High-pt physics in

The NA61

SPS Heavy Ion and Neutrino Experiment

at CERN SPS

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SHINE/NA61

- Using same detector as the NA49
  - Including some updates
- ½ of the NA49 participant continue working in the NA61
- ½ of the collaboration coming from other fields
  - Neutrino physics
  - Cosmic ray physics

Physics goals (I):

Physics of strongly interacting matter

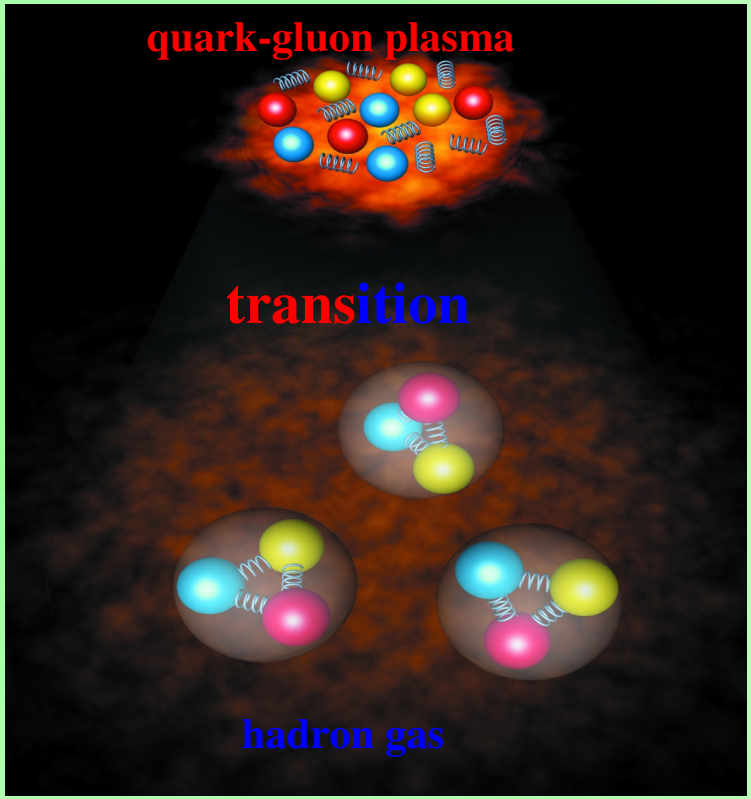
Discovery potential:

Search for the critical point of strongly interacting matter

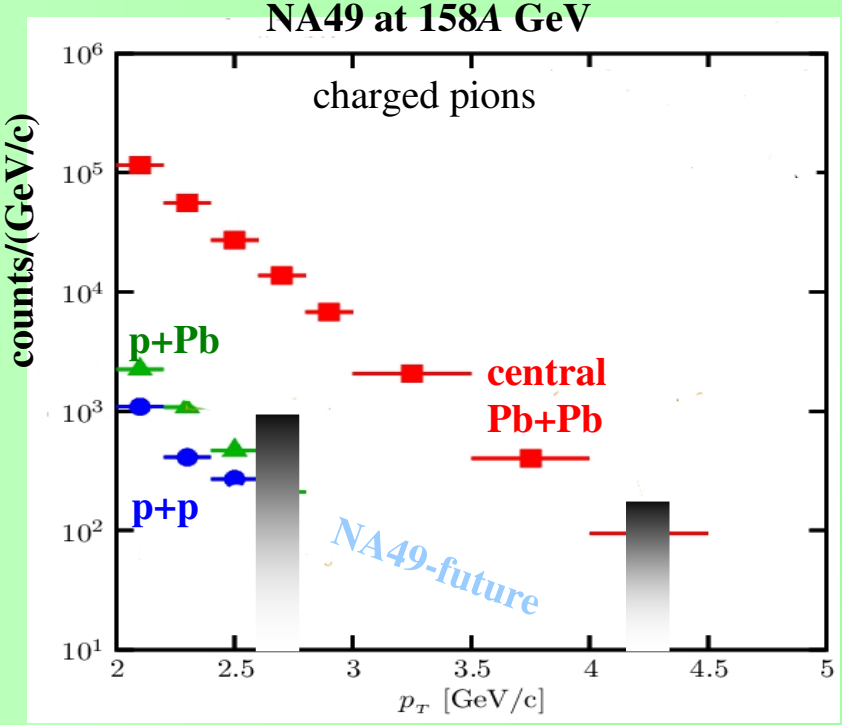
Precision measurements:

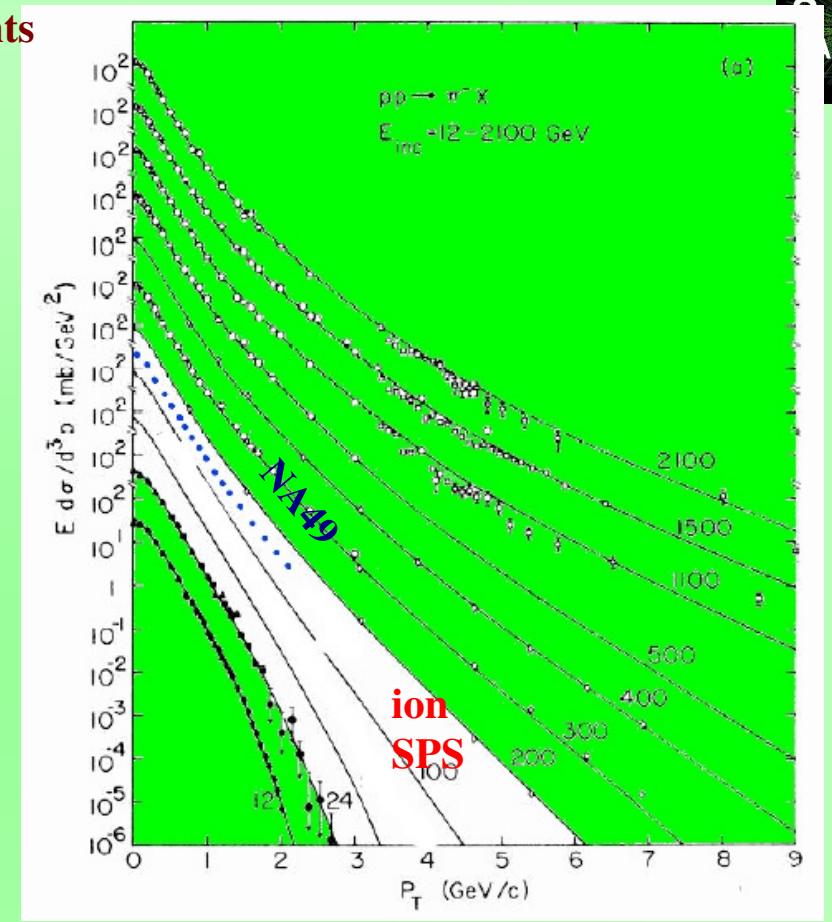
Study the properties of the onset of deconfinement in nucleus-nucleus collisions

Measure hadron production at high transverse momenta in p+p and p+Pb collisions as reference for Pb+Pb results



NA49 and other CERN SPS experiments measured high pT spectra in central Pb+Pb collisions up to 4.5 GeV/c





Bieser et al., Phys. Rev. D18, 2235 (1978)

The p_T spectra in p+p and p+Pb interactions at the ion SPS energies are measured only up to 2.5 GeV/c

NA49-future intends to measure the missing high p_T spectra in p+p and p+Pb interactions. Study of the high p_T correlations and centrality dependence will be also possible.

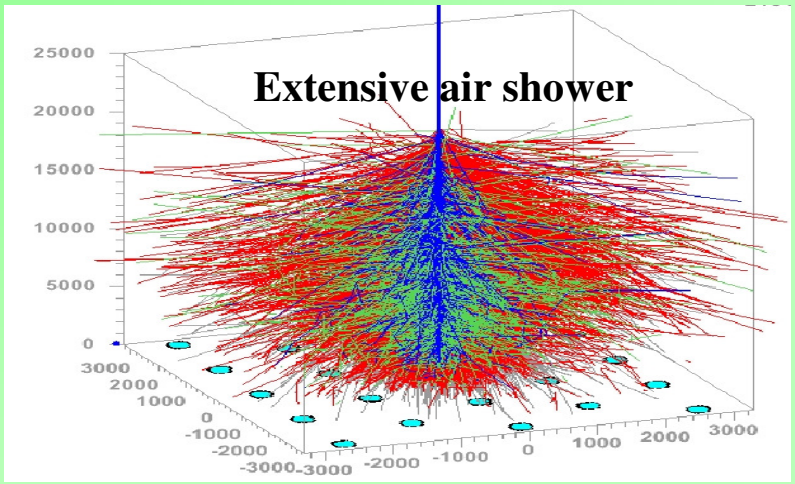
Physics goals (III):

Data for neutrino and cosmic ray experiments

Precision measurements:

Measure hadron production in the T2K target needed for the T2K (neutrino) physics

