Goals for the Phase 2 Outer Tracker workshop

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Goals of the Workshop

- Focus on the PS module assembly and sensor efforts.
- Discuss workflows
  - sensor QC, module construction, mechanics and system tests
- Organize R&D efforts
  - identify tasks and and associated funding requests
  - understand two scenarios
    - minimal R&D necessary to barely keep US presence
      - as we have been doing until now
    - desired R&D to establish US as an "equal" participant or "leader"

- Start to discuss and define responsibilities leading to construction efforts

Some tasks to consider

These are a partial list of tasks…

Please feel free to point out any important/high priority tasks which maybe missing and/or add more

Prototype Sensors

- Infineon sensors:
  - 8” by end of summer, 6” in October – November
- HPK sensors: 6” in September.
- Novati: first round in hand, second round end of 2016.
  - Could this include a MAPSA light sensor – this is the only kind of MAPSA that we have a chip for.?
  - use it then for a system / beam test?
- MAPSA light sensors:
  - Produced by CIS. First samples tested by KIT, Vienna. Observed that breakdown voltage decreases with every IV ramp.
  - Next batch to arrive in about one month.

Hybrids

- Plan to be produced and assembled in industry, QC @ CERN.
  - Currently there is one consortium of vendors but looking for more.
  - Assume good components for the FE hybrid assembly ie the FE ASICs and ancillary electronics (**CBC** (2S), the **MPA** (PS) and the **SSA** (PS), and the **CIC** (2S+PS)) are qualified prior to integration on the hybrid.
- The two steps: the fabrication of the circuit and the integration of the components will happen at a vendor.
- A functional test will be carried out by the company assembling the circuits and Q&A repeated by the centers that receive the circuits.
- **Test setup and sequence developed by the collaboration**

- We could consider for 2016
  - identifying a US vendor
  - developing the procedures and the system (with the vendor) for assembly, test, and thermal cycling

MaPSA assembly

- MaPSA-light testing
  - develop test systems, plans for various tests (bench, source, irradiation, test beams)

- Bump bonding
  - To be done by industry. It is under discussion whether HPK does this.
  - Submitted MAPSA light to three possible vendors – see what comes back.
  - Could develop a vendor in US (RTI?).

- Testing
  - Could be >2 years until we have fully functional MAPSA.
  - within US groups, develop full size, bump bonded dummies for prototypes

Module Mechanics

- Developing vendors for producing
  - Al-CF parts, CF parts production, & parylene coating
  - check for geometrical precision and coating Q&A critical for gluing surfaces to the sensor); for CF, all the edges need to be coated (e.g. with liquid epoxy) prior to the assembly in the modules, to avoid carbon dust.
  - Are we interested in developing a vendor for this task?

- Cooling system
- Rod fabrication
- Other support structures?

Module assembly

- Prototype "skeleton" modules
- ie. full size, bump bonded and wire bonded dummies
  - needed for thermal tests
  - defining the assembly process
  - alignment and assembly precisions

- produce 10 "skeleton" modules in 2015
  - discuss how / where to produce various parts and assemble modules.
  -

- Prototype modules: first prototypes in 2017.
- Module production: starts in 2019.
- Develop high capacity assembly sites.
  - 2 or 3 production lines within the US (2000 module / line) ?
  - production line is formed by collaboration of institutes

Beam Tests

- Beam test of 2S module made of 6" HPK sensors is planned at CERN in November
- No beam test of MAPSA light scheduled yet. Use stack of two MAPSA sensors to find stubs.
  - Should happen in early 2016.
  - Could do this at Fermilab.
  - We can take the lead in proposing & developing the details.

