



p+A collisions at the NA61/SHINE Experiment

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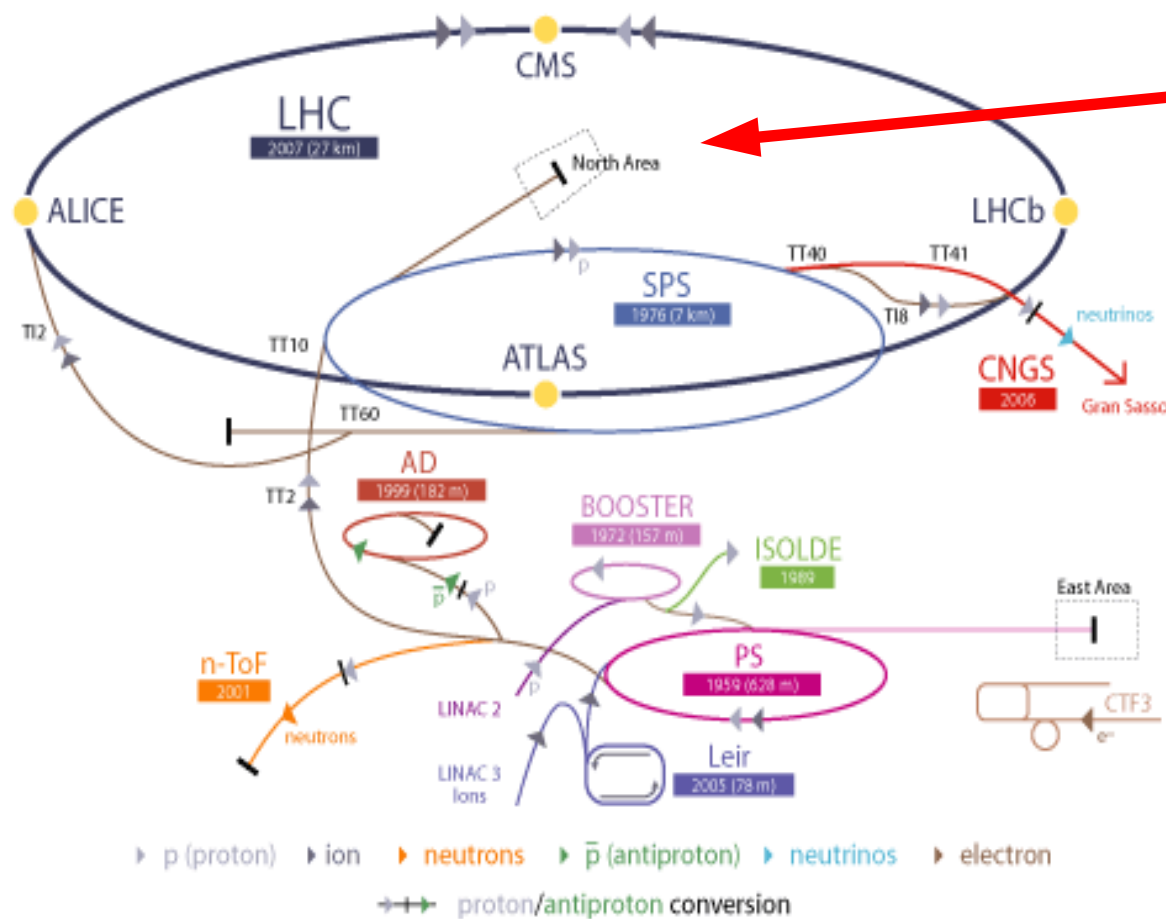
Wigner RCP, Budapest, Hungary

Outline

- NA61/SHINE Experiment at CERN SPS
- Centrality and slow protons in $h+A$ interactions
- Low Momentum Particle Detector at NA61

