



Nuclear Physics Division

Faculty of Physics

Warsaw University of Technology



Scientific activities:

Heavy Ion Reactions (HIR): *Experiments: NA61/SHINE, ALICE, NICA/MPD, STAR, HADES, CBM*

Applied Nuclear Physics (ANP): *Dosimetry and radiation protection, Nuclear physics methods in medicine and industry*

Nuclear Theory (NT): *Nuclear reactions, neutron stars, ultracold atomic gases*

Group leaders:



Dr hab. Katarzyna Grebieszkow, Univ. prof. (HIR: NA61/SHINE exp.)



Dr hab. Daniel Kikoła, Univ. prof. (HIR: ALICE exp., ANP)



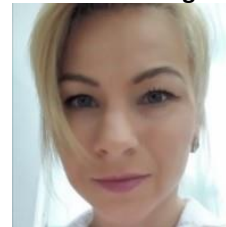
Prof. dr hab. Adam Kisiel (HIR: NICA and MPD exp.)



Prof. dr hab. Piotr Magierski (NT, Head of the division)



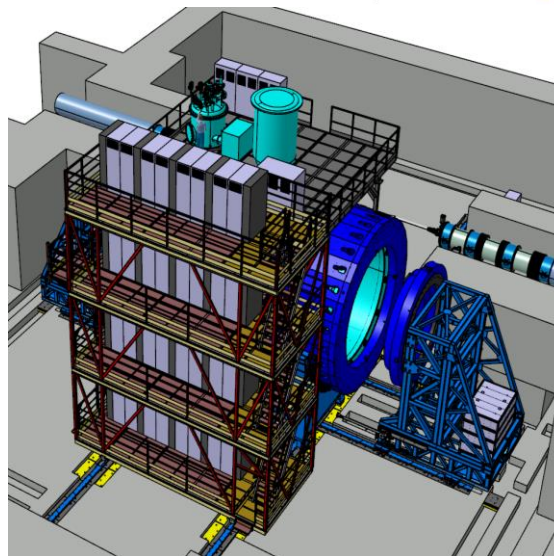
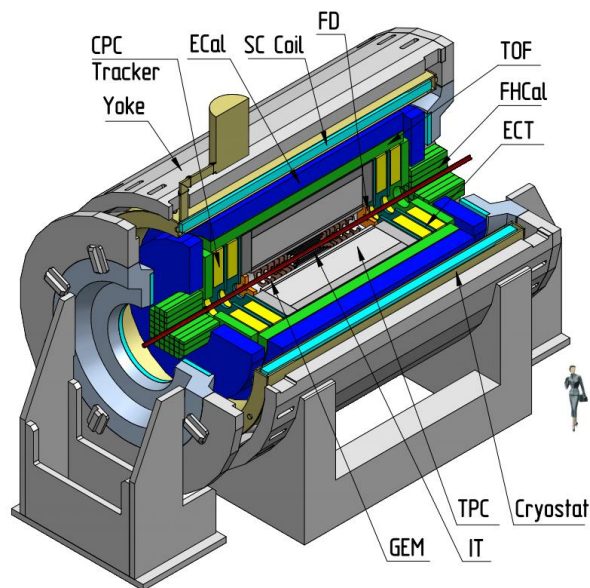
Dr hab. Gabriel Włazłowski, Univ. prof. (NT: atomic gases, supercomputing)



