Welcome to ESC23

the XIV INFN International School on

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

Oct. 4 -12 2023

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On behalf of:

The Italian Institute for Nuclear Physics (INFN):

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

The University of Bologna, Department of Physics and Astronomy

The lecturers

- and their Institutions

Attendance this year

- 19 participants were selected

- 6 from foreign Institutions,

- 11 from Italian Institutions

- 2 participant had unfortunately to drop out at the last moment

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"** (XI 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.

- A legend says that Galla Placidia, daughter of the
Roman emperor Theodosius I, drank local wine in a humble
clay chalice and said "Non di cosi' rozzo calice sei degno,
o vino, ma di *berti in oro*".

- 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 a family

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

but still today...

Bertinoro still hosted a "**Hospitality Festival**". Held at the end of August or first week of September (31/8 – 3/9 in 2023),
it includes an entire night of music, dances and events, some historic commemorations and the final Hospitality Rite.

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

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:

- **15 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);

- a **canteen with 200 seats** for breakfast, lunch and gala dinners.

- **120+ events** per year

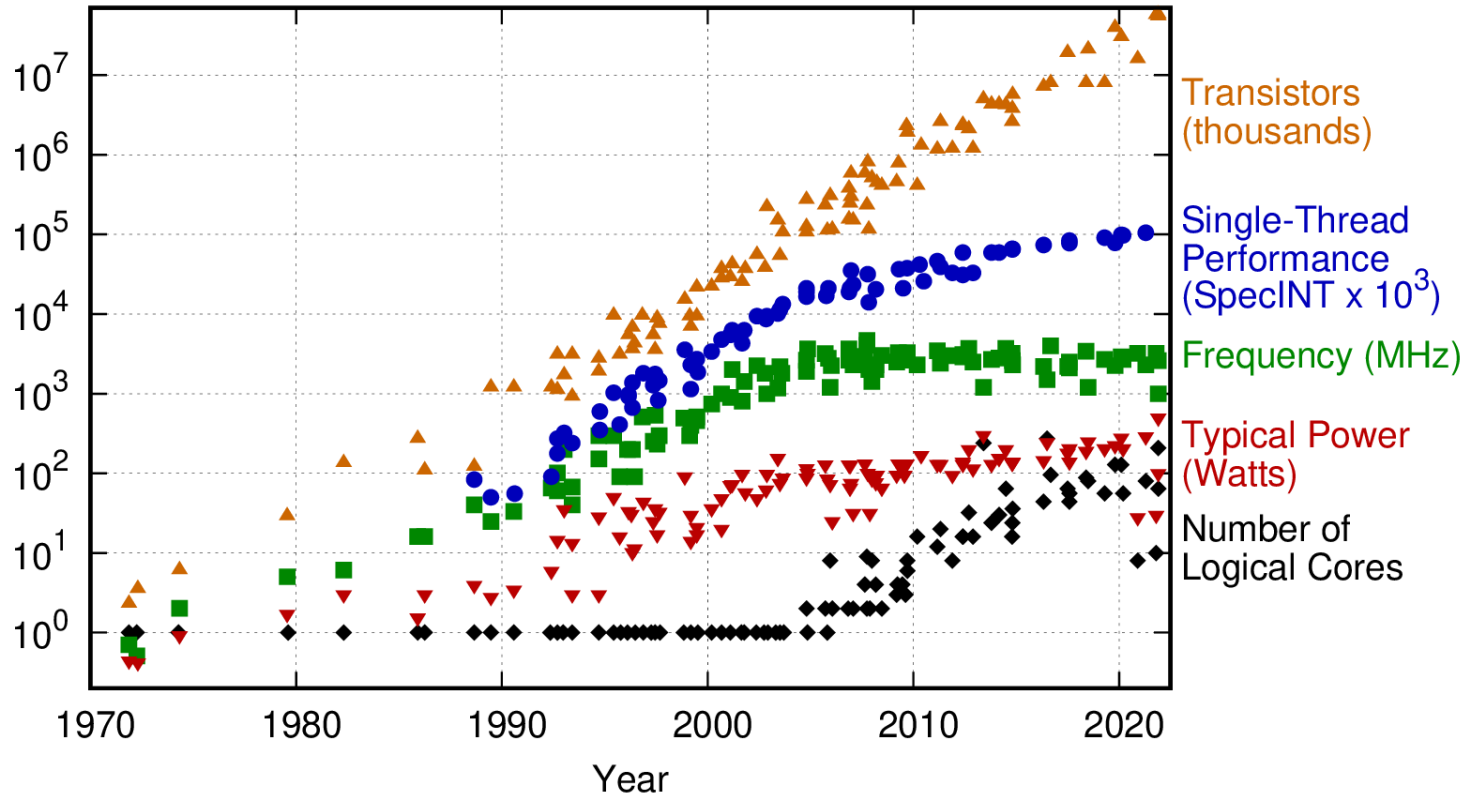- up to **30.000** daily presences per year

