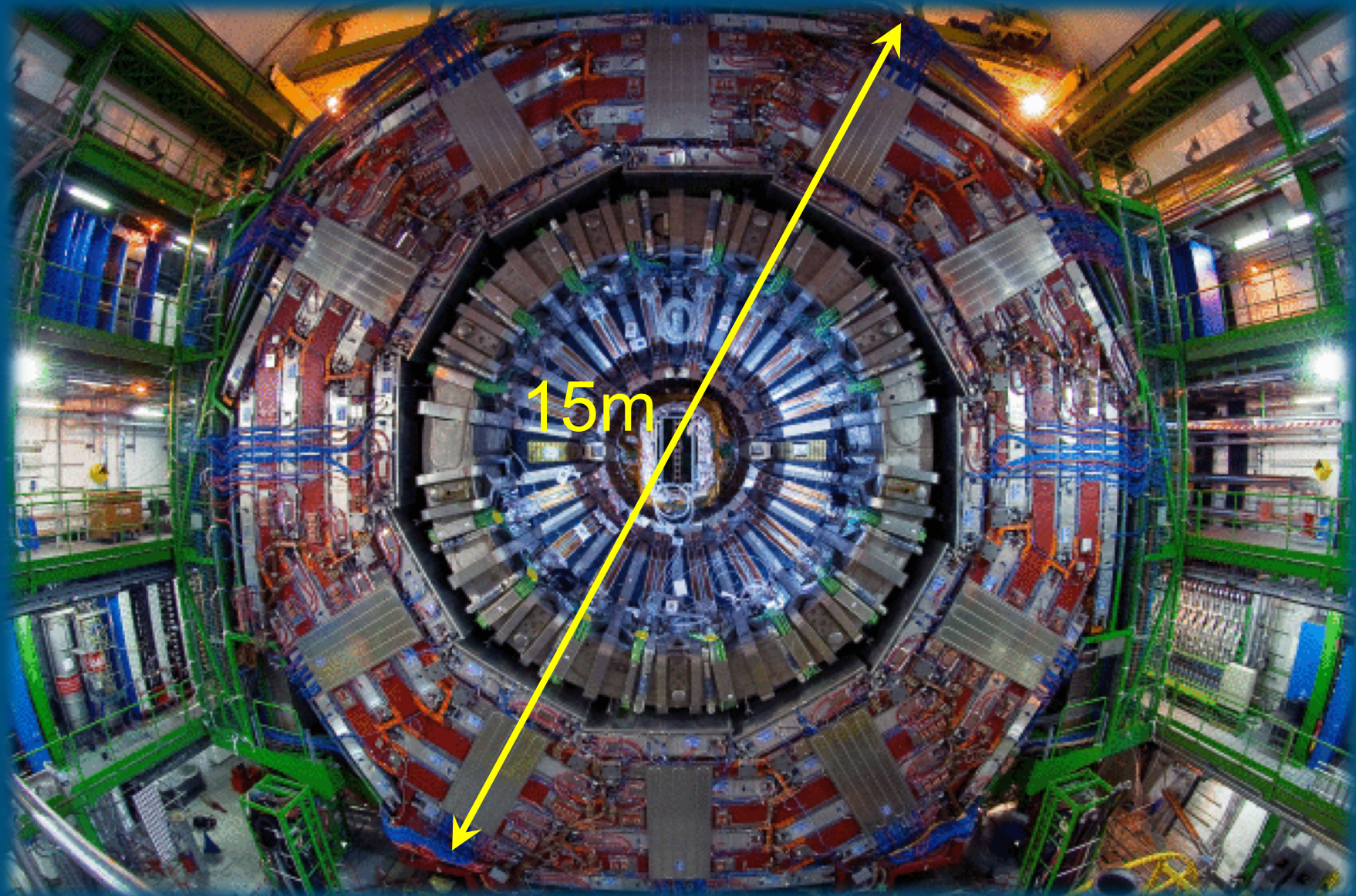


(Some) Future detector needs with focus on R&D

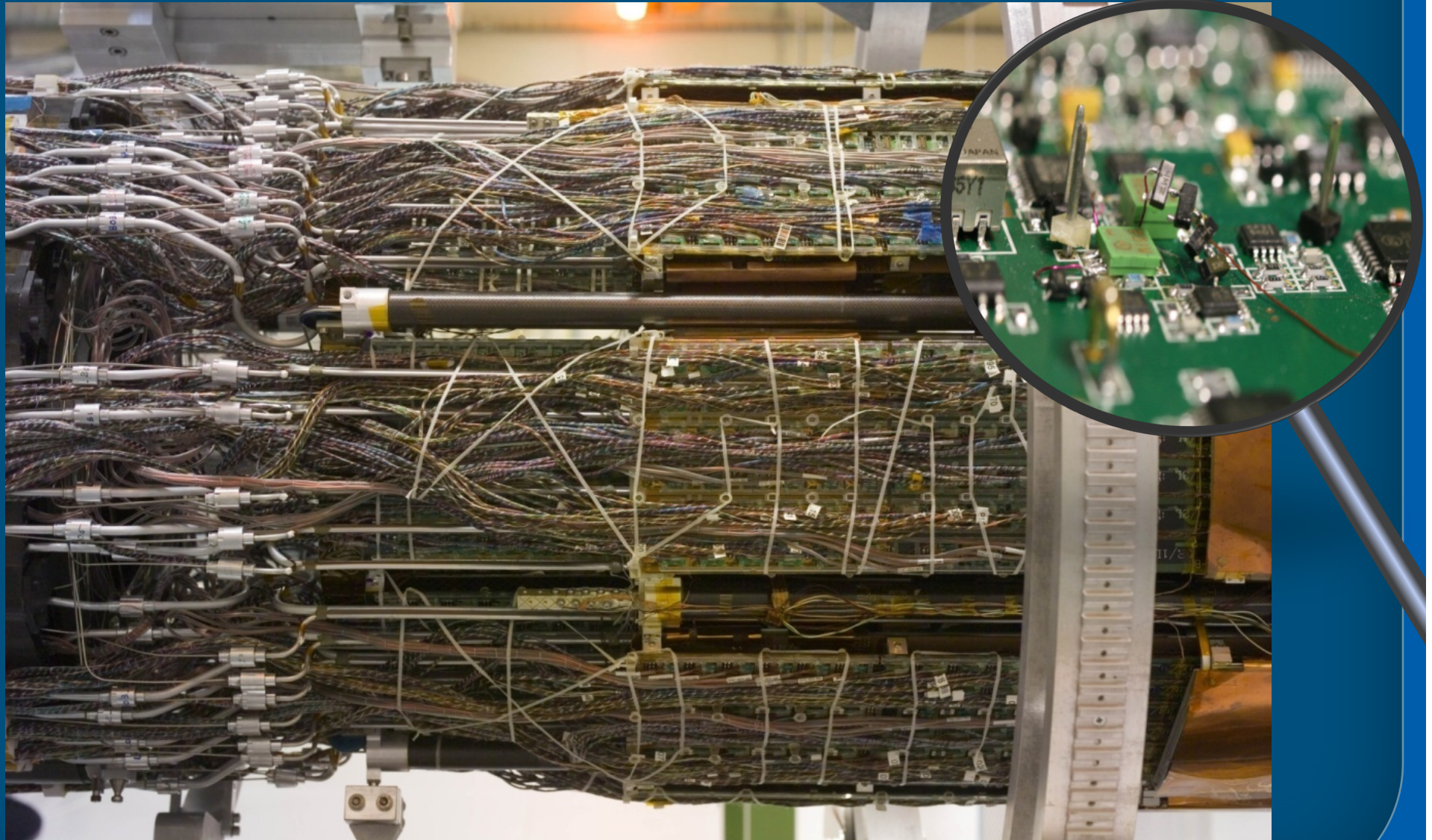
Richard Jacobsson

Detector complexity & integration!