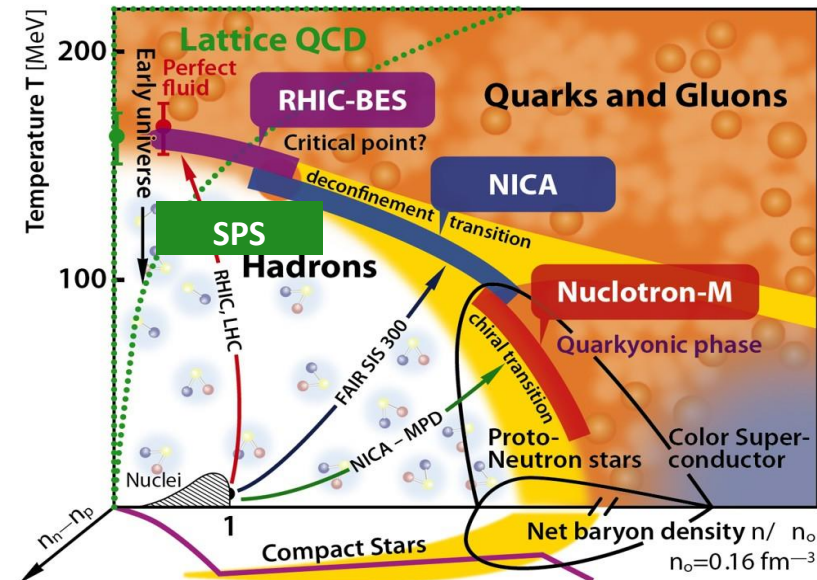
Dr hab. Hanna Zbroszczyk, Univ. prof. (HIR: STAR, HADES, CBM exp.)

NICA and the MPD experiment at WUT

- Phase diagram of **strongly interacting (SI) matter** via A+A collisions @ $\sqrt{s_{NN}} = 4 - 11$ AGeV with **light and intermediate mass nuclei**
 - **Investigation of matter at maximum baryonic density** → comprehensive search for signatures of phase transition and the critical point (CP) in collider experiment
 - **Study of dilepton and electromagnetic signatures**
 - **Full soft-physics** measurement in A+A
- Important verification of SI matter EOS **for investigation of neutron star cores and neutron star mergers**



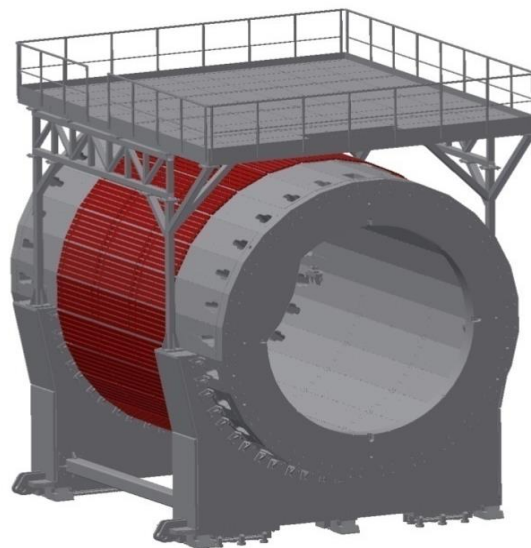
Unexplored part of QCD phase diagram



Critical stage of NICA and MPD construction. Significant contribution to detector and support systems design and construction from Poland

Major roles of WUT Collaborators in MPD:

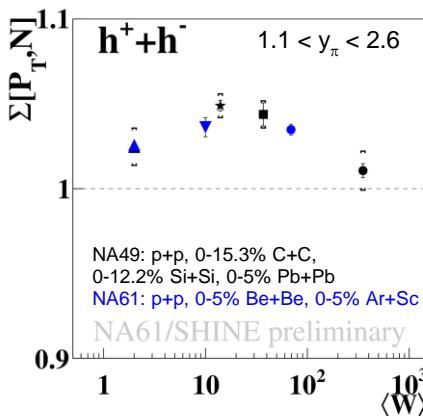
- Leadership of preparation for physics analyses and Collaboration organization
- Gas system for MPD TOF
- MPD Electronic Platform
- Experimental Control System (SCADA)
- EqDB database
- Electronics for the MPD Cosmic Ray Detector (MCORD)



