

PH-DT-DD: SSD-Solid State Detectors

- **R&D:** Development of radiation tolerant silicon detectors in the framework of RD50 and CMS
- **Service:** Characterization of semiconductor detectors

The team today (CERN & visitors):



Visiting Scientist:

- Marcos Fernandez Garcia
- Joaquin Gonzalez

Trainee/FTEC:

- Celso Manuel Pitaes Figueiredo
- Isidro Mateu Suau (0.5 FTE)

CERN Staff

- Michael Moll (0.5 FTE)

PhD students:

- Hannes Neugebauer
- Sofia OTERO UGOBONO
- Laura Franconi
- Esteban Curras Rivera

Fellow

- Christian Gallrapp



SSD activities at CERN

*....its all about silicon sensors
and their application as HEP detector.*

• RD50 Collaboration

- **Steering and Management of the RD50 collaboration** (50 Institutes, 300 members)
 - *Michael is Co-Spokesperson, Maurice budget holder, Veronique secretary*
- **Characterization and simulation of radiation effects in silicon devices**
 - Development of characterization tools (TSC, edge-TCT, Two-Photon TCT, ...)
 - Measure damage parameter (CV,IV, CCE, TCT) and defect properties (TSC, I-DLTS)
 - Simulate detector performance (TCAD, TRACS)
 - Defect/Material engineering: p/n-type, different resistivity, impurities,...
- **LGAD (Low Gain Avalanche Detectors) and APDs (Avalanche Particle Detectors)**
 - Fast timing applications
 - Charge amplification in highly damaged detectors
- **3D detectors, CMOS sensors, ...**

• CMS Collaboration

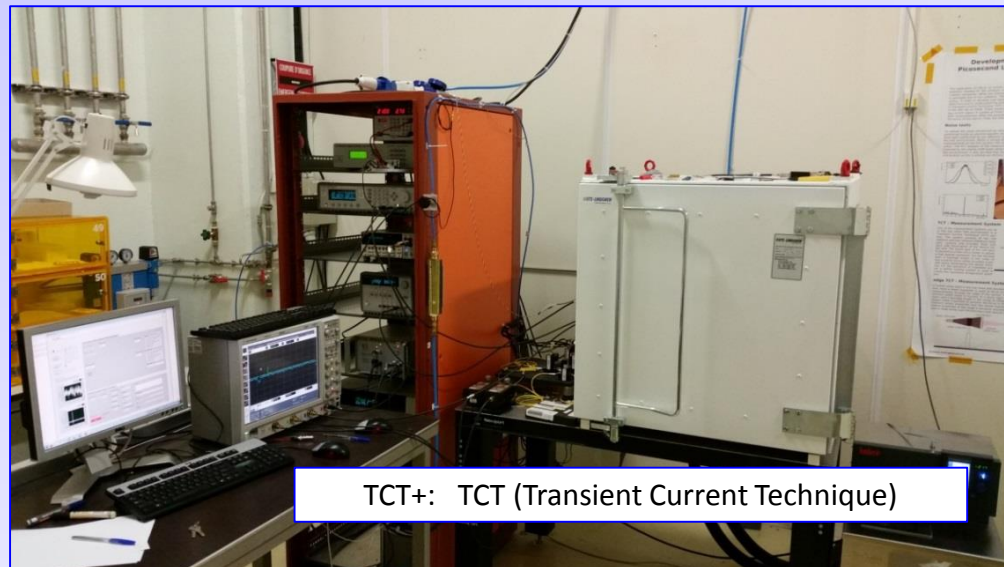
- **Sensor Development for the High Granularity Calorimeter (HGC)**

• Service

- **Measurement of sensors for/with external groups**

- **Bldgs.28/186 (4 labs, 1 sensor storage area, 4 offices, ..)**

- IV/CV [2x], Alibava (CCE) [2x], Beta (CCE), e-TCT, TCT+; I-DLTS, TSC



TCT+: TCT (Transient Current Technique)



