28th RD50 Workshop – Torino, June 7 2015

# Results from the first 300-micron thick LGAD production at FBK

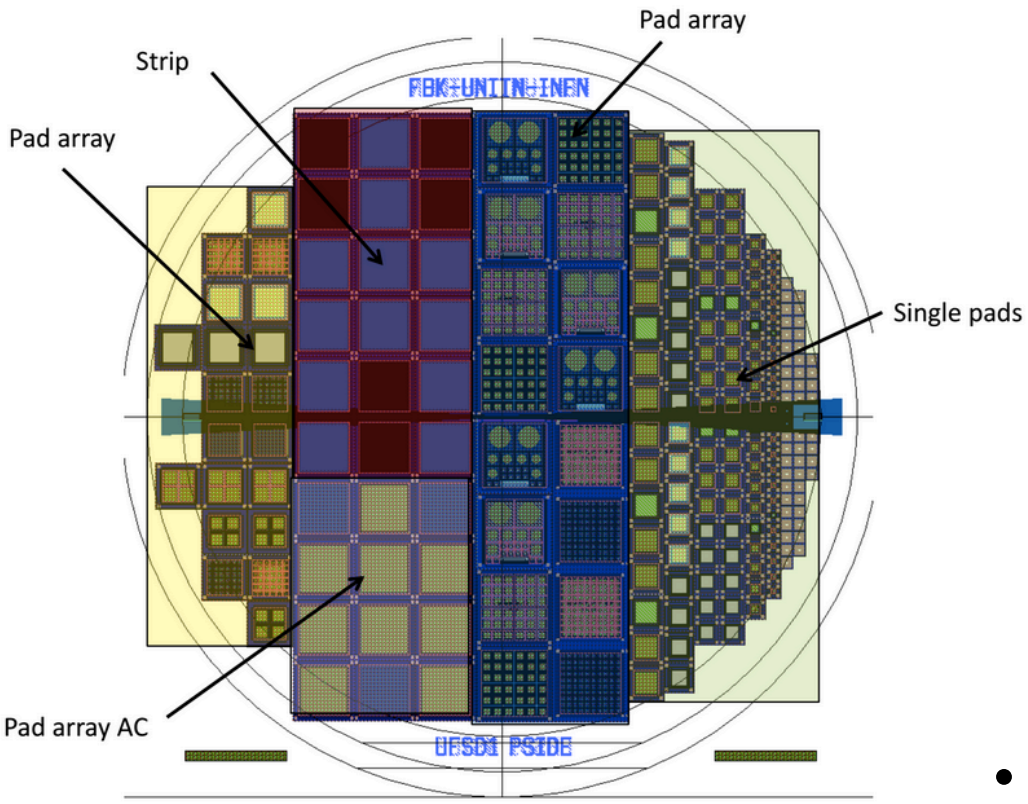
Marco Ferrero



# Outline

- FBK 300 μm LGAD production layout;
- Detector characterization:
  - Current Vs Voltage Bias (Measurements and setup);
  - Gain (Measurements and setup);
  - Time resolution (Measurements and setup);
- Beam test, preliminary results;

# LGAD production layout




*Wafer Layout for the 300µm production*

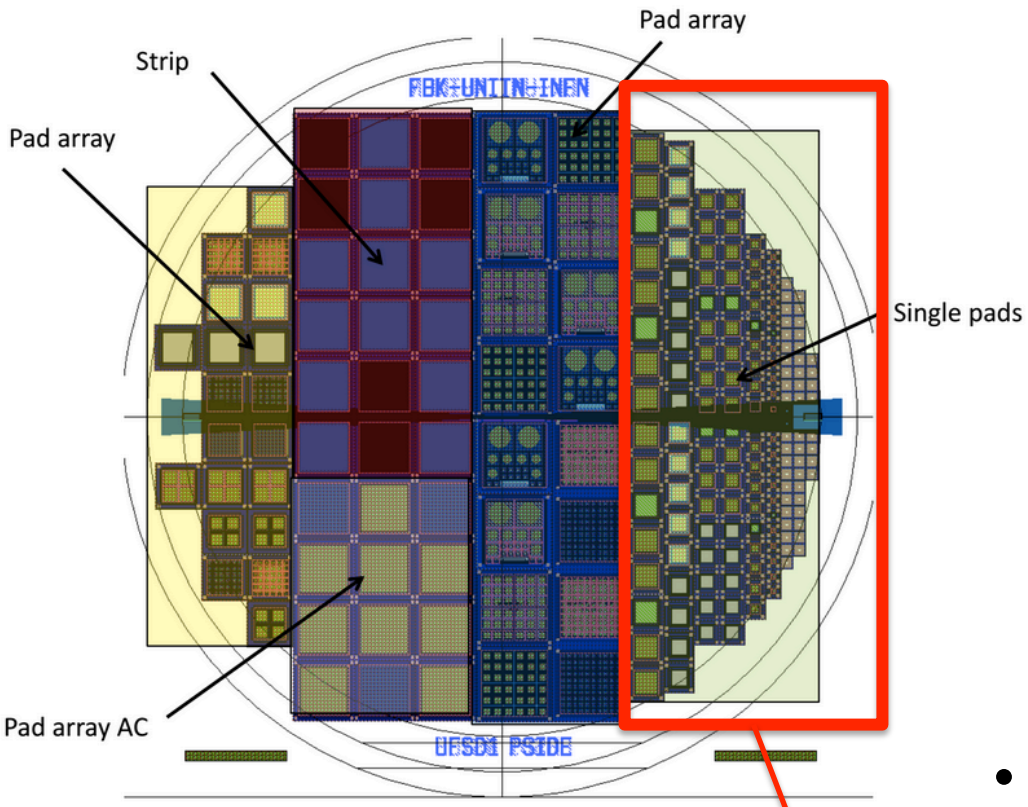
**Characteristics:**

- Thickness 300µm;
- 13 Wafers produced;
- 5 Splits of gain in 2% steps;
- Multiple structures (single pad, multi-pad, array, strip);
- n-side segmentation;
- p-side segmentation;

