FETS Laserwire Emittance Scanner – New results from CERN Linac4

on behalf of
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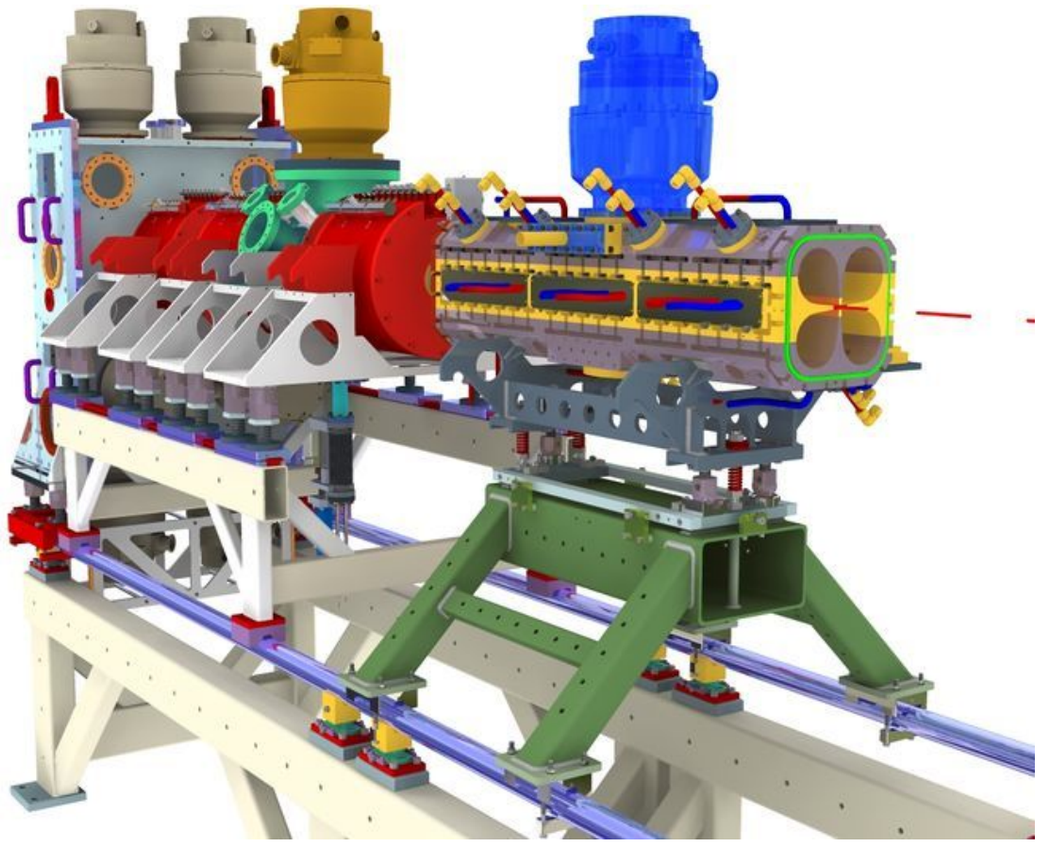
FETS Meeting, RAL
19/03/2014

Outline

- Summary of progress
- Linearity tests
- Bias scan
- Emittance scans
- Outlook



Summary of progress

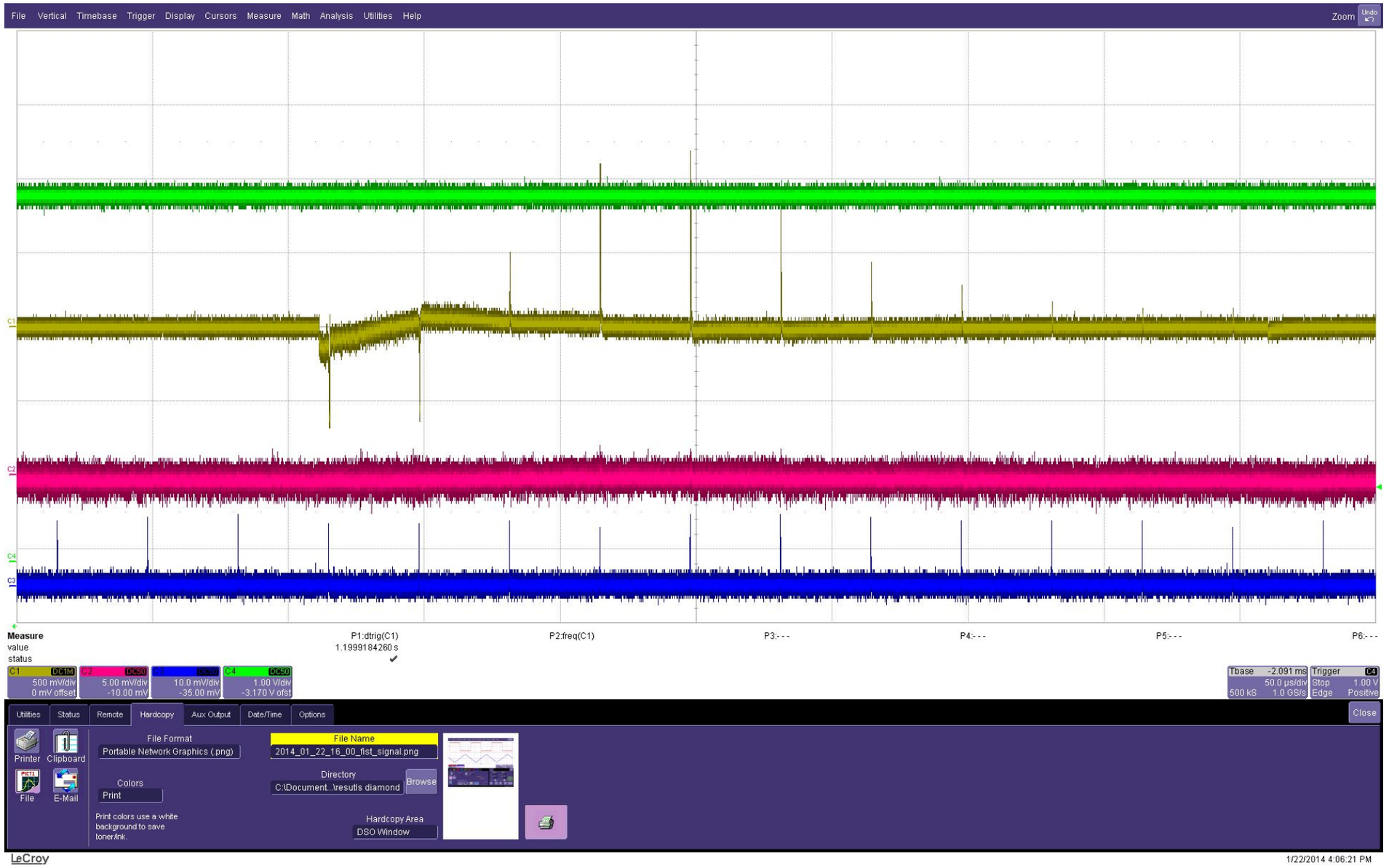
Main activities in past month:

- Reminder of trips so far this year:
  - First trip, 20th–22th Jan: first laserwire pulse signal, 22nd January.
  - Second trip, 10th–14th Feb: First vertical laser profile scan on 11th February.
- Late February / early March, continued data taking by CERN team.
  - Investigations of laser power linearity and response of diamond amplifiers.
  - 28th Feb, first emittance measurement with 2D laser and diamond detector scan.
  - Development of simultaneous beam current data acquisition. Increased rep rate.
- Third trip, March 2014, 10th–14th, last chance for data at 3 MeV.
  - Tests of charged and linear amplifier on diamond detector, during limited beam availability.
  - Emittance scan taken at interesting quadrupole settings.
  - Final scan yesterday, 18th March: fine emittance scan and slit scan at other quad settings. 3 MeV beam stops now… next beam at 12 MeV in ~May.

