Working Group 3

Reunião de 27/05/26

Alberto Martinez

Fernando Navarra

Renato Higa

Kanchan Khemchandani

Patrícia Magalhães

Ana Júlia Mizher

WG3 : aprender física de hadrons no LHC (QCD, QGP, CGC, espectros...)

Sub-produto: melhorar o nível de discussão dentro do grupo e do IFUSP

O que aconteceu entre 05/25 e 05/26 ?

I

18 Artigos Publicados

Interactions of the deuteron with a hadronic medium #1

L.M. Abreu (Bahia U.), R.O. Magalhães (Bahia U.), R. Higa (Sao Paulo U.), F.S. Navarra (Sao Paulo U.) (Oct 16, 2025)

Published in: *Phys.Rev.D* 113 (2026) 1, 014003 • e-Print: 2510.17871 [hep-ph]

pdf DOI cite claim reference search 0 citations

Initial-state geometry and multiplicity distributions in pp and $p\mathrm{Pb}$ collisions #2

R. Terra (Sao Paulo U.), A.V. Giannini (Nova U., Lisboa and Santa Catarina U.), F.S. Navarra (Sao Paulo U.) (Oct 14, 2025)

Published in: *Phys.Rev.D* 113 (2026) 9, 094009 • e-Print: 2510.12561 [hep-ph]

pdf DOI cite claim reference search 3 citations

The sharpness of the quark-hadron transition and the properties of hybrid stars #3

M.B. Albino (Coimbra U.), R. Fariello (Sao Paulo U. and Unlisted, BR), G. Lugones (ABC Federal U.), F.S. Navarra (Sao Paulo U.) (Sep 30, 2025)

Published in: *Int.J.Mod.Phys.D* 34 (2025) 15, 2550073 • e-Print: 2510.02053 [nucl-th]

pdf DOI cite claim reference search 1 citation

Multiplicity Distributions and the Frontier Between Soft and Hard Physics #4

Henrique R. Martins-Fontes (Sao Paulo U.), Fernando S. Navarra (Sao Paulo U.) (Sep 18, 2025)

Published in: *MDPI Physics* 7 (2025) 4, 57, *Physics* 7 (2025) 57 • e-Print: 2509.15056 [hep-ph]

pdf DOI cite claim reference search 6 citations

Soft and semihard components of multiplicity distributions in the k_T-factorization approach #5

H.R. Martins-Fontes (Sao Paulo U.), F.S. Navarra (Sao Paulo U.) (Jun 20, 2025)

Published in: *Phys.Rev.D* 112 (2025) 9, 094045 • e-Print: 2506.17127 [hep-ph]

pdf DOI cite claim reference search 5 citations

Universality of scaling entropy in charged hadron multiplicity distributions at the LHC #6

L.S. Moriggi (Unlisted, BR), F.S. Navarra (Sao Paulo U.), M.V.T. Machado (Rio Grande do Sul U.) (Jun 11, 2025)

Published in: *Phys.Rev.D* 112 (2025) 7, 074019 • e-Print: 2506.09899 [hep-ph]

pdf DOI cite claim reference search 7 citations

Production of η_b in ultraperipheral Pb-Pb collisions #7

C.N. Azevedo (Sao Paulo U.), F.C. Sobrinho (Sao Paulo U.), F.S. Navarra (Sao Paulo U.) (Dec 24, 2024)

Published in: *Phys.Rev.C* 112 (2025) 6, 064908 • e-Print: 2412.18567 [hep-ph]

pdf DOI cite claim reference search 1 citation

$D^*\pi$ interaction from the lineshape of $D_1(2420)$ in B-decays #1

Pedro Brandão (Bahia U.), Breno Agatão (Sao Paulo U.), Luciano M. Abreu (Bahia U.), K.P. Khemchandani (Sao Paulo U.), A. Martínez Torres (Sao Paulo U.) (Dec 30, 2025)

e-Print: 2512.24370 [hep-ph] Published in: Phys. Lett. B878 (2026), 140527

pdf DOI cite claim reference search 0 citations

Revisiting the three-kaon interaction and its relation with $K(1460)$ #2

Michael Döring (George Washington U. and Jefferson Lab), Kanchan P. Khemchandani (Sao Paulo U.), Alberto Martínez Torres (Sao Paulo U.) (Nov 4, 2025)

Published in: *Phys.Rev.D* 113 (2026) 3, 034032 • e-Print: 2511.02543 [nucl-th]

pdf DOI cite claim reference search 2 citations

Correlation functions for $n\,\bar{D}_{s1}(2460)$ and $n\,\bar{D}_{s1}(2536)$ #3

Breno Agatão (Sao Paulo U. and Valencia U., IFIC), Pedro Brandão (Bahia U. and Valencia U., IFIC), A. Martínez Torres (Sao Paulo U.), K.P. Khemchandani (Sao Paulo U.), Luciano M. Abreu (Bahia U.) et al. (Aug 7, 2025)

Published in: *Eur.Phys.J.C* 85 (2025) 10, 1136 • e-Print: 2508.05825 [hep-ph]

pdf DOI cite claim reference search 7 citations

Bolstering up the existence of $P_s(2080)$

#4

Breno Agatão (Sao Paulo U.), A. Vertel Nieto (Sao Paulo U.), K.P. Khemchandani (Sao Paulo U.), A. Martinez Torres (Sao Paulo U.), Seung-il Nam (Pukyong Nat. U. and POSTECH and APCTP, Pohang) (Dec 27, 2024)

Published in: *Phys.Rev.D* 111 (2025) 11, 116013 • e-Print: 2412.19559 [hep-ph]

pdf DOI cite claim reference search 0 citations

A study of the φN correlation function

#7

Luciano M. Abreu (Bahia U.), Philipp Gubler (JAEA, Ibaraki and Sao Paulo U.), K.P. Khemchandani (Sao Paulo U.), A. Martinez Torres (Sao Paulo U.), Atsushi Hosaka (JAEA, Ibaraki and Sao Paulo U. and Osaka U., Res. Ctr. Nucl. Phys.) (Sep 8, 2024)

Published in: *Phys.Lett.B* 860 (2025) 139175 • e-Print: 2409.05170 [hep-ph]

pdf DOI cite claim reference search 19 citations

Strangeness +1 light multiquark baryons

#10

Brenda B. Malabarba (Sao Paulo U. and Pukyong Nat. U.), K.P. Khemchandani (Pukyong Nat. U. and Sao Paulo U.), A. Martinez Torres (Sao Paulo U. and Pukyong Nat. U.), Seung-il Nam (Pukyong Nat. U. and POSTECH and APCTP, Pohang) (Apr 5, 2024)

Published in: *Phys.Rev.D* 111 (2025) 1, 016021 • e-Print: 2404.04078 [hep-ph]

pdf DOI cite claim reference search 8 citations

Understanding Large Localized CP Violation in $B^{\pm} \to K^{\pm}\pi^{+}\pi^{-}$ Using Dispersive Methods

#1

L.A. Heuser (Bonn U., HISKP and U. Bonn, Phys. Inst., BCTP), A. Reyes-Torrecilla (Madrid U.), C. Hanhart (IAS, Julich), B. Kubis (Bonn U., HISKP and U. Bonn, Phys. Inst., BCTP), P.C. Magalhães (U. Campinas) et al. (Aug 14, 2025)

Published in: *Phys.Rev.Lett.* 136 (2026) 11, 111901 • e-Print: 2508.10989 [hep-ph]

pdf DOI cite claim reference search 0 citations

#1

Mass and coupling magnetic field dependence in a scalar theory with charged bosons from an environmentally friendly renormalization group analysis

Alejandro Ayala (Mexico U., ICN and Sao Paulo U. and Sao Paulo, IFT), Flávia Fialho (UNICID, Sao Paulo), Ana Mizher (Sao Paulo U. and Biobio U.) (Dec 22, 2025)

Published in: *Phys.Rev.D* 113 (2026) 5, 056009 • e-Print: 2512.19807 [hep-th]

pdf DOI cite claim reference search 0 citations

#2

Inverse magnetic catalysis in the linear sigma model: a beyond mean field approach

Gabriela Fernández (Mexico City U., Azcapotzalco), Luis A. Hernández (Mexico City U., Azcapotzalco), Ana Mizher (Sao Paulo U.) (Oct 3, 2025)

Published in: *J.Phys.G* 53 (2026) 3, 035001 • e-Print: 2510.02747 [hep-ph]

pdf DOI cite claim reference search 2 citations

#3

Asymmetric muon-antimuon emission from Z^0 decays: A potential magnetometer in relativistic heavy-ion collisions

Alejandro Ayala (Mexico U., ICN and UNICID, Sao Paulo and Sao Paulo, IFT), Ana Julia Mizher (UNICID, Sao Paulo and Sao Paulo, IFT and Biobio U. and Sao Paulo U.), Javier Rendón (Mexico U., ICN) (Jun 13, 2025)

Published in: *Phys.Rev.C* 113 (2026) 3, 034902 • e-Print: 2506.11370 [hep-ph]

pdf DOI cite claim reference search 1 citation

#4

Strongly interacting matter in extreme magnetic fields

Prabal Adhikari (St. Olaf Coll.), Martin Ammon (U. Jena (main)), Sidney S. Avancini (Santa Catarina U.), Alejandro Ayala (Mexico U.), Aritra Bandyopadhyay (U. Heidelberg, ITP) et al. (Dec 21, 2024)

