

NA61/SHINE at the CERN SPS

SHINE – SPS Heavy Ion and Neutrino Experiment

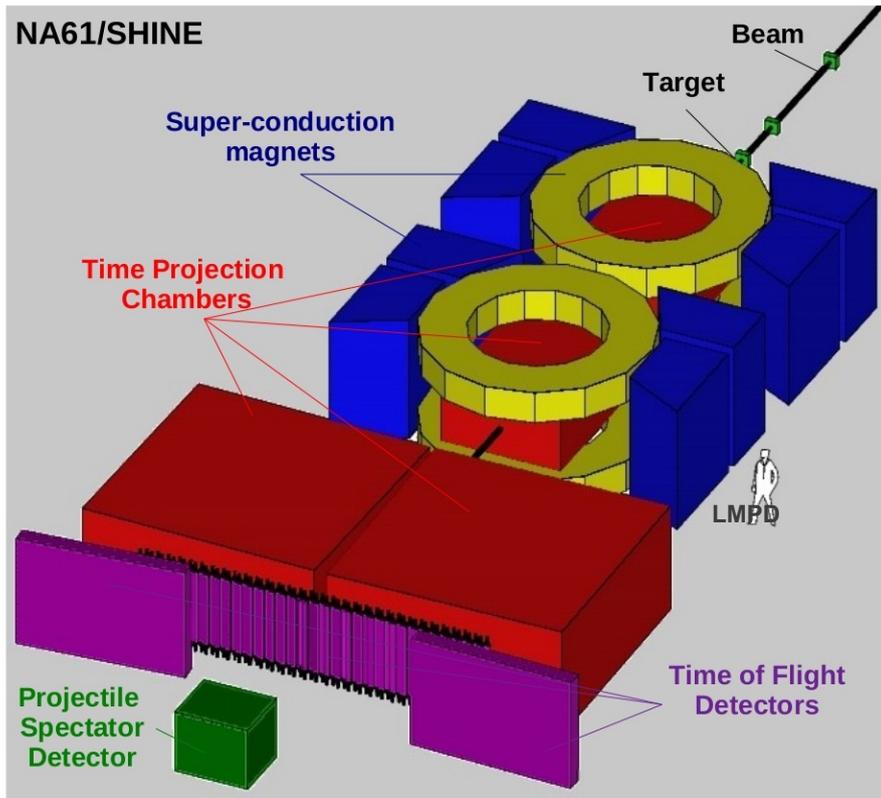


- Fixed target experiment in the north area of the CERN SPS
- Based on the upgraded NA49 detector
- Started in 2007
- Beams:
 - Ions (secondary: Be, primary: Ar and Xe) at 13A - 158A GeV/c
 - Hadrons (secondary): p at 13 - 158 GeV/c, π at 158 and 350 GeV/c, K \cdot at 158 GeV/c

NA61/SHINE physics program:

Hadron production in p+p, p+A, h+A, A+A at various energies

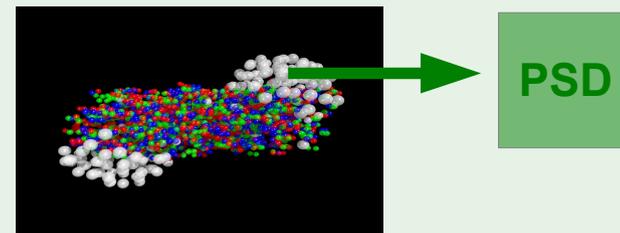
- **Heavy ion program - spectra, fluctuations, correlations**
 - search for the **critical point** of strongly interacting matter
 - study of the **properties of the onset of deconfinement**
 - study **high p_T particles** (energy dependence of nuclear modif. factor)
- **Neutrino and cosmic-ray physics programs - precision data on hadron production (spectra)**
 - **reference measurements** of p+C interactions **for the T2K experiment** for computing initial neutrino fluxes at J-PARC
 - **reference measurements** of p+C, p+p, π +C, and K+C interactions **for cosmic-ray physics** (Pierre-Auger and KASCADE experiments) for improving air shower simulations
- **Considered extensions beyond the approved program**
 - measurements of **Pb+Pb** collisions for the ion program (+ open charm and multi-strange particles, high p_T spectra)
 - measurements for the **Fermilab neutrino program**
 - measurements for the **CERN (LBNO) neutrino program**



