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NA49 future - hadron programme

G. Vesztegombi

Villars, 22-28 September 2004

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OUTLINE

Jet Quenching at RHIC and SPS

Cronin-effect at SPS

Search for pentaquarks

Exclusive hadron physics at SPS

Timescale and priorities

Jet Quenching (JQ) at RHIC

Historical comment: L. Van Hove 1982

The QGP is central question of HEP not only in Heavy Ion physics

RHIC results:

- #1: At LOW P_T nothing new relative to SPS
- #2: HIGH P_T suppression in AuAu relative to pp
- #3: No suppression in dAu relative to pp

Discovery(!?) of Jet Quenching
implies existence(!?) of QGP

- #4: JQ is seen at RHIC energies down to 62.4 GeV

**MULTIPLICITY DEPENDENCE OF p_t SPECTRUM AS A POSSIBLE SIGNAL
FOR A PHASE TRANSITION IN HADRONIC COLLISIONS**

L. VAN HOVE

CERN, Geneva, Switzerland

Received 25 August 1982

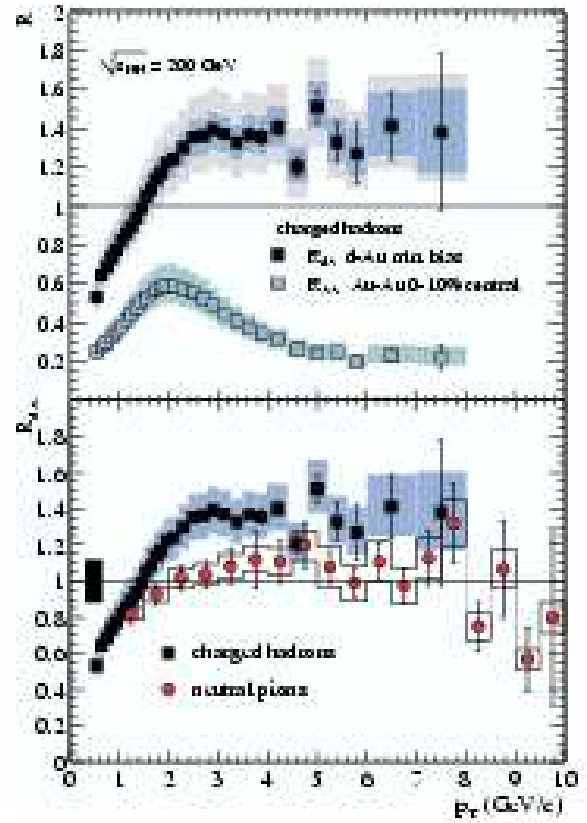
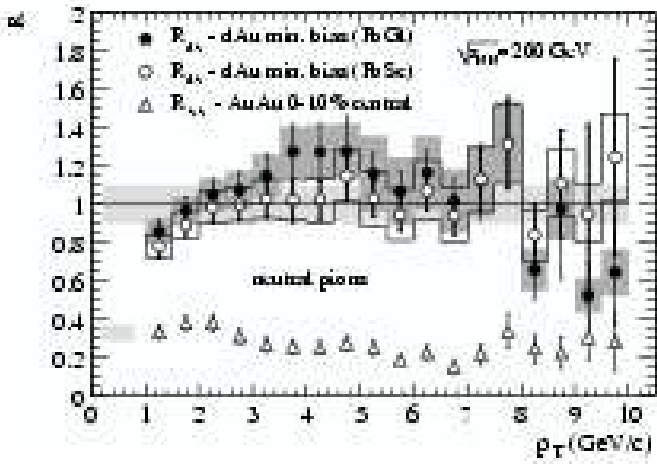
It is argued that the flattening of the transverse momentum (p_t) spectrum for increasing multiplicity n , observed at the CERN proton–antiproton collider for charged particles in the central rapidity region, may serve as a probe for the equation of state of hot hadronic matter. We discuss the possibility that this p_t versus n correlation could provide a signal for the deconfinement transition of hadronic matter.

nuclear modification factor R_{AA} , defined as

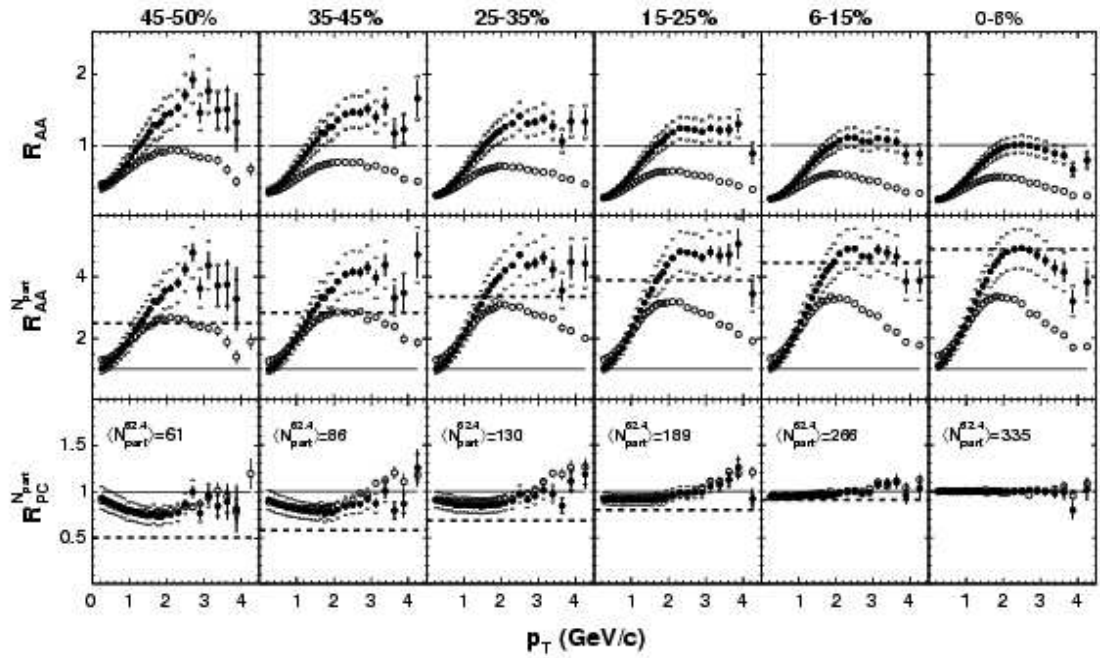
$$R_{AA} = \frac{\sigma_{pp}^{inel}}{\langle N_{coll} \rangle} \frac{d^2 N_{AA} / d p_T d \eta}{d^2 \sigma_{pp} / d p_T d \eta}. \quad (1)$$

A value of $R_{AA} = 1$ corresponds to scaling of particle

PHENIX



P H O B O S - 200 GeV (open) versus 62.4 GeV (full)



$$R_{AA} = \frac{\sigma_{pp}^{inel}}{\langle N_{coll} \rangle} \frac{d^2 N_{AA} / dp_T d\eta}{d^2 \sigma_{pp} / dp_T d\eta}$$

$$R_{AA}^{N_{part}} = \frac{\sigma_{pp}^{inel}}{\langle N_{part} / 2 \rangle} \frac{d^2 N_{AA} / dp_T d\eta}{d^2 \sigma_{pp} / dp_T d\eta}$$

$$R_{PC}^{N_{part}} = \frac{\langle N_{part}^{0-6\%} \rangle}{\langle N_{part} \rangle} \frac{d^2 N_{AA} / dp_T d\eta}{d^2 N_{AA}^{0-6\%} / dp_T d\eta}$$

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QUESTION: Is there any threshold?

