Prompt Photon Production at $\sqrt{s_{NN}}$=200GeV p+p and d+Au Collisions

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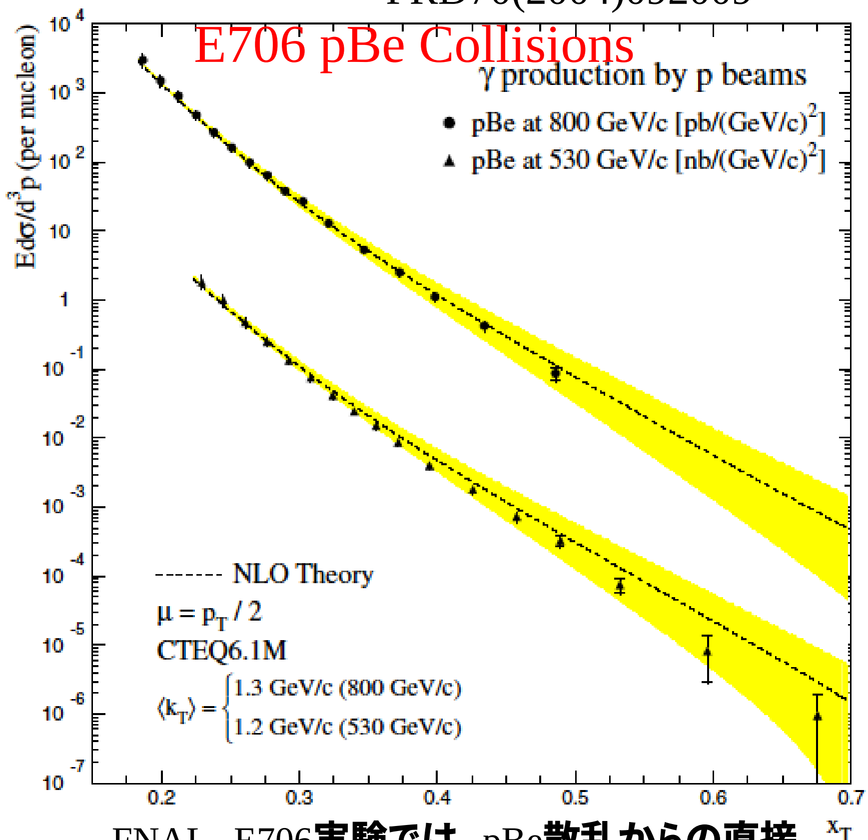
Physics Motivation

- Nuclear Effect
  - Initial Parton Distribution
    - EMC effect
    - Shadowing, anti-shadowing
    - color glass condensate
  - Final Parton Interaction
    - Multiple Scattering (Cronin effect)
    - Jet Quenching

- Prompt photon production is a good probe to measure the modification of the initial parton.

PRD70(2004)092009



FNAL E706実験では、pBe散乱からの直接光子測定により、初期パートンの横運動量にして1.3GeV/c程度の原子核効果があると結論。

In this talk, we will compare the prompt photon production in d+Au collisions with an NLO-pQCD calculation and with that in p+p collisions, and will discuss about the nuclear effect.

