Future R&D

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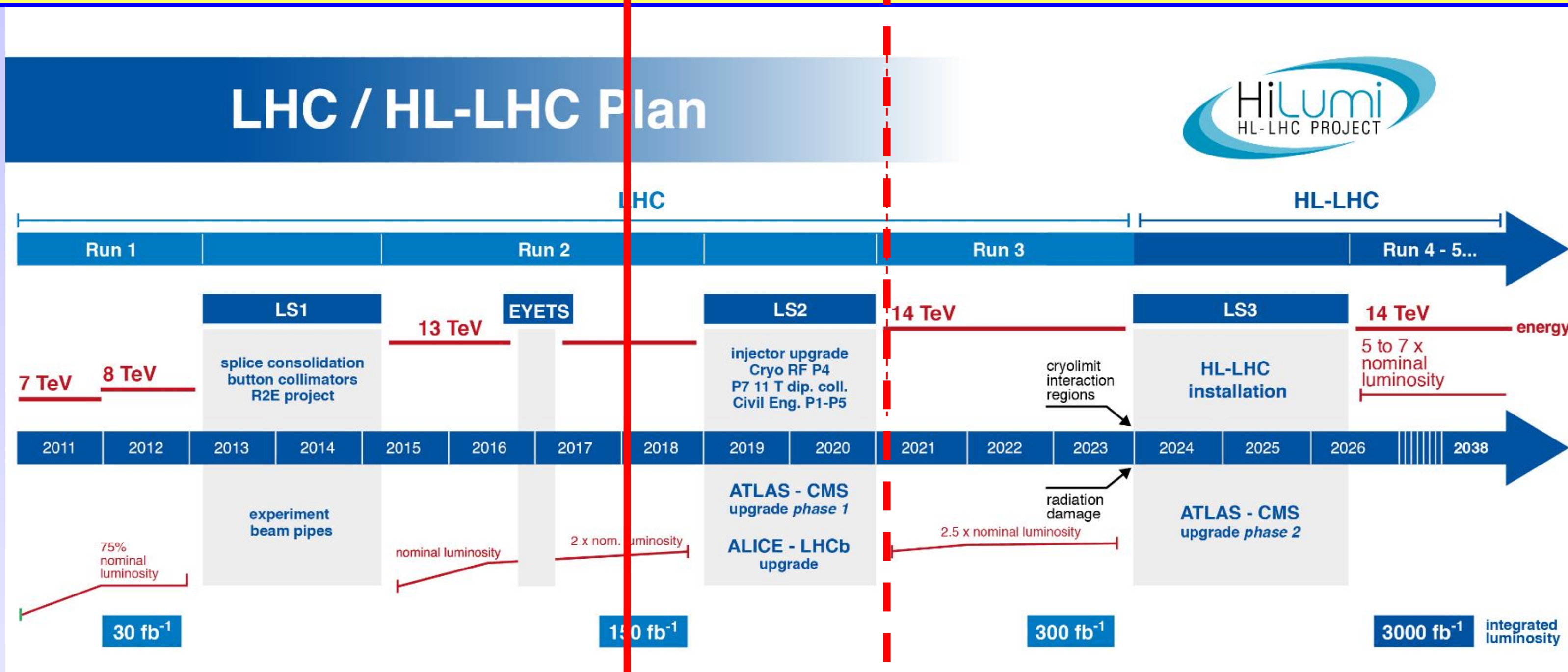

End of HL-LHC
“fundamental” R&D ??

- **Shifting RD target?**

Today, this morning!

Future work on FCC tracking

- **VERTEX Conference September 2017: Status & Challenges of Tracker Design for FCC-hh,** Zbyněk Drásal on behalf of FCC-hh detector working group

Summary & Challenges

- **The key tracker parameters have been studied & optimized:**
  - → **Layout:** ~430m^2 (391m^2 in tilted layout) of Si, with: 5461M (pixels), 9964M (macropixels), 489M (strips)
  - → The **granularity in R-Φ** driven mostly by **dp_T/p_T @p_T=10TeV/c → achieved dp_T/p_T ~20%**
  - → The **granularity in Z driven by prim. vertexing** & **pattern recognition** capabilities @PU=1000:
    - Due to minimized mat. budget **the tracker (even vertex detector) in tilted layout very advantageous** to achieve similar pattern recognition performance as with PU~140 & HL-LHC conditions → realistic engineering (technology input) with services, cooling & support structure important!
    - **Primary vertexing & correct PV assignment @PU=1000 seems feasible up-to η~4**, but only with precise timing information σ_t~5ps (2D vertexing, several timing layers assumed) → the limiting factor for **high η coverage is beam-pipe material**
  - → Expected data rates (**766 TB/s untriggered**, **19 TB/s triggered @1MHz**) implicate need for new read-out technologies (high speed, low power optical links) & dedicated trigger design!
  - → **1MeV neq fluence ~6x10^{17}cm^{-2}** & **TID ~0.4GGy** @ **R=25mm** represent **new challenges** for the tracker (vertex detector) technologies

→ **Dedicated R&D is needed to meet the challenging requirements!**

Z.Drásal, Vertex 2017 Asturias Spain (10-15th September 2017) 45

Sensor/Frontend Electronics point of view: Showstoppers!!

