



Reliability of operational Power Converters of the Swiss Light Source

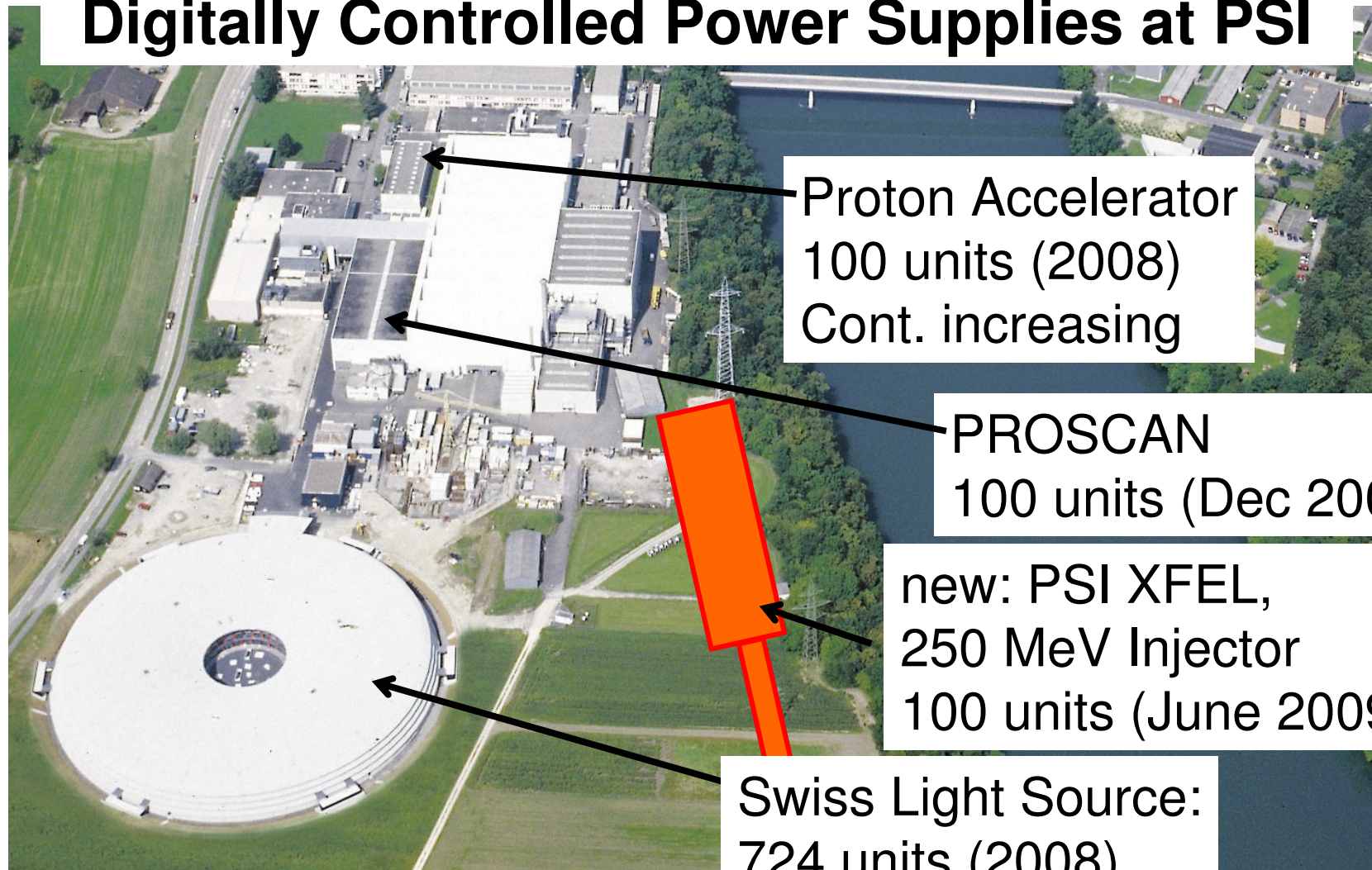
(7 years of operation experience)

How to improve MTBF and MTTR?

