Welcome to ESC19

the 11th INFN International School on

"Architectures, tools ad methodologies for developing efficient large scale scientific computing applications"

Oct. 21-26 2019

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On behalf of:

The Italian Institute for Nuclear Physics (INFN)

- Bologna, CNAF, Padova sites
- providing most of the support

The University of Bologna, Department of Physics

The lecturers, the tutors

- and their Institutions

Attendance this year

- 10 participants from ten foreign Institutions
  - 6 from Europe + India, Mexico, Bahrein
- 16 from Italian Institutions

The site

Bertinoro and hospitality

Bertinoro is a nice medieval village, famous for its **hospitality** and therefore quite well suited as a location for a center like CeUB

- the name most likely comes from **"Castrum Brittinori"** (XIth century) and it is probably due to the frequent stops pilgrims coming from Britain, in their way to Rome, used to take in the quiet surroundings of Bertinoro.
- one of the monument in Bertinoro known as **Colonna delle Anelle** ("Column of the Rings" or "Column of hospitality") is a column in white stone with 12 rings erected in 1300 by the noble families to express **their commitment to hospitality**.
  - Each one of the rings corresponded to one family;

    foreigners arriving in town, could select the family to be hosted, by **tying** the horse bridles to the corresponginds ring

but still today...

- Bertinoro still hosts a "**Hospitality Festival**". Held in between August and September (30/8 – 1/9 in 2019), it includes an entire night of music, dances and events (between Friday and Saturday), some historic commemorations and the final Hospitality Rite (Sunday late morning).
- In this ceremony visitors **can be hosted** for lunch by a family in the town simply **taking one of the envelopes** tied to the rings of the Hospitality column (which inside has the name of the hosting family).
- you will not get this opportunity this week, but I'm sure you will at least enjoy the **good food and wine** that Bertinoro will offer to you while you are staying here

CeUB: University Residential Center of Bertinoro

Visit of the fortress and the Interfaith museum
Tuesday afternoon

CeUB: the facilities

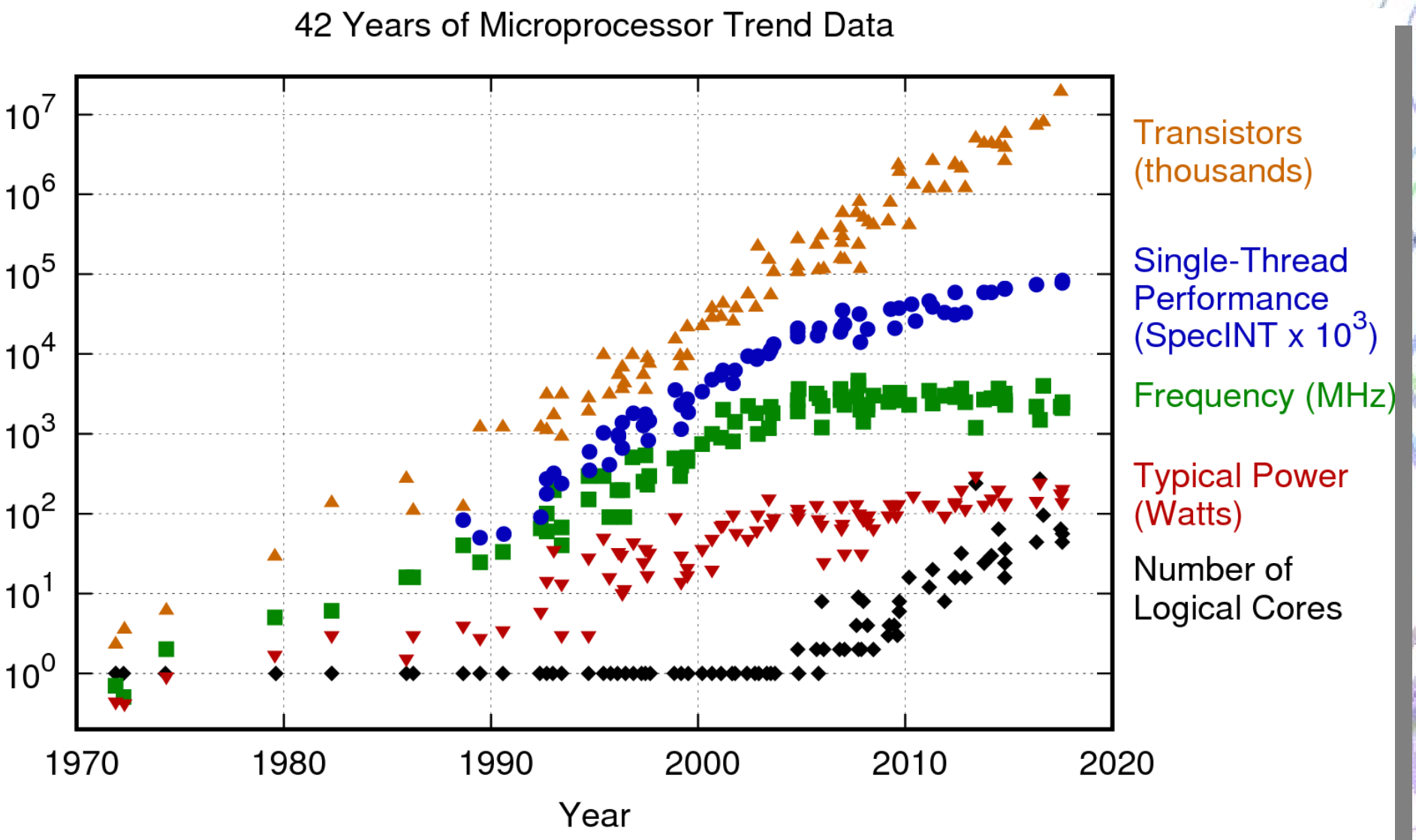
- the Center was brought back in use with renovation work that started in 1991 in the fortress and in the guest house, followed by integration of additional buildings
- today the Center offers:
  - **14 lecturing/meeting rooms** inside the Bishop's Fortress, the Rivellino, St. Sylvester church and the Theatre;
  - **2 computer labs**, 20 and 50 seats;
  - **86 bedrooms** (single, twin, double), for a total amount of 130 beds;
  - a **canteen with 200 seats** for breakfast, lunch and gala dinners.
- **120+ events** per year
- up to **30.000** daily presences per year

