Caltech's MSC Center for the Predictive Modeling and Simulation of High-Energy Density Dynamic Response of Materials

Michael Ortiz

PI Meeting

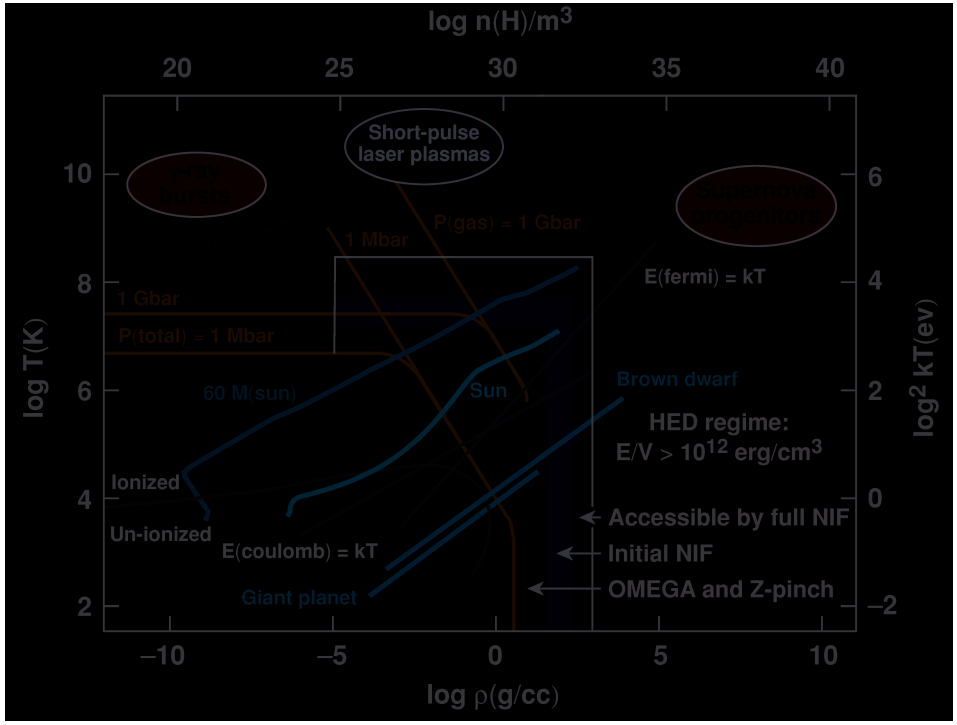
Las Vegas, February 9, 2010

Suggested presentation plan…

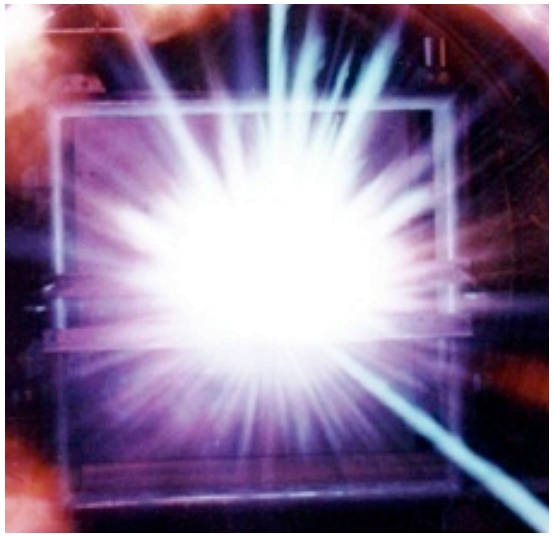
- Each of the 8 Centers will have 20 minutes. Each will give a 15 min talk (about 8 slides) and take 5 min of questions
- The 5 PSAAP Centers will briefly overview:
  - their end-end application (1 slide),
  - the key year 5 experiment they plan to predict,
  - outline their Validation and UQ methodologies
  - and accomplishments to date.
  - Stanford and Caltech should have a slide outlining their ASAP accomplishments and legacies also.

End-to-end overarching application

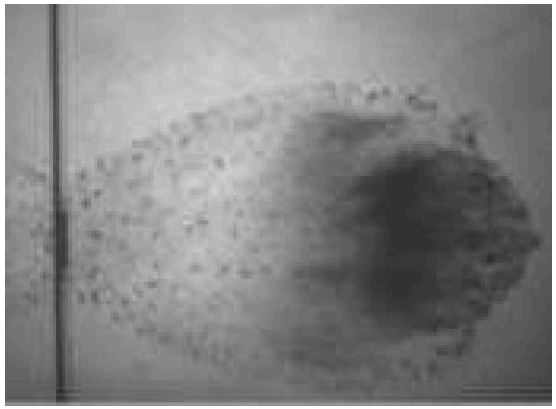
- Objective: Predict *hypervelocity impact* phenomena with *quantified margins and uncertainties*



Hypervelocity impact test bumper shield (Ernst-Mach Institut, Freiburg Germany)



