Semiconductor sensors development and applications WG-5.2.1 & WG-5.2.2

Status report

FAPESP Thematic 2020/04867-2

September 28th 2022

WG-5.2.1 & WG-5.2.2 : Recap

- WG-5.2.1 : ATLAS High Granularity Timing Detector (HGTD)
- WG-5.2.2 : Low Gain Avalanche Detectors (LGADs) for low energy applications

Details on August kick-off meeting

Perspectives for the next years highlighted in blue

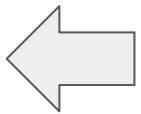
WG 5.2.1: People and Action Items (Recap)

1. Current Team
   - 1.1. M. Leite (Physicist)
   - 1.2. G. Saito (MS,PhD)
   - 1.3. R. Menegasso (TS)
   - 1.4. M. Kuriyama (TS)
   - 1.5. DD (Dedicated)
   - 1.6. DD (Sharing with PA)
   - 1.7. PD (Sharing with PA)
   - 1.8. IC (TT-2 ?)
   - 1.9. TT-4

DD–4: *Ultra-fast semiconductor sensors and associated instrumentation for radiation detection*

1. Deliverables
   - 1.1. LGAD Characterization Lab.
   - 1.2. Characterization of LGAD sensors (on-going)
   - 1.3. Performance studies on irradiated arrays (on-going)
   - 1.4. PEB test stand system
   - 1.5. Participation in HGTD assembly facility construction @ CERN (on-going)
   - 1.6. Demonstrator construction @ CERN (on-going)
   - 1.7. HGTD installation
   - 1.8. HGTD commissioning

1. Action items
   - 1.1. Equipment availability (importation)
   - 1.2. Preparing civil infrastructure for Lab
   - 1.3. Lab installation
   - 1.4. PD, DD, TT hiring
   - 1.5. Start testing sensors
   - **1.6. Significant work to commission local infrastructure (EMU FAPESP)**
   - 1.7. **Significant commitment of people on @CERN activities**

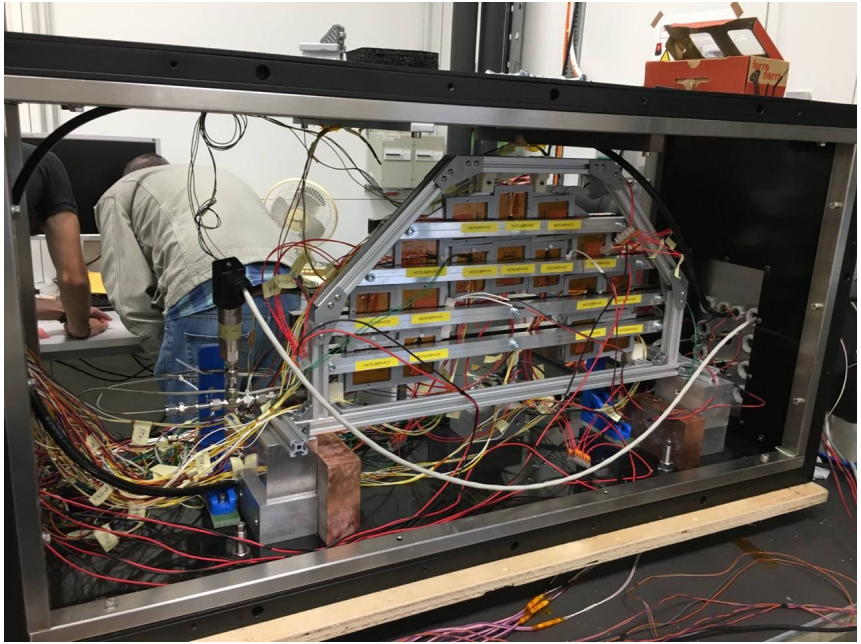


Almost zero float on these items !

