Simulation of Cold Spray Using Laser-induced Single Particle Impact

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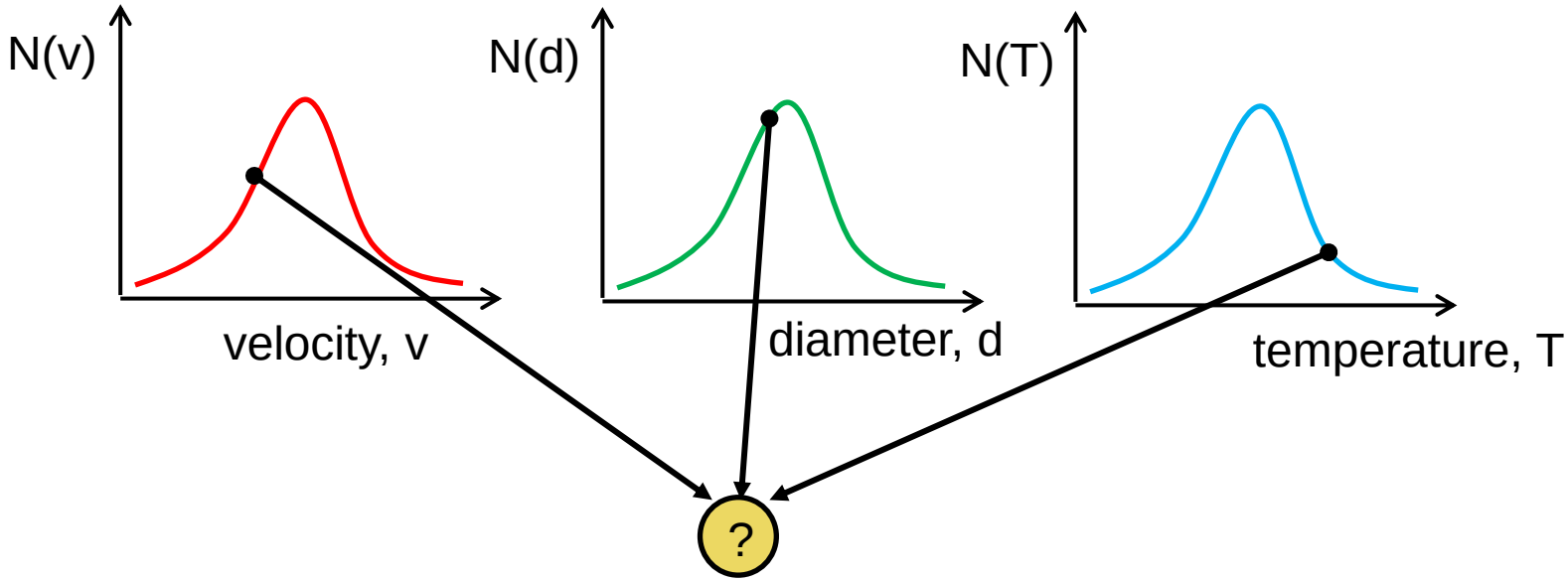
Background & Motivation

Cold spray is a **bulk** process relying on individual **microscopic extreme** deformation events.

Parameters for each microscopic event cannot be accurately identified due to their **statistical combination**.



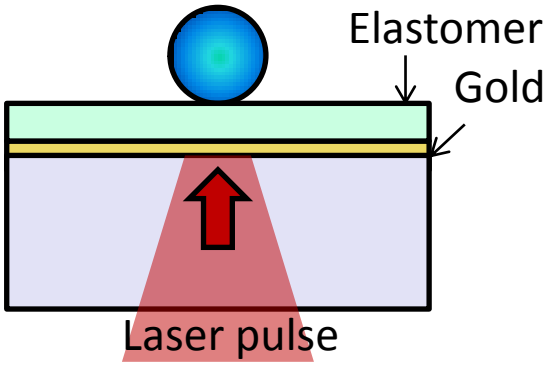
However, computational modeling needs reference experimental results with **precisely** defined parameters.

