FETS Laserwire Emittance Scanner – First results from CERN Linac4

on behalf of
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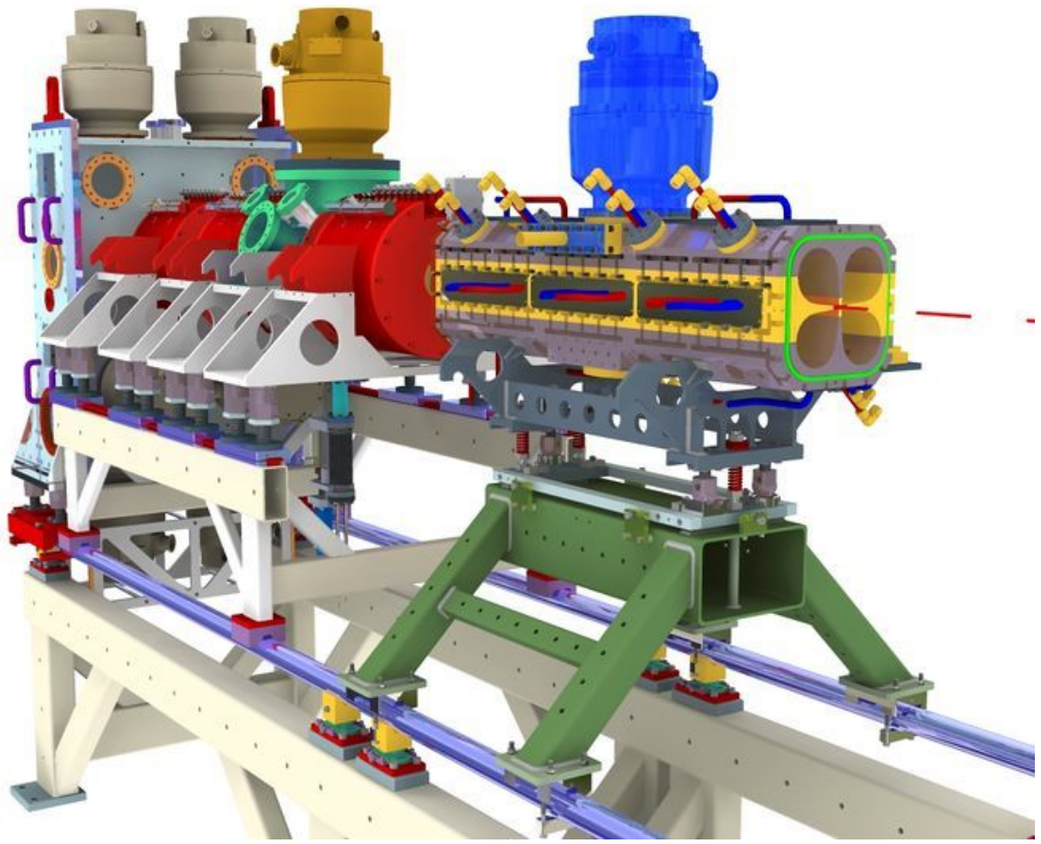
FETS Meeting, RAL
19/02/2014

Outline

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

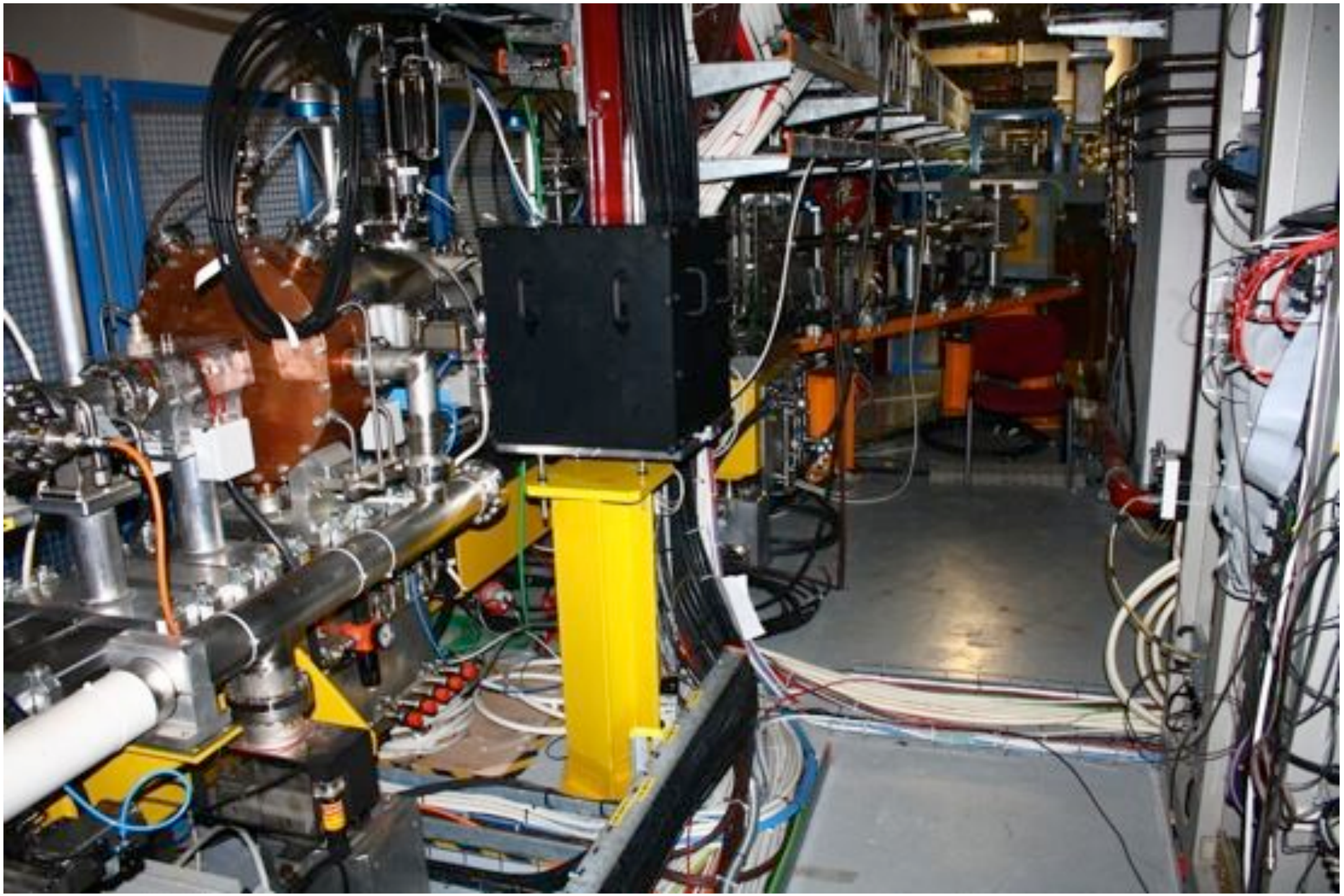


Summary of progress

Main activities in past months:

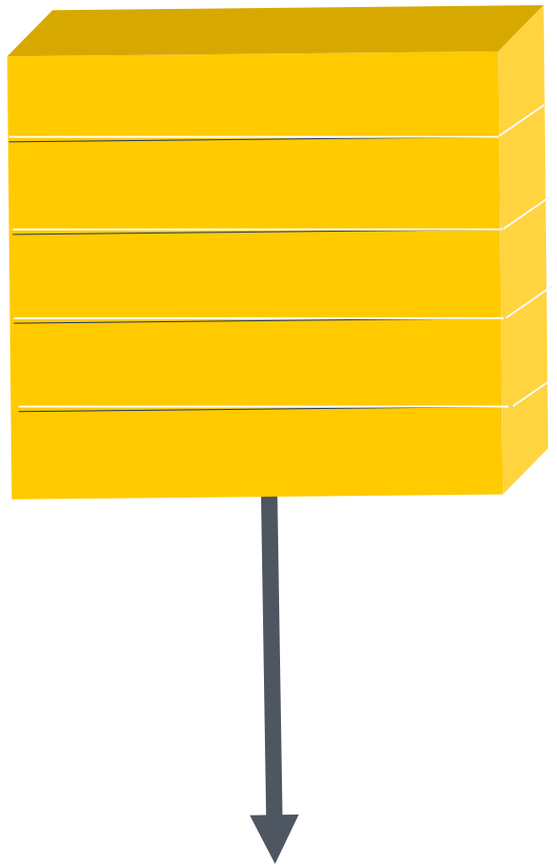
- November 2013: Installation of laserwire at CERN Linac 4, check of system.
- December 2013: trip had to be cancelled due to Linac4 vacuum leak.
- January 2014: Vacuum repaired. First trip for data taking, 20-22 January:
  - Some initial fibre issues - soon resolved:
  - Recorded ***first signal*** 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.

