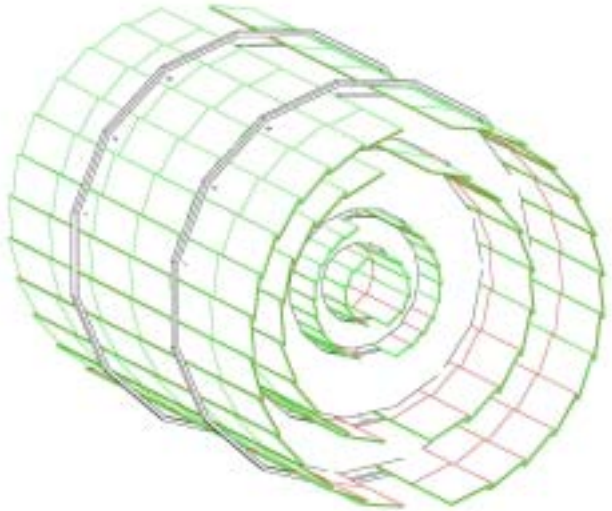
PHENIX VTX Upgade



RHIC Spin Collaboration Meeting in Torino

October 9, 2004

Yuji Goto (RIKEN/RBRC)

for the PHENIX Collaboration

Outline

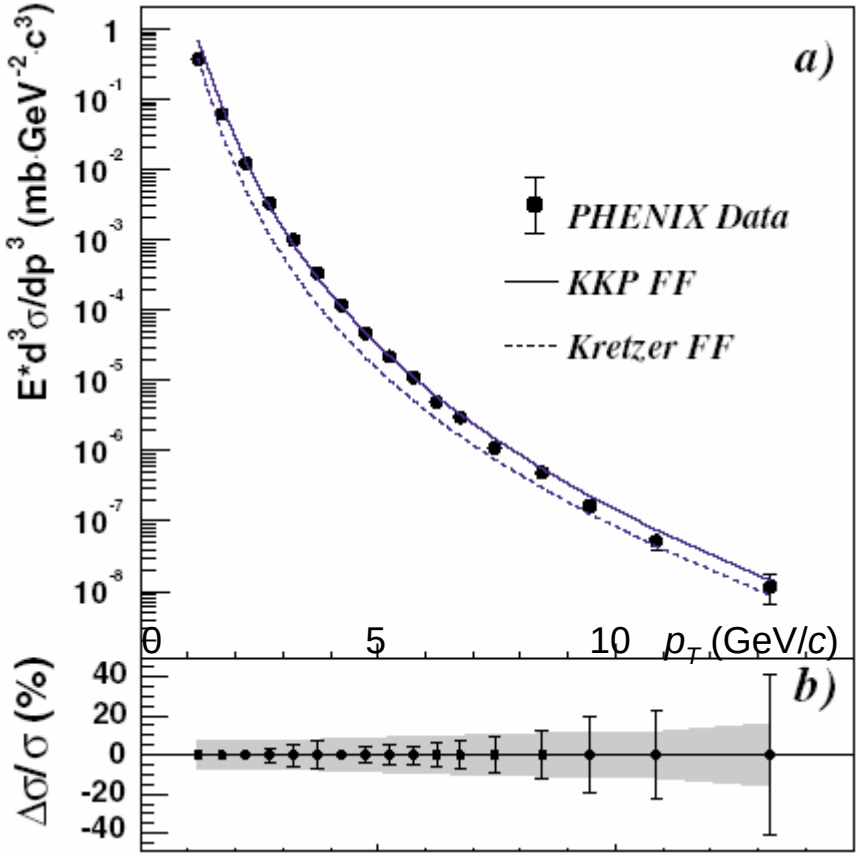
- Review of physics with PHENIX baseline system
  - achieved
  - to be achieved
- Physics with PHENIX VTX upgrade

  ➔ more in Manabu Togawa's talk in Spin 2004
- status of the VTX development and construction
  - schedule
  - collaboration

