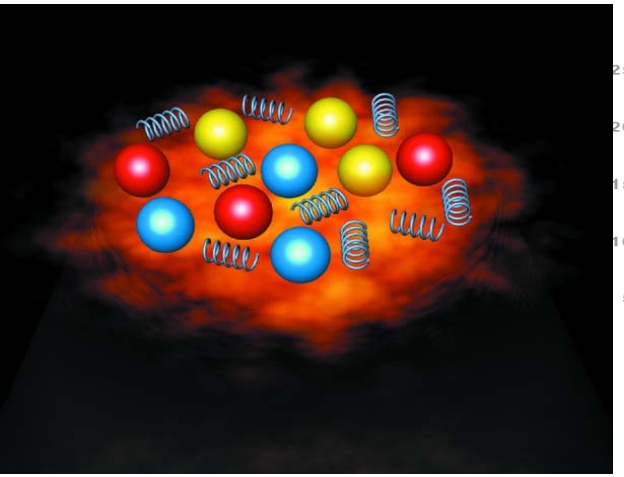
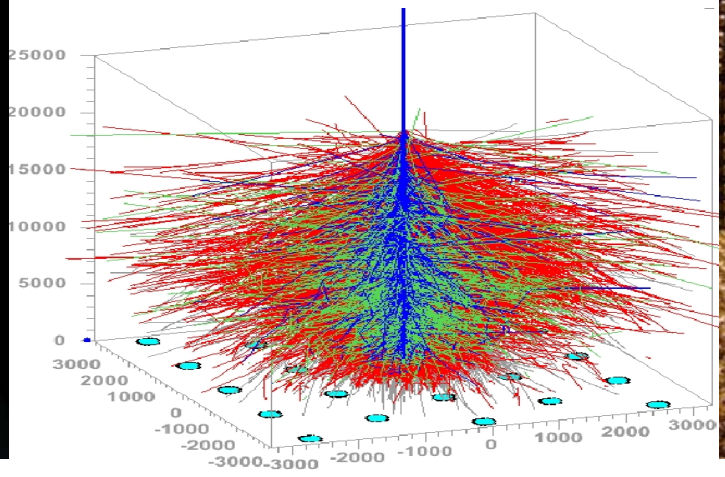
NA61/SHINE

experimental program

strongly interacting matter



cosmic-rays



neutrinos

Grzegorz Stefanek
Jan Kochanowski University in Kielce

Other NA61 talks:

W.Dominik - NA61/SHINE detector and its capabilities

J.Stepaniak - Proton-carbon data from NA61/SHINE

R.Ulrich - NA61/SHINE and cosmic ray physics

M.Gaździcki - Onset of deconfinement and critical point: nucleus-nucleus program of NA61/SHINE

SHINE = SPS Heavy Ion and Neutrino Experiment

Outline

- physics goals
- history and status
- detector and upgrades
- 2007 run
- detector performace
- status of the software/analysis/simulations
- data taking plans
- summary

Physics goals

Data for neutrino and cosmic-ray experiments

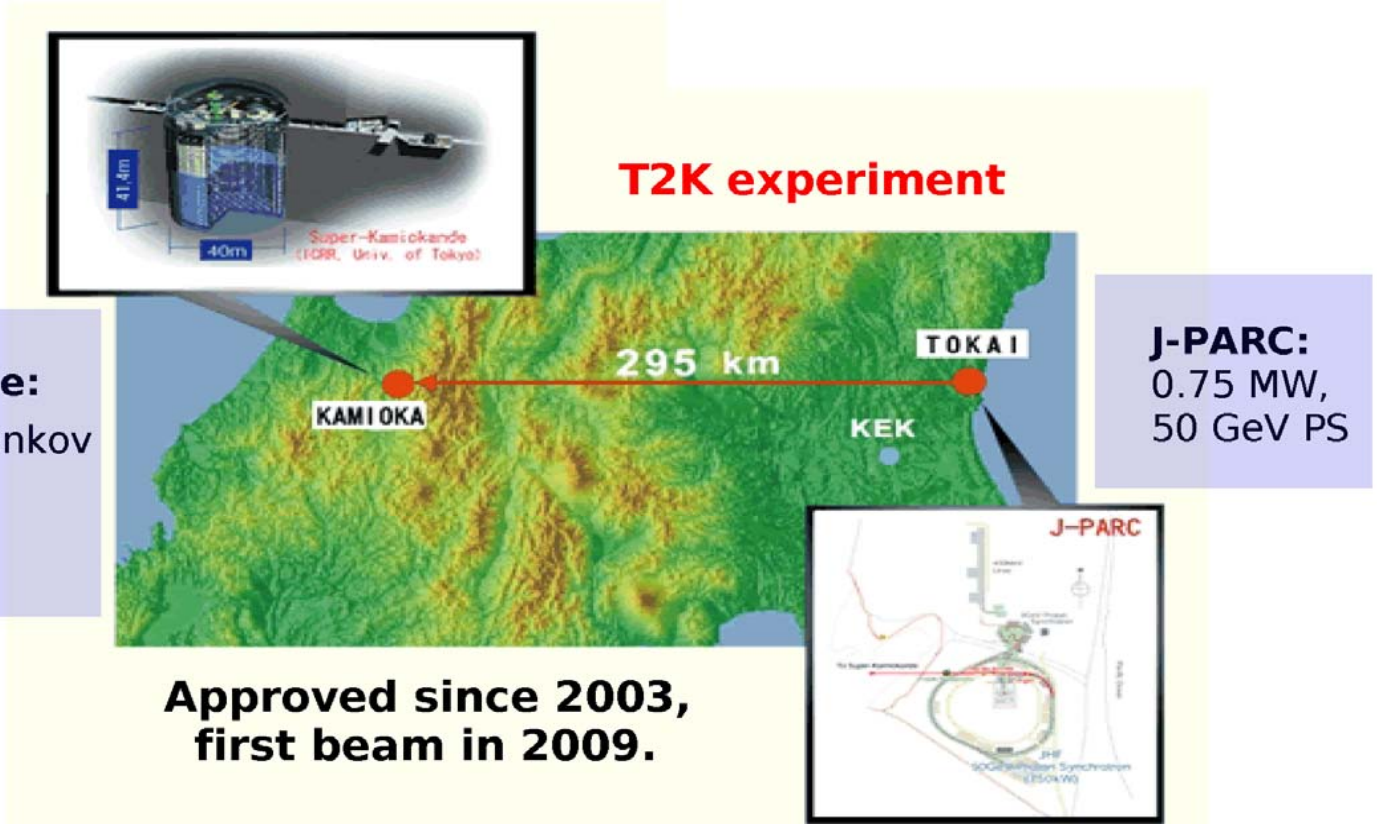
- Measure hadron production in the T2K target needed for the (T2K) neutrino physics
- Measure hadron production in p+C, π+C interactions needed for T2K and cosmic-ray, Pierre Auger Observatory and KASCADE, experiments

Physics of strongly interacting matter

- Measure hadron production at high transverse momenta in p+p and p+Pb collisions as reference for Pb+Pb results
- Search for the critical point of strongly interacting matter
- Study the properties of the onset of deconfinement in nucleus-nucleus collisions

