Accelerator-experiment interface & LS constraints, summary and next steps

Beniamino Di Girolamo

CERN

Few key points

- Very dense workshop and a lot of interesting points of attention
- Here few key points and few examples
- Inter-experiments and accelerator-experiments collaboration thanks to this workshop, LS1, next workshops, … it is paying off
  - Even before conclusions: I think everybody agrees we need to continue

HL-LHC

- How to arrive there in a few questions
- Do we need HL-LHC? YES
- Do we need it by 202x? YES YES
- Do we need y ab^{-1}? YES YES YES
- Fine, but let's work out what it needs

Limitations we need to overcome

- As soon as the threshold of 300-400 fb^{-1} is crossed the radiation damage plays a big role
  - We need a change of the inner triplets
  - We need a change of damaged detectors and mitigation measures for next candidates for failure
- To do any physics beyond 400 fb^{-1} we need to act

Long list of needs for accelerator

- Several new elements needed
  - Triplets, 11 T dipoles, collimators, updated cryogenics, crab-cavities, cold powering, machine protection
- Immediate consequences
  - Possible civil engineering in the tunnel (crab-cavities)
  - Possible civil engineering on surface

Long list of needs for detectors

- New detectors or components to fight ageing
- New electronics/detectors to make use of higher pile-up
- New readout and triggering
- New ways to maintain detectors to fight very hostile environments

Special requests

- Heavy and less Heavy Ions
- A bit of forward physics (more to come?)
- Needs in LS2 to make special things to happen
  - SPS injection upgrade
  - Dispersion suppression collimators
  - How many months are needed?
- Need a flexibility for data/analysis-driven needs when not much theory guidance is in place

But how to run at HL-LHC?

- We have seen the baseline possibilities
  - Plan A (crab-cavities, $\beta^* = 15$ cm)
  - Plan B (beam-beam wire compensator, $\beta^* = 50$ in X and 10 cm in ||)

But how to run at HL-LHC?

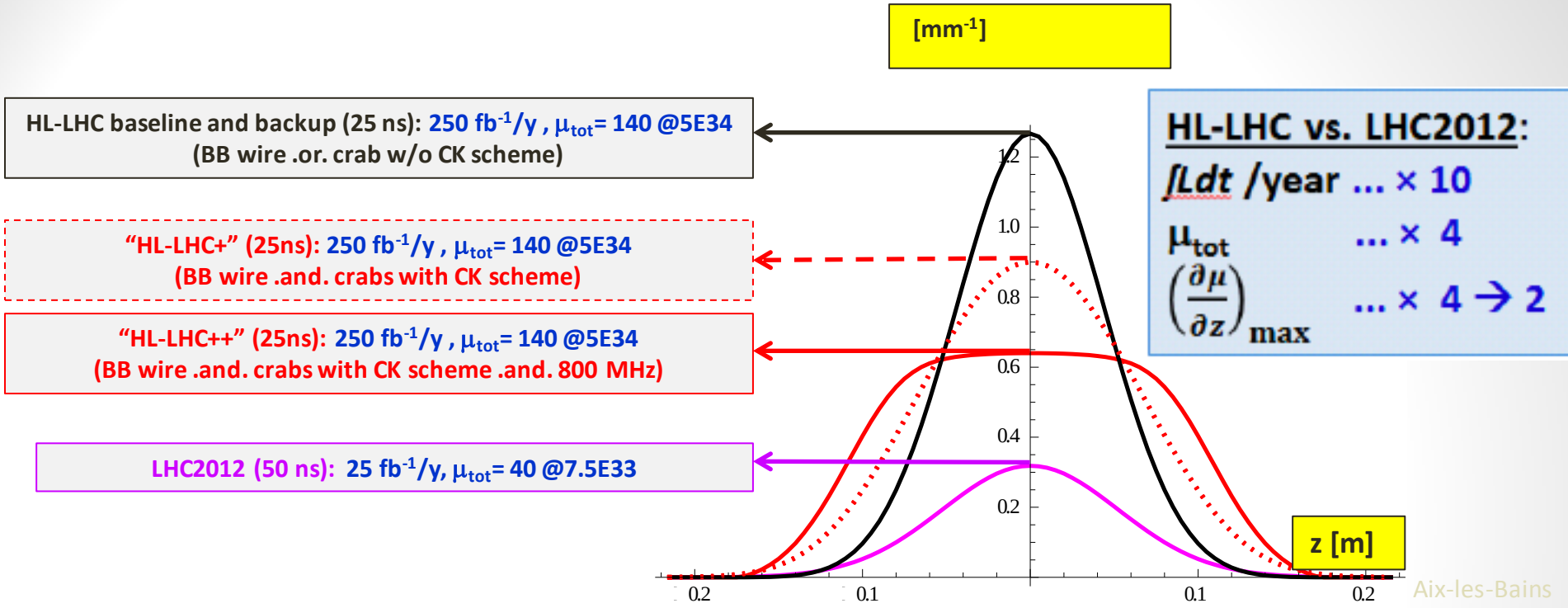
- In both cases
  - the luminous region is small (4.4 cm)
  - with the 140 pile-up events
    - we get to a line pile-up density of 1.27 evt/mm
    - and pile-up time density of 0.34 evt/ps (A) to 0.12 evt/ps (B)
- Difficult to manage a vertex separation

