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Dark current and radiation measurements at CM-2

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Accelerator: Beam Dynamics Working Group

07 October 2014



Outline

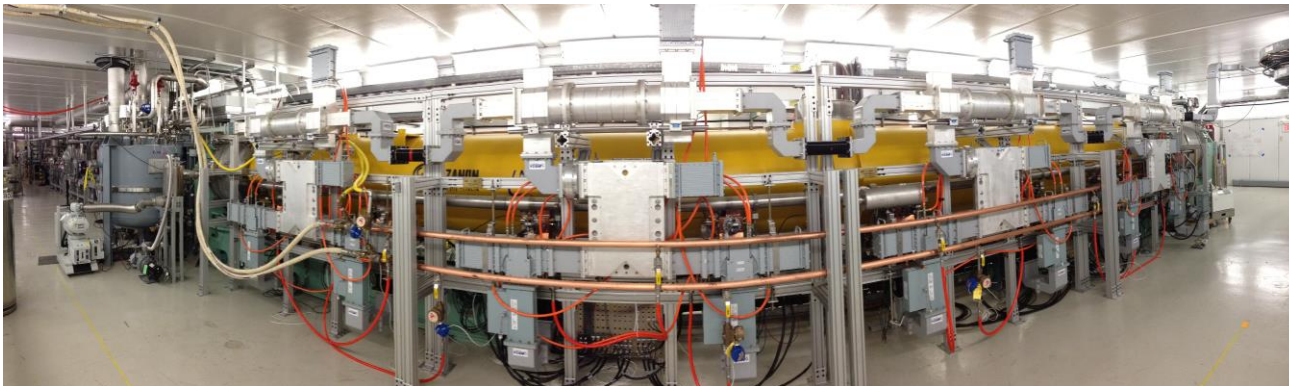


- CM-2 introduction and current situation
- Conditions and layout to make measurements
- Radiation results
- Dark current results
- Conclusions & summary

Introduction/Current situation



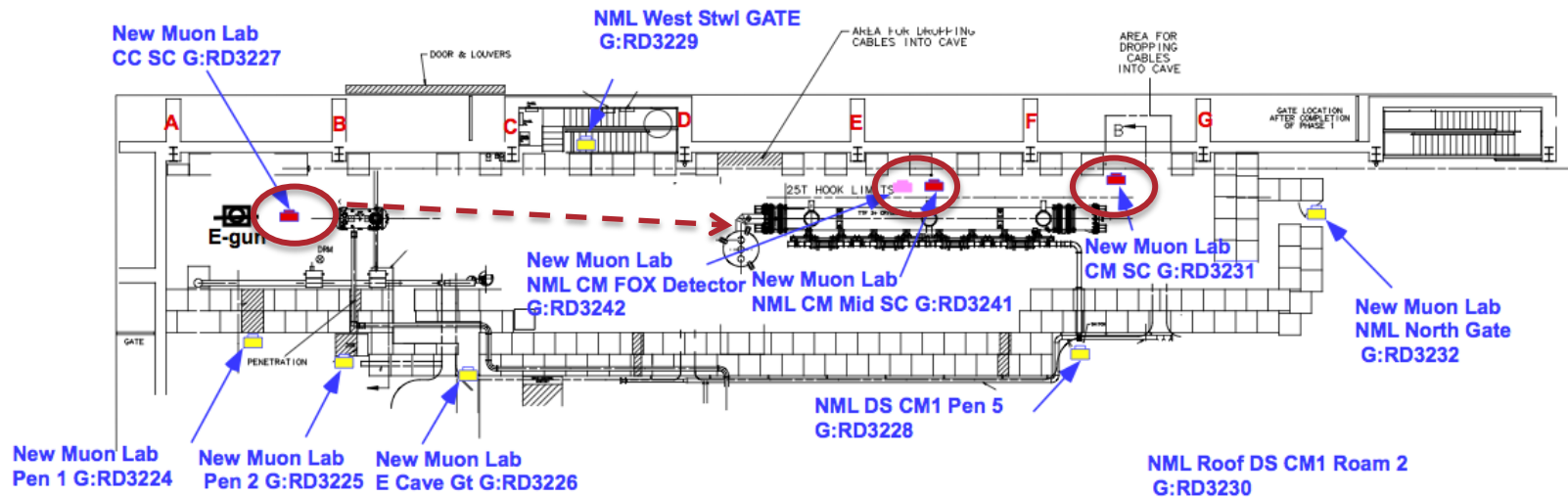
- Second ILC/Tesla style cryomodule installed at NML/ASTA
- Cavities fabricated in industry
- Vertical tests at JLab & Fermilab (35 MV/m)
- Horizontal tests (31.5 MV/m administrative limit) and assembly at Fermilab
- At NML since April 2013, cold since November 2013
- Average gradient per cavity of 31.5 MV/m achieved last week (252 MV accelerating voltage) with all 8 cavities operating



