(Analysis Note #Run15pp200-xj2) Run15pp200 Muon-Arm MUID_EFFICIENCY Comparison Between Data-Driven and HV-Methods, Muon-Arm Data Quality Checks and GoodRunLists

Xiaodong Jiang 09/21/2015 updated

This analysis note covers details of Run15pp200 MUID_EFFicency (Part-I), Muon-Arm Data Quality checks and GoodRunLists (Part-II). Detailed descriptions on understanding MUID_EFF between Data-Driven method and HV-method are provided. A new solution (mix2015) is provided, comparisons are made. Two methods of extracting MUID_EFF agree to ±3% level (FWHM). This differences can be taken as systematic uncertainties on MUID_EFF. GoodRunLists for Run15pp200 are provided.

Run15pp200 data Samples used in this analysis:

- For Mutr and MuID detector performance checks and efficiency studies, events from all triggers are used (dominated by MUID1D and SG3_MUID1D1H triggered events).
- For detector stability studies, relative yields ratios of gap2/gap4, gap3/gap4 events high momentum particle SG3_MUID1D1H triggers that were specifically developed for Run15 high momentum single-muon physics are used.

All related files and plots are posted on webpages:

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

Part-I on Run15pp200 Analysis: MUID_EFFicency

Detailed descriptions on understanding MUID_EFF between Data-Driven method and HV-method are provided. A new solution (mix2015) is provided, comparisons are made.

Conclusion: two methods of extracting MUID_EFF agree to ±3% level (FWHM) for Run15pp200. This differences can be taken as systematic uncertainties on MUID_EFF.

Summary: Run15pp200 Muon-Arm MUID_EFFICIENCY Comparison Between Data-Driven Method and HV-Method

Results and Conclusions (More details in later 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 (two free parameters for all 300 channels, incl. both arms).
- Detailed checks on MUID dark currents, channel-by-channel.
- Solutions and 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/**
- **Summary plots of comparisons, two methods agree to ±3% level (FWHM) for Run15pp200.**

All related files and plots are posted on webpages:

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

Summary: Results and Conclusions

- Traditional Data-Driven method. MUID_EFF run-by-run, tube-by-tube files were generated.
- HV-method was also used to produced MUID_EFF files, used HV-current readings to calculate effective tube-voltage, referenced to efficiencies in cosmic-ray scan (fit2014).
- **Two-methods are compared. Differences resolved, a new solution provided (mix2015).**
- Agreements between Data-Driven and HV-method typically to within ±3% level for Run15pp200.
- **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**

Conclusions on Run15pp200 MUID_EFF: we've shown that the HV_method is reasonably consistent with traditional data_driven method (to ±3% level FWHM). Still, HV_method is NOT considered as a proven independent method to obtain MUID_EFF and cross section, while data_driven method has been used in all previous analysis. **Run15pp200 analysis should use the traditional data_driven method to obtain MUID_EFF, to preserve self-consistency. HV-method as "reasonable crosscheck".**

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

Summary: 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.

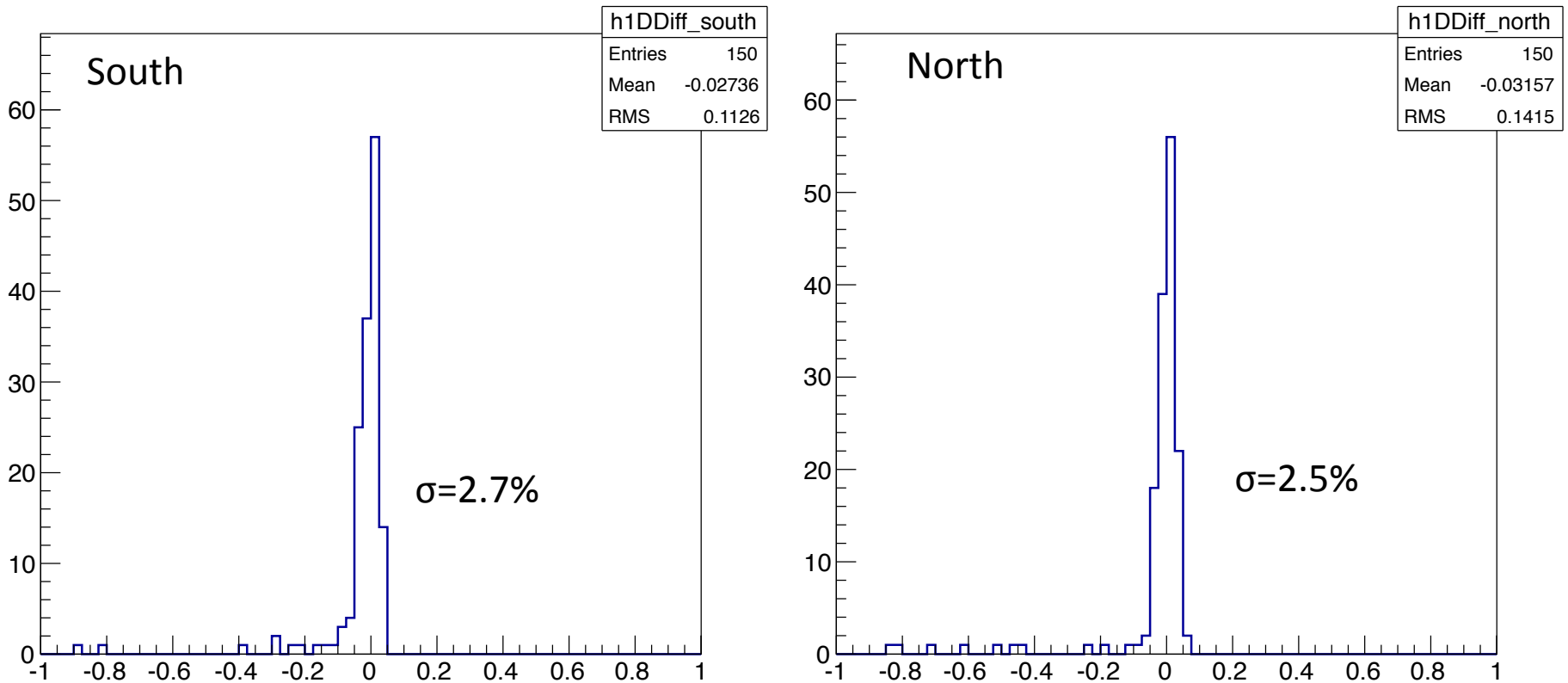
Although HV-method is not a completely independent crosscheck, it can serve as a reasonable confirmation of rate-dependent efficiency changes.

- 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.**

Summary Run15pp200: 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 difference: ~1%, Spread (FWHM): ~**6%**

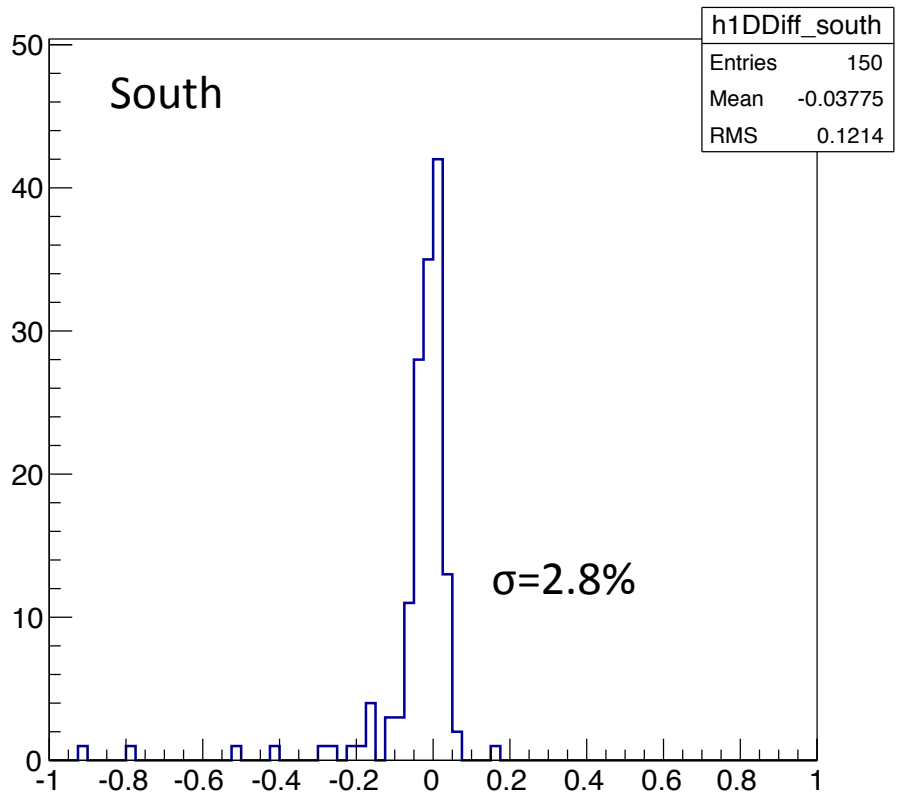
Run15pp200: two methods agree to ±3% level.

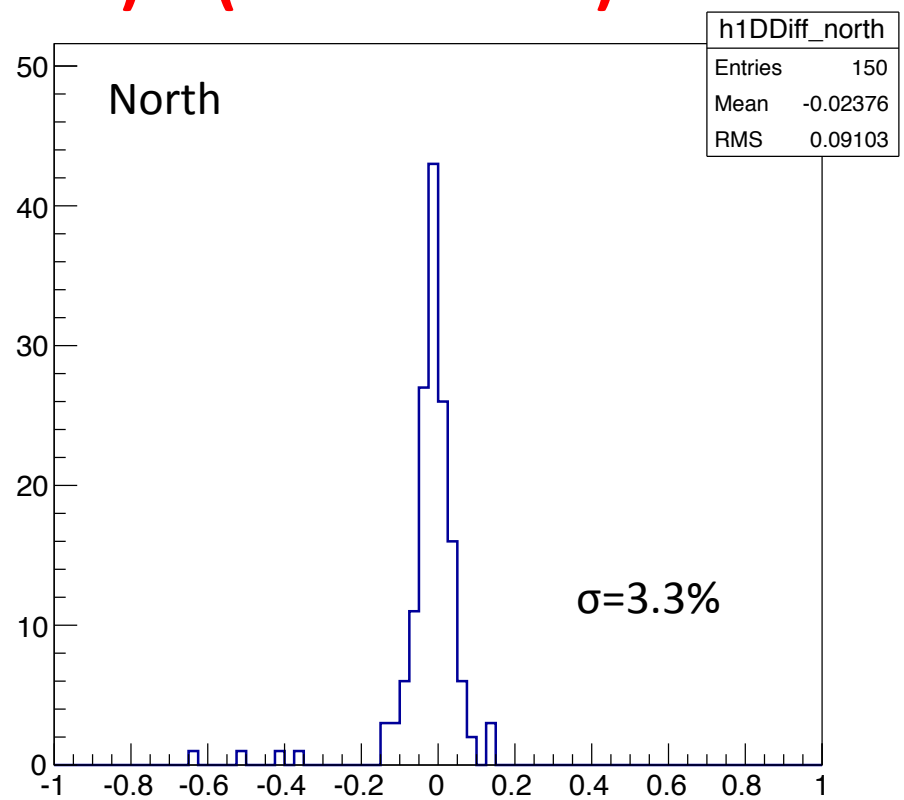
(Different luminosity run groups give the same results).

A Reminder Run12pp510: Luminosity Averaged

MUID_EFF for each hv-channel

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



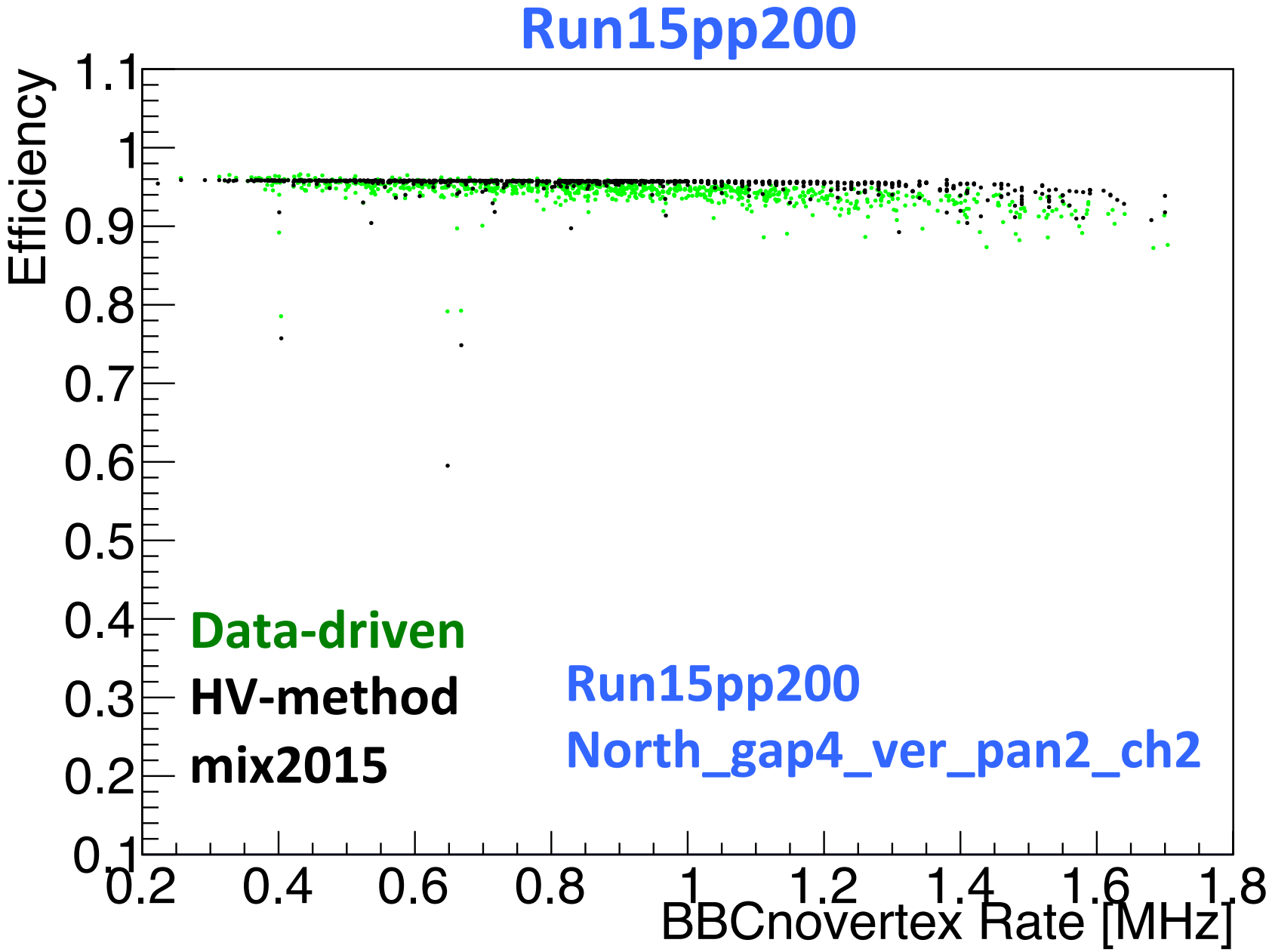


Luminosity-weighted average efficiency, one entry per hv-channel

Central value of differences: ~1%. Spread (FWHM): ~**8%**

Run12pp510: two methods agree to ±4% level.

