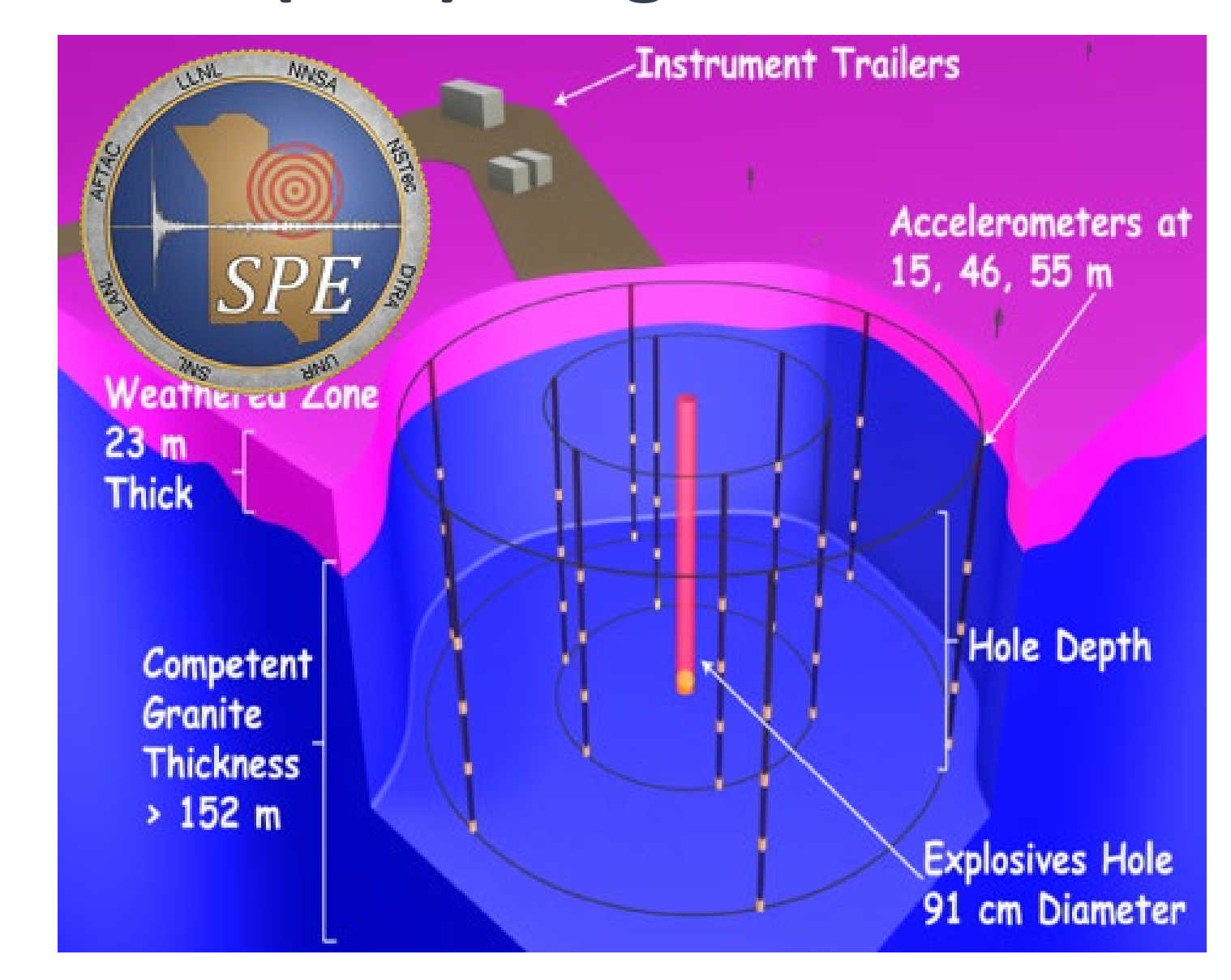




The Source Physics Experiment (SPE) Program

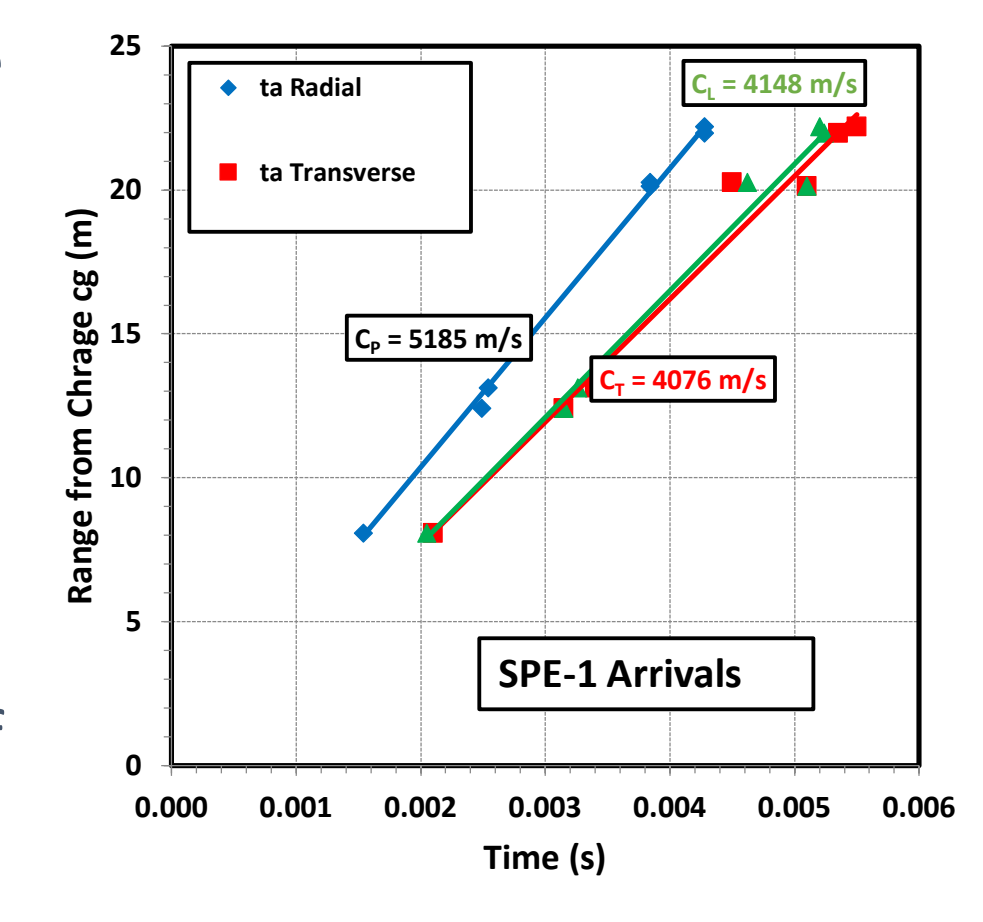
- Multiple chemical explosive sources in the same borehole
- Vary depth and yield
- Array of sensors to record all tests
- Includes borehole & surface accelerometers
- Two testbeds:
 - Phase I: Climax Stock granite
 - Phase II: Yucca Flats alluvium
 - Also known as DAG (Dry Alluvium Geology)



