# Produktion neutraler Pionen am PHENIX-Experiment des RHIC

DPG-Frühjahrstagung Tübingen
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Christian Klein-Bösing
für die PHENIX-Kollaboration

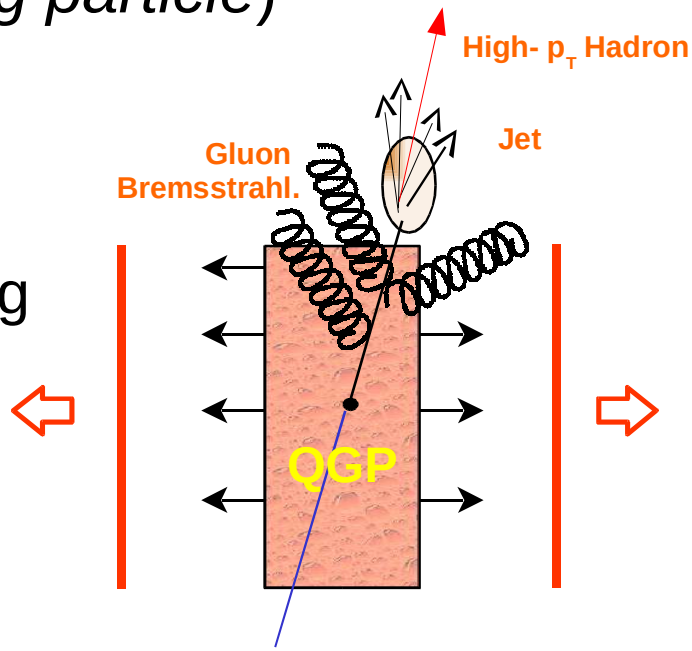
Gefördert durch das bmb+f

bmb+f - Förderschwerpunkt
Hadronen - und Kernphysik
Großgeräte der physikalischen Grundlagenforschung

# Messung von $\pi^0$'s mit hohen Transversalimpulsen

- Erstmals zugänglich in A+A ($p_T$ > 2 GeV)
- Produktion in frühen Parton-Parton Stößen mit großem $Q^2$
- Partonfragmentation $\Rightarrow$ Jets (*leading particle*)
- Sonde für partonische Phase
- Sensitiv auf Mediumeffekte:
  - ➔ QGP Energieverlust / Jet Quenching

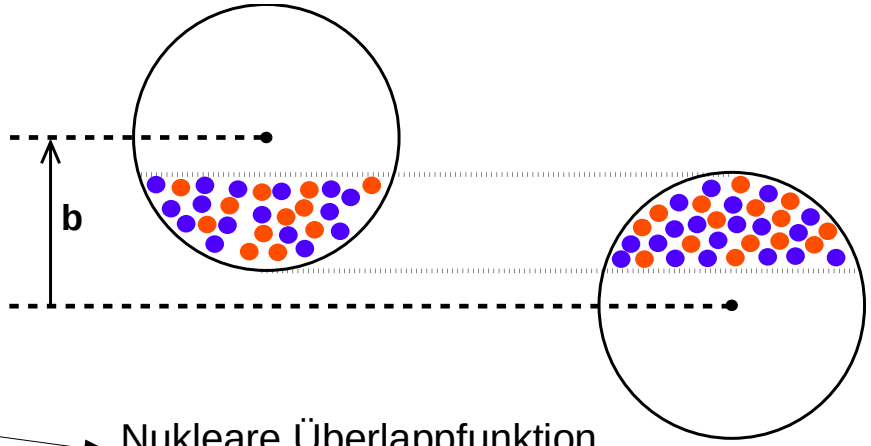
Nachweisbarkeit ??



# Glauber/$R_{AA}$

- Glauber Modell:
  - AA inkohärente Überlagerung von NN

$$\sigma_{AB}^{hard} \approx \int d^2 b \, \sigma_{NN}^{hard} T_{AB}(b)$$




Nukleare Überlappfunktion
*"Nukleonen-Luminosität"*

$$\langle N_{coll} \rangle = \sigma_{NN} T_{AB}$$

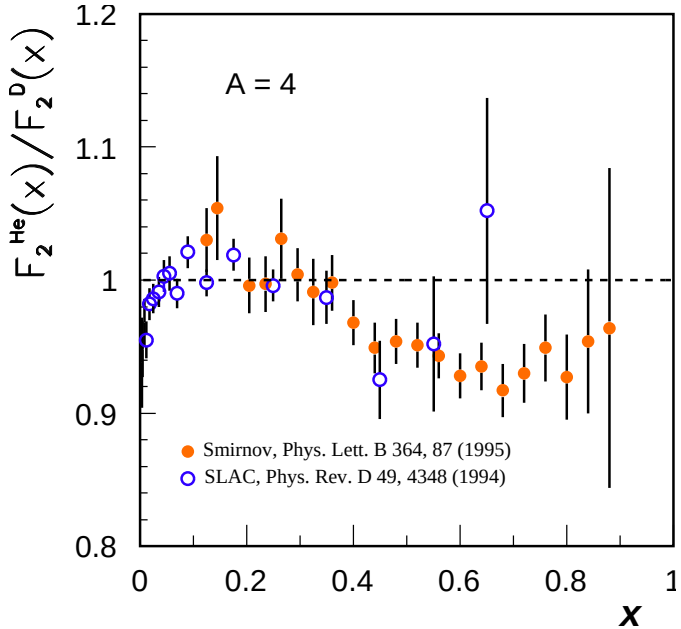
$$\sigma_{AB} \propto \langle N_{coll} \rangle$$

- Vergleich mit skalierten NN Reaktionen (QCD-Vakuum)
  - "collision scaling": $R_{AA} \approx 1$ ?

$$R_{AA} = \frac{d^2 N_{AA}^{\pi^0} / dydp_T}{\langle N_{coll} \rangle d^2 N_{pp}^{\pi^0} / dydp_T}$$

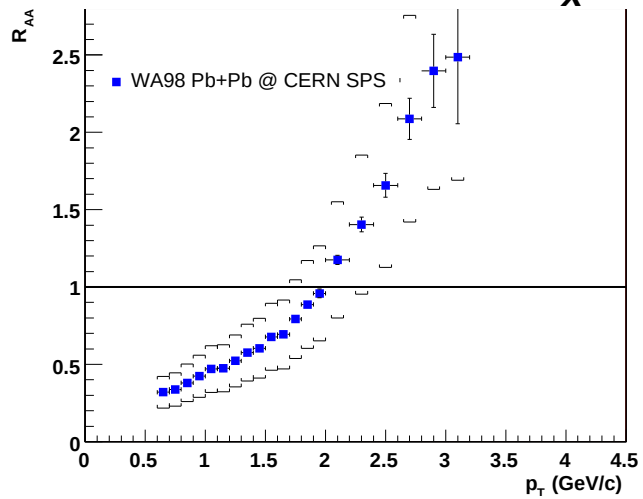
# Bekannte Effekte N → A

- Strukturfunktionen:
  - EMC-Effekt
  - (anti-)shadowing
  - $x \approx 0.02 – 0.1$ (shadowing)



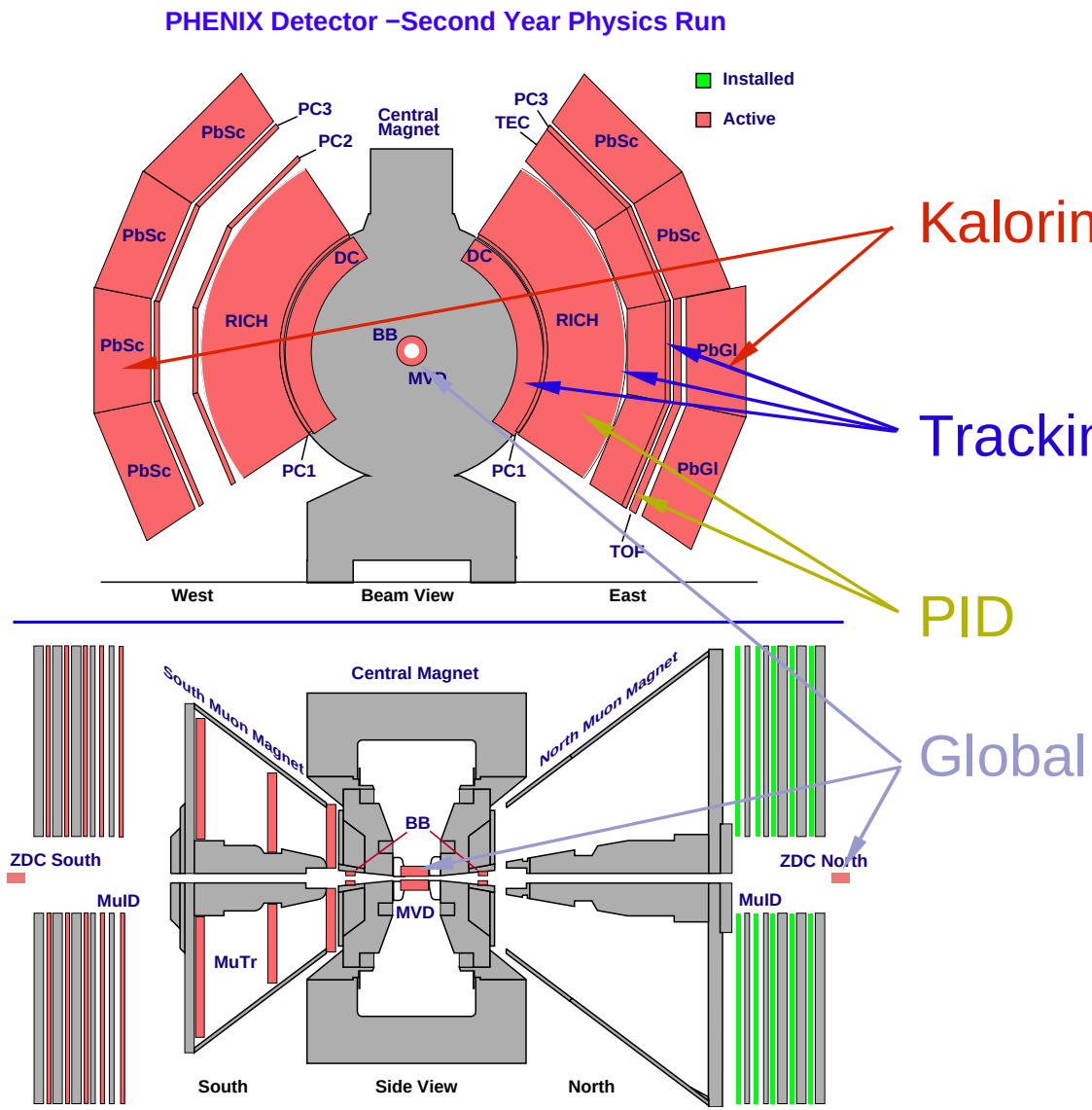

- Teilchenproduktion:
  - Cronin ähnlicher Effekt:

