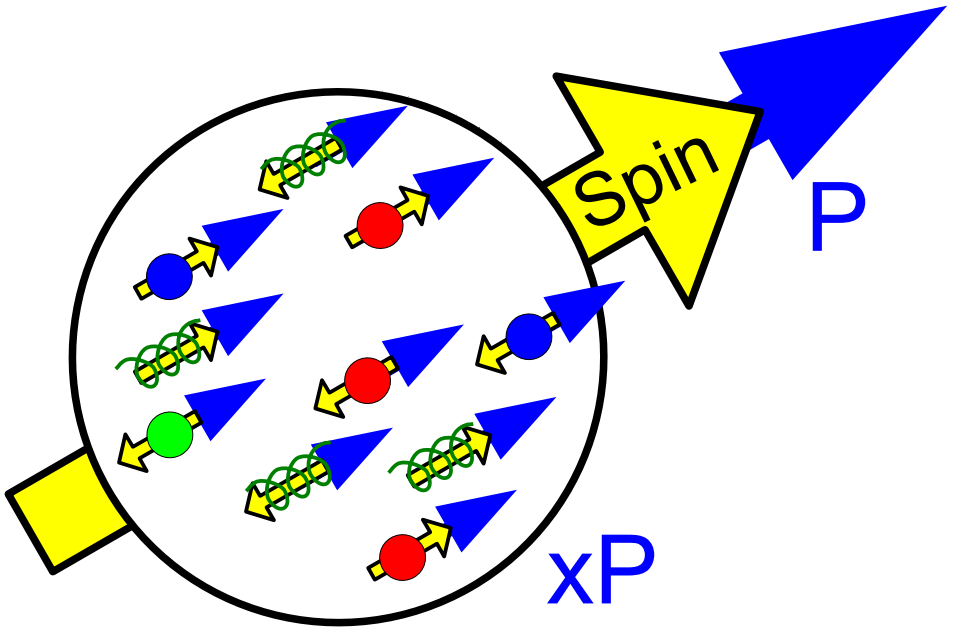
Forward upgrade for W physics at RHIC-PHENIX experiment

Apr. 29, 2009, DIS 2009

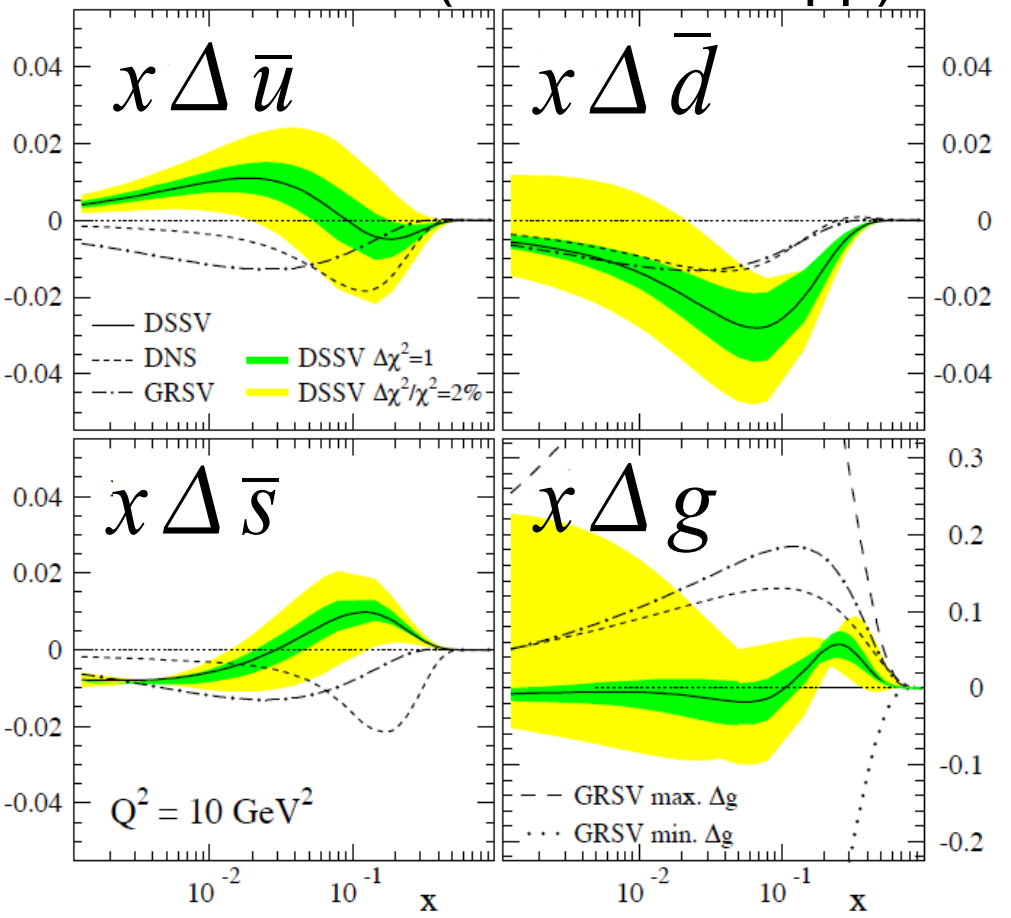
RIKEN
Yoshinori Fukao

Proton Spin Structure



Spin of parton is parallel or anti-parallel to proton?

DSSV2008 (DIS+SIDIS+pp)



$$\frac{1}{2} = \frac{1}{2}\Delta\Sigma + \Delta G + L$$

ΔQ_v : Well known

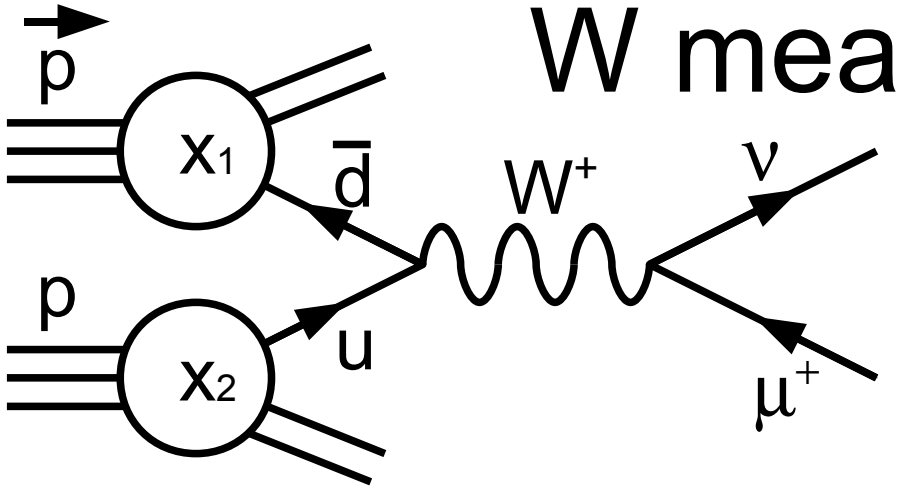
ΔG : Being revealed

$\Delta\bar{Q}$: **Less well-known**

L : Unknown

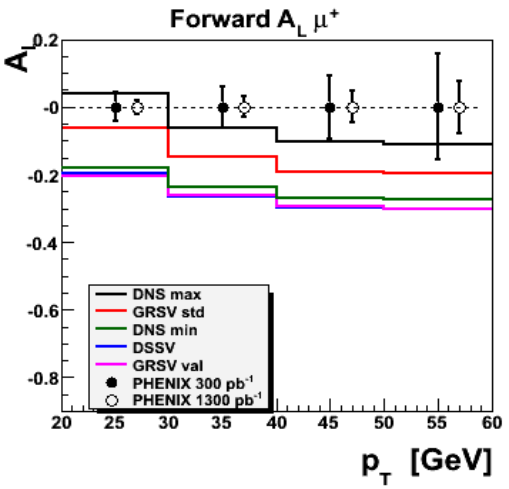
This talk focuses on sea quark, in particular about $\bar{u}$ $\bar{d}$ flavor separation by W measurement.

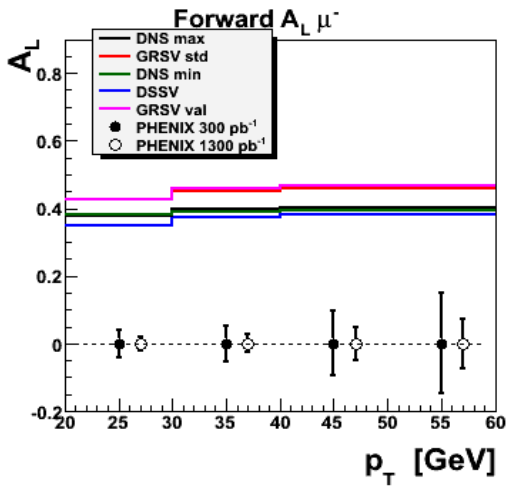
Sea Quark Polarization by W measurement

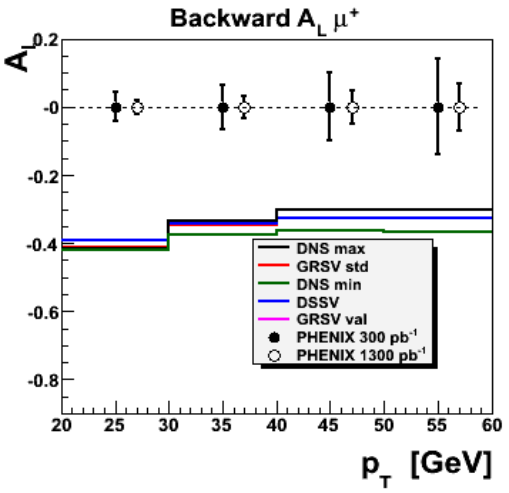


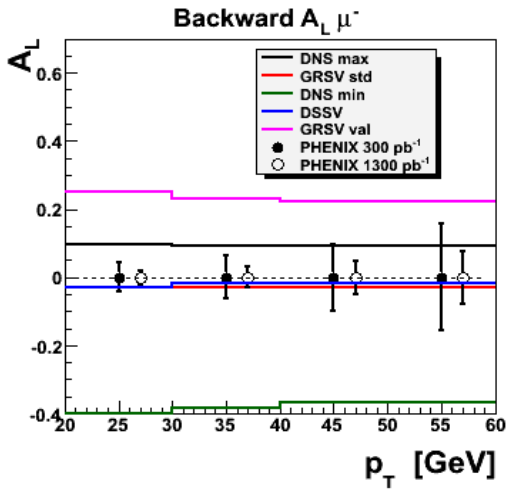
$$A_L^{W^+} = \frac{\sigma_+ - \sigma_-}{\sigma_+ + \sigma_-} \sim \frac{\Delta u(x_1)\bar{d}(x_2) - \Delta \bar{d}(x_1)u(x_2)}{u(x_1)\bar{d}(x_2) + \bar{d}(x_1)u(x_2)}$$

● 300 pb^{-1} ○ 1300 pb^{-1}









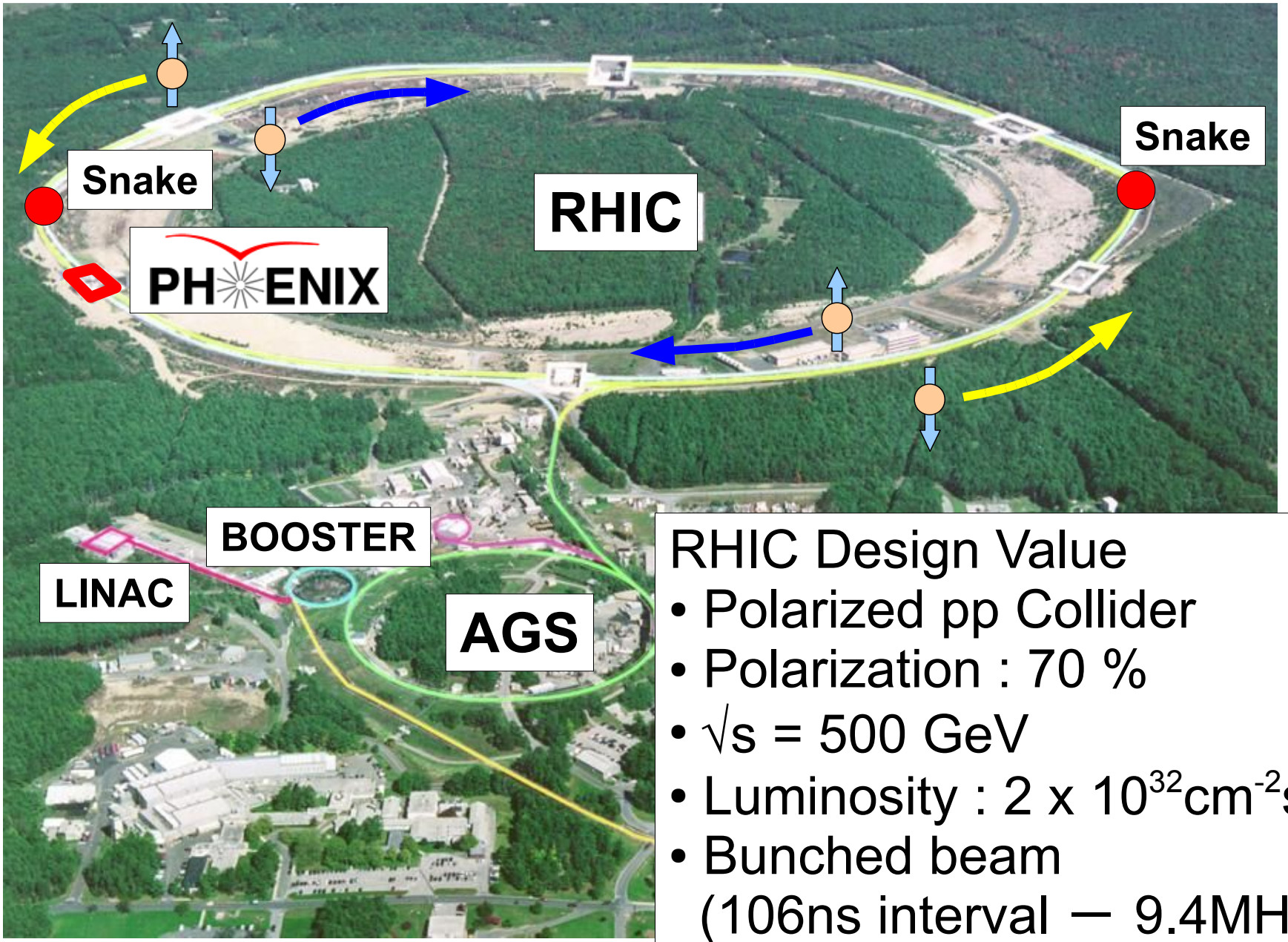
Feature of pp->W at RHIC

- u+$\bar{d}$ -> W^+, $\bar{u}$+d -> W^-
- q : helicity-, $\bar{q}$: helicity+
- No uncertainty from fragmentation function.
- But, low statistics

Talk by Todd Kempel on Monday

RHIC

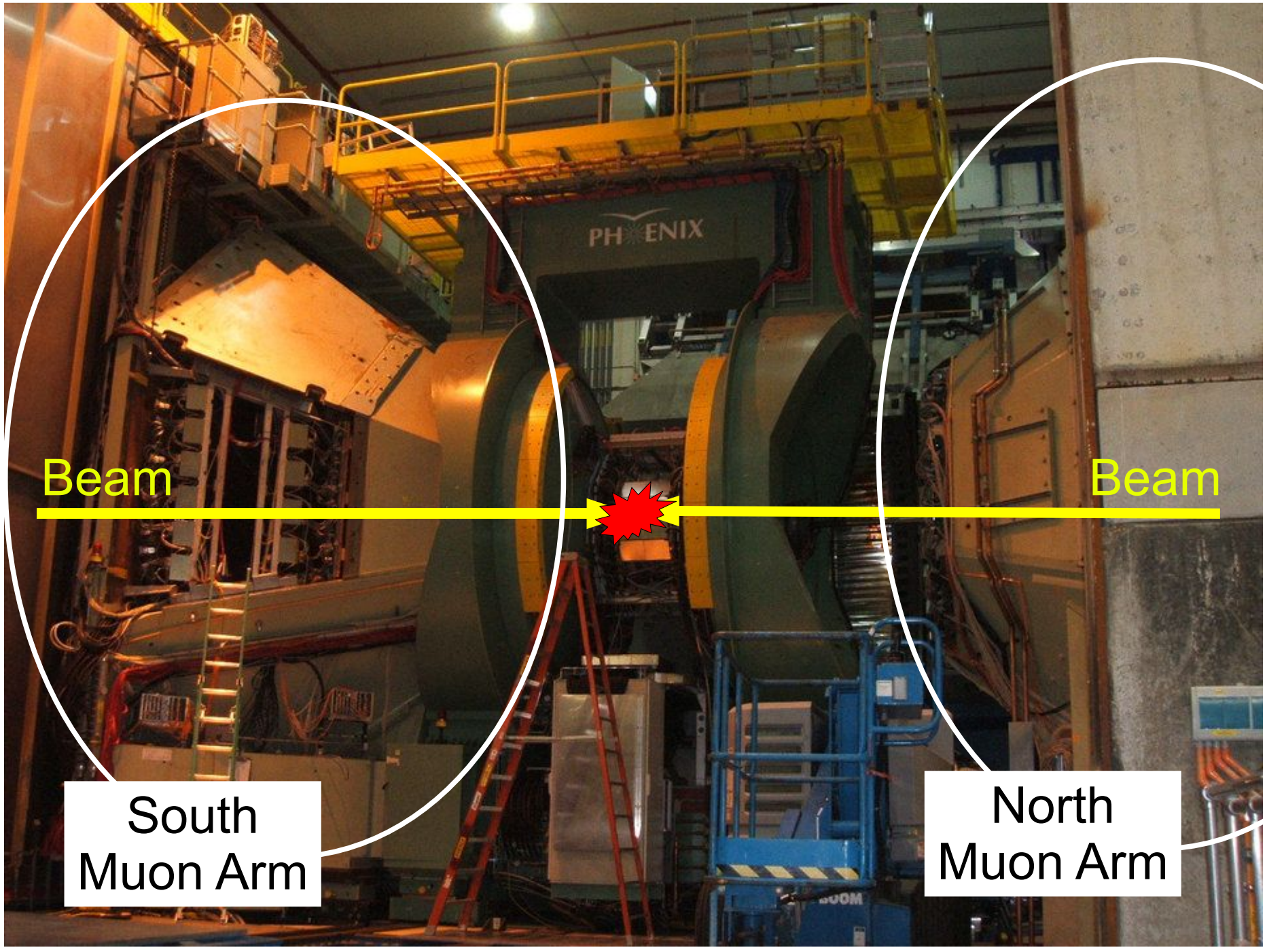
First physics run with 500GeV was operated in 2009.