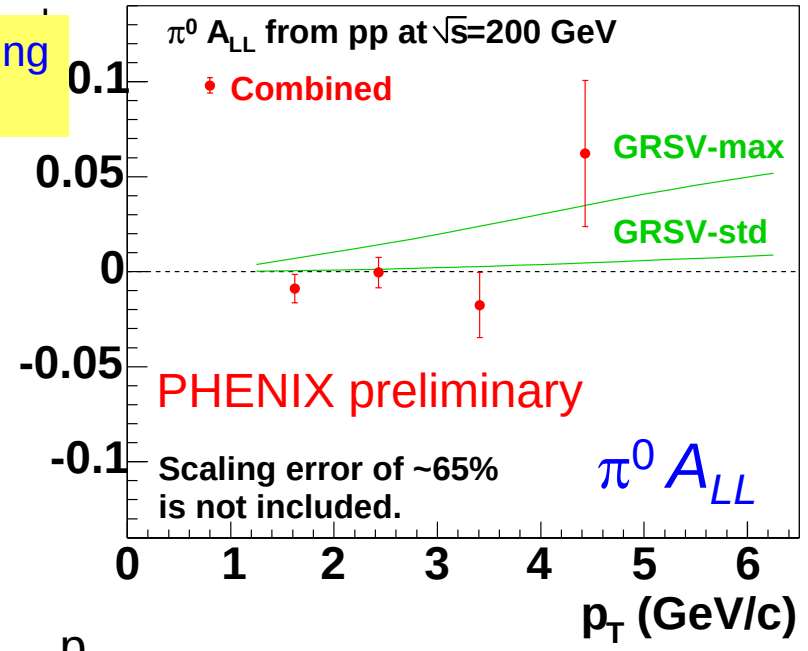
Physics with the baseline system

- π^0

Bazilevsky's talk in this meeting and Fukao's talk in Spin2004



Phys.Rev.Lett. 91 (2003) 241803



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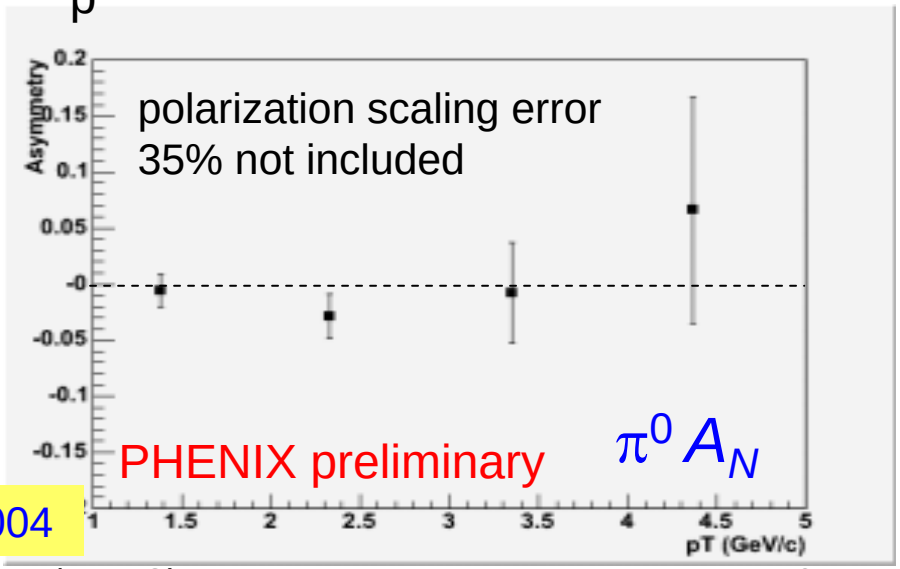
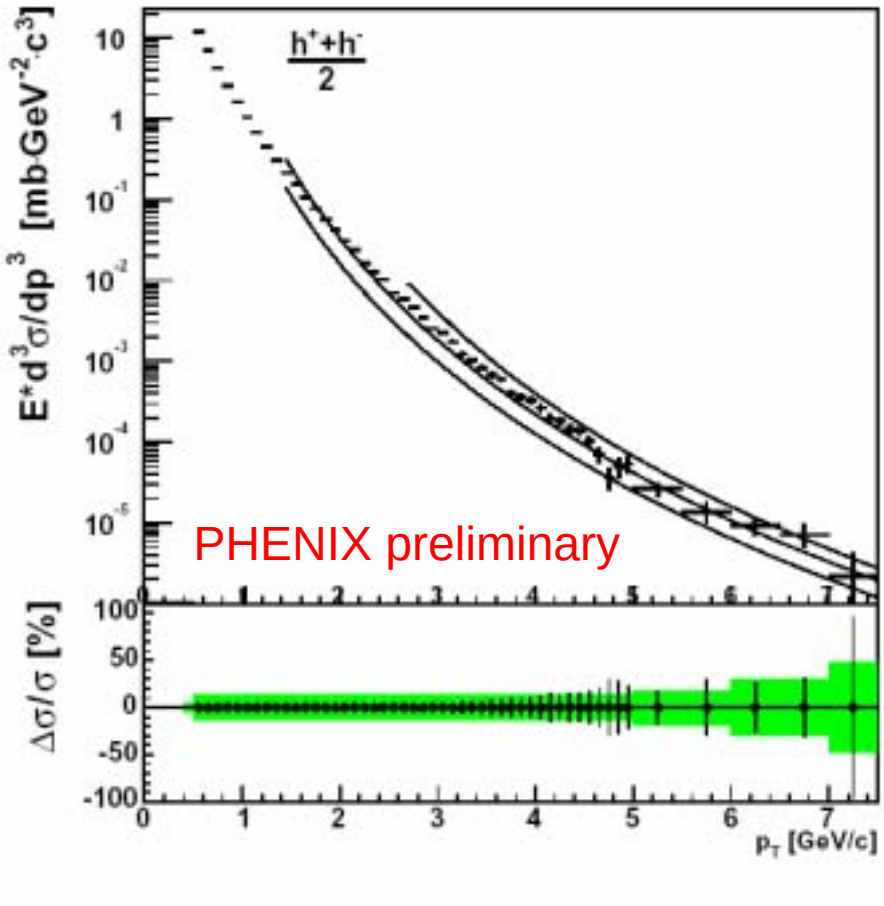
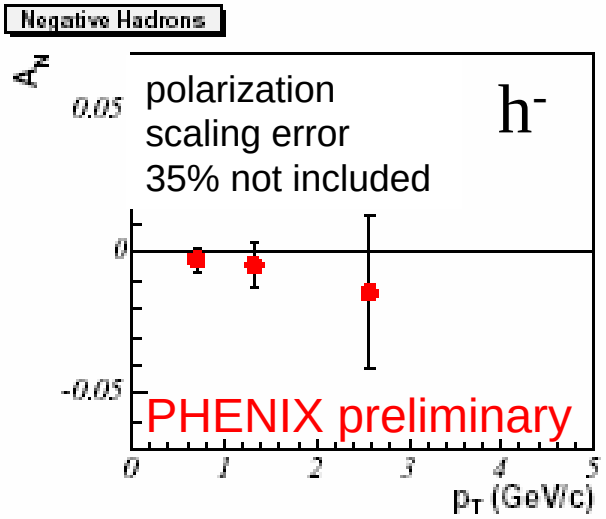


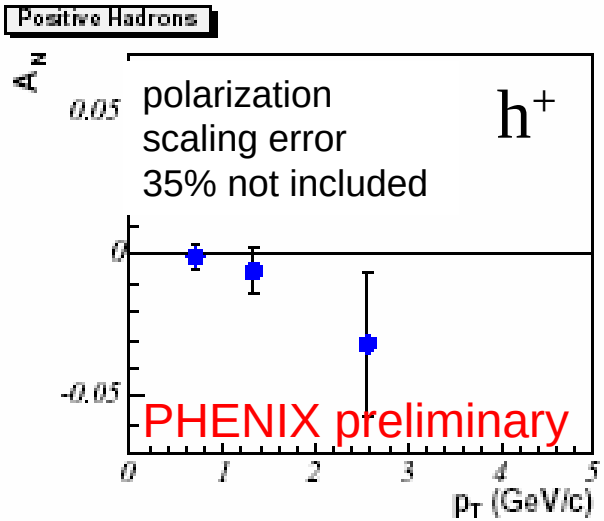
Makdisi's talk in this meeting and Spin2004

Physics with the baseline system

- Charged hadron



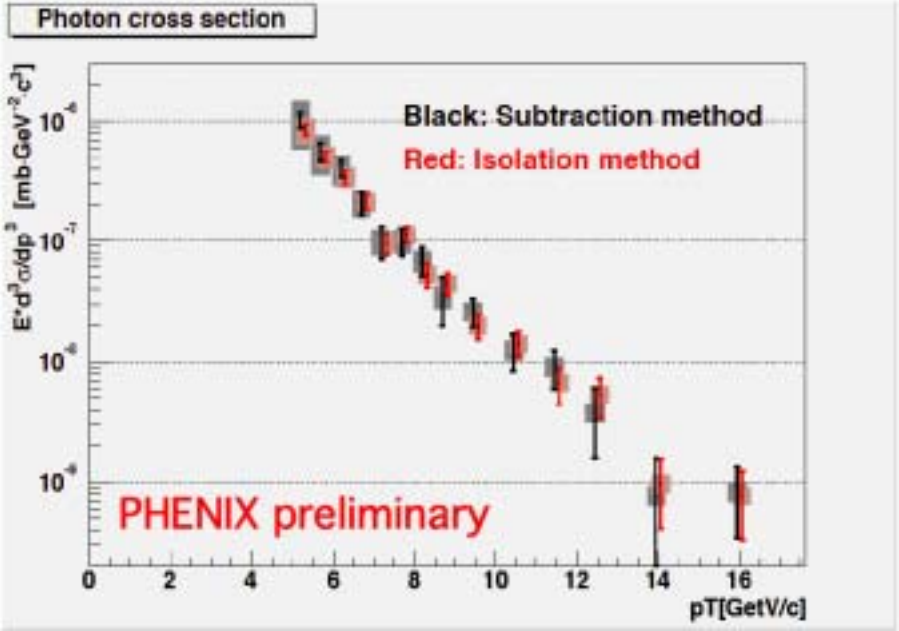




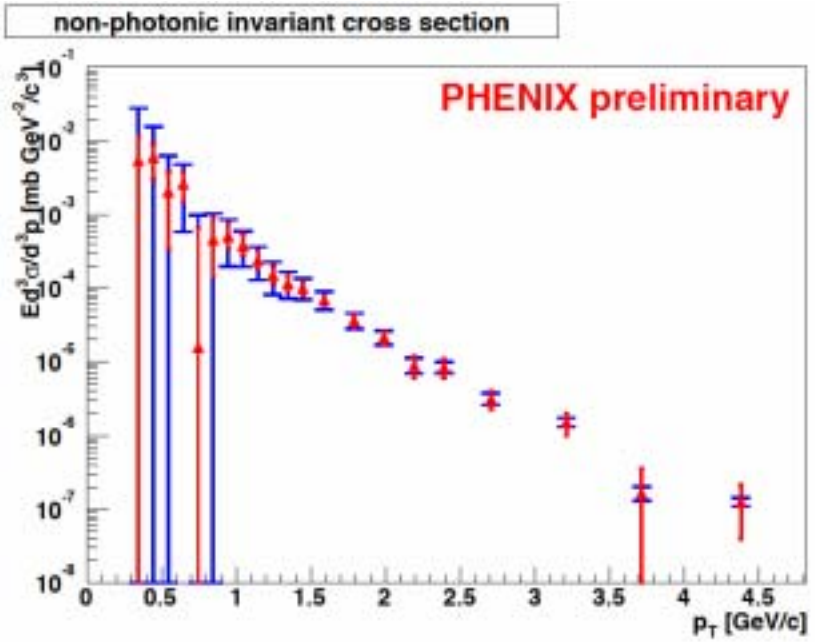
Makdisi's talk in this meeting and Spin2004

