Digital Twin of BM@N computing infrastructure for data production

D. PRIAKHINA

V. KORENKOV

V. TROFIMOV

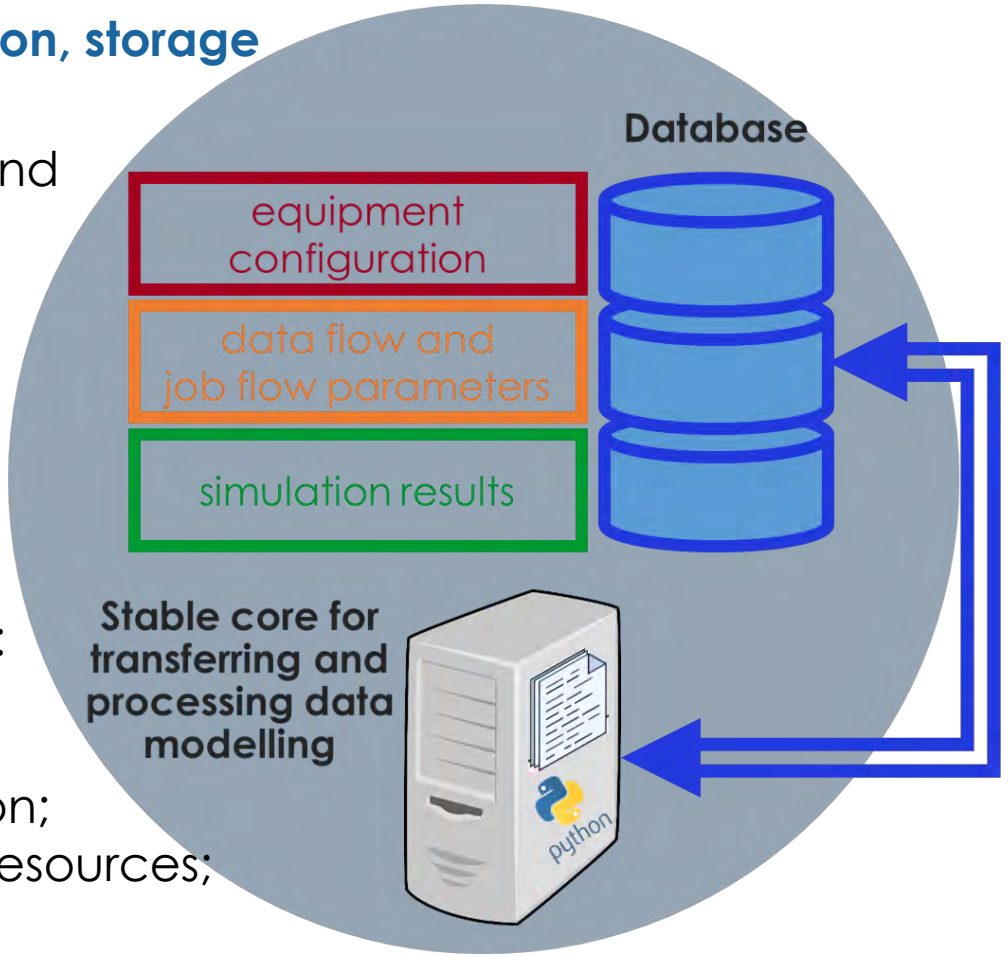
K. GERTSENBERGER

Modelling program

This work is supported by JINR grant for young scientists No. 23-602-03.

Simulation of distributed data acquisition, storage and processing systems

- Finding out how the data storage and processing system will work with the available computing power.
- Calculating the load on computing farms and communication links with the specified parameters of data flows and jobs flows.
- Modelling takes into account the probabilities of events in the system:



- changing the rate of data generation;
- changing the number of allocated resources;
- equipment failure & recovery times.

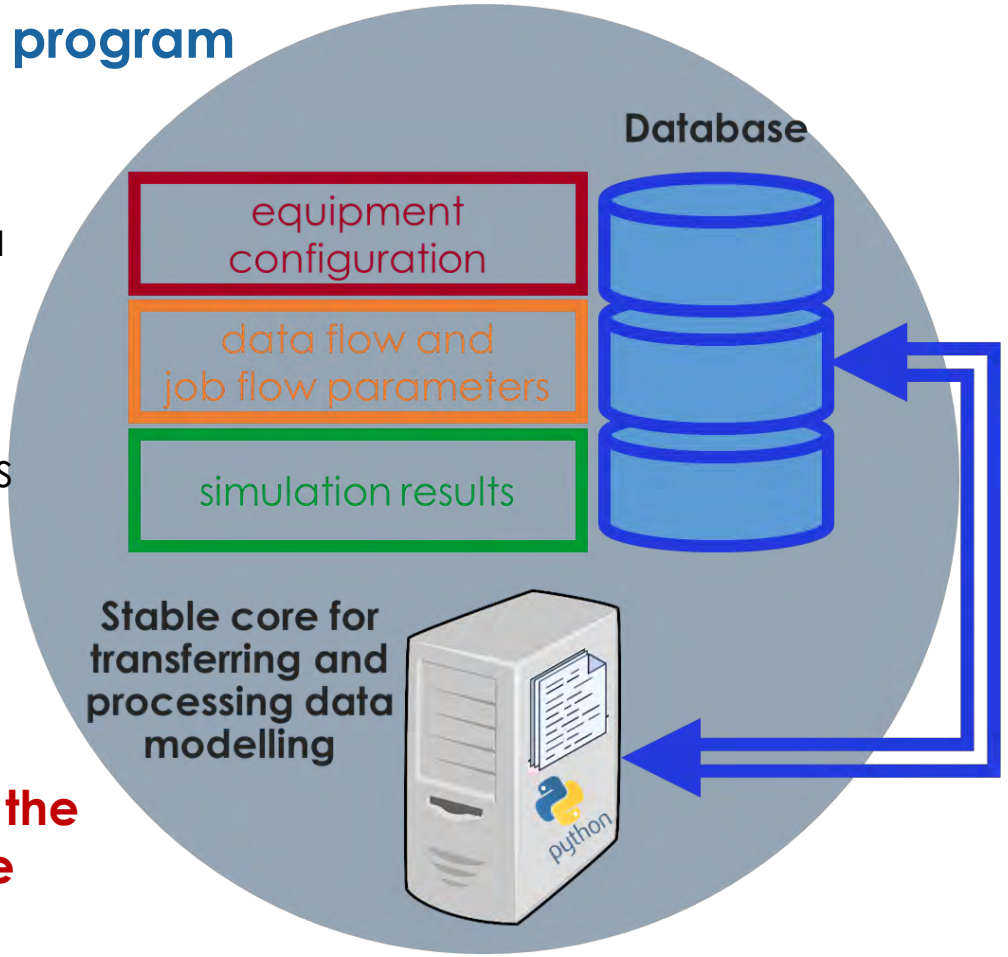
Completed works
(10th BM@N meeting)

Verification of the modelling program

1. Modelling the BM@N Computing Infrastructure with parameters of equipment, data flows and jobs flows based on Run 8 mass production.

2. Comparison of modelling results with results of BM@N Mass Data Production on distributed infrastructure for Run 8 using DIRAC.

Thanks to Igor Pelevanyuk



The verification results proved the correct and accurate of the modelling program!

Digital twin (DT)

Real-time operation throughout the entire computing infrastructure life cycle.

