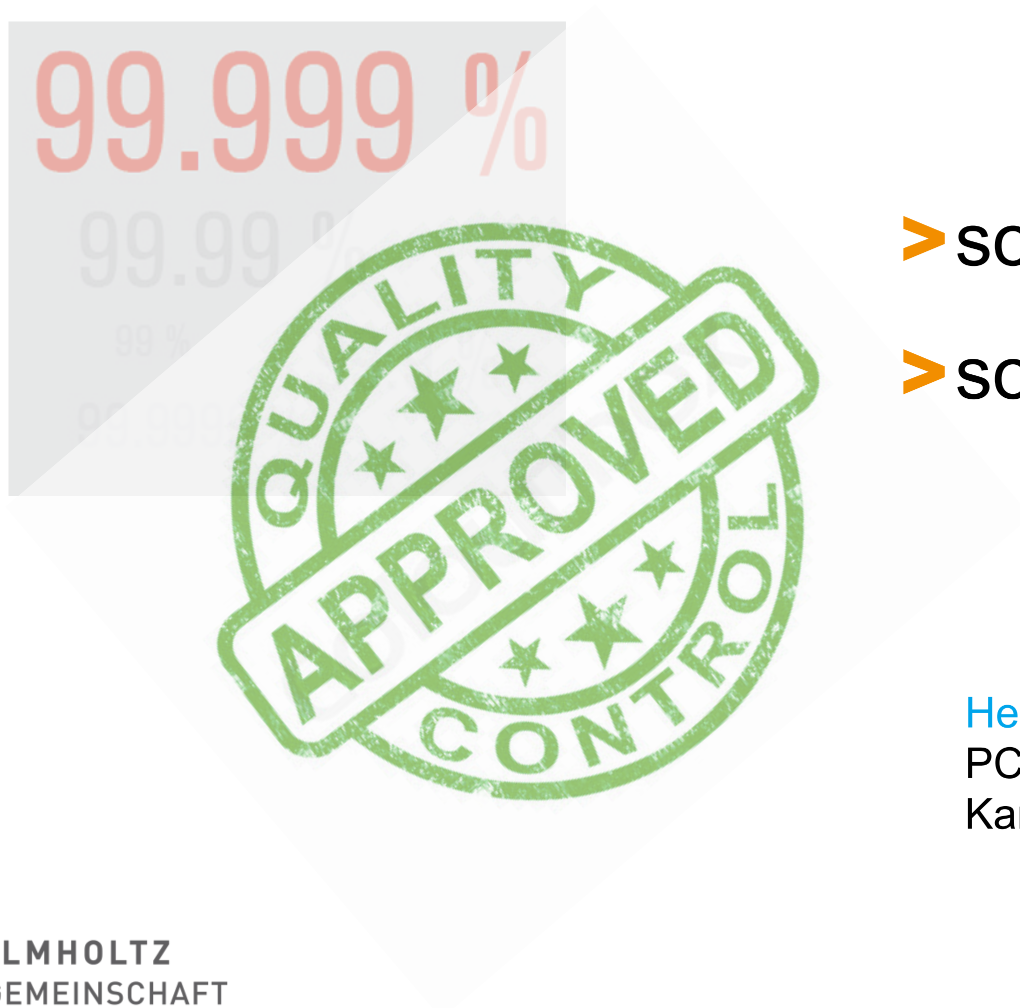
Accelerator Availability Monitoring.



- some suggestions…
- some questions…

Heiko Ehrlichmann, DESY-MDE
PCaPAC 2014
Karlsruhe,10/17/2014

the bias

- DESY Hamburg

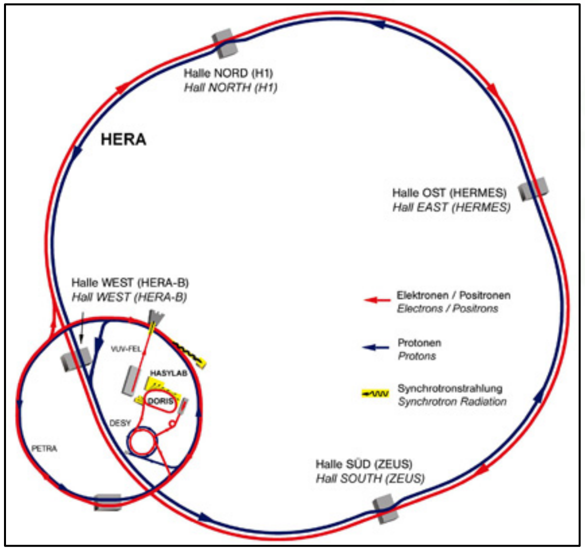
  ⇒ examples, pictures etc. mainly from DESY

  ⇒ a very **subjective view** (potentially distorted…)

