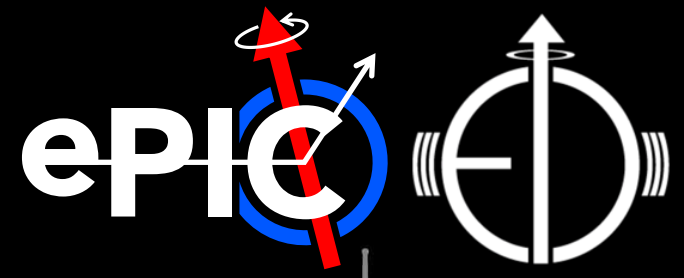




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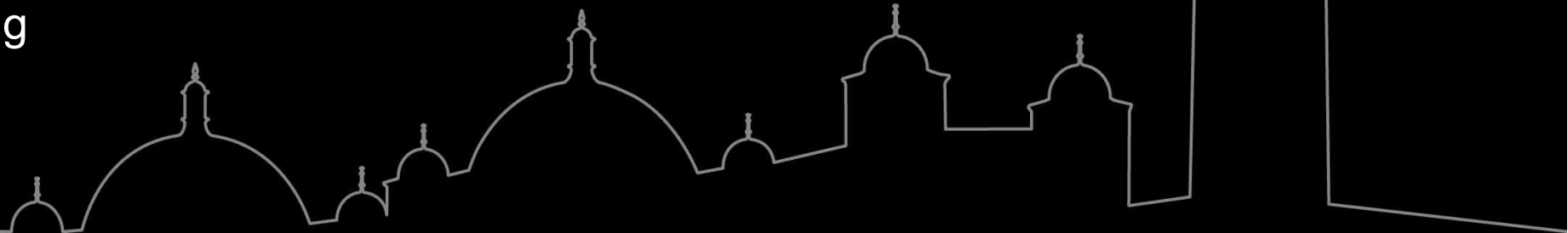