Physics with the baseline system

- Prompt photon
- Single electron



Okada's talk in this meeting and Spin2004

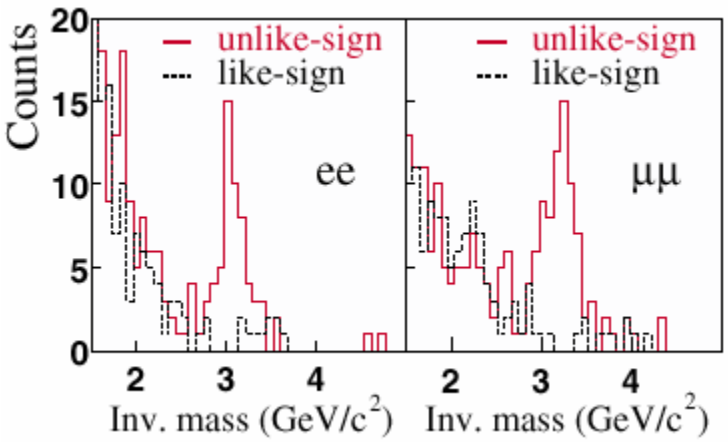


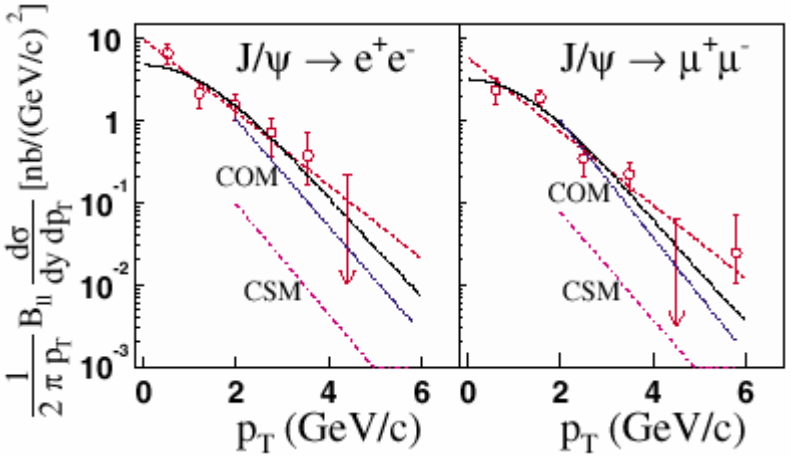
Togawa's talk in Spin2004

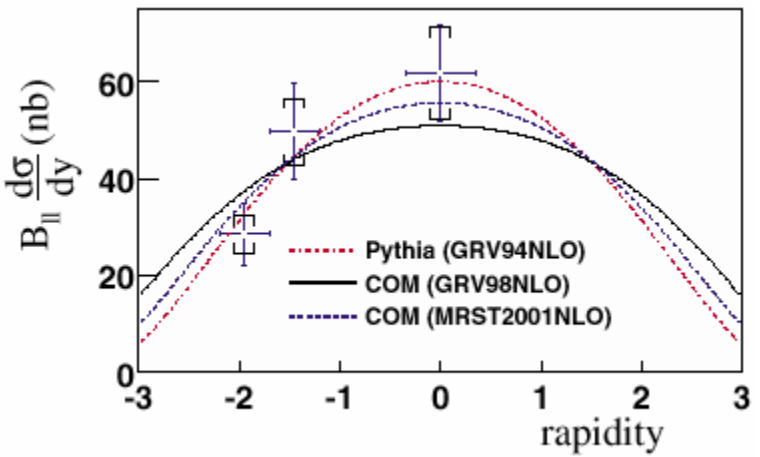
Physics with the baseline system

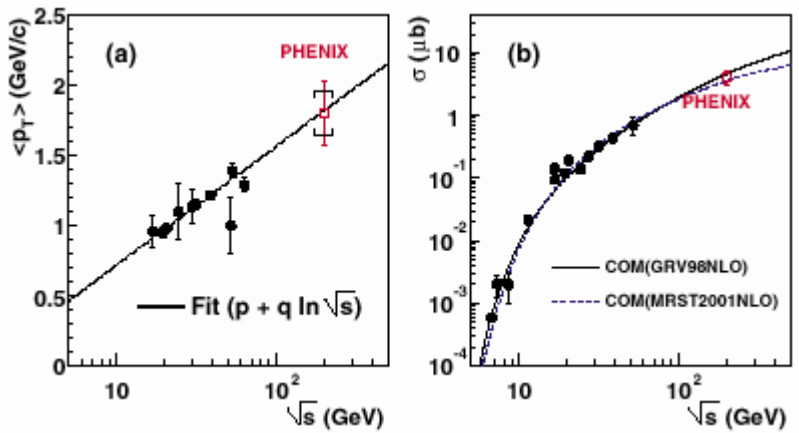
- J/ψ

Phys.Rev.Lett. 92 (2004) 051802



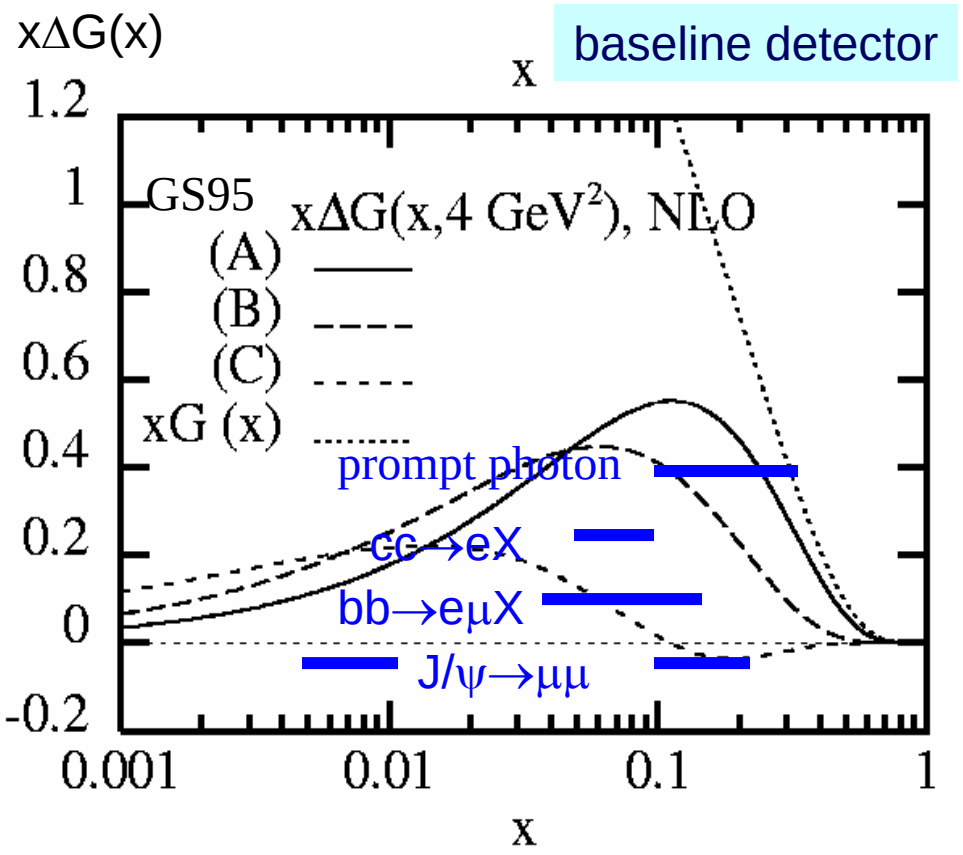




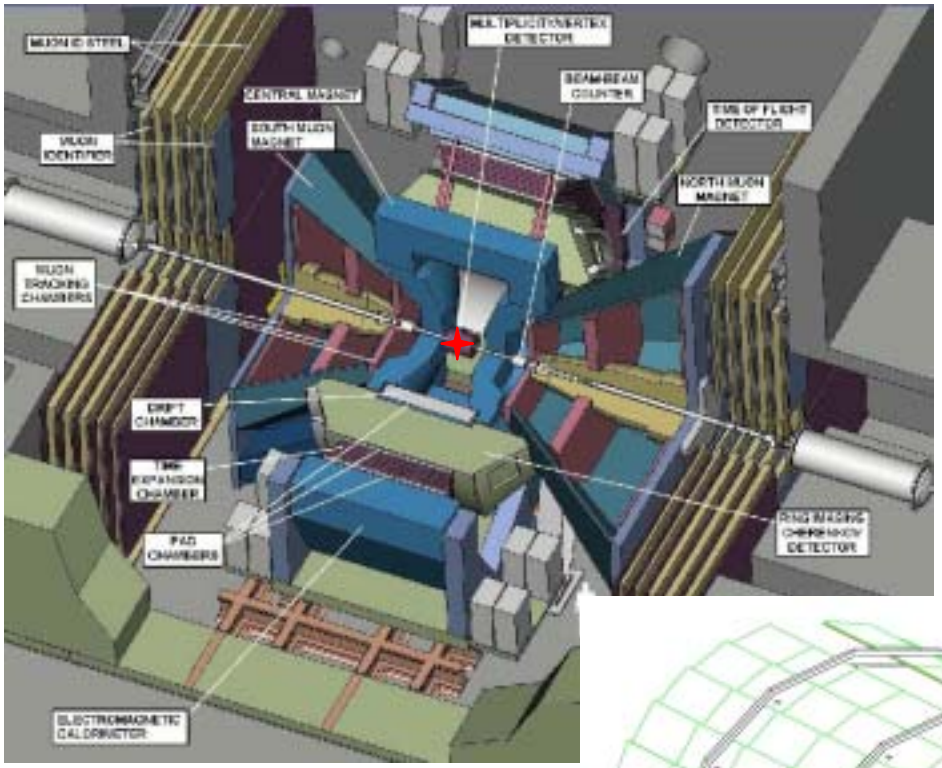


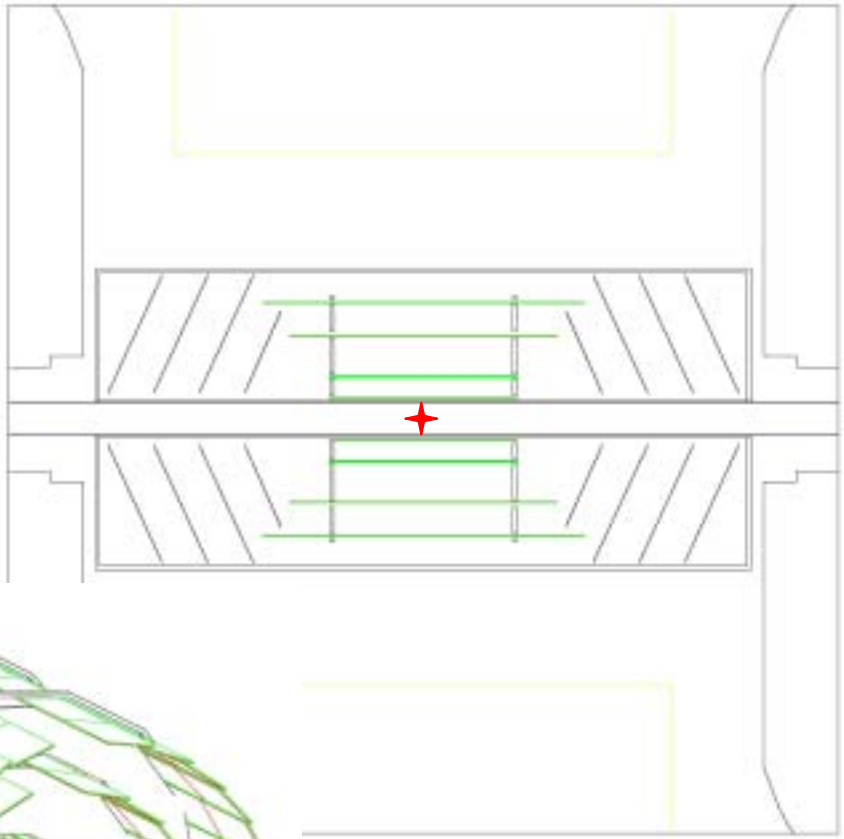
Physics with the baseline system

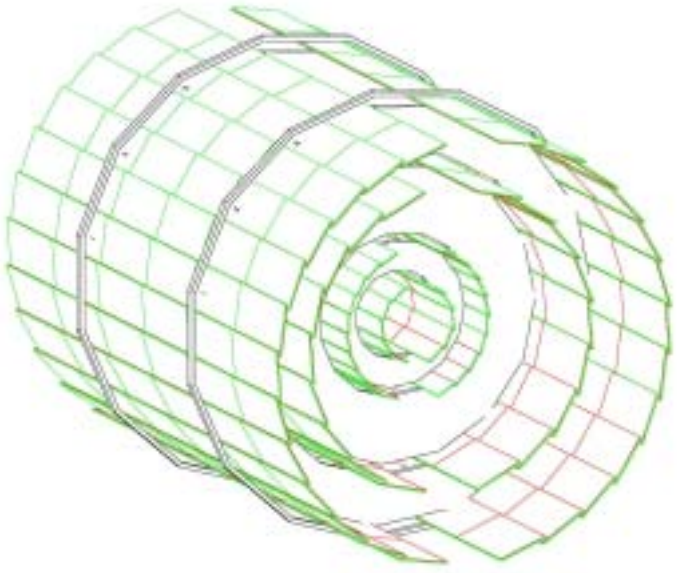
- Gluon polarization