NASA Ames Research Center
Energy flash from hypervelocity test at 7.9 Km/s

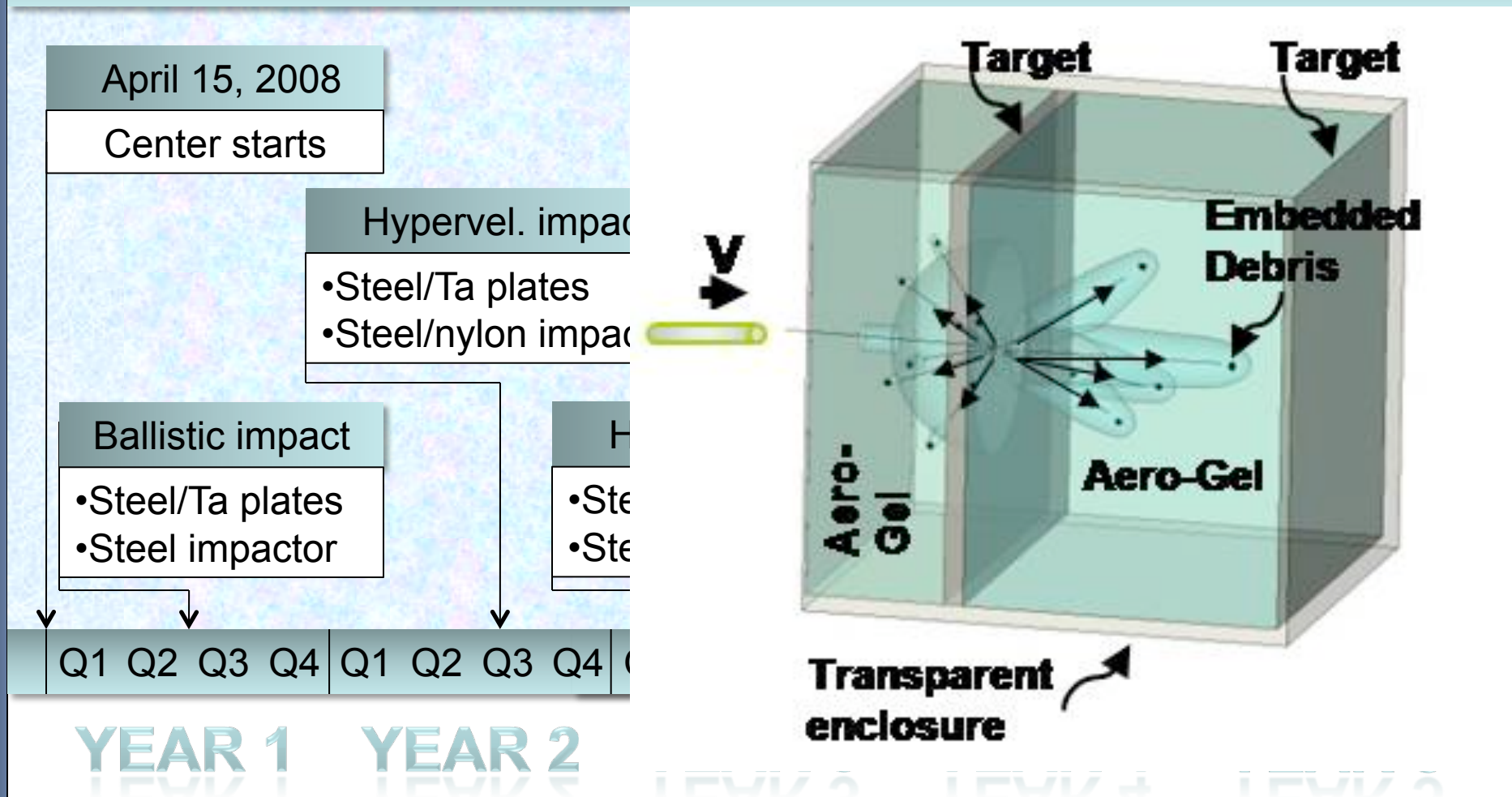


Hypervelocity impact range (SPHIR)