RHIC Design Value

- Polarized pp Collider
- Polarization : 70 %
- $\sqrt{s}$ = 500 GeV
- Luminosity : 2 x $10^{32}cm^{-2}s^{-1}$
- Bunched beam
  (106ns interval — 9.4MHz)

PHENIX detector



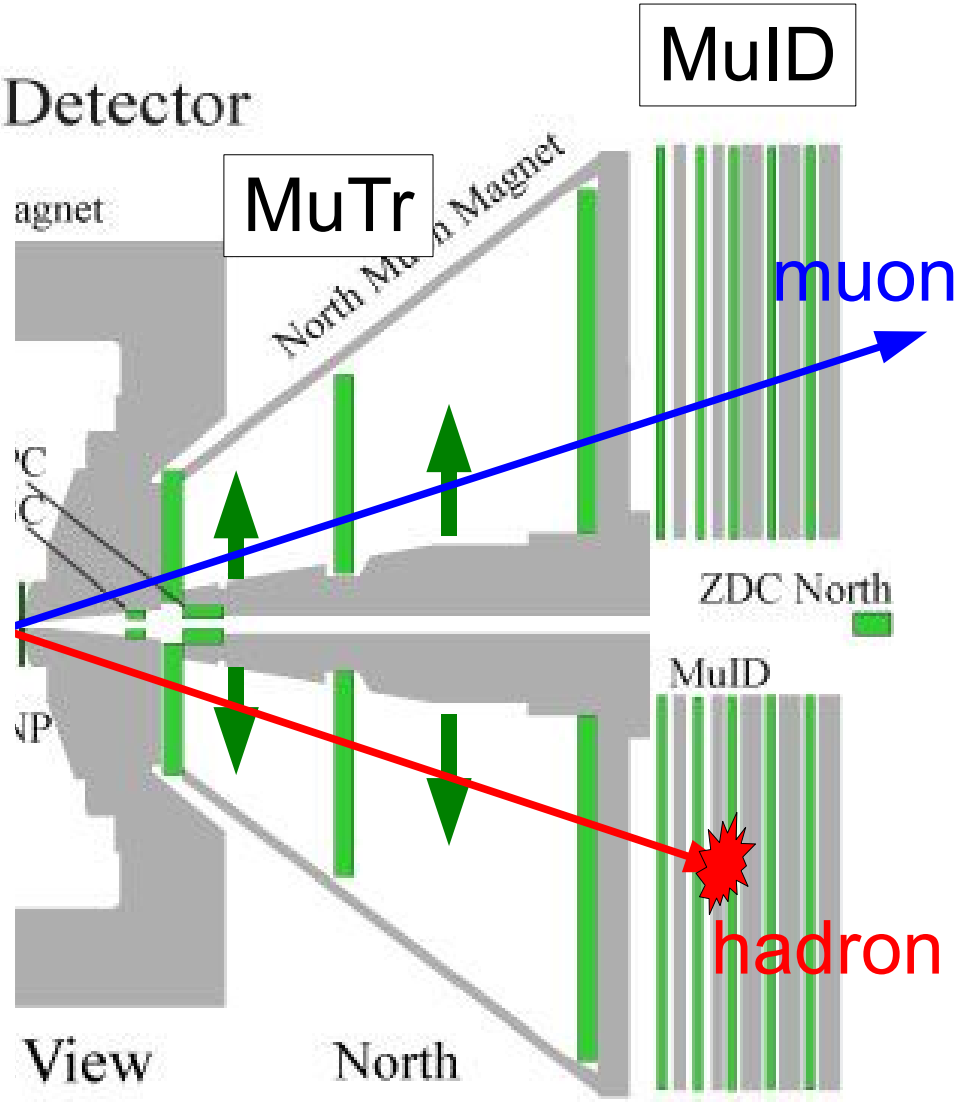
Current Muon Arm

Muon Tracking Chamber (MuTr)

- 3 stations of Cathode Strip Chambers
- 3 gaps + 3 gaps + 2 gaps
- Each gap has non-stereo plane, stereo-plane, and anode plane

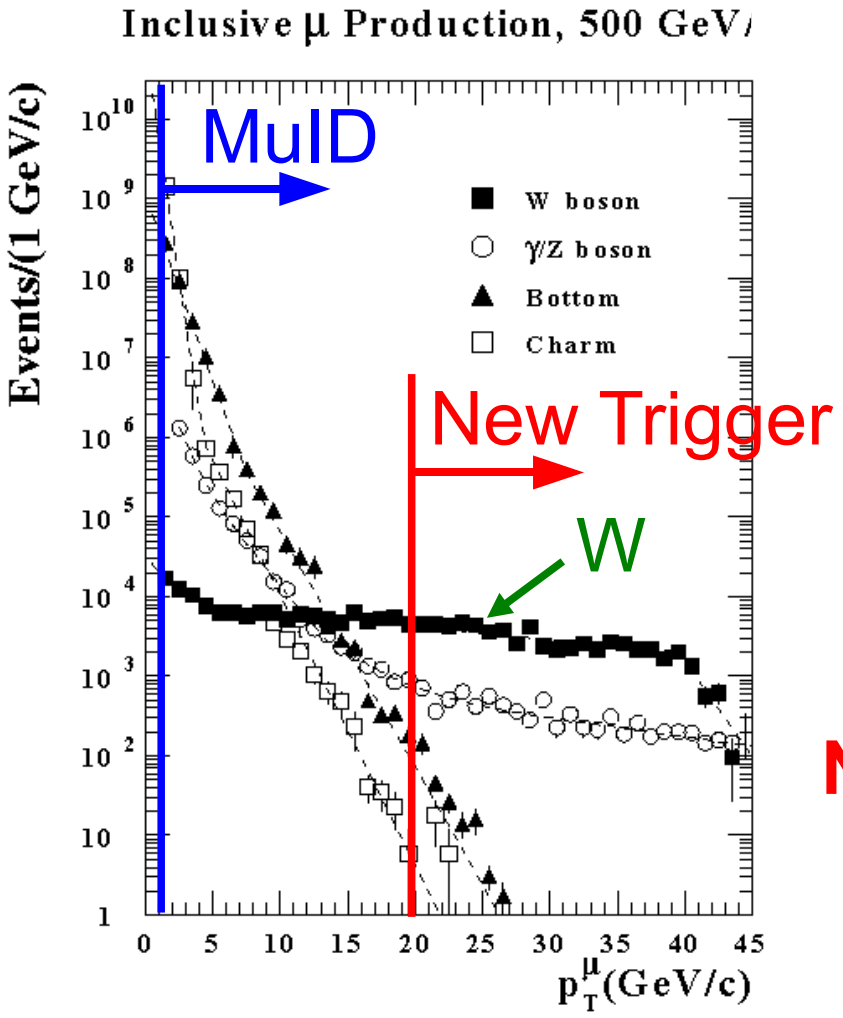
Muon Identifier (MuID)

- 5 layers of Iarocci tubes in x and y directions
- 80 cm of steel plate absorber (total)
- **Provides trigger p_{muon} > 1.5 GeV/c**



Trigger threshold by MuID is too low to collect W events.

Need of New W Trigger



Current MuID trigger

200kHz at 500GeV

↓

DAQ bandwidth for muon arm ~2kHz

↓

Additional rejection factor of 100 is required (RF~5000 for pp collision)

New Momentum Sensitive Trigger

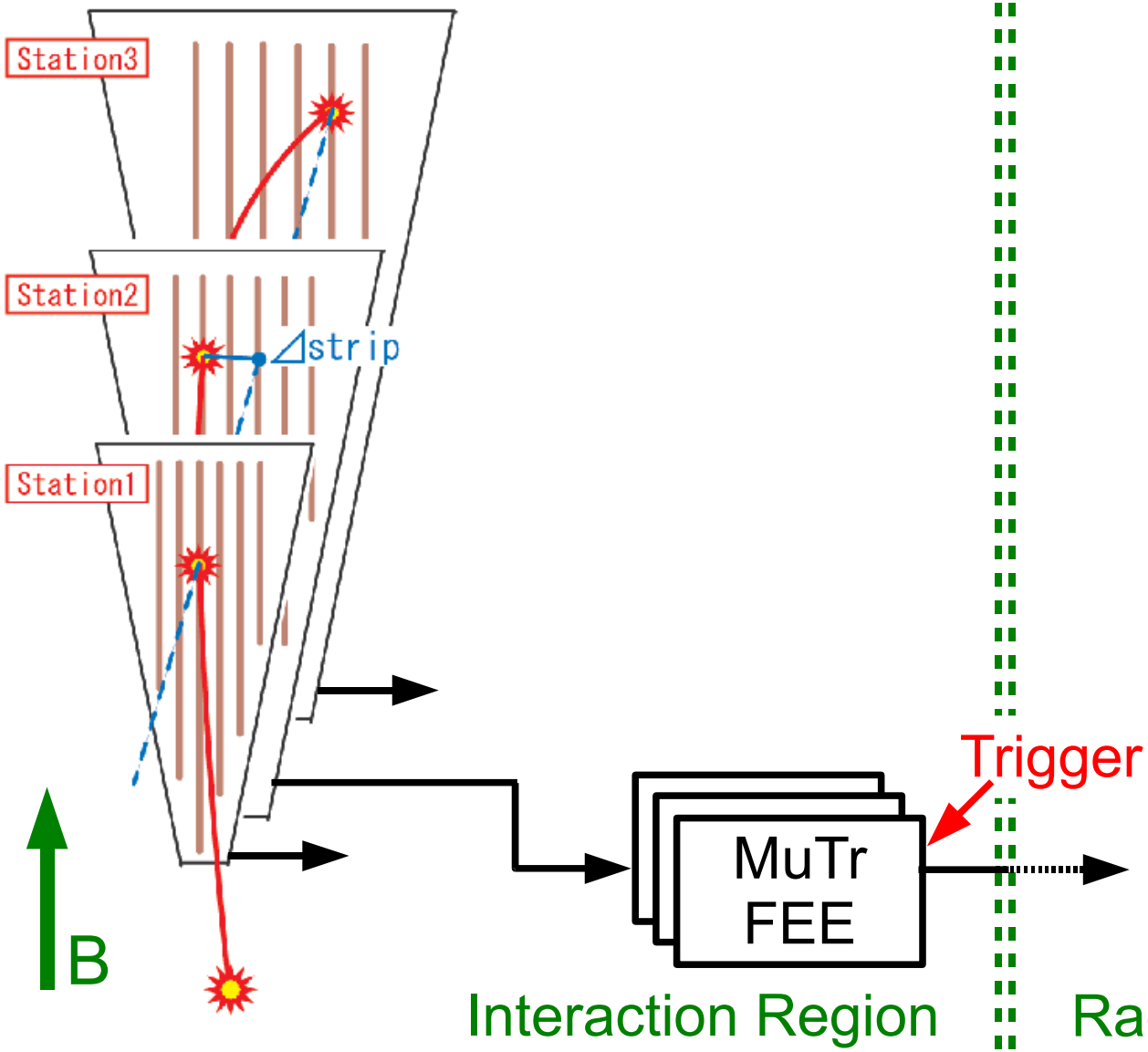
Fast online tracking and select straight track

↓

RF of 24000 for pp collision is expected. (simulation)

W Trigger System

Trigger events with straight track
(e.g. Δstrip <= 1)



W Trigger System

Trigger events with straight track
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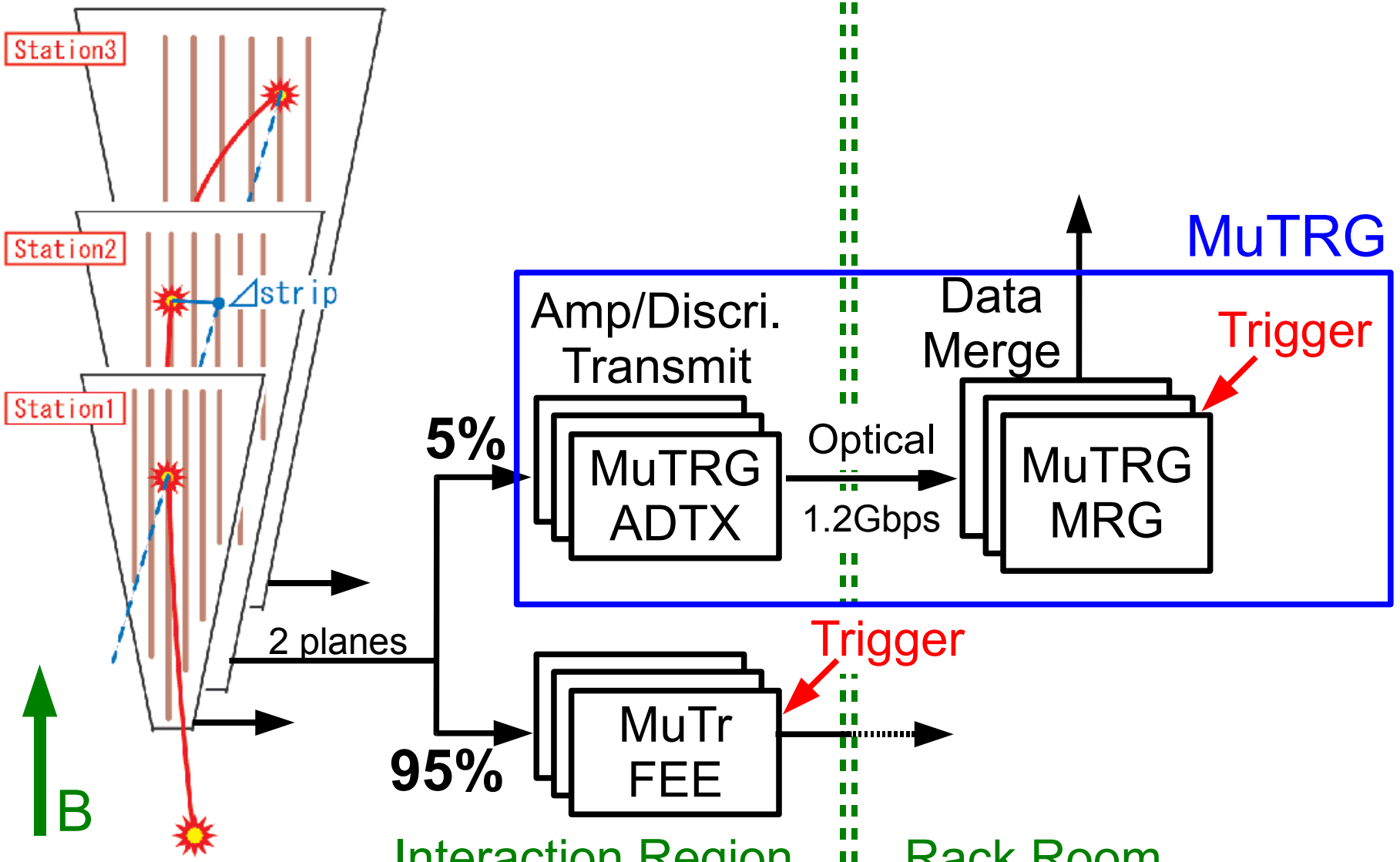
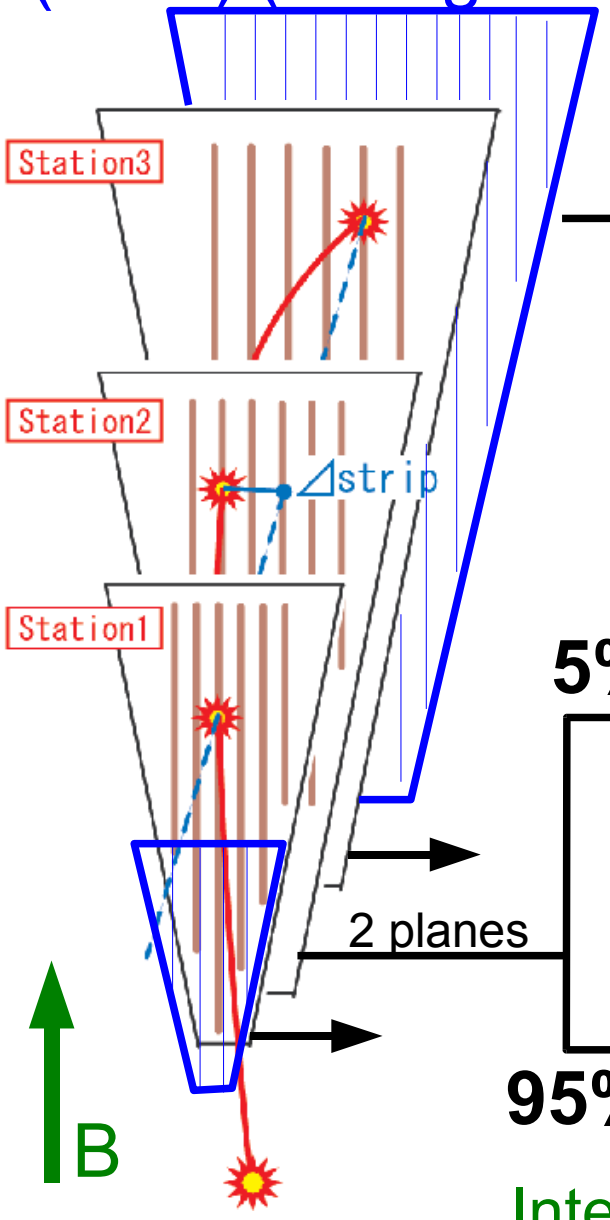


W Trigger System

Resistive Plate Counter (RPC) (Φ segmented)

Trigger events with straight track (e.g. Δstrip <= 1)



RPC FEE

MuTRG

Amp/Discri. Transmit

Data Merge

Trigger

5%

MuTRG ADTX

Optical

1.2Gbps

MuTRG MRG

2 planes

Trigger

95%

MuTr FEE

B

RPC / MuTRG data are also recorded on disk.

