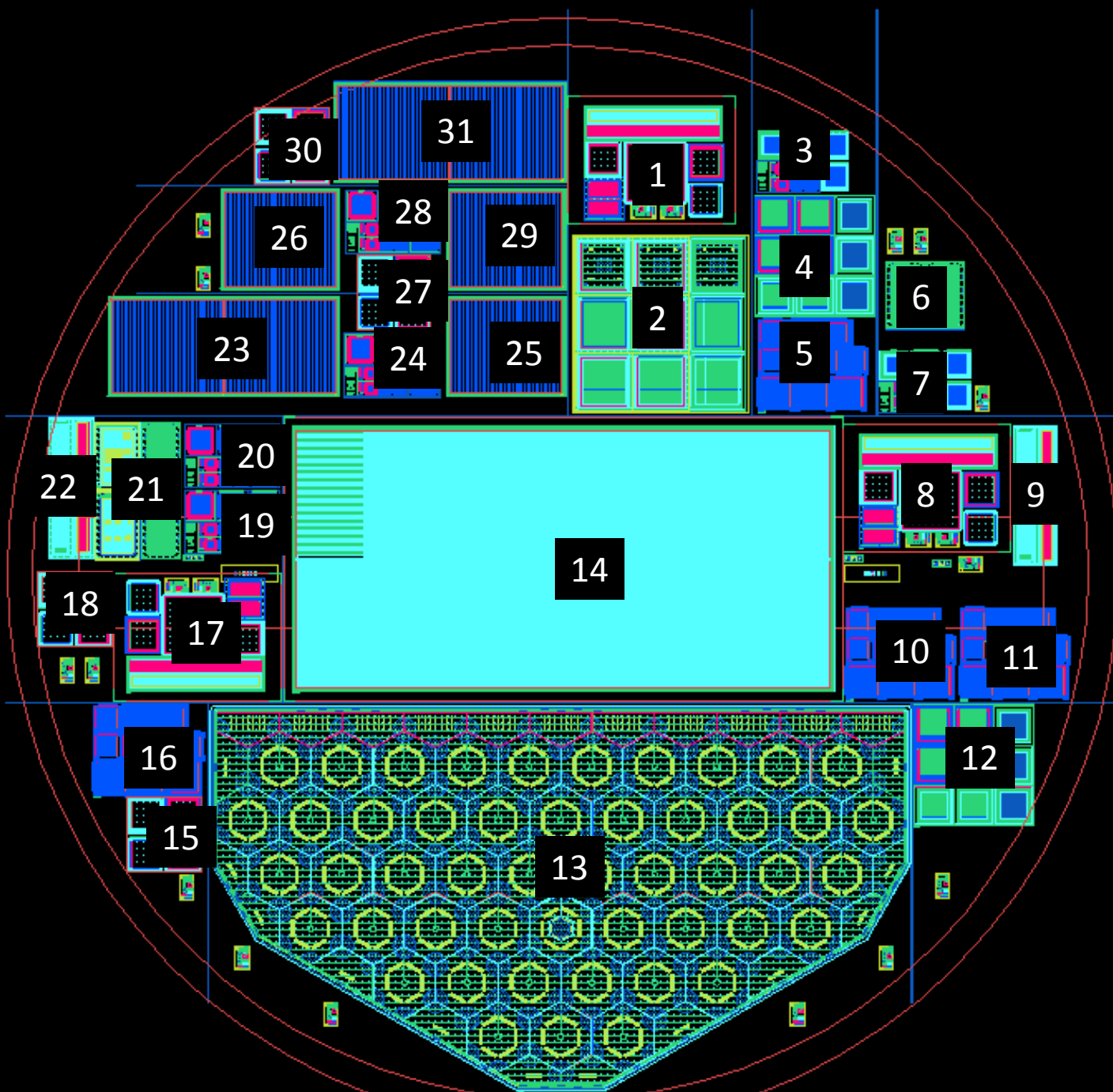


Novati SBIR-phase 1 measurements

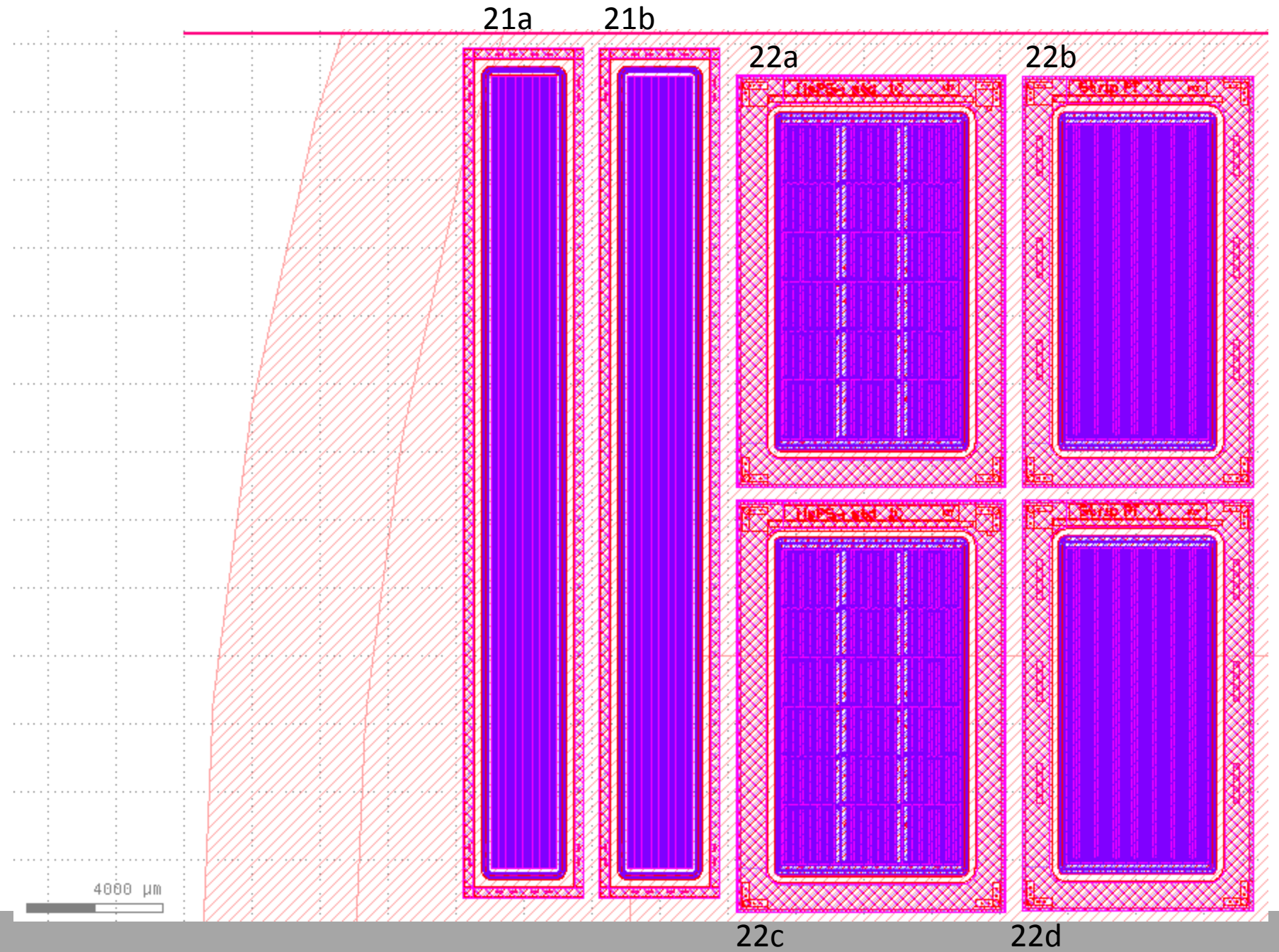
Robert Harrington, Ulrich Heintz, Meenakshi Narain, Stefan Piperov, Eric Spencer