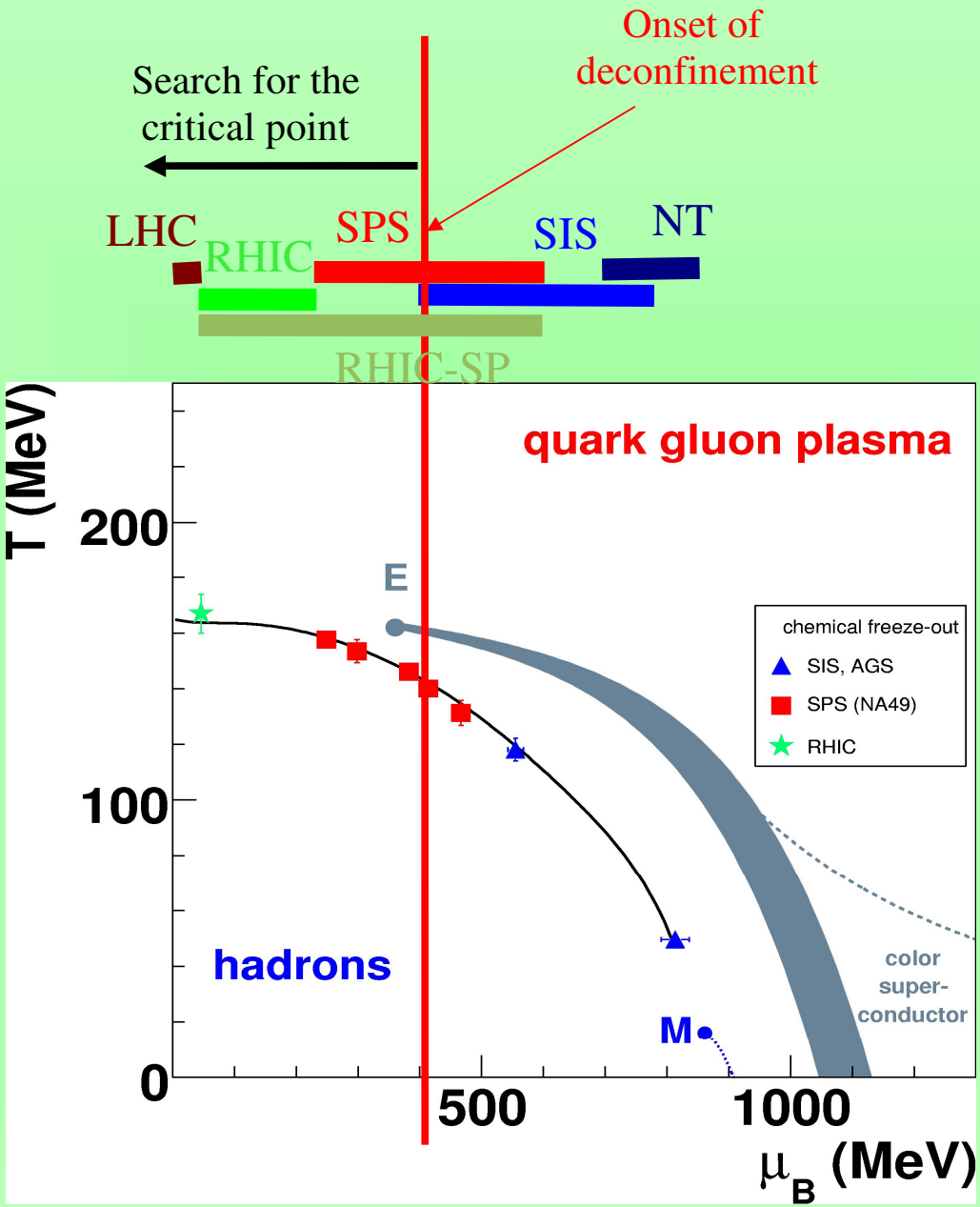
Measure hadron production in p+C interactions needed for T2K and cosmic-ray, Pierre Auger Observatory and KASCADE, experiments



What and how we want to measure?

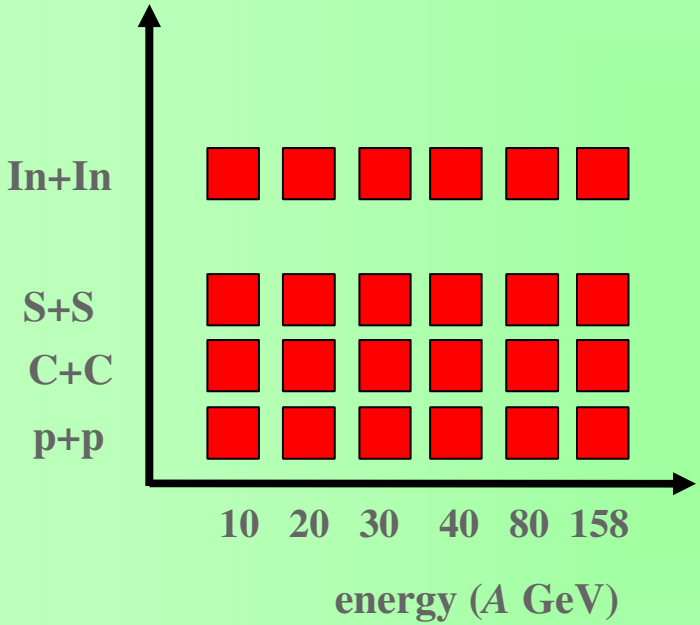
High pT in the NA61

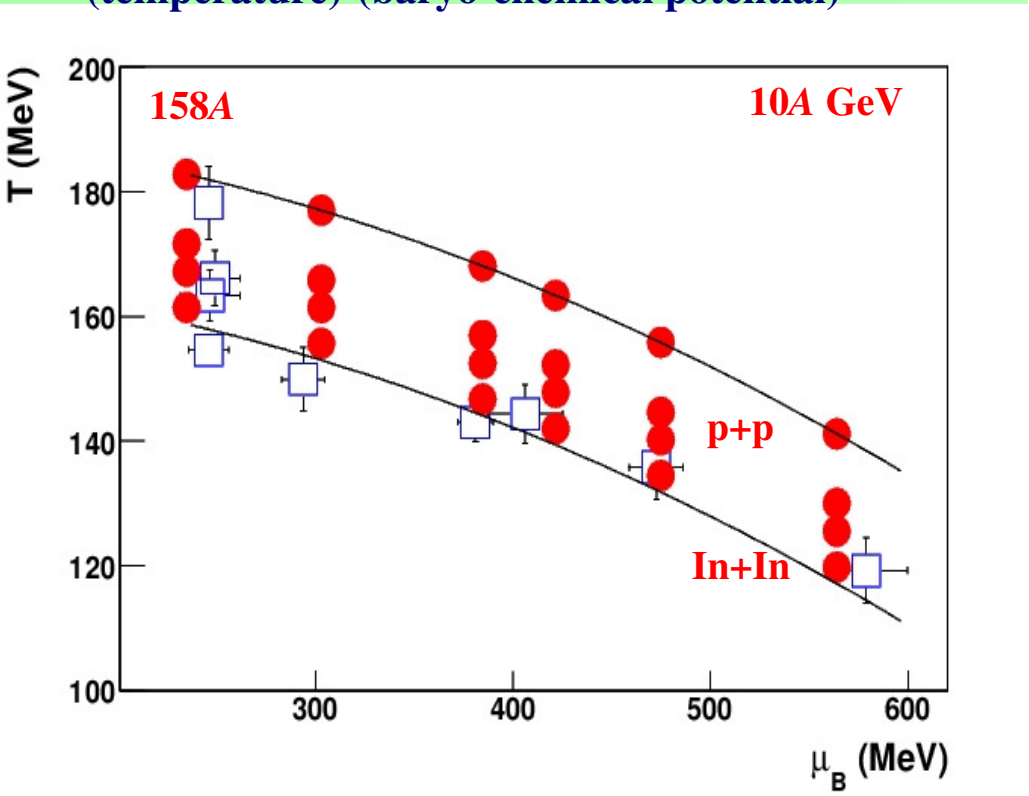
- No special trigger for high pT → We need high statistics
  - Planed to measure p+p and p+Pb reactions with a statistics minimum 50 M events → measured cross section until 4-4.5 GeV/c
  - Physics results and status in the next presentation of András László


Search for the critical point
Onset of deconfinement
LHC
RHIC
SPS
SIS
NT
RHIC-SP
quark gluon plasma
T (MeV)
200
100
0
E
chemical freeze-out
SIS, AGS
SPS (NA49)
RHIC
hadrons
color super-conductor
M
500
1000
μB (MeV)

may lead to discovery of the critical point of strongly interacting matter by an observation of a hill of fluctuations in two dimensional plane (energy)-(system size) or equivalently (temperature)-(baryo-chemical potential)

New data to register by NA61/SHINE





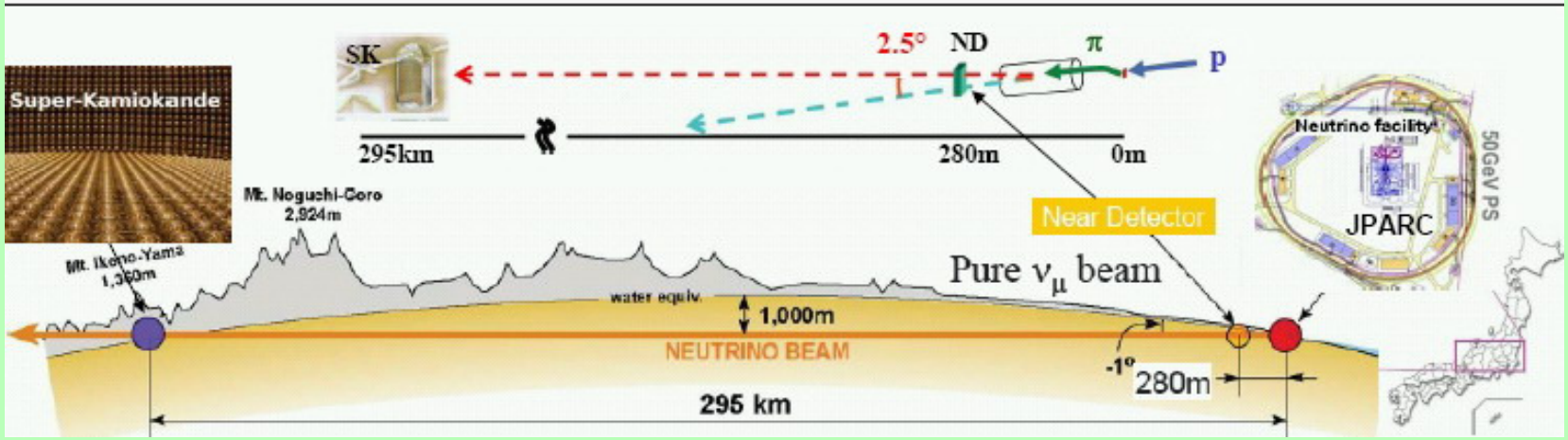
In particular the critical point should lead to an increase of multiplicity and transverse momentum fluctuations

