Detectors discussion: needs and challenges

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Results from commissioning data

Some successes in commissioning run, various worrying results

Significant concerns about triggers:

- Very high backgrounds
- Lower than anticipated efficiency and never-resolved oddities in end-to-end time difference plots seen in pre-installation commissioning

Significant concerns about GEM detectors:

- Unexpectedly high current draw at 1.5% duty factor meant beam current could not be turned up to nominal values
- Various occasions of sparks developing suddenly in GEMs that had been stable for a while
- Apparent low efficiency, compatible with preliminary observations in the lab

Without all these issues being fixed, unclear what a viable path to a 30 MeV physics run looks like.

Requirements on triggers for next run

Backgrounds: need to control both singles rates and coincidence rates better.

- One possibility is a second layer of scintillator to require coincidence: however, will also see same rates, and even higher if it's a single paddle
- More effective if possible will be increased shielding of detectors. Lead below frame will help; more concrete between experiment and upstream beamline may help, but must be tested
- Coincidence rate should be improved by shortening coincidence window as much as is safely possible

Odd end-to-end timing plots; weirdly low efficiency measurements

- Efficiency can be checked using collision data. If still confusing, might have to uninstall and re-measure in the lab, or reanalyze old data. If still < 90%, not sure what we will do ….
- TRIUMF team will continue to tackle these problems, but can't get central resources to support much further development without a convincing path forward for tracking detectors.

Requirements on tracking detectors for next run

Requirements GEMs must meet in order to be able to handle future runs:

- Be able to handle data collection with nominal beam structure: ~300 μA with 95% duty factor, and whatever current draw that entails
- Demonstrate a reasonable efficiency (over 90% hit reconstruction efficiency end to end) that will allow a reasonable fraction of tracks to be reconstructed and the data to be properly exploited
- Not spark/die at the rate at which they did this fall, or we will not be able to complete the run with four working GEMs

Nice-to-haves:

- Reduction of noisy channels/dead channels/APV weirdness ➔ in progress, thanks Manju!
- Ethernet-based signal readout, if shown to perform better than HDMIs

Realistically, if we can't get them to meet requirements, need to begin considering backup plans.

Information needed to consider each criterion met: Duty factor/current draw

Need:

- Estimate of correlation between beam current and amount of activity we see in GEMs (hits/clusters, observed current draw, total amount of charge measured including noise, maybe?). Take from combination of recorded data and test stand at Hampton?
- Estimate of amount of current draw at which GEM would see uncontrollable breakdown begin (i.e. point at which this is actually dangerous for them).
- Understand what impact increased current draw below sparking point has on effective voltage/gain
- Demonstrate at least mathematically, ideally in lab, that running at ~95% duty factor will be possible

Michael mentioned Hampton team has access to a test beam (?) where this can be experimentally examined: this is great news, please test and keep us informed.

Information needed to consider each criterion met: Efficiency

Need:

- Understanding from the literature of what efficiencies should be possible with GEMS and under which operating conditions
- Understanding of raw data at event by event level to make sure we can comprehend origins of strange structures in data and remove or account for them
- Improved efficiency measurement in central code that we can use to get reliable measurements from commissioning data as well ➔ in progress, thank you Dulitha!
- Set up code to parse data taken in GEM lab in the spring, which is our cleanest measurement taken. Extract reliable efficiency measurement. ➔ Possibly in progress?
- Improved clustering for reliable efficiency measurement in e-hall data

TRIUMF will help with clustering algorithm reoptimization. Possibly we can contribute to some of analysis work, with new master's student joining this fall. Sounds like Hampton has some code potentially ready for analyzing GEM lab test stand data?

Information needed to consider each criterion met: Sparking/shorts fixed

Need:

- Understanding of reason for sparking and/or shorts observed.
  - Think the Hampton team are off to a good start here with the ones that were sparking from screws: they already seem significantly improved
  - Repeated shorts in sector 1's as well as GEMs that have undergone taping and are still sparking suggest additional causes at play: need to believe we are addressing these
- Once repairs are thoroughly understood, remaining GEMs can go through same process

What alternatives do we have if we can’t meet these criteria?

First choice should always be to **keep using the GEMs** in understood and repaired state. But if this doesn’t pan out we need to have some plan B’s. Brainstorming:

- microRwell detectors. Multiple ways to obtain and/or to incorporate them:
  - 1) Jan thinks there might be some available at SBU (to investigate)
  - 2) Kate can investigate how much it would cost to get some from CERN. Could be an upgrade in existing GEM frames, replacement of detectors while keeping readout electronics, etc.
- Scintillator strip detector
  - MIT will investigate and see if this is viable
- ITk modules (silicon strips)
  - Laura and Kate can investigate and see if this is viable
- Other silicon options?
- Other new technologies?

Decision process

To make decision on GEMs and/or replacements, need at least one of:

- Positive results for agreed upon requirements for GEMs, or
- Viable alternative proposal(s) with clear budget and realistic idea of timeline and person power demands

Not easy!! Would propose something like:

- Divide up the various investigations that need to converge. Mostly Hampton for GEM work, with some degree of support for efficiency measurements. SBU, MIT and TRIUMF each investigating one or more alternatives.
- Define non-scientific inputs that are needed to make decisions (e.g. budgets for options, USA grant results, etc) and what are make-or-break numbers.
- Collect together all the relevant information

Fix day-long meeting (around September 1?) to discuss results and make a collective decision

Requirements of a sufficient tracking system

Criterion	Requirement
Efficiency	> 90% per layer
Sustainable hit rate	Up to 8.5 MHz at 50 MeV (see TDR) and 3.5 MHz at 30 MeV
Readout time	Not longer than GEMs (200 μs)
Integration time	Not longer than GEMs (150 ns) unless individual hit timing on the order of 50-100 ns is available to resolve ambiguity
Material thickness	?? Potentially set a threshold based on mass resolution degradation in simulation studies

Based on meeting run conditions outlined in TDR, which assumed GEM specifications in some cases. Failure to meet any of these points will increase run time required to collect dataset, unless one is improved by the same degree that another is degraded. In most cases run time increase is roughly linear, though material thickness will have nonlinear impact probably needing simulation to predict.

Requirements of a sufficient tracking system

Ideal goal: have a system we could put in place on experiment in 1 year

Mandatory goal: something that is proven to work and complete in 2 years

Not enough information yet to know how various options will line up. Some rough thoughts:

- GEM repair/refurbishment is **top priority** if looks like it can succeed
- Scintillator based detector: Need a firm idea of cost/who-does-what/etc, but semi viable to have it built in a year-ish. Might meet requirements, but sensitive to neutral backgrounds.
- Silicon: probably viable within a year if we use ITk modules, not fast if we need to develop something new. Likely killer is material thickness, especially with read out chips on top
- microRwells: person-hours and cost depend a lot on what fraction of existing system is kept, but probably so do outcomes. Lots of uncertainty here.

Discussion