Brown University



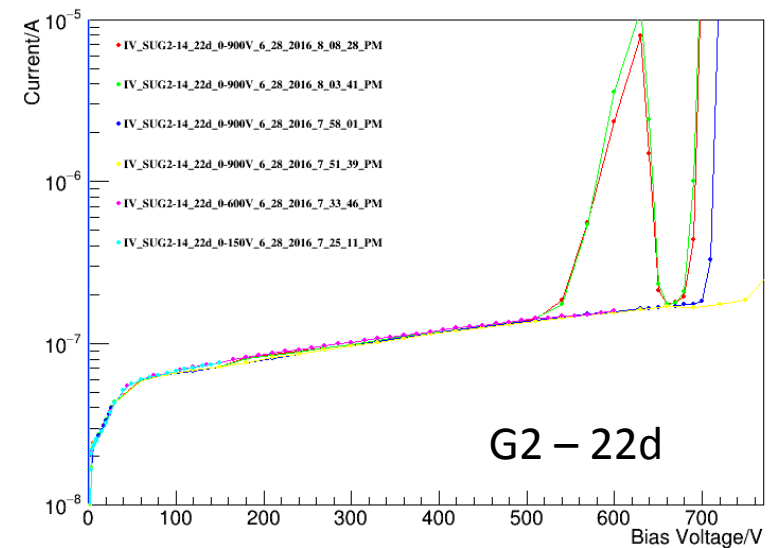
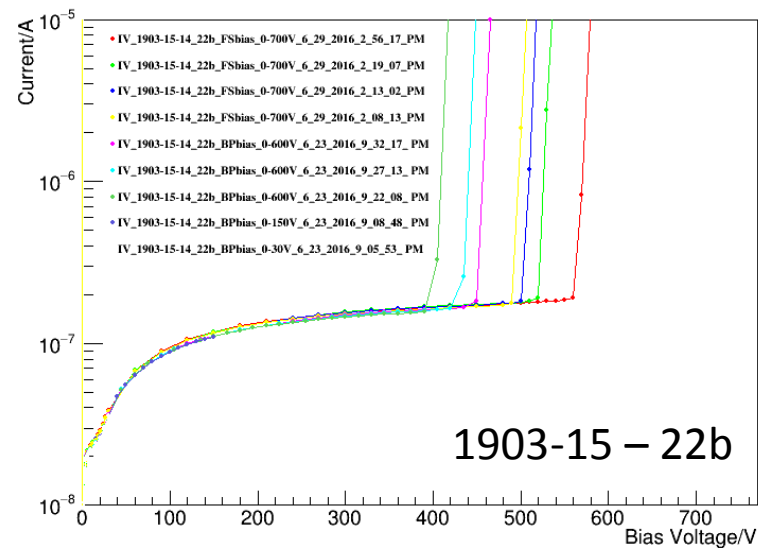
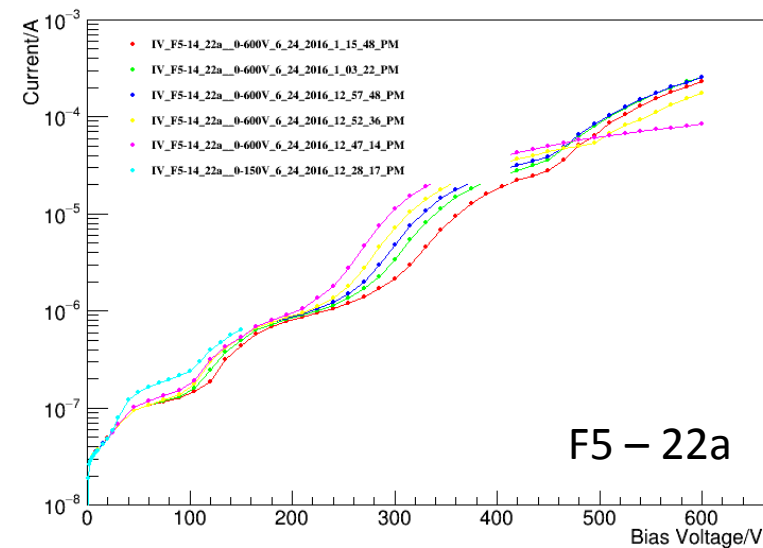
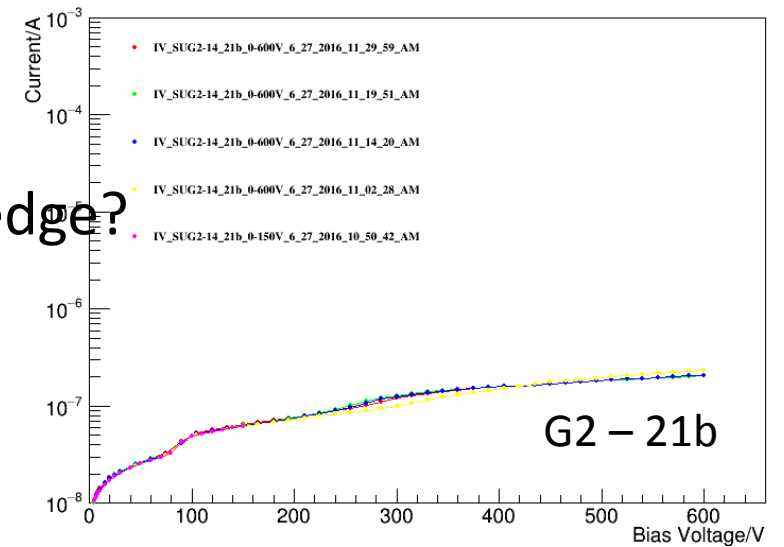


