Hungary in the PHENIX Collaboration

ECFA Meeting, October 4, 2013

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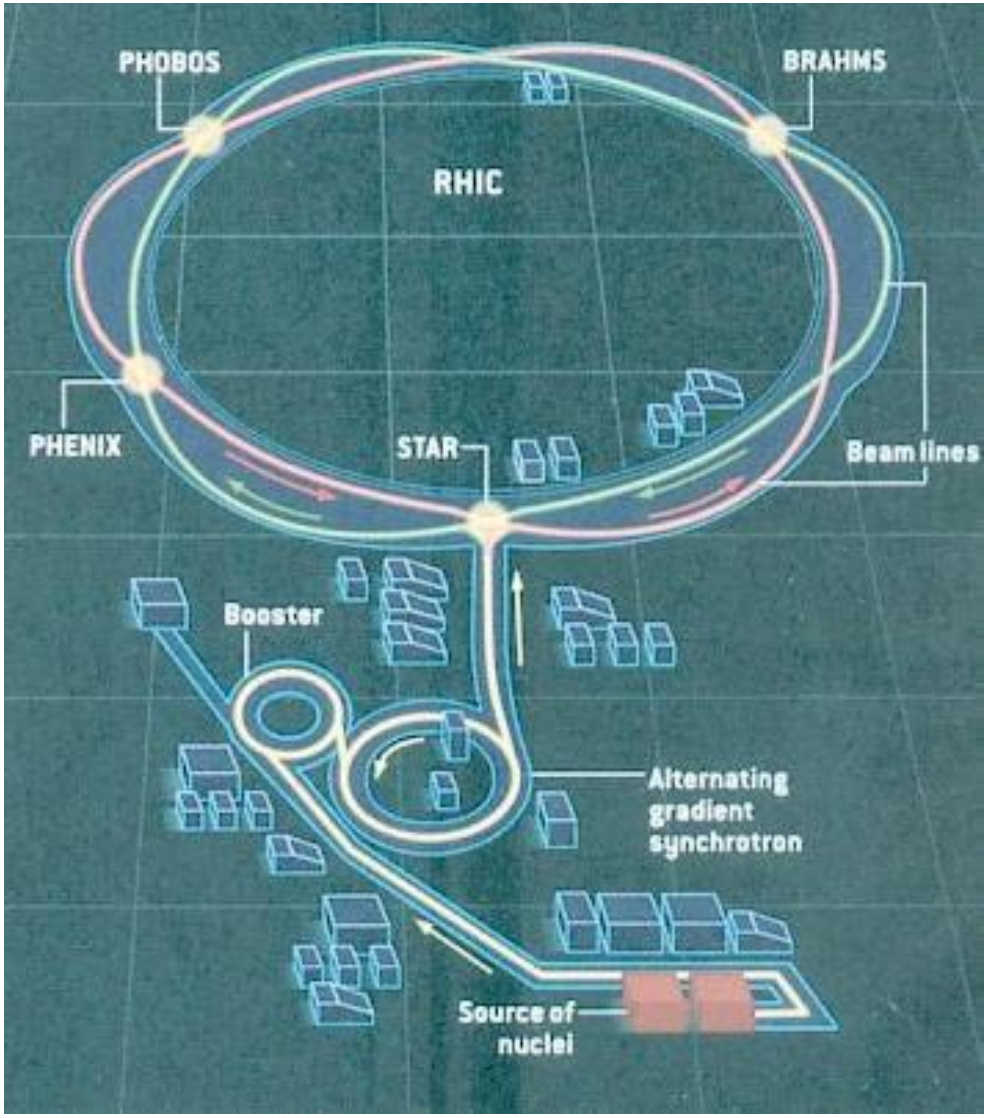
for the PHENIX Hungary group
http://phenix.kfki.hu/ – http://phenix.elte.hu/

PHENIX @ RHIC

- Au+Au, Cu+Cu, p↑+p↓, d+Au
- 7 to 200 (500) GeV
- Upgrade to eRHIC
- BRAHMS, STAR, PHENIX, PHOBOS
- PHENIX: few 100 participants from 14 countries
- Official Hungarian participation



The PHENIX-Hungary group

- Current member institutions
  - Wigner Research Center for Physics, Institute for Particle and Nuclear Physics
  - Eötvös University, Department of Atomic Physics
- Earlier: Debrecen University, Dep't of Exp. Physics (P. Tarján, J. Imrek, V. Veszprémi)