One needs measurements of JQ at SPS at $\sqrt{s} = 10-20$ GeV

Search for Jet Quenching at SPS

WA98 on PbPb $\rightarrow \pi^0 + X$

Uncertain interpretation above 2 GeV/c

No convincing data on pPb $\rightarrow \pi^0 + X$

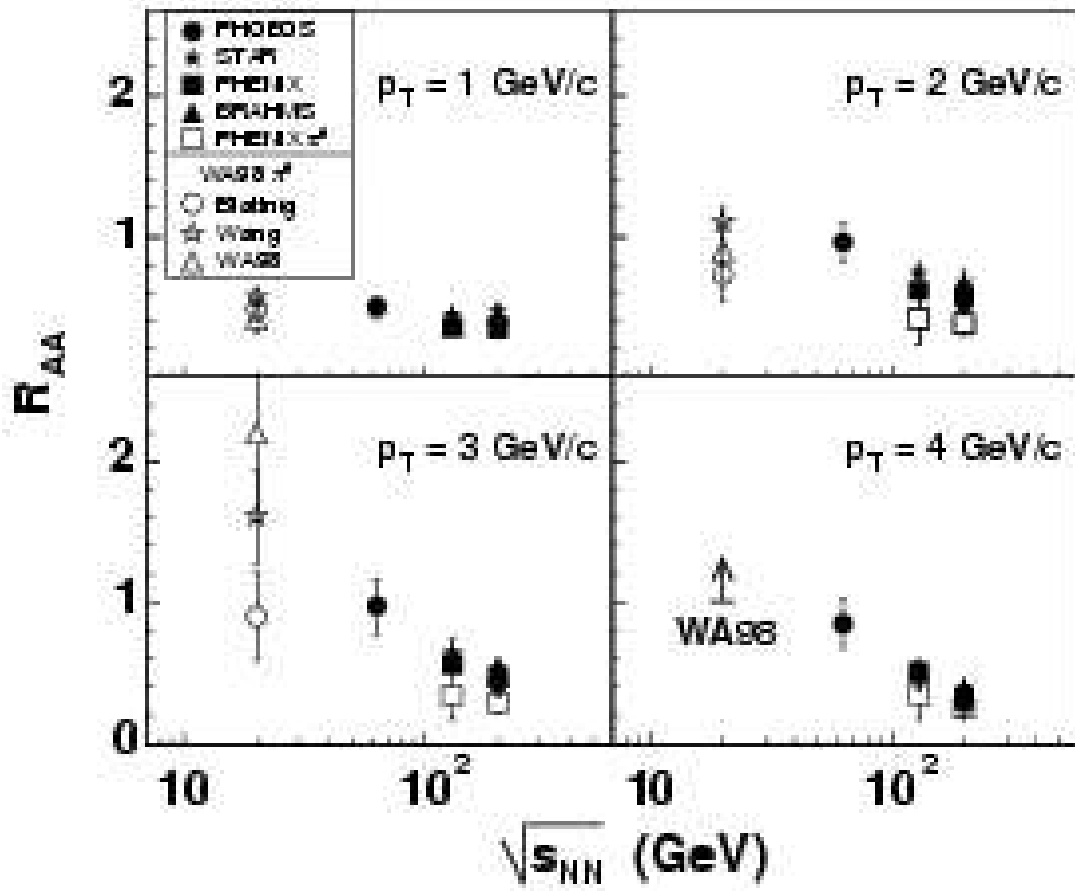
NA49 on PbPb $\rightarrow h^{+-} + X$

Sufficient statistics, but reprocessing of data is required with specialized pattern recognition for higher P_T charged particles

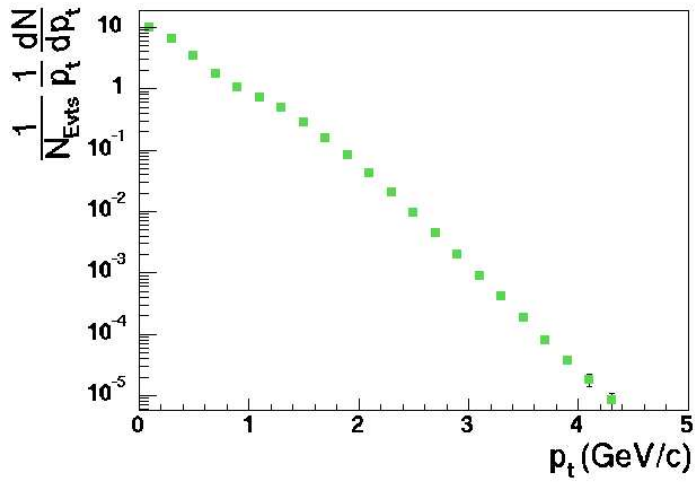
Encouraging data on lambda and kaon production above 3 GeV/c