WUT group members and responsibilities in MPD

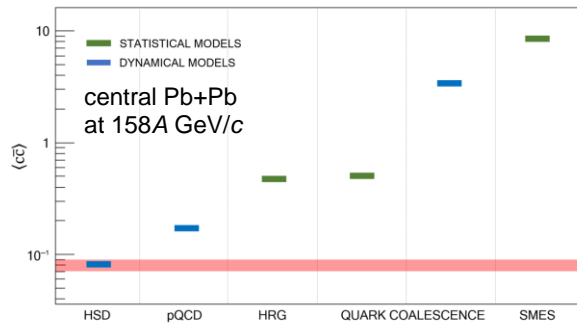
- **Adam Kisiel** (Prof, PhD, DSc) – Team Leader at WUT, participation in preparation for data analysis of correlations; **Spokesperson of the MPD Collaboration, elected for term 2019-2021**
- **Marek Peryt** (Eng.) – major design and coordination role for MPD electronic, electrical, electronic and mechanical support systems, **Head of the Engineering Support Sector and VBLHEP at JINR**
- **Jan Pluta** (Prof, Dsc, PhD) preparation for analysis of soft-physics observables, in particular two-particle correlations (femtoscropy)
- **Maciej Ławryńczuk** (Prof, PhD, Dsc Eng.) – leader of the WUT grant in Research University program, leadership in SCADA applications for MPD
- **Tomasz Traczyk** (PhD, Eng.) – main architect and leader of the Equipment Database (EqDB) project for MPD Detector construction and integration
- **Krzysztof Poźniak** (Prof, Dsc, PhD Eng.) – leader of the Electronics group (EiT Faculty), preparation of the readout and control electronics for MPD MCORD
- **Wojciech Zabołotny** (PhD, Dsc, Eng.) – read-out electronics expert, major contribution to the read-out electronics for silicon detectors in MPD and **BM@N** experiments
- In total **23 members**, including **7 PhD students**, **5 undergraduate students** and **faculty members**
- Organization of summer practices for students in JINR (more than 50 students in 2019)

-
- Data in SI program
- colliding nuclei
- beam momentum (A GeV/c)
- 2021-2024
- 2016/18
- 2017
- 2015
- 2011/12/13
- 2012/14/16/17
- 2009/10/11



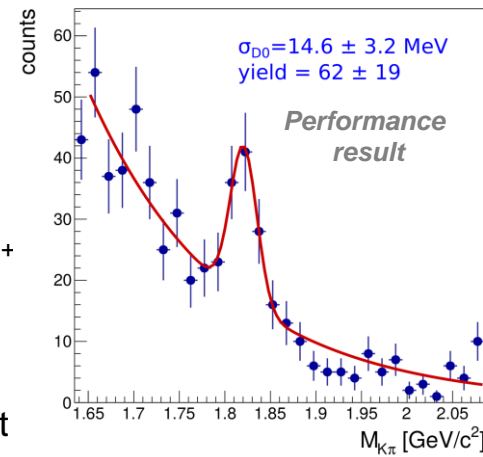
Search for CP: **transverse momentum and multiplicity fluctuations** – NA61/SHINE (p+p and Be+Be) and older NA49 results obtained by people from WUT

Open charm measurements in Pb+Pb collisions.
 Understanding mechanisms of charm production
 (various models differ by two orders of magnitude!);
 determining cross-section for charm quarks production



$\langle c\bar{c} \rangle$ measured via D^0 , D^+

← Foreseen accuracy
 of NA61 2020+ result



Search for D^0 signal
 with (Small Acceptance)
 Vertex Detector (VD)
 — result obtained by WUT
 member)

