Pixel Efficiency and HV Scans

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Reminder: Definition of Efficiency

- RecHit efficiency
  - Definition: $(N_{valid} + N_{missing\ with\ cluster})/(N_{valid} + N_{missing})$
  - For RecHits with no other RecHits within 5 mm
  - $N_{missing\ with\ cluster}$: Missing RecHits with a cluster within 500 μm
  - Layer 1: propagate valid hit from Layer 2

- Track selection – General tracks collection
  - For each hit used in the efficiency calculation, require valid hits on the other two pixel layers or disks (in order to avoid bias from pixel seeding)
  - $P_t > 0.6\ GeV$, $N_{strip\ hits} > 10$
  - Track consistent with vertex, tight cut on impact parameters *d0, dz*
  - Track separation (RecHits separated by 5mm)

- Event selection
  - $N_{vertex} \geq 1$, where $|z| \leq 15\ cm$, $|\rho| < 2.0\ cm$, $N_{dof} > 4$

Selections, Datasets

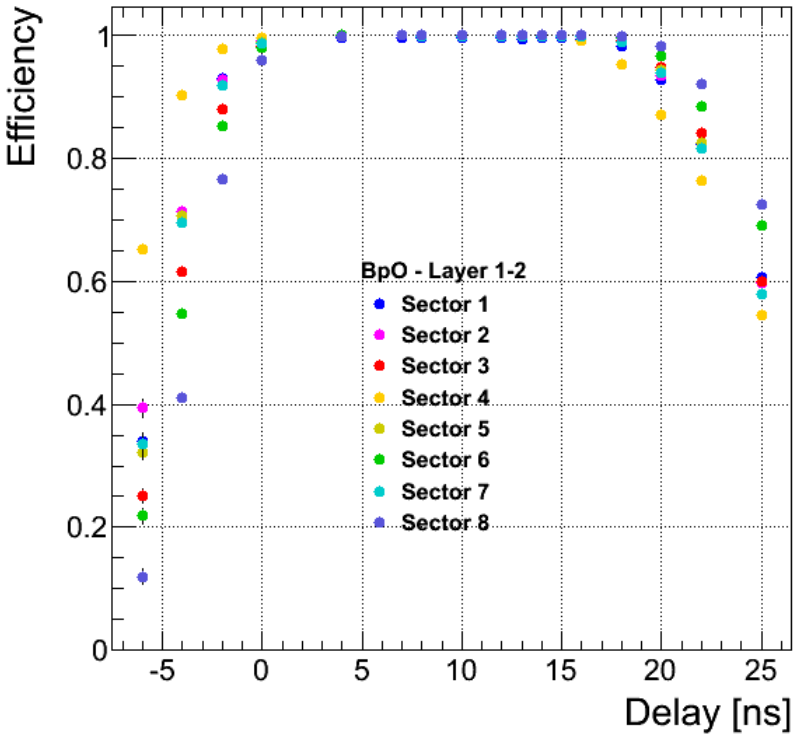
- Runs:
  - 160413,160497,160577,160578 – delay scans
  - All Good 2011 runs, up to 163869, according to JSON file
- Datasets:
  - /MinimumBias/Run2011A-PromptReco-v1/RECO
  - /MinimumBias/Run2011A-PromptReco-v2/RECO
- Software version: CMMSW_4_1_2, CMSSW_4_1_4_patch4
- Global tag: GR_P_V17
- Lumi selections:
  - Cert_160404-163869_7TeV_PromptReco_Collisions11_JSON.txt
- Fiducial region selection
  - Exlude module edges, overlapping regions and FPix plaquettes used for seeding

Verifying Internal Alignment

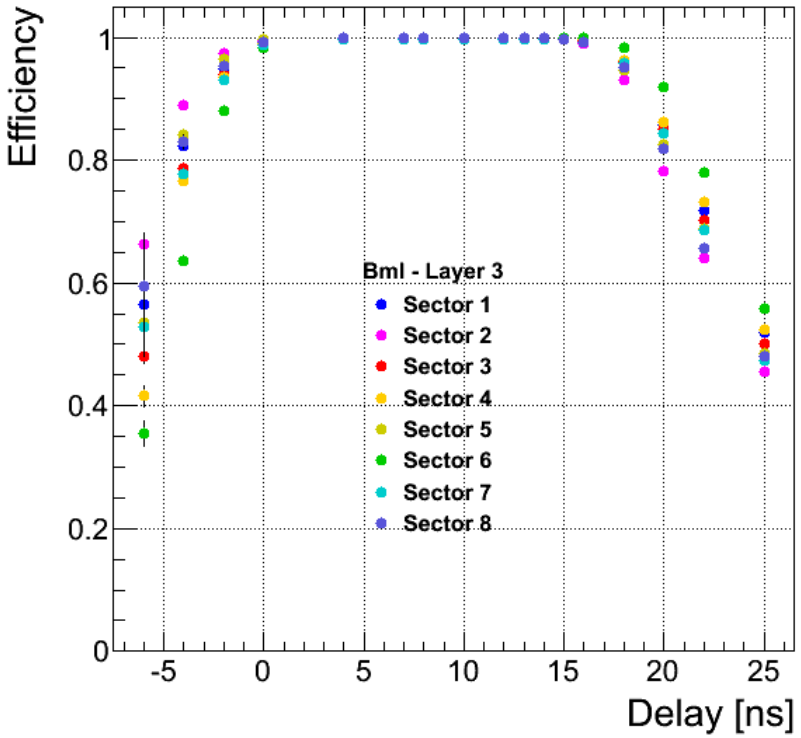
- Read-out groups were timed to collisions individually in 2010
  - Alignment maximized average cluster size
  - Verified results looking at efficiency profile as a function of clock delay
  - Accuracy of alignment was ~2 ns
- Performed cross-check on 2011 data
  - Larger statistics provides greater precision - able to drill down to the ROC level
  - Confirmed best timing based on cluster charge (MPV of Landau fit)
- Looked at relative alignment at following granularities:
  - all read-out groups
  - modules within a single ROG
  - ROCs within a single module

Time Alignment of Readout Groups

Layer 1-2



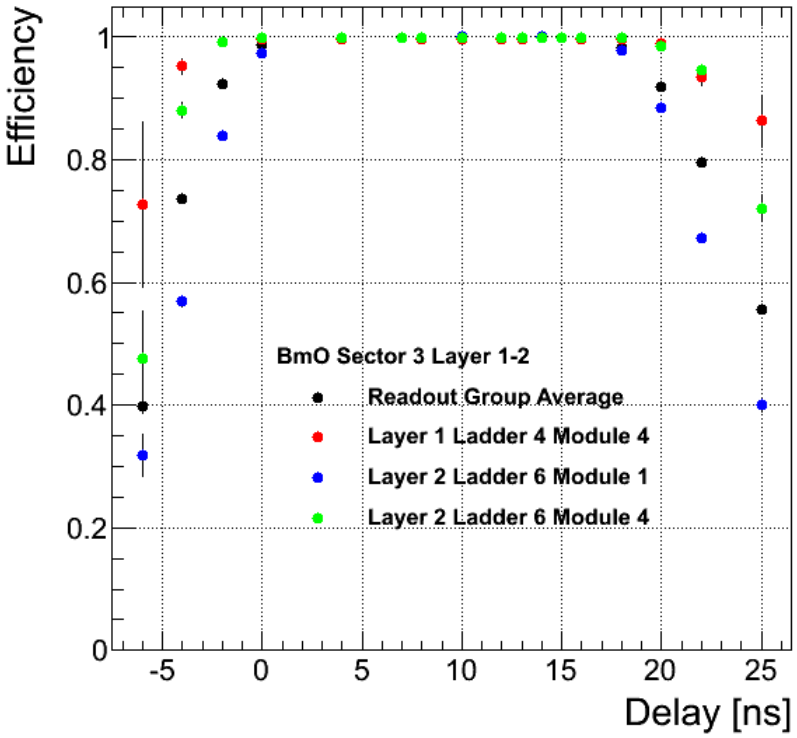
Layer 3

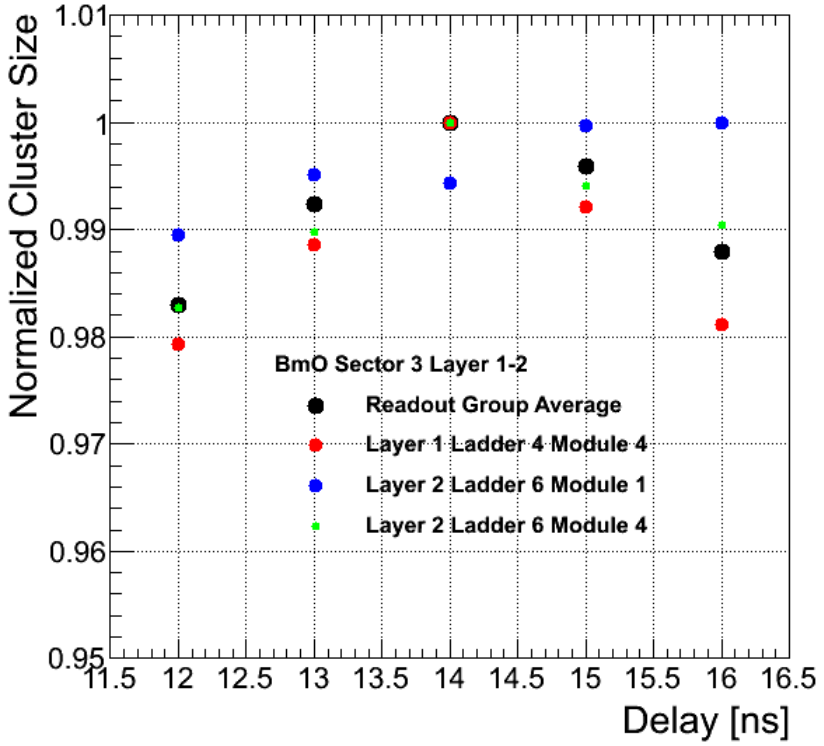


- Few readout groups are misaligned within ~2 ns, this is inside the safety margin chosen for the delay of 13.5 ns currently used
- See rest of the plots in backup slides

