



CERN/LHCC 2021-012
LHCb TDR 23
24 February 2022

Framework LHCb UPGRADE II TDR



Technical Design Report

[LHCC-2021-012](#)



Upgrade II workshop *short intro*

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*Upgrade II workshop,
March 29th 2023*



Istituto Nazionale di Fisica Nucleare

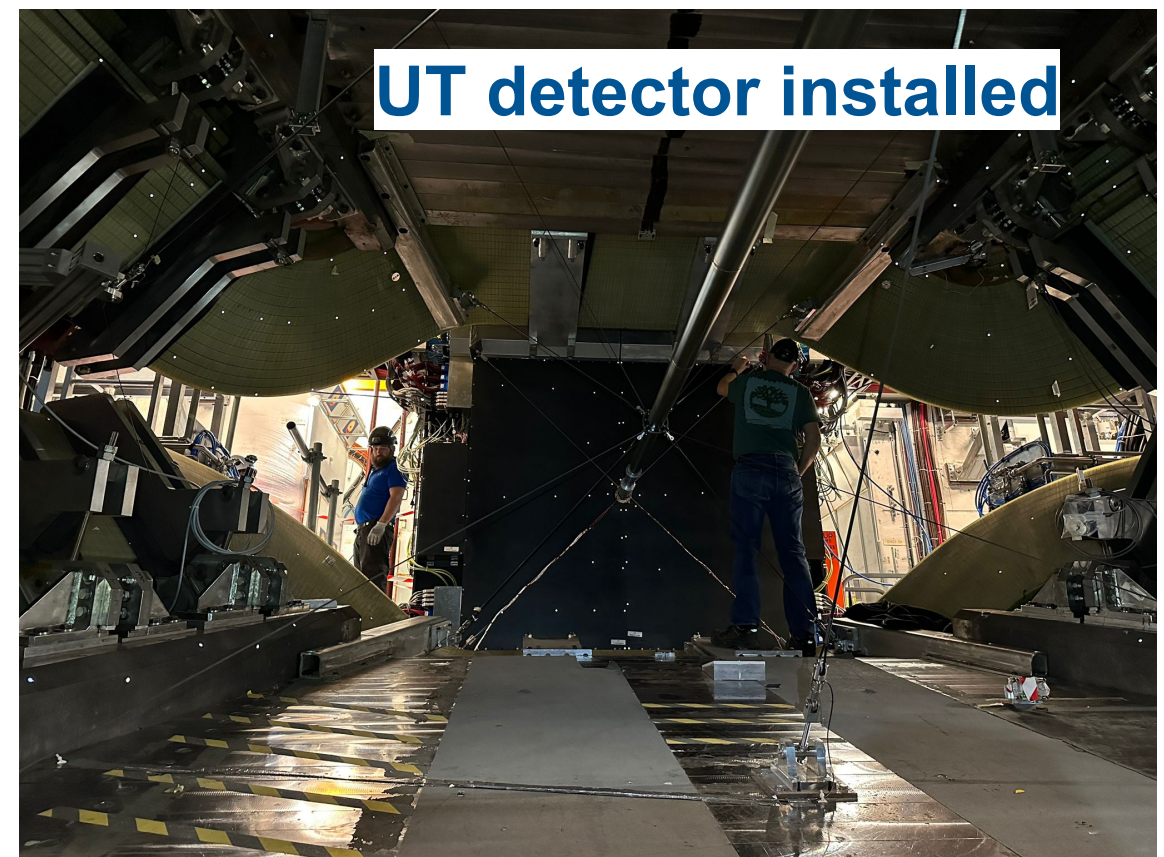
Upgrade I: installation completed!

