Experience from other Machines: RHIC

operational experience: (curtsey of W. Fischer BNL)

Minimum theoretical design report Turnaround time ➔ 5min (0.4h oper)

-RHIC had a min T_{turn} = 12 * theoretical limit in first 4 years operation

-RHIC manages a min T_{turn} = 5 * theoretical limit after 4 years operation

-RHIC has average T_{turn} = 23 * theoretical limit after 4 years operation

= 5 * operational minimum

Among other things, the long turn around times are mainly caused by aborted ramps due to beam loss monitor readings during optics squeeze (bad orbit, tune or enlarged beam sizes after instabilities) & equipment failure and due to injection tuning ➔ we can expect this also for the LHC!

operation application: the average turn around time is used for calculating the optimum store length.

Experience from other Machines: Tevatron

Tevatron operation@: @(V. Shiltsev)

minimum theoretical design report Turnaround time ➔ 1 h

theoretical beam lifetime ➔ $\tau > 13$h

Store length ➔ $T_{run} = 12$ h

minimum operational Turnaround time ➔ 2.5 h

➔ 2.5 * minimum after 6y RunII

average operational Turnaround time ➔ 8 h

➔ 8 * minimum after 6y RunII

average store length (2007) ➔ $T_{run} = 21$ h

average set-up time (2007) ➔ t = 2.4h

Experience from other Machines: HERA

- minimum theoretical Turnaround time ➔ 1.5h

(35min filling plus 2*30min ramp up and down)

- Operational experience 2005@: (10 years after HERA operation)

HERA 2005:

2.6 faults per luminosity run	*	2.5 hours per fault	= 6.5 h
1.8 p injection attempts per luminosity run	*	1.43 hours per p inj.	= 2.6 h
1.6 e injection attempts per luminosity run	*	0.83 hours per e inj.	= 1.3 h
			10.2 h

from dump to lumi

➔ average turn around time = 6 * minimum turn around time

@(M. Bieler; Arcidosso, September 2005)

Summary

- operation efficiency: all analyzed colliders have ca. 50% efficiency (time in physics / allocated operation time)
  ➔ seems to be a reasonable assumption for LHC operation

