Tracking for MuonE (doing it right)

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Thanks to

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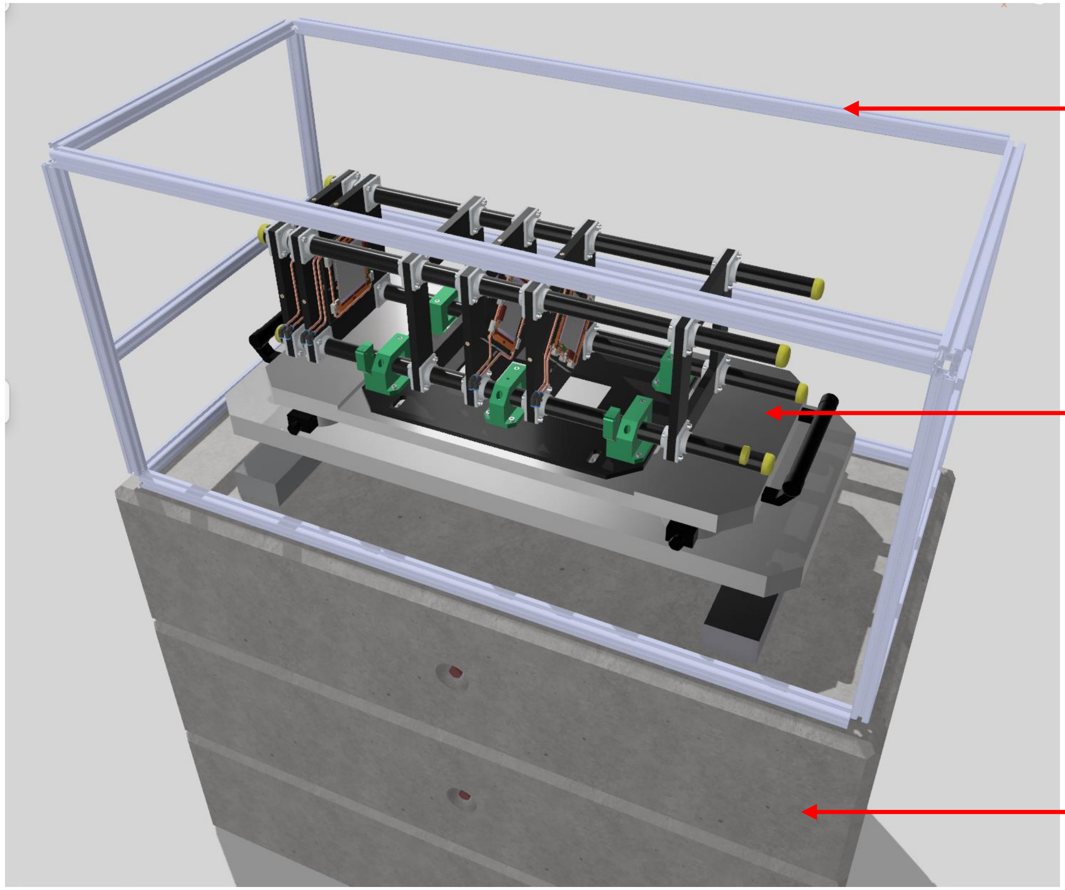
Experiment: MuonE

- A high precision tracking experiment
- Control of systematics
  - Small efficiency corrections
  - Well understood tracking errors (low amount of material)
  - High rate (but not necessarily high radiation)
  - Better resolution
- Better resolution also:
  - Smaller/cheaper tracking stations
- Ideal
  - Asynchronous (ASIC/logic) – efficiency
  - Timing layer (say 100 psor better)
  - Sub 5 micron resolution

