Accelerator Reliability Workshop

ESRF, Grenoble, 04-06.02.02

„ High Power Cyclotrons “

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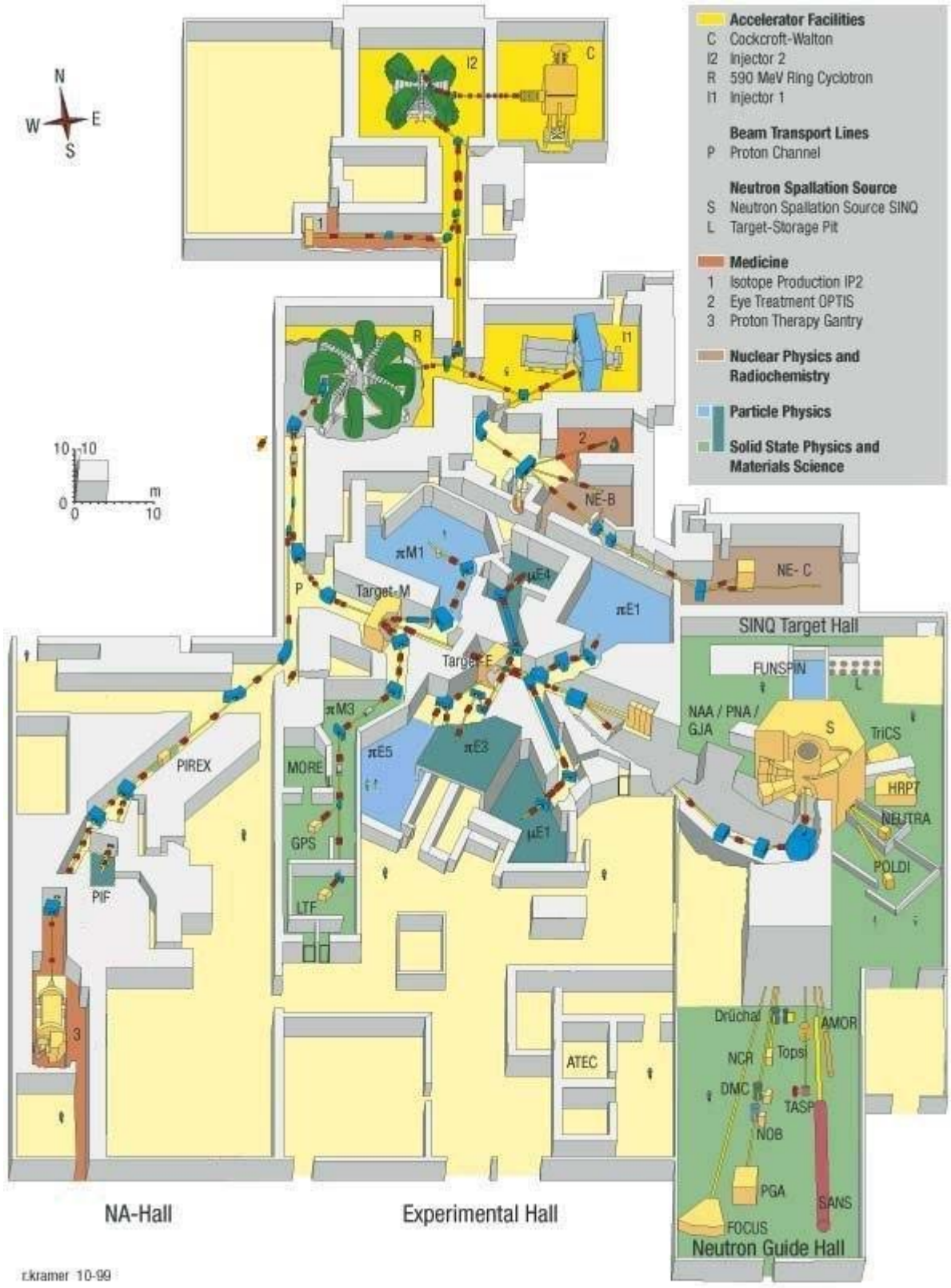
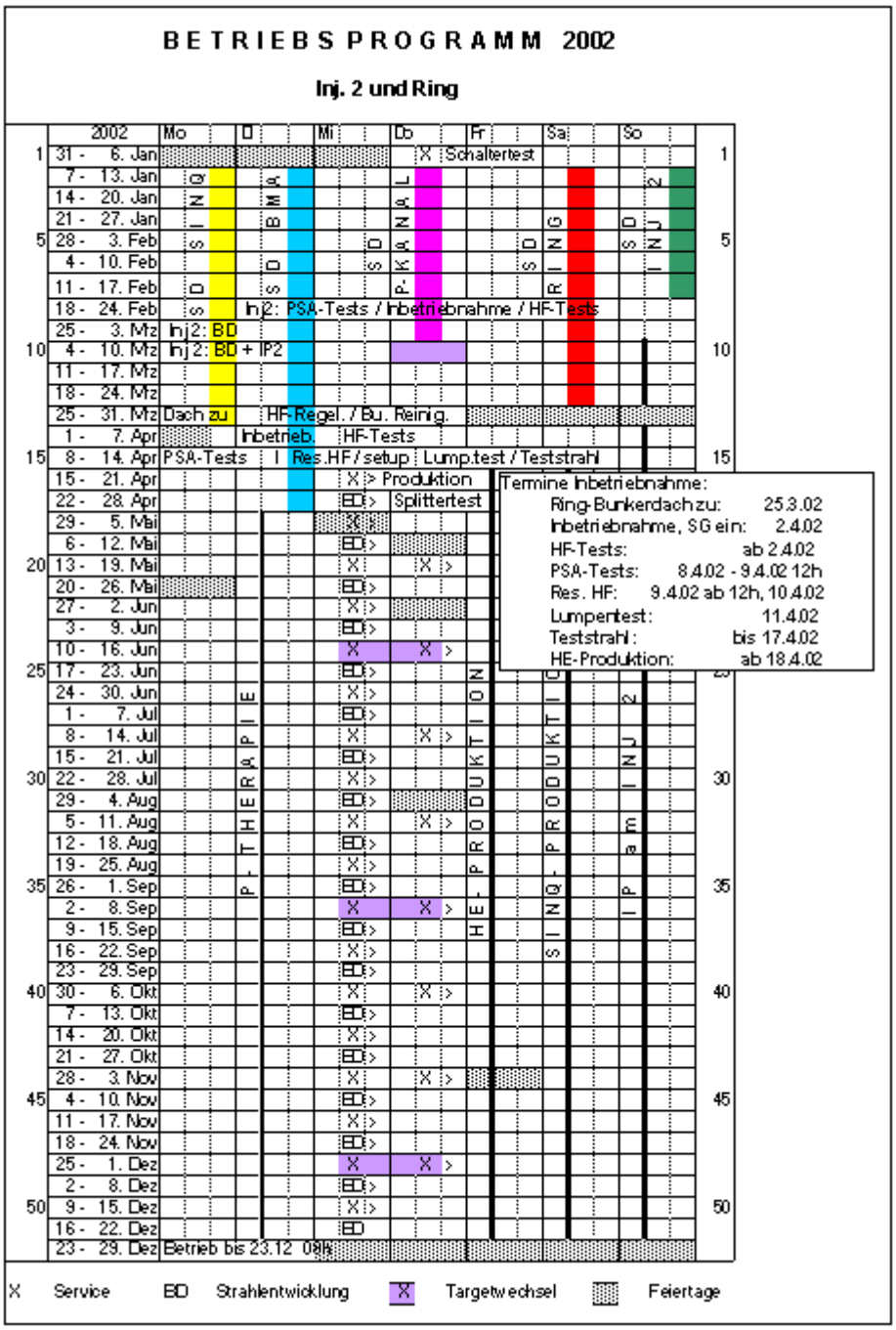
1. **The PSI Proton Accelerator Facility**
2. **Failure Analysis 2000/2001**
3. **The weak Points**
4. **How to improve the Reliability/Avialability**
5. **Conclusion**

