



... for a brighter future

Local Polarimetry at STAR Using the Zero Degree Calorimeter Shower Maximum Detector

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*on behalf of the STAR
Collaboration*



U.S. Department
of Energy

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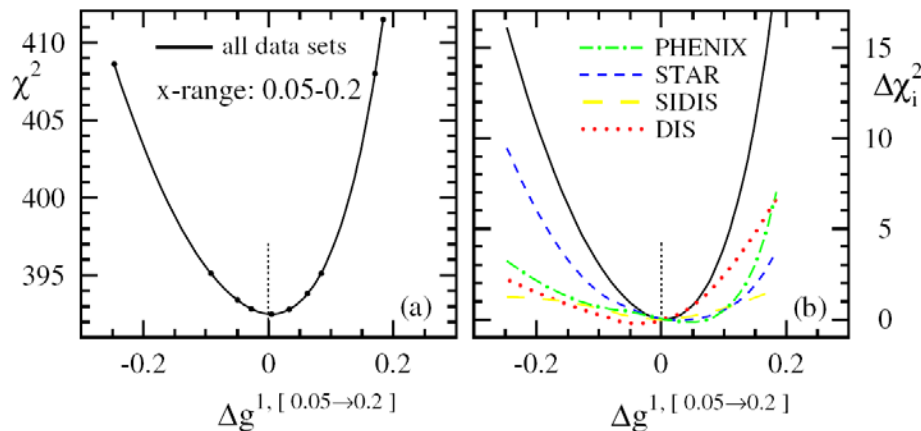
Outline



- RHIC polarized protons and polarimetry
- STAR local polarimetry
- Analysis Details
- Results
- Future

The Polarized Proton Program at RHIC

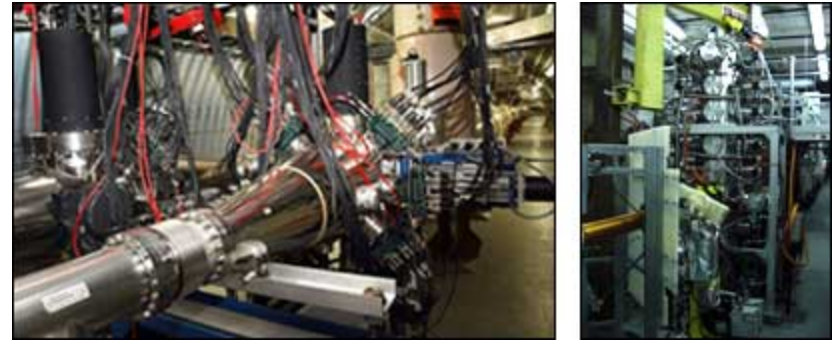
- RHIC is the world's only polarized proton collider
- Proton beams have been collided at 62, 200, and 500 GeV
- Polarized collisions directly probe $\Delta g(x, Q^2)$



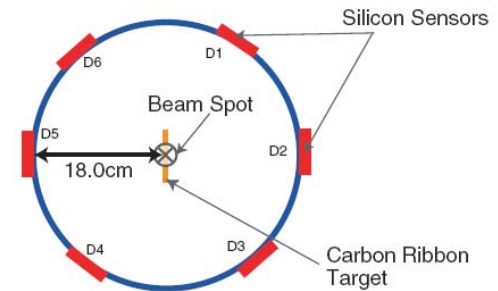
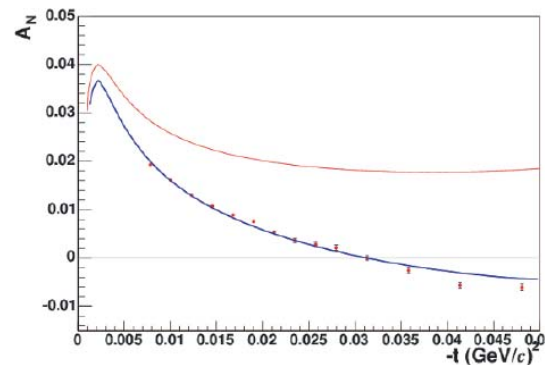
deFlorian, et al., PRL 101, 072001

