

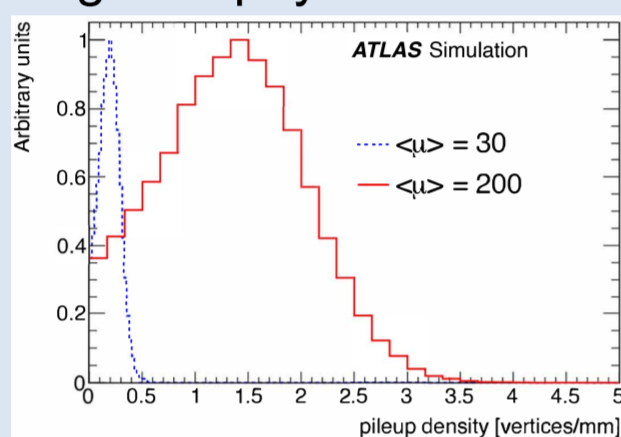


DEVELOPMENT OF THE USTC LGAD SENSORS FOR THE ATLAS HGTD UPGRADE

The 10th Edition of the Large Hadron Collider Physics Conference, May 16–20, 2022

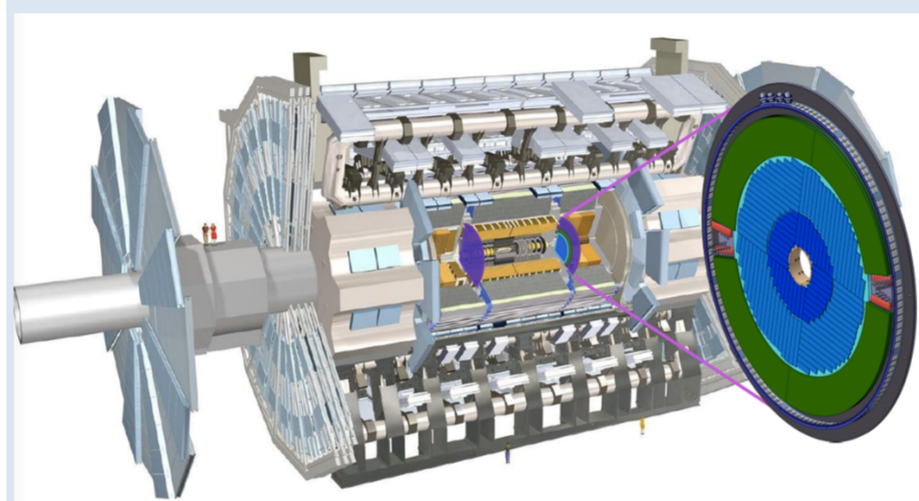
HL-LHC upgrade

- Plan to start running in 2028
- Peak instantaneous luminosity: $\sim 7.5 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$
- Integrated luminosity : $\sim 4000 \text{ fb}^{-1}$
- Average of 200 simultaneous p-p interactions ($\langle \mu \rangle = 200$) per bunch crossing
- High vertex density leads to challenges in physics studies.



