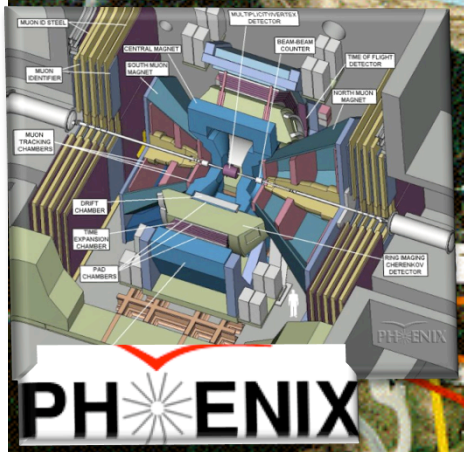
Sea Quark Polarization Measurement via W-Boson in Forward Rapidity at PHENIX

RIKEN/RBRC
Itaru Nakagawa
on behalf of
PHENIX Forward Trigger Upgrade Collaboration

Polarized Proton-Proton Operation at RHIC



RHIC

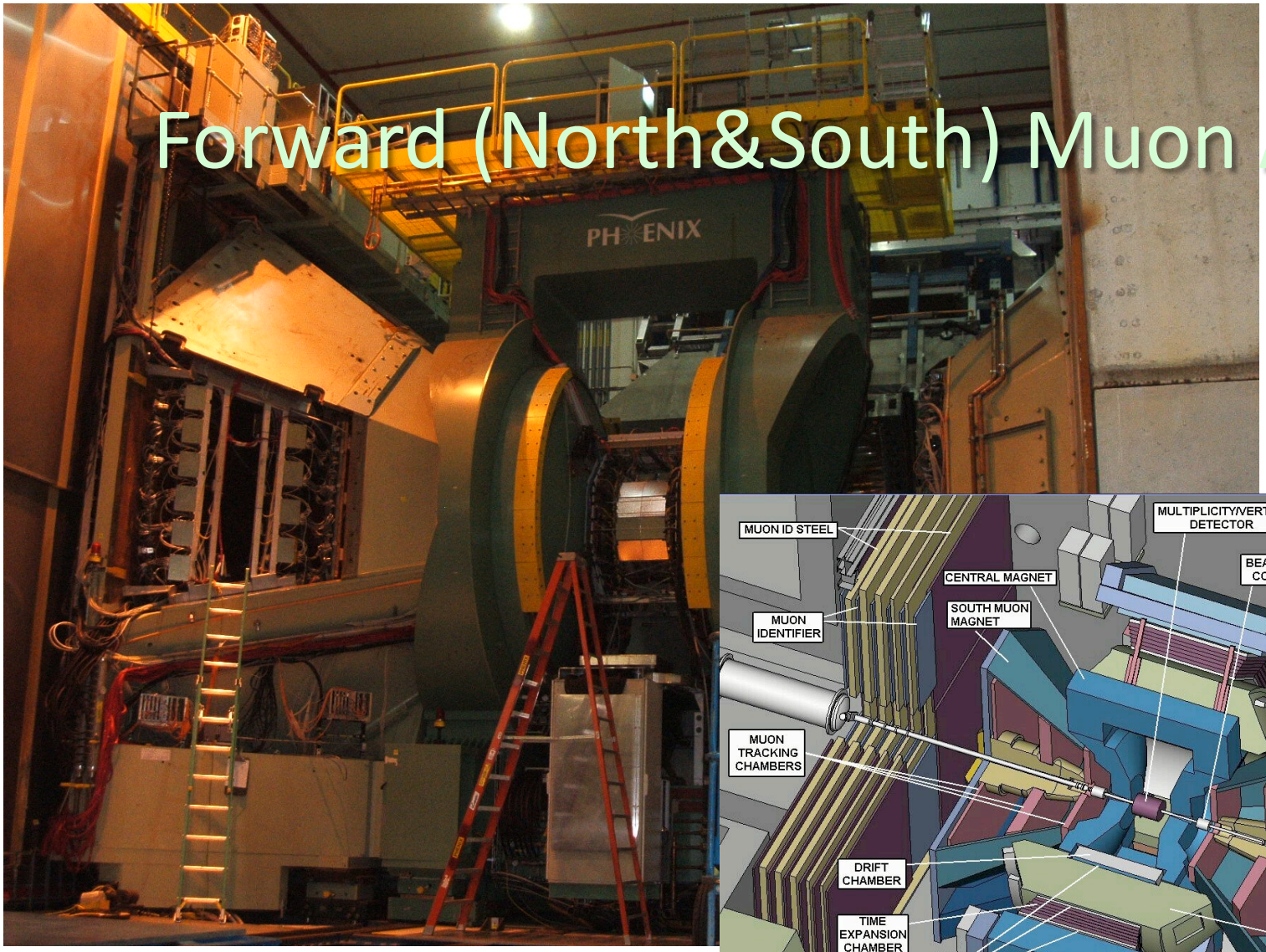
AGS

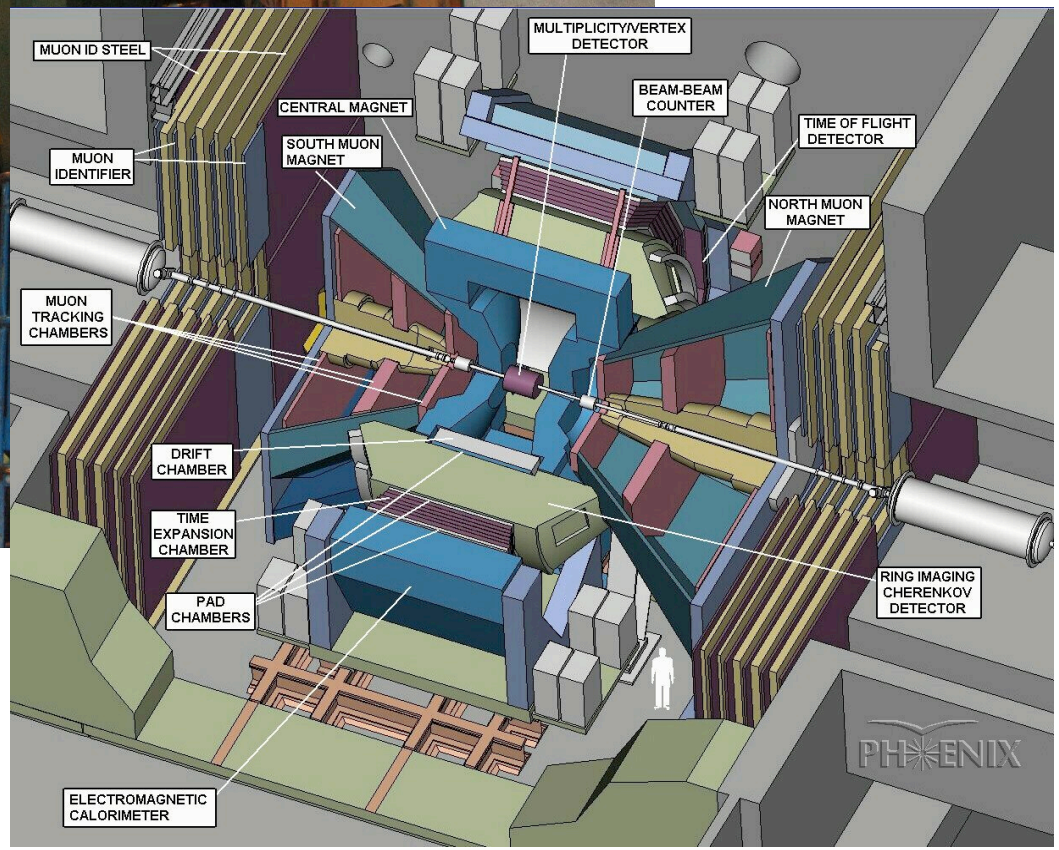
TER

HTR

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
200 GeV	test		production							
500 GeV							test		production	

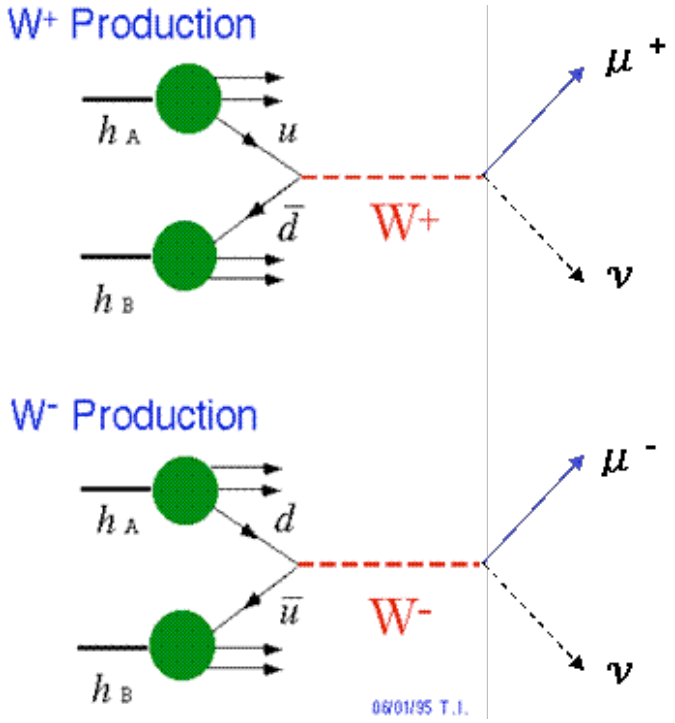
Forward (North&South) Muon Arms



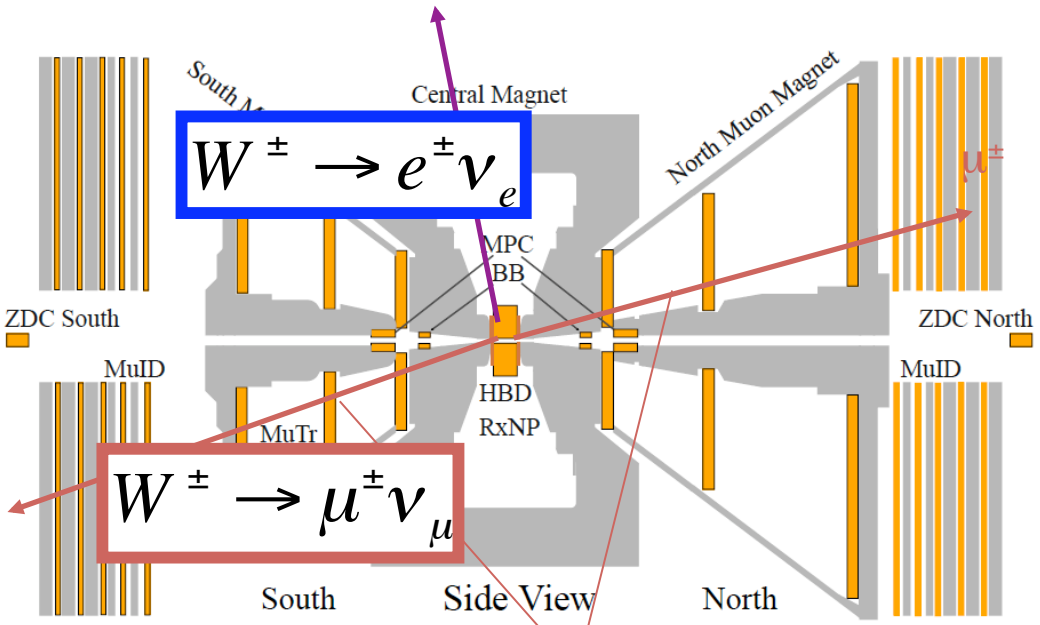


Rapidity Coverage : $1.2 < \eta < 2.2(4)$

sqrt(s)=500 GeV @ RHIC



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

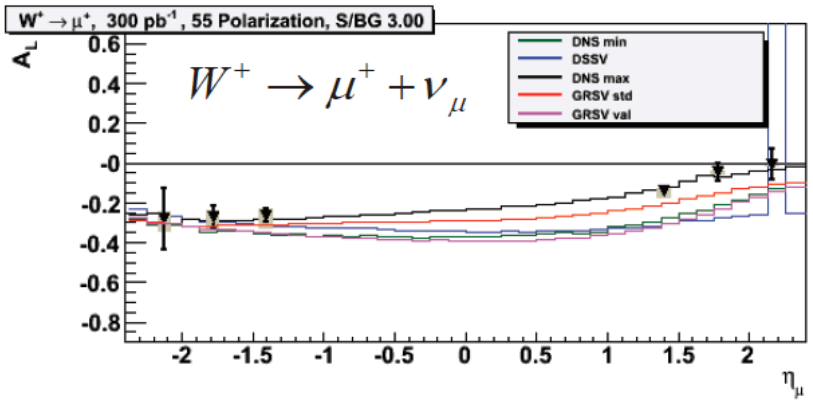


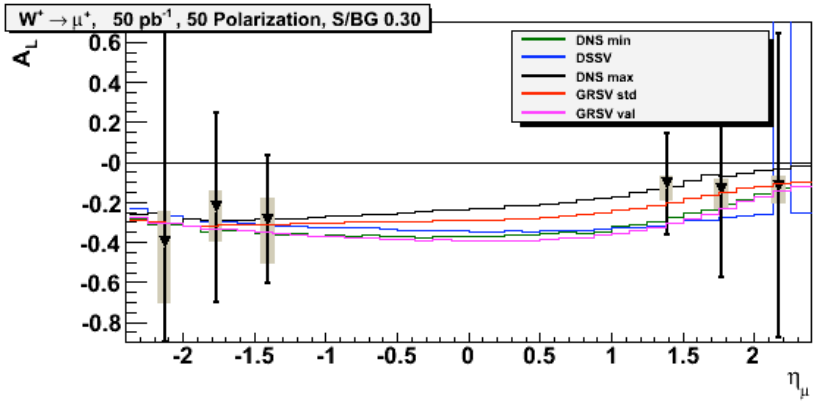
Parity Violation Asymmetry
Clean flavor separation
w/o fragmentation uncertainty

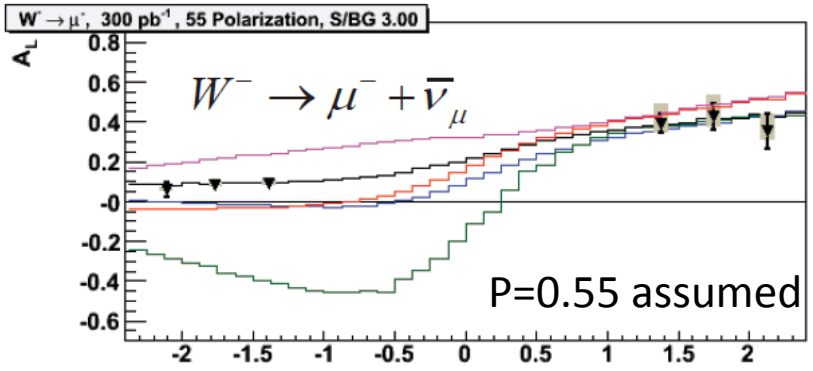
$$A_L^{W^+} \approx -\frac{\Delta u(x_1, M_W^2)}{u(x_1, M_W^2)}, \quad x_1 > x_2 \quad (y_W >> 0)$$

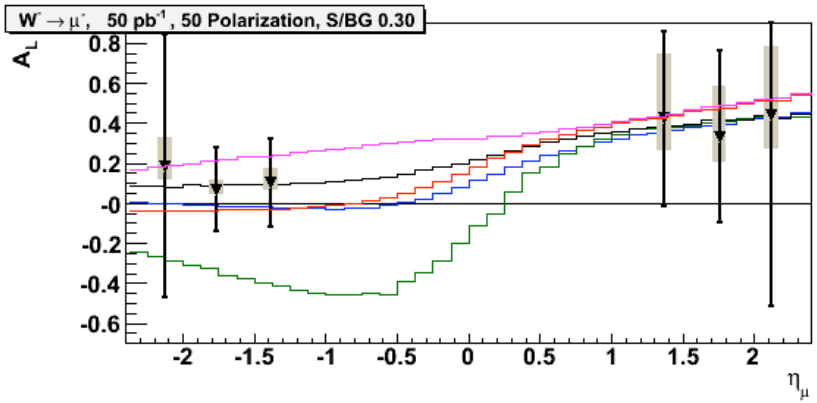
$$A_L^{W^+} \approx \frac{\Delta\bar{d}(x_1, M_W^2)}{\bar{d}(x_1, M_W^2)}, \quad x_1 < x_2 \quad (y_W << 0)$$