Measurement layout and conditions



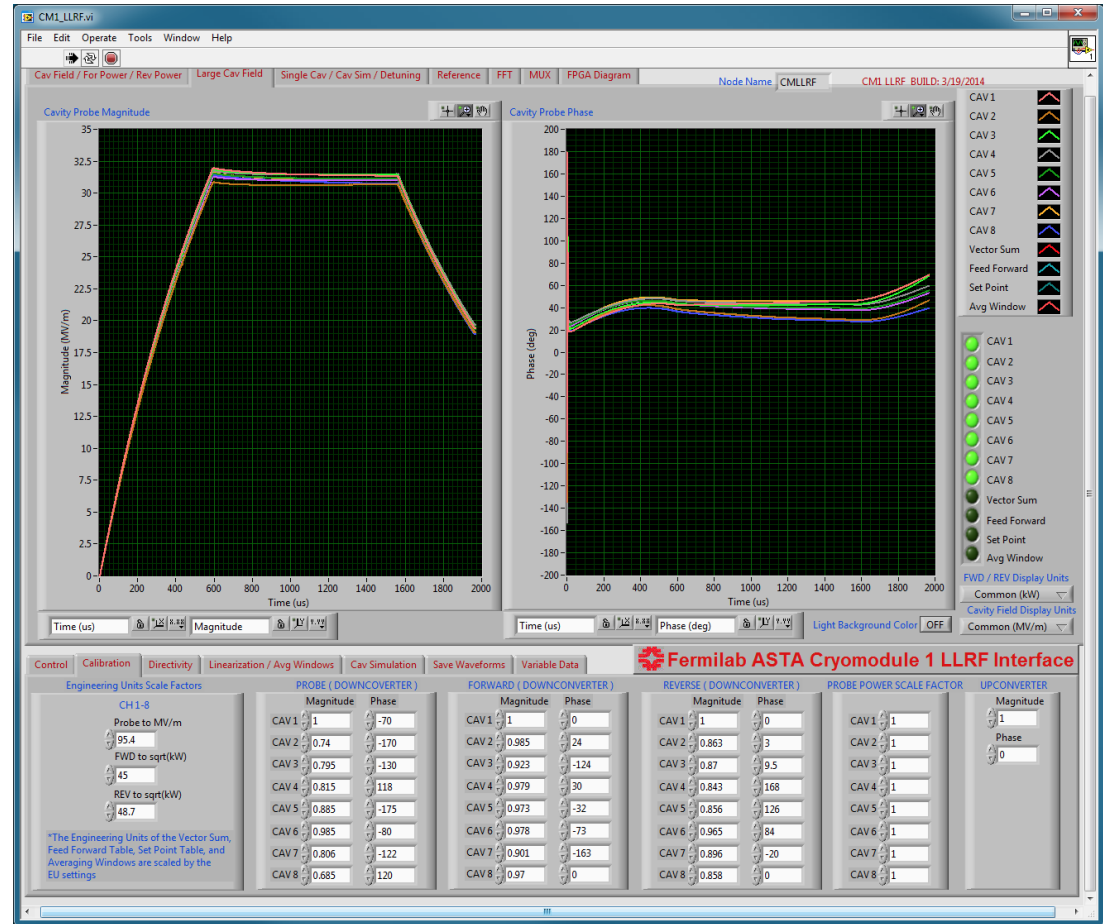
- CM-2 situated in an interlocked concrete bunker
- Extensive set of interlocked ion chambers (yellow) inside cave
- Dedicated detectors for monitoring CM-2 radiation (red, pink)
- External detectors for radiation protection as well



CM-2 operating conditions



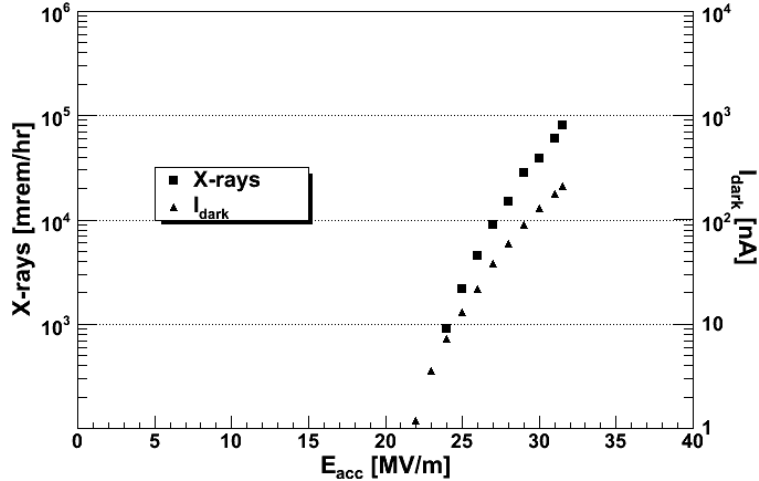
- 2 Kelvin (23 Torr)
- Pulsed operation
- 1.6 ms pulse
 - 590 μs fill + 969 μs flattop
- 5 Hz repetition rate
- Q_L set to $\sim 3.5 \text{ E}6$, variable coupling
- Cavities powered one at a time to characterize performance
- Operating as a unit since 26 September