$R_{AA} > 1$




d+Au wichtig für Interpretation von Au+Au

# PHENIX @ RHIC




Kalorimetrie

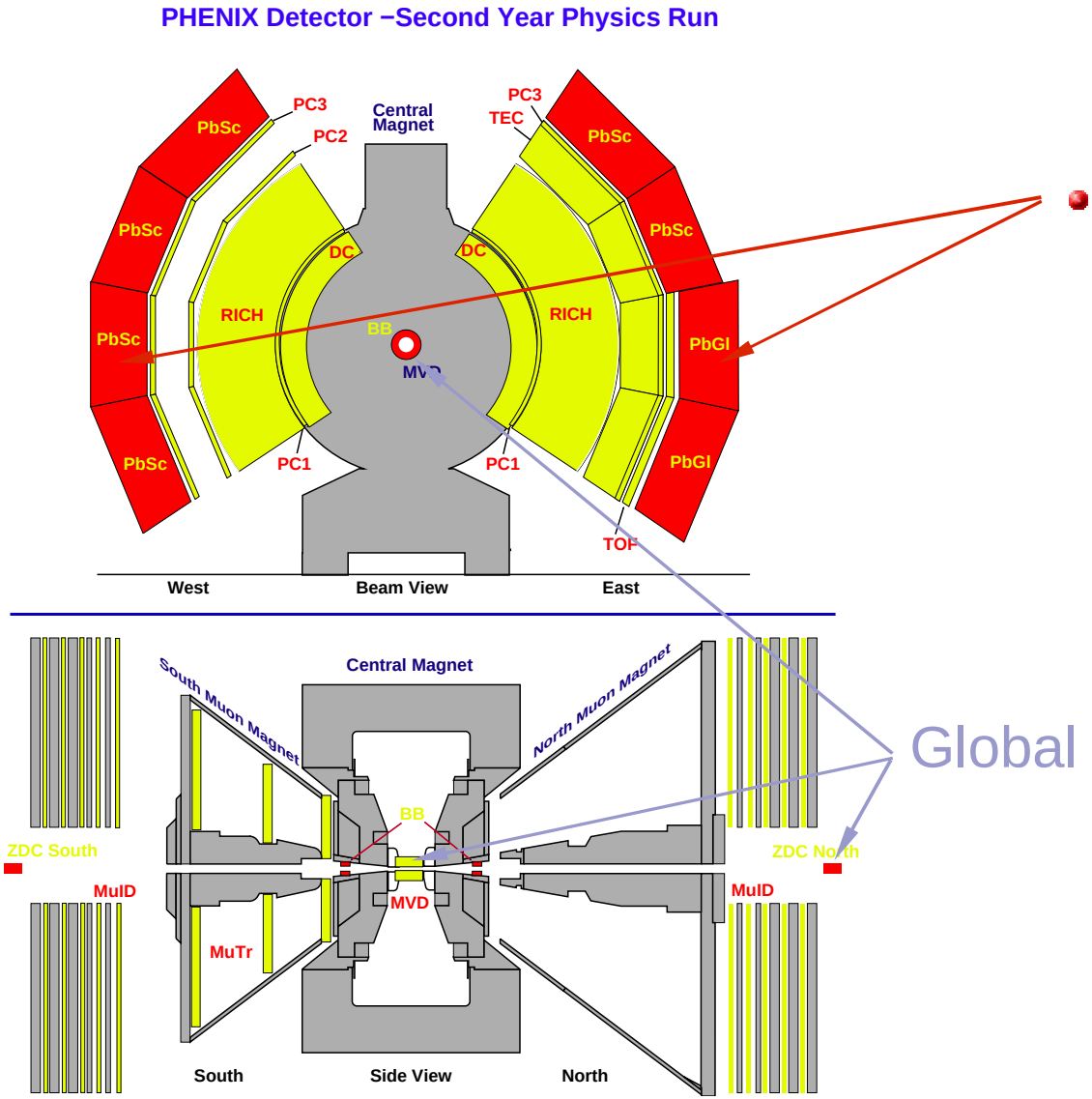
Tracking

PID

Global

RHIC Au+Au / p+p:
$\sqrt{s_{NN}}$= 200 GeV

# PHENIX @ RHIC




Global

- PHENIX-EMCal:
  - $|\eta| < 0.35$
  - $\Delta\eta \times \Delta\varphi \approx 0.01 \times 0.01$
  - 6 Sektoren Blei-Szintillator
    - Sandwich Kalorimeter
  - 2 Sektoren Bleiglas
    - Cherenkov Kalorimeter

RHIC Au+Au / p+p:
$\sqrt{s_{NN}} = 200$ GeV

# $\pi^0$ Messung

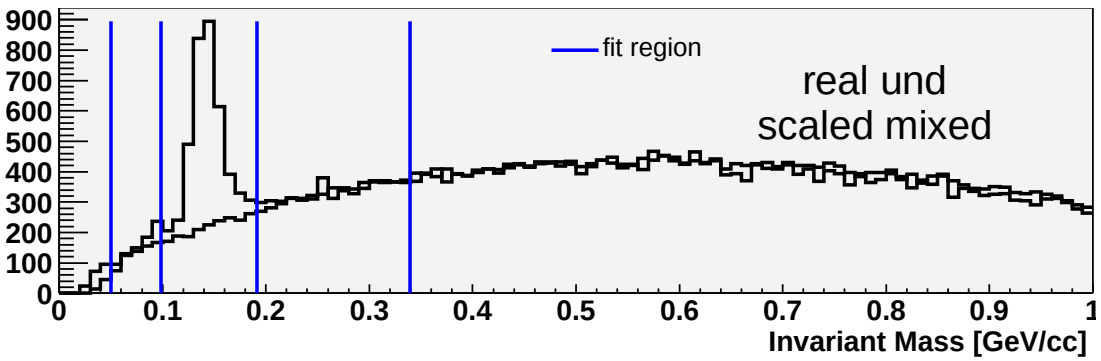
- $\pi^0$ Rekonstruktion
  - über $2\gamma$-Zerfall
  - Cuts $\Rightarrow$ Photonkanditaten
  - Paare mit $\alpha = \left|\frac{E_1 - E_2}{E_1 + E_2}\right| < 0.7$
  - Invariante Masse

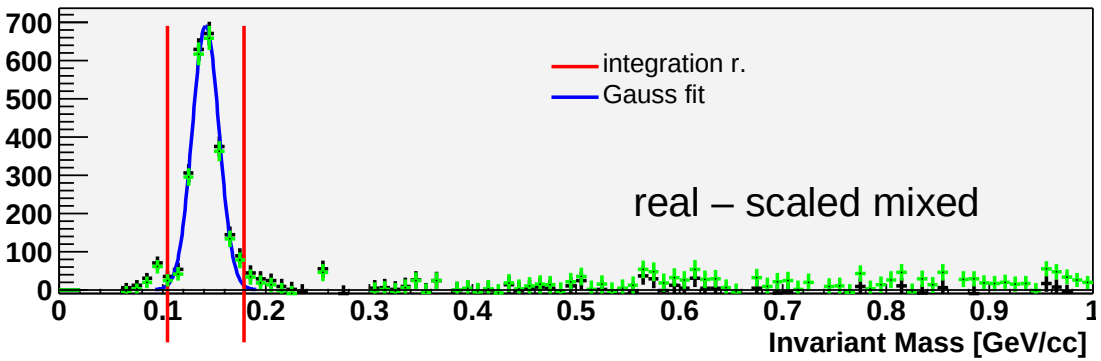
$$m_{inv} = \sqrt{2 E_1 E_2 (1 - \cos\theta)}$$

- Nötige Korrekturen
  - geometrische Akzeptanz
  - Detektoreffekte
    - ✓ Multiplizität
    - ✓ Energie/Ortsauflösung
  - Analysecuts
    - ✓ PID
    - ✓ Asymmetry
    - ✓ Randmodule

"Effizienz"

# Yield Extraktion

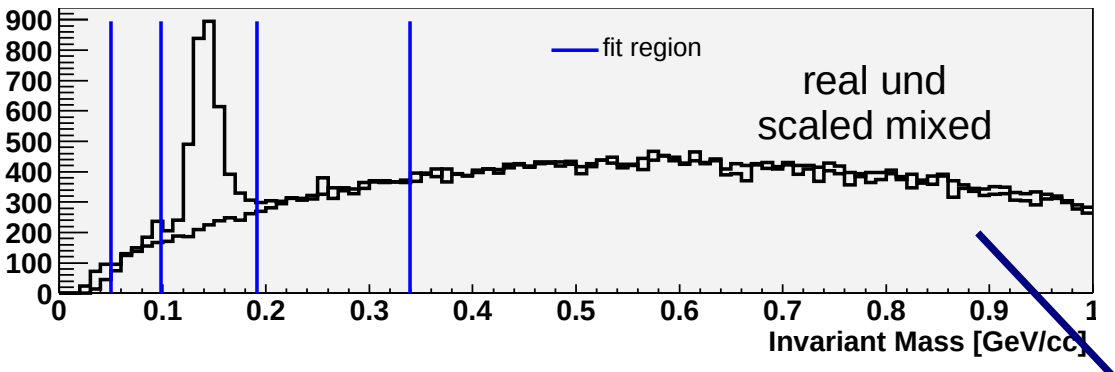


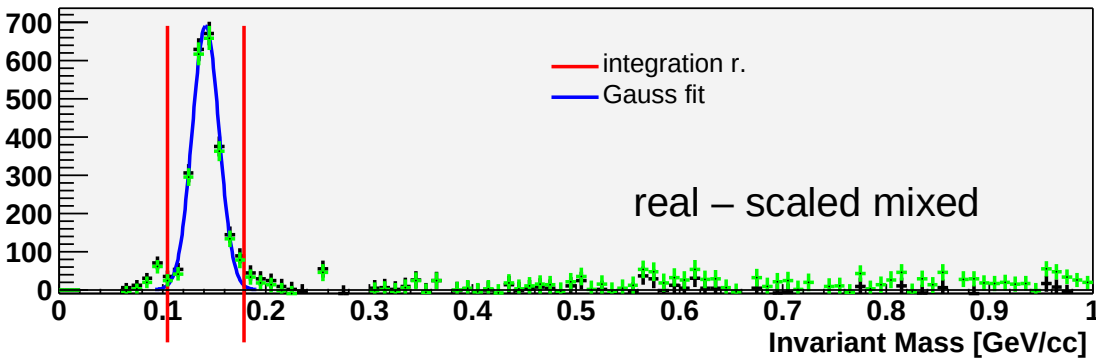




PbGl AuAu min. Bias: 4 GeV < $p_T$ < 4.5

- Mixed Events
  - Paarkombinationen aus versch. Events
  - Kombinatorischer Untergrund
- Peak Integration
  - $3\sigma$ Fenster

# Yield Extraktion

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- Mixed Events
  - ➔ Paarkombinationen aus versch. Events
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    Unterg
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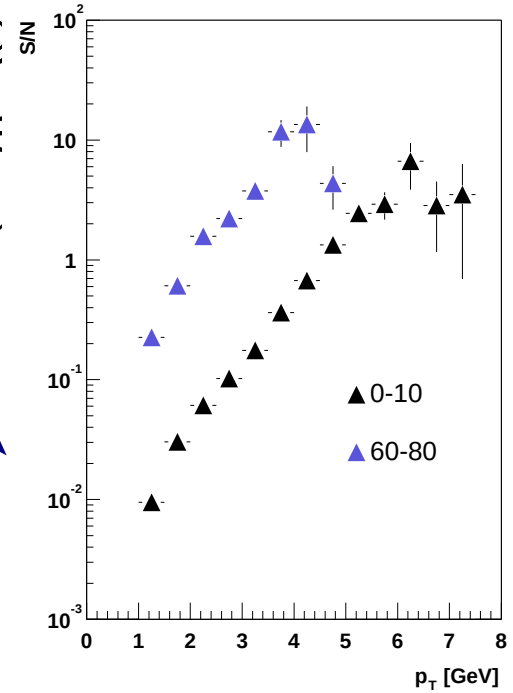
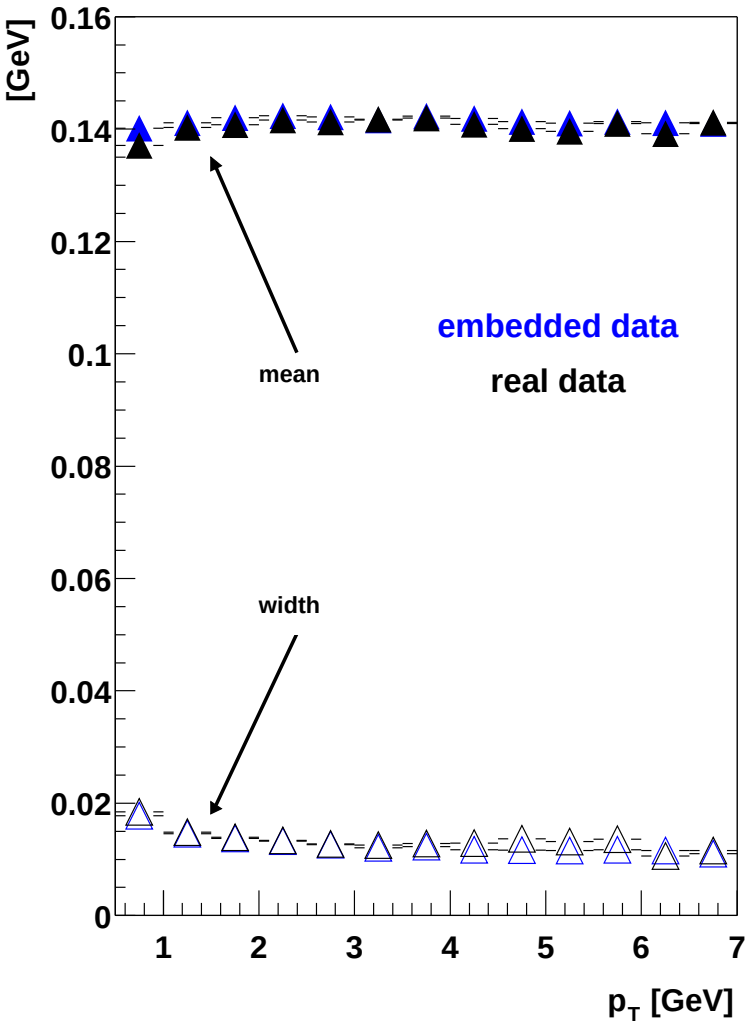
  - ➔ 3σ Fer