Projected Errors for A_L









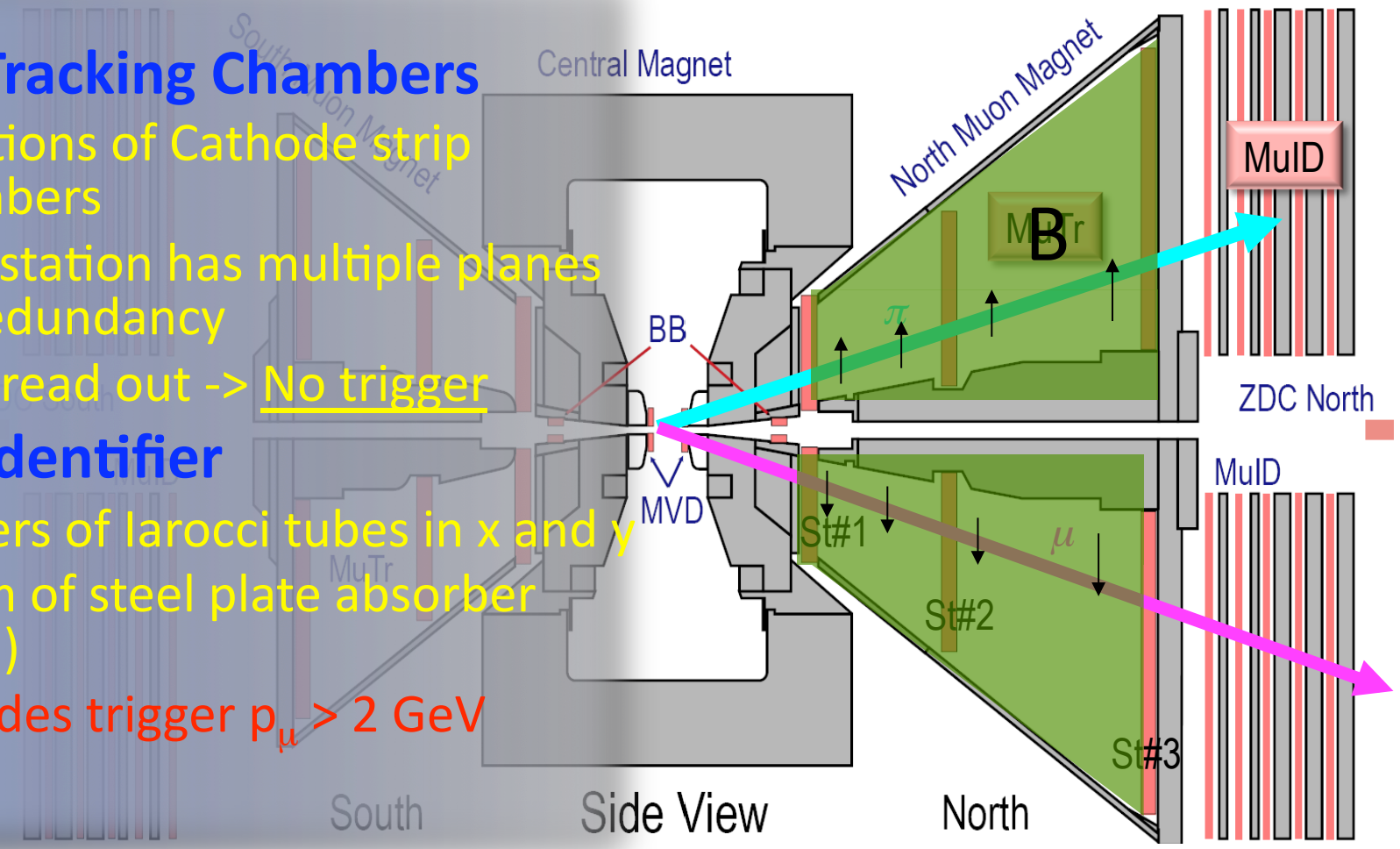
Run11 + Run12 + Run13
Integrated Luminosity = 300 pb^{-1}

Goal

Run11 Goal 50pb^{-1}

Original Muon System

1. **Muon Tracking Chambers**
   - 3 stations of Cathode strip chambers
   - Each station has multiple planes for redundancy
   - Slow read out -> No trigger
2. **Muon Identifier**
   - 5 layers of Iarocci tubes in x and y
   - 80 cm of steel plate absorber (total)
   - Provides trigger $p_\mu > 2$ GeV



Same configuration in South

6

High Momentum Muon Trigger

Run11 500 GeV Projection

Rate

σ_{tot}=60mb

L=1.5x10^{32}cm^{-2}s^{-1}

9 MHz

BBC×MuID Rejection Power

RP~100

90 kHz

Trigger Upgrade

RP ~ 45

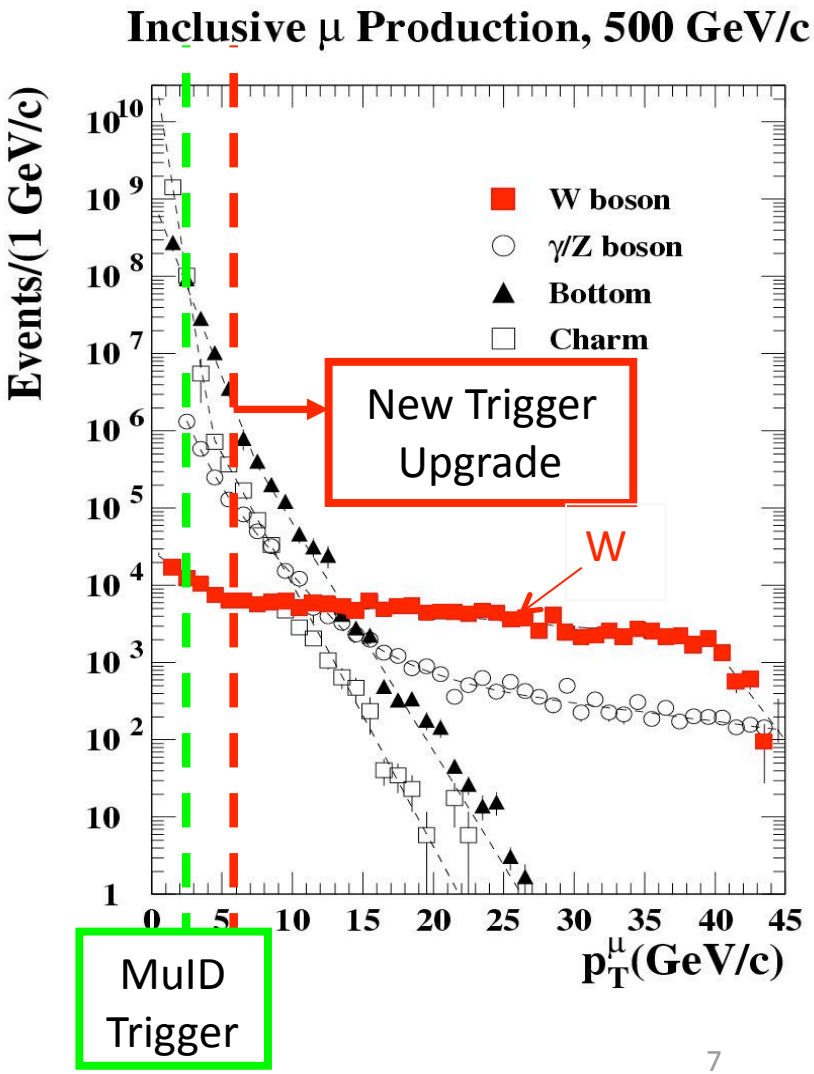
RP_{tot} ~ 4500

2 kHz

PHENIX Band Width for Muon

Required Rejection Power

1. High Rejection Power
2. High Efficiency



PHENIX Muon Trigger Upgrade

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

R1(a,b): ~12mm in φ, 4x θ pads

R2: ~5.4mm in φ , 4x θ pads

R3: ~6.0mm in φ, 4x θ pads

(Trigger only – offline segmentation higher)

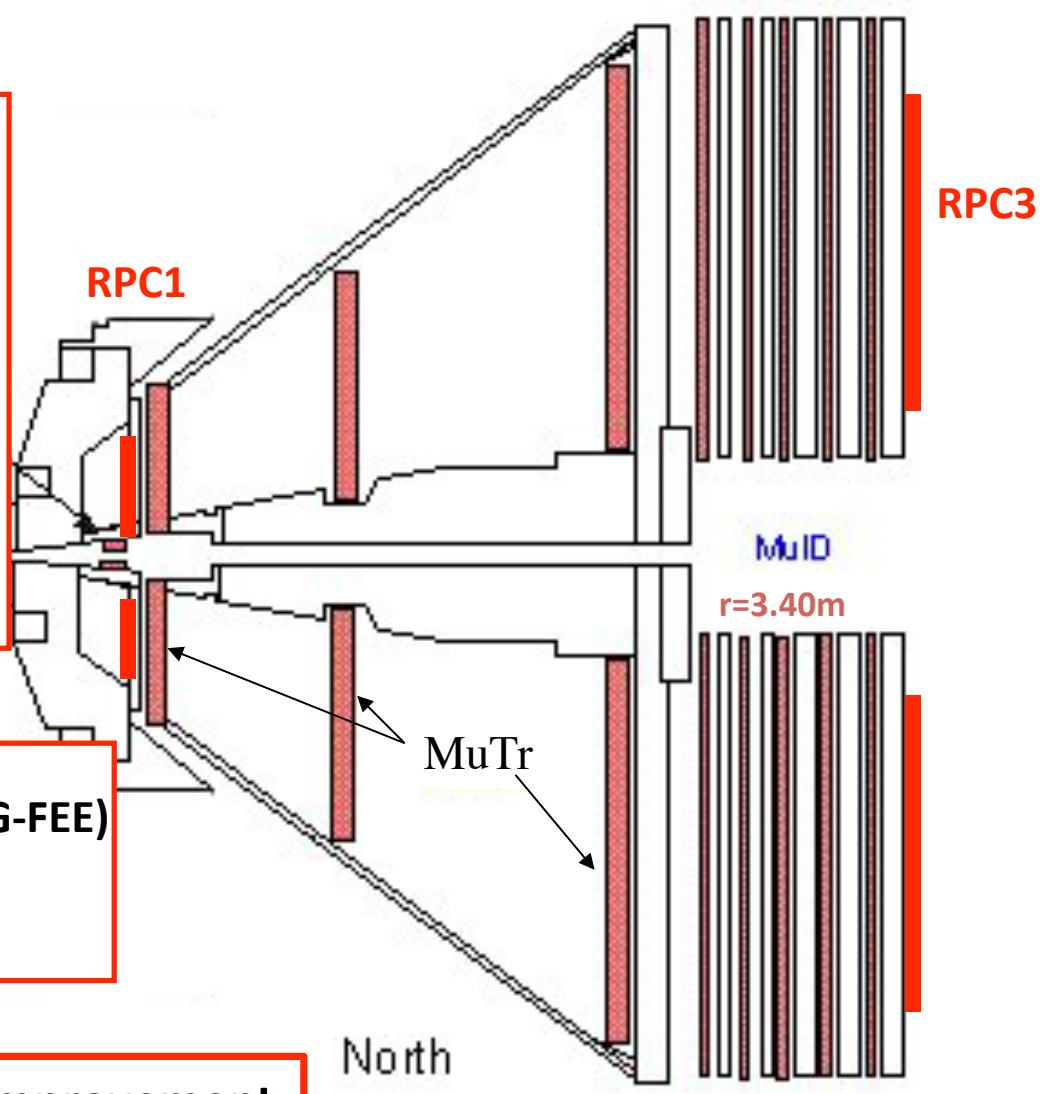
NSF (Funded)

(II) MuTr front end electronics (MuTRG-FEE)

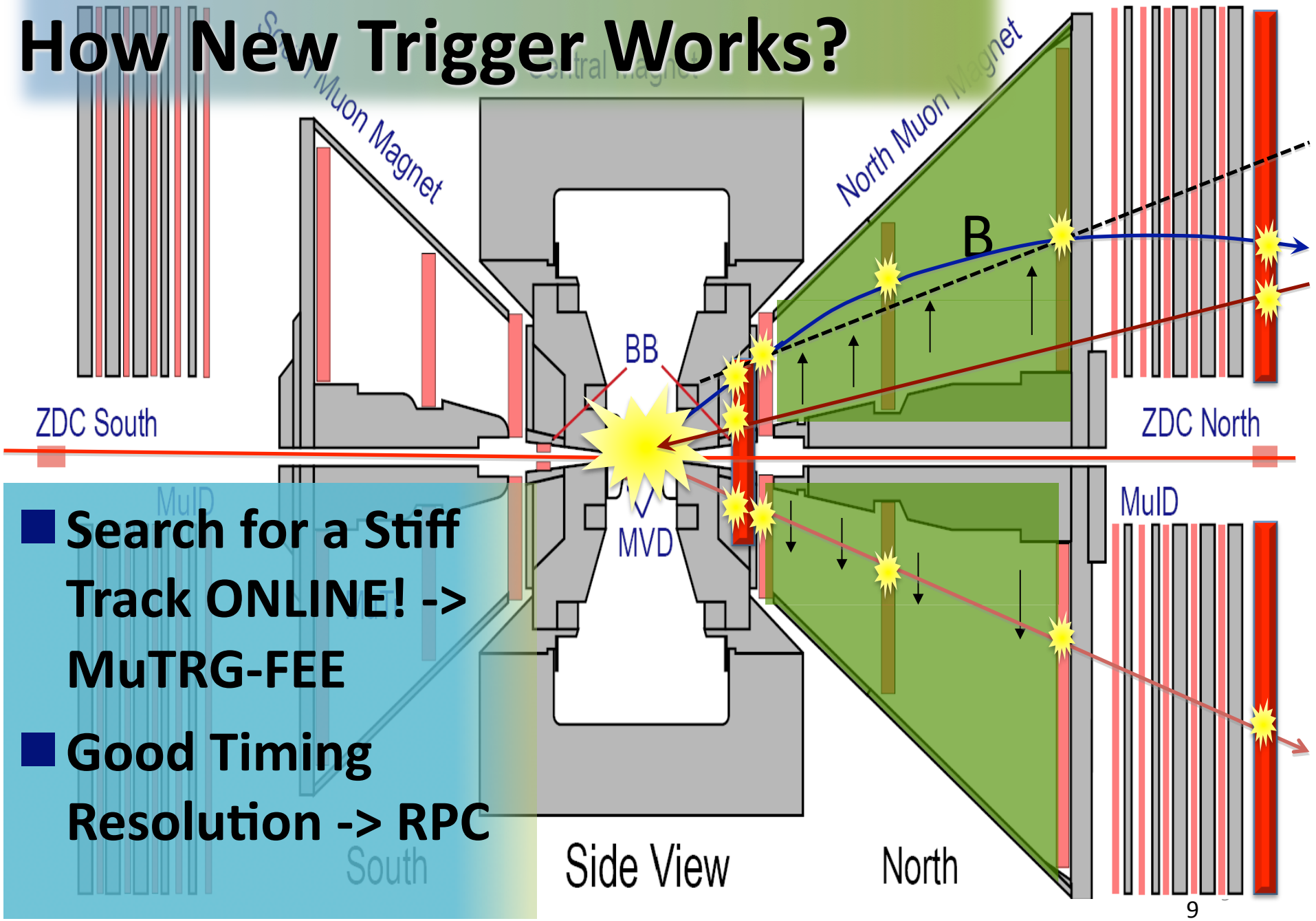
Upgrade to allow LL1 information

JSPS (Funded)

+ Hadron Absorber for Offline S/N Improvement



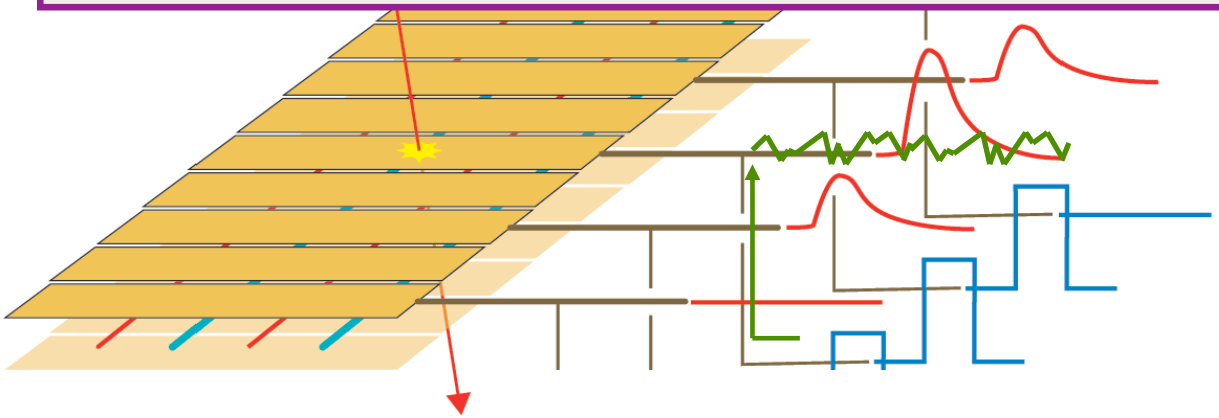
How New Trigger Works?