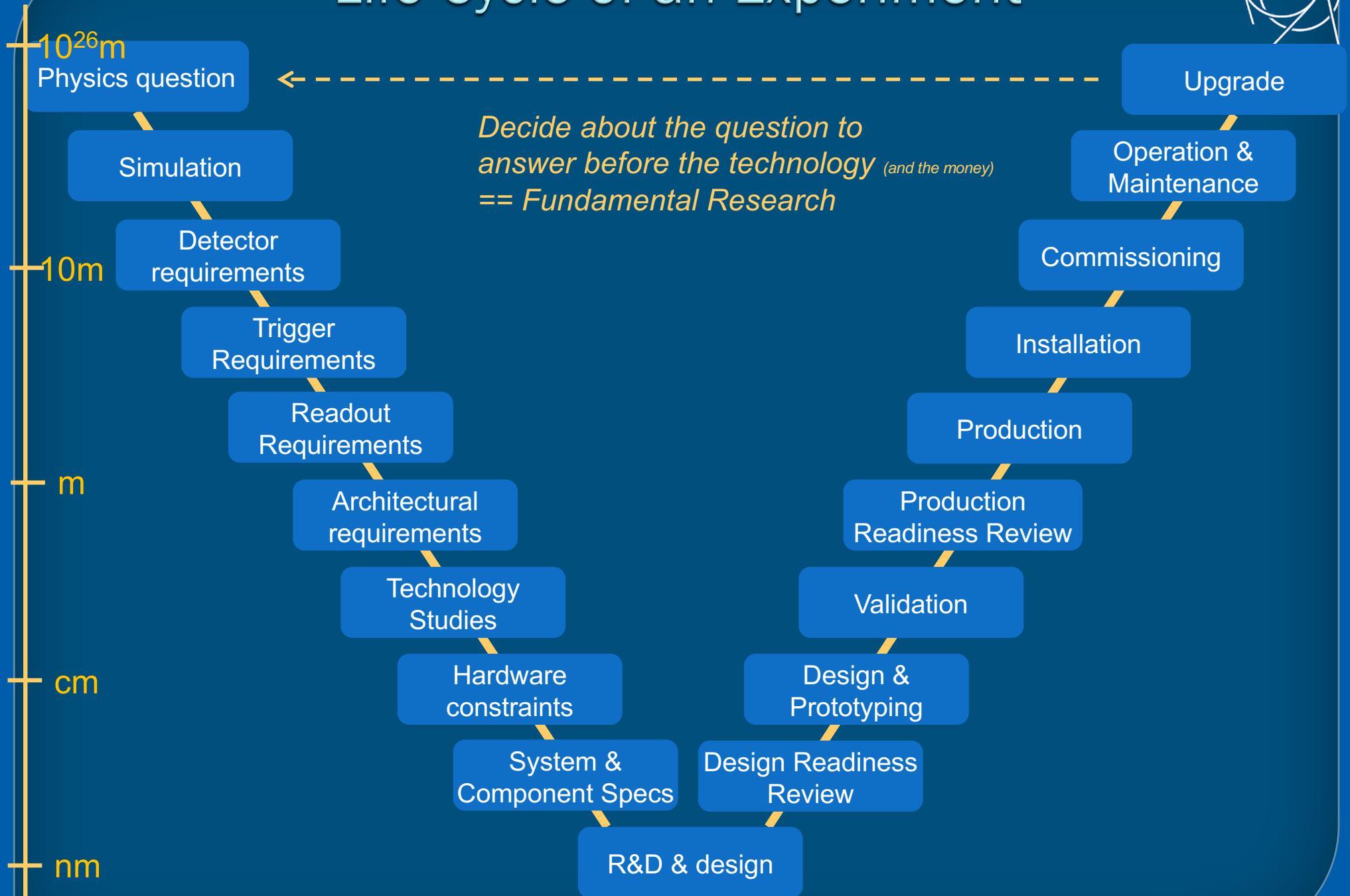


Detector integration!

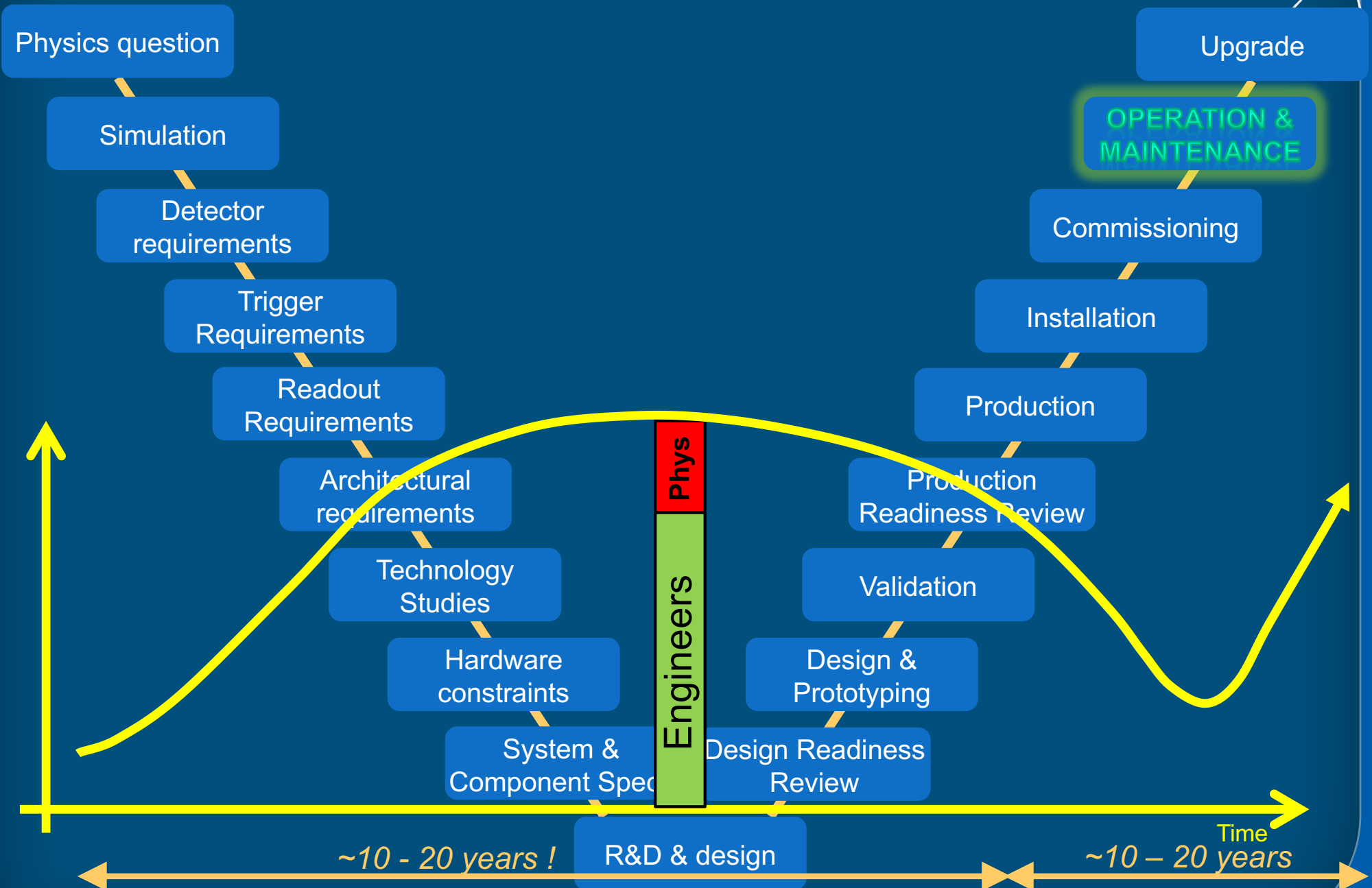
Design with emphasis on integration, global commissioning, operation, maintenance and evolution



