LHC Future Challenges

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CWP Workshop

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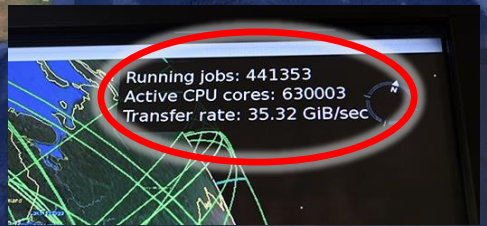
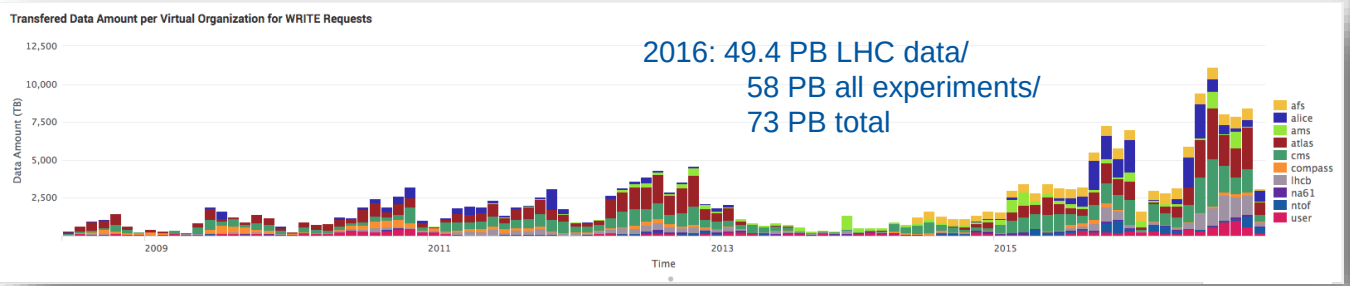
WLCG Collaboration

January 2017:
- 63 MoU's
- 167 sites; 42 countries

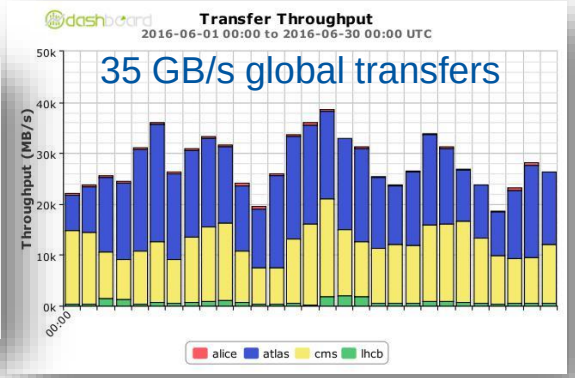
- Cores >500 k
- Disk 350 PB
- Tape >400 PB