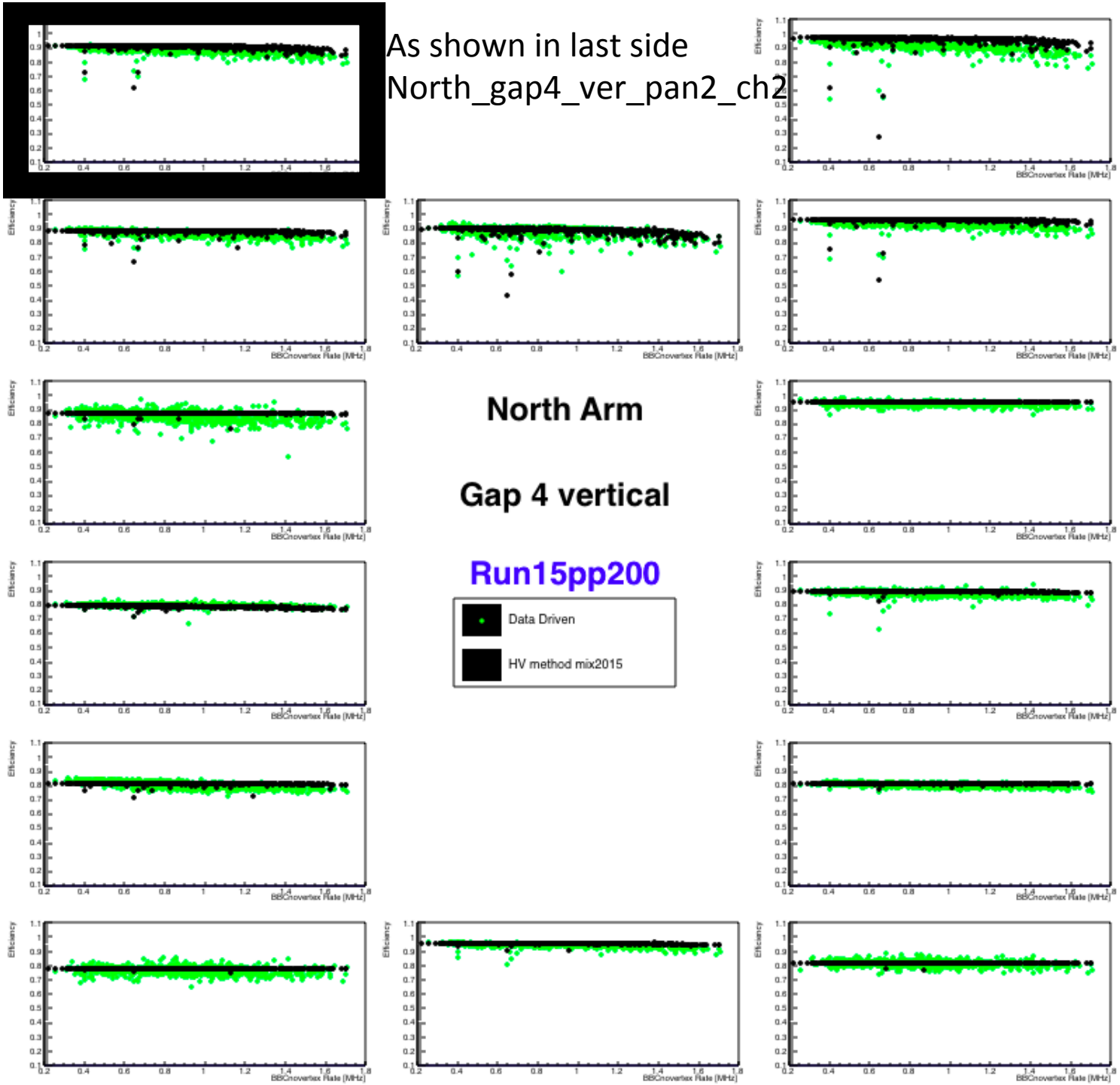
Comparison Data-Drive vs HV-method

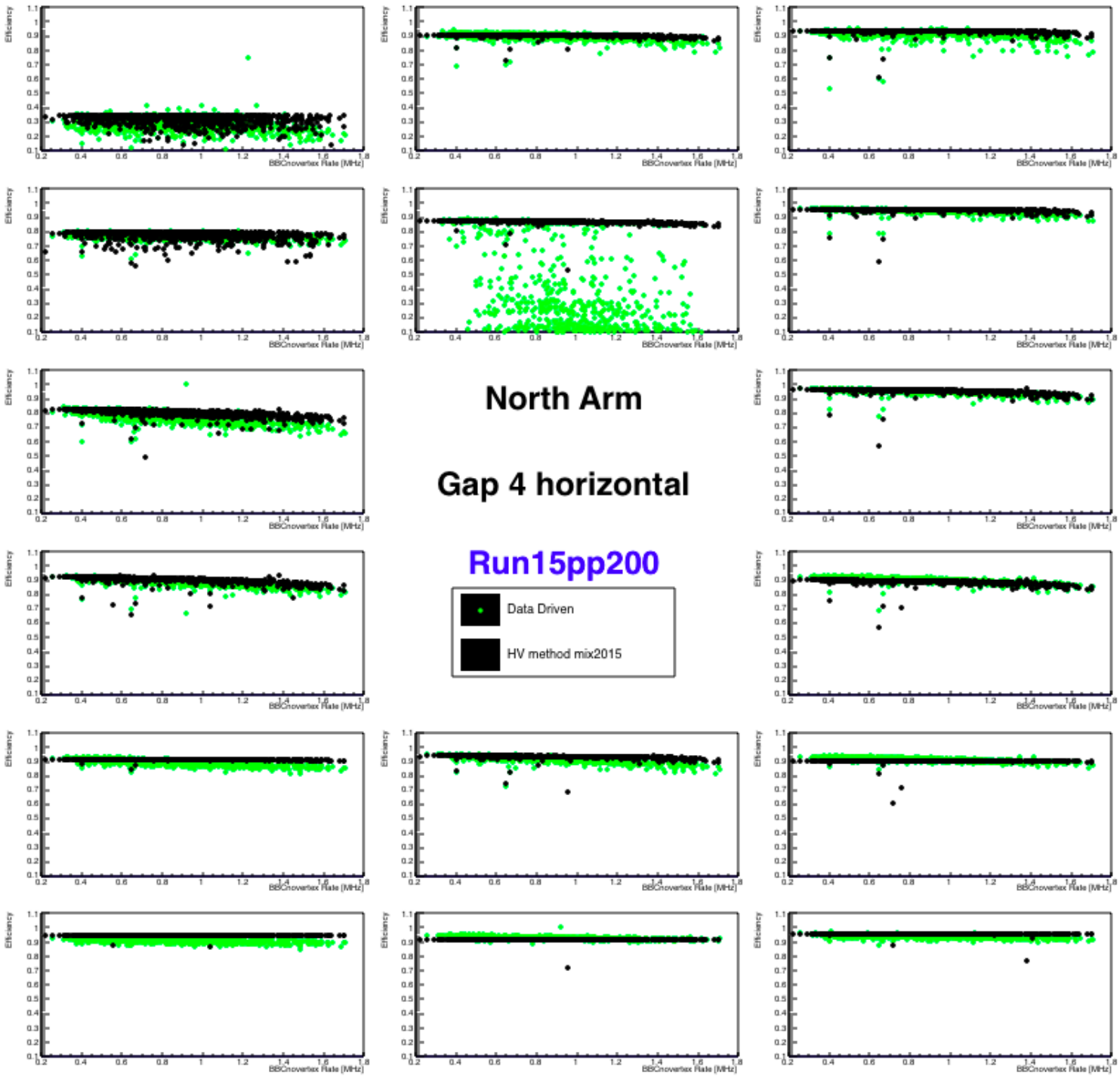


As shown in last side
North_gap4_ver_pan2_ch2

Data-driven
HV-method
mix2015

Run15pp200

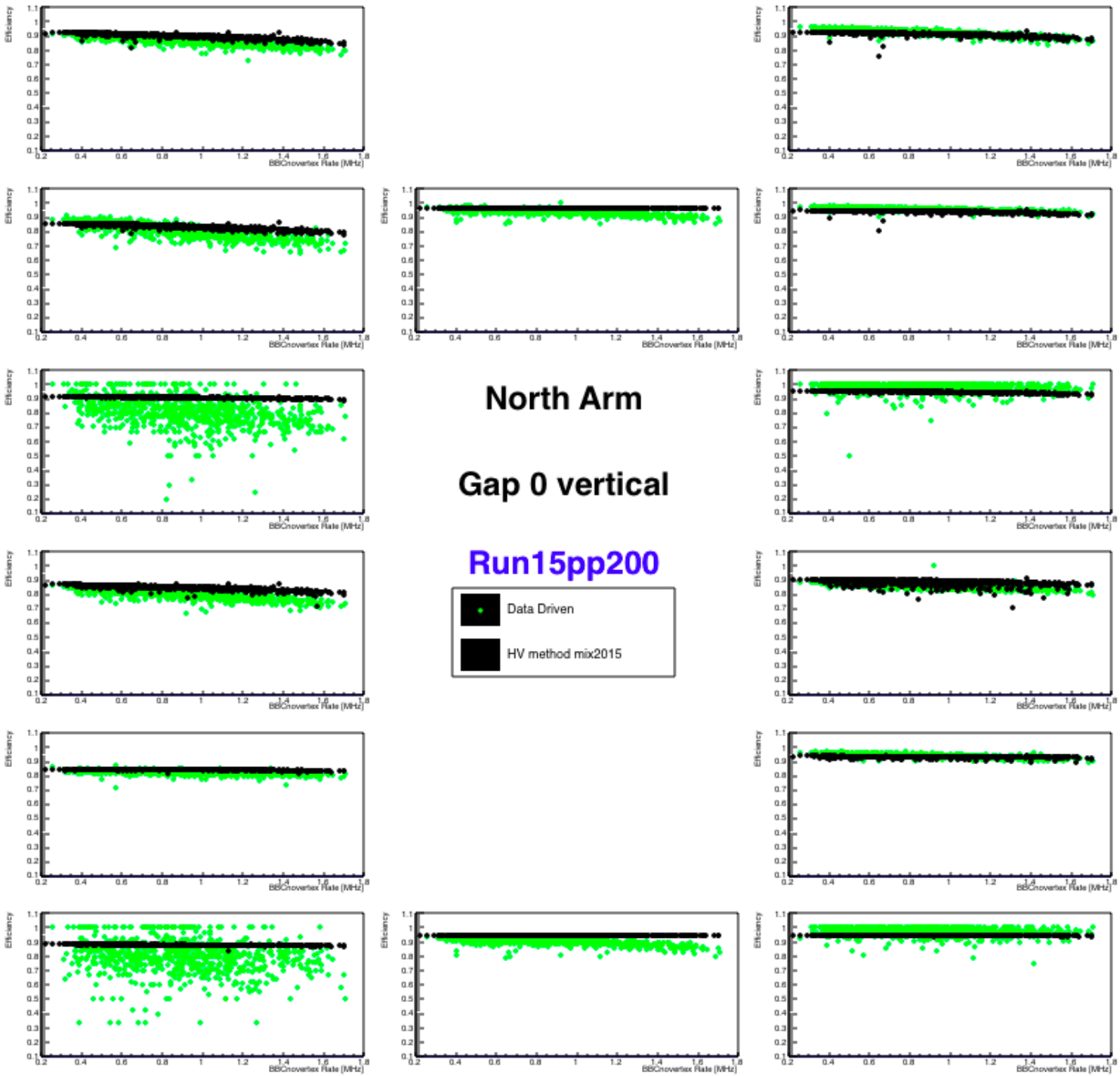




Data-driven

HV-method mix2015

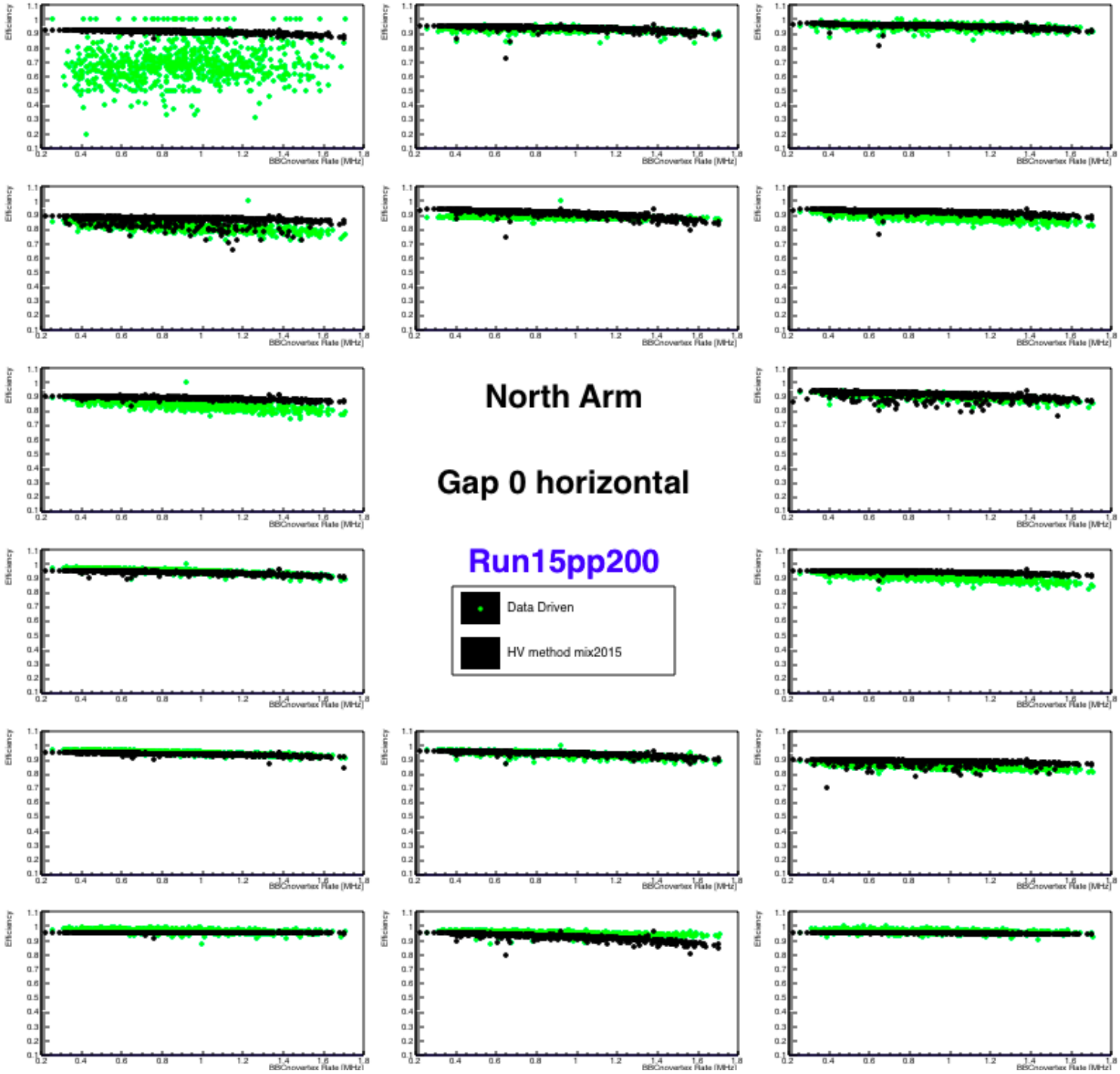
Run15pp200



Data-driven

HV-method mix2015

Run15pp200

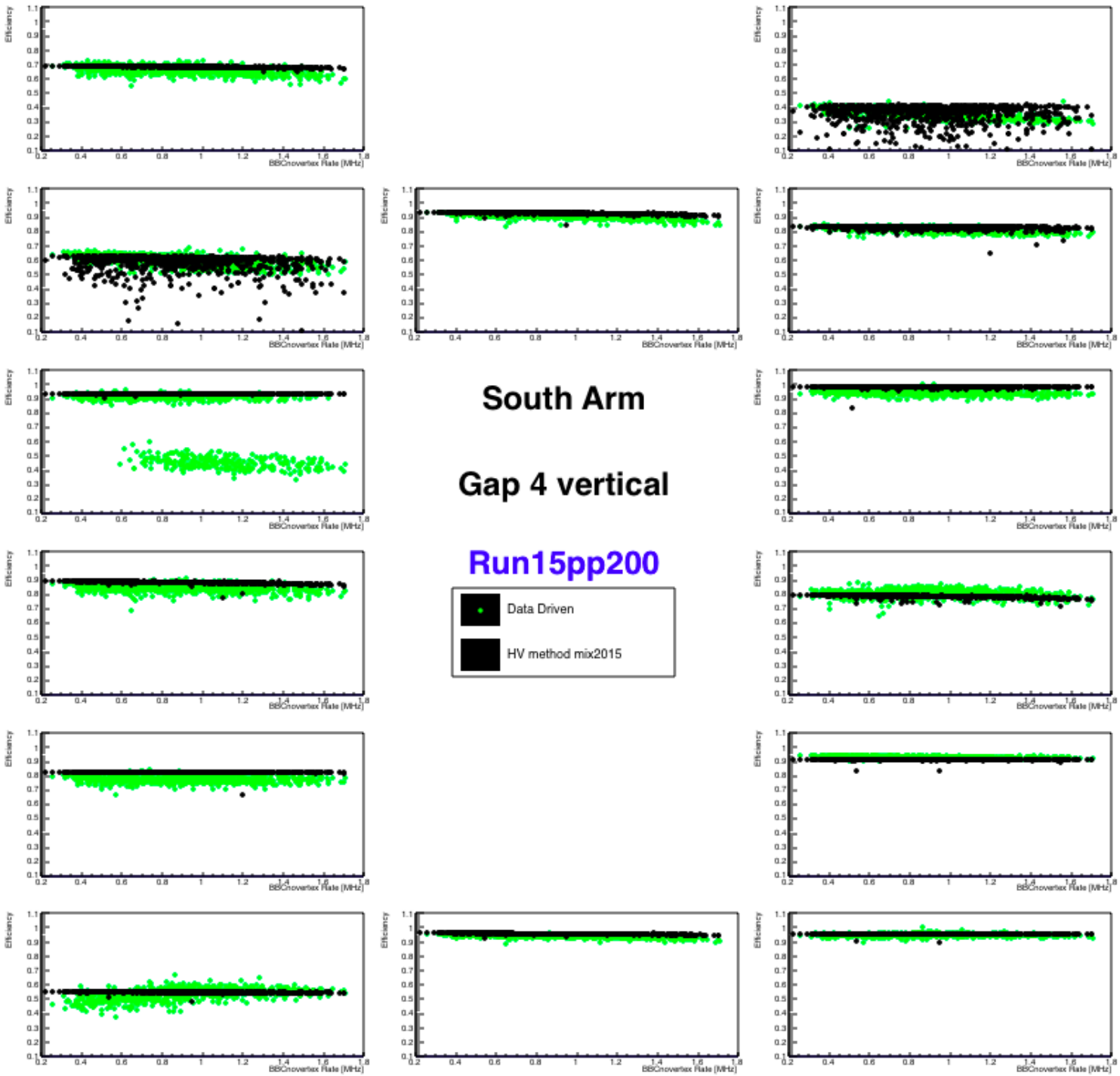


Data-driven

HV-method

mix2015

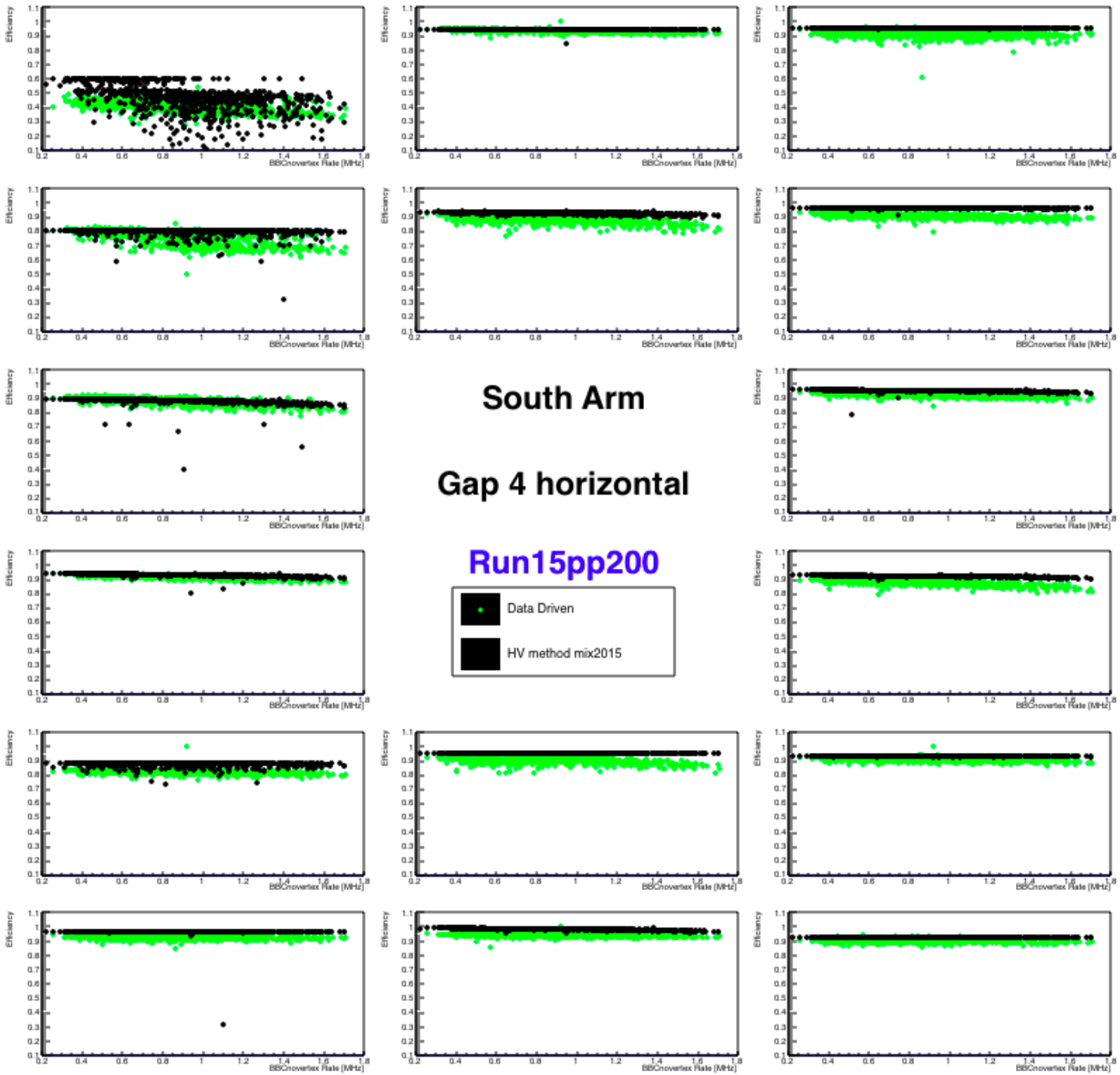
Run15pp200



Data-driven

HV-method mix2015

Run15pp200



Data-driven

HV-method mix2015

Run15pp200

More Details on HV-Method and a New Solution for Understanding MUID_EFF

- **Method Used, Agreements and Disagreements.**
- **Corrections and Cross Checks Made**
- **A New Solution (Mix2015), compared to two earlier solutions (fit2014, and fit2004).**

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

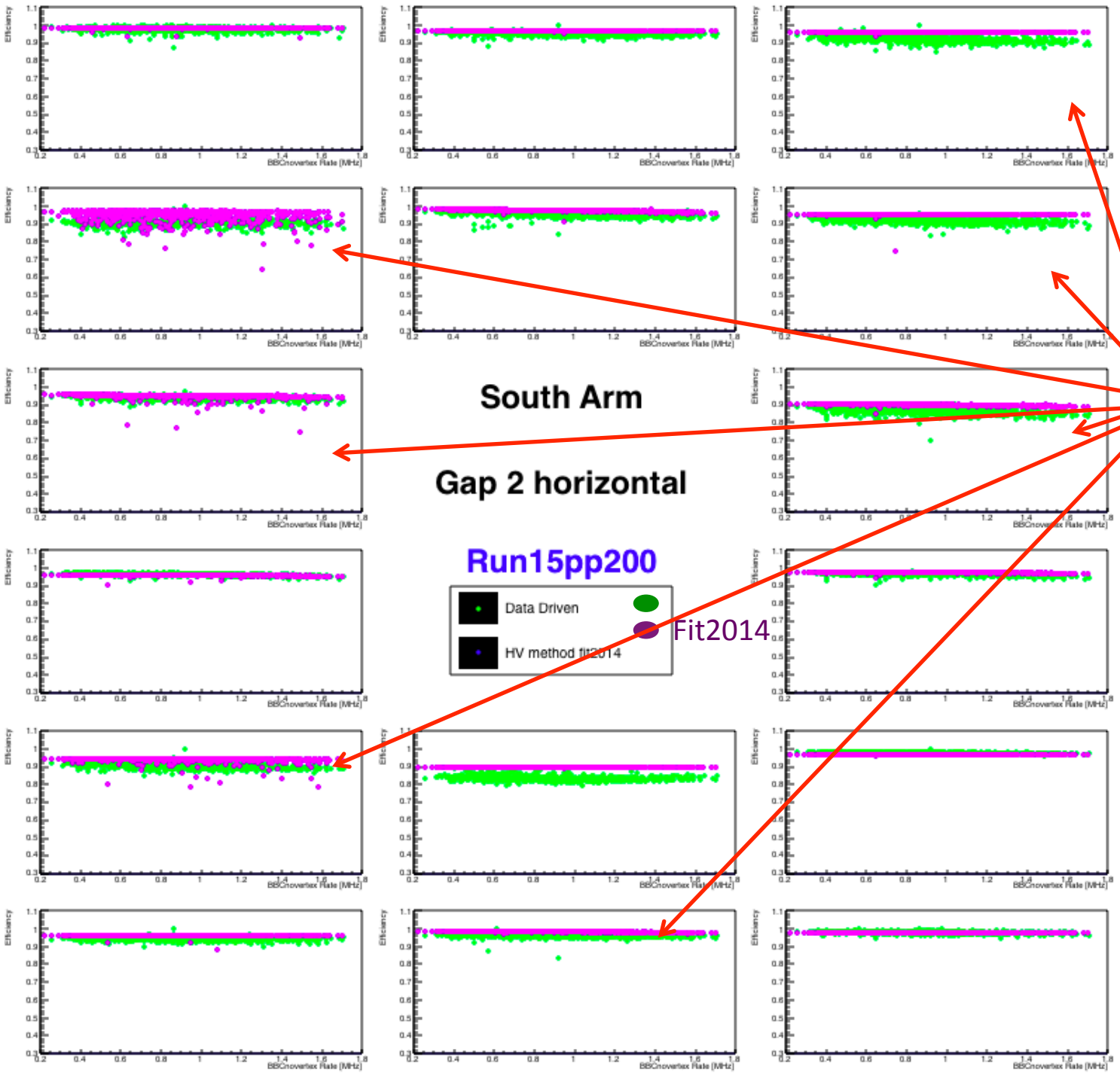
In Run15pp200 data:

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.

