Plans for Tracking Dectectors

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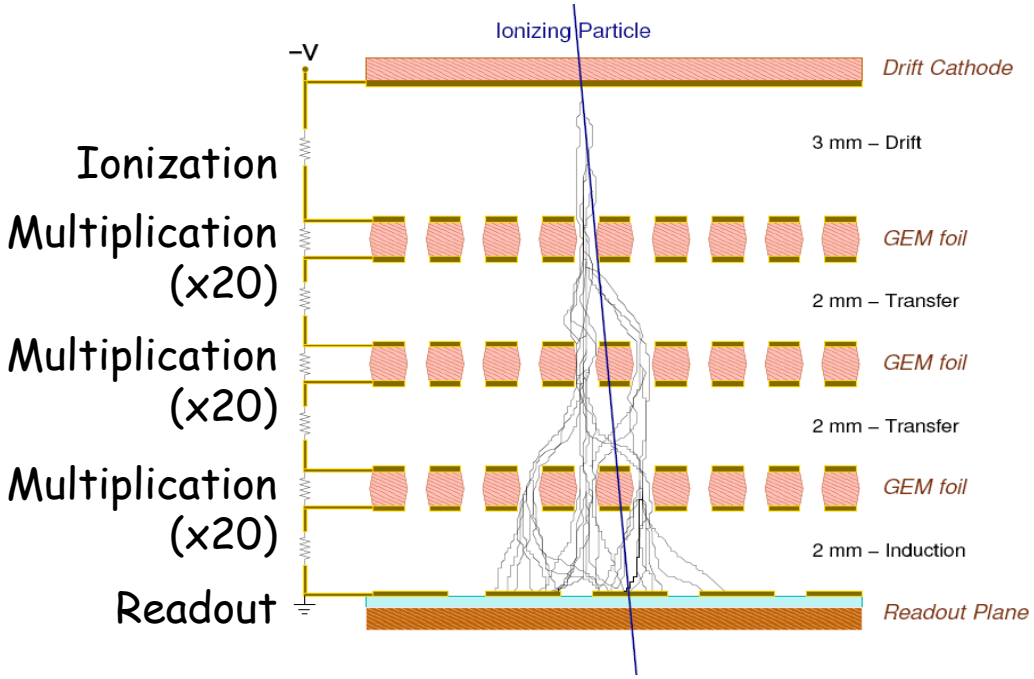
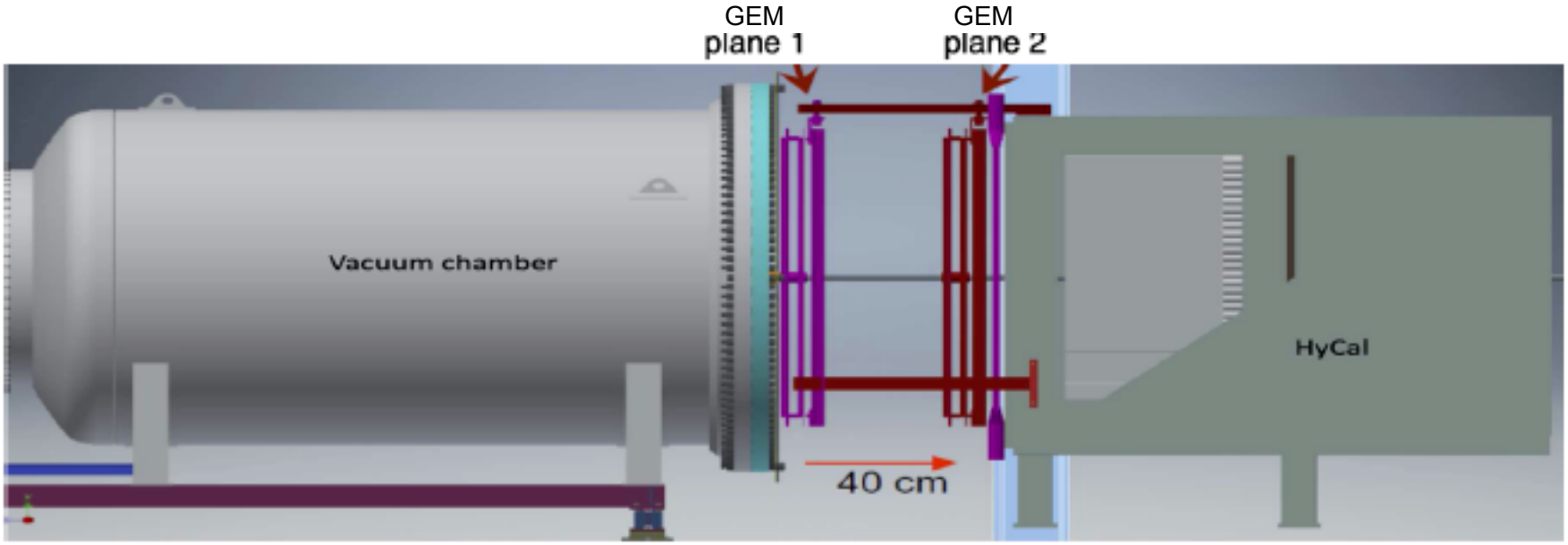
for the PRad collaboration