Lasewire enclosure in Linac4

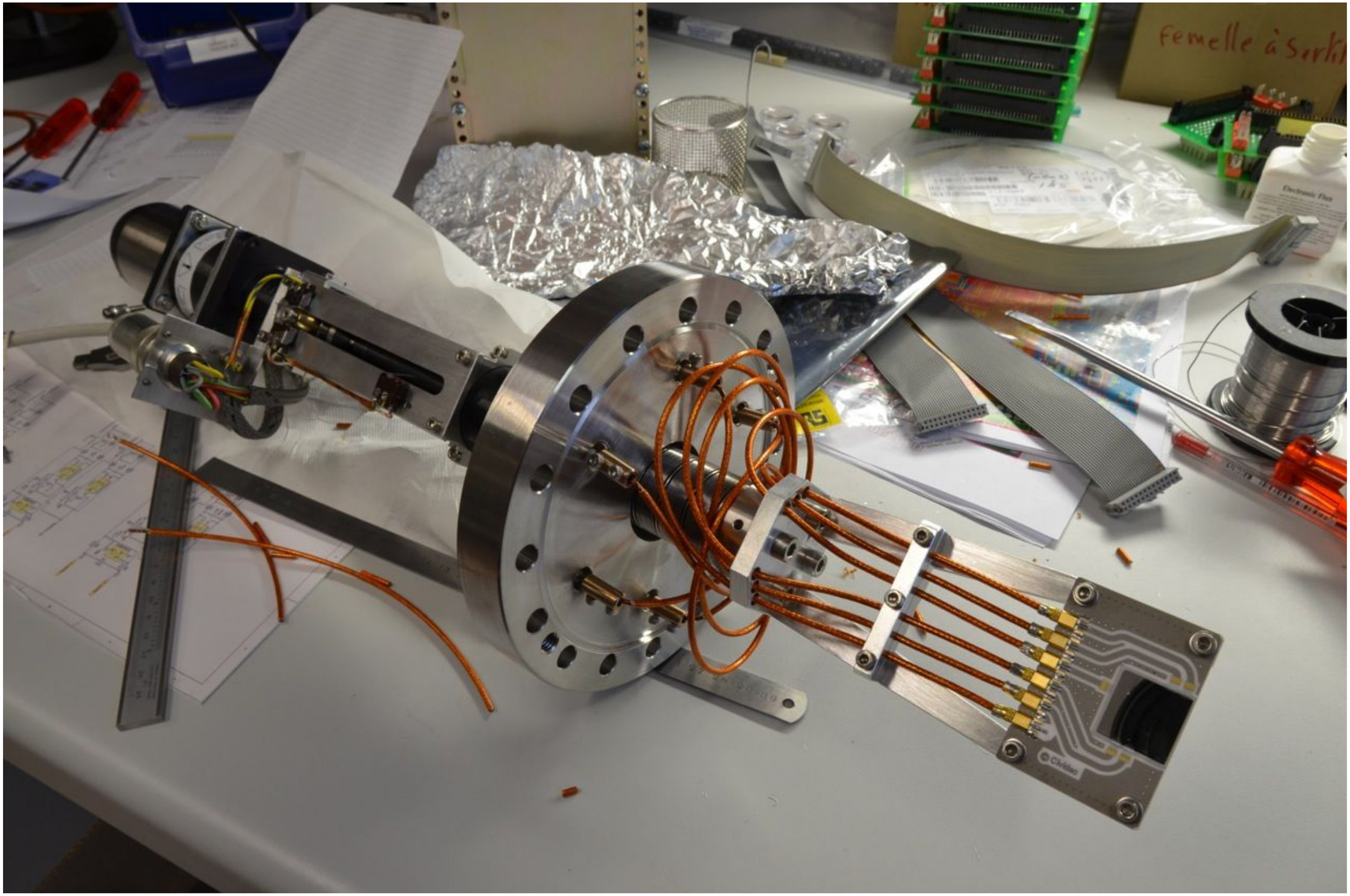


Diamond detector

- Main H^- beam deflected by spectrometer magnet.
- Neutral H^0 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.



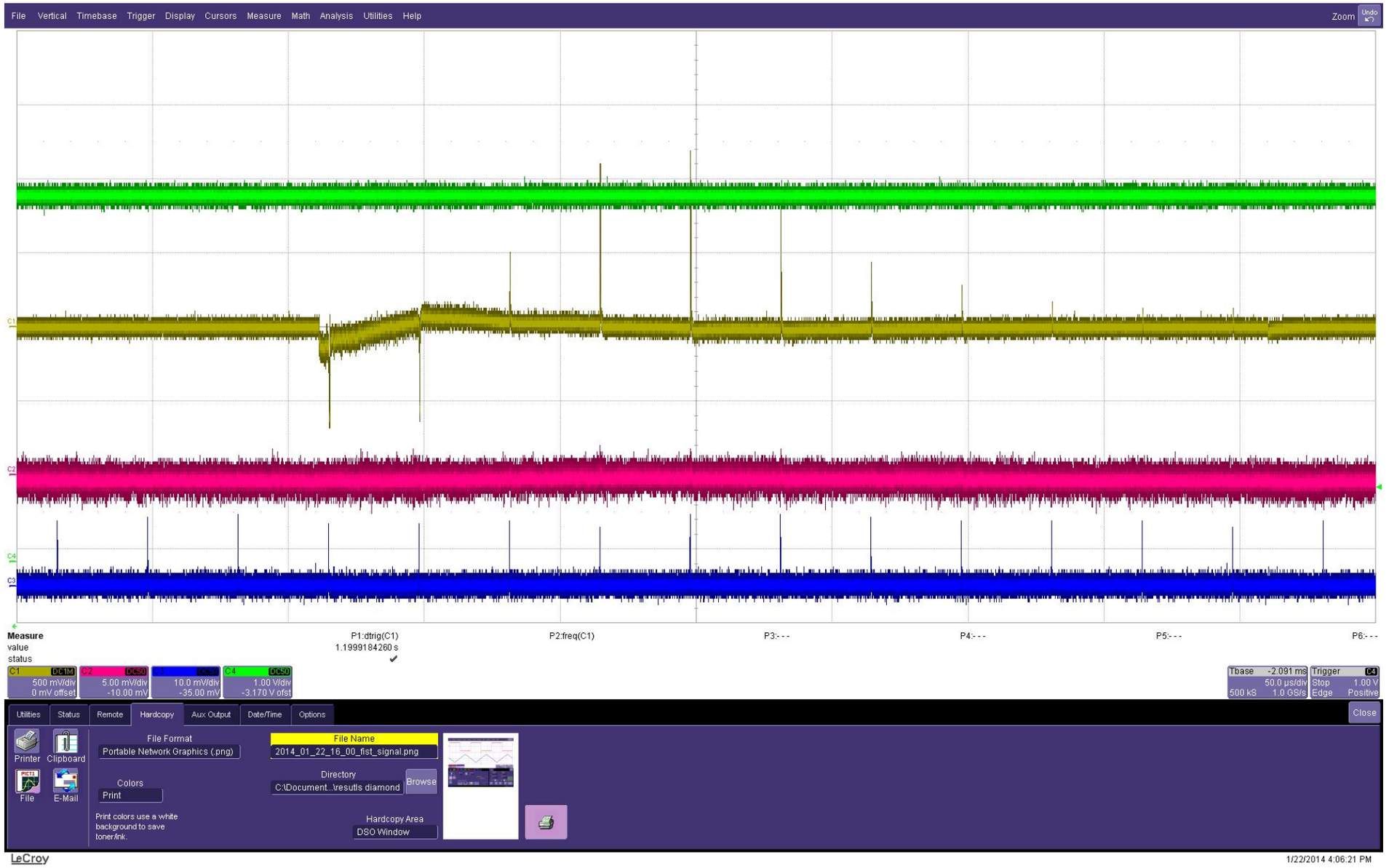
Diamond detector



First signal – 22 January 2014

Amplified diamond channel

Laser PD



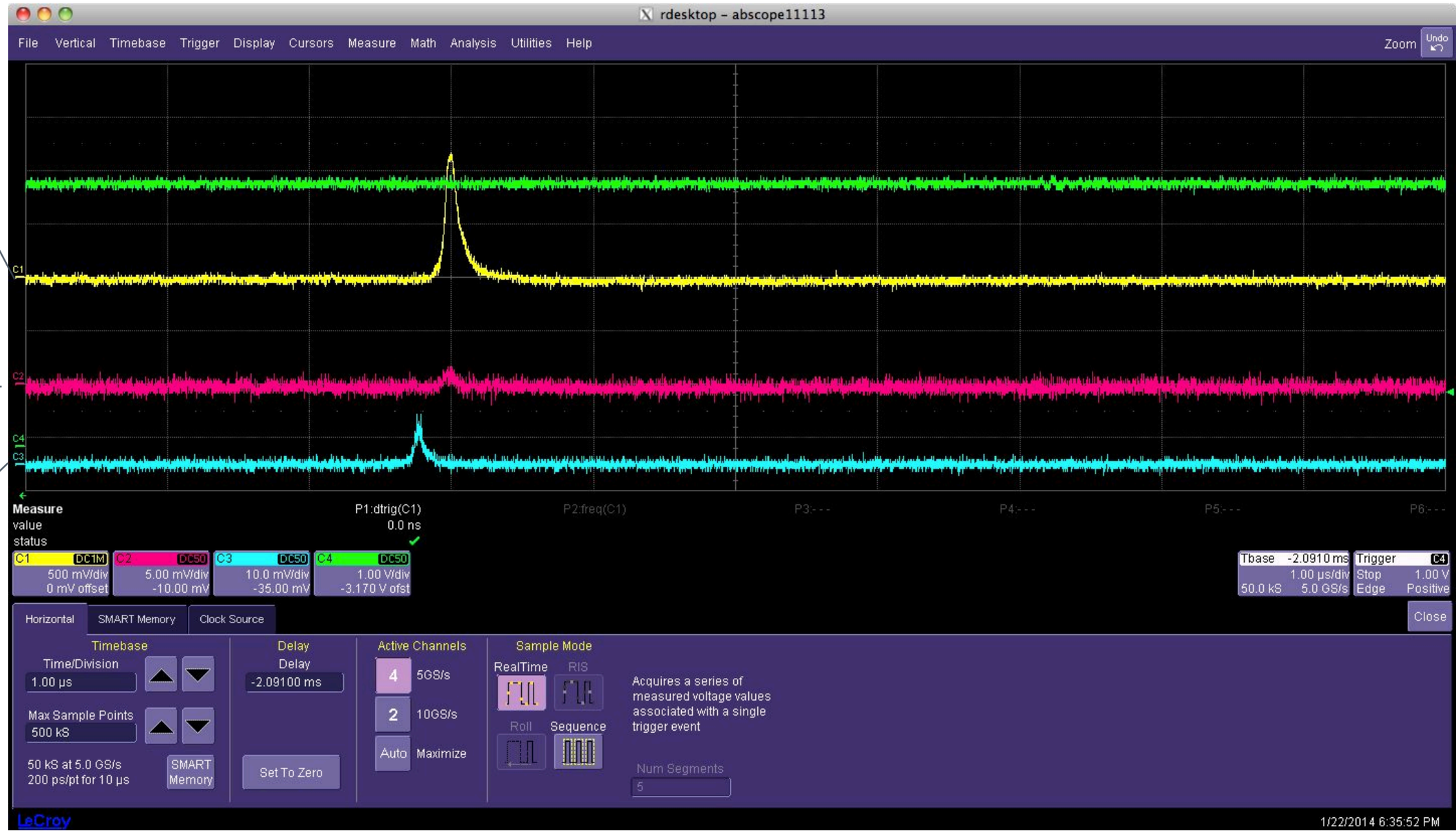
- Synchronous peaks in diamond detector with laser pulses.
  - Residual gas background in diamond detector
  - Negative / saturation effects observed – prompted addition of linear amplifier.