**Goals of this production:**

- **Investigate the gain layer**
- **Demonstrator of LGAD technology at FBK**

# LGAD production layout

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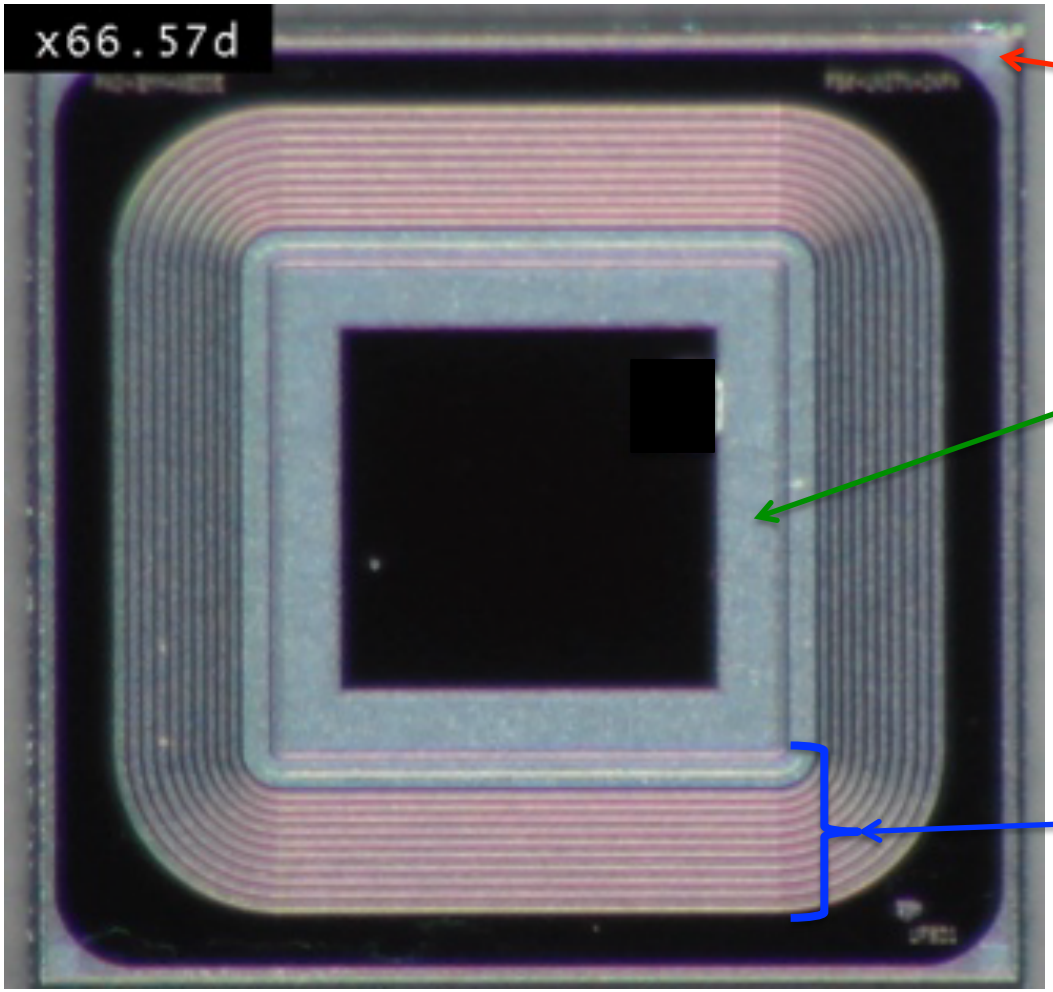
Wafer 3 → split 2 of gain
Wafer 10 → split 4 of gain

**Detector in Turin**

# Single pad LGAD




p-bulk contact

n-electrode

Frame of 11 guard ring

**Single pad size;**
0,25 $mm^2$/1 $mm^2$/4 $mm^2$/9 $mm^2$/25$mm^2$

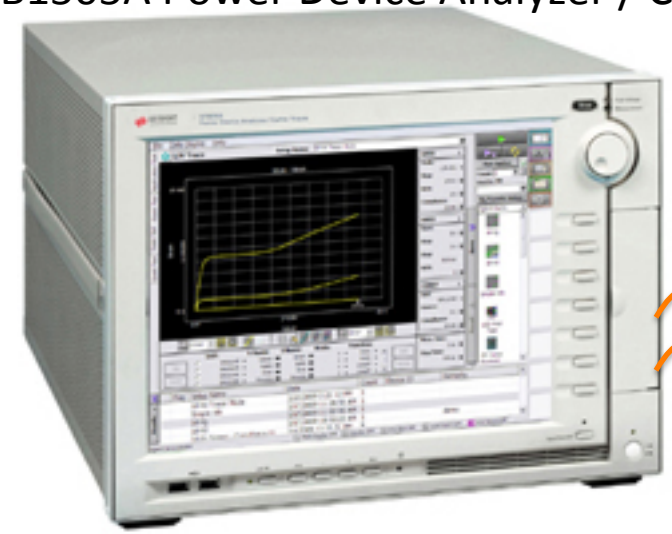
# Detector characterization

**Laboratory measurements:**

- **Current Vs Voltage curve:** measurement of the Breakdown Voltage and of the detector leakage current;
- **Signal acquisition:** measurement of the detector gain and time resolution;