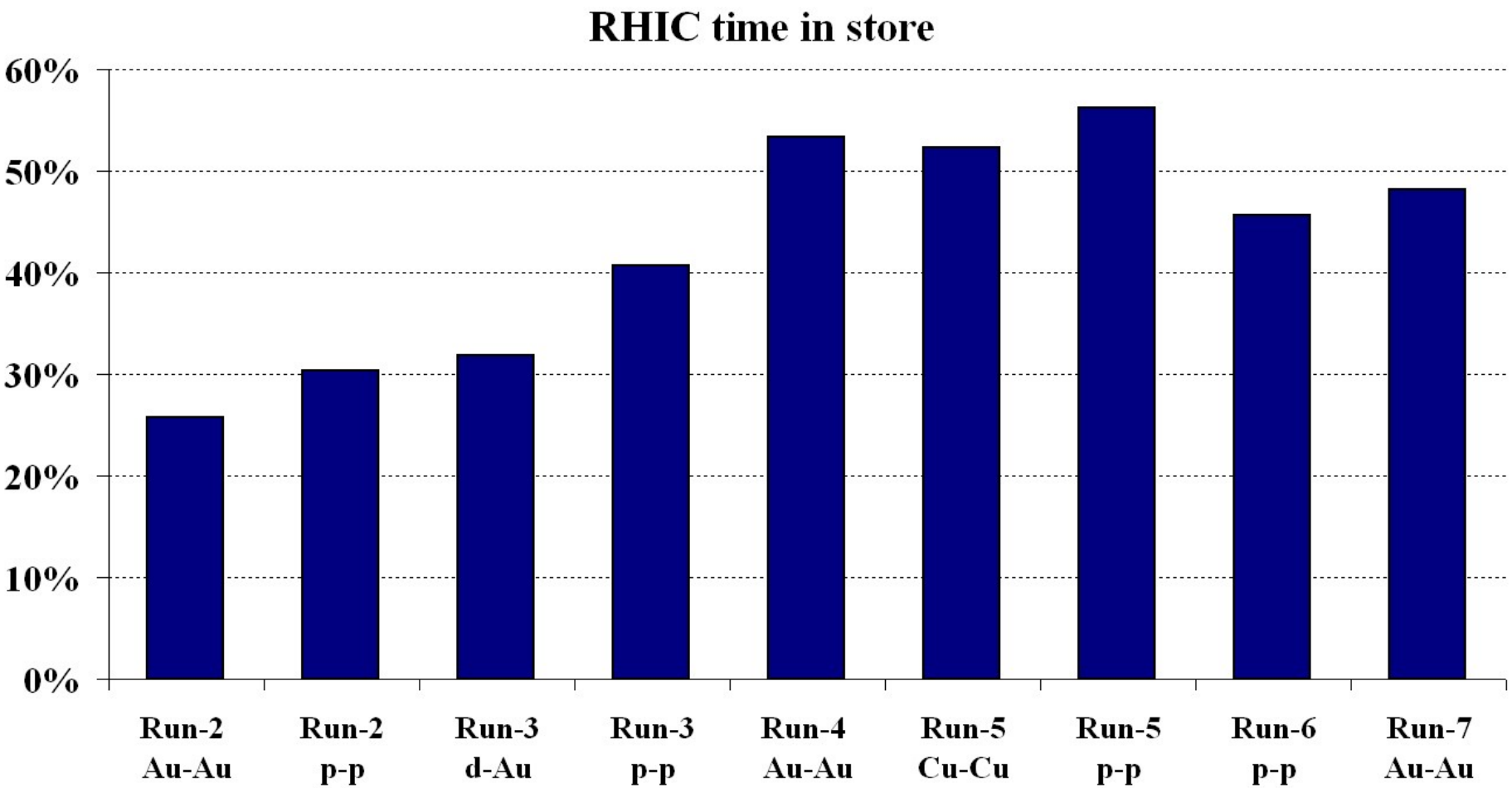
- minimum turnaround time: all analyzed colliders could not reach their theoretical minimum turn around time (injection tuning!)
  RHIC: 12 * min_{theor}; Tevatron: 2.5 * min_{theor}; HERA: 1.5 * min_{theor}

- average turnaround time: all analyzed colliders have a significantly larger average turn around time even after several years of operation (failures)
  RHIC: 5 * min_{oper}; Tevatron: 8 * min_{theor}; HERA: 6 * min_{theor}

