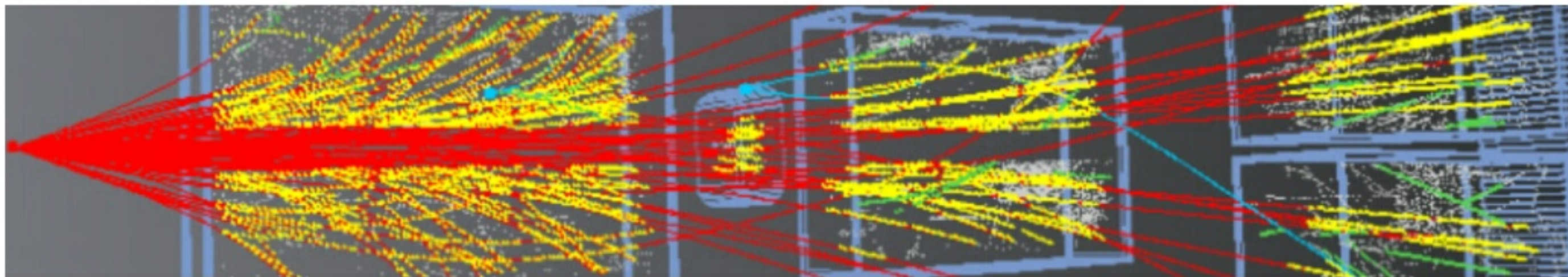


RECENT RESULTS FROM NA61/SHINE PROGRAMME ON STRONG INTERACTIONS

M. GAZDZICKI
FRANKFURT, KIELCE

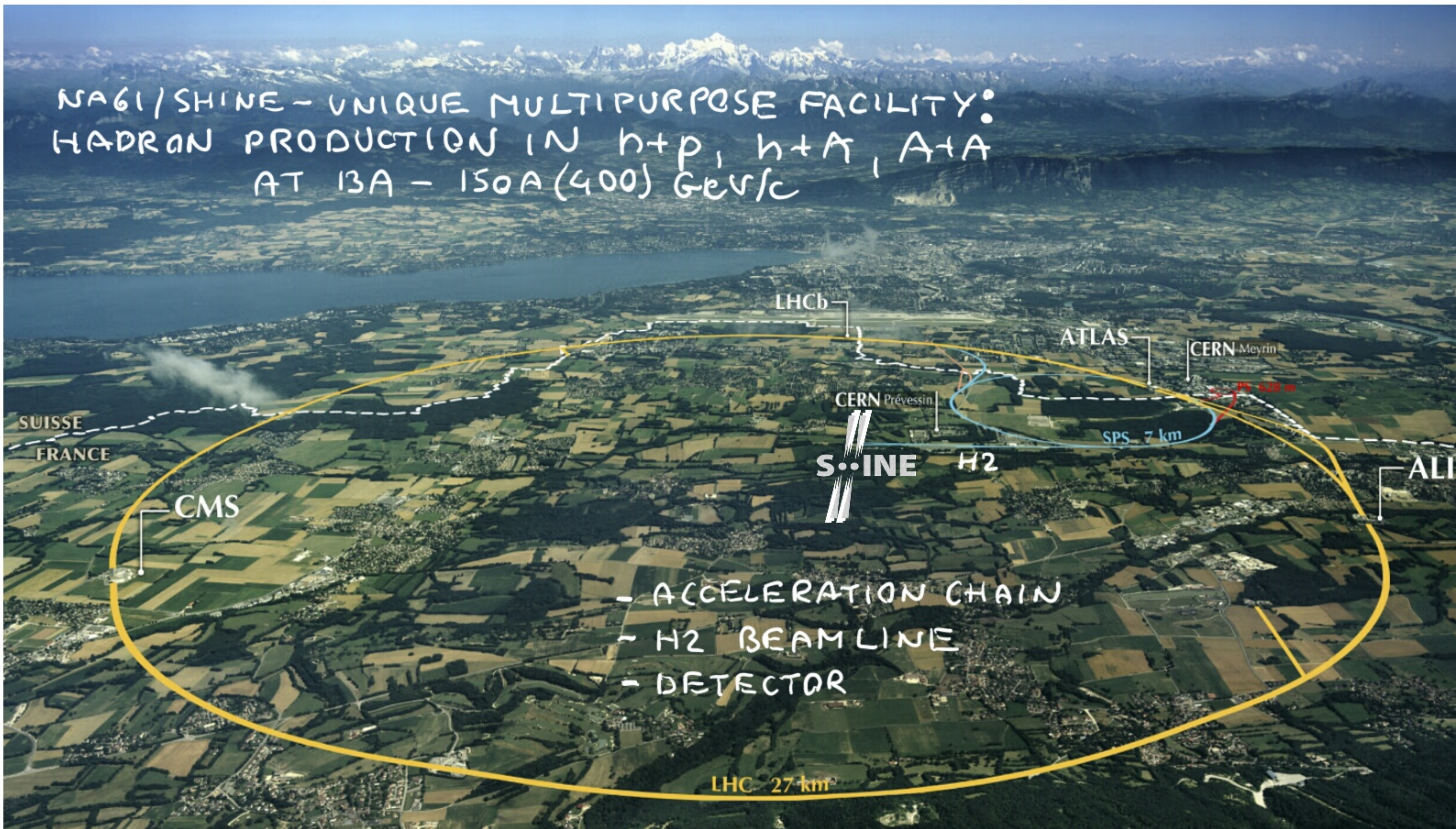
- DETECTOR
- ■ RESULTS
- ■ ■ PLANS





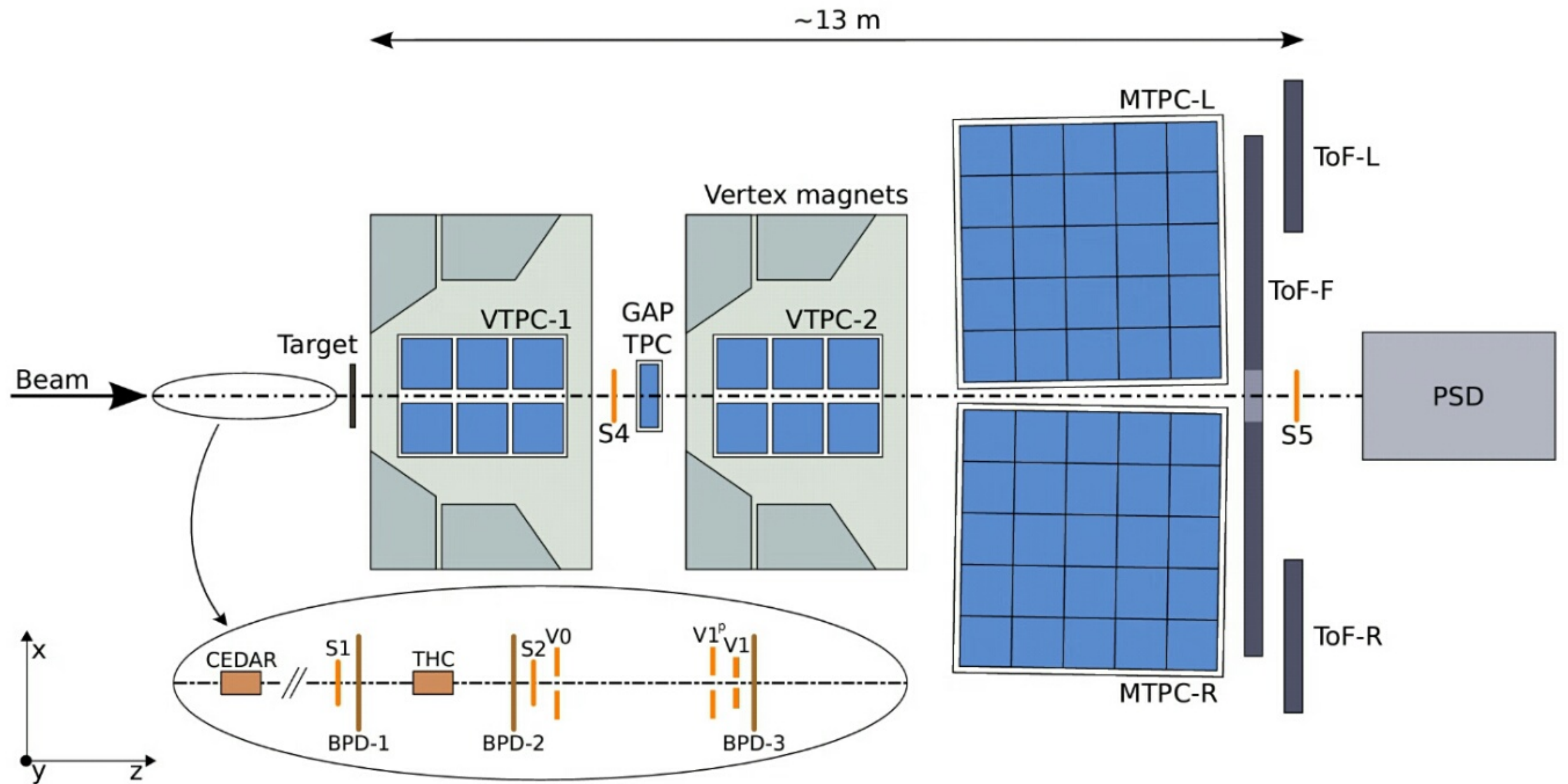
DETECTOR

NAGI/SHINE - UNIQUE MULTIPURPOSE FACILITY:
HADRON PRODUCTION IN $h+p$, $h+A$, $A+A$
AT 13A - 150A (400) GeV/c



- ACCELERATION CHAIN
- H2 BEAMLIN
- DETECTOR

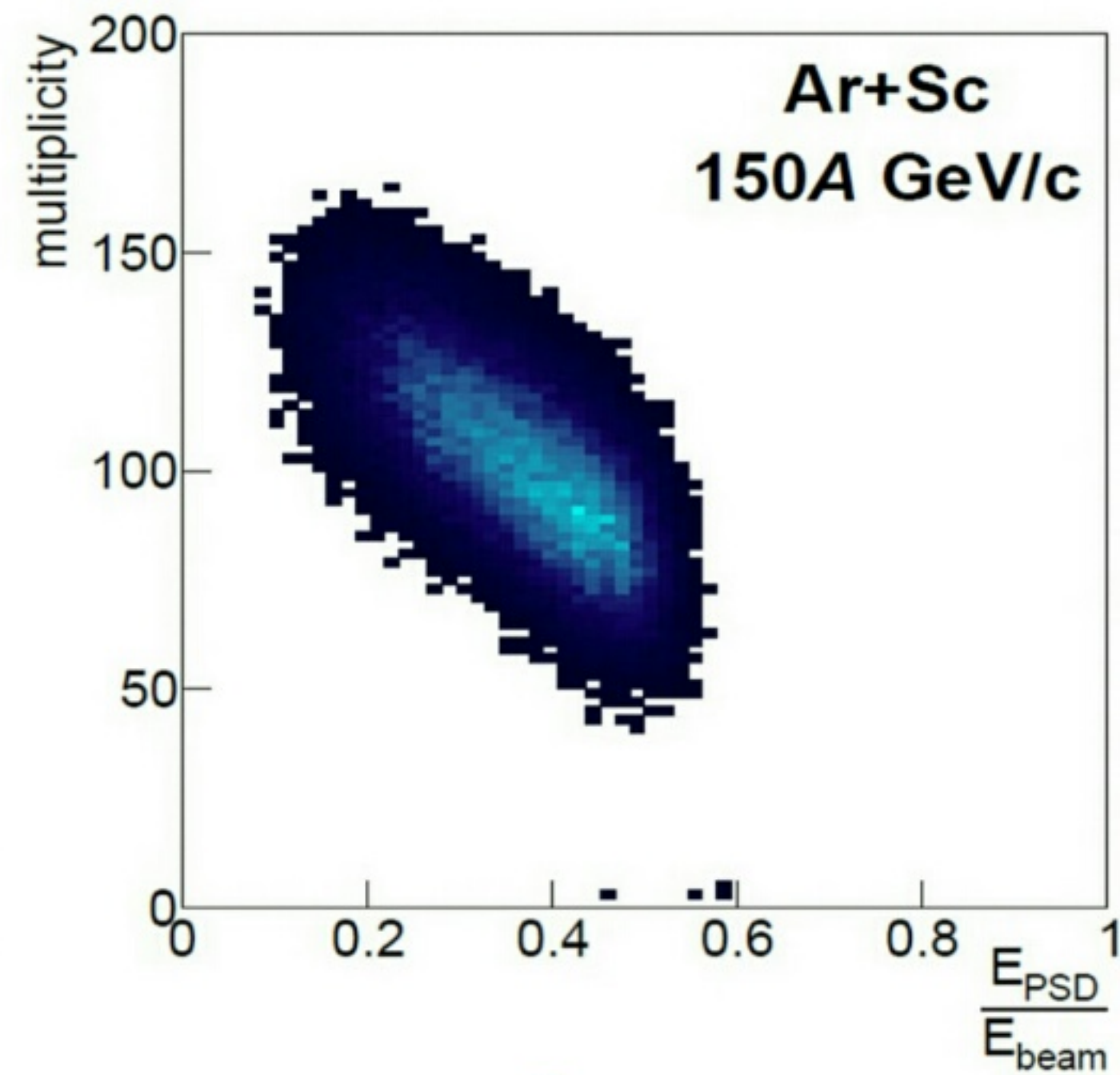
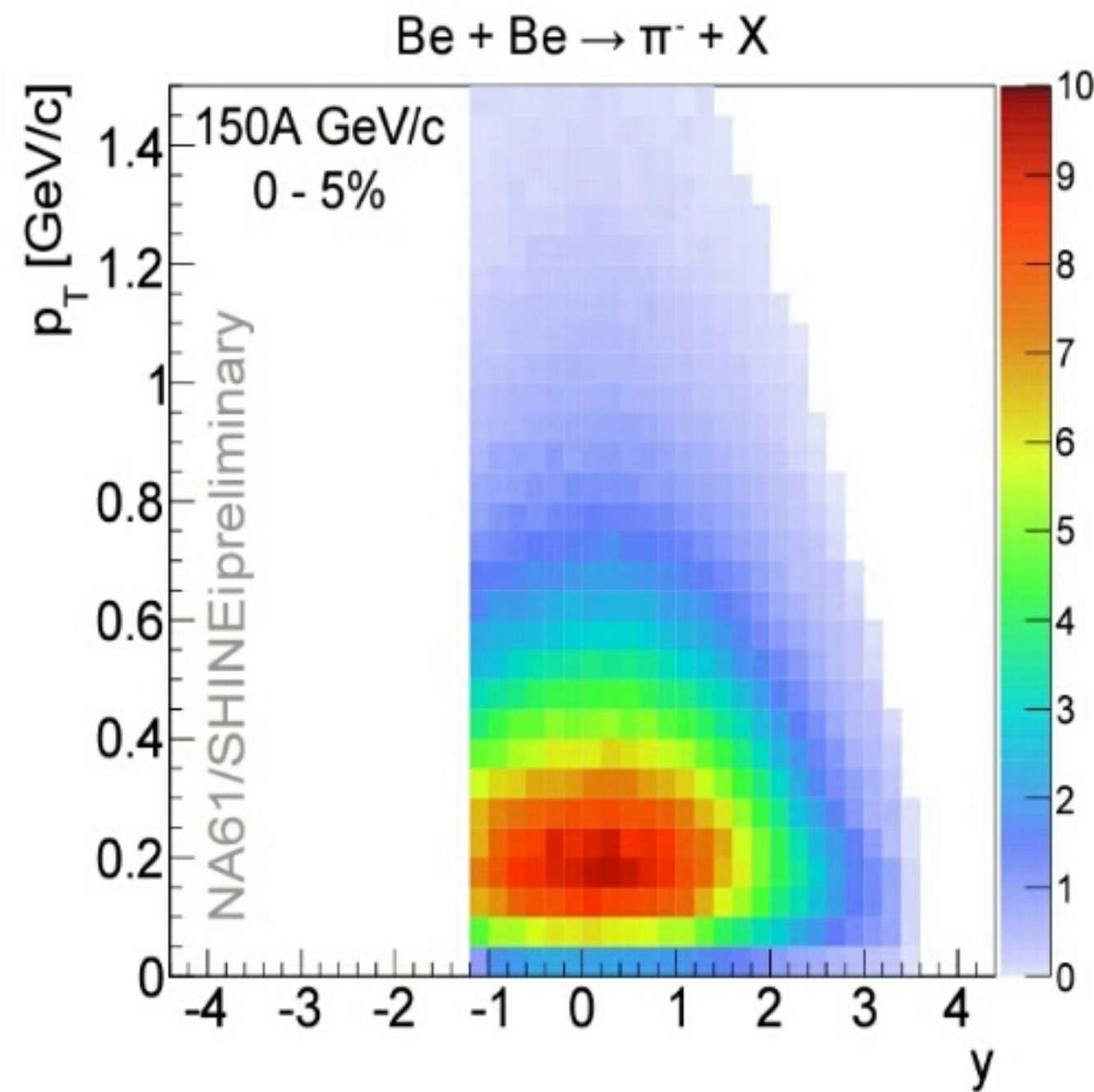
NAGI/SHINE DETECTOR