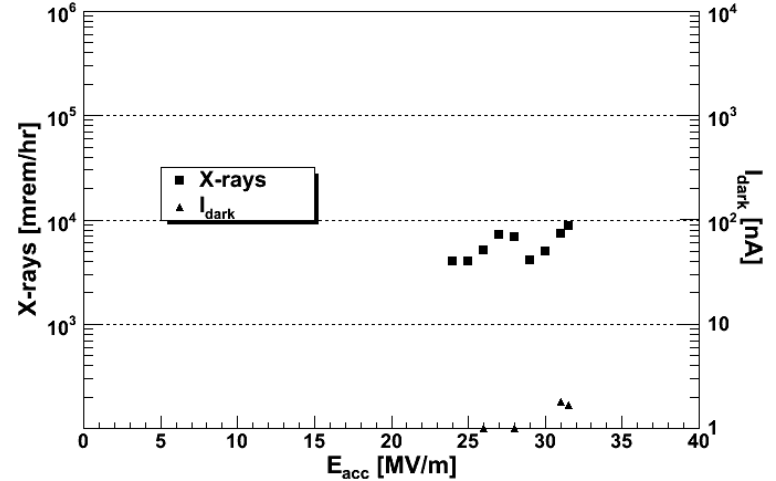
Summary plots (cavities 1-4)



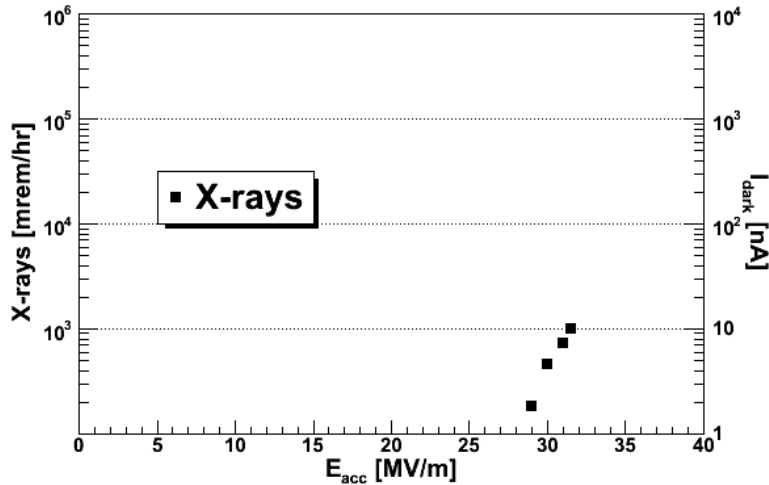
RFCA002_C1 (TB9AES008), 5 Hz, 2 K, 596+969 μ s pulse



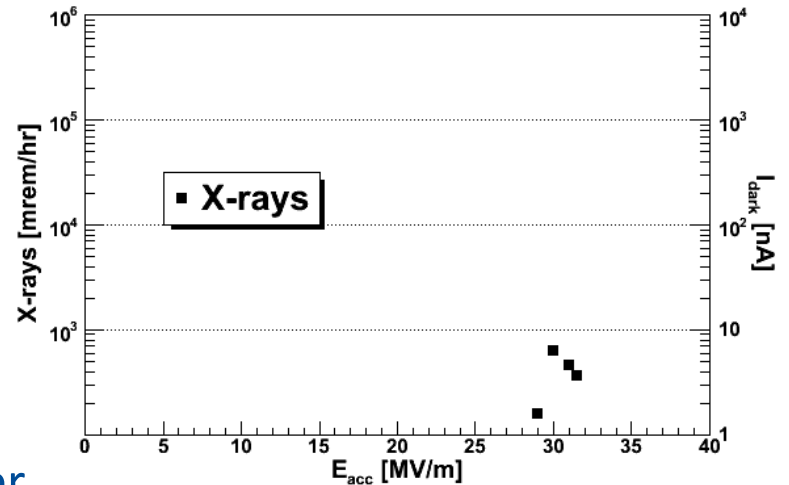
RFCA002_C2 (TB9RI018), 5 Hz, 2 K, 596+969 μ s pulse



