Laser upgrade proposal for laserwire experiment at the ATF2

Laura Corner for laserwire collaboration
July 2 2010

Laserwire experiment and proposal

- Current experiment uses Nd:YAG laser from KEK
- Oxford group have been working on a fibre based amplifier to provide laser pulses for the project.
- KEK laser designed for completely different project and not ideal in some respects for laserwire.
- Lasers are increasingly important in many applications in accelerator physics (beam diagnostics, photocathode guns, laser plasma acceleration etc.).
- So interested in testing new fibre technologies in accelerator environment.

- Proposal is to bring Oxford fibre laser to KEK to use in laserwire experiments for the first half of 2011.

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Comparison of lasers

Current KEK laser:

✓ Lots of energy

✓ Proven solid state technology

✓Used to obtain data in previous expt.

× Not ideal beam shape for small focused spot sizes

× Long pulse length (~360 ps FWHM) – although not really a problem as high energy/pulse.

× Inefficient (flash lamp pumping at 6 Hz.

× Electronics can be unreliable.

× Takes a long time to stabilise.

Fibre laser:

✓ Efficient – no water cooling of fibre

✓ Good beam profile

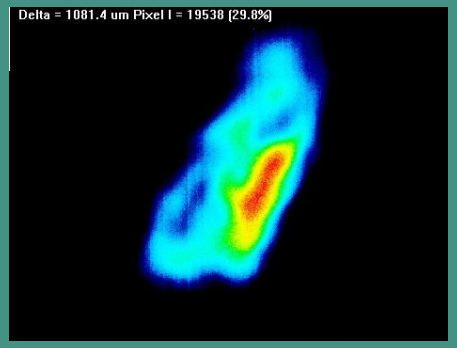
✓ Single mode Gaussian and large area amplification – advantage of photonic crystal fibre technology

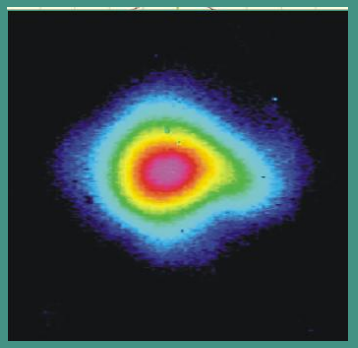
✓ 6.49 MHz in burst pulse mode – could scan individual e^- bunches.

✓ Stabilises thermally in minutes

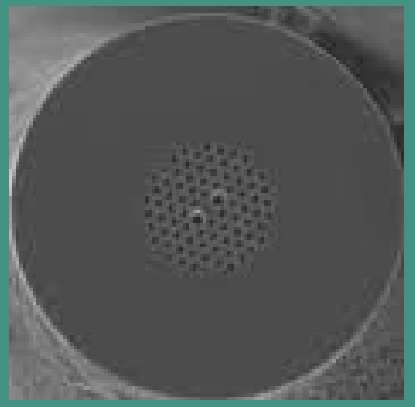
✓ Good beam pointing stability (wave guide structure)

× Major disadvantage limited pulse energy - currently 100μJ/pulse, although we expect that to increase.



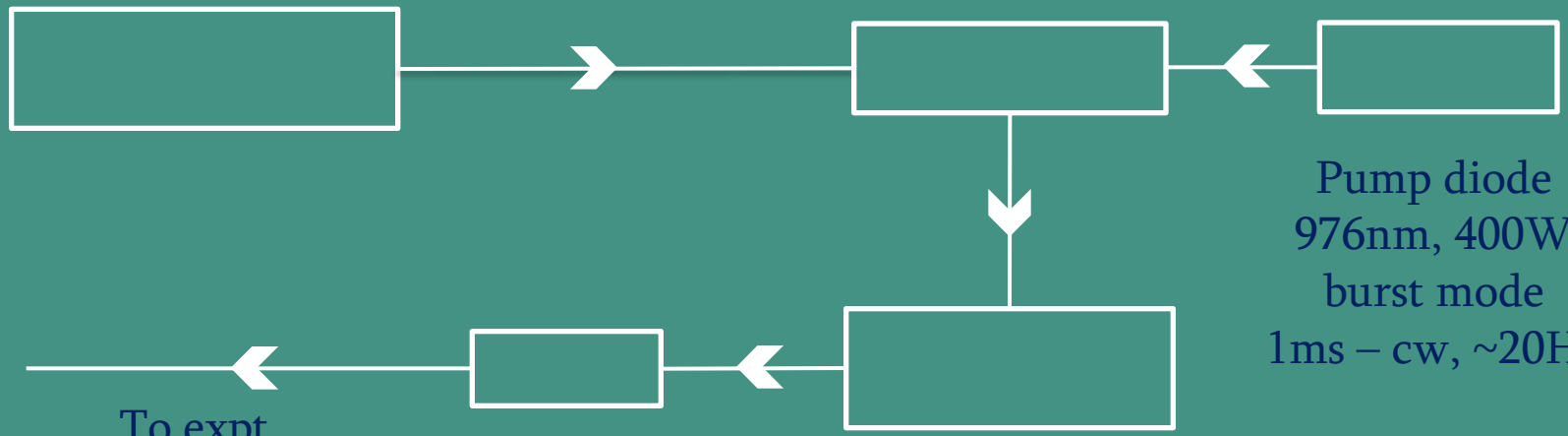


Fibre laser architecture



Seed 1037nm, 1μJ, 200ps
Burst mode 4μs – 100s ms,
15 – 20 Hz (pump dependent)