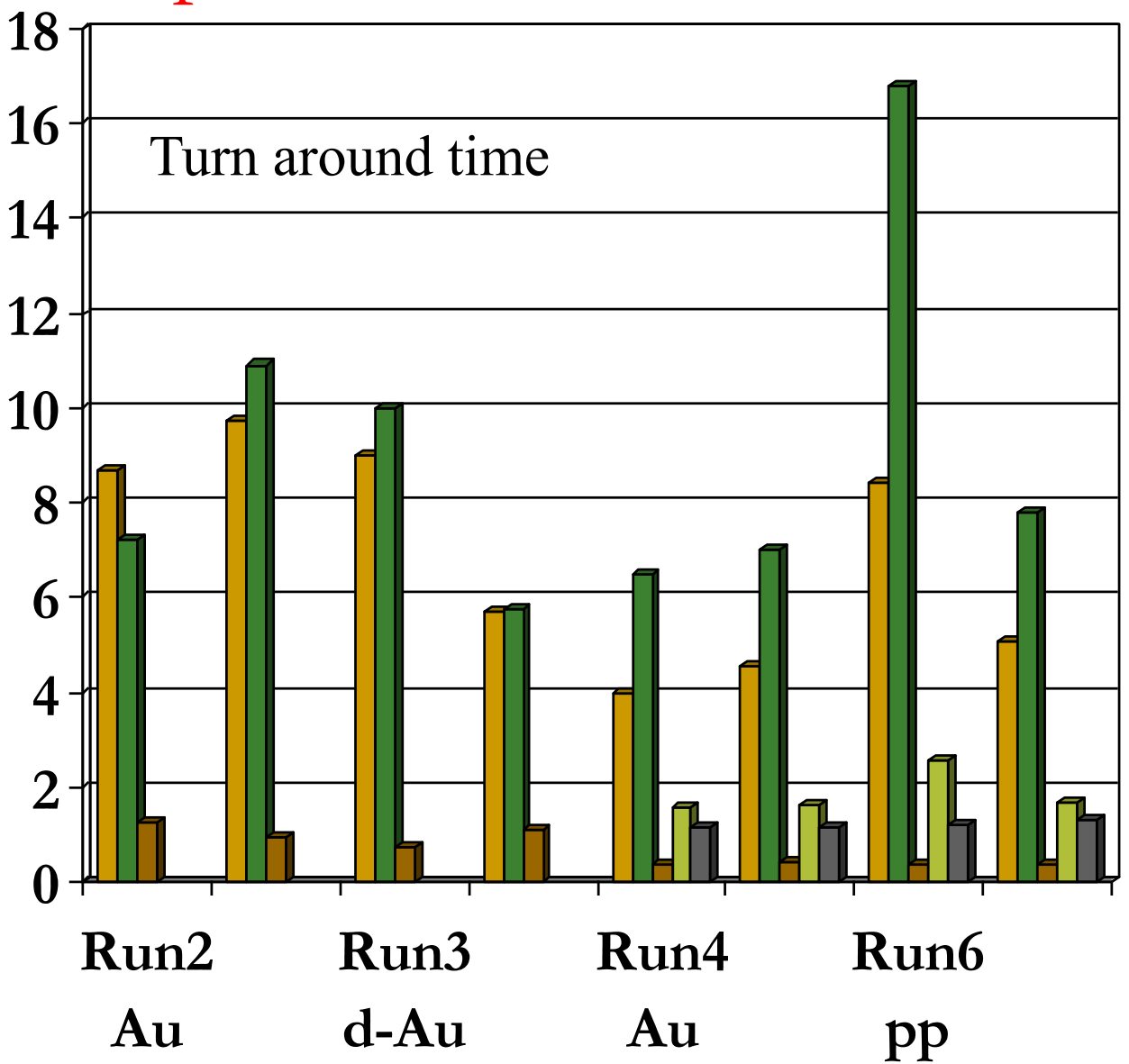
Spare Transparencies

Experience from other Machines: RHIC

operational experience: (curtsey of W. Fischer BNL)