RFCA002_C3 (TB9AES010), 5 Hz, 2 K, 596+969 μ s pulse



RFCA002_C4 (TB9RI019), 5 Hz, 2 K, 596+969 μ s pulse

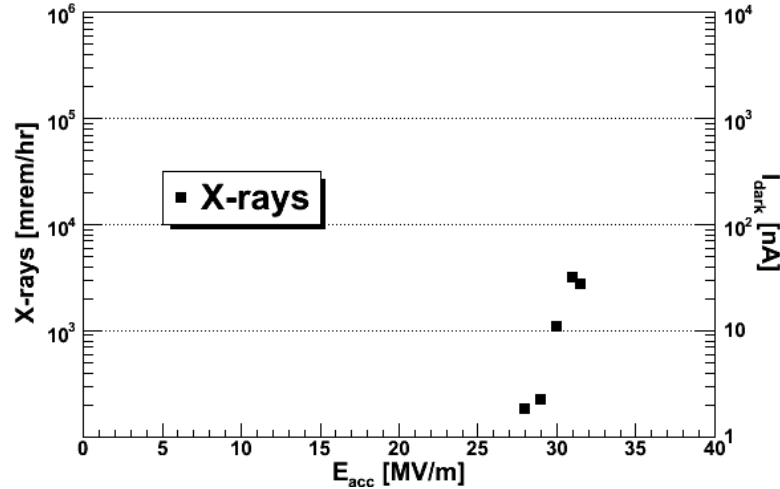


courtesy Andy Hocker

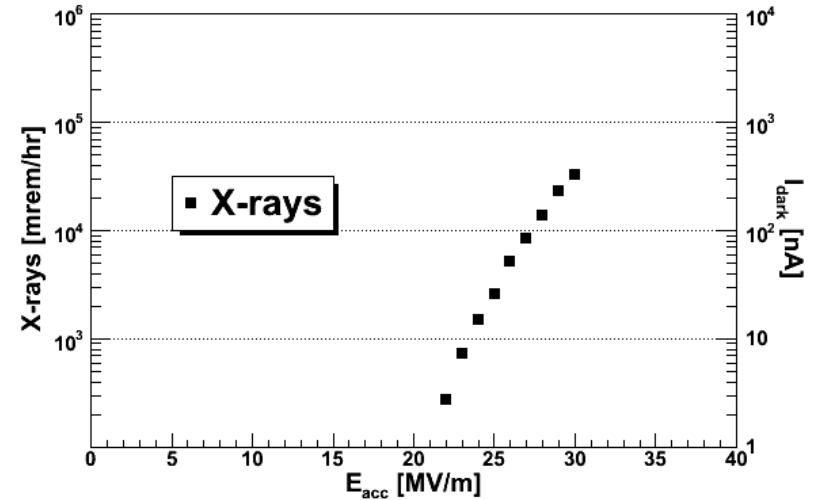
Combined summary plots (5-8)



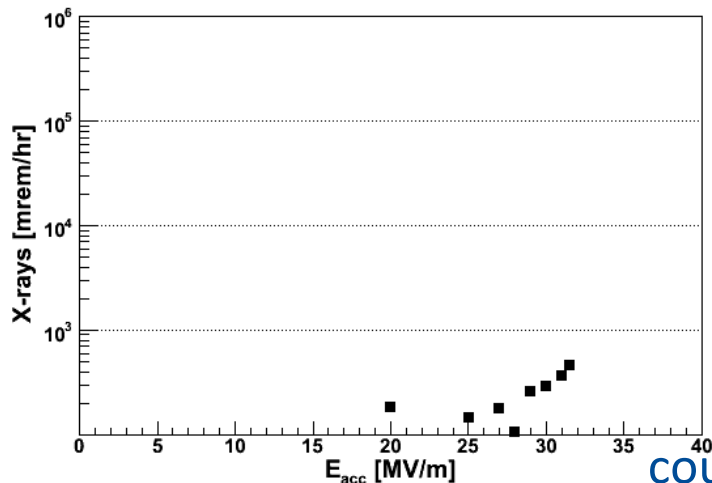
RFCA002_C5 (TB9ACC016), 5 Hz, 2 K, 596+969 μ s pulse



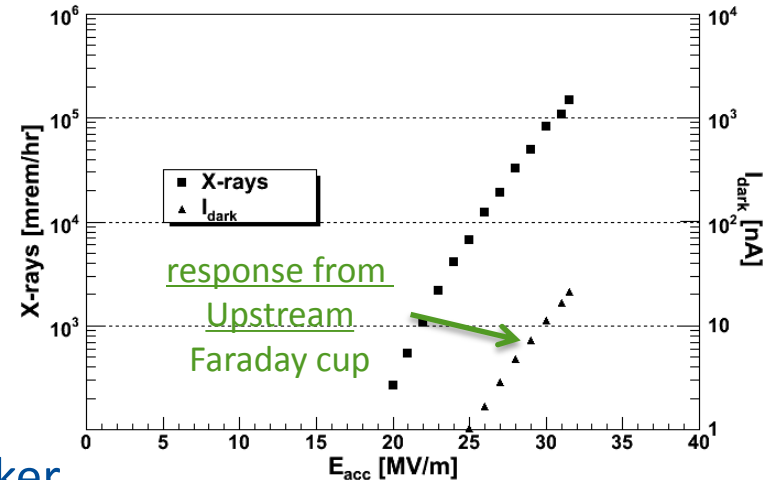
RFCA002_C6 (TB9AES009), 5 Hz, 2 K, 596+969 μ s pulse



RFCA002_C7 (TB9RI027), 5 Hz, 2 K, 596+969 μ s pulse



RFCA002_C8 (TB9RI028), 5 Hz, 2 K, 596+969 μ s pulse

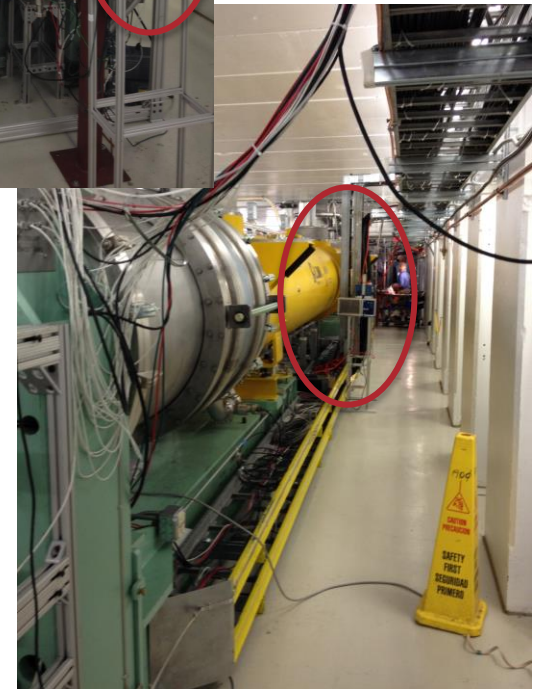
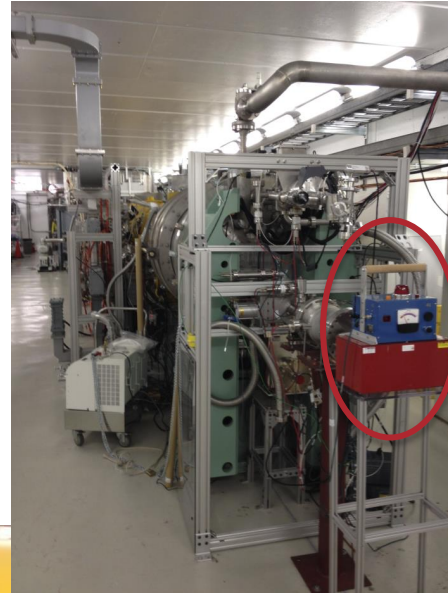


