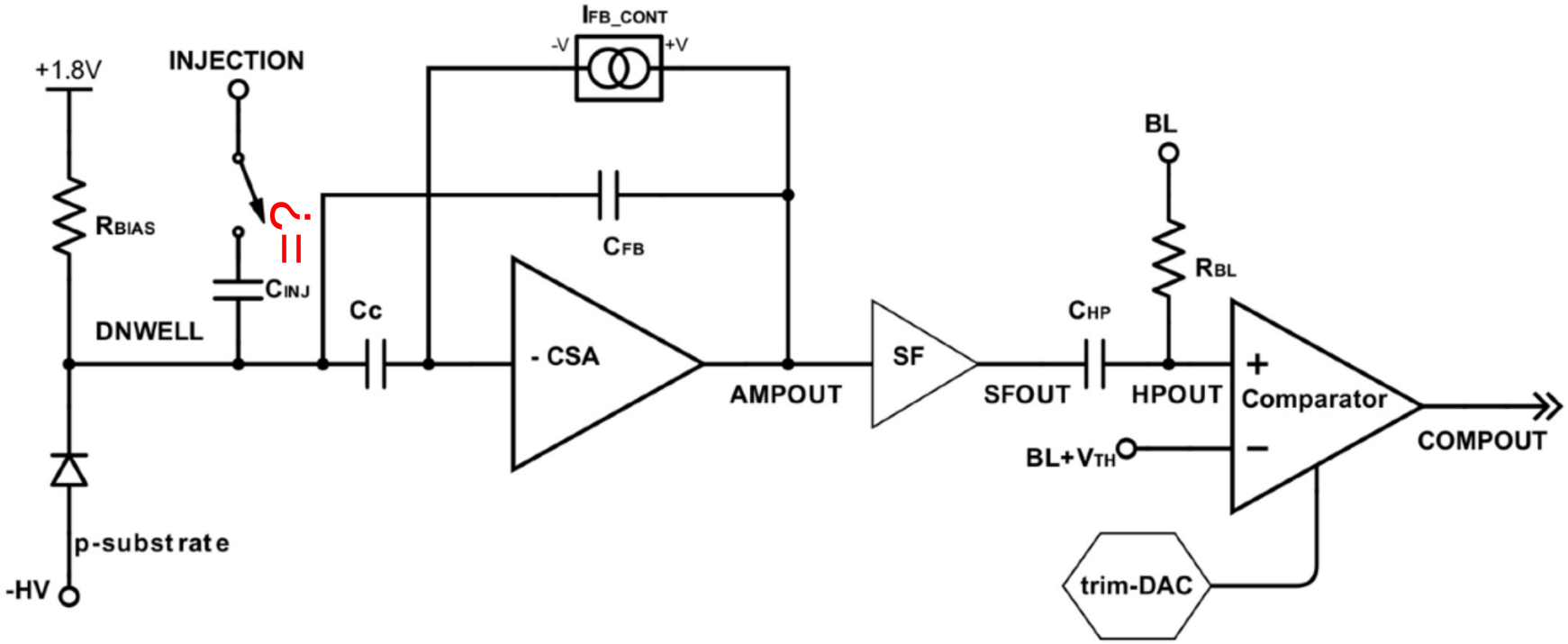
Problems with unknown capacitance for irradiated sensors