Fluctuations and CP: Stephanov, Rajagopal, Shuryak, Phys. Rev. D 60, 114028
Freeze-out points: Becattini et al., Phys. Rev. C 73, 044905

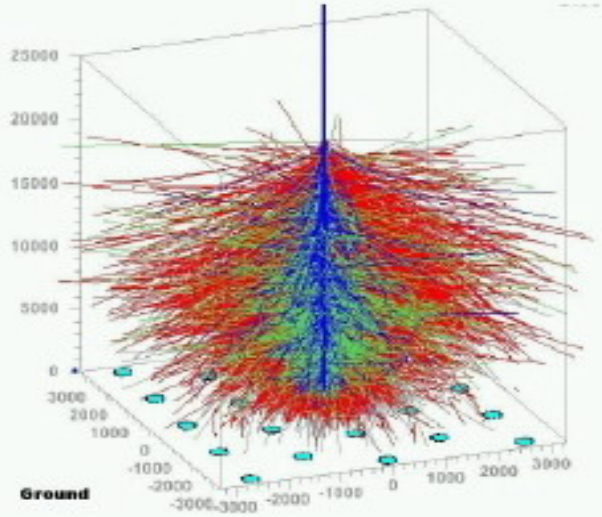
- One of the main physics goals of NA61/SHINE:

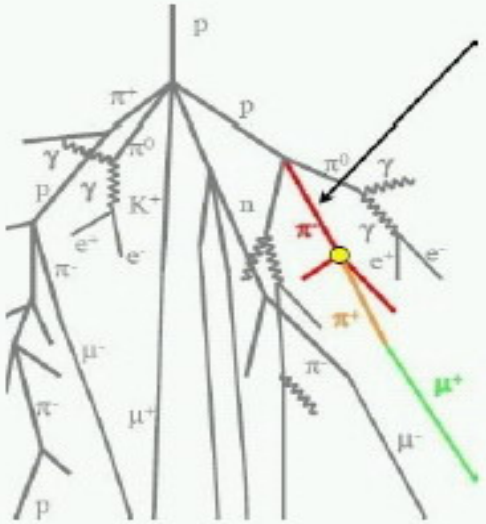
> Precision measurements of hadron production
>
> for the prediction of ν-fluxes at T2K

- T2K @ JPARC (Japan):
  - Long baseline (295km) neutrino oscillation experiment
  - Protons (30-50GeV) + carbon target (90cm) → intense off-axis ν_μ–beam
  - Neutrino spectra measured at the near and far detectors: ND280 and SK



Cosmic-ray experiments: detecting cosmic-rays by extensive air showers.





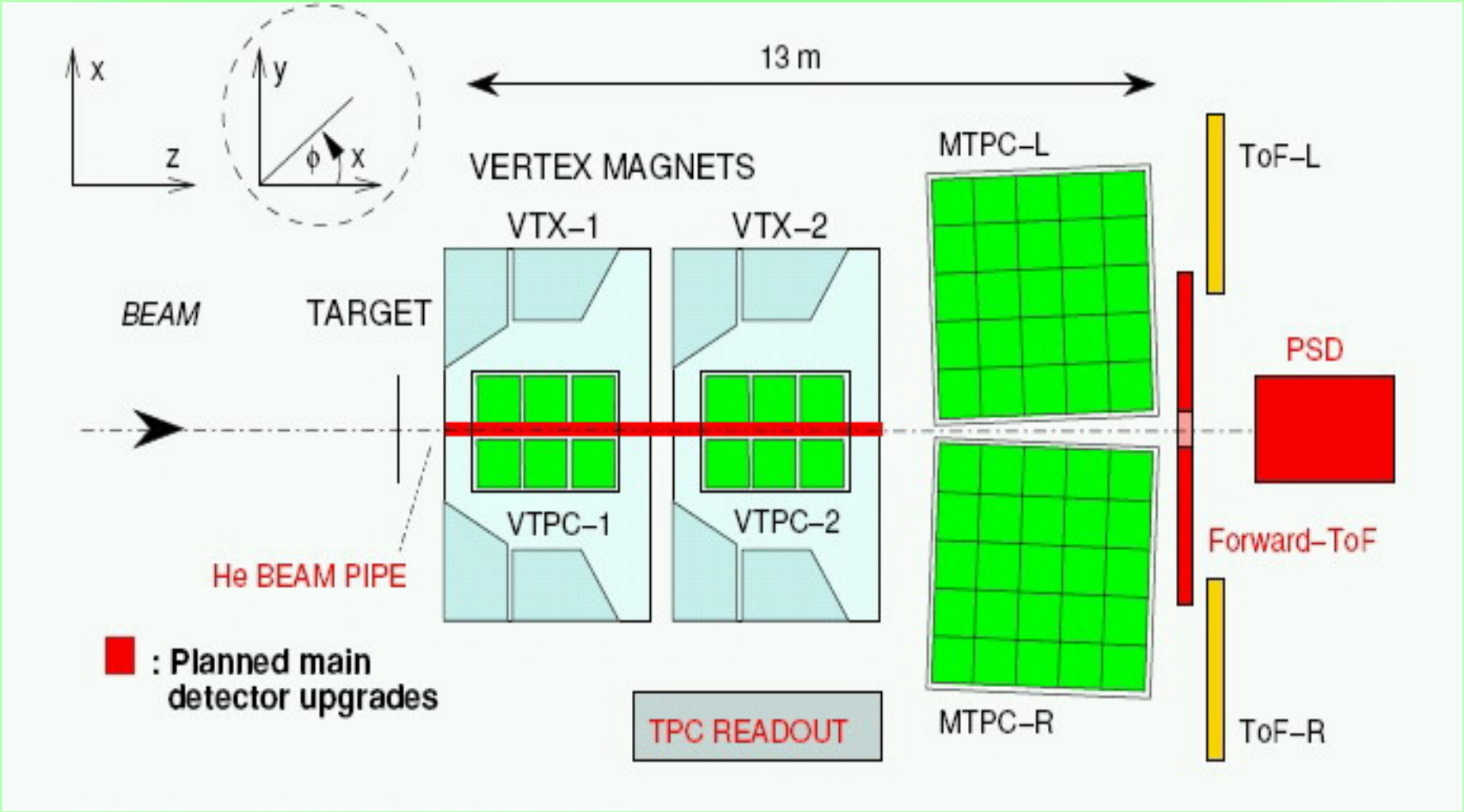
Showers are detected by large lateral coverage ground detector arrays.

$\Rightarrow$ Shower simulations needed.

These are sensitive to $\mu^{\pm}$ production in cascades.

$\mu^{\pm}$ production is mainly related to the $p, \pi + C \rightarrow \pi, K + X$ production at SPS energies (through π, K decay). NA61 will measure it.

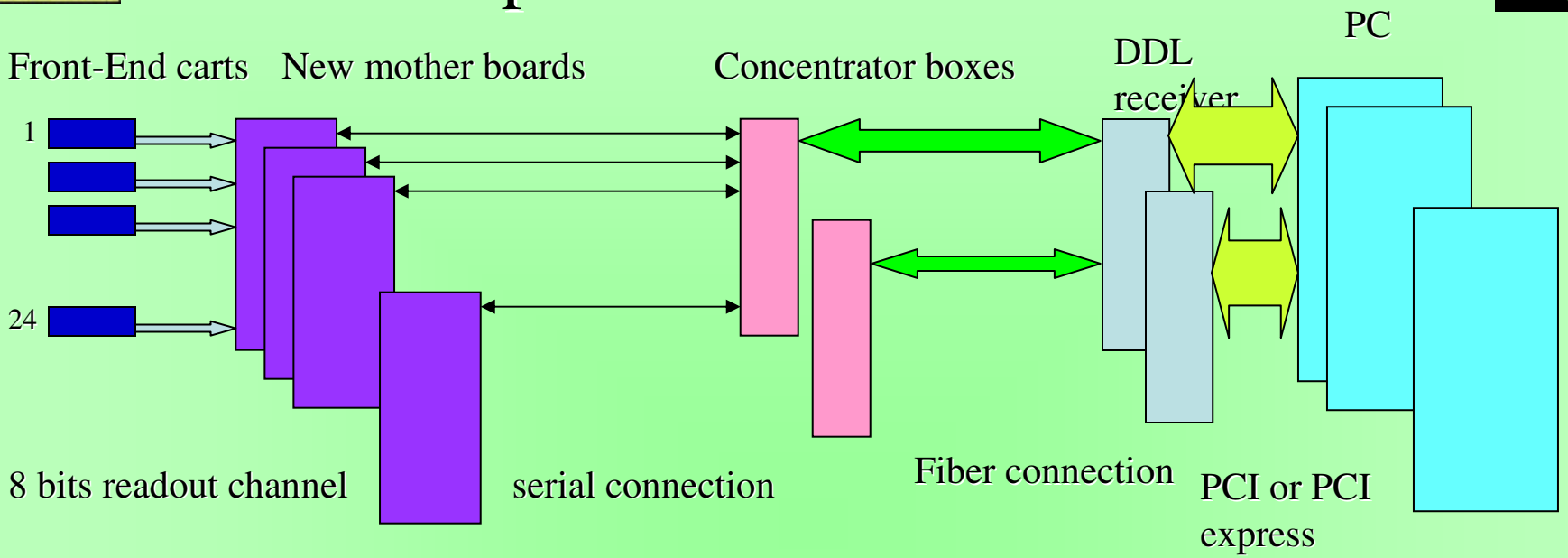
NA61 Setup


x
z
y
ϕ
x
13 m
VERTEX MAGNETS
VTX–1
VTX–2
MTPC–L
ToF–L
BEAM
TARGET
PSD
VTPC–1
VTPC–2
Forward–ToF
He BEAM PIPE
: Planned main detector upgrades
TPC READOUT
MTPC–R
ToF–R