First signal – 22 January 2014

Amplified diamond channel

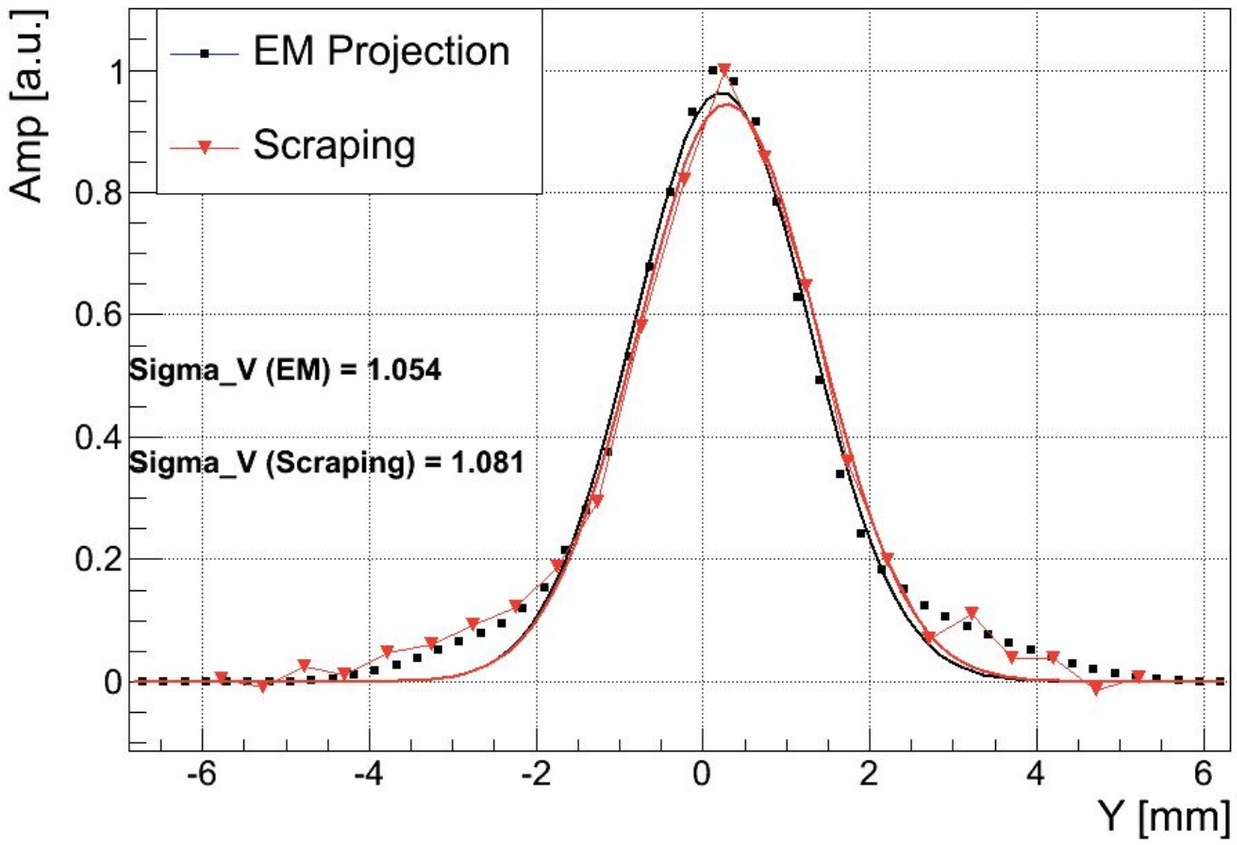
Laser PD



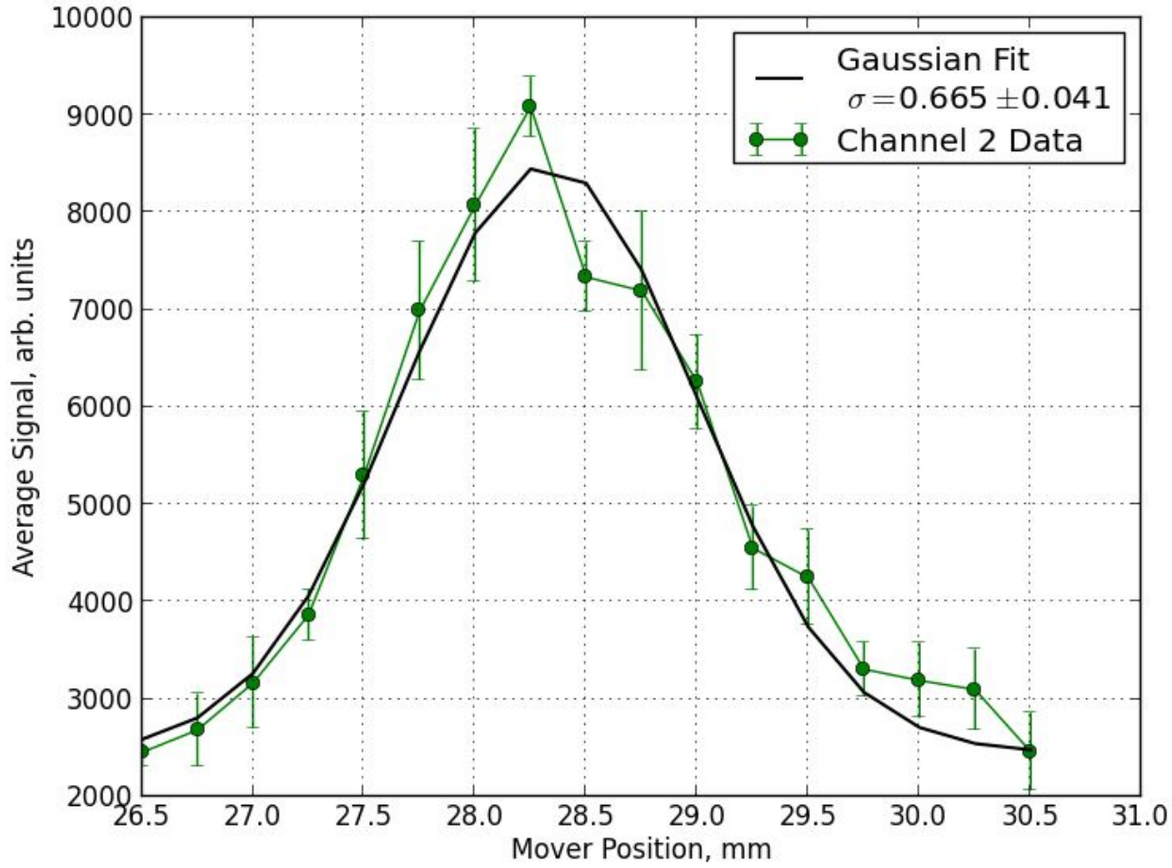
- Synchronous peaks in diamond detector with laser pulses.
  - Residual gas background in diamond detector
  - Negative / saturation effects observed – prompted addition of linear amplifier.

Early February Profile measurement

Slit-grid scan



Laserwire vertical scan



Konstantin Kruchinin earlier analysis

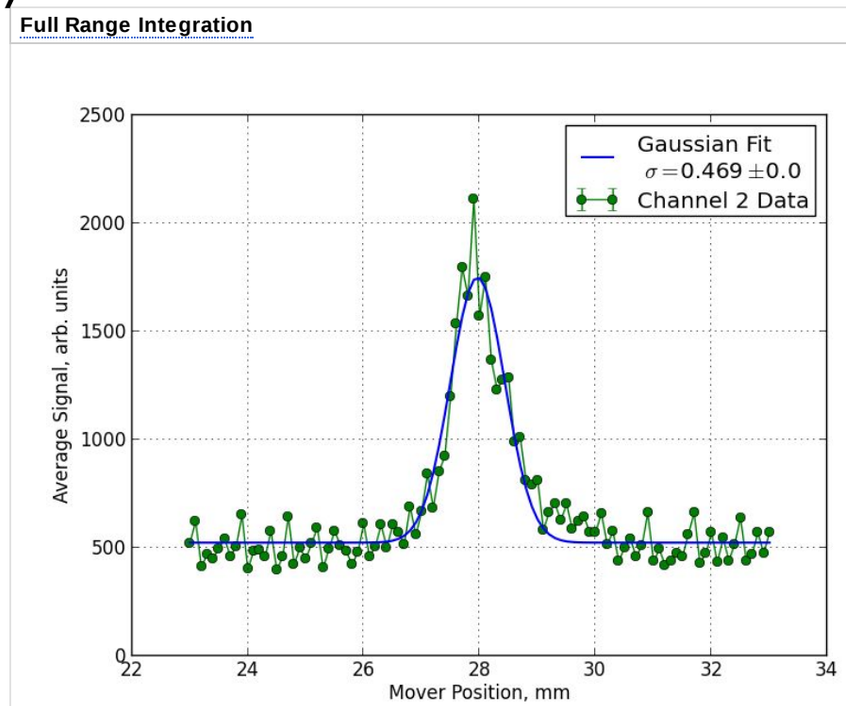
- Beam profile from traditional measurements:
  - Laser profile sigma right order of magnitude in first analysis.

