MUID Efficiency – “HV Method” Revisited

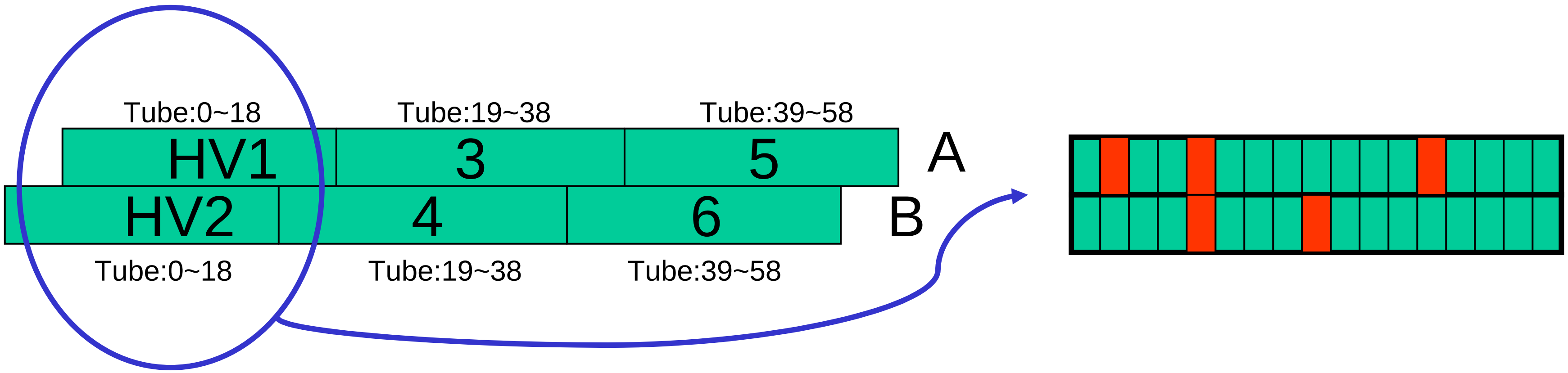
Motivation : as part of trying to learn the steps for using the method developed by mainly DongJo and MinJung, it became clear that what was done was not exactly what others (like myself) thought was being done.

This set of slides is an attempt to try to clarify the procedure. Comments and suggestions are welcomed.

Outline: 2 slides from an earlier presentation by DongJo, 1 slide on what at least I thought was done, followed by a few slides with a procedure description from MinJung, and some info and a proposal regarding future/outlook and ongoing steps.