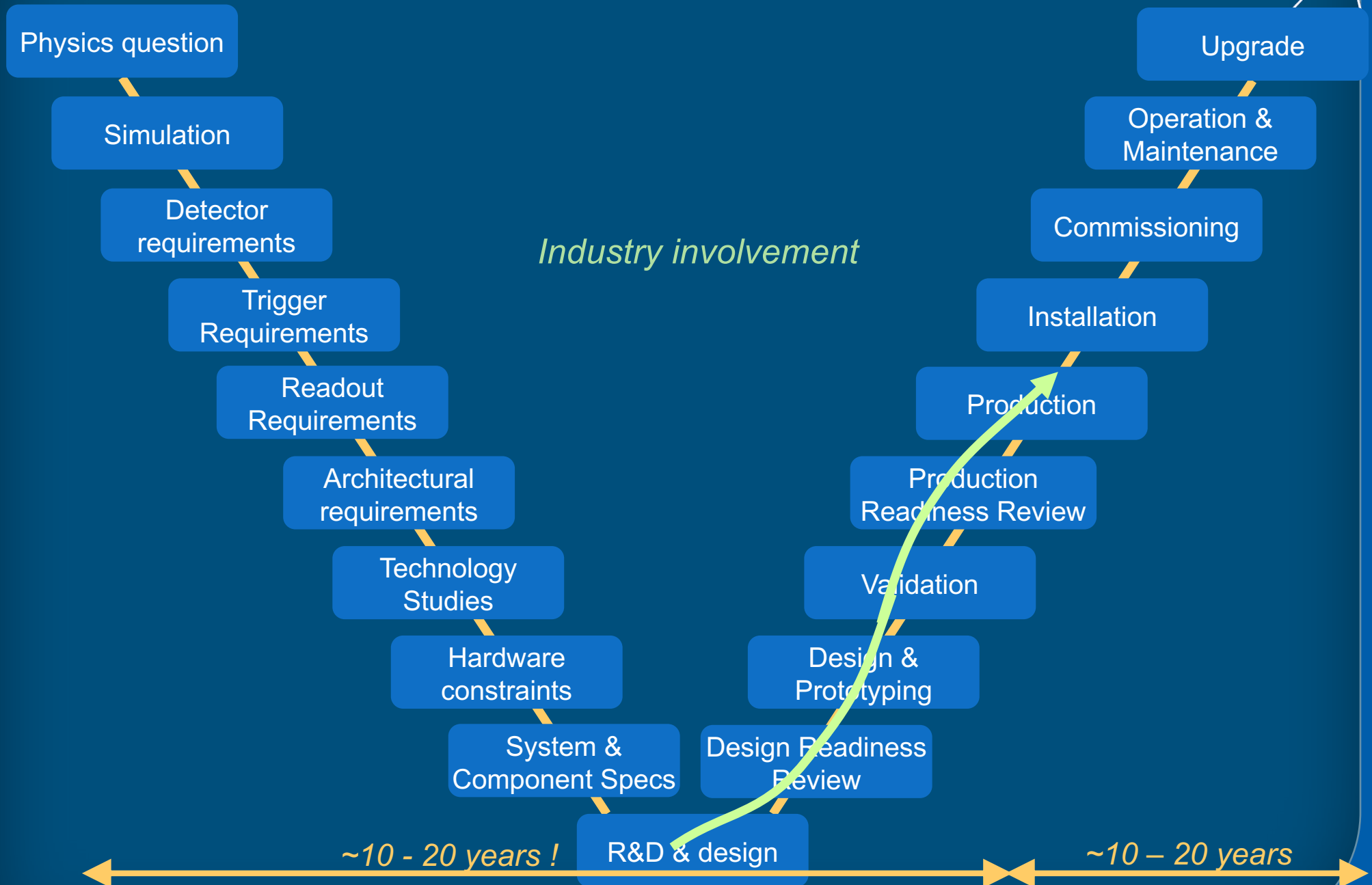
Life Cycle of an Experiment



Life Cycle of an Experiment



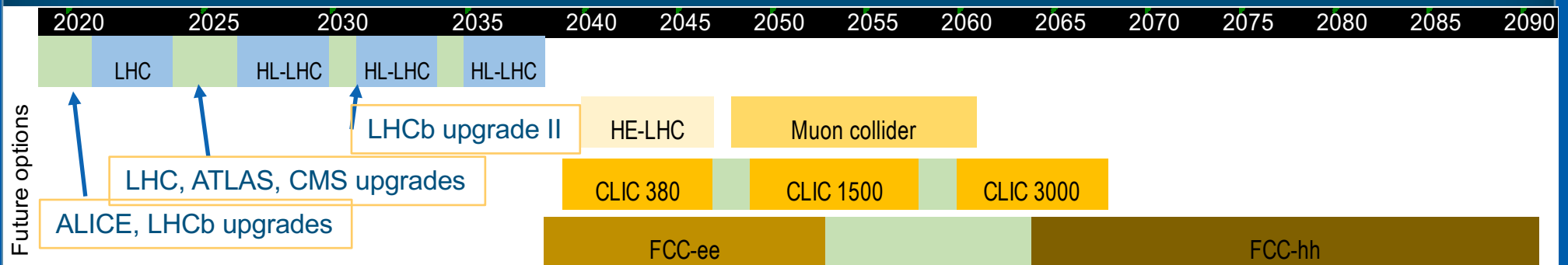
Life Cycle of an Experiment



Future

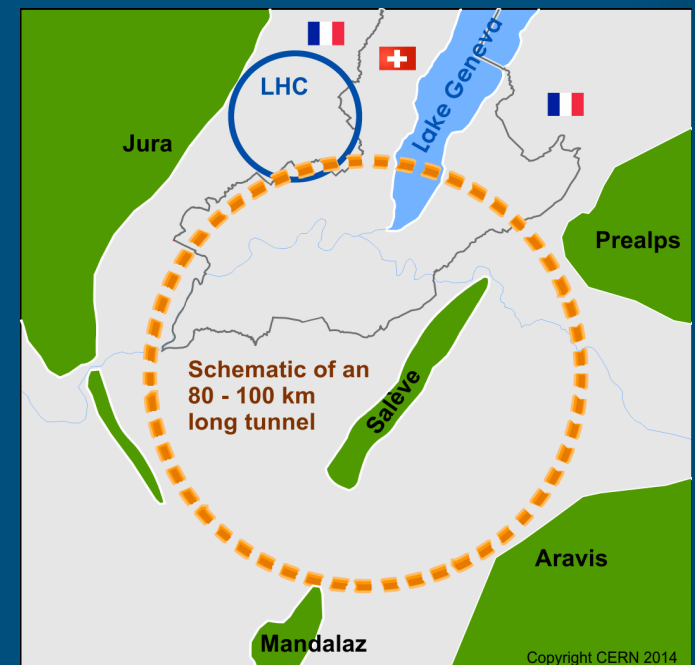


Some possible future scenario (not exhaustive!)



