

# Report on San Diego HSF CWP workshop

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15<sup>th</sup> May 2017

# Workshop layout and aims

## Community White Paper (CWP) Working Groups

During October, 2016, the process of forming CWP working groups has begun. We are letting the working groups self-organize with a bit of help from the HEP experiment software/computing coordinators and the HSF startup team. The first step for each working group is to formulate a charge to describe the challenges in that area and questions which need to be answered to produce a roadmap for the CWP.

The working group charges should be world-visible for reading. If you would like to edit them, you will need to join the [hsf-community-white-paper](#) Google group and login as your google user. If you would like organize an additional working group, please post to the [hsf-community-white-paper](#) Google group.

Note: it is possible to register to all the Google groups without a Google account. In this case, send an empty email (subject and contents ignored) to the group email, adding [+subscribe](#) after the group name. (e.g. [hsf-cwp-software-development+subscribe@googlegroups.com](#)).

**Big objective** : organize a sustainable community around the big themes in HEP computing for the next decade

**Key milestone** : deliver the "Community White Paper" (CWP) to the NSF by this summer

**Role of wkshp** : build bottom-up groups of interested people around each theme, identify conveners who can push each theme forward, develop a "charge sheet" which said group should answer for the CWP



# Why HSF and why the CWP?



## A Software “Upgrade” for HL-LHC and 2020s HEP?

Looking forward to the next 10 years, we see a number of challenges for HEP software and computing:

- **Scale:** The HL-LHC will integrate 100 times the current data, with significantly increased data (pileup) and detector complexity.
- **Performance/cost:** Estimates of computing needs run faster than Moore’s Law by factors of 3-30
- **Technology/Market evolution:** the return of heterogeneity; technology change will also make it challenging to exploit Moore’s Law without software evolution.
- **Sustainability:** Most of the current software, which defines our capabilities, was designed 15-20 years ago: there are many software sustainability challenges.

**“Computed hardware is a consumable. Software is what we keep, and invest in, over time.” – P. Elmer**



# Groups/objectives

## Computing Models, Facilities, and Distributed Computing WG

[Google Doc](#)

Google group: [hsf-cwp-models-facilities@googlegroups.com](mailto:hsf-cwp-models-facilities@googlegroups.com) ([link to subscribe](#))

Plans:

## Detector Simulation WG

[Google Doc](#)

Google group: [hsf-cwp-simulation@googlegroups.com](mailto:hsf-cwp-simulation@googlegroups.com) ([link to subscribe](#))

Plans:

## Software Trigger and Event Reconstruction WG

[Google Doc](#)

Google group: [hsf-cwp-swtrig-evtrec@googlegroups.com](mailto:hsf-cwp-swtrig-evtrec@googlegroups.com) ([link to subscribe](#))

## Visualization WG

[Google Doc](#)

Google group: [hsf-cwp-visualization@googlegroups.com](mailto:hsf-cwp-visualization@googlegroups.com) ([link to subscribe](#))

## Data Access and Management WG

[Google Doc](#)

Google group: [hsf-cwp-data-management@googlegroups.com](mailto:hsf-cwp-data-management@googlegroups.com) ([link to subscribe](#))

## Security and Access Control WG

[Google Doc](#)

Google group: None yet

Plans:

## Machine Learning WG

[Google Doc](#)

Google group: [hsf-cwp-machine-learning@googlegroups.com](mailto:hsf-cwp-machine-learning@googlegroups.com) ([link to subscribe](#))

Plans: The WG has 2 planned workshops in the coming months.

- a CWP session during the [IML topical workshop](#) at CERN, March 20 - 22, 2017
- a CWP session (TBC) during [DS@HEP 2017](#), FNAL May 8 - 12, 2017

## Conditions Database WG

[Google Doc](#)

Google group: [hsf-cwp-conditionsdb@googlegroups.com](mailto:hsf-cwp-conditionsdb@googlegroups.com) ([link to subscribe](#))

Plans:

## Event Processing Frameworks WG

[Google Doc](#)

Google group: [hsf-cwp-event-processing-frameworks@googlegroups.com](mailto:hsf-cwp-event-processing-frameworks@googlegroups.com) ([link to subscribe](#))

Plans:

# Groups/objectives

## Physics Generators WG

[Google Doc](#)

Google group: none yet

Plans:

## Math Libraries WG

[Google Doc](#)

Google group: [hsf-cwp-math-libraries@googlegroups.com](mailto:hsf-cwp-math-libraries@googlegroups.com) ([link to subscribe](#))

Plans:

## Software Development, Deployment and Validation/Verification WG

[Google Doc](#)

Google group: [hsf-cwp-software-development@googlegroups.com](mailto:hsf-cwp-software-development@googlegroups.com) ([link to subscribe](#))

Plans:

## Data Analysis and Interpretation WG

[Google Doc](#)

Google group: [hsf-cwp-analysis@googlegroups.com](mailto:hsf-cwp-analysis@googlegroups.com) ([link to subscribe](#))

Plans:

## Workflow and Resource Management WG

[Google Doc](#)

Google group: none yet

Plans:

## Data and Software Preservation WG

[Google Doc](#)

Google group: none yet

Plans:

## Careers, Staffing and Training WG

[Google Doc](#)

Google group: [hep-sf-training-wg@googlegroups.com](mailto:hep-sf-training-wg@googlegroups.com) ([link to subscribe](#))

Plans:

## Data Acquisition Software WG

[Google Doc](#)

Status: not yet active

Google group: none yet

Plans:

## Various Aspects of Technical Evolution (Software Tools, Hardware, Networking) WG

[Google Doc](#)

Status: not yet active

Google group: none yet

Plans:

## Monitoring WG

[Google Doc](#)

Status: not yet active

Google group: none yet

Plans:

# Some observations

Some groups attracted a particularly large amount of interest

Machine Learning : very well organised by the IML and DS@HEP people, extremely broad range of people attended the discussion sessions. The charge sheet is packed and could probably consume dozens of FTEs on its own.



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**Data analysis** : very lively discussions. A general rejection of “real-time analysis” as actually meaning analysis by the GPD people (to the point where they wanted to define analysis as meaning something done by individual users, not in productions). Quite a few people didn't really believe that we were serious about not reprocessing and seemed to assume this was just a gimmick.

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**Trigger&Reco** : started out as individual WGs but merged owing to the overlapping interests of the people. Will include real-time analysis as the data analysis WG explicitly refused to have it in their charge sheet. Convened, whatever that means, by David Lange and myself.