Published in: *Prog.Part.Nucl.Phys.* 146 (2026) 104199 • e-Print: 2412.18632 [nucl-th]

pdf DOI cite claim reference search 53 citations

4 Artigos Submetidos

Charm multiplicity distribution in high energy pp collisions with PYTHIA #3

Y.N. Lima (Sao Paulo U.), C. Jahnke (Campinas State U.), M. Munhoz (Sao Paulo U.), F.S. Navarra (Sao Paulo U.) (Dec 21, 2025)

e-Print: 2512.18739 [hep-ph]

pdf cite claim reference search 0 citations

Photon production from gluon splitting and fusion induced by a magnetic field in heavy-ion collisions #

Alejandro Ayala (Mexico U., ICN and Sao Paulo U. and Sao Paulo, IFT), Santiago Bernal-Langarica (Mexico U., ICN), José Jorge Medina-Serna (Mexico U., ICN), Ana Julia Mizher (Sao Paulo U. and Biobio U.) (Mar 26, 2026)

e-Print: 2603.24964 [hep-ph]

pdf cite claim reference search 0 citation

Latin American network on electromagnetic effects in strongly interacting matter: Contribution to the update of the Latin American Strategy for High Energy, Cosmology and Astroparticle Physics #4

Ana Mizher (Sao Paulo, IFT and UNICID, Sao Paulo and Biobio U.), Alejandro Ayala (Mexico U., ICN) (Aug 1, 2025)

e-Print: 2508.00771 [hep-ph]

pdf cite claim reference search 0 citations

Precision calculation of $^3\mathrm{He}(\alpha,\gamma)^7\mathrm{Be}$ for solar physics #2

Ratna Khadka (Mississippi State U.), Ling Gan (Mississippi State U.), Renato Higa (Mississippi State U. and Sao Paulo U., Sao Carlos), Gautam Rupak (Mississippi State U.) (Sep 29, 2025)

e-Print: 2509.24931 [nucl-th]

6 Proceedings

Advances in QCD at the LHC and the EIC, 09/11 – 15/11 (2025), CBPF, RJ

Effects of the magnetic field on π^0 production in ultraperipheral Pb-Pb collisions #1

C.N. Azevedo (Sao Paulo U.), R. Fariello (Sao Paulo U. and Unlisted, BR), F.C. Sobrinho (Sao Paulo U.), F.S. Navarra (Sao Paulo U.)
(May 2, 2026)
e-Print: 2605.01500 [hep-ph]

Effects of the initial-state geometry on D-meson production in pp and pPb collisions

R. Terra (Sao Paulo U.), A.V. Giannini (Nova U., Lisboa and Santa Catarina U.), F.S. Navarra (Sao Paulo U.) (Mar 25, 2026)
e-Print: 2603.24344 [hep-ph]

Remarks on the Shape Parameters of Multiplicity Distributions

H. R. Martins-Fontes, F. S. Navarra

Exotic states with charm and/or strangeness

A. Martínez Torres[1], Breno Agatão[1], Pedro Brandão[2], K. P. Khemchandani[3], Luciano M. Abreu[2], E. Oset[4,5]

Explicitly exotic heavy flavor mesons

K. P. Khemchandani[1,*], Taísa Veloso[1], G. Peres de Andrade[2], Hao-Nan Liu[2], A. Martínez Torres[2], Luciano M. Abreu[3], Philipp Gubler[4]

FSI model for an amplitude analysis of the $D^+ \to K^-K^+\pi^+$ decay

Felipe C. L. Lopes[1], Patrícia C. Magalhães[1], Gustavo A. L. Ordoñez[2], Érica Polycarpo[3], Lucas A. Q. F. da Silva[1]

Teses concluidas

Henrique Martins Fontes (mestrado – Fernando Navarra)

Alonso Vertel Nieto (mestrado – Alberto Martínez Torres)

Orientações e supervisões em andamento

3 Pósdocs

- Celsina Azevedo (F. Navarra)
- Yan Bandeira (F. Navarra)
- Liner Souza (A.J. Mizher)

9 Doutorados

- Richard Terra (F. Navarra)
- Fernando Sobrinho (F. Navarra)
- Henrique Martins Fontes (F. Navarra)
- Breno Agatão (A. Martínez Torres)
- Hao-nan Liu (A. Martínez Torres)
- Felipe C. Laterza Lopes (P. Magalhães)
- Flávia Fialho (A.J. Mizher)
- Alejandro Lopez (A.J. Mizher)
- Vinícius B. B. Ader (R. Higa)

9 Mestrados

- Taisa Veloso (K. P. Khemchandani)
- Guilherme de Cerqueira Silva (K. P. Khemchandani, A. Matinez Torres)
- Guilherme Peres de Andrade (A. Martínez Torres)
- Rafaela Costa Teles (A. Martínez Torres)
- Vinícius B. B. Ader (R. Higa)
- Lucas A. Q. F. da Silva (P. Magalhães)
- Matheus F. Cichocki (R. Higa)
- Pedro H. L. Nanzer (R. Higa)
- Elias P. Huning (R. Higa)

12 Iniciação Científica

- Natália Costa (F. Navarra)
- Davi M. Gonçalves (K. P. Khemchandani)
- Karolainy Figueira (P. Magalhães)
- Carolina Copeli (A. Martínez Torres)
- Ryan I. S. de Oliveira (A. Martínez Torres)
- Miguel M. Oliveira (P.Magalhães)
- Jun Yasumoto (A.J. Mizher)
- Lia França (A.J. Mizher)
- Mateus Chamas (A.J. Mizher)
- Caio Oliveira (A.J. Mizher)
- Joana D. C. Vidal (R. Higa)
- Theodoro S. F. Montoro (R. Higa)

Participações em Conferências

21st International Conference on Hadron Spectroscopy and Structure. HADRON 2025. (A. Martinez, K. Khemchandani)

9th Conference on Chirality, Vorticity and Magnetic Fields, 07/07 – 11/07 (2025), ICTP-SAIFR, SP (F. Navarra, Ana J. Mizher)

53rd International Symposium on Multiparticle Dynamics, 21/09 – 26/09 (2025), Corfu, Grecia (A. J. Mizher)

XXXII Reunião de Trabalho sobre Interações Hadrônicas RETINHA 32, 29/10 – 31/10 (2025), CBPF, RJ (F. Navarra, Ana J. Mizher, A. Martinez, K. Khemchandani)

Advances in QCD at the LHC and the EIC,09/11 – 15/11 (2025), CBPF, RJ (A. Martinez, K. Khemchandani, P. Magalhães)

2nd Latin American Workshop on Wlectromagnetic Effects in QCD, 24/12 – 28/12 (2025), Santiago, Chile (A. J. Mizher)

I Fronteiras da Física Teórica no Vale do Paraíba, 25/02 – 27/02 (2026), UERJ-Resende, RJ (F. Navarra, K. Khemchandani)

Workshop on Multineutron Clusters in Nuclei and Stars, June 2-6 (2025), ICTP-SAIFR, SP (R. Higa)

Pan-American Few-Body Physics Boot Camp: Fostering Collaboration, Oct 13-24 (2025) ECT*, Trento, Italy, (R. Higa)

Organização de Eventos Científicos

9th Conference on Chirality, Vorticity and Magnetic Fields, 07/07 – 11/07 (2025), ICTP-SAIFR, SP (Ana J. Mizher)

XXXII Reunião de Trabalho sobre Interações Hadrônicas RETINHA 32, 29/10 – 31/10 (2025), CBPF, RJ (F. Navarra)

Advances in QCD at the LHC and the EIC, 09/11 – 15/11 (2025), CBPF, RJ (F. Navarra)

XXXIII Reunião de Trabalho sobre Interações Hadrônicas RETINHA 33, 24/06 – 26/06 (2025), CBPF, RJ (F. Navarra)

São Paulo-Japan hadron physics collaboration meeting (2026), 13/02-21/02/2026 (K. P. Khemchandani, A. Martínez Torres, Taísa Veloso, Hao-nan Liu).

★ 22st International Conference on Hadron Spectroscopy and Structure. HADRON 2027 05/09 – 10/09 (2027), Santos, SP (A. Martínez Torres, K. P. Khemchandani, F. Navarra, P. Magalhães)

XXXIII Reunião de Trabalho sobre Interações Hadrônicas

RETINHA 33 CBPF 24 a 26 de junho de 2026

Ions pesados relativísticos

Espectroscopia de Hadrons

Estrelas Compactas

Fenomenologia da QCD

Colaboração: Sônia Ferreira

Thaissa Martins

Contato: navarra@if.usp.br

Organização

Fernando Navarra (USP)

Gabriel Denicol (UFF)

Maurício Hippert (CBPF)

Apoio: INCT-FNA, CBPF, UFF

INCT-FNA
INSTITUTO NACIONAL DE CIÊNCIA E TECNOLOGIA
FÍSICA NUCLEAR E APLICAÇÕES

CBPF

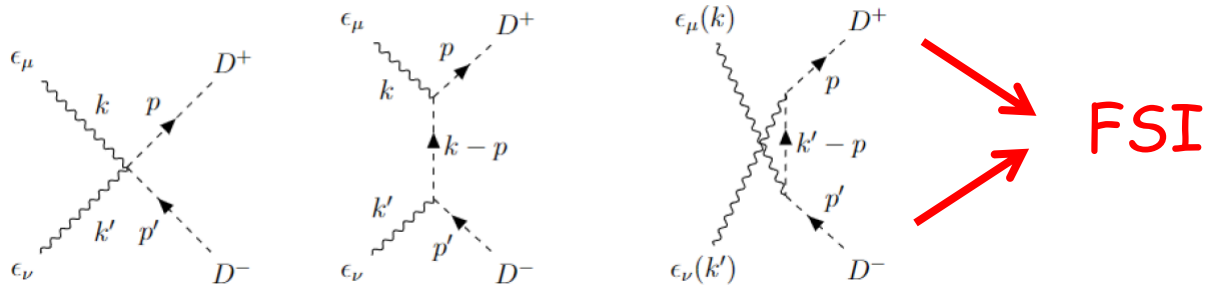
uff

II

Interações hadrônicas no estado final (FSI)

