Joint Institute for Nuclear Research (JINR)

XVIII INTERNATIONAL BALDIN SEMINAR ON HIGH ENERGY PHYSICS PROBLEMS
"RELATIVISTIC NUCLEAR PHYSICS & QUANTUM CHROMODYNAMICS"

Nuclear transparency effect in proton and deuteron interactions with carbon nuclei

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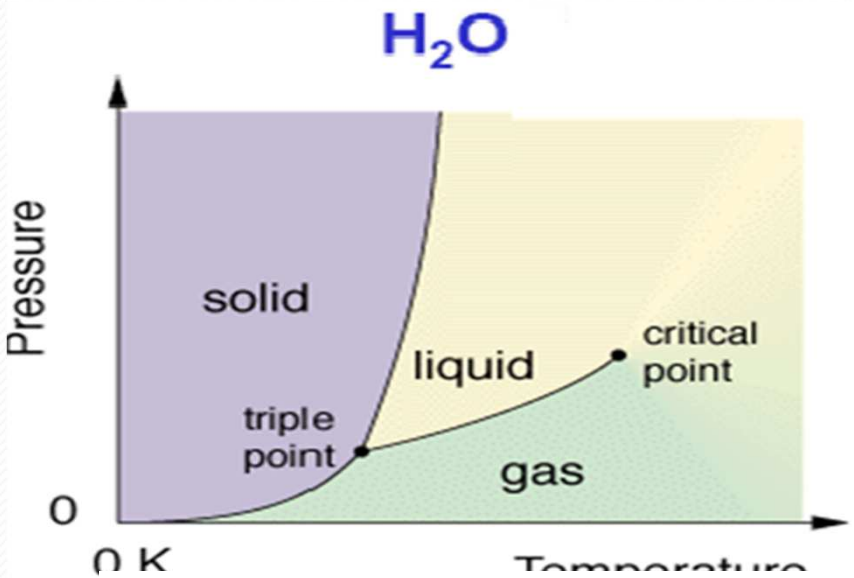
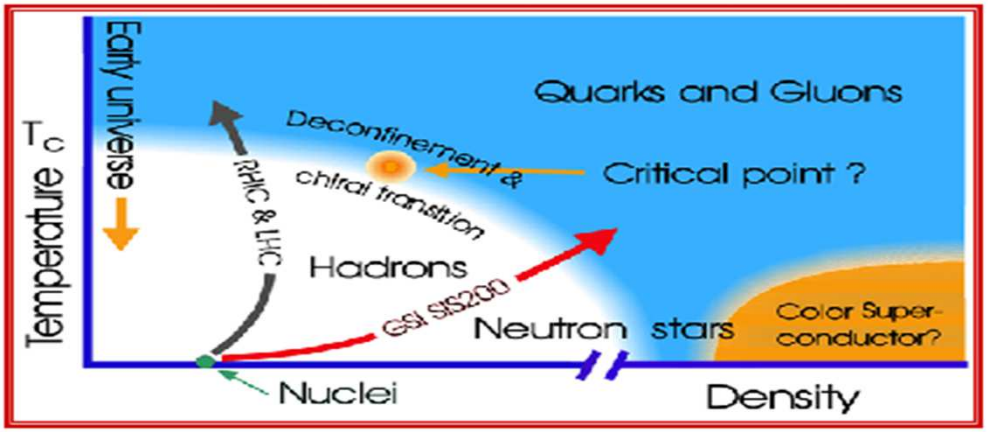
Sept. 10-15, 2012

- we studied nuclear transparency effect using $p^{12}C$- & $d^{12}C$- interactions @4.2 A GeV/c.
- half angle ($\theta_{\frac{1}{2}}$) technique is used which divide the emitted particles in two groups (incone/outcone) depending on their polar angle in the lab. frame.
- the behavior of average characteristics of the incone and the outcone protons & $\pi^{\mp}$- mesons are studied separately as a function of the number of identified protons (N_p) in an event
- the transparency observed is divided into three groups: leading effect; cascade effect; and medium effect. The last one could be connected by the coherent interactions of grouped nucleons.

