

# Probing Seismogenesis for Fault Slip and Earthquake Hazard

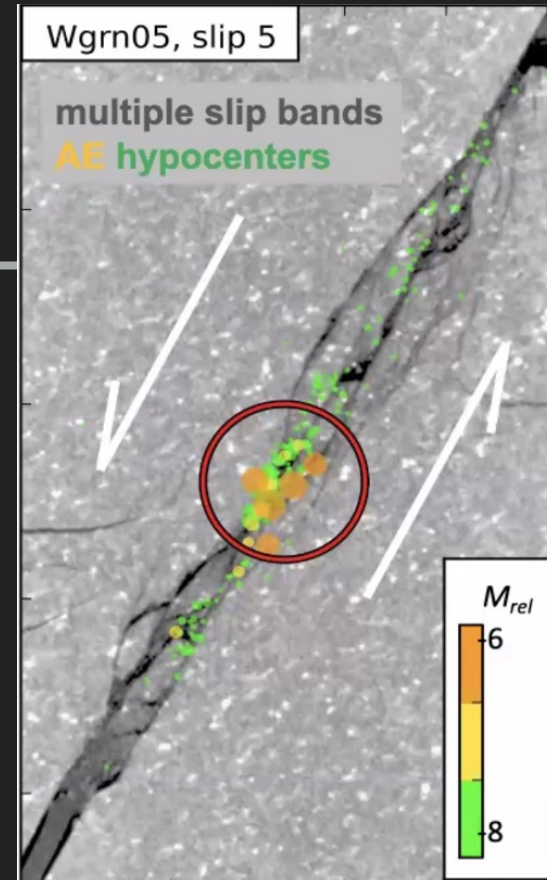
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CHRISTOPHER JOHNSON & PAUL JOHNSON

