Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani
ICSC

Advanced Machine Learning. Flash Simulation and bleeding edge applications

FlashSim: *September status report*

with a focus on the Production strategy towards M12

Lucio Anderlini

Istituto Nazionale di Fisica Nucleare, Sezione di Firenze

External Partner

Who we are

Staff members:

- Alessandro Bombini [j], INFN
- Giuseppe Piparo[l], INFN
- Maurizio Martinelli [a], Università Milano Bicocca
- Simone Capelli [a], Università Milano Bicocca
- Federica Maria Simone [i], Politecnico di Bari
- Nicola De Filippis [i], Politecnico di Bari
- Vieri Candelise [h], Università di Trieste
- Giuseppe Della Ricca [h], Università di Trieste
- Valentina Zaccolo [k], Università di Trieste
- Mattia Faggin [k], Università di Trieste
- Lorenzo Rinaldi [e], Università di Bologna
- Piergiulio Lenzi [g], Università di Firenze
- Vitaliano Ciulli [g], Università di Firenze
- Sharam Rahatlou[h], Università Roma 1
- Daniele del Re [h], Università Roma 1
- Lorenzo Capriotti [f], Università di Ferrara
- Francesco Conventi [e], Università di Napoli
- Francesco Cirotto [e], Università di Napoli

PhD students:

- Francesco Vaselli [c], Scuola Normale Superiore di Pisa
- Matteo Barbetti [b], Università di Firenze
- Muhammad Numan Anwar [j], Politecnico di Bari
- Benedetta Camaiani [g], Università di Firenze
- Alkis Papanastassiou [g], Università di Firenze
- Antonio D'Avanzo [e], Università di Napoli

External collaborators:

- Andrea Rizzi [c], Università di Pisa

KPIs

KPI ID	Description	Acceptance threshold	2024-09-24
KPI2.2.1.1	N_{MC} billion events obtained from ML-based simulation, as demonstrated by official links in experiments' simulation databases	N_{MC} >= 1	2.3 M events (completed: 0.2%)
KPI2.2.1.2	N_{EXP} experiments have tested a machine-learning based simulation	N_{EXP} >= 2	3 experiment (completed: **150%**)
KPI2.2.1.3	Machine-learning use-cases tested in the context of the CN were presented at N_{CONF} international and national events	N_{CONF} >= 3	8 use-cases (since Sept. '23) (completed: **267%**)
KPI2.2.1.4	N_{UC} different machine-learning use-cases were tested in the context of the CN and made available in git repositories	N_{UC} >= 5	4 use-cases (completed: 80%)

List of conferences for KPI2.2.1.3

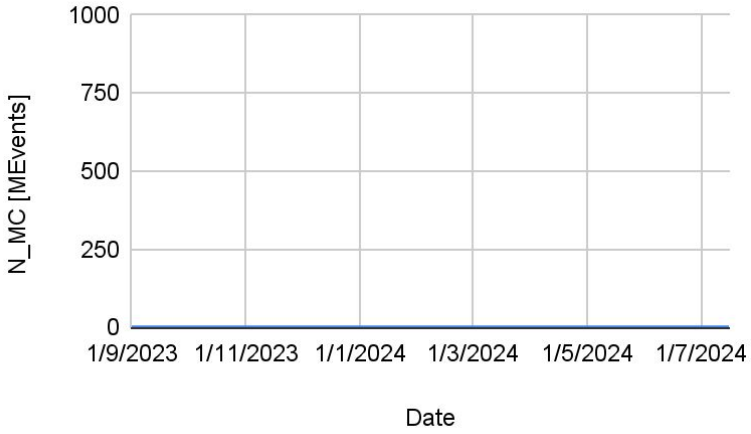
1. L.A., Generative models at the LHC, ALPACA workshop 2023, Trento
2. B. Camaiani, Example of adaptation domain in High Energy Physics, XAI 2023, Milano
3. A. Papanastassiou, “Anomaly detection with autoencoders for data quality monitoring in HEP”, XAI 2023, Milano
4. M. Mazurek (CERN), *Lamarr: implementing the flash-simulation paradigm at LHCb*, ACAT 2024
5. F. Simone, *Anomaly detection for data quality monitoring of the CMS detector*, AISSAI 2024
6. F. Corchia, *Tecniche computazionali avanzate per la simulazione veloce del calorimetro dell’esperimento ATLAS*, IFAE 2024
7. M. Barbetti, *The flash-simulation of the LHCb experiment using the Lamarr framework,* EuCAIFCon 2024
8. F. Vaselli, *FlashSim: an end-to-end fast simulation prototype using Normalizing Flow,* EuCAIFCon 2024

