



FETS Laserwire Emittance Scanner – First results from CERN Linac4

on behalf of

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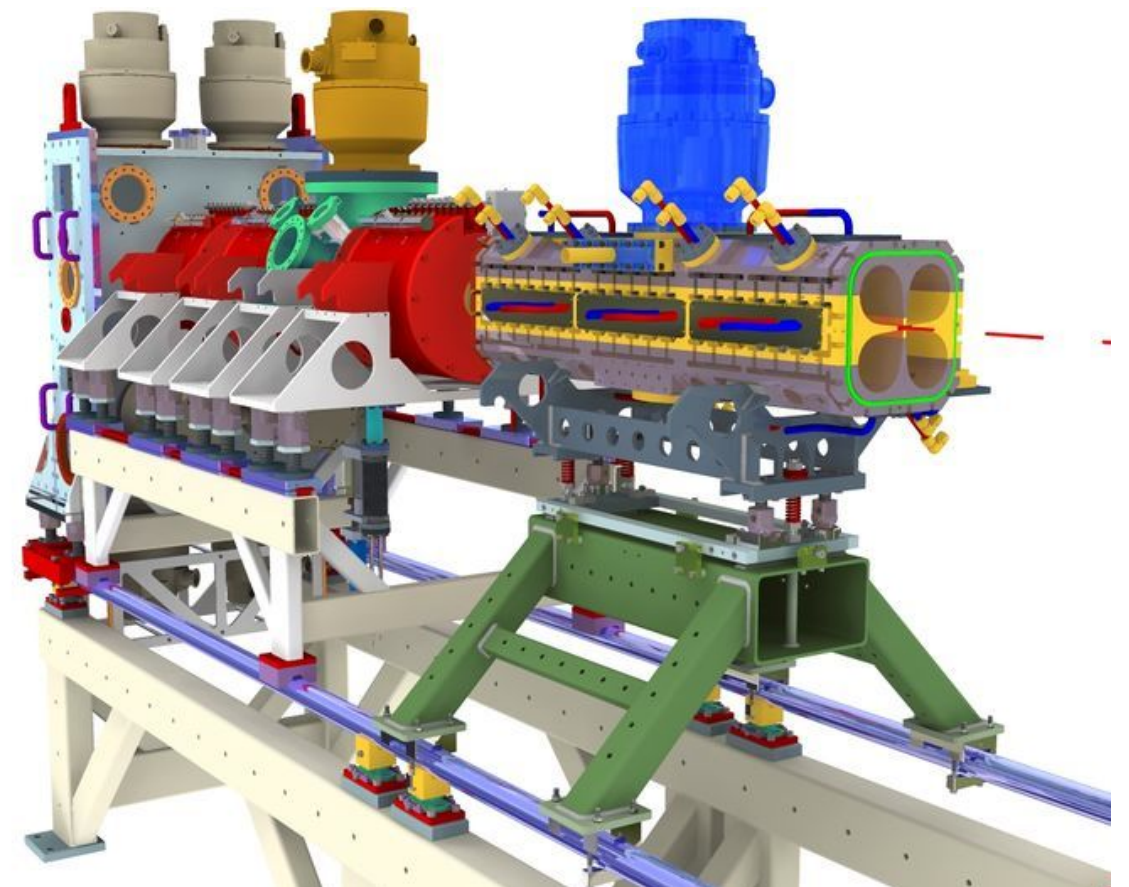
G. Boorman, A. Bosco, S. Gibson K. Kruchinin – RHUL

Thomas Hofmann, Federico Roncarolo - CERN

*FETS Meeting, RAL
19/02/2014*

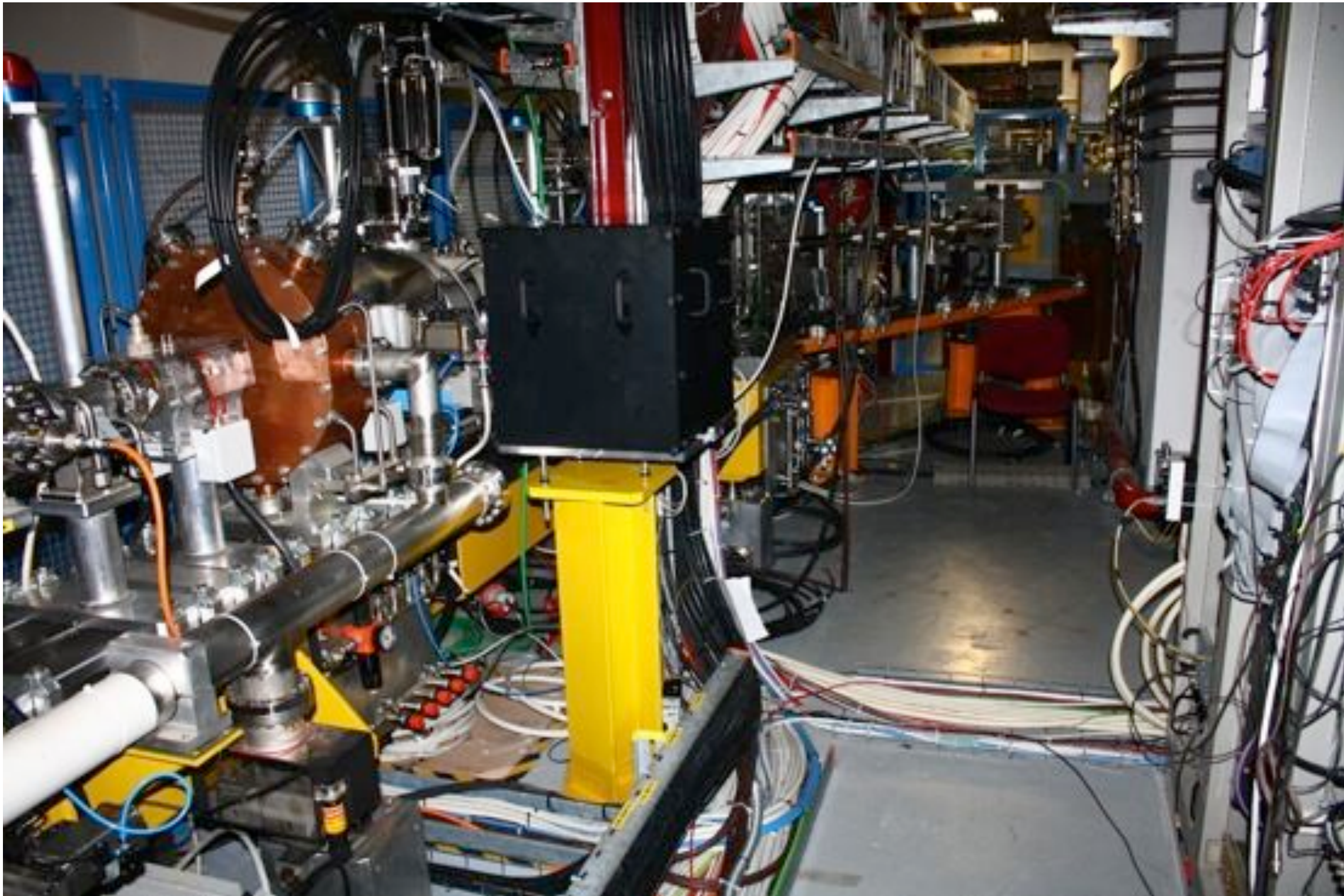
Outline

- Summary of progress
- First signal from Linac4
- First profiles from Linac4
- Outlook