WG 5.2.1 : ATLAS HGTD - Infrastructure @CERN

On Track

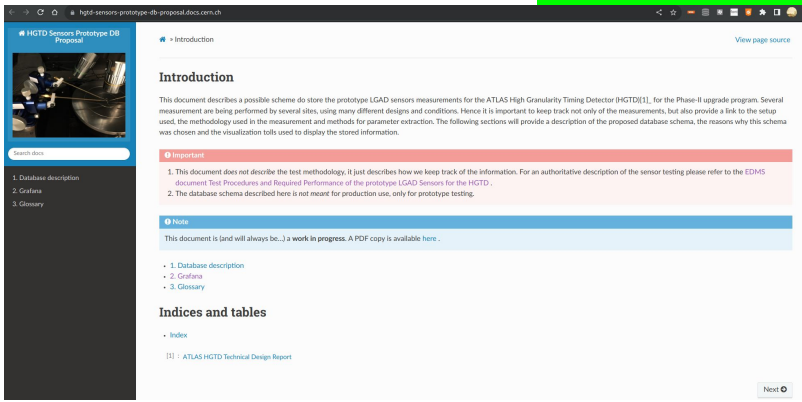
- **R. Menegasso & M. Kuriyama** @ CERN
  - Clean room and metrology setup for HGTD assembly @ B180
  - Demonstrator construction and thermal test system support
- Effort will intensify during construction and integration years (2026-2028)



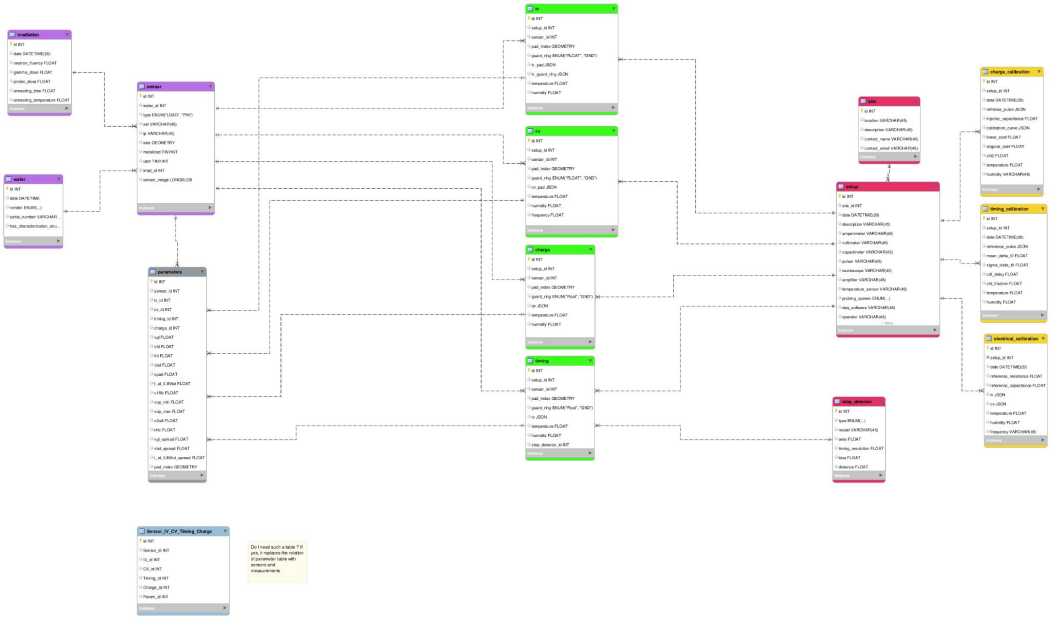
WG 5.2.1 : ATLAS HGTD - Sensor test and Database

- **M. Leite, G. Saito - collaboration in HGTD DB group**
  - Documentation (Sphinx, gitlab pages)
  - Sensor database (MySQL)
  - Plot (Grafana)
- Concludes in 2023, updates after that

