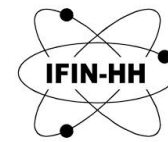
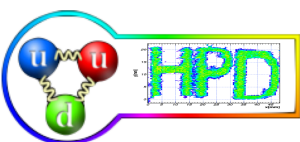




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www.ifin.ro



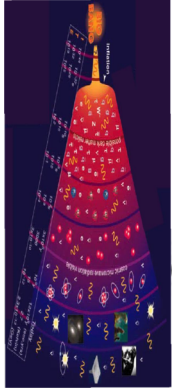
ALICE

- *Activities and achievements in the past year*
- *Remarks on additional activities*
- *Proposal for the continuation of the Project (2020-2021)*

# HADRON PHYSICS DEPARTMENT

*National Institute for Physics and Nuclear Engineering – IFIN-HH*

# Physics motivation



T

## Statistical model:

- for  $\mu_B \ll m_N$  the thermal degrees of freedom dominated by mesons
- for higher  $\mu_B$  more baryons are excited

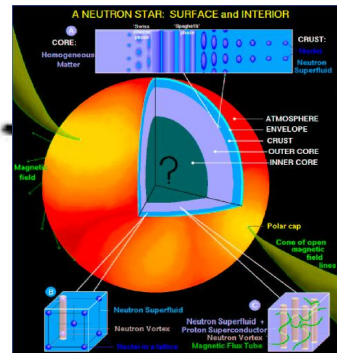
**Chiral transition:**  
 $\mu_B > \mu_E$  - first order  
 $\mu_B < \mu_E$  - crossover  
 realistic  $u, d, s$  masses

**Liquid-gas phase transition:**  
 $\mu_{NM} \cong 924 \text{ MeV}$   
 $n_0 = 0.17 \text{ fm}^{-3}$

**H**  
 $\mu_H = 350 - 400 \text{ MeV}$   
 $T_H = 150 - 160 \text{ MeV}$

Their meeting point  
 Triple point  
 H - remnant for finite  $N_c$

**E**



- large  $N_c$  QCD phase diagram:
- three regions, i.e.:
- confined
- deconfined
- quarkionic phase
- separated by 1<sup>st</sup> order phase transition

**Large  $N_c$  limit of QCD**  
 - quarks loops are suppressed by  $1/N_c$  relative to gluon contribution  
 $\Rightarrow$  cold dense matter in the  $N_c = \infty$  world for  $\mu_B \gg m_N$  - quarkyonic matter

Quark-Hadron continuity:

**G**

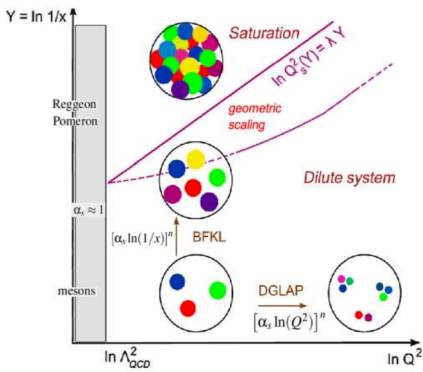
Superfluid nuclear matter  $\Rightarrow$  Superconducting quark matter

**F**

$\mu_B$

# Physics motivation

**T**

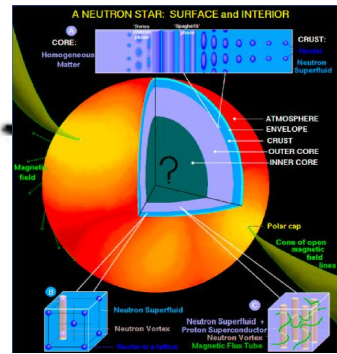


**H**

$\mu_H = 350 - 400 \text{ MeV}$   
 $T_H = 150 - 160 \text{ MeV}$

Their meeting point  
 Triple point  
 H – remnant for finite  $N_c$

- large  $N_c$  QCD phase diagram:
- three regions, i.e.:
- confined
- deconfined
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Liquid-gas phase transition:  
 $\mu_{NM} \cong 924 \text{ MeV}$   
 $n_0 = 0.17 \text{ fm}^{-3}$

**E**

**G**

**F**

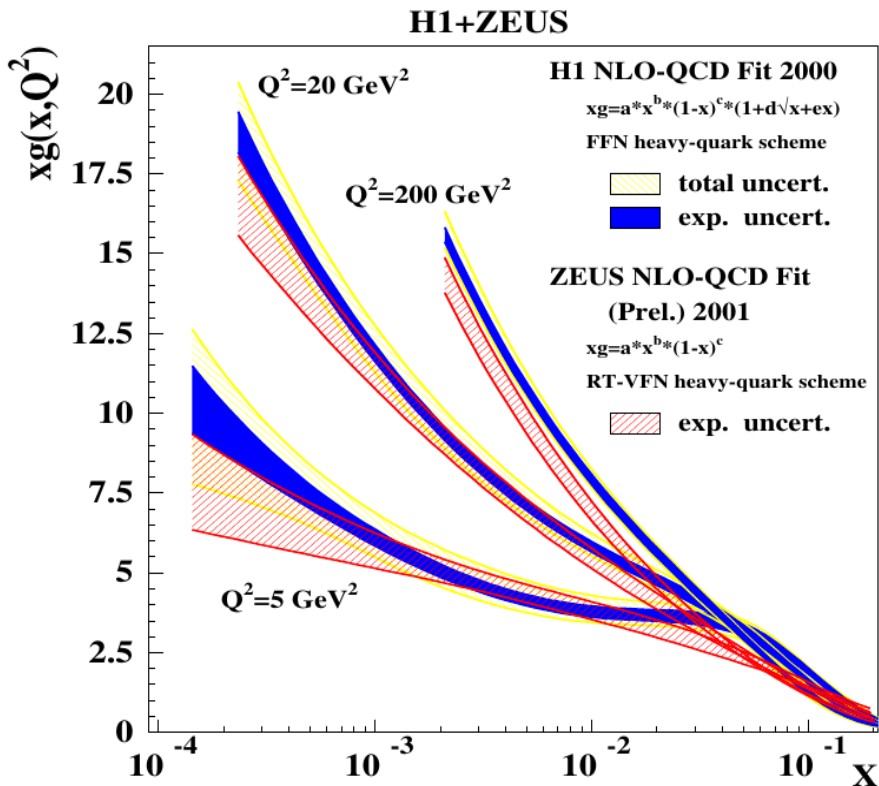
Superfluid nuclear matter  $\Rightarrow$  Superconducting quark matter

Quark-Hadron continuity:

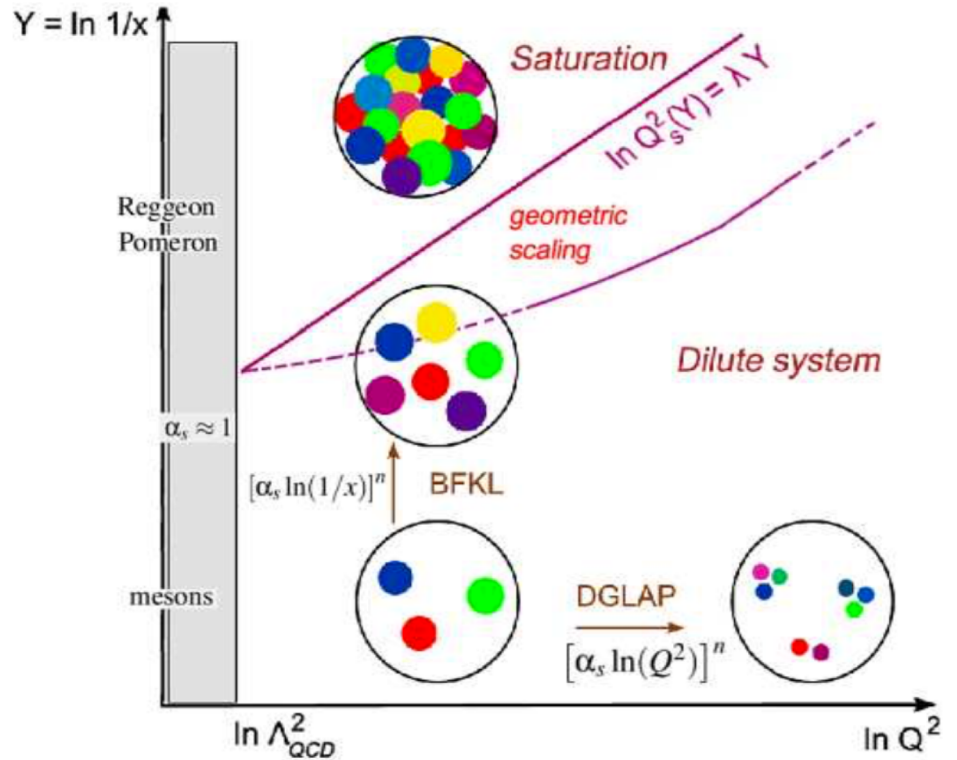
$\mu_B$



# Physics motivation



M.Dittmar et al., Proceedings HERA-LHC Workshop  
 arXiv:[hep-ph]0511119



D. d'Enterria, Eur.Phys.J. A31(2007)816

Following A.H. Mueller  
 approximations NP A715(2003)20

System	<i>Au-Au</i>	<i>Pb-Pb</i>	<i>Pb-Pb</i>	<i>pp</i>
$\sqrt{s}(GeV)$	200	2700	5020	7000
$\frac{dN_g^{in}}{dyd^2b}(fm^{-2})$	$\approx 4.7$	$\approx 11.8$	$\approx 15.9$	$\approx 18.7$
$f_{in}^g$	$\approx 0.9$	$\approx 2.3$	$\approx 3.1$	$\approx 3.6$