Phase I Cutaway View

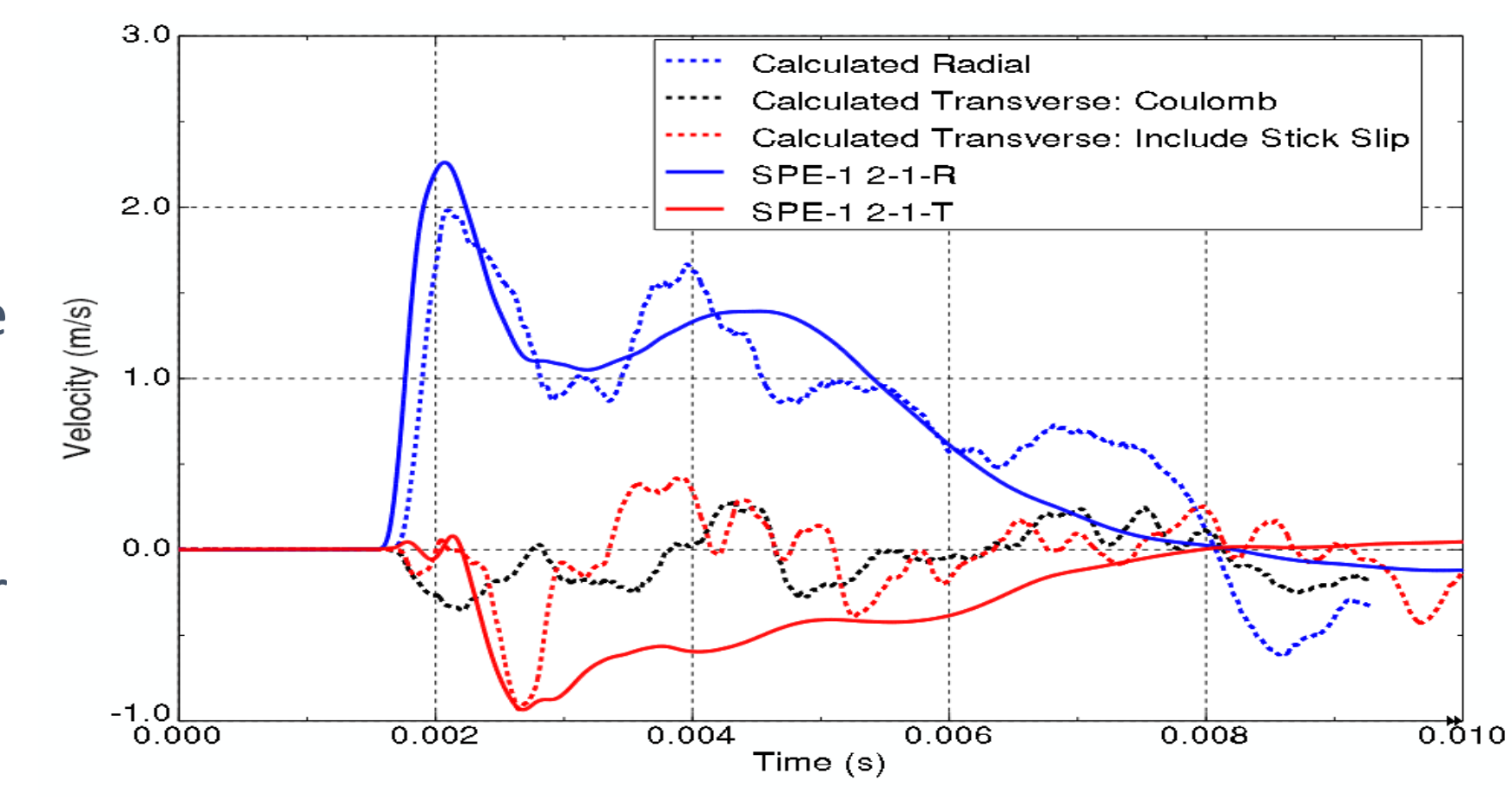
Phase I Characteristic Times (e.g., SPE-1)

- Times of tangential excursion are too fast to be a shear wave arrival from the source ($C_T \neq C_S$).
- These times are consistently seen to just lag the time of peak radial velocity ($C_T \approx C_S$).
- This indicates that the excursion occurs with the onset of unloading.



