

AN ENERGY AND BANDWIDTH EFFICIENT RAY TRACING ARCHITECTURE

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The Goal

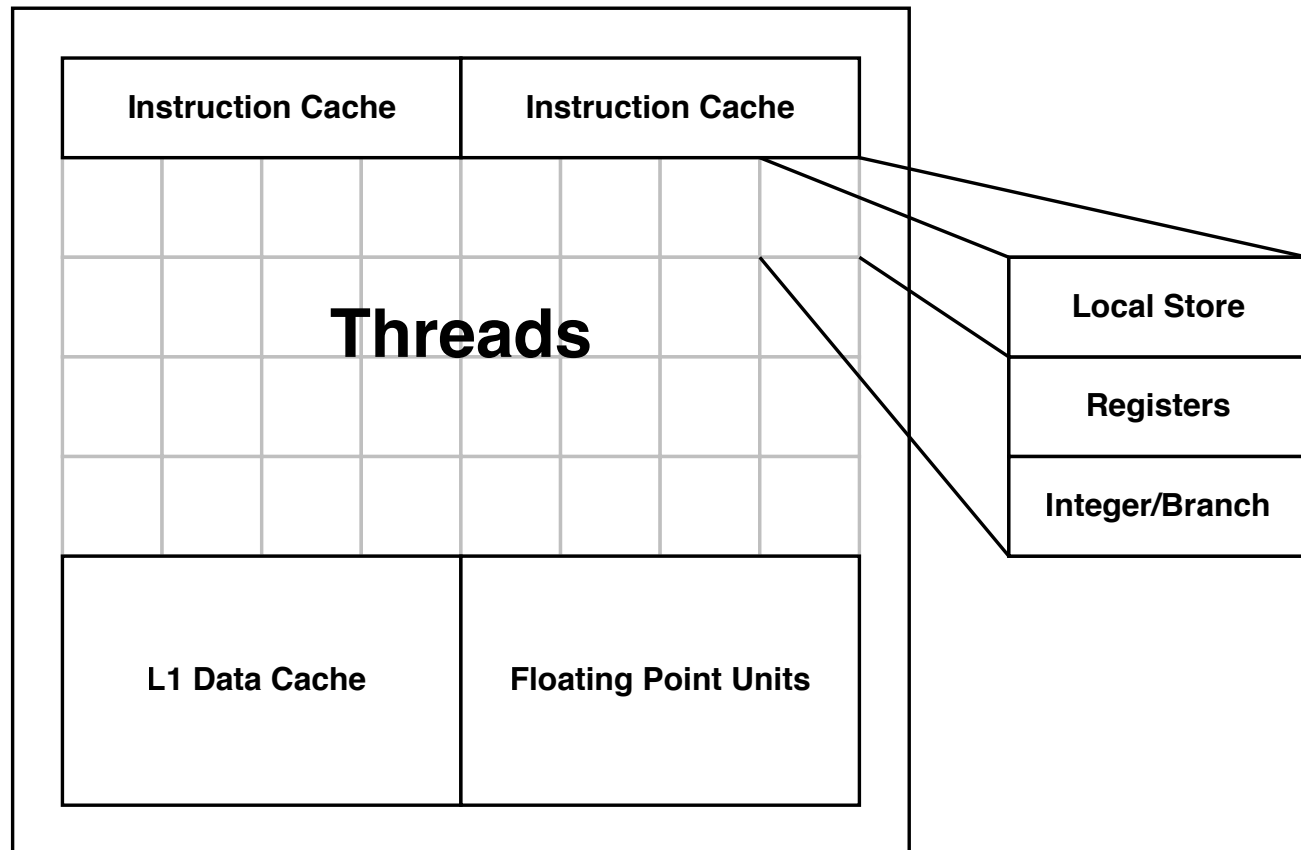
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- Can we reduce ray tracing energy consumption without hurting frame rate?

TRaX – SPMD Ray Tracing GPU

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- Cycle accurate simulator
- Tiled “Thread Multiprocessors” (TMs)