From: /p/draft/djkim/meeting/run3dAu/run3_muideff_10292003.ppt

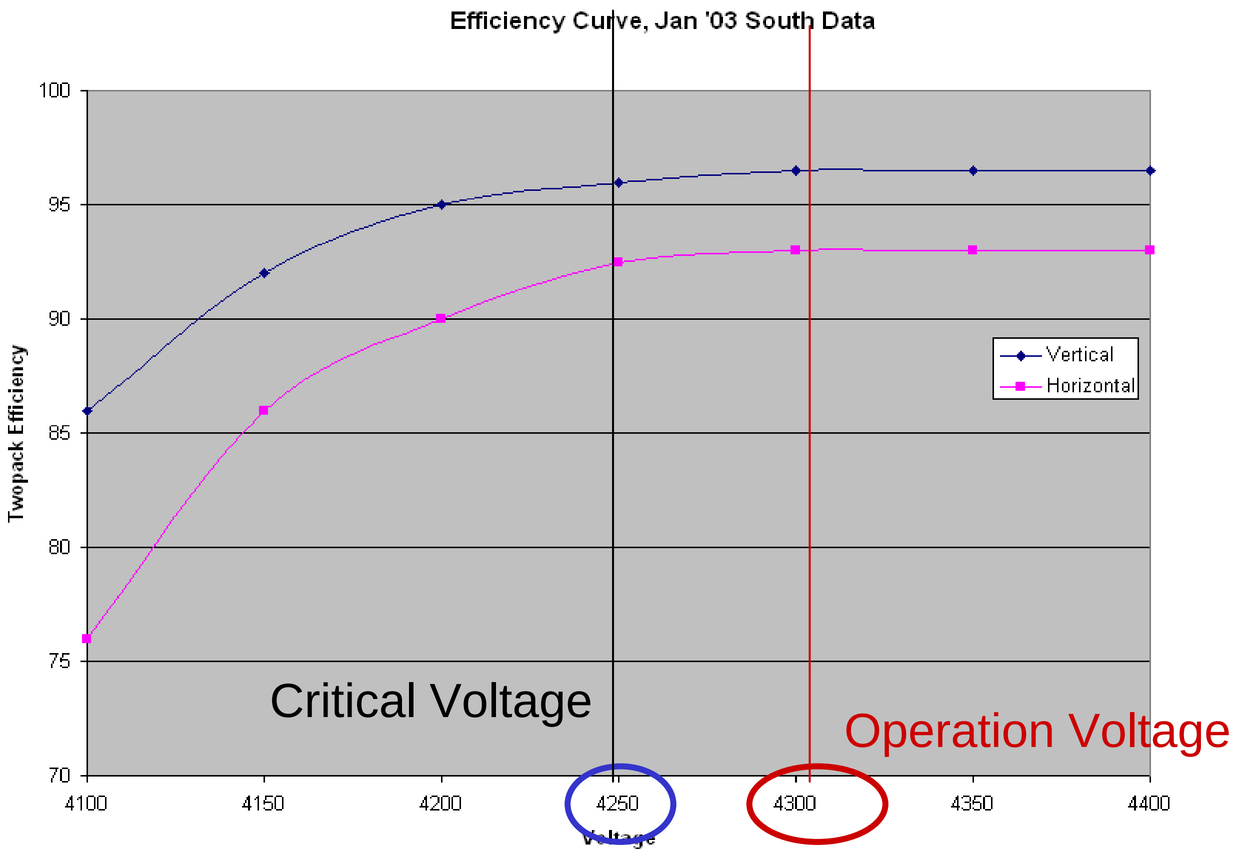
Addition Correction : Muid HV Current



- Several tubes are suffering High current during the run
- Depending on how many channels are bad, the current on the HV channel varies

From: /p/draft/djkim/meeting/run3dAu/run3_muideff_10292003.ppt

excitation curve



[DS note: this is included in DongJo's presentation but not in the method]

General idea – two steps

1. Study the HV log files (showing voltage and current for all channels every minute) => determine the channel status for each individual run;
a) on through whole run?, and b) calculate average current.

2. Based on current draw, and information on broken wires for each HV chain (majority: no broken wires), determine what the sag/drop in effective voltage is and estimate how much that reduces the nominal efficiency of ~94% (from cosmic test), as outlined later.

This is what I thought was being done.

In fact though.., step 2) is not really what's done until now.

Procedure used until now (Step 2)

From MinJung's clear description in her draft note:

From the HV current, determine how many broken wires this could correspond to for each HV chain. This gives you a disabled fraction x_1, x_2 for each of the two HV chain in a group of two-packs. E.g. if there appears to be one broken wire in a chain of 20 tubes, then the fraction x is 1/20.

Then the efficiency is estimated a la:

$Eff = 98*(1-x_1)(1-x_2) + 65*x_1*(1-x_2) + 65*(1-x_1)*x_2 =$

$98 - (98-65)*(x_1+x_2) - (2*65 - 98) *x_1*x_2$

where 98 and 65 are values assumed for the efficiency of a two-pack when both (98) or just one (65) of the tubes in the two-pack are alive.

Procedure used until now (Step 2)

Pro’s: it’s simple parameterization; has reasonable endpoints (0 eff. when all tubes have broken wires)

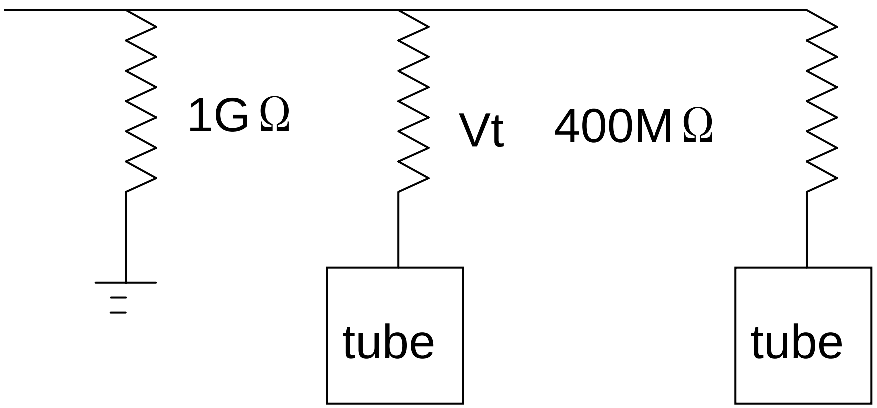
Con’s: 98% value seems pretty high, and while it is true that broken wires result in more current draw, more current draw for some runs is not necessarily due to (temporarily) broken wires..

I.e. treating the temporary high current draw from beam-related background as due to broken wires seems incorrect and too simple.
The fact that the results from this HV method and the regular MUID eff. estimates (Colorado method) more or less agree indicates (to me) more than anything else that the HV sag is mostly not too important.
Remember that MUID noise and backgrounds have been improved quite a bit since Run3. The default HV is also 4400 V nowadays to be safe on the plateau.

But we should anyway be able to do a bit better, I think.