1. TS 1
2. CMS Pixel Large
3. Argonne FGR 1
4. CMS Pixel small 1
5. SLAC top 1
6. MAPSA Strip
7. Argonne FGR 2
8. TS 2
9. Twenty Strips FGR 1
10. SLAC top 2
11. SLAC top 3
12. CMS Pixel small 2
13. HGC
14. CMS PS
15. Four diode 1
16. SLAC top 4
17. TS 3
18. Four diode 2
19. Argonne 1
20. Argonne 2
21. MAPSA Strip 2
22. Twenty Strips FGR 2
23. FEI4 2 – 1
24. Argonne 3
25. FEI4 1 – 1
26. FEI4 1 – 2
27. Four diode 3
28. Argonne 4
29. FEI4 1 – 3
30. Four diode 4
31. FEI4 2 – 2



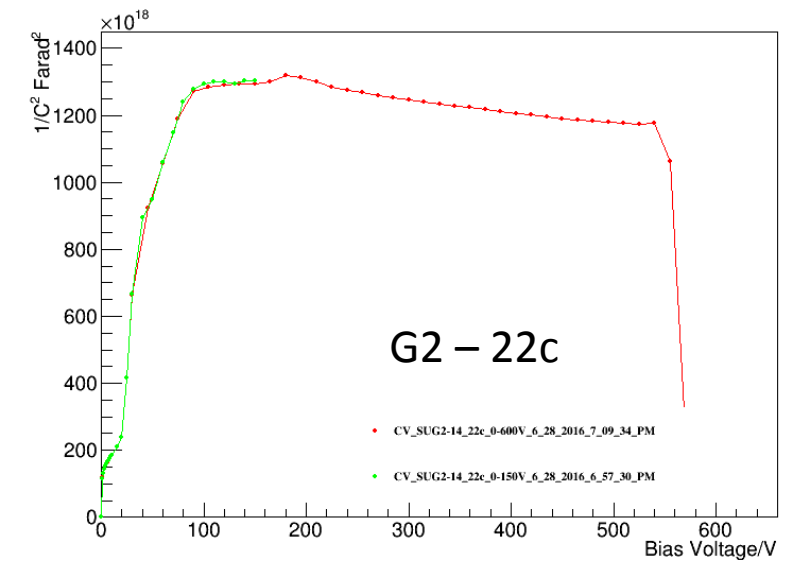
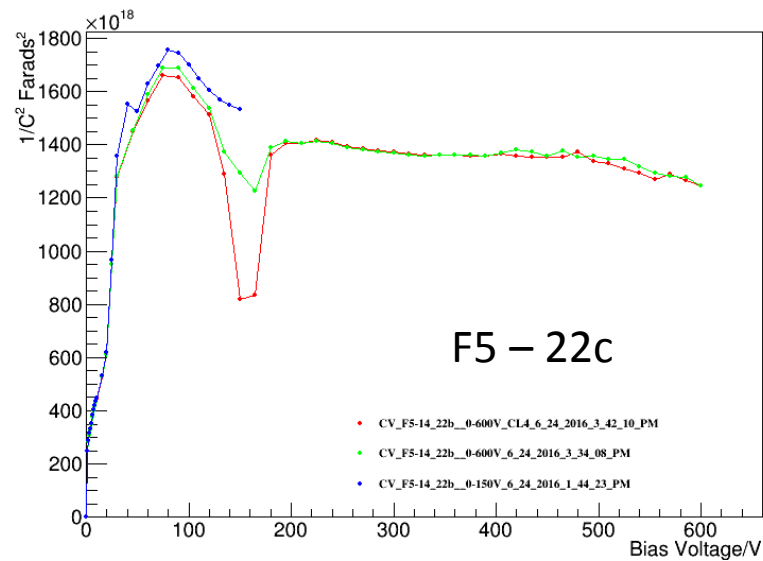
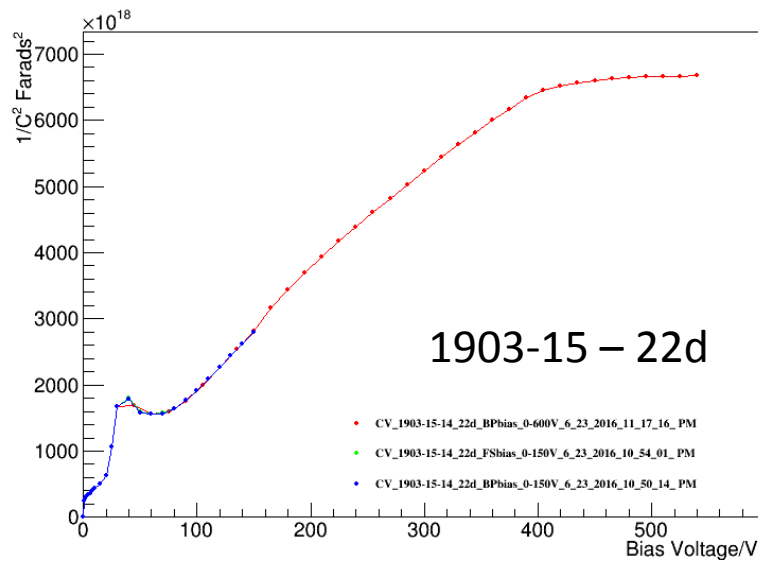
General observations

