PHENIX Vertex Tracker

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for PHENIX collaboration

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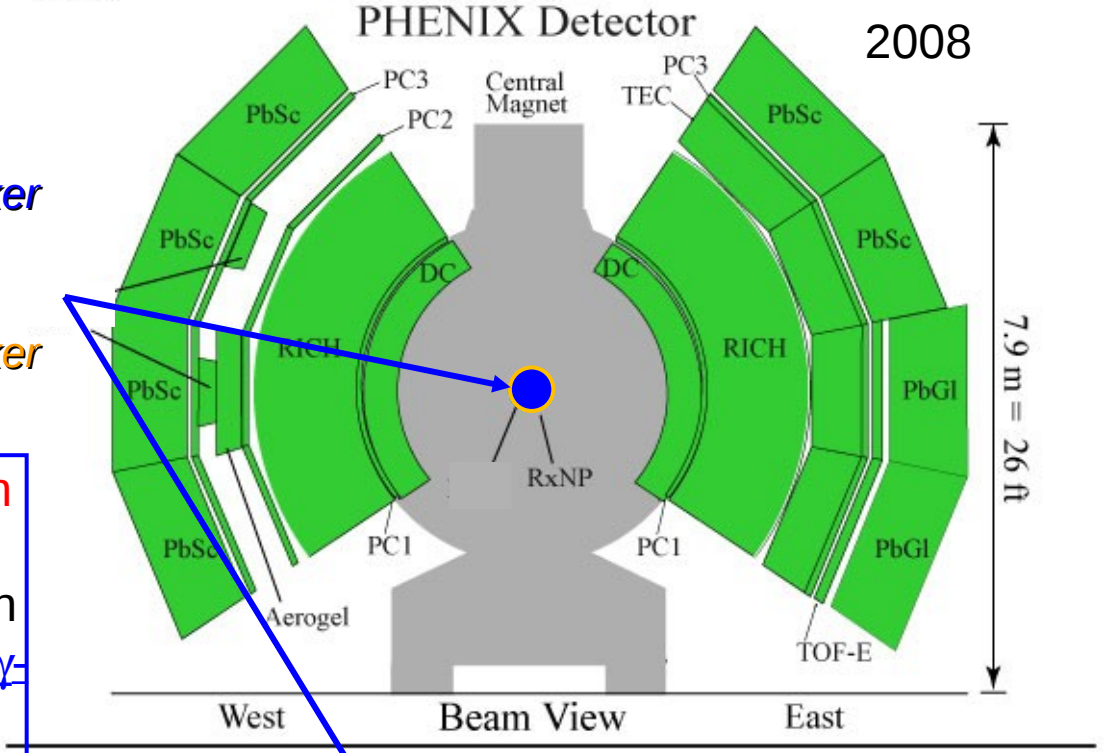
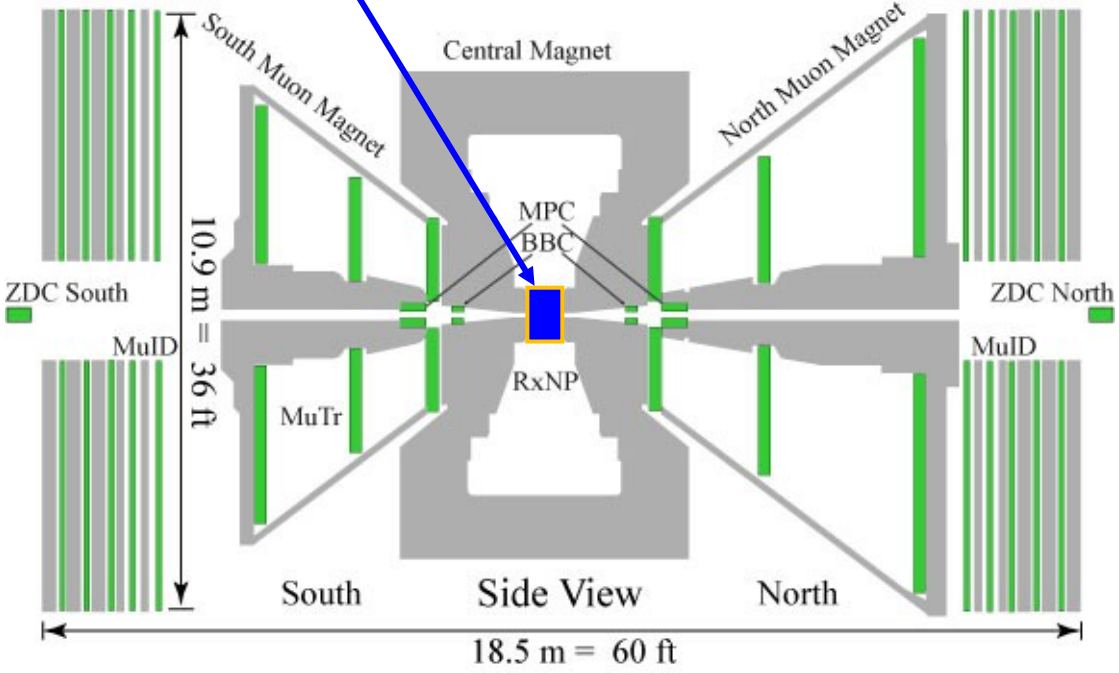
1. Over view of Vertex detector
2. Physics Goal
3. Detector detail and Status of Production
4. Expected Performance
5. Summary

Overview

Silicon Vertex Tracker
VTX (2010)
Forward
Silicon Vertex Tracker
FVTX (2011)

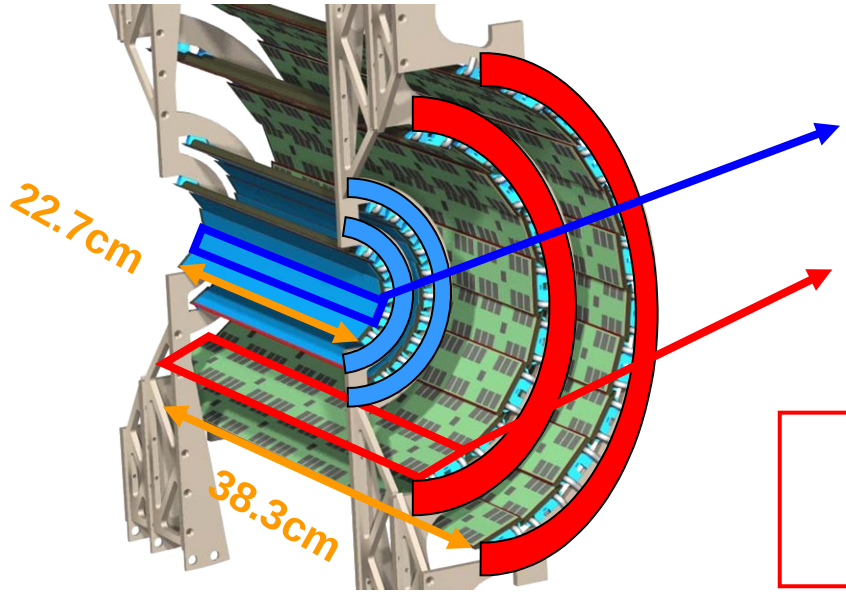
Gluon polarization (**ΔG/G**) measurement with heavy flavor and γ-jet correlation.





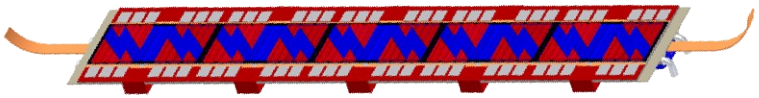
Silicon Vertex Tracker (VTX)

4 layers barrel structure → Inner 2 layer : pixel detector
Outer 2 layer : stripixel detector

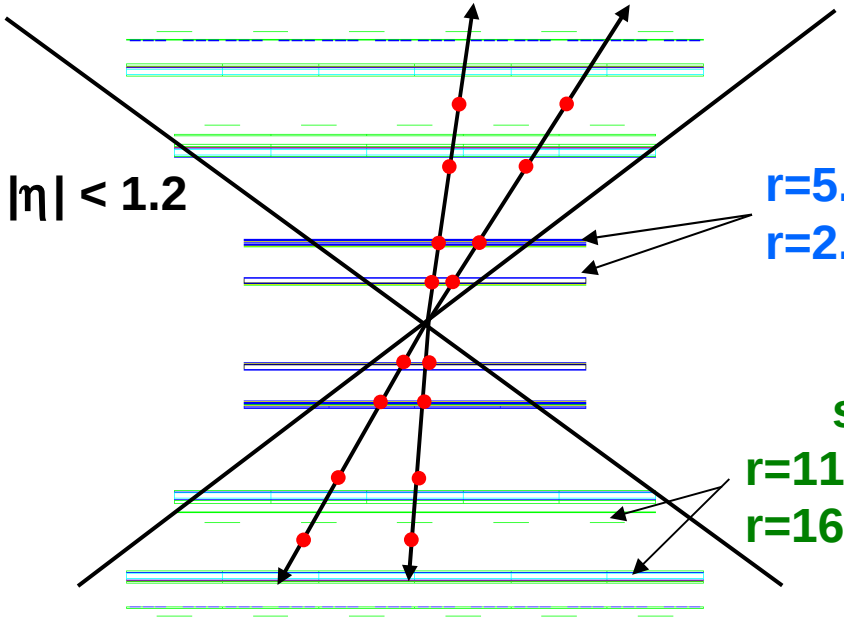


pixel full ladder

stripixel full ladder



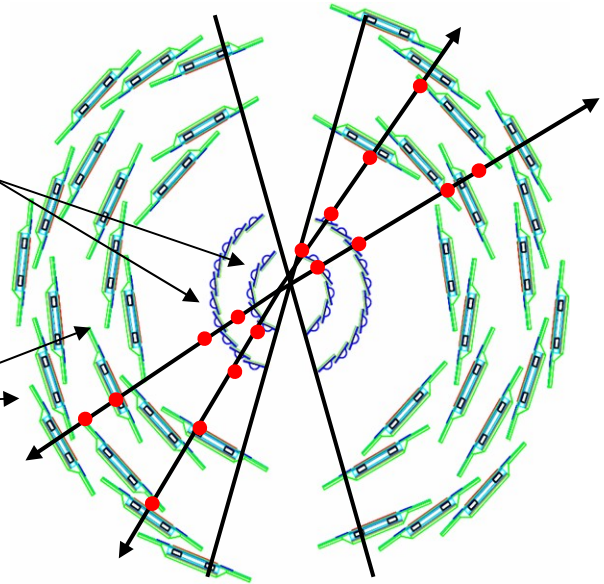
- High spatial resolution : σ_{DCA}~ 100 μm
- Large acceptance : |η| < 1.2, 2π for ϕ



