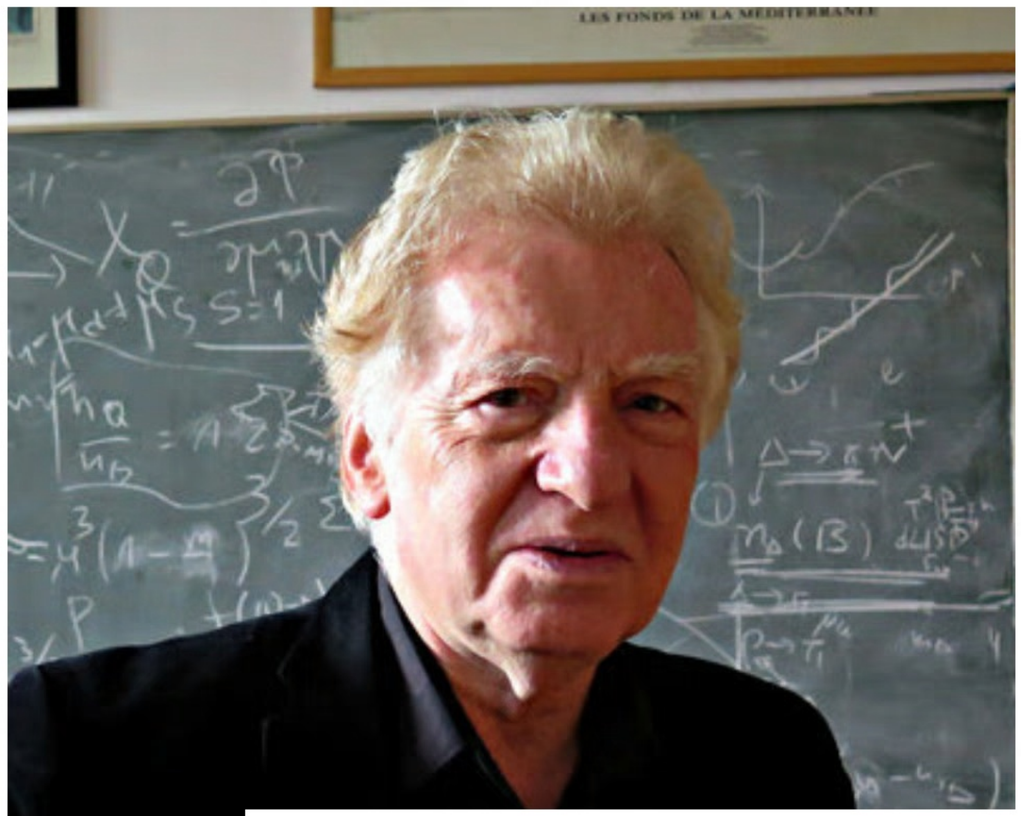
HAPPY BIRTHDAY
TO EVERYOUNG
LUDWIK !

MANY LIEFS OF LUDWIK:
THEORY AND ACADEMY



Phase Transitions in the Statistical Bootstrap Model with an Internal Symmetry

K. Redlich (Wroclaw U.), L. Turko (Wroclaw U.) (Nov, 1979)

Published in: *Z.Phys.C* 5 (1980) 201

MANY LIEFS OF LUDWIK:

PRO PUBLICO BONO

Prof. Turko donosi na siebie rektorowi UWr i zgłasza się do miejsca na ławie oskarżonych razem z "Wyborczą"

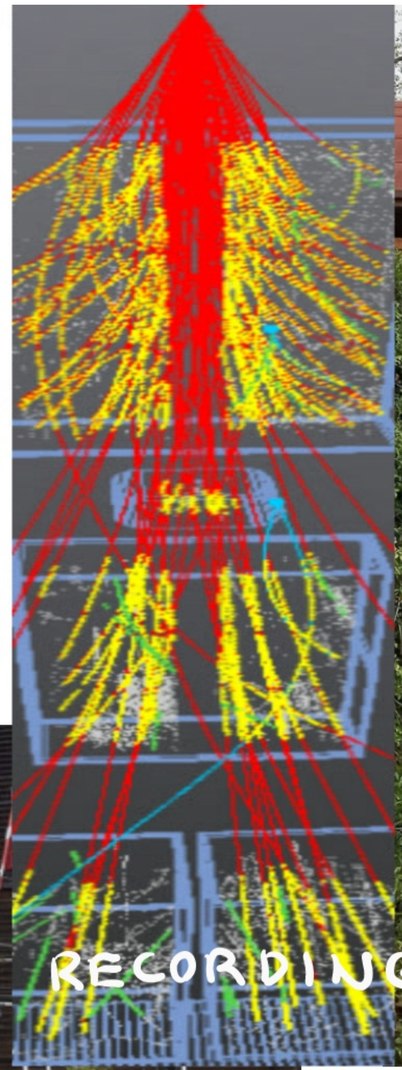
UNIWERSYTET WROCŁAWSKI LUDWIK TURKO

Gdyby miało dojść do zapowiadanego w "Oświadczeniu" UWr procesu przeciw redaktorom z "Wyborczej", to proszę uprzejmie o uwzględnienie również mojej osoby na ławie oskarżonych - pisze prof. Ludwik Turko.

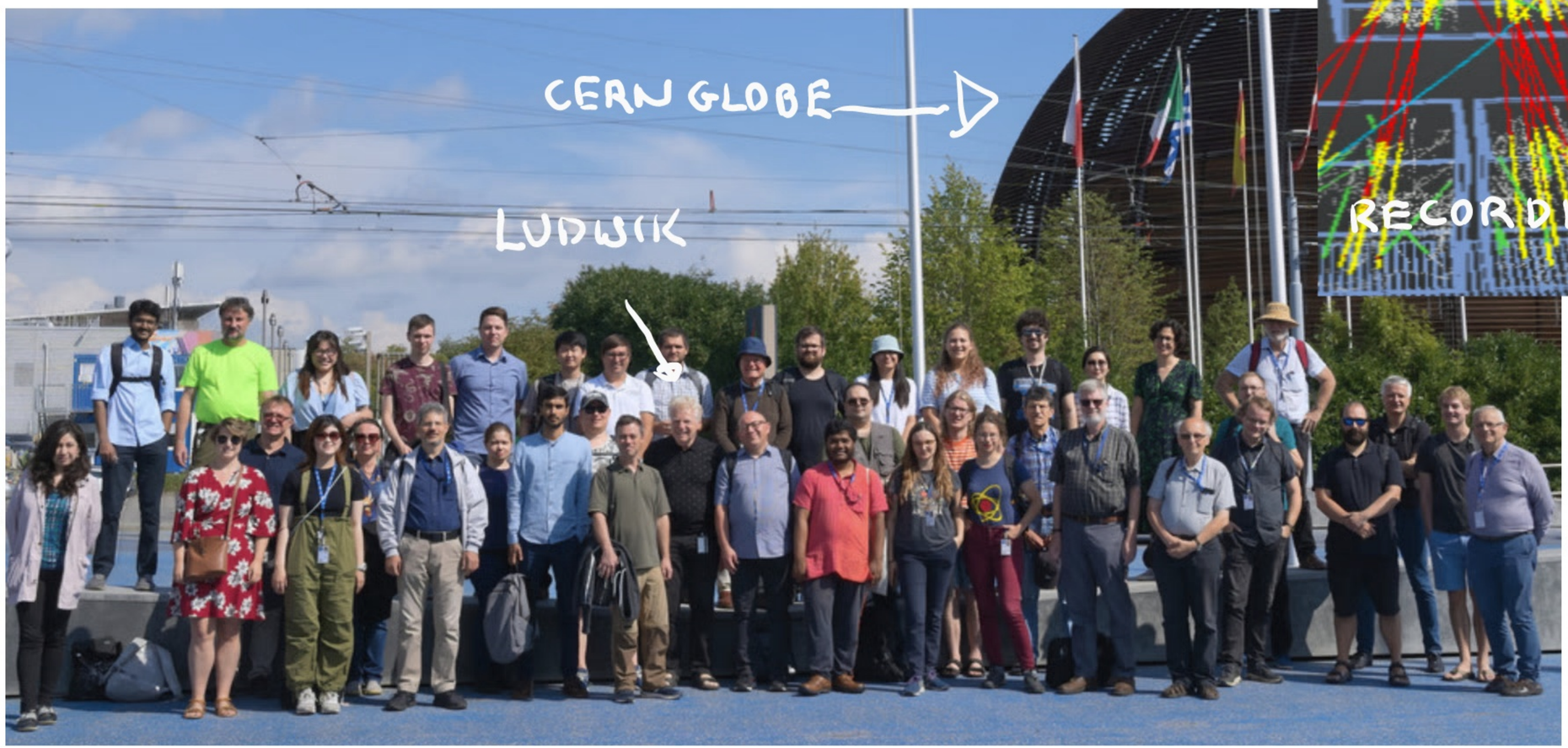
12.03.2024 | 13:13

MANY LIEFS OF LUDWIK:

EXPERIMENT



RECORDING COLLISIONS AT CERN



SHINIG LIFE OF LUDWIK + GREAT WROCLAW'S STUDENTS (MACIEK, MICHAL, OLA, LIZA, SASHA, ...):

THEORY + EXPERIMENT + PRO PUBLICO BONO

EP Newsletter of the EP department

NEWSLETTER | NEWS ARCHIVE | SEMINARS & COLLOQUIA | NEW ARRIVALS

Shining more light on the onset of deconfinement

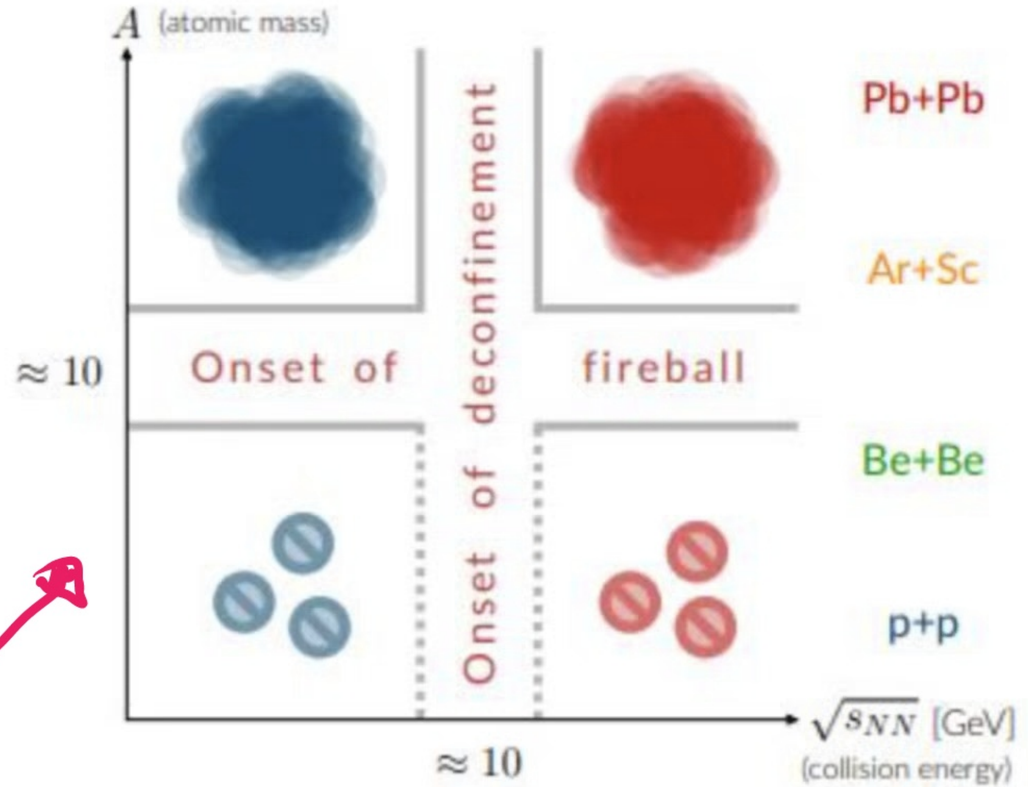
Maciej P. Lewicki and Ludwik Turko (University of Wrocław) on behalf of the NA61/SHINE Collaboration 23rd Sep 201

