NA61/SHINE experiment: ion program

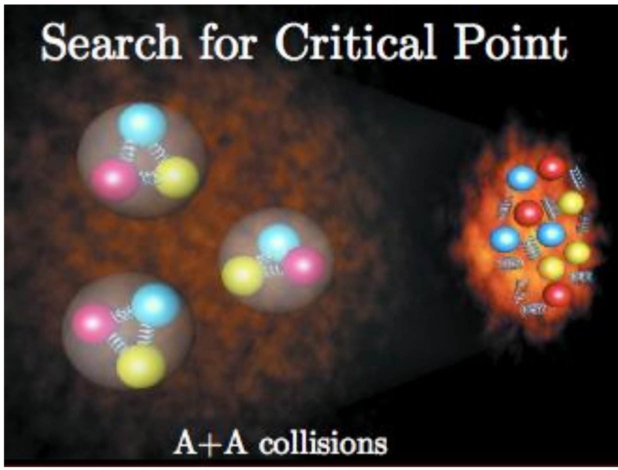
SHINE -SPS Heavy Ions and Neutrino Experiment

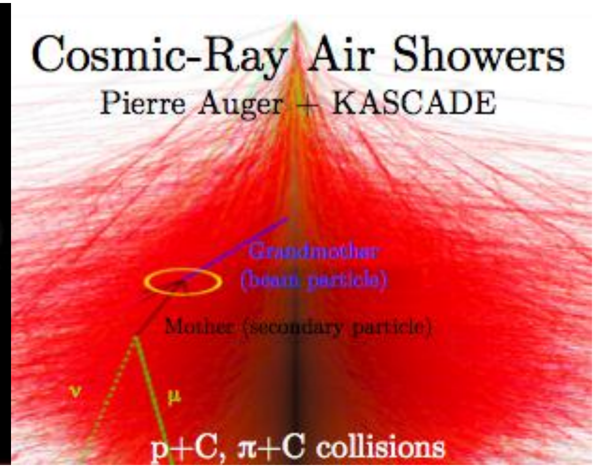
Roman Płaneta
Jagiellonian University, Kraków

for the NA61/SHINE collaboration

134 physicists from 27 institutes and 15 countries

NA61/SHINE experiment

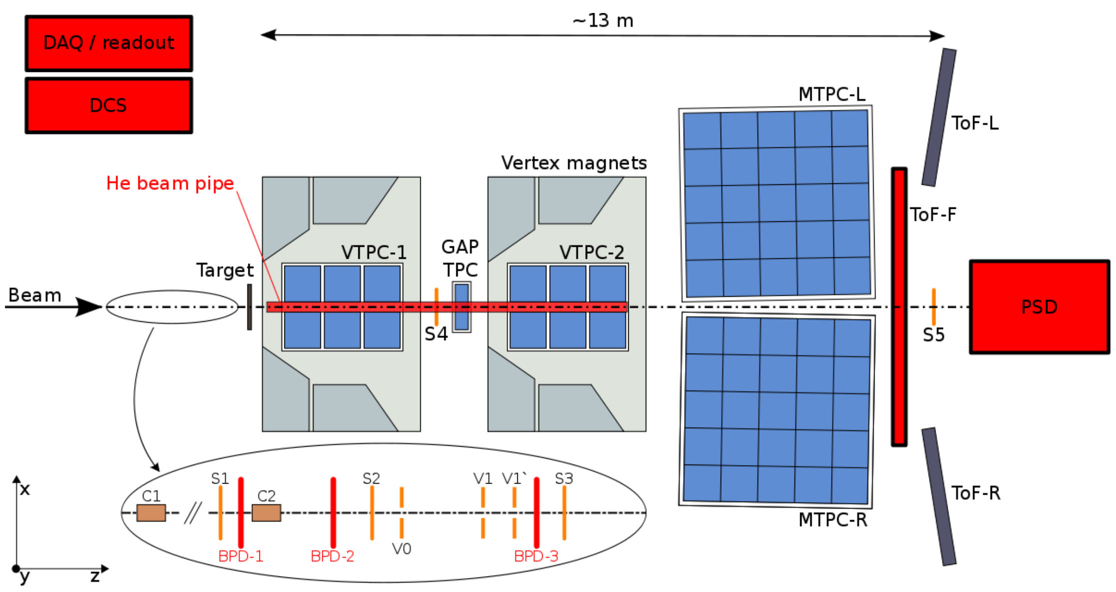


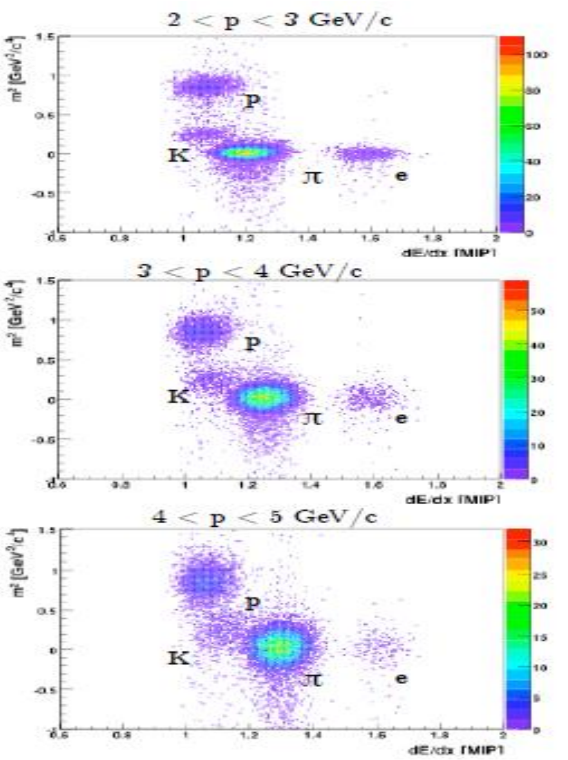


NA61/SHINE physics program:

- **Critical Point and Onset of Deconfinement,**
- **Neutrino physics,**
- **Cosmic-ray physics**

Detector





TPC read-out - an increase of the data rate by a factor of 10 compared to the NA49 rate

