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TID study of the readout chip for ATLAS silicon strip upgrade

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On behalf of the ITk group of IHEP and Tsinghua

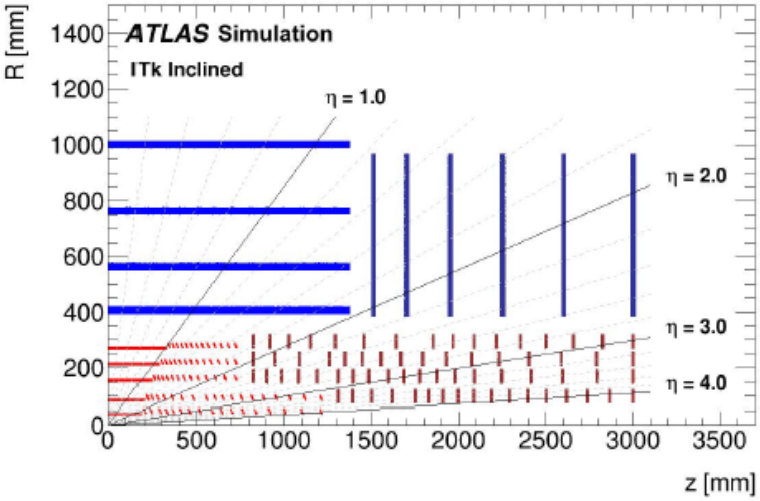
ATLAS ITk

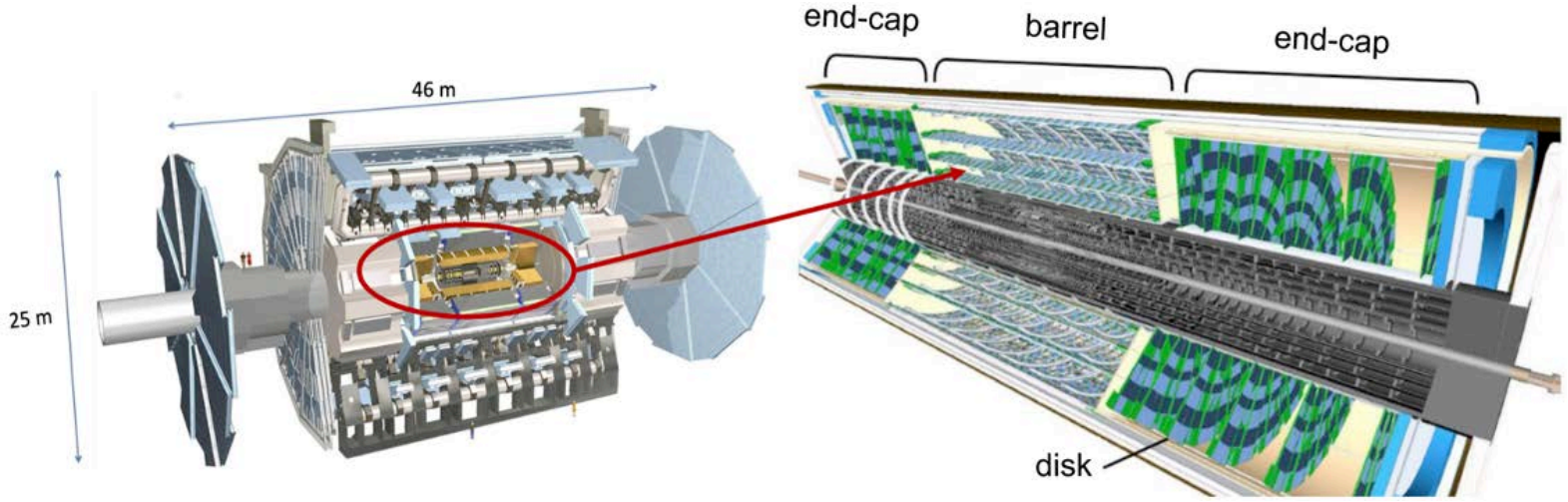
Outline

- Background
- ABCStar and performance