Motivation





So study of the Nuclear Transparency in hA & AA collisions at high energies could help to extract the information on new phases of the strongly interacting matter

Main goal

- looking for the transparency effect of nuclear matter
- to understand mechanism of the transparency

- Different mechanisms could be reason of the nuclear transparency effect

- [Y. Afek et, al., THC11NI0N - PH - 76 - 87]

I. particle-nucleus collisions is a multistep process

1. Intranuclear Cascade Models, 2. Leading particle Cascade Models, 3. Energy Flux Cascade Models, 4. Multiperipheral Regge Type Models, 6. and various types of Statistical and Hydrodynamical Models

II. particle-nucleus collisions is a single step process

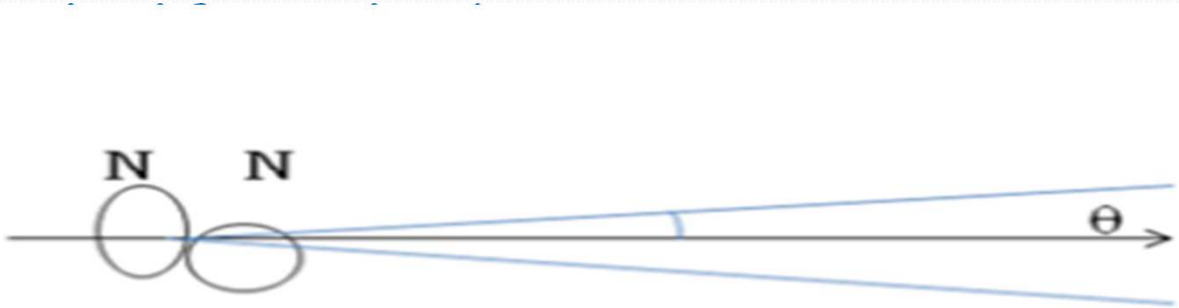
F.C. Roesler and C.B.A. McCusker, Nuovo Cimento 10, 127 (1953). W. Heitler and C.H. Terreaux, Proc. Phys. Soc. London A66, 929 (1953). S.Z. Belenkij and L.D. Landau, Nuovo Cimento 3, 15 (1956). D.S. Narayan and K.V.L. Sarma, Prog, of Theor. Phys. 31, 93 (1964). L.D. Landau in "Collected Papers of L.D. Landau, Pergamon Press London 1965 (Editor D. Ter Harr). A.M. Baldin, Proceedings of the VI Int. Conf. on High Energy Physics. A. Dar, MIT Preprint 1972 (unpublished). K. Gottfried, in "High Energy Physics and Nuclear Structure" North Holland Publ. Com. 1974 (Editor G. Tibell). A. Dar, Proceeding of the ICTP Topical Meeting on High Energy Reactions Involving Nuclei, Trieste 1974 (Editor L. Bertocci). A.Z. Patashinskii, JETP Lett. 19, 338 (1974). G.Berlad, A. Dar and G. Eilam, Phys. Rev. D13, 161 (1976). F. Takagi, Nuovo Cimento Lett. 14, 559 (1975). S. Fredriksson, Nucl. Phys. B (to be published)

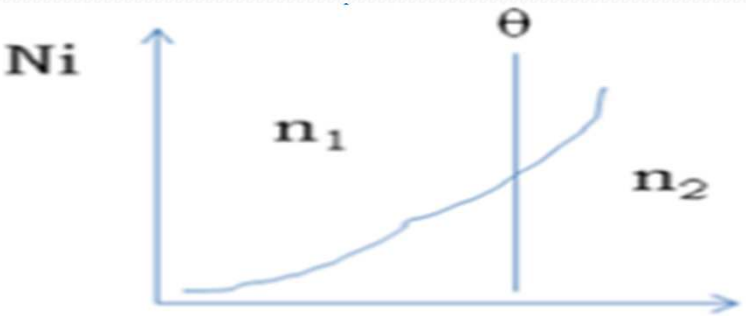
[A.M. Baldin, Proceedings of the VI Int. Conf. on High Energy Physics and Nuclear Structure, Santa Fe, June 1975 and references therein.]