Serial Powering: Questions raised from service reduction needs

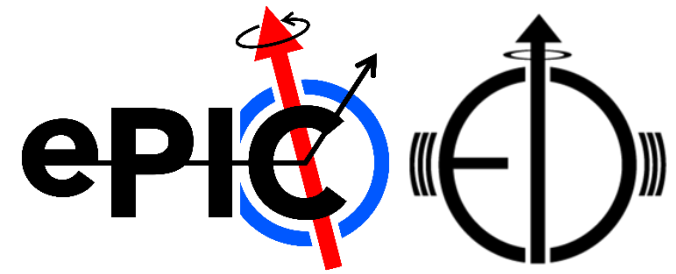
James Glover

ePIC SVT General Meeting

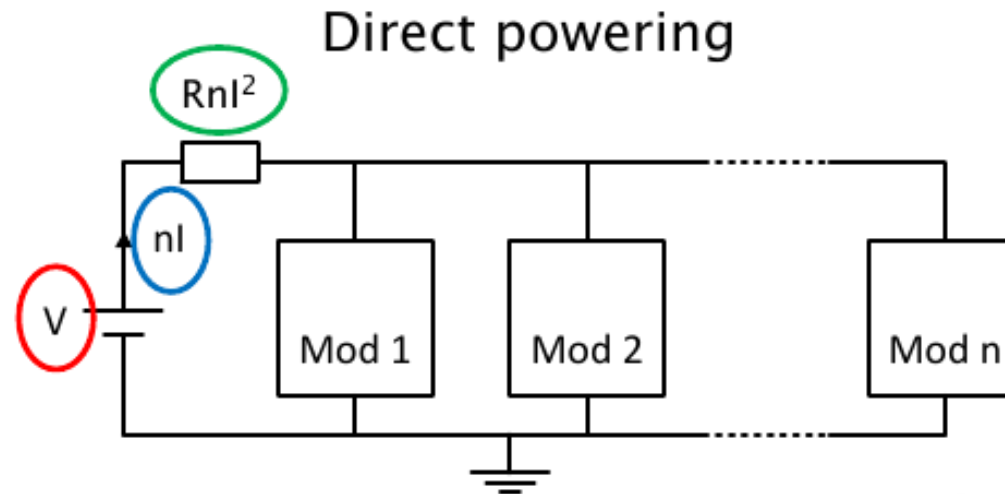
Tue, 16th Sep 2025



Direct powering basics

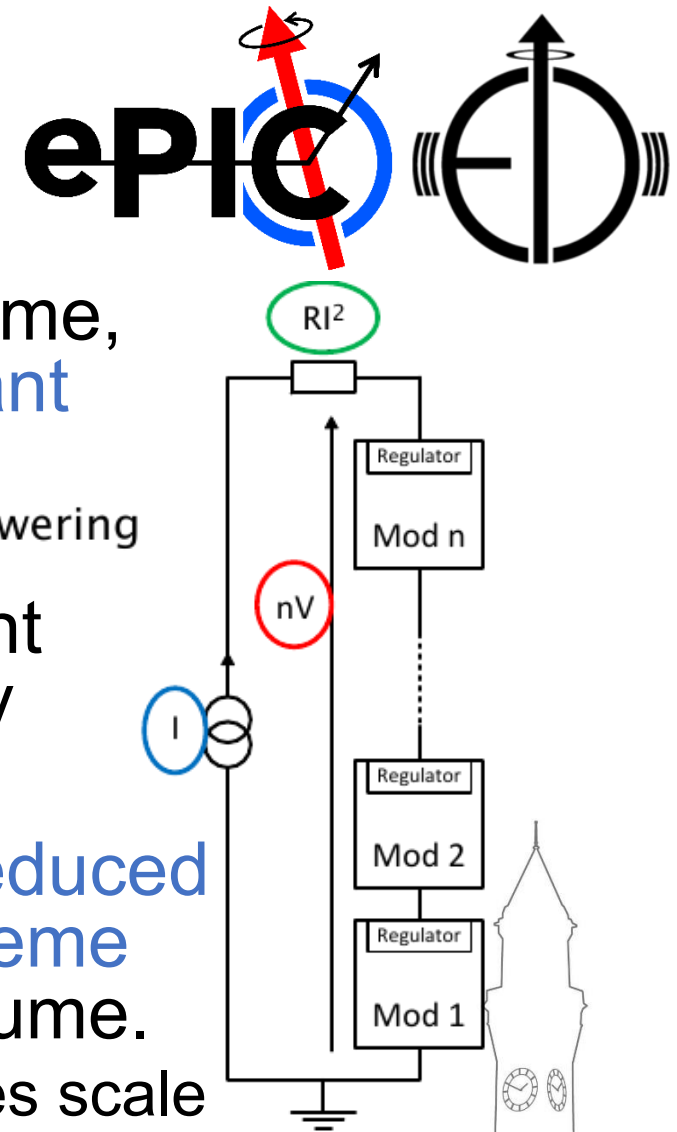


- Direct (parallel) powering is a voltage-based powering scheme, where modules are powered in parallel by a **constant voltage**.
- In a parallel powering chain made of n modules, the transmitted voltage is only the voltage needed by one module, V , while the current is only the combined current needed by all modules, nl .

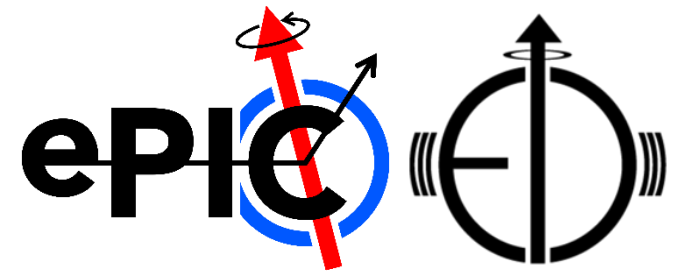


Serial powering basics

- Serial powering is a current-based powering scheme, where modules are powered in series by a **constant current**.
- In a parallel powering chain made of n modules, the transmitted current is only the current needed by one module, I , while the voltage is only the combined voltage needed by all modules, nV .
- For n modules powered in series, the **current is reduced of a factor n with respect to a direct powering scheme**
 - Higher power efficiency and reduced cable volume.
 - Cable cross-section and the power losses on the cables scale by the same factor.



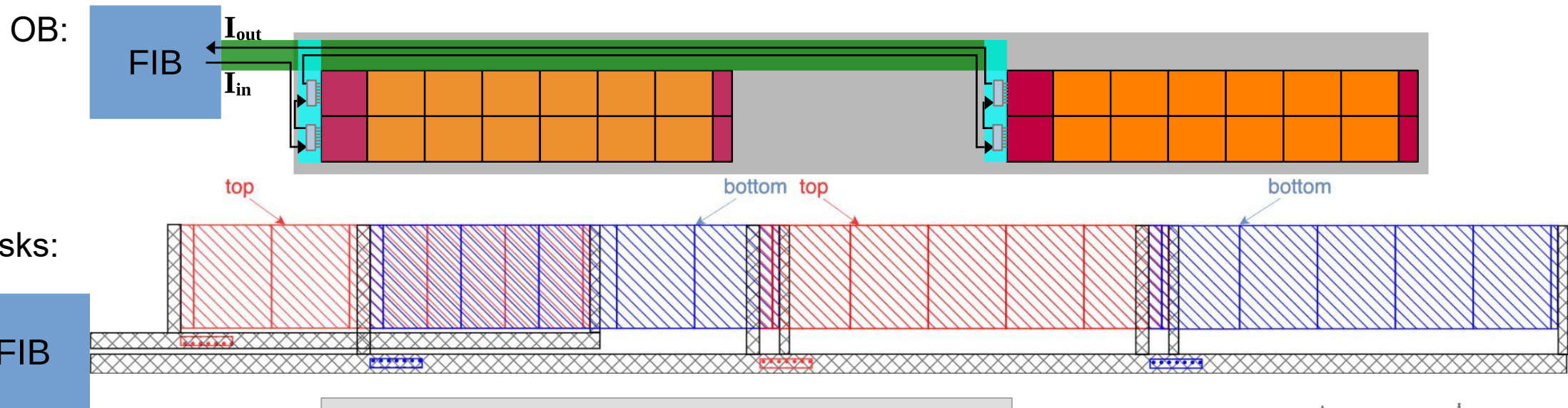
Current serial powering chains



The flexible printer circuit (FPC) will be the interconnect between clusters of EIC-LAS. This will:

- Cluster (up to) 4 EIC-LAS per SP chain.
 - This works well with VTRx+ readout channels*.

* 4 readout channels per VTRx+.

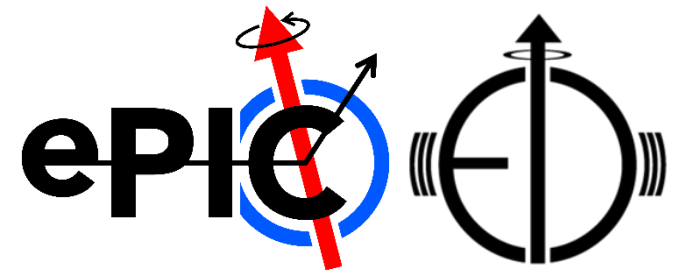


FPC hosts the AncASIC (1 per EIC-LAS) and interconnections for SP and SC chains.



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SVT services



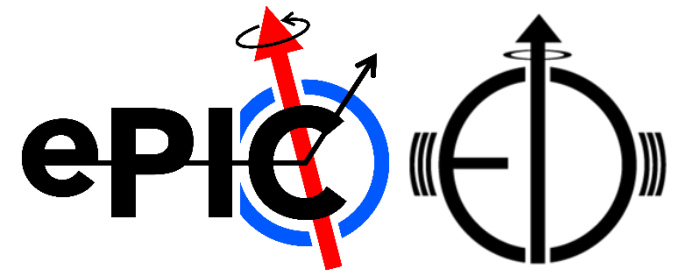
Recent work has been carried out to update the number of and volume of the SVT services: <https://indico.bnl.gov/e/29602/>.