WUT group members and responsibilities in NA61/SHINE

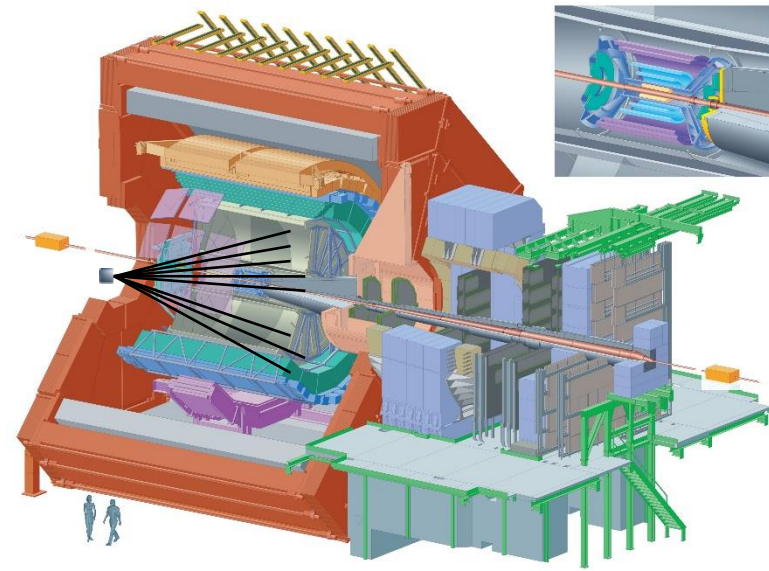
- **Katarzyna Grebieszkow** (PhD, DSc) – Team Leader at WUT, participation in analysis of fluctuations and resonance production; **SI program analysis coordinator (convener) in NA61/SHINE**
- **Dariusz Tefelski** (PhD Eng.) – detector upgrades during LS2 at CERN, participation in construction, maintenance and operation of VD, expert of data acquisition (DAQ), **TDAQ deputy in NA61/SHINE**
- **Maja Maćkowiak-Pawłowska** (PhD Eng.) – search for CP (analysis of higher order moments of multiplicity and net-charge, fluctuations of identified particles); **Monte Carlo deputy in NA61/SHINE**
- **Angelika Tefelska** (PhD Eng.) – studying collision dynamics, i.e. time between chemical and thermal freeze-outs (analysis of $K^*(892)^0$ production in p+p, A+A)
- **Marcin Słodkowski** (PhD Eng.) – web-based tools in NA61/SHINE, participation in resonance production
- **Wojciech Bryliński** (MSc Eng.) – open charm, VD data reconstruction, new TDAQ development, **Safety Officer deputy in NA61/SHINE**, **Outreach deputy in NA61/SHINE**, currently **Doctoral Student at CERN**
- **Justyna Cybowska** (MSc Eng.) – search for CP (analysis of higher order moments of multiplicity and net-charge in A+A), **Monte Carlo production deputy in NA61/SHINE**
- **Bartosz Kozłowski** (MSc Eng.) – studying collision dynamics (analysis of $\rho(770)^0$ and $K^*(892)^0$ production in A+A collisions)
- **One graduate student** (fluctuations) and **one engineering student** ($\rho(770)^0$ meson production)

A fixed-target program in the ALICE experiment

Development of a program for a fixed-target experiment at ALICE

Motivation: Probing gluon, antiquark and heavy-quark content in the nucleon and nucleus at high Feynman x_F , providing inputs for astrophysics

Cooperation with Laboratoire de physique des deux infinis Irène Joliot-Curie, Orsay, France; and Czech Technical University in Prague



Dr Daniel Kikoła (leader)

Dr Md. Rihan Haque (post-doc, funded by **Horizon 2020** grant *The strong interaction at the frontier of knowledge: fundamental research and applications*)

Dr Marcin Patecki (Marie Skłodowska-Curie Individual Fellowship: *The ALICE fixed-target programme layout using bent crystals at the CERN Large Hadron Collider.*)