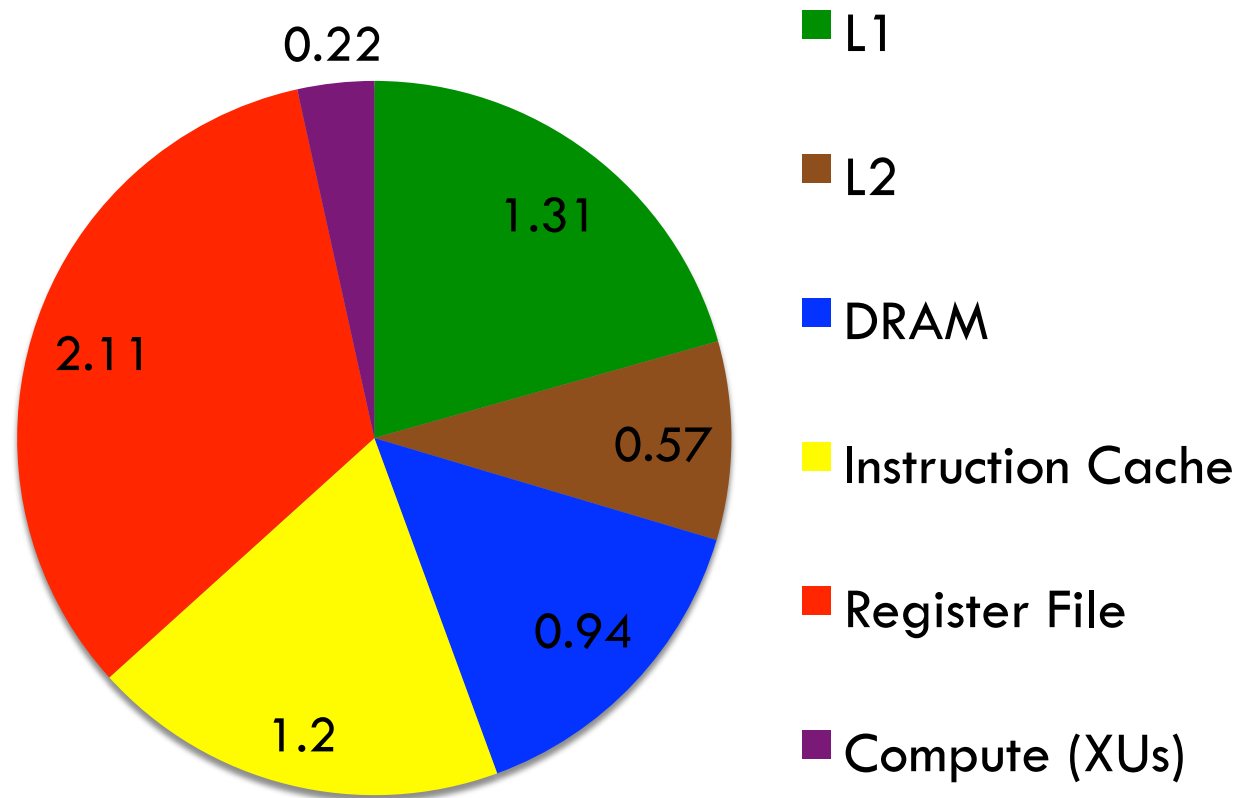


Where Does Energy Go?

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□ Energy estimates from Cacti and Synopsys

Energy/Frame (Joules)



~200 Watts at 30 FPS

What can we do?

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- Consider an ASIC
 - ▣ Great energy/delay, but not flexible

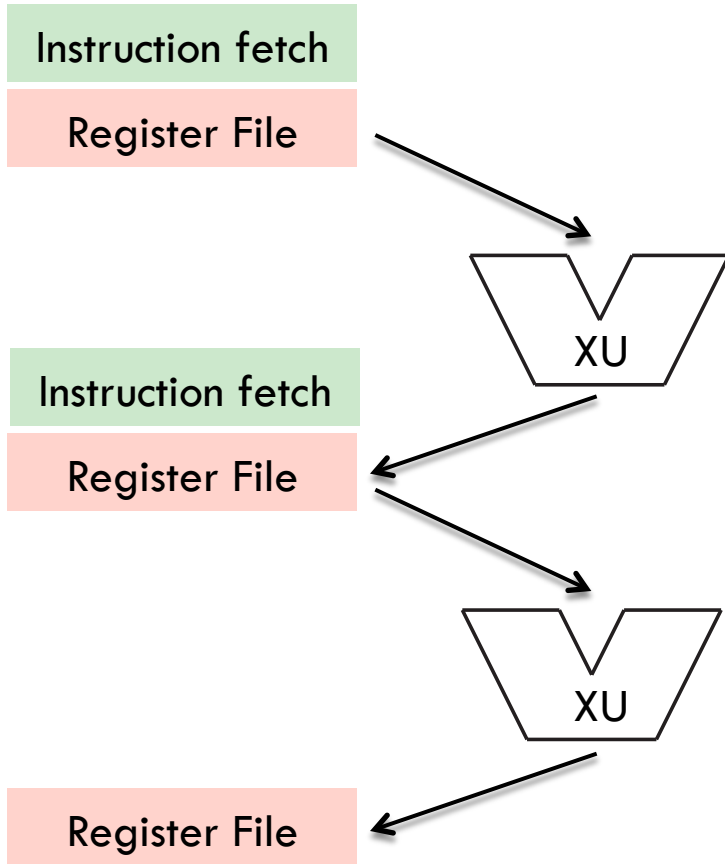
- Configurable persistent pipelines
 - ▣ Almost as good, but more flexible

- Coherent data access
 - ▣ Stay in pipeline mode longer
 - ▣ Reduce bandwidth requirements