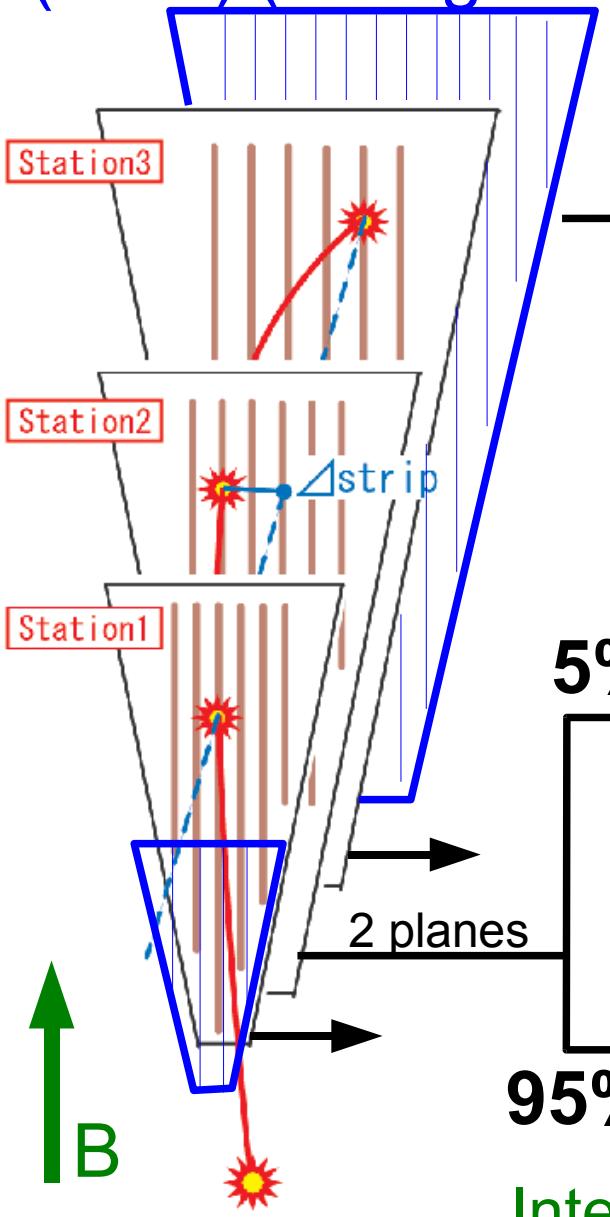
Interaction Region

Rack Room

W Trigger System

Resistive Plate Counter (RPC) (Φ segmented)

Trigger events with straight track (e.g. Δstrip <= 1)



RPC FEE

Level 1 Trigger Board

Trigger

MuTRG

Amp/Discri. Transmit

Data Merge

Trigger

5%

MuTRG ADTX

Optical

1.2Gbps

MuTRG MRG

Trigger

95%

MuTr FEE

RPC / MuTRG data are also recorded on disk.

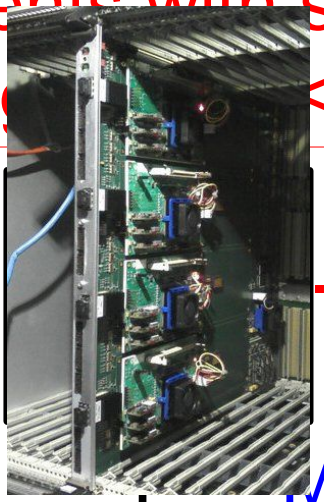
Interaction Region

Rack Room

W Trigger System

Resistive Plate Counter
(RPC) (Φ segmented)

Trigger events with straight track
(e.g. <= 1)



Trigger

RPC
FEE

MuTRG

Station3

Station2

strip

Station1

Amp/Discri.

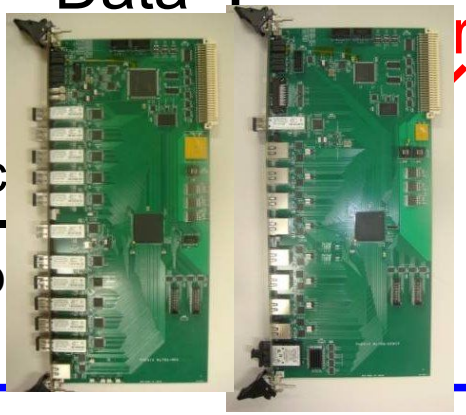
Data

rigger

5%

ptic

2Gb



2 planes

Trigger

95%

MuTr
FEE

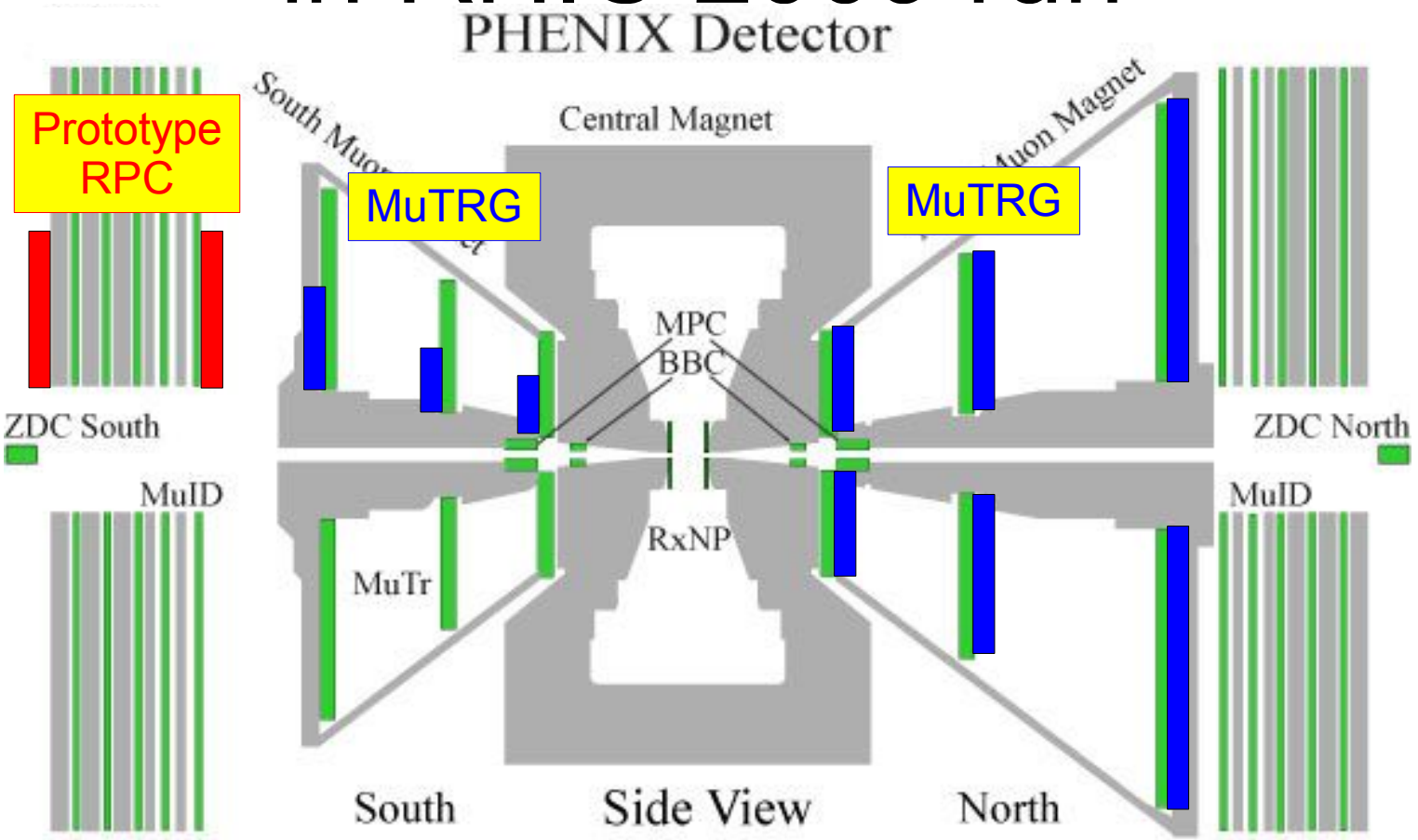
RPC / MuTRG data are
also recorded on disk.

B

Interaction Region

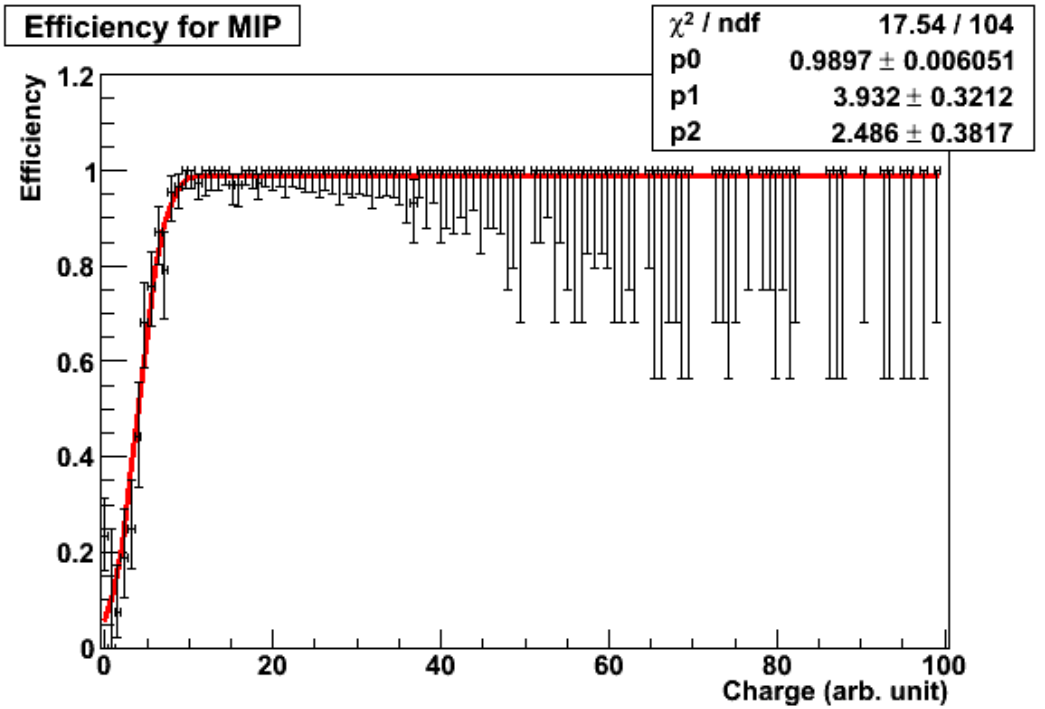
Rack Room

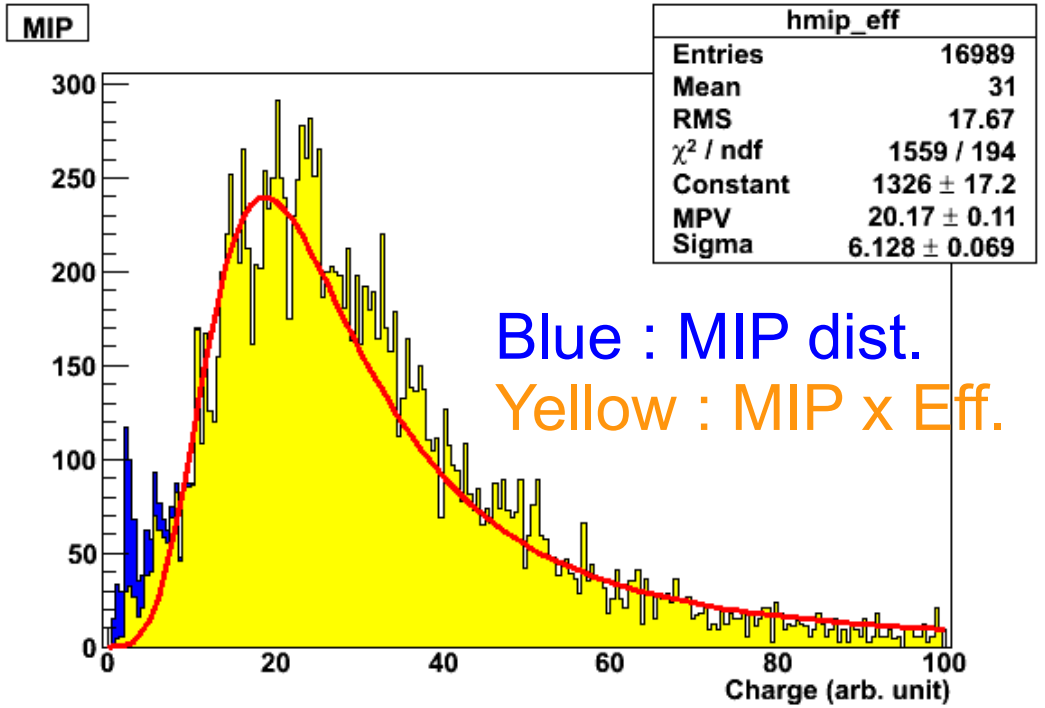
W Trigger Instrumentation in RHIC 2009 run



- MuTRG was installed fully in north arm and partially in south arm.
- Prototype RPC was installed partially in south arm.
- Evaluate performance of RPC and MuTRG with beam of $\sqrt{s}$=500 GeV.

Efficiency for MIP (MuTRG)





Efficiency ~ 100%
at Plateau

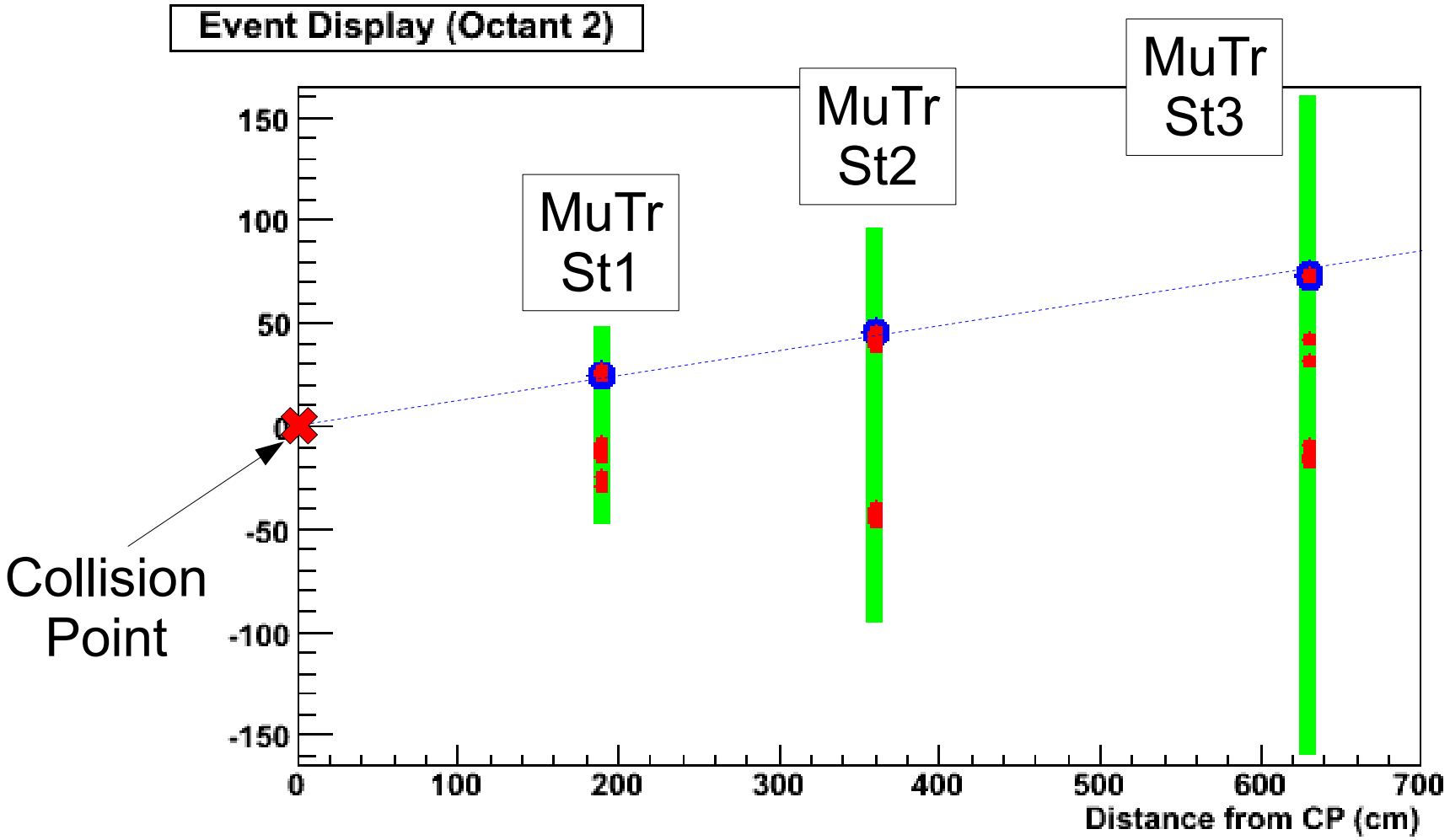
Turn on Point of
Efficiency Curve ~ 4

Most Probable Value
of MIP ~ 20

MuTRG and MuTr have matching properly.

