

# Verification, Validation, Uncertainty: Goals, Expectations, Challenges

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PSAAP Kickoff  
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# Why do we care about V&V and uncertainty?

- Prefer not to be this guy 
  - Expediency > intellectual integrity
  - No understanding of risks
  
- Natural part of scientific method
  - Observation
  - Hypothesis
  - Prediction  V&V goes here
  - Test



• Besides, we all know:  $\frac{BEM}{VLC} \notin \mathbb{R}$

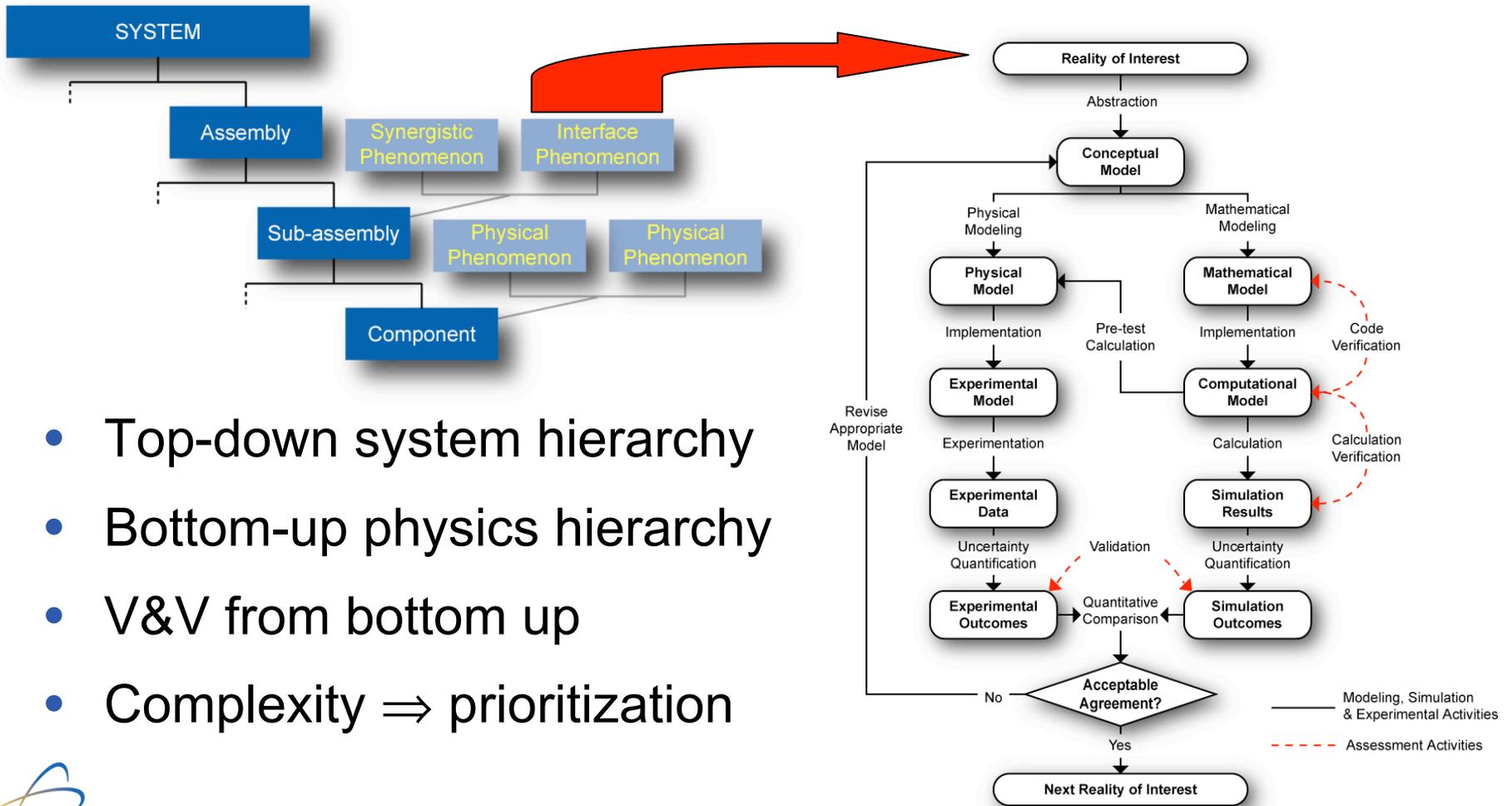
formerly a *BAC*



MCA 20080709



# The basic approach *appears* obvious.



- Top-down system hierarchy
- Bottom-up physics hierarchy
- V&V from bottom up
- Complexity  $\Rightarrow$  prioritization