MUID HV Algebra

N Tubes in a chain



Overall Resistance with n broken wires
(2.5 factor is from 1 / 0.4) :

$$R_n = \frac{1\mathrm{G}\Omega}{(1 + 2.5\mathrm{n})}$$

=> Current draw with n broken wires [normal : n=0; 4.4 kV & 4.4 μA]:

$$I_n \ (\text{in } \mu\text{A}) = (1 + 2.5\text{n})\ \text{V (in kV)}$$

Extra current over the basic current draw gives HV sag a la:

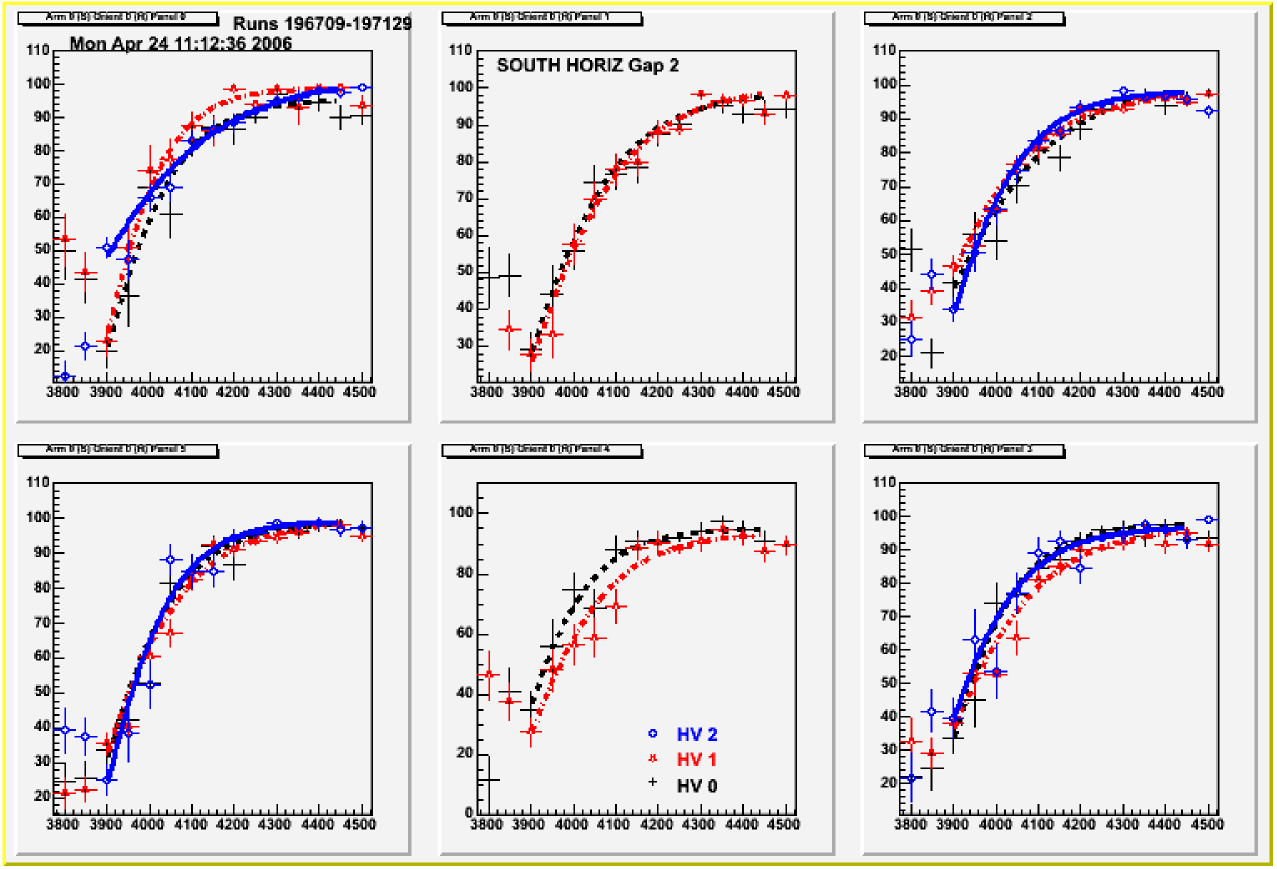
$$V_s (\text{in kV}) = \frac{I_{extra} (\text{in } \mu\text{A})}{(\text{N - n})}$$

[5μA extra current => ~100 V sag and potentially noticeable eff. loss]

Efficiency vs HV – new scans

"When life hands you lemons, make lemonade"
The recent RHIC troubles (STAR incident) gave us an unique opportunity to do an efficiency scan in the middle of a Run period, when we knew that the gas had been circulated properly for sure, unlike during our usual MUID weeks before the Runs. Chun took quite a bit of data; results at:

https://www.phenix.bnl.gov/phenix/WWW/publish/silvermy/muon/muid_eff/chun_hvscan_Apr2006/



