ON ENERGY EFFICIENCY AT CERN

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On energy efficiency at CERN

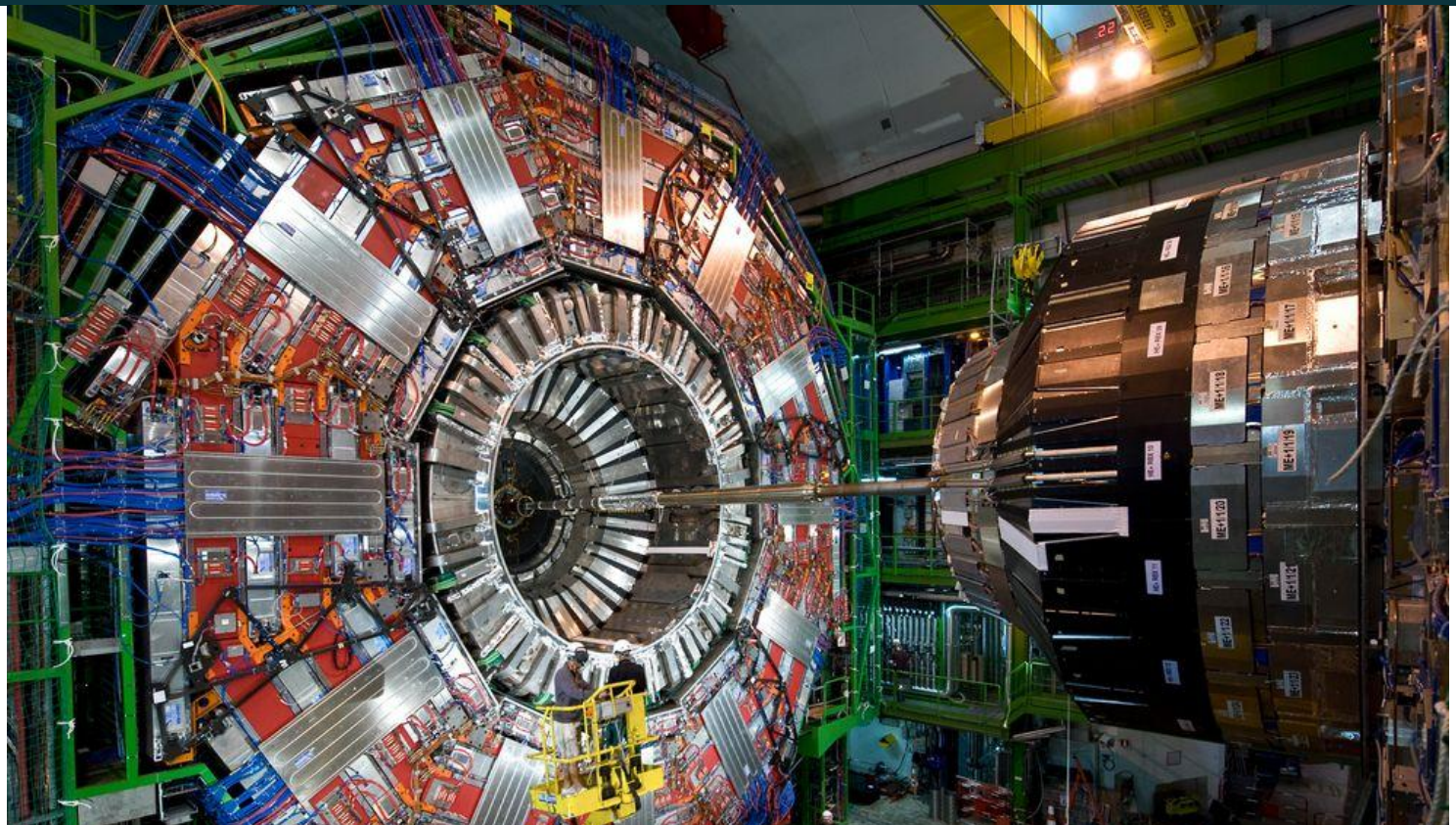
CERN & energy consumption: Higgs boson and the future

Smartphones and High Physics Computing ?