Clarification

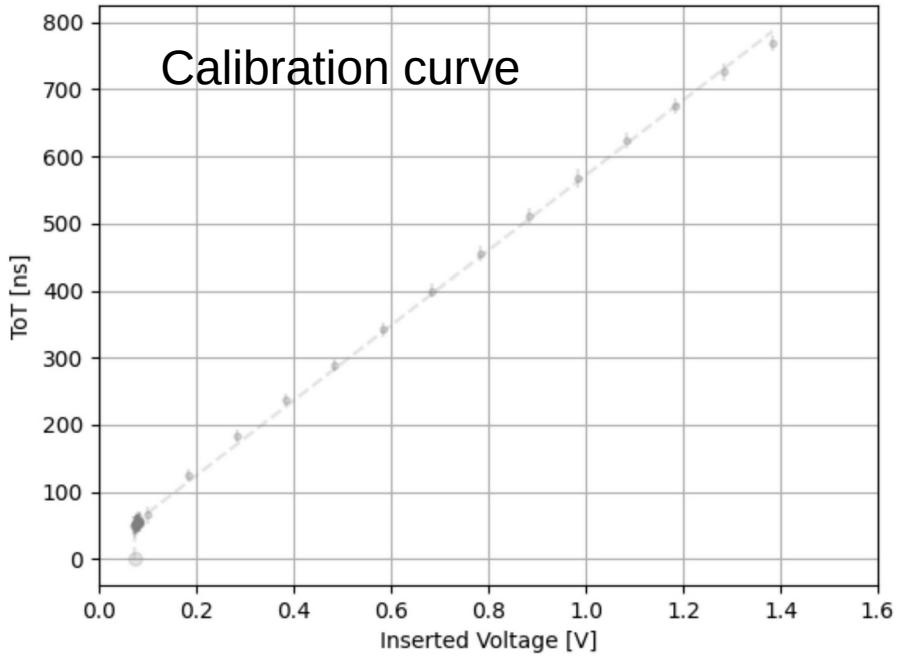
- When talking about issues for irradiated sensors, I **DO NOT** mean
  - That I think that radiation damage varies the capacitance of the injection capacitor
  - That it hinders basic operation of the sensors

- I **DO** mean
  - That evaluating the effect of radiation damage on the sensor is severely hindered

Problems with varying capacitance with the MP4

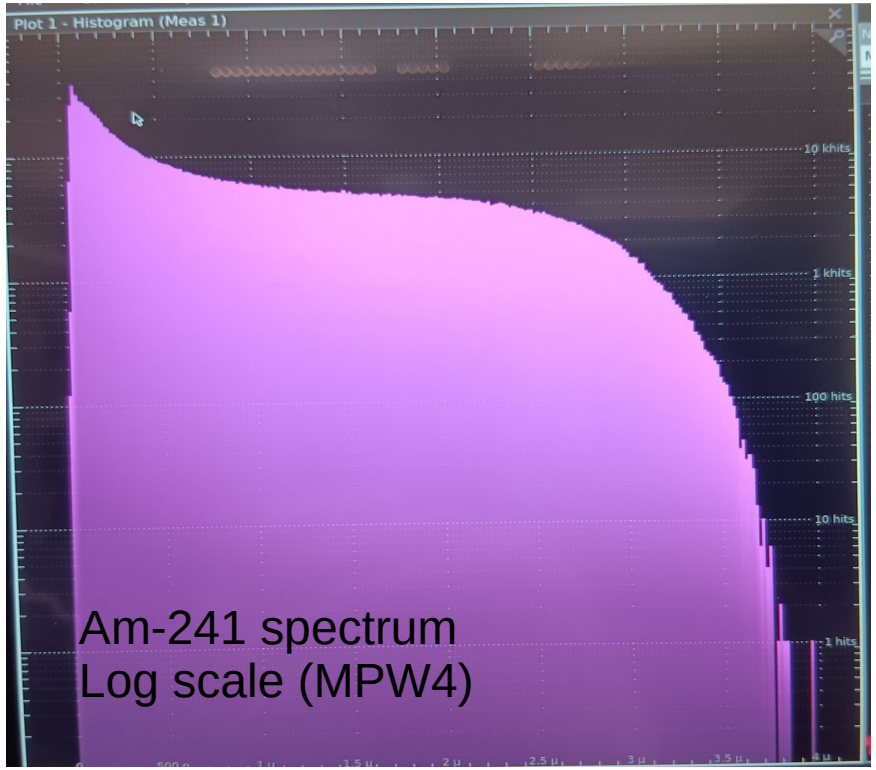
- Allows for a known voltage (charge if capacitance is known) → ToT response curve
- Calibration of charge capacitor typically done using radioactive source
  - Preferably Fe-55 or Am-241 due to distinct peaks

C_inj is a Varactor not metal traces
laying over one another (also true for C_fb?)