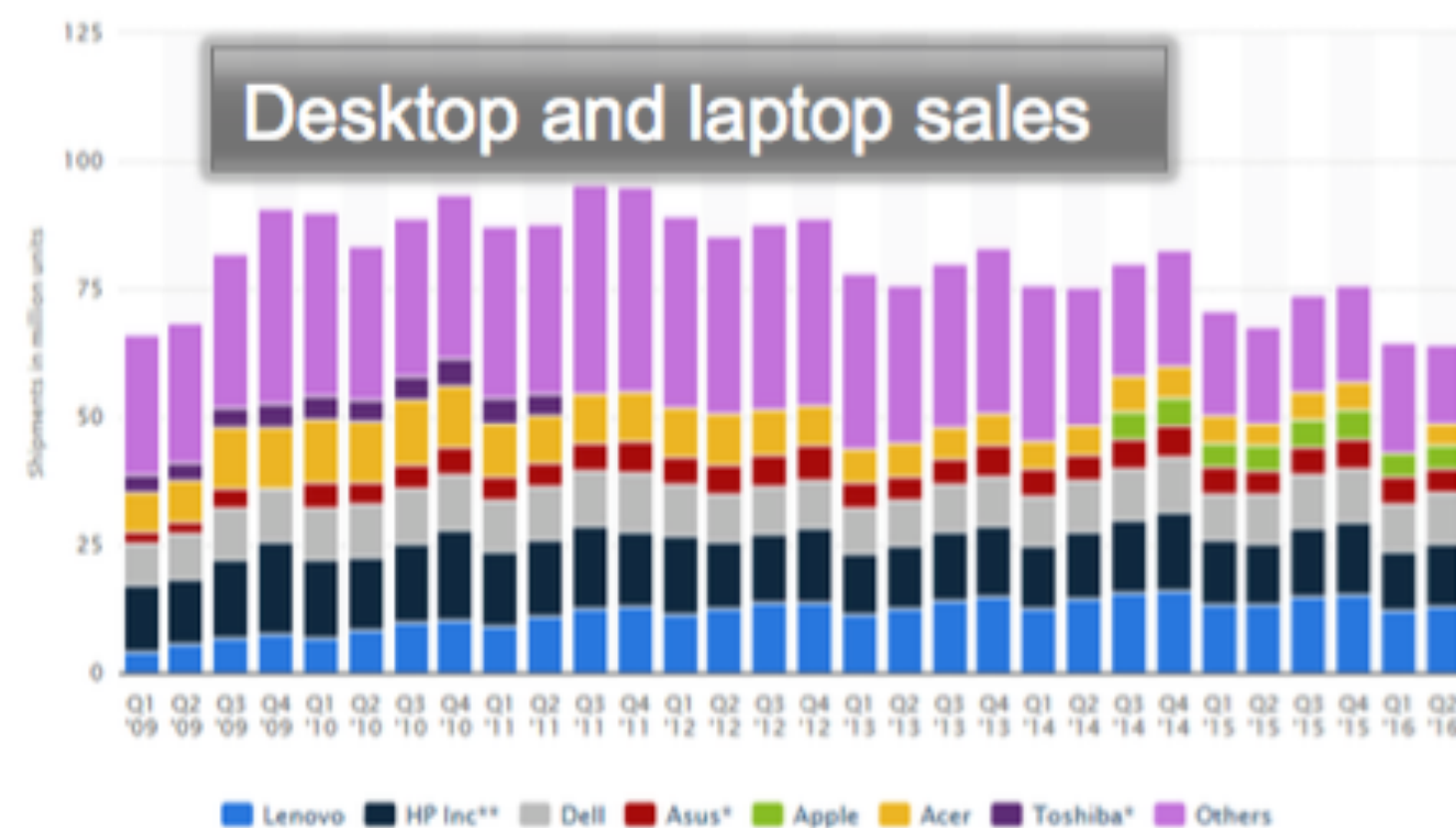
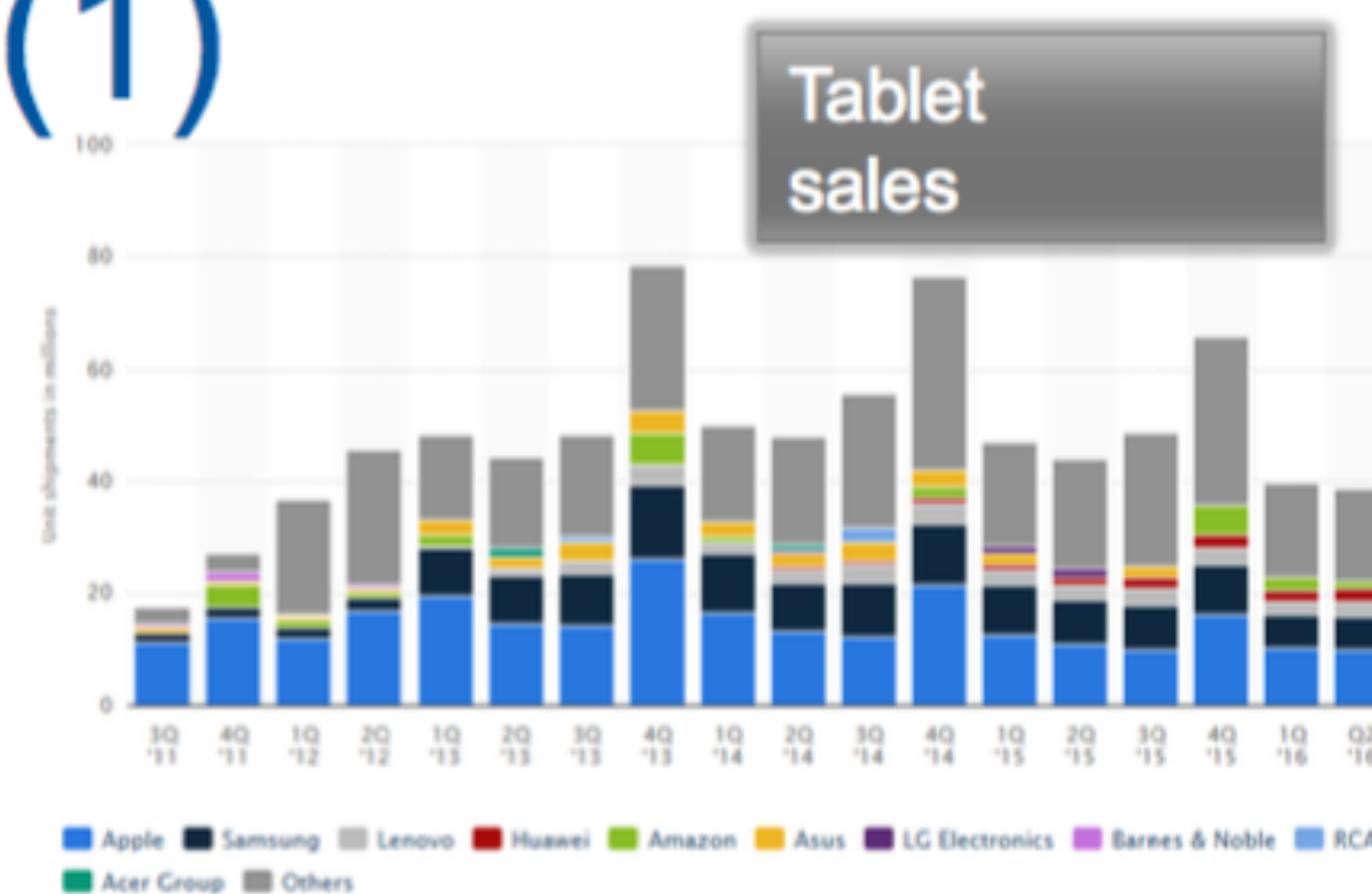
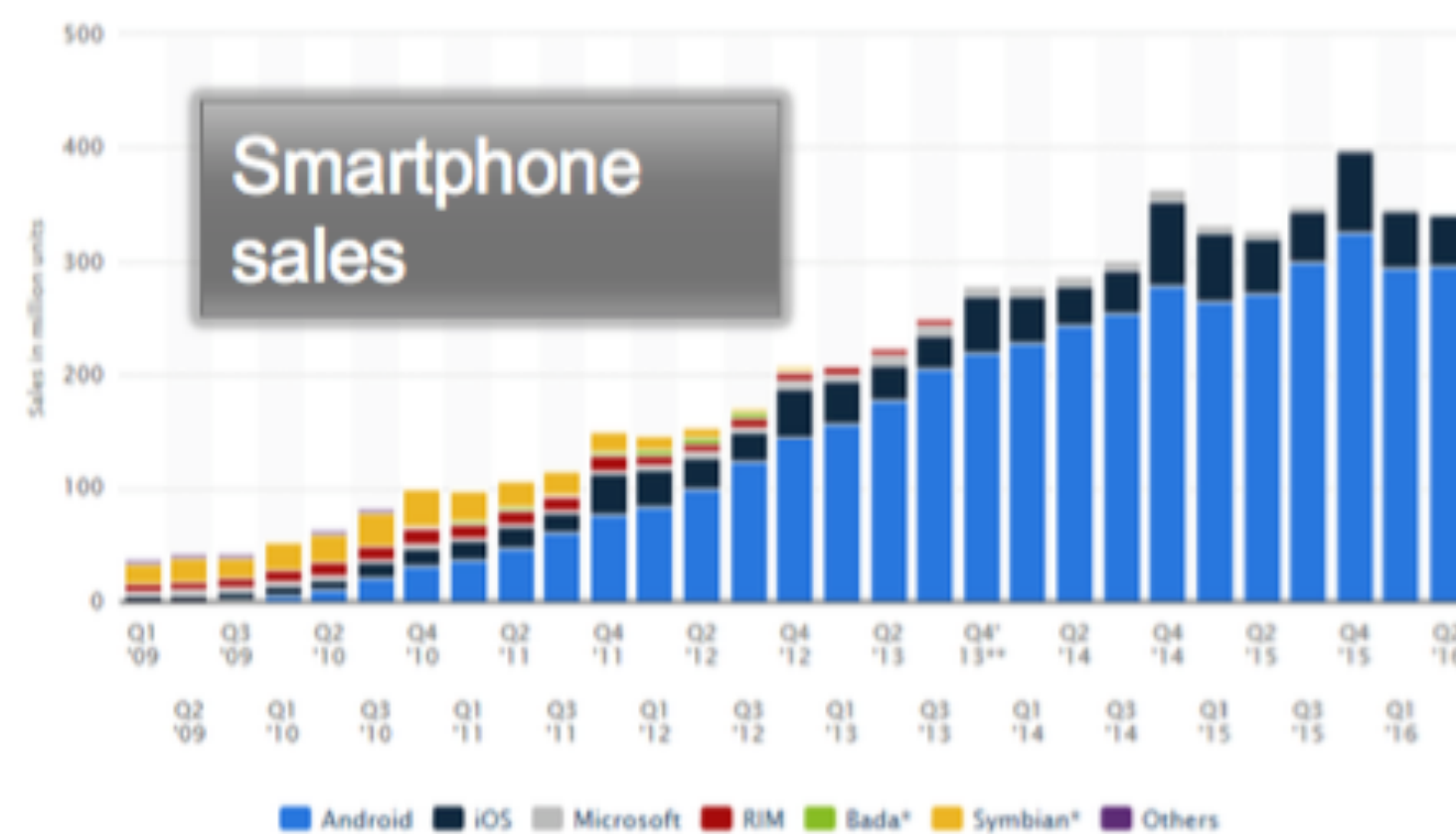
See dedicated slides by Gloria and Paul  
on the simulation and ML working groups

Will now cover some of the interesting  
points from hardware, facilities, and  
reconstruction in particular

# Key points on hardware

Some of the most useful material came in the plenary talks and panel discussion on future hardware architectures. For example, Moore's law is over because there the hardware market is saturated.. ok that's a slight simplification..