Measuring energy consumption

Energy consumption or speed: a tradeoff

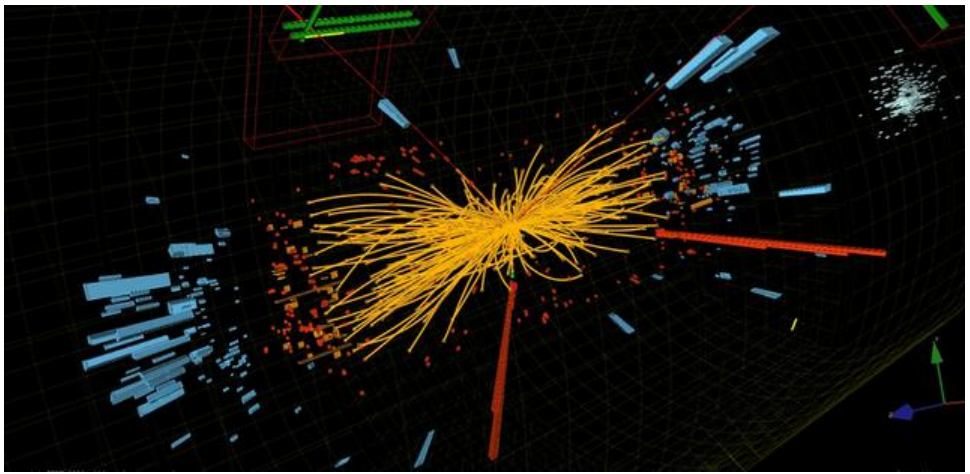
CERN & energy consumption: Higgs boson and the future

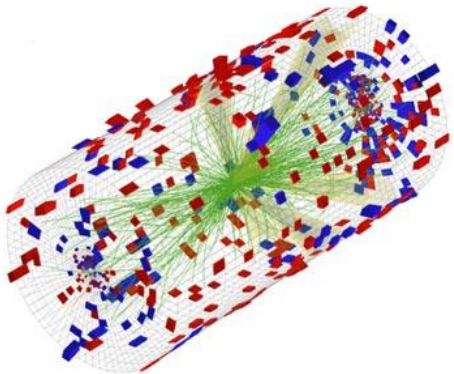


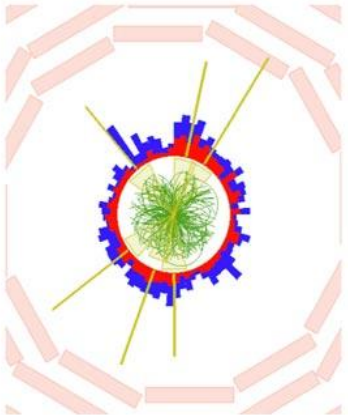
lots of events

CERN & energy consumption: Higgs boson and the future

Lots of **data** (1 Petabyte/s → 200 MB/s)







CERN & energy consumption: Higgs boson and the future

In 2012, the Worldwide LHC computing grid *equivalent capacity* of

80,000 to **100,000** x86-64 cores

result: Higgs Boson tracked down

Future

data will increase **2** - **3** orders of magnitude

processing power in proportion

How to decrease electricity bill ?

Smartphones and High Physics Computing?