First signal – zoom in peak

Amplified diamond channel

Unamplified diamond channel

Laser PD

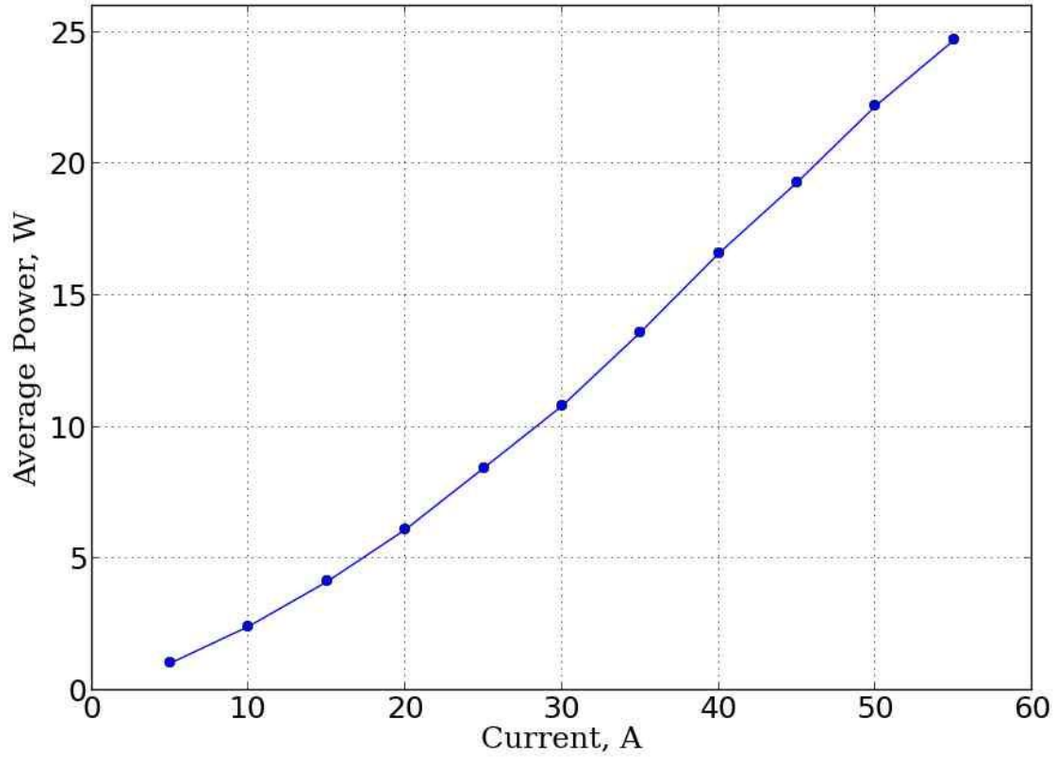


Laser power reduction

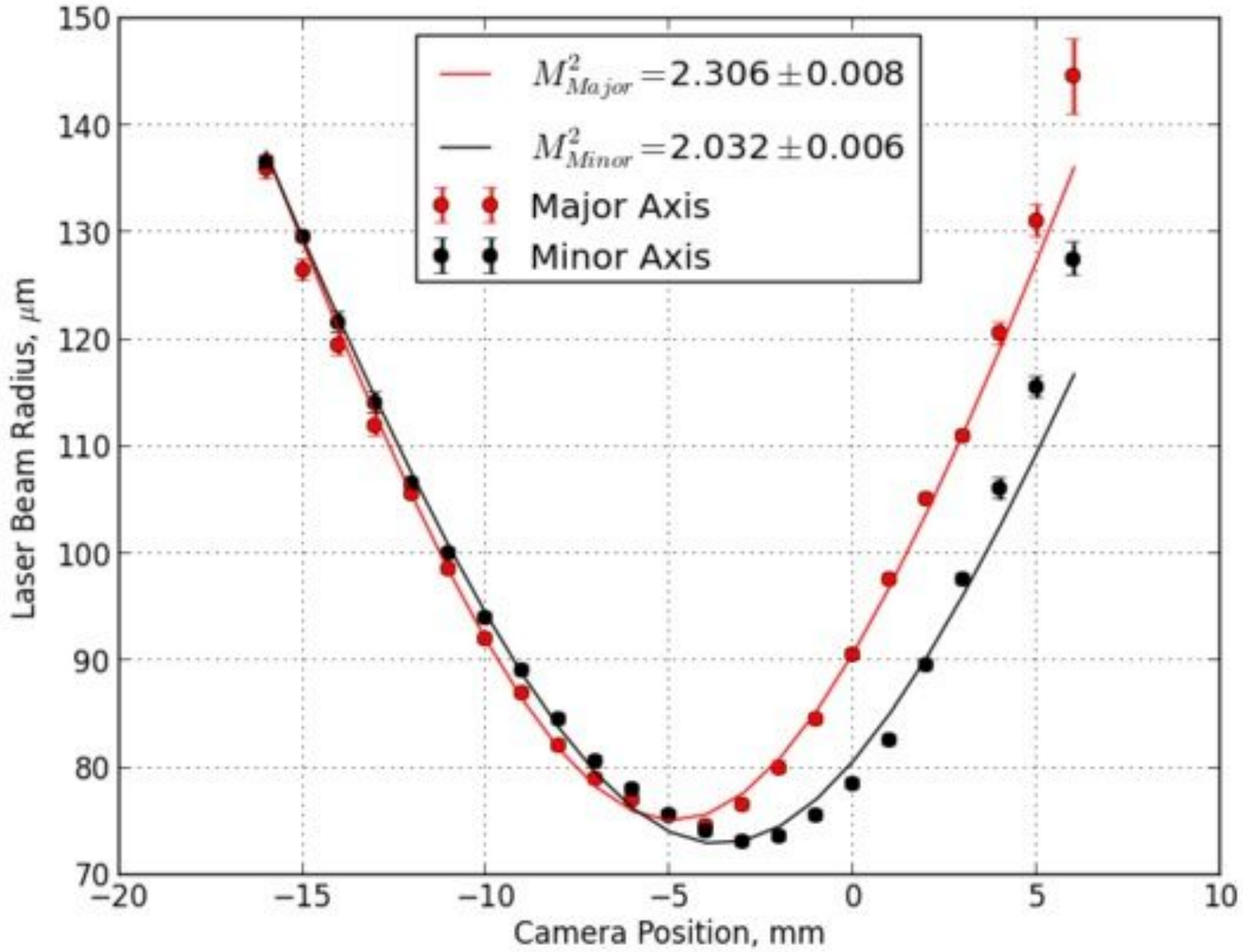
- On the January trip, laser current was set to 30A and was designed to operated with a low duty cycle (<<1%).
- However, the system suffered a control malfunction: in the event of a power glitch or software crash the laser amplifier input floated to a logic high. This lead to 100 duty cycle and therefore 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.

