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Sandia Academic Alliance Fall 2021 University of Illinois LDRD Virtual Poster Session

Linking friction scales from Nano to Macro via avalanches

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Introduction / Motivation

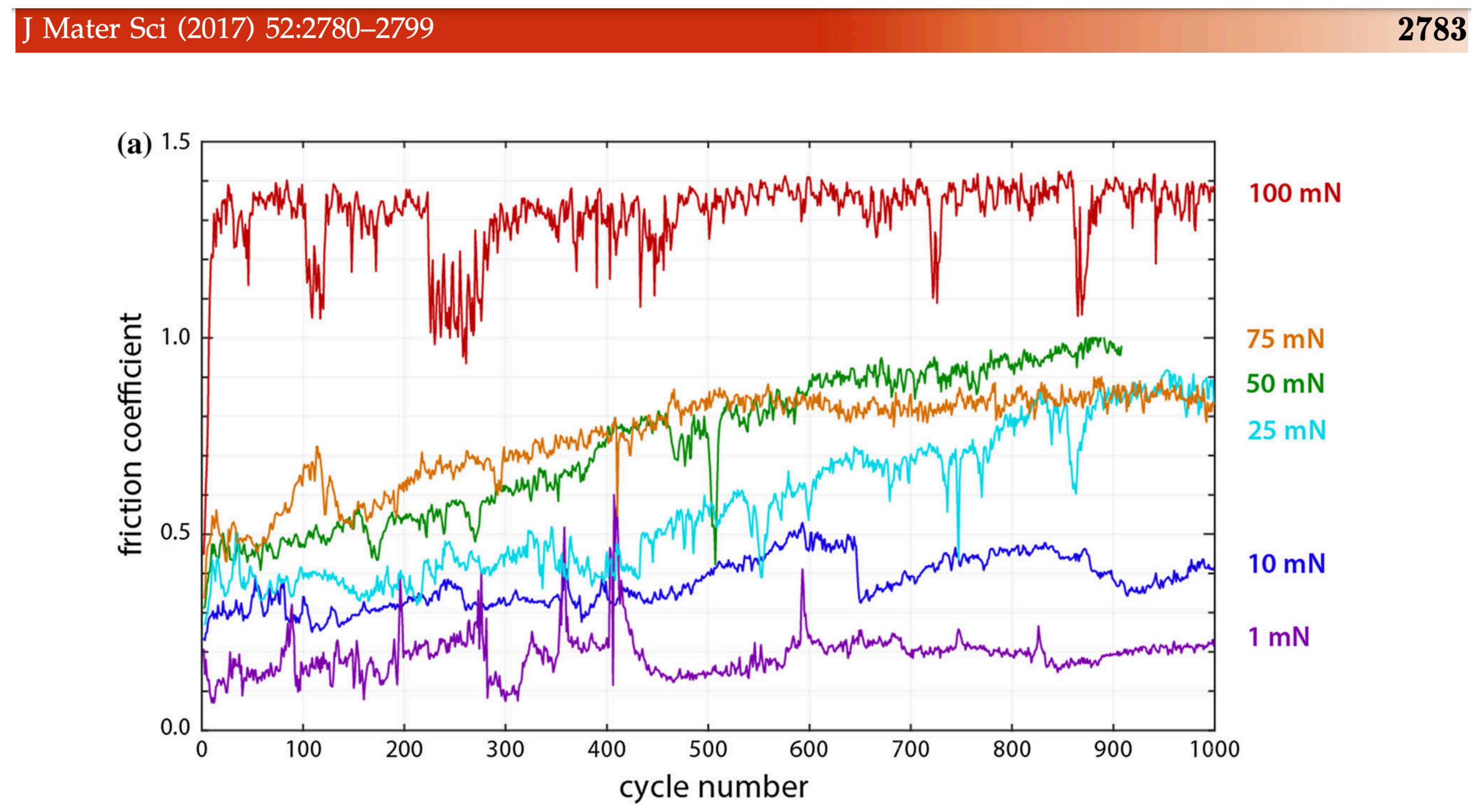
Externally driven

Quenched disorder

Elastic interactions

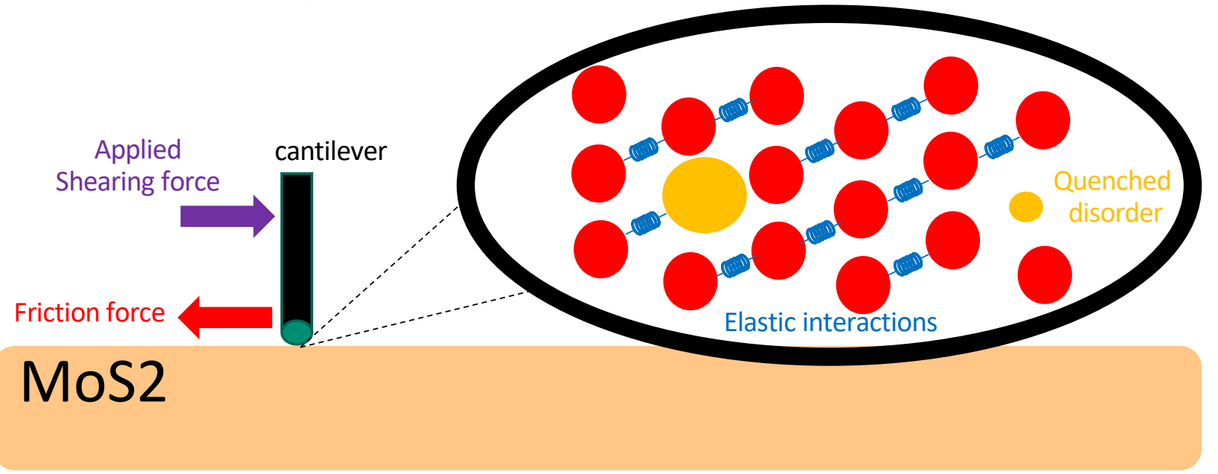
avalanches

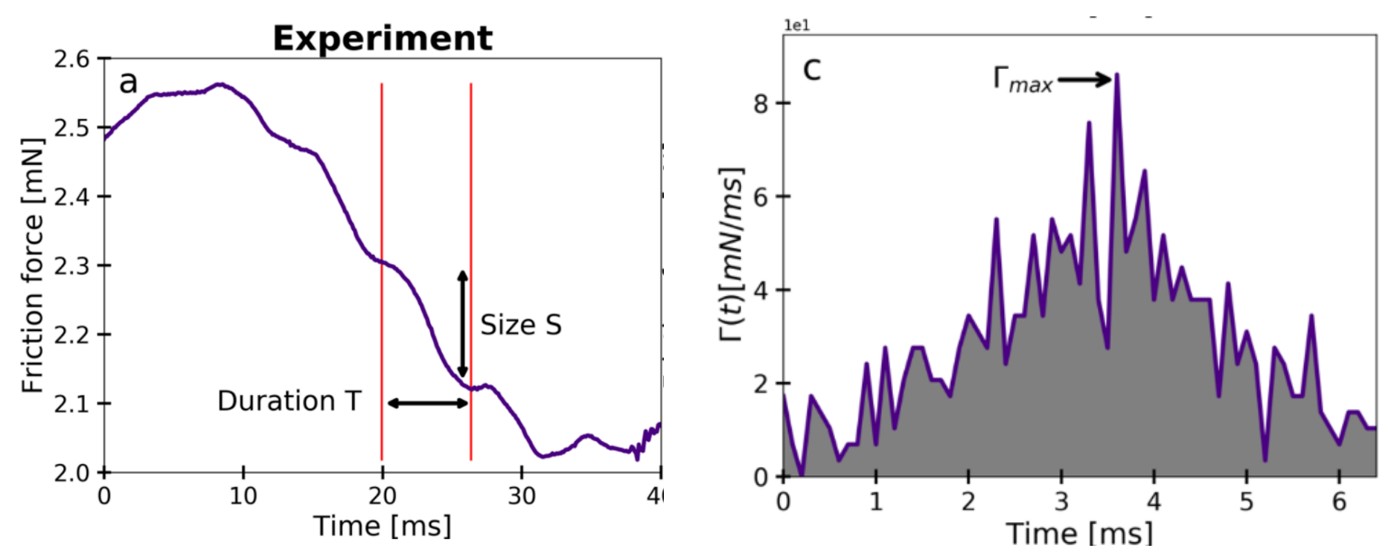
-Bulk metallic glass
-Earthquakes
-Nanocrystals
-High entropy alloys
-**Friction**?