Time Alignment of Modules in a ROG

Layer 1-2

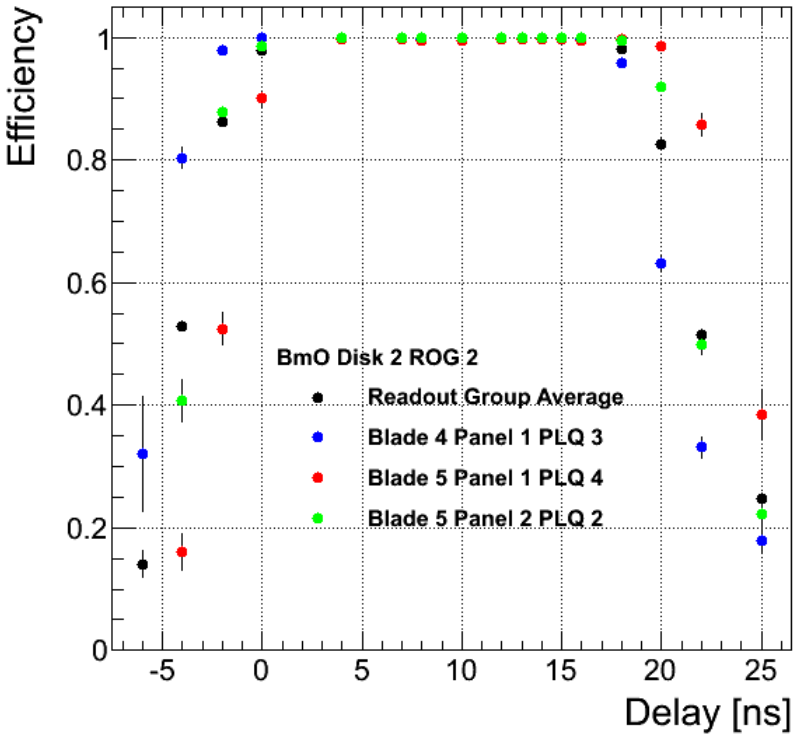


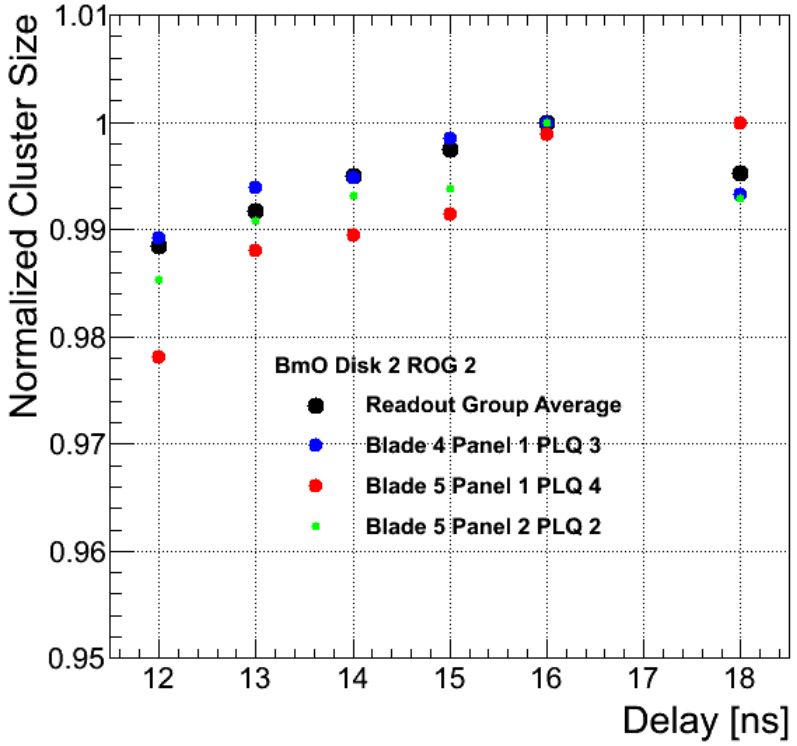


- Only modules with largest misalignment shown (blue and red)
- Width of the efficiency plateau depends on η (but optimal setting does not)
- No shift greater than ~2ns is seen on Layer 1-2

Time Alignment of Modules in a ROG

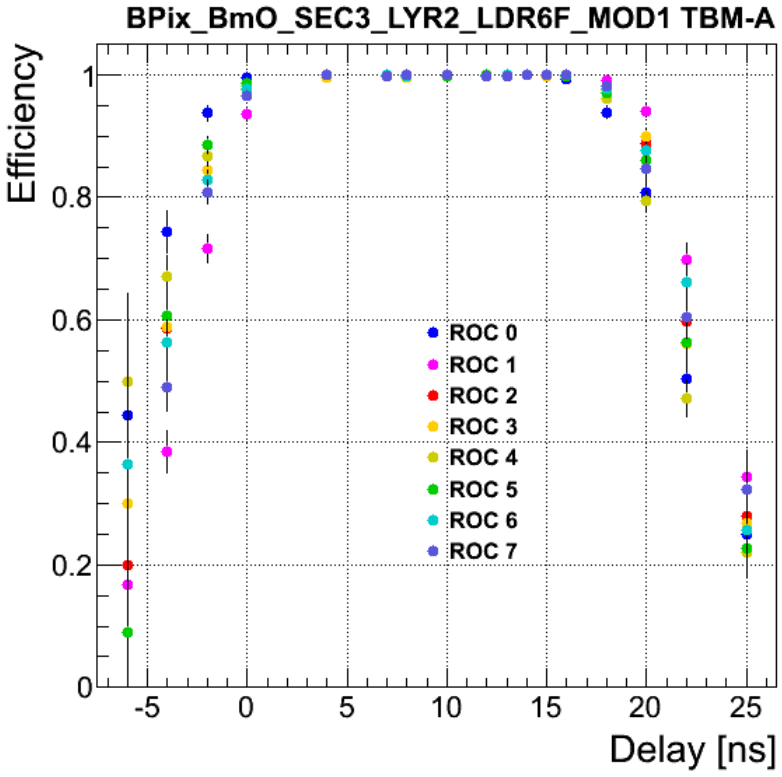
Disk 2

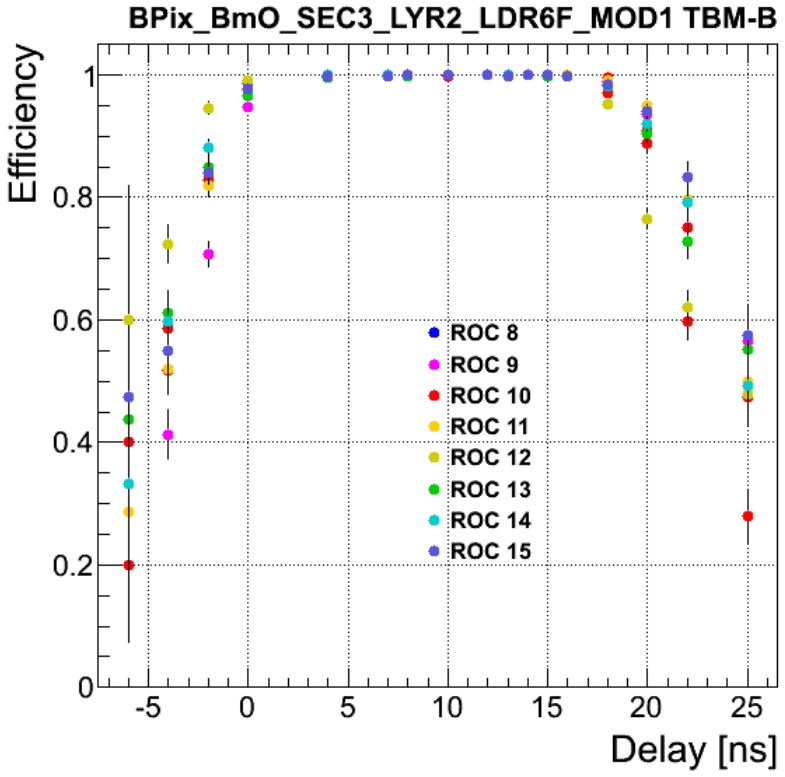




- Largest shift (red) from average is ~2 ns
- 16 ns would also be the optimal setting in FPix, but this is also the last point of efficiency plateau