NA61/SHINE at CERN SPS

CERN Accelerator Complex

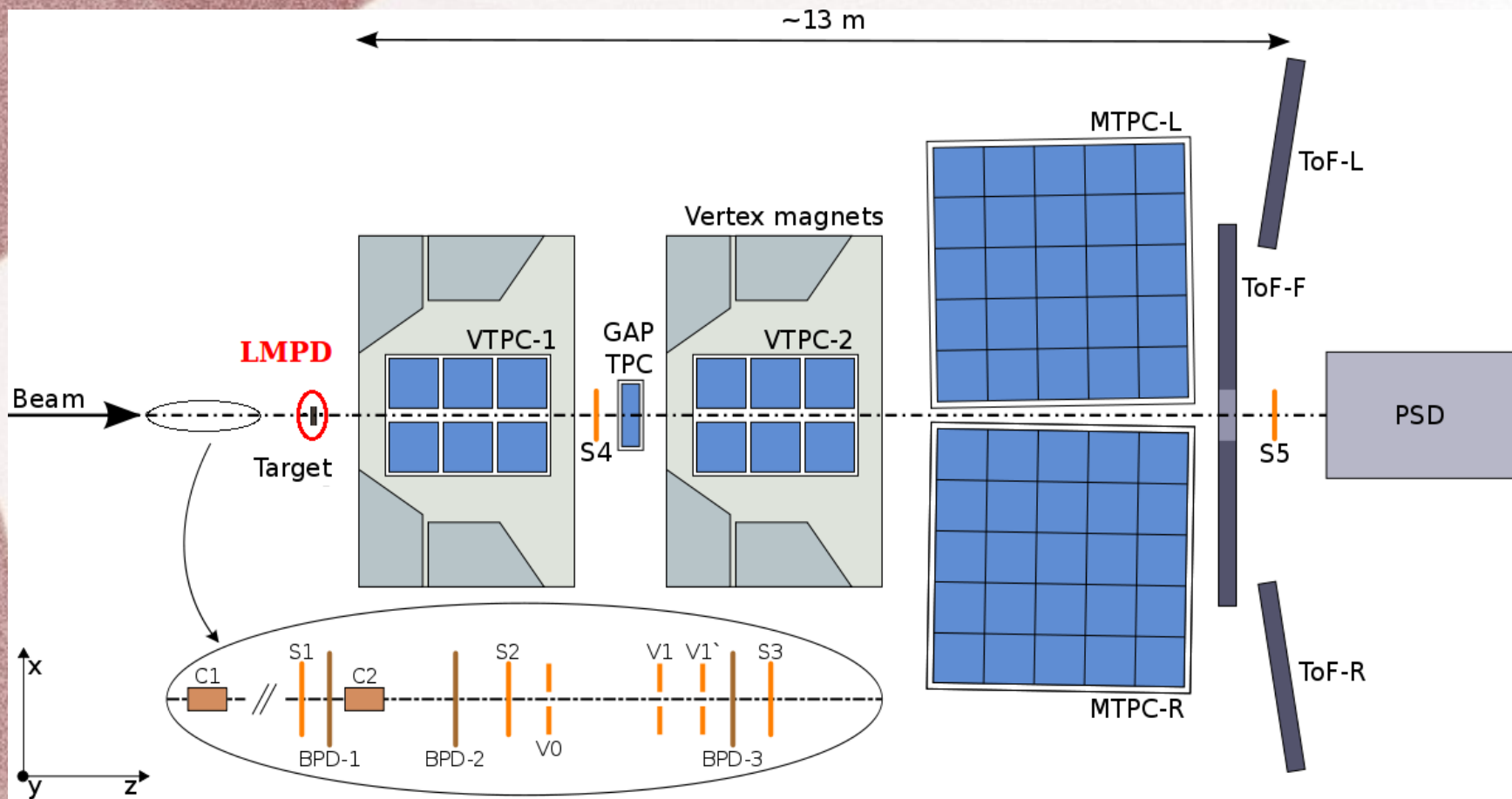


LHC Large Hadron Collider SPS Super Proton Synchrotron PS Proton Synchrotron
 AD Antiproton Decelerator CTF3 Clic Test Facility
 CNGS Cern Neutrinos to Gran Sasso ISOLDE Isotope Separator OnLine DEvice
 LEIR Low Energy Ion Ring LINAC LINEar ACcelerator n-ToF Neutrons Time Of Flight