Why this School

The context

- High Energy Physics has been **heavily relying** on computing since long
  - for many years the scale of resources needed by HEP experiments was such that the computing centers of the hosting lab **were copying well** with the core computing data processing needs
    - the UA1/2 experiments that discovered the Z and W bosons at CERN were good examples
- the model started to break at the end of the last century when experiments, like the BaBar experiment at the SLAC B-factory, had to deal with a **huge amount of data** and the computing power had to be scaled up by more than one order of magnitude w.r.t. **the initial estimates**
  - the investment needed started to grow very significant
  - for the first time it was felt necessary to distribute the processing of the data stored on tape to en external center

The end of the free ride



Original data up to the year 2010 collected and plotted by M. Horowitz, F. Labonte, O. Shacham, K. Olukotun, L. Hammond, and C. Batten
New plot and data collected for 2010-2017 by K. Rupp

Complex systems may not behave as expected

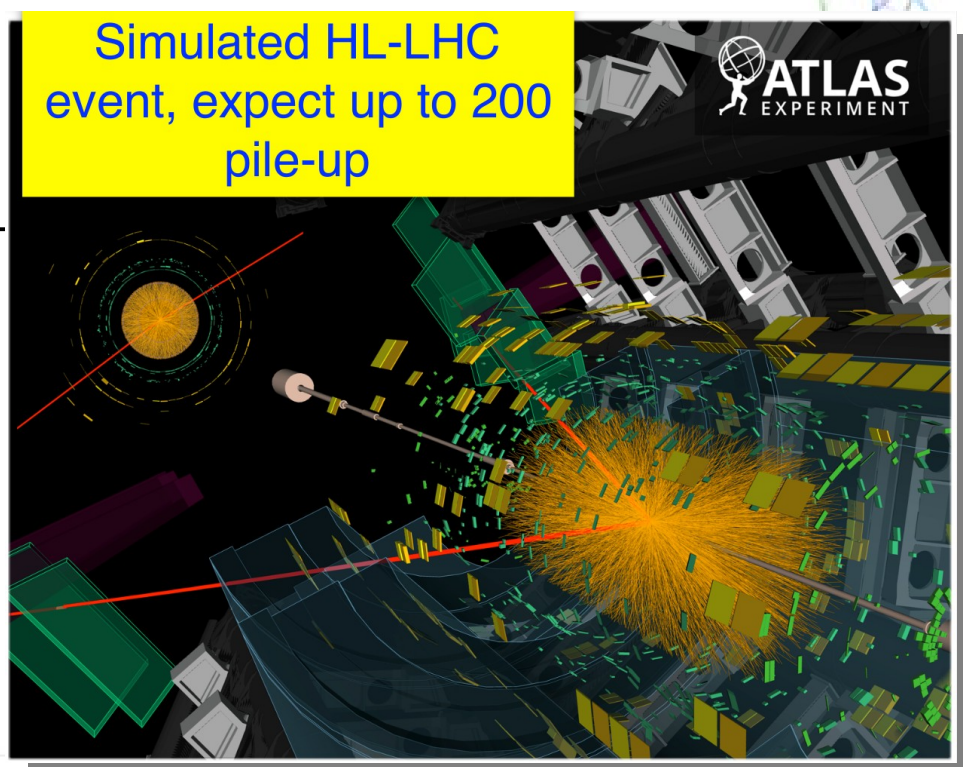
- an example from a LHC experiment of how CPU efficiency may drop when real data come in

