



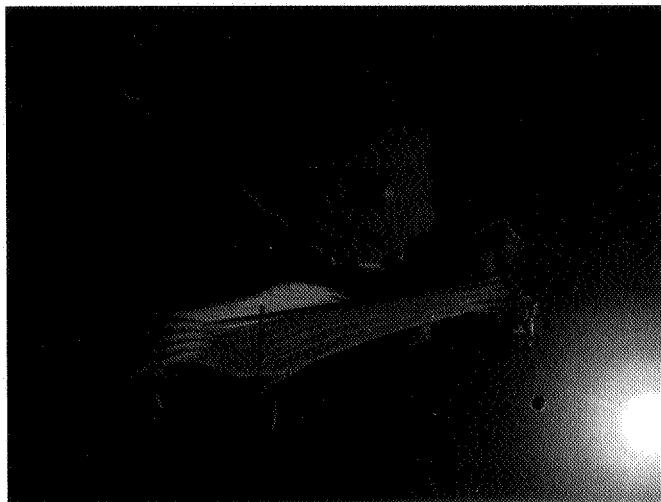
## Low Temperature (30 K) TID Test Results of a Radiation Hardened 128 Channel Serial-to-Parallel Converter.

Stephen Meyer, Stephen Buchner,, Harvey Moseley,  
Knutte Ray, Jim Tuttle, Ed Quinn, Ernie Buchanan,  
Dave Bloom, Tom Hait, Mike Pearce,  
David A. Rapchun

To be presented by Stephen Meyer and Stephen Buchner at Radiation and Its Effects on  
Components and Systems (RADECS) 2006, Athens Greece, September 27-29, 2006.