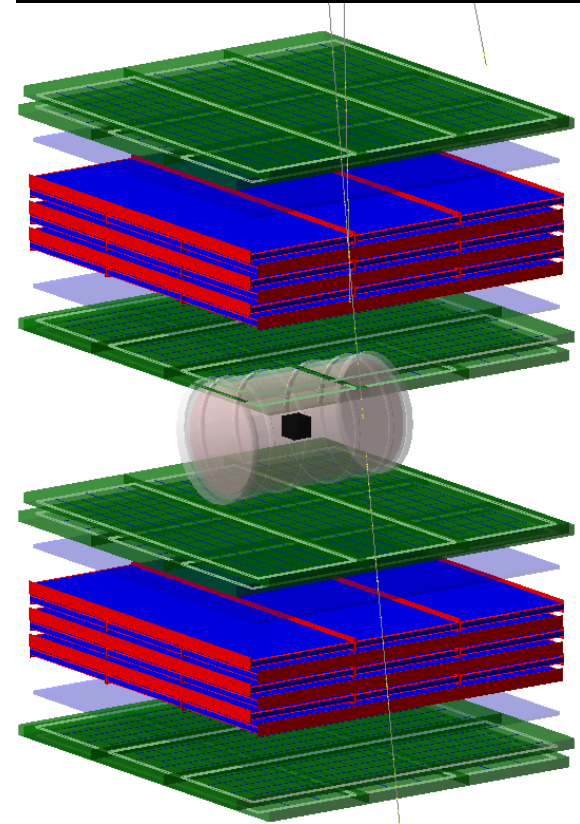
Applied Nuclear Physics Group

Dosimetry and radiation protection

Nuclear physics methods in medicine and industry

- **Dr Daniel Kikoła** (leader)
- **Rafał Dąbrowski**, **Industrial Doctorate**: Development of an automatic warning system for a nuclear power plant accident in a selected location in Poland based real-time spectro-dosimetric measurements
- **Mohammed Mhaidra**, PhD Student, **Horizon 2020** project *CHANCE: Characterization of conditioned nuclear waste for its safe disposal in Europe*, muon tomography
- **Wojciech Kubiński**, PhD Student, the CHANCE project, calorimetric measurements
- **Iwona Słonecka**, PhD Student, dosimetry

CHANCE Muon Scattering Tomography Detector



CHANCE: 12 partners, 8 European countries, Budget: 4.25 M€



The STAR experiment

at the Relativistic Heavy Ion Collider, Brookhaven National Laboratory

STAR @ RHIC (BNL, Upton, USA); Femtoscopy and Heavy Flavor: studies of properties of QCD Phase Diagram for high and intermediate baryon chemical potentials

STAR

Hanna Zbroszczyk, Prof. WUT – team lider of WUT;
Coucil Board representant
Convener of Physics Working Group

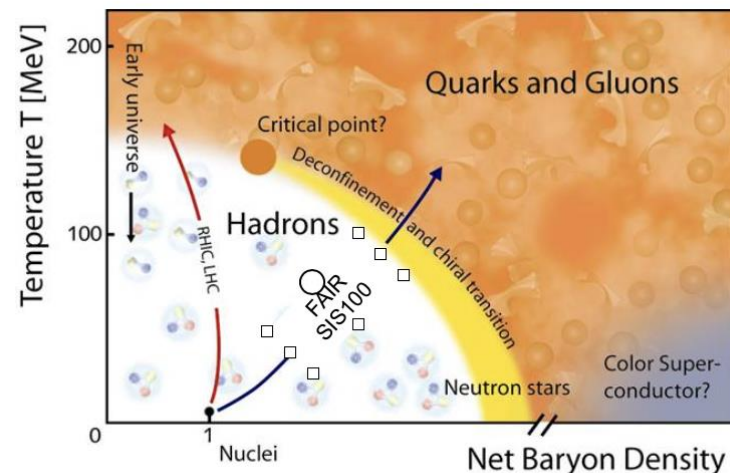
Daniel Kikoła, Prof. WUT

Jan Pluta, Prof.

Janusz Oleniacz, Dr.

6 PhD students

2 Msc/Eng students



HADES @ GSI and CBM @ FAIR (GSI, Darmstadt, Germany);

Femtoscopy: studies of properties of QCD Phase Diagram for high baryon chemical potentials:

HADES:

Hanna Zbroszczyk, Prof. WUT - team leader

5 Msc/ Eng students

CBM:

Hanna Zbroszczyk, Prof. WUT- team leader;
Collaboration Board representant

Jan Pluta, Prof.