Example: South Horizontal

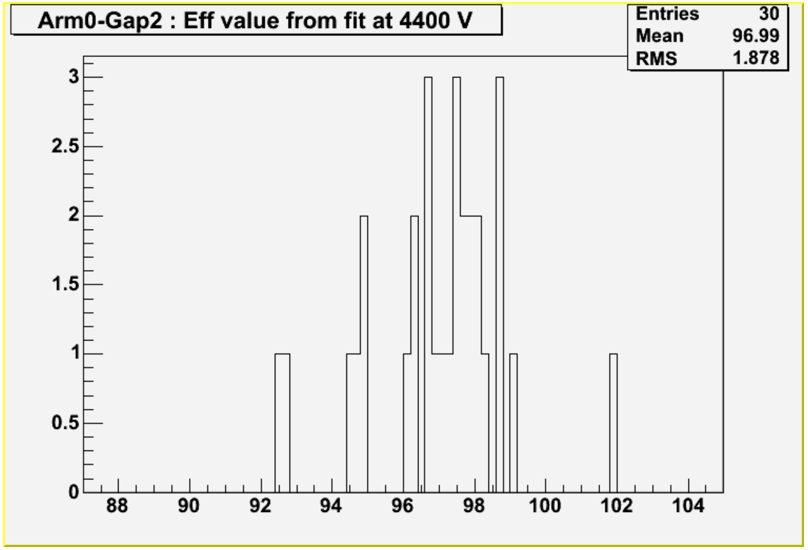
Approx. similar turn-on curves for the chains in all 6 panels.
[X-axis is HV, and Y-axis is efficiency]

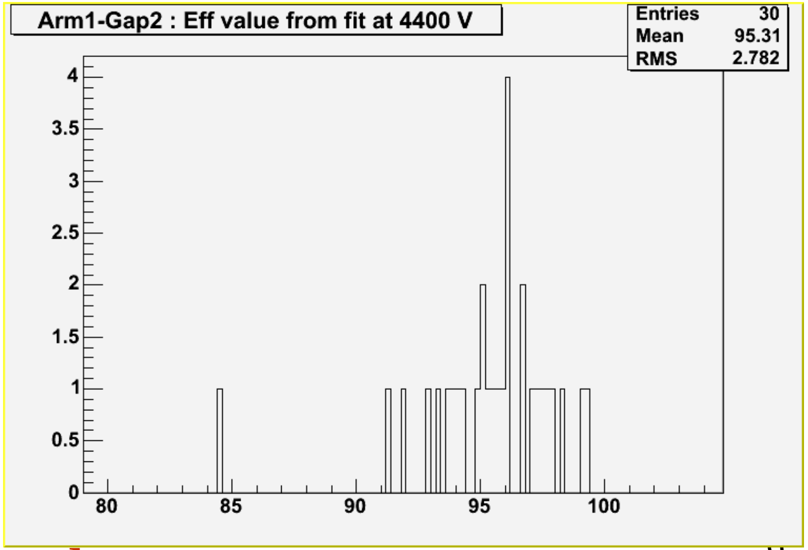
Efficiency vs HV - scans (II)

Fits were made with the function (to asymptotically reach full eff as HV->inf.):

par[0] * (TMath::TanH(par[1]*(x[0] - par[2])));

The nominal fit value for the eff. at 4400 V, which is our operating HV setting is plotted below for all HV groups in gap 2 for the two arms. We get ~96-97% eff. values from these fits, which is perhaps somewhat high(?). Again, we have typically done our HV/eff. scans early in the run previously, as operating gas was being turned on etc. so our canonical number of 94% might have been somewhat on the low side.