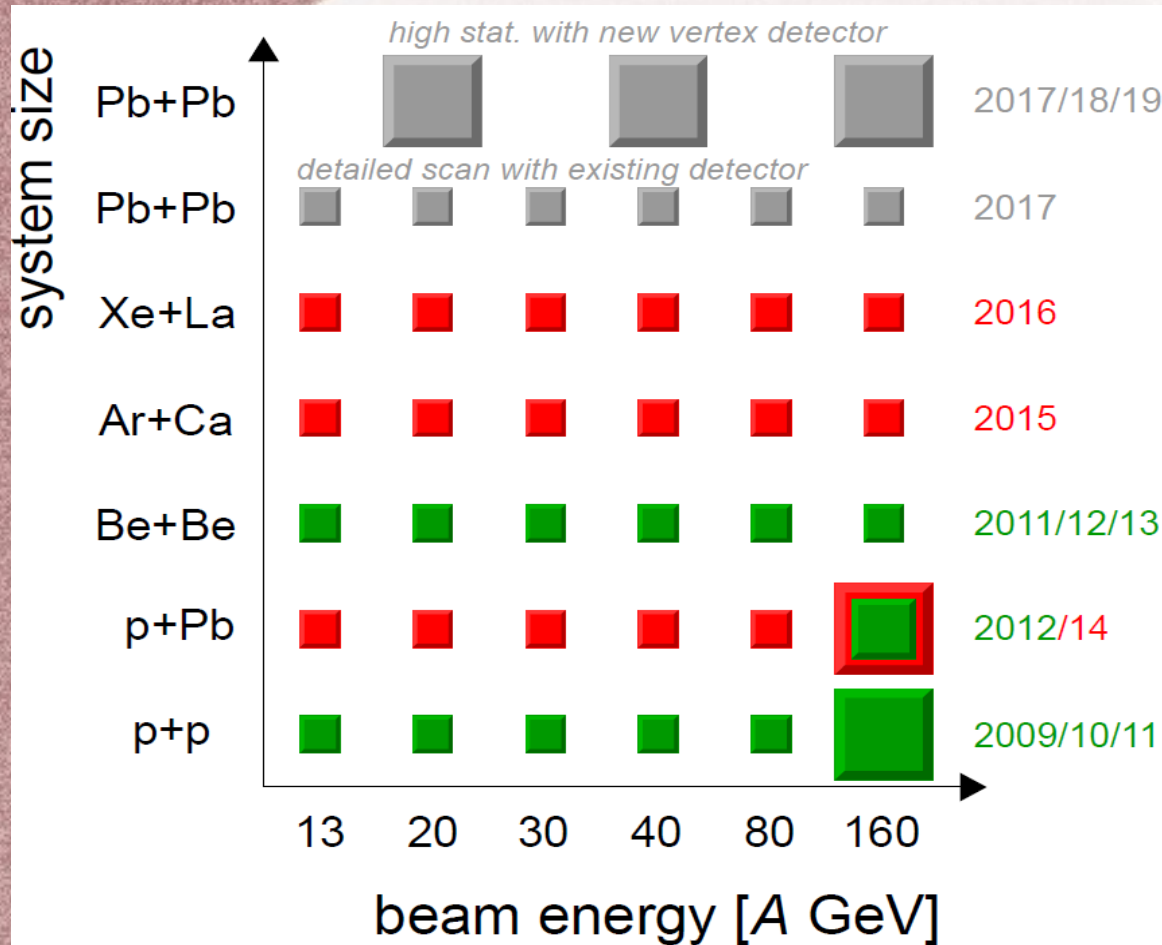
- **SPS Heavy Ion and Neutrino Experiment**
- Fixed-target experiment at CERN SPS
- Studies hadron production in hadron-nucleus and nucleus-nucleus collisions

NA61/SHINE at CERN SPS



- Large acceptance hadron spectrometer with excellent capabilities for momentum, charge and mass measurements
- Time Projection Chambers, Time of Flight and Projectile Spectator Detectors

NA61/SHINE at CERN SPS



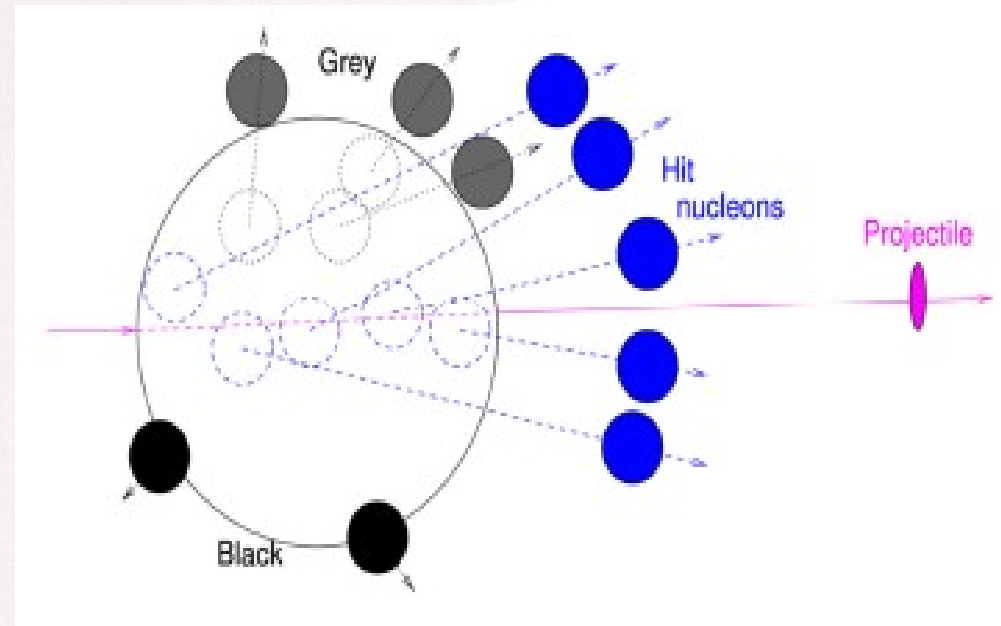
- Search for the critical point of strongly interacting matter
- Detailed study of the onset of deconfinement
- **Study of high transverse momentum phenomena in p+p and p+A**
- Reference measurements for neutrino and cosmic-ray experiments

Centrality of h+A collisions

- Centrality dependence of charged hadron production in h+A collisions is observed
- Earlier h+A measurements → centrality of the collision is correlated with the number of "grey" particles
- NA61 → **Low Momentum Particle Detector**