# IV measurements (laboratory setup)

Keysight
B1505A Power Device Analyzer / Curve Tracer



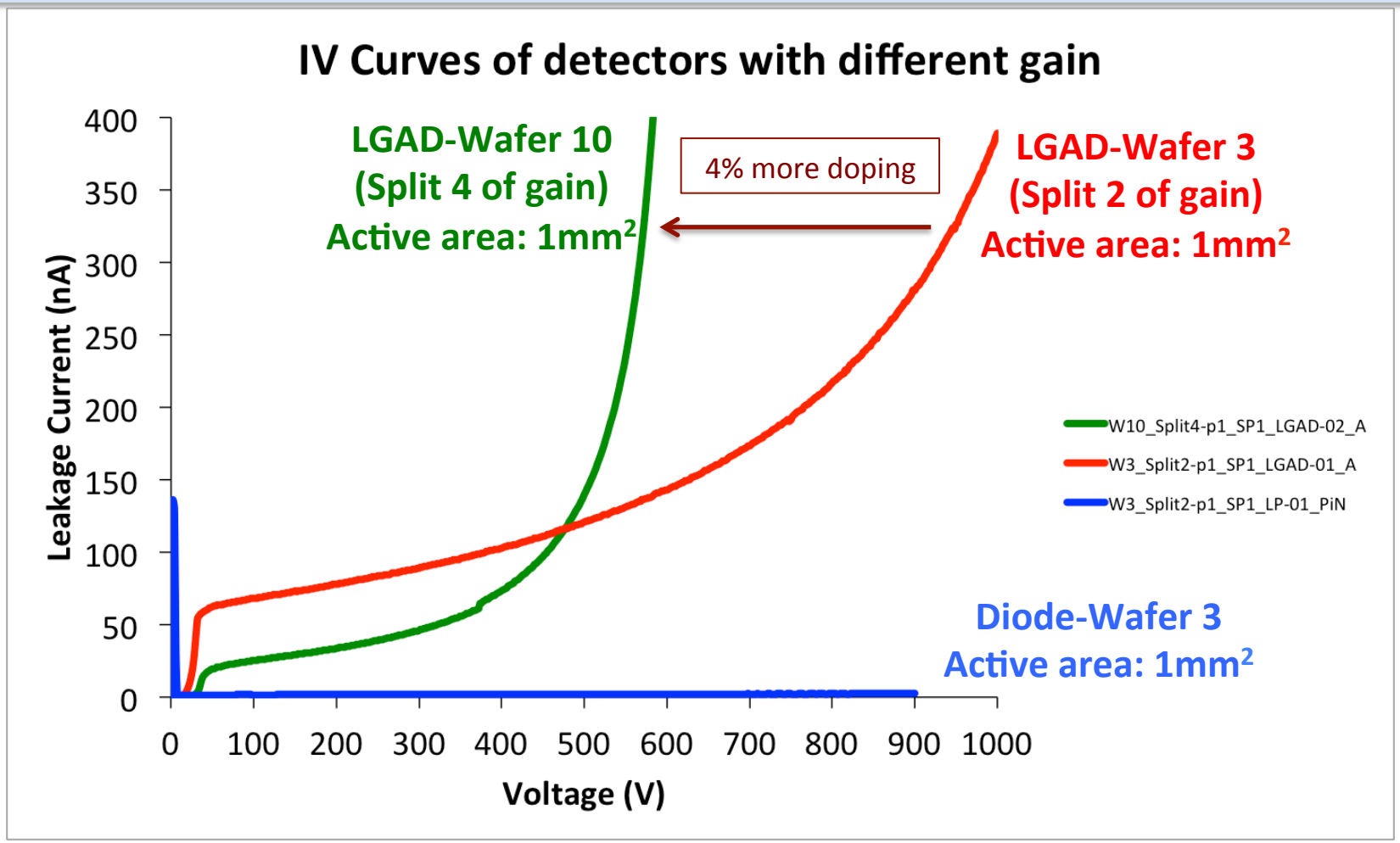
**Modules**

- High Voltage SMU: Max Range (±3000V, ±4mA);
  Min Range (200V, 1nA);
- Medium Power SMU: Max Range (±100V, ±100mA);
  Min Range (0,5V, 1nA);