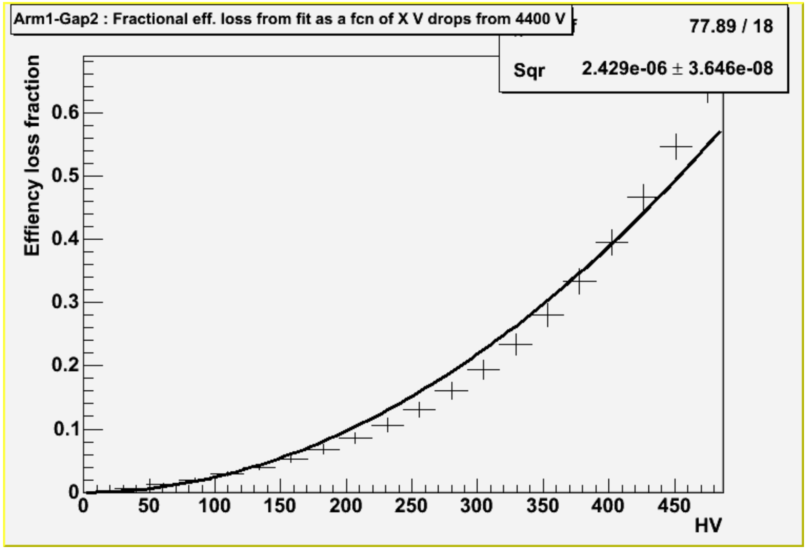
Nominal Eff. Value

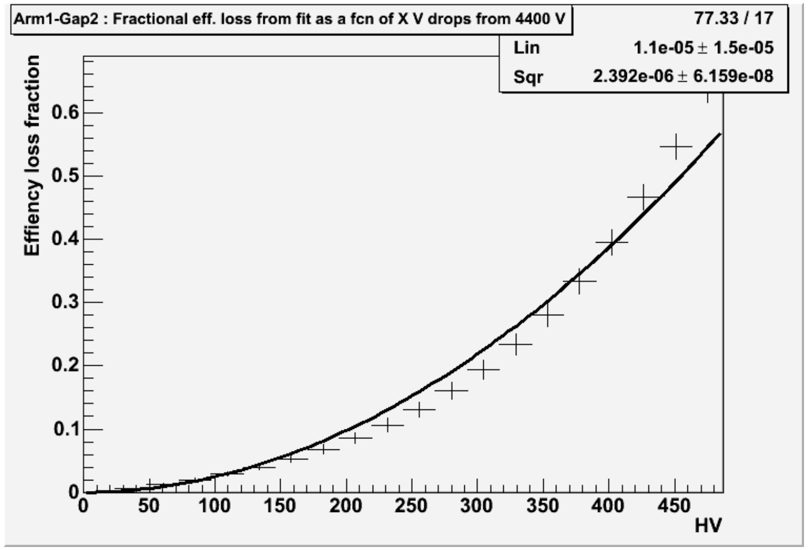
Efficiency loss vs HV drop – a parameterization

The average loss of efficiency as a function of HV drop from 4400 V can be well described by a quadratic function. We can then describe the eff. as a function of voltage sag like

$$\text{Eff} = 96\,(1 - 2.4\text{e-}6\, V_S^{\,2})$$

Eff. *loss*





HV Drop (V)

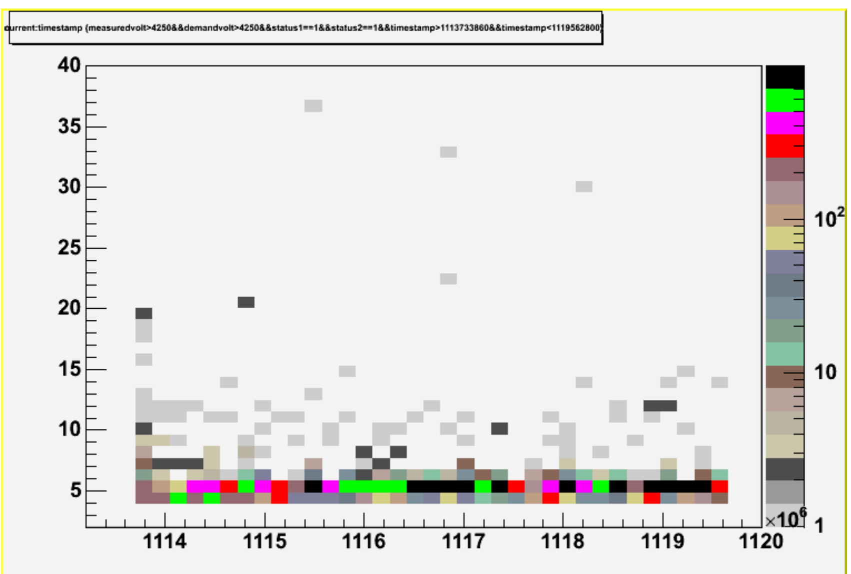
HV current vs Time – run5pp

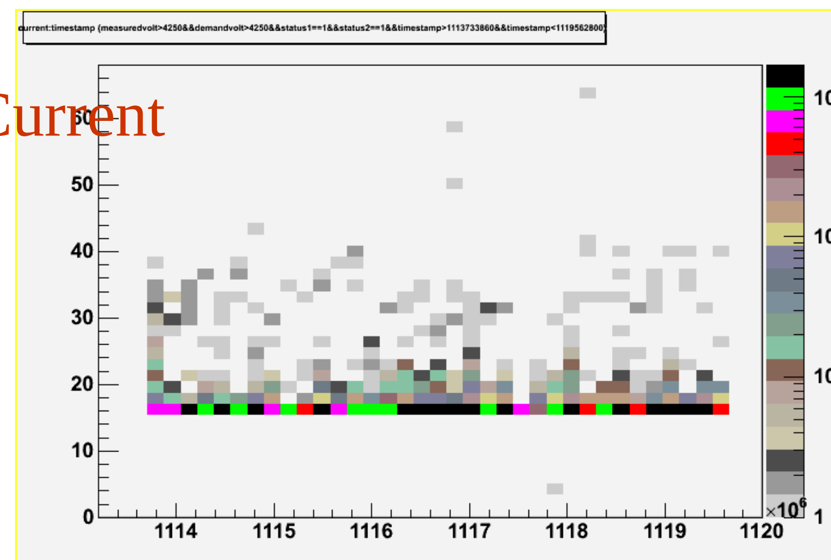
The problems with backgrounds and large currents are worst in the last gaps. Here are two plots for HV current draw vs unix-timestamp, when the channels were at full voltage, (most, but not necessarily all of that time, with beam in the machine) for a chain without broken wires, and one chain with one identified broken wire. Note that col-z info is in log-scale..