Yb doped rod PCF
Polarisation maintaining
core d = 70μm
L = 70cm



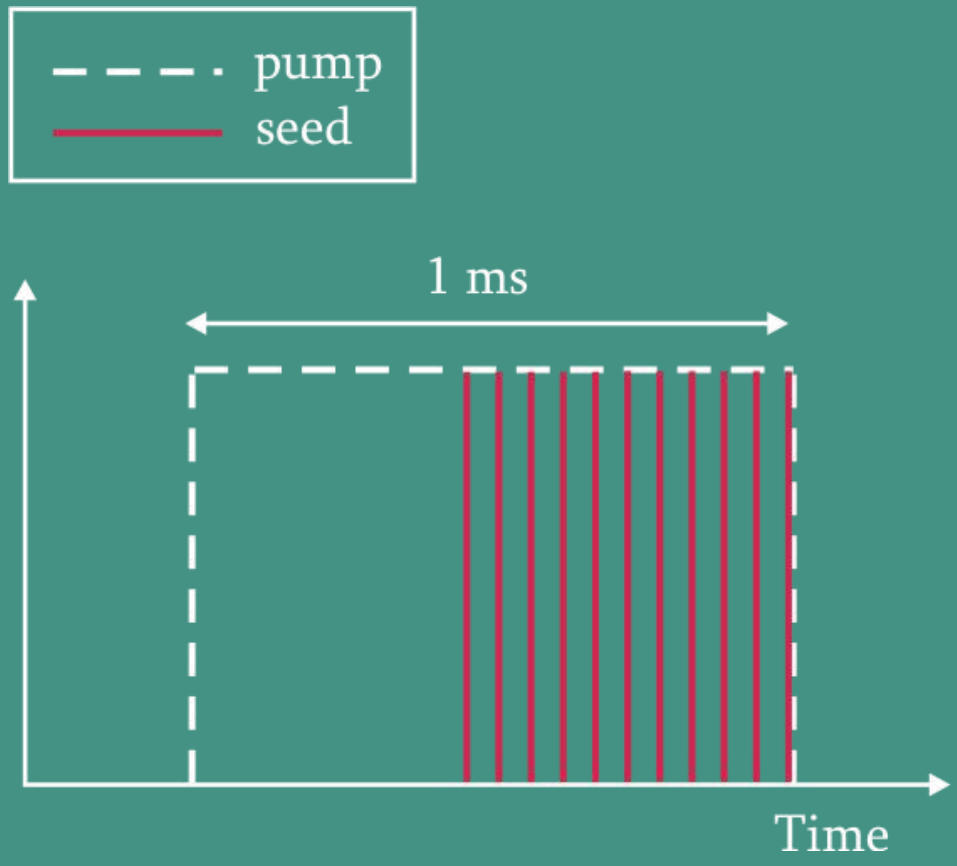
Pump diode
976nm, 400W
burst mode
1ms – cw, ~20Hz

To expt.