NA61/SHINE DETECTOR : FINAL PRODUCTS

SINGLE PARTICLE
2D SPECTRA
OF IDENTIFIED HADRONS

MULTI-DIMENSIONAL
DISTRIBUTIONS OF
EVENT PROPERTIES



TYPICAL
VARIABLES :

- $y - p_T$ (SI)
- $p - Q$ (ν)

N, p_T, E_F

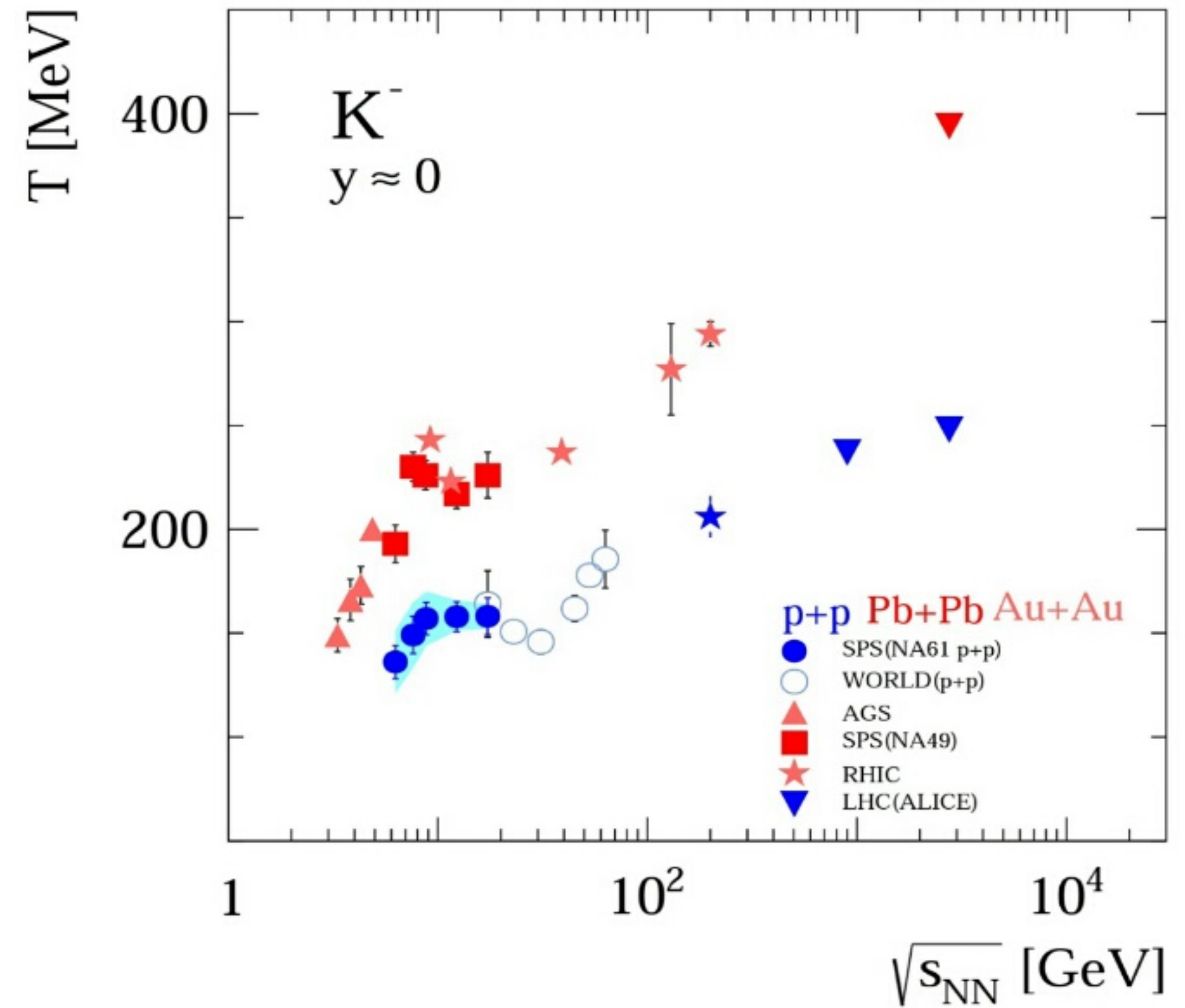
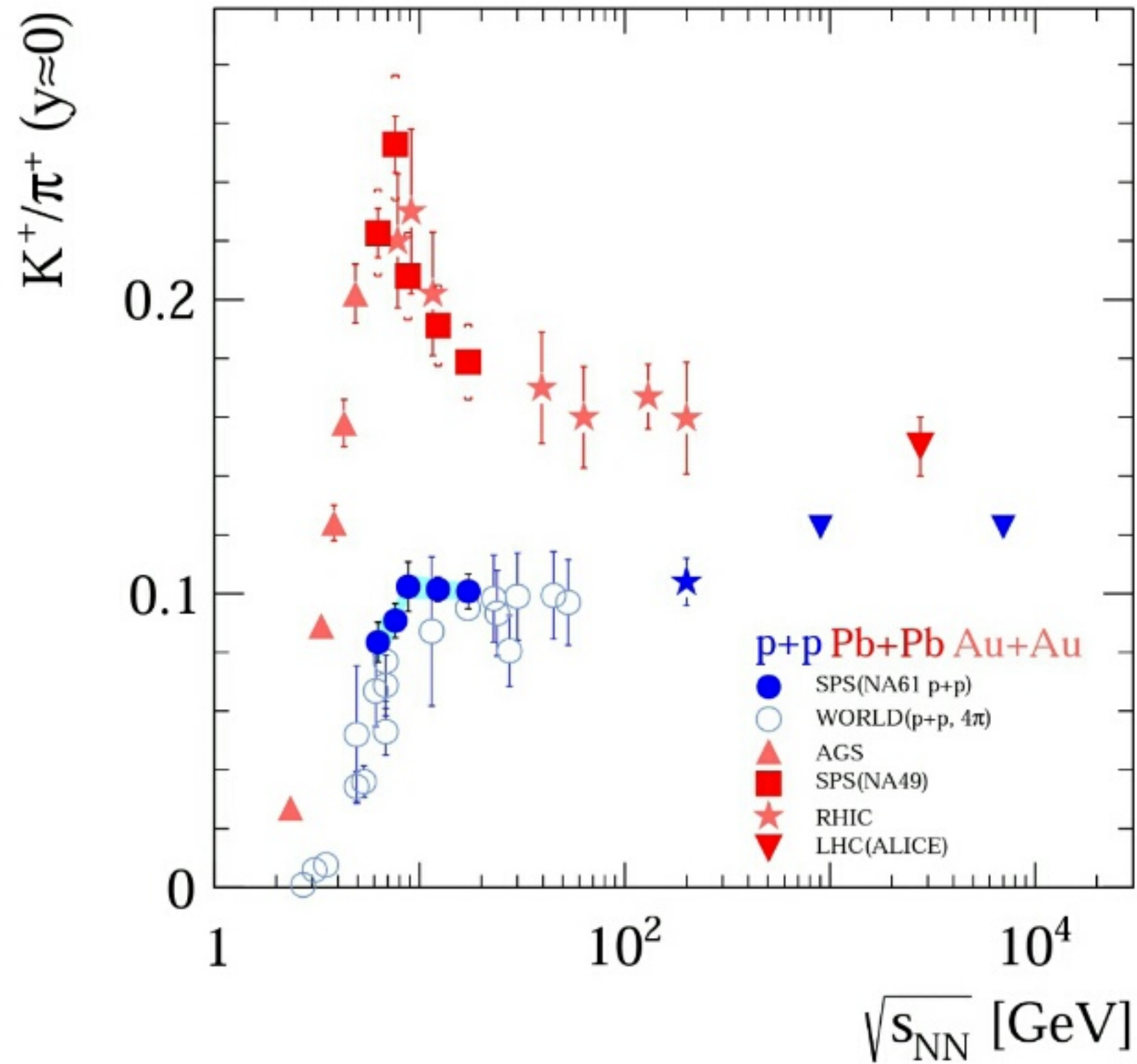
RESULTS: ONSET OF DECONFINEMENT

THE NA49 OBSERVATION OF RAPID CHANGES IN COLLISION ENERGY DEPENDENCE OF HADRON PRODUCTION PROPERTIES IN CENTRAL Pb+Pb COLLISIONS

→ ONSET OF DECONFINEMENT

→ NA61/SHINE (COLLISION ENERGY) - (NUCLEAR MASS) SCAN

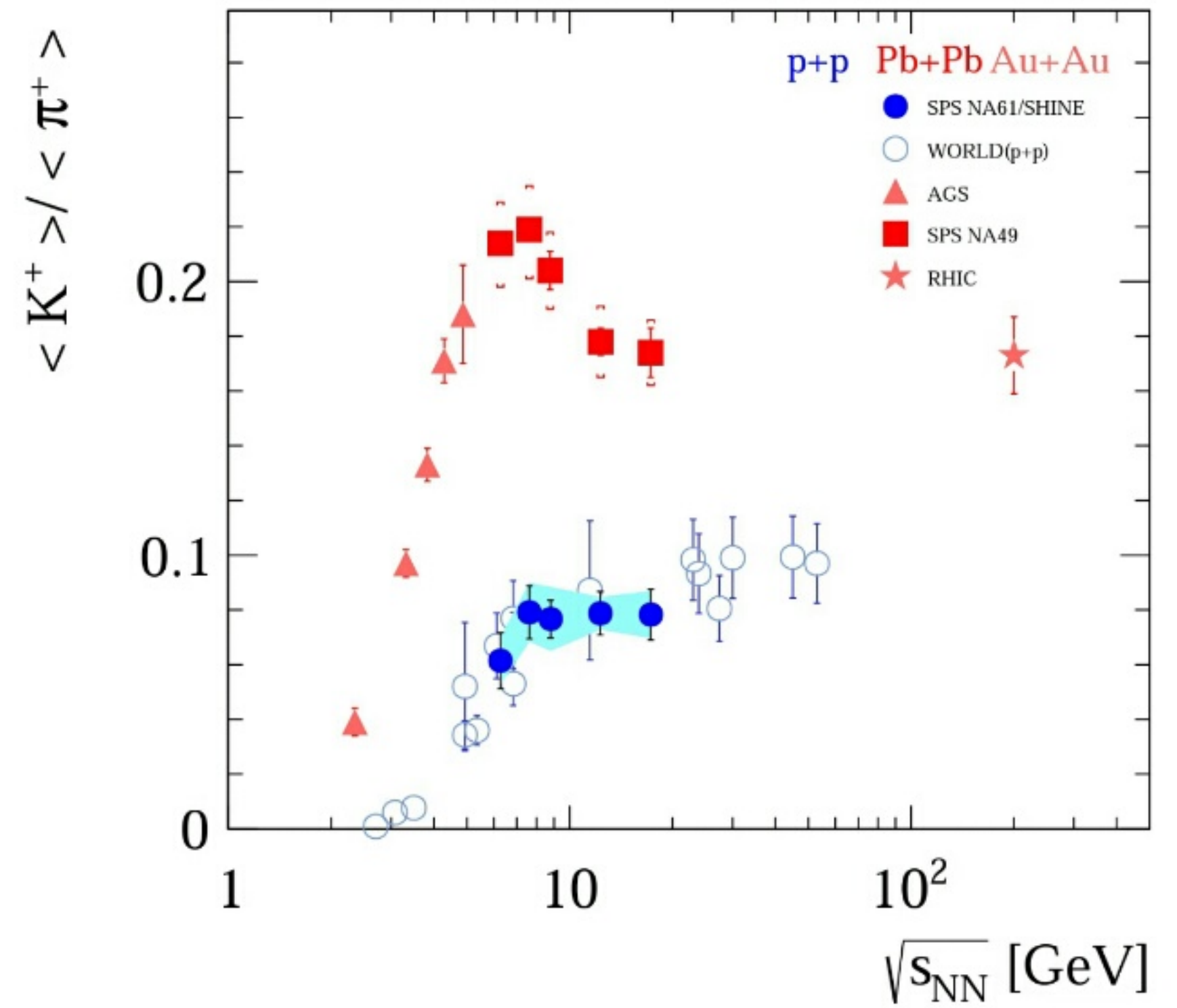
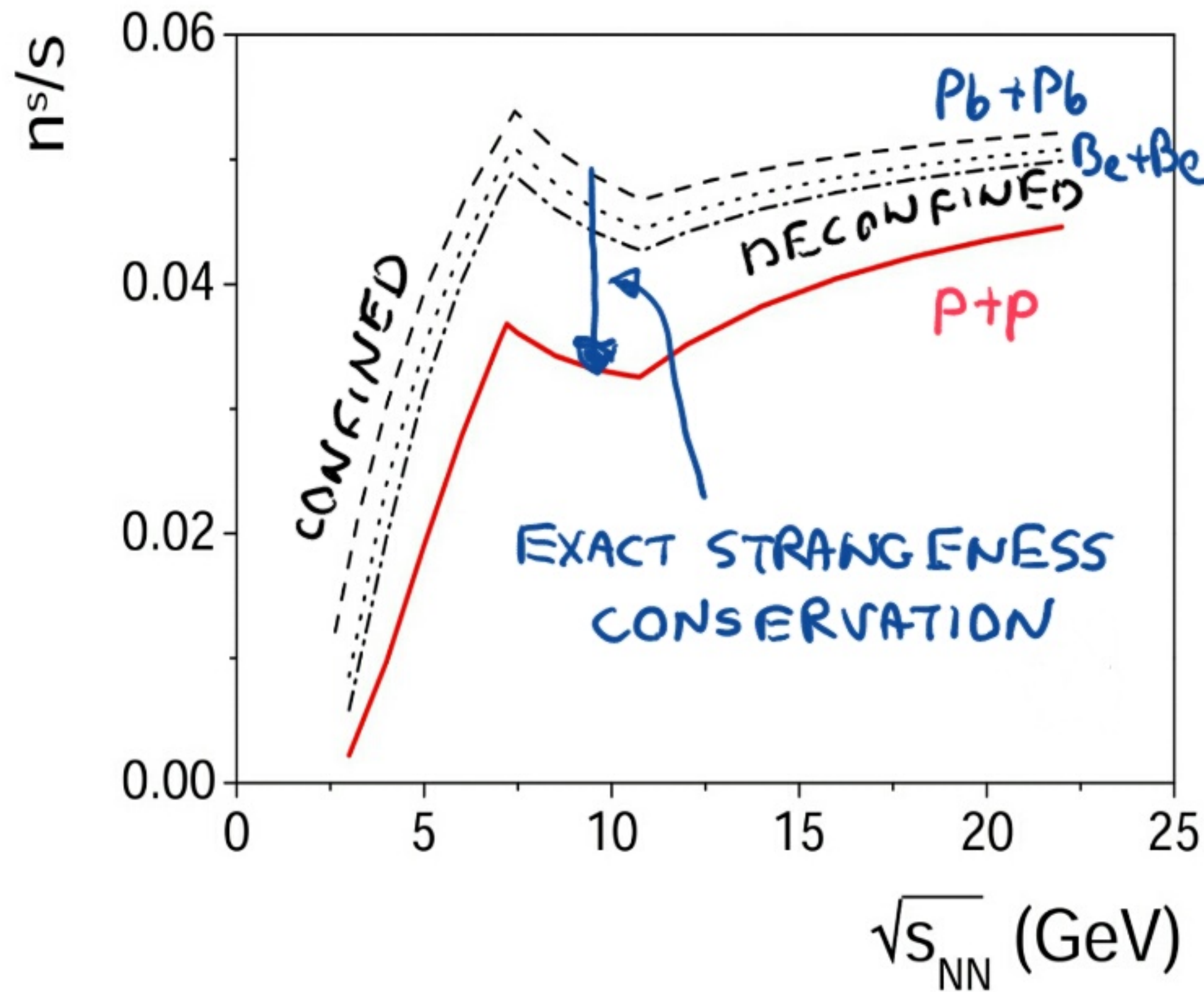
EVIDENCE FOR RAPID CHANGES IN $p+p$ AT SPS



ONSET OF DECONFINEMENT IN Pb+Pb
 → ONSET OF DECONFINEMENT IN p+p ?