Here you see a verification of (1+2.5n)*4.5 rule;

Left: most of all values are around 5 μA

Right: most of all values are around 3.5*4.5 = 16 μA





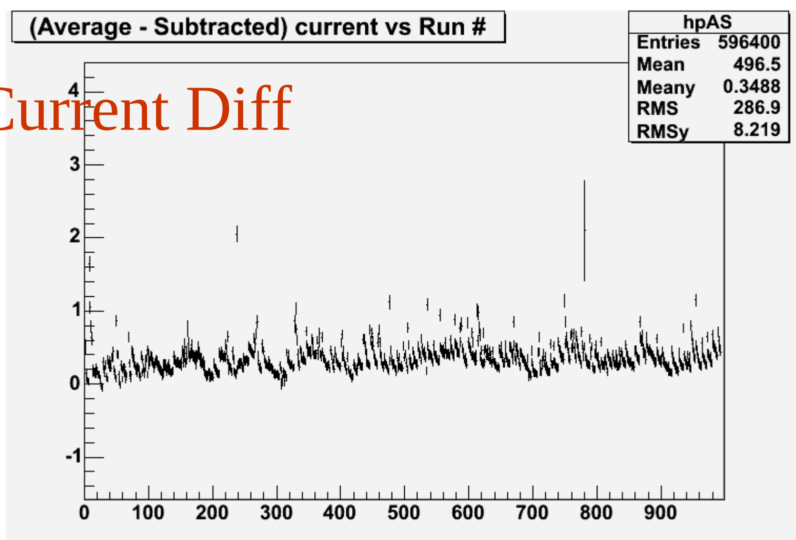
Current

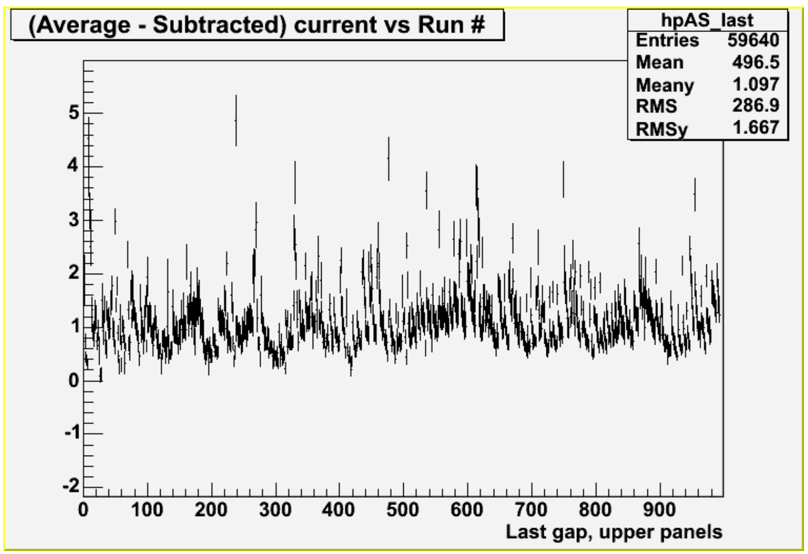
Unix Time

(Average – No_beam) current : run5pp

Here I have subtracted off the typical operating current that we get for cosmics, i.e. when there is no beam. [This is what we use for our HV GUI, to see beam-related current]

Only a slight average increase in current is seen, even for last gap upper panel chains, i.e. situation is not too bad.