This raised questions on reduction related to the serial powering:

- If we convince ourselves that multiple EIC-LAS chains can be powered in parallel; this is the origin of the difference between the “old” and current counts of power conductors.
- If (i.e. provided that) we convince ourselves that the serial powering chains can be made longer (their current length is up to 4 EIC-LAS) then the power contribution for the barrel and disks will be smaller. If the length can be up to 8 EIC-LAS then the reduction could be 200 cm^2 (including packing and misc.).



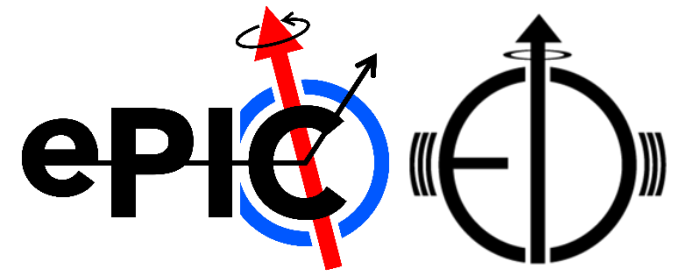
Parallel serial powering chains



- Serial powering requires a highly controlled (fixed) current.
- Parallel powering requires a highly controlled (fixed) voltage.
- Running SP chains in parallel means that both current and voltage are tightly constrained!
 - Any powering anomaly would need to be corrected by in SVT controls, so the power supply output is constant.
 - No power supply variation can be tolerated.
- This requires a lot of dedicated controls to make this possible.
 - A lot of dedicated work/manpower needed.
 - Work will be very complex.



Longer serial powering chains



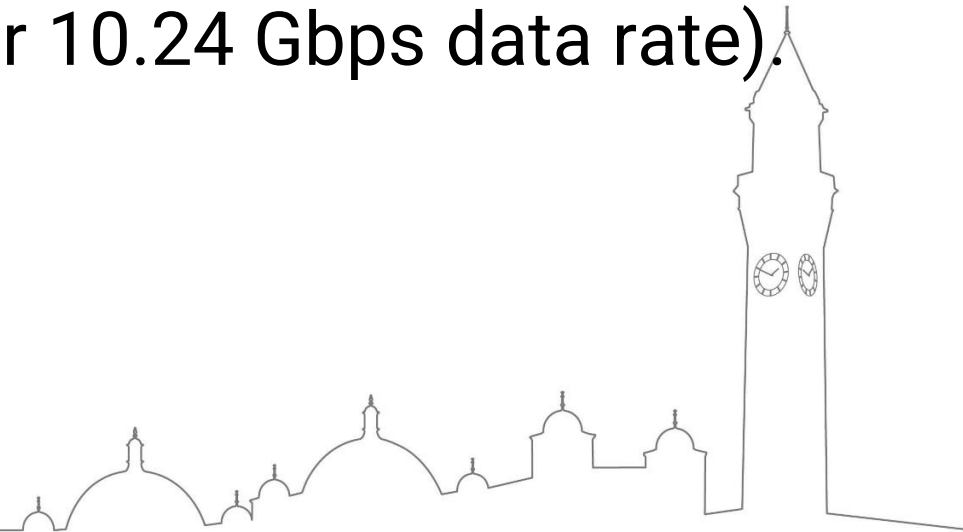
Changing length of SP chain has no effect on the requirements of the current source, only adjusts the number of PSU channels needed (\therefore number of wires going to the SVT).

Reasons why chains of (up to) 4 EIC-LAS were picked:

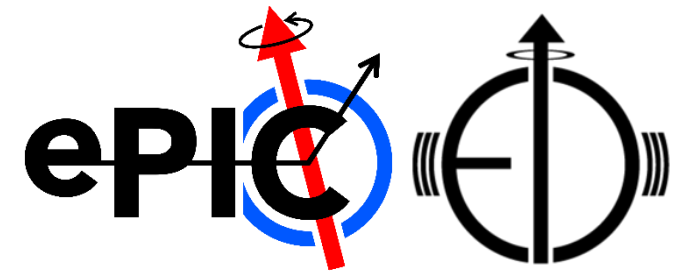
- 4 EIC-LAS per VTRx+ (readout data), \therefore matched group size.
- Maximum FPC length was to be 40 cm (for 10.24 Gbps data rate).

Other restrictions considered:

- Minimum FPC bend radius of 5 mm.



Disclaimer



The following will focus on
the SVT outer barrel staves.



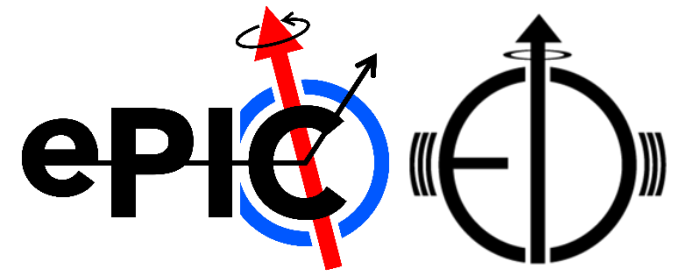
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16 Sep 2025

ePIC SVT DSC Meeting



Assumptions



Assumption 1:

Keep SP chain lengths a multiple of 4 EIC-LAS (for convenient grouping with the VTRx+).

Assumption 2:

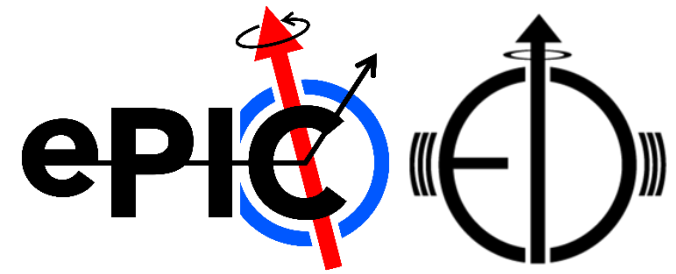
Avoid significant stave mechanical redesigns.