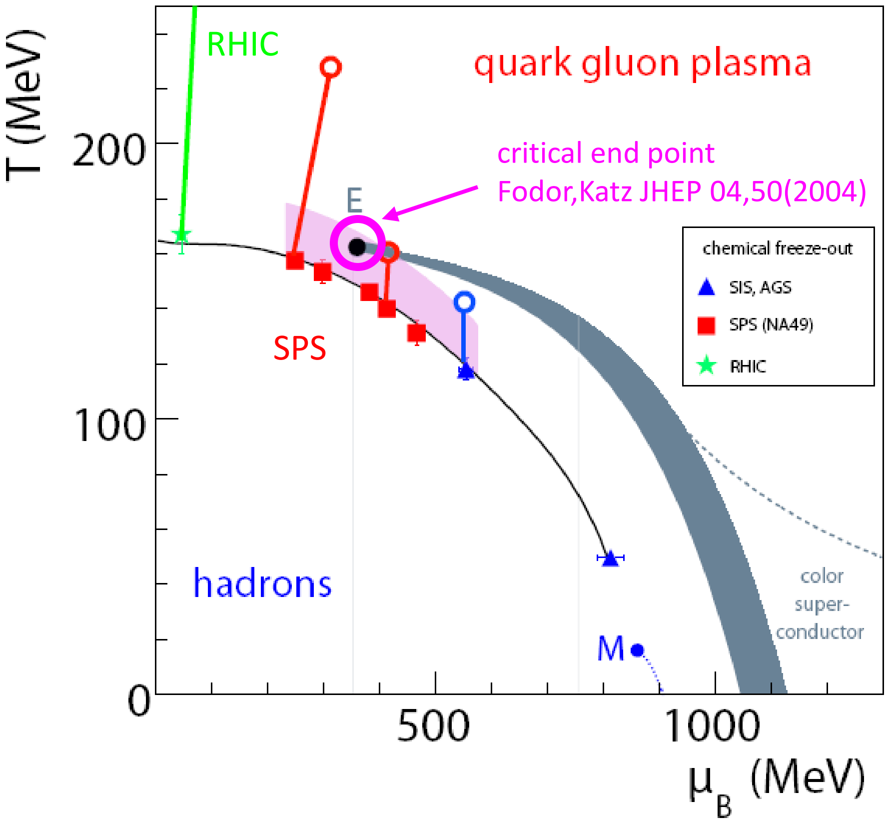
TOF-F detector - acceptance X 2

Projectile Spectator Detector - with a resolution of 1 nucleon

He beam pipe - reduction of the δ-electron background by a factor of 10

Particle identification:
Combined energy loss and Time of Flight measurements

Physics of strongly interacting matter



- QCD considerations suggest a 1st order phase boundary ending in a critical point

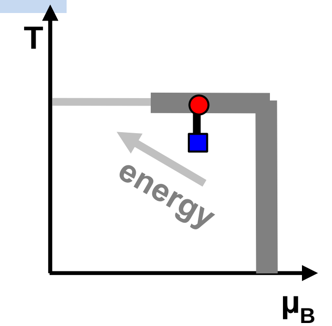
- hadro-chemical freeze-out points are obtained from stastistical model fits to measured particle yields
- T and μ_B approach phase boundary and estimated critical point at SPS

- evidence of onset of deconfinement from rapid changes of hadron production properties
- search for indications of the critical point as a maximum in fluctuations

Evidence for the onset of deconfinement

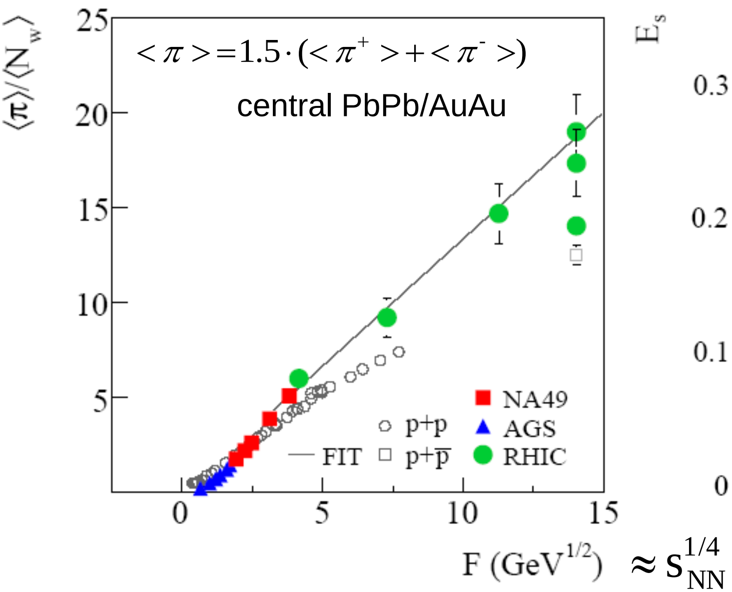
Onset of Deconfinement: early stage hits transition line,
predicted & observed signals: kink, horn, step

SMES model, M.Gazdzicki and M.Gorenstein, Acta Phys. Pol.30,2705(1999)
M.Gazdzicki et al.,arXiv:1006.1765