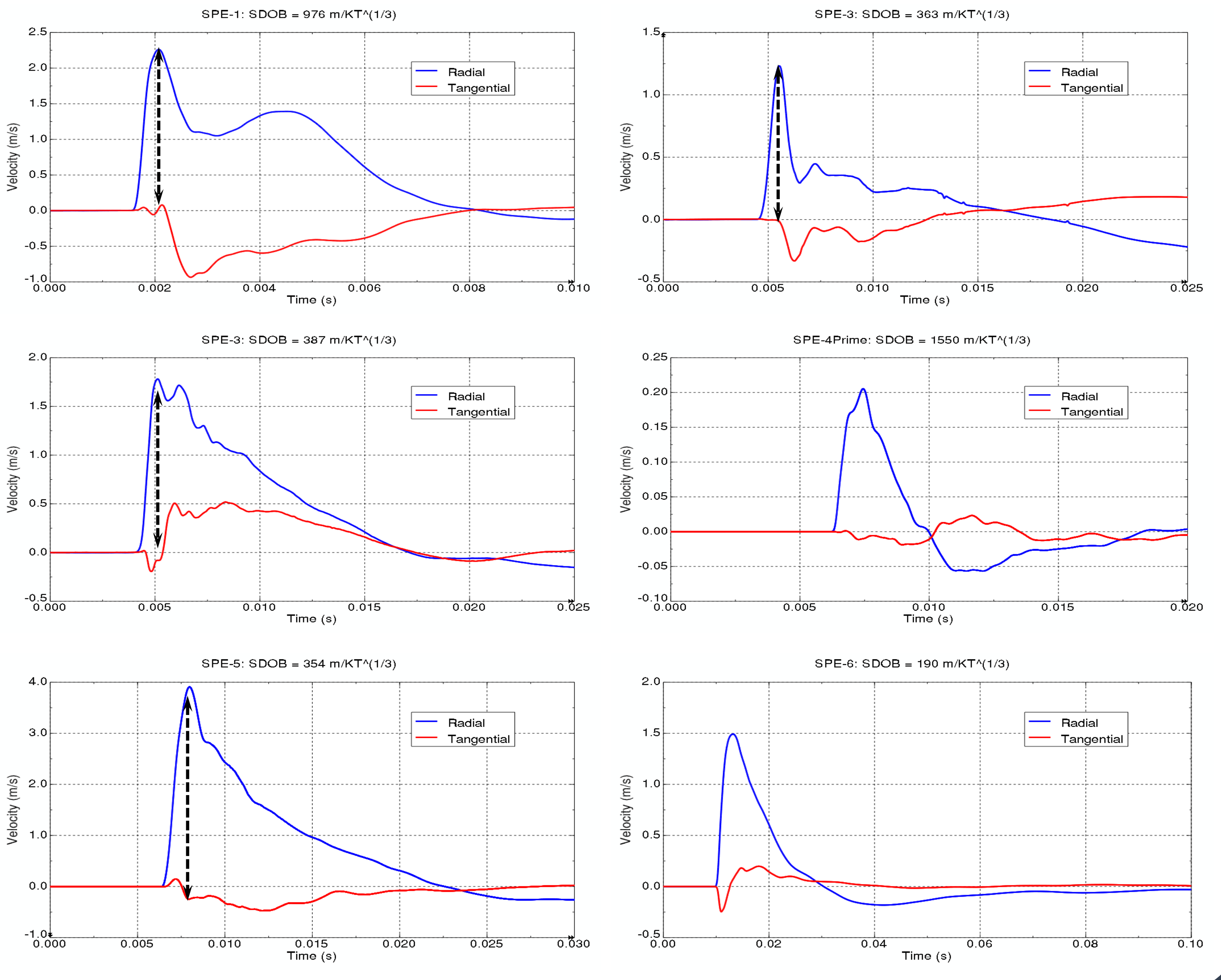
Finite Element Modeling-- Joint Simulations

- Perform high-fidelity finite element.
- Modeling with explicit joints.
- Introduce a "stick slip" response before Coulomb joint failure.
- Delays motion and enhances amplitude.
- Mimics the observed response for moderately buried Phase I tests.