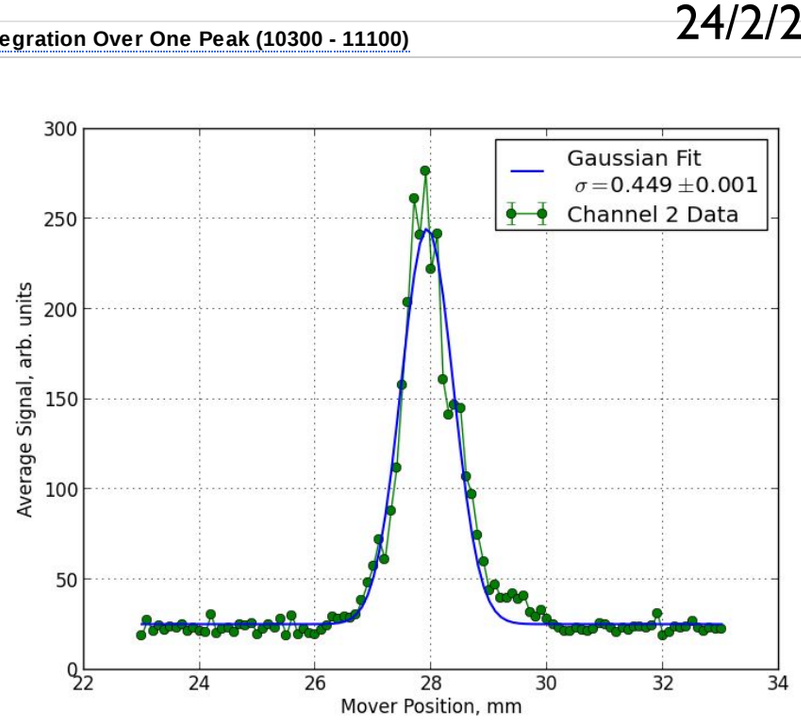
Repetition & averaging

Analysis by Konstantin Kruchinin

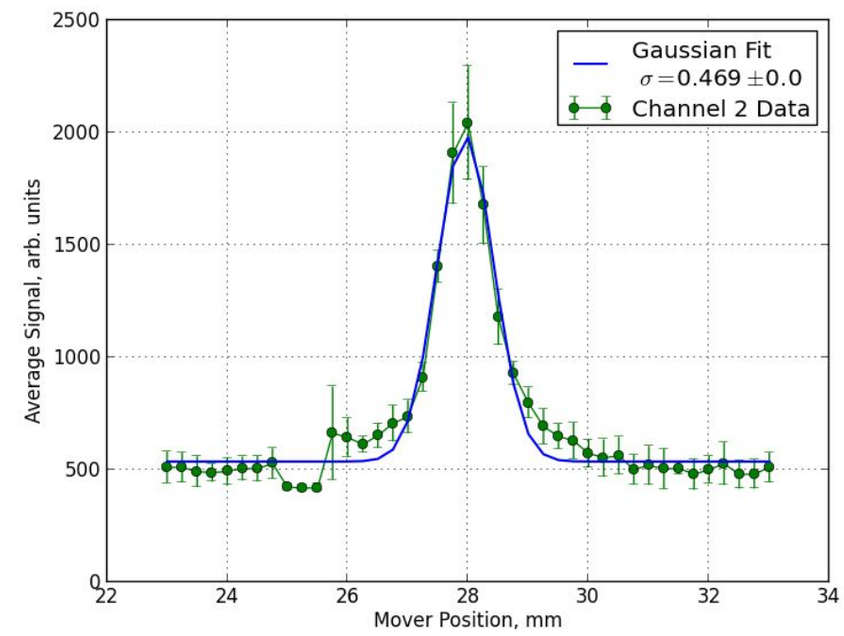
24/2/2014

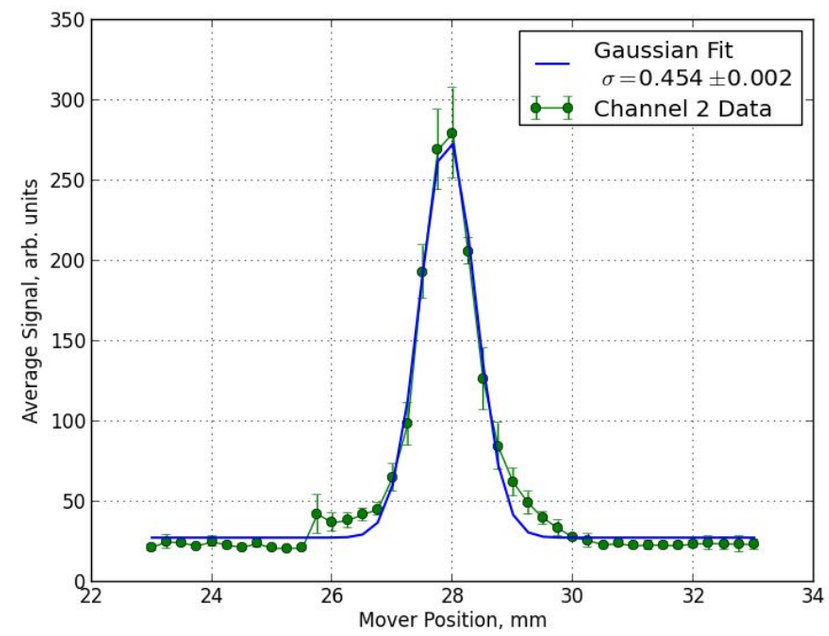
Rep 1





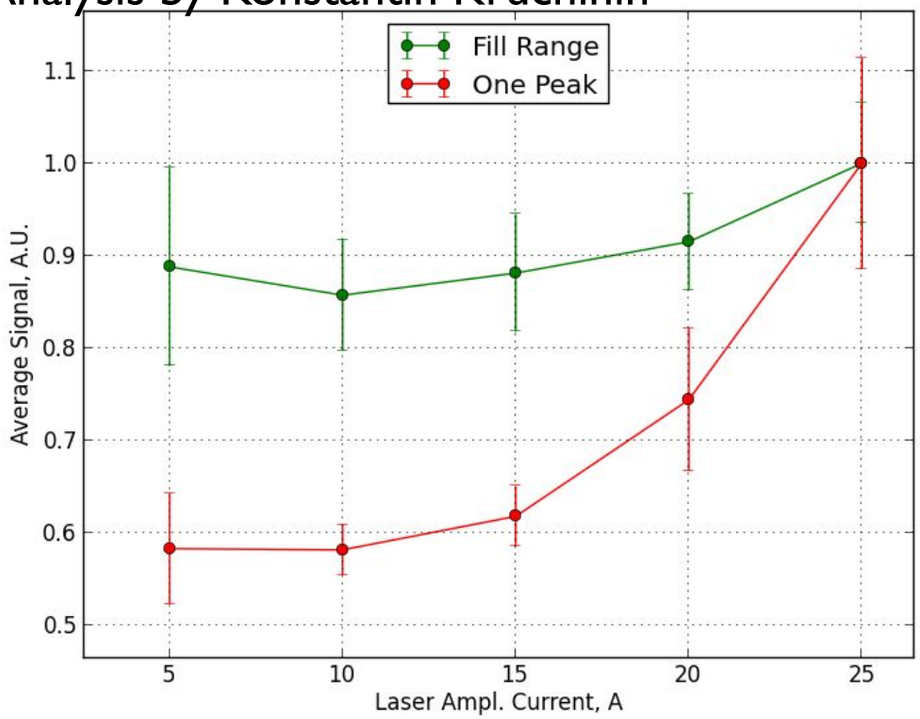
Rep 5

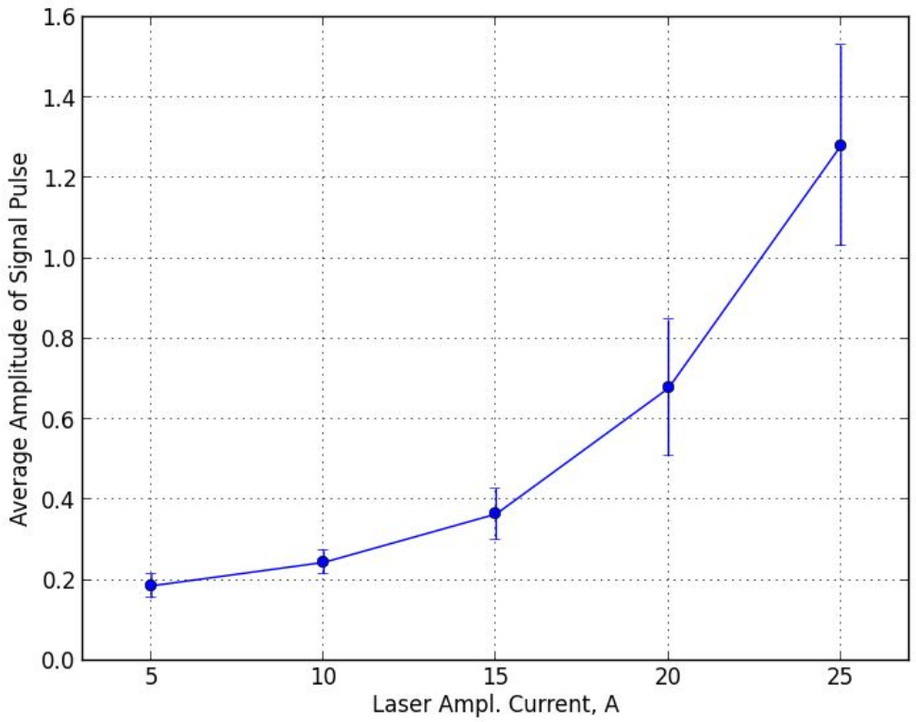




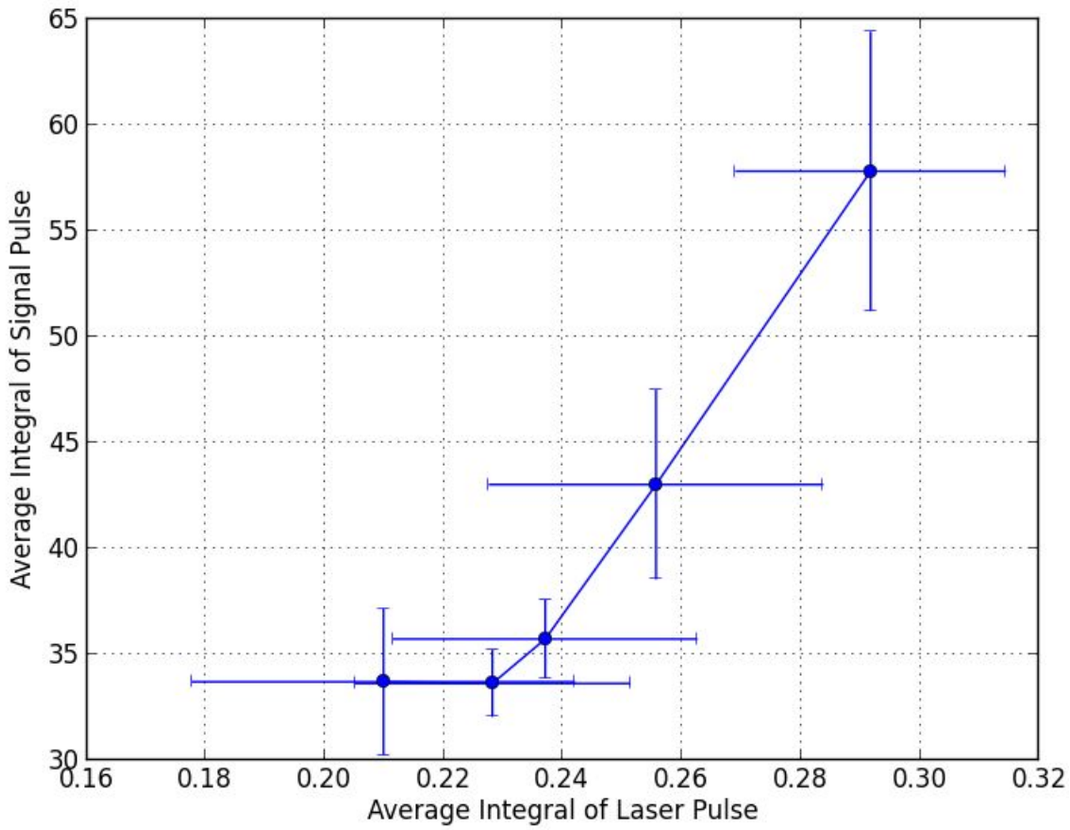
Laser power linearity test

Analysis by Konstantin Kruchinin

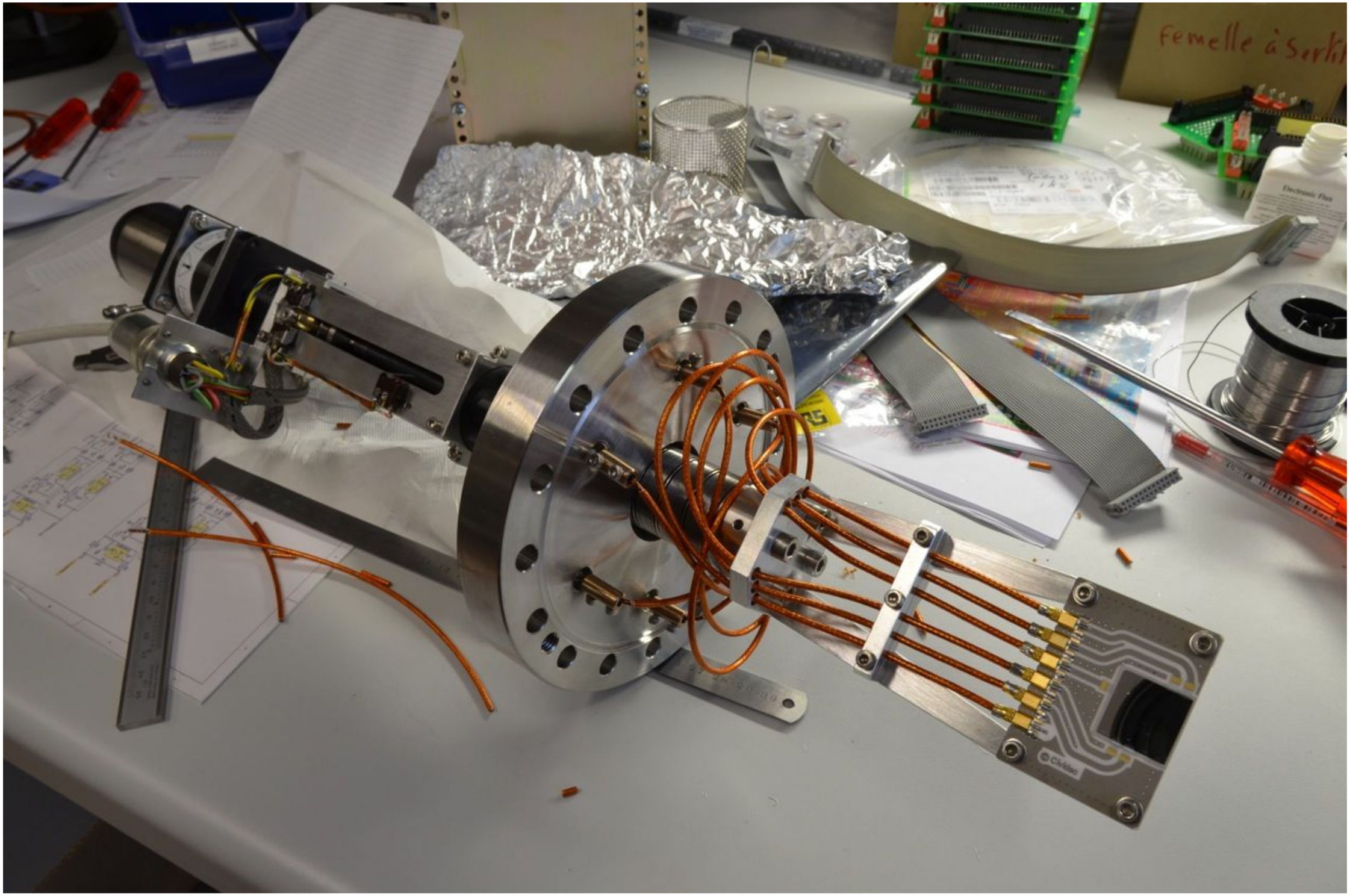




Laser current varied and check response of diamond detector signal: 600V bias, 21/2/2014

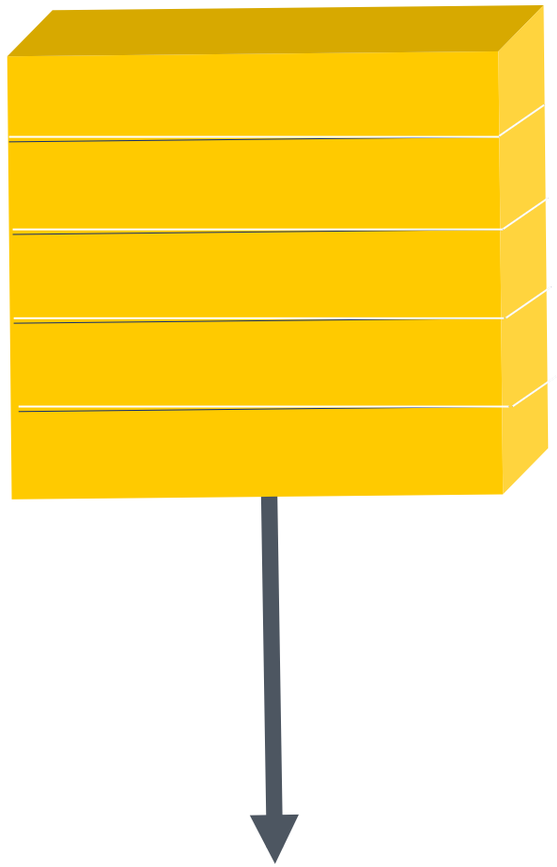


Diamond detector



Diamond detector

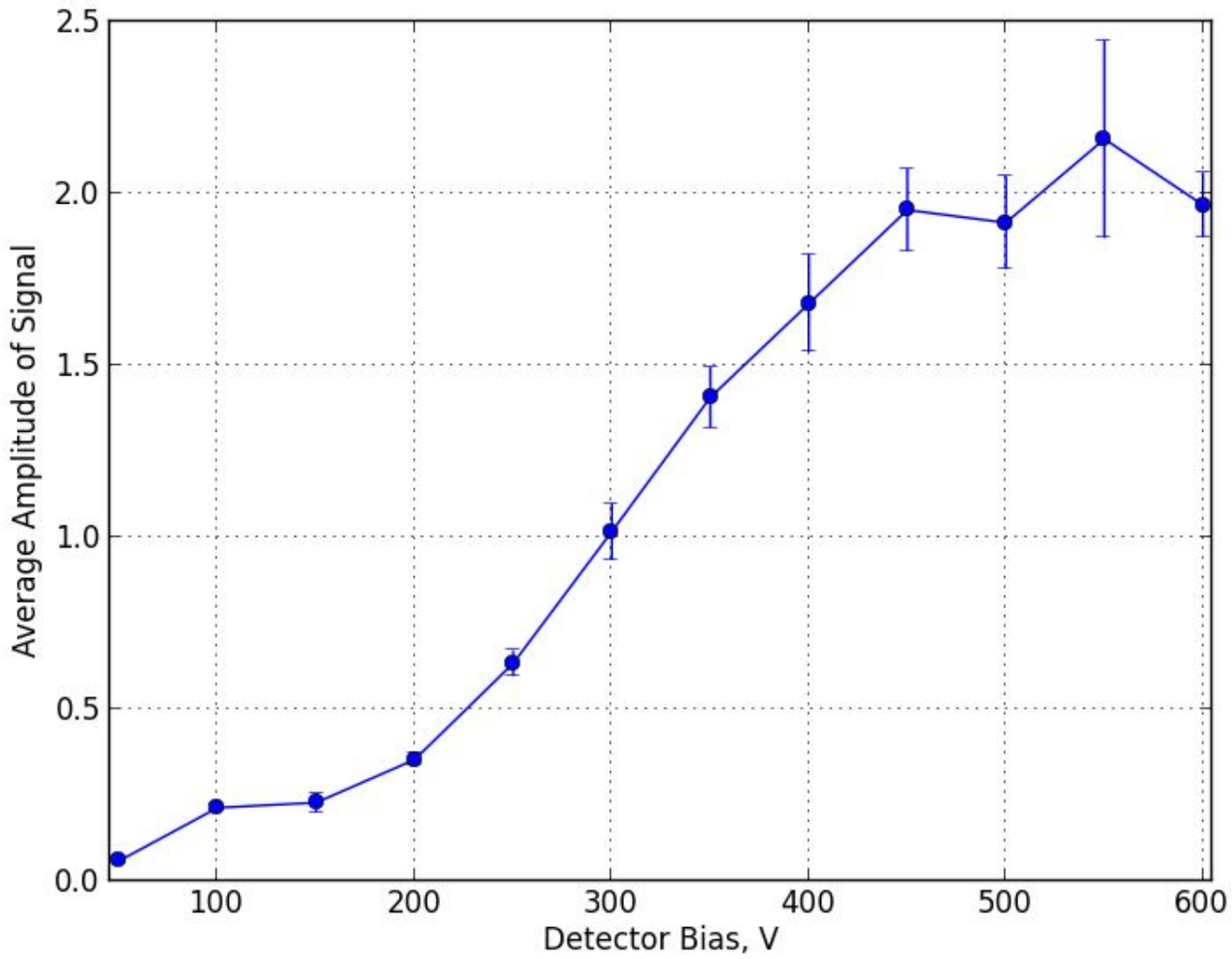
- Main H^- beam deflected by spectrometer magnet.
- Neutral H^0 are undeflected and arrive at a downstream 5 strip diamond detector, which can be moved into the beamline via translation stage:
  - Each horizontal strip has a vertical width of ~3.5mm.
  - Small gap of 300um between strips
  - 600V nominal bias (adjustable).
  - Initially one strip was instrumented with a charge sensitive amplifier.
  - Later a second strip was instrumented with a linear amplifier.



