Update on Services

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ePIC Collaboration Mtg.

Lehigh University – July 25, 2024

- This contribution is intended in the spirit of a **work**fest; it is not meant to provide an overview, but rather aims to help inform a next step on services,

- Services are a key part of the experiment – many reasons to work to get them estimated as correctly as we can; particularly timely also in view of this afternoon's workfest on integration,

- Prior work on services for ePIC SVT by Laura, Nikki, Georg, Grzegorz, ES – writeups available via EIC sharepoint at this link.

Services for the EPIC MAPS-based tracking and vertexing subsystem

Nicole Apadula (LBNL), Laura Gonella (Birmingham), Ernst Sichtermann (LBNL)

November 16, 2022

Note added: Elke Aschenauer, Brian Eng, Rahul Sha
Thursday November 16, 2022 to discuss the assumption
to insert the service estimates based on projected se
subsystems (that is, the lower estimates) and to link
discussed that an additional ground line may be neede
in the services spreadsheet. Likewise, lines for ex
environmental sensors) are not included in the services s

Introduction

The EPIC inner tracking and vertexing subsystem i
ALICE-ITS3 sensors, suitably adapted for EIC purposes
and disks with a maximum outer radius approximately 0
electron going direction to 1.80 m in the hadron going
barrel layers are foreseen complemented with five disk
total). The reticle size is thought to be 18.85 mm wic
stitched along the length axis and will be powered an
number of reticles that can be stitched this way to fo
current technology. Several sensor lengths will be requ
number of sensors per variant remain to be optimize
important consideration in this optimization. Power is th
be at the level of 1W for a sensor with an active area t
long; the variation with sensor length remains to be qua
printed circuits (FPCs) which, in turn, will be connected
FPCs remain to be designed and are outside of the
document is to estimate electrical services and co
assumptions. The goal is to arrive at reasonably
understand them to primarily serve routing paths and es

Electrical services

Barrel

The three innermost barrel layers are anticipated to be c
3, 4, and 5 reticles in the azimuthal coordinate. A total
these layers of 270 mm active length and radii of 36, 4
barrel layers have active lengths of 540 mm and 840
mm, respectively. Yield permitting, these layers will be
seven reticles, respectively, using a more traditional st
and 4 × 156 of such sensors will be required. In this n
barrel lengths of 540 mm and 840 mm, respectively,
azimuth at the target radii of 270 mm and 420 mm,

Services for the EPIC MAPS-based tracking and vertexing subsystem

Update - March 20, 2023

Nicole Apadula (LBNL), Laura Gonella (Birmingham), Ernst Sichtermann (LBNL)

Introduction

This document provides an update to the initial services estimate of the ePIC Silicon Verte
(SVT) detector. The initial estimate can be found at this link and should be read in conjunc
this document.

Sensor low voltage (LV) power

The sensor LV power is needed to power the integrated electronics. With respect to
estimate, this update assumes that the sagitta layers (L3, L4) and the disks (five disks, ED0
electron going direction; five disks, HD0-4, is the hadron going direction) will be powered in
a constant current. The length of the serial powering chain, i.e. the number of sensors in the
assumed to be, 2 for L3, 4 for L4, 3 for the disks. Each sensor is anticipated to operate at
0.85A current, giving a power consumption per sensor of 1W. We currently consider the cu
total power figures independent of sensor size. To account for the uncertainty on sensor
the sagitta layers and disks, a conservative sensor size of 1 x 4 reticles is assumed, with
on one side. This gives 450 sensors on L3, 1092 sensors in L4, 1100 sensors for the disks
side.

The table 1 gives the number of serial powering chains, i.e. the number of cable pairs neec
cable should carry 0.85A. The split of analogue and digital current, and generation of anal
digital voltages, is done by Shunt-LDO regulators placed close to or integrated in the sensc
also shows the voltage across each SP chain is calculated as the product of the number c
in the chain and the voltage across one sensor. The cables for the sagitta layers split evenly
hadron and electron going direction.

Table 1

	Number of sensors	Length of SP chain, i.e. number of sensors in the chain	Number of SP chain, i.e. cable pairs (current + return)	Voltage a SP ch
L3	450	2	225	2.4
L4	1092	4	273	4.8
ED0-4	1100	3	367	3.6
HD0-4	1100	3	367	3.6

In a serial powering scheme, the voltage drop on the cables is determined only by the allow
density and the output voltage capability of the current source. The gauge should thus b
such that the heat load in the cables could be manageable. The current source will ne
chosen such that its output voltage capability can accommodate the voltage drop acros
chain plus the voltage drop on the cables.

ePIC SVT
Notes in preparation of the
"Si Trackers/Gaseous Trackers/AG-LGAD TOF" meeting with the project
18 July 2023
N. Apadula, G. Deptuch, L. Gonella, Jo Schambach, E. Sichtermann, G. Viehhauser

Previous work on services estimates for the ePIC SVT is summarised in the documents at this link. These should be read in conjunction with this document.