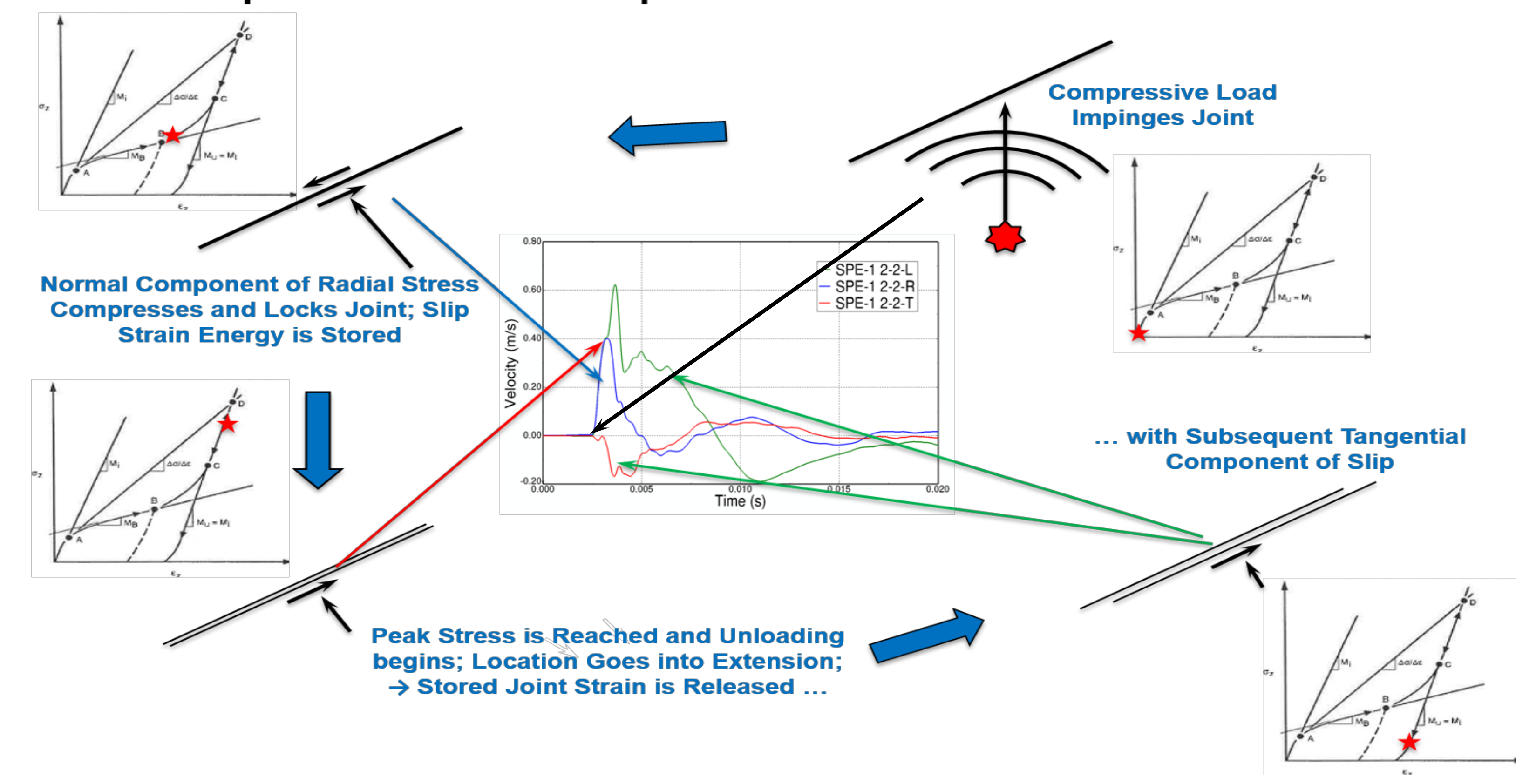


Typical Phase I Velocity Records

- For a pure explosion in a homogeneous medium we expect only radial (R) motion. But ...
- For moderately buried events (SPE-1, SPE-2, SPE-3, and SPE-5) we observed:
 - significant tangential velocities: amplitudes > 30% of co-located radial velocities;
 - the onset of tangential motion is consistently delayed with respect to the shock arrival.
- The deeply buried SPE4-Prime is consistent with a pure explosion, indicating only radial motion.
- The "nominally" buried (i.e., legacy depth) SPE-6 indicates minor tangential motion coincident with shock arrival; there is no delay and the response is incidental to passage of the shock.

