https://cds.cern.ch/record/2776420/

LHCb Upgrade II next steps

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ECAL workshop
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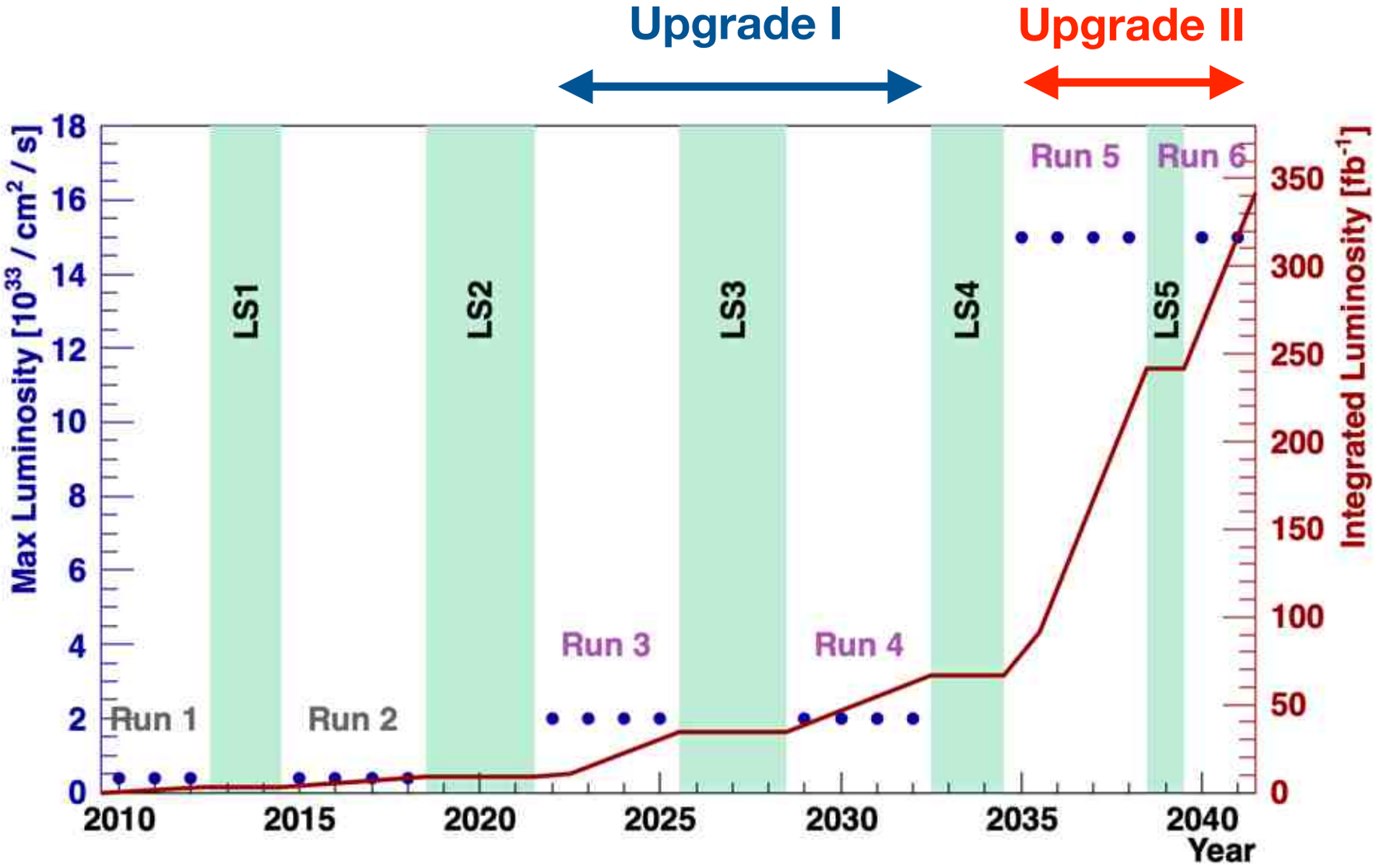
LHCb upgrades

Physics programme limited by detector, and NOT by the LHC, so there's a clear case for an ambitious plan of upgrades

Upgrade I starting now!!