Crab kissing

- Elegant solution
- However it needs that the hardware works (CC and BBWC)
- The integrated luminosity per year remains ~ 250 fb^{-1}/year
- The bunch structure doesn't ~ change

Crab kissing

- Adds flexibility (simultaneous optimization of linear and time pile-up-density) and adds Crab-Cavities on both vertical and horizontal planes for both IP1 and 5
- It is not invasive to experimental caverns
- The longer luminous region size with the 800 MHz RF upgrade
- The line pile-up density is as low as 0.65 evt/mm at 140 pile-up events (1 evt/mm at 200)



HL-LHC vs. LHC2012

Int. lumi/year 250 vs. 23 fb^{-1}

μ_{tot} 140 vs. 40

(dm/dz)max can be reduced from x4 to x2

Reminder: 0.65@140 is 1.0@200 and 1.3@140 is 1.8@200

What's next?

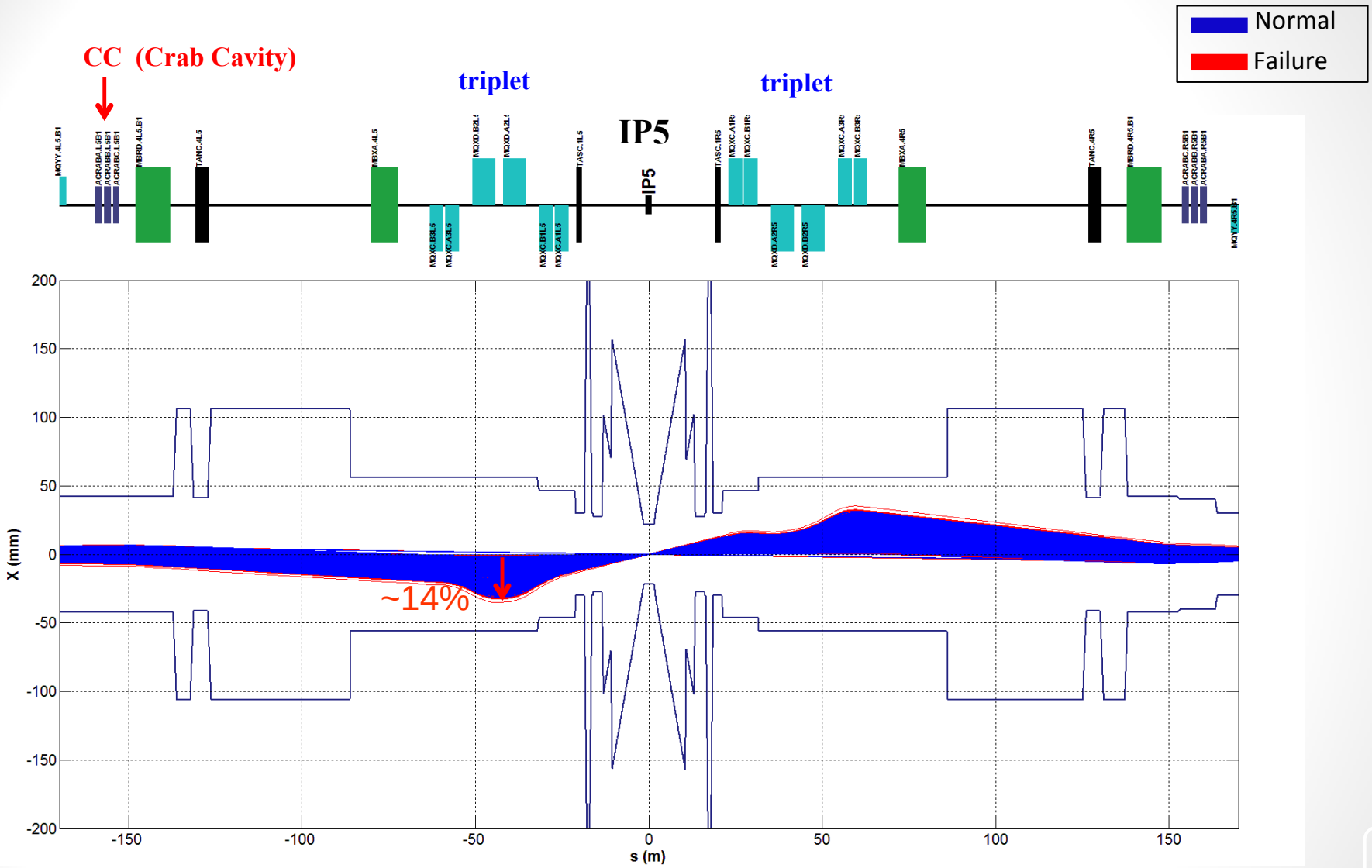
- We need now to have a comparison study
  - baseline with 4.4 cm r.m.s. (± 10 cm full length) luminous region and 1.27 evt/mm (max 1.8 evt/mm)
  - crab kissing with ± 15 cm full length and 0.65 evt/mm (max 1 evt/mm)
- We need to evaluate the impact on resolution and efficiencies and cost (size of the tracker)
- The ball is in the experiment's camp