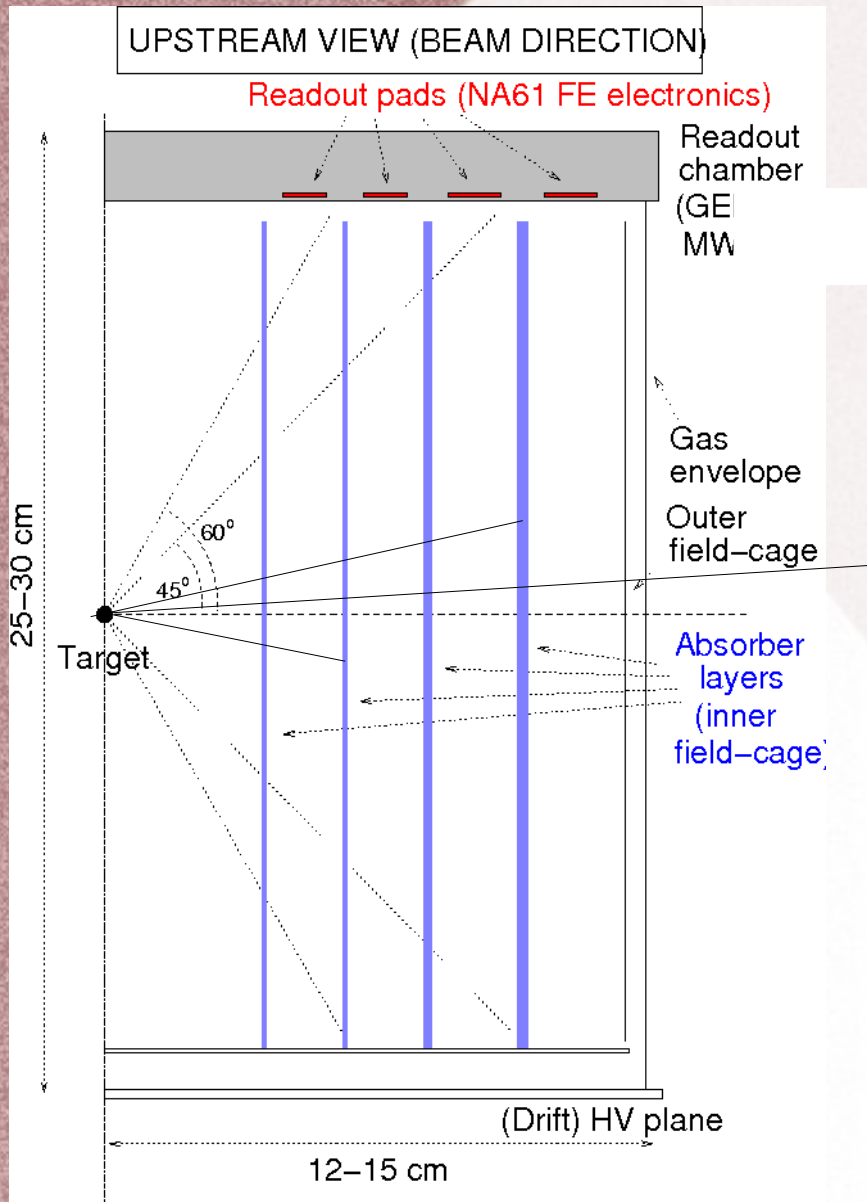
LMPD - Physics objectives

- **Centrality** of $h+A$ collision is correlated to the **number of slow** (“gray”) **nucleons** (produced by the “break-up” of the nucleus)

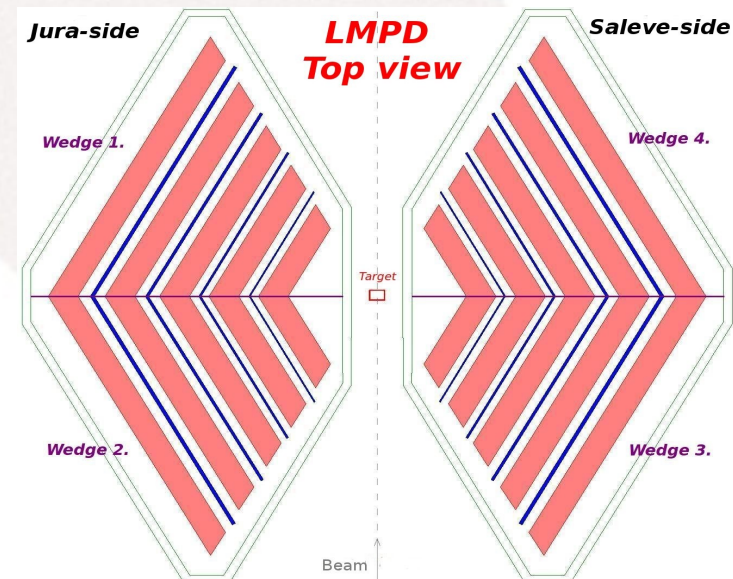


LMPD → identification and energy measurement of low momentum particles in $p+A$ collisions → ***Centrality Detector***