Assumption 3:

Avoid SP chains running between multiple staves.

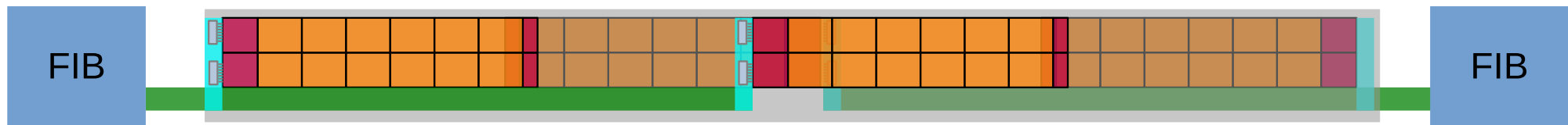


L3 staves



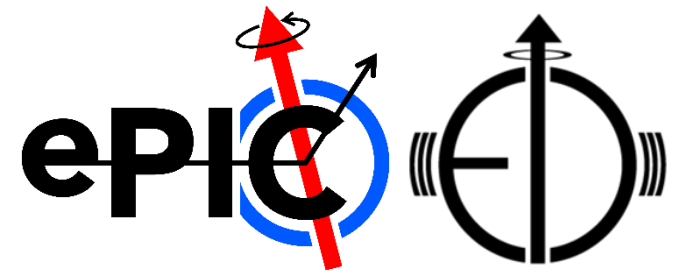
- 8 EIC-LAS/stave (4 EIC-LAS long and 2 EIC-LAS wide).
- 4 EIC-LAS on the top-side and 4 on the bottom-side.
- Currently, all EIC-LAS on the same stave side are a single SP chain.
- \therefore making all (8) EIC-LAS on an L3 stave requires FPC interconnection on top and bottom stave side*.
- FPC bend radius can be not tighter than 5 mm (advised by LTU).
 - Can not be done without making stave (significantly) thicker!

Current stave layout:

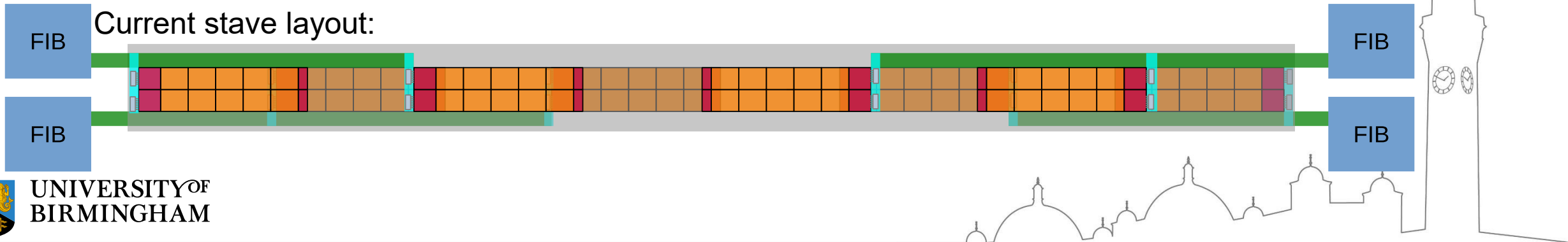


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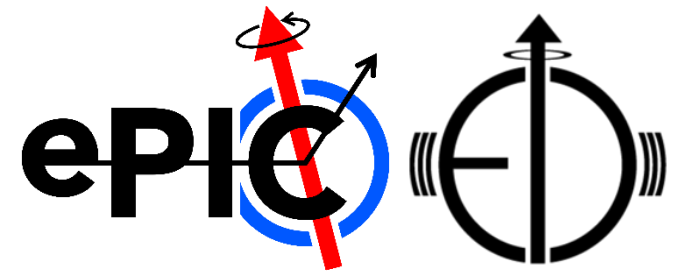
L4 staves (intro)



- 16 EIC-LAS/stave (8 EIC-LAS long and 2 EIC-LAS wide).
- 8 EIC-LAS on the top-side and 8 on the bottom-side.
- Currently, 2 SP chains (of 4 EIC-LAS) on each stave side.
- Total stave length: ~80 cm.
- FPCs were limited to 40 cm due to expected 10.24 Gbps data rates.
 - If we are only using 5.12 Gbps, can they be made longer?
 - What is LTU's limitation on length?



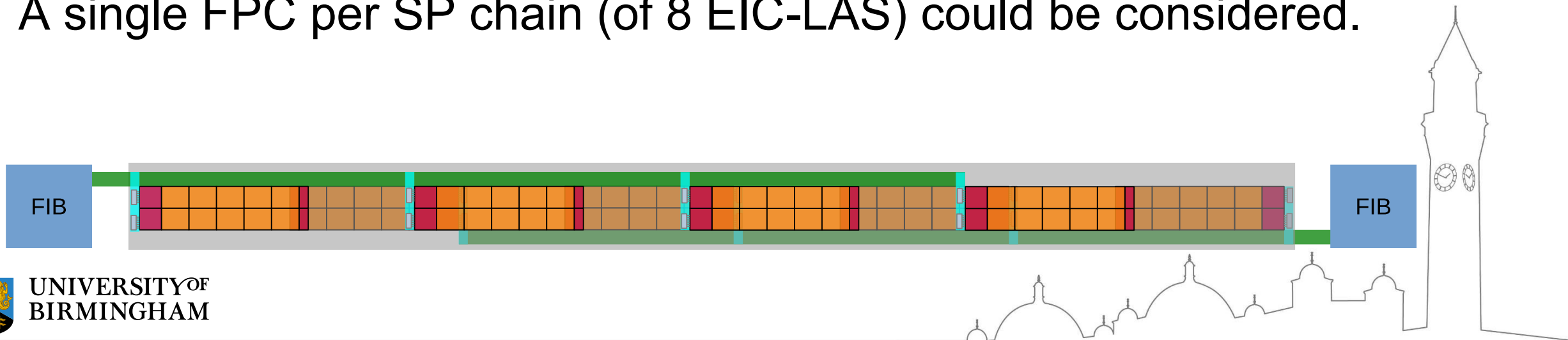
L4 staves (long FPC)