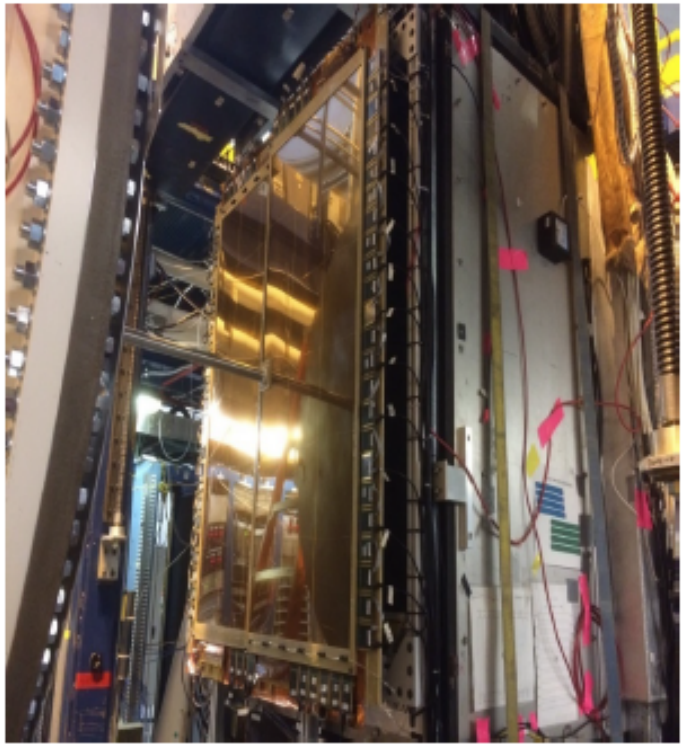
PAC recommendation:

The μRWell technology has never been used in a running experiment, and its reliability and radiation hardness have not been fully demonstrated. Since the main reduction on the total uncertainty arises from the addition of a second tracking station, the PAC recommends considering a second GEM station instead, further relying on the present GEM technology to reduce the risks of jeopardizing the final physics goal.

We fully agree with the PAC that large area μRWELL detectors have not been used in experiments yet. Given this, we plan to have two layers of GEM detectors for PRad-II.

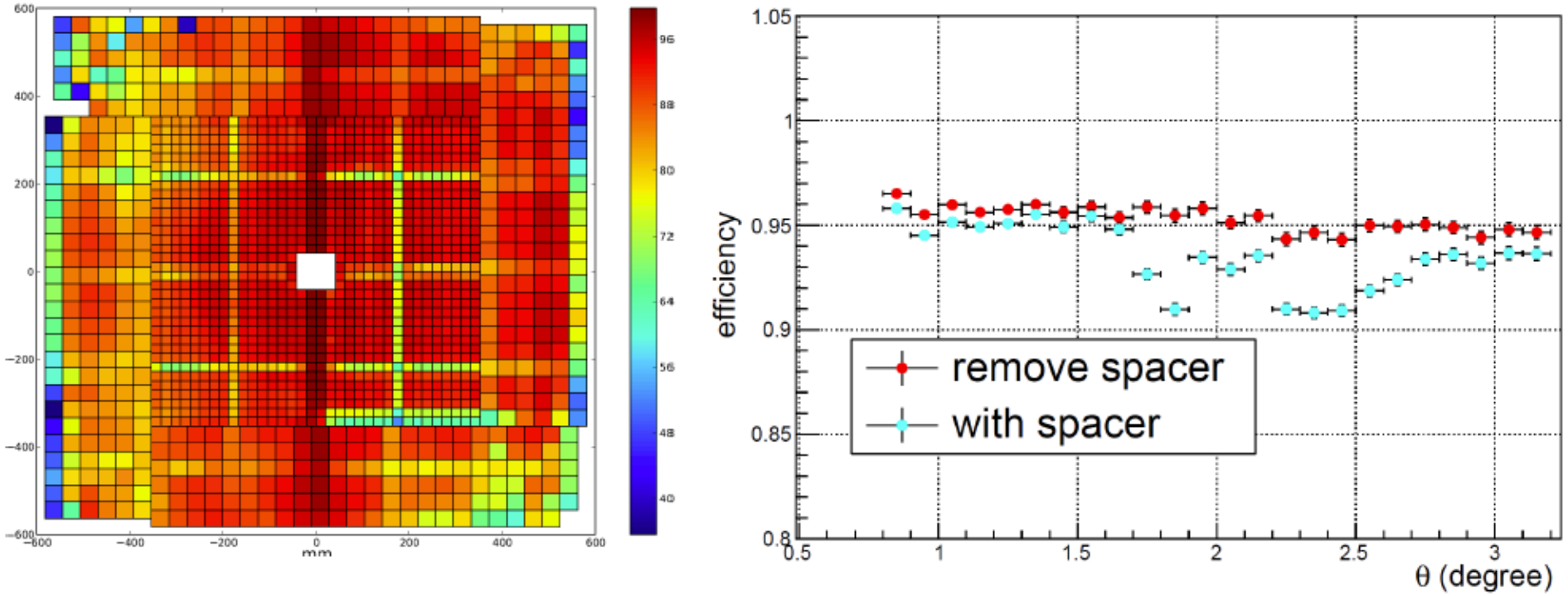






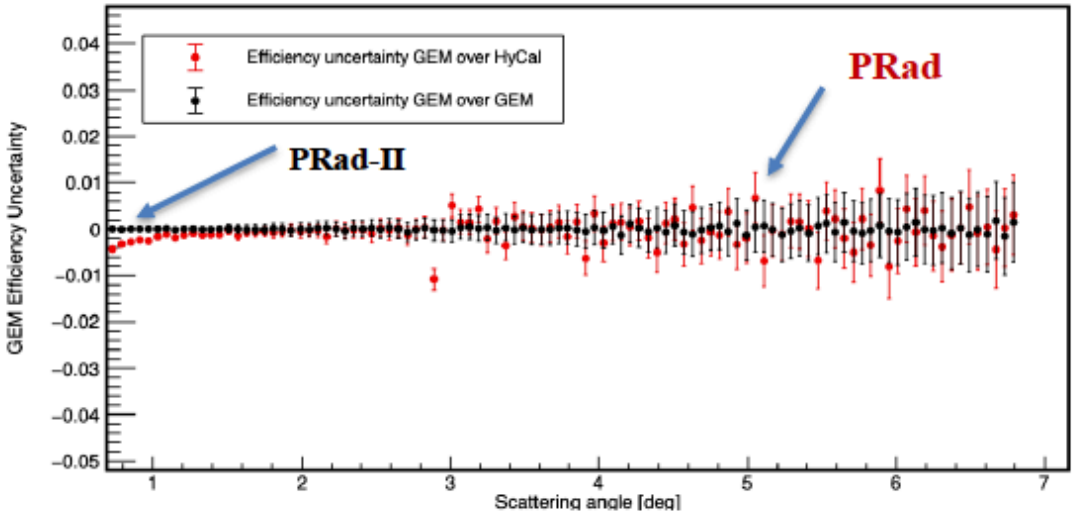
- Form a GEM tracker with 2 GEM layers separated by 40 cm
- 5 cm level vertex resolution
- GEM efficiency mapping with high precision

