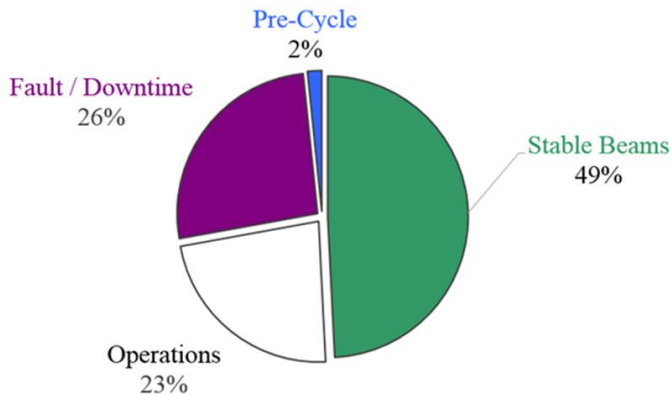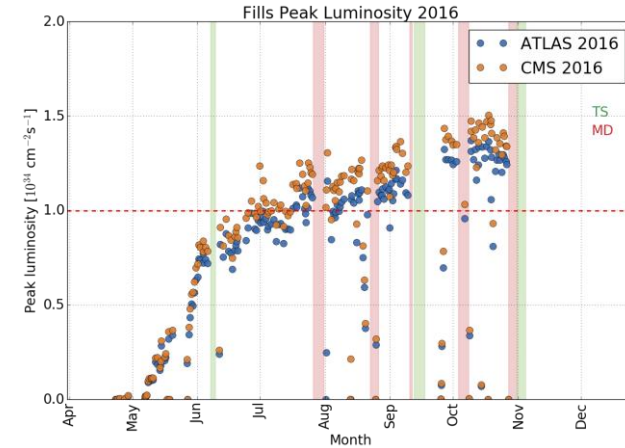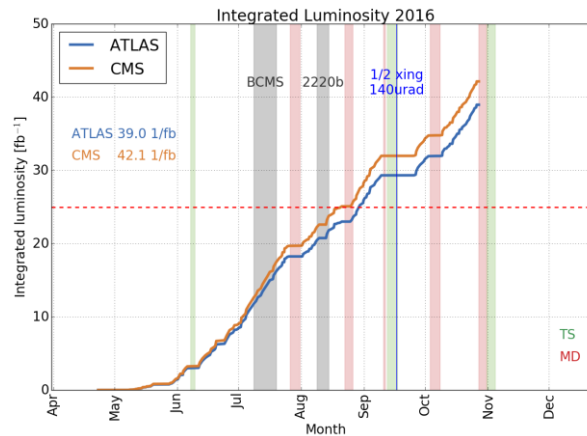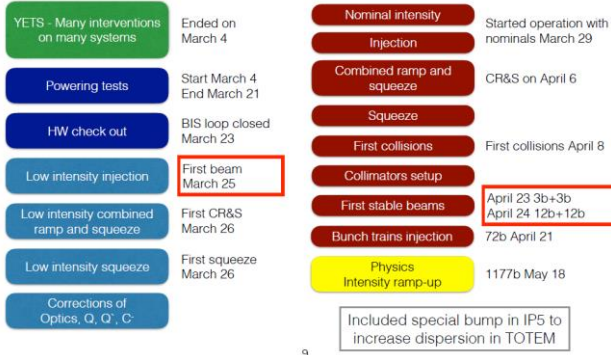# Operation of a 6 BCHF collider: do we fit the expectations?