pixel layer
r=5.0cm Δz=±10cm
r=2.5cm Δz=±10cm

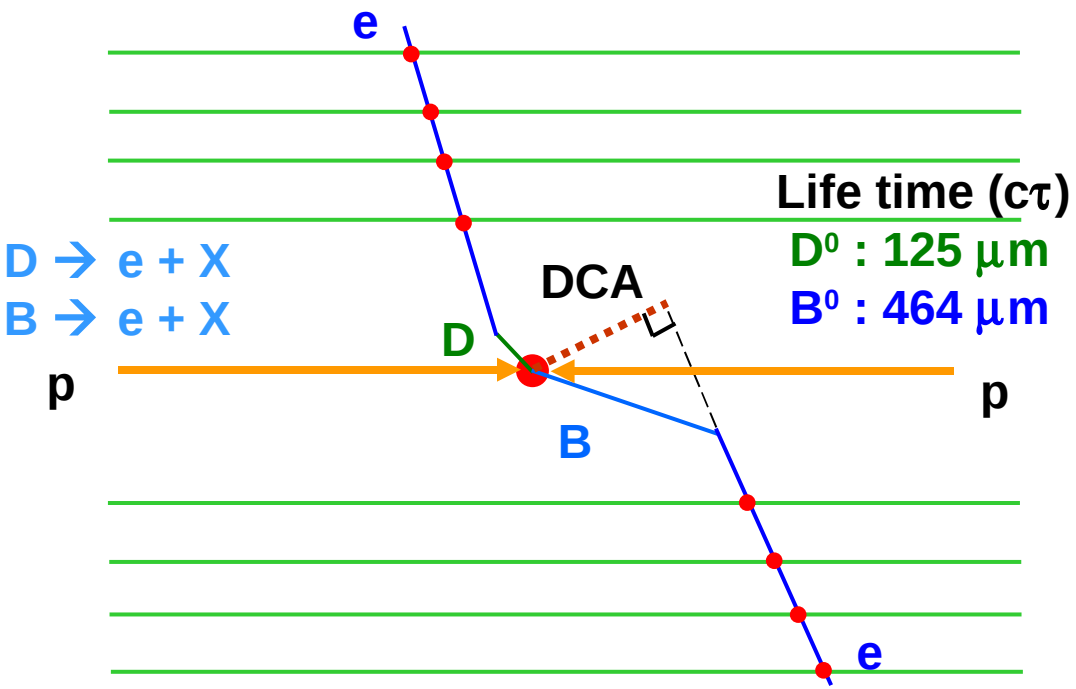
stripixel layer
r=11.5cm Δz=±16cm
r=16.5cm Δz=±19cm

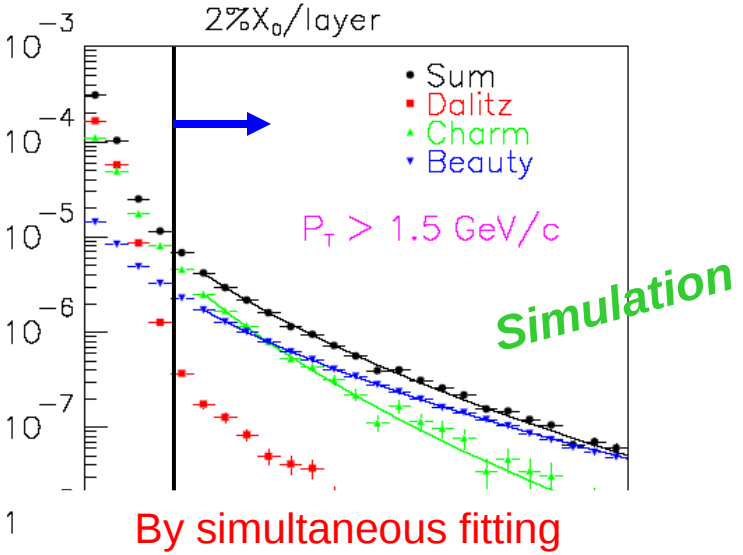
2π for ϕ



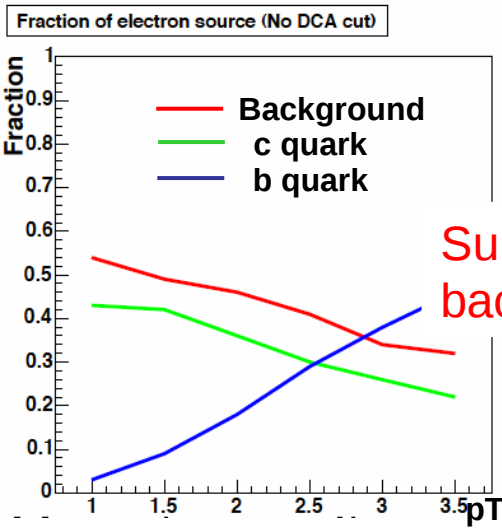
Identifying heavy flavor production by VTX

charm and beauty separation with difference of their life time

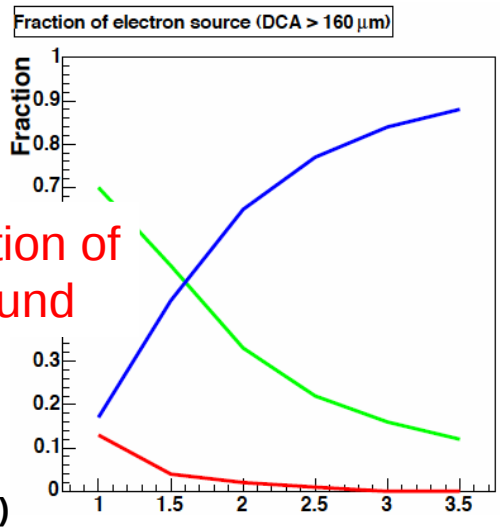


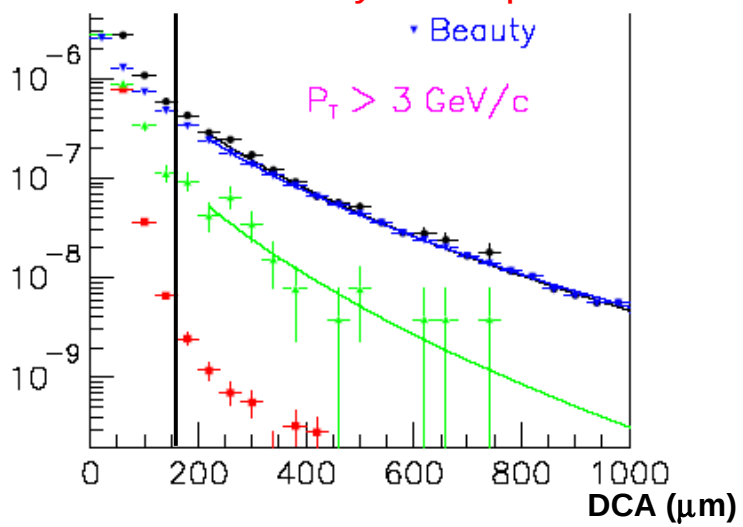


By simultaneous fitting
the DCA distribution
with the expected shapes,
charm and beauty are separated.

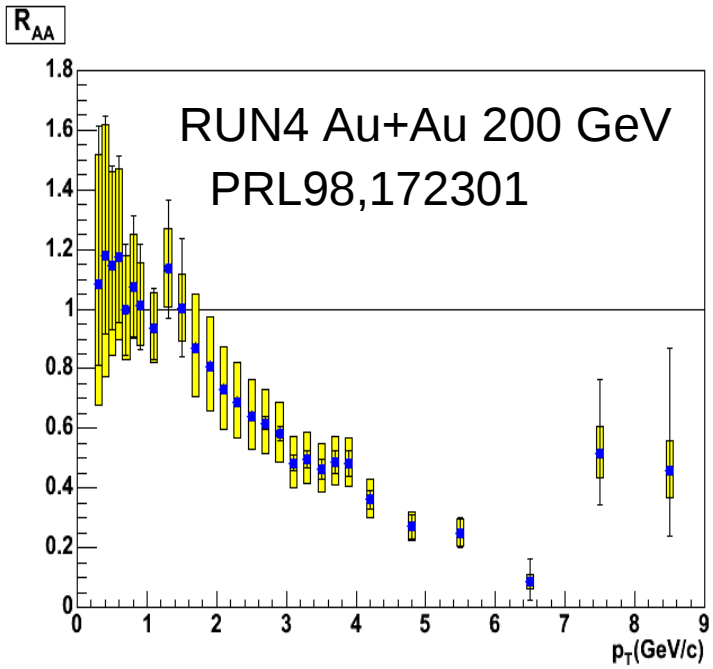


Subtraction of
background

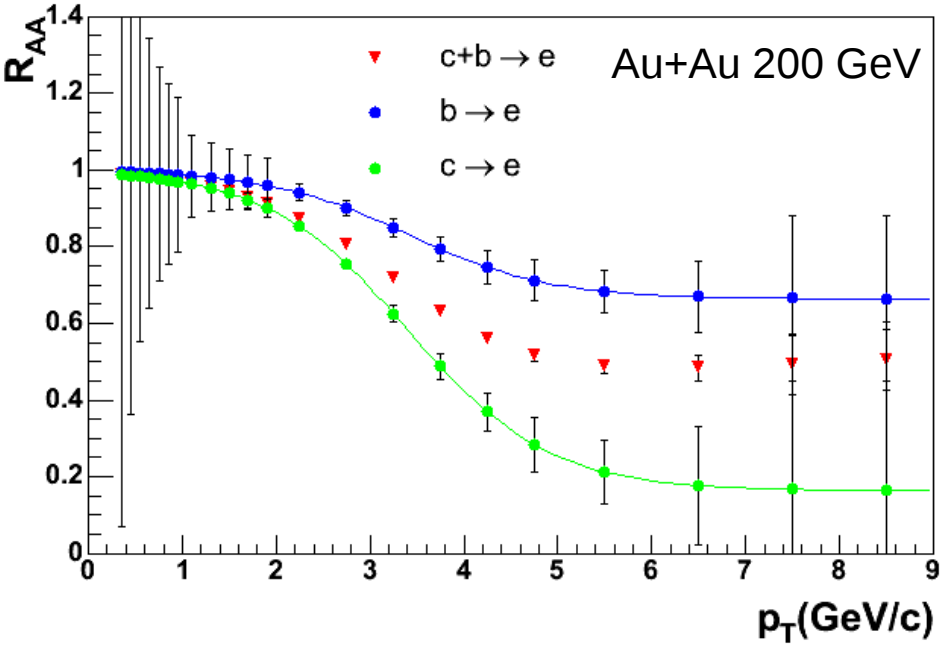




Expected R_{AA}(b→e) and R_{AA}(c→e) with VTX



Expected with VTX (0.4/nb ~3 weeks in RUN11)



