Strange and electromagnetic probes of dense nuclear matter at SIS

Janus Weil, FIAS

Electromagnetic Probes: Dilepton Spectra

(with H. van Hees, U. Mosel, S. Endres, M. Bleicher)

- dileptons are ideal to study phenomena at high temp. and densities
- in particular: vector mesons in medium and chiral sym. restoration
- here: dilepton production at SIS studied with GiBUU transport model
- comparison to recent data measured by HADES
- Eur. Phys. J. A 48 (2012); J. Phys. Conf. Ser. 426 (2013)

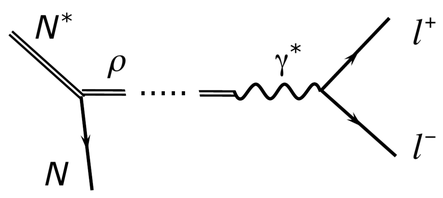
Resonance Model

- at SIS energies: particle production dominated by resonance formation
- GiBUU res. model is based on Manley PWA (Phys. Rev. D 45, 1992)
- 13 N^*/Δ^* states excited in NN collisions

	rating	M_0 [MeV]	Γ_0 [MeV]	$\lvert\mathcal{M}^2\rvert/16\pi$ [mb GeV^2] NR	ΔR	branching ratio in % πN	ηN	$\pi\Delta$	ρN	σN	$\pi N^*(1440)$	$\sigma\Delta$
$P_{11}(1440)$	****	1462	391	70	—	69	—	22_P	—	9	—	—
$S_{11}(1535)$	***	1534	151	8	60	51	43	—	2_S+1_D	1	2	—
$S_{11}(1650)$	****	1659	173	4	12	89	3	2_D	3_D	2	1	—
$D_{13}(1520)$	****	1524	124	4	12	59	—	5_S+15_D	21_S	—	—	—
$D_{15}(1675)$	****	1676	159	17	—	47	—	53_D	—	—	—	—
$P_{13}(1720)$	*	1717	383	4	12	13	—	—	87_P	—	—	—
$F_{15}(1680)$	****	1684	139	4	12	70	—	10_P+1_F	5_P+2_F	12	—	—
$P_{33}(1232)$	****	1232	118	OBE	210	100	—	—	—	—	—	—
$S_{31}(1620)$	**	1672	154	7	21	9	—	62_D	25_S+4_D	—	—	—
$D_{33}(1700)$	*	1762	599	7	21	14	—	74_S+4_D	8_S	—	—	—
$P_{31}(1910)$	****	1882	239	14	—	23	—	—	—	—	67	10_P
$P_{33}(1600)$	***	1706	430	14	—	12	—	68_P	—	—	20	—
$F_{35}(1905)$	***	1881	327	7	21	12	—	1_P	87_P	—	—	—
$F_{37}(1950)$	****	1945	300	14	—	38	—	18_F	—	—	—	44_F

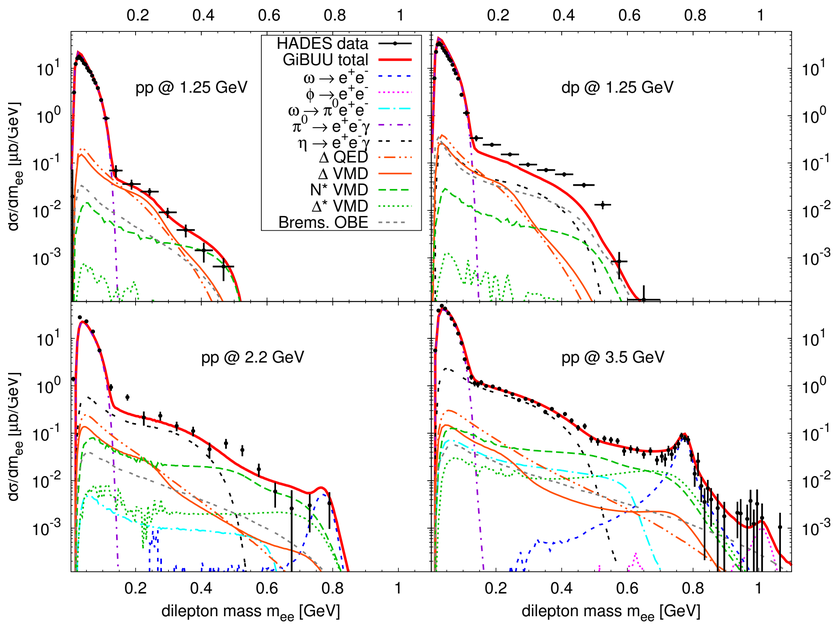
Vector-Meson Dominance

- baryon resonances play a central role at low energies
- assumption: baryons couple to em. sector only through ρ (strict VMD)