Approach

Tribological measurements → **Extract slips from experiments and molecular dynamics** → **Characterize statistics**





Model friction force slips

$$\frac{\eta\partial \boxed{u(r,t)}}{\partial t} = \boxed{F} + \boxed{\sigma_{int}(r,t)} - \boxed{f_R}[u,r,\{u(r,t' < t)\}]$$

Friction force

Applied Shearing force

Elastic interaction

Quenched disorder

↓

Meanfield approximation →

$$\sigma_{int}(r,t) = \int_{-\infty}^{t} dt' \int d^2r'\, J(r-r',t-t') \times [u(r',t') - u(r,t)]$$

$$\bar{u} = \sum_r u(r,t) \qquad \sigma_{int}(r,t) = J[\bar{u} - u(r,t)]$$

Pdf(S)~S^{-A}, Pdf(T)~T^{-B}, $\langle T\rangle$(S)~$S^{A-1/B-1}$

$$\langle\Gamma_{S_i}(t_j)\rangle/\sqrt{S_i} = \alpha(t_j/\sqrt{S_i})e^{-\beta(t_j/\sqrt{S_i})^2}$$

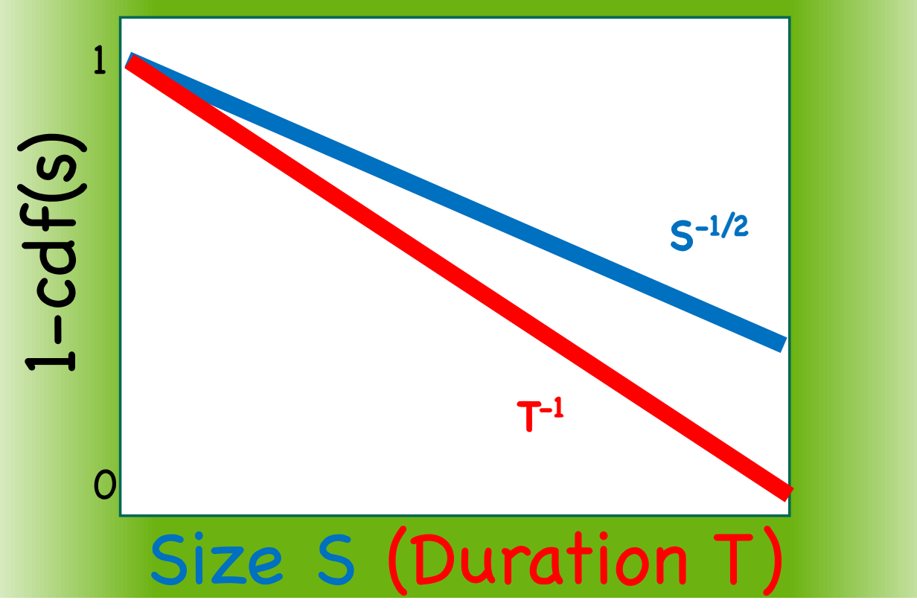
$$\langle\Gamma_{T_i}(t_j)\rangle \sim (\frac{t_j}{T_i})\left(1-(\frac{t_j}{T_i})\right)$$