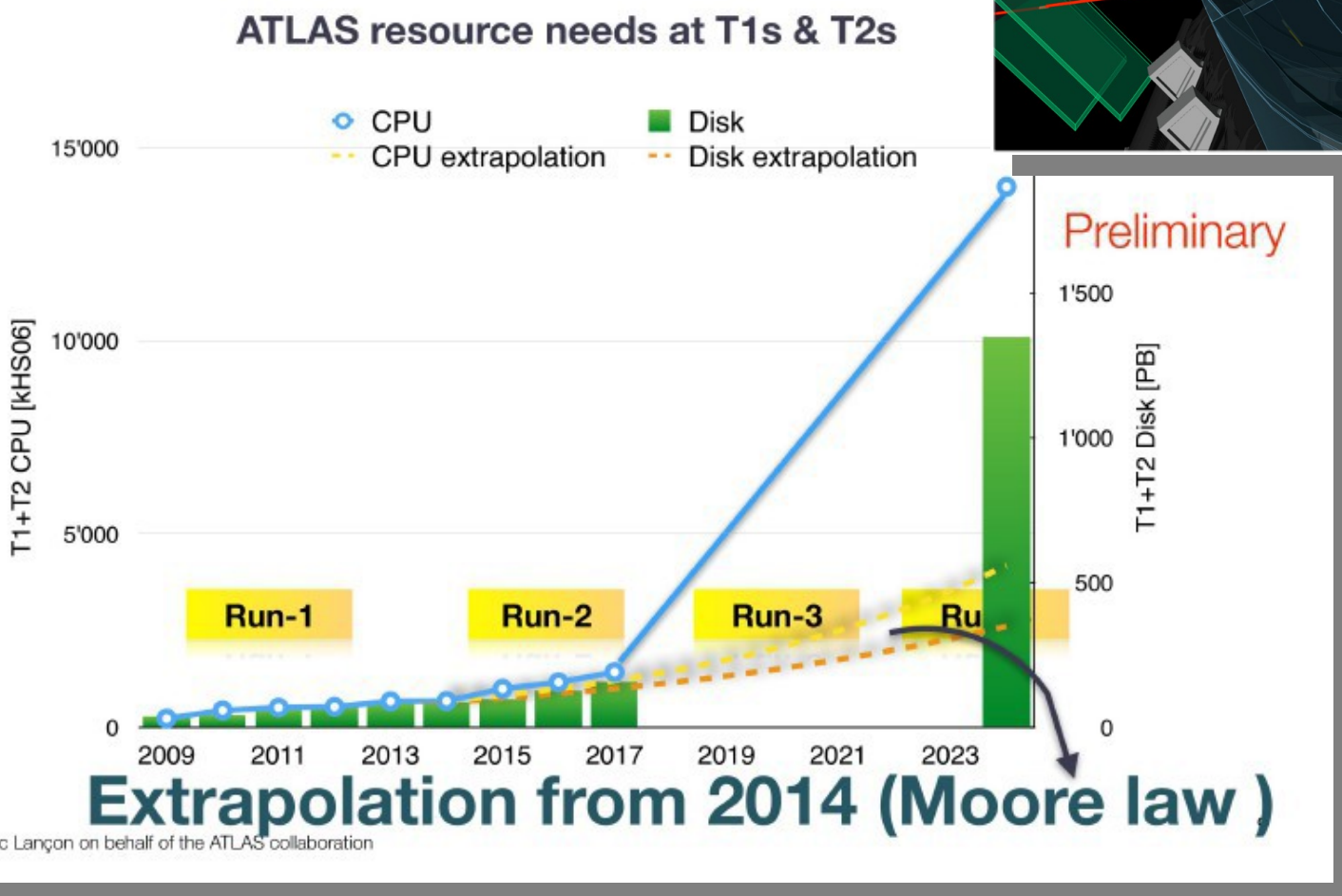
Why a School about "efficiency"

- The conception of this school was motivated by the awareness that **efficient usage of computing resources** in our field:
  - **had to be taken seriously,** given the level of computing investment now required
  - in the past **was not always well understood** and taken into proper consideration
  - **was becoming more and more challenging** due in particular to the physical constraints in increasing scalar performance and the attempts to exploit anyway Moore's law with new processor architectures
    - many cores, co-processors, GPU, vector units, etc
    - memory access getting more and more critical
    - ….

Future will be more challenging...