COMPUTER MODEL

Main component: **developed modelling program**

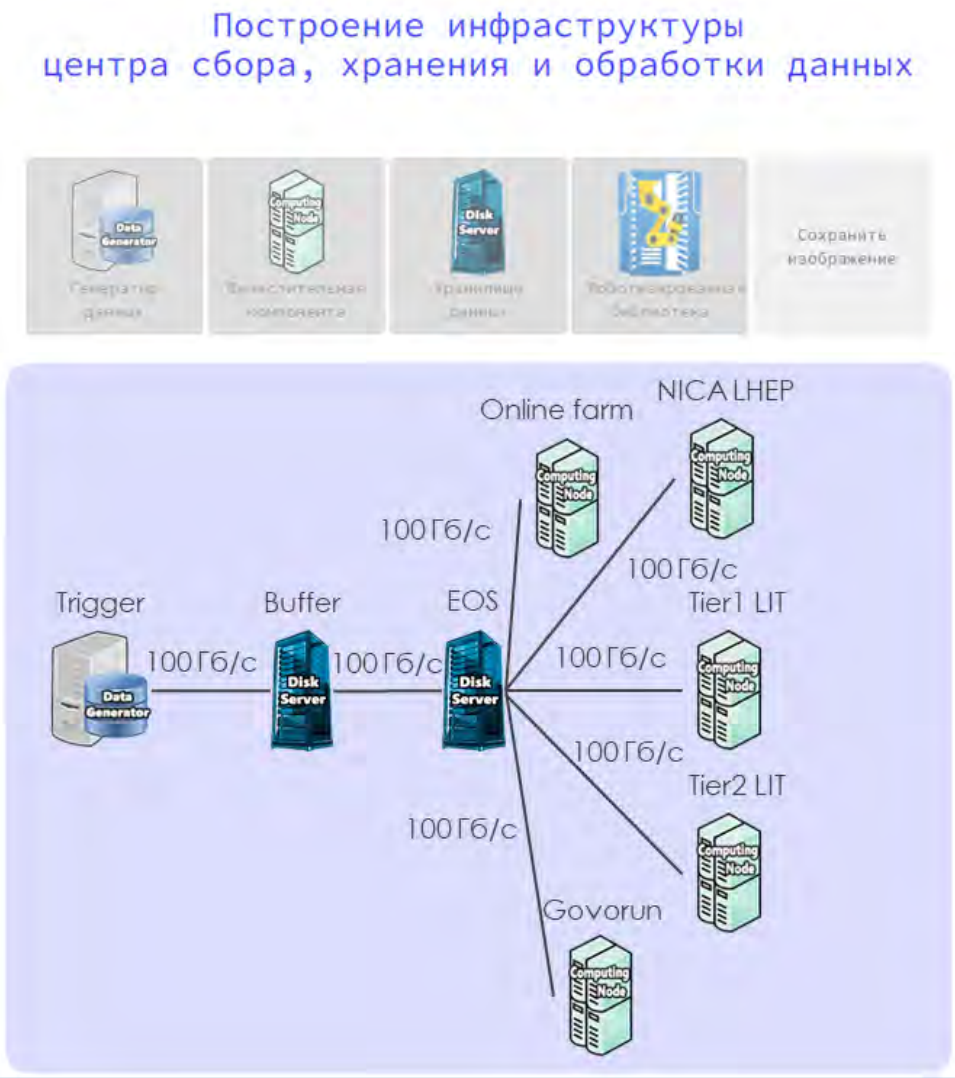
INPUT DATA

- Architecture and hardware parameters of computing infrastructure.
- Characteristics of data flows and jobs flows.

FUNCTIONAL PURPOSE

- Designing of computing infrastructure.
- Analysis of the efficiency and reliability of computing infrastructure.
- Testing scaling scenarios based on data flows and jobs flows requirements.
- Assessment of the required amount of resources for specific tasks.
- Checking jobs flows management strategies.

Software complex for creating digital twins (prototype)



Create a digital twin

Building the computing infrastructure

- Setting the equipment parameters.
- Setting characteristics of data flows and jobs flows.

The prototype of the web service has not yet been localized.

Software complex for creating digital twins (prototype)

Информация об эксперименте

Дата создания: 7 февраля 2023 г. 10:36

Название эксперимента

Test 1

Описание эксперимента

Поиск оптимального количества ресурсов для хранения данных

Параметры моделирования

- *Продолжительность работы моделируемой инфраструктуры - 800 ч.*
- *Ускорение процесса моделирования в 1000 раз.*

Параметры логирования

- *Объекты моделируемой инфраструктуры*
  - ☑ *Хранилища данных*
  - ☐ *Вычислительные компоненты*
  - ☐ *Каналы связи*
- *События*
  - ☑ *Генерация данных*
  - ☑ *Потери данных*
  - ☑ *Работа с файлами*
  - ☐ *Генерация, запуск, выполнение задач*

Посмотреть результаты

Выбрать другой эксперимент

Базовая конфигурация

Хранилища даннных

Название	Описание	Объем (ТБ)
trigger	Trigger BM@N	10000,0
buffer	Data receptipon buffer	5400,0
eoslhep	Main storage LHEP	1000,0
eoslit	Main storage LIT	1000,0
dcach	pp	1000,0

Вычислительные компоненты

Название	Описание	Количество ядер
t2lit	LIT T2 farm	500
ncxlhep	LHEP main farm	1200
super	Govorun	190

Каналы связи

Название	Описание	Пропускная способность (Гб/с)
raw0	trigger - buffer	100,0
raw1	buffer - lhep	10,0
raw2	buffer - lit	10,0
compute0	lhep - farm lhep	10,0
compute1	lit - Govorun	10,0
compute2	lit - farm lit	10,0
dataeosLhepLit	eoslhep - eoslit	10,0
dataeosLitLhep	eoslit - eoslhep	10,0

Добавить модификацию

Starting the digital twin

№	Статус	Дата обновления			
16	NEW	9 марта 2023 г. 14:52	Просмотр	Запуск	Результаты
15	DONE	10 марта 2023 г. 10:18	Просмотр	Запуск	Результаты

Simultaneous run of all modifications is possible

Software complex for creating digital twins (prototype)

The digital twin results

Available for viewing:

- data storage load volume;
- using cores on computing components;
- load on communication links;
- job queues, the number of completed jobs;
- distribution of files in storages.

Digital Twin of BM@N computing infrastructure for data production

Task

Comparison of different computing infrastructure configurations for data processing.

Data flows

Experimental data
645 x 10^6 events
(25 800 raw files)

1 raw file = 15 GB (25 000 events)
1 digit file ≈ 870 MB
1 dst file ≈ 2 000 MB

Simulation data
30 x 10^6 sim-events
(60 000 gen files)

1 gen file = 4 MB (500 sim-events)
1 sim file ≈ 300 MB
1 dst (sim) file ≈ 300 MB

Data processing stages

Experimental data

1. Conversion of raw experimental data
   RawToDigit job ≈ 2 500 seconds
   (1 event ≈ 0.1 sec)
2. Reconstruction of experimental data
   DigitToDst job ≈ 86 400 seconds
   (1 event ≈ 3 sec)

Simulation data

1. Simulation
   GenToSim job ≈ 5 400 seconds
   (1 even ≈ 10 sec)
2. Reconstruction of simulation data
   SimToDst job ≈ 5 400 seconds
   (1 event ≈ 10 sec)

Digital Twin of BM@N computing infrastructure for data production

Variant 1. Current computing infrastructure

- Processing **645 x 10^6 experimental events** (25 800 raw files) **to reconstruction data**.