Probe station


The electric contacts was made with coaxial needles

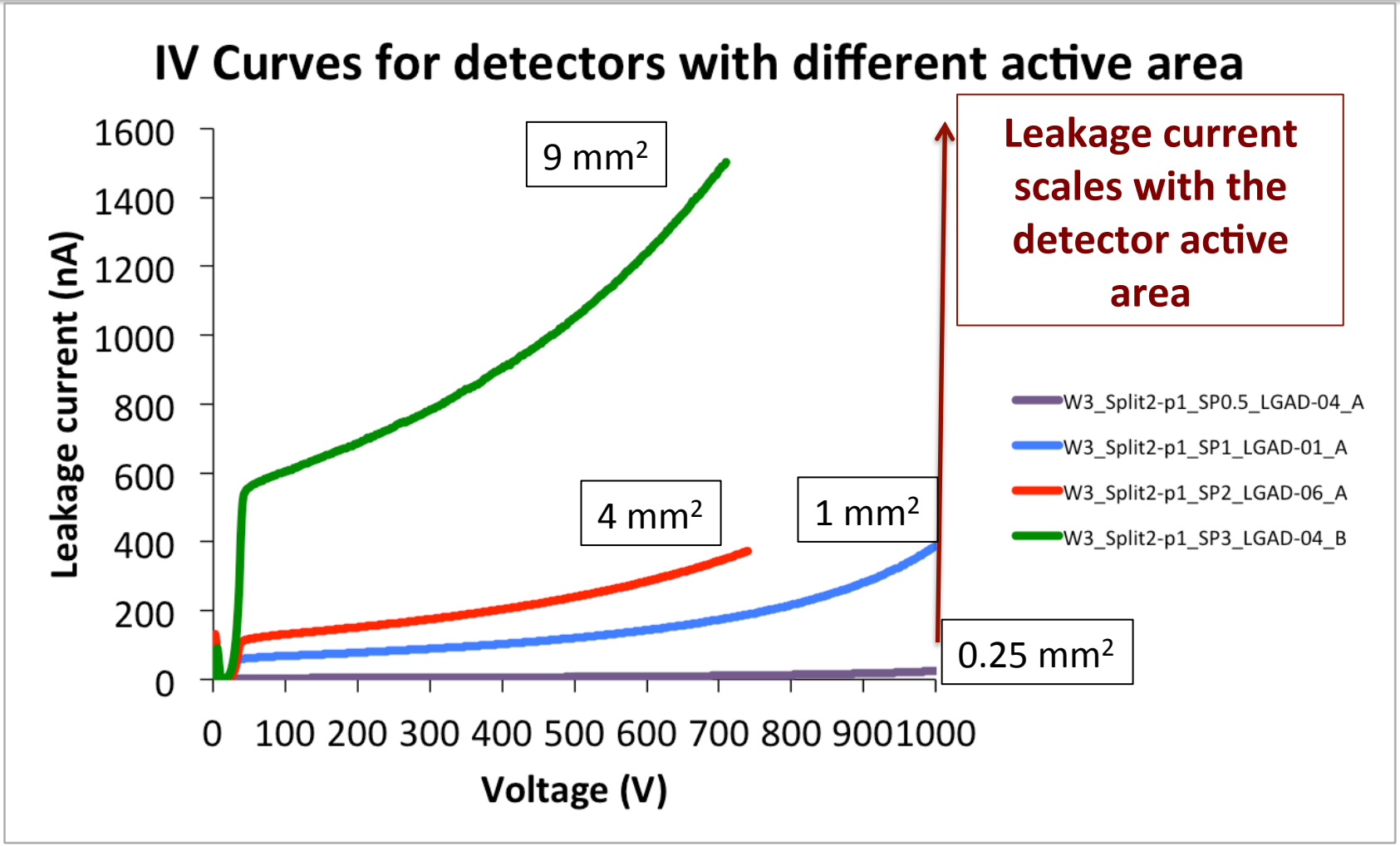
# IV measurements




**The Breakdown Voltage decreases with the increasing gain**

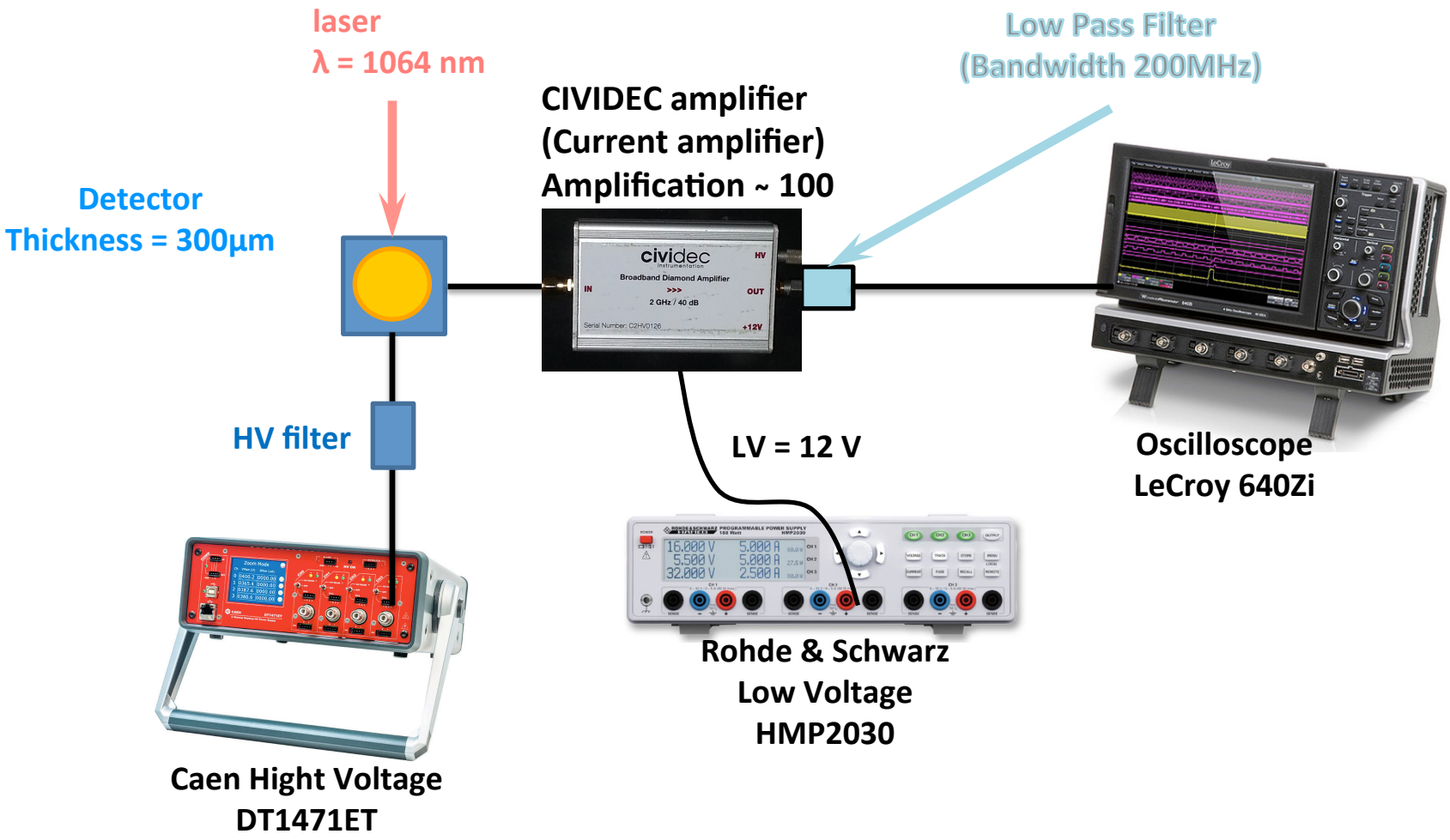
**Breakdown in simulation:**
**- wafer 3 is about 880 V**
**- Wafer 10 is about 500 V**