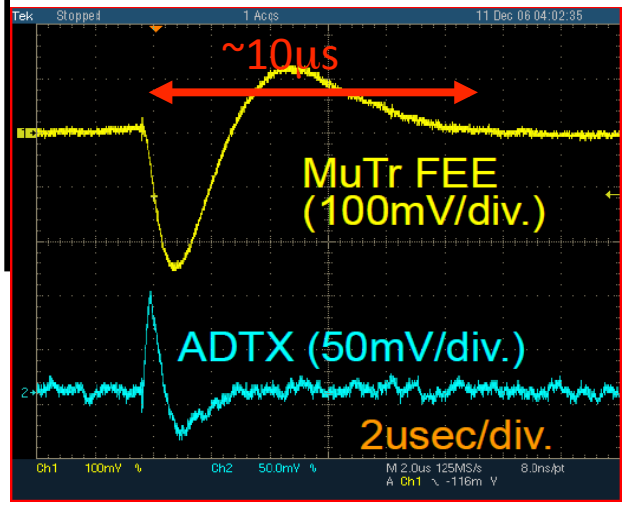


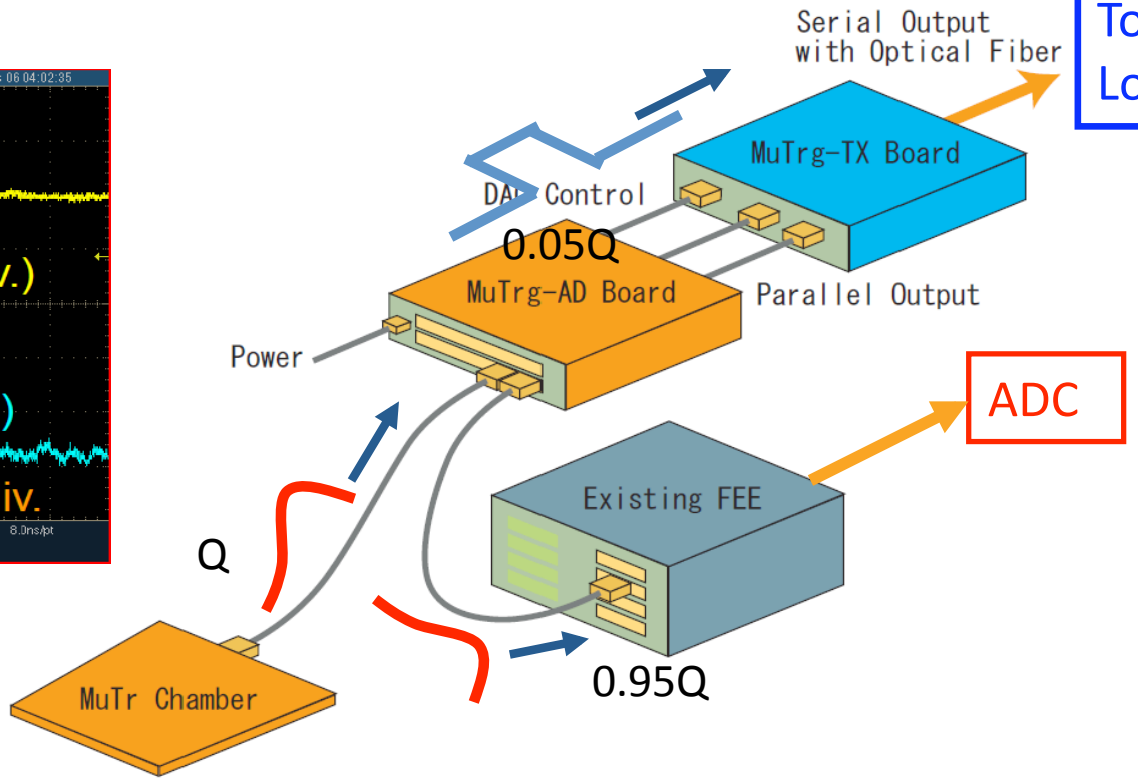
- Search for a Stiff Track ONLINE! -> MuTRG-FEE
- Good Timing Resolution -> RPC

1. Minimum deterioration to existing MuTR performance
2. High/reliable triggering efficiency

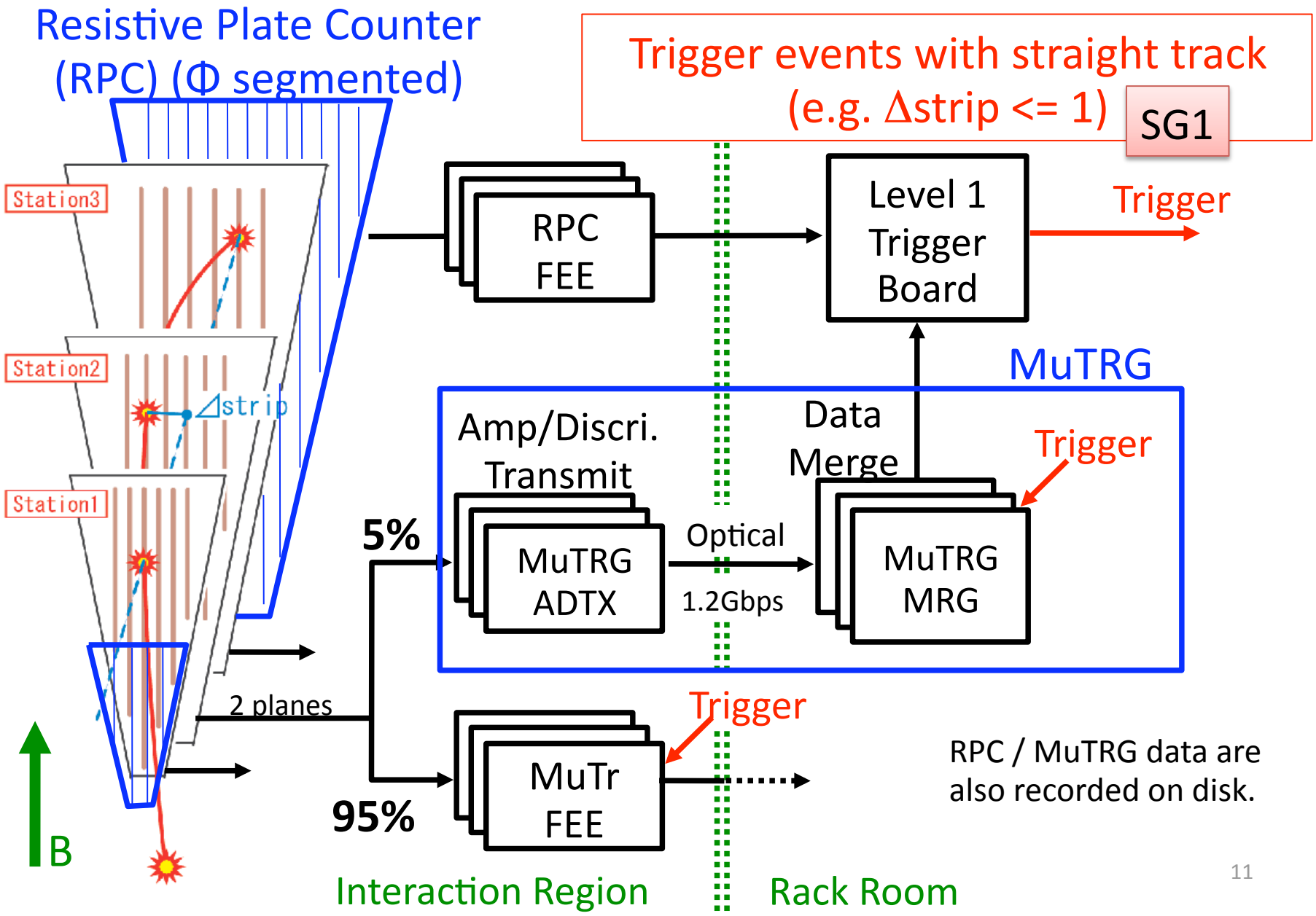
Bottom Line



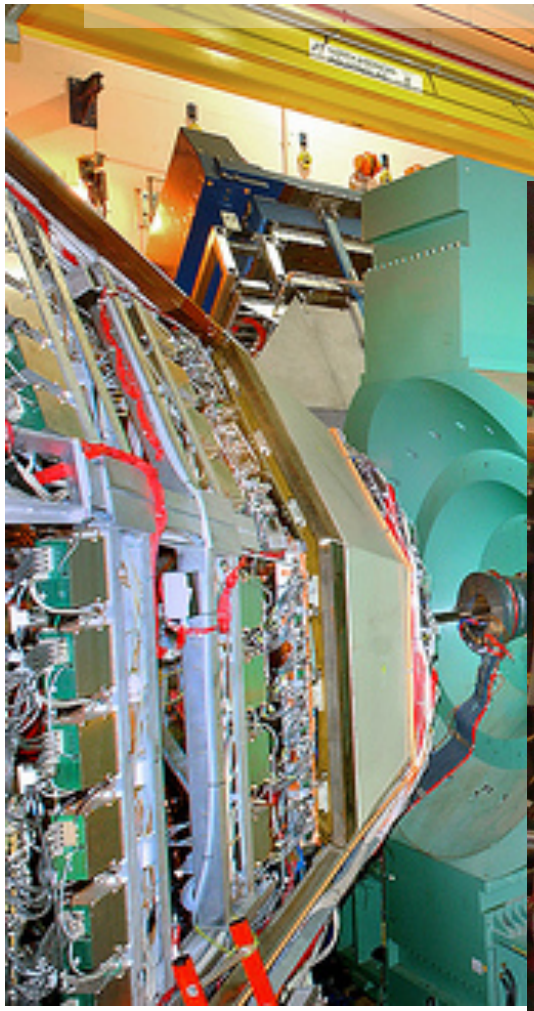




W Trigger System

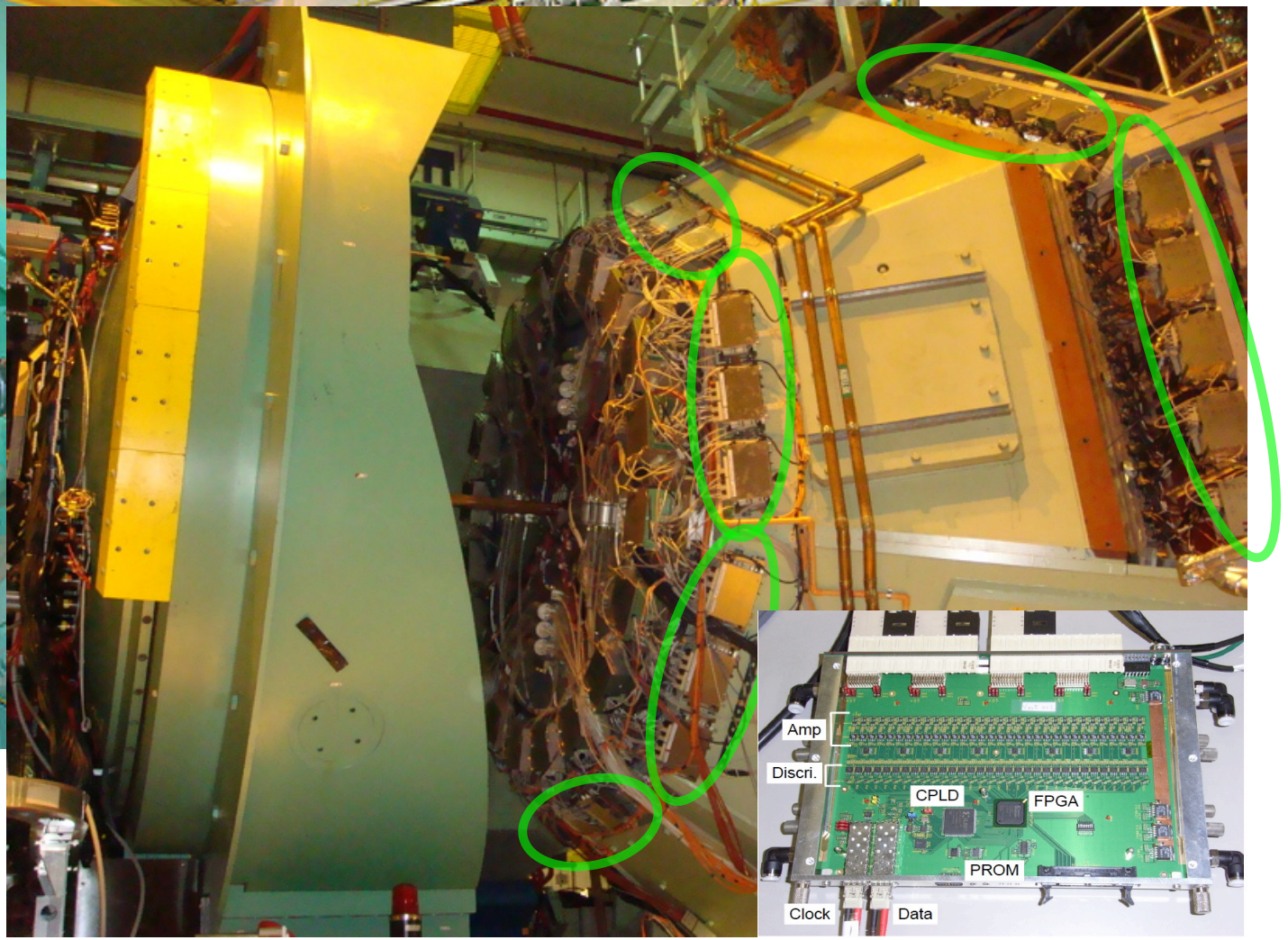


New MuTRIG-FEE in North Arm



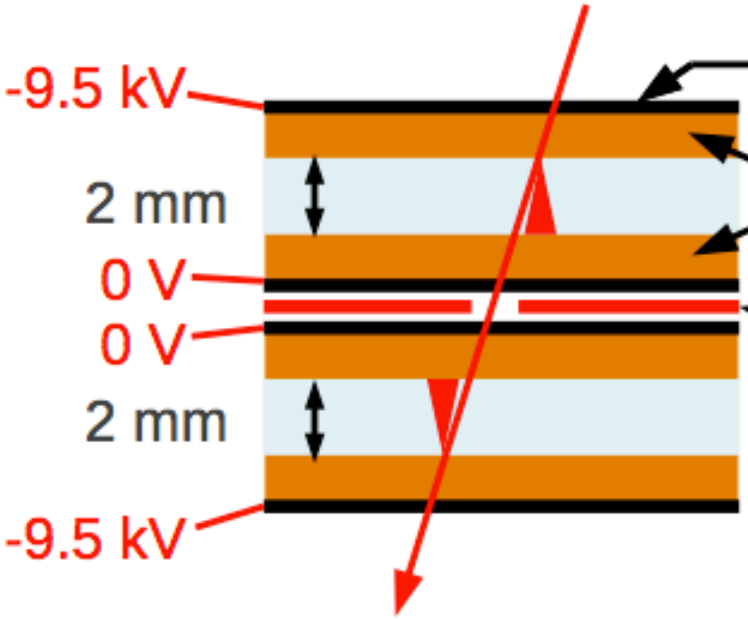
↑ Before Install

2008 Install→



Resistive Plate Chamber (RPC)

Based on CMS RPC technology



Graphite : Resistivity 100 – 500 kΩ/cm^2

Bakelite : Resistivity 10^{10} – 10^{11} Ω cm

Signal Strip

Time resolution 1-2 nsec

Efficiency 96% for MIP

Noise Rate 0.5 – 5 Hz/cm^2

Mixed Gas :

95% $C_2H_2F_4$ (base gas)

4.5% i-C_4H_{10} (photon quencher)