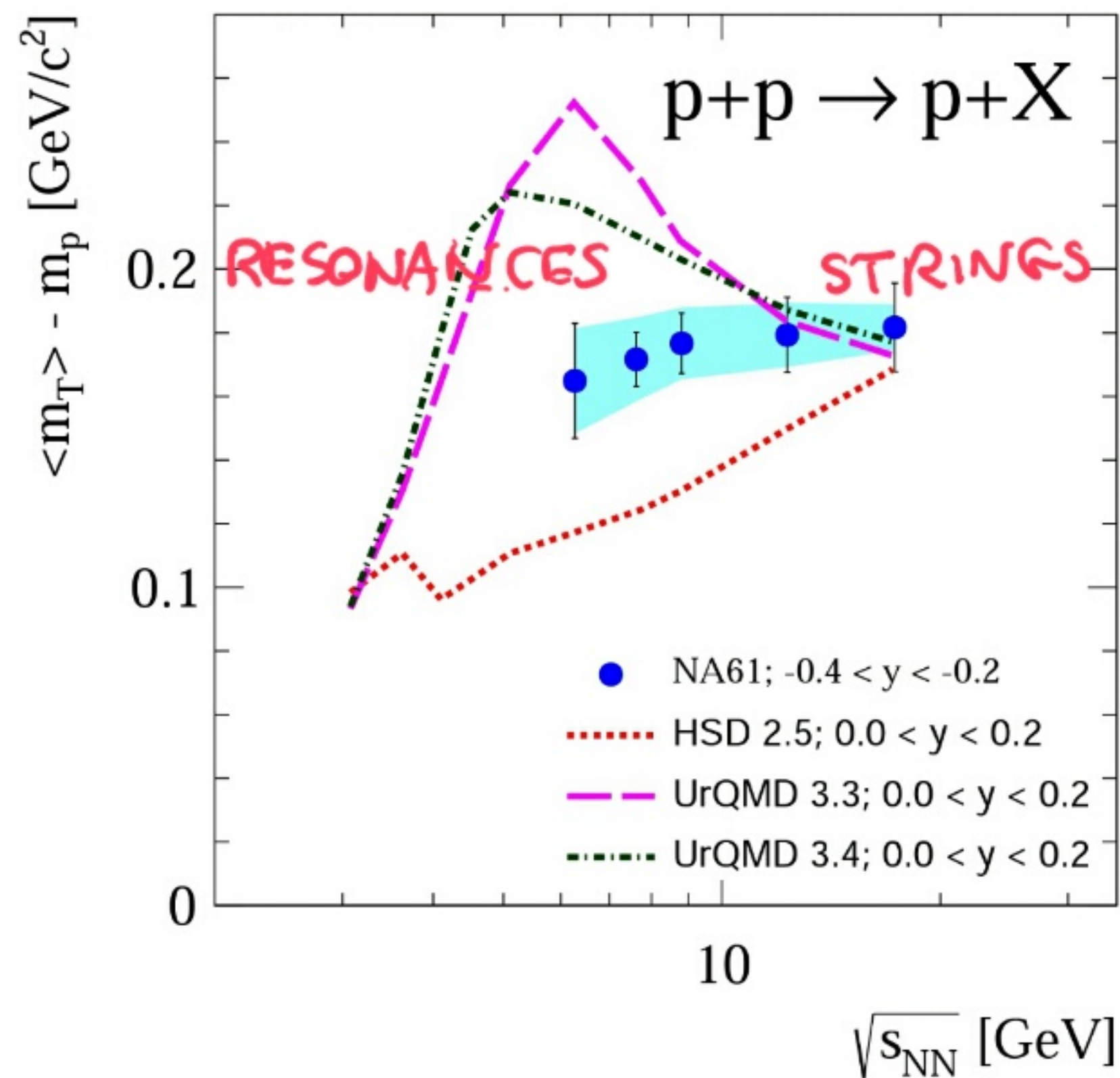
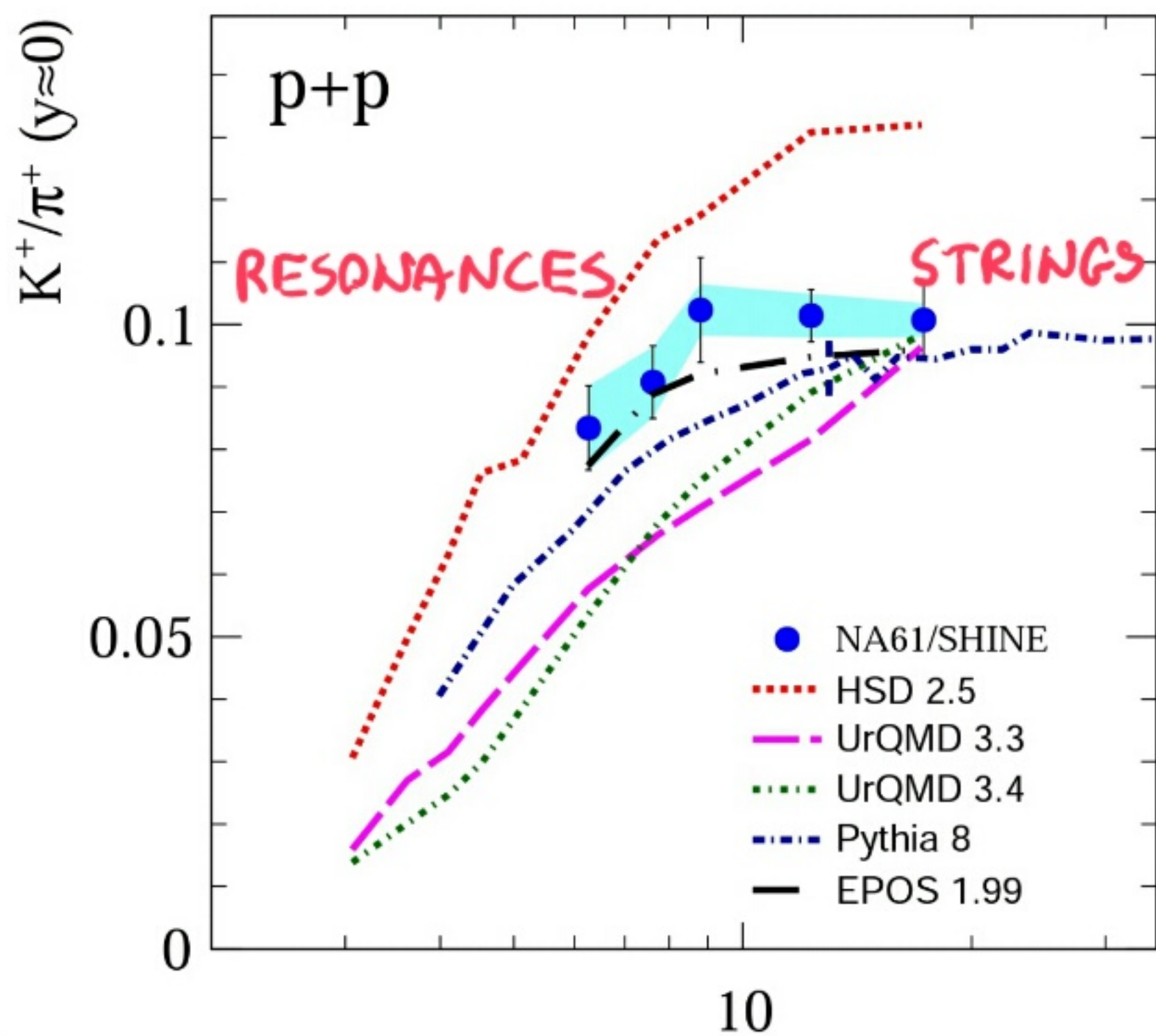
EVIDENCE FOR RAPID CHANGES IN $p+p$ AT SPS

EXPECTATIONS FOR THE ONSET OF DECONFINEMENT



APP B46 (2015) 1991

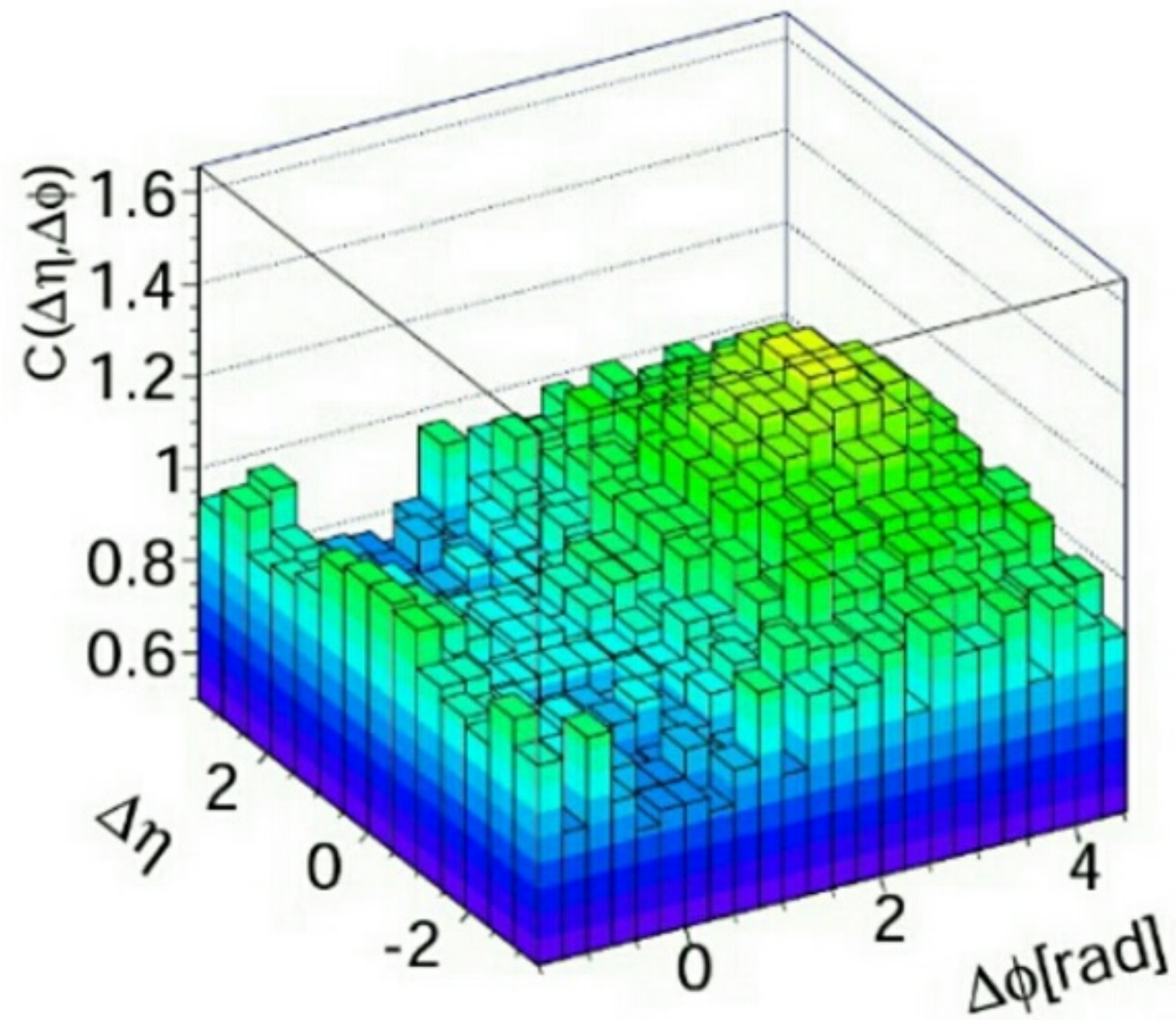
p+p: HARD TIME FOR STRING-RESONANCE MODELS



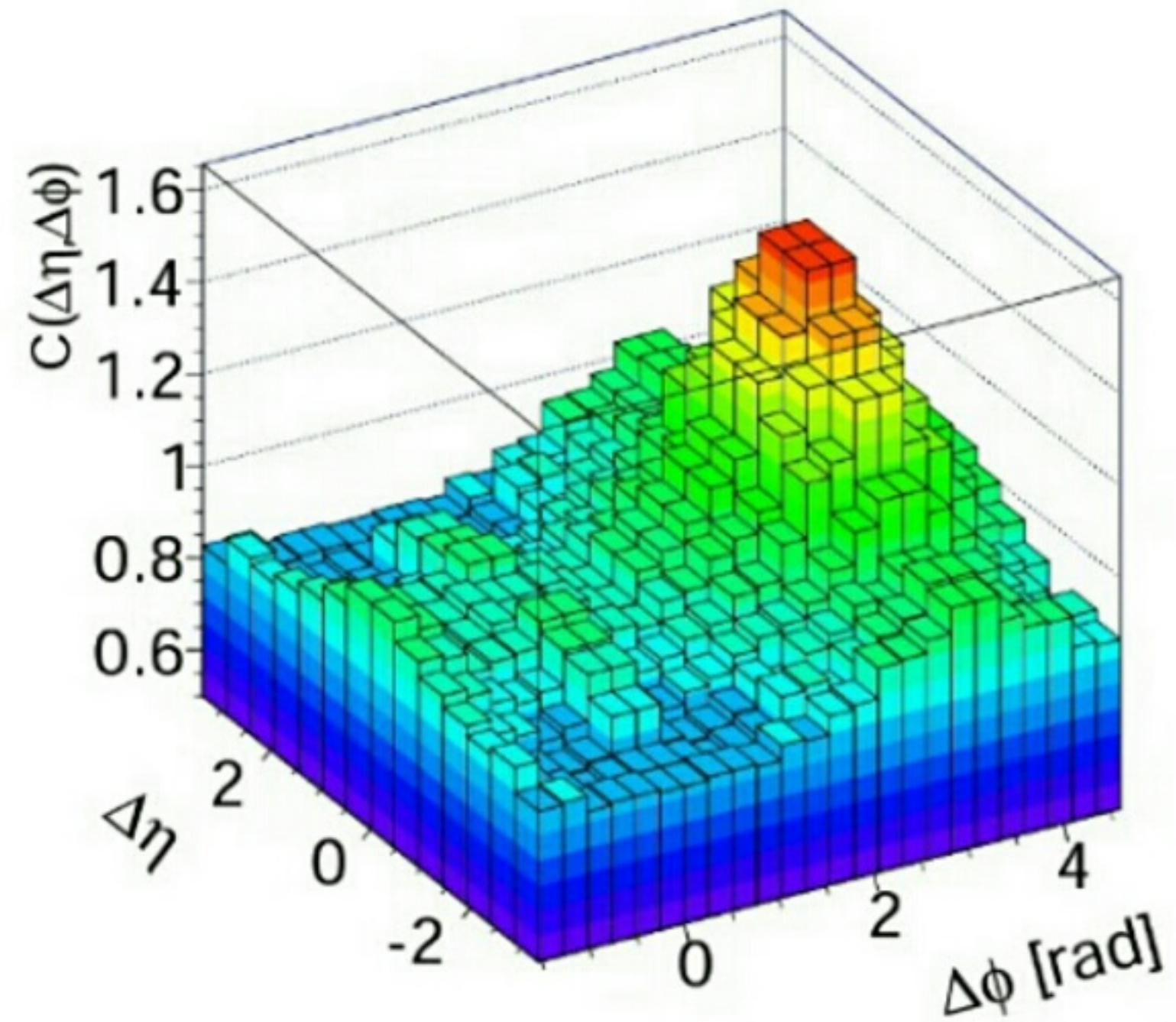
p+p: HARD TIME FOR STRING-RESONANCE MODELS