➔ **Single Particle Impact Experiment**

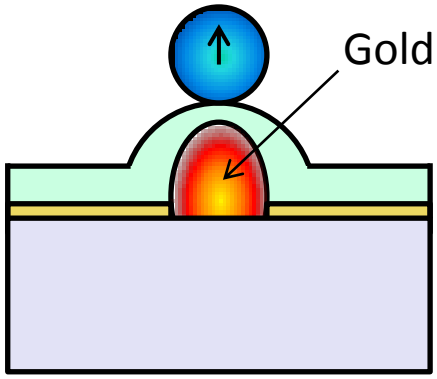
Concept of laser-induced single particle impact test

Acceleration processes

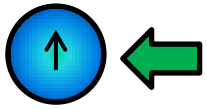
(i) Ablation



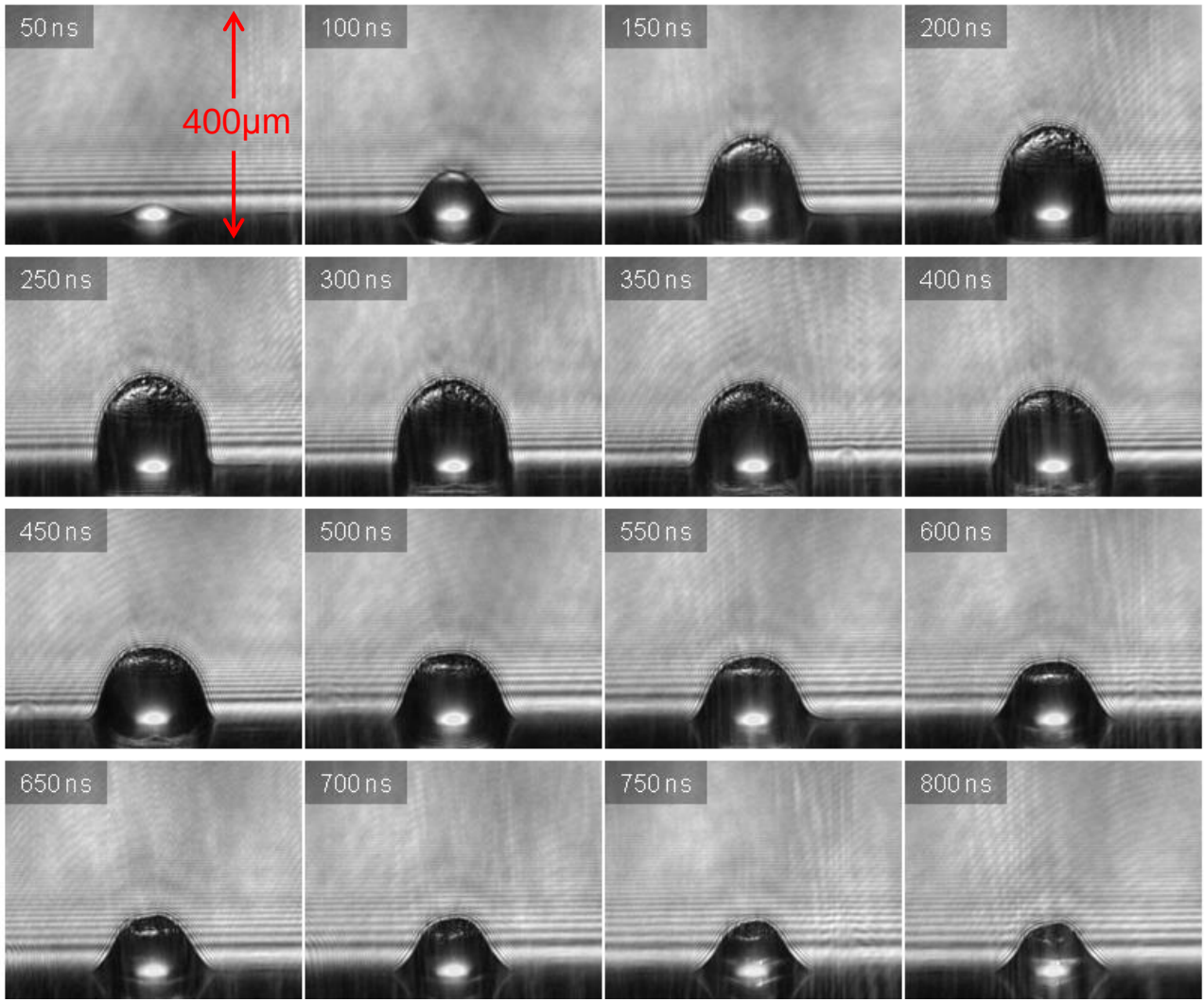
(ii) Acceleration



(iii) Image acquisition



Rapid expansion of an elastomer film by gold ablation