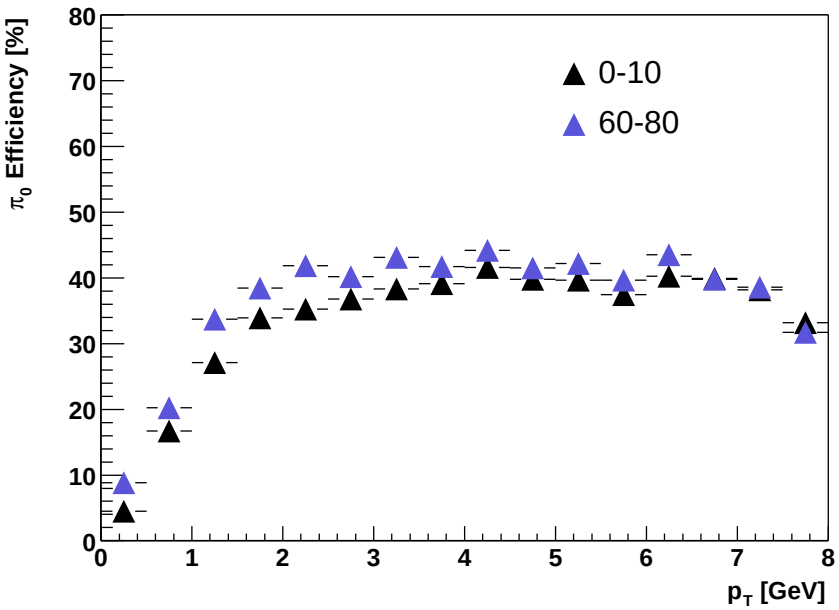
# Effizienz




- Einbetten von simulierten $\pi^0$ in reale Events
  - ➔ Schauerüberlapp
  - ➔ Analysecuts
- Reproduktion von Peakposition und Weite
- Effizienz:

$$\epsilon = \frac{dN^{\pi^0} / dp_T ||_{reconstructed}}{dN^{\pi^0} / dp_T ||_{input}}$$

# Effizienz

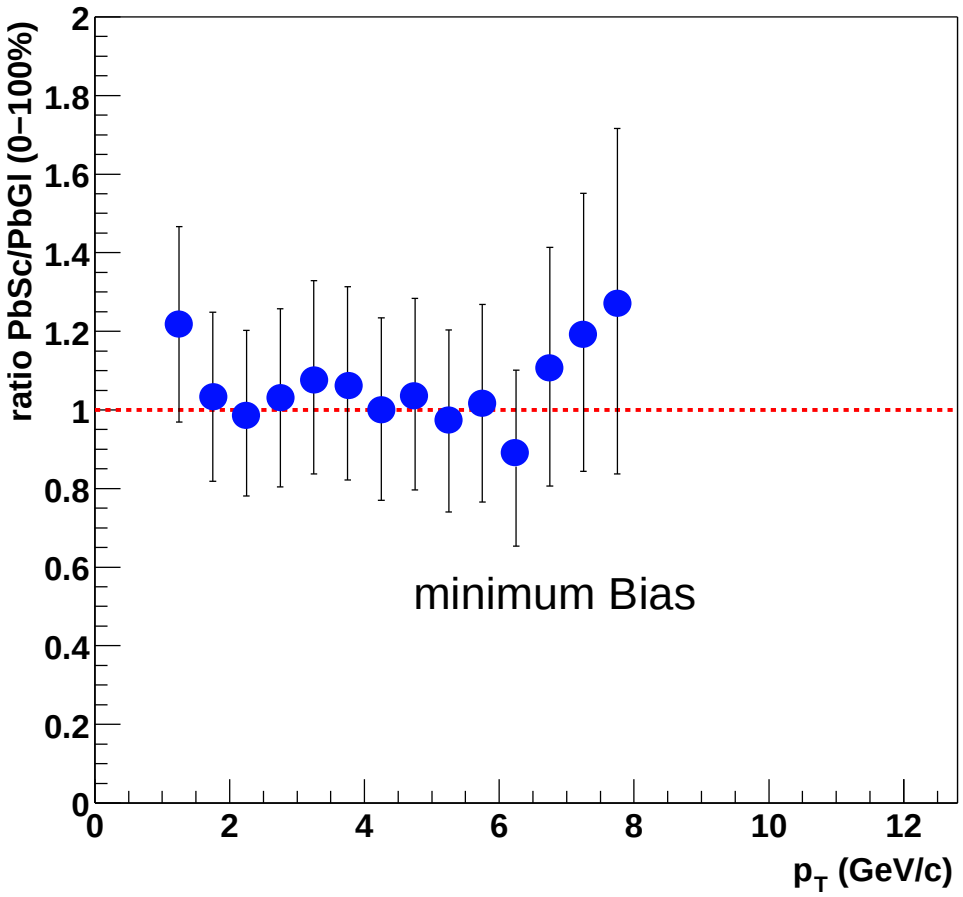



- Einbetten von simulierten $\pi^0$ in reale Events
  - ➔ Schauerüberlapp
  - ➔ Analyse-Cuts
- Check: Peakposition und Weite
- Effizienz:

$$\epsilon = \frac{dN^{\pi^0}/dp_T||_{reconstructed}}{dN^{\pi^0}/dp_T||_{input}}$$

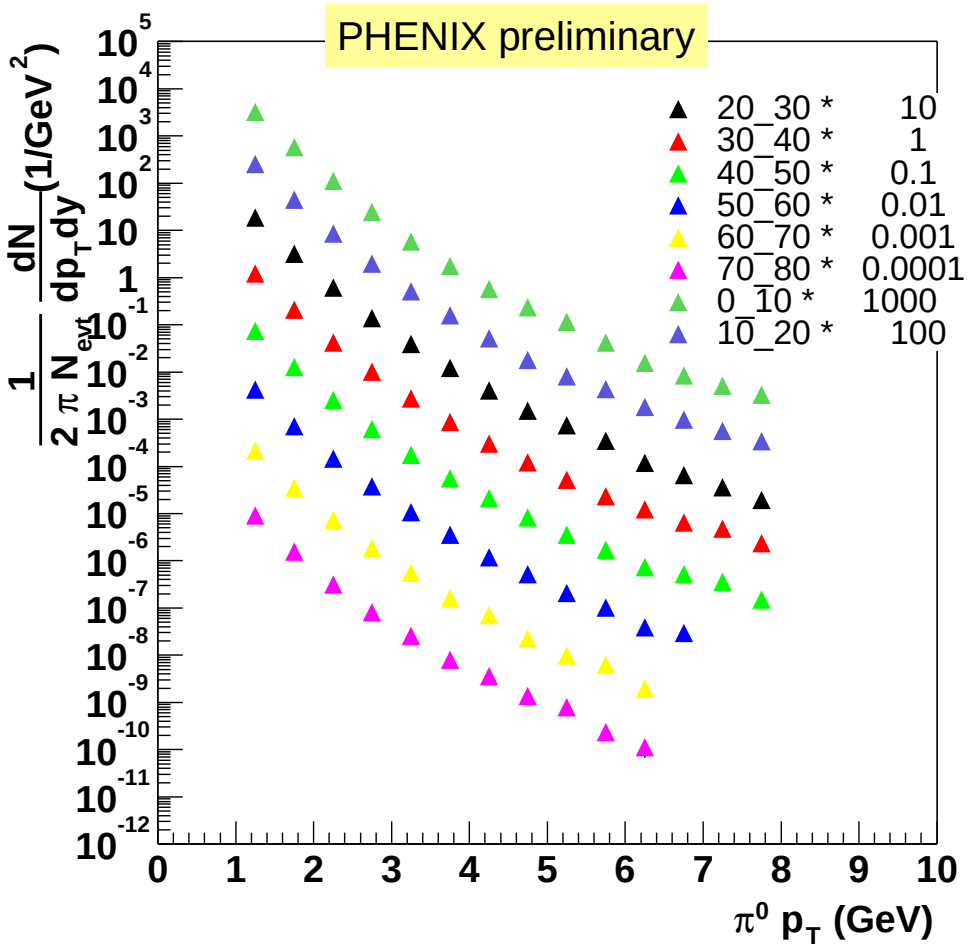
Dominiert durch Modul-Cuts ($\varepsilon \approx 60\%$) und Asymmetrie ($\varepsilon \approx 70\%$)

# Vergleich PbSc/PbGl




- PHENIX-EMCal
  - ➔ Zwei Messungen
    - ✔ PbGl und PbSc
    - ✔ unabhängige Analyse
- Gute Übereinstimmung

# Vorläufige Spektren Au+Au (PbSc)




- Unsicherheiten:
  - Extraktion: ~15%
  - Effizienz: ~15%
  - Akzeptanz: ~3%
- Endgültige Spektren
  - Kombination PbSc+PbGl
  - Reduzierte systematische Fehler...