Required updates

- For the high statistics with a very large combination of projectiles, targets and energies and high precision cross-section measurements →faster readout and DAQ
- For the better measurement of centrality for decreasing the detector effects on the fluctuations →new veto detector /Projectile Spectator Detector/
- For the particle ID in the full measured phase space mainly at lower beam energies → new TOF in the forward direction
- Reduce the background in the HI exp. → Modification of the Vertex TPC -> He sac in the TPC to reduce the delta electrons with higher beam intensity

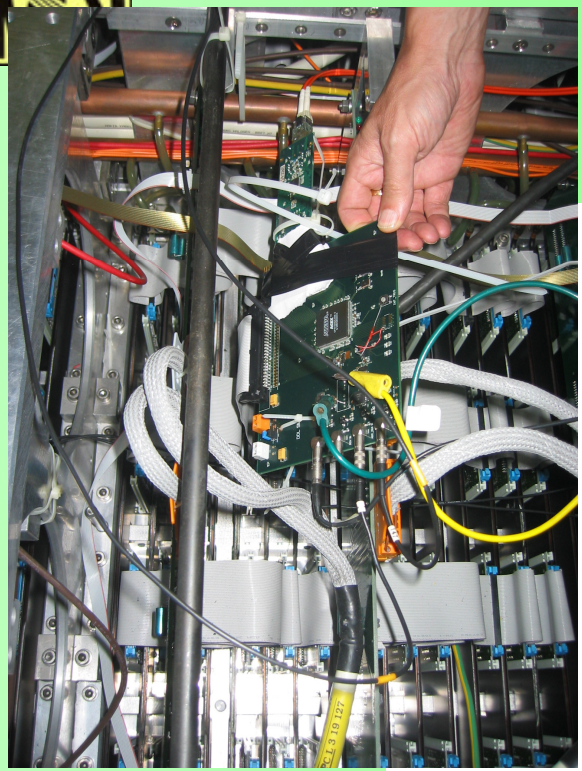
Proposed Readout Scheme

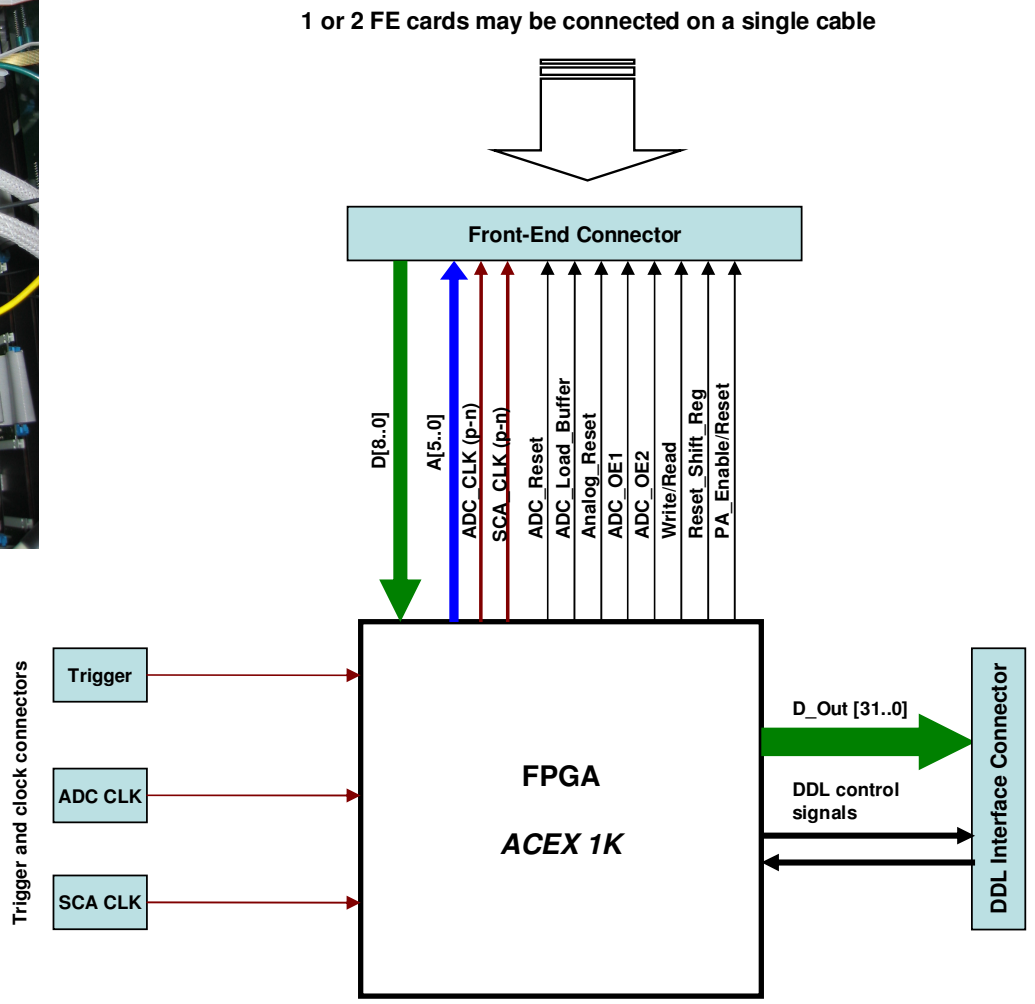


Present: 170 k events/day

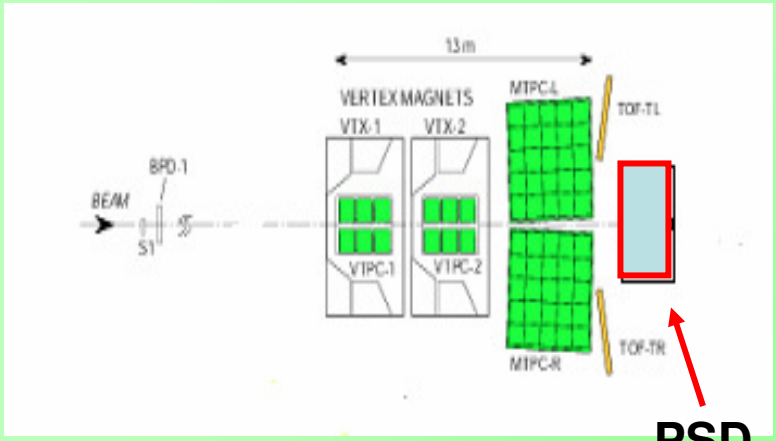
After modification: 1.7M events/day

FE Tester card

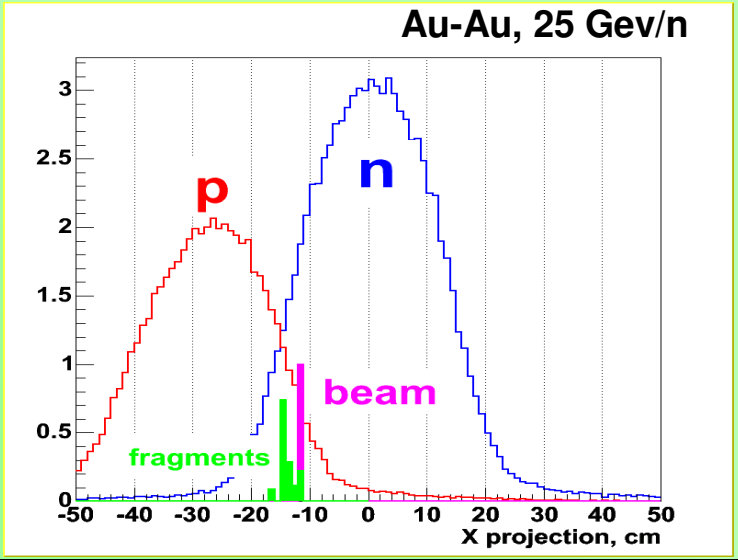


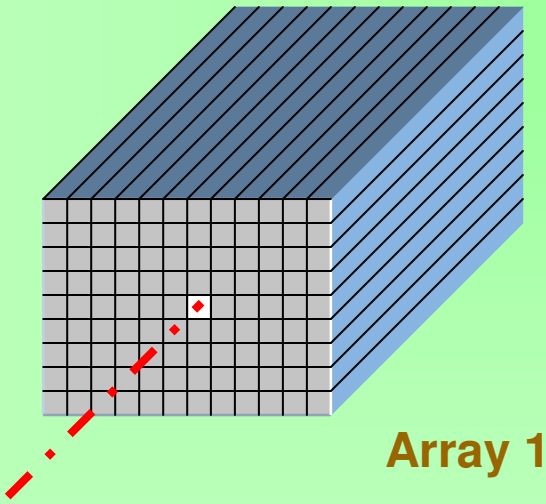


Spectators transverse spot sizes on PSD
(simulation)



PSD





Array 12 x9

(108 modules)

Z	Xcal, (cm)	Ycal, (cm)
10 GeV (z=20m)	200	160
25 GeV (z=20m)	120	90
160 GeV(z=20m)	70	50
10 GeV (Z=15m)	110	100

