Analysis Note: Run12pp510 and Run15pp200 Muon-Arm MUID_EFFICIENCY Comparison Between Data-Driven Method and HV-Method and Data Checks

Xiaodong Jiang 09/16/2015 updated

Results and Conclusions. More details in slides:

- Issues on MUID_EFF for run15pp200, following Itaru et al, 2014 cosmic studies.
- Crosschecks between traditional "data-driven method" and "HV-method",
- Agreements and disagreements compare fit2014 (channel-by-channel) vs a global fit2004 (one solution for 300 channels on all plane, panels, gaps and arms).
- Detailed checks on MUID dark currents, channel-by-channel.
- Solutions and Results.
- The case of Run12pp510, results.
- Run-by-run tube-by-tube efficiency files, data-method and HV-method.
- **Luminosity-weighted average-tube-efficiency files, for all-lumi, low-lumi, mid-lumi, high-lumi run groups. Under: Luminosity_Weighted_Average/**

All related files and plots are posted on the webpage:

https://www.phenix.bnl.gov/phenix/WWW/publish/xjiang/Run12/Run12pp510/
https://www.phenix.bnl.gov/phenix/WWW/publish/xjiang/Run2015/Run15pp200/

This file: https://www.phenix.bnl.gov/phenix/WWW/publish/xjiang/Run2015/Run15pp200/report_xj091615.pdf

Results and Conclusions

- Traditional Data-Driven method. MUID_EFF run-by-run, tube-by-tube files were generated: muid_tube_eff_south(north)_xxxxxx.txt
- HV-method was also used to produced MUID_EFF, used HV-current readings to calculate effective tube-voltage, referenced to efficiencies in cosmic-ray scan (fit2014).
- **Two-methods are compared. Chased disagreements, provide a solution (mix2015).**
- Agreements between Data-Driven and HV-method typically to within +/-5% level.
- **Run-by-run, tube-by-tube MUID_EFF files are produced**
  HVmuid_tube_eff_south(north)_xxxxxx.txt, In the same format.
- **Luminosity-weighted average-tube-efficiency files, for all-lumi, low-lumi, mid-lumi, high-lumi run groups. Under: Luminosity_Weighted_Average/… i.e.**
  muid_tube_eff_south_Run12pp510_alllumi.txt
  HVmuid_tube_eff_south_Run12pp510_alllumi.txt

Conclusions on Run12pp510 and Run15pp200 MUID_EFF for muon-arm analysis:
Although we've shown that the HV_method is reasonably consistent with traditional data_driven method. Still, HV_method is NOT considered as a proven independent method to obtain MUID_EFF, while data_driven method has been used in all previous analysis.
Run12pp510 and Run15pp200 analysis should use the traditional data_driven method to obtain MUID_EFF, to preserve self-consistency.

All related files in :
https://www.phenix.bnl.gov/phenix/WWW/publish/xjiang/Run12/Run12pp510/
https://www.phenix.bnl.gov/phenix/WWW/publish/xjiang/Run2015/Run15pp200/

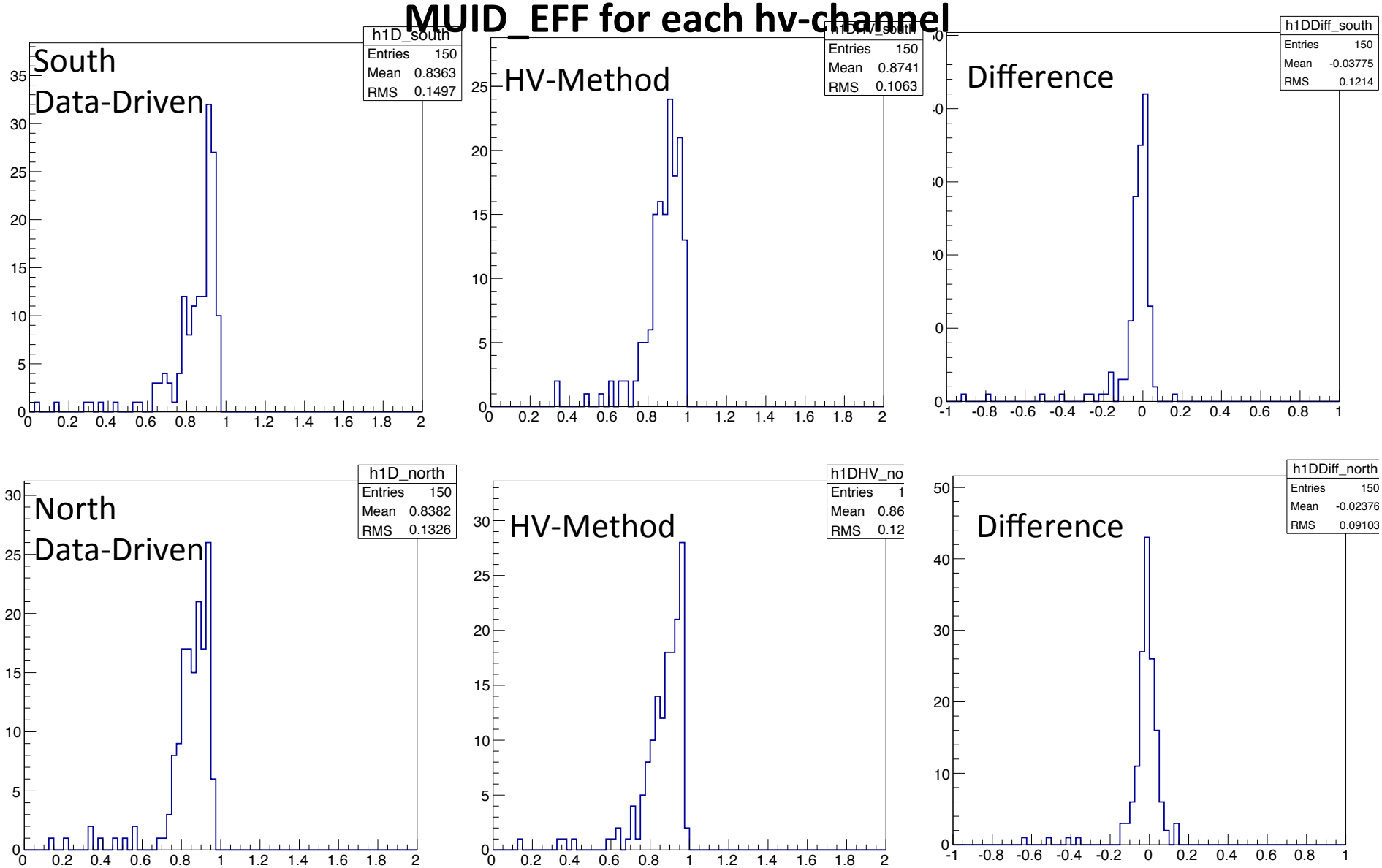
Observations, Further Works and Suggested Improvements

- MUID number of dead-tubes increased from year to year. **(109 ch in run2012pp510, 116 ch. In run15pp200, while earlier versions only listed 88 ch)**
- Degrading and instability of MUID-efficiency performance year-to-year in some channels were obvious.
- Cosmic ray HV scans are needed to obtain efficiency baseline, and check reproducibility.
- Low-collision rate data is needed to confirm MUID_EFF during production runs.

Although HV-method is not a completely independent crosscheck, it can serve as a reasonable confirmation of rate-dependent efficiency changes.

- The same solution for p+p might not directly work for p+A collision, due to higher luminosities. Need a careful check.
- Long cosmic ray runs are always needed, to check the baseline efficiency performance of detectors, and to obtain baseline dark-currents.
- **Whenever possible, should also take low-luminosity collision runs, for a direct check of efficiencies, and compared to cosmic run efficiencies.**
- **Should repeat the cosmic ray HV scans.**

A Brief Summary Run12pp510: Luminosity Averaged MUID_EFF for each hv-channel

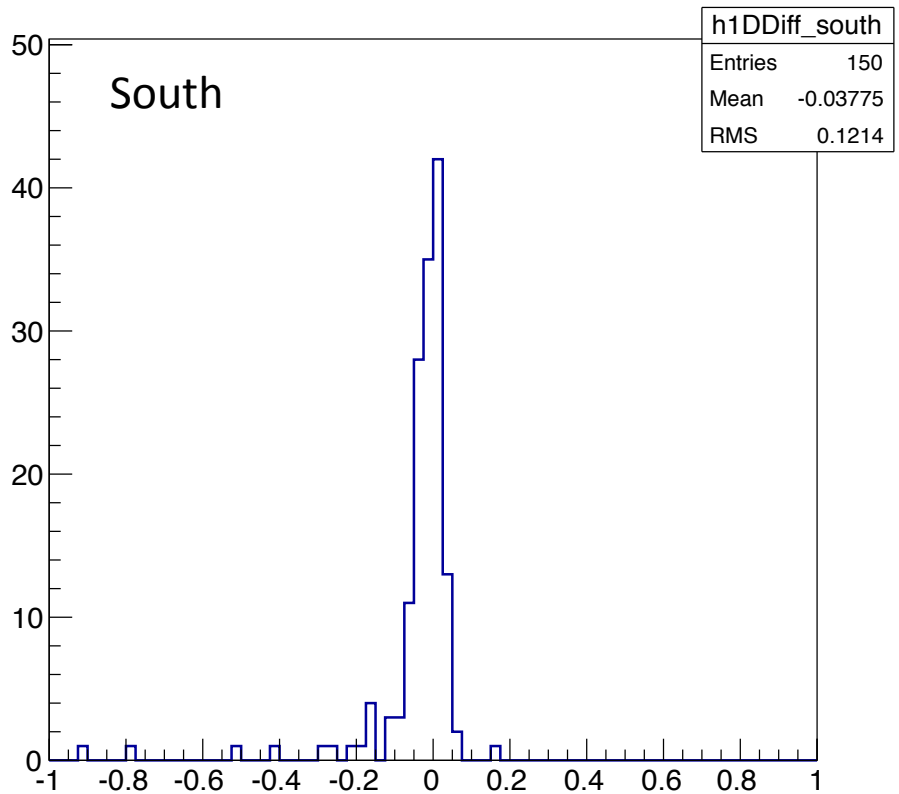


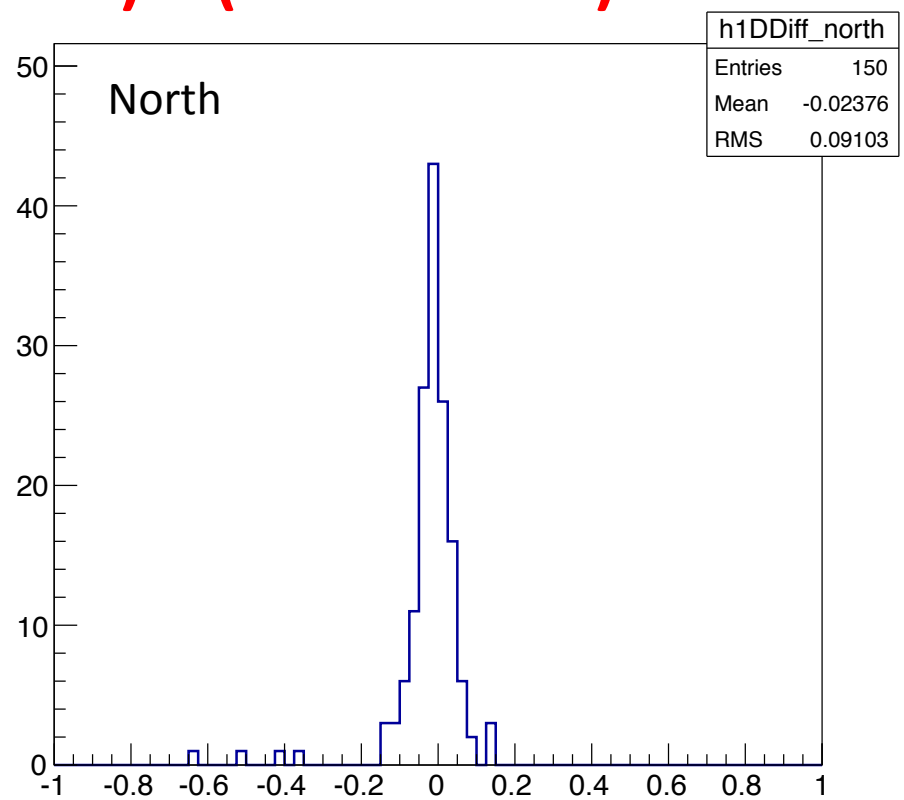
Luminosity-weighted average efficiency, one entry per hv-channel

Summary Run12pp510: Luminosity Averaged

MUID_EFF for each hv-channel

Difference = (Data-Driven) – (HV Method)