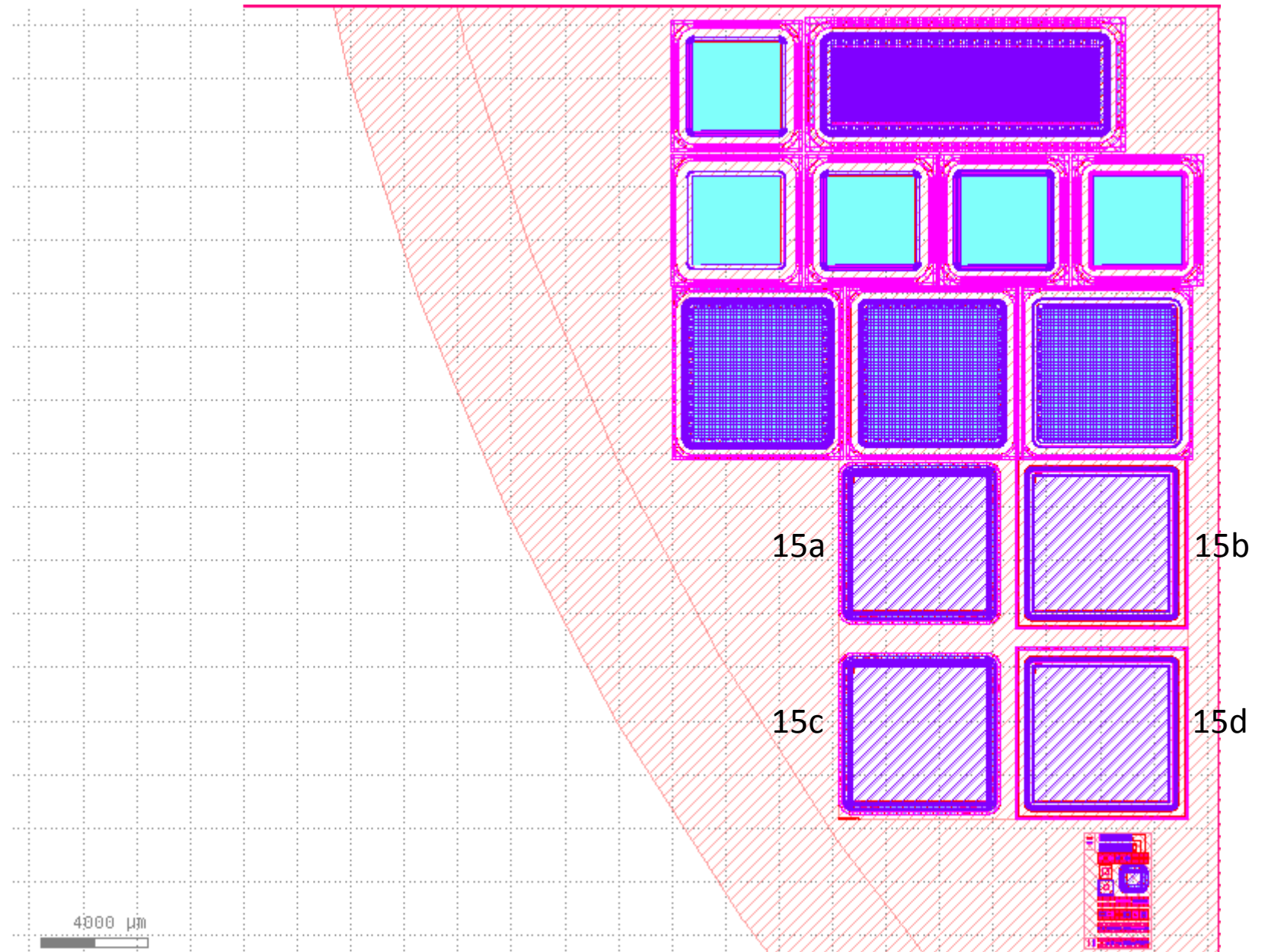
- Structure 21 - long strips
 - 21a – generally low/soft breakdown – too close to wafer edge?
 - 21b – high breakdown (except for wafer F5)
- Structure 22 – MaPSA-light and short strips
 - Breakdown voltage often increases with successive ramps
 - Sometimes show soft breakdown