## Highlights of accomplishments in the last year

### •Physics

- **Studies for obtaining  $p_T$  spectra simultaneously conditioned on multiplicity, directivity and within same-side, away-side and in between for different cuts in  $\eta$  relative to the leading particle for identified charged hadrons in pp collisions at  $\sqrt{s} = 7$  TeV. Implementation of unfolding based on a multi-dimensional detector response matrix.**
- **Studies of two charged particles correlations as a function of multiplicity and directivity in pp collisions at  $\sqrt{s} = 7$  TeV. Cross-checks at  $\sqrt{s} = 7$  TeV and similar studies for pp collisions at  $\sqrt{s} = 13$  TeV are in progress.**
- **Studies on the core-corona interplay at LHC and RHIC energies based on experimental data and Glauber MC estimates. The existing experimental data were carefully analyzed, extrapolations and interpolations of  $p_T$  spectra were performed in a consistent way, final results are expected soon.**
- **15 presentations in ALICE meetings (TPCU and Spectra-PAG)**
- **Contribution to 17 conference presentations**
- **Co-authors to 30 ALICE published papers**
- **2 ALICE related physics papers, independent of ALICE Collaboration**
- **Color Glass Condensate inspired scaling variable and system size dependence  
A. Lindner, Annual Scientific Meeting, University of Bucharest, 21-22 June, 2019**
- **Towards Color Glass Condensate at LHC energies  
D. Avramescu, IFIN – Young scientist days, Bucharest, 17 December, 2018**
- **Dependence of different observables on the CGC inspired variable for light flavor hadrons in pp and A-A collisions at RHIC and LHC energies  
A. Lindner, IFIN – Young scientist days, Bucharest, 17 December, 2018**
- **Multiplicity dependence of light-flavor hadron production in pp collisions at  $\sqrt{s} = 7$  TeV; PC members  
Phys.Rev.C99(2019)024906**

## Highlights of accomplishments in the last year

### •Physics

- **On similarities as a function of system size in heavy ion collisions**  
M.Petrovici, A.Lindner and A.Pop  
AIP Conference Proceedings 2076(2019)040001
- **Multiplicity-dependent pT distributions of identified particles in pp collisions at 7 TeV within the HIJING/B<sup>-</sup>B v2.0 model**  
V. Topor Pop and M. Petrovici  
Phys. Rev. C 98, 064903 – Published 10 December 2018
- **Why pp collisions at 14 TeV ?**  
C. Andrei, D. Avramescu, I. Berceanu, A. Bercuci, A. Herghelegiu, A. Lindner, M. Petrovici, A. Pop, C. Schiaua, M. Tarzila  
ALICE-ANA-2019-26.08 - Internal Note
- **Charged particle multiplicity and event shape dependence of two charged particle correlations in pp collisions at  $\sqrt{s}=7$  TeV**  
M.Tarzila, C.Andrei, M.Petrovici, A.Pop  
ALICE Week, PWG-MM mini workshop, March 28, 2019
- **What's really new at LHC energies ?**  
C. Andrei, D. Avramescu, I. Berceanu, A. Bercuci, A. Herghelegiu, A. Lindner, M.Petrovici, A. Pop, C. Schiaua, M. Tarzila  
Spectra PAG, September 16, 2019
- **$R_{AA}$ ,  $R_{CP}$  and normalized ratios, with and without Core-Corona corrections scaling as a function of  $N_{part}$  – in progress**
- **A consistent treatment of pp and A-A collisions at LHC energies was started.**  
First results within CGC framework for pp and Pb-Pb collisions at LHC energies were obtained – work in progress (Dana Avramescu - YSF presentation)
- **NIHAM Status and Performance**  
C. Schiaua  
9<sup>th</sup> Annual ALICE Tier-1/Tier-2 Workshop, 14-16 May, Bucharest, 2019

## Highlights of accomplishments in the last year

### •ALICE upgrade

- 20 TPC - OROCs were successfully finalized, tested and transported at CERN, passing the upon arrival tests; already installed in the TPC, preliminary tests are in progress.

### •Computing

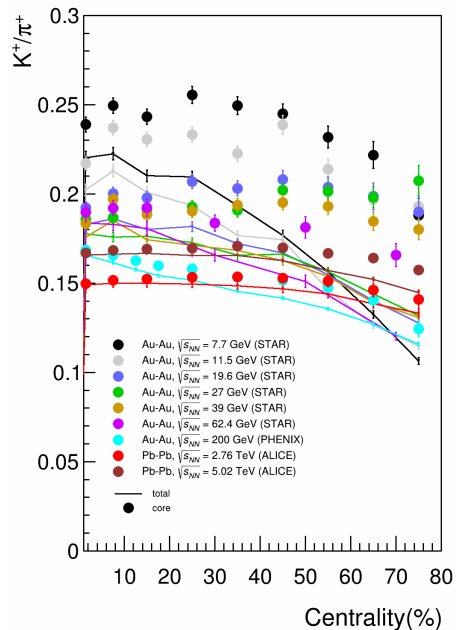
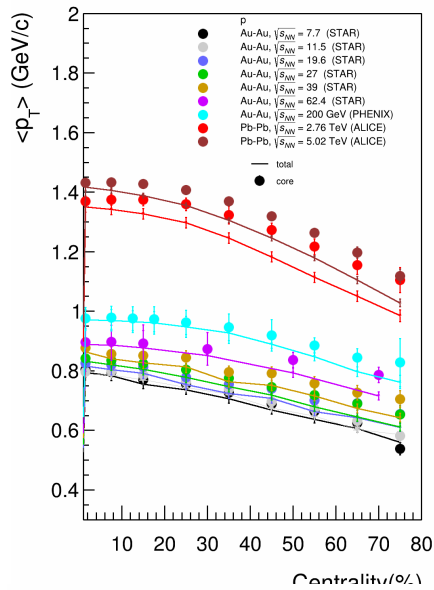
- NIHAM maintained the leading position among Tier2s ALICE GRID centers.  
A new data storage capacity of 4.6 PB raw and 3.82 PB effective was installed and is currently in operation.  
Another data storage unit of 2.3 PB raw and 1.91 PB effective was purchased and will be installed beginning next year.  
Two new cooling units were purchased and their installation is in progress.  
NAF is efficiently managed.

### •Teaching & Outreach

- Summer student program: 3 participants: 2 from Faculty of Physics, University of Bucharest and 1 from Universidad Complutense de Madrid, Spain.  
Lectures were presented by HPD members (<http://niham.nipne.ro/lectures.html>)
- Numerous visits of Romanian and foreign delegations, Romanian pupils winners of International Competitions in Physics
- The first number of the HPD Courier was issued ([http://niham.nipne.ro/HPD-Courier\\_electronic-version.pdf](http://niham.nipne.ro/HPD-Courier_electronic-version.pdf))  
The second one will be dedicated to the 70<sup>th</sup> anniversary of the Institute for Physics of Romanian Academy, founded by Horia Hulubei, the precursor of IFIN-HH and will be issued in December 2019
- visit of the participants to the 9<sup>th</sup> Annual ALICE Tier-1/Tier-2 Workshop, 14-16 May, Bucharest, 2019
- More details could be seen in:  
<https://niham.nipne.ro>  
<https://www.youtube.com/watch?v=OJd4fA0xUh0>  
<https://www.facebook.com/Hadron-Physics-Department-211078852968333/>