TWO-PARTICLE CORRELATIONS IN $\Delta\eta$ $\Delta\phi$
ALL CHARGED PAIRS

NA61/SHINE preliminary, 20 GeV/c

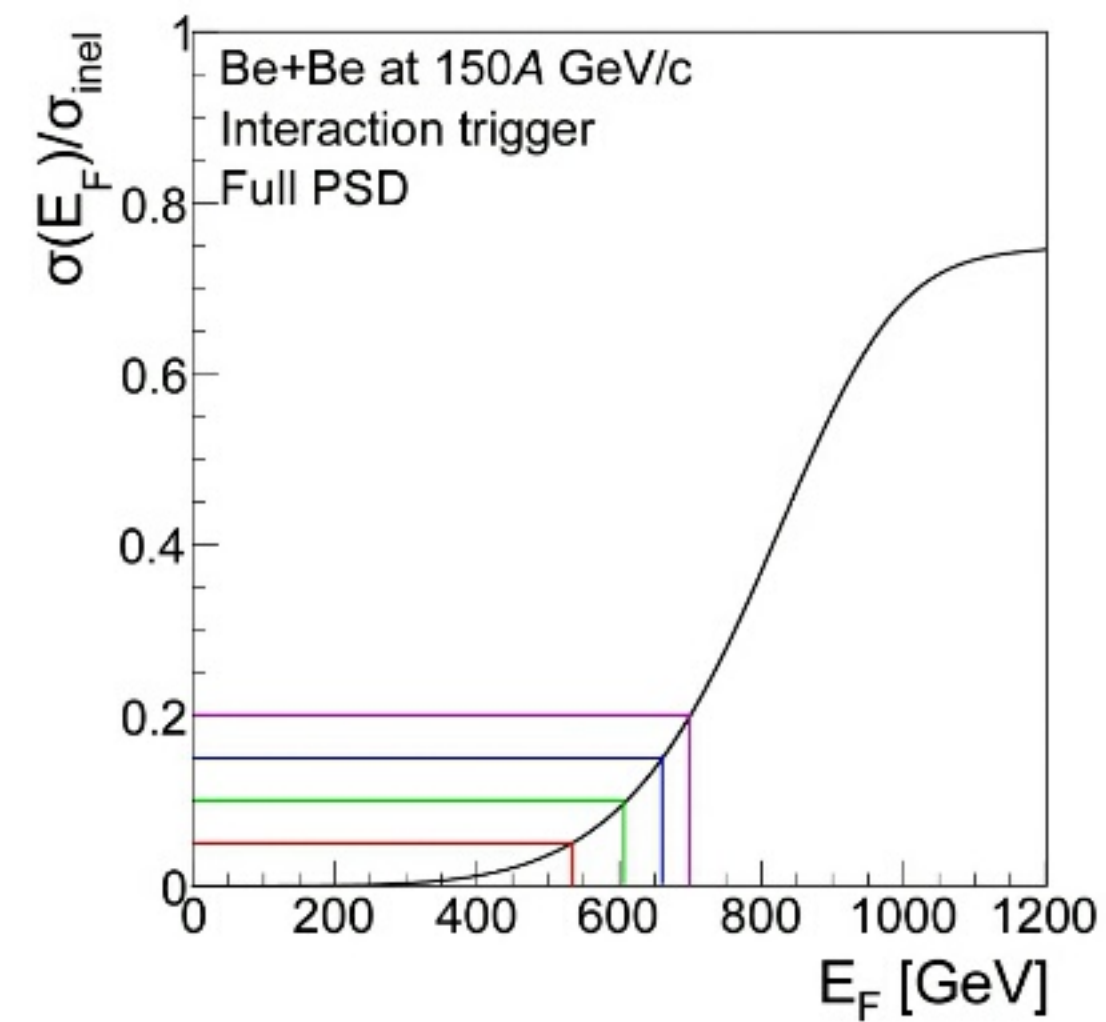
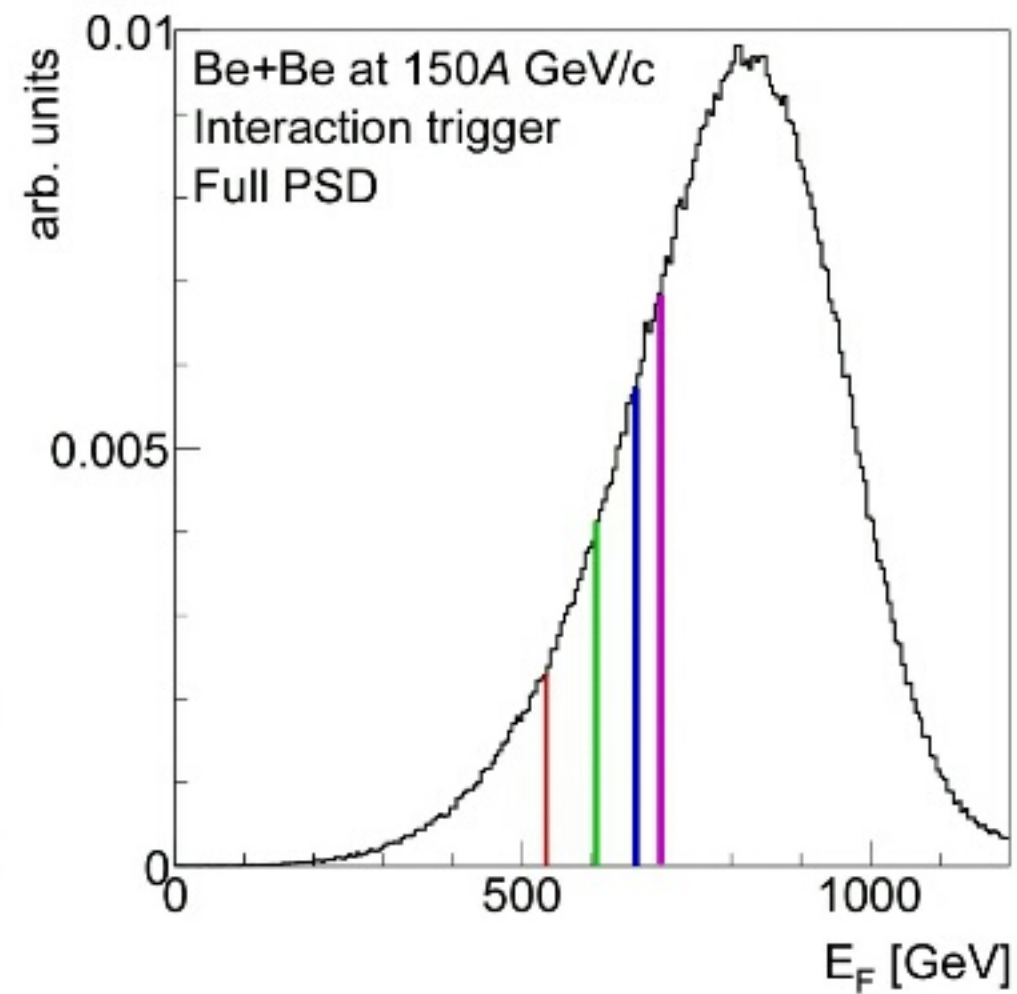
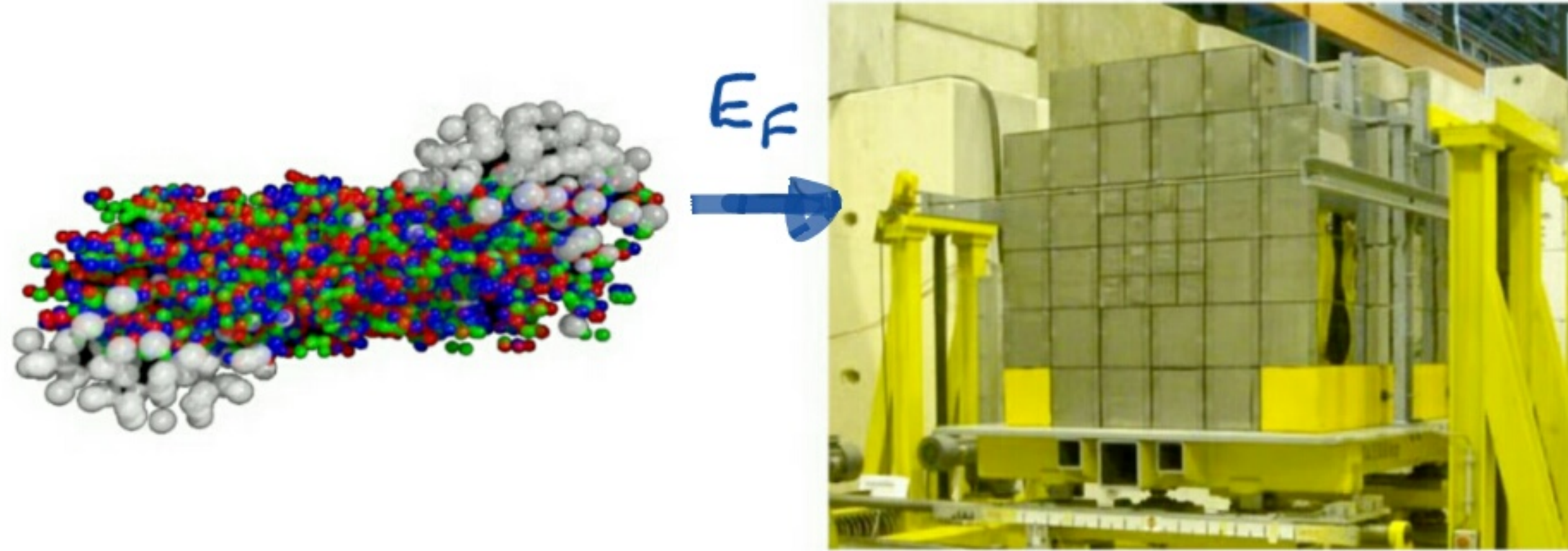


UrQMD, 20 GeV/c, NA61 acceptance

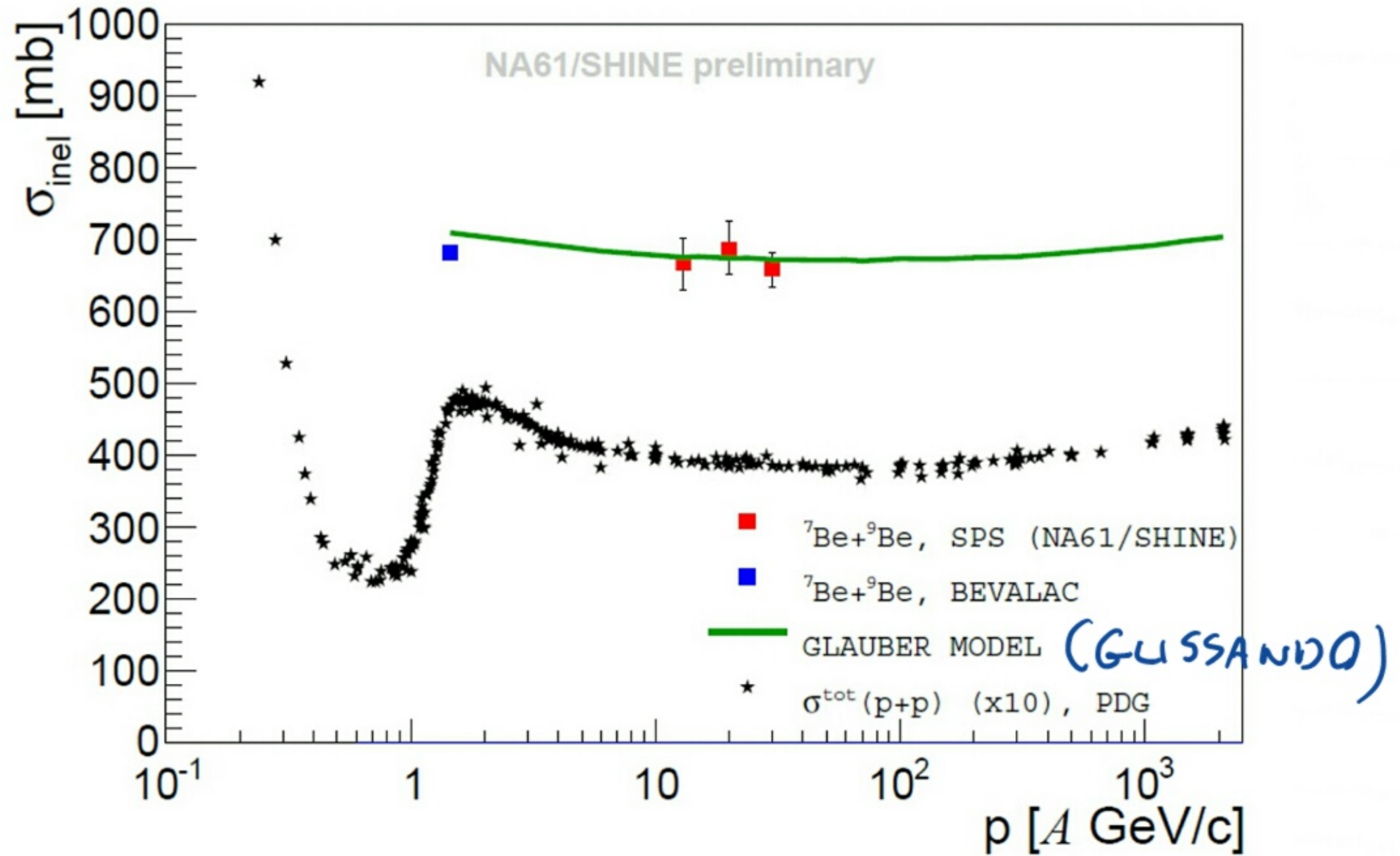


Be+Be AND ArtSc

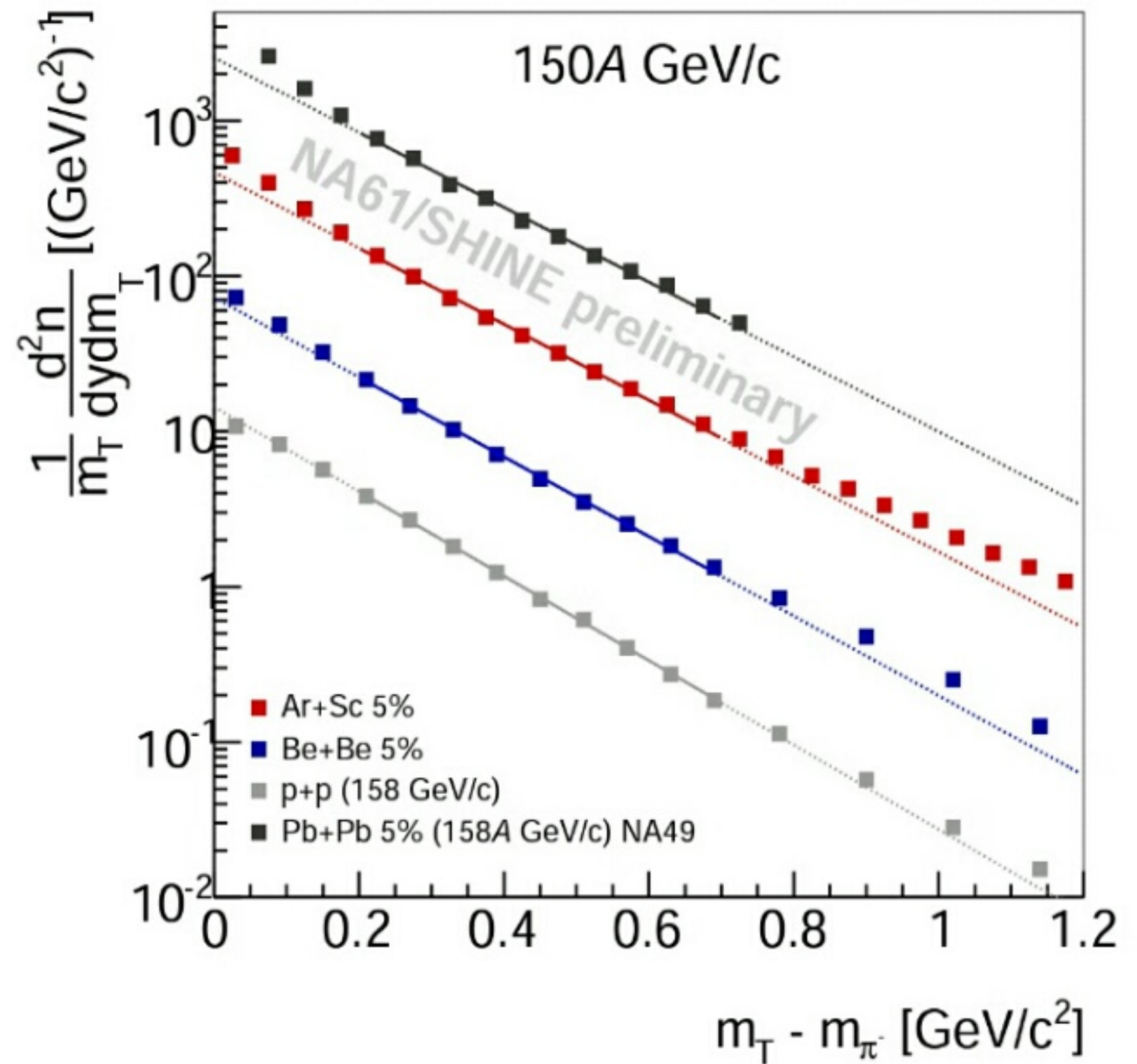
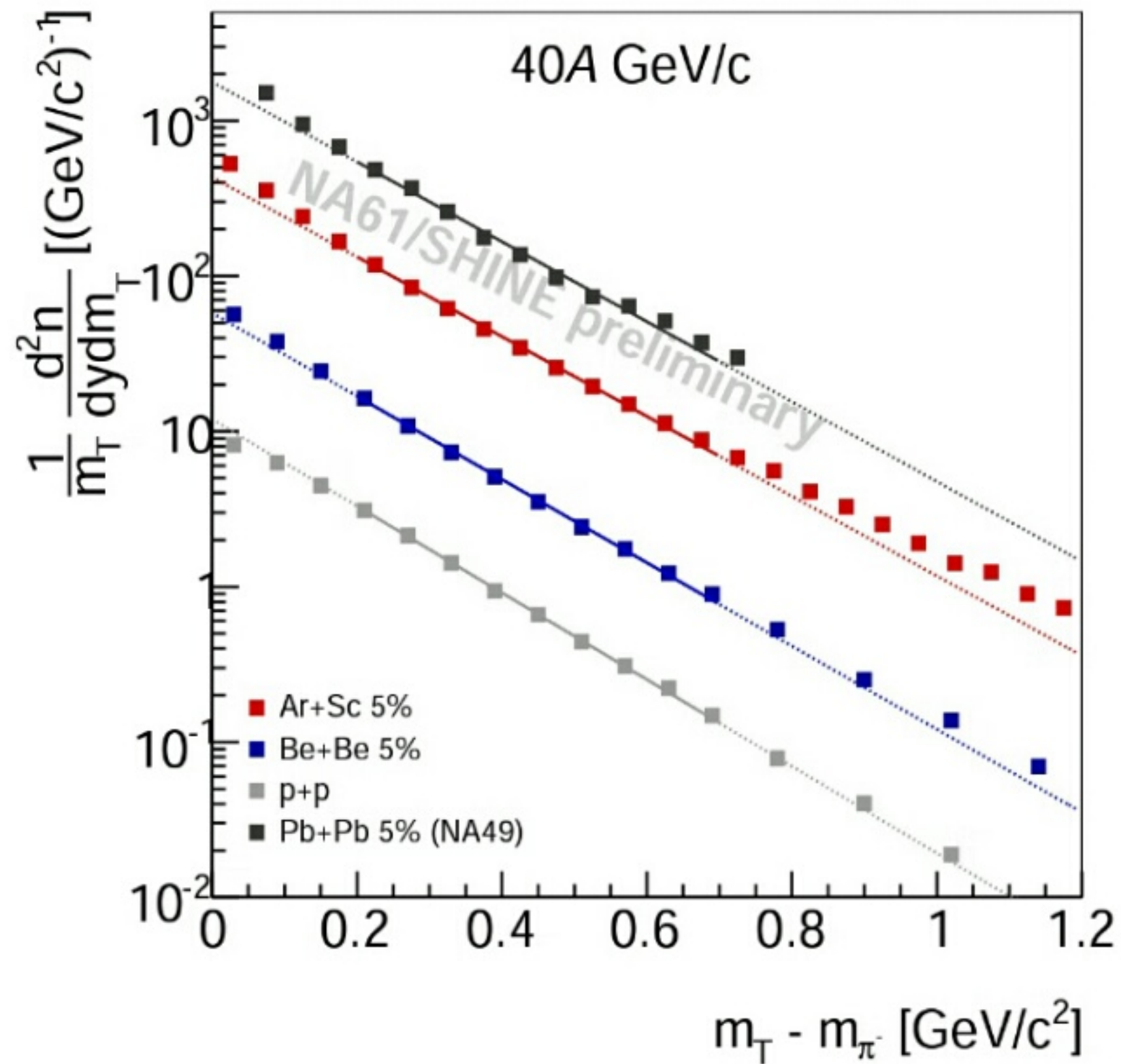
CENTRALITY SELECTION OF A+A COLLISIONS PSD CALORIMETER