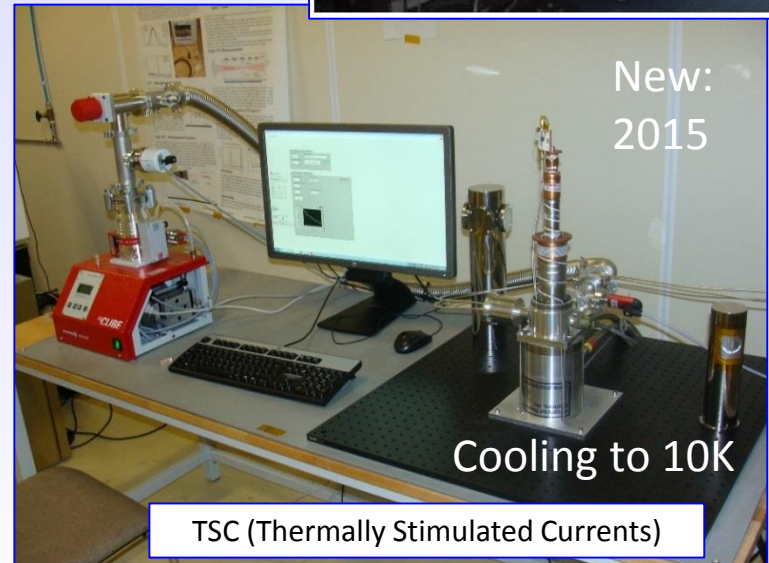
New room 2015
Wafer/Sample storage



New: 2015
-70C to 180C
CCE (Charge Collection Efficiency)



New lab 2015
I-DLTS (Current Deep Level Transient Spectroscopy)



