Radiation Testing of Versatile Transceiver for Versatile Link Project

Results and plans

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Opto Working Group Mini Workshop

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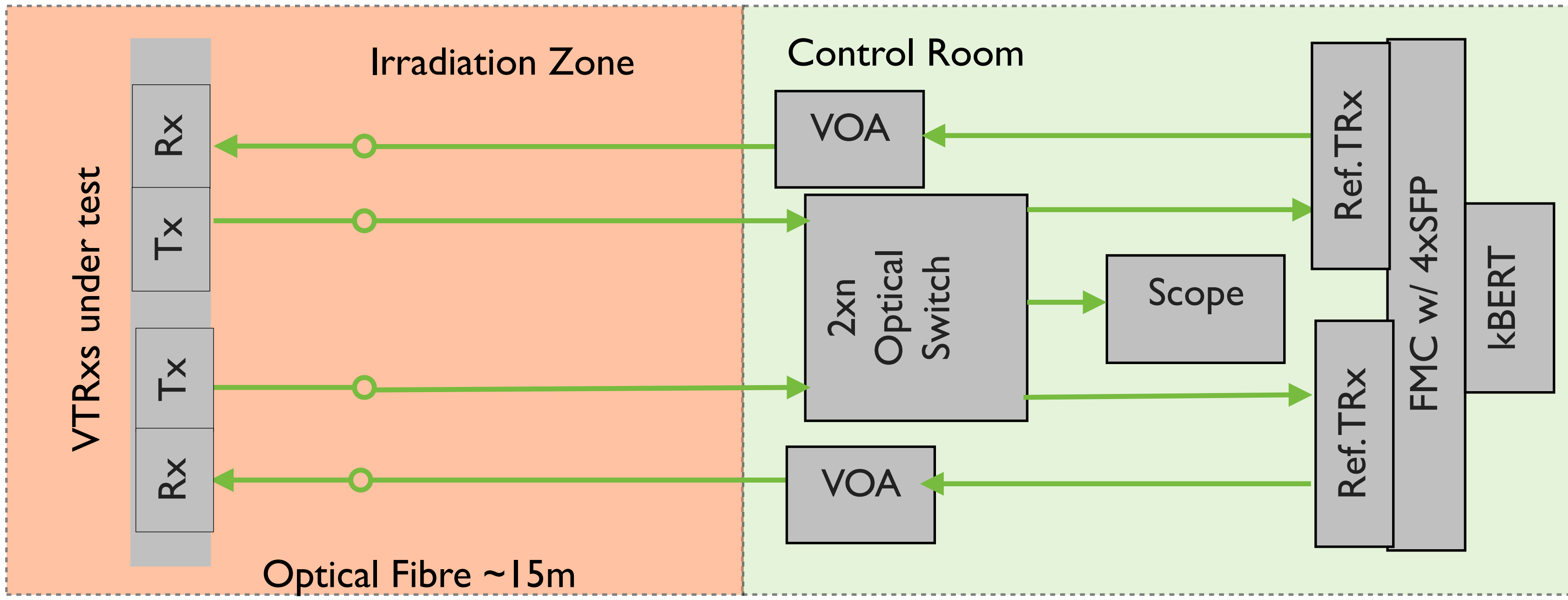
CERN

University of BRISTOL

Outline

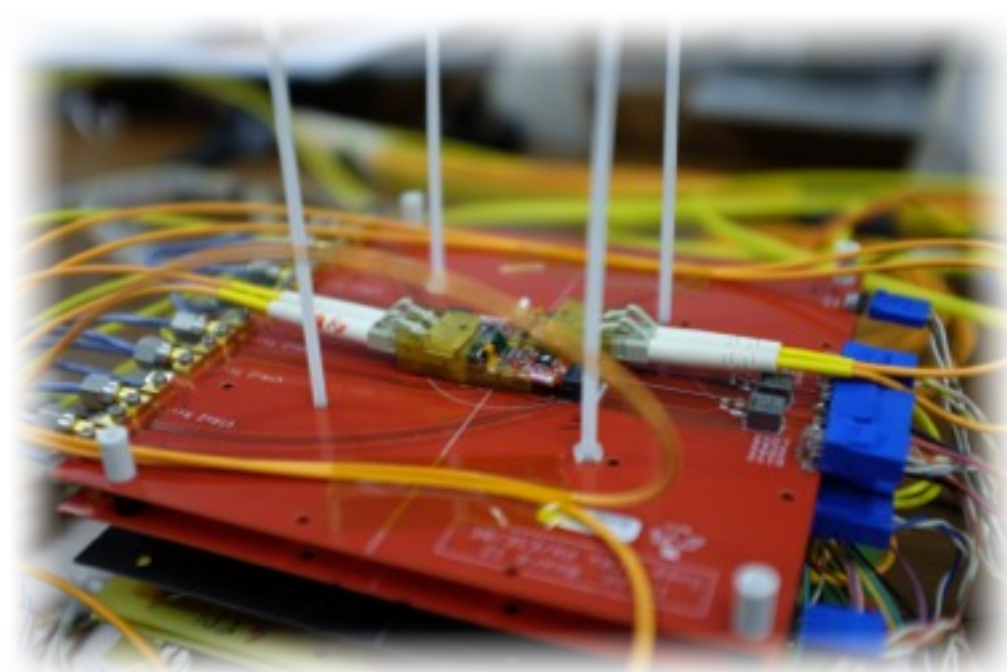
- Introduction
- Results from radiation test
- Conclusions

- First radiation test of complete Versatile Transceiver
  - 20 MeV neutron beam in Louvain-La-Neuve , total dose of ~ 1×10^{15} n/cm^2



DUTs	Tx	ROSA	# Tested
SM VTRx	1310 nm EEL	InGaAs	2
MM VTRx	850 nm VCSEL	GaAs	2

Devices irradiated in UCL November 2013



VTRx on irradiation PCB

VTRx Irradiation Louvain-La-Neuve November 2013

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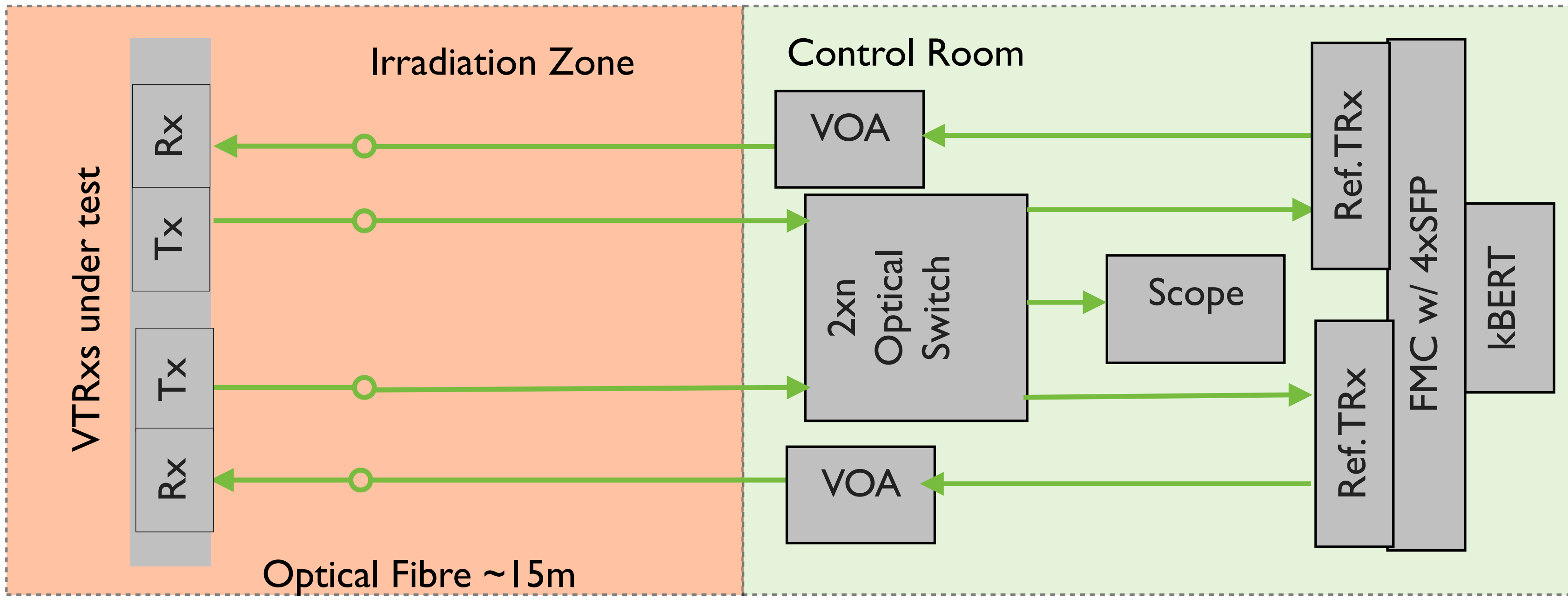
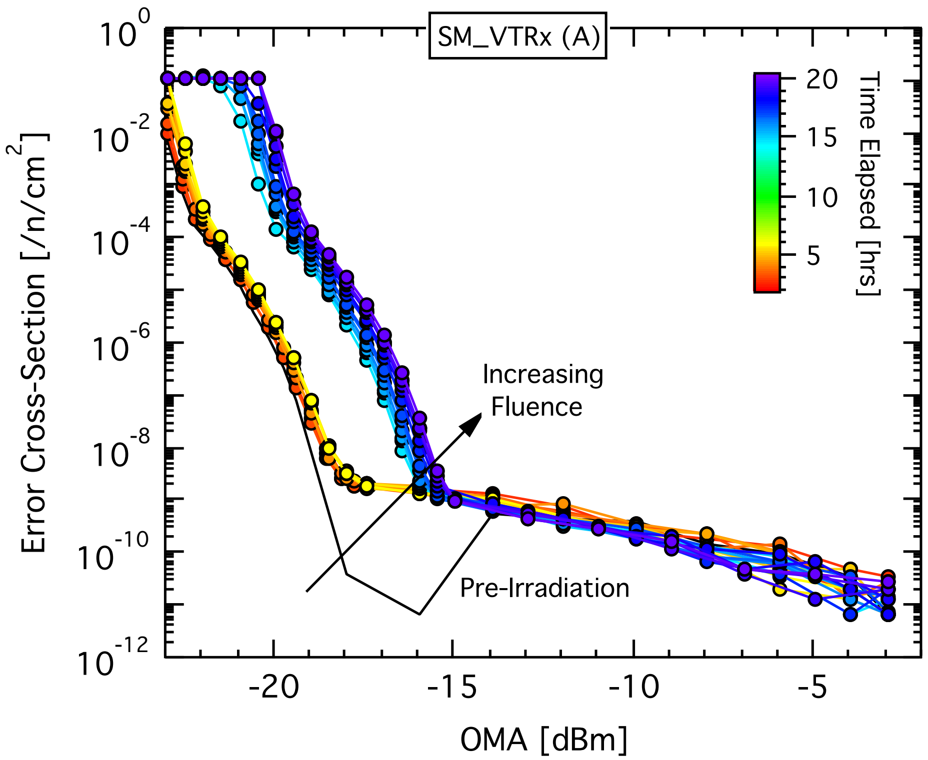
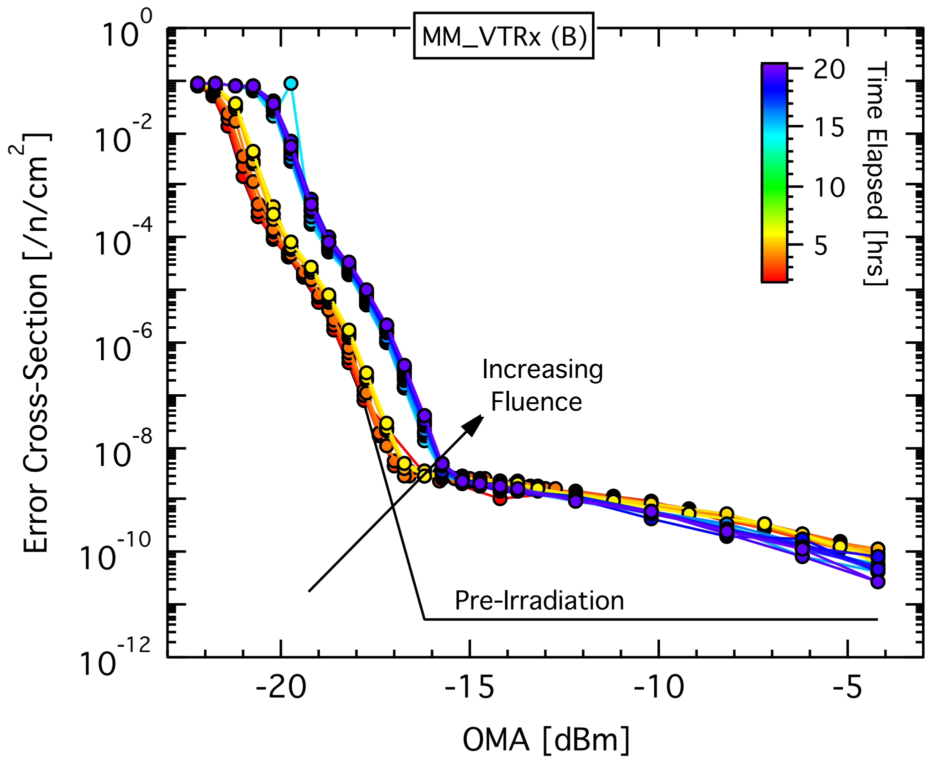