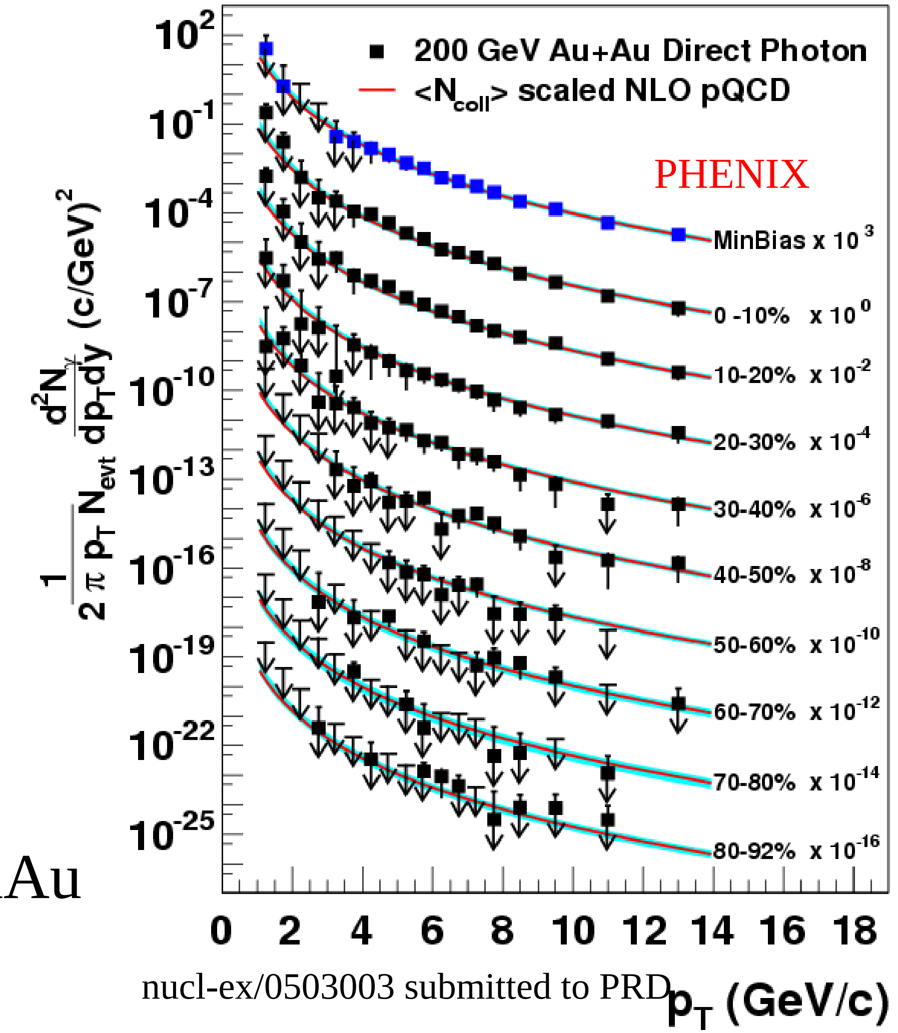
Physics Motivation

- Prompt photon in AuAu
  - Prompt photon production can be described as the

consistent

Jet Quenching Scenario
(π^0 suppression)

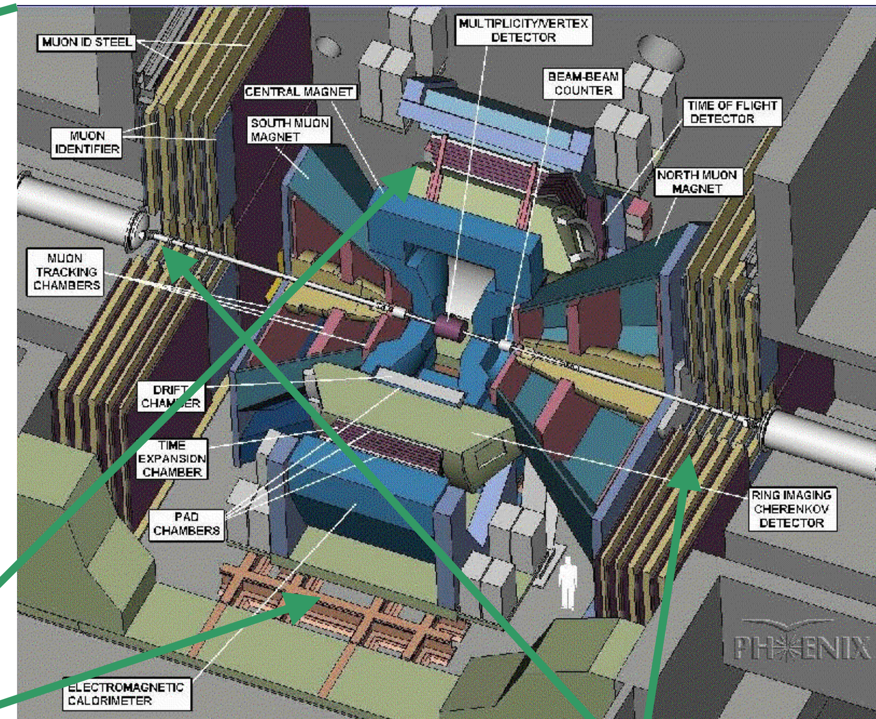
One remained question is the nuclear effect on the photon production in AuAu



nucl-ex/0503003 submitted to PRD

We want to measure the nuclear effect for the prompt photon production to answer the question.