Data for neutrino T2K experiment

Neutrino flying across Japan

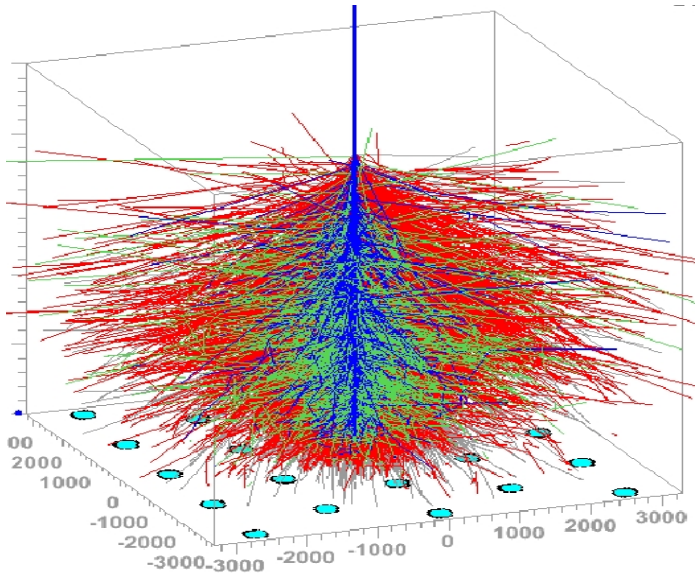


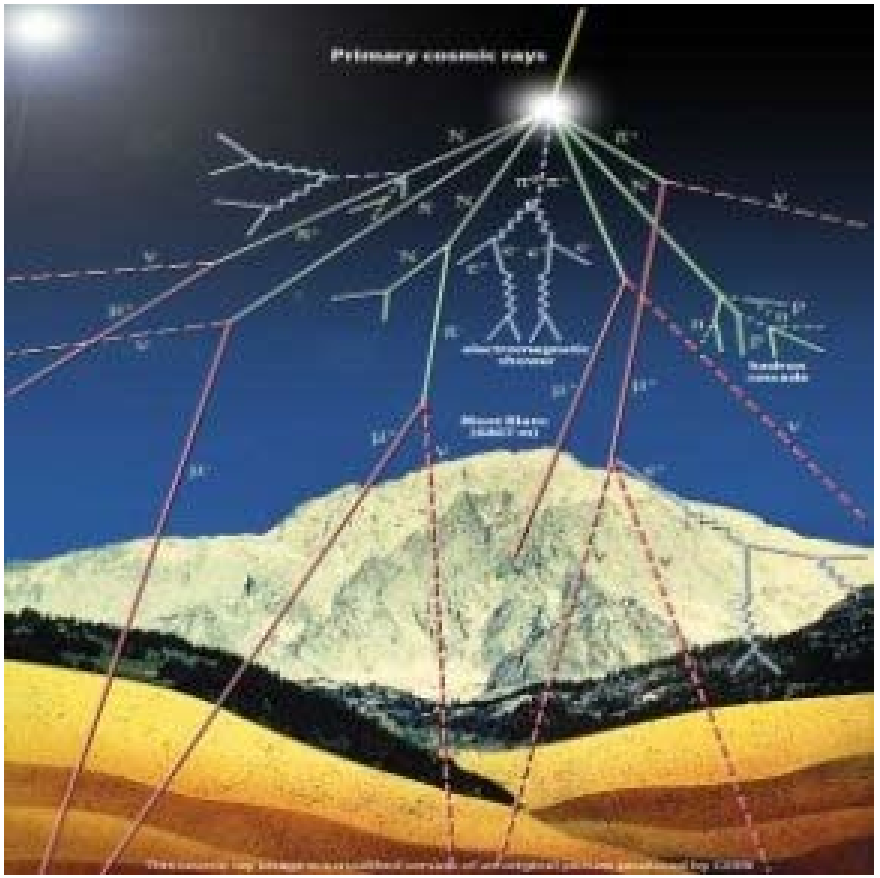
NA61 goal:

Precision measurements of hadron production for prediction of ν-fluxes in the T2K experiment

NA61 talk by J.Stepaniak

Data for cosmic-ray experiments





Number of generations ~ 5..6

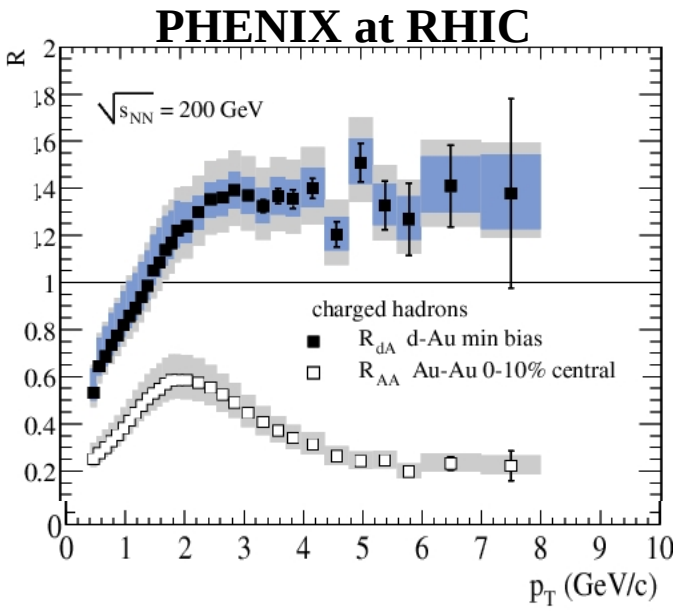
Important energy range: 10…1000 GeV

NA61 talk by R.Ulrich

NA61 input to C-R:

$$p+C \longrightarrow \begin{matrix}\text{pions}\\ \text{kaons}\\ \text{protons}\end{matrix} + X$$

Hadron production at high p_T

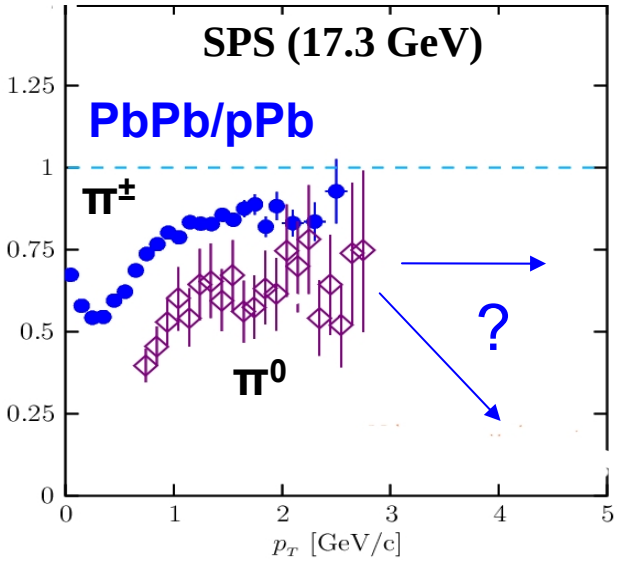


PHENIX, Phys. Rev. Lett. 91, 072303

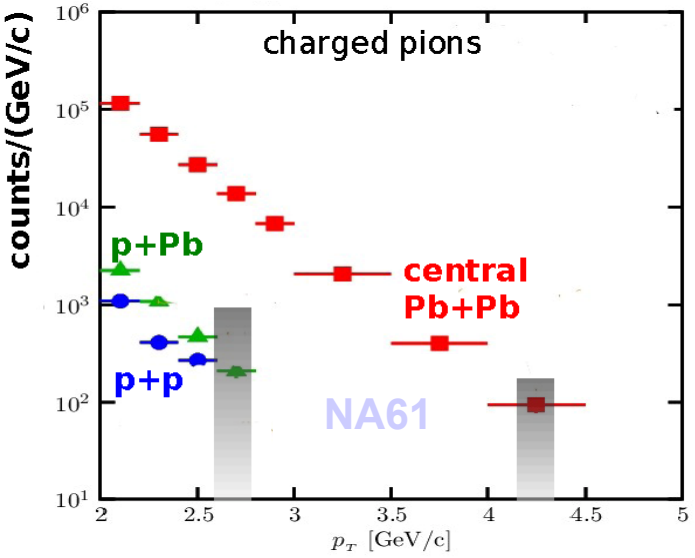
The Cronin enhancement in d+Au (multiple scattering of the projectile)

The high pT suppression in Au+Au (jet quenching in high density matter)

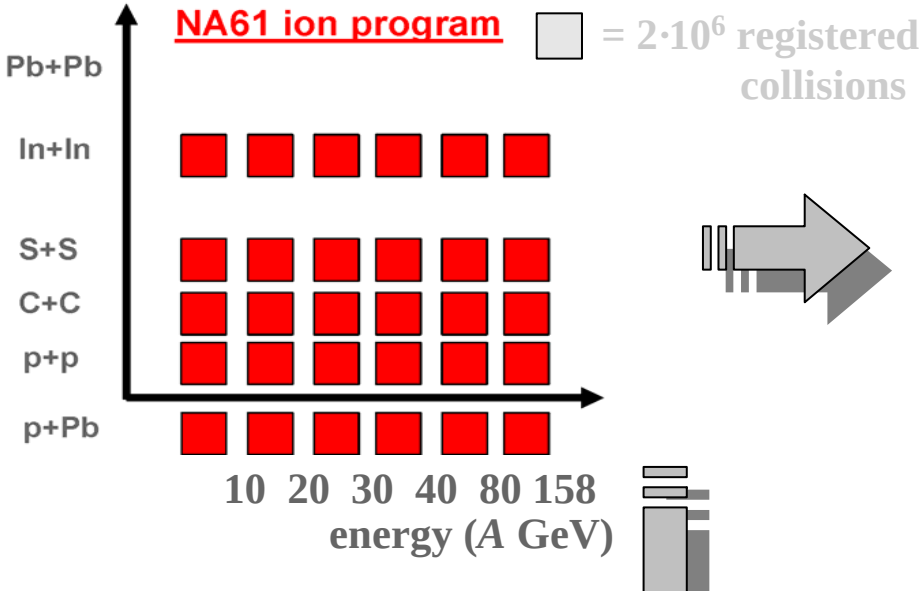
Study of energy dependance of this effect is necessary for its final interpretation

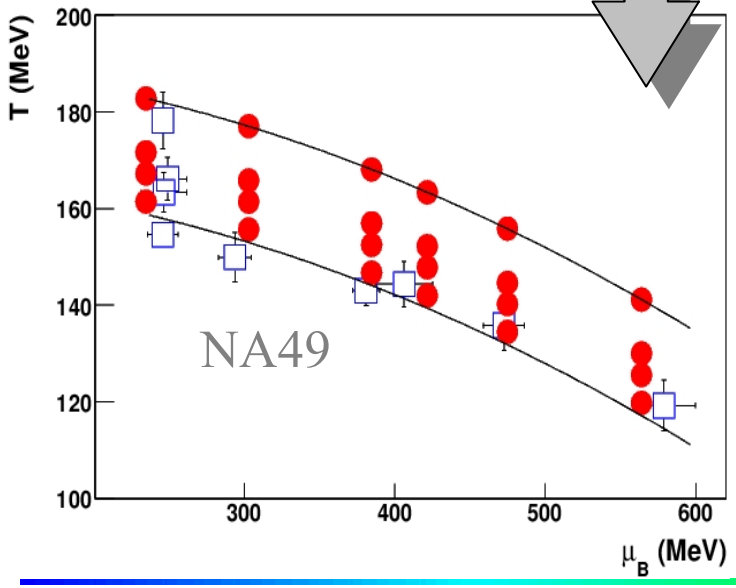


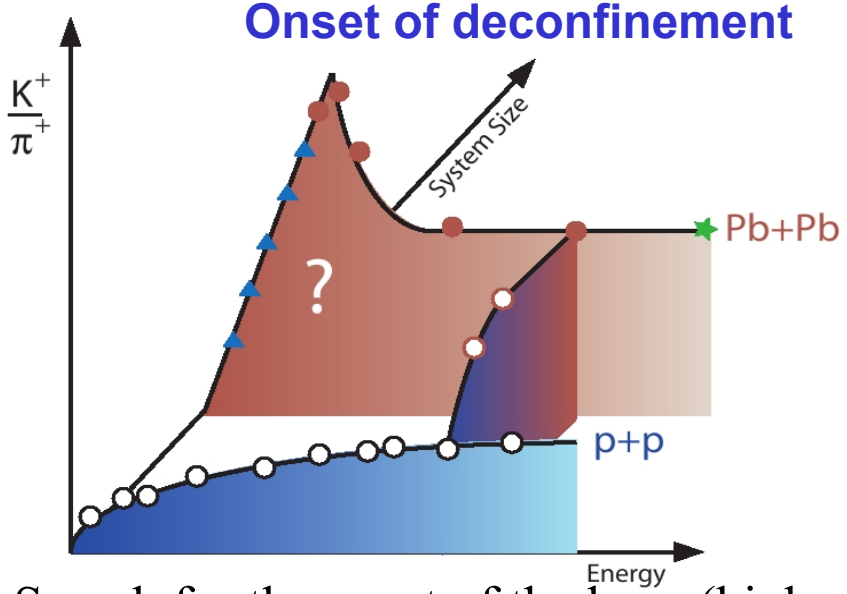
New measurements are needed to clarify the behaviour at SPS energie