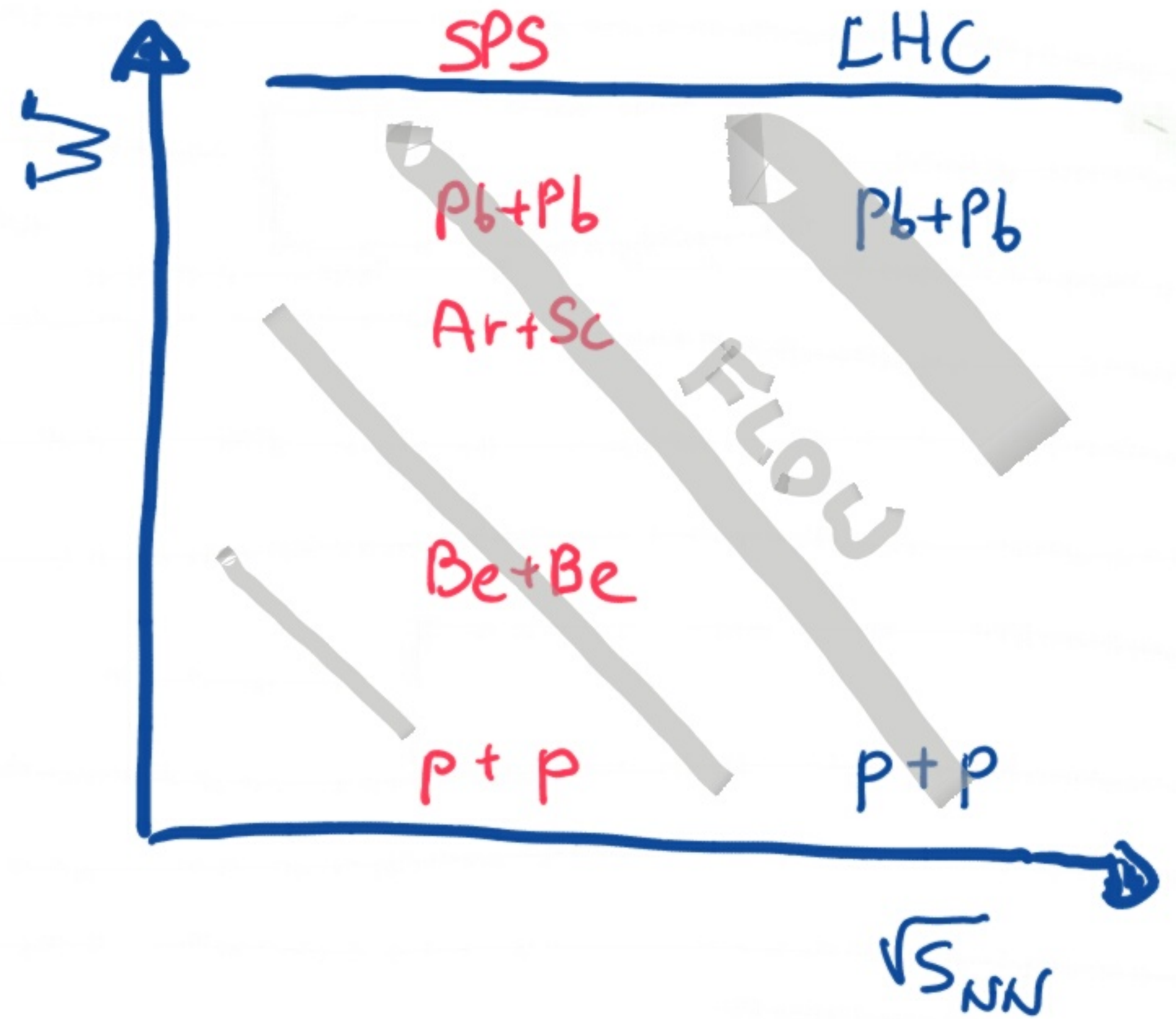
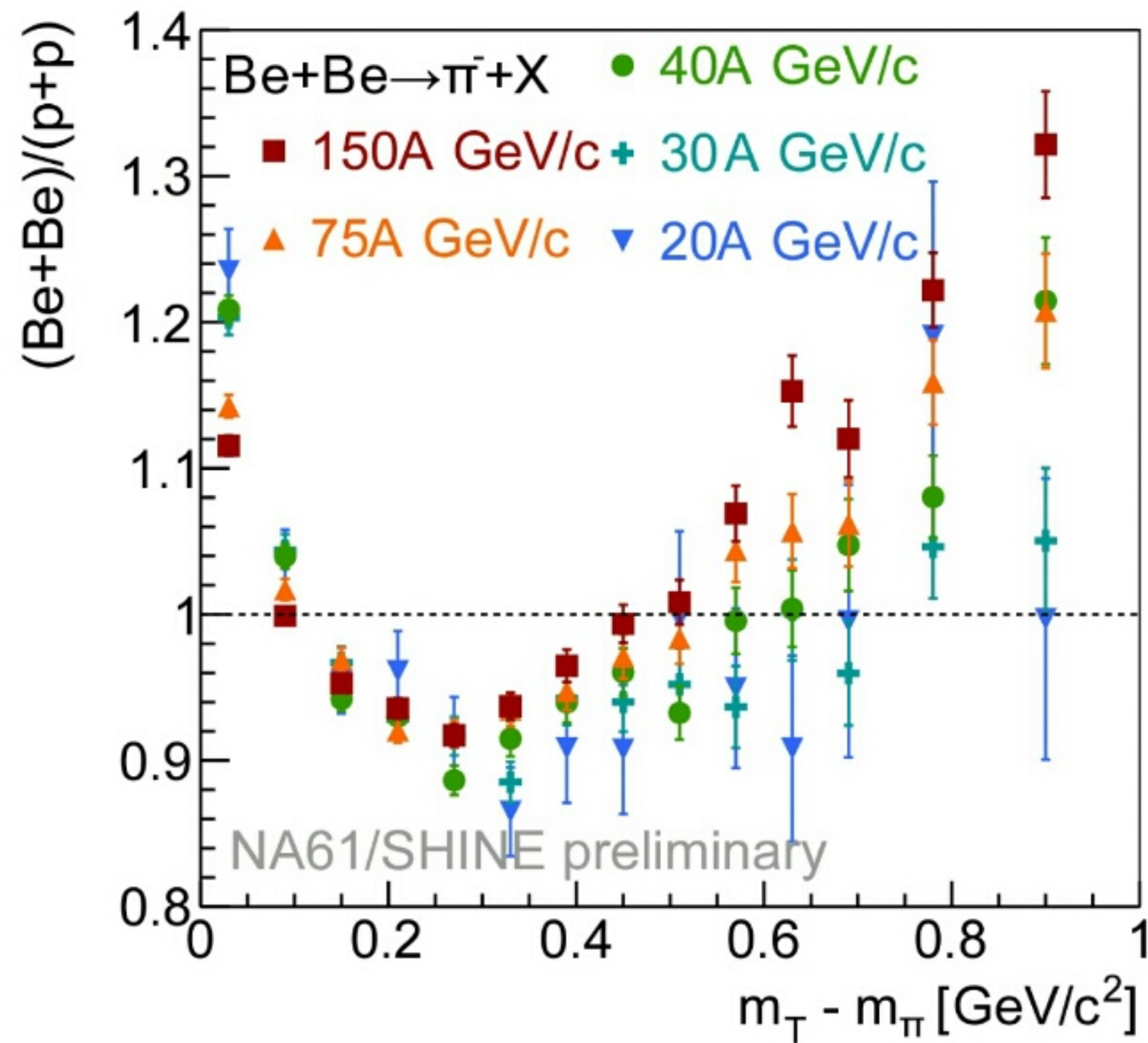
Be+Be COLLISIONS



Be+Be AND Ar+Sc + (p+p, Pb+Pb)
SINGLE PARTICLE SPECTRA

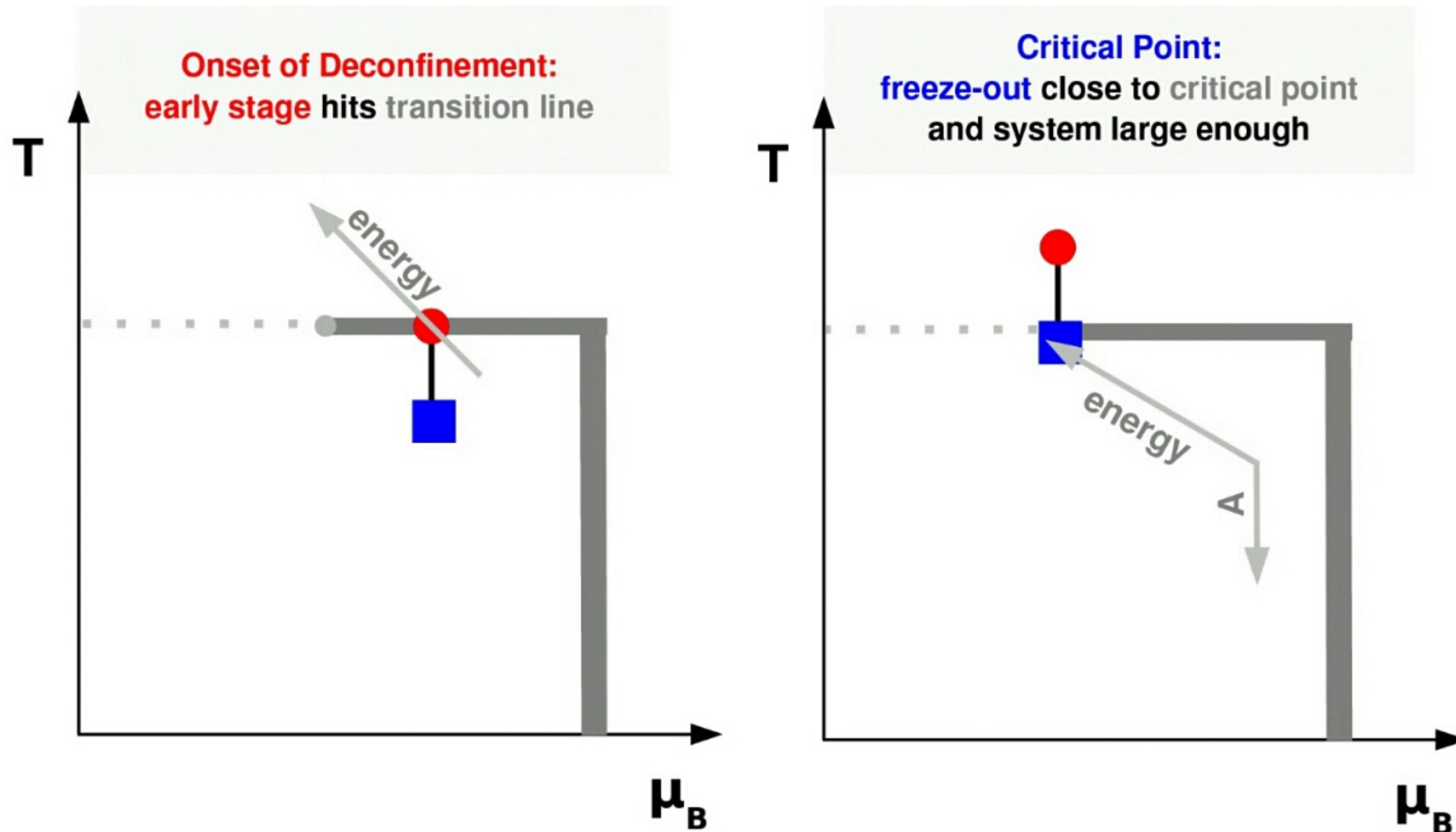


RADIAL FLOW VS ($\sqrt{s_{NN}}$ AND \bar{W})