CALTECH
PSAAP

Year-5 experiment to be predicted

SPHIR configuration timeline



Year-5 experiment - Diagnostics

CALTECH PSAAP

Diagnostic deployment timeline

April 15, 2008
Center starts

Perforation area
Olympus SZ61 Microscope

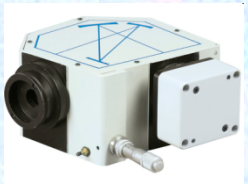
Profilometry
Optimet MiniConoscan 3000

Velocimetry
Valyn Multi-Beam VISAR

Back-lighting
Real-time silhouette imaging

Real-time CGS
Full-field surface slopes

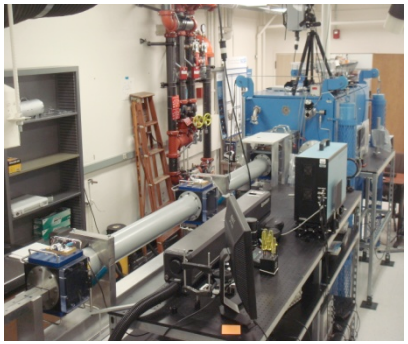
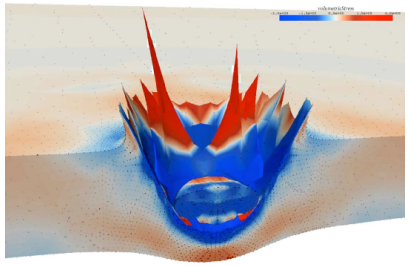
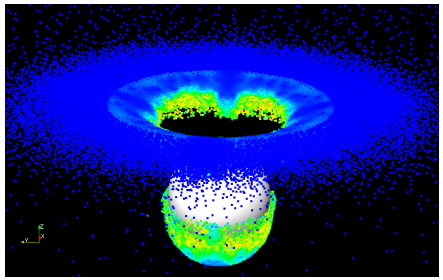
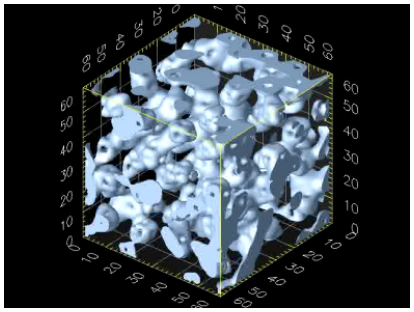
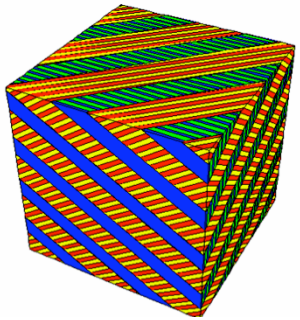
Spectrometry
Real-time spectra



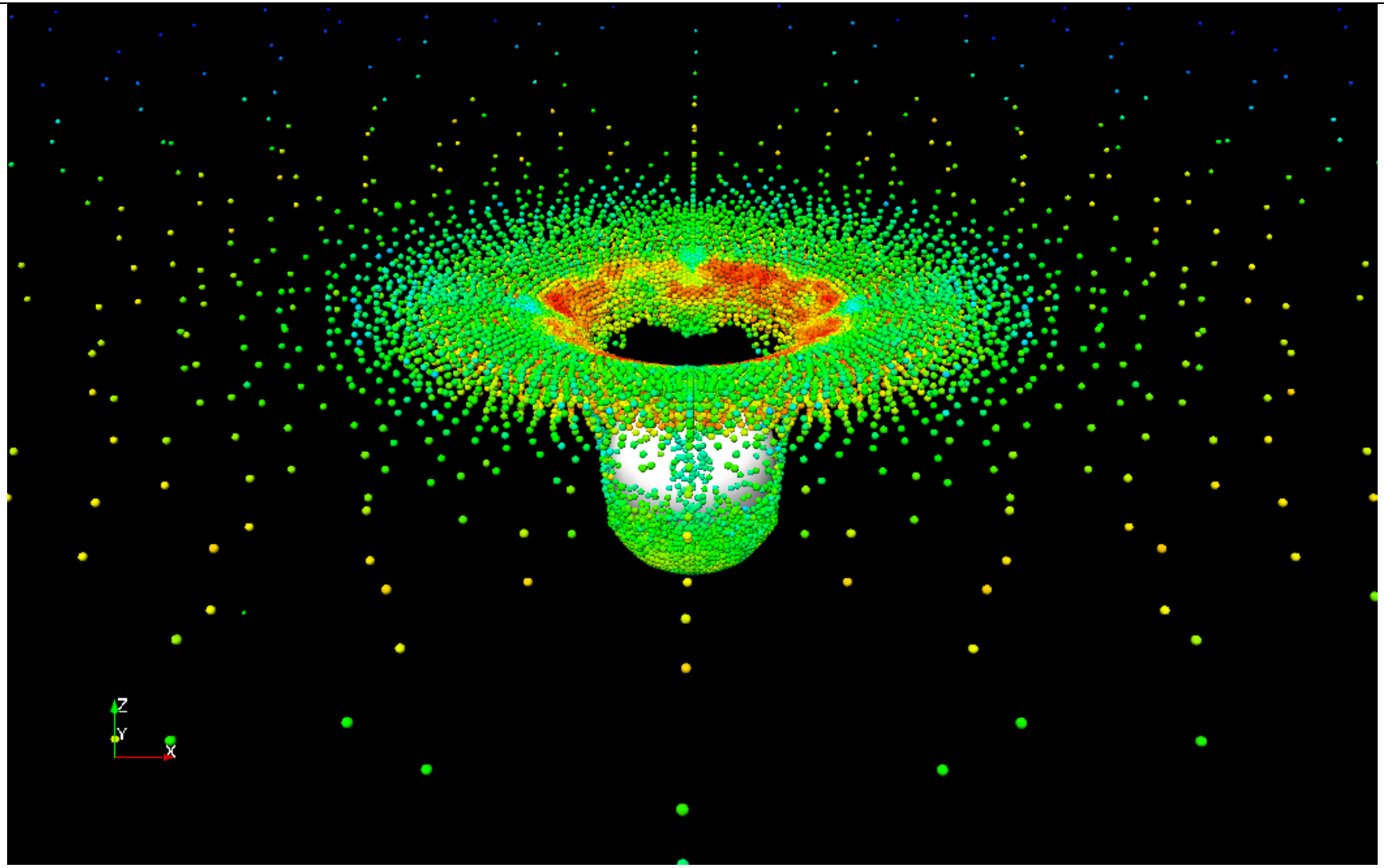
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3