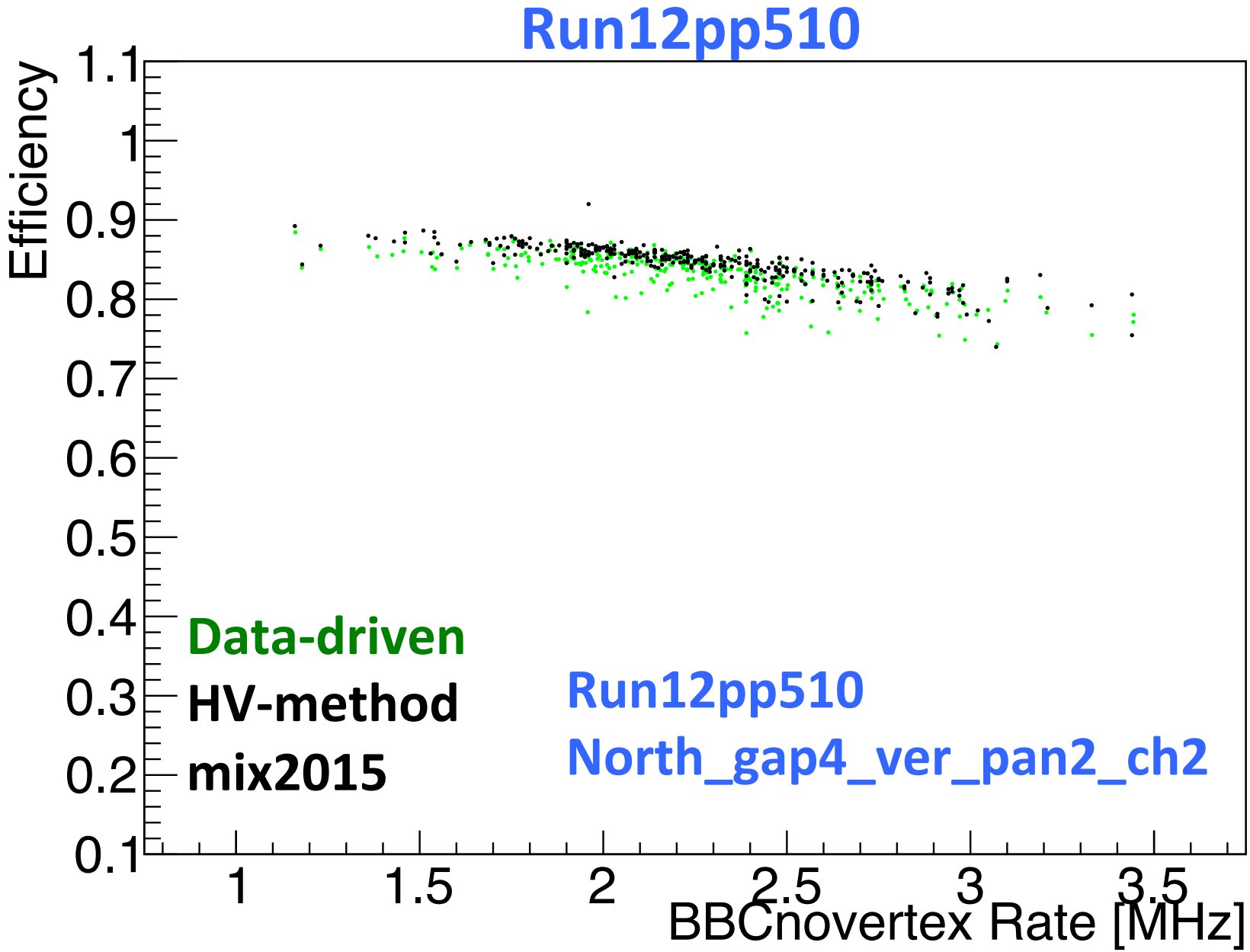


Luminosity-weighted average efficiency, one entry per hv-channel

Central value of disagreements: 2~4%

Spread of disagreements within: ~+/- 5%

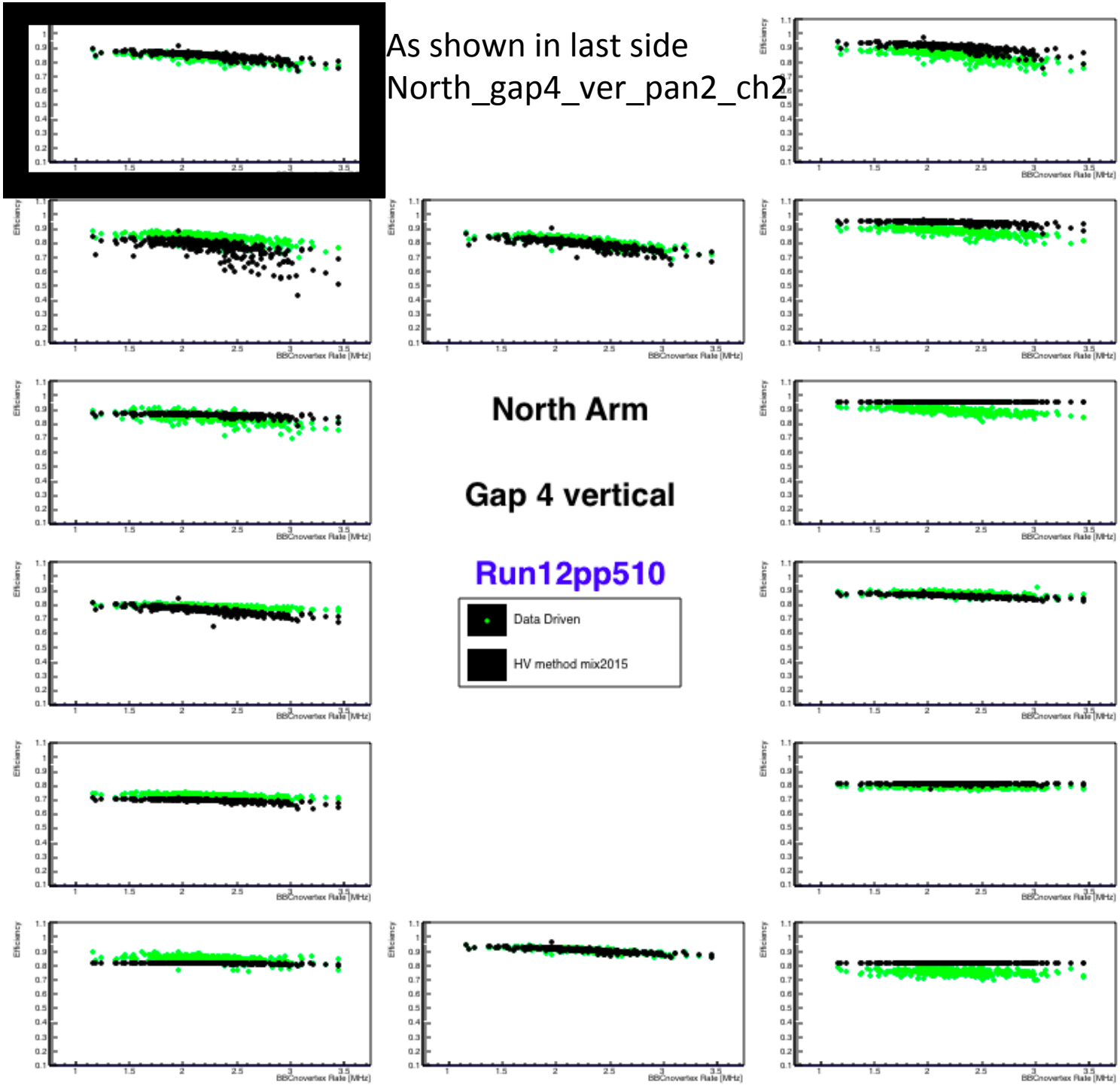
Comparison Data-Drive vs HV-method

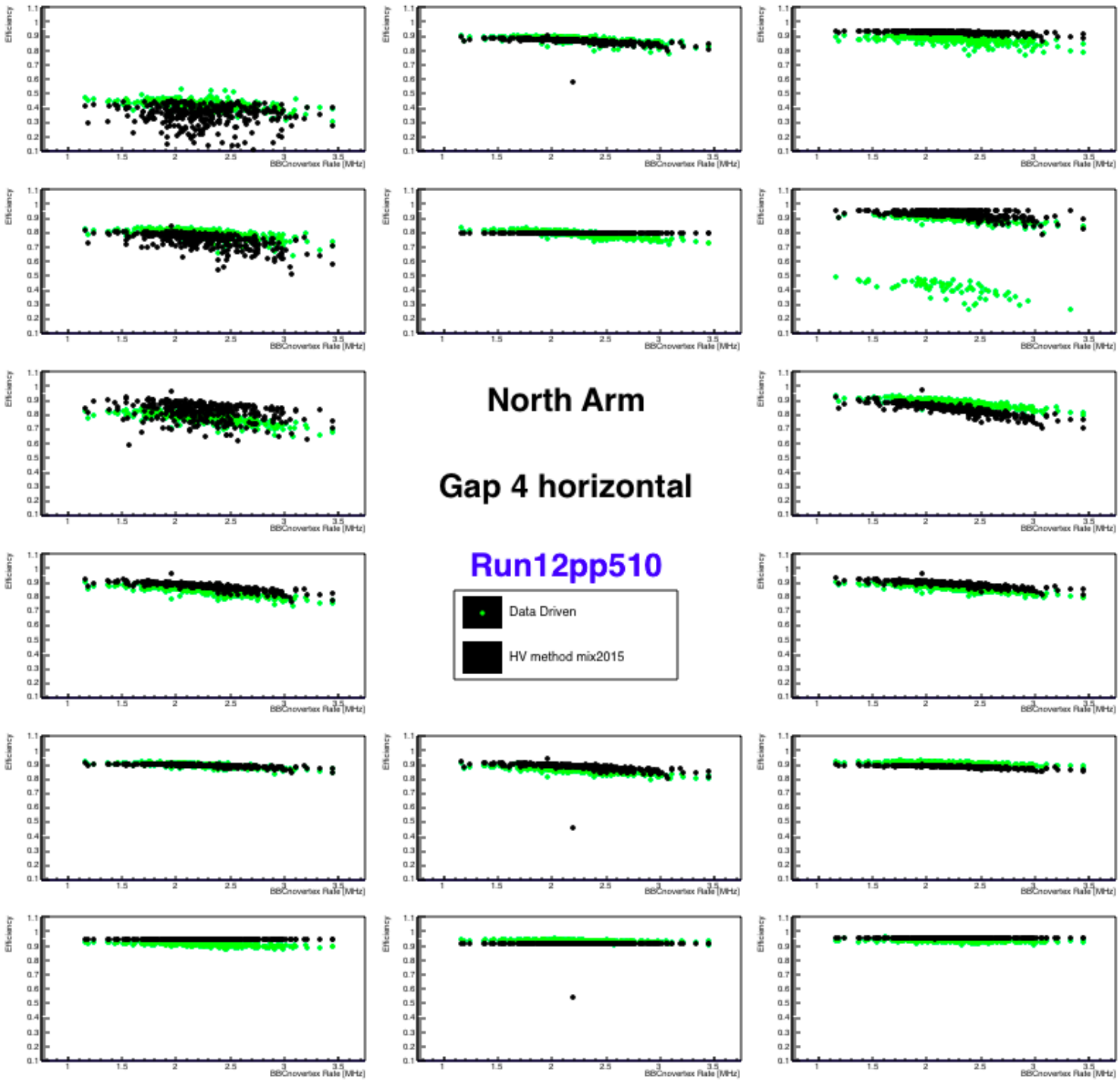


As shown in last side
North_gap4_ver_pan2_ch2

Data-driven
HV-method mix2015

Run12pp510

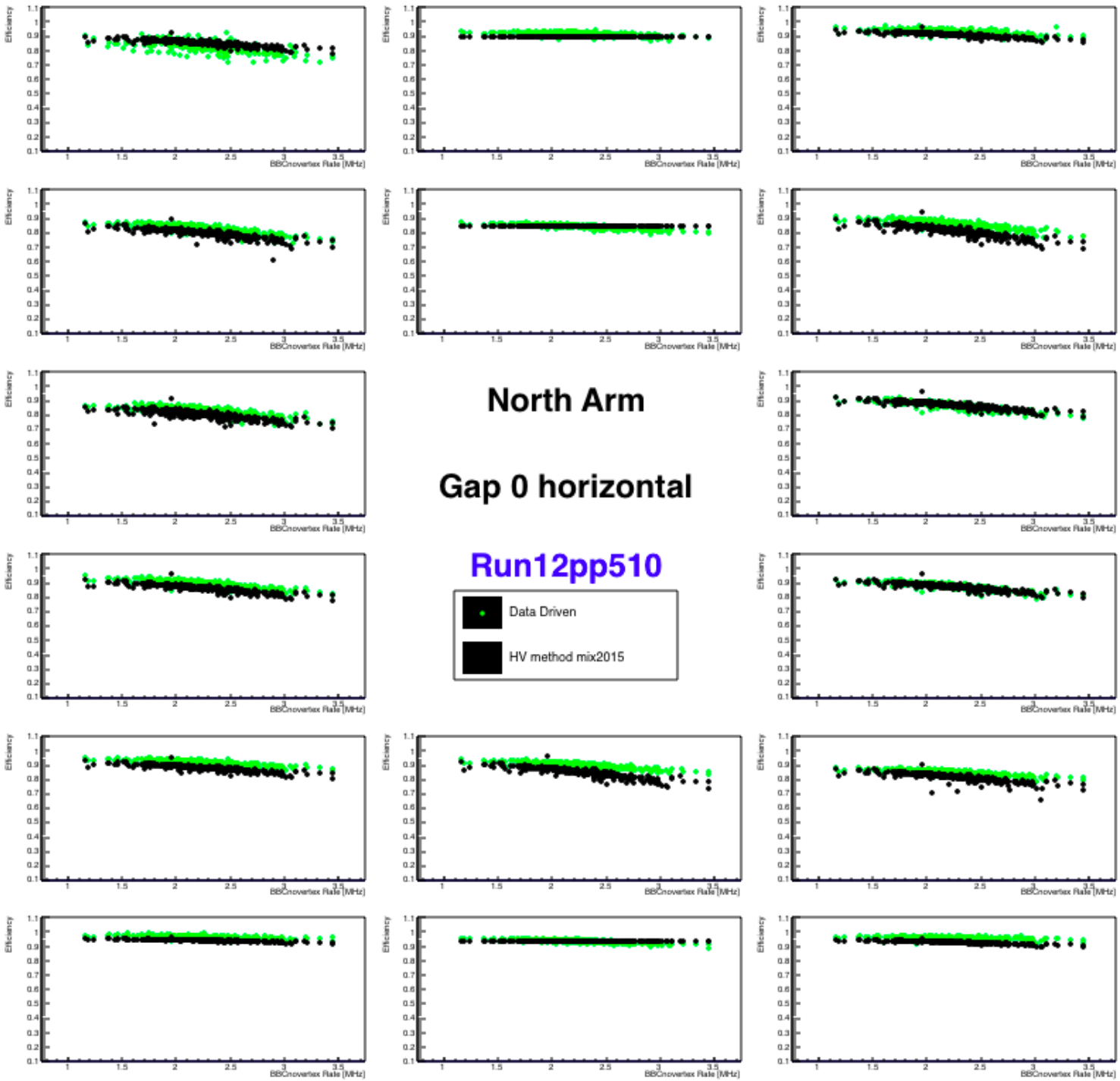




Data-driven

HV-method mix2015

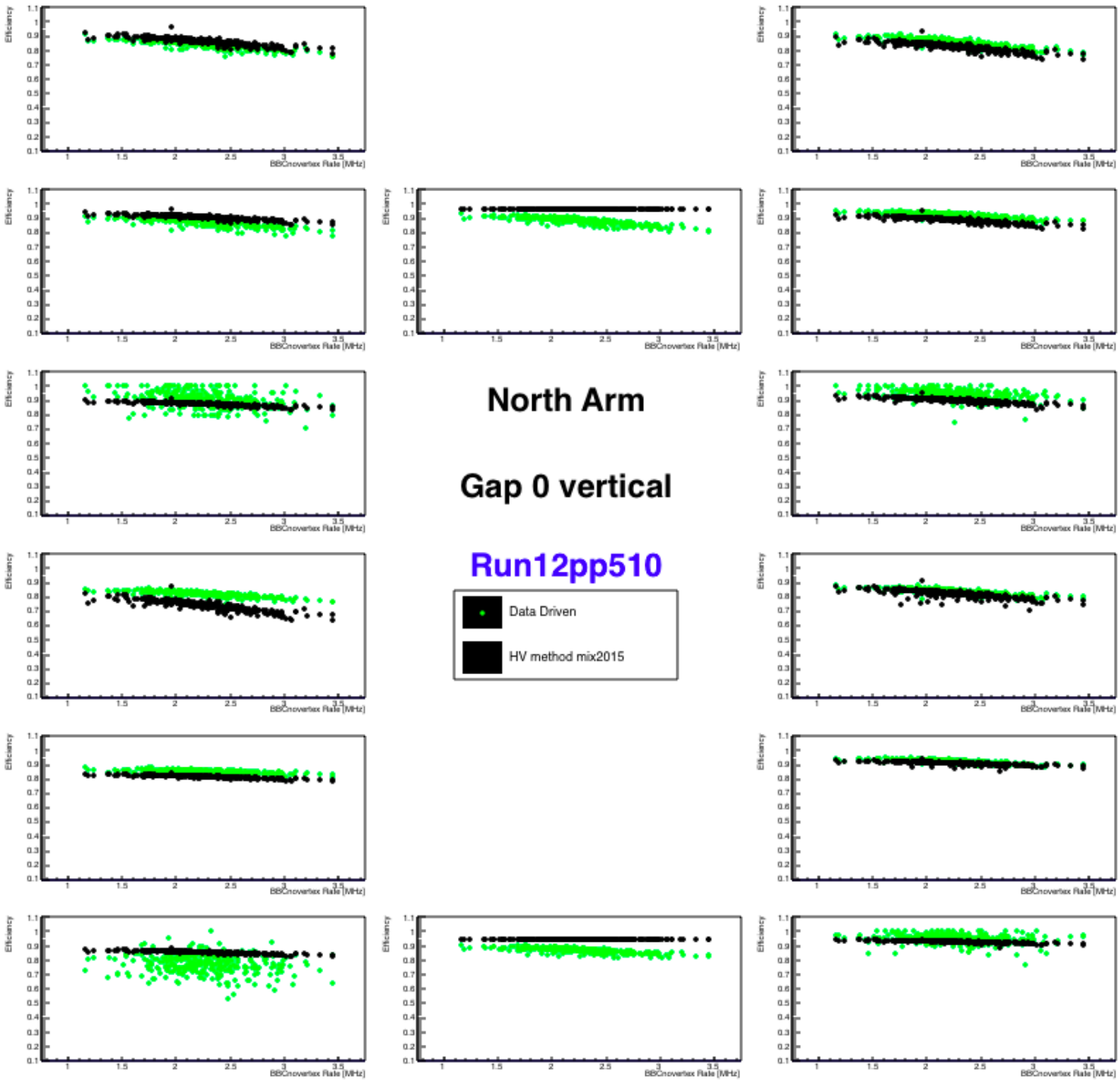
Run12pp510



Data-driven

HV-method mix2015

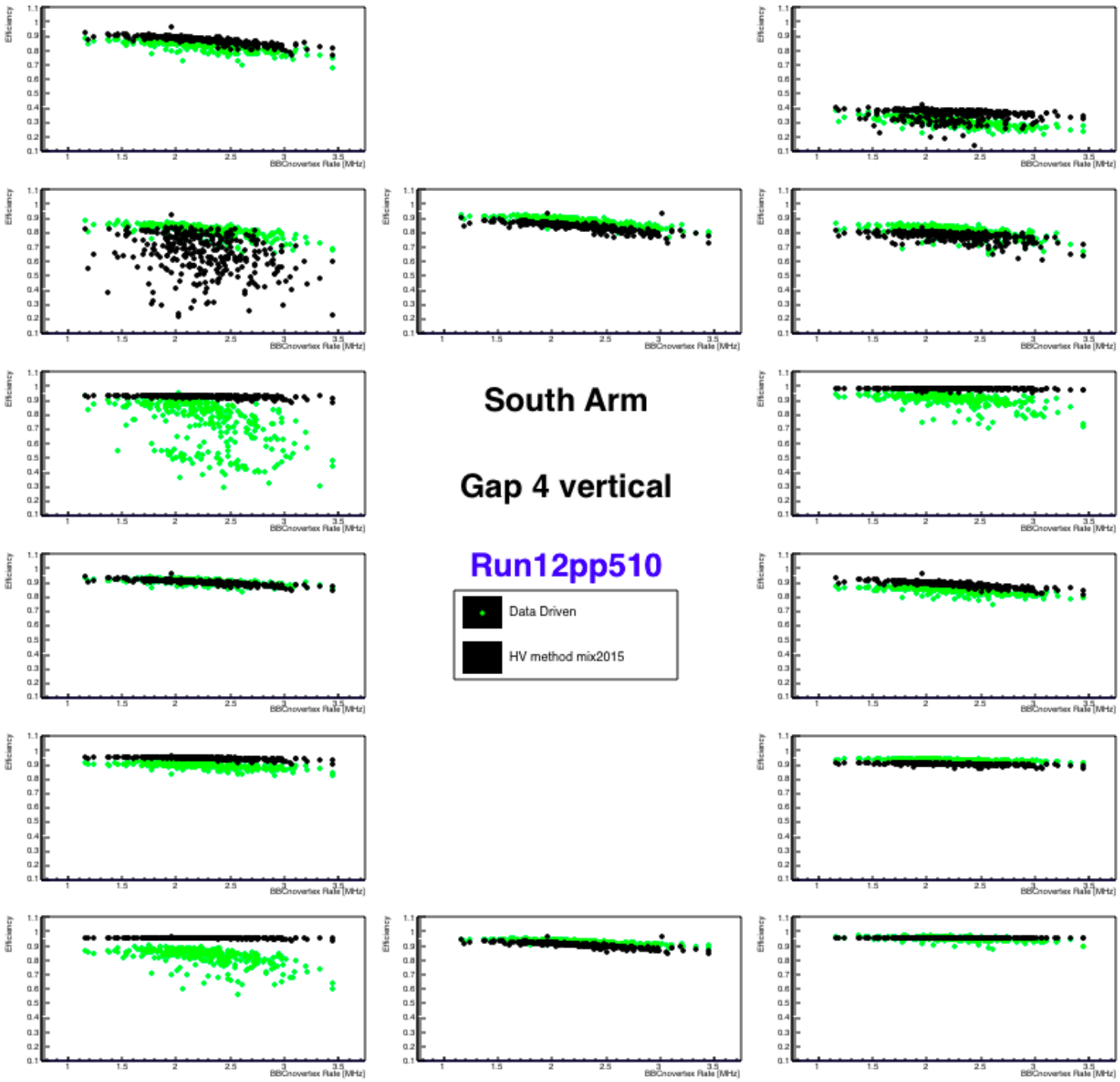
Run12pp510



Data-driven

HV-method mix2015

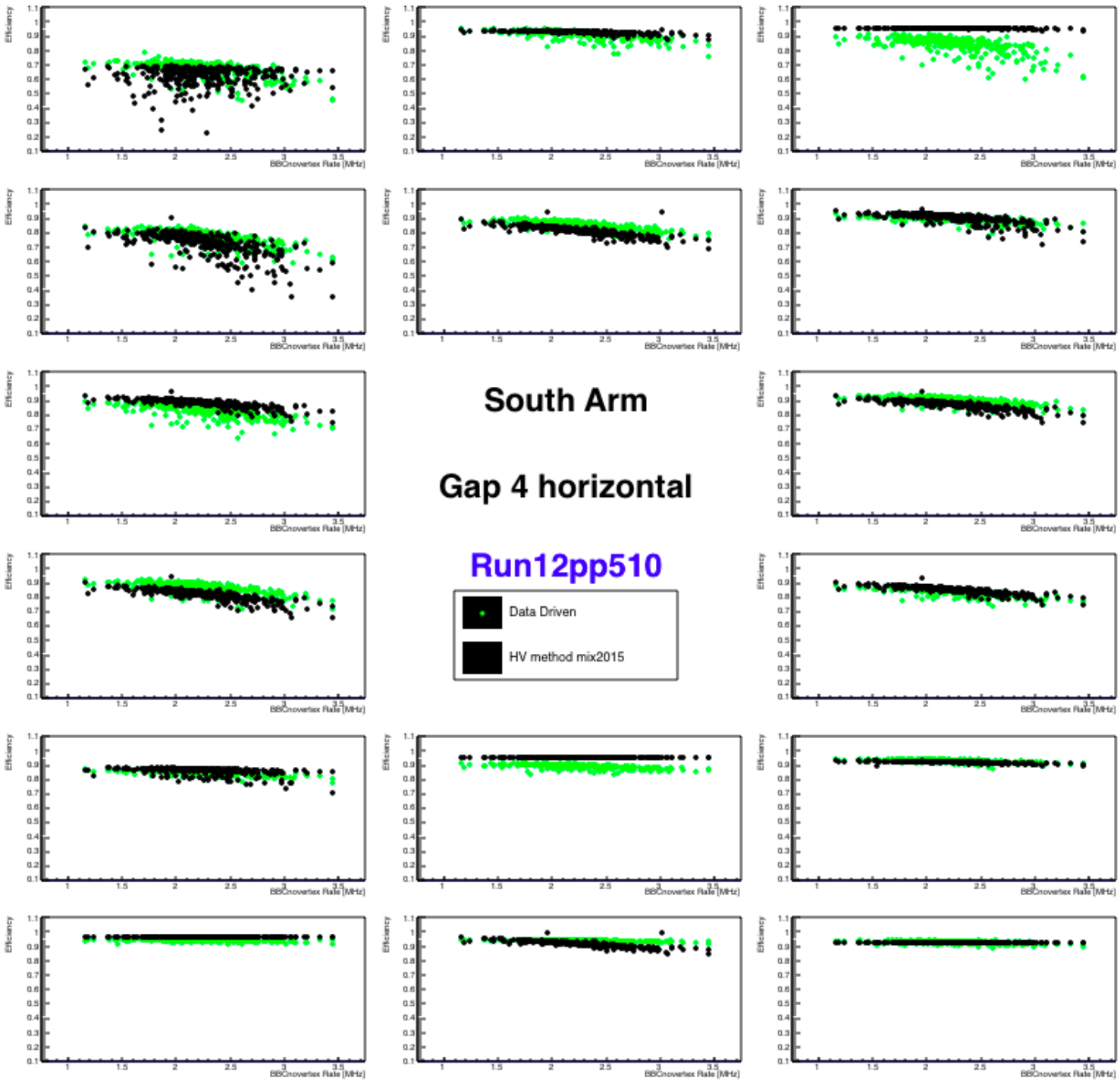
Run12pp510



Data-driven

HV-method mix2015

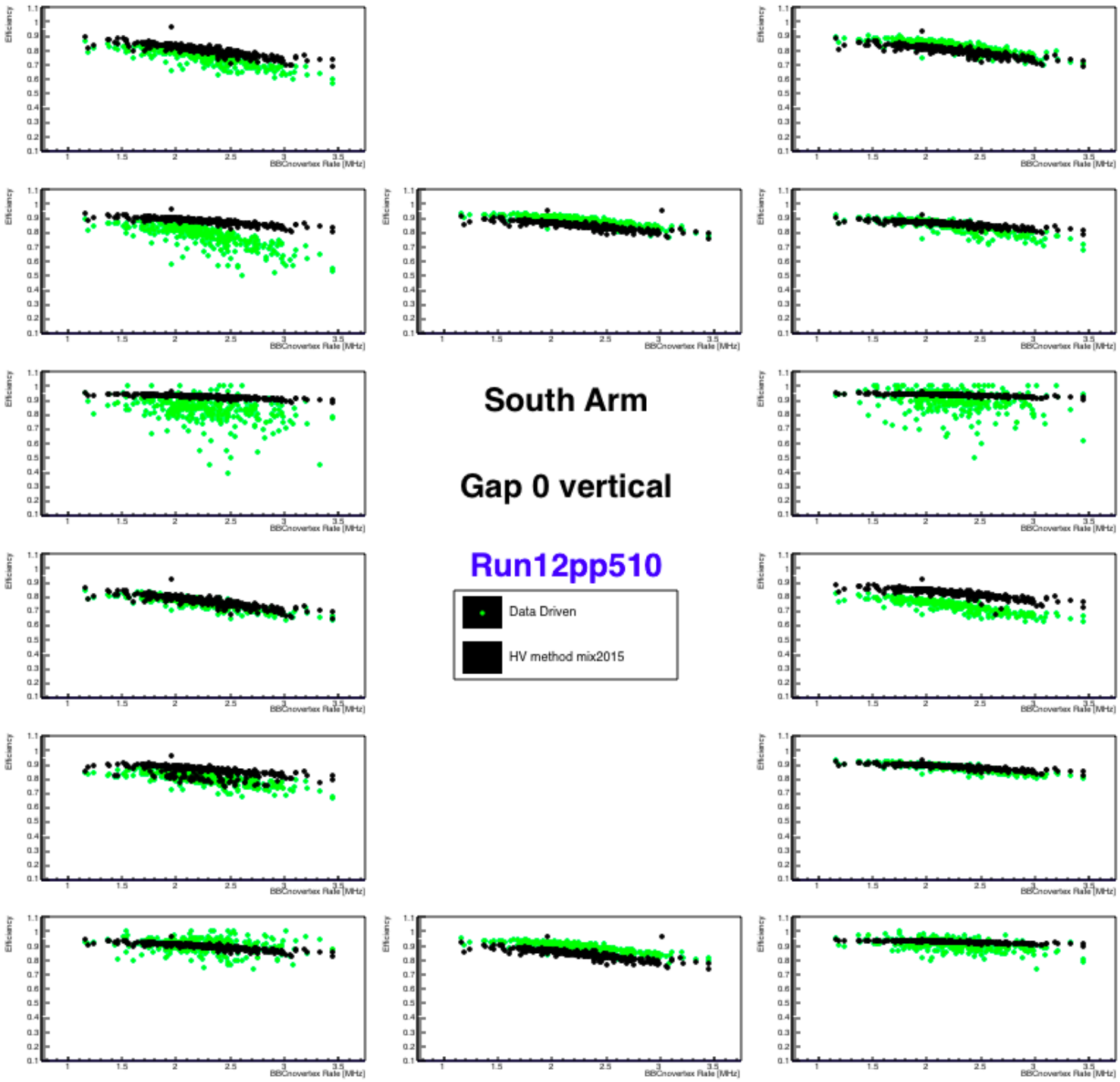
Run12pp510



Data-driven

HV-method mix2015

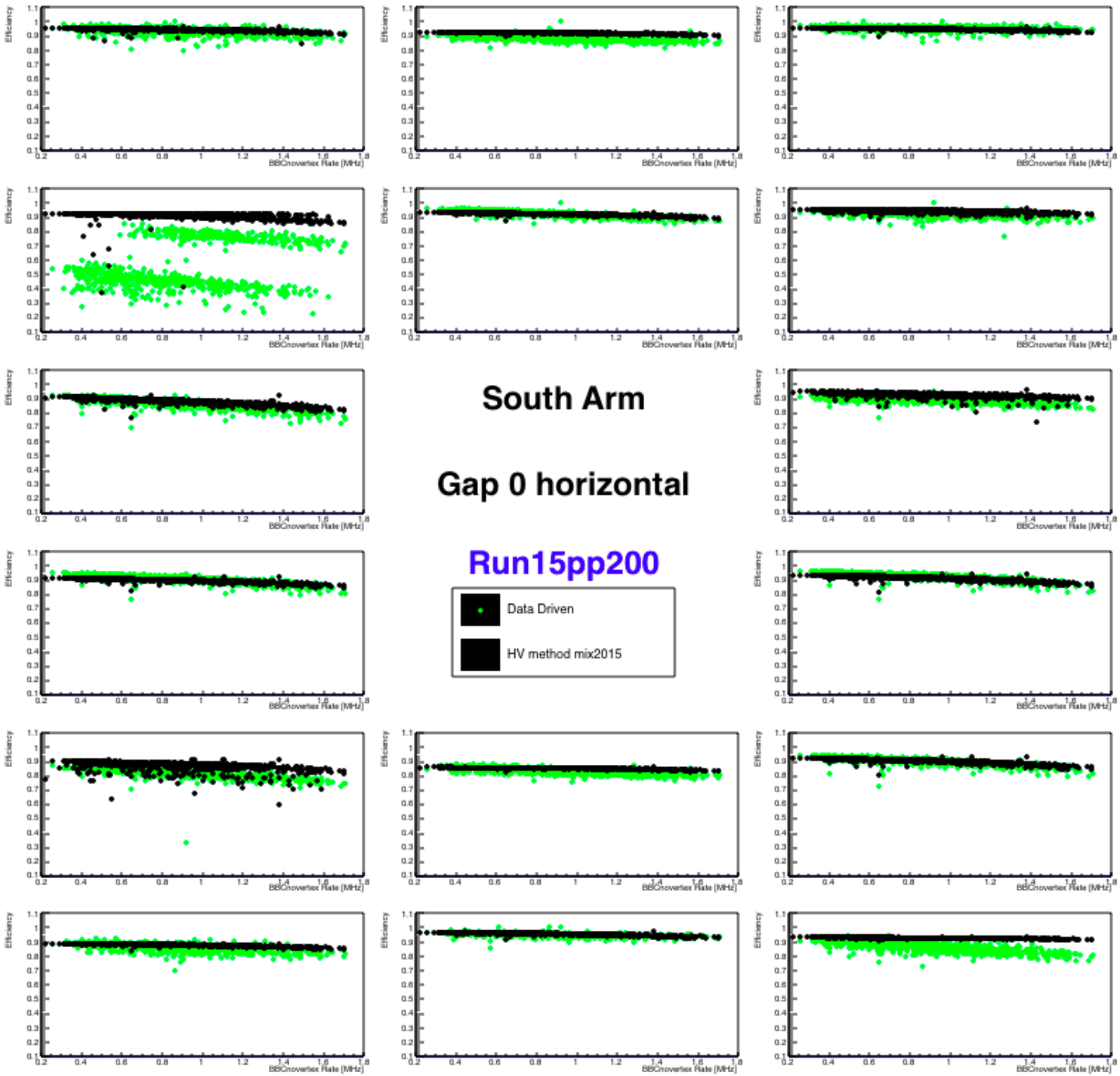
Run12pp510



Data-driven

HV-method mix2015

Run12pp510