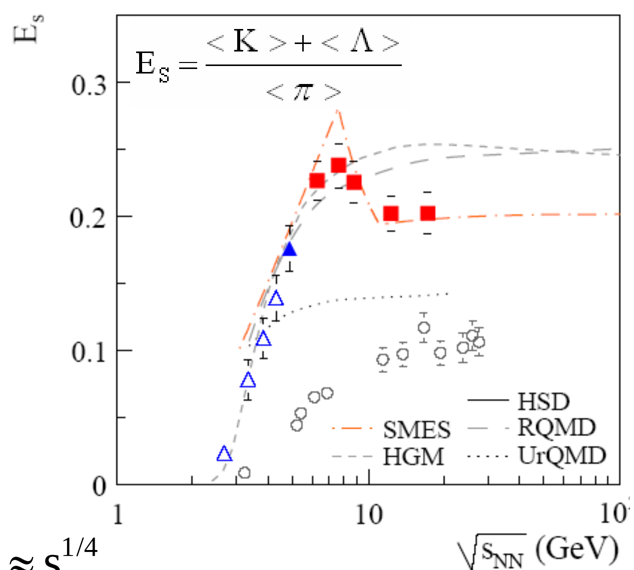
the kink

pion yield per participant



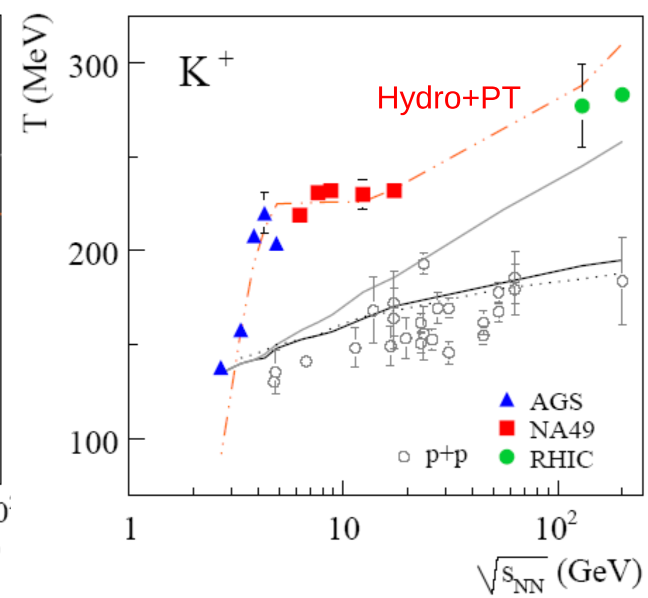
the horn

ratio of strange particle to pion yield



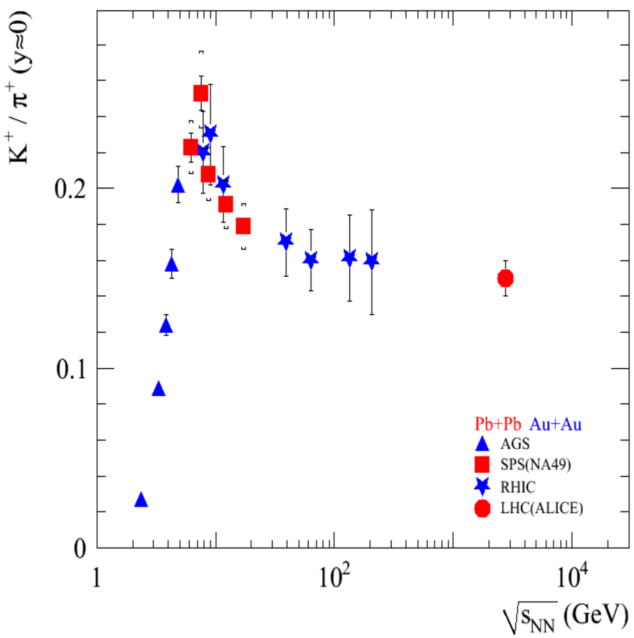
the step

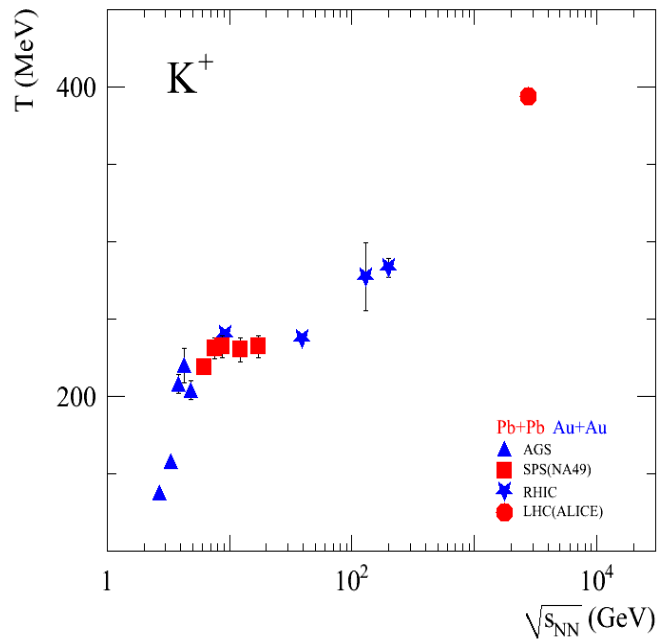
shape of transverse mass spectra



NA49,C.Alt et al.,PRC77,024903(2008)

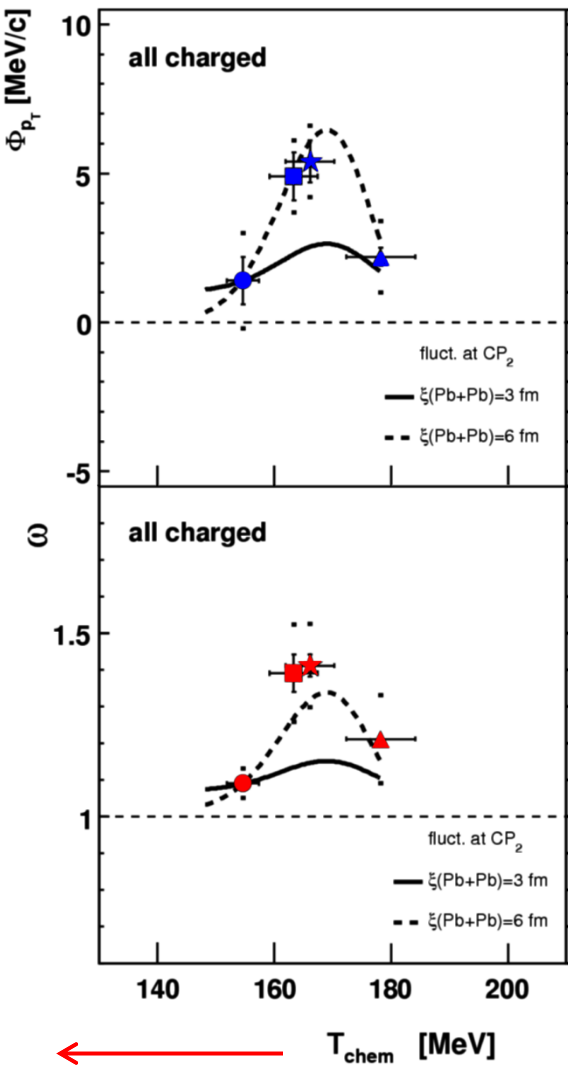
Verification of the NA49 results by STAR and ALICE



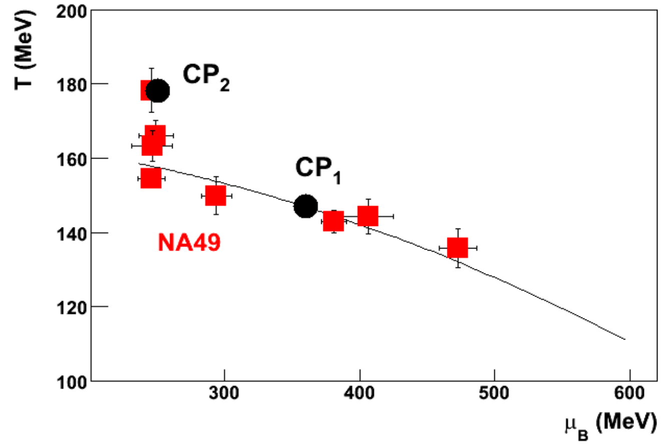


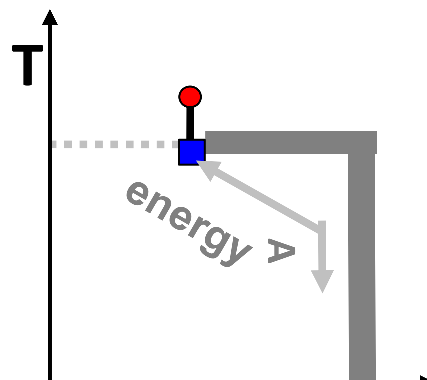
- The RHIC results confirm the NA49 measurements at the onset of deconfiment
- The LHC data demonstrate that the energy dependence of hadron production properties shows rapid changes only at low SPS energies