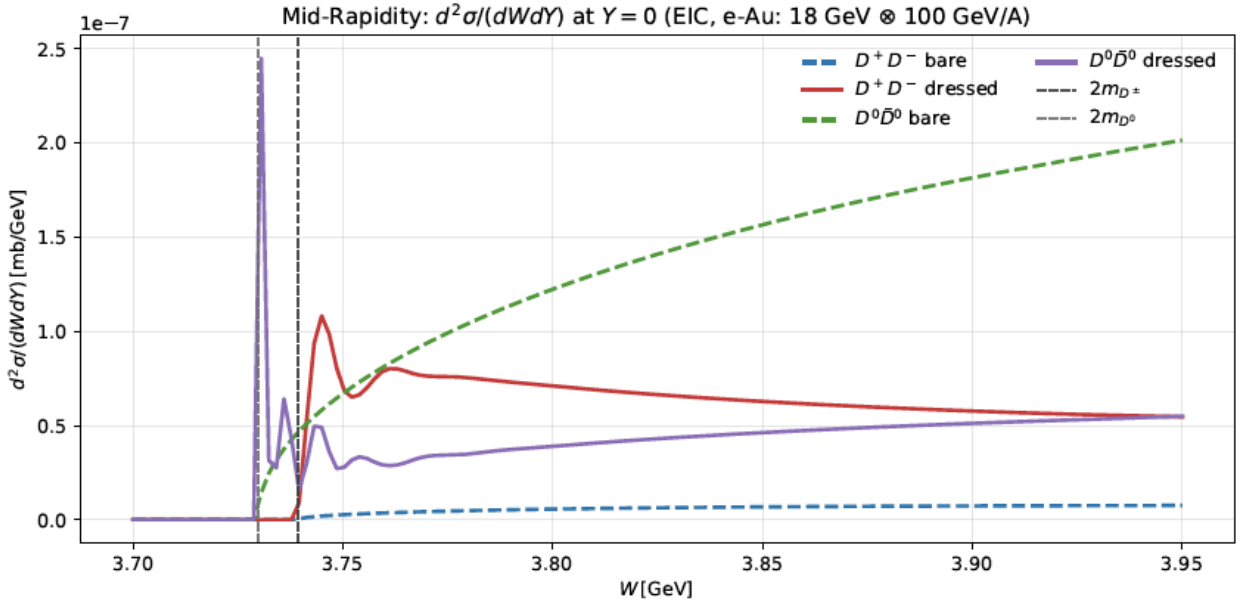
Produção de exóticos em UPCs : gamma-gamma + FSI

(F. Navarra, Fernando Sobrinho, Kanchan Khemchandani)



Extensão para o Electron-Ion Collider

Eq. Bethe-Salpeter para estudar ressonâncias geradas dinamicamente



ver seminário do F. Sobrinho

Produção de exóticos em decaimentos fracos:

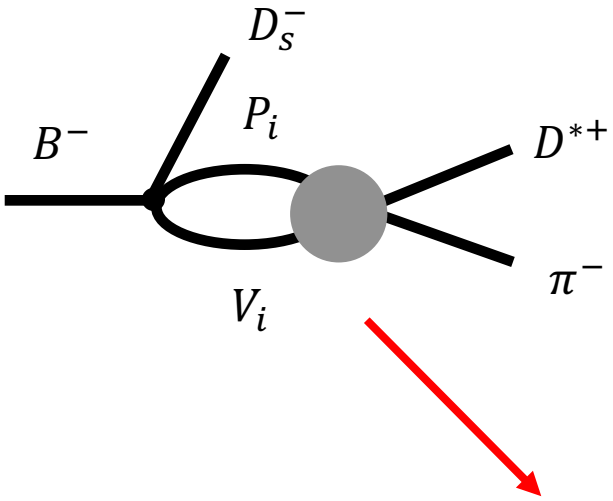
(Breno Agatão, P. Brandão, Alberto Martínez Torres, Kanchan Khemchandani, Luciano Abreu)

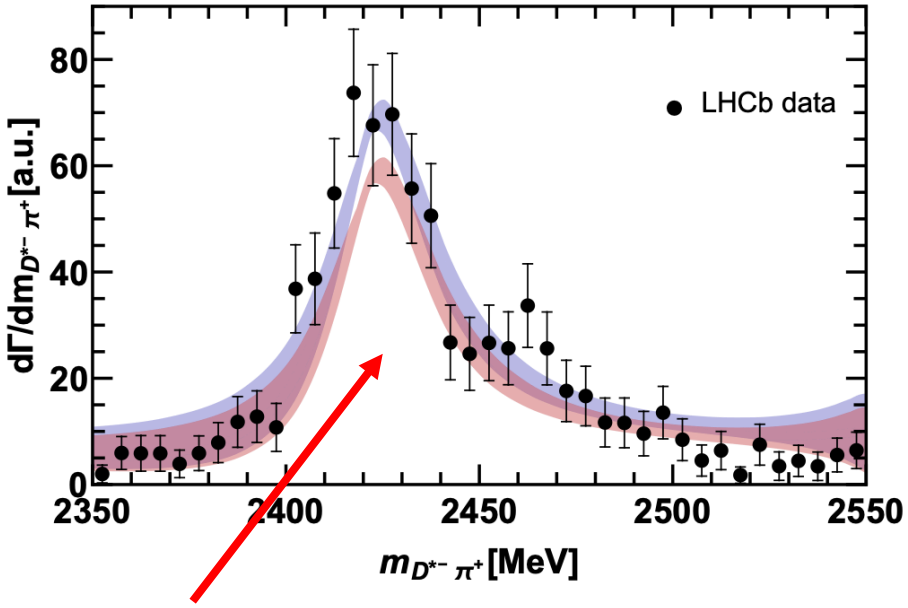
$B^- \to D_s^- D^{*+} \pi^-$

ver seminário do Alberto

ver seminário do P. Brandão

R.Aaij et al. (LHCb), JHEP08,165 (2024)



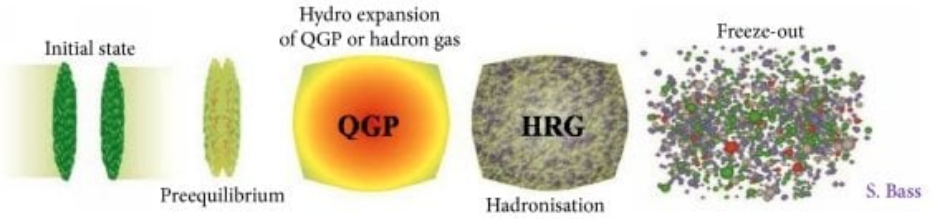


Matriz de espalhamento: geração de D_1 (2420)

Produção de partículas em colisões AA centrais:

(F. Navarra, Luciano Abreu, Renato Higa)

Preconceito: moléculas hadrônicas são destruídas no gás !



2015 : observação inesperada de deuterons

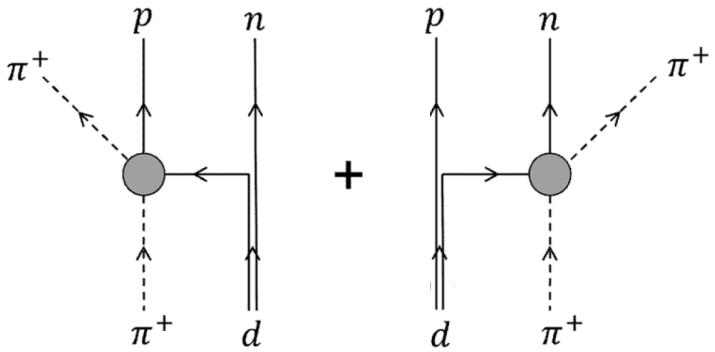
FSI

STRONG INTERACTIONS | FEATURE

ALICE investigates 'snowballs in hell'

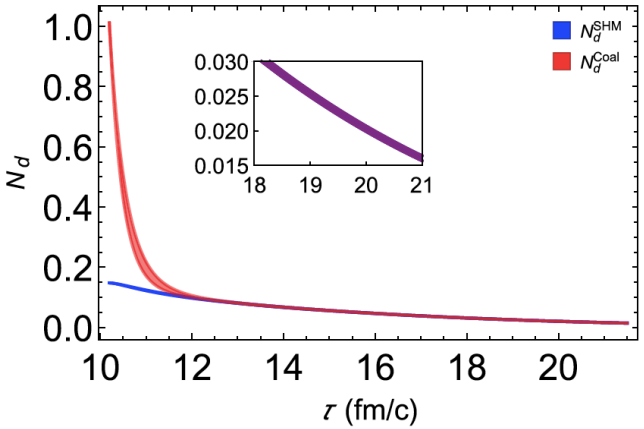
26 August 2015

How is it that loosely bound objects are observed in high-energy nuclear collisions?



Deuteron quase-livre

Fácil de destruir e fácil de criar



Sistema atinge rapidamente o equilíbrio químico !