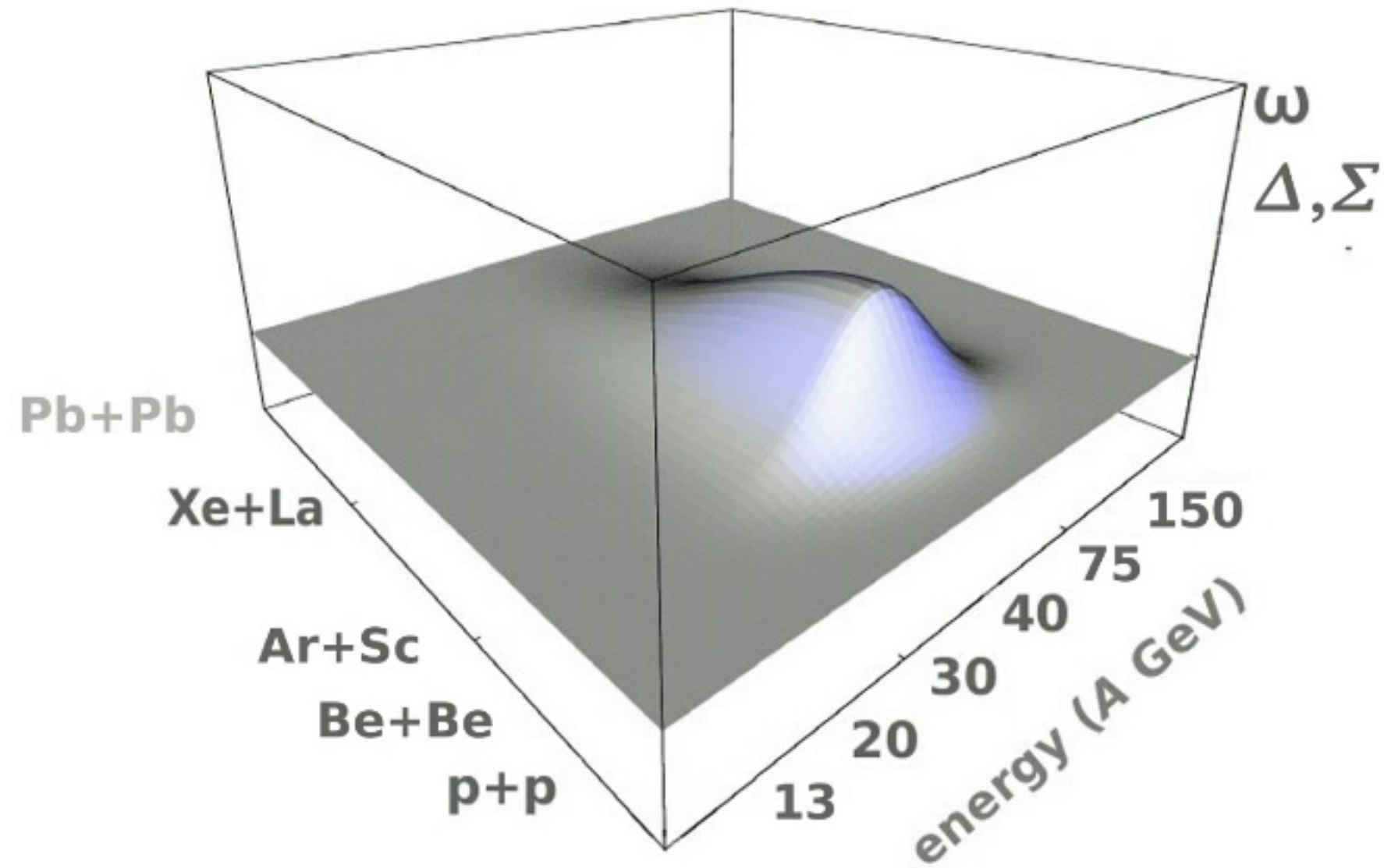
\bar{W} -NUMBER OF WOUNDED NUCLEONS

RESULTS: CRITICAL POINT

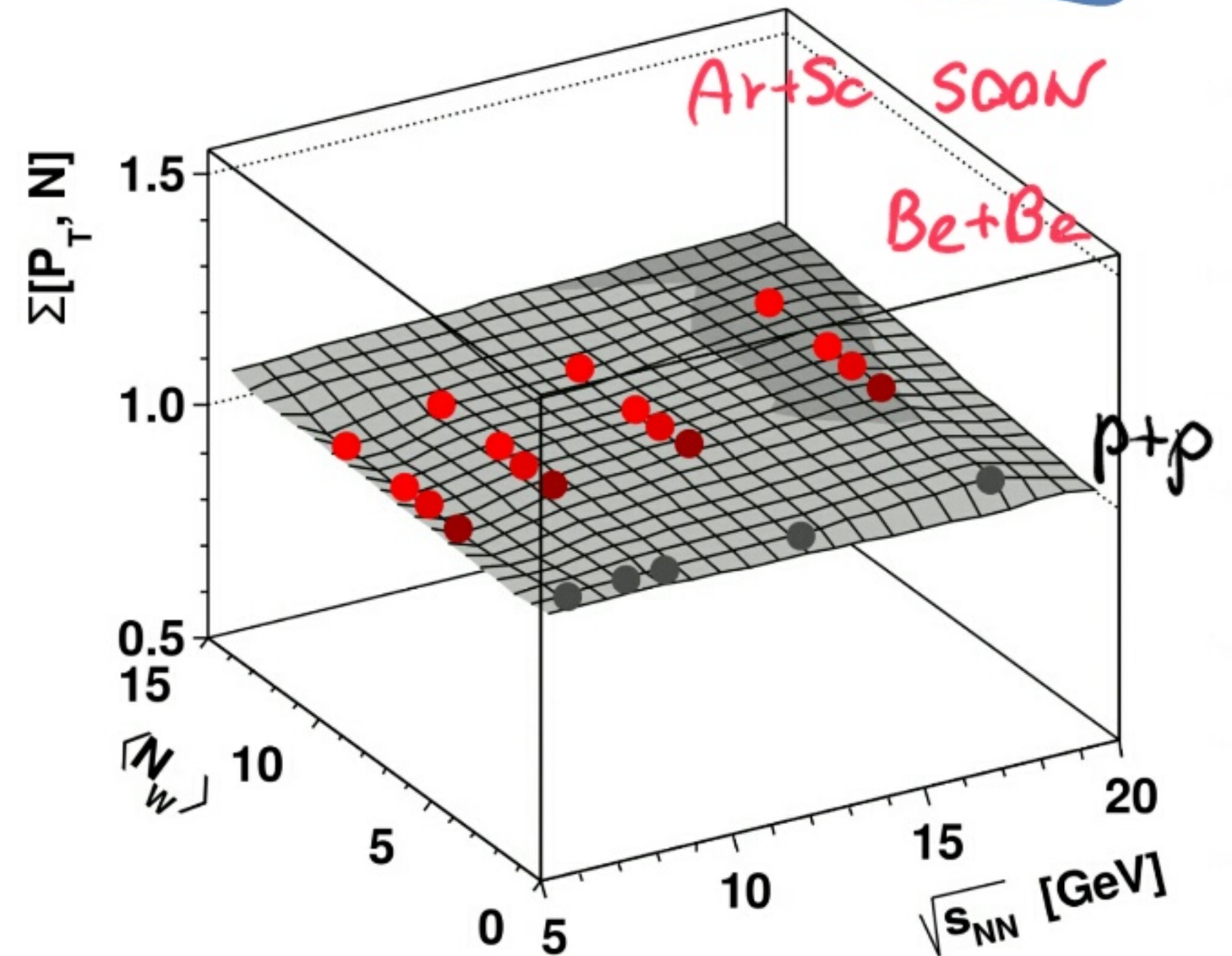


SEARCH FOR THE CRITICAL POINT

HILL OF FLUCTUATIONS

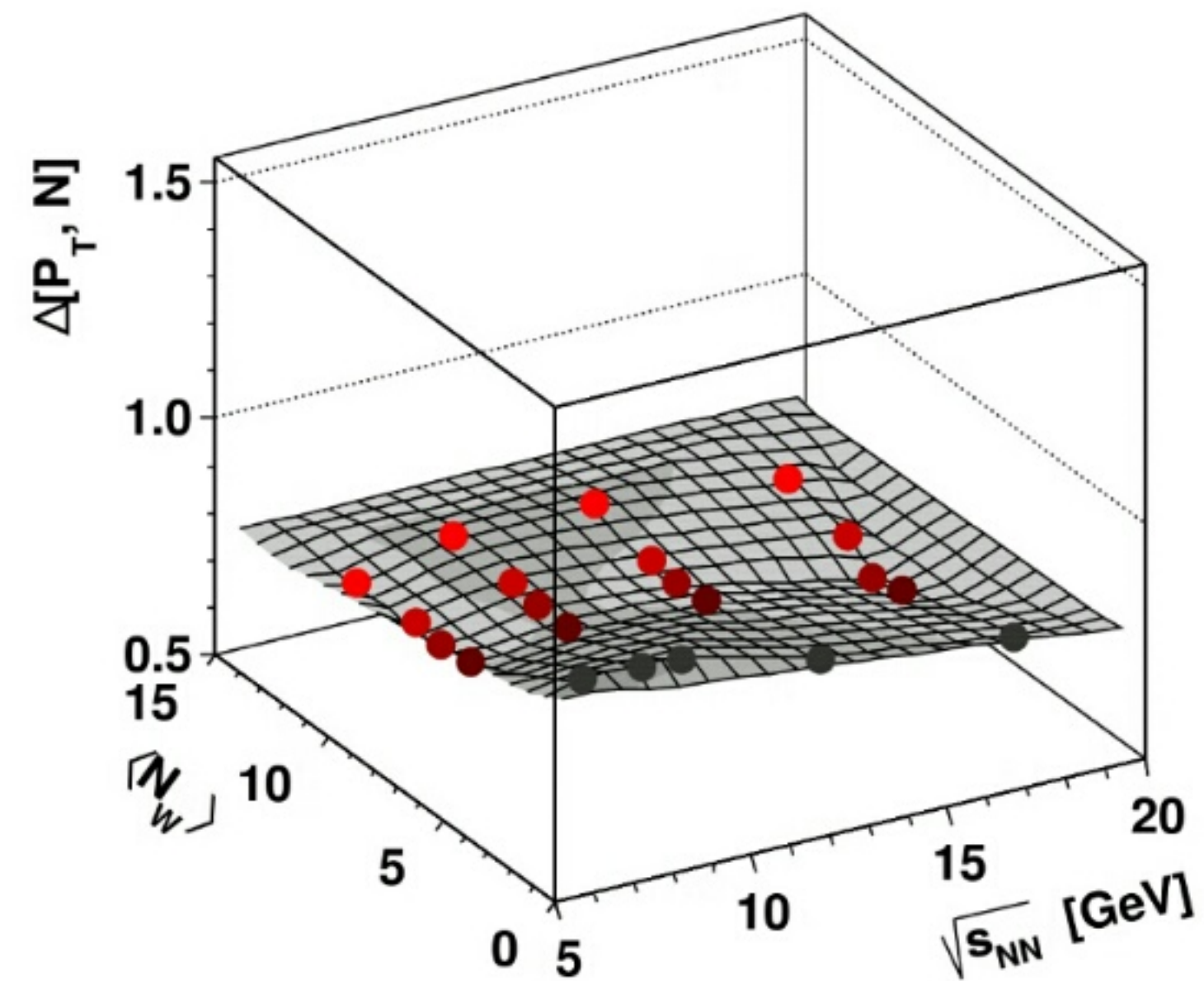
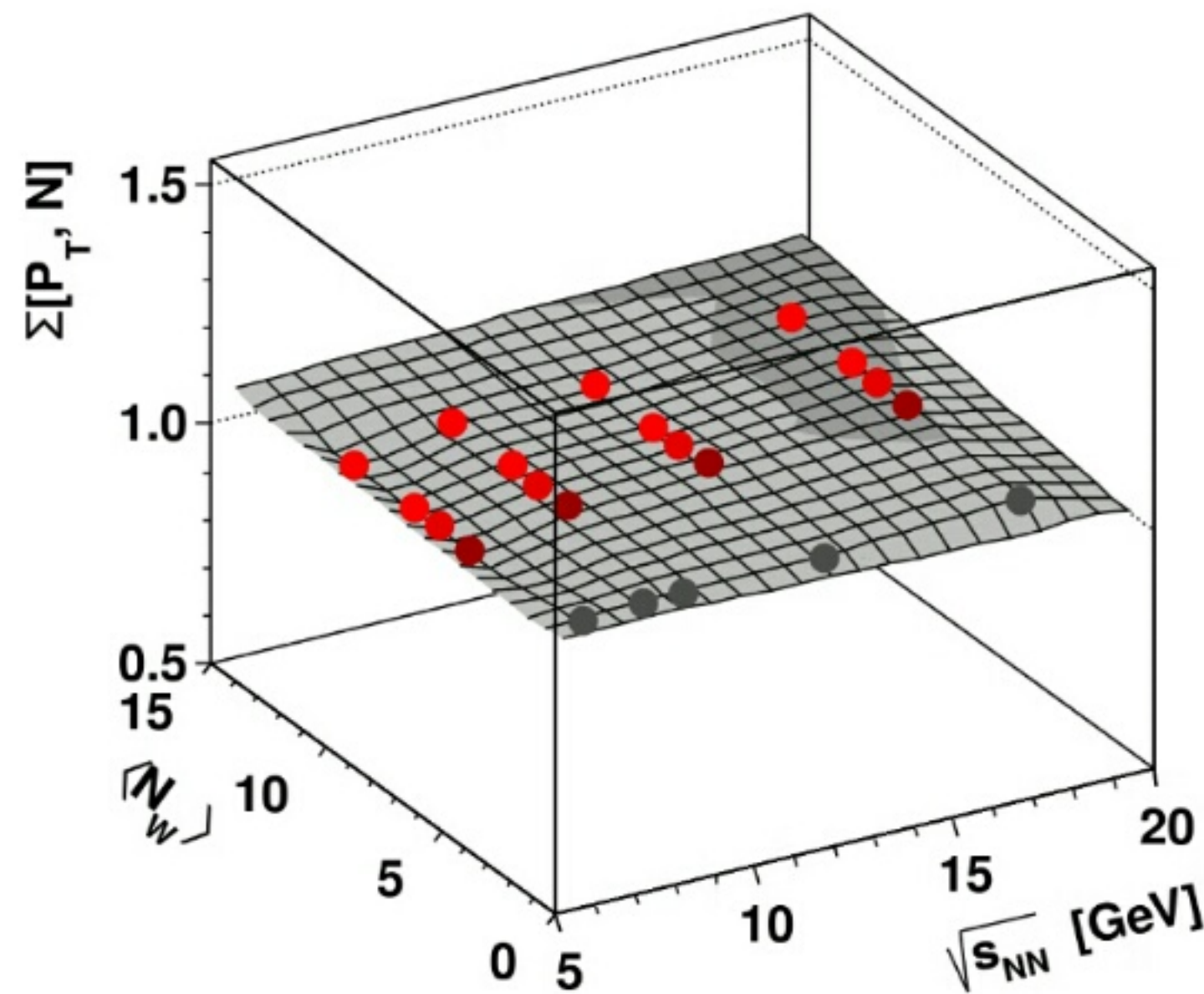