- TID test of ABCStar V0
- Conclusion

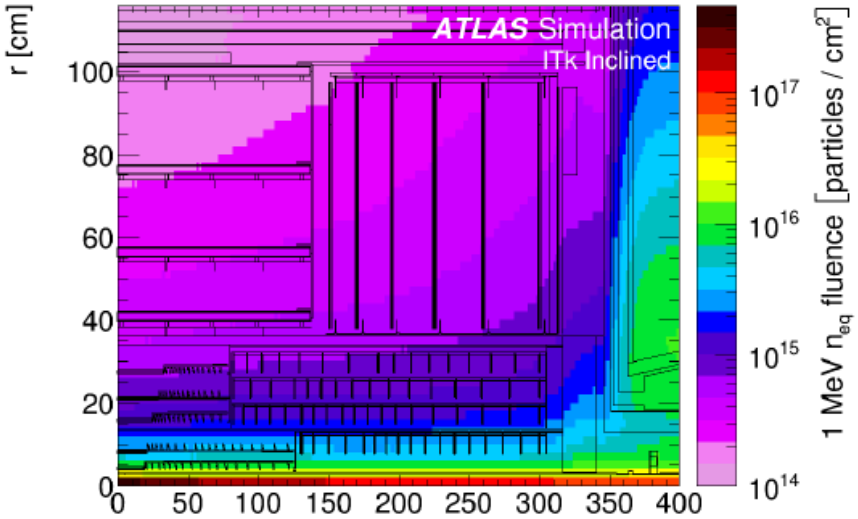
Background

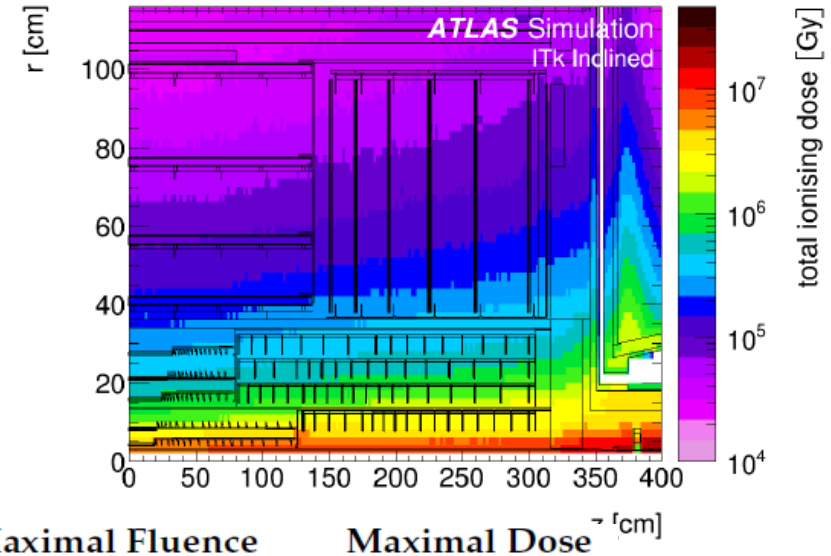
- ATLAS ITk(Inner Tracker) will be the new all-silicon track detector for ATLAS in the Phase II of the HL-LHC project
- The Strip detector is made up of the Barrel cylinders and End-cap discs and totals ~165 m2 of silicon micro-strip sensors