  ⇒ **change of research direction** a few years ago

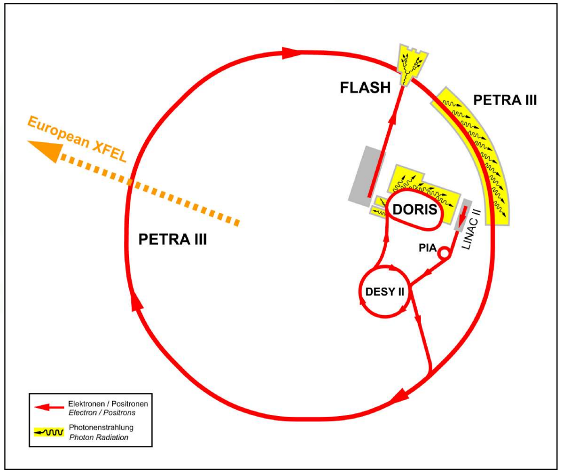
many years of accelerator operation

mainly for **high energy physics**



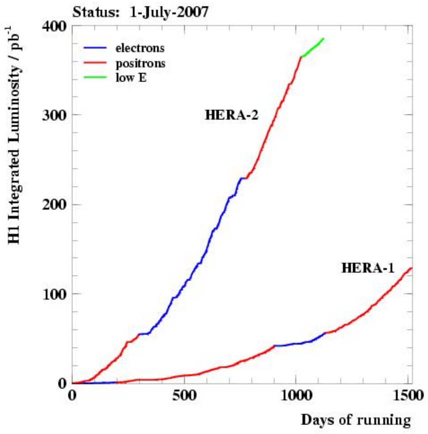
now:

synchrotron light delivery



the users requirements

- in high energy physics: **integrated** luminosity
  - duration of experiments typically years
  - “short breaks” in data taking not relevant, integrated performance counts
  - quality measure: integrated luminosity

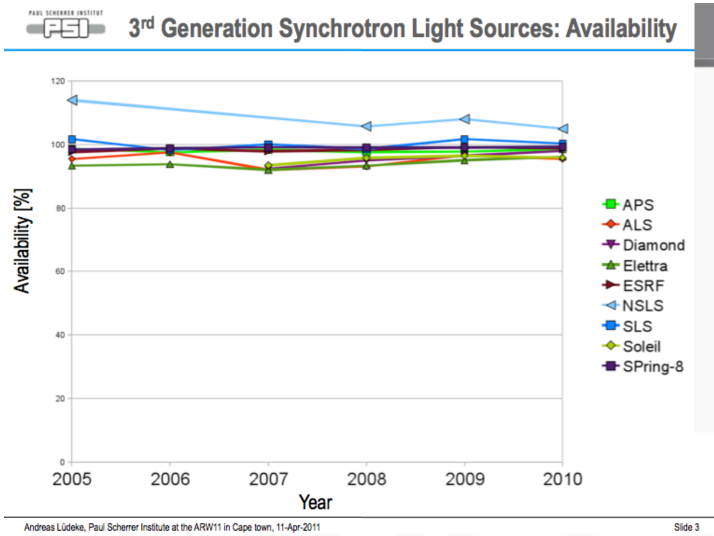


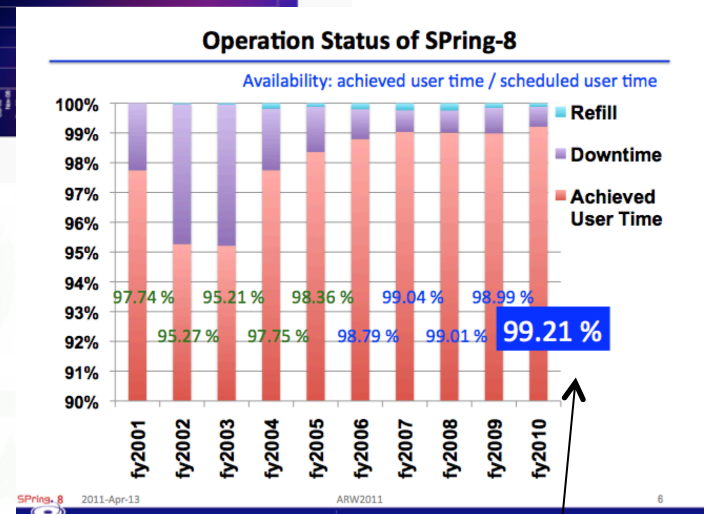
- at light sources: **constant** conditions
  - duration of experiments typically days / shifts / hours
  - “short breaks” could feel really long …
  - quality measure: **availability**

this talk: focus here

- at accelerators for medical use
  - duration of treatment typically minutes
  - short breaks” could cause serious delays
  - quality measure: **availability**
  - strong economical aspects…

the synchrotron light source competition





accelerator availability

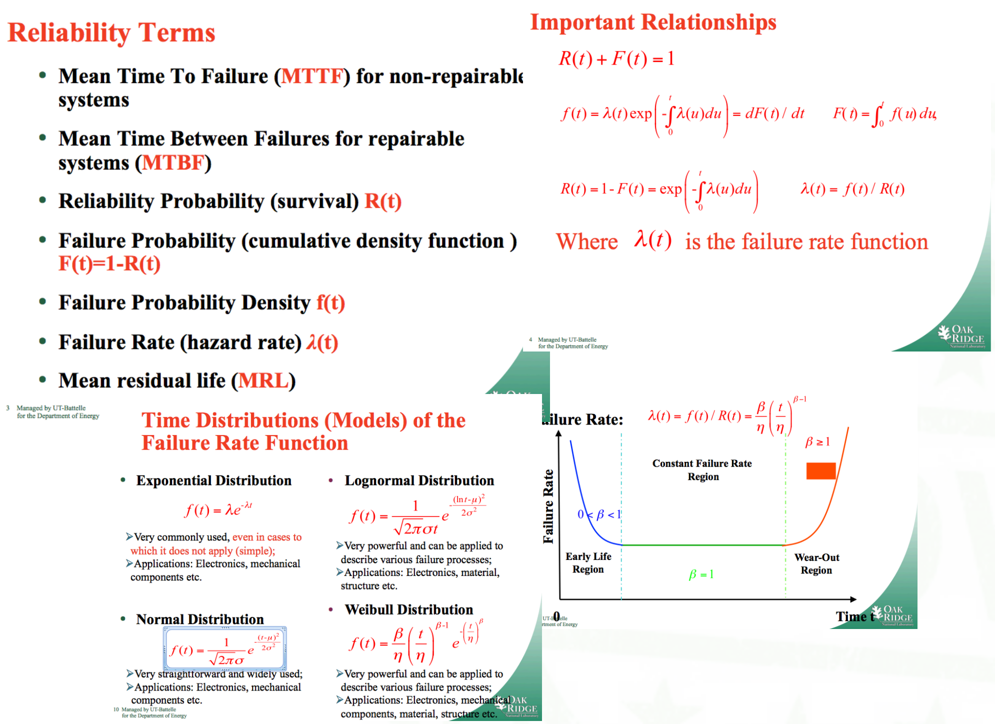
- typically well above **95%**
- good if better then **98%**

