• 6 UVa GEMs are used in the PRex experiment (50cm x 60 cm)
  ○ 22 APV cards on each UVa GEM
  ○ ~17,000 APV readout channels

• Each HRS contains
  ○ 3 UVa GEMs (50cm x 60cm)
    ■ HDMI cables
    ■ Low voltage
    ■ High Voltage
  ○ 3 ISU GEMs (10cm x 20 cm)
- 6 GEM detectors are put in parallel
  - ~ 5 cm² hot area (PRex elastic peak area)
  - ~150K trigger rate => ~ 30 kHz/cm² (run on Sep 03)

- GEMs allow High rate operation during the PRex counting mode

- Test the GEM detector in a real experiment environment
  - Same length HDMI cables (10m + 1m)
  - same low voltage modules
  - same voltage regulators
  - same patch panels
  - cooling

5V scalable low voltage module designed for SBS

3 UVa GEMs
3 ISU GEMs
VDC

2.5V/1.25V voltage regulators
Pedestal Distribution

- HDMI cable length 11m for UVa GEMs
- Area for UVa-GEM is much larger than that of ISU GEMs
  - UVa-GEM strip length is much longer
  - Higher capacitance -> Higher noise
- For L-HRS, the HDMI cables are different brand compared with RHRS
  - Kondo and Thir did a careful study of the noise level for several different kinds of HDMI cables.
  - This independent test also shows the RHRS HDMI are the best.
  - For SBS experiment, we will use the HDMI cables giving the best noise level

RMS distribution for All APV Cards

- X : APV Card.
  - On each bin, it have 128 points which is the RMS of the 128 channels on each APV Card.
- Y : RMS
Pedestal Distribution

- HDMI cable length 11m for SBS GEMs
- Area for SBS-GEM is much larger than ISU GEMs
  - SBS-GEM strip length is much longer
  - Higher capacitance -> Higher noise
- For L-HRS, the HDMI cables are different brand compared with RHRS
  - Kondo and Thir did a careful study of the noise level for several different kinds of HDMI cables.
  - This independent test shows the RHRS HDMI are the best.
  - For SBS experiment, we will use the HDMI cables giving the best noise level

APV data from LHRS and RHRS.
GEM detector Noise Level

- GEM Signal/background distribution (log scale)
  - Blue line: strip ADC did not pass the 5-sigma cut
  - Red line: strip ADC passed the 5-sigma cut (hit candidate)
  - Y dimension strip is wider -> higher noise level

strip ADC did not pass the 5-sigma cut
GEM detector X-Y hit distribution

- GEM Signal/background distribution (log scale)
  - Blue line: strip ADC did not pass the 5-sigma cut
  - Red line: strip ADC passed the 5-sigma cut (hit candidate)
  - Y dimension strip is wider -> higher noise level

- X-Y 2D hit Distribution at each UVa GEM
  - all the GEM detectors are working well

The shape of the distribution due to the PReX optics tune

R-HRS run 20862
- Track Event Viewer
  - Hit on each GEM
  - Hit reconstructed from TreeSearch
  - Track reconstructed from VDC

- Residual
  - The distance between GEM hit and the hit of VDC project to each GEM plane

The residuals are dominated by the multi-scattering of electrons in the ~2 mm thick aluminum top cover of the VDC protection box and travelling through ~3 m of Air.
GEM efficiency study

**GEM Detected Hit**: Project VDC to GEM plane and search for GEM Hit within 2cm square area
**VDC Projected Hit**: Project VDC to GEM plane

- If the total number of projected events in a given bin is smaller than 30, that bin is not used in the efficiency calculation
  - background caused by cosmic etc
  - fake hit caused by VDC ghost hit combinations at high rates (U-V wire signature of VDCs clearly visible)

- Efficiency quoted for each bin (0.5cm x 0.5 cm)
GEM efficiency study

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**GEM efficiency study**

**GEM Detected Hit**: Project VDC to GEM plane and search for GEM Hit within 4cm square area

**VDC Projected Hit**: Project VDC to GEM plane

- If the total number of projected events in a bin is smaller than 30, that bin is not used in the efficiency calculation
  - background caused by cosmic etc
  - fake hit caused by VDC ghost hit combinations at high rates (U-V wire signature of VDCs clearly visible)

- Efficiency quoted for each Bin (1cm x 1 cm)

- GEM High voltage: 4050

*‘V’ shape is due to the PReX optics tune.*

*‘X’ shape is due the misconstruction of VDC*
GEM efficiency study

**GEM Detected Hit**: Project VDC to GEM plane and search for GEM Hit within 4cm square area

**VDC Projected Hit**: Project VDC to GEM plane

- If the total number of projected events in a give bin is smaller than 30, that bin is not used in the efficiency calculation
  - background caused by cosmic etc
  - fake hit caused by VDC ghost hit combinations at high rates (U-V wire signature of VDCs clearly visible)

- Efficiency quoted for each Bin (1cm x 1 cm)

- GEM High voltage: 4050

Efficiency distribution for each Bin

![Efficiency distribution graph](image)
GEM efficiency study

**GEM Detected Hit**: Project VDC to GEM plane and search for GEM Hit within 4cm square area

**VDC Projected Hit**: Project VDC to GEM plane

- If the total number of projected events in a given bin is smaller than 30, that bin is not used in the efficiency calculation
  - background caused by cosmic etc
  - fake hit caused by VDC ghost hit combinations at high rates (U-V wire signature of VDCs clearly visible)
- Efficiency quoted for each Bin (1cm x 1 cm)

- GEM High voltage: 4050

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![Efficiency distribution for each Bin](image_url)

- Efficiency distribution for each Bin
  - Efficiency distribution Bin_std
  - Entries: 152
  - Mean: 0.9402
  - Std Dev: 0.02767

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UVa GEM #3
LHRS GEM performance study

- High voltage
  - 4050
  - 4100 for the LHRS-SBS-CH5.

- Very preliminary result
  - The detectors is not aligned very well
  - There is a bug in the analysis code for the LHRS
    - There are a lot of APV frame does not have the right size (skipped in the analysis).
    - will need to contact Seamus to fix the bug
  - expect the efficiency would be lower than its real value
GEM efficiency study

- High Voltage 4050V
- efficiency \( \sim 0.88 \)
Very Preliminary Result

GEM efficiency study

- High Voltage 4100V
  - The working voltage is higher than rest of GEMs

- Some of the APV frame (3 time sample x 128 strips) is not right when analysis the data. But in another standalone code, this problem did not show up. Maybe this is a bug in the PRex-Analyzer

- Efficiency ~0.66
GEM efficiency study

- High Voltage 4050V
- efficiency ~0.92
GEM detector Noise Level

- Common mode suppression
- Pedestal suppression
- Strip ADC that did not pass the 5-sigma cut
SBS GEM 2-D Cluster distribution

RHRS-SBS-CH4

- Entries: 24733
- Mean x: 0.0391
- Mean y: 0.004665
- Std Dev x: 0.02974
- Std Dev y: 0.01997

RHRS-SBS-CH5

- Entries: 24581
- Mean x: -0.0393
- Mean y: 0.004344
- Std Dev x: 0.028689
- Std Dev y: 0.01892

RHRS-SBS-CH6

- Entries: 24568
- Mean x: -0.0372
- Mean y: 0.022993
- Std Dev x: 0.007250
- Std Dev y: 0.01763
max adc of 3
time
samples

Fit Sigma: 7.85

Fit Sigma: 6.97

Fit Sigma: 7.66

Fit Sigma: 9.31

Fit Sigma: 9.36

Fit Sigma: 9.35