- *L_{peak} = 2x10^{33} cm^{-2} s^{-1}*
- *L_{int} = 50 fb^{-1} during Run 3 & 4*
- *Healthy competition with Belle II at 50 ab^{-1}*



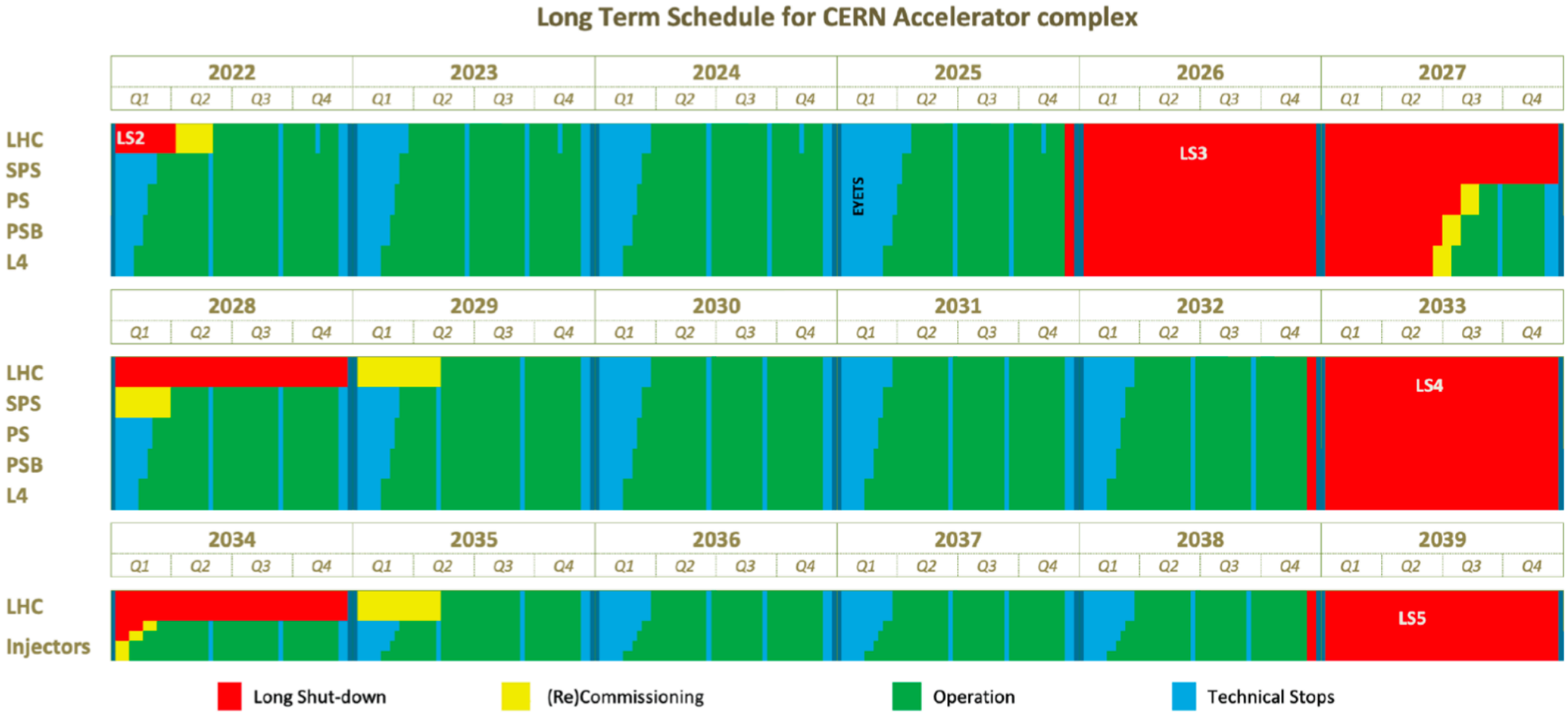
Upgrade II

- *L_{peak} = 1.5x10^{34} cm^{-2} s^{-1}*
- *L_{int} = ~300 fb^{-1} during Run 5 & 6*
- *Potentially the only general purpose flavour physics facility in the world on this timescale*

Long-term HL-LHC schedule

Mid-term schedule for HL-LHC is official and approved by Council until LS3.