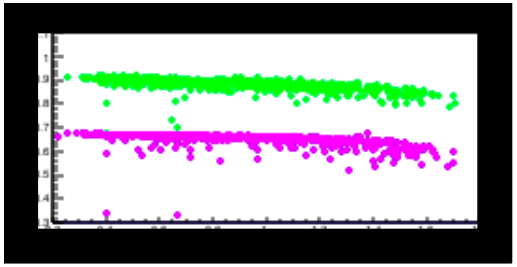


Data-driven

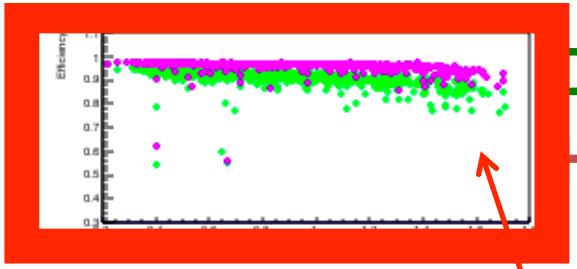
HV fit2014

Agreements in many HV channels

For example…

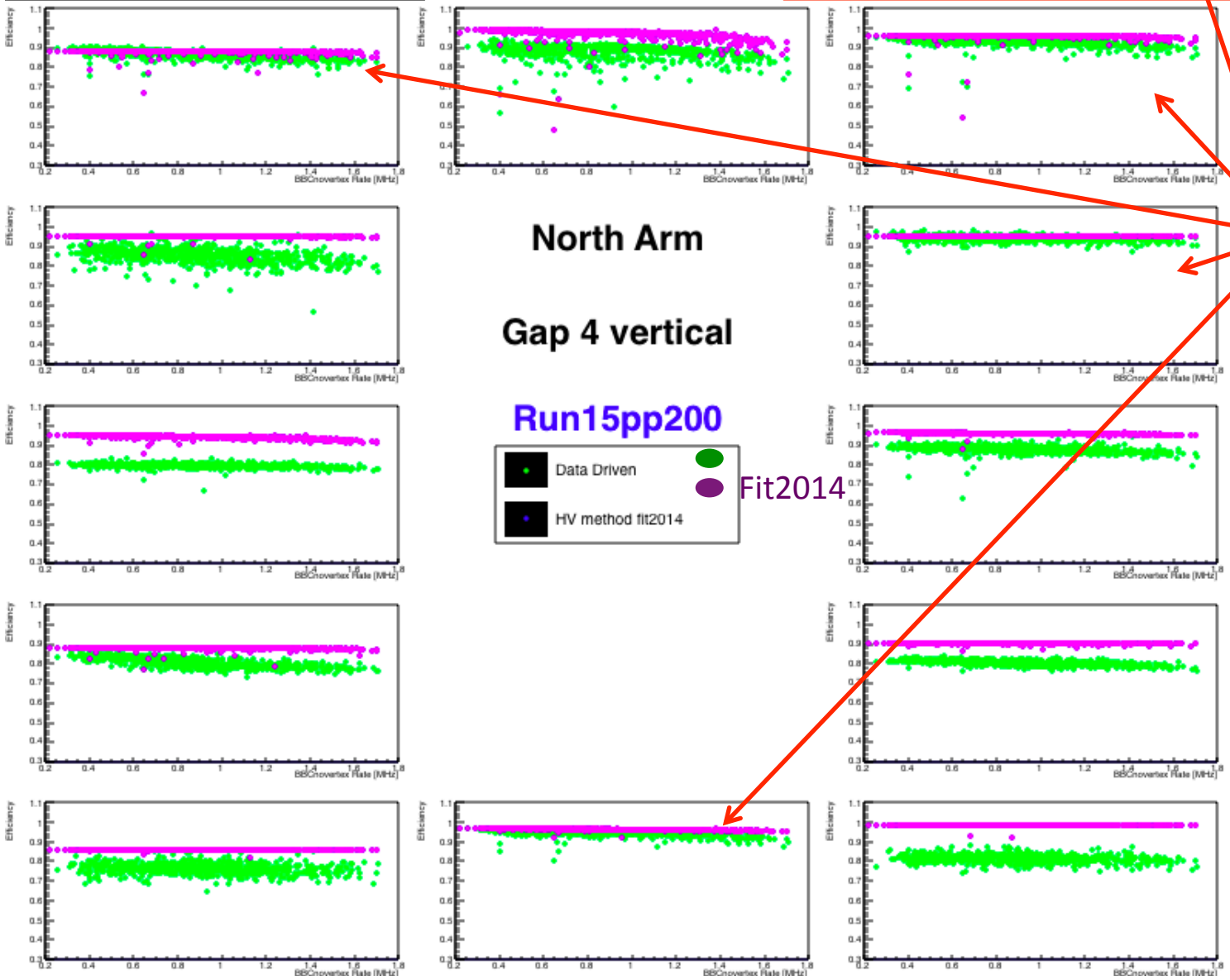


However, obvious disagreements in several HV channels

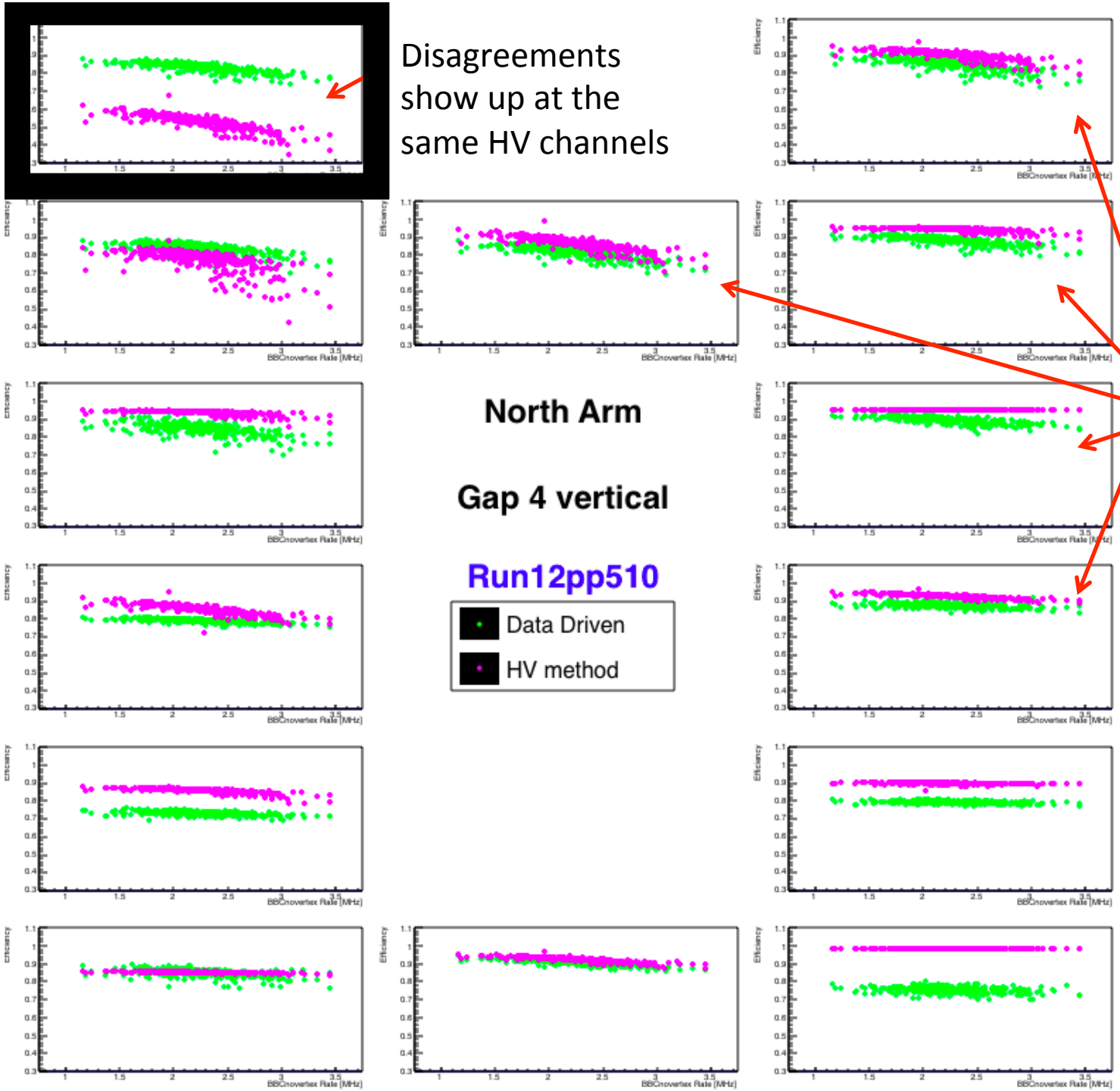


Data-driven

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

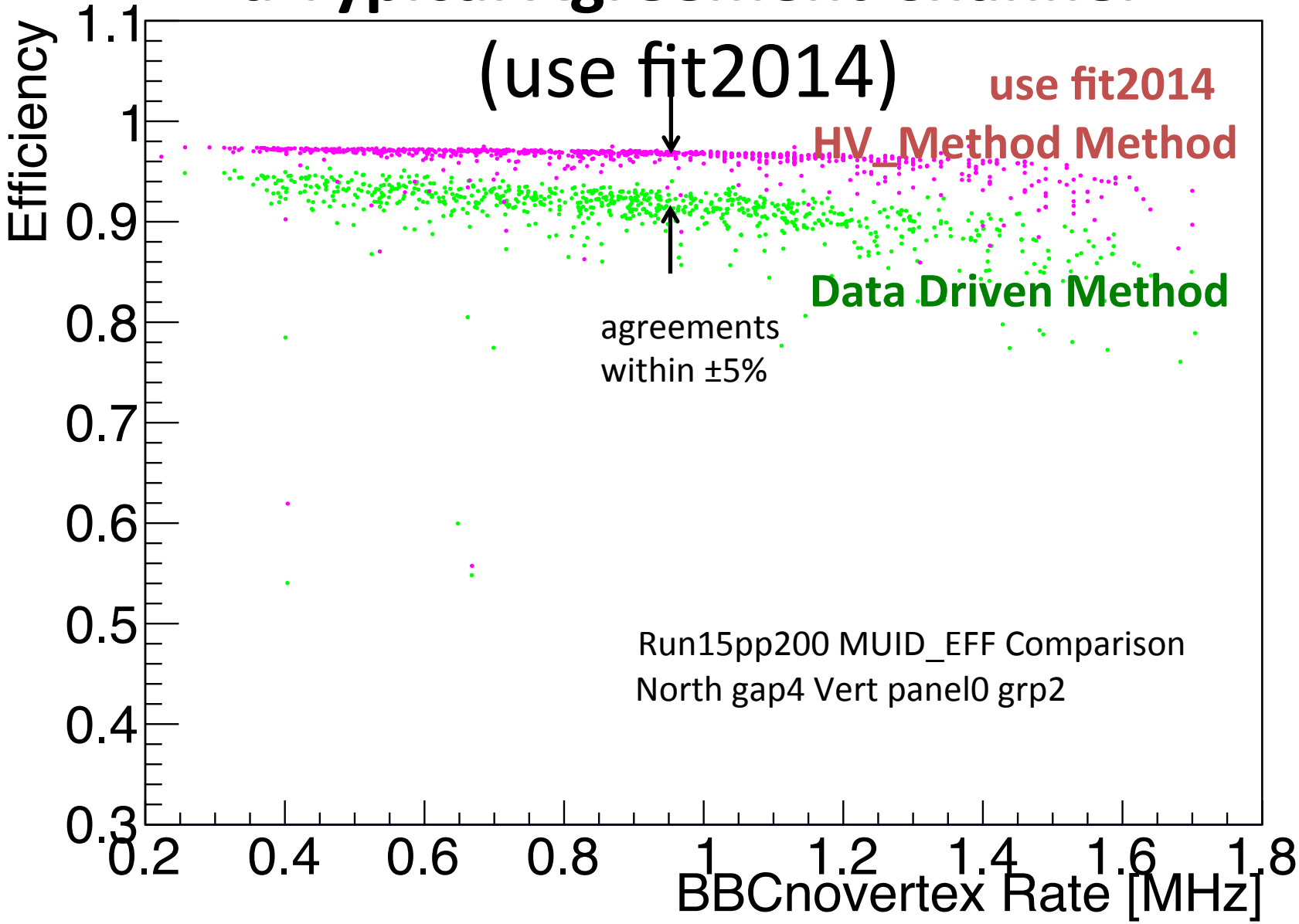
A typical example: North gap4 Vert panel0 grp2
The old “fit2004” works well in many channels.
(No needs for improvements to start with).
The new “fit2014” might not improve on all-channels, due to limited data in cosmic-ray HV scans conducted in 2014.

Disagreements

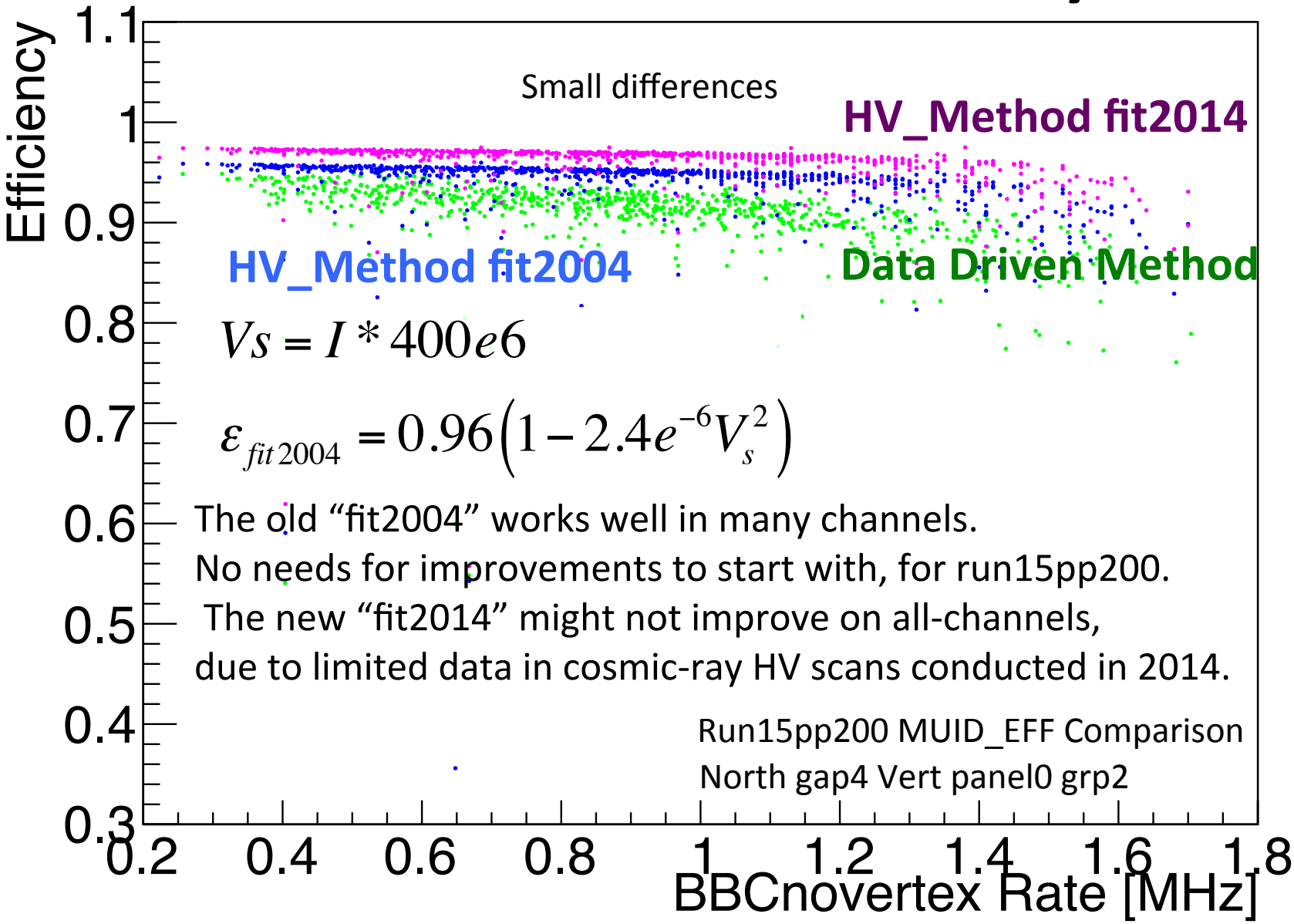
A typical example: North gap4 Vert panel2 grp2

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 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
422452	4.669
423543	4.629

0-dead-tubes 4400 volt/1 GΩ ≈ 4.4 μA

Baseline/Current_0_4_2_0_4.txt

421312	15.472
422442	15.458
422444	15.485
422452	15.512
423543	15.498

1-dead-tubes (4400 volt/1 GΩ) *(1+1/0.4) ≈ 15.4 μA

Baseline/Current_0_4_2_0_5.txt

421312	26.622
422442	26.636
422444	26.662
422452	27.343
423543	26.636

2-dead-tubes (4400 volt/1 GΩ) *(1+2/0.4) ≈ 26.4 μA

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

Extreme Case: Baseline Currents with 7 Dead Tubes

Baeline/Current_1_4_2_0_6.txt

421312	82.028
422442	82.188
422444	82.214
422452	82.201
423543	82.294

7-dead-tubes !!! (4400 volt/1 GΩ) *(1+7/0.4) ≈ 82 μA

More dead-tubes in run15 vs run13,

for example…

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-tube during Run15

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

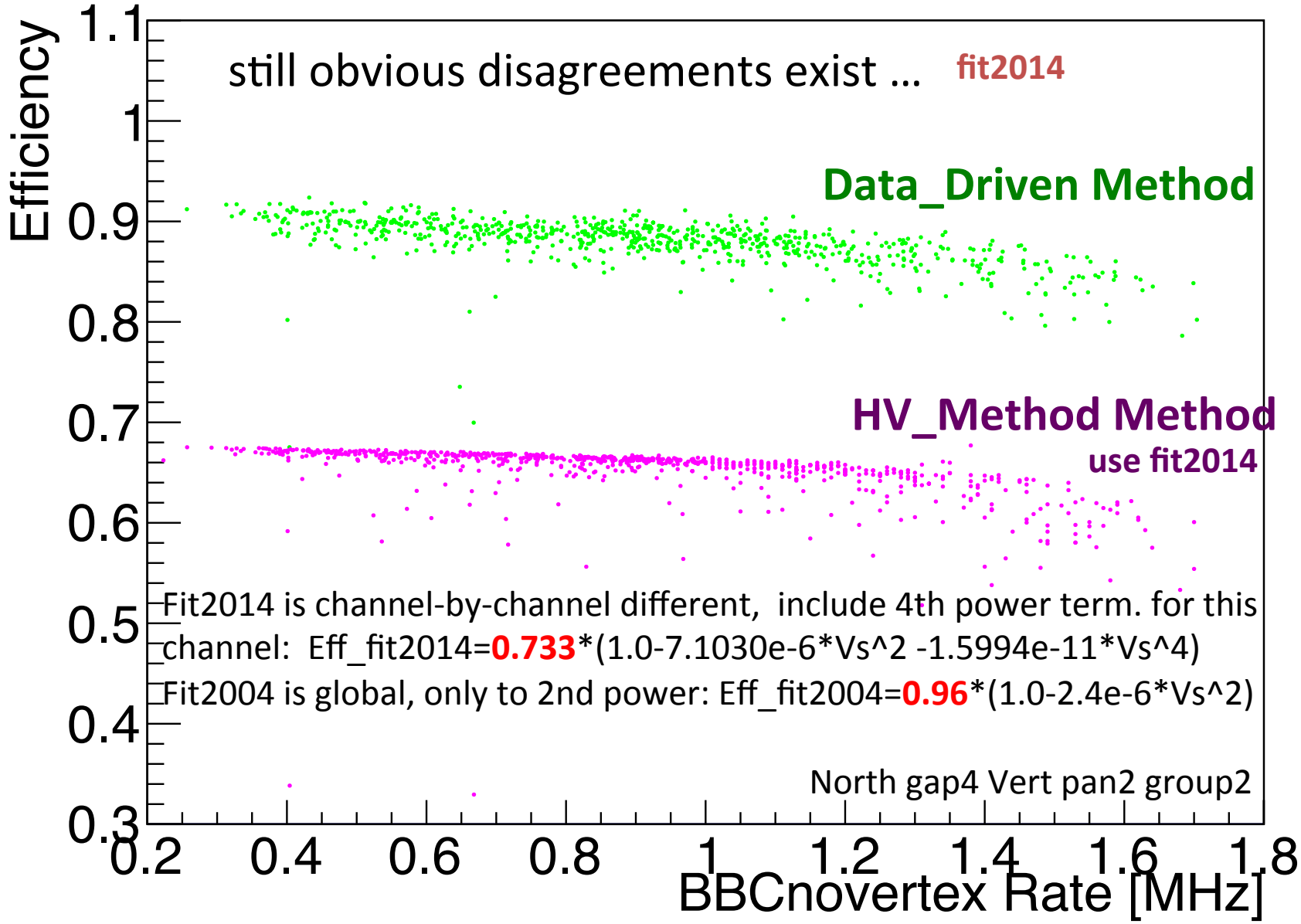
0-dead-tube during Run13

109 HV ch have dead-tubes in Run12pp510.

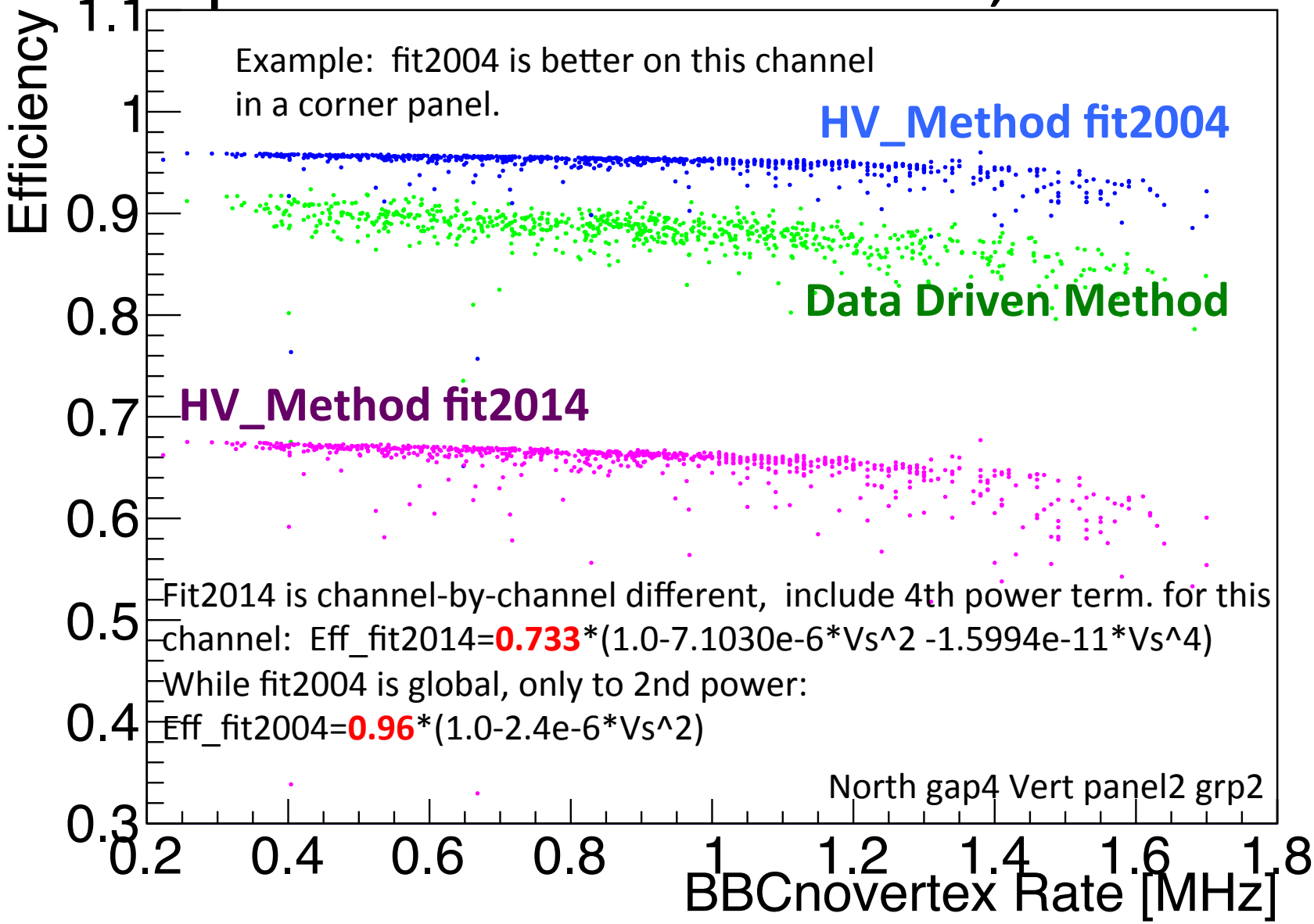
116 HV ch have dead-tubes in Run15pp200

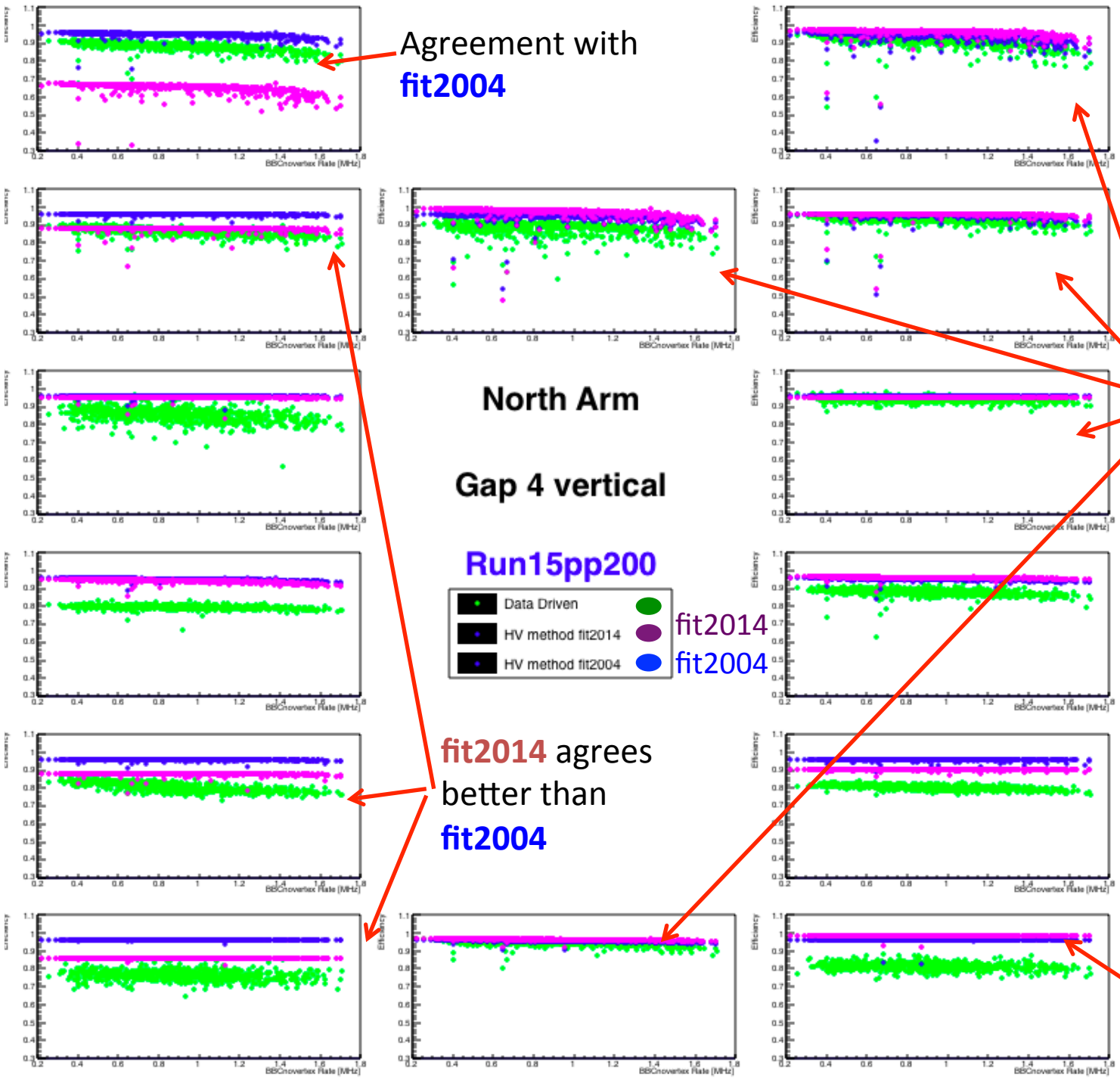
Earlier files listed 88 hv ch have dead-tubes (2007).