The PSI Cyclotrons as backbone of a multiuser facility



What means availability/reliability ?

- **Typical operating schedule**



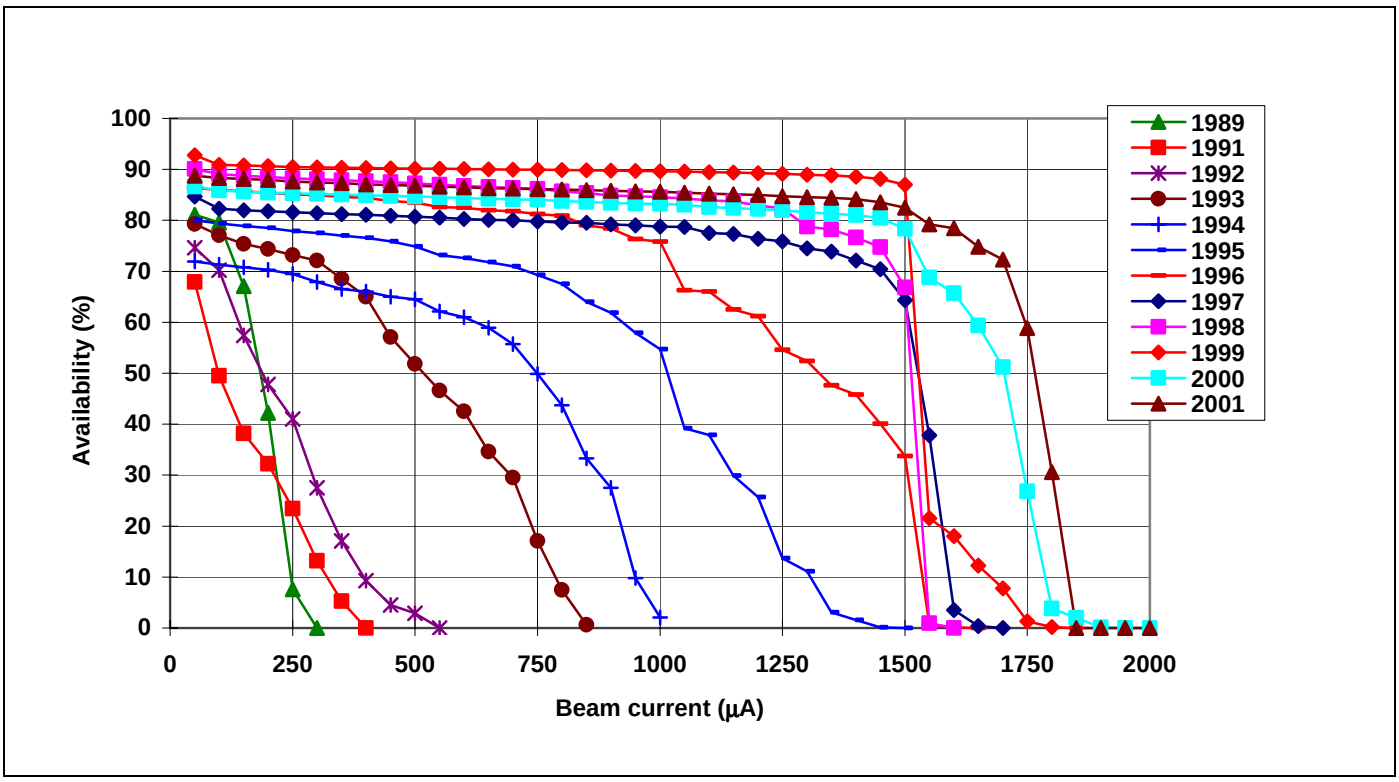
in the average :4000 to 5500 hours of beam production per year

- **Our definition:**

  Availability = Ratio of beam time over 1.5 mA on the pion production targets to the scheduled beam time.