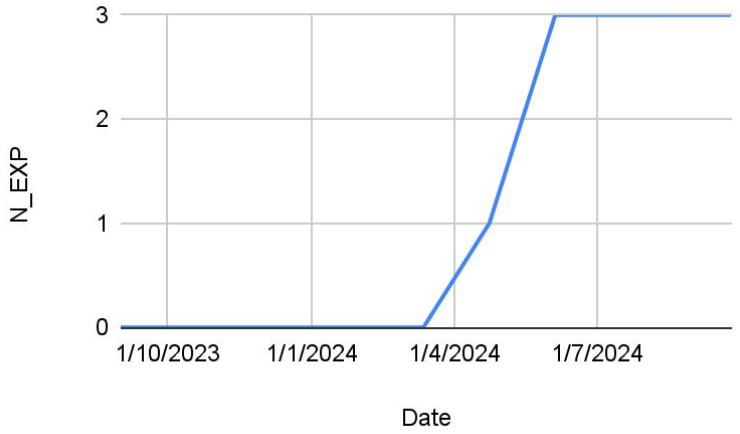
List of use-cases tested on the platform (4/5)

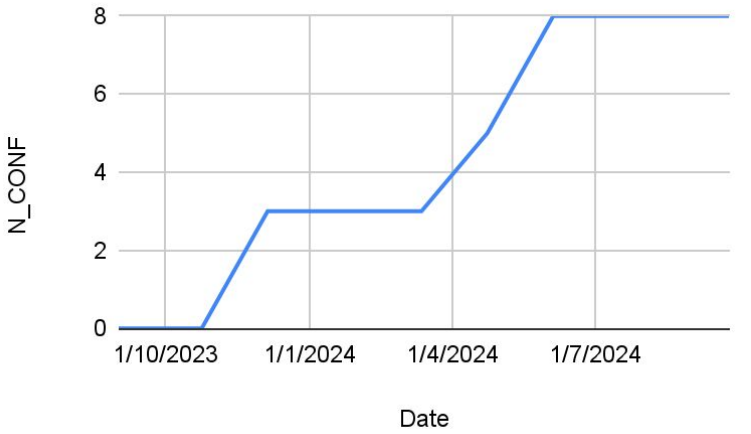
- Lamarr, the ultra-fast simulation option for the LHCb experiment (tracking parametrizations)
- Lamarr, the ultra-fast simulation option for the LHCb experiment (particle identification and neutral reconstruction parametrizations)
- Theory-independent classifiers for the data analysis with the CMS experiment
- Machine-learning-based simulation of the response of resistive solid-state detector to the charge generated by a traversing minimum-ionizing particle

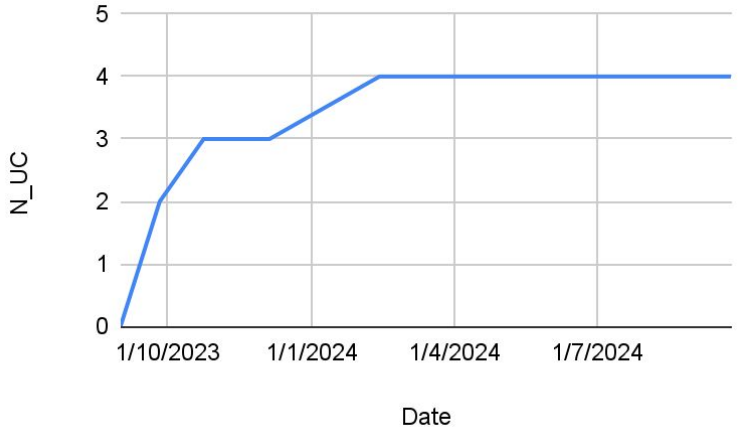
\+ *Preliminary discussion with Muhammad Numan Anwar to bring HPO in the Cloud platform*

KPIs


N_MC [MEvents]
1000
750
500
250
0
1/9/2023
1/11/2023
1/1/2024
1/3/2024
1/5/2024
1/7/2024
Date


N_EXP
3
2
1
0
1/10/2023
1/1/2024
1/4/2024
1/7/2024
Date


N_CONF
8
6
4
2
0
1/10/2023
1/1/2024
1/4/2024
1/7/2024
Date


N_UC
5
4
3
2
1
0
1/10/2023
1/1/2024
1/4/2024
1/7/2024
Date

Status of the resources integration

Focus is now on integration with ICSC resources allocated by RAC.