European Strategy for Particle Physics

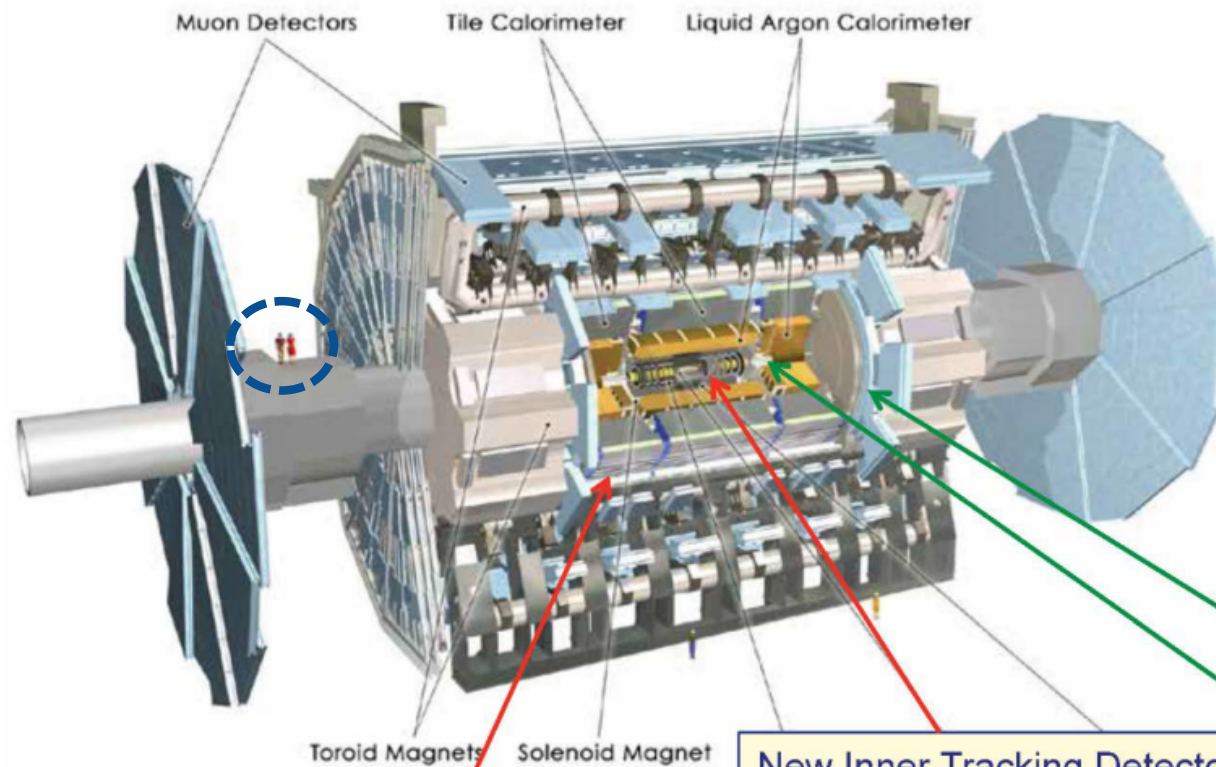
- European roadmap in the worldwide context of the field
- Update being prepared 2019 - 2020



Ex. ATLAS HL-LHC upgrade (2023-2024)



- Upgrade of LHC : seven times higher collision rate than what ATLAS/CMS were designed for
→ 200 simultaneous proton-proton collisions every 25ns
- New detectors with radiation-hard elements, finer granularity and faster readout.



Upgraded Trigger and Data Acquisition System:

- L0: 1 MHz
- Improved High-Level Trigger

Electronics Upgrade :

- LAr Calorimeter
- Tile Calorimeter
- Muon system

New Inner Tracking Detector
(all silicon tracker, up to $|\eta| = 4$)

New muon chambers
in the inner barrel region

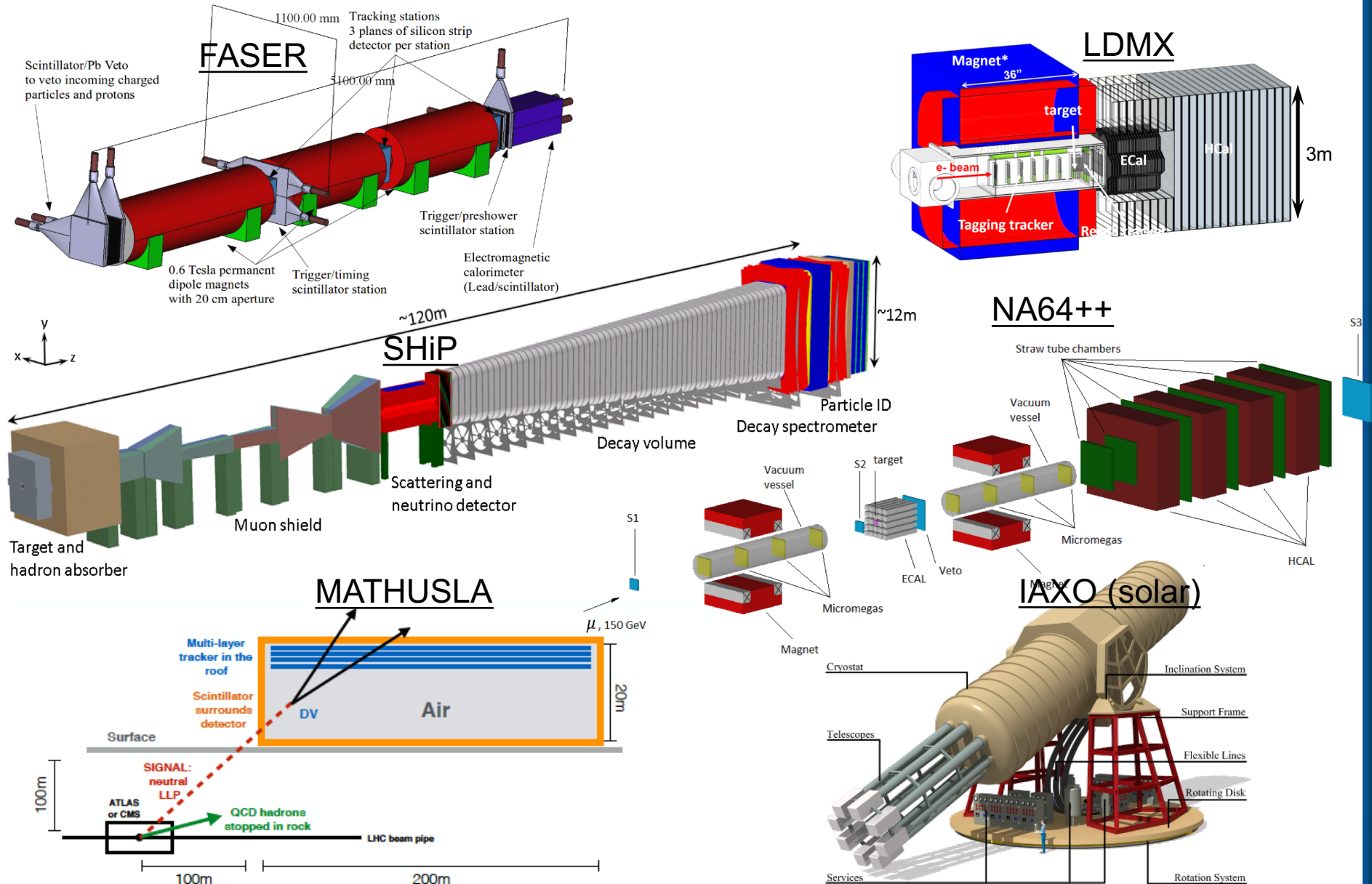
Options:

- High granularity timing detector (forward region)
- High- η muon tagger
- Forward detectors, incl. luminosity

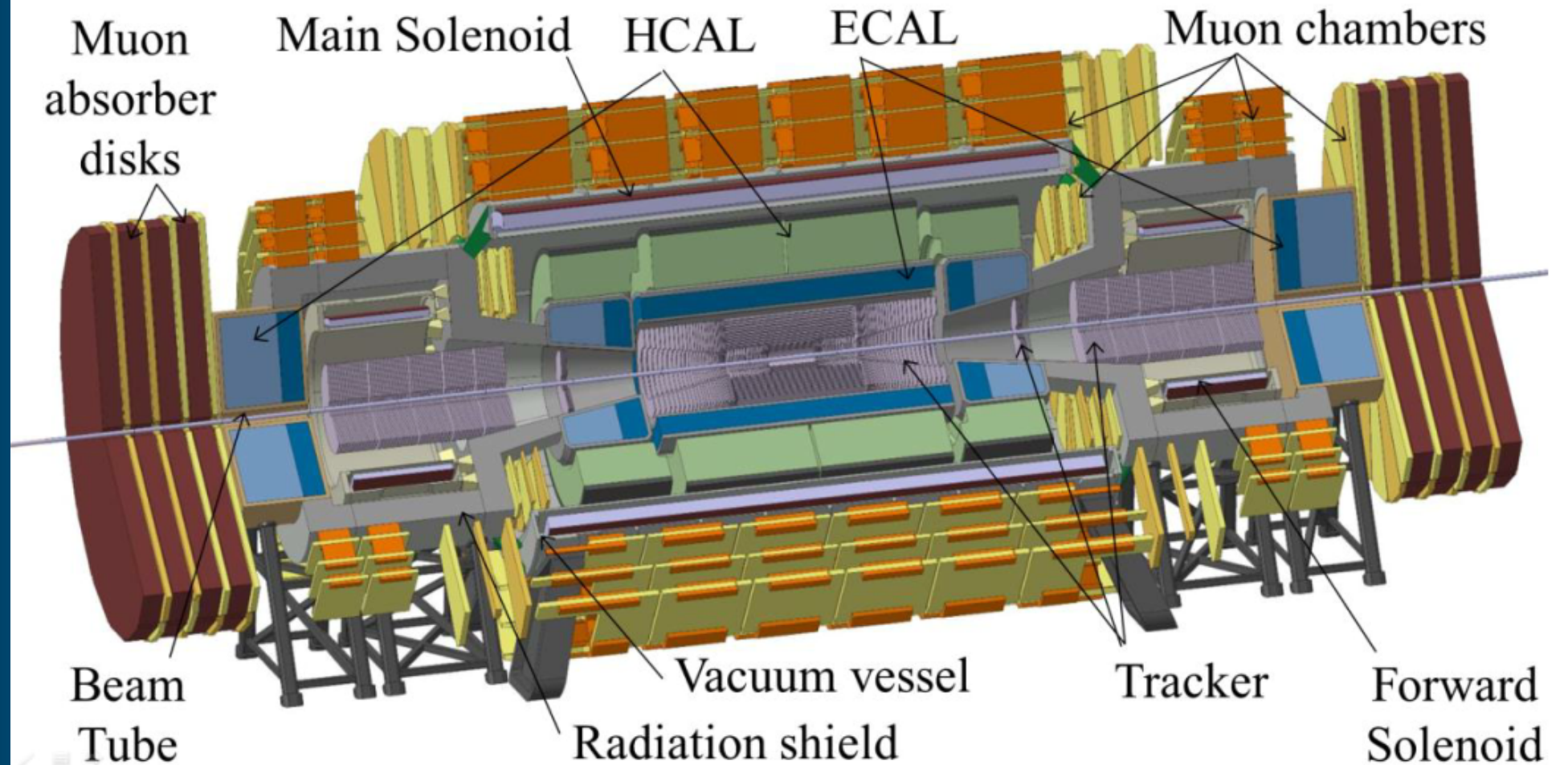
weiler - Lawrence Berkeley Lab

4/23/2018

Other experiment proposals on the table



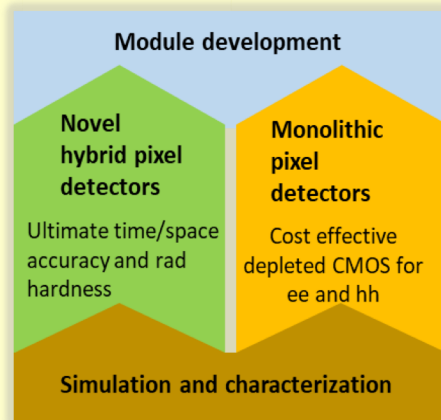
FCC-hh detector (20XX)....



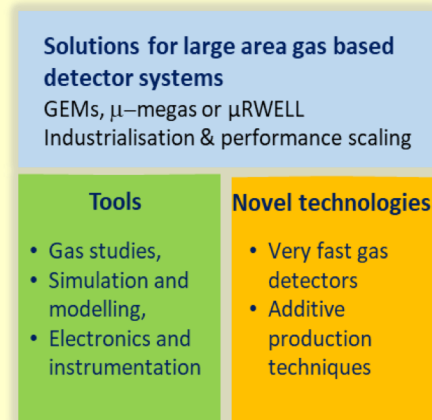
Detector R&D (CERN)