Results of critical point search from NA49

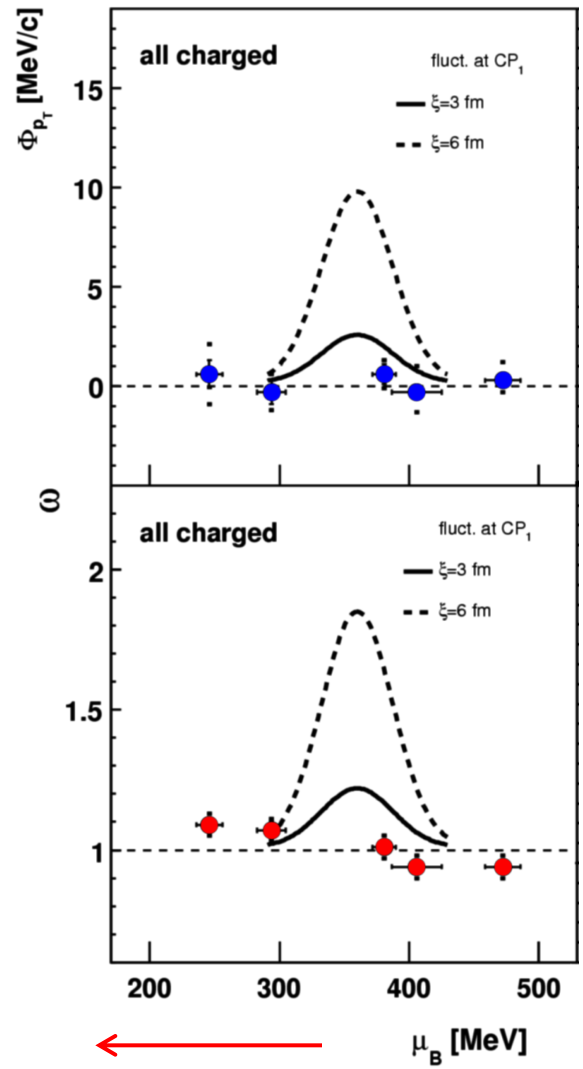


system size at 158 GeV



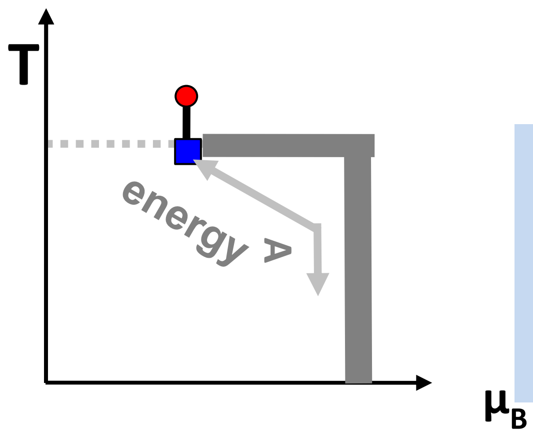


first hint of the
hill of fluctuations?