# IV measurements



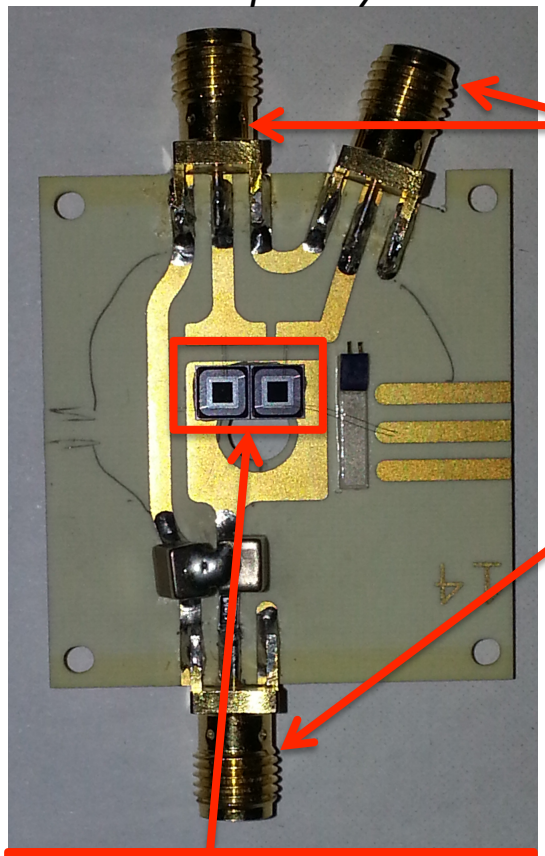

**Structure tested:**
LGAD single pad of the Wafer 3 (Split of gain: 2)

# Gain and time resolution (laboratory setup)

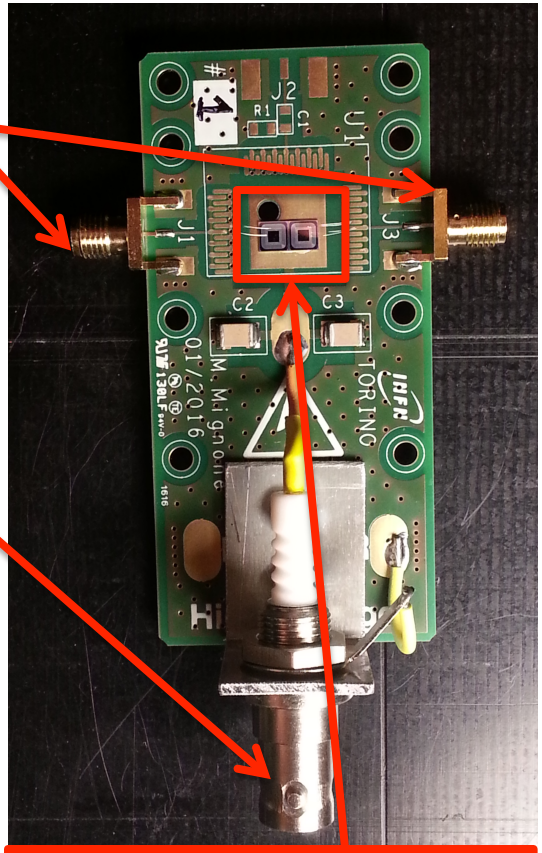


# Sensor tested

*PCB developed by CERN*



*PCB developed by INFN, Turin (Marco Mignone)*



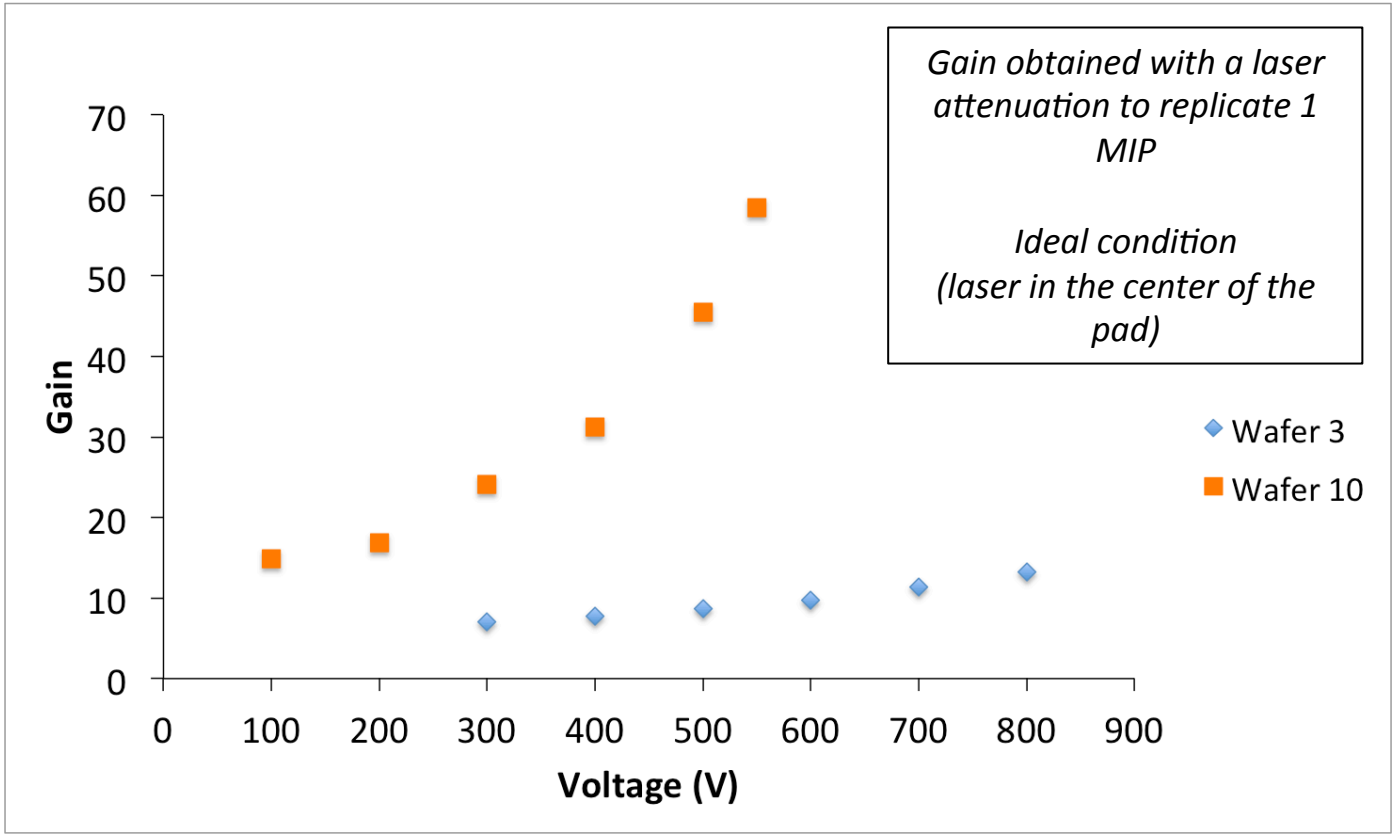
**Read out channels**

**High Voltage**

***Wafer 3-Split 2 of gain***
***Detector Single Pad***
***(LGAD + DIODE)***
***Area 4 mm²***

***Wafer 10-Split 4 of gain***