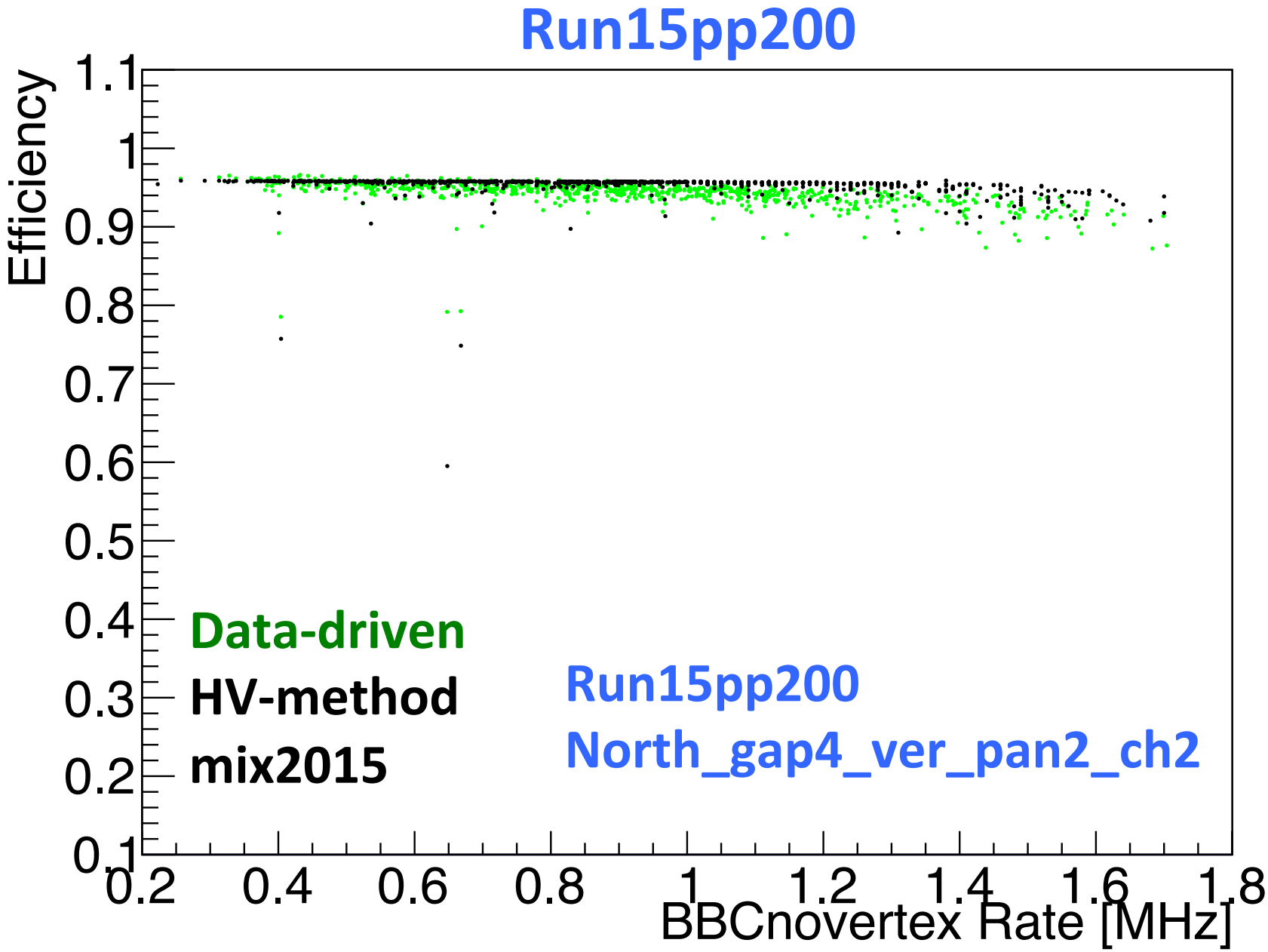


Data-driven

HV-method mix2015

Run12pp510

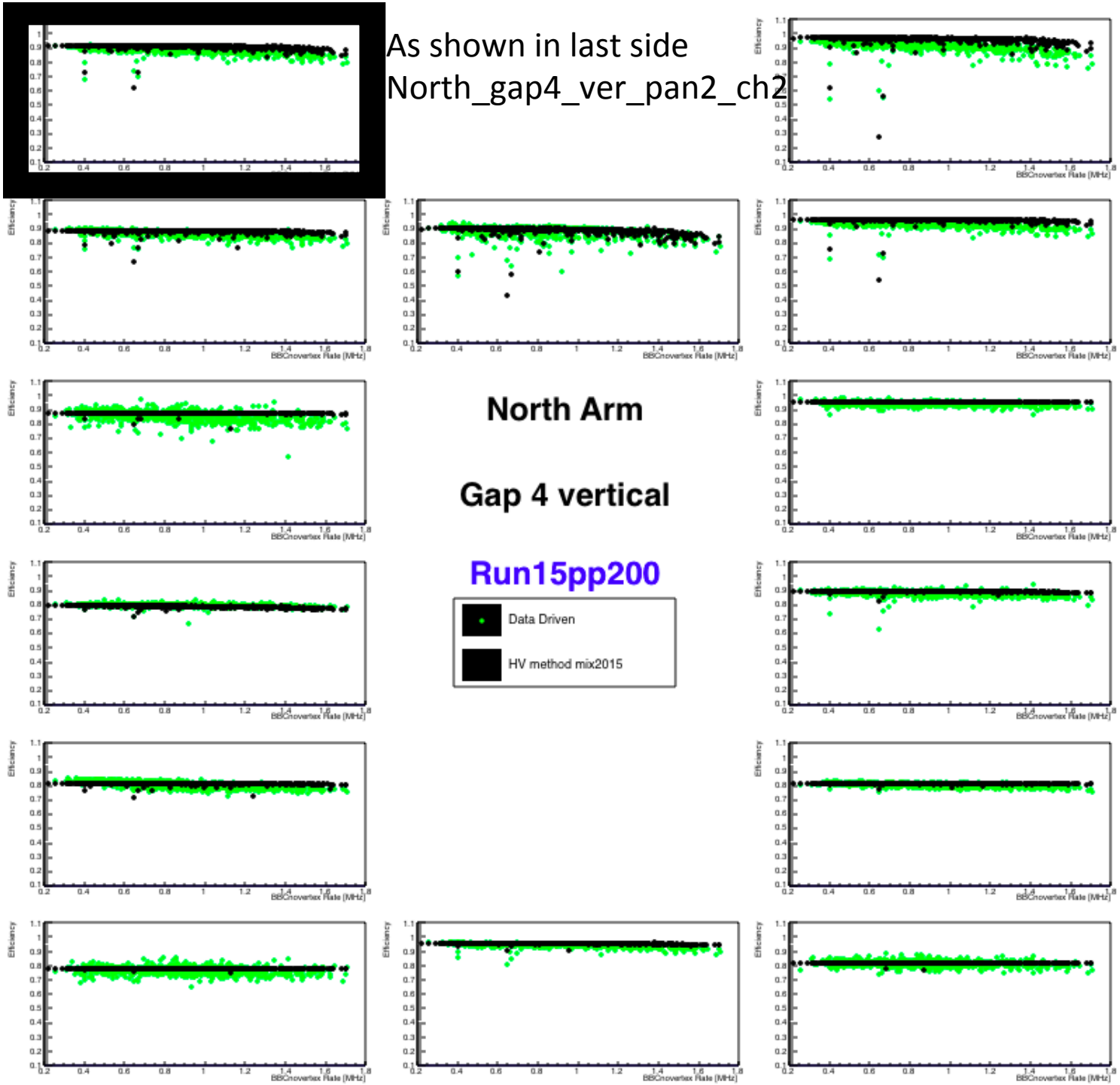
Comparison Data-Drive vs HV-method

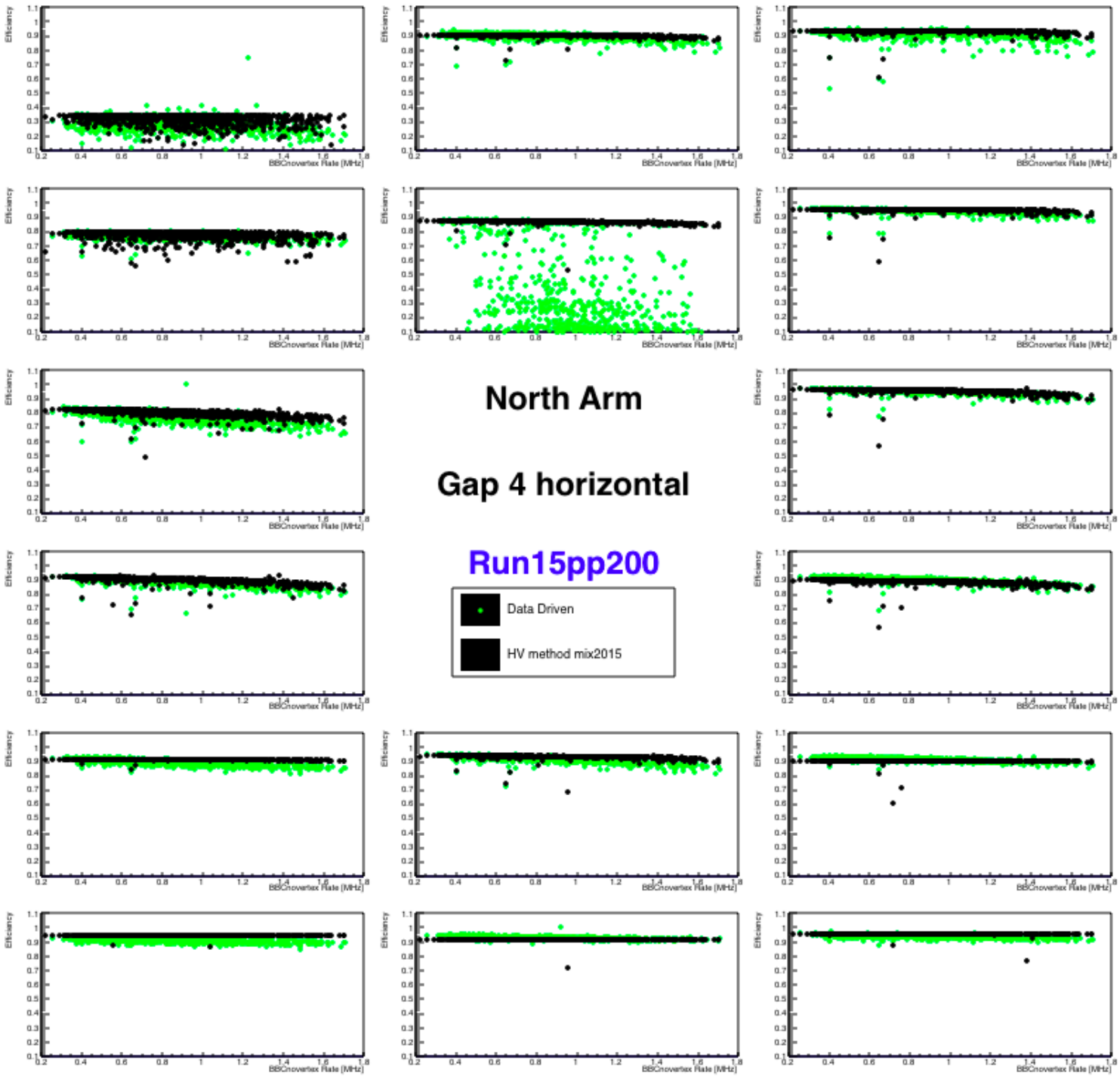


As shown in last side
North_gap4_ver_pan2_ch2

Data-driven
HV-method mix2015

Run15pp200

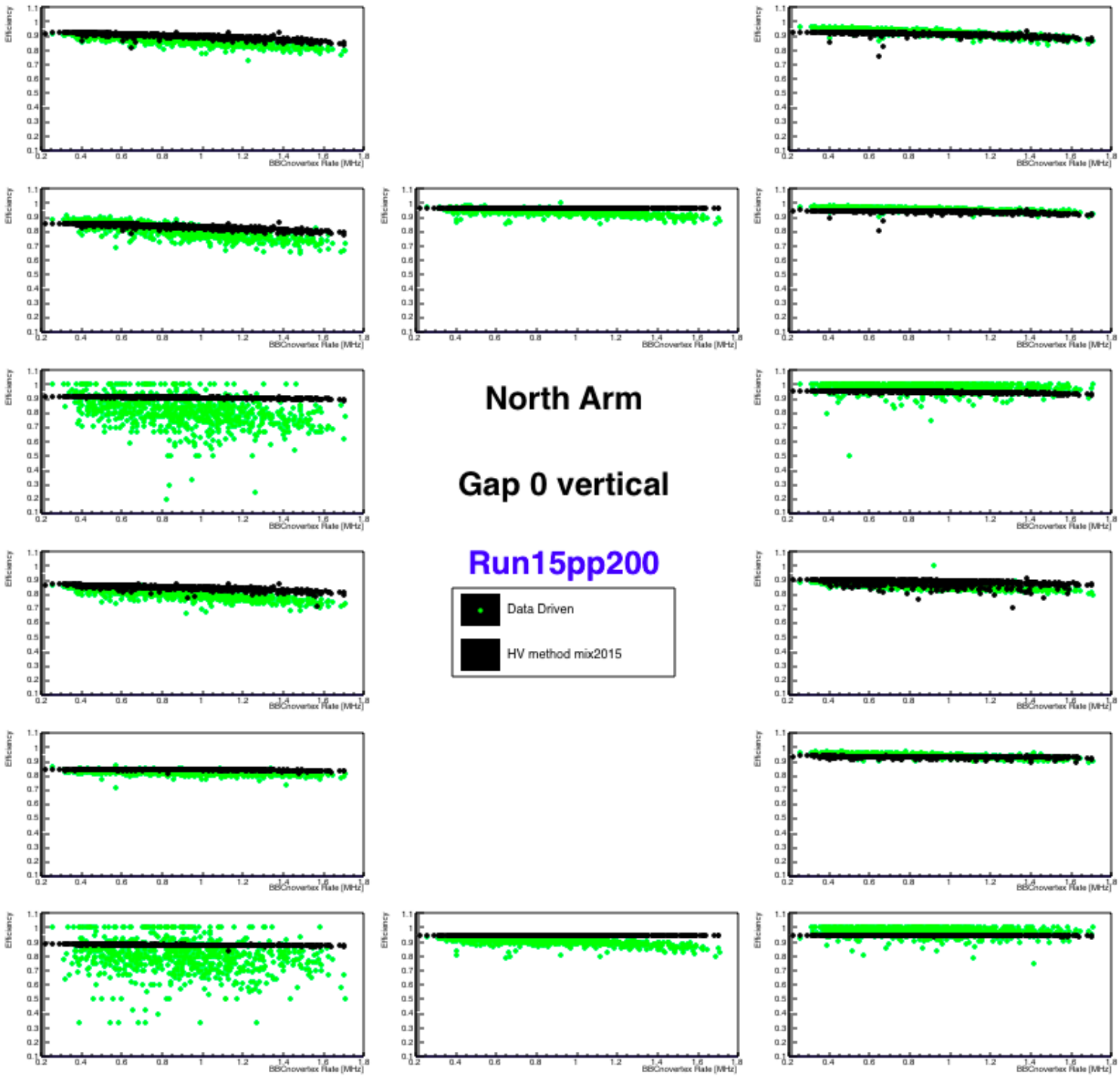




Data-driven

HV-method mix2015

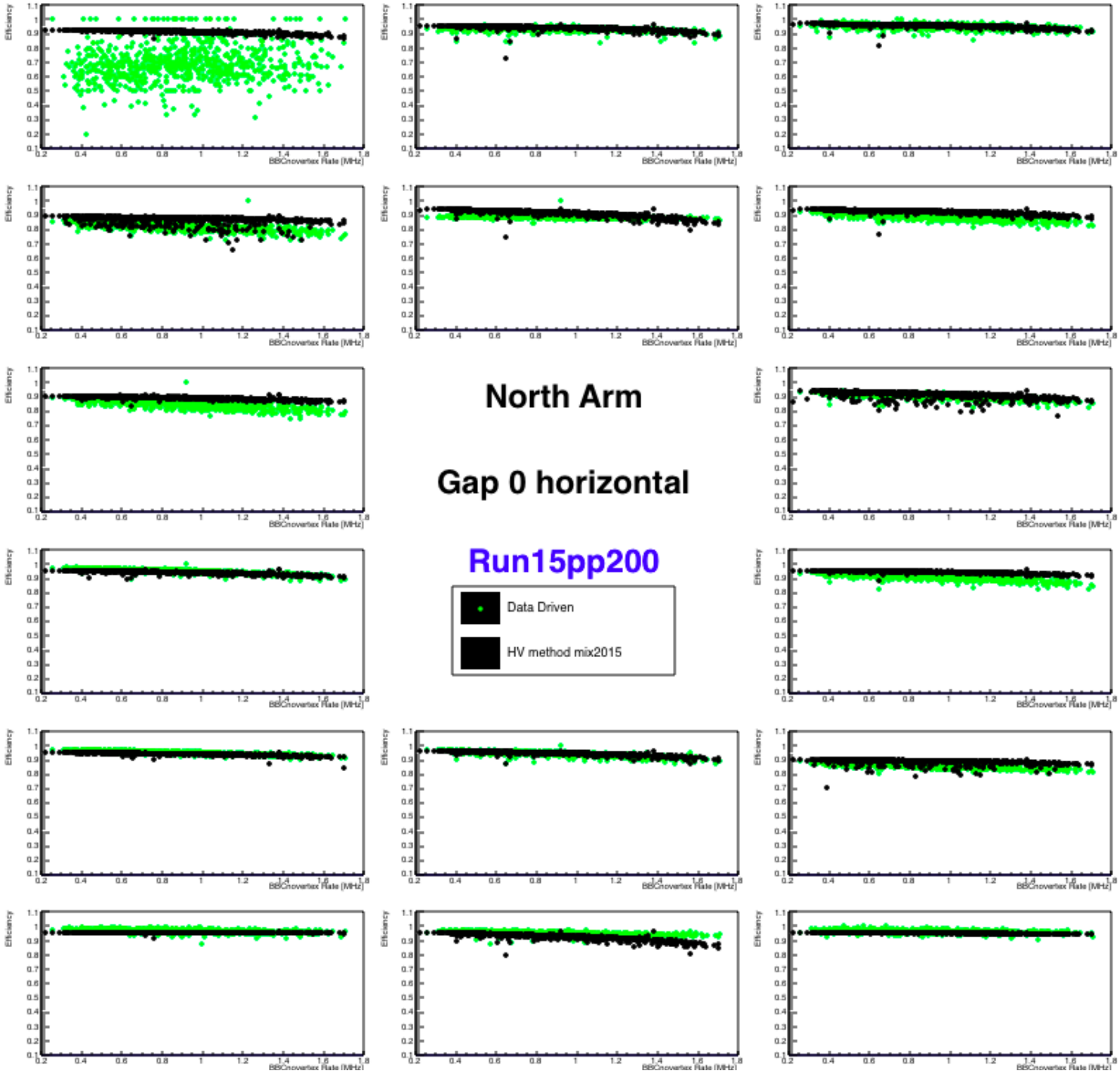
Run15pp200



Data-driven

HV-method mix2015

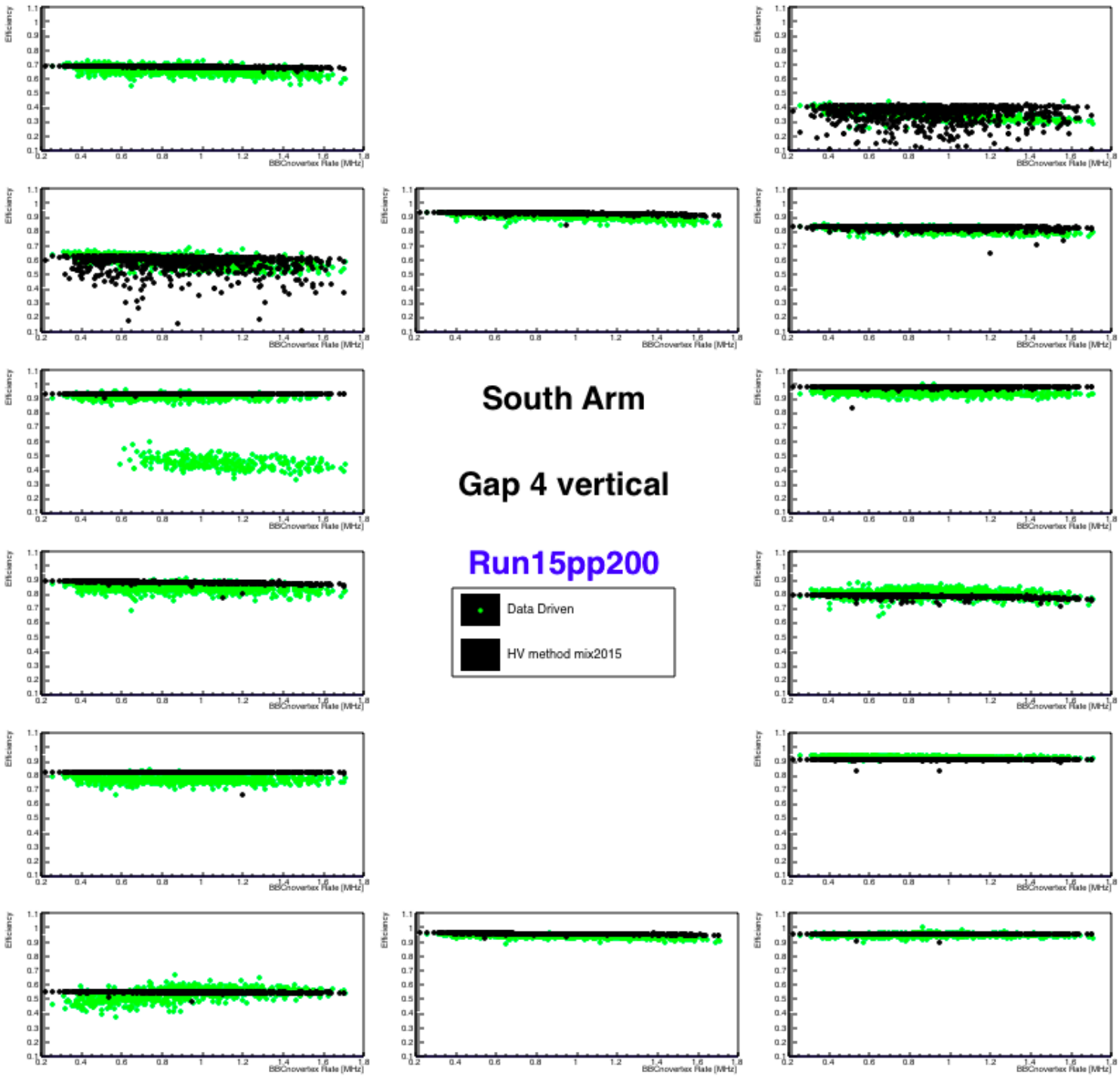
Run15pp200



Data-driven

HV-method mix2015

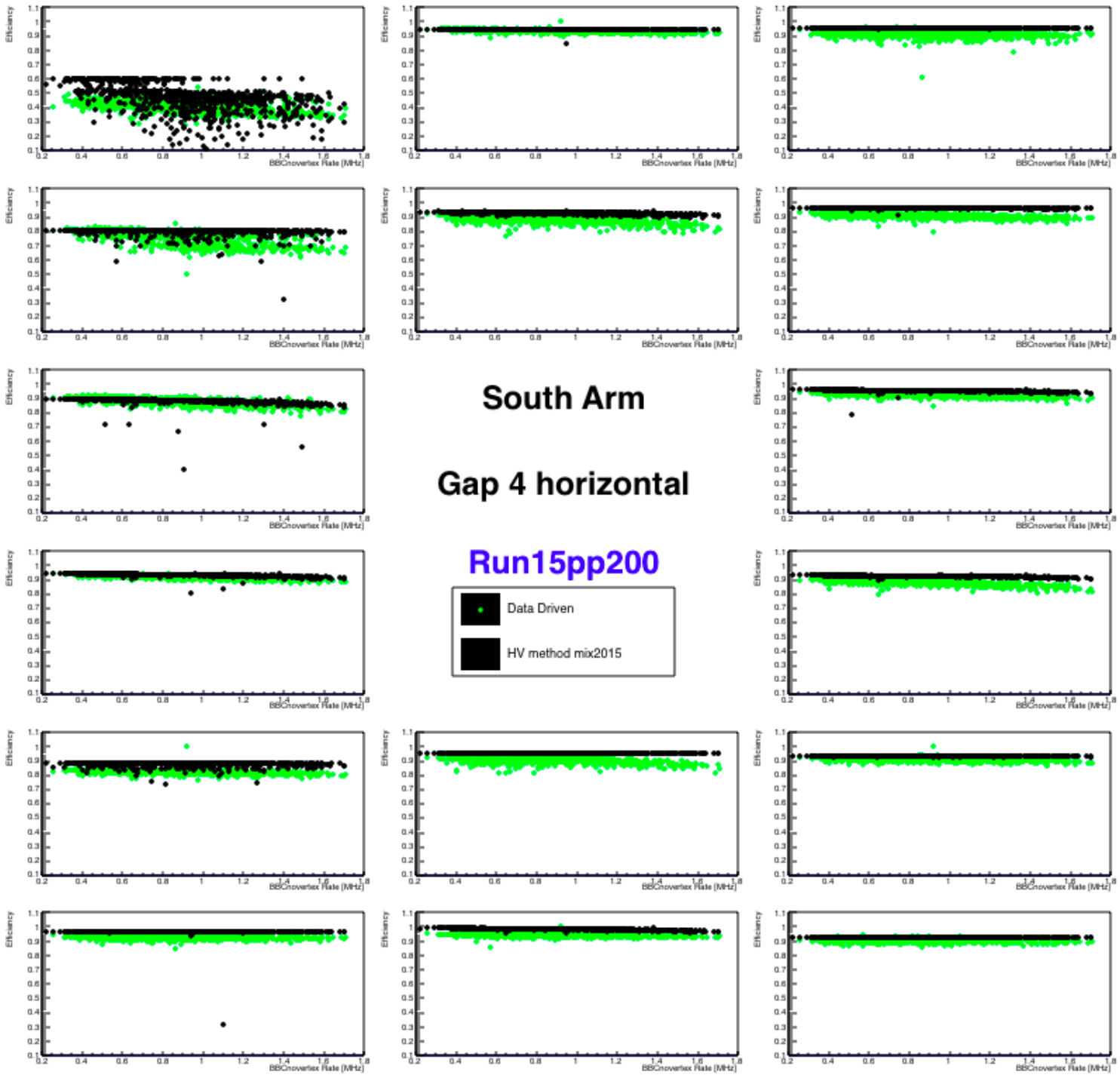
Run15pp200



Data-driven

HV-method mix2015

Run15pp200



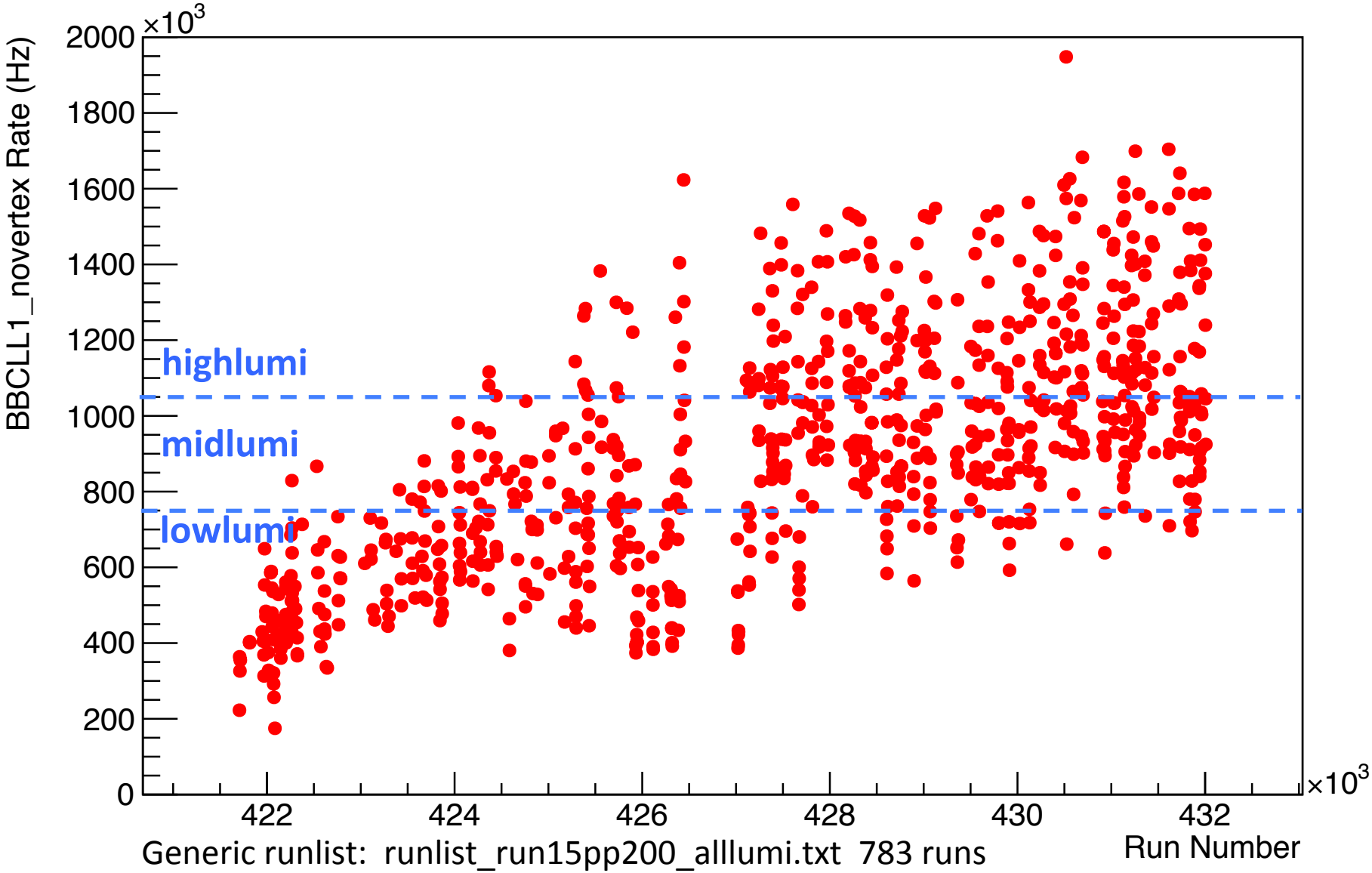
Data-driven

HV-method mix2015

Run15pp200

The Details

Run15pp200 BBC Rate (Hz) vs Run Number



Generic runlist: runlist_run15pp200_alllumi.txt 783 runs

- **highlumi:** runlist_run15pp200_highlumi.txt 258 runs, BBCRate>1.05 MHz