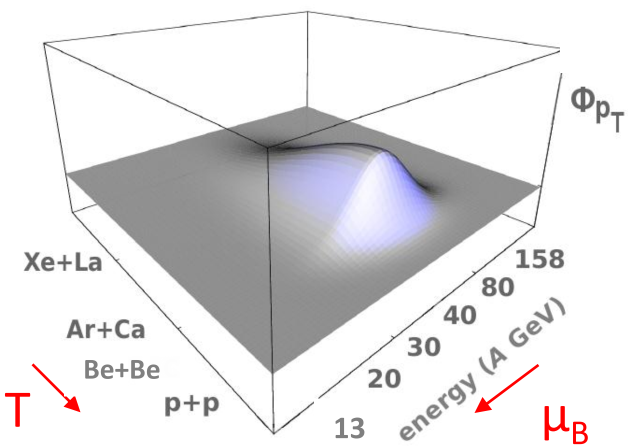


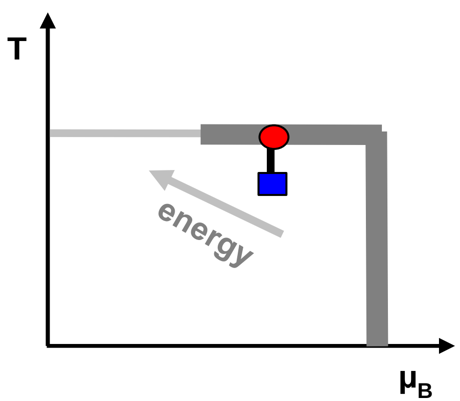
energy for cental Pb + Pb

Ion physics program of NA61/SHINE: scan in energy and system size

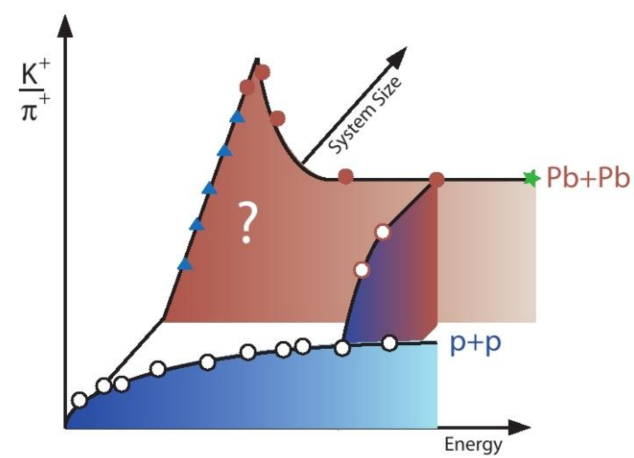


search for hill of fluctuation measures
as signature of critical point

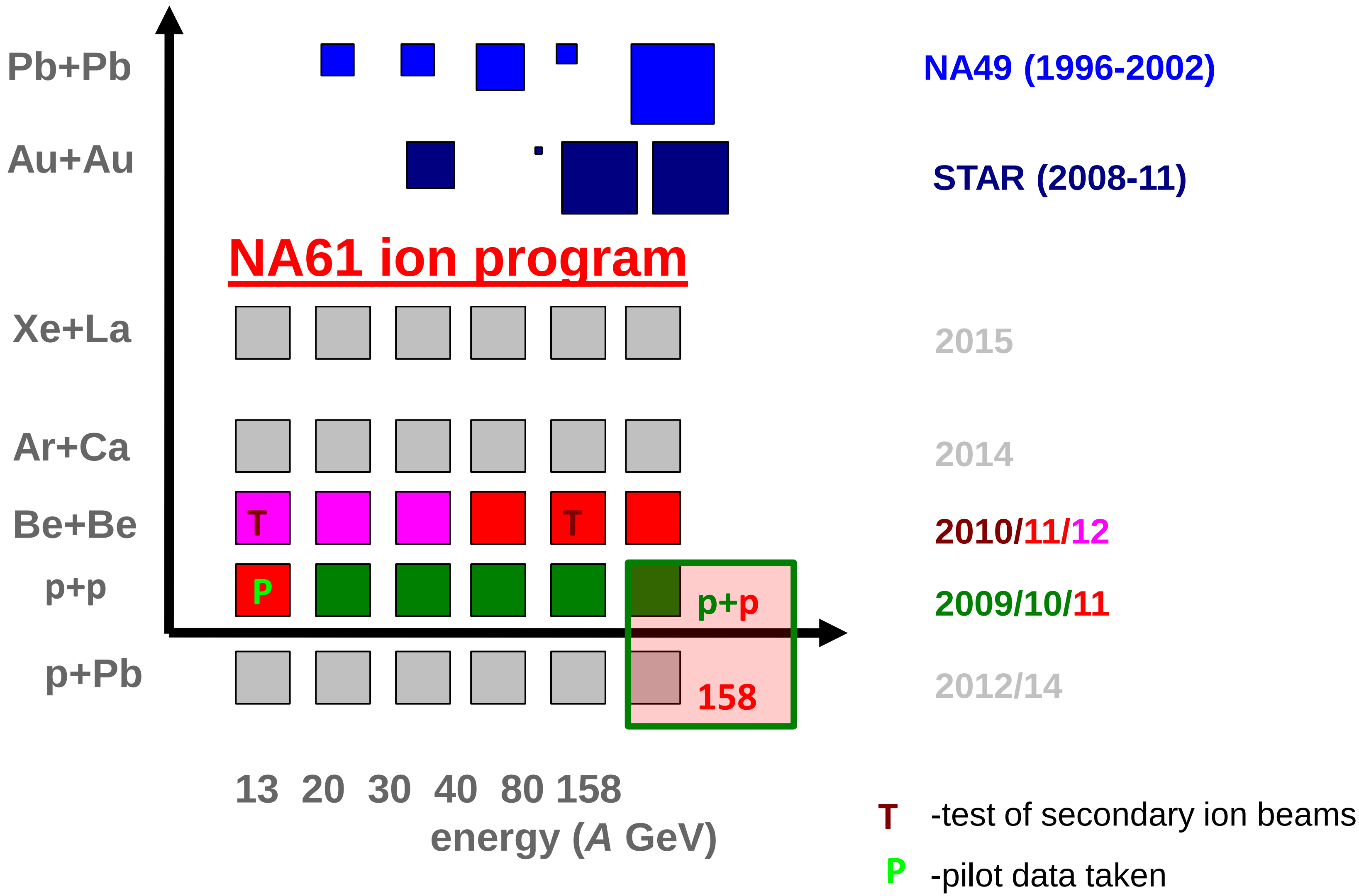




study onset of deconfinement:
e.g. disappearance of horn etc.



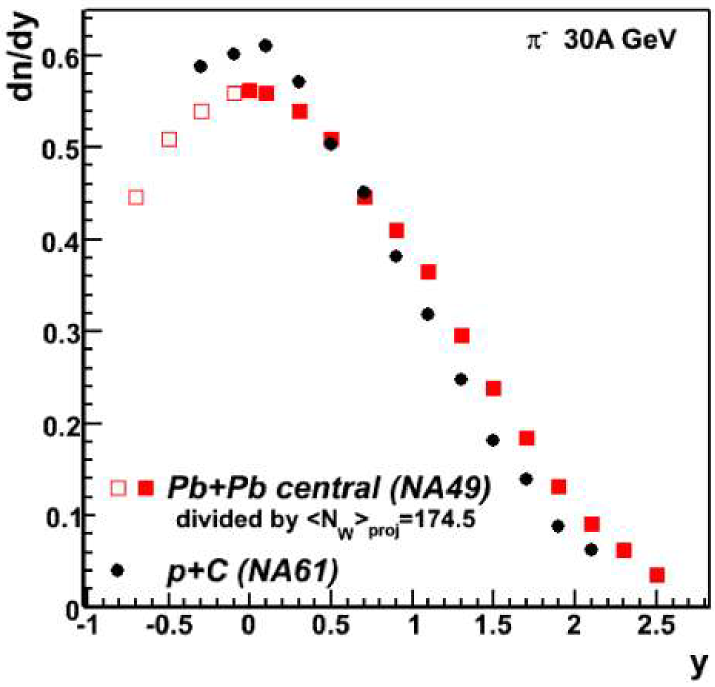
Progress and plans in data taking for CP&OD



NA61 preliminary results on p+C collisions

Pion spectra at 31 GeV/c *(arXiv:1101.3250 and*
(A. Aduszkiewicz and T. Palczewski, Thu. P153)

Comparison between p+C (NA61) and central Pb+Pb (NA49) at 30*A* GeV

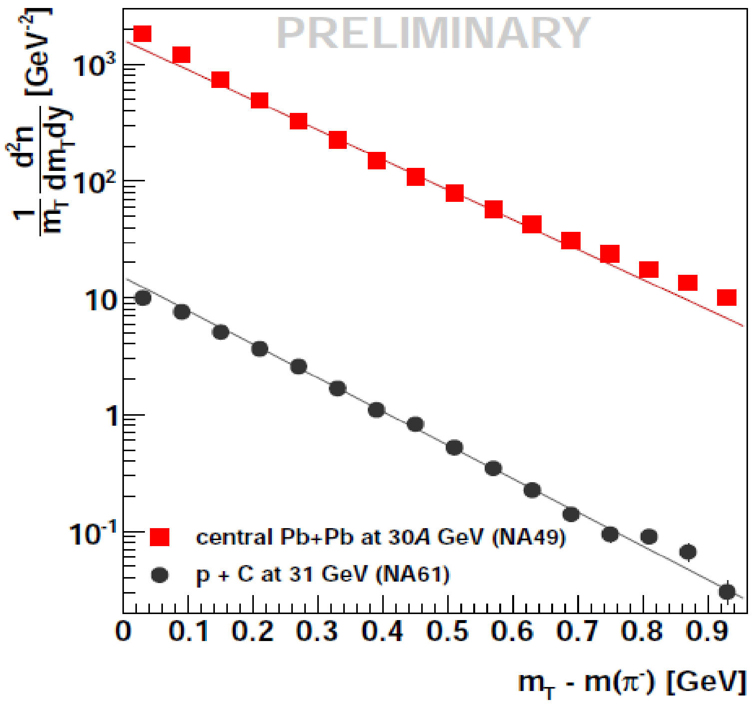


- **Mean pion multiplicity is approximately proportional to the mean number of wounded nucleons in the projectile nucleus**
- **Precise data on p+A add significant constrains for models**

NA61 preliminary results on p+C collisions

Pion spectra at 31 GeV/c *(arXiv:1101.3250 and*
(A. Aduszkiewicz and T. Palczewski, Thu. P153)

Comparison between p+C (NA61) and central Pb+Pb (NA49) at 30*A* GeV



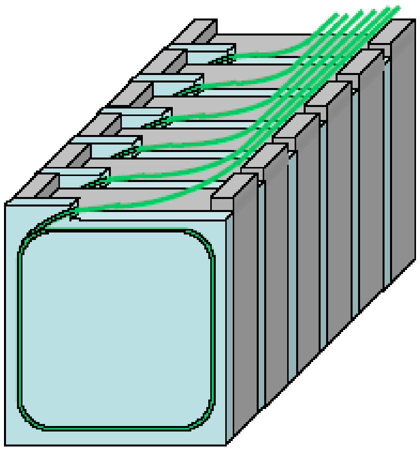
- **p + C - convex form (with respect to the coresponding exponential fit) of the transverse mass spectrum**
- **Pb + Pb –concave spectrum**
- **significant colective flow in Pb + Pb collisions**

Summary

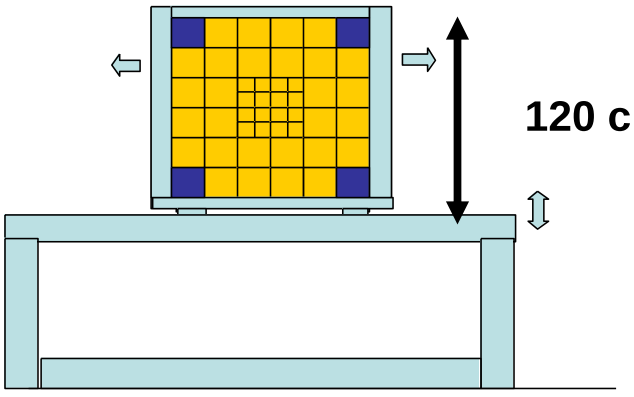
- **verification of NA49 results on the onset of deconfinement by STAR and ALICE**
- **search for critical point of strongly interacting matter presently inconclusive**
- **2D scan of fluctuations in μ_B, T phase diagram was started by NA61/SHINE with p+p interactions at six momenta (13-158 GeV/c)**
- **first results are being released**
- **energy scan with secondary Be beam will start this year**