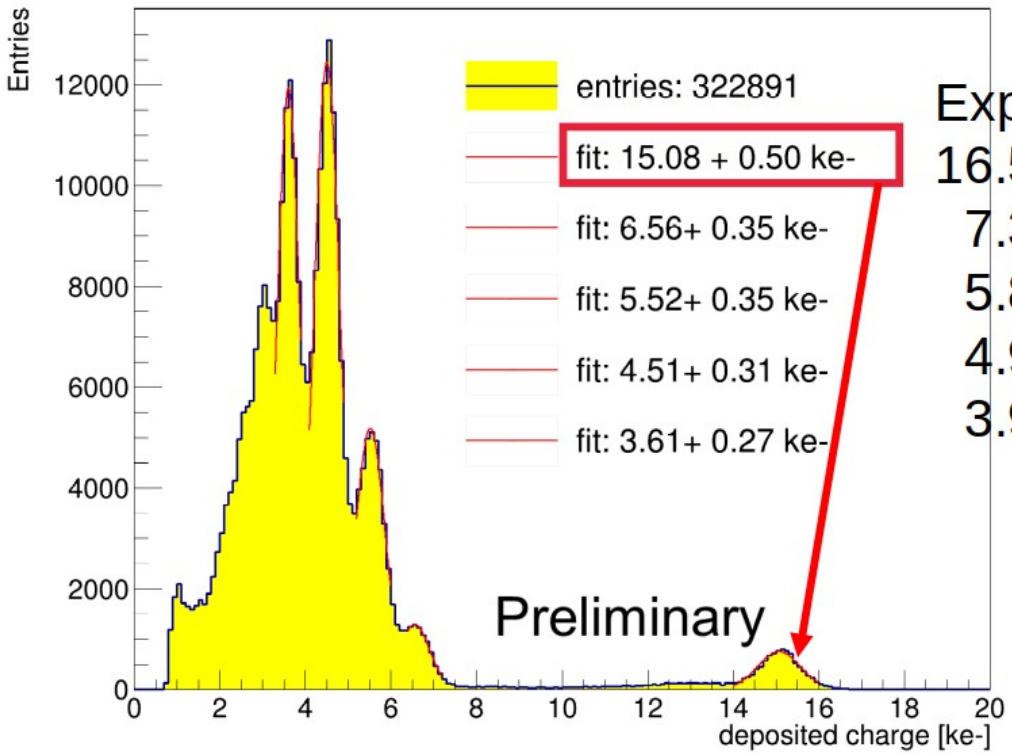
Measuring capacitance

- Fe-55 is not possible as
  Q_Fe55 < Q_threshold
- Am-241 is not possible as we cannot discern any peaks (noise?)
  - A different sensor (200 micron hybrid) had no such issues



Am-241 spectrum
Log scale (MPW4)