1% corresponds to **15min** per day

⇒ strong requirements on every single component reliability…

⇒ high precision of data collection (counting seconds…)

the theoretical view (taken from SNS, ARW2011)



> **important** for preventive maintenance etc.

> **but completely ignored for this talk**

the definition?

- **availability** = available time / overall time foreseen for user operation
- available time = period when all parameters specified for user operation are fulfilled

- consequences for availability monitoring:
  - **definition** of time foreseen for user operation (well in advance…)
  - **specification** of all parameters to be fulfilled during user operation (well in advance…)
  - **monitoring** the actual status status of the accelerator
  - **comparison**

quite easy…

or not?

the downtime

- **downtime** = period when the machine is not available for users?

  or

- **downtime** = period when the machine is really broken = “down”?

⇒ how to deal with

- necessary time for magnet cycles
- unavoidable injection time
- tuning time “machine preparation time”…
- beamline stabilisation times (reaching thermal equilibrium)

⇒ does it count as available or unavailable?

⇒ does it count as downtime?

the different methods worldwide

- there are a lot…

- dedicated Accelerator Reliability Workshop series: "ARW"

  many different opinions …

  ⇒ **no common method** for availability calculation

  ⇒ **no agreement on details** (but seconds are details…)

  ⇒ **no comparable availability numbers** (at least uncertainty)

  ⇒ different machine state categories, different assignment rules, different procedures

  ⇒ no public accessible raw data

- availability numbers are a measure for the quality of the laboratory …

  ⇒ it's a **political number**, at least to the outside world

  ⇒ as many different ways of calculations as accelerators in the world

the creative way

or: “I only believe in statistics that I doctored myself…”

- operation schedule with **planned buffer periods** for **downtime compensation** (initially not assigned to users)
  - ⇒ included in availability calculation?
  - ⇒ possibility for availabilities better than 100%?
- **re-calibration / re-definition** of the availability

  example: usually 20% of time is needed for machine preparation

  (experience -> expectation = downtime flat-rate)

  - ⇒ availability = available time / 80% of overall time foreseen for user operation
  - ⇒ possibility for availabilities better than 100%?
- …

⇒ **possibilities for availability tuning**

the preferred solution

accelerator availability monitoring should be

- **honest** (no self-deception)
- **transparent** (not hidden in complicated excel sheets)

⇒ ***an internal statement of accounts***

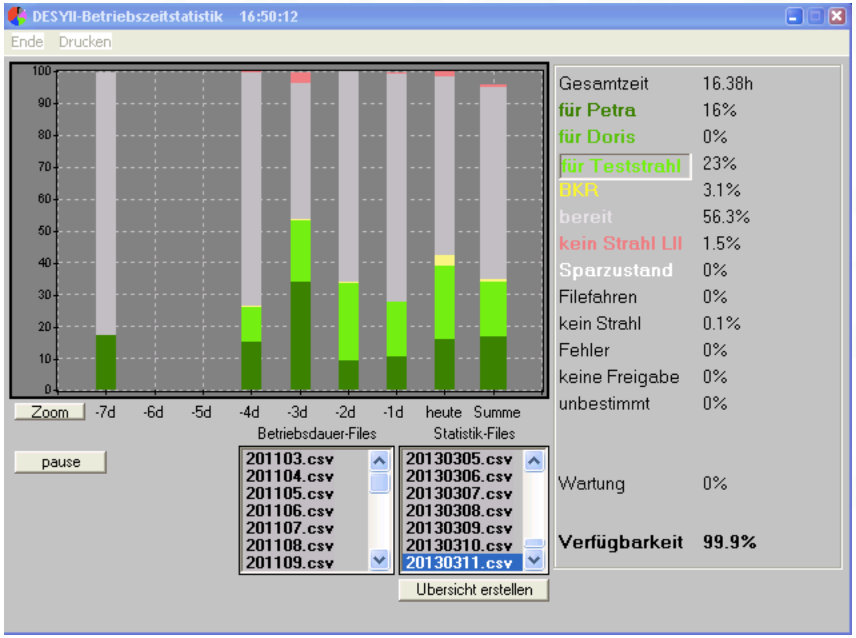
- ***online*** **= *automated, live data***

  = active part of the accelerator controls

the different data collection methods at DESY (1)

> DESYII:

