Control system for a 200 TW laser

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Andreas R. Maier
with S. Jolly, B. Kim, V. Leroux, M. Schnepp, D. Trosien
CFEL, UHH, LAOLA.
andreas.maier@desy.de
LUX Junior Research group

Junior Research group at CFEL and Hamburg University

commission & operate 200 TW ANGUS laser system

build and operate the LUX beamline for laser-plasma driven undulator radiation

lux.cfel.de

* also group Georg Korn

** group Prof. Grüner

Andreas R. Maier

Andi Maier
Andi Walker
Matthias
(Prof. Grüner group, UHH)

Paul
Manuel
Chris
Niels
Vincent
Spencer
Irene (Prof. Grüner group, UHH)

Max
Sören
Henning
Philipp
Our goal

ANGUS parameters
• 200 TW
• 5 J, 25 fs, 5 Hz rep. rate

performance
• < 3 µrad rms pointing
• < 1 % rms energy stability
• strehl better 0.9

… so let’s talk about
• availability
• stability
• reproducability
Availability - 7 Week Performance Test

... get some data
Monitoring Tools

LAOLA.

TINE Control System

Quality and stability monitoring software for a 200TW laser

- Power/energy measurement:
  - After every amplification stage
  - Photodiodes for MHz and kHz range (power)
  - Thermoelectric sensors for 5Hz Pulses (energy)

- Temperature measurement:
  - Temperature measurement of the different laser crystals
  - Measurement of air/table temperature of each laser box

- Spectrometers
  - to get the laser spectrum to the corresponding energy/power values

- Camera server:
  - to monitor the beam -pointing in crucial parts of the laser chain

- Future plan: humidity sensors

Big number of monitored important laser parameters

Integration into the DESY Tine Control System to be able to access it from any DESY pc and to store the data permanently

TINE: Three-fold Integrated Networking Environment

- Multi-Platform (Win, UNIX, MACOS,…)
- Multi-Protocol (UDP, TCP, IPX, and PIPEs)
- Multi-Architecture: Client-server-Publisher-Subscriber-Consumer

Plug and Play!

Local Storage (for 90 days)

- Short-term: 10min with 1/s, long-term (>10min) with 1/15min when changes<10%

Central Archive (for years)

- Adjustable for all kinds of needs

Professional and approved solution for data archiving

Long-term Analysis / Benefits

- We are now able to see how the system reacts on:
  - Perturbations like vibration (people working in the lab)
  - Temperature changes
  - Influence/quality of the cooling circuit
  - Degradation over time
  - Warm up time to get stable
  - Energy correlations between the amplification stages
  - Correlations between energy, temperature, beam pointing and spectrum

Therefore we can locate and solve problems faster

Important for a reliable and stable laser

Power/Energy stability measurements of the oscillator and the whole laser chain:

A. Measurement of the ML power loss of the oscillator during normal working conditions

B. Full chain stability measurement, right after starting the laser

C. Observation of the oscillator behavior while keeping it in ML

Control Panels and Analysis Software

- Control panels showing all important laser parameters for all amplification stages
- Data access for analysis:
  - MatLab
  - Different in-house java applications

- Monitored values:
  - Picture of the beam spot,
  - beam centroid,
  - energy trend and latest value,
  - temperature,
  - current spectrum and reference spectrum

Angus Laser in Concept

Oscillator Regen Booster PreAMP AMP1 AMP2

1.8 J, 5 Hz
1.8 J, 5 Hz
1.8 J, 5 Hz
14 J, 5 Hz

4.6 W
25 W, 1 kHz

Stretcher
Compressor XPW Stretcher

1.8 J, 5 Hz

• based on a THALES ALPHA 5
• we replaced all diagnostics
• added many more diagnostics
• added active stabilization
• integrated to system into the accelerator controls system @ DESY
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LAOLA.

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ANGUS
for each box...

- Spectrum with reference
- Temperature at relevant points (crystals)
- Near- and farfield at the output
- Online energy (power) measurement with trend chart
- Get centroids of NF/FF and display trend chart on laser position and direction

In focus
Out of focus
... the whole system ...
... and in real life.
One more thing … beam stabilization

- Monitoring Tools
  - LAOLA
  - TINE Control System
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Everything goes in the Controls System

temperature
beam position, centroids, size, …
spectrum
energy
timestamp
communication
data archive
displays
matlab console
interface to python, C, …
We generate a lot of data…

- energy/power
- pointing
- temperature

- spectrum centroid
- spectrum width
First Results
Availability - 7 Week Performance Test

- 7 weeks, 35 days
- turn on the system every day at 09.00 am
- let it run for two hours
- with all diagnostics channels getting data
- then use the laser…

- test does not include last pump laser
- identified timing system as a major problem

- successfully completed daily startup & test
- timing system failed during the test

• 91 %
• 9 %
Availability - 7 Week Performance Test

- 7 weeks, 35 days
- turn on the system every day at 09.00 am
- let it run for two hours
- with all diagnostics channels getting data
- then use the laser…

Daily startup time including warm-up

- only pushing buttons
- not opening covers or touching mirrors
- touch only 5Hz multipass mirrors

49 %
40 %
11 %

more significant work
Case Studies
Beam Stabilization works…

stabilization OFF

stabilization ON
Stabilizes energy

stabilization OFF

stabilization ON
Helps to identify problems…

**stabilization OFF**

- eliminated drift
- only S2S jitter
- where do the jumps come from? seems like correlation w/ spectrum

**stabilization ON**
Think about auto-tuning…

- Preamp output into Amp1 not yet stabilized
- Clear correlation between pointing and energy
- Stabilize!!
- auto-tune??
Found Oscillations in the REGEN Energy…

> even with stabilization there seem to be some oscillations in the energy.

> yeap, there are real.

> obviously caused by pump laser

> is it the chiller? - add temperature sensors…
Conclusion

> Conclusions…

> we think the software is as important as the hardware

> make the laser a klystron and do laser shooting - no trouble shooting

> … although we are fare from being done…

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