## Device Markets (1)



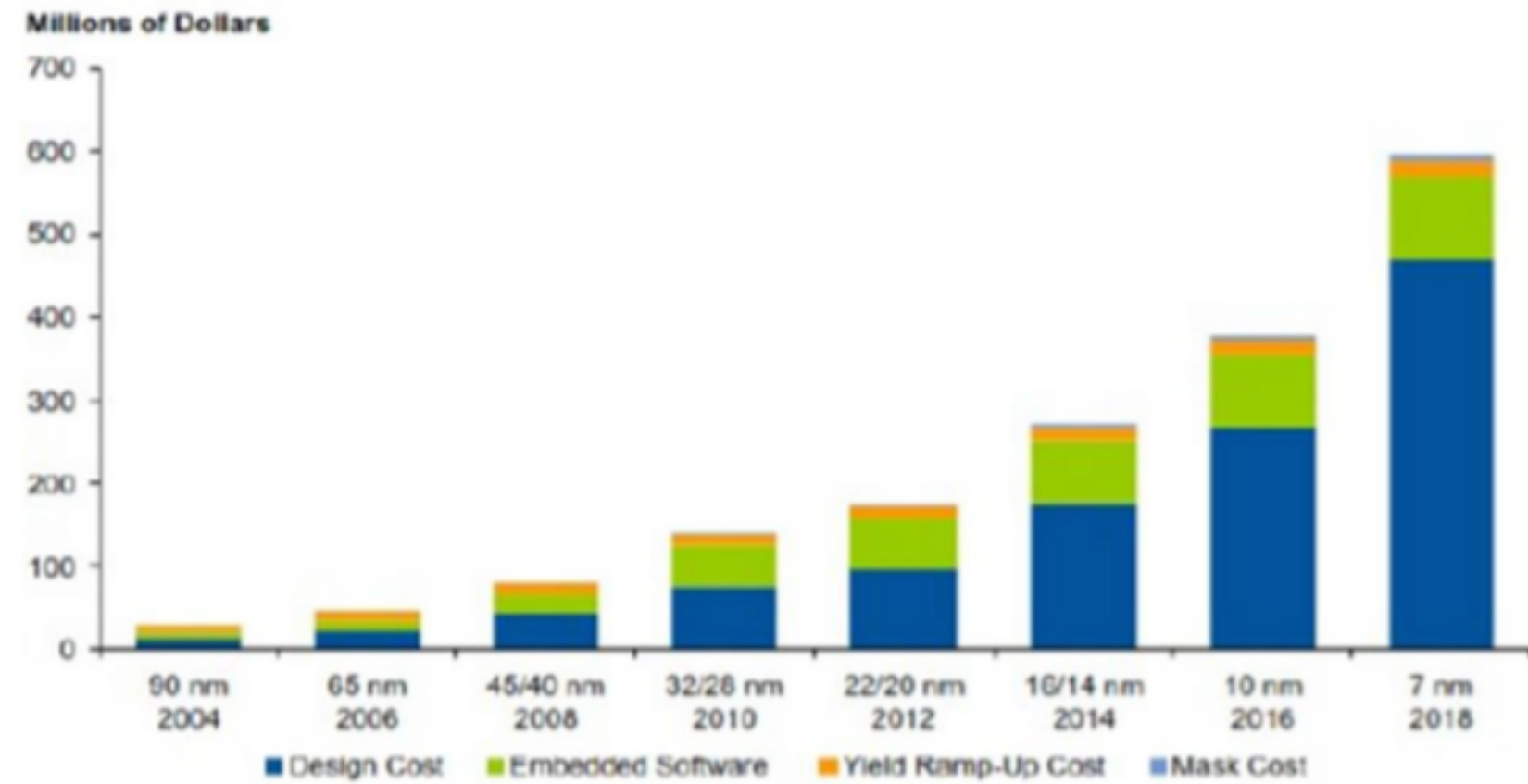
Market saturation:  
minimal or negative growth rates  
Longer product lifetimes

Smartphones	0-2 %
Tablets	-12%
Desktops and laptops	-7%
Servers	-3%



# Tick-tock-tick-...-tick-...-...-...?

Estimated Cost of Developing Lower Node Chips



Market Realist

Source: Gartner

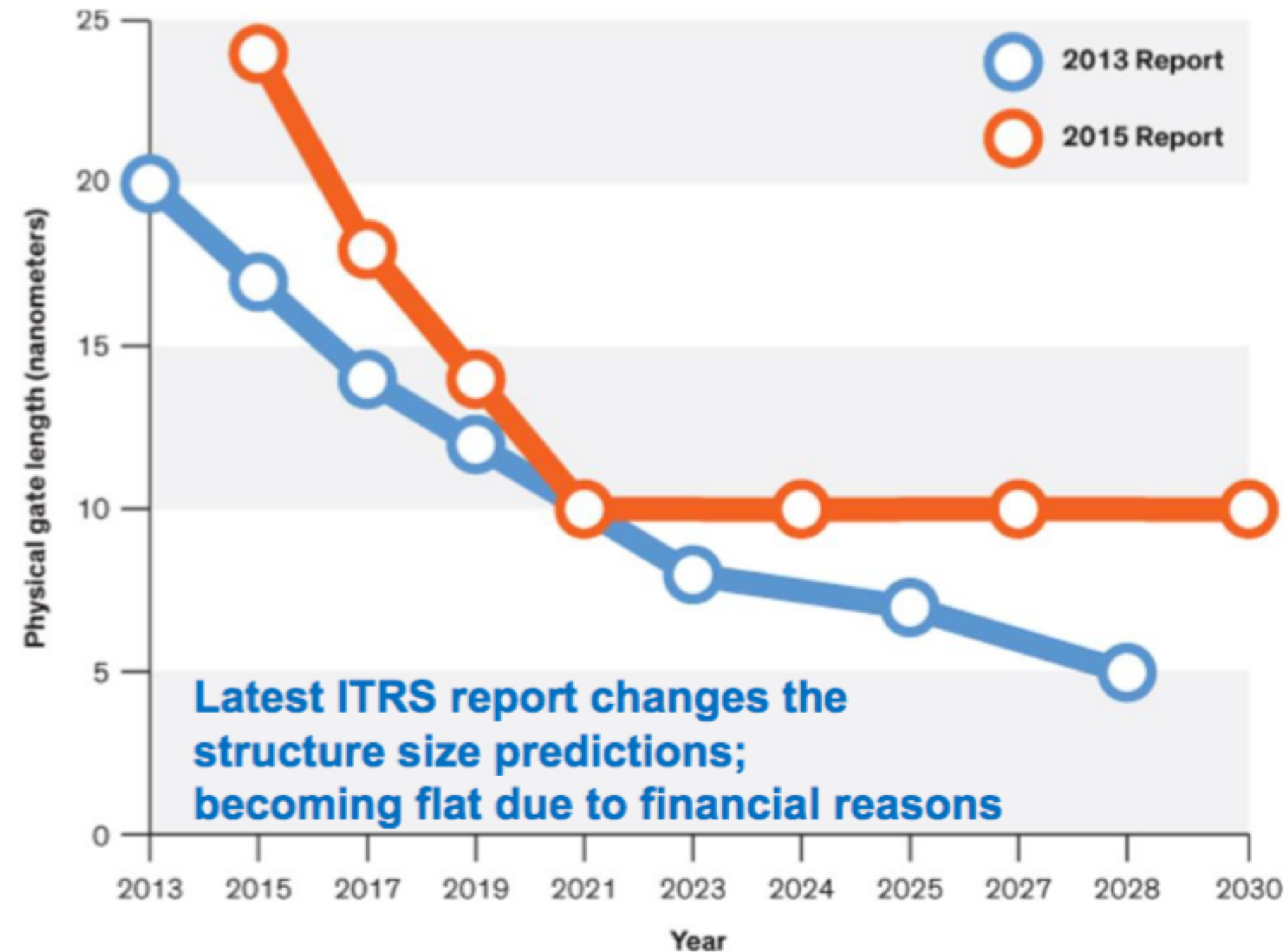
Source: IBS, Inc. (Los Gatos, CA)

Year	2001	2003	2005	2007	2009	2012	2015
SMIC							
Hitachi							
NEC							
Sony							
NXP							
Infineon							
Renesas							
Freescale							
TI							
Fujitsu							
Panasonic							
Toshiba							
UMC							
IBM							
STM							
G'Foundries							
TSMC							
Samsung							
Intel							

Figure 4. Dramatic Consolidation of state of the art CMOS Fabs. Source: IBS, Inc. (Los Gatos, CA).

## Non-linear costs for development

- Only four companies able to fabricate 14 nm chips
- 10 nm Samsung fab costs \$14 B