1. Conversion of raw experimental data
   RawToDigit job ≈ 2 500 seconds
   (1 event ≈ 0.1 sec)
2. Reconstruction of experimental data
   DigitToDst job ≈ 86 400 seconds
   (1 event ≈ 3 sec)

1 raw file = 15 GB (25 000 events)
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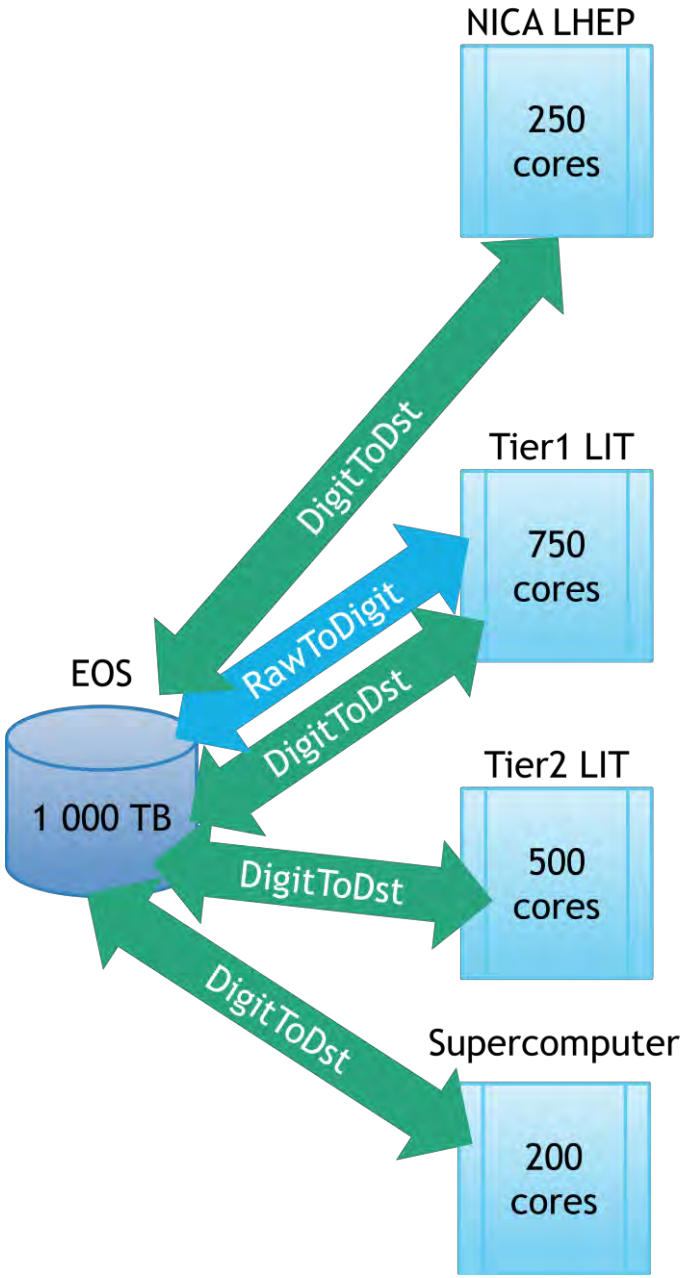
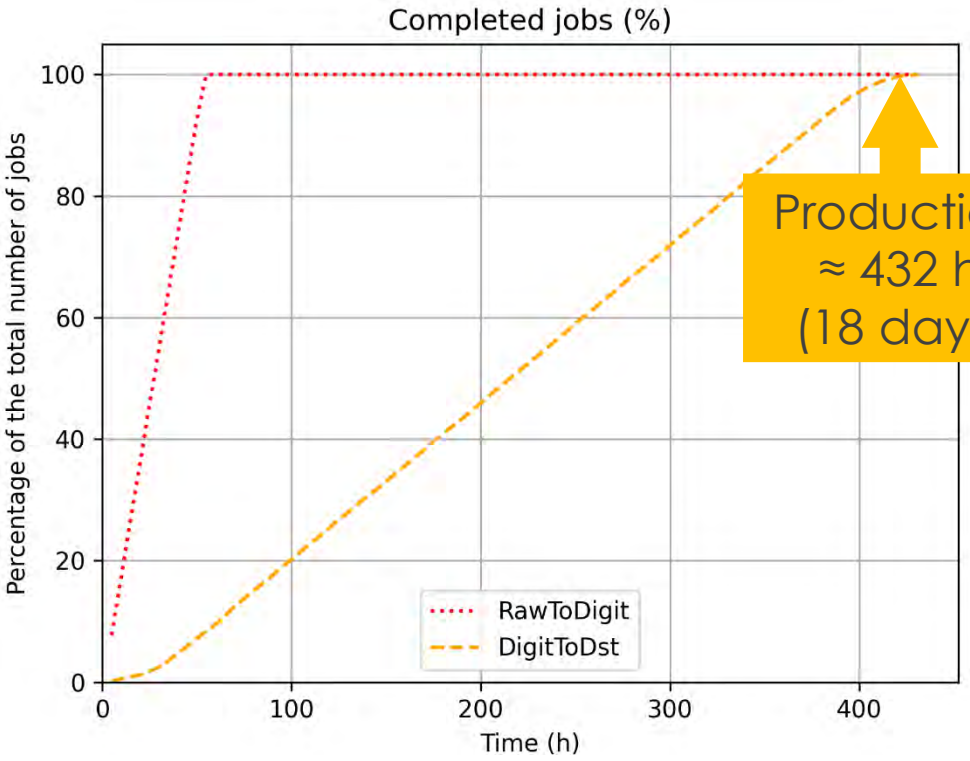


Digital Twin of BM@N computing infrastructure for data production

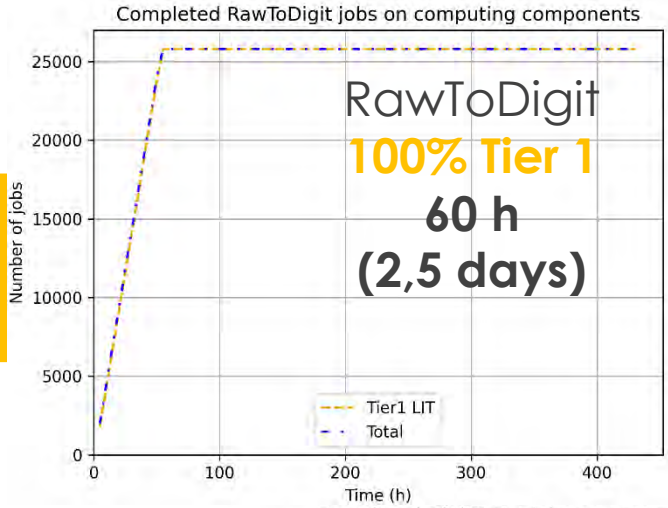
Results 1

Completed jobs

Processing experimental data

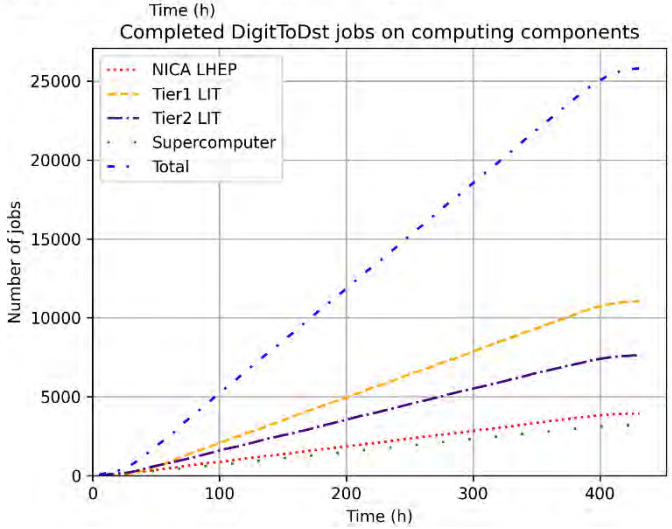


Production
≈ 432 h
(18 days)