Long-term schedule after LS3 is now semi-official and can be taken as the baseline by the experiments



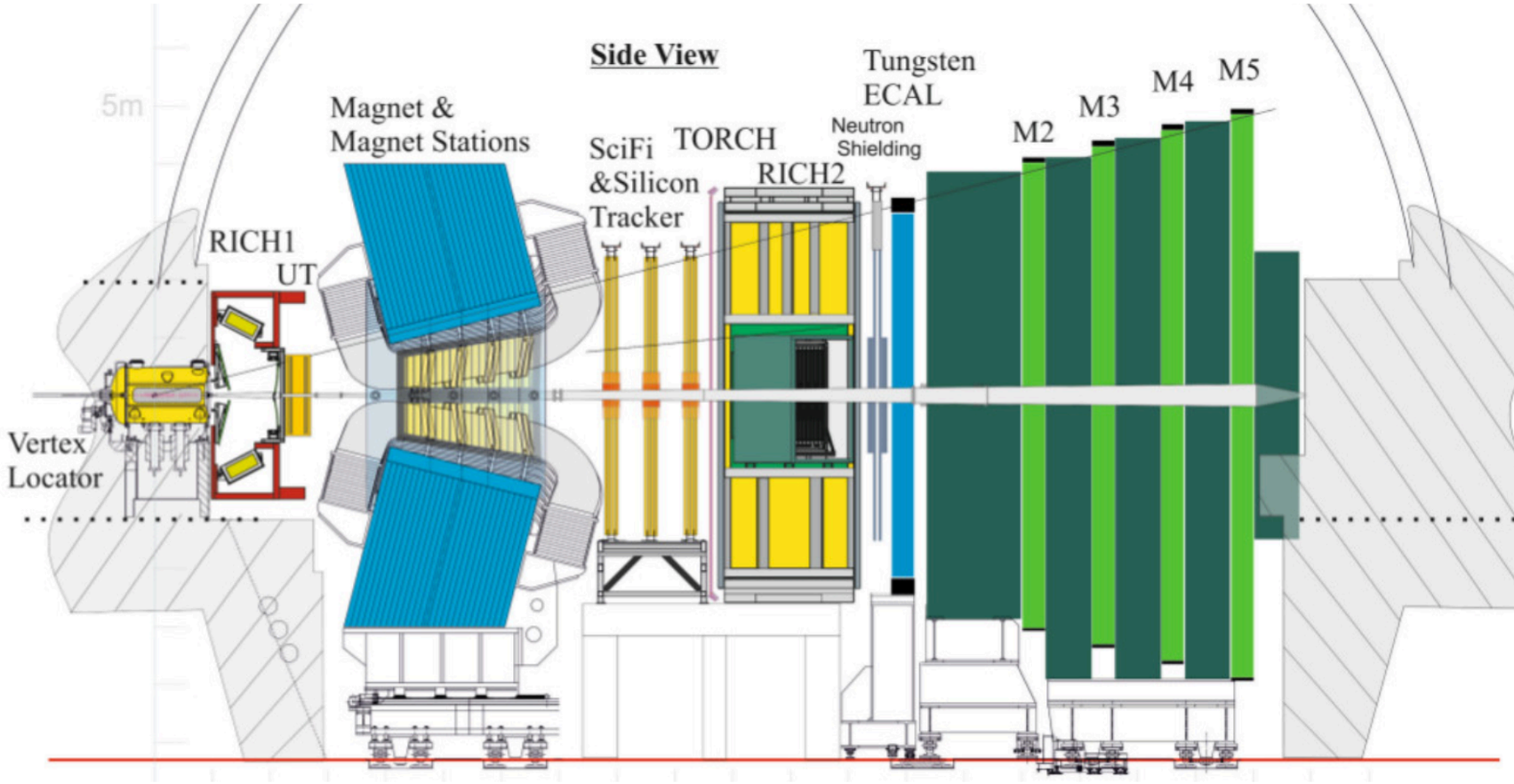
Installation of LHCb Upgrade II is guaranteed by LS4 of 2 years, LS5 and Run 6 are also planned

Impact on machine infrastructure: need to increase protection for both machine elements and cryogenic equipment in the UX85 cavern

- *erection of a shielding wall to protect the cryogenic equipment: complex logistic and interference with LHCb, 22 months needed → LS3 is the optimal period for execution, discussion on resources ongoing*

The detector challenge

Targeting same performance as in Run 3, but with pile-up ~40!