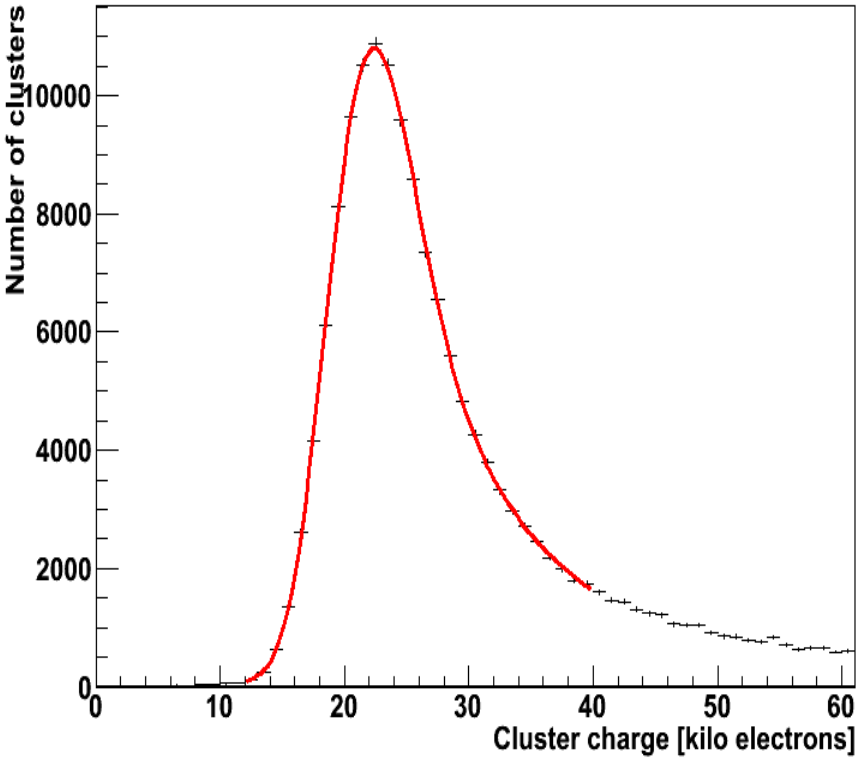
Time Alignment of ROCs in a Module

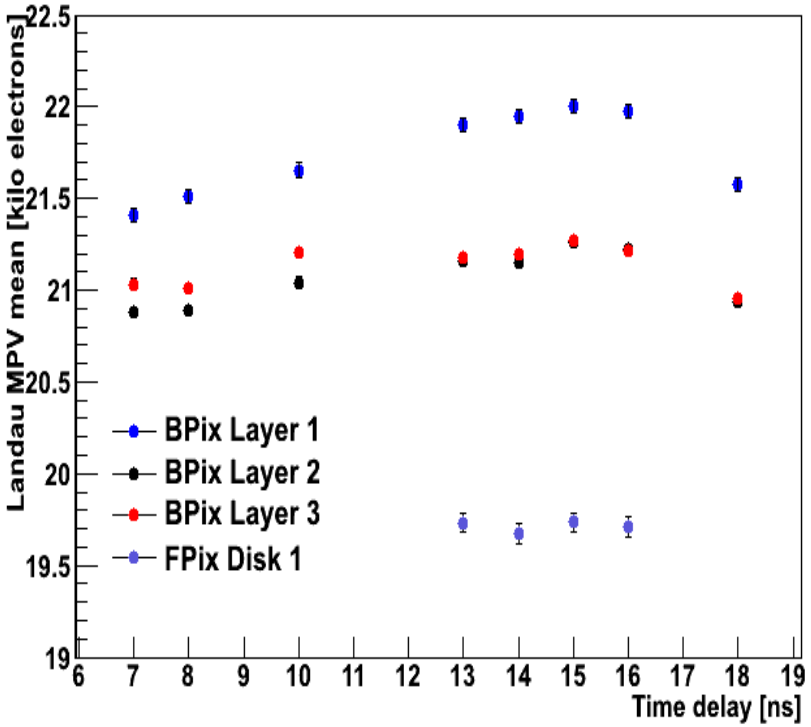




- Module chosen is marked by blue on slide 6
- A 2 ns timing difference is observed among ROCs within a module
- Using TPLL or delay 25 for alignment the achievable best accuracy is ~2ns

Best Timing with Cluster Charge



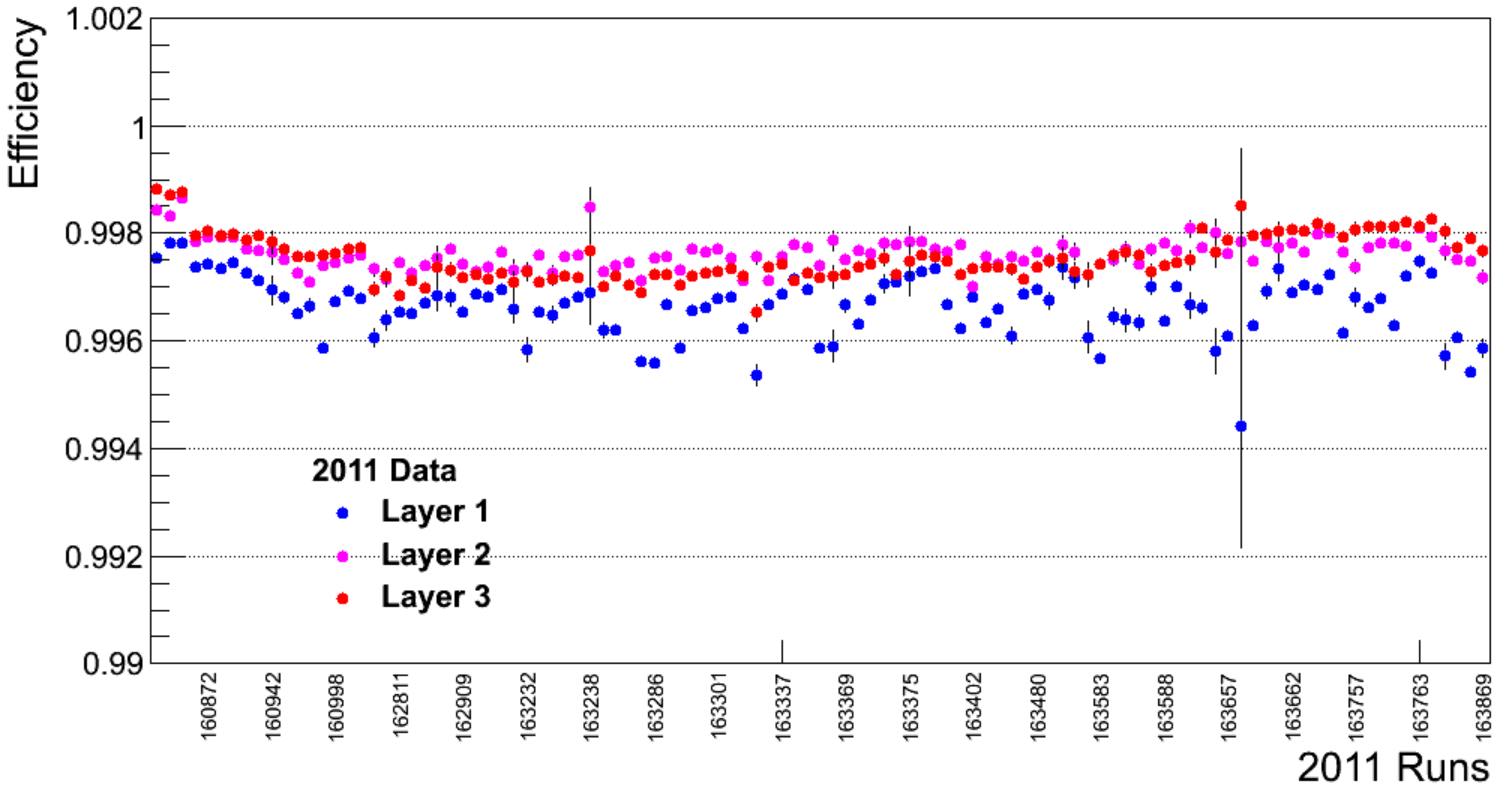


- Lef plot: Landau+Gaus fit on each ROCs cluster charge distribution
- Right plot: average Landau MPV per Layer/Disk vs clock delay
- Best timing setting on BPix is 15 ns (as opposed to 14 ns predicted by average cluster size)