Polarimetry at RHIC

- Polarimeters located at 12 o'clock
 - Hydrogen-Jet (H-Jet) measures *absolute* polarization
 - Proton-carbon (pC) measures *relative* polarization
- Transverse beam polarization components measured at STAR IR



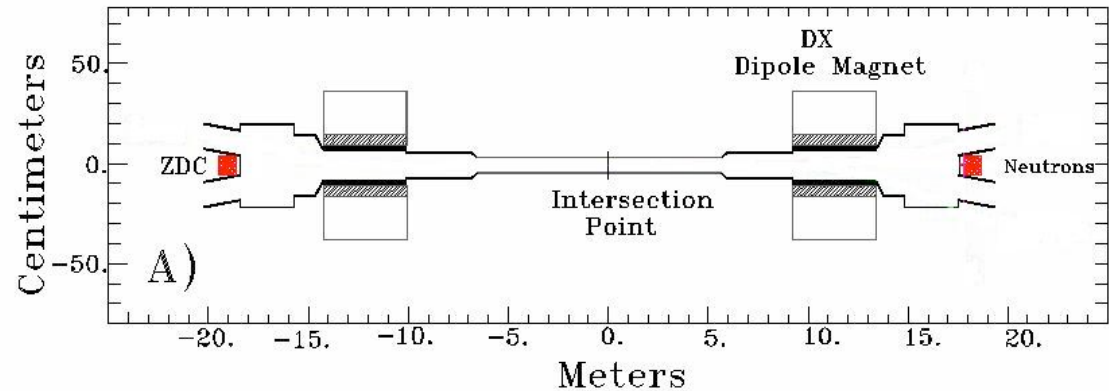
[CERN Courier](#), Sep 29, 2005



Eur. Phs. J. Special Topics 162, 259-265 (2008)

Local Polarimetry at STAR

Zero Degree Calorimeter



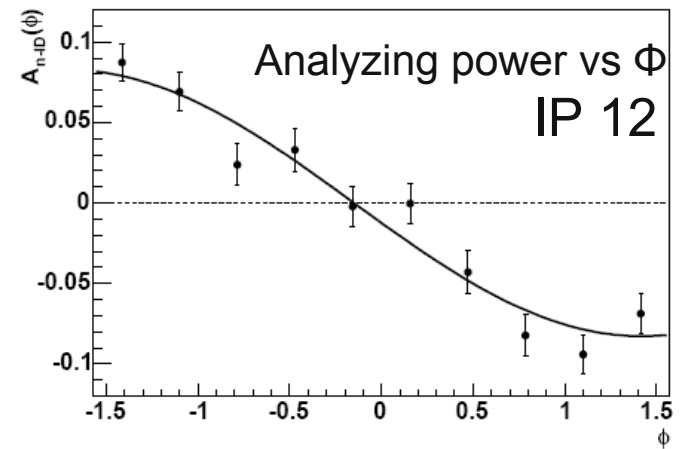
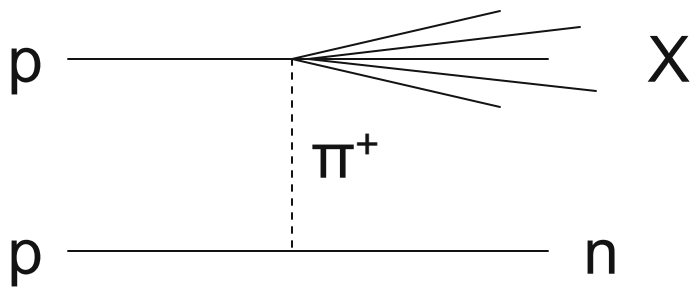
Vertex Position Detector & Beam-Beam Counter

Detector	$ z $ (cm)	$ \eta $ Range
BBC	374	3.3, 5
VPD	568	4.2, 5
ZDC	1800	6.5, 7.5