VTRx Component under test	On-line Measurement
ROSA	Sensitivity to SEUs
ROSA	Responsivity
ROSA	Leakage Current
TOSA	Threshold Current
TOSA	Slope Efficiency
TOSA	Transmitted Eye
GBLD	SEUs

Sensitivity of ROSAs to SEUs

- Sensitivity of VTRx to SEUs (on receiver side) measured during the test
  - Expected increase in BER during irradiation because of SEUs





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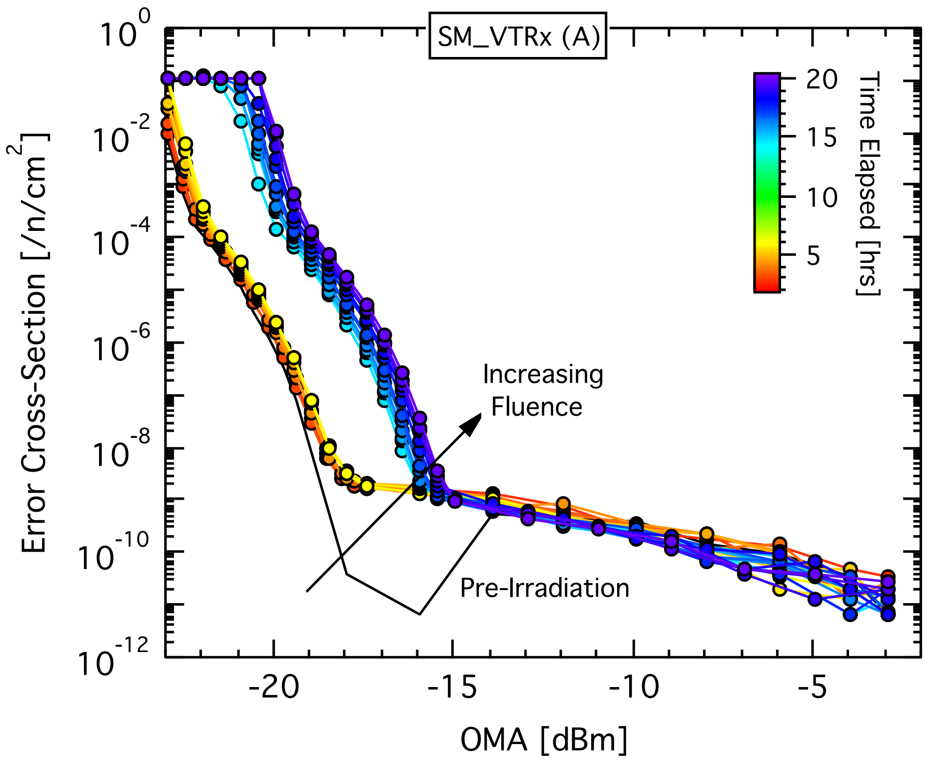
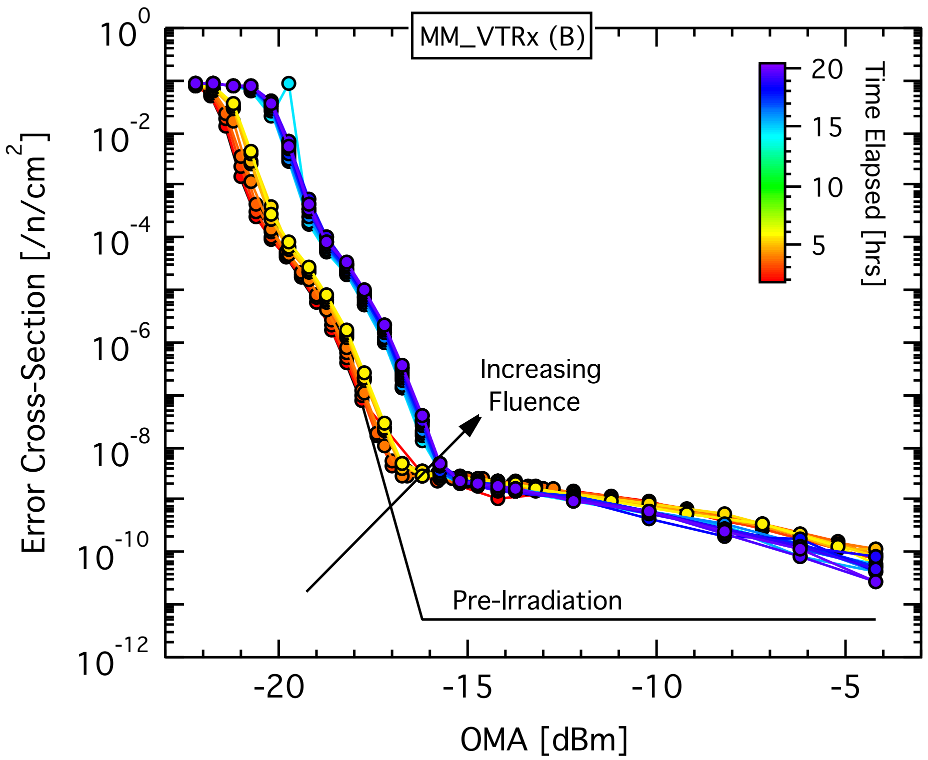
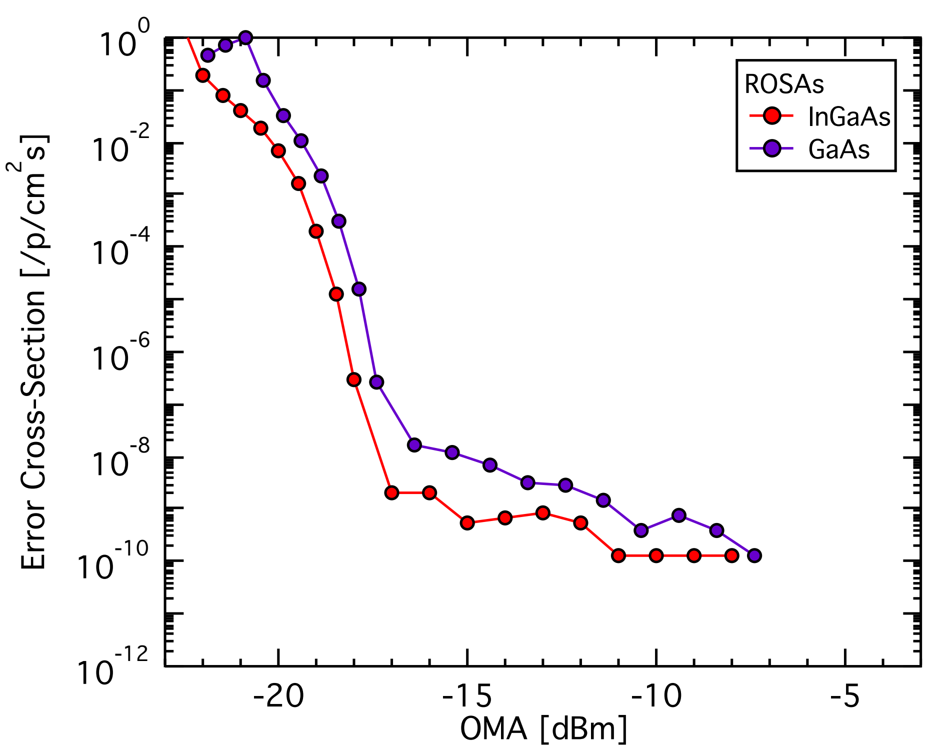




- Error cross-section comparable with other test results
  - same ROSAs tested in PSI proton beam-line



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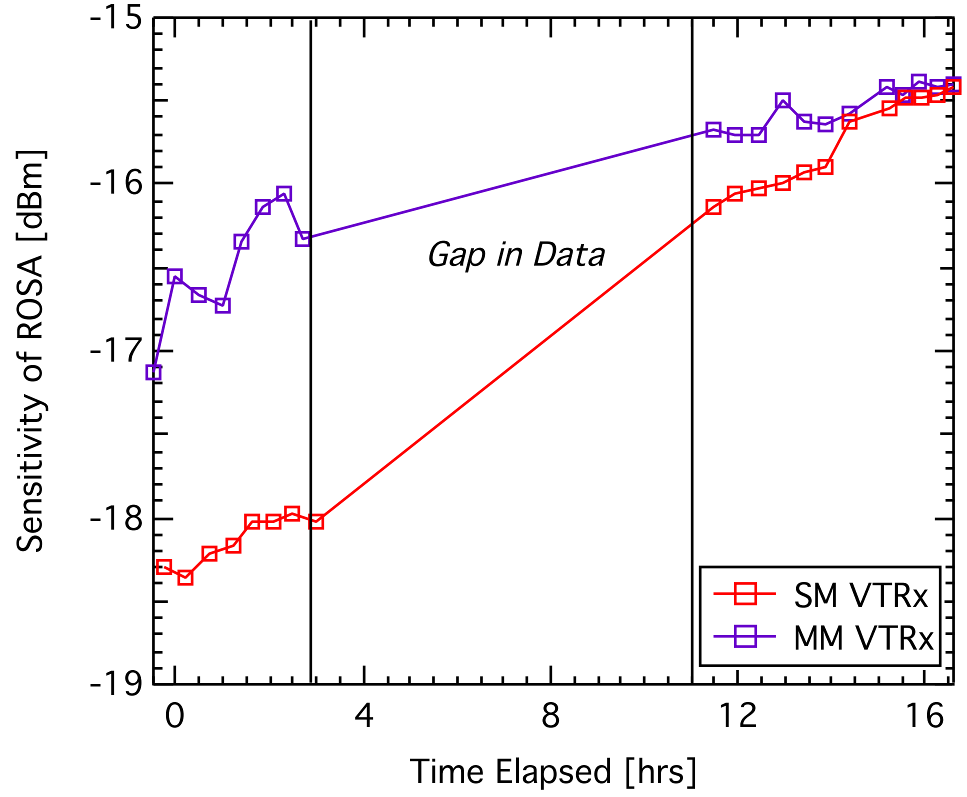
  - bigger change in SM VTRx compared to MM VTRx



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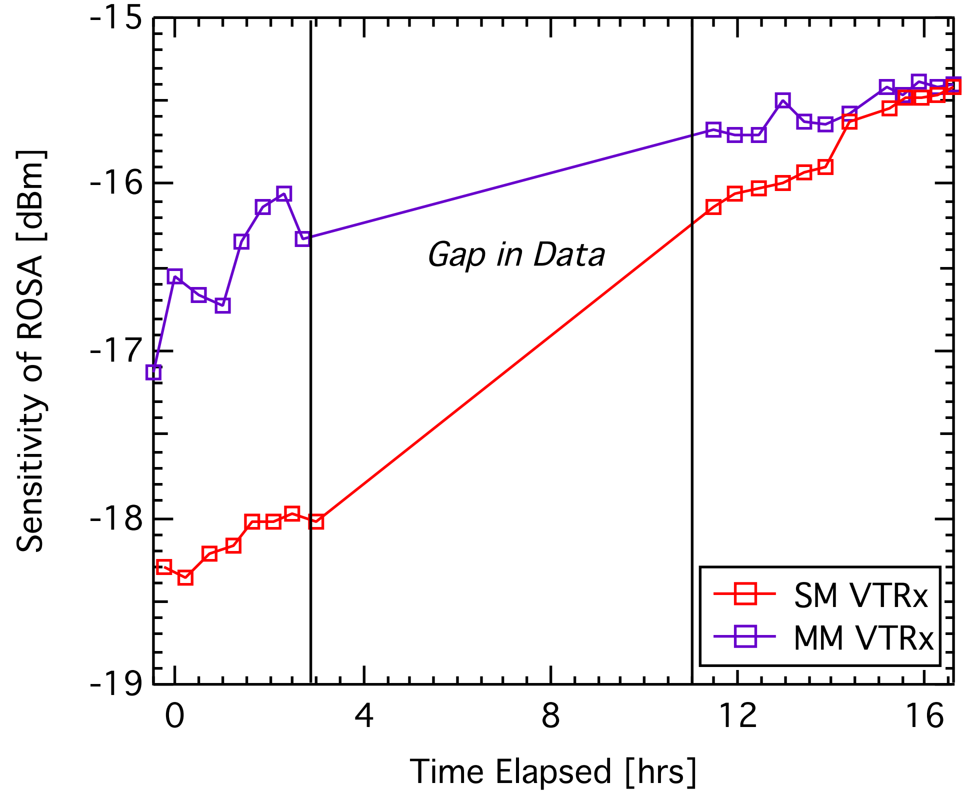

