Universitatea Transilvania din Brașov

Institutul de Cercetare-Dezvoltare AL UNIVERSITĂȚII TRANSILVANIA DIN BRAȘOV

The ROC integrated circuit for the ATLAS Experiment at LHC

Prof. Mihai Ivanovici

Ro-Micro, ICDT, 28 June 2024

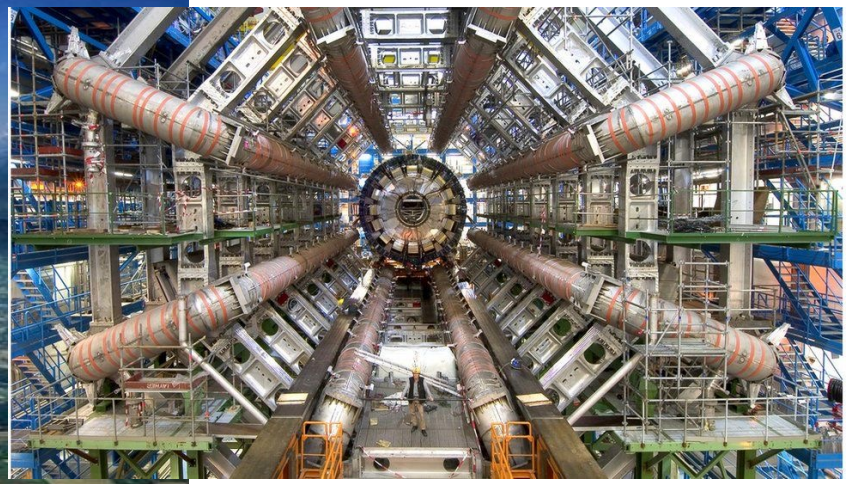
Context

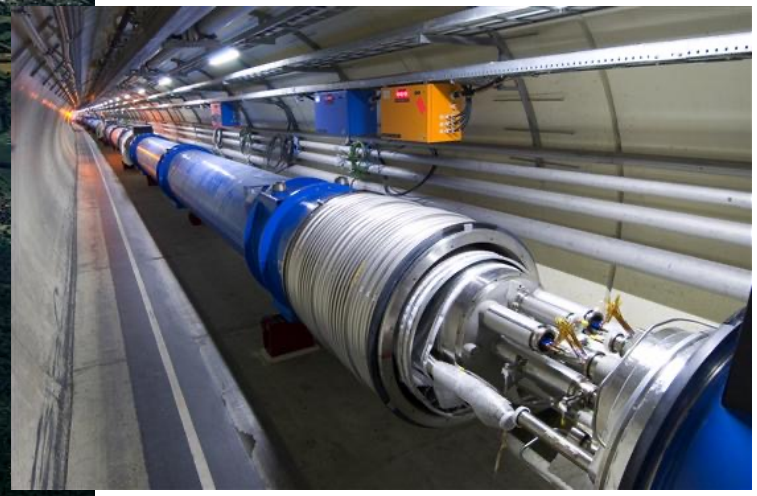
- Romania is contributing to the ATLAS experiment at CERN since early 2000s