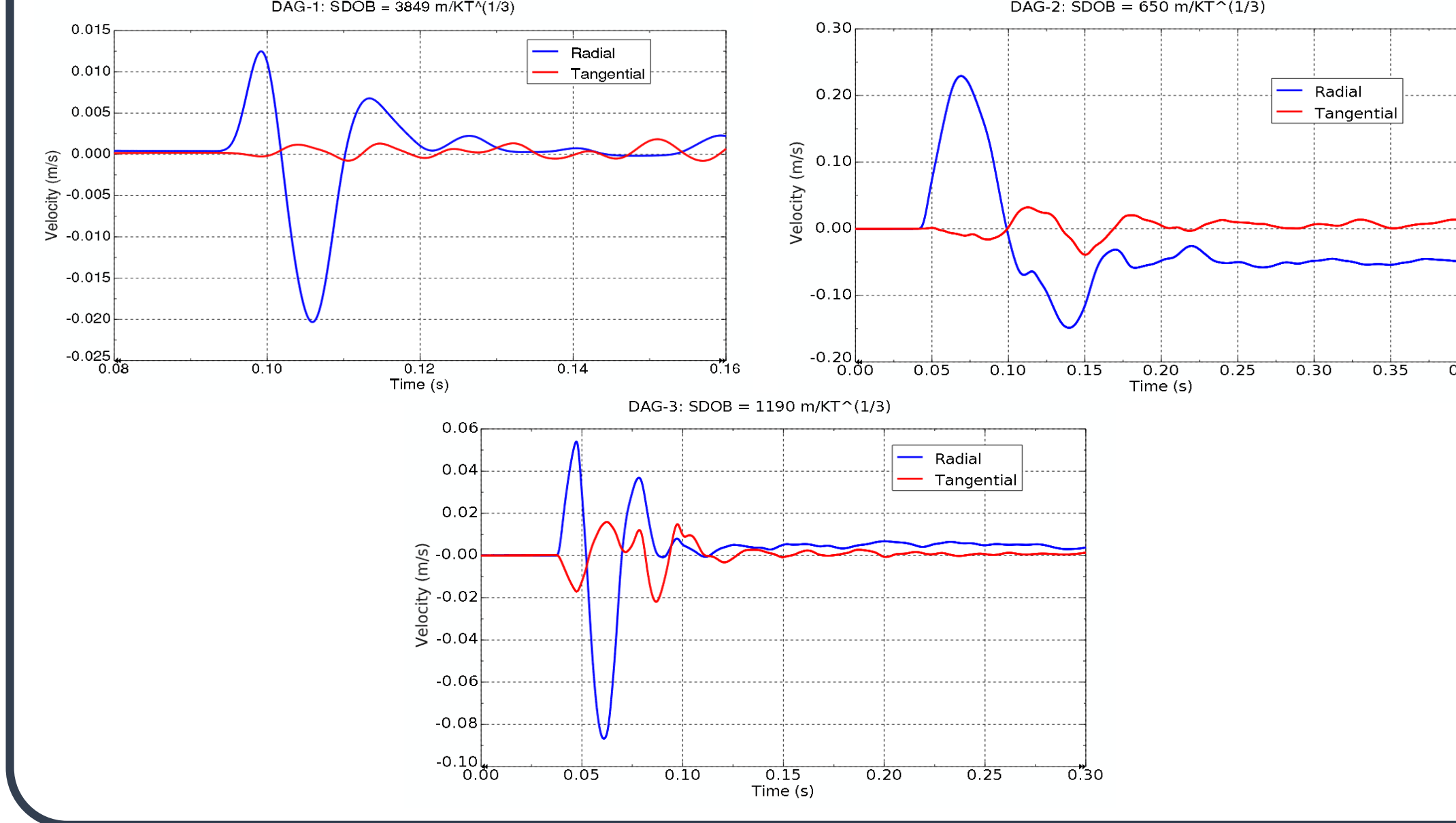


Conceptual "Shear Release"



Typical Phase II Velocity Records

- Deep alluvial geology has no identified joints or other structure.
- Velocity data indicate no significant tangential motion.
- This site is relatively homogeneous for ground shock propagation, thus providing a "baseline" case for comparison to the jointed medium.