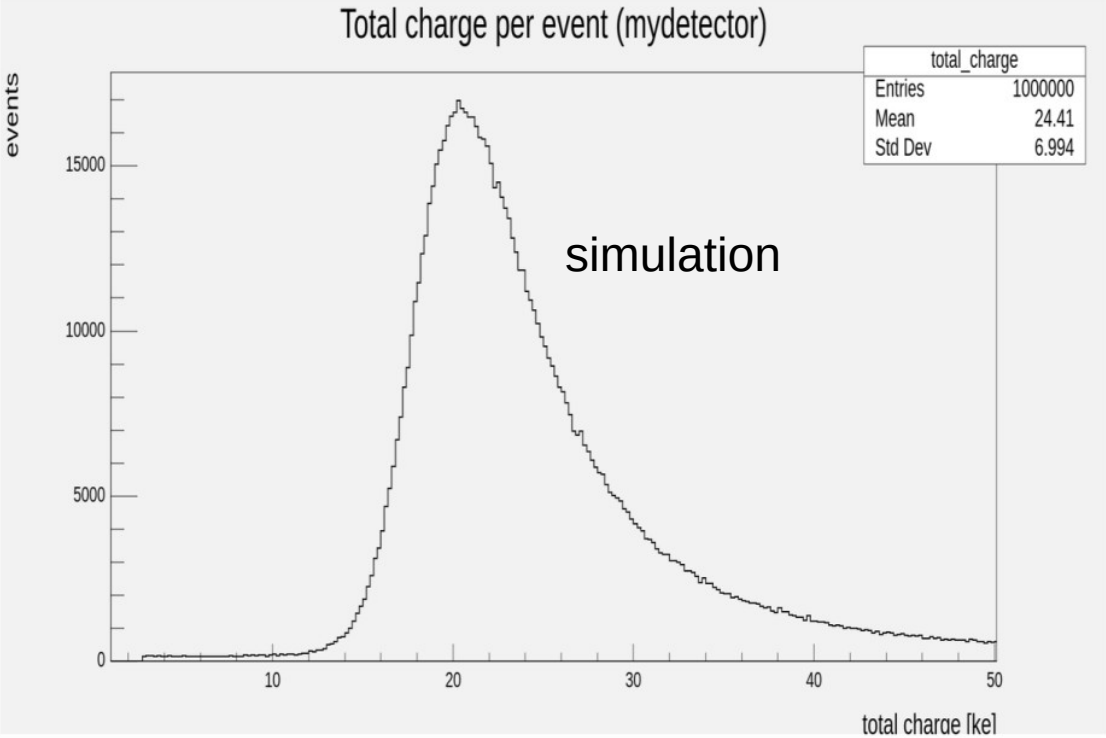
Am-241 spectrum
Reference hybrid

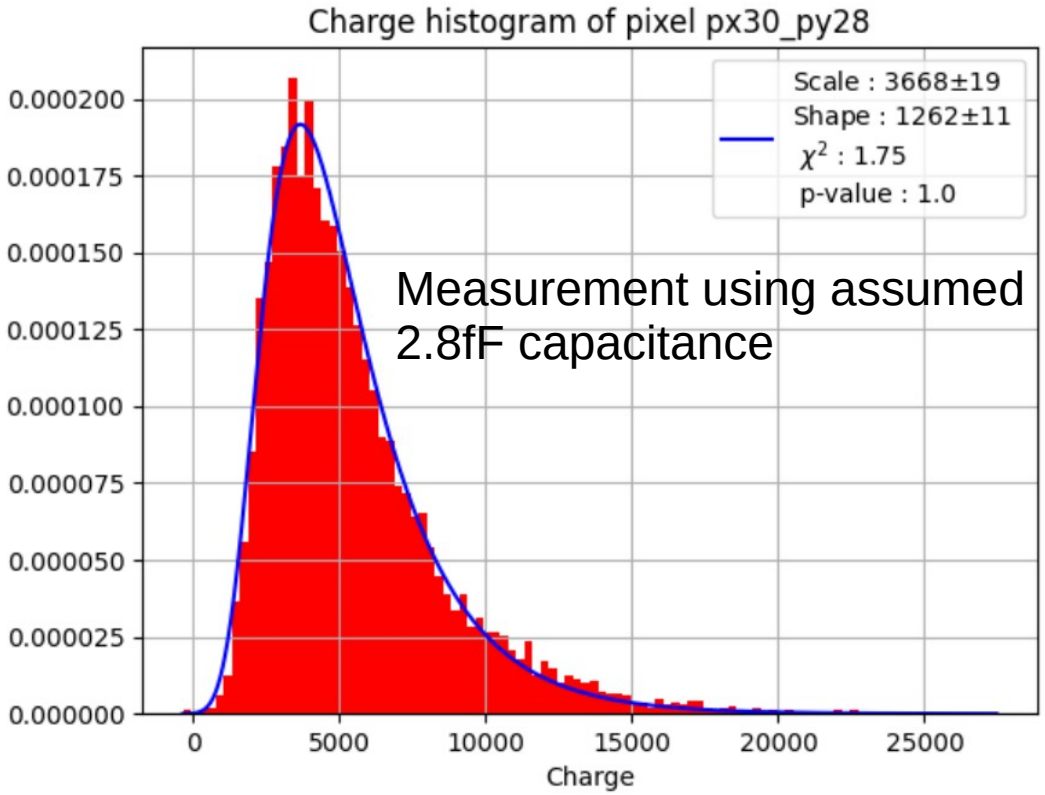


Expected:
16.5 ke
7.3 ke
5.8 ke
4.9 ke
3.9 ke

Measuring capacitance

- Alternative is using Sr90 using the MPV basing it on MIP deposition
- The ratio of seen charge to expected charge gives the “true” capacitance
- This works only because we make the assumption that we see all charge