- Strong suppression of single electrons from heavy flavor decay in Au+Au is one of the most surprising results in RUN4
- The present measurement is mixture of b→e and c→e
- VTX can separately measure RAA of b→e and c→e

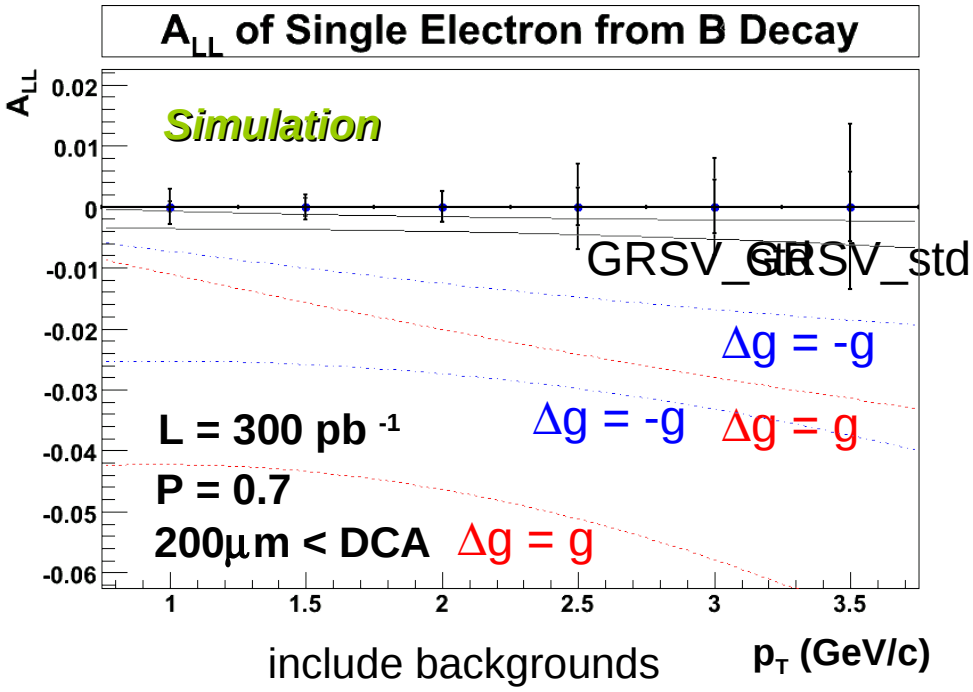
Double Spin Asymmetry

Heavy flavor measurement

Center of mass energy $\sqrt{s} = 500GeV$

Integrated Luminosity $L = 300\,pb^{-1}$

A_{LL} distribution as function of p_T



include backgrounds

Gamma - jet correlation

Direct γ (pT(γ), η_γ)

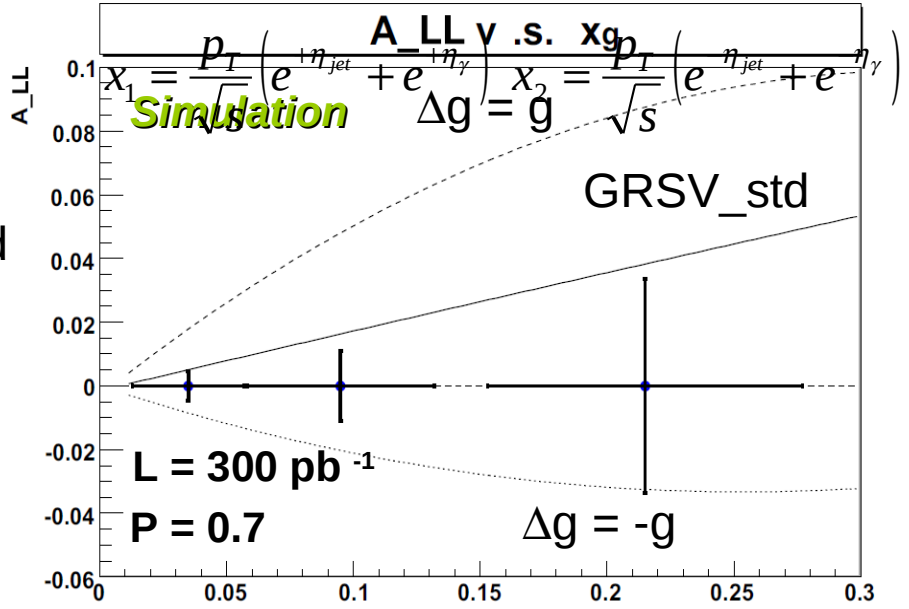
Center of mass energy $\sqrt{s} = 500GeV$

Integrated Luminosity $L = 300\,pb^{-1}$

A_{LL} distribution as function of x_g

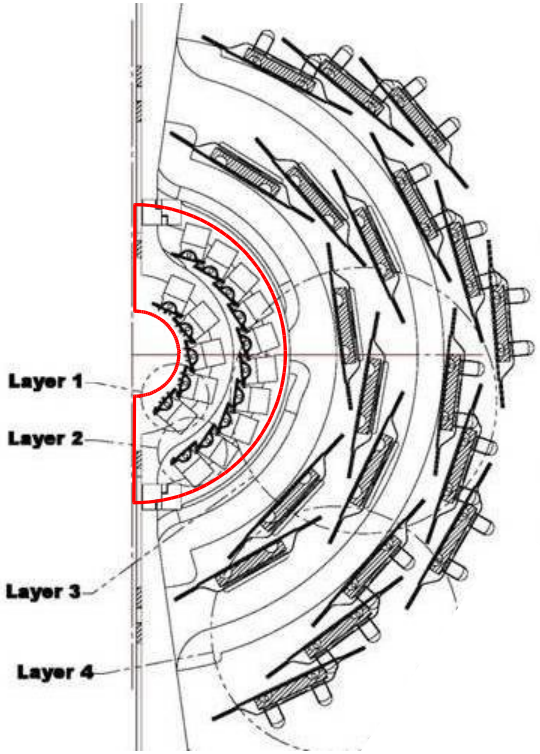
PYTHIA Simulation

Jet (η_{jet})



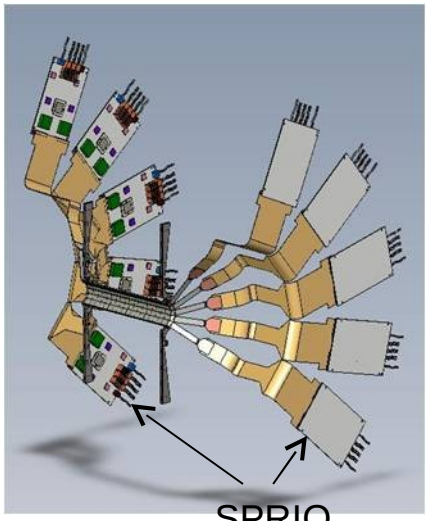
no backgrounds

Pixel Detector



Sensor module

50μm x 425μm



Pixel bus

Pixel sensor modules

Pixel stave (with cooling)

Full ladder

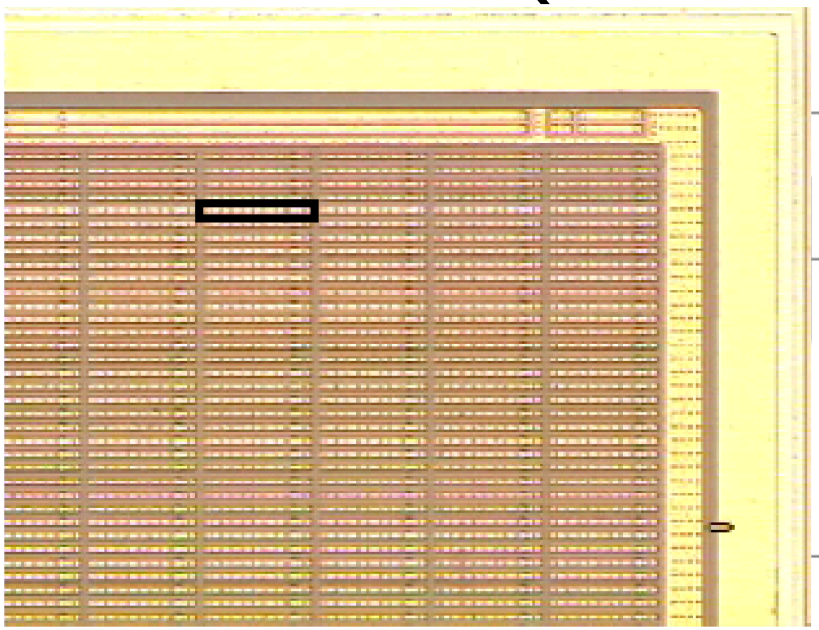
Pixel detector = inner 2 layers of VTX

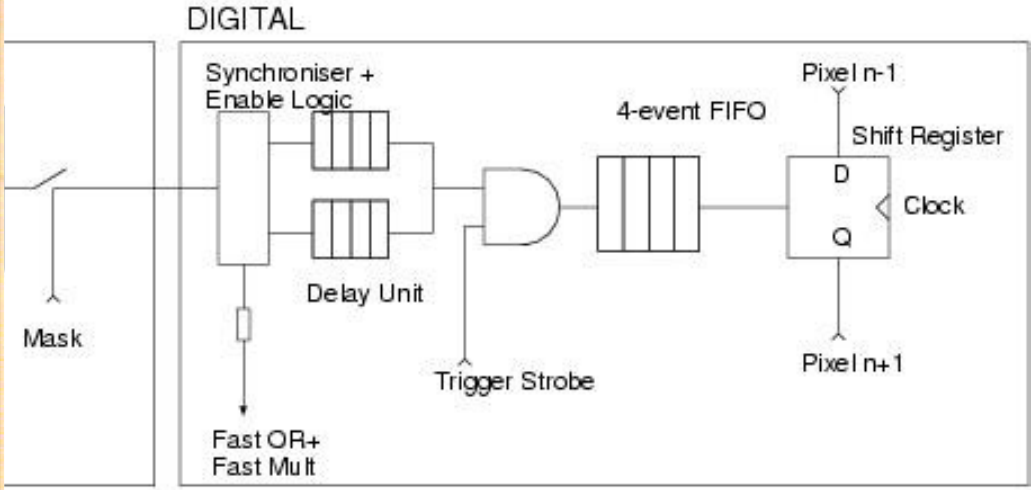
1st layer: 10 full pixel ladders = 20 half ladders = 40 sensor modules