PSD (VETO) detector structure

PSD 120x90x124.8 cm
(107 Modules)

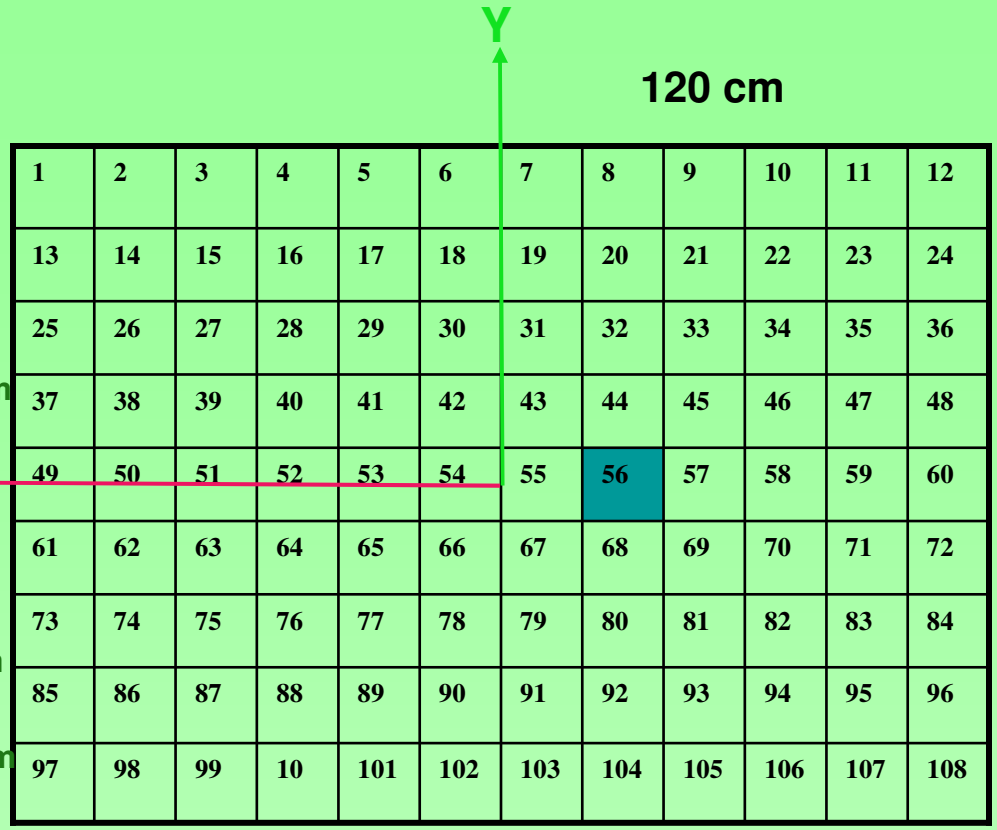
Module 10x10x124.8 cm
(107 modules, Iron)

"Iron" 9.7x9.9x2 cm
(2 slices / module)

"Tyvec" 9.7x9.9x0.02 cm
(120 slices / module)

"Scint." 9.66x9.86x0.4 cm
(60 slices / module)

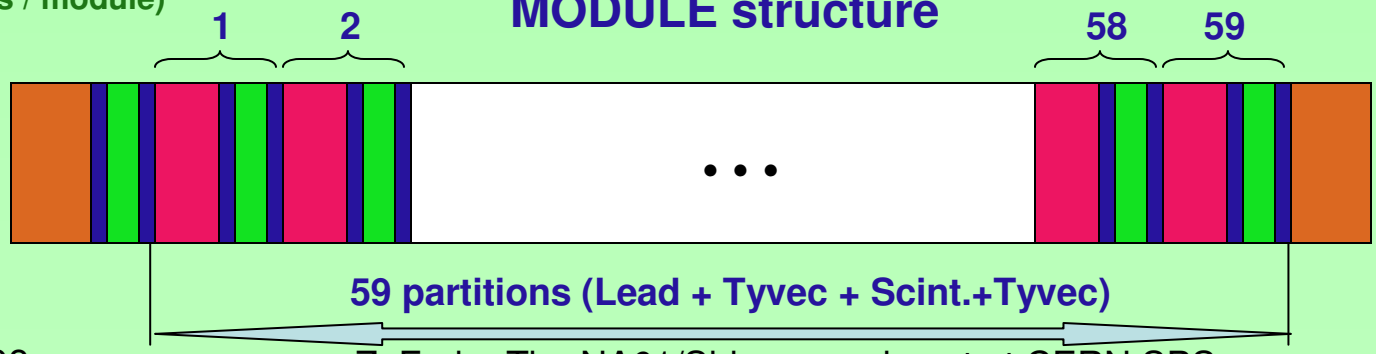
"Lead" 9.7x9.9x1.6 cm
(59 slices / module)



HOLE is located at module 56 position

Each "Scint" slice is covered with "Tyvec"

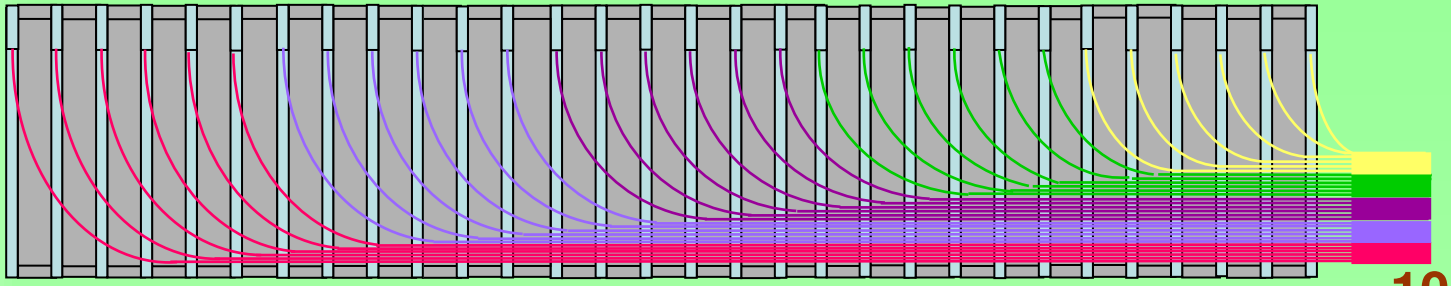
MODULE structure



The PSD general conception

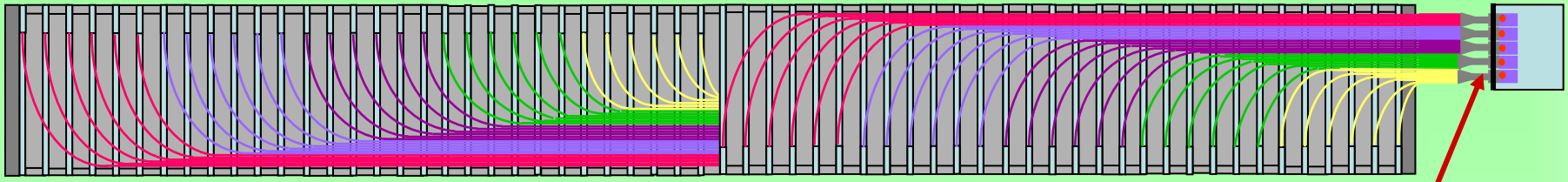
(I) Light readout from scintillators

Half of module.

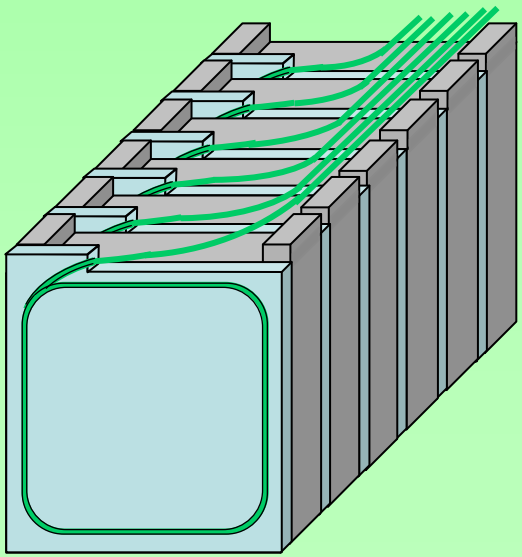


6 fiber/MAPD
10 MAPDs/module

60 lead/scintillator sandwiches.