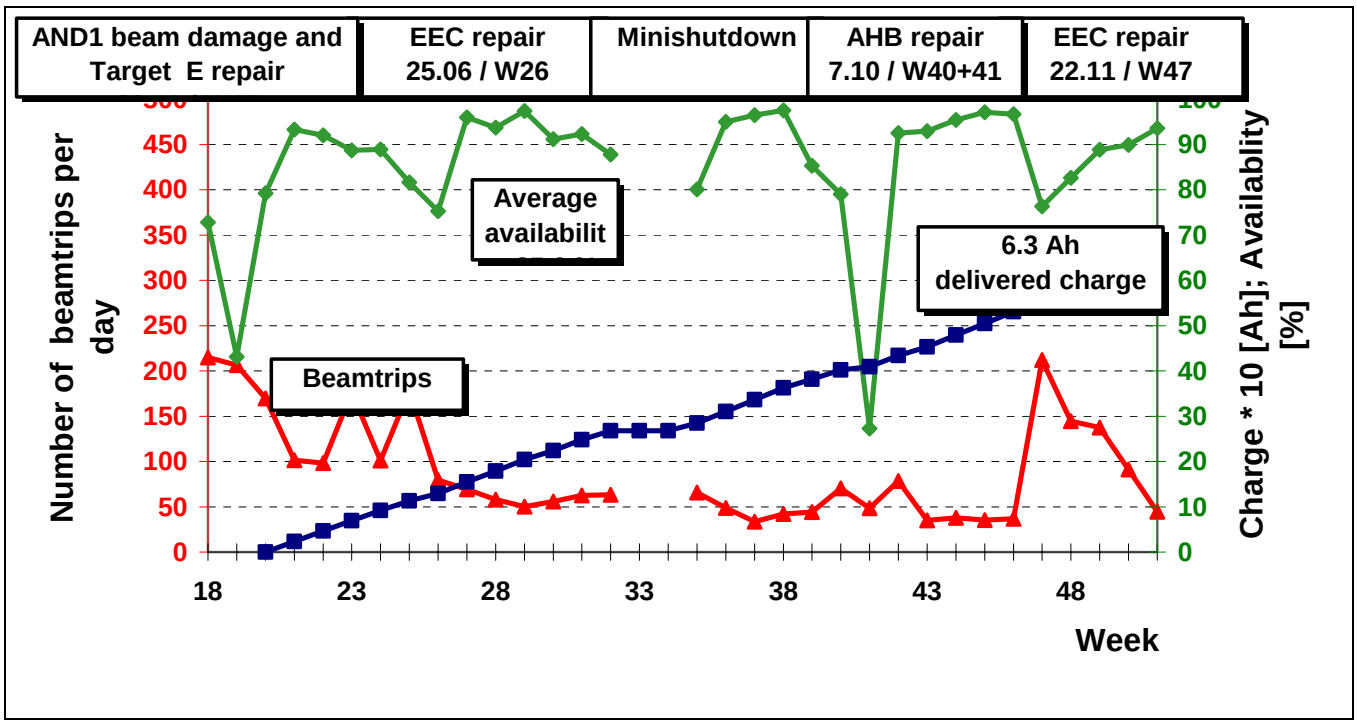
  Also to optimize: delivered charge on target

Routine production is 1.8 mA (1.2 mA on SINQ with 4 cm thick Target E)



Availability of the beam on the meson production targets as it developed since 1989. Plotted is the percentage of the scheduled beam time during which the beam current exceeded the values given on the x-axis