# The goal of the V&V program is to help build & maintain a *credible* predictive capability.

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- **Assess Simulation Credibility**
  - *Objectively* apply V&V approach
  - Evaluate thru the “lens” of UQ
  - Build tools & test suites
- **Advise Simulation Community**
  - Inform users of strengths & weaknesses
  - Communicate needs with developers
  - Summarize for managers
- **Advocate Simulation Capability**
  - Facilitate best practices for users
  - Enable investment prioritization
  - Inform decision making process

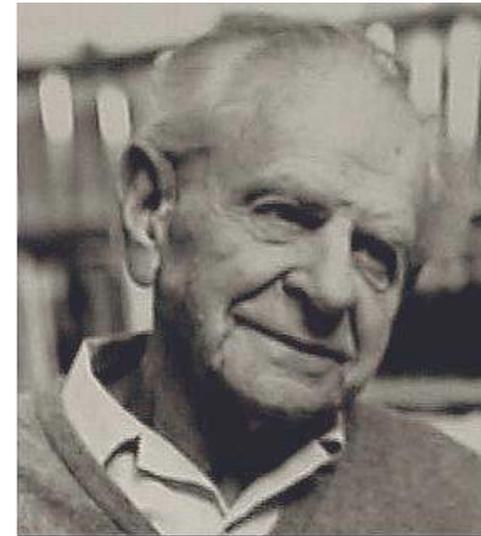


*The Justice, Pietro de Miniato, ca. 1415*

## Our expectations of the PSAAP are high.

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- Focus on
  - Scientific discovery
  - Creative applications
  - Intellectual rigor
- V&V is concerned with the “rigor”
  - Evidence, not proof
  - Falsification
  - Quantification
- PSAAP requirements
  - Verification & validation
  - Uncertainty estimation
  - Communication

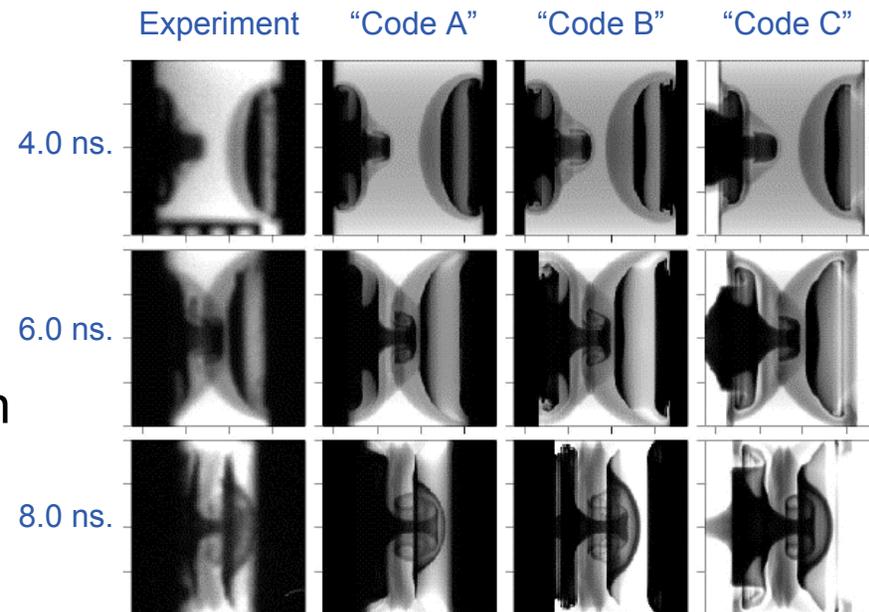
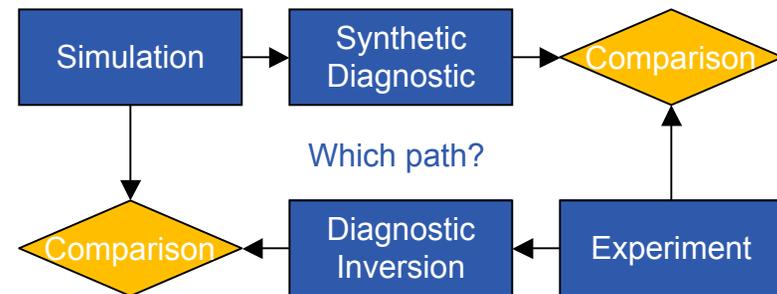


Sir Karl Popper (1902-1994)

“Theories are not verifiable, but they can be corroborated.” in *The Logic of Scientific Discovery*

# There are serious technical challenges associated with every step of the V&V process.

- General challenges
  - Hierarchical decomposition
  - Features & metrics
  - Rollup of assessments
- Verification challenges
  - Test problems
  - Convergence analyses
  - Code invasive approaches
- Validation challenges
  - Experimental characterization
  - Diagnostic simulation
  - Evaluations with UQ