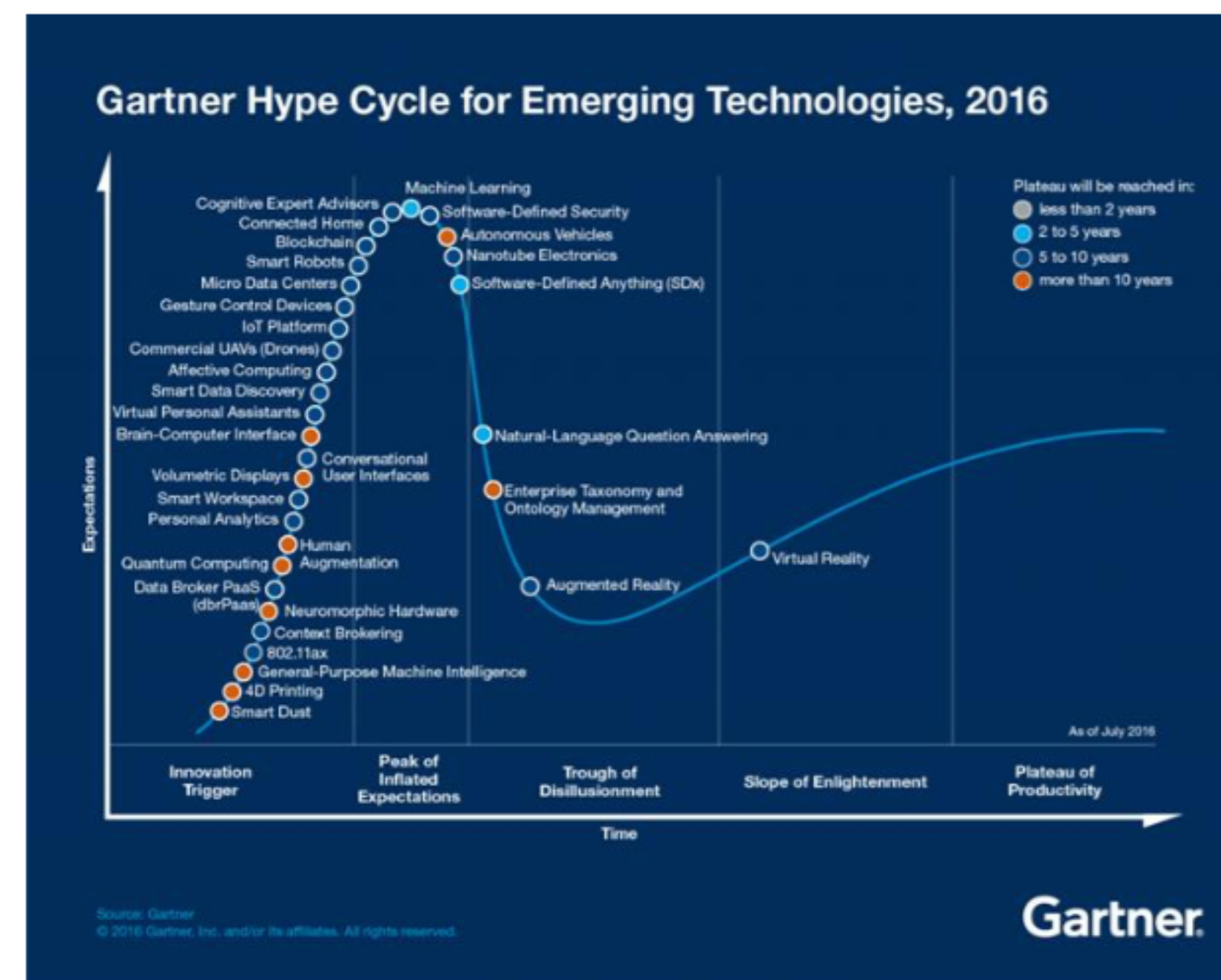
Latest ITRS report changes the structure size predictions; becoming flat due to financial reasons



# Who needs precision anyway?

Architecture fragmentation, backed up in panel discussion : focus will be more and more on specialized instruction sets for particular problems.

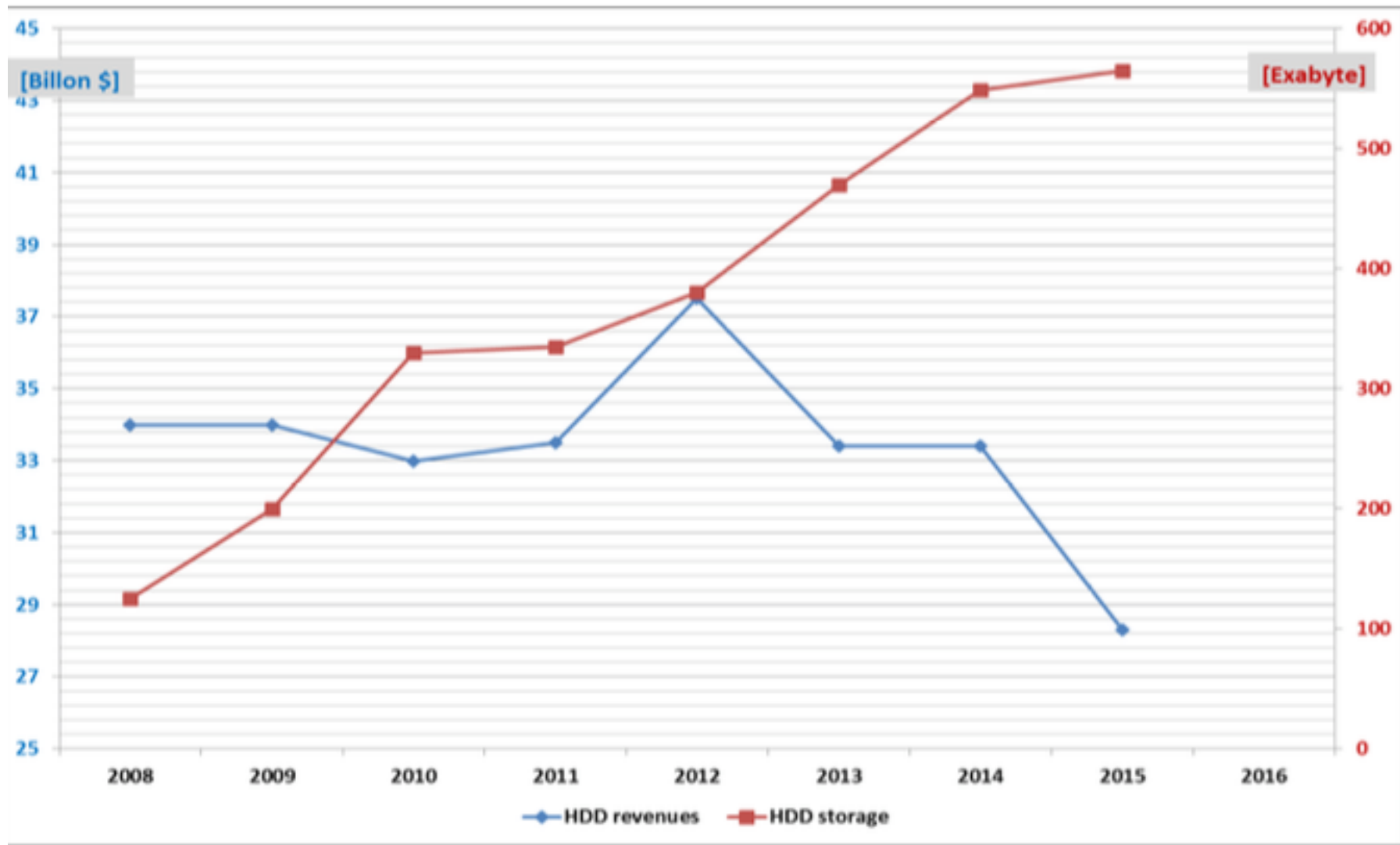
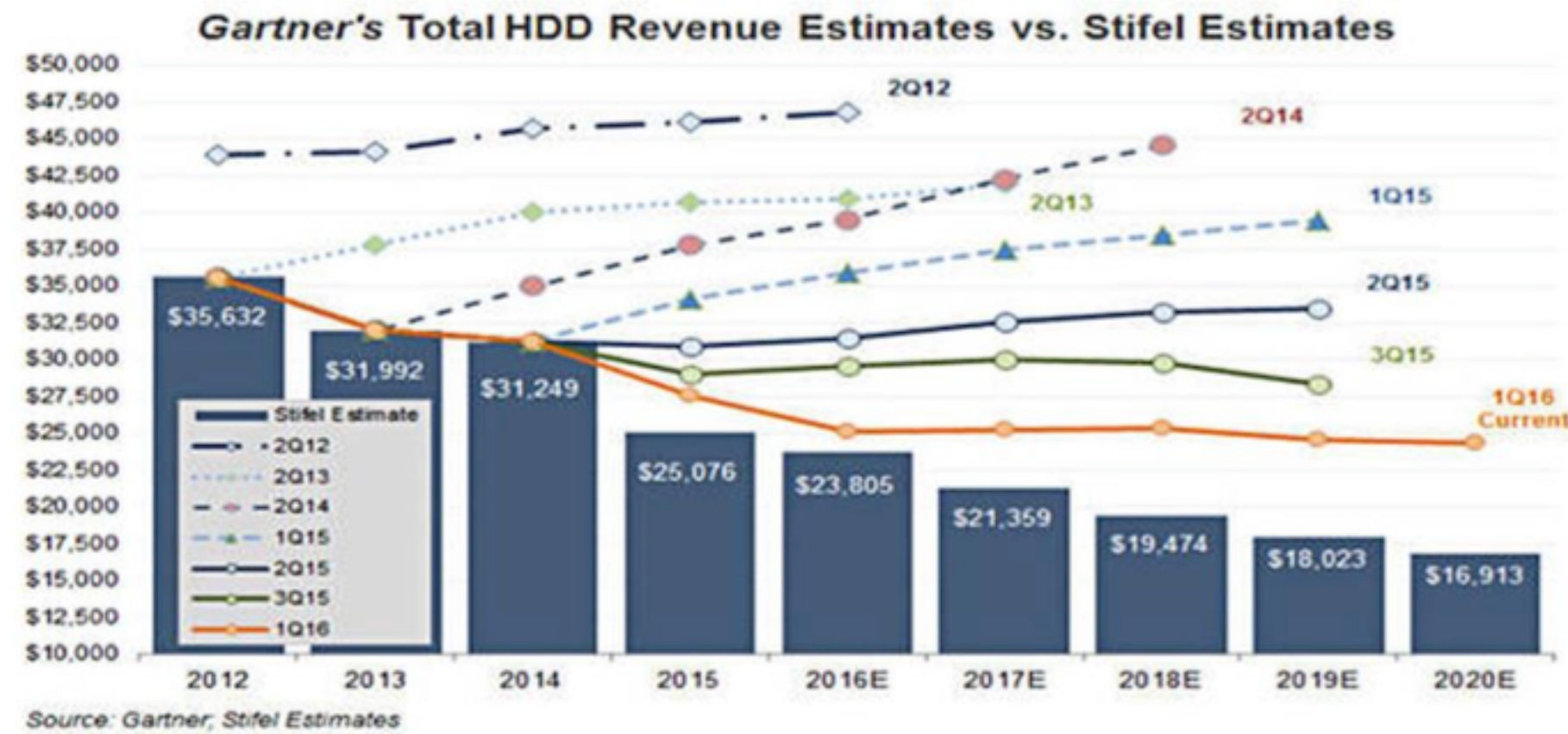
- New focus for graphic cards: machine learning
- Move to FP16 and even INT8 architectures, less precision → 8 bit processing !
- Google TPU Tensor Processing Unit
- New start-ups with special processor designs: e.g. KnuEdge, Nervana (just bought by Intel), krtkl, Eyeriss
- Essentially not usable as general purpose processors (online?!)
- Intel changing strategies also for their KnightsXX processors, 'forking' models (increase FP16 and decrease DP)  
~100k units per year, very small market