YEAR 1 YEAR 2 YEAR 3 YEAR 4

QMU – Center's assets

Experimental Science		Simulation codes	
			
SPHIR	HSRT	VTF	OTM
Physics models		**UQ tools**	
			
Plasma/EoS	Strength/Fracture	Probability/CoM	UQ pipeline

QMU – Simulation codes – OTM



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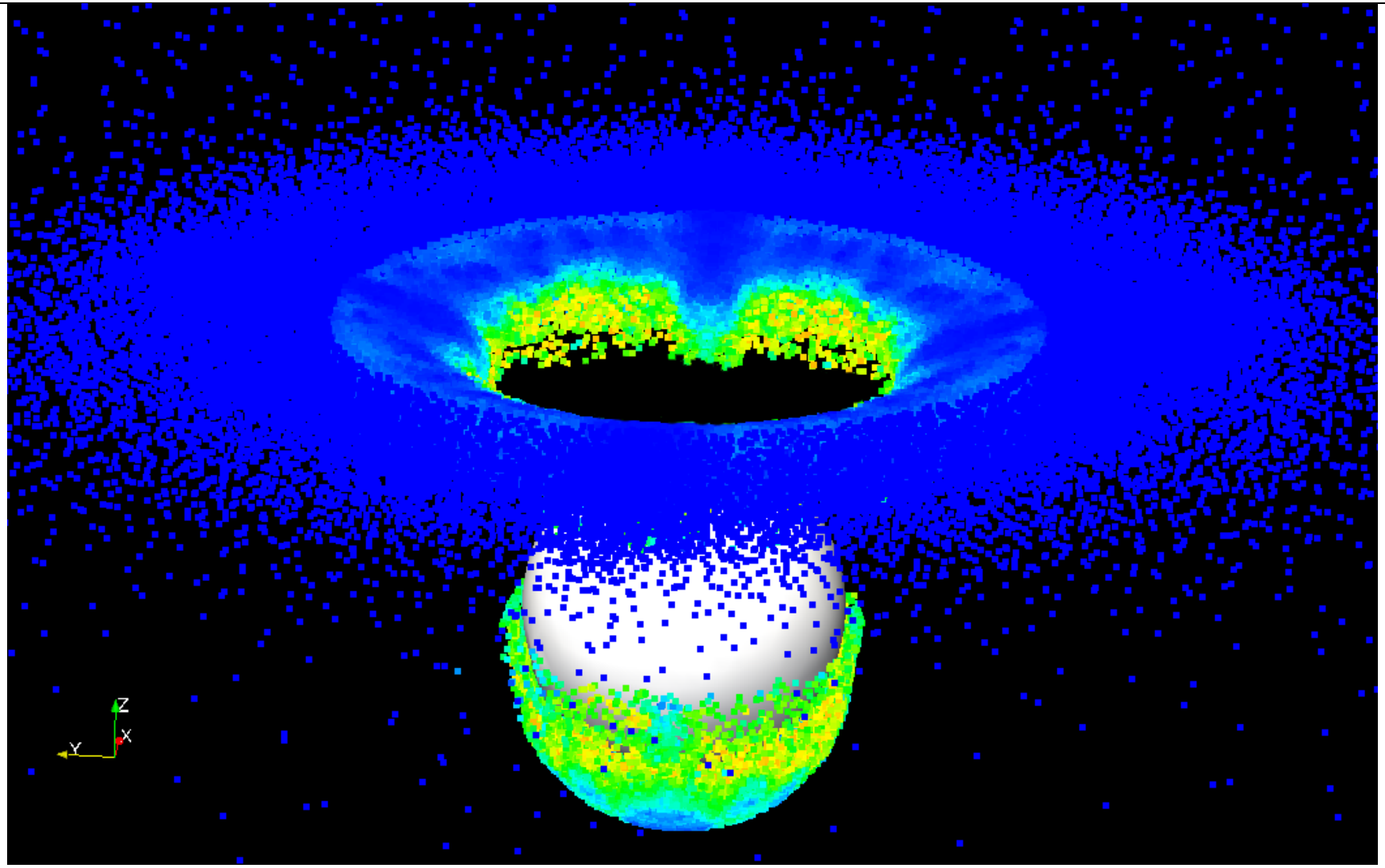