Same spectrometer footprint, innovative technology for detector and data processing

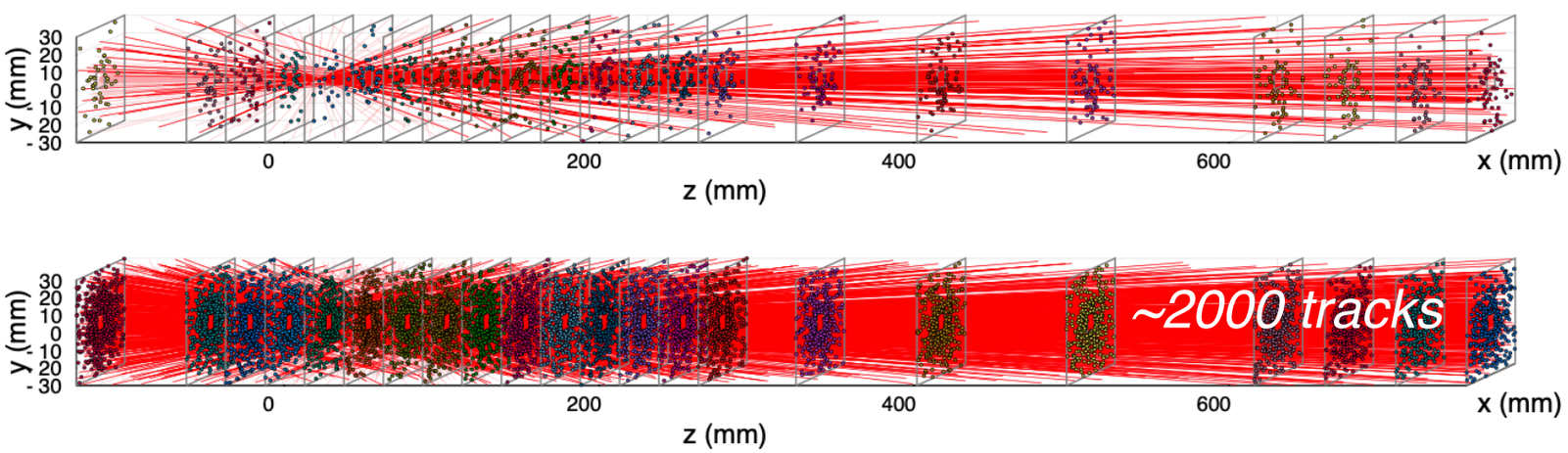
Key ingredients:

- *granularity*
- *fast timing (few tens of ps)*
- *radiation hardness (up to few $10^{16} n_{eq}/cm^2$)*

Run 3: pile-up ~6

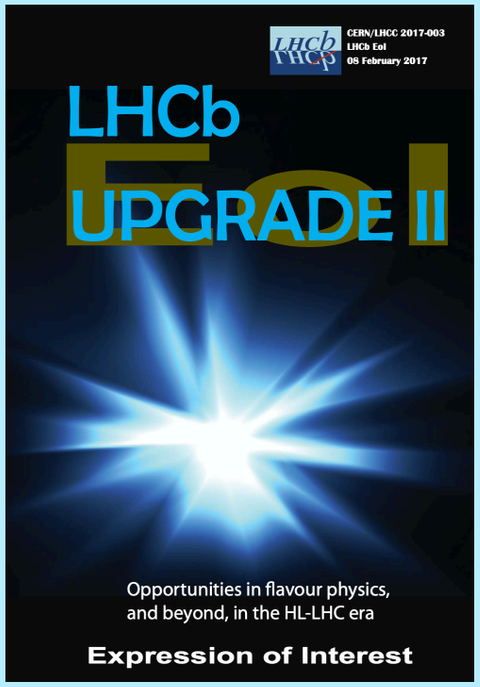
Upgrade II: pile-up ~40

VErtex LOcator (VELO)