  - A_{LL} of prompt photon
  - A_{LL} of single electron
- Quark polarization flavor decomposition
  - A_L of weak boson
- Transversity
  - with $\pi^+\pi^-$ interference fragmentation function
  - with Collins effect in jet
- at $\sqrt{s}$ = 200 GeV and 500 GeV



VTX upgrade

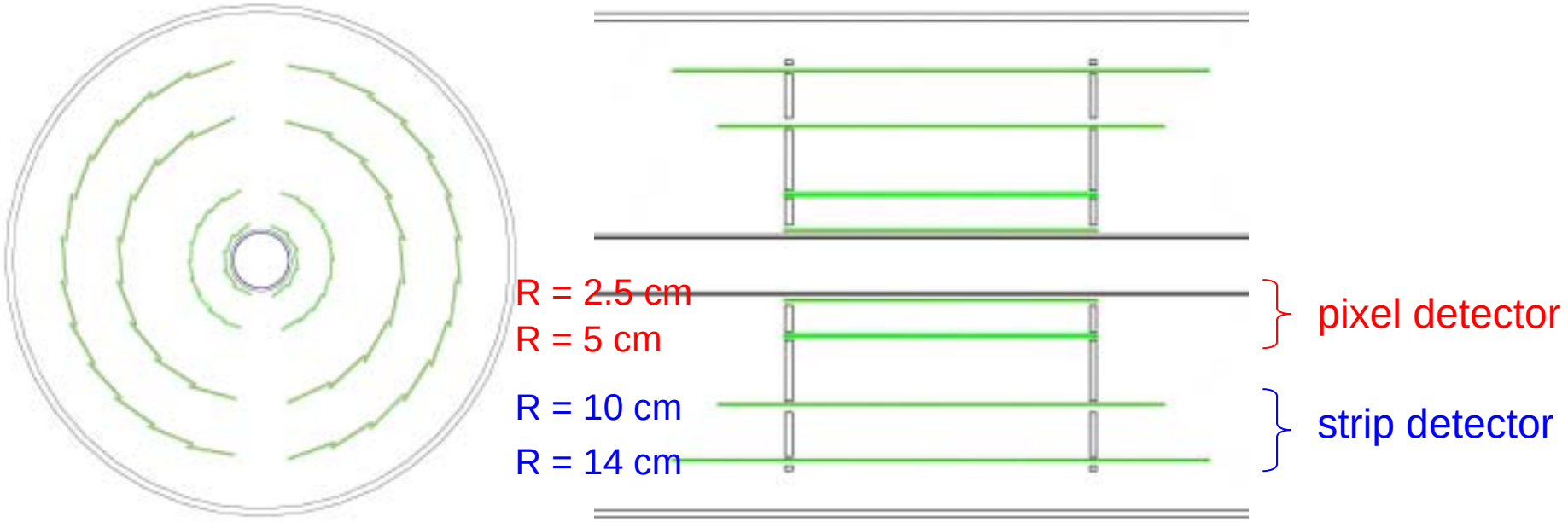

MUON ID STEEL
MULTIPLICITY/VERTEX DETECTOR
BEAM-BEAM COUNTER
CENTRAL MAGNET
TIME OF FLIGHT DETECTOR
SOUTH MUON MAGNET
MUON IDENTIFIER
NORTH MUON MAGNET
MUON TRACKING CHAMBERS
DRIFT CHAMBER
PAD CHAMBERS
RING IMAGING CHERENKOV DETECTOR
ELECTROMAGNETIC CALORIMETER