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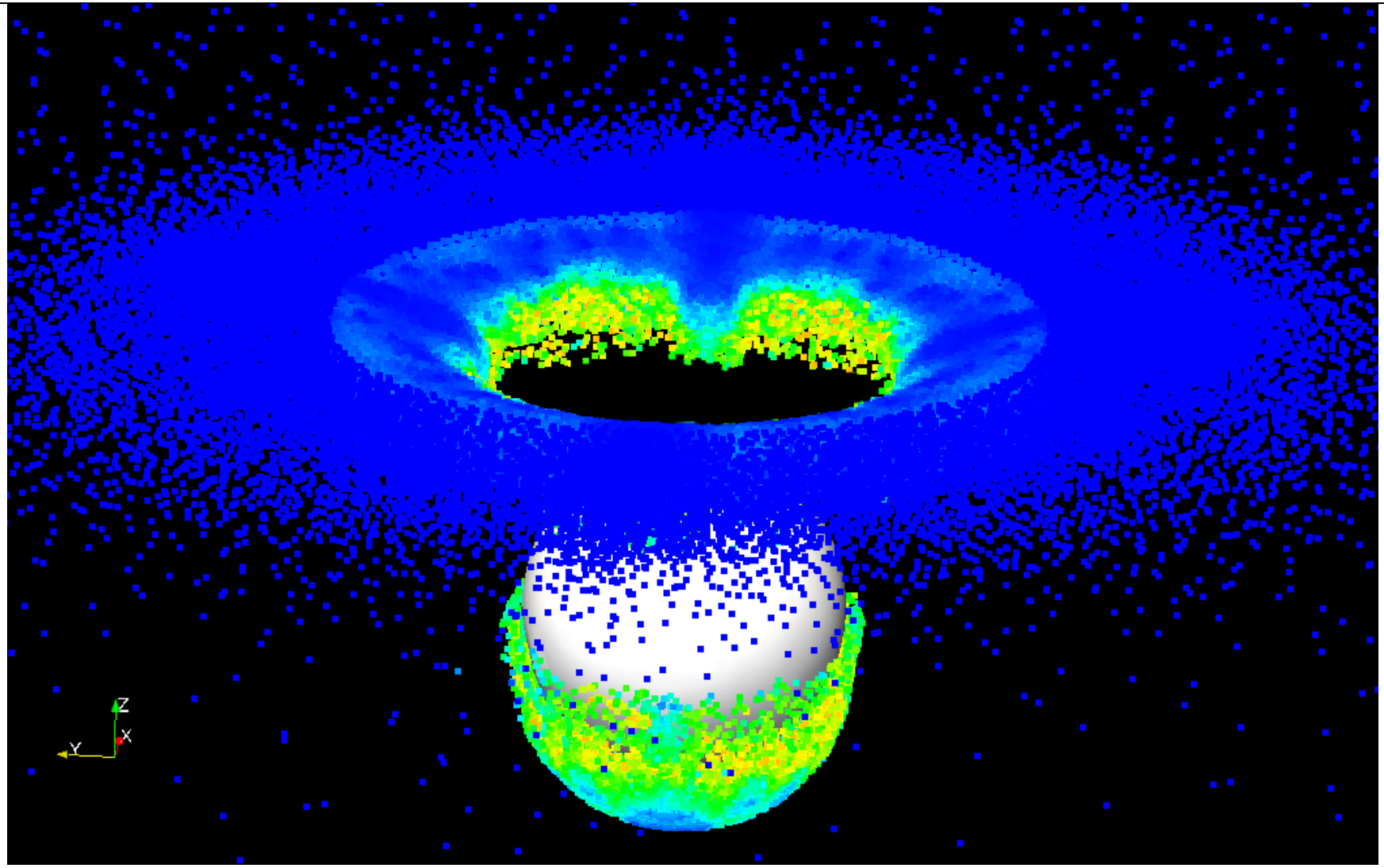