0.5% SF_6 (electron quencher)

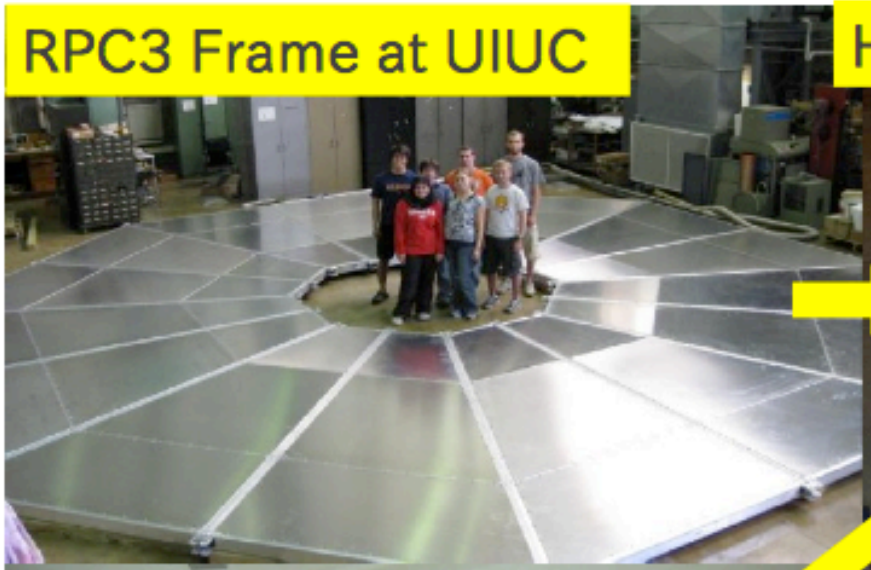
20 – 40 % relative humidity

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

Requirements for W trigger

RPC3 North Installation (2009)

RPC3 Frame at UIUC



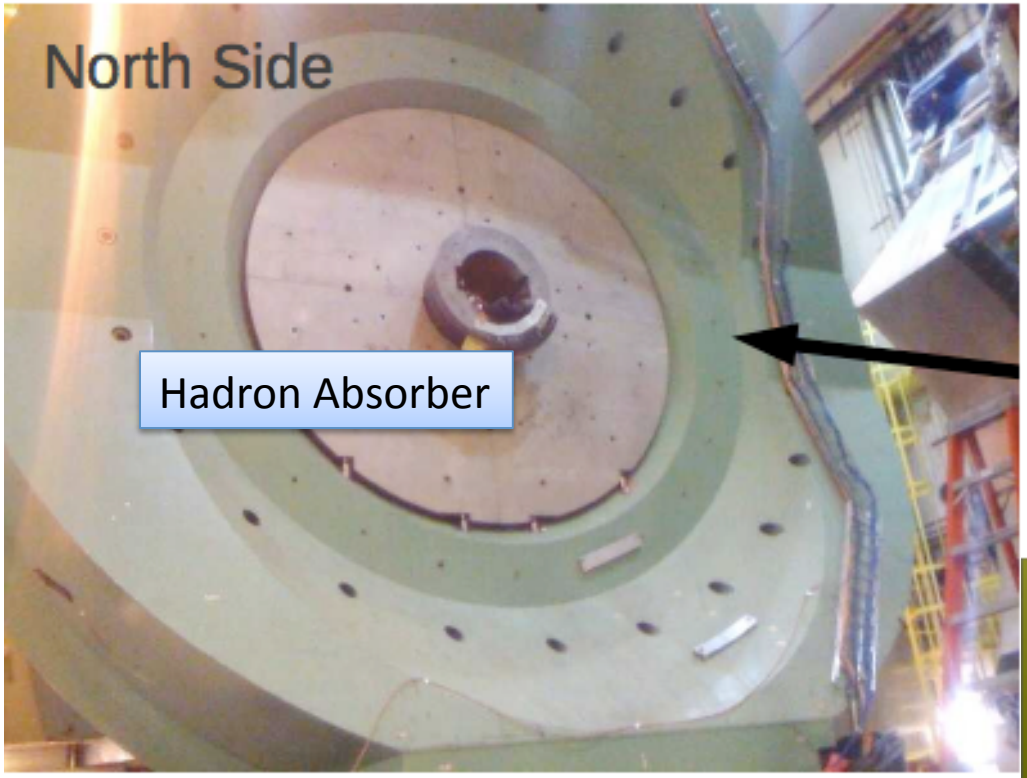
Half Octant assembly at BNL Factory

RPC3 North installation at PHENIX

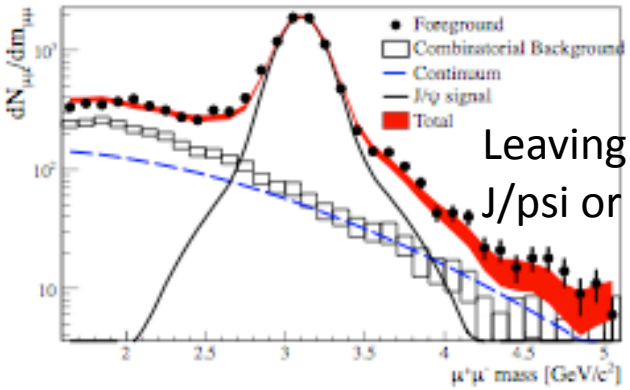
Installation completed

Hadron Absorbers

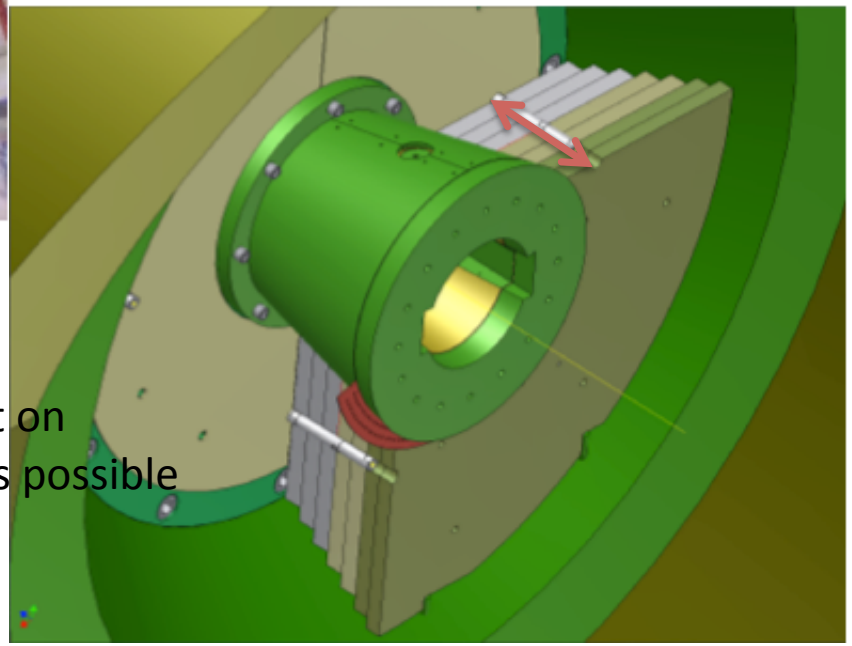
SUS310
Fe : 51.5%
Ni : 20%
Cr : 25%



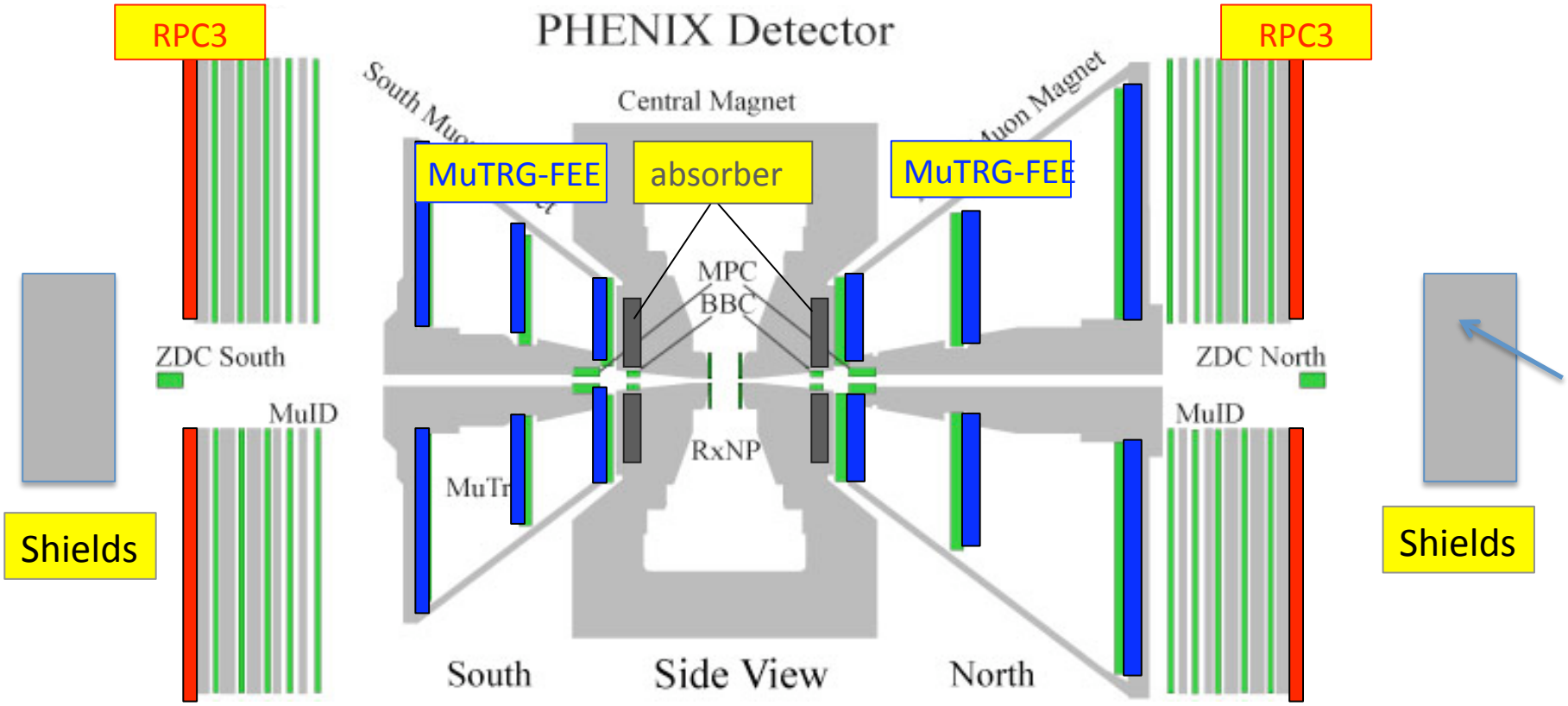
35cm	λ / λ_{int}	λ / λ_{EM}
SUS310	2.2	20
Pb	2.0	58