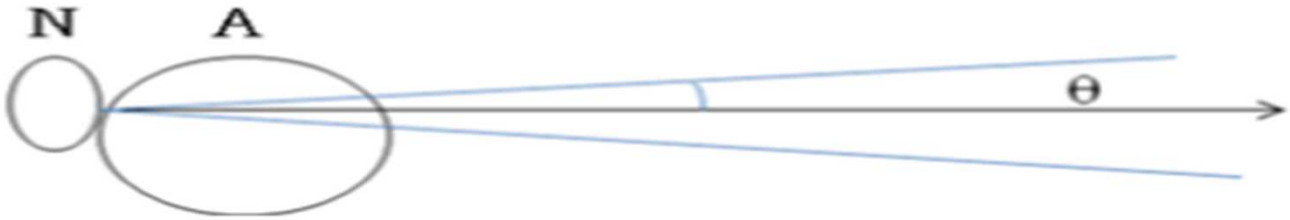
- To reach the goal we used **“half angle” technique** for lightest nuclear system at relativistic energies

half angle ($\theta_{1/2}$) technique

- We define $\theta_{1/2}$ from NN interaction at 4.2 GeV/c which divide the particle multiplicity in two equal parts







$n_1 = n_2$

Experimental Procedure

- We have studied the average characteristics of the secondary charged particles produced in p^{12}C- and d^{12}C-interactions at 4.2 A GeV /c as a function of N_p;

- **Experimental Data**
  - <n>, <p> and <p_T> of protons (incone and outcone)
  - <n>, <p> and <p_T> of π^+ (incone and outcone)
  - <n>, <p> and <p_T> of π^- (incone and outcone)
- **CASCADE Model**
  - <n>, <p> and <p_T> of protons (incone and outcone)
  - <n>, <p> and <p_T> of π^+ (incone and outcone)
  - <n>, <p> and <p_T> of π^- (incone and outcone)
- **Fitting**
  - to get quantitative results

EXPERIMENTAL DATA

- We used the experimental data obtained from the 2-m propane bubble chamber of Joint Institute for Nuclear Research (JINR, Dubna)
- The chamber placed in a magnetic field of 1.5 T
- was exposed to beams of light relativistic nuclei
- Practically all secondaries emitted at a 4π total solid angle were detected in the chamber.
- pion registration threshold 70 Mev/c.
- proton registration threshold 150 Mev/c.
- 12757 pC , 9016 dC interactions @ 4.2 A GeV/c

RESULTS FROM THE EXPERIMENT

$P^{12}C$ & $d^{12}C$ INTERACTION AT 4.2 A GeV/c

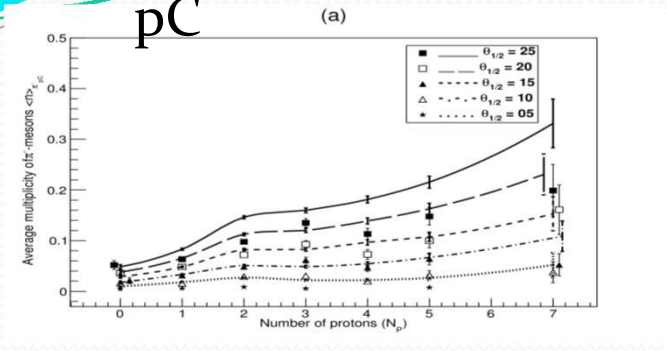
$\langle n \rangle_p$, $\langle p \rangle_p$ and $\langle p_T \rangle_p$ vs N_p (in cone)