Detector Bias Scan

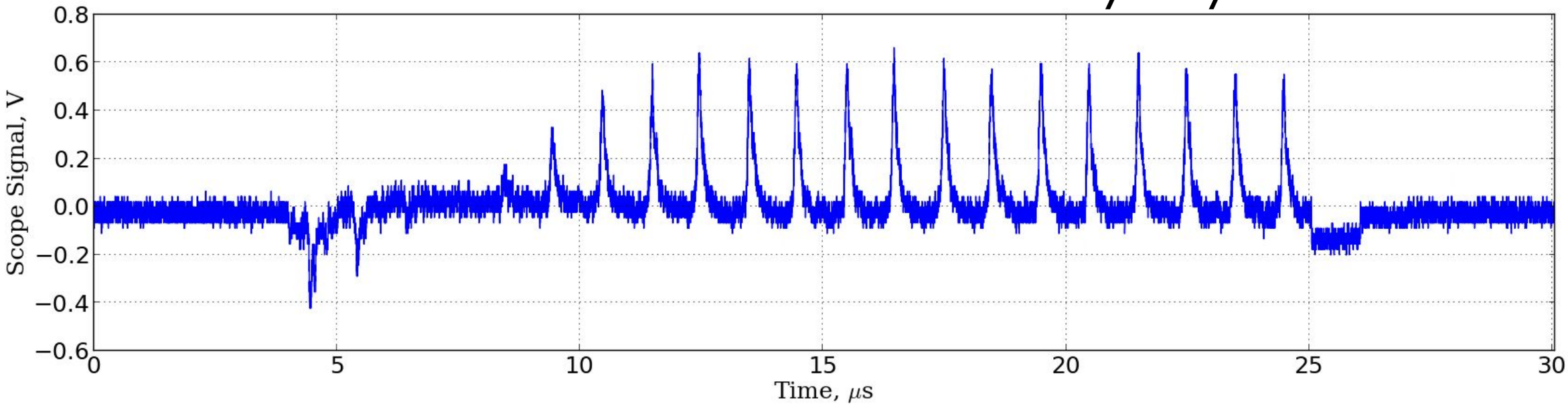
Analysis by Konstantin Kruchinin

Check response of diamond detector signal as bias voltage is varied:
(24/2/2014)
[Bunchers were not stable during measurement – envelope of the beam could have changed!]



Increased laser frequency

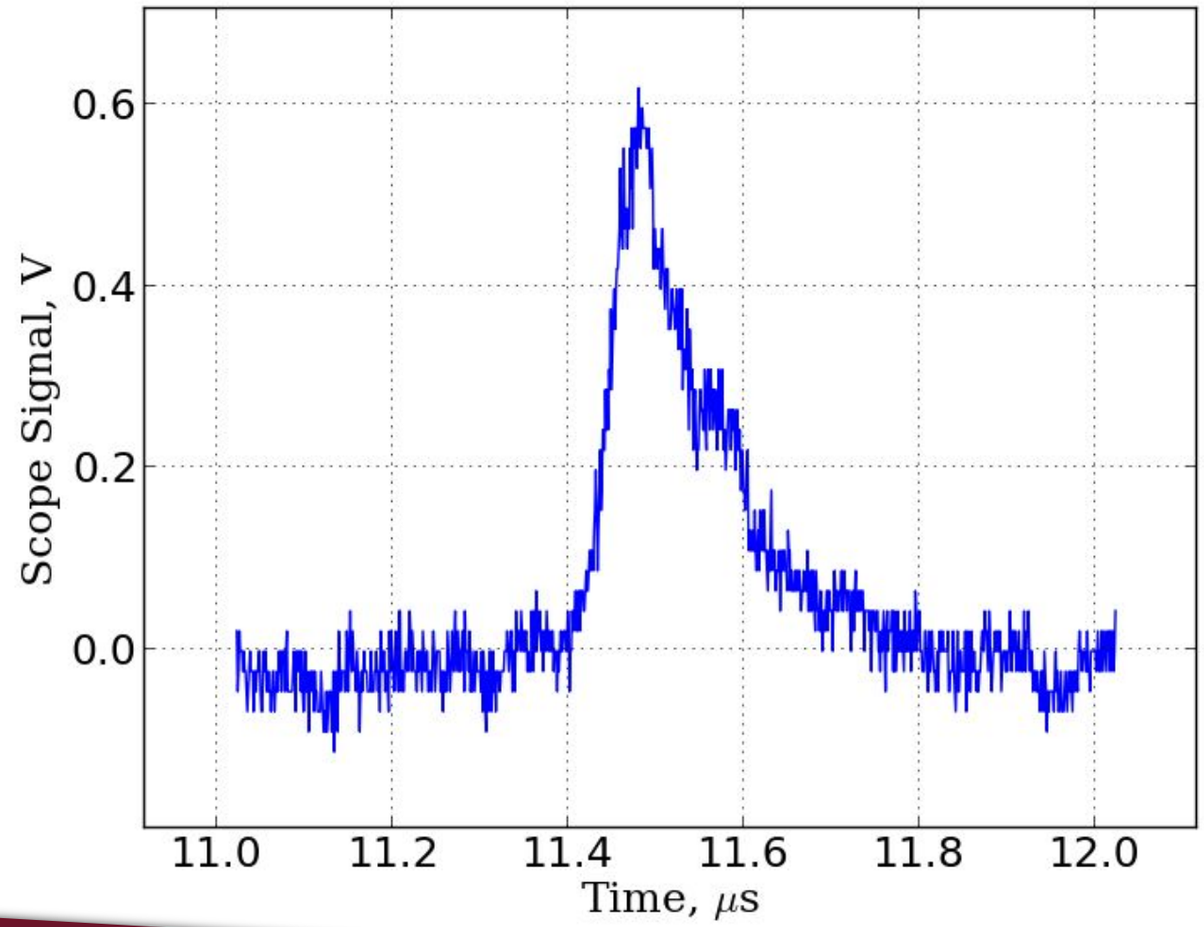
Analysis by Konstantin Kruchinin



Laser frequency increased from 30kHz to 60kHz, to double # of laser pulses per a particle pulse. Laser current increased accordingly to maintain peak height.

Laser emittance scan data taken, 28/2/2014
Diamond chl5, with charge sensitive amplifier.

File: 140228_130212, Diamond channel 5, laser position = 28, diamond Position = -3.62, integration for segment 12, in range 11.4 - 11.7 us (second third of the segment).

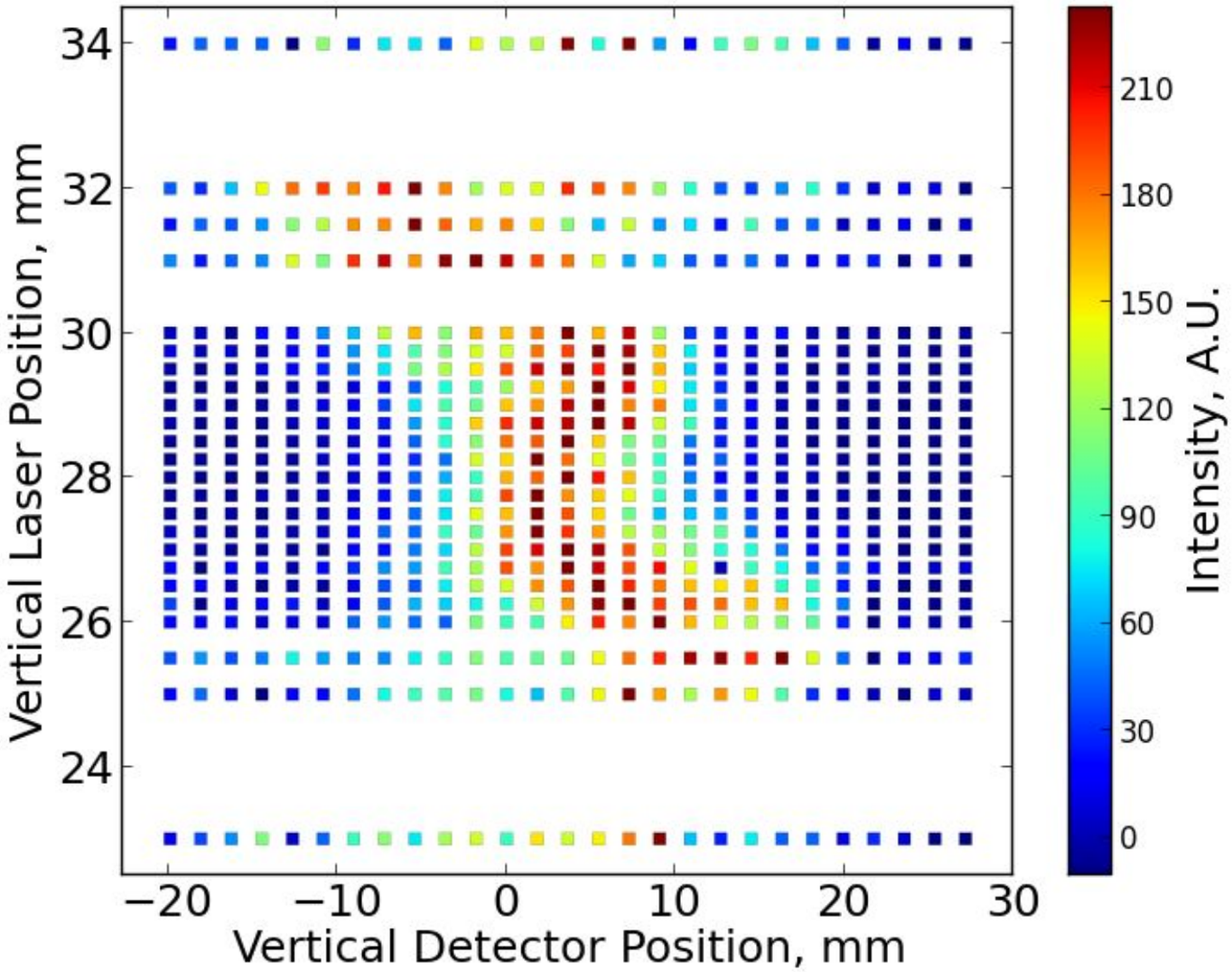


Laser and slit emittance scans

Analysis by Konstantin Kruchinin

Laser emittance data taken, 28/2/2014
Diamond ch15, with charge sensitive amplifier.