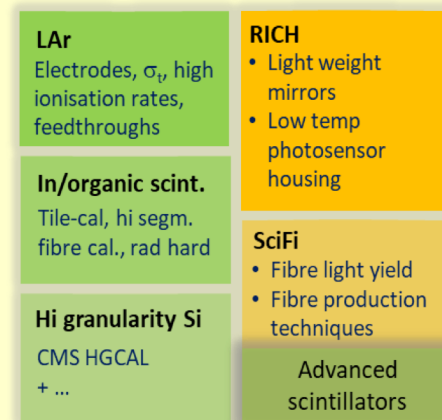
WP1: Silicon Sensors



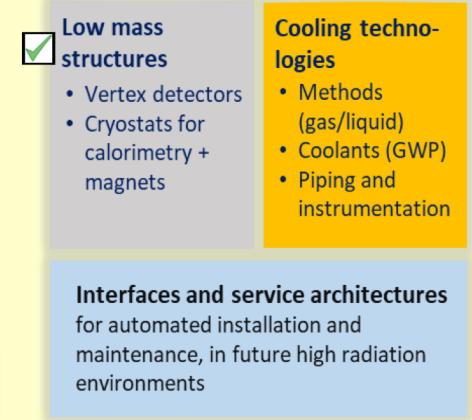
WP2: Gas Detectors



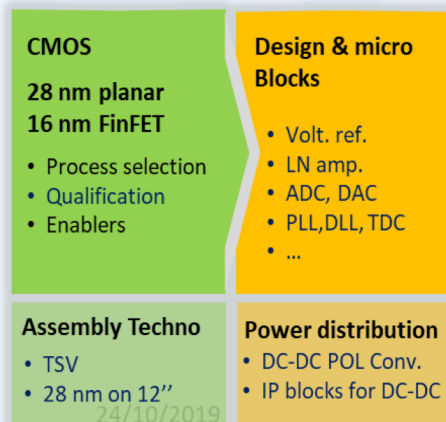
WP3: Calorimetry + Light based



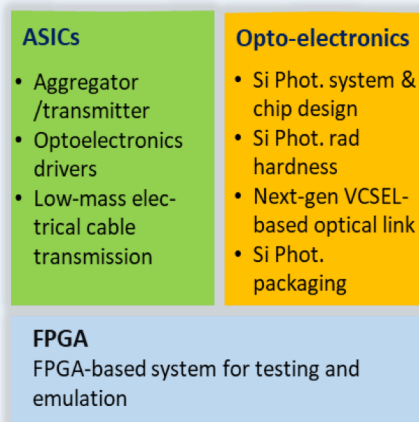
WP4: Mechanics⁺⁺



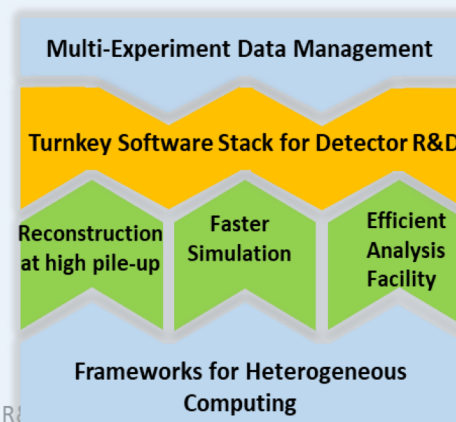
WP5: IC Technologies



WP6: High Speed Links



WP7: Software



WP8: Exp. Magnets



From C. Joram

Detector mechanics

- ◉ Structure Design
 - *Ultra lightweight vertex detector structure; large scale composite structures, ...*
- ◉ Cooling Design
 - *New system design and coolants, polyimide micro tubes, microchannel 3D print, air cooling, ...*
- ◉ Materials
 - *Carbon materials, carbon nanotube, CVD diamonds, adhesive and composite for high radiation level, ...*
- ◉ Processes
 - *3D print micro and macro scale, large composite manufacturing and Out of Autoclave curing, ...*
- ◉ Integration
 - *High integrated system, low mass CNT power and signal cables, metrology, 3D tomography, ...*
- ◉ Installation and Maintenance
 - *Robotic Remote Manipulator System, service Umbilical Mechanism Assembly, alignment and survey, radiation shielding, augmented reality, ...*
- ◉ Environment and Stability
 - *High radiation level, vibration and hygro thermo elastic behaviour, monitoring (Fibre Bragg Grating sensors), ...*

➔ Many of which require R&D for development, production and assembly

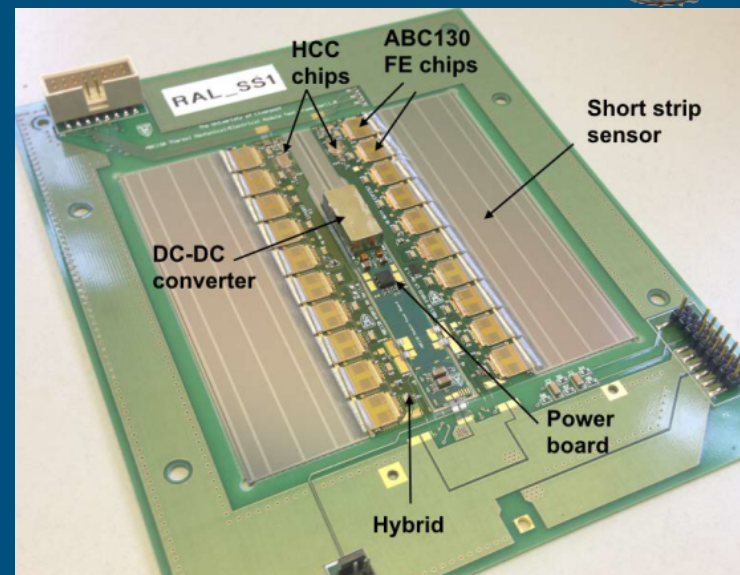
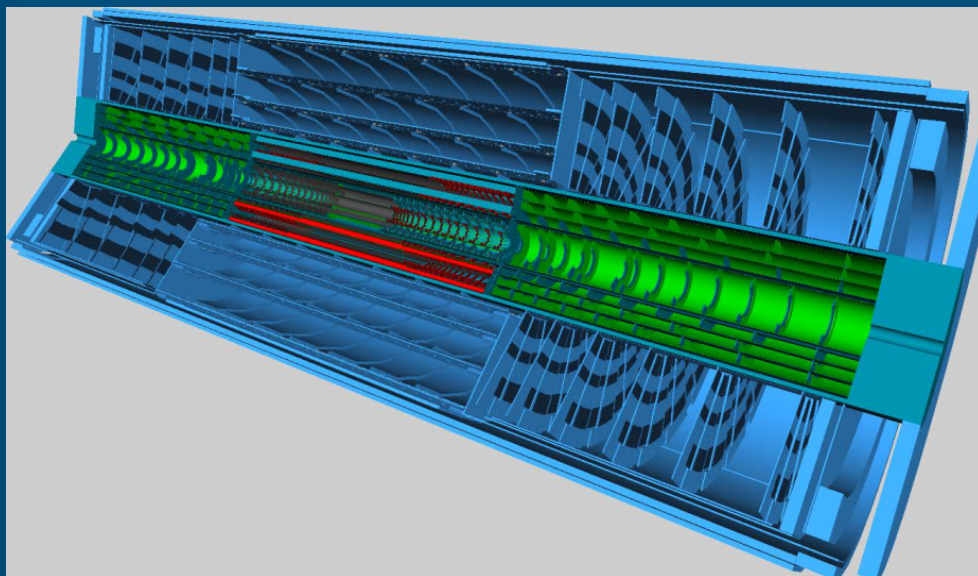
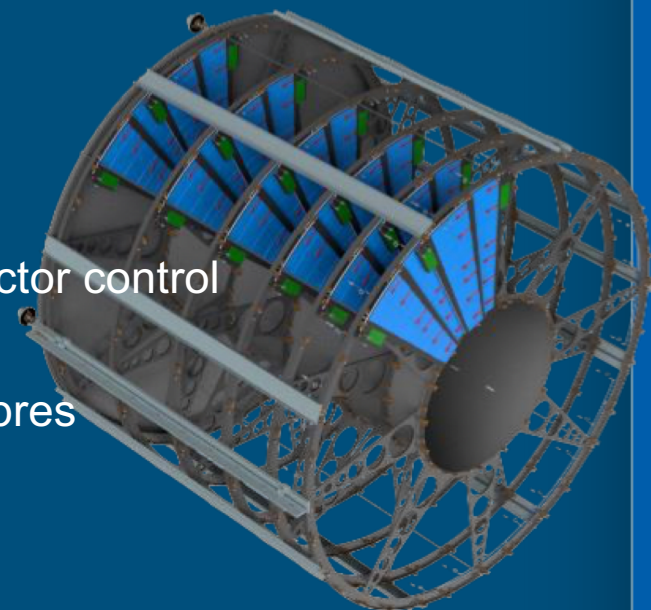
Key words: Radiation hard, low power, low material, redundant/reliable....