Are smartphones' CPUs

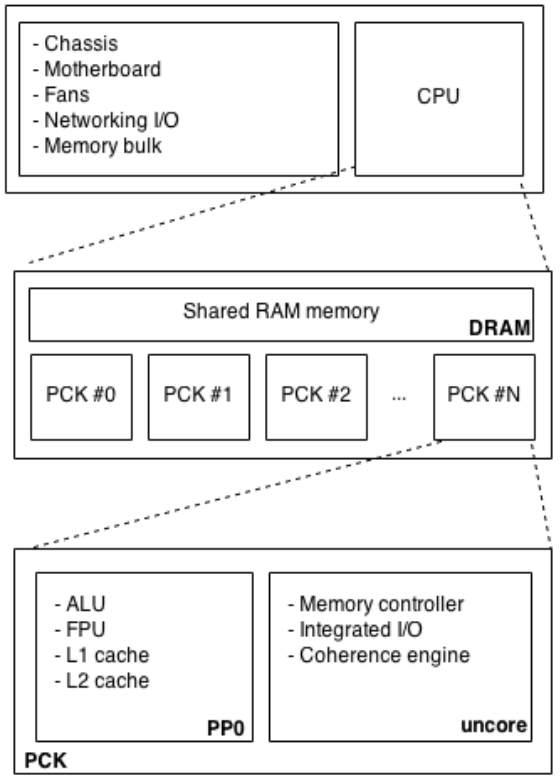
the future of High Throughput Processing ?

Measuring energy consumption

Techniques and **tools** for measuring energy consumption are *needed* ...

Measuring energy consumption

… and systems are **complex**



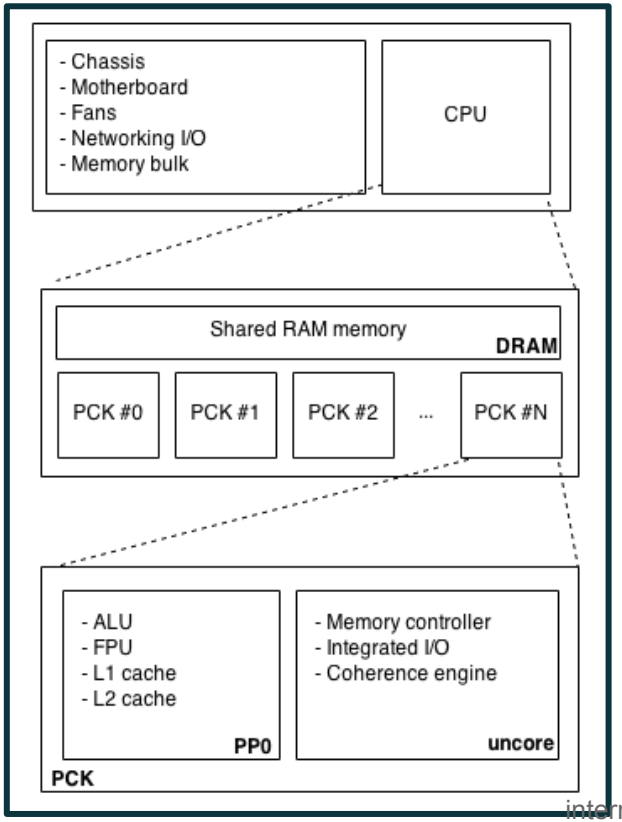
several layers and granularities

external

Measuring energy consumption

External measurements

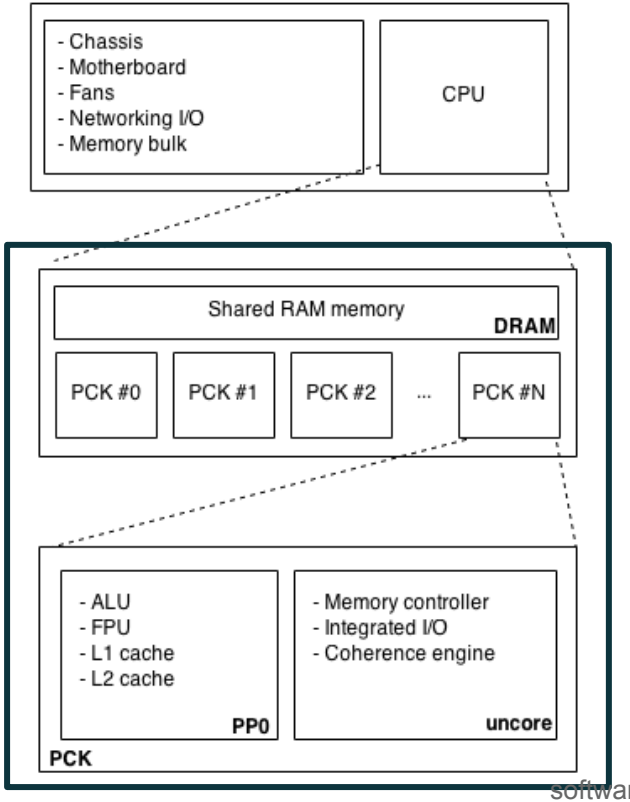
Power consumed without breaking down the system into components