Tamás Csörgő (Wigner RCP), group leader, member since 2003

Márton Nagy (Eötvös U.), member since 2005

András Ster (Wigner RCP), member since 2001

Márton Vargyas (Wigner RCP), member since 2010

Máté Csanád (Eötvös U.), member since 2003

Róbert Vértesi (Wigner RCP), member 2004-2012

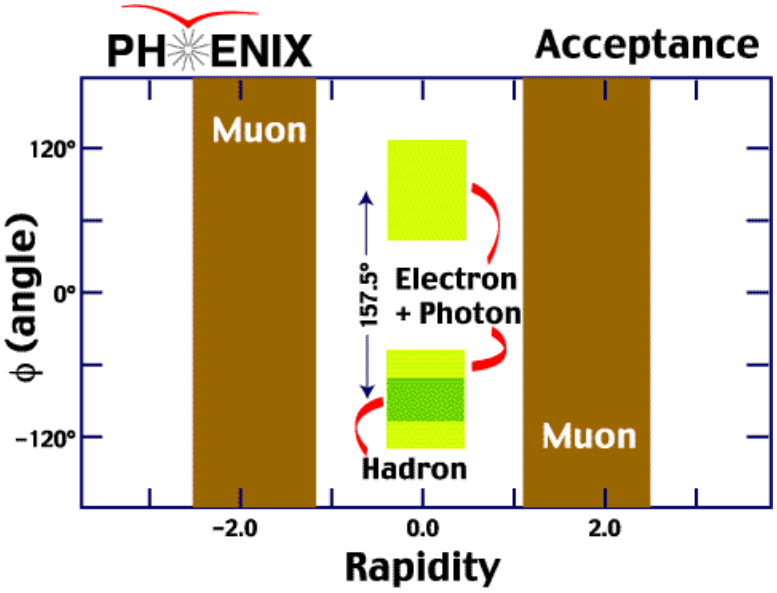
János Sziklai (Wigner RCP), member since 2005

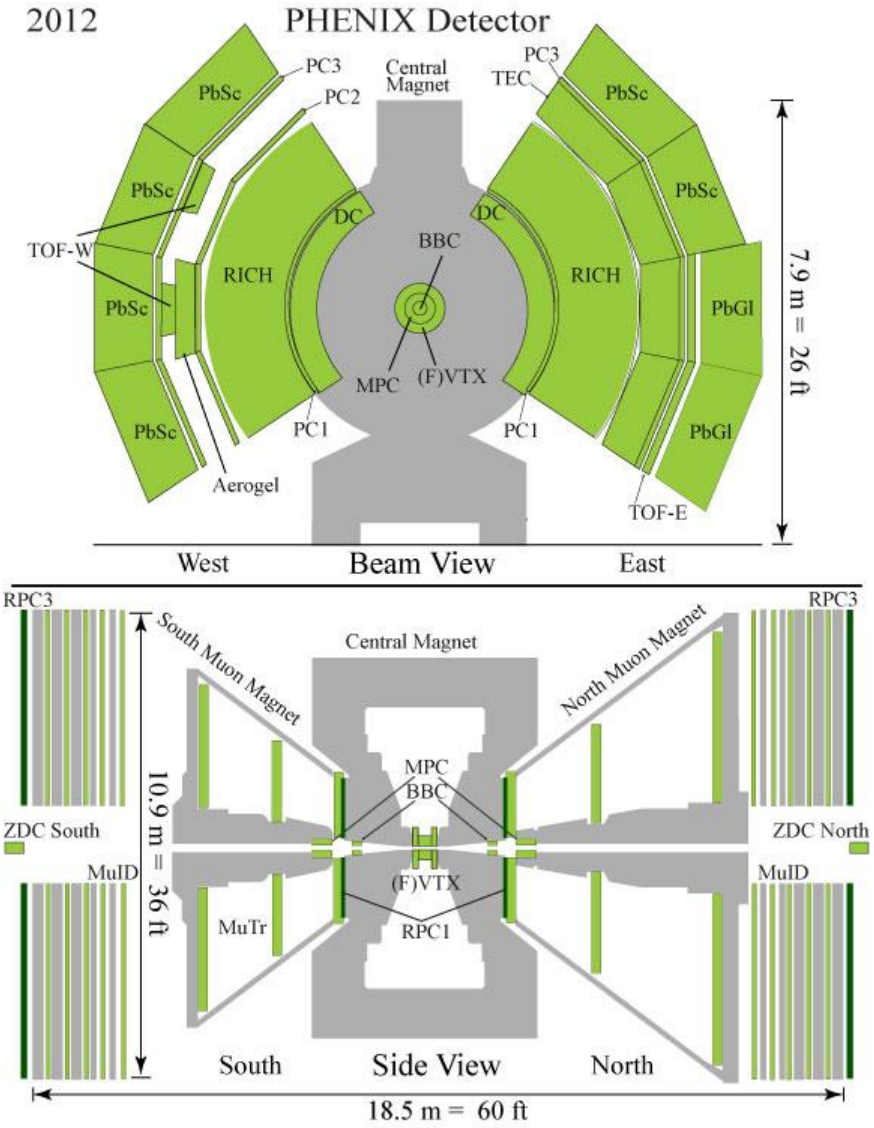
Ádám Kiss (Eötvös U.), member since 2003