High quality data in pp and pPb but limited P_T at 3 GeV/c

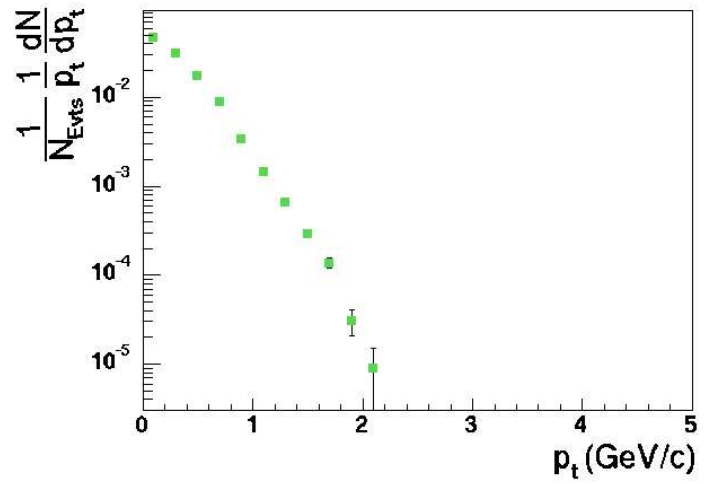
WA98 results



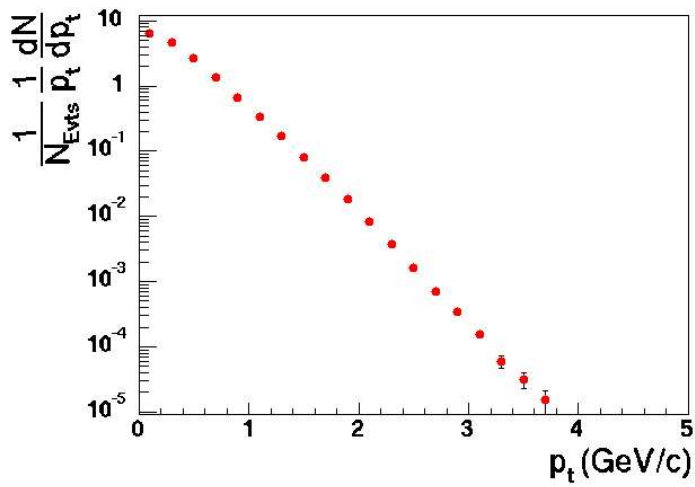
Lambda PbPb



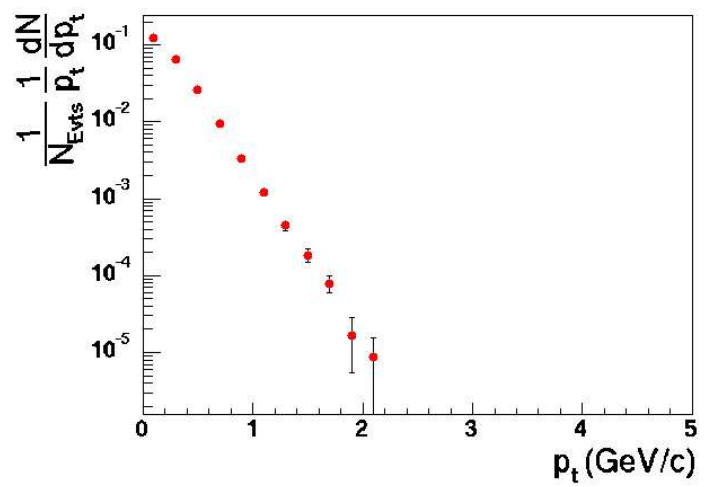
Lambda pp



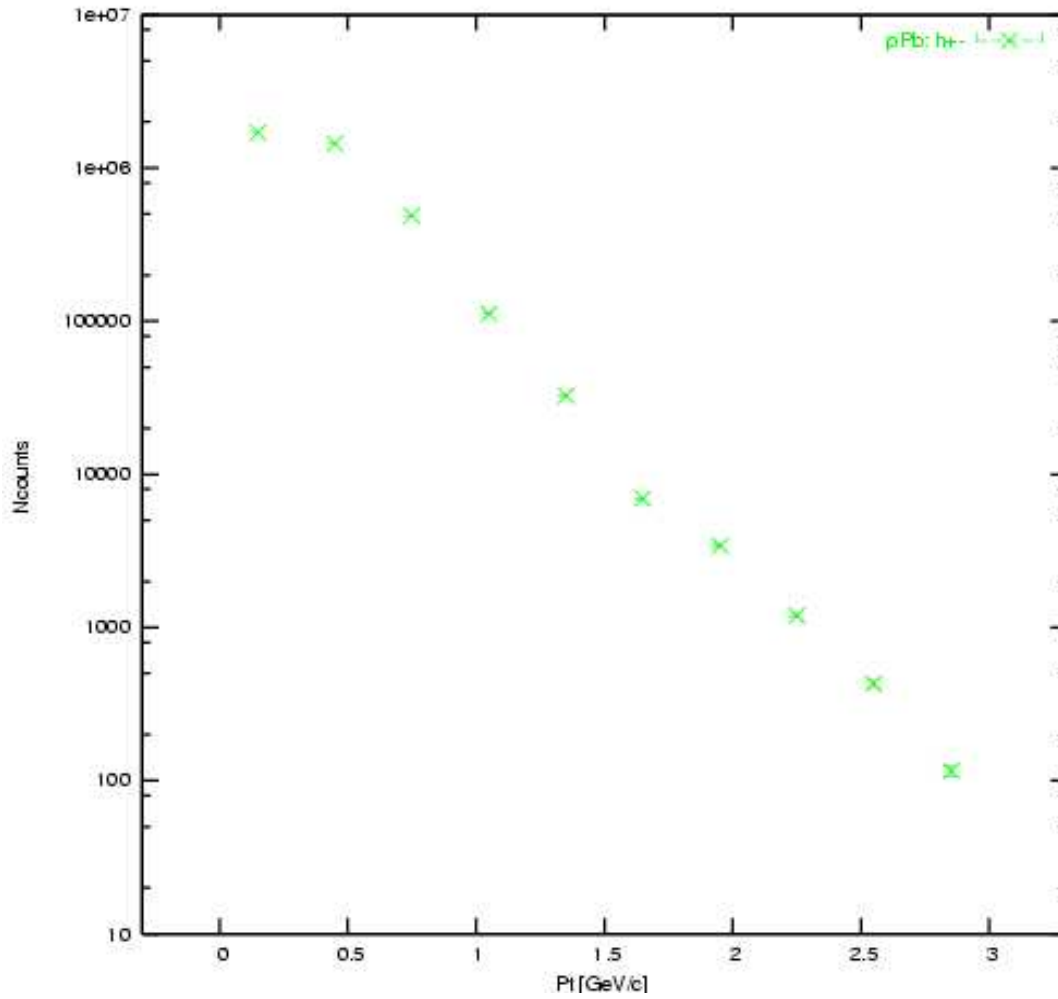
Kaon PbPb



Kaon pp



Total $pPb \rightarrow h^{+/-}$ statistics



0-10

Search for Jet Quenching at SPS

WA98 on PbPb $\rightarrow \pi^0 + X$

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Conclusion

One needs to increase the pPb statistics to few 100M events to reach 4 GeV/c in order to measure R_{pPb} providing the RHIC level of breakthrough with the dAu measurement.

N_{coll} versus N_{part}

What is the correct normalization factor for different processes?

Number of participants: N_{part}

Number of binary collisions: N_{coll}

RHIC's philosophy:

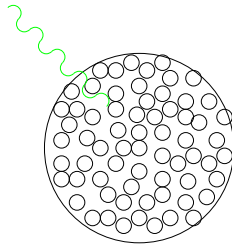
Low P_T processes are proportional to N_{part}

Multiplicities at different energies and processes show agreement

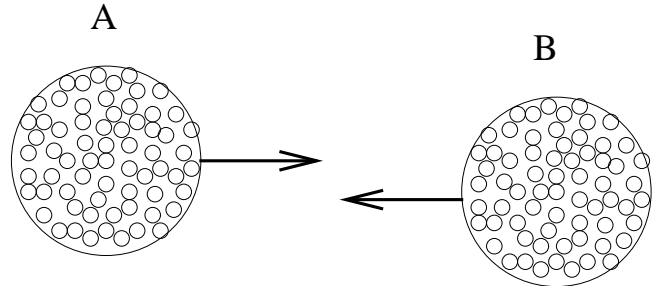
High P_T processes are proportional to N_{coll}

This is motivated by DIS lepton scattering. BUT!!!! There is a difference!

eA – DIS versus hadronic AB interaction



Photon can hit any nucleon



Any nucleon inside A or B can hit another nucleon inside only after collision(s) with surface nucleons. Primary importance of the first collision.