Pixel Efficiency

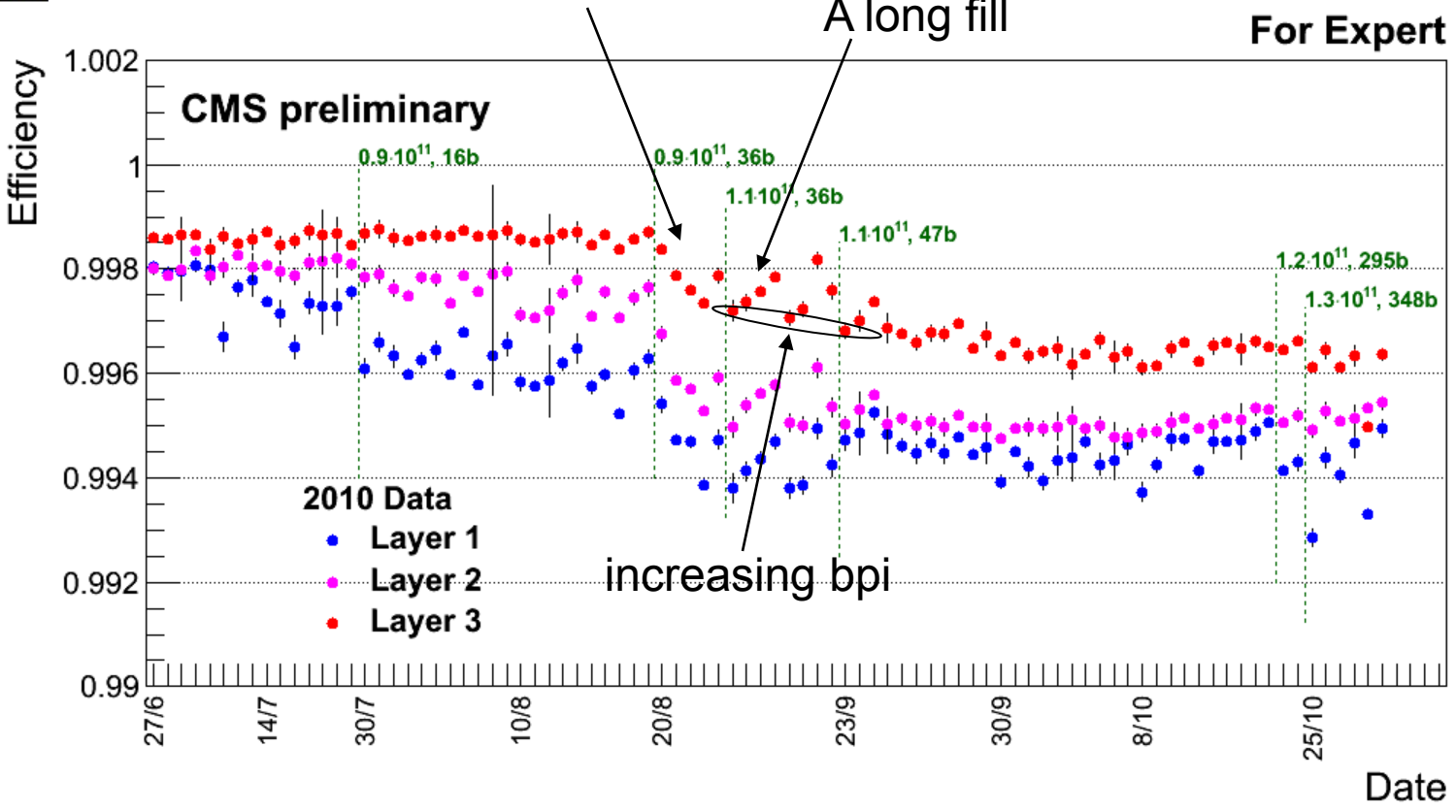
- Working on using FED error information in hit efficiency calculation
  - Some missing hits will be relabeled inactive after implementing this (expect a little increase in efficiency)
  - FED error information at the moment is available at the module level – need for smaller granularity is being investigated
- Continued to investigate causes of efficiency loss
  - In 2010, we observed a dependence on bunch charge, no other effect beyond the size of errors
  - In 2011, efficiency stays within 0.2 ns

2011 Runs – Barrel Pixel



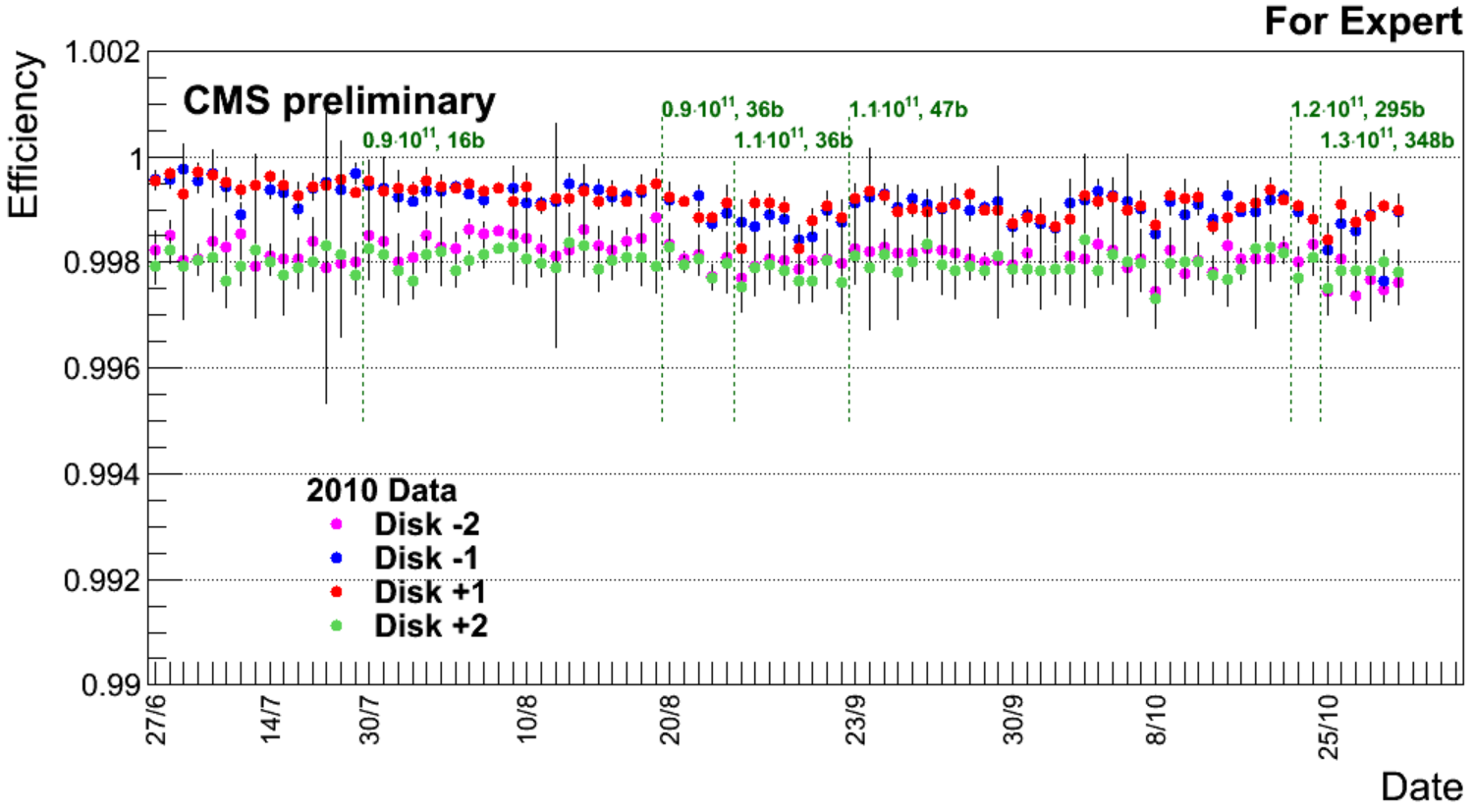
2010 Runs – Barrel Pixel

Multiple short fills, increasing bx charge



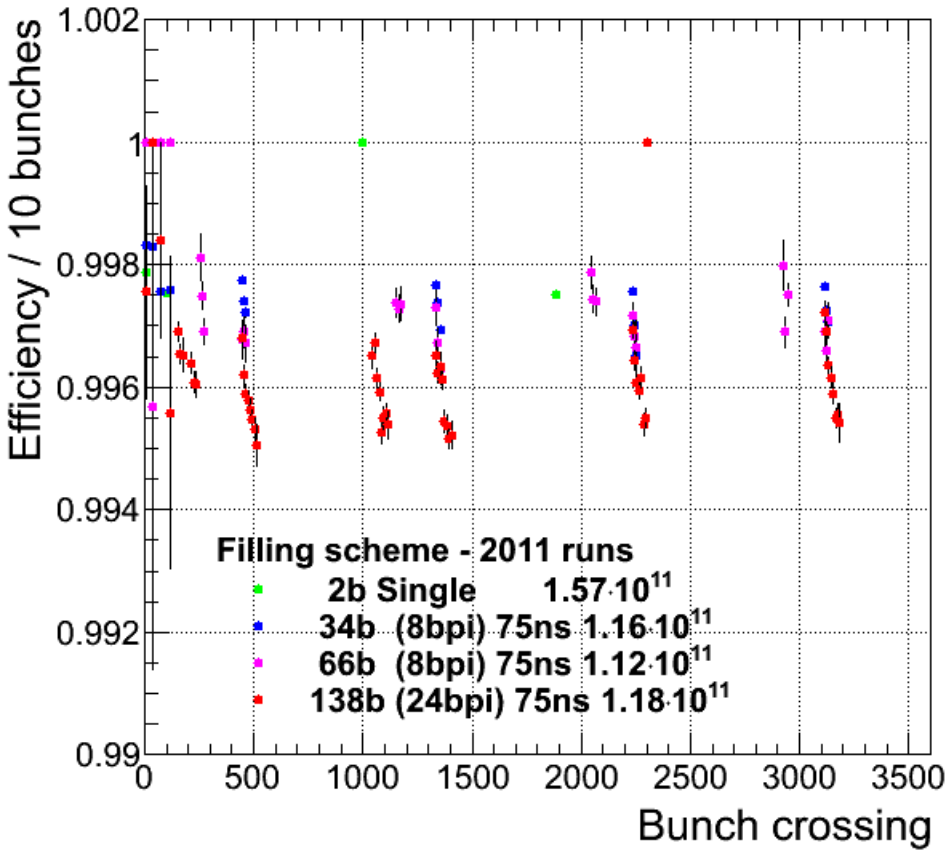
- An overall decrease in efficiency is seen on all layers: 0.2 – 0.4 %
- Efficiency is correlated with bunch charge, some very small dependence observed due to increasing number of bunches (bpi)