Run15pp200 MUID_EFF Comparison



Run15pp200 MUID_EFF Comparison example: better with fit2004, not fit2014





Agreement with **fit2004**

Data-driven

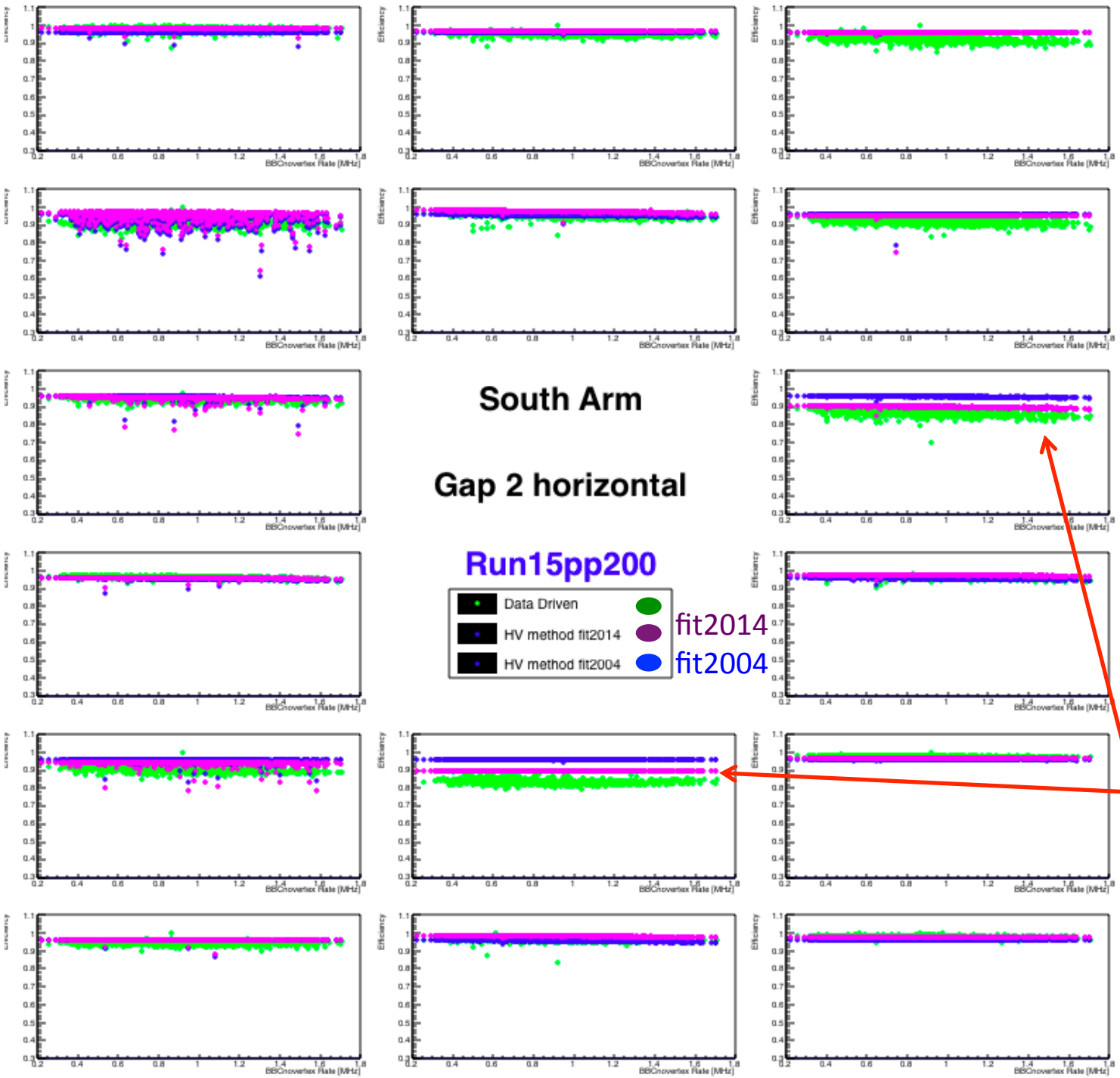
HV fit2014

HV fit2004

Agreements in many HV channels

fit2014 agrees better than **fit2004**

Disagreement at a corner panel



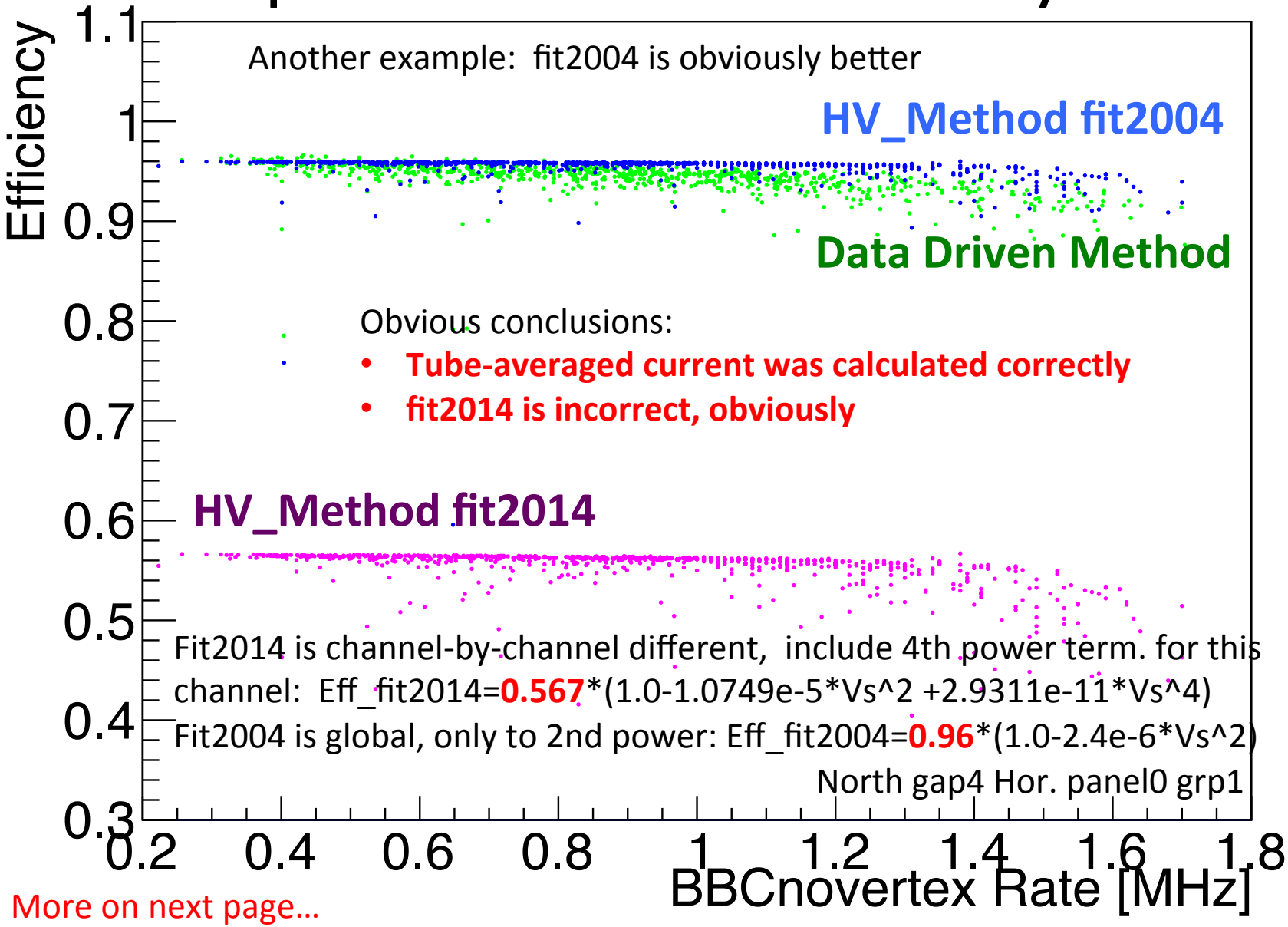
Data-driven

HV fit2014

HV fit2004

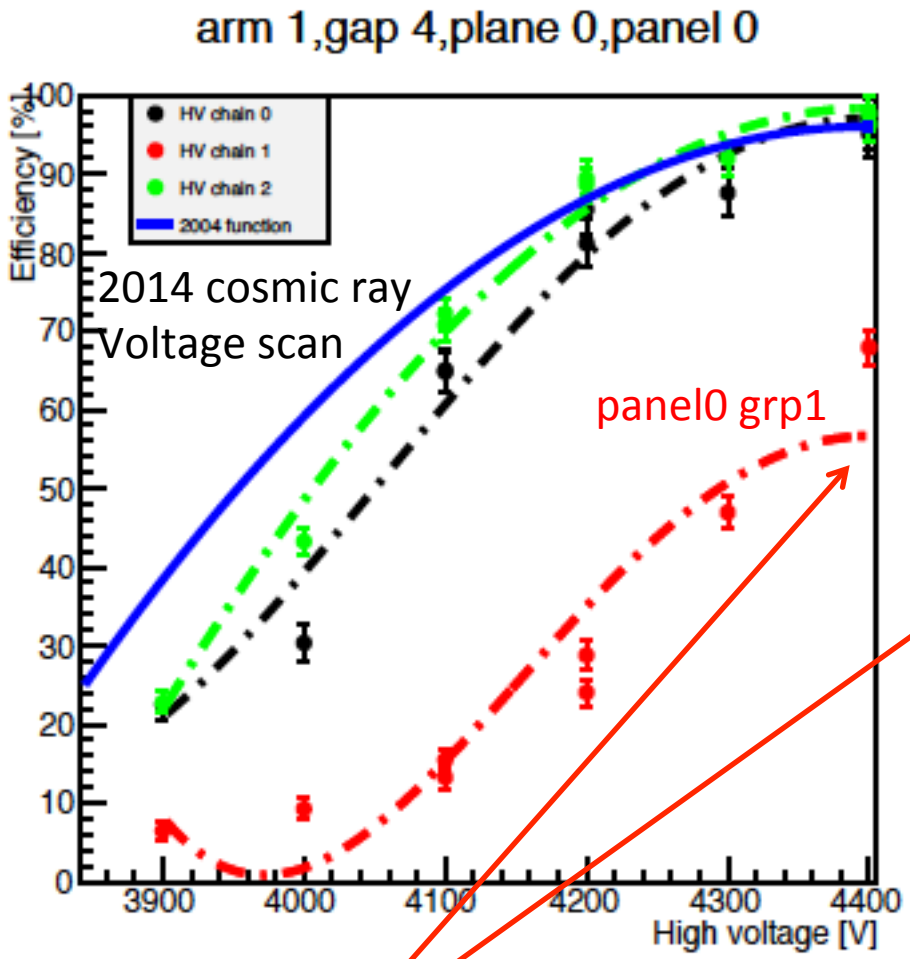
Overall, **fit2014** appears to agree better than **fit2004**

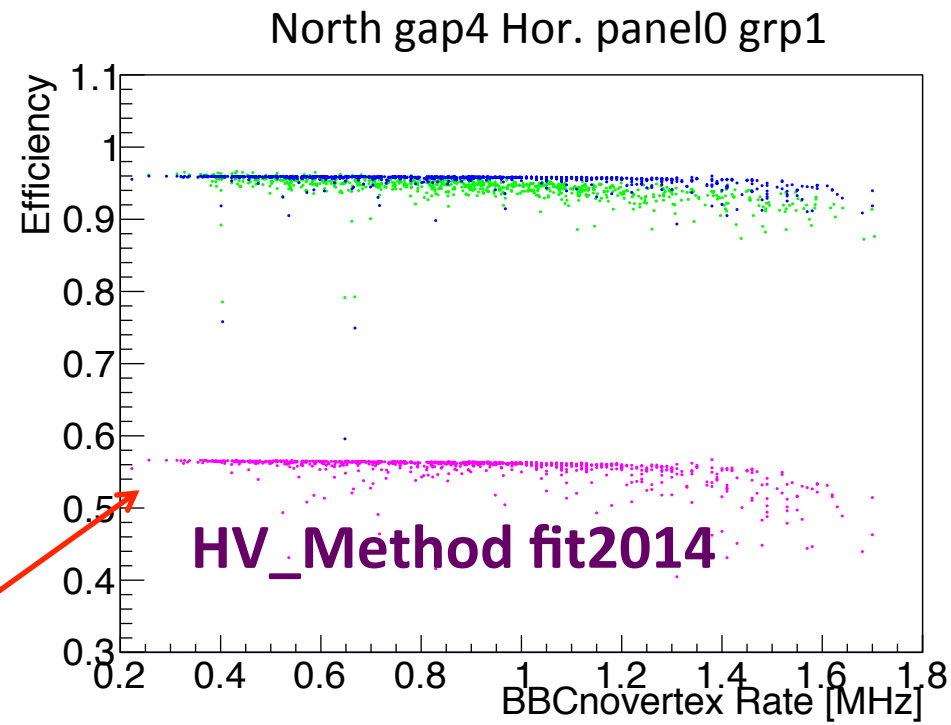
Run15pp200 MUID_EFF Comparison example: fit2004 is obviously better



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 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 ±4% level.

Conclusions on 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.
Run15pp200 analysis should use the traditional data_driven method to obtain MUID_EFF, to preserve self-consistency.

Part-II on Run15pp200 Analysis: Muon-Arm Data Quality Checks and GoodRunLists

Conclusion and Summary: Run15pp200 preliminary good run lists are produced based on MuTr and MUID detectors

FVTX and VTX data quality checks are much more time consuming due to various hardware issues involved during data collection. Two Ph.D. students were assigned to perform this task as part of their Ph.D. thesis work.

All files on webpage:

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

Conclusion: Run15pp200 Muon-Arm GoodRunLists

Updated run15pp200 muon-arm “good-run-list”:

South-Arm:

698 runs goodrunlist_run15pp200_south_alllumi.txt

217 runs goodrunlist_run15pp200_south_lowlumi.txt
243 runs goodrunlist_run15pp200_south_midlumi.txt
238 runs goodrunlist_run15pp200_south_highlumi.txt

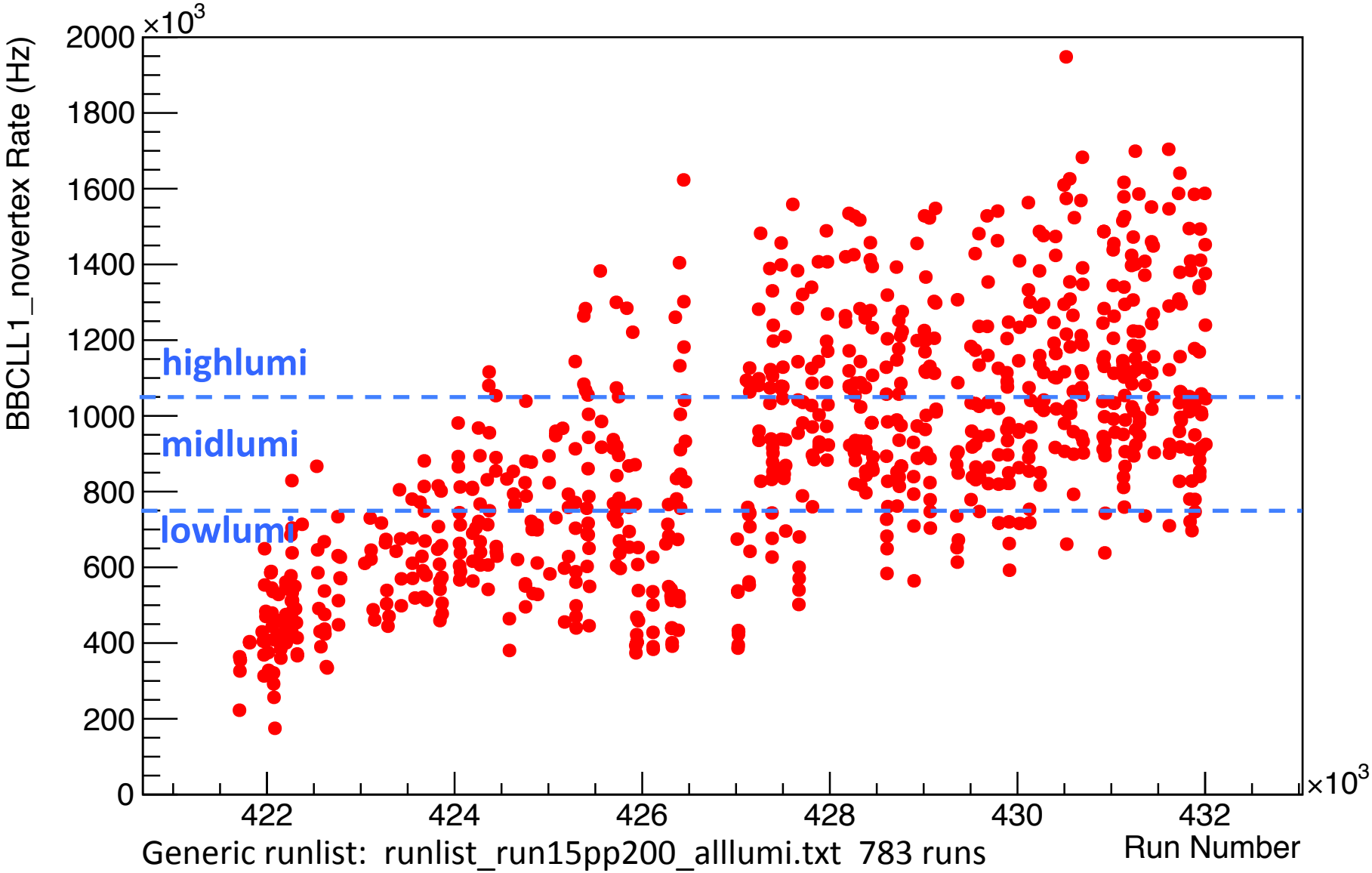
North-Arm:

672 runs goodrunlist_run15pp200_north_alllumi.txt

213 runs goodrunlist_run15pp200_north_lowlumi.txt
228 runs goodrunlist_run15pp200_north_midlumi.txt
231 runs goodrunlist_run15pp200_north_highlumi.txt

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

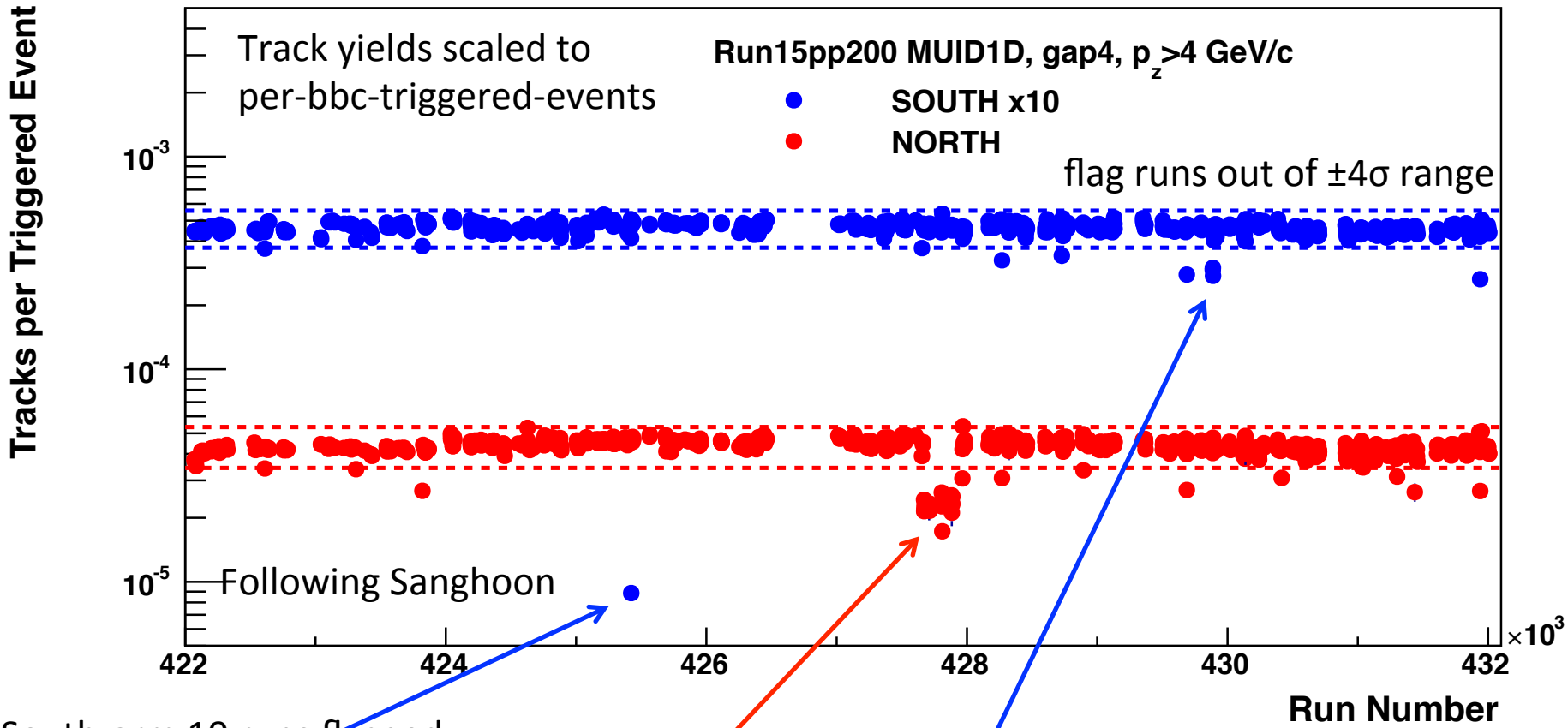
Run Summary: Run15pp200 BBC Rate (Hz) vs Run Number



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

Tracks-per-Triggered-Events: Trigger=MUID1D, lastgap=4



South-arm 10 runs flagged:
422611,**425423**,427654,428269,428728,429687,**429886,429887,429888**,431939.

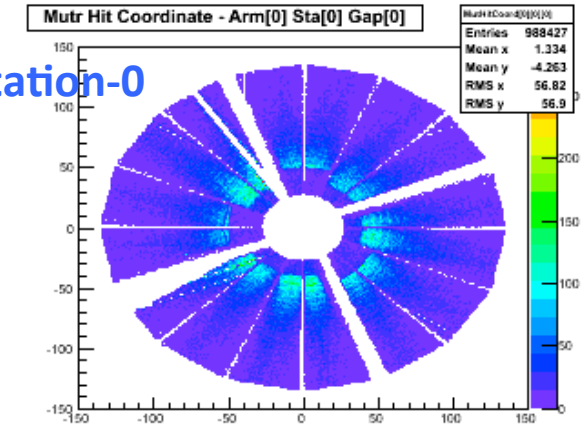
North-arm 40 runs flagged:
422611,423311,423820,**427670,427671,427672,427673,427674,427708,427709,427710,427711,427712,427713,427805,427806,427807,427810,427811,427813,427814,427815,427829,427878,427879,427881,427882,427883,427885,427886,427887,427964,427968,**428269,428894,429687,430415,431301,431437,431939.