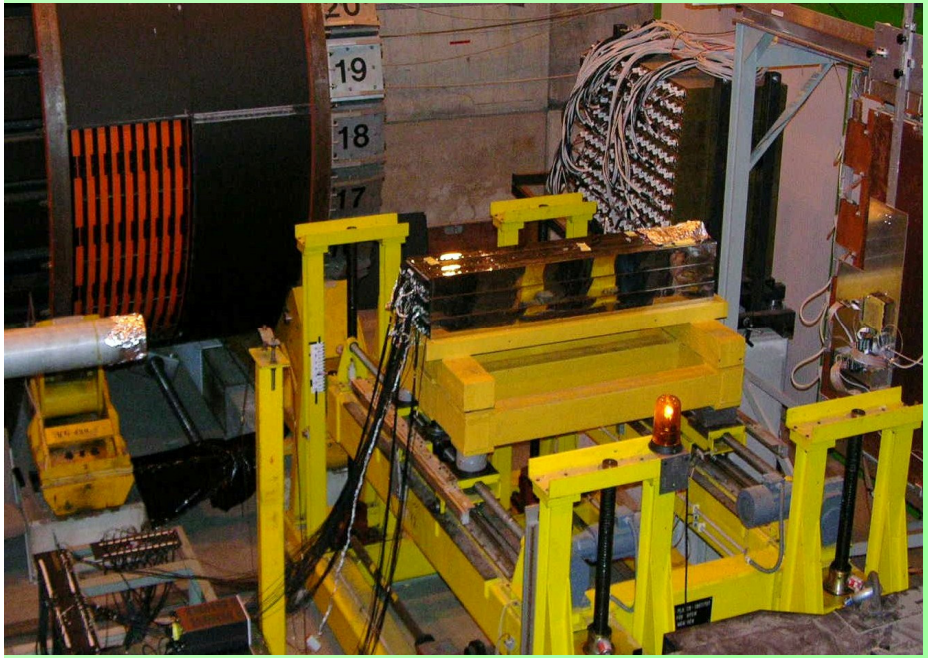


10 Amplifiers
(Gain~40)



PSD supermodule beam test at NA61

(Sept. 27 – October 1, 2007)



Program of measurements:

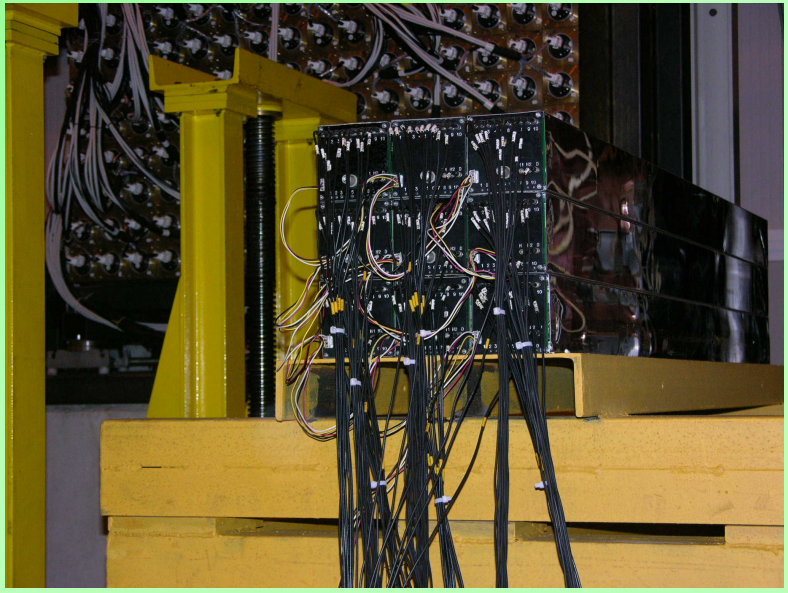
-modules calibration with muon beam;

-study of the response and energy resolution

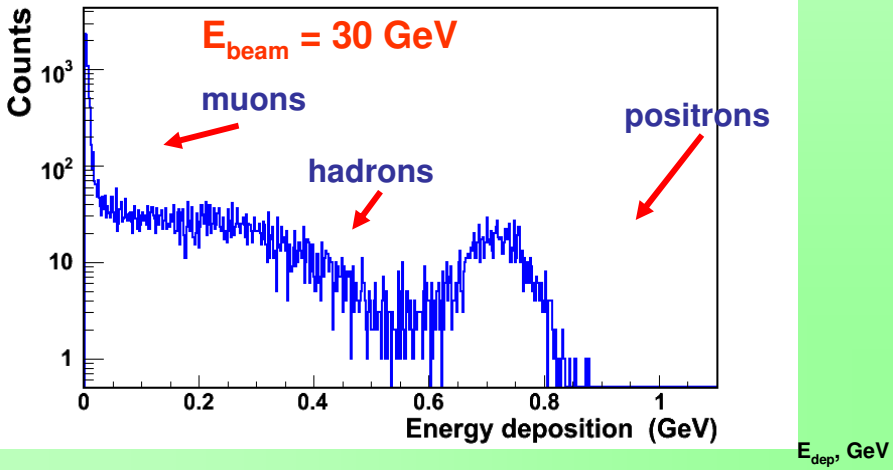
of the PSD on hadron beams 20, 30, 40, 80, 158 GeV/c;

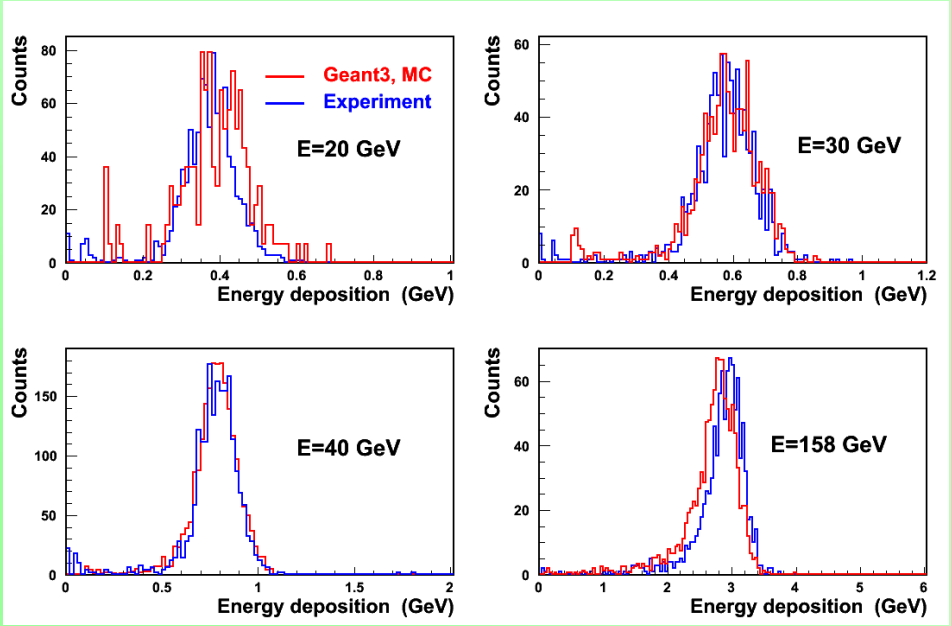
-study of the PSD compensation;

-study of APDs long term stability



Study of e/h ratio





Energy deposition in 1 section

Energy	EXP	SIM
20	1.36	1.13
30	1.22	-
40	1.16	1.09
60		1.10
80		1.10
150		1.11

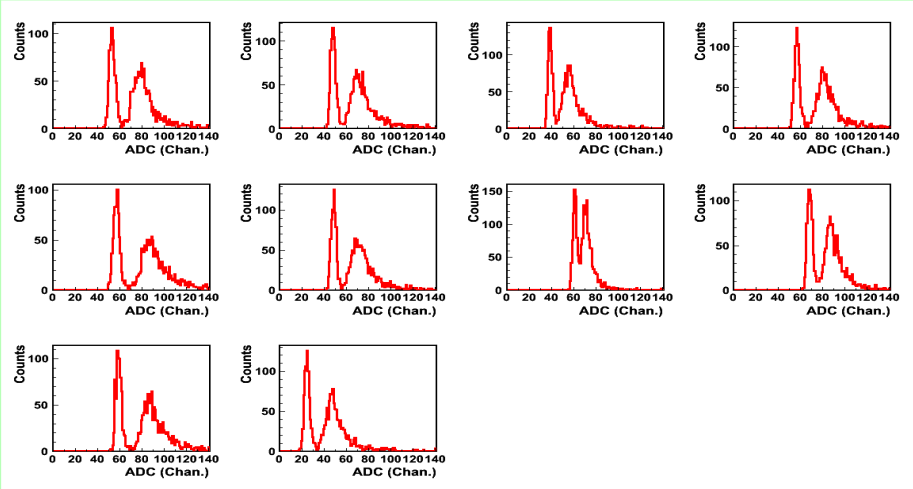
Energy deposition in full supermodule

Energy resolution for positrons at E=30GeV is 6.5%

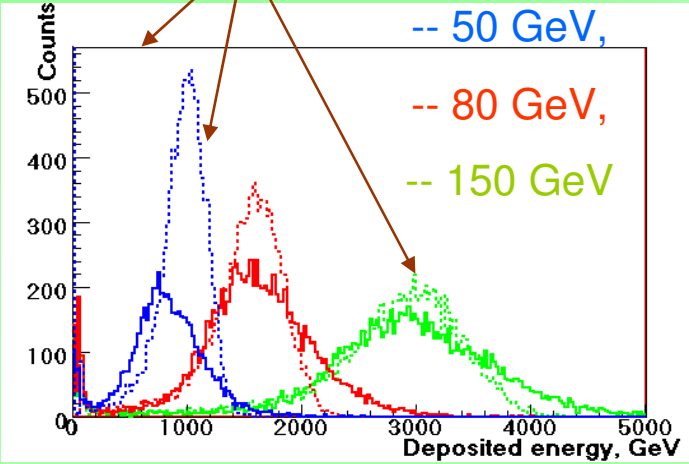
e/h ratio

Results of beam test of first PSD module.