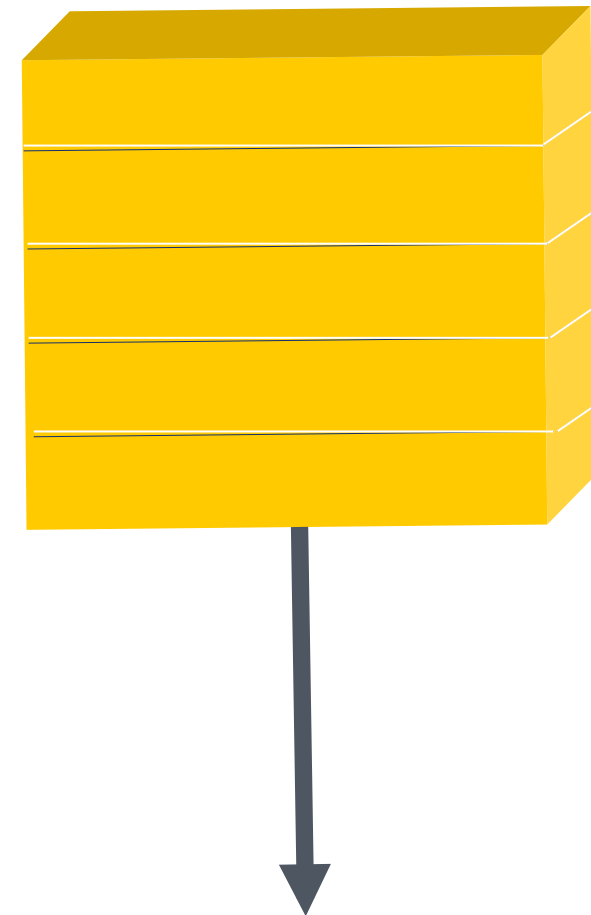


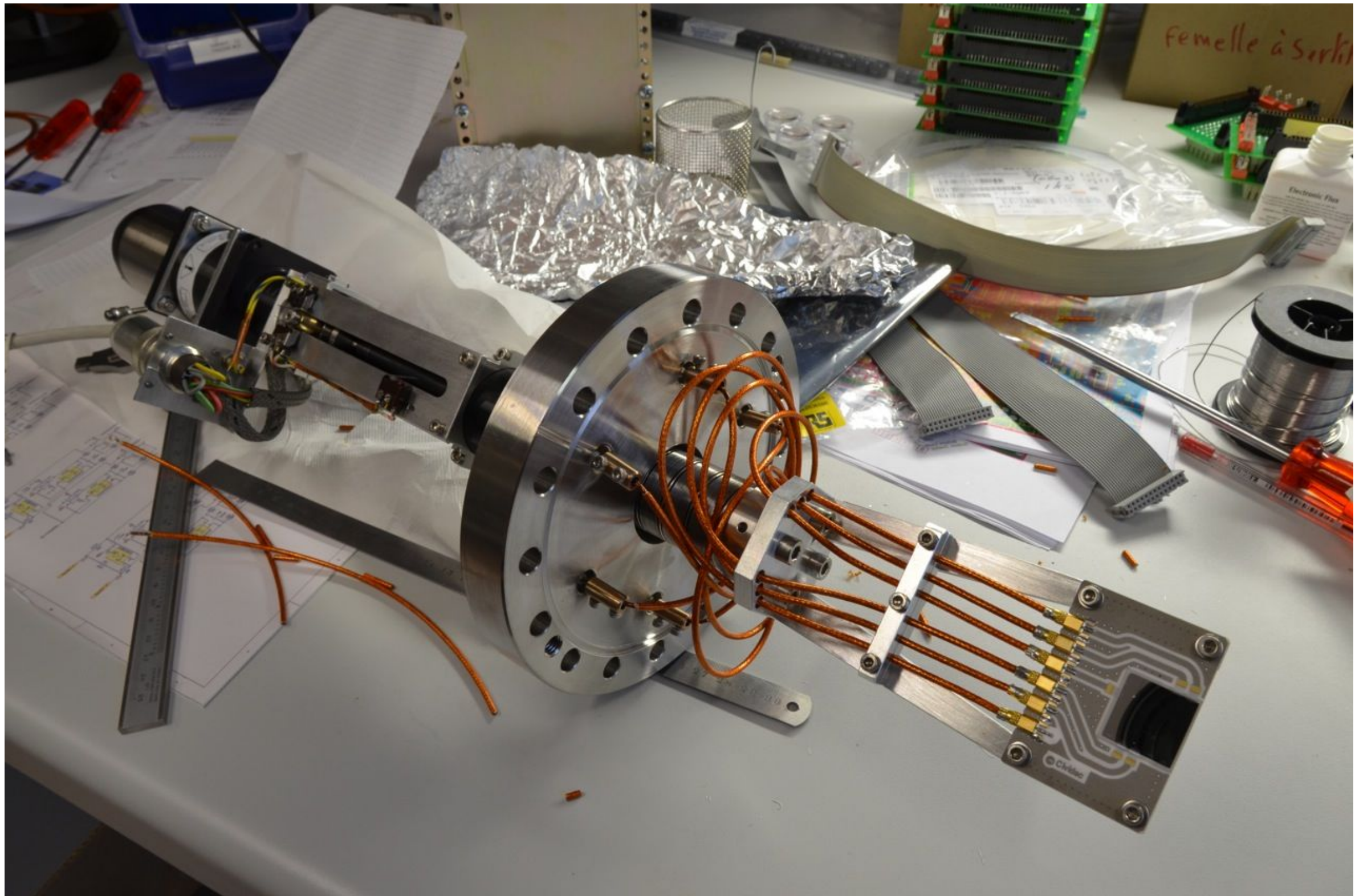
Main activities in past months:

- November 2013: Installation of laserwire at CERN Linac 4, check of system.
- December 2013: trip had to be cancelled due to Linac4 vacuum leak.
- January 2014: Vacuum repaired. First trip for data taking, 20-22 January:
 - Some initial fibre issues - soon resolved:
 - Recorded **first signal** on 22 January (date of last FETS meeting).
 - Diamond strip detector instrumented with additional amplifier channel.
- February 2014, 10th–14th, trip for data taking: (RHUL team joined by Juergen and Christoph).
 - Significant progress on the DAQ, synchronization.
 - **First profile** scan on 11 February.
 - Repeated vertical laser scans, with different diamond detector positions.
 - Ongoing analysis and data taking at present. Next trip being planned now.



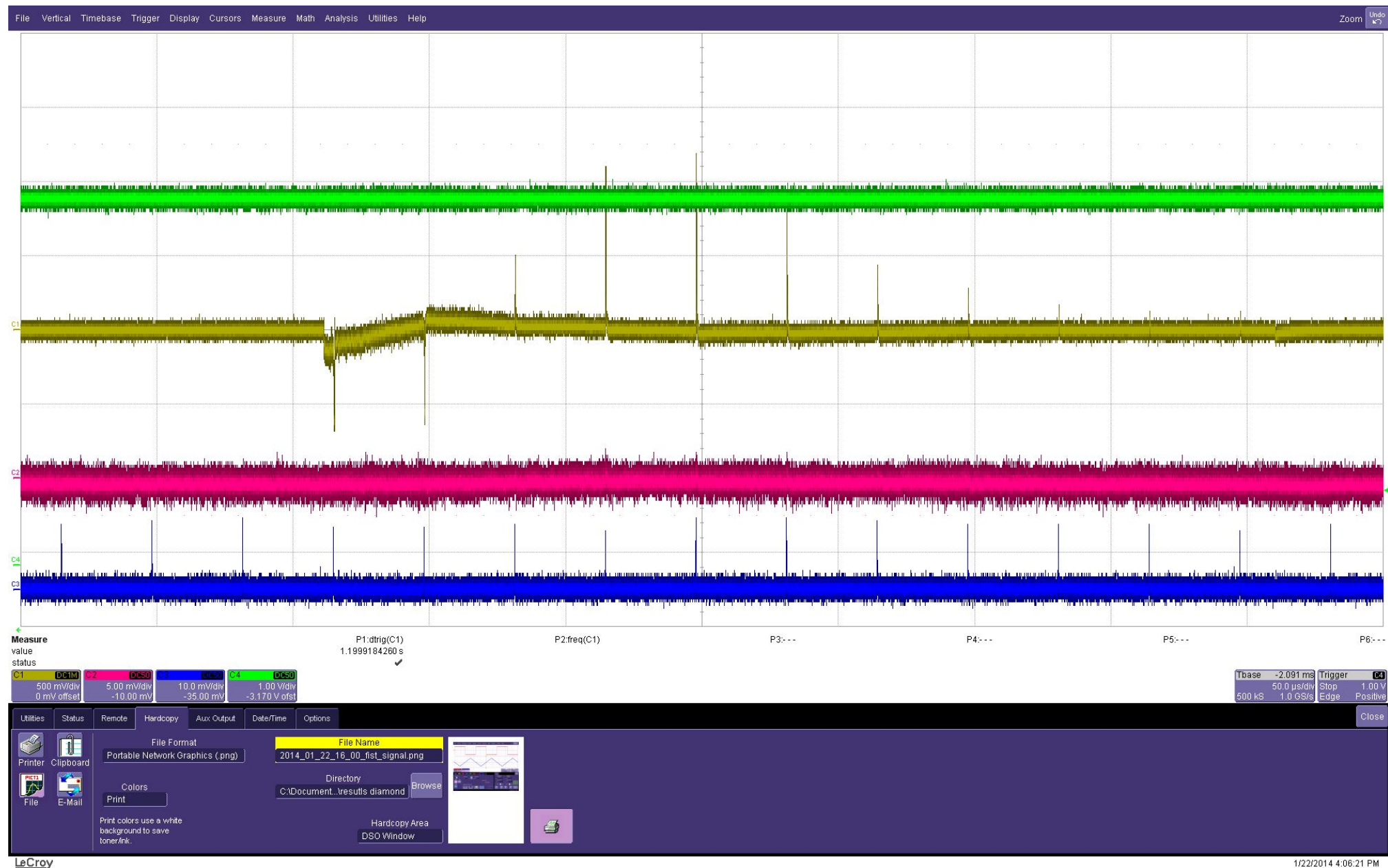
- Main H⁻ beam deflected by spectrometer magnet.
- Neutral H⁰ are undeflected and arrive at a downstream 5 strip diamond detector, which can be moved into the beamline via translation stage:
 - Each horizontal strip has a vertical width of ~3.5mm.
 - Small gap of 300um between strips
 - 600V nominal bias (adjustable).
 - Initially one strip was instrumented with a charge sensitive amplifier.
 - Later a second strip was instrumented with a linear amplifier.





Amplified
diamond
channel

Laser PD



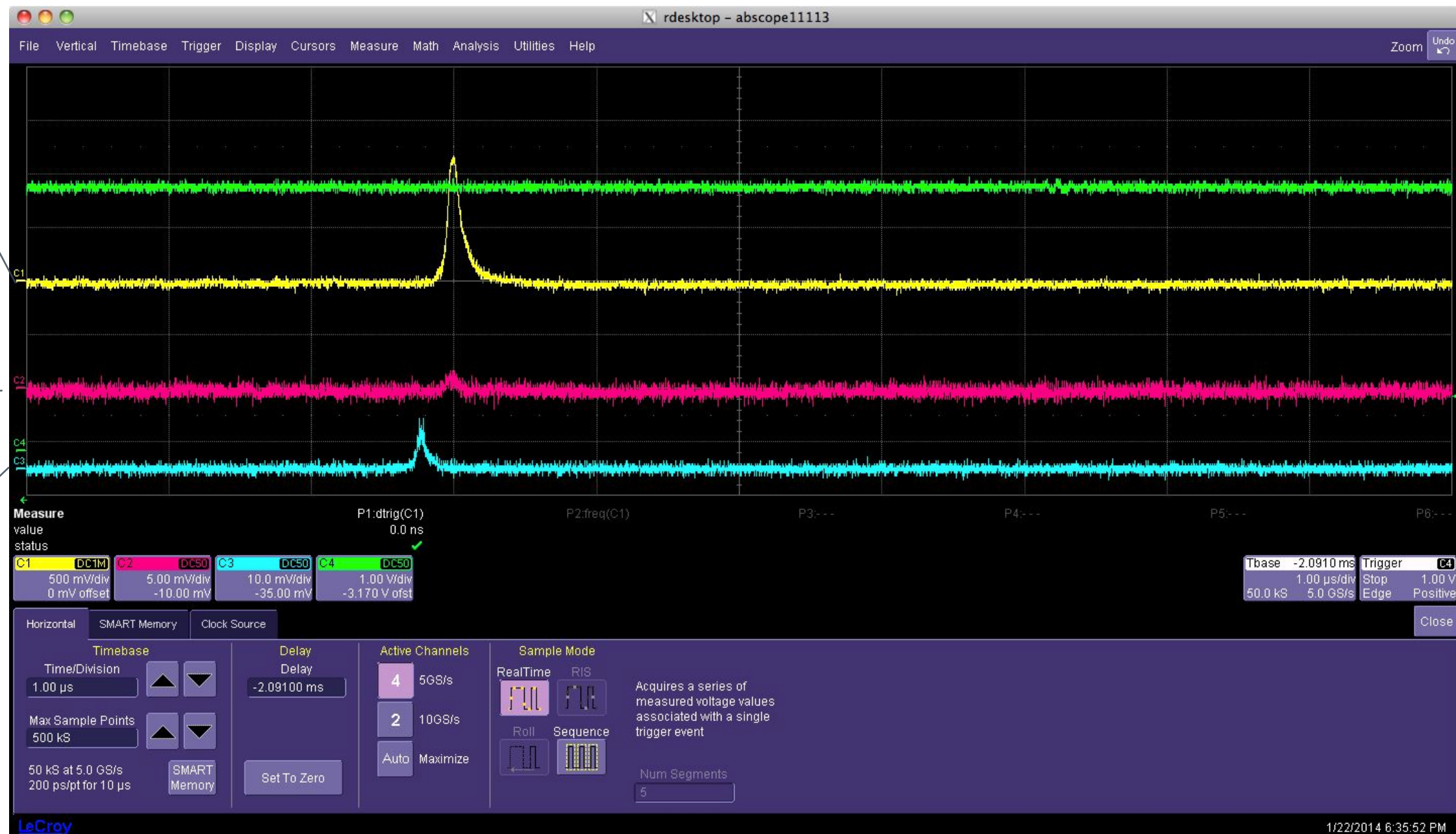
- Synchronous peaks in diamond detector with laser pulses.
- Residual gas background in diamond detector
- Negative / saturation effects observed – prompted addition of linear amplifier.