Experience from other Machines: RHIC@



average $T_{turn\text{-}around}$:
ca. 1.9h for 5h cut

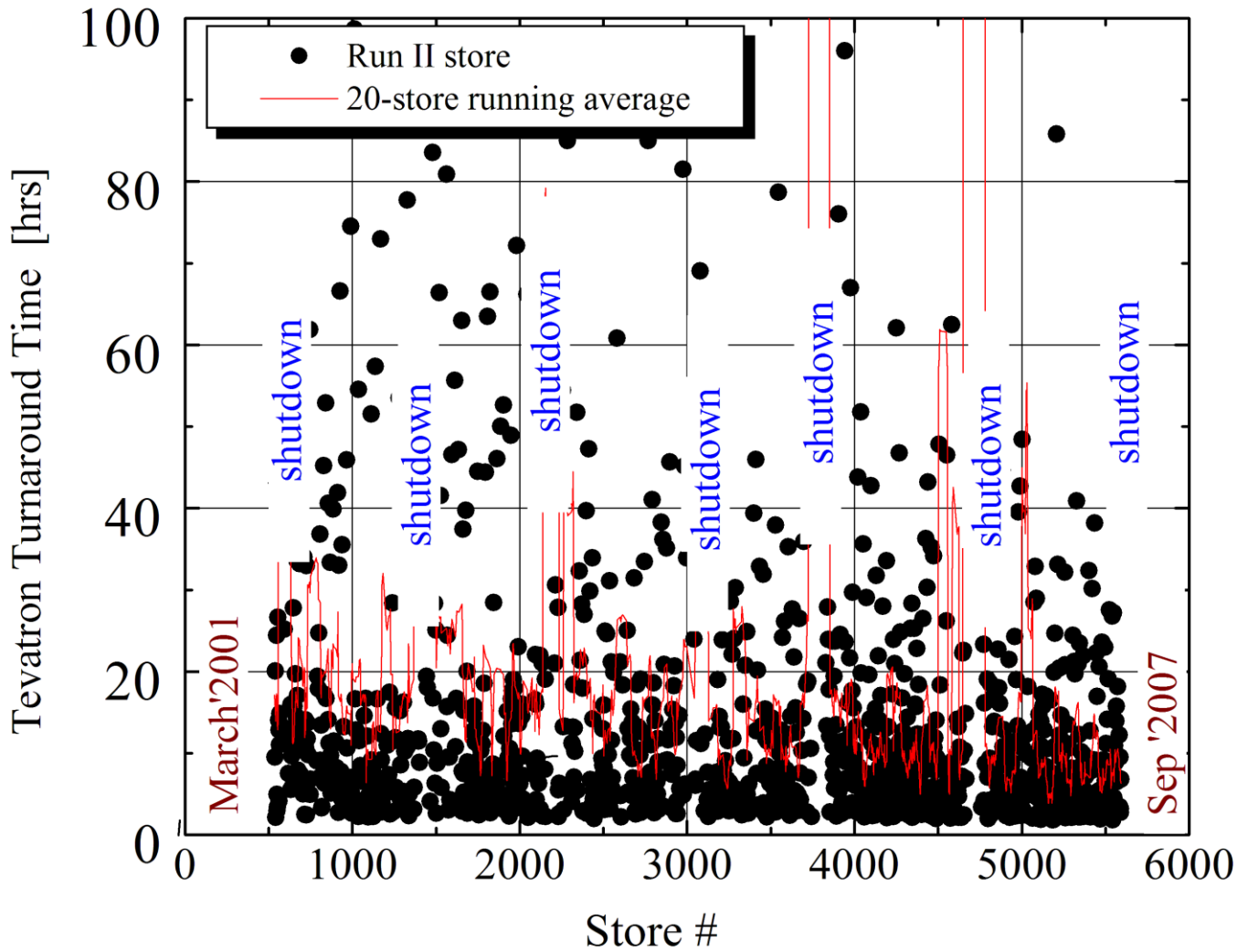
min $T_{turn\text{-}around}$:
ca. 1h for 2nd & 3rd run
ca. 0.4h for last 4 years

@(curtsey of W. Fischer BNL)

Experience from other Machines: Tevatron

average turn-around time: (V. Shiltsec)