courtesy Andy Hocker

Radiation measurements



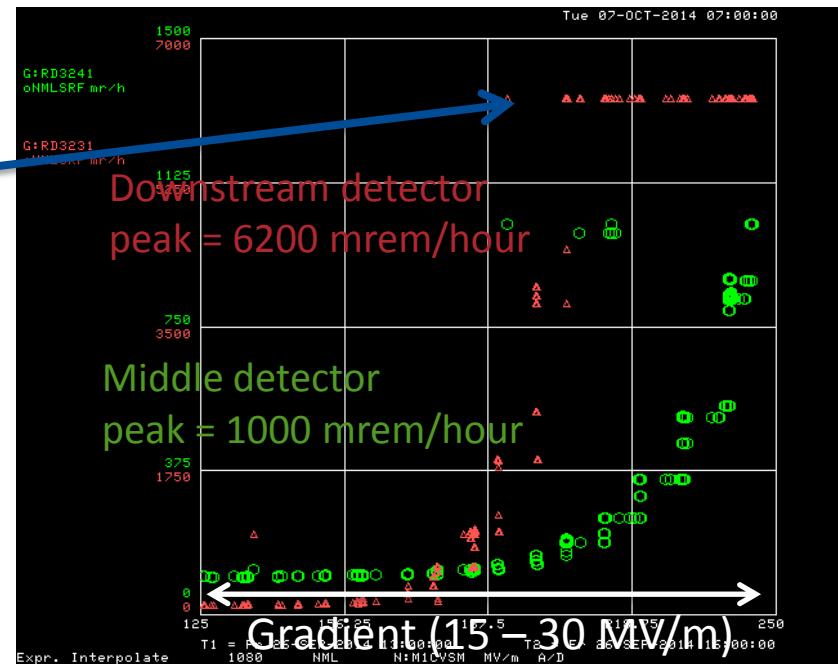
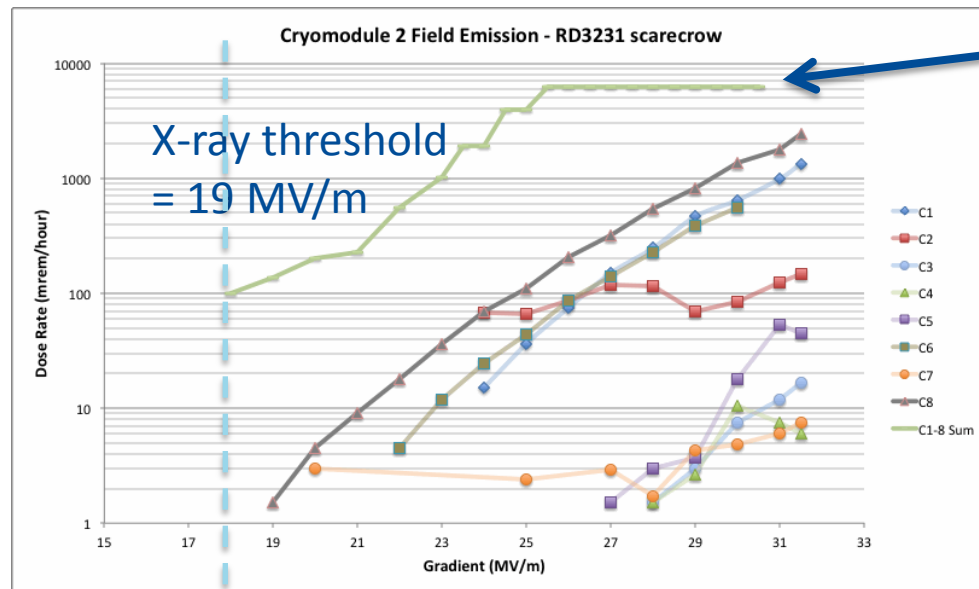
- ‘Scarecrow’
 - standard measurement device
 - one located under cavity being tested
 - placed in middle for unit testing
 - another at downstream end