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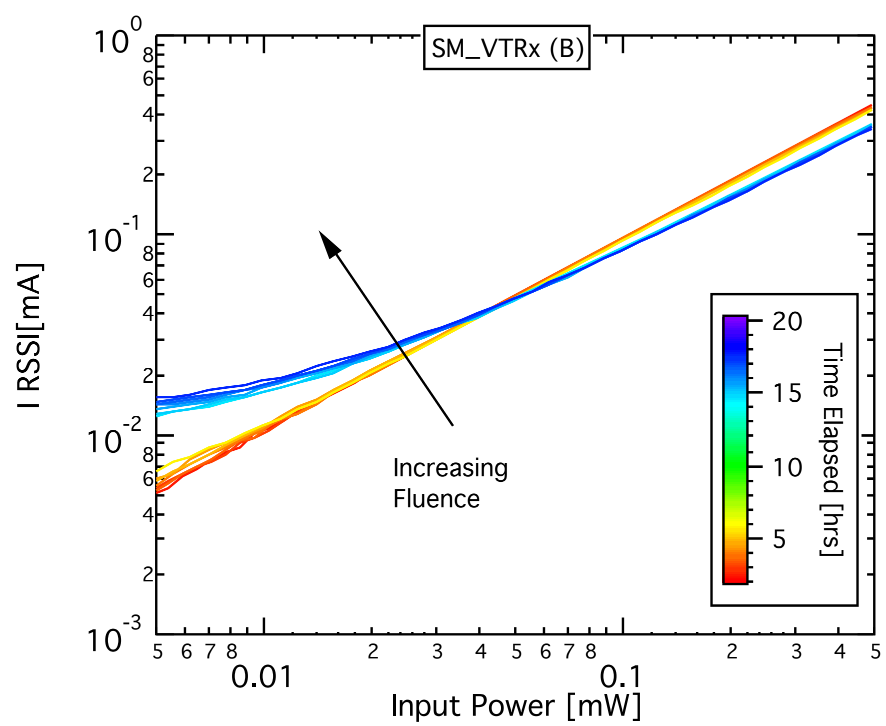
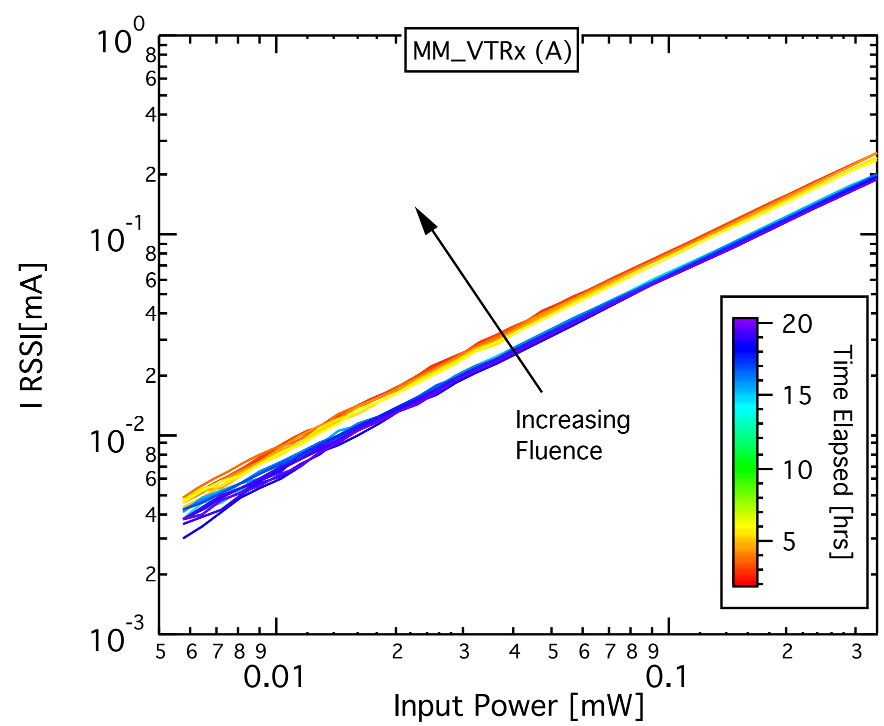
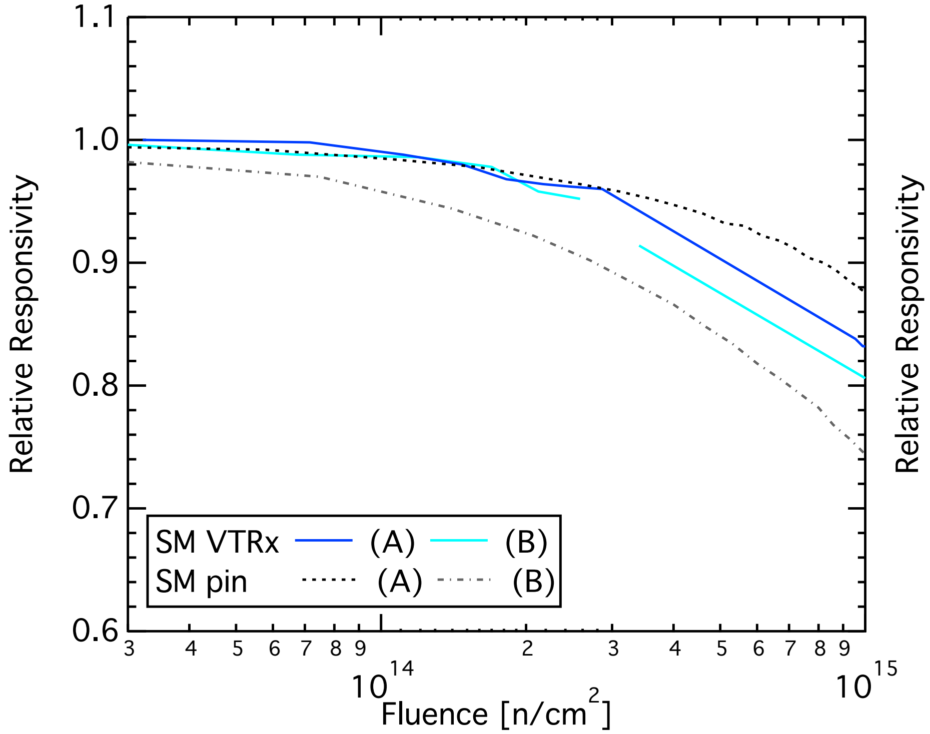
- RSSI current measurement used to calculate change of responsivity of ROSAs during irradiation

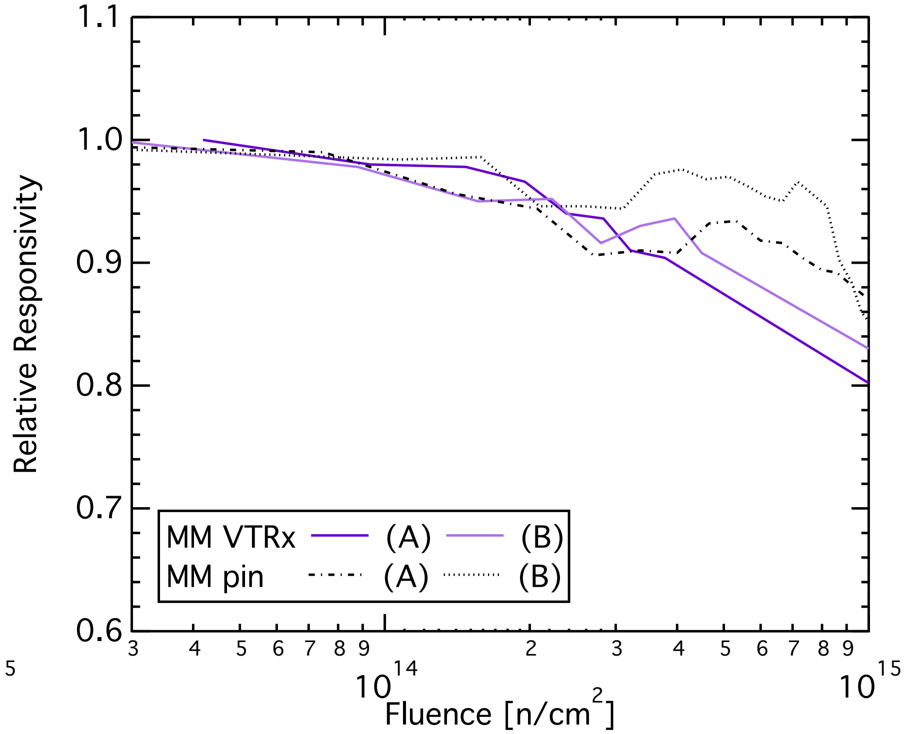


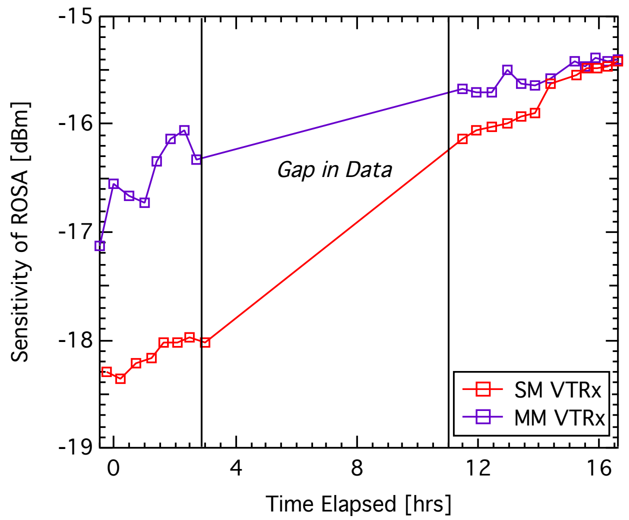


Sensitivity of ROSAs to SEUs

- Change in responsivity of devices comparable with pin photodiodes tested







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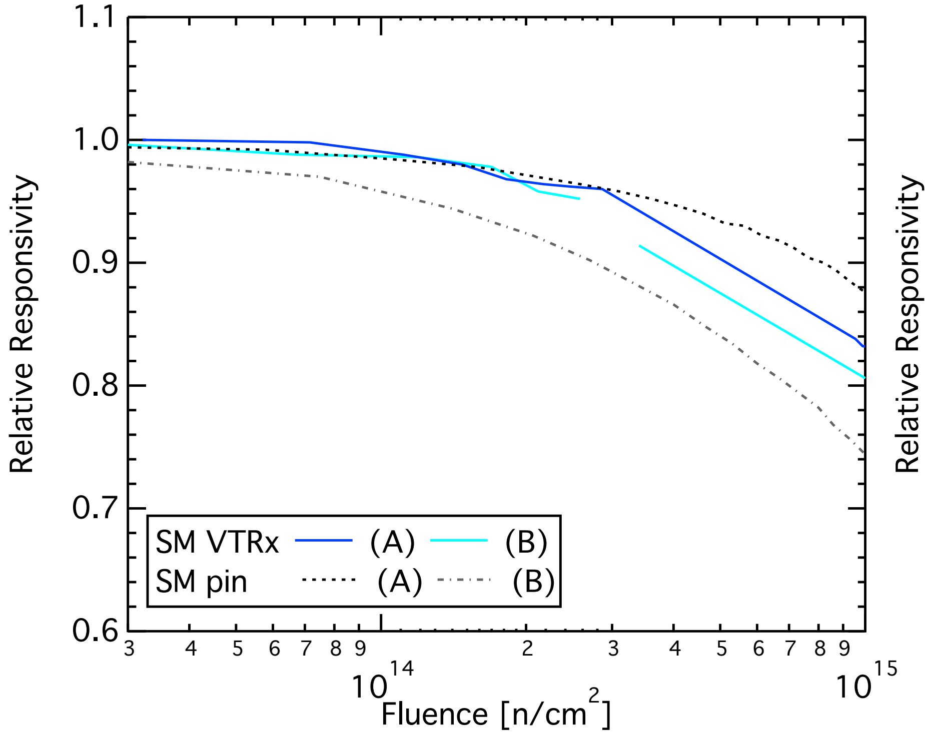