József Zimányi†2006, (Wigner RCP), member 2003-2006

The PHENIX detector

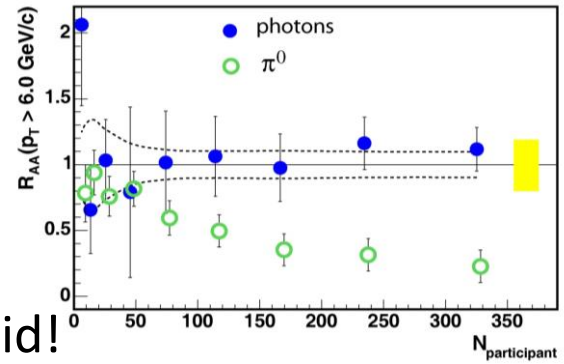
- Charged hadrons ($\pi^{\pm}$, $K^{\pm}$, etc.)
- Photons: direct or decay (η, π_0)
- Light mesons: ϕ, ω, η, η'
- Single leptons (flavor tagged)
- Di-leptons (flavor tagged)



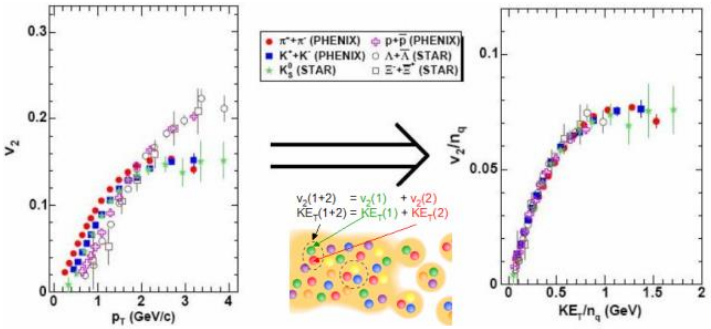


PHENIX Milestones

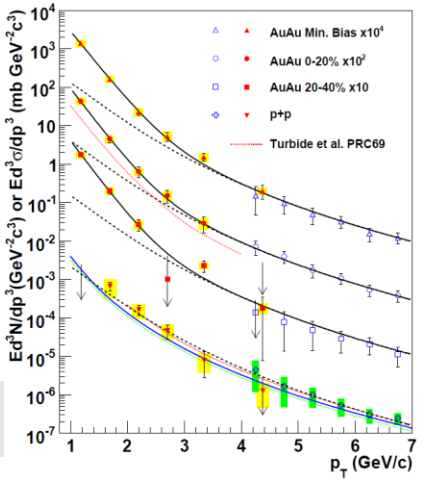
- Jet suppression: new phenomenon of missing high energy jets
  - Phys.Rev.Lett. 88.022301 (2002)



- No jet suppression in d+Au: new form of matter
  - Phys. Rev. Lett. 91, 072303 (2003)
- Collective dynamics (thermal spectra, flow): it is a liquid!
  - Nucl. Phys. A 757, 184-283 (2005)