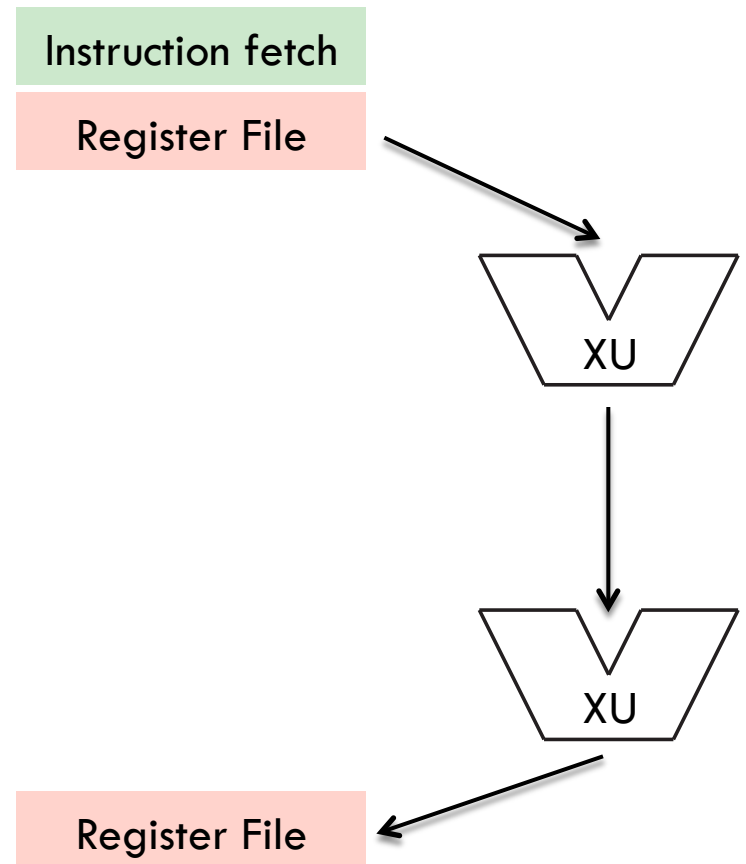
Macro Instruction Pipelines

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General Purpose

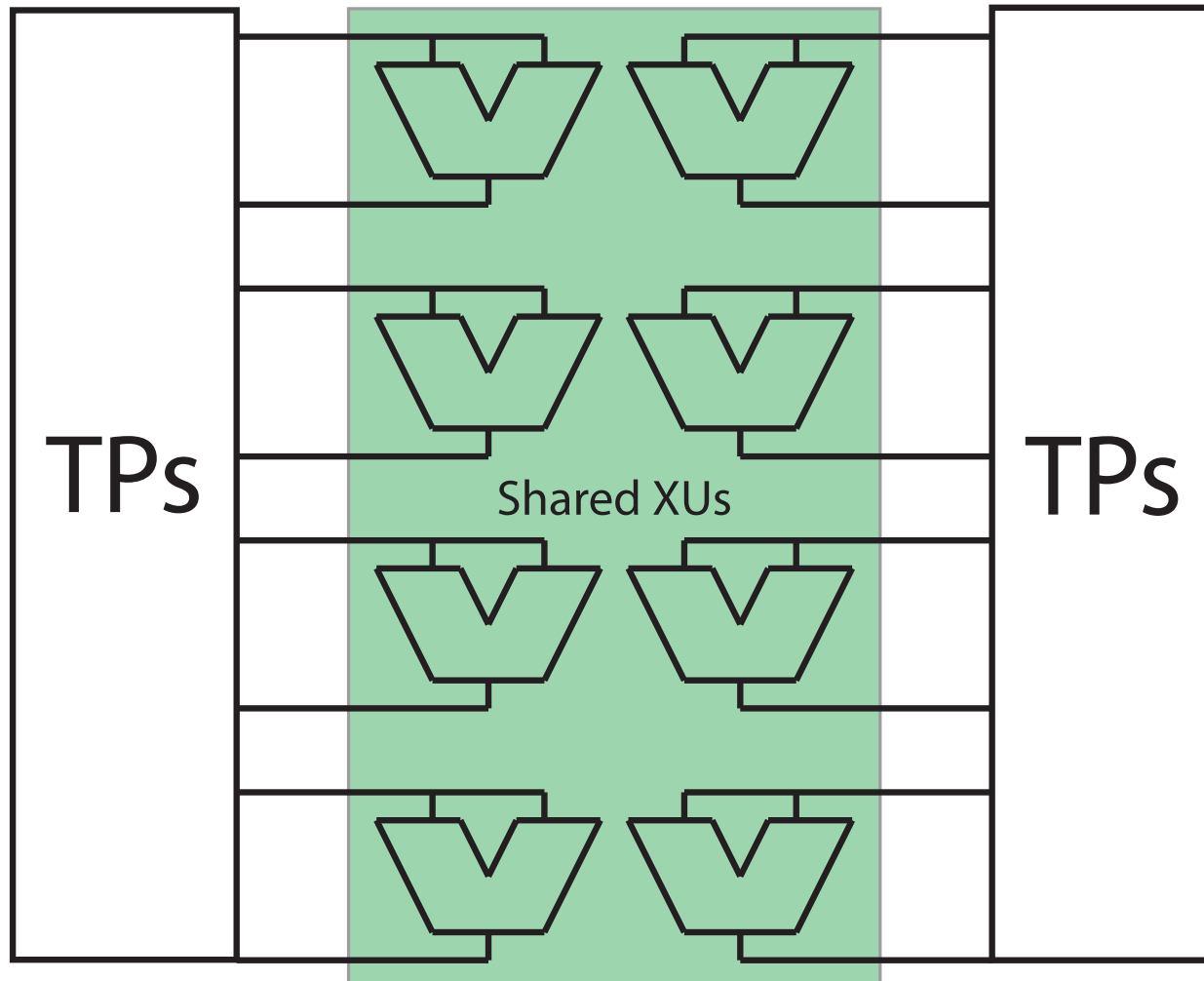


Reconfigurable Pipeline



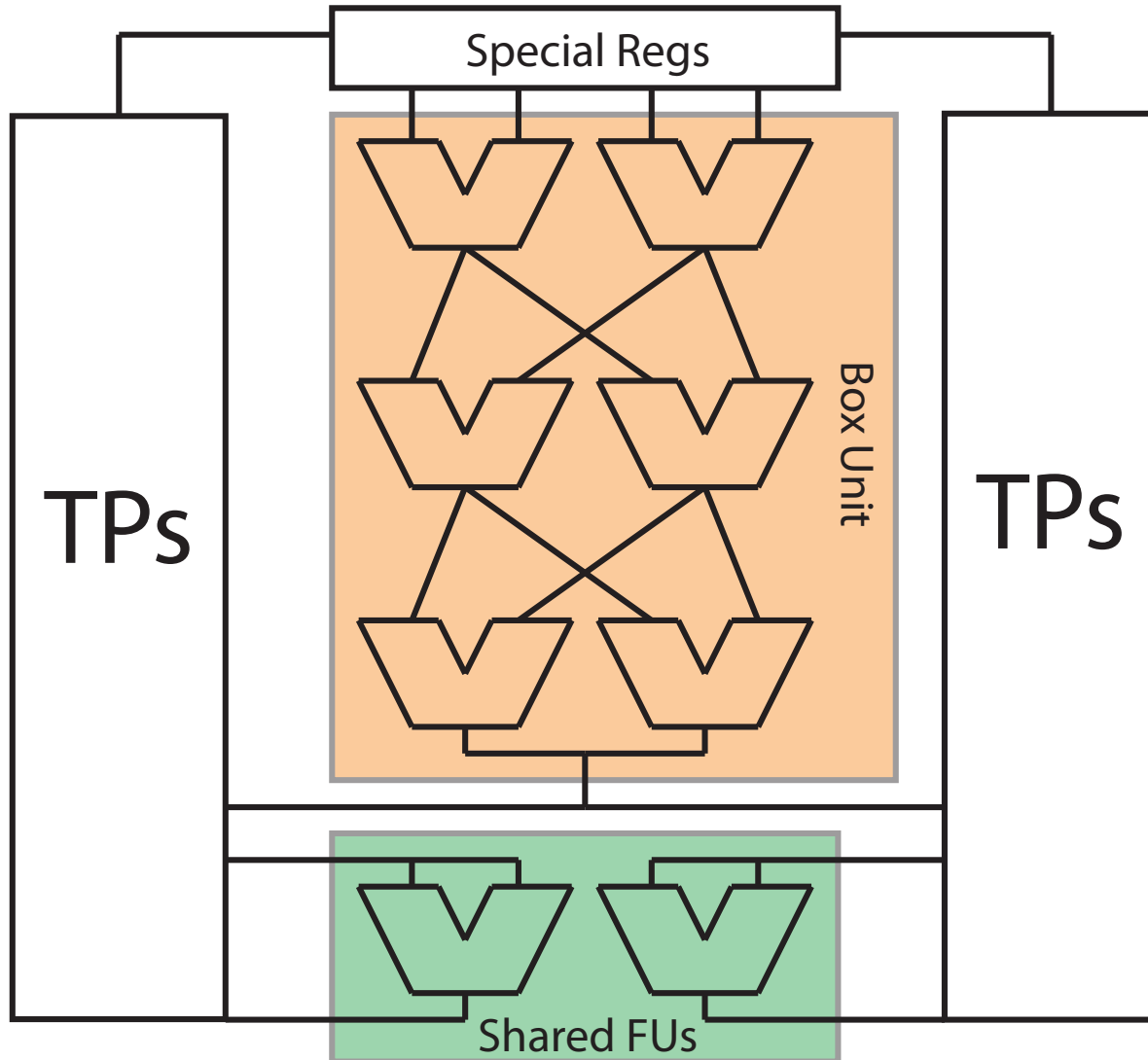
TRaX™

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Reconfigured Pipeline