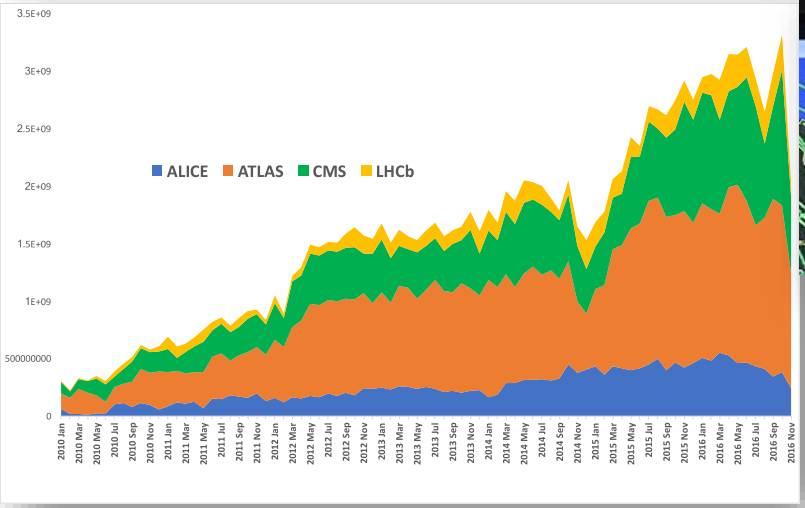
WLCG in Run 2 – 2016

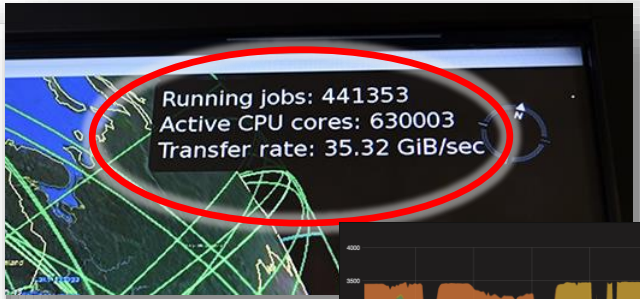


2016: 49.4 PB LHC data/
58 PB all experiments/
73 PB total



New performance records set everywhere





>800 PB moved across WLCG in 2016

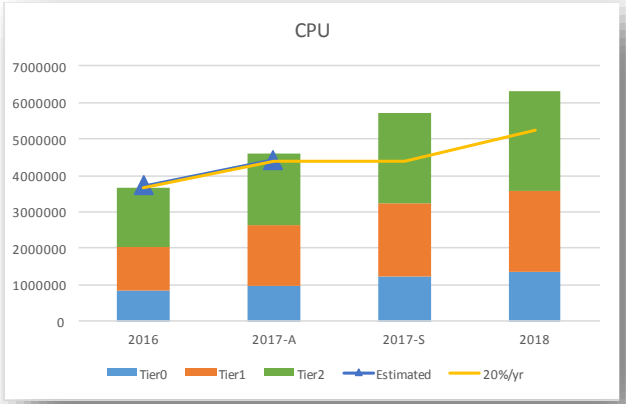
Run2: Increased computing needs

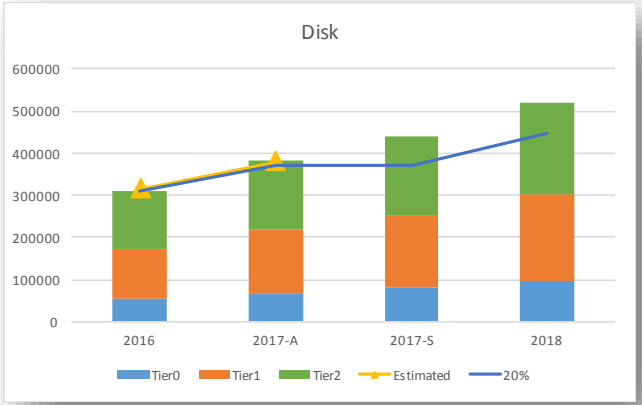
- LHC performance is above expectations: All factors driving computing have increased above anticipated levels

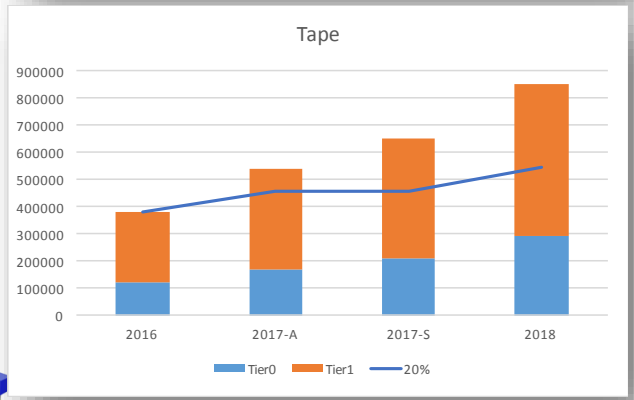
	2016 exp	2016	2017 exp	2017	2018
Live M sec	5	~7.4	5.5	7.8	7.8
Inst. Lumi (x10^{34})	1.0	1.0 → 1.3	1.0	1.4	1.4
<pile-up>	21	21→ 27	25	33	33

- For 2016, the available resources were sufficient
  - More tapes at CERN have been bought
- Re-analysis for 2017,18
  - Expectations are increased requirement above previous estimates of ~20%