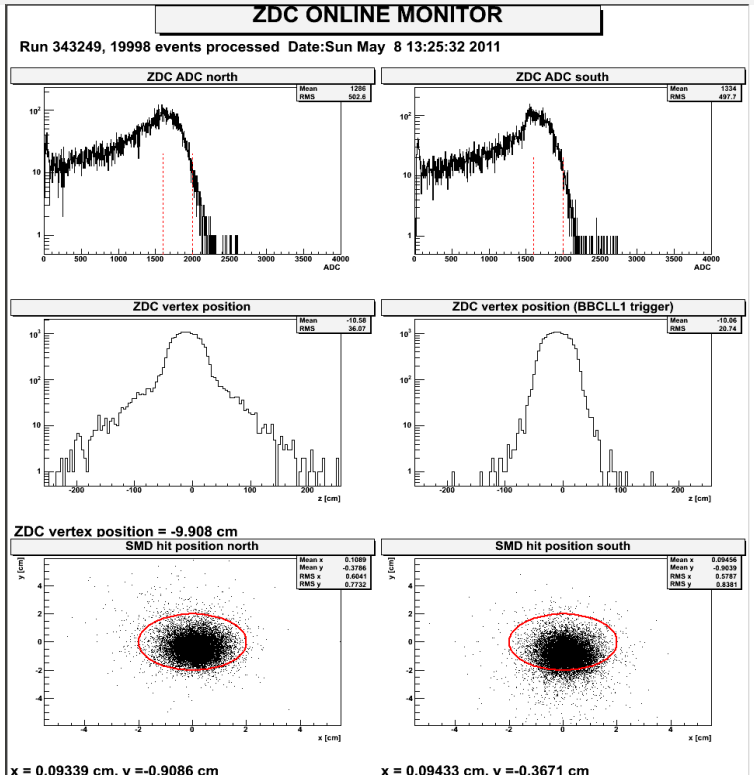


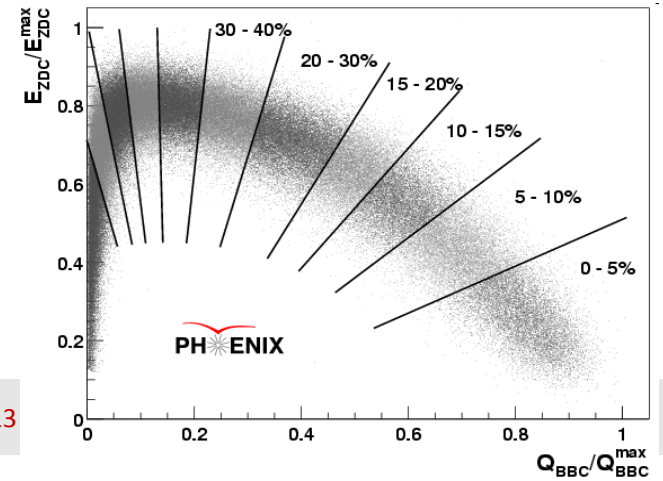
- Scaling properties of the ell. flow: valence quarks
  - Phys. Rev. Lett. 98, 162301 (2007)
- Energy loss of heavy quarks: nearly perfect liquid
  - Phys. Rev. Lett. 98, 172301 (2007)
- Thermal photons: very high initial temperature
  - Phys. Rev. Lett. 104, 132301 (2010)



ZDC and SMD monitoring

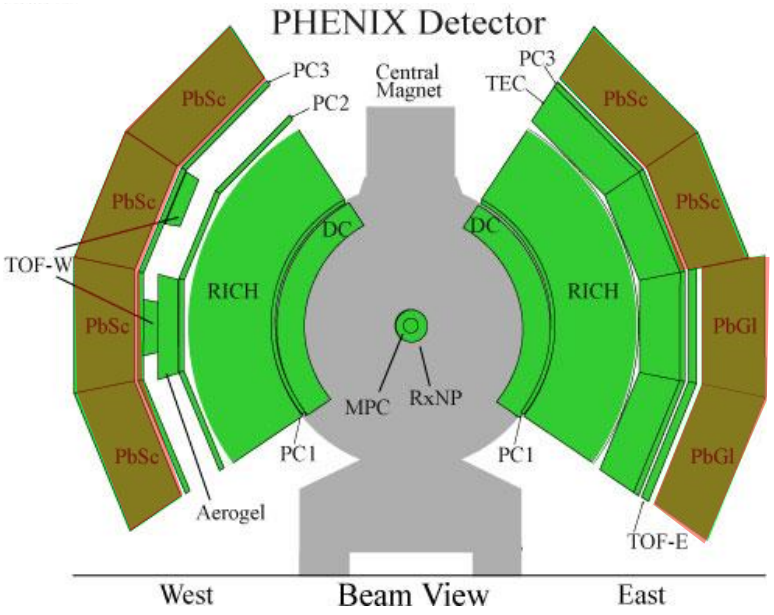
- ZDC: neutron detector at $\eta = \pm\infty$
  - Shower generating and scintillating layers, analog sum equals E_{neutron}
  - Vertex position from timing
- SMD: transverse mapping of neutrons before ZDC
  - Slabs in x and y direction
  - Shower maximum indicates neutron distribution
  - Spread is larger than beam size
    (due to Fermi motion)
- Primary goal: trigger, centrality determination, beam monitoring
- Creation of the ZDC and SMD online monitoring
  - tn419
- Simulations for the operation
  - tn418, an935, an936