SHG
517.5nm

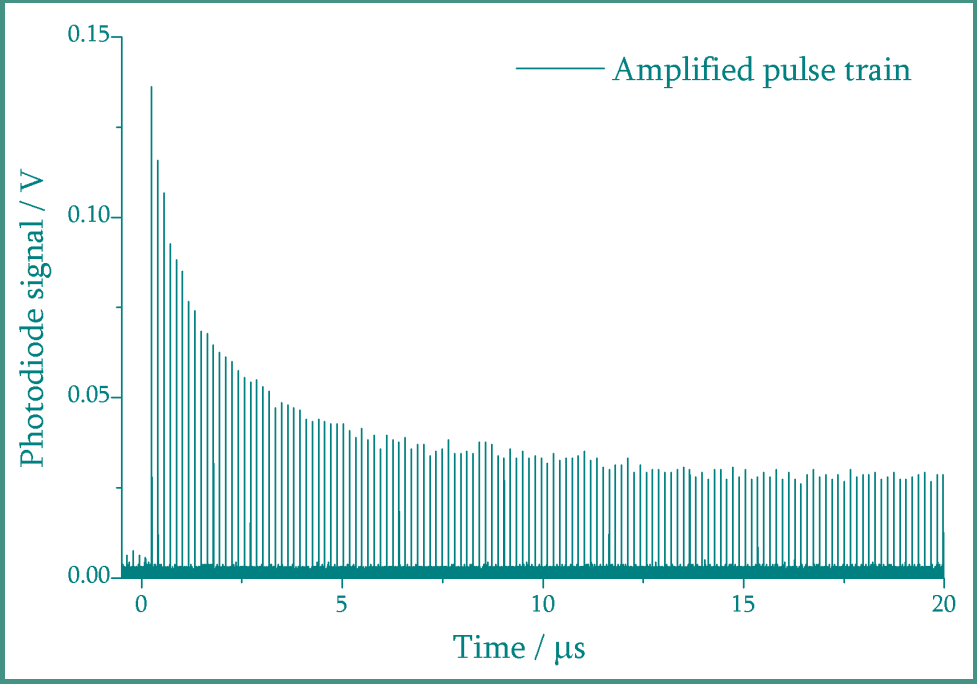
Compressor
1 – 10ps

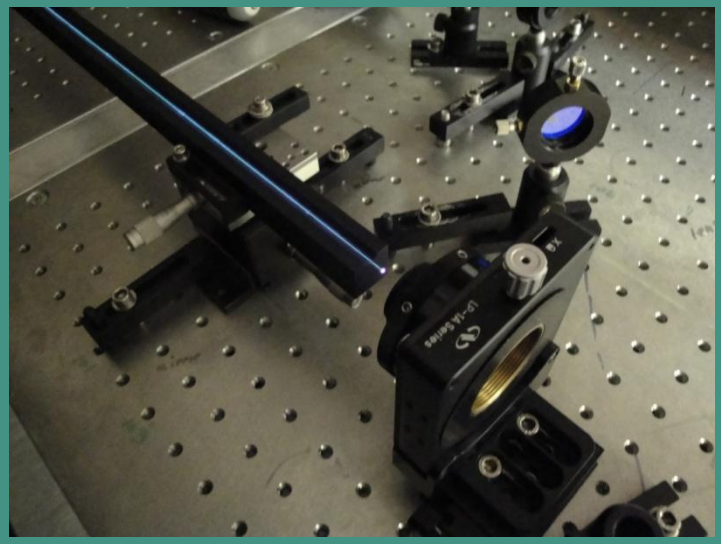
Fibre laser current results



unamplified seed pulse train

Fibre laser current results





- Initial results - first pulse in train ~ **95 - 105** μJ.
- Have achieved design spec. for pulse energy.
- Currently 2 Hz (limited by diagnostics).
- Can go to ATF2 6 Hz.
- This result is in 70 cm length of fibre.

Further research required

Fibre laser:

100μJ in first pulse @ 1037nm.

Pulse trains of 6.49MHz spaced at 2Hz, easily able to get 6 – 10Hz.

Pulse length 200ps. Unamplified pulses down to 2ps.

Need to do this with amplified output. Have to consider damage threshold of gratings.
Improve seed coupling and amplification to get 3 or 4 leading pulses from each train
> 100μJ/pulse (100μJ in 2ps = 50MW).

Frequency double to 517nm with > 50% efficiency.

Laserwire:

Need collisions with new setup to study S/N and timing synchronisation and determine if the fibre system has enough power to be used in the experiment.

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Possible timetable

June – Nov 2010: Continued fibre laser development in Oxford.

Oct – Nov 2010: Laserwire experiments at KEK to obtain collisions, optimise experiment, reduce background, study S/N and determine minimum laser power requirements.

Dec 2010: Ship fibre laser from Oxford to KEK.

Jan – June 2011: Laserwire experiments with fibre laser – aim to show fibre technology works successfully in accelerator environment, improvement of speed of data collection with higher collision rate, better resolution with smaller focus, demonstrate single seed / many amplifier architecture for multiple diagnostics, investigate fibre delivery for flexibility and safety.

Resource requirement

Resources: my shipping estimate for 400kg, £300,000 of laser equipment to Narita is ~ £7000 for air freight and insurance.

Need to get equipment from Narita to KEK and installed (Cost? Manpower?). Then support for running (water, electricity) from KEK (although will be less than for current laser).

Some additional hardware to ensure correct timing between laser and accelerator.

Space: commercial seed and pre-amp 1m x 1.25m

pump diode and PCF amplifier 1 m x 1m

19" electronics rack for electronics + 2 chillers, floor space for small chiller.

All easily accommodated in current laser hut.

Possible laser collaboration?

- We are very keen to help other groups develop laser technology.
- This could be an opportunity to transfer knowledge from Oxford group to any interested groups at KEK.
- But stress this is not dependent on presence of fibre laser system in KEK – we can still help or advise if this is useful without our own hardware present in Japan during visits in 2010 – 2012.
- Possibly help build systems for other applications?