Radiation environment



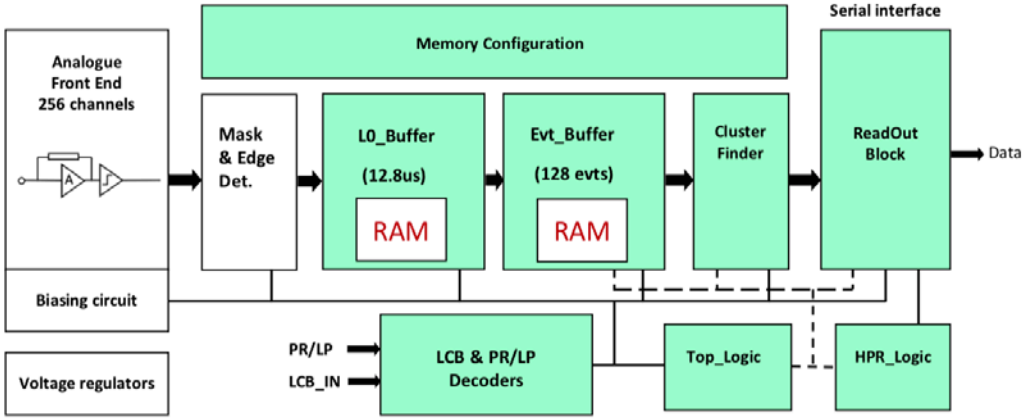


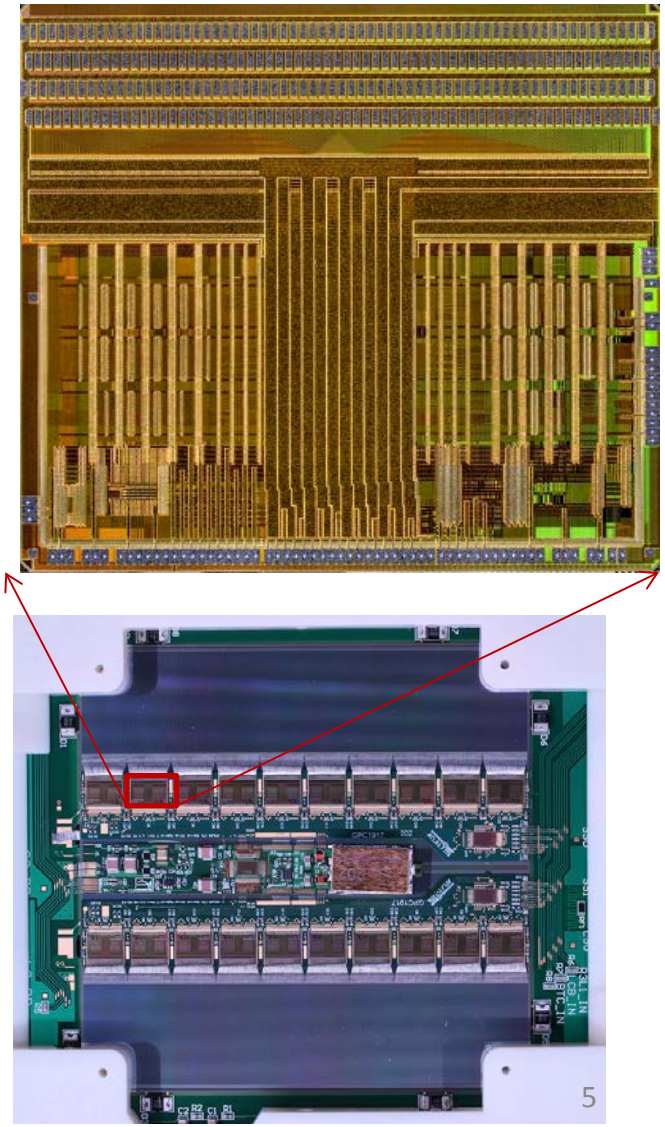
Layer	Radius [mm]	Maximal Fluence [n_{eq}/cm^2]	Maximal Dose [MRad]
Strips			
Long Strips	762	3.8×10^{14}	9.8
Short Strips	405	7.2×10^{14}	32.5
End-cap	385	1.2×10^{15}	50.4

- The fluence and dose distributions for the ITk layout
- Safety factor 1.5 has been used in the table
- Irradiation tests evaluate components up to twice of the expected fluences
  - ~66Mrad for end-cap