1. This type of transparency is connected to leading effect

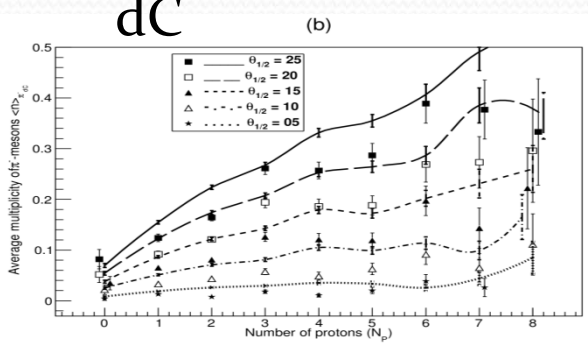
Leading particles are projectiles which could give some part of their energy during interaction. The particles will have maximum energy in an event and would be identified in an experiment as incone particles due to their high energy /low angle. Due to their high energy they passes very fast through the medium. That is why medium

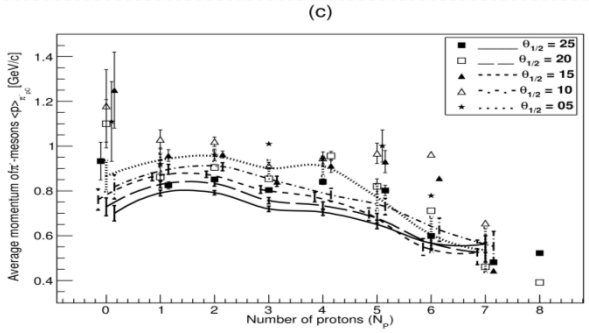
<n>$_{\pi^-}$ and <p>$_{\pi^-}$ vs N_p (in cone)

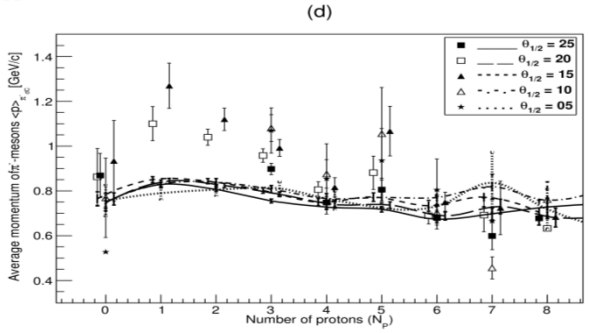
pC



dC



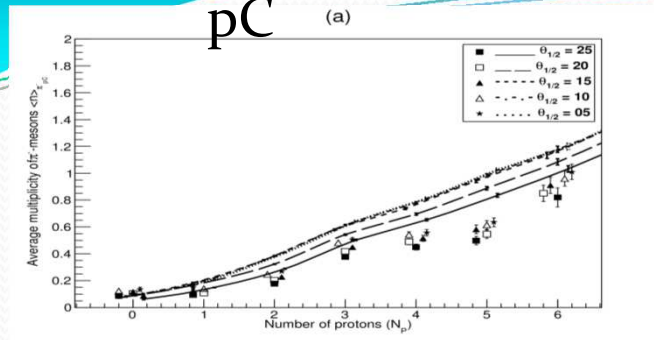


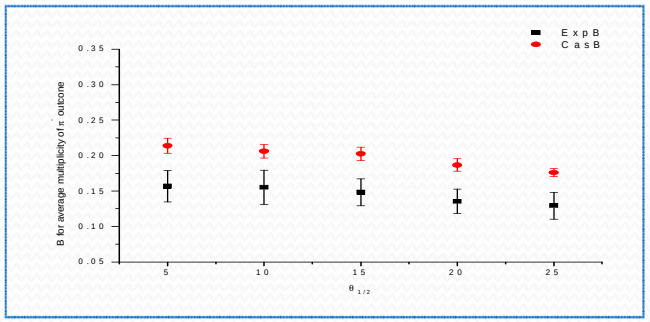


We support that these fast and small angle mesons could be connected with leader nucleons too. They could appear as a result of charge exchange reactions for the leader nucleon $n \rightarrow p + \pi^-$ and $p \rightarrow n + \pi^+$. It confirmed with the comparison of pC and dC-data. In pC the difference between model and experimental data become smaller compare with dC-data due to absent