Efficiency for MIP is 97.5% (Yellow / Blue)

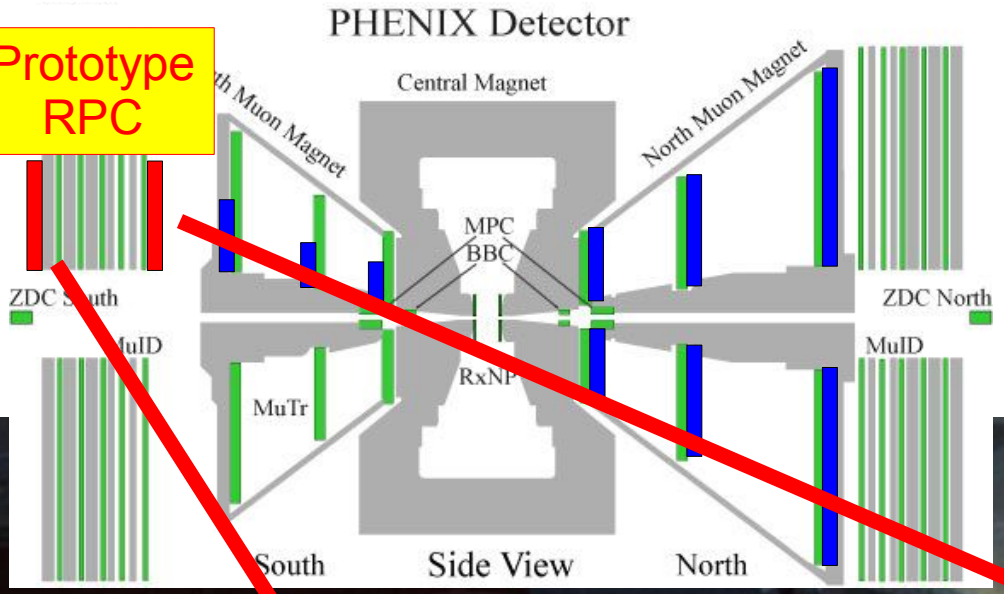
Trigger Emulation in Offline Analysis (only MuTRG)

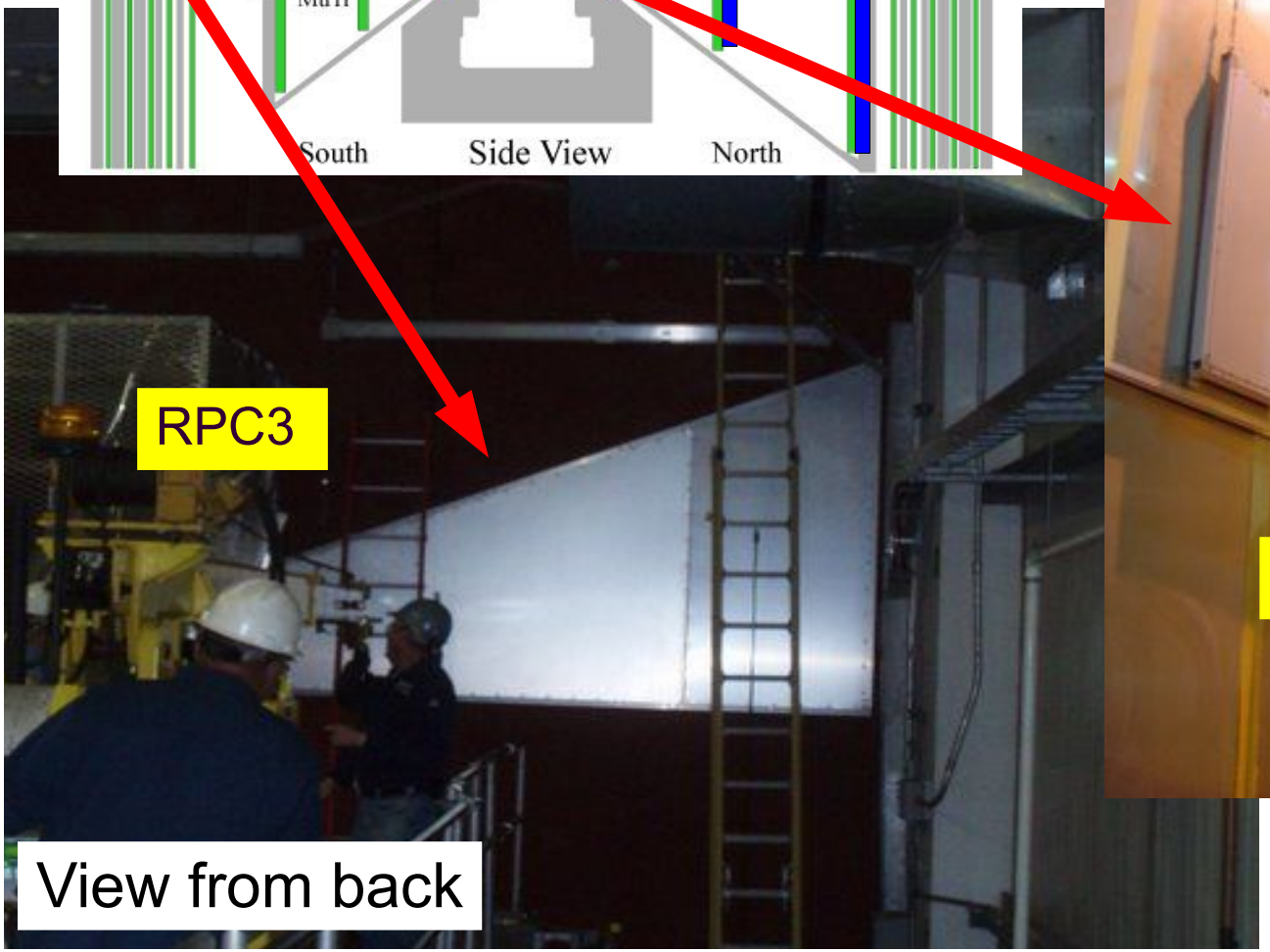


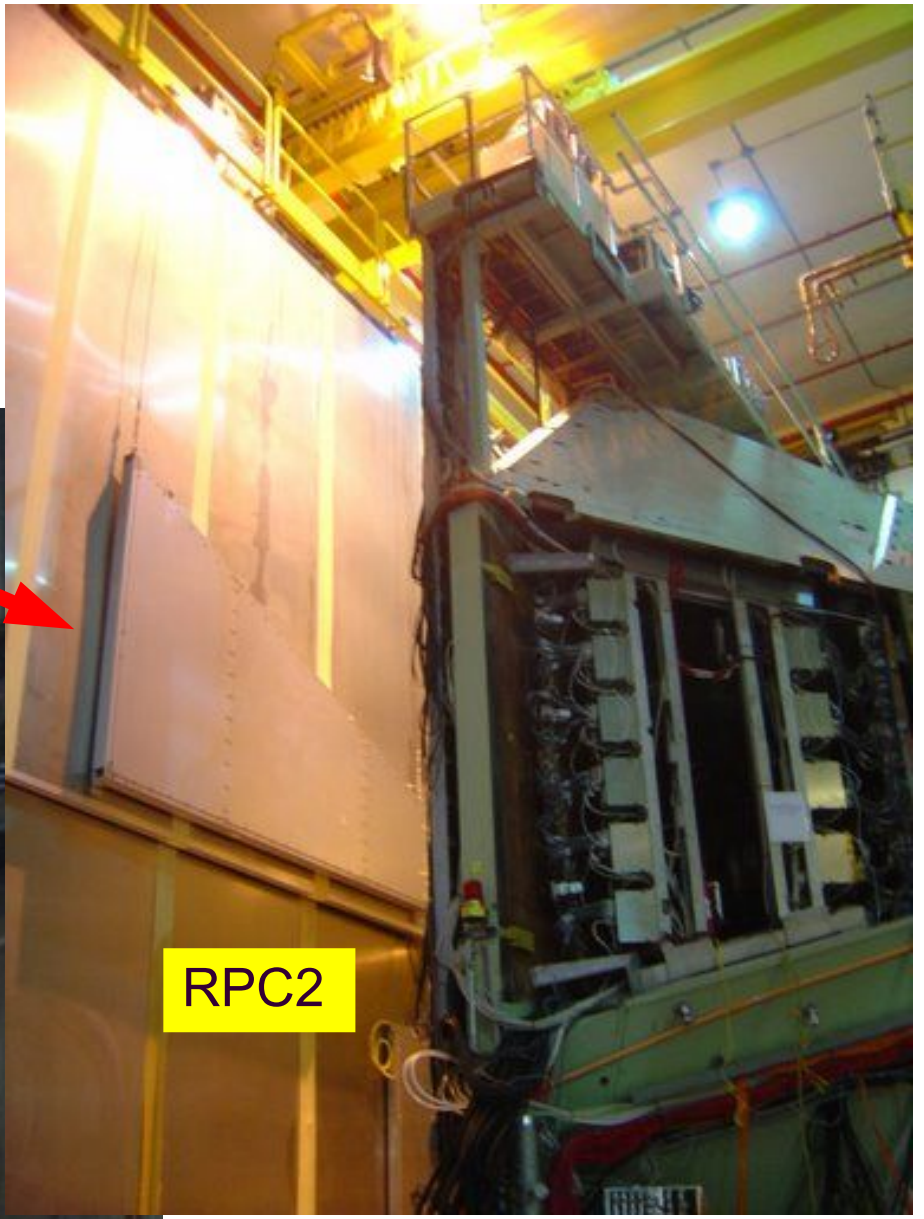
Red : MuTRG Hit, Blue : Accepted Track

Study of rejection power is ongoing in offline analysis.

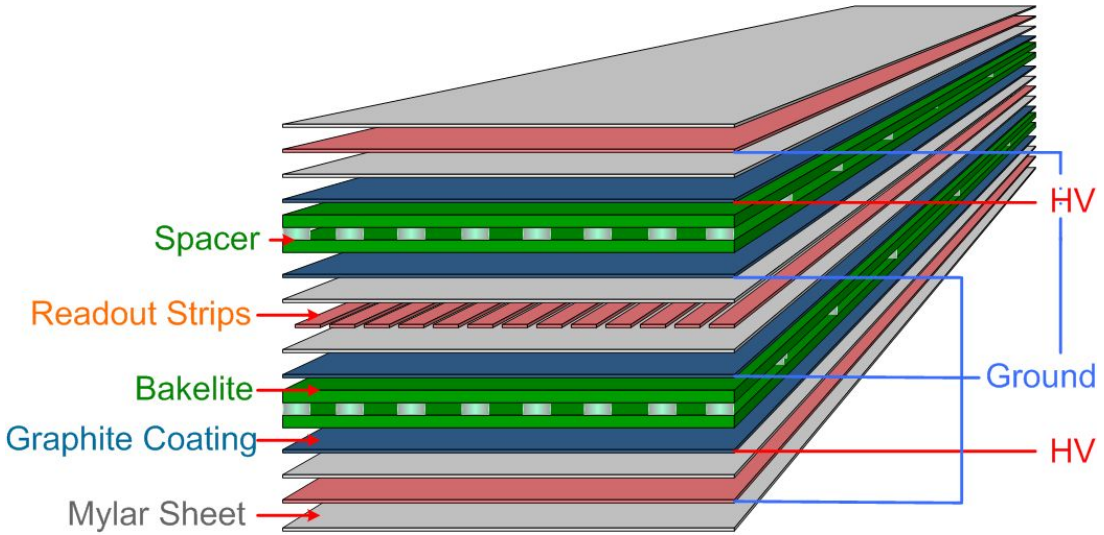
Prototype RPC installed in 2009 run

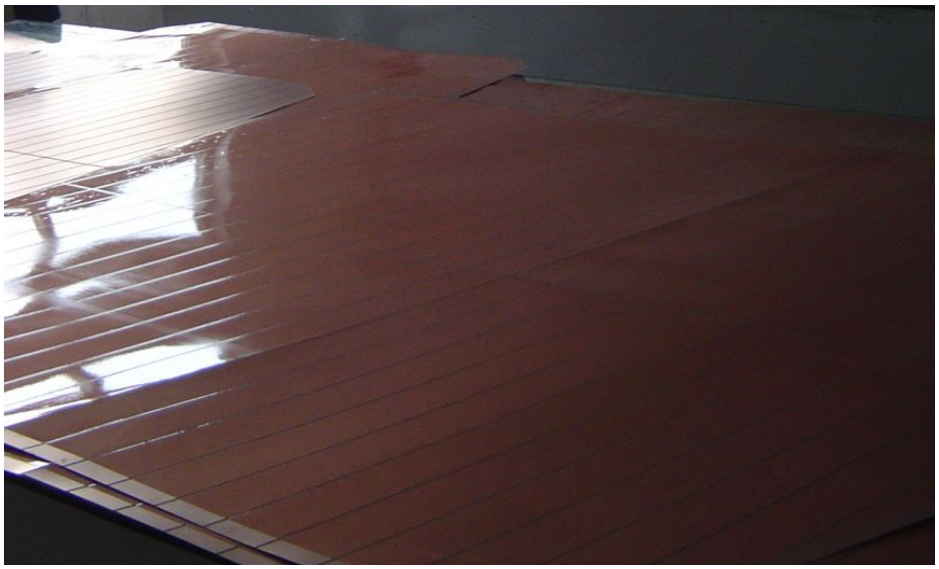






RPC





PHENIX RPC picked LHC-CMS technology

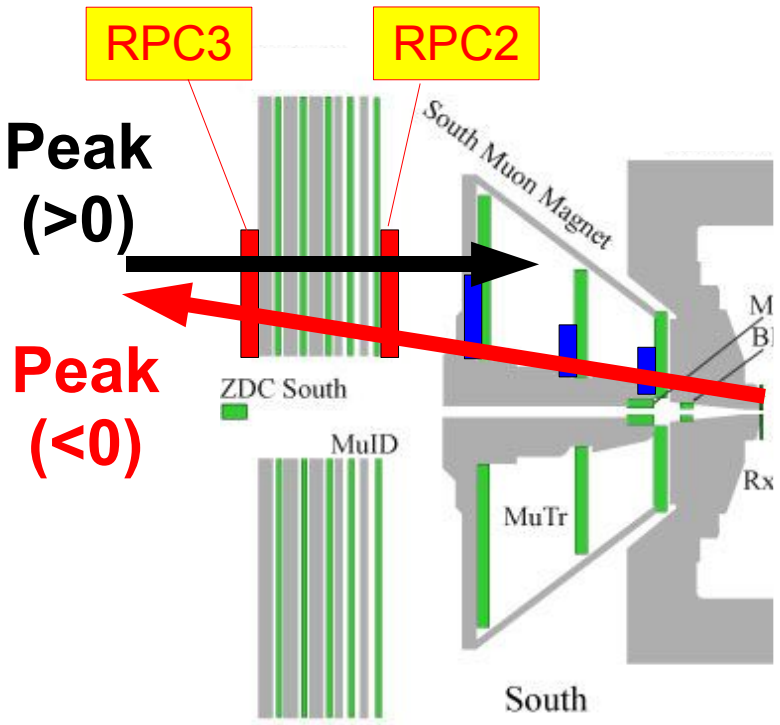
Readout strips are segmented (~1 degree in Φ angle)

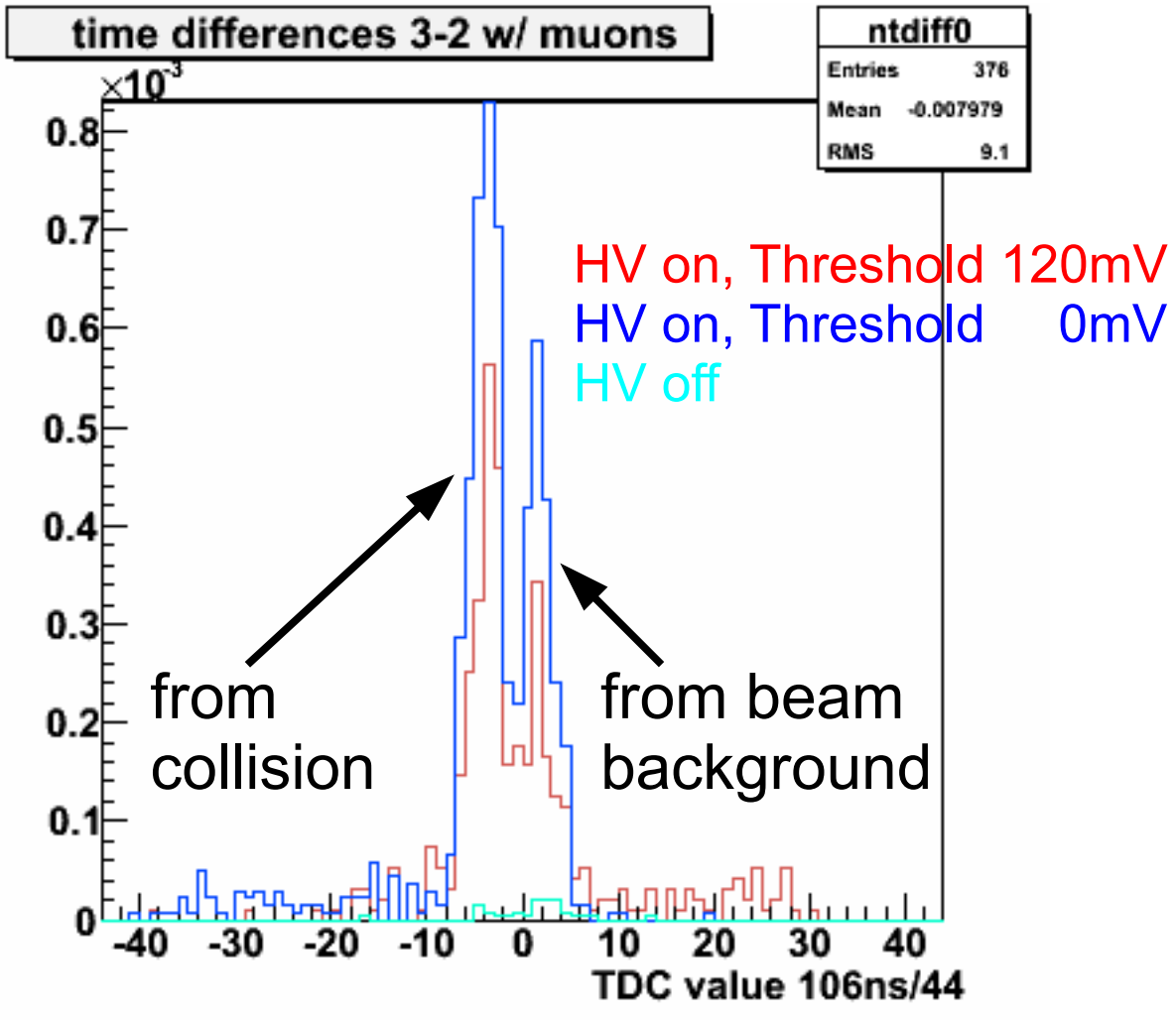
RPC Feature

- Fast Response
- **Good Time Resolution : 1-2 ns**
- Good Spacial Resolution : ~cm
- Small Cluster Size
- High Rate Capability