RawToDigit
100% Tier 1
60 h
(2,5 days)

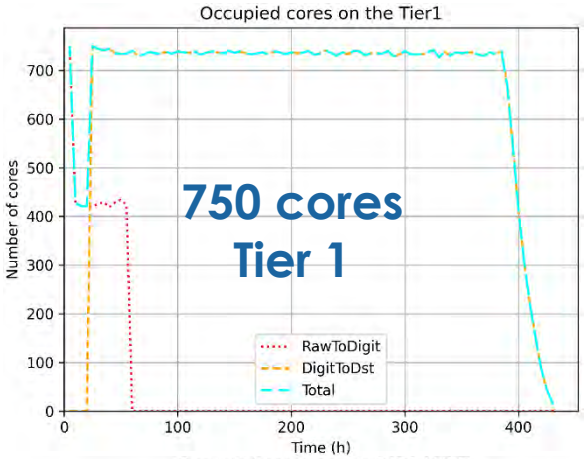
DigitToDst
15% LHEP
43% Tier 1
30% Tier 2
12% Sup

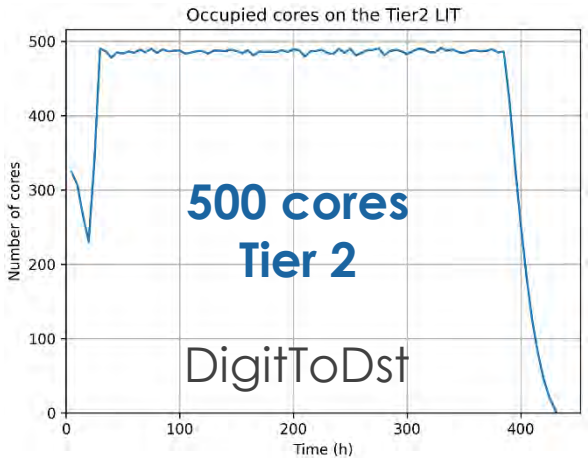


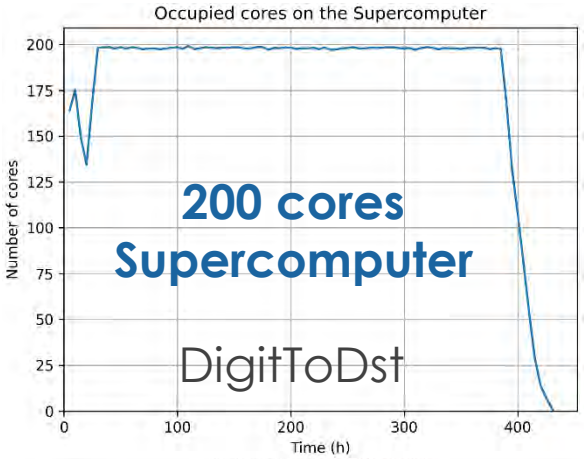
Digital Twin of BM@N computing infrastructure for data production

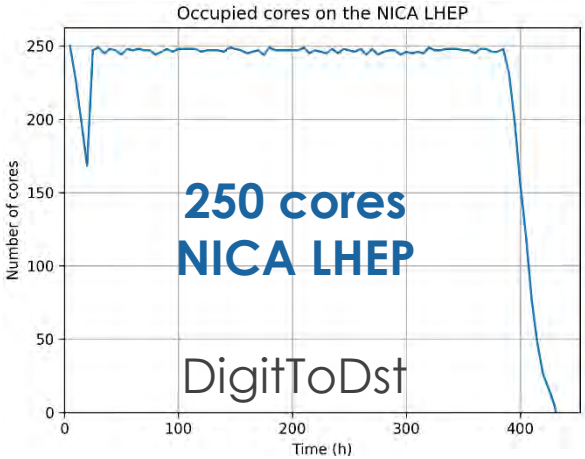
Results 1
Computing resources

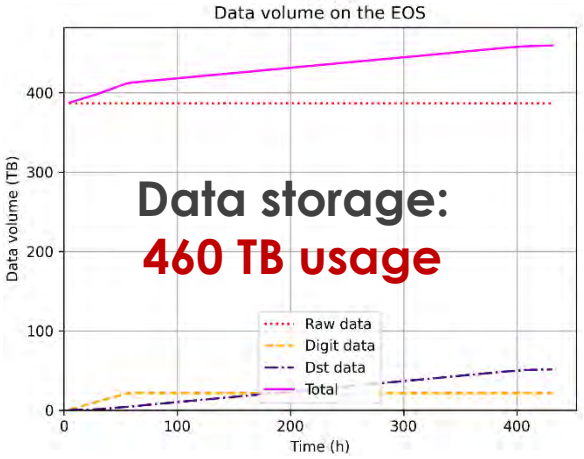
Processing experimental data (100% resource usage)











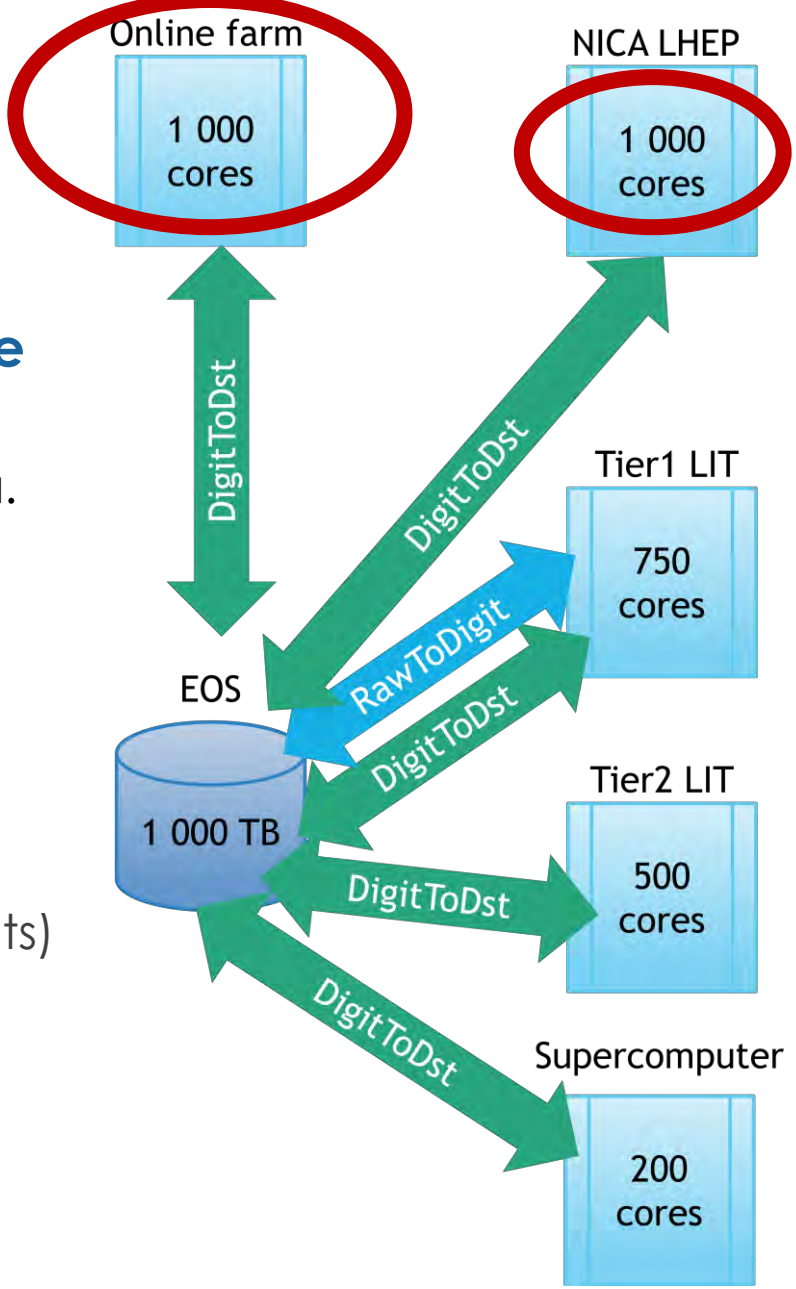
Digital Twin of BM@N computing infrastructure for data production