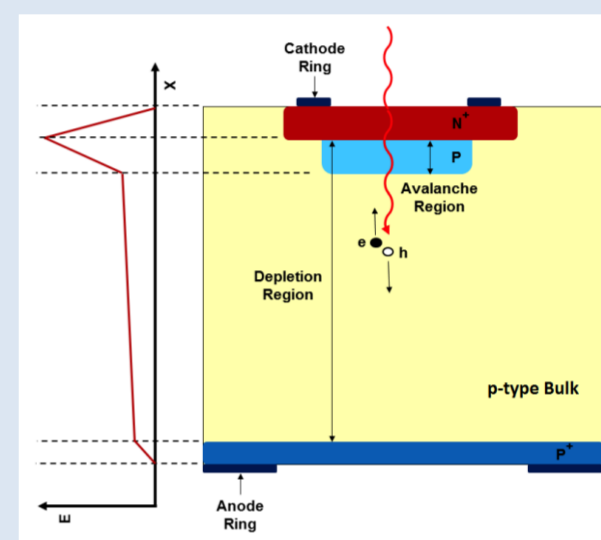
ATLAS HGTD project

- The HGTD (High-Granularity Timing Detector) can provide time information.
- High precision timing to mitigate pileup effects
- Coverage: $2.4 < |\eta| < 4.0$
 $110 \text{ mm} < R < 1000 \text{ mm}$
- Time resolution per track: 30 ps
- Sensor technology: LGAD (Low-Gain Avalanche Detector)
- Potential LGAD vendors: CNM, FBK, BNL, HPK, IHEP-IME, USTC-IME...

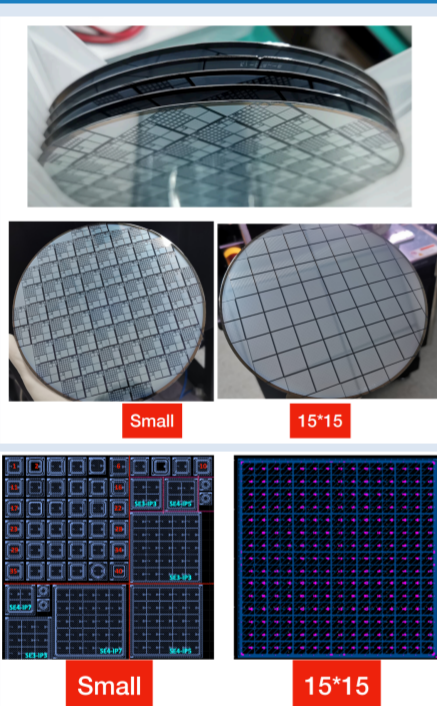


Design parameters of LGAD

- N-in-p silicon detectors with an extra highly-doped gain layer
- High electric field in gain layer generates avalanches.
- Active thickness: $50 \mu\text{m}$
- Pad size: $1.3 \times 1.3 \text{ mm}^2$
- Hit efficiency: $> 95\%$
- Radiation tolerance: $2.5 \times 10^{15} \text{ n}_{\text{eq}} \text{ cm}^{-2}$, 1.5 MGy
- Time resolution per hit: 35 ps (start), 70 ps (end of lifetime)

