Pixel Endcap Type-I Services Mockup

- Status of setups
- Plans for testing

Pixel Endcap Integration Workshop, 18.03.2020

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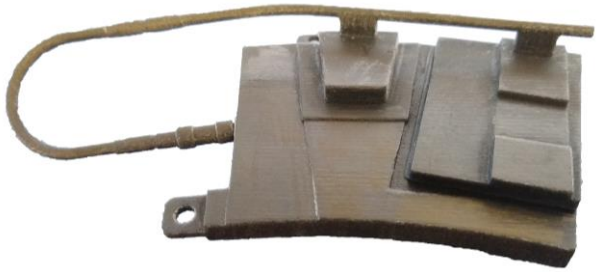
Single Half Ring Mock Up

- 20cm Al L2 half cylinder & Al L2 half rings
  - mounting points for half rings & dummy modules
  - components to play with:
    - 3D-printed: ends of half rings, modules, …
    - dummy modules with data pigtails
    - Mock data cable end with data pigtail
    - Type-I cables: only MOPS com still missing…
    - CF shell to play with still at Liverpool…

Mock data cable end (made last week):
13x Twinax bundle glued to prototype data pigtail

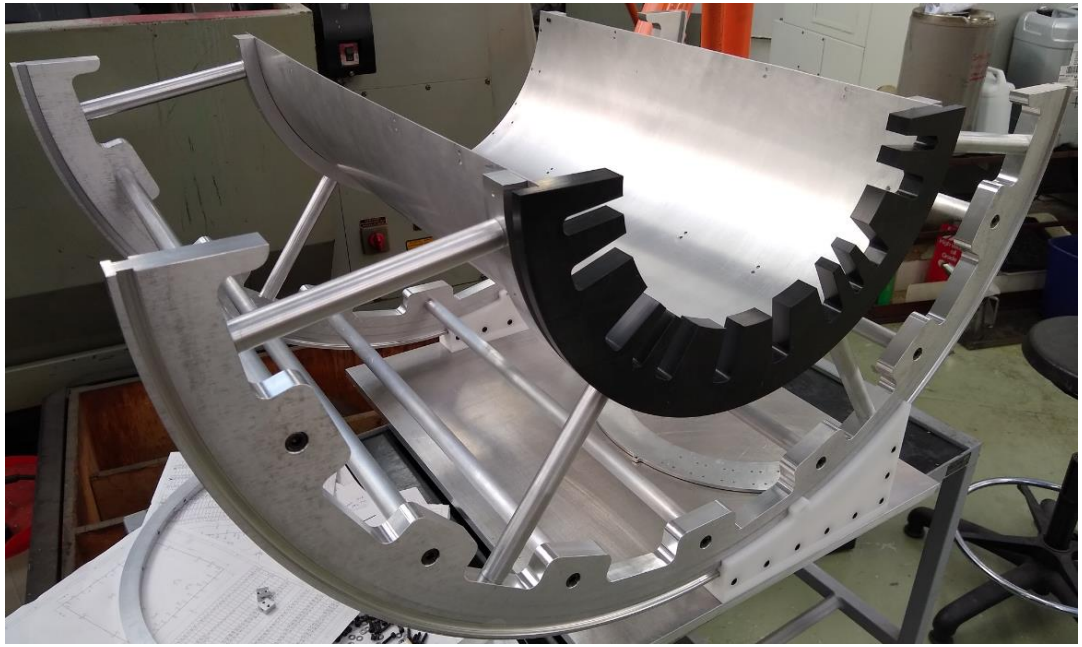


3D-printed half ring end

Data pigtail & dummy module

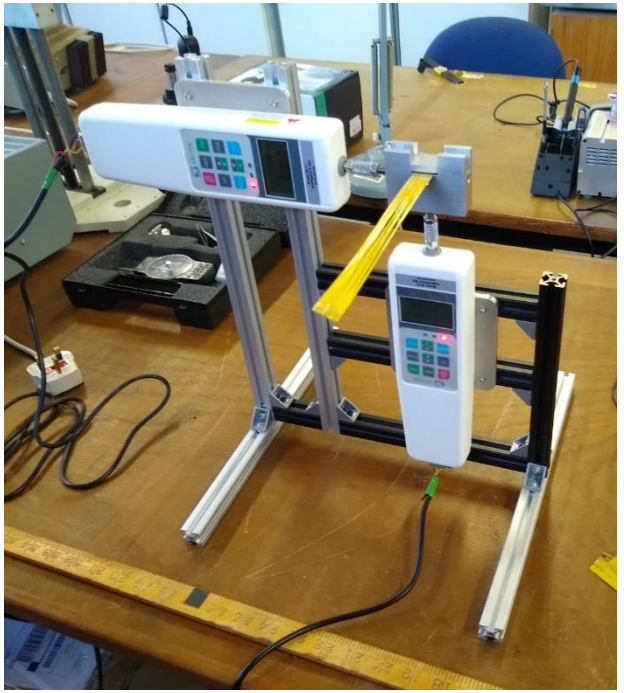
60cm Half Ring Mock Up

- Al-frame (currently supporting >90° rotation, can be extended e.g. to 270°):
  - cradle with modular frame on Teflon gliders
  - can mount L2, L3, L4 60cm models, individually or simultaneously, via Al mounting lugs
  - currently mounted:
    - L2 sheet metal half cylinder with POM end flange
  - first sheet-rolled L2 half-cylinder had 1mm bow
    → currently being redone



Force Measurement Setups

- Cable bending tester:
  - x-y-mount of two force gauges with simultaneous readout
  - custom adapters, dedicated for each cable bundle type
  - to study forces on cable bundles for cable routing scenarios & cable bundle types if you:
    - bend
    - twist
    - turn
  - plastic bending standards (e.g. various radii)
  - 2x Sauter FH-5 force gauges:
    - range: 0-5N
    - resolution: 0.001N
    - up to 2000 samples/s
    - RS232 readout
    - Edinburgh readout software (by Chloe)

