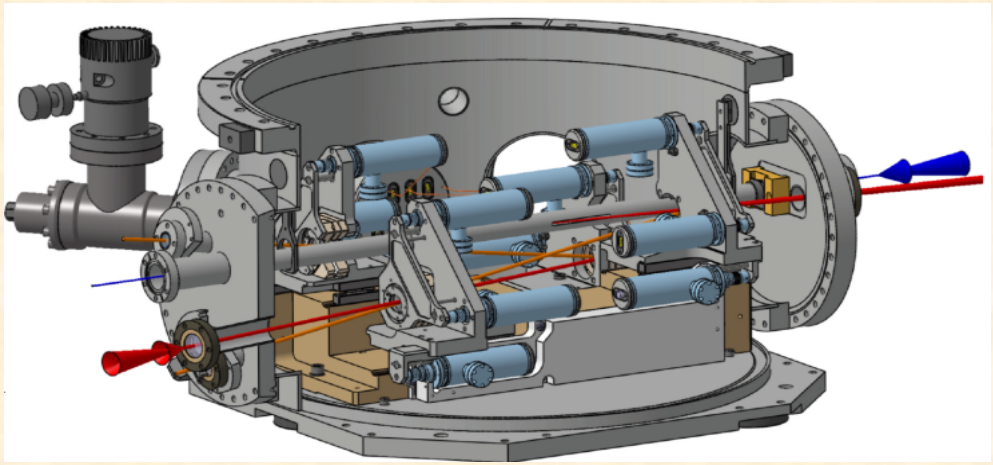


Recent results from MightyLaser

Nicolas Delerue
On behalf of the MightyLaser collaboration
LAL (CNRS and Université de Paris-Sud)

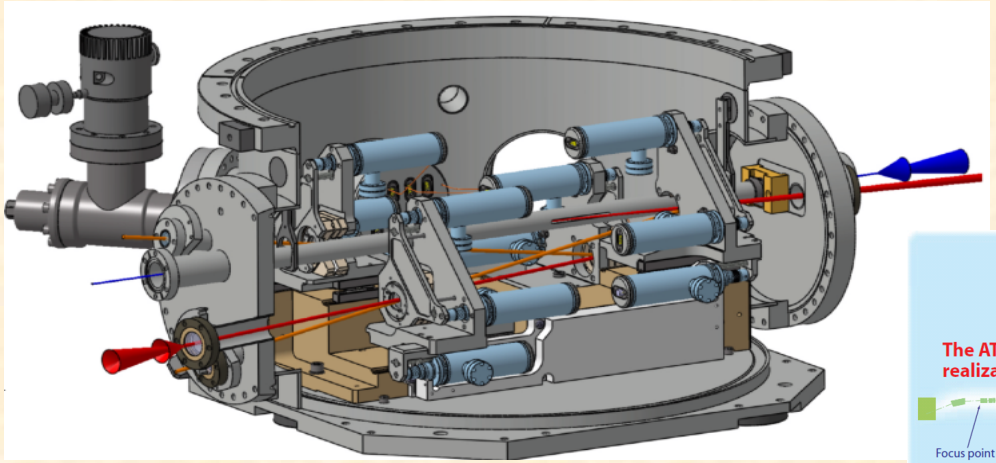
UNIVERSITÉ PARIS SUD
Comprendre le monde, construire l'avenir®

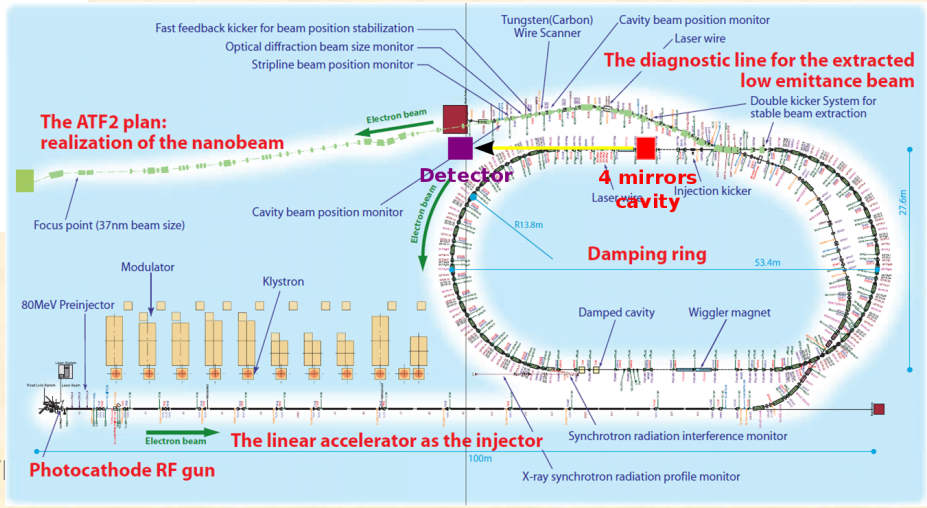
LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

cnrs dépasser les frontières
IN2P3 Les deux infinis

Reminder Mighty Laser

- Aim: produce high flux of polarised gammas by Compton scattering in a 4-mirror Fabry-Perot cavity.
- Installed in a straight section of the ATF-DR.