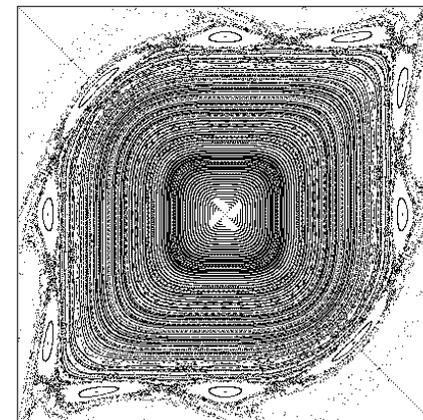
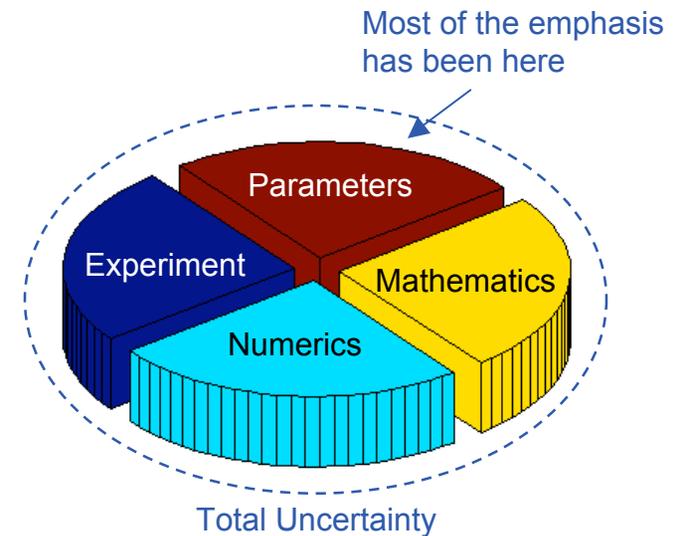


Radiation-driven Interacting Jet-shock

Kamm, J.R., et al., "Image Quantification of Experiments and Simulations of Laser-driven Jets," LA-UR-05-1441, March 2005

# Perhaps the most perplexing challenges are associated with uncertainty quantification.

- Contributors to uncertainty
  - Experiment characterization & data
  - Mathematical models & parameters
  - Numerical models & parameters
- Available methods
  - Measure theoretic
  - Set theoretic
  - Dynamical systems
- We need new ideas
  - Total uncertainty
  - Non-sampling based methods
  - Global sensitivity analysis



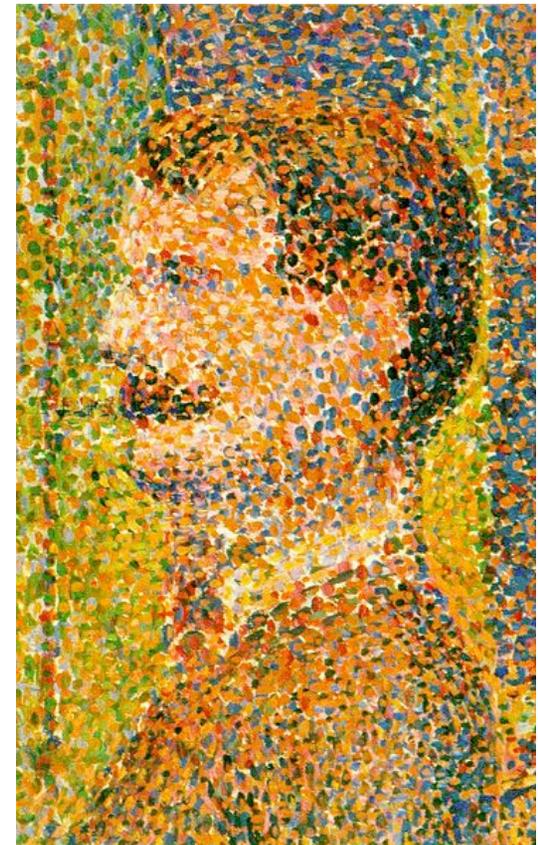
## So...what?

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- Simulations are *potentially useful representations* of reality

$$\frac{BEM}{VLC} \sim \mathbb{R}$$

- V&V provides evidence for the scientific integrity of “~”
- Uncertainty is the lingua franca of “~”
- We are very excited about working with you



Detail from *The Parade*, Georges Seurat, 1889

# Abstract

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This presentation describes the goals, expectations, and challenges of the LANL Verification and Validation (V&V) for the Predictive Science Academic Alliance Program (PSAAP). The need for V&V is discussed, along with the basic process. The V&V goal of helping to build a credible predictive capability is delineated, as are the expectations for the PSAAP. Challenges associated with the V&V process and the requisite uncertainty quantification are summarized.