- **midlumi:** runlist_run15pp200_midlumi.txt 264 runs, 0.75MHz<BBCRate<1.05 MHz
- **lowlumi:** runlist_run15pp200_lowlumi.txt 261 runs, BBCRate<0.75 MHz

Generic runlist files, runnum vs luminosity files posted on webpage:

https://www.phenix.bnl.gov/phenix/WWW/publish/xjiang/Run2015/Run15pp200/runlist

From new production pro104, which has a slightly improved tracking for MuTr, (compared to the online run15 production code)

Regenerated MUID tube_efficiency files, for all runs out of pro104 (~50 runs more than online production, Sanghoon also generated the same files earlier). Files in:

https://www.phenix.bnl.gov/phenix/WWW/publish/xjiang/Run2015/Run15pp200/MUID_EFF/data_driven_method/run15pp200_tube_eff_pro104/

Noticed small differences compared to the files generated by online MUID_EFF root files, on low statistics channels. On a few panels, noticed small improvements (within ~1 %) on tube_eff when using pro104 files, vs using online MUID_EFF files. Might be related to the slightly better MuTR track selection in pro104.

Details: Use MuID HV Channel Current Reading to Calculate MuID Efficeincy

following Itaru et al, 2014 studies.

Establishing the efficiency-baseline:

Cosmic rays HV scans (mid-2014) -> MUID efficiencies vs HV as the baseline

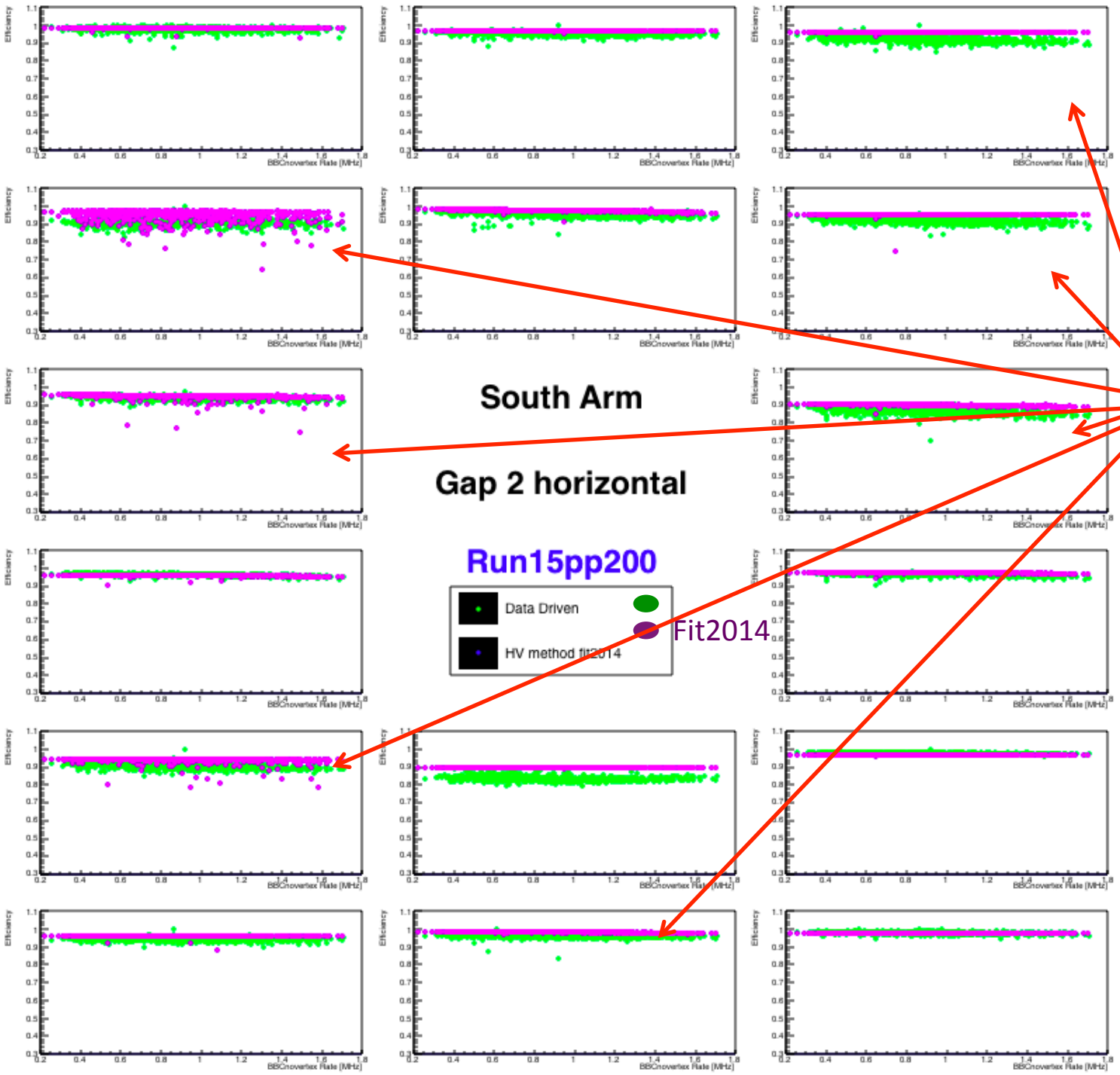
In Run15pp200 data:

MuID HV current -> averaged dark current per live-tube -> effective HV on tube

-> check efficiency-baseline, obtain muid-tube-efficiency

The procedure of HV-method:

- Cosmic ray run obtain baseline dark current. Calculate number of dead tubes per HV channel.
- Read-in current per HV channel in data, calculate averaged dark-current per tube. Calculate effective voltage drops.
- Reference to cosmic-ray HV scan for the corresponding MUID HV-group efficiencies.
- Obtain tube-by-tube efficiencies.