ABCStar chip

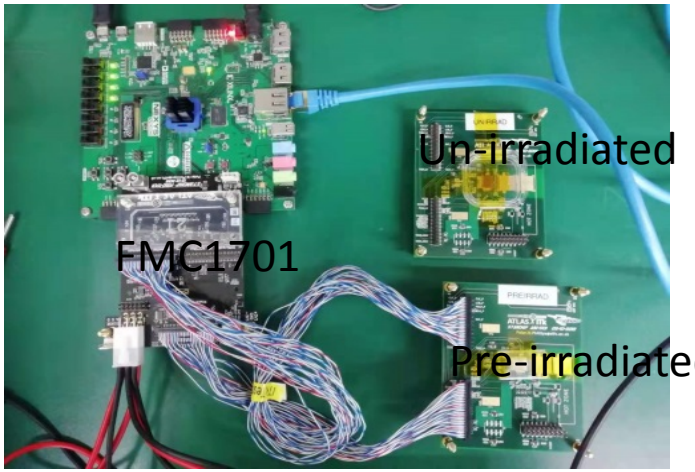
- The ABCStar (ATLAS Binary Chip) is the front end readout ASIC for ATLAS' Inner Tracker (ITk) Strip detector
- Process of signals from 256 silicon strips, allows a multi-trigger data flow control
  - Each channel has an analogue amplifier, shaper, discriminator and masking
  - The readout takes place using Level 0 triggers, followed by Low Priority (Level 1) or Priority Request (Regional Readout Request) triggers, with 2 levels of data pipelining
  - Control takes place using ITk Strips' custom LCB protocol; readout is in the custom format
- Key component of the ITk strip module, ~300,000 needed for production considering yield





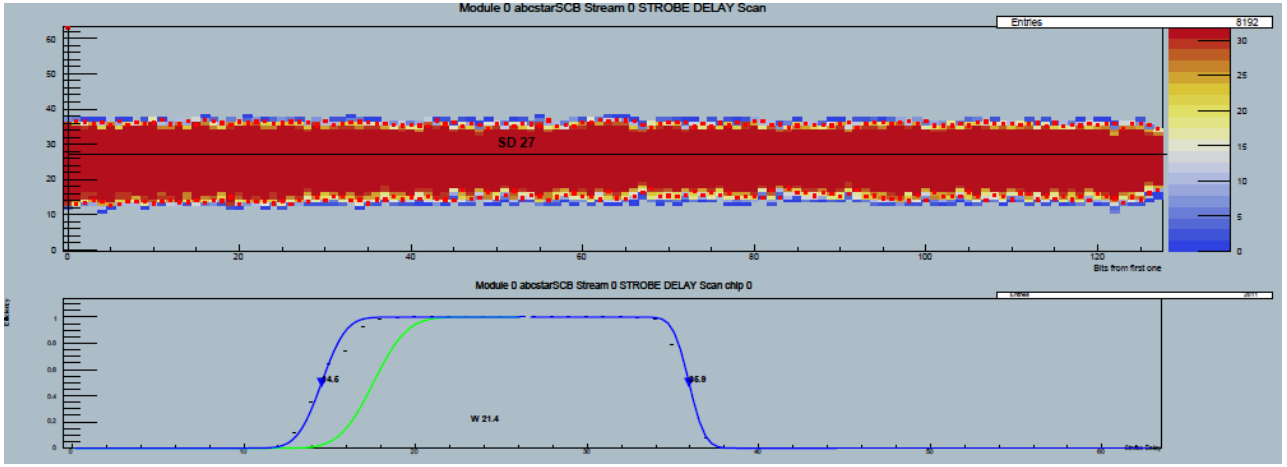
Single chip test

- Setup at IHEP
  - SCB + FMC1701 + NV + PC
  - Two ABCStar V0 chips, one un-irradiated(chip1) another pre-irradiated(chip2)