2010 Runs – Forward Pixel



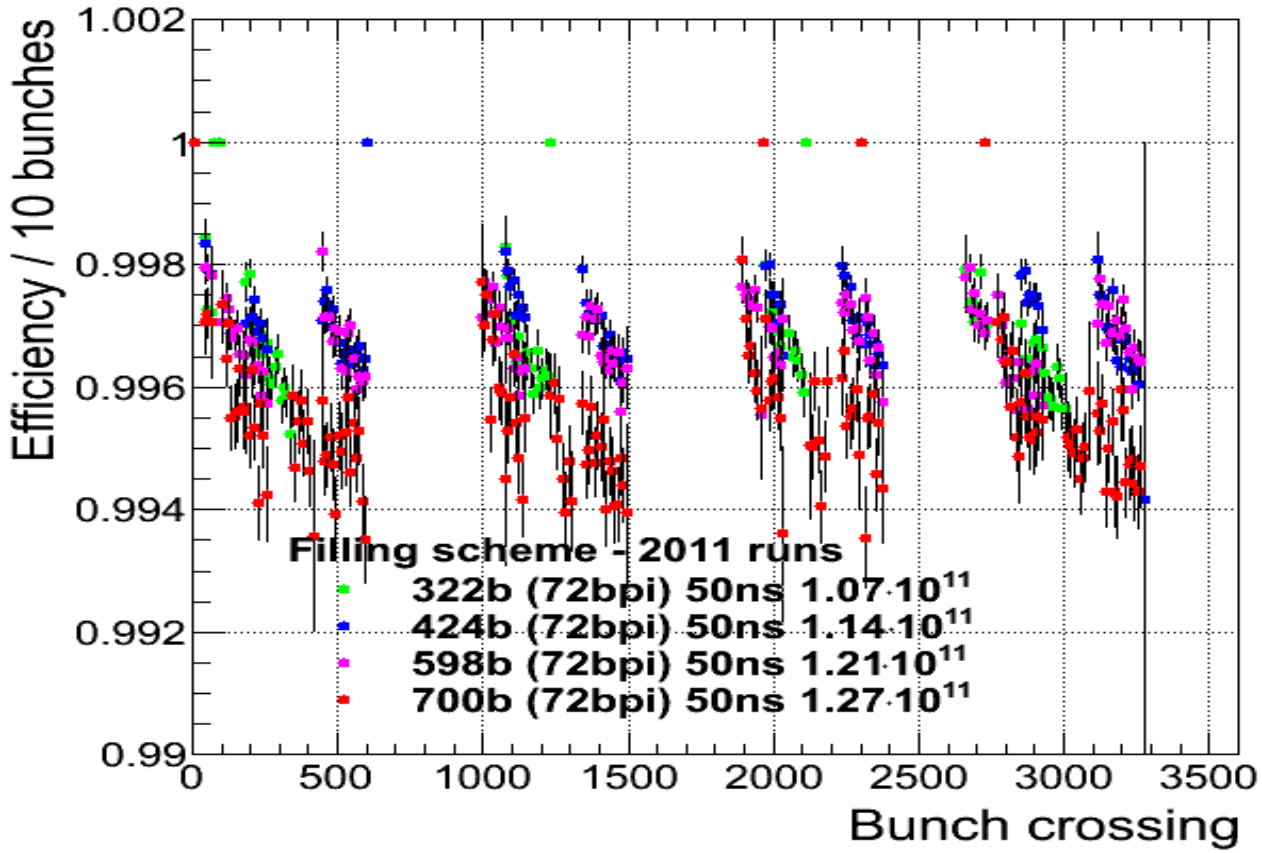
- Efficiency on FPix remains roughly the same during 2010
- Difference between Disk +/- 1 and Disk +/- 2 is systematic, reproduced in simulation

Eff vs bx – 75ns – Layer 1



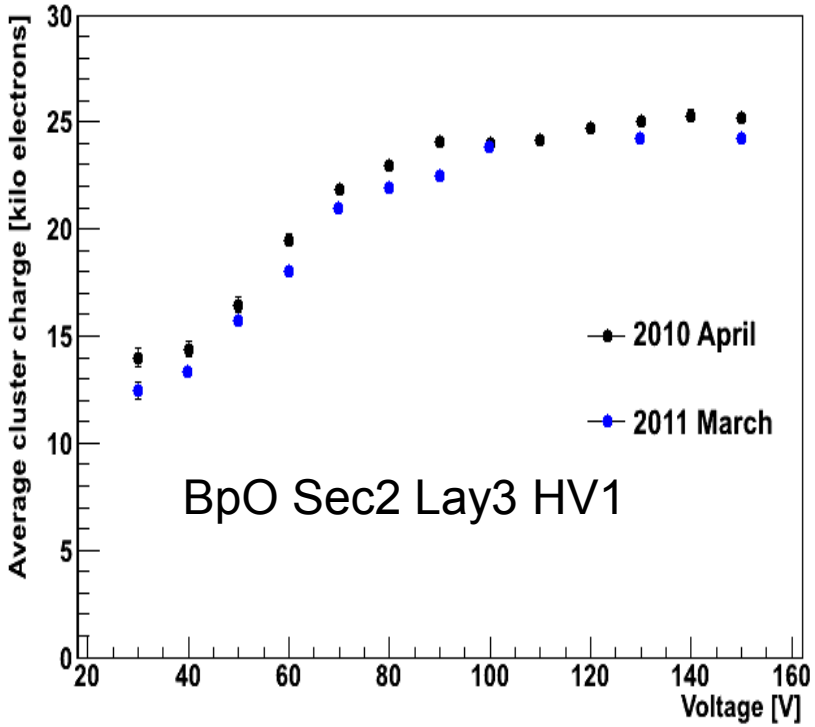
- Efficiency depends on the length of the train
- Blue points correspond to an average fill in 2010 – did not see it earlier because effect was less than measurement errors

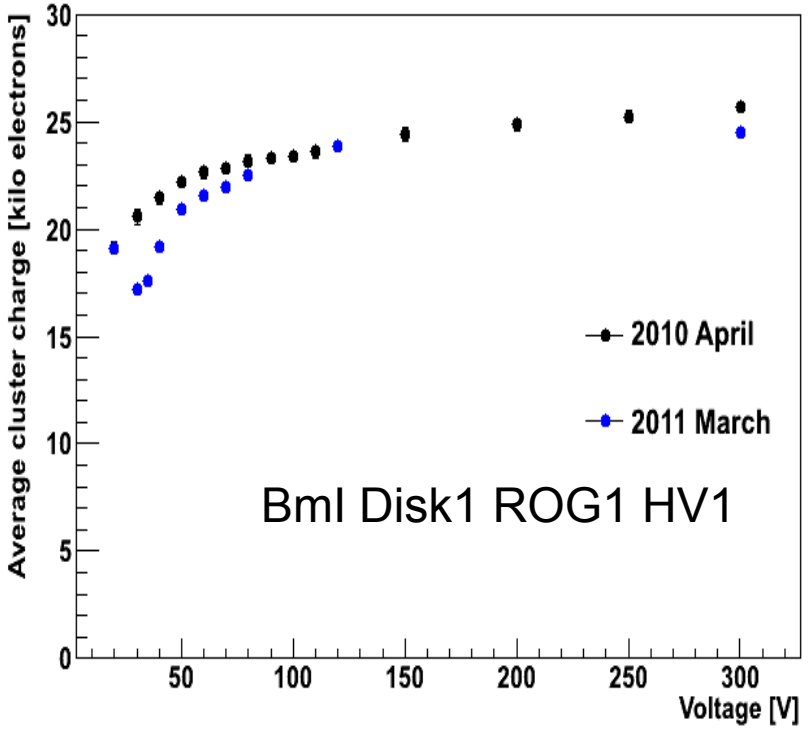
Eff vs bx – 50ns 72bpi – Layer 1



- Largest drop of ~0.3% observed during fill represented by red points on Layer 1
- This still does not explain the first 0.3% drop