Leaving as small impact on
J/psi or other physics as possible

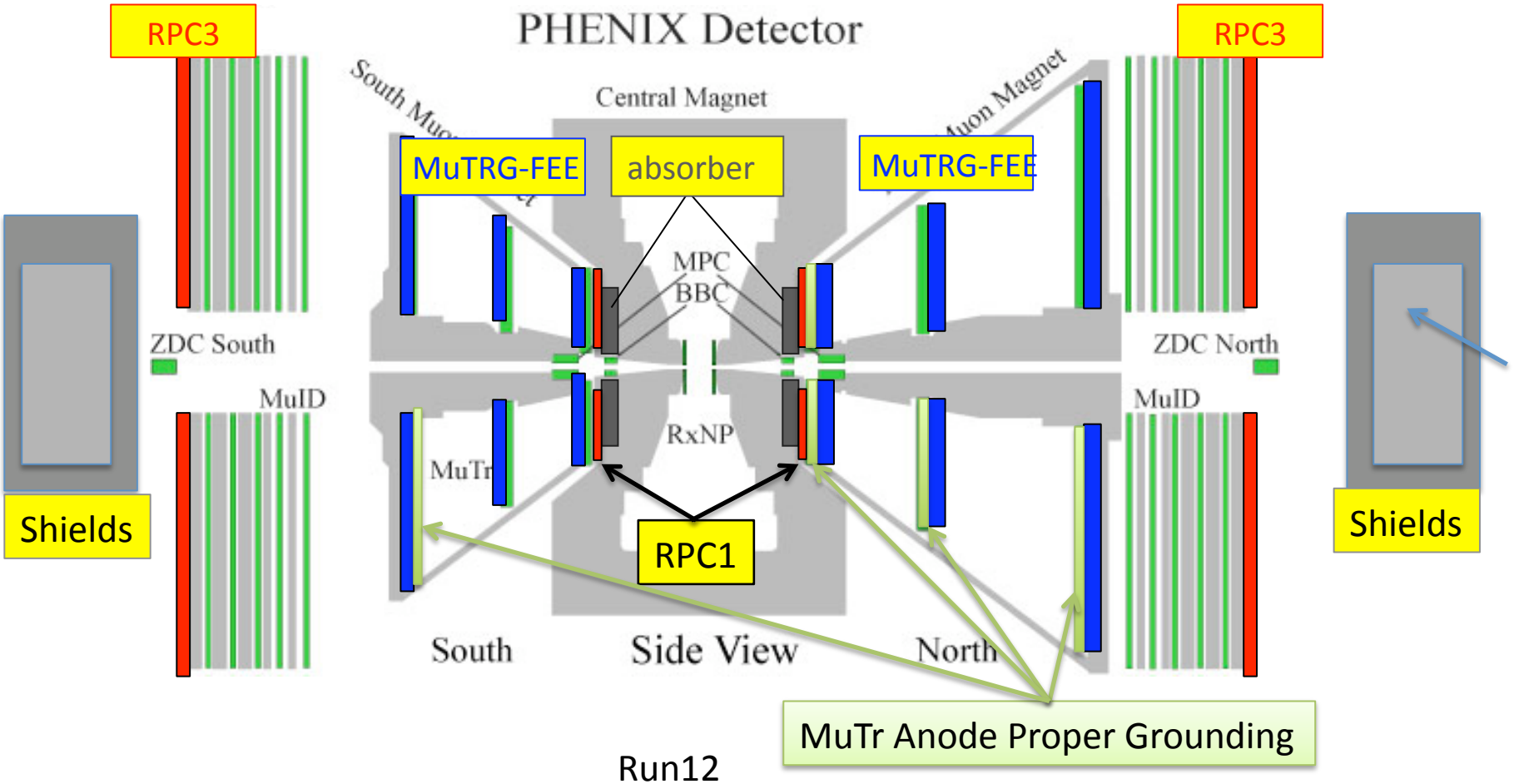


Forward Muon Arm Upgrades



Run11

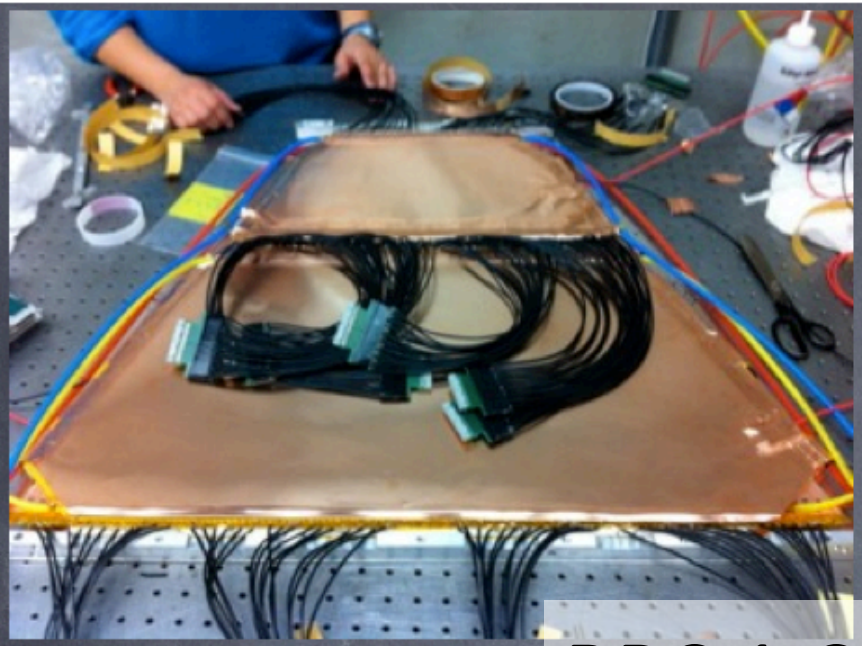
Forward Muon Arm Upgrades

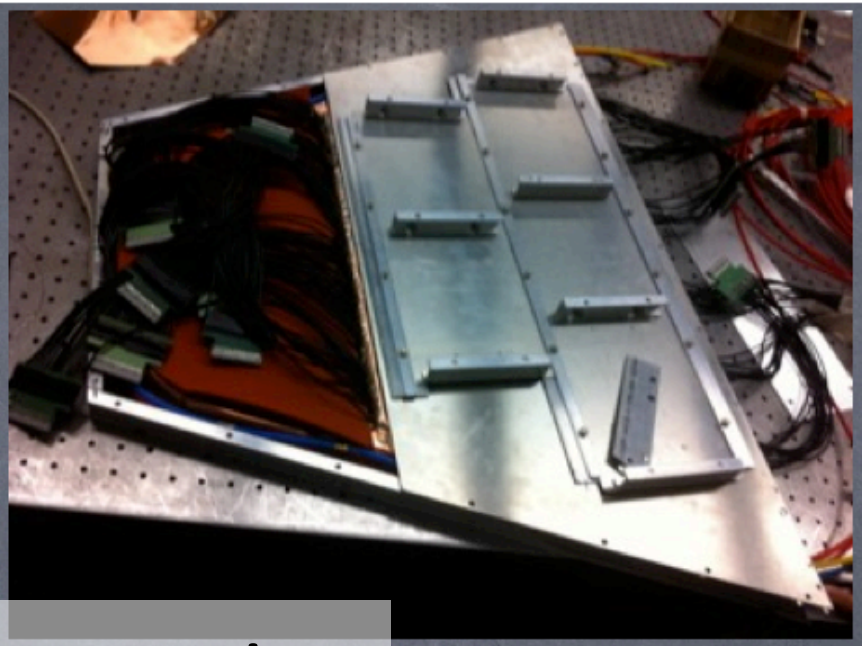


Run12

and LL1 algorithm, Neutron Absorber, etc…

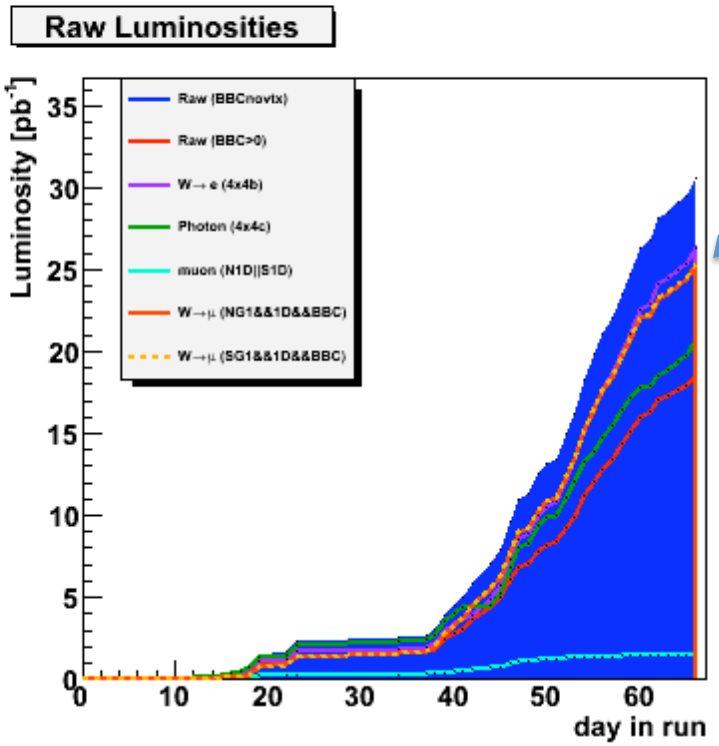
Muon Arm Will be Continuously Improved its Performance!





