

# NA61



András László

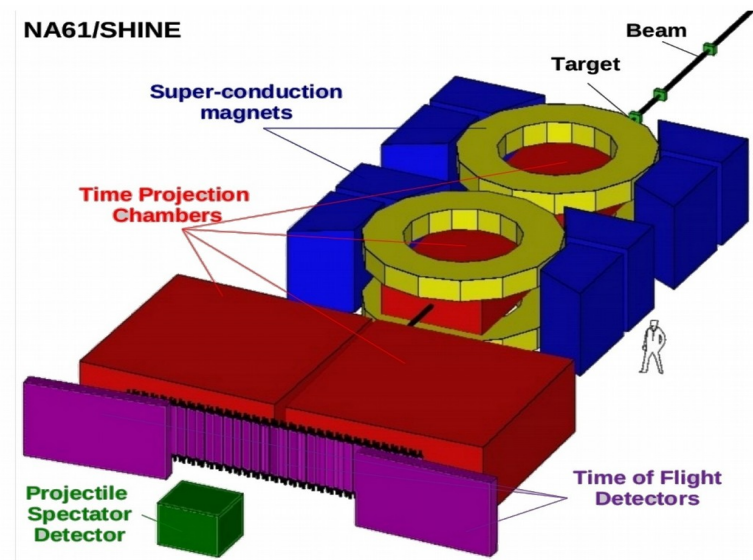
*Wigner RCP, Budapest*



# Outline

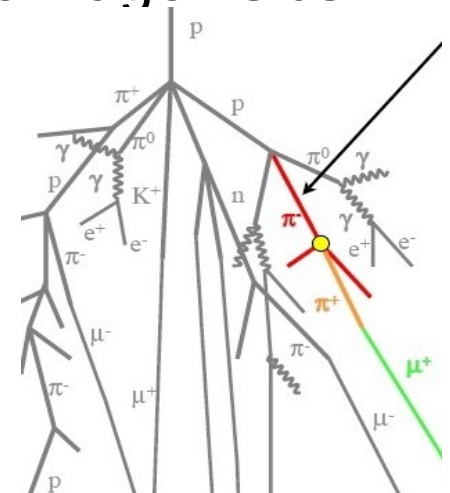
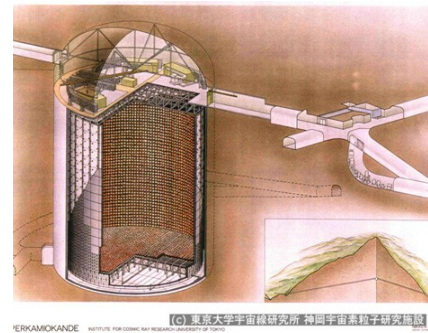
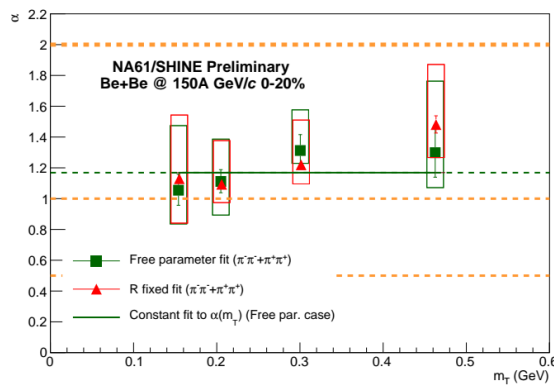
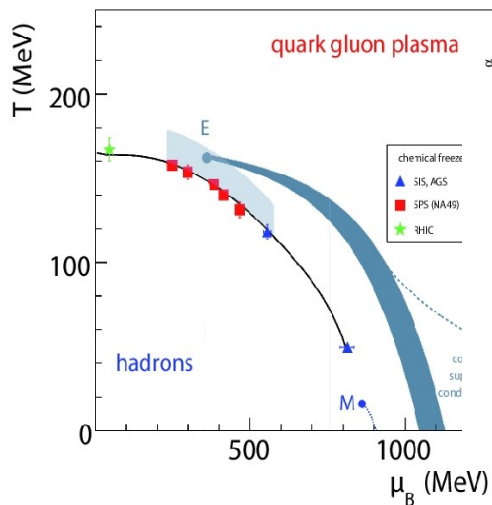
- NA61/SHINE experiment
- Hungarian participation in NA61/SHINE
- Resources
- Summary