1

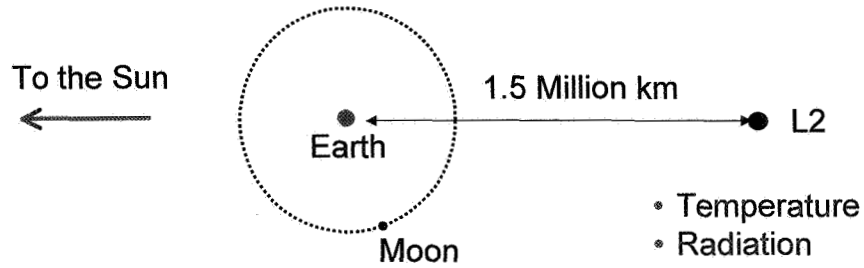
## James Webb Space Telescope



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2

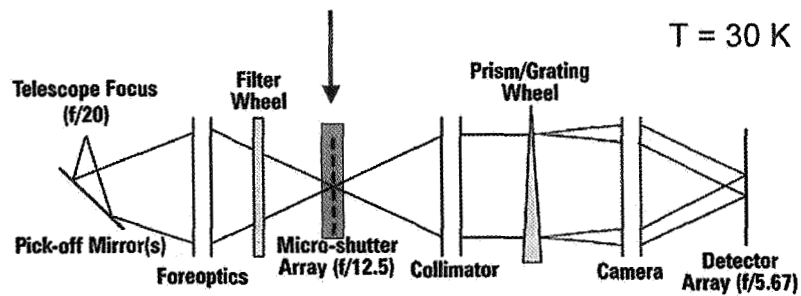
# JWST Orbit



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3

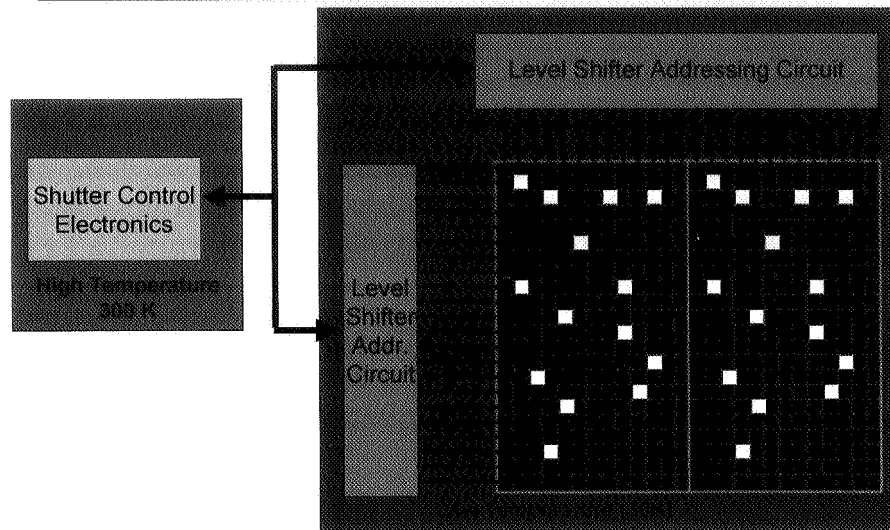
# NIRSPEC Optics



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4

# Electronic Circuit



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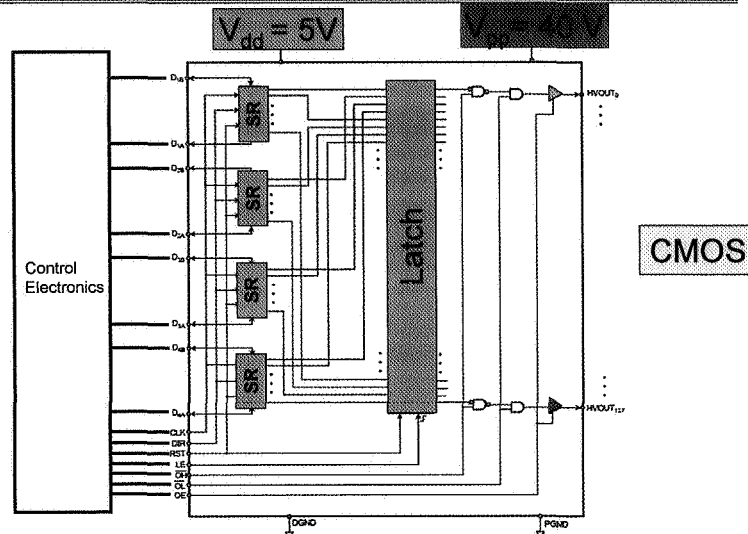
5

# HV583 COTS

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# HV583 – COTS Part



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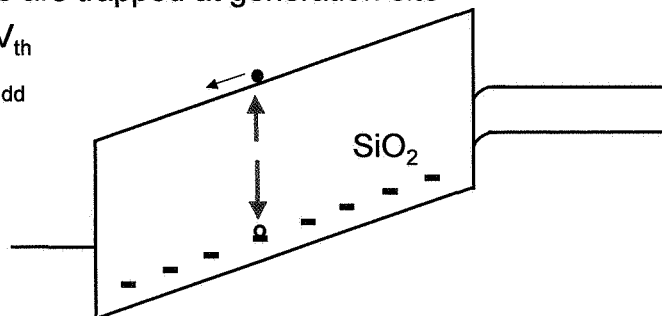
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# TID at 30 K

- TID Effects (1  $\mu\text{m}$  process) in gate and field oxides.

- Electrons exit oxide
- Holes are trapped at generation site

- o  $\Delta V_{th}$
- o  $\Delta I_{dd}$

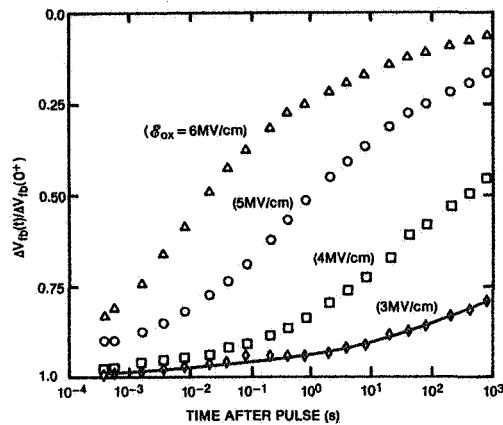


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## TID at 80 K

- Above approximately  $3 \times 10^6$  Volts/cm, the holes and protons are mobile.