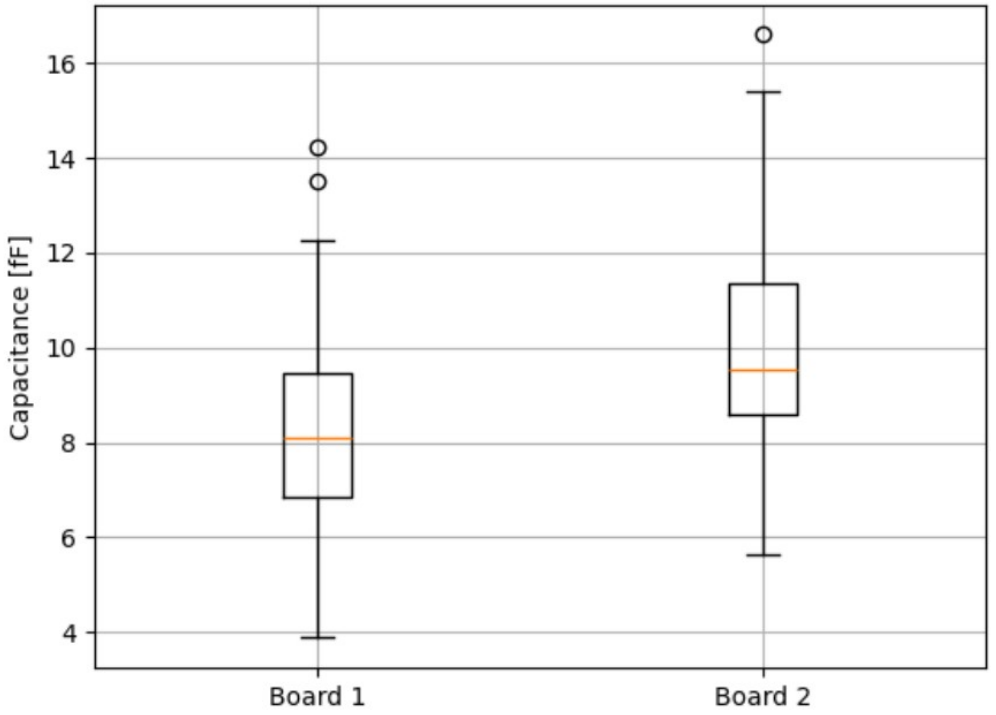




We make the assumption charge is 20ke-

- The whole basis on which we determine the capacitor is the assumption that we collect 100% of the expected charge
- With this assumption we can see the capacitance in the same board, pixel-pixel varies by up to a factor 3.5

- This assumption does **NOT** work for irradiated sensors
- At some level we will see charge loss due to
  - trapping
  - insufficient depletion