Measurable predictions →

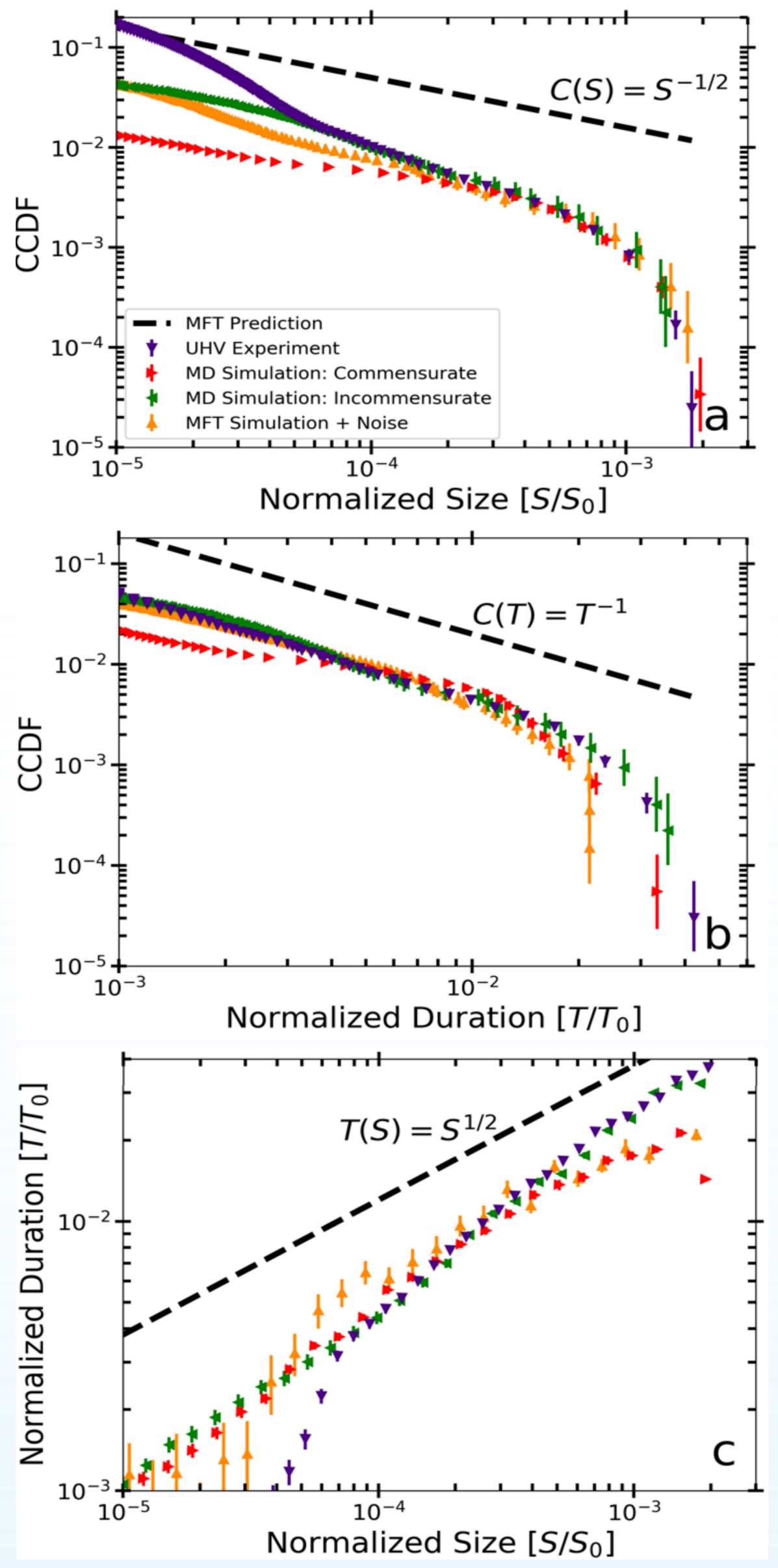
PDF~Histogram

$$\text{CDF(s)} = \int_0^s \text{PDF(s')}\, ds'$$

***still a power law; different exponent
A=3/2→1/2
B=2→1

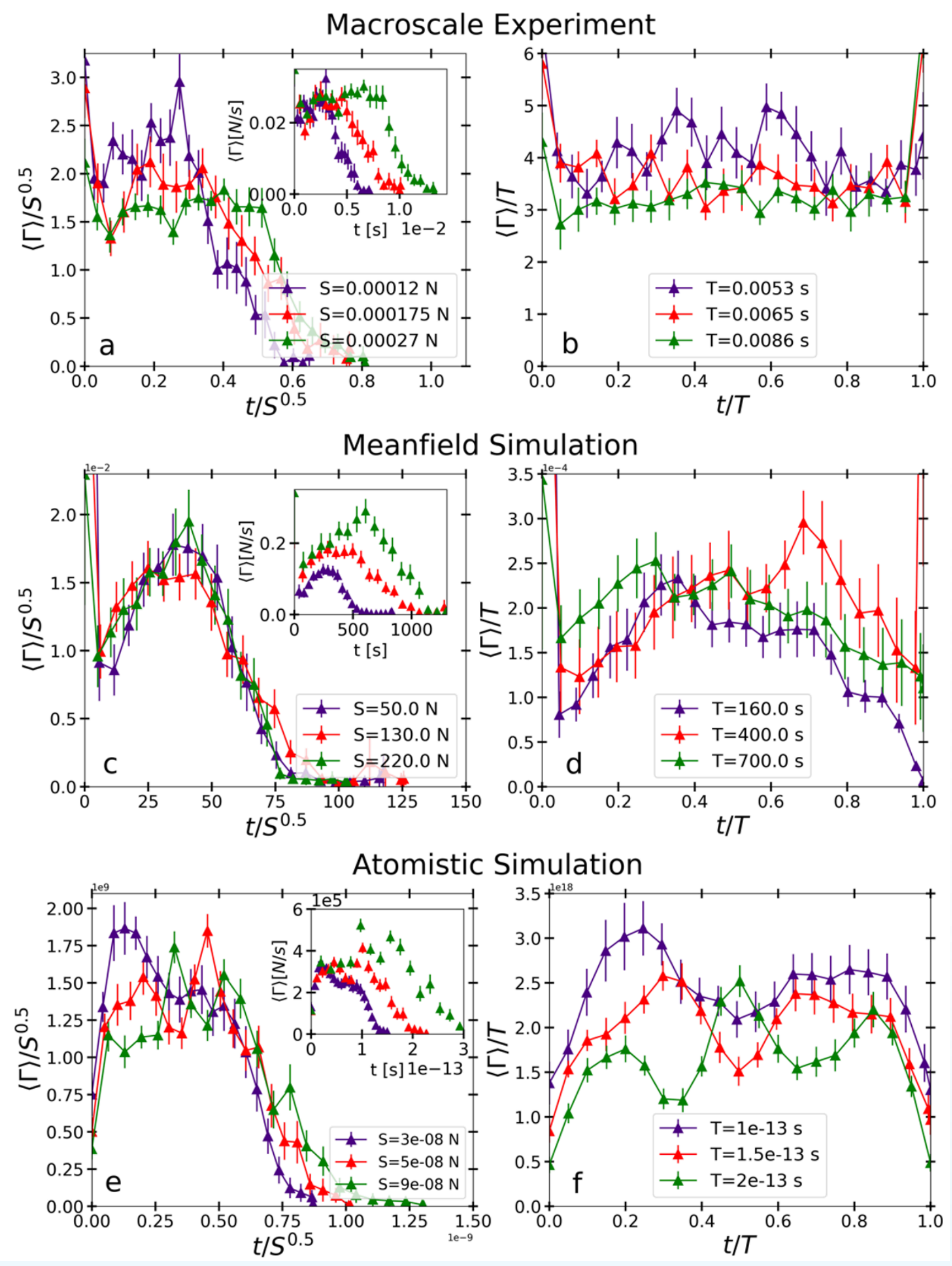


Current Status/ Results

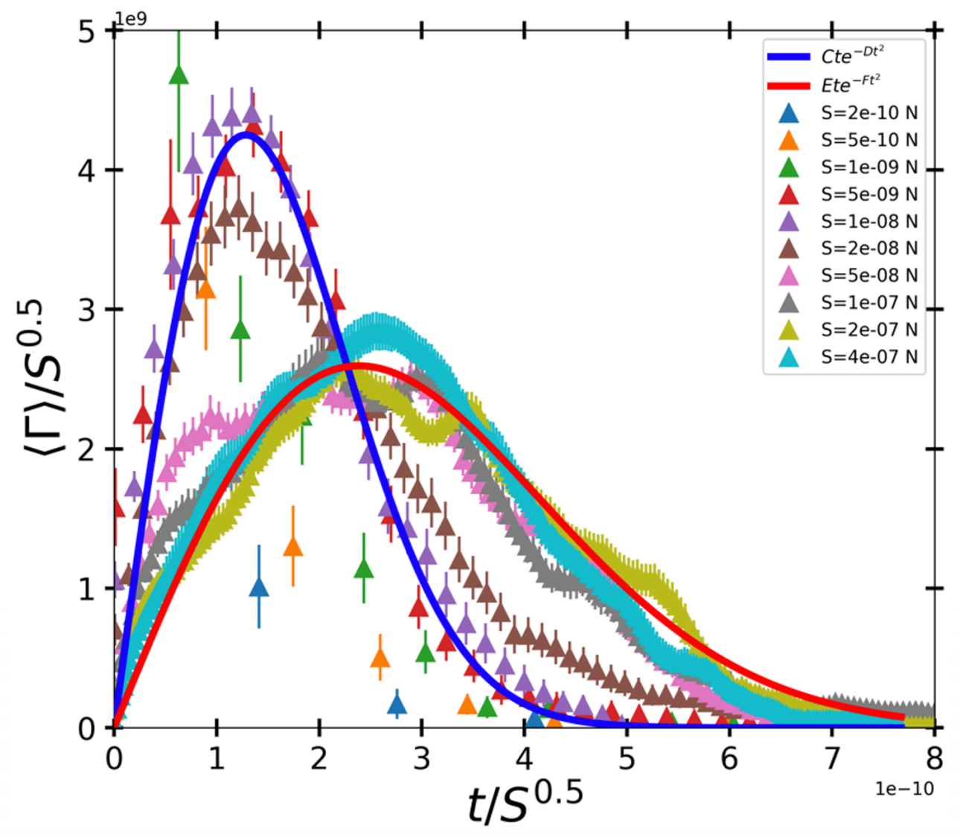


- ❖ Probability distributions of avalanche size and durations follow a power law for all systems
- ❖ The duration averaged in size follows a power law for all systems
- ❖ Averaged avalanche profiles can be collapsed onto each other
- ❖ Oscillations in the experiments and simulations disrupt the scaling regime
- ❖ Experimental apparatus can cause periodic noise that offsets the beginning of avalanche shape profiles (emulated by mean field simulations).