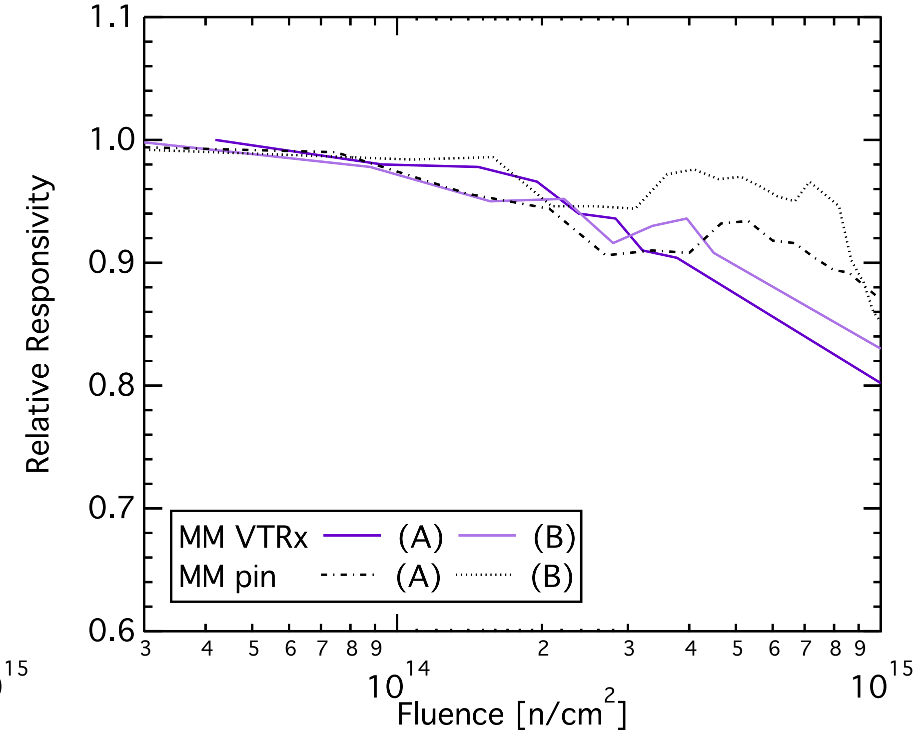

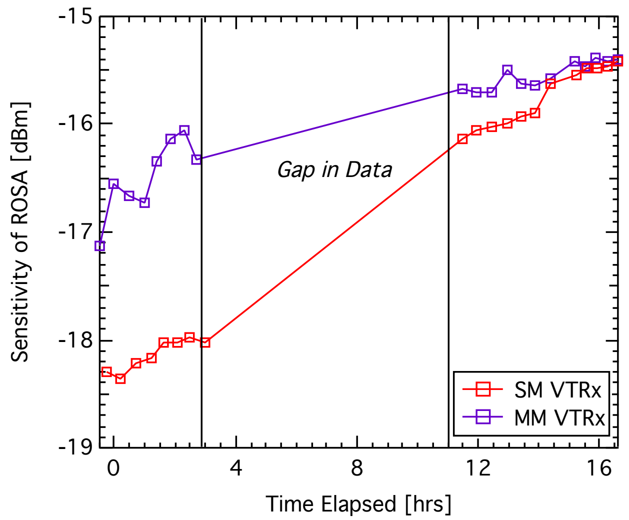

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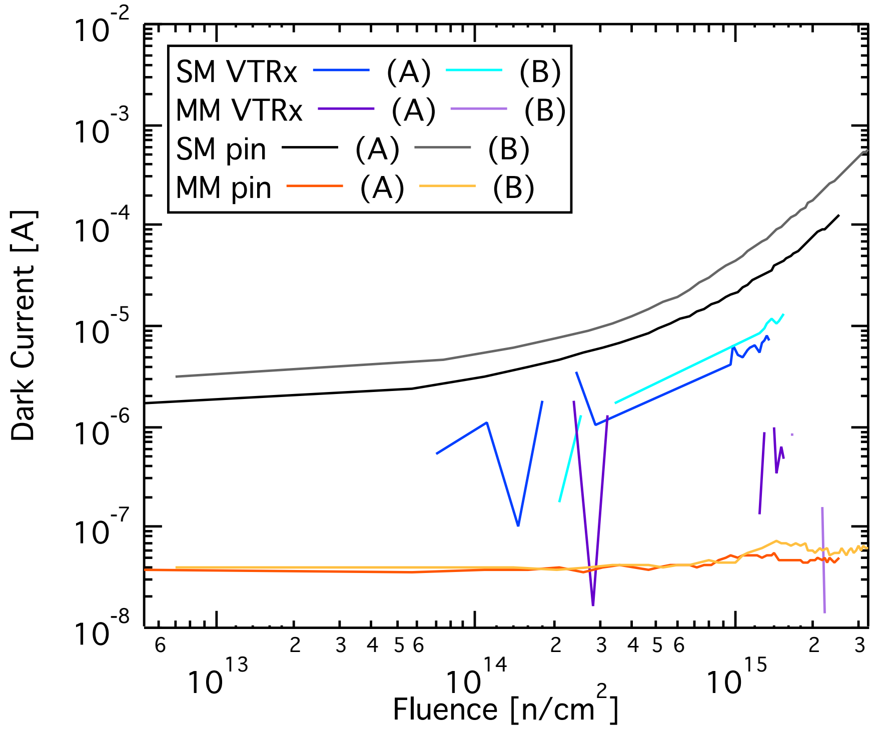
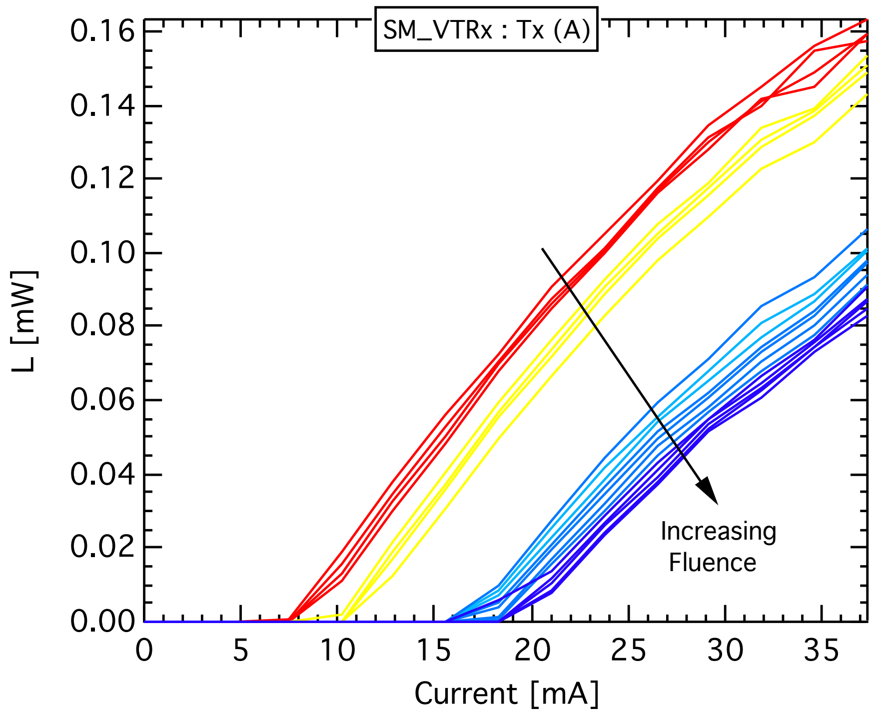
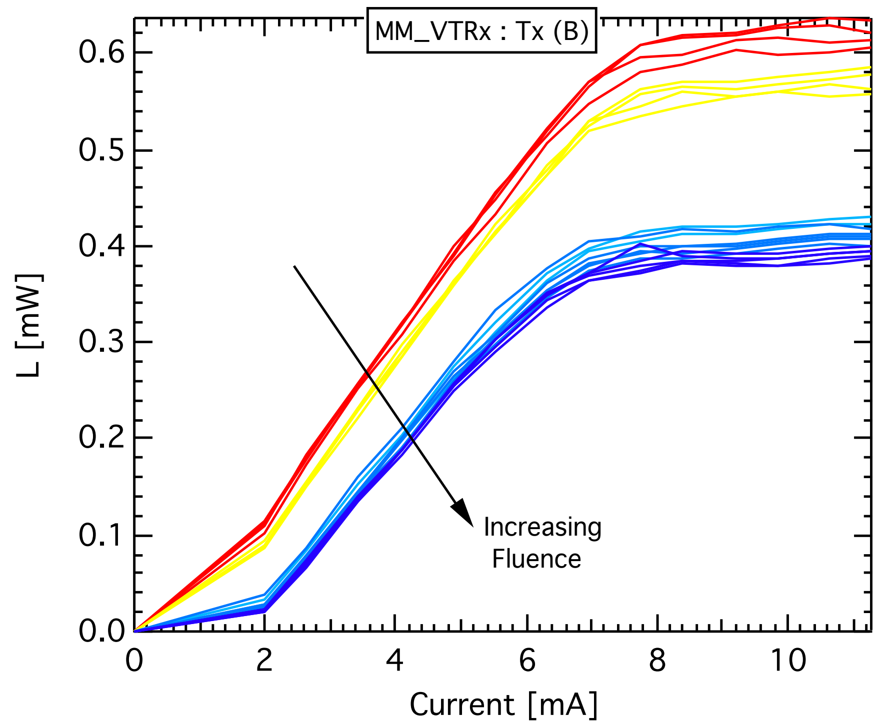
- Points to change in leakage current being more important than previously thought?



Effect of radiation on transmitter, DC

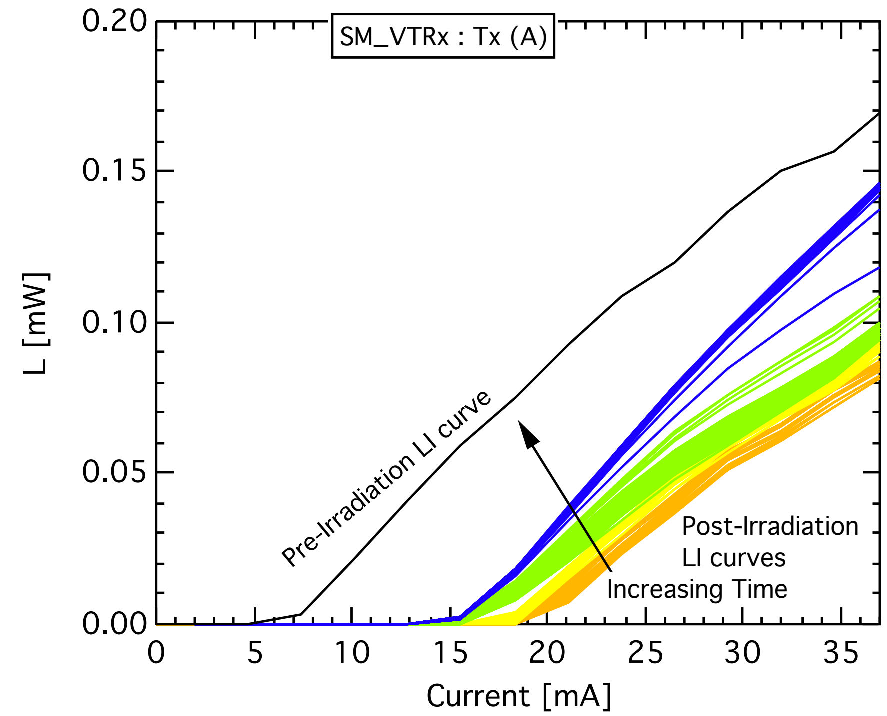
- LI curves of transmitters collected during irradiation
  - gap in the data due to problems with set-up during test

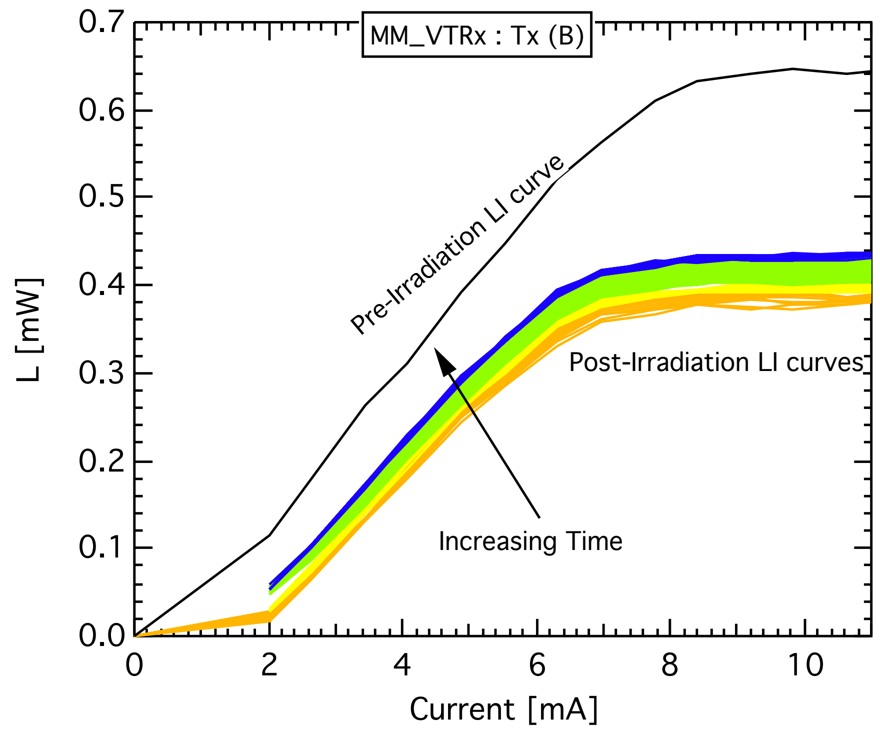




- Expected change in performance of transmitters : increase in threshold current and decrease in slope efficiency

- Fraction of the damage anneals post-irradiation





Effect of radiation on transmitter, DC

- **Are predictions for the expected change in threshold current in VTRx transmitters from irradiations on components measured DC-only of the VTRxs accurate ?**
  - transmitters from the same manufactures irradiated in the same test
  - comparison between the change in threshold current in both VTRx and transmitter therefore possible