SME

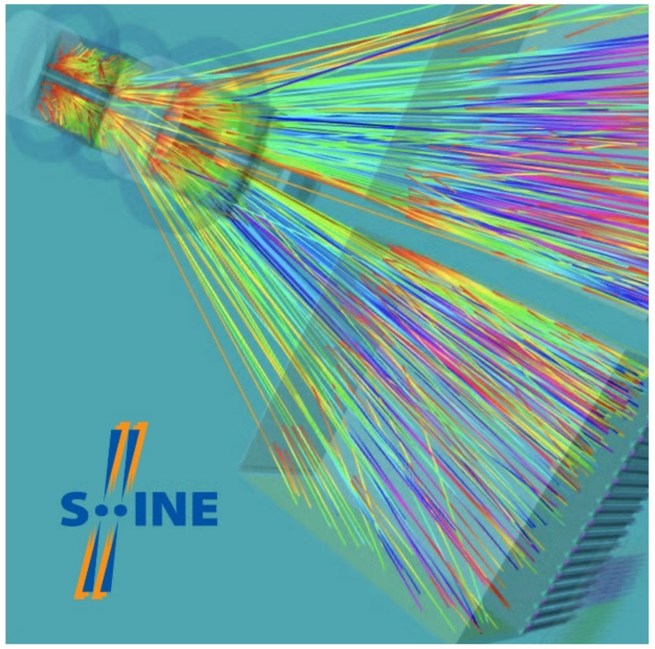
"It was easier to know it than to explain why I know it." said Sherlock*.

- A Study in Scarlet, Sir Arthur Conan Doyle 1886

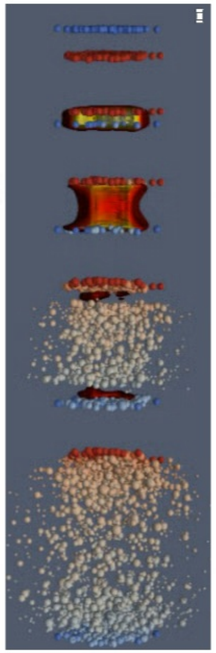
THE FIRST SHINING DIAGRAM OF HIGH-ENERGY NUCLEAR COLLISIONS



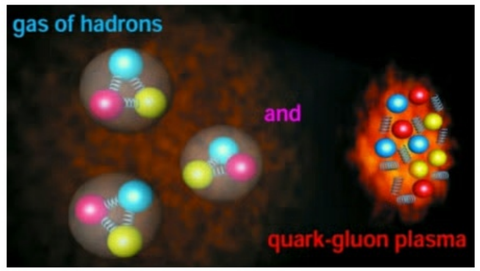
DATA ON
NUCLEUS- NUCLEUS
COLLISIONS AT HIGH ENERGY

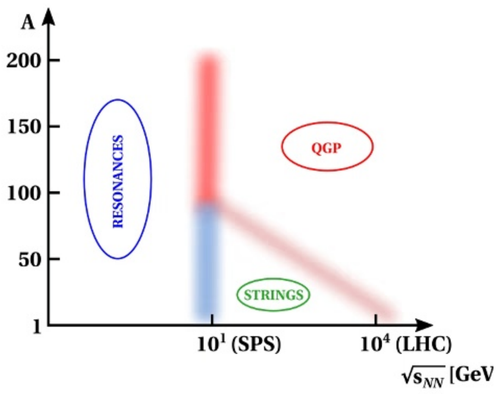


MODELS



STATISTICAL AND
HYDRODYNAMICAL
MODELS





PHASE DIAGRAM OF
STRONGLY INTERACTING MATTER

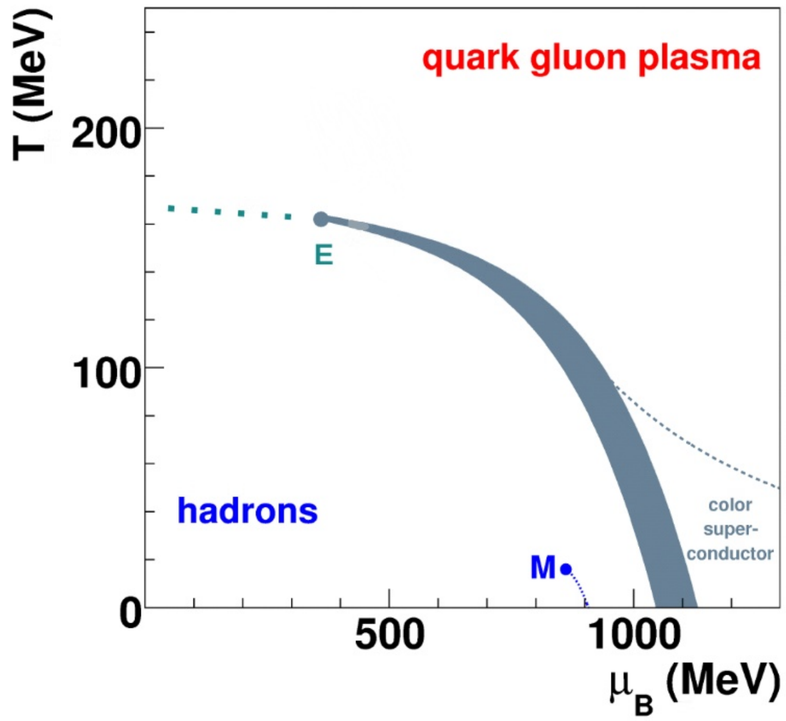


DIAGRAM OF HIGH-ENERGY
NUCLEAR COLLISIONS

DIAGRAM OF HIGH-ENERGY NUCLEAR COLLISIONS FROM NA61/SHINE

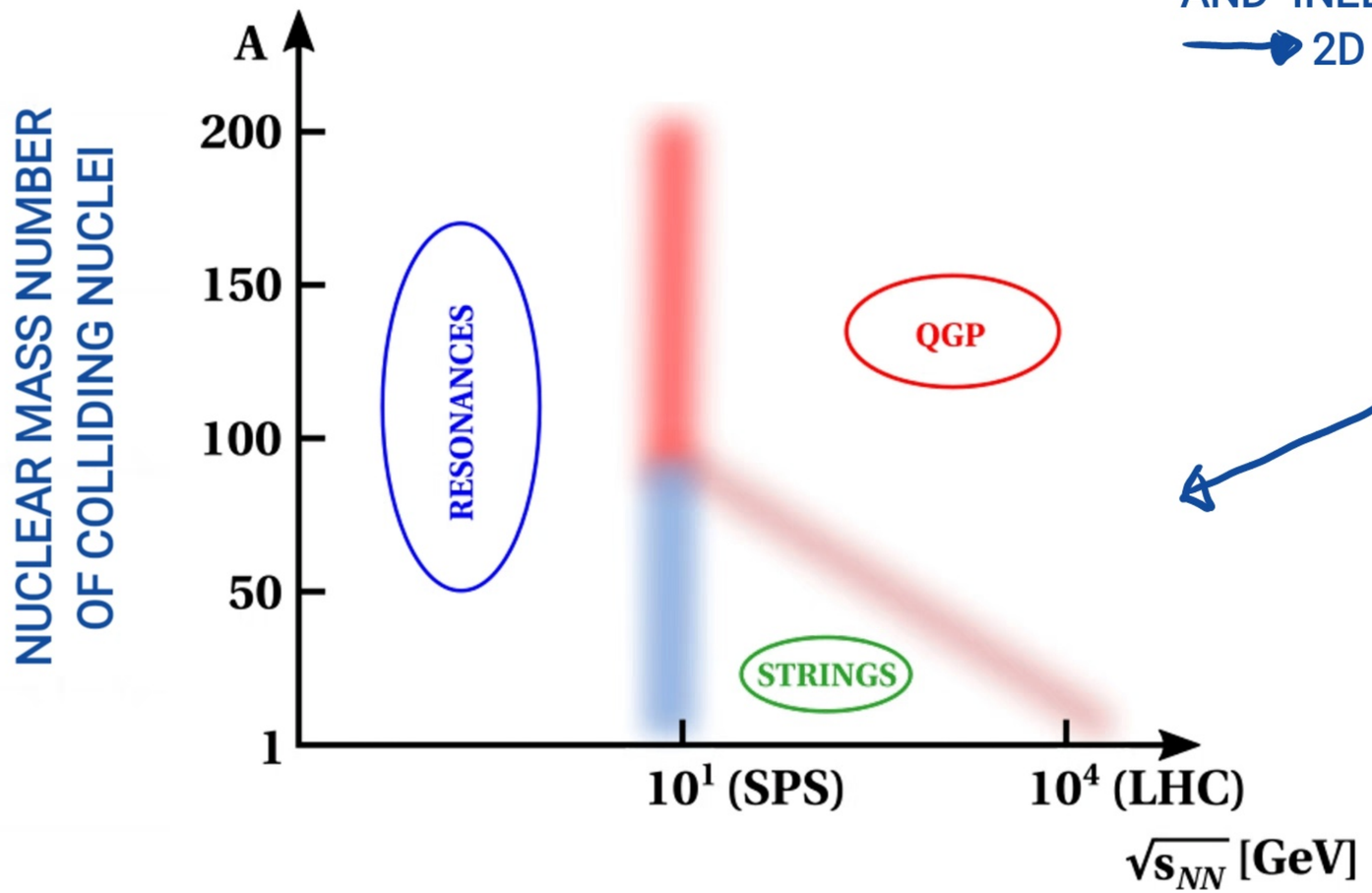
M. GAZDZICKI, JAN KOCHANOWSKI UNIVERSITY KIELCE

- DEFINITIONS
- IDEAS AND DATA
- DIAGRAM OF HIGH-ENERGY NUCLEAR COLLISIONS

DEFINITIONS: DIAGRAM OF HIGH-ENERGY NUCLEAR COLLISIONS

≡ CHART SHOWING EXPERIMENTAL CONDITIONS
(COLLISION ENERGY, NUCLEAR MASS NUMBER, ...)
AT WHICH DISTINCT HADRON PRODUCTION PROCESSES DOMINATE

THE EXAMPLE DISCUSSED HERE: ONLY CENTRAL A+A COLLISIONS
AND INELASTIC p+p INTERACTIONS
→ 2D PLOT



HADRON PRODUCTION PROCESSES

ANDRONOV, KUICH, MG
2205.06726
UNIVERSE 9 (2023) 106

DEFINITIONS: HADRON PRODUCTION PROCESSES

POPULAR PROCESSES FOR MODELLING HADRON PRODUCTION
IN PROTON-PROTON AND NUCLEUS-NUCLEUS COLLISIONS:

RESONANCES - CREATION, EVOLUTION AND DECAYS OF RESONANCES
- EXCITED STATES OF STABLE HADRONS

STRINGS - FORMATION, EVOLUTION AND FRAGMENTATION OF STRINGS
- GLUON-FLUX TUBES BETWEEN A PAIR OF COLOUR CHARGES

QGP - CREATION, EVOLUTION AND HADRONISATION OF QUARK-GLUON PLASMA

DEFINITIONS: QUANTITATIVE MODELS

TWO POPULAR MODELS OF HIGH-ENERGY NUCLEAR COLLISIONS
COVERING THE DATA RANGE IN COLLISION ENERGY AND NUCLEAR-MASS NUMBER:

PHSD ~ INCLUDES RESONANCES, STRINGS AND QGP

CASSING, BRATKOVSKAYA
NPA 831, 215 (2009)

SMASH ~ INCLUDES RESONANCES AND STRINGS

MOHS, RYU, ELFNER
JPG 47, 065101 (2020)

DEFINITIONS: EXPERIMENTAL PROBE

THE RATIO OF POSITIVELY-CHARGED KAONS AND PIONS MEASURED AT MID-RAPIDITY, K^+/π^+

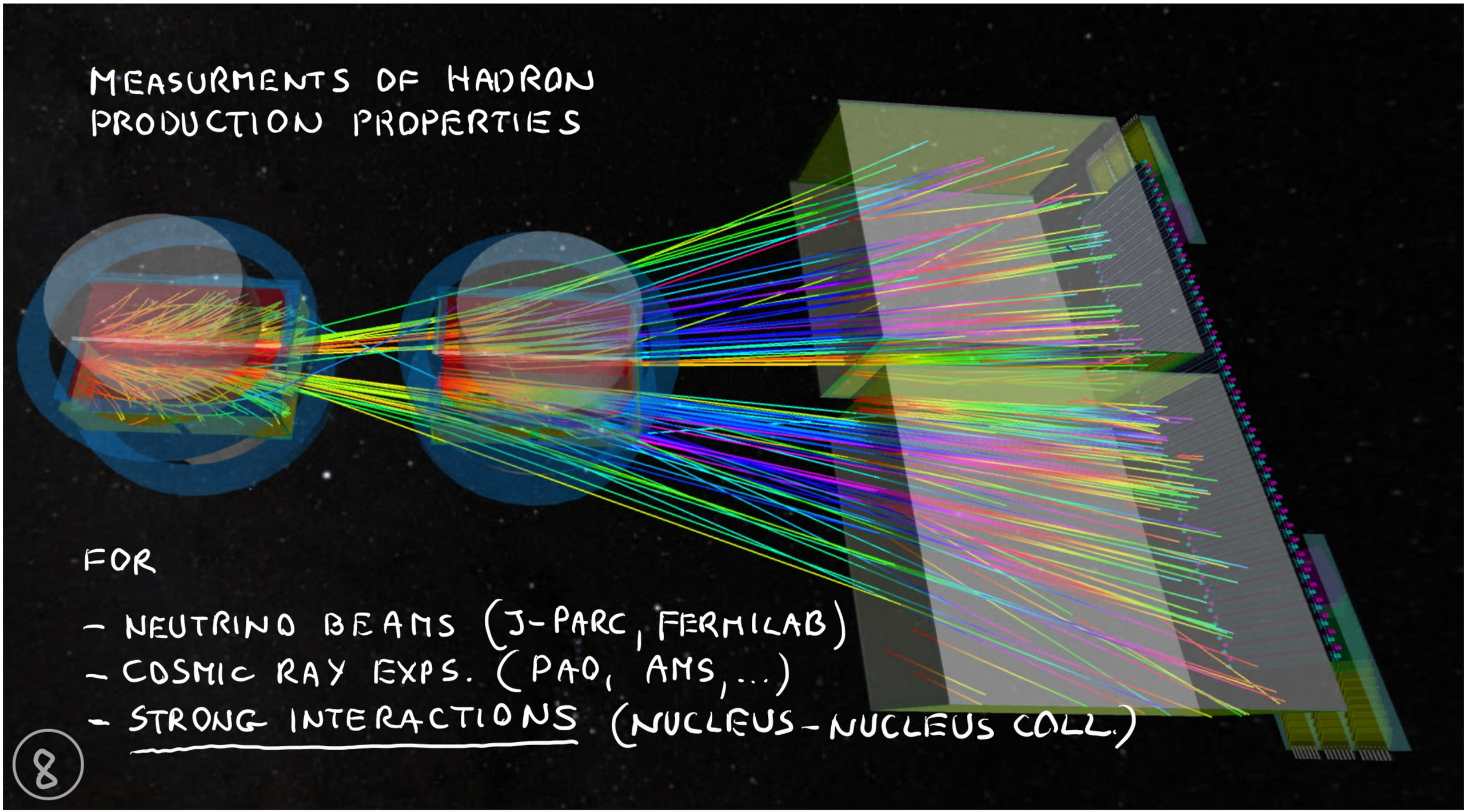
- APPROXIMATELY PRPORTIONAL TO THE RATIO OF (ANTI-)STRANGE QUARKS TO ENTROPY
- SENSITIVE TO HADRON-PRODUCTION PROCESSES DUE TO MASS AND NUMBER DIFFERENCES BETWEEN STRANGE AND NON-STRANGE PARTICLES - QUARKS AND GLUONS OR HADRONS

RAFELSKI, MULLER
PRL 48, 1066 (1982)

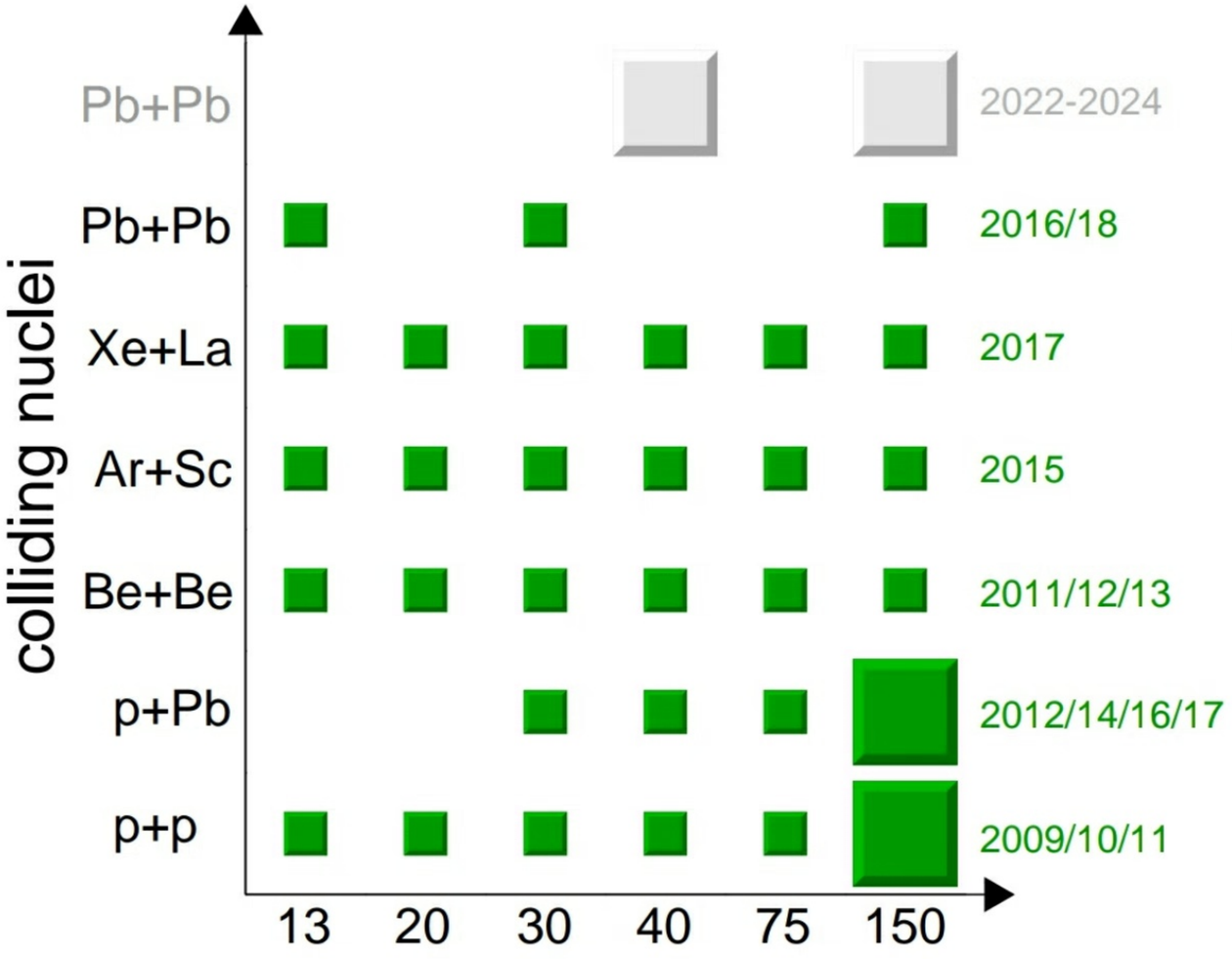
MG, GORENSTEIN
APP B 30, 2705 (1999)