- Large acceptance: $\approx 50\%$
- High momentum resolution:
 $\sigma(p)/p^2 \approx 10^{-4} (\text{GeV}/c)^{-1}$ (at full $B=9 \text{ T}\cdot\text{m}$)
- ToF walls resolution:
 ToF-L/R: $\sigma(t) \approx 60 \text{ ps}$; ToF-F: $\sigma(t) \approx 120 \text{ ps}$
- Good particle identification:
 $\sigma(dE/dx)/\langle dE/dx \rangle \approx 0.04$; $\sigma(m_{inv}) \approx 5 \text{ MeV}$
- High detector efficiency: $> 95\%$
- Event rate: 70 events/sec

- Four large volume **Time Projection Chambers (TPCs)**: VTPC-1, VTPC-2 (inside superconducting magnets), MTPC-L, MTPC-R; measurement of dE/dx and p . **Time of Flight (ToF)** detector walls.

- **Projectile Spectator Detector (PSD)** for centrality measurement (energy of projectile spectators) and determination of reaction plane; **resolution of 1 nucleon (!)** in the studied energy range (important for fluctuation analysis).

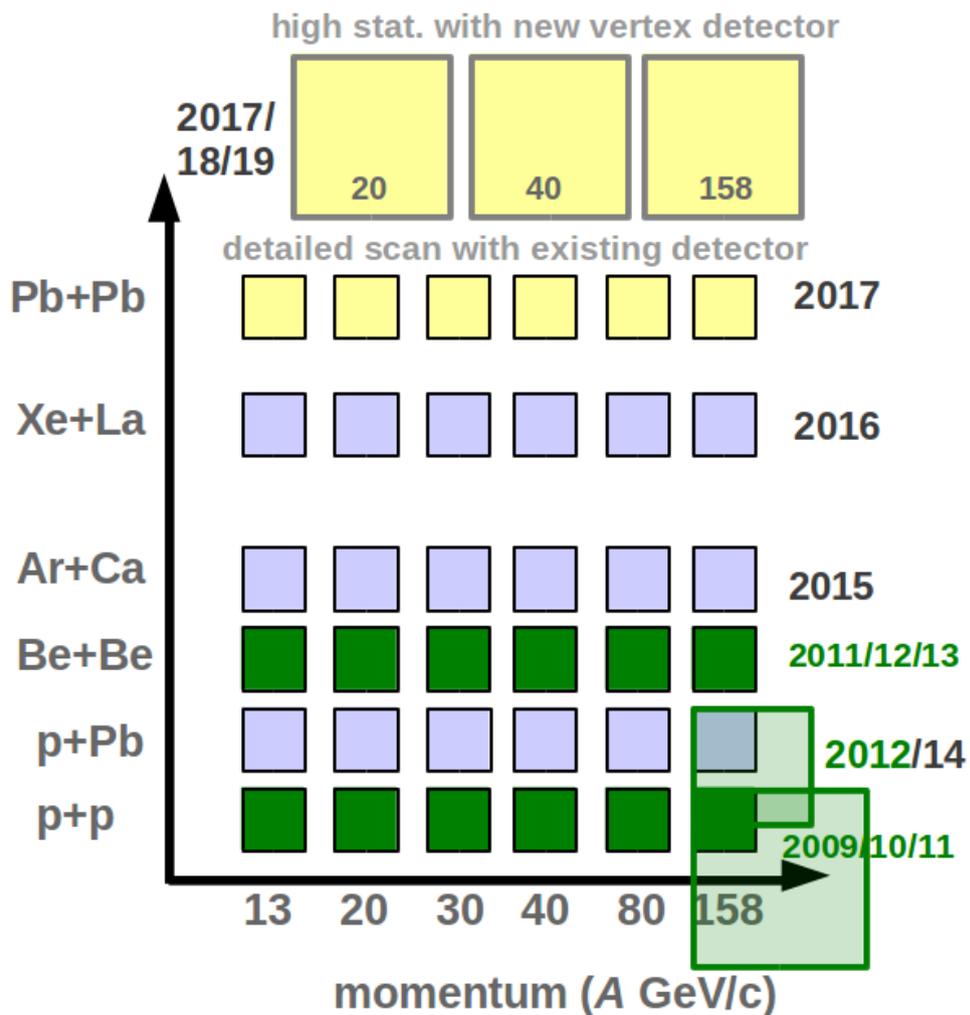


- **Helium beam pipes** inside VTPC-1 and VTPC-2 (to reduce δ -electrons).