LMPD - Operation principle



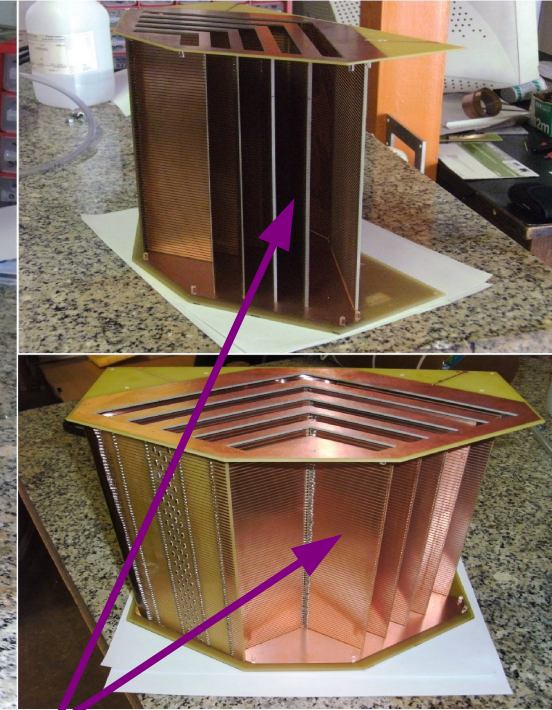
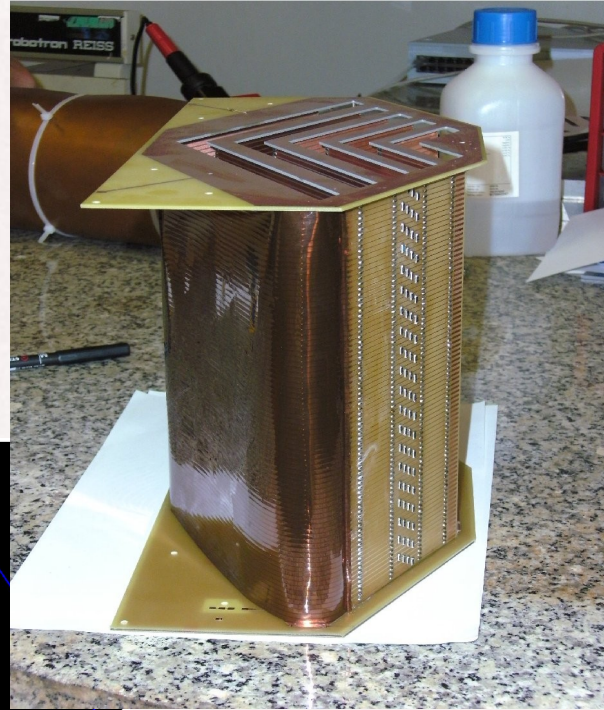
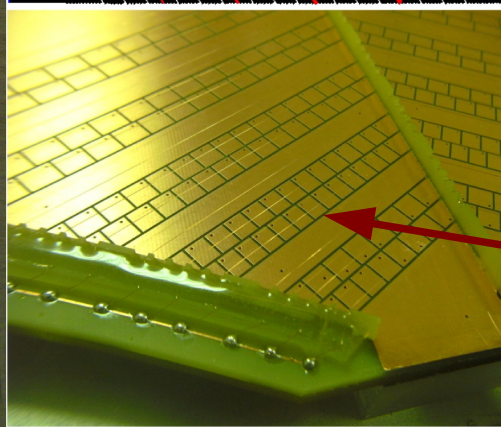
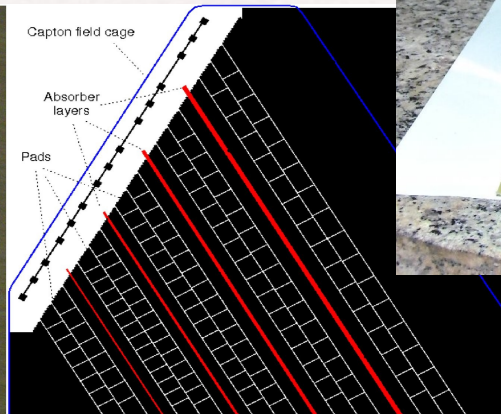
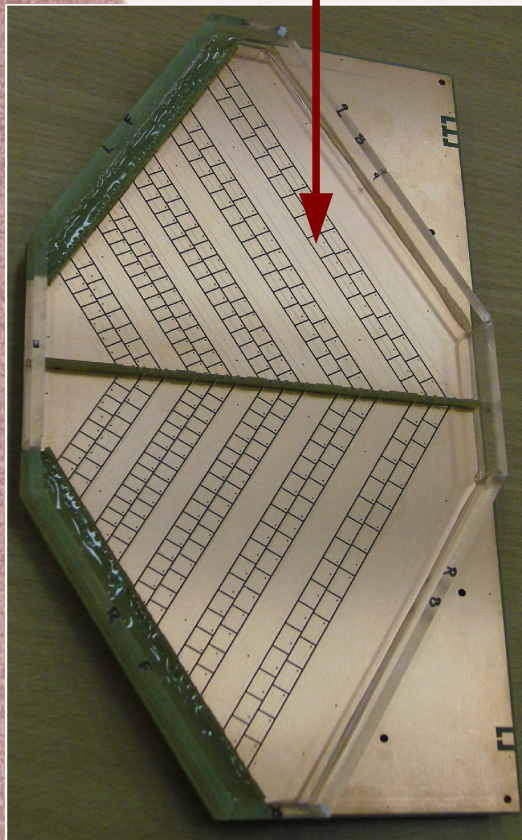
- **TPC**, intervals in particle range defined by **absorber layers**
- Simultaneous measurement of **dE/dx** and **range**: energy and identification