Different INITIAL state generation:

VOLUME-EFFECT

SURFACE-EFFECT

N_{coll} versus N_{part}

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Multiplicities at different energies and processes show agreement

High P_T processes are proportional to N_{coll}

This is motivated by DIS lepton scattering. BUT!!!! There is a difference!

Question: JQ is a suppression in N_{coll} or excess in N_{part} ?

If it is an excess, then JQ is the artifact of pA Cronin-effect in AA.

→ → → One must understand more deeply pA.

→ → → New measurements are needed.

Cronin-effect at SPS

Existing experimental data

- a) h^{+-}
- b) π^0
- c) E_T

Only mid-rapidity and forward measurements. No centrality control.

Present NA49 setup

- a) h^{+-}

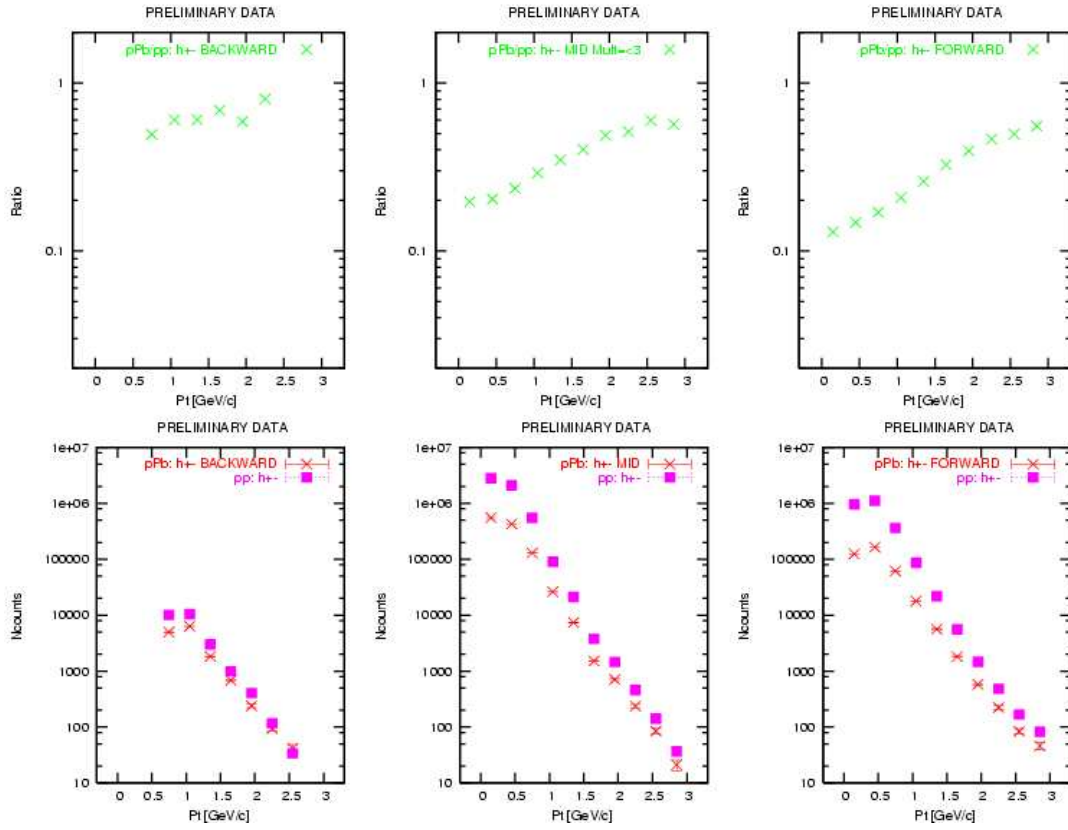
Ratios $\frac{pPb}{pp}$ upto P_T 3 GeV/c, backward and forward comparison

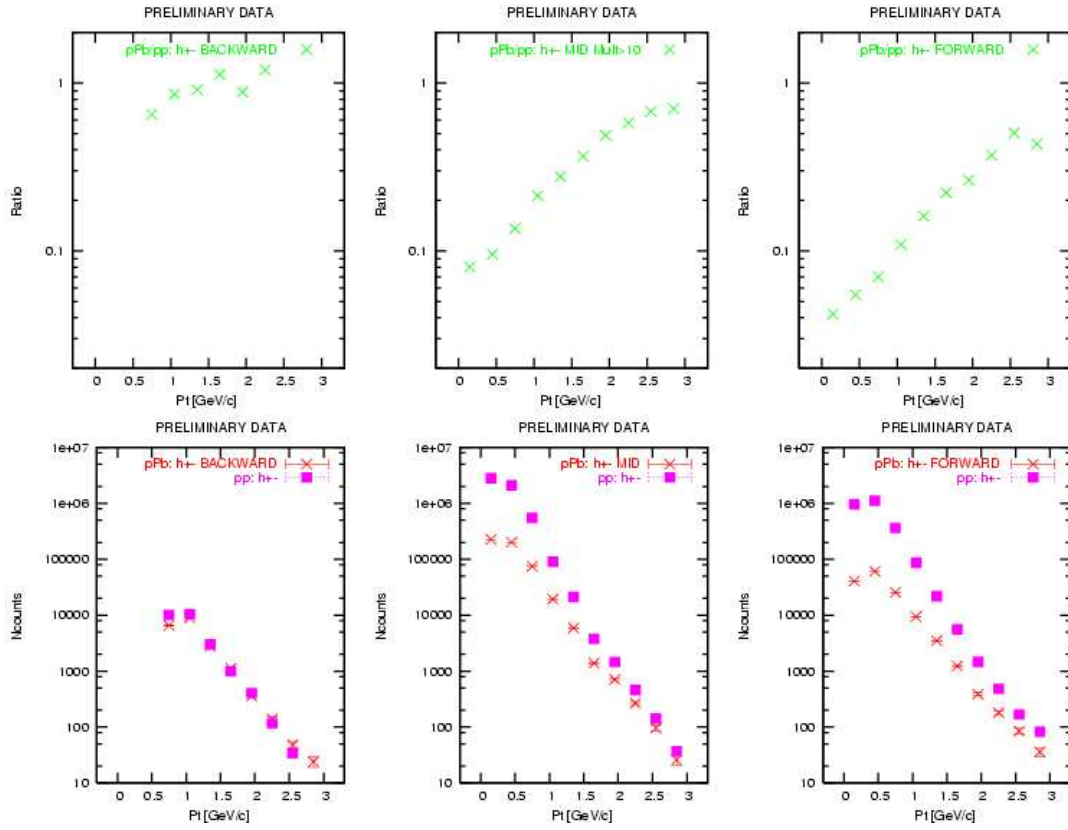
dependent on centrality (ν number of collisions)