Variant 2. Planned computing infrastructure

- Processing **645 x 10^6 experimental events** (25 800 raw files) **to reconstruction data**.

1. Conversion of raw experimental data
   RawToDigit job ≈ 2 500 seconds
   (1 event ≈ 0.1 sec)
2. Reconstruction of experimental data
   DigitToDst job ≈ 86 400 seconds
   (1 event ≈ 3 sec)

1 raw file = 15 GB (25 000 events)
1 digit file ≈ 870 MB
1 dst file ≈ 2 000 MB

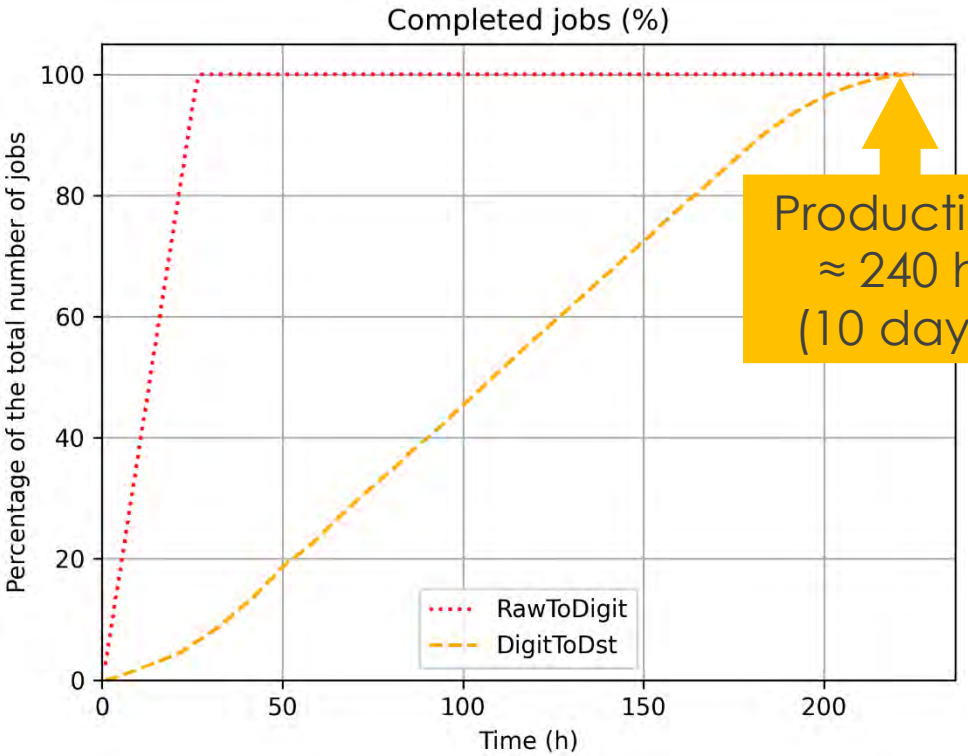


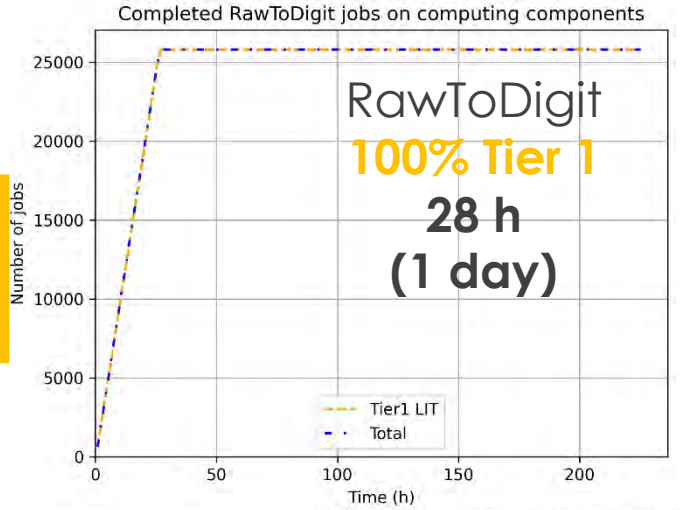
Digital Twin of BM@N computing infrastructure for data production