- RICH EXPERIMENTAL DATA IN HIGH-ENERGY NUCLEAR COLLISIONS

DEFINITIONS: NA61/SHINE PHYSICS PROGRAMMES



DEFINITIONS: NA61/SHINE DATA ON HIGH-ENERGY NUCLEAR COLLISIONS

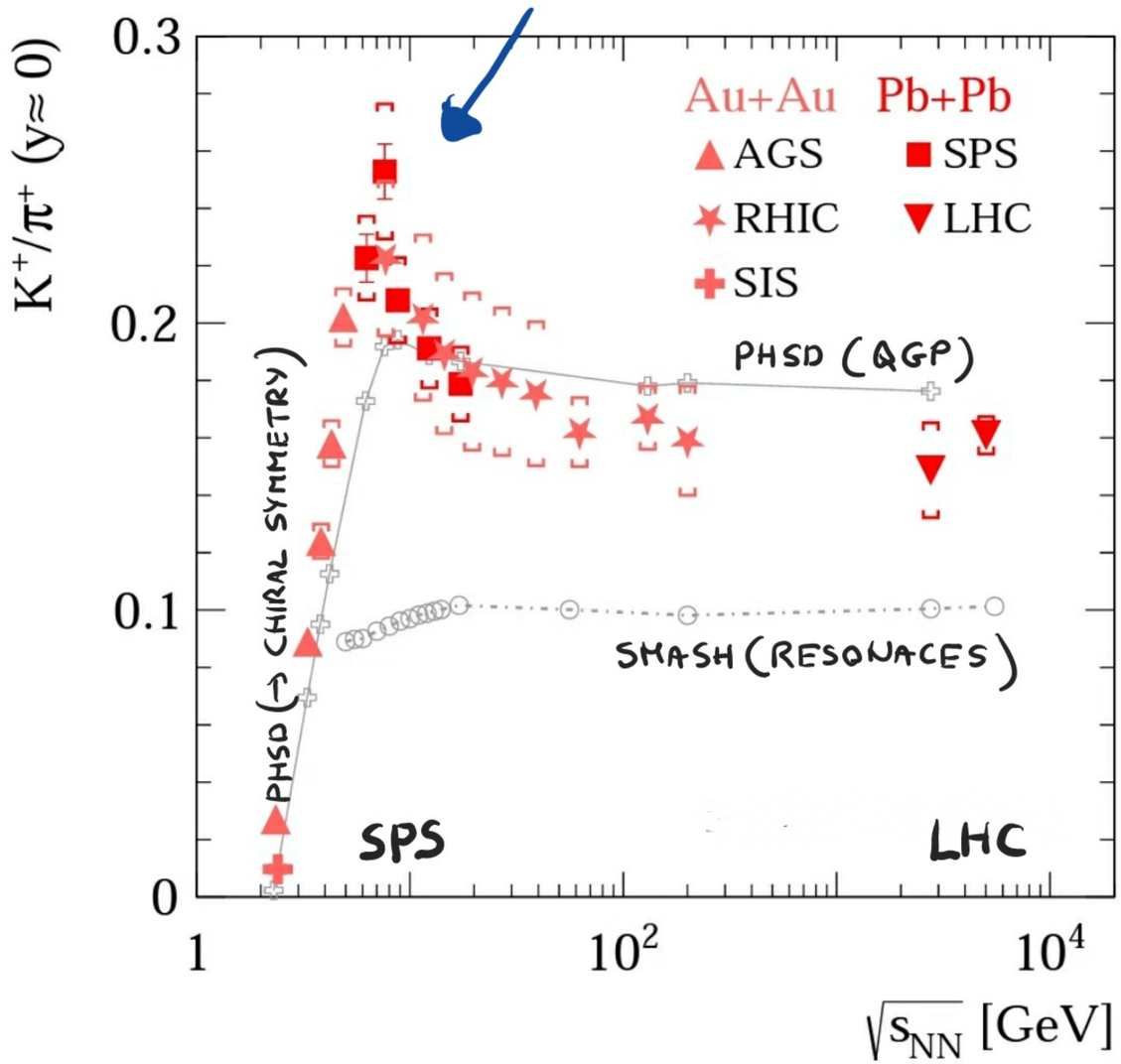


UNIQUE INPUT TO ESTABLISH DIAGRAM OF HIGH-ENERGY NUCLEAR COLLISIONS

$\sqrt{s_{NN}} \approx 5 \longleftrightarrow 17$ GeV

IDEAS AND DATA: HEAVY- ION COLLISIONS

THE HORN STRUCTURE



NA49, PRC 66, 054902

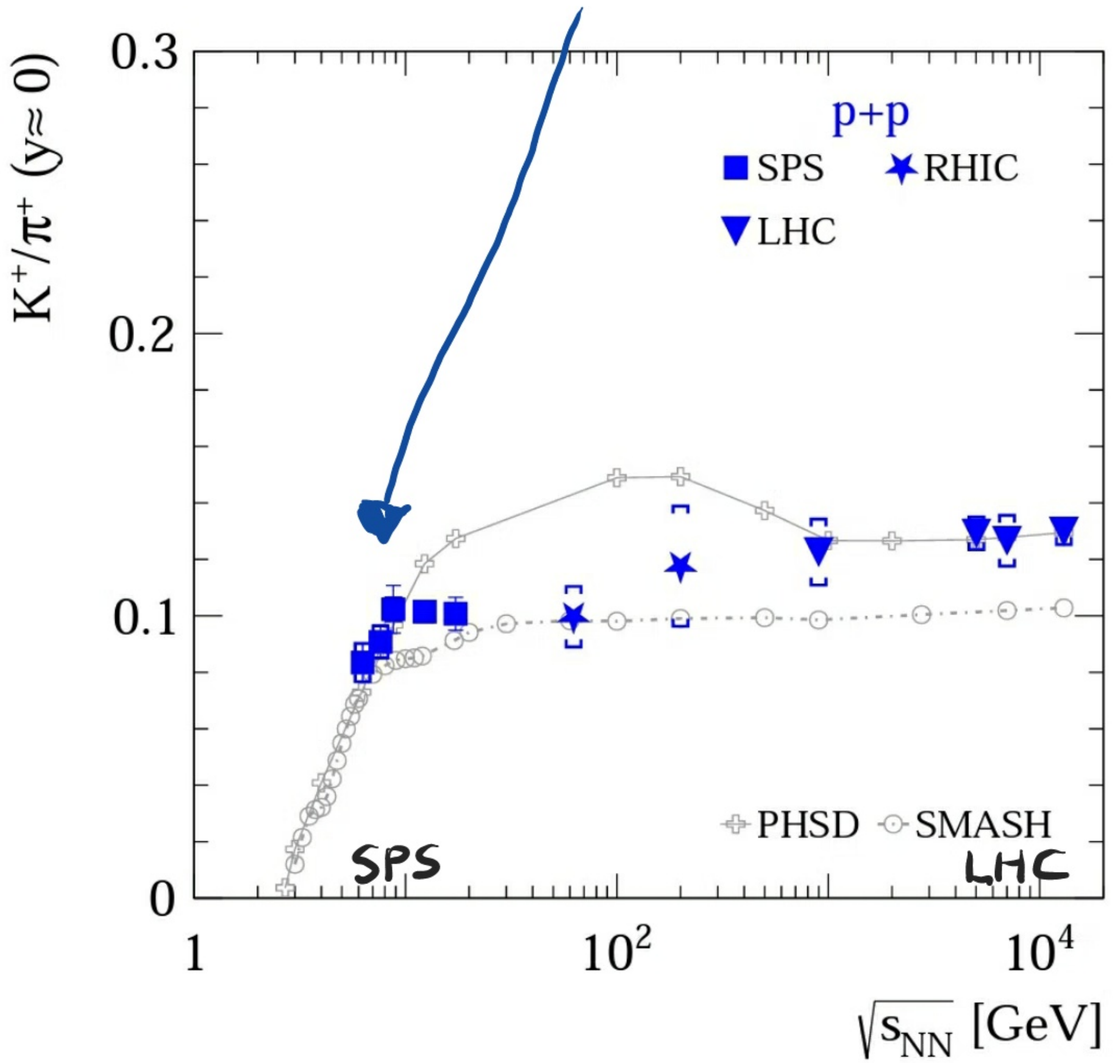
RESONANCES - QGP CHANGEOVER (ONSET OF DECONFINEMENT)

MG, GORENSTEIN APP B 30, 2705 (1999)

SUPPORTED BY AGREEMENT OF PHSD (DECONFINEMENT + CHIRAL SYMMETRY RESTORATION) AND DISAGREEMENT OF SMASH (STRINGS)

IDEAS AND DATA: PROTON-PROTON INTERACTIONS

THE BREAK STRUCTURE



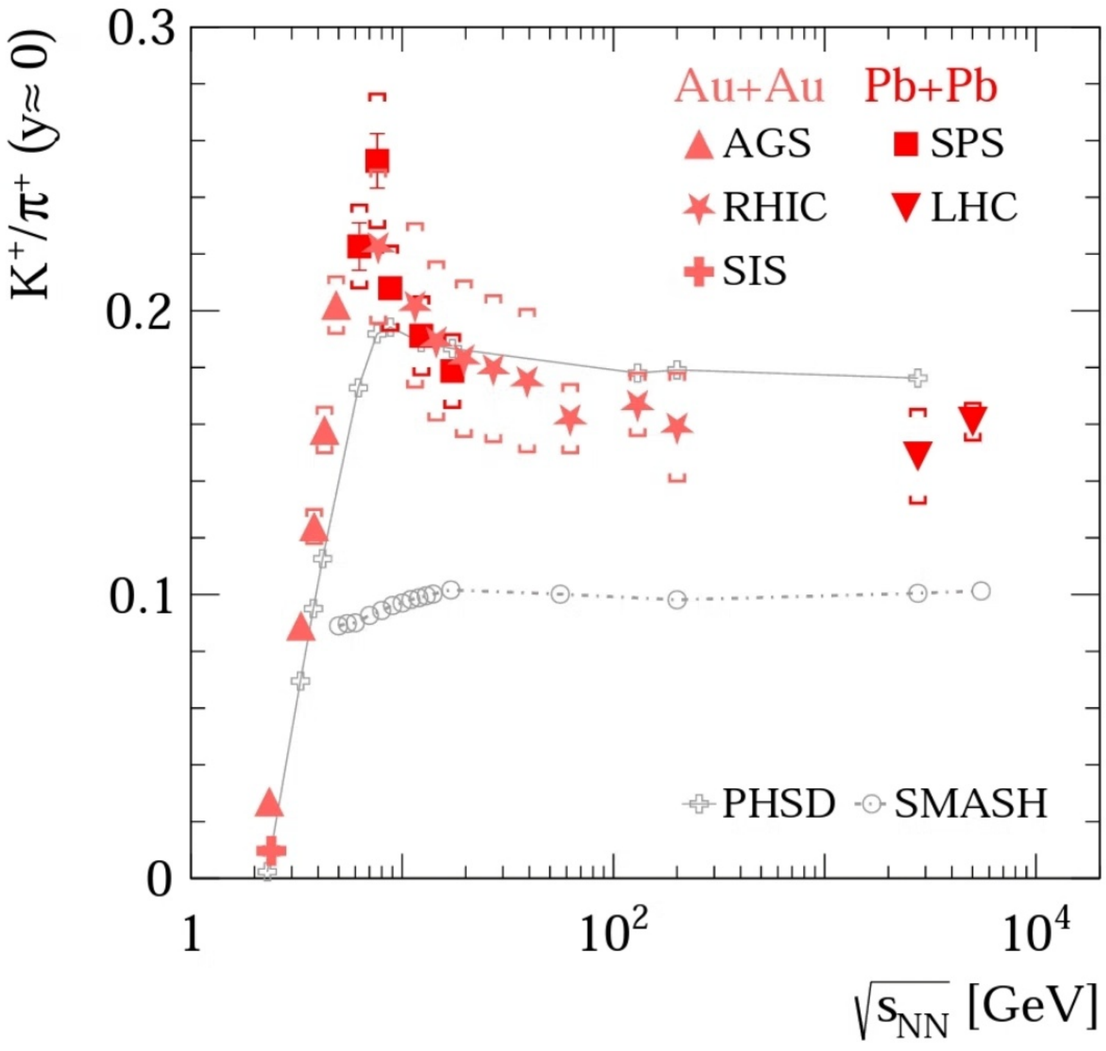
NA61/SHINE, PRC 102, 011901 (2020)