Tracking Station Concept

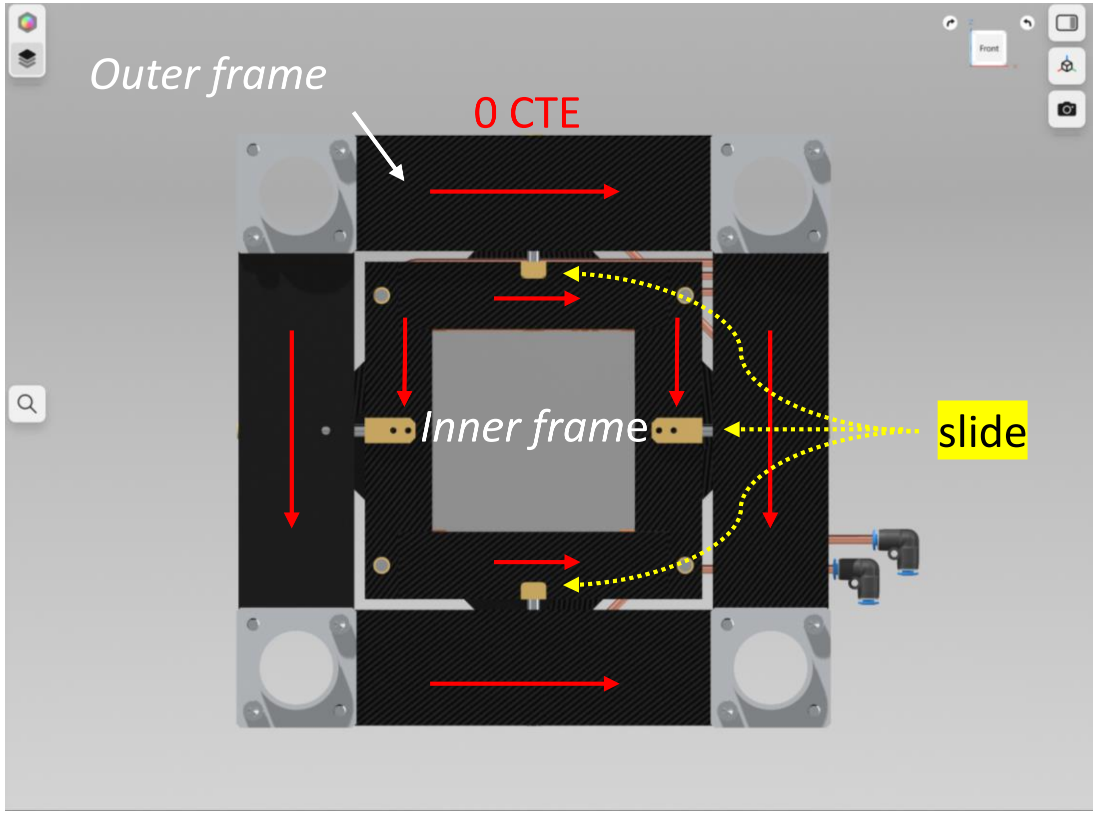
- Separate
  - Cheap
  - 0 CTE
  - Kinematic mounts

BMS



- Step model beamline
- Height etc correct
- Concept
  - Removable (hadron)
  - Replaced to a few microns