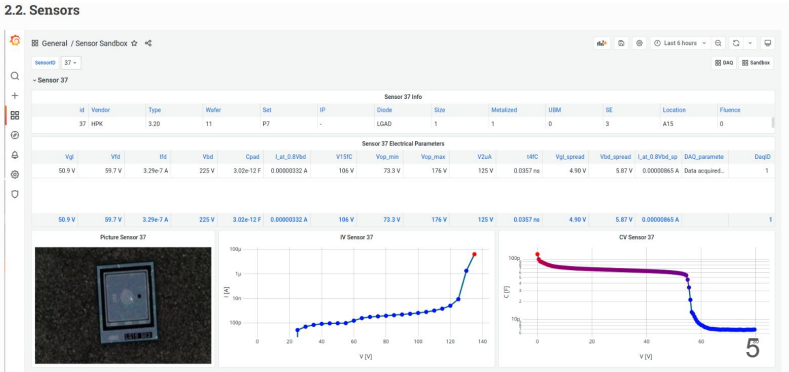
On Track



DB Schema



DB Query and plot in Grafana

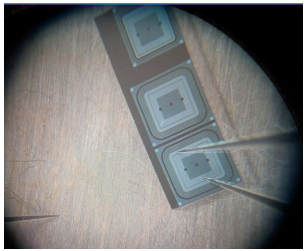


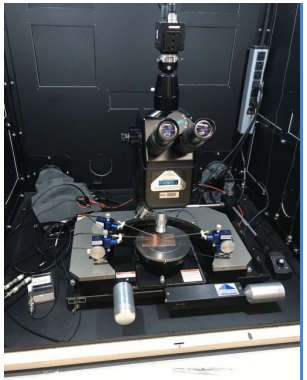
Example of a grafana dashboard showing information about sensors.

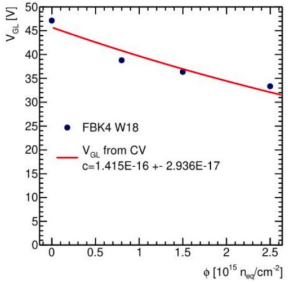
WG 5.2.1 : ATLAS HGTD - Sensor tests and Database

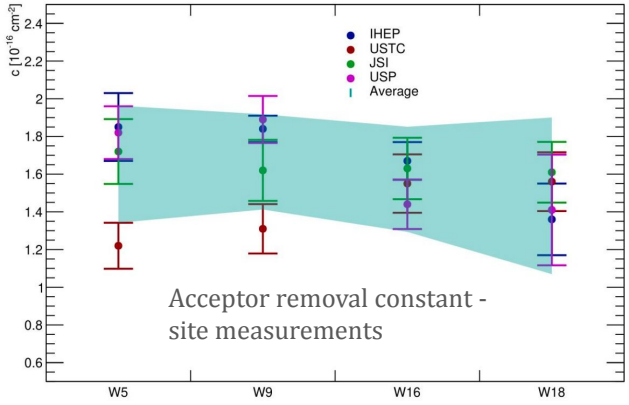
On Track

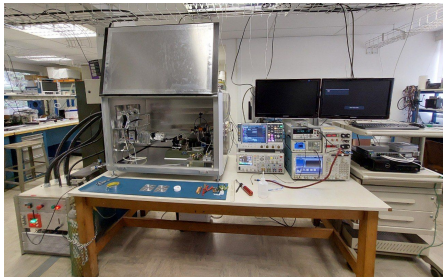
- **M. Leite, G. Saito - ongoing sensor testing**
  - Sensor tests at USP (cold box ready -58oC in 40min, PID controlled)
  - FBK Irradiated sensor high voltage IV/CV at FEI (lot of help from M. Pavanello)
- Part of the commitments for HGTD (forever …)

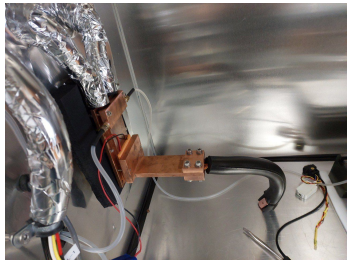












WG 5.2.1 : ATLAS HGTD - Infrastrucutre @USP

Critical

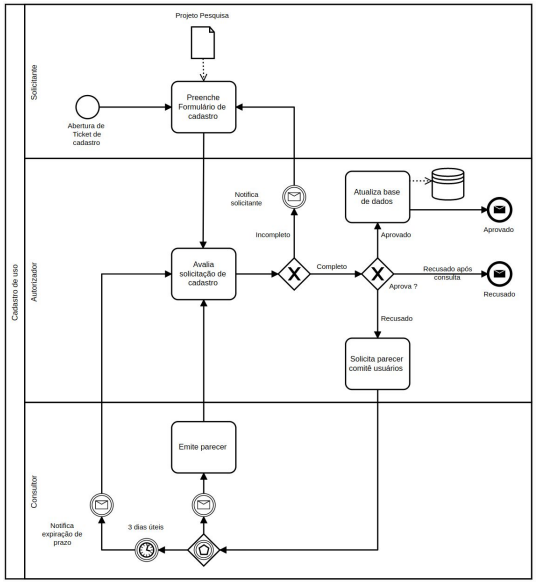
- We need to be ready by March 2023
- Difficult and long tendering with probe station suppliers
  - Got amendment to FAPESP EMU budget 👍
  - First choice (MPI) does not accept LC, CAD, Net30 👎
  - Second choice (FormFactor) on going
- Participate in DAQ development for QA/QC sites
  - USP- CERN-IHEP-USTC-JSI
  - Very long lead time for T&M (over 1 year in some cases)
  - Must plan carefully !
  - Measurement of sensors and test structures
- Lab space still an issue
  - Need to setup temporary area
  - Negotiation on-going
- Needs to settle in 2022; finalize in 2023