- b) K_S and Λ upto 1.5 GeV/c

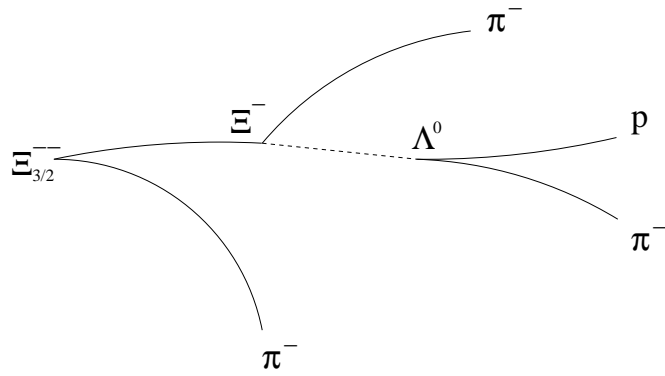
The aimed improvements in the experimental setup

- a) h^{+-} and π^0 in the same experiment
- b) almost 4π acceptance
- c) Higher P_T range upto 4 GeV/c with controlled centrality





Search for pentaquarks

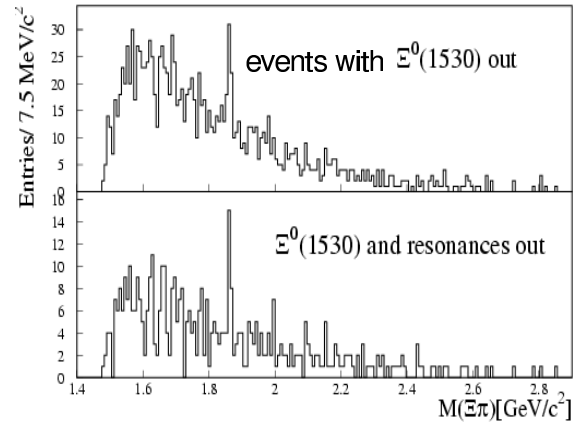


Remove resonances:

	π^-	K^-	\bar{p}
π^+	97.6 \pm 10	92.0 \pm 30	115.7 \pm 10
K^+	69.0 \pm 60 92.0 \pm 30	019.0 \pm 10	520.0 \pm 15
p	115.7 \pm 10	520.0 \pm 15	

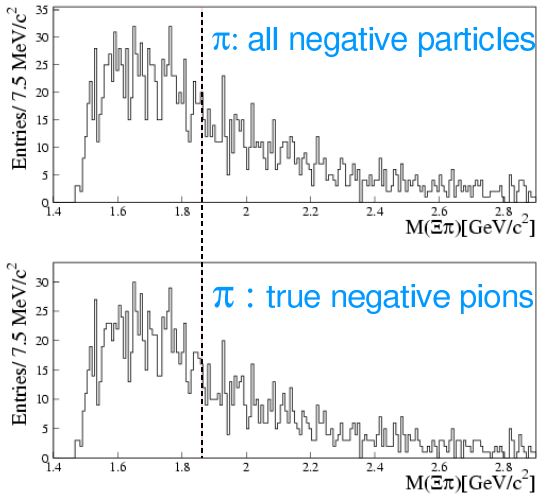
By changing:

- mass cuts around Ξ and Λ
- dE/dx cut
- number of points cut
- b_x, b_y cuts
- e.t.c.

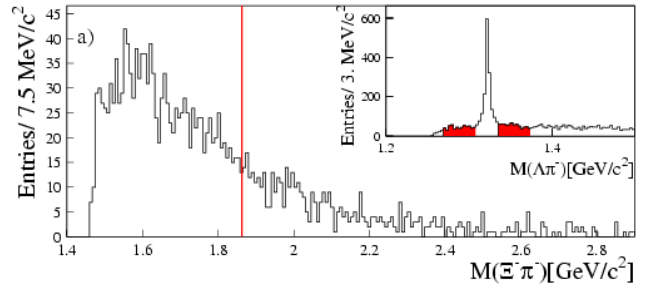


Peak remains robust !

$\Xi^- \pi$ (VENUS + GEANT + REC.)



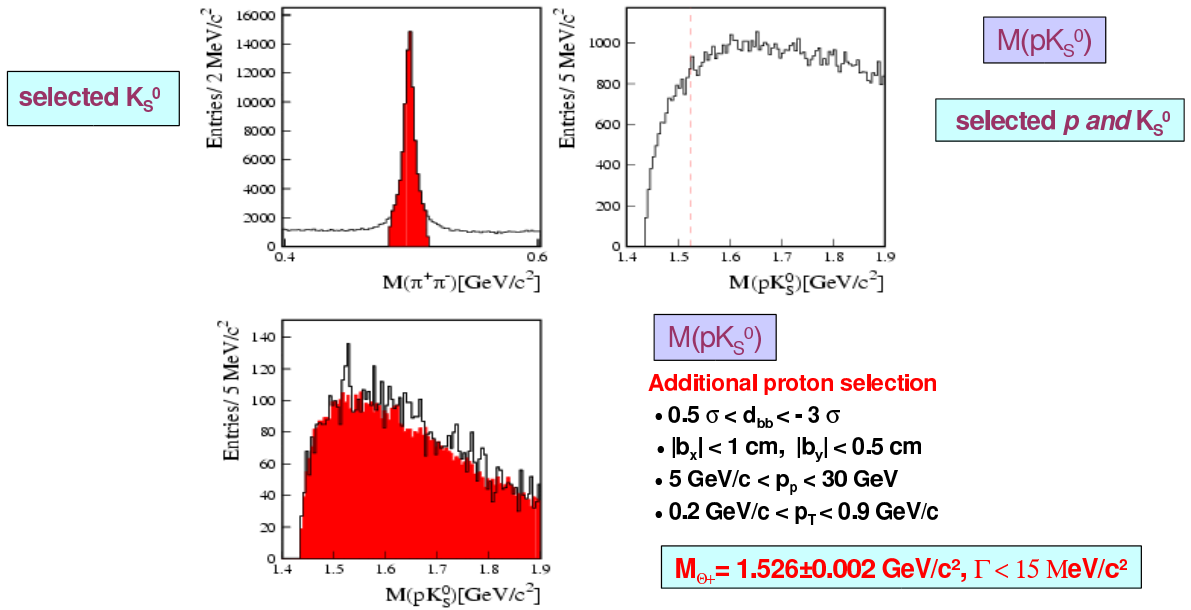
DATA (Ξ shoulders)



No structure at 1.86 GeV



$M(pK_S^0)$: Preliminary results



Kreso.Kadija@cern.ch

Pentaquark04. 20.07.-23.07.2004.