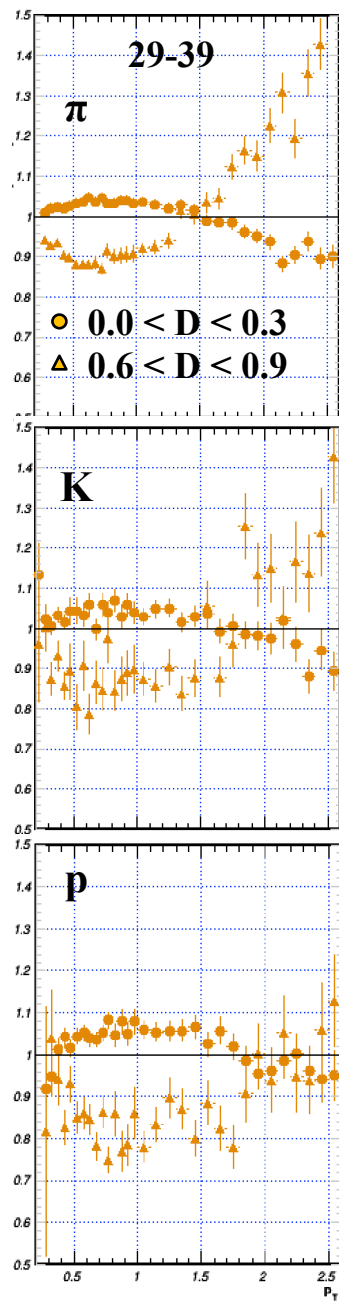


# Core-Corona



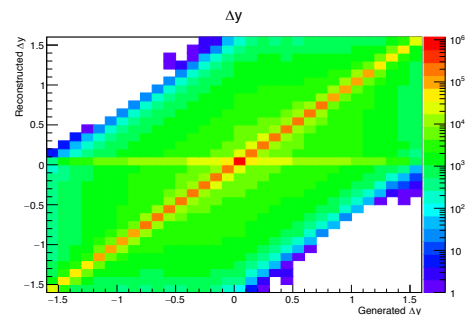
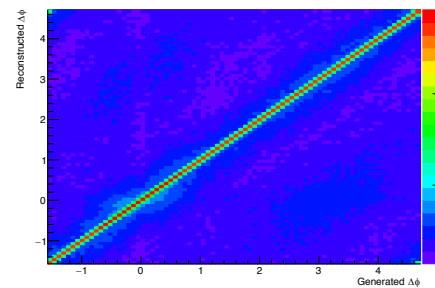
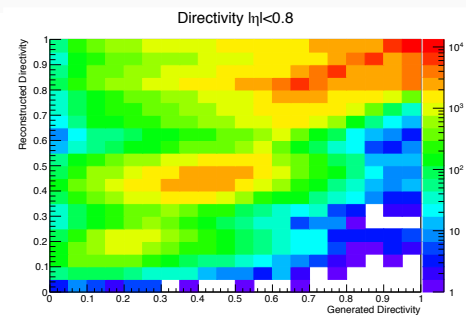
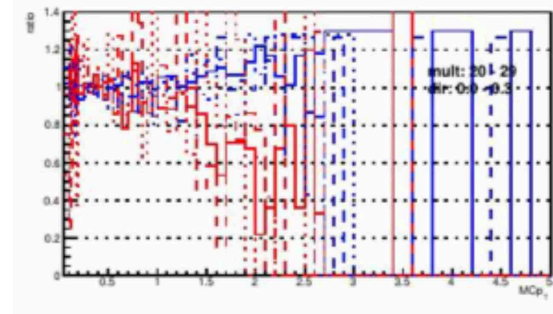
# Physics

## $p_T$ spectra - ratio to mult. cut

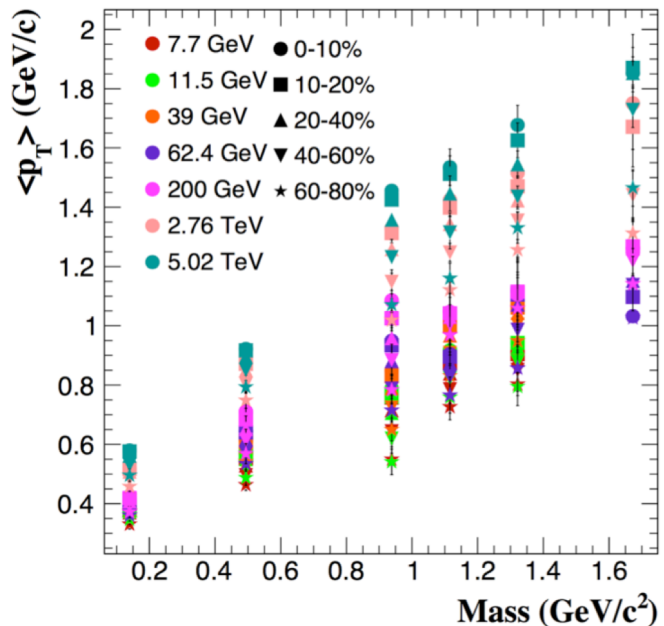
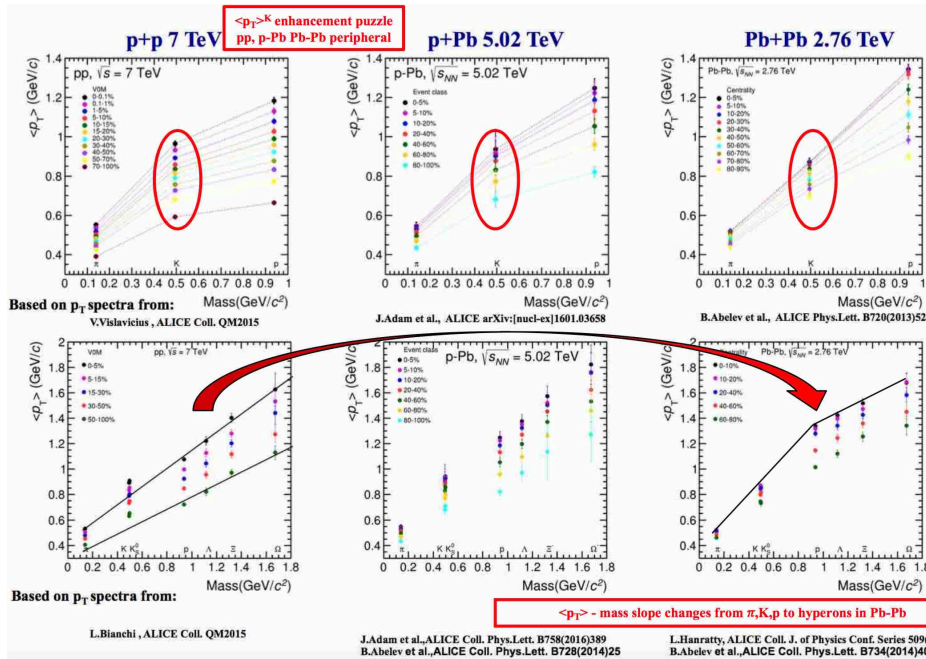
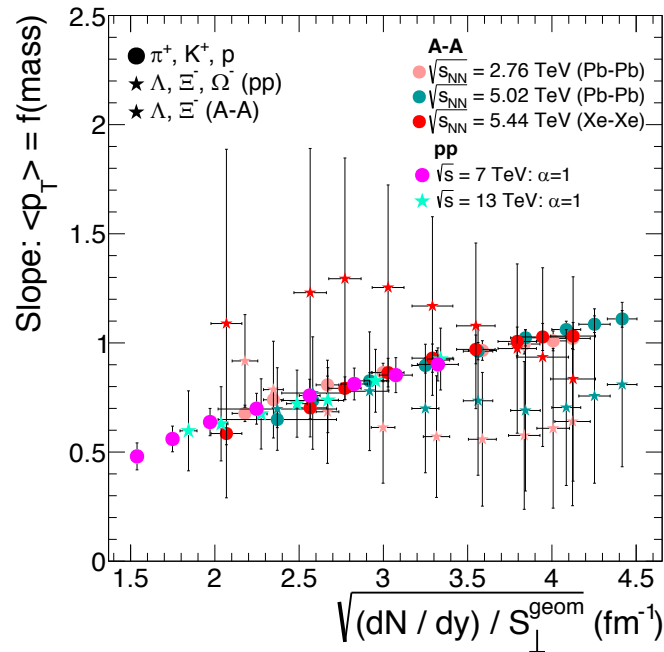
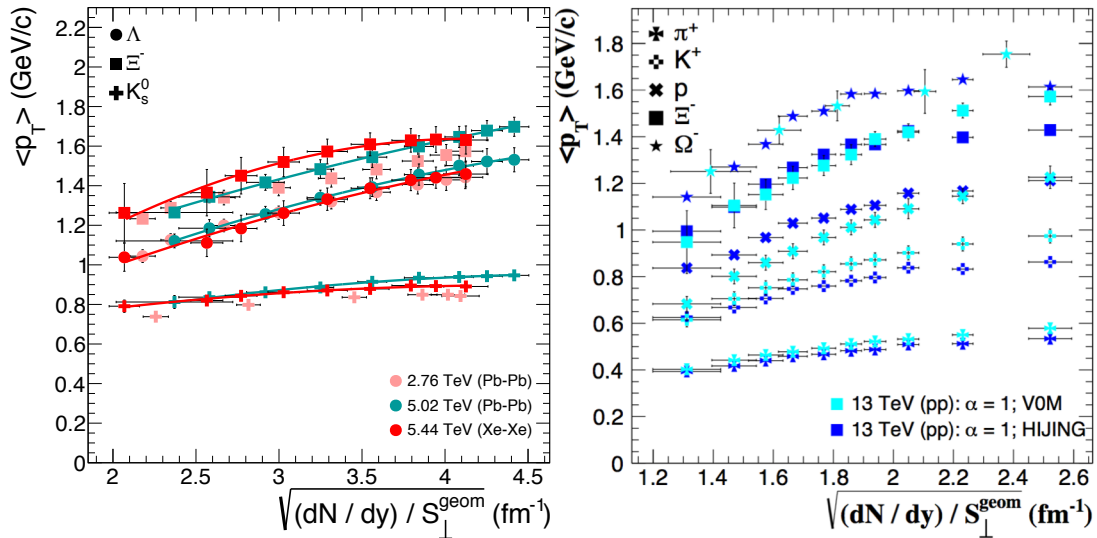