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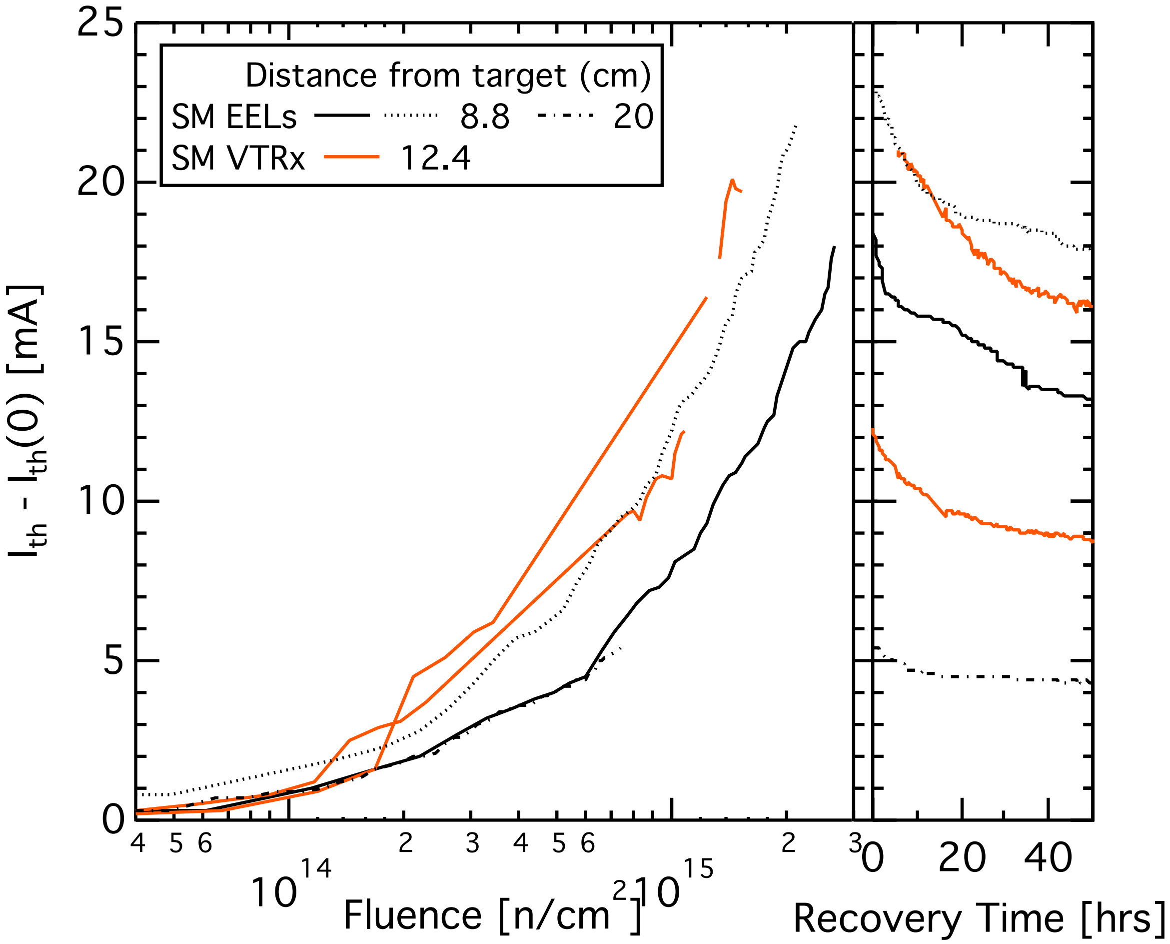

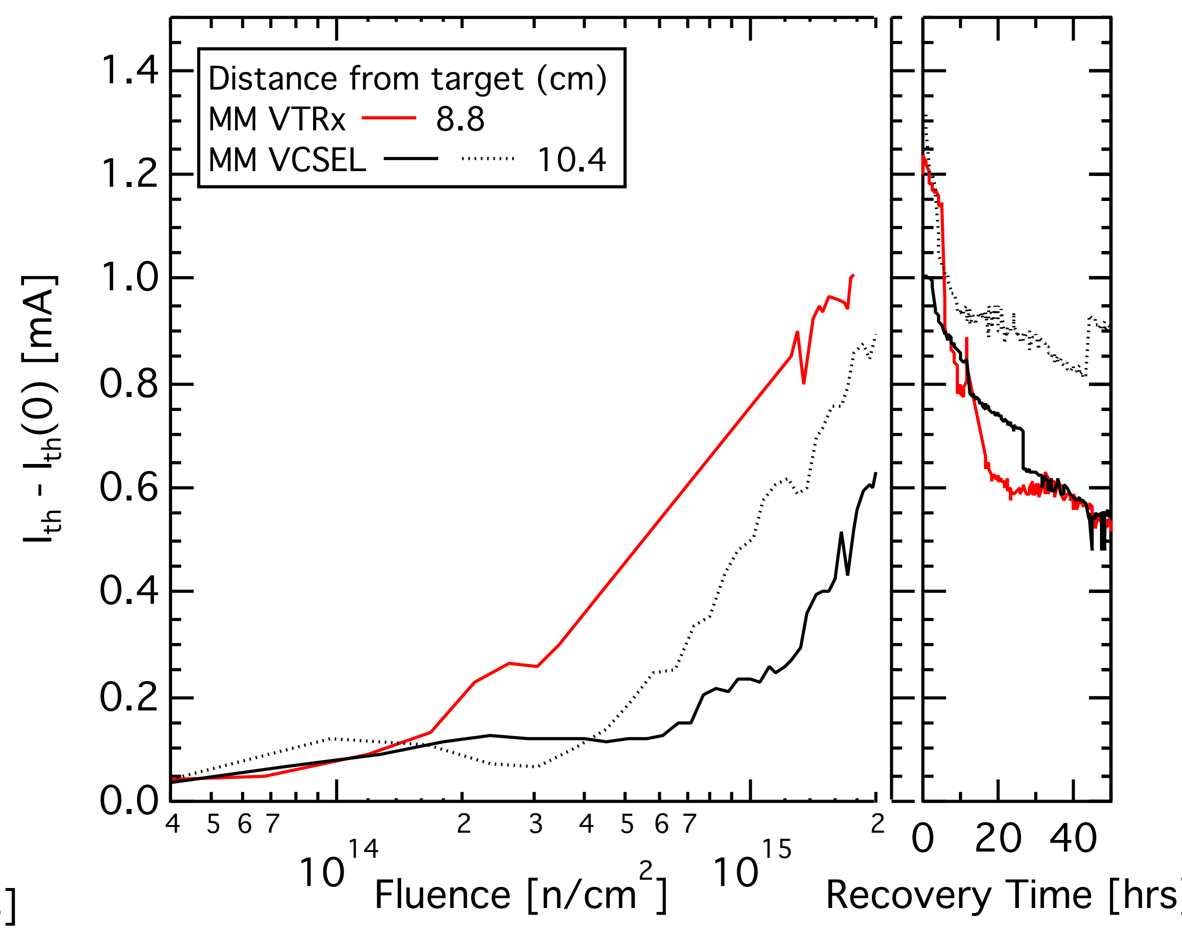

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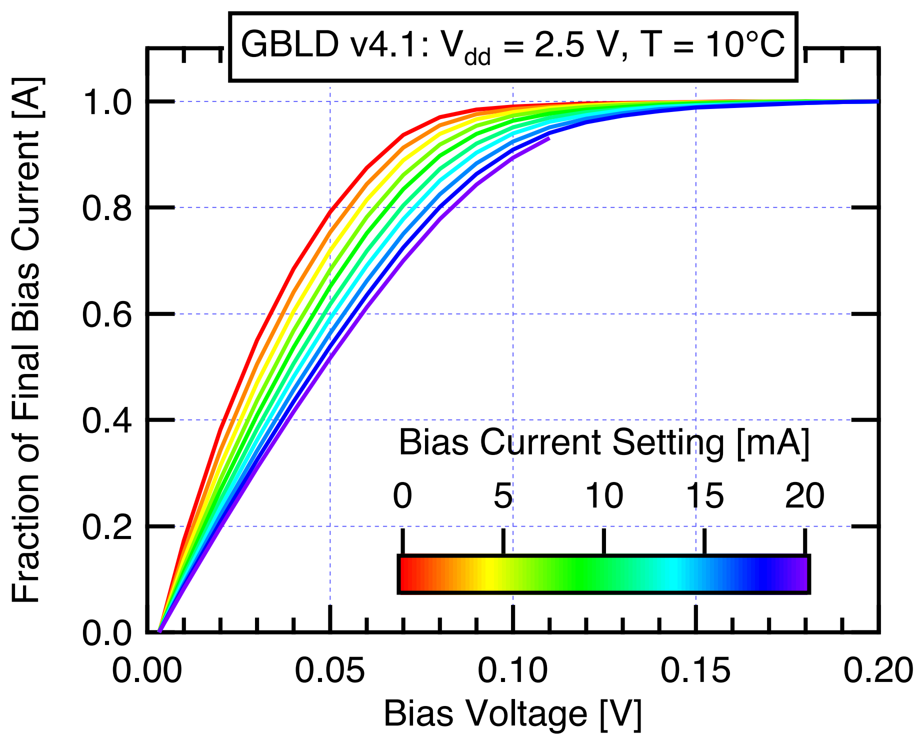
- **Can radiation tests on MM VCSELs predict how the voltage headroom changes during exposure to radiation ?**
  - Voltage headroom problem
    - bias current that the GBLD is capable of supplying to the transmitter is limited by the voltage headroom of the chip



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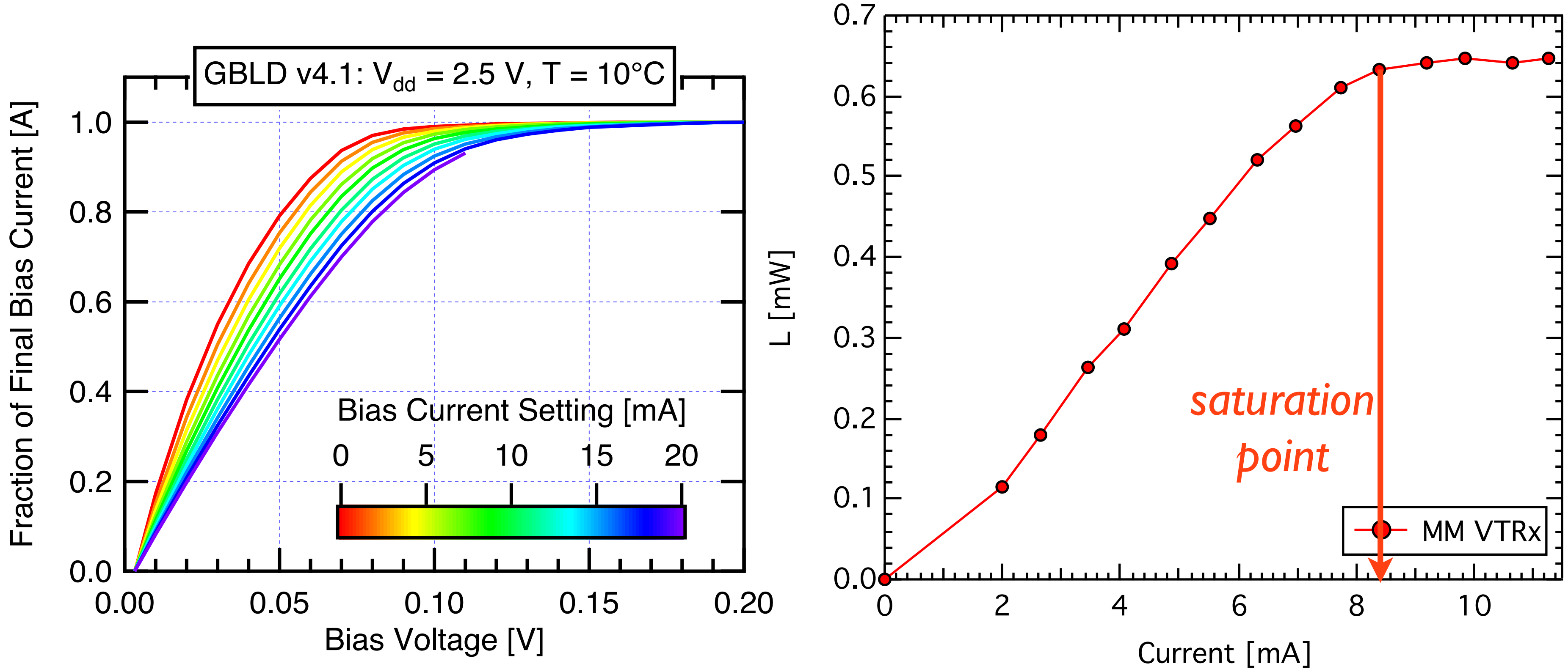