Estudo da violação de CP

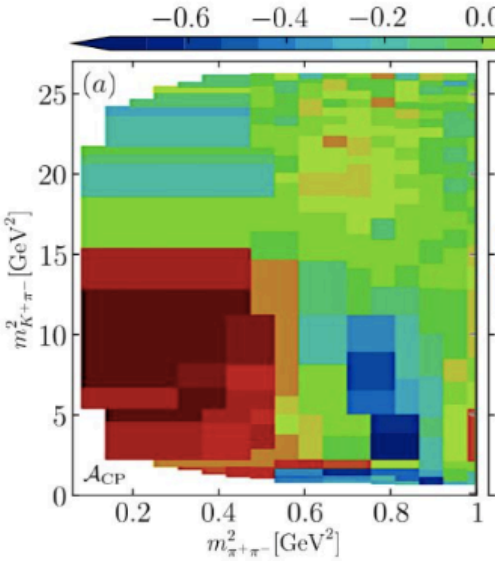
(Patrícia Magalhães et al.)

Understanding large localized CP violation in $B^{\pm} \to K^{\pm}\pi^{+}\pi^{-}$ using dispersive methods

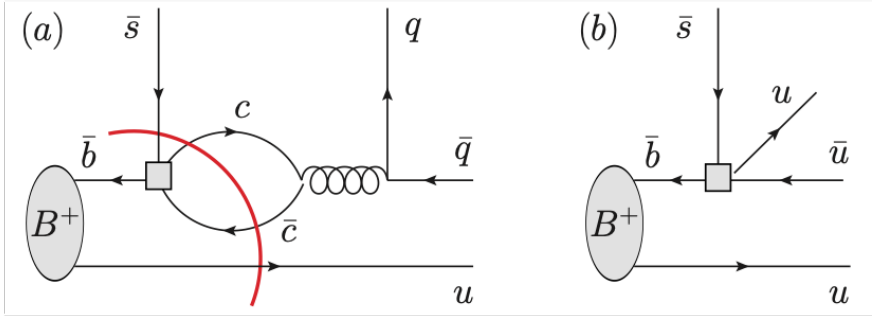
1 $B^{+} \to K^{+}\pi^{+}\pi^{-}$

2 $B^{-} \to K^{-}\pi^{+}\pi^{-}$

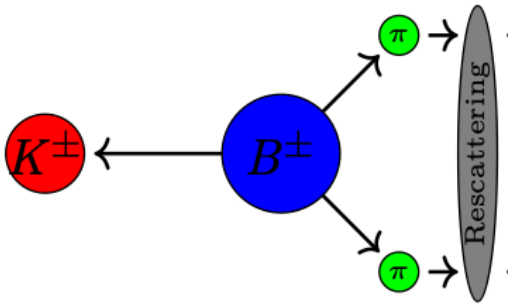
$$A_{CP} = \frac{1 - 2}{1 + 2}$$



Decaimento fraco



FSI



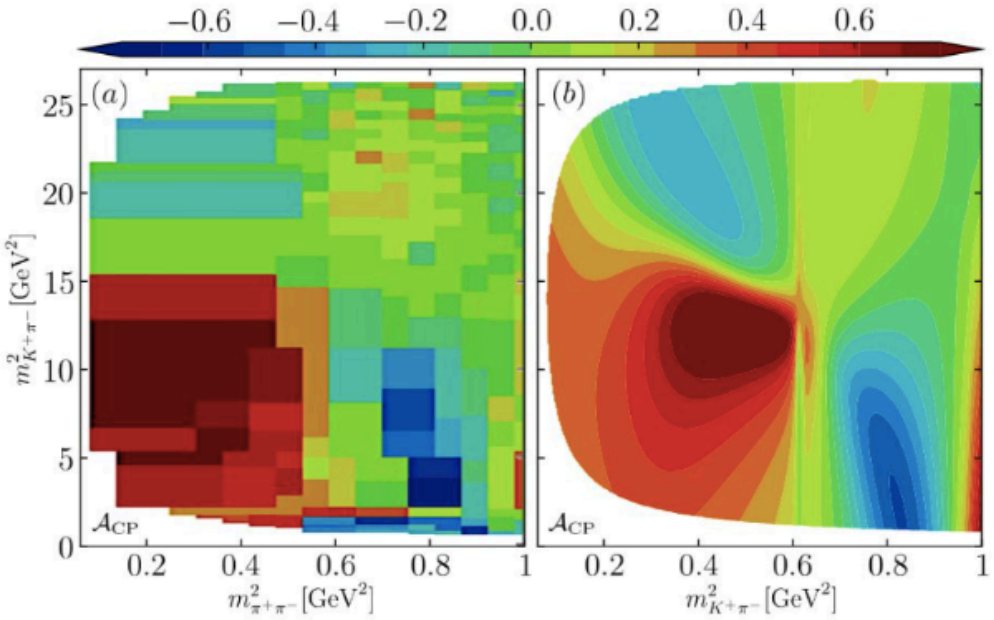
$$\mathcal{A}^{\pm}(s,t) = \sum_i f_i(s,t) P_i(s) \Omega_i(s) \bar{\mathcal{A}}_i^{\pm}$$

$$\bar{\mathcal{A}}_i^{\pm} = \hat{A}_i + e^{\pm i\gamma} \hat{B}_i = a_i + i c_i \pm i b_i$$

Weak decay

$$\Omega_i(s) = \exp\left\{ \frac{s}{\pi} \int_{4M_\pi^2}^{\infty} \mathrm{d}s' \frac{\delta_i(s')}{s'(s' - s - i\epsilon)} \right\}$$

FSI



FSI explicam intensidade e localização da violação de CP

Estrutura Hadrônica

Propriedades de estados exóticos: larguras de decaimento, seções de choque, etc.

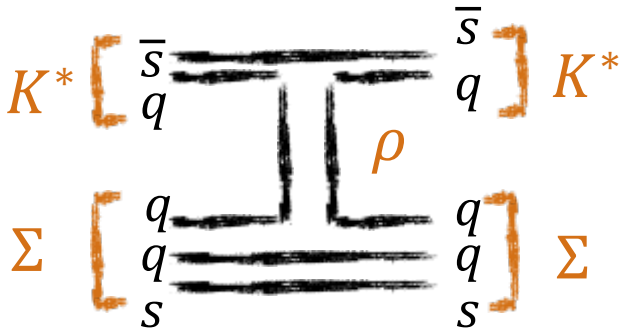
(Breno Agatão, Alberto Martínez Torres, Kanchan P. Khemchandani)

ver seminários do Alberto e do Breno

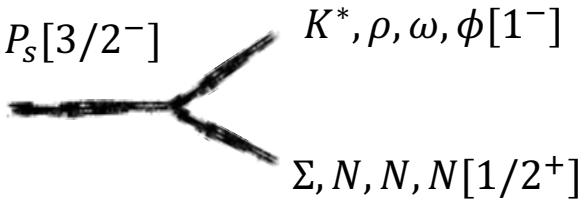
$P_s(2080)$

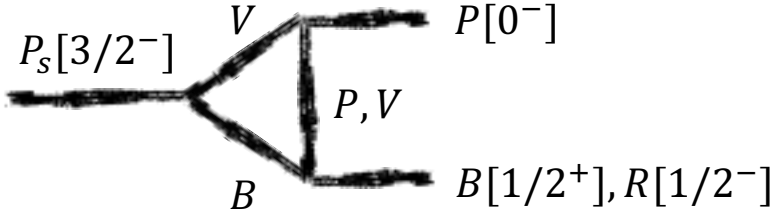
Previsão:

Estado gerado da interação V-B



Observação através de decaimentos:





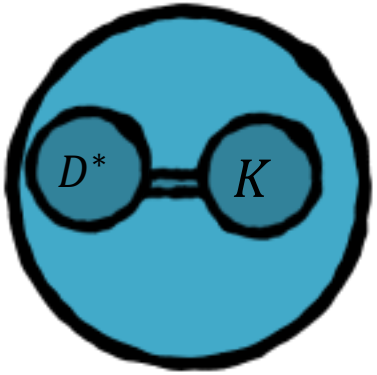
$R \equiv \Lambda(1405), N^*(1535), N^*(1650)[1/2^-]$

Estado pseudoscalar barion: loops triangulares !

Formação de exóticos em Sistemas de três corpos

(Breno Agatão, Alberto Martínez Torres, Kanchan P. Khemchandani)

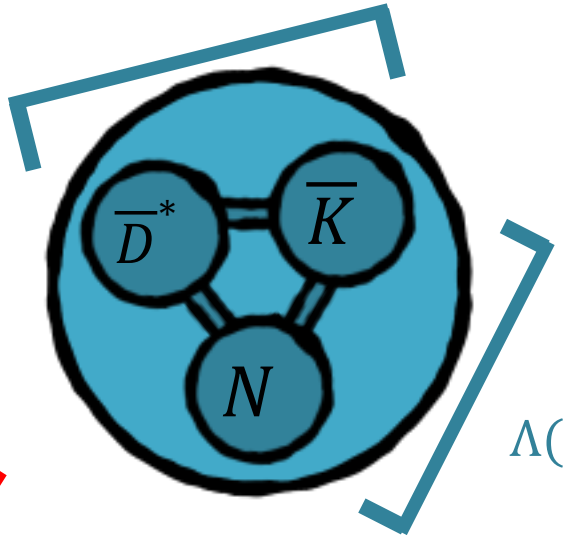
$D_{s1}^{*}(2460)[J^P = 1^+]$



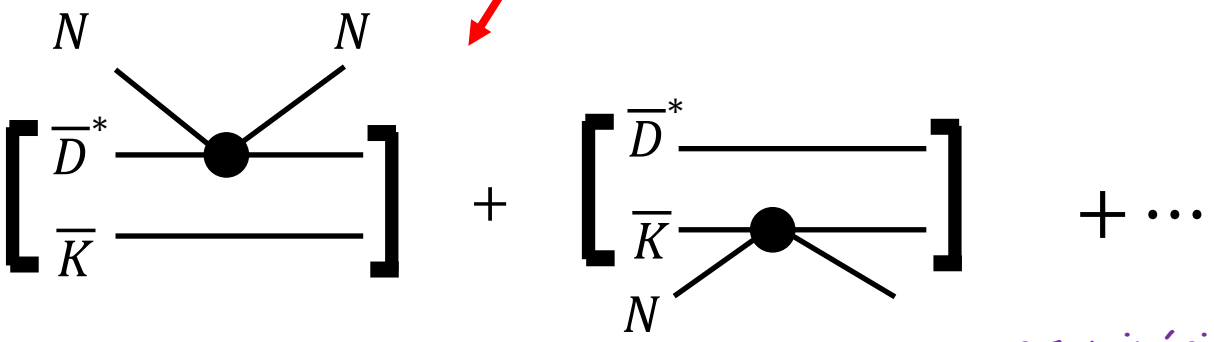
Diversos estudos (até Lattice QCD) mostram uma natureza molecular

E se adicionamos outro hádron tal que tenhamos atração em mais de um par? Podem aparecer estados ligados?