VTX upgrade

- Barrel silicon vertex tracker
  - jet axis measurement and isolation cut by charged particle detection with wider acceptance
  - displaced vertex measurement for heavy flavor tagging



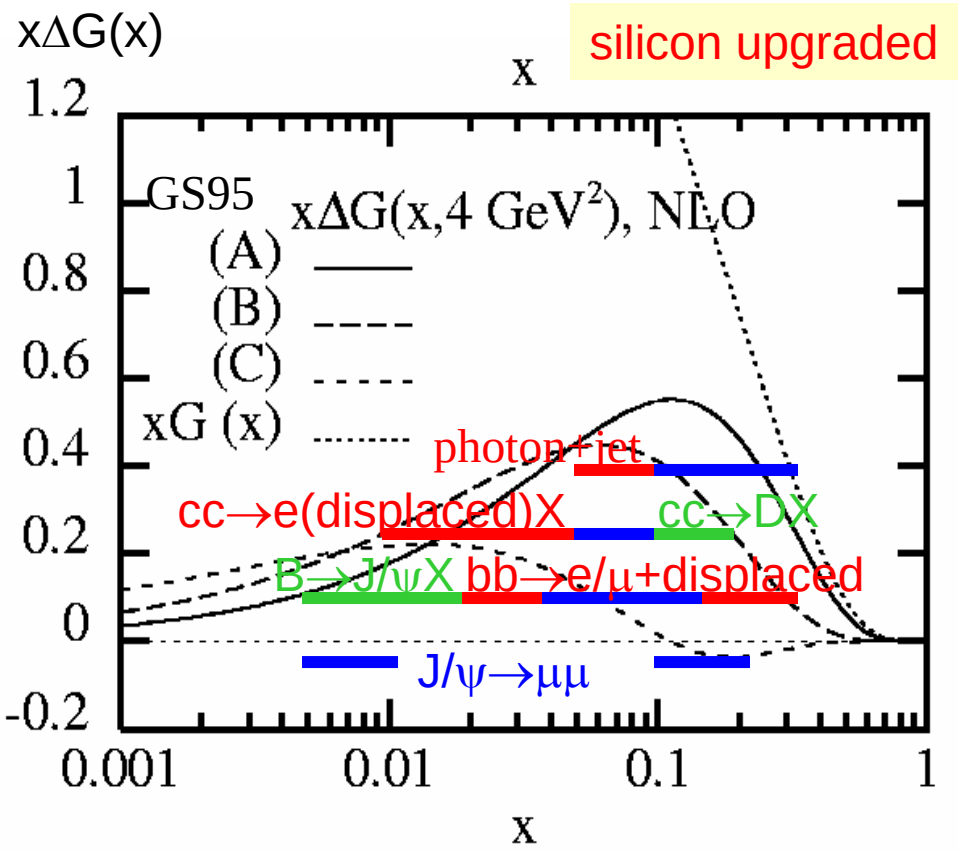
VTX upgrade

pixel strip

VTX	Layer	R1	R2	R3	R4
Geometrical dimensions	R (cm)	2.5	5	10	14
	Δz (cm)	21.8	21.8	31.8	38.2
	Area (cm^2)	280	560	1240	1600
Channel count	Sensor size R × z (cm^2)	1.28 × 1.36 (256 × 32 pixels)		3.43 × 6.36 (384 × 2 strips)	
	Channel size	50 × 425 μm^2		80 μm × 3 cm (effective 80 × 1000 μm^2)	
	Sensors/ladder	2 × 8		5	6
	Ladders	10	20	18	26
	Sensors	160	320	90	156
	Readout chips	160	320	1080	1872
	Readout channels	1,310,720	2,621,440	138,240	239,616
Radiation length (X/X0)	Sensor	0.2%		0.5 %	
	Readout	0.16%		0.8 %	
	Bus	0.14%			
	Ladder & cooling	0.7%		0.7 %	
	Total	1.2%		2.0 %	

Physics with VTX upgrade

- Gluon polarization
  - photon + jet
  - charm and bottom tagging
- Quark polarization flavor decomposition
  - $W^{\pm}$ with improved isolation cut
- Transversity
  - improved correlation study (near side and far side)
  - with wider acceptance

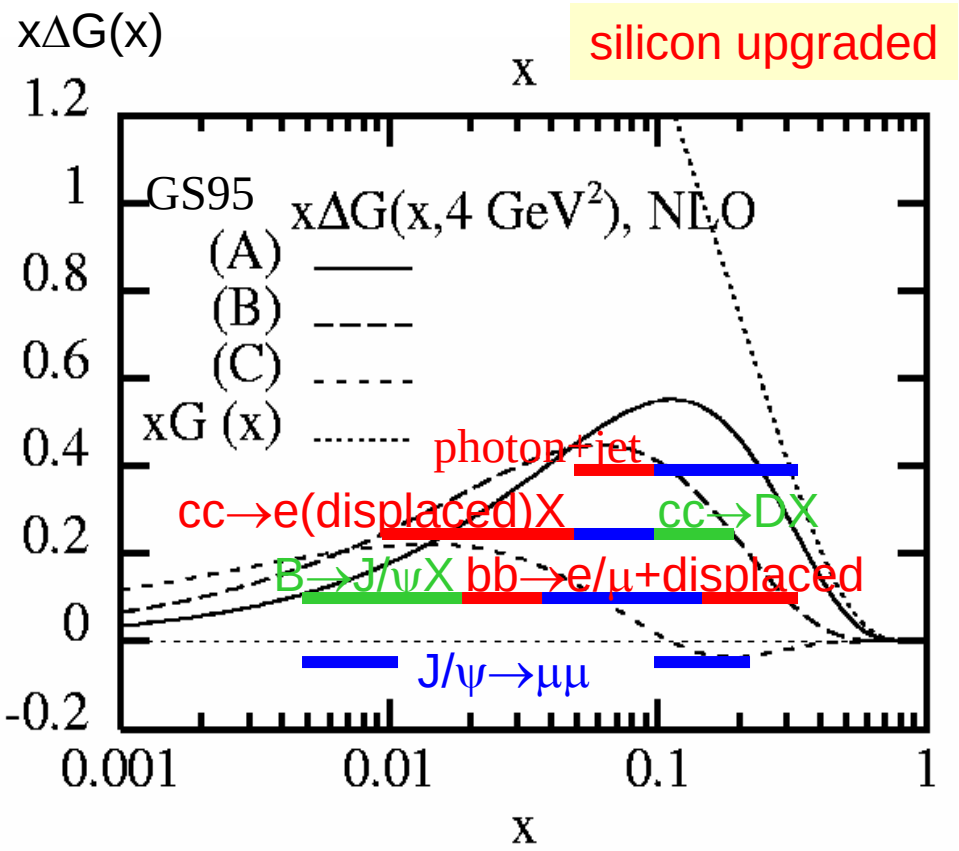


Physics with VTX upgrade

Process	Physics Objectives	Without VTX	With VTX
$c \rightarrow e$	Charm energy loss	$0.5 < p_T < 2.5$ GeV/c	$0.3 < p_T < 6$ GeV/c
$D \rightarrow K\pi$ ($p_T > 2$ GeV/c)	Charm energy loss	No (2σ significance in central Au+Au)	$> 7\ \sigma$ significance in central Au+Au
Total charm yield	Charm production	~ 20 %	~ 10 %
$(c \rightarrow e)/(b \rightarrow e)$ ratio	Search for thermal charm produciton	No	~ 1 %
$b \rightarrow e$	Beauty production Beauty energy loss	$p_T > 3$ GeV/c with model dependence	$1 < p_T < 6$ GeV/c
$B \rightarrow J/\psi$	Beauty production	No	$\Delta\sigma/\sigma \sim$ 10 - 15 %
Total beauty yield	Beauty production	No	~ 10 %
High p_T charged	Light quark energy loss	$p_T \leq 10$ GeV/c	$p_T < 15$ -20 GeV/c
$p+p \rightarrow c \rightarrow e$	$\Delta G(x)$	$0.03 < x < 0.08$	$0.01 < x < 0.15$
$p+p \rightarrow b \rightarrow e$	$\Delta G(x)$	No	$0.02 < x < 0.15$
$p+p \rightarrow \gamma$+jets	$\Delta G(x)$	No	$0.04 < x < 0.3$
$p+A$ (dA) $\rightarrow$ c/b	Nuclear shadowing of $G(x)$	$0.03 < x < 0.3$	$0.01 < x < 0.3$