Re-assessment of needs







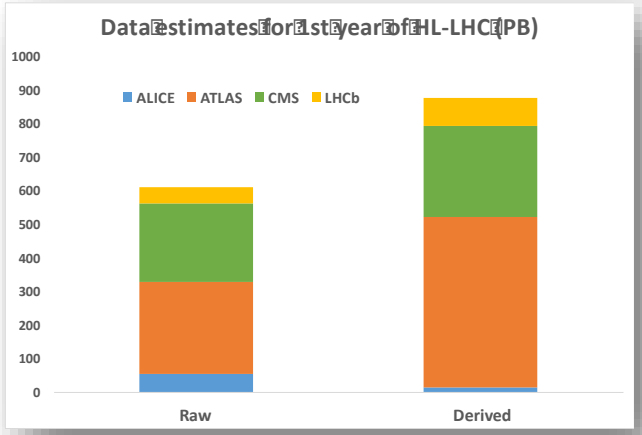
Estimated: Estimates made in 2014 for Run 2 up to 2017 – *largest uncertainty is LHC live time*

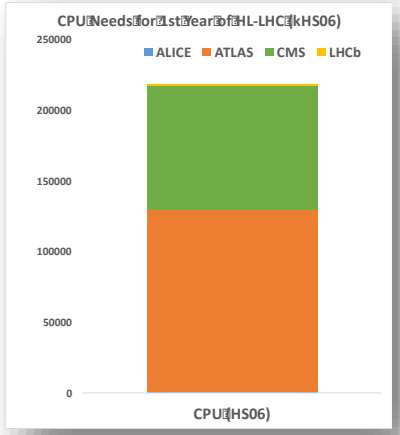
20%: Growth of 20%/yr starting in 2016 (“flat budget”)

Outlook

- Ongoing and continual evolution
  - Computing models & software performance in the experiments
  - Infrastructure – use of clouds, HPC, volunteer computing etc., etc.
- Anticipate:
  - Run 2 and Run 3 will be manageable with an ~evolutionary approach
    - But making use of technology advances where useful
    - ALICE Upgrade TDR done, LHCb this year
  - HL-LHC will require more revolutionary thinking
- NB: We are starting from a working system

Estimates of resource needs for HL-LHC





Data:

- Raw 2016: 50 PB → 2027: 600 PB
- Derived (1 copy): 2016: 80 PB → 2027: 900 PB

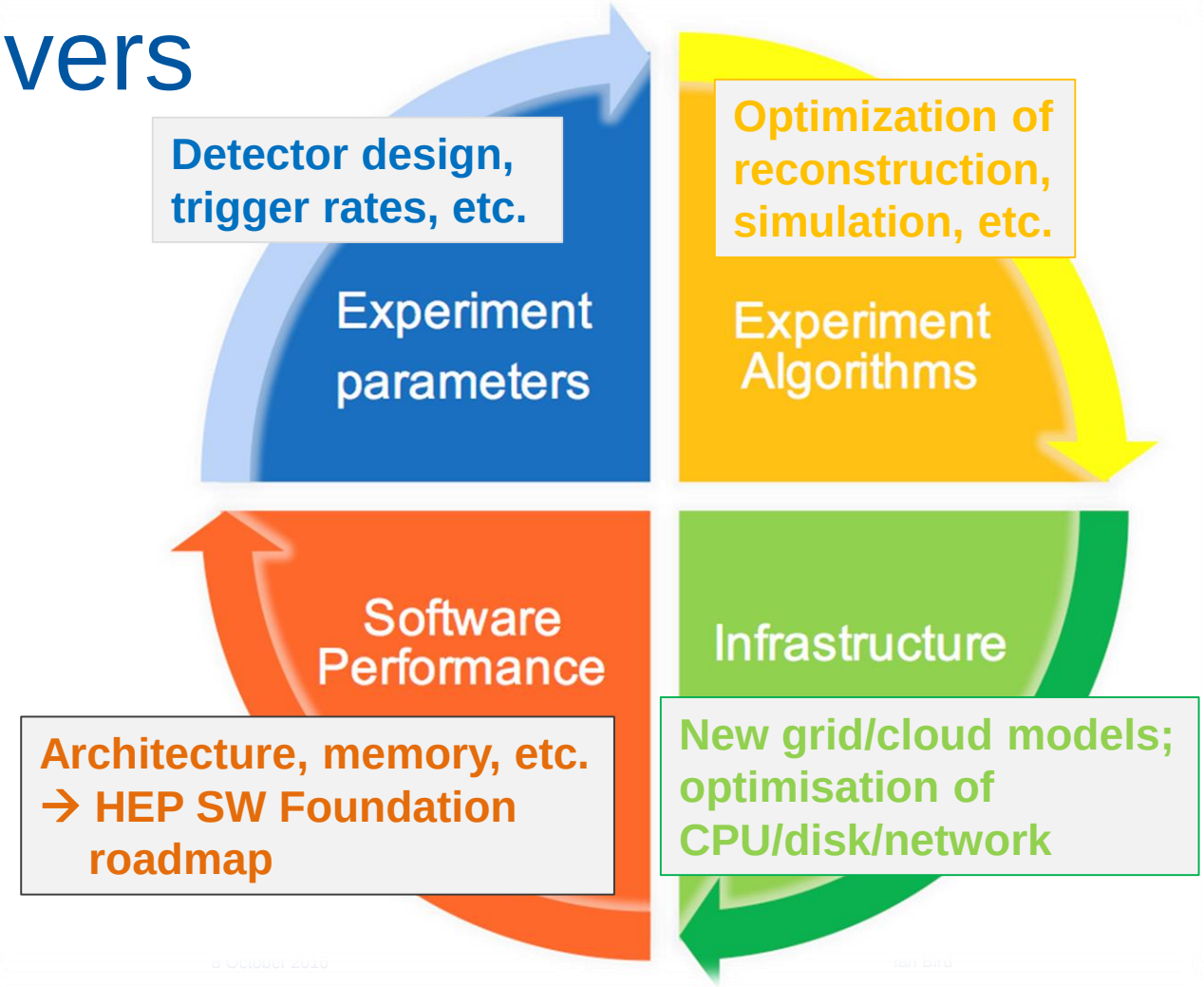
CPU:

- x60 from 2016

Technology at ~20%/year will bring x6-10 in 10-11 years

- Simple model based on today's computing models, but with expected HL-LHC operating parameters (pile-up, trigger rates, etc.)
- At least x10 above what is realistic to expect from technology with reasonably constant cost

Cost Drivers



Challenges – 1

- Technical challenges:
  - Optimization of the physics output vs cost
  - Software, algorithms, computing models, distributed infrastructure → and implications (e.g. on networks needed)
  - Integration of *all* available resources: HPC, Cloud, opportunistic, traditional, etc.
  - Technology evolution – will it be as much as we need?
  - Opportunity to re-think the computing models – may be very different than today
- Sociological challenges:
  - Remove the "online-offline" boundary – there is a computing challenge from detector to physics
  - Must ensure that Computing and Software careers are seen as Physics careers – essential to build and maintain the skills we need
    - This requires change in the collaborations & in the Universities
  - Consolidation of resources (e.g. storage) must not be interpreted as removing the need for a global community and global contributions
    - Must find a path to reducing cost while maintaining the most broad and open contributing community

Challenges – 2

- Funding outlook is still to maintain a flat budget for computing even for HL-LHC
- There are other funding-related challenges:
  - What are the boundary conditions? e.g.:
    - Can we imagine joint procurements of commercial resources to achieve economy of scale? What are the boundaries of that?
    - What will the national infrastructures look like? Will small university clusters be moved to (non-local) clouds?
      - Implications for synergy (opportunistic resources) – versus improved cost and elasticity?
- ☞ Building an affordable model for HL-LHC computing will require all of these areas to be addressed

Process for HL-LHC

- Agreement with LHCC
  - TDR for HL-LHC Computing to be produced in 2020
  - 2017: provide a “CDR” or vision/roadmap towards the TDR
    - Hope is that this CWP can provide a lot of the input for this roadmap
      - And that community working groups will address the work that is required to produce the eventual TDR
- The LHCC (LHC Scientific review), SPC (CERN Science Policy Committee – member states), and RRB (funding agencies) are all wanting to see progress towards understanding the costs of computing for HL-LHC