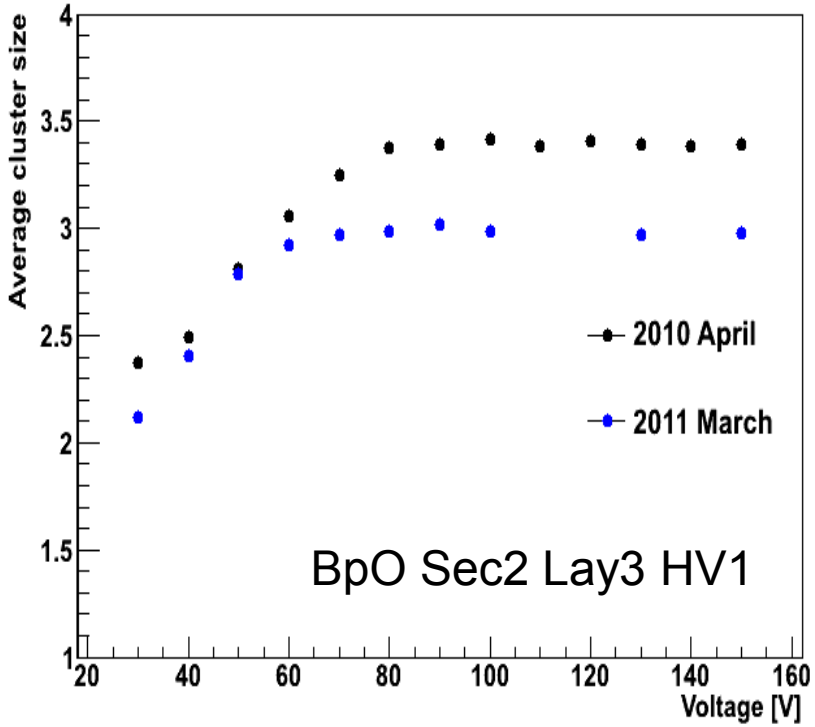
Pixel HV Scan

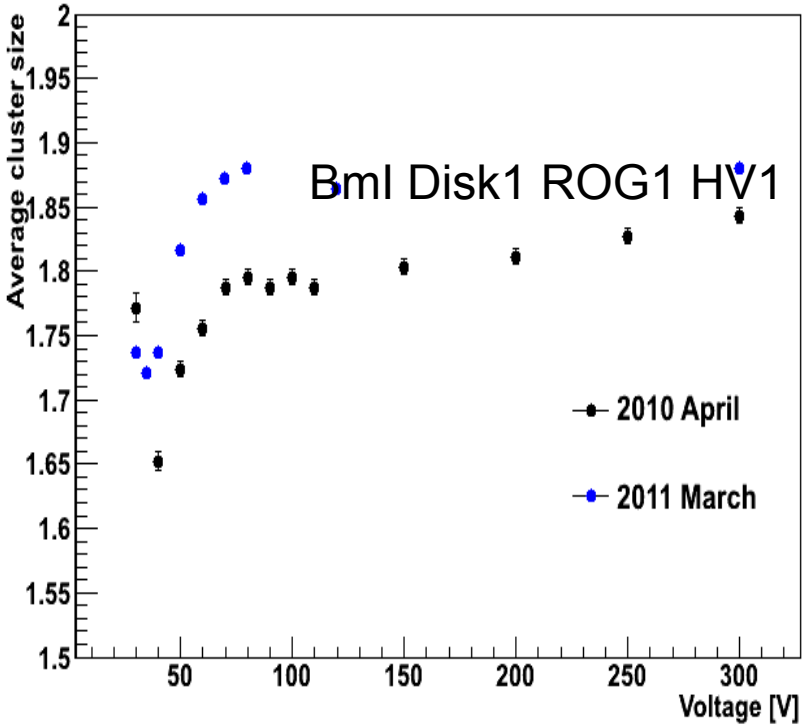




- Increasing HV bias increases the depth of depleted region
- Radiation damage compensated by HV to reach full depletion again
- Full depletion reached at ~100 Volts
- No change observed between 2010 April and 2011 March in BPix, some effect in FPix

Pixel HV Scan



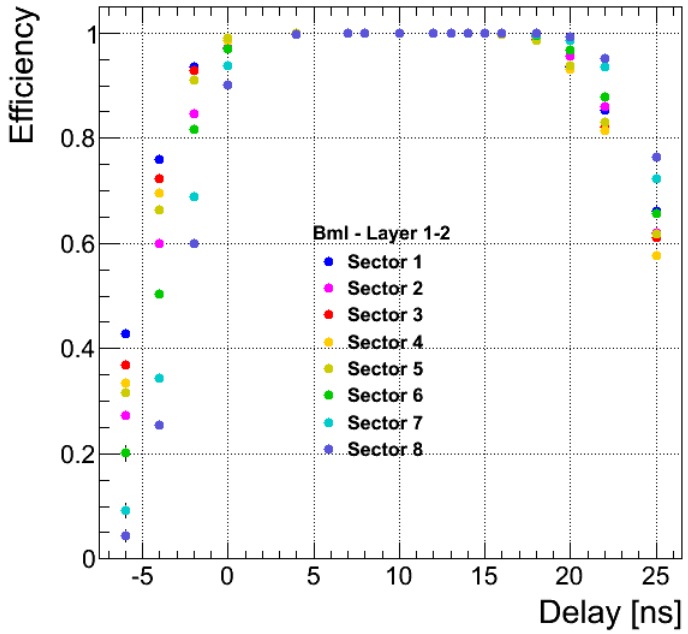


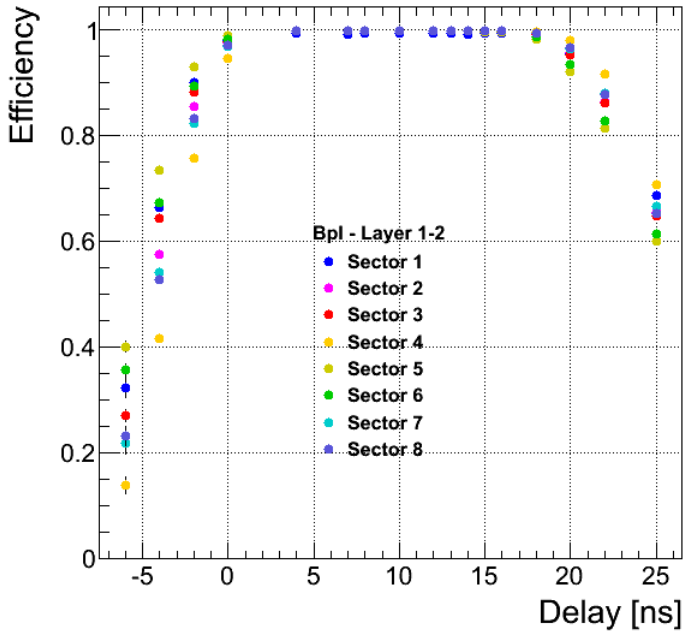
- Differences in average cluster size qualitatively agree with change in average impact angle (track pt). - Change in event composition?
- See no effect of this on previous plot due to normalizing charge to impact angle

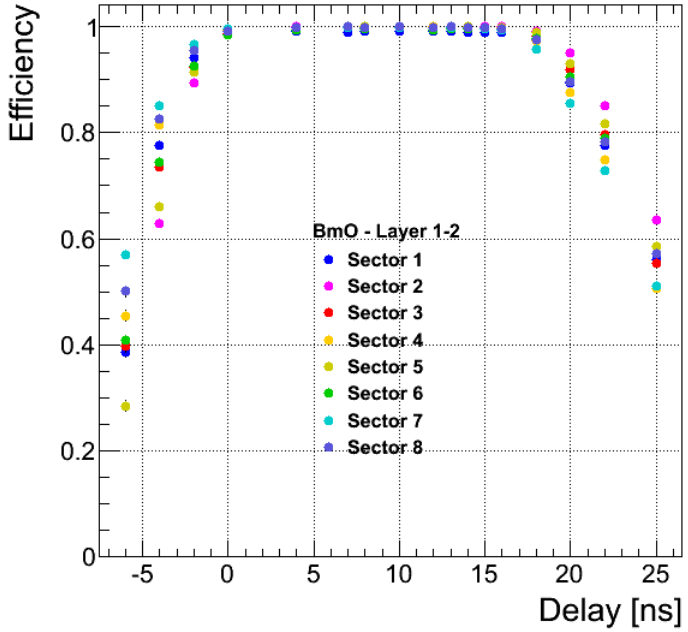
Conclusions

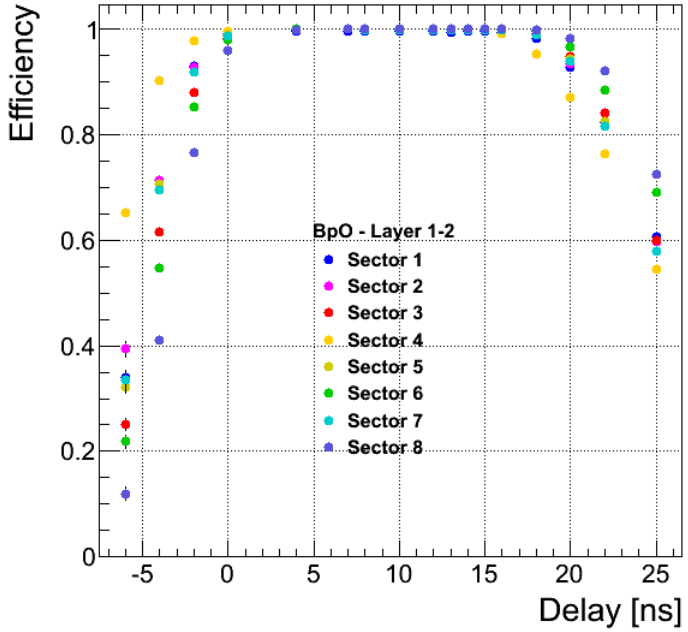
- Verified internal alginment of the Pixels
  - There is a ROC by ROC variation in timing of about 2ns
  - ROG alignment within ~2 ns is confirmed
  - Using TPLL or Delay 25, the best achievable accuracy for time alignment is ~2 ns
  - Overall best setting is 14-15 ns, but a 2 ns safety margin needs to be respected
- Started to investigate reasons of efficiency loss
- Started to investigate effects of detector aging and method to compensate it
  - No aging is visible yet