Scarecrow results



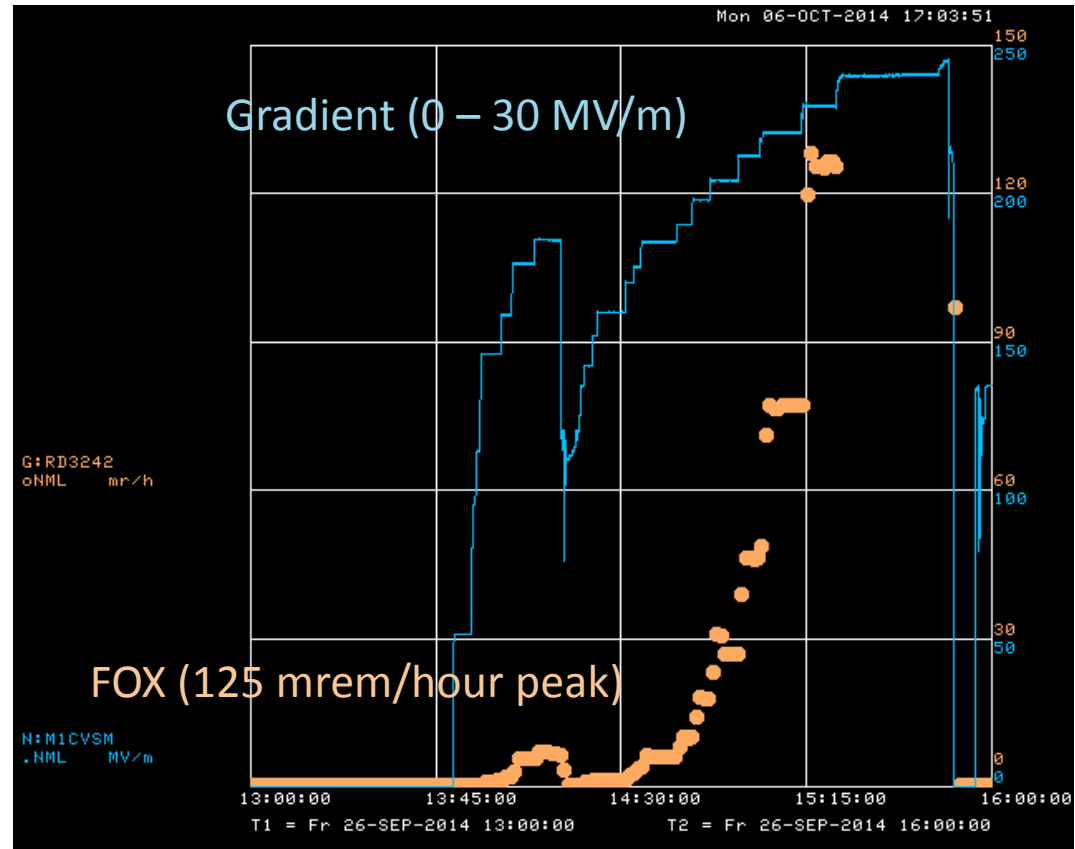
- No response below ~ 19 MV/m from any cavity
- Varied results from cavity to cavity
- More response from end detector ($\sim X5$)
- Saturation (needs investigating)



Radiation measurements – FOX detector



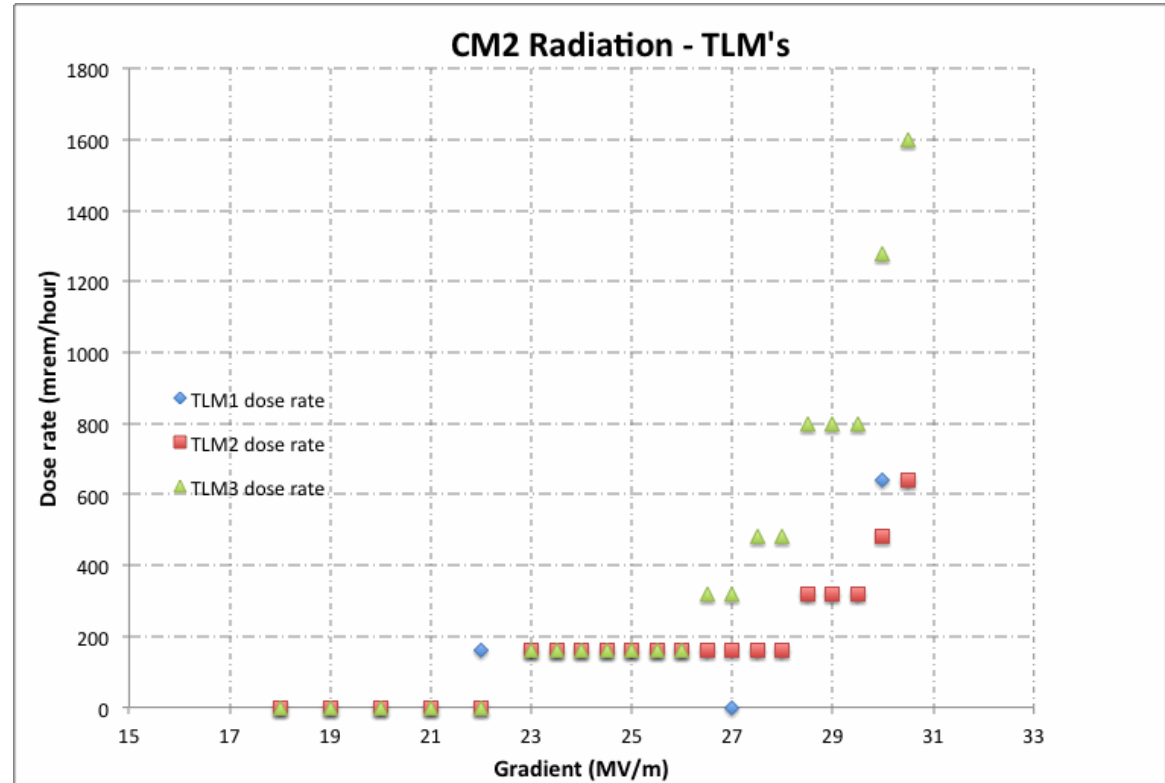
- Fermilab detector (propane-filled ion chamber) designed to be more sensitive to x-rays
- Placed at middle of cryomodule
- More analysis needed, correlate with scarecrow



