18, 2014

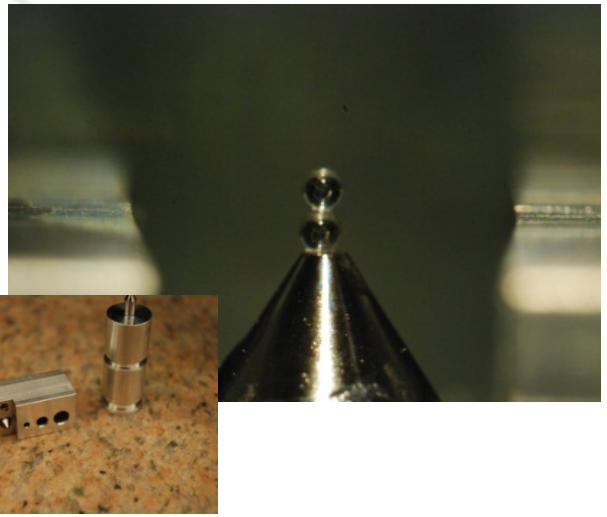
Over 40 experiments were completed during this run using X-ray imaging on the IMPULSE system at Sector 32 IDB

- **Summary of new experiments:**
  - Idealized sphere compaction – Capture progression of dynamic densification through an idealized system on 0.500 mm borosilicate glass spheres **(Slide 1)**
  - Detonator and EBW Imaging Experiments on IMPULSE – First time HE was intentionally detonated at APS **(Slide 2)**
  - Spall and high strain rate crack nucleation/propagation in PMMA – PCI data is providing new and unique insights for model validation **(Slide 3)**
  - Fiber composite for armor applications was studied under ballistic impact of Dyneema (Collaboration with Army Research Laboratory) **(Slide 4)**
- **Summary of on-going experiments;**
  - Crack propagation in vitreous carbon – observed crack motion and caustic
  - Jet formation experiments on large grain cerium to examine phase dependent strength
  - Ballistic impact of Comp-B and TNT to examine thermo-mechanical response in-situ with various penetrator geometries to vary shear concentration
- **Other efforts**
  - IMPULSE system moved and installed in Sector 35 (DCS). This includes the 4-frame X-ray detection system, 4-channel PDV, and other gun diagnostics
  - New remotely operated mobile IMPULSE structure in fabrication – to be delivered to APS in April
  - 4 Mini-VISAR Systems and 4-channel PDV installed in DCS instrumentation room with all associated diagnostics

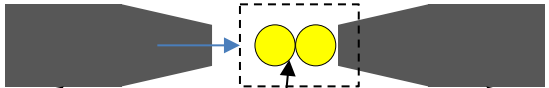
Idealized Compaction: Impact of two 0.5 mm diameter Borosilicate spheres at 0.3 km/s on IMPULSE (Shot # IMP-14-029) imaged using Multi-frame PCI

- Goal: capture progression of dynamic densification through an idealized system on boro-silicate glass spheres for real-time validation of compaction models
- Additional experiments planned using smaller spheres (0.1-0.3 mm) and a variety of materials (BS, Vitreous carbon, etc.)