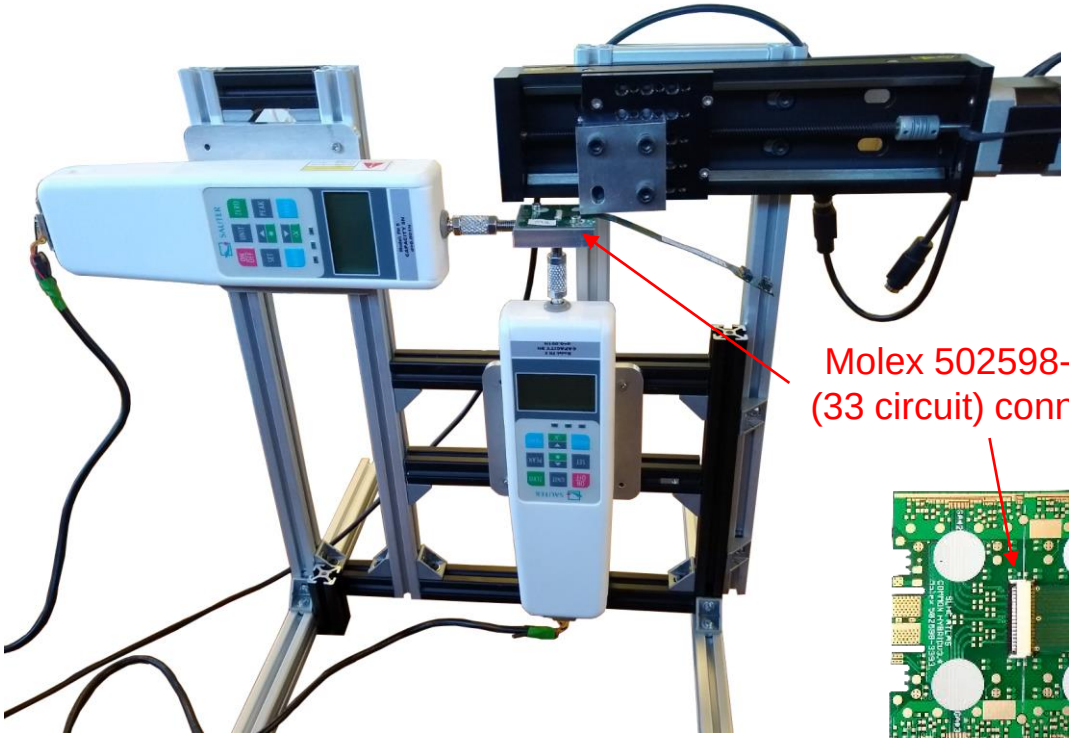


Cable bending force measurement system

Force Measurement Setups

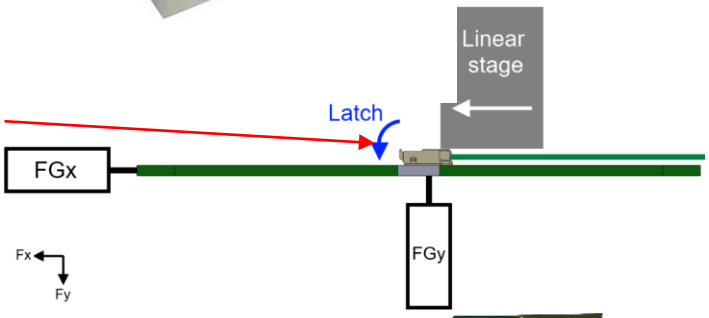
- Connector latch force tester:
  - 2x Sauter FH-5 force gauges + Zaber T-LSR150B motorised linear stage(s) :
  - controlled, repeatable connector latch operation & x-y force measurement
  - issue: entanglement of x-&y-channel leads difficult to calibrate residuals

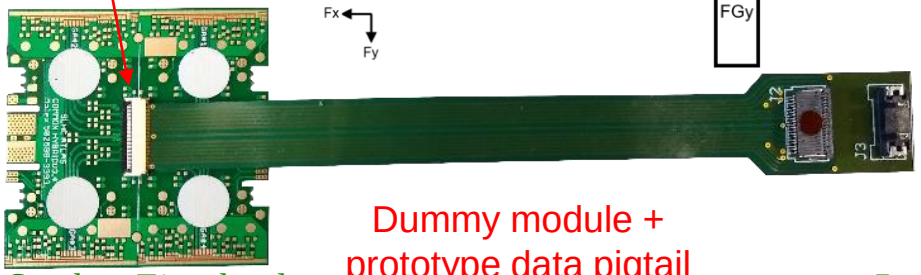
    → ordered x-y-z-load cell to disentangle:



on order - Interface:
3-axis load cell
K3D40-10N

Molex 502598-3393
(33 circuit) connector





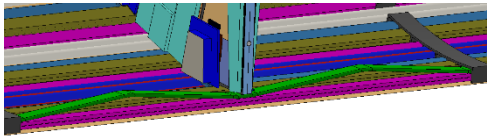
Dummy module +
prototype data pigtail

Services Mock-up & Cable Routing

- Status & progress:
  - design, setup & production of test jigs in progress
    - available: preliminary layer 2 jigs
    - available: mock layer 2 half-ring & 3D-printed half-ring ends with modules & piping
    - available: new forge gauges
  - questions answered:
    - design to build mock-up enabling rotation in ϕ
    - design to build test jig for quantitative force test on cable bundle samples

Services Mock-up & Cable Routing

- Status & progress:
  - questions open:
    - trial & document behaviour of routing cable bundles (turning, twisting, side-shifting & stacking)
    - trial cable mount/fixation options
    - trial CTE compliance strategy ('wavy' routing of cable bundles)