Physics with VTX upgrade

- Gluon polarization
  - photon + jet
    - jet axis measurement
  - charm and bottom tagging
    - with single electron measurement



Physics with VTX upgrade

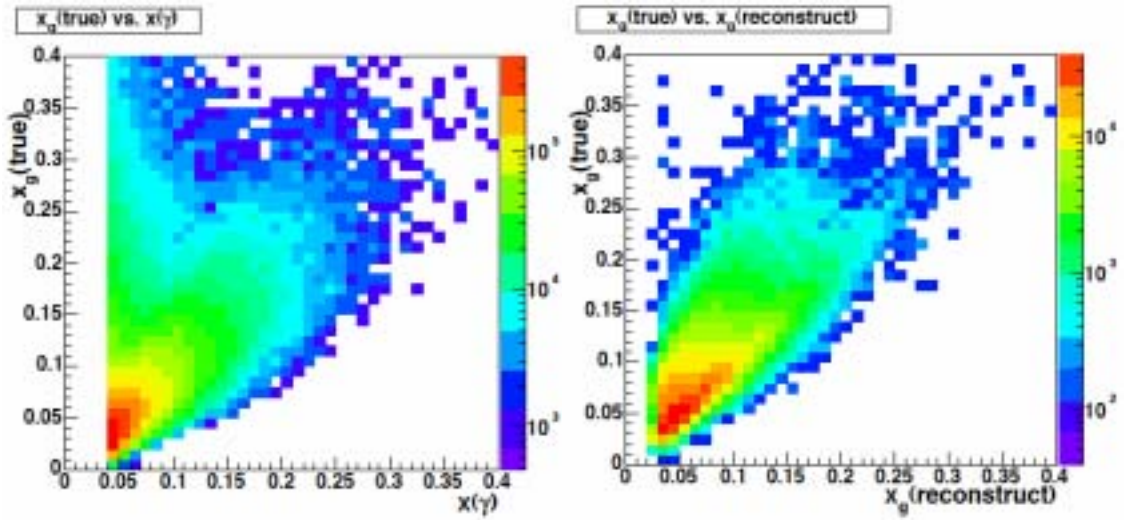
- Gluon polarization
  - photon + jet
    - improved gluon's *x* evaluation by kinematic reconstruction with jet axis

$$x_1 = x_2 = x_T = \frac{p_T}{2\sqrt{s}} \qquad x_1 = \frac{p_T}{\sqrt{s}}\left(e^{+\eta_{jet}} + e^{+\eta_\gamma}\right)\; x_2 = \frac{p_T}{\sqrt{s}}\left(e^{-\eta_{jet}} + e^{-\eta_\gamma}\right)$$

Togawa's talk in Spin2004

$\sqrt{s} = 200GeV$

No VTX **With VTX**

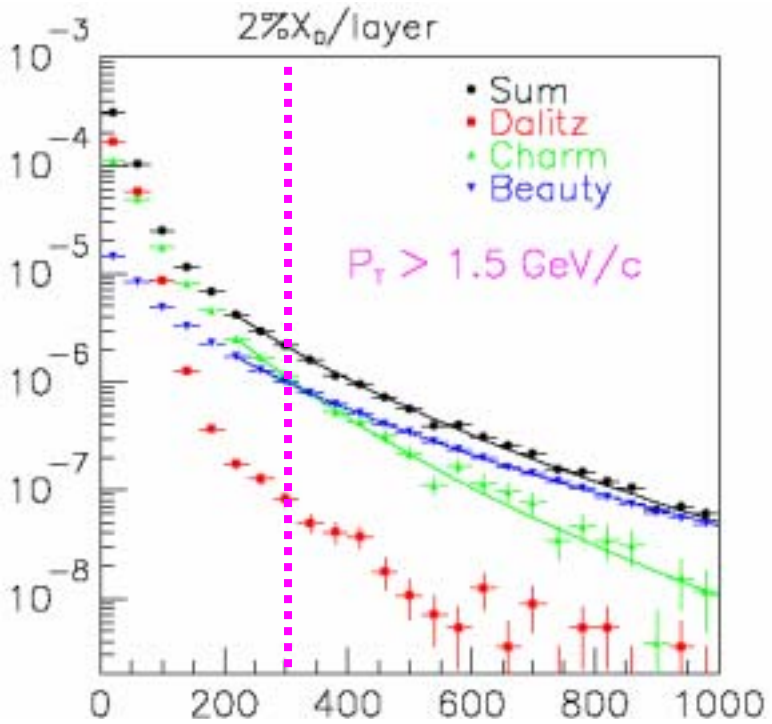


x_g(true) vs. x_g(reconstruct)

- correlation study: "k_T" issue in inclusive photon measurement

Physics with VTX upgrade

- Gluon polarization
  - charm and bottom tagging with displaced vertex measurement
  - charm
    - D $\rightarrow$ single electron
    - D $\rightarrow \pi$ K
    - J/$\psi \rightarrow e^+e^-$
  - bottom
    - B $\rightarrow$ single electron
    - B $\rightarrow$ J/ψ
  - single electron with displaced vertex measurement



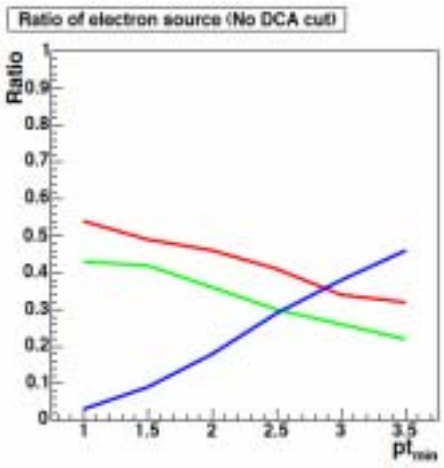
DCA = Distance of Closest Approach (μm)

Physics with VTX upgrade

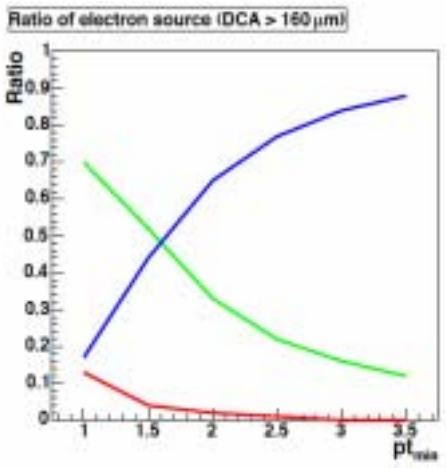
- Gluon polarization
  - single electron with displaced vertex measurement
    - Dalitz + conversion suppressed
      - $A_{LL}^{\text{Dalitz+Conversion}}$ to be known from $A_{LL}^{\pi 0}$
    - bottom enhanced
      - A_{LL}^{charm} and A_{LL}^{bottom} decomposed

