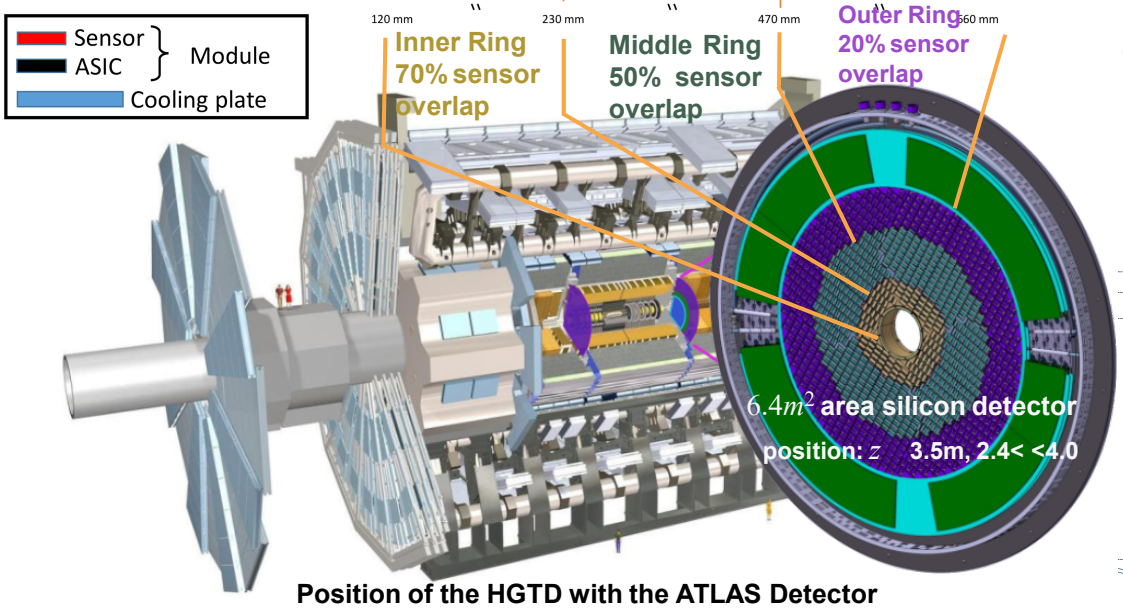
Performance of carbon implantation LGAD developed by IHEP and IME

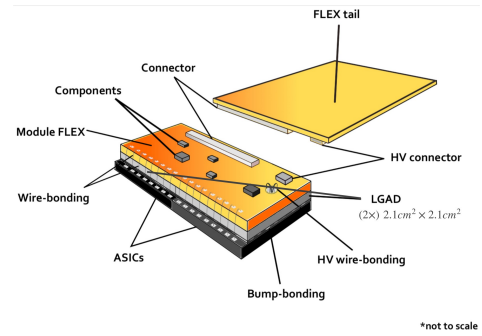
Mengzhao Li, on behalf of the IHEP HGTD group
The Institute of high energy physics, Chinese Academy of Sciences

HGTD: High-Granularity Timing Detector



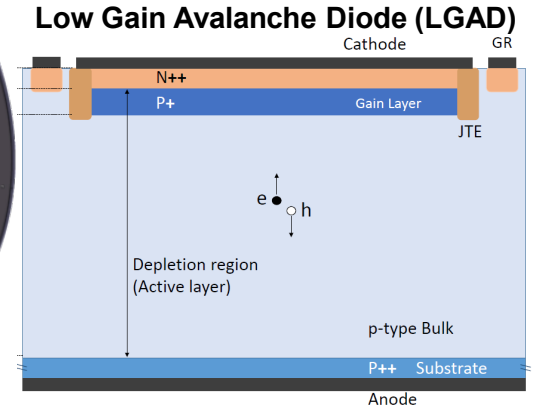
Position of the HGTD with the ATLAS Detector

module: **2 15×15 LGADs** and **2 ASICs**



- Timing resolution is required to be around 50 ps/track at beginning
- ~3.7×10^6 channels with $1.3 \times 1.3 mm^2$ readout channel
- Radiation hardness: $2.5 \times 10^{15} N_{eq}/cm^2$ and 2.0 MGy

Low Gain Avalanche Diode (LGAD)