Why this School

The context

- High Energy Physics has been **heavily relying** on computing since long time

- 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

50 Years of Microprocessor Trend Data

Transistors (thousands)

Single-Thread Performance (SpecINT x 10^3)

Frequency (MHz)

Typical Power (Watts)

Number of Logical Cores

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 2010-2021 by K. Rupp

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, new architectures (RISC-V), etc

- memory access getting more and more critical
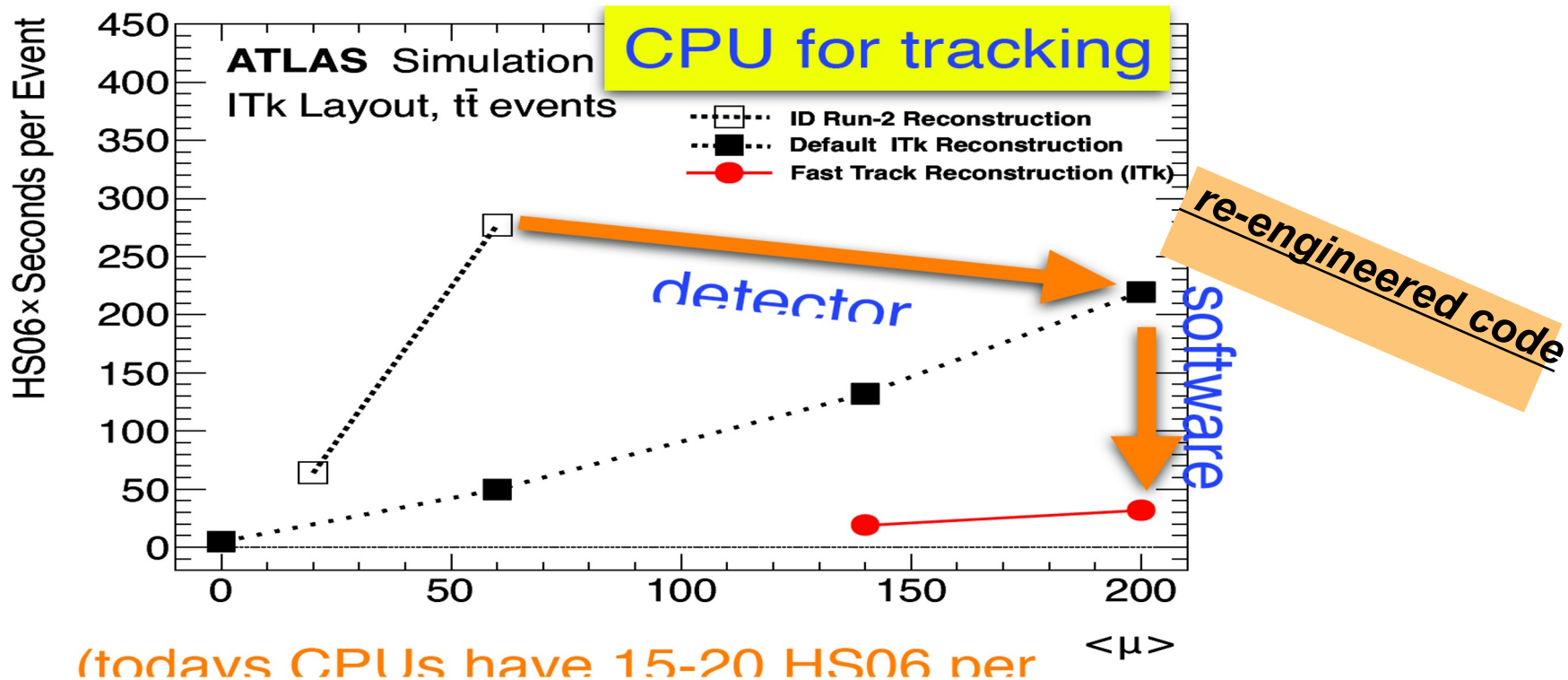
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Future will be more challenging...