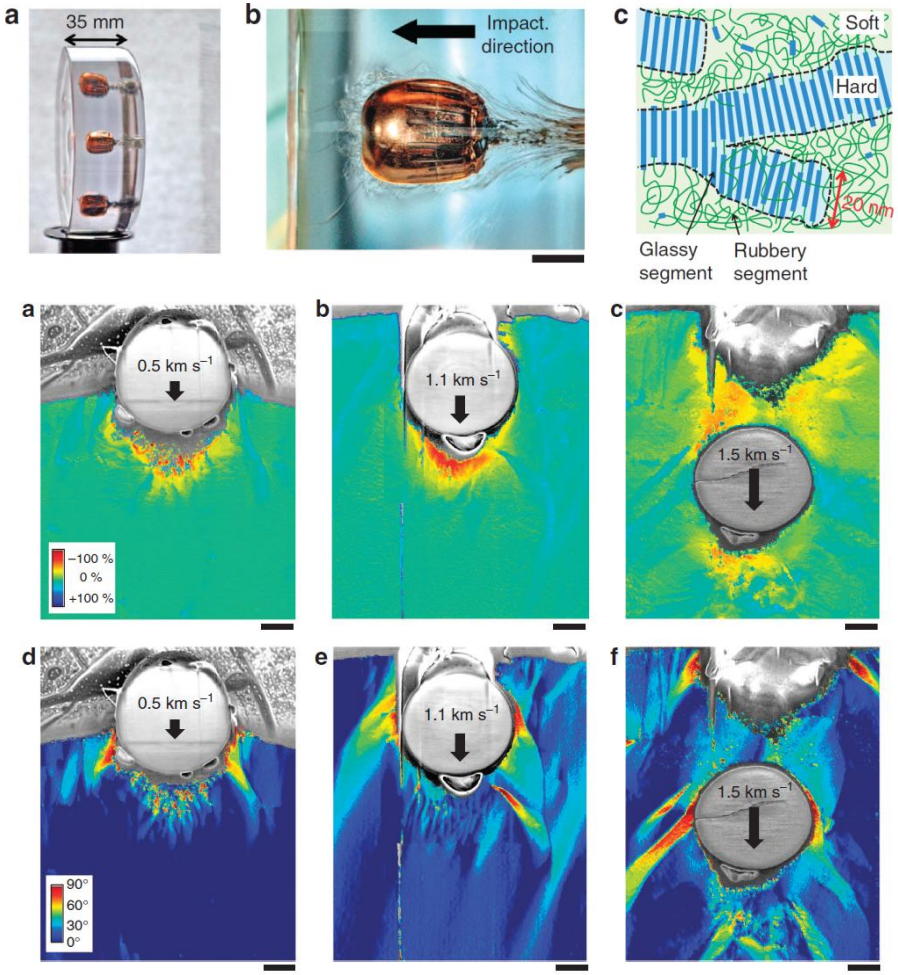


Previous results using the micro-ballistic method

Fundamental mechanism of polyurethane armor

J.-H. Lee et al. *Nature Communications*, **3**, 1164 (2012)

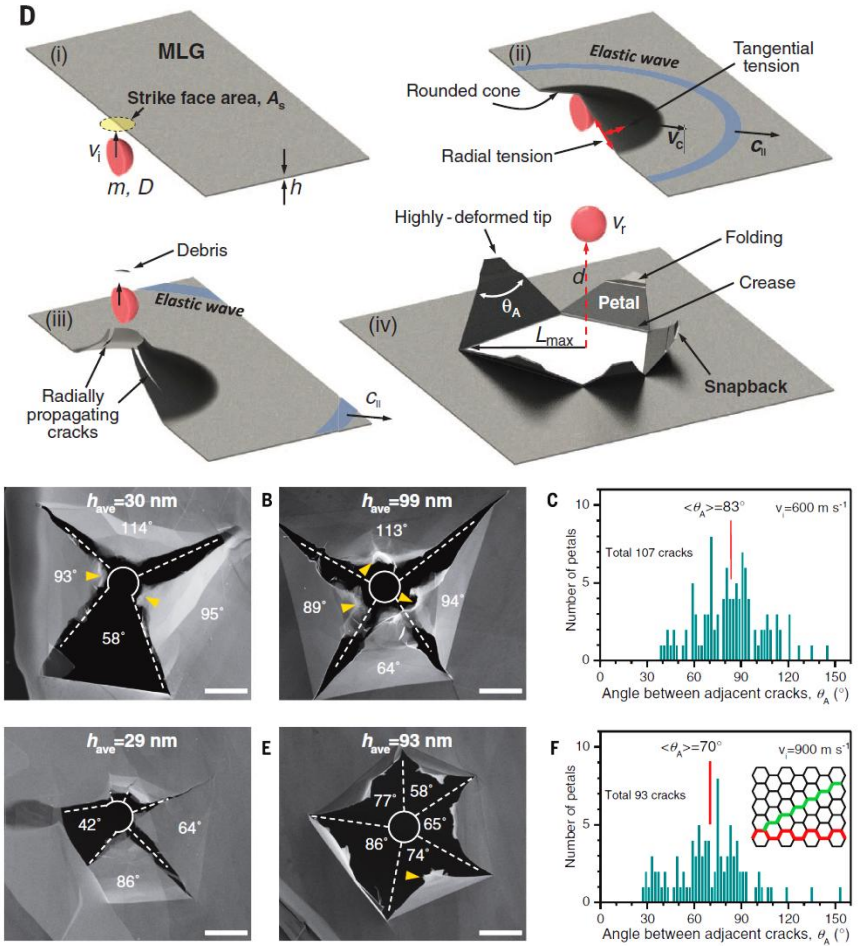
* This research was supported by the **US Army Research Office** under contract W911NF-07-D-0004.