RPC meets W trigger requirement

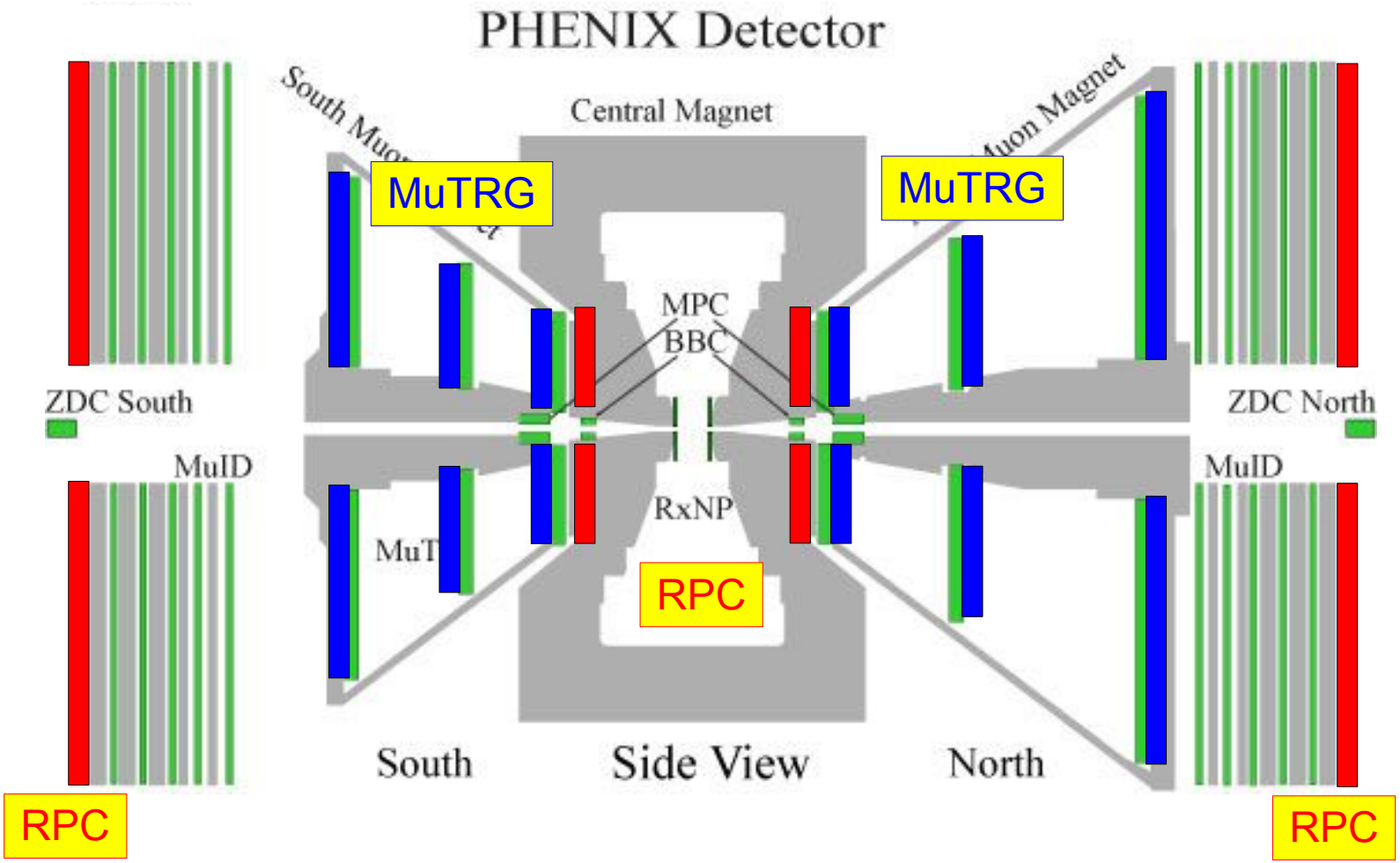
Prototype RPC Timing Distribution





Peak (<0) : Tracks coming from collision or outgoing beam.
Peak (>0) : Background by incoming beam.
Width of each peak : 3ns

Final W Trigger Instrumentation



Installation of RPC and MuTRG will complete by 2010 and they are ready for the next 500 GeV run.

Summary

- PHENIX upgrades forward W trigger (RPC + MuTRG) to study sea quark polarization in proton.
- Development of RPC and MuTRG is ongoing. A part of detectors were installed during shutdown period in 2008.
- RHIC operated 500GeV pp run in 2009. RPC and MuTRG took data and we evaluate performance of the detector.
- Installation of RPC and MuTRG will complete by the next physics run with 500 GeV.

Back Up

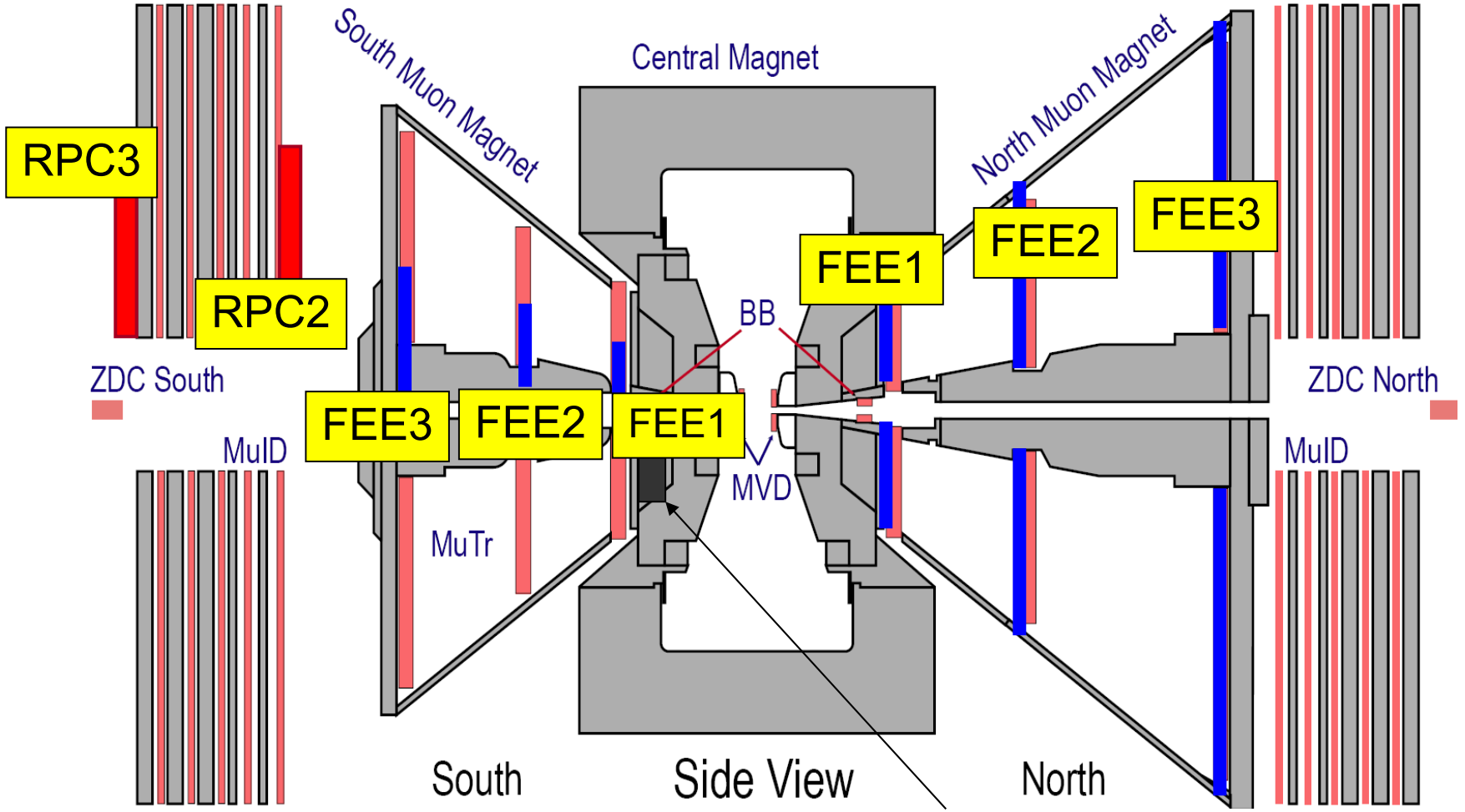
What is the features of W measurement, compared with SIDIS experiments.