We made it! Largest CERN detector project since completion of LHC

On-budget, and near schedule

**Functionality of detector components already demonstrated in 2022,
this year will commission UT, too**

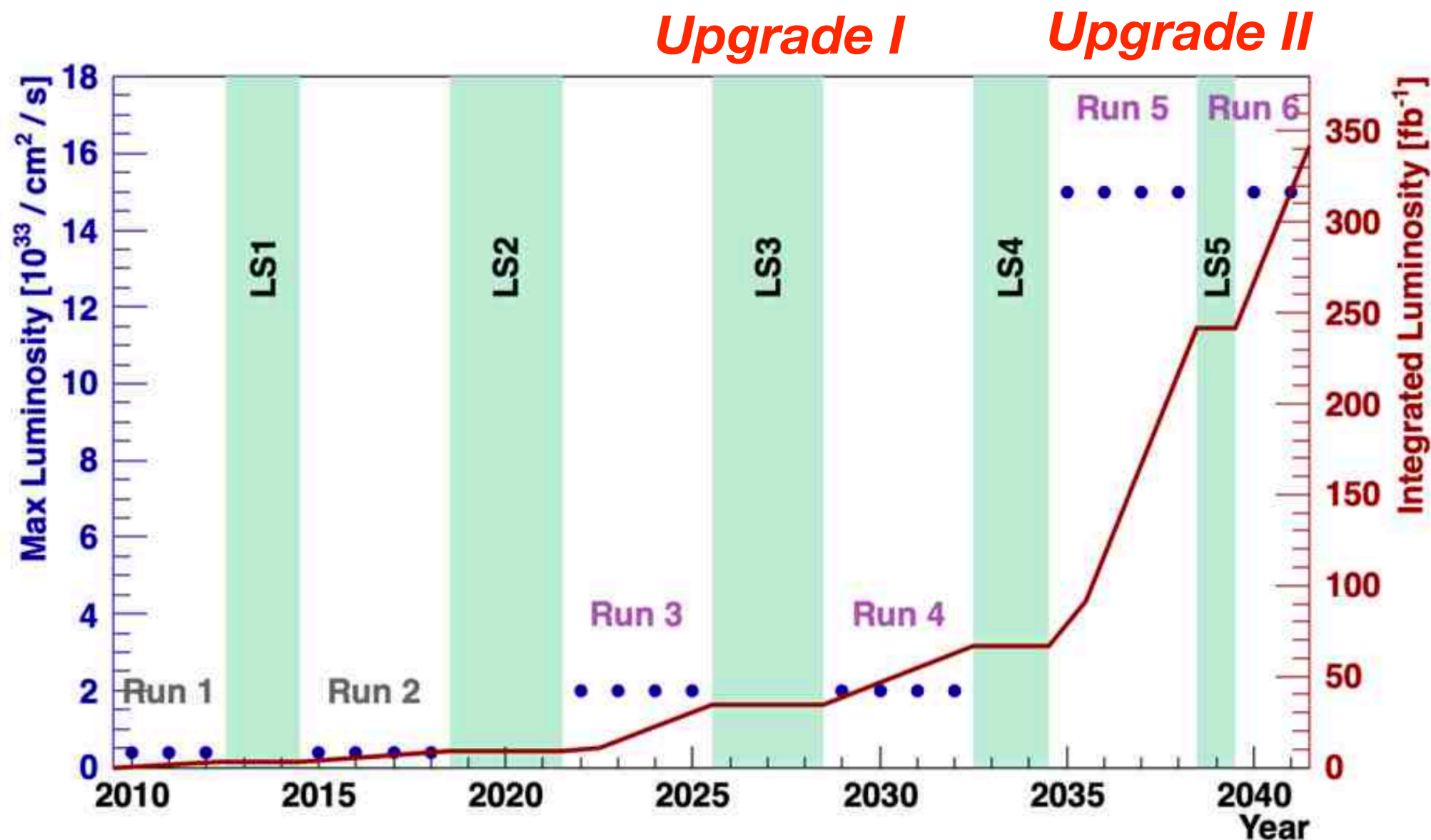
Need to bring to full performance before declaring victory!



Let's not forget: this is the first brick of Upgrade II

Upgrade II: setting the scene

Upgrade I will not saturate precision in many key observables: Upgrade II will fully realise the flavour-physics potential of the HL-LHC