- ***CINECA Leonardo Booster**: using the official slurm plugin*
  ***Status: can submit simple jobs**, work needed for integration with FlashSim workflow*
  ICSC RAC allocated 200000 core-hours
- ***INFN Tier-1**: recently deployed an InterLink plugin connecting to the condor-CE*
  ***Status: can submit simple jobs**, odd behaviour of apptainer+fuse (debugging…)*
  ICSC RAC promised 100 core on Cloud resources, we are trying to assess batch resources instead (more efficient).

Paper on the infrastructure ("Developing Artificial Intelligence in the Cloud…") in preparation for Computer Science Journal currently in circulation.

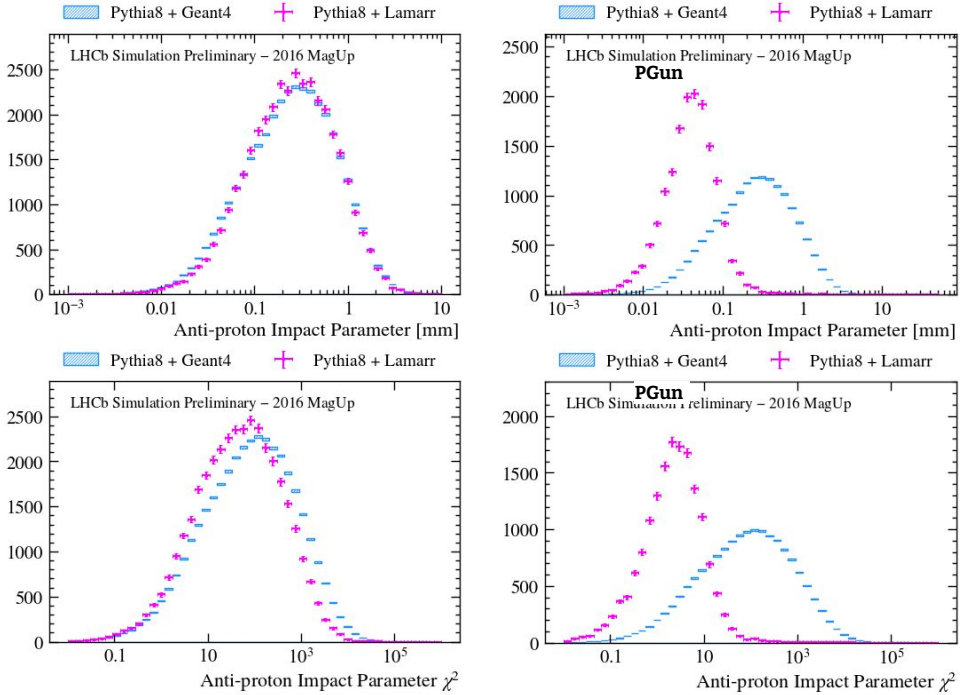
Status of the Flash Sim framework (Lamarr)

Overall good agreement of the parametrized response with the full simulation when using **Pythia8** as generator.

Some problems arose when **importing primary vertices** imported with ParticleGun and is being investigated.

Enabling particle guns will introduce **further speed up in validation** of the new parametrizations.