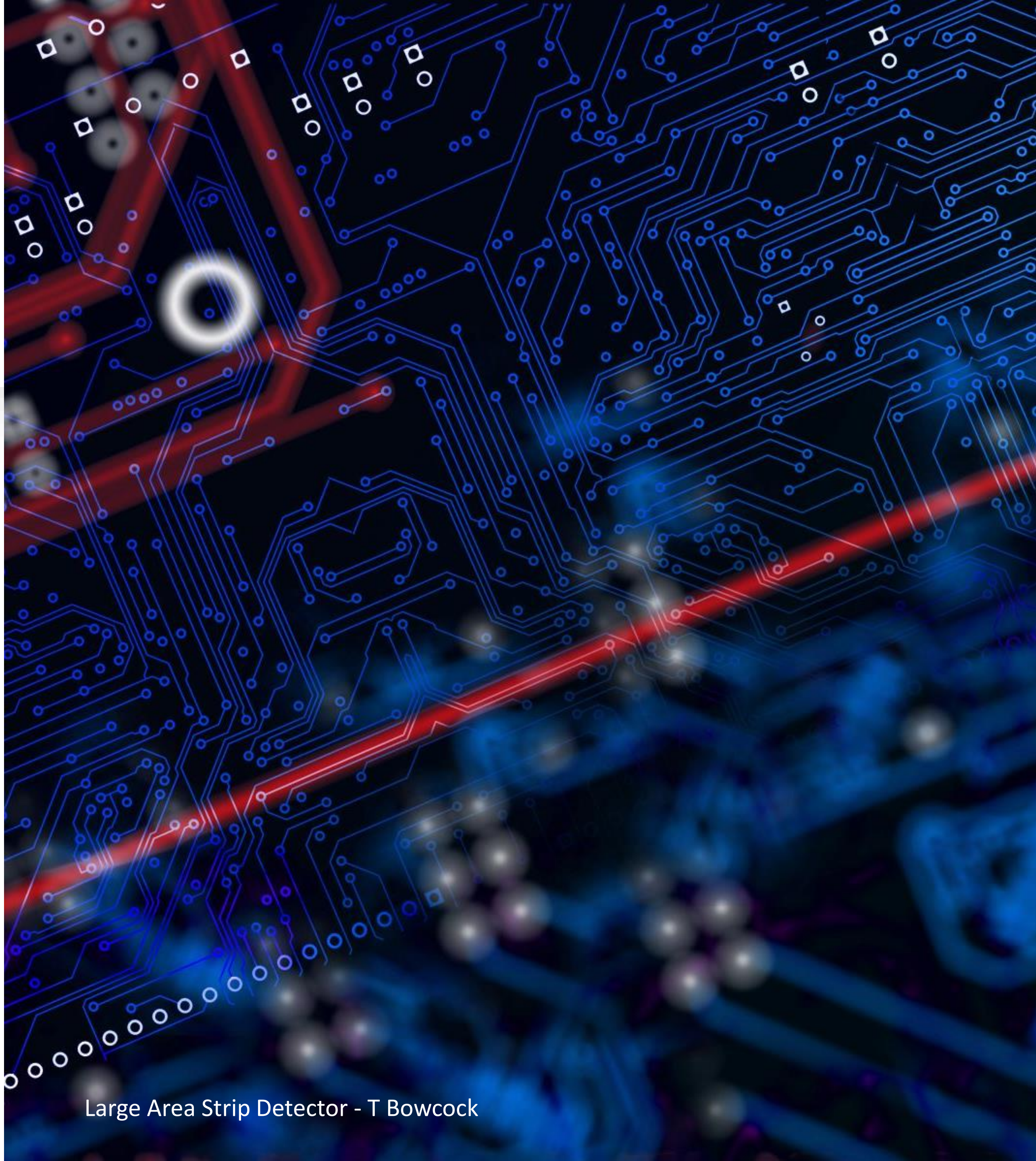
Module (2S) Mounting



- Outer frame
  - Connects to bars
  - 0 CTE direction shown
- Inner frame is also 0CTE (for low temp matched to Si)
- Module mounted to inner frame (identical mounting to tracker)

Detector Concept

- There are many clever, state of the art technologies out there
  - Even some that can, in principle, achieve 200nm resolution
  - Monolithic CMOS chips
  - Hybrid Pixels
  - Timing
- Provide a demonstrator to help benchmark these
  - How far can we push traditional (cheap) strips sensor in the 10cmx10cm format (Speed/Resolution)
  - There are general uses for this kind of sensor
    - Including **medical imaging** as well as HEP
  - A practical, safe, option.
  - We had a number of DAMPE sensors in hand (but pitch too coarse)