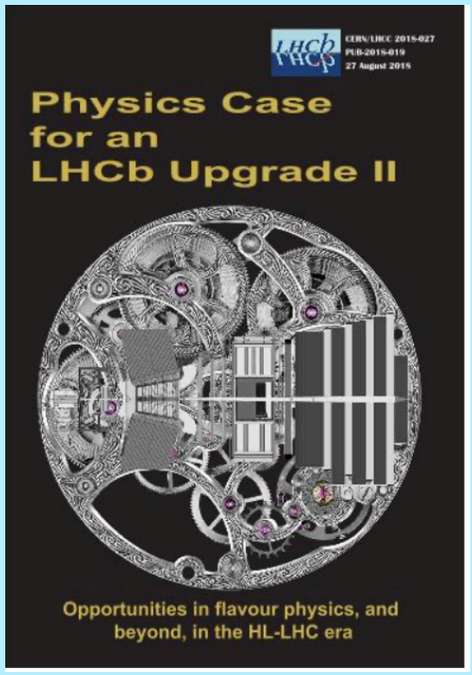
Upgrade II: approval steps so far

EoI



LHCC-2017-003

Physics case



LHCC-2018-027

Accelerator study

CERN-ACC-2018-038

CERN Research Board September 2019

"The recommendation to prepare a framework TDR for the LHCb Upgrade-II was endorsed, noting that LHCb is expected to run throughout the HL-LHC era."

LHCC-2021-012

Approved March 2022

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

LHCC recommendations on FTDR

- *Continue R&D to complete TRDs on the proposed schedule*
- *Continue investigating descoping and other cost-saving possibilities*
- *Careful planning of personnel resources, in addition to what is needed to operate and maintain the present detector, to make data analysis, and to carry out LS3 activities*

LHCC proposed to the Resource Review Board (*LHCC + CERN management + Funding Agencies)* ***an approval process in multiple steps, following what has been done for ATLAS/CMS phase 2***

- the approval process has been approved at RRB meeting october 27th

The Upgrade II approval process

WELL-DONE!

1.1 Letter of Intent: *overall description of the upgrade programme, with discussion of physics notation and performance, detector elements, plan for R&D, technologies*

"LHCb has fulfilled this step with the submission of the EoI, the Physics case document and the FTDR, all very favourably review by LHCC"

WE'RE HERE

1.2 Scoping Document: *estimated cost scenarios (baseline and descoped) with analysis of physics performances, person-power and funding profiles, project organisation and milestones, list of TDRs and project schedule; the document will be complemented by a money matrix (country vs sub detectors) to be agreed with Funding Agencies*

Document will be reviewed by the LHCC (physics and technical aspects) and by the Upgrade Cost Group (financial and project organisation)

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

2 Subdetector TDRs: *fully detailed design, respecting the envelope of the Scoping Document*

3 Start of construction

Scoping document: what is requested

1) Complete the evaluation of the descoping options, by presenting a cost table and physics performance studies (at the same level of what presented for baseline scenario)

- multiple options are also possible (lumi decrease, reduce detector features)

- assessing the physics impact of reducing a certain detector feature is also recognised as very important for strengthening the baseline design

2) Present a credible plan for person-power, demonstrating that we're able to carry on both data taking and physics exploitation of Upgrade I detector and preparation of Upgrade II

Preparation of the Scoping Document will certainly help in clarifying the contours of new participations

- strong interest from the scientific community in our physics case → collaboration size doubled during last decade and keeps growing

- while the descoping scenario should be tailored on the strength of the present collaboration, features of the baseline may be linked to a possible expansion of the collaboration

Target is to produce the Scoping Document within the next 2 years

Directions for downscoping

Consequences of downscoping are being studied, effect are driven by physics or technology, a few examples below, taken from the FDTR

system	what	cost reduction	impact/comments
RTA	reduce peak luminosity to 1.0×10^{34}	8 MCHF	reduce integrated lumi by ~15% , equivalent to one year of data taking, significant risk at this stage of the project
ECAL	single readout on outer region => reduce readout ch. by ~30%	13 MCHF	significant degradation in detector performance is expected, impact on physics under evaluation; effect on electrons (*i.e.* LFU studies) particularly important
TORCH	reduce coverage by 1/3	3.5 CHF	acceptance on low momentum particles reduced by ~25%, degradation on particle identification, with effect especially on flavour tagging, to be estimated
MT-CMOS	reduce CMOS pixel area by 40%	7 MCHF	this is possible if scintillating fibres with better radiation hardness properties become available to complement the pixels; reduction in tracking performances under study