The good performance is shadowed by single events



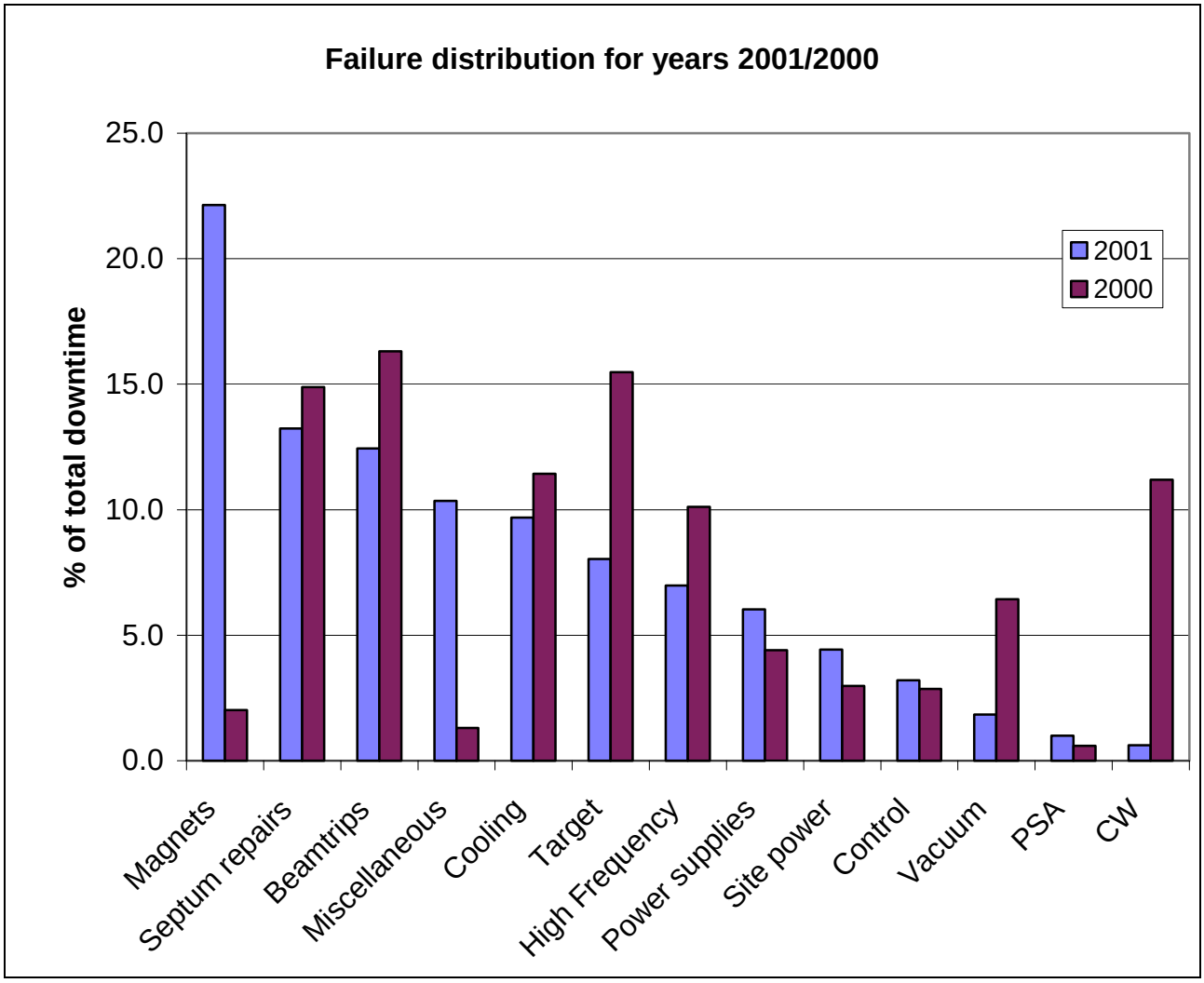
High Energy Operation at the PSI Accelerators in 2001: Availability, main failures, delivered charge and beamtrips due to discharges in the electrostatic elements inside the Ring cyclotron

What reduces the availabilty ?