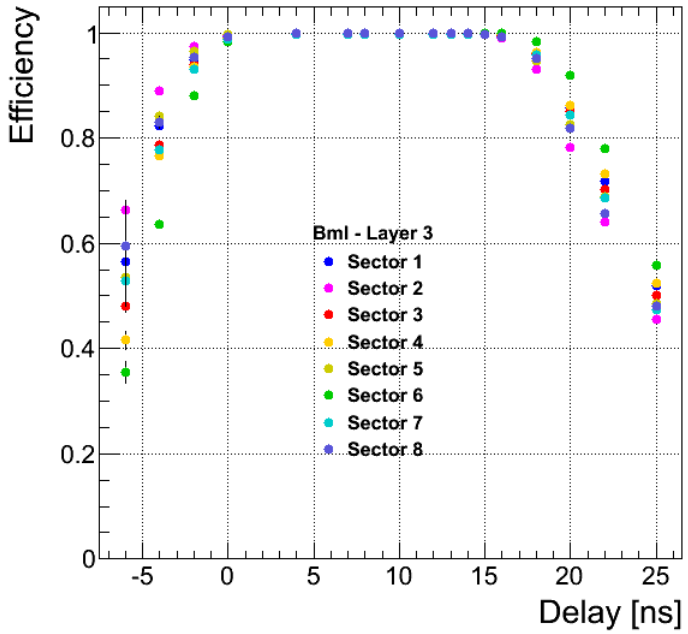
Backup Slides

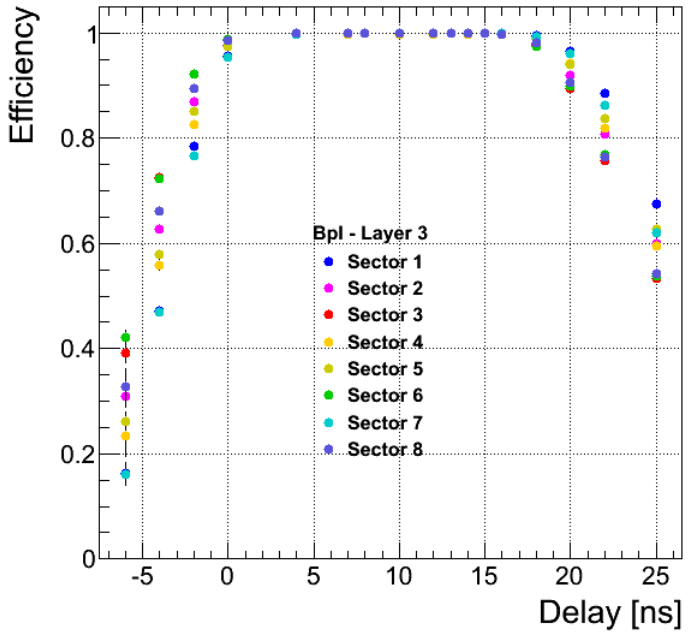

Efficiency
Delay [ns]
BmI - Layer 1-2
Sector 1
Sector 2
Sector 3
Sector 4
Sector 5
Sector 6
Sector 7
Sector 8

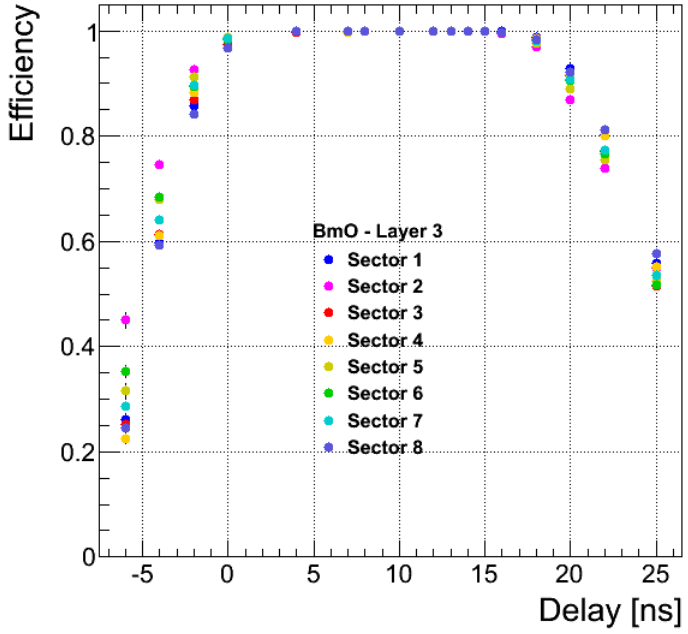

Efficiency
Delay [ns]
BpI - Layer 1-2
Sector 1
Sector 2
Sector 3
Sector 4
Sector 5
Sector 6
Sector 7
Sector 8

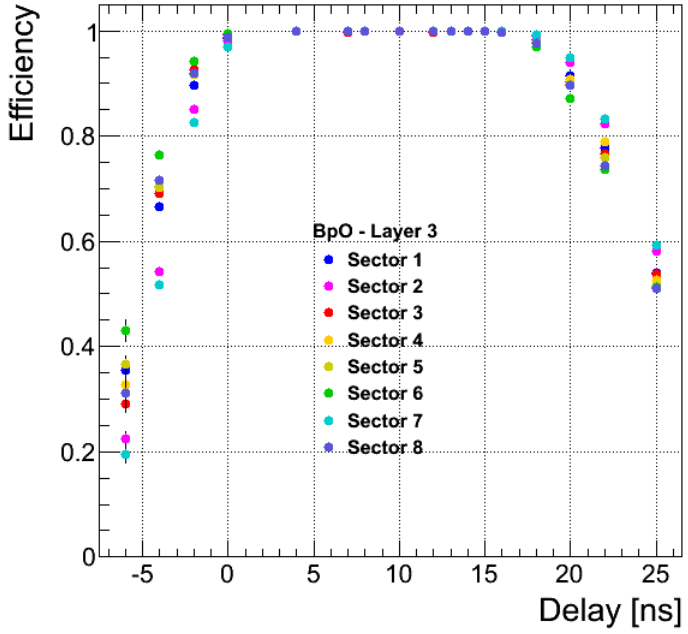

Efficiency
Delay [ns]
BmO - Layer 1-2
Sector 1
Sector 2
Sector 3
Sector 4
Sector 5
Sector 6
Sector 7
Sector 8

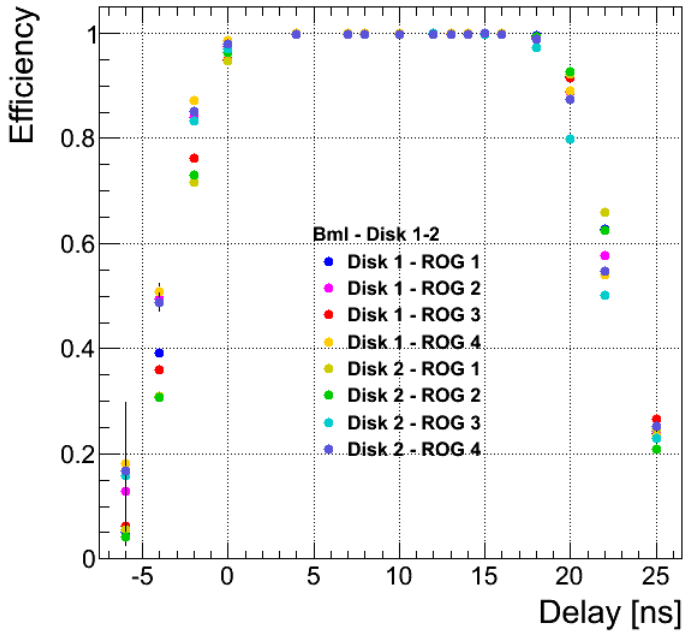

Efficiency
Delay [ns]
BpO - Layer 1-2
Sector 1
Sector 2
Sector 3
Sector 4
Sector 5
Sector 6
Sector 7
Sector 8

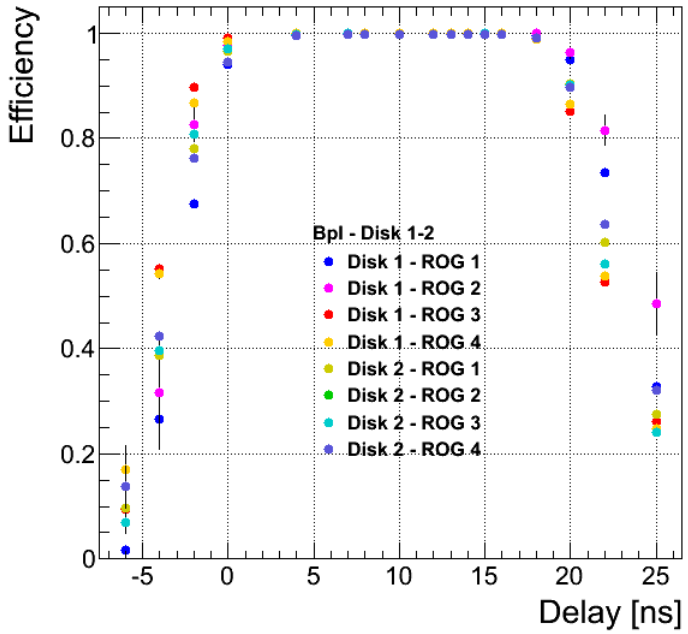

Efficiency
Delay [ns]
BmI - Layer 3
Sector 1
Sector 2
Sector 3
Sector 4
Sector 5
Sector 6
Sector 7
Sector 8