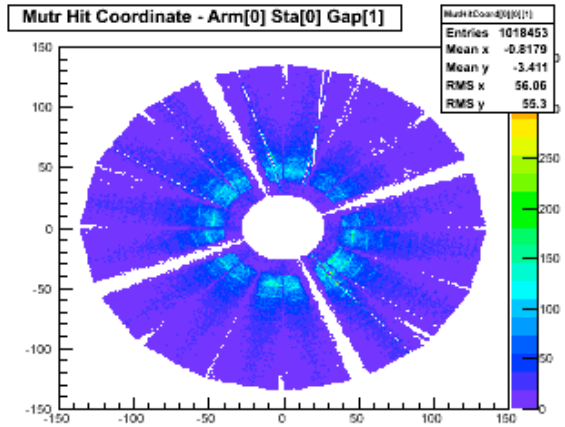
Tracks-per-BBC-triggered events

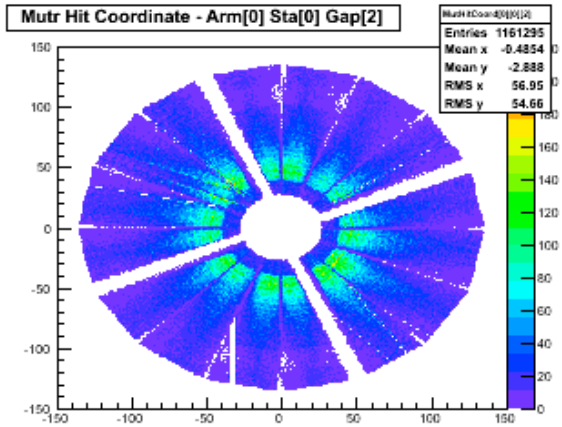
Related to the cross section, for example in MUID1D trigger,

$$\text{Tracks-per-BBC-triggered-events} = \frac{(\text{\#-Tracks-in-MUID1D})*(\text{Scale-down-factor-MUID1D} + 1)}{(\text{BBC-novtx-scaled-counts})*(\text{Scale-down-factor-BBC-novtx} + 1)}$$

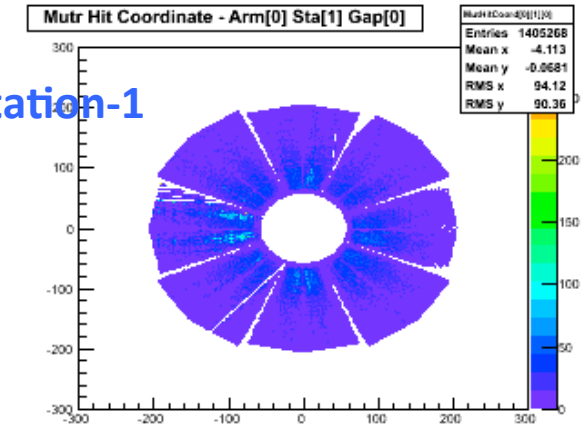
Station-0

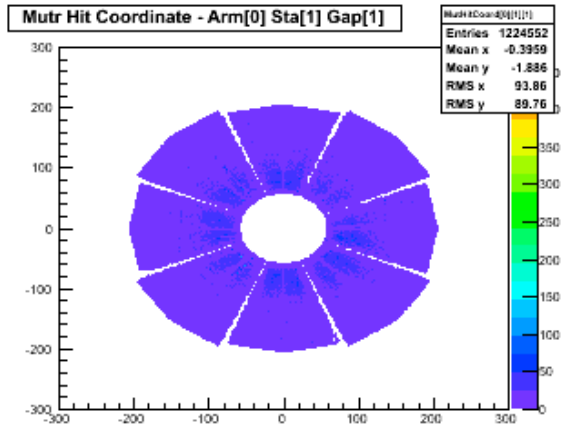


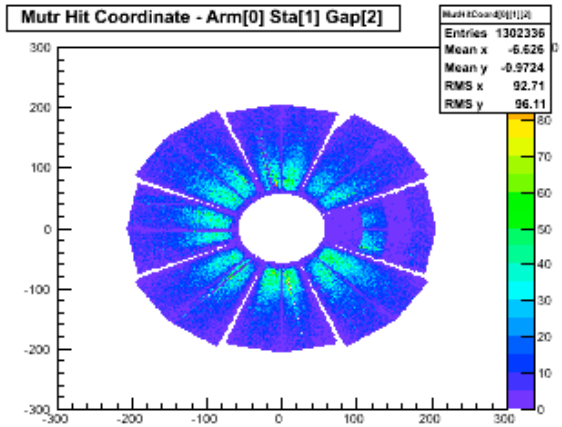




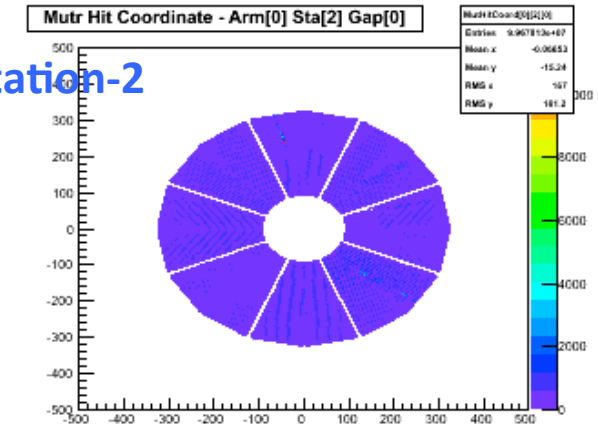
Station-1

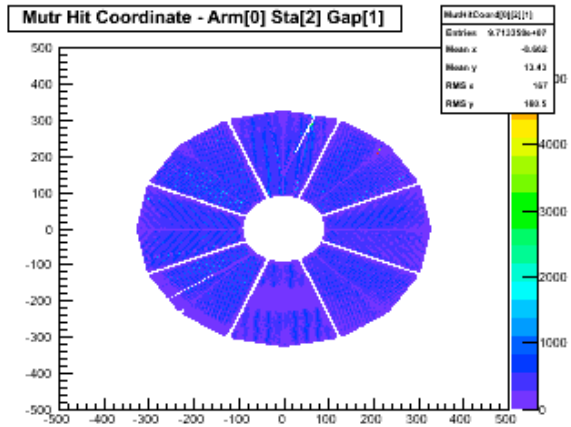






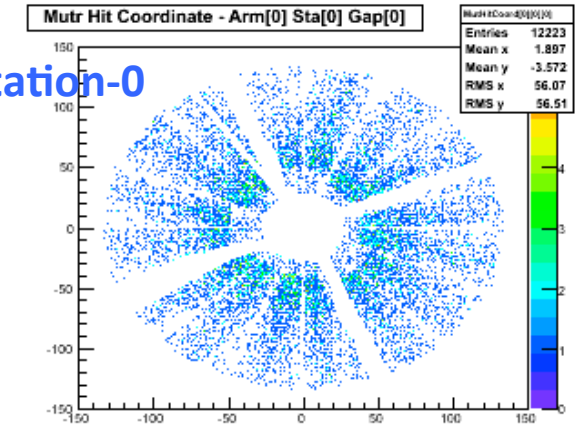
Station-2

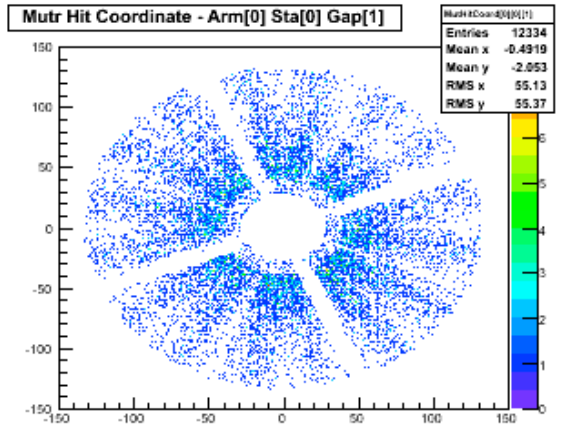


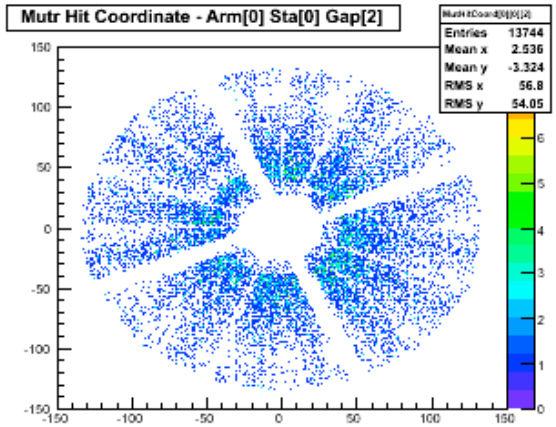


Run 425422. A Good run
South-arm MuTr

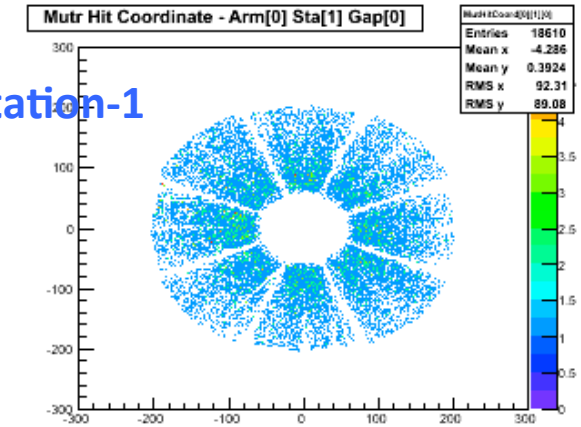
Station-0

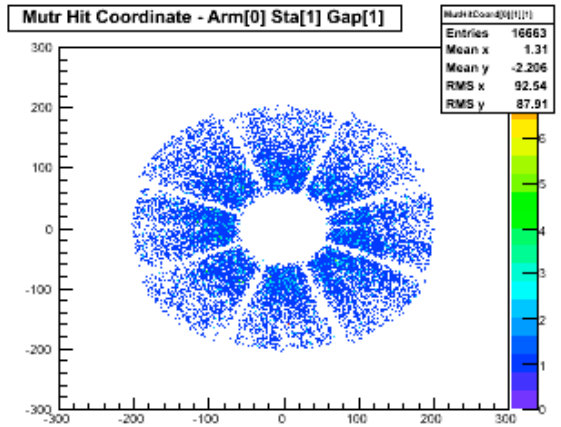


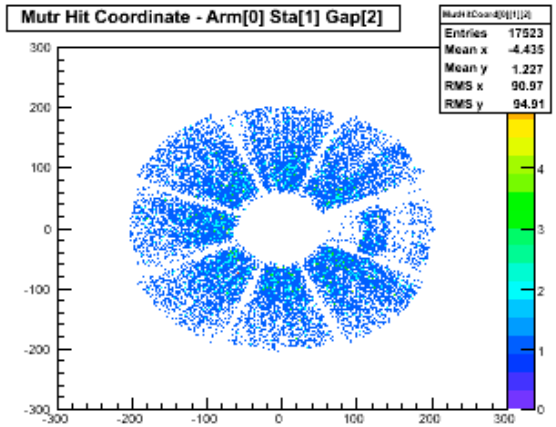




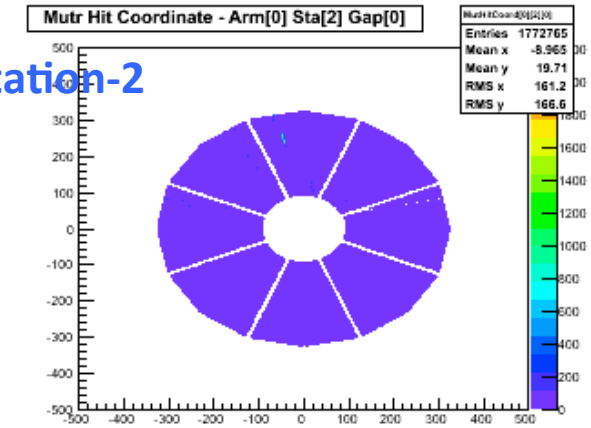
Station-1

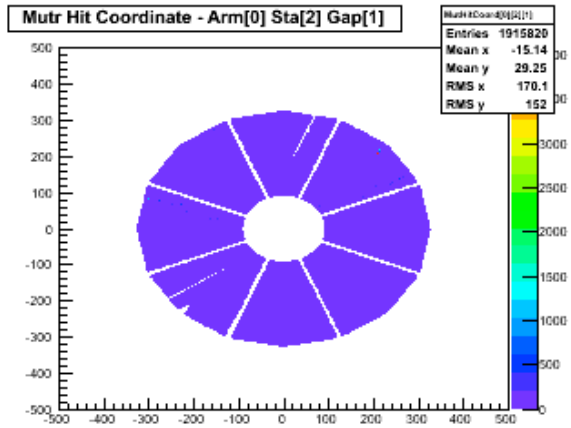






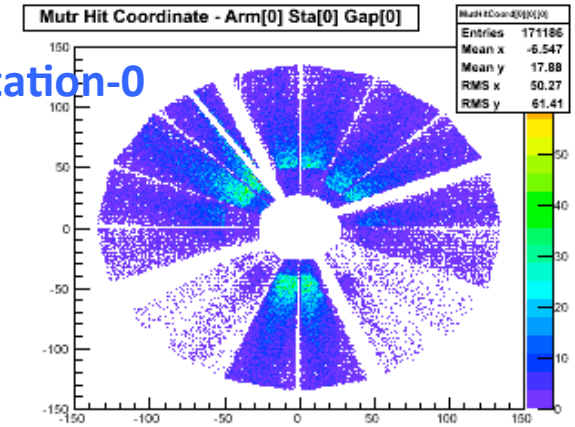
Station-2

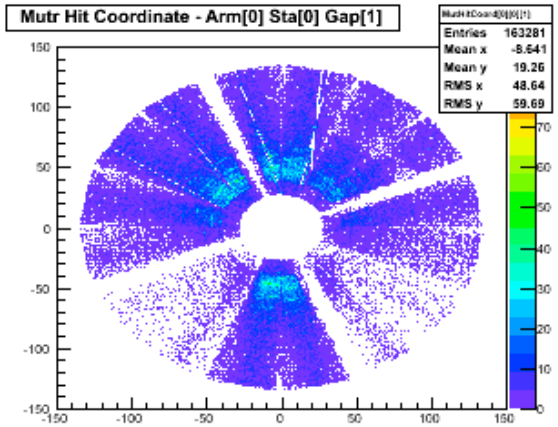


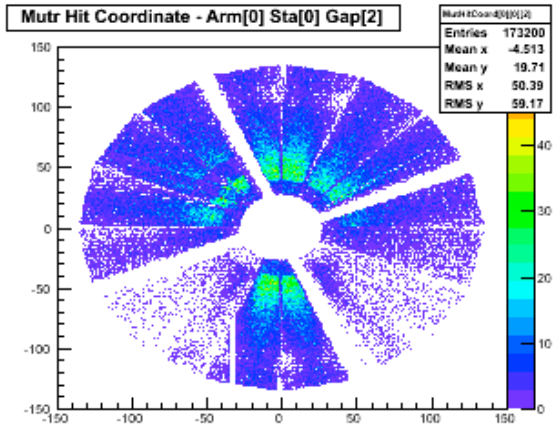


Run 425423
South-arm MuTr
St0, St1 problems.

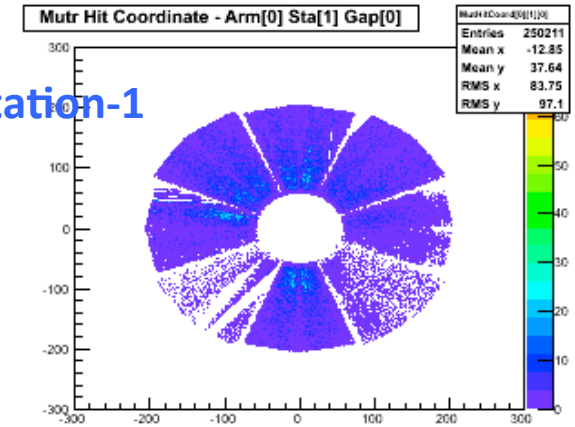
Station-0

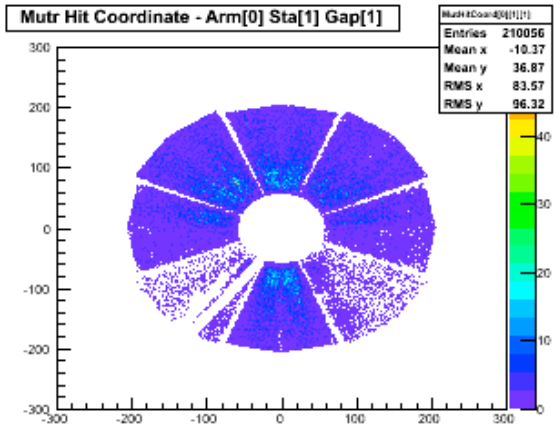


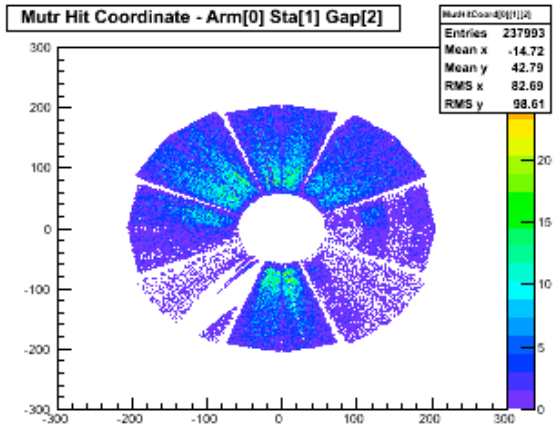




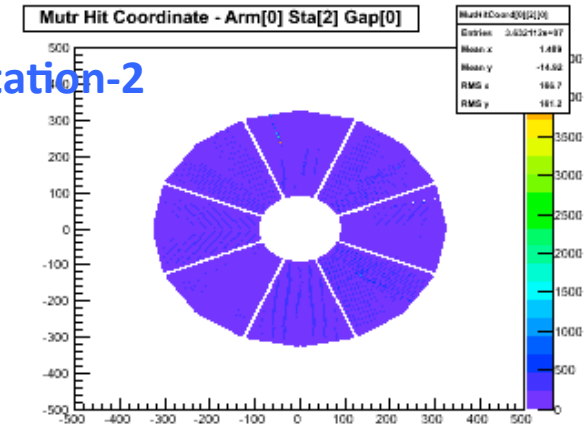
Station-1

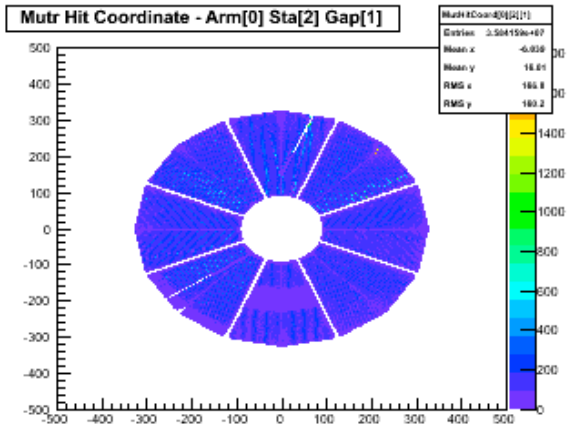






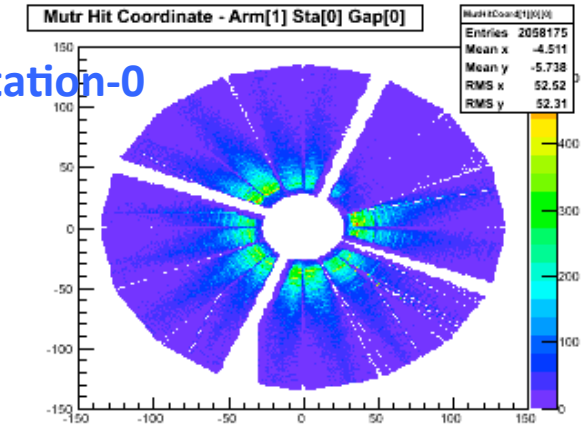
Station-2

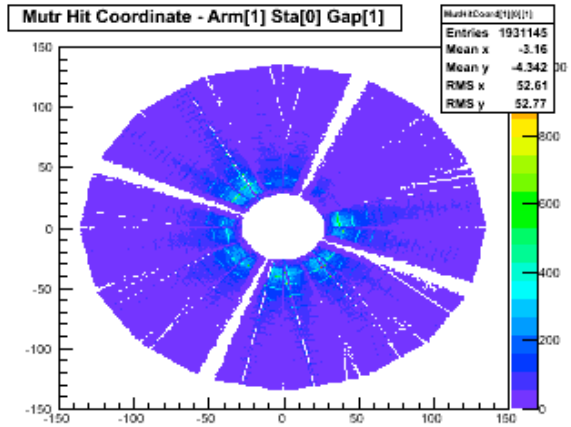


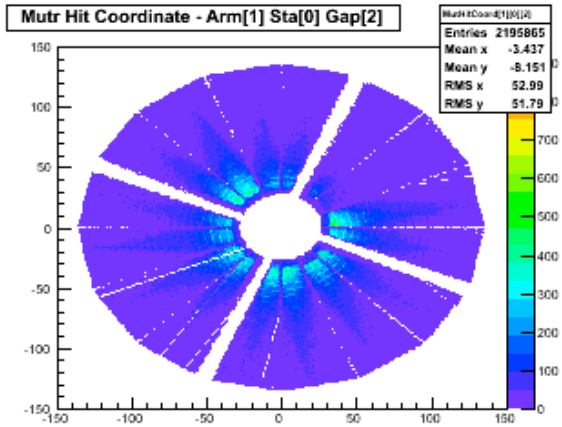


Run 429886-429888
South-arm MuTr
St0, St1 problems.