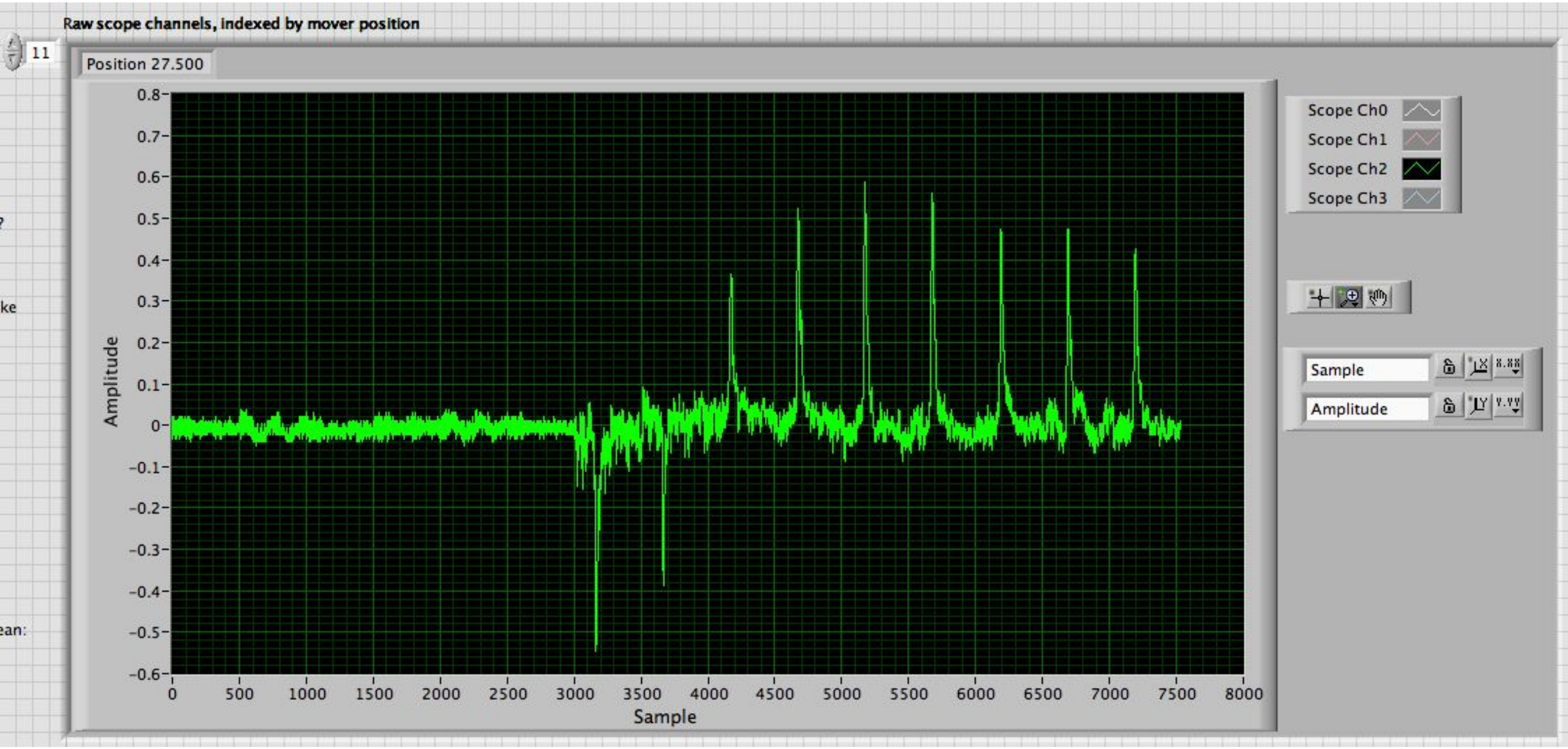


Beam quality measurement M^2



- February trip: First perform M2 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.