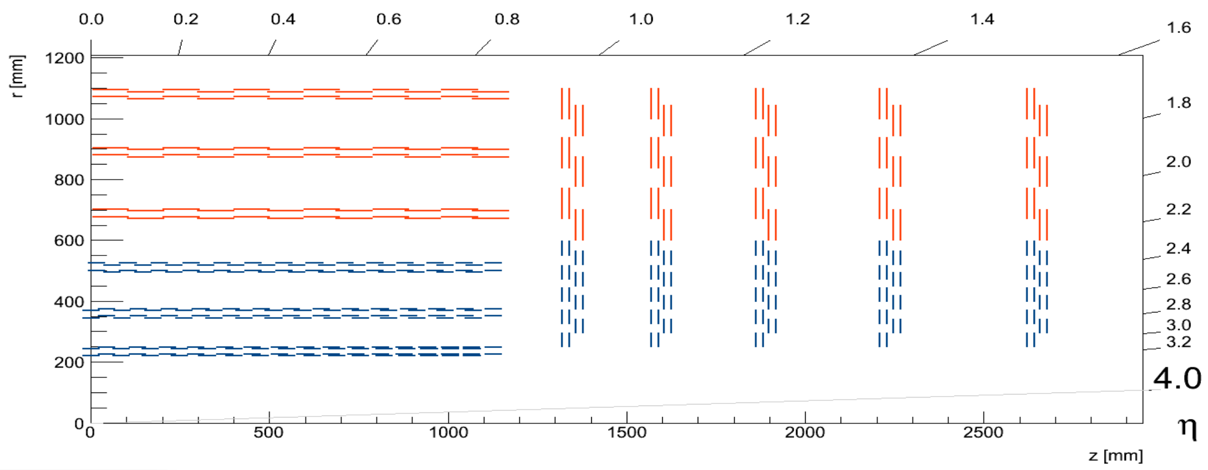
Construction Data Base

- essential to track items, log test results, and implement correct assembly rules.
- Data need to remain accessible even later, during operation.
- One institute should take the responsibility to provide a suitable implementation, as well as user support all along the production.

Backup

Outer Tracker modules

- The layout of the phase 2 tracker consists of a barrel section with 6 concentric layers and two endcap sections with 5 identical disks each.
- There are two basic types of modules:
  - 2S modules (red in the figure) at larger radii (>60 cm) consist of two strip sensors
  - PS modules (blue in the figure) at smaller radii (20-60 cm) consist of one strip sensor and one sensor with macro pixels.



OT modules

- The table summarizes the number of modules of each kind in the baseline design with flat inner barrel modules and in the modified design with tilted inner barrels modules.
- There are 8424 2S modules in either design.
  - These sensors will be about 10x10 cm^2 in size for a total silicon area of 170 m^2.
- The PS sensors will be about 5x10 cm^2 in size.
  - In the baseline design there will be 7004 of them for a total silicon area of 70 m^2.
  - In the modified design the number of PS barrel modules in the barrel would be reduced from 4164 to 2908.

2S modules	Both designs
Layer 6	1824
Layer 5	1488
Layer 4	1152
All barrels	4464
All disks	3960
Total	8424

PS modules	Baseline design	Modified design		
		Flat	Tilted	Total
Layer 3	1836	540	936	1476
Layer 2	1320	286	624	910
Layer 1	1008	126	396	522
All barrels	4164	952	1956	2908
All disks	2840			2840
Total	7004			5748

Our interests in OT modules

1. develop and build the support and cooling structure for the flat part of the barrel
2. and in the assembly of a number of the PS modules.
   - The PS modules consist of a strip sensor and a pixel sensor.
   - The strip sensor has two rows of AC coupled strip with a length of 2.5 cm and a pitch of 100 μm. It is bonded on either side to a hybrid with a row of short-strip ASIC (SSA) readout chips.
   - The pixel sensor has 32 rows of macro-pixels of length 1.5 mm and pitch 100 μm. The macro-pixel ASIC (MPA) readout chips will be bump-bonded directly onto the sensor to form a macro-pixel-sub-assembly (MaPSA).
   - The module assembly has to provide for precise alignment of the two sensors relative to each other and supply power and cooling to the sensors and readout chips.