Lead Neutron Production

- The ZDC detects very forward neutrons
 - Small contamination from K_L^0 , photons
 - IP 12 experiment measured photon A_N consistent with 0
 - K_L^0 fraction $\sim 3\text{-}4\%$
- Cross section of forward neutrons is understood
- However, source of spin asymmetry is not well understood

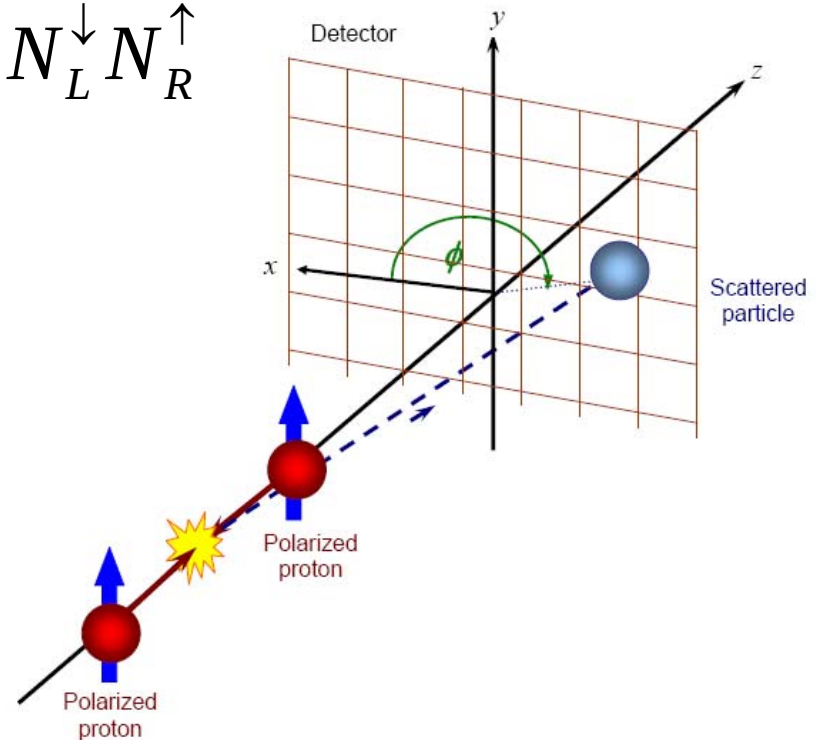


Phys. Let B 650, 325-330 (2007)

Single Spin Asymmetry

$$\varepsilon_{phys} = \frac{\sigma^{\uparrow} - \sigma^{\downarrow}}{\sigma^{\uparrow} + \sigma^{\downarrow}} \approx \frac{\sqrt{N_L^{\uparrow} N_R^{\downarrow}} - \sqrt{N_L^{\downarrow} N_R^{\uparrow}}}{\sqrt{N_L^{\uparrow} N_R^{\downarrow}} + \sqrt{N_L^{\downarrow} N_R^{\uparrow}}}$$

$$A_N = \frac{\varepsilon_{phys}}{P}$$



Analysis

- Dedicated trigger requires BBC coincidence and high energy deposit in front and back ZDC calorimeter modules
- SMD ADC counts are pedestal-subtracted and gain-matched
- Require coincidence of vertical & horizontal slats above pedestal and count the single highest hit
- RHIC CNI polarization measurements used in evaluating A_N

