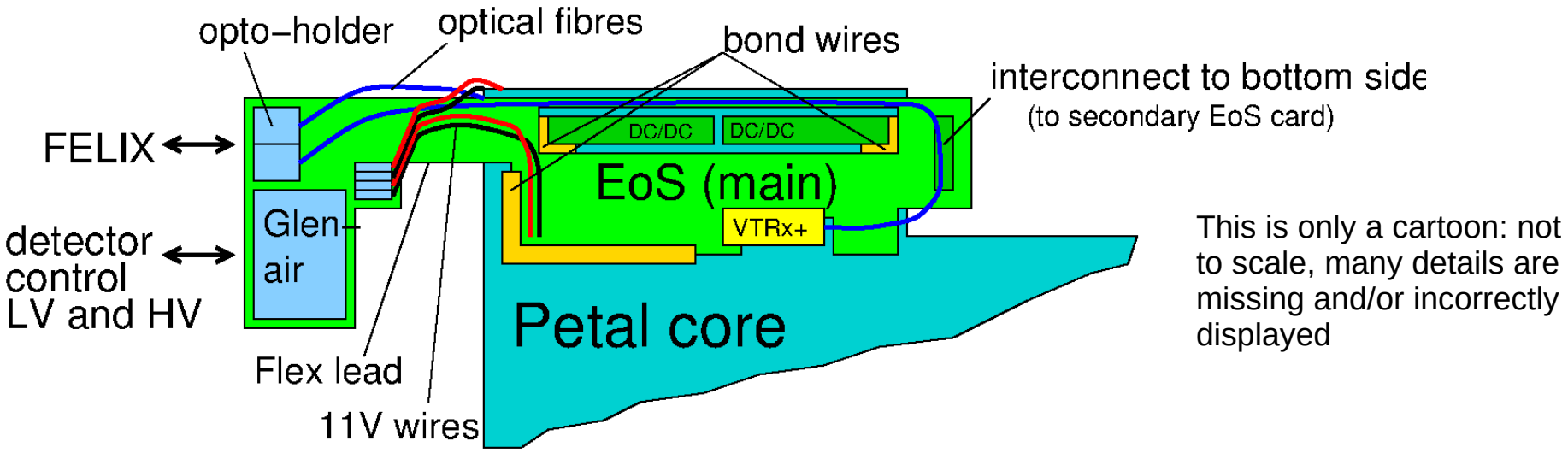
End-of-Substructure card: towards production

Stefan Schmitt for the EoS team at DESY

The EoS system in the ITK system



- EoS system: electrical and optical interface between Petal core and ATLAS systems.
- Optical link to FELIX
- Electrical connection from Detector Control to Petal core
- Two cards powered by a single Glenair connector
- This talk: EoS card (DESY deliverable)