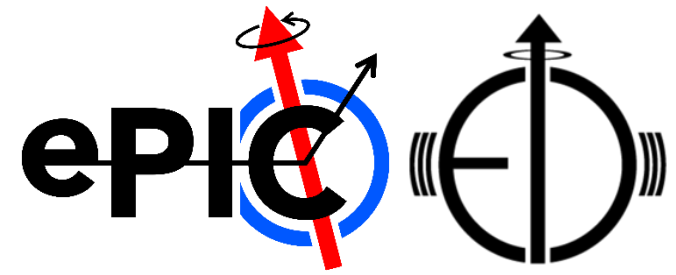
If long FPCs can now be considered.

- LTU's manufacturing limits to be checked and data rate testing required!

A single FPC per SP chain (of 8 EIC-LAS) could be considered.



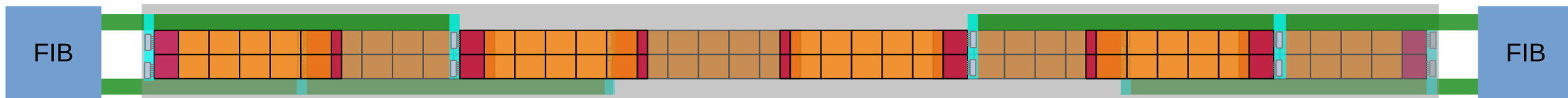
L4 staves (interconnecting FIB)



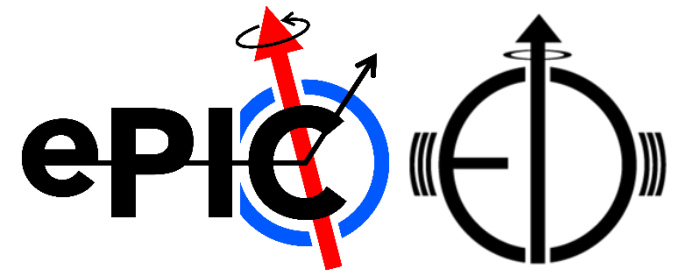
An alternative could be to have two FPCs (1 top and 1 bottom) interconnect via a FIB.

- Relies on the FIB to redistribute the SP chain from 1st to 2nd FPC.
- No FPC design change, only double up on VTRx+ per FIB.

This is likely to be the best option for the disks as well.
Keep in mind the disk will not always have full SP chains.



Possible L3 workaround

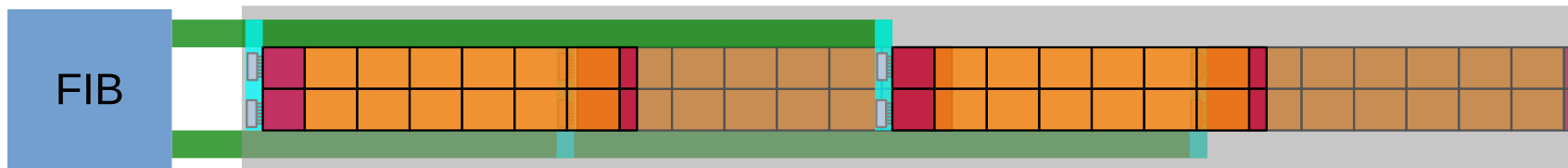


If all stave services exit the stave on the same side:

- Separate top and bottom stave side FPCs can be used (no bend).
- The **FIB** could then be used to **interconnect 2 FPCs** (each of 4 EIC-LAS) into **one SP chain**.

Relies on the castellated layout (2 sub-layers of differing radii) to ensure an even # of staves. Could have*:

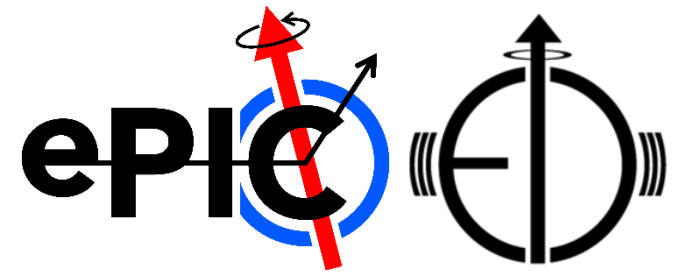
- all L3 inner-radius staves with h-going services, and
- all L3 outer-radius staves with e-going services.



* Or vice-versa.



Summary

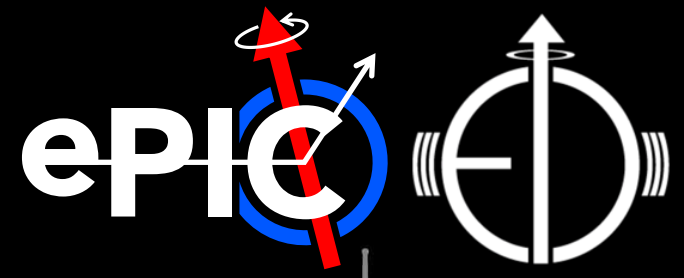


- Additional service reduction options have been considered for the SP chains.
- Parallel SP chains is likely to be a big headache.
 - Recommendation would be to avoid.
- Longer SP chains are feasible (multiple options available for L4).
 - Most universal solution would use the FIB to link FPCs to the same SP chain.
 - Considerations need to be made to the daisy chained slow controls.
- No consideration for additional chain redundancy was made.