# Multi differential analysis

“in-jet” & “out-of-jet” relative to integrated

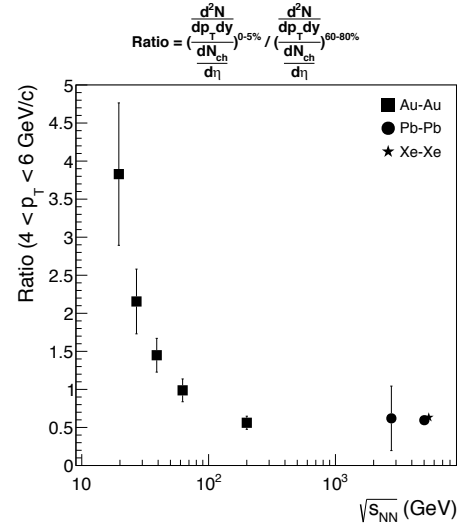
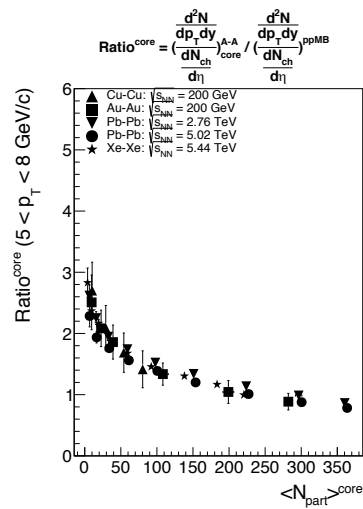
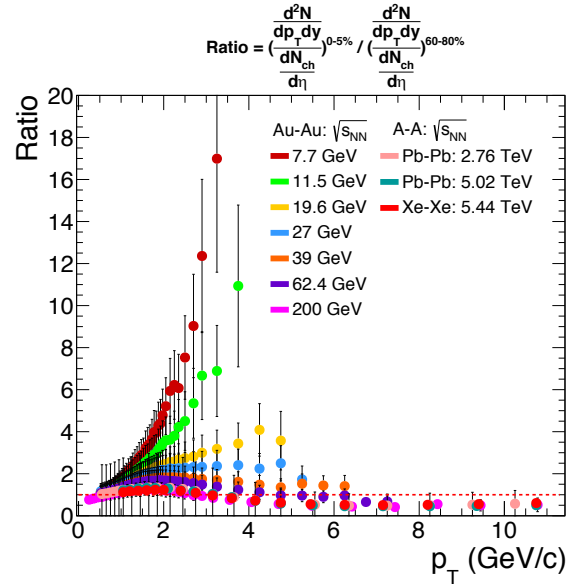
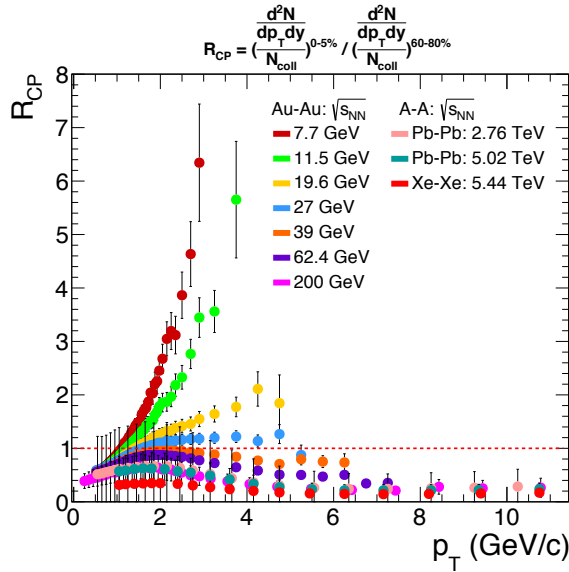


# Physics



# Physics

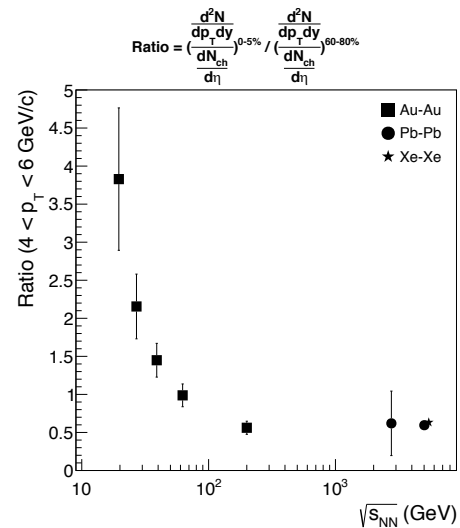
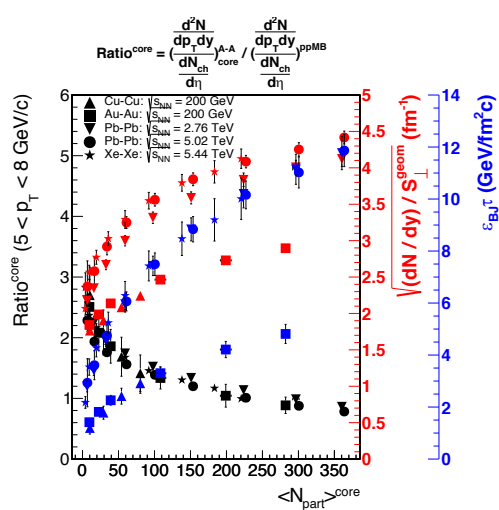
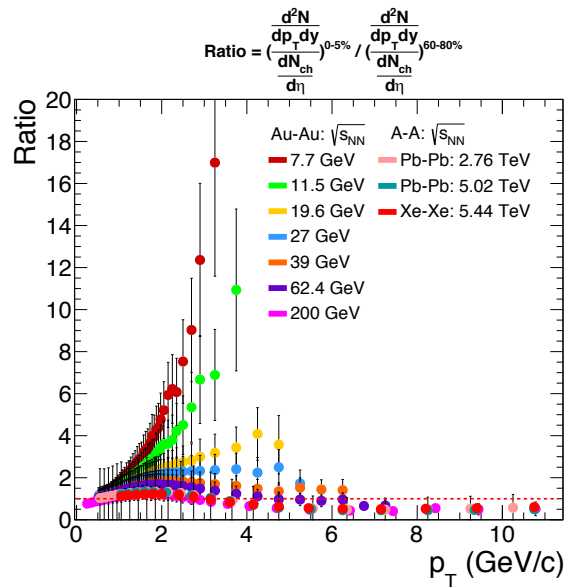
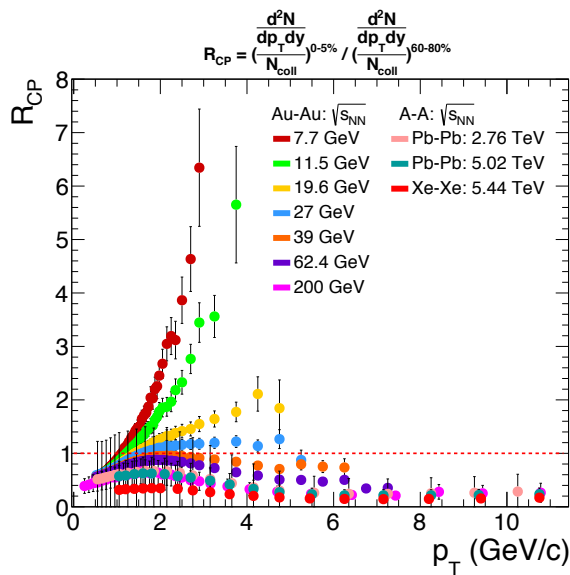
$$R_{AA}, R_{CP} \text{ and } \frac{\left[ \frac{d^2\sigma}{dydp_T} / \langle dN_{ch}/d\eta \rangle \right]^{(\% \text{bin})}}{\left[ \frac{d^2\sigma}{dydp_T} / \langle dN_{ch}/d\eta \rangle \right]^{(p+p)^{MB}}} N_{part} \text{ scaling}$$





# Physics

$$R_{AA}, R_{CP} \text{ and } \frac{\left[ \frac{d^2\sigma}{dydp_T} / \langle dN_{ch}/d\eta \rangle \right]^{(\% \text{bin})}}{\left[ \frac{d^2\sigma}{dydp_T} / \langle dN_{ch}/d\eta \rangle \right]^{(p+p)^{MB}}} N_{part} \text{ scaling}$$