Radiation measurements – TLM's



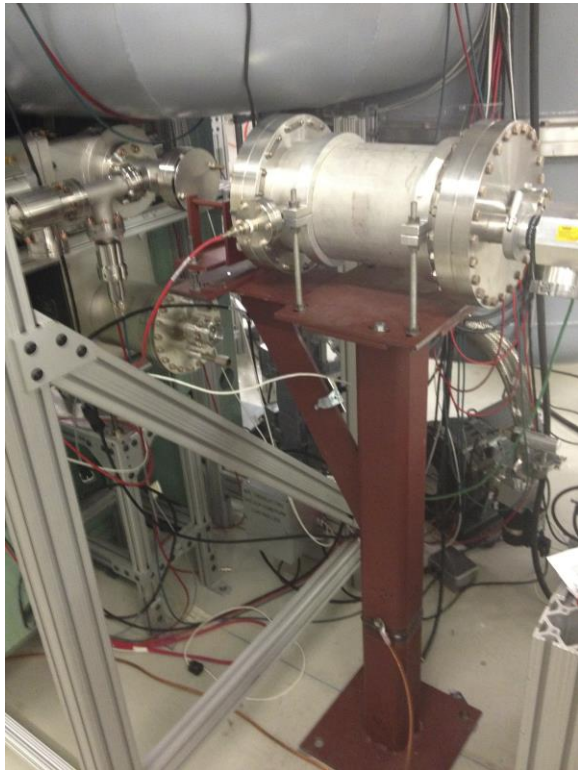
- TLM = Total Loss Monitor
 - alternate detector to Fermilab 'chipmunk' ion chamber
 - ArCO₂ filled heliax
 - length at user discretion
 - 4 installed under CM2
 - 2nd two read out in sum
 - 1 cpm ~ 160 mrem/hour



Dark current measurements



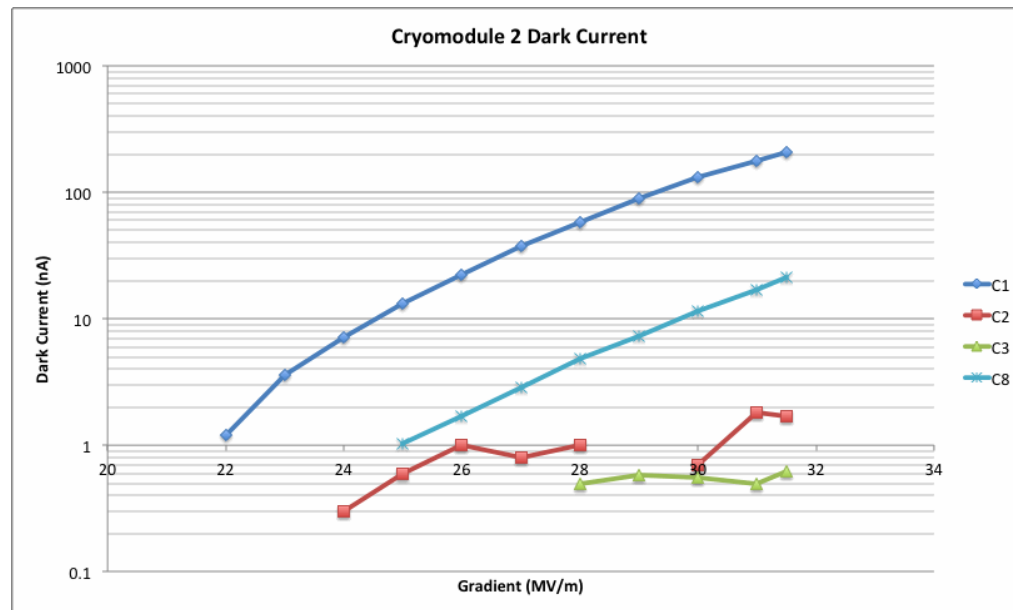
- Faraday cups at each end of cryomodule
- Integrating amplifier - 10 nA/volt