Measuring energy consumption

Onchip measurements

Power consumed by different components of CPU



Energy consumption or speed: a tradeoff

Software-based measurements

Such as **IgProf**, which was extended with energy consumption features.

Smartphones and High Physics Computing?

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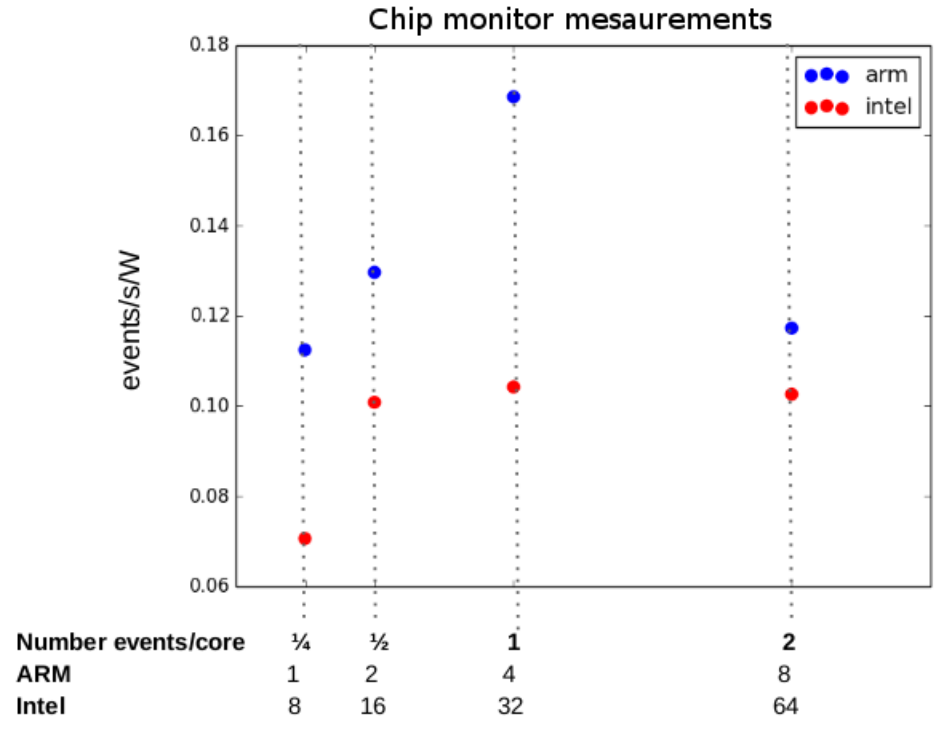
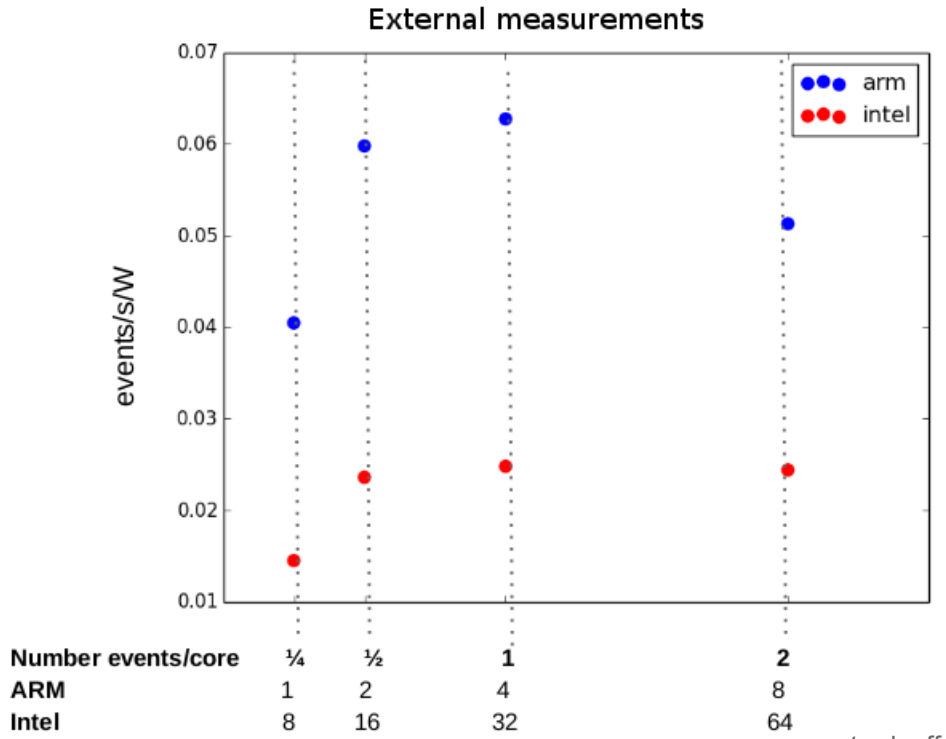
Measuring energy consumption