$\overline{D}_{s1}^{*}(2460)$



Equações de três corpos: Matriz de espalhamento partícula-cluster

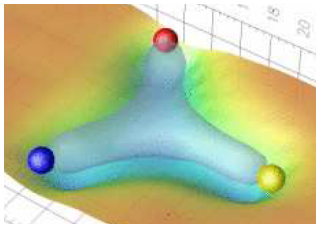


ver seminário do Alberto

Estrutura do proton: busca da junção bariônica

(F. Navarra, Richard Terra, André Giannini)

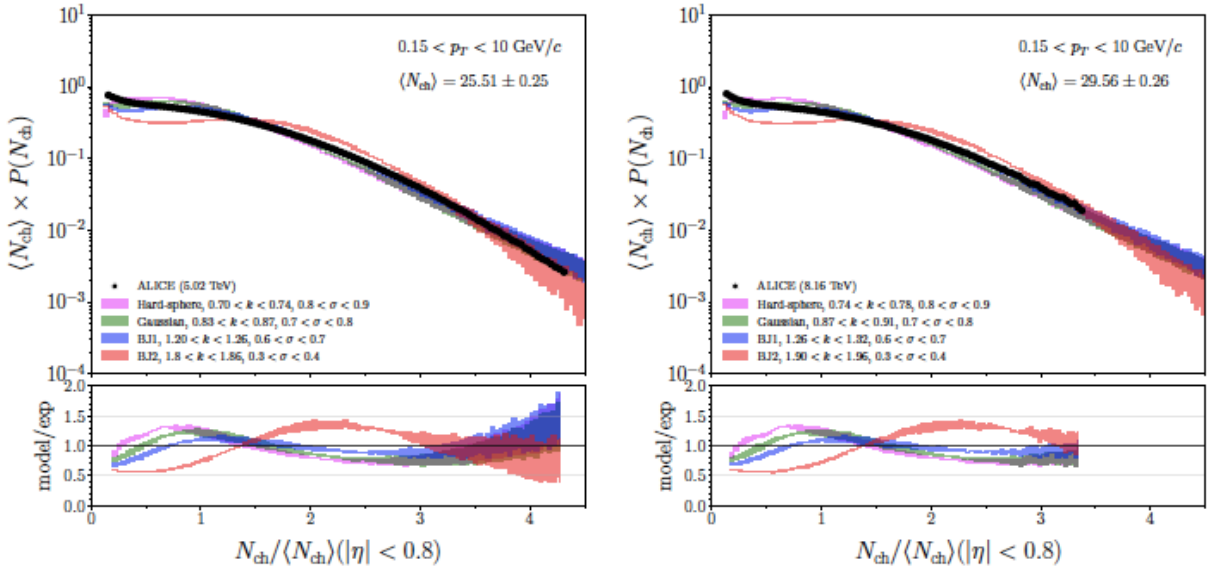
Junção bariônica:



MCKT: Monte Carlo com Glauber e CGC

Distribuição de multiplicidades em p - Pb

Flutuações geométricas e intrínsecas



Junção é a melhor, mas outras configurações não podem ser excluidas !

Em andamento: escoamento elíptico v_2

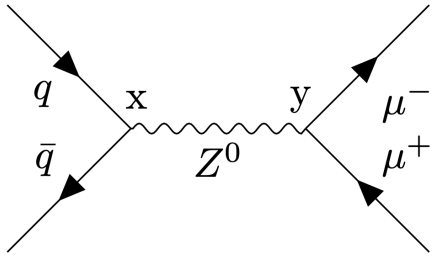
ver seminário do R. Terra

Efeitos do Campo Magnético

Decaimento do bóson Z^0 como um observável para o campo magnético em HIC

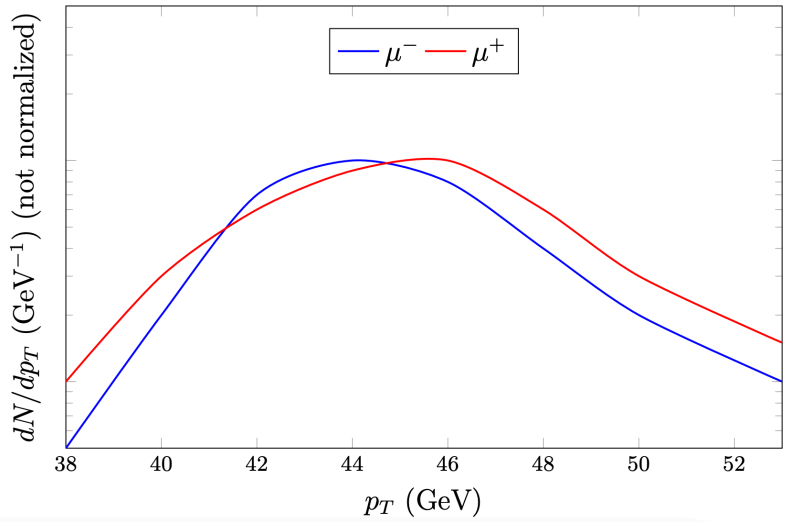
(Ana Mizher, Alejandro Ayala, Javier Rendon)

O bóson Z^0 é produzido nos instantes iniciais após a colisão de íons pesados, quando o campo magnético é mais intenso. O fato dele ser produzido e decair na presença de campo pode deixar uma marca nos dileptons finais?



O Z^0 decai em um par de muon-antimuon, que não interage com o plasma

Devido à preferência da interação fraca de haver acoplamento com partículas left e anti-partículas right haverá um split de momento entre o espectro de momento do muon e do anti-muon.

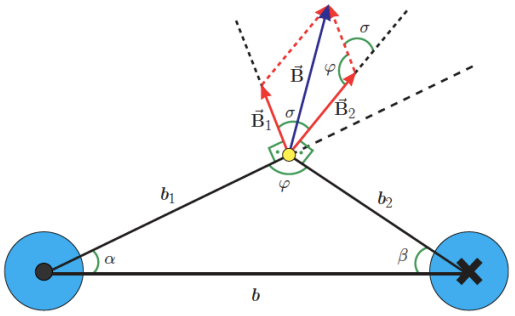


Efeito do campo magnético na produção de pions em UPCs

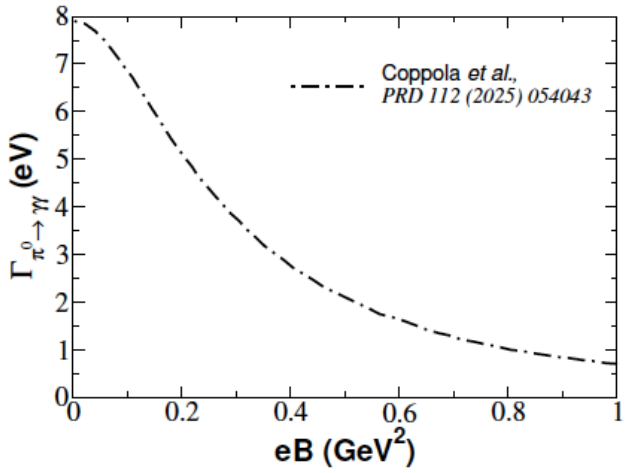
(F. Navarra, Celsina Azevedo, Fernando Sobrinho)

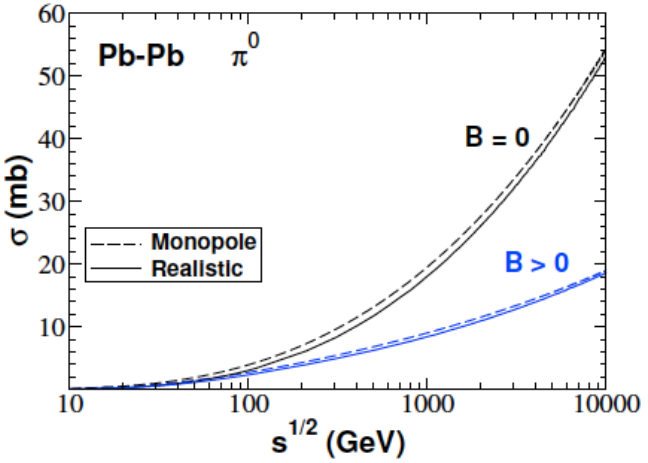
$$\sigma(PbPb \to Pb \otimes \pi^0 \otimes Pb; s) = \int \hat{\sigma}(\gamma\gamma \to \pi^0; W) N(\omega_1, \mathbf{b}_1) N(\omega_2, \mathbf{b}_2) S^2_{abs}(\mathbf{b}) \mathrm{d}^2\mathbf{b}_1 \mathrm{d}^2\mathbf{b}_2 \mathrm{d}\omega_1 \mathrm{d}\omega_2,$$

$$\hat{\sigma}_{\gamma\gamma\to\pi^0}(\omega_1, \omega_2) = 8\pi^2(2J+1)\frac{\Gamma_{\pi^0\to\gamma\gamma}}{M_{\pi^0}}\delta(4\omega_1\omega_2 - M^2_{\pi^0})$$



$$B_i = \frac{1}{4\pi}\frac{Ze\,\gamma_L b_i\, v}{[\gamma_L^2 v^2 t^2 + b_i^2]^{3/2}}$$