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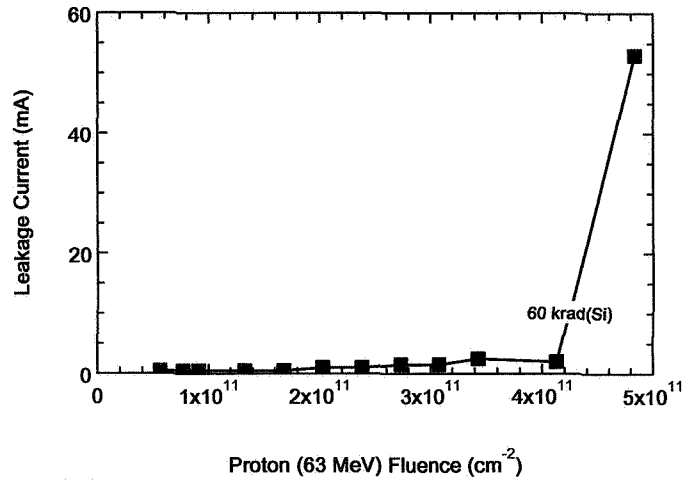
## Proton (63 MeV) Testing

- Both TID and SEE at the same time
- Devices at 30 K during irradiation
- Heavy ion needed for Single Event Dielectric Breakdown (SEDB) test

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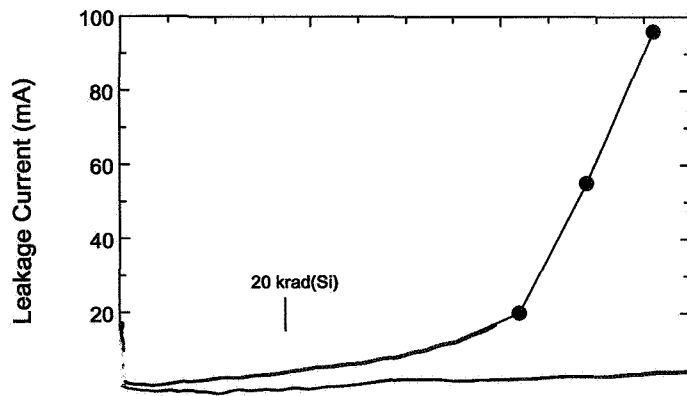
## Proton Test Results (40V)



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## Proton Test Results (5V)



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# HV584

## Redesigned Part

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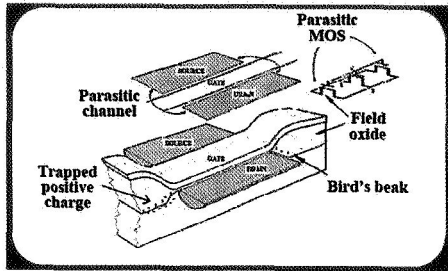
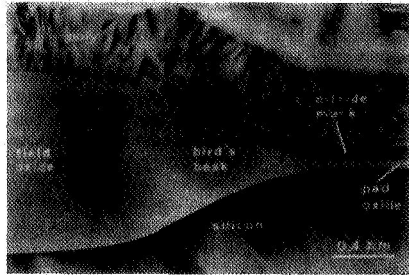
## HV584 – Rad-Hard by Design

- Features
  - 1.0  $\mu\text{m}$ , Single Poly/Double Metal, HV CMOS
  - Closed transistors via ion implantation to suppress leakage currents in “bird’s beak” region of NMOSFETs
  - Gate oxide thickness reduced by 50%
    - 1100 Å for HV transistor (SEGR)
    - 200 Å for LV transistor
- Added Functions
  - Mask to isolate faulty outputs
  - Comparator to measure  $V_{\text{out}}$