tradeoff

Energy consumption or speed: a tradeoff

energy efficiency

vs

speed

Wrapping up

Energy efficiency is needed

How to measure energy consumption in complex systems ?

ARM shows potential for HPC …

… but *tradeoffs* are important to consider

Vague but exciting ...

CERN DD/OC

Tim Berners-Lee, CERN/DD

Information Management: A Proposal

March 1989

Information Management: A Proposal

Abstract

This proposal concerns the management of general information about accelerators and experiments at CERN. It discusses the problems of loss of information about complex evolving systems and derives a solution based on a distributed hypertext sytstem.

Keywords: Hypertext, Computer conferencing, Document retrieval, Information management, Project control

Q & A

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backup

IgProf

IgProf

application profiler developed at CERN by the CMS software team

general purpose. open source. not experiment specific
measures performance (time spent in functions) and memory usage at *runtime*

allows developer to understand:
- bottlenecks
- where code needs to be optimised

cross platform: recently ported to 64-bit ARM, also supports 32-bit ARM, Intel x86 and x86-64

IgProf & energy profiling

Uses RAPL and PAPI to measure energy consumed.

Map functions and low level operations with **energy consumption**

more info (strategies, results, examples)
paper** and **http://igprof.org/

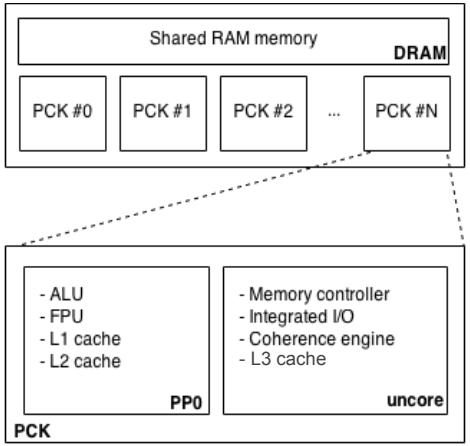
RAPL

Running Average Power Limiting *(RAPL) by Intel*

Provides a platform for power monitoring and power limiting of SoC.

