**ABSTRACT**

The 1.7 GeV light source BESSY II features about 50 beamlines overlayed by a factor of 2 on the average. Thus availability of high quality synchrotron radiation is a central asset. Users at BESSY II can base their beam time expectations on numbers generating according to the common operation metrics [1]. Main failures of the facility are analyzed according to [1] and displayed in real time. Analysis of minor deviations are provided regularly by off-line tools. Many operational constituents are required for extraordinary availability figures: meaningful alarming and dissemination of notifications, complete logging of program, device, system and operator activities, post mortem analysis and data mining tools.

**OPERATIONAL MODES**

- Multibunch hybrid mode:
  - 298mA total current
  - Top-up injections
  - 300 bunches — 100 buckets gap

- 5 special bunches:
  - 4mA purely controlled camshaft bunch in center of gap
  - 3 bunches opposite of gap — for fs-slicing [2,3]
  - 3mA PPRE bunch close to end of gap — resonantly horizontally excited for pseudo-single bunch experiments [4].

- Single bunch mode:
  - Single 14mA per controlled bunch for time resolved experiments (2-3 wk/y)
  - Top-up injections

- Low Alpha mode [5]:
  - Even filling of
    - 100mA (short pulse mode)
    - 15mA (THz mode, non-bunching coherent synchrotron radiation)
  - Decaying beam - injections every 4h (2-3 wk/y)
  - 12m gap dark gap
  - Camshaft at center
  - Horizontally excited PPRE bunch close to start of gap
  - <30μA Ultrashort low current bunch close to end of gap

- PTB mode:
  - Conditions according to specific experimental requirements.
  - Availability is as long as facility is functional.

**IMPLEMENTATION OF THE METRICS**

Metric evaluated in real time since 2016 determining primary:
- low beam: $I < I_{\text{min}}$ with $I_{\text{min}} = 500\, \text{mA}$
- no beam: $I < I_{\text{f}}$ with $I_{\text{f}} = 665$ = 165mA

and secondary failure modes:
- distorted orbit: BPM RMS deviation > 80μm or no orbit feedback running
- low lifetime: beam $I < I_{\text{f}}$ with $I_{\text{f}} = 42\, \text{mA}$
- beam blowup: $\hat{I} < \hat{I}_{\text{f}}$ horizontally as well as vertically
- distorted fill pattern: $|\hat{I}_{\text{min}} - \hat{I}_{\text{max}}| > 10%$
- back-up: $\text{current} < 0.005$

Limits differ depending on operational/shift mode.

Shift mode is determined from official beam time schedule and may be overridden.

Primary failures are "outaged" starting at time of event and ending as nominal values are restored and beam is available for the users again.

User time of $T_{\text{now}} < t$ is not counted as user time but accounted to the preceding or follow-up outage.

**OPERATIONAL TOOLS**

**Parameter Checks**
- Crucial parameters are permanently checked against proper set boundaries.
- Boundaries are much smaller to alarm operations crew so they can take precautions to prevent any secondary failure.

A hardware parameter check has been set up to prevent an top-up injection with a too low booster synchrotron current. This prevents top-up interruptions that would enforce closure of beamshutters.

User time of $T_{\text{now}} < t$ is not counted as user time but accounted to the preceding or follow-up outage.

**Correlation**
- Several correlation configurations of diverse signals over time (shift, day, week or month) are available.
- A correlation overview is a set of plots created from archived data.

Discussing a list of pre-configured plots of important parameters is part of formal shift handover procedure.

- Identical time-axes ease correlation of concurrent changes and aid identification of causes.
- Slow drifts can be recognized before an alarming state is reached.

**RESULTS**

Extraction of information with strategic relevance still require combination and correlation of information in all available data stores. At BESSY II this is still a "manual" iterative process of presentation, analysis and discussions. Significant steps visible in cumulative primary failure graphics plotted according to root causes have been worked on e.g. with a refurbishment campaign of all quadrupole power supplies, improved diagnostics allowing on-line monitoring and new RF settings.

A week without any outages and 100% free of secondary failures is tagged "perfect week" internally.

**SUMMARY**

For long term operational light source facilities like BESSY II transparent availability analysis and maintenance are crucial. Potential users as well as regular customers need to know how the facility of their choice handles disaster prevention and recovery. And management has to know if the preservation and modernization activities are adequate or need readjustment. As a result of the analysis and tuning tools developed at BESSY II there has been practically no beam loss for "unknown reasons" within the last years.

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