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Pipeline Persistence

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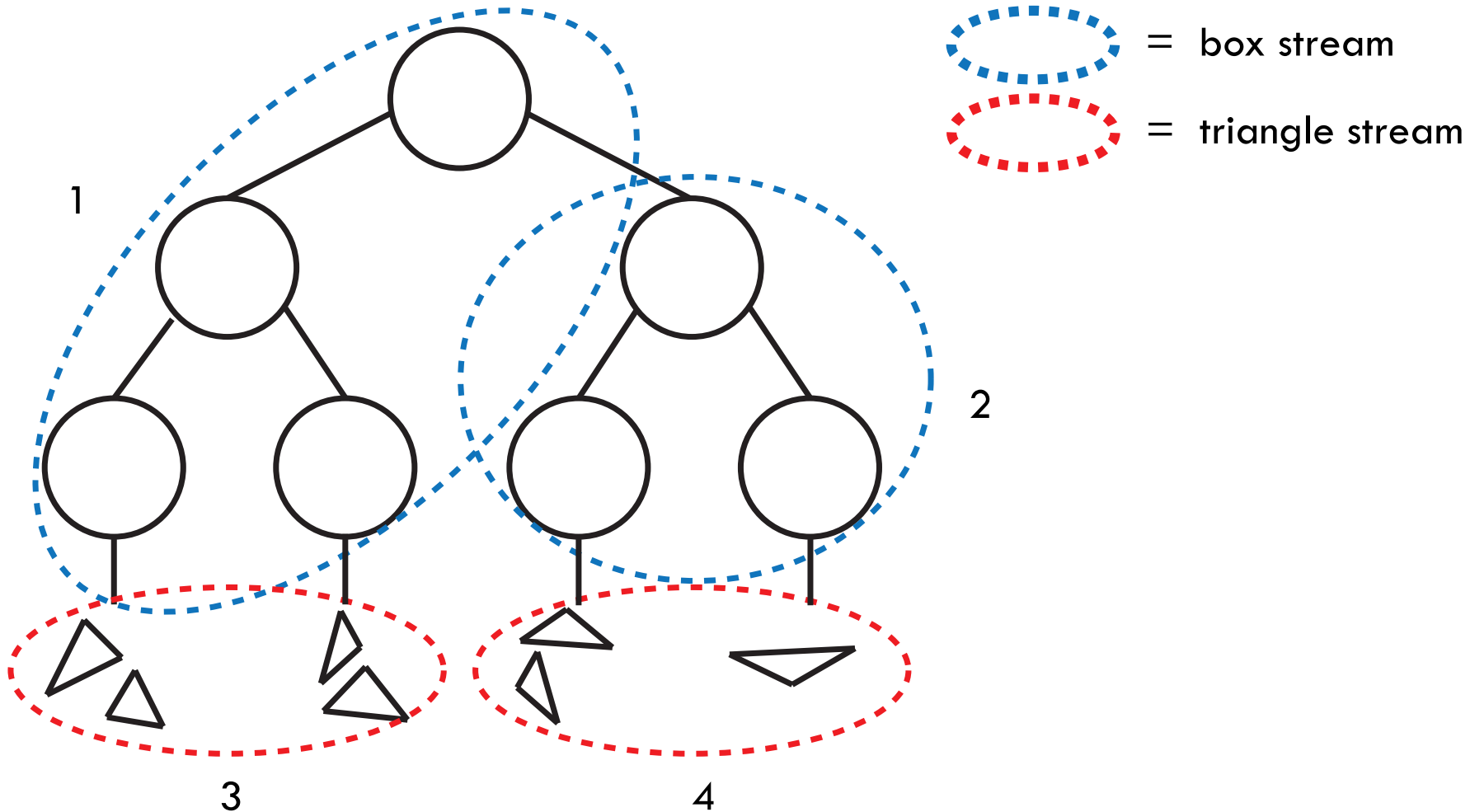
- Opportunities in RT
 - ▣ Box test (traversal)
 - ▣ Triangle test (intersection)
 - ▣ Others?

- Streaming, Ray sorting, etc...
 - ▣ StreamRay: Gribble, Ramani, 2008, 2009
 - ▣ Treelet decomposition: Aila & Karras, 2010

Treelets