From Andres presentation last week

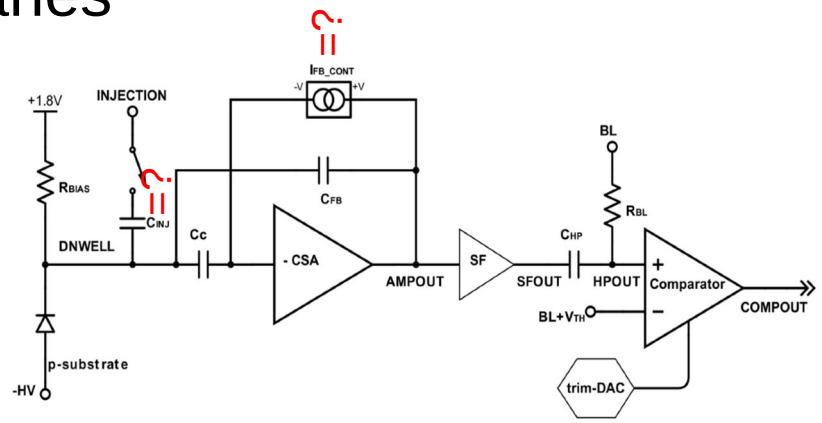
Conclusion

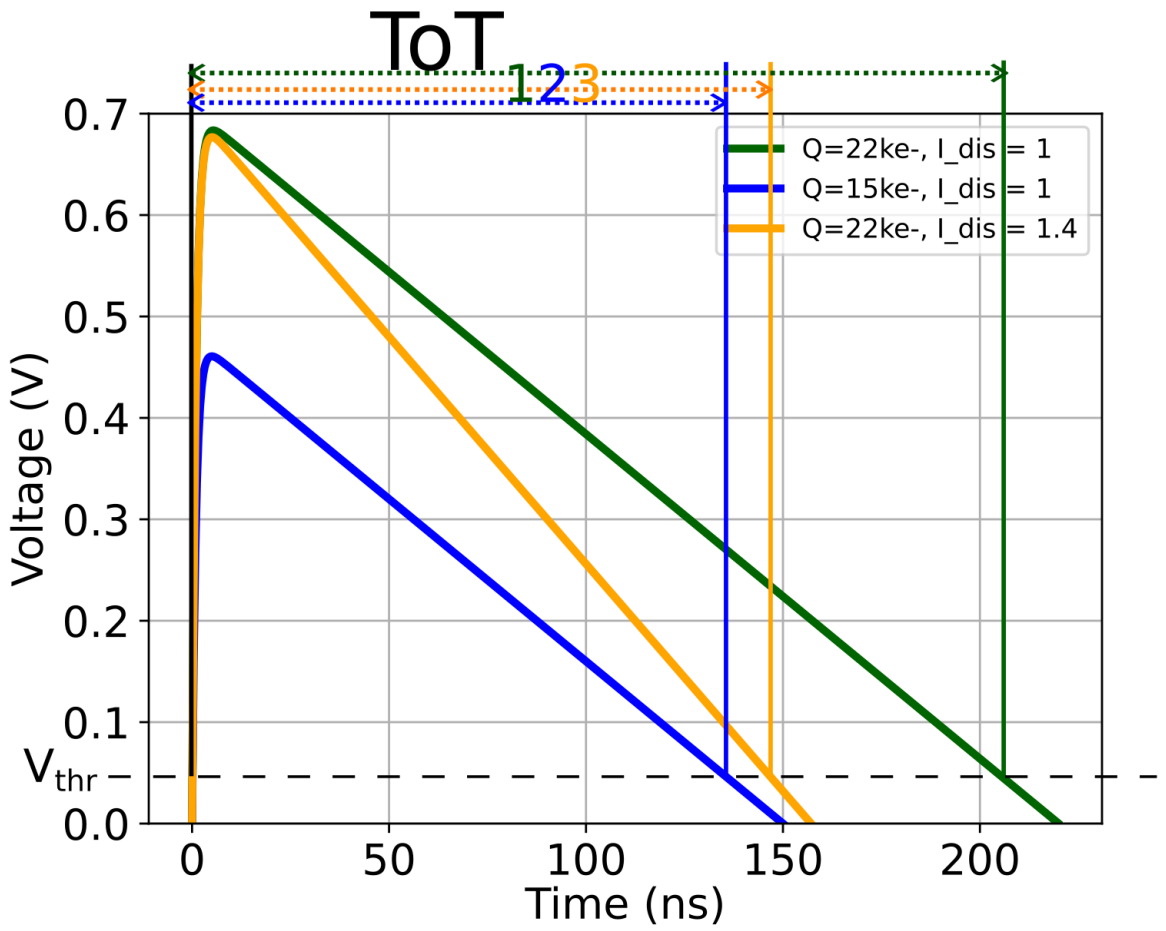
- When operating with irradiated chips we have one equation with two unknowns
  - The injection capacitance
  - The amount of collected charge

    → Not possible to determine the true performance
- One possibility is to see if other monochromatic sources of charge beyond Fe-55 instead of Am-241 work (x-ray fluorescence for example, but that requires a lot of setup)
- Another possibility is to irradiate already bonded chips on boards, however that means a lot of irradiated material meaning the system is very “hot”

Update: Alternative explanation for difference. I_FB not C_inj

- We measure ToT. Affected by both charge input and feedback current
- Affects all measurements with charge injection
- Does not affect radioactive source measurements (not part of circuit)
- Sr90 MPV ToT should be the same for all if only injection capacitance varies