Low Momentum Particle Detector

Readout chamber (MWPC)

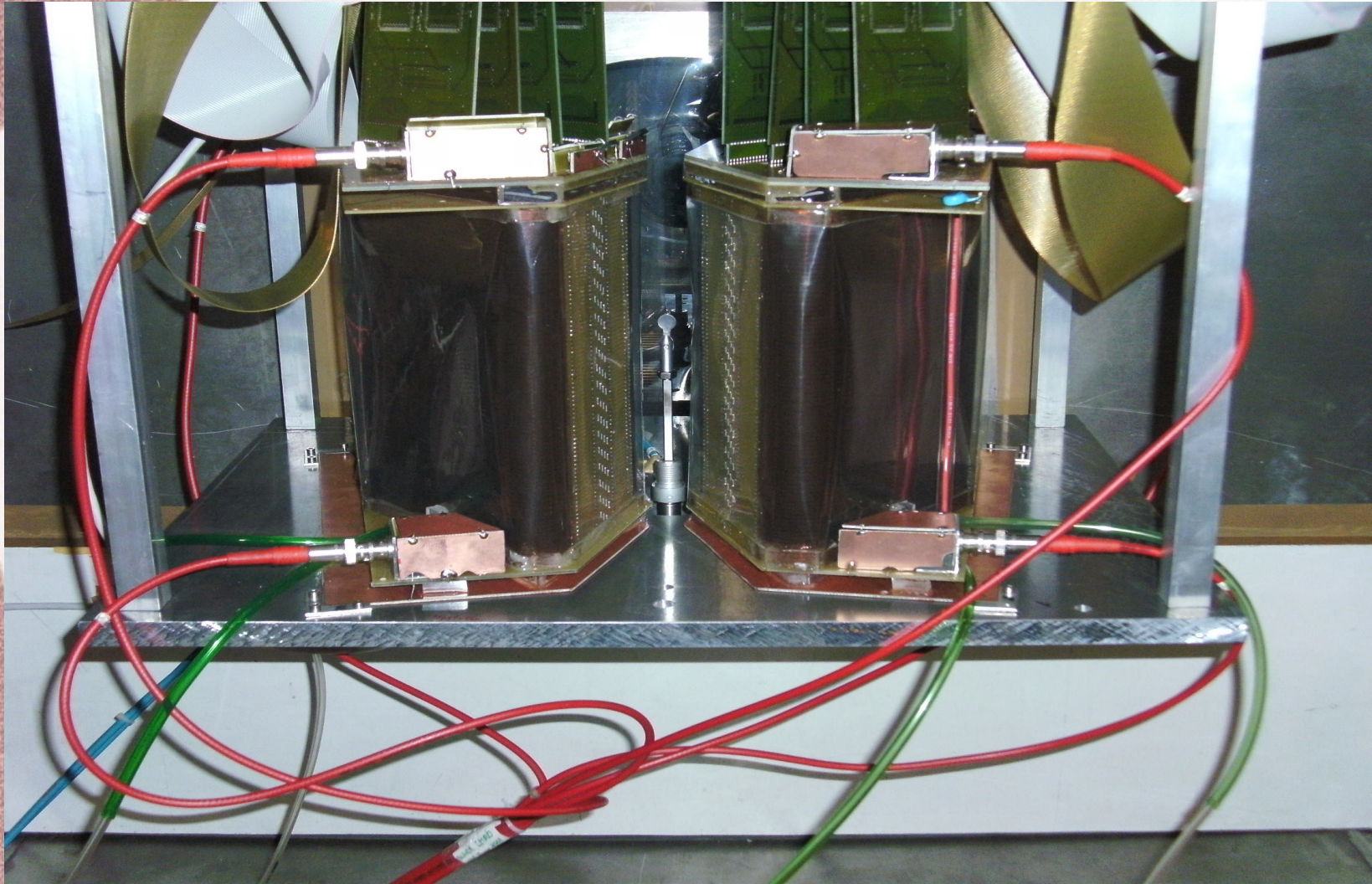
Cathode plane



Absorber layers