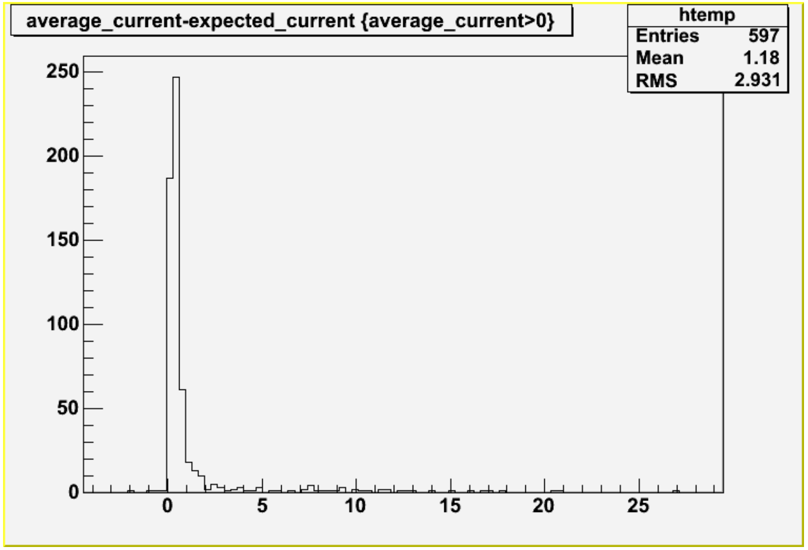


Run-Index

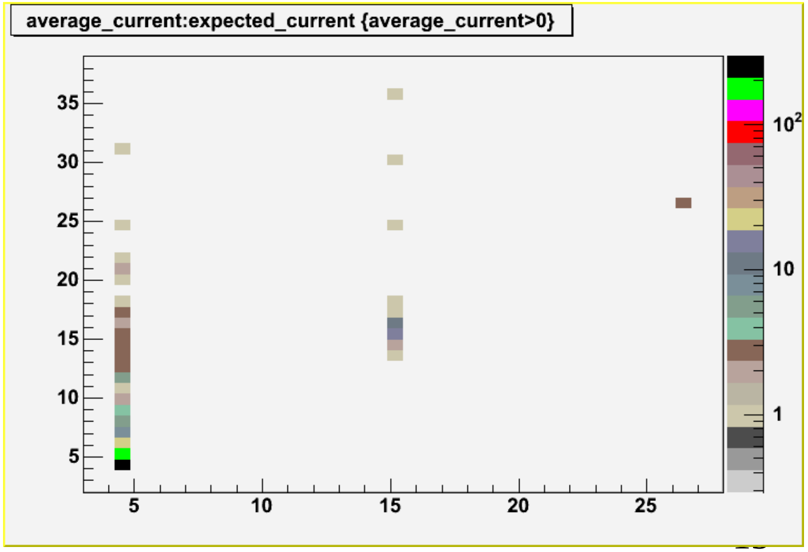
(Average - Expected) current – run5pp

First and last run in run period. Expected current is from a list of broken wires determined from current draw at 100 V.
~18 chains (out of 600) display significantly higher currents than expected – same for both runs, some have known issues.

Average – Expected Current



Average vs Expected Current



(Average & Expected) current – run5pp

List of unexpectedly high currents (18 out of 600 chains):

arm	gap	panel	orient	chain	aver	expec
1	0	2	1	1	16.07	4.40
1	2	2	0	4	24.51	4.40
1	2	2	0	6	37.34	15.40
1	2	5	0	2	14.64	4.40
1	3	5	0	6	29.16	15.40
1	4	2	0	4	16.56	4.40
1	4	2	0	5	20.89	4.40
1	4	2	0	6	26.85	4.40
1	4	2	1	4	16.55	4.40
1	4	3	1	4	14.87	4.40
0	0	0	0	6	16.33	4.40
0	0	3	0	1	23.30	4.40
0	0	3	0	4	30.65	4.40
0	0	5	0	1	15.94	4.40
0	1	0	0	2	18.86	4.40
0	1	3	0	4	16.27	4.40
0	1	4	0	3	14.41	4.40
0	4	5	0	6	15.57	4.40

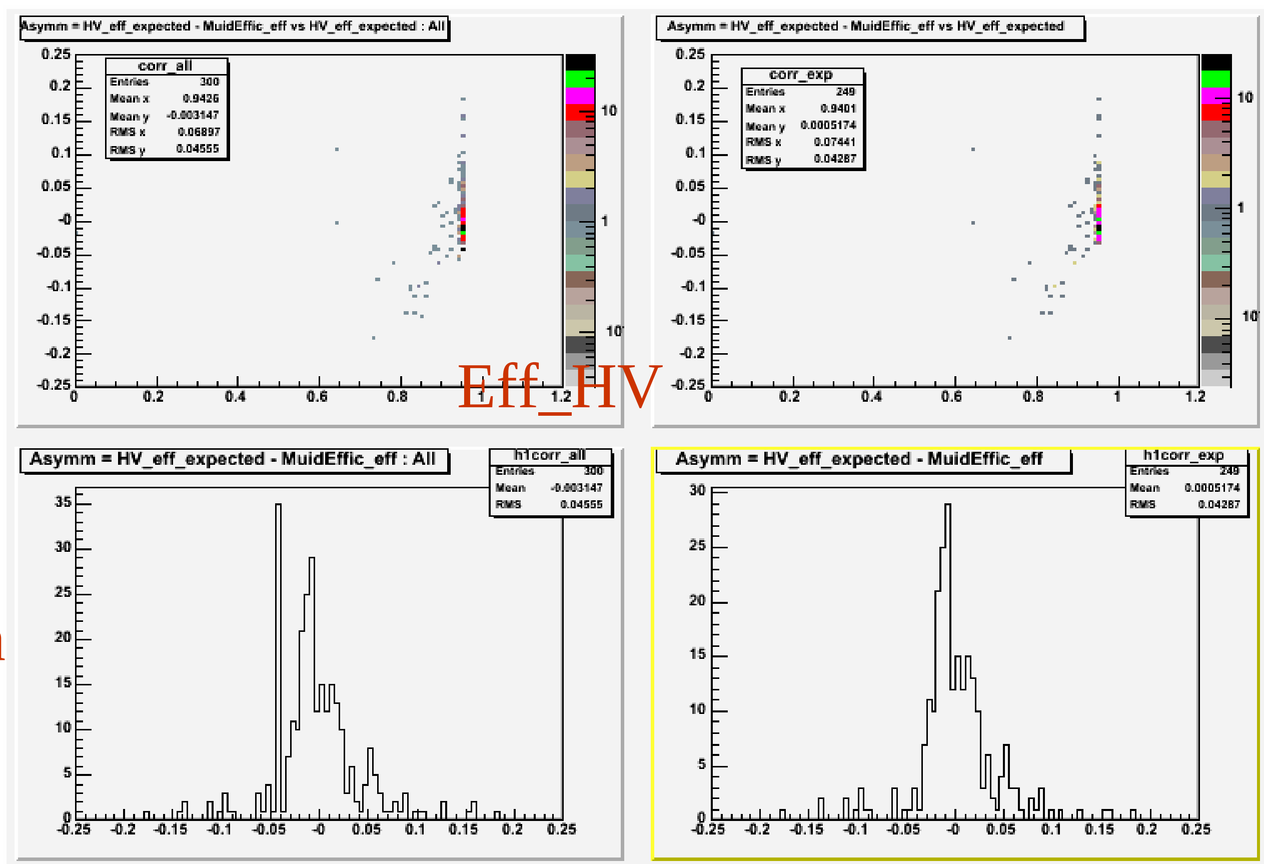
These were high with and without beam, at operating voltage. Again, some are on Vince's 'known suspicious' list.