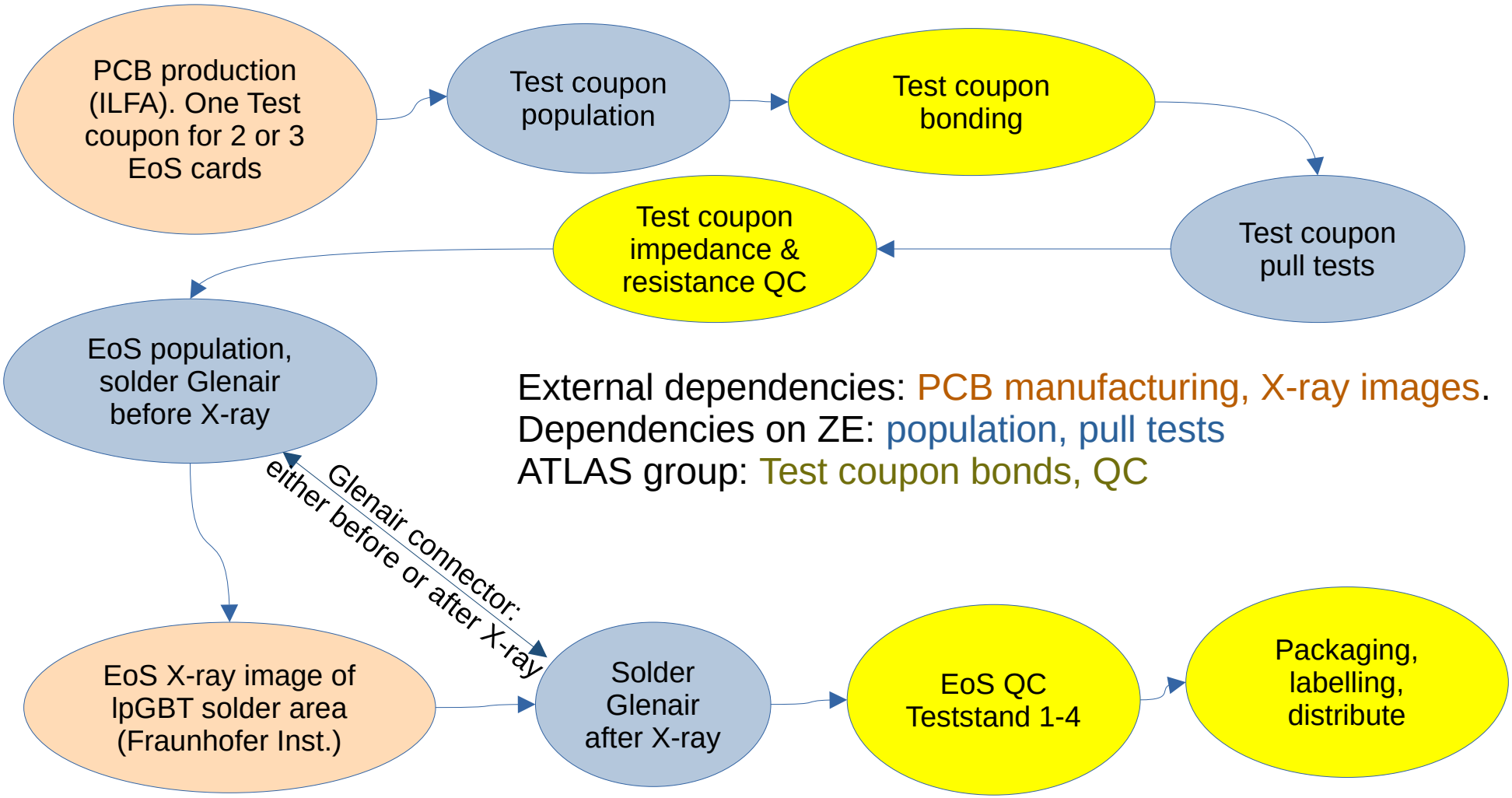
Petal: 2 variants
Stave: 8 PCB variants,
12 population variants
3 wire length variants
→ difficult for planning

The EoS team

- DESY:
  - FE department: **Peter Goettlicher**, Harald Ceslik, Artur Boebel
    activity ccordination, design of cards, QA, test stands, FPGA
  - ZE department: PCB reception, population, test coupon pull tests (?)
  - Physicists: **Marcel**, Sara, Stefan: testing, QC, production planning
  - Dario and others: test stand mechanics, petal opto-holders, VTRx cover (petal and stave)
  - Eric and Celine: test coupon bonding (for pull tests) (?)
- Cape town:
  - Cameron Garvey, James Keaveney: ITk production database [not covered in this talk]
- Copenhagen:
  - Mogens Dam with engineers: DC/DC cards [not covered in this talk]