Apertures

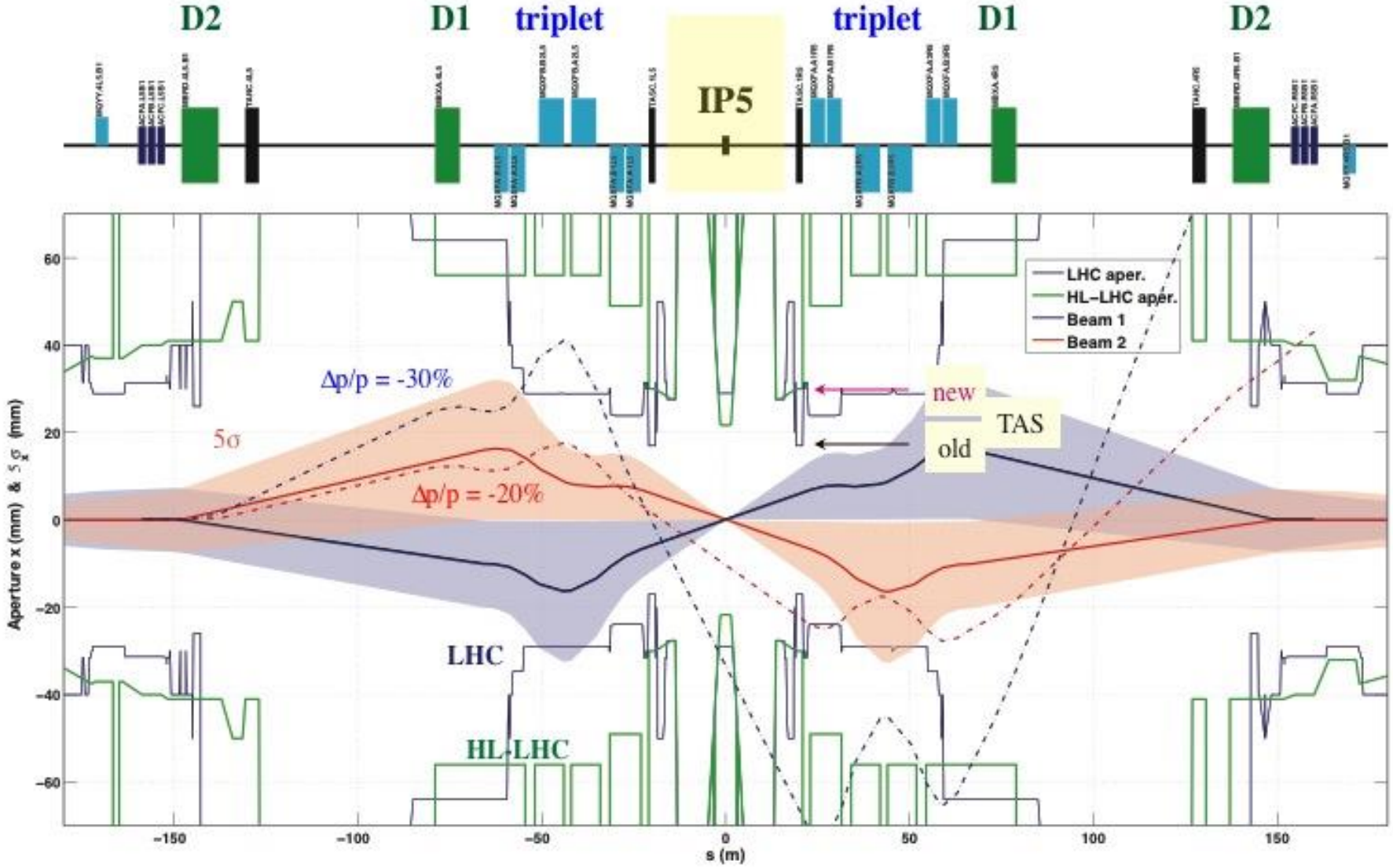
- The HL-LHC has big apertures (so far)
- The experiments would like to keep low diameters beam pipes
- Existing simulations are looking at risks to machine elements vs. apertures
  - We need to have a look at the risks to experiments inner layers vs. apertures
  - And help each other!
  - A lot of work started and it is vital to continue
    - So far no indications of big issues, but it needs more work