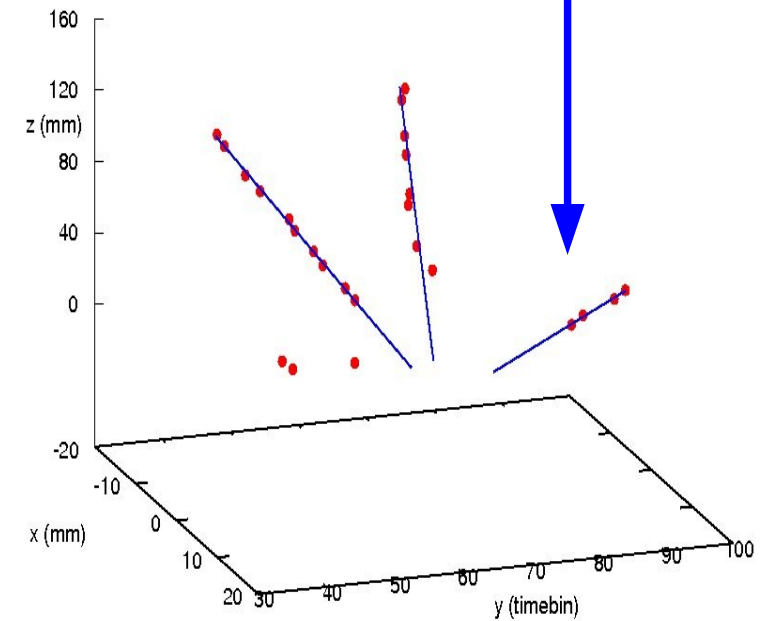
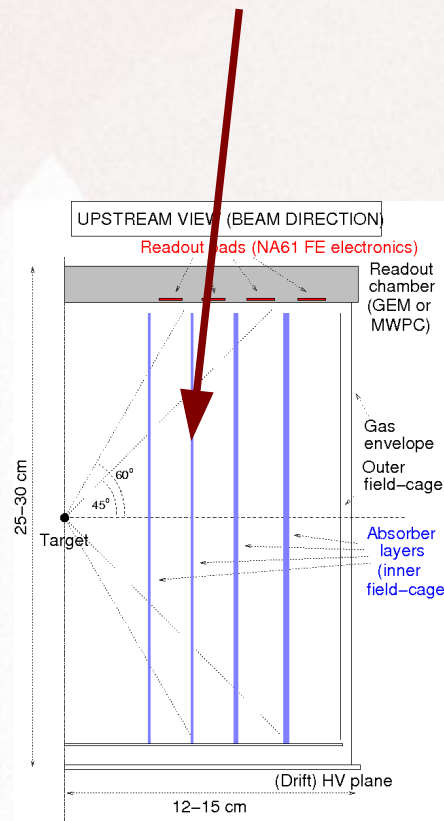
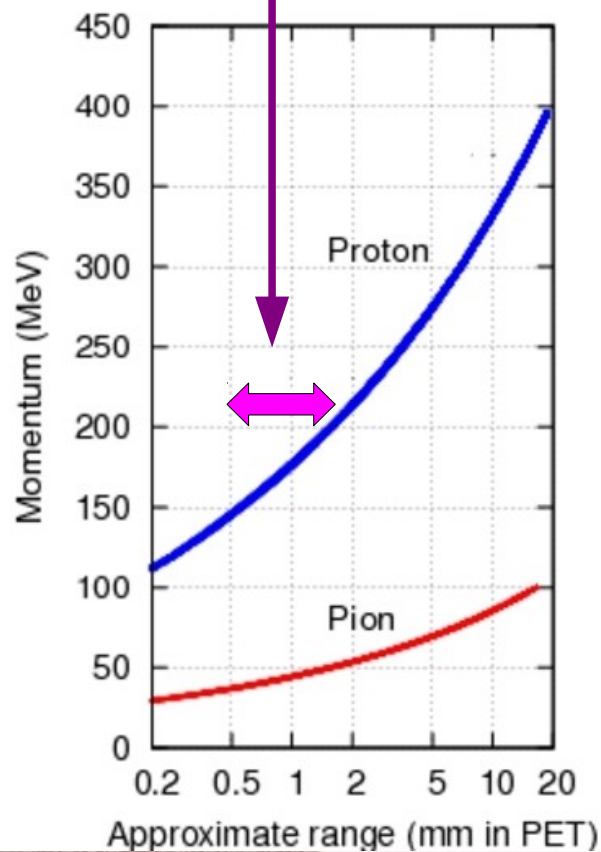
Wires