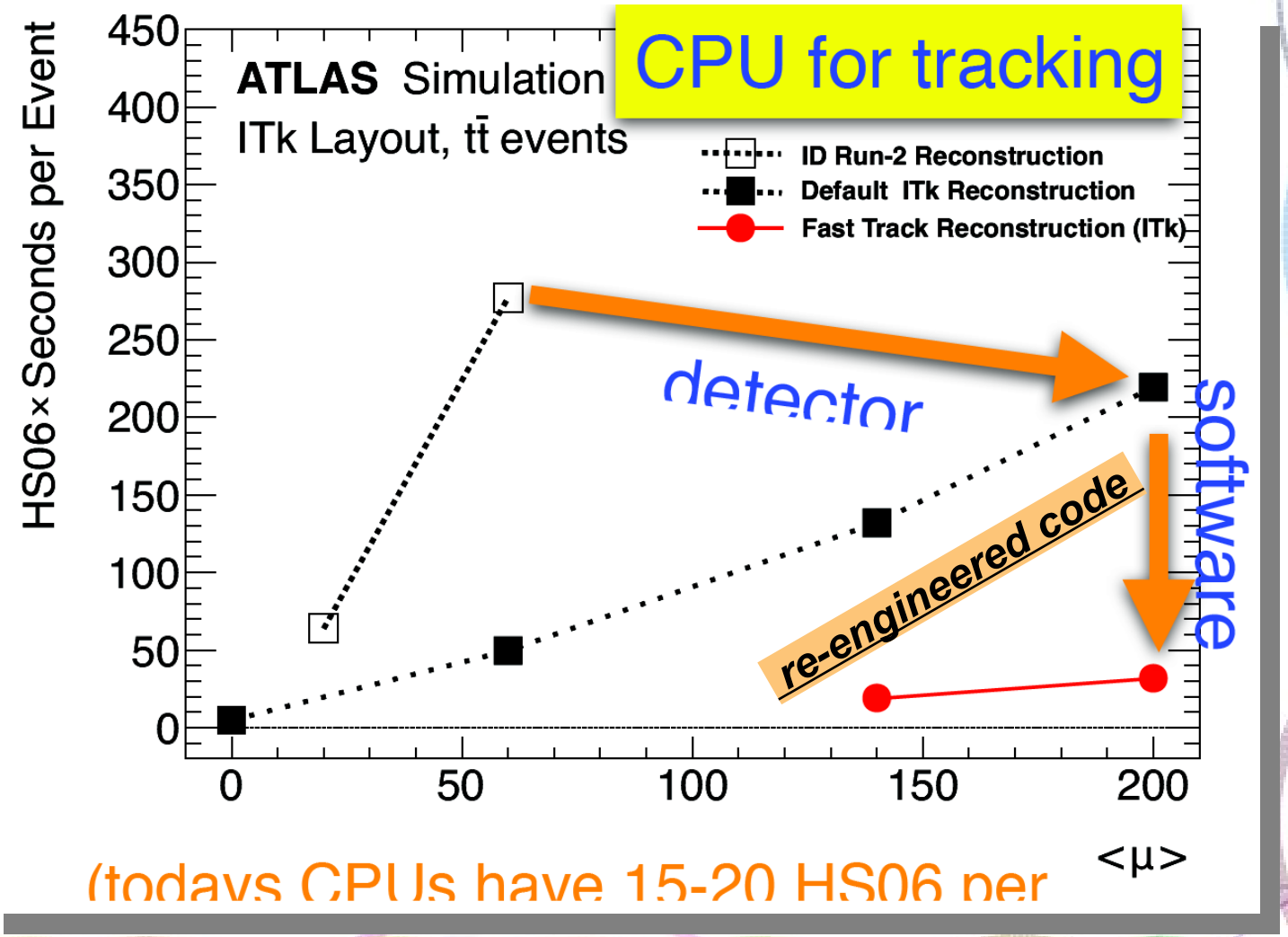
Simulated HL-LHC event, expect up to 200 pile-up