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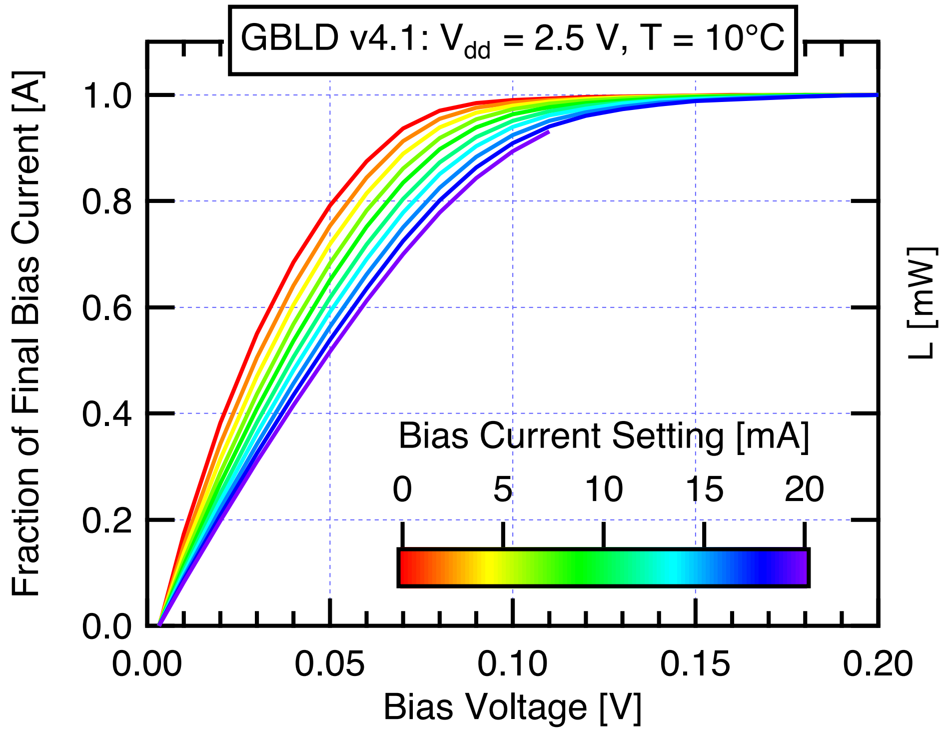
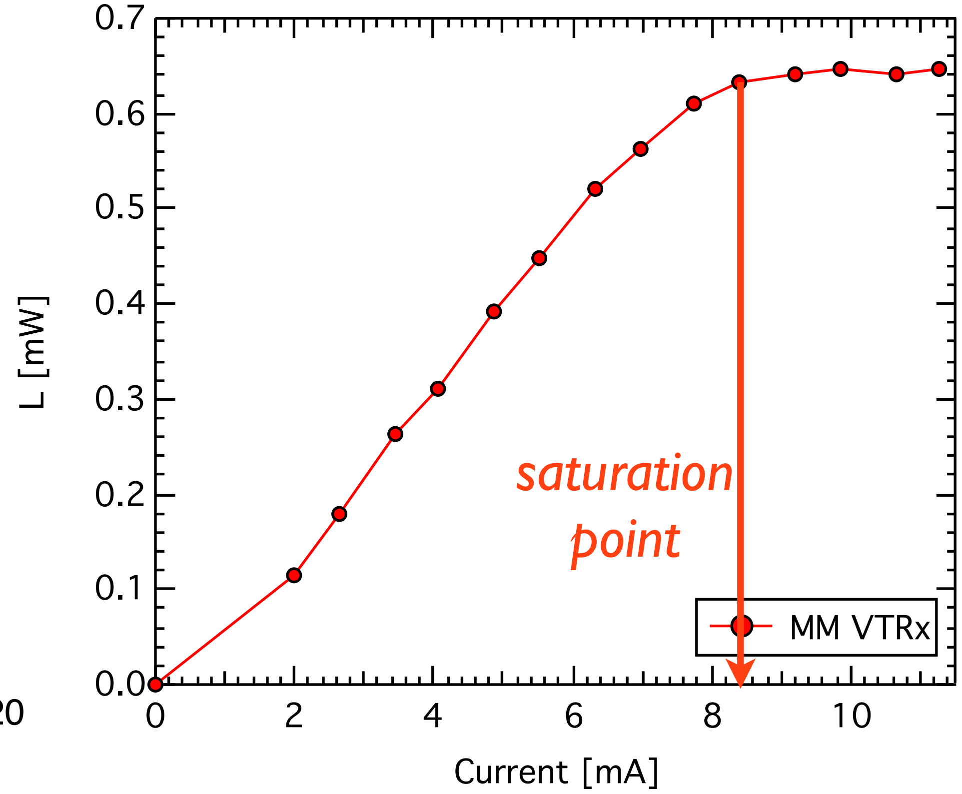
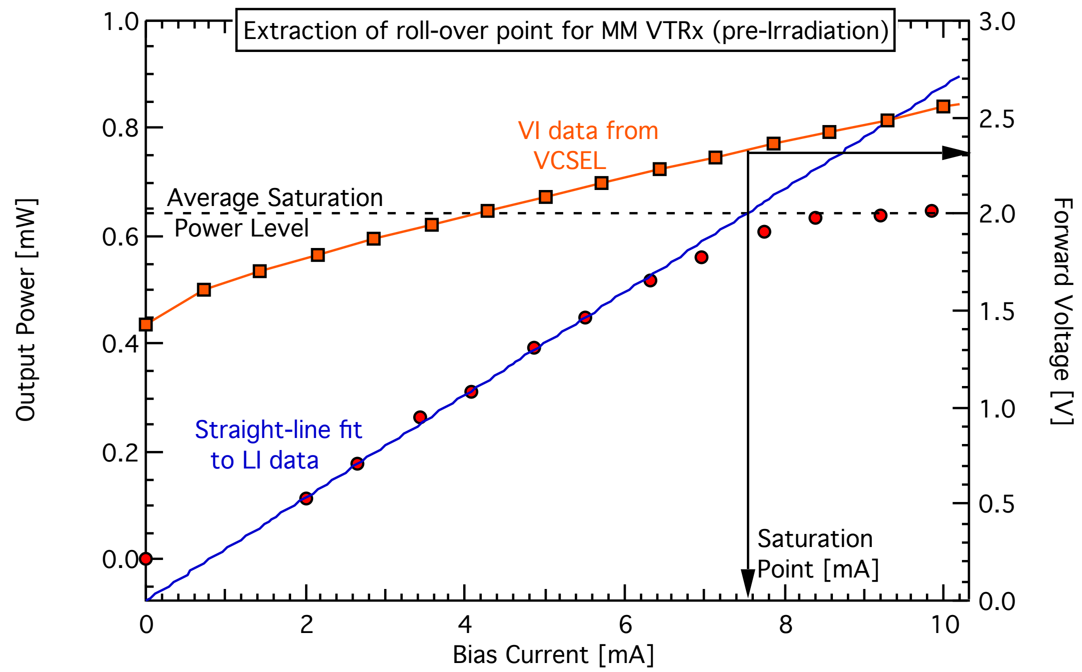




- Expect to see a change in the saturation point of the MM VTRx during irradiation
  - can we use the information from the VI curves of irradiated transmitters to predict how the saturation point changes?

Effect of radiation on transmitter, DC

- Voltage at which the GBLD head-room is no longer sufficient extracted from the pre-irradiation data (V_{max})



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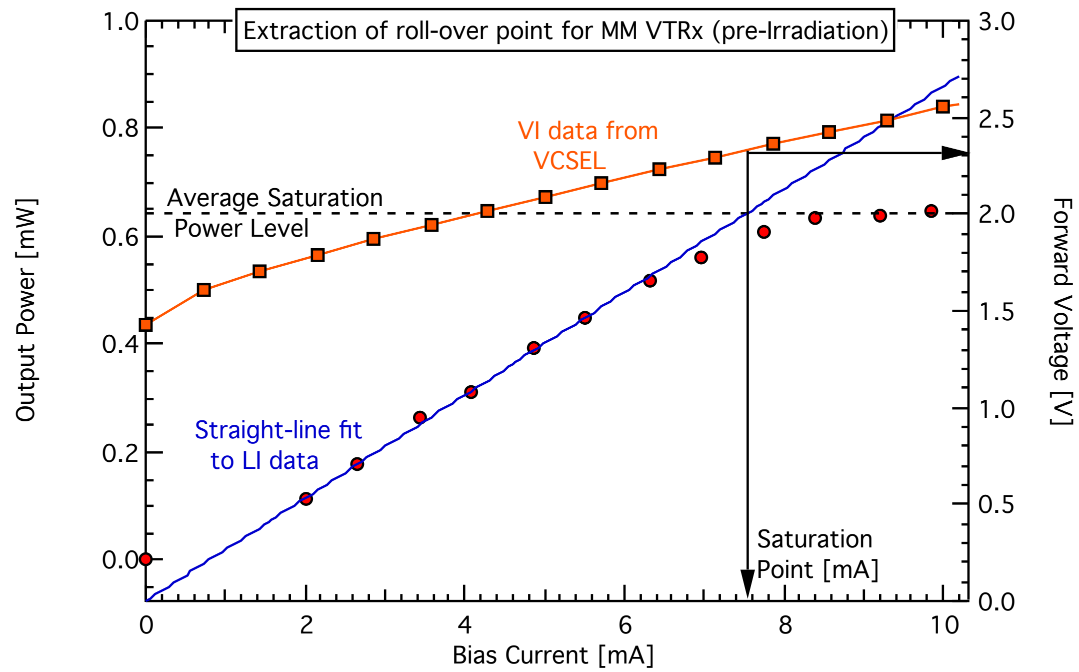
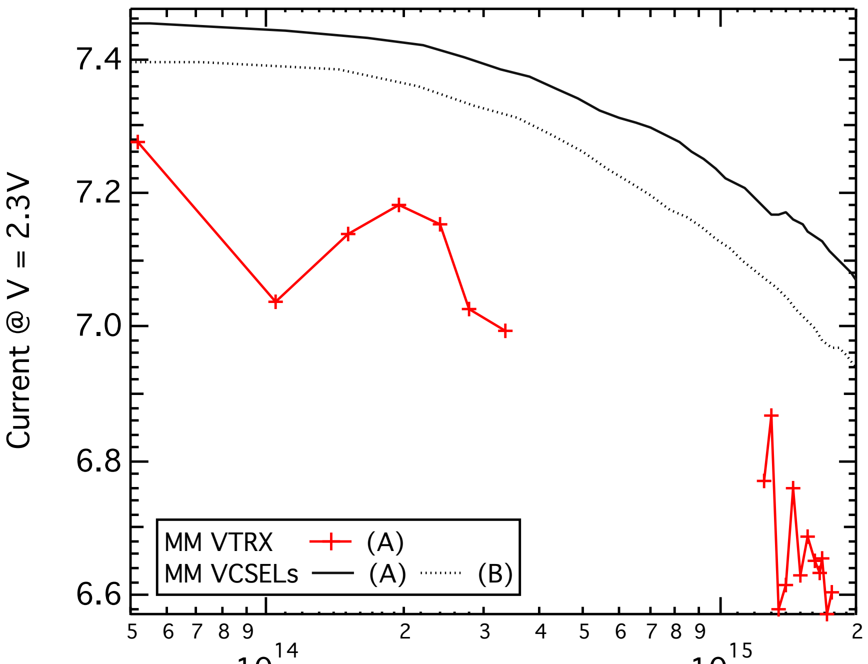


- Compare bias current at (V_{max}) from VI curves of transmitters to saturation point from LI curves of MM VCSELs during irradiation
  - trends are the same for both devices
  - can use VI data of MM VCSEls to predict change in saturation point of MM VTRxs



Effect of radiation on transmitter, AC

- **Assumption has alway been that the spec for the slope efficiency of the transmitter is such that no additional radiation penalty is required :**
  - transmitters threshold current and slope efficiency change during irradiation
  - OMA depends on both
  - can we maintain the minimum OMA during irradiation?
  - if not, can we adjust the settings of the VTRx to compensate?

$$OMA = P_1 - P_0 \approx I_{\text{mod}}\eta \Rightarrow \eta = \frac{OMA}{I_{\text{mod}}}$$

$$\left.\frac{OMA}{I_{\text{mod}}}\right|_{irrad} \geq \eta_{\text{min}}$$

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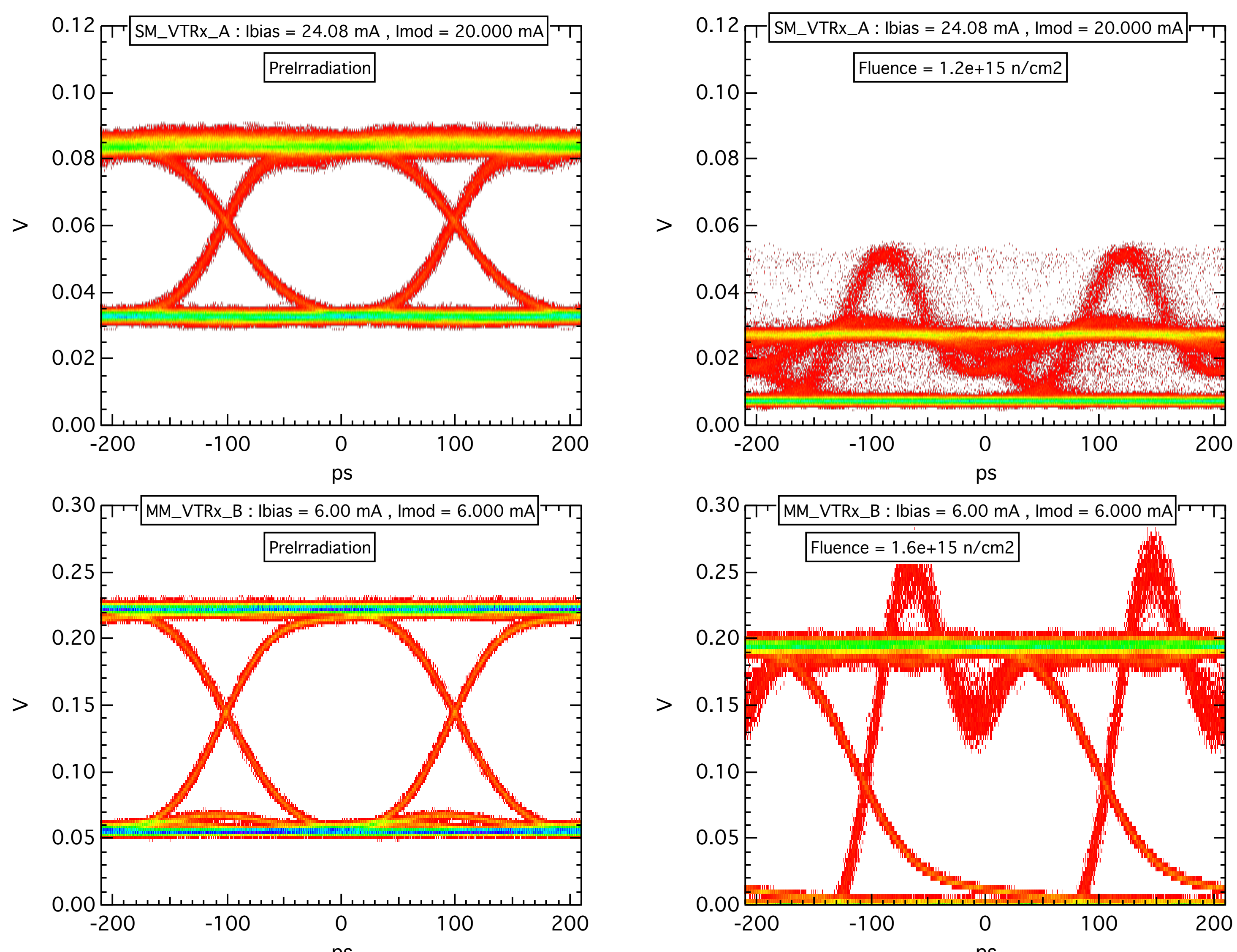
$$\left.\frac{OMA}{I_{mod}}\right|_{irrad} \geq \eta_{min}$$