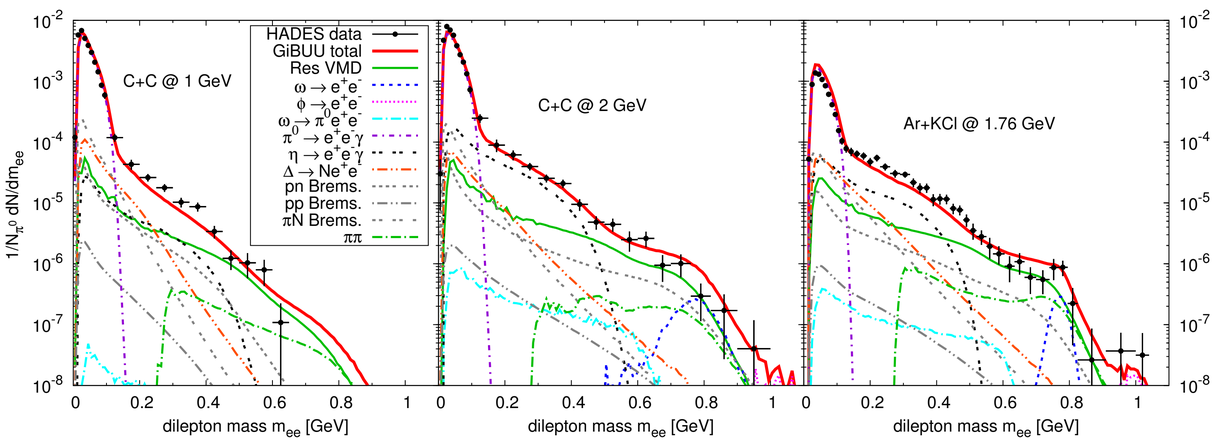
- in transport model: two-step treatment (factorization)
- $\Delta(1232)$: introduce ρN coupling with on-shell BR of $5 \cdot 10^{-5}$

Elementary Results



- excellent agreement with all pp data
- Δ: significant only at low energies (even with VMD)
- dp underestimated (despite inclusion of OBE bremsstrahlung by Shyam et al.)
- further isospin-enhancement of ρ in np required?

AA Results



- on-shell transport (with vacuum spectral functions) already yields rather good results
- further improvements can be obtained by including explicit in-med. spectral functions (via 'coarse graining' or 'off-shell transport')

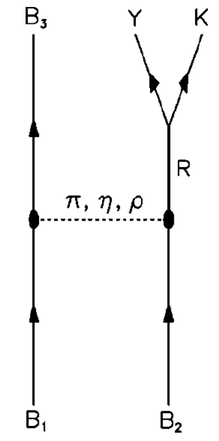
Strange probes: Kaon production in p+Nb

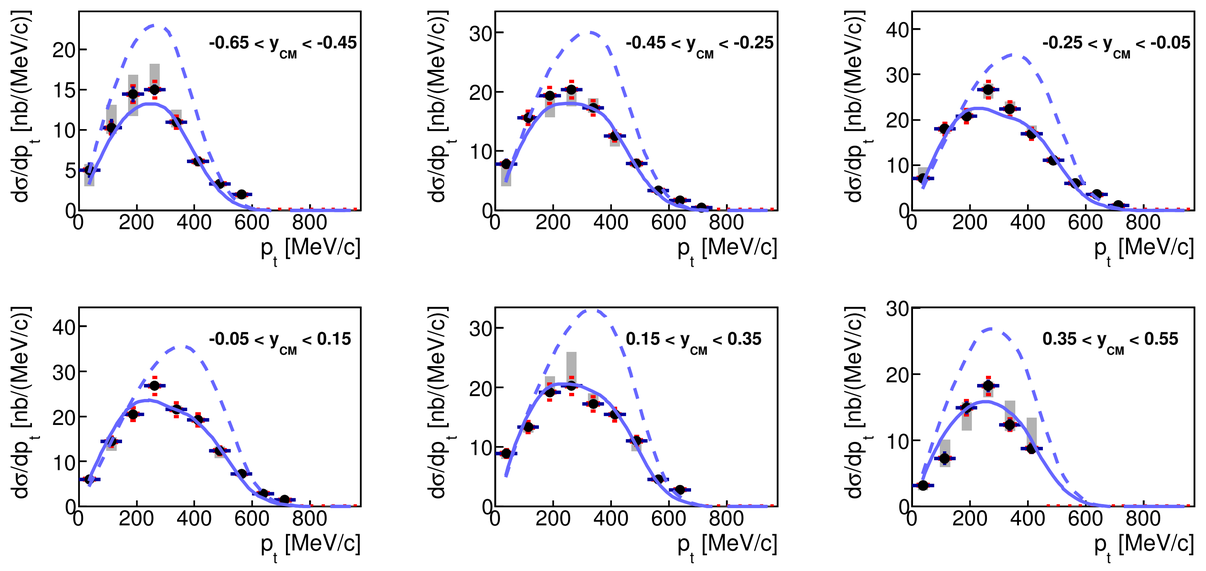
(with T. Gaitanos, K. Lapidus, L. Fabbietti)