- Qualcomm plans to add neuromorphic chips into the smartphone

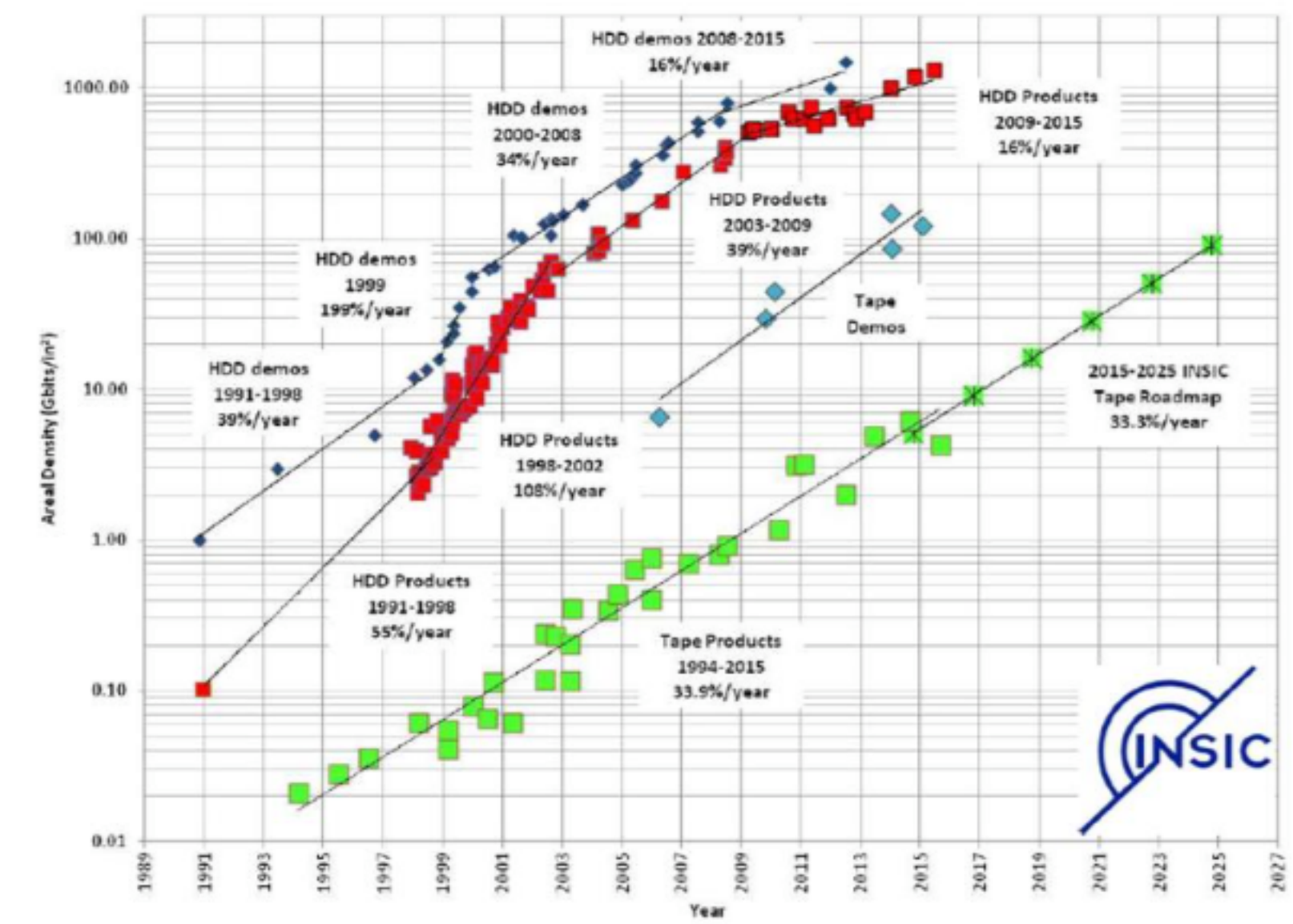


# Disque d'or



## Areal Density Trends

Chart provided courtesy of the Information Storage Industry Consortium (INSIC)



©2016 Information Storage Industry Consortium - All Rights Reserved

Areal density improvement dropped from ~40% to 16% per year

# Overall hardware summary

- Moore's Law and Kryder's Law are slowing down
  - 18 months  $\rightarrow$   $\geq$  3 years
- Real cost/performance evolution driven by financial and market aspects rather than technology

**Translation : we are a tiny market hence totally screwed by this.**



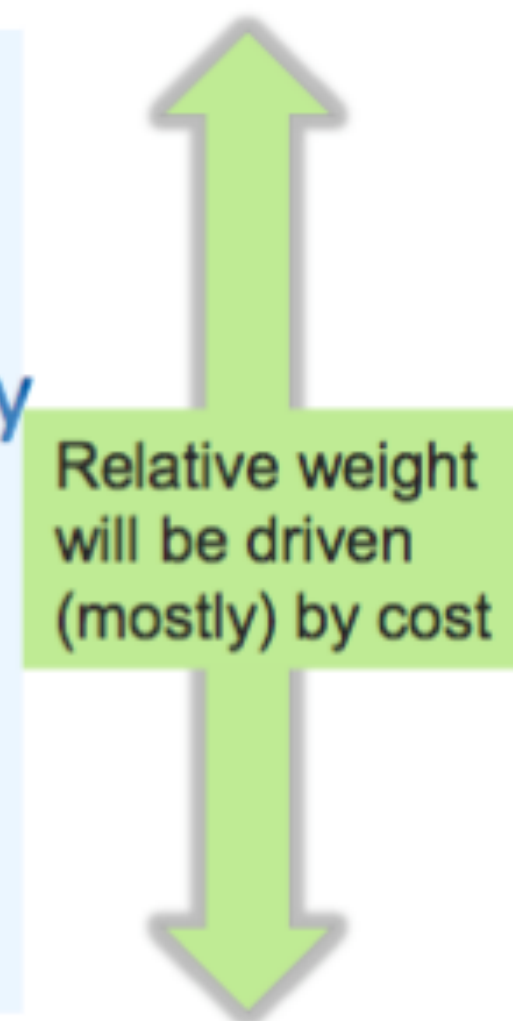
# Clouds everywhere

Most of the slides from CERN about infrastructure were about clouds. A personal comment, also driven by the way AFS is being phased out : there seems to be a desire to cut costs by shifting the analysis model to laptops+cloud, which will hurt the poorest groups which don't have local clusters the most.

An interesting tension between the analysis WG which seems to want to treat analysis as "what individuals do" and the drive from facilities side towards production style work for anything but the most cursory data inspection.

## CERN Facilities – longer term

- ❑ CERN Meyrin + Preveessin data centres
  - Aim to keep fully occupied
  - Option: "Wigner-like" or hosting for business continuity
    - Could be a cloud-like solution too
  - 2<sup>nd</sup> Network hub
- ❑ Elasticity from cloud/commercial resources
  - Use as required – within cost envelope
- ❑ Extended with other opportunistic resources
  - HPC, <lhcxperiment>@home, etc.





# Options for Future Computing

- **Example: LHC Run 4 (2026 and beyond) will start the exabyte era for HEP!**

- How will the data be processed and analyzed?