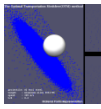

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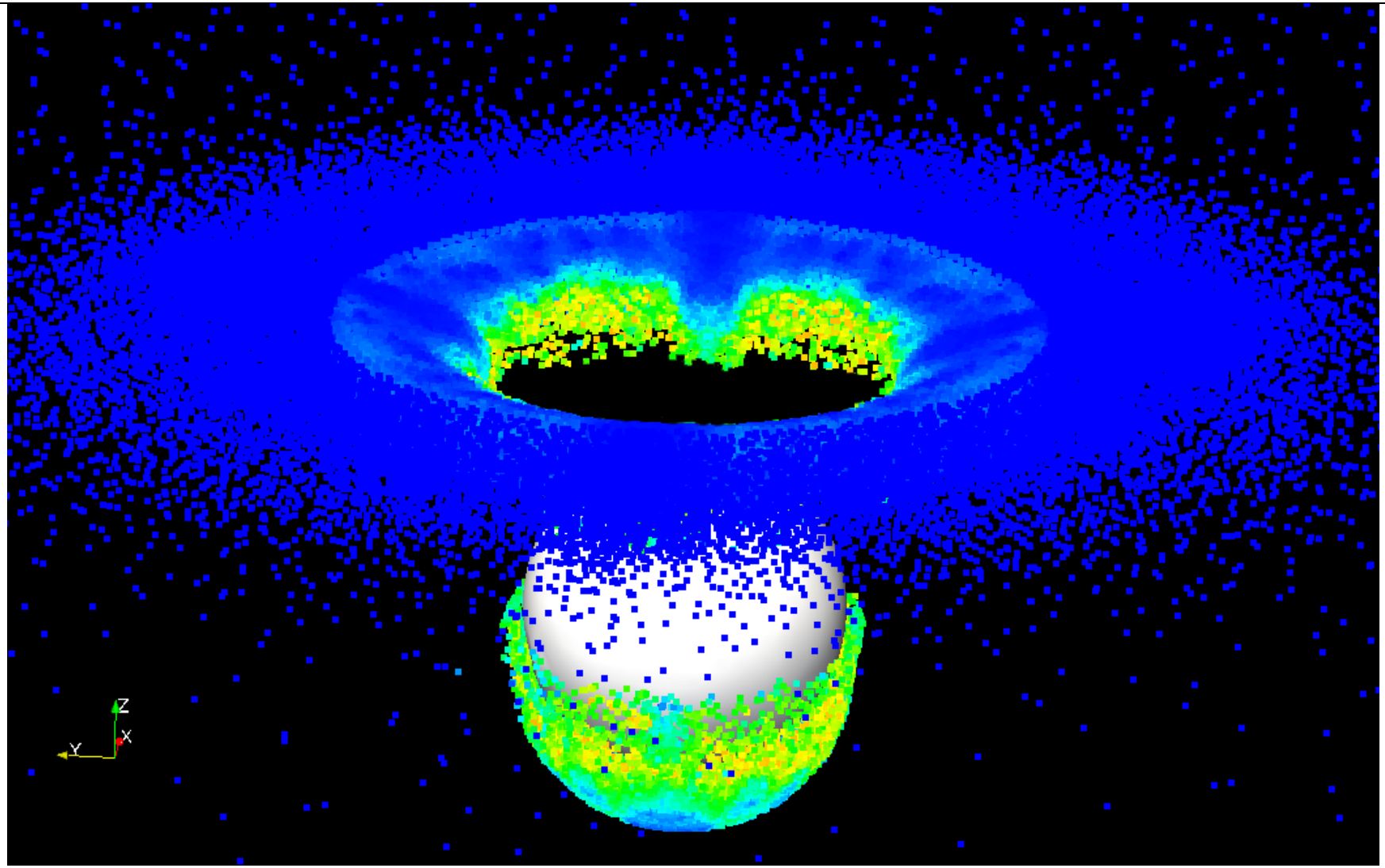
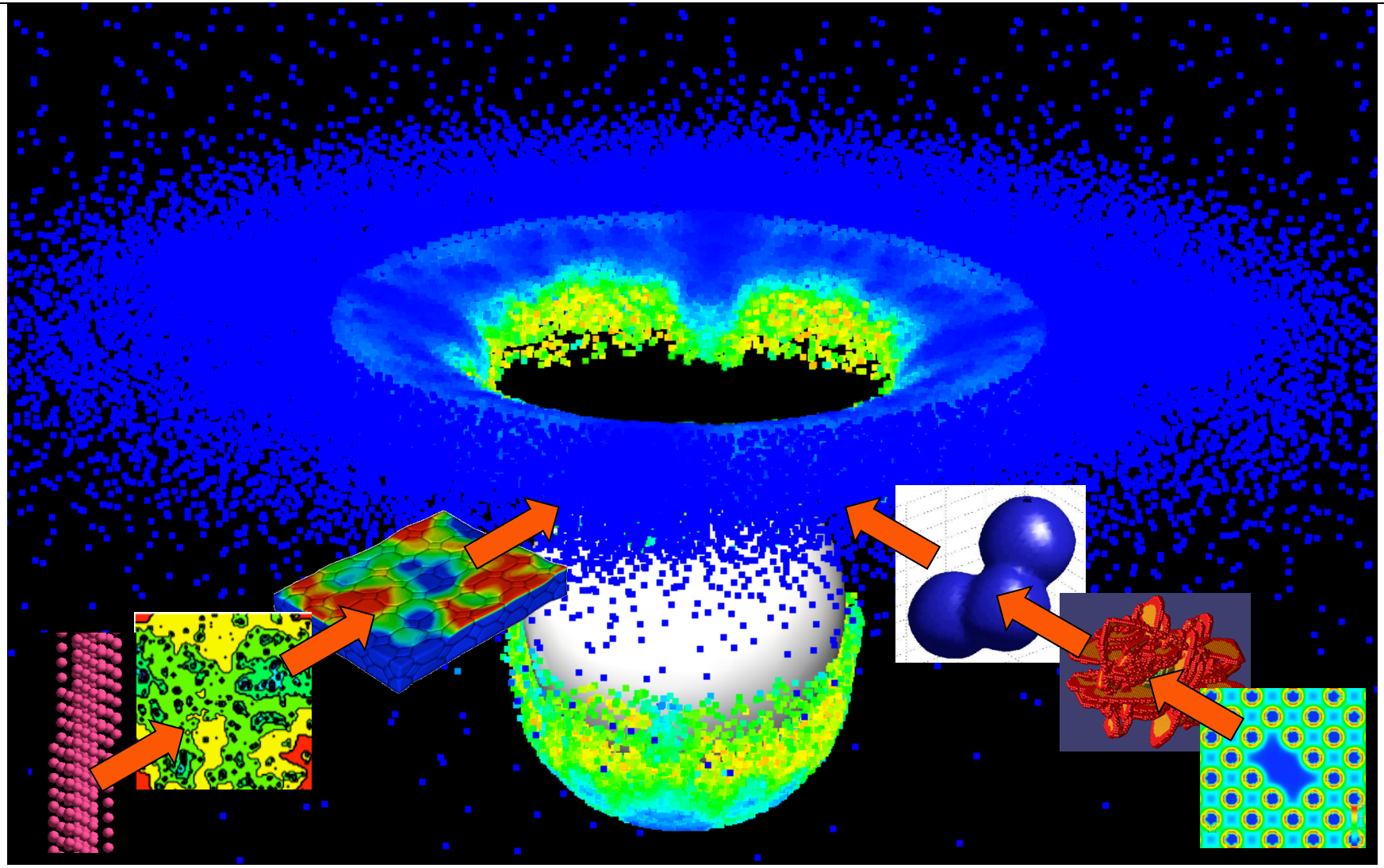
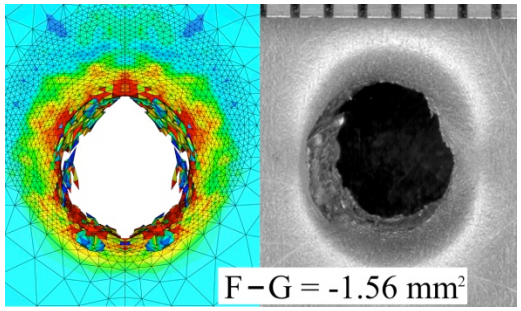