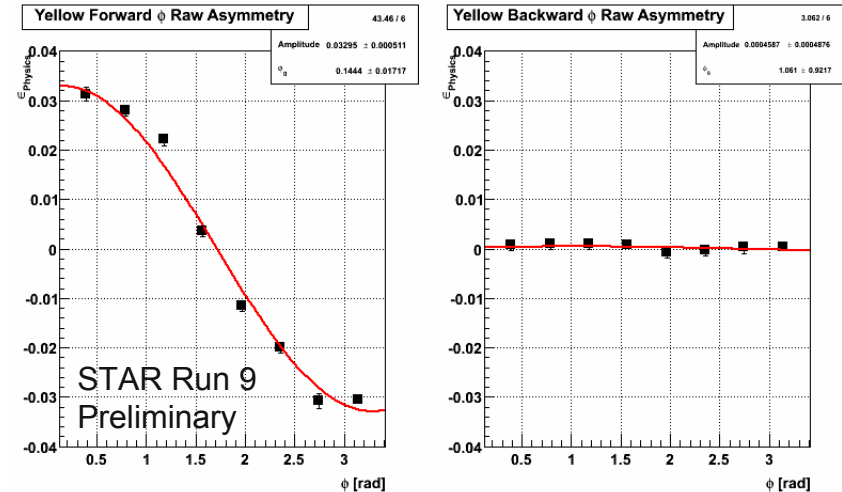


SMD located between ZDC calorimeter modules. It is composed of 8 horizontal slats and 7 vertical slats. Total area ~ 10 cm X 10 cm in transverse plane.

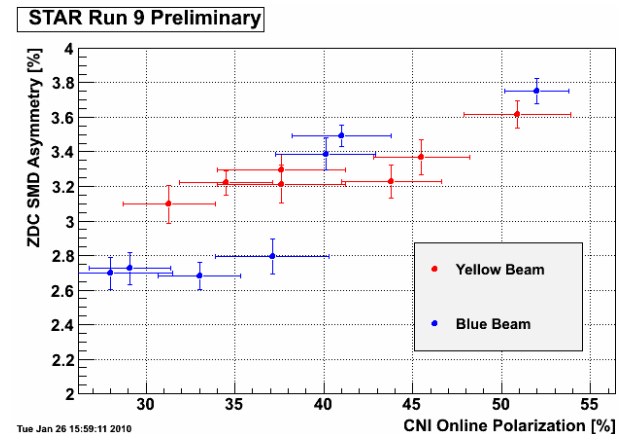
Results

- ZDC SMD commissioned at $\sqrt{s} = 200$ GeV in 2004
- Further development in 2009 $\sqrt{s} = 500$ GeV running
 - Will be the source of local polarization measurements for analysis
 - Online monitoring of asymmetries
- $A_N^{\text{ZDC}} \sim 8\%$

Physics asymmetry vs Φ for yellow beam

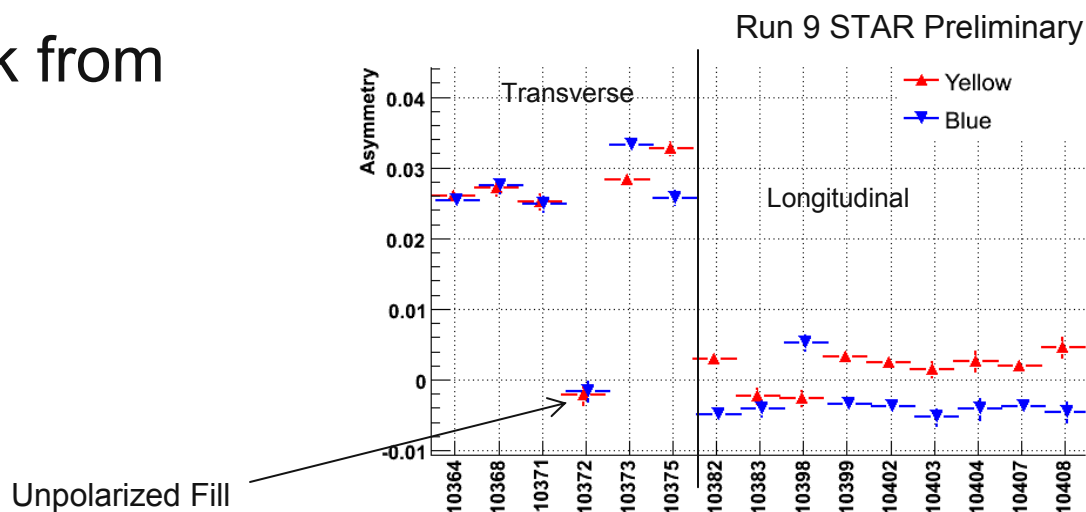


ZDC SMD asym. vs RHIC CNI asym.