- **online** tool (developed 15 years ago)
- counting of seconds for predefined operation mode categories
- generation of a downtime list
- online viewer (for the last seven days)



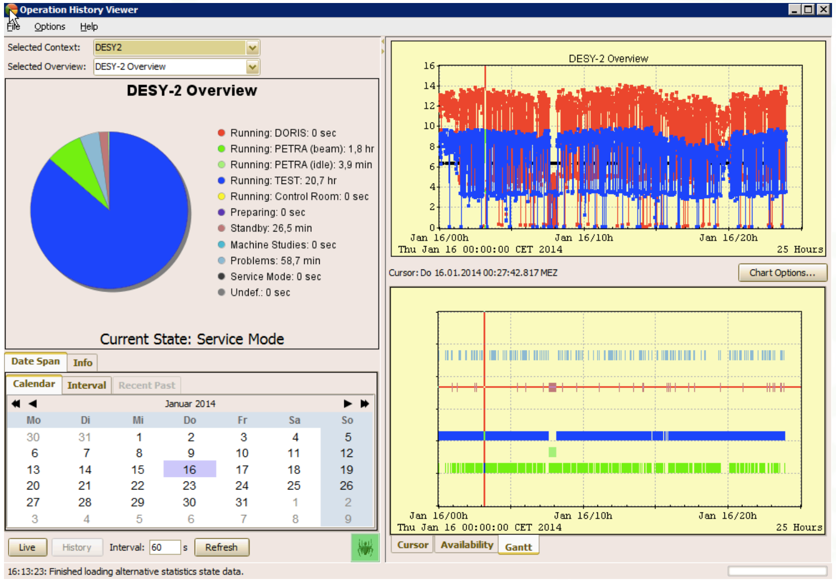
the different data collection methods at DESY (2)

> **universal solution**: the official "*operation history viewer*"

- **online** tool for all accelerators operated at DESY

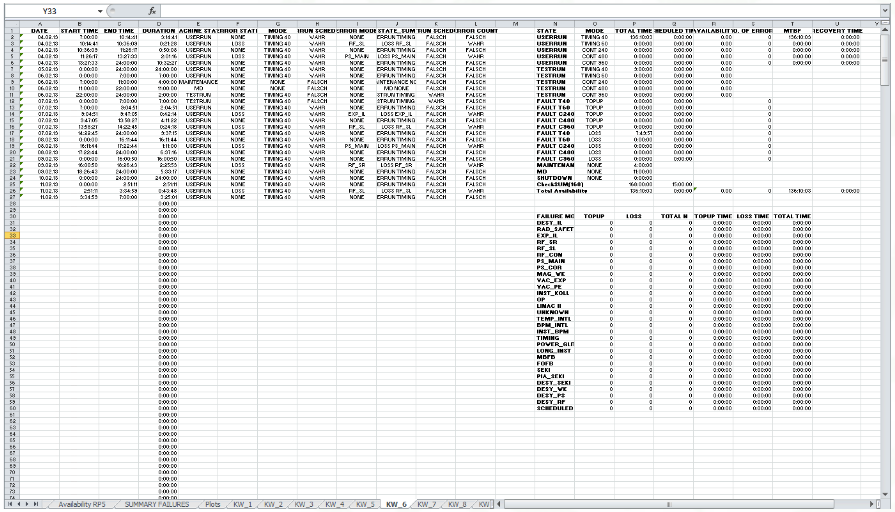
  provided by the official control system

- online viewer (flexible, sometimes confusing)



the different data collection methods at DESY (3)

- PETRAIII:
  - excel sheet, filled **manually** every morning
  - using archived data and the logbook



⇒ ***why the existing automated system is ignored?***

the different data collection methods at DESY (4)

> FLASH:

- excel sheet, filled manually every morning,
- using the logbook (shift statistics for every shift, manually generated time stamps by the shift crew)

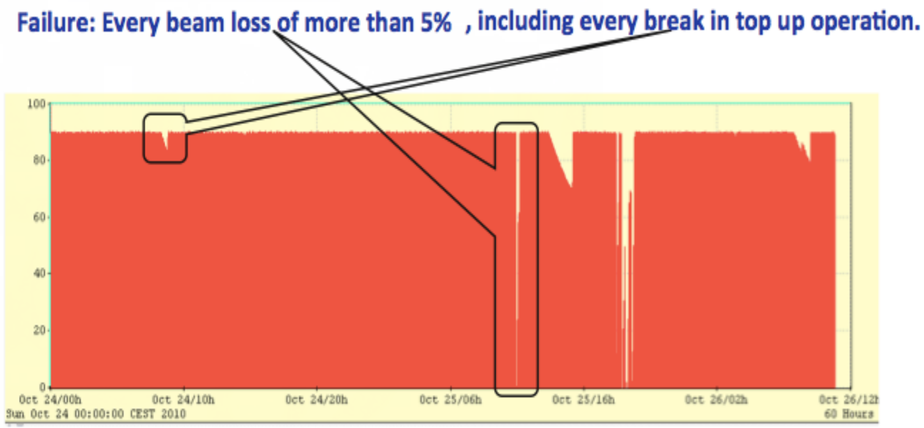
- ***why the existing automated system is ignored?***

the answers

> **fear to lose control of resulting** (political) **numbers?**

> **it's work !** to be done **in advance**

> clean machine status definition needed…

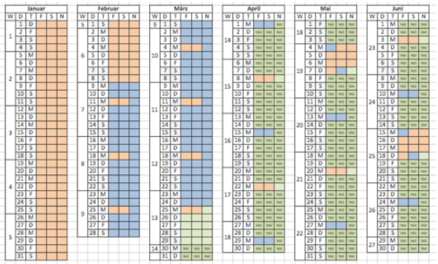


> first it will not be perfect
iterative process for improvement

> **but** (never ending) **paperwork is reduced !**

the difficulties: clear specifications

- specification of **nominal conditions** ***in advance***
  - ⇒ operation schedule must be “known” by the control system
  - ⇒ maintenance scheduling…
  - ⇒ even machine preparation scheduling, if possible