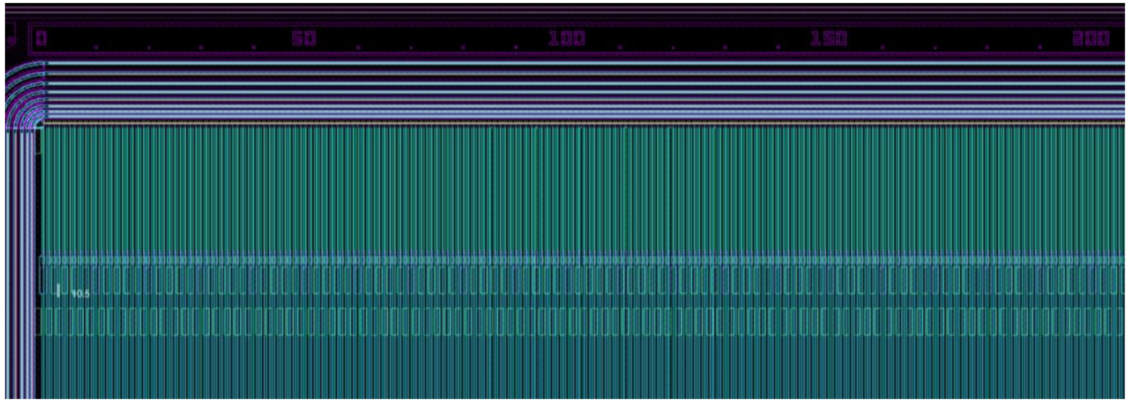


TTT19(SS) AC - MicronSemiConductor

- Large Area Strip Detector

ACTIVE AREA	92115 x	92115 um^2
CHIP	96000 x	96000 um^2

- Designed for < 5um resolution
  - With suitable ASIC(!)



Strip Width (implant)	15 um (readout and floating)
Strip Width (metal)	15 um (readout only)
Strip Length (implant)	92115 um
Strip Pitch	25 um (readout to floating strip)
Strip Pitch	50 um (readout)
Total Number of Strips	3685
Number of Readout Strips	1843
Number of Floating Strips	1842

TTT19(SS) AC Design

- Bonding (up to 6mm wire bonds)
- Readout either end
- 100V operation
- n in p (radiation tolerant)
- Strip capacitance
  - O(30pf)

Based on LHC c 2000 era design technology (and DAMPE)

- Safe (relatively risk free)
- High Yield
- Tunable

TTT19(SS) AC

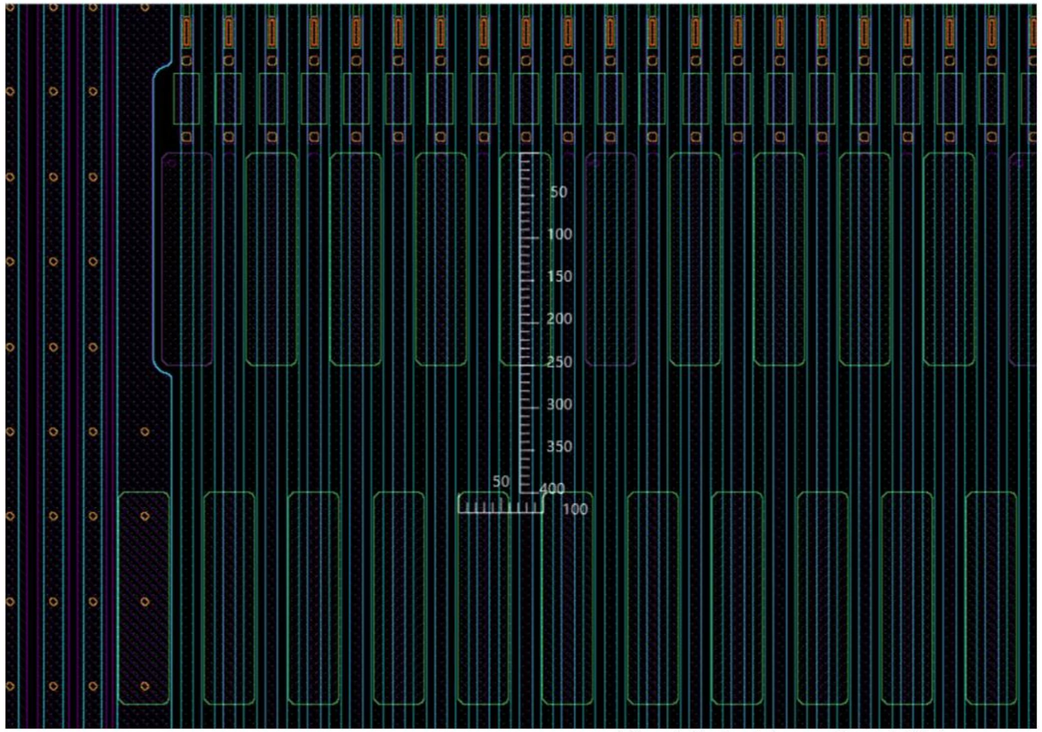


Figure 4: Bond pad stagger at top end of strip.