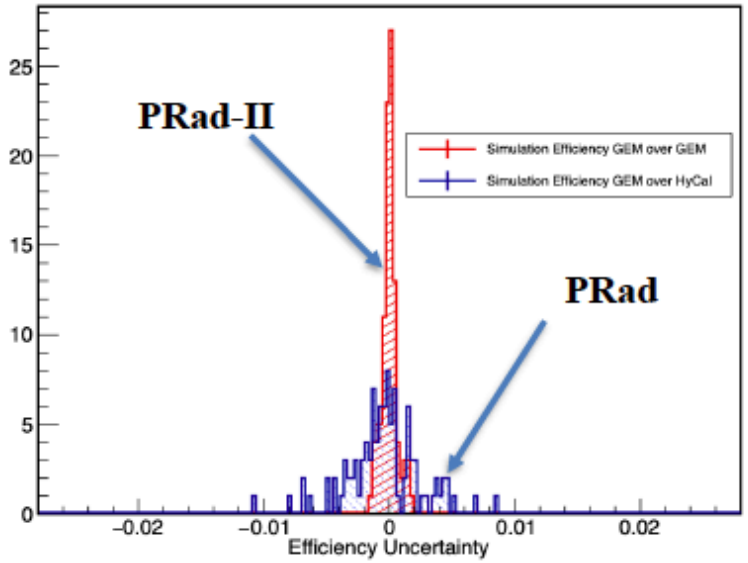
Better determination of efficiency profile



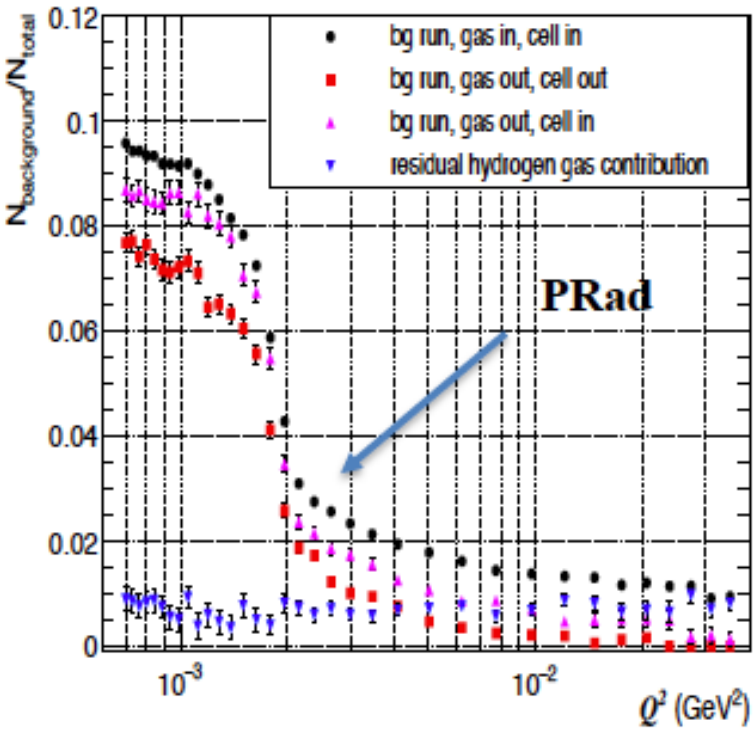
- In PRad GEM efficiency was determined w.r.t HyCal: Due to not so great position resolution of HyCal, cm level inefficiency bands
- Had to use bin-by-bin method normalization for $\theta<3^{o}$; leading to increased uncertainty.
- A ~ 0.1% level measurement of GEM efficiency would allow the integrated Moller method to be used over the entire angular acceptance of the experiment
- This is possible with second GEM layer: measure efficiency with respect to each other