5 turns after the failure

Beam 1 IP5 horizontal plane



First results rather encouraging:
fast but still manageable growth times protected by collimator system



Based on studies and plots by Frederic Bouly

5σ envelopes, β* = 15 cm

The TAS

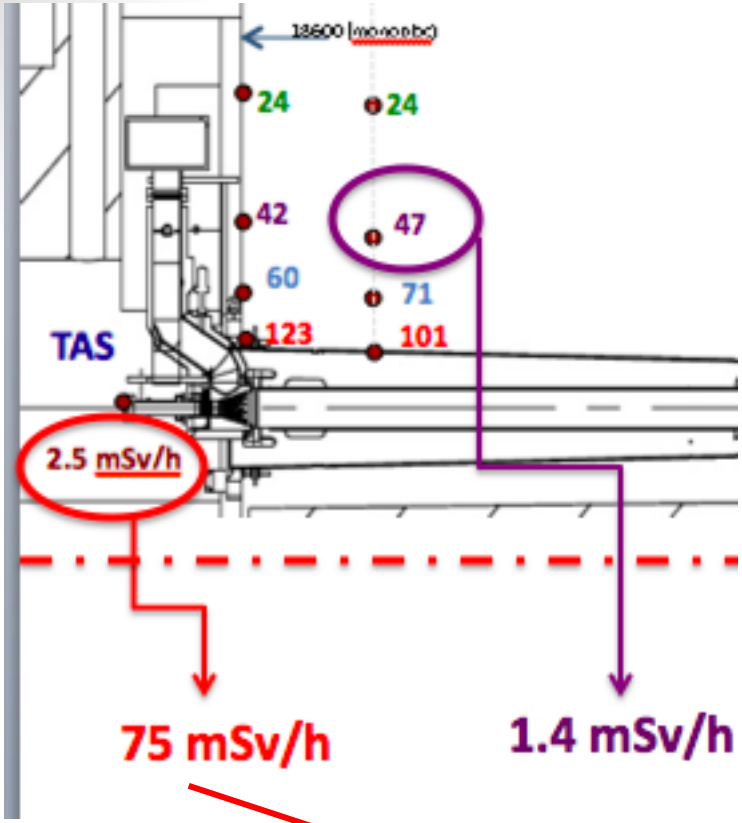
- The TAS aperture change implies the access to highly activated material
  - anticipate to LS2? How long it takes?
  - With removable lower diameter core?
  - Triplets will need it to be 60 mm?
    - Let's have it even larger with the concept of removable cores
    - Modify it as soon as possible or the work will impact LS3 length!