Simulated HL-LHC event, expect up to 200 pile-up
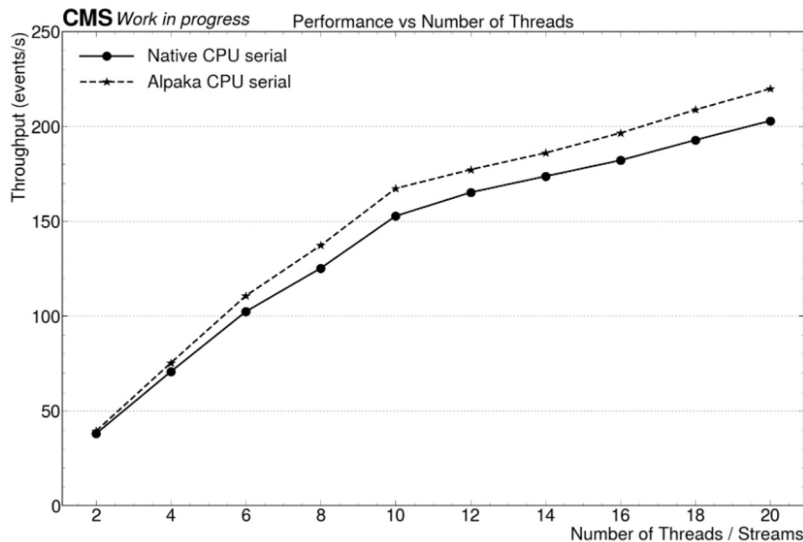
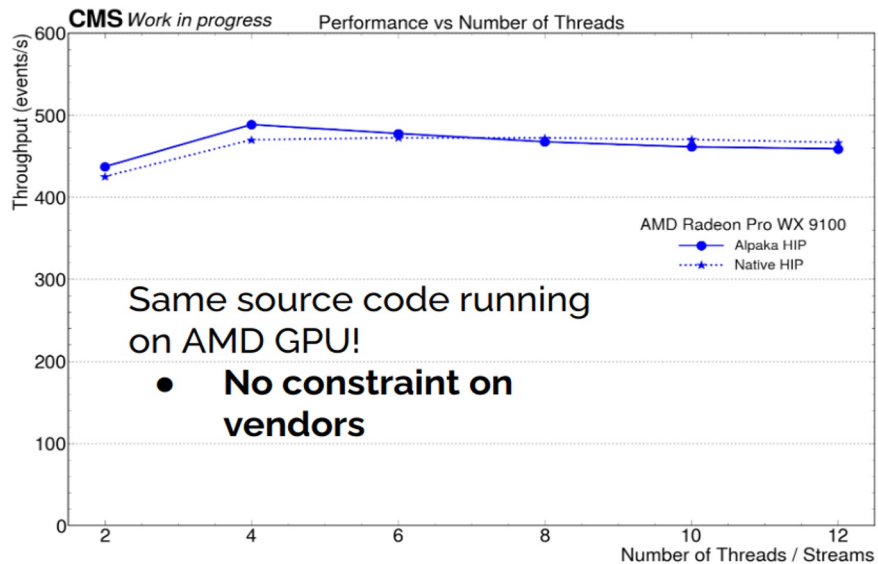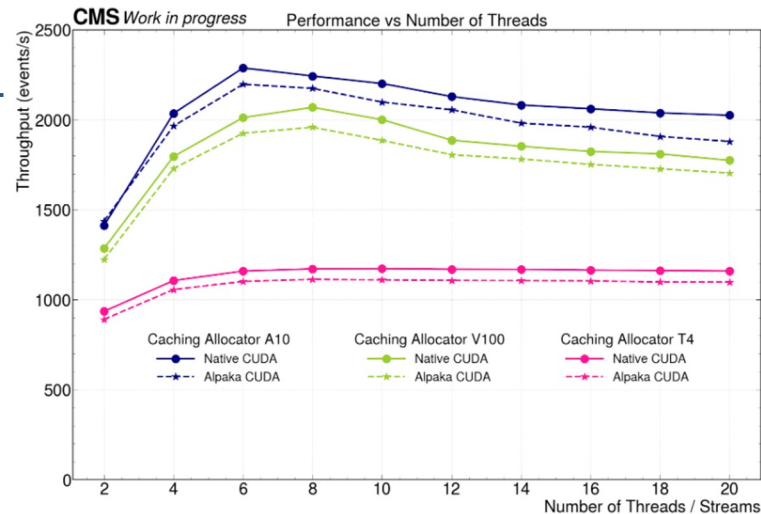ATLAS EXPERIMENT