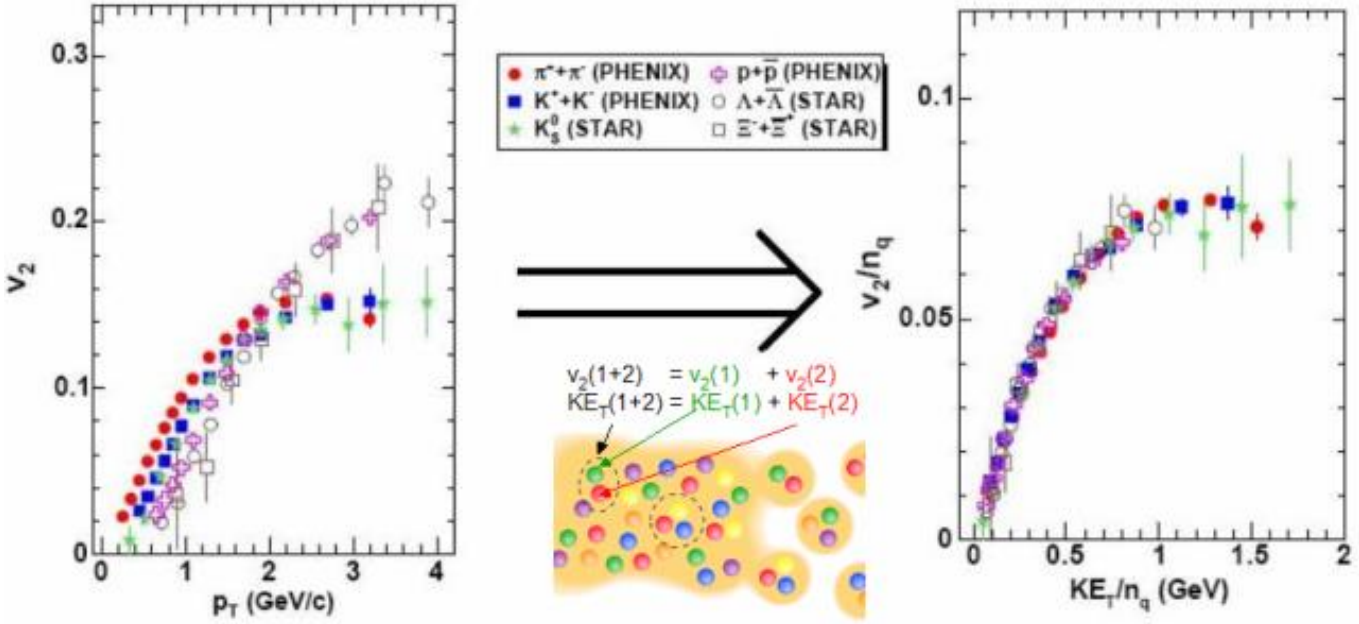
EMCal time of flight calibration

- EMCal: two different detectors for the same purpose (PbSc and PbGl)
- Lead scintillator: 66 absorber and scintillator layers
  - Excels in timing, linearity of response
- Lead glass: Cherenkov photon produced in the material
  - Accurate energy measurement, already used in WA98
- Primary goal: electrons and photons
- ID via shower shape
  - an330
- Hadron energy: much smaller deposition
- Hadron PID: via Time of Flight
- Needs calibrations (corrections)
  - Tower-by-tower, sector-by-sector effects
  - Energy dependence
  - tn400, tn428



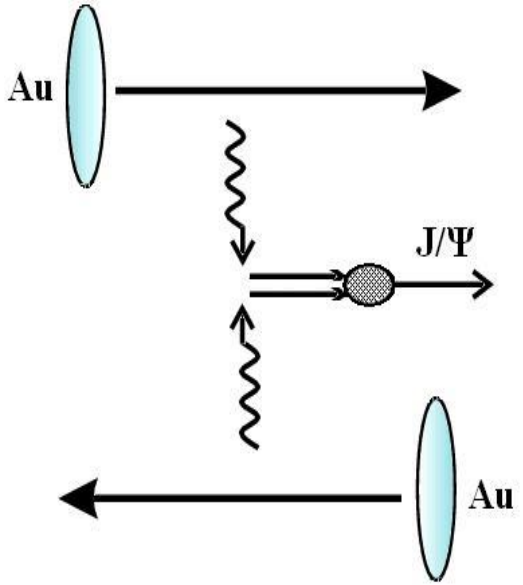
Scaling of the elliptic flow

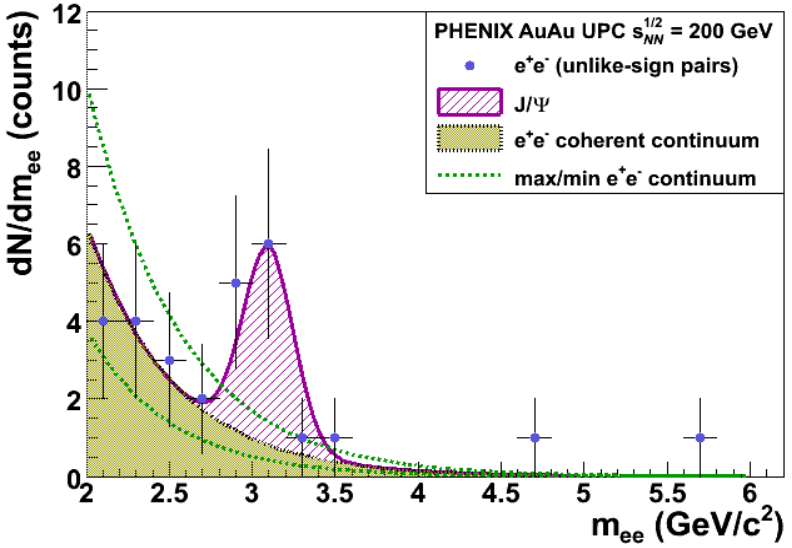
- Hydrodynamics: transverse kinetic energy is a scaling variable
- Scaling breaks at medium energy
- Elliptic flow of mesons & baryons may originate from a quark-gluon medium
- Can be restored if both axes rescaled by valence quark number
- Appearance of quark degrees of freedom?
- PRL98,162301(2007)