*** manuscript submitted for publication

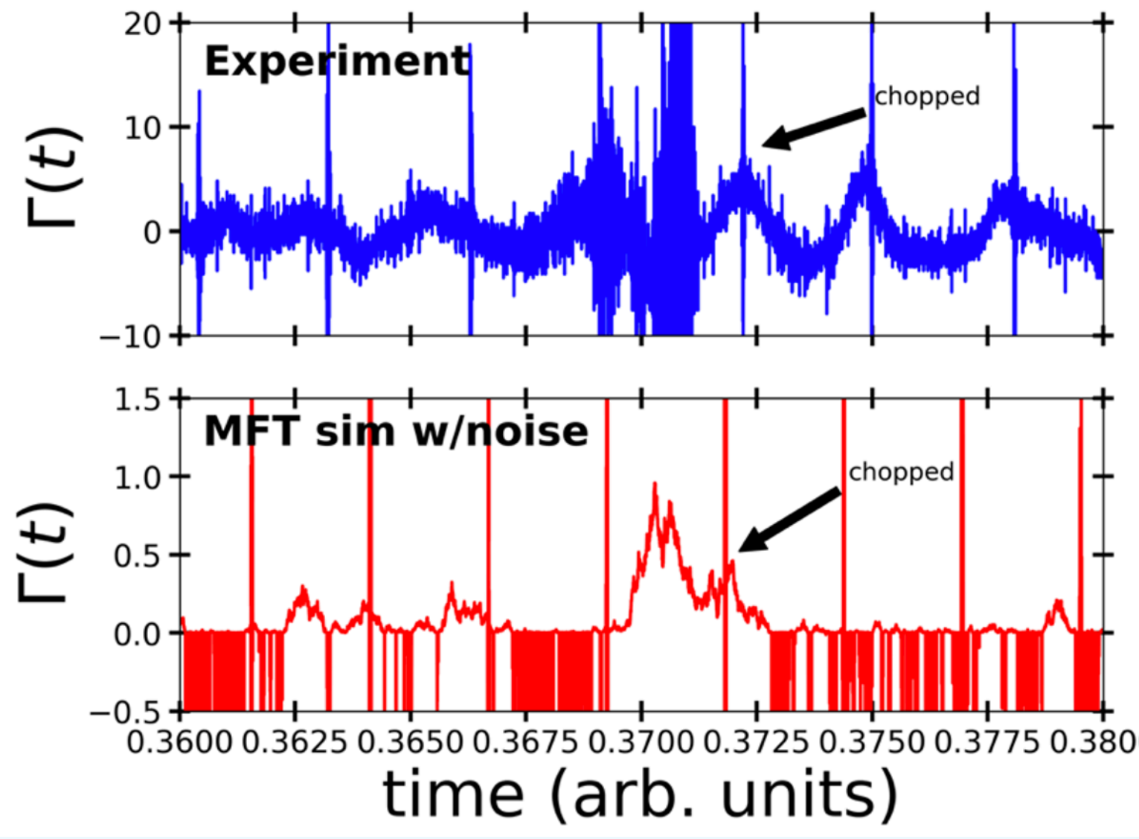


Challenges



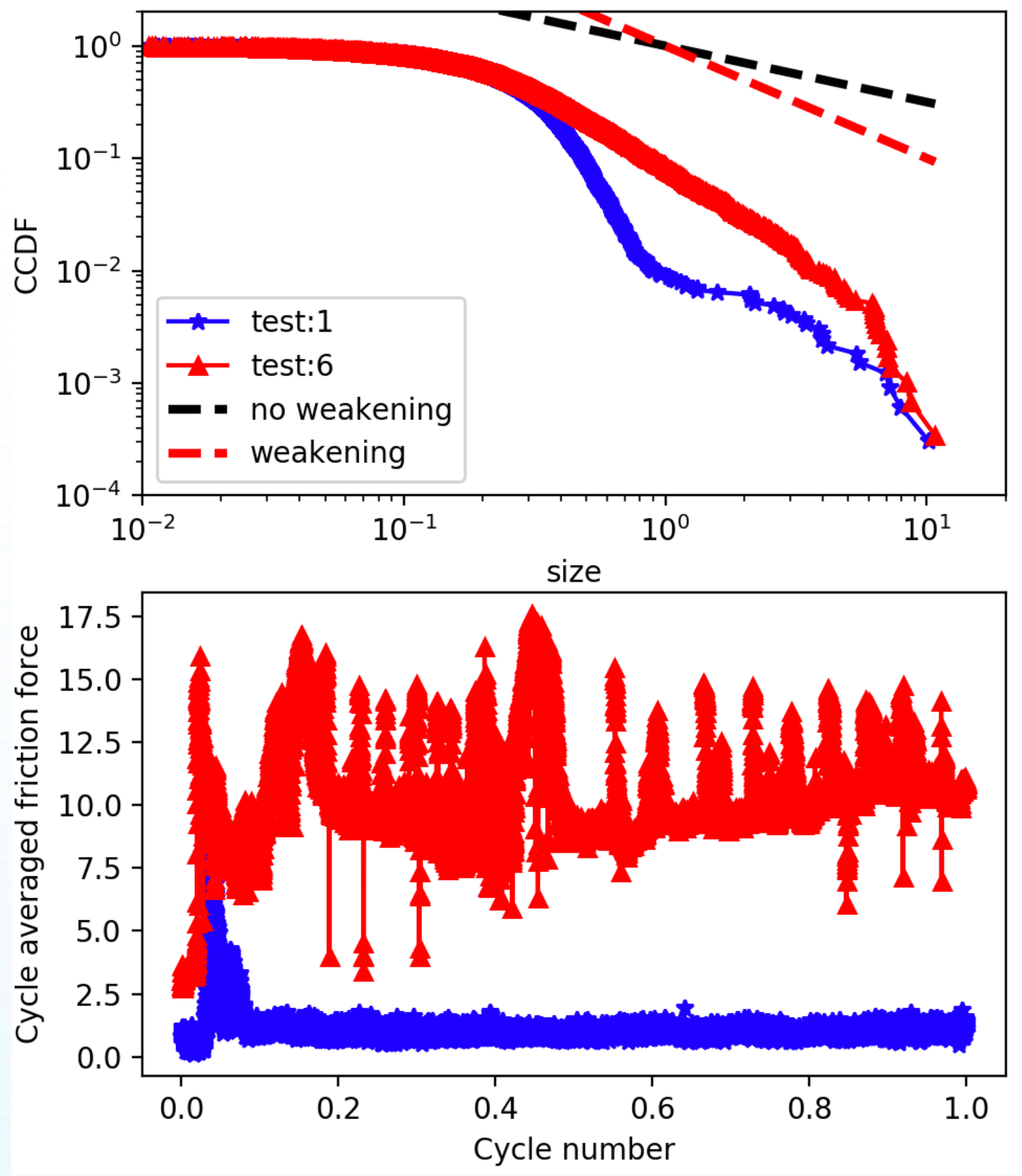
Oscillations

Periodic Noise



Next Steps / Future Work

❖Predictive modeling of frictional wear events with avalanche statistics



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