Better determination of efficiency profile

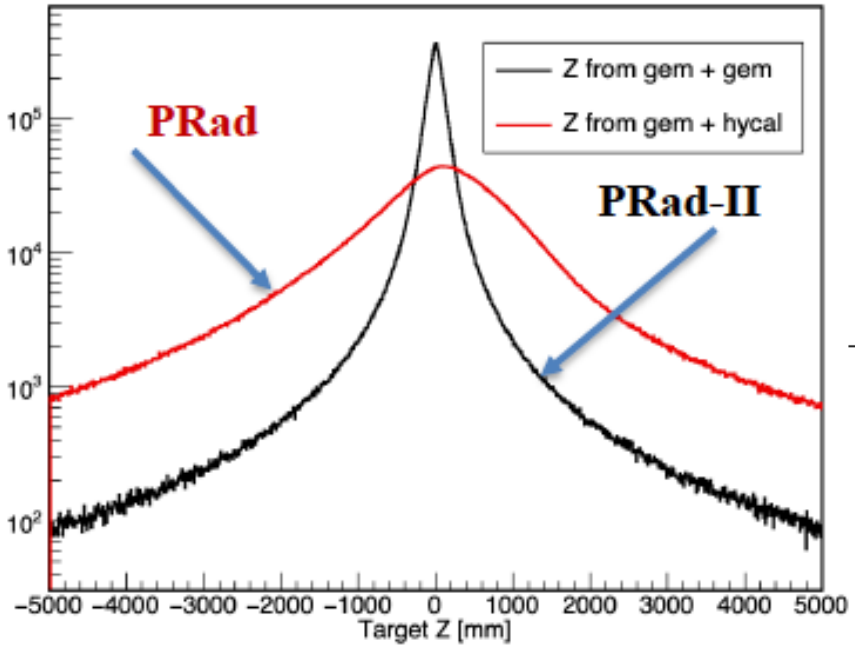


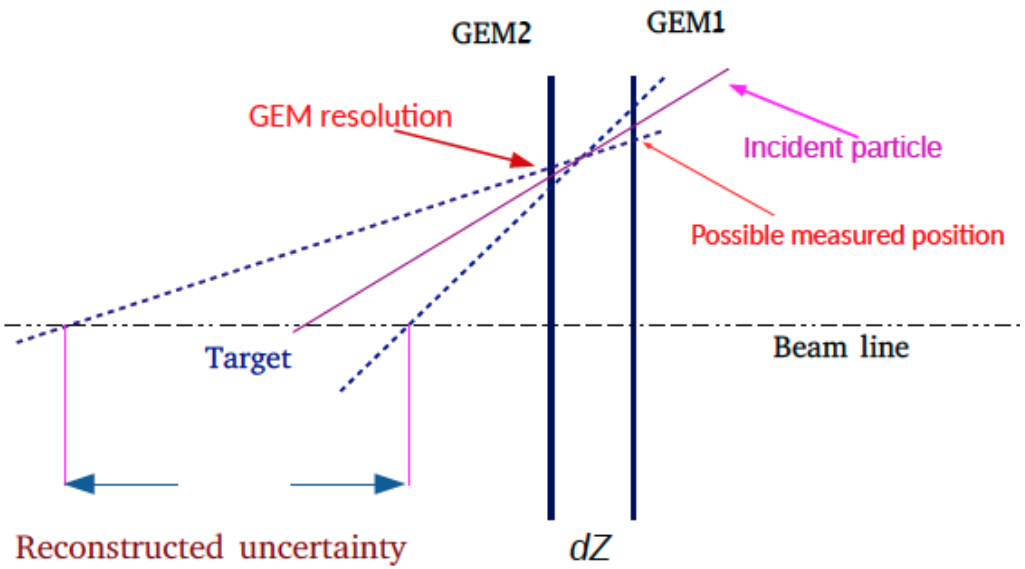


z-vertex determination



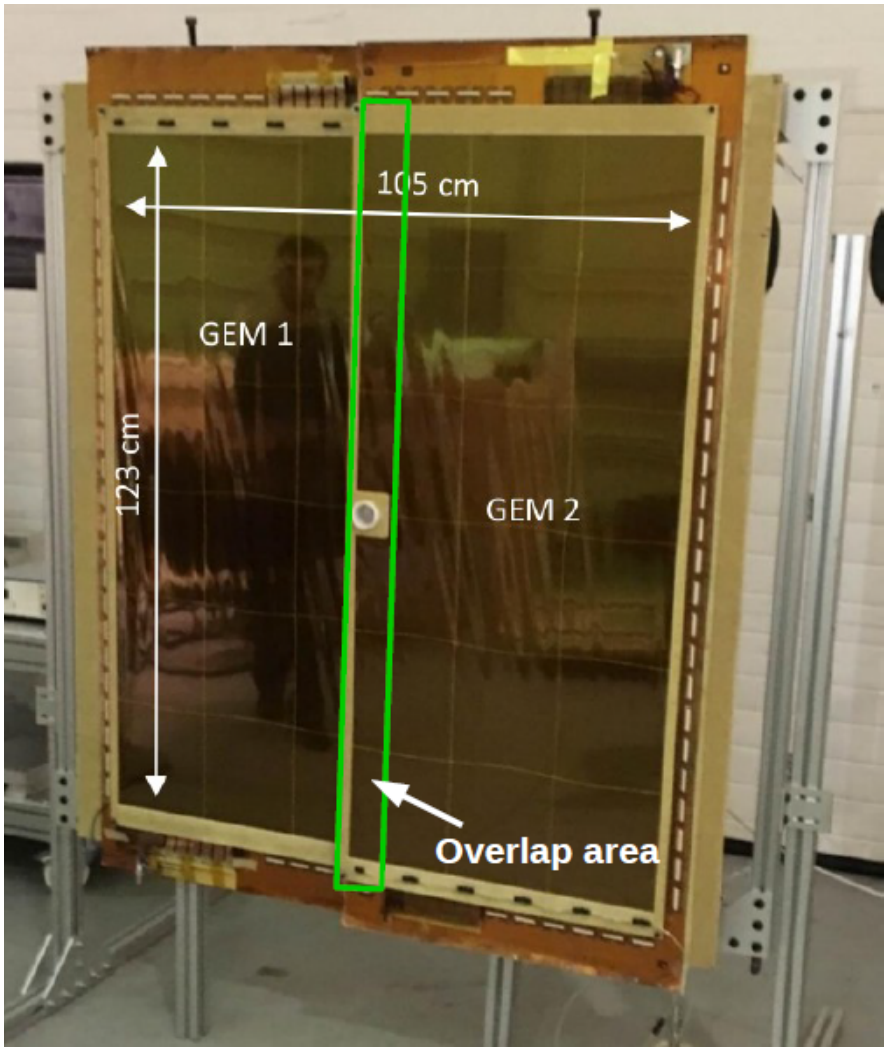
- Beam line background, detected at forward angles, was a cause of dominant uncertainty in PRad
- The two GEM layer tracker provides 5 cm level vertex resolution.
- Allows elimination of much of the beam line background