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- Sized to fit in L1 cache



- Streaming Treelet Ray Tracing Architecture

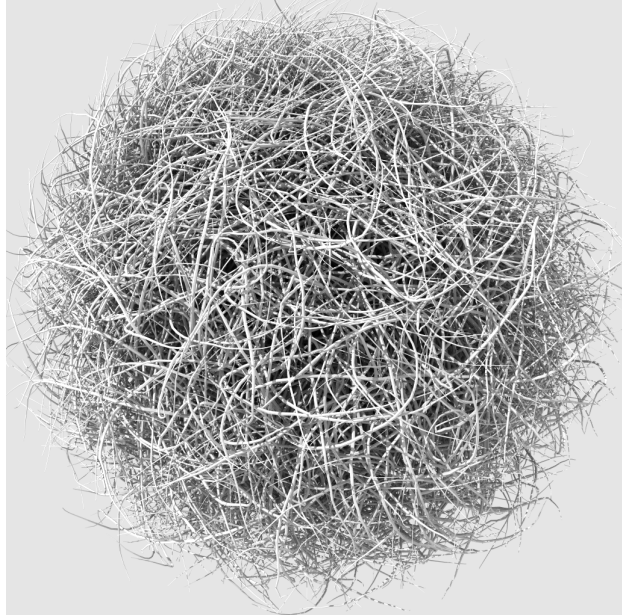
- HW support for treelet ray streams
 - Repurposes most of L2 cache
 - L1 hit rate increases, off-chip access decreases

- Enables pipelines to persist longer
 - Reduce instruction fetch and register access