Low Momentum Particle Detector



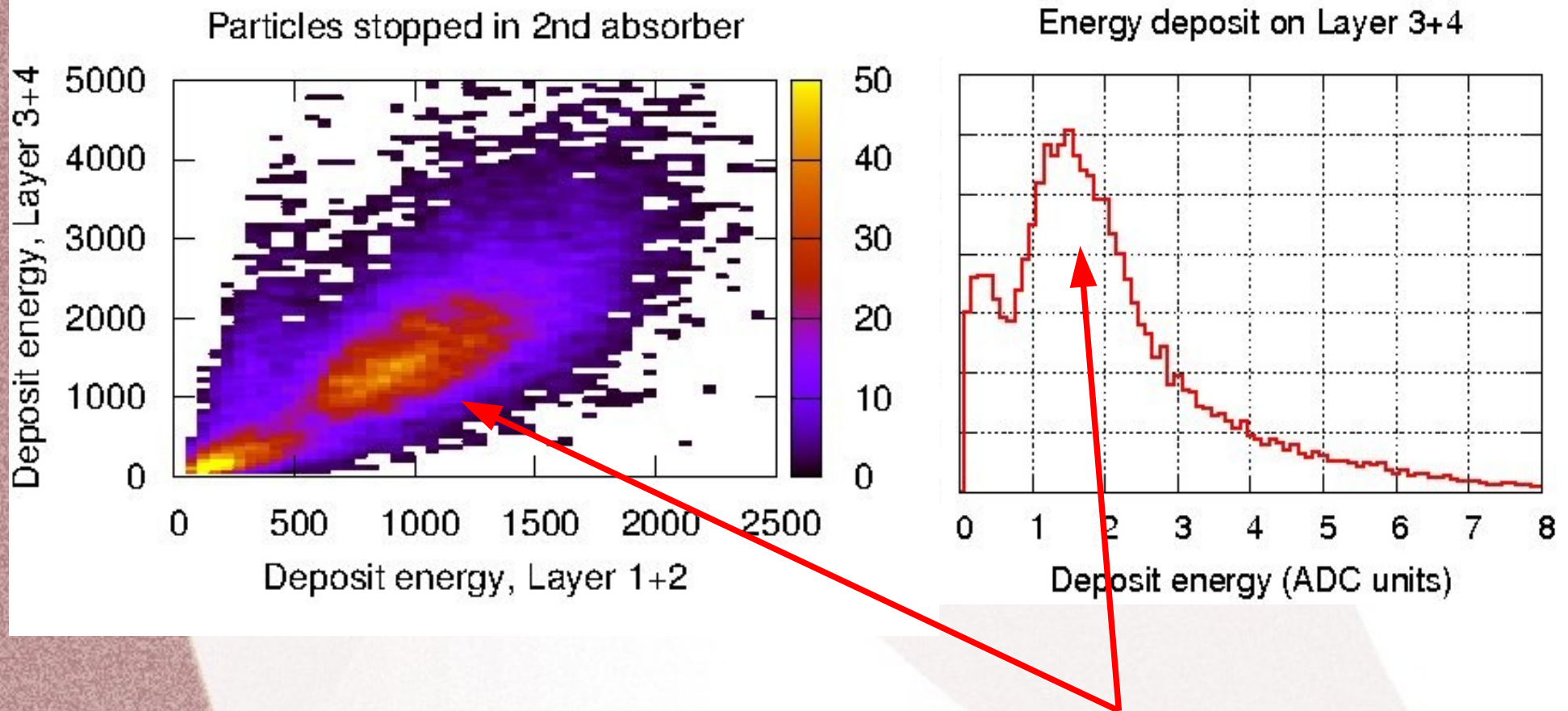
Proton identification with LMPD

Particles reconstructed
with range $0.5\text{mm} < r < 1.5\text{mm}$
stop in 2nd absorber



*Typical event in LMPD
(p+Pb data, 2011)*

Proton identification with LMPD



Particles stopped in 2nd absorber → **proton peak** visible

Summary

- NA61/SHINE → fixed target experiment at CERN SPS
- LMPD → TPC with absorber layers
 - detect and identify low momentum protons
 - particle identification based on the simultaneous measurement of dE/dx and range
 - Centrality Detector in the p+Pb collisions in NA61

Thank you for your attention!

Low momentum particles in $h+A$ collisions

- Early emulsion experiments → number of "heavy tracks" ($\beta < 0.7$) is correlated to the number of hadron-nucleon collisions inside the nucleus
- Black tracks ($\beta < 0.3$)
 - isotropic angular distribution
 - associated with the last stage, the evaporation of the final nucleus
 - their number measures the nuclear excitation energy
- Grey particles ($0.3 < \beta < 0.7$)
 - angular distribution forward peaked
 - originate from the intranuclear cascade

Low momentum particles in $h+A$ collisions

- Angular distributions of grey protons
 - significant dependence on A (the target mass number), stronger forward-peaked for lighter targets than for heavier ones
 - shape and height of the angular distributions do not depend on the incoming energy
 - at fixed A the dependence on the projectile is only weak

The number of slow particles measures the centrality or peripherality of a hadron-nucleus collision.