Future

- Investigation of the source of the asymmetry underway
- Study ways to improve analysis
 - Trigger conditions
 - Algorithm
- Implement ZDC into STAR scaler system
 - No longer requires dedicated runs
 - Constant feedback from online monitoring



Summary

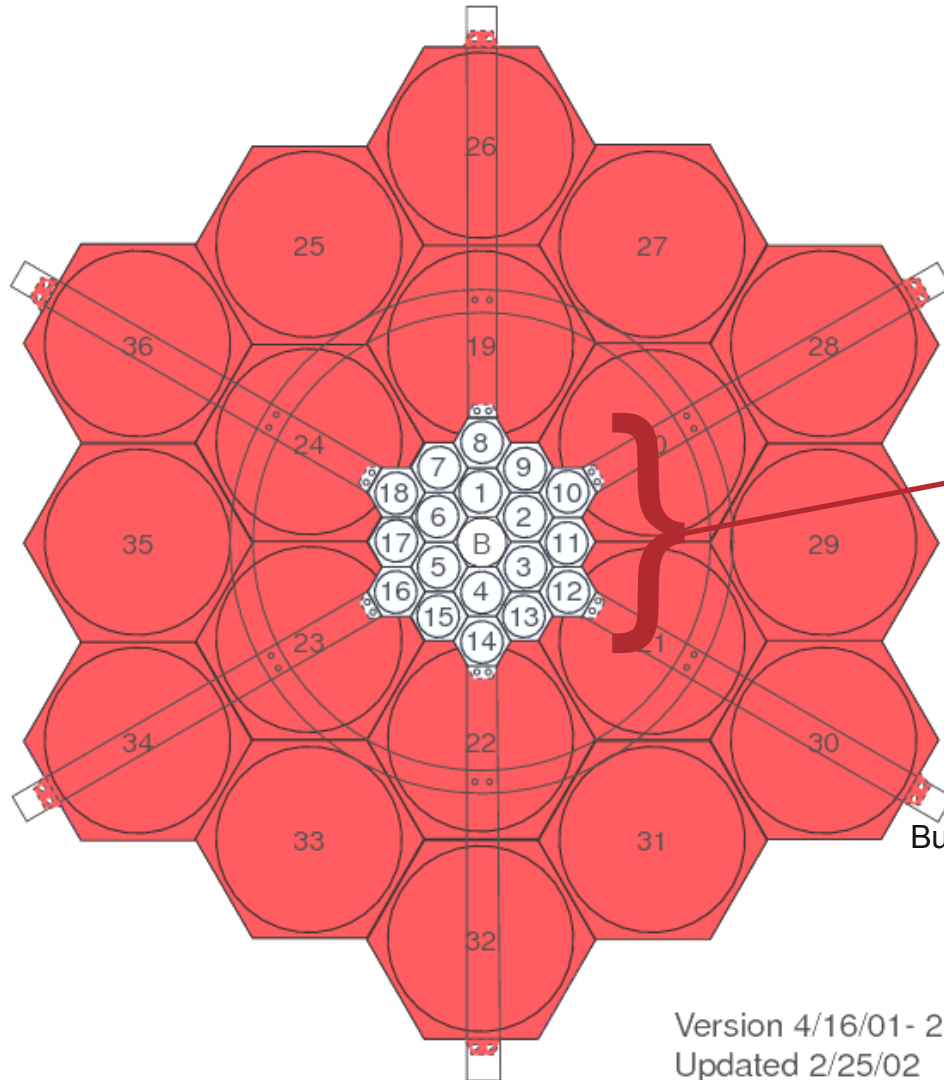
- ZDC SMD is an important component of the STAR local polarimetry system, especially at $\sqrt{s} = 500$ GeV
- Large analyzing powers observed at $\sqrt{s} = 200$ and 500 GeV
- Physics mechanism(s) of large asymmetry is being studied

Thank you to everyone in the STAR collaboration who contributed to this work!