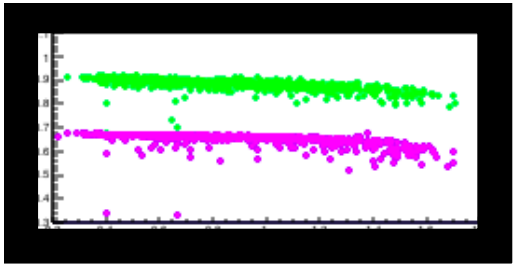


Data-driven

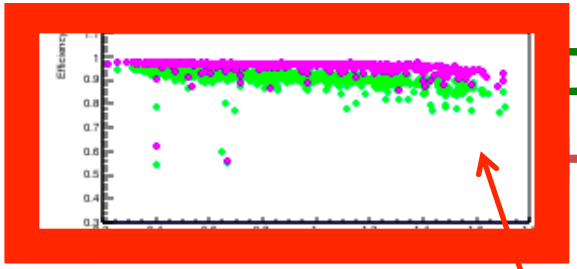
HV fit2014

Agreements in many HV channels

For example…

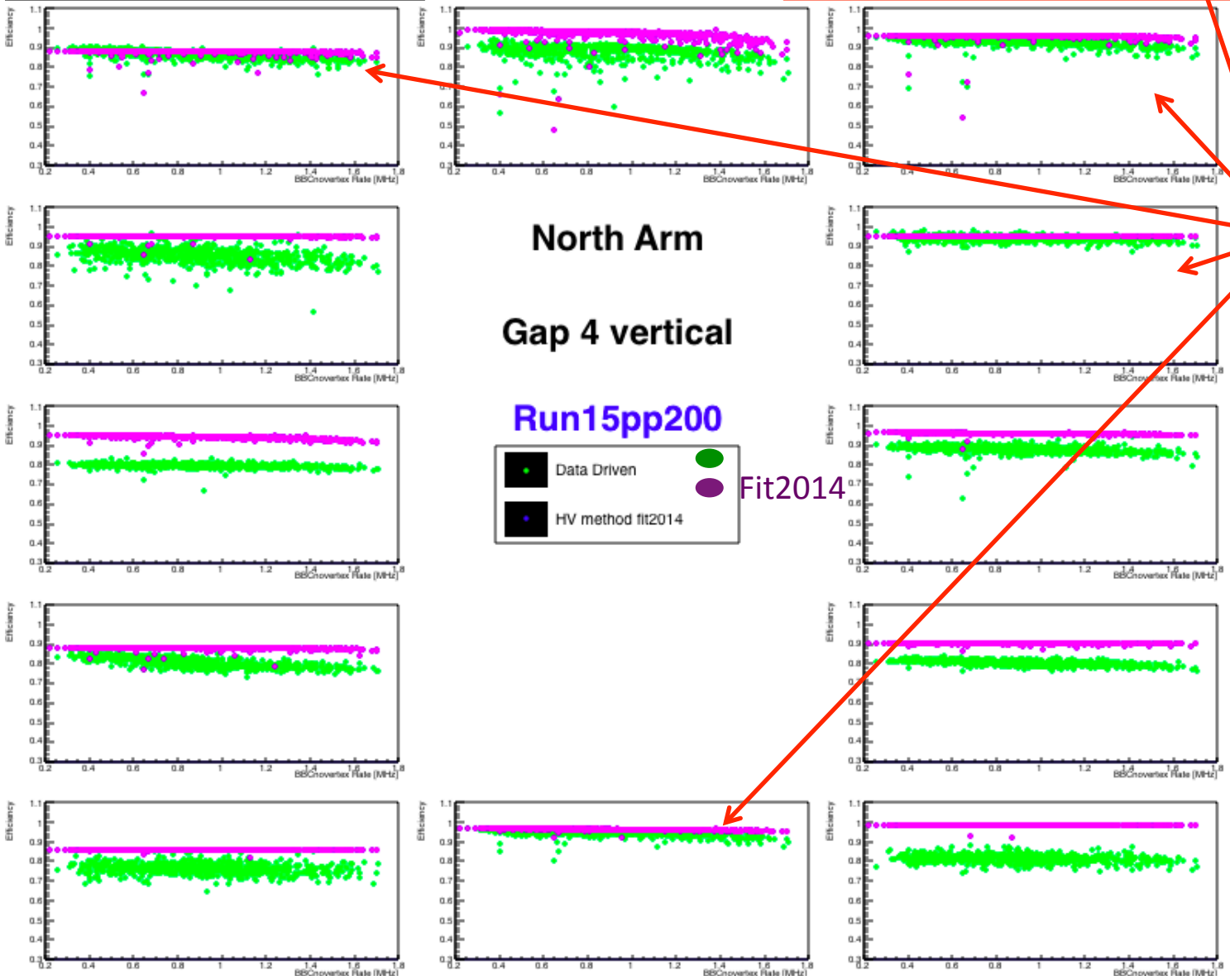


However, obvious disagreements in several HV channels

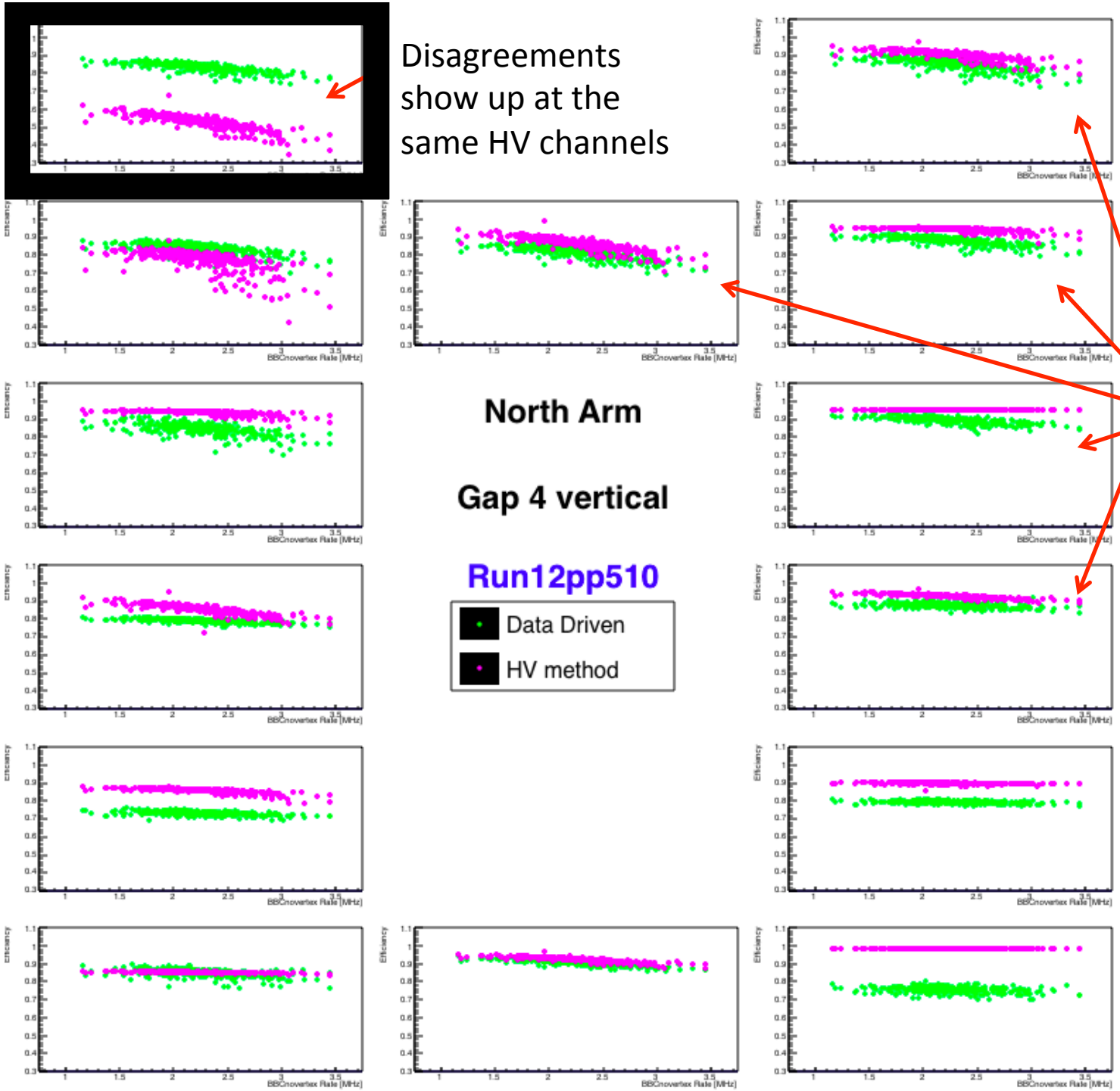


Data-driven

HV fit2014



Agreements in many HV channels



Disagreements show up at the same HV channels

Run12pp510 use fit2014

Clear agreements in many HV channels

Disagreements show up at the same HV channels In Run12pp510 analysis as well.

Agreements

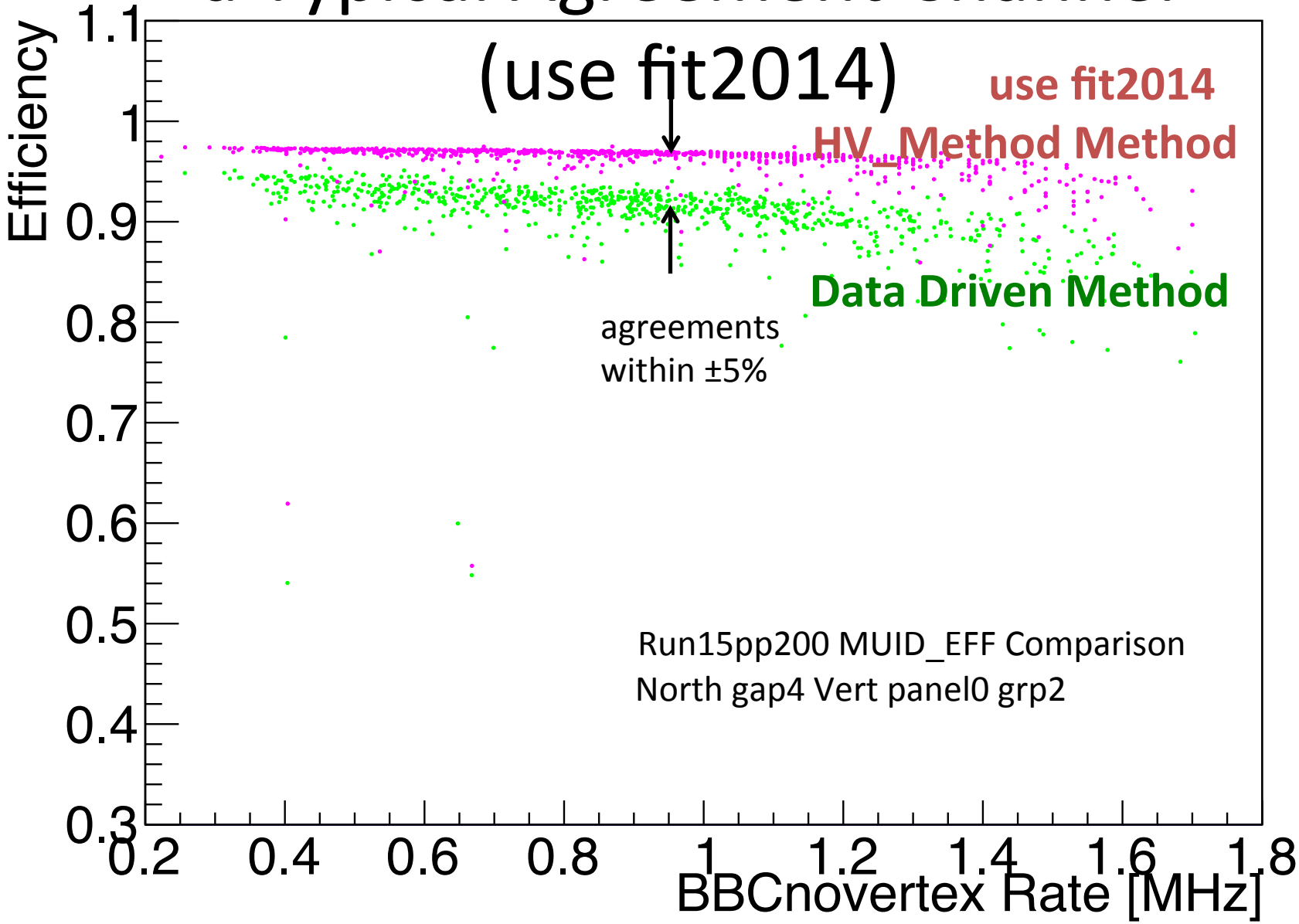
A typical example: North gap4 Vert panel0 grp2
The old “fit2004” works well in many channels.
(No needs for improvements to start with).
The new “fit2014” might not improve on all-channels, due to limited data in cosmic-ray HV scans conducted in 2014.

Disagreements

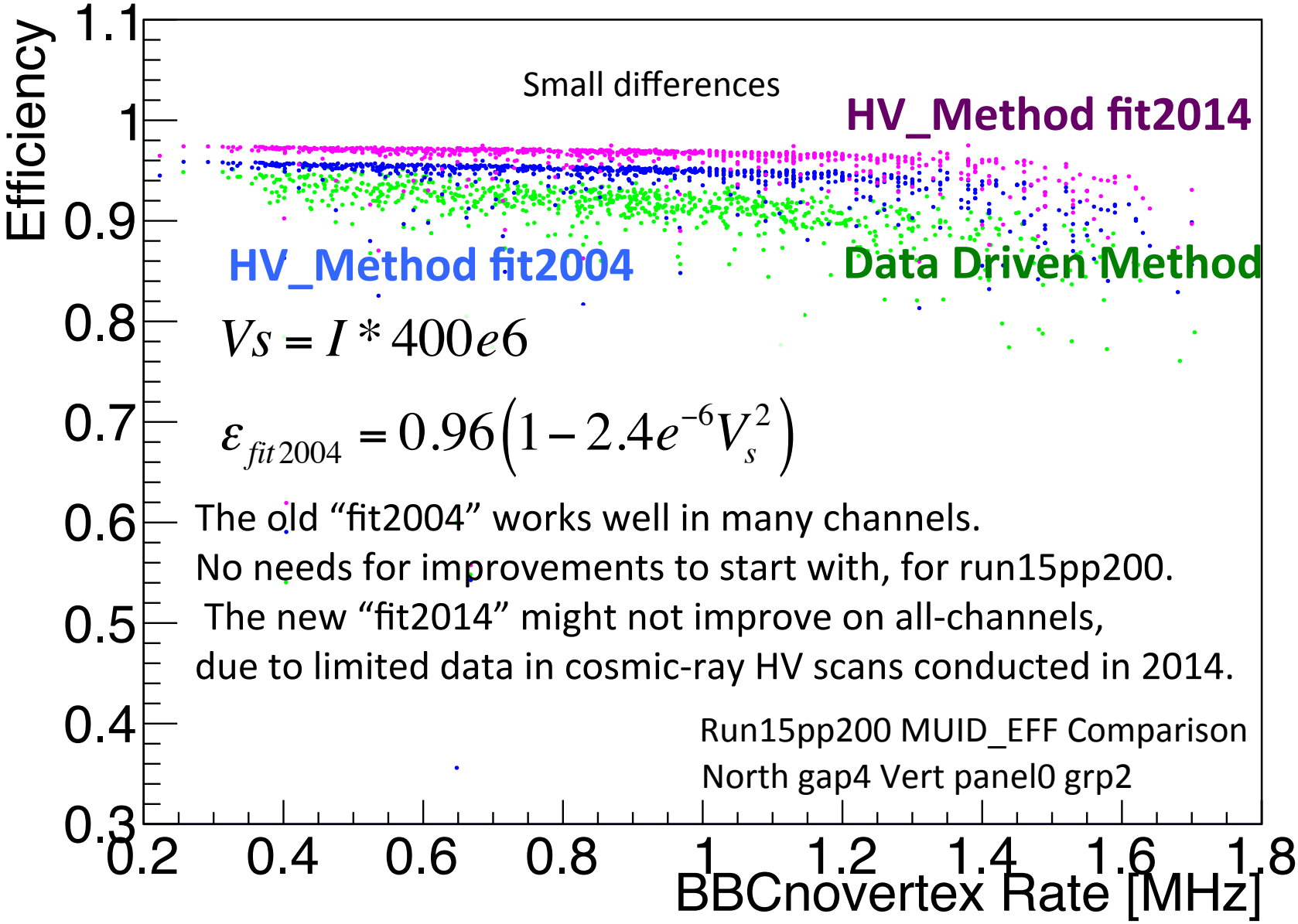
A typical example: North gap4 Vert panel2 grp2

Detailed checks on MUID dark currents, channel-by-channel.
The solution.

Run15pp200 MUID_EFF Comparison
a Typical Agreement Channel



Run15pp200 MUID_EFF Comparison
"Old" fit2004 works well in many channels



Check MUID HV dark-currents

Establish the MUID baseline dark currents when there's no beam.
(need a reasonable set of real cosmic ray runs taken, not available during run15pp200).
Based on the baseline dark-current, calculate the number of dead-tubes in each HV channel.

Cosmic runs taken during run15pp200, for obtaining the baseline currents:

421312
422442
422444
422452
423543

Number of dead tubes changed slightly for run15…

Typical Values of Baseline Currents and the method to Calculate Number of Dead Tubes

Baseline/Current_1_4_0_1_2.txt

Run-number	current (uA)		
421312	4.696		
422442	4.682		
422444	4.642	0-dead-tubes	4400 volt/1 GΩ ≈ 4.4 μA
422452	4.669		
423543	4.629		

Baseline/Current_0_4_2_0_4.txt

421312	15.472		
422442	15.458		
422444	15.485	1-dead-tubes	(4400 volt/1 GΩ) *(1+1/0.4) ≈ 15.4 μA
422452	15.512		
423543	15.498		

Baseline/Current_0_4_2_0_5.txt

421312	26.622		
422442	26.636		
422444	26.662	2-dead-tubes	(4400 volt/1 GΩ) *(1+2/0.4) ≈ 26.4 μA
422452	27.343		
423543	26.636		

Based on the baseline current to calculate the number of dead tubes each channel. ~20 more dead tubes compared with run13.

