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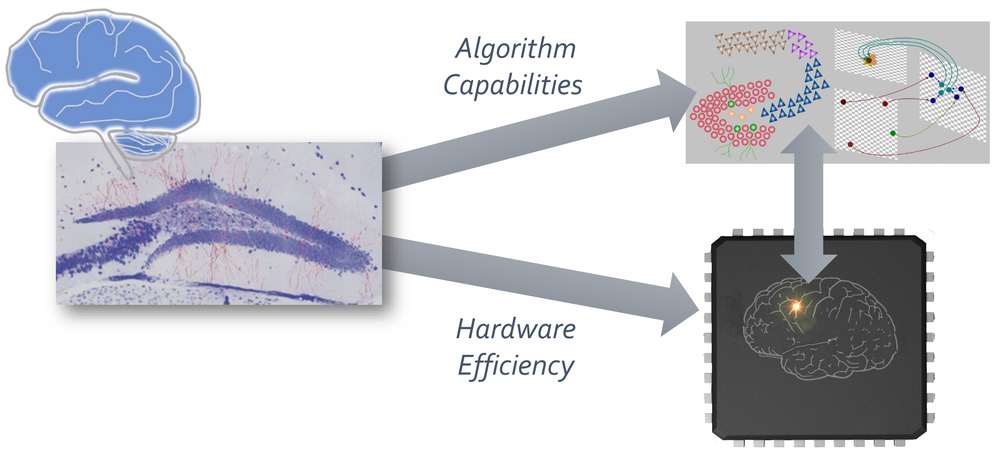
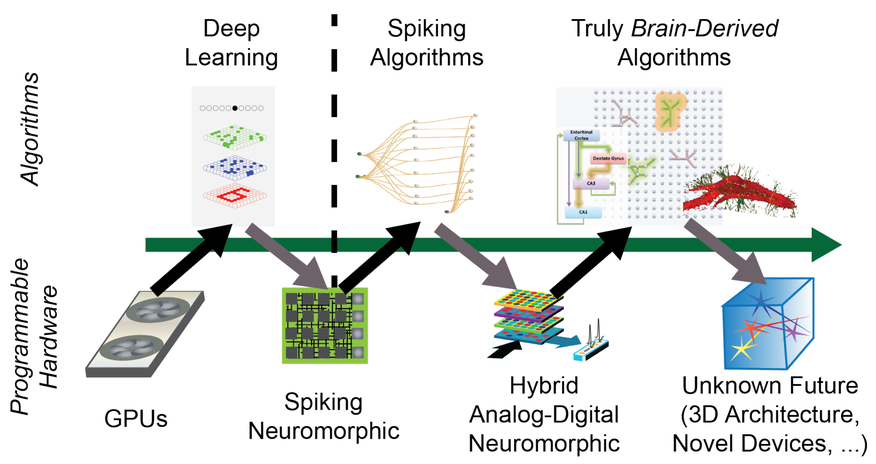
A Probabilistic Future for Neuromorphic Computing

Brad Aimone
Sandia National Laboratories
jbaimon@sandia.gov

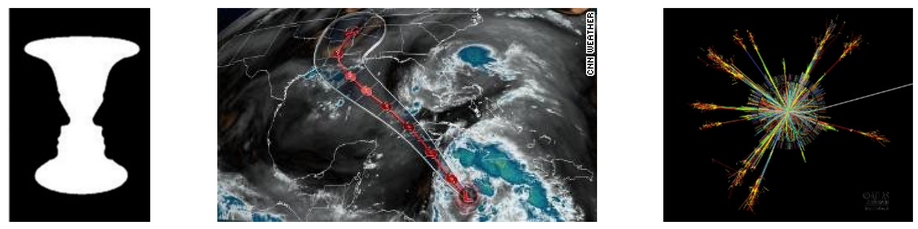
Neuromorphic Computing Captures Brain-Like Capabilities and Efficiencies