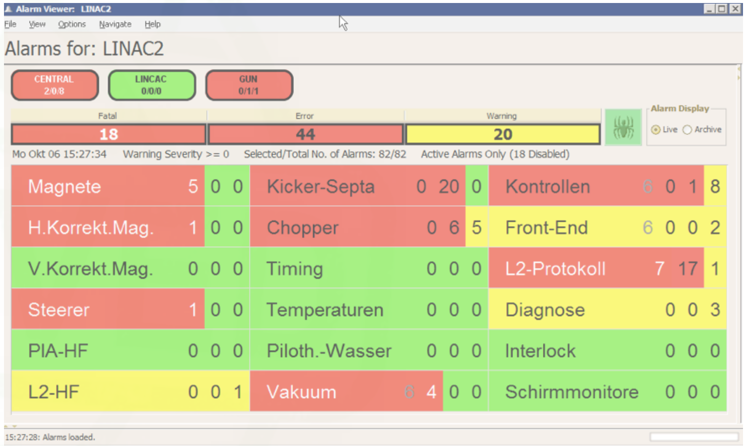


- definition of **possible machine states = categories**
- definition of unique **assignment rules**
  - ⇒ states and rules can turn out to be inadequate / incomplete
  - ⇒ **corrections = offline editing = iteration** will be necessary
    - ⇒ archiving of automatically generated **and** manually corrected data
    - ⇒ offline reprocessing…
- **reliable failure detection** needed

not completed for PETRA and FLASH

the online failure detection = the alarm system

- coverage of all possible failure states
- avoidance of false alarms
- consideration of operational / procedure faults
  - ⇒ covering hardware problems
  - ⇒ typically not covered: performance loss



unavoidable:

unexpected failures / situations

⇒ **a constantly expanding system**

every failure event should be analysed and, if not already covered, integrated into this system

⇒ it's a very long way to a **reliable** alarm system

⇒ **but it's worthwhile**

- example: **SLS** machine status display

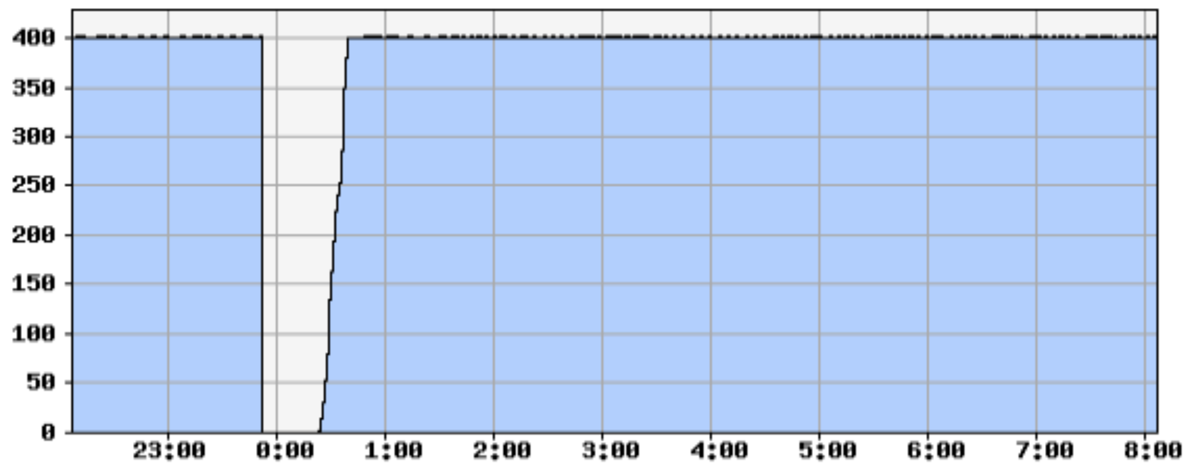
SLS Status

Beamcurrent	401.1 mA
Lifetime	7.9 h
Uptime	7.5 h
hor. Beamsize	54.9 µm
ver. Beamsize	11.1 µm

Shift Plan: Beamline development, Light Available

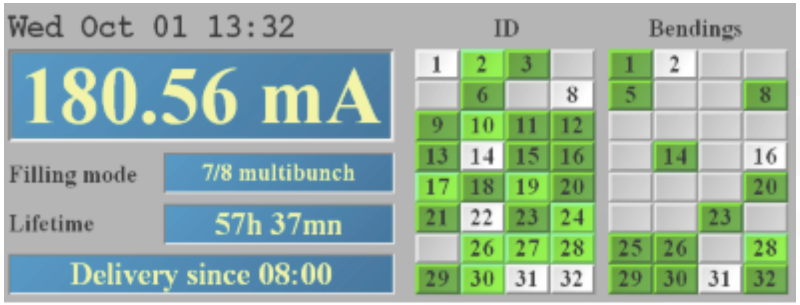
Messages from the Control Room:

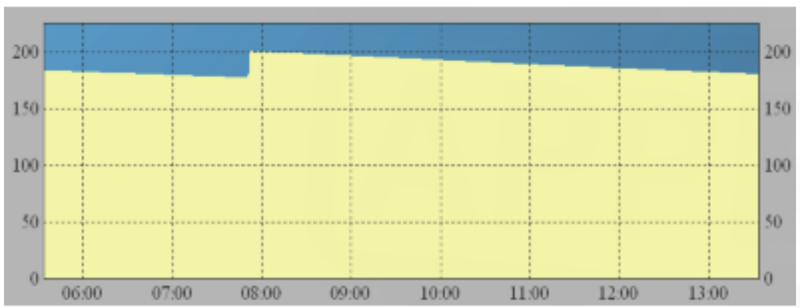
02.10.14 00:39 Beamline Development, 400mA Top-up
02.10.14 00:26 accumulation started
01.10.14 23:59 30 minutes to restart
01.10.14 23:53 Beam Loss, reason yet unknown
01.10.14 23:01 Scheduled start of Beamline devel.

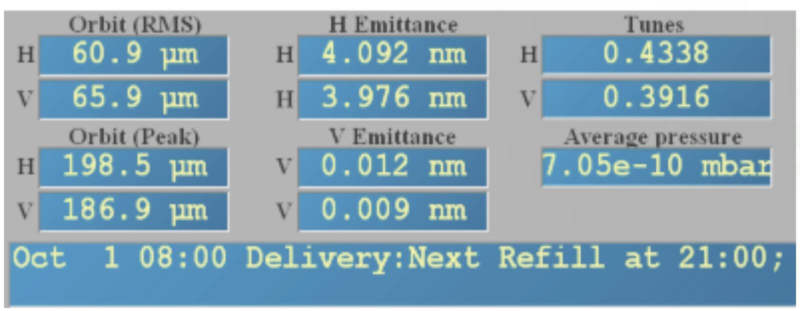


Beam current (last update 02.OCT.2014 08:05)

the current machine status (2)