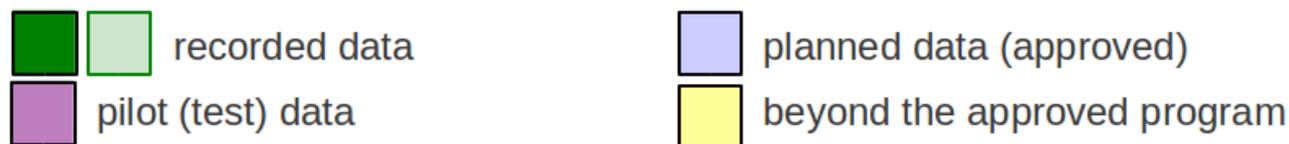
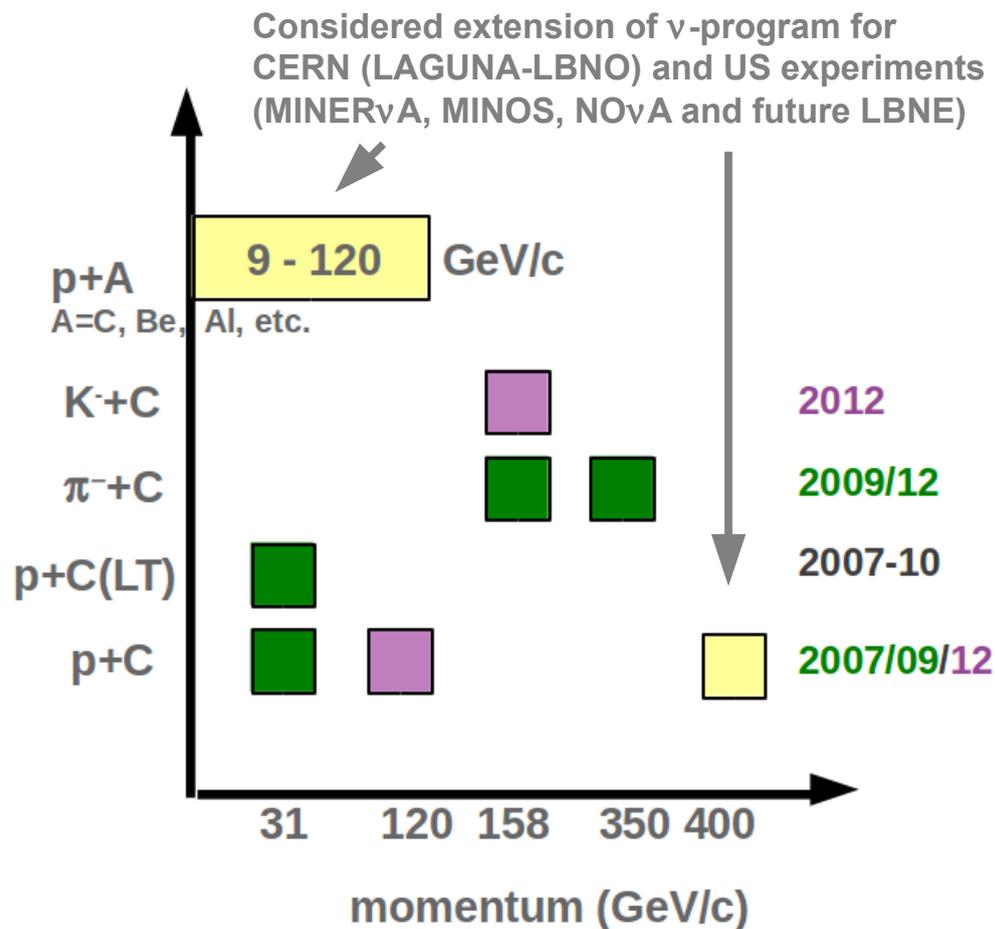
- **Z-detector** (measures ion charge for on-line selection of secondary ions), **A-detector** (measures mass composition of secondary ion beam).

- Low Momentum Particle Detector (**LMPD**) for centrality determination in $p+A$; measures target nucleus spectators.