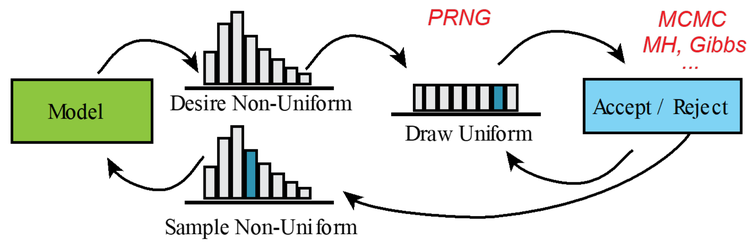


Aimone JB, Advanced Intelligent Systems, 2021

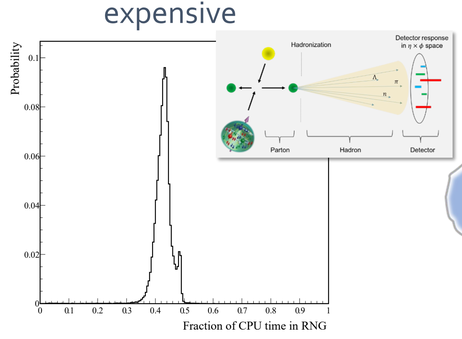
Many of Today's Computing Applications Leverage Randomness



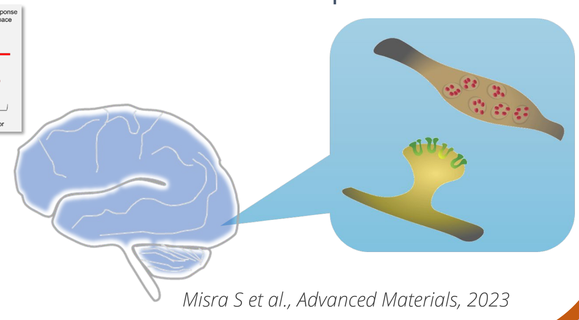
Today we use pseudo-random number generators to artificially generate "randomness" in computers



These PRNGs are extremely expensive

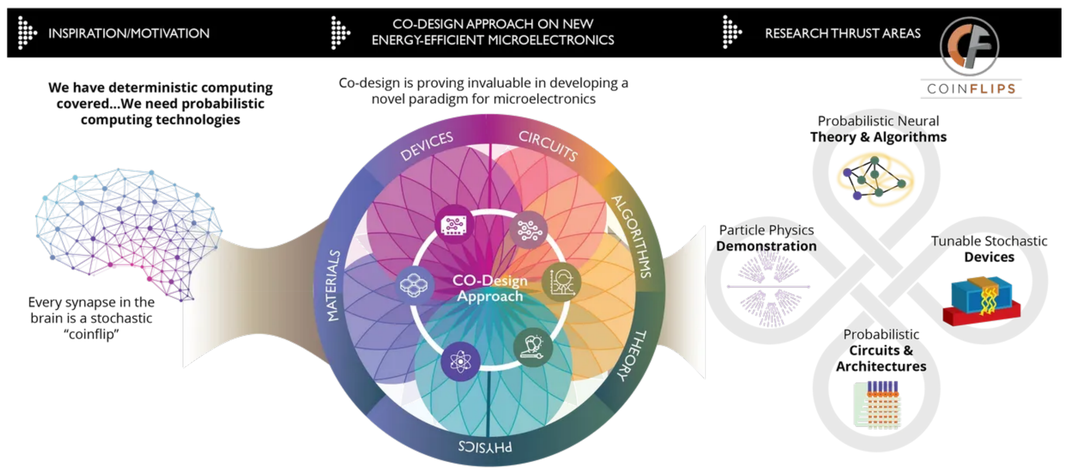


Our brain generates ~10^{15} random "coinflips" a second

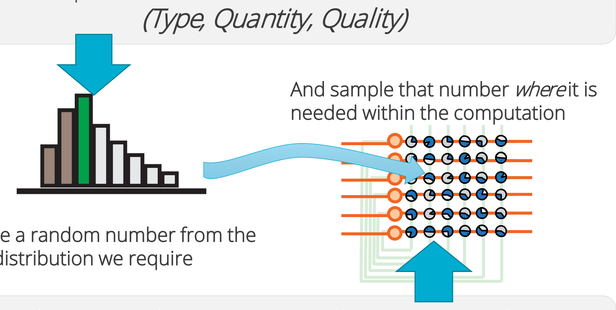


Misra S et al., Advanced Materials, 2023

COINFLIPS project aims to generate *true* random numbers from device physics and incorporate into neuromorphic architecture to maximize computational efficiency