2nd layer: 20 full pixel ladders = 40 half ladders = 80 sensor modules

7

PIXEL (Sensor and Readout)



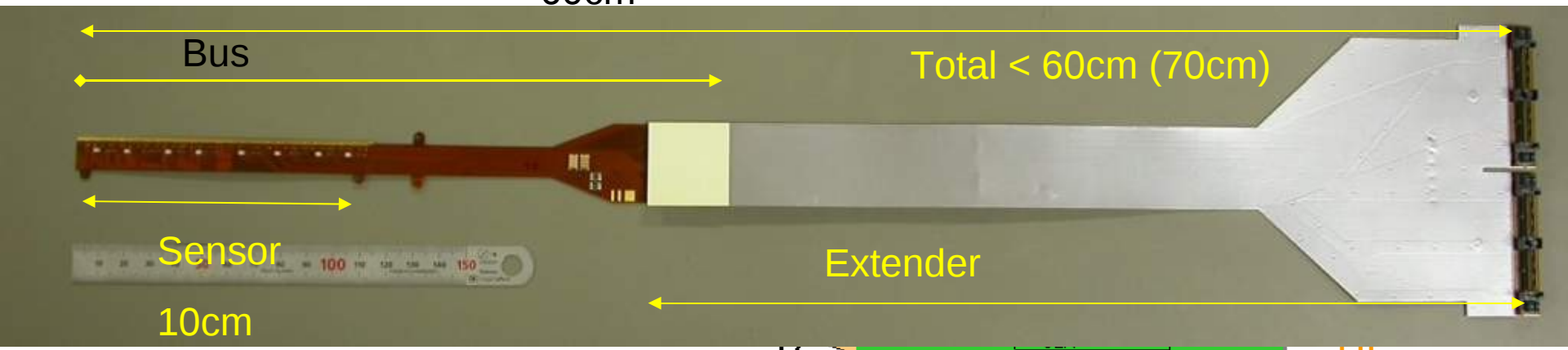


Pixel size(Φ x z) 50 µm x 425 µm
Sensor Thickness 200µm
ΔrΦ = 1.28cm, Δz = 1.36 cm (Active area)
256 x 32 = 8192 channel / sensor
4 chip / sensor
4 sensor / stave

Readout by ALICE_LHCB1 chip

- Amp + Discriminator / channel
- Bump bonded to each pixel
- Running 10MHz clock (RHIC 106nsec)
- Digital buffer for each channel > 4µsec depth
- Trigger capability > FAST OR logic for each crossing
- 4 event buffer after L1 trigger

Pixel Readout Overview

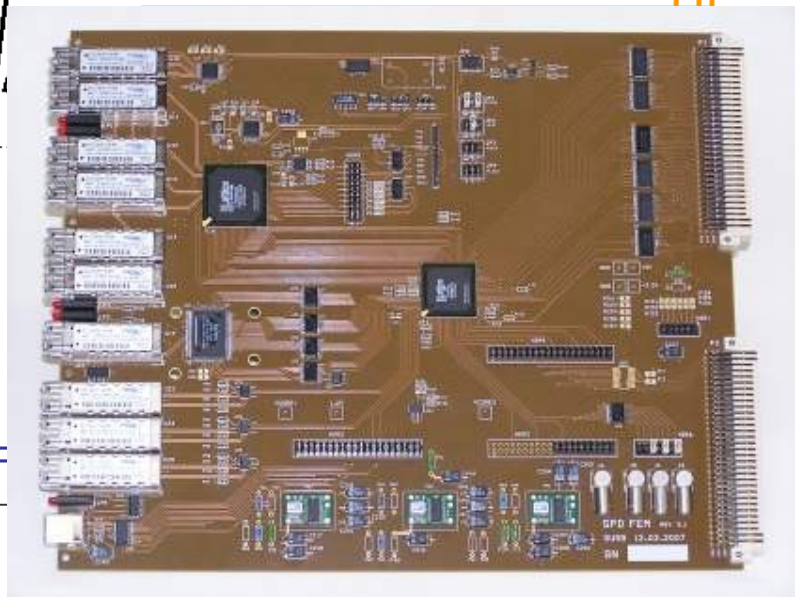


Parallel
32x4bits@10MHz

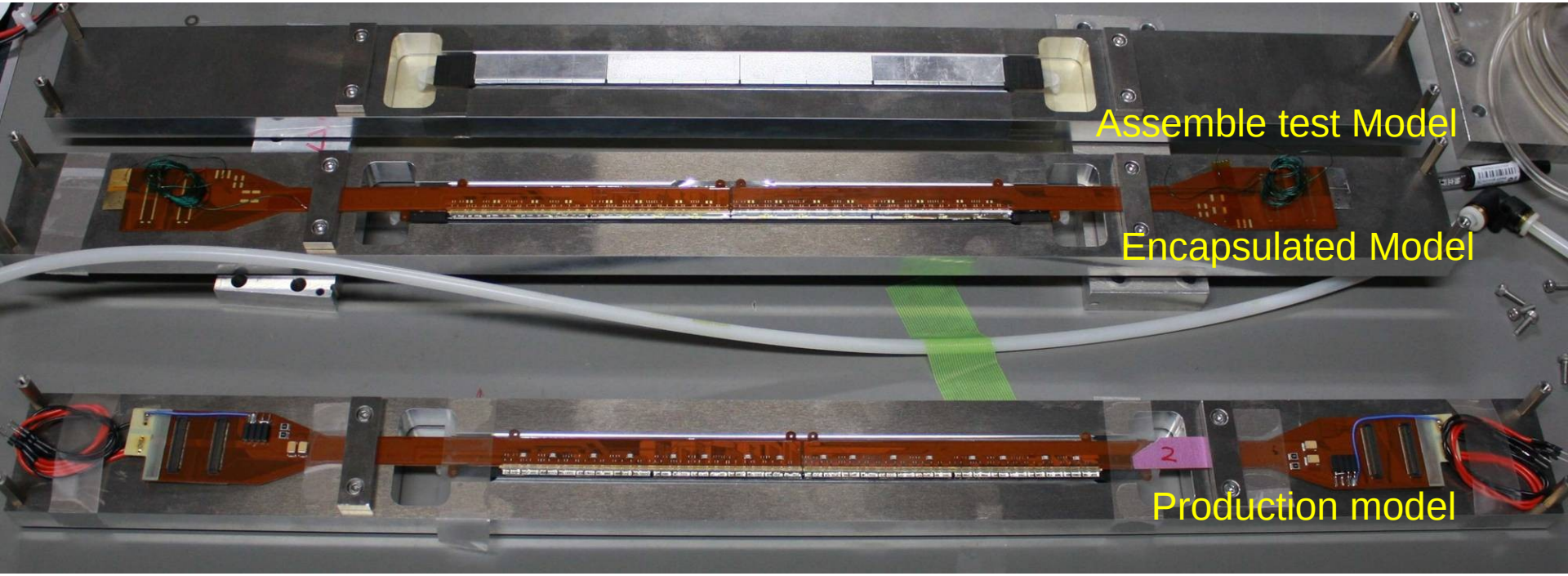
2 1 32bits

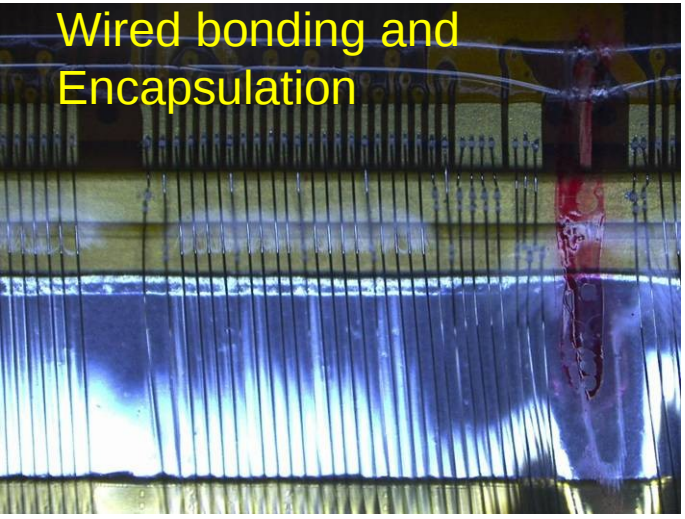
51.2 µs

5cm)