> Independent from Fragmentation Function

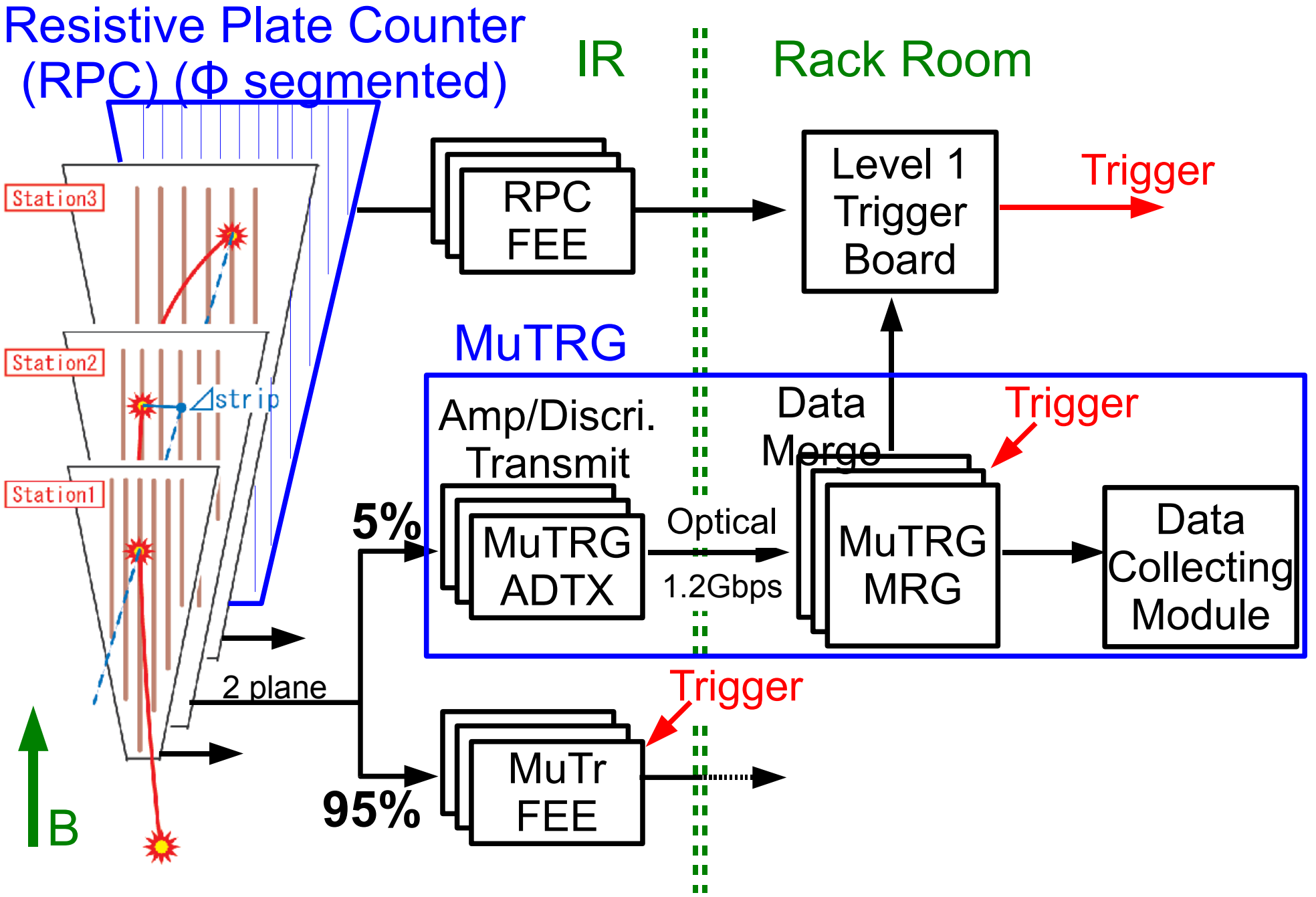
> Energy Scale is high

> u, d separation

W Trigger Instrumentation in RHIC-Run09



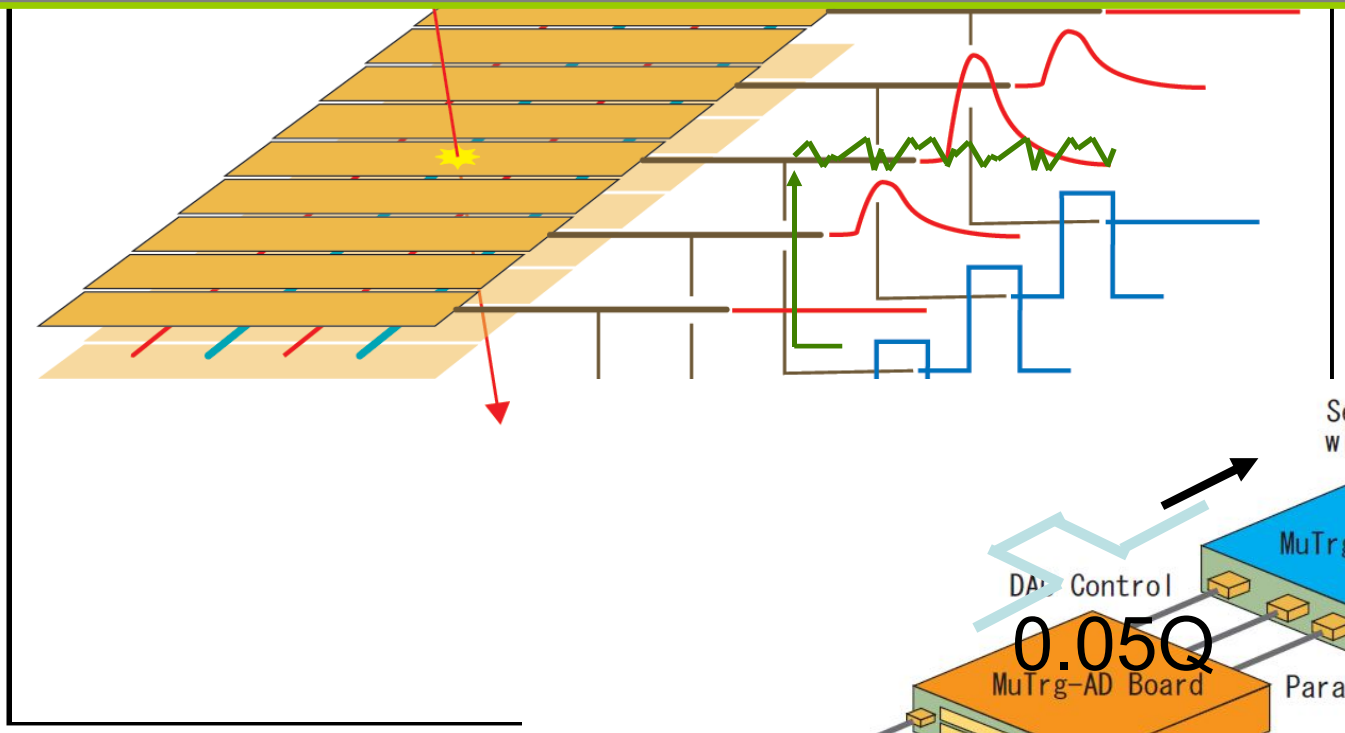
South Arm : Half Octant

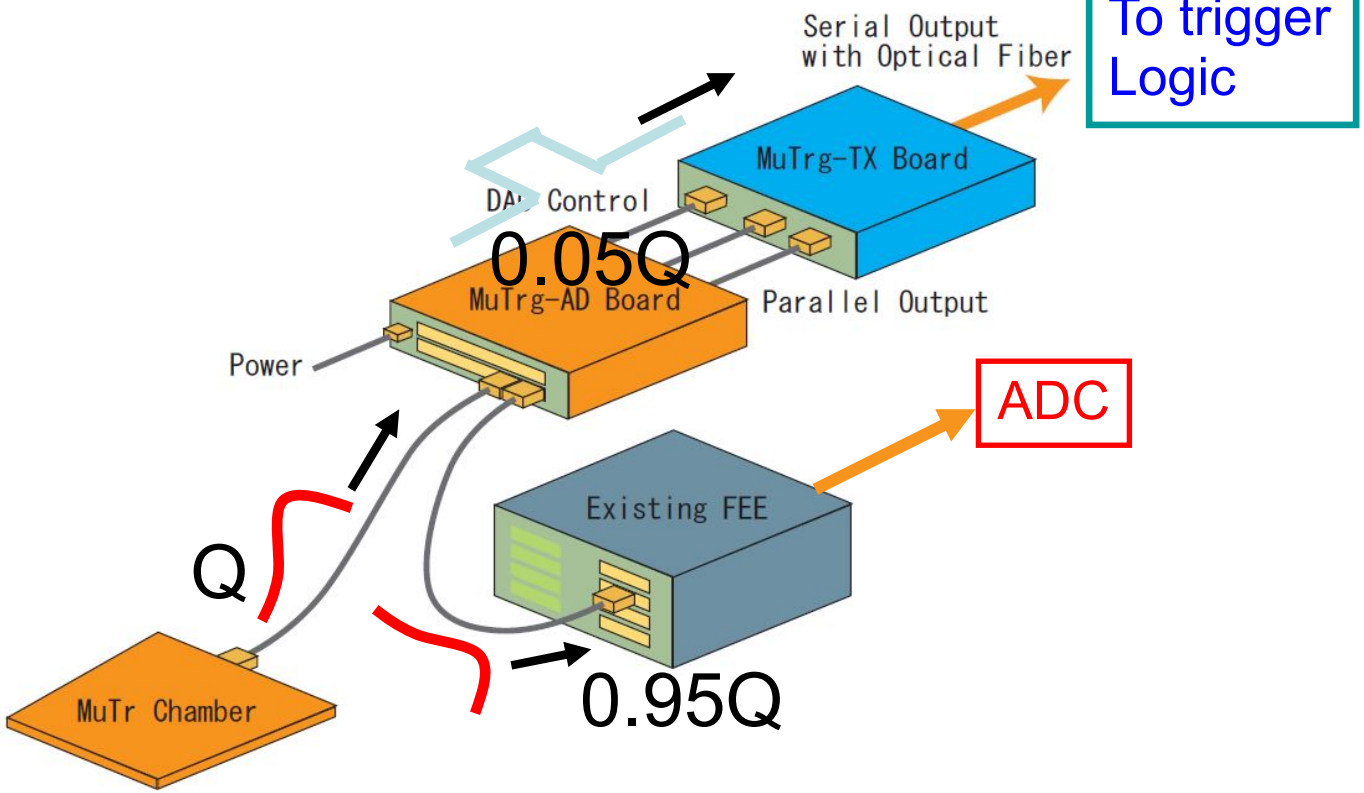

Resistive Plate Counter
(RPC) (Φ segmented)
IR
Rack Room
Station3
Station2
Station1
strip
RPC
FEE
Level 1
Trigger
Board
Trigger
MuTRG
Amp/Discri.
Transmit
Data
Merge
Trigger
5%
MuTRG
ADTX
Optical
1.2Gbps
MuTRG
MRG
Data
Collecting
Module
2 plane
Trigger
MuTr
FEE
95%
B

1. Minimum deterioration to existing MuTR performance

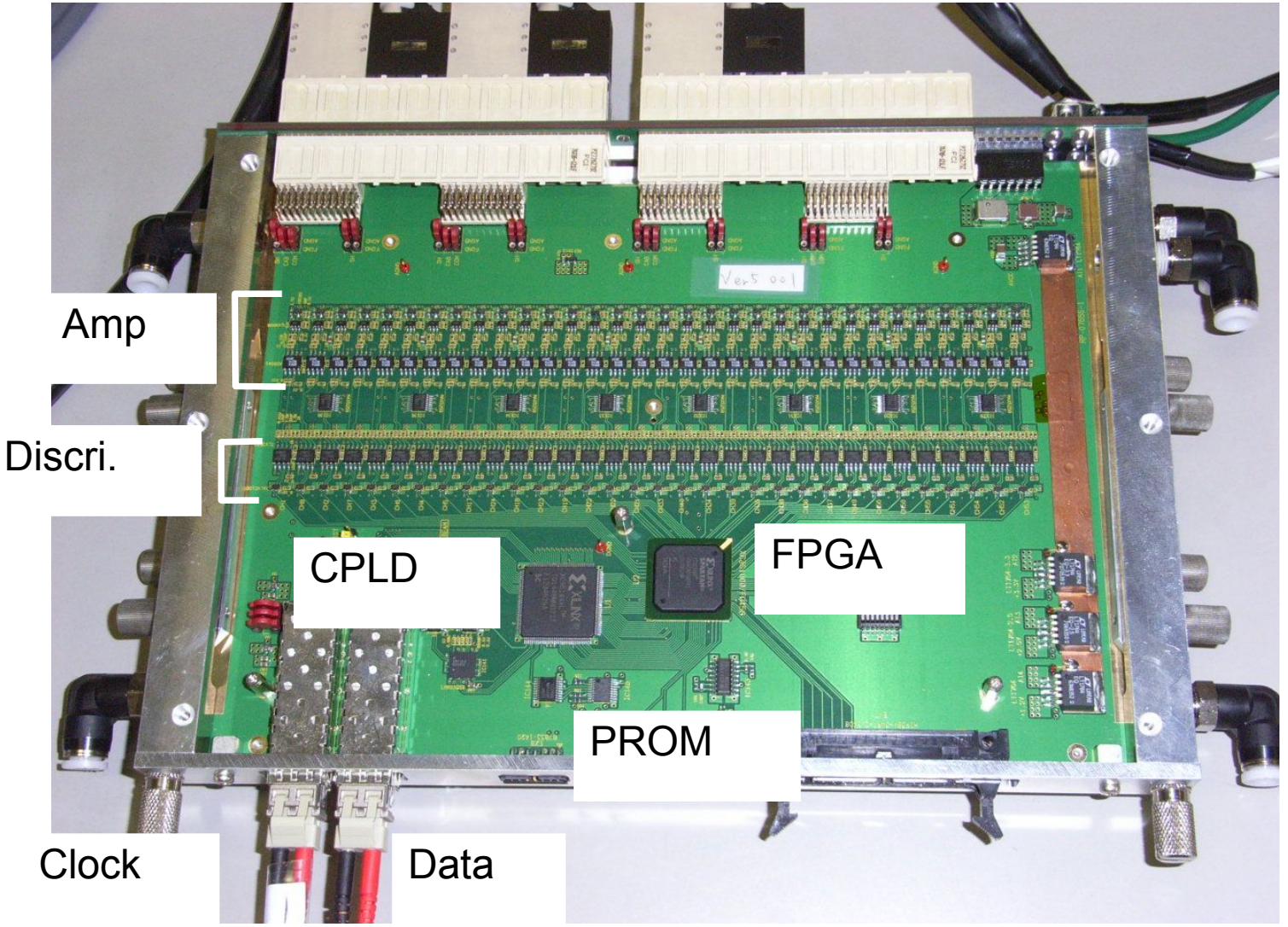
1. High/reliable triggering efficiency

Bottom Line

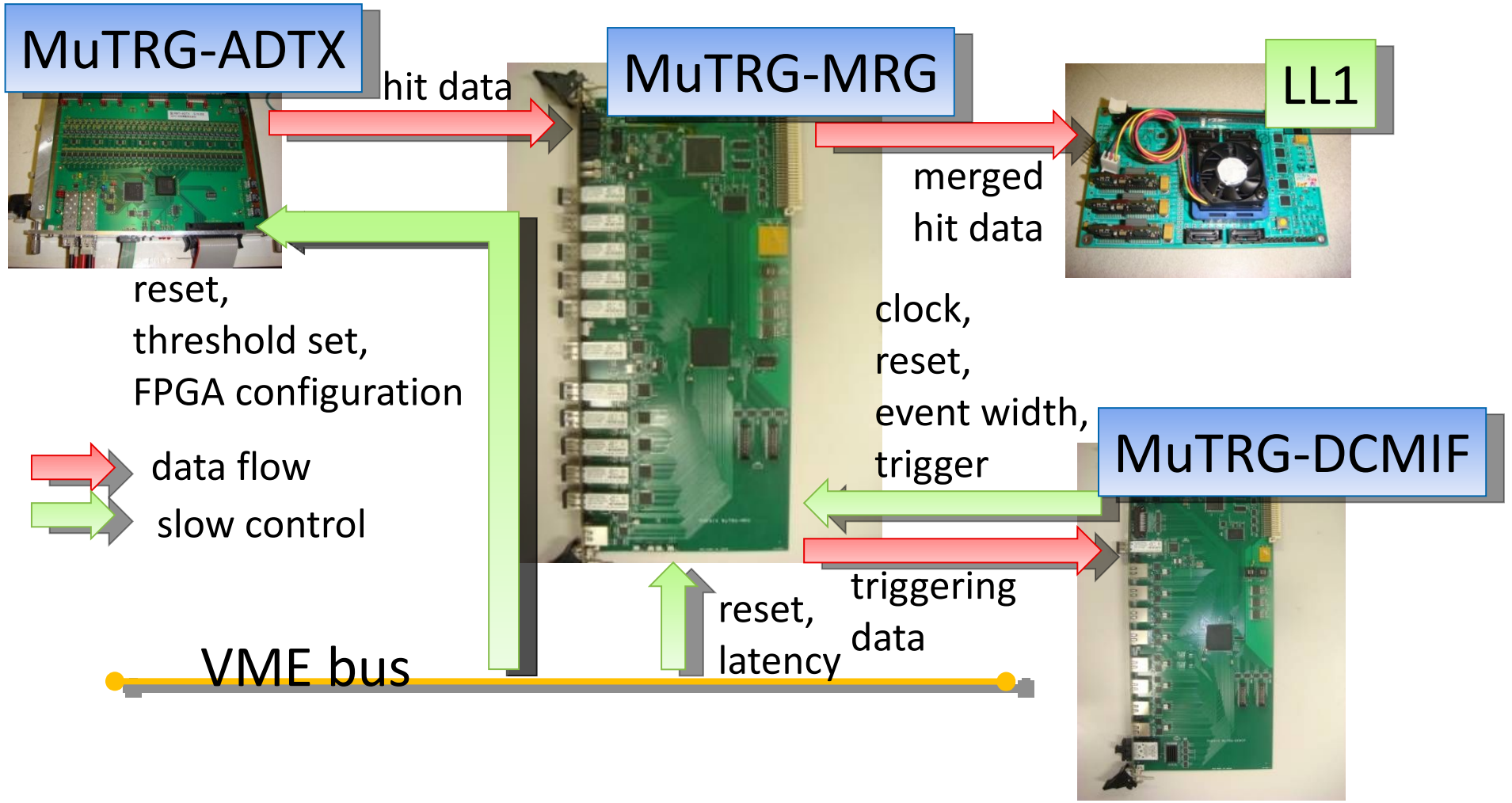




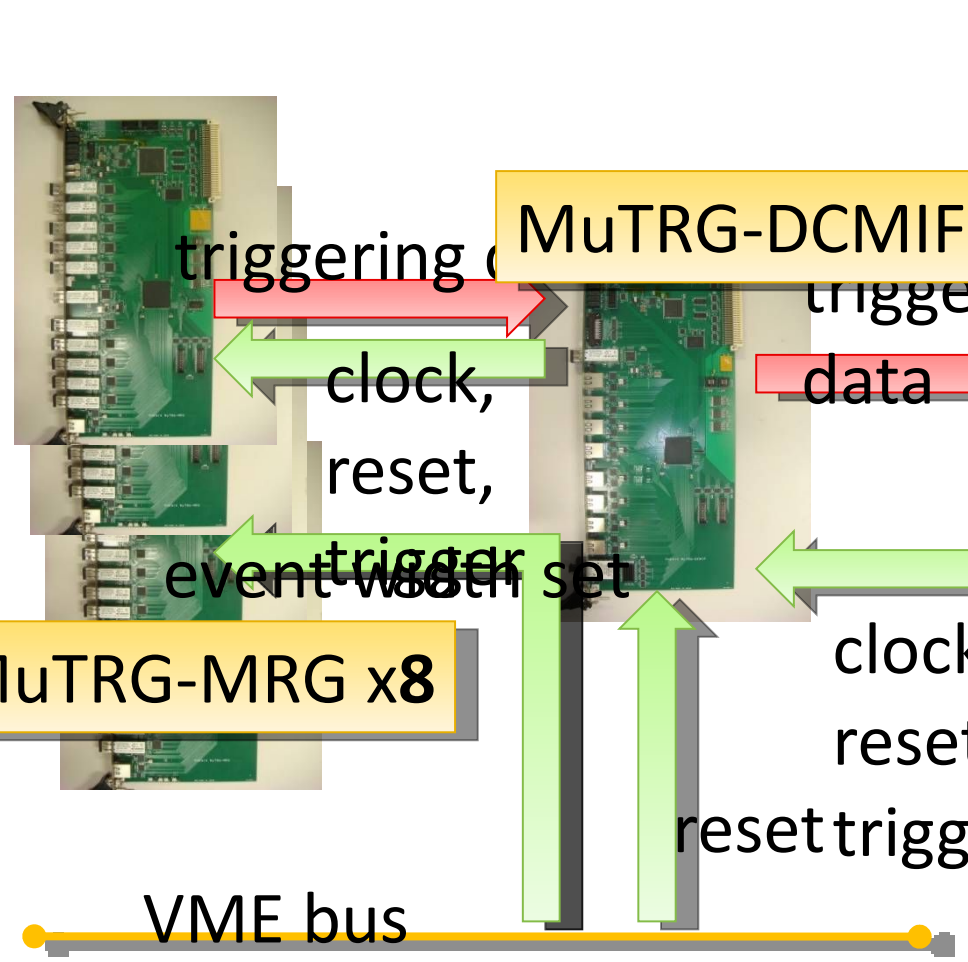
MuTRG-FEE (ADTX)



MuTRG-FEE (MRG and DCMIF)