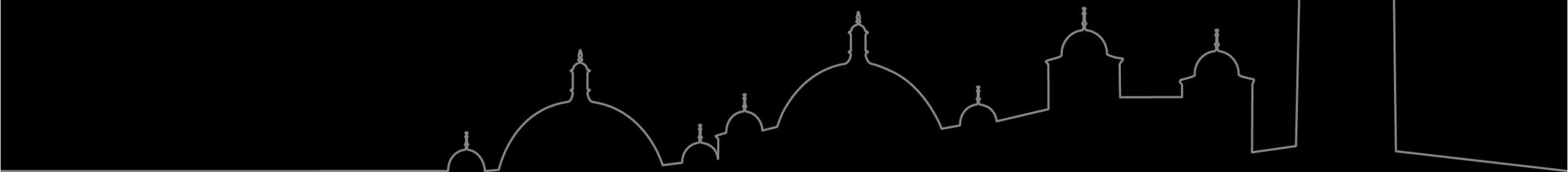


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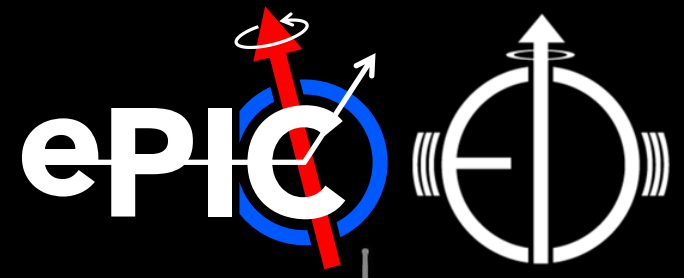
Thank you very much!

Any questions?

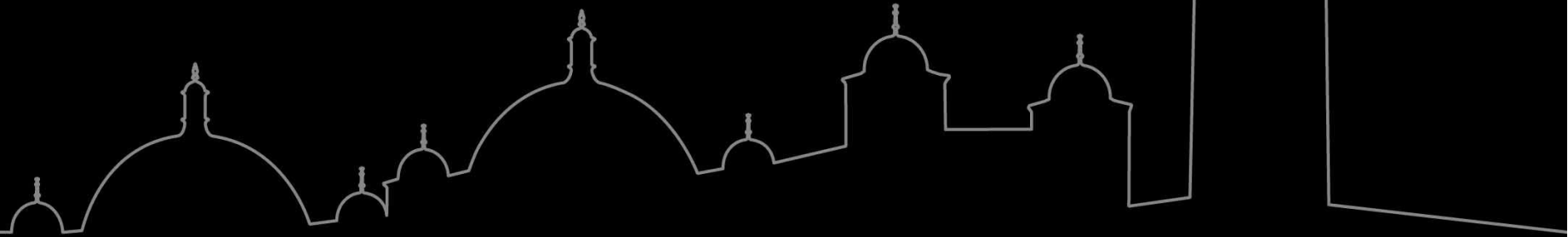




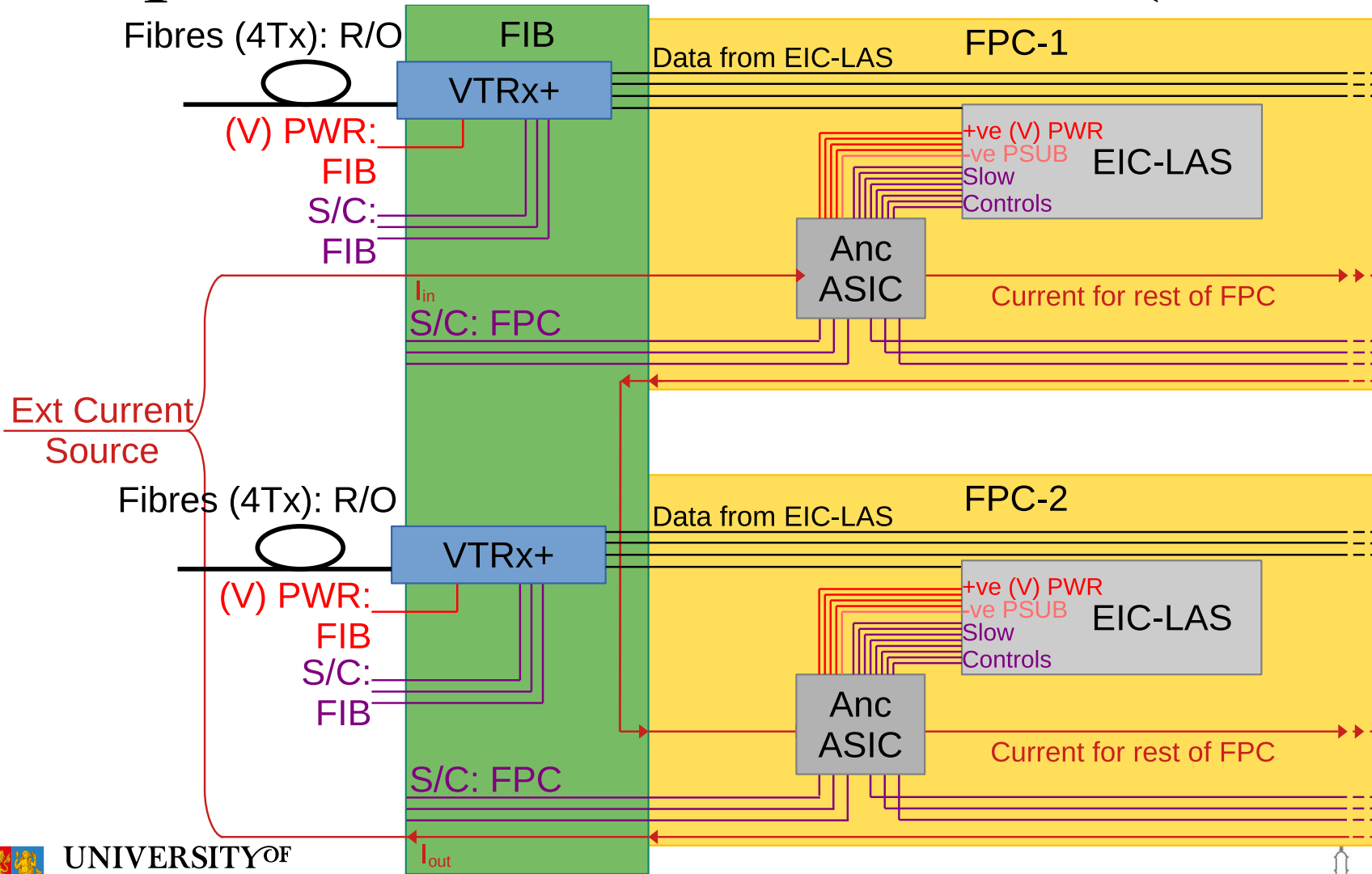
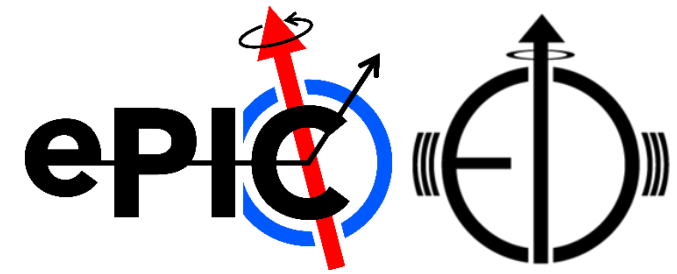
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Additional (support) slides