RPC 1 Construction

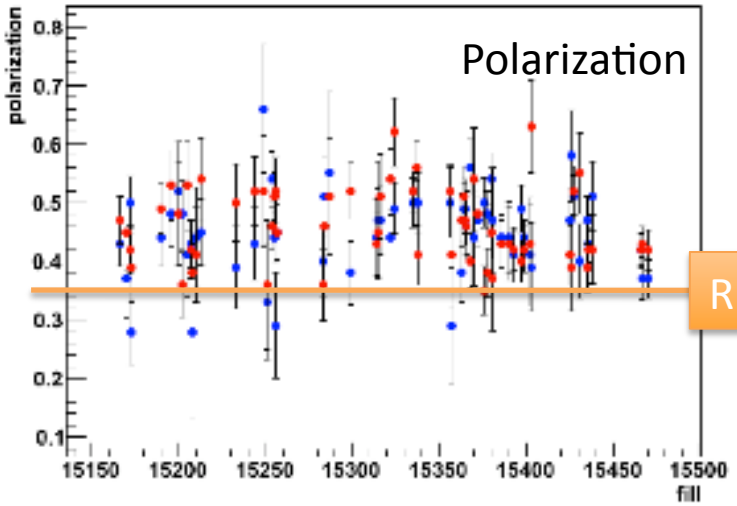
Run11 High Momentum Trigger Performance



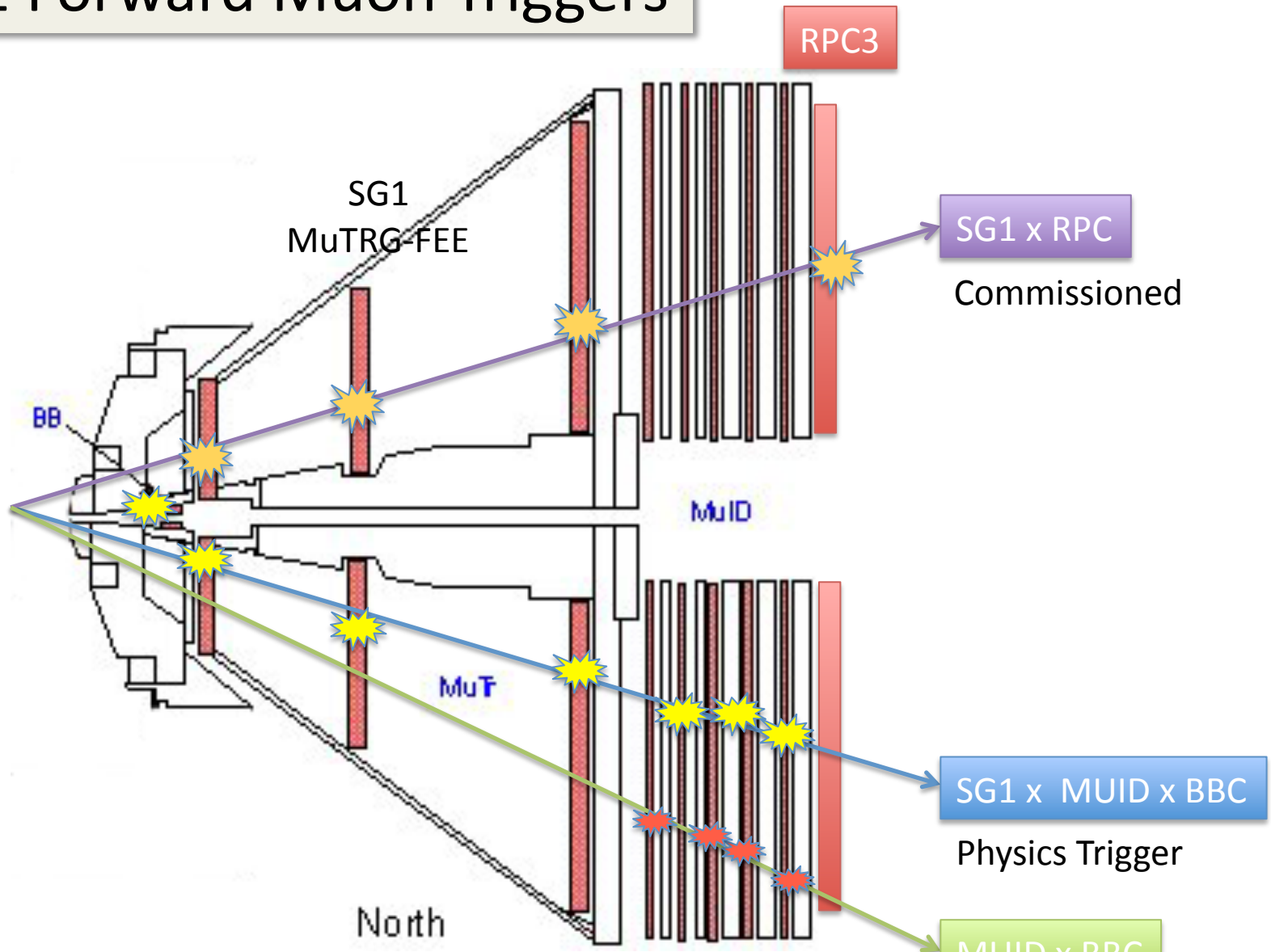
Feb/27

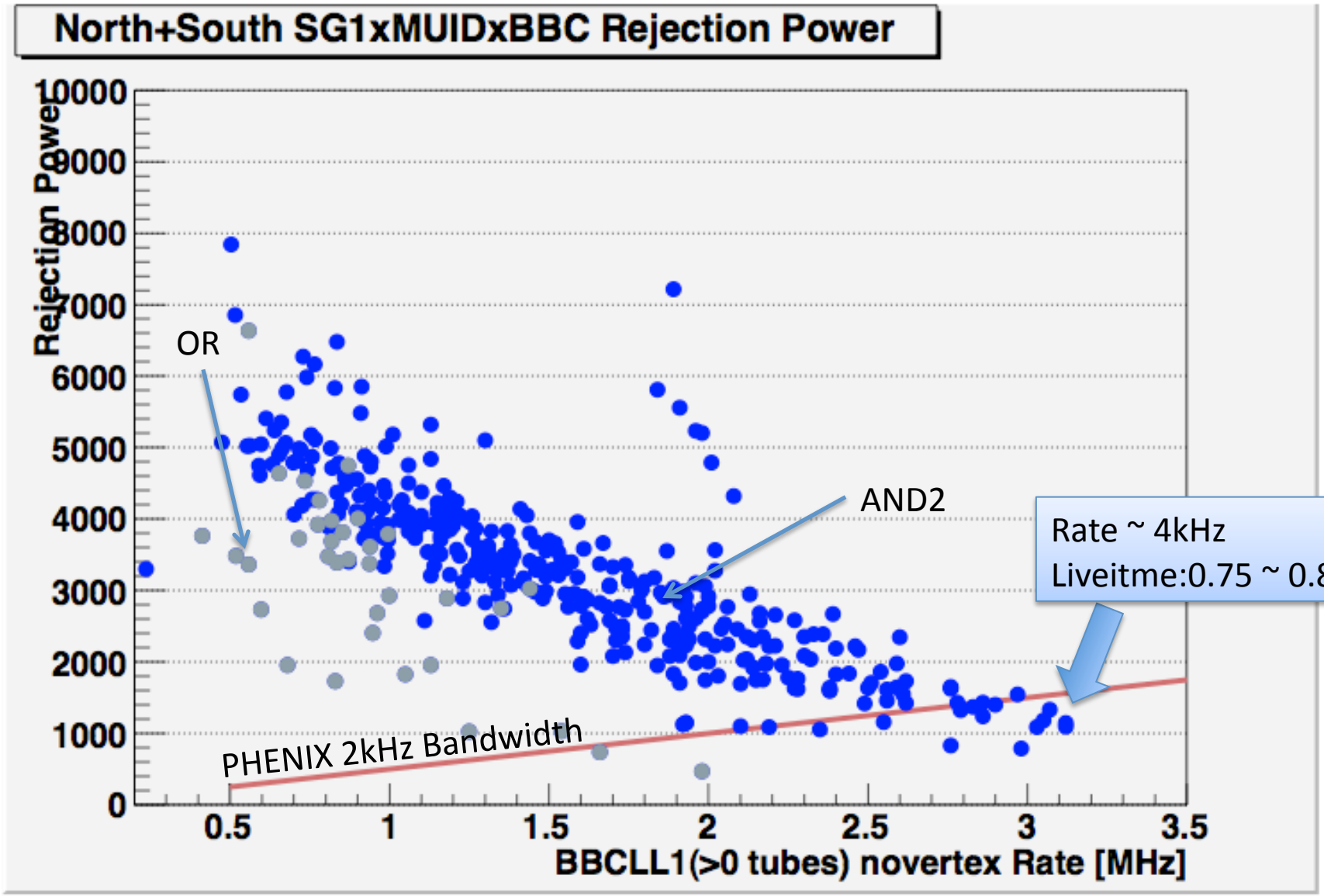
Apr/18

W->μ Trigger Integrated Luminosity ~ 25pb^{-1}



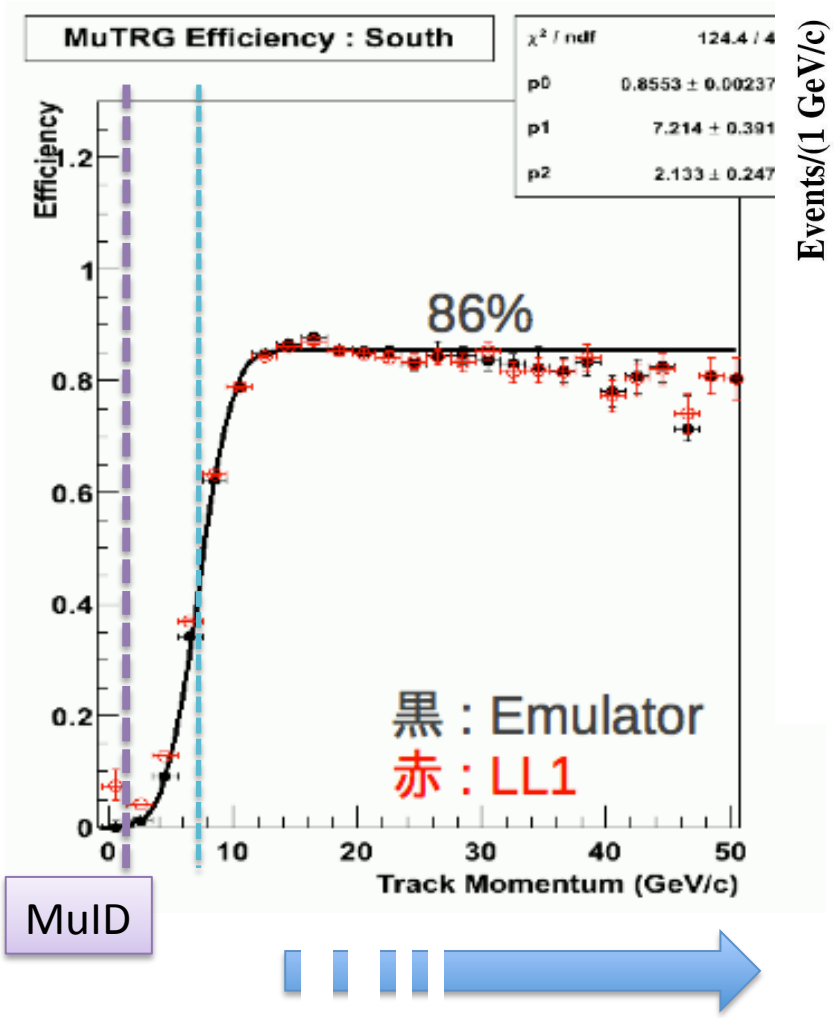
Run11 Forward Muon Triggers

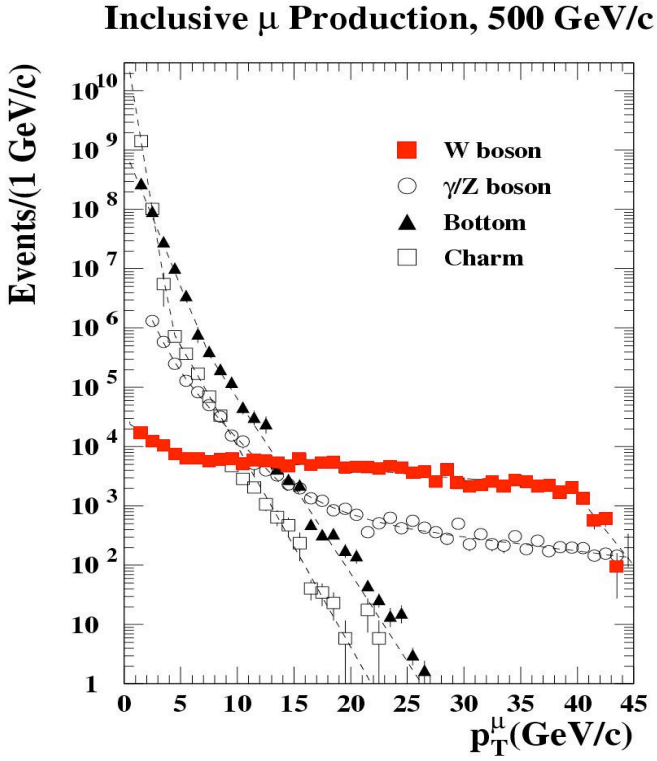


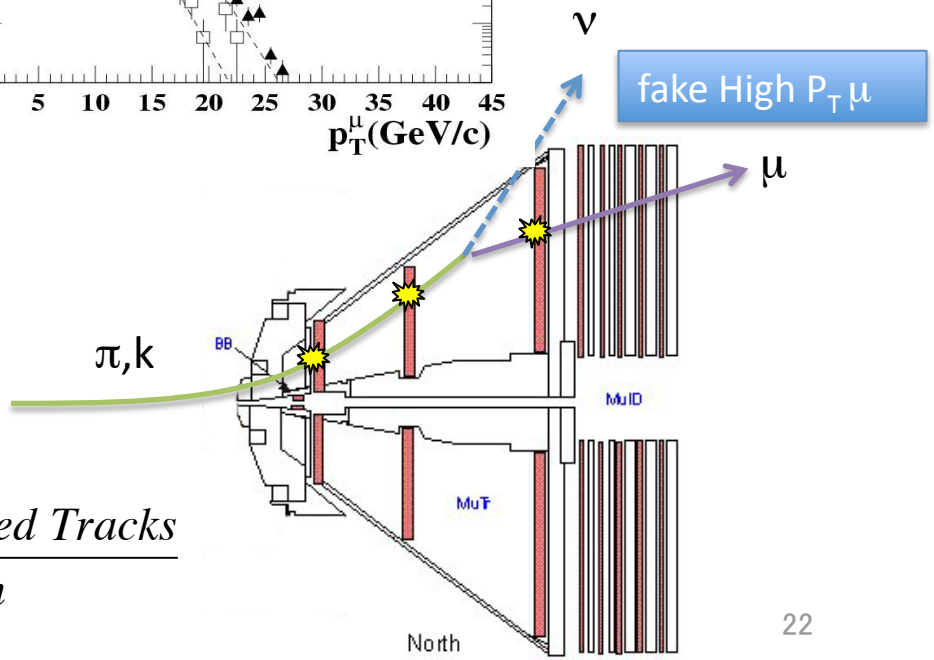


The trigger performed well in rejection power except for very high luminosity run BBC>3MHz.

High Momentum Trigger Efficiency



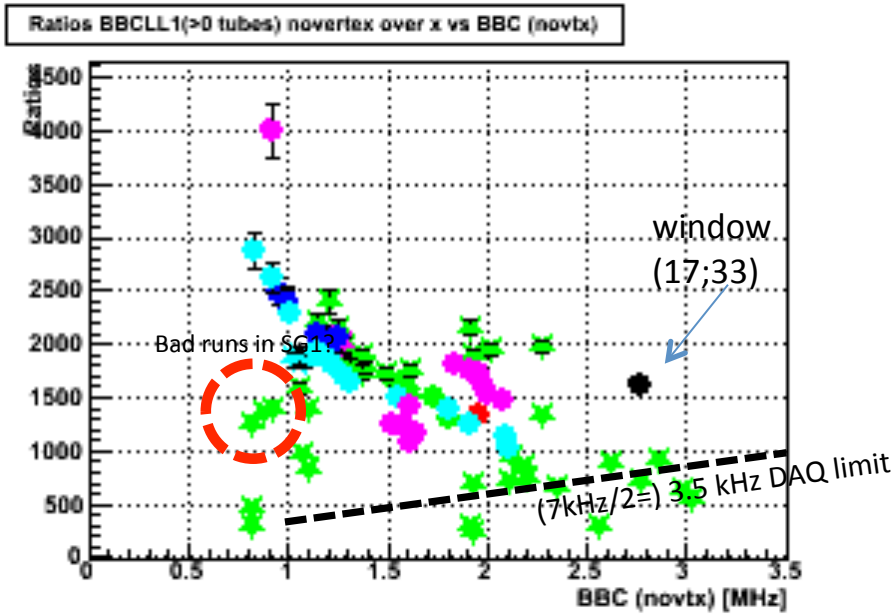




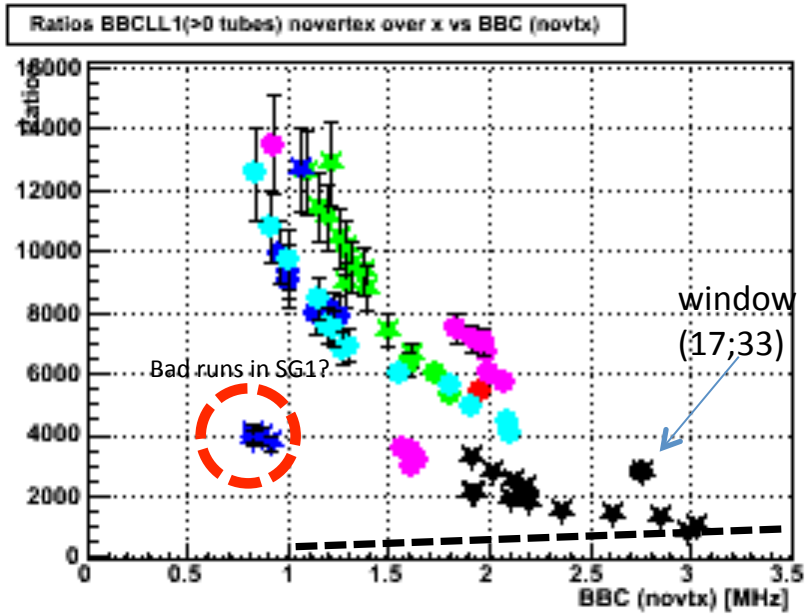
$$Efficiency = \frac{\#\ of\ \ High\ Momentum\ Trigger\ Fired\ Tracks}{All\ Tracks\ in\ Muon\ \ Arm}$$

SG1 x RPC Trigger Rejection

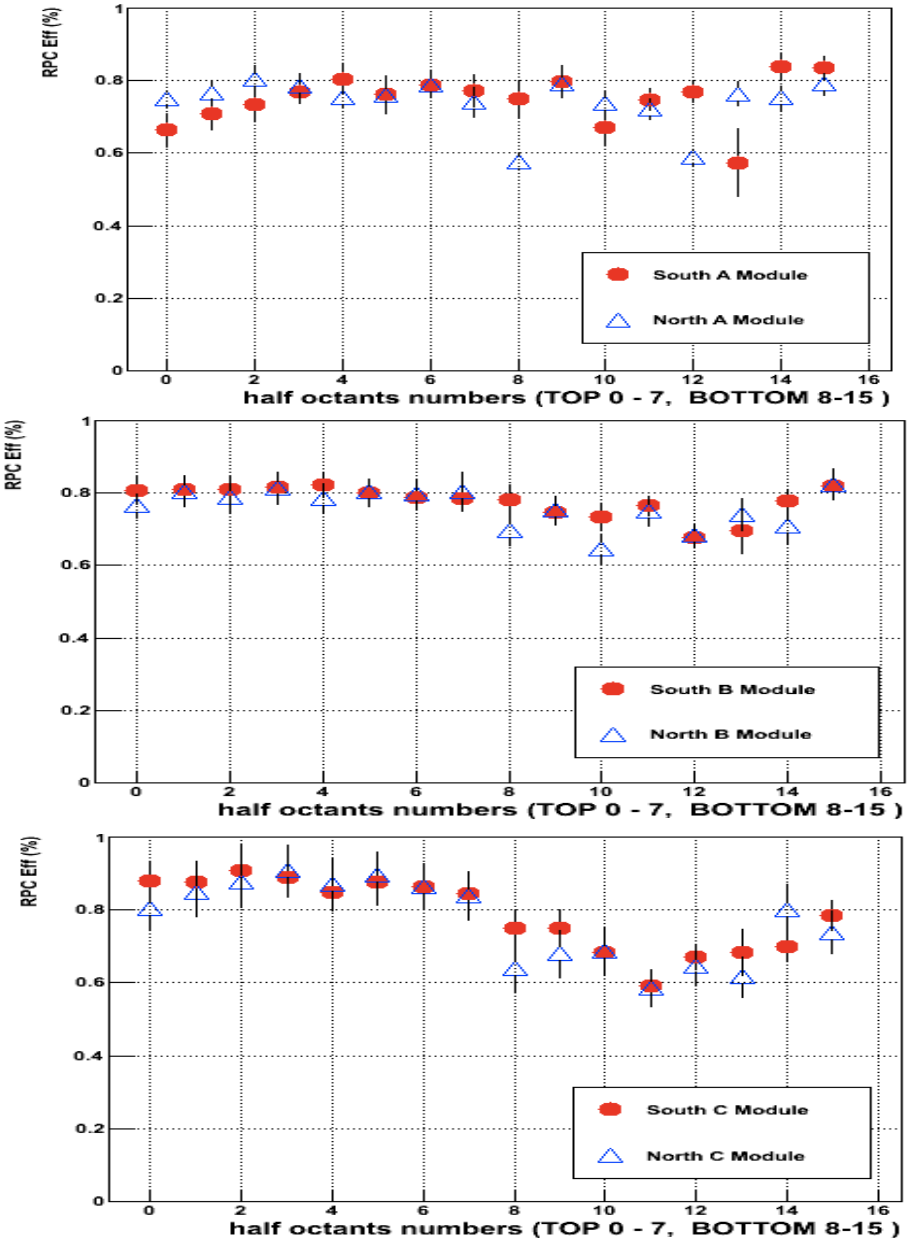
N(SG1&&RPC)A||B||C)



S(SG1&&RPC)A||B||C)



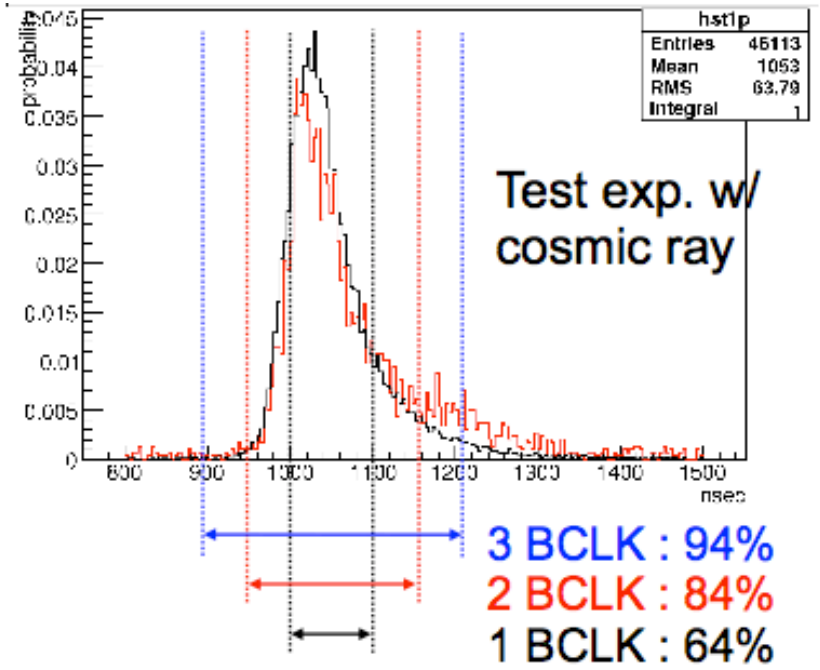
Tighter timing cut, Background shielding, better geometrical matching…

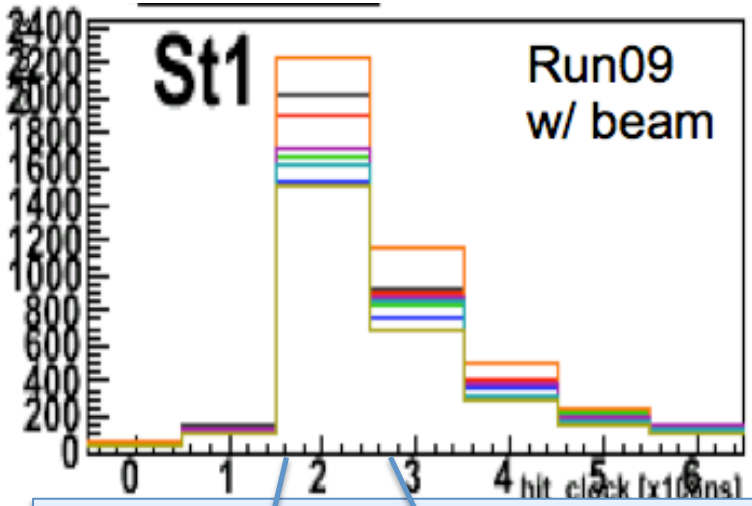


RPC Efficiency

- Initially we struggled to stabilize gas operation, but eventually it was settled.
- Overall 80% efficiency was established in Run11.

MuTrig-FEE and RPC Timing Resolution



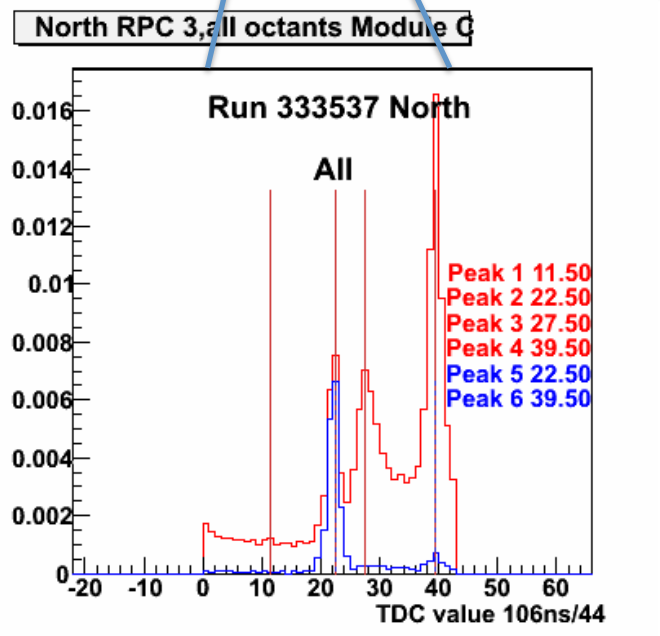


MuTRG Signal Timing Resolution > 1 BCLK

RHIC Beam Bunch

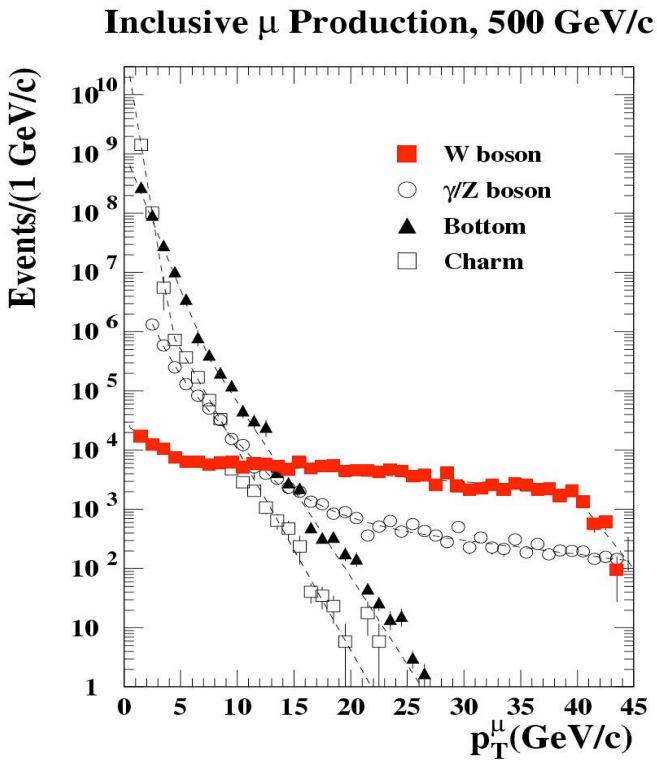
MuTrig-FEE cannot identify the collision bunch.