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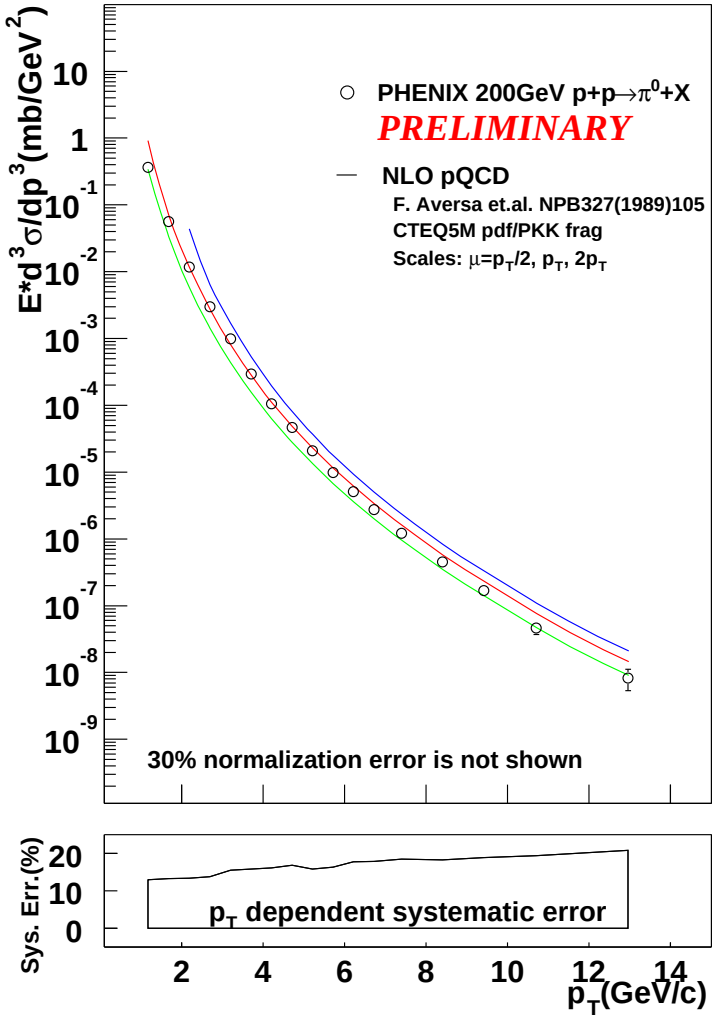
# Vorläufige Spektren p+p (PbSc)




- $\sqrt{s_{NN}}$ = 200 GeV
- Gleicher Detektor
- Unsicherheiten:
  - Extraktion: ~14%
  - Effizienz+Akzeptanz: ~13%
  - Absolute Normalisierung: ~30%
- Konsistent mit NLO-Rechnungen

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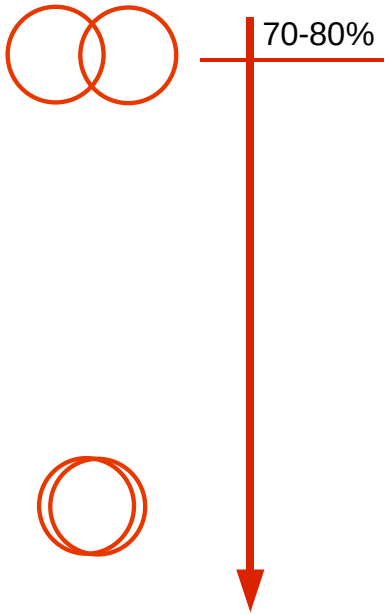
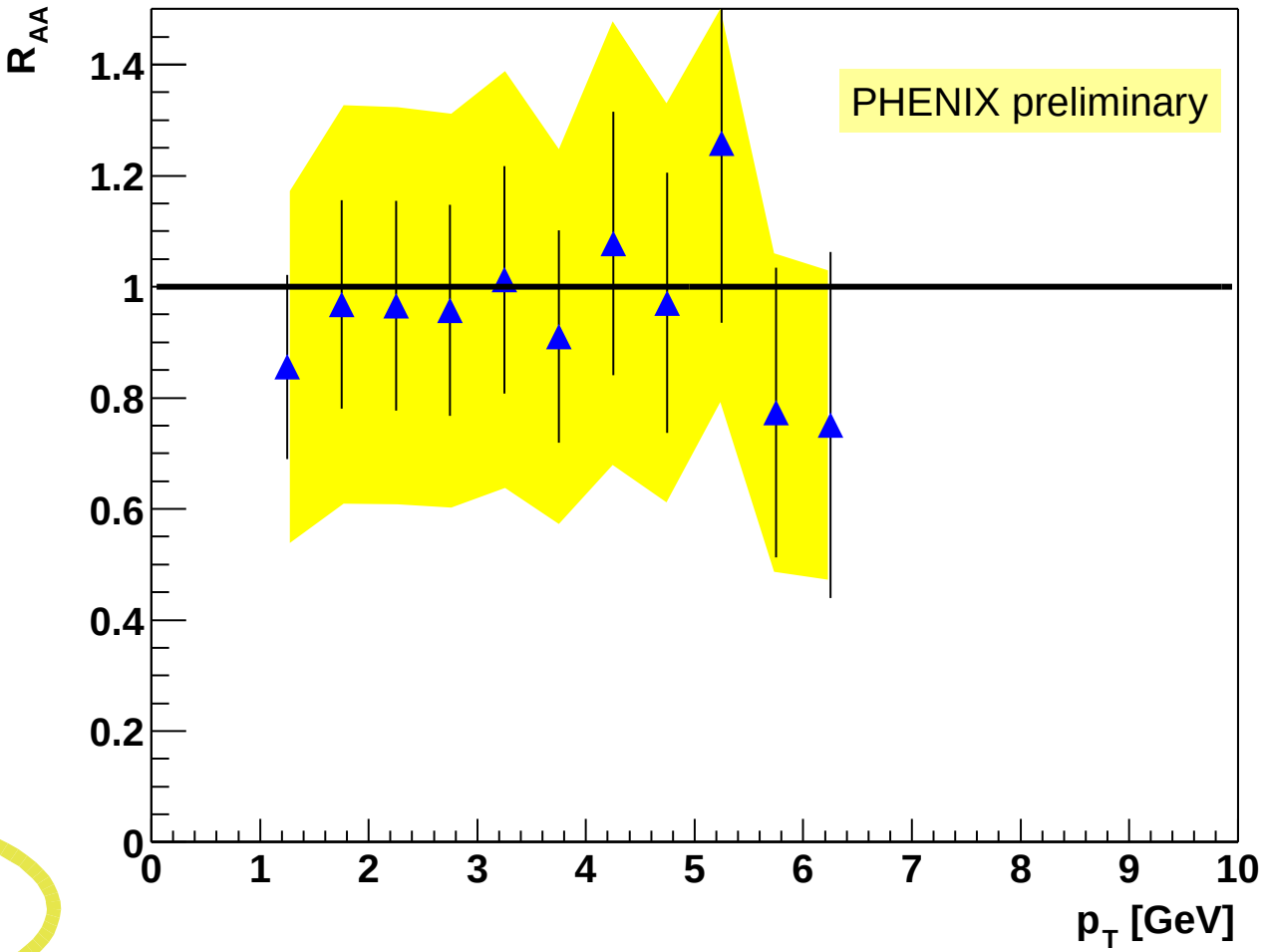
# $R_{AA}$




$$R_{AA}^{coll} = \frac{d^2 N_{AA}^{\pi^0} / dydp_T}{\langle N_{coll} \rangle d^2 N_{pp}^{\pi^0} / dydp_T}$$

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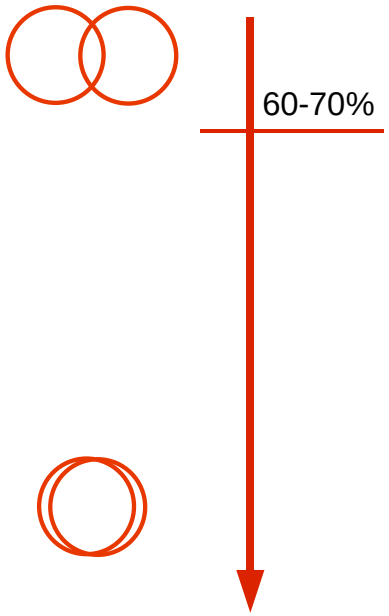


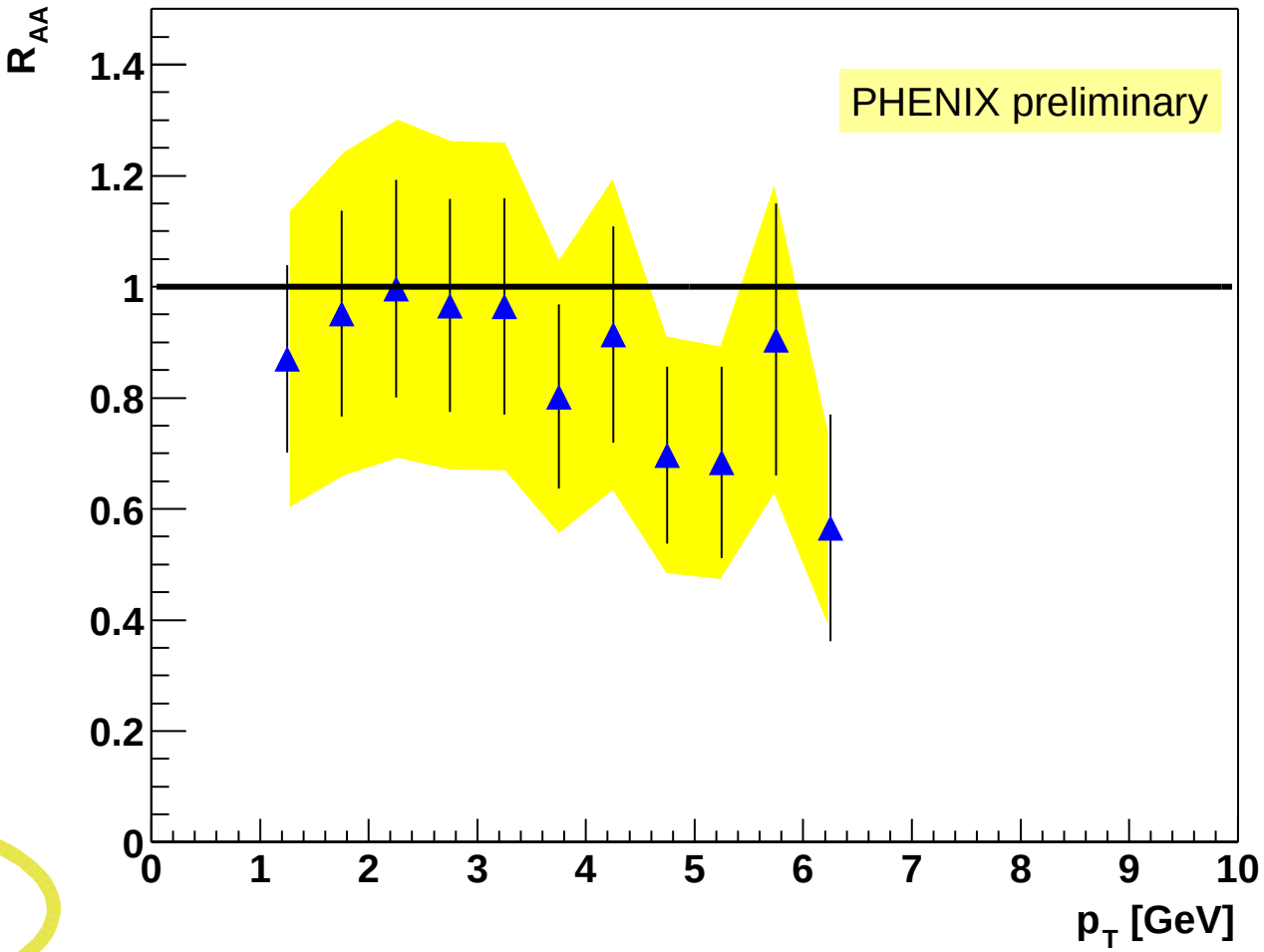


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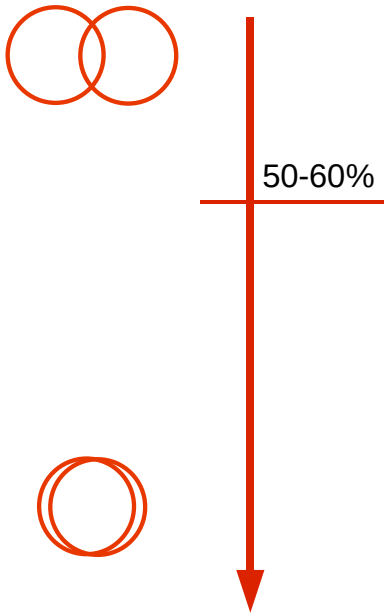