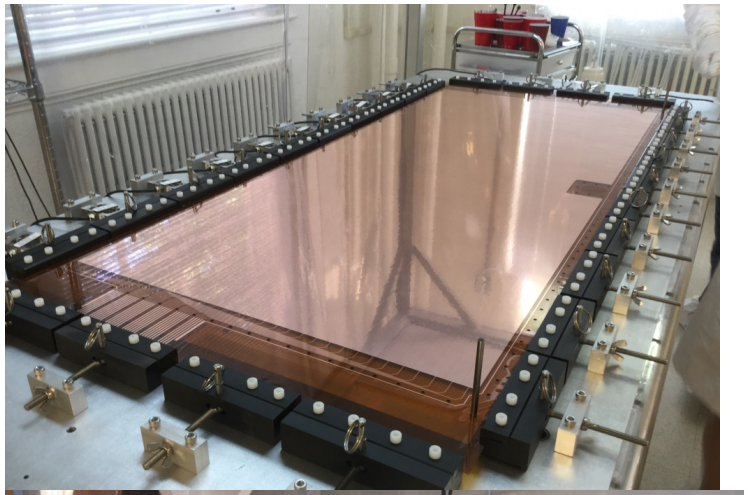


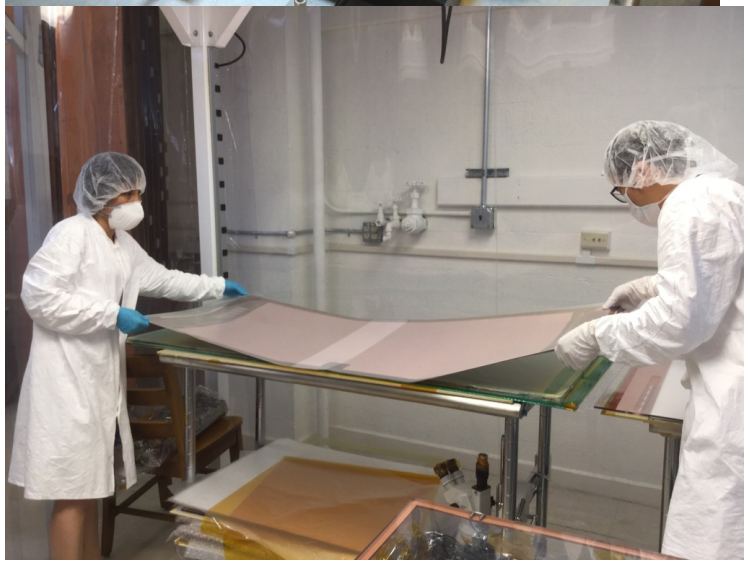


Plans for the GEM tracker

- Build 2 new GEM layers: 4 detectors based on the same design as for PRad; active area 55 cm x 123 cm, with a hole for the beamline.
- Keep the two original detectors as spares
- Build at UVa; expect to complete in one year from start.