- Buy facilities**

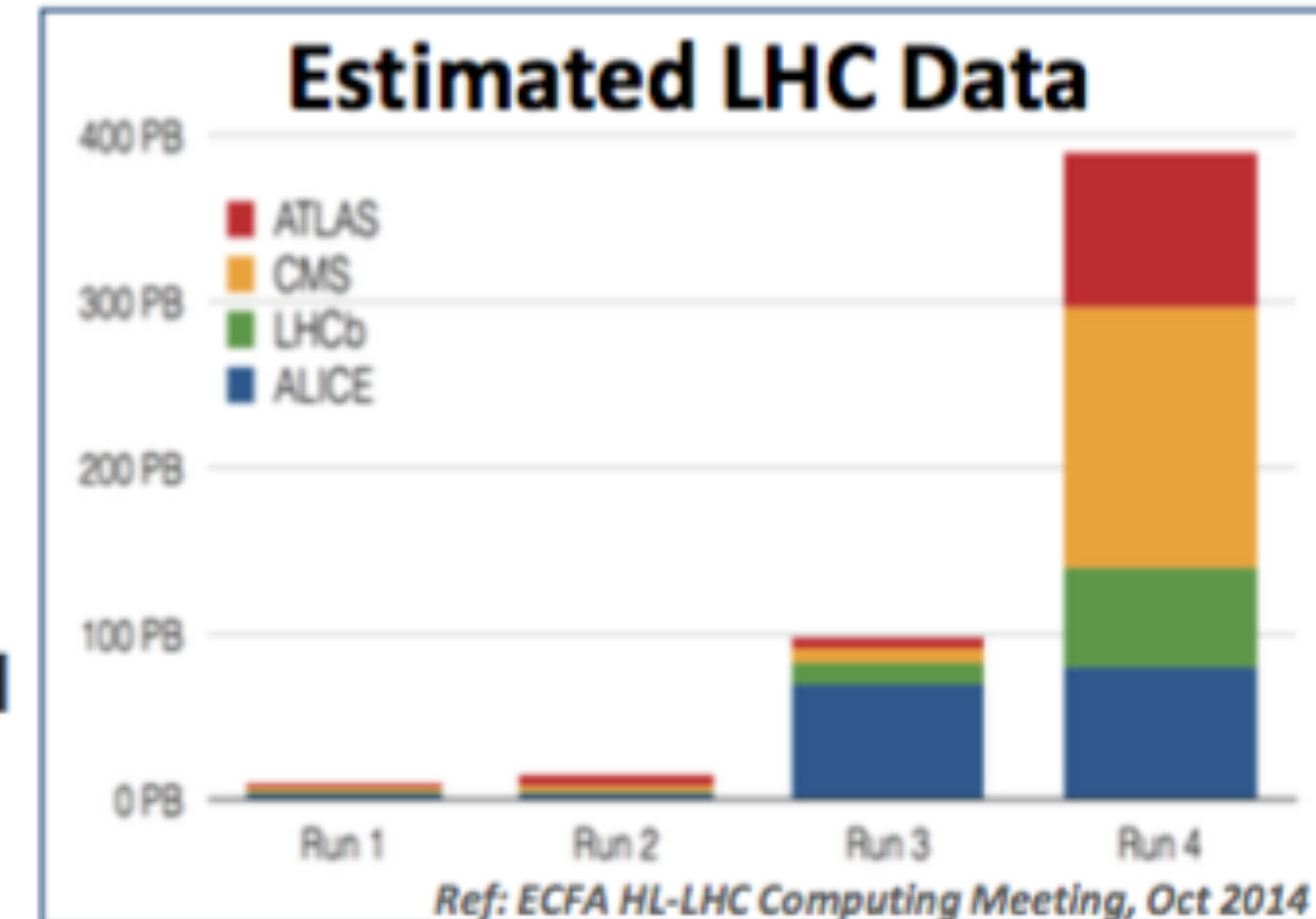
- ✓ **Pro:** Own it! No impediment to running at full capacity when needed

- ✗ **Con:** Must invest for peak utilization even if not used

- Use services from other providers**

- ✓ **Pro:** Others make capital investments

- ✗ **Con:** Will usage be available/affordable when needed?



- **Current computing model provides examples of infrastructure not owned by HEP**

- Like ESNNet, NERSC, commercial clouds; not necessary for HEP to purchase all hardware

- Hybrid model**

- ✓ **Own baseline resources that will be used at full capacity**

- Reliable cycles available for reconstruction, MC generation, etc.

- ✓ **Use service providers for peak cycles when needed**

- Conference analysis season, special collaboration needs, etc.

- ? **Community and agencies exploring this approach, *but* future cost model uncertain**

- **To achieve P5 global vision, all partners need to bring in their available resources!**



# Options for Future Computing

Example: HIC Run 4 (2026 and beyond) will start

A lot of chat about peak vs. on demand use, capital investment, and so on.

In my personal view, this ignores or sidesteps the tradeoffs between disk space and CPU usage which will become more relevant as we go on into the HL-LHC era.

Partly I mean that the less disk you have, the more you have to use CPU. But also what I mean is that e.g. we could easily burn all our CPU 10x over generating MC all the time for analysis, but we wouldn't have the disk space to store it even if we did.

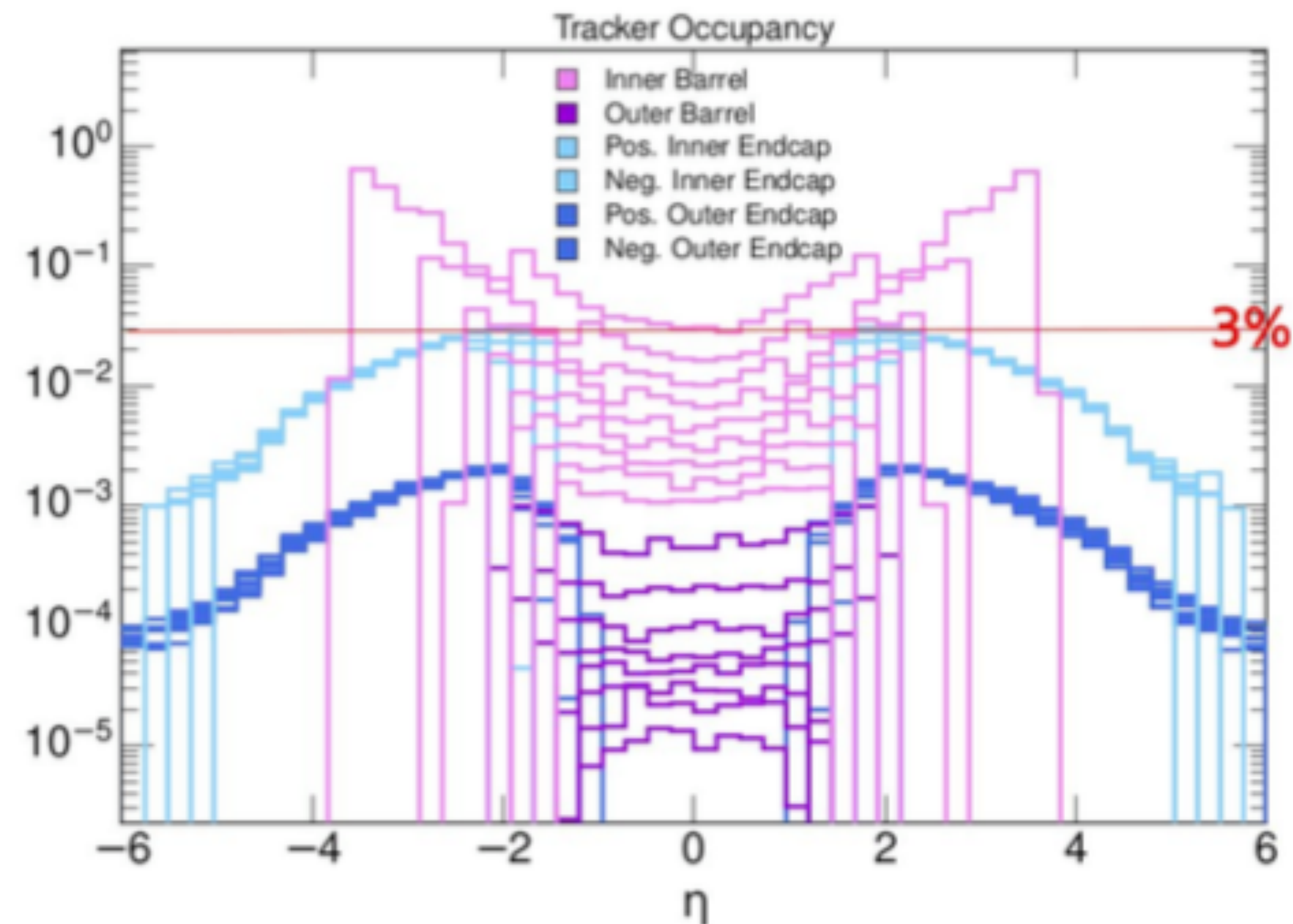
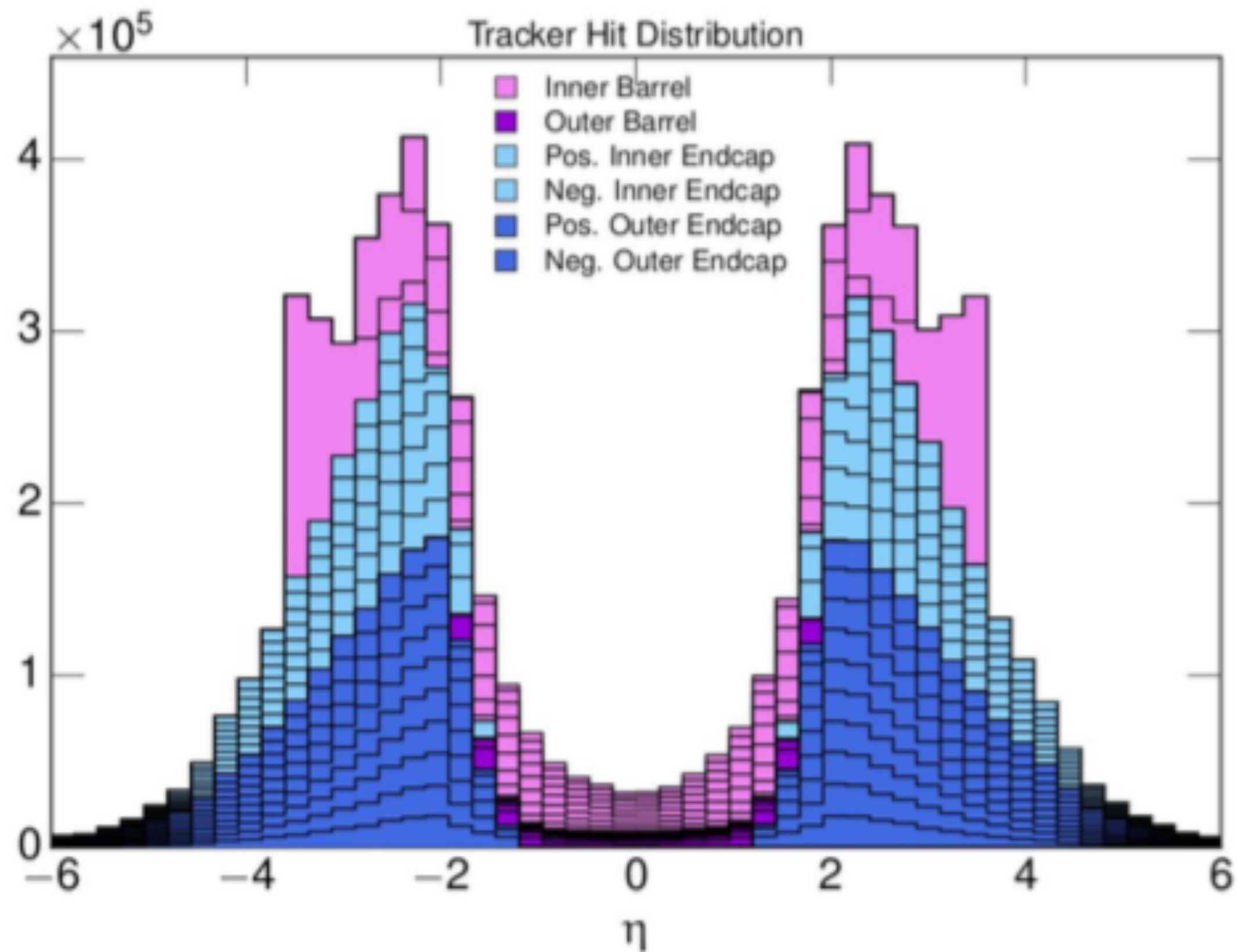
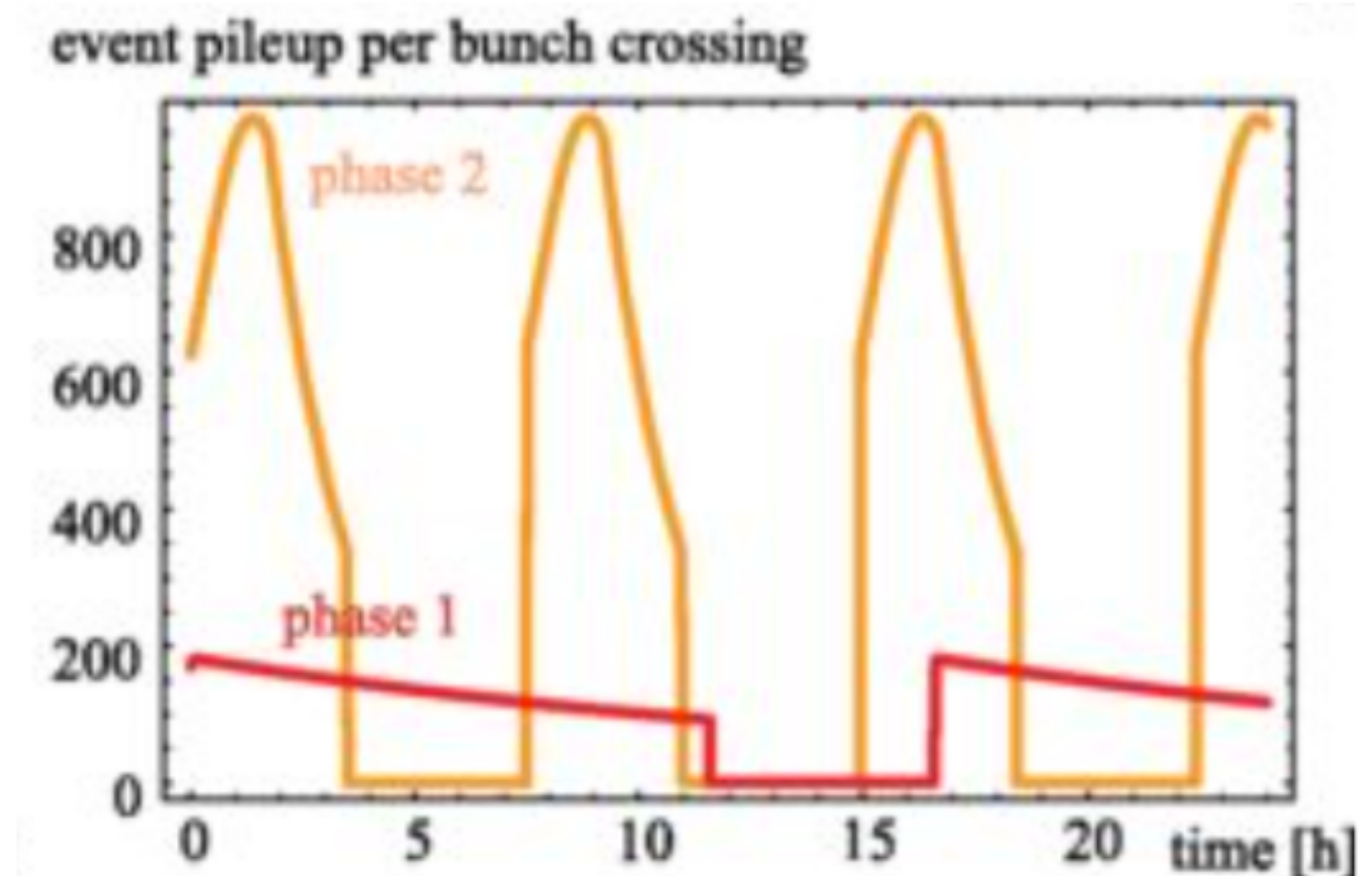
However as we move towards analysis trains and true real-time reproducible analyses, we will in principle be able to generate all the MC we want, run it through the analysis, and then discard it (or keep a heavily reduced analysis format for reproducibility). So should never be idling anywhere.