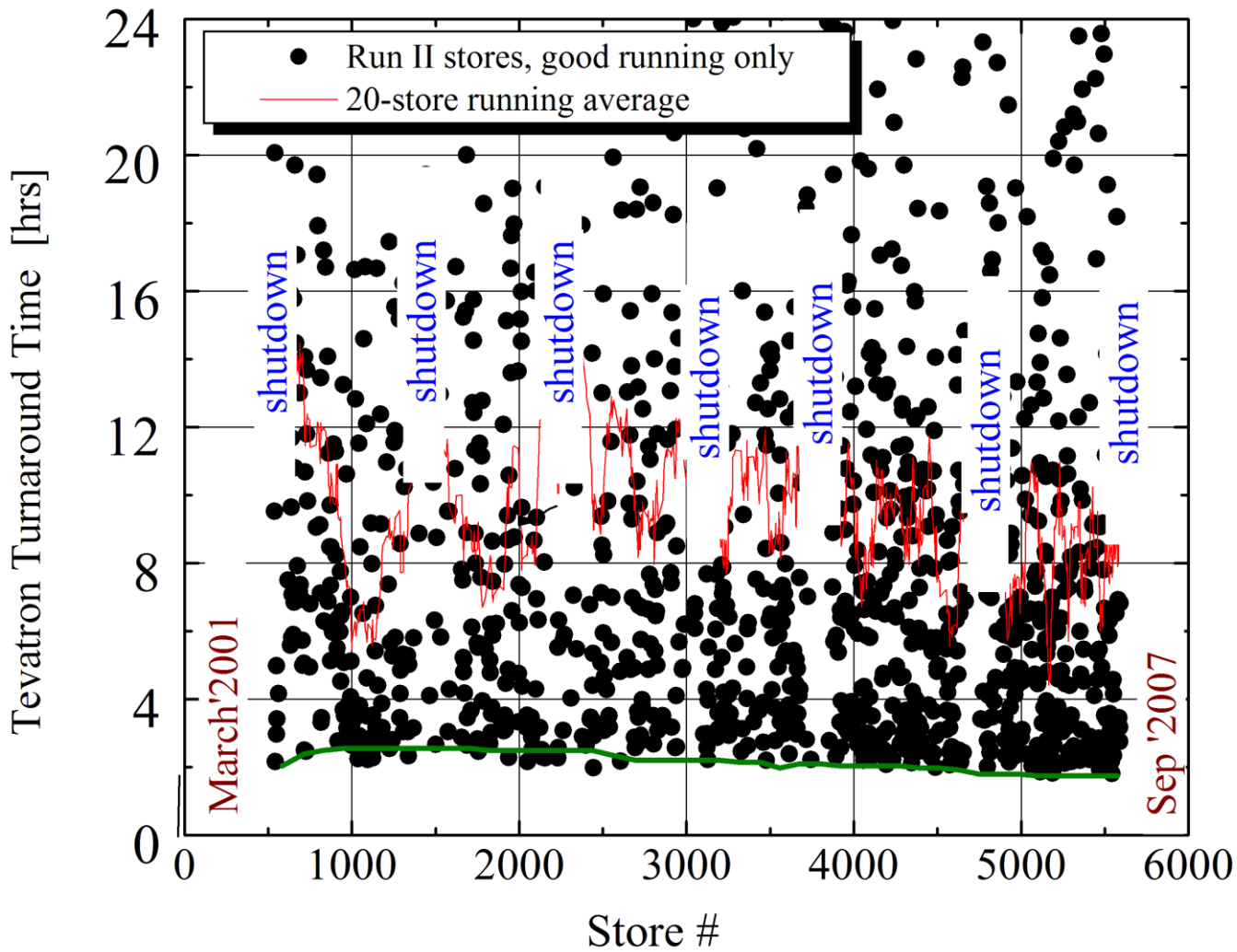
without cut



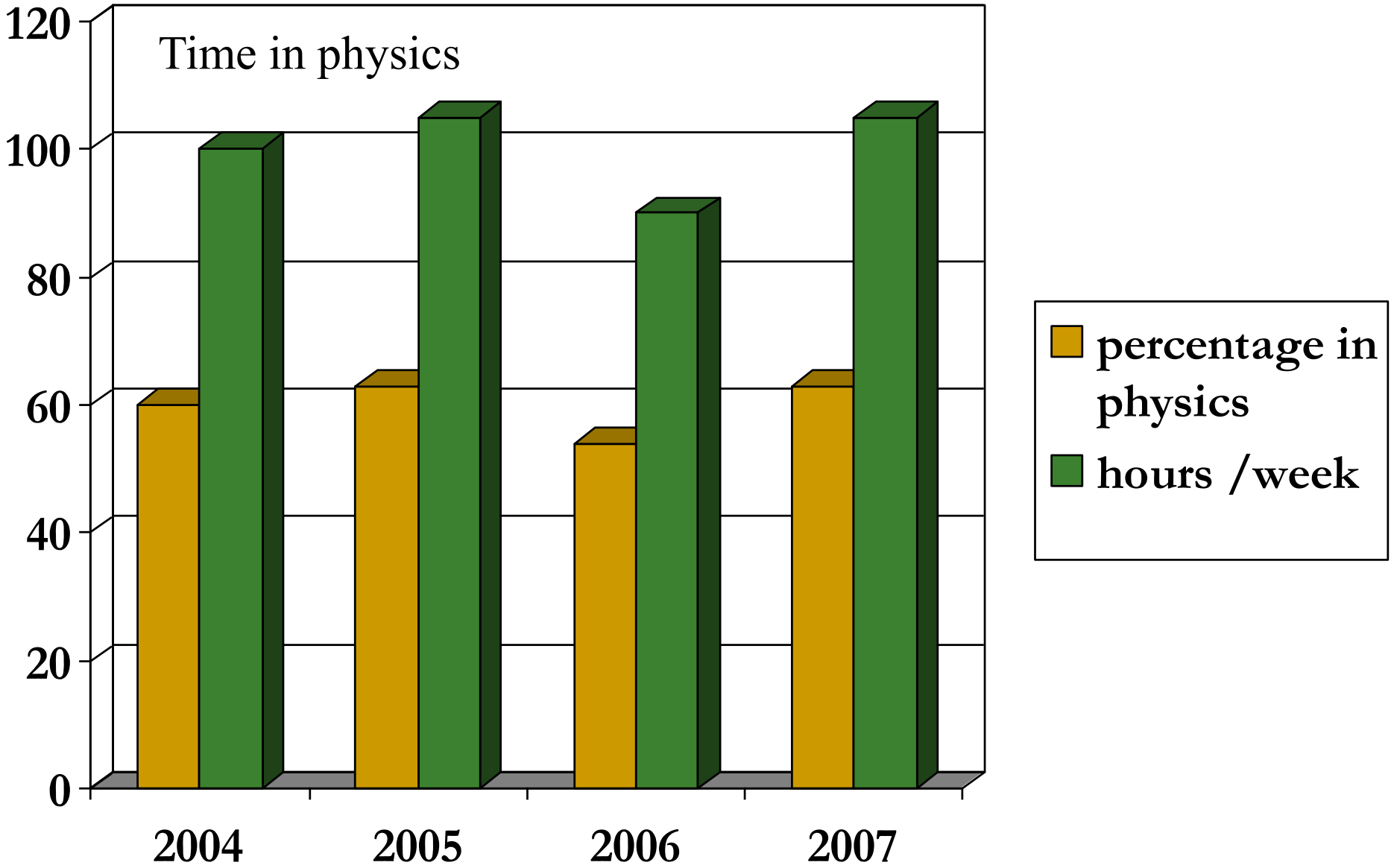
Experience from other Machines: Tevatron

average turn-around time: (V. Shiltsec)

