LUXE - A few thoughts on lasers

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Parameters: top-down

Parameters and discussion based on M. Wing et al.,
https://indico.desy.de/indico/event/21203/contribution/3/material/0/

intensity
> we target for a peak intensity I_0 about 10^{20} W/cm^2
> focal spot about 10 μm FWHM (intensity)
> focal spot: sinc, i.e., fourier-transformed flat-top
> a_0 about 6

power
> 100 TW on target
> pulse length 35 fs FWHM (intensity)
> pulse energy 3.5 J on target
> pulse temporal profile (intensity) is gaussian

laser
> TiSa at 800 nm wavelength
> 1Hz rep-rate - 10Hz possible but more challenging
> about 1 m focal length and 10 cm beam diameter (flat-top)

some remarks (I)

general properties

> 800 nm central wavelength
> 40 nm FWHM bandwidth in focus
> linearly polarized
> carrier-envelope phase can be stabilized

real laser pulses

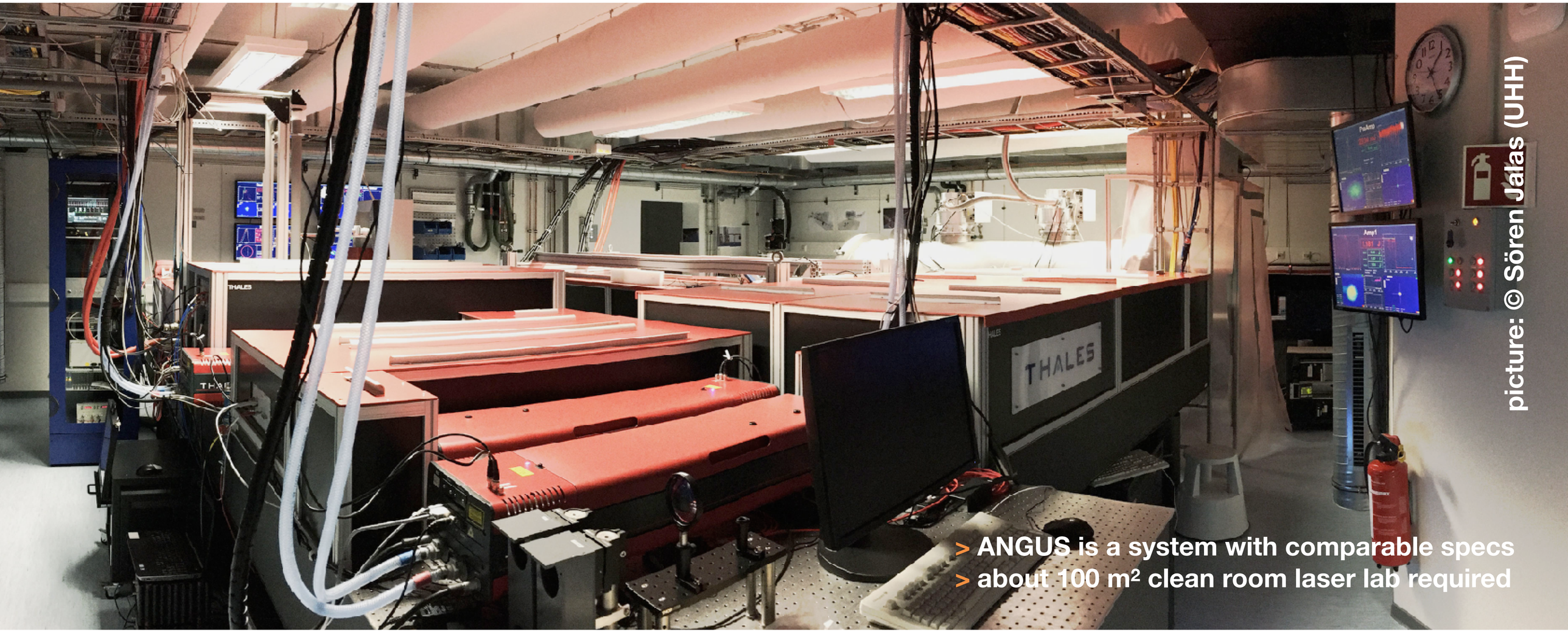
> there might be residual spatiotemporal couplings on the pulse:
> need careful tuning
    > pulse front tilt, from spatial or angular wavelength chirp in the beam
    > linear and higher order frequency chirp, if the pulse is not fully compressed
> parameter jitters
    > laser energy - few percent rms
    > pulse length - few percent rms
    > focus spot size - fraction of a spot size rms
> drifts in parameters (energy, bandwidth, direction, …) if not carefully stabilized

some remarks (II)

diagnostics
> relative changes can be measured relatively easy
> absolute values might be more tricky
> we have solutions to measure required parameters
> diagnostics should be considered from the very beginning

what can we tune
> pulse length - making the pulse longer at constant energy
> energy - lower/attenuate the energy
> focus spot size - by shifting the focus position, but not straightforward
> …

in real life…



> ANGUS is a system with comparable specs
> about 100 m² clean room laser lab required

Cost Estimate (I)

5 M€ rough estimate

> with headroom in parameters
> focus on availability
> excluding laser lab

running costs

> 10% of invest per year for replacement of optics, spares
> requires 2 FTE/year to build, and later operate
> saving on running costs or man power does not pay off

Cost Estimate (II)

> most expensive part is the green pump lasers, roughly 2/3 of the cost
> about 10% conversion from green pump energy to useful laser energy in the focus
> whatever requires more energy causes costs

> you can save some budget once the laser design becomes more clear

> comparing prices for different systems consider:
  > the number that is typically used as a benchmark is power, i.e., TW, which can be misleading
  > typically power is quoted after the compressor neglecting losses in beam transport and due to imperfect focussing
  > just assuming an optimistic pulse length, e.g., 25 fs instead of 35 fs, saves you 30% of pump power in the budget

focusability	0,80
beamline transmission	0,80
compressor efficiency	0,60
Green Pump-to-TiSa efficiency	0,25
Green Pump-to-Target	**0,10**

Summary

> laser system can provide necessary parameters
> this discussion is simplified
> need to develop parameters and requirements