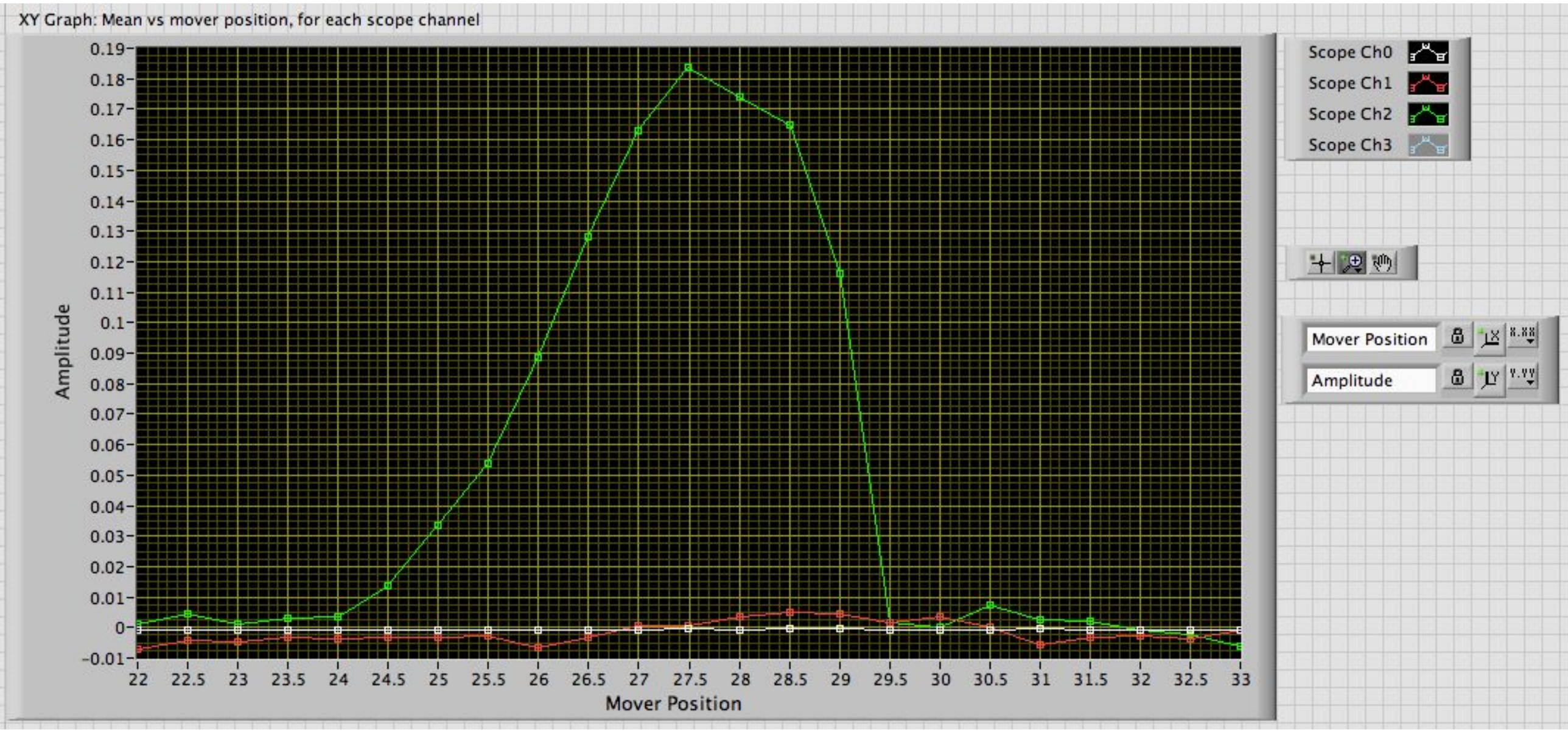
February: signal at reduced power



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

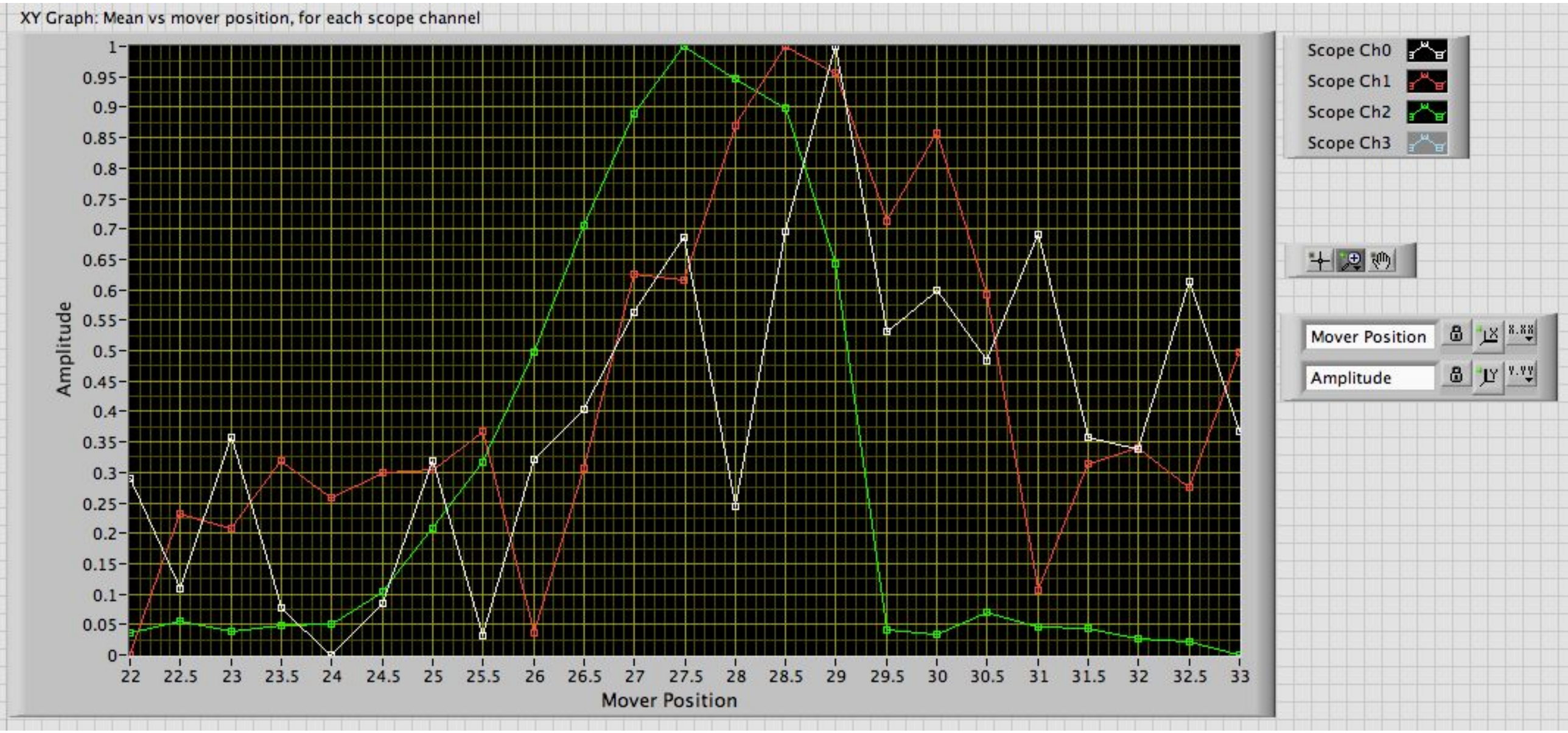
First profile at reduced power

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



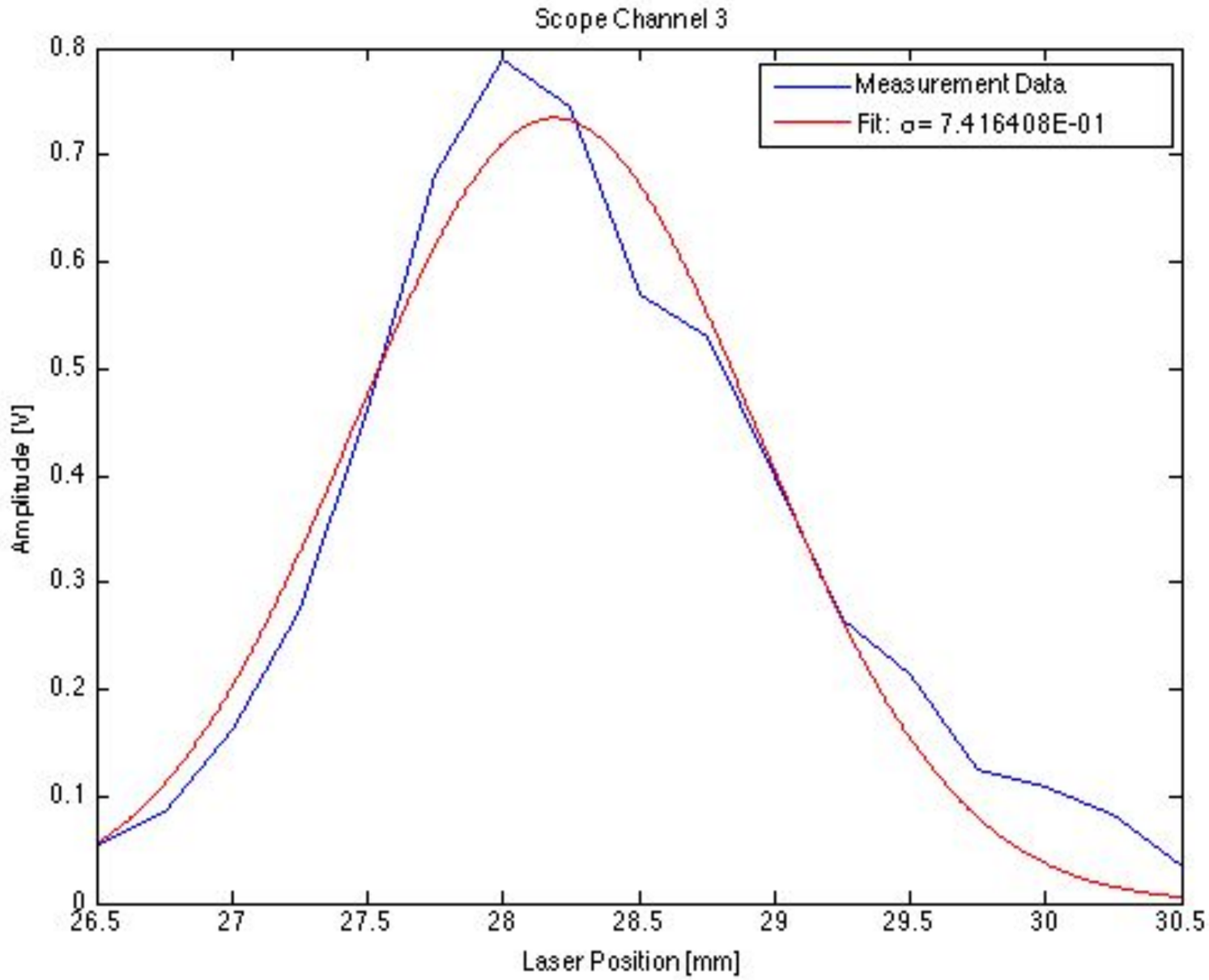
First profile at reduced power

- Normalise profile of other channels:
  - ch0 = DiamondStrip1 non-amplified;
  - ch1 = DiamondStrip2 linear amplifier;
  - ch2 = DiamondStrip3, charge sensitive amplifier.



Latest profile measurement

Matlab analysis by Thomas Hofmann



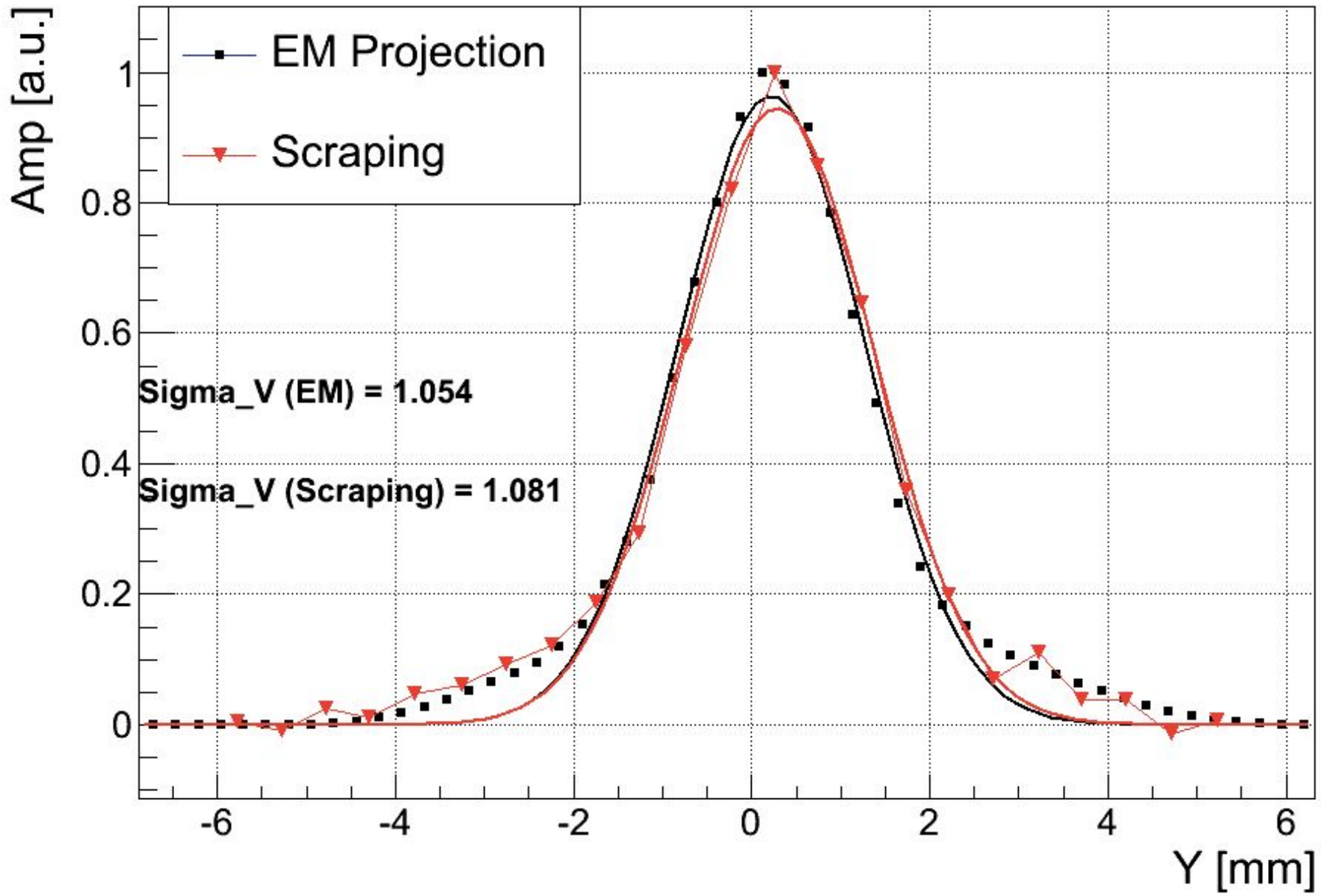
Diamond:
Bias: +600V
Pos: 0 mm
Channel: 5 with charge amp.