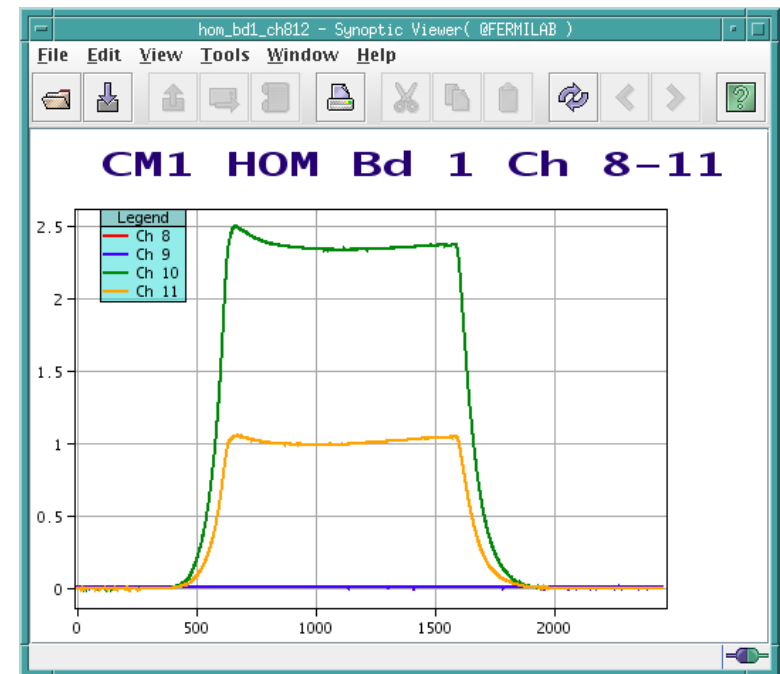
Dark current measurements



- Response from 4/8 cavities
- Greatest response from 'end' cavities



Single cavity response

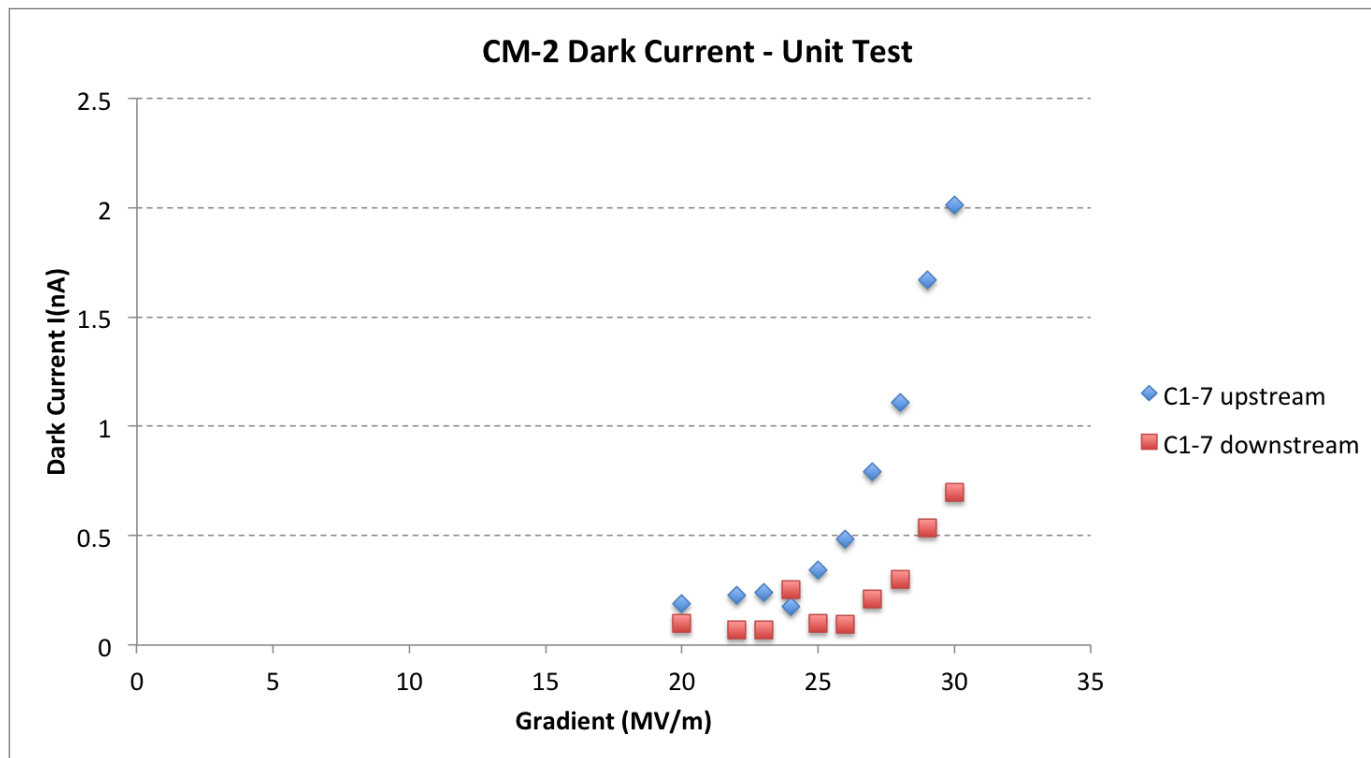


'Raw' digitized signal

Dark current measurements – unit test



- No response < 20 MV/m
- Greatest response at upstream end



Still to do



- Attempt to get energy spectrum of dark current
- Correlate response of rad detectors
- Evaluate detectors installed inside cryomodule
 - diamond detector
 - 2 helium-filled ion chambers
 - next 2 weeks or so
- ...



Conclusions & Summary

- Dark current and field emission are generated by CM-2
- Threshold for production ~ 20 MV/m
- No external radiation seen
- Variety of detection means available
- TLM's are promising option for measuring radiation
- Further analysis needed
- Internal detectors to be commissioned soon



Thank you for your attention