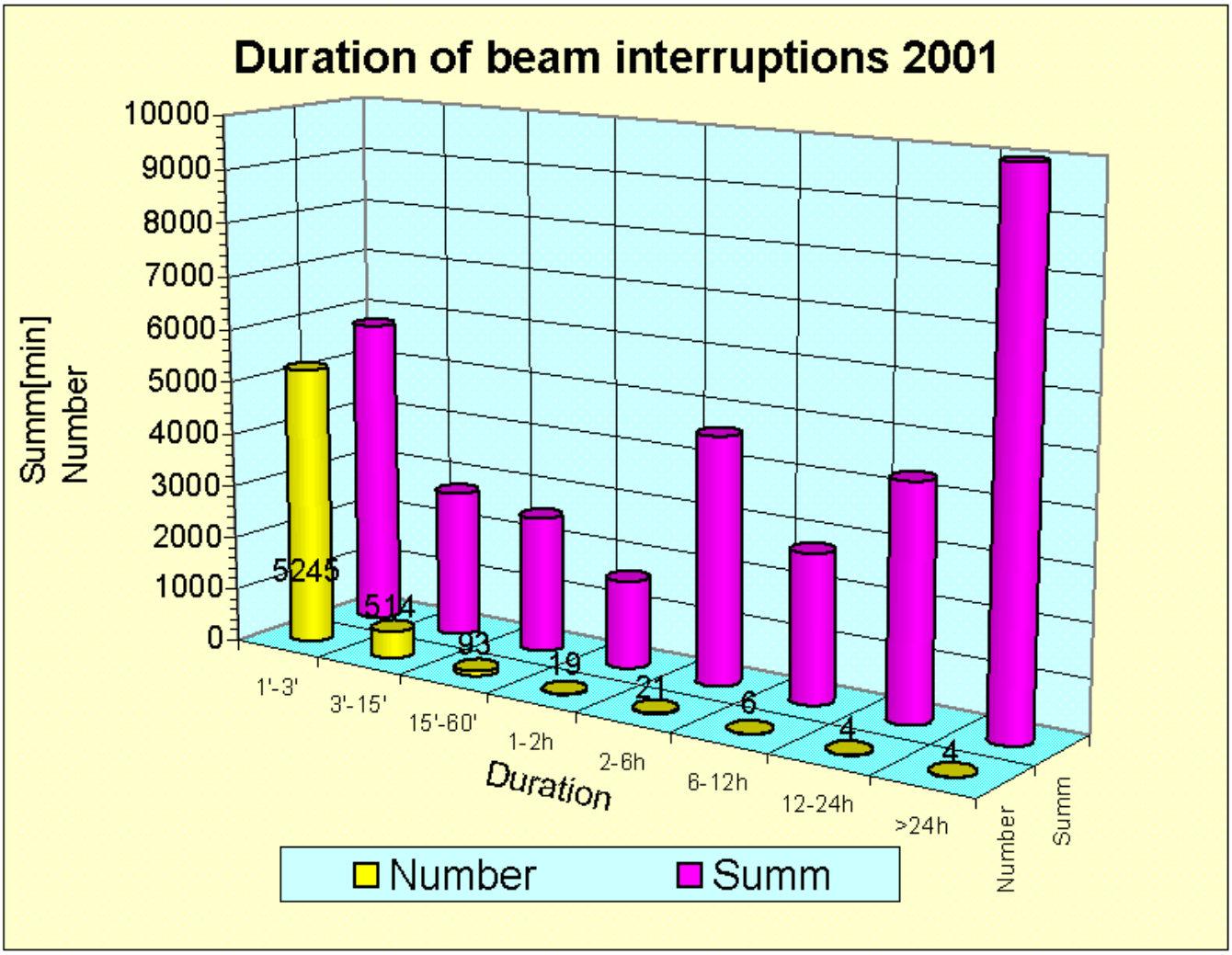
- **Short interruptions after beam trips: 20 s to ramp the intensity, more if operator intervention is needed. About 10000 per year = 1% of the beam time, but nevertheless disturbing for some users.**
- **Failures of components, infrastucture, … , repairs, cause outage of >10% of the schedulded beam time**