First signal – zoom in peak

Amplified
diamond
channel

Unamplified
diamond
channel

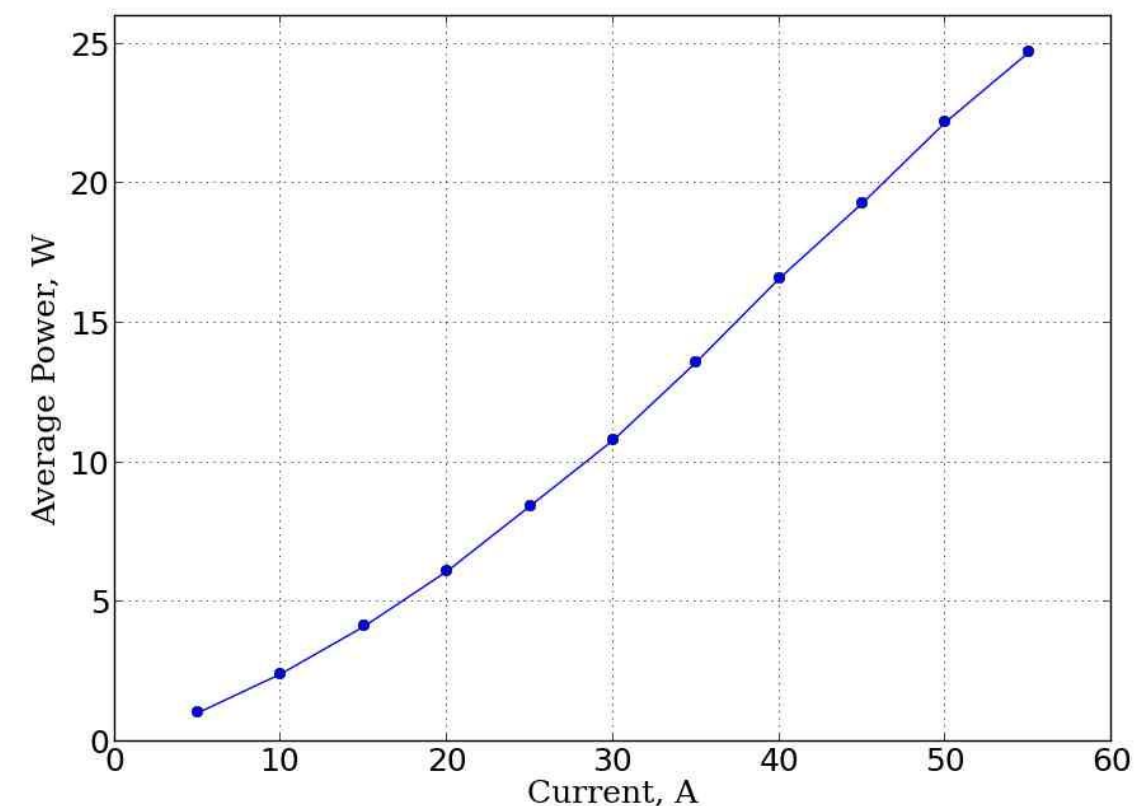
Laser PD



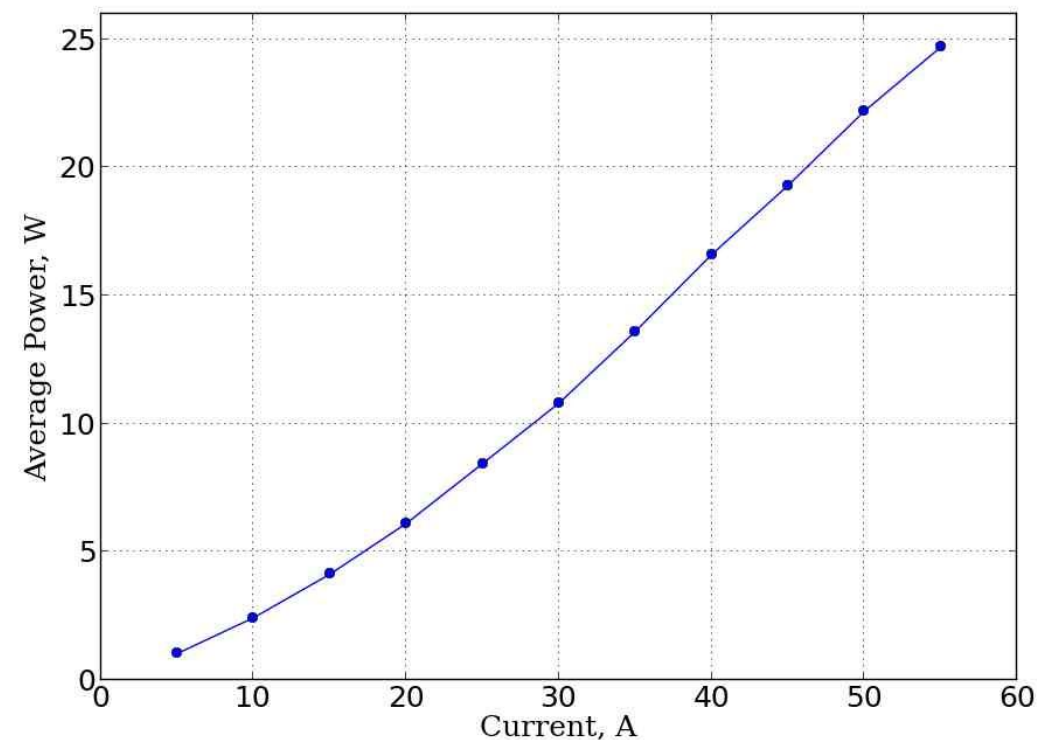
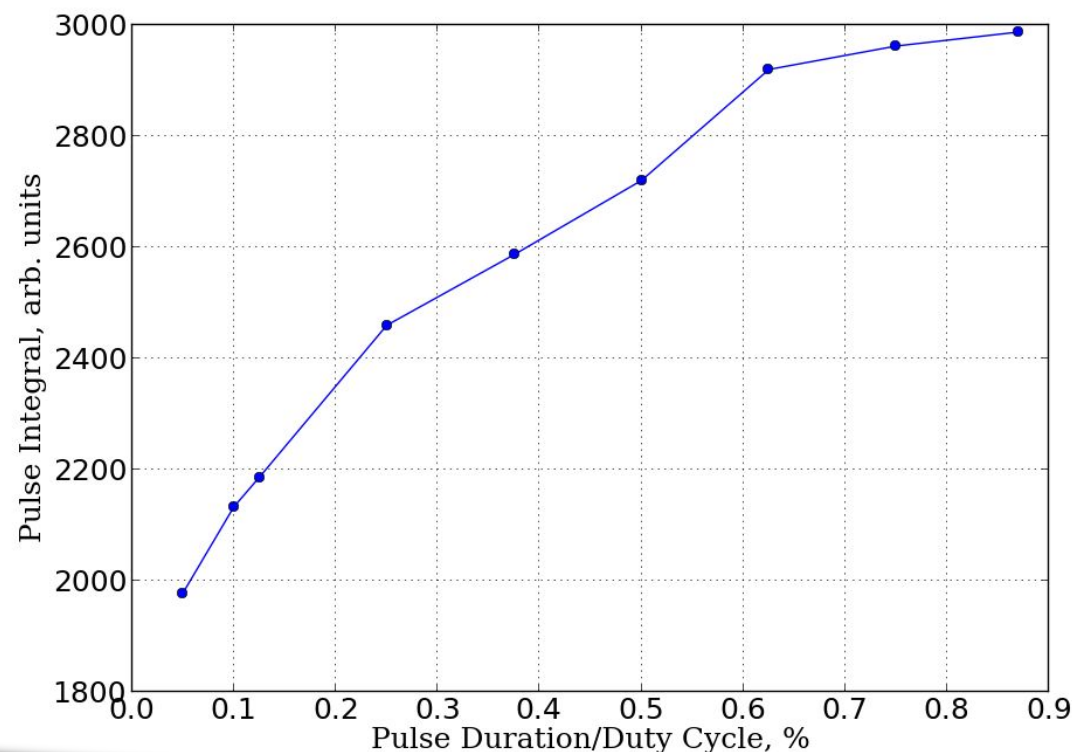
- On the January trip, laser current was set to 30A and was designed to operate with a low duty cycle ($\ll 1\%$).
- However, the system suffered a control malfunction: in the event of a power glitch or software crash the laser amplifier input floated to a logic high. This led to 100% duty cycle and therefore damage of the input fibre.
- Required access and time consuming repolishing of the fibre face.
- Could have been remedied with a pull-down resistor, but went for the most robust solution:

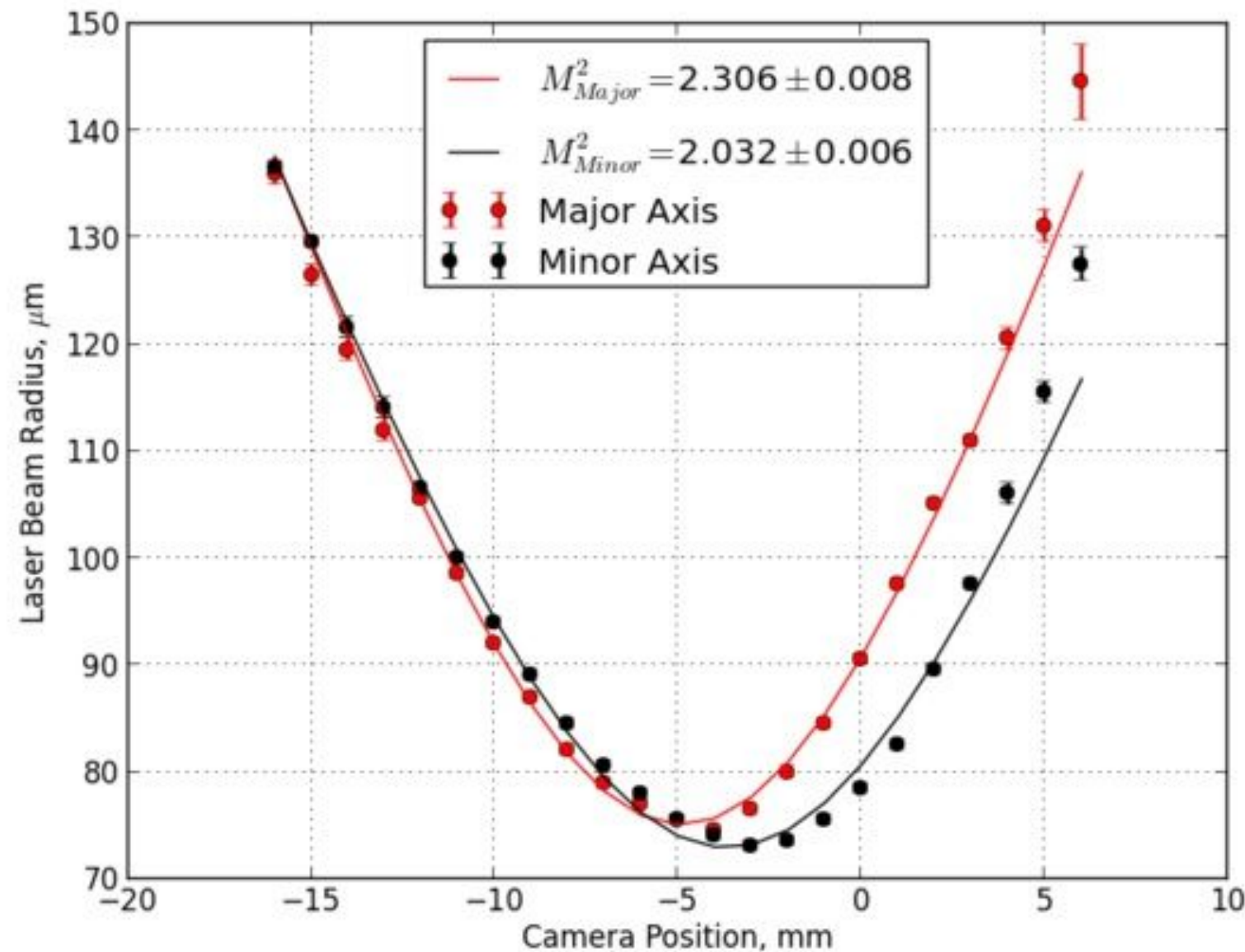
Solution

- Completely isolated the laser-amplifier input by using a function generator to control the duty cycle, synchronized from the master Linac4 trigger.
- Laser current was also reduced to 20A on subsequent trip.

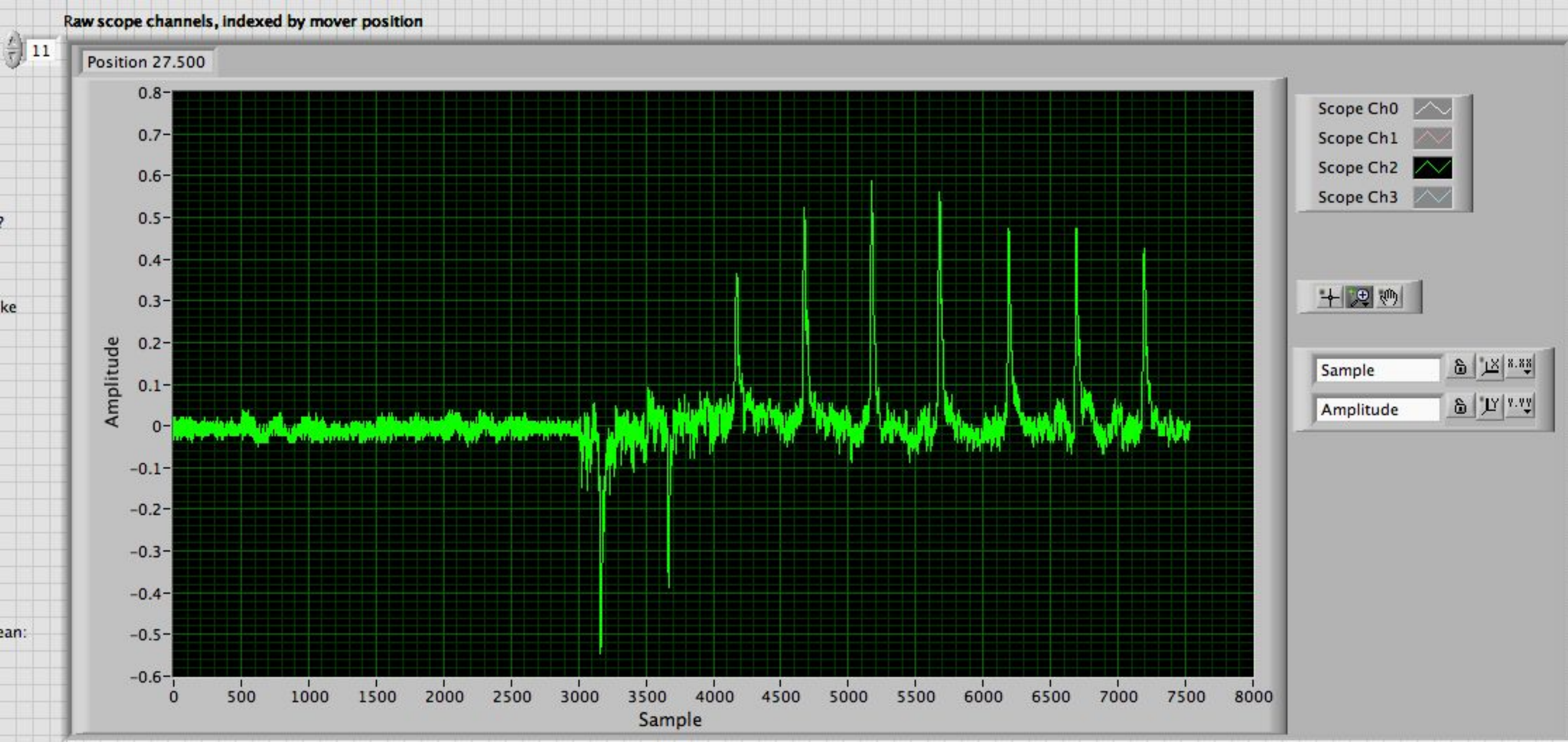


- Average Power @ 20A pumping with 100% Duty Cycle is around 6W.
- This corresponds to a peak power @ 30kHz, 100 ns of about 2kW.
- This 2kW need to be rescaled due to the peak power reduction dependent on the duty cycle (circa 66% at 0.05% duty cycle in or measurement).
- So input peak power before the fibre is about 1.3 kW.
- Assuming 70% coupling efficiency and some losses from the fibre output to the IP, Alessio estimates that 50% of that power gets to the IP, making it about 650W.





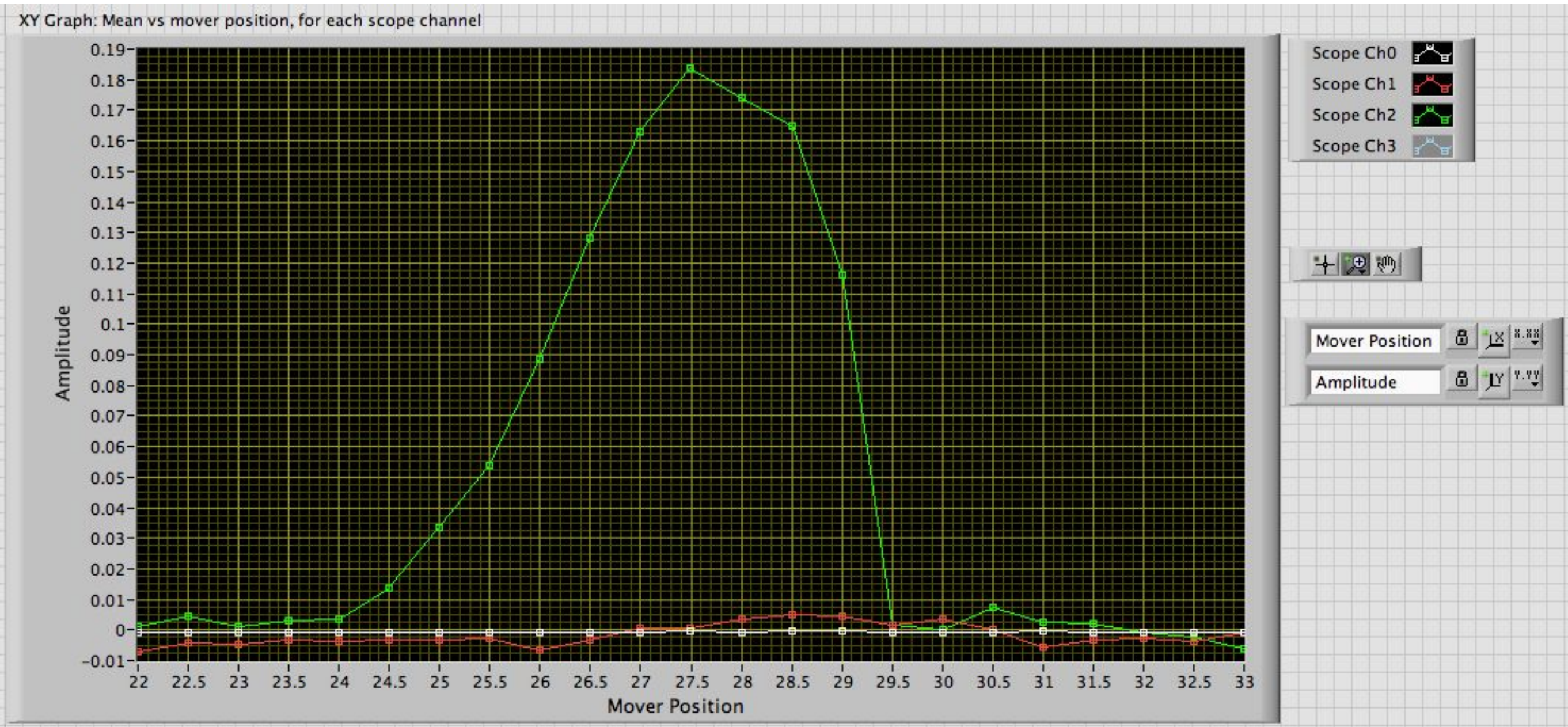
- February trip: First perform M^2 measurements in situ with camera.
- Slight astigmatic laser beam that seem at RHUL (Could be recent fibre alignment). However, laser Gaussian beam waist is small.