PHENIX



2 central Spectrometers

2 forward Spectrometers

- 3.8km with 2 rings
  - 120bunch/ring
  - 106ns crossing time
- Maximum energy
  - 250GeV for p(polarized)
  - 100GeV/nucleon for Au
- Luminosity
  - Au-Au : 2 x 10^{26}cm^{-2}s^{-2}
  - p-p : 2 x 10^{32}cm^{-2}s^{-2}
- 6 Crossing points

- 3 detectors to measure the collision point, the luminosity, and the multiplicity.
  - Beam Beam Counter(BBC)
  - Zero Degree Calorimeter(ZDC)
  - Multiplicity and Vertex Detector(MVD)

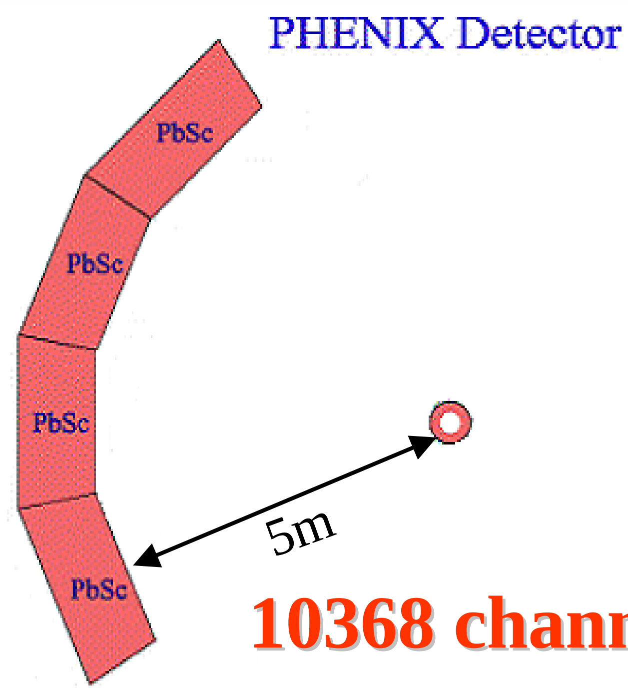
Electro-Magnetic Calorimeter

Lead Scintillator (PbSc)

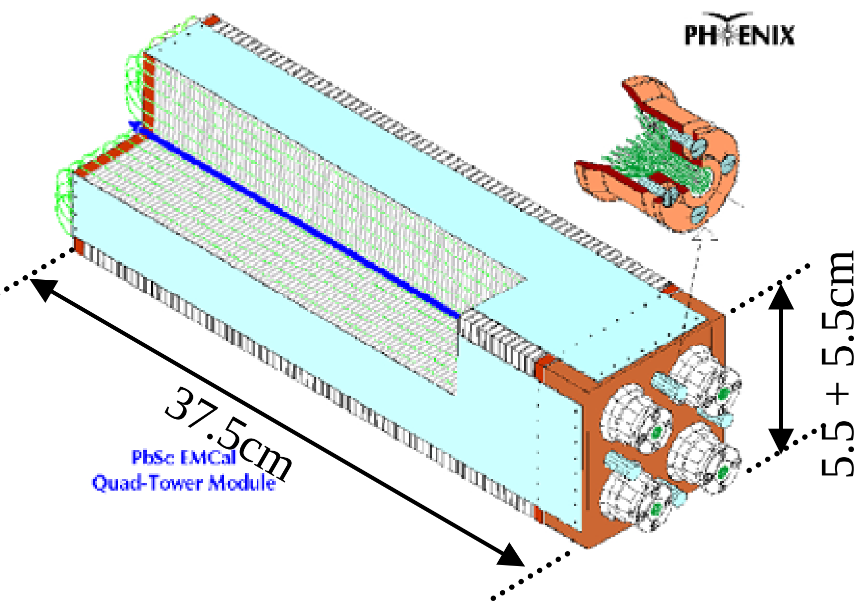
- –Sandwich type calorimeter
  - •Lead 110.4x110.4x1.5mm
  - •Scintillation 55.2x55.2x4mm
- –Shish-kebab type readout
  - •With wave length shifter fiber
- –6 sectors(15552 channels)