*SHINE: SPS Heavy-Ion and  
Neutrino Experiment*



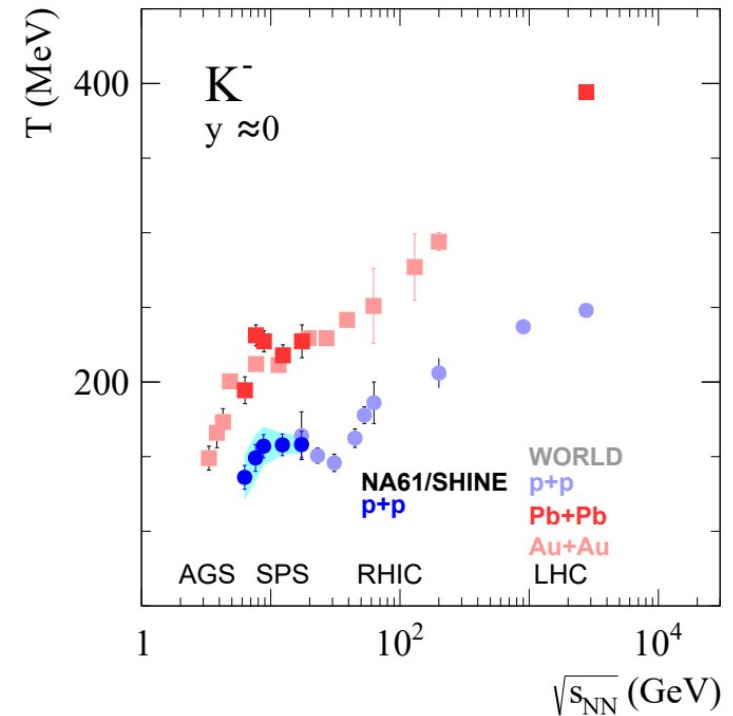
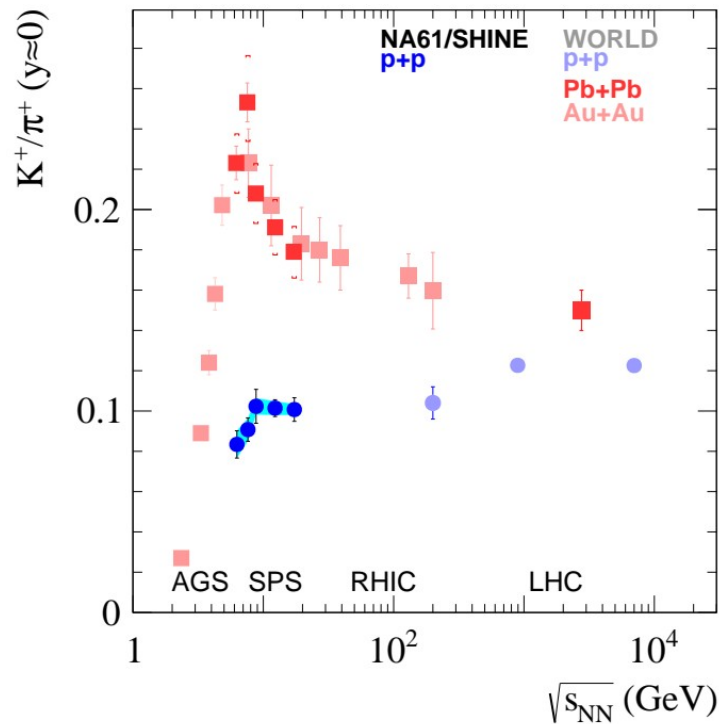
# NA61/SHINE experiment

- NA61 is a large acceptance hadron spectrometer experiment at the CERN SPS. Main tracking components: 40m<sup>3</sup> TPC system.
- Main physics goals are to measure:
  - Hadronic spectra and fluctuations in A+A for studying Onset of Deconfinement and searching for Critical Point in strong interactions, intermediate  $p_T$  physics in p+p, p+A, A+A, open charm measurement
  - Reference hadron spectra in p+A for DUNE, T2K ( $\nu$ -beams)
  - Reference hadron spectra in  $\pi^-$ +A for the Pierre Auger Obs.