Image of spheres on Target Anvil



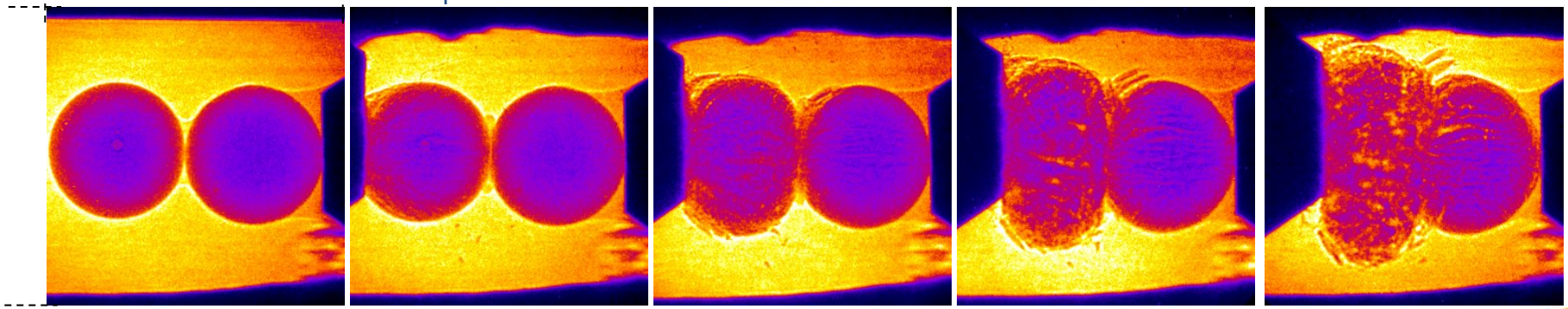
Experiment Configuration



Projectile
Hardened Steel Anvil
Proj. Velocity = 0.3 km/s

0.5-0.6 mm
BS Spheres

Target Hardened Steel Anvil



Static Image | **T = 307 ns** | **T = 767 ns** | **T = 1226 ns** | **T = 1686 ns**

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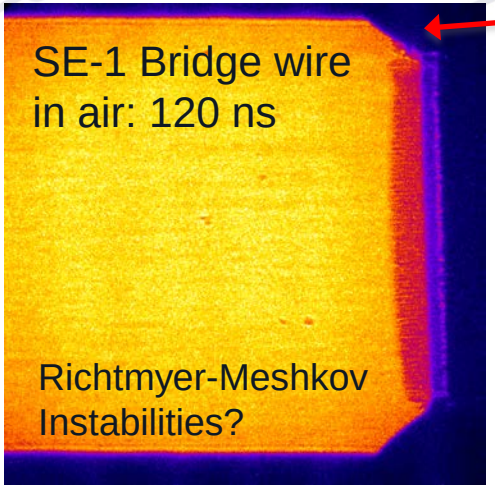
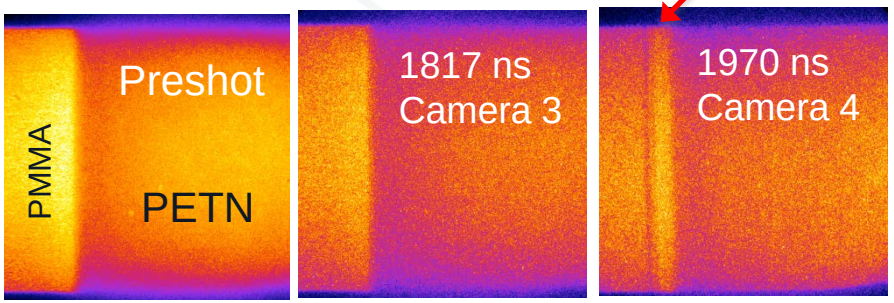
Detonator and EBW Imaging Experiments on IMPULSE – First time HE was intentionally detonated at APS