Production has been started





We have all pieces of parts

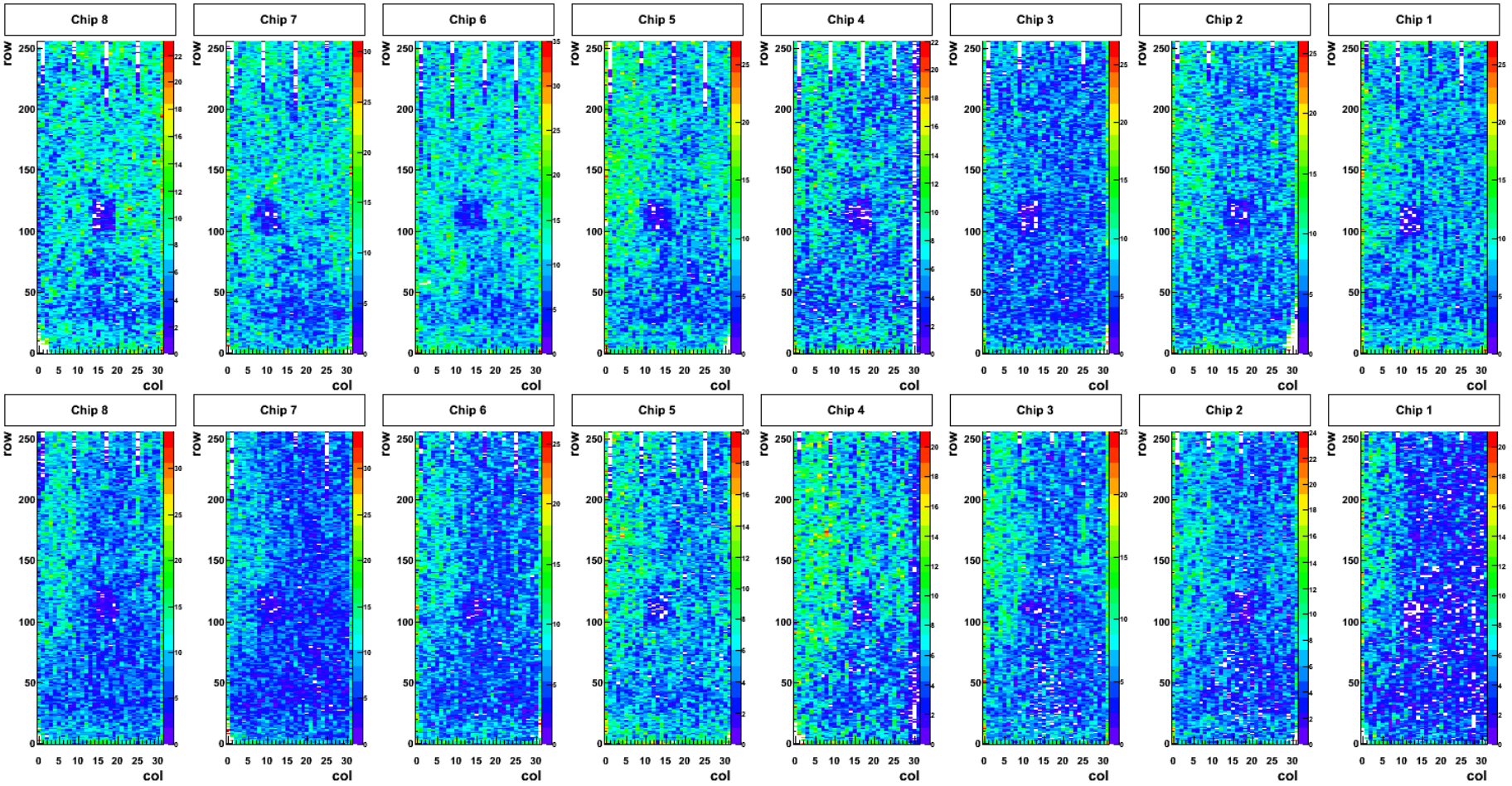
- Sensor modules
- Carbon staves
- Readout bus

And Assembly technique.

6 ladder produced. Need 30 ladders.

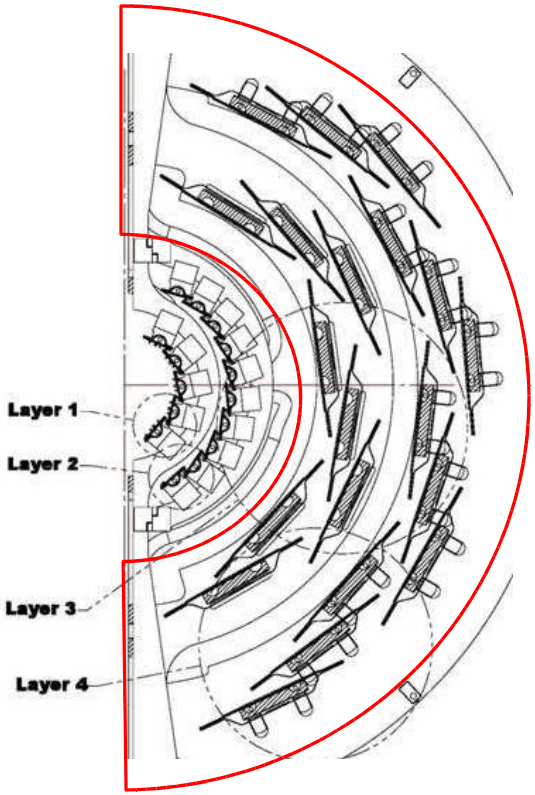
Electrically working well.

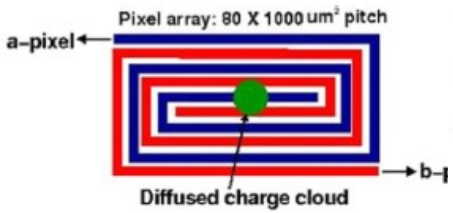
1st Complete Pixel Ladder on Dec 25.

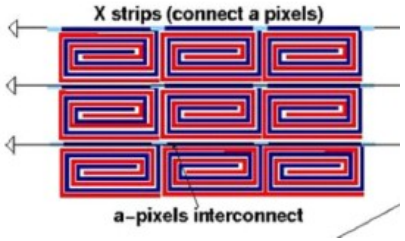


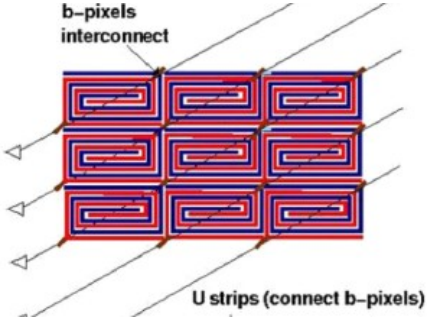
All chips on Ladder #6 has good hit map by beta-ray source test

Strip detector







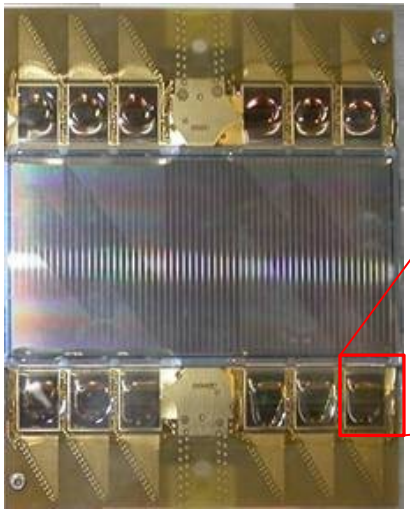


80μm x 30mm “stripixel”
80μm x 1mm pixel size

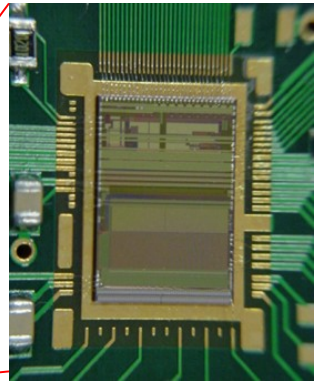
Stripixel sensor(Z. Li, BNL)
1 side, 2 direction read-out