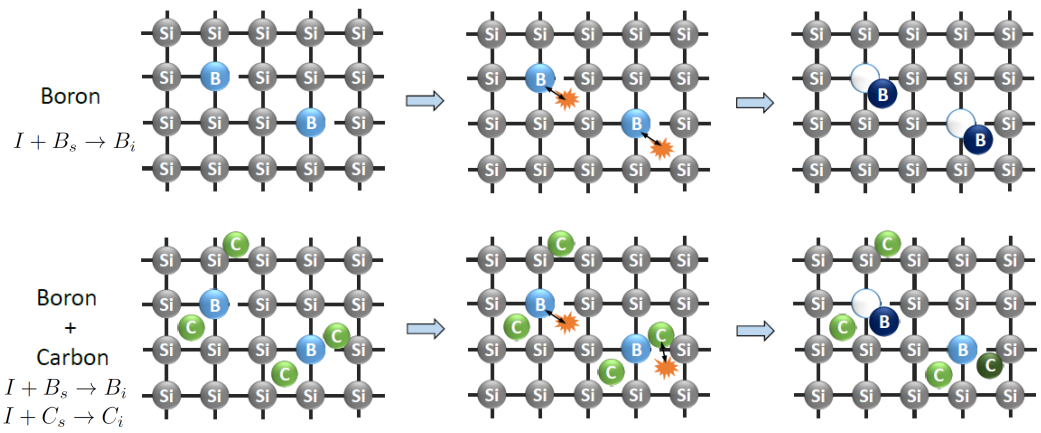


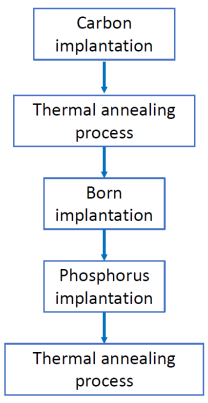
n on p sensor with p-type gain layer

- Low gain: **10-50**
  - to improve signal slope but control noise
- Thin sensor: **~50 μm**
- Fasting timing: **~30 ps** (pre-irradiation)

- HGTD collaborator CNM(Spain), HPK(Japan), FBK(Italy), BNL(America), IHEP(China) , NDL(China), USTC(China),

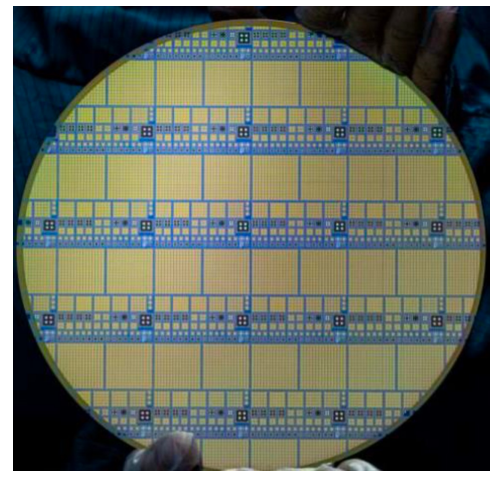
Sensor design：carbon implantation in the gain layer

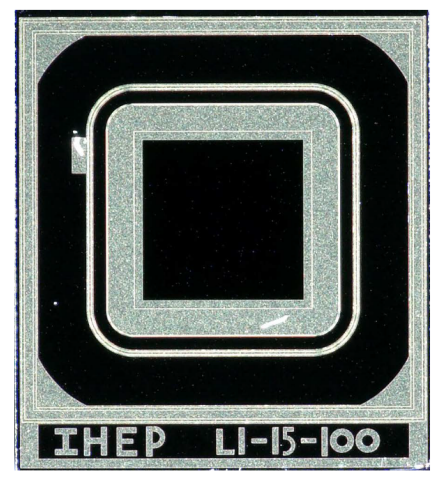




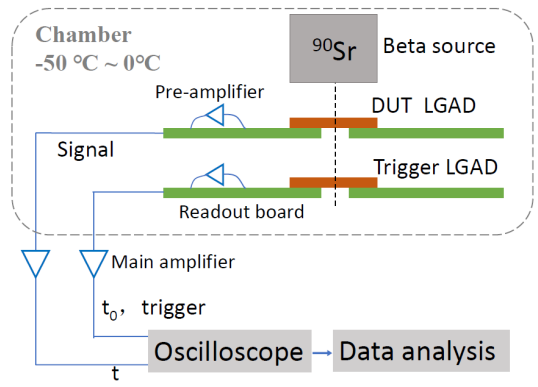
Sensors	Carbon dose	Annealing time
IHEP-IMEv1-W7 （W7）	No	-
IHEP-IMEv1-W1 （W1）	0.2 C	very fast
IHEP-IMEv2-W7Q1 （v2-W7Q1）	0.2 C	long time
IHEP-IMEv2-W7Q2 （v2-W7Q2）	0.5 C	long time
IHEP-IMEv2-W7Q3 （v2-W7Q3）	1.0 C	long time
IHEP-IMEv2-W7Q4 （v2-W7Q4）	3.0 C	long time