Results

A comparison between HV method (for run 179846) estimates and the MuidEff estimates (all of run5pp), is below. The results for most HV groups are within a few %. For the !(All) versions (right plots), MuidEff estimates with errors > 10%, or errors==0 (MuidEff==100%) have been excluded.

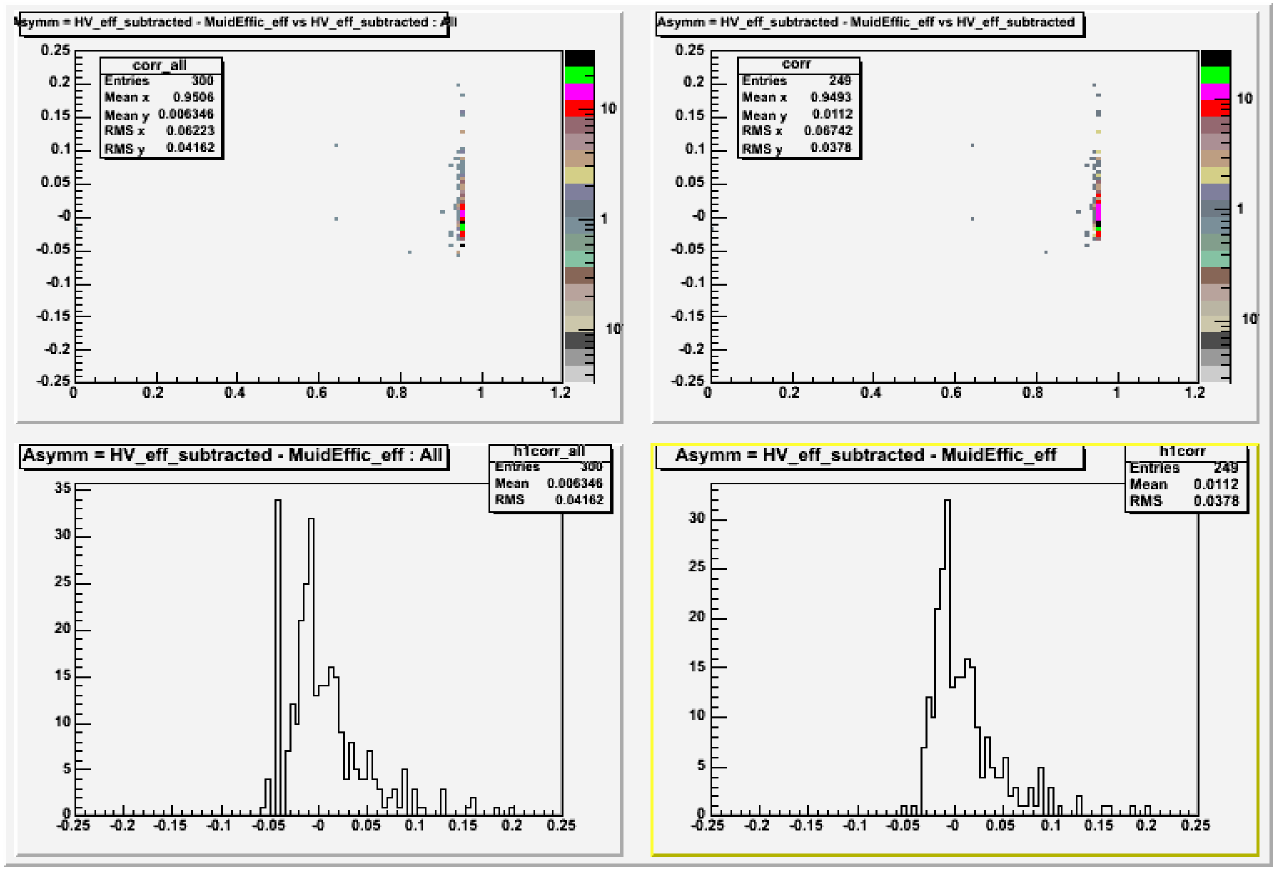
Asymm

Projection



Results II

Same as previous slide but here using *Average – Subtracted* (no beam current) to determine voltage sag instead of *Average - Expected*. This perhaps does a better job for the ‘suspicious’ chains.



Plan ahead

Thanks to the work of MinJung, DongJo and others, we have the run-grouped HV current draw info ready for use.

We will compare the results more closely with MuidEff./Colorado method results, for this and other datasets, over the next few weeks, and try to understand the discrepancies for the some tens of chains/groups where the results do not quite agree (yet).

And fully document everything, check macros into CVS etc..