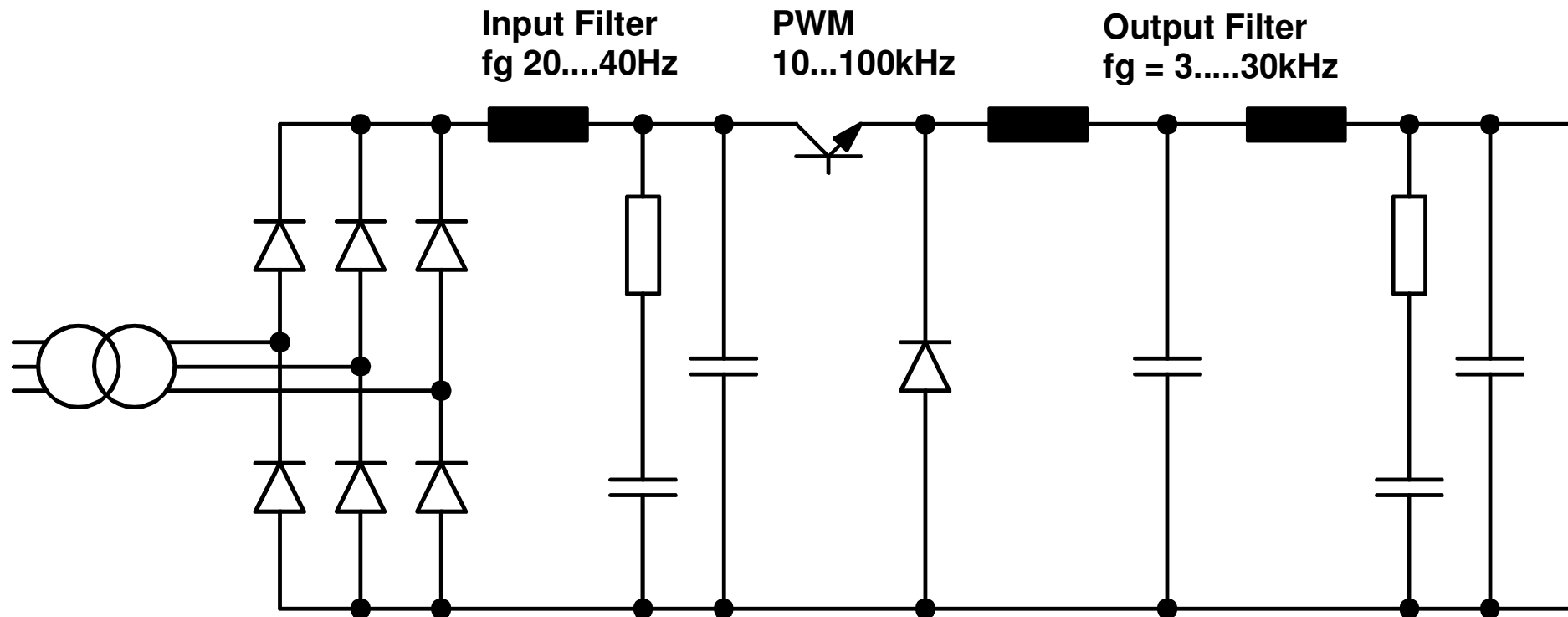
René Künzi, PSI, Switzerland

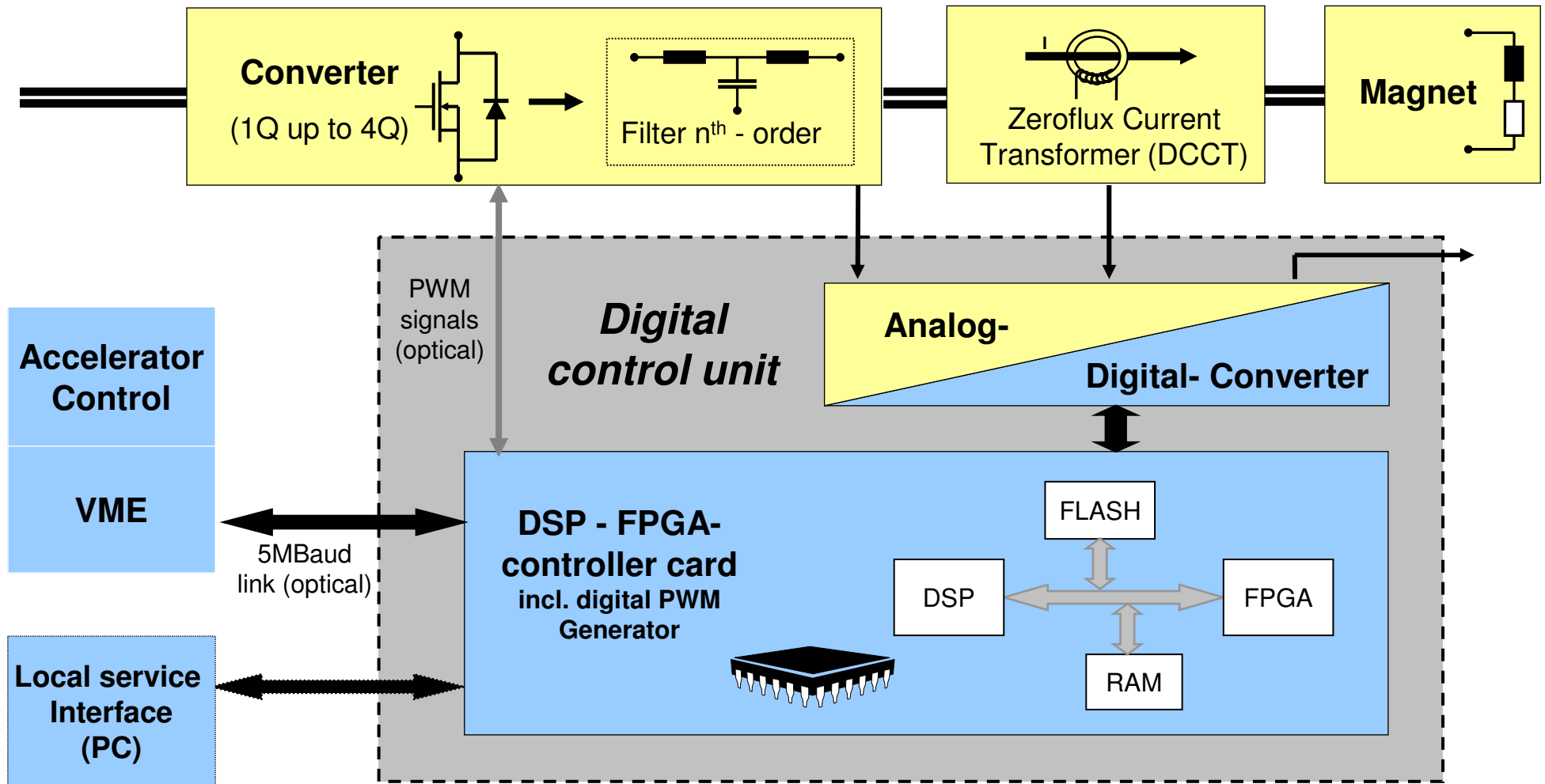


Digitally Controlled Power Supplies at PSI



PS Topology

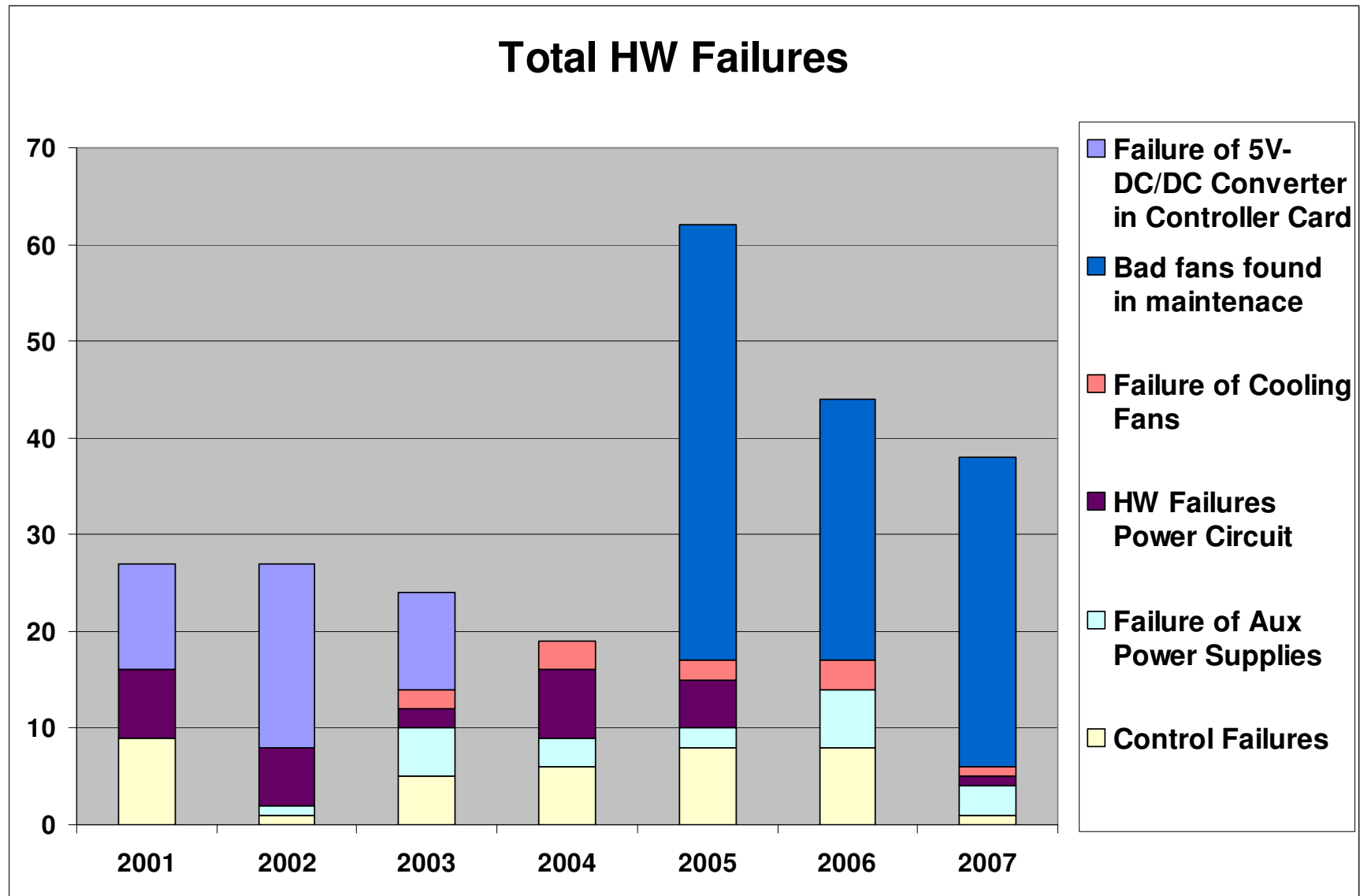


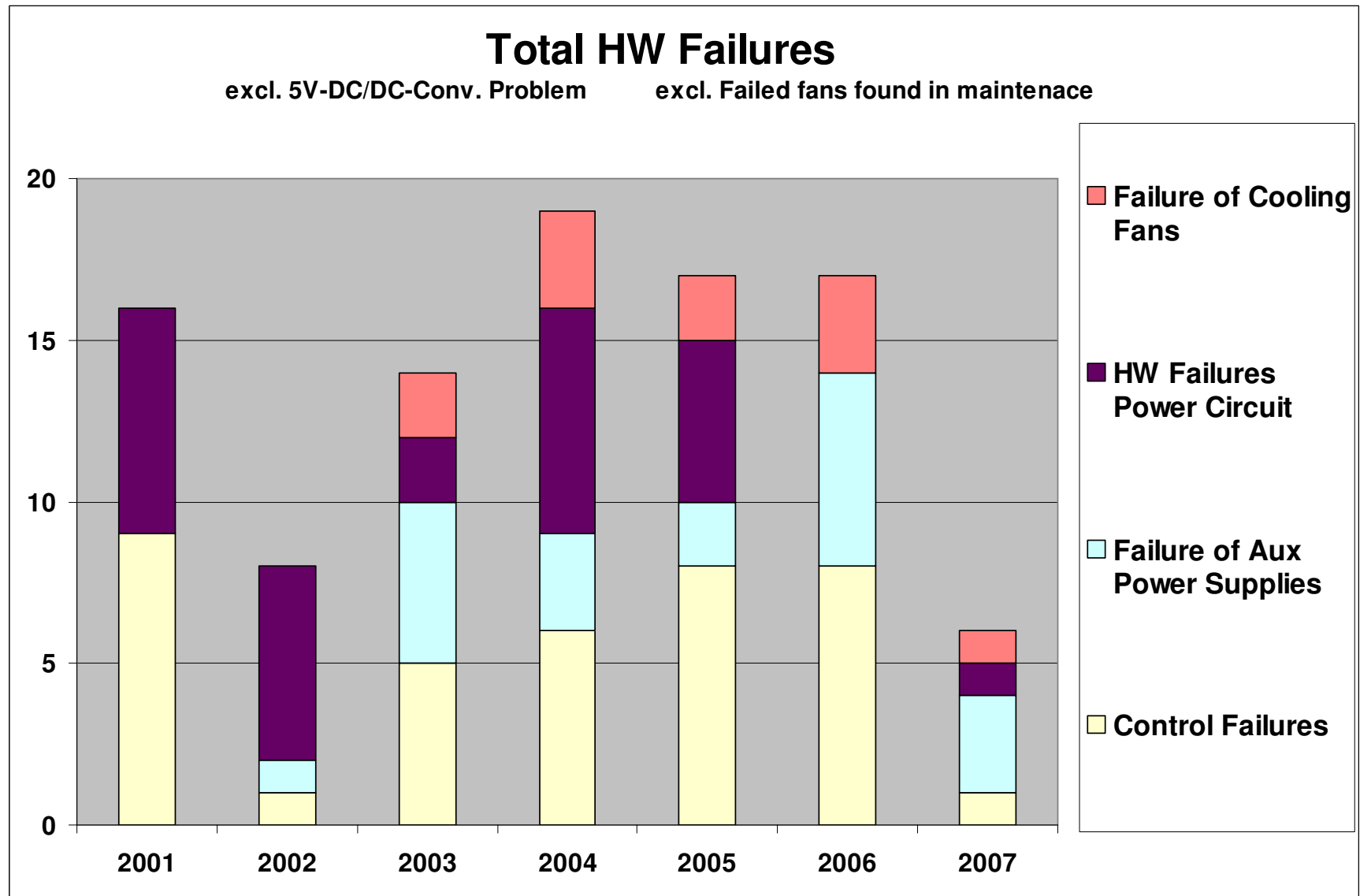


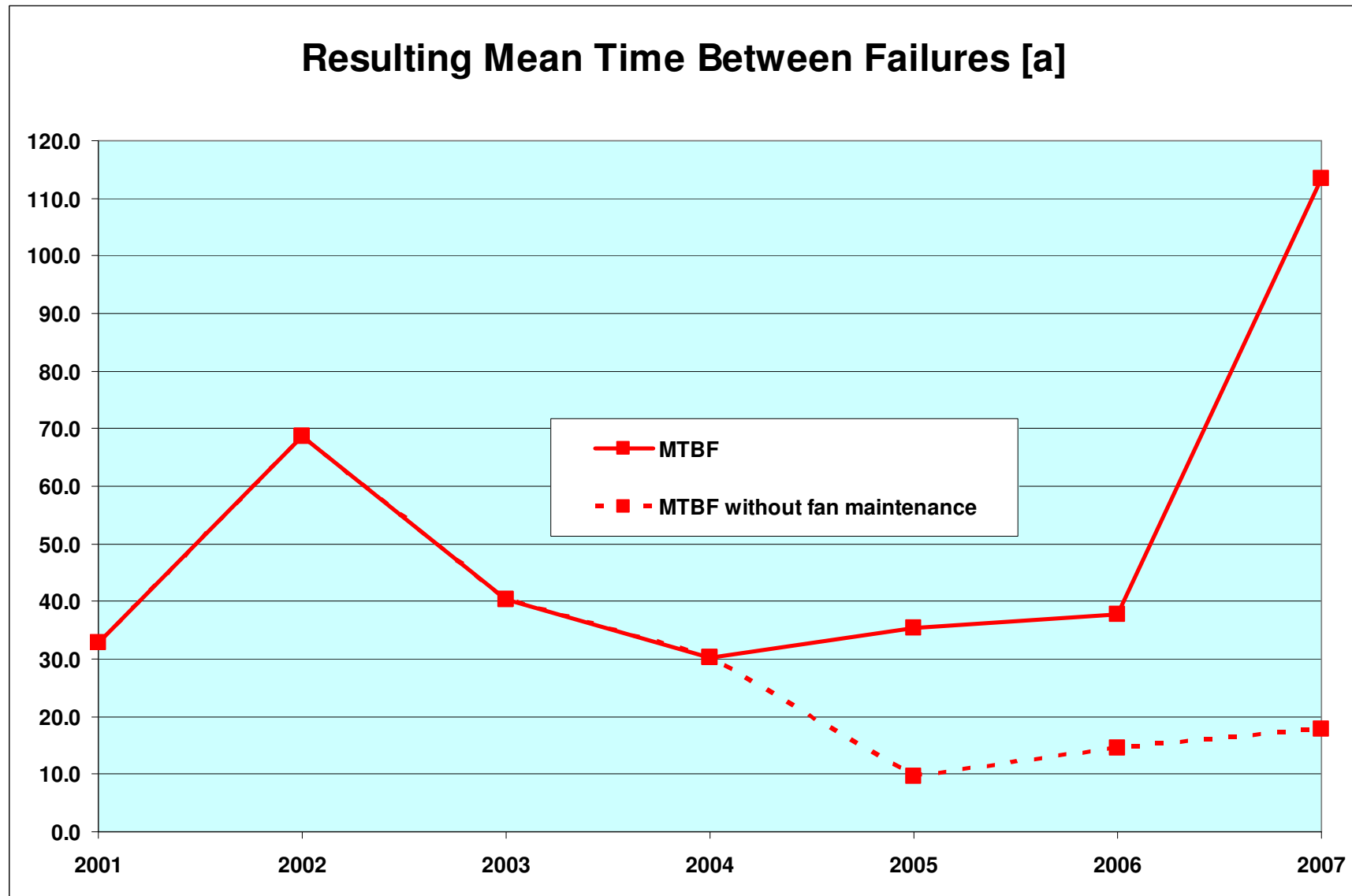


| No of installed devices By end 2004 | Output Current [A] | Output Voltage [V] | Output Power [kVA] | Switching frequency [kHz] | 8h stability requirement [ppm] ** |
|--|--------------------|--------------------|--------------------|---------------------------|-----------------------------------|
| 1 | 950 | +/-1000 | 1000 | 10 | 10 |
| 1 | 500 | 880 | 440 | 16.7 | 15 |
| 6 | 120 | 75 | 9 | 100 | 100 |