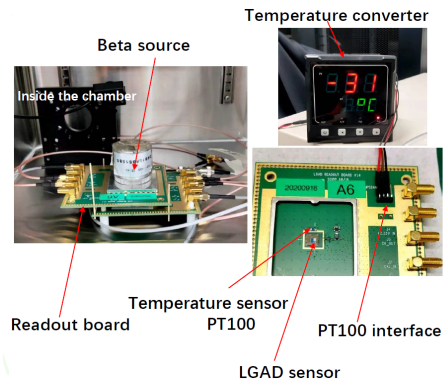
Sensors, irradiation and test





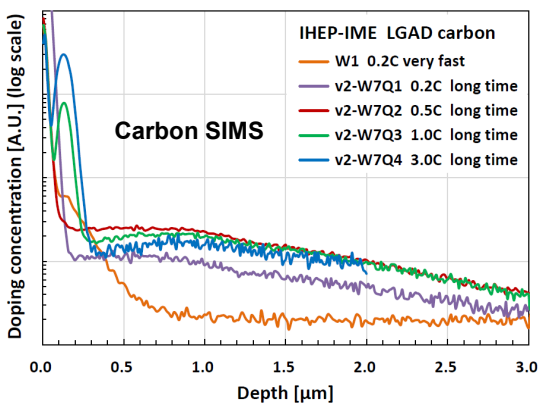
IHEP-IME LGAD wafer and sensor

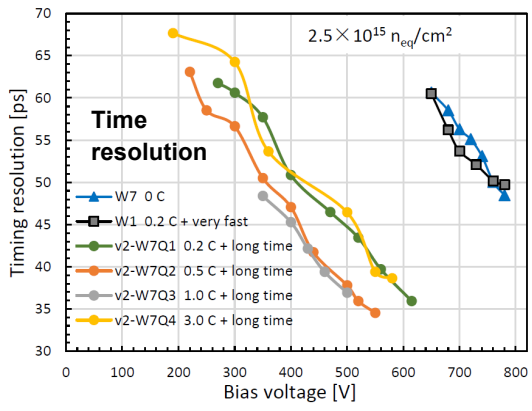


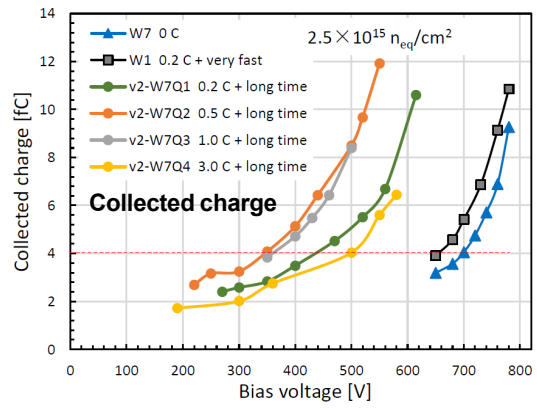


Beta source test

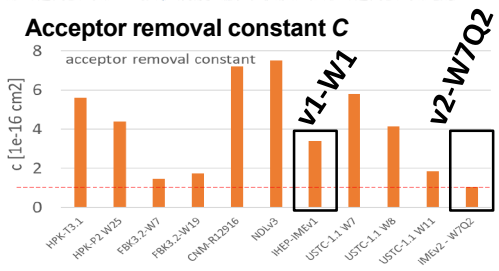
Carbon profile，time resolution, collected charge







Acceptor removal constant C



IHEP-IMEv2-W7Q2

- 0.5C+long time annealing
- Timing resolution **35ps**
- Collected charge **12fC**, 4fC@ **350V**
- *C* ***1.1***

Summary

The HGTD will play a key role to mitigate the impact of pile-up at HL-LHC. The carbon implantation LGAD sensors designed by the Institute of High Energy Physics (IHEP) and fabricated by Institute of Micro Electronics (IME). After irradiation fluence of 2.5 × 10^{15} n_{eq}/cm^2, the collected charges of the IHEP-IME LGAD reaches 4 fC with a time resolution of better than 50 ps at 400 V. The operating voltage of the IHEP-IMEv2 sensors can effectively avoid the single event burnout effect.