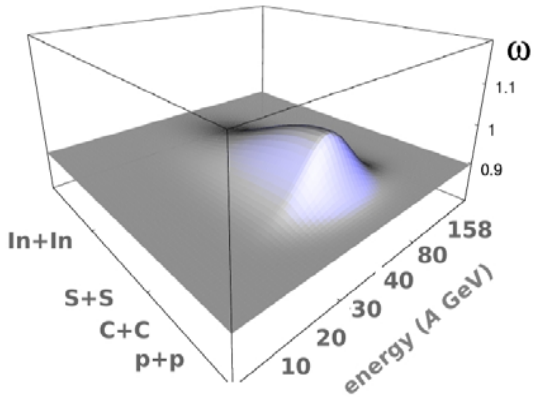
Critical Point and Onset of Deconfinement







Search for the onset of the horn (kink, step) in collisions of light nuclei



Critical point

NA61 talk by M.Gaździcki

Search for the hill of fluctuations

The NA61/SHINE Collaboration

121 physicists from 24 institutes and 14 countries:

University of Athens, Athens, Greece
University of Bergen, Bergen, Norway
University of Bern, Bern, Switzerland
KFKI IPNP, Budapest, Hungary
Cape Town University, Cape Town, South Africa
Jagiellonian University, Cracow, Poland
Joint Institute for Nuclear Research, Dubna, Russia
Fachhochschule Frankfurt, Frankfurt, Germany
University of Frankfurt, Frankfurt, Germany
University of Geneva, Geneva, Switzerland
Forschungszentrum Karlsruhe, Karlsruhe, Germany
Jan Kochanowski Univeristy, Kielce, Poland
Institute for Nuclear Research, Moscow, Russia
LPNHE, Universites de Paris VI et VII, Paris, France
Pusan National University, Pusan, Republic of Korea
Faculty of Physics, University of Sofia, Sofia, Bulgaria
St. Petersburg State University, St. Petersburg, Russia
State University of New York, Stony Brook, USA
KEK, Tsukuba, Japan
Soltan Institute for Nuclear Studies, Warsaw, Poland
Warsaw University of Technology, Warsaw, Poland
University of Warsaw, Warsaw, Poland
Rudjer Boskovic Institute, Zagreb, Croatia
ETH Zurich, Zurich, Switzerland

Organization and information

Spokesperson
M.Gaździcki (Kielce, Frankfurt)

Deputy/contact person
A.Bravar (Geneva)

Safety
Z.Fodor (Budapest)

Collaboration board

- chairman (G.Versztergombi, Budapest)
- deputy (P.Seyboth, Kielce)
- institute representatives
- physics board members
- technical coordinator (Z.Fodor, Budapest)
- software coordinators
  (G.Stefanek, Kielce; B.Popov, Dubna)
- physics coordinator (P.Seyboth, Kielce)

Web page: http://na61.web.cern.ch

History and status

-NA61 was approved at CERN in June 2007,

-the pilot run was performed during October 2007,

-the commissioning of the TPC read-out upgrade and DAQ was performed during September 2008

-the 2008 run has been cut due to the LHC incident

Status Report: *CERN-SPSC-2008-018, SPSC-SR-033 (July 2, 2008)*

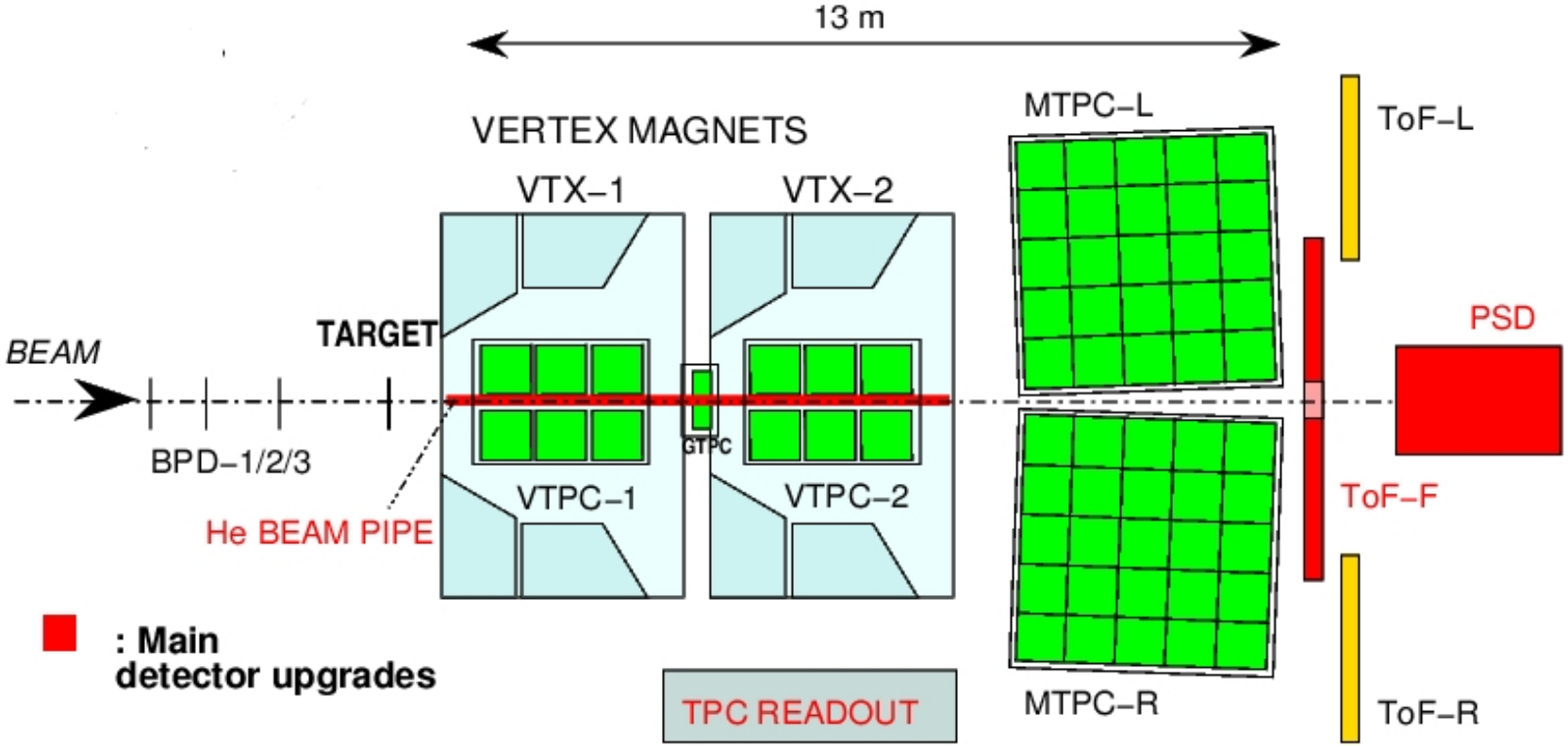
Addendum-3 *CERN-SPSC-2007-033, SPSC-P-330 (November 16, 2007)*
Addendum-2: *CERN-SPSC-2007-019, SPSC-P-330 (June 15, 2007)*
Addendum-1: *CERN-SPSC-2007-004, SPSC-P-330 (January 25, 2007)*
Proposal: *CERN-SPSC-2006-034, SPSC-P-330 (November 3, 2006)*
Status Report: *CERN-SPSC-2006-023, SPSC-SR-010 (September 5, 2006)*
LoI: *CERN-SPSC-2006-001, SPSC-I-235 (January 6, 2006)*
EoI: *CERN-SPSC-2003-031, SPSC-EOI-001 (November 21, 2003)*

Report from the NA61/SHINE experiment at the CERN SPS, CERN-OPEN-2008-012
NA61/Shine at the CERN SPS, CPOD 2007, arXiv:0709.1867

Location:

Detector and upgrades

NA61 apparatus:



NA61 talk by W.Dominik

NA49: Nucl. Instrum. Meth. A430, 210 (1999)

Upgrades: CERN-SPSC-2006-034, SPSC-P-330

Basic upgrades

2007: Modification and replacement of obsolete equipment, construction of the forward ToF wall
→ reestablish the full functionality of NA49 and T2K acc.