Upgrades since 2011

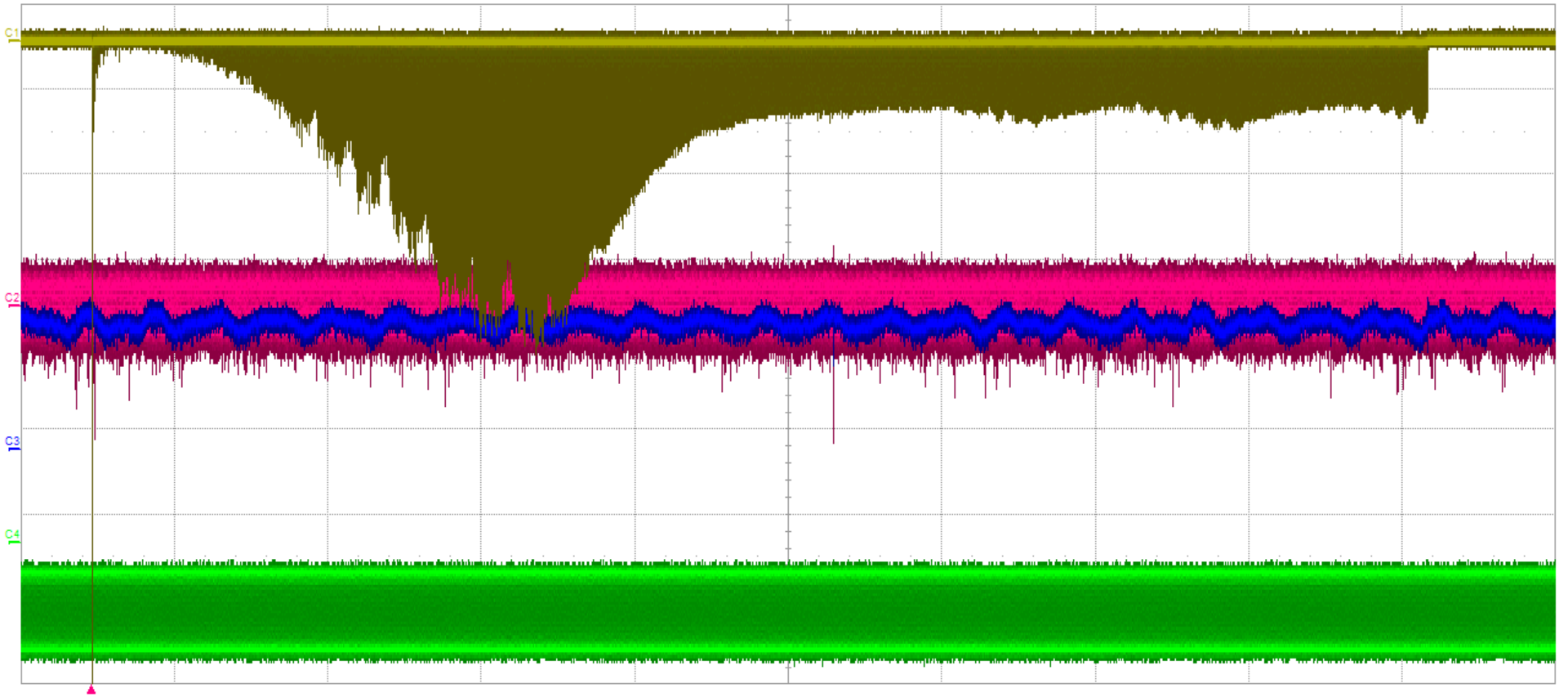
- Laser changed for better control over CEP and better reliability but phase noise.
- The laser amplification chain has been fully upgraded (based on fibres).
- Mirrors finesse improved to 40k.
- Extensive tests at LAL to improve the locking (best power stored at LAL: 81kW locked).
- Best power during our run 40kW locked.