J/Ψ in ultra-peripheral collisions

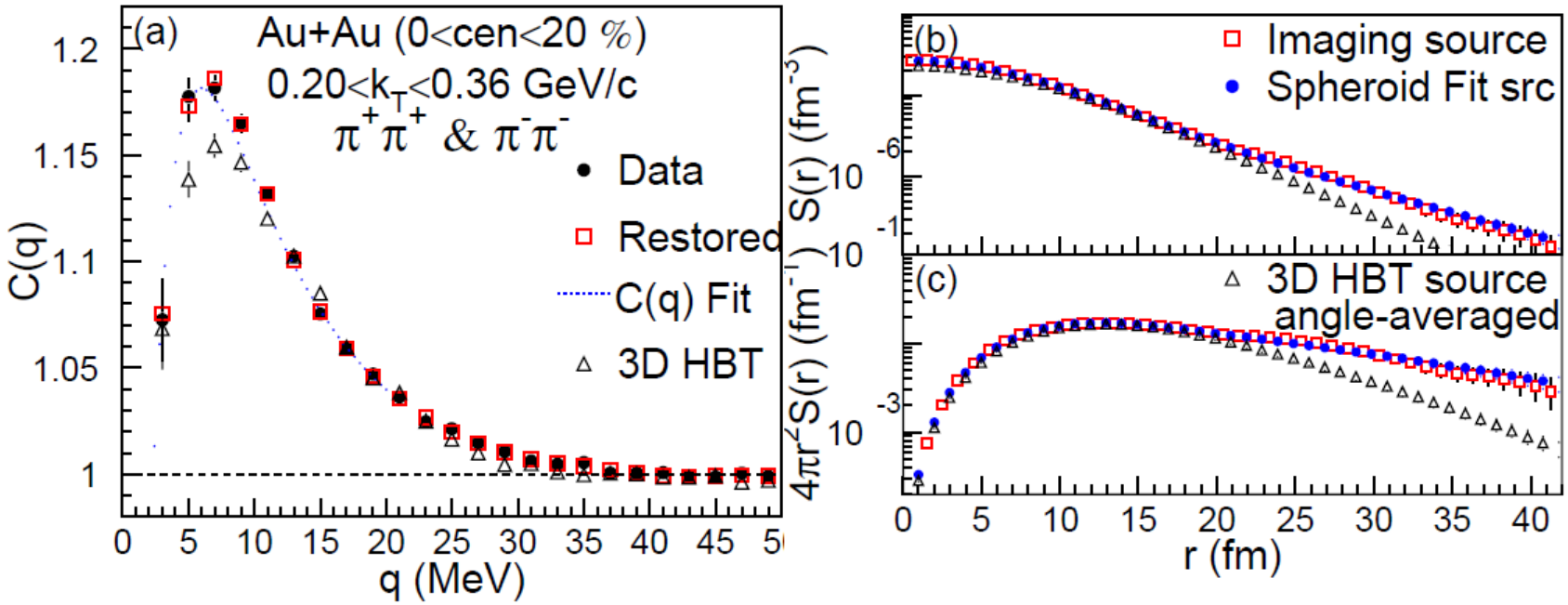
- Nonlinear QCD dynamics at small x and Q^2 is in focus of theoretical activity
- Vector meson production cross-sections: sensitive to gluon distribution at small x
- $\gamma\gamma$ processes tested at HERA
- Ultra-peripheral collisions @ high E: complementary to conventional studies
- Di-electron production probable:
- $A + \gamma + \gamma \rightarrow A^* + e^+ + e^-$
- Coherent meson production:
- $A + \gamma \rightarrow A^* + J/\Psi$
- Incoherent meson production:
- $A + \gamma \rightarrow A' + xN + J/\Psi$
- Experimentally challenging to ID them
- PLB 679, 321 (2009), an756, an593





Two-particle sources and heavy tails

- Identical two-particle momentum correlations: affected by quantum-stat. eff.
- Due to symmetric two-pion wave-function, $C(q) - 1 \propto \left|\tilde{S}(q)\right|^2$
- Source function moments can be reconstructed: imaging technique
- Non-Gaussian sources discovered, may be due to anomalous diffusion?
- Lévy-shaped tail to be analyzed
- PRL98,132301(2007), PRL100,232301(2008), an527, an920



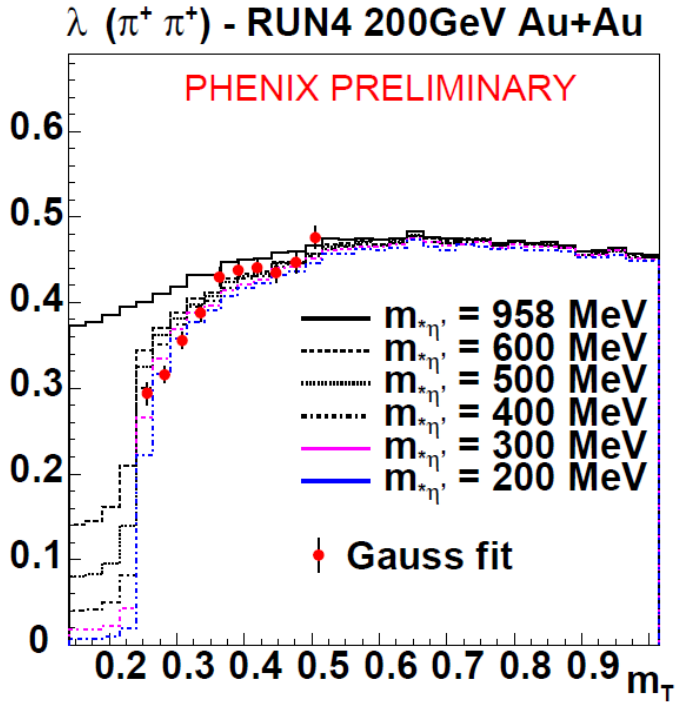
Two-pion correlations and the $U_A(1)$ symmetry