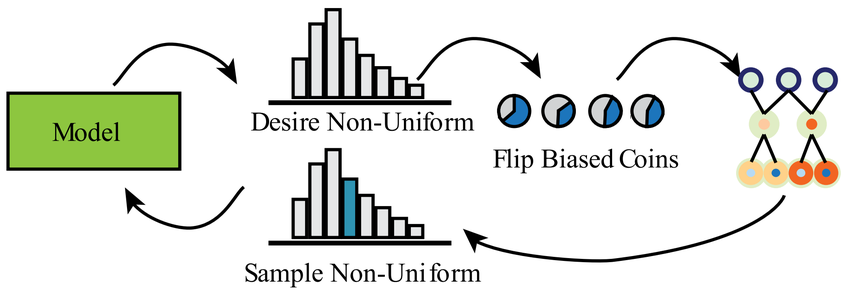


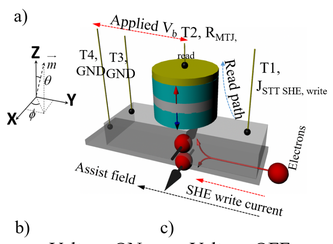
Improved Random Number Generation
(Type, Quantity, Quality)



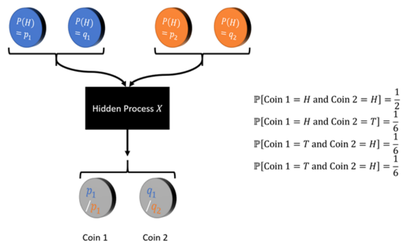
Architecture that integrates ubiquitous random numbers with computing and memory

Generate the *type* of random numbers that applications require





Example: Neuromorphic circuits can combine multiple coins with biases to fit any numerical probability distribution



$$\mathbb{P}[\text{Coin 1} = H \text{ and Coin 2} = H] = \frac{1}{2}$$
$$\mathbb{P}[\text{Coin 1} = H \text{ and Coin 2} = T] = \frac{1}{6}$$
$$\mathbb{P}[\text{Coin 1} = T \text{ and Coin 2} = H] = \frac{1}{6}$$
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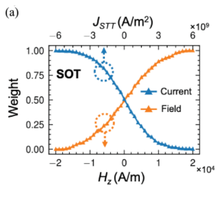
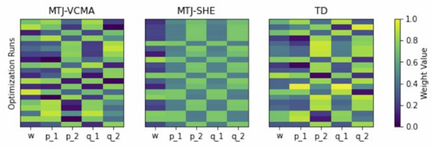
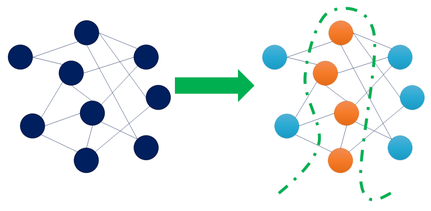


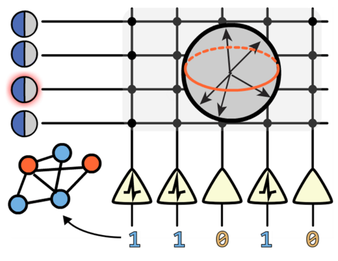


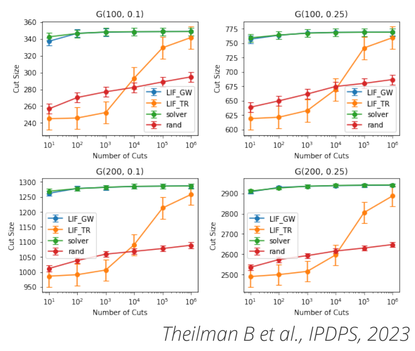
Cardwell S et al., IEEE ICRC, 2022

Can we compute and solve problems *differently* if random numbers are free?



Example: The Max Cut of a graph can be approximated using sampling. A neuromorphic circuit with stochastic devices can match theoretically guaranteed computer science algorithms





Theilman B et al., IPDPS, 2023

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