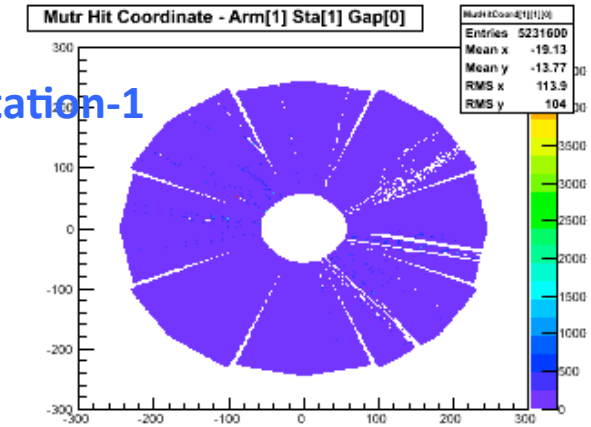
Station-0

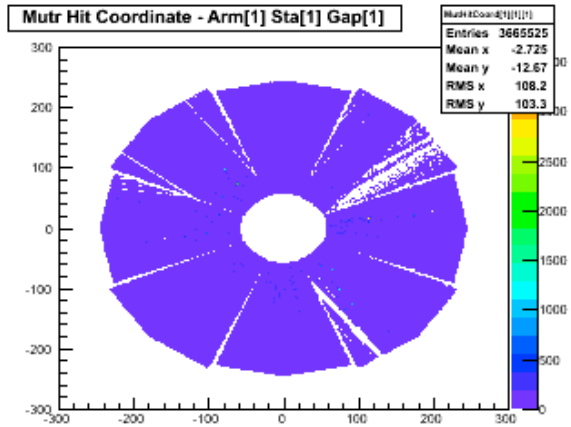


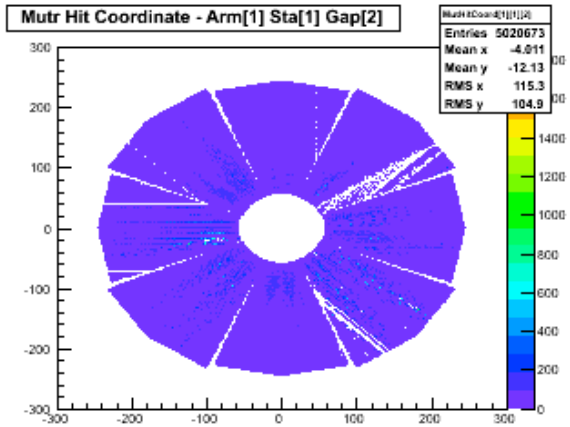




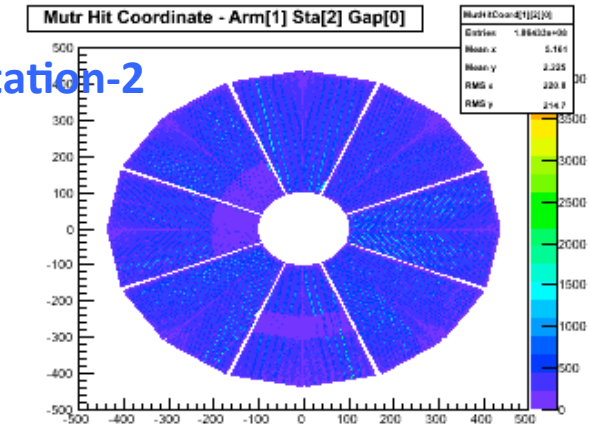
Station-1

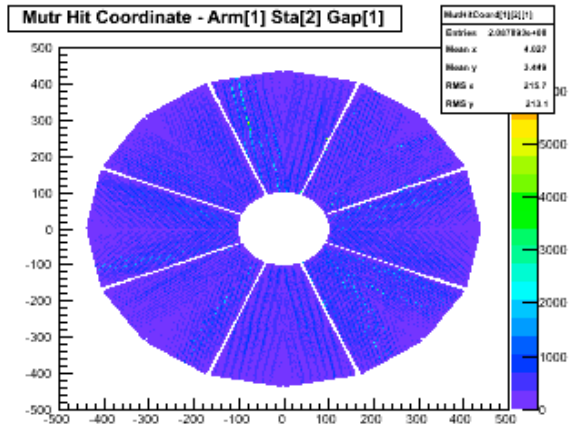






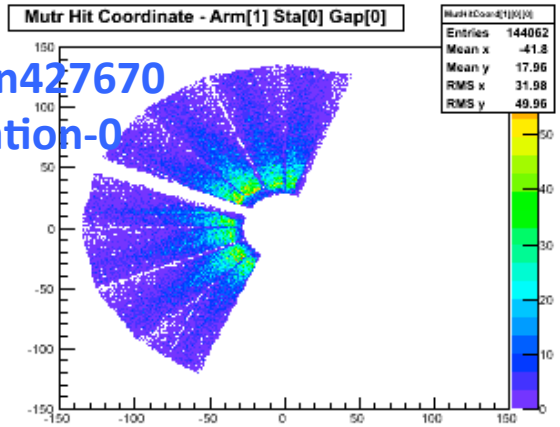
Station-2

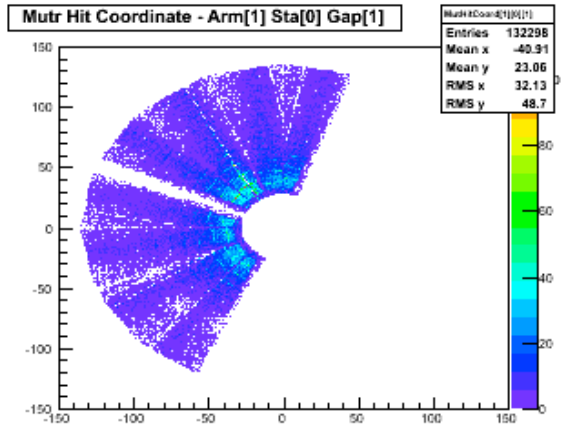


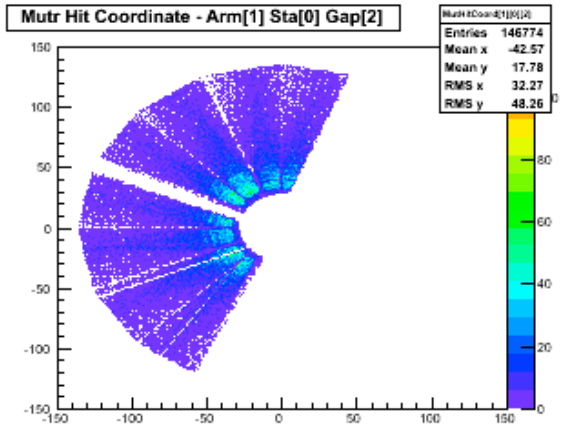


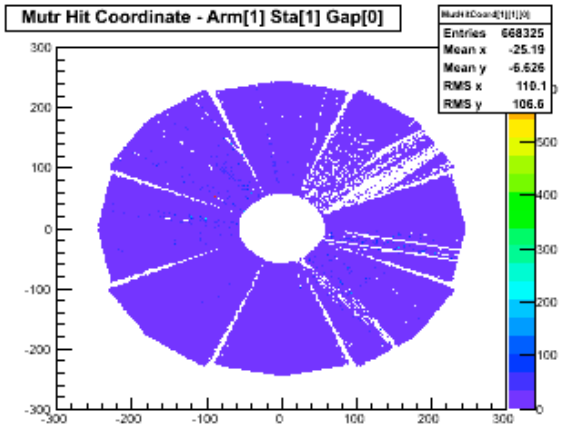
Run 425422. A Good run
North-arm MuTr

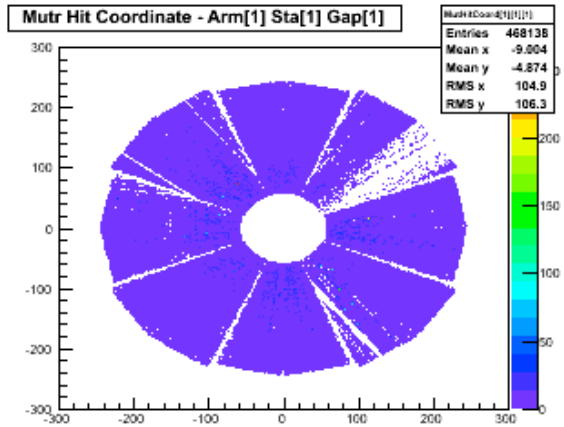
Run427670
Station-0

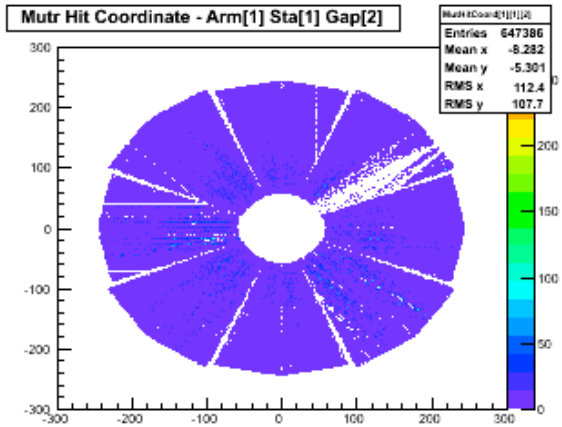


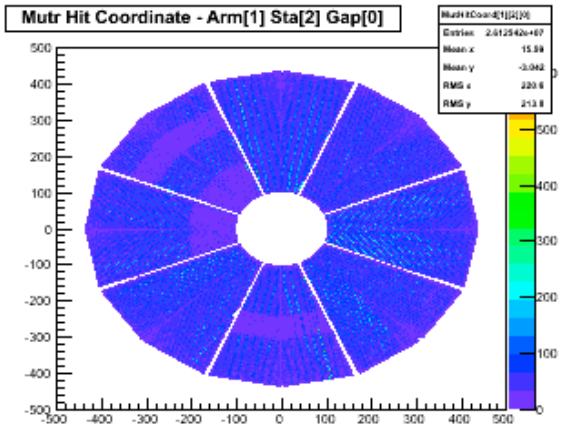


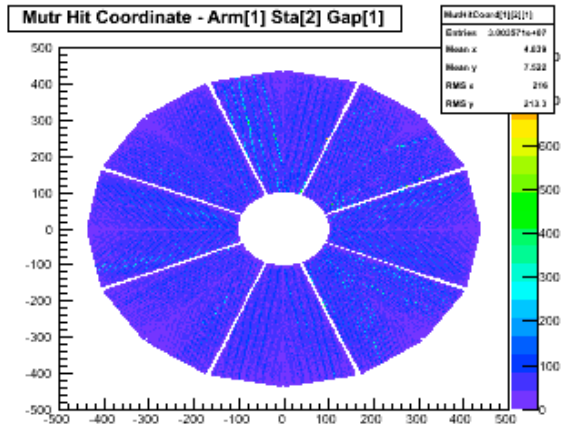






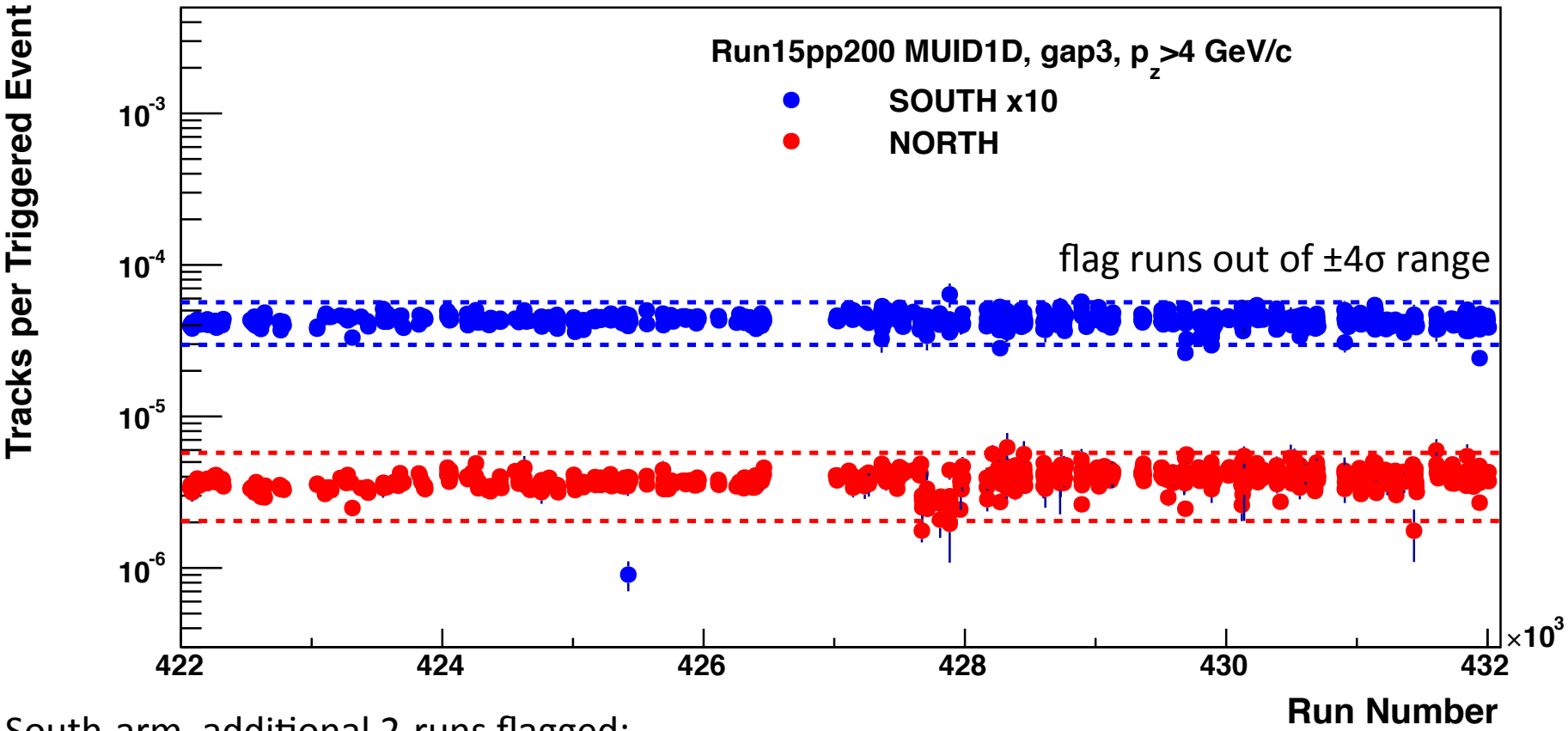






Run 427670-427969
North-arm MuTr
Station-0 half-off.
glink problems on N.St0, N.St1.

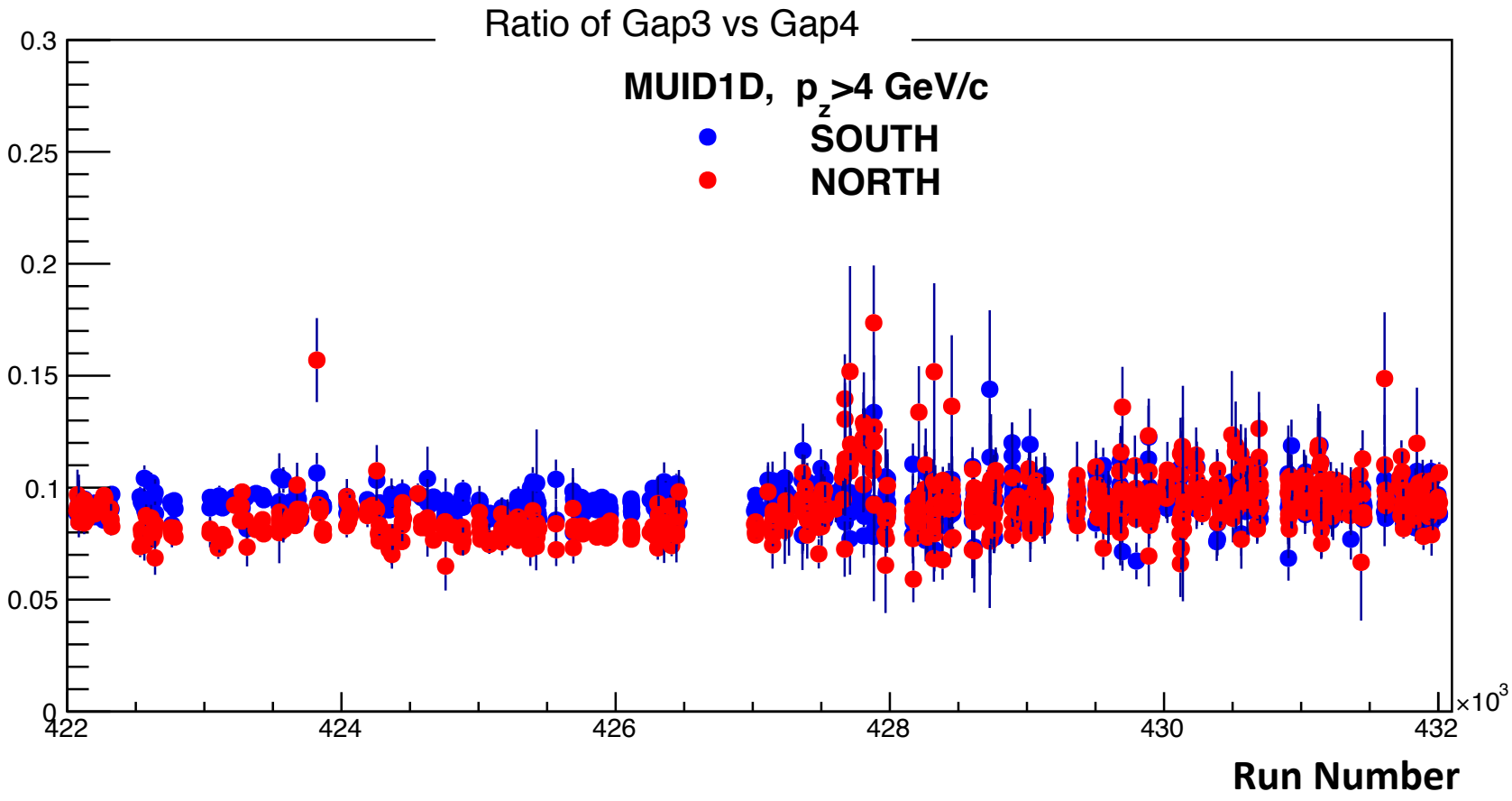
Tracks-per-Triggered-Events: Trigger=MUID1D, lastgap=3



South-arm, additional 2-runs flagged:
427883 (very short run),428891 (15 min. Comment: Stopped due to low livetimes ~0.70)

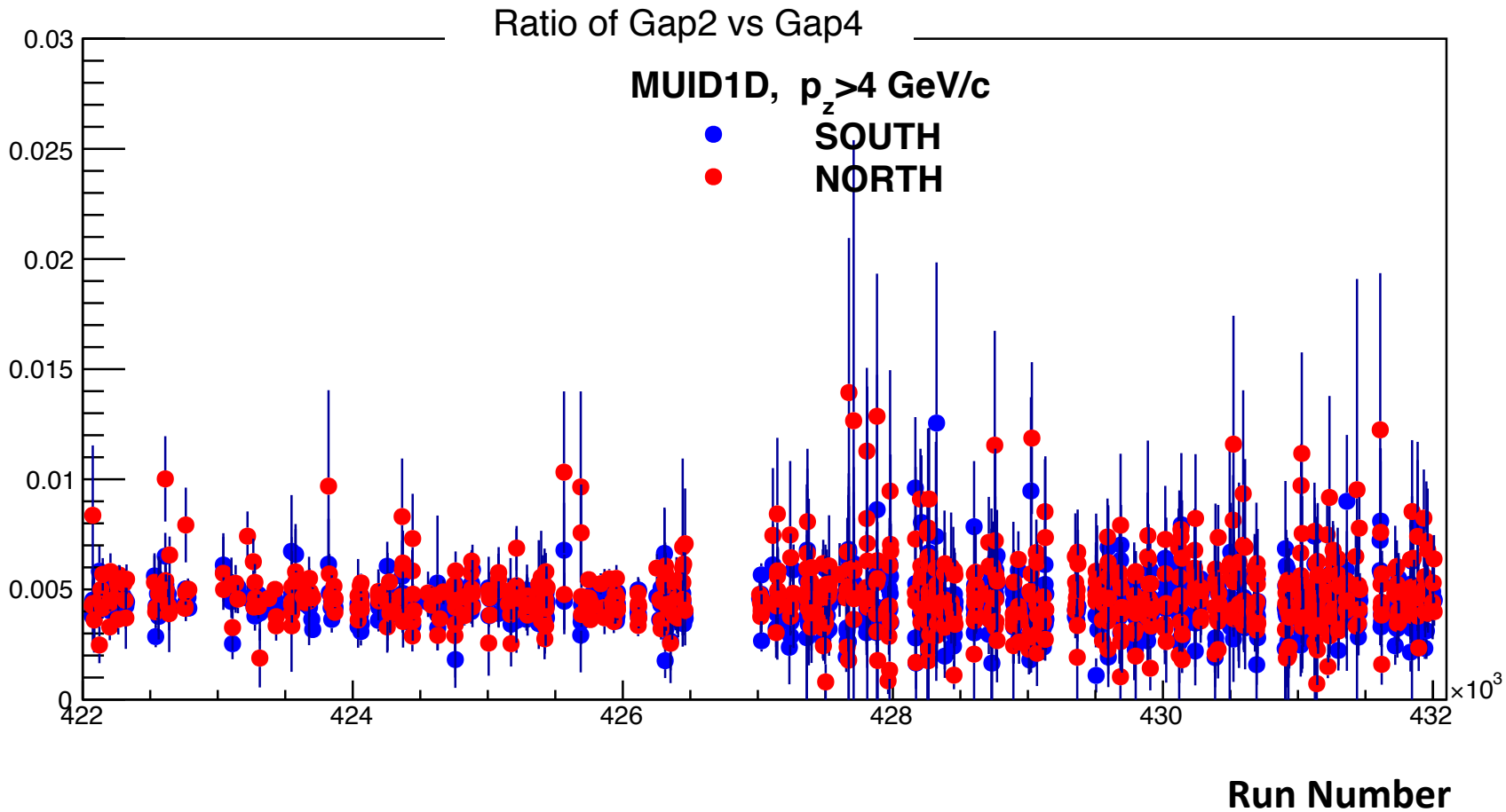
North-arm, additional 2-runs flagged:
428323 (short run, 7 min),431608 (short run, 8 min.)

Ratio gap3/gap4: Trigger=MUID1D



Ratio of gap3/gap4 in MUID1D triggered events is reasonably stable, ~10%

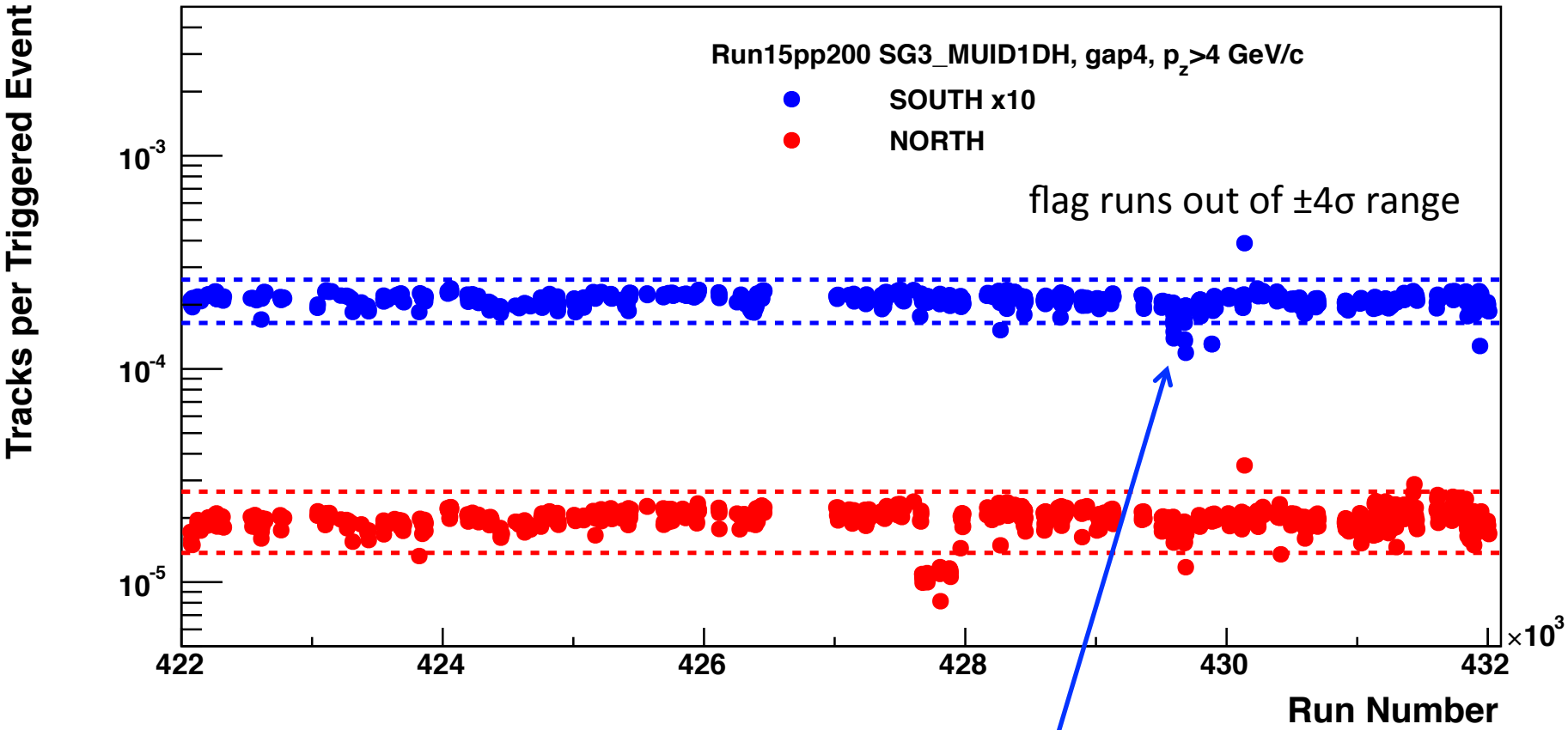
Ratio gap2/gap4: Trigger=MUID1D



A very small fraction (~0.5%) of MUID1D triggered events end-up as lastgap=2 events after reconstruction. Ignore them for the moment.