Vertical diamond detector scan at each laserwire vertical position.
Integration for segment (laser pulse)12 only:

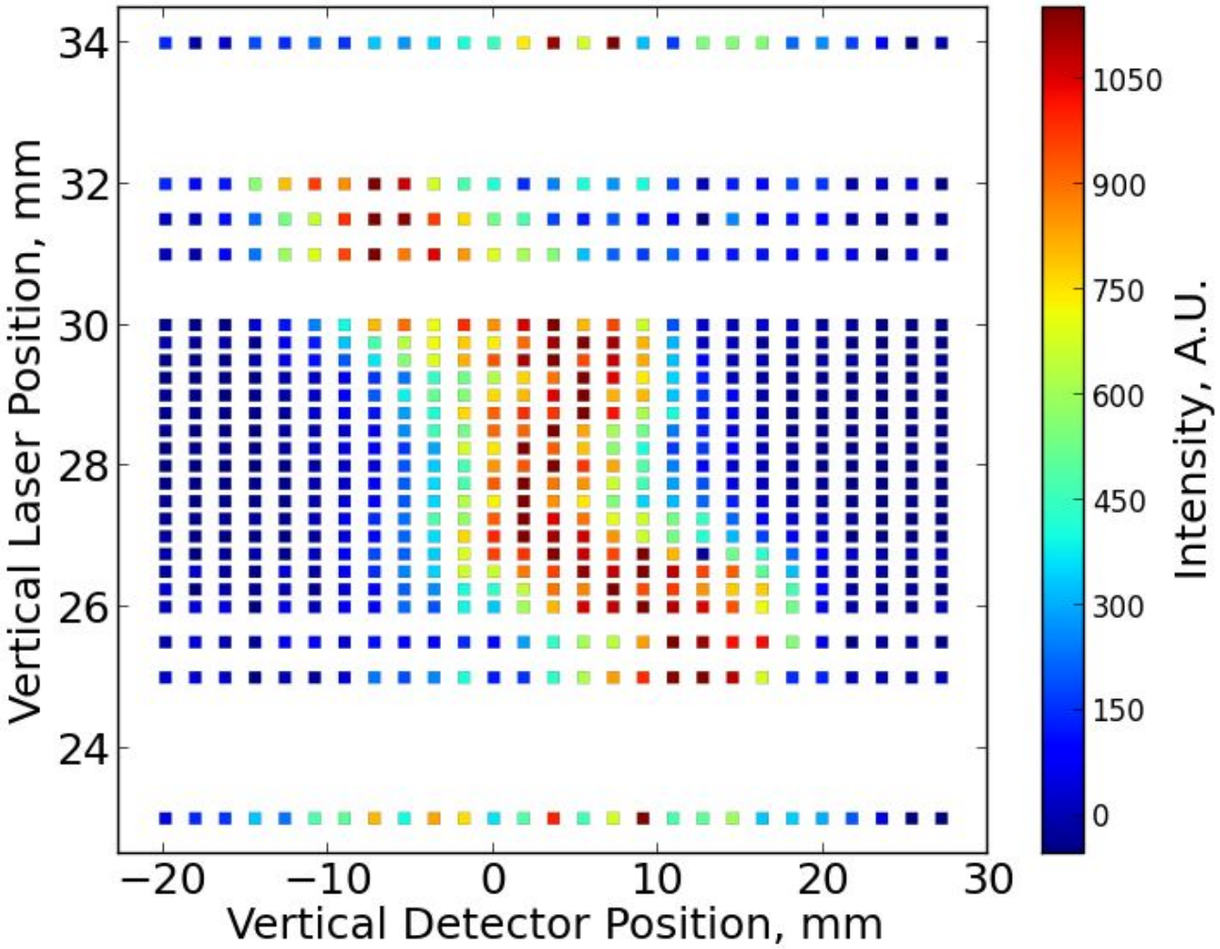


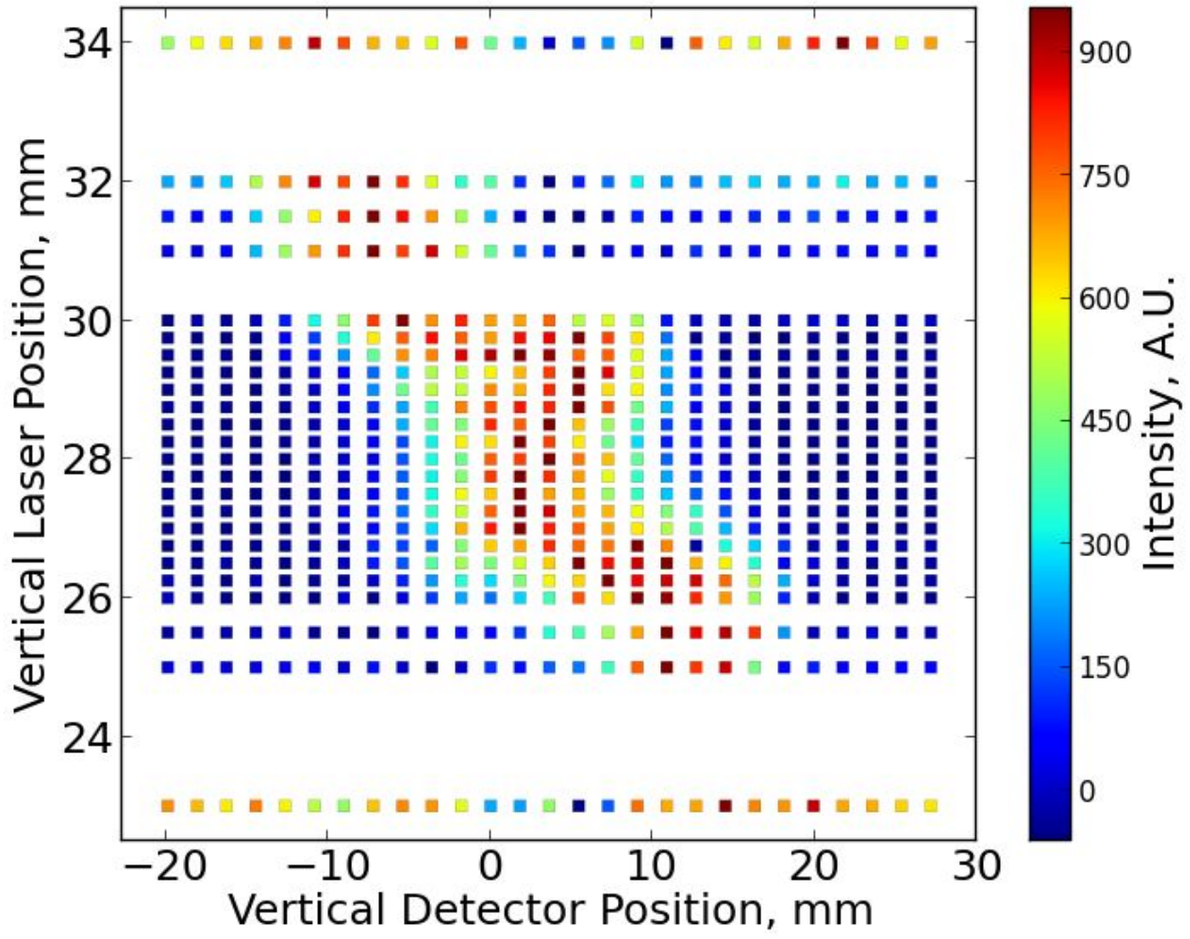
Laser and slit emittance scans

Laser emittance data taken, 28/2/2014
Diamond ch15, with charge sensitive amplifier.

Analysis by Konstantin Kruchinin

Vertical diamond detector scan at each laserwire vertical position.
Integration for segments from 12 to16 (left) and from 20 to 24 (right)



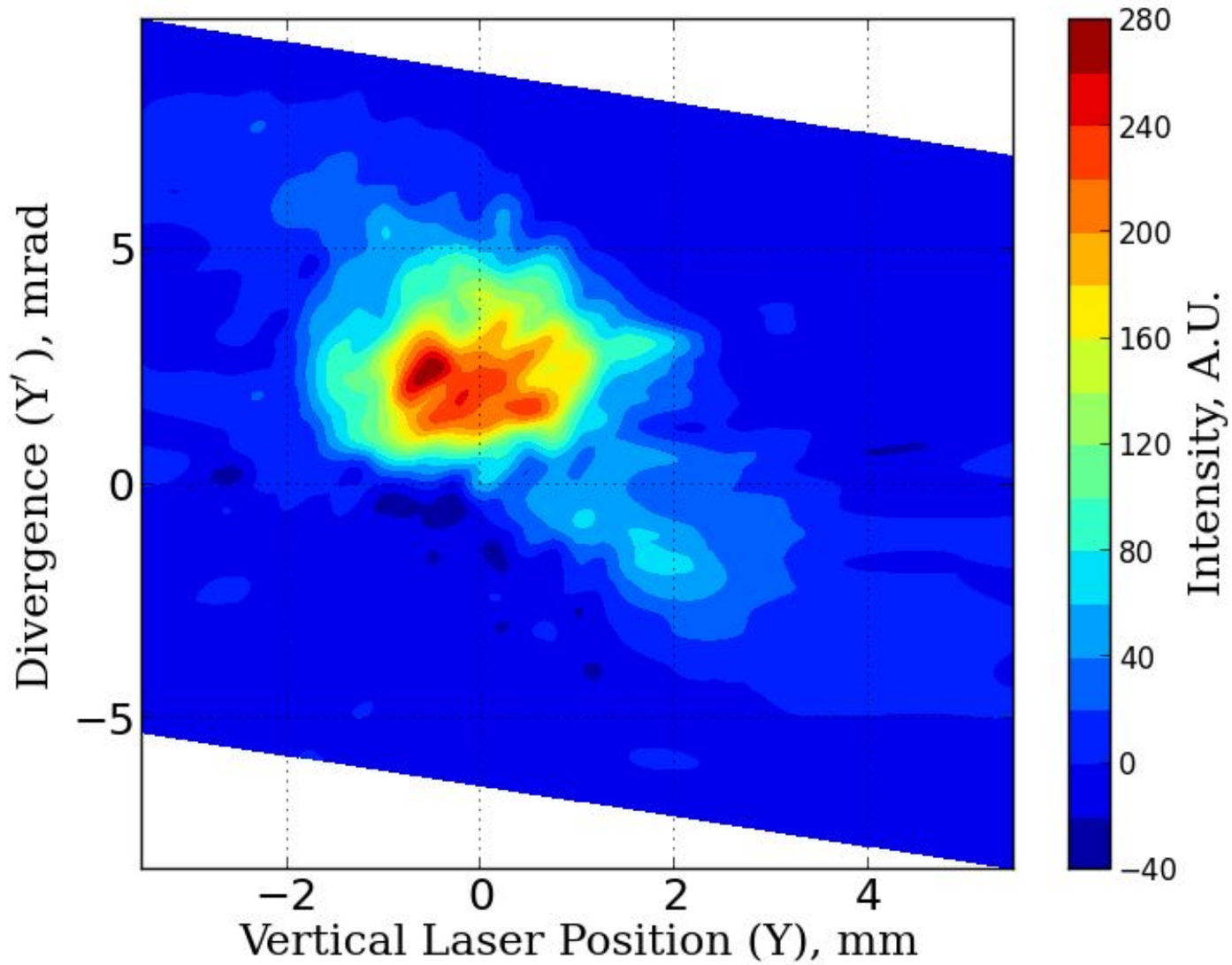


Laser and slit emittance scans

Laser emittance data taken, 28/2/2014

Analysis by Konstantin Kruchinin

Emittance for, diamond strip4 (scope ch11)

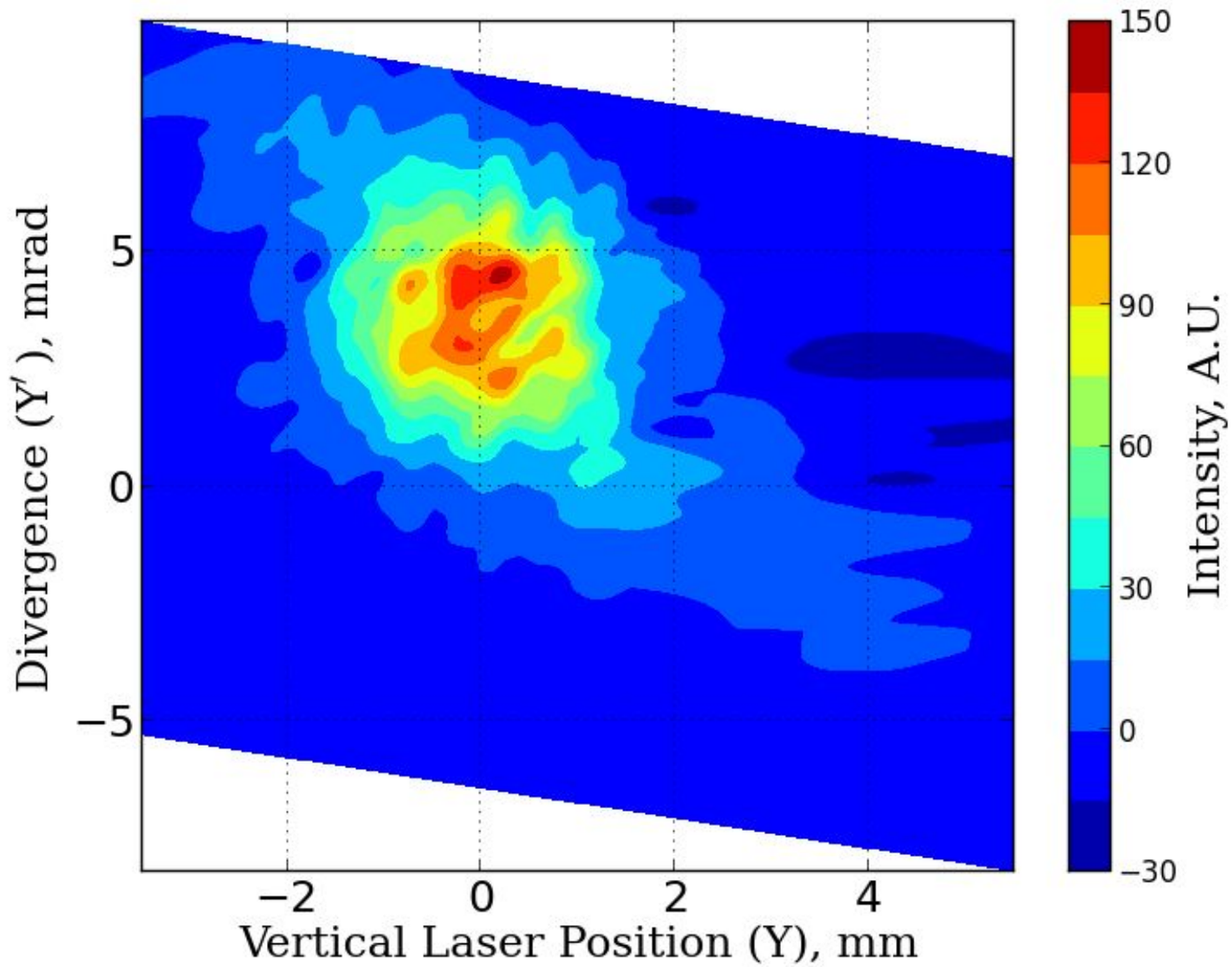


Laser and slit emittance scans

Laser emittance data taken, 28/2/2014

Analysis by Konstantin Kruchinin

Emittance for, diamond strip2 (scope chl2)