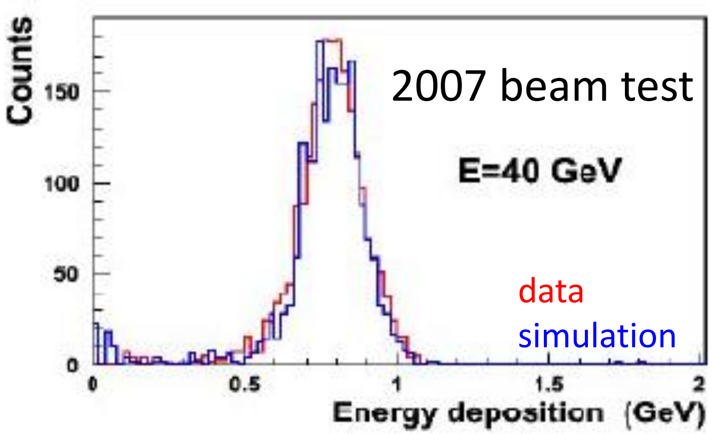
Additional slides

PSD – Projectile Spectator Detector (completion for 2012)

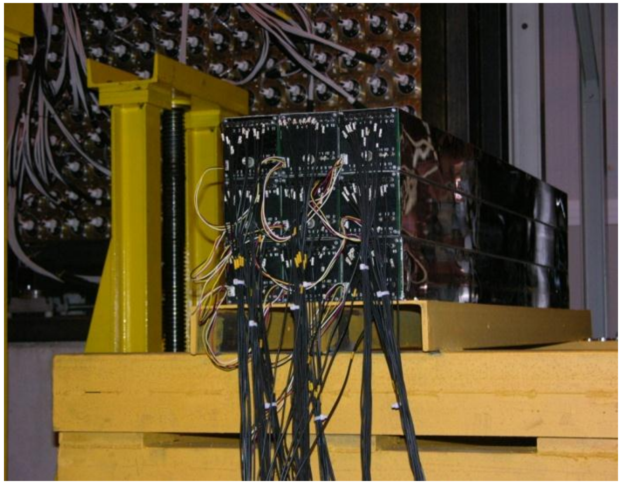


- 60 lead/scintillator sandwiches
- 10 longitudinal sections
- 6 WLS-fiber/MAPD
- 10 MAPDs/module
- 10 Amplifiers with gain~40





$\sigma(E)/E = 56\%/\sqrt{E(GeV)} + 2\%$



Fluctuation measures studied by NA49

- scaled variance ω of the multiplicity distribution P(N)

$$\omega = \frac{Var(N)}{<N>} = \frac{<N^2> - <N>^2}{<N>}$$

superposition model: ω(A+A)=ω(N+N)+<N>ω_{part}
independent particle emission: ω = 1
ω affected by participant fluctuations

- Φ_x measure of fluctuations of observable x (<p_{PT}>, <Φ>, Q, identity, …)

M.Gazdzicki and S.Mrowczyski, Z.Phys.C54,127(1992)

$$\Phi_x = \sqrt{\frac{<Z^2>}{<N>}} - \sqrt{<z^2>}\ ; \quad z = x - <x>\ , \ Z = \sum_{i=1}^{N}(x_i - <x>)$$

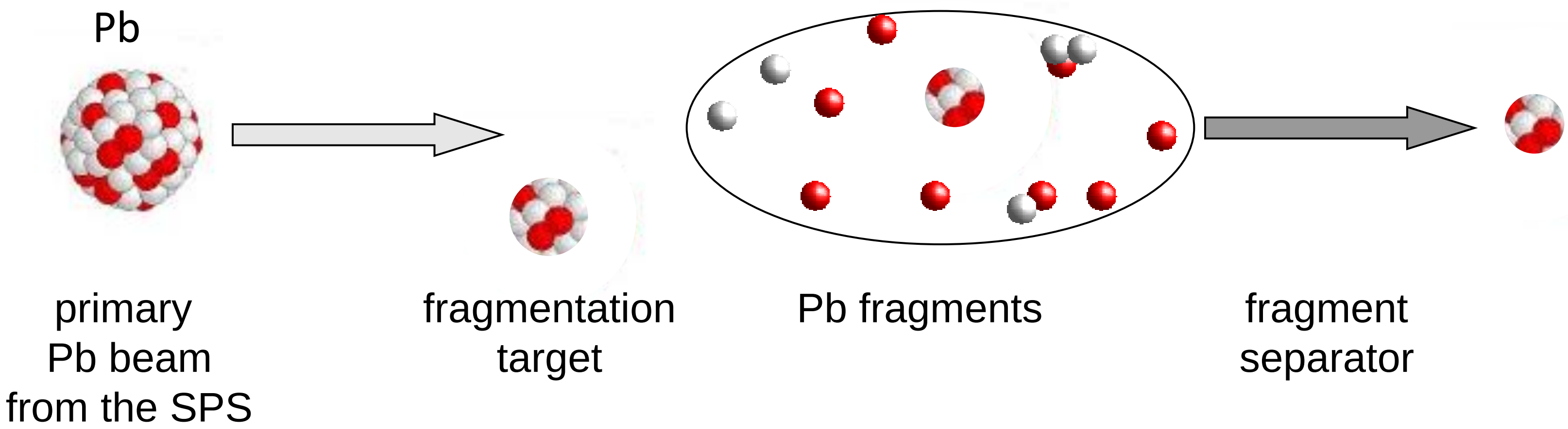
superposition model: Φ_x(A+A)= Φ_x(N+N)
independent particle emission: Φ_x= 0
Φ_x strongly intensive fluctuation measure