For high-momentum single-muon triggered events only (SG3_MUID1D1H)

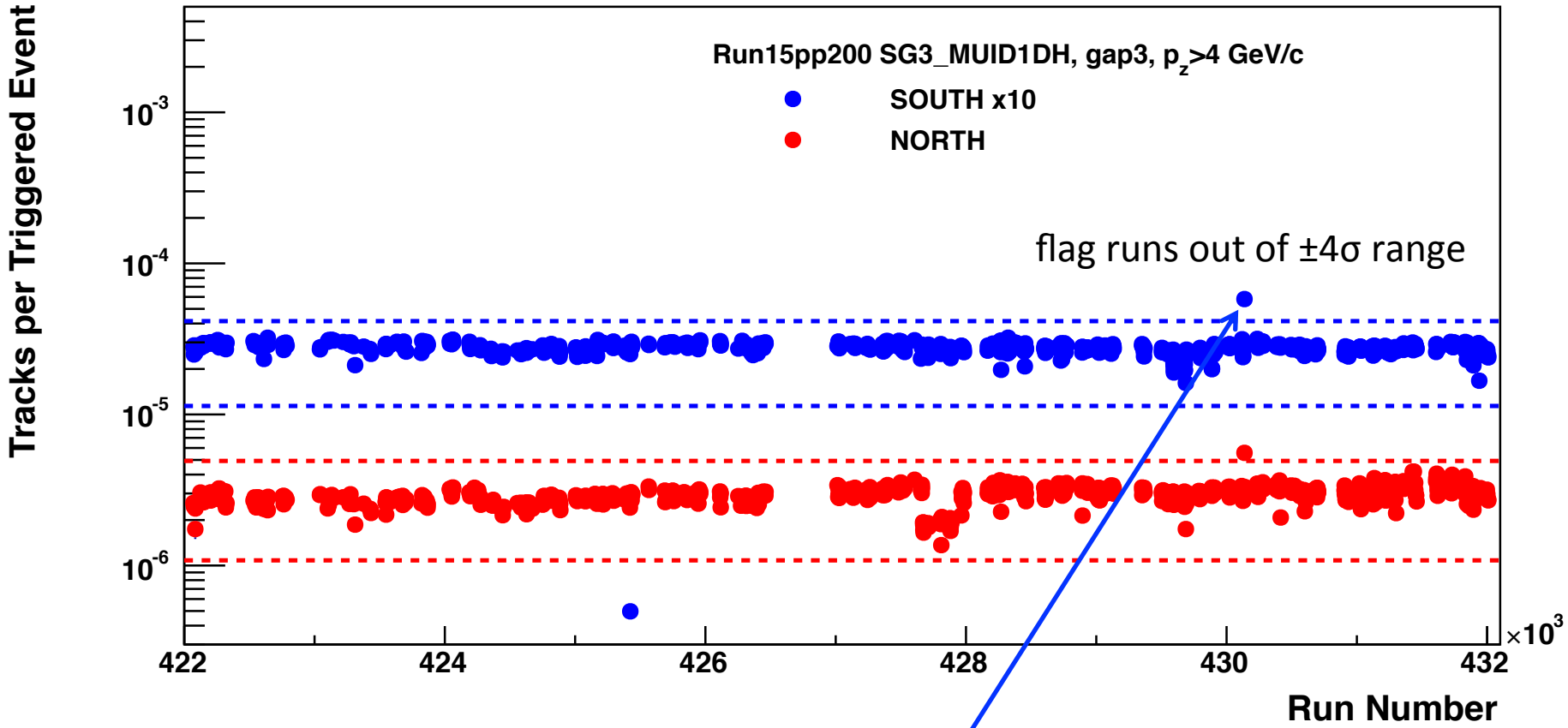
Tracks-Scaled-to-per-BBC-Triggered-Events: Trigger=SG3_MUID1D1H, lastgap=4



South-arm for SG3 triggered-events only, additional 5 runs flagged:
429593,429594,429595,429678,429680 (comments: ended with mutrigger issues)

North-arm for SG3 triggered-events only 7 runs flagged:
431932,431937,431938,431940,431941,431942,431943 (comments: north sg3 taken out).

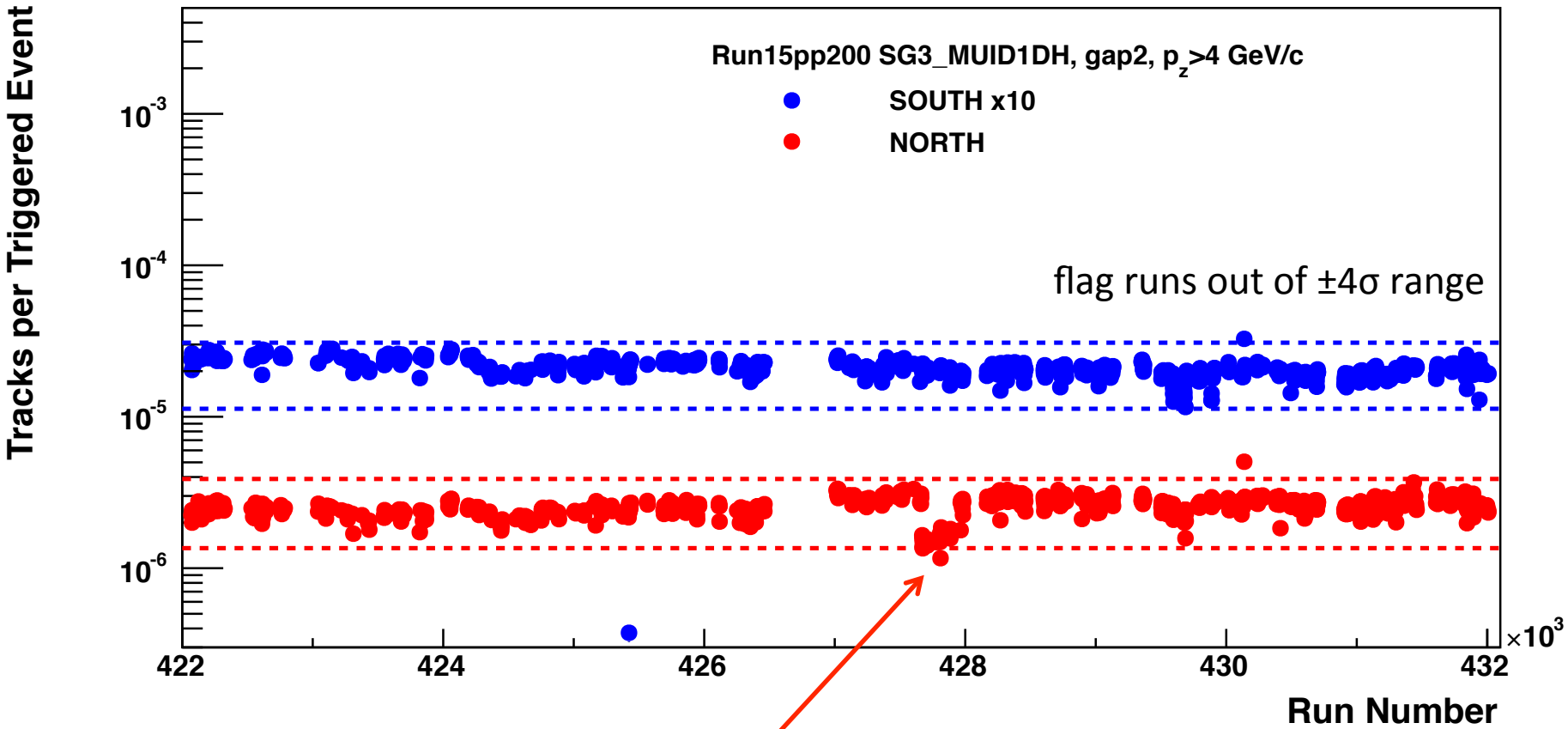
Tracks-Scaled-to-per-BBC-Triggered-Events: Trigger=SG3_MUID1D1H, lastgap=3



South-arm for SG3 triggered-events only, 1-runs flagged:
430137 (short run, 6 min)

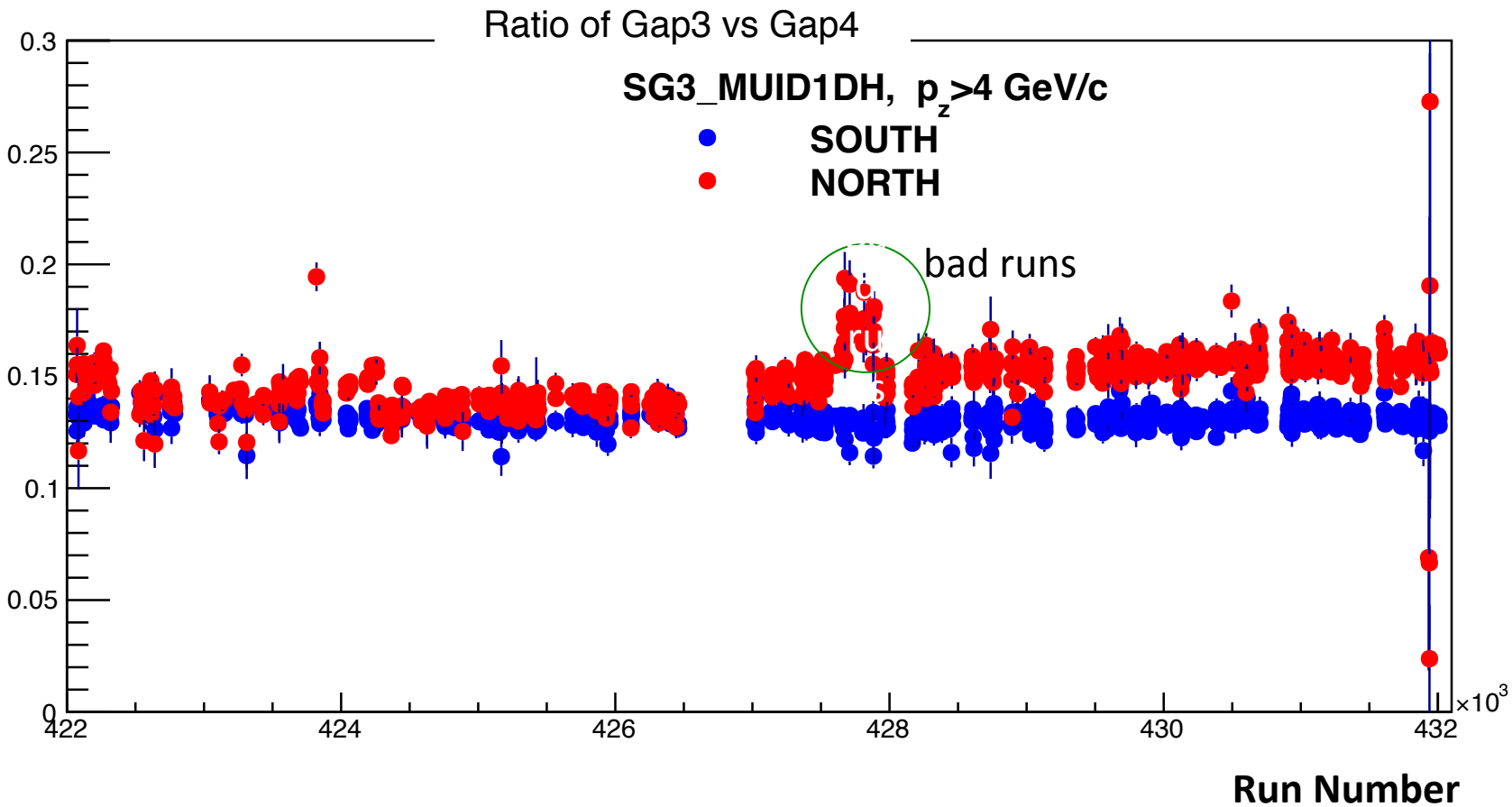
North-arm for SG3 triggered-events only, 7 runs flagged:
431932,431937,431938,431940,431941,431942,431943 (comments: north sg3 taken out).

Tracks-Scaled-to-per-BBC-Triggered-Events: Trigger=SG3_MUID1D1H, lastgap=2



North-arm for SG3 triggered-events only, 2 runs flagged:
427674 (Low live rate ~0.72), 427810 (short run, 6 min.)

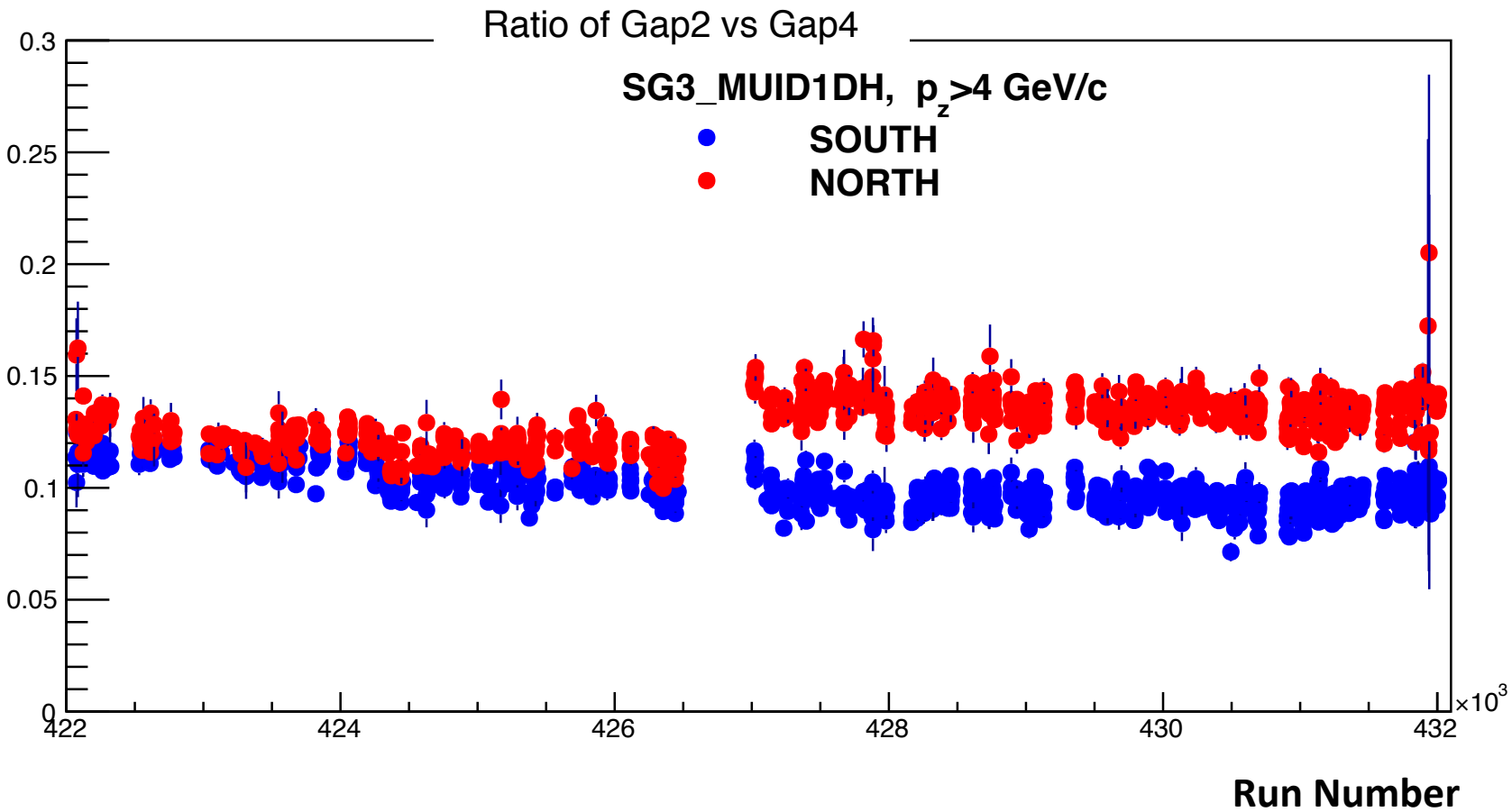
Ratio gap3/gap4: Trigger=SG3_MUID1D1H



Ratio of gap3/gap4 in SG3_MUID1D1H triggered events is reasonably stable, ~13-15%.

High statistics gap3 events in SG3 trigger.

Ratio gap2/gap4: Trigger=SG3_MUID1D1H



Ratio of gap2/gap4 in SG3_MUID1D1H triggered events is reasonably stable, ~10-15%.

1H trigger worked-well

High statistics gap2 events in SG3 trigger.

Summary: run15pp200 Flagged Runs

N-422611, S-422611 Comment: a. Backgrounds were high in N1~N3 for whole period. Stopped the Run once Backgrounds improved seriously by MCR

425433: rejected. missing MuID HV record, RunLog looks fine. Might be a good run.
N-427654,S-427654, MuID HV were off for the last 5 minutes in the run.

N-427656-427969, N.St0, N.St1 daq problems.
427674, short 14 min. Comment: Low live rate ~0.72.

N-428728, S-428728, low live-time, ~0.25.
N-428891, S-428891, 15 min. Comment: Stopped due to low livetimes ~0.70.
N-423311, S-423311, Comment: MuTr were testing out trigger rates.
N-423820, S-423820, Comment: High background, and poor livetime ~0.60.
N-429687, S-429687. 24 min run, both arm yields low.

S-429886-429888. S.St0, S.st1 problems.
430519: MuTr HV was OFF
Missing on taxi-6729 from production 424439, 427656, 430402, 430519.
430415 North yield low, for both MUID1D and SG3

N-431939, S-431939, both arm yields low, Comment: Muon North SG3 triggers off due to detector problems.

From Itaru, on possible spin-sign screw-ups:

Missing Runs Summary (pp)

pp

Fill	Run	Duration [min]	Symptom
18678	422375	49	Magnet trip
18697	423413	70	Magnet trip
18723	424439	22	Can be recovered
18754	425567	35	Magnet trip
18765	425941	76	Magnet trip
18787	427129	6	Recovered
	427136	7	Recovered
	427137	60	Recovered
18942	431236	31	Magnet trip

None of them passed run selection.

For SG3-MUID1D1H triggered events only flagged-runs

South-arm for SG3 triggered-events only, additional 5 runs flagged:
429593,429594,429595,429678,429680 (comments: ended with mutrigger issues)

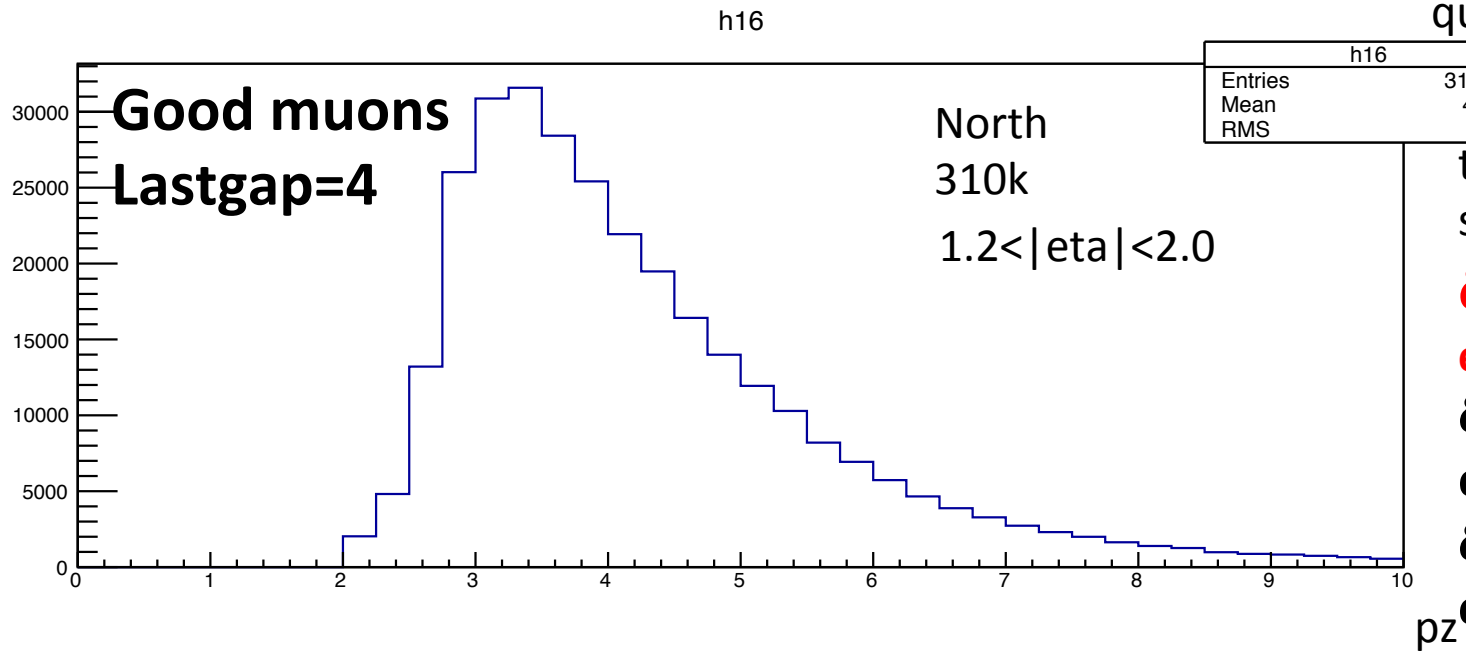
North-arm for SG3 triggered-events only, additional 7 runs flagged:
431932,431937,431938,431940,431941,431942,431943 (comments: north sg3 taken out).

An example of a typical good run in Run15pp200 for physics analysis

Extremely high-quality and high-statistic data for single-particle asymmetry physics !!!