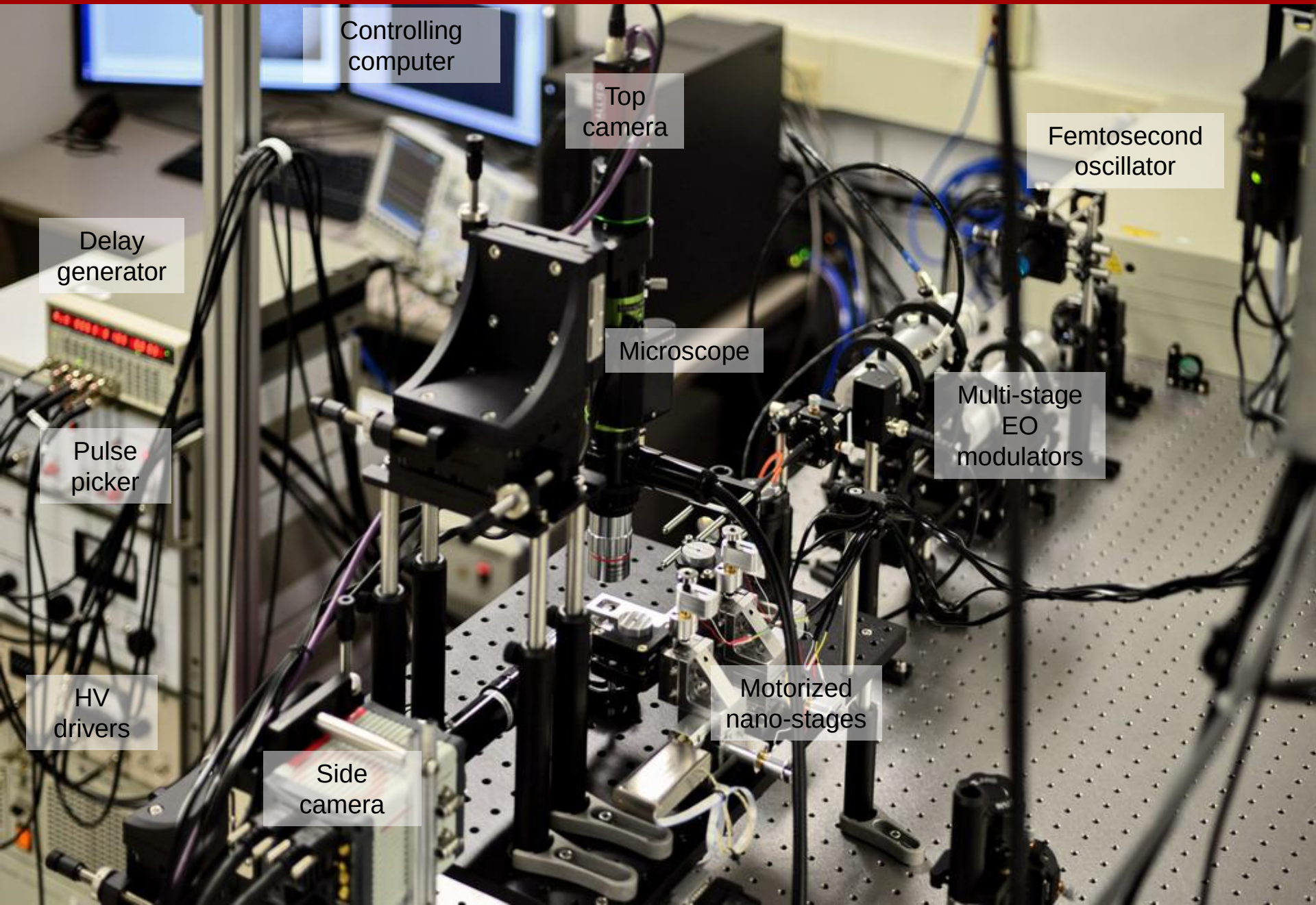
Intrinsic bullet-proof performance of multilayer graphene

J.-H. Lee et al. *Science*, **346**, 1092 (2014)

* This research was funded by the **Defense Threat Reduction Agency** under contract 1-12-10008.