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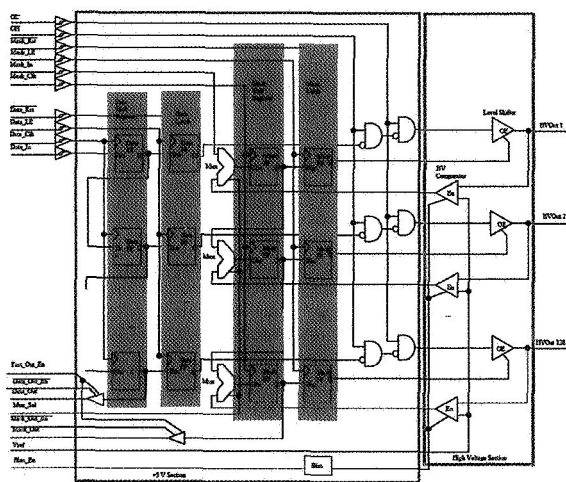
# Leakage Current via Bird's Beak



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# HV584



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## TID Test

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- Performed at 30 K in a dewar
  - Eight devices
- Co<sup>60</sup> (gamma ray source)
  - Up to 200 krad(Si)
- Dose rate was ~7 krad(Si)/hr

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## $I_{dd}(nA) - 5 V$ Supply

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Total Current Through Eight Devices

Test #	0 krad	5 krad	10 krad	20 krad	50 krad	100 krad	200 krad
1	0	75	72	0	79	83	0
2	1	68	72	2	79	78	0
3	1	68	75	1	78	82	0
4	0	75	71	1	80	83	0
5	0	66	78	1	81	83	0
6	0	67	74	1	79	81	0
7	1	72	71	1	77	81	0
8	392	392	391	392	392	391	392
9	196	196	196	196	196	196	196
10	196	196	196	196	196	196	196
11	3	64	69	4	6	6	0

↑ ↑ ↑ ↑  
Tested While Irradiated with Gamma Rays

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## $I_{pp}(nA) - 40 V$ Supply

### Total Current Through Eight Devices

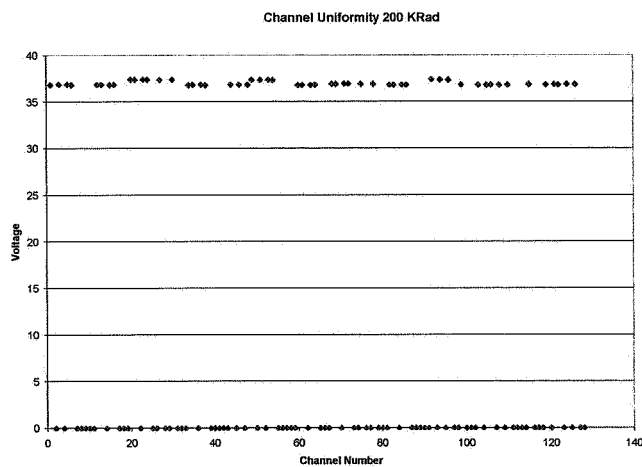
Test #	0 krad	5 krad	10 krad	20 krad	50 krad	100 krad	200 krad
1	0	63	64	1	80	67	6
2	0	67	64	0	57	67	11
3	0	92	80	12	80	86	4
4	0	74	66	5	70	77	3
5	0	67	64	0	68	70	2
6	0	68	64	0	68	63	2
7	1	67	63	2	69	75	2
8	0	64	75	1	68	73	2
9	0	67	68	2	68	72	3
10	0	65	67	1	68	72	2
11	0	62	66	1	68	71	2

↑ ↑ ↑ ↑  
Tested While Irradiated with Gamma Rays

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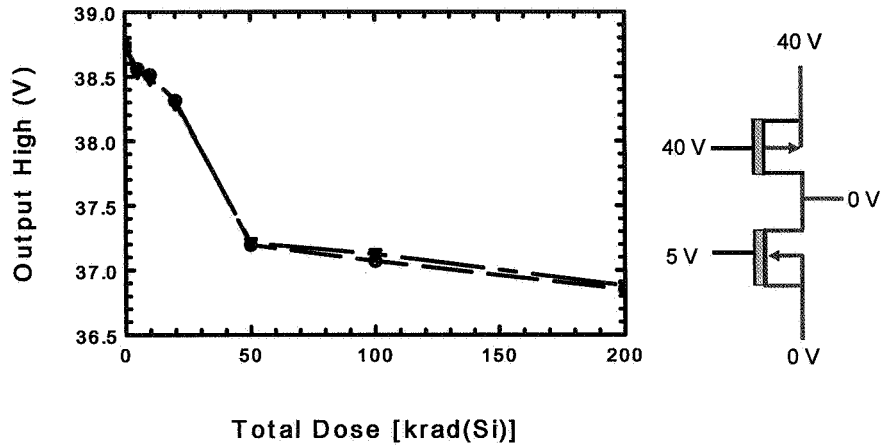
## Output Voltage after 200 krad(Si)