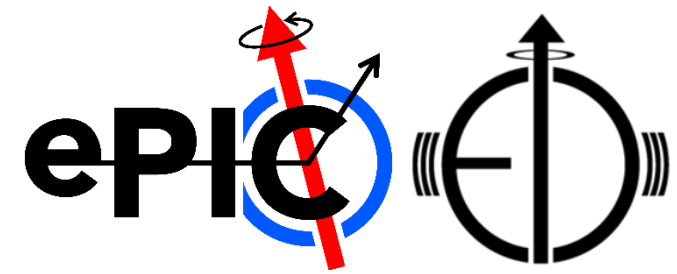
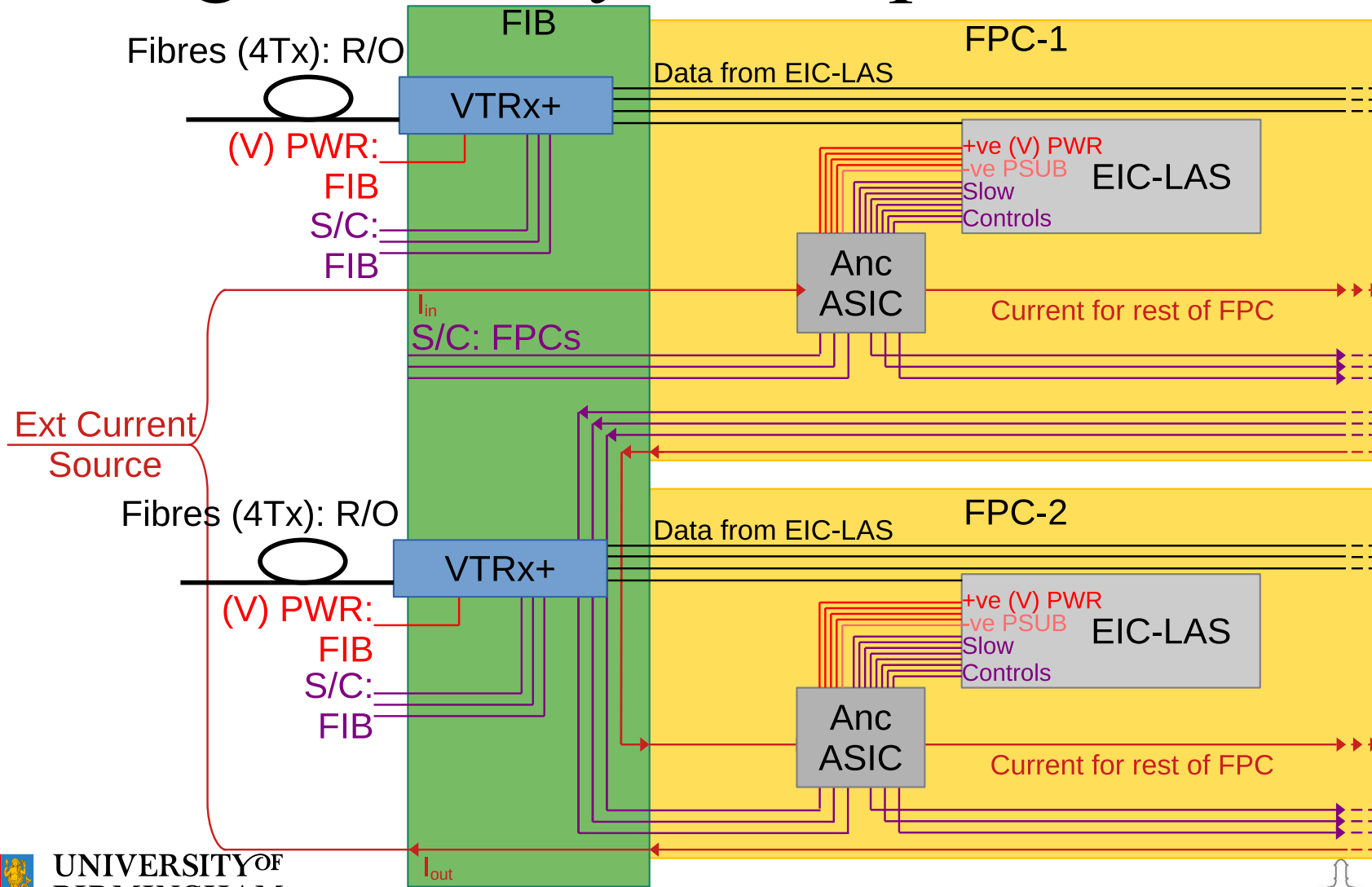
Separate S/Cs for each FPC (1 FIB)