Ex. Silicon sensors and light mechanics



New ATLAS central Tracker: ITk

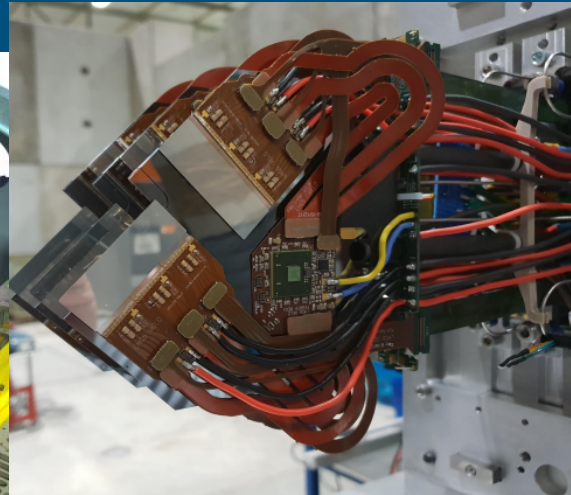
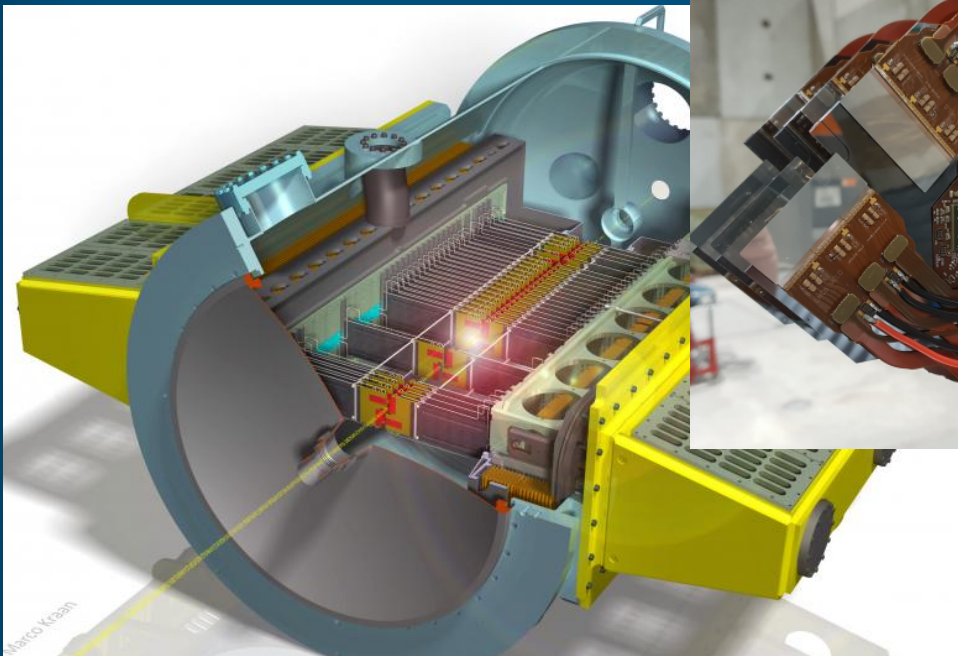
- ◉ More than 100 m² of silicon sensor have to be produced
- ◉ ASICs for the detector front-end readout electronics and detector control
- ◉ Flex cables, optoelectronics and fibers
- ◉ Light and precise mechanical support structure with carbon fibres



Integrated cooling

Thermal management of detector electronics through ultra-thin micro-structured silicon cooling plates

LHCb Vertex Locator

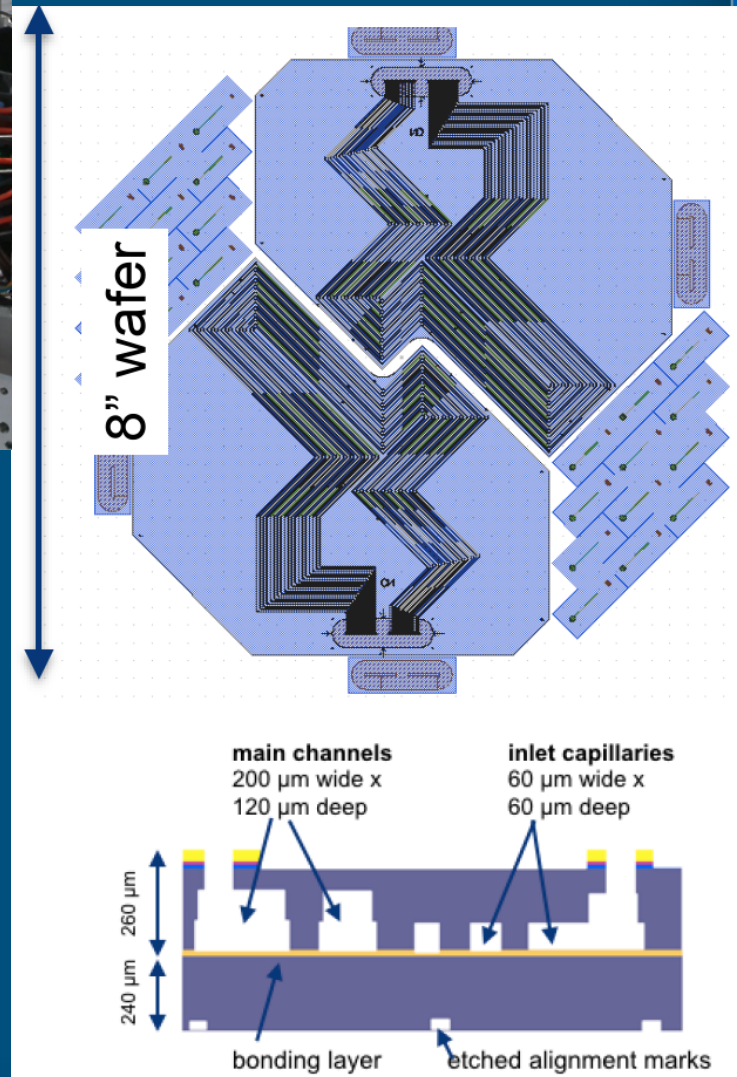


Row of silicon hybrid pixel modules, 5mm from beam
Data bandwidth: up to ~15 Gbit/s for central ASICs and 2.9 Tbit/s in total
Sensor temperature < -20 °C (CO₂ @ -35°C)

400 μ m thick silicon substrate
19 parallel micro-channels

- 60 x 60 μ m (restrictions)
- 200 x 120 μ m (channels)

 Pressure up to ~65 bar at room temperature, qualified to 186 bar



Experiment magnets

Search for Hidden Particles (SHiP) experiment (Proposal)