Backup

BBC Scaler Readout

STAR Beam-Beam Counter Schematic
Front View



Scaler Boards

Discriminated
phototube outputs

East-West Coincidence

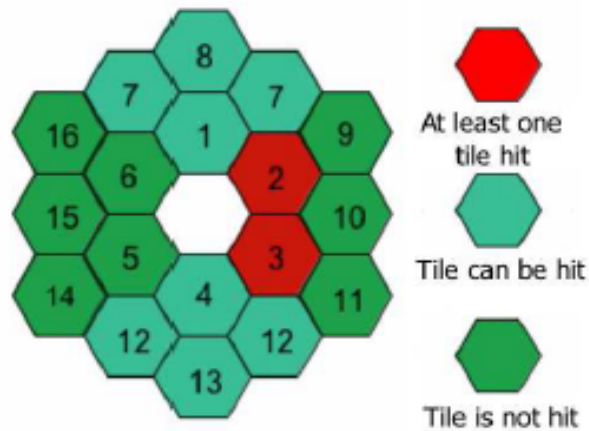
Bunch Crossing (7-bit)

24-bit word is
histogrammed
every clock cycle

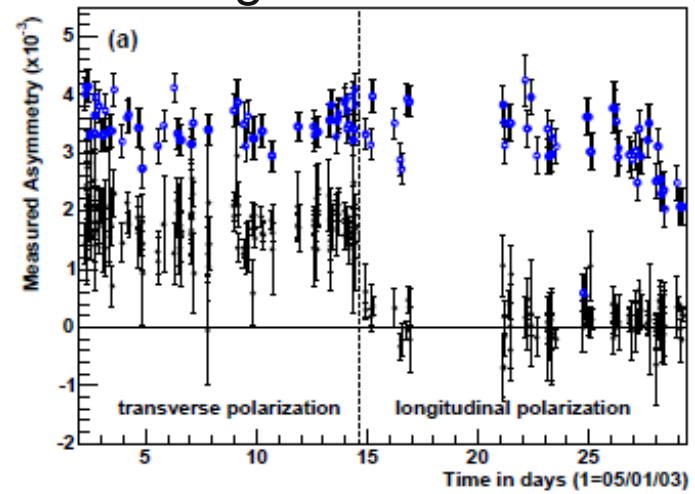
Version 4/16/01 - 2
Updated 2/25/02

BBC Asymmetry

Inner right tiles.