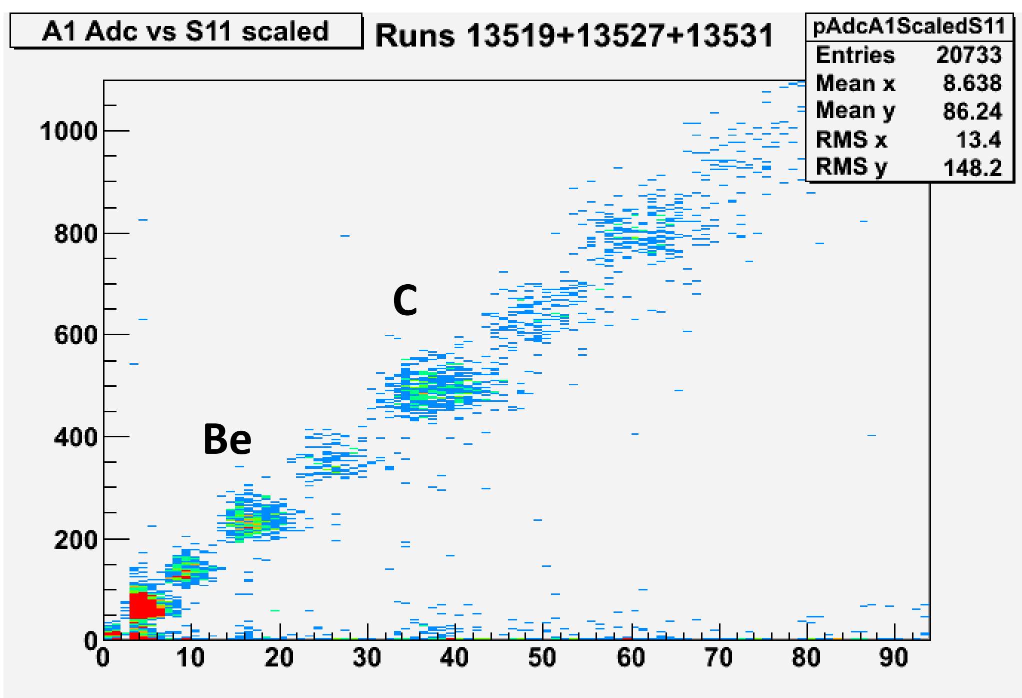
- σ_{dyn} measure of particle ratio fluctuations (K/π, p/π, K/p)

$$\sigma_{dyn} = \mathrm{sign}(\sigma^2_{data} - \sigma^2_{mix})\sqrt{\left|\sigma^2_{data} - \sigma^2_{mix}\right|}\ ; \quad \sigma^2_{dyn} = \left|\nu_{dyn}\right|$$

E-by-E fit of particle multiplicities required
mixed events used as reference
intensive fluctuation measure