NA49 (existing data)

Data sample increase by up to ~ 30%

Improve analysis and:

Reanalyse existing data sample

Look for known resonances

Look for other possible decay channels

$\Xi_5 \diamond \Xi(1530) \pi, \Xi_5 \Lambda K$ etc.

Look for other pentaquark states

NA49' Project (Expression of Interest CERN-SPSC-2003-038)

In particular:

(3-6) • 10^7 p+p events (new DAQ system)

Neutral pions

These ideas were not mentioned in the EOI, they reflect only the speaker's opinion

Exclusive hadron physics at SPS

How can one reveal SPACE-TIME EVOLUTION?

Initial - Intermediate - Final states

PROJECTILE/TARGET factorization is possible in single collision?

Try all beam and target combinations

What are the INTERMEDIATE OBJECTS in multiple collisions?

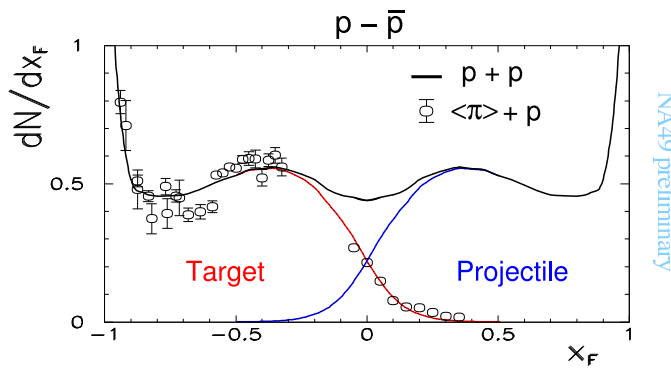
- A) Parton propagation (colored objects)*
- B) Hadron propagation (colorless objects)*

What is the RELATION between $ep \rightarrow pp$ and $eA \rightarrow pA$?

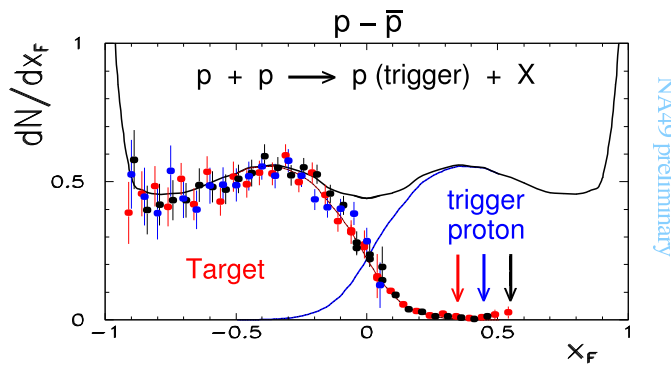
Is it possible to derive hadron-hadron from lepton-hadron

NEW RESEARCH TOOL: EXCLUSIVE experiment

Components of baryon density in h+h interactions: factorisation



- Baryon number free projectile: **pion beam**



- Fixing baryon number in the forward hemisphere

Dezső Varga for NA49, ICHEP04, Beijing, 16-22 Aug. 2004.

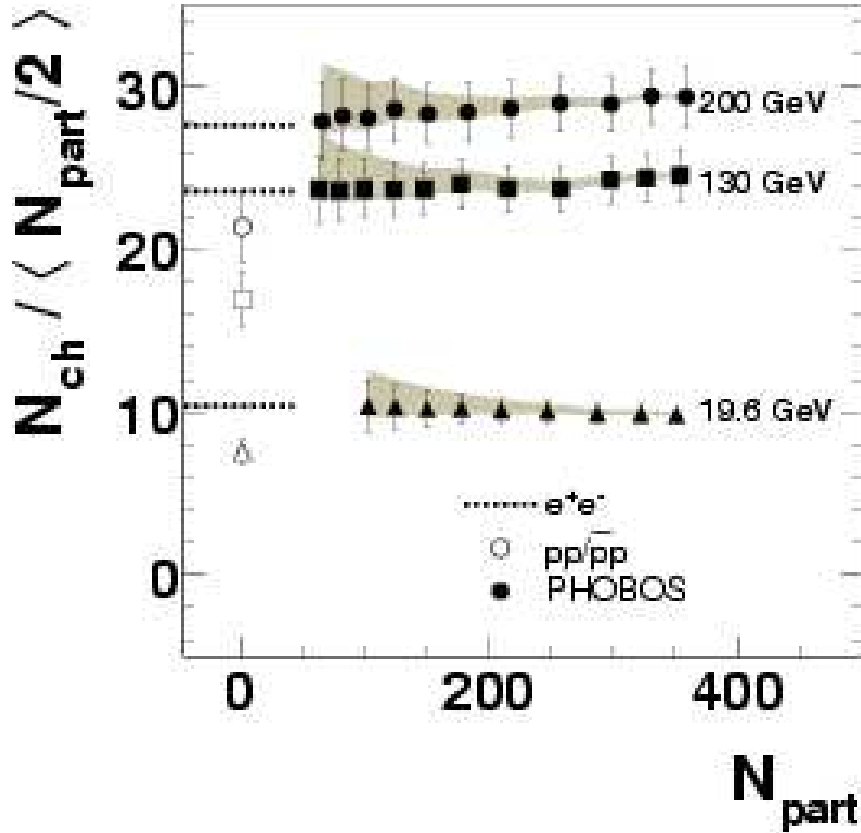
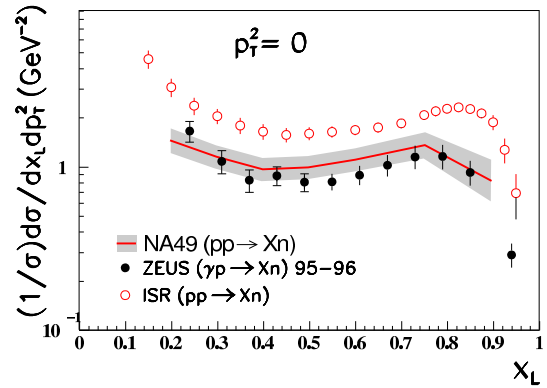
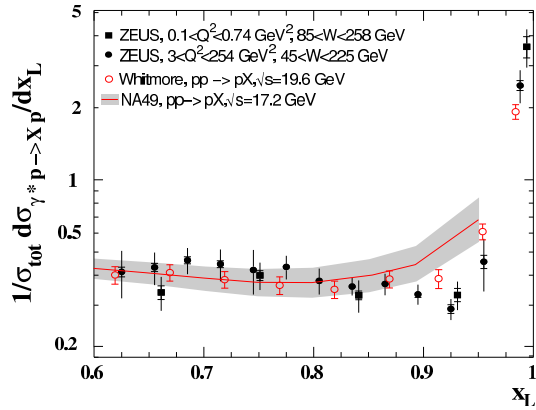


FIG. 3: $\langle N_{ch} \rangle / \langle N_{part}/2 \rangle$ is shown vs. N_{part} for $\sqrt{s_{NN}} = 19.6, 130,$ and 200 GeV as closed symbols. The error includes contributions from the uncertainty on overall N_{ch} scale and N_{part} scale. The shaded band shows the uncertainty on the extrapolation procedure. The open symbols show UA5 data at 200 GeV and results from an interpolation for the lower energies. The dotted lines show the values from the e^+e^- fit.