- 5 September 2016 – Romania becomes an official member state of CERN

image source: https://home.cern/

The LHC – Large Hadron Collider





images source: https://home.cern/

The ATLAS detector

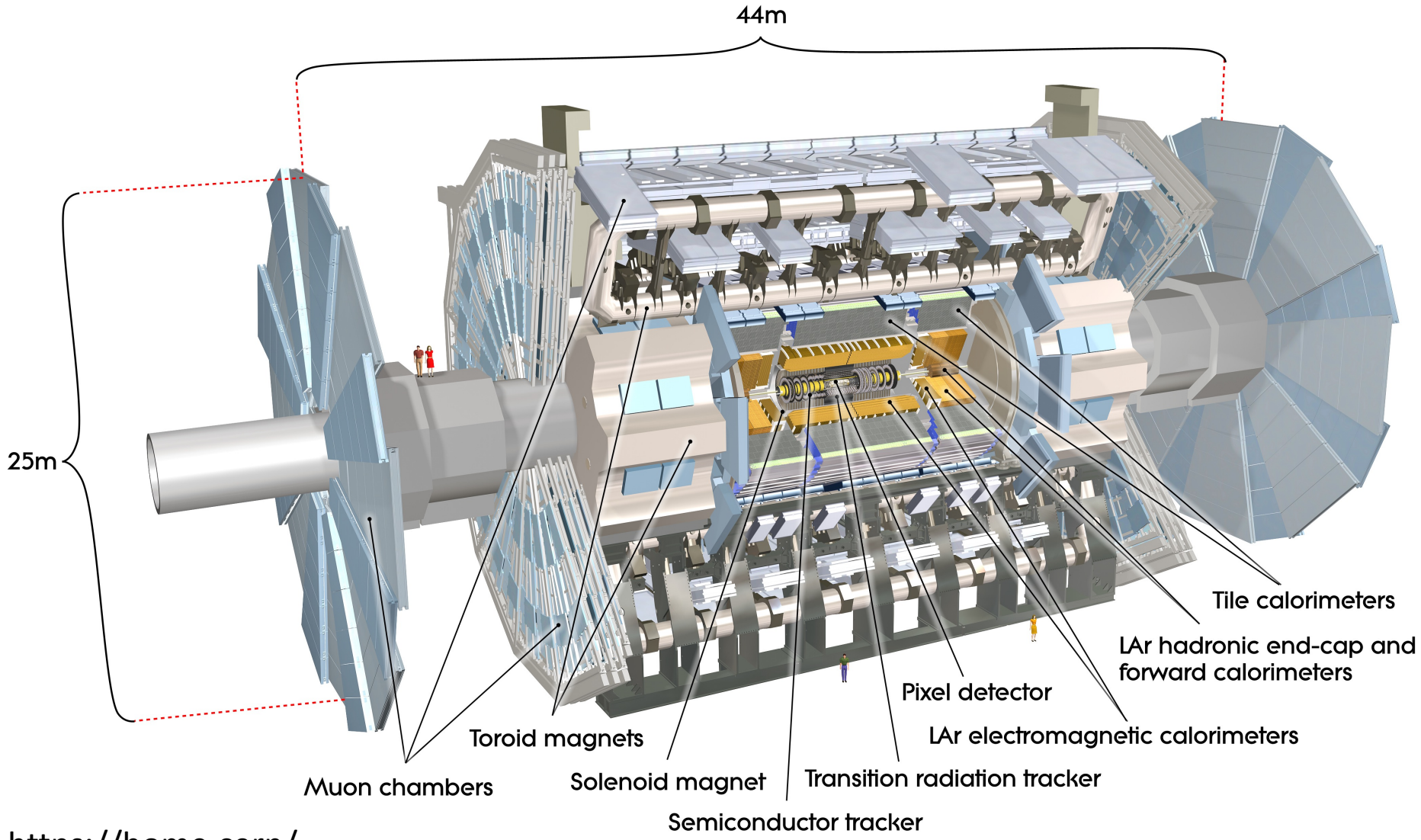


image source: https://home.cern/

Few figures

- LHC p^+ beams
  - 7 TeV → 99.9999991 % of c
  - 25 ns → 40 MHz collision rate
- 100 million readout-channels × 40 MHz → PB/s
- TDAQ (trigger & data acquisition) system → real-time selection of the ROI from the collisions of interest → 1 GB/s
- muon = μ^-, elementary particle, similar to e^-, greater mass, highly penetrating, unstable
- ATLAS New Small Wheel = 2.45×10^6 new muon detectors