Micro-ballistic system (MBS) at UMass



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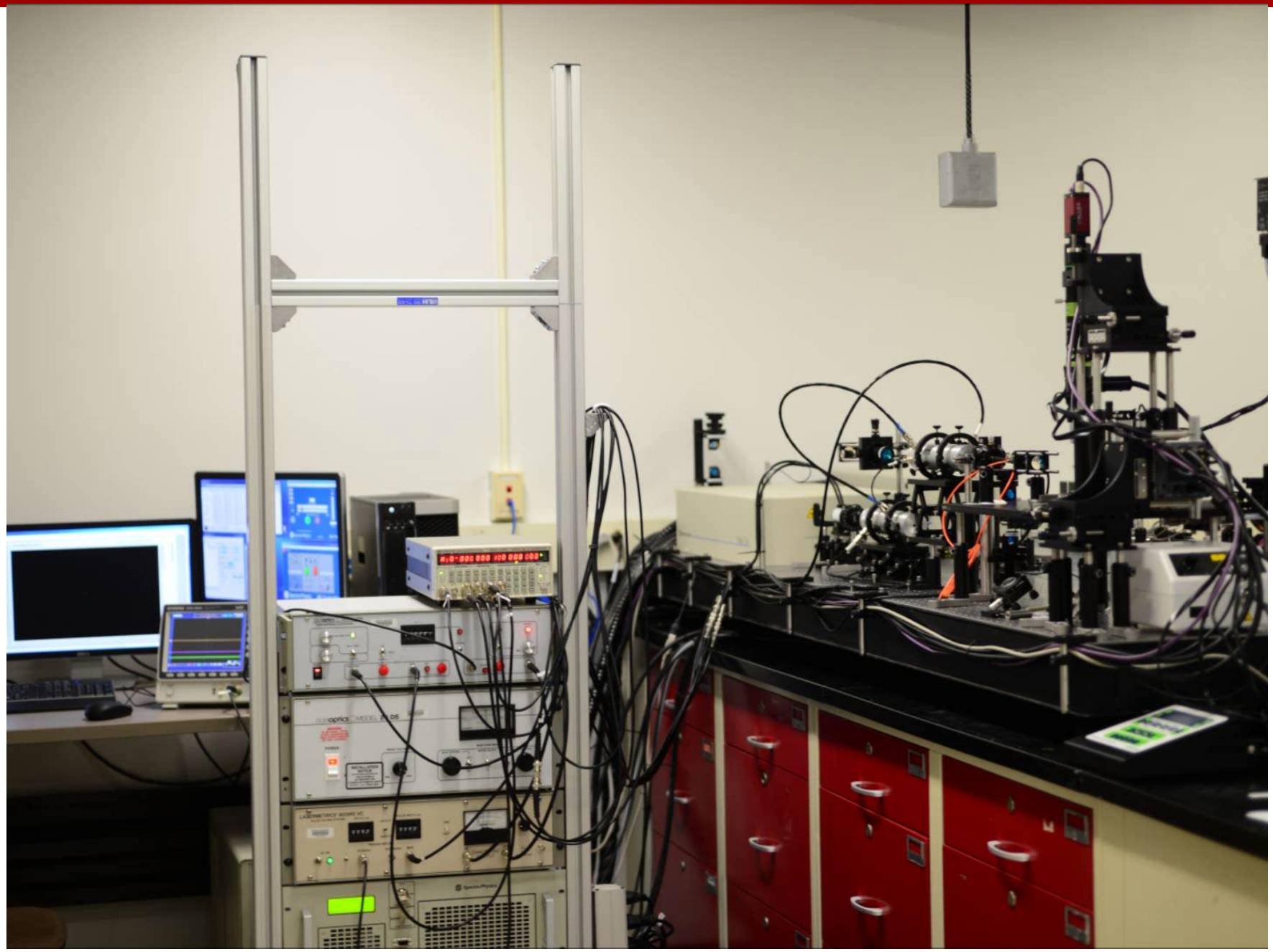
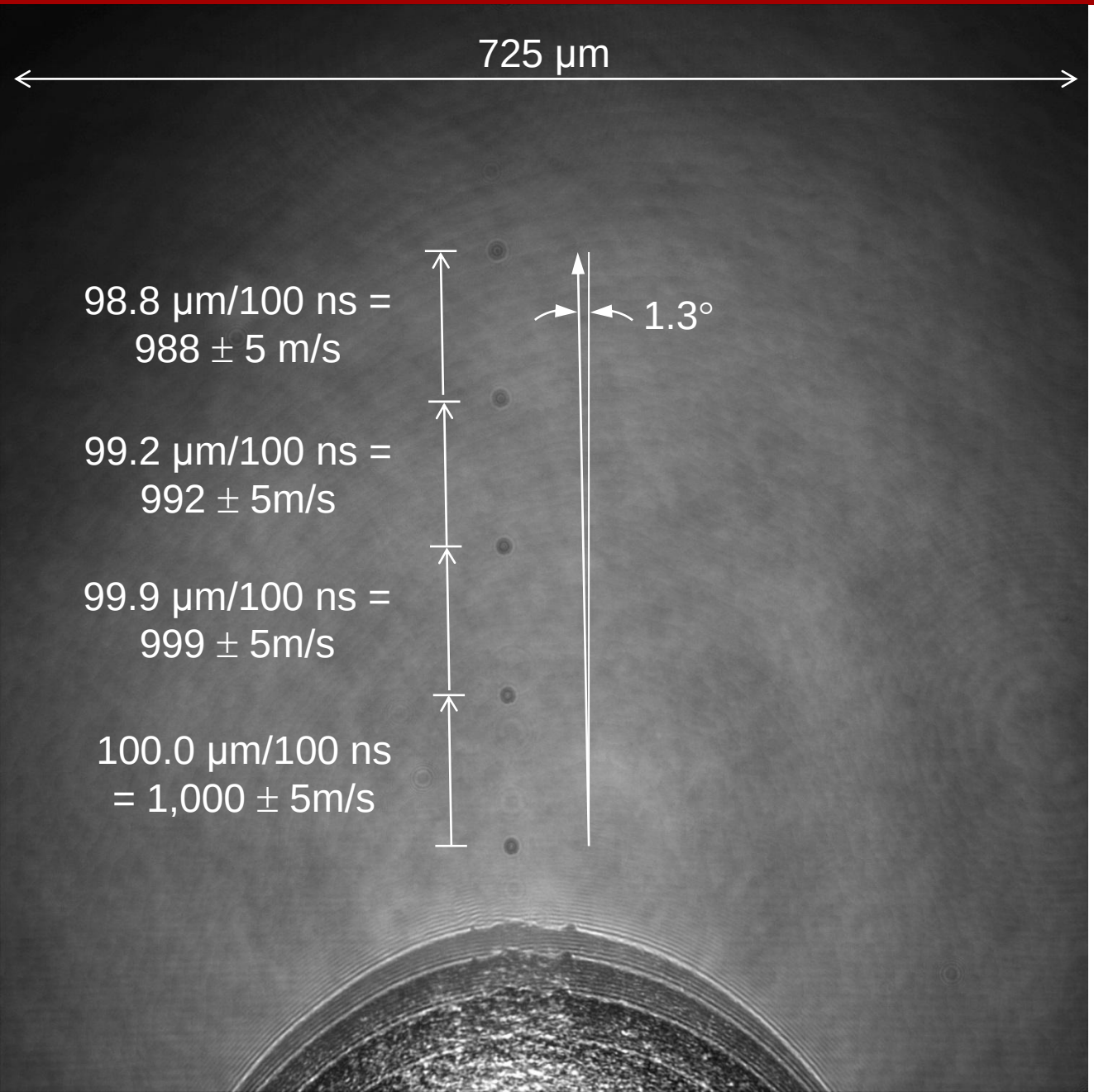