- goal: determine Kaon potential
- HADES has measured $K^0_s \to \pi^+\pi^-$ in pp and pNb collisions at 3.5 GeV
- arXiv:1404.7011

Elementary production (pp)

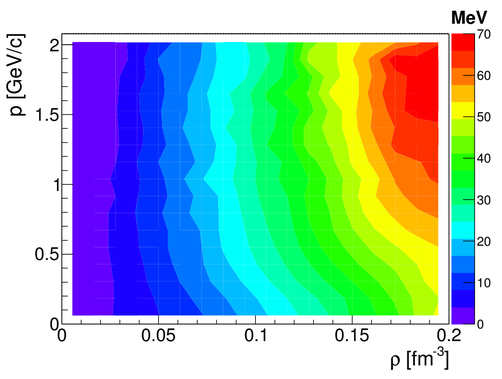
- strangeness production channels: $BB \to BYK$ with $B = N, \Delta$; $Y = \Lambda, \Sigma$
- parametrized as $\sigma = a(s/s_0 - 1)^b (s/s_0)^c$ with parameters a,b,c for each channel
- original model: Tsushima et al. (PRC59, 1999; dashed)
- modified to fit elem. HADES Kaon data (solid lines):
  - parameters had to be adjusted for some channels
  - 5-body channels added ($pp \to \Delta Y^* K \to \pi\pi NYK$)





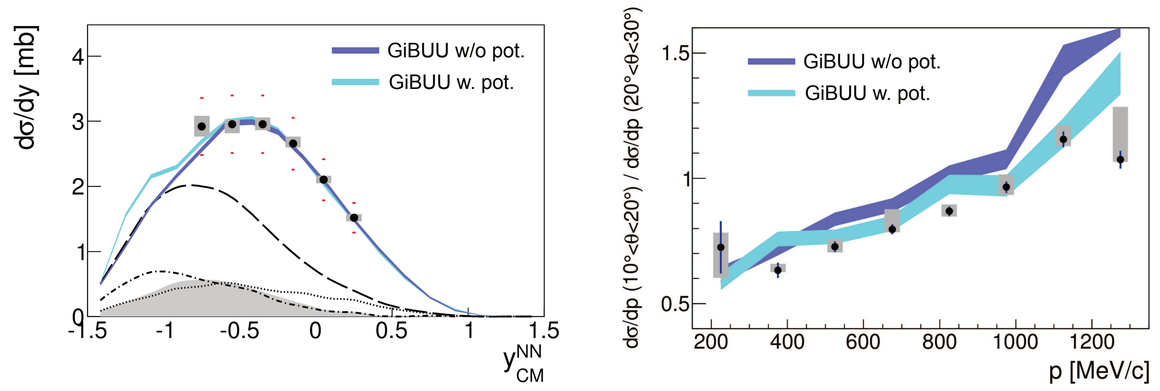
Kaon Potential

- ChPT kaon potential: $m^*_K = \sqrt{m^2_K - \frac{\Sigma_{KN}}{f^2_\pi}\rho_s + V_\mu V^\mu}$
- includes density and momentum dep.
- repulsive for K^+, K^0
- attractive for $K^-, \overline{K}^0$
- $U = E^* - E \approx 35$ MeV at $\rho = \rho_0$, $\vec{p} = 0$



Results: $p\mathrm{Nb} \to K^0_s X$

- rap. spectrum mostly insensitive to potential in measured region (left)
- momentum spectra most sensitive in forward region (right)
- take ratio of two polar-angle bins to get rid of systematic uncertainties in abs. norm.



Conclusions

- data show indications of repulsive potential for K^0_s
- consistent with ChPT potential of $U(\rho_0) = 35$ MeV

FIAS Frankfurt Institute for Advanced Studies

HIC for FAIR
Helmholtz International Center

Email: weil@fias.uni-frankfurt.de