Which conditions cause beam interruptions ?

- **2500 inputs in accelerator interlock/run permit system**
- **140 beam loss monitors (ionization chambers, slits)**
- **users devices (IP, Medicine, SINQ)**
- **Personel protection**



Characterization of the 590 MeV-accelerator downtimes. The total downtime was 440 hours



Distribution of beam interruptions > 1 minute in 2001.

The weak points:

- **A few events are responsible for large downtimes**
  - **e.g. Cooling: missing redundancy**
  - **e.g. Magnets: save on spare parts, repairs time consuming**
  - **e.g. RF: components used untill they fail**
  - **e.g. Target :used untill they fail**
  - **e.g. Septa: used untill they fail. Causes ?**

- **The electrostatic elements in the Ring Cyclotron are responsible for most of the beam trips. This problem seems to become particularily critical as the power increases (1.5 -> 1.8 mA ?).**

Ways to improve the situation:

In most of the failure categories a reduction of the down time rate to less than 0.5 % (or even 0.2%) of the schedulded beam time is not a technical but "only" a financial problem. The ongoing improvement program includes:

- **New Ring central region with "plug-in" magnets**
- **Replacement of the 25 years old power supplies (also relevant for the beam stability)**
- **Fully assembled spares for some magnets (now coils only)**
- **Redundancies in the cooling water plant (?)**
- **Preventive replacement (Target E), modularity (e.g. RF)**

The reduction of beam trips remains a major problem.

- **The number of trips due to interlocks from the RF-system has been dramatically reduced by a fast, on-line discharge analysis (see contribution by Peter Sigg). Part of the problem is however only shifted to another components (Extraction septum ?).**
- **The behaviour of the electrostatic elements is by far not fully understood. R&D is needed (design, sensitivity to RF-leakage and X-Rays, surface physics, beam halo, …)**
- **The interlock system should be improved to allow for a better sequence analysis. More intelligence, e.g. by inclusion of transient detection and more sophisticated decision making procedures, can suppress unnecessary beam interruptions.**

Conclusions

- **The unschedulded outage is dominated by single events, in some case with an occurrence of once in 25 years. Stastitical analysis ?**
- **Improving the present reliability of the utilities is not a technical problem.**
- **Components should be redesigned such that repair is fast (plug-in techniques, exchange of whole modules, “Wechselflaschen”)**
- **The electrostatic elements are the “talon d’Achille” of the Ring cyclotron. The elimination of this problem requires a considerable R&D effort. Alternative solution ?**