1 PhD student, 4 Msc / Eng students



Facility for Antiproton
and Ion Research
in Europe GmbH



Nuclear Theory Group

Nonequilibrium phenomena in superfluid Fermi systems

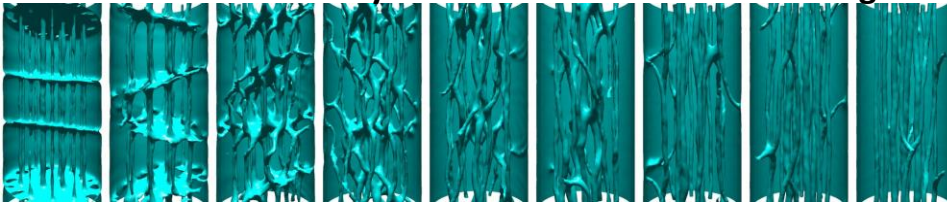
Ultracold atomic
(fermionic) gases.

Astrophysical
applications
(neutron stars).

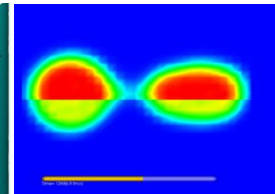
Nuclear reactions.

Selected Highlights:

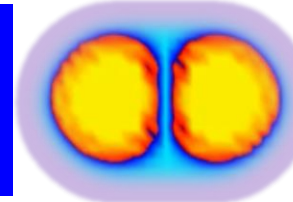
Formation and decay of turbulent state in ultracold gas



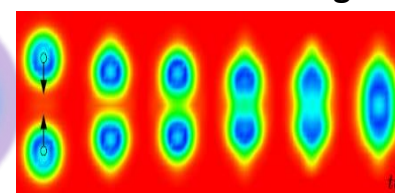
Induced fission
of ^{240}Pu



Solitonic excitation
in $^{90}\text{Zr}+^{90}\text{Zr}$



Collisions of fermions
in ultracold atomic gas



Research topics

1. Collisions of medium-mass and heavy nuclei
2. Induced nuclear fission
3. Dynamics of vortices in the neutron star crust
4. Quantum turbulence in ultracold gases and neutron stars
5. Spin imbalanced Fermi gases
6. Transport through Josephson junction in ultracold gases
7. Bose-Fermi mixtures in ultracold gases
8. Application of supercomputers of various architectures to model superfluid systems

Scientific staff:

A. Barresi, Ph.D. student (4,5)
Dr. M. Barton (1,2)
Dr. A. Boulet (1,4)
K. Kobuszewski, Ph.D. student (4,5)
Prof. P. Magierski (1-7)
A. Makowski, Ph.D. student (1,2)
Dr. D. Pęcak (3,4)
Prof. G. Wlazłowski (1-8)
B. Tüzemen, Ph.D. student (5)
Dr. M. Tylutki (4,7)

Access to computational infrastructure:

SUMMIT (ORNL, USA)
PIZ DAINT (SNSC Switzerland)
TSUBAME (Tokyo I. Tech.)
CYGNUS (CCS Tsukuba)
PROMETHEUS (AGH)
OKEANOS (ICM)





Nuclear Physics Division Faculty of Physics Warsaw University of Technology



Professors: 2

A. Kisiel, P. Magierski

Professors Emeriti: 2

J. Pluta, B. Słowiński

University Professors: 5

P. Duda, K. Grebieszko, D. Kikoła, G. Wlazłowski, H. Zbroszczyk

Adjuncts: 6

Ł. Graczykowski, M. Janik, M. Maćkowiak-Pawłowska, J. Oleniacz, M. Słodkowski,
D. Tefelski

Postdocs: 8

M. Bahmani (HIR), M. Barton (NT), A. Boulet (NT), R. Haque (HIR), G. Kornakov (HIR),
M. Patecki (HIR), D. Pęczak (NT), M. Tylutki (NT)

Ph.D. students: 22

Computational infrastructure: GPU cluster **DWARF** (about 100 Tflops)