NSW TDAQ Context

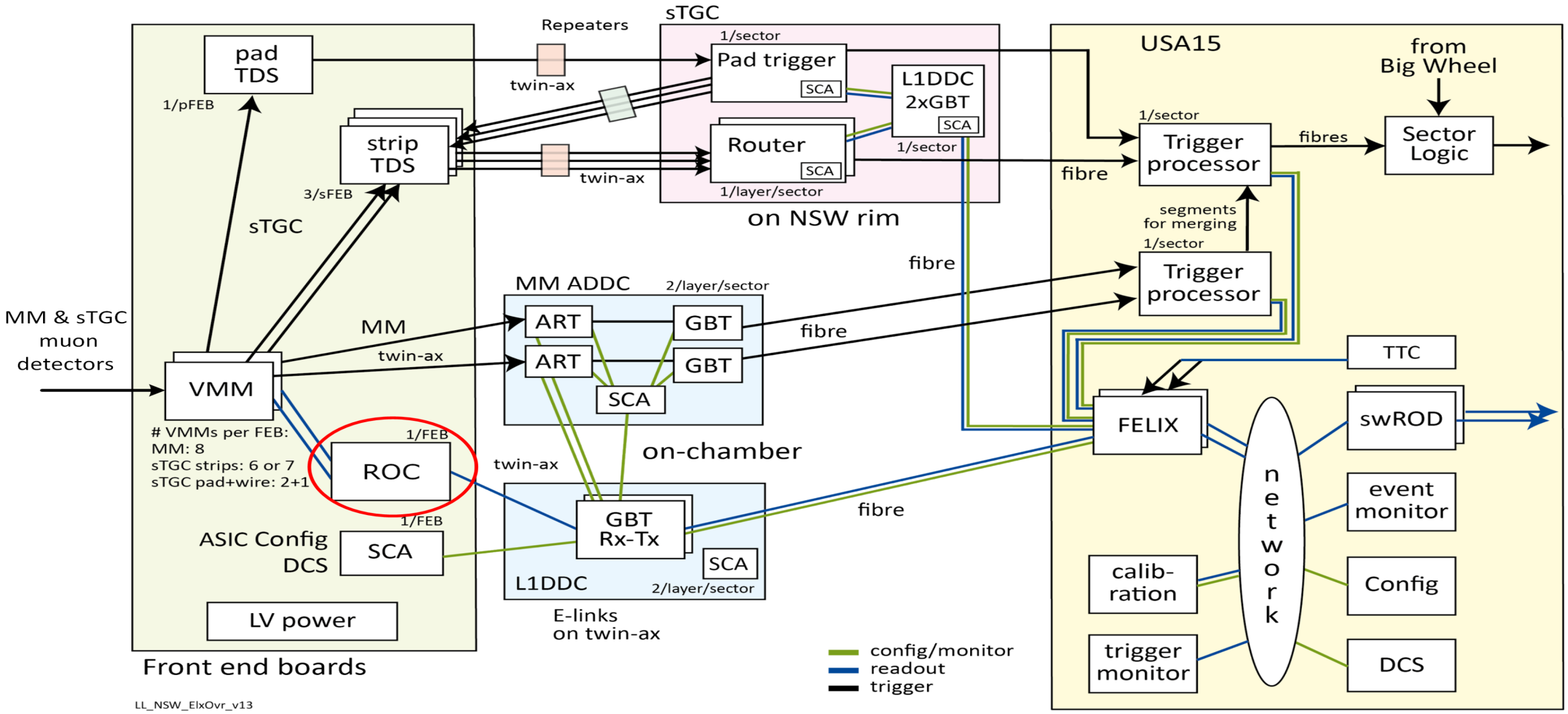
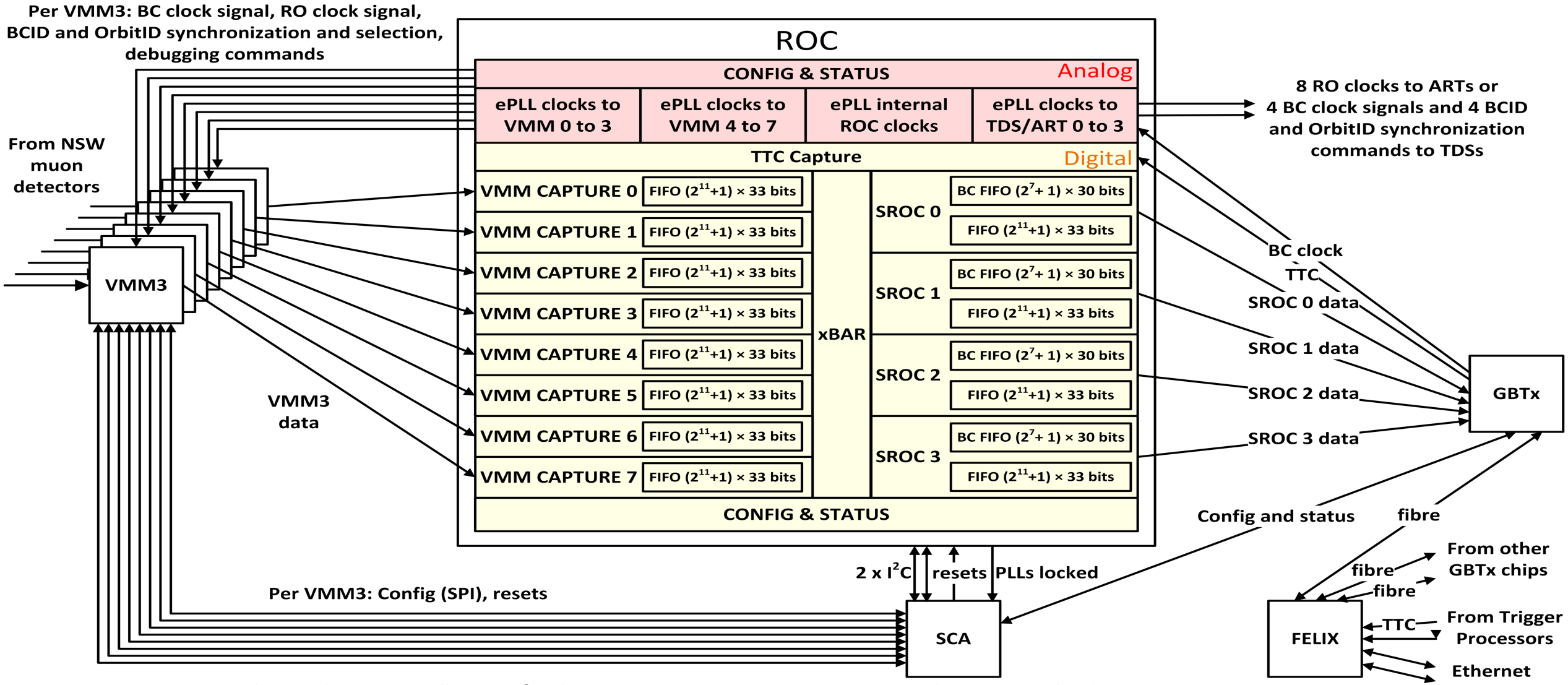


image source: Popa, S. *The Read-Out Controller ASIC for the ATLAS Experiment at LHC*; Springer: Cham, Switzerland, 2022