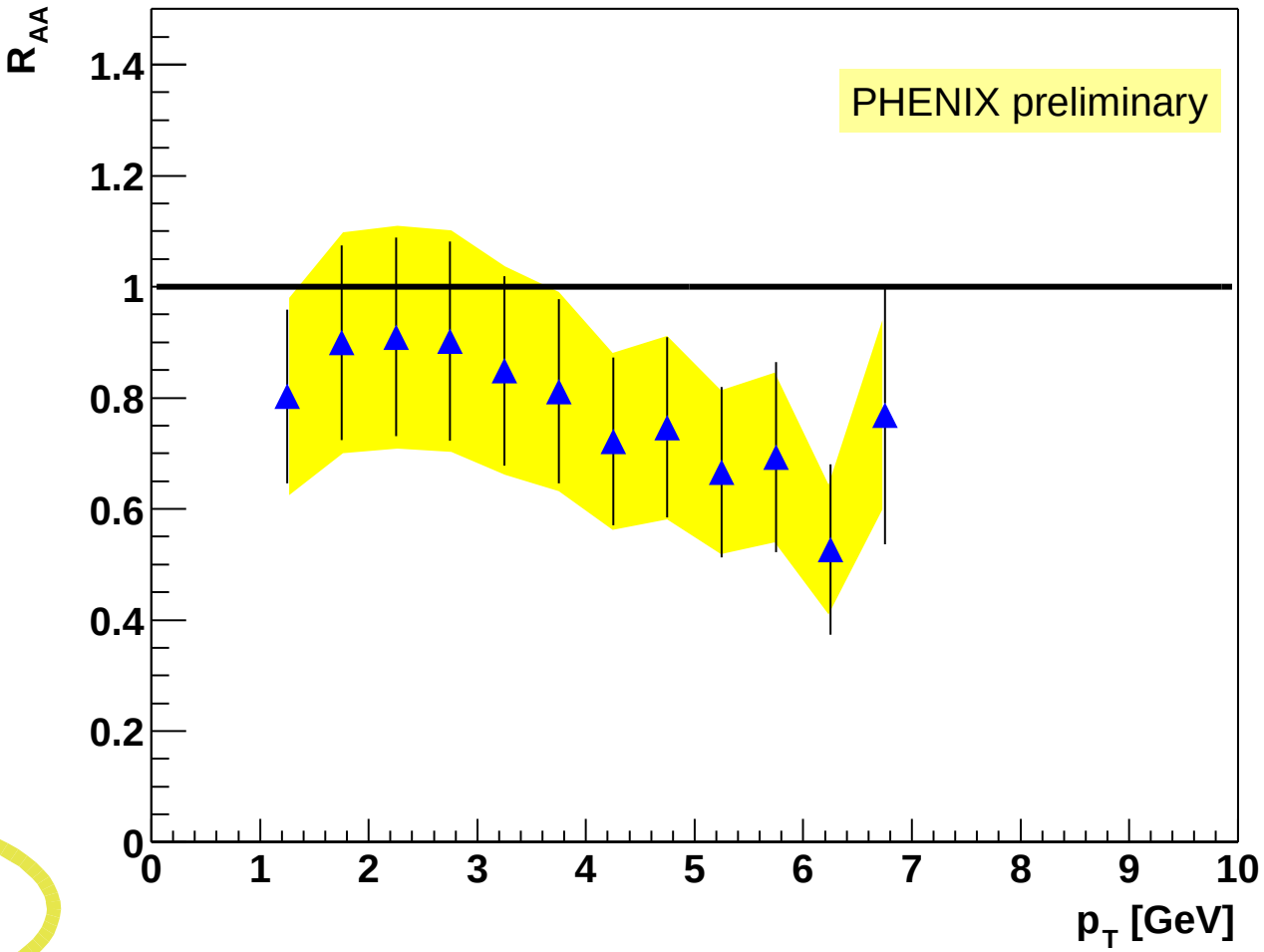


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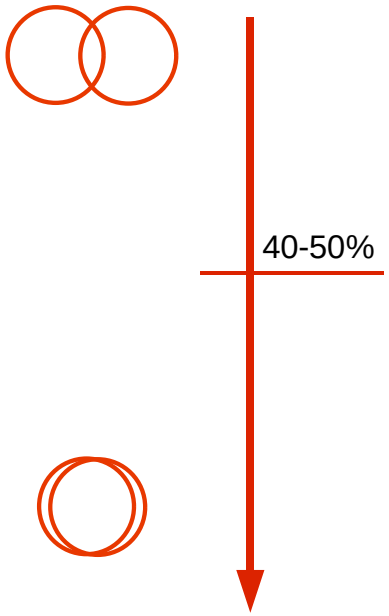


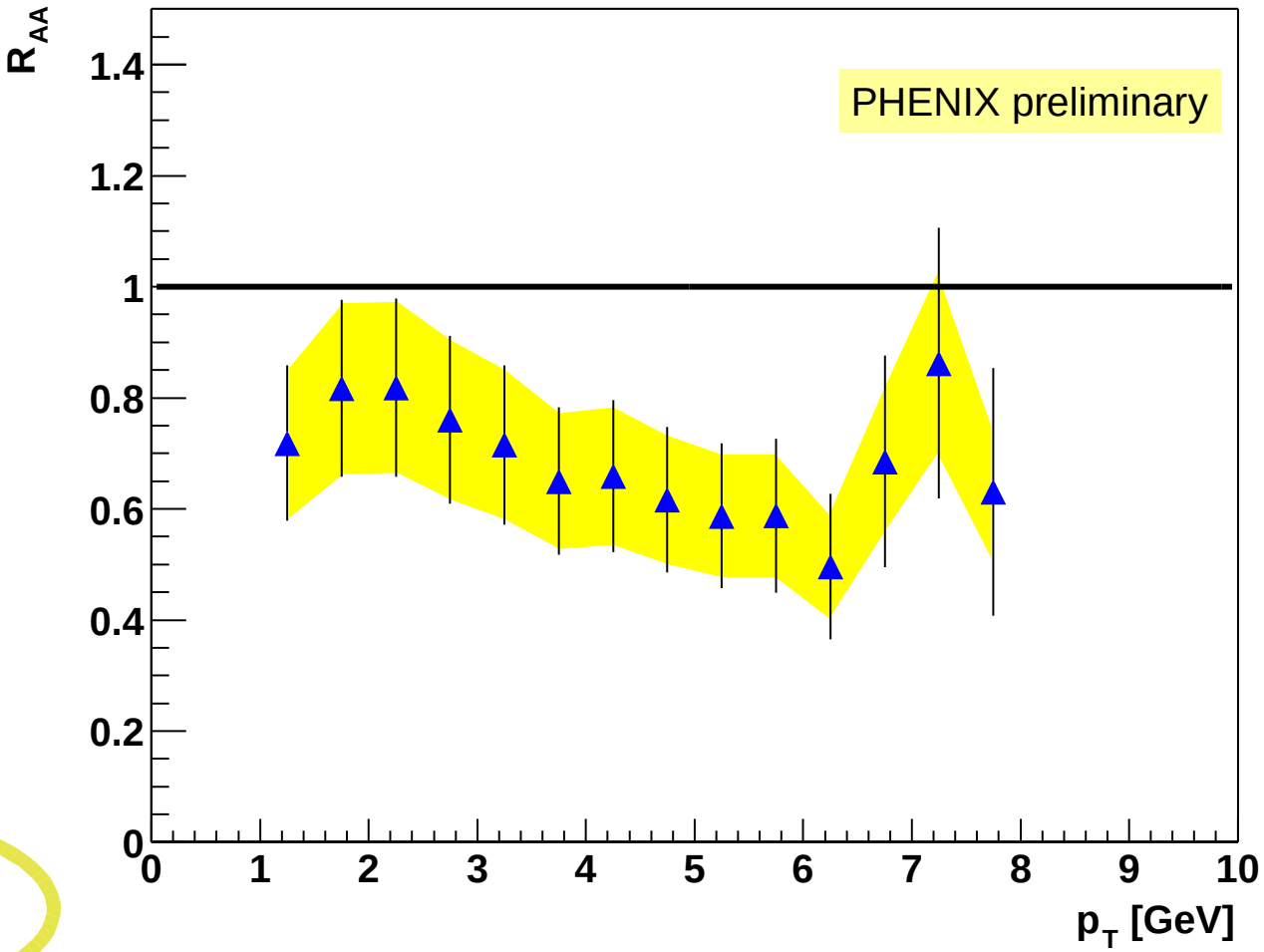


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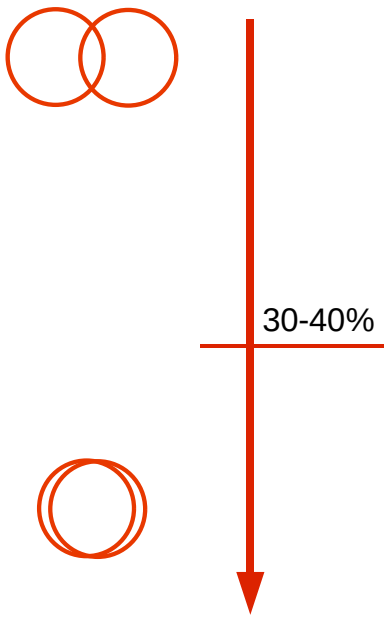


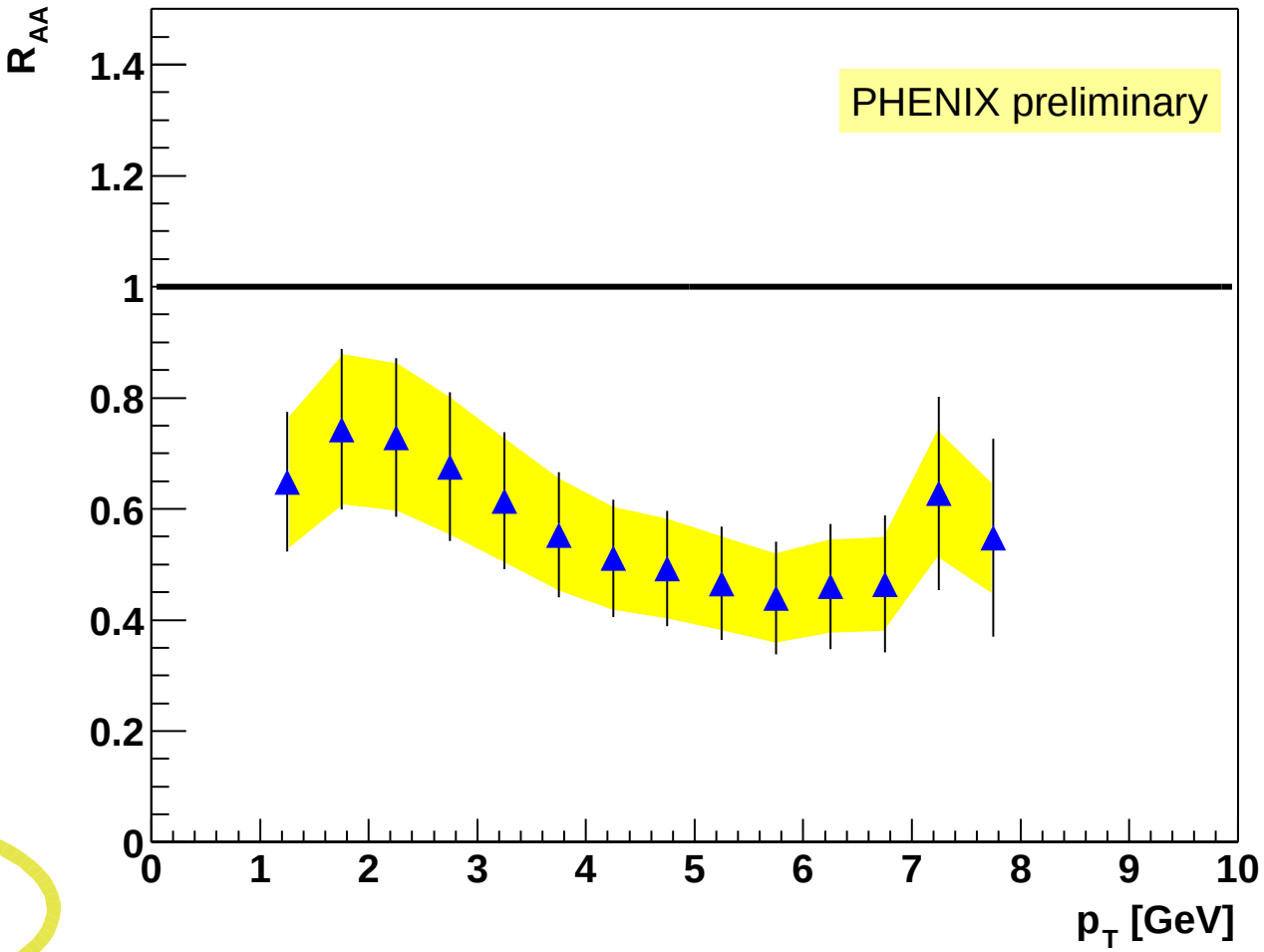


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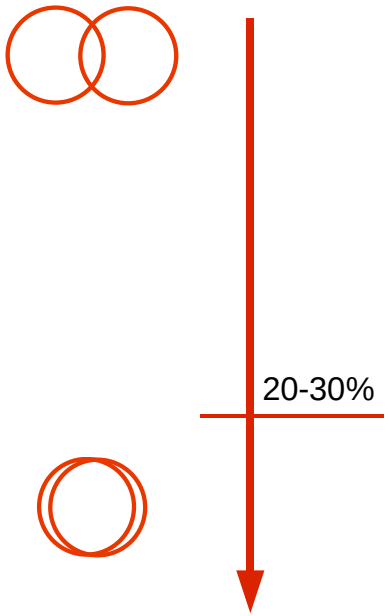