General observations

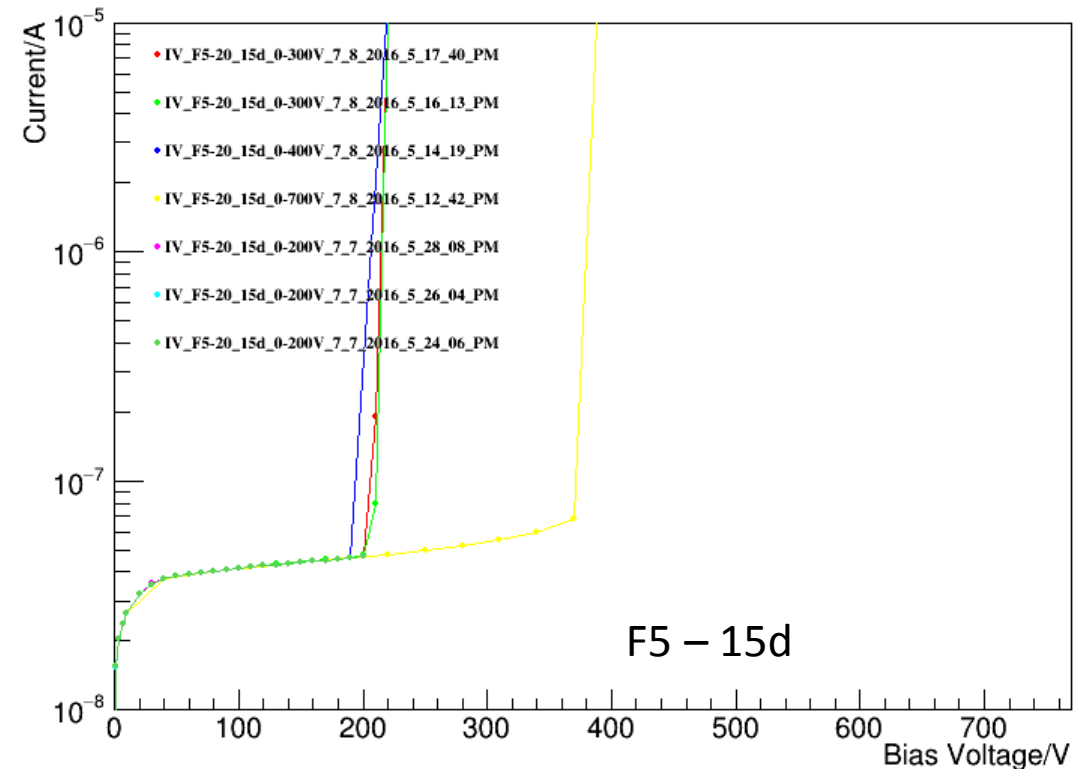
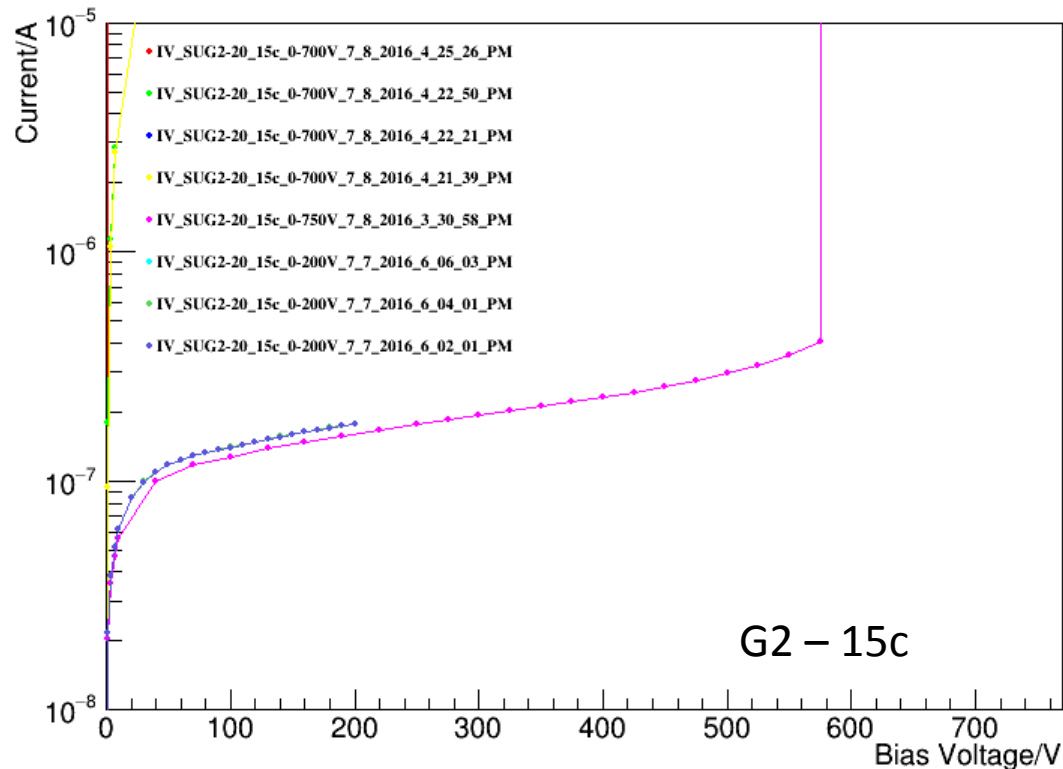
- CV curves show a lot of structure