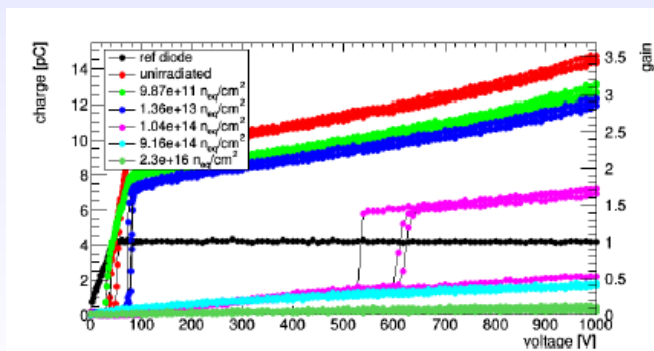
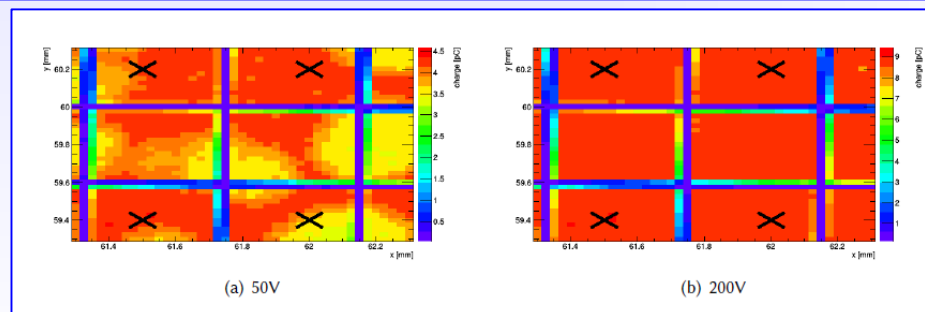
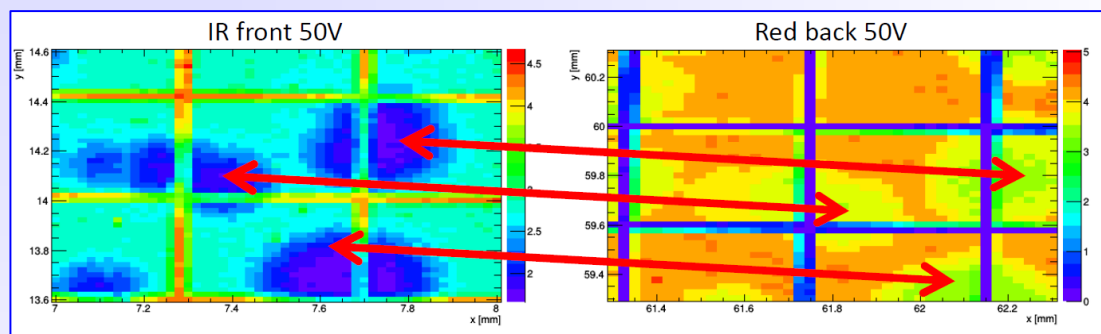
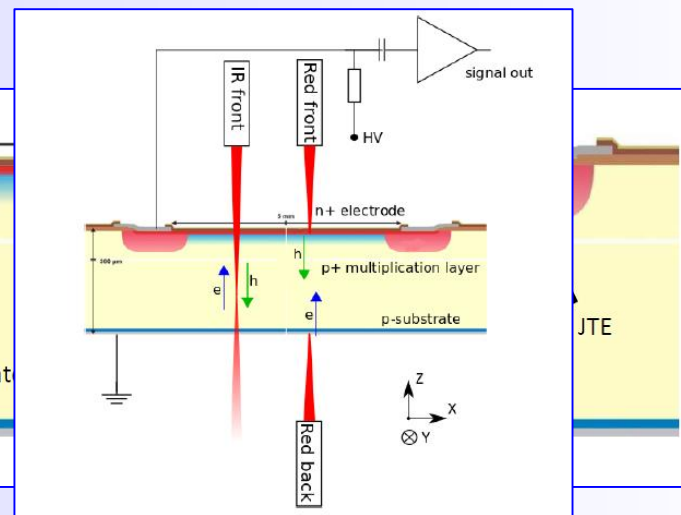
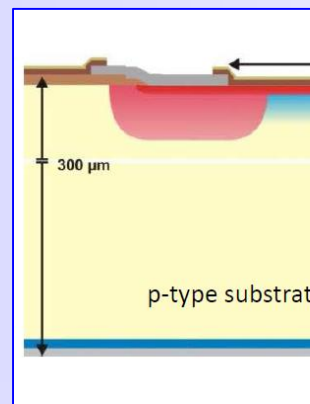
New: 2015
Cooling to 10K
TSC (Thermally Stimulated Currents)

Low Gain Avalanche Detectors LGAD

- Collaborative effort within RD50
- Produced at CNM Barcelona (RD50)
- Aim for (a) stable signal gain after irradiation (b) fast signals
- Problem:
 Loss of gain after irradiation!

SSD at CERN:

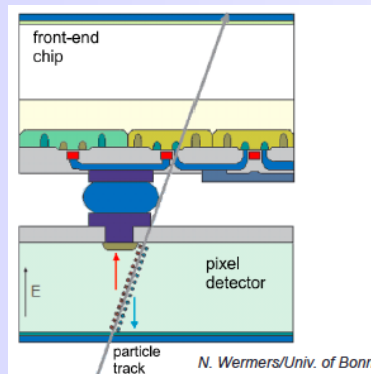
- Irradiation, CV/IV, TCT
- CCE (beta, laser)
- homogeneity scans:
- Gain measurements