***Detector Single Pad***
***(LGAD + DIODE)***
***Area 4 mm²***

# Gain measurements



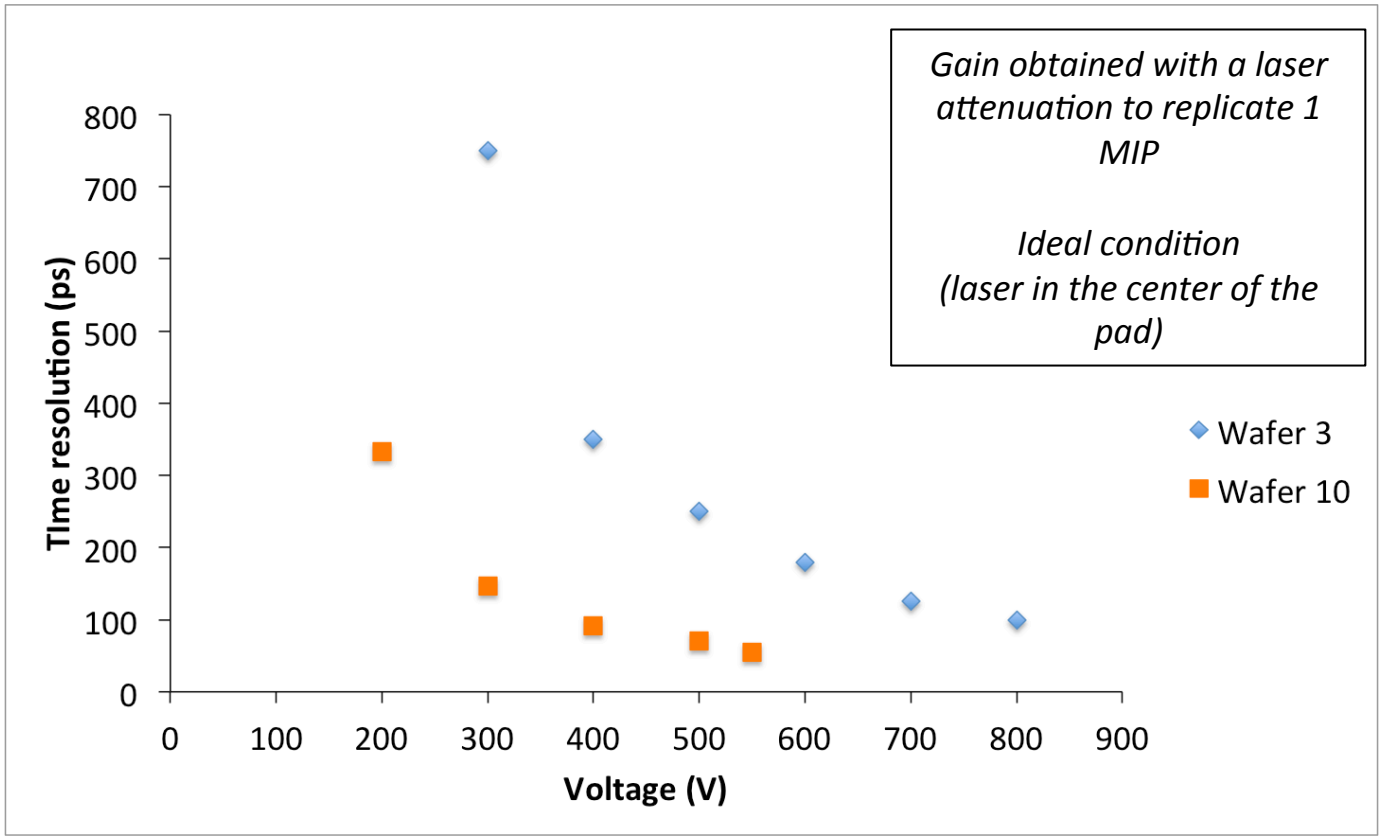

*Gain = LGAD area signal/DIODE area signal*

**Wafer 3 → Gain between 7 and 13**

**Wafer 10 → Gain between 14 and 60**

**Measurements of gain in agreement with the simulation**

# Time Resolution measurements

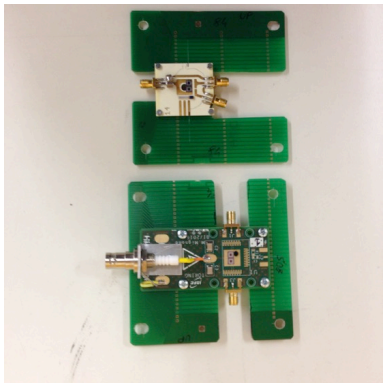



*Measurements using constant fraction at 50% of the amplitude*

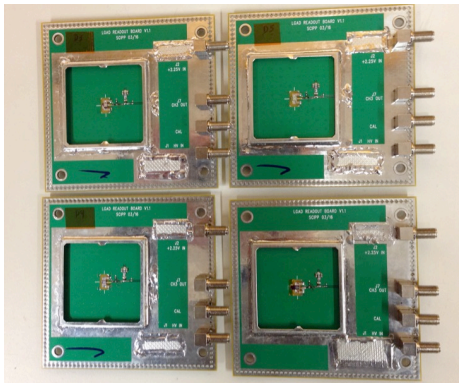
**Wafer 3 → Time resolution of 91 ps at 800 V**