Results 2

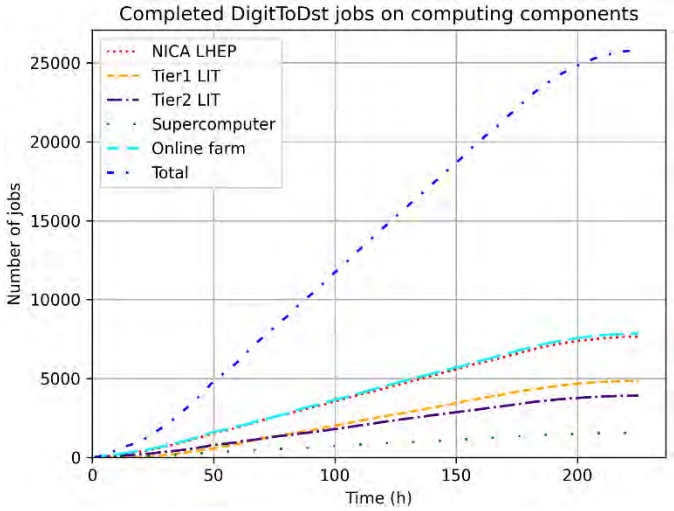
Completed jobs

Processing experimental data





DigitToDst
30% LHEP
20% Tier 1
14% Tier 2
6% Sup
30% Online

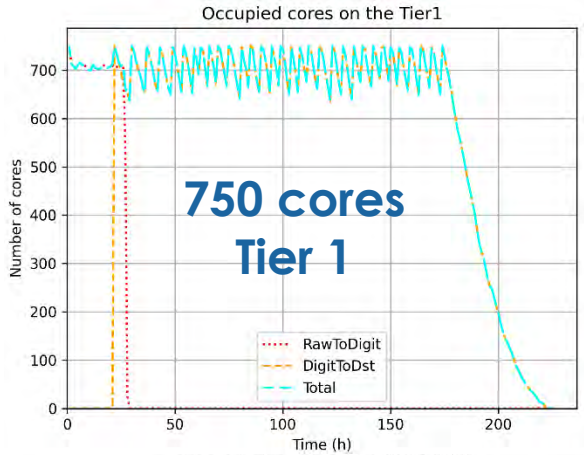


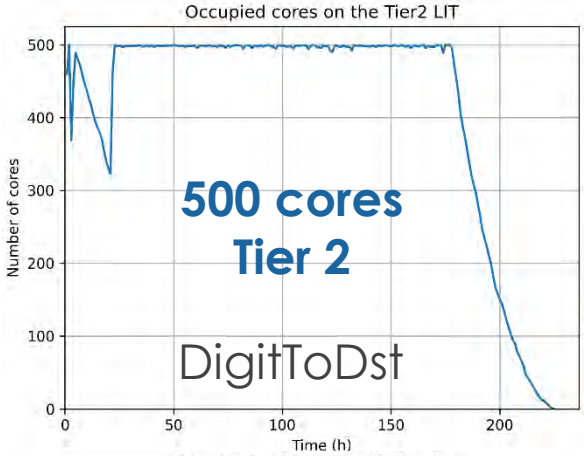
Data production speed up 2 times with 1 000 cores on NICA LHEP and 1 000 cores on Online farm !

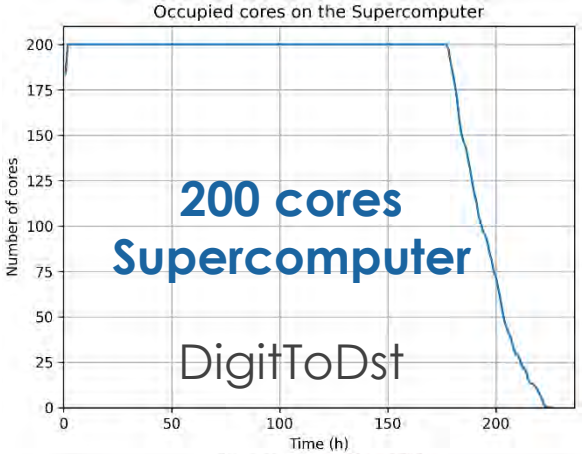
Digital Twin of BM@N computing infrastructure for data production

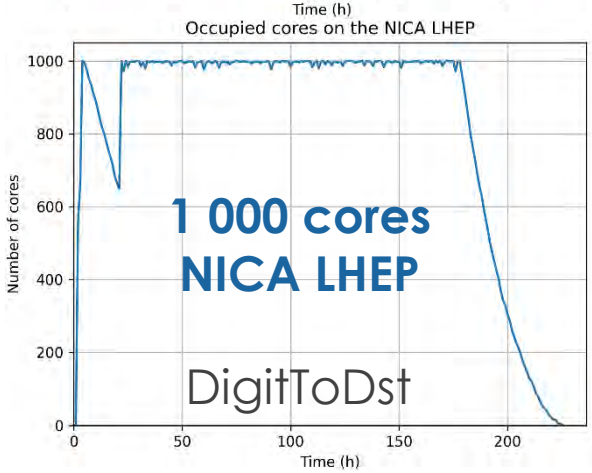
Results 2
Computing resources

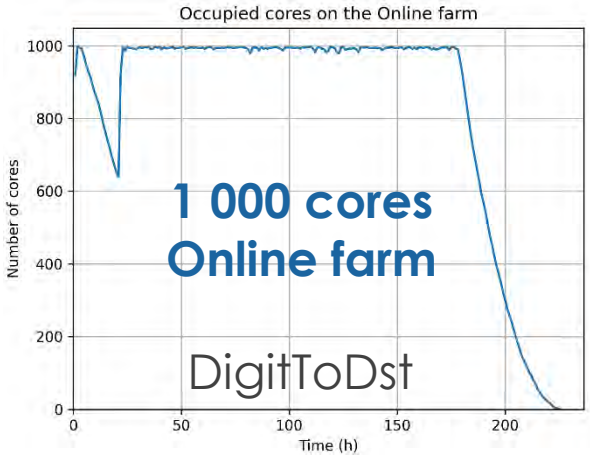
Processing experimental data (100% resource usage)

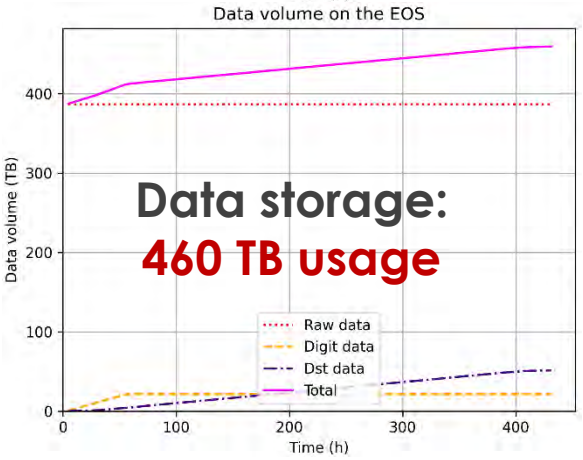












Digital Twin of BM@N computing infrastructure for data production

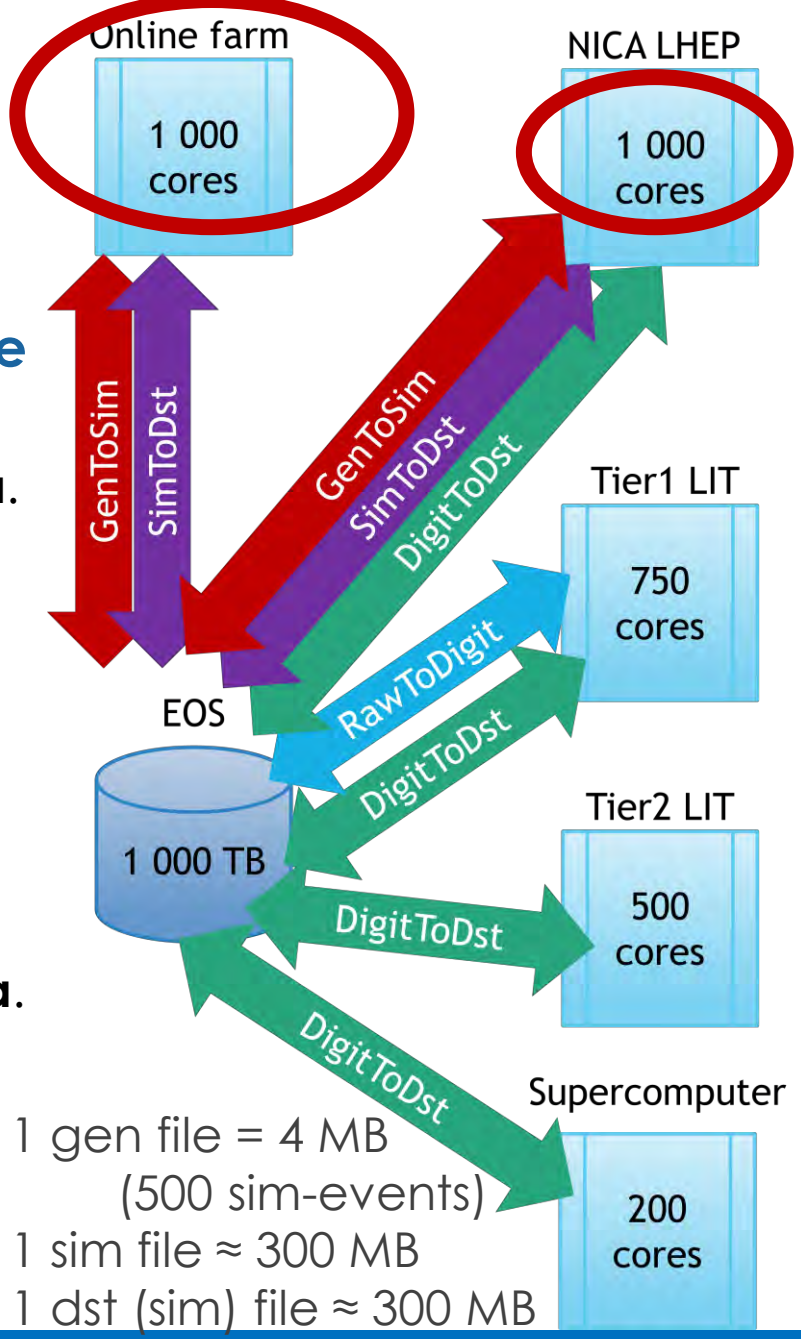
Variant 3. Planned computing infrastructure