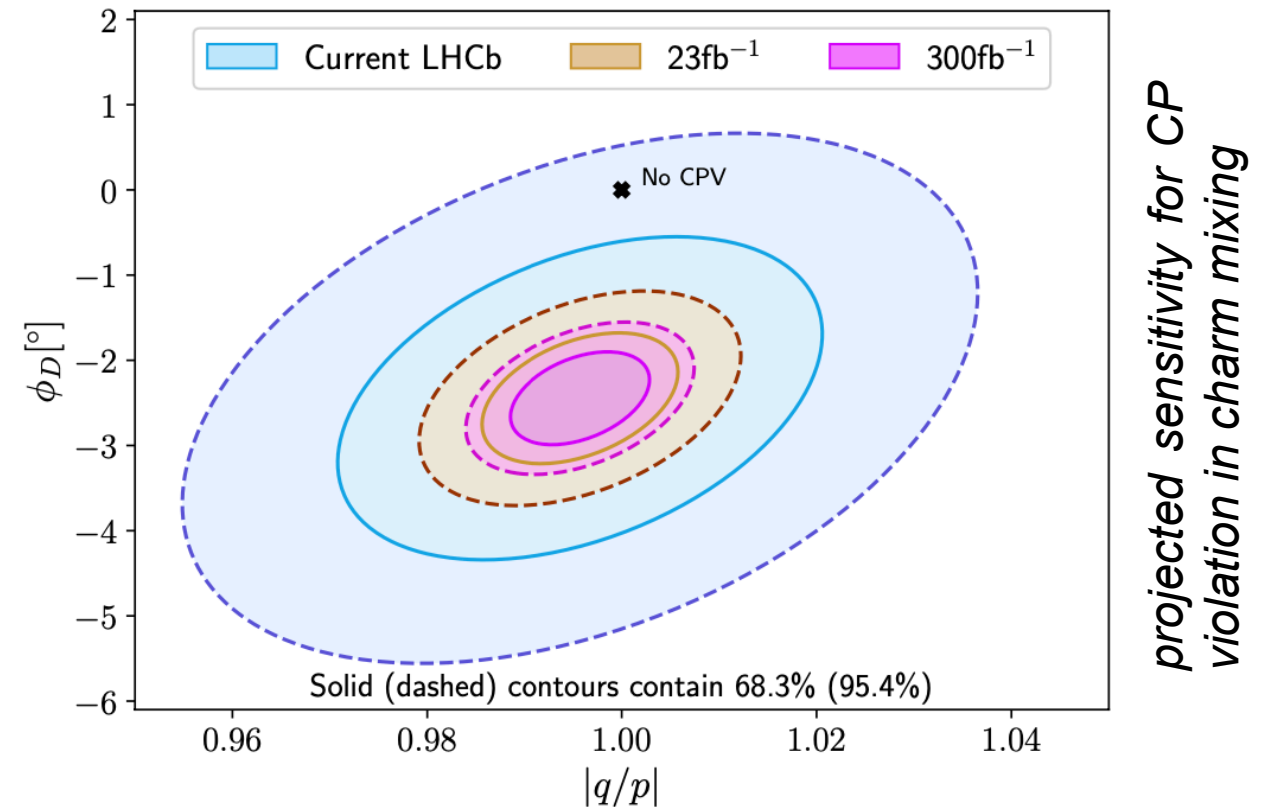
The project consists of a major change of the detector during LS4, in order to sustain an instantaneous luminosity of up to $1.5 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$ and integrate 50 fb^{-1} per year during Run 5 and Run 6 of LHC. **Key features of the HL-LHC schedule in order to be able to realise the Upgrade II programme are a duration of LS4 of two years, to install the new detector, and at least six years of data taking between Run 5 and Run 6.**

Upgrade II: where we stand

Let's not forget: we've a unique physics case!



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Unprecedented potential for heavy-flavour at the HL-LHC!

NOT ONLY: LHCb, as a general purpose detector in forward region, will keep pursuing an ambitious programme in spectroscopy, EW precision and Higgs physics, dark sector, heavy ions and fixed target physics ...

Approved March 2022

- Detector design and technology options
- R&D program and schedule
- Cost for baseline, options for descoping
- National interests

Upgrade II: where we stand

Upgrade II part of CERN baseline plan, the scope is what we discuss



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- *Detector design and technology options*
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- *National interests*

SCOPING DOCUMENT

Estimated cost scenarios (baseline and descoped) with analysis of physics performances

LHCC: "Some elements of this have been fulfilled by LHCb with FTDR"