Enrico Bravin

7th Evian workshop – Evian, 12-15 December 2016

The facts

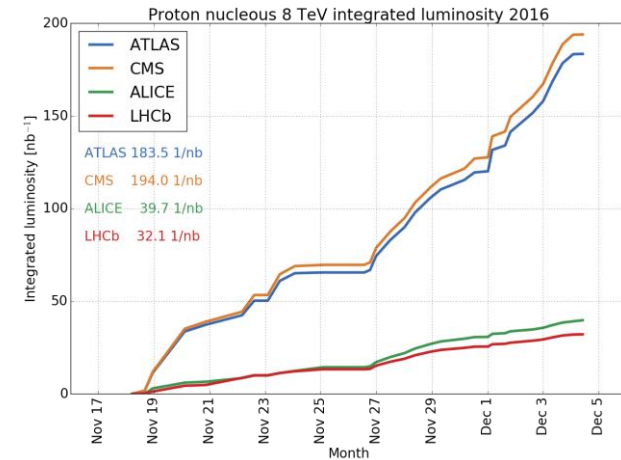Commissioning milestones

YETS – Many interventions on many systems	Ended on March 4	Nominal intensity	Started operation with nominals March 29	
Powering tests	Start March 4 End March 21	Injection		
HW check out	BIS loop closed March 23	Combined ramp and squeeze	CR&S on April 6	
First beam March 25		Squeeze		
Low intensity injection		First collisions	First collisions April 8	
Low intensity combined ramp and squeeze	First CR&S March 26	Collimators setup		
Low intensity squeeze	First squeeze March 26	First stable beams	April 23 3b+3b April 24 12b+12b	
Corrections of Optics, Q, Q`, C`		Bunch trains injection	72b April 21	
		Physics Intensity ramp-up	1177b May 18	

Included special bump in IP5 to increase dispersion in TOTEM

Integrated Luminosity 2016

ATLAS 39.0 1/fb
CMS 42.1 1/fb

Fills Peak Luminosity 2016

Pre-Cycle 2%
Fault / Downtime 26%
Stable Beams 49%
Operations 23%

Special runs

- Forward physics
- 5 TeV p-Pb
- LHC-f
- >60 MDs

Proton nucleous 8 TeV integrated luminosity 2016

ATLAS 183.5 1/nb
CMS 194.0 1/nb
ALICE 39.7 1/nb
LHCb 32.1 1/nb

Conclusion

In 2016 LHC surpassed by far the expectations

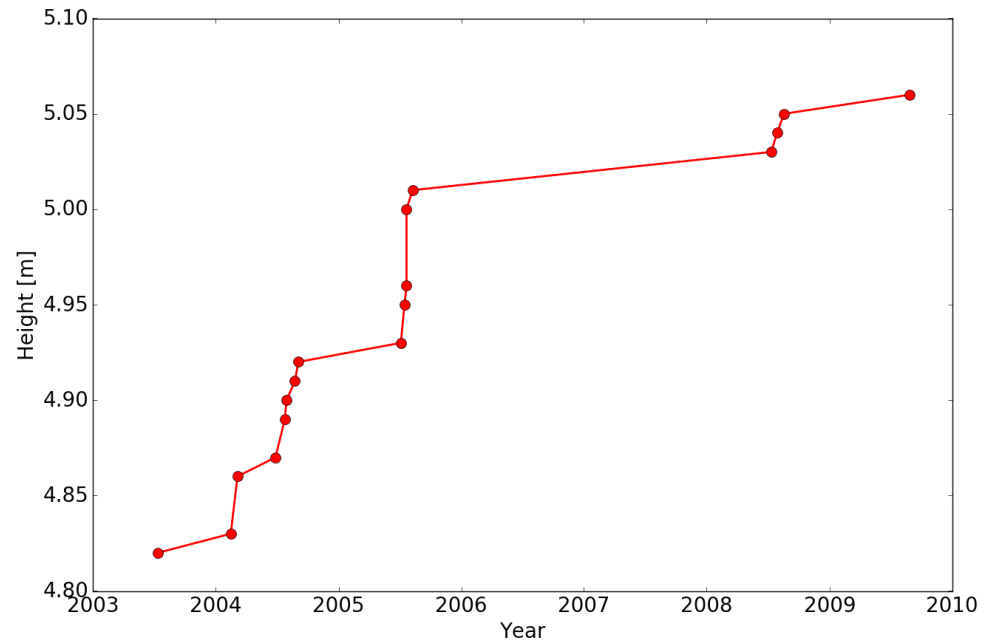Results are as good as the weakest link allow