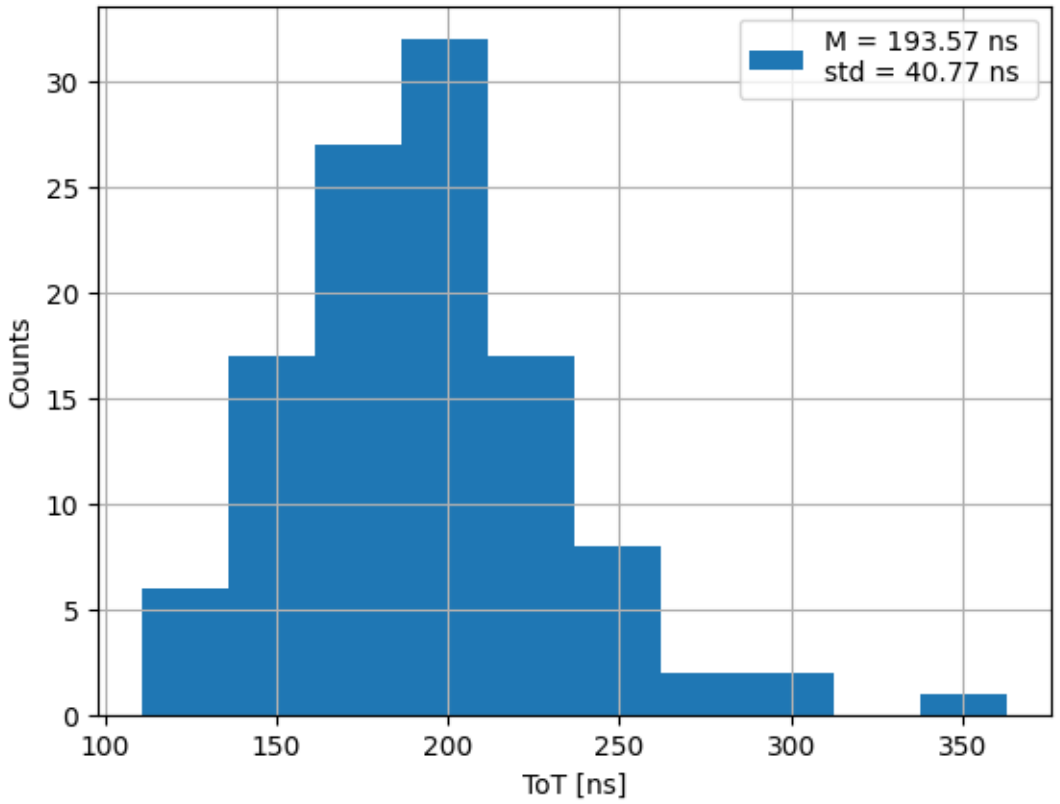




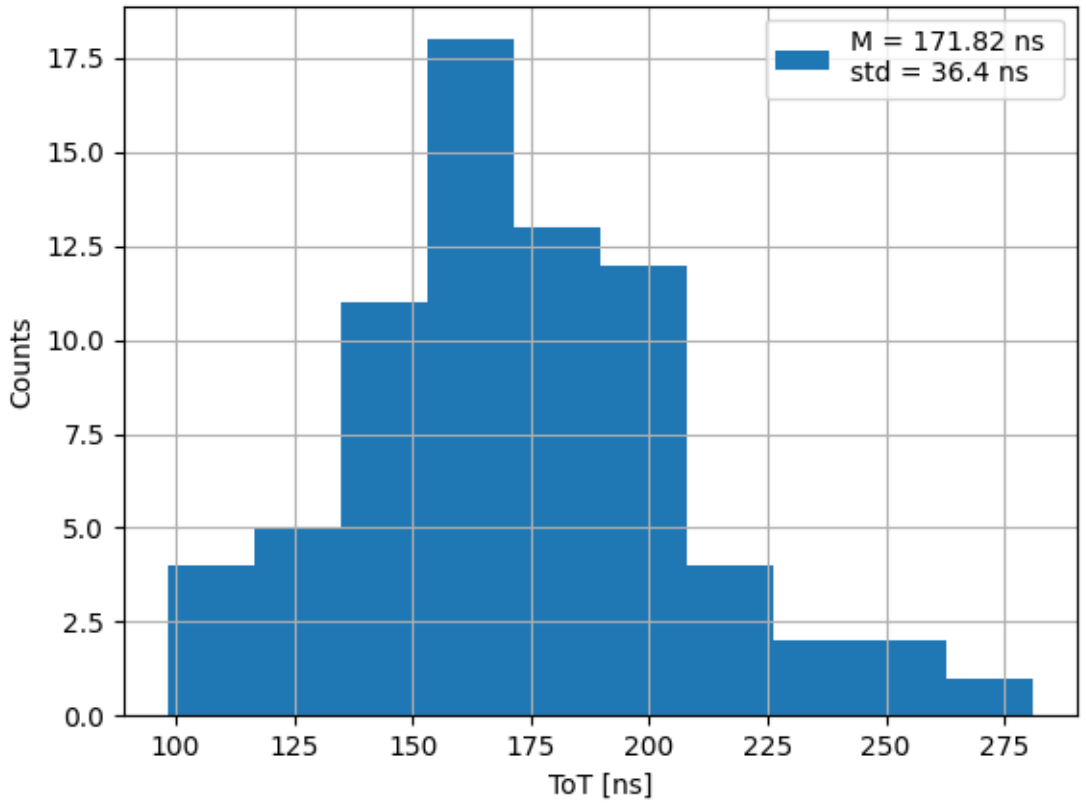
ToT distribution Sr90

- Large variation in ToT for MPV
  - → Variation in parts due to Feedback current variation