Lamarr simulation framework

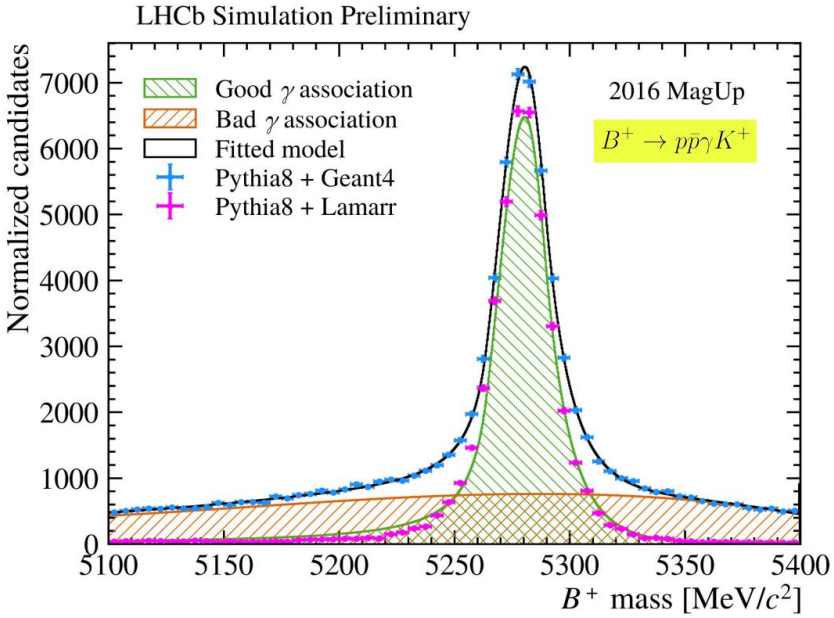


Status of the development of parametrizations

Activity on the parametrization of the calorimeter response for photons.

1 photon ⟶ 1 cluster parametrization is rough, *n* photons ⟶ *k* clusters extremely challenging

We produced the training sample for a 1 photon ⟶ k clusters parametrization which will be insufficient for a complete parametrization of the background, but may be enough for the signal.



Additional detail in Matteo Barbetti's talk at ICHEP 2024

Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani
ICSC

Next steps

1. We need to answer to ICSC on the possibility of switching from cloud to **batch CPUs**. Enabling Tier-1 CPUs via InterLink would also be an important milestone towards mixed HTC/HPC workloads.
   Infrastructure activity will be presented at **CHEP**, in 1 month.
2. Framework side, we need to enable **ParticleGun generator** to achieve further speed up in the simulation.
3. We produced a new training sample for studies on the parametrization of the photons, which we could use to prepare hands-on/exercises...

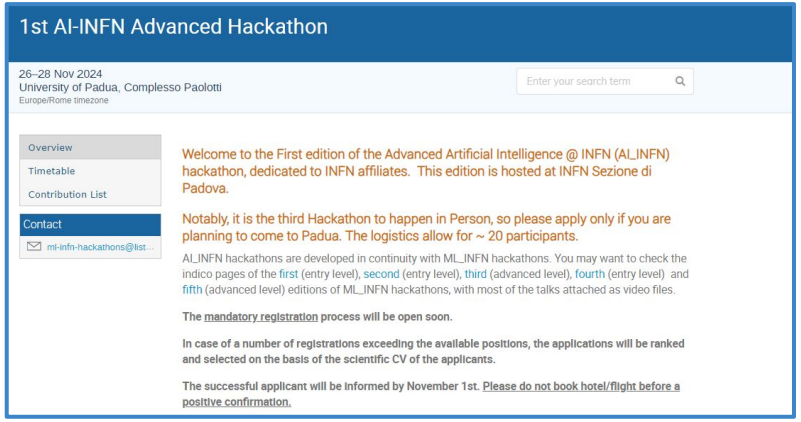
Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani
ICSC

Anteprima

AI_INFN will circulate soon the agenda of the 1st **Hackathon on Artificial Intelligence**.
The event is supported by **ICSC** and Flash Simulation will (most probably) be included as one of the use case.