•Coverage

- –|η|<0.38
- –ϕ = 180°



10368 channels



	PbSc
Size(cm x cm)	5.52 x 5.52
Depth(cm)	37.5
Number of towers	15552
Sampling fraction	~ 20%
η cov.	0.7
ϕ cov.	90+45deg
η/mod	0.011
ϕ/mod	0.011
X_0	18
Molière Radius	~ 3cm

Prompt Photon Production

Prompt photon production consists of two processes .

$$\sigma = \sigma_{dir} + \sigma_{frag} = \sum_{i,j,k} \int dx_i dx_j \times f_1^i(x_i,\mu) \cdot f_2^j(x_j,\mu)$$

parton distribution function(PDF)

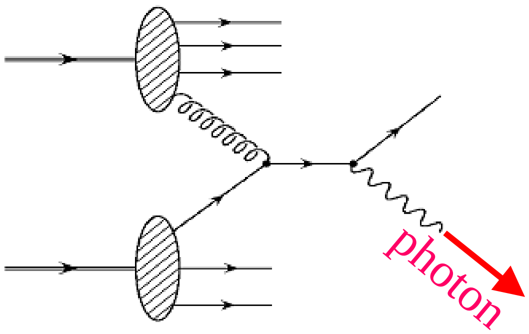
fragmentation function(FF)

$$\times \left\{ \sigma(i + j \to \gamma) + \int dz\, \sigma(i + j \to k) \times D_k^3(z_k, \mu_F) \right\}$$

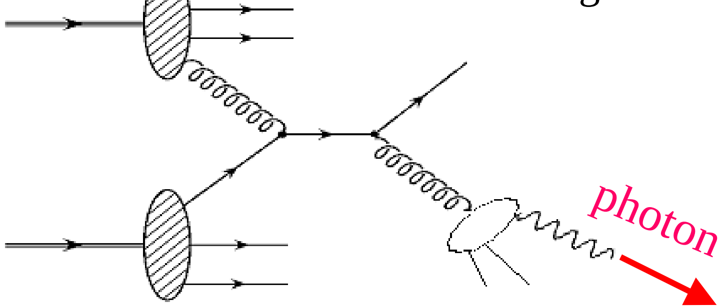
Direct Process

Fragmentation Process

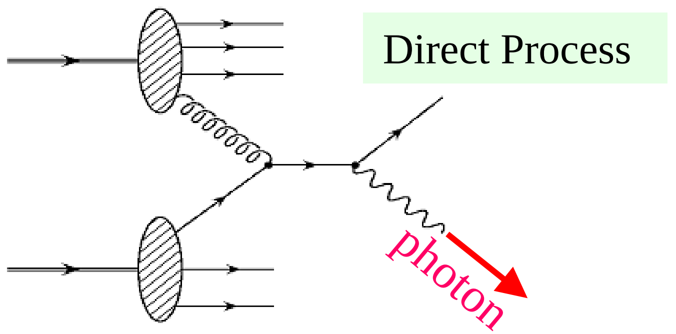
bremsstrahlung radiation

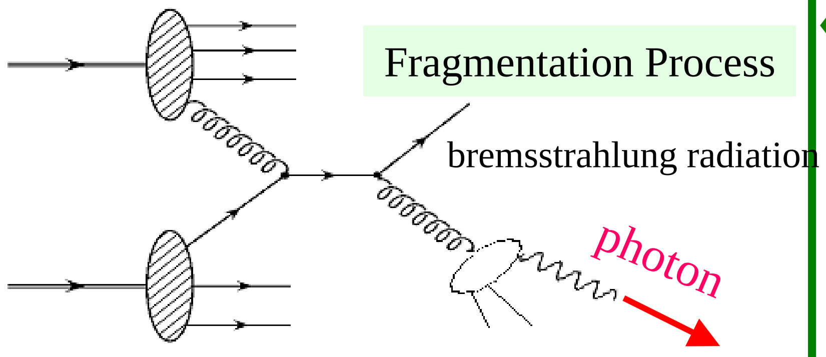


Compton/Annihilation process



How to Measure?