# Physics

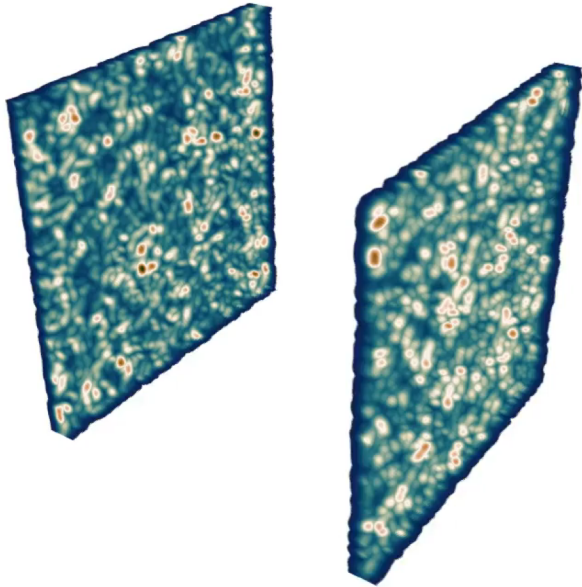
## Simulating the initial stage of hadron-hadron collisions

A. Ipp, D. Mueller [arXiv:1703.00017]

- Real-time lattice gauge simulations for the initial conditions of hadron-hadron collisions, done in the CGC framework.

Energy density for Au-Au at  $\sqrt{s_{NN}} = 200$  GeV

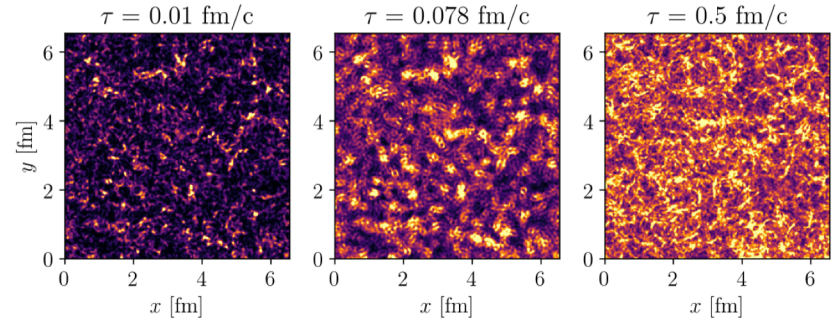
- Longitudinal chromo-electromagnetic fields



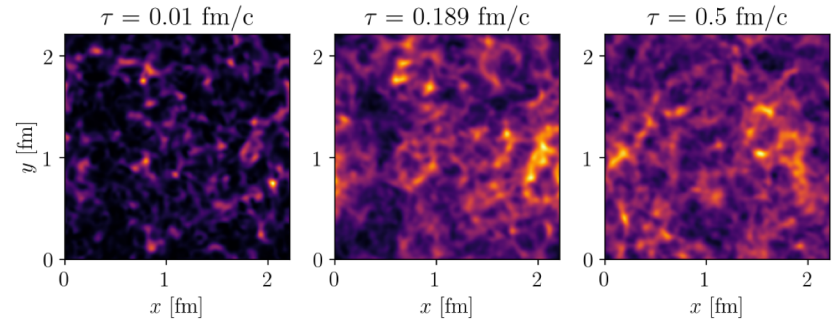
Transverse energy density  $\varepsilon(\tau, \mathbf{x}_T)$

- Expanding Glasma flux tubes

Pb-Pb  $\sqrt{s_{NN}} = 5.02$  TeV



pp  $\sqrt{s_{NN}} = 5.02$  TeV



# Physics

## *ALICE Upgrade - a must for multidimensional analysis and rare probes*

### *Scale down factors for pp collisions at 7 TeV*

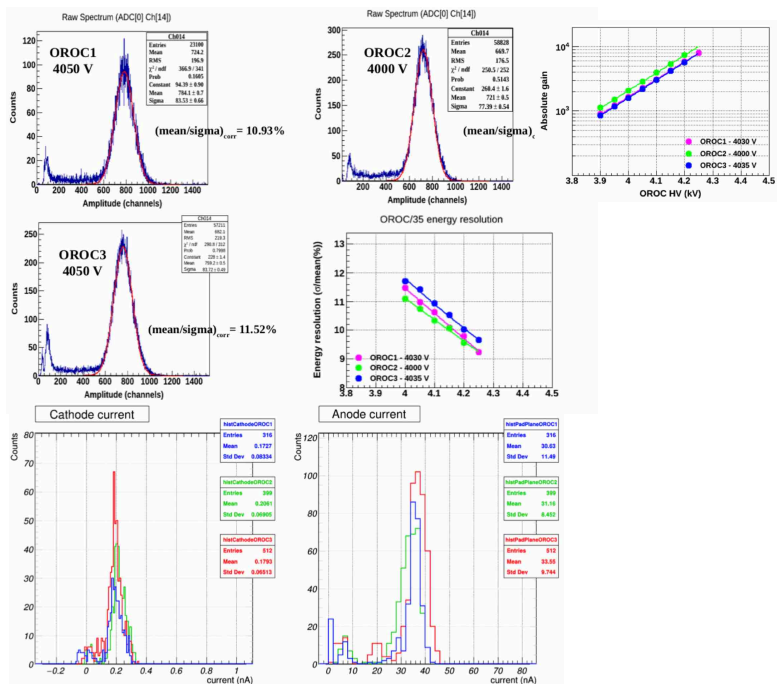
AND	pions (no TOF matching condition)	Reduction factor
MB	53534470	-
& multiplicity 40-49	1807777	30
& directivity 0-0.3	327839	5.5
delta phi - outside peaks	87815	3.7
delta y  > 1.0 (>1.4)		10 (40)
total	-	6100

STANDALONE	pions (no TOF matching condition)	Reduction factor
MB	53534470	-
multiplicity 40-49	1807777	30
directivity 0-0.3	2938389	18
delta phi - outside peaks	14768870	3.6
delta y  > 1.0	-	10