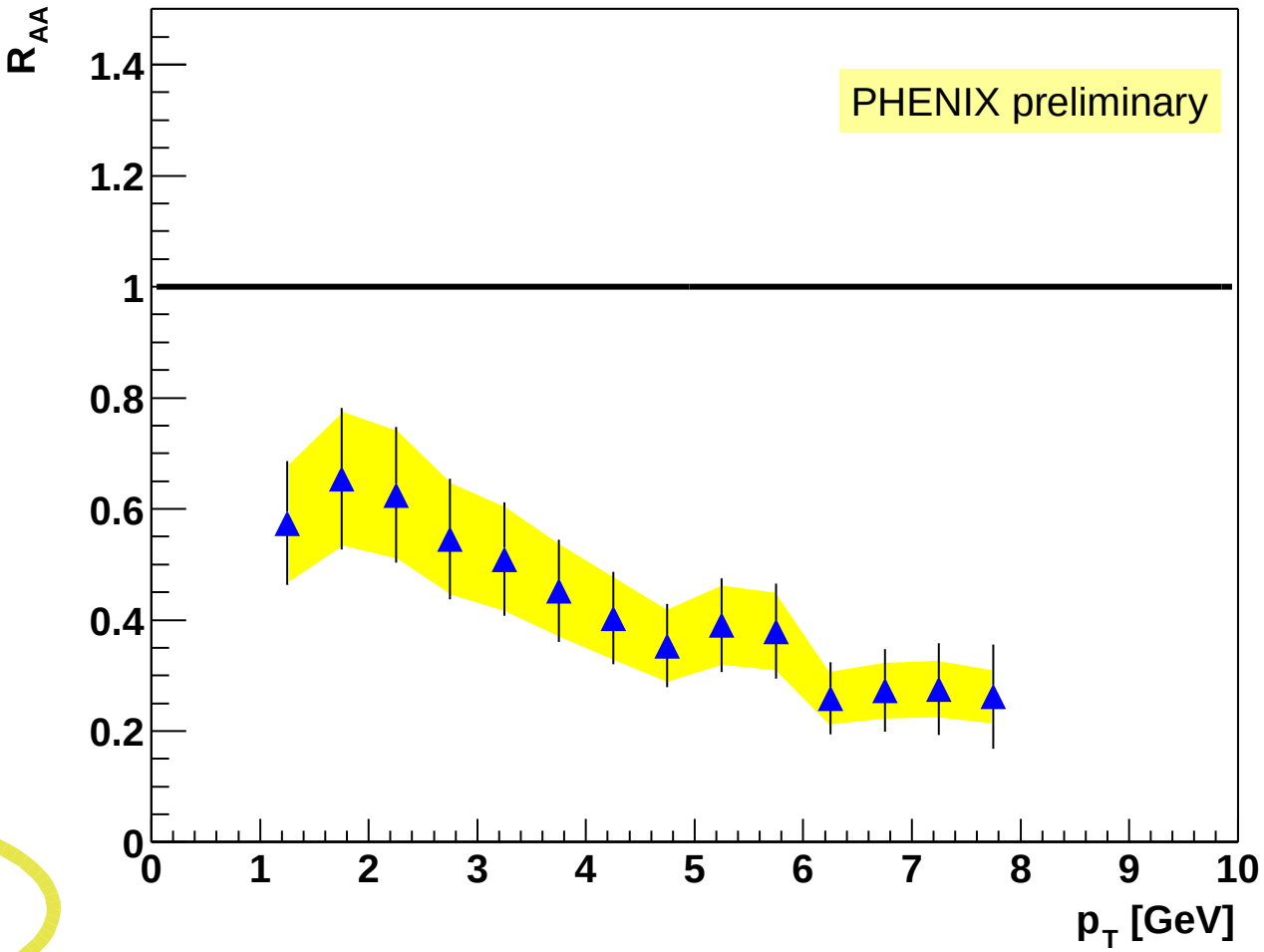


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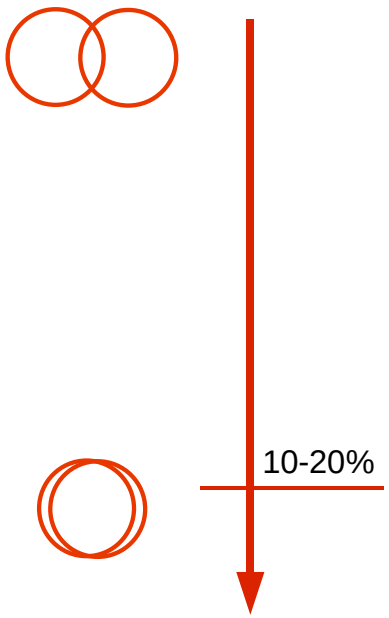


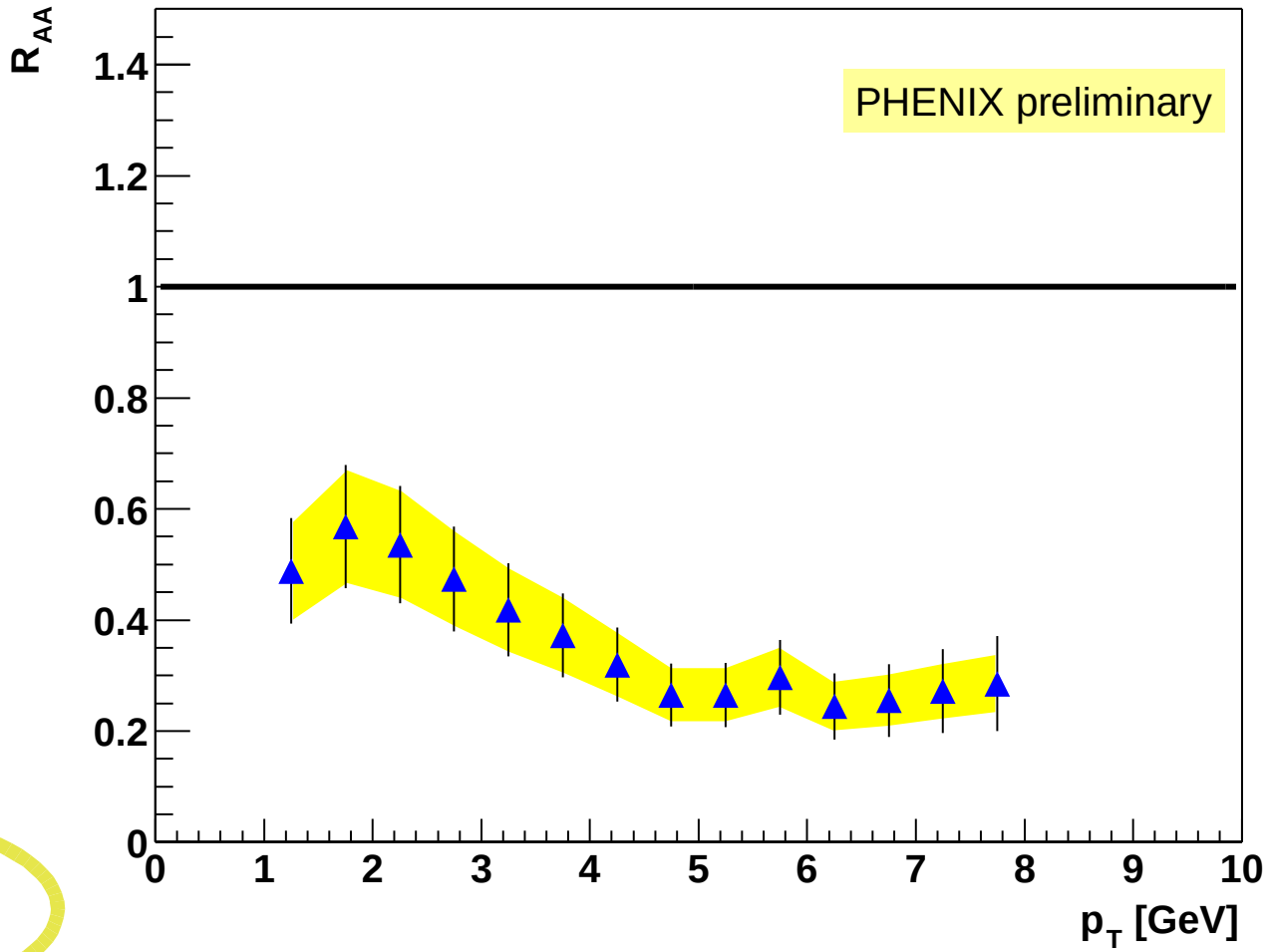


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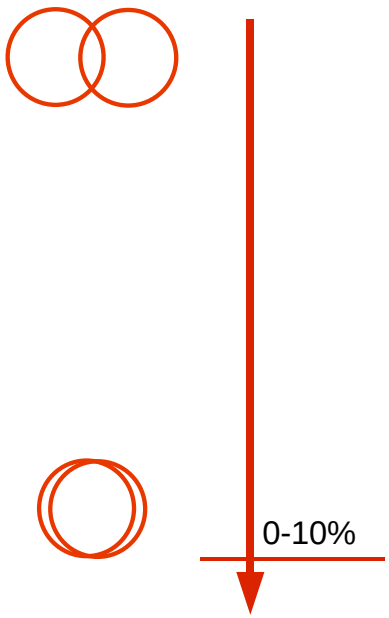