Solder Post

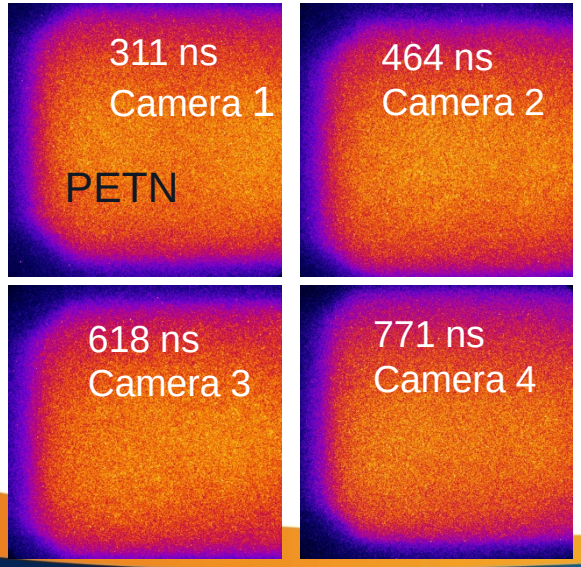
1.4 x 1.4 mm
Field of View

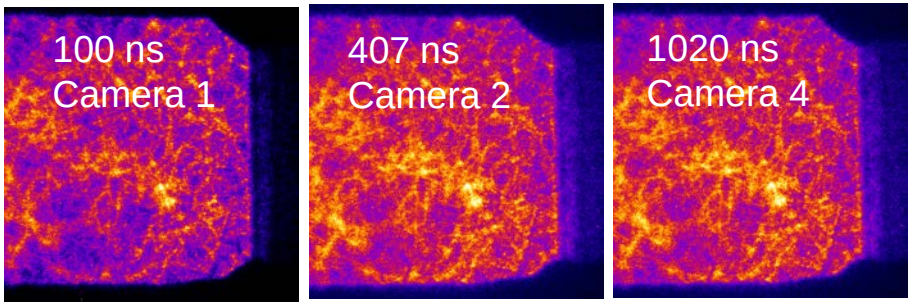
Shock wave seen at the PMMA/PETN interface



Sugar Mock allows for better tracking of interfaces: No compaction wave seen after bridge burst indicating initiation could possibly be due to heating

SE-1: No compaction wave observed early on



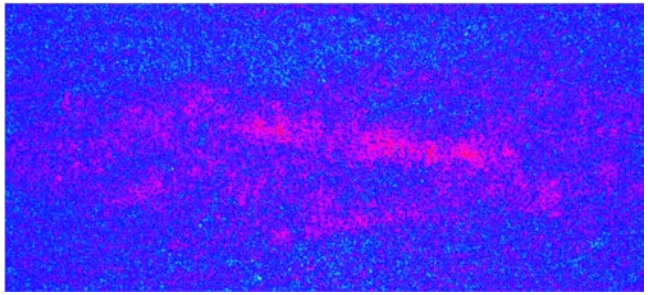


- First time HE was detonated intentionally at APS
- APS synchrotron/fire set & shutters were synchronized successfully
- No compaction wave is observed indicating a heating mechanism leading to initiation could be possible
- Improved experiments planned for June

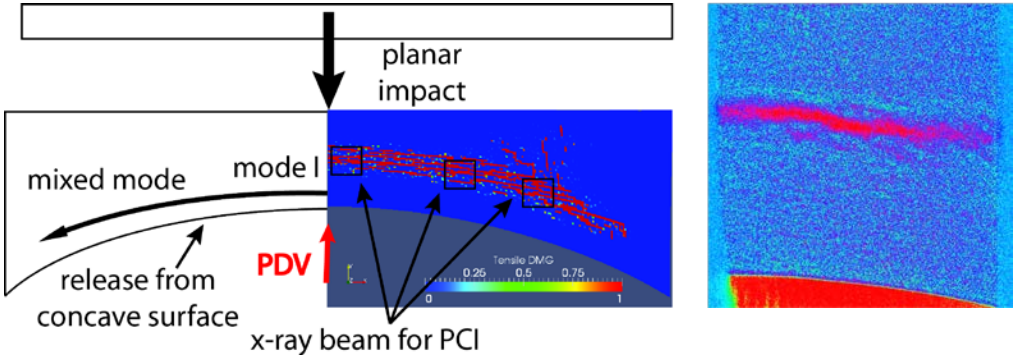
Spall and high strain rate crack nucleation/propagation in PMMA – PCI data is providing new and unique insights for model validation

- Spall and crack nucleation were observed in PMMA with PCI at high strain rates in three separate configurations to support model validation
  - Symmetric impact and release to determine spall strength and threshold for cracking experiments
  - Concave configuration to examine shear dependence (i.e. mode I vs mixed mode)
  - Convex configuration to examine stochasticity and confirm model predictions for velocimetry
- Future experiments will further quantitative comparison of results to model predictions for PMMA and extend studies to other materials such as semicrystalline polymers and hexagon metals