- In hot and dense matter: partial UA(1) restoration, η' mass reduction
- Enhanced η' content, decay:

  $\eta' \to \eta + \pi^+ + \pi^- \to \pi^0 + \pi^+ + \pi^- + \pi^+ + \pi^-$
- Long lifetime, creating pion pairs quite far from the vertex: resonance halo
- Correlation function:

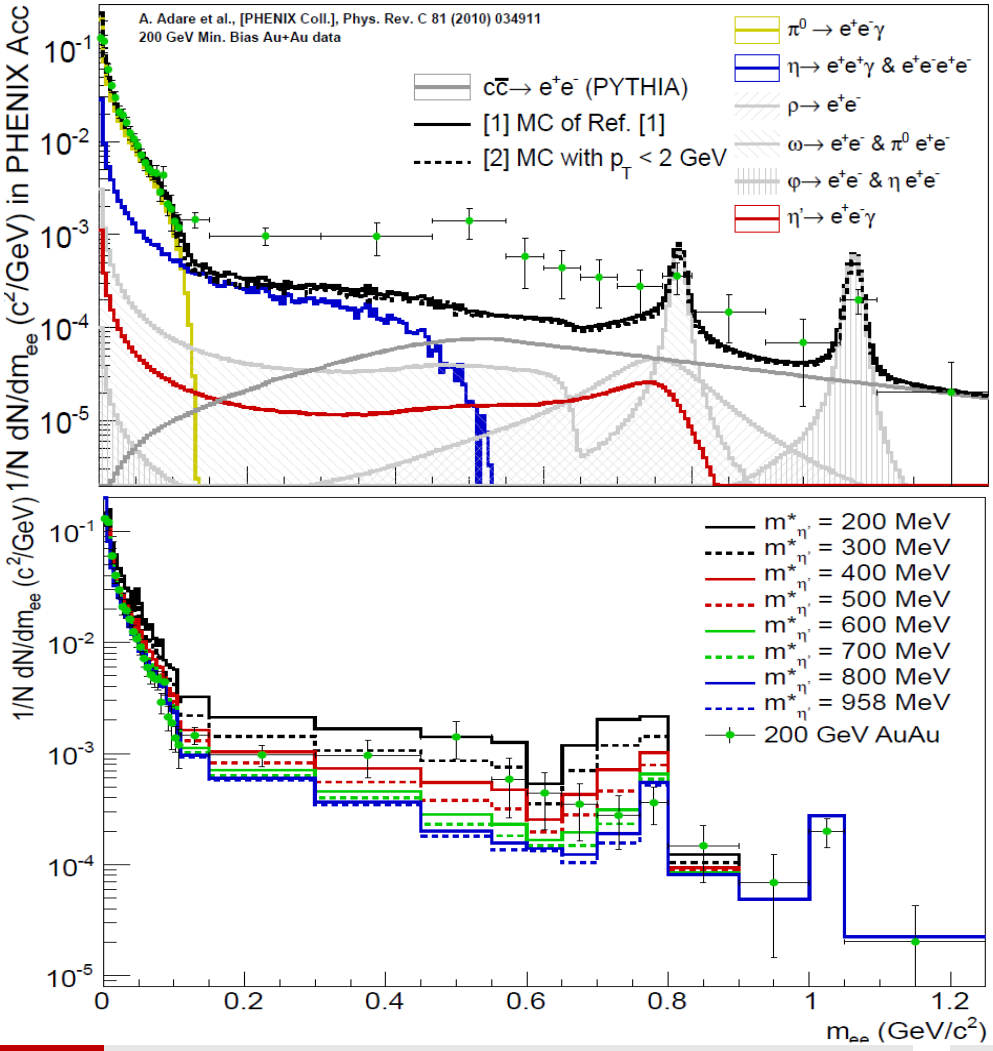
  $C(q) - 1 = \left|\tilde{S}(q)\right|^2 = \left|\widetilde{S_{\mathrm{core}}}(q) + \widetilde{S_{\mathrm{halo}}}(q)\right|^2$
- At small relative momentum:

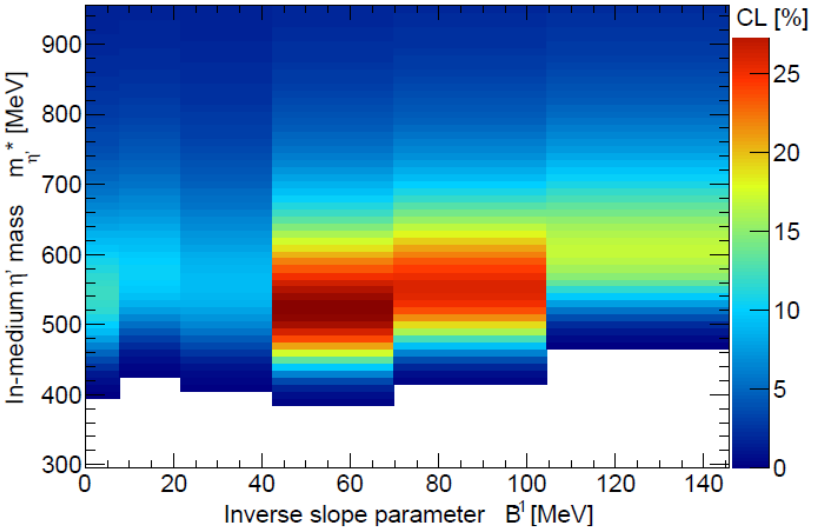
  $\mathrm{C}(0) - 1 \to \lambda =$ relative core fraction
- Enhanced η' content ⇒ large halo ⇒ decreased λ
- Nucl.Phys. A774 (2006) 611, an404, an436, an920