STATUS OF THE NAGI/SHINE SEARCH



SEARCH FOR THE CRITICAL POINT

STRONGLY INTENSIVE QUANTITIES



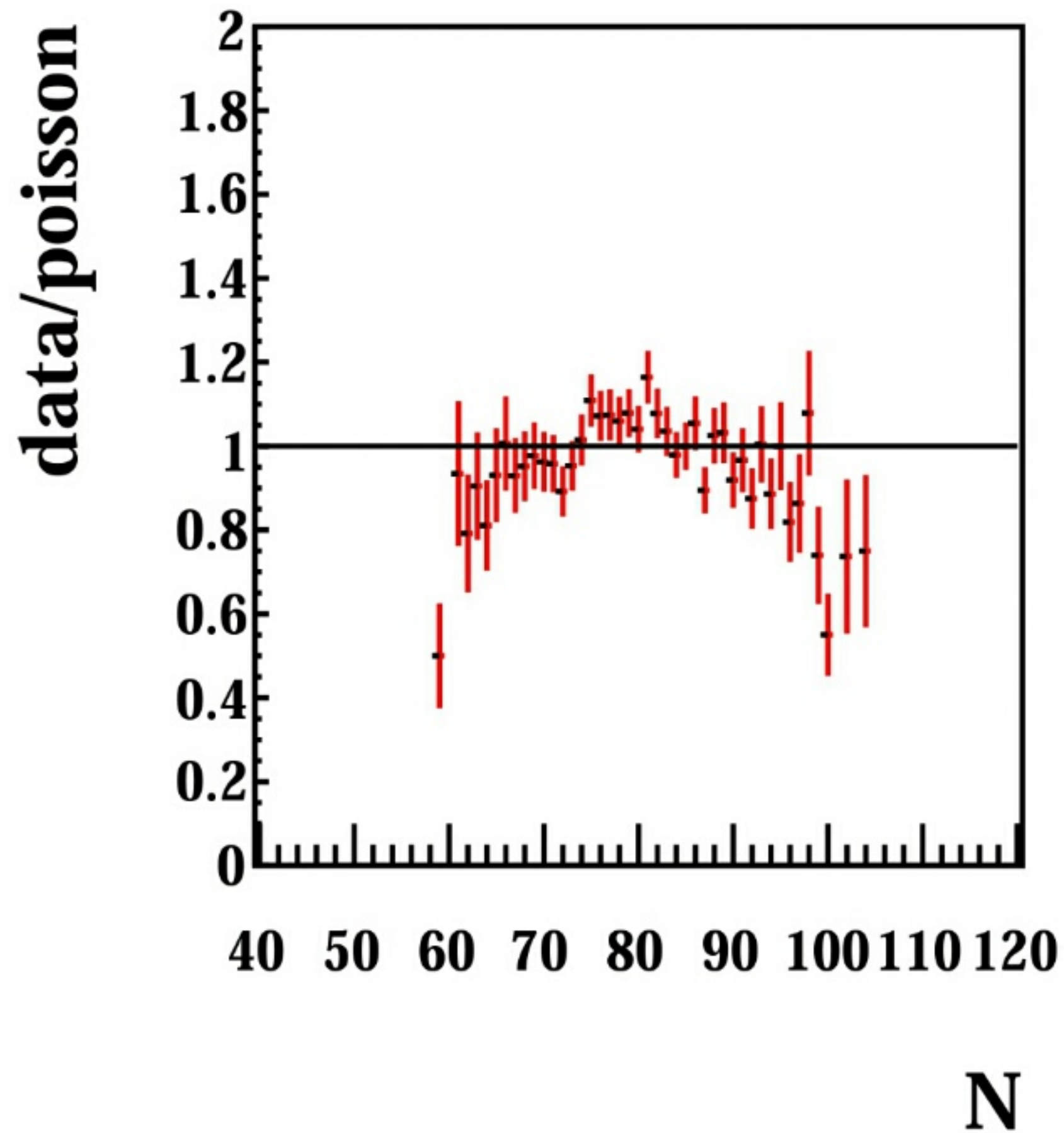
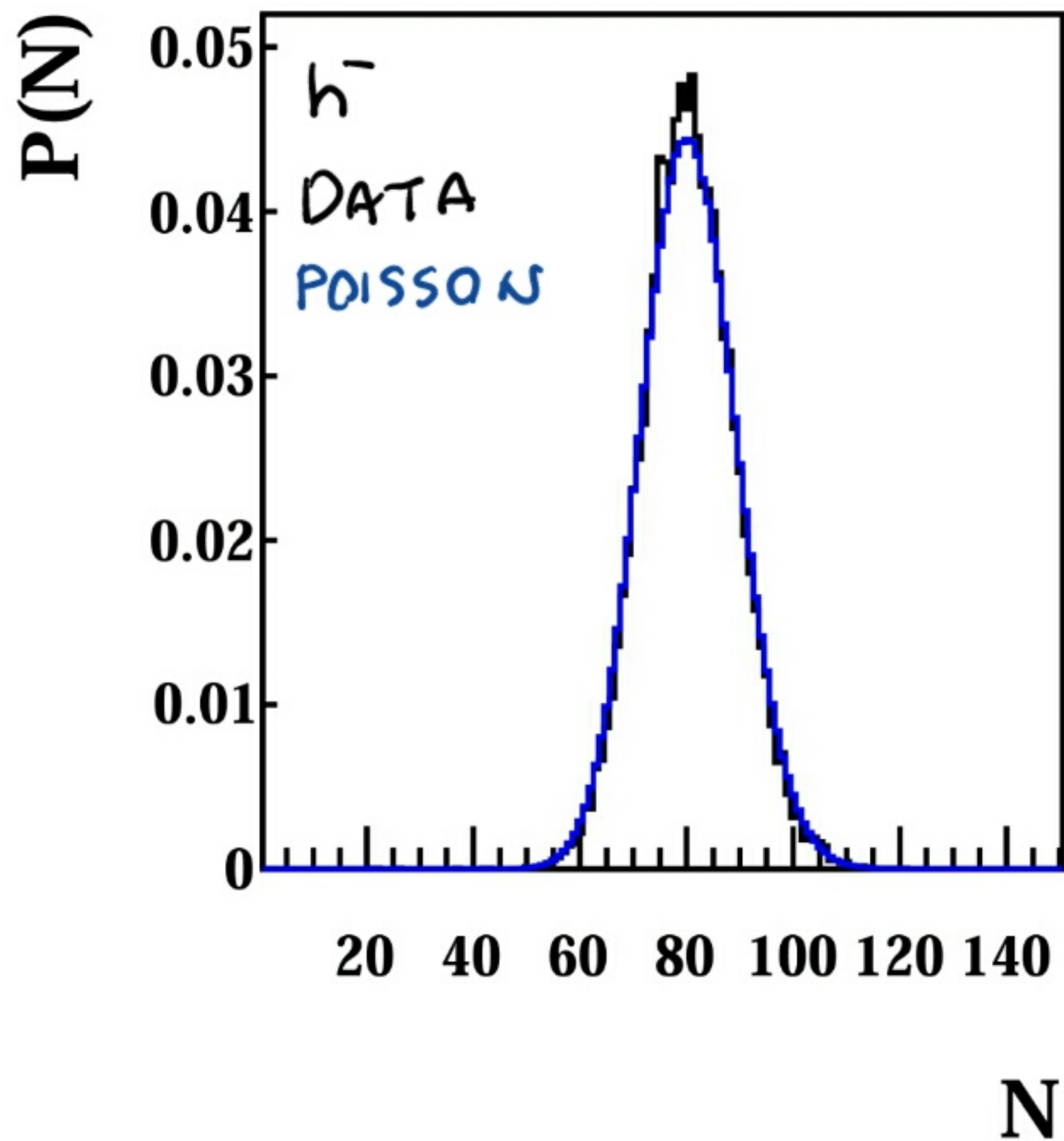
Σ AND Δ STRONGLY INTENSIVE QUANTITIES FOR FLUCTUATIONS

N - EVENT MULTIPLICITY

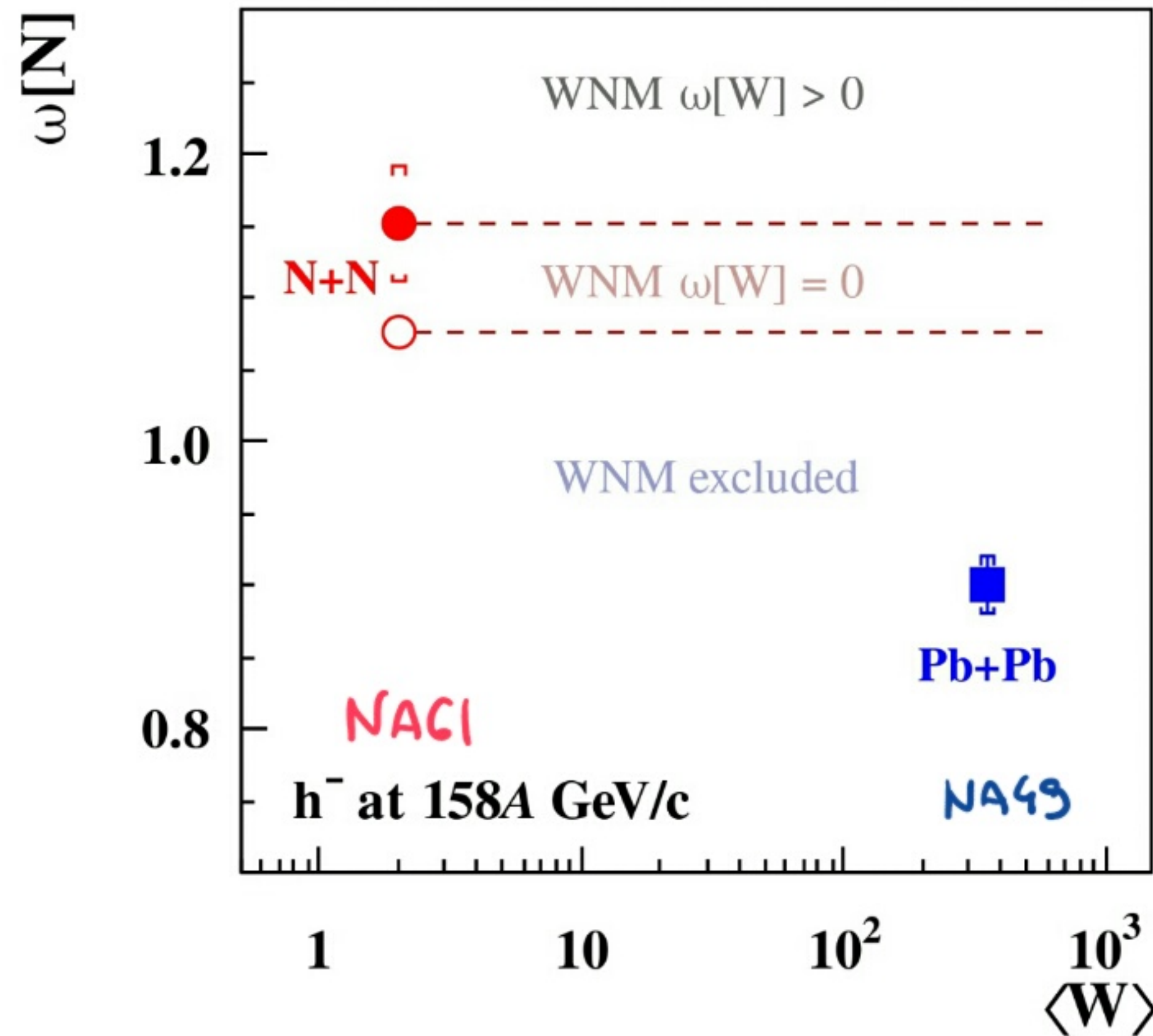
$P_T = \sum |p_T^i|$ - EVENT TRANSVERSE MOMENTUM

MULTIPLICITY DISTRIBUTION

0-10% CENTRAL Au + Sc AT 150A GeV/c



P(N) AND WOUNDED NUCLEON MODEL



$$\omega[N] \equiv \frac{\langle (N - \langle N \rangle)^2 \rangle}{\langle N \rangle}$$

WNM:

$$\omega[N] = \omega^*[N] + \frac{\langle N \rangle}{\langle W \rangle} \cdot \omega[W]$$

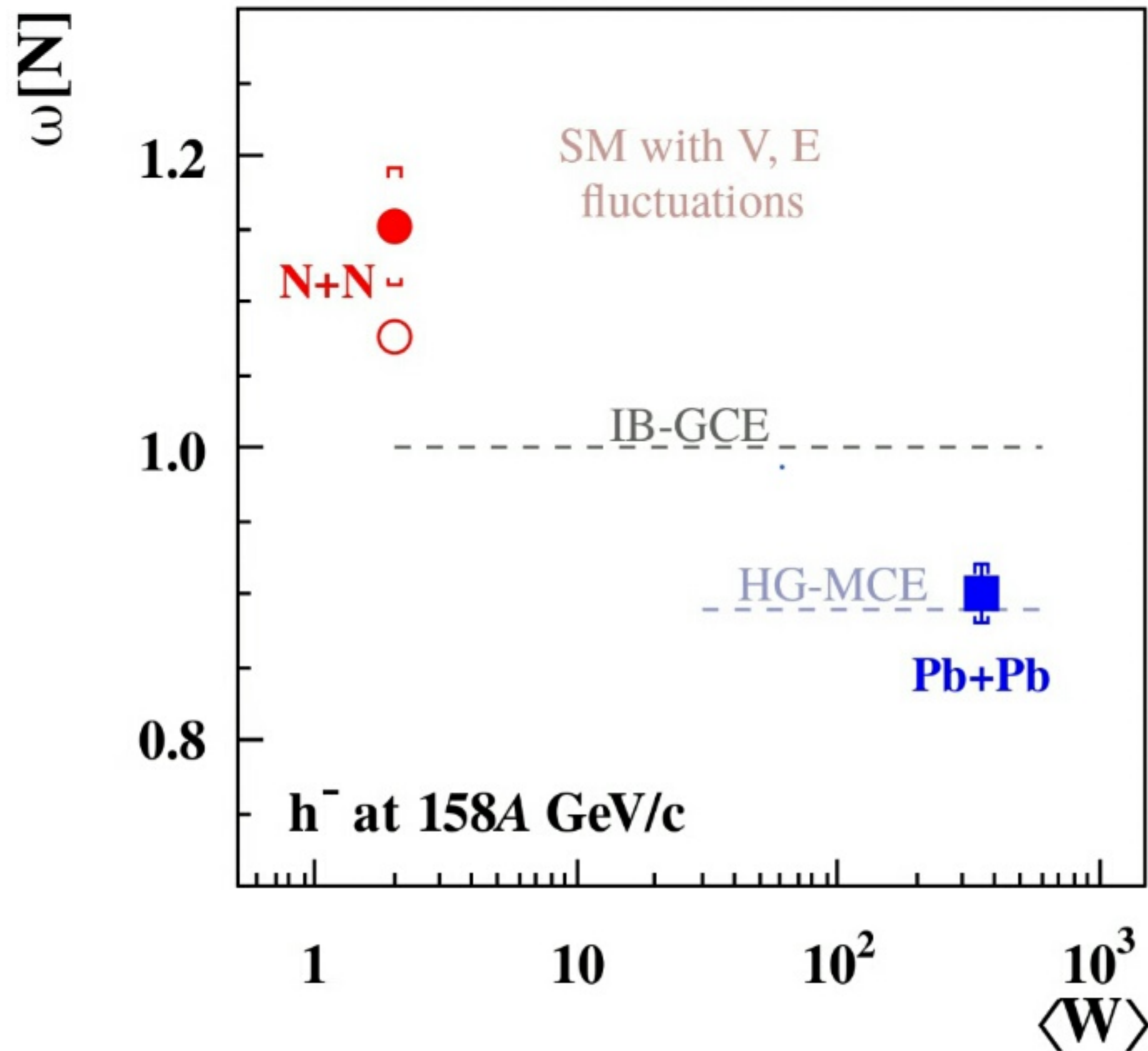
$$\omega^*[N] = \omega[N] \text{ FOR } \bar{W} = \text{CONST}$$

WNM IN QUALITATIVE
DISAGREEMENT WITH
THE $\omega[N]$ DATA

1510.00163

W - NUMBER OF WOUNDED NUCLEONS

P(N) AND STATISTICAL MODEL



SM (IB-GCE)

$$\omega[N] = \omega^*[N] + \frac{\langle N \rangle}{\langle V \rangle} \cdot \omega[V]$$

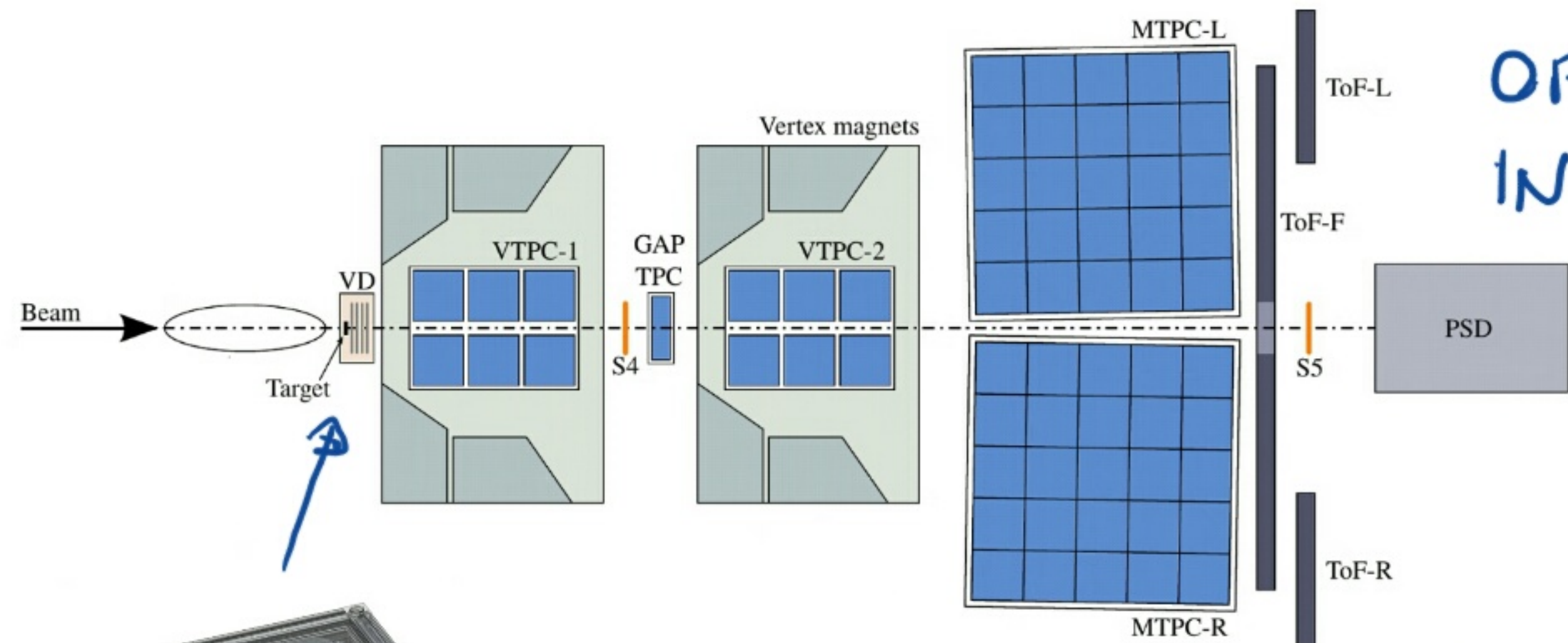
$$\omega^*[N] = \omega[N] = 1 \text{ FOR } V = \text{CONST}$$