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

File:
140218 165110.tdms (on afs)

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

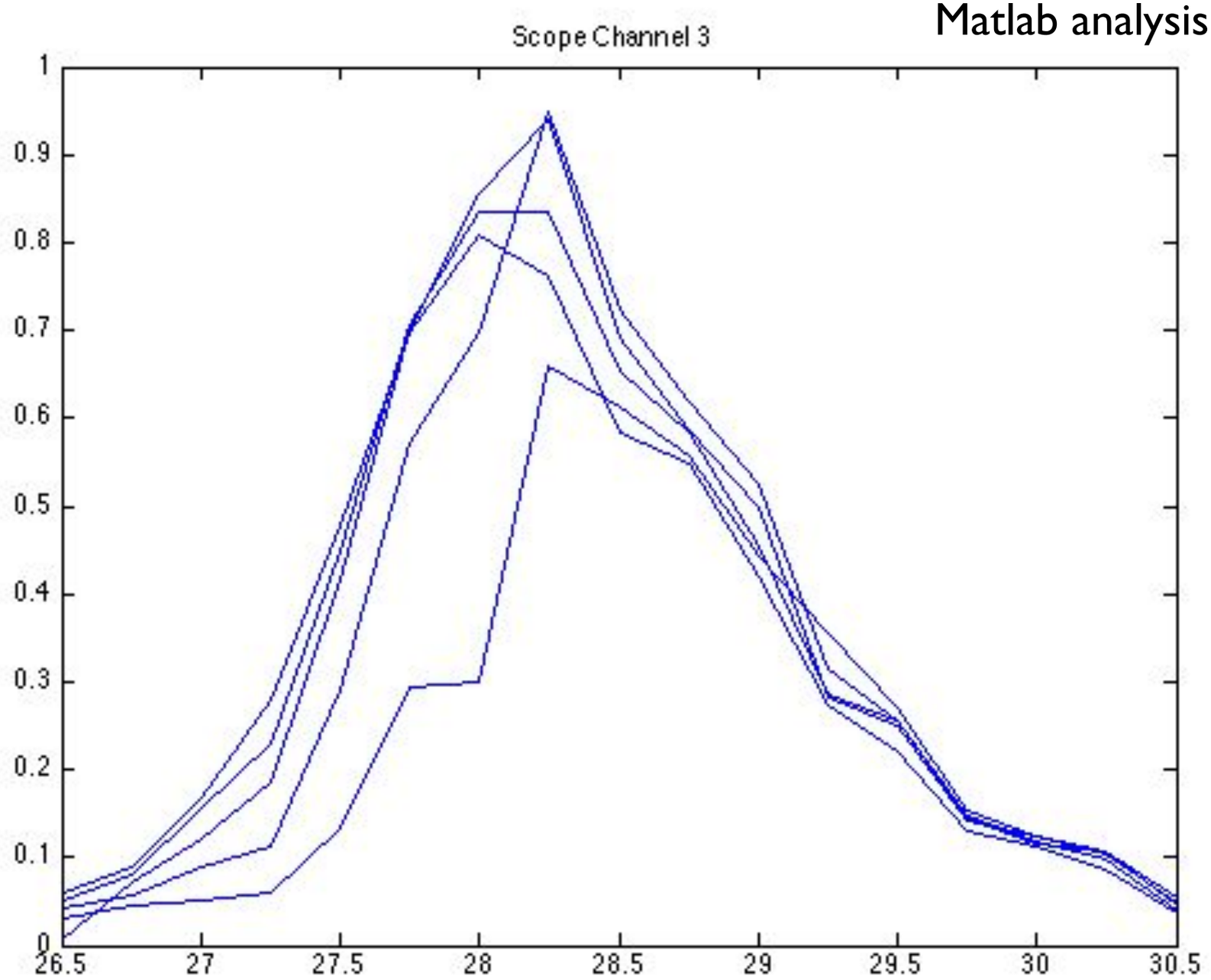
Latest profile measurement



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

Latest profile measurement

Matlab analysis by Thomas Hofmann



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

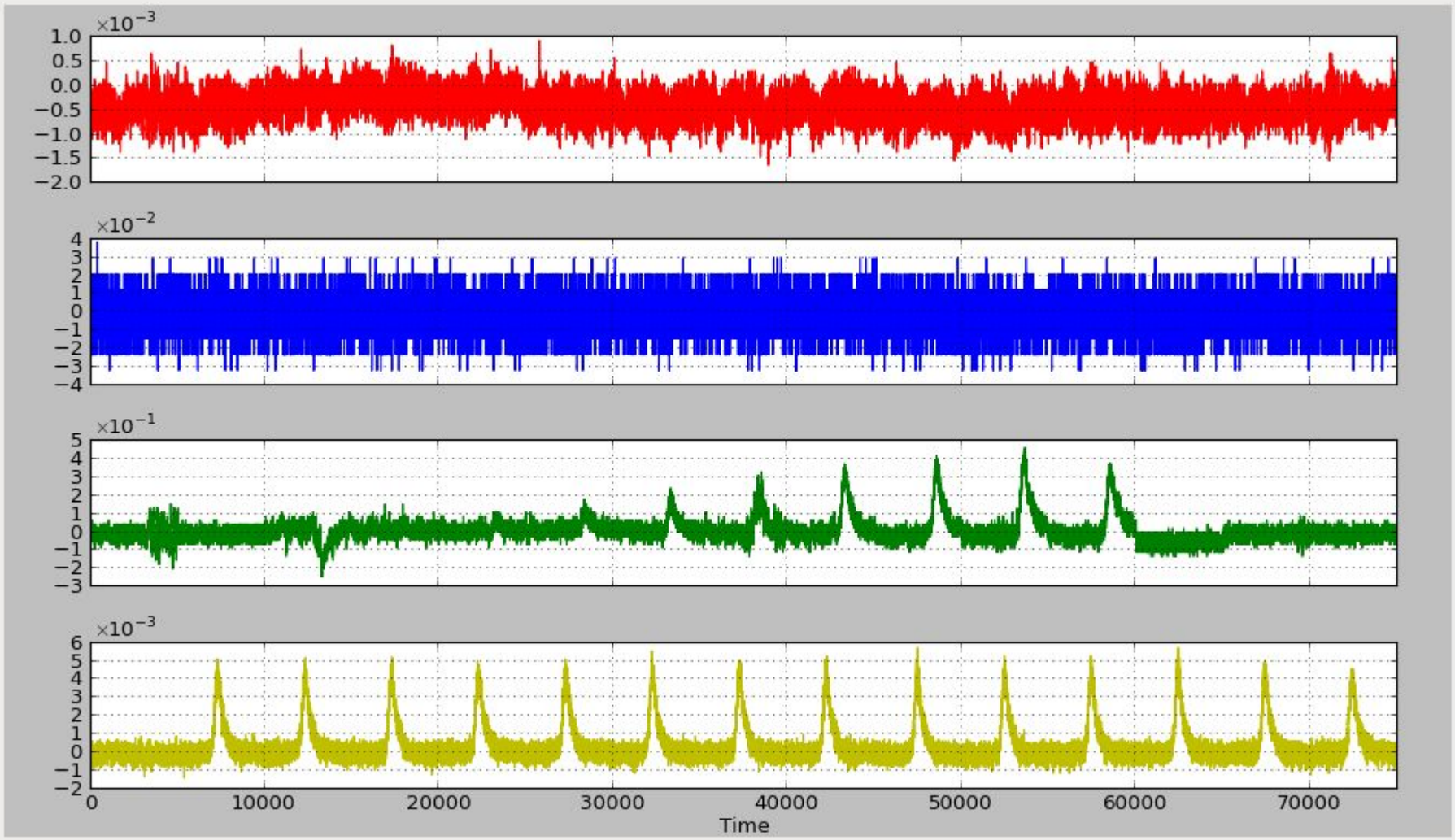
Python analysis by K. Kruchinin

Linac 4 Laserwire Analysis

File

File: /home/konstantin/Work/LINAC_4_LW/dat/2014_02_18/140218 165110.tdms Channel: << >> Current Mover Pos: 27.00001