Need for radhard precise timing detectors 5ps:
→ Not existing!
…so far 30ps seems feasible.

Need for ultra-radhard detectors – Present detectors will not work at 6e17 neq/cm2 → Not existing!
Note: We not even understand the solid state physics in devices irradiated to this level of fluence.

Exploit new technologies, reduce radiation length, reduce complexity (i.e. increase integration) … go monolithic.

….note that RD50 is already working on many of the challenges (next slides)

RD50 Workplan for 2017/2018 (1/2)

Understand the Physics of radiation damage

- **Defect and Material Characterization** *(Convener: Ioana Pintilie, Bucharest)*
  - Consolidate list of defects and their impact on sensor properties (Input to simulation group) including introduction rates & annealing for different type of irradiations and materials
  - **Extend work on p-type silicon including low resistivity material**
    - Understand boron removal in lower resistivity p-type silicon: Performance of MAPS, CMOS sensors, LGAD … adding new macroscopic measurements
    - Working group on acceptor removal formed!
  - Characterization of **Nitrogen enriched silicon** (starting project, wafers ready)

Provide the tools to characterize and predict damage and optimize devices for performance

- **Detector Characterization** *(Conv*
  - **TCAD sensor simulations**
    - Cross-calibration of different simulation tools (ongoing) and comparison of "TCAD models"
    - Refine defect parameters used for modeling (**from effective to measured defects**)
    - Extend modeling on charge multiplication processes
    - Surface damage working group
    - Extend use of signal simulation tools towards fitting of measured data
  - **Extend experimental capacities on e-TCT equipment**
    - Parameterization of electric field (fluence, annealing time, etc.)
  - **Exploit full potential of Two Photon Absorption for sensor characterization; build setup at CERN**
  - **Continue parameterization of radiation damage (performance degradation) of LHC like sensors !**
  - **Explore fluence range to10^{17}cm^{-2}and beyond** (to prepare for future needs in forward physics and FCC)

RD50 Workplan for 2017/2018 (2/2)

- **New structures** *(Convener: Giulio Pellegrini, CNM Barcelona, Spain)*
  - Continue work on thin and 3D sensors (especially in combination with high fluence)
  - **Continue characterization of dedicated avalanche test structures** (LGAD, DD-APD)
    - Understand impact of impl[illegible]esses
    - Study of Gallium based amplification layers and impact of Carbon co-implantation
  - **LGAD, DD-APD: intensify evaluation of timing performance and radiation degradation (Where are the limits? How to overcome radiation damage? How much gain is optimum?)**
  - **HVCMOS**
    - Continue characterization of existing devices (close collaboration with ATLAS HVCMOS group)
    - End of year: submission of first RD50 devices in an engineering run

Provide precision timing detectors

Go monolithic

- **Full detector systems** *(Convener: G.Kramberger, Ljubljana University, Slovenia)*
  - Further studies of thin (low mass) segmented silicon devices
  - **Study performance of thin and avalanche sensors in the time domain (Fast sensors!)**
  - Long term annealing of segmented sensors (parameterize temperature scaling)
  - Continue study on "mixed" irradiations (segmented detectors)
  - Continue RD50 program on slim edges, edge passivation and active edges
- **Merging of RD39 into RD50**
  - Cryogenic operation at high fluences?
- **Links with LHC experiments and their upgrade working groups**
  - **Continue collaboration on evaluation of radiation damage in LHC detectors**
  - **Continue common projects with LHC experiments on detector developments**

Keep close link with the Experiments
(both: in planning/preparation and in operation)

European Strategy

GLOBAL PARTICLE PHYSICS STRATEGY

ICFA (International Committee for Future Accelerators)

Japan: Future HEP Projects
– „... Japan should take the leadership role in an early realisation of an e+e- linear collider.“

Update of European Strategy for by CERN Council (May 2013)
- LHC, incl. HL-LHC
- accelerator R&D
- strong support for ILC
- long-baseline neutrino
- importance of theory

European Strategy for Particle Physics

USA: Snowmass conclusions and recommendations to P5 in line with worldwide strategy statements

> Different flavours in different regions of the world

> But looks like an emerging global, coherent strategy in particle physics

> Next update of European strategy 2020; US to follow 2-3 years after.

Joachim Mnich I The Future of High-Energy Accelerators I IPAC17

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DESY