Activation aspects

- Anticipating the bottom line: HL-LHC and the experiment will become difficult
- Long lived radio nuclides make that 1 year cooling after LS > 3 is less effective than 1 year cooling after LS1

Activation aspects

- Nice work of evaluation
  - It needs an unification of the assumptions
  - Can we agree?
    - After LS1, Run 2, 45 fb^{-1}/y
    - After LS2, Run 3, 55 fb^{-1}/y
    - After LS3++, Run 4++, 300 fb^{-1}/y
- Problem
  - How to reconcile next slide?



How to reconcile these snapshots?

3 Oct. 2013

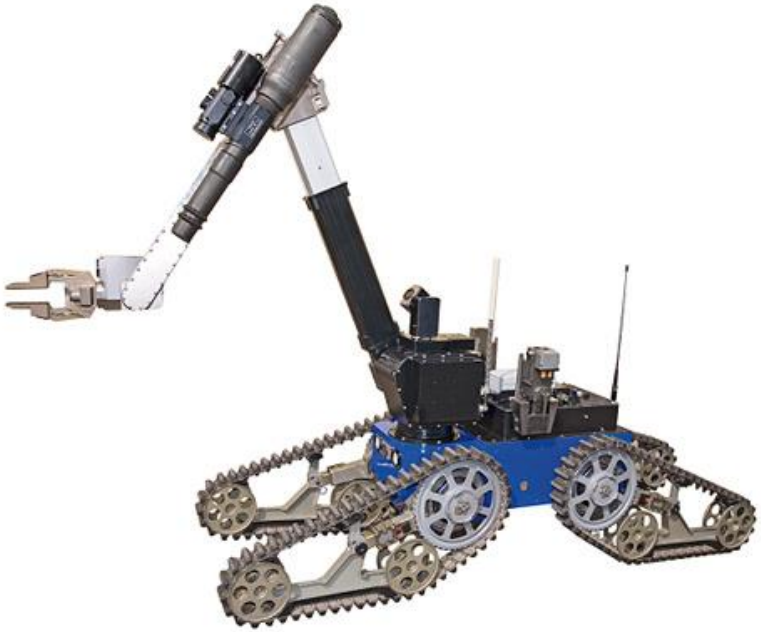
Individual dose equivalent	Level I	100 µSv	Level II	1 mSv	Level III
Collective dose equivalent		500 µSv		5 mSv	

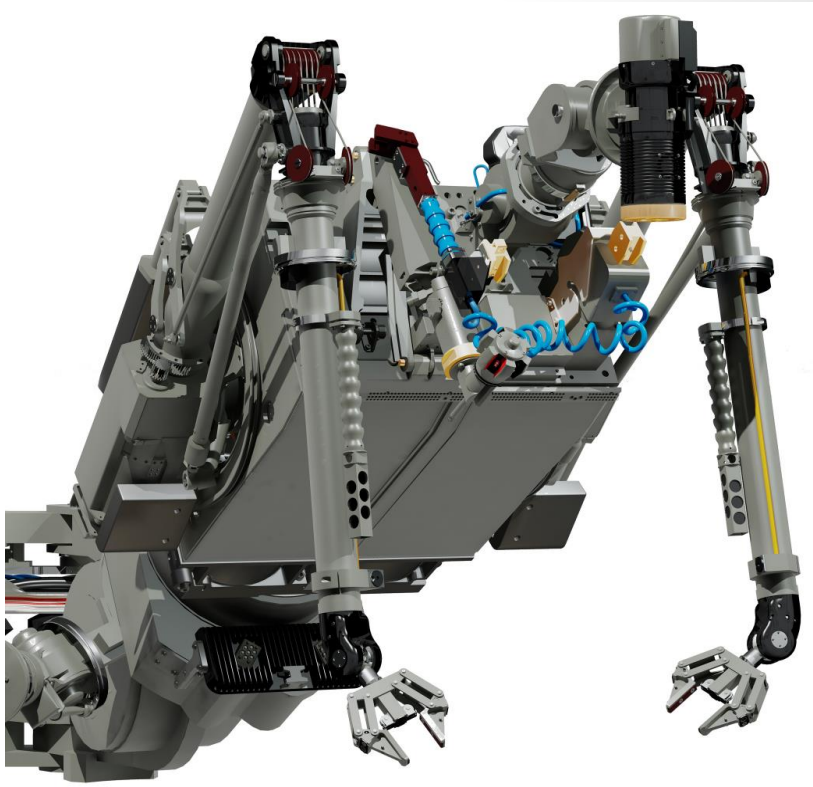
Group 1 criteria: determine ALARA Level classification