From: 0
To: 1000
☑ Full Range
☐ Channel 0
☐ Channel 1
☑ Channel 2
Profile

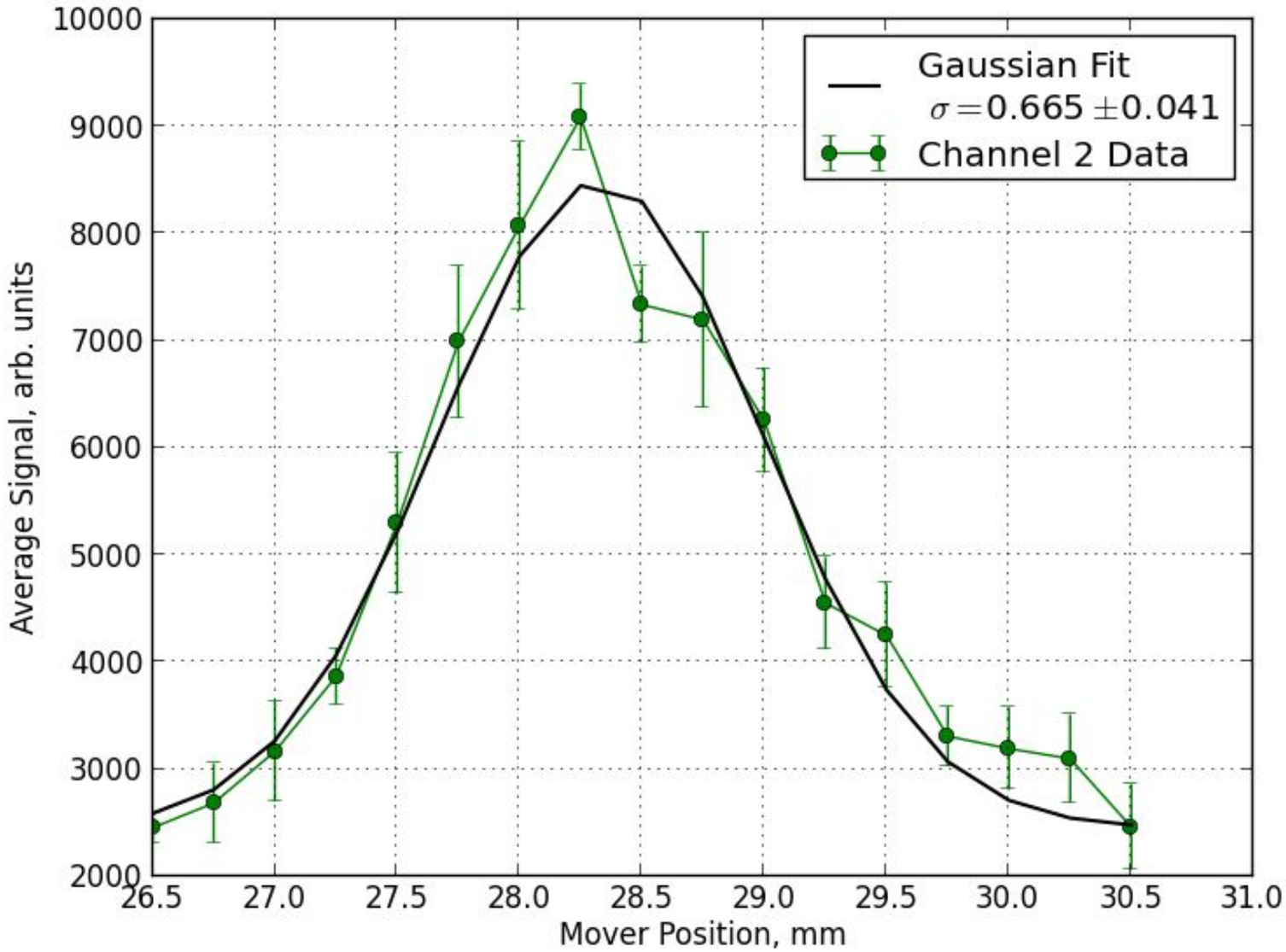


Repeats: 5
Axis: 1
Start: 26.5
End: 30.5
Step: 0.25

Expand: 5985.0
Det Pos: 15.0
M Y Pos: 28.40001
M X Pos: -0
M Z Pos: -3.0

Sample: 5.0
S Rate: 1e-07
Segm: 15.0
T Delay: -2.9e-05
T Sourc: 0

Python analysis by K. Kruchinin



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

Outlook / plans

- Next trip to CERN being planned currently, eithe rnext 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 laserwireY 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.

Future 12 MeV Laserwire?

2014 in detail

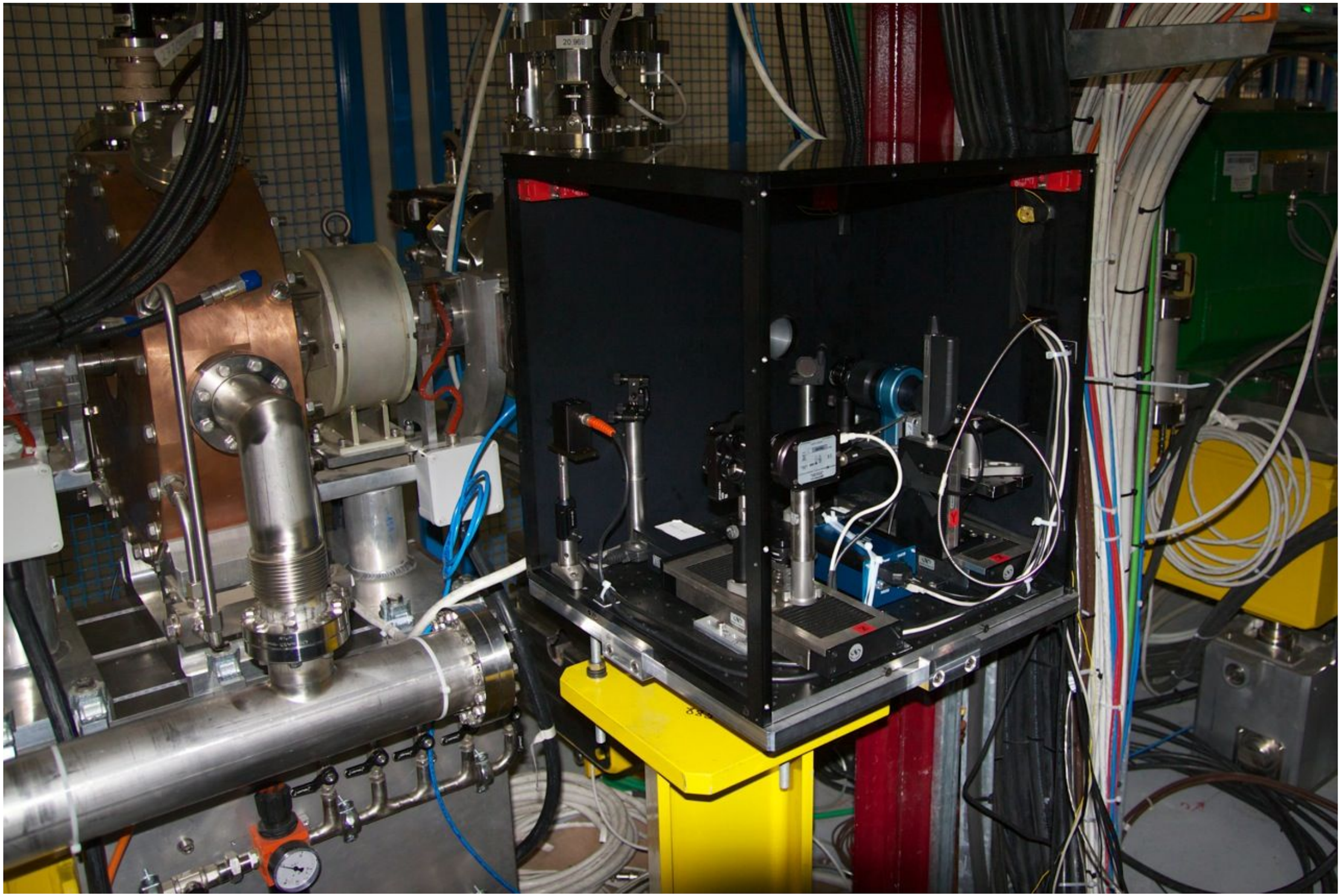
ID	Task Name	Dec	2014 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	Commissioning Linac4 in 2014													
2	3 MeV HW and beam tests													
3	DTL1 + test bench installation													
4	DTL1 RF conditioning, HW tests													
5	DTL1 beam commissioning													
6	DTL3 installation + test bench exchange													
7	DTL3 conditioning													
8	DTL2 installation													
9	DTL2 conditioning													
10	DTL 2/3 beam commissioning													
11	CCDTL 3-7 and PIMS1 installation													
12	CCDTL 3-7 and PIMS1 conditioning													
13	H- source2 installation & commissioning													
14	CCDTL 1-2 and test bench installation													
15	Transfer line installation 1													
16	HW commissioning 100 MeV + bendings													
17	Linac4 HW ready for 50 MeV protons													01/12

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

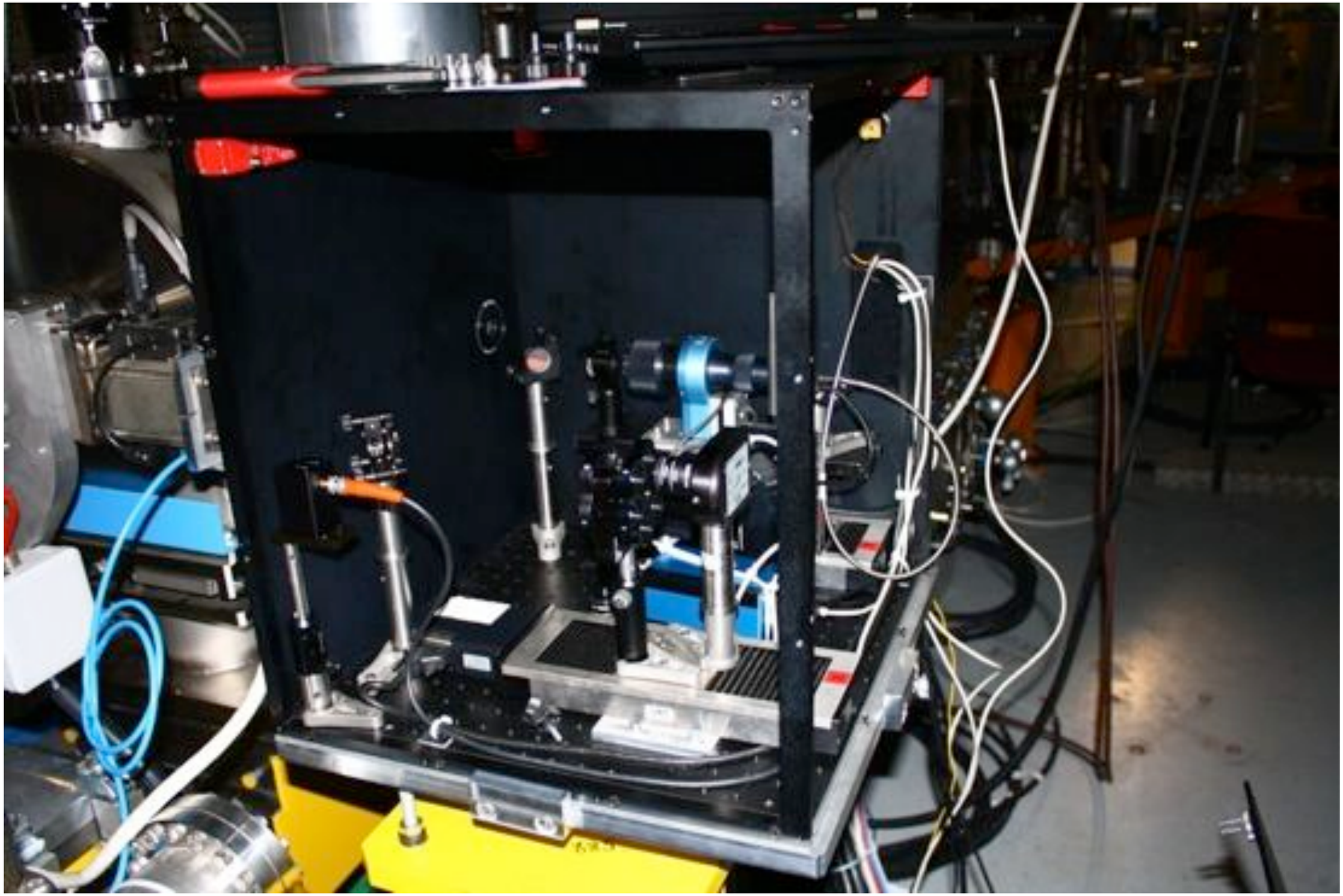
Next step: Drift Tube Linac commissioning (see presentation by S. Ramberger) – DTL1, DTL2, DTL3