ROC – architecture & interfaces



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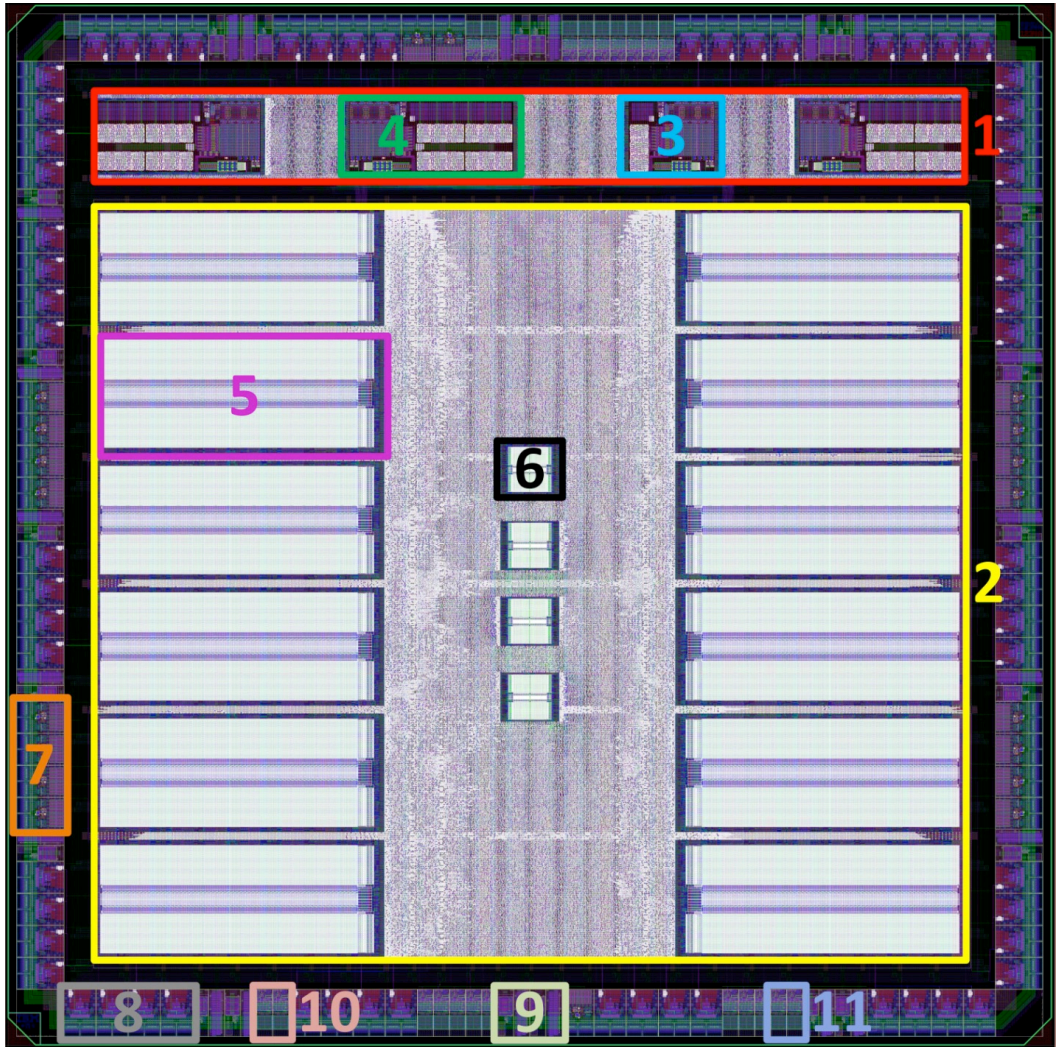
ROC layout

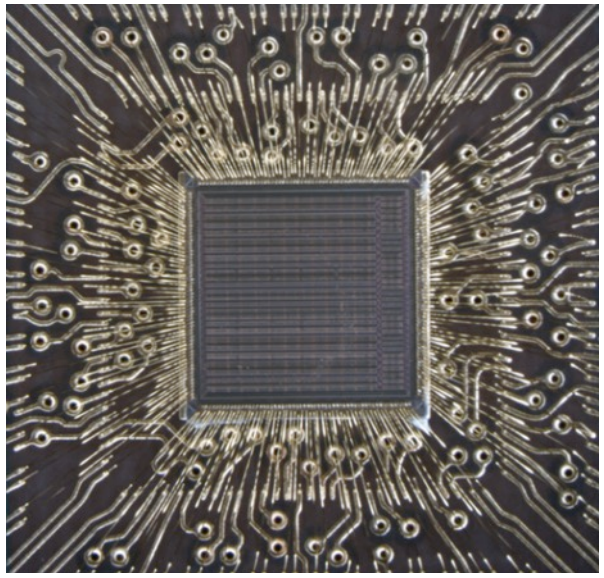


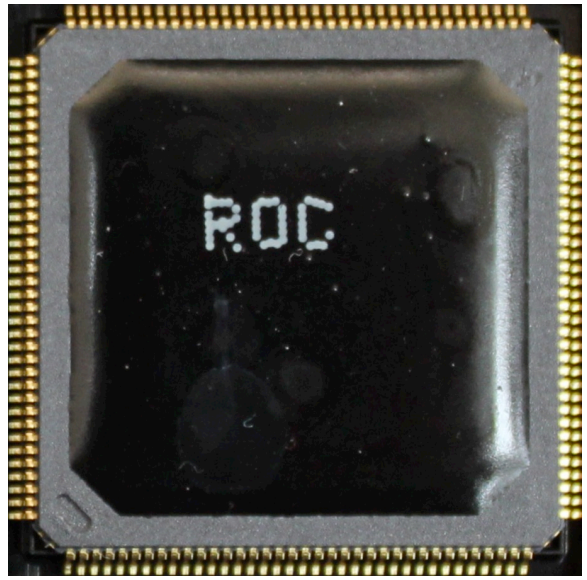
- 1. Analog part
- 2. Digital part
- 3. PLL for the internal clocks
- 4. PLL for the external clocks
- 5. Dual port, dual clock domain 2K × 33-bits SRAM
- 6. Dual port, single clock domain 128 × 30-bits SRAM
- 7. Input SLVS pads
- 8. Output SLVS pads
- 9. Power supply pads
- 10. Output single-ended pads
- 11. Input single-ended pads