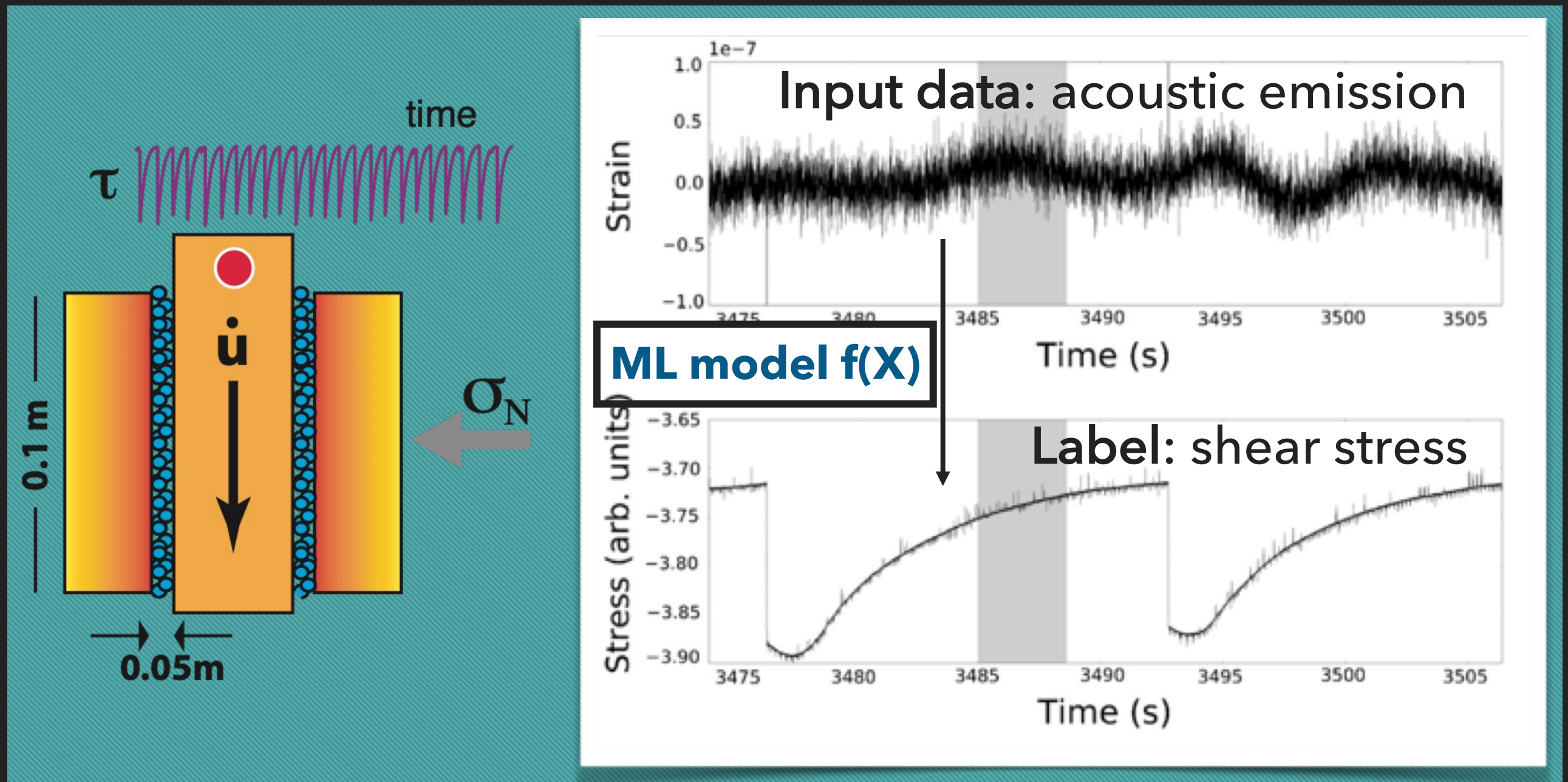
LOS ALAMOS NATIONAL LABORATORY

with Bertrand Rouet-LeDuc, Claudia Hulbert,  
Kun Wang, Chris Marone, Ian McBrearty,  
Kane Bennett and many more.....

How to capture the  
controlling physics  
of such a complex  
system?



# LEARNING FAULT PHYSICS USING THE CONTINUOUS ACOUSTIC EMISSION



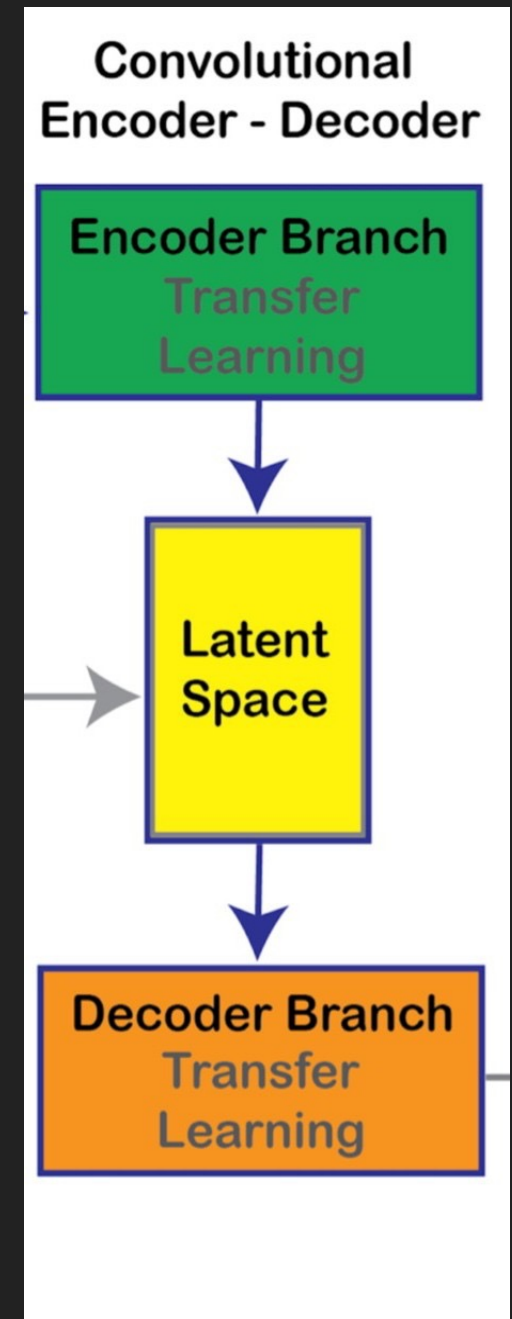
# EXAMPLE: TRAIN ON SIMULATIONS+DATA AND TEST ON LAB (EARTH) DATA

How to characterize and forecast timing of earthquakes with repeat times of 30-1000 years?