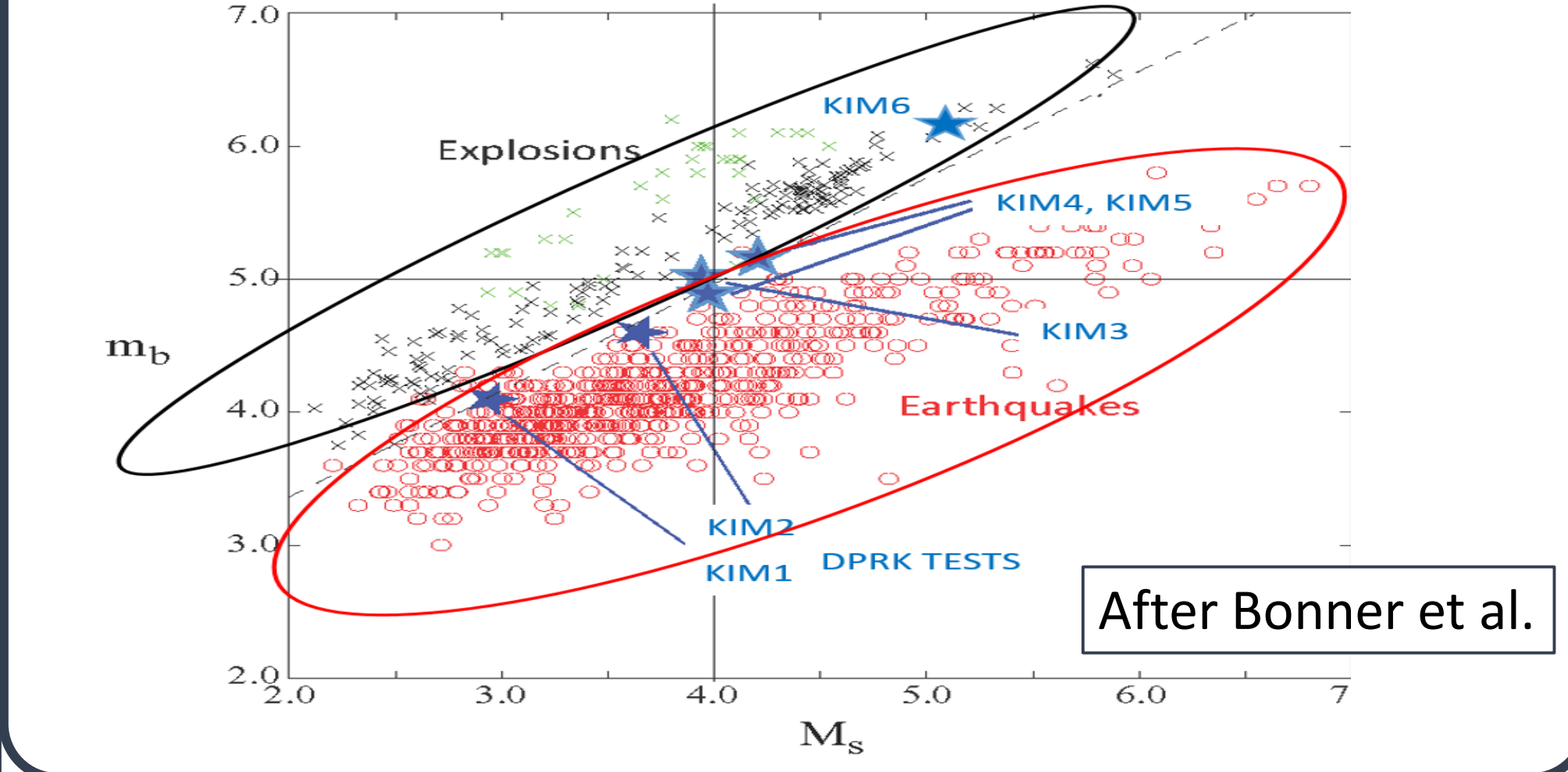


SDOB/SR Effect

- Modeling and data suggest dilation during unload initiates sudden shear release on the natural joint sets for moderate SDOB.
- The model also implies:
 - Joints in deep, small-yield sources likely do not store sufficient strain energy to overcome the background geostatic load.
 - Nominal SDOB sources create sufficient load to immediately overcome the geostatic; no strain energy is stored and so no release occurs.
- This will not occur in unjointed media.
- Current DAG tests in alluvium confirm this.

$m_b:M_s$ Discriminant & DPRK

- Body wave to surface wave magnitude ratios ($m_b:M_s$) are generally reliable for earthquake/explosion discrimination.
- The moderately buried DPRK events fail this discriminant.
- But the recent nominally buried event fits the legacy data.