**Wafer 10 → Time resolution of 55ps at 500 V**

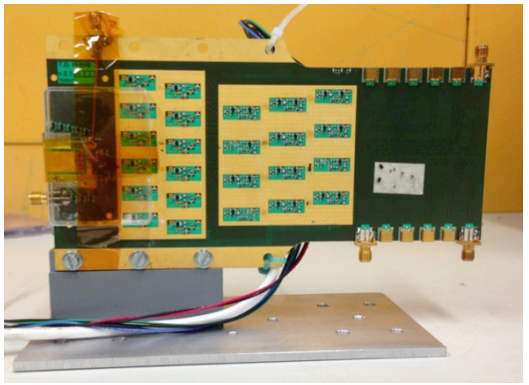
# Beam test setup



FBK LGADs on CERN and Torino Board



UCFS Board with 75µm CNM and 300µm FBK LGADs

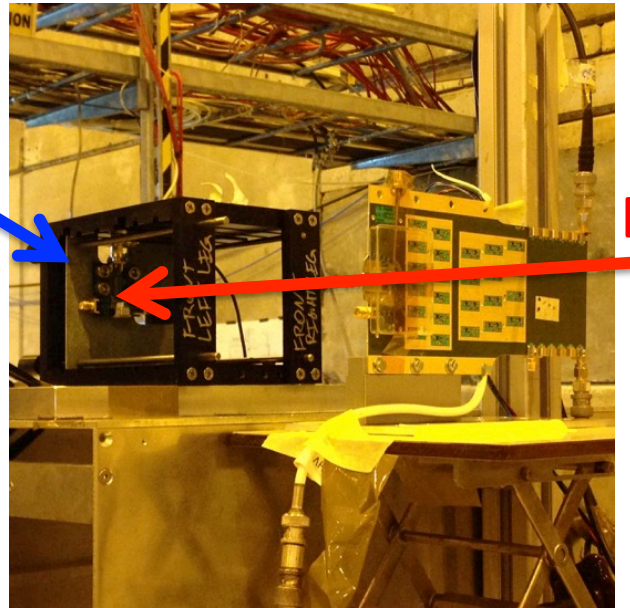


TOTEM-UCFS Board with 300µm FBK LGAD

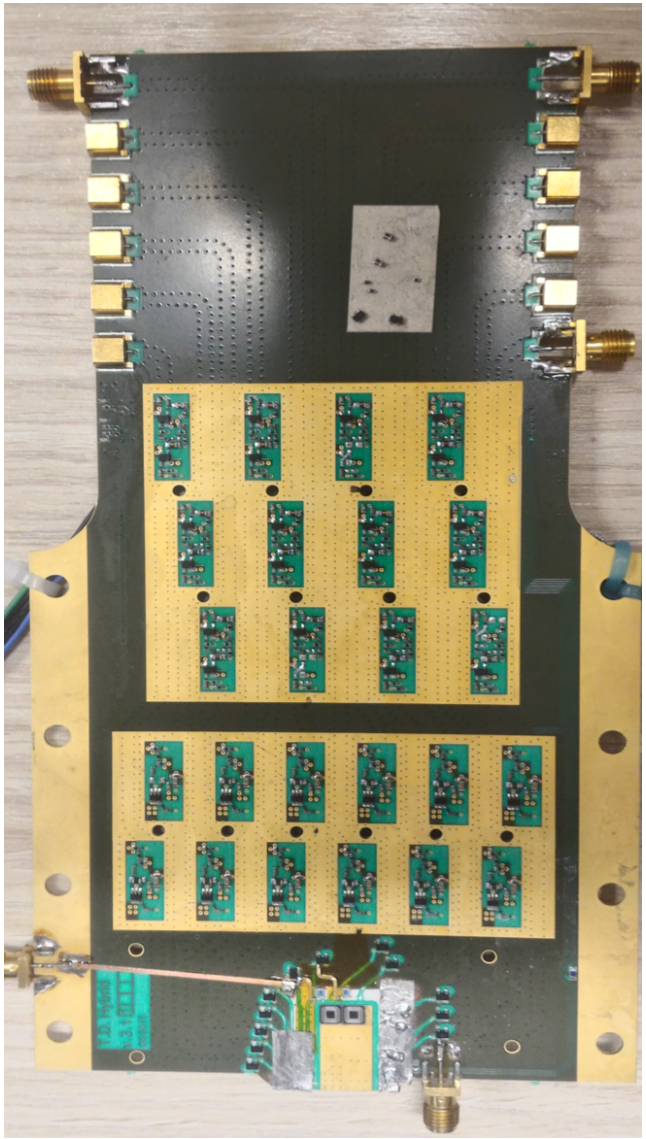
**Second stage amplifier for UCSC board/CERN board/ Torino board:**

- BB amplifier (Cividec);
- CSA amplifier (Cividec);
- Cardarelli amplifier (CAEN);

**Telescope for UCSC Board**



# Beam test very preliminary results on FBK detectors (TOTEM-UCSC Board)

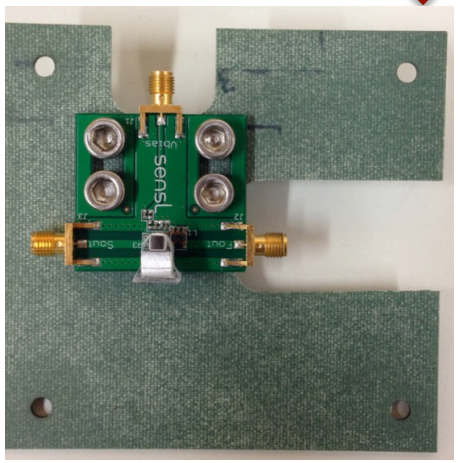


**TOTEM board (for diamond) modified by UCSC to match UFSD impedance and signal charge**

**3 amplification stage for a gain of about 200**

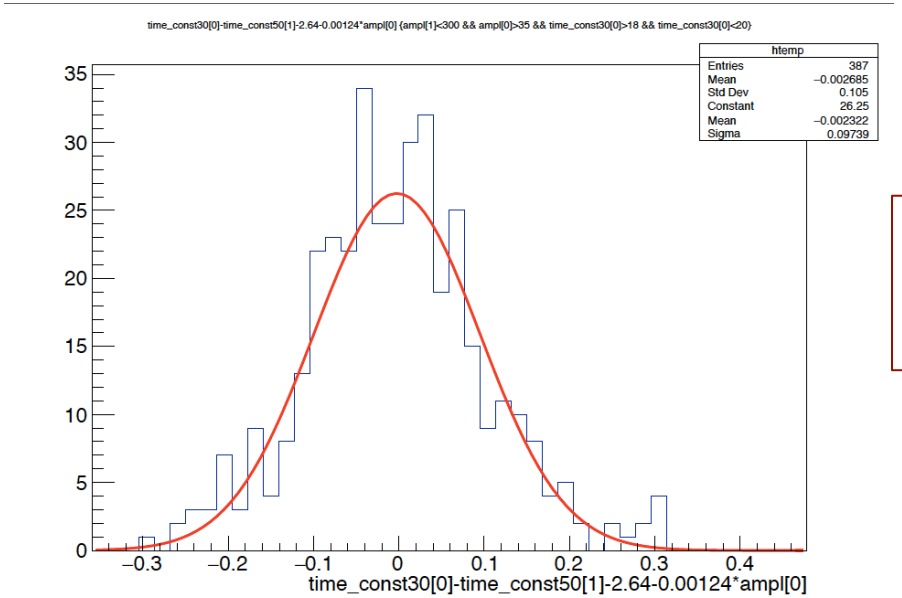
**FBK detector (4 mm$^2$ ) of the wafer 3**