All systems **including operation** fulfilled expectations

How high the bar

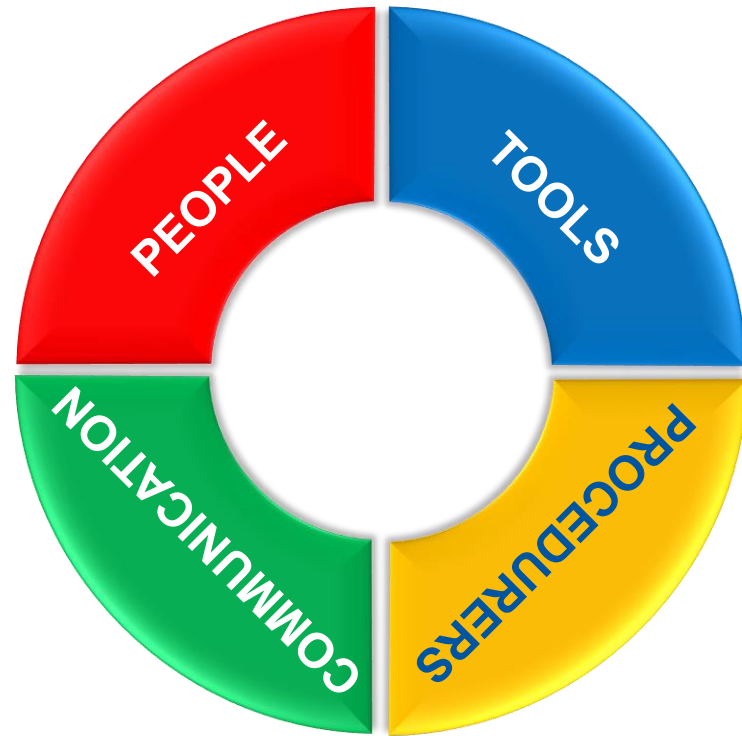### Yelena Isinbayeva world records

Between 2003 and 2010 she set 17 world records in pole vaults

How can we improve operation further?

Operation

- Operate the systems for a safe and efficient exploitation of the LHC

- Document what has been done (logbook)

- Keep other people informed (logbook, vistars)

PEOPLE

TOOLS

COMMUNICATION

PROCEDURERS

The People

- ❑ Competent and experienced operation crew

- ❑ EiC and operators with various backgrounds
  - ▪ Cover all aspects of the machine
  - ▪ May respond differently to a given situation (QA)

- ❑ Very steep learning curve for new arrivals
  - ▪ Learning almost exclusively by shadowing
  - ▪ In 2008 lot of time to teach/learn, now much less

- ❑ Some key knowledge concentrated in few people

The tools

❑ Impressive codebase

❑ Many specific tools

  ▪ Often ad-hoc tools

  ▪ Lack of homogeneity

❑ Few generic tools

  ▪ Powerful, cover-all, open to mistakes

❑ Could profit from more "intelligent" tools

  ▪ Fix the knowledge into analysis tool

❑ Could profit extending the documentation

What tools can we add?

- ❑ Time consuming cases (analysis tools)
  - ▪ Diagnose injection problems
    - o Transverse losses in TI
    - o Insufficient scraping
    - o Longitudinal losses
  - ▪ Diagnose injection mechanism
    - o Many interlocks from different machines
    - o Complex timing/control infrastructure
  - ▪ Self diagnosing systems
    - o Faster response in case piquet/expert should be called

The procedures

- ❑ Well established procedures for all operation scenarios
- ❑ Large part coded into the sequencer (and state machine)
  - ▪ This covers nearly 100% for physics production
- ❑ The rest part of EiC and operators knowledge
  - ▪ May lead to differences especially during commissioning and MDs (QA)
- ❑ Could profit from "documented" procedures
  - ▪ Preserve/share knowledge with procedures and documentation

Operational mistakes

❑ Can happen (no way we can remove all!)

❑ 52 events recorded in AFT

- Most are at injection

❑ Little impact overall during physics production

❑ Examples:

- During ion run 4 events: "Injection cleaning ON"

- Trim of Q or orbit with FB ON

- SBF forced to FALSE during MDs

- Forgot to mask some interlock for MD/commissioning

Communication

❑ Tools and structure in place

❑ Not always optimized

  ▪ We should improve MC <-> OP channel

  ▪ We can improve the communication between shifts

    o Systematic preparation during dead times

  ▪ We can improve the use of the logbook

    o Screen shots are useful, with comments even more

    o Systematic re-editing during dead times

    o Do we need all the automatic entries?

  ▪ We can improve the use of VISTARS

    o Can people understand what is going on?

Parallel activities

❑ Every EiC and Operator has other activities on top of operation

❑ During shifts operation is however the main activity

❑ Difficult to draw a line or suggest rules

▪ It is part of the professionalism of the people to make sure the two aspects can live side by side

CCC ecosystem

❑ CCC main purpose is to provide a place for operating the accelerators and the relative infrastructure

❑ Often also used as office, meeting room, visitor center, chatting place

- There are positive sides to all of this
- Also dilutes the concentration of people on shift

Conclusions

❑ The facts indicate that the operation of the LHC is certainly up to expectations

❑ Important to consolidate the high point reached

❑ Need to fix the knowledge/expertise

❑ People turnaround in the future would benefit from faster and more systematic learning tools

❑ Communication in and out of the CCC can be improved