    - trial data cable bundle building strategy (fusing only every few O(10cm), leaving freedom to bend)
    - trial cable stripping & connector mounting
    - check cable bundle fitting for layer 2, ring 10 (densest population of cables)
    - data pigtail to module mounting:
      - connector orientation: to high-r (direct routing) or to low-r (loop-back routing)
      - when: at module production, after module mounting or after half-ring integration
      - trial & compare mating action under various mock conditions
      - tooling & test interfaces needed
    - study region of overlap of two half-rings (services routing & possible conflicts)
    - develop strategy for production jigging for Type-I services
    - develop labelling/colour scheme for bookkeeping
  - time scale for results:
    - for discussion: what is depending on input from these tests, and when?



detail of L2 cable routing option:
with clamps & excess cable to address CTE

Mock Up Test Programme

- Non-data Type-I cables:
  - insulator: Polyimide vs PEEK } bending radii vs force & vs spring-back
  - conductor: single- vs multi-stranded } CTE & cable bulging, routing stability / Ø
  - conductor: copper vs TPC — connector mounting / tinning procedure
  - cable: single vs already twisted — reliable TWP manufacture from single cables
  - cable: — insulator stripping (chemical/mechanical)
  - cable bundle: — routing & fixation

  - unsolved: how to build shielded AWG 32 — … try to gain understanding to enable manuf.