Geant-MC



Energy deposition of muons in each section of the PSD module



MeV

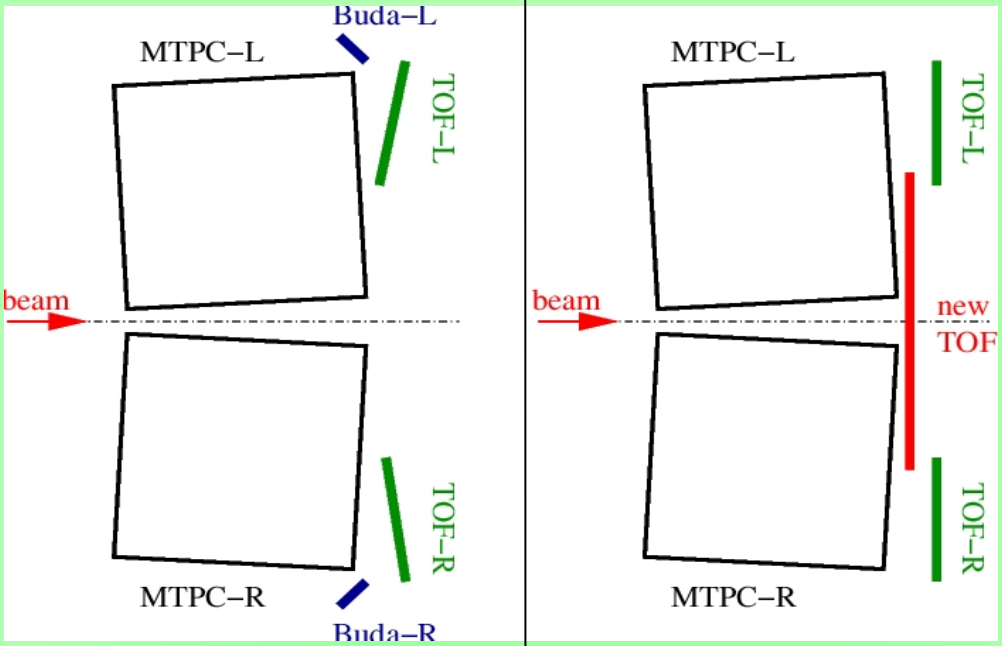
Summary energy deposition in PSD module for different hadron energies.

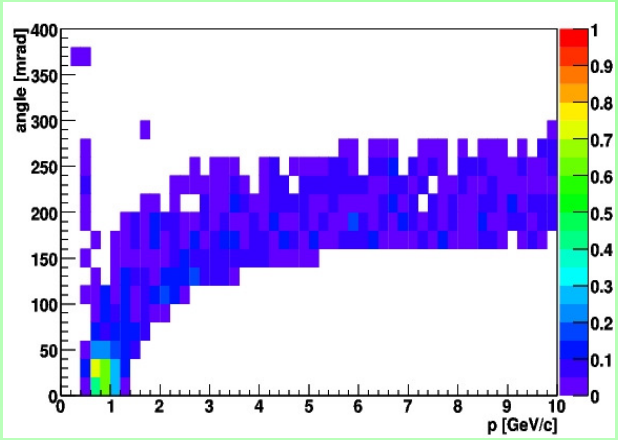
Signal readout revealed a reliable performance during the beam test.

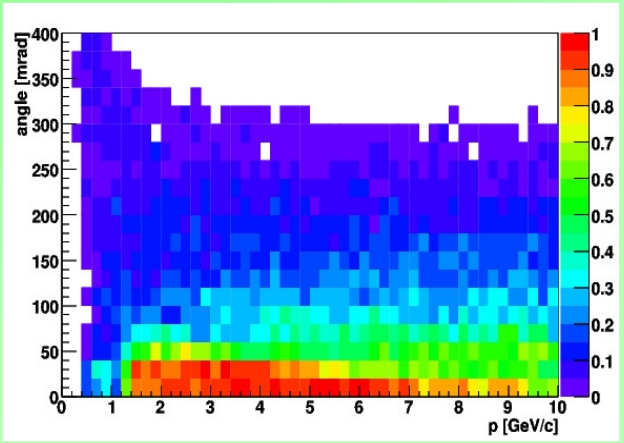
Modification for neutrino running

Construction of the forward TOF:

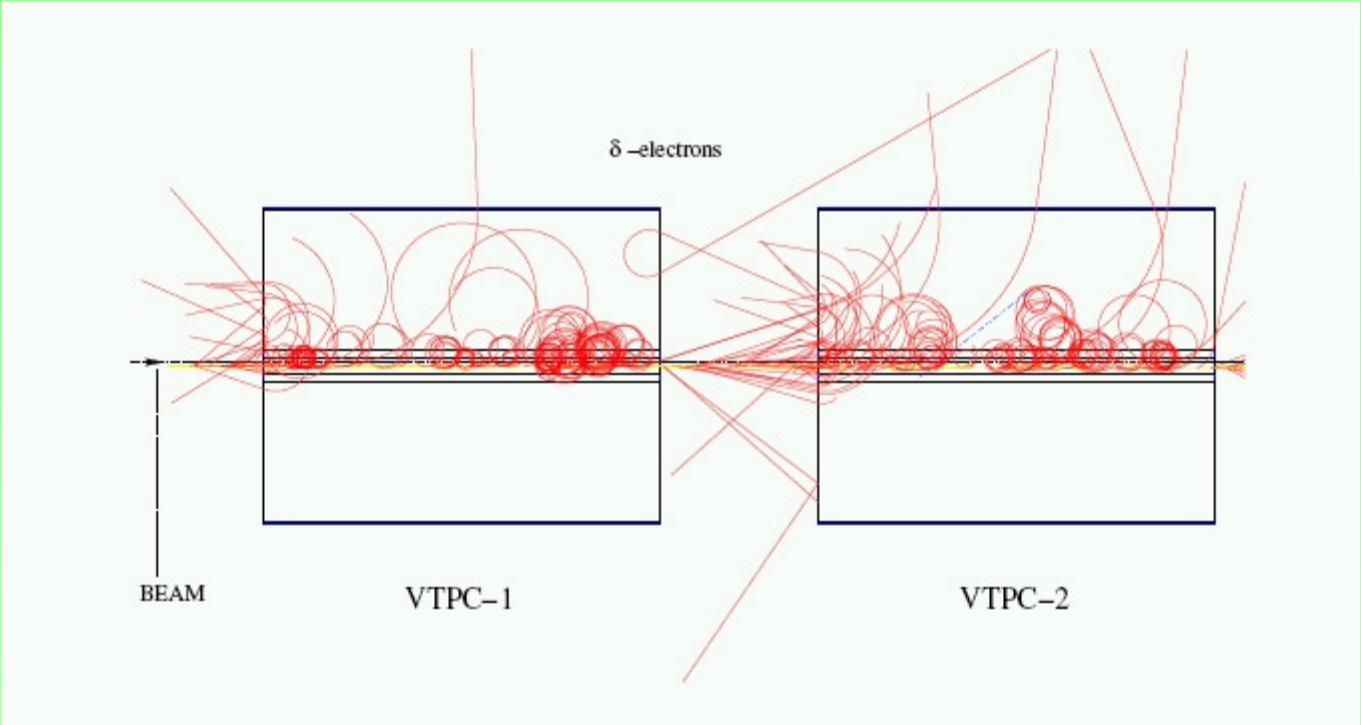
NA49 | **NA61**







Deltas from Hi beam



Proposal for beam request

Year	Beam+target	Energy	#days	Physics
2008	p+C	30		T2K
2008	p+p	158		high pT
2008	π+C	350		Cosmic
2009	p+p	10,20,30,40,80,158	30	CPOD
2009	p+Pb	158	30	high pT
2010	S+S	10,20,30,40,80,158	30	CPOD
2010	p+Pb	10,20,30,40,80,158	30	CPOD
2011	In+In	10,20,30,40,80,158	30	CPOD
2012	C+C	10,20,30,40,80,158	30	CPOD

2008 run aproved

Goals of the run of 2007

- PSD test
- pC cross-section measurement at 31 GeV

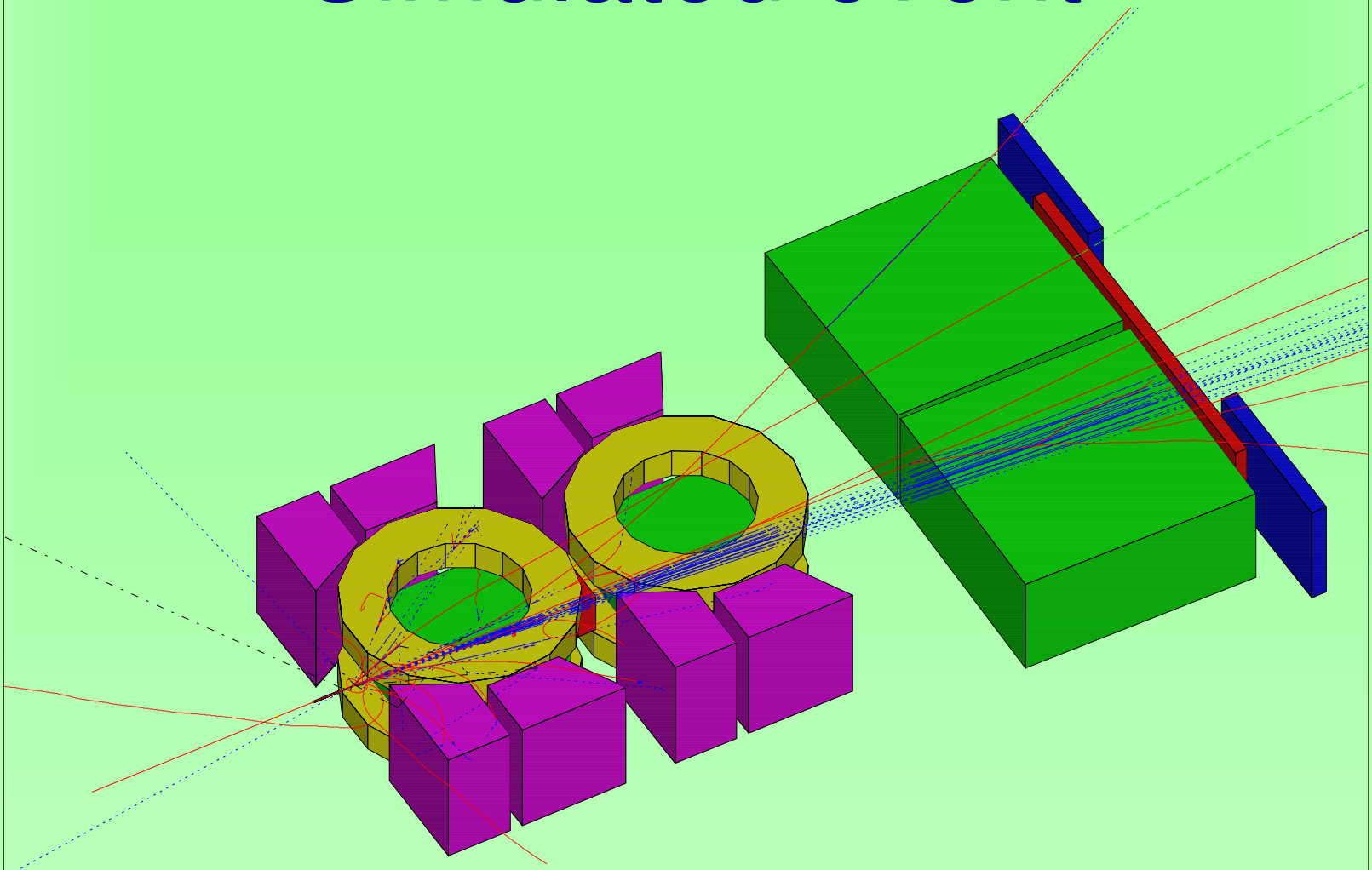
  Measurement of the π, K, .. Production for T2K target