- Processing **645 x 10^6 experimental events**
  (25 800 raw files) **to reconstruction data**.

  1. Conversion of raw experimental data
     RawToDigit job ≈ 2 500 seconds
     (1 event ≈ 0.1 sec)
  2. Reconstruction of experimental data
     DigitToDst job ≈ 86 400 seconds
     (1 event ≈ 3 sec)

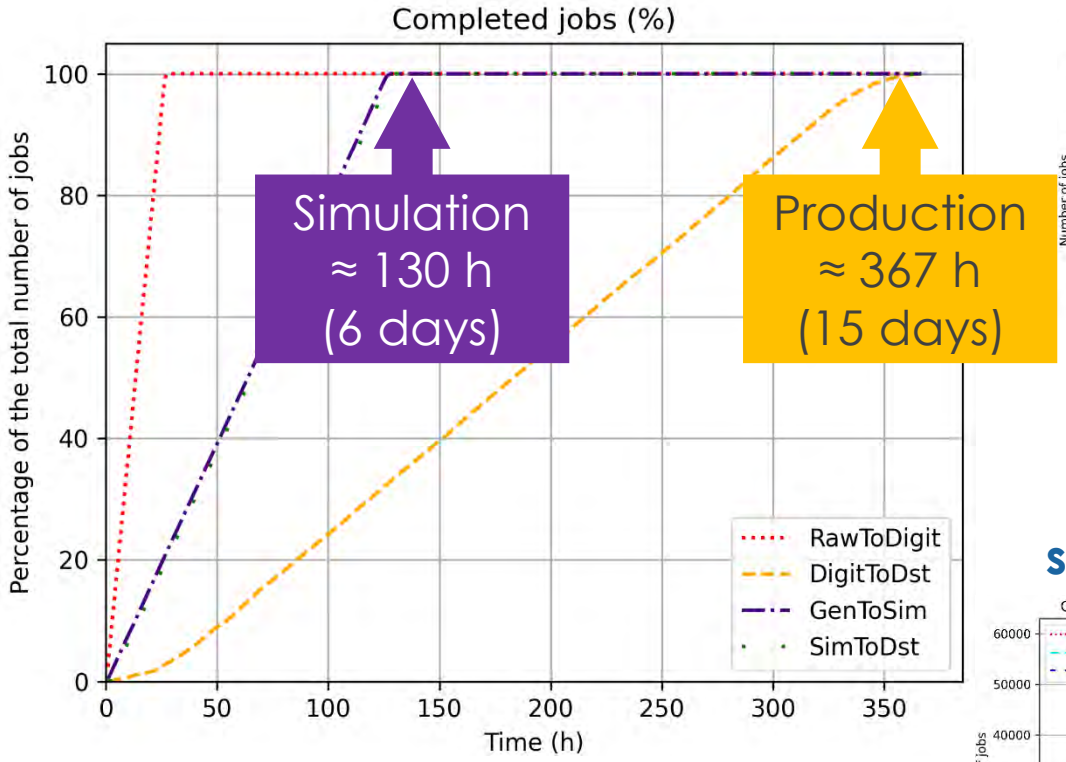
- Processing **30 x 10^6 sim-events**
  (60 000 gen files) **to reconstruction data**.

  1. Simulation GenToSim job ≈ 5 400 seconds
     (1 even ≈ 10 sec)
  2. Reconstruction of simulation data
     SimToDst job ≈ 5 400 seconds
     (1 event ≈ 10 sec)



1 gen file = 4 MB
(500 sim-events)
1 sim file ≈ 300 MB
1 dst (sim) file ≈ 300 MB

Digital Twin of BM@N computing infrastructure for data production



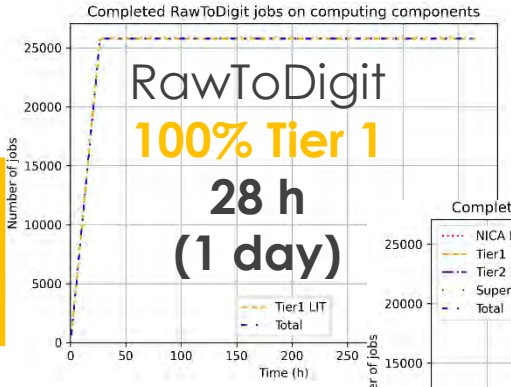
More time to processing experimental data !

BUT: Only 6 days to process simulation data !