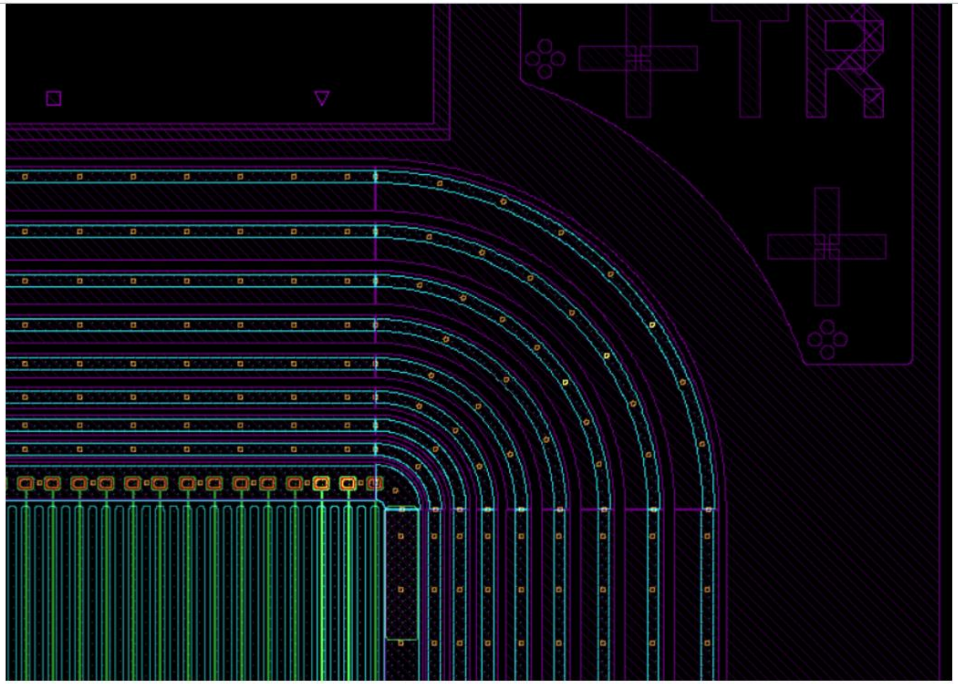
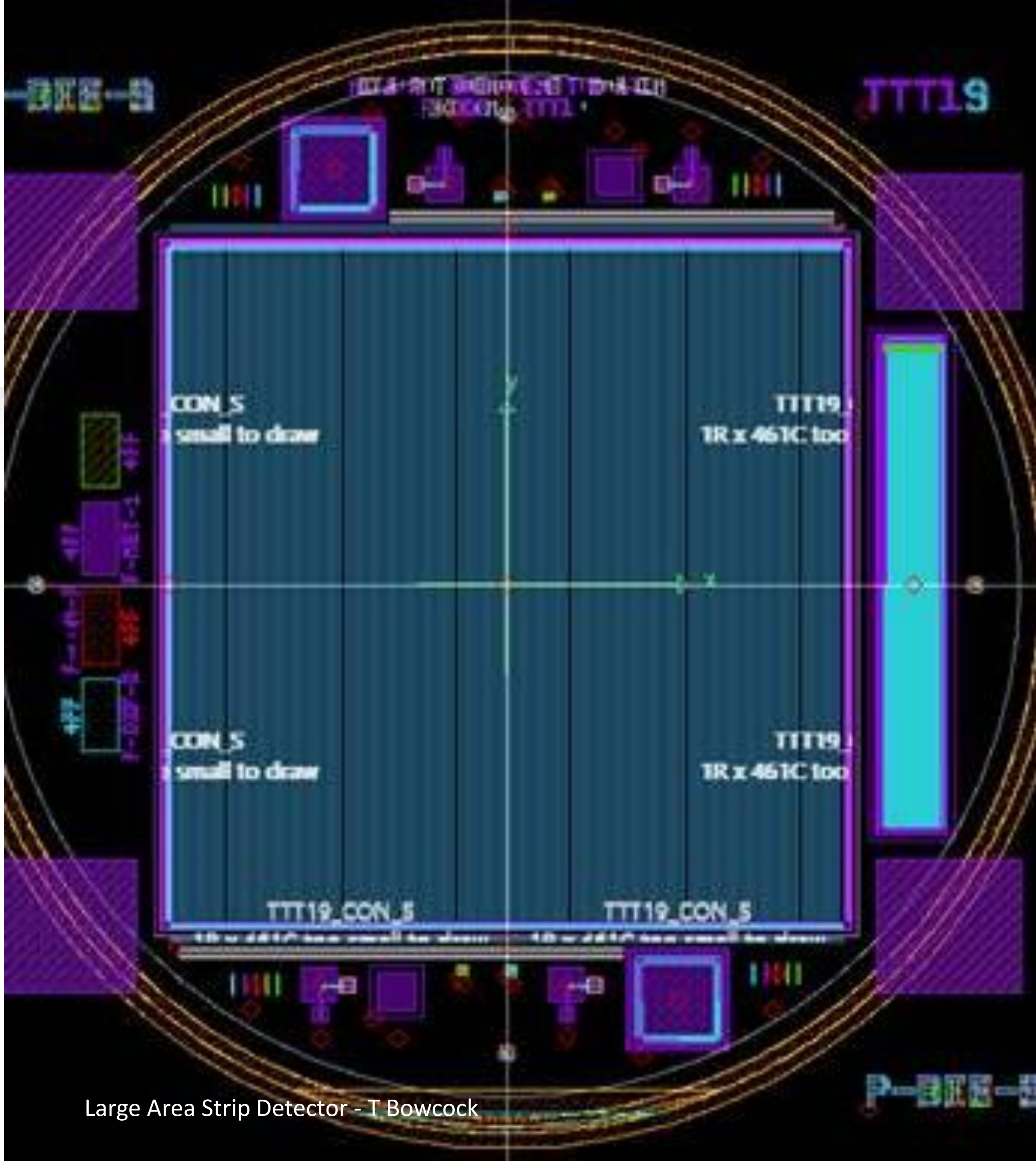