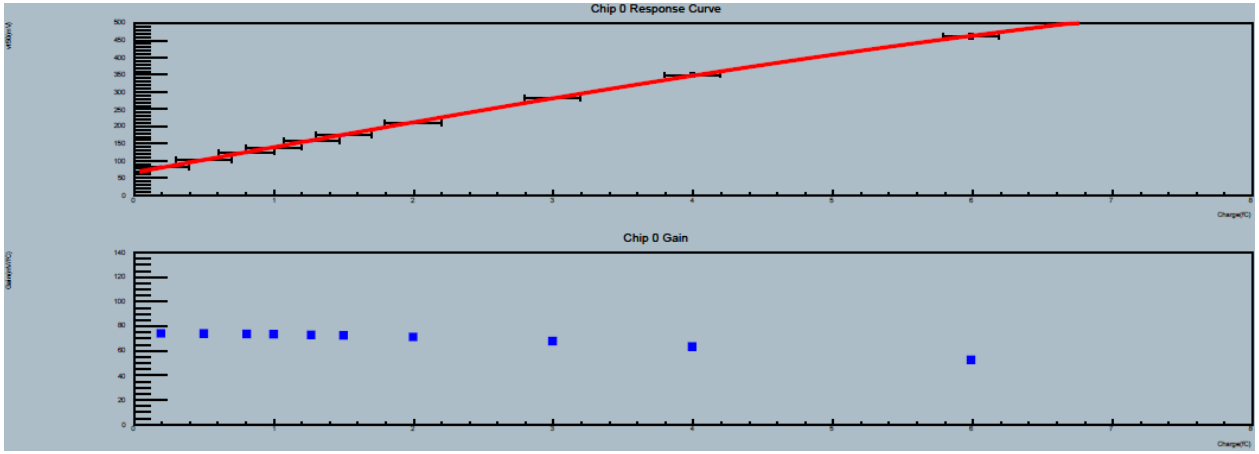


Selected test results

- Strobe delay test

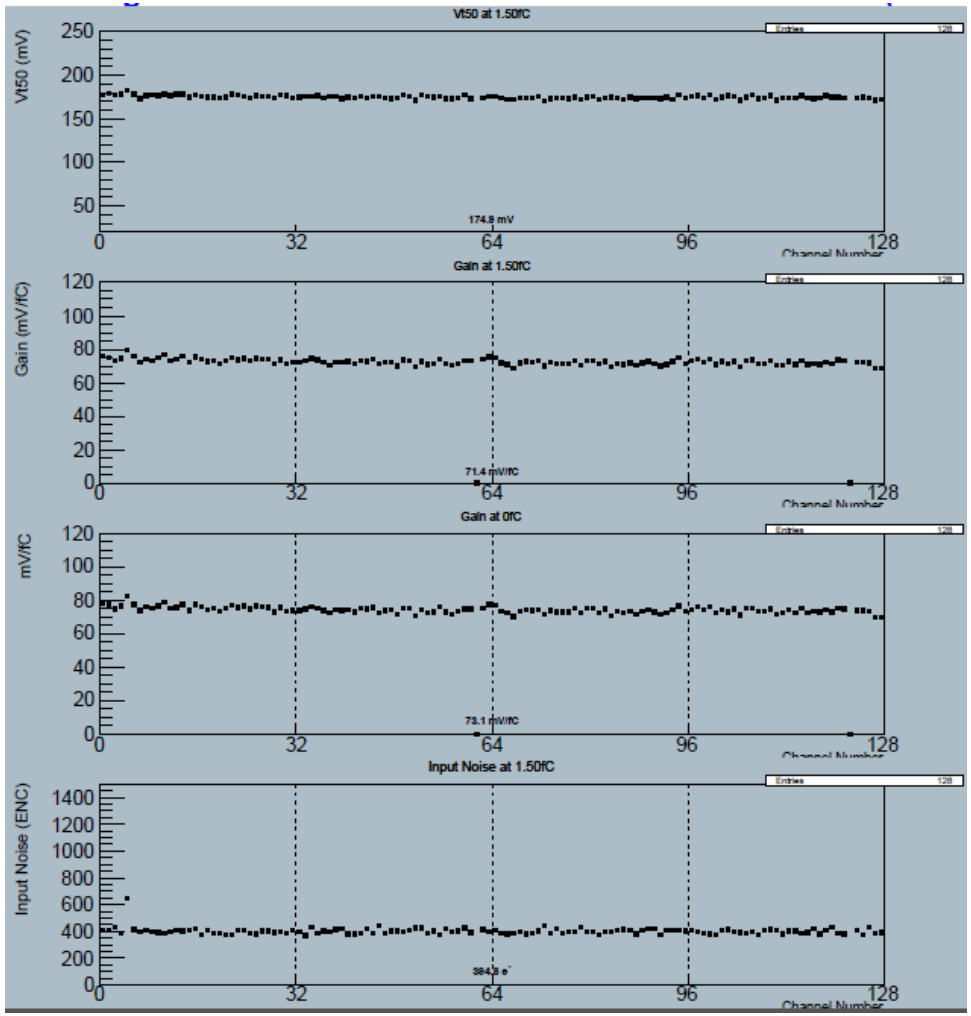


- Response curve



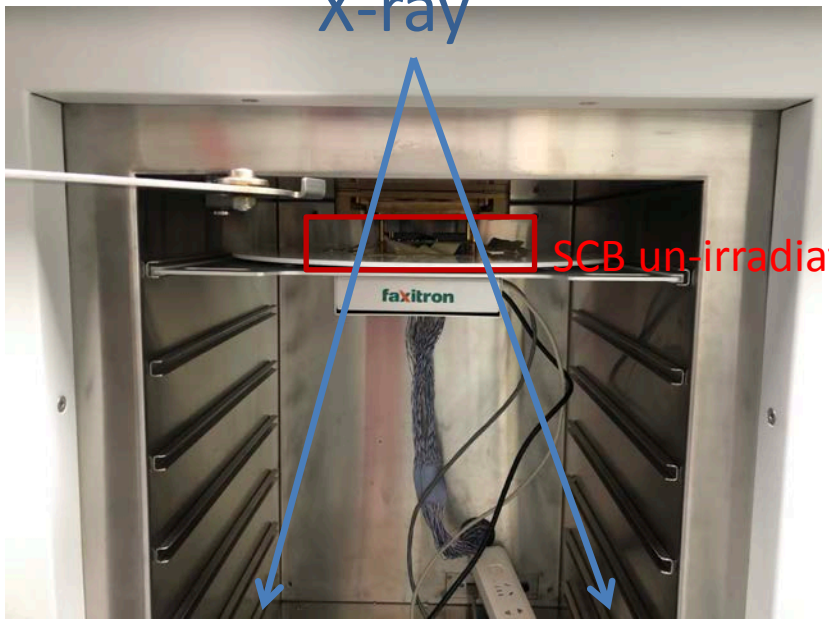
Selected test results

- Response vs channel
  - Vt50
  - Gain
  - Noise



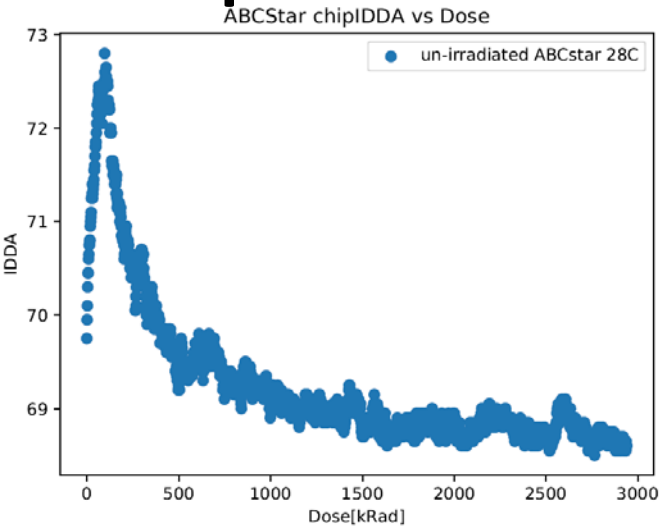
TID test

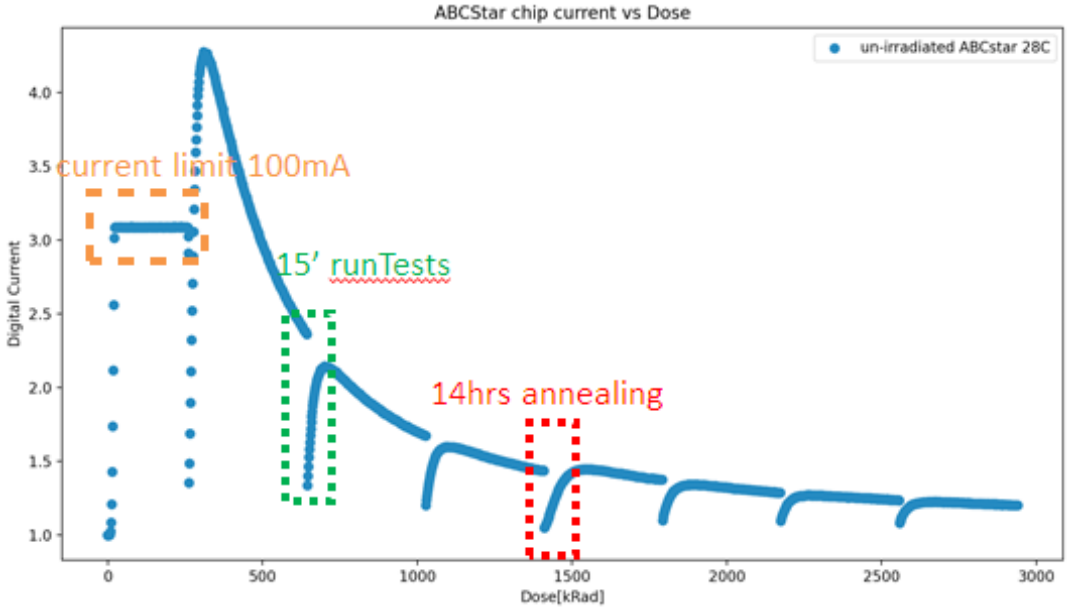