The above preliminary numbers are given to illustrate the expected size of effects

We need to evaluate the impact on the physics programme, and to make best possible use of R&D on technology

For the Scoping Document, we need to take the challenge of discussing the size of the project in terms of physics opportunities vs collaboration strength vs funds availability

Impressions from the RRB

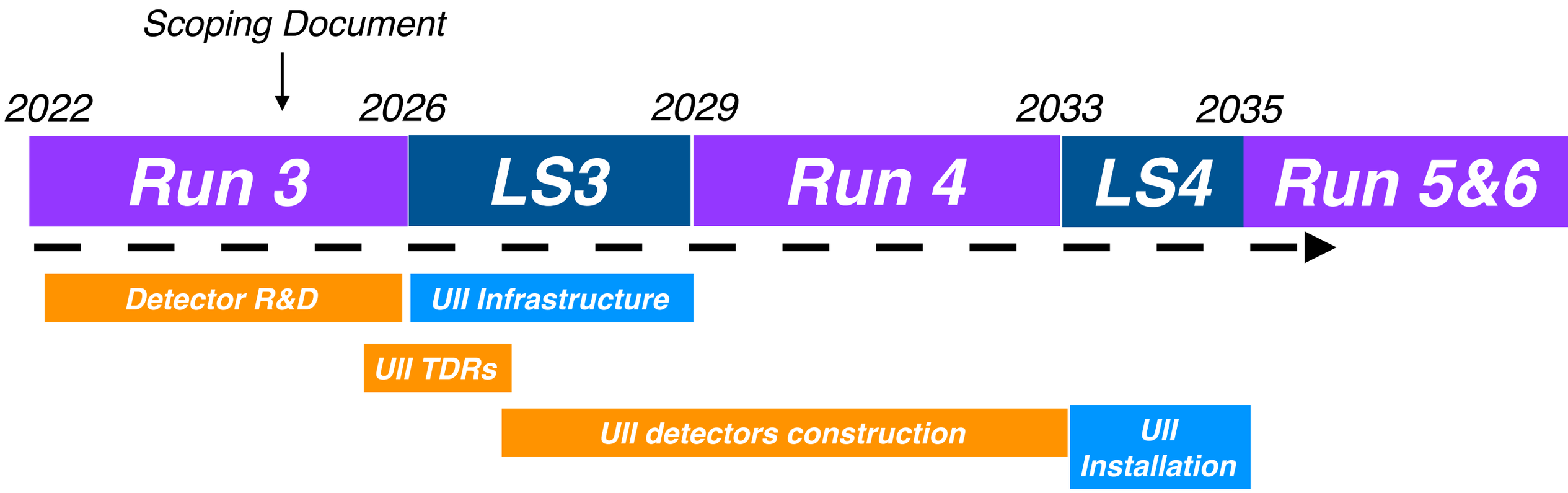
The ongoing effort on detector R&D was very well received

Things are start moving in several countries, with discussions being organised, or about to start, to define investments and/or define the steps to reach a decision: ~2 years seems in general a good target to have a more comprehensive view of the scope of the project. Some of the decisions will come definitely later.

There's a strong push from CERN management to keep pace with the Scoping Document preparation, in order to help convergence from the various countries

Discussions with the LHCb national PIs happening in these days: many thanks to all involved proponents for their effort in supporting the project!

Timeline and constraints



Constraints on Upgrade II plans

- Bring the Upgrade I detector to its full performance during 2023!

- LS4 duration of 2 years will be fully needed for Upgrade II installation

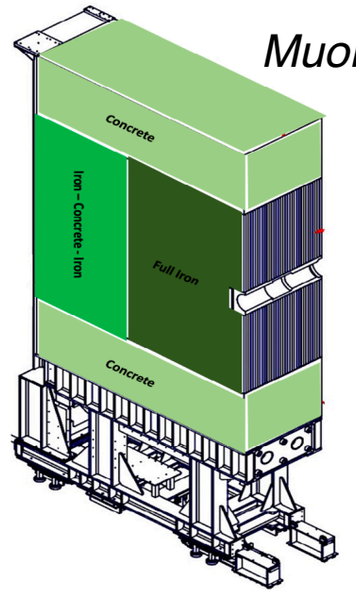
→ All detector components need to be ready at beginning of LS4!