- On return of the beam, the diamond detector signal was refound and reasonable signal seen, even at reduced laser power.

First profile at reduced power

- Then made first profile scan of laserwire: profile from quasi-online analysis.
- Green plot shows the amplified detector channel.

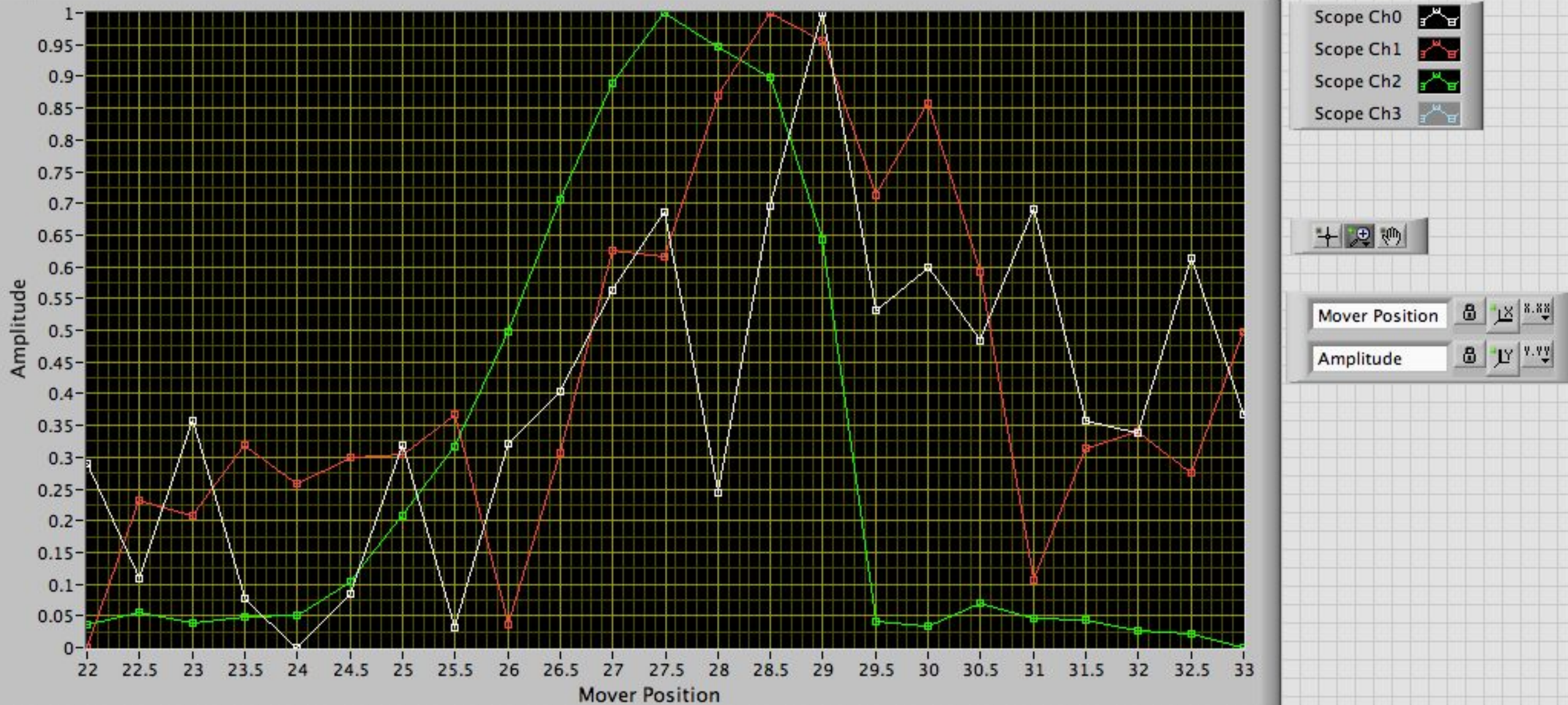


First profile at reduced power

■ Normalise profile of other channels:

- ch0 = DiamondStrip1 non-amplified;
- ch1 = DiamondStrip2 linear amplifier;
- ch2 = DiamondStrip3, charge sensitive amplifier.

