1. Introduction

- The HL-LHC ATLAS and CMS pixel detectors will be powered using a serial powering scheme.
- Constant current will be provided to a chain of pixel modules powered in series, whereas chips within a module will be powered in parallel.
- This scheme is based on the design of a Shunt-LDO regulator [1] that has been integrated on the new RD53A [2] prototype pixel readout chip.
- This poster shows first results of serial powering tests with the RD53A powered using the on-chip Shunt-LDO regulators and without sensors.

2. Single RD53A chip tests

a) Line regulation
- The slope of the Vin is equivalent to the input impedance. Parasitic resistance can affect the input impedance: A slope offset of ~200mΩ was measured.
- Line regulation measurements were performed using the internal bandgaps for the offset and reference voltages (left plot) and when providing them externally (right plot).
- The line regulation behavior is dominated by the interaction of Shunt-LDO with the bandgap voltages.

b) Climatic chamber test
- Chip was tested in a climatic chamber, operated in Shunt-LDO mode with \( \text{Vin} = 2.2 \text{A} \) and using internal bandgaps.
- The temperature was measured using NTC on carrier card.
- The Shunt-LDO output voltages change by ~20-25mV/°C.

c) Transient measurement
- Both digital and analog domains were configured to have ~0.5A consumption.
- Digital load transient was done by turning off/on the clock of a part of the pixel matrix.
- Impact of the transient to analog voltage is almost not visible (as expected by simulation).
- Decoupling capacitors used: Shared input \( C_{\text{in}}=20 \mu \text{F} \), per regulator output \( C_{\text{out}}=2.2 \mu \text{F} \).

3. Serial power chain

a) Setup
- First tests were done putting four chips in a serial power chain as depicted below.
- The chips were configured with the same Shunt-LDO parameters using internal bandgap offset and reference voltages and a constant current of 3.6A was provided to the chain.
- Four readout systems were used to communicate with the chips (not synchronized).

b) Operating chips in a serial power chain
- Two tests were performed with all four chips at the same time:
  - Digital scans with a customized mask to assess functionality.
  - Threshold scans with the arbitrarily chosen, linear front end (UNTUNED) to a first study of the impact of power mode to noise levels.

- Example of a digital scan from one of the chips operated in the chain.
- No significant impact of serial powering to the noise levels of the chips was observed.

4. Summary & future work

- First serial powering results with the 2.0A Shunt-LDOs of the RD53A are shown.
- The Shunt-LDO works well. A comprehensive evaluation of its characteristics is ongoing.
- The line regulation behavior is dominated by bandgaps as expected from simulations.
- The RD53A chip can be fully operated in a serial chain using the Shunt-LDO with all the internal voltages provided by the bandgaps.

Future work
- Further electrical characterization of the RD53A Shunt-LDO and reliability testing for radiation and temperature corner analysis.
- Transients and failure tests, studying the noise and failure propagation in a chain.

References