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).

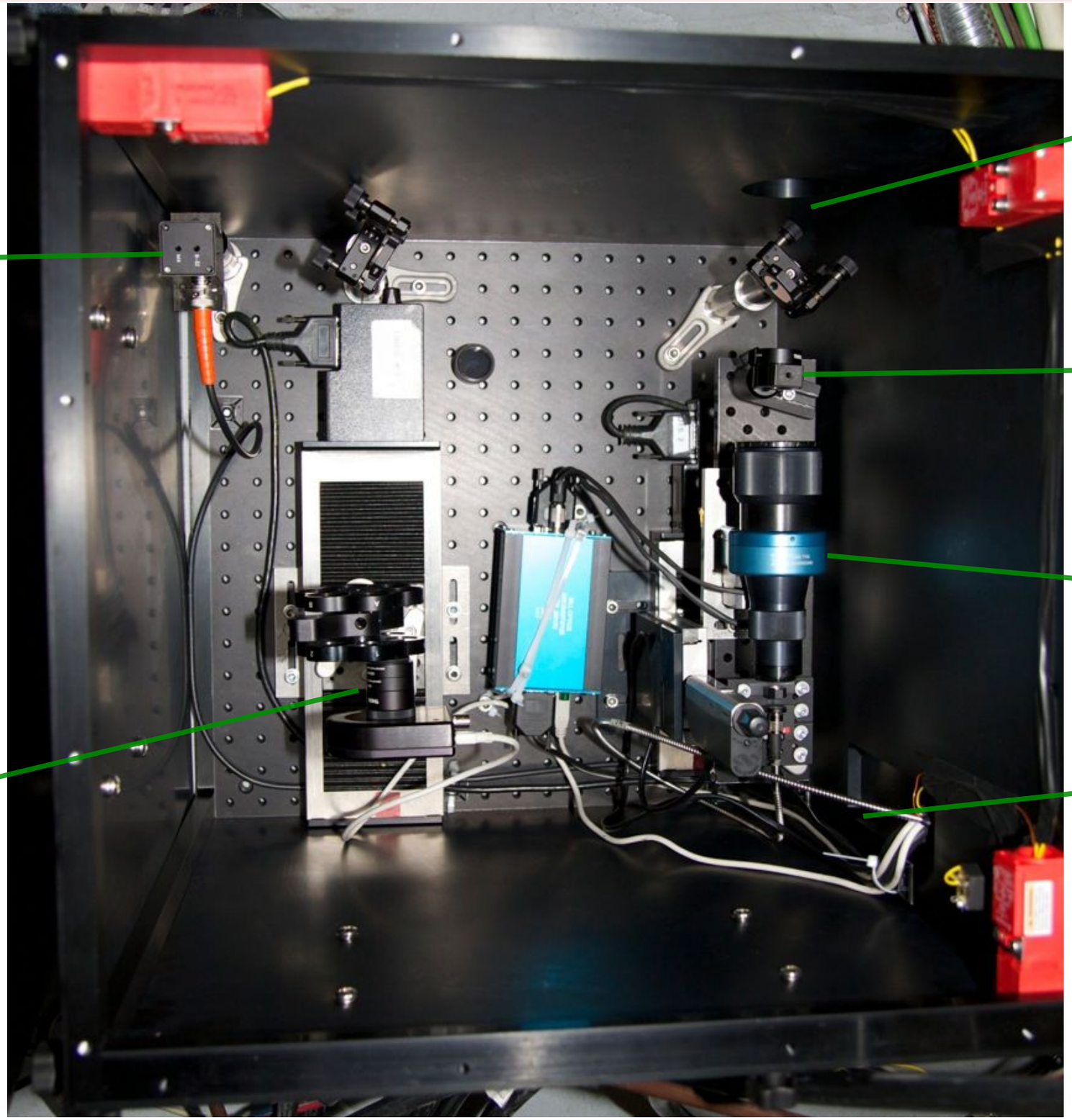
With safety panels removed



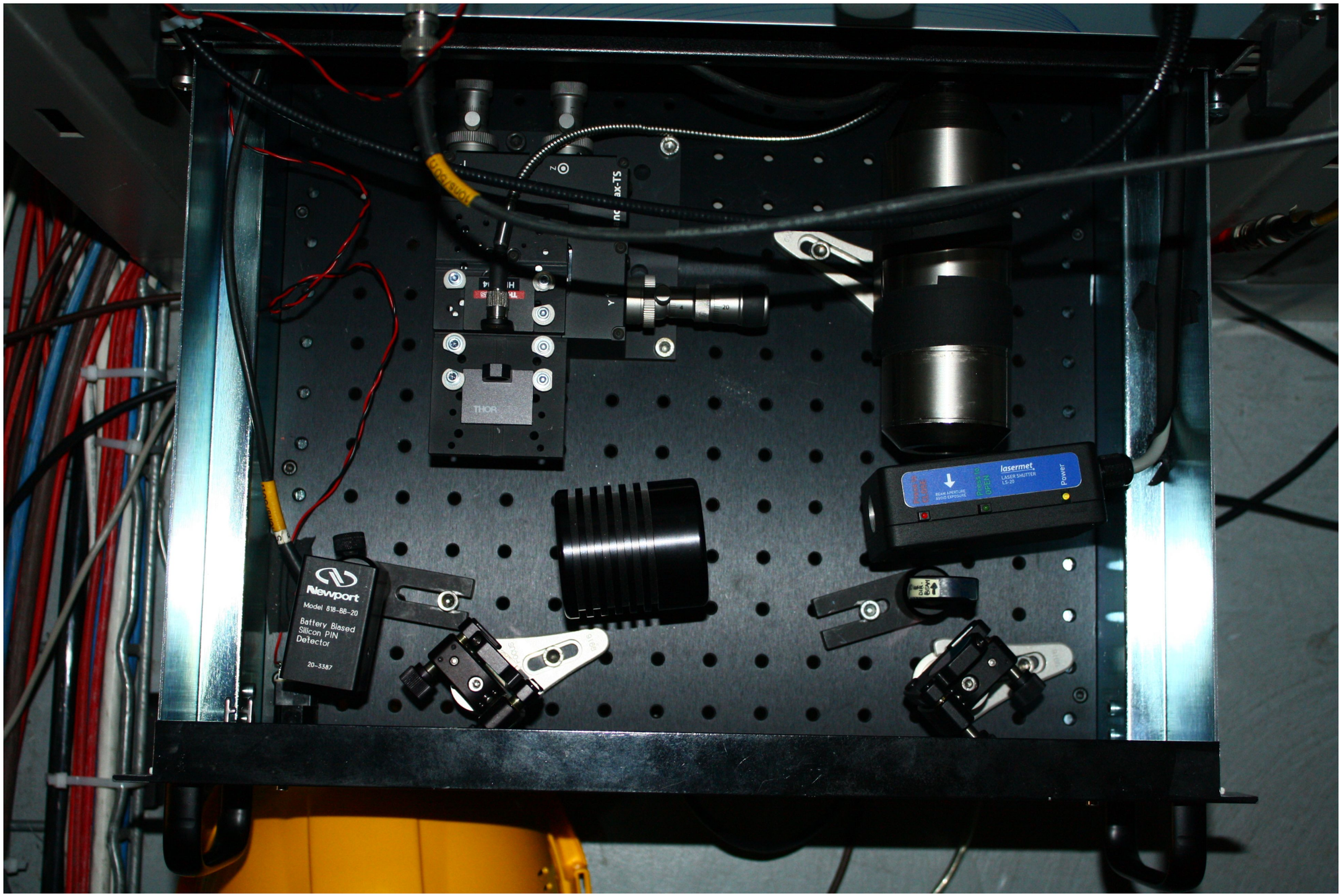
With safety panels removed



Overview


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

Coupling box optics



Outlook