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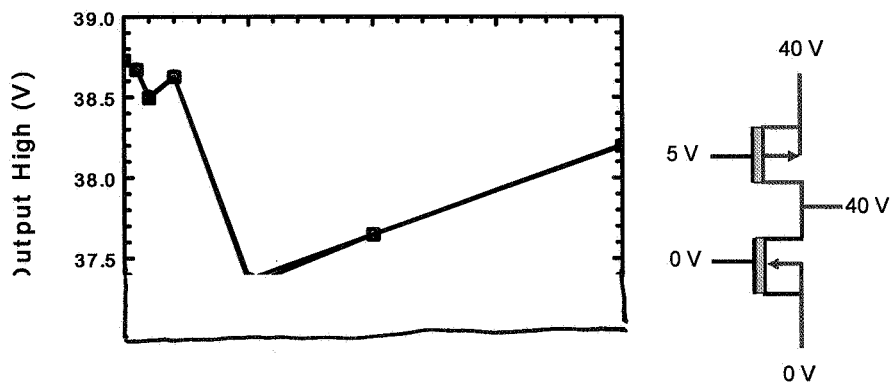
## Output Low During Irradiation



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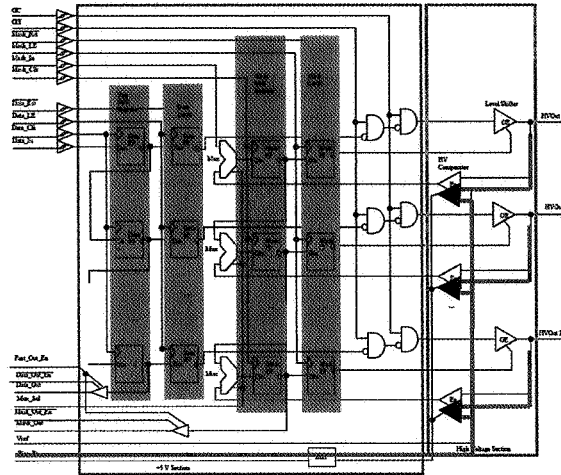
## Output High During Irradiation



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22

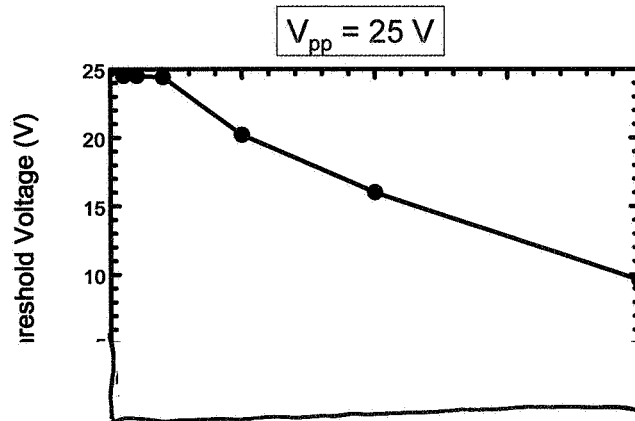
# Output Voltage Measurement



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# $V_{out}$ Measured by Comparator



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## Summary and Conclusions

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- The original HV583 level shifter – a COTS part - was not suitable for JWST because the supply currents exceeded specs after 20 krad(Si)
- The HV584 – functionally similar to the HV583 – was designed using RHBD approach that reduced the leakage currents to within acceptable levels and had only a small effect on the level-shifted output voltage.