| 2 | 140 | +/-120 | 17 | 50 | 100 |
| 24 | 140 | 60 | 8.4 | 100 | 100 |
| 3 | 120 | 240 | 28.8 | 25 | 100 |
| 4 | 145 | 70 | 10.2 | 50 | 100 |
| 2 | 120 | 130 | 15.6 | 25 | 100 |
| 150 | 120 | 60 | 7.2 | 100 | 100 |
| 4 | 120 | 60 | 7.2 | 100 | 40 |
| 18 | 120 | 15 | 1.8 | 100 | 500 |
| 2 | +/-40 | +/-40 | 1.6 | 100 | 100 |
| 3 | +/-6 | +/-110 | 0.66 | 100 | 500 |
| 356 | +/-7 | +/-20 | 0.14 | 100 | 15 |

** much better stability figures have been achieved









Reliability

Not all HW Failures lead to a beam loss:

| | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|------------------------------|------|------|------|------|------------|------------|------------|
| No. of HW Failures | 16 | 8 | 14 | 19 | 17 | 17 | 6 |
| No. of resulting beam losses | ? | ? | ? | ? | 5 (30%) | 8 (47%) | 2 (33%) |

Availability for an average repair time of 2h and an operation time of 6'800h

| | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|-----------------------|-------|-------|-------|-------|-------|-------|-------|
| No. of HW Failures | 16 | 8 | 14 | 19 | 17 | 17 | 6 |
| Availability (all PS) | 99.5% | 99.8% | 99.6% | 99.4% | 99.5% | 99.5% | 99.8% |



How to improve Mean Time Between Failure (1)

- **€€€ \$\$\$ Be aware that quality costs something! \$\$\$ €€€**
 - Competition (price) levels down the quality
 - Chose your supplier carefully
 - Specify your quality requirements
 - Behave like a technical colaborator rather than a bargain hunter