RPC tag the bunch in offline analysis!



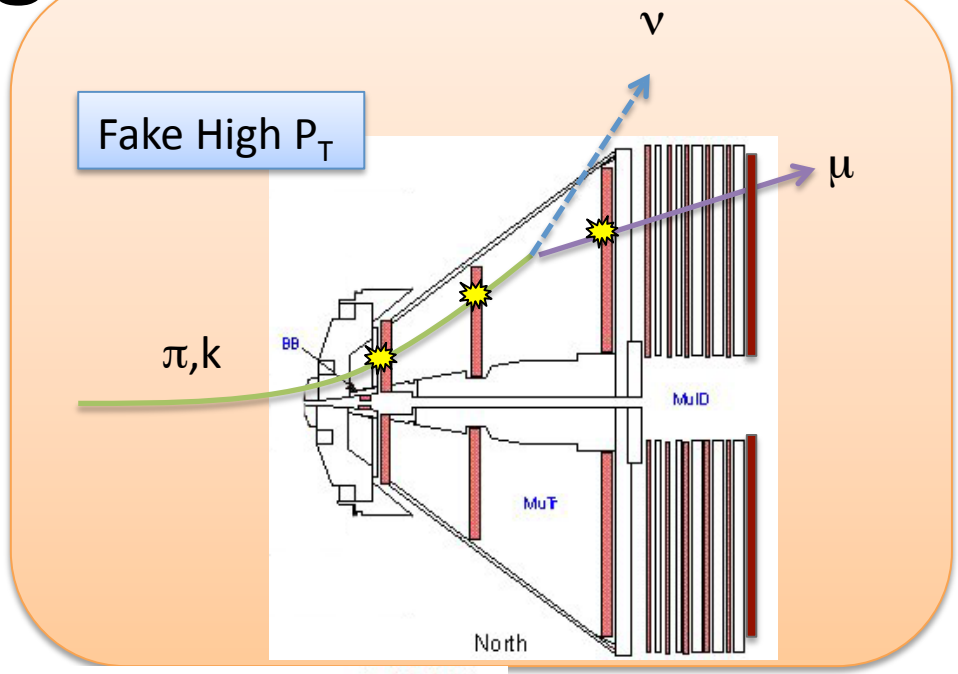
Offline Analysis

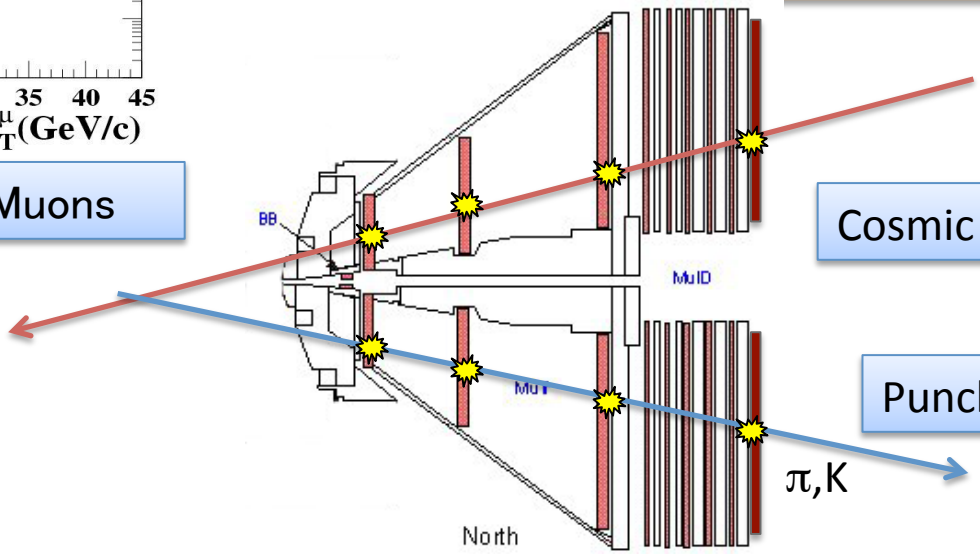
Backgrounds



Heavy Flavor Decay Muons

Fake High P_T

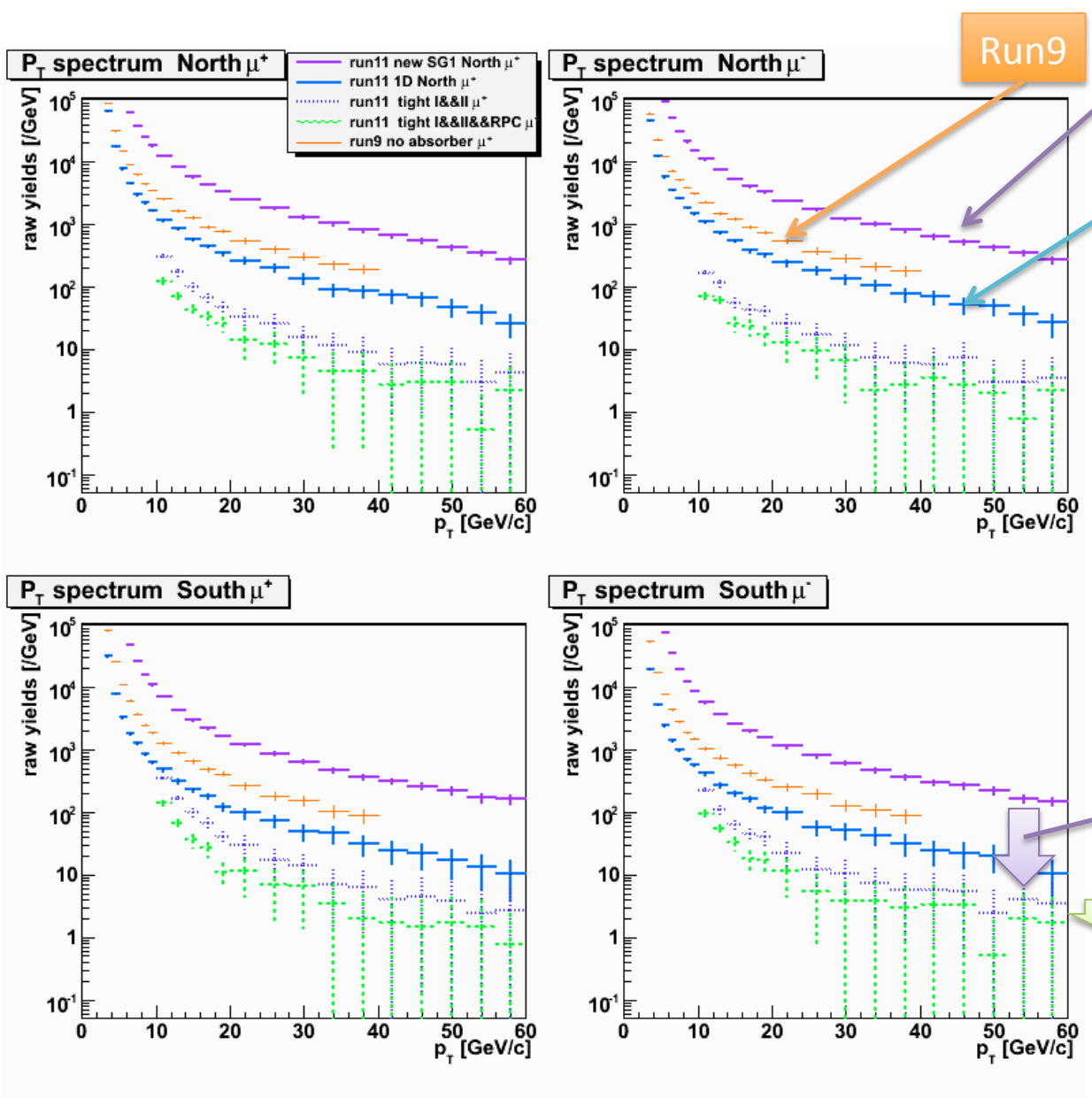




Cosmic & Beam BG

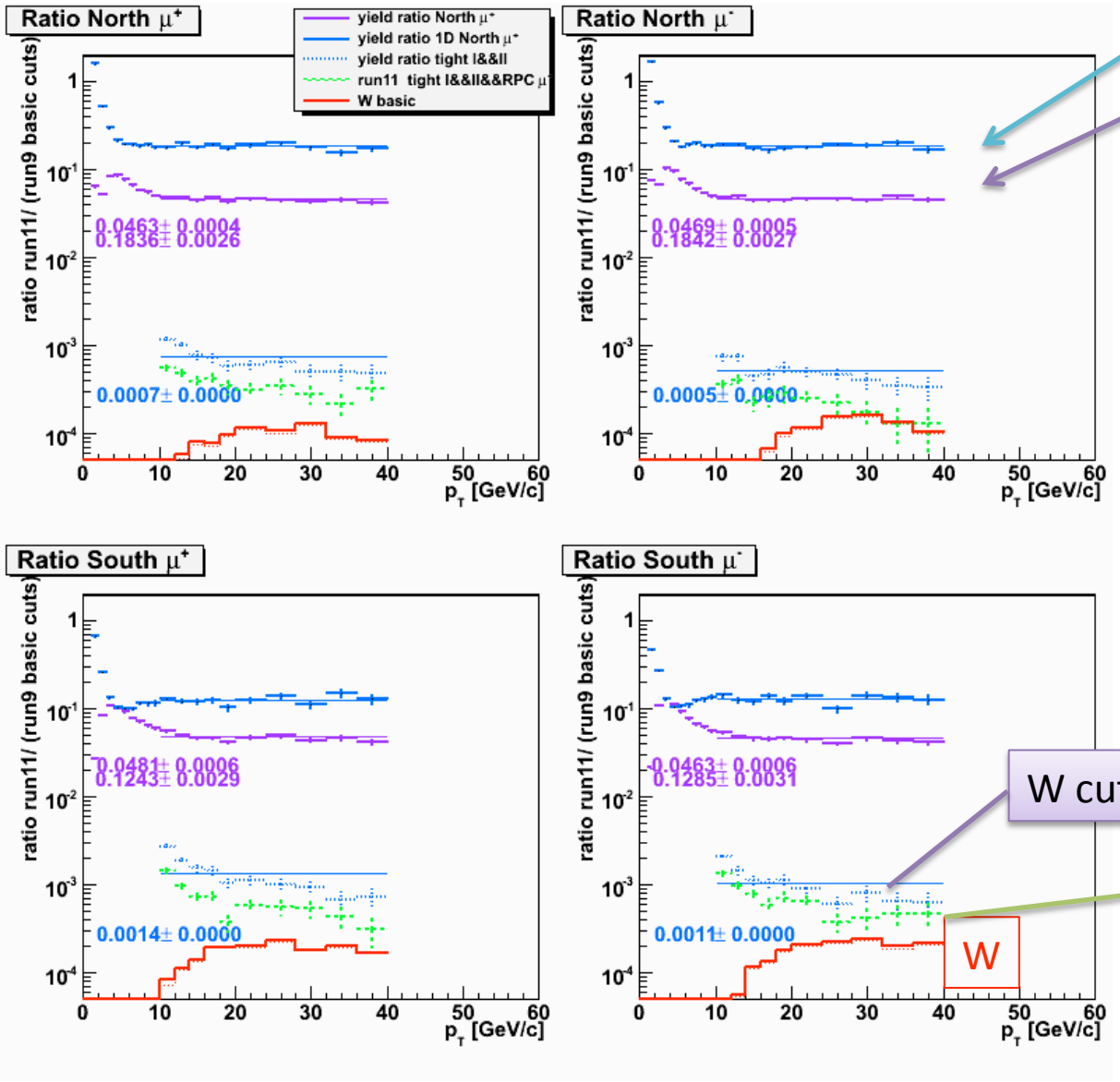
Punch Thru

Raw Yields



- Raw Yields for different triggers
- Applied different level of Cuts

Yield Ratio to Run9



MUID

SG1xMUIDxBBC

- Spectra are normalized by Run9 yields
- Compared to expected W yields (RHICBOS)

W cut

+ RPC cut

Summary

- First Production Run was executed with New Forward Muon Trigger (accumulated 25pb^{-1}).
- Combined Trigger with MuTRG-FEE and MuID provided Physics trigger.
- RPCs were fully commissioned and will give the timing info in offline analysis.
- Forward W analysis team is initiated and analysis now underway.
- We continue to improve performance of existing detectors (hardware and software wise).