- Setup
  - X-ray machine: MultiRad 160
  - 60 kV, 20 mA
  - Raw beam, no filter
  - SCB on the top shelf
    - Source to shelf (dose meter) distance 14.5cm, beam diameter 10cm
  - Dose rate : 63.662Gy/min
    - The chip is ~1cm higher so higher dose rate expected
- Test procedure
  - 8 loop of 1 hr irradiation + 15min test
  - ~8 hrs of irradiation to ~3Mrad

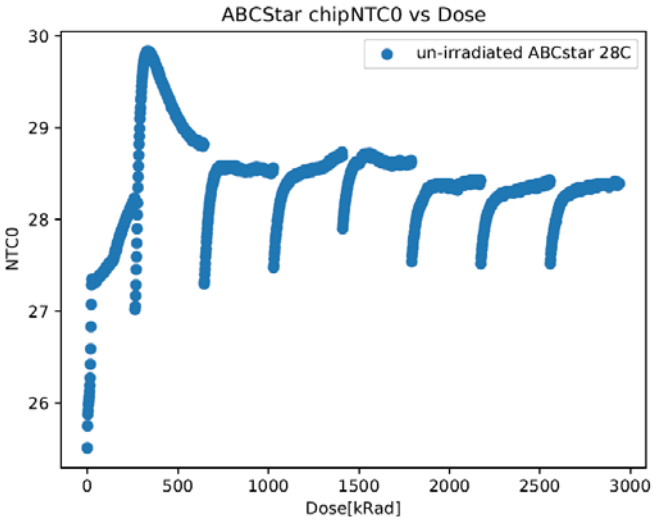


Digital current bump

- First round test of the un-irradiated ABCStar V0
- 63.662Gy/min=106.1 Rad/s at room temperature
- Current setting limits part of digital current bump
- Annealing effect
- Small current increase of analog part after design improvement