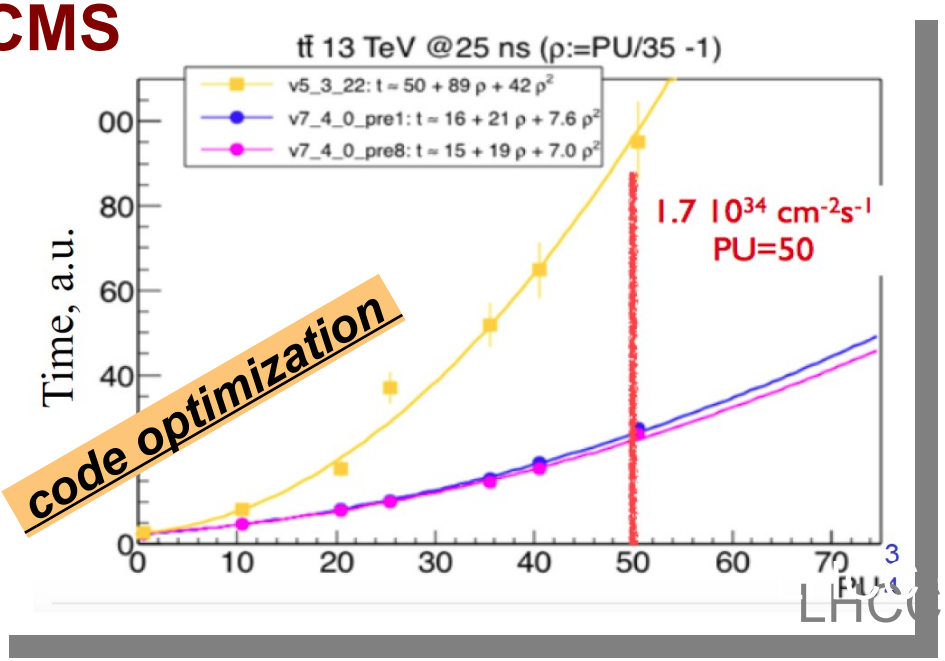
Improving the software pays off

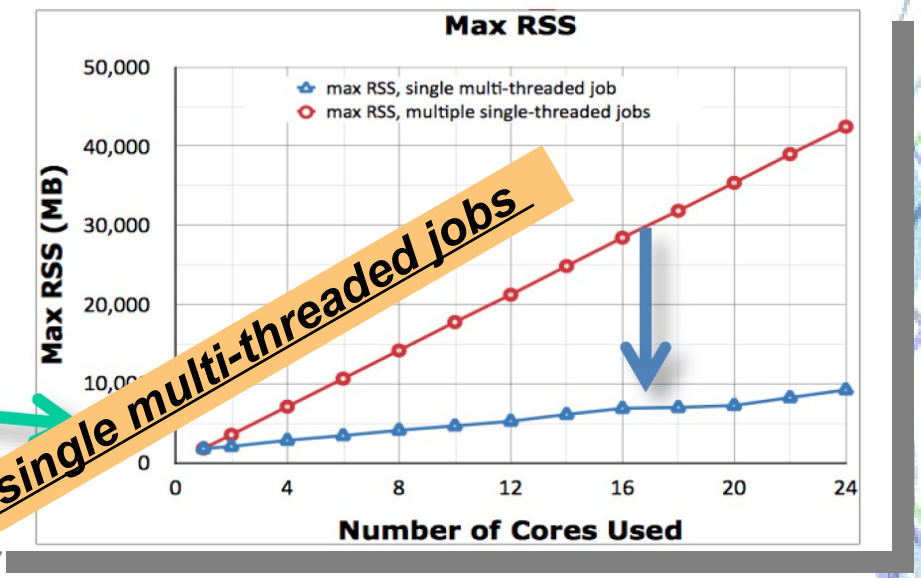
ATLAS

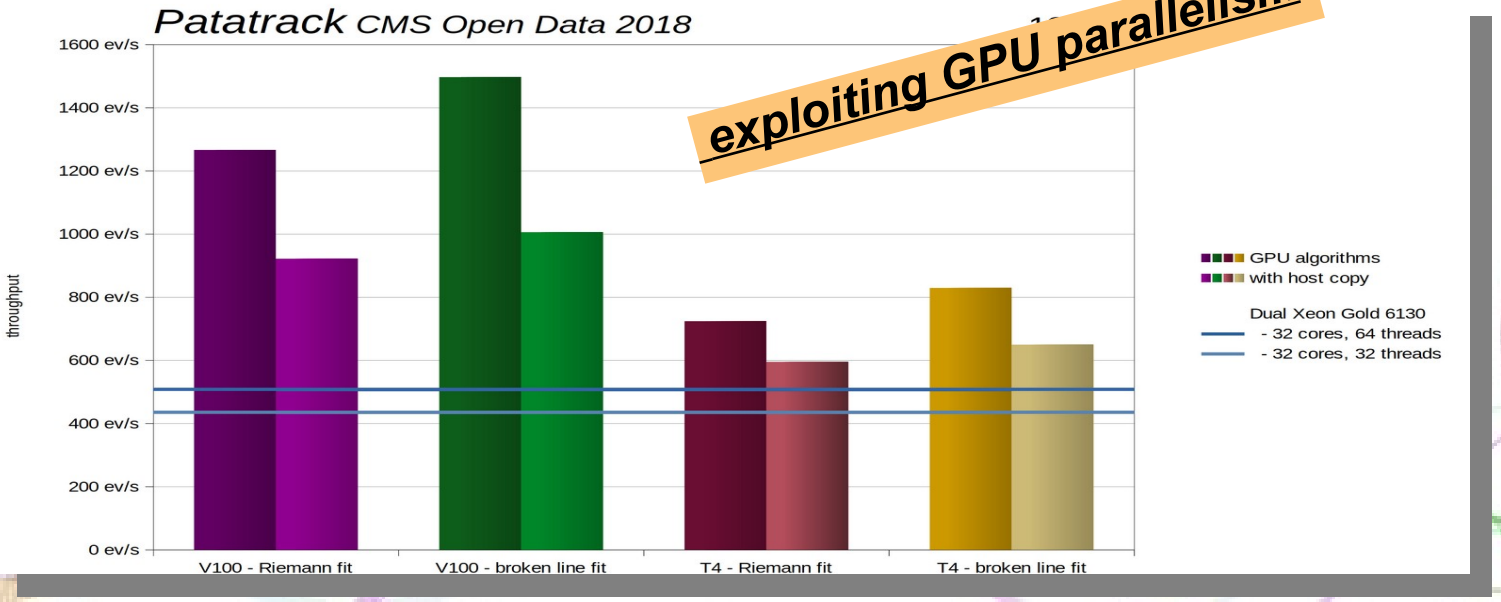


Other examples

CMS

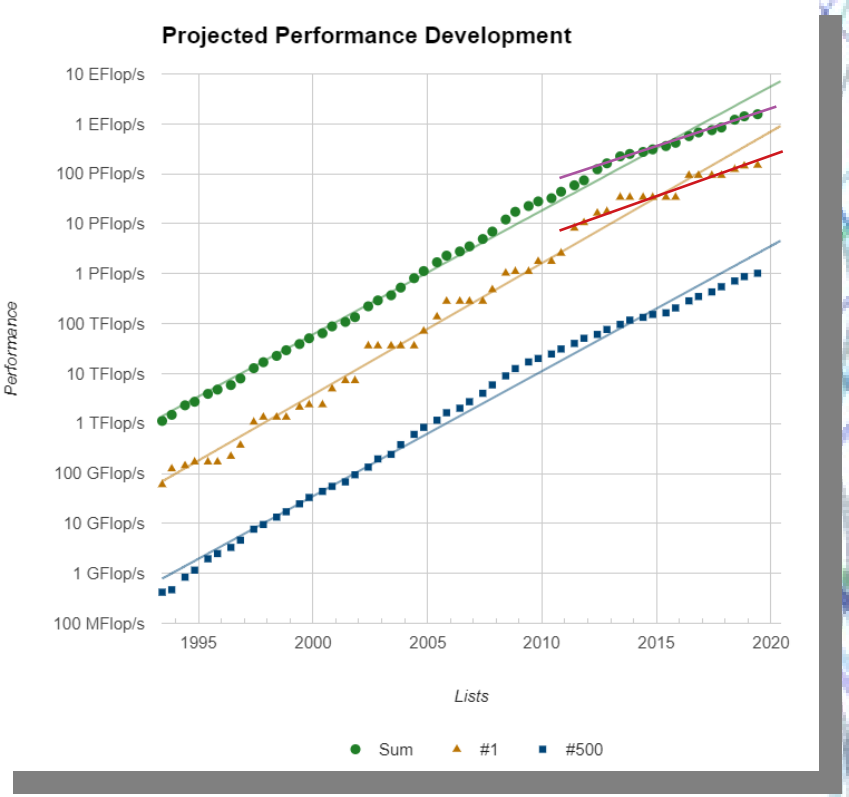






a look at HPC computing

- the next big milestones for HPC systems is Exascale computing
  - ✗ 1000 PFlops, 1000 PBytes
- we are progressing towards the goal, although at reduced pace
- however, **no supercomputer runs real applications faster than five percent of its design speed**
- the natural trend is towards **poorer and poorer efficiencies** as systems scale out to Exascale
- "it is not **power** or **reliability** that are the **exascale challenges**: it's **programmability of complex memory hierarchies**"



Supinski - ISC HPC '15 - FrankfurtConference and Exhibition in Frankfurt in July.

Another example

Impact of software engineering

Plane wave pseudopotential calculations:
2 atoms in 1981, 400 atoms in 1991.

Increase in computational effort of this calculation (using 1981 techniques) at least 10^8 – or 40 years of Moore's Law

Increase in power of hardware in this period < 100.

Software development increased efficiency of calculation by at least 10^6 over this period.

Without this software development 99.9999% of compute cycles would be wasted!