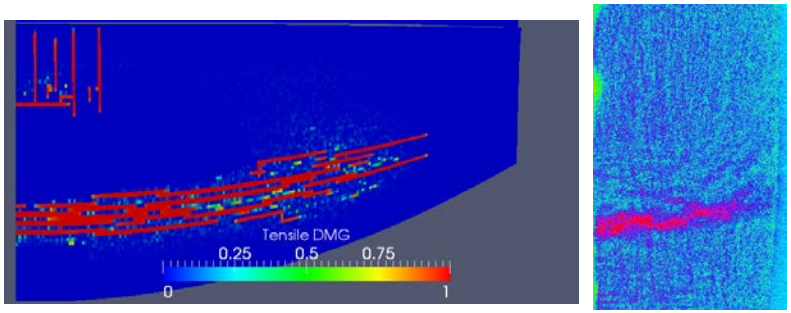
Damage on spall plane



Concave configuration to examine shear dependence of crack dynamics



Convex configuration to examine stochasticity

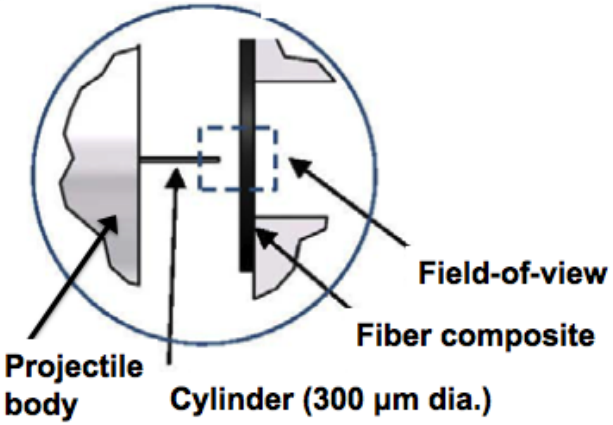


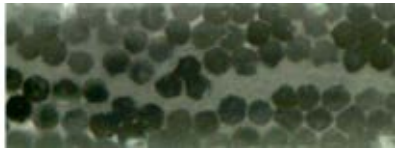
Funding: C2 Polymers
Managers: Dattelbaum and Martineau

Fiber composite for armor applications was studied under ballistic impact of Dyneema (Collaboration with Army Research Laboratory)

- Fiber deformation was observed in composite with PCI during ballistic impact and penetration
  - Cylinder hardness varied using different metals
  - PDV fielded in three orthogonal directions to quantify orthotropic response
- Future experiments will be optomized to further resolve fiber deflection and shear, will use various penetrator geometries to vary shear concentration, and will be used to inform the development of composite material models

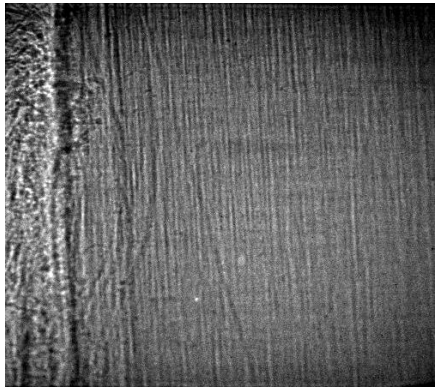
Magnified view of ballistic impact



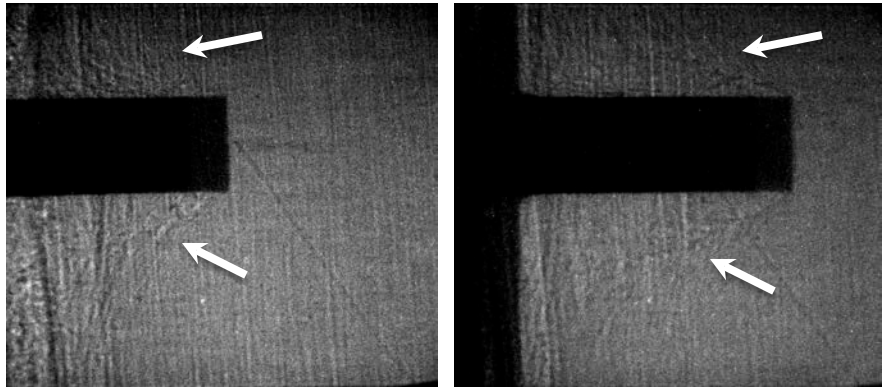


Optical microscopy of orthogonal view

PCI before impact



PCI images revealing fiber deflection and shear



Funding: WFO contract
PI: Zellner (ARL)