# HI physics and NA61/SHINE

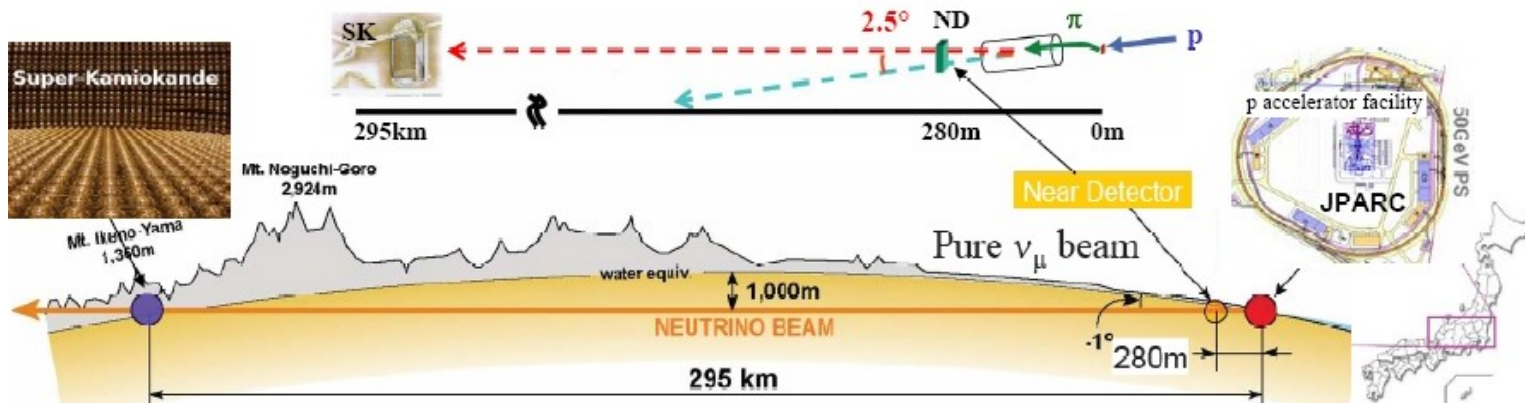
- Change of energy dependence of hadronic observables around SPS energies in A+A.



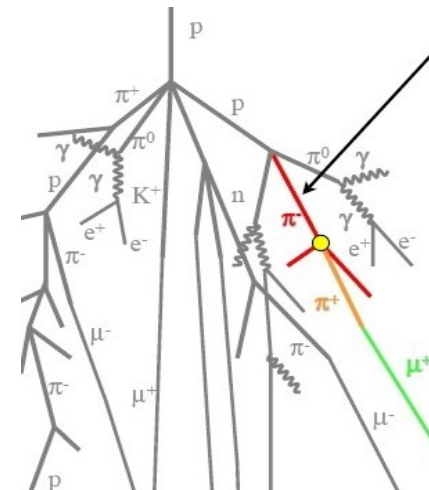
- Lattice QCD indicates existence of a critical point of strongly interacting matter at freeze-out temperatures foreseen to be accessible around SPS energies.
- NA61 is searching for CP and is studying OoD by performing an E—A scan program with large statistics, optimal acceptance [PRC102(2020)011901].

# Neutrino-beam and CR physics

- In  $\nu$ -beam experiments, such as T2K, mesons are produced with a proton beam on a production target. Neutrinos are produced from decay of mesons. Precise knowledge is needed on the meson production cross section differentiated in momentum space. NA61 provides these p+A reference spectra.



- In large coverage cosmic ray observatories, such as Pierre Auger Observatory, the modelling of cosmic air showers is most sensitive to  $\pi^\pm/K^\pm$  production in  $\pi^\pm/K^\pm + \text{air}$  nucleus collisions. NA61 provides precise  $\pi^\pm/K^\pm$  spectra in  $\pi^\pm/K^\pm + \text{C}$  collisions.