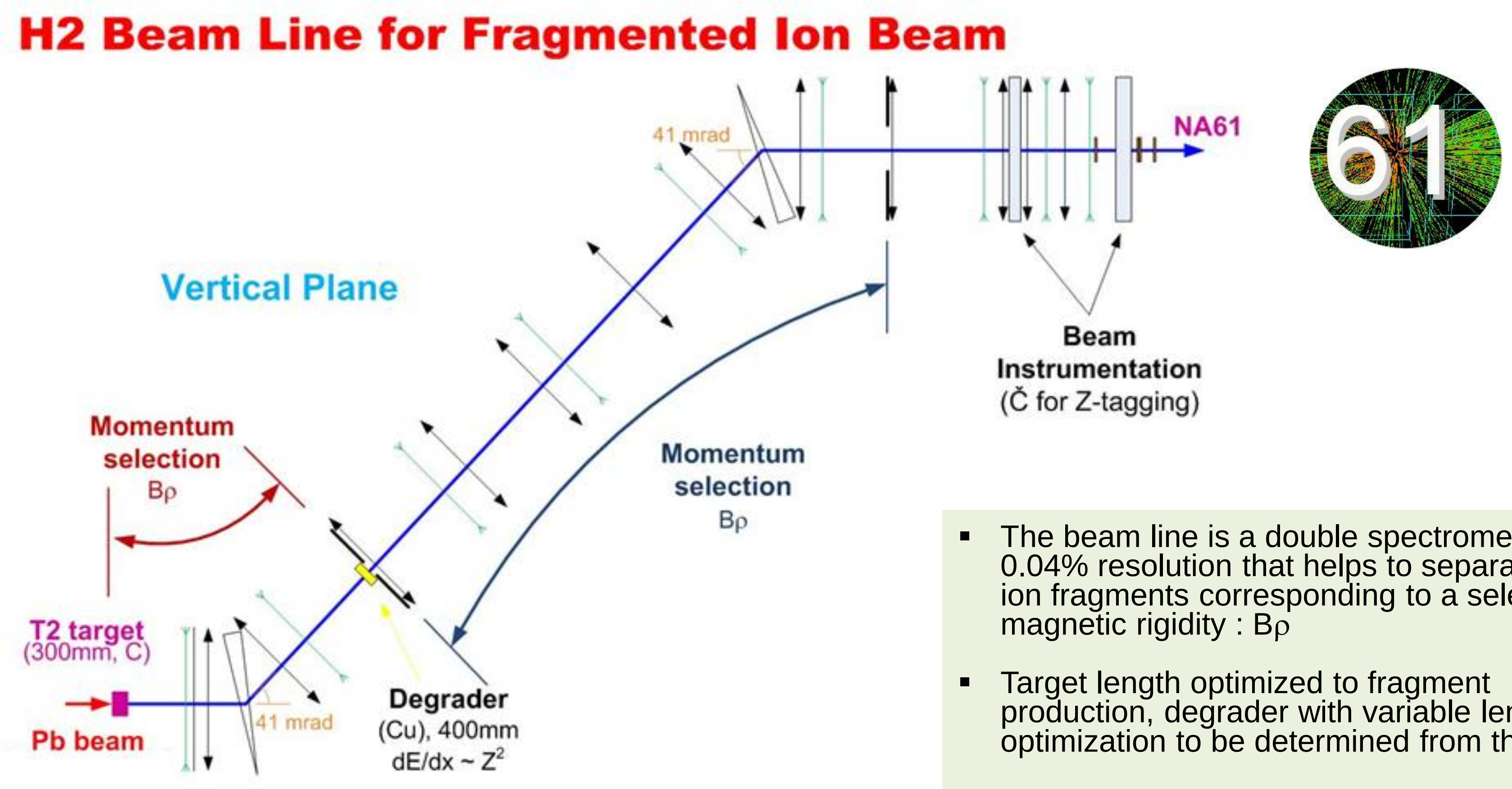
Secondary Be beam: basic idea





Test of secondary ion beams

Secondary Be beam: fragment separator

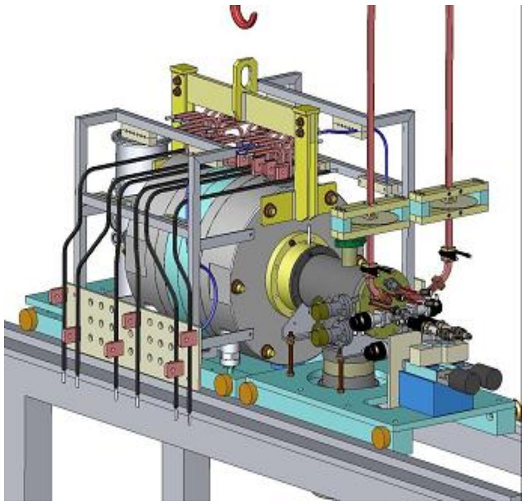


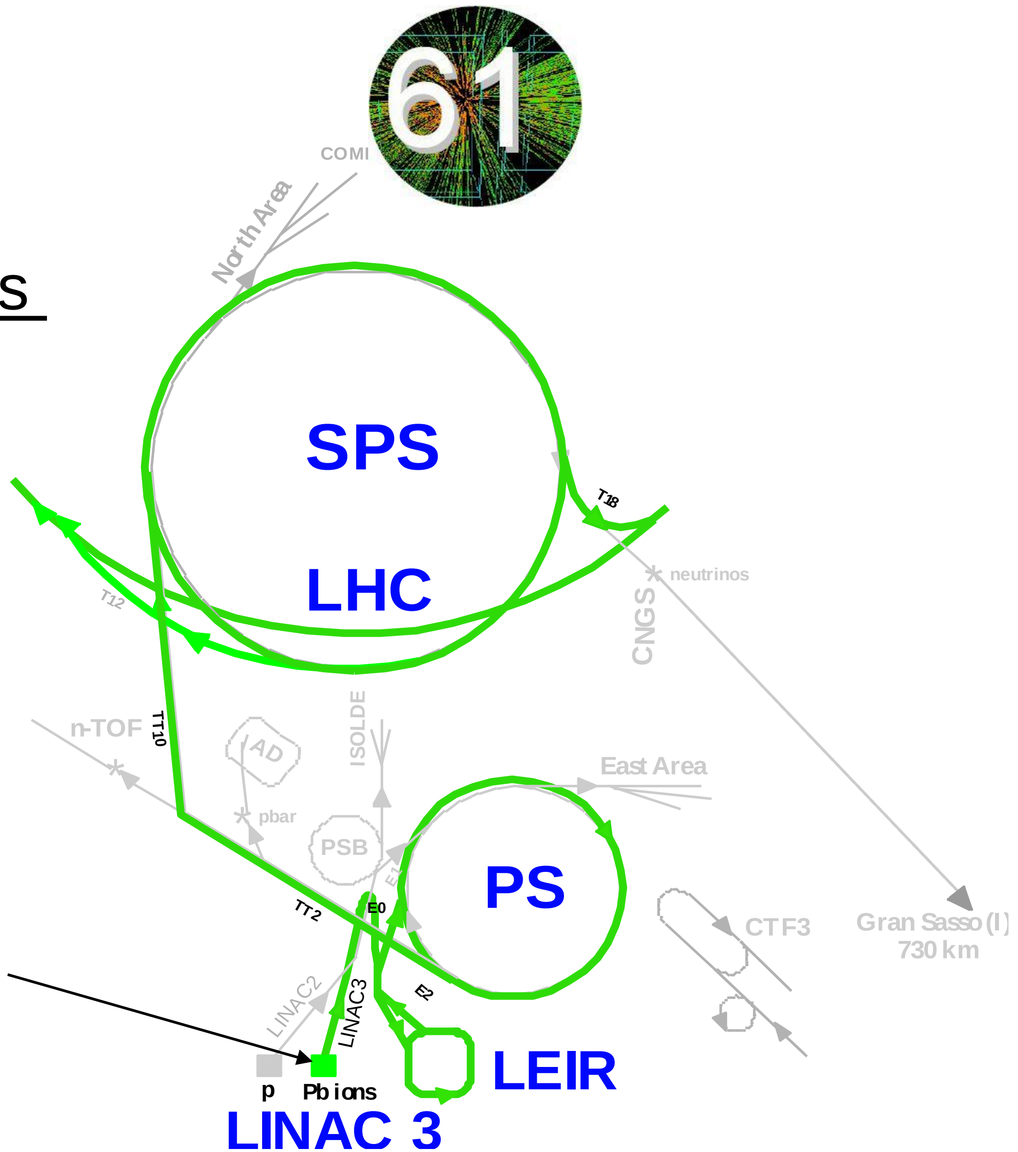
- The beam line is a double spectrometer with 0.04% resolution that helps to separate the ion fragments corresponding to a selected magnetic rigidity : Bρ
- Target length optimized to fragment production, degrader with variable length – optimization to be determined from the tests

Ion beams for NA61

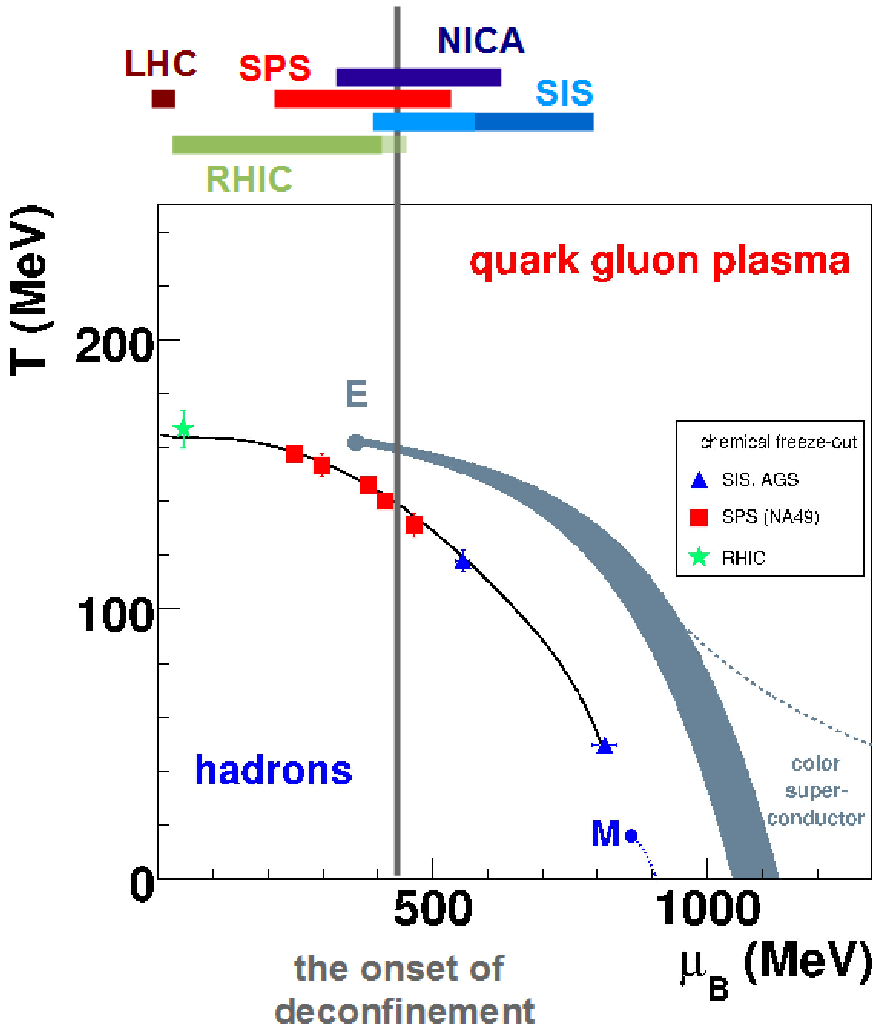
Primary Ar, Xe and Pb beams

ECR ion source





QCD critical point searches – future experimental landscape



partly complementary programs
planned at CERN SPS 2011
BNL RHIC 2010
DUBNA NICA 2015 ?
GSI SIS-CBM 2017 ?

<u>strong points of NA61:</u>

- tight constraint on spectators
- high event rate at all SPS energies
- flexibility to change A and energy

<u>Strong points of BNL/STAR:</u>

- full uniform azimuthal acceptance
- excellent TOF identification
- low track density