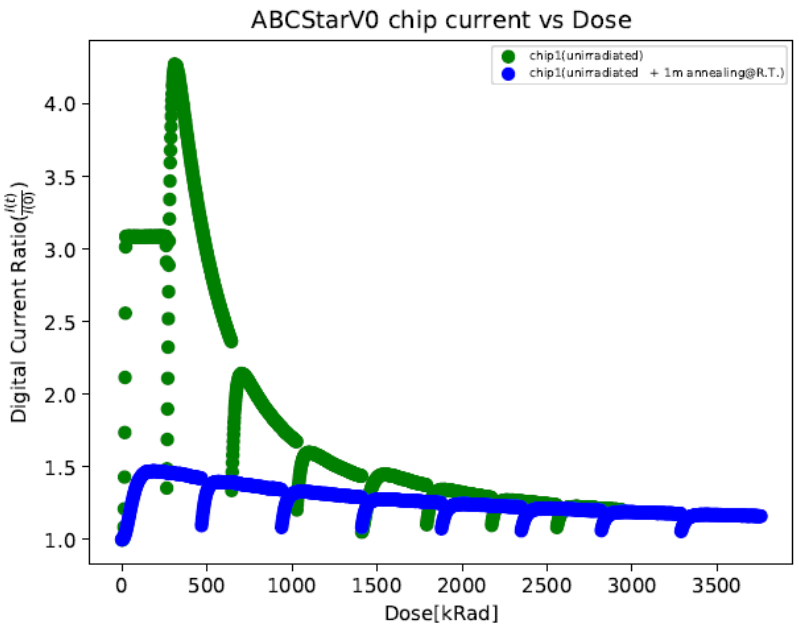


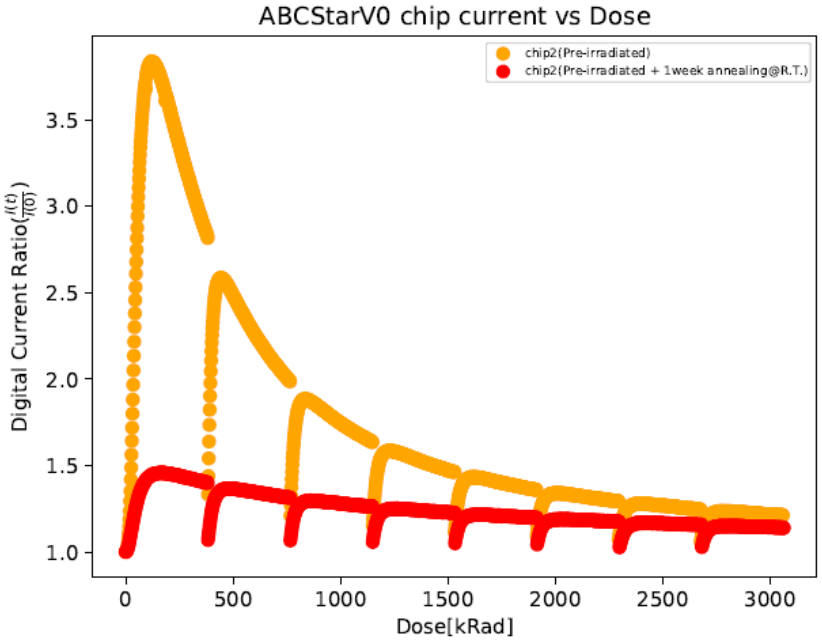




Pre-irradiation

- Pre-irradiation method shown to work for ABCStar V0 to pass the TID bump
  - Relatively small bump may due to batch variation and irradiation history
- Pre-irradiation using a tungsten tube has also been shown to work for chip1(left) and chip2(right)





Conclusion

- ABCStar chip is the key component for ITk strip upgrade
- Test setup have been built at IHEP and key parameters are measured
- TID test crosschecked the current bump effect and the pre-irradiation method
- Calibration of the doserate and further test to be done using forthcoming chips