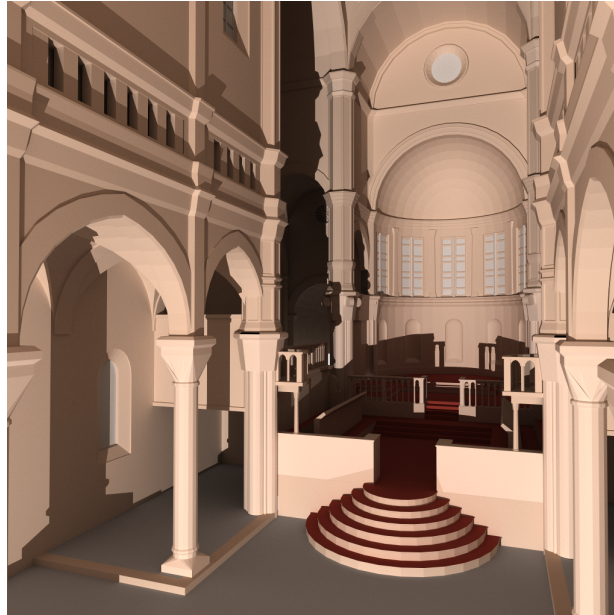
Test Scenes

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Hairball



Sibenik

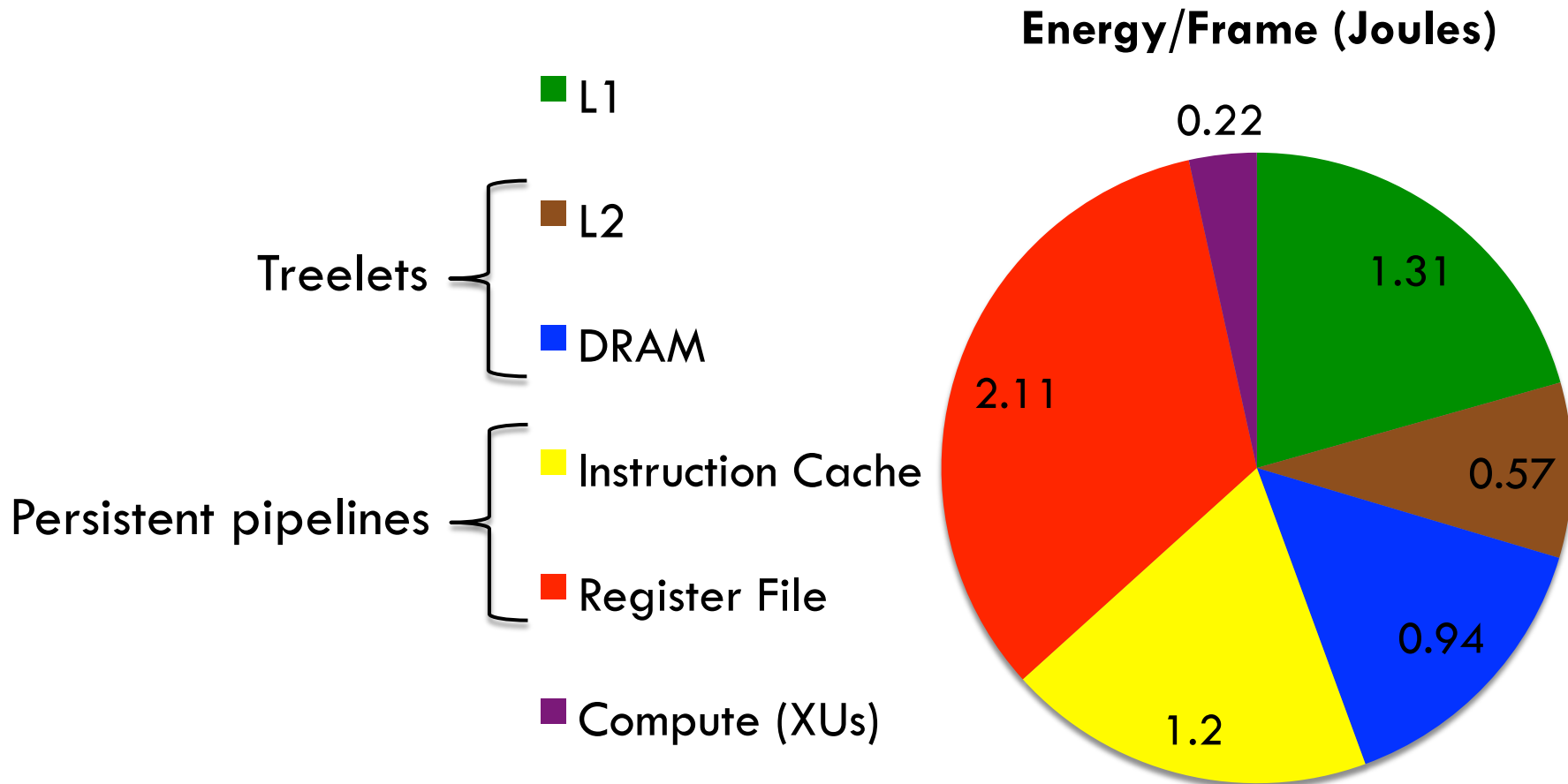


Vegetation



Where Does Energy Go?