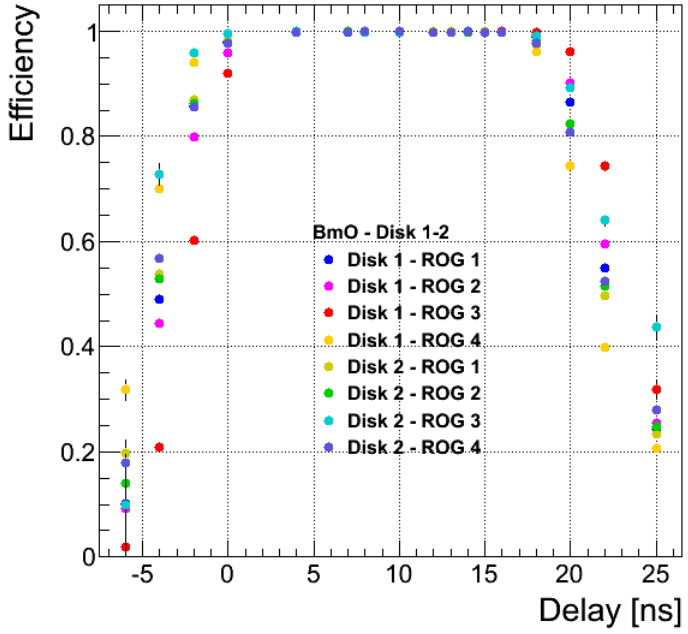

Efficiency
Delay [ns]
BpI - Layer 3
Sector 1
Sector 2
Sector 3
Sector 4
Sector 5
Sector 6
Sector 7
Sector 8

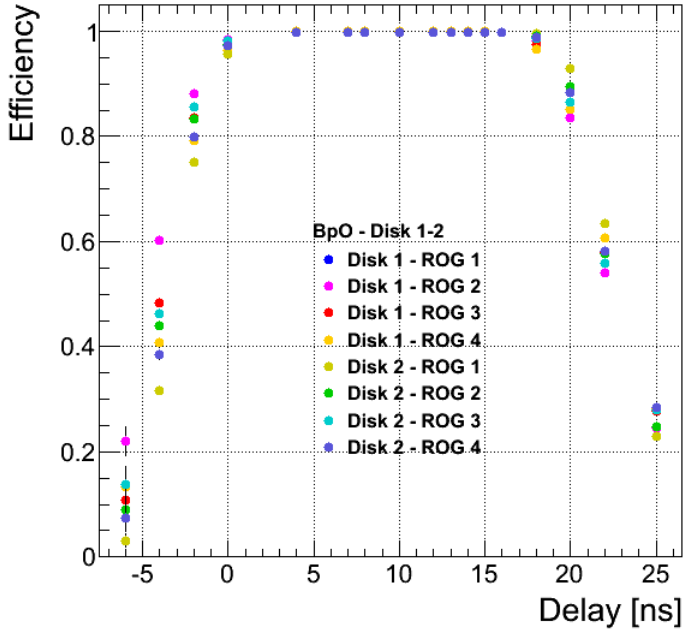

Efficiency
Delay [ns]
BmO - Layer 3
Sector 1
Sector 2
Sector 3
Sector 4
Sector 5
Sector 6
Sector 7
Sector 8


Efficiency
Delay [ns]
BpO - Layer 3
Sector 1
Sector 2
Sector 3
Sector 4
Sector 5
Sector 6
Sector 7
Sector 8


Efficiency
Delay [ns]
BmI - Disk 1-2
Disk 1 - ROG 1
Disk 1 - ROG 2
Disk 1 - ROG 3
Disk 1 - ROG 4
Disk 2 - ROG 1
Disk 2 - ROG 2
Disk 2 - ROG 3
Disk 2 - ROG 4

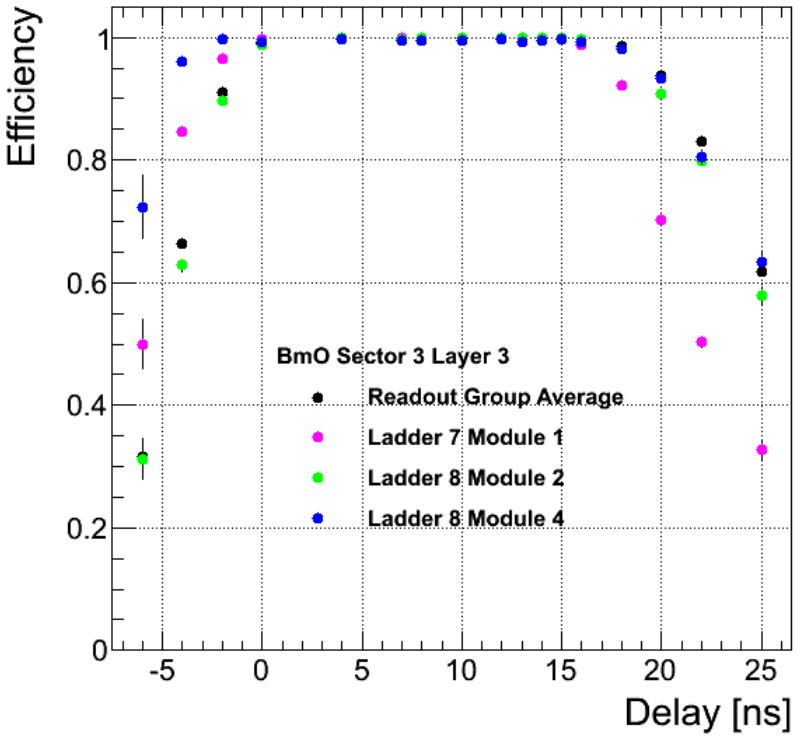

Efficiency
Delay [ns]
BpI - Disk 1-2
Disk 1 - ROG 1
Disk 1 - ROG 2
Disk 1 - ROG 3
Disk 1 - ROG 4
Disk 2 - ROG 1
Disk 2 - ROG 2
Disk 2 - ROG 3
Disk 2 - ROG 4

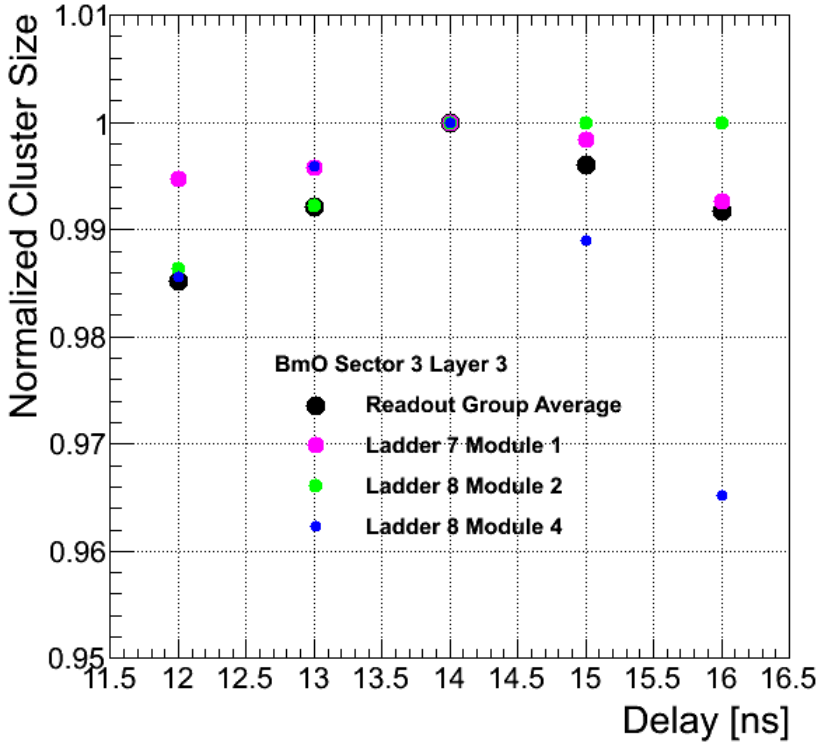

Efficiency
Delay [ns]
BmO - Disk 1-2
Disk 1 - ROG 1
Disk 1 - ROG 2
Disk 1 - ROG 3
Disk 1 - ROG 4
Disk 2 - ROG 1
Disk 2 - ROG 2
Disk 2 - ROG 3
Disk 2 - ROG 4


Efficiency
Delay [ns]
BpO - Disk 1-2
Disk 1 - ROG 1
Disk 1 - ROG 2
Disk 1 - ROG 3
Disk 1 - ROG 4
Disk 2 - ROG 1
Disk 2 - ROG 2
Disk 2 - ROG 3
Disk 2 - ROG 4

Time Alignment of Modules in a ROG

Layer 3





- Largest difference (magenta) from mean (black) is < 2 ns on Layer 3
- Average cluster size plot shows that current setting is actually the optimal

2011 Runs – Forward Pixel