DONE

2008: Replacement of the TPC digital read-out and DAQ:
→ an increase of the event rate by about 20 to 80 Hz

DONE

2011: Replacement of the VETO Calorimeter by a Projectile Spectator Detector:
→ an increase of the resolution in the measurement of the number of projectile spectators by a factor ≈5 to $\Delta E/E \approx 50\%/E$,
→ *a* possible determination of the reaction plane

PROTOTYPE TEST

Installation of the Helium beam pipe in the VTPC cage
→ a reduction of the delta-electron background by a factor of 10

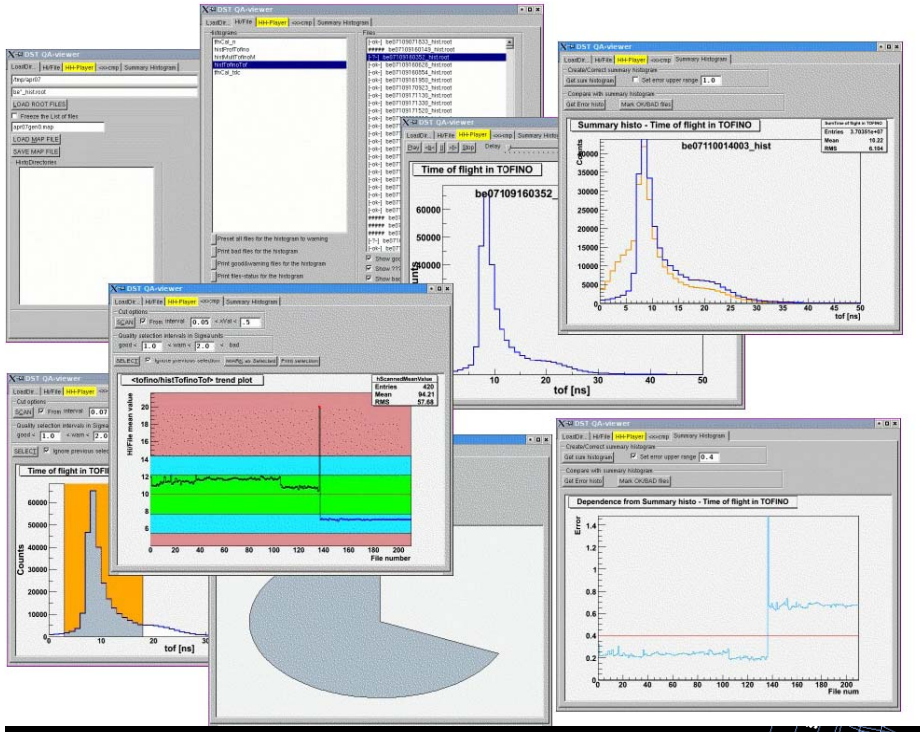
DESIGN STUDY

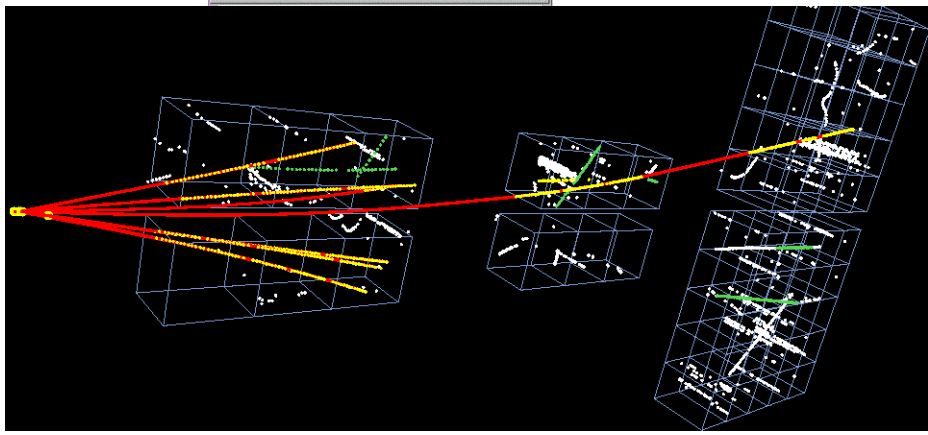
→ secondary ion beam system

Status of the software

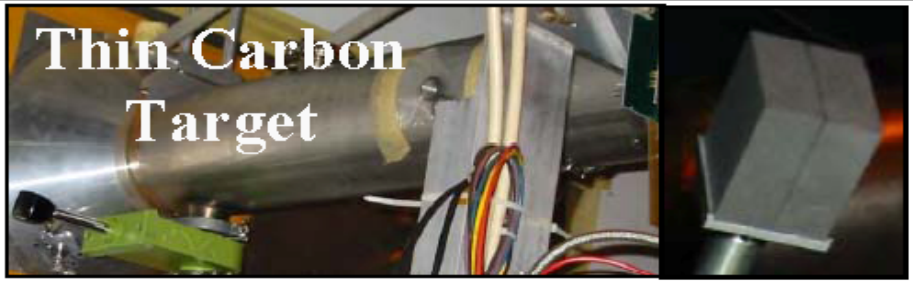
Components of the NA61 software:

- DSPACK package
- Data Base
- reconstruction chain
- simulation chain
- online monitoring and quality assessment (QA) software
- NA61 root libraries (T61DST, T61ANA)
- visualisation tools (eye-scan program,event browser)
- www and Twiki pages





2007 run



- 2 different carbon targets (isotropic graphite)

Thin Carbon Target
- length=2 cm, cross section 2.5x 2.5 cm^2
- ρ = 1.84 g/cm^3
- ~0.04 λ_{int}

T2K replica Target
- length = 90 cm, Ø=2.6 cm
- ρ = 1.83 g/cm^3
- ~1.9 λ_{int}

- During October 2007 Run (~30 days):

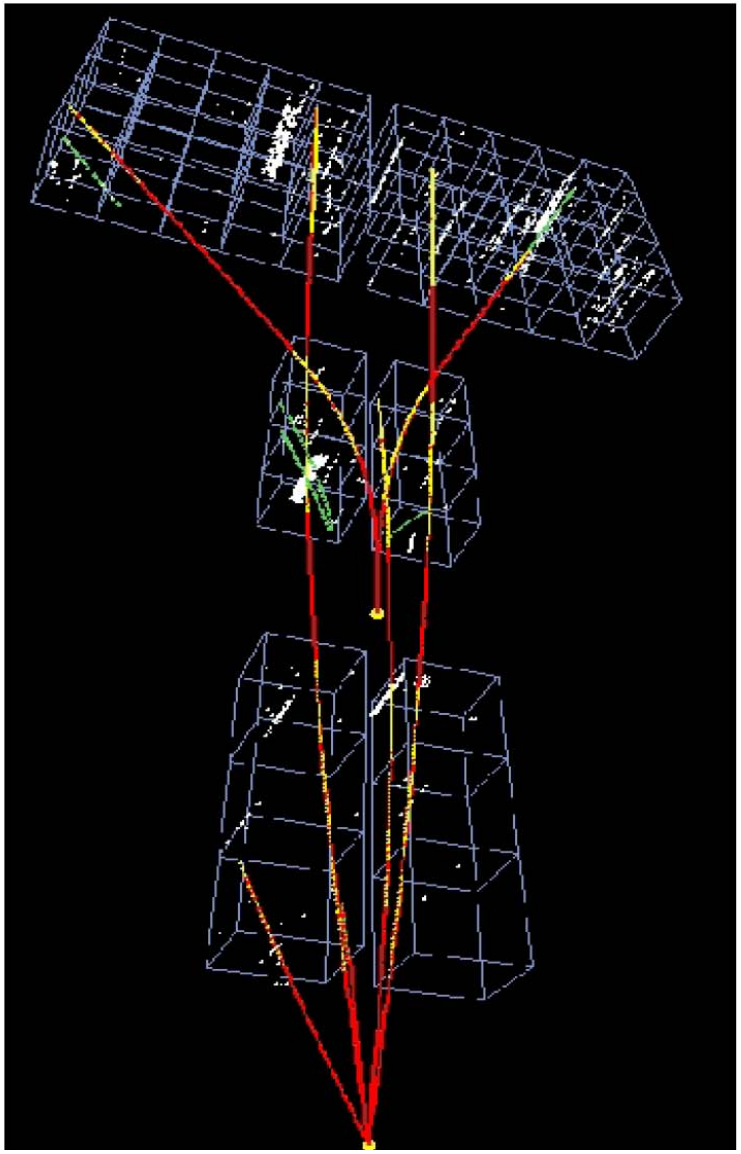
- taken pilot physics data for T2K with 30.9 GeV/c protons (~2 weeks)

Thin target: ~670k triggers **Replica target: ~230k triggers**

Empty target: ~80k triggers

Data fully calibrated and under analysis !!!