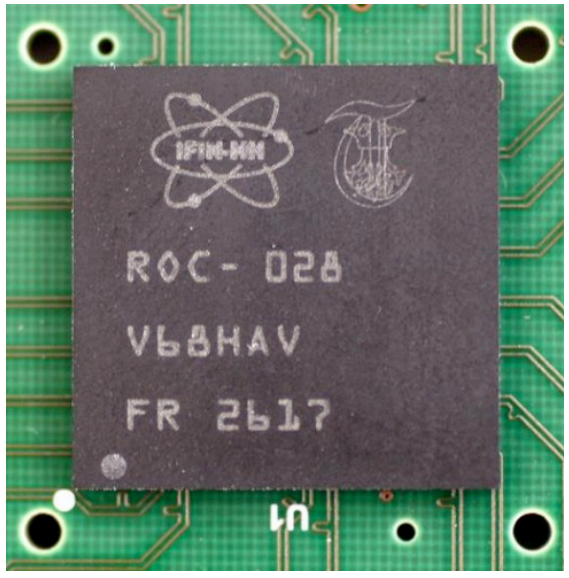
image source: Popa, S. *The Read-Out Controller ASIC for the ATLAS Experiment at LHC*; Springer: Cham, Switzerland, 2022

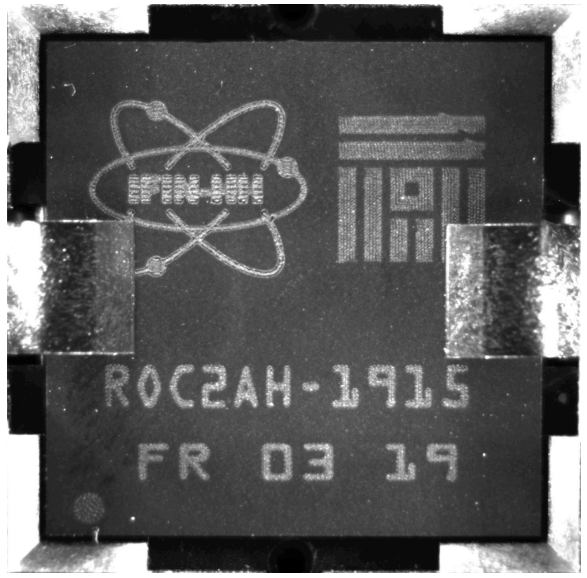
Few figures and packaging

- 232 pads - 187 IO, 45 power supply
- 4.744 × 4.744 mm ≈ 22.5 mm^2 ≈