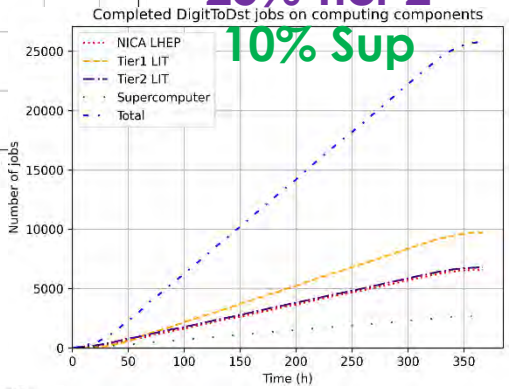
Results

Completed jobs

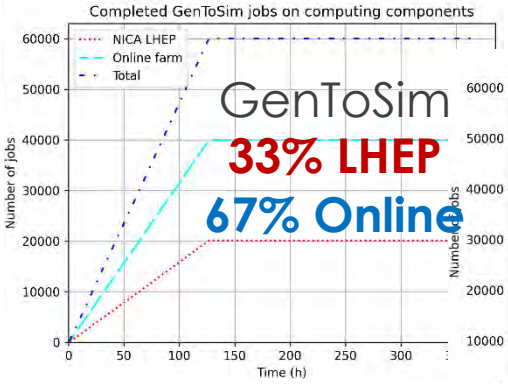
Processing experimental data

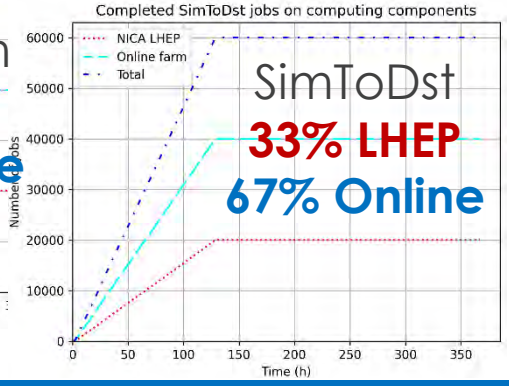


DigitToDst
25% LHEP
40% Tier 1
25% Tier 2
10% Sup



Processing simulation data

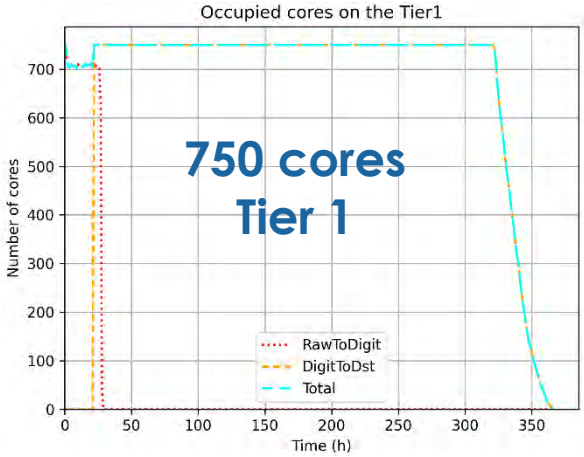


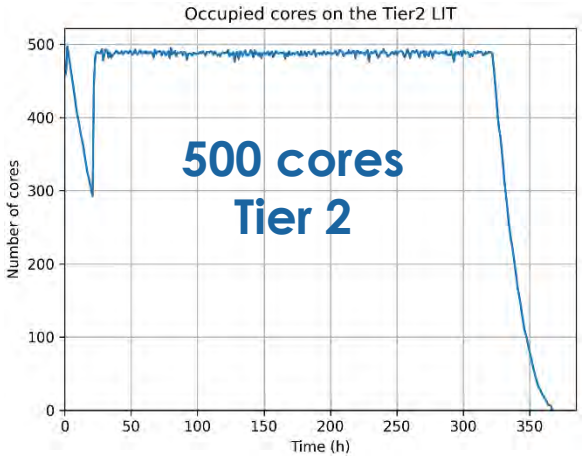


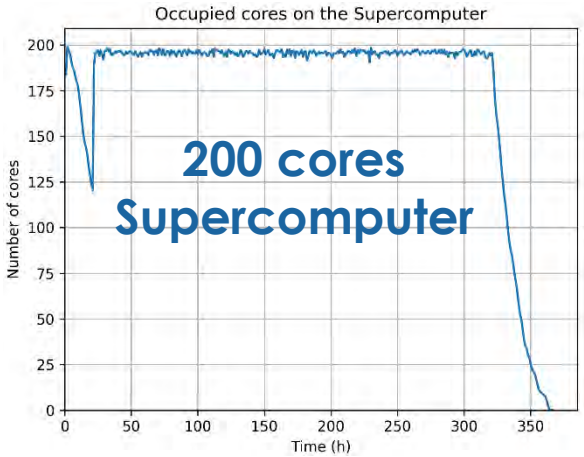
Digital Twin of BM@N computing infrastructure for data production

Results
Computing resources

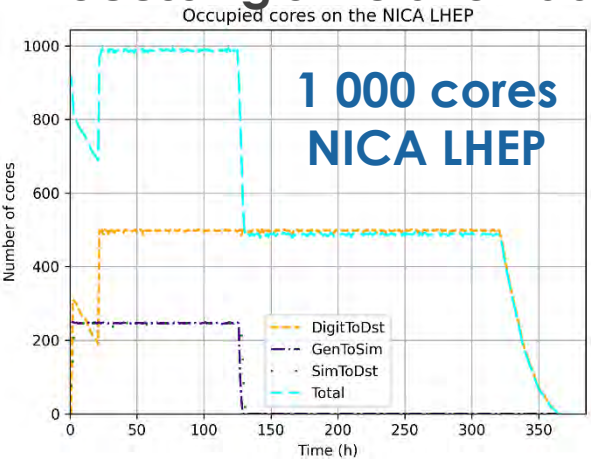
Processing experimental data (100% resource usage)

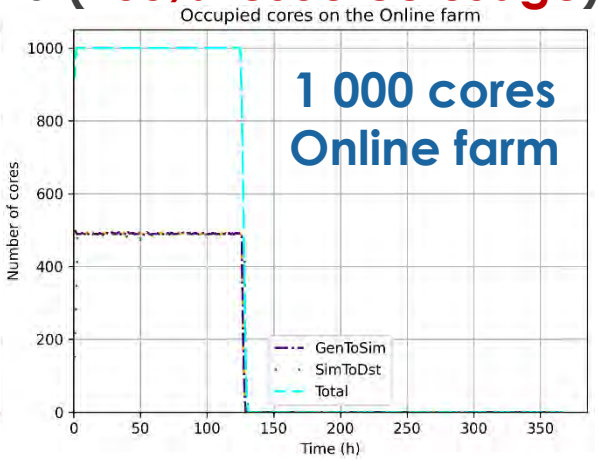


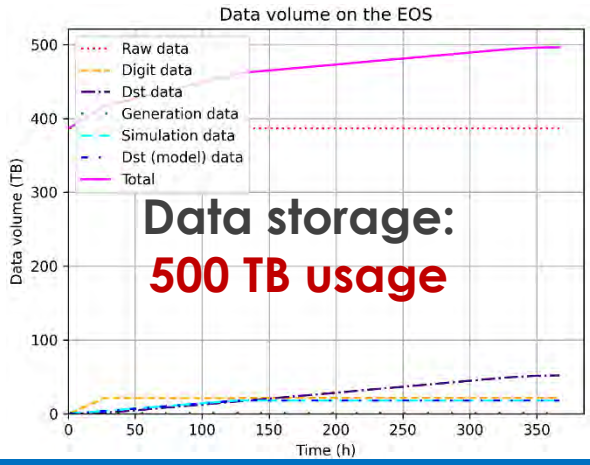




Processing simulation data (100% resource usage)







Conclusions

Comparison of different computing infrastructure configurations for data processing

	Current	Planned (exp. data)	Planned (exp. + sim. data)
During of conversion of raw experimental data	60 h **2,5 days**	28 h **1 day**	28 h **1 day**
During of processing experimental data to reconstruction data	432 h **18 days**	240 h **10 days**	367 h **15 days**
During of processing simulation data to reconstruction data	---	---	130 h **6 days**
Volume of data storage	460 TB	460 TB	500 TB

Should be:

✓ increase number of resources on NICA LHEP to 1 000 cores;

✓ add Online farm resources (1 000 cores).

Conclusions

Best configuration of planned computing infrastructure for data processing

- Processing experimental & model data to reconstruction data:
  - **645 x 10^6 raw events** (25 800 raw files) – 367 h (**15 days**)
  - **30 x 10^6 sim-events** (60 000 gen files) – 130 h (**6 days**)
- 100% usage of computing resources:
  - **Tier1 LIT** – 750 cores (RawToDigit & DigitToDst jobs)
  - **Tier2 LIT** – 500 cores (DigitToDst jobs)
  - **Supercomputer** – 200 cores (DigitToDst jobs)
  - **NICA LHEP** – 1000 cores (DigitToDst jobs & GenToSim & SimToDst jobs)
  - **Online farm** – 1000 cores (GenToSim & SimToDst jobs)
- Data storage – **500 TB**.

Conclusions

Future plans

Creation a digital twin to obtain predictive values for the amount of required resources in the future computing evolution of the BM@N experiment for 2024-2030.

Other suggestions are welcome…

Thank you for the attention!

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