→ Mitigation: anticipate some LHCb detector infrastructure work to LS3

Opportunities for the detector at LS3

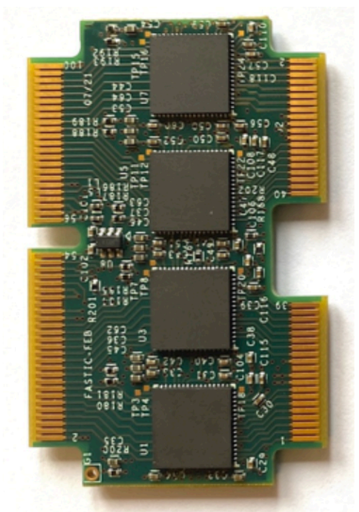
Upgrade II detector infrastructure preparation

- *Facilties/buildings for detector cooling, assembly, clean room, storage*
- *Additional shielding for Muon detector in place of HCAL*
- *New platforms for ECAL FE electronics*
- *Refurbishment of underground infrastructure for the online system*
- *Power distribution, safety systems*

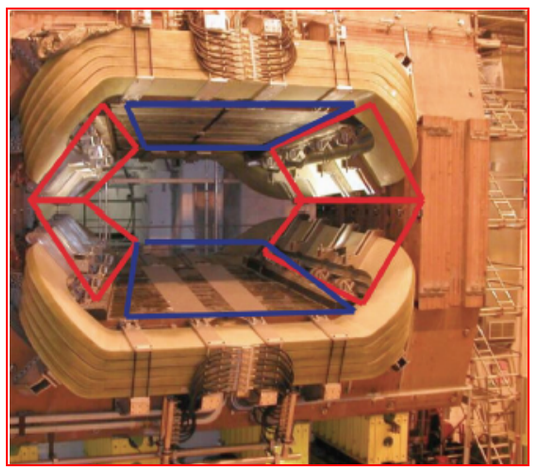


Muon shielding

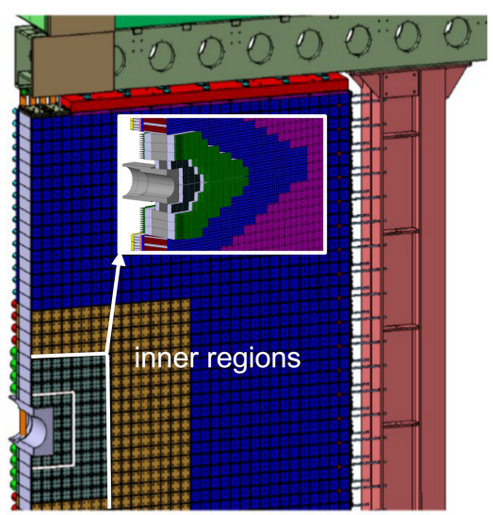
***Limited-size detector consolidations also proposed**, which will bring some physics benefits already in Run 4 while anticipating features of the Upgrade II*