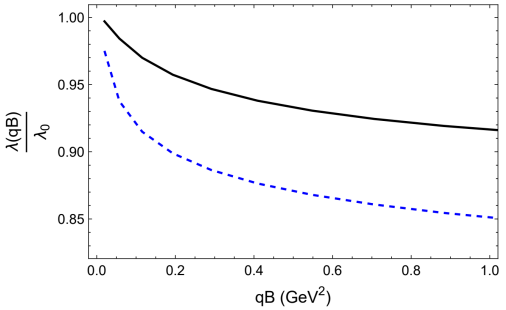




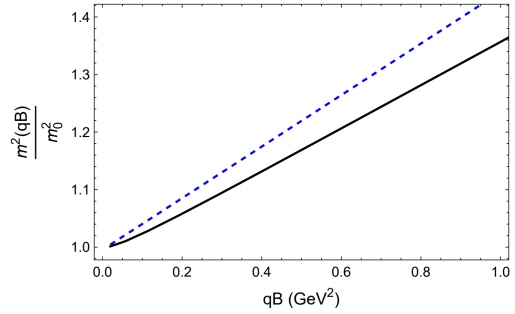
Efeito de um campo magnético de fundo na função beta de uma teoria escalar

(Ana Mizher, Alejandro Ayala, Flavia Fialho)

A função beta de uma teoria descreve a dependência do acoplamento com a escala de energia. Esta dependência é afetada na presença de campos externos?



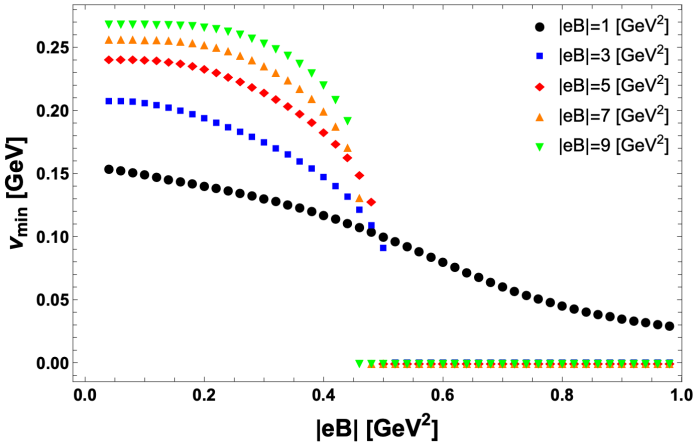
Acoplamento como função do campo magnético



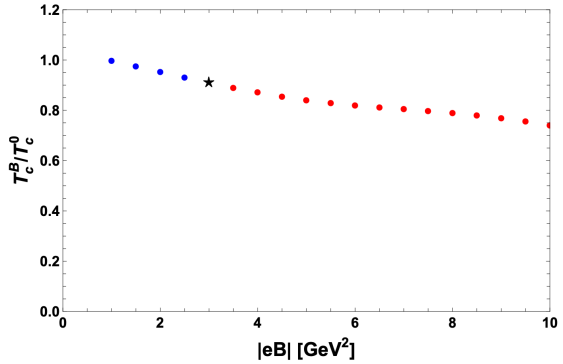
Massa como função do campo magnético

Efeito de um campo magnético de fundo no diagrama de fases da QCD

(Ana Mizher, Ana Gabriela Vargas, Luis Alberto Hernandez)



Mínimo do potencial indicando quebra ou restauração da simetria como função de campo



Ponto crítico indicando um ponto crítico

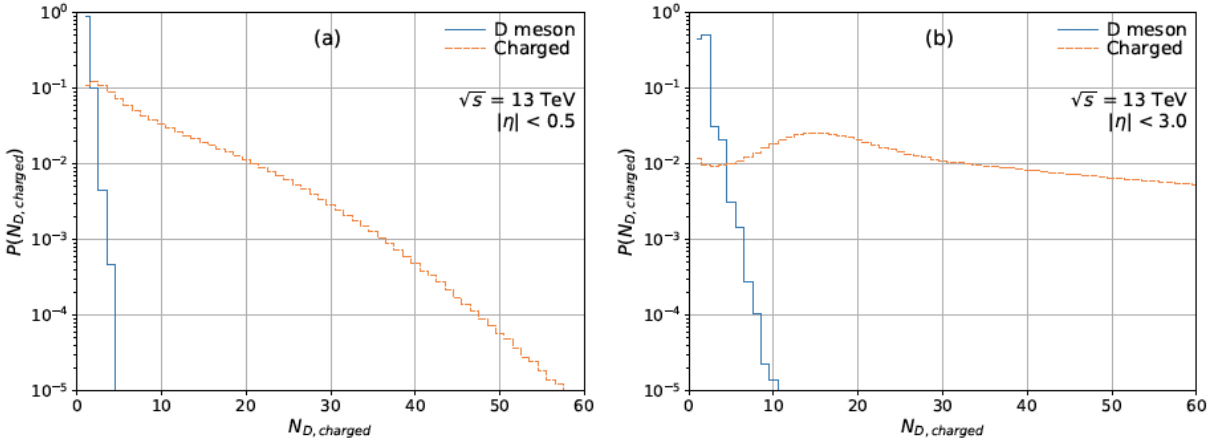
Produção de partículas e distribuição de multiplicidades

ver seminário do Yuri Lima e do Richard Terra

Charm multiplicity distribution in high energy pp collsions via PYTHIA

Yuri N. LIMA,[1,*] Cristiane JAHNKE,[2,†] Marcelo G. MUNHOZ,[1,‡] and Fernando S. NAVARRA[1,§]

arXiv:2512.18739



P(n) do charme é muito mais estreita !

Distribuições de multiplicidade

(F. Navarra, Henrique Martins Fontes)

Hipótese 1: física "hard" (pQCD) em rapidez pequena e física "soft" em rapidez grande. ✖

Hipótese 2: KNO scaling é violado por "minijatos" (pQCD) ✖

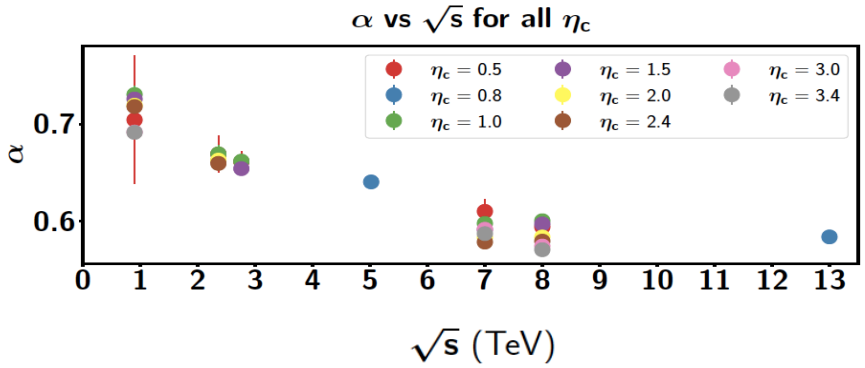
Fatorização kt + dupla binomial negativa:

$$\frac{dN}{dy} = \frac{K}{S}\frac{4\pi N_c}{N_c^2-1}\left[\int_{p_{\perp min}}^{\Lambda}\frac{dp_\perp^2}{p_\perp^4}\alpha_s(Q^2)xG_2(x_2,p_\perp^2)xG_1(x_1,p_\perp^2) + \int_{\Lambda}^{p_{\perp max}}\frac{dp_\perp^2}{p_\perp^4}\alpha_s(Q^2)xG_2(x_2,p_\perp^2)xG_1(x_1,p_\perp^2)\right]$$

2 NBD $$P(n) = \lambda\,[\,\alpha\,P(n,\langle n\rangle_s,k_s) + (1-\alpha)\,P(n,\langle n\rangle_{sh},k_{sh})\,],$$

fração de eventos soft

fração de eventos semihard



1) Eventos soft diminuem igualmente em todas as janelas de rapidez !

2) Minijatos crescem em todas as janelas de rapidez ! KNO é violado só na janela central !