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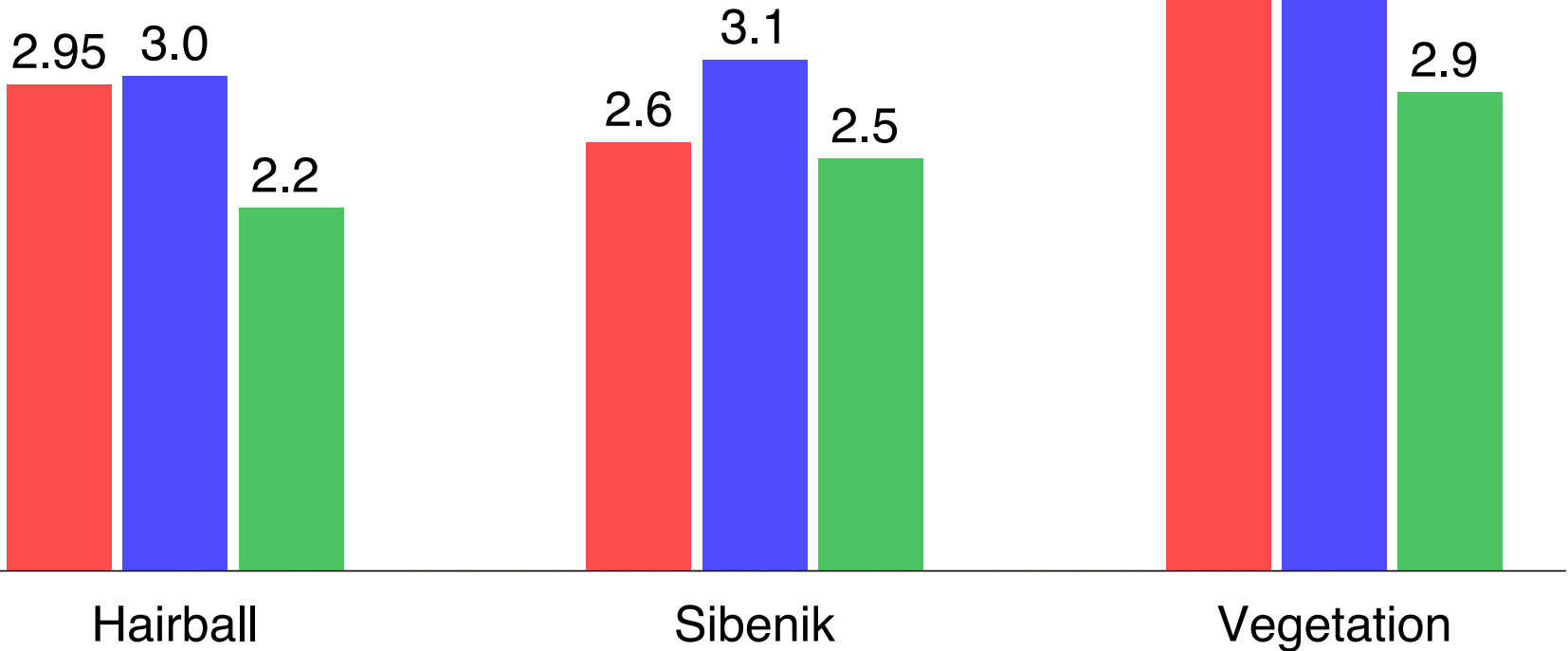


Results (ICache + RF)

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I\$ + Register File energy (Joules)