Extreme Values: Baseline Currents

Baeline/Current_1_4_2_0_6.txt

421312	82.028		
422442	82.188		
422444	82.214	7-dead-tubes	(4400 volt/1 GΩ) *(1+7/0.4) ≈ 82 μA
422452	82.201		
423543	82.294		

More dead-tubes in run15 vs run13…

Run15pp200 cosmic runs ../HV/Baseline/Current_0_1_0_1_5.txt

421312	15.313
422442	20.738
422444	15.286
422452	15.3
423543	15.26

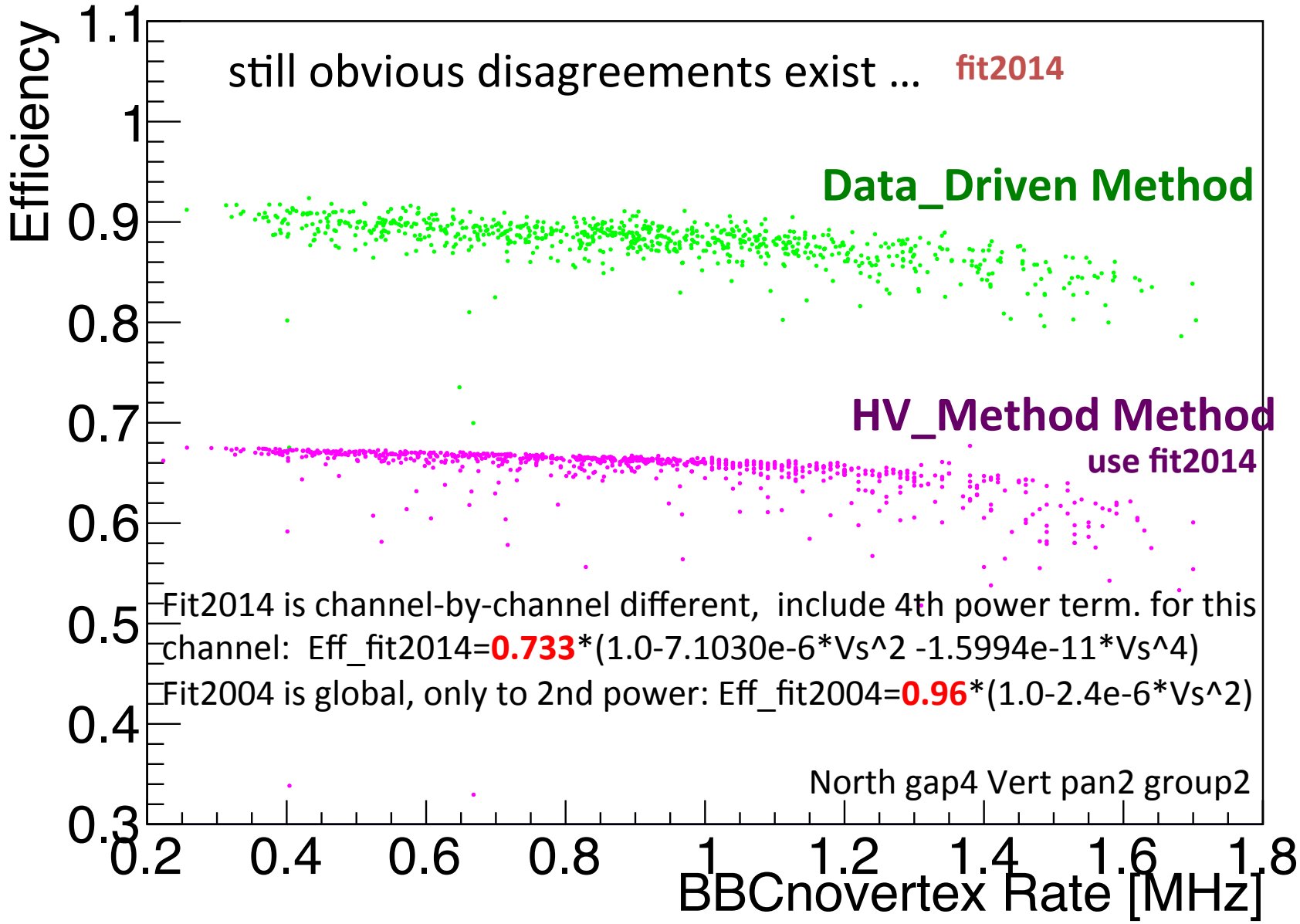
1-dead-tubes

Run13pp510 cosmic runs Baseline/Current_0_1_0_1_5.txt

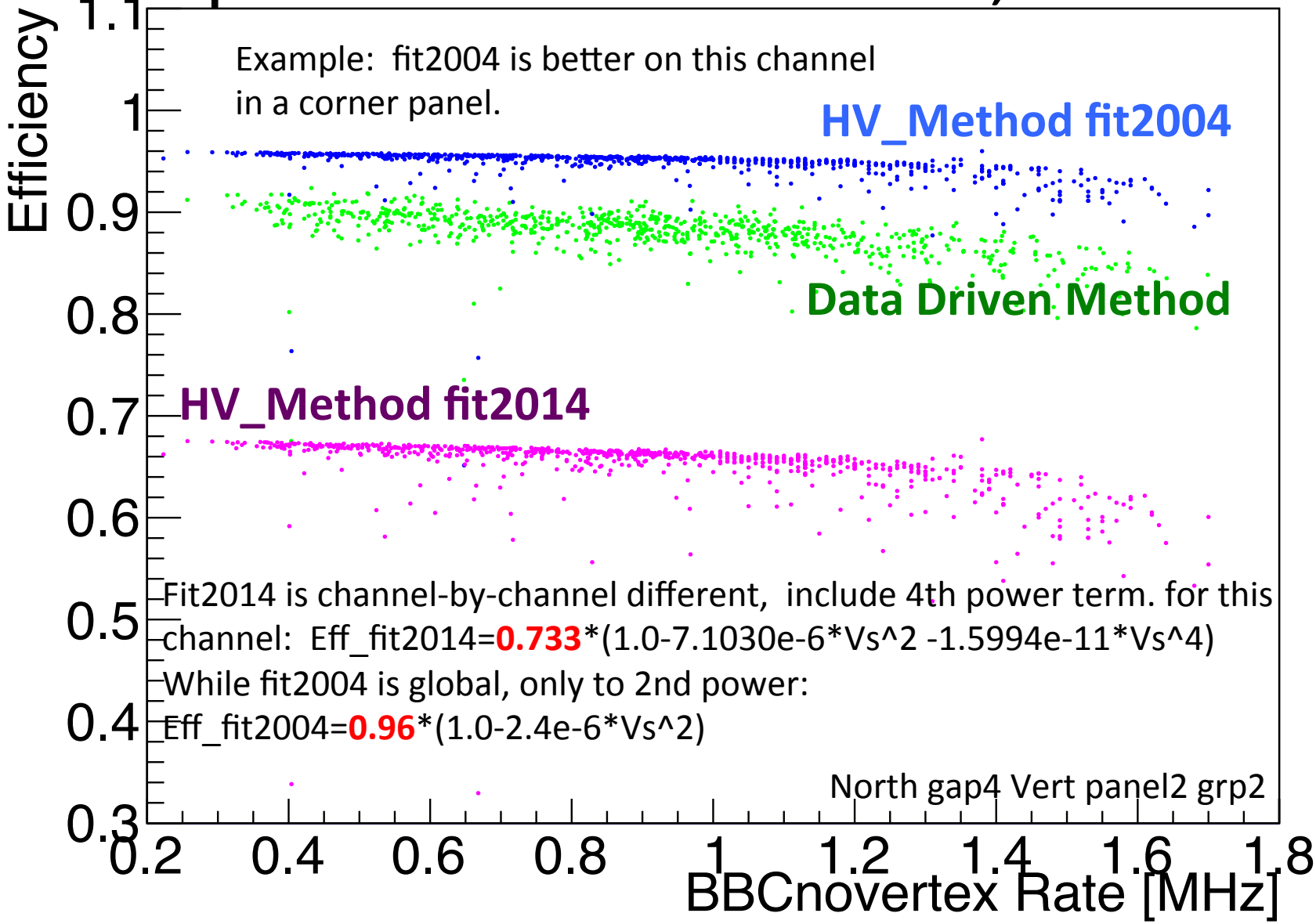
397165	4.422
397166	4.436
397396	4.476
397670	4.529
397798	4.436