Low mass dilepton enhancement

- The η' mass reduction and production enhancement apparent in $\ell^+\ell^-$ spectra
- Enhancement in A+A dilepton spectra, compared to cocktail based on p+p
- Cocktail simulation: EXODUS
- η' spectra replaced based on hydrodynamic calculations

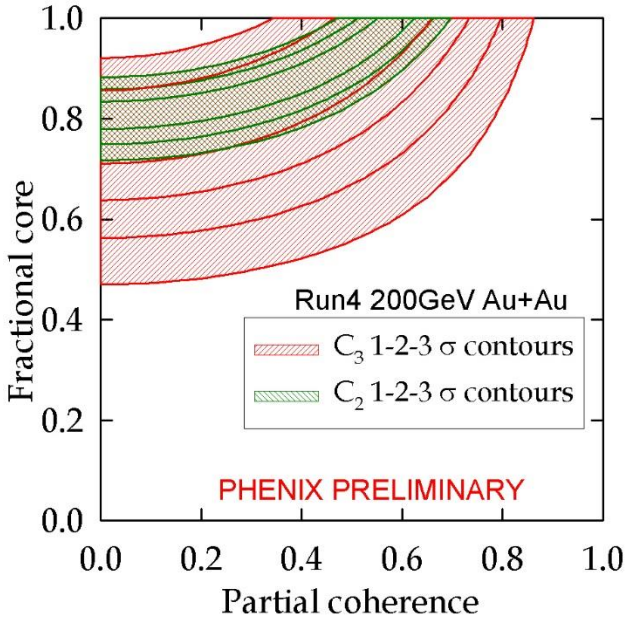




Three-pion correlations and coherent sources

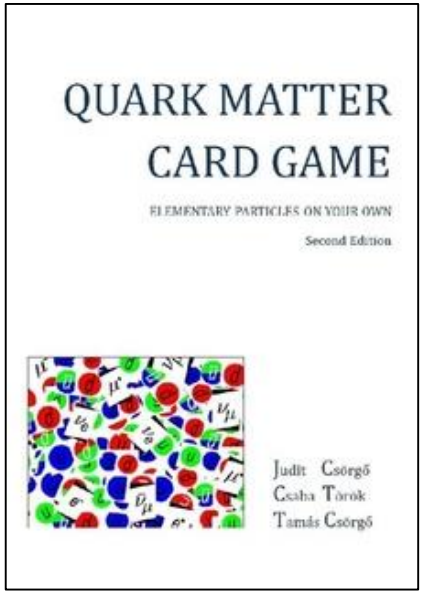
- Three-particle correlations: also sensitive to quantum-statistics
- If core/halo model is valid
  - $C_2(q \to 0) \to 1 + \lambda_2$, $C_3(q \to 0) \to 1 + \lambda_3$, and
  - $\lambda_2 = f_c^2$ while $\lambda_3 = 3f_c^2 + 2f_c^3$ with f_c being the core fraction
- In case of partially coherent particle production (à la pion-laser):
  - $\lambda_2 = f_c^2\left((1-p_c)^2 + 2p_c(1-p_c)\right)$
  - $\lambda_3 = 3f_c^2\left((1-p_c)^2 + 2p_c(1-p_c)\right) + 2f_c^3\left((1-p_c)^3 + 3p_c(1-p_c)^2\right)$
- If both measured: coherent part to be revealed
- Measurement ongoing, but also

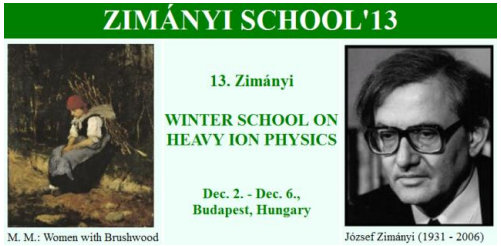
Nucl.Phys. A774 (2006) 611, an404, an436



Other contributions

- Direct photon measurement with PbSc (an490)
- Identified charged hadron spectra in p+p (an640, PRC83,064903(2011))
- Squeezed back-to-back correlations (an846)
- Identical kaon correlations (an609, PRL103,142301(2009))
- Low-energy task force (an824)
- Search for the critical point via Lévy-exponents (an920)
- Quark Matter Card Game
- Zimányi School





- >20 official PHENIX talks and internal notes (some mentioned above)
- More details at http://phenix.kfki.hu/ or http://phenix.elte.hu/
- Thank you for your attention!