with 36h cut



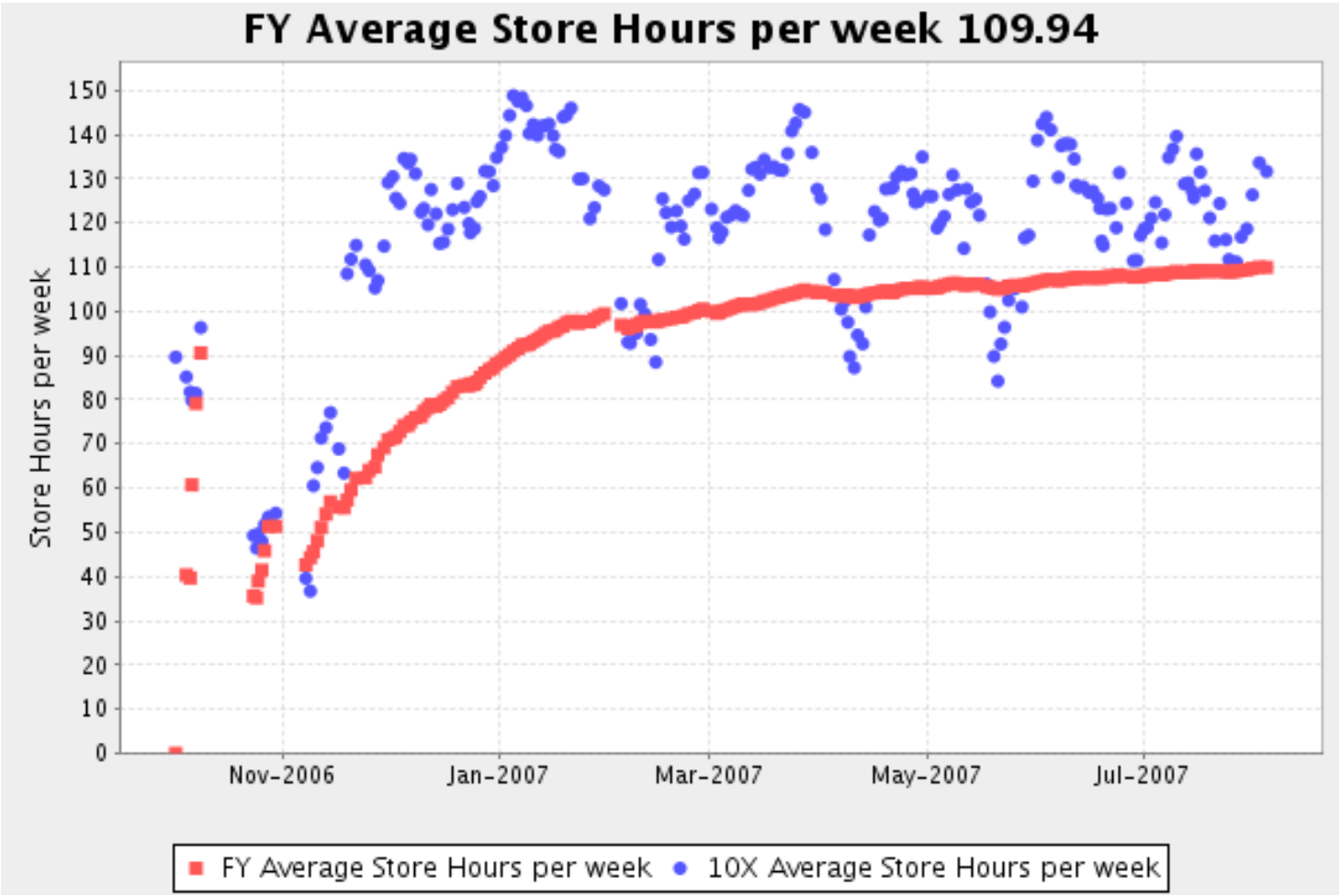
Experience from other Machines: Tevatron



@(http://www-bd.fnal.gov/pplot/index.html)

Experience from other Machines: Tevatron

operational experience: (http://www-bd.fnal.gov/pplot/index.html)



Experience from other Machines: Tevatron

Tevatron operation first 6 years of RunII[&]: [&](Cons Gattuso)

1292 stores in total

932 stores were terminated intentionally; average store length: 22.4h

360 stores ended due to failures; average store length: 10.23h

Top 10 causes:

-cryogenics	49 → 13%
-lightening	40 → 11%
-quench protection	33 → 9%
-controls	29 → 8%
-separators	25 → 7%
-RF	25 → 7%
-low β quadrupoles	24 → 7%
-corrector magnets	20 → 5.5%
-human error	20 → 5.5%
-PC	20 → 5.5%

one can expect most of them also for the LHC operation!

Experience from other Machines: HERA

HERA 2006 operation statistics[&]: [&](B. Holzer; DESY)

115 stores in total

230 faults; average store length: 7.4h; (min = 0.16h; max = 14.3h)

# of p-injections = 164; number of e-injections = 185

Top 10 causes: (frequency)

-operation	40 ➔	17%
-e-RF	35 ➔	15%
-power supplies	29 ➔	13%
-beam loss	19 ➔	8%
-controls	18 ➔	8%
-injector complex	13 ➔	6%
-proton RF	9 ➔	4%
-SC cavities	7 ➔	3%
-quench protection	7 ➔	3%
-beam instrumentation	7 ➔	3%

one can expect most of them also for the LHC operation!