

# Data Center Simulation for the BM@N experiment of the NICA Project

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## Introduction

#### The important task

Simulation of data storage and processing centers that come from experimental setups of the NICA complex, in particular, BM@N detector, or are generated using special software for checking of the developed data processing algorithms and for comparison with the expected physical result.

#### New approach to simulate

- Representation of information processes as byte streams.
- Using of probability distributions of significant data acquisition processes – the probabilities of loss of incoming information should be determined for different configurations of the data centers equipment.

### Main simulation goal

Determine the hardware configuration that will ensure the operability of the data storage and processing system – takes into account hardware parameters and expected data flows and jobs.

## The simulation software complex



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# Stages of the software complex



## The simulated structure



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## Data processing



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# **Classes of jobs**

N∘	Class	Event processing time on one processor (ms)	The average amount of input (GB)	Number of events in the file (1 file = 1 job)	Job execution time (s)	The average amount of output (GB)	Number of jobs
1	RawToDigit	350 (HPC) 1 000 (NCX)	35	175 000	61 250 (HPC) 175 000 (NCX)	1	15 552
2	DigitToDst	150 (HPC) 430 (NCX)	1	175 000	26 250 (HPC) 75 250 (NCX)	1	15 552
3	GenToSim	60	0,6	175 000	10 500	8	300
4	SimToDst	30	8	175 000	5 250	1	300
5	DstToAna	10	1	175 000	1 750	0,1	1 000

**TO DO:** simulating the process of data processing for the BM@N experiment for the subsequent quality evaluation of the obtained distribution of job flows across the available processing centers.

## Scenarios for executing jobs

Nº	Class	Location of the executing jobs / % of jobs					
		Scenario 1	Scenario 2	Scenario 3			
1	RawToDigit	NCX LHEP / 50% T2 LIT / 15% Supercomputer / 35%	NCX LHEP / 80% T2 LIT / 10%	T2 LIT / 10% Supercomputer / 90%			
2	DigitToDst	NCX LHEP / 50% T2 LIT / 15% Supercomputer / 35%	NCX LHEP / 80% T2 LIT / 10%	T2 LIT / 10% Supercomputer / 90%			
3	GenToSim	T2 LIT / 20% Supercomputer / 80%	Supercomputer / 100%	NCX LHEP / 100%			
4	SimToDst	T2 LIT / 20% Supercomputer / 80%	Supercomputer / 100%	NCX LHEP / 100%			
5	DstToAna	T2 LIT / 20% Supercomputer / 80%	NCX LHEP / 70% T2 LIT / 10% Supercomputer / 20%	NCX LHEP / 80% T2 LIT / 20%			
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## **Results of Scenario 1 RawToDigit** jobs

### Total number: 15 552

T2 LIT farm: **500 slots** 

#### LHEP farm: 400 slots 50% jobs - 7 776 Execut. time - 175 000 s



- Completed ≈1 500 jobs by 720 h
- All jobs will be completed for ≈1 700 h after finish session

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- Completed ≈1 400 jobs by 720 h
- All slots are occupied. All slots are occupied. Processing jobs is stopped

#### Supercomputer: 200 slots 35% jobs - 5 443 Execut. time - 61 250 s



- Completed ≈1 900 jobs by 720 h
- Processing jobs is stopped

Only 30% of all jobs session can be processed by 720 h

## **Results of Scenario 1** DigitToDst jobs

#### Total number: 15 552

T2 LIT farm: **500 slots** 





- Completed ≈1 500 jobs by 720 h
- All jobs will be completed for ≈1 700 h after finish session

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- Completed ≈1 500 jobs by 720 h
- All slots are occupied. All slots are occupied. Processing jobs is stopped





- Completed ≈1 800 jobs by 720 h
- Processing jobs is stopped

Only 30% raw data will be converted to reconstruction data by 720 h

### Results of Scenario 1 GenToSim jobs



Completed all jobs by 200 h

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Time (h)

Completed all jobs by 600 h

Time (h)

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#### 100% jobs can be processed

## Results of Scenario 1 SimToDst jobs

#### Total number: 300



- Completed ≈80 jobs by 720 h
- All slots are occupied.
  Processing jobs is stopped

Supercomputer: 200 slots 70% jobs – 210 Execut. time – 5 200 s Completed SimToDst jobs on the Supercomputer 



- Completed ≈180 jobs by 720 h
- All slots are occupied.
  Processing jobs is stopped

#### 90% of simulation data will be converted to reconstruction data

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## Results of Scenario 1 DstToAna jobs



- Completed 8 jobs by 720 h
- All slots are occupied.
  Processing jobs is stopped

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- Completed 16 jobs by 720 h
- All slots are occupied.
  Processing jobs is stopped

#### Only 2% of all analyze jobs can be processed

## Results of Scenario 1 Free slots



#### All slots are occupied on all resources

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## Results of Scenario 1 Conclusions

- Only 30% raw data will be converted to reconstruction data (during session – 30 days).
- 90% of simulation data will be converted to reconstruction data by 720 h.
- We will have to wait several more months until the end of processing all the raw data after the end of the session.
- > There are not enough resources for data analysis.

### This jobs allocation scenario is not suitable!

## Results of Scenarios 2 & 3 Conclusions

The results obtained were similar to the results of the first scenario.

Scenario 2	Scenario 3					
10%	15%					
of all jobs session can be processed by 720 h						
1.5%	1%					
of raw data will be converted	of raw data will be converted to reconstruction data by 720 h					
100%	100%					
of simulation data will be cc	of simulation data will be converted to reconstruction data					
LHEP farm & T2 LIT farm	LHEP farm & Supercomputer					
all slots are occupied						
This jobs allocation scenarios are not suitable!						

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## **Total conclusions**

- 1. Model data analysis can be done on one of computing resources.
- 2. Full processing a single file with experimental data takes a lot of time.

#### Scenario 4 with express file processing.

# Express processing should be run simultaneously with full processing.

Express processing: 1% of file (350 MB) on LHEP farm and T2 LIT farm.

## **Results of Scenario 4 RawToDigit jobs**



iobs

pleted

<u>T2 LIT farm: 500 slots</u> 15% jobs - 2 333

Supercomputer: 200 slots 35% jobs - 5 443





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## **Other results**



per session – 338 TB

- Maximum load of link to the LHEP farm – 90 MB / sec
- Maximum load of link to the LIT farm – 50 MB / sec

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# **Conclusions and Outlook**

- Developed a tool for modeling the process of data acquisition and processing.
- Based on the simulation results, we can predict problems that may appear during the experiment and data processing.
- 3 scenarios (which are provided by physicists) for executing jobs are modeled. Some problems were found:
  - model data analysis can be done on one of computing resources;
  - o full processing a single file with experimental data takes a lot of time.
- We offer scenario with express file processing to solve problems. Results: 45% of all jobs session can be processed by 720 h.

### > Next steps:

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developing module like pilot for starting jobs;

 conducting computational experiments taking into account the fact that the equipment does not have absolute reliability (calculating probability of equipment failure and recovery times).



# Thank you for the attention!

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