This is also a bigger problem for LHCb because I can see more and more precision analyses asking for MC closure tests before approval, which in the case of things like Charm will mean infinite samples and CPU time even with "fast" options. This is a real difference with ATLAS/CMS and should be communicated better to outside world.

# Reconstruction

My favourite talk was on the FCC : insane stuff

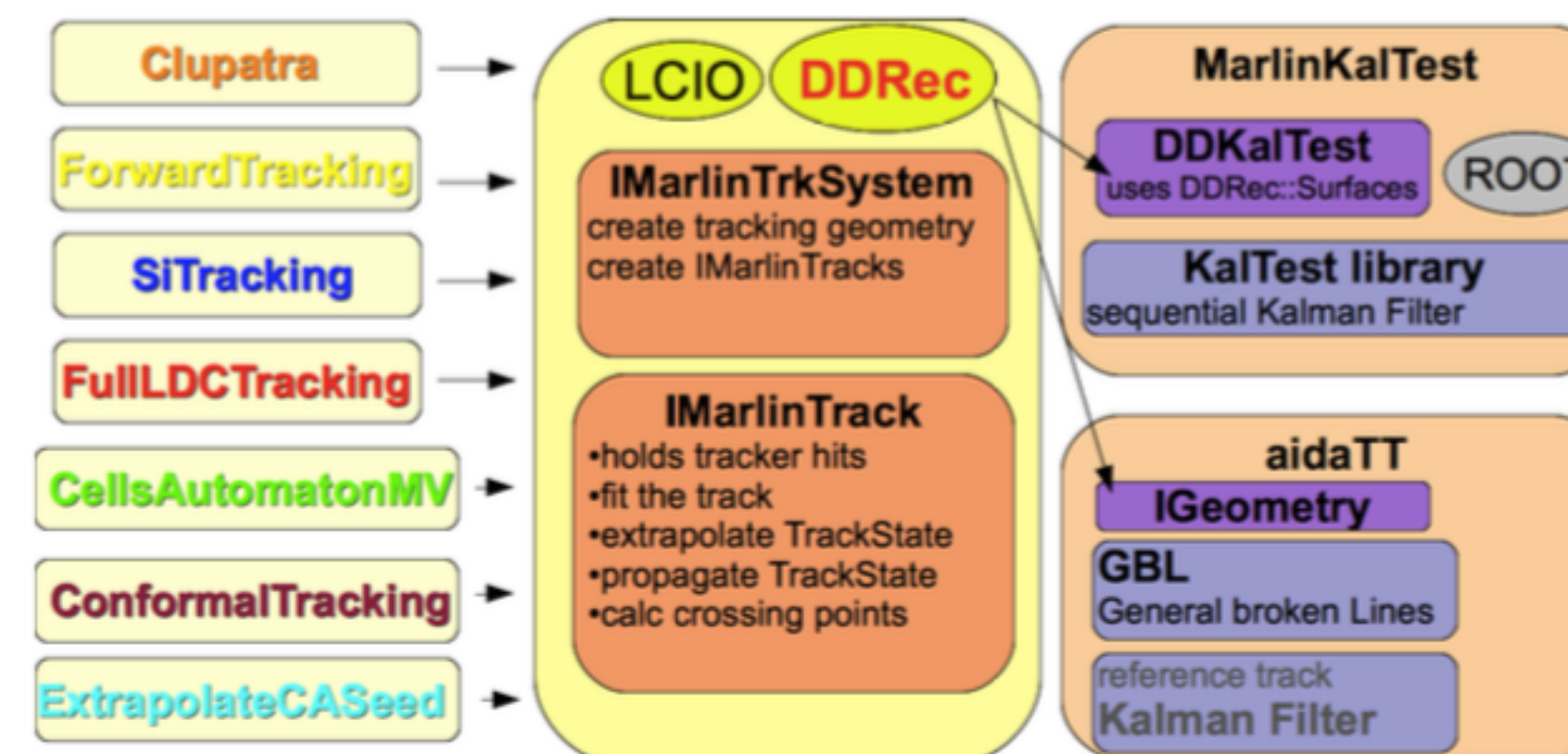
Completely absurd without 4D tracking, likely silly even with this.