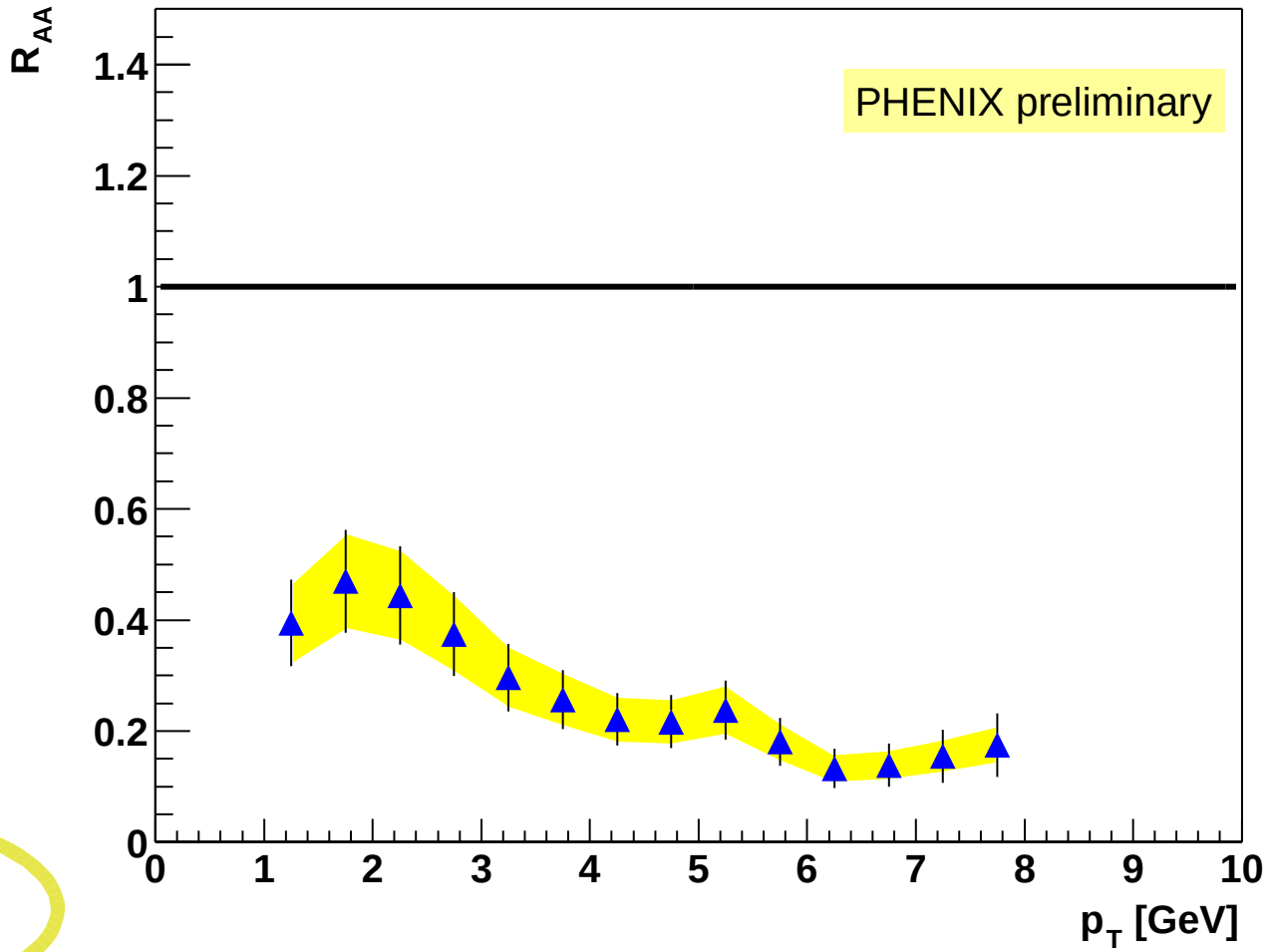


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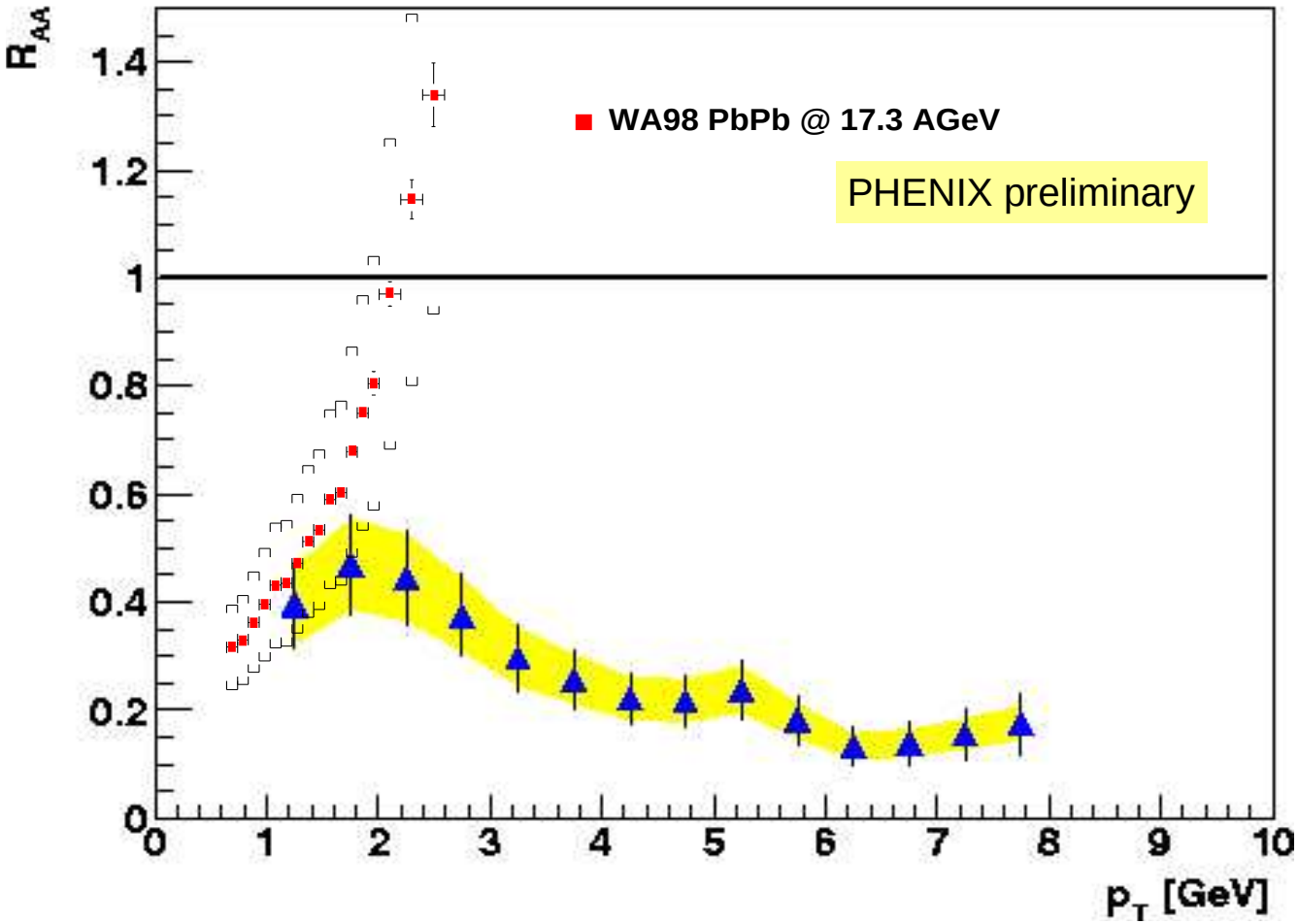
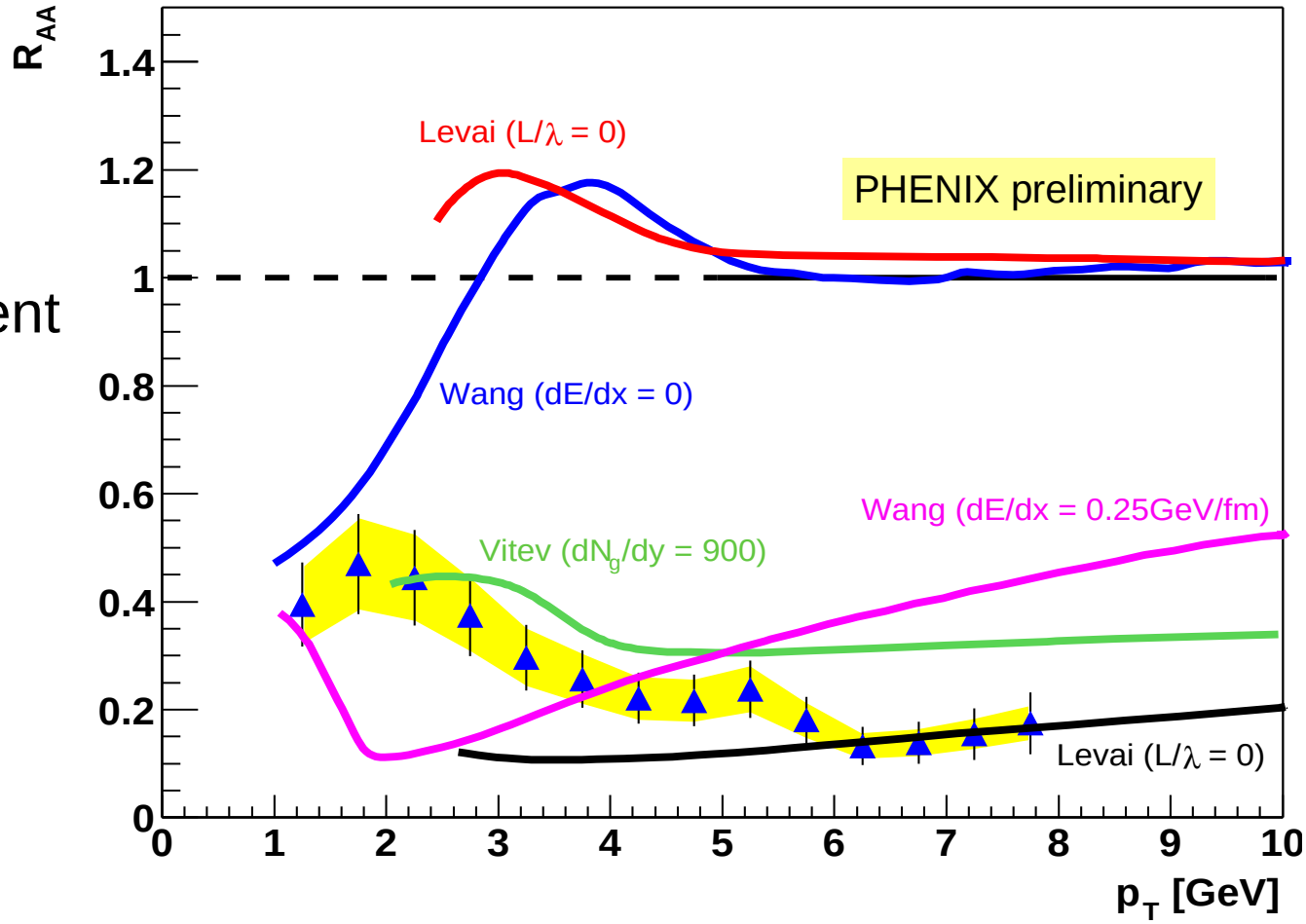
# $R_{AA}$