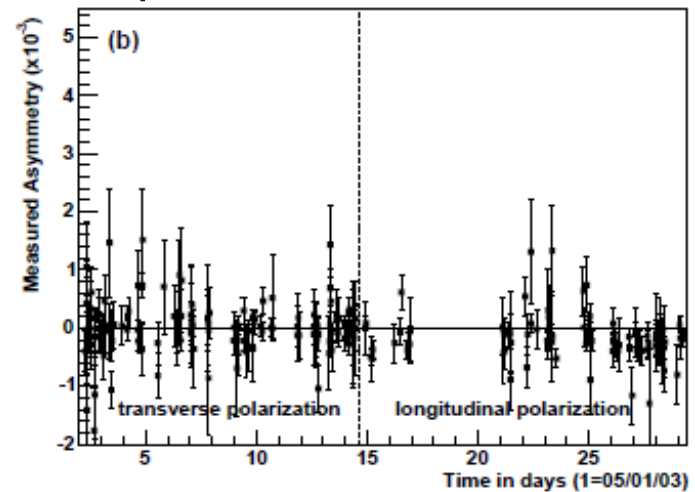


Left-right



CNI
BBC

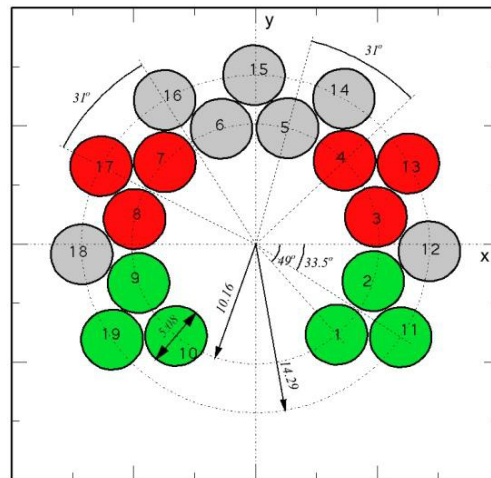
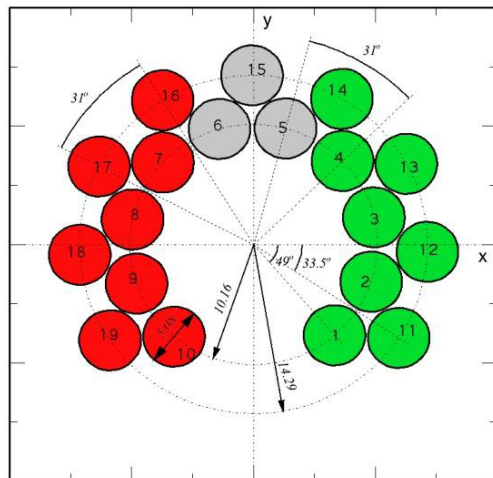
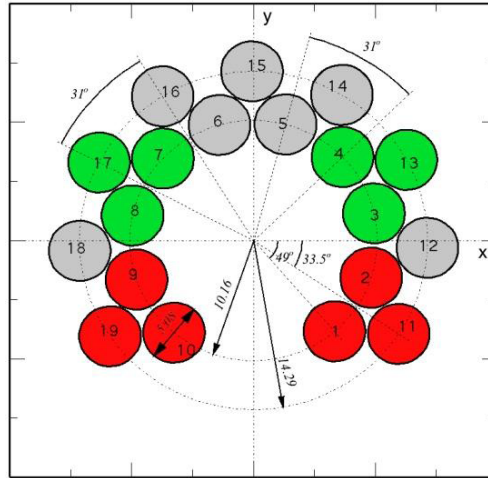
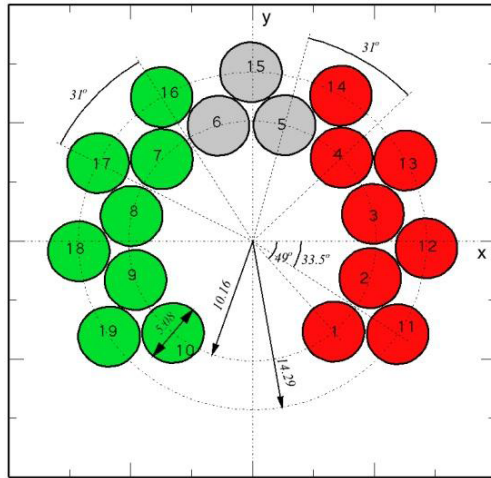
Up-down