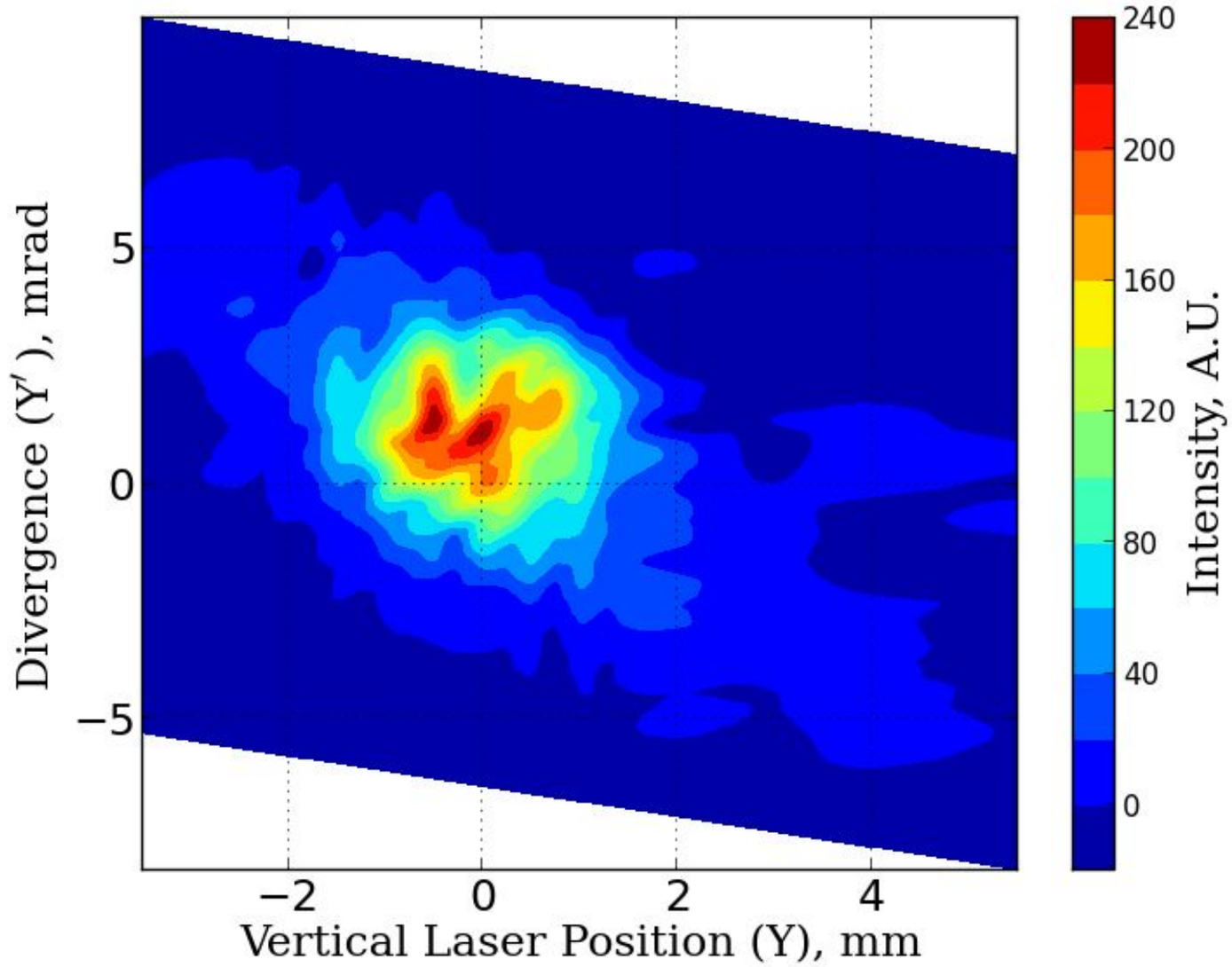


Laser and slit emittance scans

Laser emittance data taken, 28/2/2014

Analysis by Konstantin Kruchinin

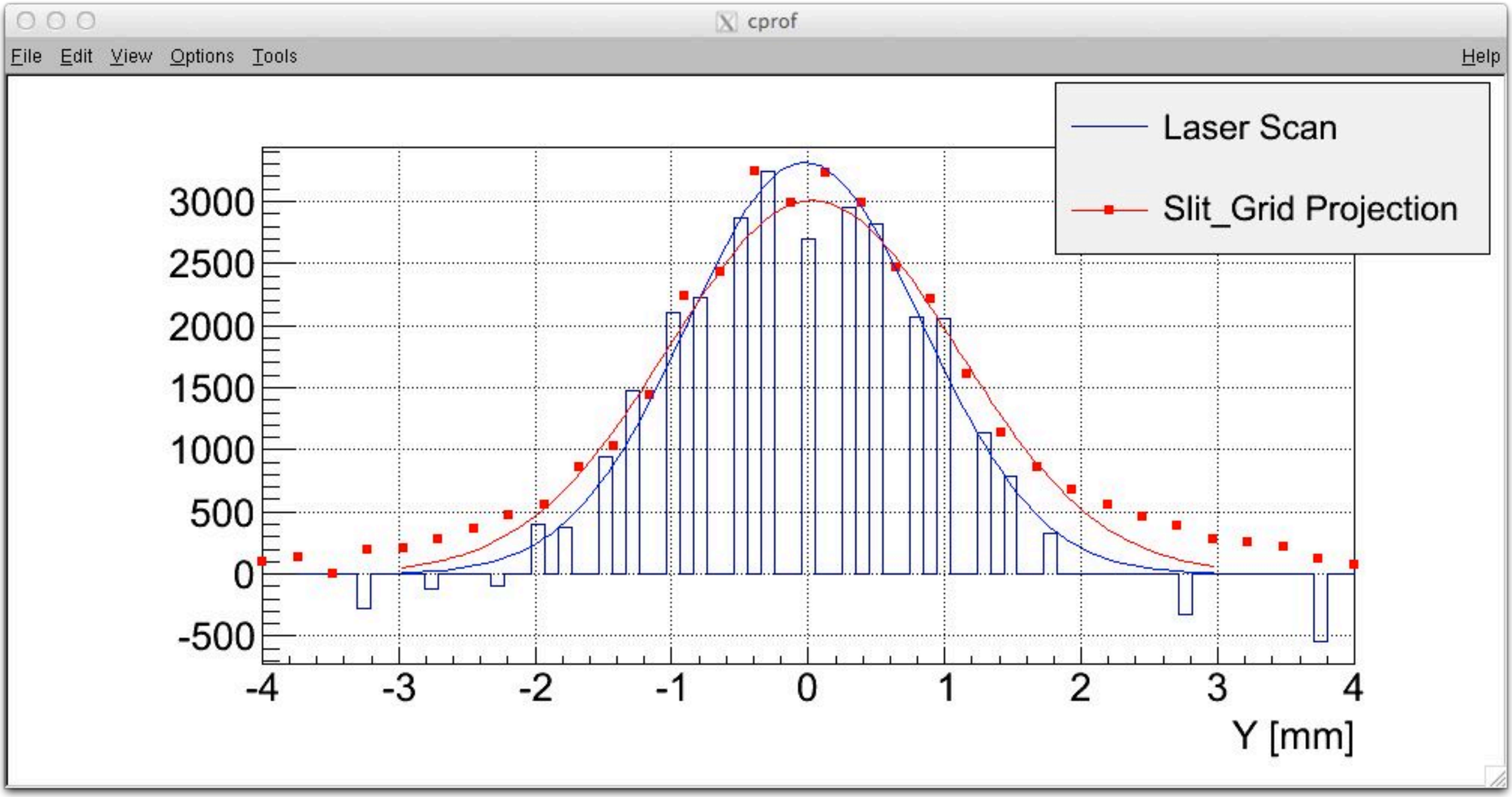
Emittance for, diamond strip5 (scope chl3)



28th February, emittance scan

Analysis by
Federico Roncarolo

Laser emittance data taken, 28/2/2014
Diamond with charge sensitive amplifier, analysis of

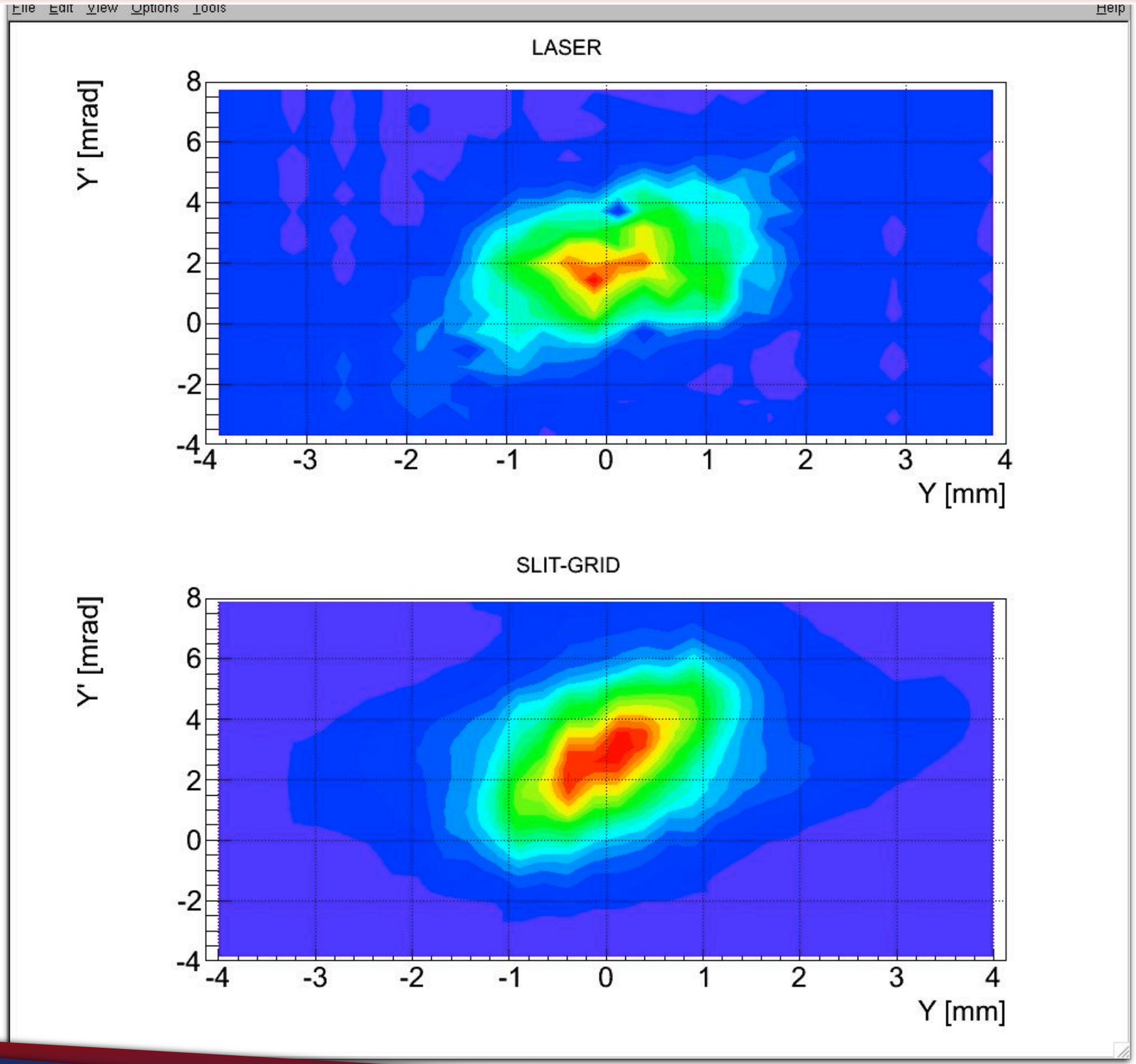


Laser and slit emittance scans

Analysis by
Federico Roncarolo

Laser emittance data taken, 28/2/2014
Diamond with charge sensitive amplifier, analysis of