- Data Type-I cables (twinax):
  - cable: — bending forces / material fatigue
  - cable bundle: — building bundles of 5 / 9(?) / 13 twinax cables
  - cable bundle: — bending properties, stiffness, spring-back, …
  - pack of cable bundles: — turning options 90° bend / sideway shift
  - pack of cable bundles: — trial of looming options (inside/outside bulkhead)
  - pack of cable bundles: — fixation options, with slip/bulge for CTE

Spare Slides

Endcap Type-I Services Mock-Up

- Schedule:
  - target dates to work towards:
    - all Services PDR: 25.10.2019
    - all Services FDR: 04.06.2021
    - all Services PRR: 08.07.2022

    - Endcap:
    - Type-1 non-data cables – preliminary design: 15.04.2019 – 05.07.2019
    - Type-1 non-data cables – design & prototyping: 28.10.2019 – 10.04.2020
    - Type-1 non-data cables – test of prototypes: 23.12.2019 – 14.02.2020
    - Type-1 non-data cable bundle – design & prototyping: 23.04.2020 – 25.09.2020
    - Type-1 non-data cable bundle – prototypes during design phase: 08.06.2020 – 28.08.2020
    - Type-1 non-data cable bundle – prototype testing: 31.08.2020 – 23.10.2020

    - Endcap Type-1 cable bundle pre-production & QA: 21.06.2021 – 27.08.2021
    - Endcap Type-1 cable bundle production: 11.07.2022 – 23.12.2022
    - Endcap Type-1 cable bundle QC tests: 26.12.2022 – 04.08.2023

    - Endcap Type-0 production: 13.03.2020 – 12.05.2023
    - Endcap EoS production: 20.04.2020 – 05.05.2023

Endcap Type-I Services Mock-Up

- Issues identified at 01.05.2019 Mock-up workshop:
  - corrections to Fred's cable model:
    - non-data cable multiplicities & cross-section allocation
  - most critical location: bypass of services for rings R0-R9 at L2 ring R10
    - highest number of data links & lowest available cross-section
    - filling factor ~100%, maybe even beyond…
    - identified suggestions to mitigate this
  - data cable assembly: no space for mating action – blocked by cables from lower-z rings
    - discussed alternative layouts: a) turn connector by 180°, b) take connector off ring surface (w. flex)
    - see spare slides: "Issue with Assembly of Data cables" for discussion & "Data EoS Interface" for illustration

Endcap Type-I Services Mock-Up

- Aims / questions to answer:
  - CAD validation:
    - gain experience in handling bundles of cable: study bending radii, side-way shifting, spring-back, …
    - are the packing factors realistic & which envelopes do we have to use at turns/side-way shifts?
  - cable harness topology:
    - multiplicity and accuracy of different cable bundles needed
    - (how) can we split into manageable sub-assemblies/harnesses?
    - services routing between end-flange & PP1 to patch EC to PP1 connector assignment
  - assembly of cable harnesses:
    - which production & assembly steps to be out-sourced to industry
    - jigging & tooling
    - transition from 2D to 3D assembly
    - order of assembly on 3D jig
  - fixation of cable harness:
    - on assembly jig
    - in CF half-shell
    - slack needed to account for differences in CTE (carbon fibre vs. cables, +20…-35°C or +60…-55°C)
  - …

Endcap Type-I Services Mock-Up

- Aims / questions to answer: (cont'd)
  - installation in CF shell:
    - installation order (services & half-rings)
    - connector mating/de-mating (needed space & tooling)
    - connection procedure (must be practical and safe, e.g. securing floppy connector ends…)
  - jigging/support for cables outside heavy flange:
    - for services: assembly, mounting in 3D, transport, transfer to CF half-shells, during system tests
    - assembled EC shells: transport to CERN, integration into ATLAS, mounting to PP1

Endcap Type-I Services Mock-Up

- Next practical steps:
  - 60cm half-shells at Liverpool & Edinburgh
    - Tim suggested: CFRP outer & middle layer and Al inner layer
    - decide on location: inner to Edi? → study most crowded feed-through at L2 R10
  - acrylic flanges & dummy half-rings (2 per layer), plastic ring mounts
    - make in Uni workshops
  - dummy EoS & PP1 interfaces
    - using preliminary / trial connector choices
  - cables:
    - order non-data cables
    - get data cables from US partners
  - connectors:
    - get samples & trial cabling up
  - cable mount design options:
    - trial different approaches (e.g. could use 3D printed prototypes to try arbitrary concepts)
- Think about / plan for:
  - jigging concepts & options for cable harness assembly
  - implications for transport & integration into half-shells
  - options for harness support outside end-flange

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