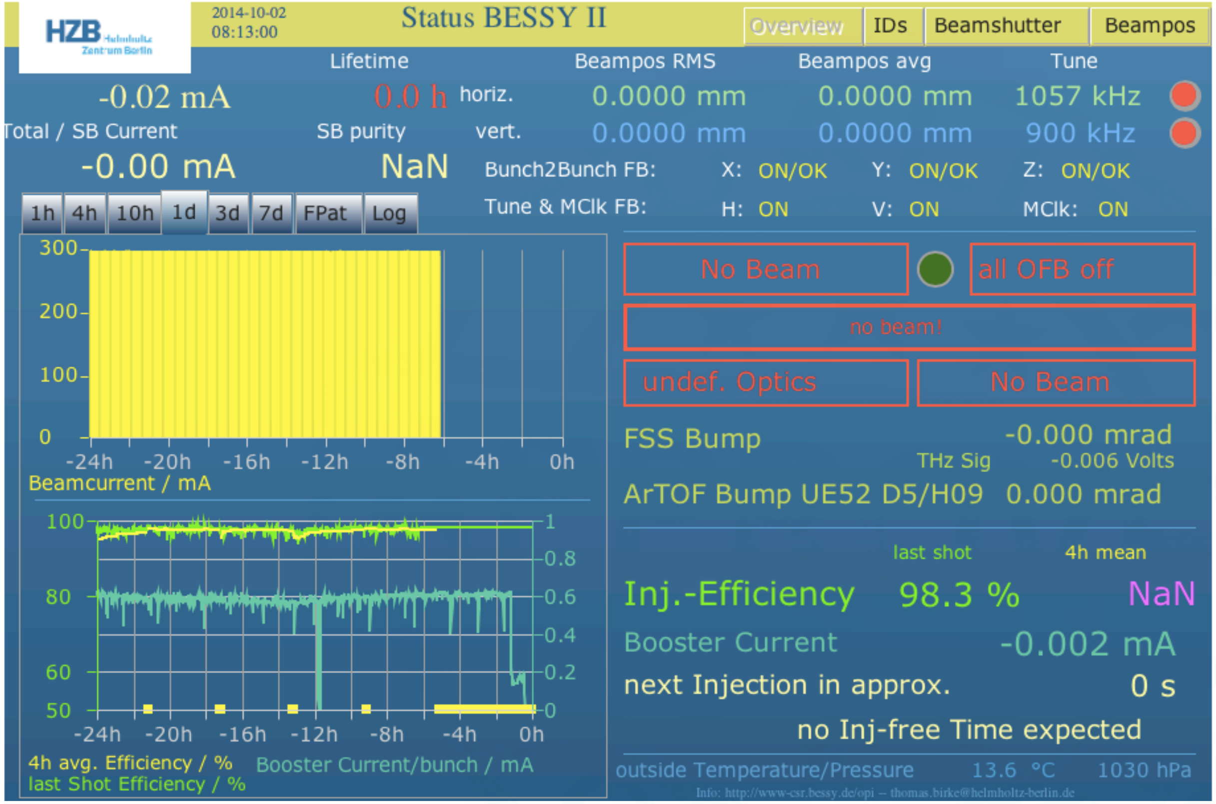


> example: **ESRF** machine status display

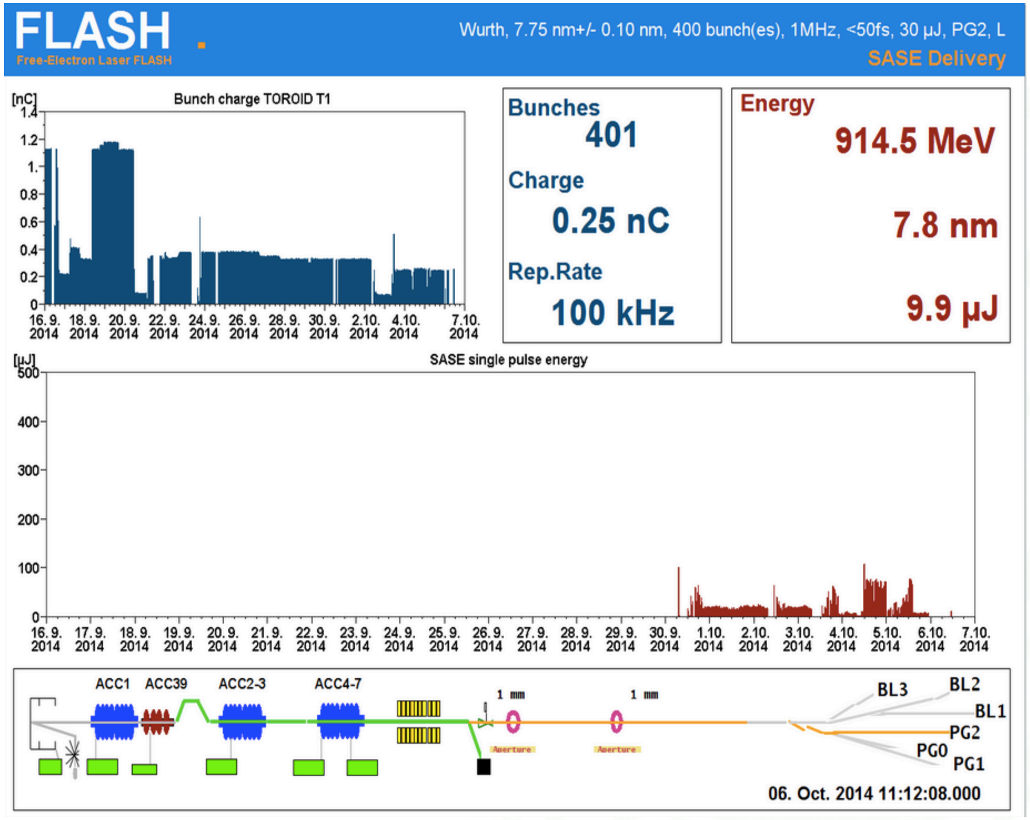
⇒ which numbers are relevant for the decision between available and unavailable?

⇒ unimportant details or relevant information?

the current machine status (3)



- example: **BESSYII** machine status display
  - ⇒ many details
  - ⇒ which numbers are relevant?



- example: **FLASH**

⇒ easy to identify good or bad states?

  - scheduled breaks?
  - all parameters ok?

very hard to identify…

⇒ **availability monitoring starts already at the online status display level** (or should already be integrated here)

the reason for availability monitoring

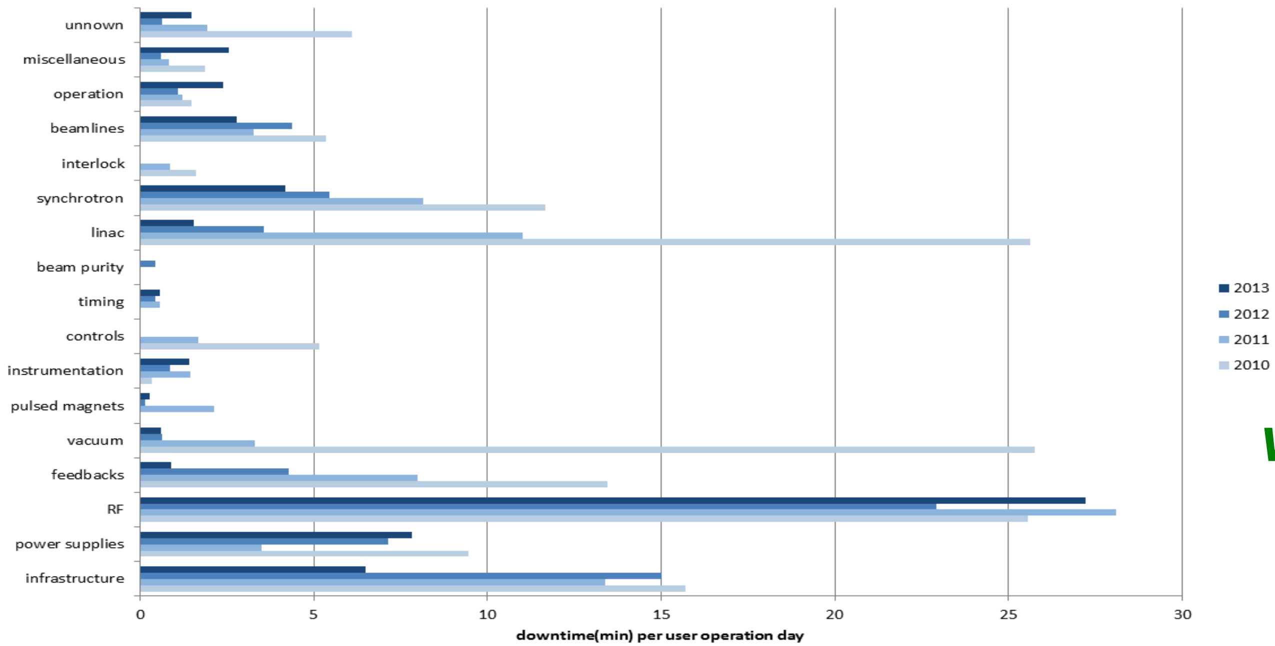
> identification of improvement potential