Capability of the UMass micro-ballistic system



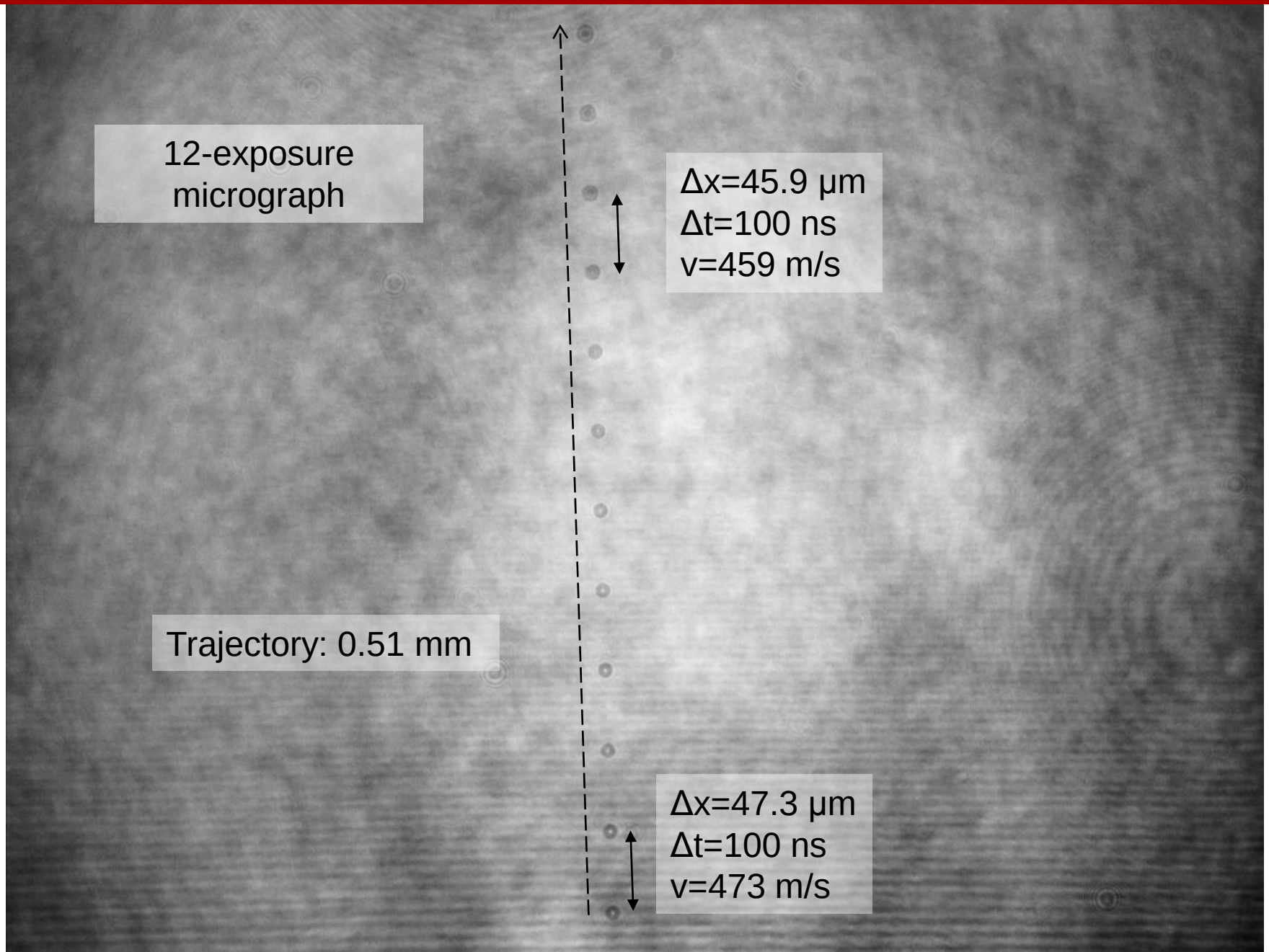
Exposure time < 100 fs

➔ Image drift =
1 km/s x100 fs = 0.1nm

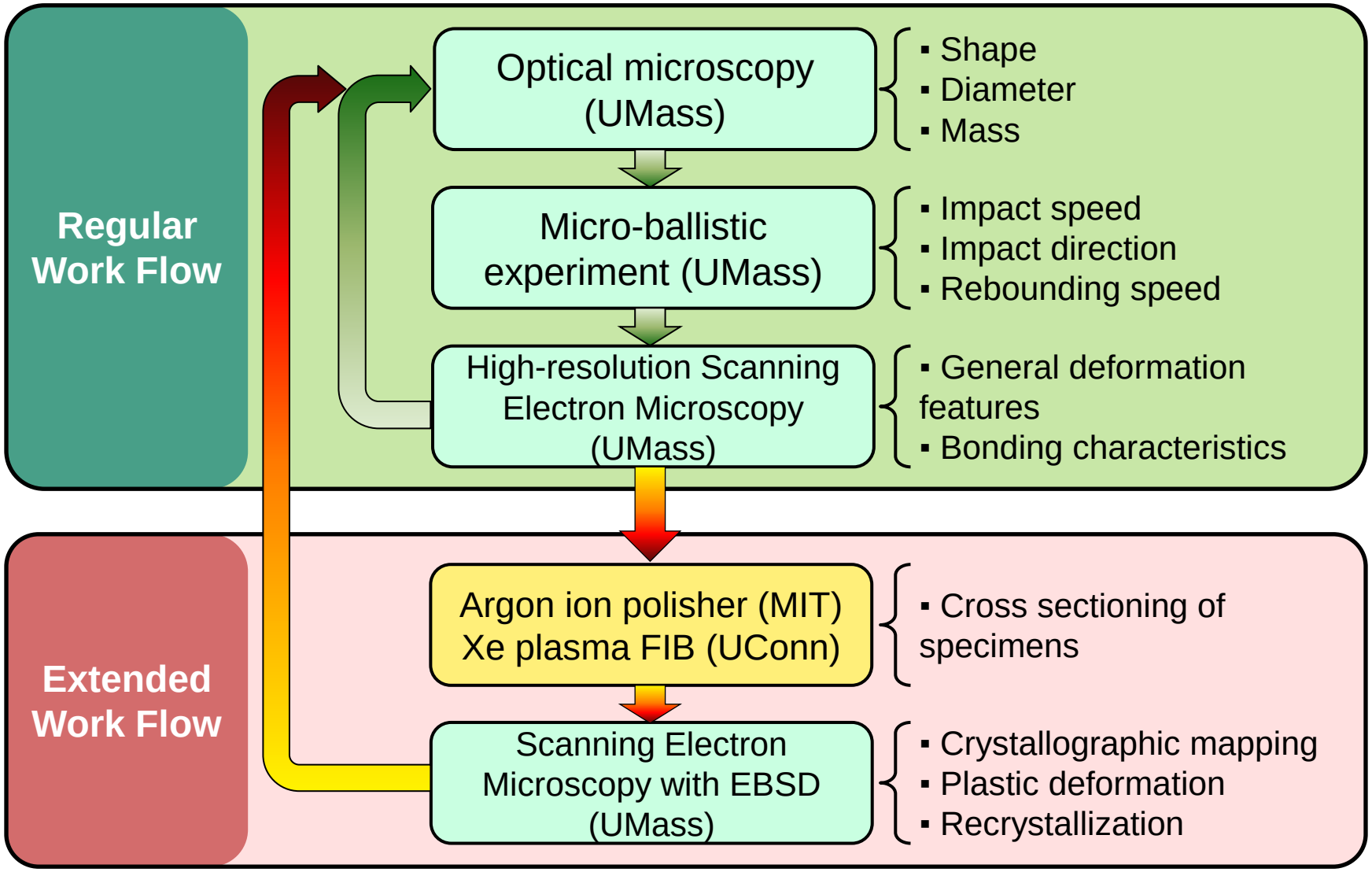
Variable time gap
between exposures

12.5 ns – 1 ms

Capability of the UMass micro-ballistic system



Plan for the experimental work flow



Plan for the overall work flow

Annealed aluminum 6061 alloy particles (UTRC)

Micro-ballistic experiment (UMass)