- **Cooling Fans**
 - Avoid them whenever possible
 - Use Water Cooling or natural convection instead
 - If used anyhow
 - Build in redundancy (makes only sense if monitored)
 - Turn them on only if needed (lifetime extension)
 - Check them periodically
 - Replace them periodically



How to improve Mean Time Between Failure (2)

- **Keep the junction temperature of semiconductors below 100°C**
- **Do not operate transformers or chokes at 100% power (current) permanently**
 - **Manufacturers go close to the limits**
 - **Allow free air circulation for natural convection**
- **Operate electrolytic capacitors well below their current capability**
- **Build your system as simple as possible, be careful with redundancy**
 - **Redundancy needs to be monitored**
 - **Redundancy makes your system more complicated**
 - **Hot Standby systems require monitoring and are fed together via a bottleneck**



How to improve Mean Time To Repair (MTTR)

- **Skilled personnel must be available on short notice**
 - At PSI: 24h/365d on-call service (in less than one hour at site)
 - Difficult to achieve with external companies (suppliers)
- **Extensive self diagnostic**
 - Can easily be offered from digital control systems
 - Allows quick detection of the faulty element
- **Modular Design (reuse of modules in different applications)**
 - allows quick replacement of faulty components
 - Reduces the number of spare parts (inventories)