XY Graph: Mean vs mover position, for each scope channel



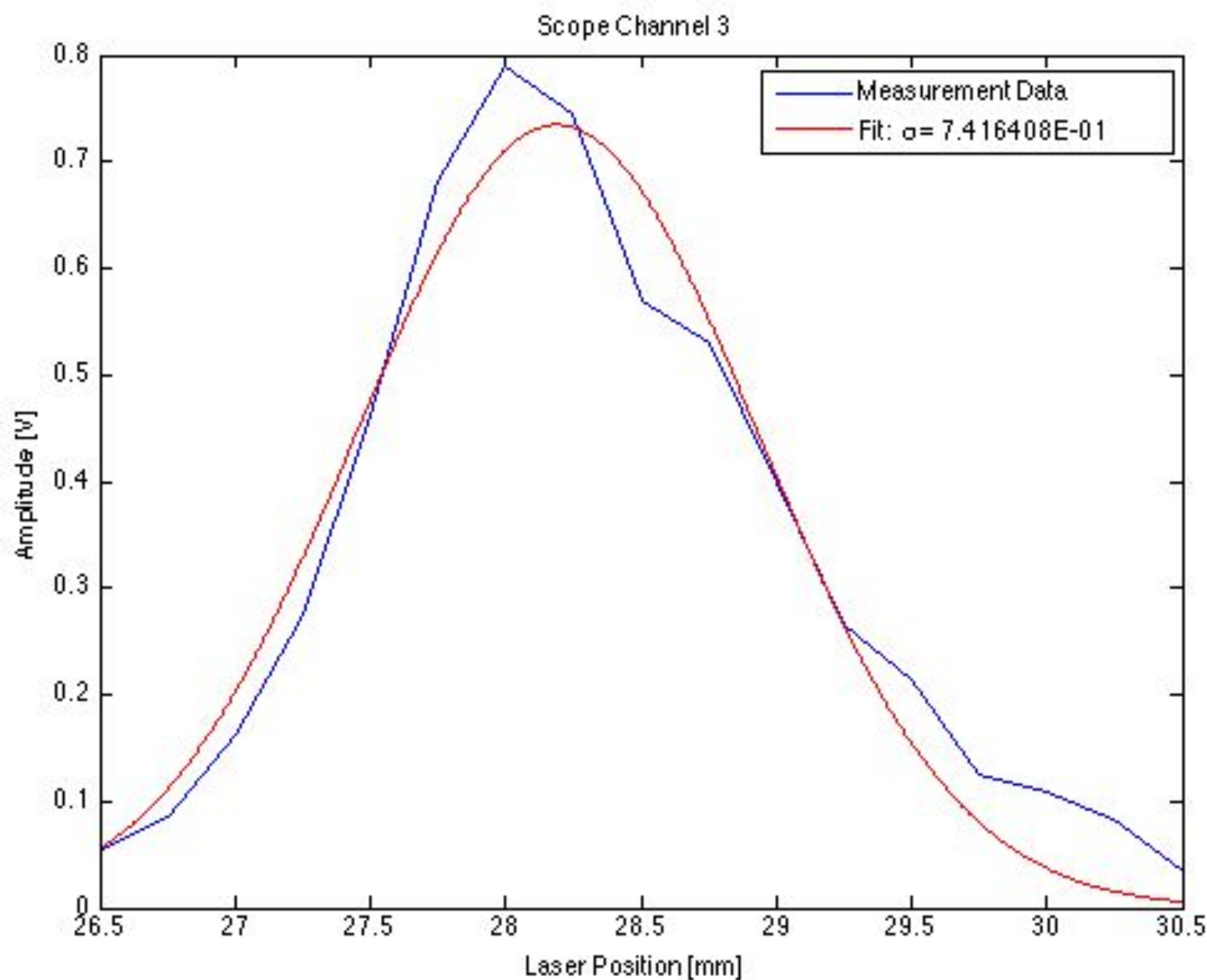
Matlab analysis by Thomas Hofmann

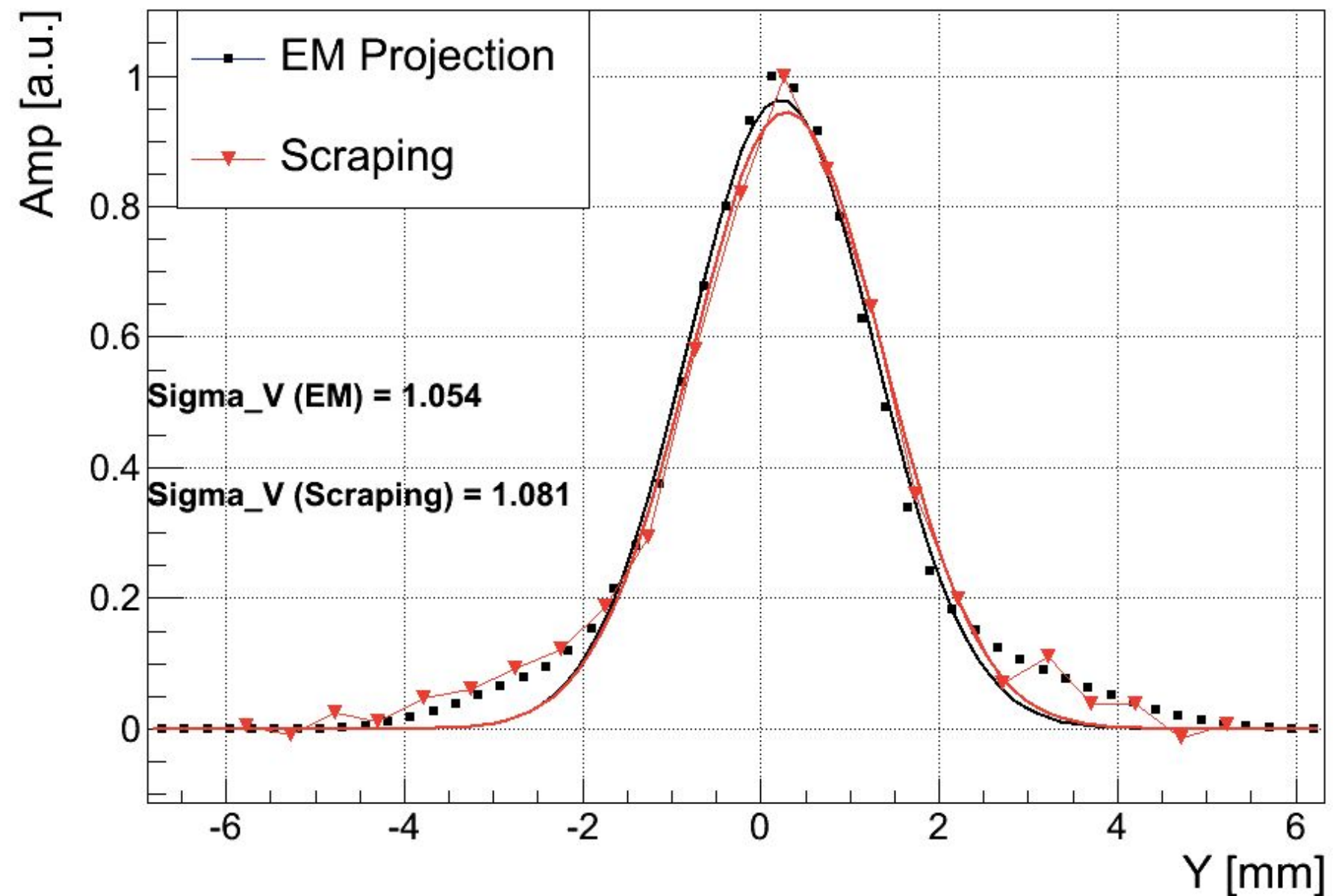
Diamond:
Bias: +600V
Pos: 0 mm
Channel: 5 with charge amp.

Laser:
Amp. Current = 20 A
Long. Pos = 0 mm

File:
I40218 I65110.tdms (on afs)

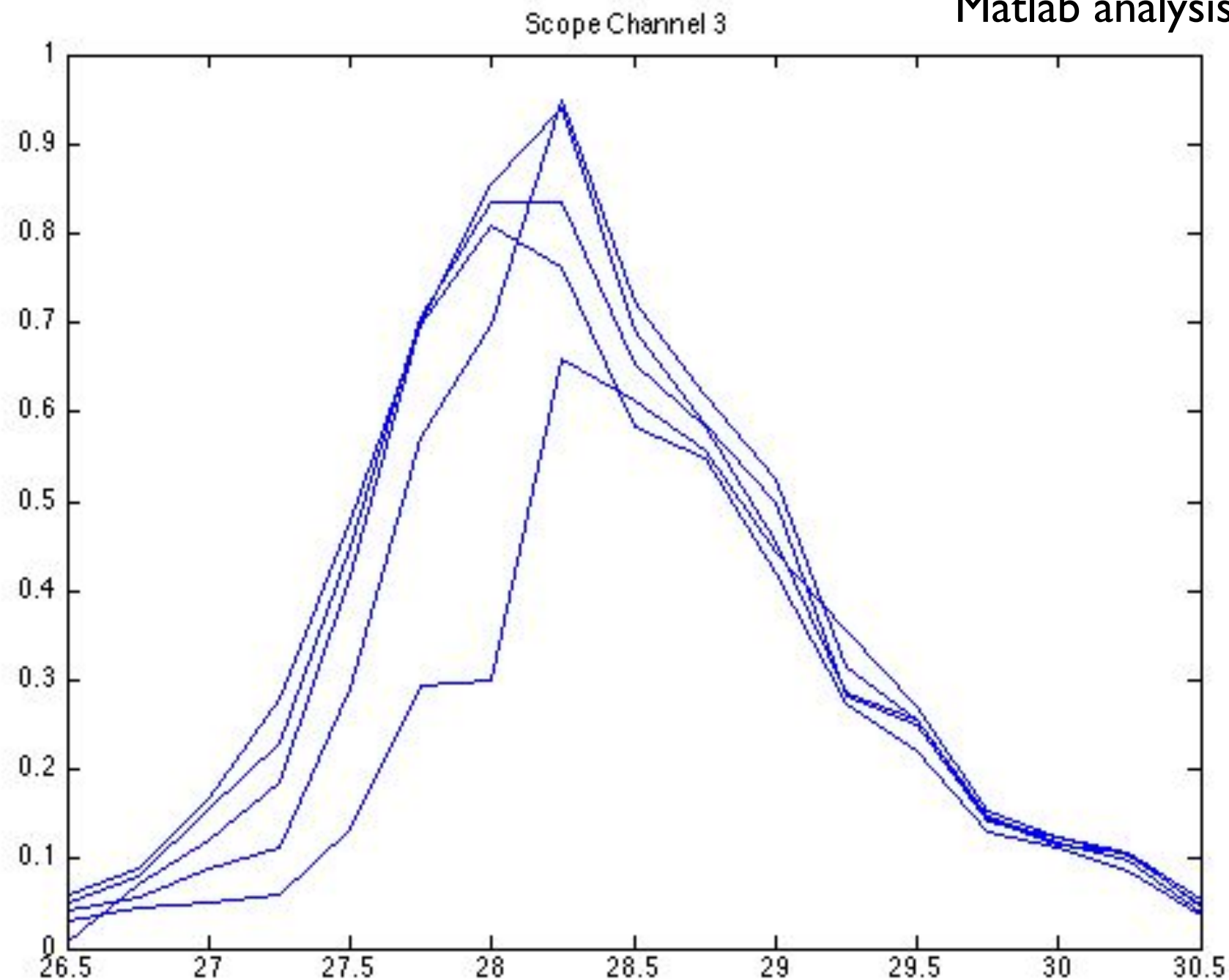
Analysis:
Scope channel 3
Average over one laser pulse (between 9.6 & 9.8 us, if I remember right)