VPD Asymmetry

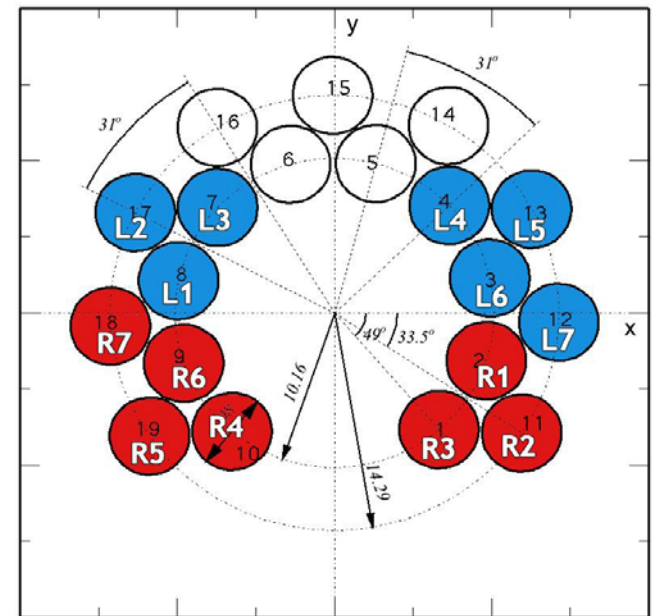
Left-Right

Top-Bottom



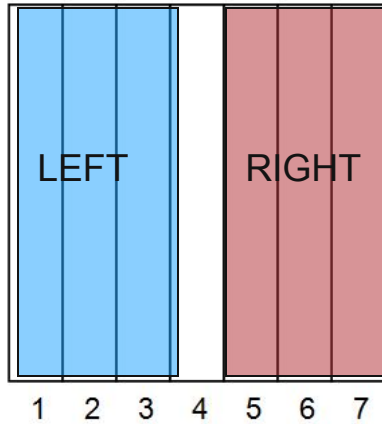
Hits Allowed
No Hits Allowed
No Restriction

Phi Distribution



ZDC Asymmetry

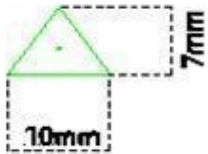
ZDC Shower Max Detector (SMD)



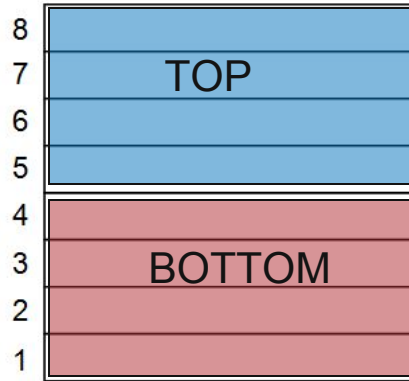
Vertical slats (X)

(21 strips)

SMD Strip Dimensions



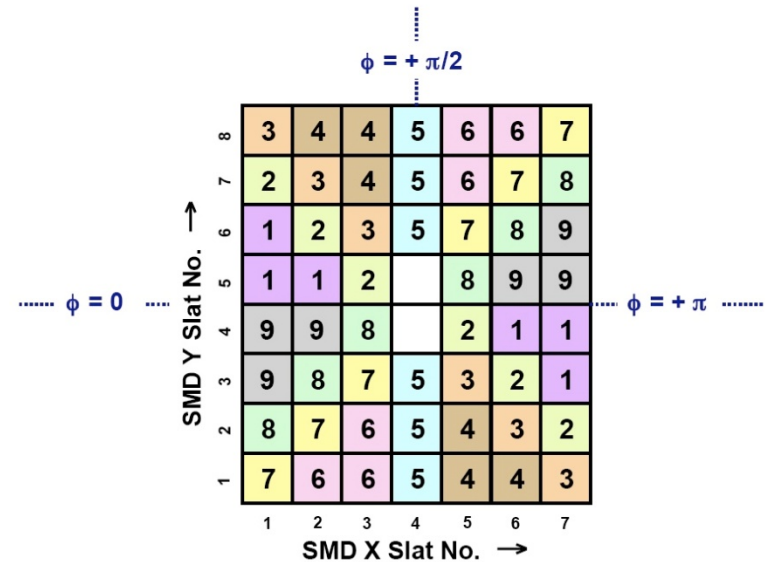
SMD Layer



Horizontal slats (Y)

(32 strips)

Phi Distribution



ZDC Trigger Details

■ Trigger imposes various BBC and ZDC SMD requirements

- BBC ADC > Threshold
- ZDC front and back ADC > Threshold
- BBC/ZDC TAC

■ 200 GeV commissioning runs

- (BBC E > X) && (BBC W > X) && (BBC TAC Diff) && (ZDC E TAC || ZDC W TAC)

■ 500 GeV runs tested many conditions

- ((ZDC E Front > X && ZDC E Back > Y) || (ZDC W Front > X && ZDC W Back > Y)) with and without BBC E > X && BBC W > X
- (ZDC E Front > X && ZDC E Back > Y) && BBC E > X
- (ZDC E Front > X && ZDC E Back > Y) && BBC W > X
- Etc....