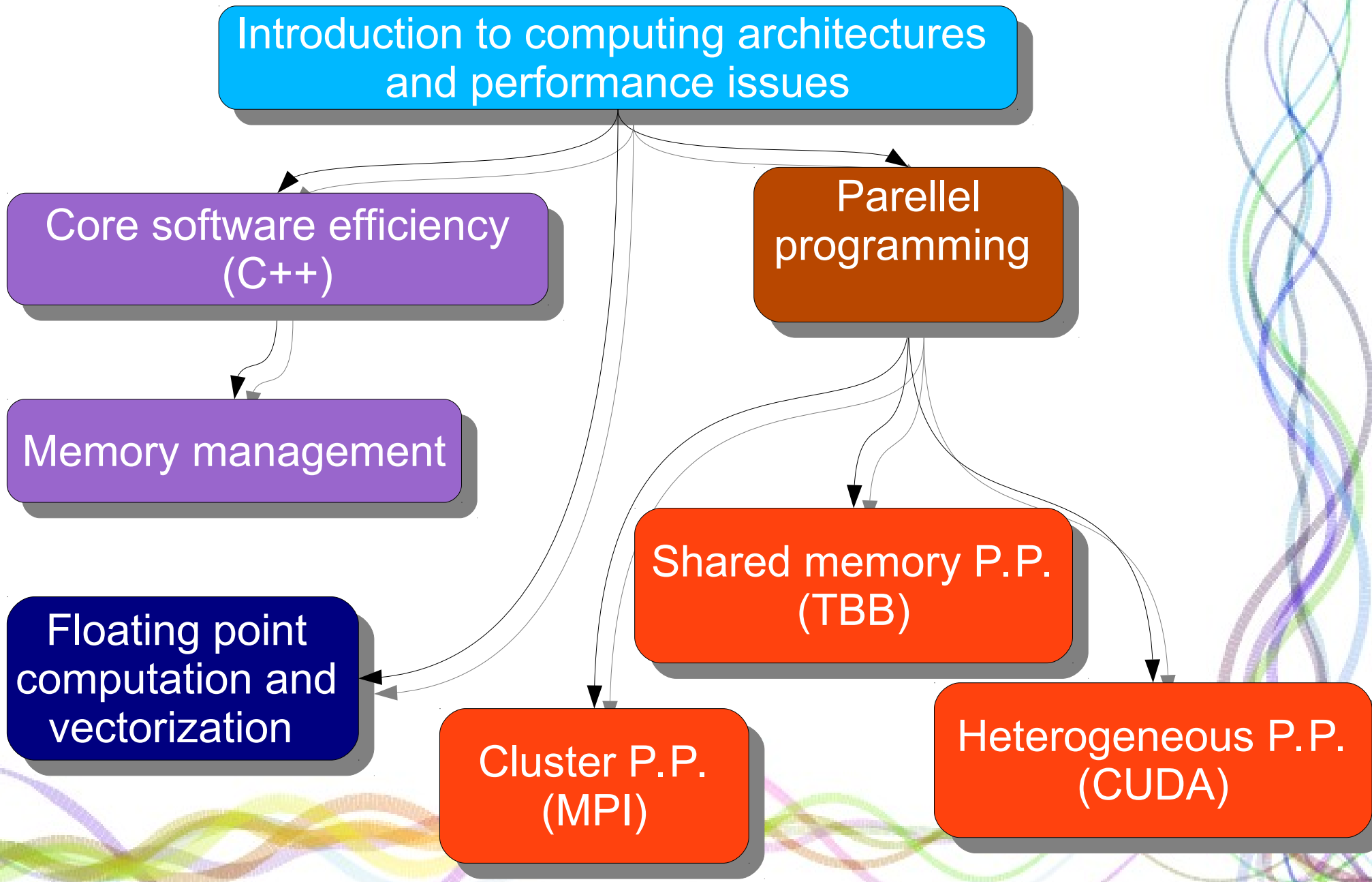
M. Payne – Digital Infrastructure for research 2018

The School evolution

- In the first editions of the School we tried to embrace **several key aspects** related to the efficient usage of computing resources in scientific applications, from **exploitation of modern CPUs** to **I/O related issues**
- however we realized that the scope was too vast for a one week long School
- a few years ago we decided therefore to focus the School on the area where developments looked most disruptive and challenging: **memory management** and **parallel processing**

The 2019 edition

ESC19 School lecture plan



Improving the School

- we have been striving to **improve the School** year after year
- the feedback we got from the students has always been **very useful**
- on Saturday morning we will give you an opportunity to evaluate:
  - the **perceived quality** of various aspects of the School
    - feedback questionnaire
  - the **competences you have acquired**
    - final test
    - a piece of information that is of course **valuable to us too**

Consolidation time

- to accommodate the need of students had to have some time for assimilating the material presented in the lectures there are some consolidation time slots for a total of 10 hours, i.e.:

  - Mo.: 30′
  - Tu.: 1h00′
  - Wed.: 2h30′
  - Thu. : 3h15′
  - Fri.: 2h45′

- after the lectures... you **can stay here** until dinner time

The week together

- thank you for preparing the **lightning talks and bringing here your posters !**
  - ✗ we have received slides from several **participants**
    - please send us the the missing slides by 2 pm today
- dinners: on Mon., Tue., Wed. you can organize yourself and **enjoy what local restaurants have to offer**
  - ✗ **a list of restaurants with a map has been distributed** together with the **vouchers** worth 25 €
    - check which restaurant are closed on Mondays!
  - ✗ if you tell the restaurant that you are going to use the voucher, they will usually propose an “optimized” menu

Special events

On **Thursday night**

- **Social dinner (with surprise)** at the "La Grotta" restaurant in Bertinoro
  - ✗ menu is meat based
  - ✗ please report to the secretary any special food requirement

On **Tuesday afternoon** :

- **Visit** to the Bertinoro Fortress and the InterFaith museum
  - ✗ please put your name on the booking sheet that will be posted today afternoon

On **Friday night**:

- **Final dinner**
  - ✗ menu is meat based
  - ✗ please report to the secretary any special food requirement

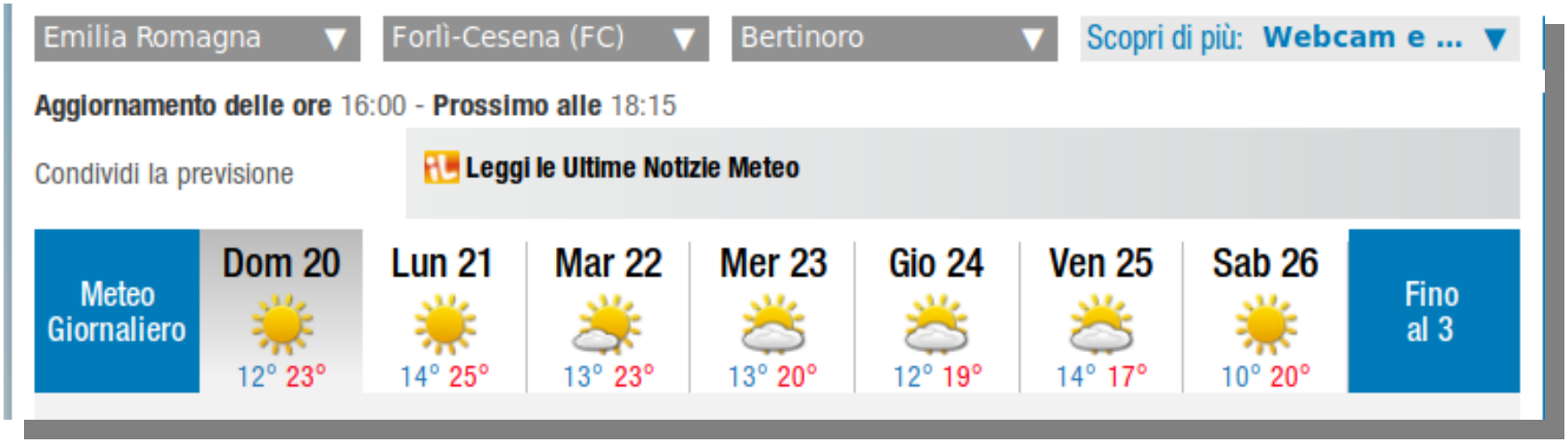
School computing infrastructure

- we believe that:
  - **learning-by-doing** is an effective way of **learning**
  - but it is also an effective way of **teaching**
    - guiding students **to discover by themselves** new notions and concepts
- therefore a **computing infrastructure** suitable for supporting hands-on activities has been setup for you
  - HPC cluster located at the CNAF INFN site
- **this year:**
  - each of you will get shared access, through a **login gateway** (bastion.cnaf.infn.it), to:
    - **two Intel dual processors Linux (E5-2640v2 ivy bridge, 2x8 phys. cores 128 GB)** servers equipped with GPUs (2 x Tesla K20m/40m)
    - one **Intel dual processor Linux (Gold 6148 sky lake, 2x20 phys. cores 192 GB)** server with 4xv100 GPU
  - there is a dedicated web site with teaching material and exercises: **https://infn-esc.github.io/esc19/**

Wireless networks

- we have here two infrastructures:
  - **INFN wireless network**, available only in this room; it can be accessed
    - ✗ using Eduroam credentials **[eduroam SSID]**
    - ✗ or via captive portal **[INFN-Captive SSID]**
      - you should already have the credentials for it
  - **Bertinoro wireless network**, available available in all rooms including the guest house **[CeUB SSID]**
    - ✗ credentials should have been given at registration time, otherwise ask Rossana

Last but not least



We wish you a very pleasant and "efficient", great week in Bertinoro