# AIDA etc.

- *MarlinTrk* is a generic tracking toolkit
  - based on the **LCIO-EDM** and **DD4Hep** geometry description
  - used by ILC, CLICdp and CEPC
- *IMarlinTrk* interface separates pattern recognition from concrete track fitters
- *DDRec* provides surfaces with material properties -automatically extracted from the detailed DD4hep detector geometry



- plan to evolve into a truly generic HEP tracking toolkit
- need to investigate synergies with *ACTS* ?

Lots of chat about generic tracking frameworks. It is not obvious to me that this is really what will help us with our real data problems, although I can see the conceptual interest from ILC/CLIC/FCC etc. people.

On the other hand, implementing our baseline tracking in this, combined with DELPHES, could make it a lot easier to perform standalone proof-of-concept studies and collaborate with non-LHCb people, which would be great.

# Software trigger & reco WG chapter

## Software trigger and event reconstruction

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# Software trigger & reco WG chapter

## Challenges posed by Future Facilities

### Goals:

1. Describe expected evolution in accelerator operating conditions. For CMS/Atlas, its the move towards higher pileup (200, perhaps limited by experiment and/or software algorithm performance (physics and technical), similarly for LHCb Phase II upgrade
2. Describe the overabundance of signal problem faced by experiments, e.g. with reference to Kaon/Charm physics at LHCb or B-physics at CMS/ATLAS

## Landscape of Experimental apparatus

### Goals:

1. Describe expected experimental hardware changes on 5-15 year timescale. Focus on new experimental features that trigger the need for R&D. Eg, move towards silicon trackers, CMS high-granularity calorimeter, tracking triggers, high-precision timing detectors, desire to fully exploit the LHC's cross-section for light-quark physics which necessitates a reconstruction of ultra-low-PT objects

# Software trigger & reco WG chapter

## Challenges from Event rates and real-time processing

Goals:

1. Describe evolution in trigger systems expected on 5-15 year timescale. Examples are
  - Increase in event rates. Eg, CMS/Atlas up to 1MHz L1 rate (HLT input rate), and 7.5 kHz output rate (event reconstruction input rate)
  - Move towards quasi-realtime processing of ~all events (examples at LHCb, CMS, etc)
2. Describe implications for trigger, reconstruction, monitoring, calibration and alignment

## Challenges from Evolutions in Computing technology

Goals:

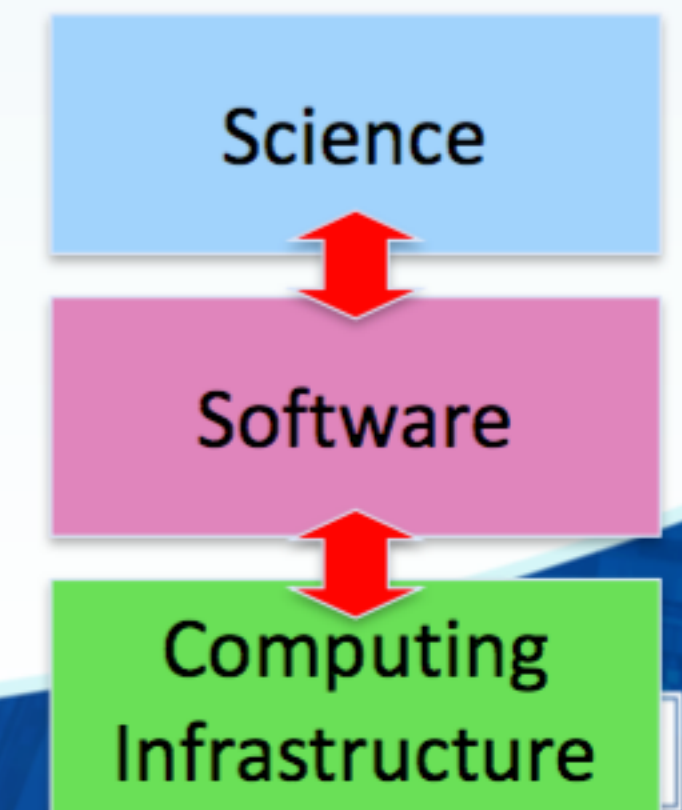
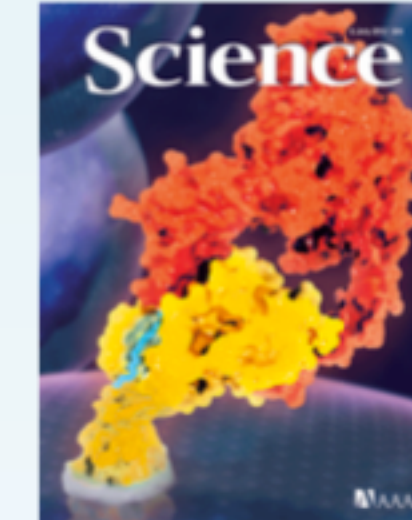
1. Summarize challenges faced by current algorithms in making efficient use of today's and future computing resources. Eg, vectorization, manycore, memory locality, I/O...
2. Describe the challenges posed by data structure optimization for both processing and readback (eg, analysis). Include in this the increasing emphasis on online data



# Sustainability of software and jobs

## Software as infrastructure

- Software (including services) essential for the bulk of science
  - About half the papers in recent issues of Science were software-intensive projects
  - Research becoming dependent upon advances in software
  - Wide range of software types: system, applications, modeling, gateways, analysis, algorithms, middleware, libraries
- Software is not a one-time effort, it must be sustained
  - Development, production, and **maintenance** are people intensive
  - Software life-times are long vs hardware
  - Software has under-appreciated value

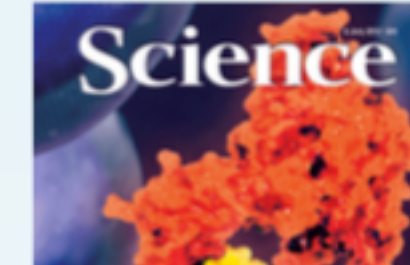


Can't do this justice, see whole slides at the workshop page

# Sustainability of software and jobs

## Software as infrastructure

- Software (including services)



Personal comment : this is a very well meaning initiative but I think it completely misses the point.

Focus is on “metrics to judge contributions to software” but at the risk of being boring, we have all the metrics we need already. The issue is that funding agencies to a large extent knowingly favour work on analysis and hardware over work on software.

The software institute which will hopefully be something concrete coming out of the CWP process will do more to solve that problem than any amount of metrics can.

Computing  
Infrastructure

Can't do this justice, see whole slides at the workshop page



# Please contribute to CWP and attend



The screenshot shows the website for the HEP Software Foundation Workshop. At the top, there is a blue header with the HSF logo and the text "HEP Software Foundation Workshop". Below the header, the dates "26-30 June 2017" and location "LAPP (Annecy)" are listed, along with the time zone "Europe/Zurich timezone". A search bar is visible on the right. A navigation menu on the left includes links for Overview, Timetable, Registration, Hotel Information, Travel Information, Participant List, Contribution List, and LAPP Venue and Rooms. The main content area contains three paragraphs of text. The first paragraph states the workshop location at LAPP in Annecy, France. The second paragraph describes the focus on the Community White Paper (CWP) and the roadmap for HEP software and computing R&D for the 2020s. The third paragraph discusses the challenges of software and computing in HEP over the next 10 years and the need for a software upgrade. At the bottom, there are logos for LAPP and Grand Annecy, along with event details: "Starts 26 Jun 2017 13:00", "Ends 30 Jun 2017 14:00", and "Europe/Zurich". A location pin icon indicates the venue is "LAPP (Annecy)".

**HEP Software Foundation Workshop**

26-30 June 2017  
LAPP (Annecy)  
Europe/Zurich timezone

Search...

- Overview
- Timetable
- Registration
- Hotel Information
- Travel Information
- Participant List
- Contribution List
- LAPP Venue and Rooms

Support


✉ [HSF2017@lapp.in2p3.fr](mailto:HSF2017@lapp.in2p3.fr)

This workshop will take place at Laboratoire d'Annecy le Vieux de Physique des Particules (LAPP) in Annecy, France.

This HEP Software Foundation (HSF) workshop will focus in particular on the [Community White Paper \(CWP\)](#), [A Roadmap for HEP Software and Computing R&D for the 2020s](#). This workshop at LAPP will be the final workshop supporting the CWP process and will work towards reaching consensus on the context of the community roadmap. There will be plenary sessions covering topics of general interest as well as parallel sessions for the [many topical working groups](#) in progress for the CWP.

Realizing the physics programs of the planned and/or upgraded HEP experiments over the next 10 years will require the HEP community to address a number of challenges in the area of software and computing. It is expected that the computing models will need to evolve and a significant "software upgrade" is required to prepare. In order to identify and prioritize the software research and development investments required, we are now beginning a community planning process. The aim is to produce a Community White Paper (CWP) which will describe the community strategy and a roadmap for software and computing R&D in HEP for the 2020s. This activity is organised under the umbrella of the HSF. The LHC experiments and HSF have been specifically [charged by the WLCG project](#) and we are reaching out to other HEP experiments around the world to participate.

 **Starts** 26 Jun 2017 13:00  
**Ends** 30 Jun 2017 14:00  
Europe/Zurich

 LAPP (Annecy)

[https://docs.google.com/document/d/1QR08RA488fwfSg5CSjmvm16-pZpGApSA01666g\\_mS\\_0/edit](https://docs.google.com/document/d/1QR08RA488fwfSg5CSjmvm16-pZpGApSA01666g_mS_0/edit)

<https://indico.cern.ch/event/613093/>