III

Conclusão:

Bons indicadores de produção

Crescente integração entre o membros do GRHAFITE e experimentais

Experimentais orientando teóricos e virando fenomenologistas

FIM

14 Artigos Publicados

Interactions of the deuteron with a hadronic medium #1

L.M. Abreu (Bahia U.), R.O. Magalhães (Bahia U.), R. Higa (Sao Paulo U.), F.S. Navarra (Sao Paulo U.) (Oct 16, 2025)

Published in: *Phys.Rev.D* 113 (2026) 1, 014003 • e-Print: 2510.17871 [hep-ph]

pdf DOI cite claim reference search 0 citations

Initial-state geometry and multiplicity distributions in pp and $p\mathrm{Pb}$ collisions #2

R. Terra (Sao Paulo U.), A.V. Giannini (Nova U., Lisboa and Santa Catarina U.), F.S. Navarra (Sao Paulo U.) (Oct 14, 2025)

Published in: *Phys.Rev.D* 113 (2026) 9, 094009 • e-Print: 2510.12561 [hep-ph]

pdf DOI cite claim reference search 3 citations

The sharpness of the quark-hadron transition and the properties of hybrid stars #3

M.B. Albino (Coimbra U.), R. Fariello (Sao Paulo U. and Unlisted, BR), G. Lugones (ABC Federal U.), F.S. Navarra (Sao Paulo U.) (Sep 30, 2025)

Published in: *Int.J.Mod.Phys.D* 34 (2025) 15, 2550073 • e-Print: 2510.02053 [nucl-th]

pdf DOI cite claim reference search 1 citation

Multiplicity Distributions and the Frontier Between Soft and Hard Physics #4

Henrique R. Martins-Fontes (Sao Paulo U.), Fernando S. Navarra (Sao Paulo U.) (Sep 18, 2025)

Published in: *MDPI Physics* 7 (2025) 4, 57, *Physics* 7 (2025) 57 • e-Print: 2509.15056 [hep-ph]

pdf DOI cite claim reference search 6 citations

Soft and semihard components of multiplicity distributions in the k_T-factorization approach #5

H.R. Martins-Fontes (Sao Paulo U.), F.S. Navarra (Sao Paulo U.) (Jun 20, 2025)

Published in: *Phys.Rev.D* 112 (2025) 9, 094045 • e-Print: 2506.17127 [hep-ph]

pdf DOI cite claim reference search 5 citations

Universality of scaling entropy in charged hadron multiplicity distributions at the LHC #6

L.S. Moriggi (Unlisted, BR), F.S. Navarra (Sao Paulo U.), M.V.T. Machado (Rio Grande do Sul U.) (Jun 11, 2025)

Published in: *Phys.Rev.D* 112 (2025) 7, 074019 • e-Print: 2506.09899 [hep-ph]

pdf DOI cite claim reference search 7 citations

Production of η_b in ultraperipheral Pb-Pb collisions #7

C.N. Azevedo (Sao Paulo U.), F.C. Sobrinho (Sao Paulo U.), F.S. Navarra (Sao Paulo U.) (Dec 24, 2024)

Published in: *Phys.Rev.C* 112 (2025) 6, 064908 • e-Print: 2412.18567 [hep-ph]

pdf DOI cite claim reference search 1 citation

Revisiting the three-kaon interaction and its relation with $K(1460)$ #1

Michael Döring (George Washington U. and Jefferson Lab), Kanchan P. Khemchandani (Sao Paulo U.), Alberto Martínez Torres (Sao Paulo U.) (Nov 4, 2025)

Published in: *Phys.Rev.D* 113 (2026) 3, 034032 • e-Print: 2511.02543 [nucl-th]

pdf DOI cite claim reference search 2 citations

Correlation functions for $n\,\bar{D}_{s1}(2460)$ and $n\,\bar{D}_{s1}(2536)$ #2

Breno Agatão (Sao Paulo U. and Valencia U., IFIC), Pedro Brandão (Bahia U. and Valencia U., IFIC), A. Martínez Torres (Sao Paulo U.), K.P. Khemchandani (Sao Paulo U.), Luciano M. Abreu (Bahia U.) et al. (Aug 7, 2025)

Published in: *Eur.Phys.J.C* 85 (2025) 10, 1136 • e-Print: 2508.05825 [hep-ph]

pdf DOI cite claim reference search 7 citations

Understanding Large Localized CP Violation in $B^{\pm} \to K^{\pm}\pi^{+}\pi^{-}$ Using Dispersive Methods #1

L.A. Heuser (Bonn U., HISKP and U. Bonn, Phys. Inst., BCTP), A. Reyes-Torrecilla (Madrid U.), C. Hanhart (IAS, Julich), B. Kubis (Bonn U., HISKP and U. Bonn, Phys. Inst., BCTP), P.C. Magalhães (U. Campinas) et al. (Aug 14, 2025)

Published in: *Phys.Rev.Lett.* 136 (2026) 11, 111901 • e-Print: 2508.10989 [hep-ph]

pdf DOI cite claim reference search 0 citations

#1

Mass and coupling magnetic field dependence in a scalar theory with charged bosons from an environmentally friendly renormalization group analysis

Alejandro Ayala (Mexico U., ICN and Sao Paulo U. and Sao Paulo, IFT), Flávia Fialho (UNICID, Sao Paulo), Ana Mizher (Sao Paulo U. and Biobio U.) (Dec 22, 2025)

Published in: *Phys.Rev.D* 113 (2026) 5, 056009 • e-Print: 2512.19807 [hep-th]

pdf DOI cite claim reference search 0 citations

#2

Inverse magnetic catalysis in the linear sigma model: a beyond mean field approach

Gabriela Fernández (Mexico City U., Azcapotzalco), Luis A. Hernández (Mexico City U., Azcapotzalco), Ana Mizher (Sao Paulo U.) (Oct 3, 2025)

Published in: *J.Phys.G* 53 (2026) 3, 035001 • e-Print: 2510.02747 [hep-ph]

pdf DOI cite claim reference search 2 citations

#3

Asymmetric muon-antimuon emission from Z^0 decays: A potential magnetometer in relativistic heavy-ion collisions

Alejandro Ayala (Mexico U., ICN and UNICID, Sao Paulo and Sao Paulo, IFT), Ana Julia Mizher (UNICID, Sao Paulo and Sao Paulo, IFT and Biobio U. and Sao Paulo U.), Javier Rendón (Mexico U., ICN) (Jun 13, 2025)

Published in: *Phys.Rev.C* 113 (2026) 3, 034902 • e-Print: 2506.11370 [hep-ph]

pdf DOI cite claim reference search 1 citation

#4

Strongly interacting matter in extreme magnetic fields

Prabal Adhikari (St. Olaf Coll.), Martin Ammon (U. Jena (main)), Sidney S. Avancini (Santa Catarina U.), Alejandro Ayala (Mexico U.), Aritra Bandyopadhyay (U. Heidelberg, ITP) et al. (Dec 21, 2024)

Published in: *Prog.Part.Nucl.Phys.* 146 (2026) 104199 • e-Print: 2412.18632 [nucl-th]

pdf DOI cite claim reference search 53 citations

5 Artigos Submetidos

$D^*\pi$ interaction from the lineshape of $D_1(2420)$ in B-decays #1

Pedro Brandão (Bahia U.), Breno Agatão (Sao Paulo U.), Luciano M. Abreu (Bahia U.), K.P. Khemchandani (Sao Paulo U.), A. Martínez Torres (Sao Paulo U.) (Dec 30, 2025)

e-Print: 2512.24370 [hep-ph]

pdf DOI cite claim reference search 0 citations

Charm multiplicity distribution in high energy pp collisions with PYTHIA #3

Y.N. Lima (Sao Paulo U.), C. Jahnke (Campinas State U.), M. Munhoz (Sao Paulo U.), F.S. Navarra (Sao Paulo U.) (Dec 21, 2025)

e-Print: 2512.18739 [hep-ph]

pdf cite claim reference search 0 citations

Photon production from gluon splitting and fusion induced by a magnetic field in heavy-ion collisions #

Alejandro Ayala (Mexico U., ICN and Sao Paulo U. and Sao Paulo, IFT), Santiago Bernal-Langarica (Mexico U., ICN), José Jorge Medina-Serna (Mexico U., ICN), Ana Julia Mizher (Sao Paulo U. and Biobio U.) (Mar 26, 2026)

e-Print: 2603.24964 [hep-ph]

pdf cite claim reference search 0 citation

Latin American network on electromagnetic effects in strongly interacting matter: Contribution to the update of the Latin American Strategy for High Energy, Cosmology and Astroparticle Physics #

Ana Mizher (Sao Paulo, IFT and UNICID, Sao Paulo and Biobio U.), Alejandro Ayala (Mexico U., ICN) (Aug 1, 2025)

e-Print: 2508.00771 [hep-ph]

pdf cite claim reference search 0 citations

Precision calculation of $^3\mathrm{He}(\alpha,\gamma)^7\mathrm{Be}$ for solar physics #2

Ratna Khadka (Mississippi State U.), Ling Gan (Mississippi State U.), Renato Higa (Mississippi State U. and Sao Paulo U., Sao Carlos), Gautam Rupak (Mississippi State U.) (Sep 29, 2025)

e-Print: 2509.24931 [nucl-th]

4 Proceedings

Effects of the magnetic field on π^0 production in ultraperipheral Pb-Pb collisions #1

C.N. Azevedo (Sao Paulo U.), R. Fariello (Sao Paulo U. and Unlisted, BR), F.C. Sobrinho (Sao Paulo U.), F.S. Navarra (Sao Paulo U.) (May 2, 2026)

e-Print: 2605.01500 [hep-ph]

pdf cite claim reference search 0 citations

Effects of the initial-state geometry on D-meson production in pp and pPb collisions #2

R. Terra (Sao Paulo U.), A.V. Giannini (Nova U., Lisboa and Santa Catarina U.), F.S. Navarra (Sao Paulo U.) (Mar 25, 2026)

e-Print: 2603.24344 [hep-ph]

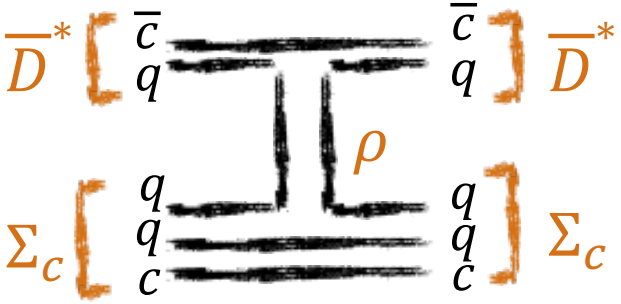
pdf cite claim reference search 0 citations

Remarks on the Shape Parameters of Multiplicity Distributions

H. R. Martins-Fontes, F. S. Navarra

Advances in QCD at the LHC and the EIC, 09/11 - 15/11 (2025), CBPF, RJ

$P_c(4457)[J^P = 3/2^-]$



Visto no LHCb

Participações em Conferências

21st International Conference on Hadron Spectroscopy and Structure. HADRON 2025.