Back up Slides

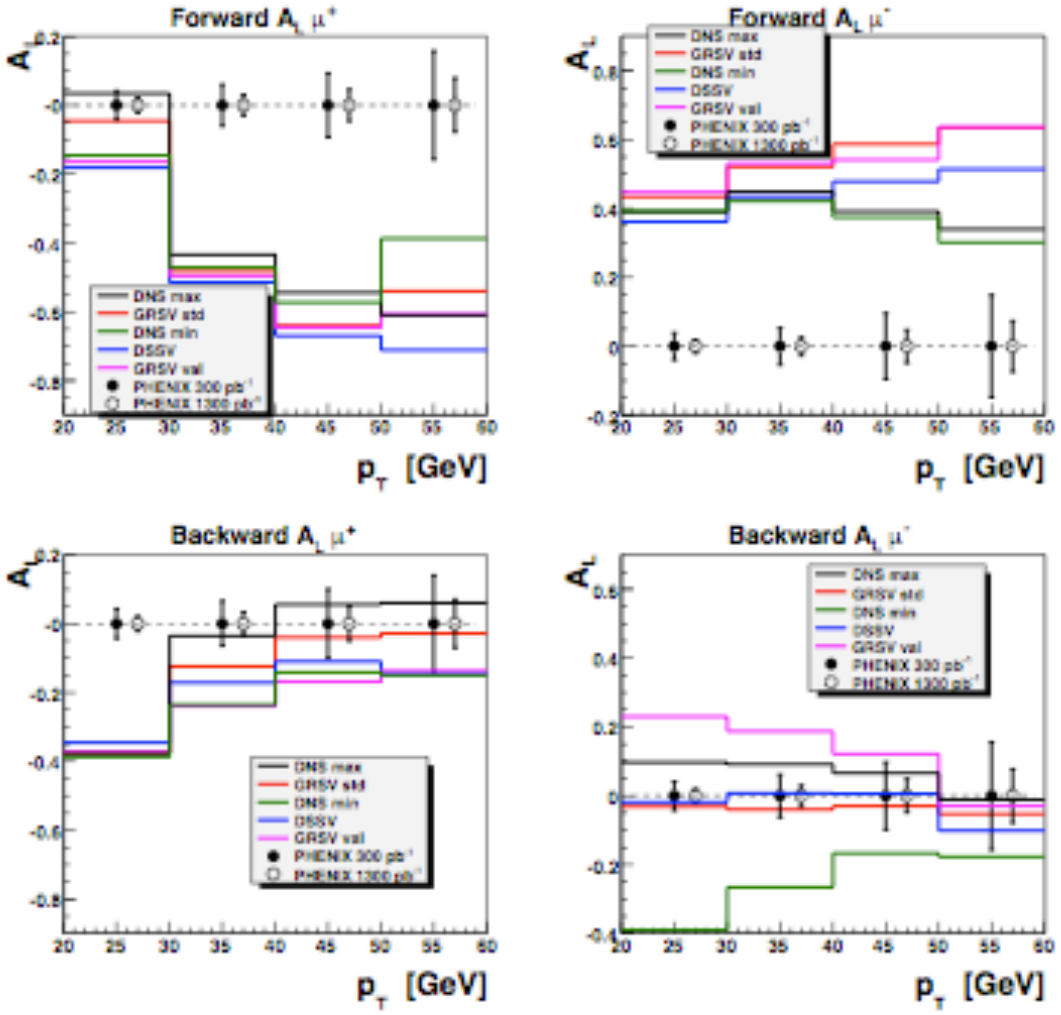
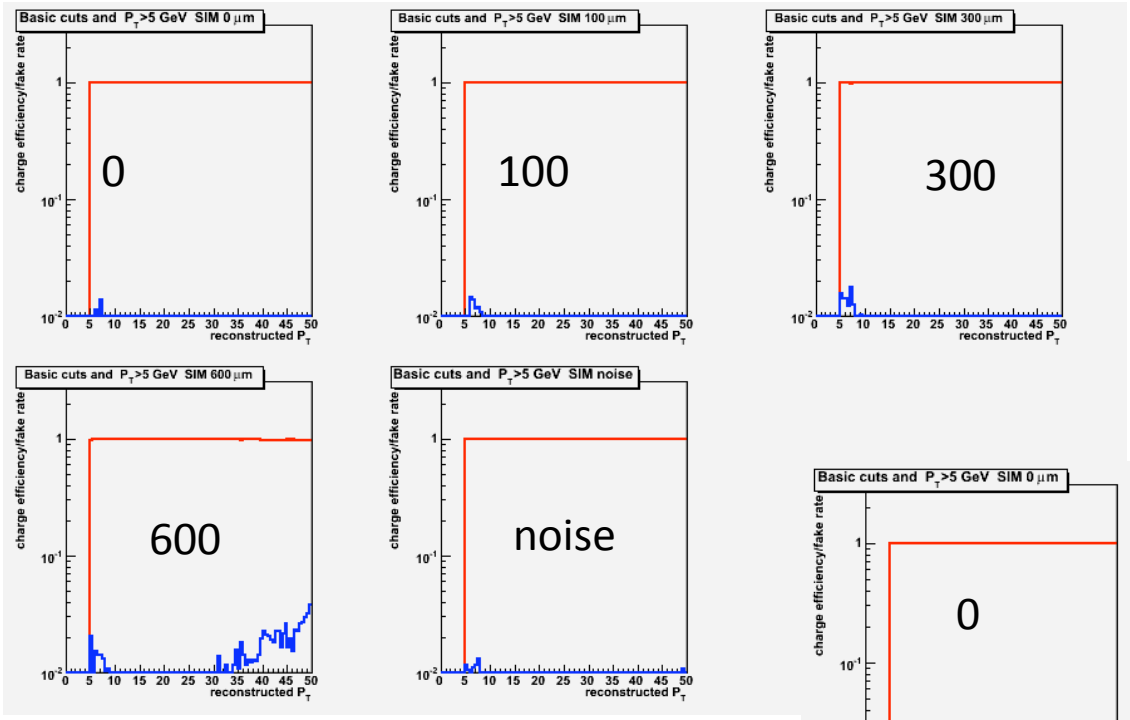
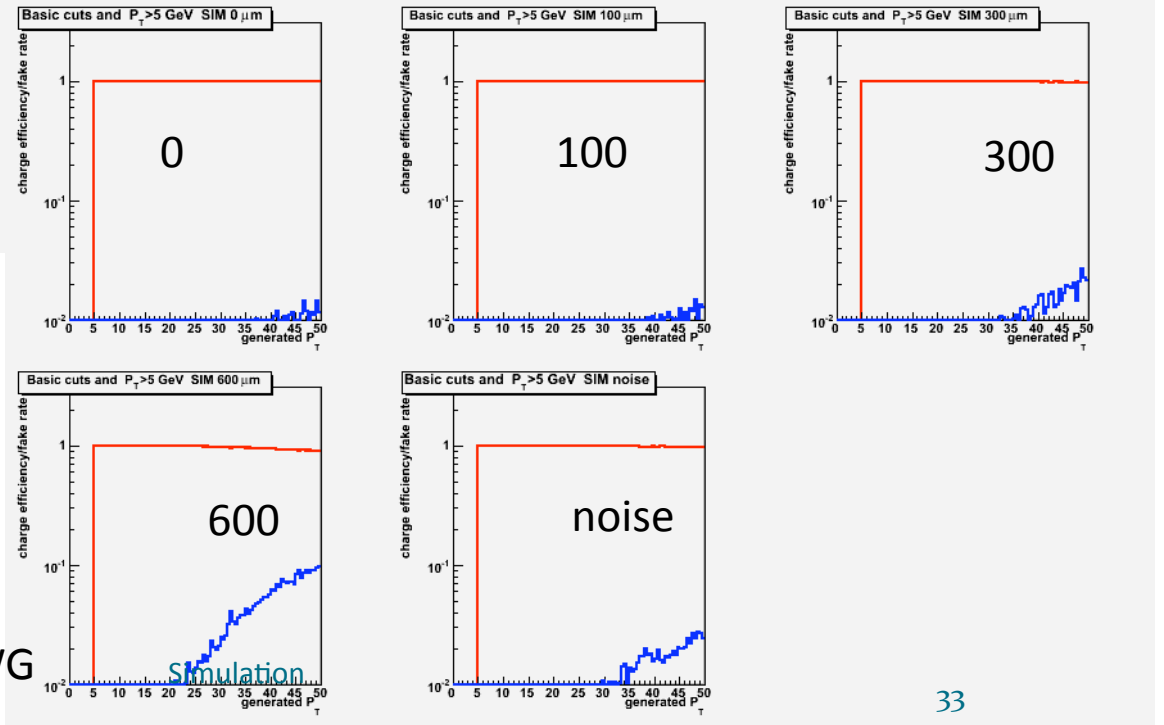


Figure 16: *Longitudinal single spin asymmetries for μ^+ and μ^- in the forward (top plots) and backward (bottom plots) regions of the PHENIX detector as a function of the reconstructed muon p_T. The data has been obtained for GRSV standard, GRSV valence [45], DSSV [14], and DNS [47] using a maximal and minimal sea polarization scenario in RHICBOS [58] after detector simulation and inclusion of background for 300 pb^{-1} (full symbols) and 1300 pb^{-1} (open symbols) assuming 70% beam polarization.*

Charge reconstruction basic cuts

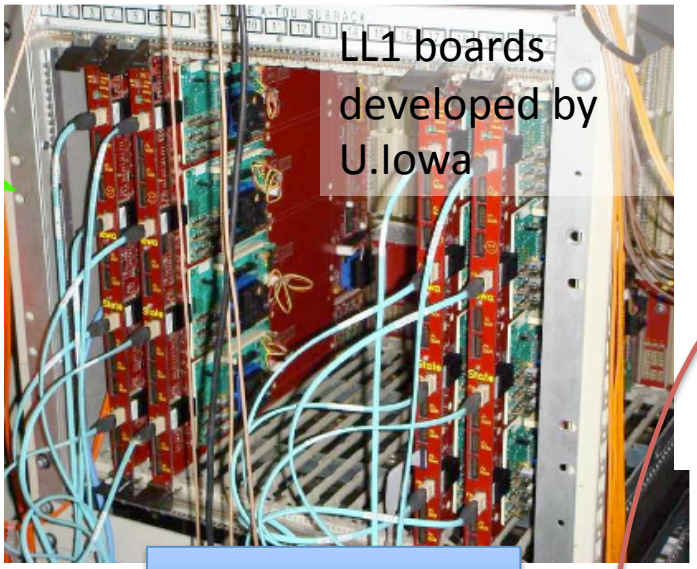


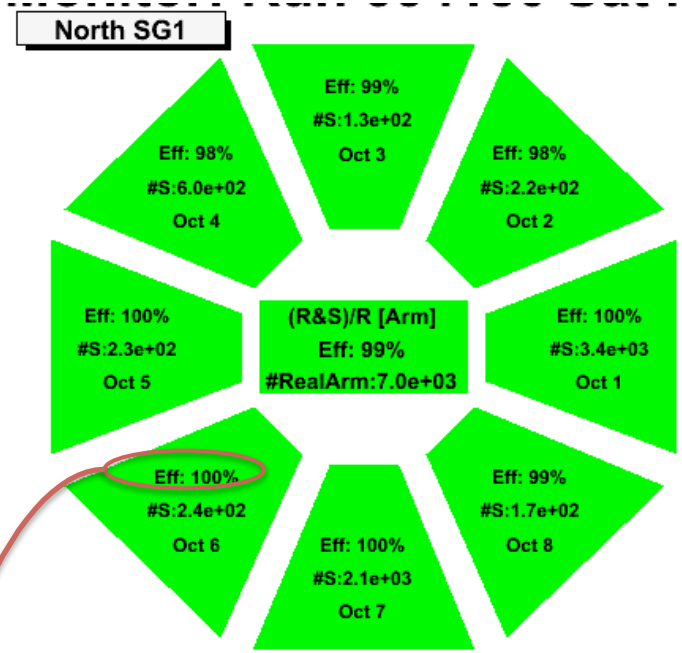
- Log plots, for reconstructed and generated Pt
- small misid event at high Pt
- other arm, charges similar



Slide from R.Seidl presented for Spin PWG

LL1 Efficiencies





Josh Perry's Online Monitor

MuTr

ADTX

MRG

LL1

GL1 Trigger

DCMIF

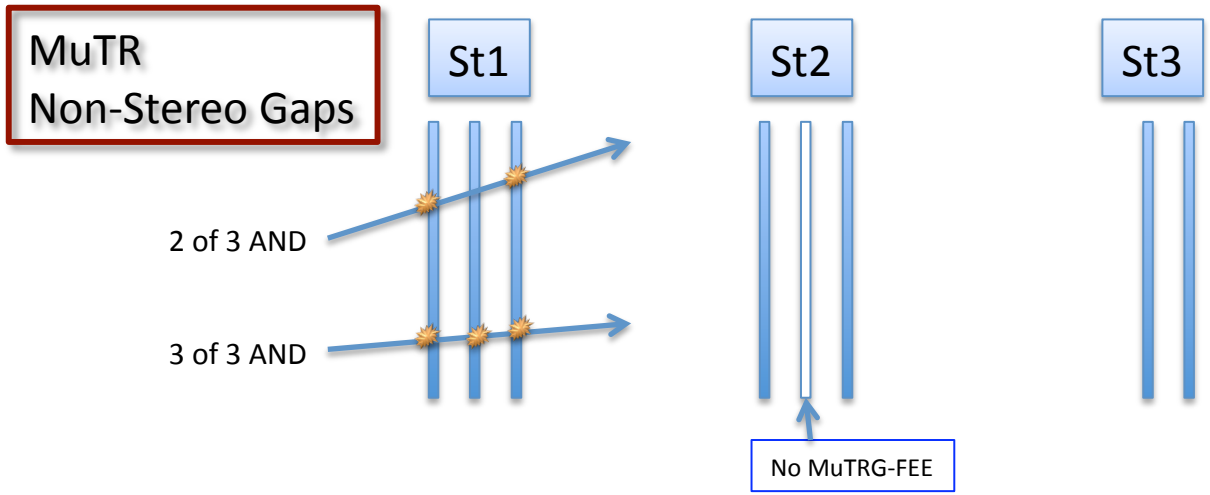
DCM

Identical hit information

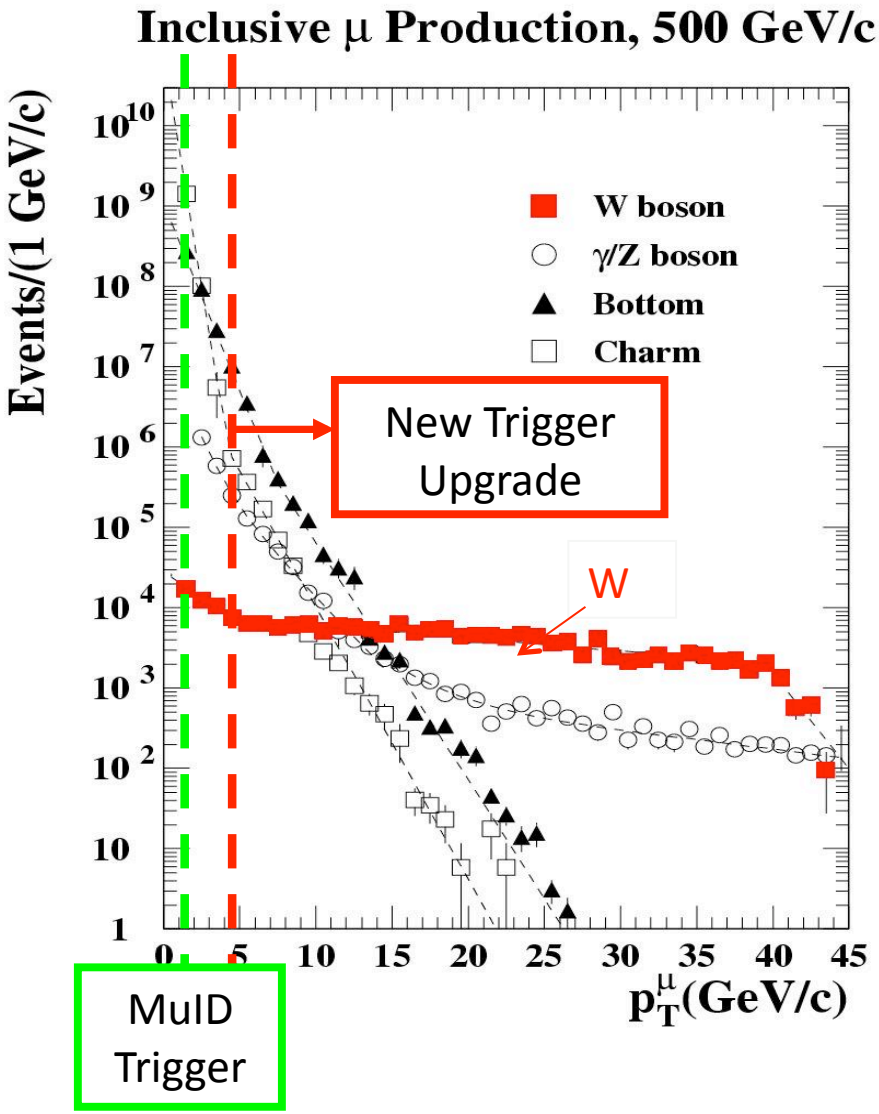
$$Efficiency = \frac{\#\ hits\ processed\ thru\ LL1}{\#\ hits\ processed\ thru\ DCMIF}$$

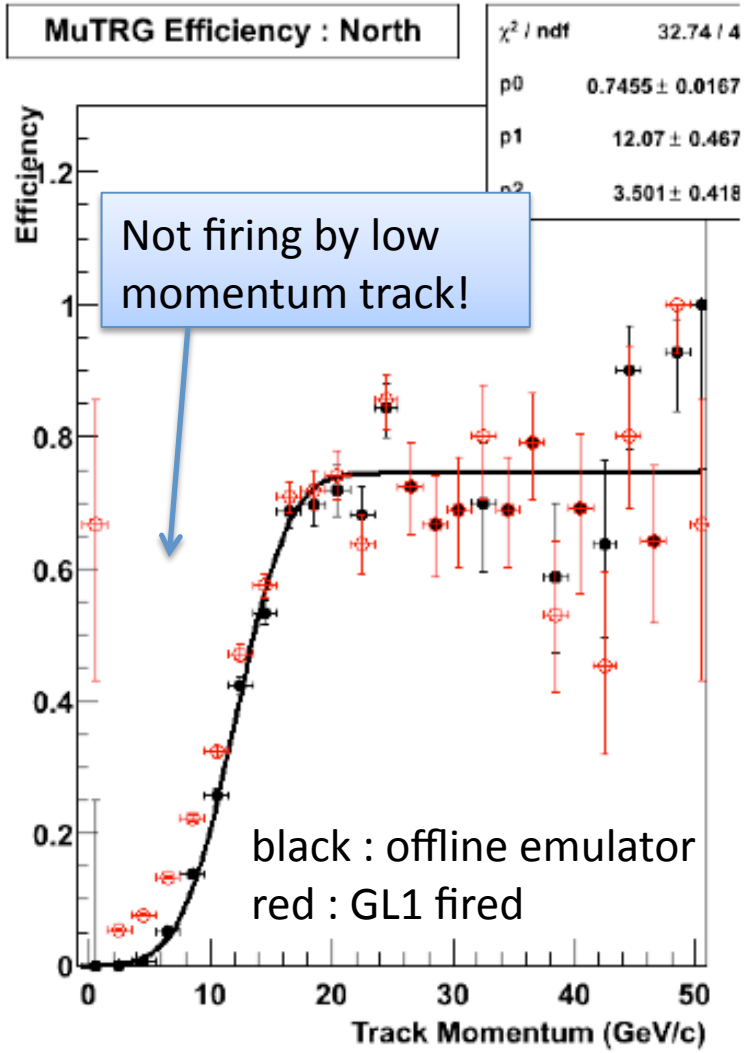
MuTrig-FEE Parameters

Function	Options		
Discriminator	LED	CFD	
Threshold	0 ~ 100 mV (40,60mV)		
Gap LOGIC	OR	AND	
		2 of 3	3 of 3
LL1 Width	1 ~ 7 (2,3)		



Efficiency Turn on Curve





MuTRG System Run09 performance

Better efficiency is the trade off of weak rejection power

- MuID Algorithm
- Track Matching w/ MuID
- Timing cut w/ RPC
- Track Matching w/ RPC
- Neutron Backgrounds
- etc ..