No one know which photon from what.

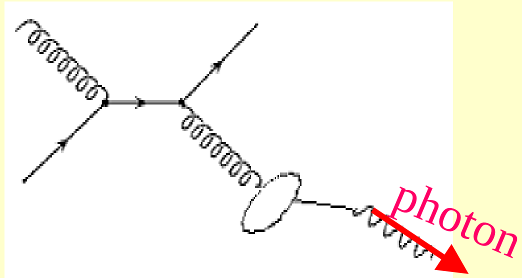
Background

Non-vertex Photon

Neutral hadron contribution

Noise in the detector

Hadron(π^0,η,ω..) decay

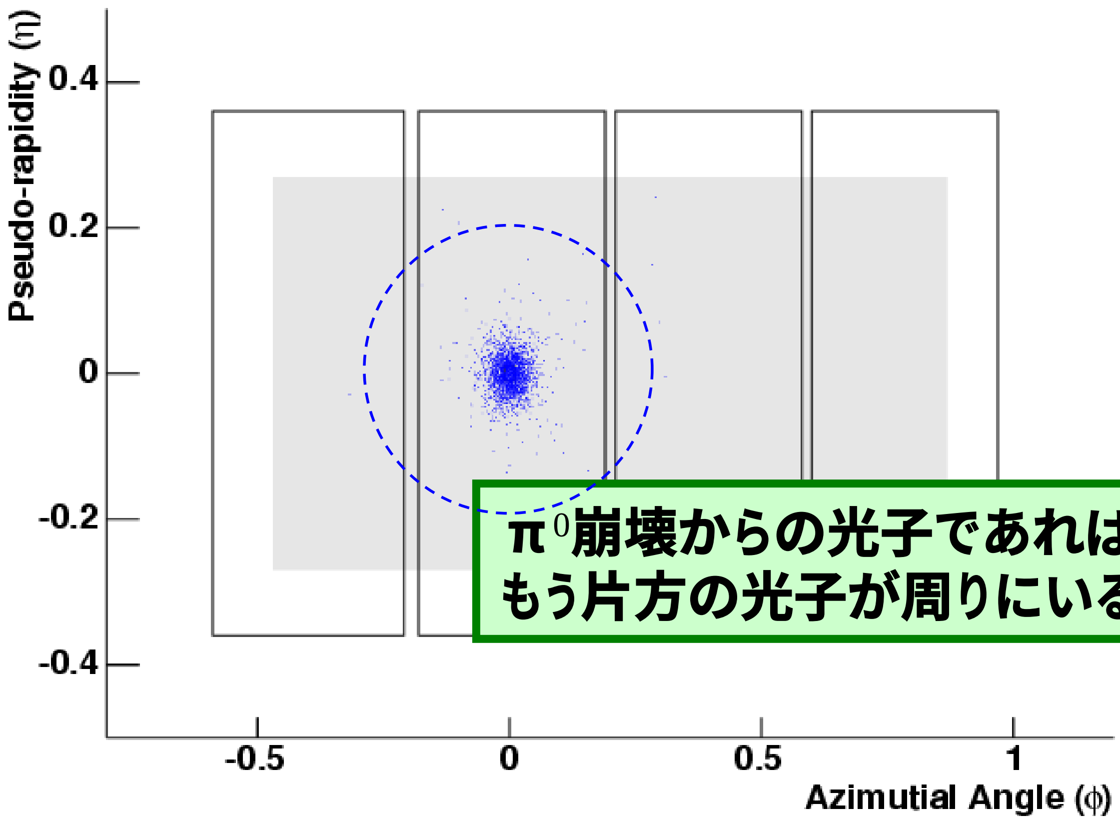


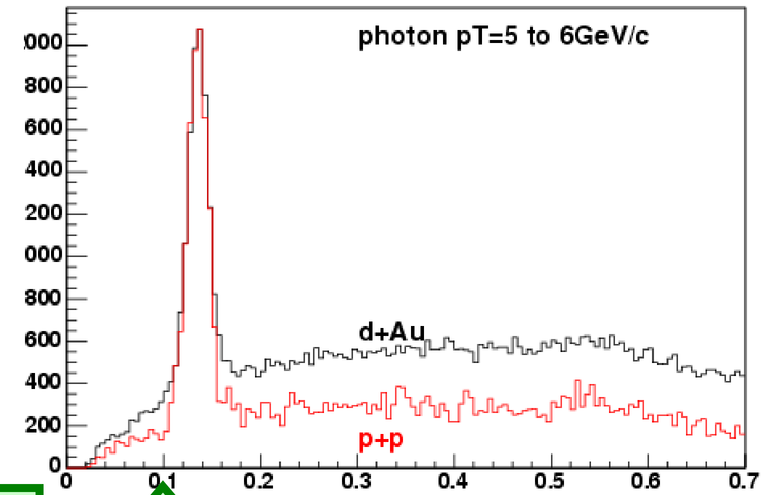
Estimate all backgrounds

After subtracting all backgrounds,

the remained photons are the signals.

Background from π^0





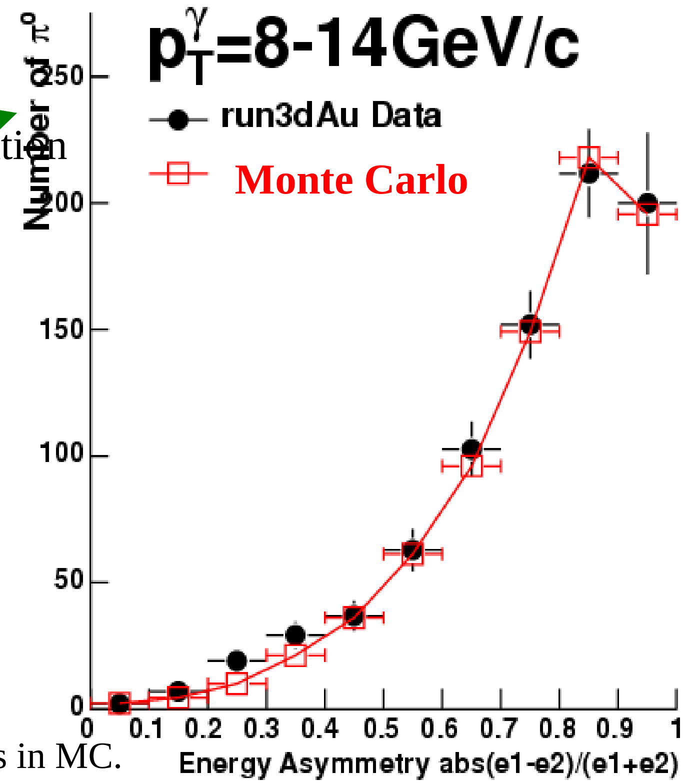
π^0崩壊からの光子であれば、
もう片方の光子が周りにいる。

By taking all combination between the target photon and the surrounding photons, we can know the photon from pi0 decay.

➔ 70% of pi0 decay can be identified from the mass distribution

Background from π^0

- Identified π 0 decay(~70%)
  - Check measured π0
    - Peak position and width is consistent with the expectation
    - Energy asymmetry is consistent with the expectation
  - All channels of EMCal are working.
    - We confirmed all channels are working properly.
    - No-Position dependence
  - Systematic uncertainty due to the combinatorial bg.
- Un-identified π0 (~30%)
  - Corrected by a Monte Carlo simulation
    - The main loss is due to the geometrical acceptance.
    - Systematic error on the Monte Carlo
      - Was estimated from the possible miss-tuned parameters in MC.
- Other Hadron
  - PHENIX measured η
  - ω and other hadron was estimated by assuming m_T scaling
- Other souce
  - Neutral/charged hadron and non-vertex photon was estimated by the GEANT simulation and data itself.