Non-baryonic beam: $p+\gamma^*$ interactions at HERA

$p+\gamma^* \rightarrow p+X$ vs. $p+p \rightarrow p+X$

$p+\gamma^* \rightarrow n+X$ vs. $p+p \rightarrow n+X$



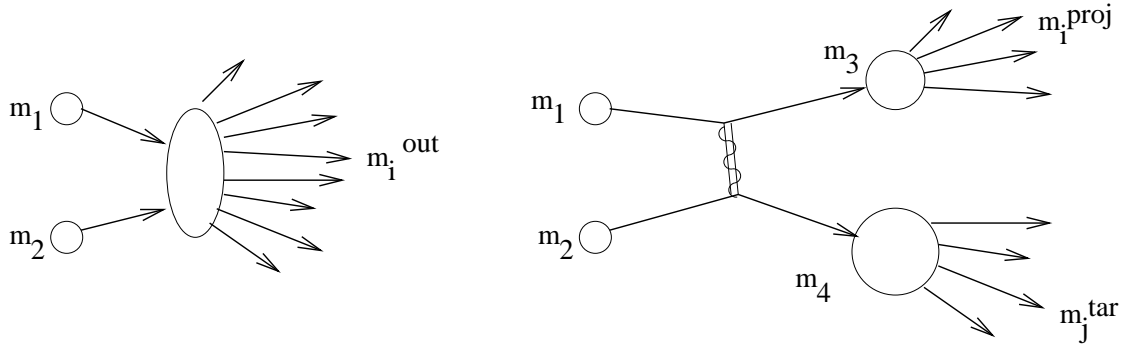
- Factorisation holds

- NA49 result confirms factorisation
- Inconsistency between NA49 and ISR measurement

Dezso Varga for NA49, ICHEP04, Beijing, 16-22 Aug. 2004.

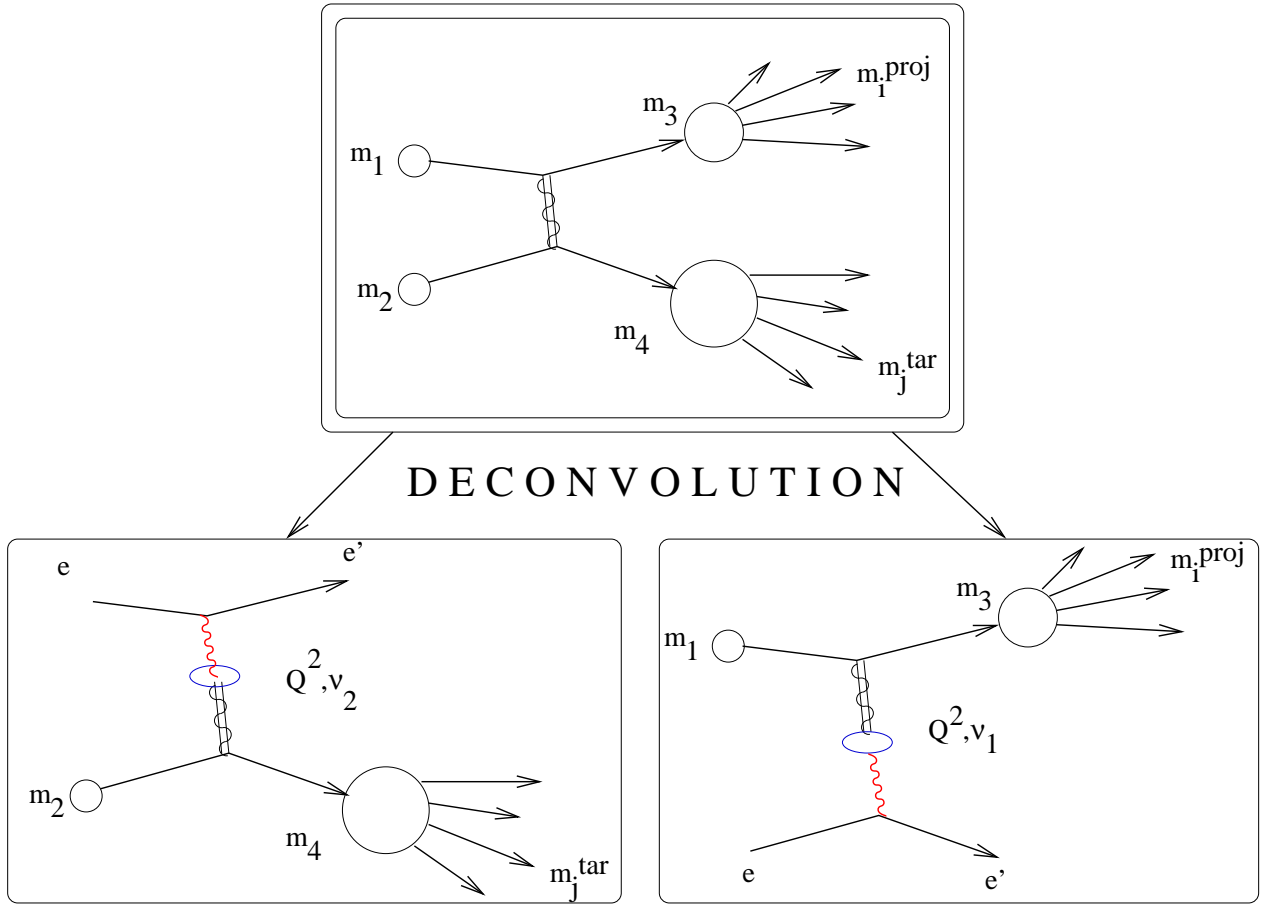
FACTORIZATION

Interaction blob is separable (not necessarily uniquely)



Final state particles are belonging either to class of projectile or target particles emerging from m_3 and m_4 intermediate states.

One doesn't expect that this is an absolute rule, but for a first step Copernicus was also good enough with circular trajectories



HERMES-SIDIS: hadron multiplicities on Krypton and Nitrogen were measured relative to deuterium. Comparable to proton-nucleus relative to proton-proton.