Ambient dose equivalent rate	Level I	50 µSv/hr	Level II	2 mSv/hr	Level III
Airborne activity in CA		5 CA		200 CA	
Surface contamination in CS		10 CS		100 CS	

Activation aspects

- Strategy
  - Shielding
  - Supervision
  - Robotics
  - Stopwatch
- Decommissioning of the existing detectors needs to make use of these as well as installation of new ones





- Challenge: adapting also to detector needs
  - The accelerator has a floor for movements
  - Experiment would need a flying object or built on-the-spot floor

Infrastructure

- Complicated issues for ageing infrastructure
- Need of closer collaboration among experiments Technical Coordination to prioritize and synchronize the schedule
  - No synchronization: call for failures
- Long list in the presentation

Infrastructure

- Many example also from other talks, only two here
- xTCA is 4x more demanding in power and has (by default, but can be modified) back-front cooling; a crate has 14 slots vs. 21 in VME. The price of high speed.
  - We need to adapt the cooling and if we don't want the space needed to explode we need higher density of channels readout per board

Infrastructure

- More civil engineering on surface needed for accelerator needs
- More civil engineering also for CO_2 plants?
  - Quantum: 20 kW plant
  - Size ~ LxWxH = 1x2x3 m^3
  - 5 plants could fit in the space now taken by compressors in ATLAS, but could CO_2 tank(s) as well fit?