# Hungarian participation in NA61/SHINE

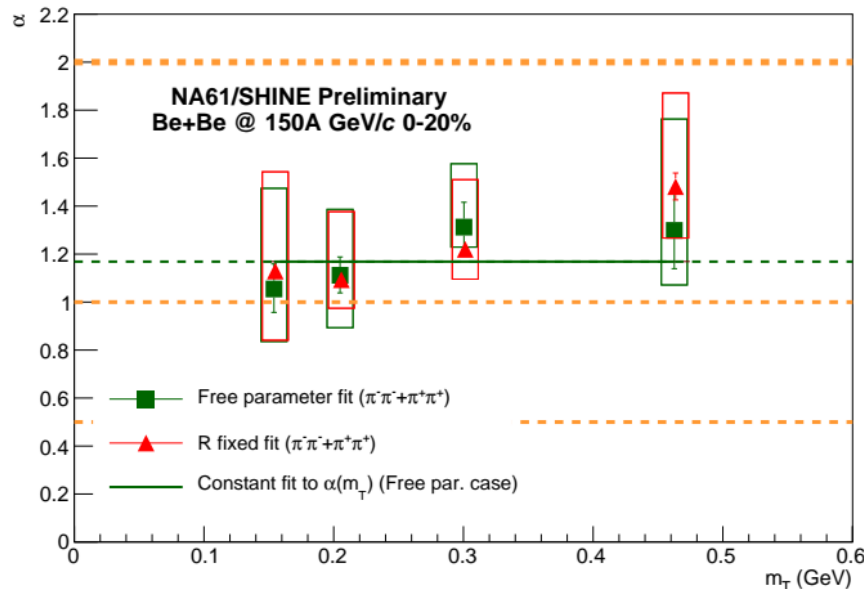
- Hungarian group is present in NA61 since its proposal.
- Main interest is p+p and p+A physics, BE correlations in A+A, h+A hadron spectra for  $\nu$ -beam experiments, detector devel.
- Members:
  - András László (Wigner, physicist, TL)
  - Yoshikazu Nagai (ELTE, physicist, TL)
  - Máté Csanád (ELTE, physicist)
  - Ádám Gera (Wigner, engineer)
  - Tivadar Kiss (Wigner, electronic engineer, DTL)
  - Krisztina Márton (Wigner, PhD student)
  - Botond Pálfi (Wigner, BSc student)
  - Barnabás Pórfy (ELTE-Wigner, PhD student)
  - Z.Fodor and G.Pálla (Wigner, emeritus physicists)

All members are from Wigner and ELTE, Budapest.

- Close collaboration with Vesztergombi Lab at Wigner RCP:
  - Ferenc Siklér (contact), Dezső Varga (gaseous det.) et al

# Contributions of Hungarian group in NA61/SHINE

- [p+p, p+A physics part in EOI, LOI, Proposal]
- [specific detector development for p+A]
- [design, realization, operation of DAQ (until LS2), offline sw]
- analysis for Bose-Einstein correlations in A+A to scan E-A dep.



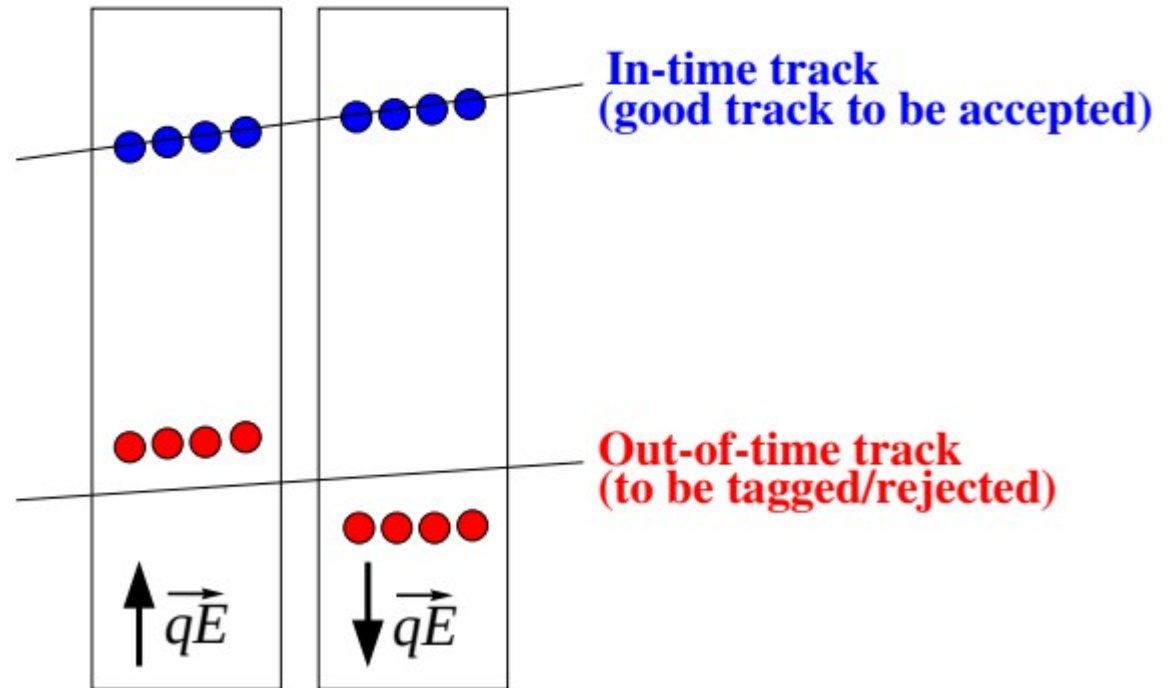
change in Lévy exponent  $\alpha$  as indicator of CEP