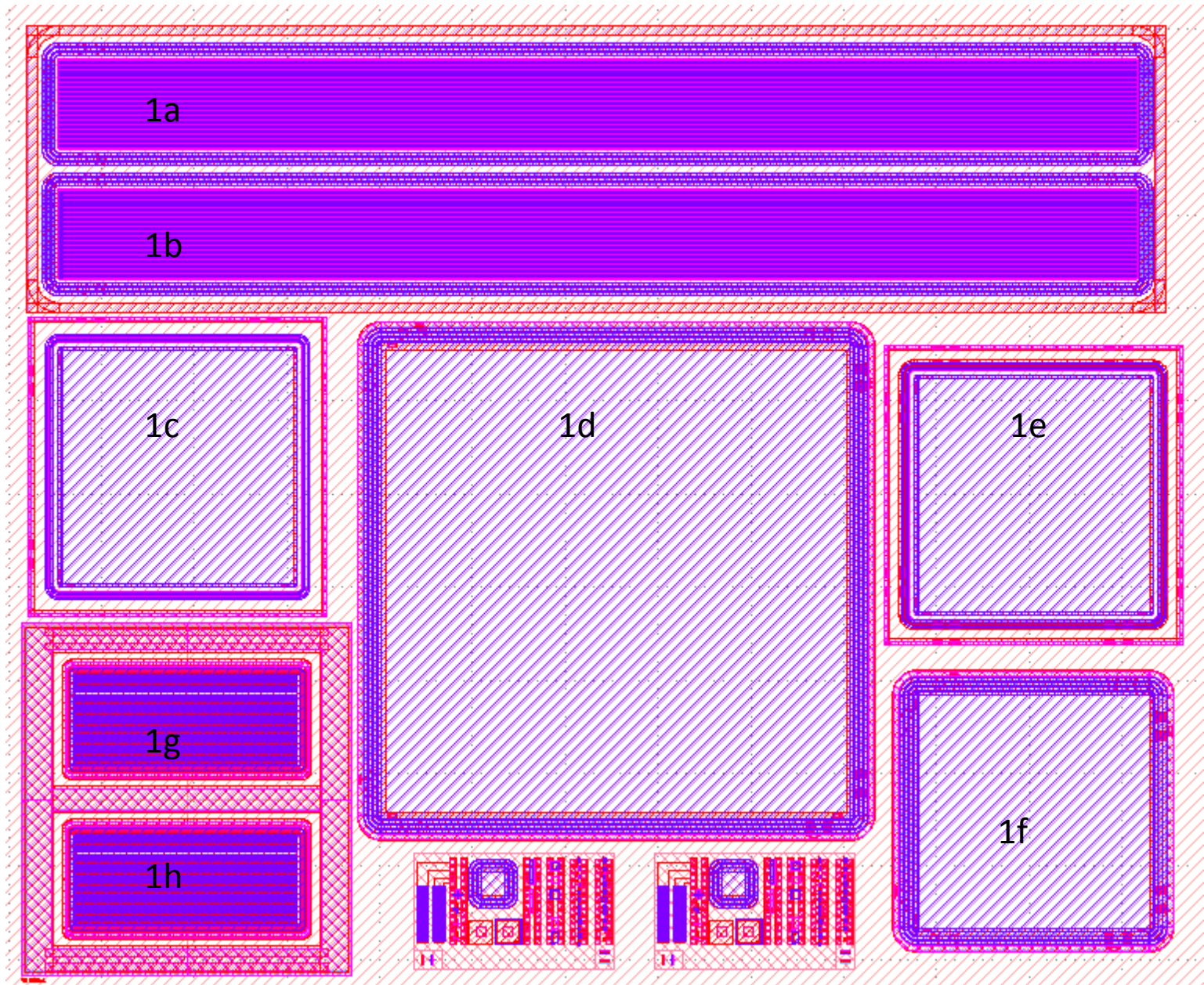




General observations

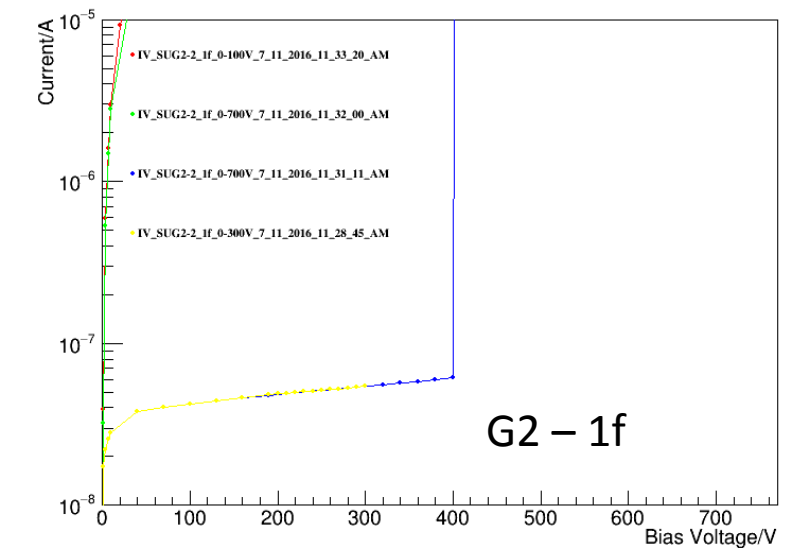
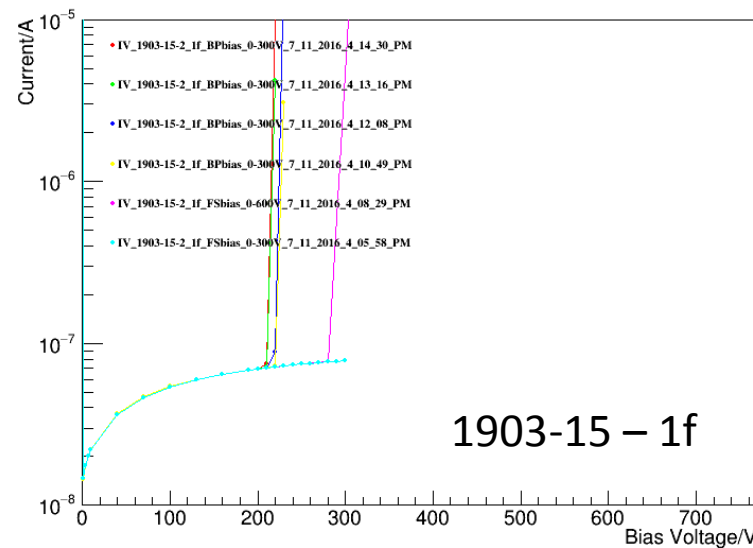
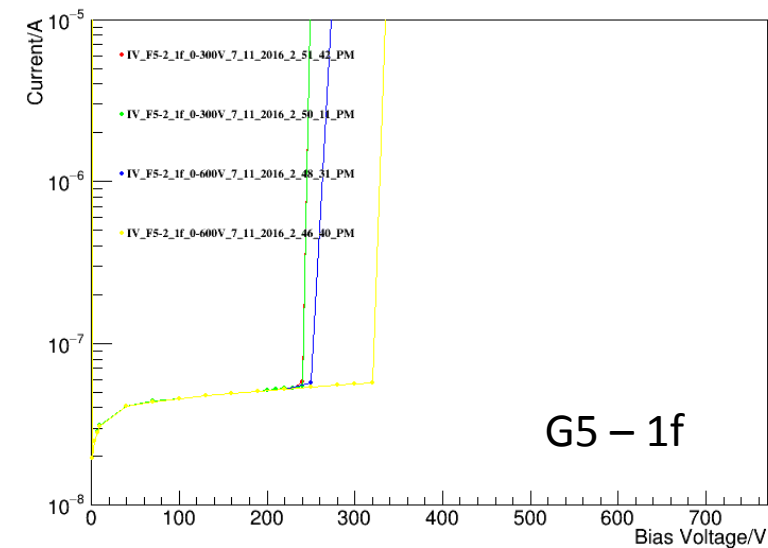
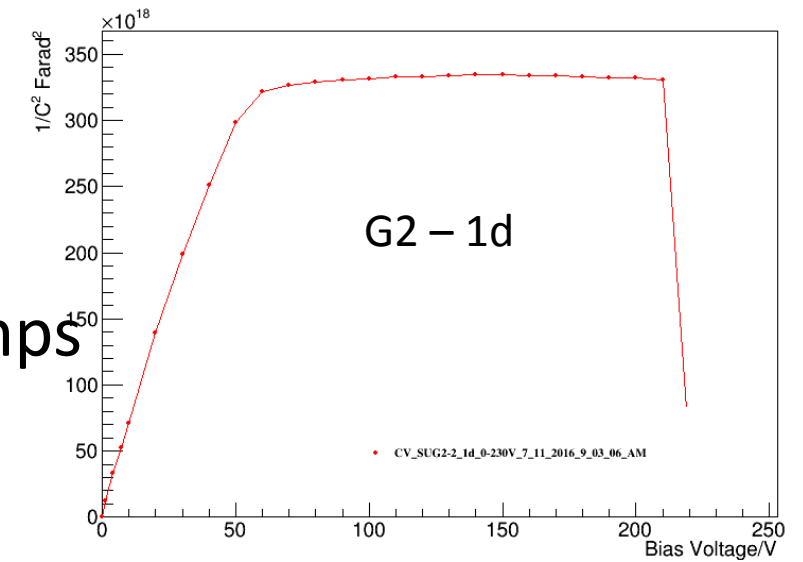
- Typically hard breakdown
- Breakdown voltage decreases with successive IV ramps
- FNAL guard ring has highest breakdown