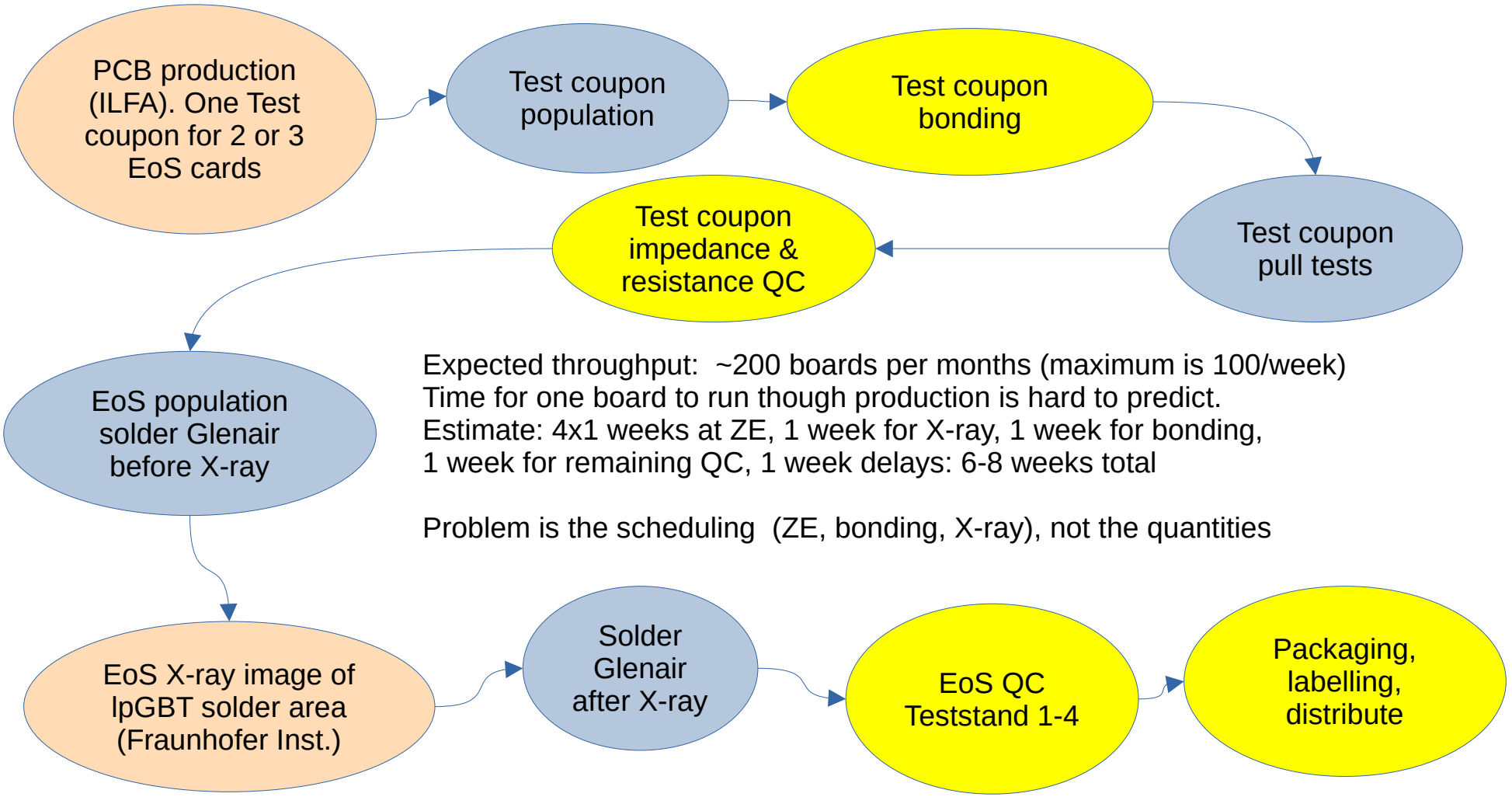
Peter & Marcel: leading the DESY efforts

EoS production overview: dependencies



External dependencies: PCB manufacturing, X-ray images.
Dependencies on ZE: population, pull tests
ATLAS group: Test coupon bonds, QC

EoS production overview: timing



Expected throughput: ~200 boards per months (maximum is 100/week)
Time for one board to run though production is hard to predict.
Estimate: 4x1 weeks at ZE, 1 week for X-ray, 1 week for bonding,
1 week for remaining QC, 1 week delays: 6-8 weeks total

Problem is the scheduling (ZE, bonding, X-ray), not the quantities

EoS PCB production schedule

- EoS preproduction done. Only a few cards of this type left in stock [petal: 3 pairs]
- Recently we started production
- Initial choice of EoS flavors is driven by PCB delivery
- End of this year: all PCBs at DESY
- End 2024: production finished [can be earlier if we try hard]

ILFA PCB delivery this year (their prediction):

September: ~70 EoS
October: ~700 EoS
November: ~200 EoS
December: ~750 EoS

In addition: ~700 test coupons

Petal: now producing 9 EoS pairs – most likely ready in October

Staves: plan to start EoS pairs with “special” flex lead (both A and C) as the PCBs arrive
Likely ready in November