Performance of the detector



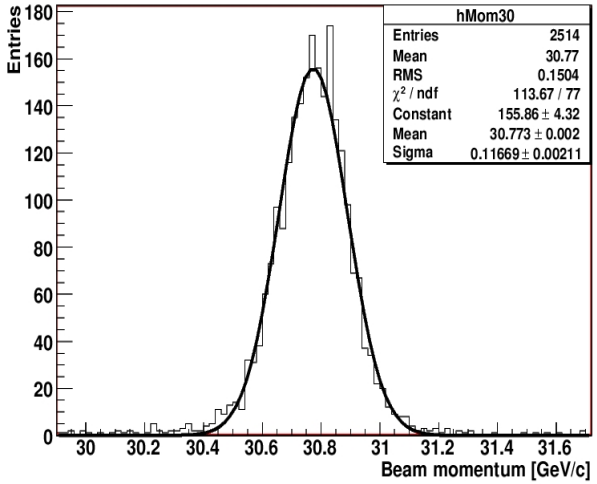
Results of the 2007 run:

- Large acceptance: ≈50%
- High momentum resolution:
  $\sigma(p)/p^2 \approx 10^{-4} \quad ((GeV/c)^{-1})$
  at full magnetic field
- Good particle identification:
  $\sigma(TOF) \approx 100\,ps,$
  $\sigma(dE/dx)/\langle dE/dx \rangle \approx 0.04,$
  $\sigma(m_{inv}) \approx 5\,MeV$
- High detector efficiency:
  > 95%

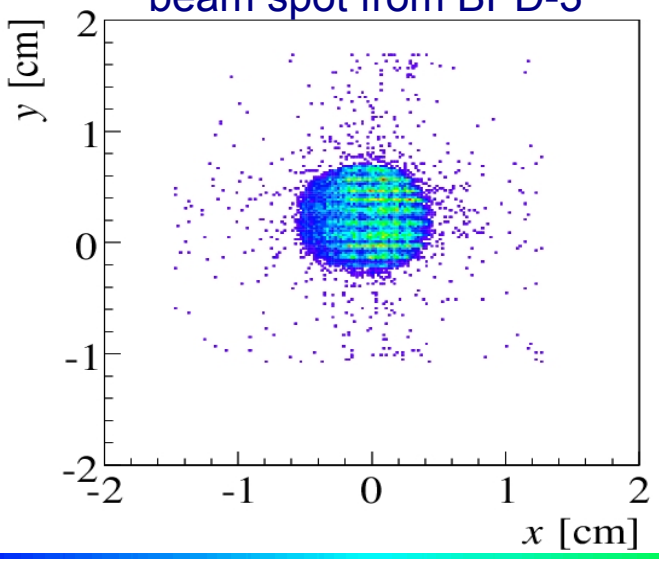
Performance of the NA61 detector

Proton beam properties:

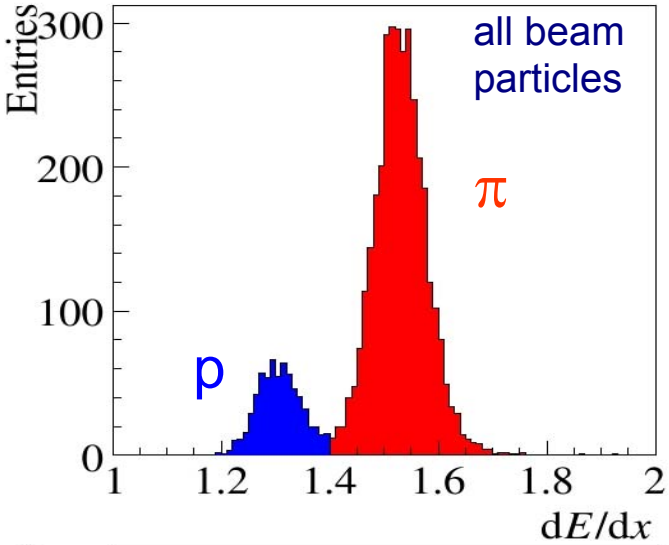
momentum from TPC

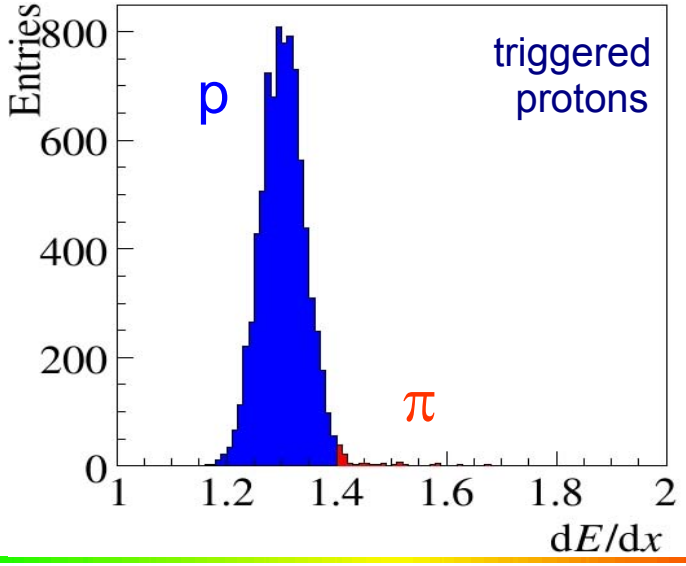


beam spot from BPD-3



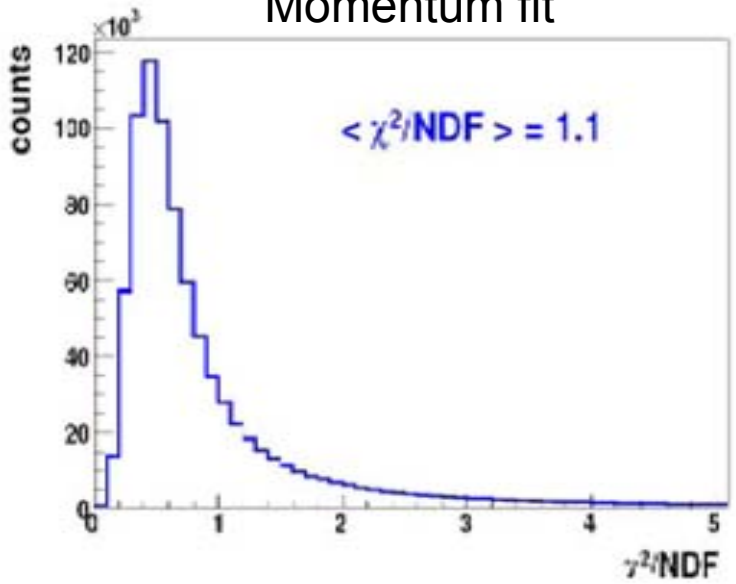
dE/dx from TPC



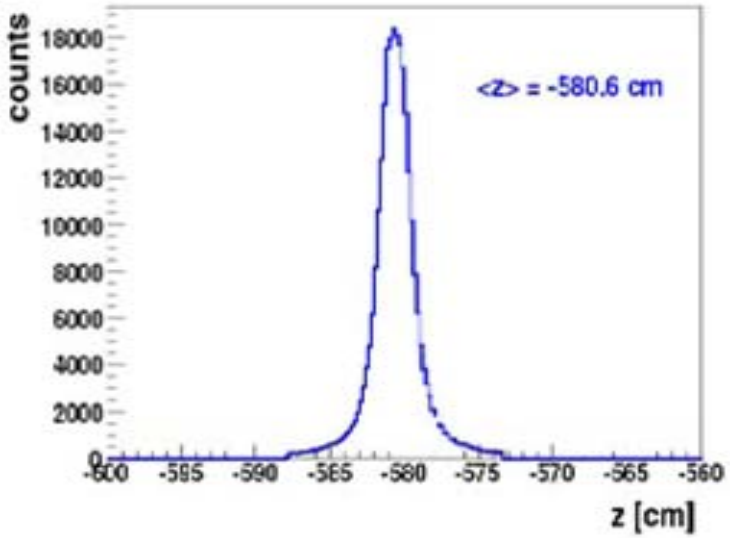


Performance of the NA61 detector

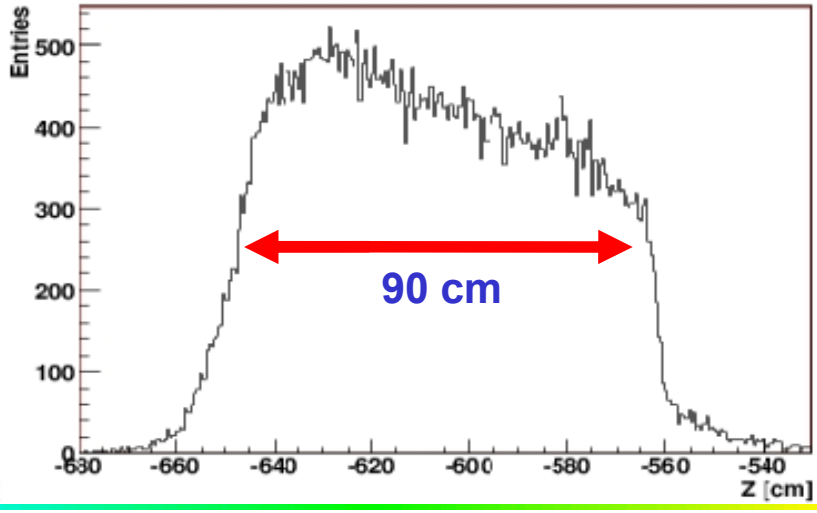
Momentum fit



Vertex fit



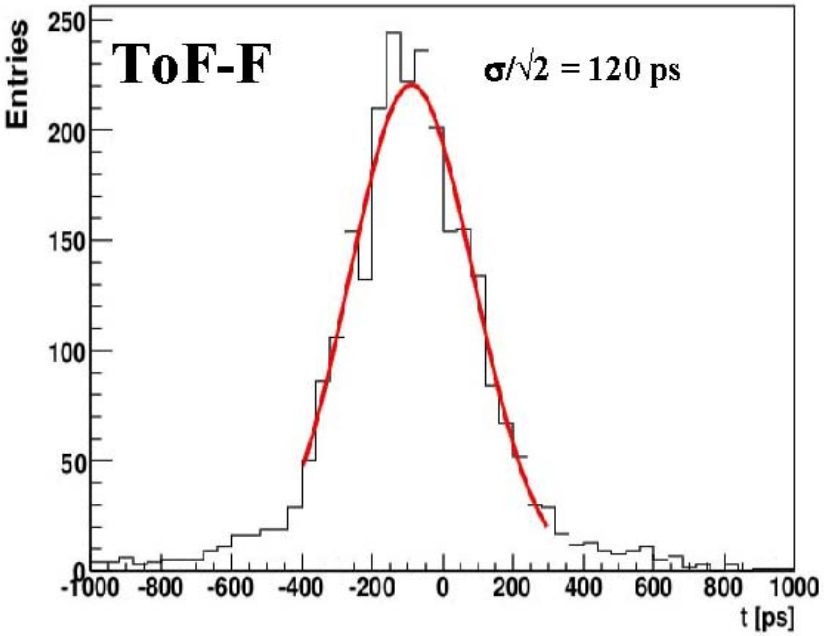
T2K replica vertex fit



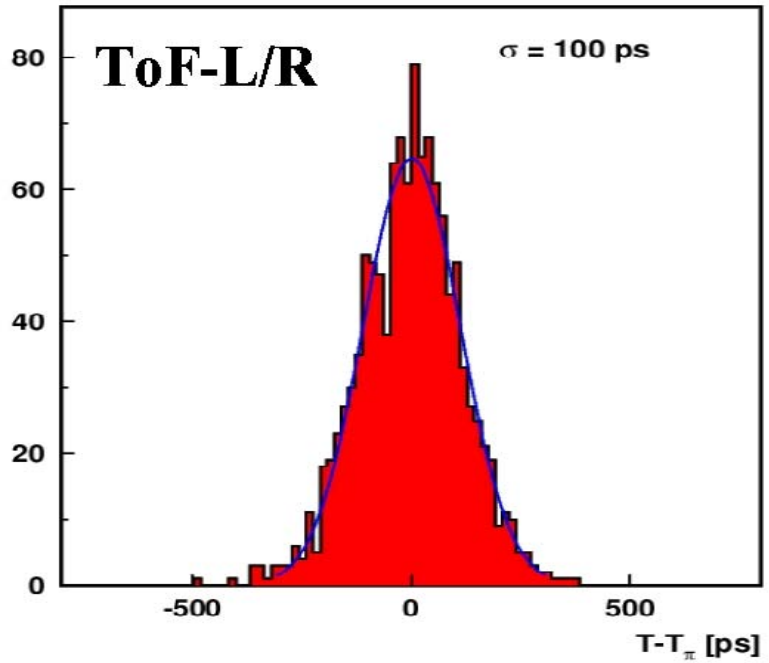
Performance of the NA61 detector

ToF-F and ToF-L/R resolution after calibration for:

-detector geometry
-time off-set



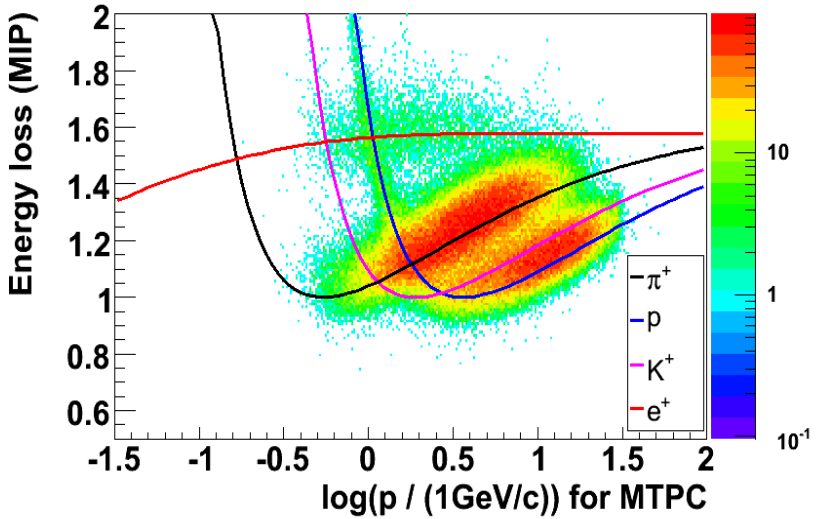
time difference between two overlapping scintillators



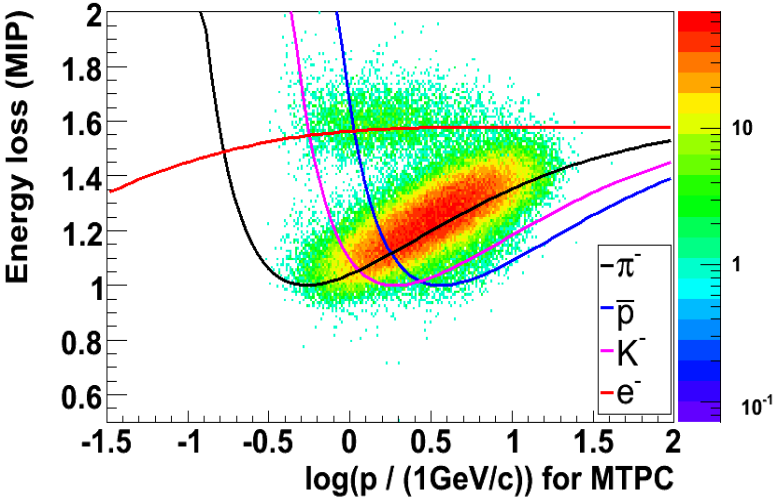
time difference between measured and calculated values