Save the date: 26 – 28 November 2024, Padova

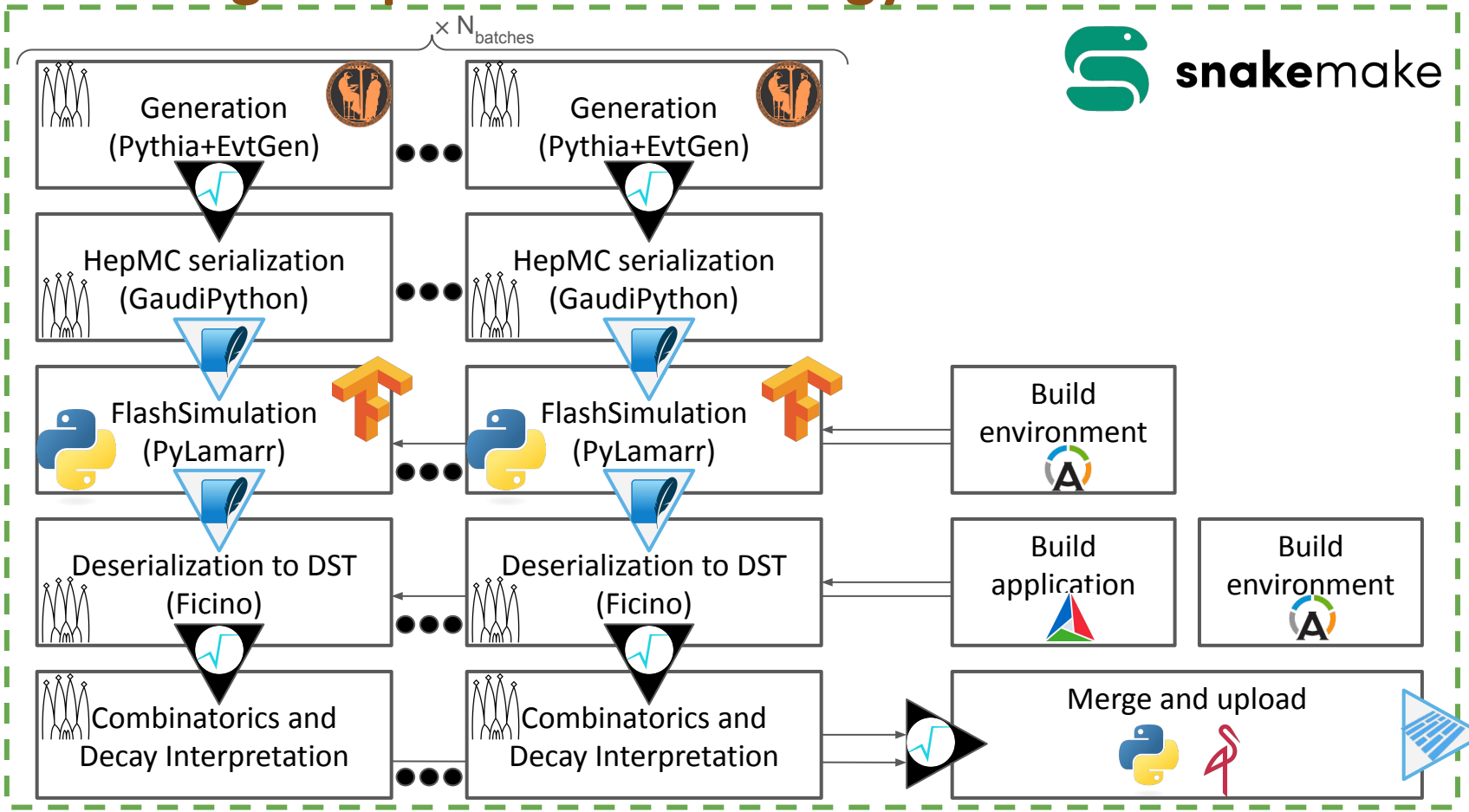
Link to the agenda: agenda.infn.it/event/43129/



Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani
ICSC

Backup

Recalling the production strategy



Resources

Pythia8 (full event)

Generates the whole proton-proton collision event, with pileup and spill-over.
Then processes all particles with Lamarr and Bender to produce nTuples.

1M events (on 50 parallel jobs) require:

- O(48h) × 50 CPUs
- 0.8 TB of buffer in S3.

Particle Gun (signal-only)

Generates only the heavy hadron decay.
Then processes particles with Lamarr and Bender to produce nTuples.
Less tested than Pythia8 productions

1M events (on **up to** 50 parallel jobs) require:

- O(1h), *limited by submission latency*
- 4 GB of buffer in S3

Requests for the validation part

Resource	Full Request	Strictly required for KPI 1 (Full-Pythia option)
CPU on INFN Cloud	2 M CPU hours	2.4 M CPU hours*
GPU on INFN Cloud	4 H200 for 18 months	0
GPU on Leonardo Booster via InterLink	10000 hours	0
Storage	25 TB	10 TB

Preliminary

- 0.5 M hours from opportunistic borrowing from AI_INFN Platform