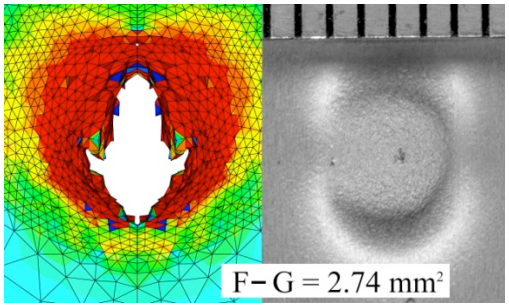
QMU – Physics models – Multiscale



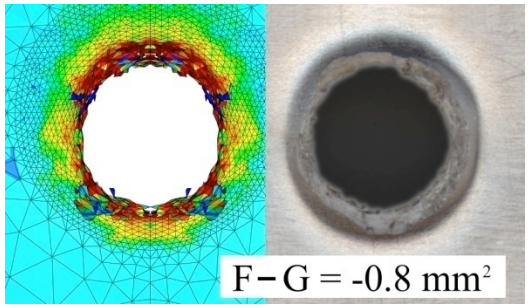
QMU/CoM – Results from Y1

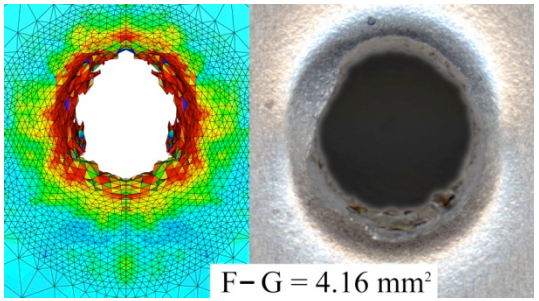
0) Initialization:
Comparison at point
(0.105”, 21°, 0.090”)



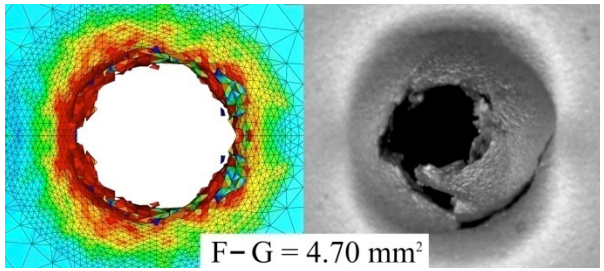


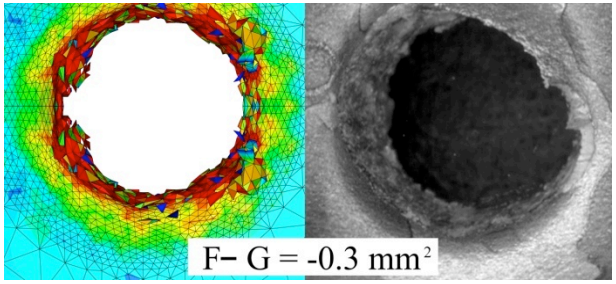
1) First Iteration:
Comparison at point
(0.090”, 11°, 0.073”)



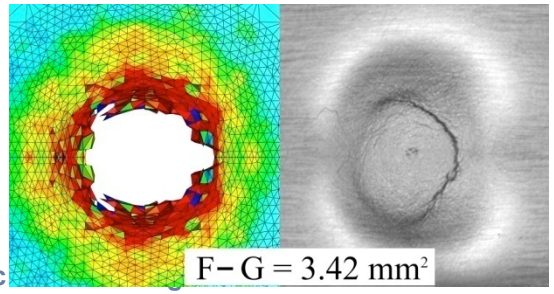


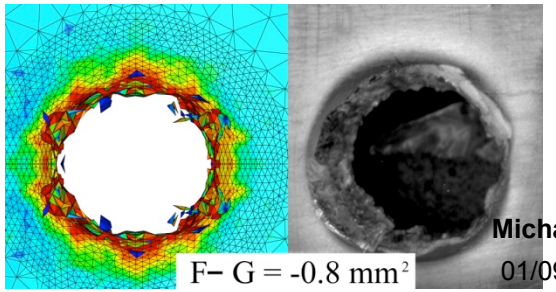
2) Second Iteration:
Comparison at point
(0.105”, 5°, 0.090”)





