Update on ePIC SVT services estimate

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ePIC SVT services estimate

- Work on estimating services for the ePIC is needed for the EIC project reviews: CD-3A Design Review by the DAC at the end of August, Director's Review in October

- Three iterations, documented on the ePIC/Tracking/Silicon sharepoint
  - Sensor low voltage and bias services defined with project engineers (March 2023 update)
  - More recently, update on data links and cooling (July 2023 update) provided to project engineers

- Information collected in project spreadsheet

- General assumption
  - As the final EIC LAS sensor size and yield are not yet known, the estimate assumes tiling the OB/EE/HE with EIC LAS sensors that are on average 1 x 4 RSUs long; this gives 450 sensors in L3, 1092 sensors in L4, 1100 in each set of disks

Sensor low voltage (LV) power

- Serial powering (SP) assumed for OB/EE/HE
  - The length of the serial powering chains is assumed to be 2/4/3 EIC LAS sensors for L3/L4/disks
- The EIC LAS power consumption is estimated from the initial ITS3 sensor specifications (20 mW/cm^2) at 1.2V and 0.85A
  - Most power consumed by the periphery; current assumption is that this does not scale with size, so ~ 1W power consumption per EIC LAS, independently of size
- The IB is assumed to be powered with a conventional, voltage-based scheme, where each sensor receives analogue and digital voltage (both 1.2V) with an independent set of cables
  - Analogue current 0.2A, digital current 0.65A (estimates)
- The IB is serviced only from the hadron going direction. The cables for the OB split evenly between hadron and electron going direction. Cables for the LV should be made of aluminium

Sensor low voltage (LV) power

- The current LV estimate does not include
  - The power overhead for the Shunt-LDO
  - The power needed for the readout boards

- Further updates will be needed following submission of the ER2 and completion of the ePIC SVT tiling study as these will provide
  - Update on the size, and thus number, of EIC LAS sensors
  - Better estimate of the EIC LAS power consumption
  - Decision on whether the power will be distributed to the sensor from both sides

- Further comment
  - As the R&D progresses to develop redundancy options and test system robustness, longer chains might be considered to reduce material further
  - SP might also become an option for the IB

Sensor bias voltage

- Each sensor will need bias voltage to deplete the substrate for charge collection
  - The sensor bias voltage is in the range of 4 to 6 V, with a sub-μA current
- It is currently assumed that each sensor will have its own pair of cables to bias it to avoid shorting the SP chain, where each sensor is on a different ground potential
  - Part of the eRD113 programme is to develop a circuit to generate the sensor bias voltage out of the LV on the sensor to reduce the cables for sensor biasing
- The IB is serviced only from the hadron going direction. The cables for the OB split evenly between hadron and electron going direction. Cables for the sensor bias voltage should be made of aluminium

Cooling

- The total power consumption of the sensors is currently estimated at 4kW
  - This estimate does not include the overhead for the serial powering regulator and circuitry needed for the readout
- The operating temperature will be around 25C; the coolant temperature will need to be lower than this (TBD)
- For the inner barrel layers, air cooling is assumed to reach the 0.05% X/X0 targeted material budget
  - The beam pipe will be baked out with the SVT in place
  - Any cooling solution for the IB will need to be specified to include cooling of the SVT during bakeout, with the required redundancy

Cooling

- For the OB/EE/HE, common solutions are under consideration for the SVT, MPGD, and the TOF
  - Material budget critical for SVT; study of lower material solutions is a potential R&D area in FY24 (eRD111)
  - Two-phase CO2 is an option, but current applications are material heavy
  - Other options would be heat exchanger or liquid cooling that is concentrated in specific areas in the SVT
  - Cooling solutions will need to consider the different power density in the sensor endcaps and RSUs

- All cooling solutions will need to consider the power and power density of the readout circuitry, Shunt-LDO, and their locations.

Data links

- Current estimate includes (only) links for output data from the sensor (i.e. uplinks)

- For the OB/EE/HE, multiplexing of data links is assumed to have only one link per EIC LAS sensor
  - MUX either in EIC LAS sensor endcap or with an external FPGA

- For the IB, where the ITS3 sensor is used, there are 6 links per segment
  - No multiplexing assumed for now
  - If data rates allow to multiplex links, this will be done with an external FPGA

- After multiplexing, data are converted to optical and sent over optical fibers to the DAM boards