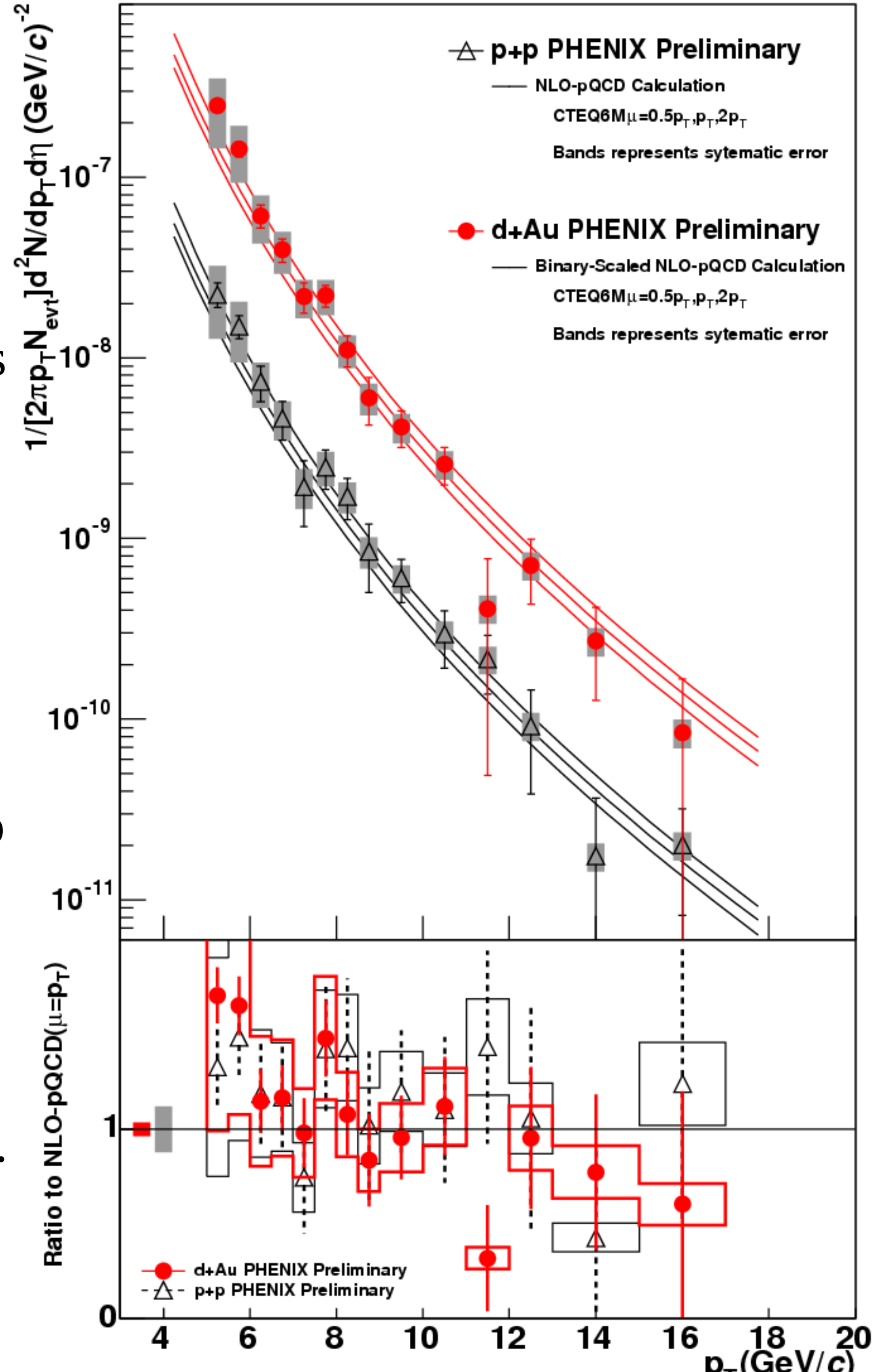


モンテカルロ自体は過去のテスト実験等で測定してきたEMCalの性能を再現するように調整済み。

Result

- Result in p+p
  - Was already reported in previous meeting
- NLO pQCD Calculation
  - p+p collisions
  - Calculated by W.Vogelsang
  - CTEQ5M
  - Scale(renormalization and factorization scale)を0.5,1.0,2.0p にとる。
- In comparison with d+Au
  - Averaged number of collisions (8.42) from the Glauber model was multiplied to the calculation.