- digital part → 13.3 mm^2









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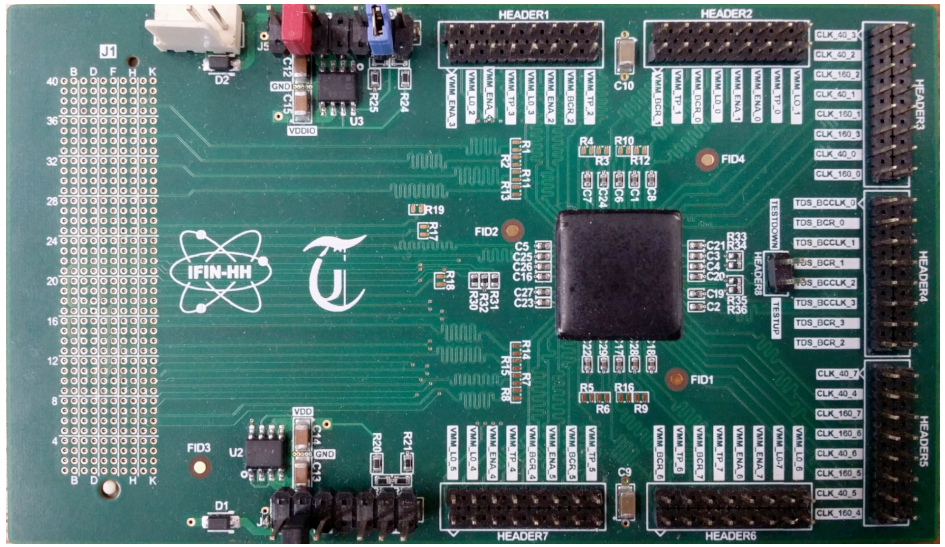
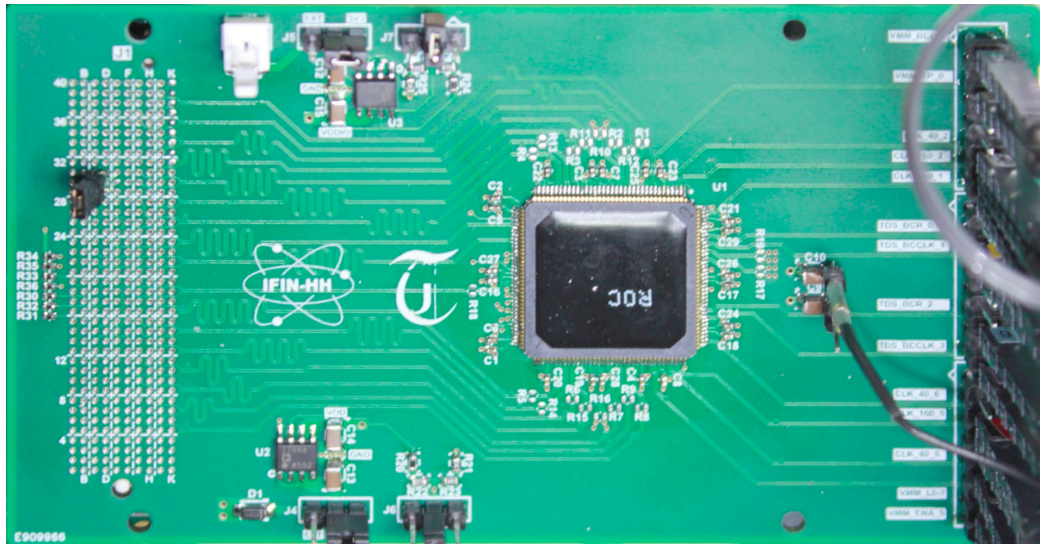
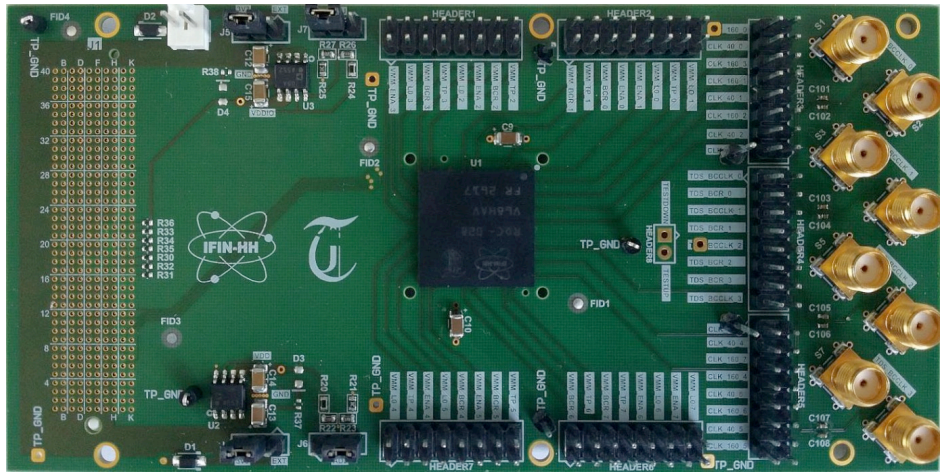
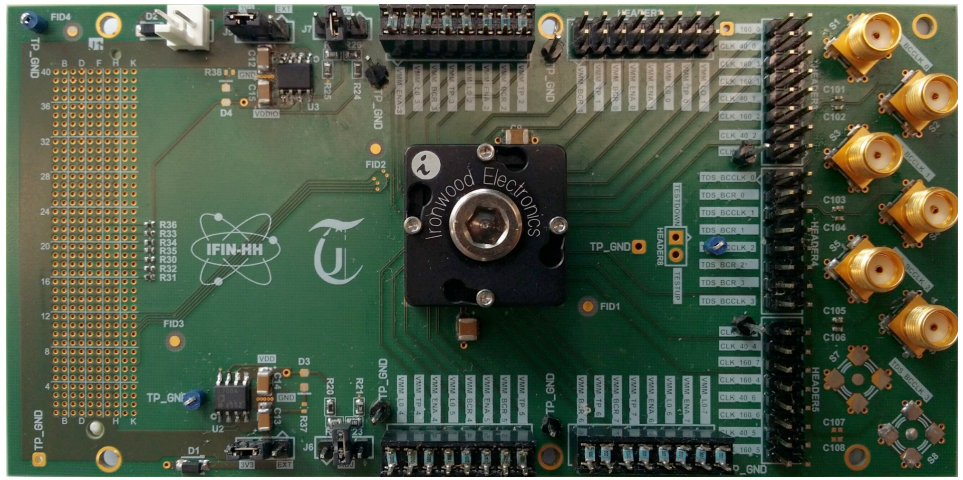
ROC testing PCBs