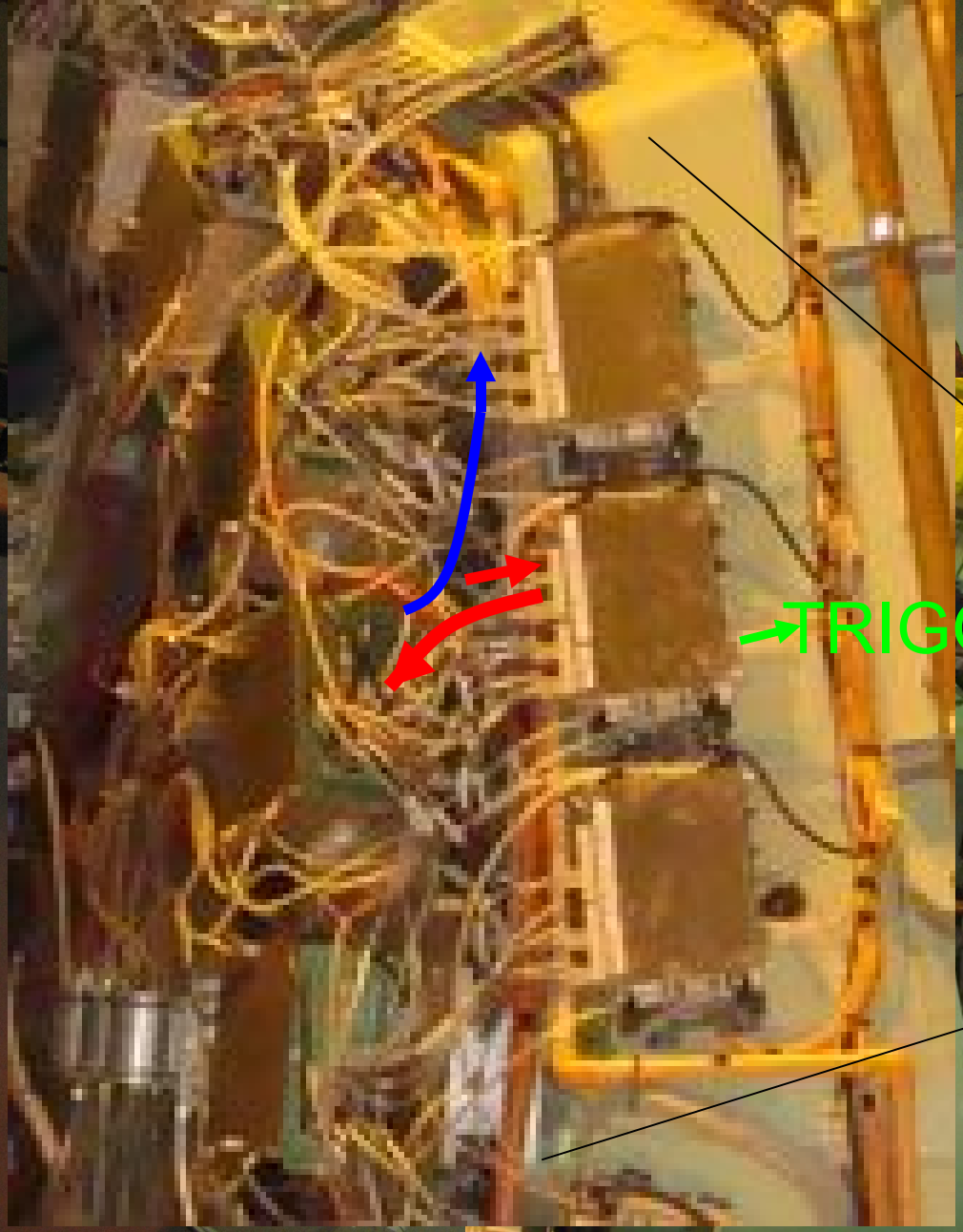


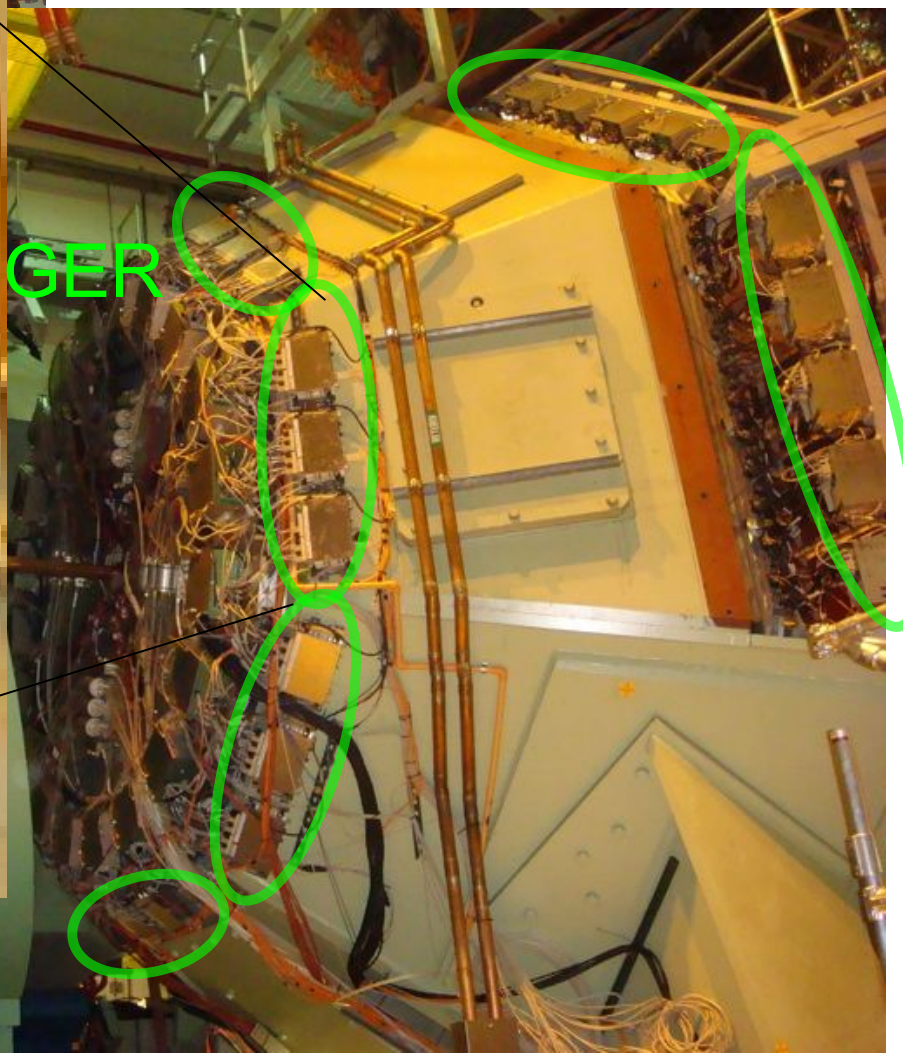
the roles of MuTRG-DCMIF

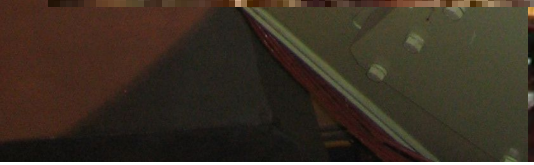


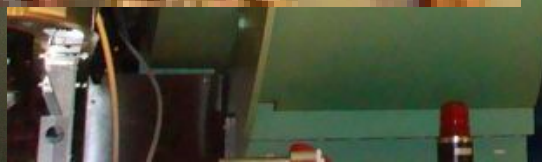
- one DCMIF board handles 8 MRG boards
- merge triggering data from MRG and send it to DCM
- distribute GTM signal (clock, reset, trigger) to MRG

all Status









PHENIX Muon Trigger Upgrade

(I) Three dedicated trigger RPC stations (CMS design):

R1(a,b): ~12mm in φ, 4x θ pads

R2: ~54mm in φ , 4x θ pads

R3: ~60mm in φ, 4x θ pads

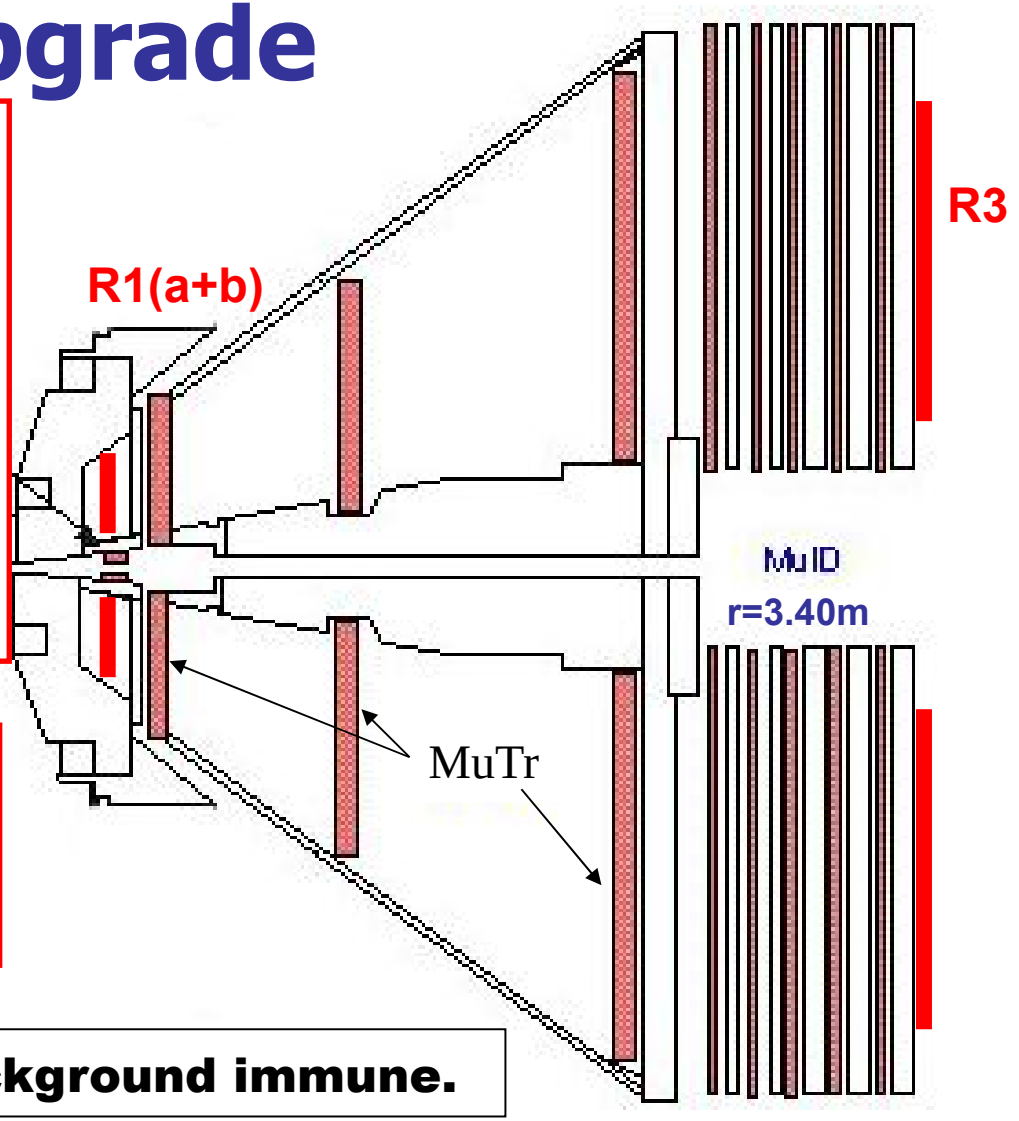
(Trigger only – offline segmentation higher)

NSF (Funded)

(I) MuTr front end electronics

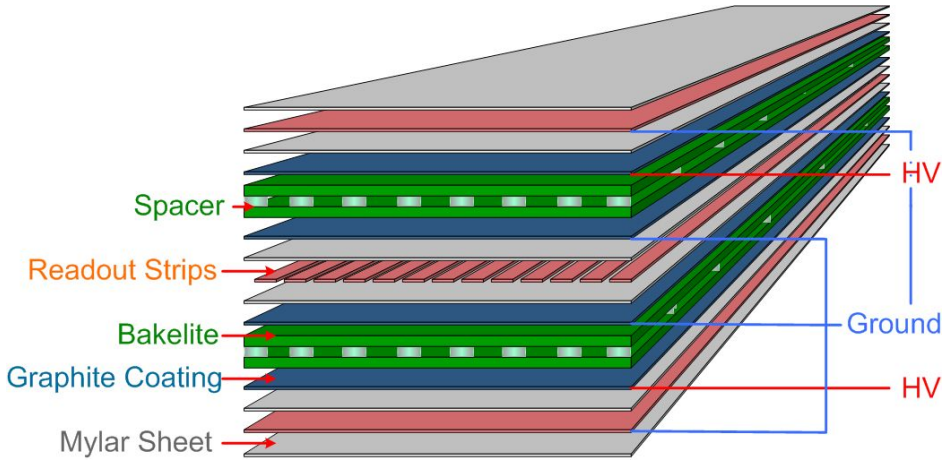
Upgrade to allow LL1 information

JSPS (Funded)



Rejection ~12,000, beam background immune.

RPC

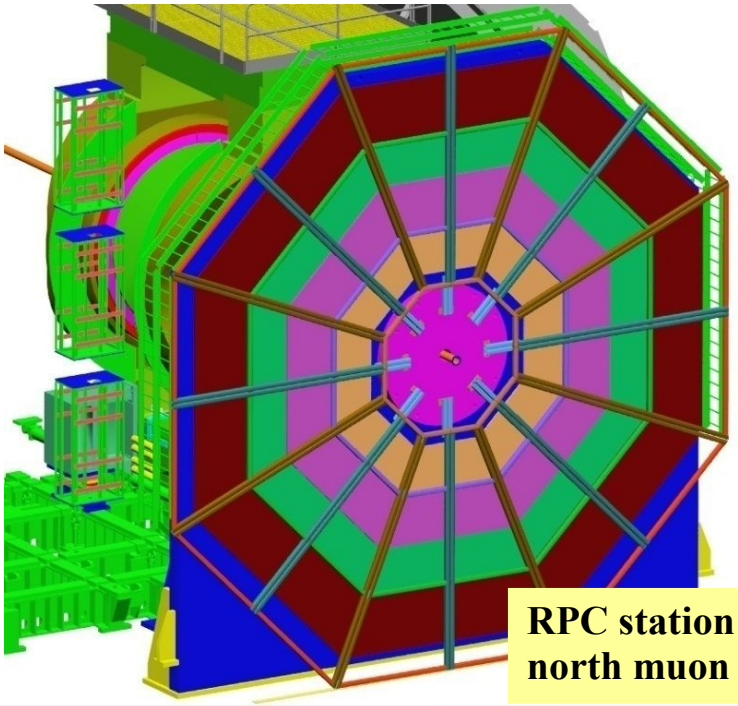


PHENIX detector requirement

Efficiency	> 95%
Time resolution	≤ 3 ns
Average cluster size	≤ 2 strips
Rate capability	0.5 kHz/cm^2
Number of streamers	< 10 %

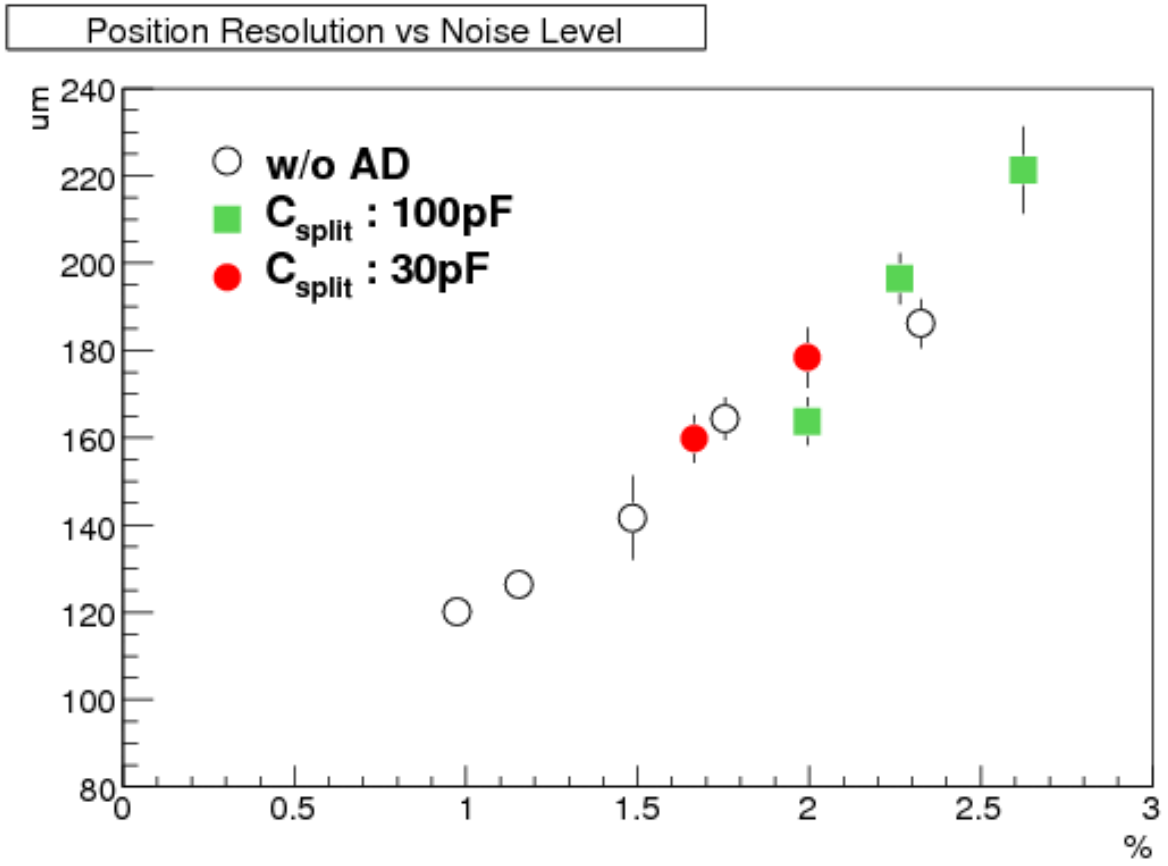
Characteristics of RPC

- Fast response
  - Suitable for the trigger device
- Good time resolution: 1-2 ns
- Good spatial resolution: typically ~ cm
  - Determined by the read-out strip width and cluster size
- Low cost
- Typical gas mixture
  - 95% $C_2H_2F_4$ + 4.5% i-C_4H_{10} + 0.5% SF_6



RPC station 3 at north muon arm

Noise Level to Position Resolution



Correlation between noise level and position resolution was observed in test experiment at Tohoku Univ. (Uncertainty of reference track ~50um)

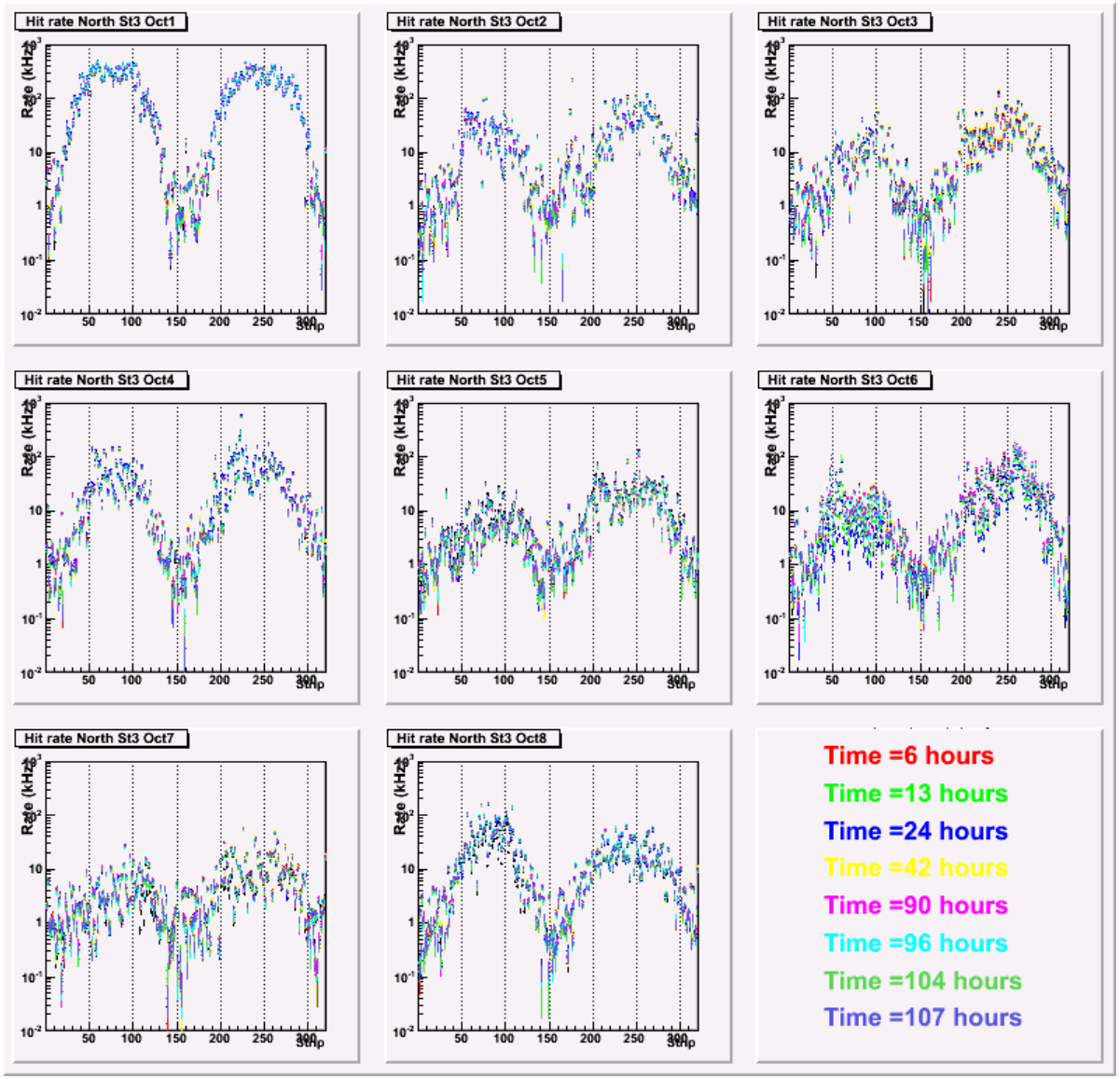
	Noise Level	Position Resolution
St1	1.2%	110 um
St2	1.3%	120 um
St2(HV+25V)	1.0%	100 um

Degradation of position resolution is acceptable.