> preventive maintenance, but when? bathtub curves …

⇒ failure source analysis

- ***usually done offline by hand***

a painful job…



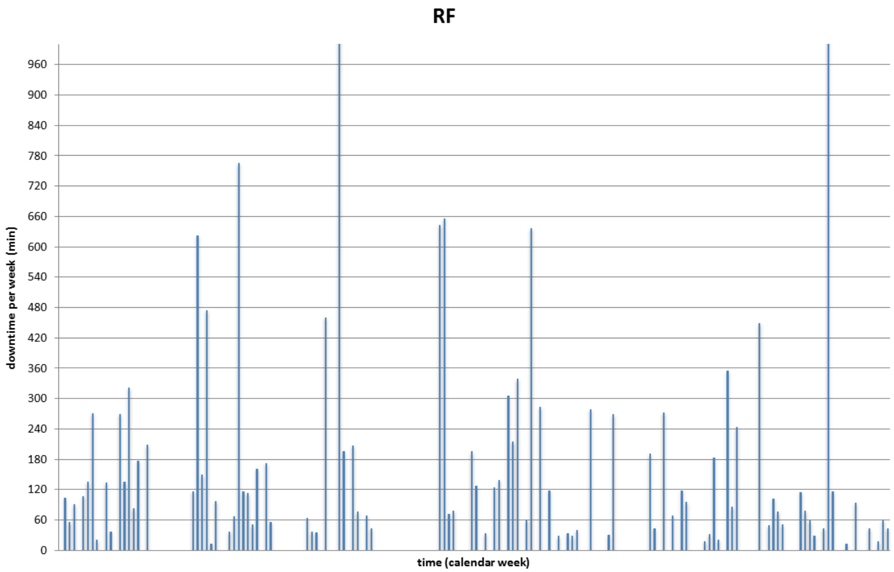
why not online?
why not live?

the failure source analysis

> **automated online** generation of several plots, histograms, tables

- (normalized) component downtime versus time, for all relevant components
- (normalized) number of component failures versus time, for all relevant components
- MTBF for all relevant components
- etc.

everything live…



again challenging: reliable failure source classification etc.

large (and increasing) number of failure categories

⇒ **flexible system** needed, offline editing possibility unavoidable

the intelligent option (I have to ride my hobbyhorse…)

- very often: series of **subsequent** faults (or error bits etc.)
  - a chicken-egg problem …
- approach: **expert system** for online failure classification
  - database of classification rules / conditions
  - sufficient space for expansion needed

constantly manual input necessary failure-follow-up by accelerator / component experts
⇒ increasing classification quality

- a dream: more ***intelligence***:

self learning systems for ***failure pattern recognition***

  - fuzzy logic ???
  - neural networks ???
  - …

the questions raised in the abstract

- **would it be possible to rely completely on fully automated data collection** for predefined states and predefined operation schedules?

  not completely, but one should try

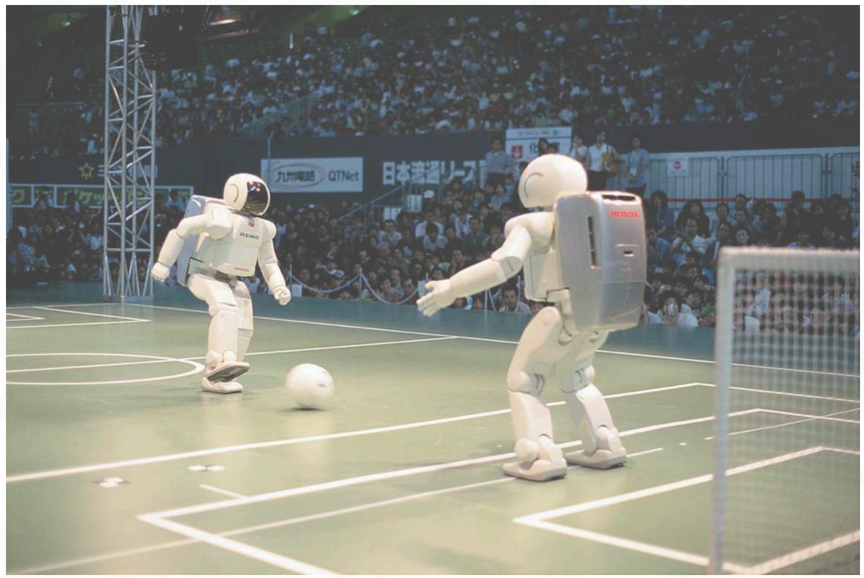
- or is **offline data manipulation** unavoidable?

  no system is perfect ...

  but it will become better and better…

the general point of view

- a **high degree of automation** is absolutely necessary for state-of-the-art particle accelerator operation



- availability monitoring is only one very special example…

the end

- who actually observes the availability of the availability observer?

Thank you for your attention!