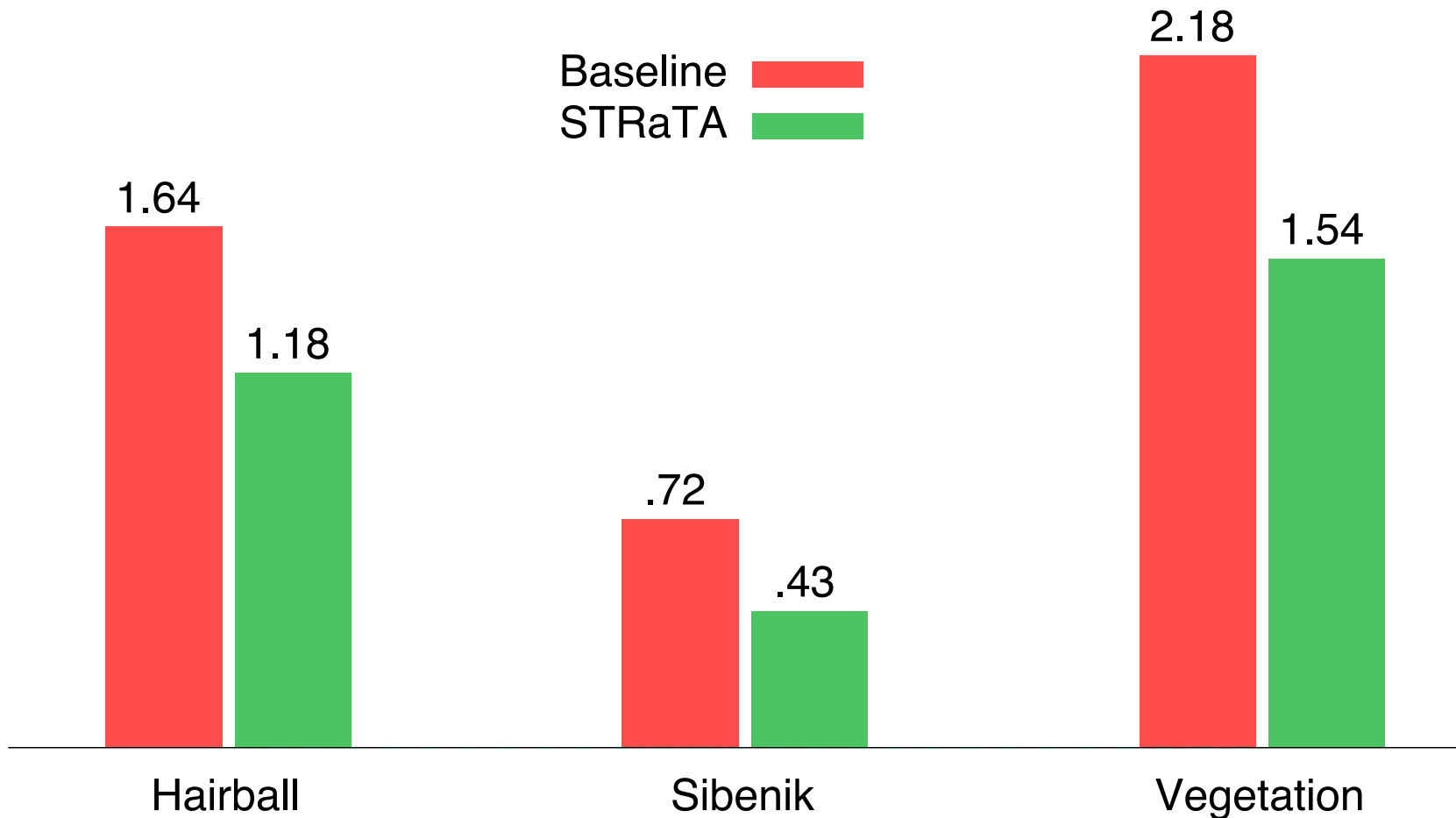
Baseline █
 Treelets Only █
 STRaTA █



Results (L2 + DRAM energy)

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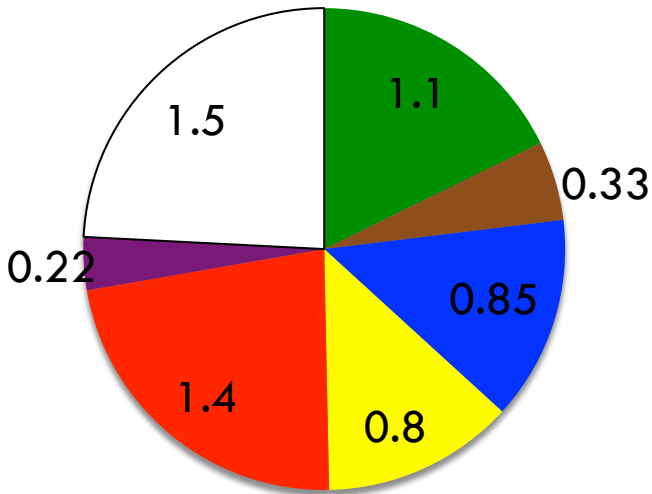
L2 Dcache + DRAM energy (Joules)



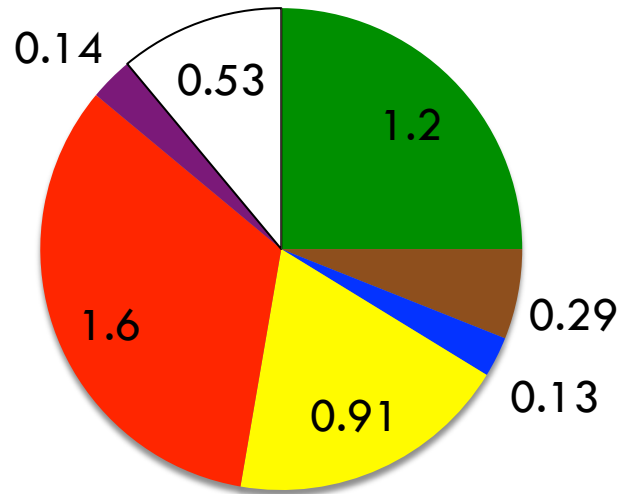
Results

Energy/Frame (Joules)

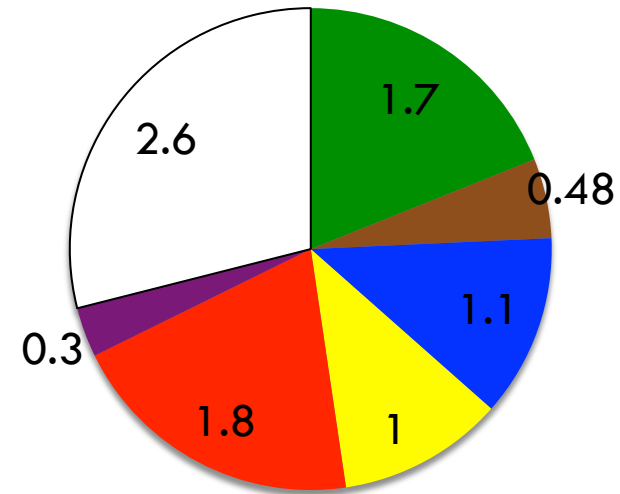
Hairball



Sibenik



Vegetation



■ L1

■ Instruction Cache

□ Saved

■ L2/Stream

■ Register File

■ DRAM

■ Compute (XUs)

Conclusions

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- Up to 38% combined energy reduction
 - ▣ (memory hierarchy, I\$, RF)

- No significant change in performance

- Simple HW/SW modifications

Thanks!

Thanks to:

Samuli Laine for Hairball and Vegetation,
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Anonymous reviewers

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