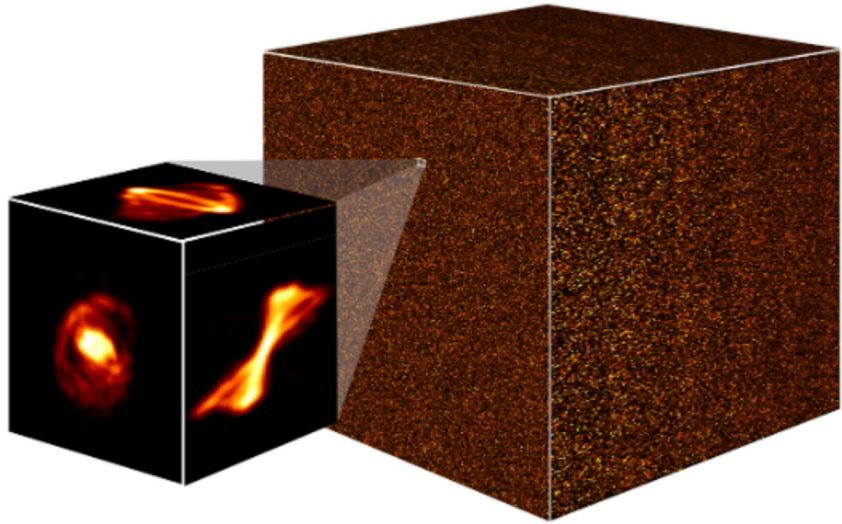
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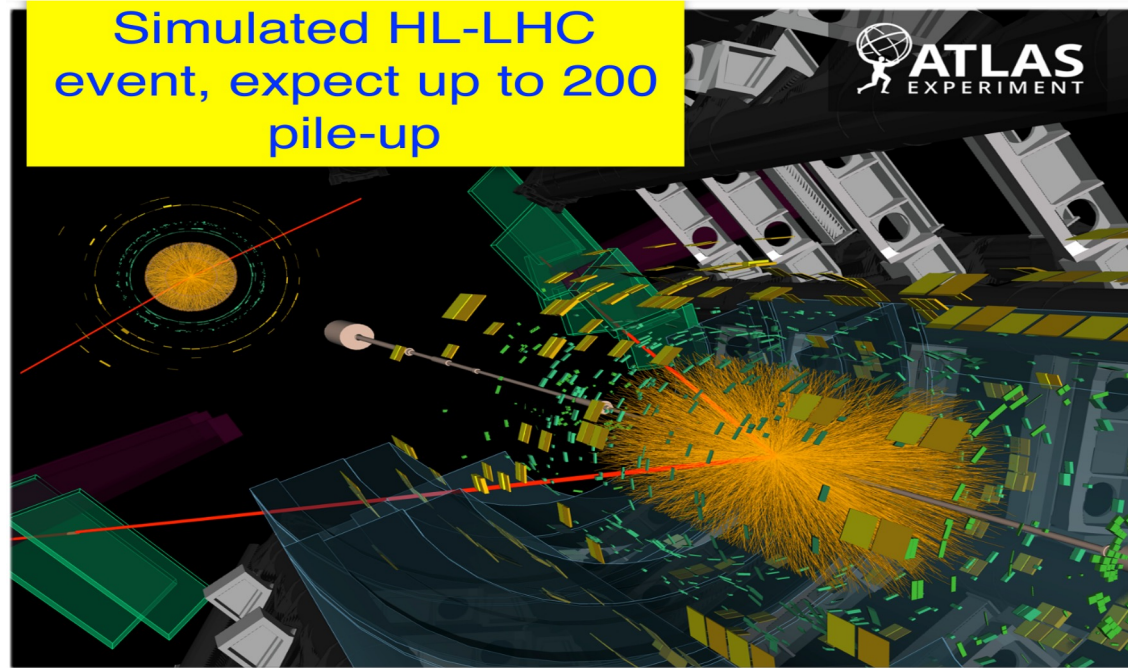
Improving the software pays off