(participation also in related PHENIX+STAR @ RHIC to explore phase diagram)

- Conceptualization, development, building of Forward TPCs:
  - novel tandem-TPC concept for higher rates

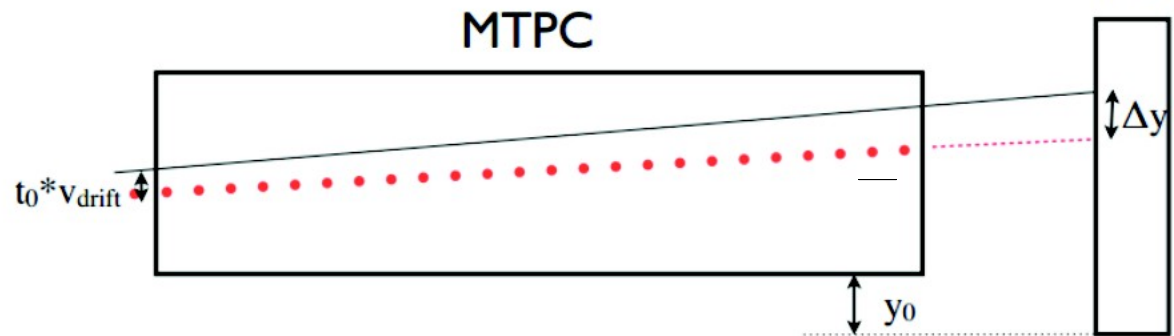


**In-time and out-of-time tracks in a tandem TPC pair**





- Special auxiliary detector (Geometry Referenc Chamber):
  - for in-situ drift velocity determination in large TPCs



- New challenge (ELTE-Wigner-Boulder):
  - conceptualization of a high-resolution target tracker TPC

- Responsibilities within the experiment:
  - detector board coordinator, safety: Zoltán Fodor
  - software board & wg deputy coordinator: Yoshikazu Nagai
  - TPC calibration wg deputy coordinator: András László
  - active sw developers: Yoshikazu Nagai, András László
  - low-energy beamline coordinator: Yoshikazu Nagai
  - [former DAQ/online coordinator, until LS2: András László]

# Resources

## *Funding grants:*

- FK123842-123959 (2017-2021): 46kCHF, over 4 years.
- K138136-138152 (2021-2025): 58kCHF, over 4 years.

(NKFIH/OTKA: Hungarian Scientific Research Fund)

Largely used for M&O coverage, travels.

- TKP2021-NK (NRDI Fund): joint use of VLAB infrastructure

# Summary

- NA61 is a unique hadron spectrometer facility to study strongly interacting matter in the region of onset of deconfinement and close to presumed critical point (fixed-target SPS energies), quite unique facility for p+A hadron spectra for  $\nu$ -beams ref.
- ELTE+Wigner Hungarian groups are present in NA61 with key contributions to the experiment from start. Main interest is measurement of BE correlations in A+A, hadron spectra in p+A up to intermediate  $p_T$  range and for  $\nu$ -beams, detector development. The groups have a number of responsibilities within the collaboration.