- **Tried to change the transmitter settings (I_{mod}, I_{bias}) during the test with information obtain from the LI curves to maintain a "good" eye**
  - if we do nothing (i.e. default settings)
  - worst in SM case than MM case



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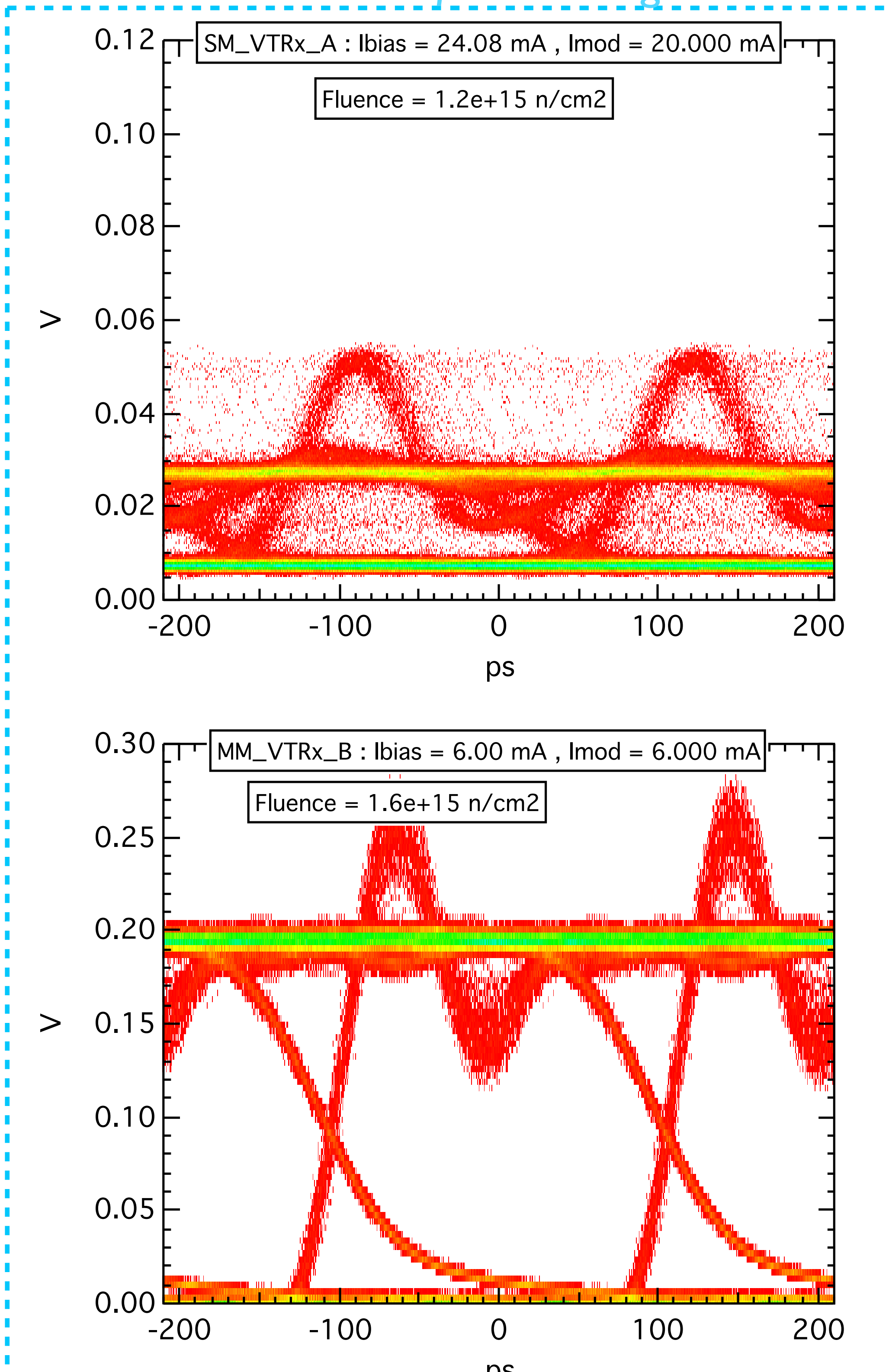
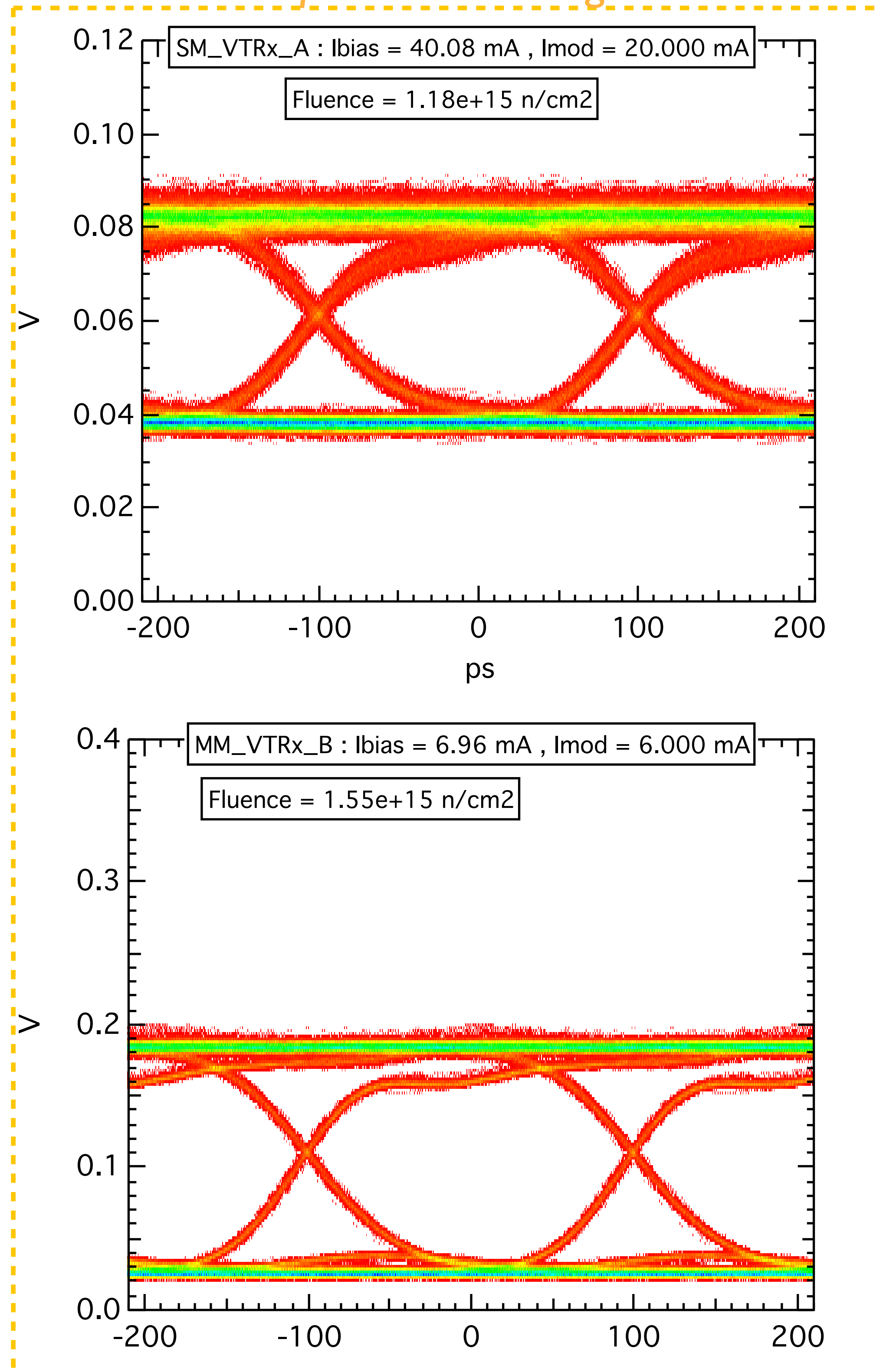
Default Settings

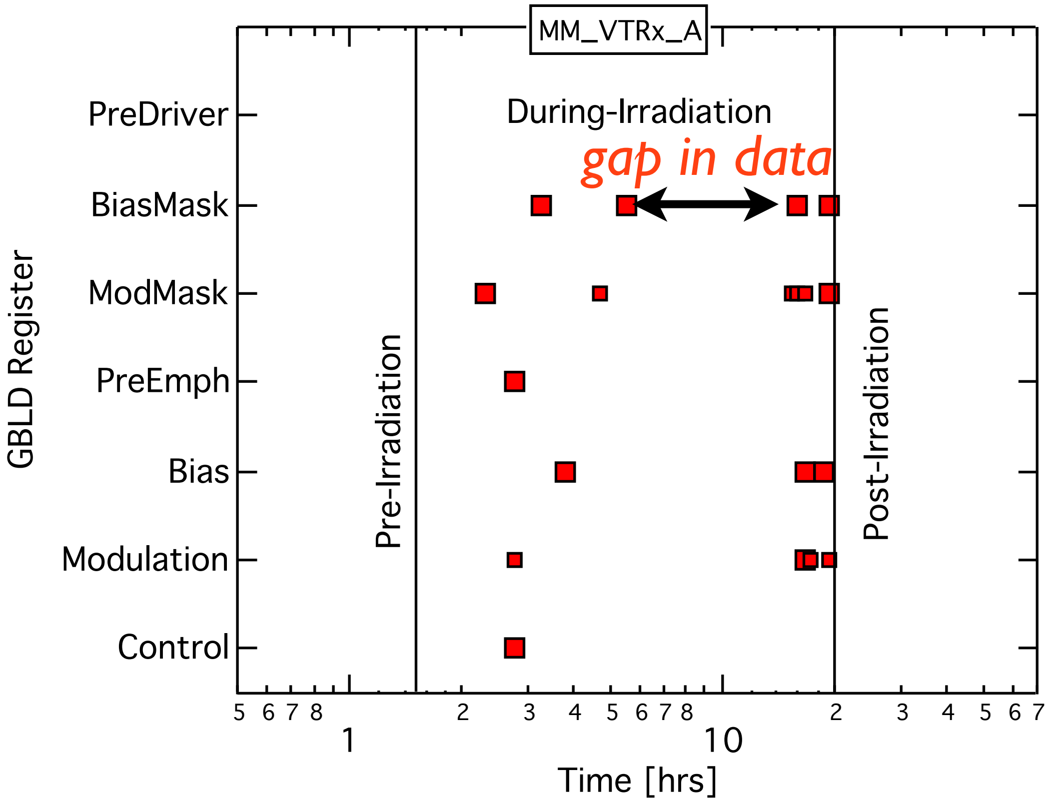


Optimized Settings



Effect of radiation on GBLD v4

- Checked for SEUs in the GBLD during irradiation
  - GBLD registers read at regular intervals during the test and compared against "default" values