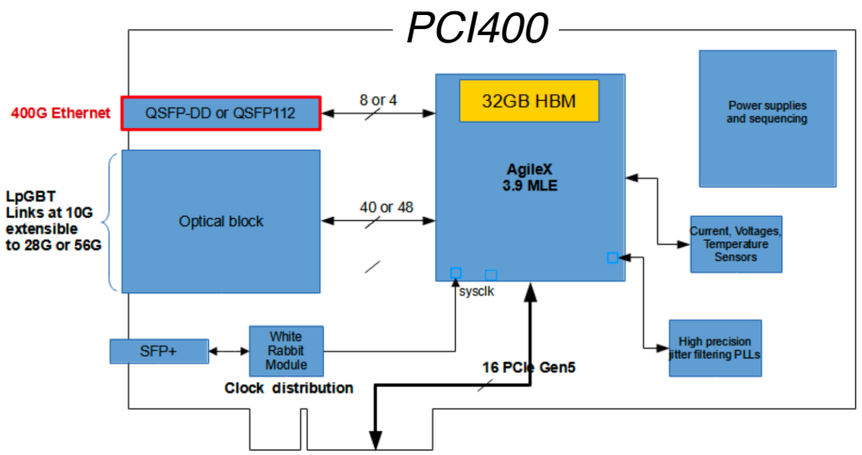
RICH electronics with timing



Magnet Stations



ECAL inner modules



New DAQ board with 400Gb/s Downstream tracking with FPGA

Limited size, carried on independently of the Upgrade II approval discussion, but cost accounted as part of Upgrade II for reused elements

U2PG reviews for LS3 projects

Upgrade 2 Planning Group is organising reviews of LS3 projects, covering the following points:

- *Physics motivation for Run 4;*
- *Technical readiness for TDR;*
- *Financial and human resources, with money matrix of countries/institutes and components (not yet commitments but strong feasibility);*
- *Safety margins on cost and person-power;*
- *Schedule of TDR and construction;*
- *Accounting of LS3 project cost in Upgrade II core must be clearly defined.*

ECAL referees: Hassan Jawahery, Guy Wilkinson, Tim Gershon

If approved, proposals will be discussed in TB and then proceed to a light-weight TDR to be submitted to the LHCC

TDR for LS3 proposals are due within early-2024

- *opportunity to submit to LHCC a common RICH-ECAL TDR in september 2023*

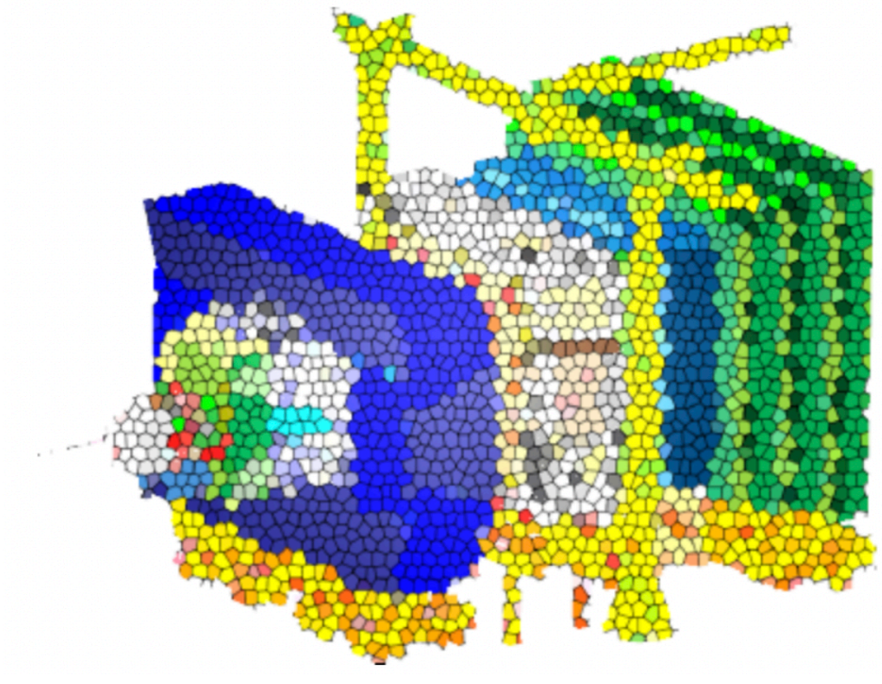
Conclusions

LHCb has fulfilled the first step of the approval for the Upgrade II project with a lot of documentation produced, the EoI, the Physics Case Document, and the framework TDR, all very favourably reviewed by the LHCC

There's now a clear strategy proposed by the LHCC to give final approval to the project (same as ATLAS/CMS): next step is a Scoping Document, coming within then next 2 years, to decide on the detector scenario which has best chances to be realised

In the meanwhile, we will need to discuss the feasibility of the LS3 consolidation plans and present the related lightweight TDRs

All of the above will be discussed at the



6th Workshop on LHCb Upgrade II

29.03-31.03 2023
Barcelona

https://indico.icc.ub.edu/event/163/