  – Registered 700k pC collisions with thin target

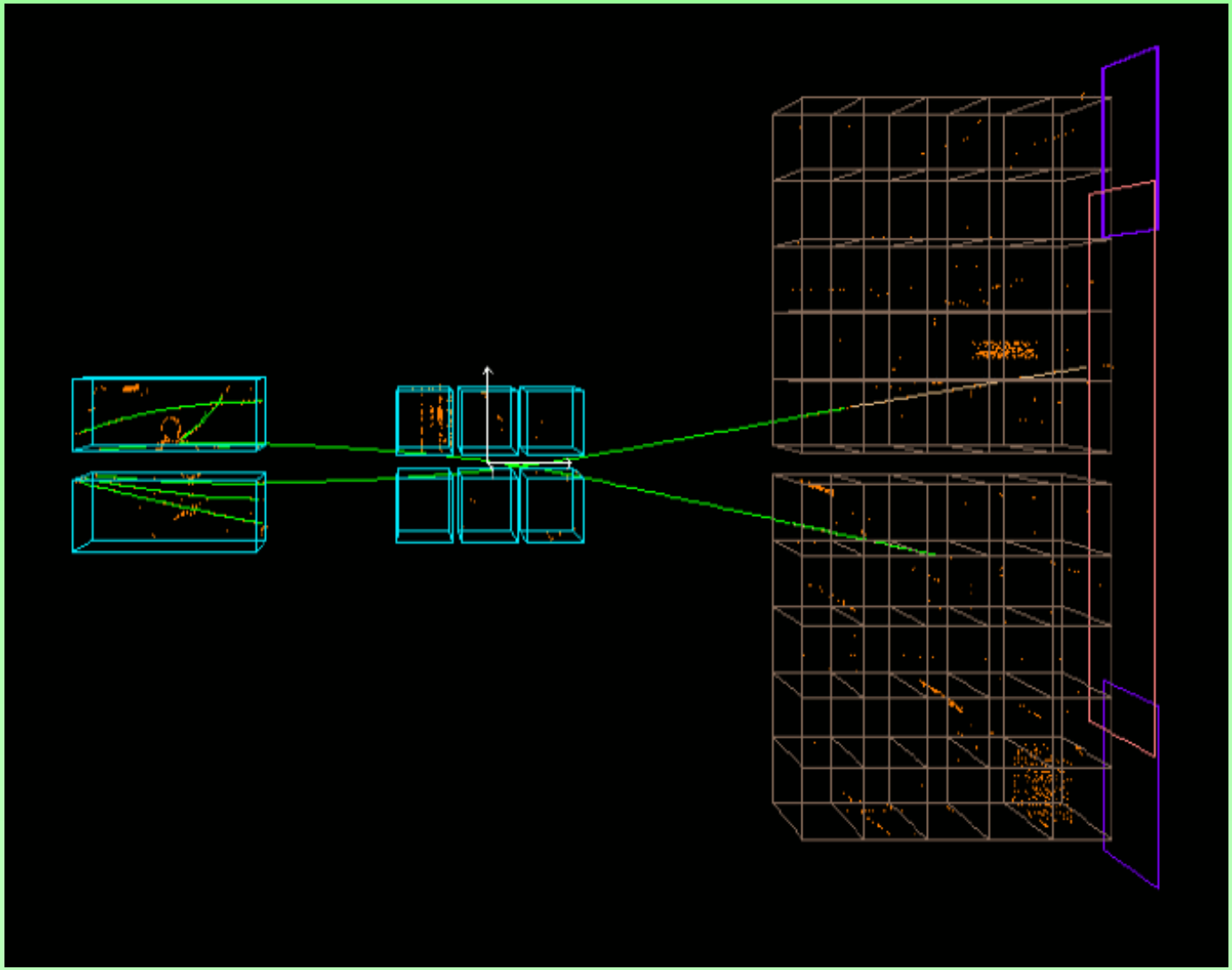
  – Registered 220k pC collisions with T2K replica target
- Test of the new TPC readout

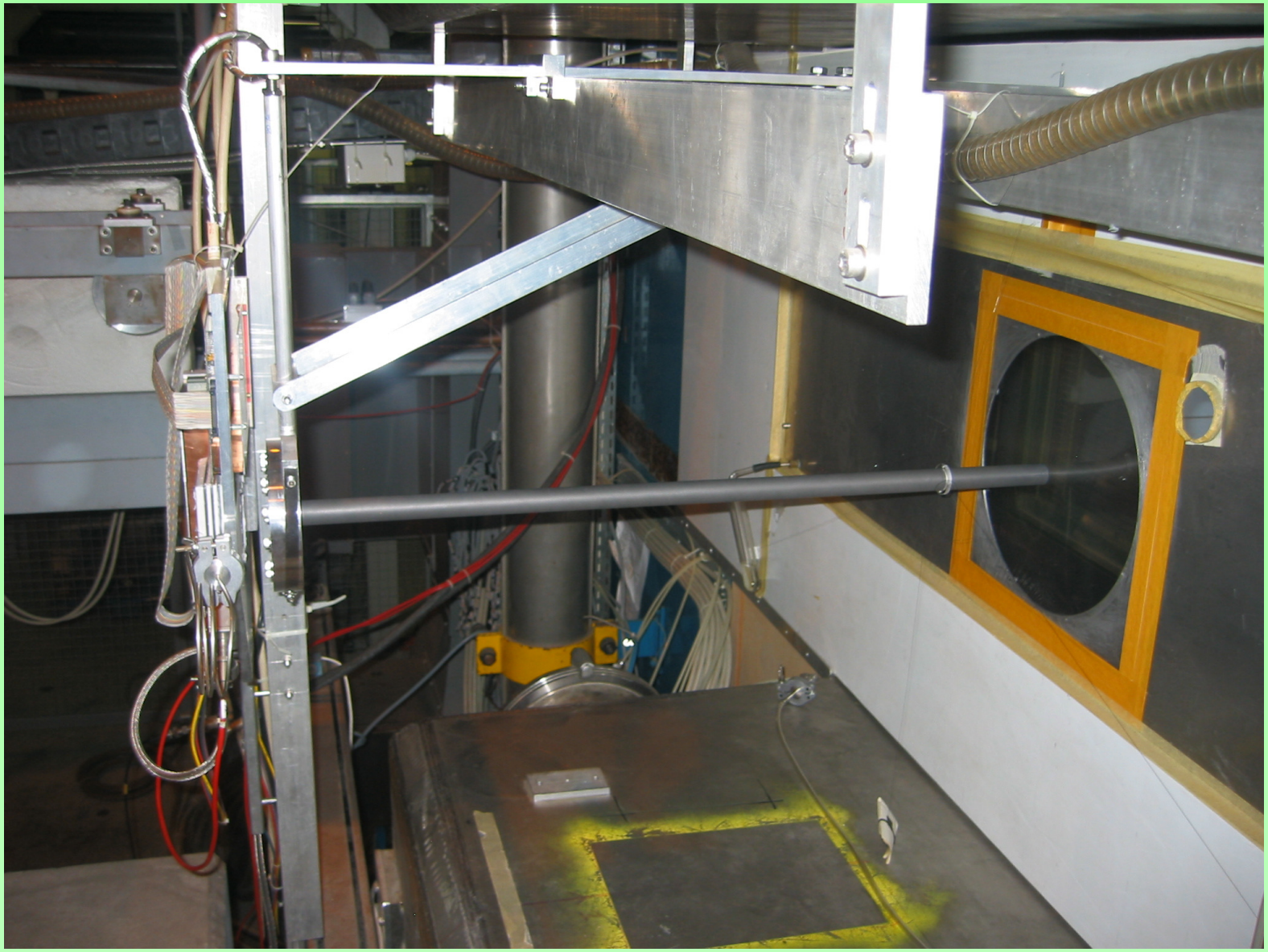
We had some trouble, but much less then was expected
The run was very successful!

Simulated event



Measured event





The NA61/SHINE Collaboration:

118 physicists from 25 institutes and 15 countries:

University of Athens, Athens, Greece
University of Bari and INFN, Bari, Italy
University of Bergen, Bergen, Norway
University of Bern, Bern, Switzerland
KFKI IPNP, Budapest, Hungary
Cape Town University, Cape Town, South Africa
Jagellionian 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
Swietokrzyska Academy, 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

NA61/SHINE