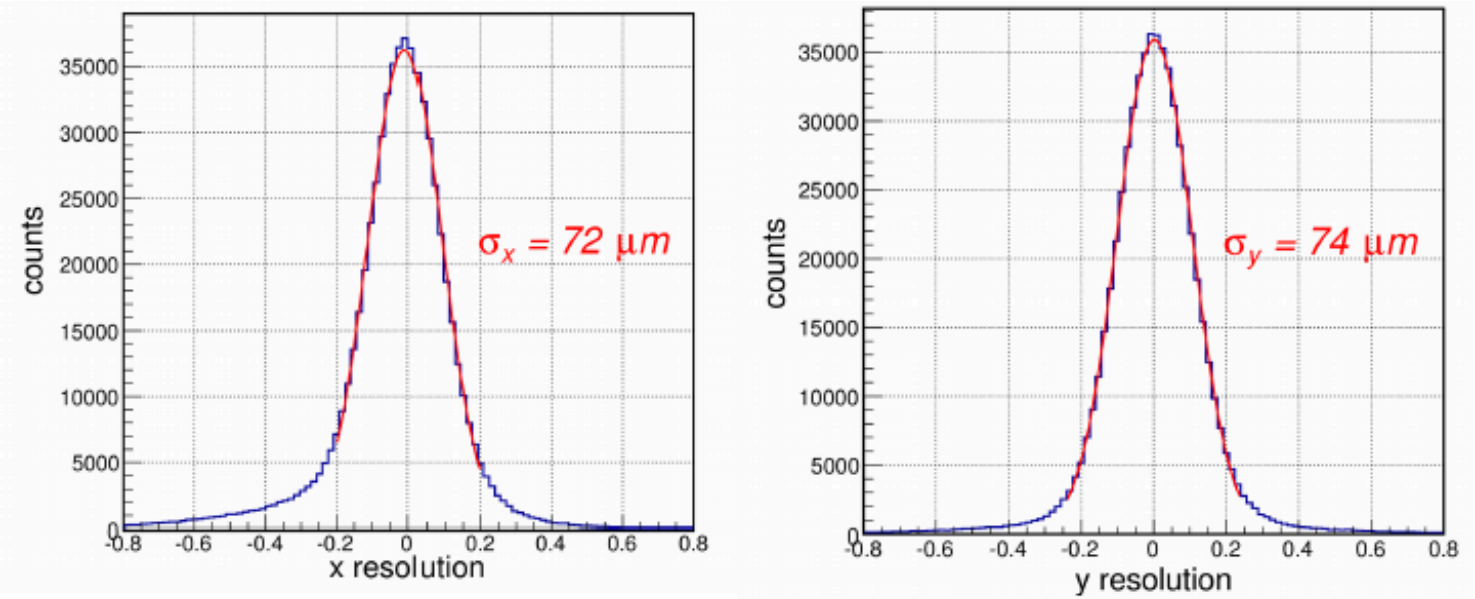


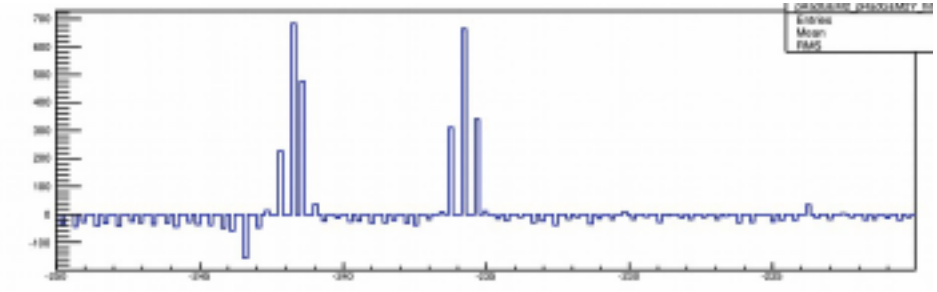




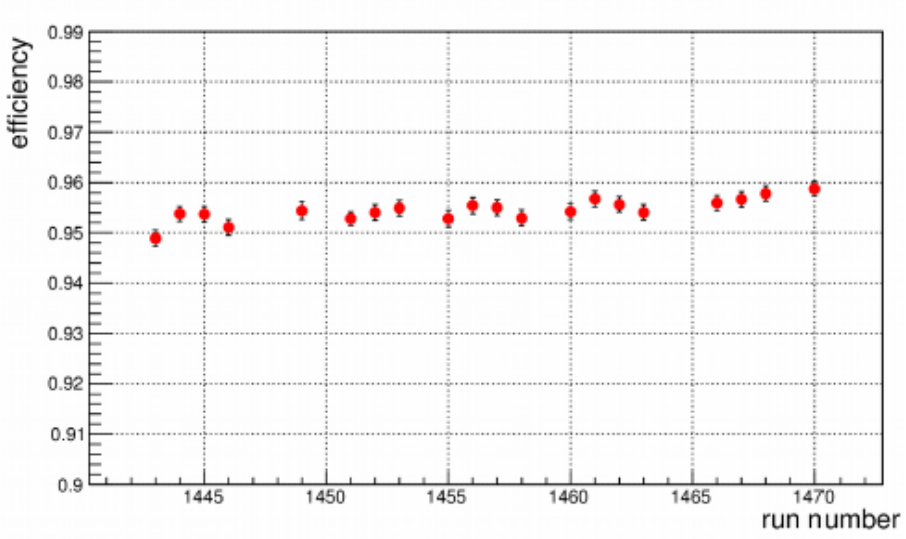
PRad GEM performance

- Excellent position resolution and stable performance throughout the run





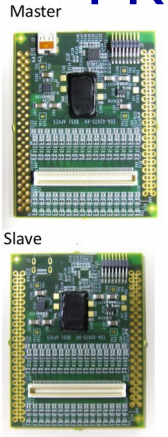
Typical GEM hits from PRad event. horizontal axis is strip number while the vertical axis is strip ADC value



PRad GEM DAQ

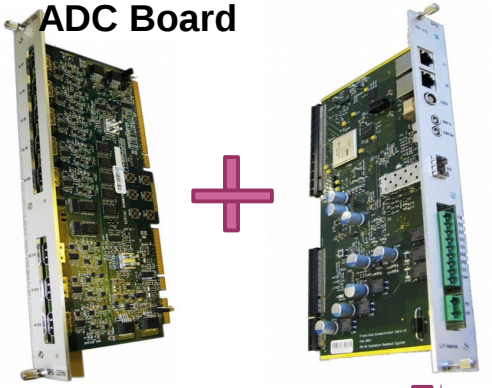
GEM

Panasonic Connector



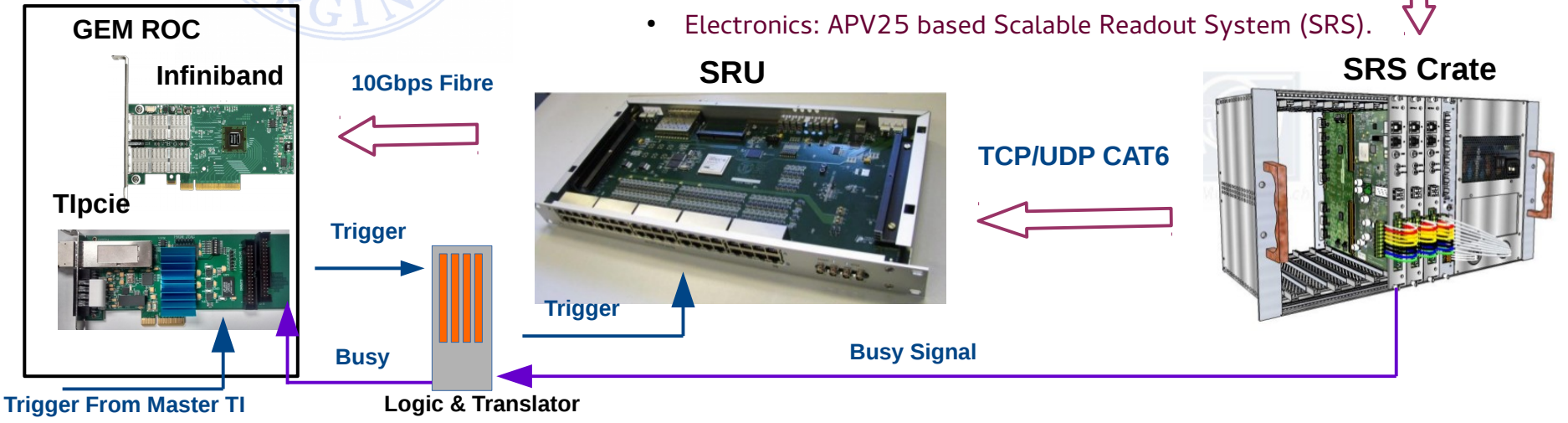
HDMI Connection

Data Flow



- Normal event rate: ~ 4kHz
- 2 SRUs for 2 GEM chambers
- 8 FEC + ADC's
- 72 APVs (a total of 9216 channels)
- 3 time sample
- Normal data transfer rate per ROC: 150~250MB/s

- DAQ software: Hall B CODA.
- Electronics: APV25 based Scalable Readout System (SRS).