Effect of radiation on GBLD v4

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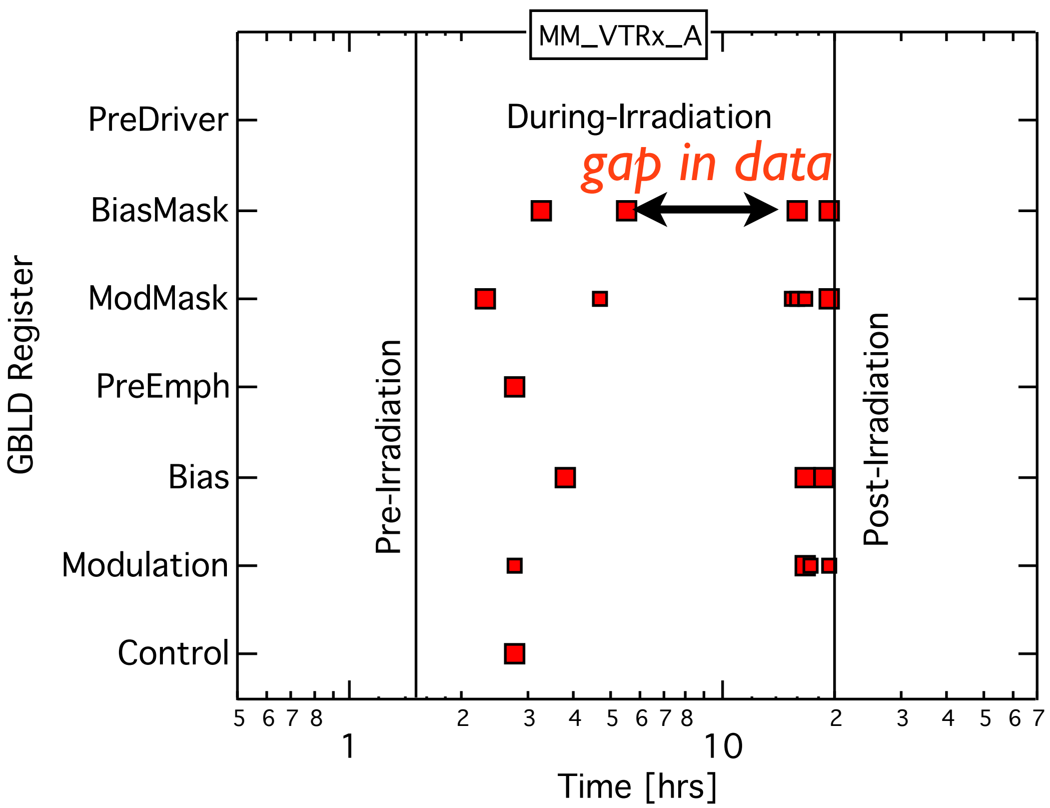
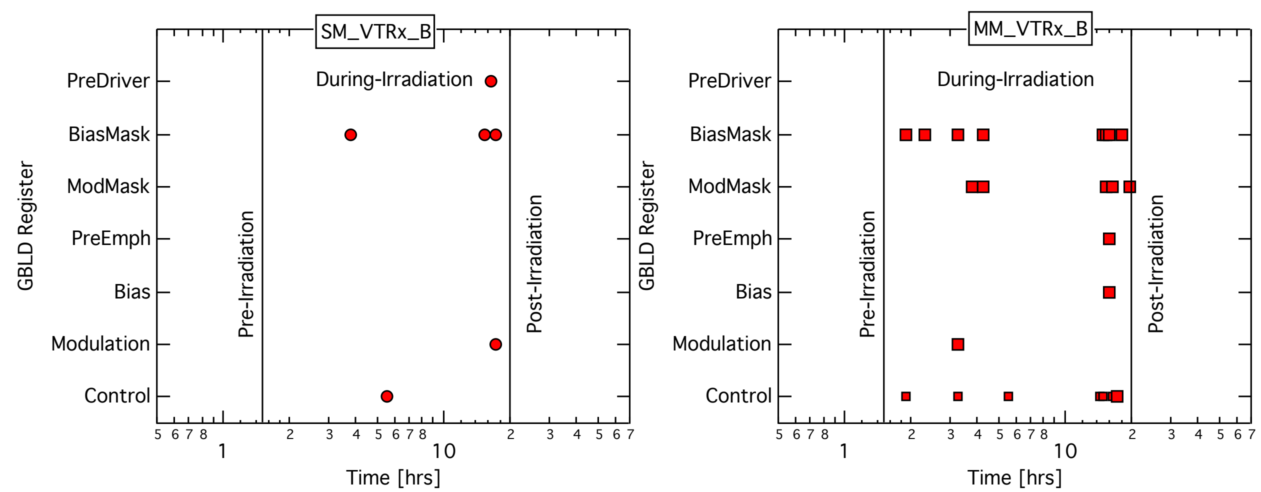


- Clearly see errors in the GBLD during irradiation
- error cross section : 1.2×10^{-14} errors/n/cm2
- other devices behaved in a similar manner



further away from the beam

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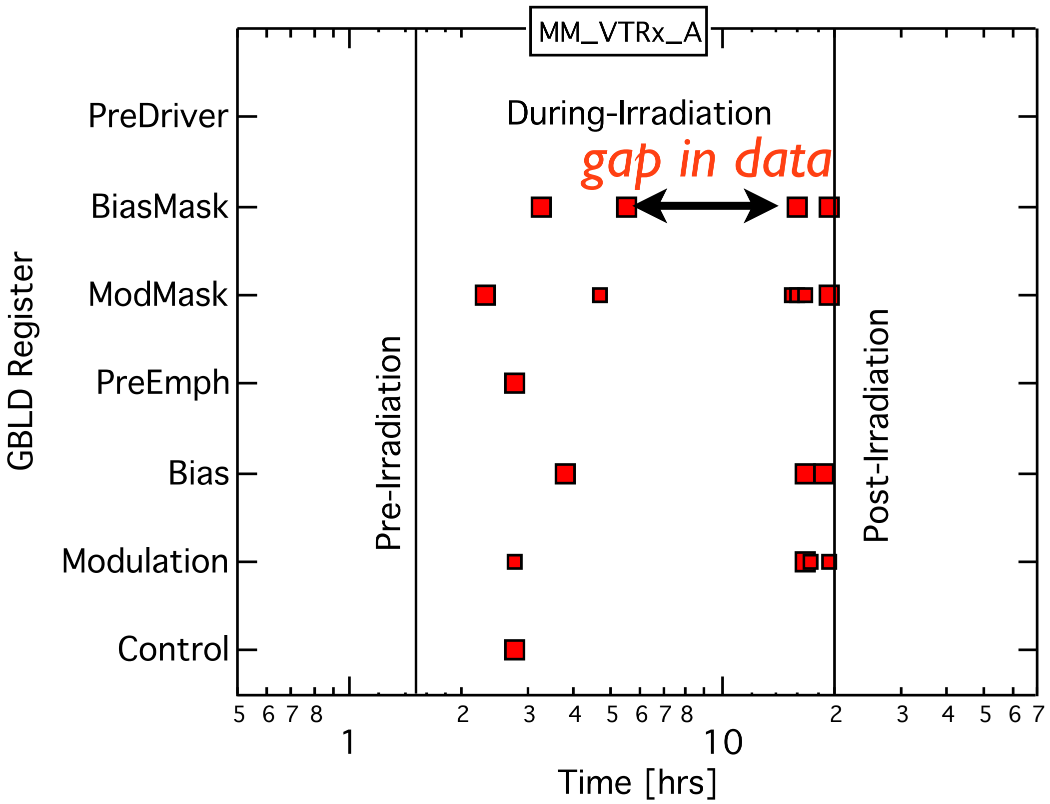

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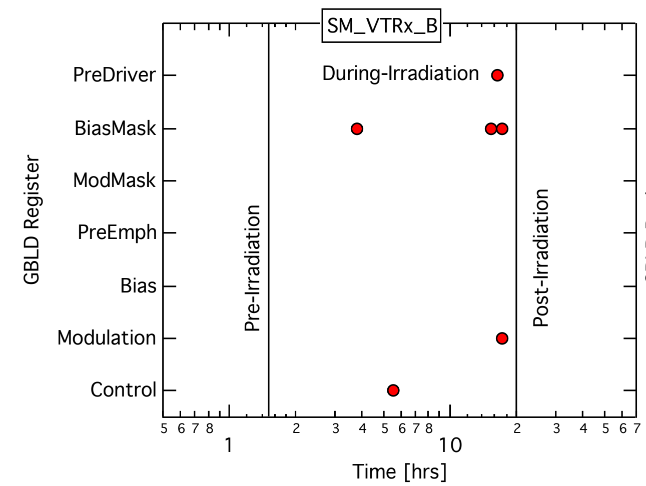
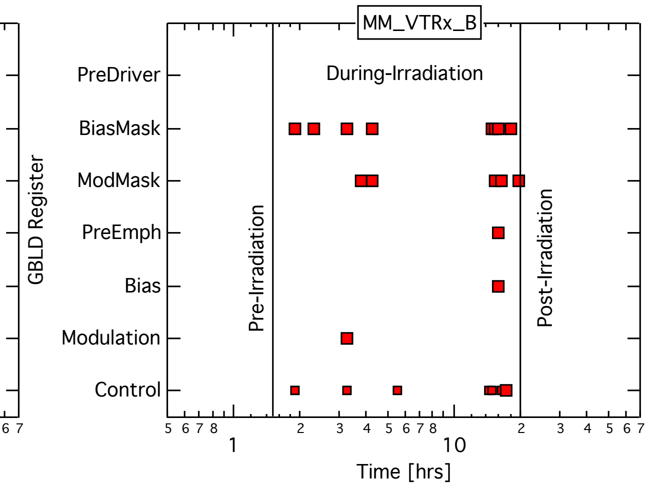
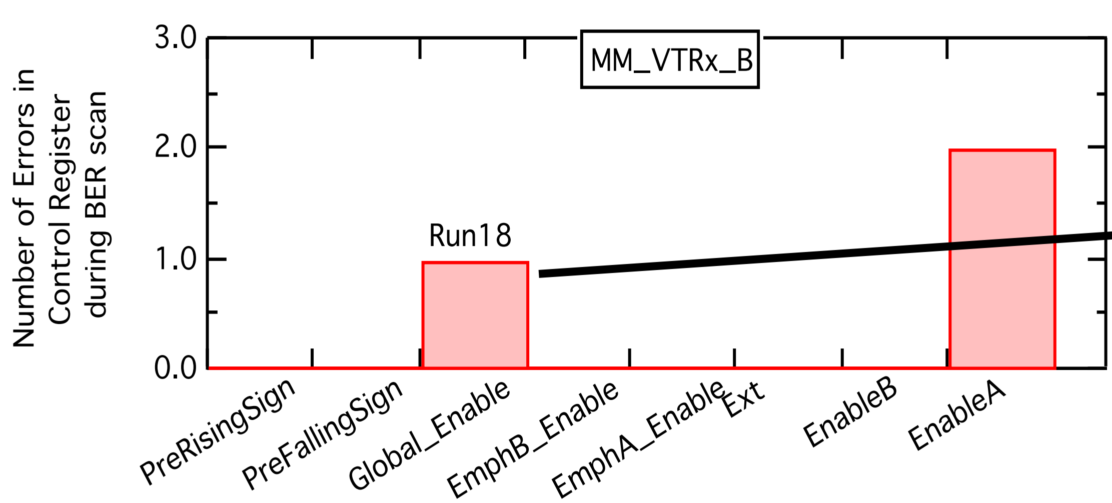
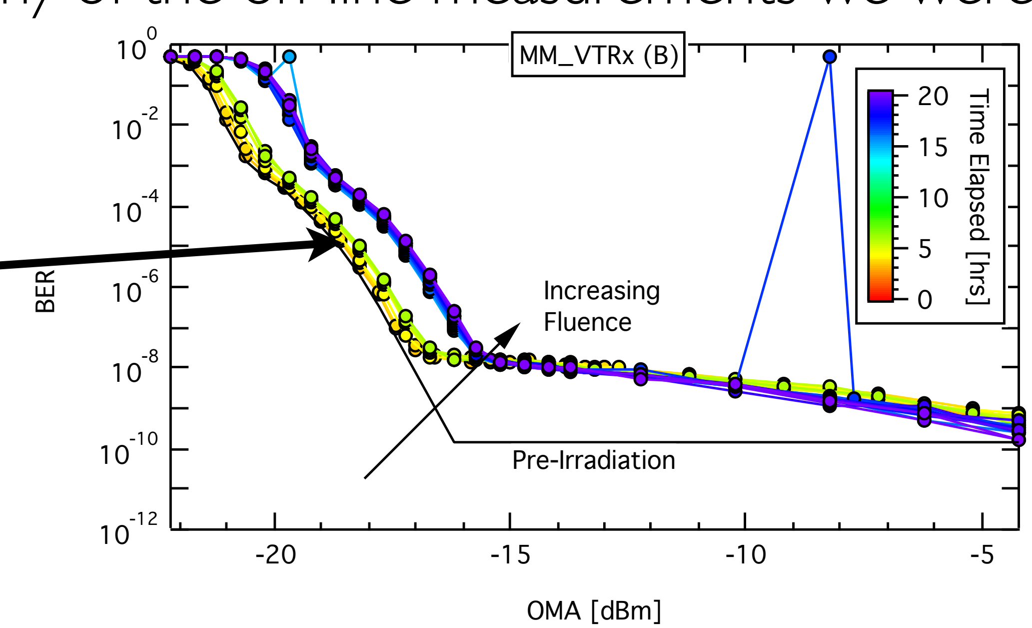




further away from the beam

- Checked whether these errors were "detectable" by any of the on-line measurements we were doing





Conclusions

- **First radiation test on full VTRx object**
  - SM and MM variants with GBLD v4.1 and GBTIA v.2 tested
  - transmitters degrade in the same manner predicted by radiation tests carried out on the passive components
  - change of saturation point of MM VTRxs can be predicted from the change in the VI curves of the transmitters during irradiation
  - leakage current of the photodiodes has a higher than expected impact on the sensitivity of the ROSAs to SEUs
  - SEUs observed in the GBLD

- **Future Plans**
  - Qualification of lasers and photodiodes for production of VTRxs

Back-Up Slides