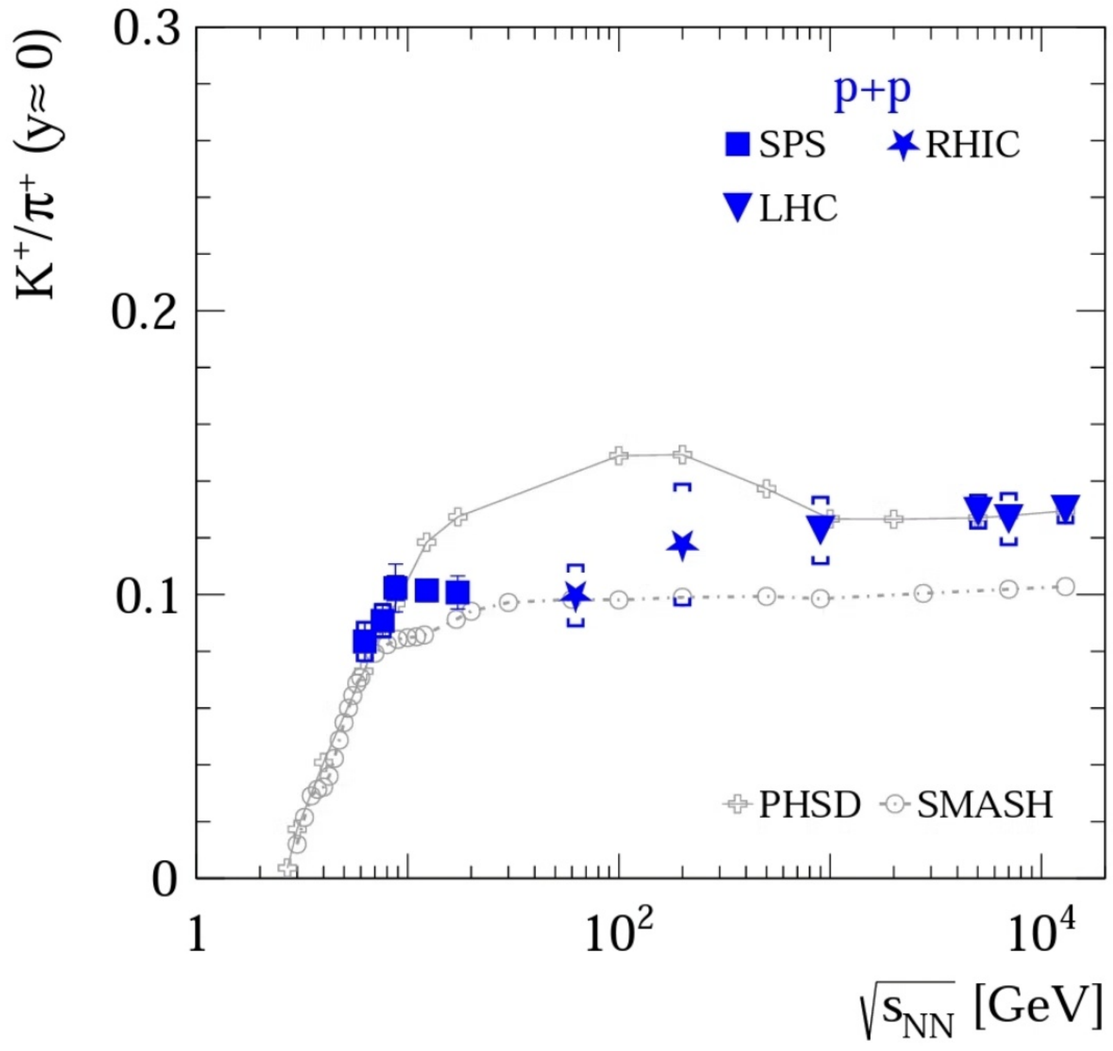
RESONANCES-STRINGS CHANGEOVER

SMASH AND PHSD INCLUDE RESONANCES-STRINGS CHANGEOVER, BUT LOCATE IT AT LOWER ENERGIES (3-4 AND 2.6 GeV)

FOR p+p THE SAME UNDERLYING PHYSICS, BUT DIFFERENT PREDICTIONS OF SMASH AND PHSD

IDEAS AND DATA: Pb+Pb vs p+p

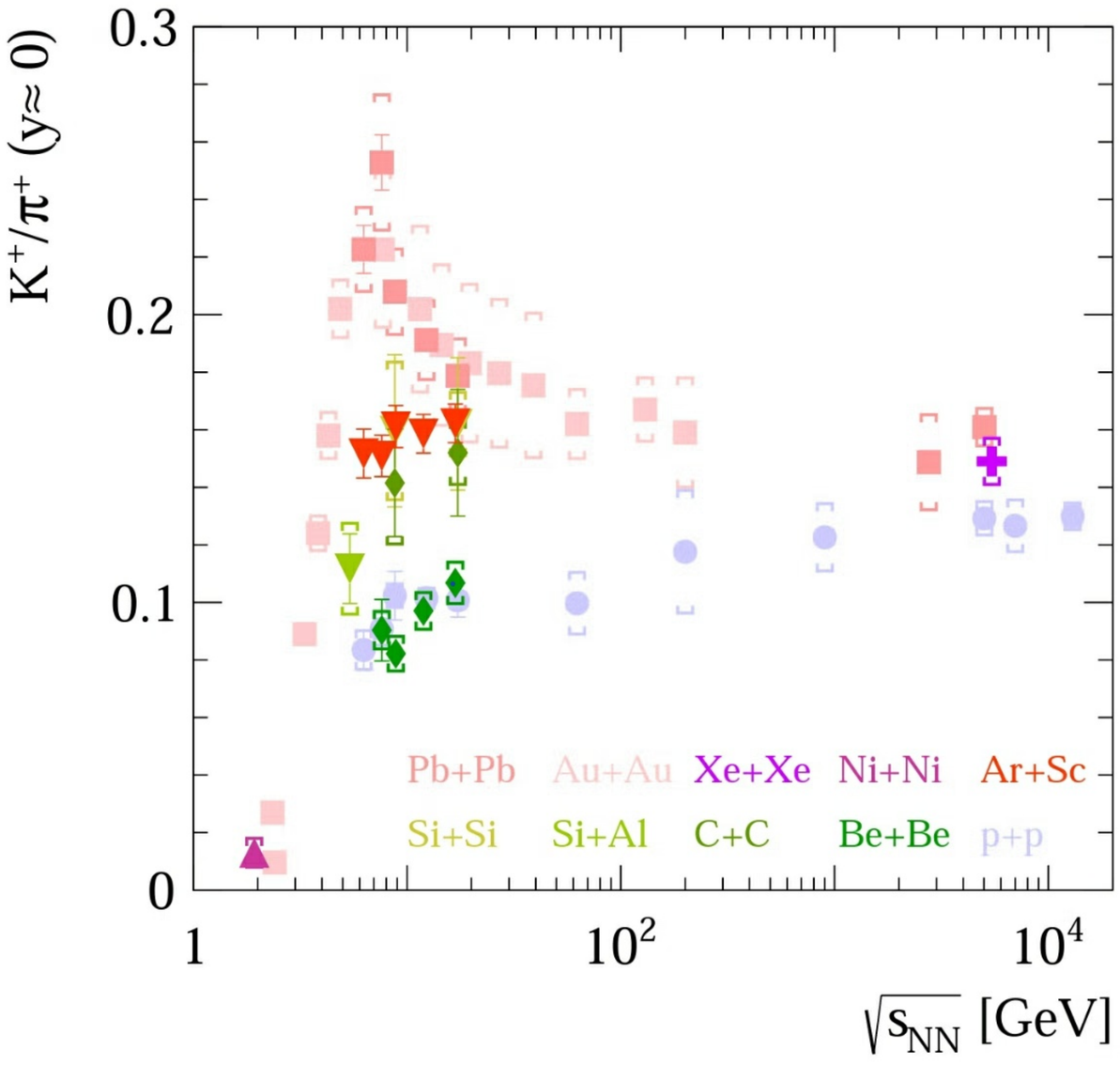




VERY DIFFERENT ENERGY DEPENDENCE

→ COLLISIONS OF INTERMEDIATE-MASS NUCLEI

IDEAS AND DATA: COLLISIONS OF INTERMEDIATE-MASS NUCLEI



Be + Be ≈ p + p

NA61/SHINE:
EPJ C80, 961 (2020)
EPJ C81, 73 (2021)

Ar + Sc ≈ Pb + Pb
AT THE TOP SPS

NO HORN IN Ar + Sc

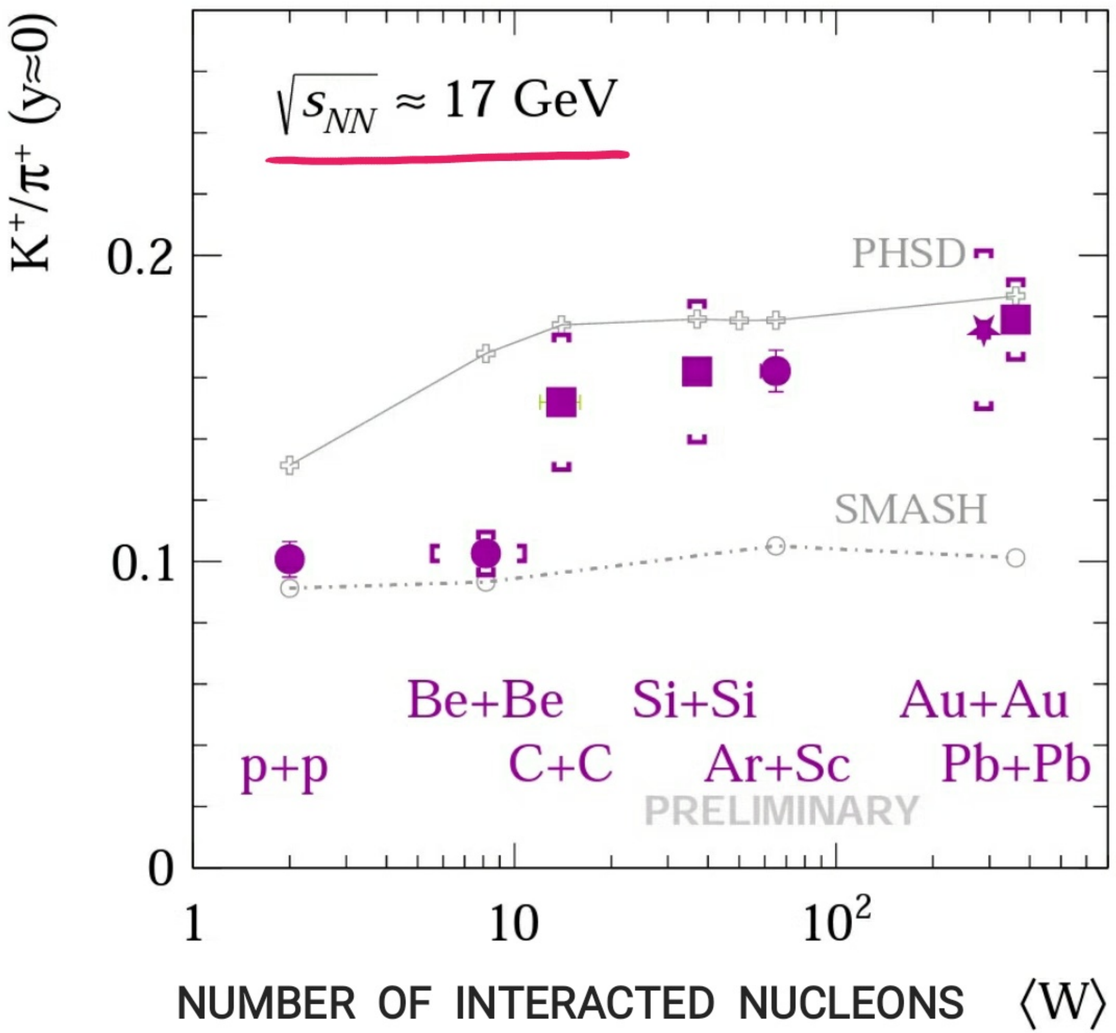
NA61/SHINE:
EPJ C81, 397 (2021)

p + p ≈ Xe + Xe ≈ Pb + Pb AT LHC

ALICE
NATURE PHYS. 13, 535 (2017)