# Assembling, Testing & Transport to CERN - SUCCESSFULLY FINALIZED!

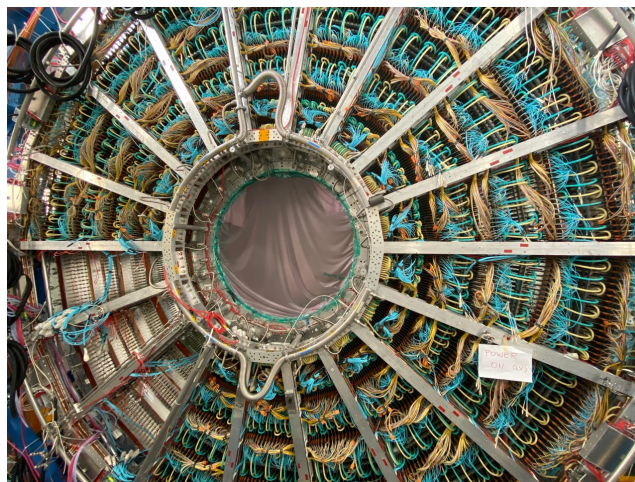
## 20<sup>th</sup> OROC test results



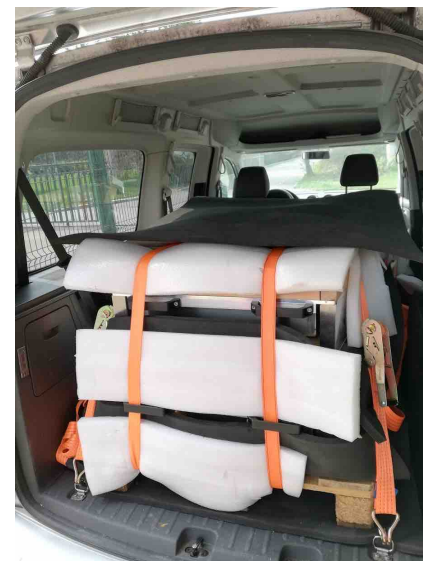
Assembling and testing team



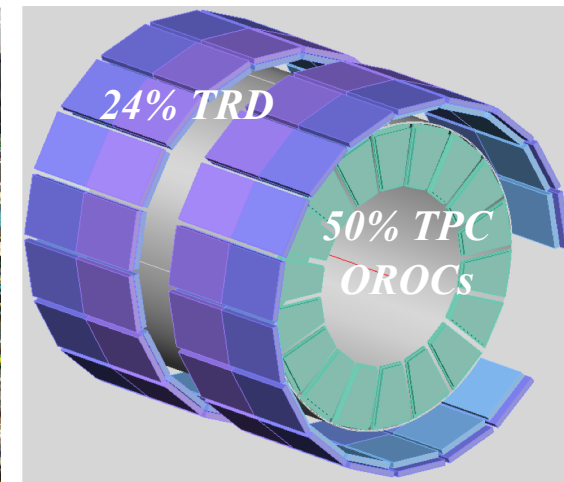
Upgraded TPC ready for tests



Last transport to CERN

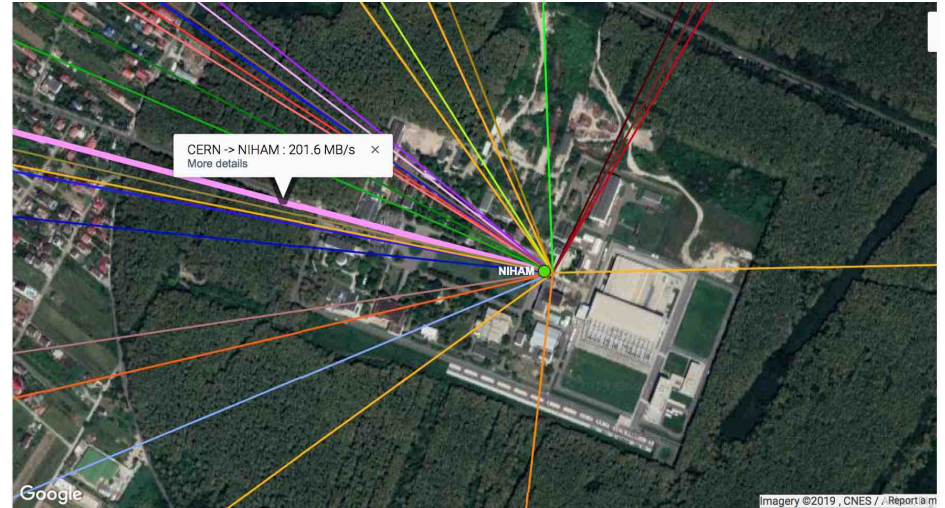


HPD contribution to the ALICE Experiment

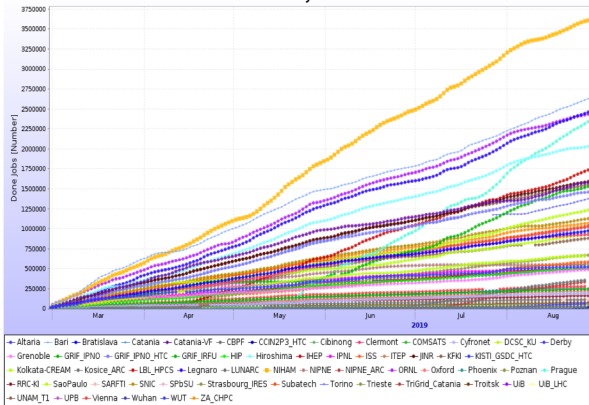




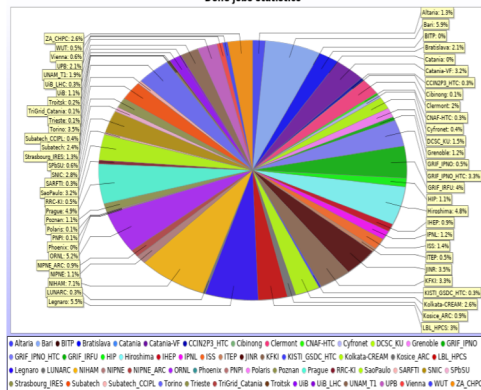
# NIHAM Data Centre performance



Done Jobs



Done jobs statistics



## Contribution to ALICE GRID

*HPD contribution ~58% of Romanian TR2 Federation*

*Done jobs - NIHAM:*

*-  $6.2 \cdot 10^6$*

*- 6.6% of total Tier2 ALICE contribution*

*CPU time - NIHAM:*

*- 6.6 Mhours*

*- 6.18% of total Tier2 ALICE contribution*



## *NIHAM Upgrades*

*A new data storage of 4.6 PB Raw/3.82 PB Effective was installed and is currently in operation*



*An upgrade with 50% more data storage will be done in the next months.*

*Two new cooling units*

*A.*



*B.*





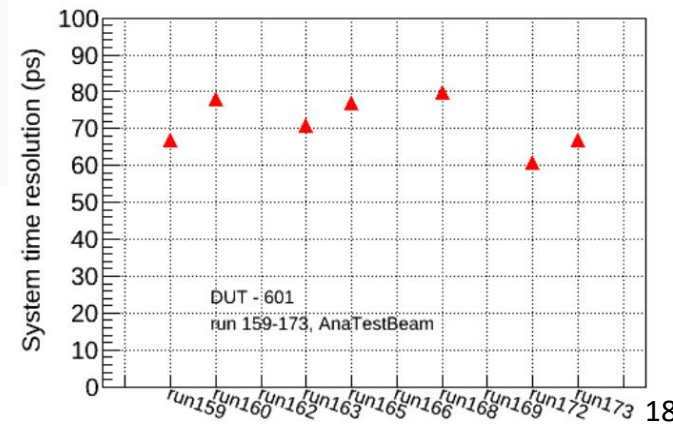
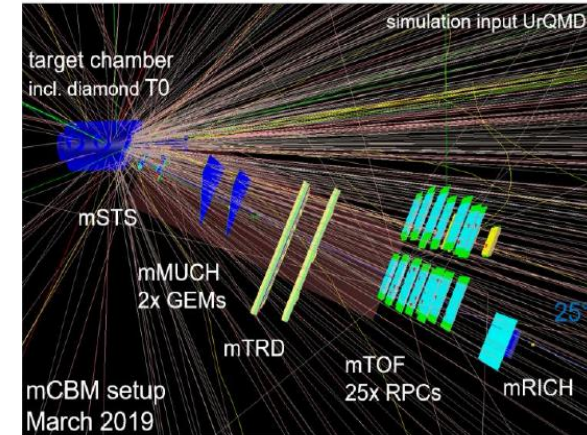
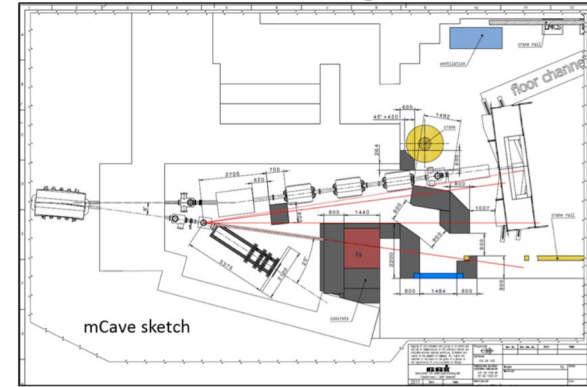
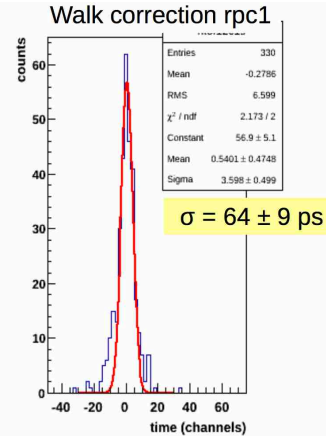
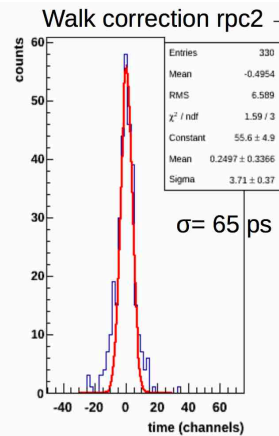
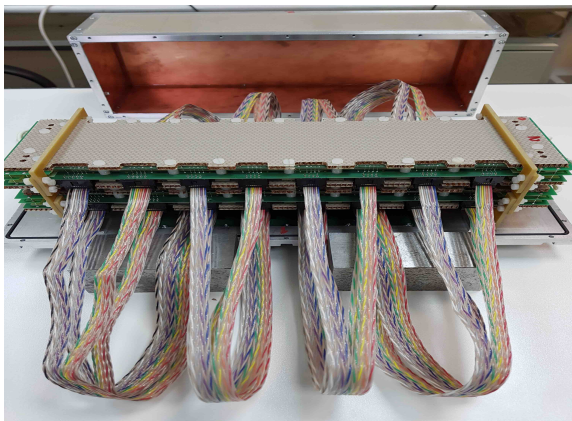
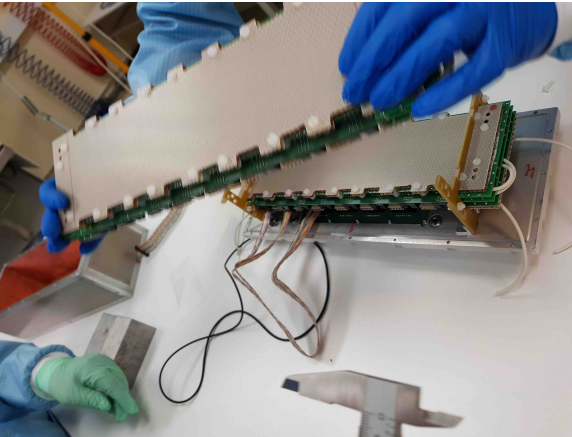
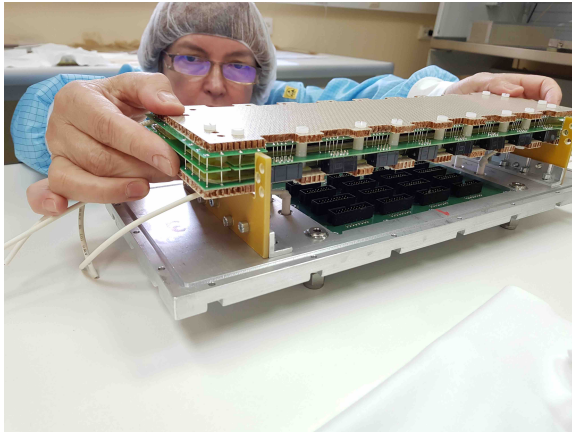
*Remarks on additional activities*