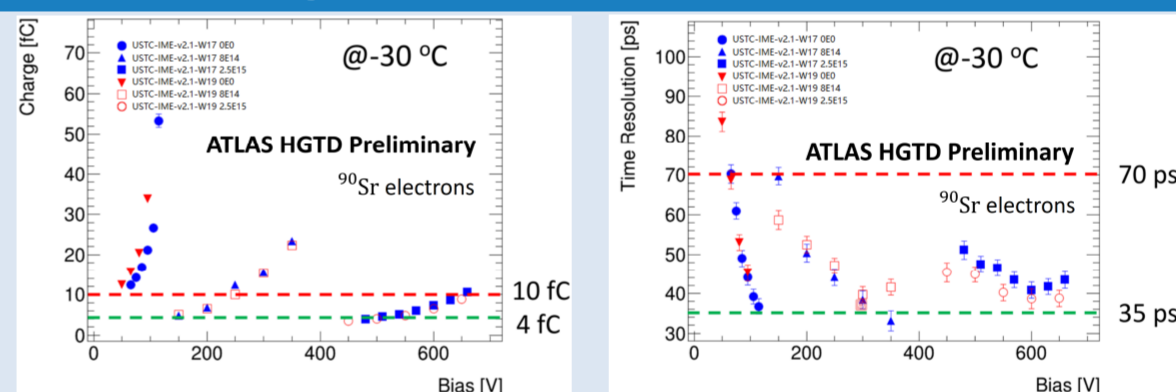


Overview of USTC-IME-v2.X sensors



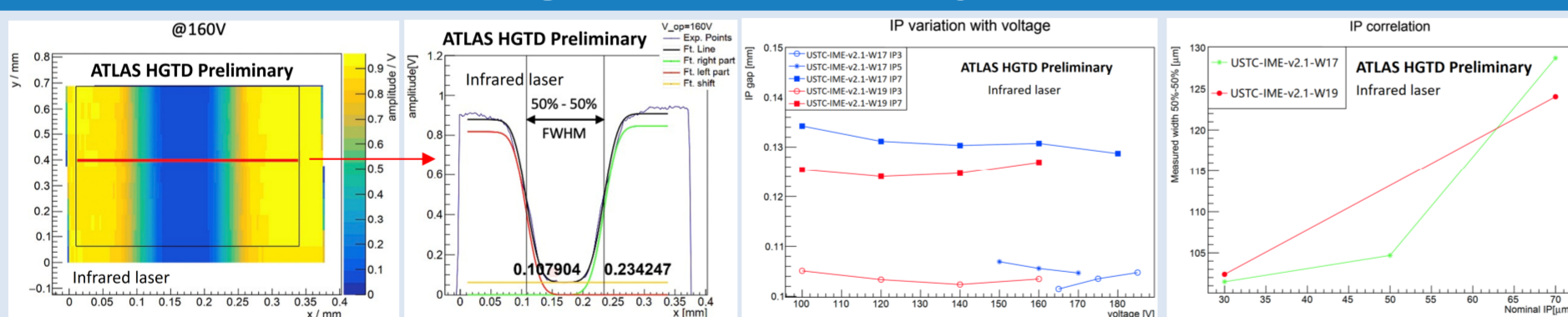
Production version	Wafer No.	GL Dose	Implantation	Layout arrays	VBD [V]
USTC-2.0	W12	Low	B	Small	~174
	W13	Low	B	15x15	~172
	W14	High	B	Small	~84
	W15	High	B	15x15	~100
	W16	High	B+10C	Small	~50
USTC-2.1	W17	Medium	B+1C	Small	~190
	W18	Medium	B	15x15	~190
	W19	Medium	B+2C	Small	~165
	W20	Medium	B+C	15x15	~220
	W21	Medium	B+C	Small	~215

Collected charge and time resolution of USTC-IME-v2.1



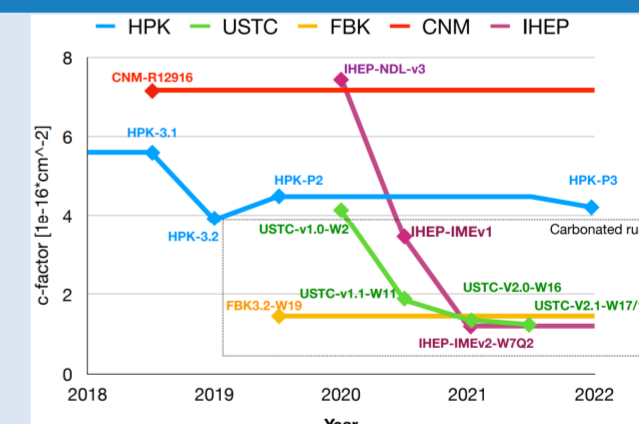
- The USTC-IME-v2.1 is undergoing β -scope and beam tests to get collected charge and time resolution.
- The current β -scope results from USTC and JSI show the W17/W19 LGADs' σ_t can reach 70 ps with bias voltage below 500 V after 2.5×10^{15} fluence.

Inter-gap measurement by TCT test



- The TCT measurement with infrared laser has been performed on USTC-IME-v2.1 sensors at USTC.
- For un-irradiated sensors, sensors with nominal IP3 and IP5 have inter-pad gap closed to $100 \mu\text{m}$.
- More measurements will be performed.

Acceptor removal c-factor



The c-factor of USTC W17 is $1.23 \times 10^{-16} \text{ cm}^2$

HGTD test devices in USTC



Conclusion

- Probe station/ β -scope/laser TCT/beam test are being performed on USTC-IME-v2.1 sensors.
- The preliminary test result shows USTC-IME-v2.1 sensors have good performance and satisfy the requirement on the collected charge and time resolution before and after irradiations.