2 → QGP IN p + p AT LHC

IDEAS AND DATA: COLLISIONS OF INTERMEDIATE MASS NUCLEI



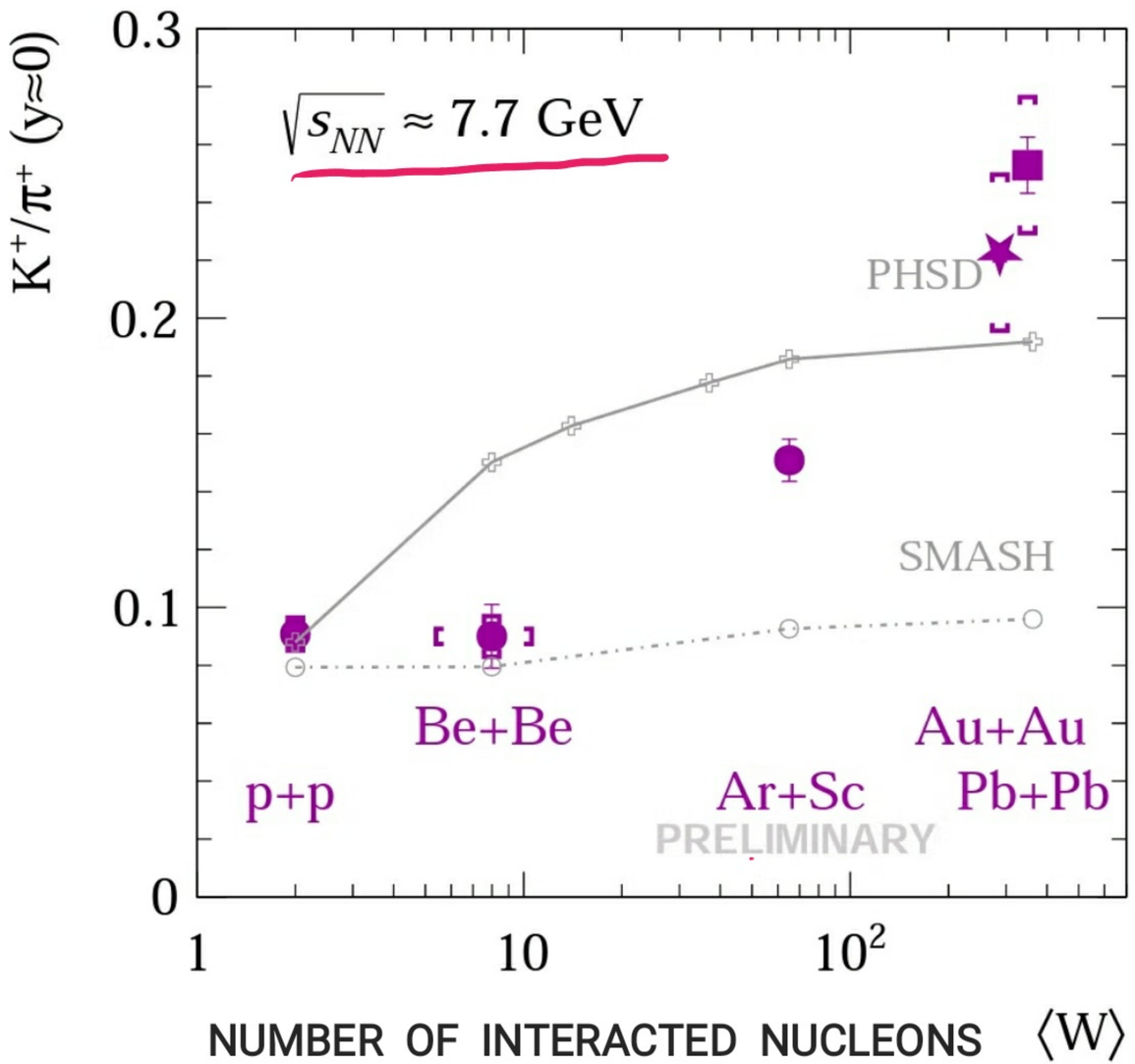
JUMP BETWEEN p + p, Be + Be AND Ar + Sc, Pb+ Pb AT THE TOP SPS ENERGIES

NOT REPRODUCED BY THE MODELS

IDEA: JUMP IS DUE TO STRINGS TO QGP COLLAPSE PICTURED AS THE BLACK-HOLE FORMATION USING AdS/CFT DUALITY

KALAYDZHYAN, SHURYAK
PRC 90, 014901 (2014)
PRD 90, 025031, (2014)

IDEAS AND DATA: COLLISIONS OF INTERMEDIATE MASS NUCLEI



SMOOTH INCREASE BETWEEN
Be + Be, Ar + Sc AND Pb + Pb
AT THE LOW SPS ENERGIES

POSSIBLY DUE TO:

- APPROACHING EQUILIBRIUM WITH INCREASING <W> AND SYSTEM LIFE-TIME
- WEAKENING OF CANONICAL STRANGENESS SUPPRESSION WITH INCREASING <W>
- INCREASING ROLE OF CHIRAL-SYMMETRY RESTORATION