Figure 6: Image showing example of bias rail bond pad at the detector corner.

TTT19(SS) AC Test Structures

- 2 x Implant dumbells
- 2 x Capacitor TS
- 1 x MOS
- 1 x MSX03-2 with MSL MGR design 2M/2M (standard 1 x 1 cm^2 chip)
- 1 x P-MET Resistance TS that is included on all AC designs
- 1 x TTT19 5 Strip section
- 1 x 10 array of resistor TS with strip implant
- 1 x 10 array of resistor TS with no strip implant



TT19(SS) AC Status

- Design complete
- Mask Set Fabricated
- First set of detectors (10 off) in production
  - 4 week deliver

- By May 2025 should have first sensors in the Lab under test

Testing the principle

- We have limited access to suitable ASICS
- To maximize performance we need an ASIC that does not exist(!)
  - Analog 10+ bits?
  - Fast (ish) > 40MHz (120 MHz)
  - Power (?)
  - Footprint (Design for pitch)
- And a DAQ matched

- We will perform some tests with LHCb
  - e.g. SALT (6bit, 40Mhz)matched to 20pf+
  - Laser/Lab tests in first instance
    - Inject charge into back side
- Could, in principal, use 1S CMS electronics
- Note
  - FBK willing/able design to design a suitable CMOS ASIC

We aim to demonstrate

Aim to develop a 10x10cm strip sensor suitable for high speed/high resolution performance

- 100 MHz readout
- 5 micron or better resolution

This can be used to create tiles or to test various ASICs

We will make this generally available (cost per cm^2)

1. **First step is building the sensor**
2. *Second is to develop a suitable ASIC available for large areas*
3. Look at our DAQ architecture
   - FPGA R/O (based on developments for next generation LHC experiments)

What would have

- A superb experiment (!!!)
  - Quantum step forward (MuonE)
  - Enabling technology
- A chip (ASIC) and sensor that would be very useful for medical and HEP
  - Synchronous
  - Asynchronous version
  - High Capacity (pf)
- Capable of reading thin/thick detectors
- In many experiments 10x10cm is an interesting size
  - And in proton tomography
- Note I believe this not easy:
  - is a 5 iteration 3 year project …
  - World class team

Further discussion welcome …

- ASICS
- Fast detectors
- Hybrid Detectors

- We see large area CMOS as a an interesting technology
  - We design/build
    - Mu3e
    - LHCb Might tracker
    - ALICE
- But high precision at high speed is a challenge