The current ePIC SVT layout (i.e. October 2022 geometry, see figure 1) comprises:

- 3 Inner Barrel (IB) layers (curved silicon layers) – L0/L1/L2
- 2 Outer Barrel (OB) layers (stave-based layers) – L3/L4
- 5 Disks in the electron going direction – ED0/ED1/ED2/ED3/ED4
- 5 Disks in the hadron going direction – HD0/HD1/HD2/HD3/HD4

Total (active) area ~ 8.5 m^2.

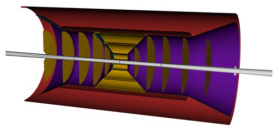

Figure 1: ePIC SVT geometry. The MPGD tracker is shown in red, and the support cone in purple.

The IB will consist of ITS3 wafer-scale sensors, thinned and bent around the beam pipe. The OB and ED0-4/HD0-4 will be made of carbon fibre support structures (staves and disks) tiled with the EIC Large Area Sensor (LAS). This will be a smaller size version of the ITS3 sensor, possibly with some modification in the endcaps to accommodate the ePIC readout needs (see section below on readout). The EIC LAS will come in 2-3 size variants to achieve the required coverage/acceptance and work within foundry manufacturing rules.

A description of the October 2022 configuration, sensor design, R&D progress and challenges can be found in the Technical overview of the ePIC SVT presented at the ePIC SVT kickoff meeting (9 June 2023).

It is worth noting that the design of the first ITS3 sensor prototype, i.e. the ER2 sensor, is advancing rapidly and thus even the recent information on the sensor design, presented at the ePIC SVT kickoff meeting, is in part outdated and more changes are expected over the next few months towards submission (planned for Q1-24). This has an impact on the overall ePIC SVT design (powering, readout, mechanics, cooling).

- Thanks to R&D effort, we know (much) more than at the start in November 2022,
- Still, these notes are meant to be read in conjunction with one another – please keep this in mind of you decide to read them,
- Most recent update was in July 2023 – we certainly know more today than a year ago and it thus seems timely to pursue an update,
- The SVT notes inform the ePIC Interface Control Document for Services, also available via sharepoint (link), and Roland Wimmer's modeling of services.

One of the SVT tabs from the ePIC Control Interface document – other tabs cover inner barrel, readout, disks.

See accompanying notes in ePIC/Tracking/Silicon at https://brookhavenlab.sharepoint.com/:f:/s/EICPublicSharingDocs/EqFKiVvqFBFOpMyAEEtw4McBUss2SE8o9JzeJc9W44vHSA?e=NIWYDB

Barrel Silicon Sagita layer Services

Person to contact - Laura Gonella (Birmingham) / Ernst Sichtermann (LBNL)

Cables, Fibers, etc.

Item	Description	Quantity	Diameter	Estimated Length	Notes	Assumptions	Tray Rated? (Y/N)	Cable Rating
LV current	Cables for serial powering to deliver 0.85A (2.4V for L3, 4.8V for L4)	57	9.0mm	8.0m	From active area to patch panel; aluminium cables; half in the hadron direction, half in the electron direction		Y	Cables are custom made and can be tested by vendo for VW-1 flammability rating, but will have to look int NRTL Tray Rating req.
LV current return	Return for the current (included in 9.0mm cable)	0		0	From active area to patch panel; aluminium cables; half in the hadron direction, half in the electron direction			
Sensor bias	Cables to provide the sensor bias voltage (4-6 V)	1542	3.0mm	8.0m	From active area to patch panel; aluminium cables; half in the hadron direction, half in the electron direction		Y	Cables are custom made and can be tested by vendo for VW-1 flammability rating, but will have to look int NRTL Tray Rating req.
Sensor bias return	Return for the sensor bias voltage	0		0	From active area to patch panel; aluminium cables; half in the hadron direction, half in the electron direction			
data		1542			Number of data output links. Assume these are after multiplexing and ready for transmission on optical fibers. See accompanying note (July 2023) for how and where MUX can happen.			

- SVT overall configuration has been stable; 3 inner barrel layers, 2 outer barrel layers, 5 disks on either side of the interaction point; overall dimensions,

- Sensor (number) estimates continue to hold – see e.g. Jo's talk at the lpGBT/VTRx+ FDR,

- Sensor power dissipation estimates have changed from the previously assumed 1W per left endcap (for a total of a 4kW subsystem),

- Ancillary IC power dissipation is now known to be non-negligible,

- Better knowledge exists for the serial powering chain in L3; the estimate for the disks on this point can also be refined,

- In our current baseline design, the ancillary IC supplies the bias voltages,

Further candidates for refinement:

- Fiber (number) estimates – VTRx+ known, concept for harnesses to reach max-|z|
- Power needs of VTRx+ and lpGBT are known,
- Cooling – more is known, but open questions remain (power density of ancillary IC and other),
- Grounding
- …