TCT and HVCMOS

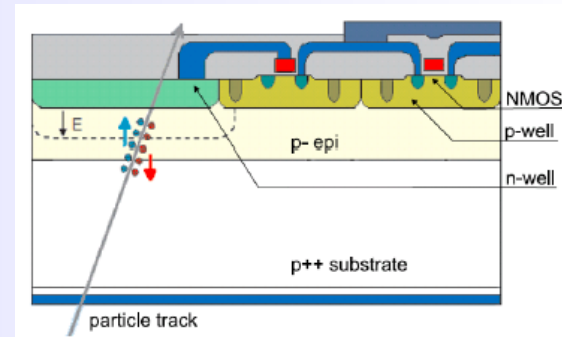
CMOS sensors

- Today: **Hybrid Pixel Detectors (HAPS)** used in LHC experiments
- Vast efforts ongoing to develop **monolithic sensors (MAPS)** imbedding sensing volume and electronics in the same chip
- One flavour: DMAPS (Depleted MAPS) **"HVCMOS": HV = High Voltage**

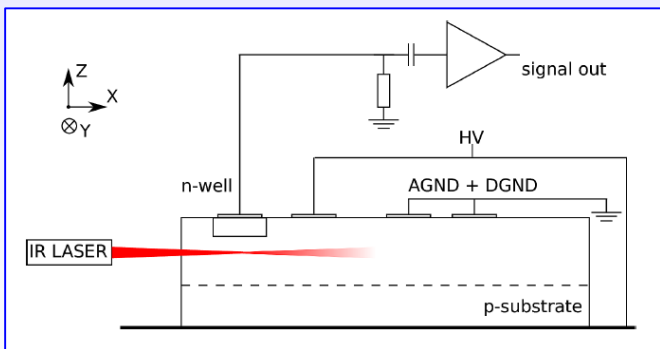
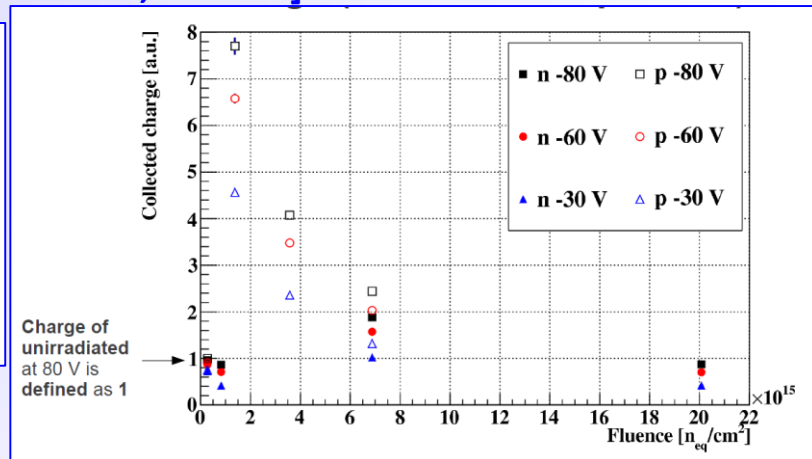
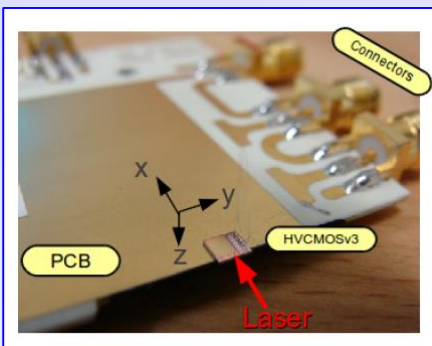
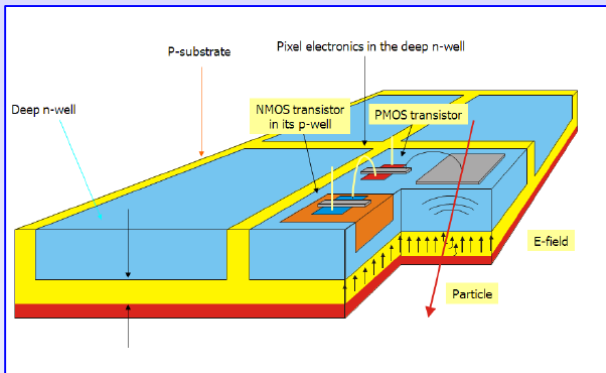