FIB cross section (U Conn/MIT)

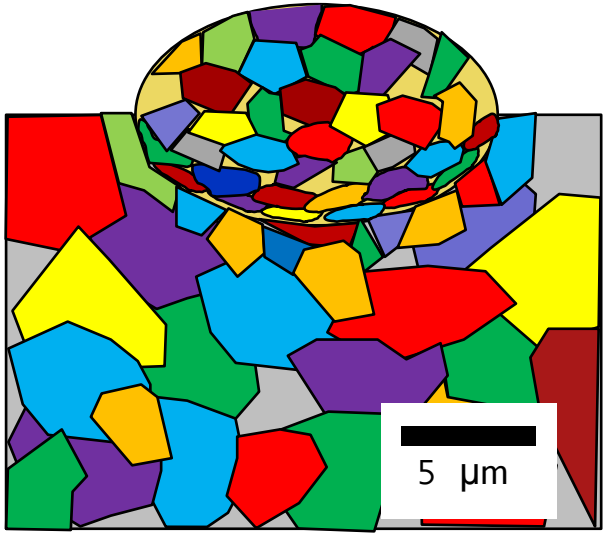
Characterization SEM/TEM/EBSD (UMass)

Experimental parameters d, v, T, etc.

Computational Simulation Groups

Deformation map
Temperature history
Local interface issues
Oxide fracture
Melting/recrystallization

Cross sectional SEM with EBSD



Parameters =========
Initial diameter: 25.4μm
Initial mass: 2.53μg
Impact speed: 745m/s
Impact direction: 88.7°
Temperature 300K

Thank you