Thinks to be discussed – setting priorities

- VTRx cover
  - Petal one variant done (Dario), mirrored version to be done
  - Stave: need four different variants, to be done
  - Have to do a mass production
- Opto-holder for petal
  - Needs to be glued. Can this be done by ZE? Documentation by glue experts needed (which glue, handling, tools?)
- QC mass testing
  - Initial QC tests by experts, to optimize procedures (Harald, Sara, Stefan, …)
  - Agreement to hire students for mass production (for all of 2024?)
- Glenair
  - Screws to be exchanged – do we have to take over?
- Pull-tests on test coupons
  - **We have ~700 test coupons but no definite person-power allocated**
  - ATLAS wants to have pull-tests (plus temperature cycling) for all – can we reduce this by factor 4 (1/panel)?
  - 20 bonds per test coupon
  - First six test coupons in 26, Eric and Celine agreed to bond them
  - Pull-tests: ZE could possibly do that, but we have no definite answer yet
  - Machine for pull-test & temperature cycling: available in ZE

Summary

- EoS production started (now: 9 petal pairs, soon: 14+14 special pairs)
- All PCBs are promised by ILFA for this year
- PCB population by ZE, X-ray by Fraunhofer.
- QC is set, with two exceptions
  - X-ray: about to refine handling, shipment, and reports by Fraunhofer Institute
  - Test coupon pull-tests: who is doing it? Present thinking: bonding by ATLAS engineers in building 26, pull-tests by ZE. Have ~700 Test coupons total
- Estimated throughput: can do ~200 EoS boards per months
- Initial phase until March 2024: may be difficult to meet production demands for specific EoS types (if several stave variants are requested)
- Other items yet to be sorted: VTRx cover, needed for start of production
- Opto-holder glueing to be sorted for petal EoS production

Backup

The stave EoS variants nightmare

- Staves have two sides: A, C with mirrored PCB design
- Inner part: short strips – two lpGBTs per board
- Outer part: long-strips – one lpGBT per board
- Radial variants of flex-lead (and corresponding 11V wire length)
  - “short” flex, “short” wires
  - “long” flex, “long” wires
  - “special” flex, “special” wires

Main (no flex)	wire	Secondary (with flex)
A-side-long	special	A-side-long-special
	long	A-side-long-long
	short	A-side-long-short
A-side-short	short	A-side-short-short
C-side-long	special	C-side-long-special
	long	C-side-long-long
	short	C-side-long-short
C-side-short	short	C-side-short-short

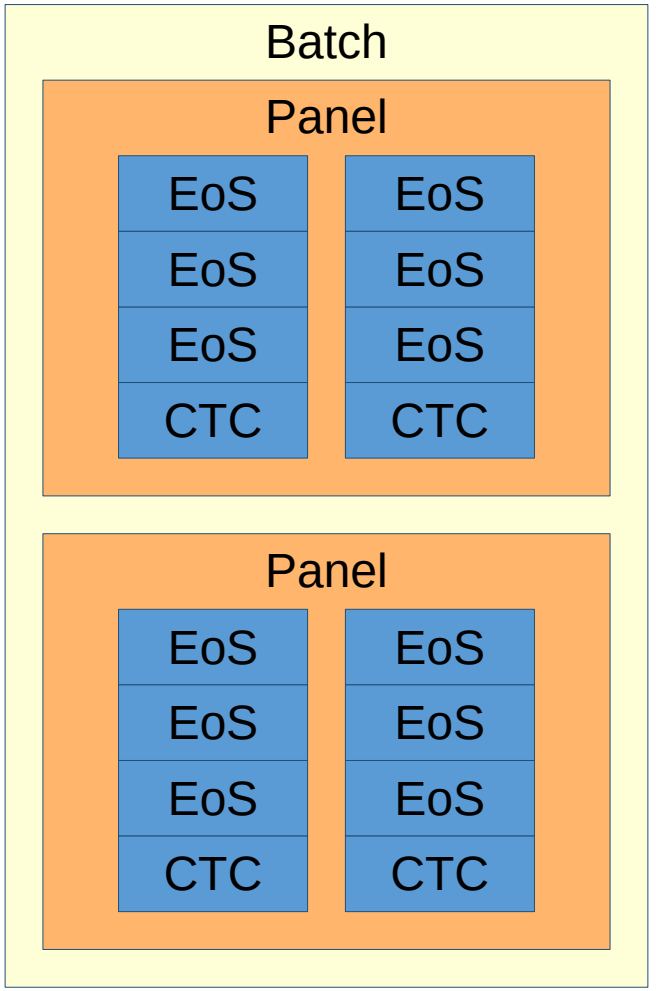
2 PCB variants
4 population variants
8 population variants (counting wires)