9th Conference on Chirality, Vorticity and Magnetic Fields, 07/07 – 11/07 (2025), ICTP-SAIFR, SP (Fernando Navarra, Ana Júlia Mizher)

XXXII Reunião de Trabalho sobre Interações Hadrônicas RETINHA 32, 29/10 – 31/10 (2025), CBPF, RJ (Fernando Navarra, Ana Júlia Mizher,)

Advances in QCD at the LHC and the EIC,09/11 – 15/11 (2025), CBPF, RJ (Alberto Martinez Torres, Kanchan, Khemchandani, Patrícia Magalhães)

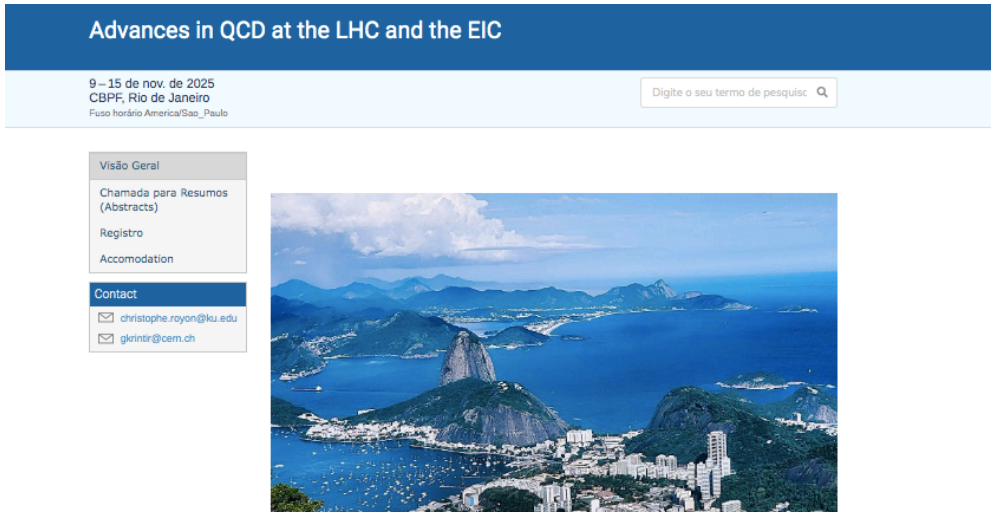
Organização de Eventos Científicos

XXII Escola de Verão Jorge André Swieca de Física Nuclear Teórica, 28/04 a 02/05 (2025), UFF, Niteroi, RJ (K. Khemchandani)

XVI International Workshop on Hadron Physics 2025, 10/03 – 14/03 (2025), Porto Alegre, RS (K. Khemchandani)

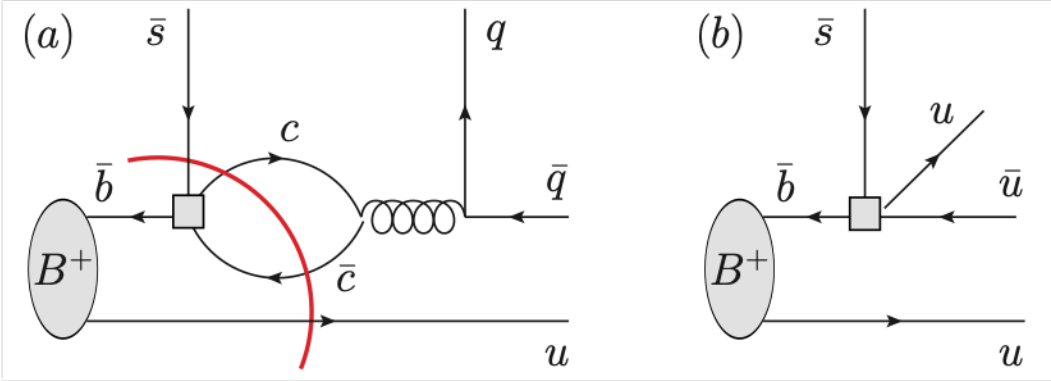
XXXII Reunião de Trabalho sobre Interações Hadrônicas RETINHA 32, 29/10 – 31/10 (2025), CBPF, RJ (F. Navarra)

Advances in QCD at the LHC and the EIC, 09/11 – 15/11 (2025), CBPF, RJ (F. Navarra)

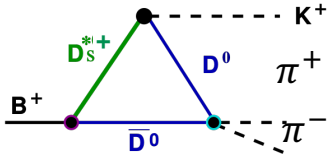


Weak transitions

- weak effective field theory: $H_{\text{eff}} = \frac{G_F}{\sqrt{2}}\left(|V_{cb}^* V_{cs}|(\bar{b}c)(\bar{c}s) + e^{i\gamma}|V_{ub}^* V_{us}|(\bar{b}u)(\bar{u}s)\right)$



- charm triangle



near 1GeV ~ constant complex number

- Cabibbo favored but loop suppressed

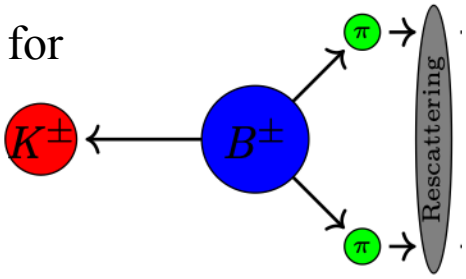
- Tree contribution
- $b \to u$ cary the weak phase γ

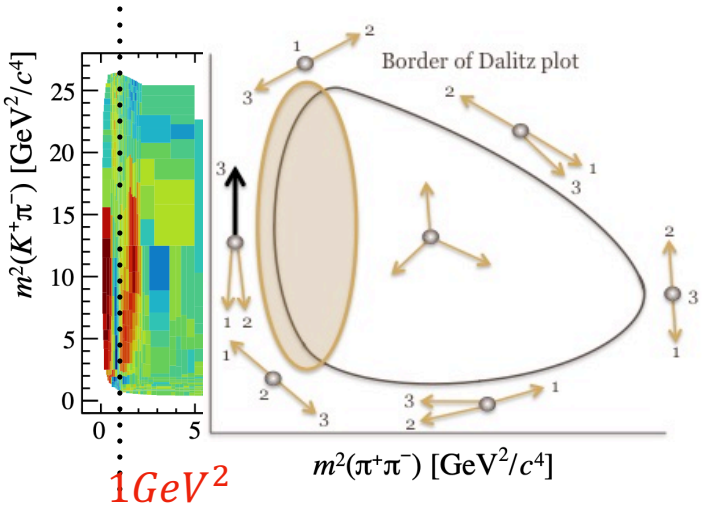
$$c_i = \text{Im}\hat{A}_i$$
$$a_i = \text{Re}\hat{A}_i + \hat{B}_i \cos\gamma$$
$$b_i = \hat{B}_i \sin\gamma$$

- weak vertex parametrized as: $\bar{\mathcal{A}}_i^{\pm} = \hat{A}_i + e^{\pm i\gamma}\hat{B}_i = a_i + ic_i \pm ib_i$

10 free parameters

- spectator approximation for $m^2_{\pi\pi} < 1\text{GeV}$





Decay amplitude = Weak x FSI

$$\mathcal{A}^{\pm}(s,t) = \sum_i f_i(s,t) P_i(s) \Omega_i(s) \bar{\mathcal{A}}_i^{\pm}$$

FSI

- $P_i(s)$: linear polynomial to deal with production environment- free to fit
- $\Omega_i(s) = \exp\left\{ \frac{s}{\pi} \int_{4M_\pi^2}^{\infty} \mathrm{d}s' \frac{\delta_i(s')}{s'(s'-s-i\epsilon)} \right\}, \ \Omega_i(0) = 1.$ universal $\pi\pi$ interaction from Dispersion Relation

$i \equiv$ channels with J and Isospin for $\pi\pi$ interactions

$$i \in \{S0n, S0s, S2, P\}$$

scalar: $\mathcal{A}^{\pm}_{S0} = \mathcal{A}^{\pm}_{S0n} + \mathcal{A}^{\pm}_{S0s}$

$S0s$ (strange form factor) to generate $KK \to \pi\pi$

I=2, J=0 - free of resonance

vector I=0 - $\rho(770)$ & I=1 (ω) $\rho - \omega$ mixing

- $f_i(s,t)$ spin term, $f_{i\neq P}(s,t) = 1$ and $f_P(s,t) = \cos\theta$

Produção de exóticos em colisões AA centrais:

(Alberto Martinez, Kanchan Khemchandani, Luciano Abreu, Lisheng Geng...)

Estudo de funções de correlação

$$C(k) = \int d^3r S_{12}(\vec{r}) |\Psi(\vec{k};\vec{r})|^2$$

Koonin-Pratt

$$\frac{dN}{d\vec{p_1}\, d\vec{p_2}}$$

medida

$$S_{12}(\vec{r}) = \frac{1}{(4\pi)^{\frac{3}{2}} R^3} \exp\left(-\frac{r^2}{4R^2}\right)$$

Função de onda do estado de duas partículas

fonte emissora

$$C_i(k) = 1 + 4\pi\theta(q_{max} - k) \int_0^\infty dr r^2 S_{12}(\vec{r}) \left(\sum_j w_j |j_0(kr)\delta_{ji} + T_{ji}(\sqrt{s})\tilde{G}_j(r;s)|^2 - j_0^2(kr) \right)$$

matriz de espalhamento