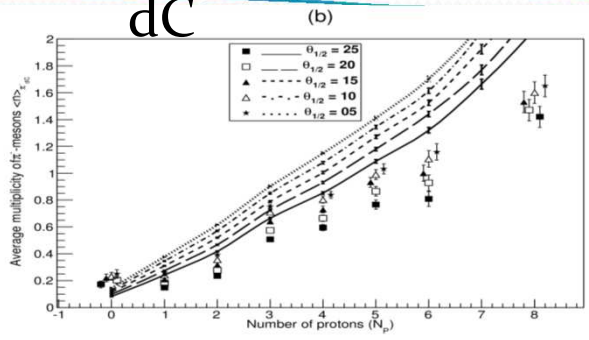
$\langle n \rangle_{\pi^-}$ and $\langle p_T \rangle_{\pi}$ vs N_p (out cone)

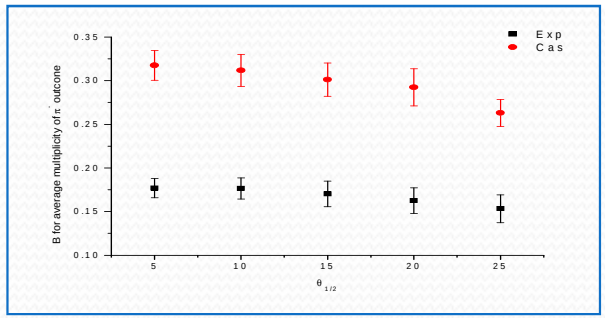
pC

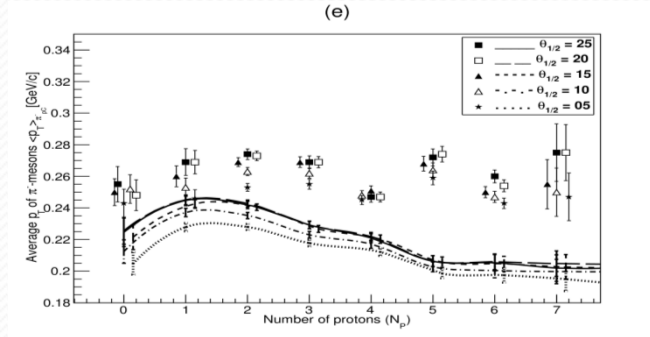


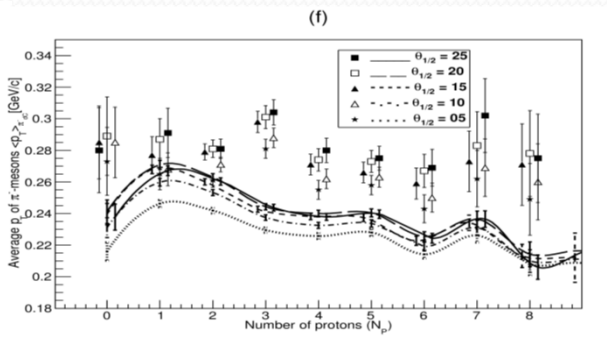


dC









Not describe by the cascade model and it could not be consider as a leader effect because the behavior is observed for the outer cone π^-- and π^+-mesons (low energy secondary particles with large angle). We consider the result as some signal on appearance of the transparency which could be connected with some particular properties of the medium. Because the average momentum and average transverse momentum of these

CONCLUSION

- We observed several cases for which behaviors of some characteristics didn't depend on the N_p- some signals on appearance of nuclear transparency effect.
- The signals were characterized in three groups of transparency:

I. Transparency due to leading effect: projectile gives some part of its energy during interaction and could save other essential part of its energy. The particle will have maximum energy in an event, very fast passes the medium, cannot interact more and that is why medium seems transparent for it.

II. Cascade Transparency because data coming from the code could satisfactorily describes the effects.

III. Transparency due to medium effect : which could

Thanks