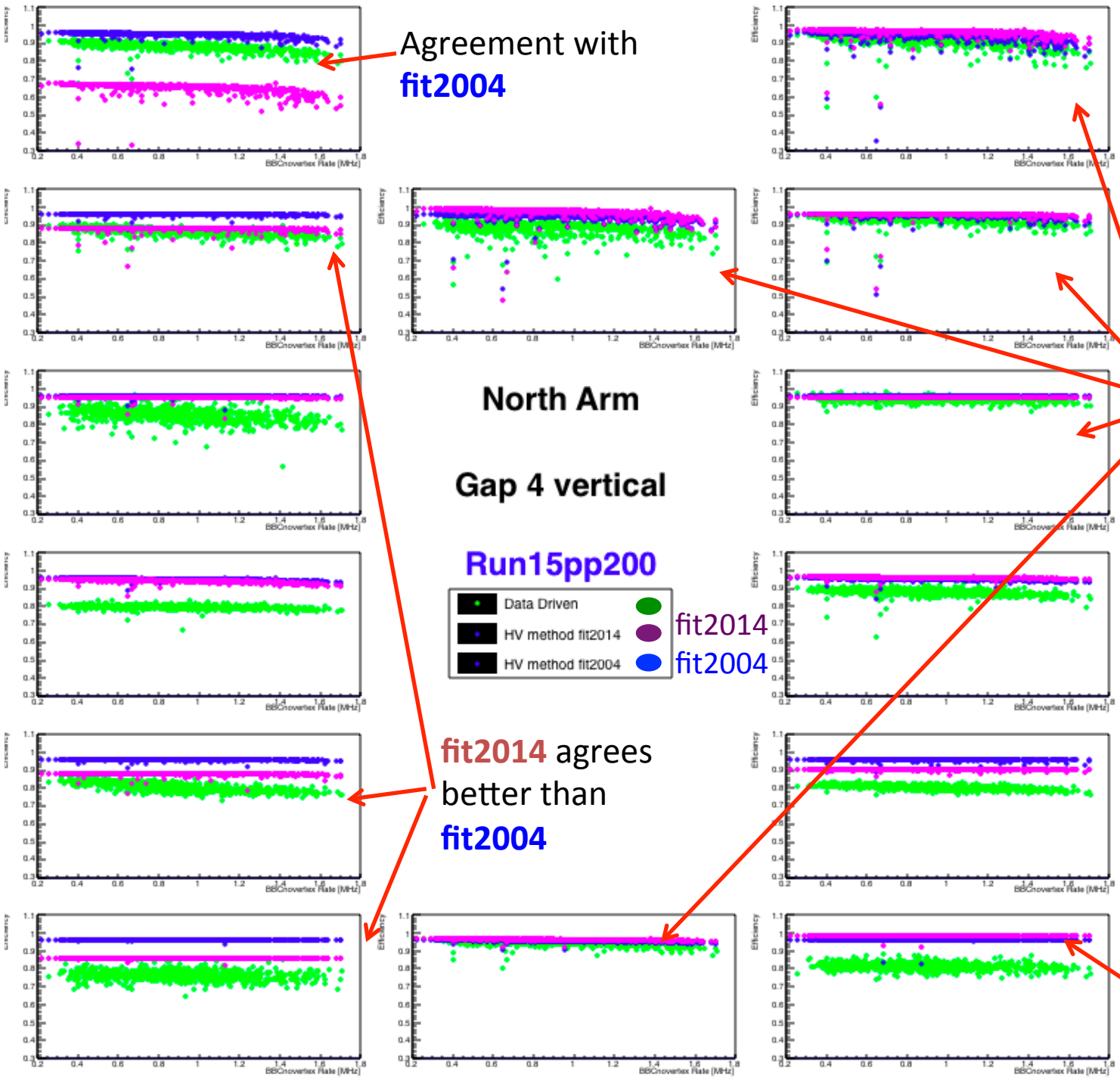
0-dead-tubes

Run15pp200 MUID_EFF Comparison



Run15pp200 MUID_EFF Comparison example: better with fit2004, not fit2014





Agreement with **fit2004**

Data-driven

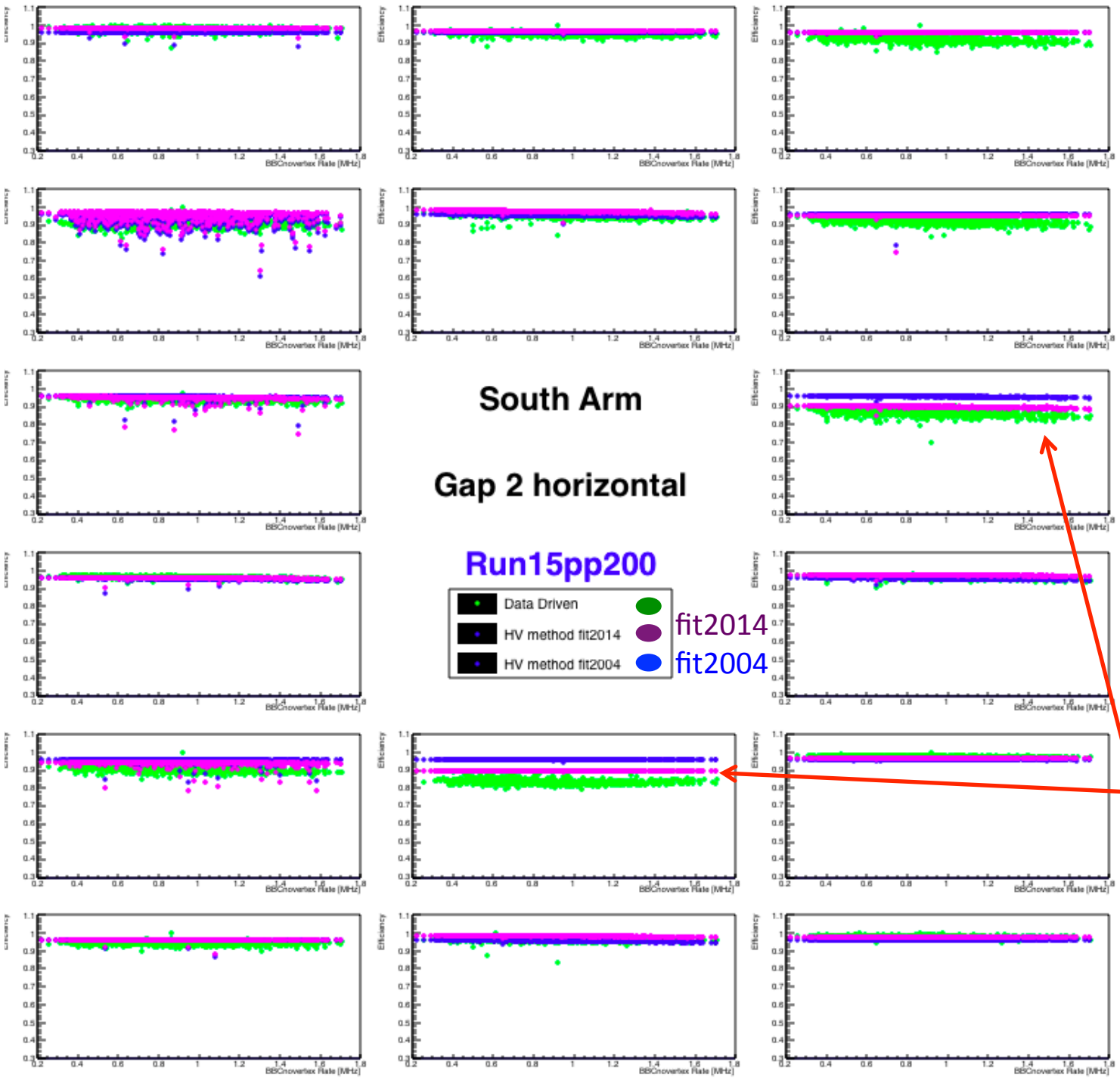
HV fit2014

HV fit2004

Agreements in many HV channels

fit2014 agrees better than **fit2004**

Disagreement at a corner panel



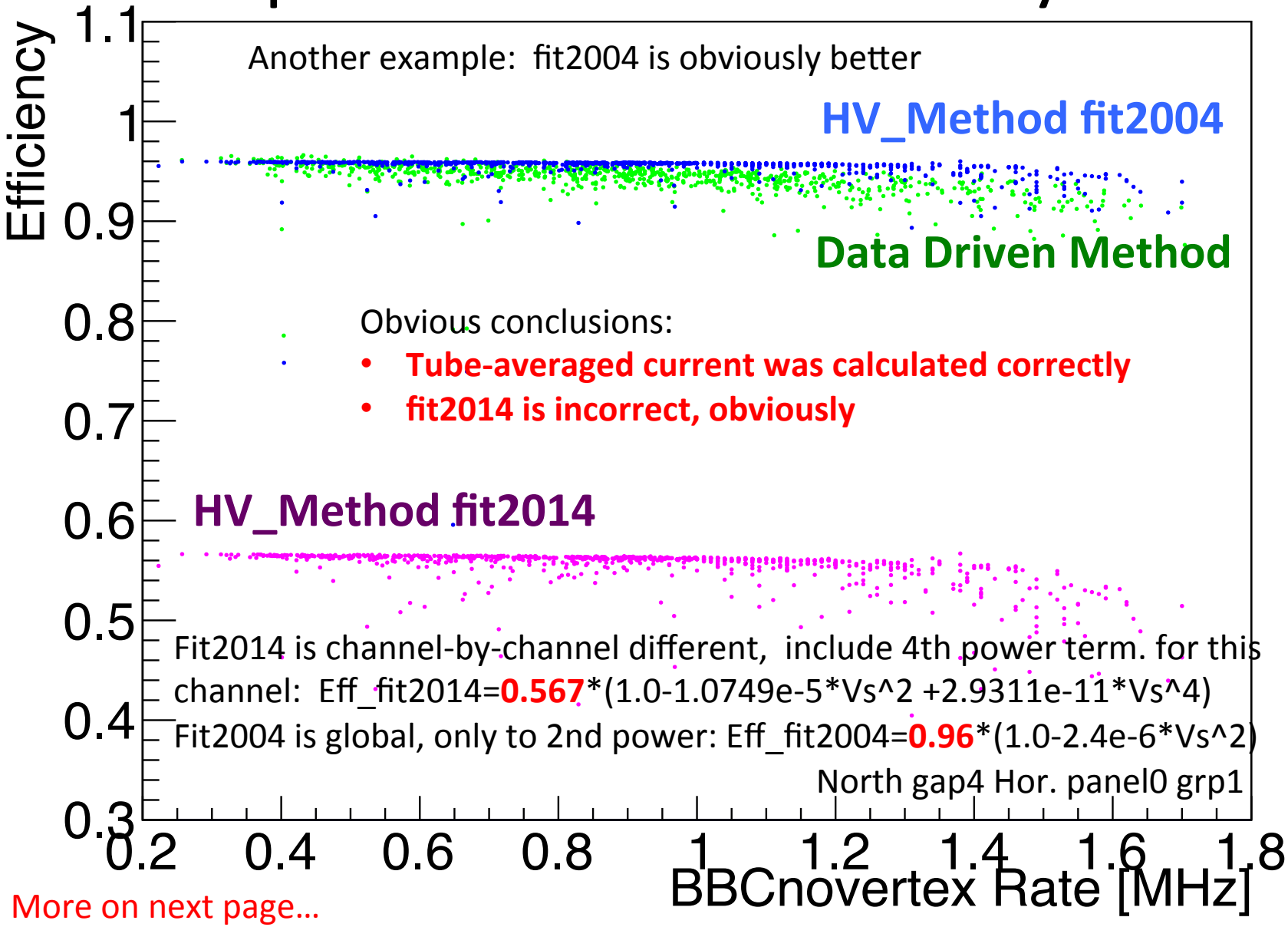
Data-driven

HV fit2014

HV fit2004

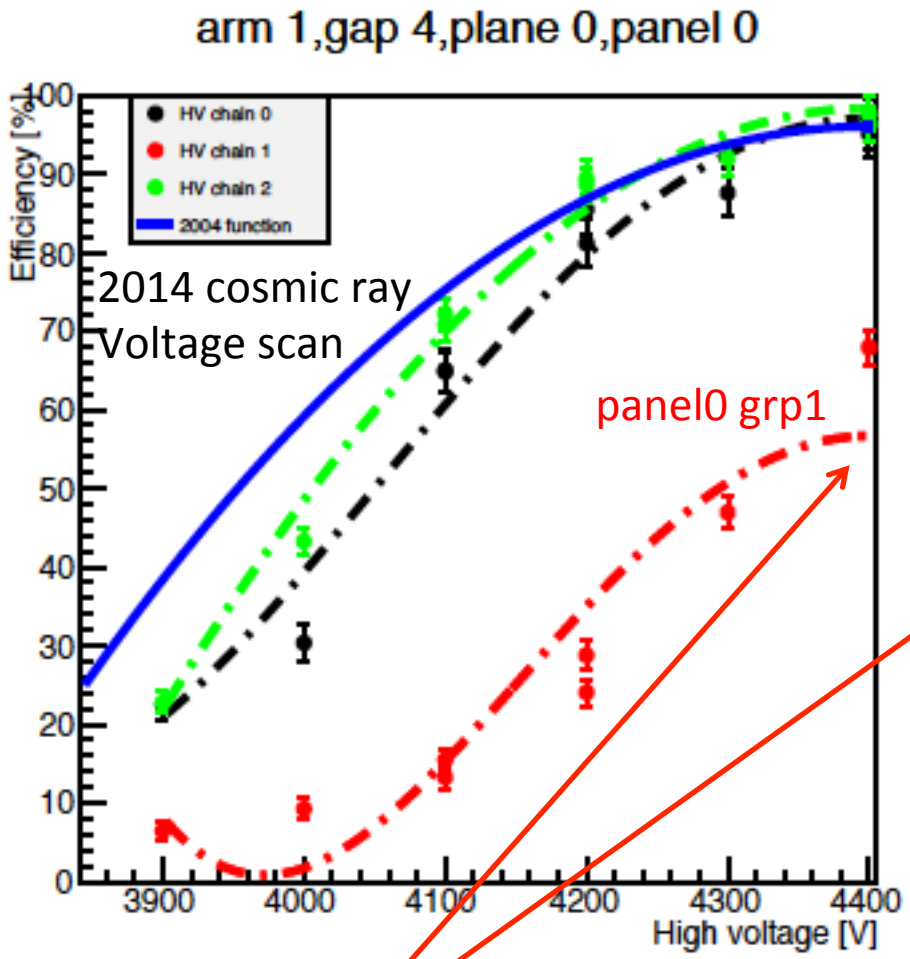
Overall, **fit2014** appears to agree better than **fit2004**

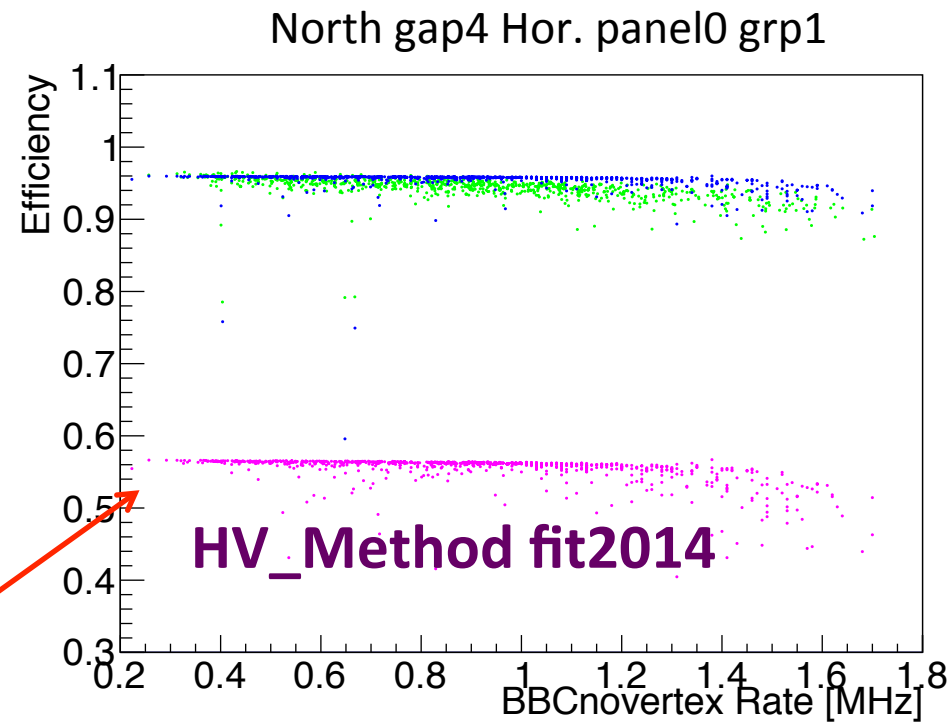
Run15pp200 MUID_EFF Comparison example: fit2004 is obviously better



More on next page…

One Obvious Problem: Run15pp200 MUID_EFF





Eff_fit2014=**0.567***(1.0-1.0749e-5*Vs^2 +2.9311e-11*Vs^4)

Low efficiency appeared in 2014-cosmic scan data.
But run15 data has a high efficiency.
Detector performance is not stable on this channel

The Solution: **mix2015**

Basic observations and assumptions:

- Run15pp200 luminosity is relatively low (~1MHz), compared to Run13pp510 (>3 MHz).
- MUID currents, and MUID_EFF have a weak luminosity dependency, most channels don't need 4th power corrections.
- When lack of cosmic ray data, MUID_EFF in very low luminosity runs can be considered to be close to MUID_EFF in "real" cosmic ray runs.

Solution:

- **Keep fit2014 when it works well. If fit2014 agrees with fit2004 within ±10%: mix2015=fit2014, (~120/150 channels in each arm, or ~80% of channels)**

In the remaining ~20% channels when fit2014 disagrees with fit2004 beyond ±10%:

- **For ~ 10% of channels when eff>90%, take the old universal fit2004, Eff_mix2015=fit2004 =0.96*(1.0-2.4e-6*Vs^2).**
- **For ~10% of channels, when eff<90%, take the form Eff_mix2015=P0*(1.0-2.4e-6*Vs^2) where P0 should be anchored by cosmic runs, but we take the lowest luminosity run in Run15pp200, (run#422085, 175kHz bbc rate), due to the lack of good cosmic ray data in run15.**

Conclusion on MUID_EFF HV_Method for Run12pp510 and Run15pp200

Our goal to start with: hope to demonstrate that HV-method is reasonably consistent with the traditional data-driven method, such that we can use the differences as an estimation for systematic uncertainty. In reality…

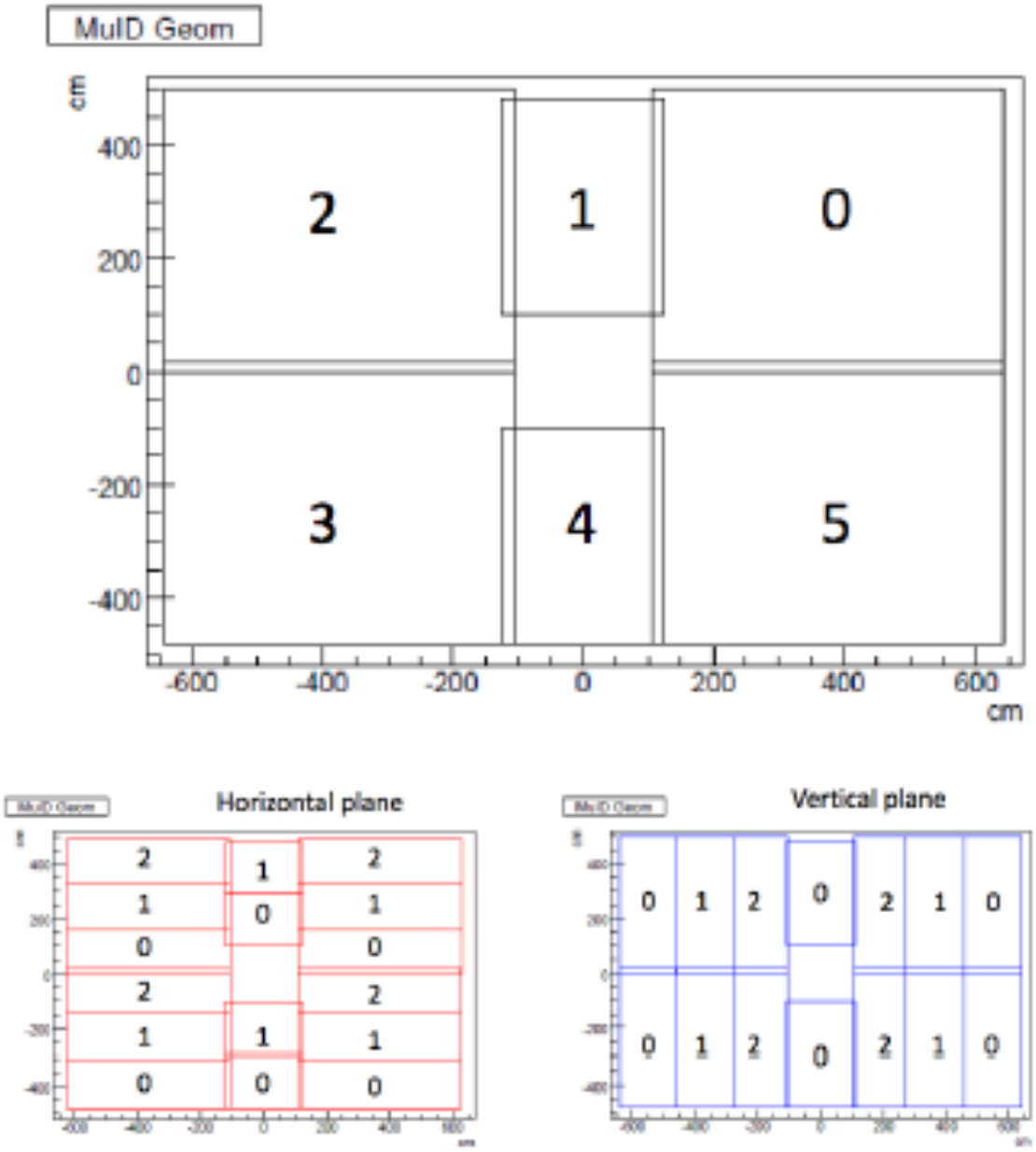
Good: using fit2014, when the basecurrent and number-of-dead-tubes are determined right, reasonable agreements (within ±5% level) between two methods are obtained in most HV channels (~80% of channels).

When disagreements at ~10%-level still exist between fit2014 and fit2004, Using the old global fit2004, , avoiding 4th power corrections, resolves most of the inconsistency.

Still, in about ~10/150 channels in each arm disagreements remain. These channels were further anchored by the lowest-luminosity run, assuming MUID_EFF are "almost the same" as in the cosmic runs. Agreements reached to within ±5% level.

Conclusions on Run12pp510 and Run15pp200 MUID_EFF for muon-arm analysis:
Although we've shown that the HV_method is reasonably consistent with traditional data_driven method. Still, HV_method is NOT considered as a proven independent method to obtain MUID_EFF, while data_driven method has been used in all previous analysis.
Run12pp510 and Run15pp200 analysis should use the traditional data_driven method to obtain MUID_EFF, to preserve self-consistency.

Backup Slides



5 gaps: 0-4,

2 planes each gap:0-1

6 panels each plane: 0-5

3 hv groups each panel:0-2
(except panel #1, #4)

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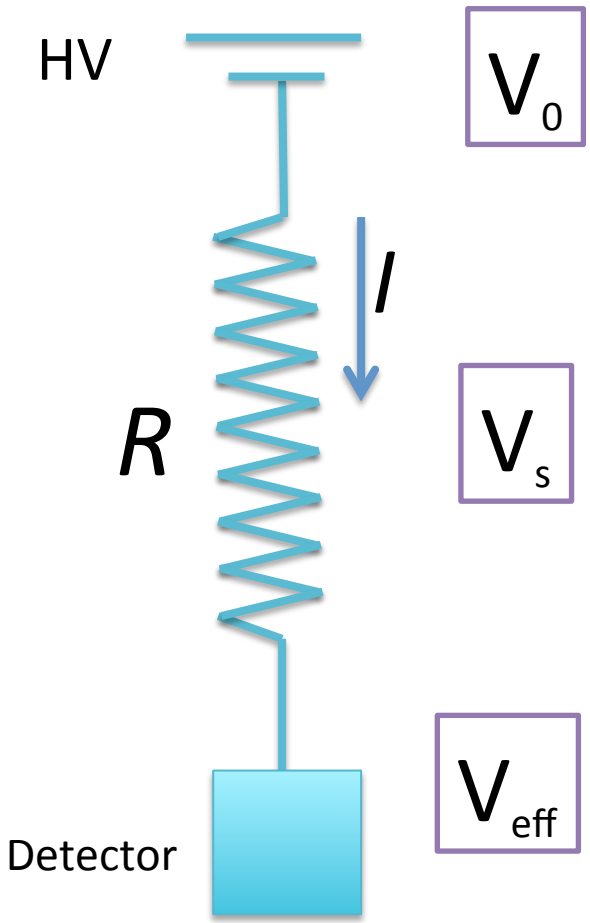
Figure 1.1: The top plot shows panel numbering scheme. Each plane has six panels. The bottom plots show the structure of hv groups for each horizontal and vertical plane.

HV method

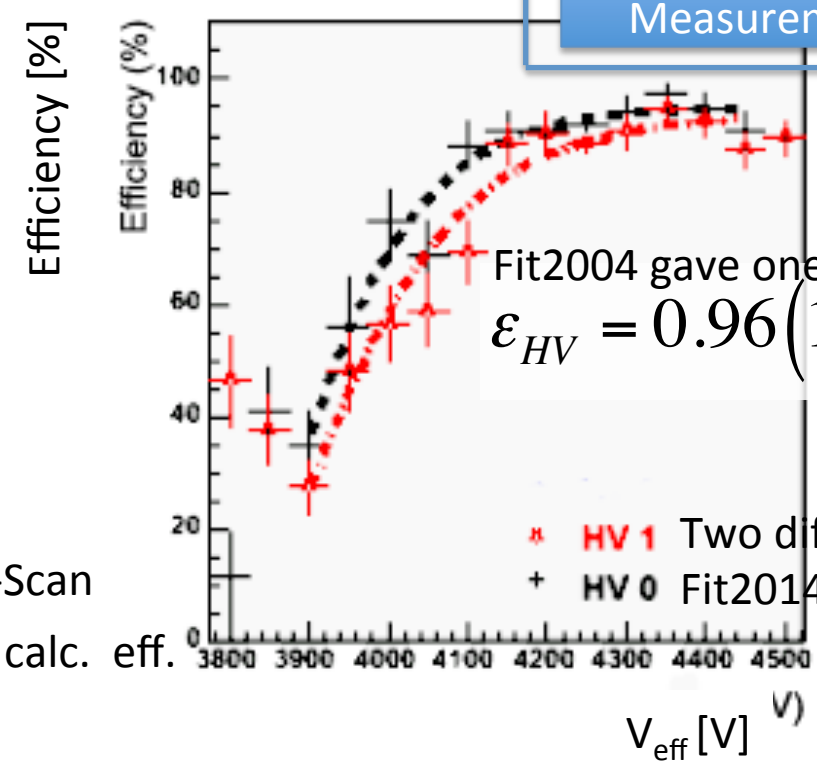
Effective voltage on MUID-tubes are lower due to dark current caused voltage drops.
Take dark currents in cosmic-runs as BaselineCurrent



Operation Voltage

$$V_{eff} = V_0 - V_s = V_0 - I\,R$$

Independent Measurement



Fit2004 gave one fit to all ch

$$\varepsilon_{HV} = 0.96\left(1 - 2.4e^{-6}V_s^2\right)$$

Two different HV ch

Fit2014 fit each ch separately

From Itaru, July 2014 MUID HV-Scan

Cosmic ray, scan oper. Voltage, calc. eff.