General observations

- No access to bias ring for long strips (1a/b)
- Typically hard breakdown and clean CV curves
- Breakdown voltage decreases with successive IV ramps
- FNAL guard ring has highest breakdown



Summary F5

| Wafer | Type | Oxide | P-dose | Structure | GR | Site | Device | BD Max | Step | BD Min | Step | Comments | |
|-------|------|-------|----------|-----------|---------------|-------|--------|--------|------|--------|------|-----------|----------------|
| F5 | SOI | wet | 5.00E+12 | 1c | SLAC | Brown | | 190 | 30 | 130 | 20 | decrease | |
| F5 | SOI | wet | 5.00E+12 | 1d | LD | Brown | | 310 | 10 | 220 | 10 | decrease | |
| F5 | SOI | wet | 5.00E+12 | 1e | HPK | Brown | | 200 | 10 | 150 | 10 | decrease | |
| F5 | SOI | wet | 5.00E+12 | 1f | FNAL | Brown | | 340 | 20 | 250 | 10 | decrease | |
| F5 | SOI | wet | 5.00E+12 | 15a | HPK pstop | Brown | | 370 | 30 | 290 | 10 | decrease | |
| F5 | SOI | wet | 5.00E+12 | 15b | HPK | Brown | | 400 | 30 | 210 | 10 | decrease | |
| F5 | SOI | wet | 5.00E+12 | 15c | FNAL | Brown | | 520 | 30 | 260 | 10 | decrease | |
| F5 | SOI | wet | 5.00E+12 | 15d | HPK no pstops | Brown | | 400 | 30 | 220 | 10 | decrease | |
| F5 | SOI | wet | 5.00E+12 | 21a | long strips | Brown | | 50 | 10 | 50 | 10 | no change | |
| F5 | SOI | wet | 5.00E+12 | 21b | long strips | Brown | | 255 | 15 | 285 | 15 | no change | soft breakdown |
| F5 | SOI | wet | 5.00E+12 | 22a | MAPSA | Brown | | 255 | 15 | 300 | 15 | increase | soft breakdown |
| F5 | SOI | wet | 5.00E+12 | 22b | short strips | Brown | | 330 | 15 | 300 | 15 | no change | soft breakdown |
| F5 | SOI | wet | 5.00E+12 | 22c | MAPSA | Brown | | 165 | 15 | 210 | 15 | increase | soft breakdown |
| F5 | SOI | wet | 5.00E+12 | 22d | short strips | Brown | | >600 | | | | | |

- Depletion voltage $\approx 60V$ (based on diodes)
- Breakdown between 130 and $>600 V$
- MaPSA and strips have low/soft breakdown