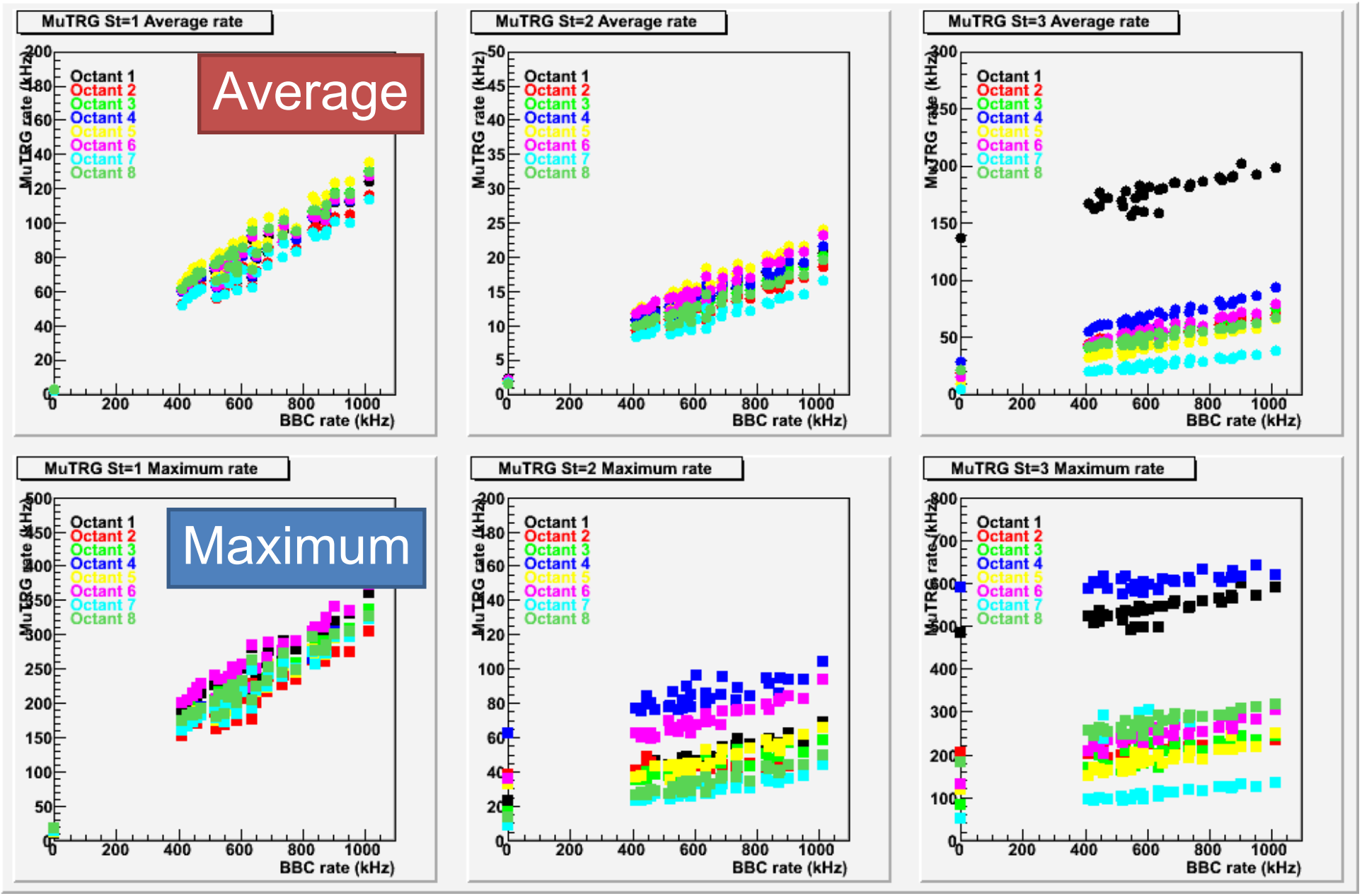
Design value is achieved by raising HV by 25V.

Fake hit rate (beam-off, 20 mV)

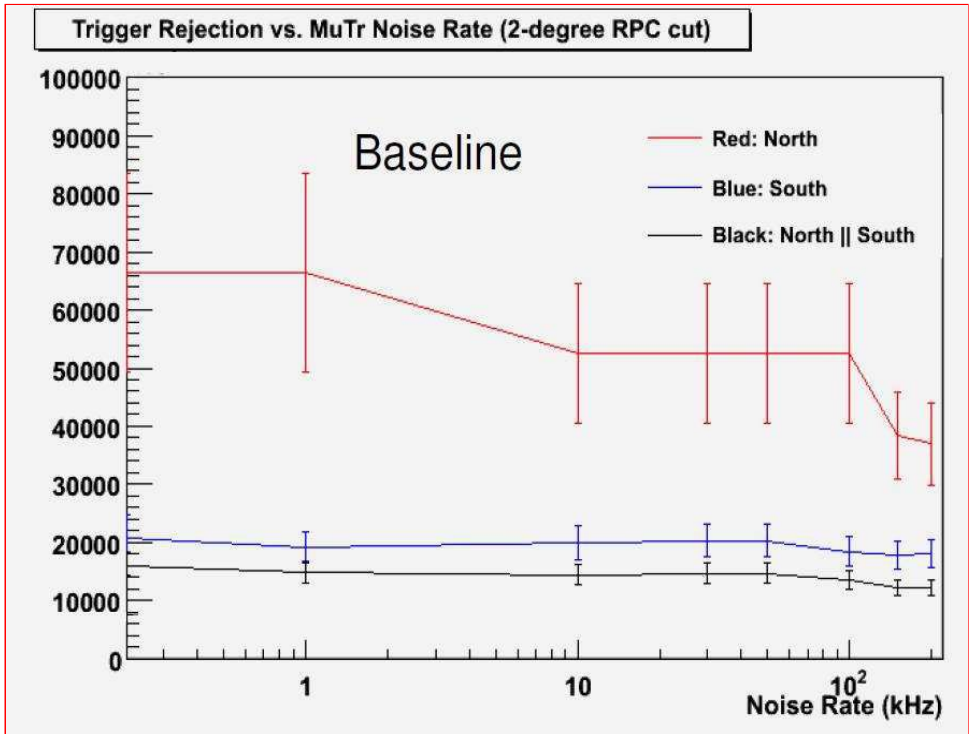
- The fake hit rate is typically 1-10k Hz
- Larger (~100k Hz) at N.St1.Oct1
- The fake hit rate is stable over a month.



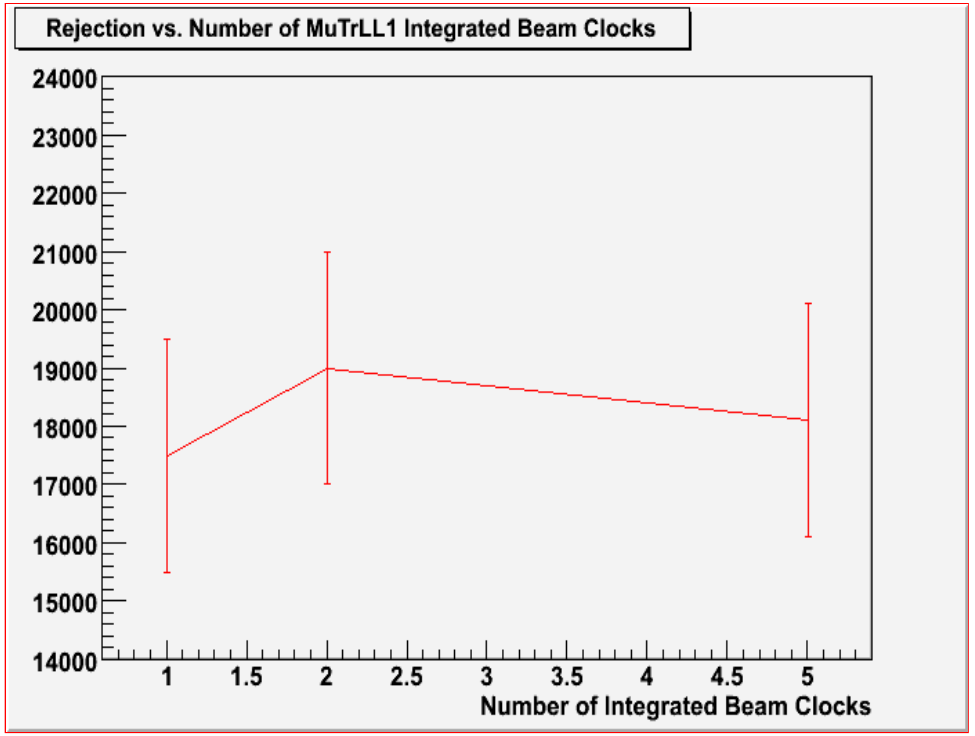
MuTRG single rates / strip (20 mV)



シミュレーション



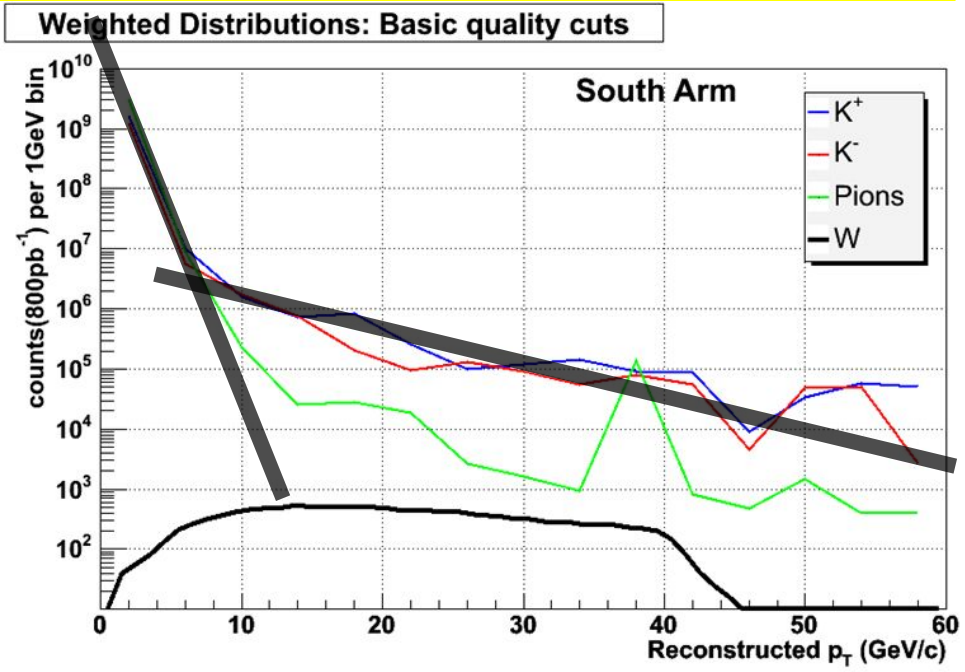
Fake Hite Rateと
棄却能力

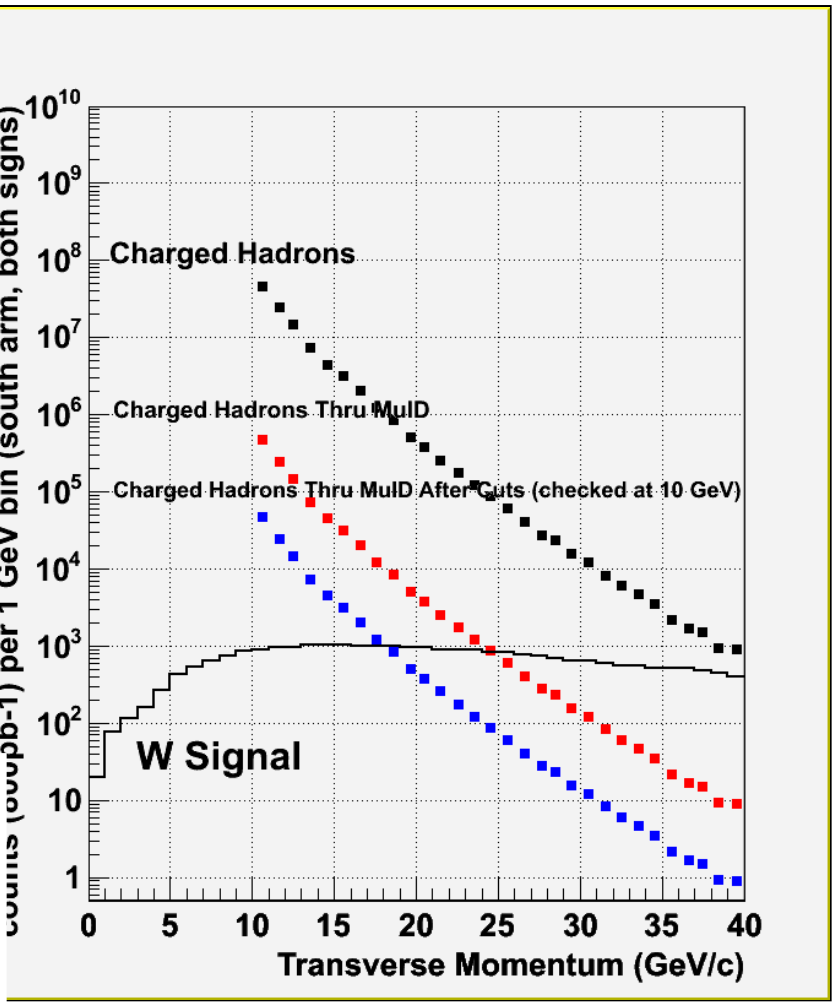


トリガーのゲート幅と
棄却能力
（Fake Hit Rate = 1kHz）

Background for W measurement

1. Low PT π,K Decay in Flight 2. Hi P_T π,K punch through





Prima
- *Tracker Alignment*
- *Absober*
- *EM Calorimeter*
- *Etc..*

Future Plan

(Need to ask RPC about updated installation plan)

2008 Run08 : 200GeV pp
MuTRG-FEE North installation

2009 Run09 : 500GeV pp, 200GeV pp
RPC3 South installation
MuTRG-FEE South installation

2010 Run10 : 200GeV Au+Au
RPC1 North & South installation
RPC3 North installation

2011 Run11 : 200GeV U+U

2012 Run12 : 500GeV pp, 200GeV pp

Near Future Run Plan @ RHIC

2003 ~ 2008 : sqrt(s)=200 GeV

Tentative RHIC Run Plan Following 2008 PAC Recommendations
(assumes 6-month CR in FY09, then FY10-14 budgets sufficient to support 2-species runs each year; incorporates best available information on detector upgrade schedules as of 6/20/08)

Fiscal Year	Colliding Beam Species/Energy	Comments
2009	500 GeV p+p	Assuming ~April 1 start, about 5-6 physics weeks to commission collisions, work on polarization & luminosity and obtain first W production signal to meet RIKEN milestone
2010	200 GeV p+p	~12 physics weeks to com could be swapped with 50 March 1, 2009; STAR DA
	200 GeV Au+Au	9-10 physics weeks with P TOF permits low-mass dil test of transverse stochasti
2011	Au+Au at assorted low E	1st energy scan for critical luminosity improvement – decided; commission PHE
	200 GeV U+U	1st U+U run with EBIS, to
2012	500 GeV p+p	1st long 500 GeV p+p run, with PHENIX muon trigger and STAR FGT upgrades, to reach ~100 pb^{-1} for substantial statistics on W production and ΔG measurements
	200 GeV Au+Au	Long production run with full stochastic cooling upgrade implemented, PHENIX VTX and prototype STAR HFT installed; focus on RHIC-II science goals: heavy flavor, γ-jet, quarkonium, multi-particle correlations
2013	500 GeV p+p	Reach ~300 pb^{-1} to address 2013 DOE performance milestone on W production and sea antiquark polarizations
	200 GeV Au+Au or 2nd low-E scan	To be determined by results from 1st low-E scan and 1st upgraded luminosity runs, progress on low-E electron cooling, and on installation/commissioning of PHENIX FVTX and NCC and full STAR HFT
2014	200 GeV Au+Au or 2nd low-E scan	Run option not chosen for 2013 run – low-E scan addresses 2015 DOE milestone on critical point, full-E run addresses 2014 (γ-jet) and 2016 (identified heavy flavor) milestones. Proof of principle test of coherent electron cooling
	200 GeV p+p	Address 2015 DOE performance milestone on transverse SSA for γ-jet; provide reference data for HI runs with new detector subsystems; test electron lenses for p+p beam-beam tune spread reduction