CRONIN-effect was observed: the Ratio is rising above 1 for $p_t^2 > 1 \text{ GeV}^2$.

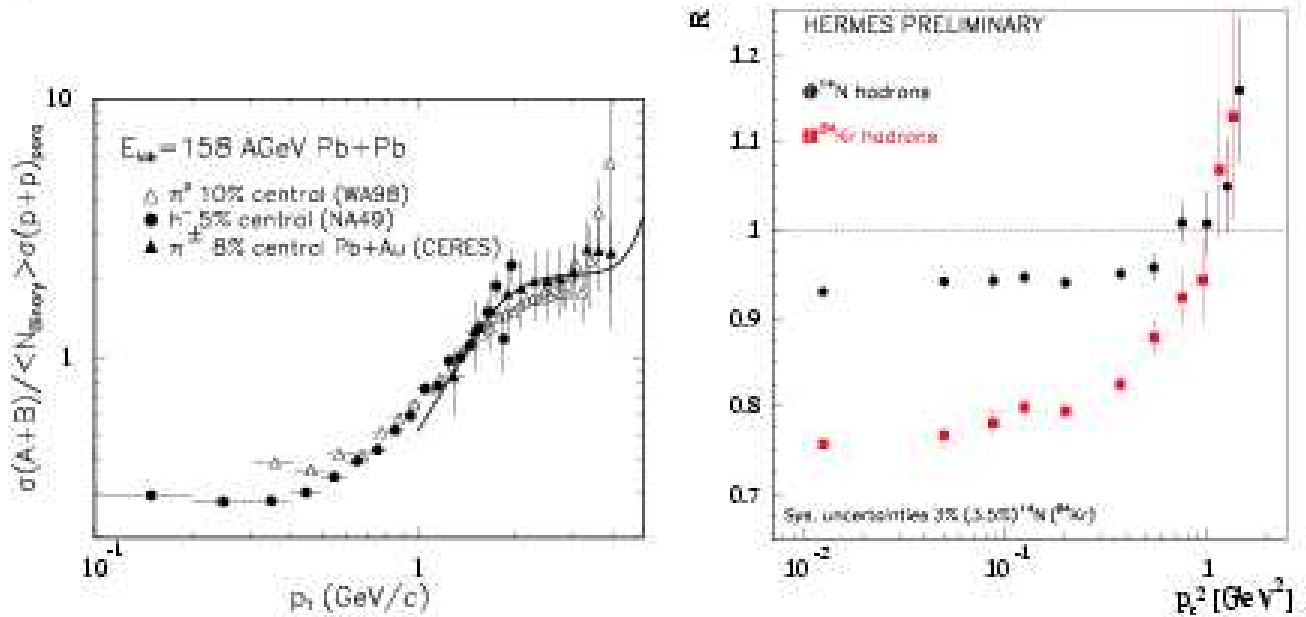


Figure 8. p_t -dependence of nuclear modification factor in heavy-ion reactions [15] (left) and of the nuclear multiplicity ratio in SIDIS (right). The curve is a QCD parton model calculation [16].

Special OPPORTUNITIES at SPS

- a) Highly developed detector technology from Heavy Ion experiments

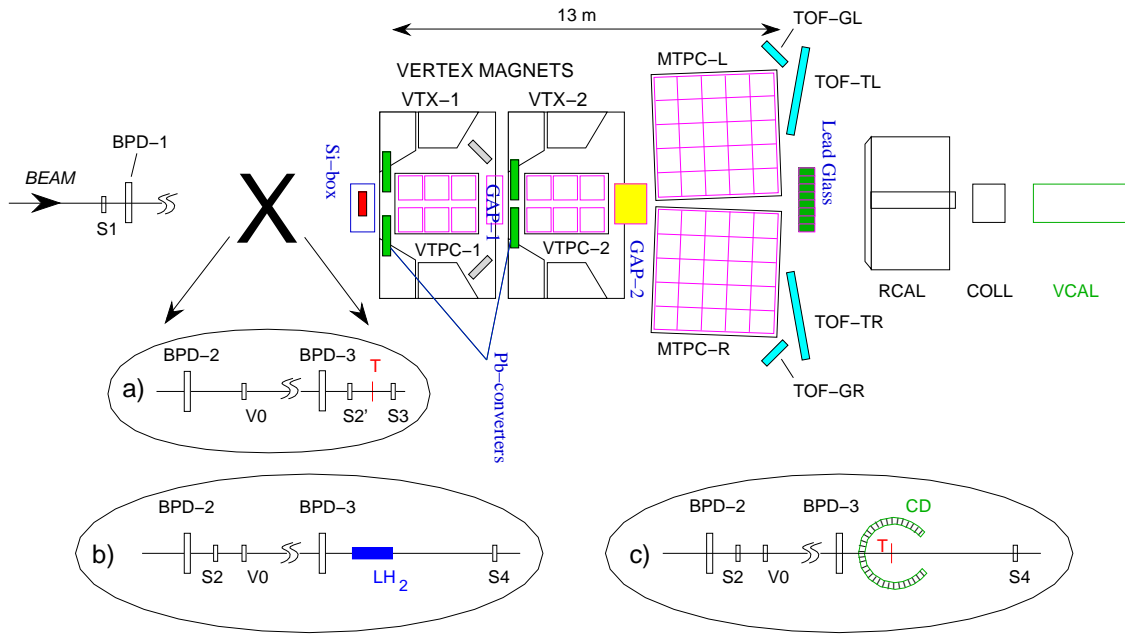
- b) Though it is overkill for inclusive hh and hA, but hidden resources
 - for high precision tracking and platform for CHEAP extension
 - for 4π acceptance

- c) Relatively small multiplicity in SPS energy range makes database size still inside managable limits

- d) Large cross-sections can be studied with modest beam intensity,
 - complementarity to COMPASS

- e) Fix-target experiment: versatile beam choices
 - e, μ , π , K, p, anti-p, d, α , etc.

NA49 experiment



Large acceptance hadron detector

Timescale and priorities

2005 - Preparation (no beam at SPS)

2006 - Running with present setup
test new DAQ and photon detection systems

2007 - Concentrate on pPb Cronin-effect
in connection with Jet Quenching
RHIC competition is expected around this time
——— Reference pp data are used for pentaquark search,
too

2008 - Start systematic exclusive data taking with full de-
tector
beams e, muon, pion, kaon, p, anti-p, d etc.
energies e.g. 20, 40, 80, 160 GeV

This is only part of the envisaged NA49' program. The harmonized version with light ion and astro parts will be presented in the final version or in the actual proposal.

SUMMARY

NA49-future: multipurpose experimental facility

Several physics programs:

- Light ion program (deconfinement, critical point)
- Astro-particle physics (reference data for hadron production)
- Hadron program (jet quenching, Cronin-effect, pentaquarks)
- Universal facility for exclusive studies of soft hadron physics