Different sampling **domains**

package *(PKG),* DRAM, core



Low level measurements	package, cores, dram
Resolution	according to Intel, sampling frequency up to ~1 kHz
Power capping	is also supported by RAPL
Accuracy	high (according to *Intel*)

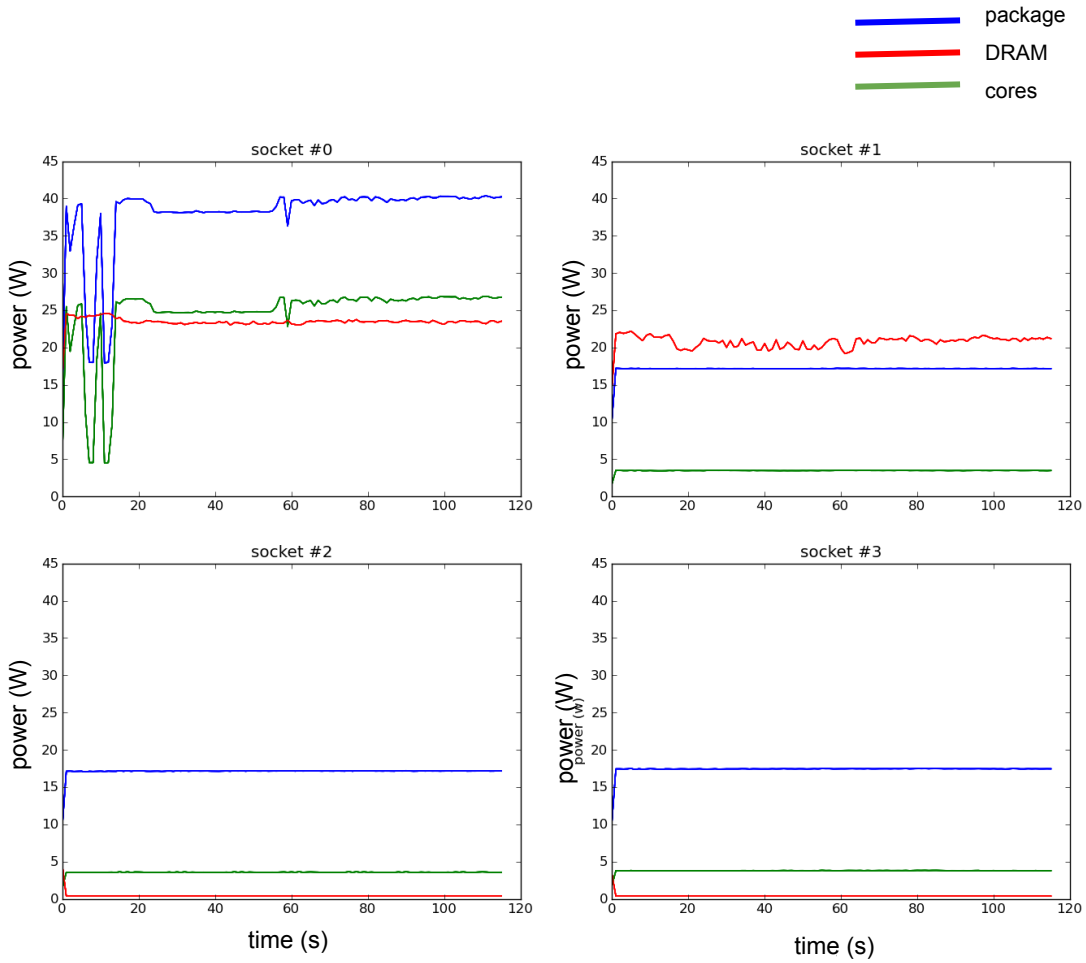
Example of RAPL

System with 4 sockets

Sockets #0 and #1 working

Sockets #2 and #3 idle

Possible to understand how **packages**, **cores** & **dram** consume energy



Comparison ARM vs Intel

Comparison ARMv7 vs Intel XEON

32bit ARMv7 is used on smartphones. comparison with Intel XEON

measurements

Internal

RAPL for *Intel*

cross platform *chip monitor* integrated (TI INA 231) for ARMv7

External

workload

ParFullCMS

Multithreaded

Geant4 benchmark application

Uses the CMS geometry

ARMv7 Exynos5 Octa Cortex™
4x A15 @ 1.6Ghz and/or A7 cores (big.LITTLE technology)
2 GB RAM
ARMv7/32bit
development board

Intel **32x** Intel™ Xeon™ CPU E5-2650 @ 2.00GHz
252 GB RAM
system on a rack