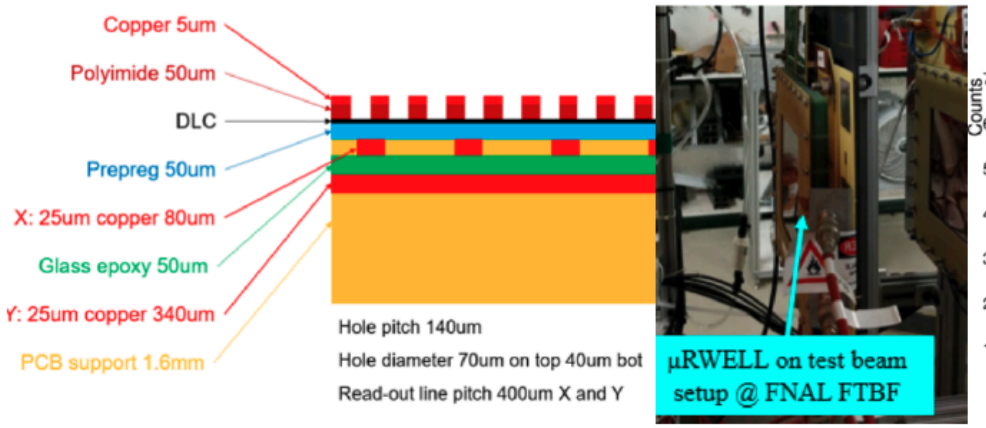


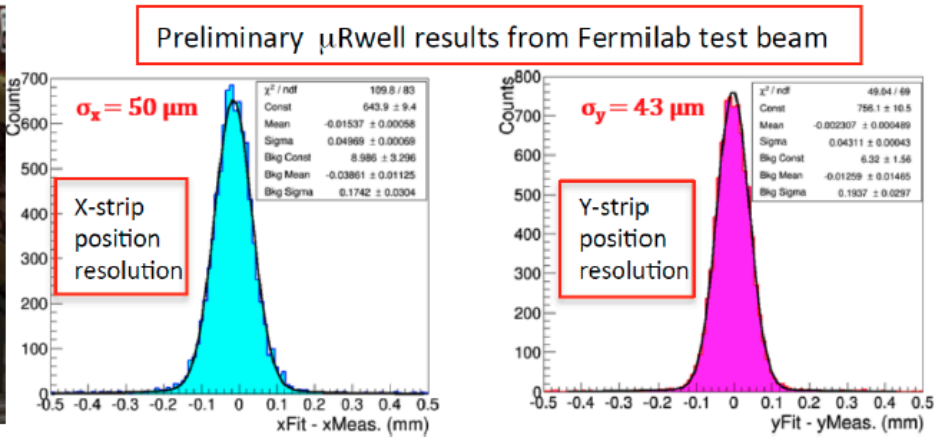
GEM DAQ for PRad-II

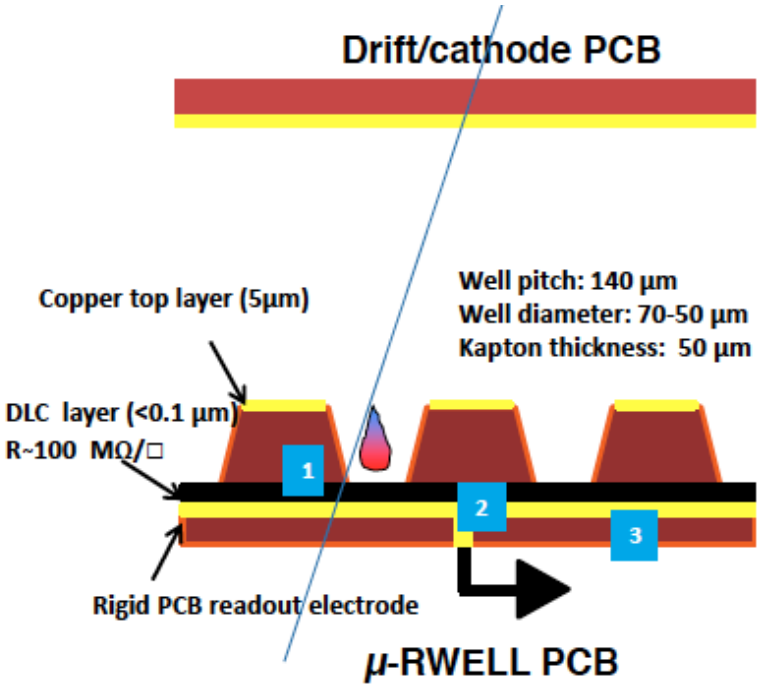
- PRad–II will need 20 k channels including spares
- We only have 10 k SRS channels.
- However, a large set of APV channels gathered for Hall A experiments:
  - SBS has a set of 145 k channels
  - MOLLER will have a set of 15 k channels
- Depending on when PRad runs, we could borrow the required number of channels from one of these experiments.
- The fall back option is to get a new set of electronics for PRad-II.
  - Currently GEM electronics development based on SAMPA and VMM chips ongoing at Jlab:
  - Based on this we can build a new set for PRad-II in two years.