Status of the NA61 data taking within the heavy ion program



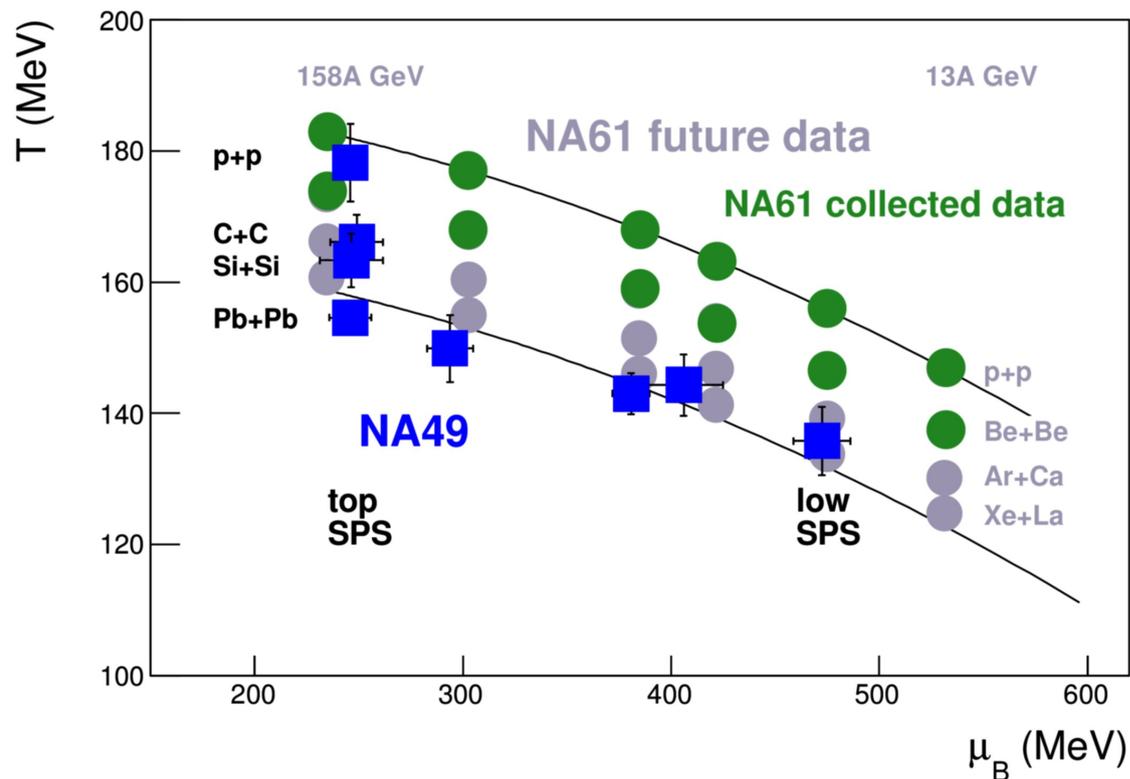
Status of the NA61 data taking within the neutrino and CR programs



NA61/SHINE heavy ion program

The most interesting region of the phase diagram is accessible at the SPS

- Onset of deconfinement at $\cong 30A$ GeV PR C77, 024903 (2008)
- Critical point? Example: $(T^{\text{CP}}, \mu_B^{\text{CP}}) = (162 \pm 2, 360 \pm 40)$ MeV JHEP 0404, 050 (2004)