# Assembling and tests of 2 new RPC prototypes

In mCBM

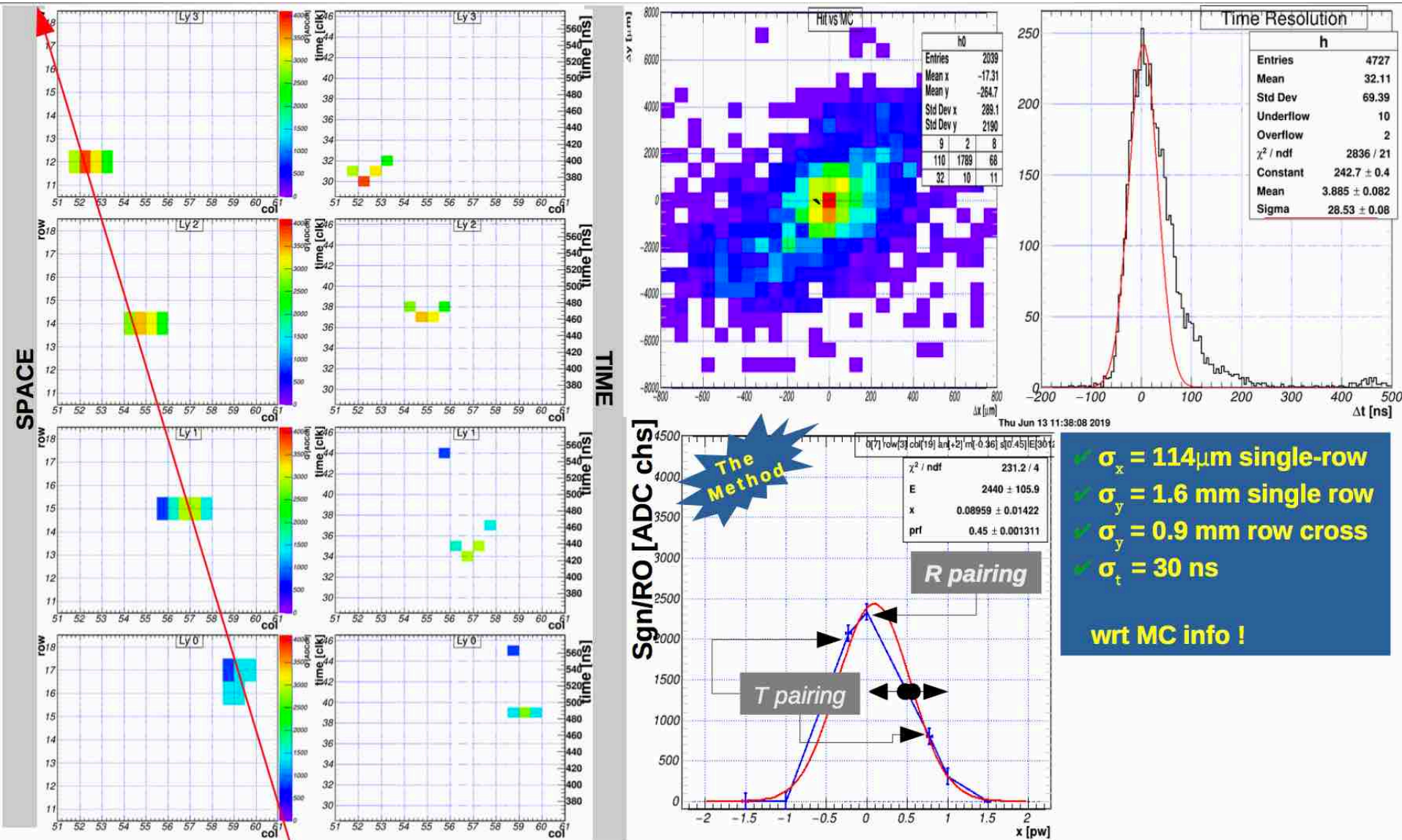
FAIR Phase0 @ SIS18

## In house tests

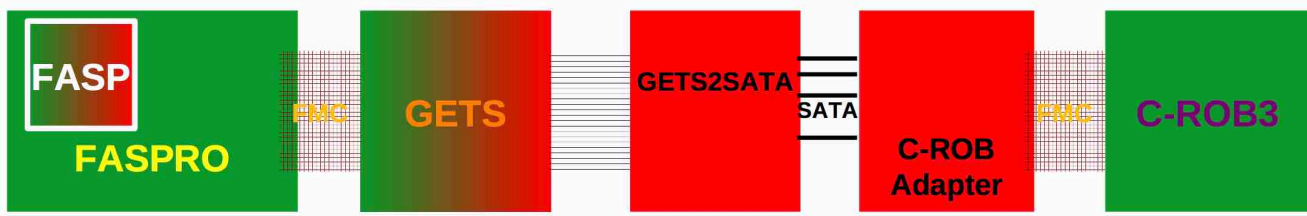
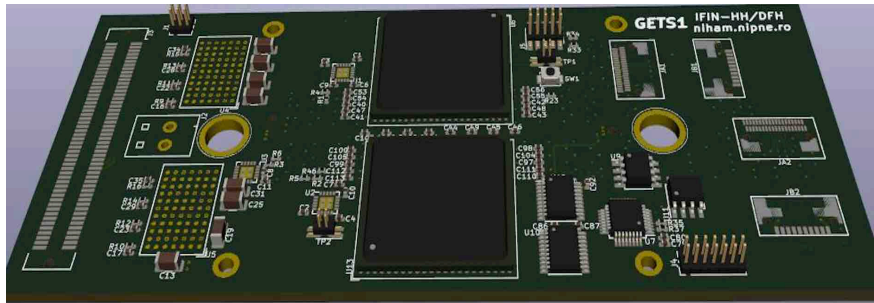
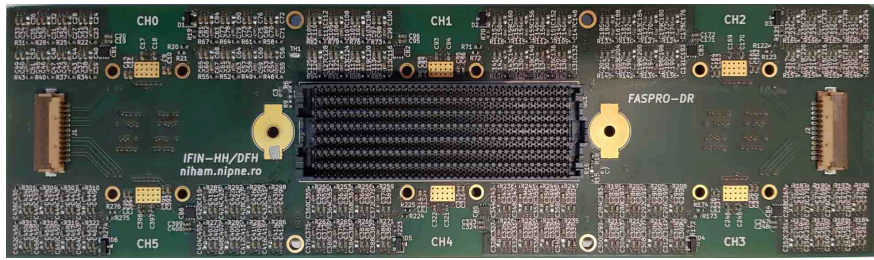
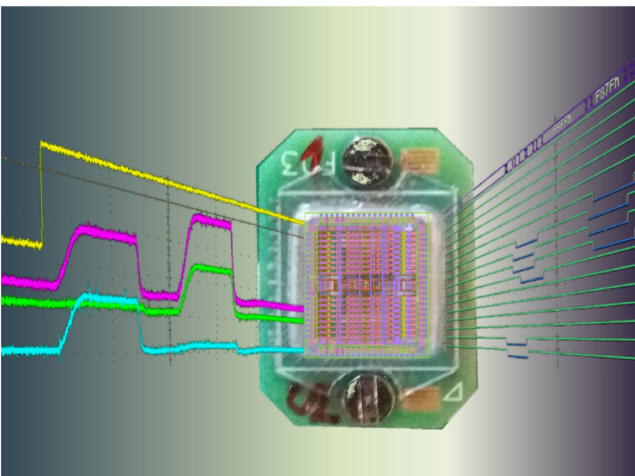




# TRD - reconstruction performance



# Hdw chain (PCBs) to connect FASP FEE to the C-ROB3 and their realization status



■	ready
■	in progress
■	missing

**FASP** : Production ready for up to 80 pcs (45 % of 1 module)  
Bonding in progress

**FASPRO** : tested, fixed, 9 pcs available.

**GETS** : Design ready; components available (PolarFire)  
Production ready (details solved)

**GETS2SATA** : Connector board  
Convert I/O to 4 SATA cables  
Design not started (1 month)

**C-ROB Adapter** : Maps 5x4 SATA input cables to FMC connector on C-ROB  
Design not started (1 month)

**C-ROB3** : 1 pcs available in Bucharest  
We might need another one



# Training & teaching

Would you like to contribute to understand the secrets of the Universe?