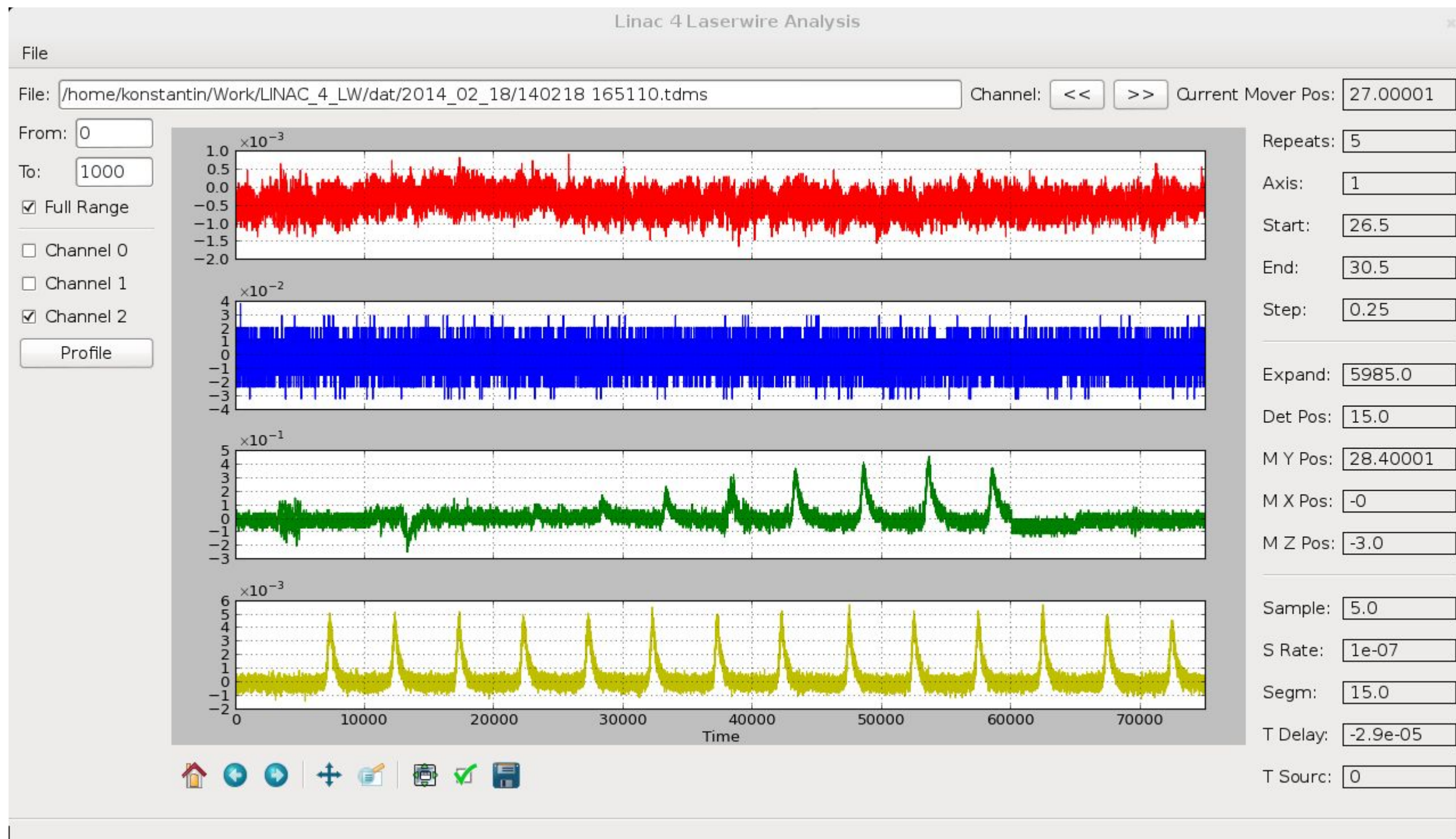


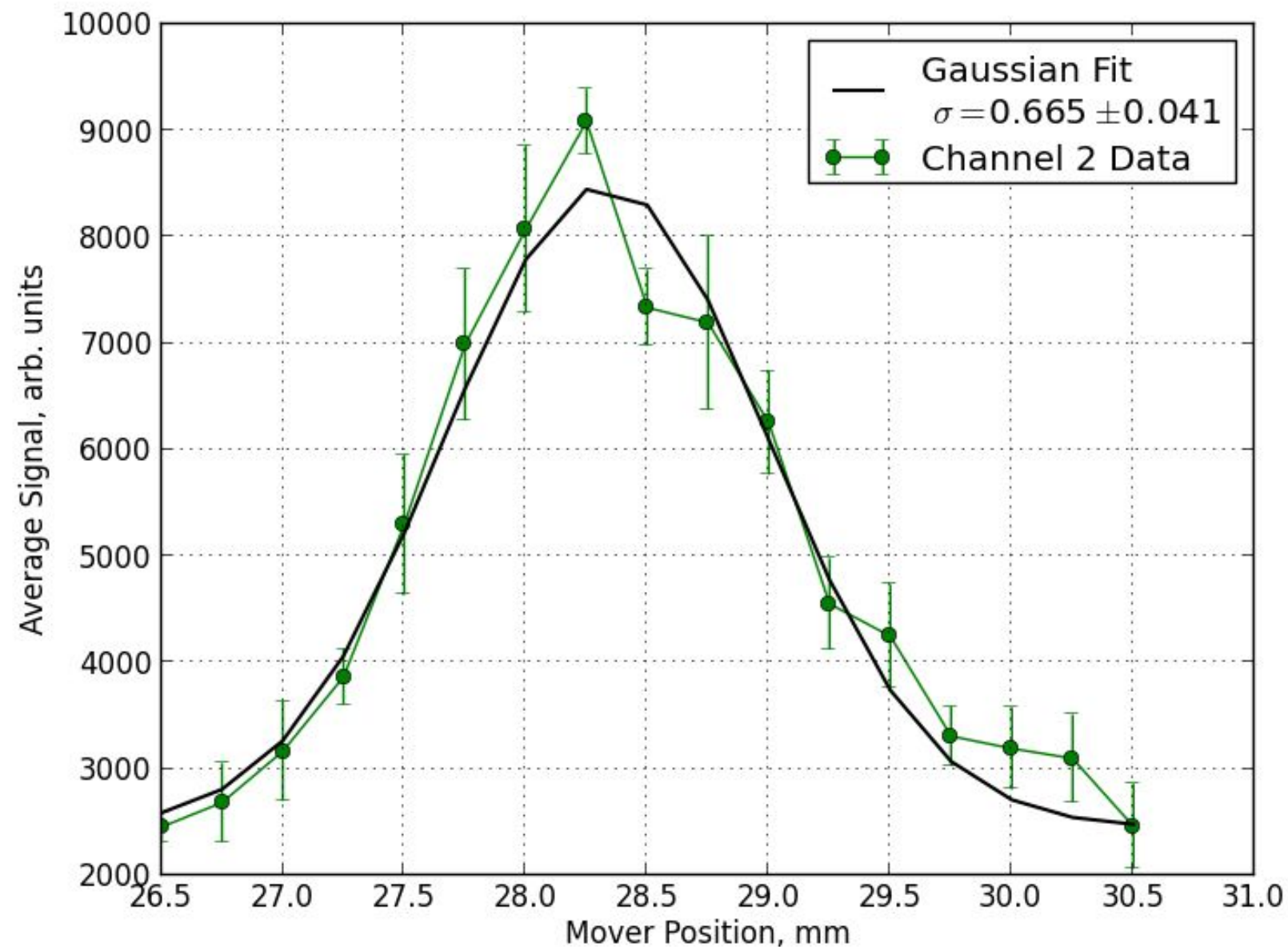
- Beam profile from traditional measurements:
 - Laser profile sigma right order of magnitude.

Matlab analysis by Thomas Hofmann



- First look at profiles per laser pulse (larger errors)



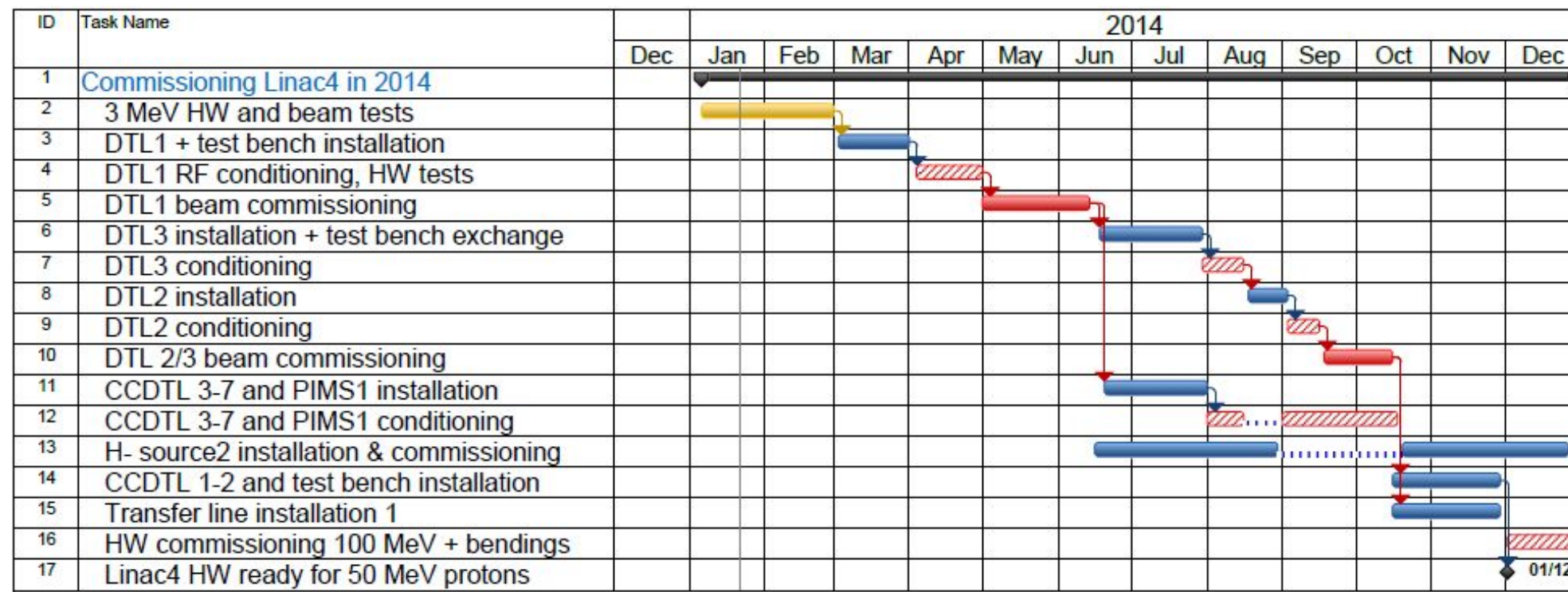


- Averaged over all laser pulses and for five particle beam per laserwire position
- Error bars show standard deviation.

- Next trip to CERN being planned currently, either next week or early March, dependent on how long 3 MeV beam is available.
- Aim to take data for:
 - 2 dimensional scan in X and Y
 - 2 dimensional scan in laserwire Y and diamond Y
 - Laser power scan
 - Beam current scan
 - Effect of modifying quad settings.
- Longer term: spectrometer will be moved downstream of DTL for 12 MeV beam commissioning in May / June 2014. Possibility for laserwire at 12 MeV. CERN would buy longer fibre to reach from current laser position.