SM (IB-GCE) IN QUALITATIVE DISAGREEMENT WITH $\omega[N]$ DATA

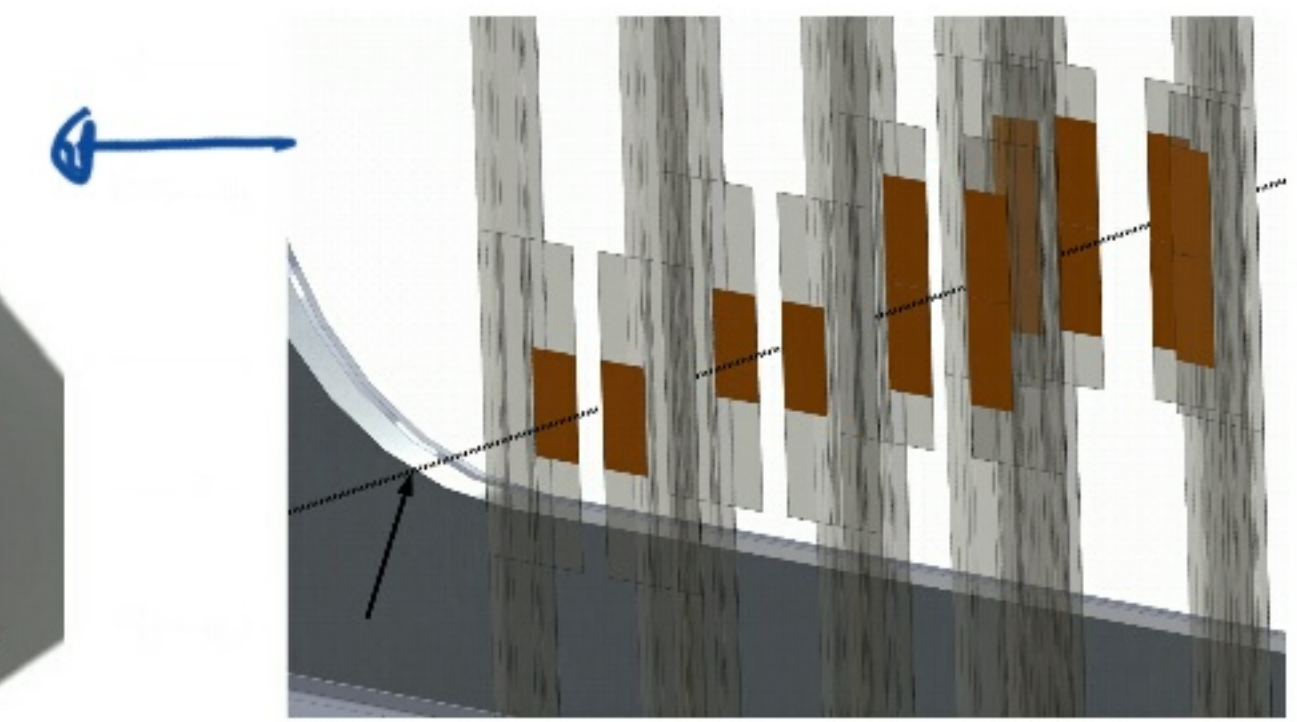
1510.00163 PRC 76 (2007)024902

V - VOLUME

PLANS ET AL.



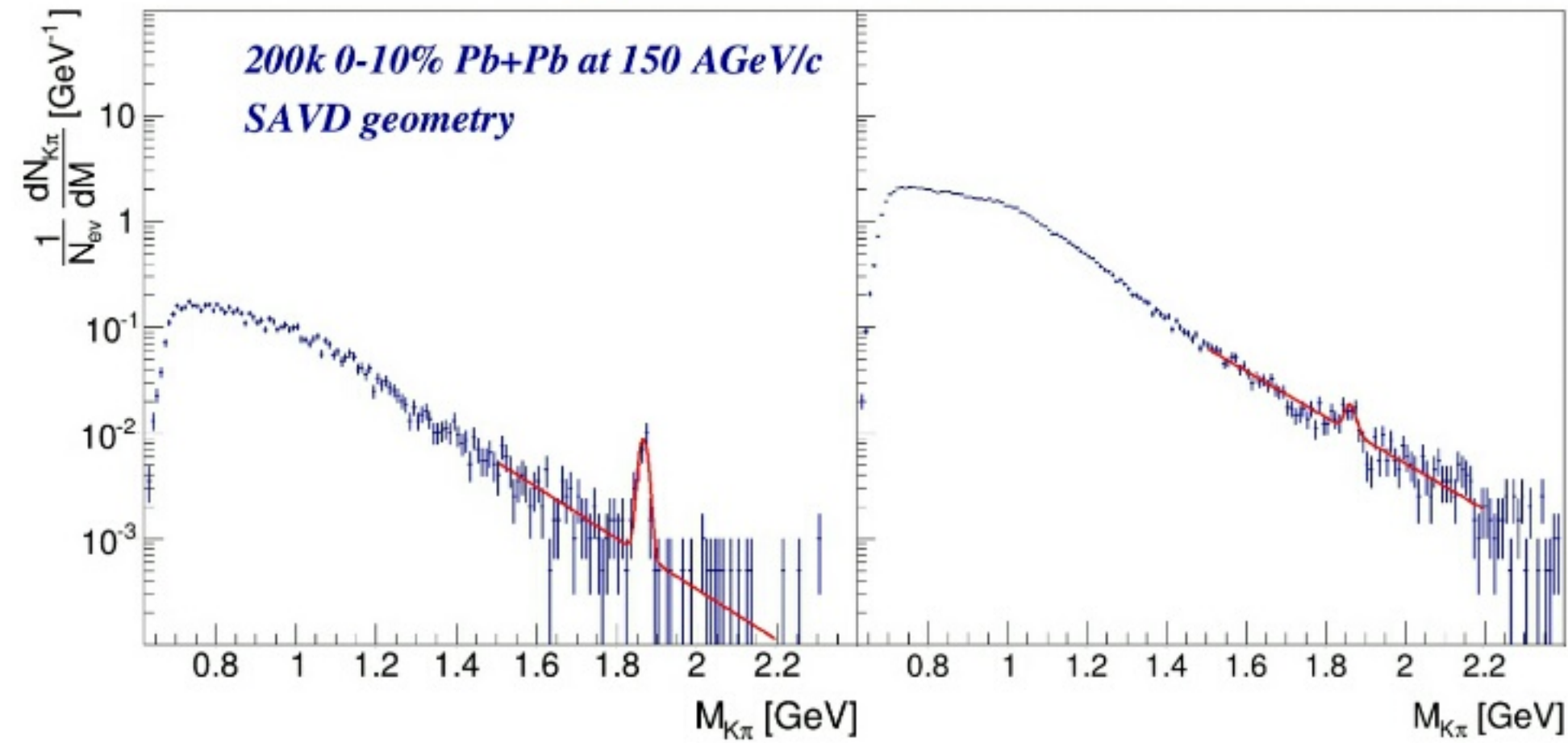
OPEN CHARM
IN Pb+Pb COLLISIONS



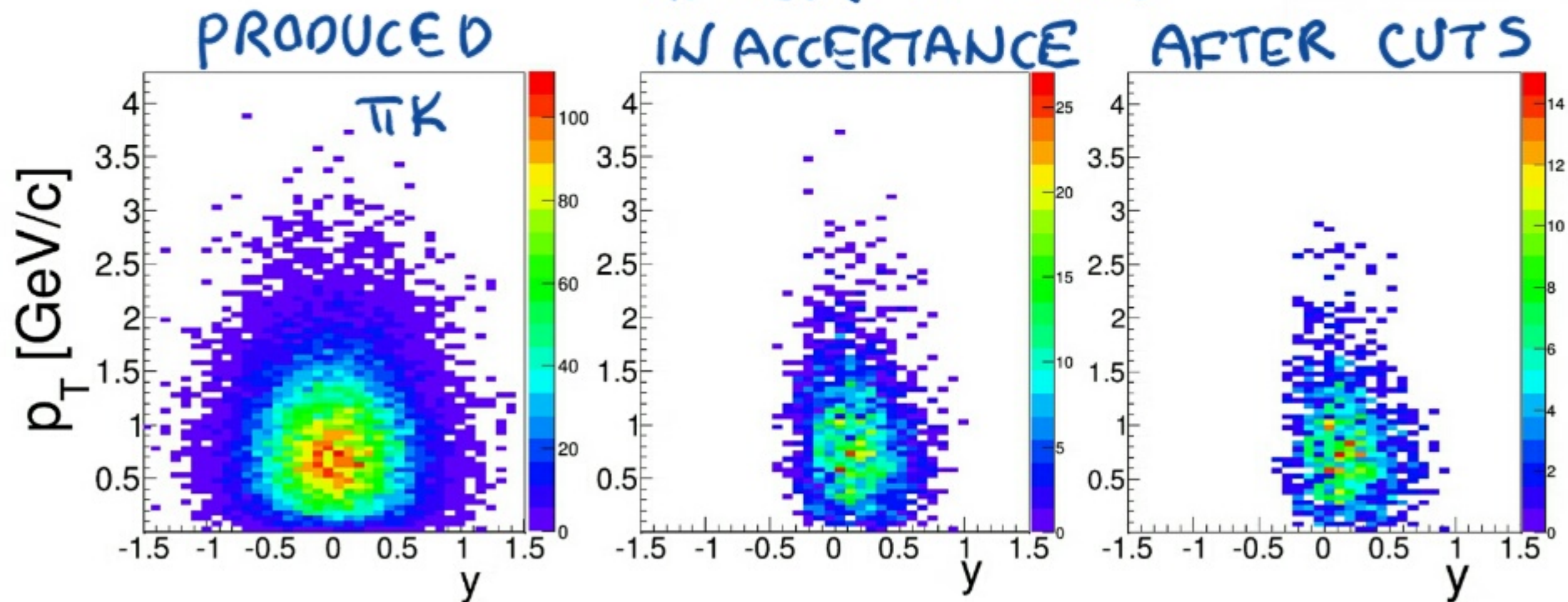
SMALL ACCEPTANCE
VERTEX DETECTOR
2016: FIRST TESTS
2018: PHYSICS DATA

PLANS ON OPEN CHARM IN Pb+Pb

AFTER 2 DAY



AFTER 10 DAYS

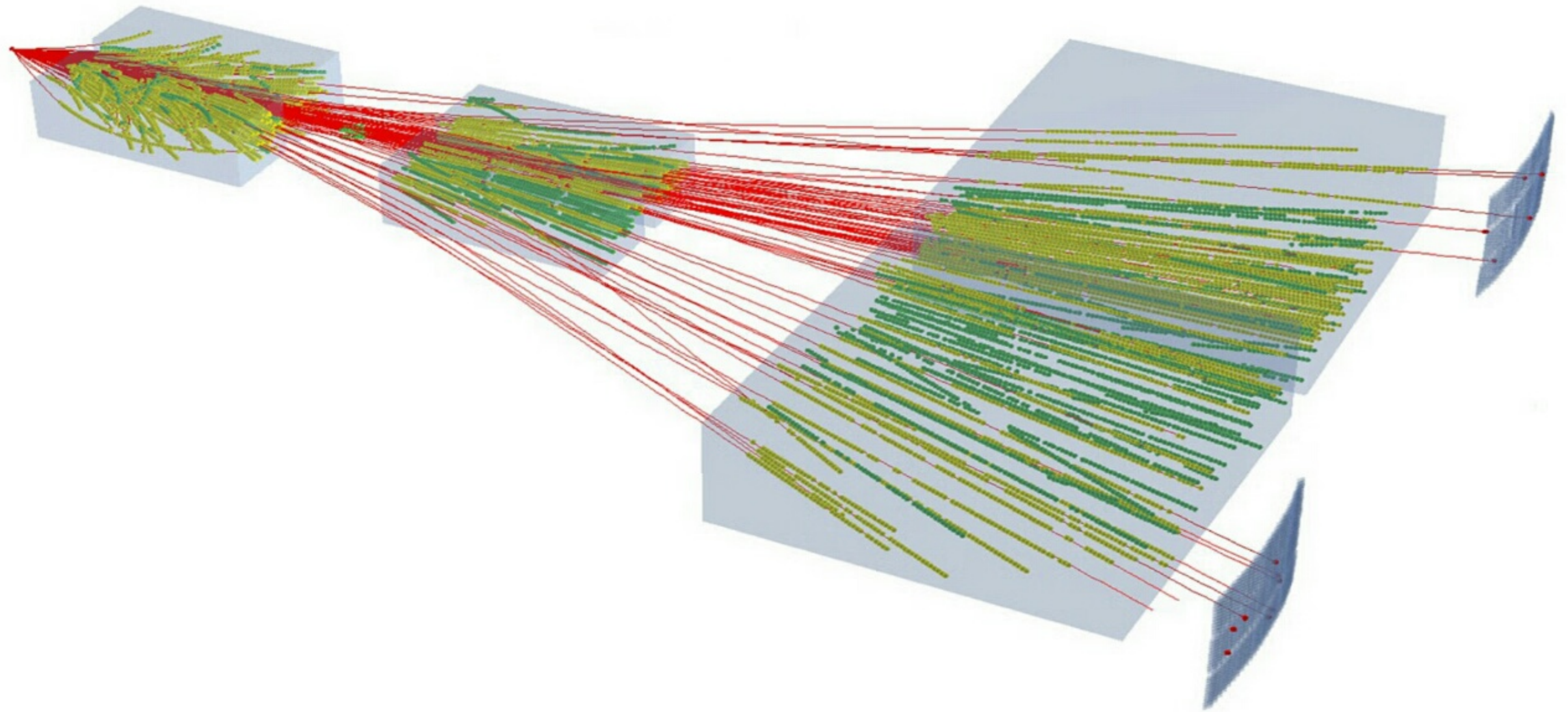


BEAM REQUEST: 2016-2018

Beam		Target	Momentum (A GeV/c)	Year	Days	Physics
Primary	Secondary					
p	h ⁺	A	400 400	2016	4x7 days	installation/tests
p	p	p	400 400	2016	28 days	SI
p	h ⁺	A	400 30-120	2016	42 days	ν
Pb		Pb	13, 19, 30, 40	2016	40 days	SI
Pb		Pb	150	2016	5 days	tests
p	p	p/Pb	400 13, 19, 30, 40, 75	2017	35 days	SI
p	h ⁺	A	400 30-120	2017	42 days	ν
Xe		La	13, 19, 30, 40, 75, 150	2017	60 days	SI
p	p	p/Pb	400 13, 19, 30, 40, 75	2018	35 days	SI
p	h ⁺	A	400 30-120	2018	42 days	ν
Pb		Pb	75, 150	2018	40 days	SI

SUMMARY

- NAGI/SHINE FACILITY:
UNIQUE MULTI-PURPOSE FACILITY FOR MEASUREMENTS
OF HADRON PRODUCTION IN $h+p$, $h+A$ AND
 $A+A$ COLLISIONS AT 13A-150A (350) GeV/c



SUMMARY

NEUTRINOS:

- MEASUREMENTS FOR T2K ARE COMPLETED
- MEASUREMENTS FOR FERMILAB HAVE JUST STARTED
- MEASUREMENTS FOR HYPER-K UNDER DISCUSSION

STRONG INTERACTIONS:

- DATA TAKING FOR \sqrt{s} - A SCAN IS WELL ADVANCED
- OBSERVATION OF RAPID CHANGES OF HADRON PRODUCTION PROPERTIES IN p+p AT SPS (ONSET OF DECONFINEMENT VS RESONANCE \rightarrow STRING)
- NO CP SIGNAL IN p+p, Be+Be; FIRST DATA ON Ar+Sc
- PLANNED \sqrt{s} SCAN WITH Pb+Pb (OPEN CHARM, COLLECTIVE EFFECTS, FLUCTUATIONS)

COSMIC-RAYS:

- MEASUREMENTS FOR HIGH- AND ULTRA-HIGH-ENERGY COSMIC RAYS: PIERRE AUGER OBSERVATORY, TELESCOPE ARRAY, KASCADE, ICETOP, AMS UNDER DISCUSSION



National Nuclear Research Center, Azerbaijan
Faculty of Physics, University of Sofia, Bulgaria
Ruder Boskovic Institute, Croatia
LPNHE, University of Paris VI and VII, France
Karlsruhe Institute of Technology, Germany
Fachhochschule Frankfurt, Germany
Institut für Kernphysik, Goethe-Universität, Germany
Nuclear and Particle Physics Division, University of Athens, Greece
Wigner RCP, Hungary
Institute for Particle and Nuclear Studies (KEK), Japan
University of Bergen, Norway
Institute of Physics, Jan Kochanowski University, Poland
National Center for Nuclear Research, Poland
Institute of Physics, Jagiellonian University, Poland
Institute of Physics, University of Silesia, Poland
Faculty of Physics, University of Warsaw, Poland
Department of Physics and Astronomy, University of Wrocław, Poland
Faculty of Physics, Warsaw University of Technology, Poland
Institute for Nuclear Research, Russia
Joint Institute for Nuclear Research, Russia
St. Petersburg State University, Russia
National Research Nuclear University MEPhI, Russia
University of Belgrade, Serbia
ETH Zürich, Switzerland
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Department of Physics and Astronomy, University of Pittsburgh, USA
Fermilab, Neutrino Division, USA