**Trigger: SPM**



**Time resolution less than 30ps**

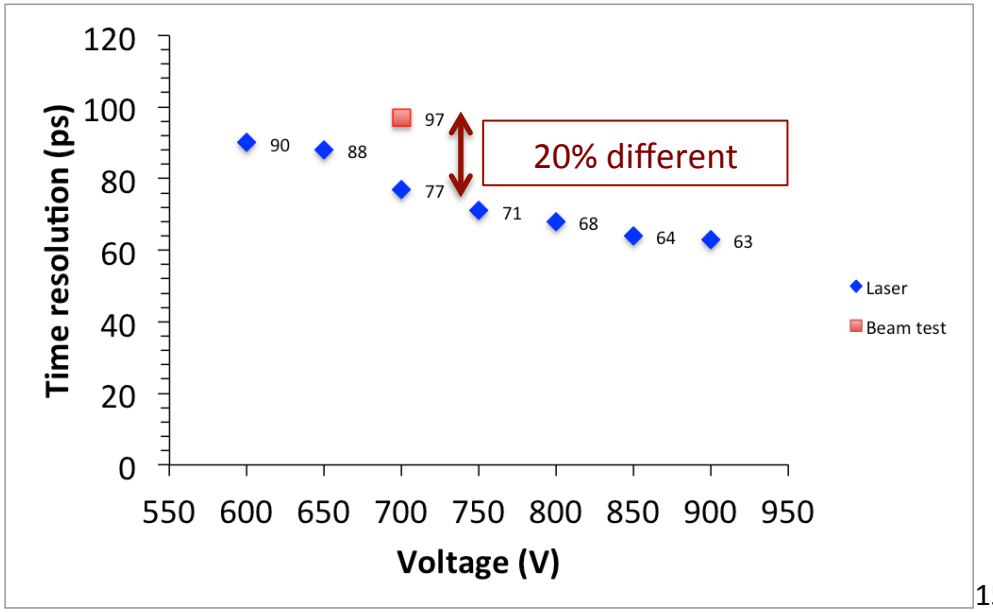
# Beam test very preliminary results on FBK detectors (TOTEM-UCSC Board)




*Constant fraction 30%*

**Time resolution in Beam test: 97ps**

Comparison between laboratory measurements and beam test measurements



# Conclusion

The preliminary measurements on the FBK's LGAD give good results:

- Breakdown voltage in agreement with the simulation
  ~ 900 V for wafer 3
  ~ 500 V for wafer 10

- Internal gain in agreement with the simulation
  Wafer 3: between 7 and 13
  Wafer 10: between 14 and 60

- Good time resolution for 300µm detectors
  Wafer 3 and BB amplifier: 91 ps at 800 V (laboratory measurement)
  Wafer 10 and BB amplifier: 55 ps at 500 V (laboratory measurement)
  Wafer 3 and TOTEM board: 97 ps (beam test)

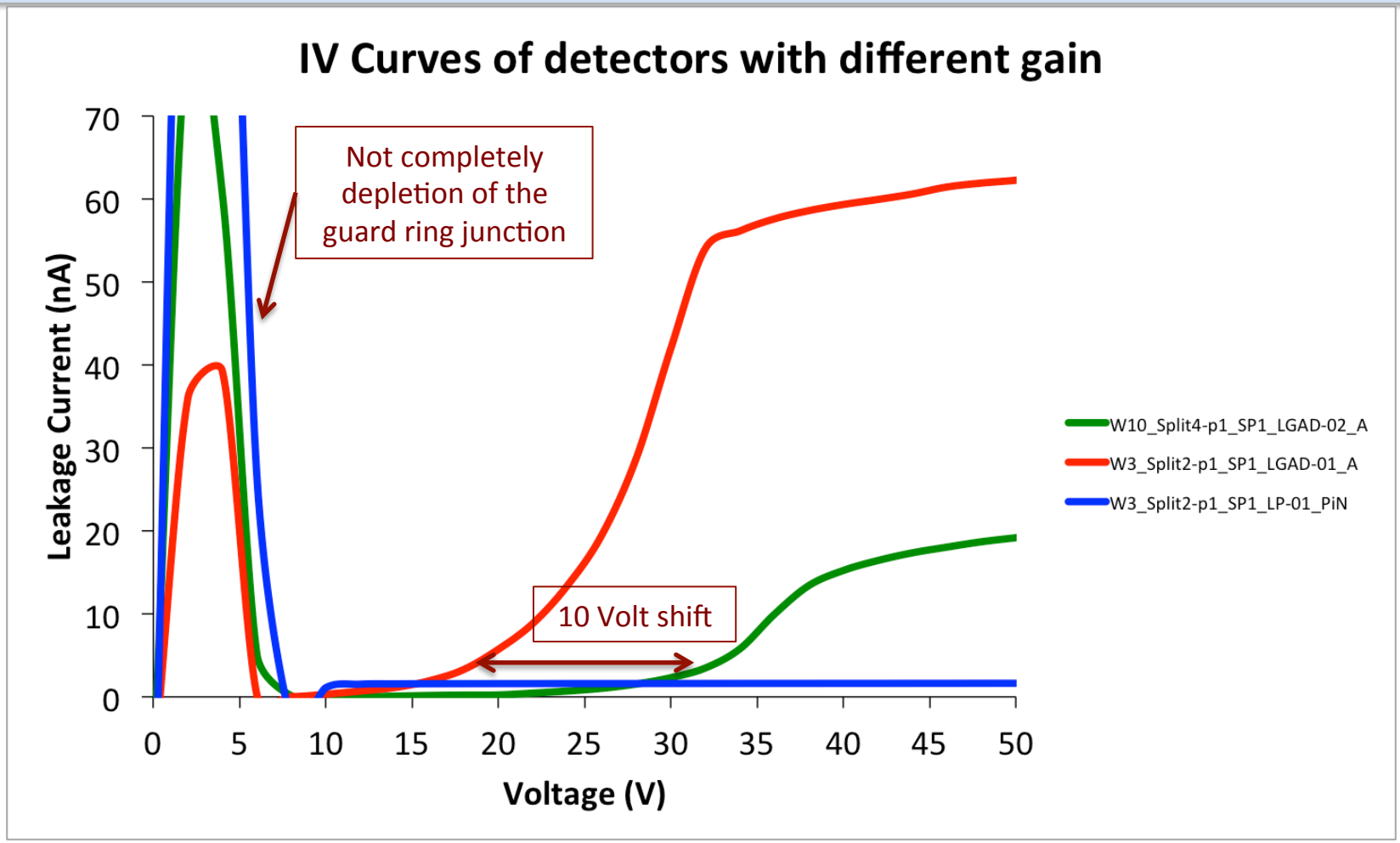
# Acknowledgements

We kindly acknowledge the following funding agencies, collaborations:

- INFN - Gruppo V
- Horizon 2020, grant UFSD669529
- Horizon 2020, grant INFRAIA
- Ministero degli Affari Esteri, Italy,MAE, “Progetti di Grande Rilevanza Scientifica”
- U.S. Department of Energy grant number DE-SC0010107
- RD50, CERN

# Backup

# IV measurements (focus at low voltage)




**The foot at low voltage shows the depletion of the gain layer**

**The foot shifts towards high voltage with gain increasing**