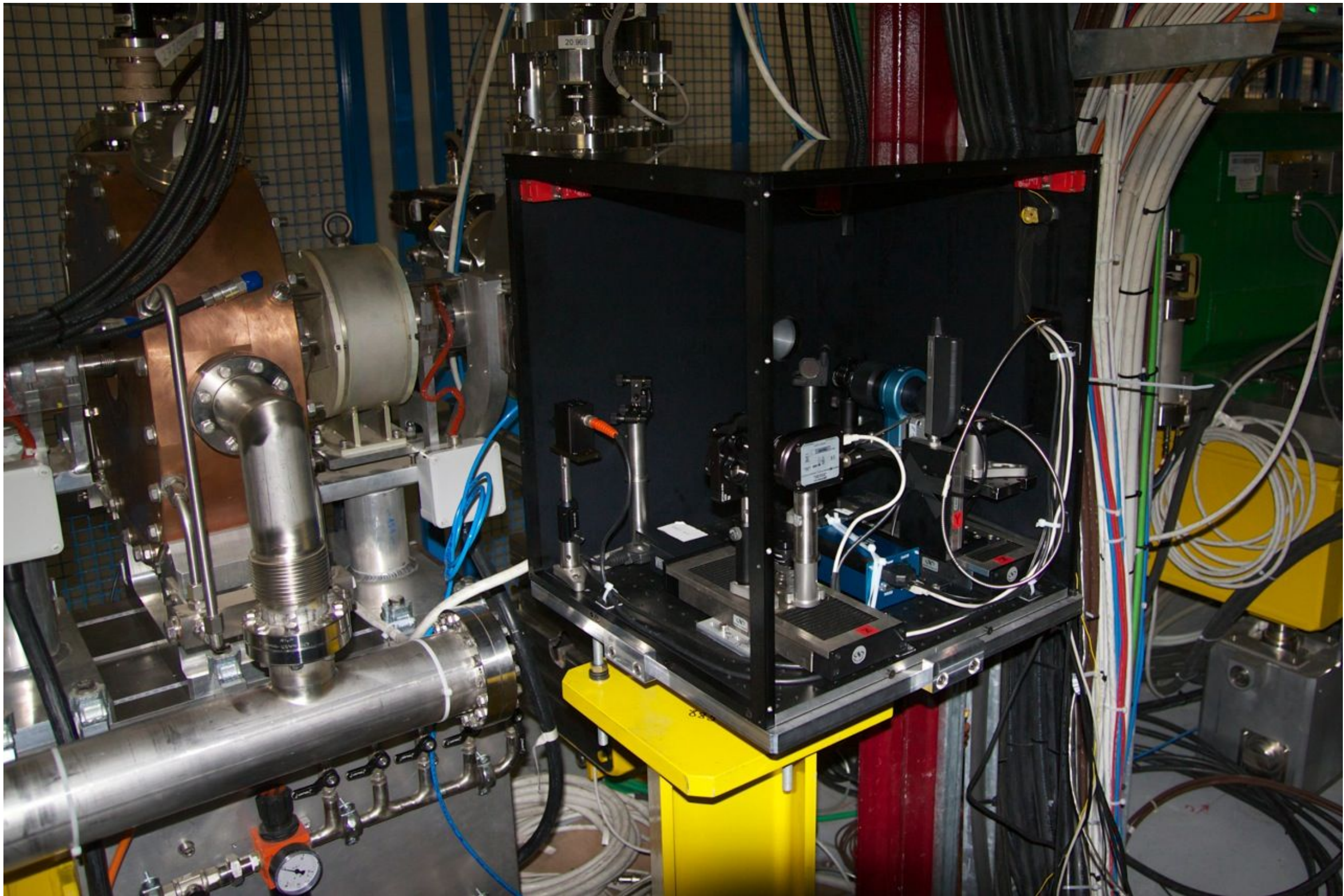
2014 in detail

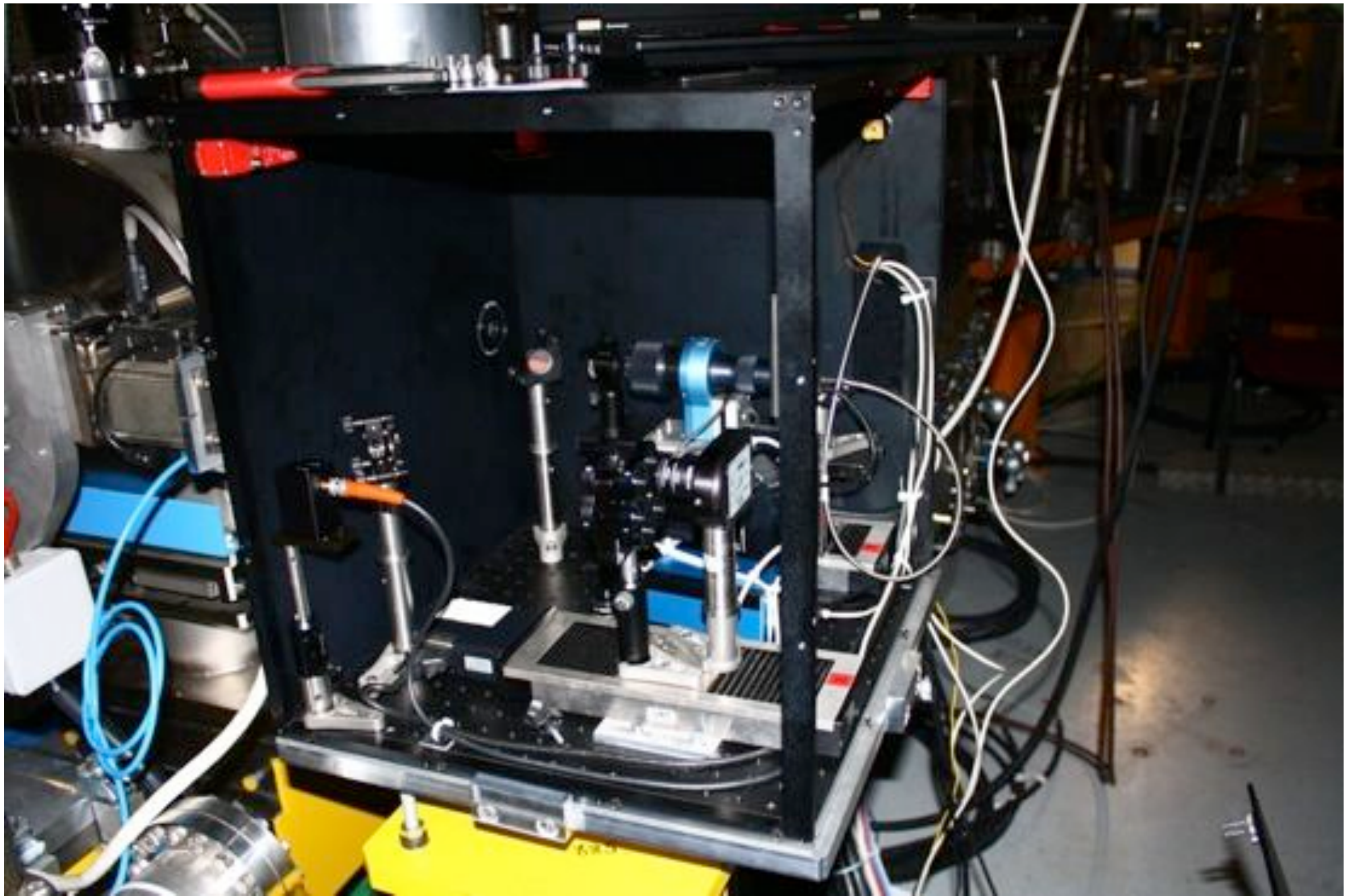


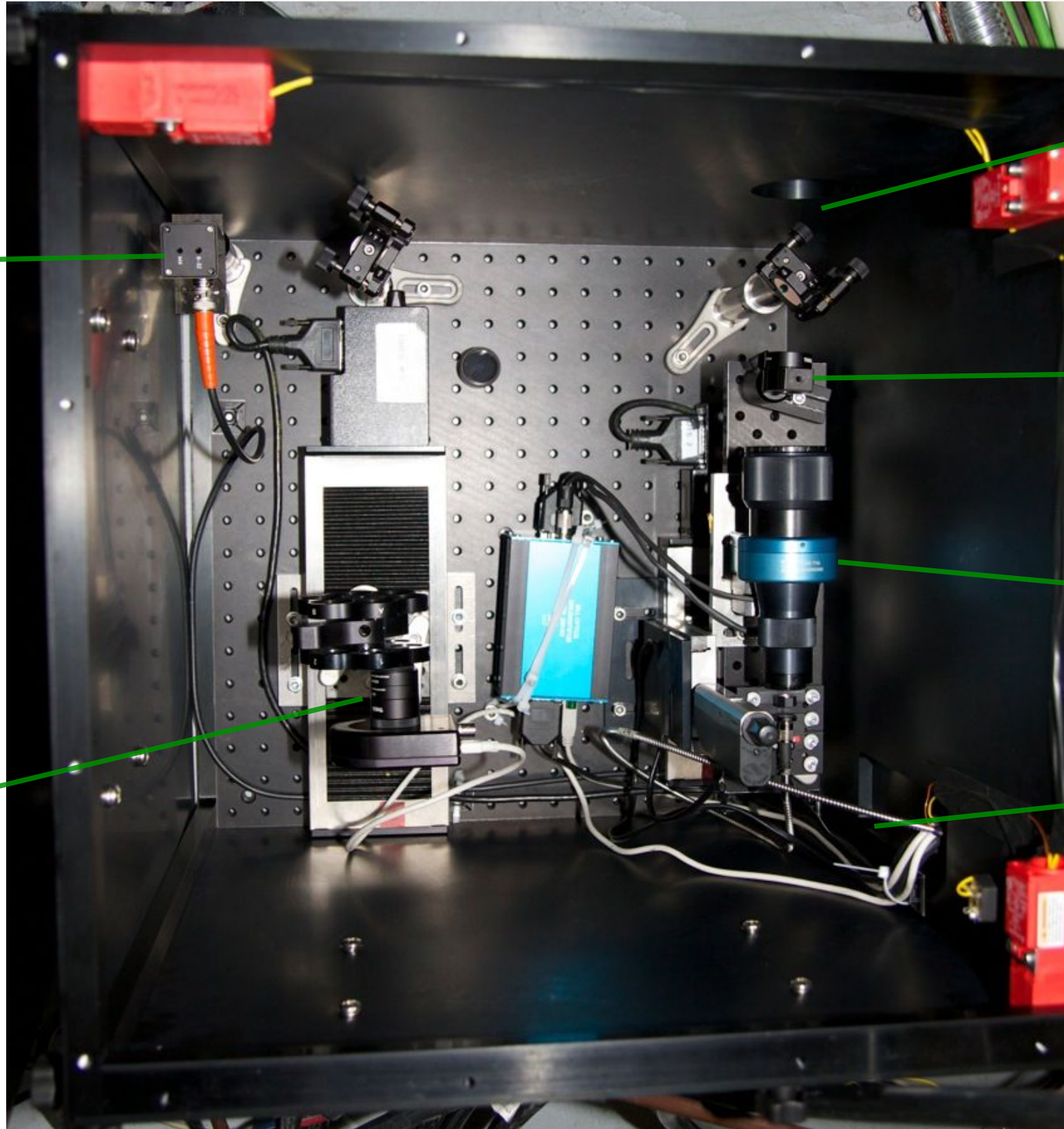
Schedule different from what discussed on Monday – to be now detailed by Julie

Next step: Drift Tube Linac commissioning (see presentation by S. Ramberger) – DTL1, DTL2, DTL3

February. 3 MeV measurements – **March:** moving diagnostics line, installing **DTL1** at end March – **April:** RF conditioning of DTL1 (tunnel closed, access possible during day) – **May:** Beam tests DTL1 (beam permit for May 1st!) – from **June 15th:** moving and rearranging diagnostics line, installation CCDTL and PIMS1, **DTL3** installation at end July – **August:** 1st half RF conditioning DTL3 (tunnel closed, access possible during day), 2nd half installation **DTL2** – **September:** conditioning DTL3 (2 weeks), beam measurements – **October:** beam measurements until 15.10 – **From October 15th:** installations (CCDTL last 2 modules, 100 MeV diagnostics line, transfer line) – **December:** Start HW tests 105 MeV. Windows for ion source (IS02 installation): 15.6 – 30.8 (2.5 months), 15.10 – 31.12 (2.5 months).







Fast
photodiode

Port to
accelerator
vacuum chamber

Focussing lens

Beam expander on
motion stages,
X and Y

Filter wheel and
camera on Z
translation stage

Fibre input /
services