- PRad trigger rates were up to 4 kHz
- Online zero suppression and high rate data transmission techniques were developed for SBS: implemented and tested right now.
- Would allow trigger rates up to 20 kHz for PRad-II

Large Area uRwell development in parallel







G. Bencivenni et al., 2015_JINST_10_P02008

- uRwell is powerful new technology. Compared to GEM:
  - No spacers, so no dips in efficiency
  - easier to build
  - cheaper
  - better position resolution
- Not suitable at very high rates: but not a problem for PRad
- Need to demonstrate stable performance in beam.
- Kondo Gnanvo currently working with Hall B to build a large prototype for CLAS 12 and test in beam later this year
- based on the outcome, revisit use for PRad-II

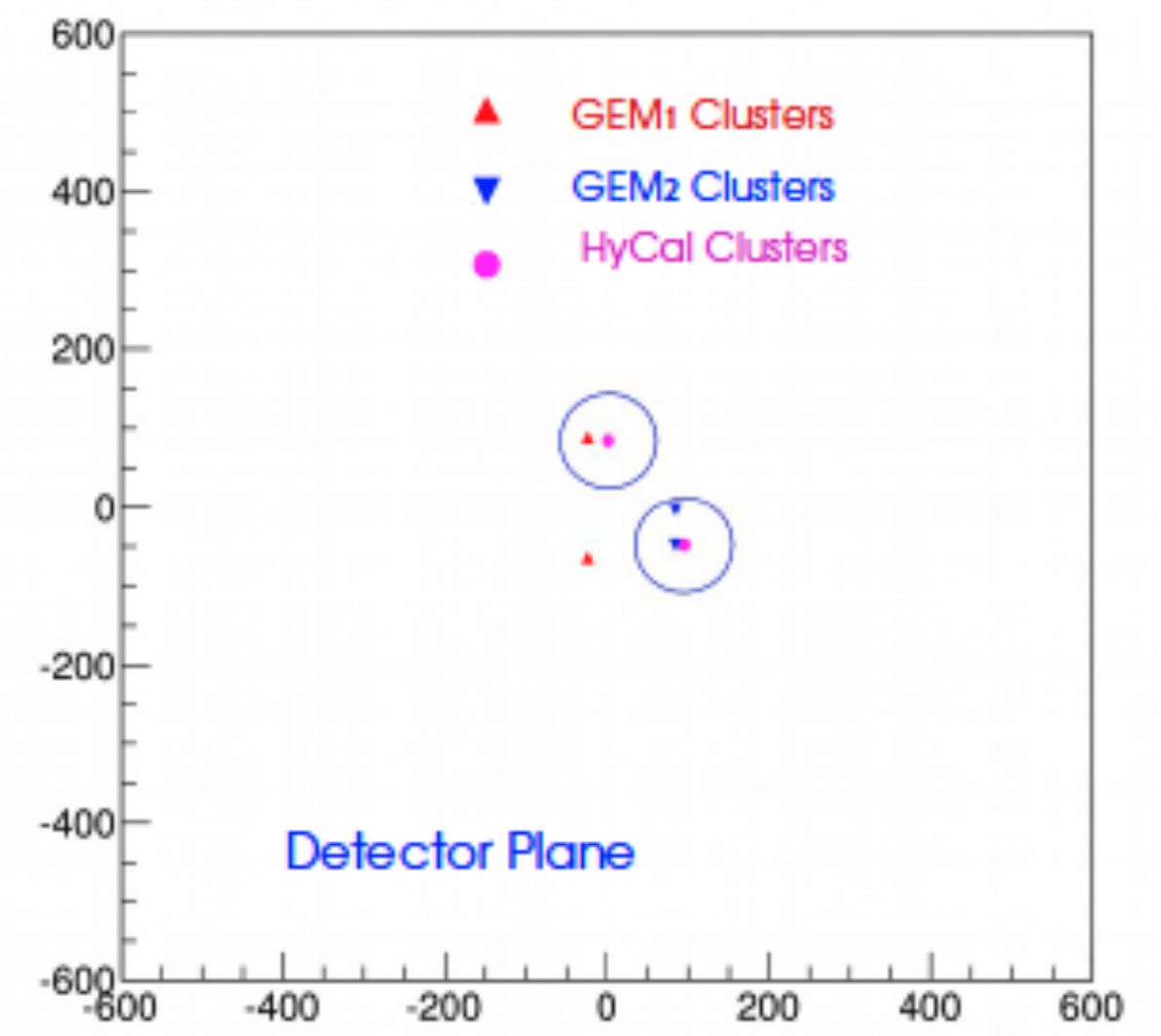
Conclusion

- Following the recommendation of PAC, will put together a tracking system based on two layers of GEMs for PRad-II.
- The two layer tracker will reduce systematic uncertainty:
  - Better determination of GEM efficiency profile
  - Target vertex cuts to remove beamline background
- Build the GEM detectors based on the successful PRad design
- The team and setup in place at UVa: time scale for fabrication ~ 1 year
- Benefit from high rate GEM DAQ developments for SBS and SoLID
- Parallel R&D for uRwell detectors ongoing for CLAS 12 upgrade

Backups

PRad GEM performance

- The high energy electron track in the GEMs identified by matching with the HyCal hit location.



GEM Budget

Item	quantity	Item cost	Total
GEM detector components	4	$35,000	$140,000
Manpower (post-doc years) FTEY	0.5	$72,000	$36,000
Manpower (Grad-student years)	1	$41,000	$41,000
Manpower (Technician) FTEY	1	$78,000	$78,000
Machine-shop time	1	$15,000	$15,000
Total direct costs			$310,000
Indirect costs			$80,600
Total			$390,600

Plus ~ $ 300 k if we are to buy new electronics