Board 1



Board 2

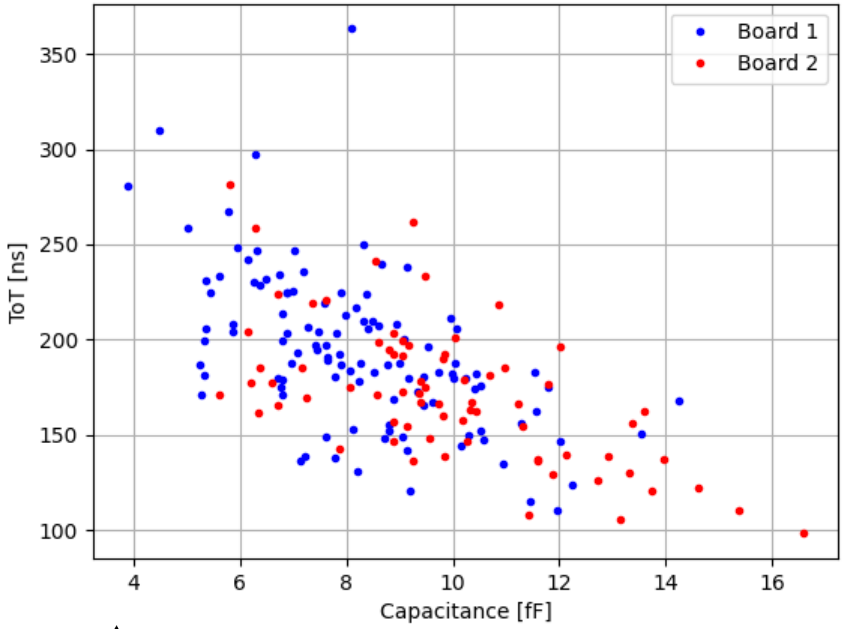


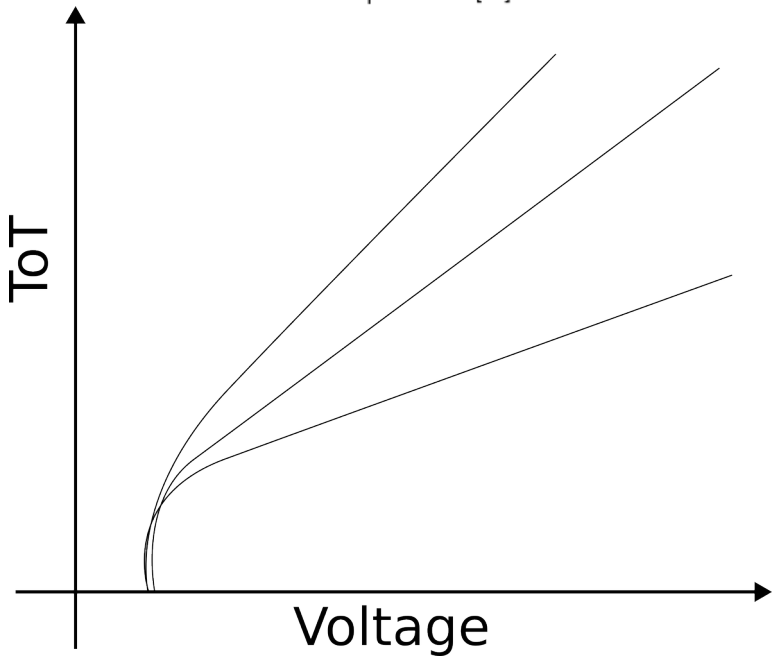
ToT distribution Sr90

- Variation correlates with measured “capacitance”
- So the charge injection capacitance is not varying as much as we feared
- Will force all ToT values for the MIP to the same point
  - Try to figure out corresponding intersection point in calibration curve

    → Correct voltage for MIP ToT

    → Correct value for injection capacitance and spread





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