Performance of the NA61 detector

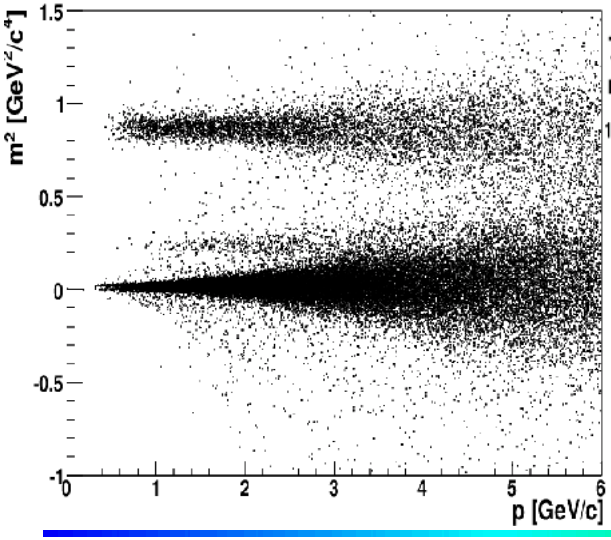
Positive tracks



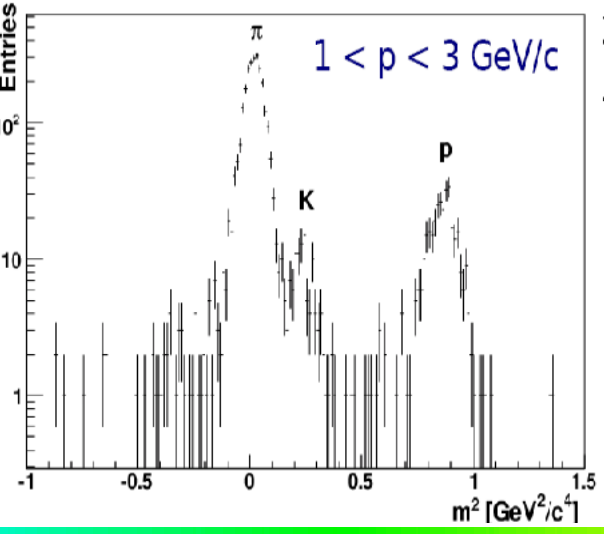
Negative tracks



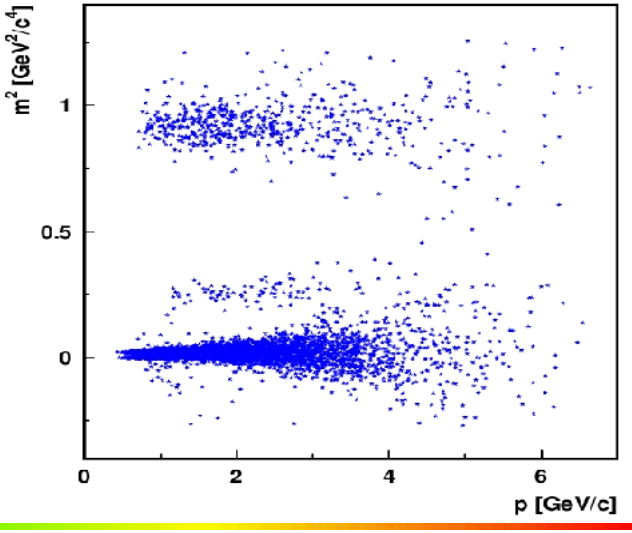
ToF-F calibrated spectrum



Mass-squared from ToF-F



ToF-L/R calibrated spectrum



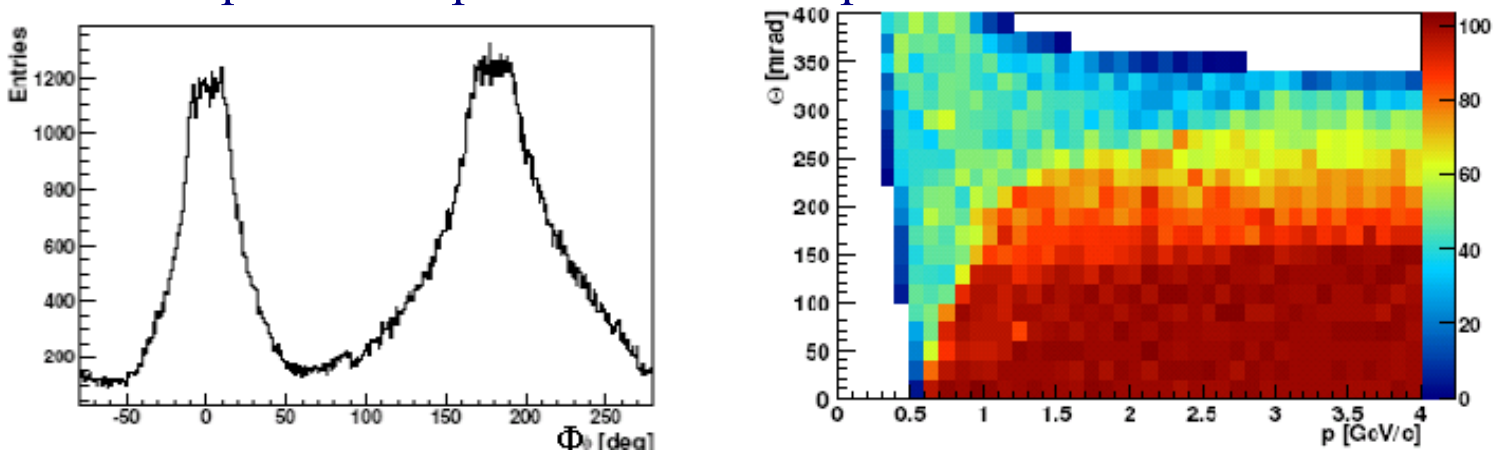
Status of the simulation

The simulation chain includes:

- event generation: primary interaction (VENUS,…)
- particle propagation through the detector (GEANT 3.21)
- distortions and TPC digitization
- embedding of simulated raw data into real events
- reconstruction of the simulated data

→ the corrections to the raw spectra → acceptance

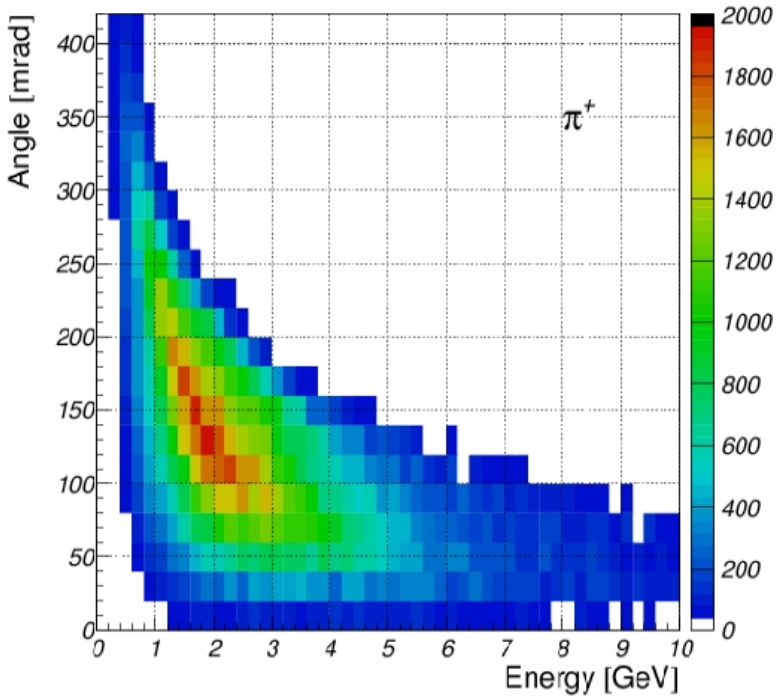
Example of acceptance studies for positive tracks in all TOFs



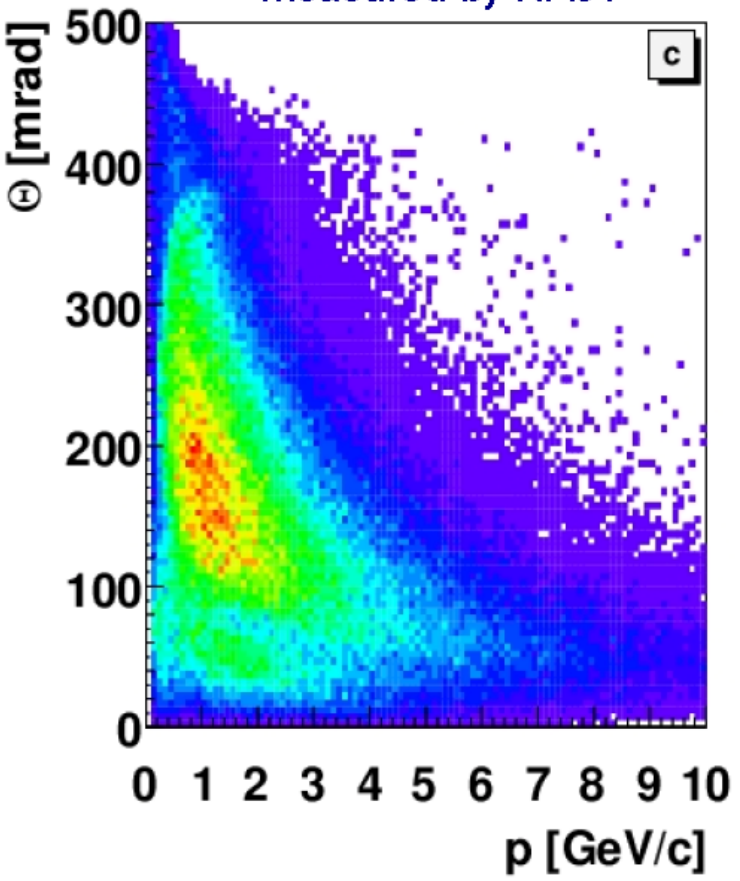
Status of the analysis

Negatively charged hadrons

Pions which produce neutrinos measured by Super-Kamiokande

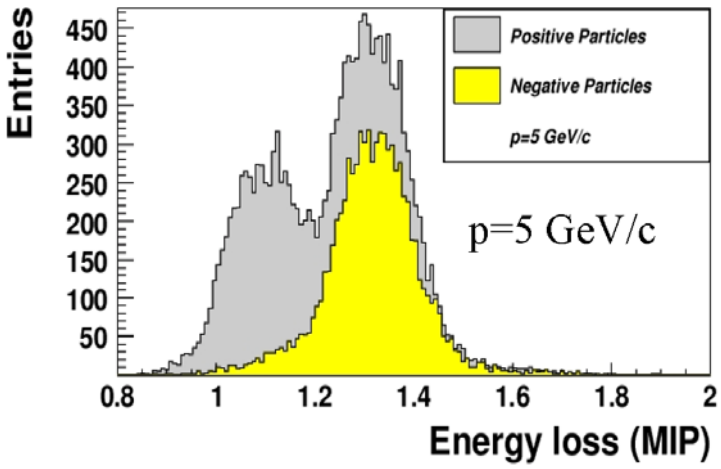


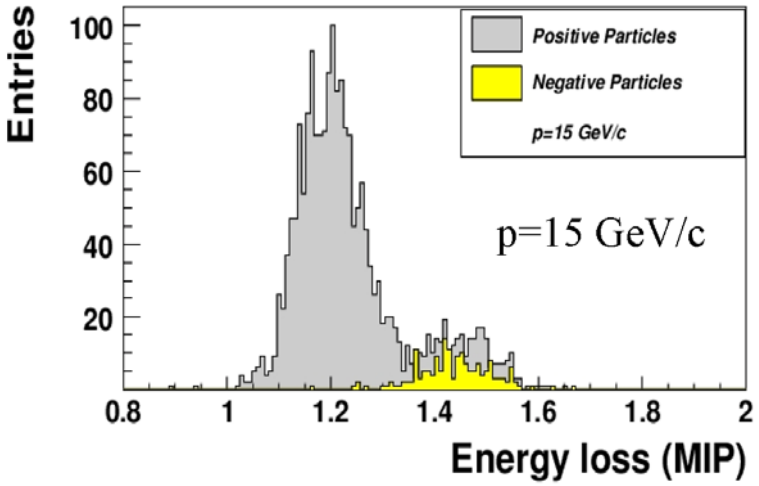
Raw distribution of negatively charged hadrons measured by NA61