WG 5.2.1 : ATLAS HGTD - Infrastructure @USP

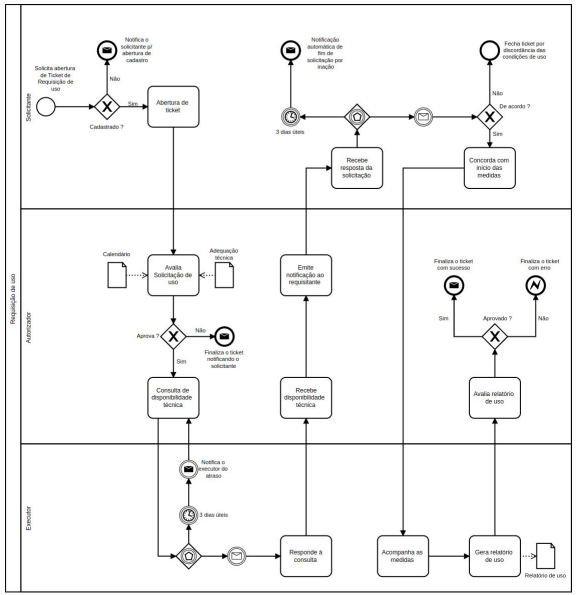
Requires attention

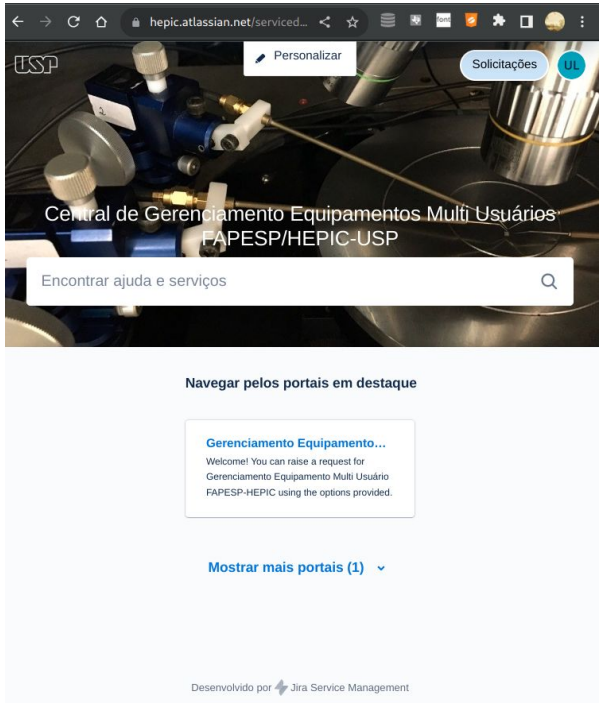
- Semiconductor lab will be a FAPESP E.M.U
  - Most of heavy work already done ….
  - EMU Site documentation
  - EMU user registration and request portal (JIRA)
  - Workflow implemented as Jira services (needs test…)
  - Starting the process formalities
- Must complete soon (2022)

Solicitação de cadastro



Solicitação de uso





WG 5.2.2 : WBS and Deliverables

WBS (Tentative)