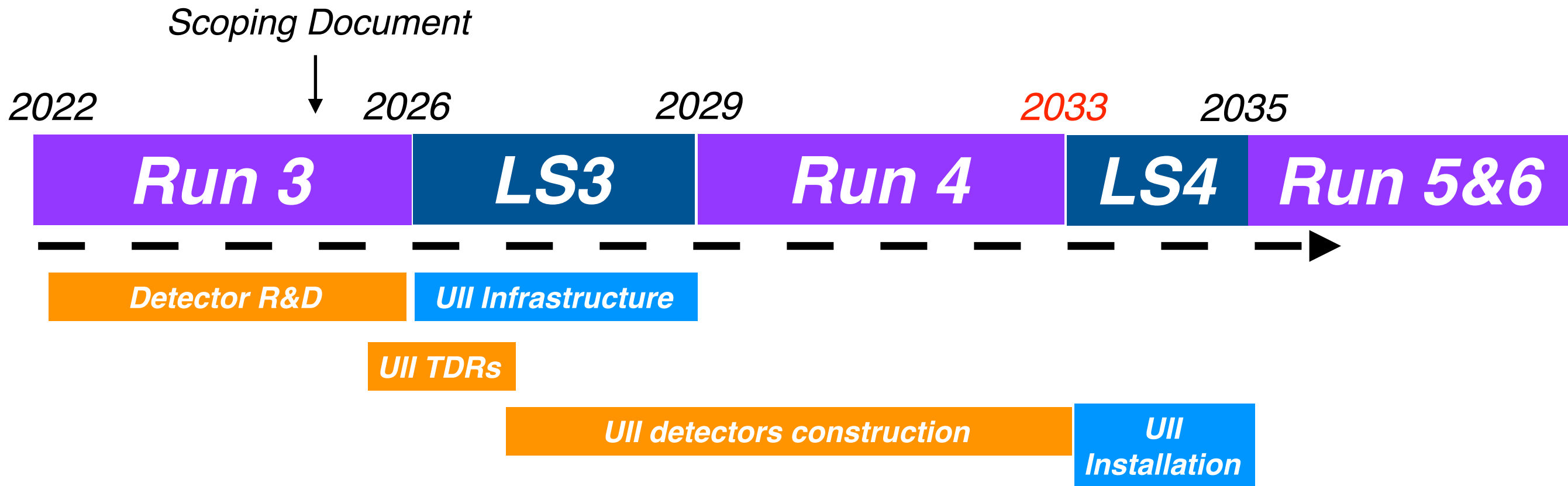
Need to complement with more detailed plans on the descoping option, and with a matrix of participations (person-power and funds) discussed with the funding agencies

This is needed before proceeding with sub-detector TDRs

Target is to produce the Scoping Document within 2024

CERN recommendation: *Need to bring realistic plans that can be achieved in the timescale available with appropriate contingency*

Timeline constraints



Constraints on Upgrade II plans

- All detector components fully ready at beginning of LS4, in 2033
- LS4 duration of 2 years will be fully needed for Upgrade II installation
 - Start detector element construction during LS3
 - Anticipate some LHCb detector infrastructure work to LS3

For the above reasons we need a Scoping Document reasonably soon, with sub-detector TDRs following at beginning of LS3.



Financial constraints

Funding boundaries investigated with national PIs at the end of 2022

In most countries things are developing well, with R&D funds secured or in discussion, and with a clear strategy to identify the envelope of the Upgrade II investment and to prepare the application.

Positive answers from UK and CERN already on the Upgrade II investment phase.

A lower/upper bound for the investment has been given by all PIs. Summing those numbers we defined LOW and MEDIUM envelopes to be compared with FTDR estimate

<i>LOW</i>	<i>MEDIUM</i>	<i>FTDR</i>
<i>~120 MCHF</i>	<i>~150 MCHF</i>	<i>~175 MCHF</i>
<i>conservative</i>	<i>optimistic, but not completely unrealistic</i>	<i>clearly above what can be achieved by present collaboration</i>
<i>all FTDR descopes</i>	<i>some FTDR descopes</i>	<i>full FTDR option</i>

*Impression is **very positive**, there's interest around our project, we can and we should build motivated detector scenarios for the MEDIUM and LOW envelopes.*

MEDIUM, in particular, can certainly offer nice physics opportunities for Upgrade II.

many thanks to the national PIs

Scoping scenarios

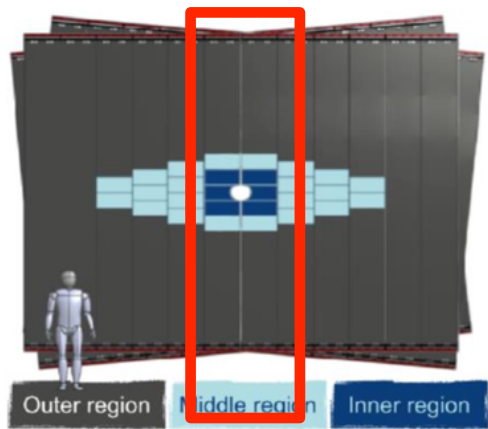
- Simulation studies will be needed to define the detector scenarios that maximise the physics output while matching the above financial envelopes (full details will be implemented only for sub-detector TDRs)
- Improved knowledge built on R&D results coming after the FTDR needs to be injected in the process
- In FTDR we indicated two main directions to explore: reduce peak luminosity (from $1.5 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$ down to $1.0 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$) and optimise and/or reduce detector features
- There's a lot to explore and to gain in the context of a global optimisation process; this will include also detector design VS online/RTA/offline
- New ideas are more than welcome, but need to bring clear benefits to the project and be realistic to achieve

We need a good organisation, we're too few to duplicate the efforts!