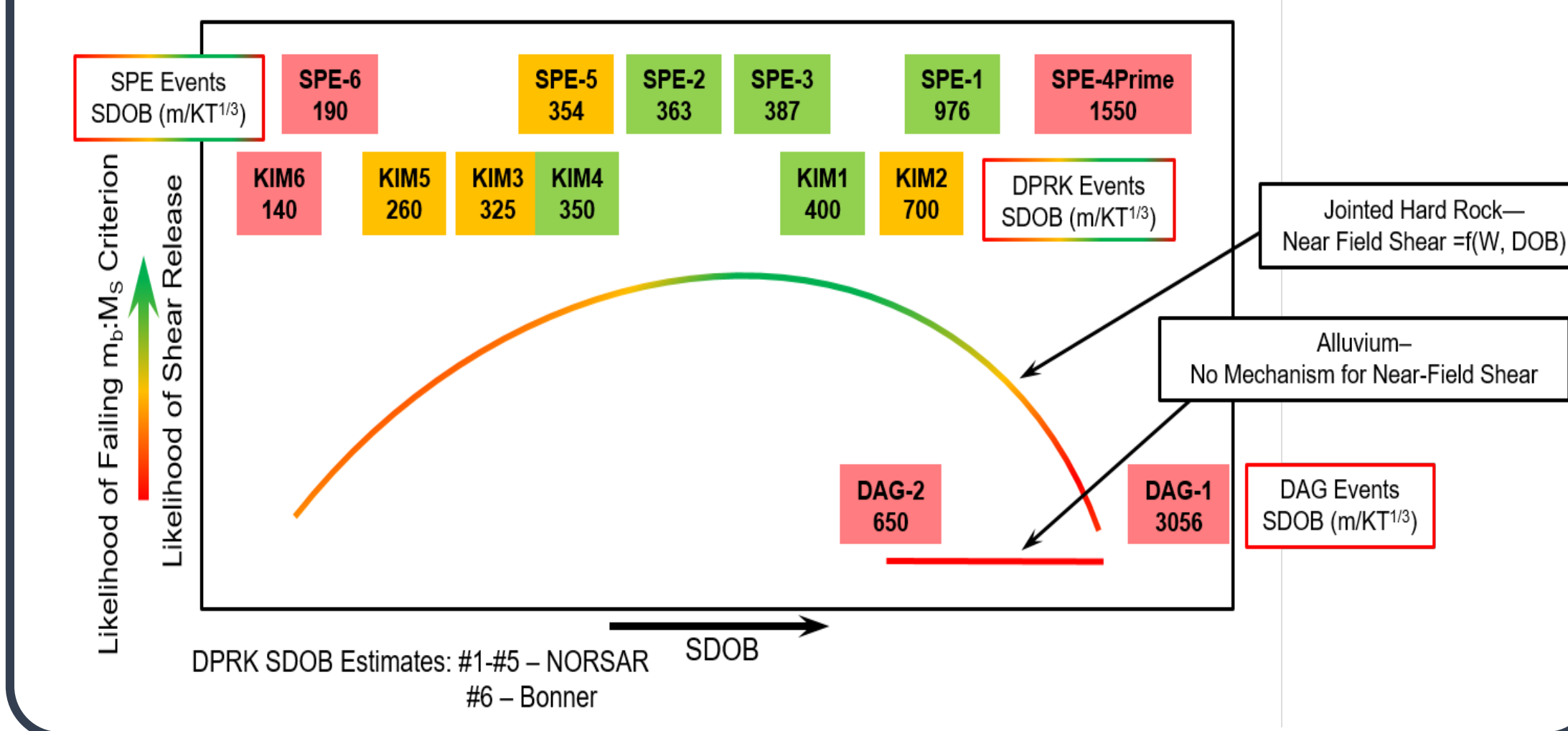


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DPRK Events vs. SPE

- Likelihood of SPE shear release maps to likelihood of DPRK events failing accepted shear-based discriminant in a similar geology
- Hypothesis: SDOB in a jointed medium determines whether anomalous shear content is generated.**



References

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 Bonner, J. L. et al. (2006). Development of a time-domain, variable-period surface wave magnitude measurement procedure for application at regional and teleseismic distances, part II: application and $M_b:m_b$ performance, Bull. Seism. Soc. Am. 96, 678 – 696.

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