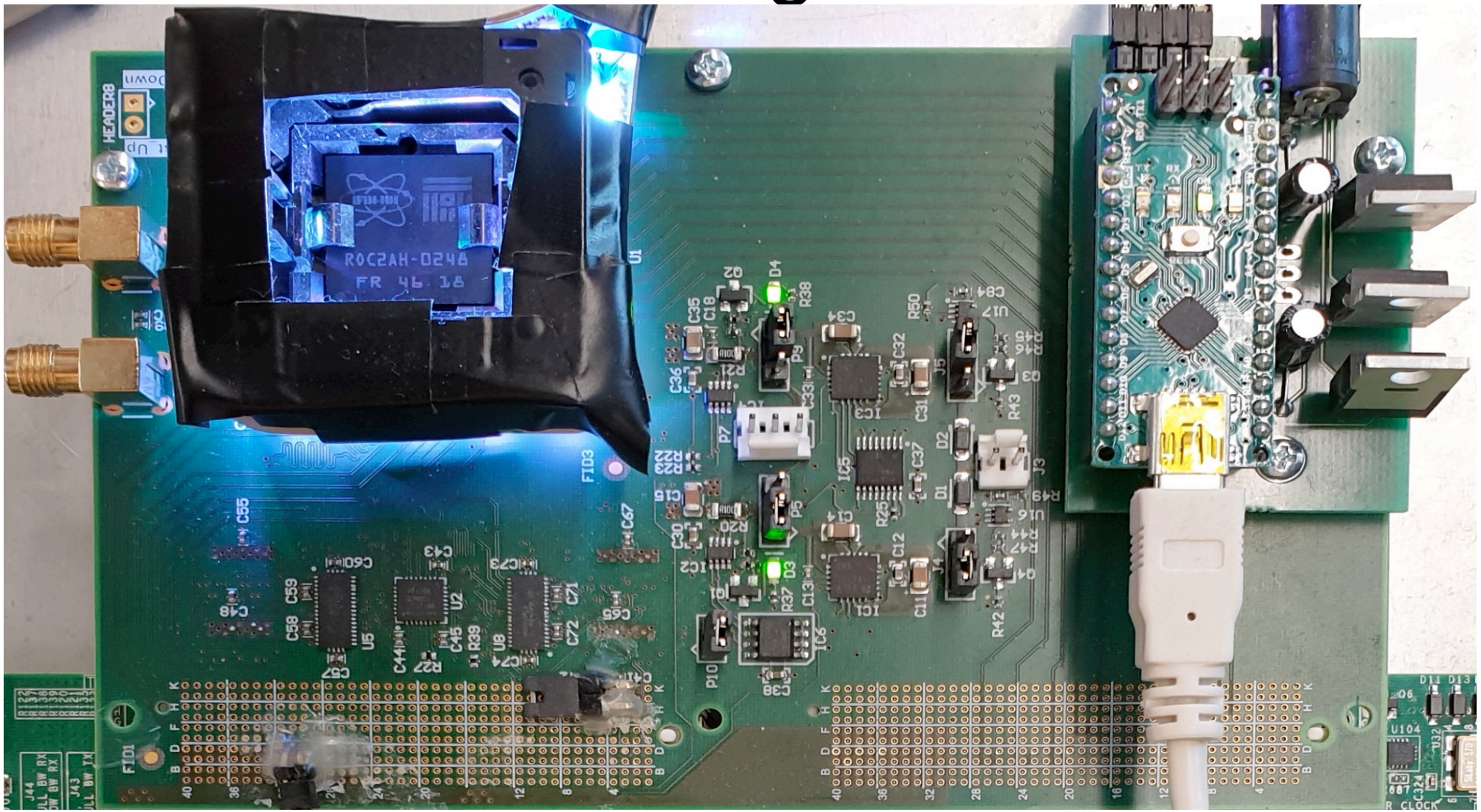








Final ROC mass testing PCB



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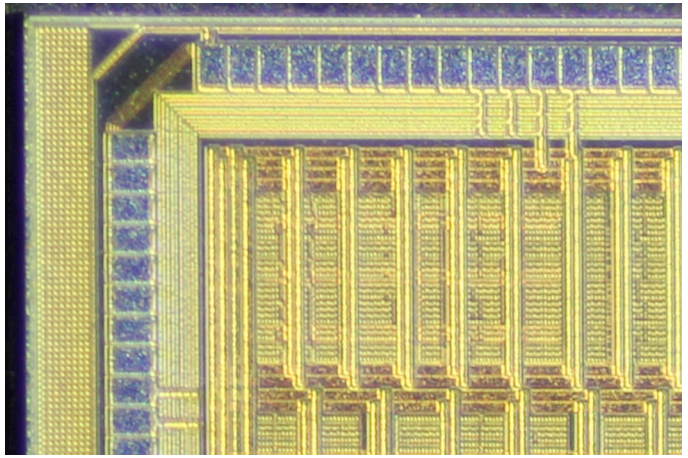
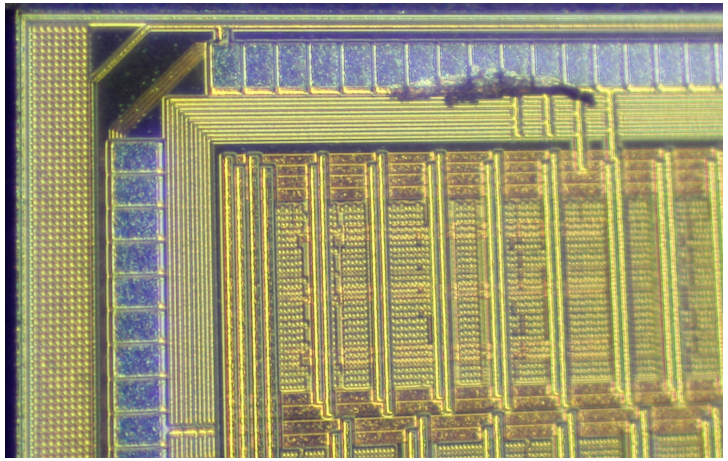
Mass testing





- suite of 10 tests → all digital functional features
- testing both @ nominal & sub-nominal voltages → separation of quality samples
- mass testing @ UnitBv: 2677 ROCs, *87.52 %* good at 1.2 V, *67.95 %* good at 1.1 V

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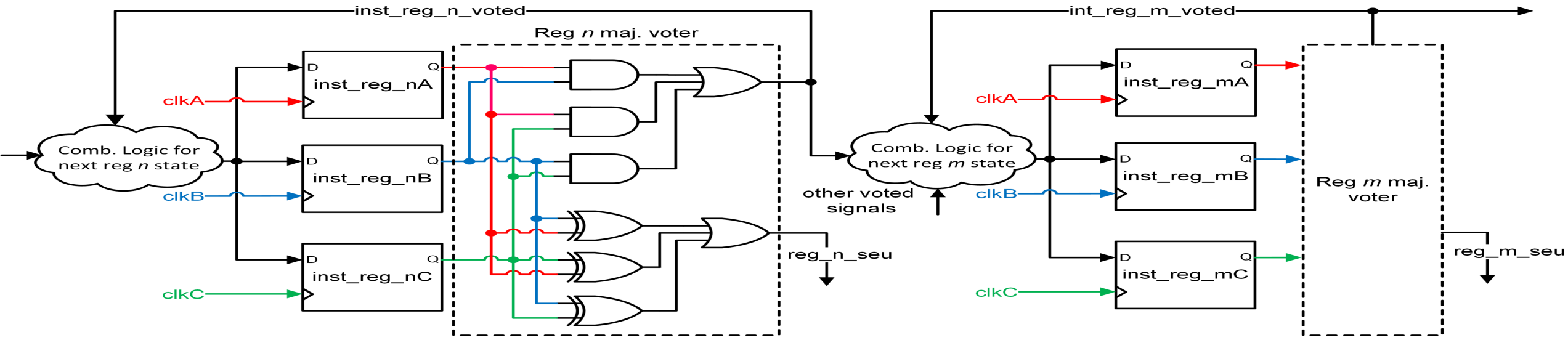
Immunity to radiation-induced effects