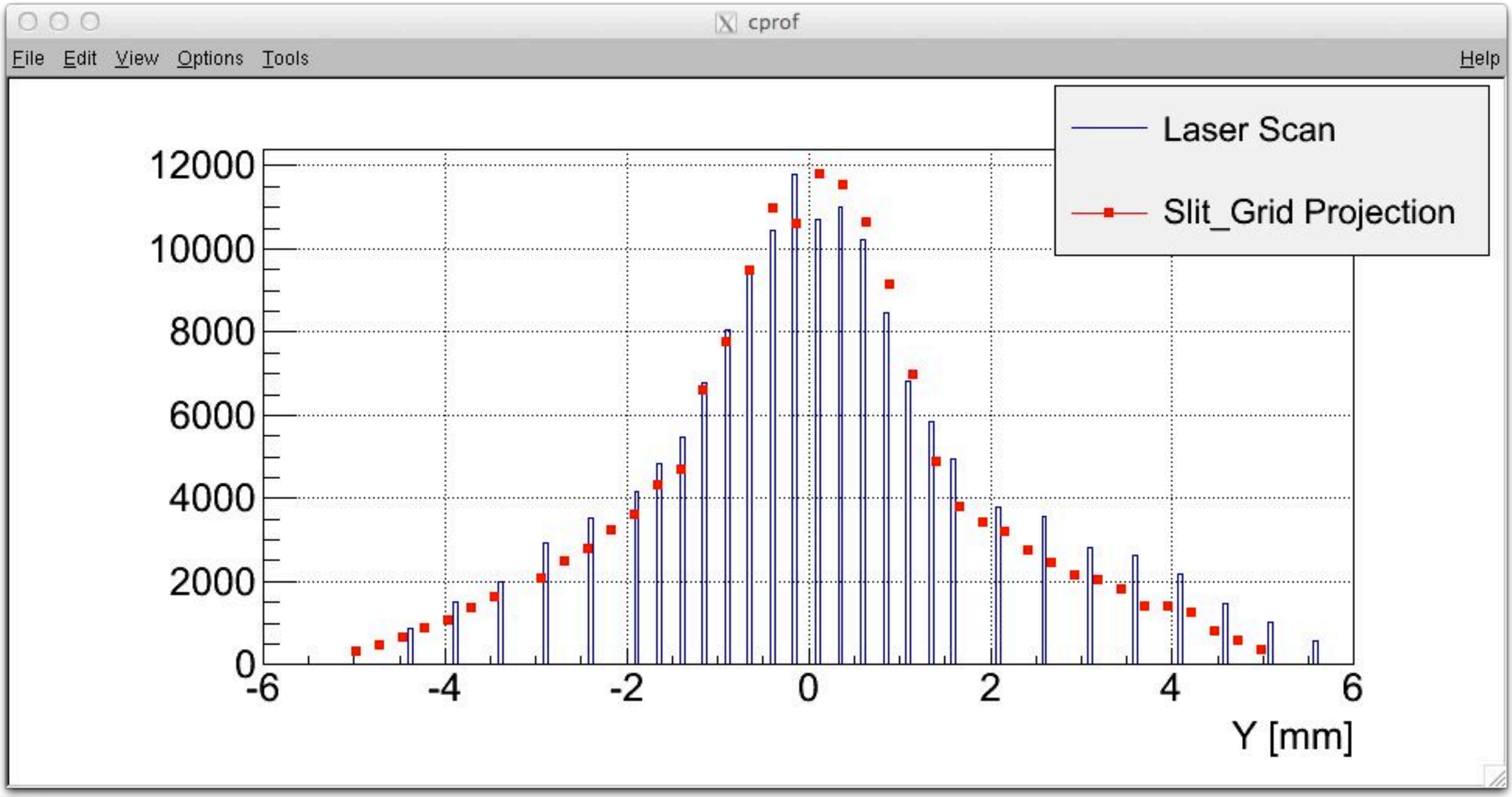
Conventional slit + SEM grid emittance measurement, taken with the same quadrupole settings:



Fine profile scan, 18th March

Analysis by
Federico Roncarolo

Comparison of laser vertical scan and slid-grid profile:
First look - remarkable agreement. Analyzing emittance…
Ch12, linear amplifier, average 10th and 11th laser pulses (of 30)



Outlook / plans

- The 3 MeV run quite a success – now have lots of data to analyse!
- Scan types recorded:
  - 1D vertical laserwire scan – many!
  - 1D vertical detector scan – many!
  - 2 dimensional "emittance" scan in laserwireY and diamond Y: 28/2 (shown today) and 18/3 (fine scan)
  - Laser power scan – done.
  - Beam current scan – not possible, but beam current recorded so may be able to use rising pulse shape / variations.
  - Effect of modifying quad settings – laserwire data taken at two settings (one with small vertical size and strong divergence, so limited slit-grid data).
  - 2 dimensional scan in X and Y – not a priority (not enough beam time)
- The detailed analysis now begins… aim to learn as much as we can before 12 MeV run in May / June.

Future 12 MeV Laserwire?

2014 in detail

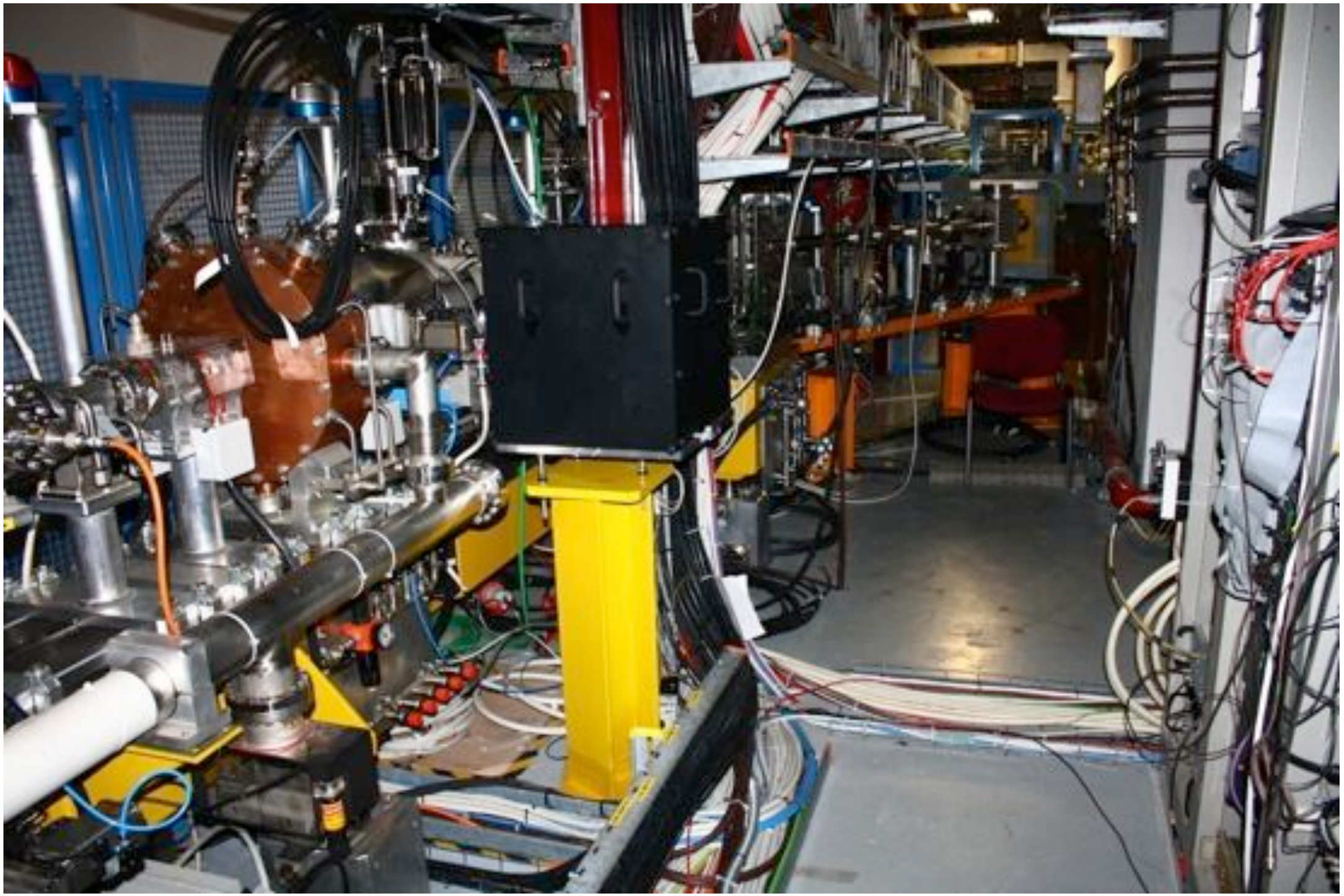
ID	Task Name	Dec	2014 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	Commissioning Linac4 in 2014													
2	3 MeV HW and beam tests													
3	DTL1 + test bench installation													
4	DTL1 RF conditioning, HW tests													
5	DTL1 beam commissioning													
6	DTL3 installation + 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

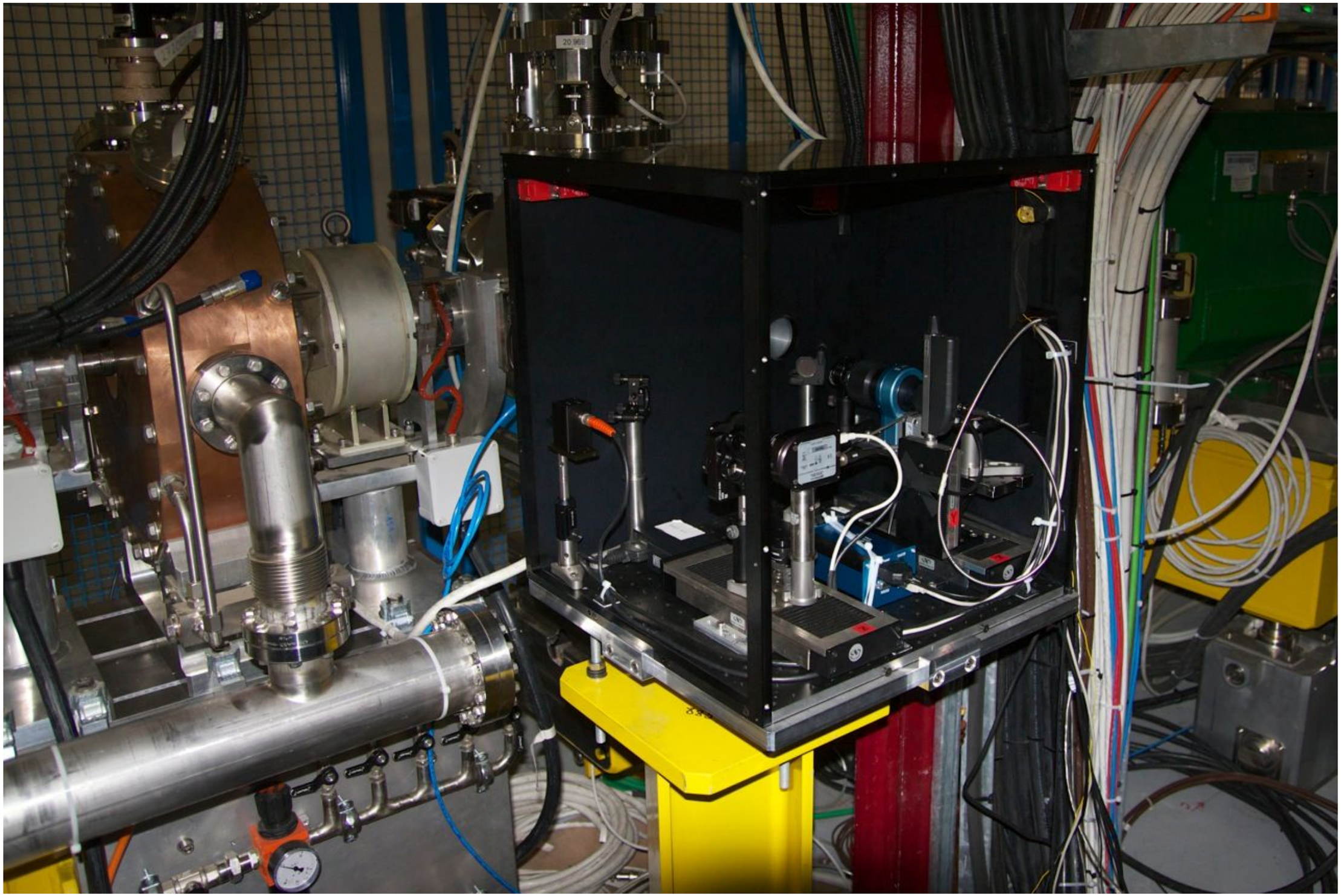
Next step: Drift Tube Linac commissioning (see presentation by S. Ramberger) – DTL1, DTL2, DTL3

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).