CMS Patatrack R&D

- Heterogeneous computing and performance portability a reality at LHC experiments

A look at HPC computing : TOP 500, June 2023

Rank	System	Cores	Rmax (PFlop/s)	Rpeak (PFlop/s)	Power (kW)
1	**Frontier** - HPE Cray EX235a, AMD Optimized 3rd Generation EPYC 64C 2GHz, AMD Instinct MI250X, Slingshot-11, HPE DOE/SC/Oak Ridge National Laboratory United States	8,699,904	1,194.00	1,679.82	22,703
2	**Supercomputer Fugaku** - Supercomputer Fugaku, A64FX 48C 2.2GHz, Tofu interconnect D, Fujitsu RIKEN Center for Computational Science Japan	7,630,848	442.01	537.21	29,899
3	**LUMI** - HPE Cray EX235a, AMD Optimized 3rd Generation EPYC 64C 2GHz, AMD Instinct MI250X, Slingshot-11, HPE EuroHPC/CSC Finland	2,220,288	309.10	428.70	6,016
4	**Leonardo** - BullSequana XH2000, Xeon Platinum 8358 32C 2.6GHz, NVIDIA A100 SXM4 64 GB, Quad-rail NVIDIA HDR100 Infiniband, Atos EuroHPC/CINECA Italy	1,824,768	238.70	304.47	7,404

https://www.top500.org/lists/top500/2023/06/

A look at HPC computing

- Exascale computing

- 1000 PFlops, 1000 PBytes

- however, **no supercomputer runs real applications faster than 10 percent of its maximum peak 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**" Bronis R. de Supinski Chief Technology Officer (CTO) for Livermore Computing