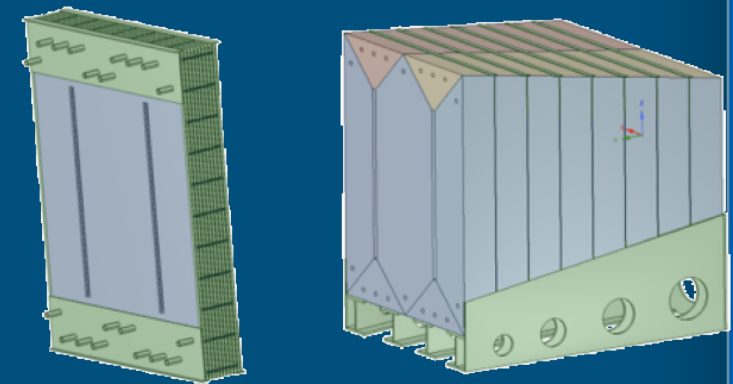
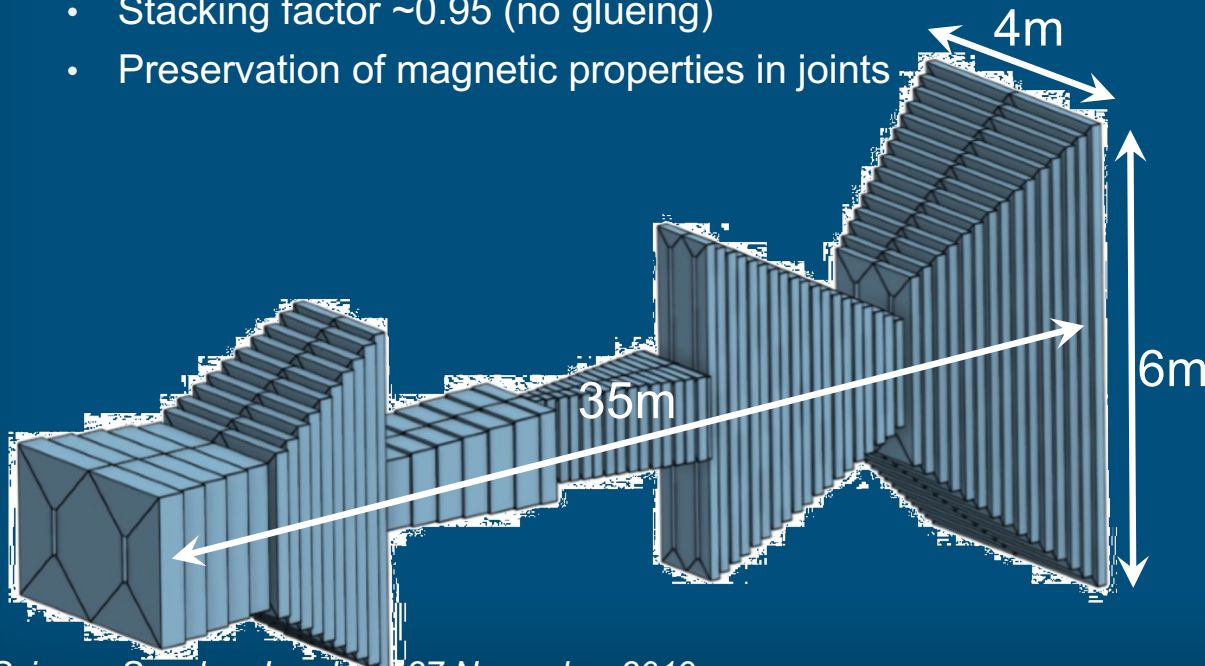
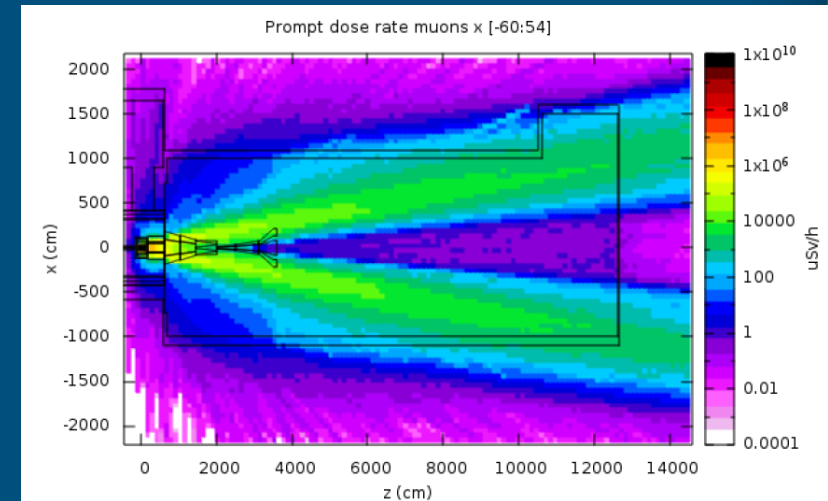
- Construction ~2025 - 2028

- Magnetic deflector of beam induced muon particles

- Optimized by Machine Learning
- 35m in length and 1500 tonnes of magnetic mass
- Complex shapes
- Operational assumption: $<1.7\text{T}>$
- Use of CRGO steel

- Critical parameters

- Stacking factor ~ 0.95 (no glueing)
- Preservation of magnetic properties in joints



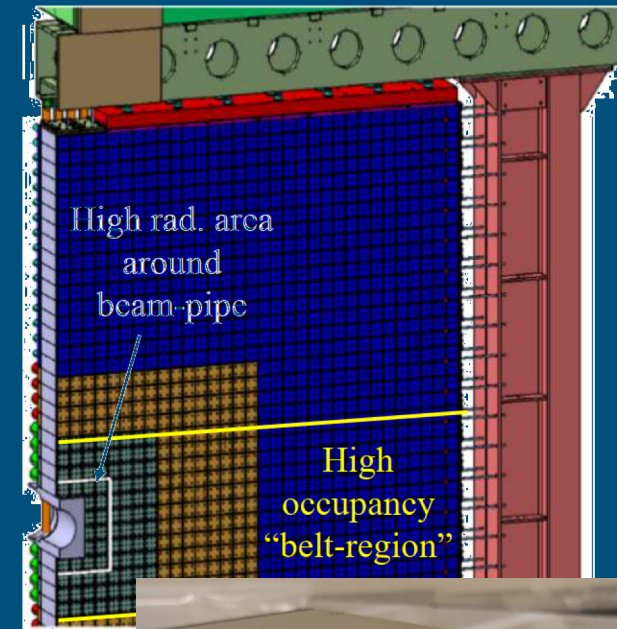
Packs of 50 mm thickness
with 150-160 x 0.3mm sheets

Energy measurement detectors



Calorimeter R&D (LHCb, TauFV, future collider experiments):

- Radiation hard, hi-light yield 1x1mm² crystal fibres and tungsten alloy (Pb, Cu) converters



- ◉ Up to ~150 modules of 12x12 cm² in 2026

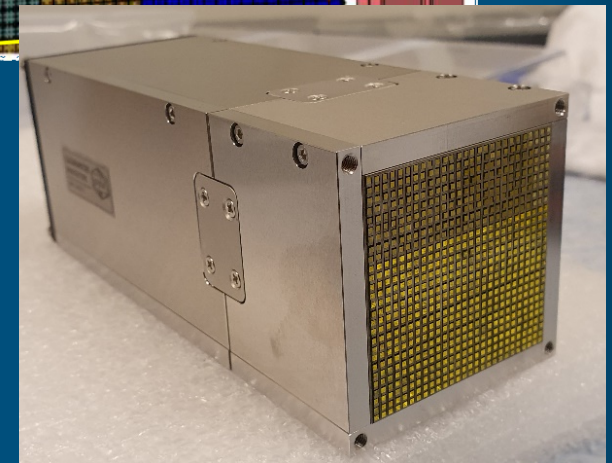
- Up to 500 000 fibres ...
- 2.5 – 3 tonnes converter

→ Crystal manufacturing (e.g. GAGG)

→ Converter manufacturing from powder metallurgy

→ Photosensors: New: Perovskite structure QD ($X^{II}A^{2+VI}B^{4+}X^{2-}_3$)

- E.g. CsPbX₃ (X = Cl, Br, I),



Low mass composite cryostats



- ◉ Cryostats in HEP are still the purview of metals.
- ◉ Need for Ultra Light Weight (ULW) cryostats for both magnets and calorimeters.
- ➔ Organic composite material at low temperatures
 - Carbon Fibre Reinforced Plastic (CFRP)
 - Aluminium-oxide-fibre-reinforced plastics?
 - Silicon-carbide-fibre-reinforced plastics?
- ◉ E.g. Status of CFRP cryo tank for aerospace LH2 and LOX.