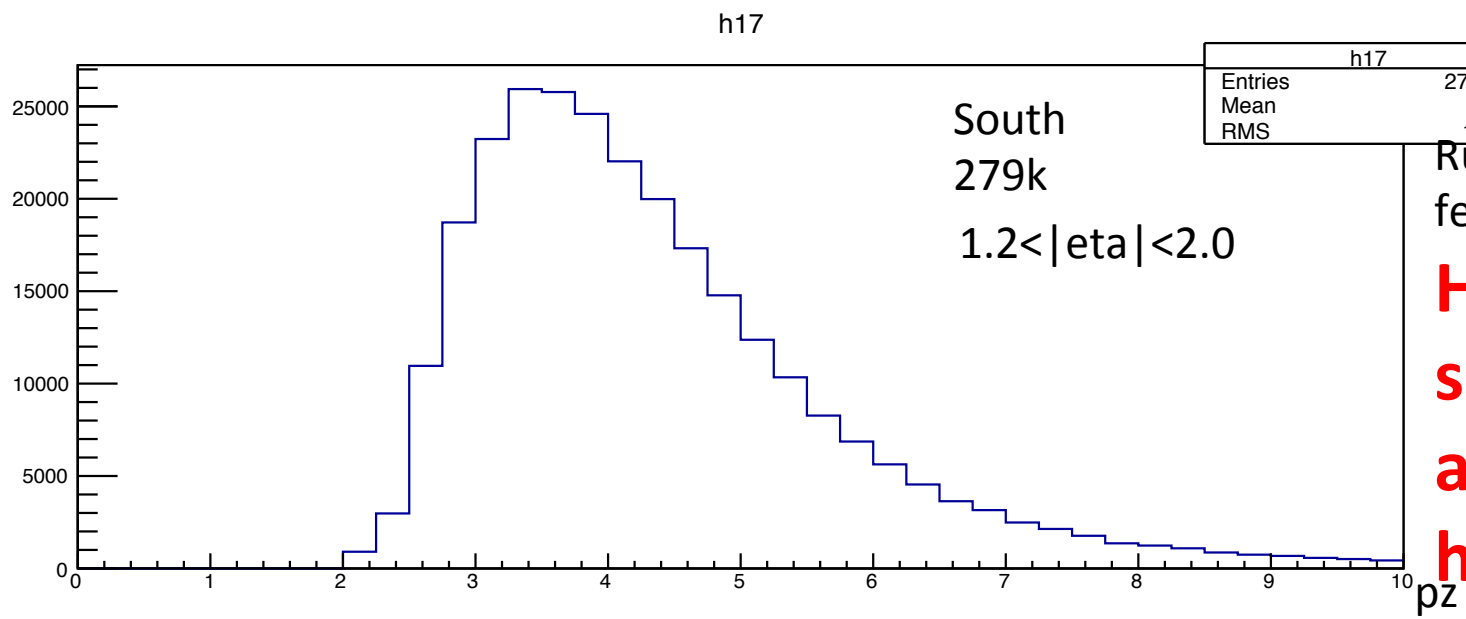
Run427360 BBC_rate=1.56 MHz, March 20th, 2015.
100 minutes. sg3_N: 1kHz, sg3_S: 240 Hz.

sg3&MUID1D triggered good quality muon events



this run alone:
stat. uncertainty:

$\delta(A_N) = 0.5\%$
each arm for muon
$\delta(A_N) = 1.3\%$
each arm for gap3
$\delta(A_N) = 1.6\%$
each arm for gap2

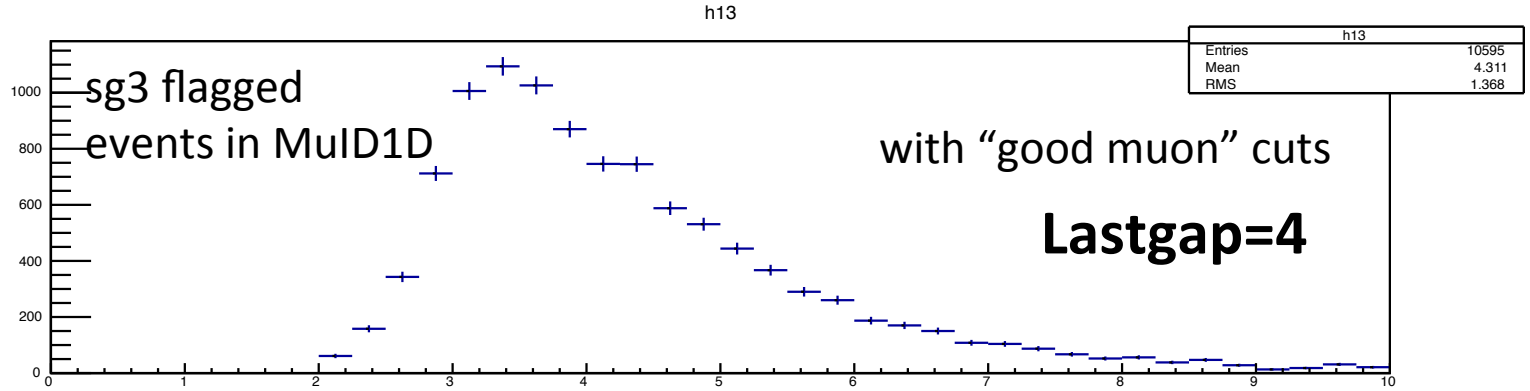


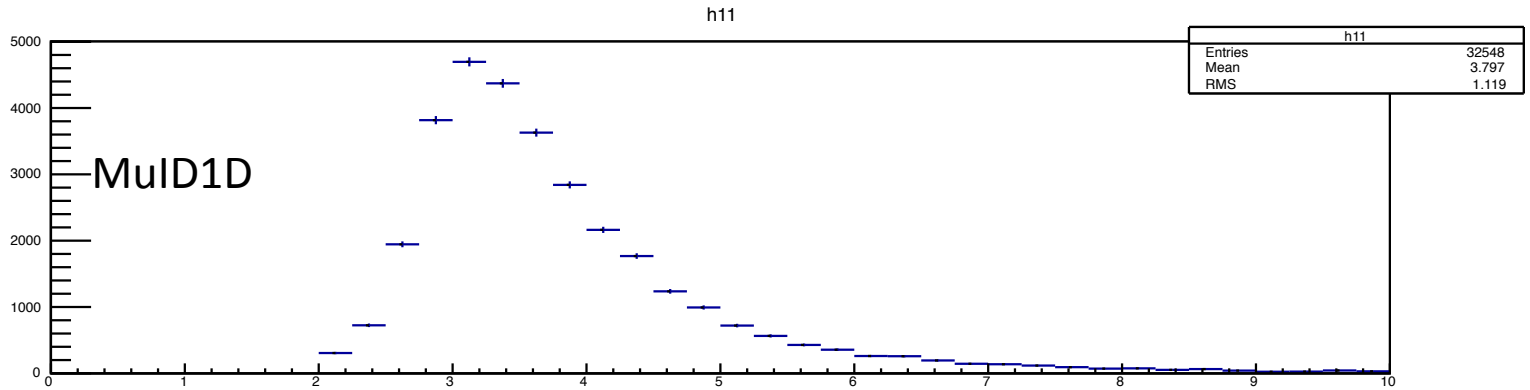
Run15 pp200 have few 100 good runs.

High precision single-muon and single-hadron A_N !!!

Run-426445, taken on March 14th, 2015

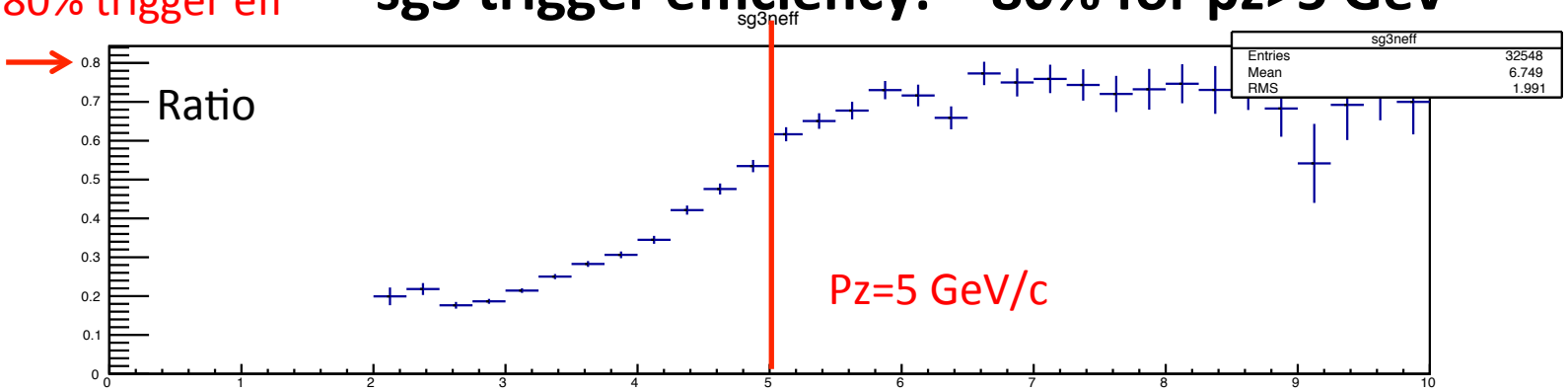
North Arm





80% trigger eff

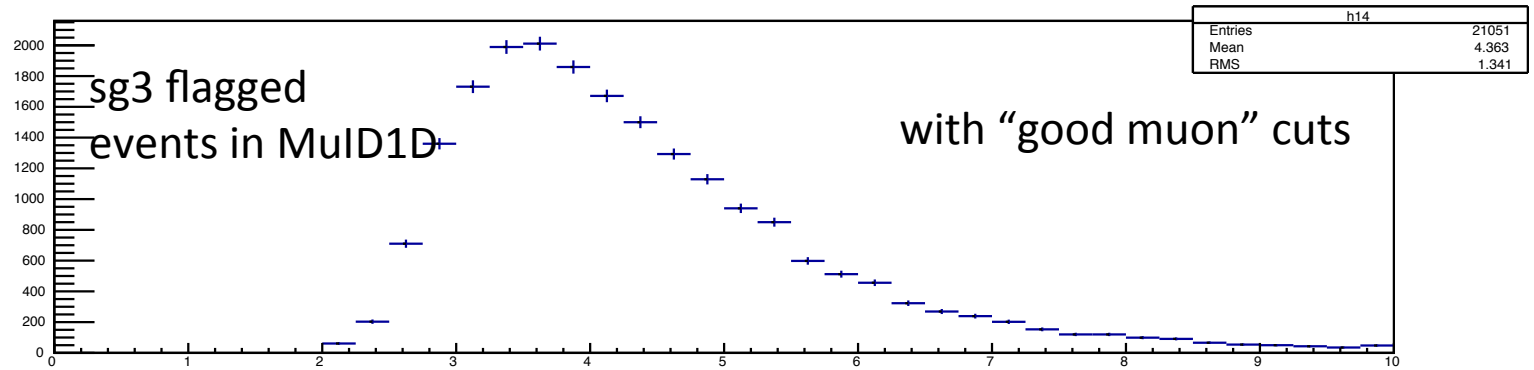
sg3 trigger efficiency: ~ 80% for pz>5 Gev

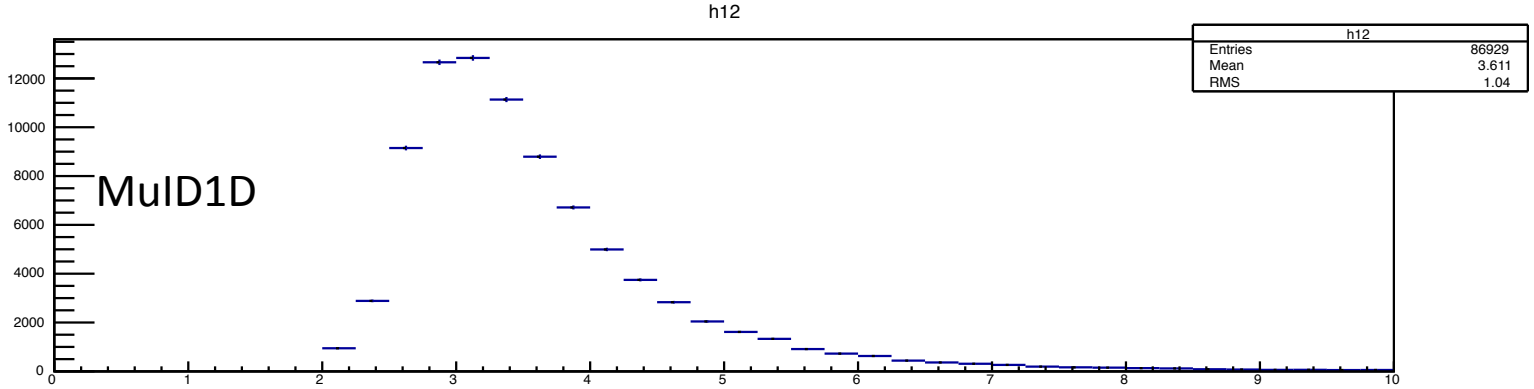


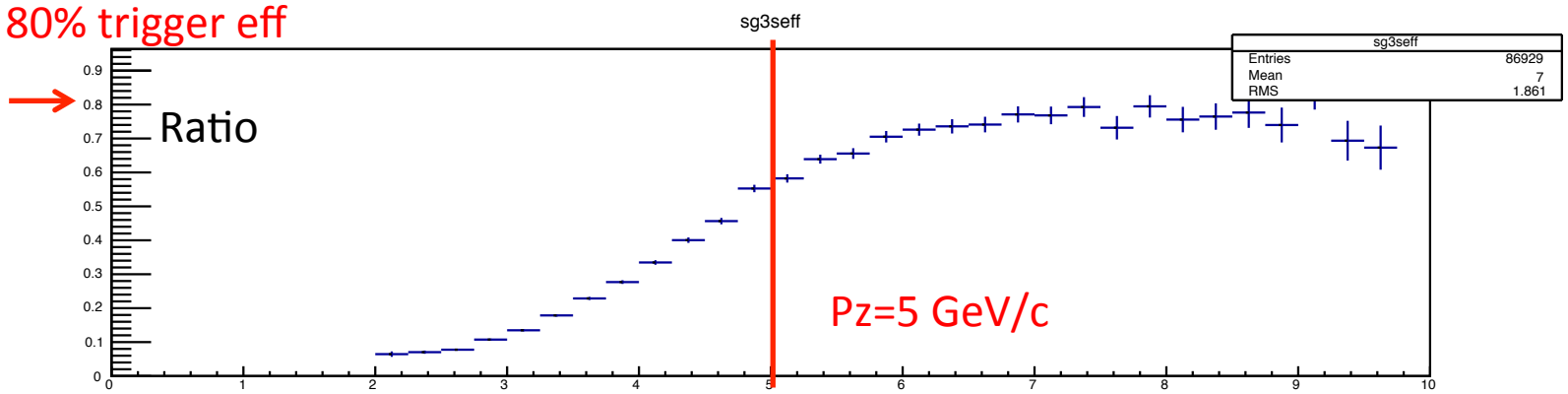
Pz (GeV/c)

Run-426445, taken on March 14th 2015

South Arm







Pz (GeV/c)

Conclusion: Run15pp200 Muon-Arm GoodRunList

Updated run15pp200 muon-arm “good-run-list”:

South-Arm:

698 runs goodrunlist_run15pp200_south_alllumi.txt

217 runs goodrunlist_run15pp200_south_lowlumi.txt
243 runs goodrunlist_run15pp200_south_midlumi.txt
238 runs goodrunlist_run15pp200_south_highlumi.txt

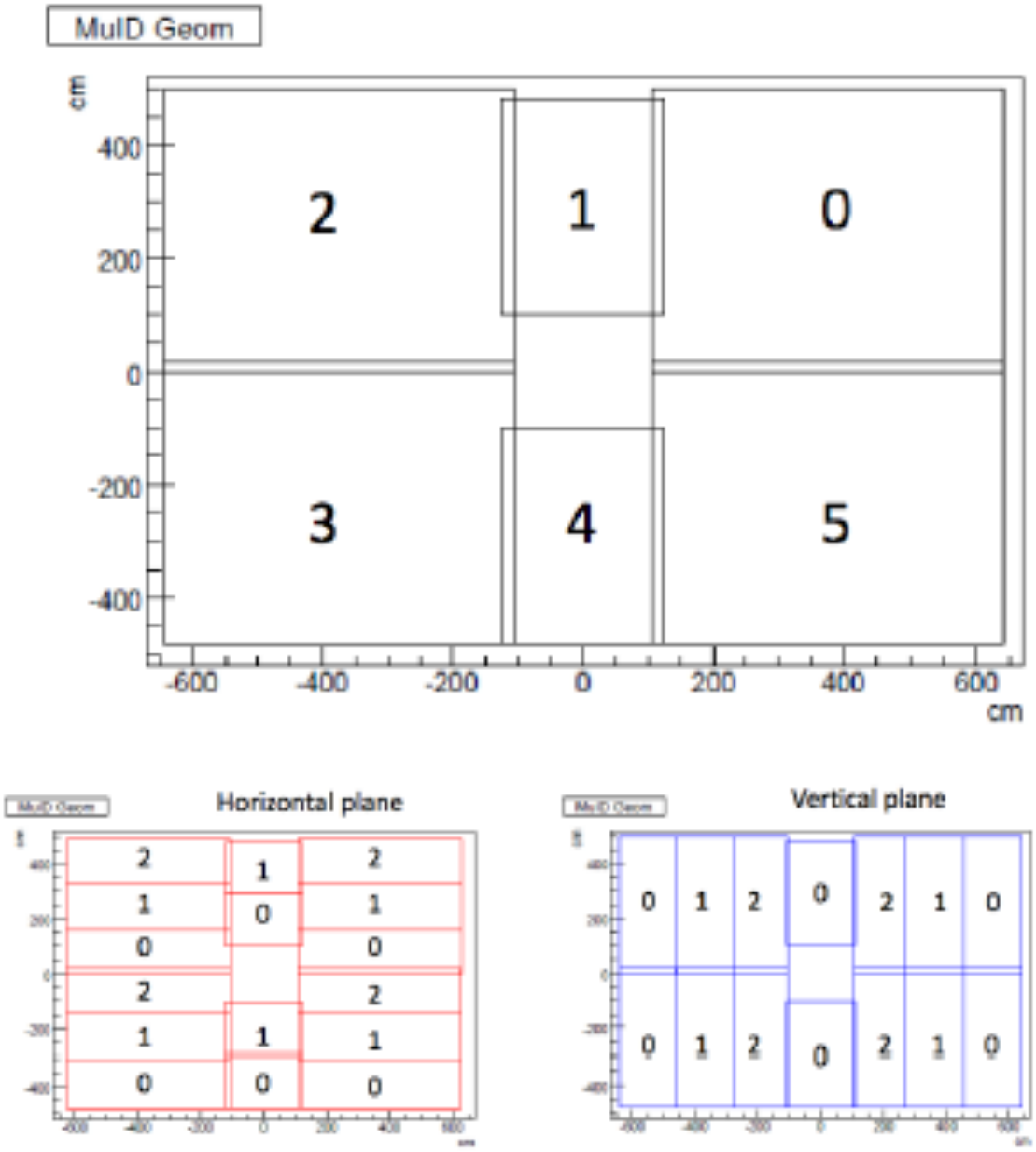
North-Arm:

672 runs goodrunlist_run15pp200_north_alllumi.txt

213 runs goodrunlist_run15pp200_north_lowlumi.txt
228 runs goodrunlist_run15pp200_north_midlumi.txt
231 runs goodrunlist_run15pp200_north_highlumi.txt

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

Backup Slides and Reminders



5 gaps: 0-4,

2 planes each gap:0-1

6 panels each plane: 0-5

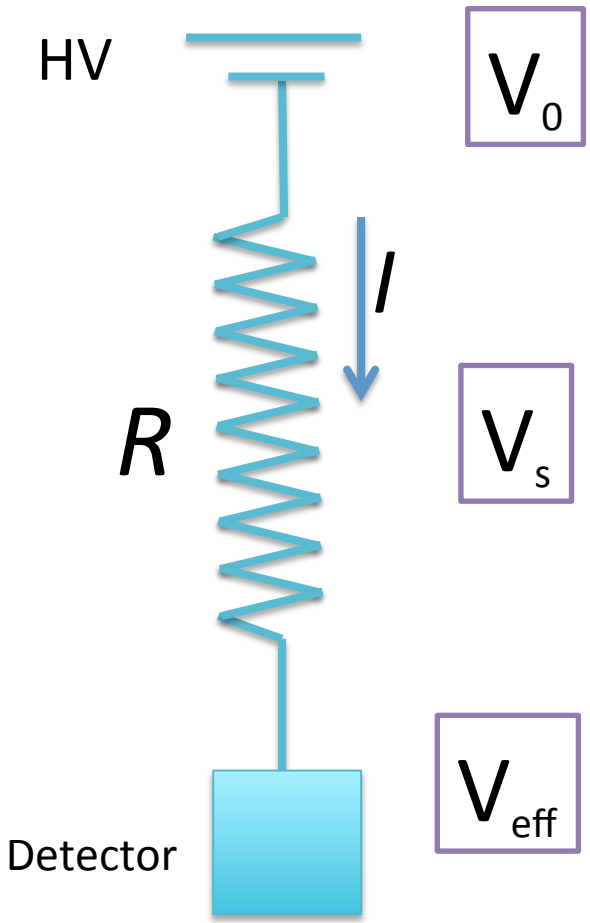
3 hv groups each panel:0-2
(except panel #1, #4)

AnaNote1137
Run13pp510W2mu

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

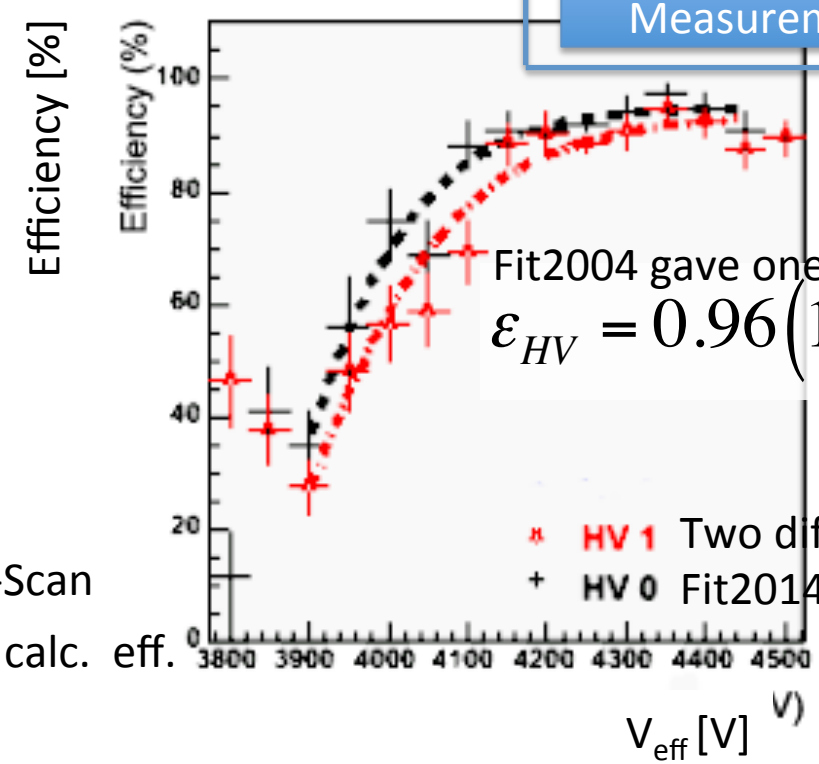
Effective voltage on MUID-tubes are lower due to dark current caused voltage drops.
Take dark currents in cosmic-runs as BaselineCurrent



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.