1. Simulation
   - 1.1. Geant4 Simulation (LGAD, AC-LGAD) (**M. Moralles - IPEN**)
   - 1.2. TCAD Simulation (LGAD, AC-LGAD) (**R. Buehler, R. Giacomini**)
   - 1.3. Multiplication Mechanism Simulation (Weightfield2, KDetSim)
   - 1.4. Radiation damage processes
   - 1.5. Charge Sharing and position determination (Custom Code)
   - 1.6. Circuit and Layout simulation (ELDO, Spice, Hyperlinx)
   - 1.7. Integration framework
2. Characterization of *available* LGAD, AC-LGAD
   - 2.1. Sensors electrical characterization
   - 2.2. Aux. structures electrical characterization
3. Readout electronics for *available* LGAD, AC-LGAD
   - 3.1. Fast amplifier and calibration board
   - 3.2. Prototype readout system (ATLAS-FELIX based)
4. Radiation testing of *available* LGAD, AC-LGAD
   - 4.1. X-Ray testing
   - 4.2. Charged particle testing (electrons, protons, ions)
   - 4.3. Time Resolved X-Ray testing (**M. Leite & UCSC**)
5. Irradiation of *available* LGAD, AC-LGAD
   - 5.1. Photons
   - 5.2. Neutrons

Deliverables

1. Analysis and interpretation of simulation results (G4)
2. Analysis and interpretation of simulation results (TCAD)
3. Readout board simulation, design, assembly and test
4. Analysis of *available* LGAD and AC-LGAD X-Ray testing
5. Analysis of *available* LGAD and AC-LGAD picosecond X-Ray testing
6. Analysis of LGAD charged particle testing
7. Validation of framework integration for simulation/beam test
8. Electrical testing of irradiated/non-irradiated sensors

WG 5.2.2 : WBS and Deliverables

On Track

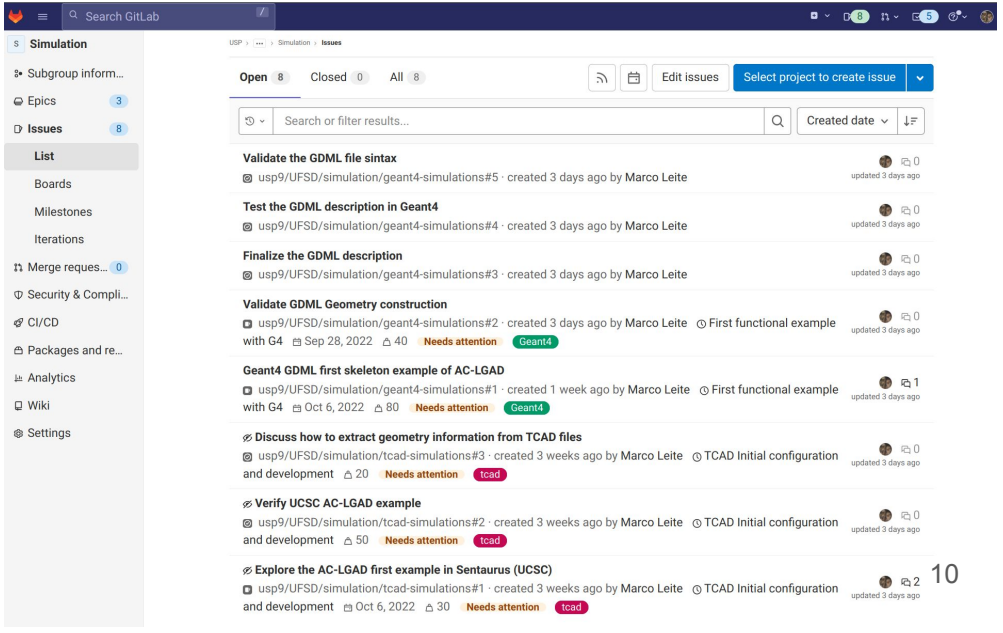
1. Simulation
   - 1.1. Geant4 Simulation (LGAD, AC-LGAD) (**M. Moralles - IPEN**)
   - 1.2. TCAD Simulation (LGAD, AC-LGAD) (**R.Buehler, R. Giacomini, M. Guazelli**)

Starting with AC-LGADs (see next slide)

Weekly meetings

WG 5.2.2 - Simulation and tests of existing LGAD structures for XRays applications