Togawa's talk in Spin2004

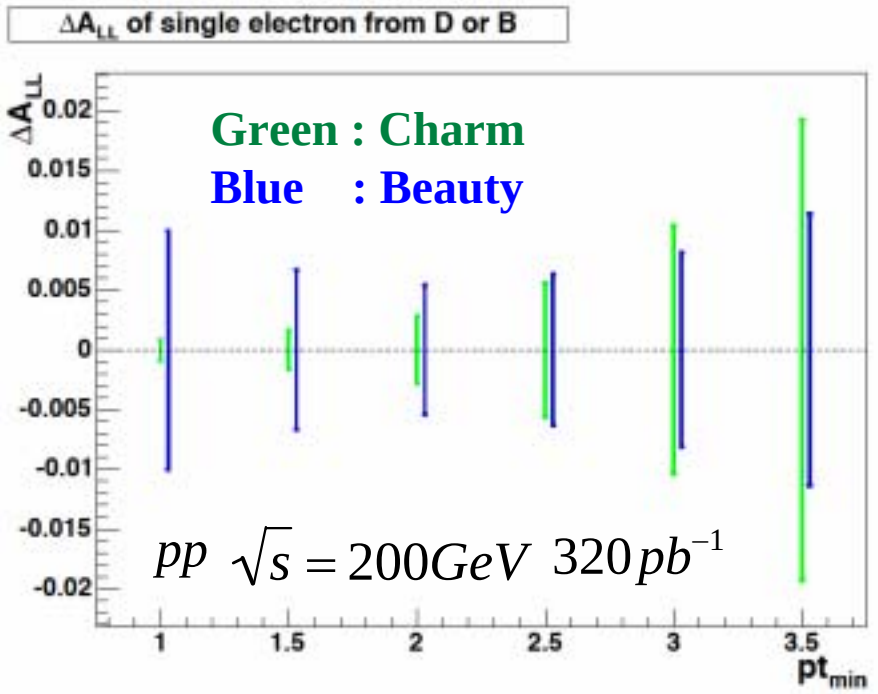
no DCA cut



with DCA cut

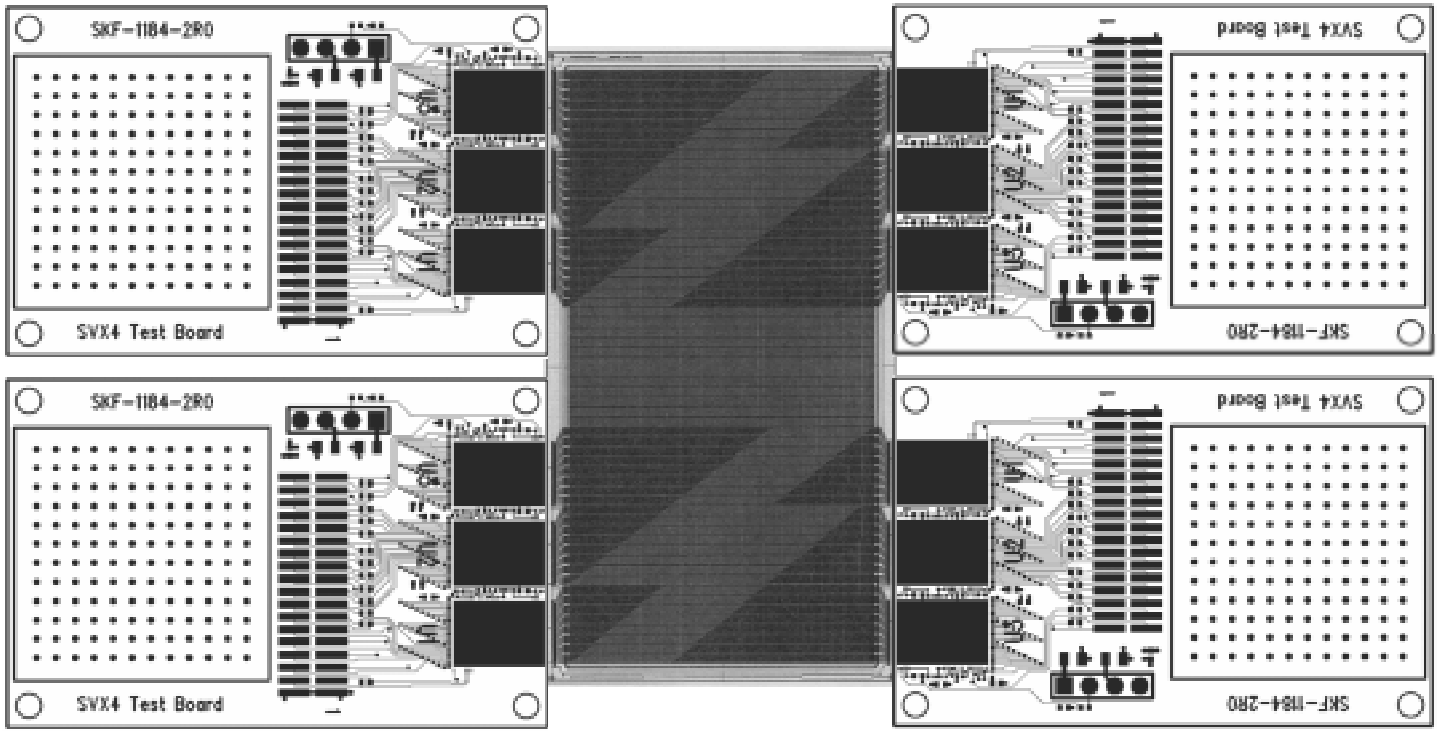


Red : Dalitz+Convesion
Green : Charm
Blue : Beauty



VTX upgrade

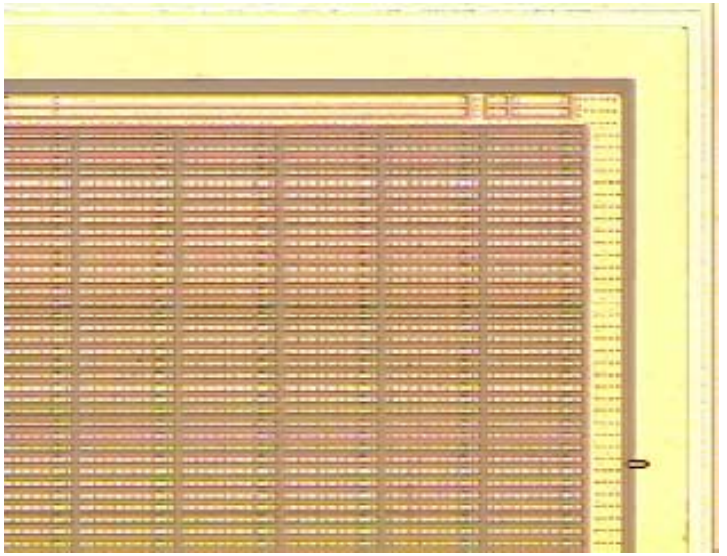
- Silicon strip detector
  - final test sensor design (Hamamatsu) + test hybrid module design (ORNL) with SVX4 readout chip (Fermilab)
    - to be built and tested early next year