- 2 types of effects of nuclear radiation:
  - cumulative - proportional to the integrated flux
  - e.g. SEUs - immediate results of ionization
- rad-tolerant - operate in rad. despite being vulnerable → TMR



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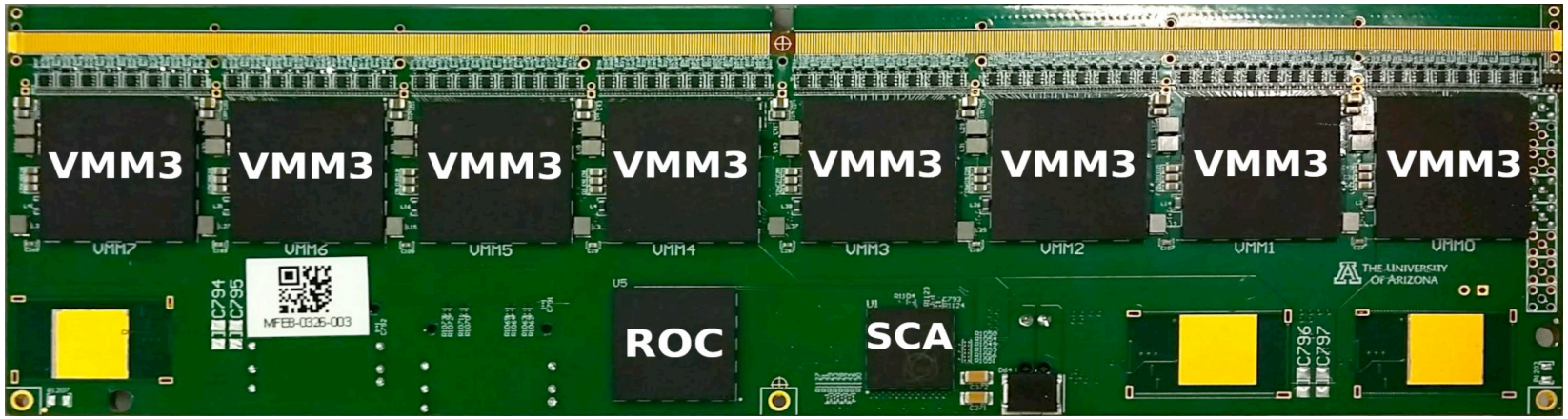
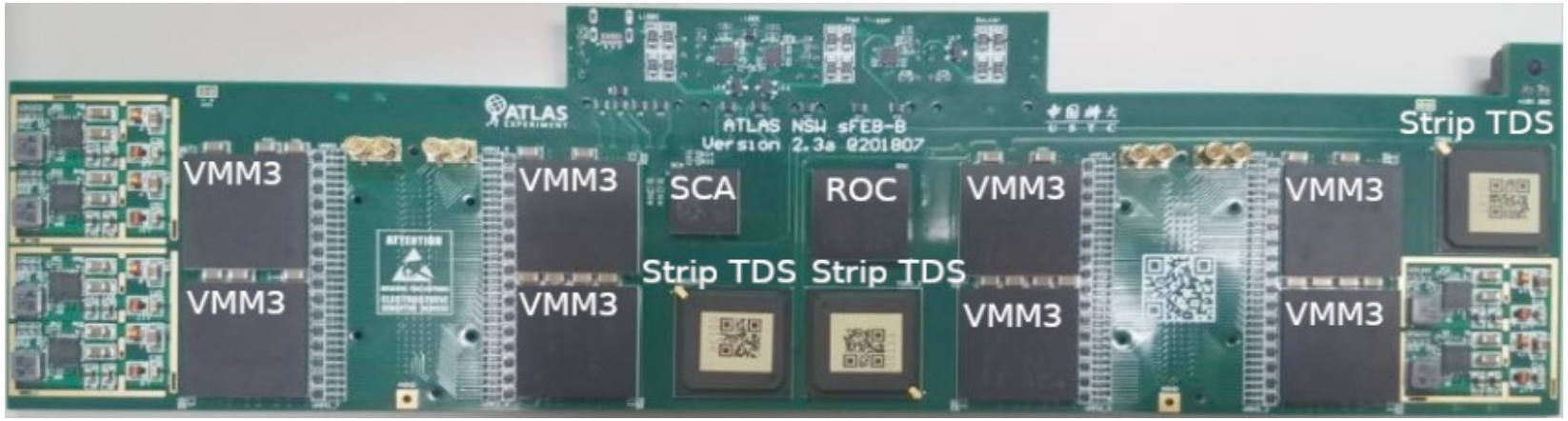
ROC integration

- MMFE8 & sFEB
- 4900 pcs. (ROCs) installed in NSW





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ROC (NSW) commissioning

- One complete NSW, 25th June 2021 → installation on 4 November 2021

images source: https://home.cern/

Instead of conclusions