(384 X + 384U strips) x 2

silicon module

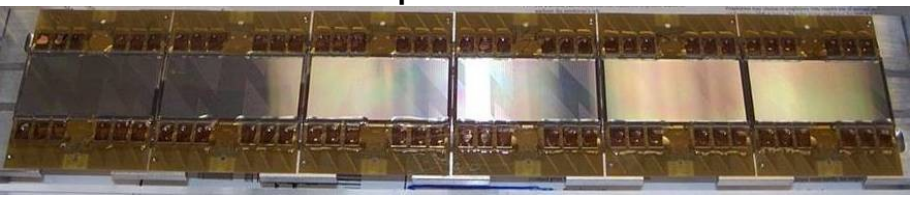


SVX4



128 ch/chip
8 bit ADC

Strip Ladder

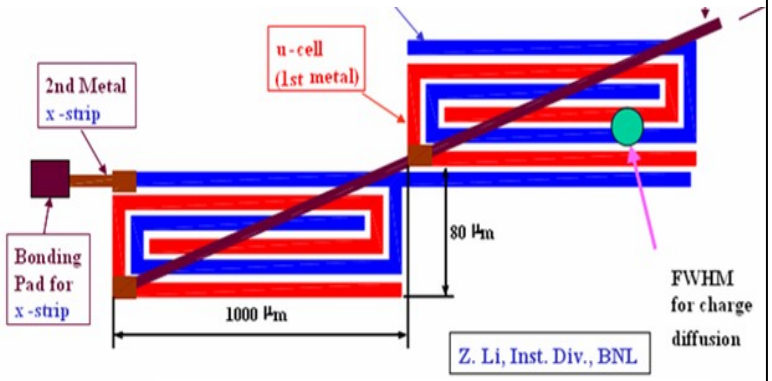


5 (L3) or 6 (L4) silicon modules
Read-out by 1 LDTB

1 sensor + ROC + 12 SVX4
Read-out by RCC board

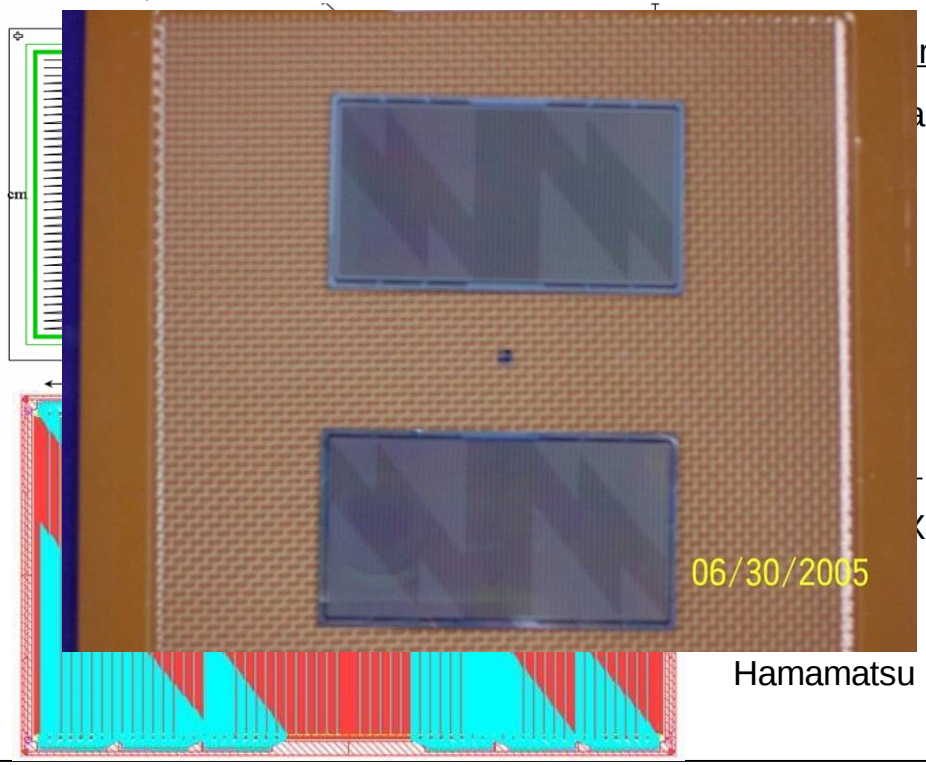
Stripixel layer

Sensor elements:



Pixels: 80 μm × 1 mm, projective readout via double metal XU/V "strips" of ~3 cm length.

Two strip-pixel arrays on a single-sided wafer of 500 μm thickness, with 384 + 384 channels on 3 x 3 cm² area.



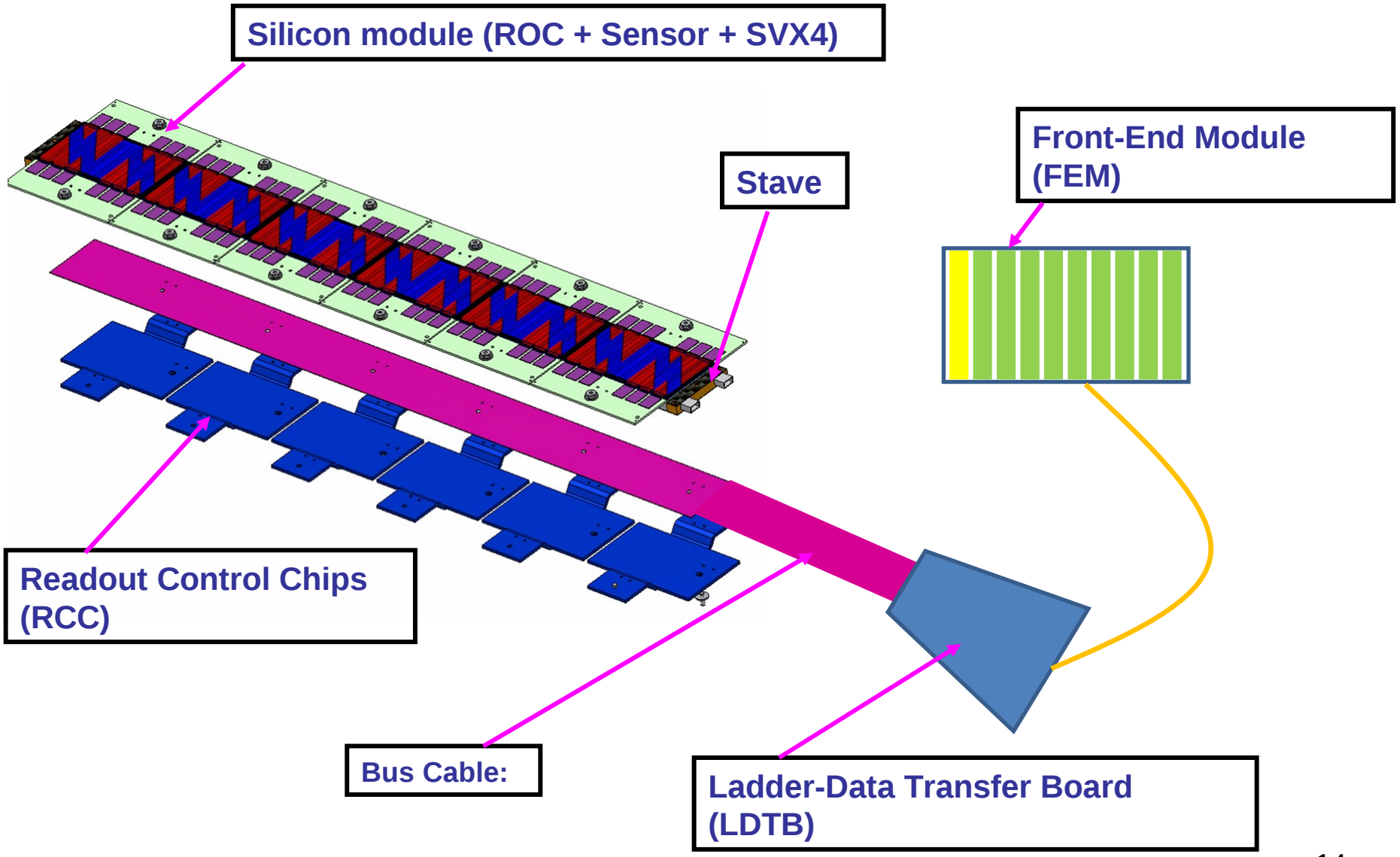
Hamamatsu

Developed at BNL Instrumentation Gr.

- **Single sided**
- **1+1 dimensional readout (X and U direction)**
- **768 X strip and 768 U strips/chip**
- **3cm x 3cm sensor x 2 / chip**

Position resolution is 25μm by test beam

Structure of Strip ladder

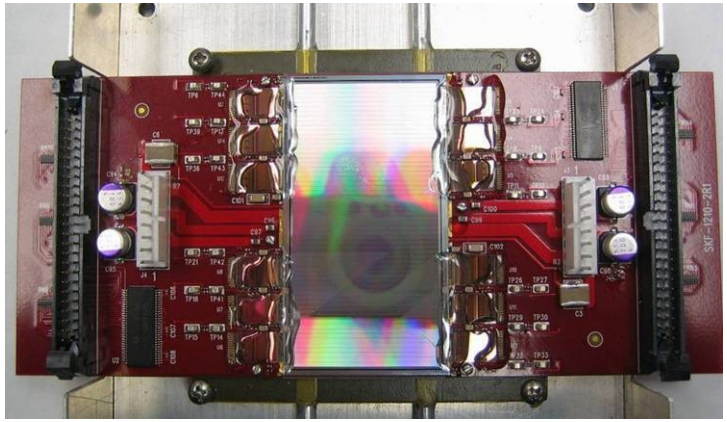


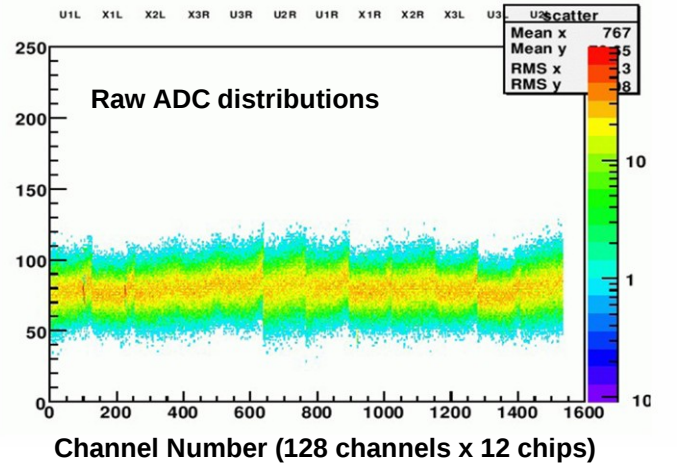
Executive Summary I:

- Silicon Module: assembly issues of the ROC-3 have been solved

- **June 2008:**

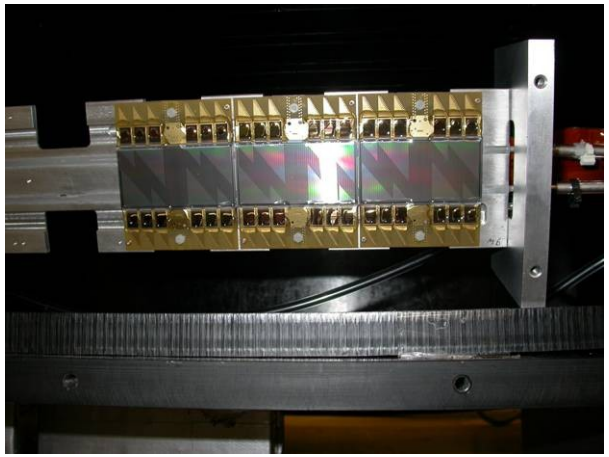
One silicon module with ROC-3

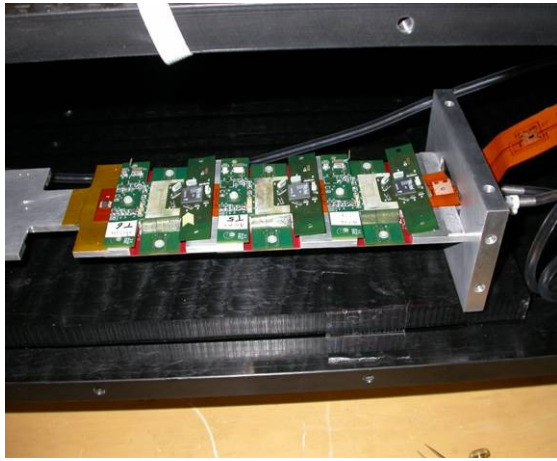


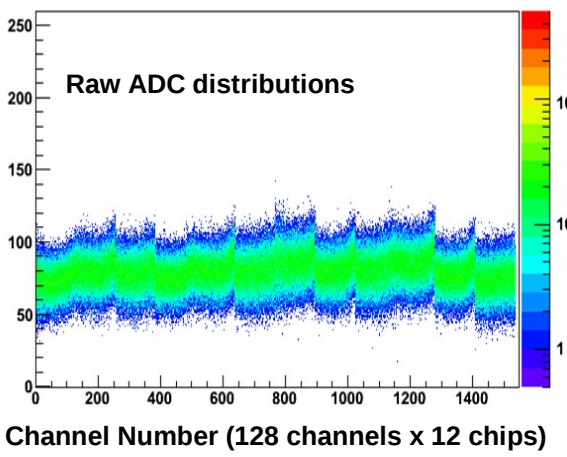


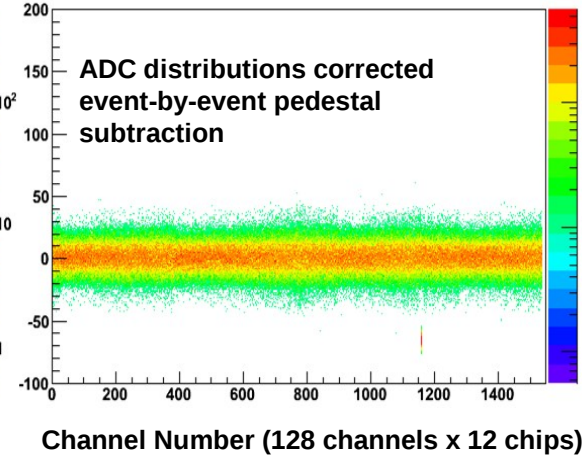
- **Today: Pre-production (8 modules)**

3 silicon modules readout simultaneously



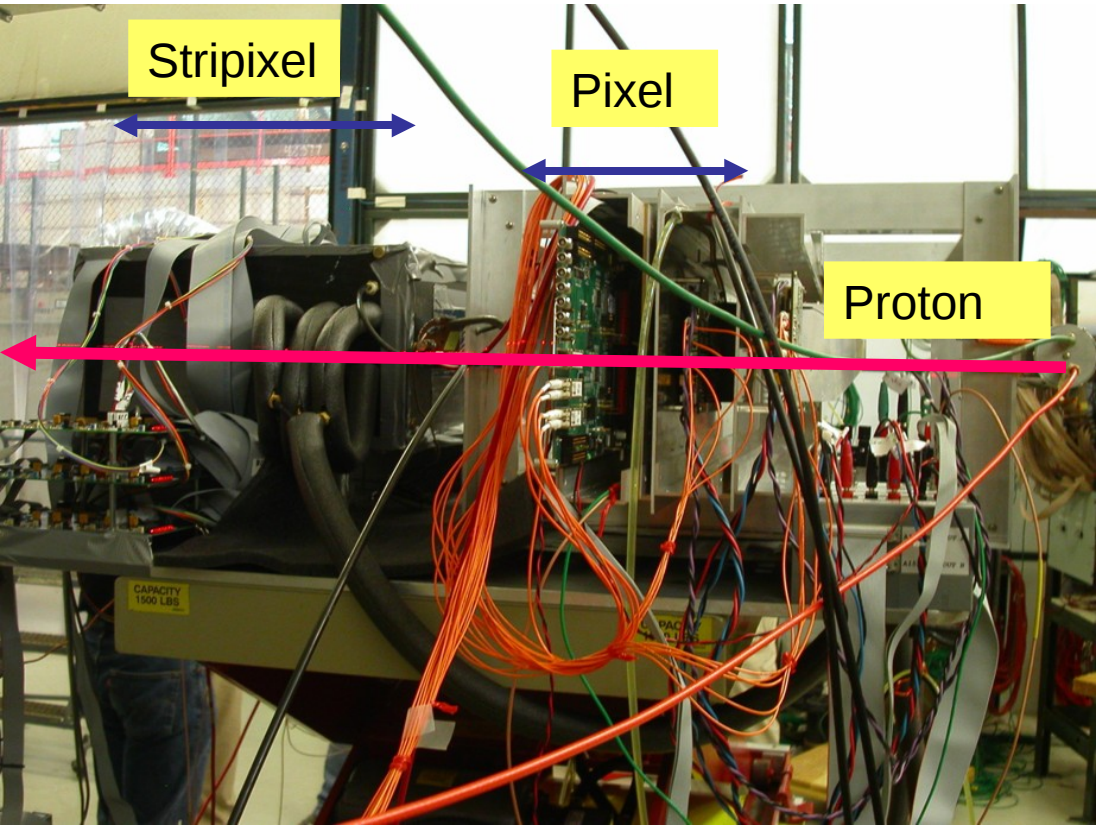






The silicon module gave good performance results → starting mass production

Test beam at 120GeV Proton



FERMILAB Meson Test area

120 GeV Proton

5-30mm beam spot

4.5 sec spil per 1 min.

2×10^{10} proton / spil

Independent DAQ for Pixel and Stripixel.

Using trigger scintillation counters

Stripixel

3 Prototype ROC

Trigger: Beam defining Scinti.

DAQ : SVX4+ ROC+RCC

Pixel

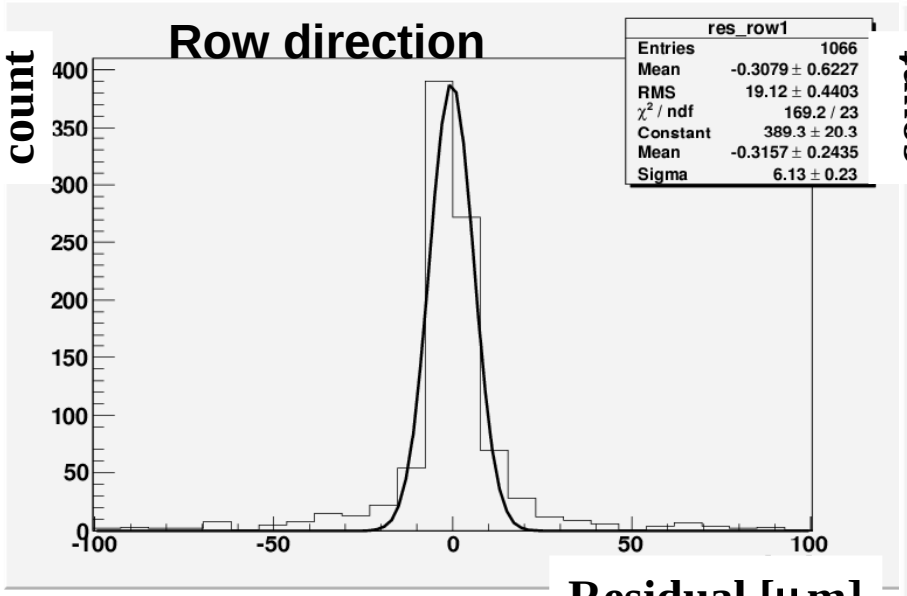
3 Prototype pixel ladder

Trigger: Scinti * FAST_OR (3layer)

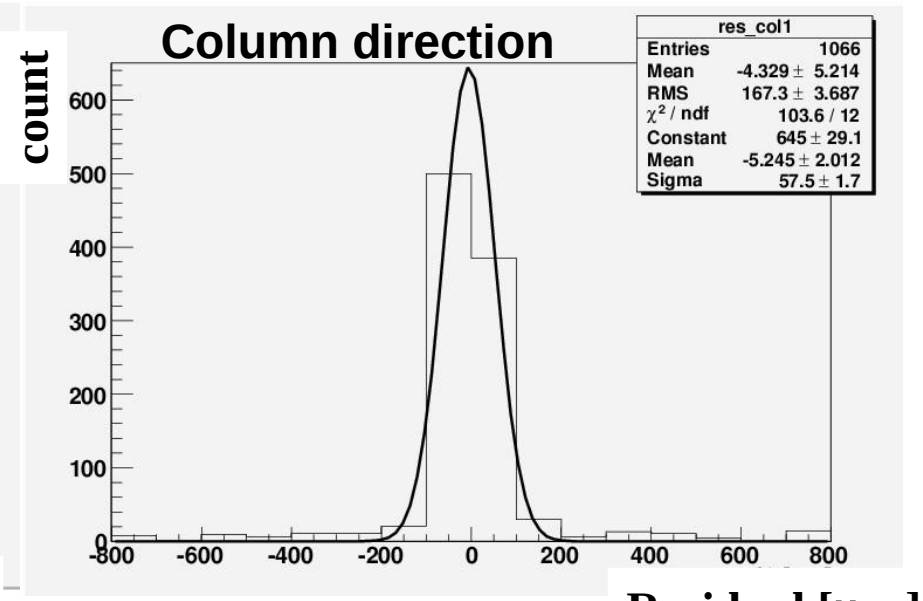
DAQ: Prototype Readout + PHENIX DAQ

Pixel performance

$$\textbf{\textit{Residual}} = \sum_{i=1}^{3} (Fit - X_i)^2$$



σ_{res} = 6.1μm



σ_{res} = 57μm

Un-convolute

Fit include all 3 layers hit position

Multiple scattering effect

→

Intrinsic resolution

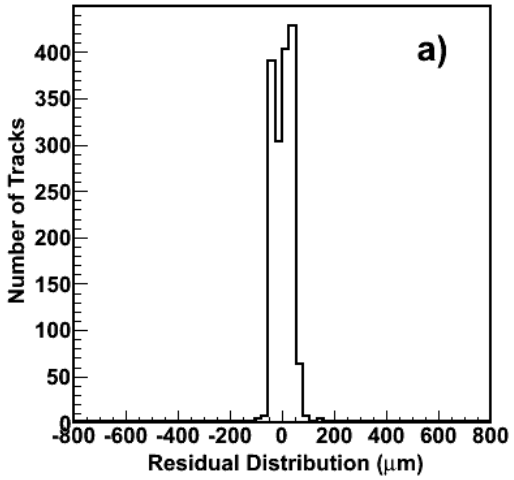
row : 14μm

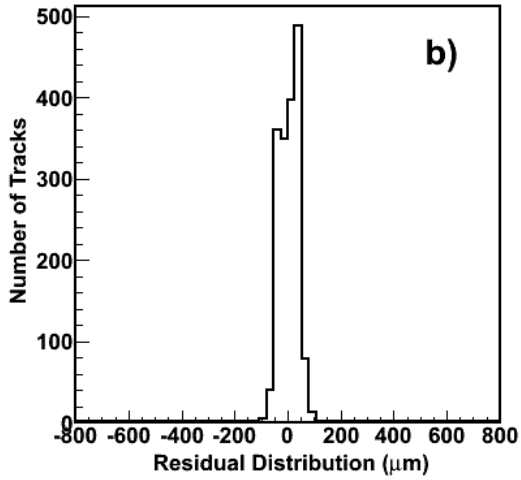
column : 152μm

Stripixel performance from Beam test result

- Residual distribution (position resolution)

- X-stripixel 0.42 x 80 (μm) = 33.6 (μm)
- U-stripixel 0.44 x 80 (μm) = 35.2 (μm)
  - from the RMS values
  (tracks are defined by layers 1 and 3).