3) Third Iteration:
Comparison at point
(0.105”, 0°, 0.073”)

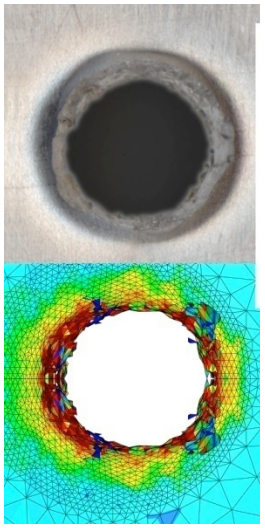




QMU/CoM – Results from Y1

Prediction goal: Perforation area

Target: 304 SS
Projectile: 440C SS
Model: ABAQUS
DF: DAKOTA 4.2
DF-G: BFGS

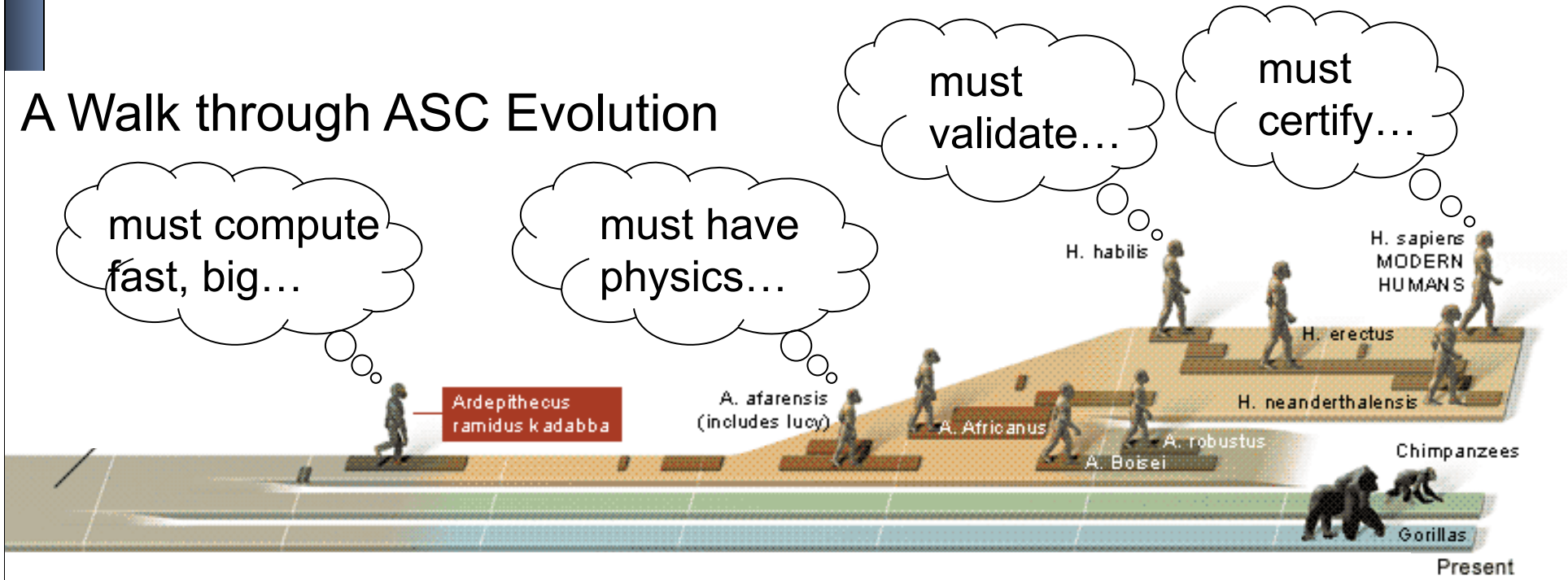


Diameters	Model $D_{\langle F \rangle}$	thickness	1.82 mm^2
		obliquity	2.41 mm^2
		total	3.02 mm^2
	Modeling error $D_{\langle F\text{-}G \rangle}$	thickness	1.80 mm^2
		obliquity	4.50 mm^2
		total	4.85 mm^2
	Experimental scatter $D_{G'}$	total	7.78 mm^2
Mean values	Model E[F]	total	3.30 mm^2
	Modeling error E[F-G]	total	0.32 mm^2
Probability of no perforation	CoM with exp. scatter		~80%
	CoM without exp. scatter		23.7%
	Monte Carlo with surrogate		2.6%

The ASAP-to-PSAAP transition

CALTECH PSAAP

A Walk through ASC Evolution



circa 1995 → 3D massively parallel codes (hero runs)

circa 1998 → Multiscale material models

circa 2002 → Small-scale experiments, testing

→ QMU

Caltech PSAAP Center

Thank you!