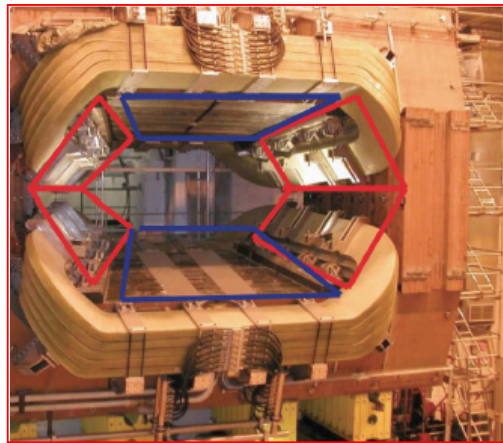
Opportunities for the detector at LS3

Limited-size detector consolidations also proposed for LS3, which will bring some physics benefits already in Run 4 while anticipating features of the Upgrade II

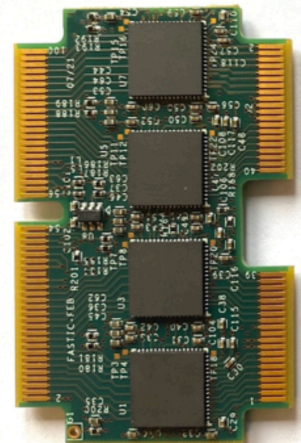
Several proposals presented in FTDR



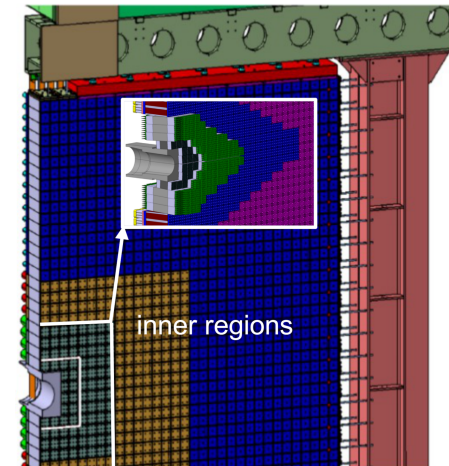
SciFi consolidation plus MAPS modules



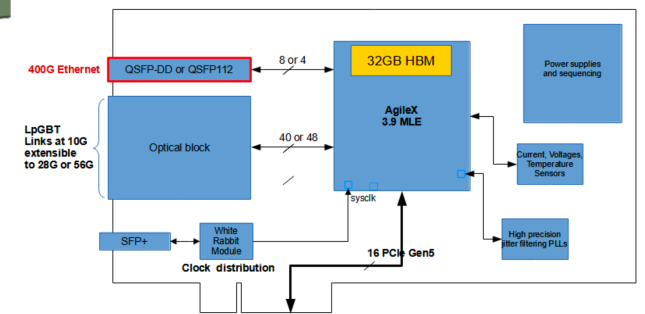
Magnet Stations



RICH electronics with timing



ECAL inner modules



New DAQ board with 400Gb/s

Downstream tracking with FPGA

Upgrade 2 Planning Group is organising reviews to carefully evaluate what can be achieved on LS3 timescale, depending on physics opportunities, technology readiness, availability of person-power and resources. If review is positive, light-weight TDRs will be prepared, which are due within late 2023/early 2024, in order to be presented to the LHCC

- RICH review March 22, ECAL May 3-4, both targeting TDR within September
- Downstream tracking with FPGA: review being organised
- Tracking detectors: to be discussed

Unlikely that all will be able to go forward on this timescale

**many thanks to
U2PG members
taking care of this!**

Conclusions

With the FTDR approved, and the SCOPING document ahead of us, this is the period in which we will form the collaborations for design and construction of our future detector

This is also the optimal period for new collaborators to join!

Ambitious targets need a larger collaboration

**The next phase of the project:
ambitious target + realism =
challenge => FUN!**



Conclusions

Two days in front of us to make the point on

- *detector optimisation*
- *tracking detectors*
- *PID detectors*
- *Online and infrastructure*
- *RTA and offline*

For speakers: please respect the allocated times!

discussion time needs to be preserved!



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so...let's discuss!