High-Luminosity LHC

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Large Hadron Collider LHC - the pp-collider at the energy frontier

- LHC has been operating since 2008
 - collected ~30 fb⁻¹ at a collision energy of 8 TeV
 - Discovery of the Higgs Particle and a Nobel Prize to F Englert & P Higgs
 - expect ~300 fb⁻¹ till 2023 at 13-14 TeV
 - need another factor of 10 to fully exploit its potential

TI2



High-Luminosity Large Hadron Collider

- Launched as the FP7 HiLumi LHC **Design** Study in 11/2011
 - Developed concepts for magnets, crab cavities and 300 m high power superconducting links
 - continued till 10/2015
- was launched as a **project** at CERN in October 2015
 - will be implemented in two consecutive shutdowns; the last ending 2025









Implications

- The two large experiments ATLAS and CMS have to tackle a much higher • rates and a much larger level of background (parasitic) collisions (μ =200).
 - Physics has to be extracted from a much more complex environment
 - **New** or **refurbished** detectors
 - High luminosity upgrade as a landmark project of ESFRI
 - Similarly the HL-LHC detector upgrades figure on the national • roadmaps
 - Much more powerful online data selection to cope with the data • rates
 - Data selection with fast switching *commodity hardware*



 $H \rightarrow 4 \text{ l in } 2012$





HL-LHC Detector Upgrades – 1 Example

- Innovative Si-based detectors
 - ~200 m² of active Silicon sensors
 - ~0.5 bn readout channels
- Challenge for industry and a breakthrough demand for compact sensors for other fields of science



Detector	Silicon Area [m ²]	Channels [10 ⁶]
Pixel barrel	5.1	445
Pixel end-cap	3.1	193
Pixel Total	8.2	638
Strip barrel	122	47
Strip end-cap	71	27
Strip total	193	74

HL-LHC Computing

- To maintain a low level of occupancy the individual detectors have to be small; the high granularity implies large data rates and requires sophisticated algorithms for data reduction
 - LHC Grid computing (WLCG)
 - may evolve (partially) into Science Cloud (virtualisation techniques)
 - Could evolve into the Open Science Cloud; citizen engagement has been successfully demonstrated LHC@Home, ATLAS@Home ...

worldwide computing model for LHC

has been exercised successfully

Requires even more computing resources and a privacy policy



Outlook

- recognised as an ESFRI Landmark
- Project will imply
 - Detector and sensor development and applications Medical, biological and radiation sensors...
 - data to extract physics signal (Ready for Cloud, Science Cloud and Open Science Cloud)

FP7 HiLumi LHC Design Study led to the HL-LHC Project, which is now

Massive frontend and distributed computing to cope with vast amount of