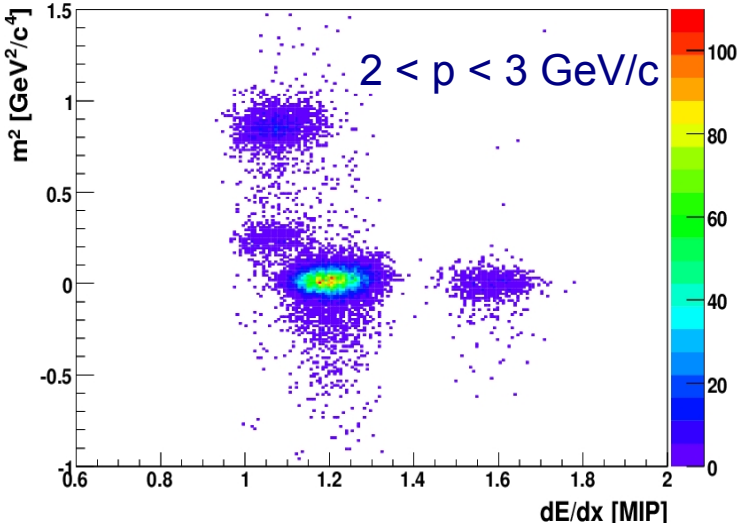
π^- = h^- - small (5%) corrections

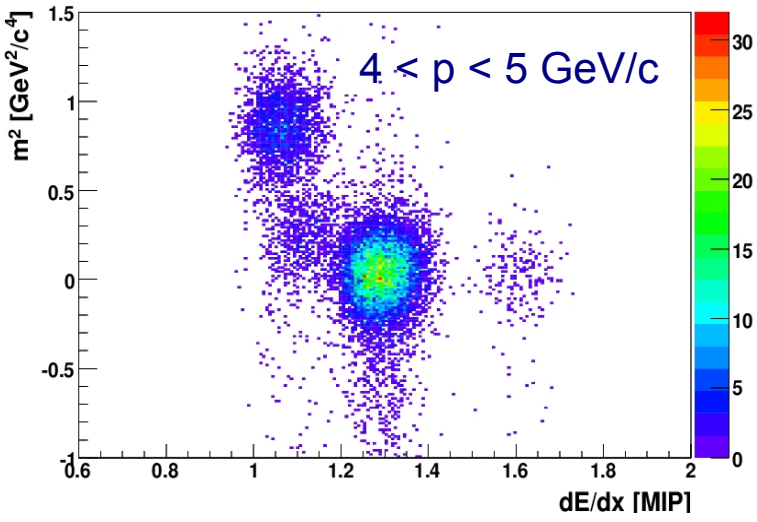
Status of the analysis





- dE/dx resolution ~ 4-5 %

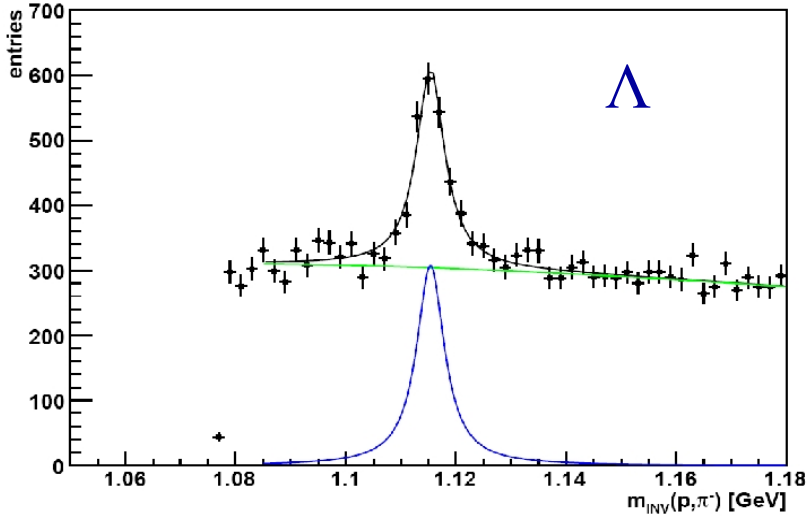


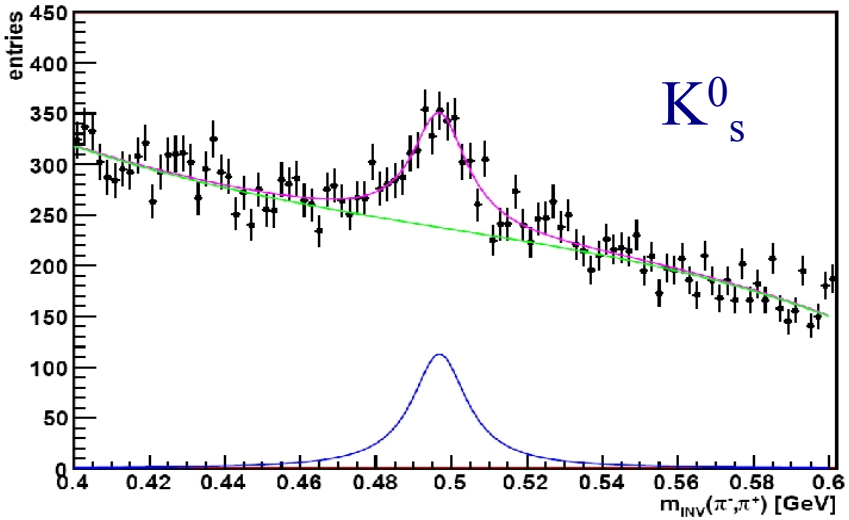


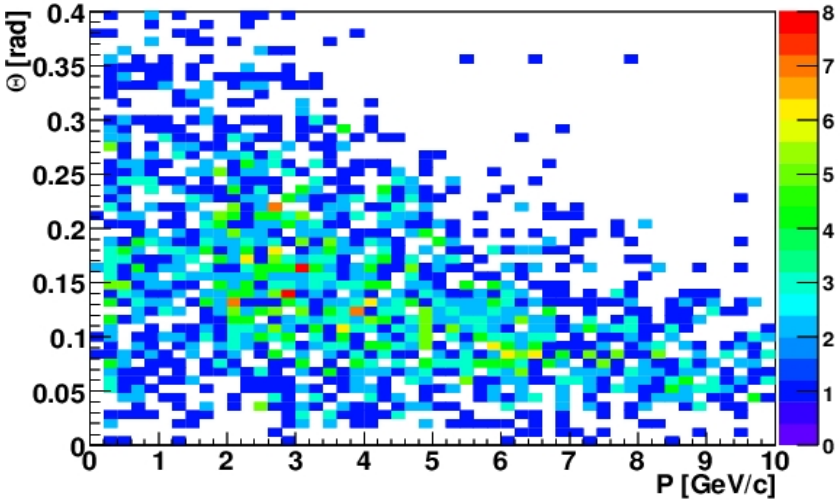
- particle identification by combined dE/dx and tof measurements

Status of the analysis

Invariant mass spectra for V^0 candidates







V^0 raw yield measured by NA61

First physics results from the 2007 run are expected soon

Data taking plans

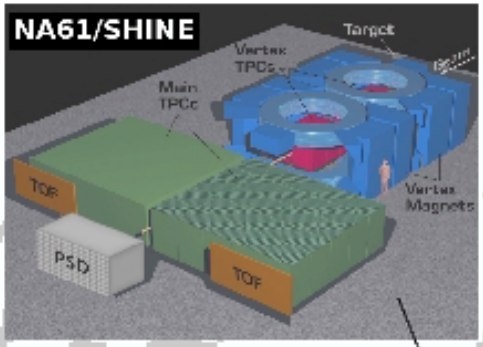
2009: August 12 to November 16

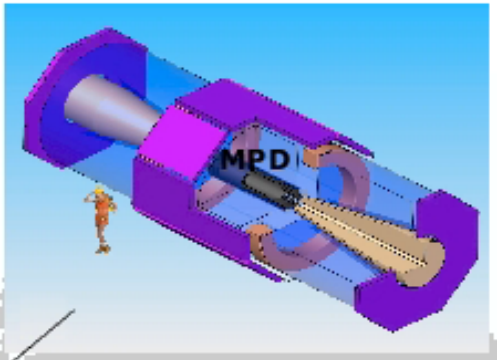
p+C at 31 GeV/c	3 weeks (T2K)
π+C at 158, 300 GeV/c	2 weeks (C-R)
p+p at 6 energies	6 weeks (SIM)
p+p at 158 GeV/c	2 weeks (high pT)

2010:	p+p at 158 GeV/c	11 weeks (high pT)
2011:	30+30 at 6 energies	6 weeks (SIM)
2011:	p+Pb at 158 GeV/c	6 weeks (high pT)
2012:	10+10 at 6 energies	6 weeks (SIM)
2012:	p+Pb at 6 energies	6 weeks (SIM)
2013:	100+100 at 6 energies	6 weeks (SIM)
2013:	…	

6 energies*: *10, 20, 30, 40, 80, 158 GeV/c

Complementary programs of AA collisions





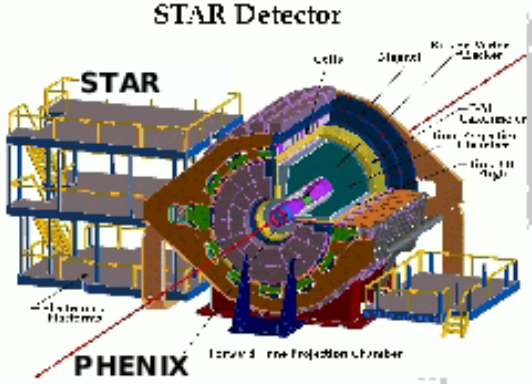
NICA

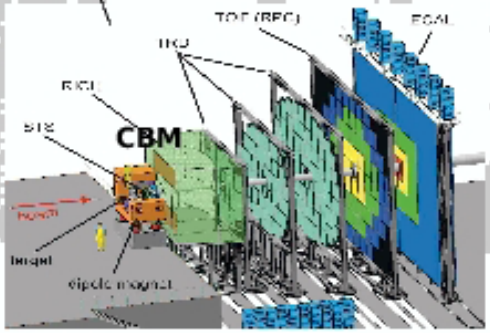
SIS

SPS

RHIC

STAR Detector





Summary

The NA61/SHINE program gives the unique opportunity to reach exciting physics goals in a very efficient and cost effective way

It has the potential to discover the critical point of strongly interacting matter and guarantees a broad set of important precision measurements

It is complementary to the efforts of other international and national laboratories, FAIR, JINR, KEK and RHIC and to the heavy ion program at the CERN LHC

It is of common interest for different physics communities, heavy ions, neutrino and cosmic-rays

Thank you for your attention