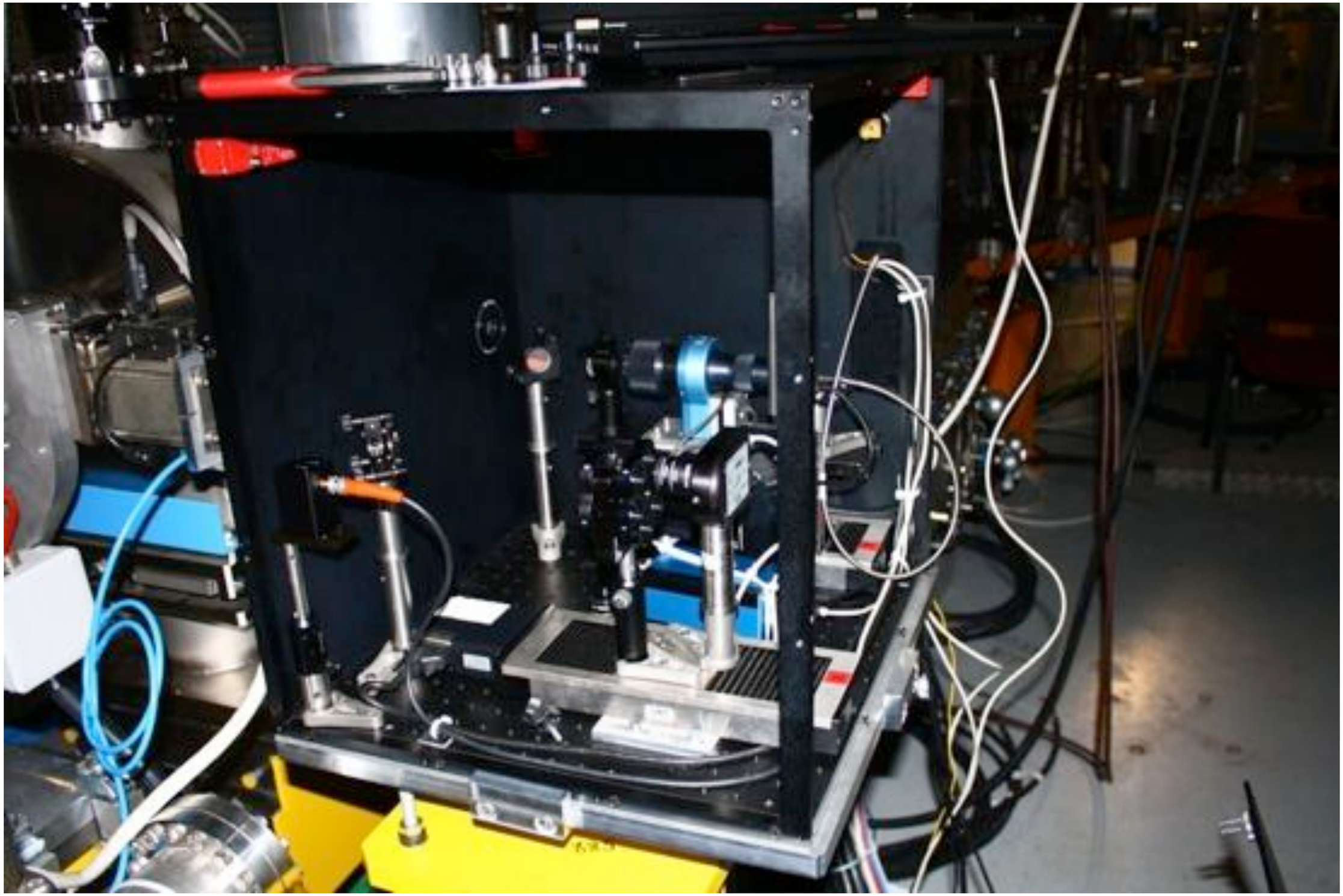
Lasewire enclosure in Linac4



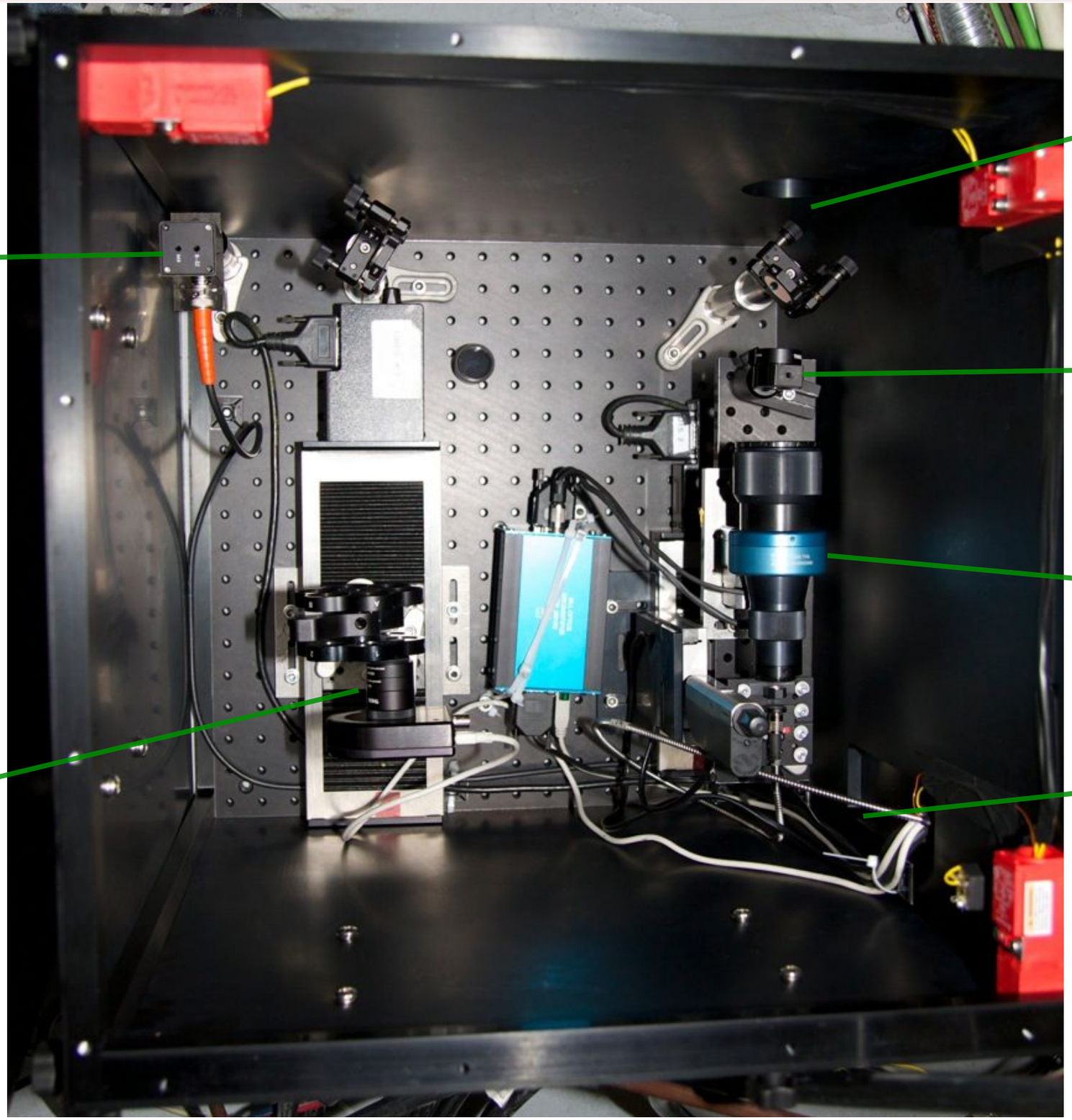
With safety panels removed



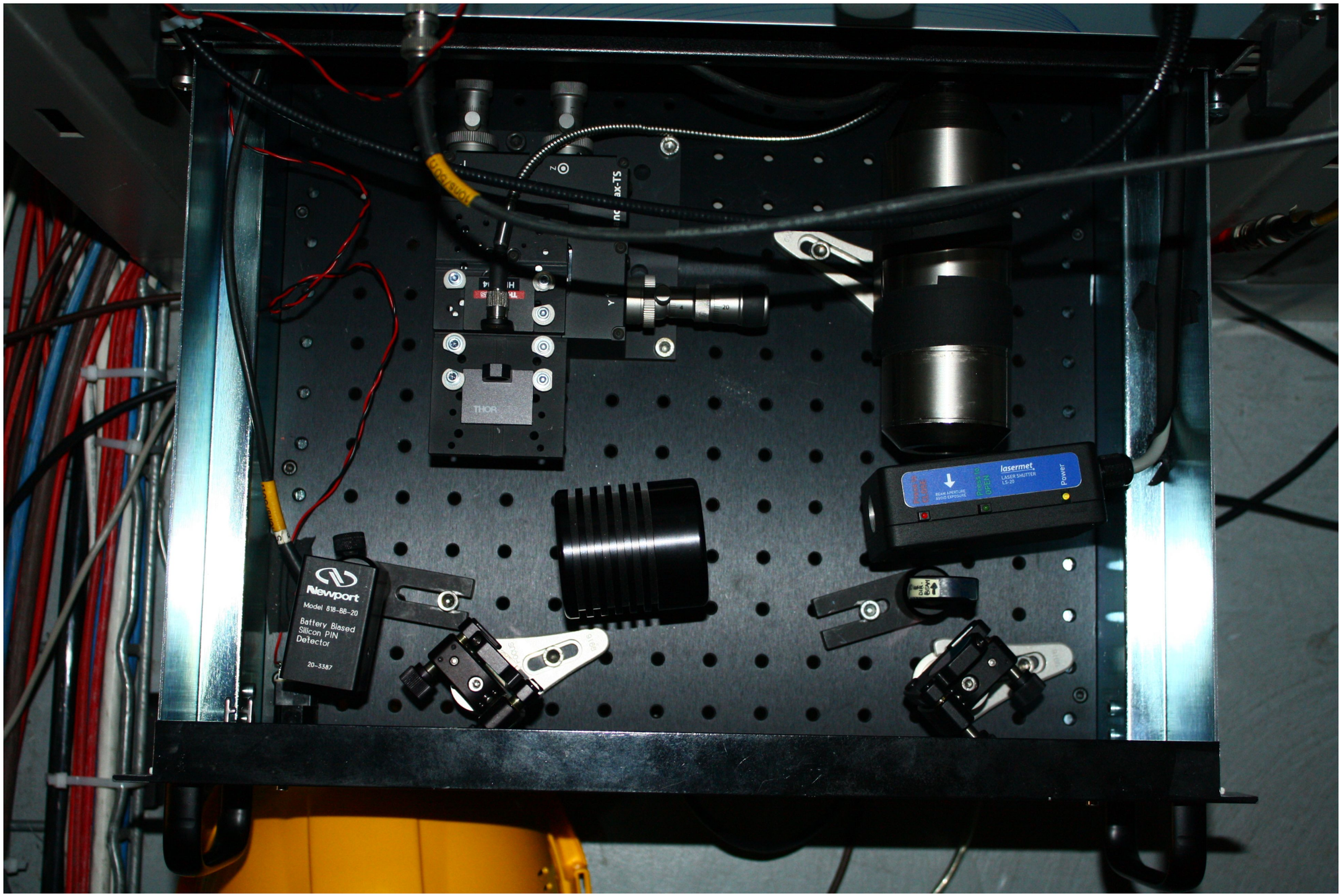
With safety panels removed



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