Project evolution follow-up on gitlab



Long range and continuous effort forever …

WG 5.2.2 : WBS and Deliverables

AC-LGADS for pico-second X-ray

On Track

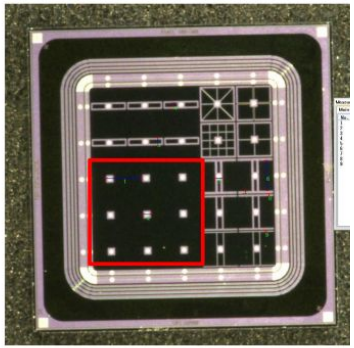
4. Radiation testing of *available* LGAD, AC-LGAD
   - 4.1. X-Ray testing
   - 4.2. Charged particle testing (electrons, protons, ions)
   - 4.3. Time Resolved X-Ray testing (**M. Leite & UCSC**)

Participate on Stanford SLAC SSRL test beam with UC Santa Cruz in November 2022 / January 2023

X-ray/VUV Standard Proposal

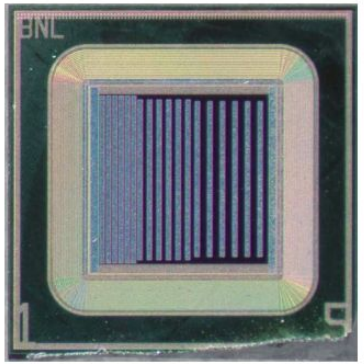
Proposal Information

Proposal Number	S-XV-ST-6041
Proposal Title	Characterization of Ultra-Fast Solid-State Sensors for Time-Resolved X-ray Science
Proposal Type	
Research Area Review Panel	MAT1 - The materials-1 panel reviews proposals for hard x-ray materials science, including soft materials, materials for energy, catalysis, and structural studies. Examples include using diffraction, scattering, microscopy or tomography techniques or any of the x-ray absorption or emission spectroscopies to study complex fluids, biological or synthetic polymers, batteries, organic electronics, and other materials.
Experimental Station(s)	2-3, XAS Microprobe Imaging 14-3b, XAS Microprobe Imaging
Shifts requested	40
Abstract	A broad coalition of institutions, including universities, national laboratories, and private companies, have coalesced in pursuit of the development of solid-state sensors for next-generation experimental applications. Many of these applications are proposed for the needs of X-ray science, including imaging, diffractive reconstruction, and accelerator diagnostics. The perfection of graded doping techniques has led to a new family of "LGAD" silicon diode sensors with internal gain, provided advantages to applications requiring precise timing, high frame rate, and low-energy X-ray detection. While much work has been done to characterize these devices with charged-particle beams, most of the unique performance characteristics associated with their use as X-ray detectors remains unexplored. The coalition is also developing high-bandwidth readout systems for diamond sensors, which feature fast signal collection speeds and are considered to have great promise for high frame-rate imaging. Here, we propose a set of studies, unique to X-ray facilities in general and the high frame-rate environment of the SSRL in particular, designed to promote the understanding of the fast, sensitive solid-state X-ray detectors, and associated electronics, that will be required for next-generation applications.
Proposal	Filename: SSRL-Proposal_10-21_Clean.pdf (/urawi/proposal.html?method=downloadAttachment&id=24922) (320701 bytes) Comment: Text of full proposal, in PDF format
Spokes Person	Schumm, Bruce A / U CALIFORNIA SANTA CRUZ (UCSC) / baschumm@ucsc.edu



UCSC (FBK)

- ➔ 20~35ps
- ➔ 5~7um
- ➔ 100% FF



BNL

- ➔ ~35ps
- ➔ < 15 um
- ➔ 100% FF

Long range and continuous effort - also interest @ Sirius

WG 5.2.1 & WG 5.2.2 : **Final remarks and action items**

- ATLAS HGTD : on track, but very aggressive schedule
- Commitments on construction and testing
  - Sensor testing and DAQ development
  - Sensor testing DB development
- Simulation (TCAD and Geant4) for new structures
  - Ramping up
  - Need to speed up for upcoming TB @SLAC

Action items for next months

- Move ahead with USP infrastructure
  - Most critical item
  - Involves space, import and equipment purchase
  - Needs to prepare lab infrastructure while space discussion is on-going
- First functional TCAD and Geant4 simulation (even separated now)
- Hiring of TT-4 (2023
- DAQ development and DB integration @ USP (in sync with CERN/IHEP/USTC/JSI)
- Participate on TB @SLAC, resume discussion with Sirius (more people involved…)
- Understand irradiation needs and prepare infrastructure at local facilities (X-Ray, Ions, protons …)