Accelerator/CP Family - Systems Share
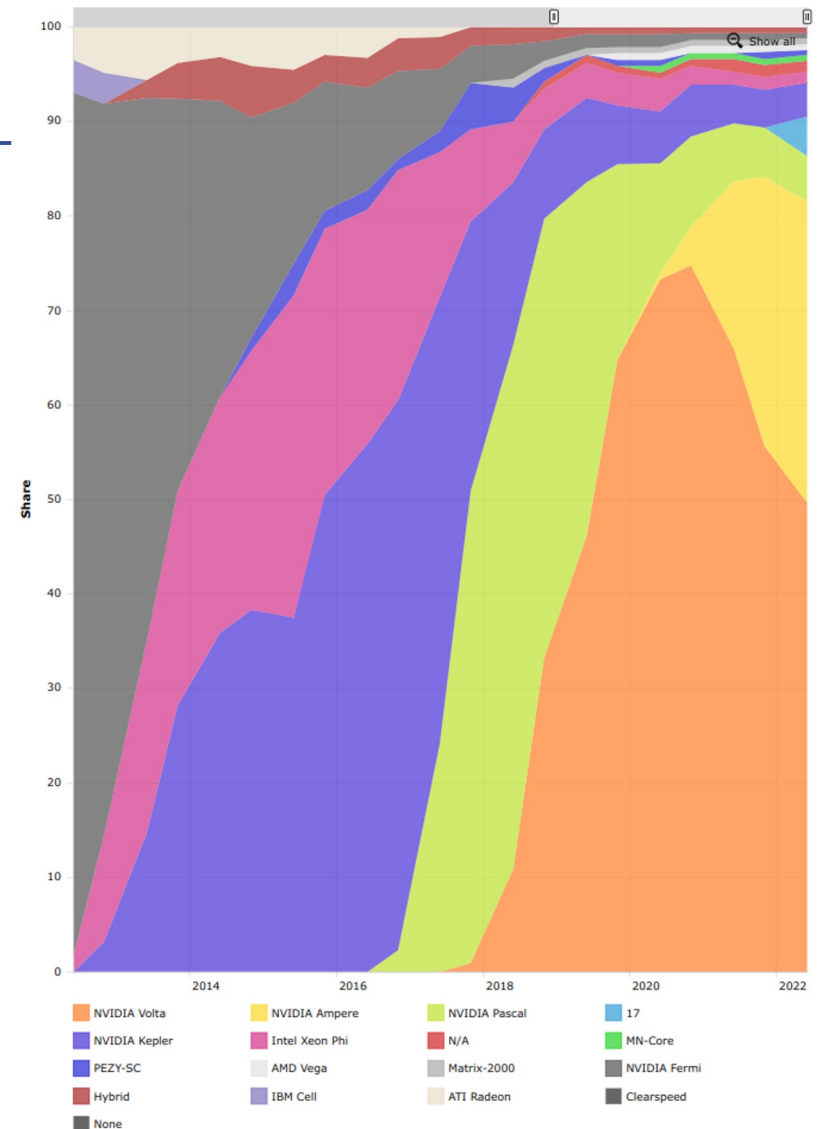
The School evolution

- 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: this year we experience a longer (8 days) school to go deeper on few topics.

- a few years ago, we decided therefore to focus the School on the area where developments looked most disruptive and challenging: **parallel processing**

The 2023 edition

ESC23 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 Thursday 12 morning we will give you an opportunity to evaluate:

    - the **perceived quality** of various aspects of the School via the feedback questionnaire

    - the **competences you have acquired**

       - through a final test

- information collected 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**

Evening lectures

speaker: **Tim Mattson**

- Tuesday (Oct 10):

The sixth Epoch of distributed computing: heterogeneity and the future of HPC in the Cloud

- Wednesday (Oct 11)

The evolution of programming models and the future of software development

The week together

- thank you for preparing the **lightning talks and bringing here your posters !**
- we have received slides from **all participants** but **two**
- please send us the the missing slides by today afternoon

Dinners:
- on Wed (Oct 4) welcome dinner at the canteen
- Thu-Sat (Oct 5-7) we have organized dinner in different restaurants, details will be given later
- Sun (Oct 8): social event (please stay tuned!)
- Mon-Tue (Oct 9-10): dinner in different restaurants, details will be given later
- Wed (Oct 11): social dinner … surprise!

Special events

On **Sunday** :

- Visit to Ravenna

or

- trip to Mirabilandia park

please confirm your participation if not done, yet.

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:

- **three 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

- you should have received a mail message with the credentials to login into bastion; if not, check your spam folder, or let us know

- there is a dedicated web site with teaching material and exercises: **https://infn-esc.github.io/esc23/**

Wireless network and Social networks

Bertinoro wireless network, available available in all rooms including the guest house **[CeUB SSID and eduroam SSID]**

- credentials should have been given at registration time, otherwise ask Laura or Rossana

A **Telegram** group has been created:

https://t.me/+7dXUD8HuowhmMjlk

- Join them to receive communications, interact, provide feedbacks

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