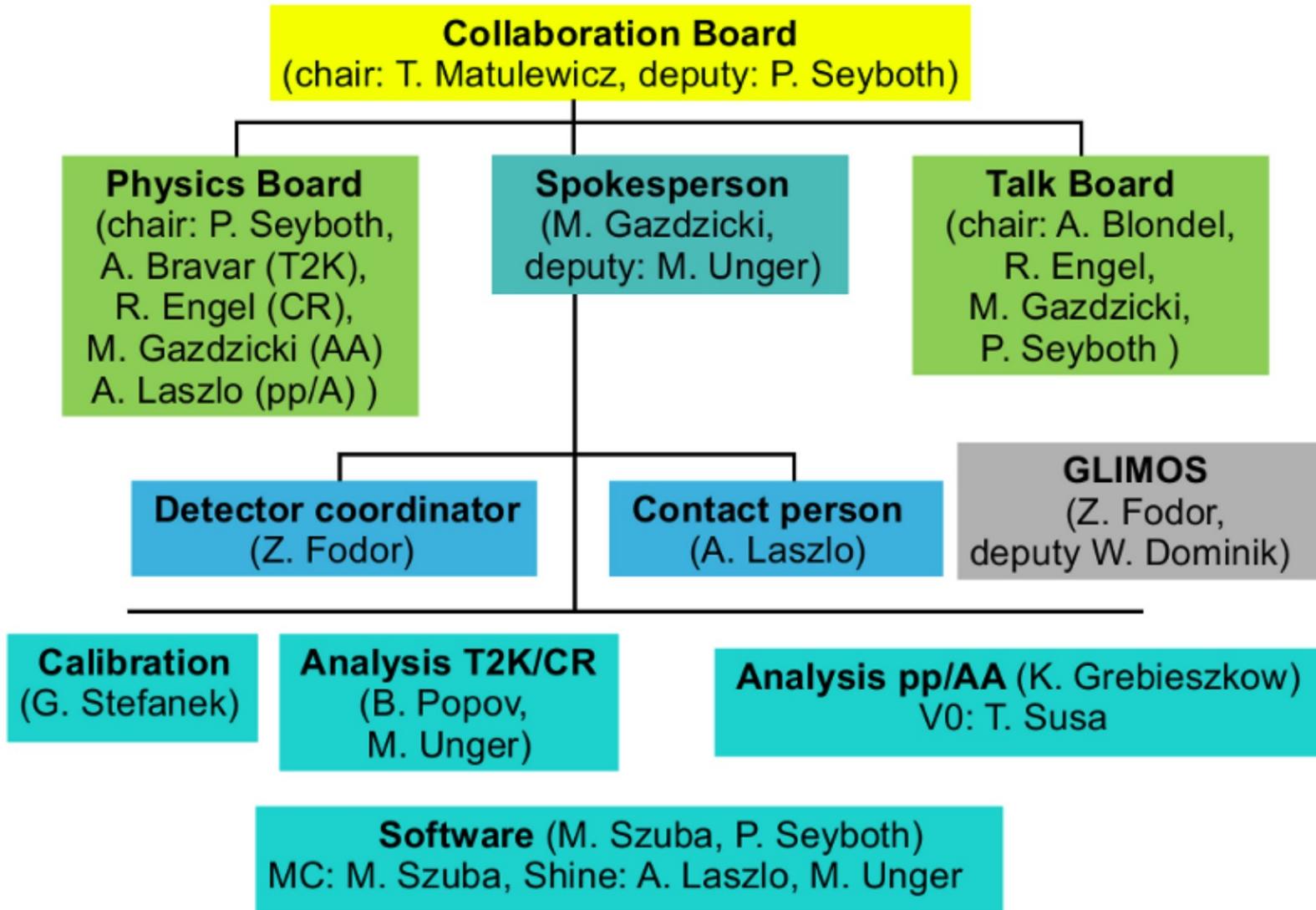


Estimated (NA49) and expected (NA61) chemical freeze-out points according to PR C73, 044905 (2006)

Comprehensive scan in the whole SPS energy range (13A-158A GeV) with **light and intermediate mass nuclei**

- **Search for the Critical Point**
Search for a maximum of CP signatures: fluctuations of N , average p_T , etc., intermittency, when system freezes out close to CP
- **Study of the properties of the Onset of Deconfinement**
Search for the onset of the horn/kink/step in collisions of light nuclei; additional analysis of fluctuations and correlations (azimuthal, particle ratios, etc.)

NA61 Collaboration organization on 28/11/2013



NA61 group from Faculty of Physics, Warsaw University of Technology

K. Grebieszko, M. Słodkowski, K. Dynowski, M. Maćkowiak-Pawłowska

PhD students: T. Czopowicz, B. Maksiak

1. Analysis

- Transverse momentum and multiplicity fluctuations of non-identified particles in p+p and Be+Be → Tobiasz Czopowicz, Katarzyna Grebieszko
- Azimuthal angle and pseudorapidity correlations in p+p → Bartosz Maksiak
- Chemical (particle type) and multiplicity fluctuations of identified particles in p+p (via *identity method*) → Maja Maćkowiak-Pawłowska
- Multiplicity fluctuations of non-identified particles in Be+Be → Maja Maćkowiak-Pawłowska

2. Hardware

- NA61 Detector Control System → Tobiasz Czopowicz (NA61 expert), Bartosz Maksiak, Krzysztof Dynowski

3. Simulations, reconstruction, production

- Reconstruction (production of data sets for NA61) → Bartosz Maksiak
- Production of Monte Carlo data sets (VENUS/EPOS + Geant + reconstruction) → Marcin Słodkowski

4. Web-based utilities

- NA61 Shift Scheduler → Mateusz Piwek