Summary G2

| Wafer | Type | Oxide | P-dose | Structure | GR | Site | Device | BD Max | Step | BD Min | Step | Comments |
|-------|------|-------|----------|-----------|---------------|-------|--------|--------|------|--------|------|---------------------------|
| G2 | SOI | wet | 5.00E+11 | 1c | SLAC | Brown | | 210 | 10 | 130 | 10 | decrease |
| G2 | SOI | wet | 5.00E+11 | 1d | LD | Brown | | 380 | 20 | 220 | 10 | decrease |
| G2 | SOI | wet | 5.00E+11 | 1e | HPK | Brown | | 320 | 10 | 180 | 10 | increase |
| G2 | SOI | wet | 5.00E+11 | 1f | FNAL | Brown | | 420 | 20 | 10 | 3 | decrease permanent dama |
| G2 | SOI | wet | 5.00E+11 | 15a | HPK pstop | Brown | | 400 | 25 | 310 | 10 | decrease |
| G2 | SOI | wet | 5.00E+11 | 15b | HPK | Brown | | 290 | 10 | 280 | 30 | no change soft breakdown |
| G2 | SOI | wet | 5.00E+11 | 15c | FNAL | Brown | | 600 | 25 | 1 | 1 | decrease permanent dama |
| G2 | SOI | wet | 5.00E+11 | 15d | HPK no pstops | Brown | | 420 | 20 | 330 | 10 | no change |
| G2 | SOI | wet | 5.00E+11 | 21a | long strips | Brown | | 270 | 15 | 255 | 15 | no change soft breakdown |
| G2 | SOI | wet | 5.00E+11 | 21b | long strips | Brown | | >600 | | | | |
| G2 | SOI | wet | 5.00E+11 | 22a | MAPSA | Brown | | 600 | 15 | 570 | 15 | no change |
| G2 | SOI | wet | 5.00E+11 | 22b | short strips | Brown | | 795 | 15 | 720 | 15 | increase soft breakdown |
| G2 | SOI | wet | 5.00E+11 | 22c | MAPSA | Brown | | >600 | | 585 | 15 | decrease |
| G2 | SOI | wet | 5.00E+11 | 22d | short strips | Brown | | 810 | 30 | 600 | 30 | decrease multiple breakdo |

- Depletion voltage $\approx 60V$ (based on diodes)
- Breakdown between 130 and $>600 V$
- Two diodes seem to have permanent damage after IV ramp
- MaPSA and strips have high/hard breakdown



Summary 1903-15

| Wafer | Type | Oxide | P-dose | Structure | GR | Site | Device | BD Max | Step | BD Min | Step | Comments |
|---------|------|-------|----------|-----------|---------------|-------|--------|--------|------|--------|------|--------------------------|
| 1903-15 | FZ | wet | 5.00E+12 | 1c | SLAC | Brown | | 190 | 30 | 130 | 10 | decrease |
| 1903-15 | FZ | wet | 5.00E+12 | 1d | LD | Brown | | 400 | 30 | 270 | 10 | decrease |
| 1903-15 | FZ | wet | 5.00E+12 | 1e | HPK | Brown | | 160 | 30 | 130 | 10 | decrease |
| 1903-15 | FZ | wet | 5.00E+12 | 1f | FNAL | Brown | | 310 | 30 | 220 | 10 | decrease |
| 1903-15 | FZ | wet | 5.00E+12 | 15a | HPK pstop | Brown | | 190 | 10 | 150 | 10 | decrease |
| 1903-15 | FZ | wet | 5.00E+12 | 15b | HPK | Brown | | 180 | 10 | 140 | 10 | decrease |
| 1903-15 | FZ | wet | 5.00E+12 | 15c | FNAL | Brown | | 250 | 10 | 210 | 10 | decrease |
| 1903-15 | FZ | wet | 5.00E+12 | 15d | HPK no pstops | Brown | | 200 | 10 | 150 | 10 | decrease |
| 1903-15 | FZ | wet | 5.00E+12 | 21a | long strips | Brown | | 60 | 10 | 60 | 10 | no change soft breakdown |
| 1903-15 | FZ | wet | 5.00E+12 | 21b | long strips | Brown | | >600 | | | | |
| 1903-15 | FZ | wet | 5.00E+12 | 22a | MAPSA | Brown | | 480 | 30 | 375 | 15 | increase soft breakdown |
| 1903-15 | FZ | wet | 5.00E+12 | 22b | short strips | Brown | | 580 | 10 | 420 | 15 | increase |
| 1903-15 | FZ | wet | 5.00E+12 | 22c | MAPSA | Brown | | 590 | 10 | 480 | 15 | increase |
| 1903-15 | FZ | wet | 5.00E+12 | 22d | short strips | Brown | | 510 | 10 | 600 | 15 | increase |

- Depletion voltage $\approx 400V$ (based on MaPSA and short strips)
- Diodes break down before depletion
- MaPSA and strips have high/hard breakdown



Summary 1903-13

| Wafer | Type | Oxide | P-dose | Structure | GR | Site | Device | BD Max | Step | BD Min | Step | Comments | |
|---------|------|-------|----------|-----------|--------------|-------|--------|--------|------|--------|------|-----------|----------------|
| 1903-13 | FZ | dry | 5.00E+12 | 21a | long strips | Brown | | 150 | 30 | 120 | 30 | no change | soft breakdown |
| 1903-13 | FZ | dry | 5.00E+12 | 21b | long strips | Brown | | 540 | 30 | 270 | 30 | decrease | |
| 1903-13 | FZ | dry | 5.00E+12 | 22a | MAPSA | Brown | | 150 | 30 | 120 | 30 | increase | soft breakdown |
| 1903-13 | FZ | dry | 5.00E+12 | 22b | short strips | Brown | | 210 | 30 | 180 | 30 | increase | soft breakdown |
| 1903-13 | FZ | dry | 5.00E+12 | 22c | MAPSA | Brown | | 150 | 30 | 120 | 30 | increase | soft breakdown |
| 1903-13 | FZ | dry | 5.00E+12 | 22d | short strips | Brown | | 150 | 30 | 60 | 30 | decrease | soft breakdown |

- Depletion voltage \approx 120-180V (based on MaPSA and short strips)
- Low breakdown voltage
- Soft breakdown