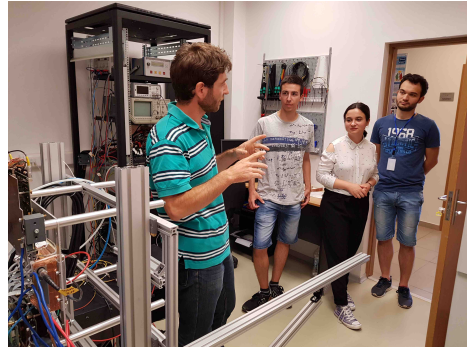
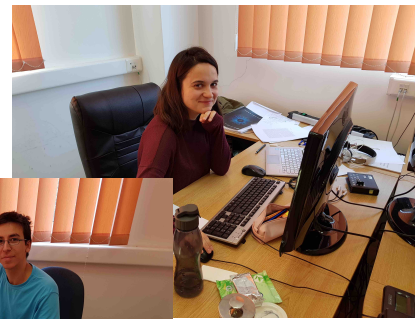
High Energy Physics  
Nuclear Astrophysics  
Particle Detection Systems  
Front-End Electronics & IT

## Summer Student Program 2019

Dedicated to advanced undergraduate level (3<sup>rd</sup> to 5<sup>th</sup> year of study, i.e. last year of Bachelor or during Master studies)

Organized by: Hadron Physics Department  
Horia Hulubei National Institute of Physics and Nuclear Engineering

Duration: July 15 - September 15 / Deadline for application: March 31, 2019  
Contact: 0040-21-4066215, [registrator@nipne.ro](mailto:registrator@nipne.ro)  
For further information visit the Training / Summer Student Program at <http://niham.nipne.ro>



## Summer Student Program 2019

FROM HIGH DENSITY BARYONIC MATTER TO THE COLLISION OF HIGHLY PACKED GLUONIC SYSTEMS.

HORIA HULUBEI NATIONAL INSTITUTE FOR PHYSICS AND NUCLEAR ENGINEERING  
HADRON PHYSICS DEPARTMENT

# Outreach

International group of Post Docs  
PhD and Master students

[http://niham.nipne.ro/HPD-Courier\\_electronic-version.pdf](http://niham.nipne.ro/HPD-Courier_electronic-version.pdf)

Winners of  
International Competitions in Physics



ASSEMBLED & TESTED

- 130 THO-MWPs (20%)
- 20 TPC CHOCs (50%)
- based on GEM technology

DESIGNED

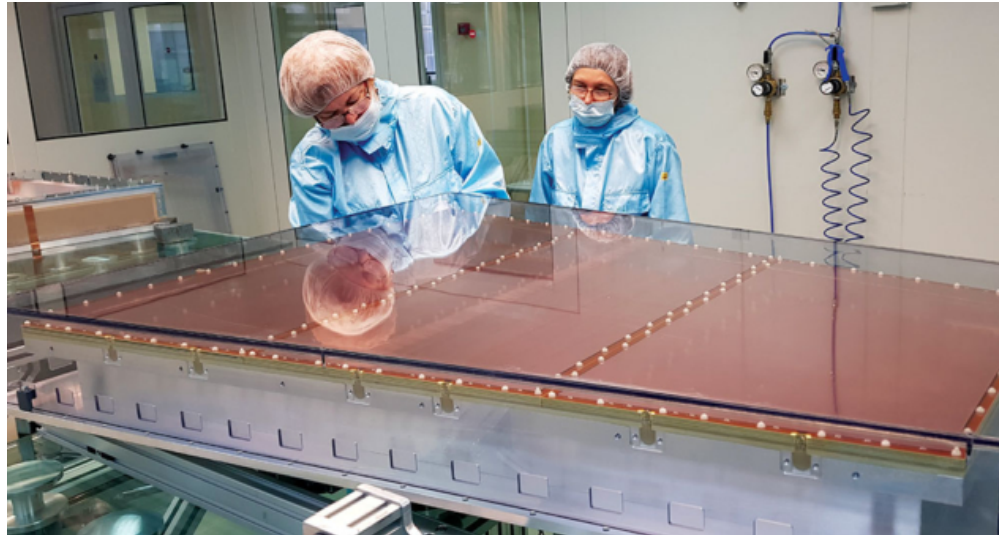
- 3<sup>rd</sup> version of FASP
- Fast-Scaling Signal Processor
- fully operational



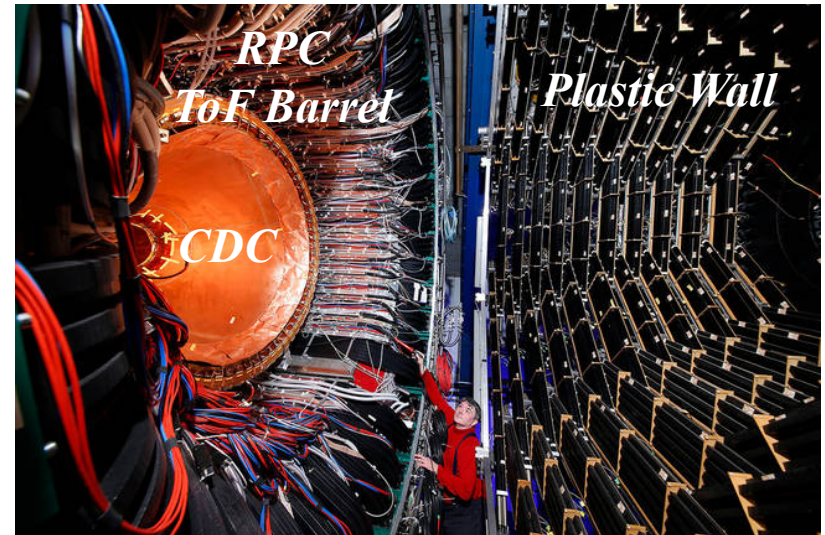


# *Outreach*

*CERN Courier January 24, 2019  
ALICE revitalised*



*FOPI Photo selected  
on the occasion of GSI 50<sup>th</sup> Anniversary*



*Some of our essential contributions*

## **New Project**

### **Objectives:**

- O1. Analysis and physics interpretation of experimental p+p data obtained with the ALICE detector, comparison with p+Pb, Xe-Xe and Pb-Pb results at LHC energies and detailed Monte Carlo simulations.**
- O2. Commissioning of the ALICE-TPC using the new ROCs based on GEM technology**
- O3. Contribution to the data taking based on ALICE experimental upgraded device**
- O4. Operation and development of the NIHAM Data Centre: ALICE GRID site and NAF**

## Main project activities

- ✓ Geometrical scaling of different observables including strange and multi-strange hadrons.
- ✓ The influence of corona contribution on the trends of different observables and scaling will be studied and core contributions will be extracted based on experimental data and the Glauber Monte-Carlo approach.
- ✓ The influence of the charged particle multiplicity phase space selection on the obtained results.
- ✓ Detailed studies of the dependence of corrections applied to raw spectra on the event shape global variables, the key ingredients in order to access unbiased information based on their selection power.
- ✓ The analysis of experimental data in terms of transverse momentum distributions, yields, average transverse momentum, BGBW fit parameters and their systematics, by applying two dimensional cuts in charged particle multiplicity and event shape will be continued.
- ✓ Differential studies of two-particle correlations as a function of multiplicity and event shapes will be finalized.
- ✓ Based on the previous results and in-progress work, we are planning to extend these studies for pp collisions at  $\sqrt{s} = 13$  TeV using the charged particle multiplicity in the central barrel.
- ✓ Detailed comparisons with PYTHIA, EPOS, HIJING and other model predictions will be done.



***The main actors behind the achievements summarized above:***

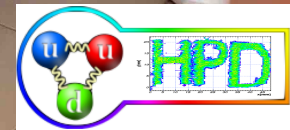
***Cristian Andrei, Valerica Aprodu, Dana Avramescu, Daniel Bartos, Alexandru Bercuci, Gheorghe Dima, Gheorghe Caragheorghopol, Vasile Catanescu, Constanta Dinca, Viorel Duta, Andrei Herghelegiu, Amelia Lindner, Adrian Mare, Gheorghe Mateescu, Mariana Petris, Alexandrina Petrovici, Mihai Petrovici, Amalia Pop, Lucia Prodan, Andrei Radu, Laura Radulescu, Claudiu Schiaua, Victor Simion, Georgiana Toma, Vasile Pop Topor, Madalina Tarzila***







*Merry Christmas  
and  
a happy, healthy and successful  
New Year  
for you and your family !*





*“The only way to make progress  
is to defy one of those prohibitions that are  
uncritically accepted without good reasons”  
(M. Gell-Mann)*

*Thank you!*

<https://niham.nipne.ro>

<https://www.youtube.com/watch?v=OJd4fA0xUh0>

<https://www.facebook.com/Hadron-Physics-Department-211078852968333/>