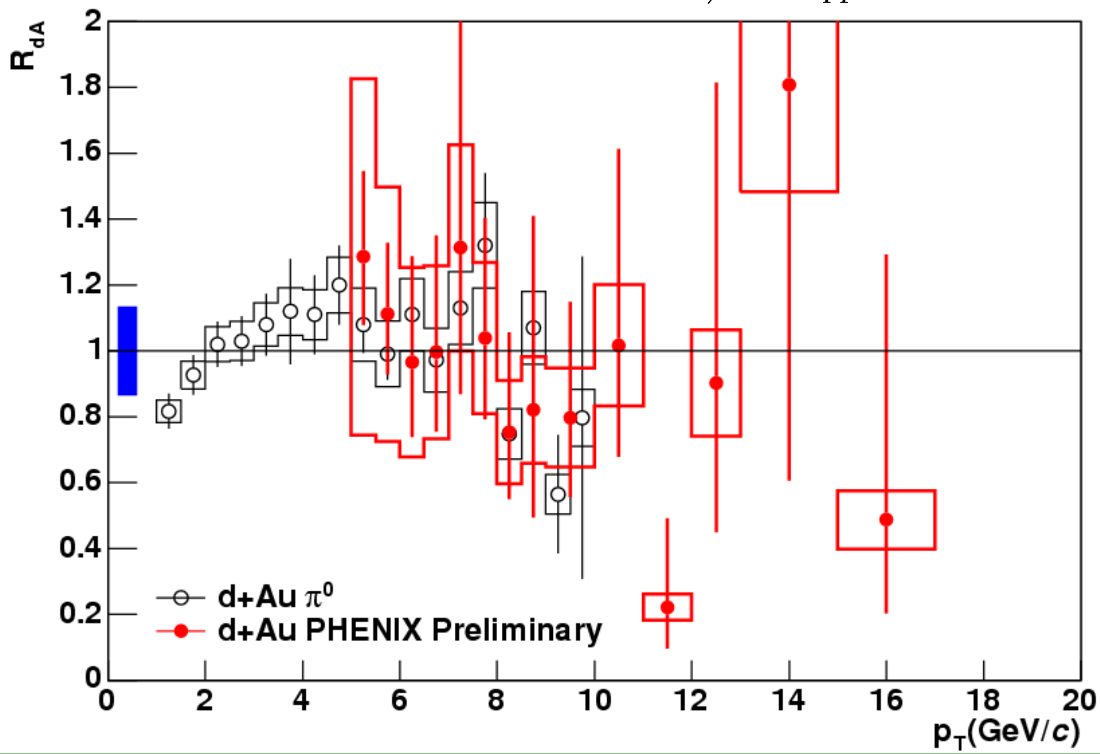
Result is consistent with the binary – scaled NLO-pQCD calculation



Result

Nuclear Modification Factor

$$R_{dA} = \frac{\left[d^2 N_{dA} / dp_T \, d\eta \, dN_{evt} \right]}{\langle N_{coll} \rangle / \sigma_{pp}^{inel} \times \left[d^2 \sigma_{pp} / dp_T \, d\eta \right]}$$



Consistent with 1 ➔ No modification within the error

This is consistent with what we measured in π^0

Conclusion

- We measured the prompt photon production in 200GeV d+Au collisions.
  - The first time in the world.
  - pT range is 5-16GeV/c $|\eta| < 0.35$
- In comparison with NLO-pQCD
  - Result in d+Au collisions is consistent with the binary-scaled NLO-pQCD calculation.
- Nuclear Modification Factor
  - Consistent with 1 ➔ No modification within the errors
    - Prompt photon production in d+Au can be described as
    - Result is consistent with what we measured in $\pi0$
  - We can conclude the nuclear effect in the prompt photon production is small.

➔ This is consistent with non-suppression of photon production in AuAu collisions.