- No change to FPC needed.
- 2 S/C groups (at different ref voltages).
- (V) PWR: FIB can be run in parallel for both VTRx+



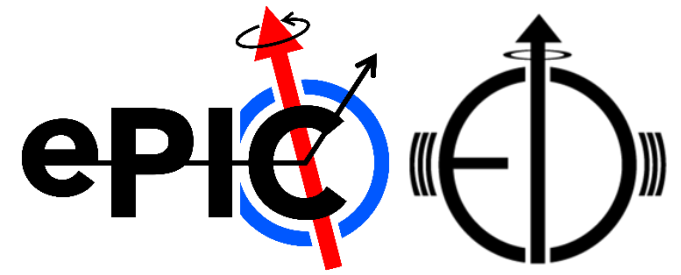
Long S/C daisy chain per FIB



- FPC needs S/C return.
- 1 S/C group per FIB.
- Longer daisy chain means more signal delays.



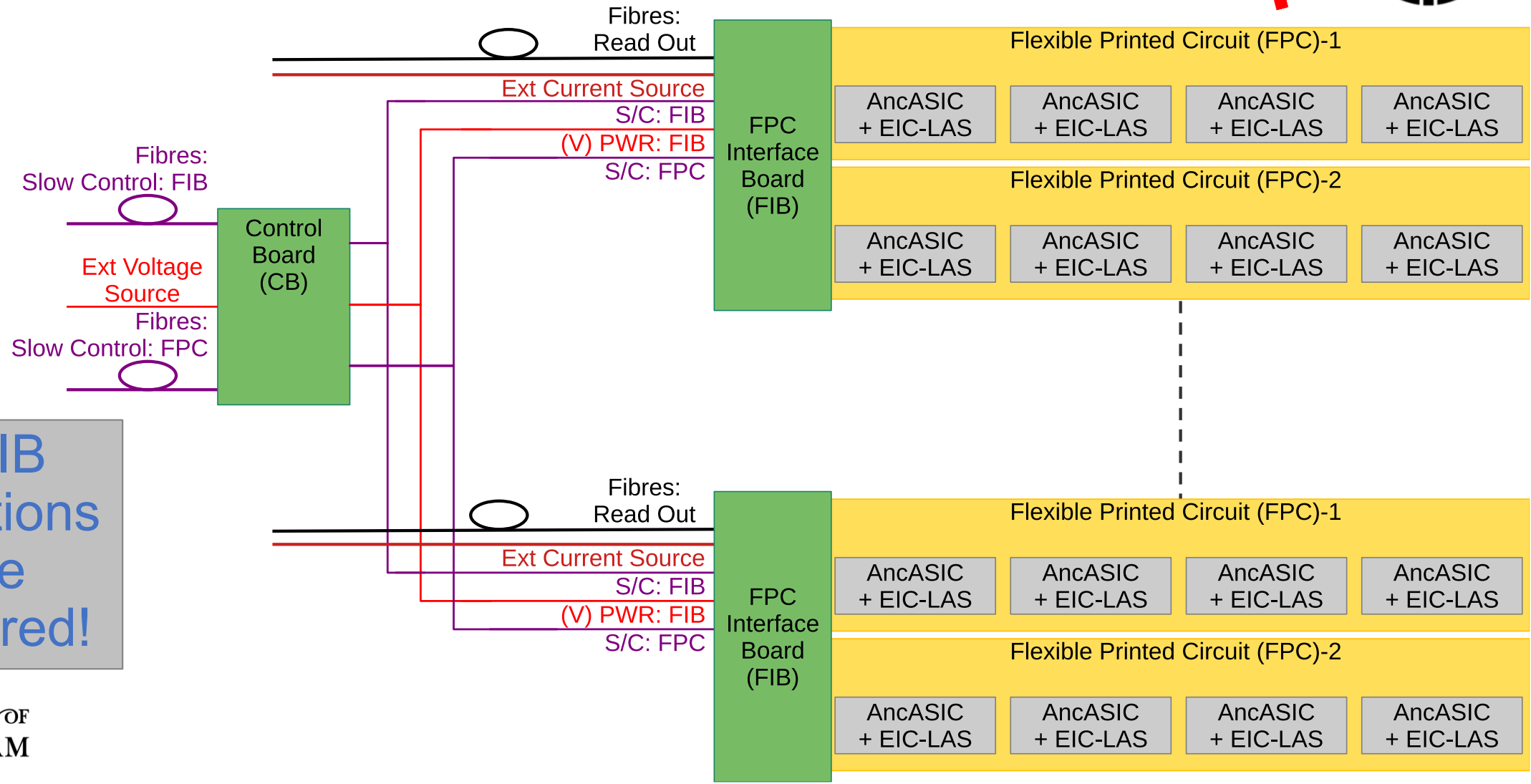
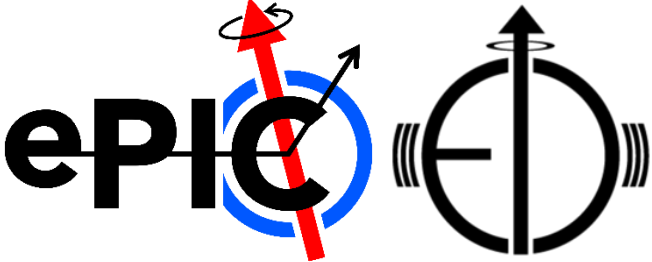
Daisy chained slow controls



- Can we extend the slow control chains to a length of 8?
 - Issues due to increased delay?
 - Do we have enough AncASIC addresses available?
- Two slow control chains of 4?
 - Considerations for FIB design (both S/C chains have a different reference voltage).



General RDO architecture



CB to FIB connections still to be considered!