6 PCB variants
8 population variants

Staves: 16 variants (8 types of EoS pair)
Petals: 2 variants (1 type of EoS pair)

EoS in ITk production DB

- Original design had to be refined: several types of flex-lead, better understanding of QC tests ...
- Latest clarification from Itk week: no lpGBT object, import relevant calibration constants to the EoS component → for possibly extraction into operation's database
- EoS related production database objects
  - Batch: several Panels
  - Panel: several EoS and CTC
  - EoS card
  - Customer Test coupon (CTC)
- Can quantify production efficiencies at all levels



EoS identification in ITk DB

- EoS card identifiers at hardware level:
  - Imprint on the board
  - RFID chip
  - LpGBT identifier (readout)
  - Glenair connector number
- DC/DC identifier
  - Imprint on the PCB
- VTRx identifiers
  - Imprint on the PCB
  - ASIC identifier (readout)

- EoS IDs in Database
  - EoS imprint is related to EoS ATLAS serial number

    → can be found through panel alternative ID
  - LpGBT identifier is the “alternative ID”

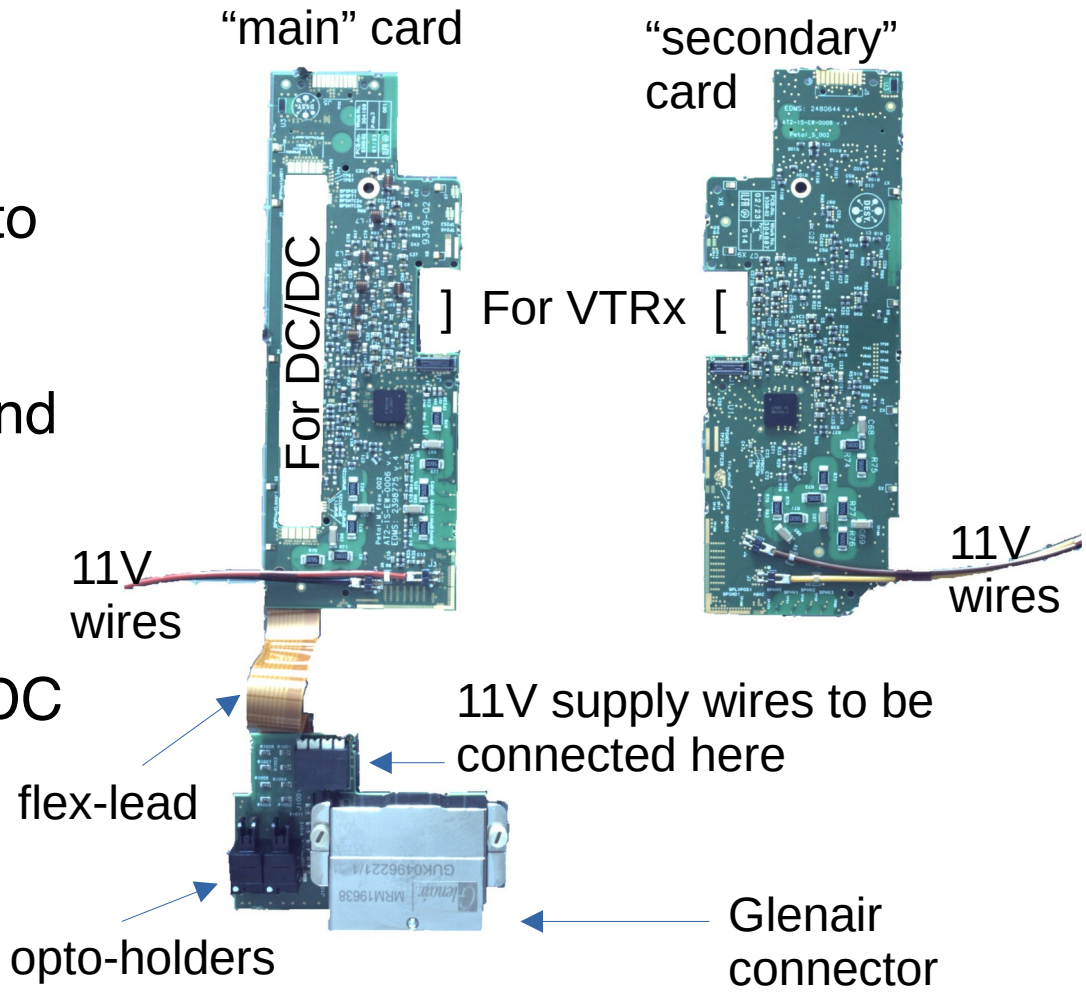
    → can be searched for in the database