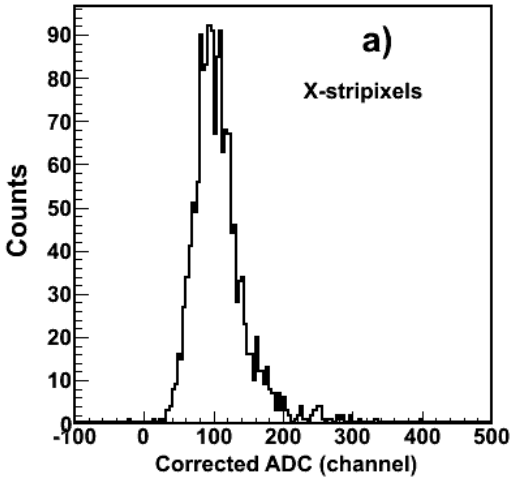


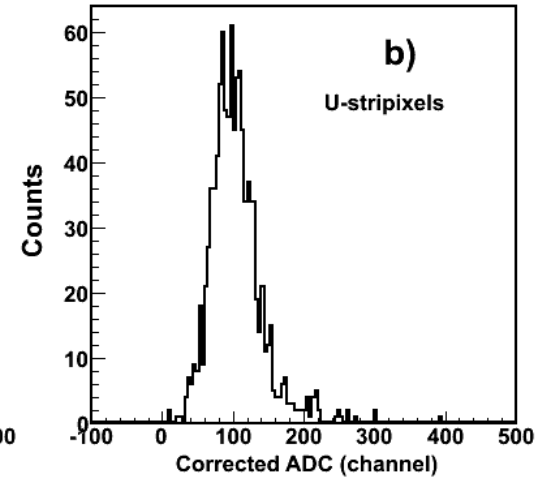


- Tracking efficiency (detection efficiency)

- X-stripixel: 99.5 +/- 0.2 %
- U-stripixel: 98.9 +/- 0.2 %

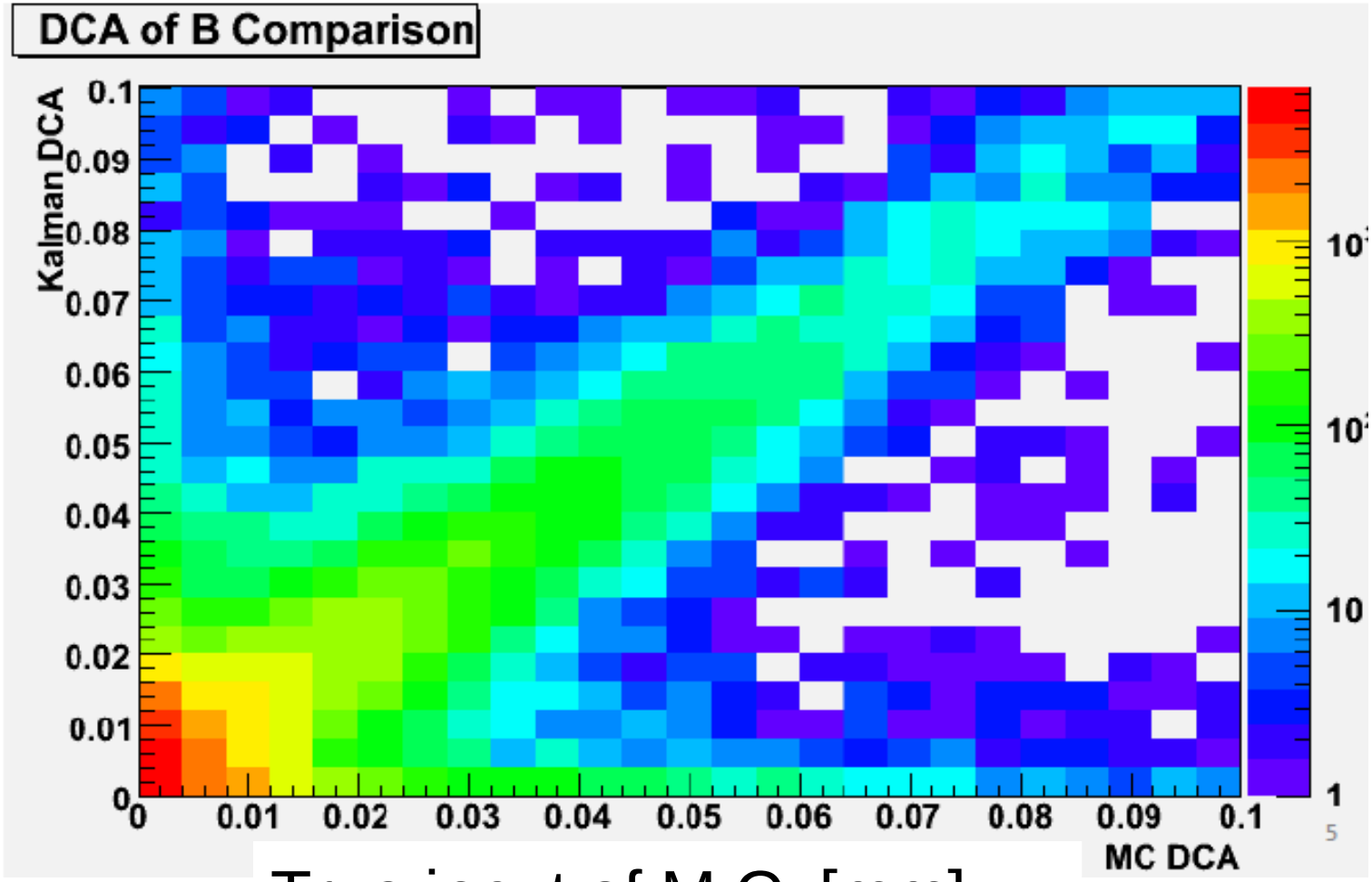
Tracking efficiency very good





Expected Performance from GEANT

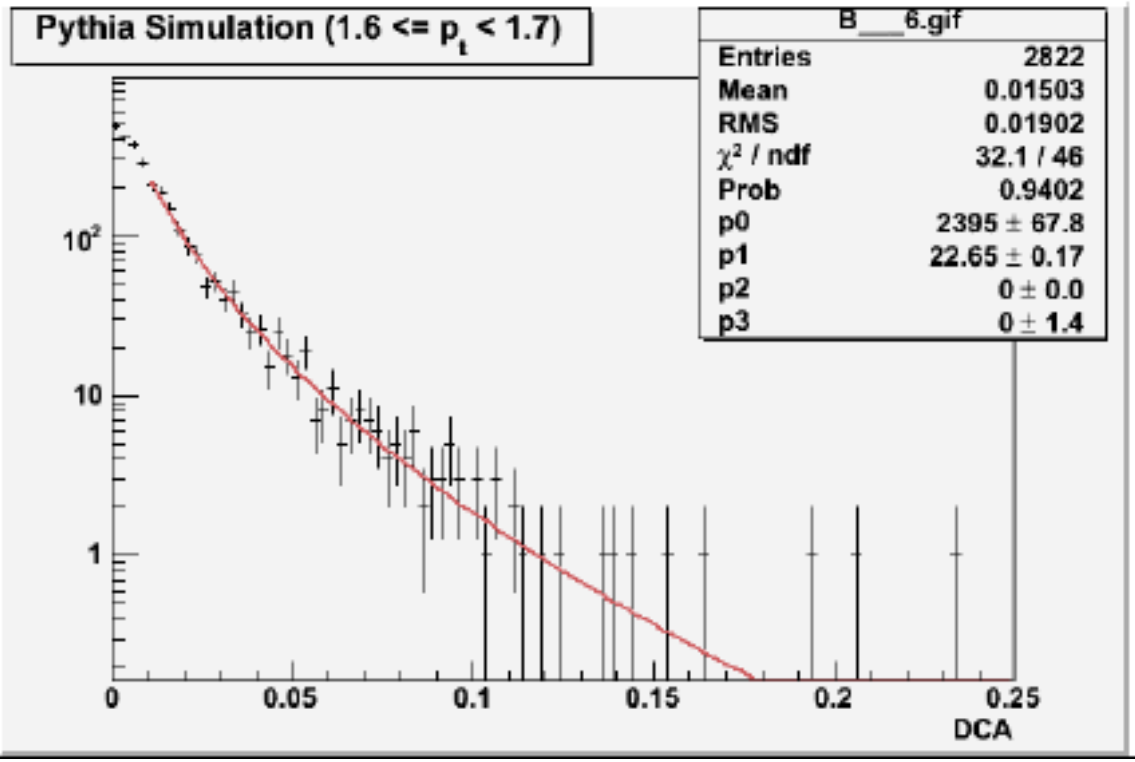
DCA Comparison of Bottom -> e



DCA fit for mixed Charm and Bottom event sample

D or B Mesons Only $f(x) = Ae^{-\omega\sqrt{x}}$

Both Together $f(x) = A_D e^{-\omega_D \sqrt{x}} + A_B e^{-\omega_B \sqrt{x}}$



DCA [mm]

Summary

- PHENIX Vertex Tracker will be installed in 2010 and be operated from next RHIC.
- VTX is capable to identify Charm and Bottom with fine spatial resolution and jet with larger geometry acceptance.
- VTX will enhance physics capability in both spin and Heavy Ion program.