DIAGRAM OF HIGH-ENERGY NUCLEAR COLLISIONS

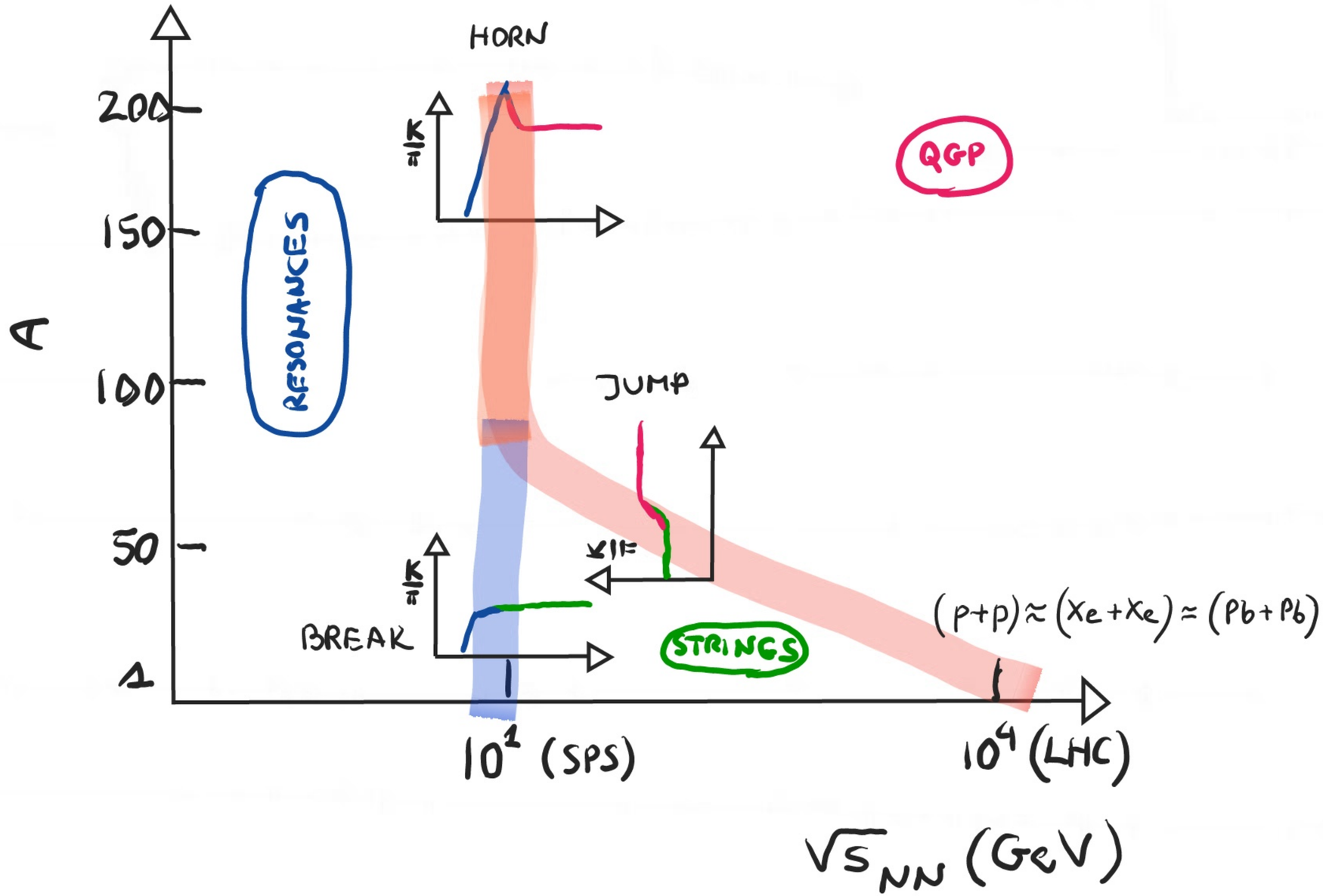


DIAGRAM OF HIGH-ENERGY NUCLEAR COLLISIONS

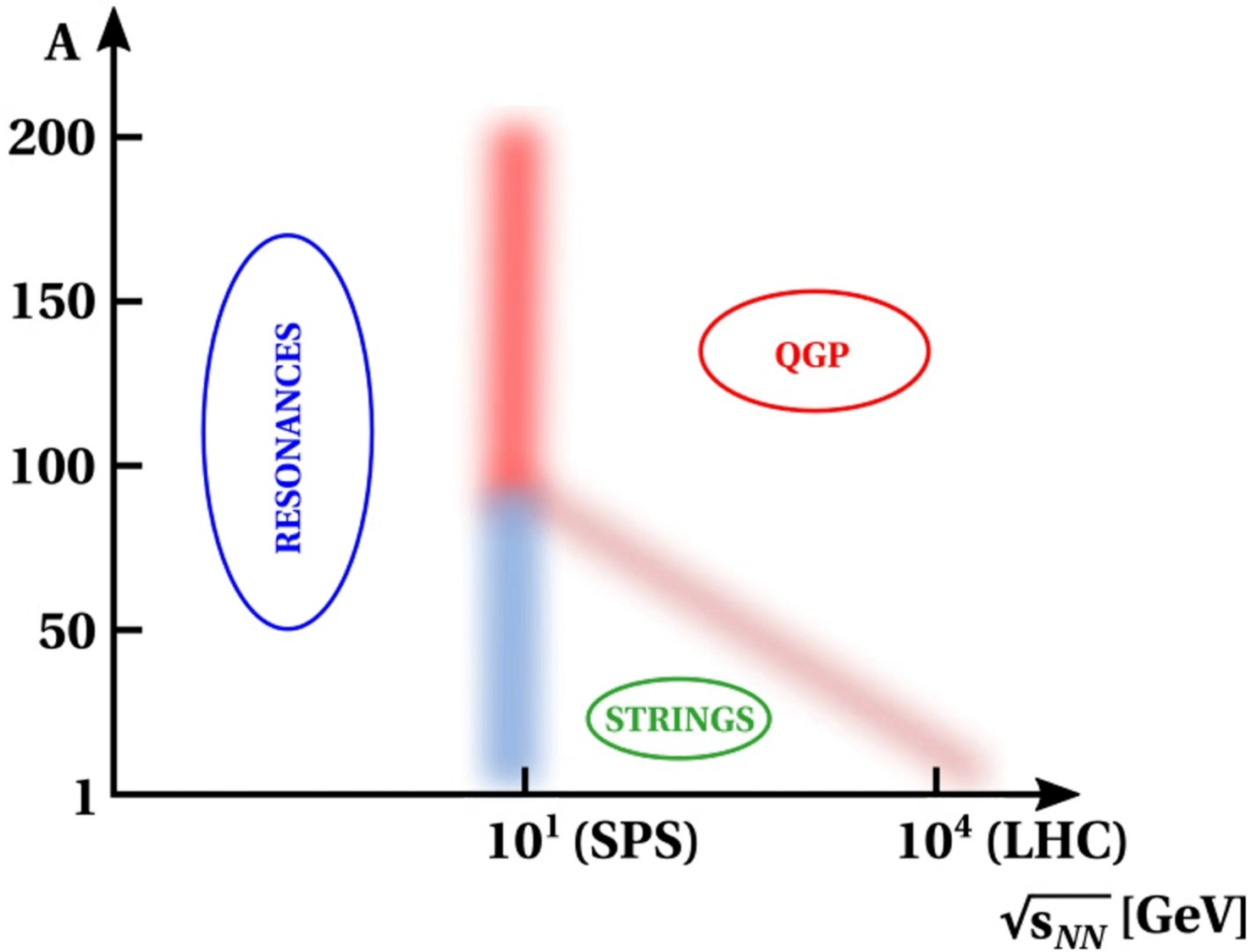


DIAGRAM OF HIGH-ENERGY NUCLEAR COLLISIONS ON CRITICAL POINT

PHASE DIAGRAM

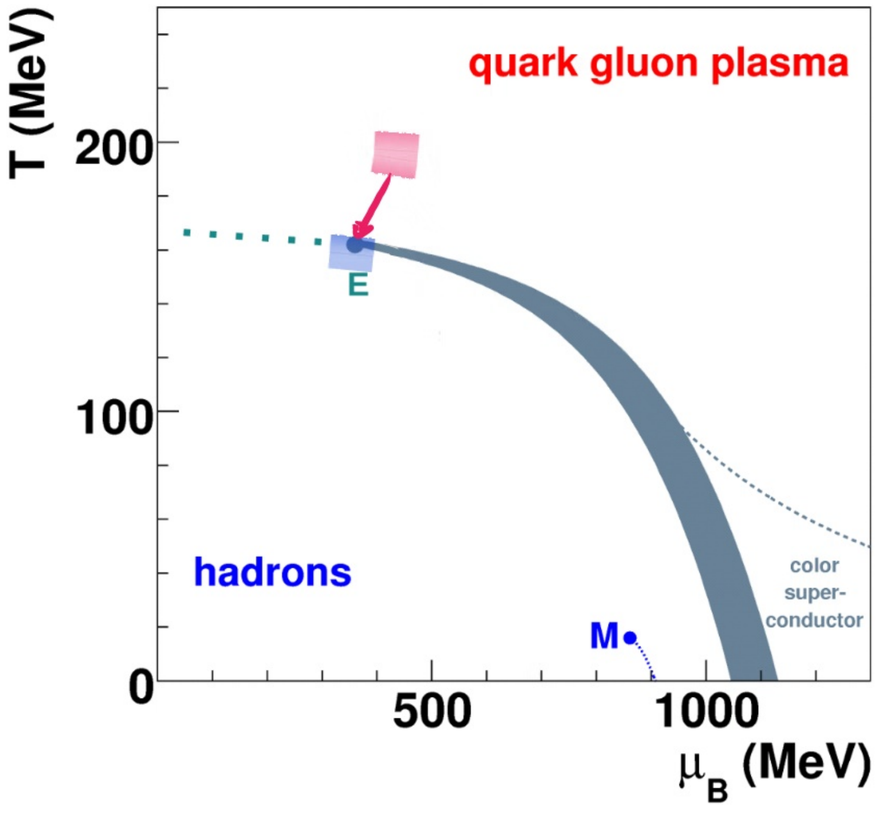
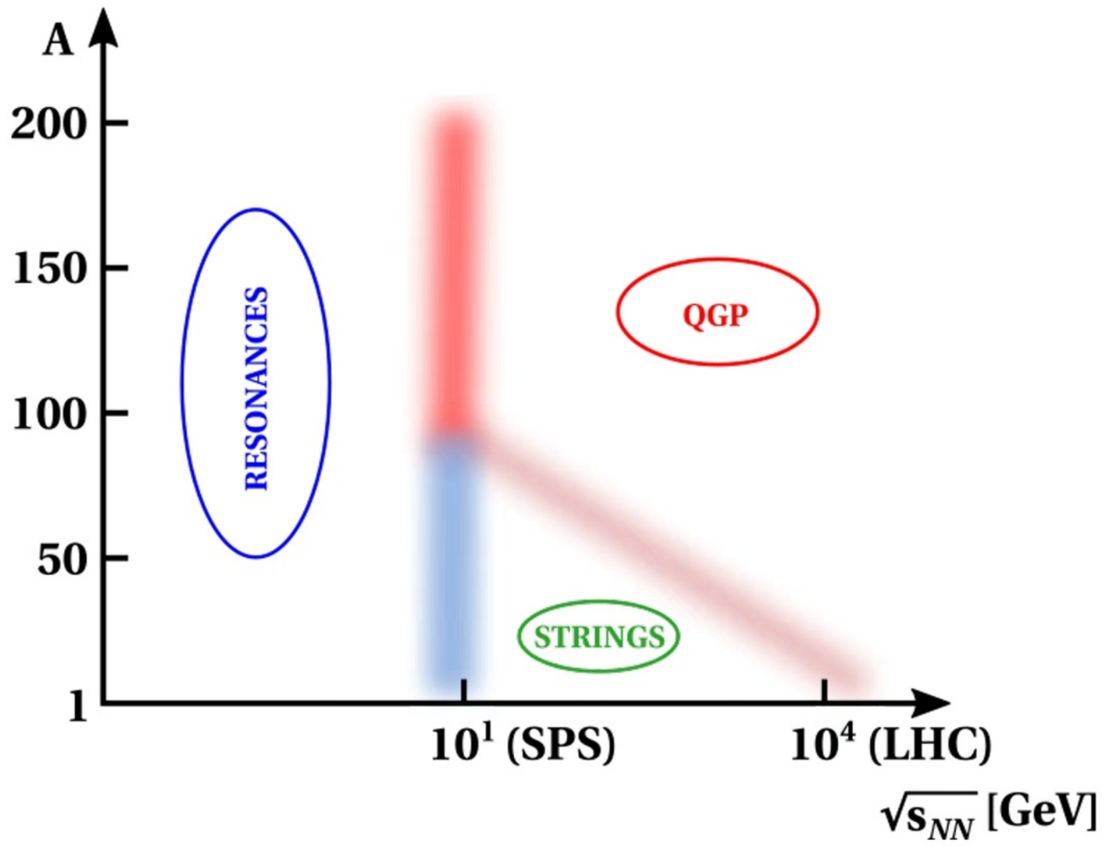


DIAGRAM OF HIGH-ENERGY NUCLEAR COLLISIONS

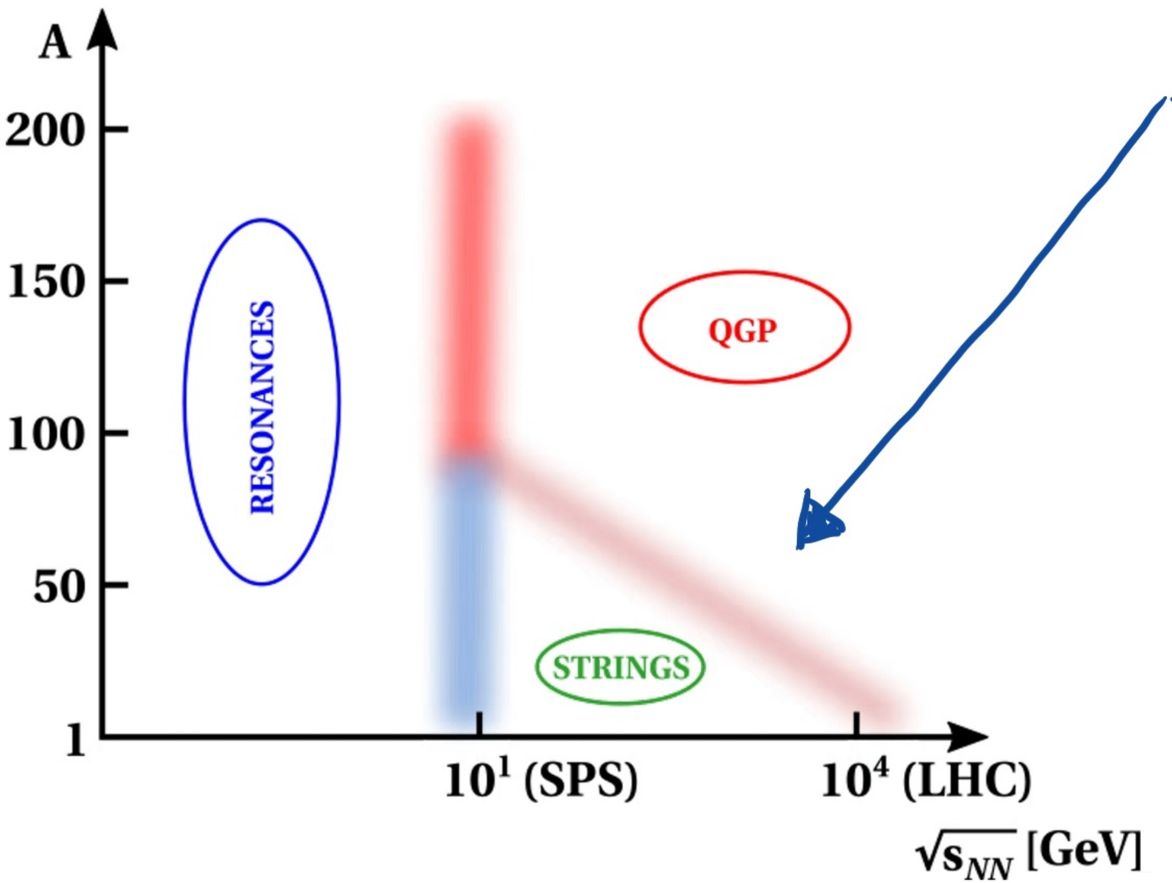


CP SEARCH IN HIC:

- FREEZE-OUT CLOSE TO CP
- QGP AT EARLY STAGE

→ SEARCH FOR CP MAKES SENSE IN THE QGP-DOMAIN OF THE DIAGRAM

DIAGRAM OF HIGH-ENERGY NUCLEAR COLLISIONS ON FUTURE MEASUREMENTS: STRINGS-QGP?