    → possibility to use production database for system test
  - RFID is stored by not searchable
  - Glenair ID is stored but not searchable
- DC/DC: PCB number will be in database
- VTTx: not managed by the EoS team

A closer look at the petal EoS cards

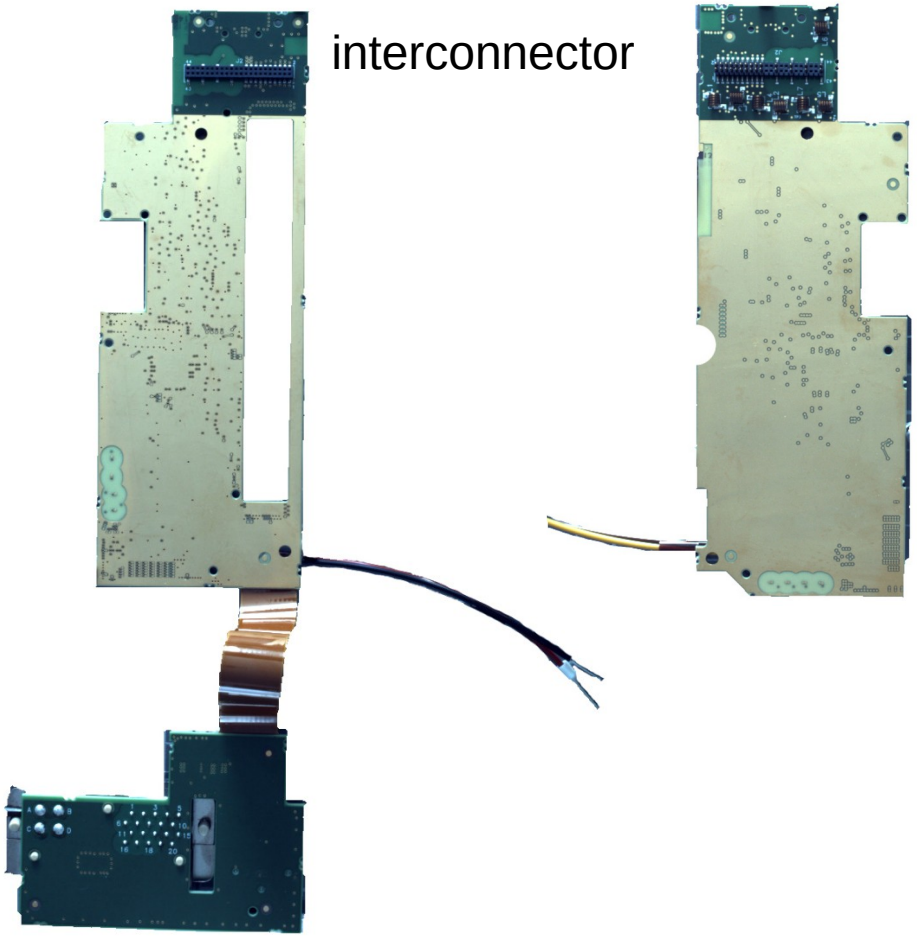
- One EoS card per bus tape, so two cards for one petal
- Only one card has a connector to ATLAS