## TRANSFER LEARNING

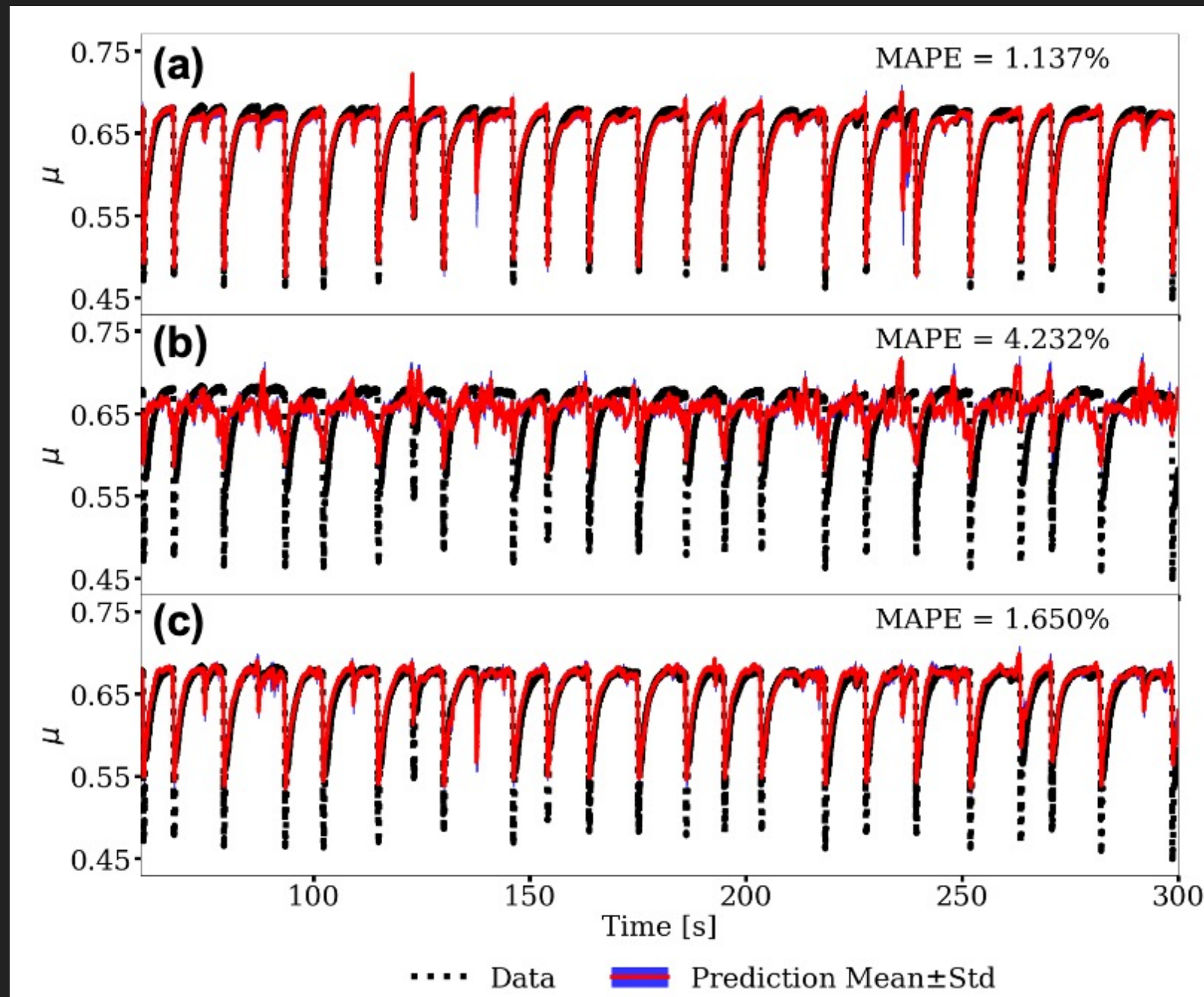
Encoder and Decoder trained by simulation data only.

Latent Space trained by FDEM data then Lab data.





## CROSS-TRAINING MODEL



Trained: Lab

Tested : Lab

Trained: Simulations

Tested : Lab

Trained: Simulations

Cross Trained : Lab

Tested : Lab

# WORK IN PROGRESS: APPROACHES TO SEISMOGENIC FAULTS IN EARTH

- ▶ Train on Earth-scale fault simulations, test on actual faults
- ▶ Applying NLP approaches to near future prediction
- ▶ Physics of Informed Learning—add frictional physics to loss function
- ▶ Data driven: train on a large number of previous earthquakes to predict timing of upcoming quake



<https://epod.usra.edu/blog/2006/11/elkhorn-scarp-along-san-andreas-fault.html>





## ***TAKE HOME MESSAGE***

**THE 'NOISE' IS THE SIGNAL  
GIVING INSIGHT INTO  
FAULT PHYSICS—  
INSTANTANEOUS  
DISPLACEMENT AND  
FUTURE TIMING.**

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**ML TOOLS REVEALED THESE  
CHARACTERISTICS!**