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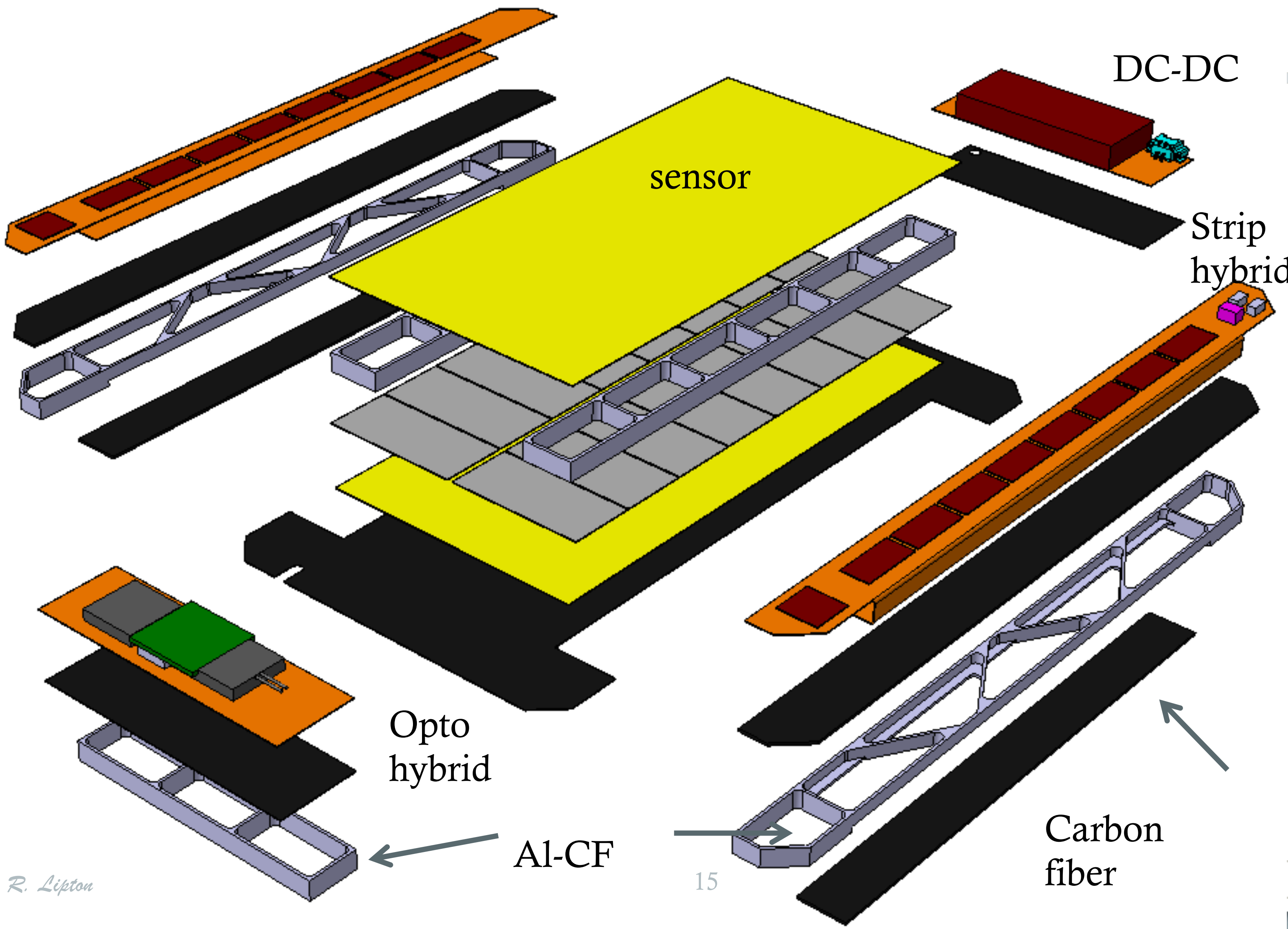
Assemble and test PS Module



Infrastructure: module assembly

- Wire bonder : ~$200K
- Pull tester. e.g. Dage 4000: ~10K$
- Microscope for optical inspection. Microscope with LED display for quick viewing. ~5K$
- Glue dispensing robot. ~20K$
- Gantry style robot. Aerotech AGS10000 for TOB construction. ~100K$
- Automatic Probe station with cold chuck: ~150K$
- Camera with LabVIEW Vision system for robot. ~$20k
- Keithley 237 voltage sources. Standard lab power supplies. ~10-20K$
- Vacuum oven: ~20K$
- Dry storage units with grounding capability. ~10-20K$
- Anti-static protection system. ~5-10K$

- CMM ???
- Cooling system
- Burn-in system
- Test systems
- Clean Room?

- Estimate: 400K$ + wire bonder (200K$) + clean room

Infrastructure: sensors

- Clean room (class 100,000 or better)
- Basic equipment
  - Source meter $\geq$ 1000V, Imax $\geq$ 1mA
  - pAmmeter
  - LCR-Meter 100Hz $\leq$ f $\leq$ 1MHz
  - Voltage source
  - Temperature controlled vacuum chuck (~20°C) for sensors up to 16 cm long
  - Light-tight and humidity controlled metallic enclosure
  - Probes, vacuum tweezers, microscope
  - Humidity controlled storage
- Additional equipment for strip measurements
  - automatic probe station (up to 2032 strips, 5 parameters each)
  - XYZ-stage (accuracy ~5μm)
  - Switching-matrix including HV switching
  - Long-term setup to monitor leakage current at 500 V for 48h
- Estimate: 250K$ + wire bonder (200K$) + clean room