  Connector is attached with flex-lead. Flex-lead is used for HV and monitoring
- Thick wires from connector to both cards: 11V supply
- “main” card has cut-out for DC/DC converters
- Both cards have cut-out for VTRx+



Back-side: interconnection

- Back side is a flat surface for glueing to the core
- Outside the core region there is an interconnector of the two cards
- The interconnector is required to
  - bring the HV from the “main” card to the “secondary” card
  - Connect the secondary card to its DC/DC converter, located on the other side of the core

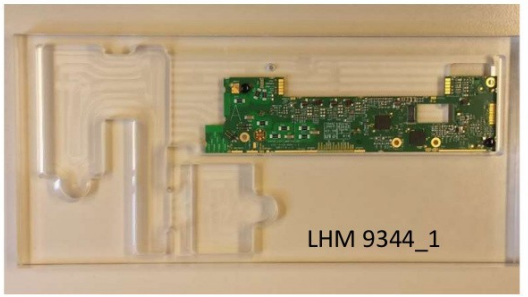


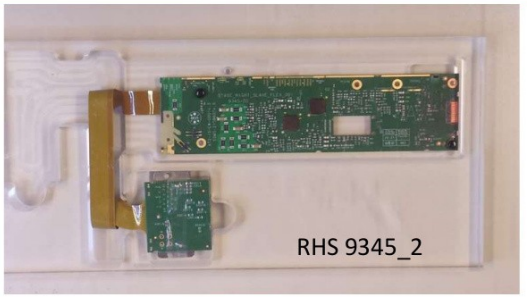
Barrel EoS: differences to petal

- Barrel: flex-leads are with “secondary”, not “main” card
- Extra complication #1: A-side and C-side are mirrored
- Extra complication #2: inner cards have twice the number of channels (2 lpGBT chips)
- Extra complication #3: three different flex-lead lengths
- And other differences...

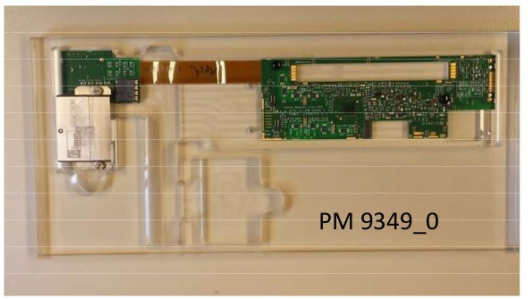
  → petal: 2 EoS variants

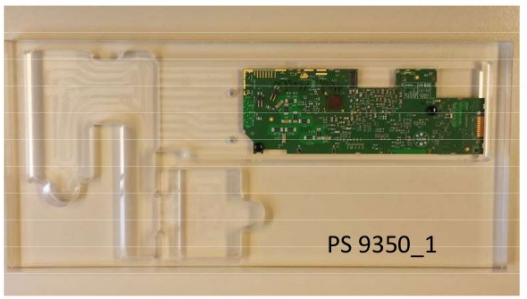
  → stave: 12 EoS variants





Five of the 12 variants in a protective plastic holder





Auxillary mechanical parts for the EoS

- EoS also comes with a number of “auxillary” mechanical parts, mostly designed here at DESY
  - Wire guide to fixate the wires and optical fibres
  - Opto-holders to receive sockets for connecting the optical fibres
  - Light-tight enclosure around the VTRx+ to shield stray light from the sensors
  - Of course all these parts are different for petal and staves…

EoS Quality control

- The EoS is a single point of failure for one side of a petal of stave
- Make sure the Eos is 100% functional prior to shipping

  → QC
- Most of the QC is done here at DESY
- External quality control: PCB manufacturer, X-ray images

- QC at DESY
  - Bonding and pull-tests
  - Test coupons: resistivity of long traces, via chains, ball grid
  - Test coupons: impedance of trace pairs
  - Optical and IR images
  - Test lpGBT and VTRx+ configuration
  - Thermal cycling between -35 and +25 including basic function test (10x)
  - HV test at 1100V (2x nominal)
  - Full function test of all connections using needle prober on test points near the bond pads
  - 15 minute bit-error rate tests using random patterns on each E-link