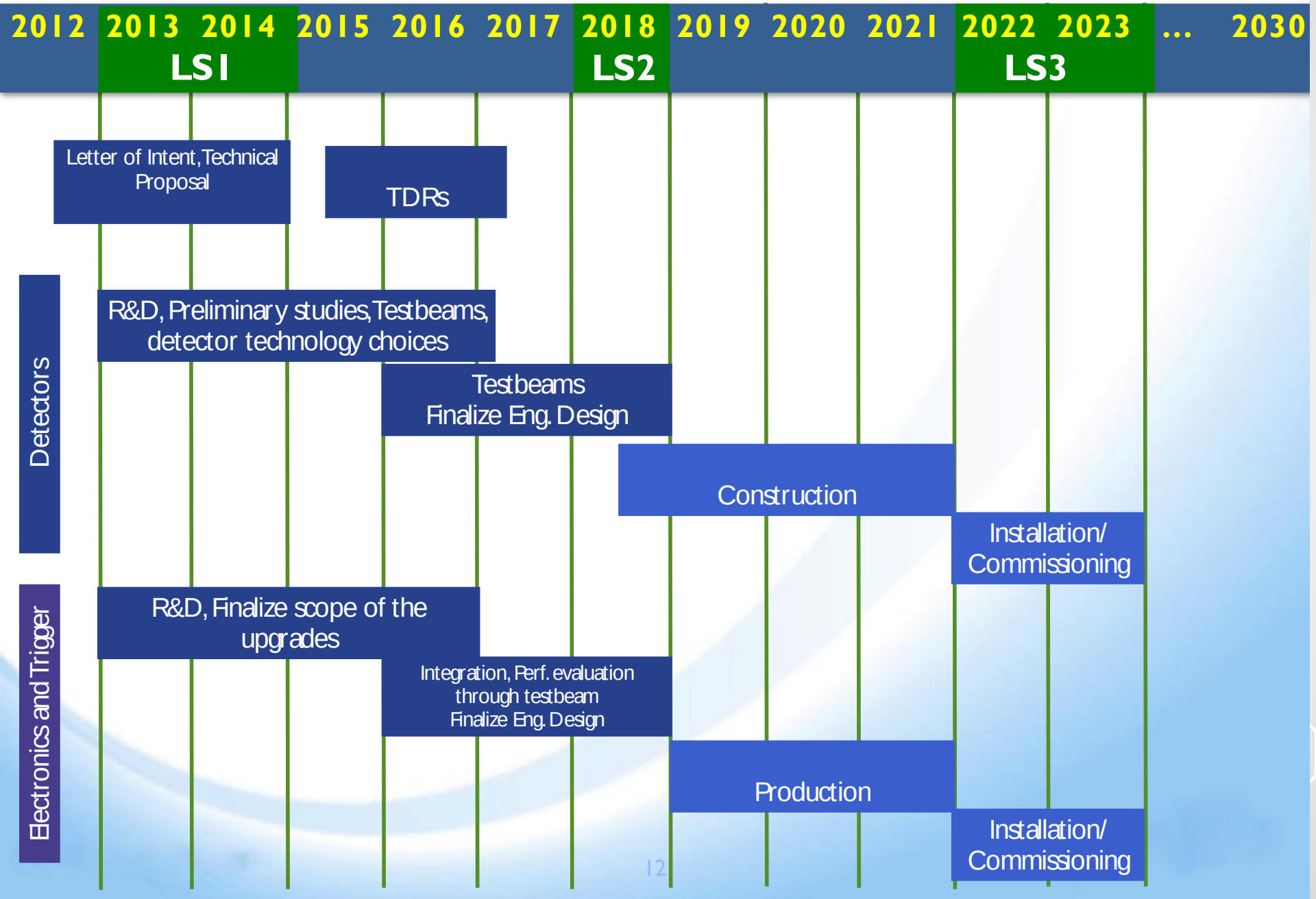
Schedule and constraints

- LS1 half way
- YETS request in 2016/2018
- LS2 18 months request and 6-12 months later than baseline
  - We heard that there is a need also from the accelerator: we need a confirmation
  - Advancing the work on TAS can have an effect
- LS3 could become longer due to activation aspects, infrastructure increase and maintenance, longevity issues still to discover and… our usual packing of whatever we can
- Bottom line **$LS^3 > LS^1$**

How to exploit then HL-LHC?

- Important ingredient is to have a strategy to implement the Strategy
- We have now experience and many elements (to be complemented continuously) to draft a more precise planning
- If we know when things happen we can use the information. Example next slide

Possible Timeline for upgrades to be installed in LS3



Simple math

- We don’t need high math skills to calculate that at 250 fb^{-1}/y we need ~10 years to achieve our target
  - Even counting 300 fb^{-1} from LHC

Limitation to flexibility to be imposed?

- Flexibility/resilience is an important skill
- However we need to have a vision
- Adding the number of months of the previous slides I can only project the x ab^{-1} being reached at ∞
- Whatever is the shutdown pattern, we need to calculate what is the running pattern. Work it out and stamp it a.s.a.p.

Long term strategy

- We are stretching the timeline
- Our vision has to be larger than HL-LHC or we won't do other than it
- What about dreams and future colliders (ee, pp, ep, μμ, and else?)
- Will this community stop thinking at building future detectors? I doubt

Price for flexibility or a recipe

- The price: x ab^{-1} not reached on human affordable time
- A possible personal recipe: in view of the scenarios that can moderate the pile-up density (crab kissing) we may need to decide
- to accept higher pile-up than 140 to be able to integrate more luminosity in less time.
  - HL-LHC will provide 10^{35} lumi to be leveled
- Or ask for more efficient

Consequences

- Fixing the plans is important
  - we can't delay too much the decisions on the limits on the electronics and the bandwidth of the links
  - We need to work out the strategy for funding and the strategy for running
  - We may need to make some compromise and better usage of the shutdown times
  - LS>3 will be increasingly difficult, if we will need them shorter even better

Conclusions (1/2)

- The communication established by experiments internally and with the accelerator needs to be maintained at the high level achieved:
  - Design the right machine for the right detector and vice versa

Conclusions (2/2)

- The schedules needs to be fixed very soon and respected
  - Loaded with resources (personnel, infrastructure and money)
  - Synchronized among experiments and with accelerators (input to RLIUP)
- We need to merge the previous points with a long and wide vision

THANKS!