Kein Cronin
ähnlicher Effekt

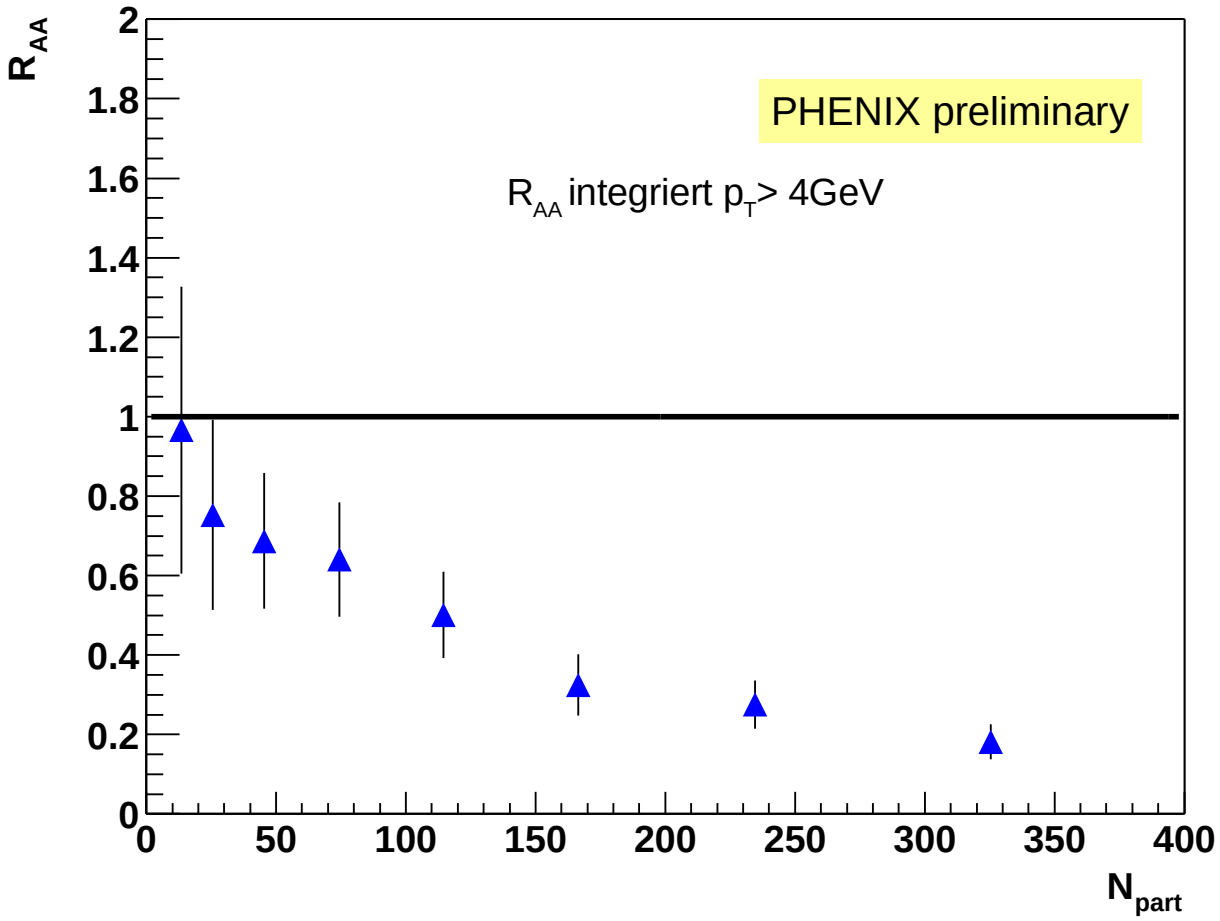


# $R_{AA}$

Unterdrückung konsistent mit Energieverlust



# Zentralitätsabhängigkeit $R_{AA}(N_{coll})$



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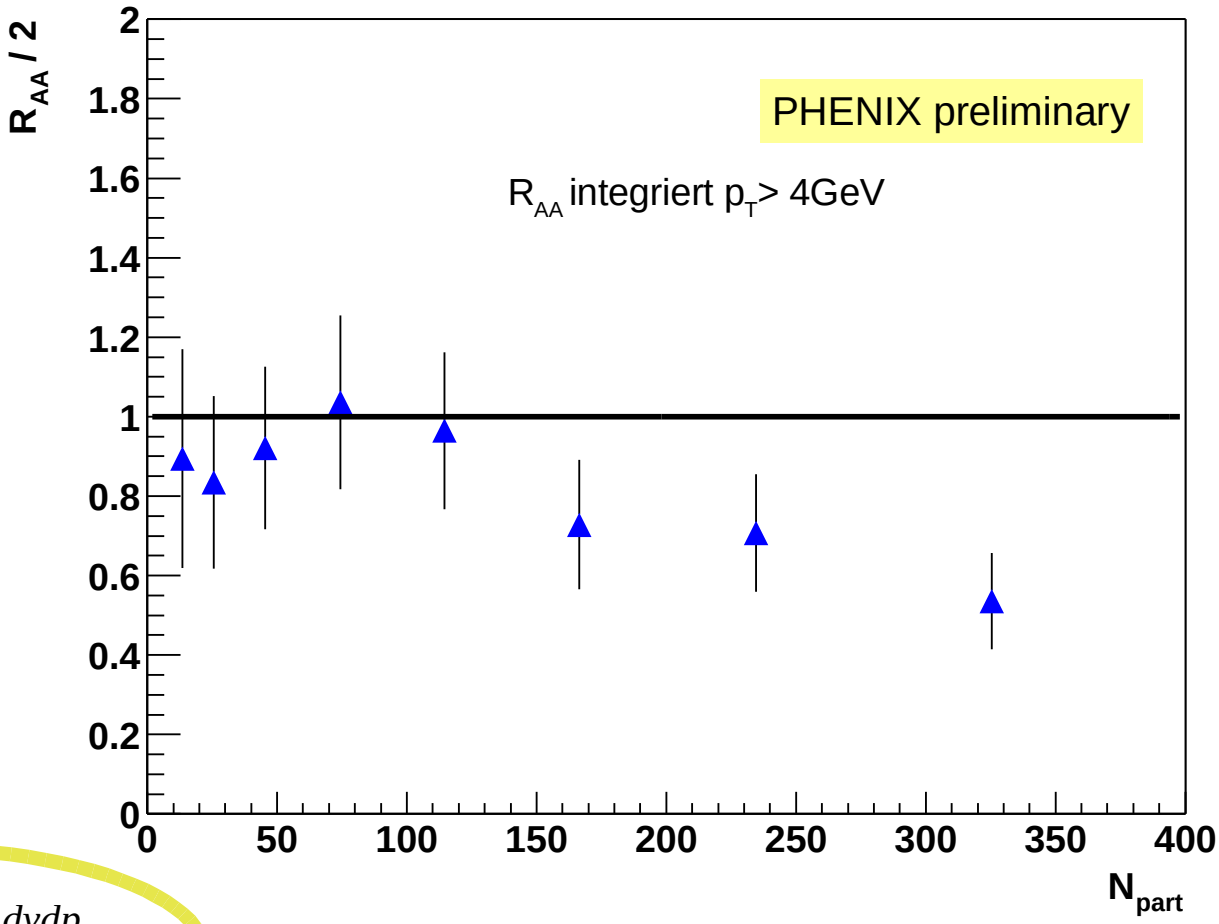


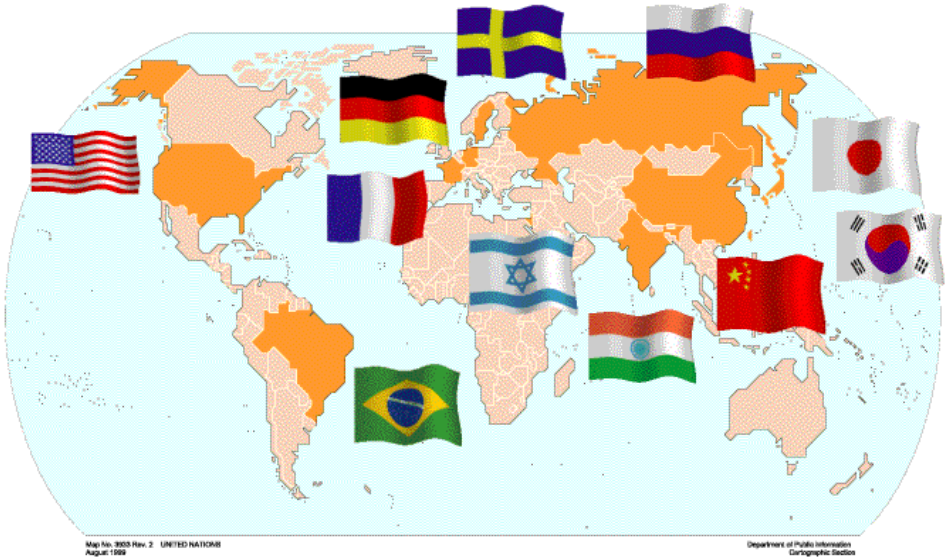

$$R_{AA}^{part} = \frac{2\, d^2 N_{AA}^{\pi^0} / dydp_T}{\langle N_{part} \rangle d^2 N_{pp}^{\pi^0} / dydp_T}$$

# Zusammenfassung

- $\pi^0$ Produktion in Au+Au ($\sqrt{s_{NN}}$ = 200 GeV) bis $p_T$ ~ 8 GeV
- $\pi^0$ Produktion in p+p ($\sqrt{s_{NN}}$ = 200 GeV) bis $p_T$ ~ 12 GeV
- Periphere Kollisionen skalieren mit $N_{coll}$
- Zentrale Kollisionen unterhalb der skalierten p+p (Faktor 2-5)
- Übereinstimmung mit Energieverlust-Szenario
- Kein Cronin ähnlicher Effekt sichtbar
- Mehr Information zu Cronin-Effekt und shadowing @ 200GeV aus d+Au (momentane RHIC Strahlzeit)

# Danke

PHENIX



University of São Paulo, São Paulo, Brazil
Academia Sinica, Taipei 11529, China
China Institute of Atomic Energy (CIAE), Beijing, P. R. China
Laboratoire de Physique Corpusculaire (LPC), Universite de Clermont-Ferrand, 63170 Aubiere, Clermont-Ferrand, France
Dapnia, CEA Saclay, Bat. 703, F-91191, Gif-sur-Yvette, France
IPN-Orsay, Universite Paris Sud, CNRS-IN2P3, BP1, F-91406, Orsay, France
LPNHE-Palaiseau, Ecole Polytechnique, CNRS-IN2P3, Route de Saclay, F-91128, Palaiseau, France
SUBATECH, Ecole des Mines at Nantes, F-44307 Nantes, France
University of Muenster, Muenster, Germany
Banaras Hindu University,Banaras, India
Bhabha Atomic Research Centre (BARC),Bombay, India
Weizmann Institute, Rehovot, Israel
Center for Nuclear Study (CNS-Tokyo), University of Tokyo, Tanashi, Tokyo 188, Japan
Hiroshima University, Higashi-Hiroshima 739, Japan
KEK, Institute for High Energy Physics,Tsukuba, Japan
Kyoto University, Kyoto, Japan
Nagasaki Institute of Applied Science, Nagasaki-shi, Nagasaki, Japan
RIKEN, Institute for Physical and Chemical Research, Hirosawa, Wako, Japan
University of Tokyo, Bunkyo-ku, Tokyo 113, Japan
Tokyo Institute of Technology, Ohokayama, Meguro, Tokyo, Japan
University of Tsukuba, Tsukuba, Japan
Waseda University, Tokyo, Japan
Cyclotron Application Laboratory, KAERI, Seoul, South Korea
Kangnung National University, Kangnung 210-702, South Korea
Korea University, Seoul, 136-701, Korea
Myong Ji University, Yongin City 449-728, Korea
System Electronics Laboratory, Seoul National University, Seoul, South Korea
Yonsei University, Seoul 120-749, KOREA
Institute of High Energy Physics (IHEP-Protvino or Serpukhov), Protovino, Russia
Joint Institute for Nuclear Research (JINR-Dubna), Dubna, Russia
Kurchatov Institute, Moscow, Russia
PNPI: St. Petersburg Nuclear Physics Institute, Gatchina, Leningrad, Russia
Lund University, Lund, Sweden
Abilene Christian University, Abilene, Texas, USA
Brookhaven National Laboratory (BNL), Upton, NY 11973
University of California - Riverside (UCR), Riverside, CA 92521, USA
Columbia University, Nevis Laboratories, Irvington, NY 10533, USA
Florida State University (FSU), Tallahassee, FL 32306, USA
Georgia State University (GSU), Atlanta, GA, 30303, USA
Iowa State University (ISU) and Ames Laboratory, Ames, IA 50011, USA
LANL: Los Alamos National Laboratory, Los Alamos, NM 87545, USA
LLNL: Lawrence Livermore National Laboratory, Livermore, CA 94550, USA
University of New Mexico, Albuquerque, New Mexico, USA
New Mexico State University, Las Cruces, New Mexico, USA
Department of Chemistry, State University of New York at Stony Brook (USB), Stony Brook, NY 11794, USA
Department of Physics and Astronomy, State University of New York at Stony Brook (USB), Stony Brook, NY 11794-, USA
Oak Ridge National Laboratory (ORNL), Oak Ridge, TN 37831, USA
University of Tennessee (UT), Knoxville, TN 37996, USA
Vanderbilt University, Nashville, TN 37235, USA