HAPS

MAPS

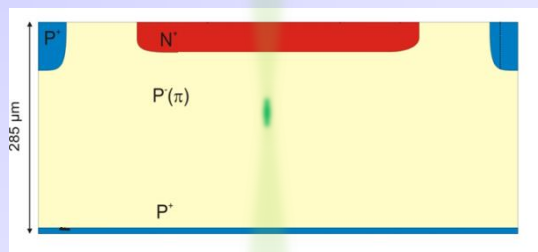
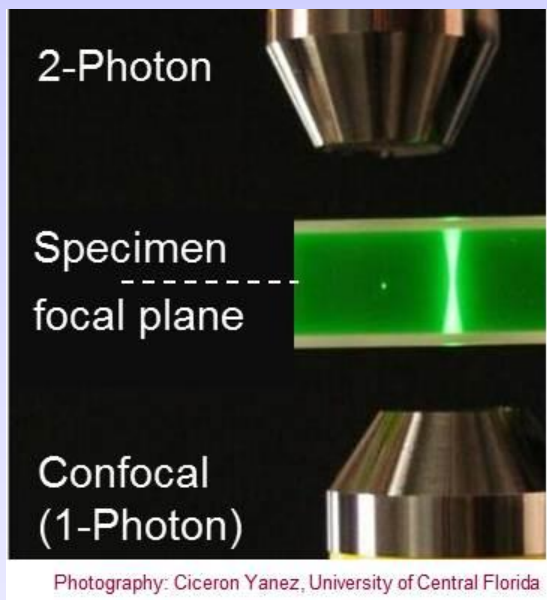


SSD: e-TCT measurements on irradiated HVCMOS sensors [ams H18, 10Ωcm]



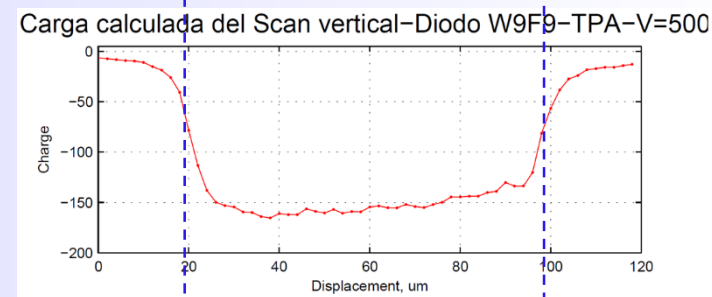
- Irradiated sensors: Amount of collected charge is increasing with radiation damage!**
- Reason:** The doping is "de-activated" by radiation and compensating defects are produced \rightarrow less space charge in detector \rightarrow bigger active volume \rightarrow bigger signal
- Unfortunately with further rising fluence signal reduces (trapping, too many defects)
- R&D:** Optimize substrate for best performance in LHC fluence range

- Continue LGAD and TCT work
- TPA – Two Photon Absorption [with IFCA]



Scanning beam through detector:

$$80 \times n_{index_Si} \sim 280 \mu m$$



Service (2015): eTCT for ATLAS (SOI) and CLIC (MAPS), timing measurements for CMS, CV/IV for LHCb UT CMS, TCT for RD50,...

• 2016: Reduction in manpower → Reduction in work program

2015 (9 FTE)

- CERN Staff Physicist (0.5 FTE)
- Trainee/FTEC: (1.5 FTE)
- PhD students (4 FTE)
- Fellow (1 FTE)
- Visiting Scientist (2FTE)

2016 (4 FTE + X)

- CERN Staff Physicist (0.5 FTE)
- Trainee/FTEC: (0.5 FTE)
- PhD students (2 FTE)
- ~~Fellow~~
- Visiting Scientist (1FTE) + X (?)

Work program in 2016

- **Reduce service**, keep most R&D, HGC
- **Look out for fresh resources!**
- ~~TCAD, Damage parameterization~~
- ~~3D sensors~~
- **Focus: TCT, LGAD, timing sensors, some work on defects**