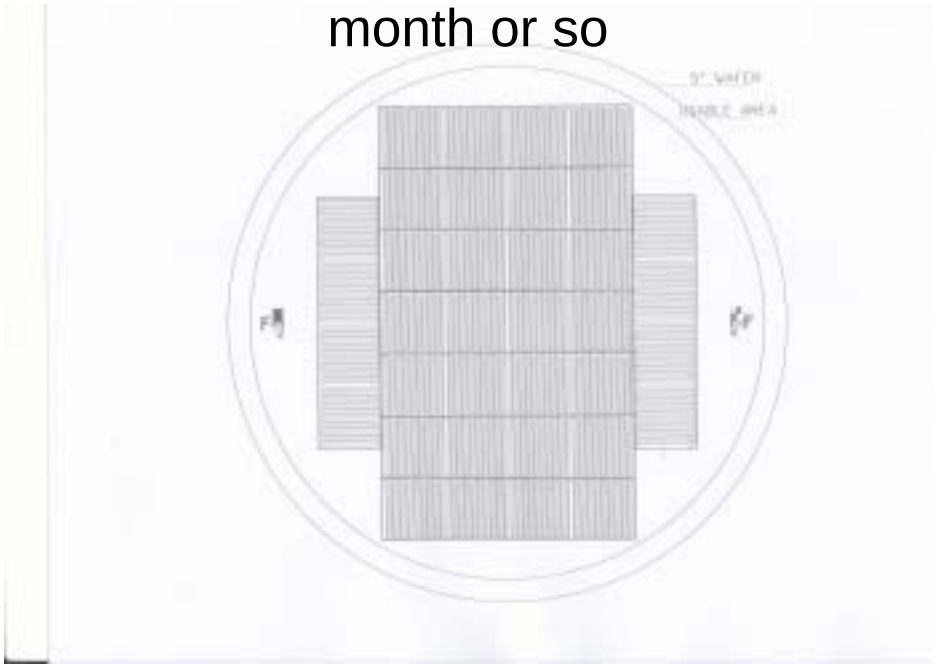


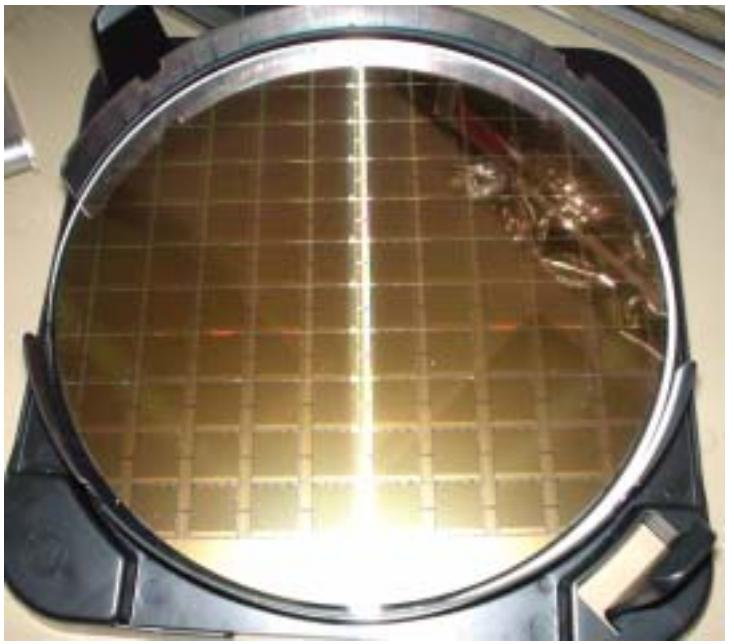
  - final hybrid module will be packaged on the sensor …

VTX upgrade

- Silicon pixel detector
  - ALICE hybrid
    - PHENIX sensor delivered in this month
    - electronics QA done
    - to be bump-bonded in a month or so

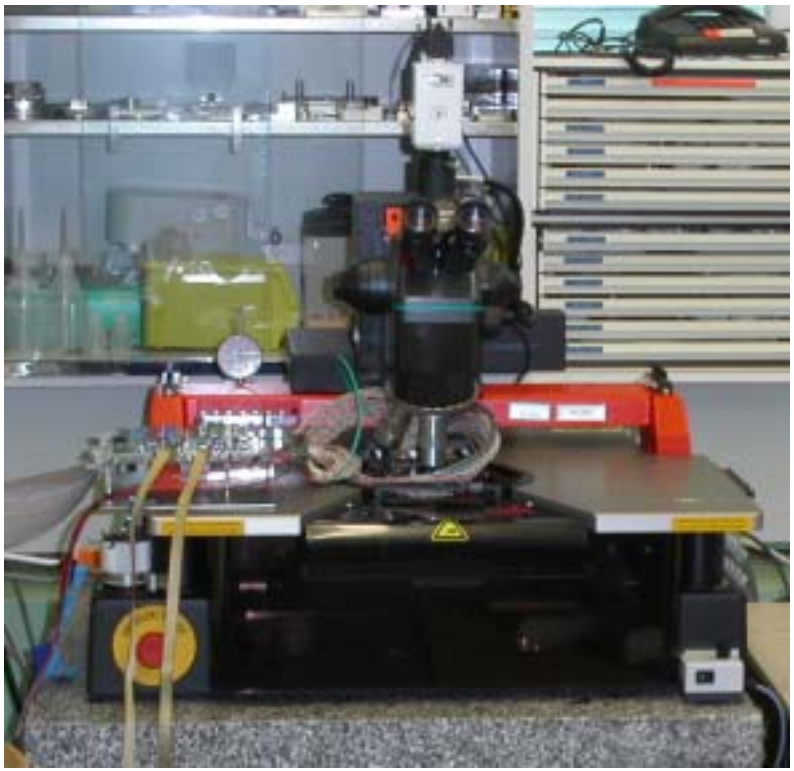






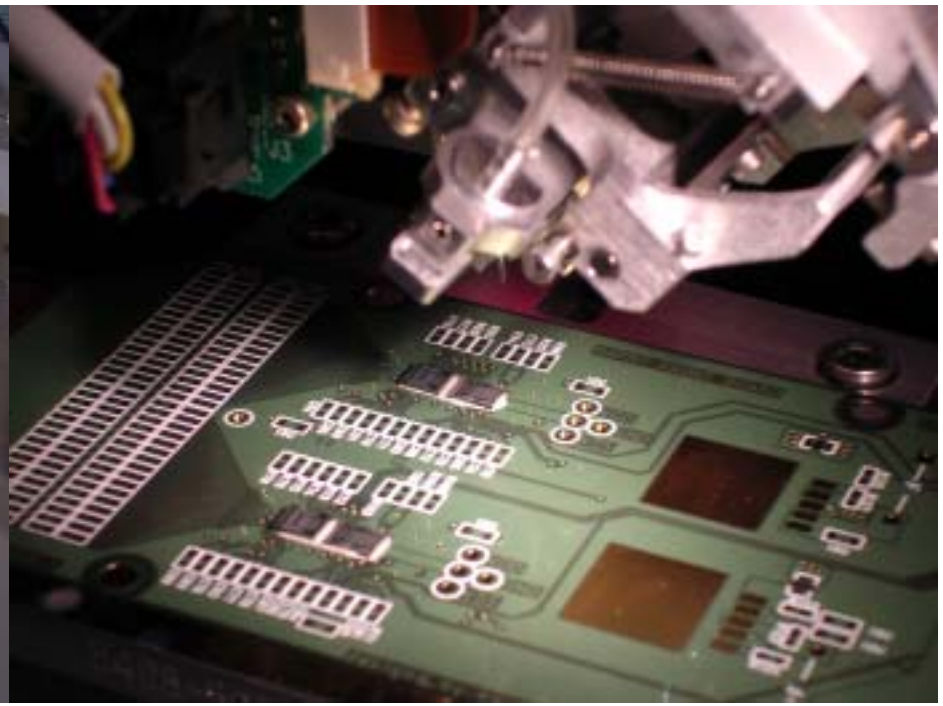
VTX upgrade

– probe station and quality assurance test of pixel readout chips in a clean room laboratory at CERN



VTX upgrade

– wire bonding facility in a clean room at RIKEN



VTX upgrade

- Schedule
  - March 03
    - approved by PHENIX+BNL management
  - endorsed by NSAC sub-committee for RHI
  - September 04
    - proposal submitted to DOE
    - being reviewed …
  - partially funded by RIKEN
    - development and construction underway …
  - summer 06
    - inner pixel layer + part of strip layers installed
  - summer 07
    - full VTX detector completed
    - to be ready for RHIC 2007-2008 run

VTX upgrade

- Collaboration
  - more than 70 people, 14 universities/institutes
    - BNL, Chemistry Department
    - BNL, Instrumentation Division
    - BNL, Physics Division
    - Florida State University
    - Iowa State University
    - KEK
    - Kyoto University
    - LANL
    - Niigata University
    - ORNL
    - RIKEN
    - RIKEN BNL Research Center
    - Stony Brook University
    - University of New Mexico
  - lots of more opportunity for new groups

Summary

- Many measurements have been achieved and will be done with the PHENIX baseline system
  - gluon polarization
  - quark polarization flavor decomposition
  - transversity
- PHENIX VTX will improve those measurements
  - with jet axis measurement: e.g. photon + jet
  - with displaced vertex measurement: e.g. single electron from charm and bottom
- Completion in summer 2007 to be ready for RHIC 2007-2008 run
  - development and construction underway …
  - lots of more opportunity for new groups …