TO ESTABLISH COLLISION-ENERGY DEPENDENCE OF THE STRINGS-QGP CHANGEOVER

PRECISION DATA ON COLLISIONS OF LIGHT AND MEDIUM-MASS NUCLEI AT CERN SPS, FIXED-TARGET LHC AND LHC ARE NEEDED

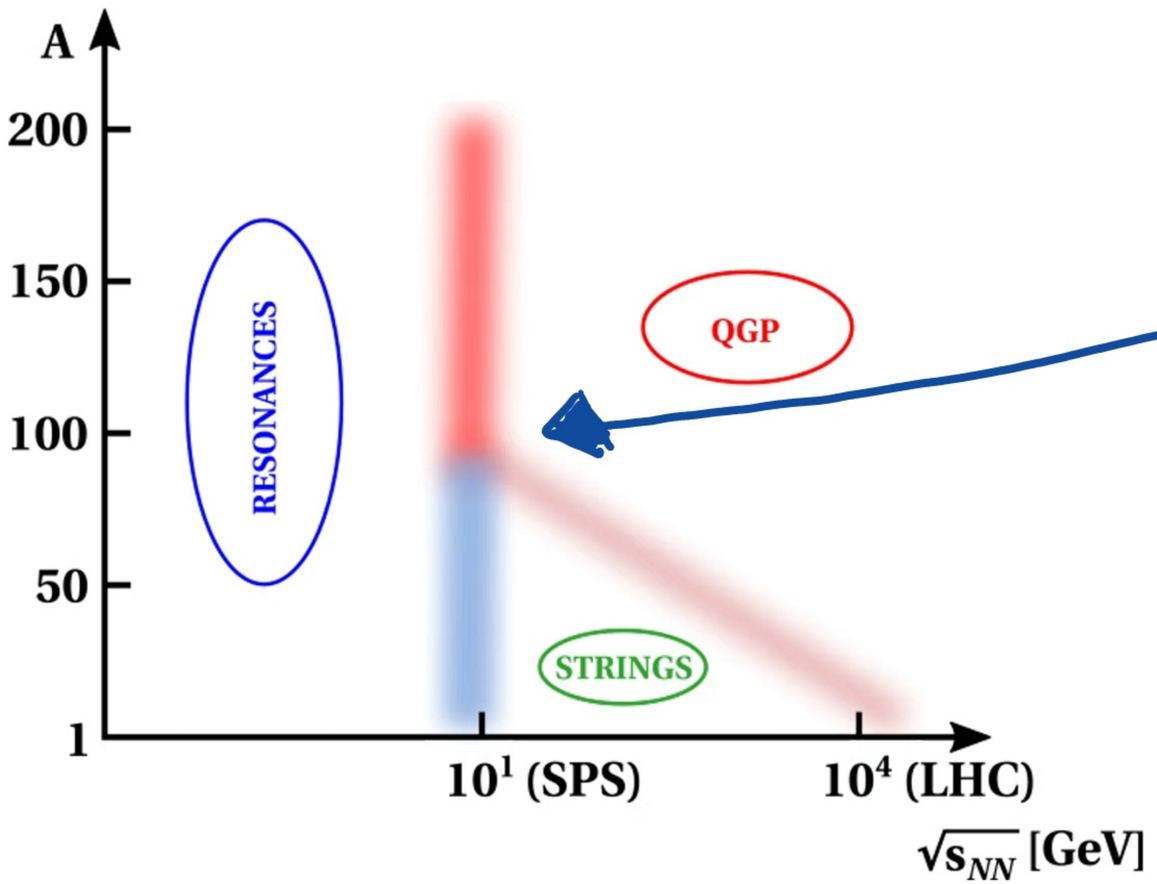
TEST MEASUREMENTS WITH OXYGEN BEAM ARE PLANNED IN 2025 BY LHC EXPERIMENTS AND NA61/SHINE AT SPS

POST-LS3 MEASUREMENTS WITH LIGHT AND MEDIUM-MASS NUCLEI ARE PROPOSED BY NA61/SHINE

HAPPY BIRTHDAY TO EVERYOUNG LUDWIK !

COMMENTS

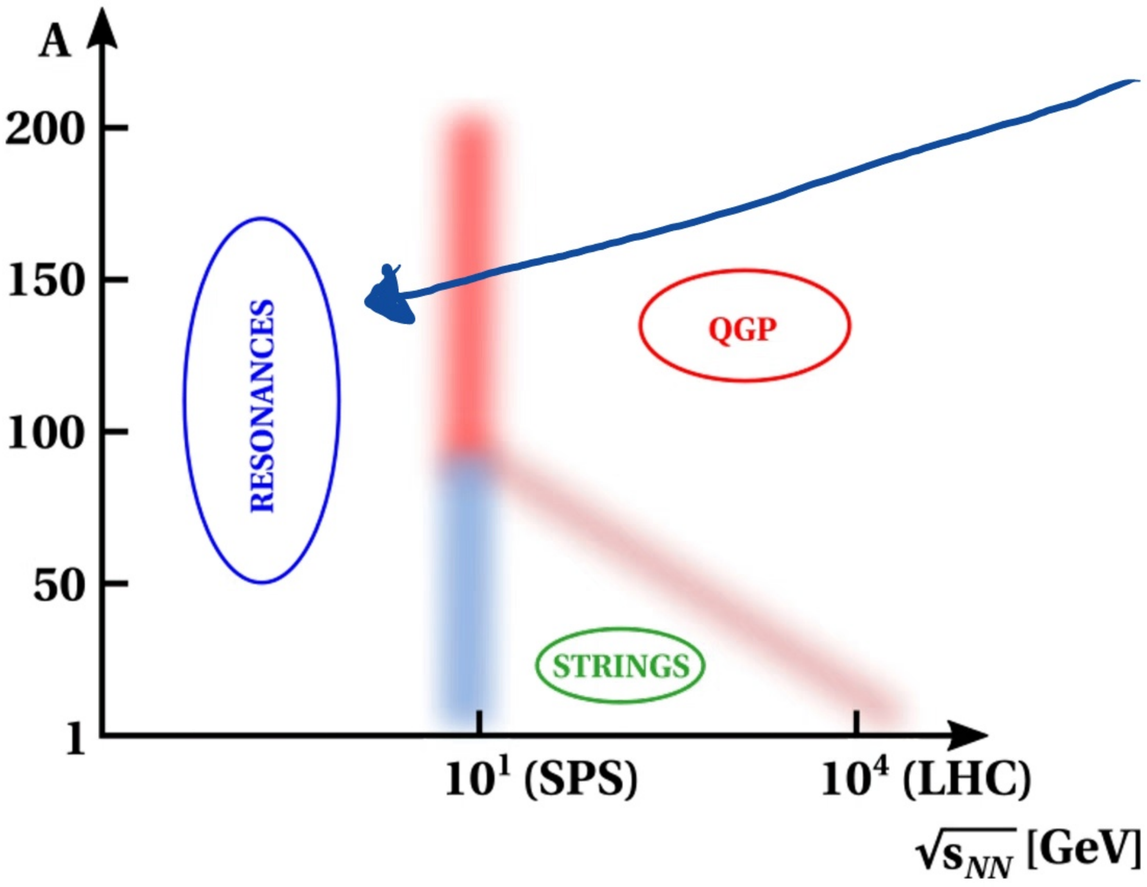
DIAGRAM OF HIGH-ENERGY NUCLEAR COLLISIONS ON FUTURE MEASUREMENTS: TRIPLE REGION?



NEED FOR:

- MODELLING
- SIGNALS
- EXPERIMENTAL SEARCH AT CERN SPS AND JINR NICA (THE RUSSIAN AGRESSION ON UKRAINE STOPPED INTERNATIONAL COLLABORATION ON THIS PROJECT)

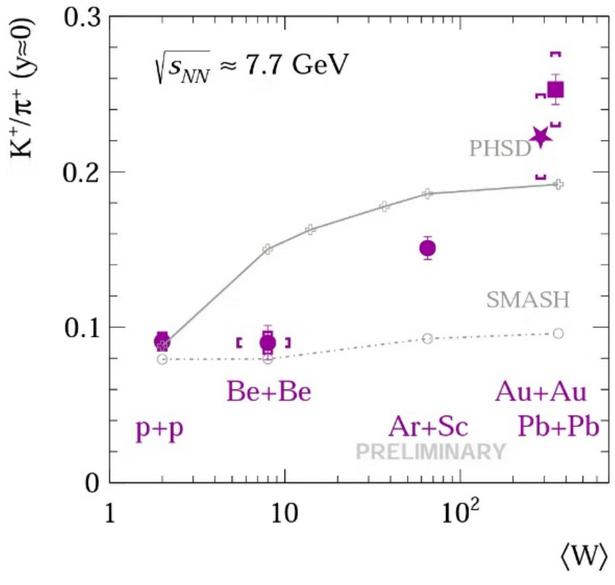
DIAGRAM OF HIGH-ENERGY NUCLEAR COLLISIONS ON FUTURE MEASUREMENTS: EQUILIBRATION IN RESONANCE DOMAIN?



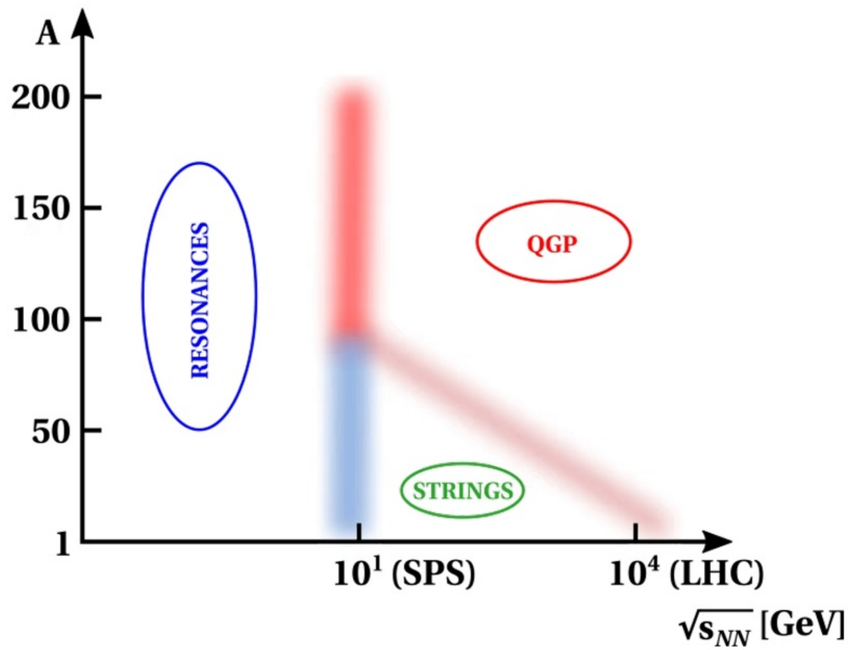
TO UNDERSTAND EQUILIBRATION AND PROPERTIES OF MATTER IN RESONANCE DOMAIN

PRECISION DATA ON NUCLEAR MASS DEPENDENCE FROM J-PARC AND FAIR ARE NEEDED

IN PARTICULAR DATA ON EVENT-BY-EVENT FLUCTUATIONS ARE MISSING



(1)



The changeover resonances–strings and resonances–QGP are located at similar collision energies (≈8 GeV/c). This suggests that the resonances–QGP changeover is driven by the resonances–strings one. At high masses of colliding nuclei, strings produced above at the resonances–strings changeover would have density exceeding the strings–QGP changeover. Thus the string domain disappears, and one observes direct resonances–QGP changeover. This locates the resonances–QGP changeover at the energy of the resonances–strings one.

(11)

It is interesting to consider other diagrams of high-energy collisions. Here, we discuss a simple example of the hadron–resonance gas diagram. Hagedorn's early papers postulated that hadrons in high-energy collisions are produced according to statistical thermodynamics [71]. Thus, following Hagedorn's postulate, the diagram would include only one production process—the statistical-thermodynamical production, with Hagedorn's temperature $T_H \approx 150$ MeV. This model is clearly in contradiction with the experimental results, as it predicts the K^+/π^+ ratio to be independent of energy and nuclear mass number of colliding nuclei. Over the years, the simple Hagedorn approach evolved into many models that are much more flexible in fitting the data; for a recent review, see Ref. [72]. In particular, it has been popular to fit mean hadron multiplicities, which include multiplicities of kaons and pions, assuming that a hadron gas in equilibrium is created at high-energy collisions. The temperature, the baryon chemical potential, and the gas volume are free parameters of the model and are fitted to the data from each reaction separately. The model cannot predict the energy and nuclear mass dependence of hadron production in this formulation. Thus, it is unsuitable for the diagram construction.