Operations in December 2012

- 2 weeks of data taking.
- 6 collaborators from LAL at KEK
  + remote support from colleagues in Europe.
- Most data taking done parasitically.
- Aim:
  demonstrate that high power can be stored in the cavity and that the resulting gamma-ray flux can be sustained for a long time.

Collisions achieved very easily!

- Very strong & clear signal (after adjusting the movers)

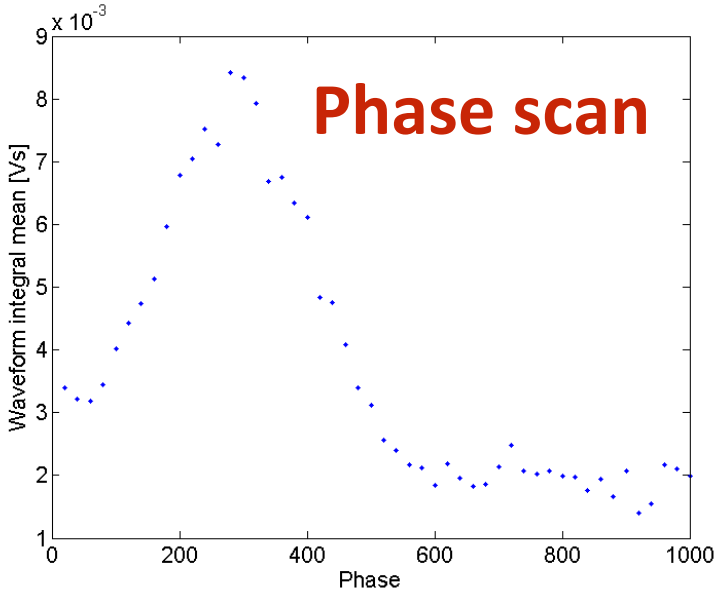


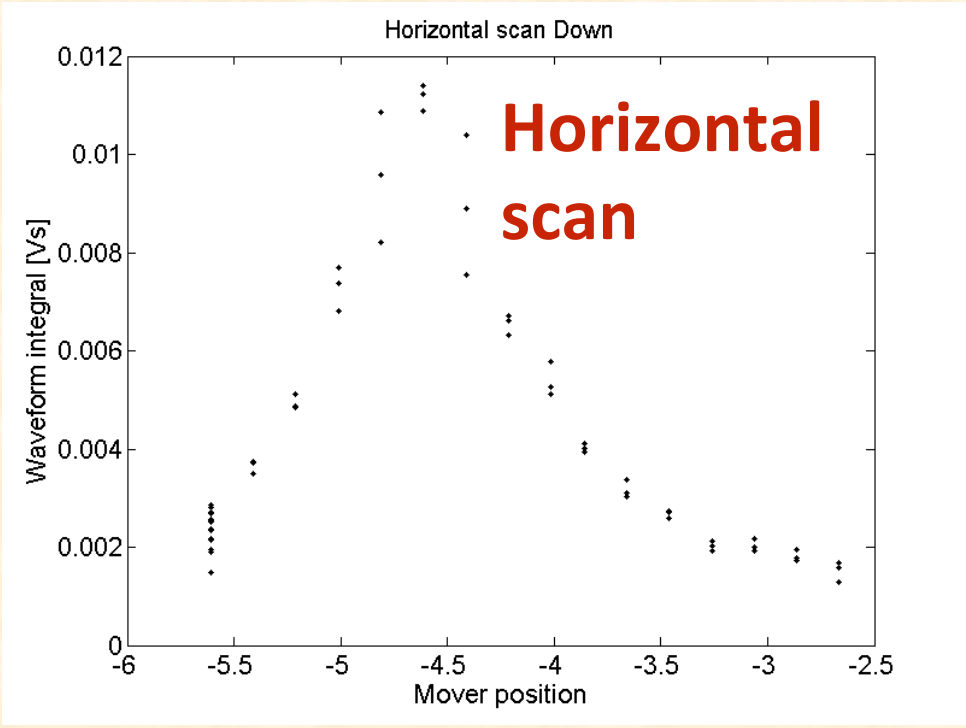
Measure	P1:area(C1)	P2:mean(C3)	P3:Rescale(P2)	P4:- - -	P5:- - -	P6:- - -	P7:- - -	P8:- - -
value	-12.546107150 mVs	73.4 mV	29.35 kW					
mean	-5.94207922978 mVs	67.544 mV	27.0175 kW					
min	-15.771320502 mVs	57.3 mV	22.90 kW					
max	603.163061 µVs	75.8 mV	30.32 kW					
sdev	5.66748991845 mVs	5.255 mV	2.1021 kW					
num	394	400	400					
status	✔	✔	✔					

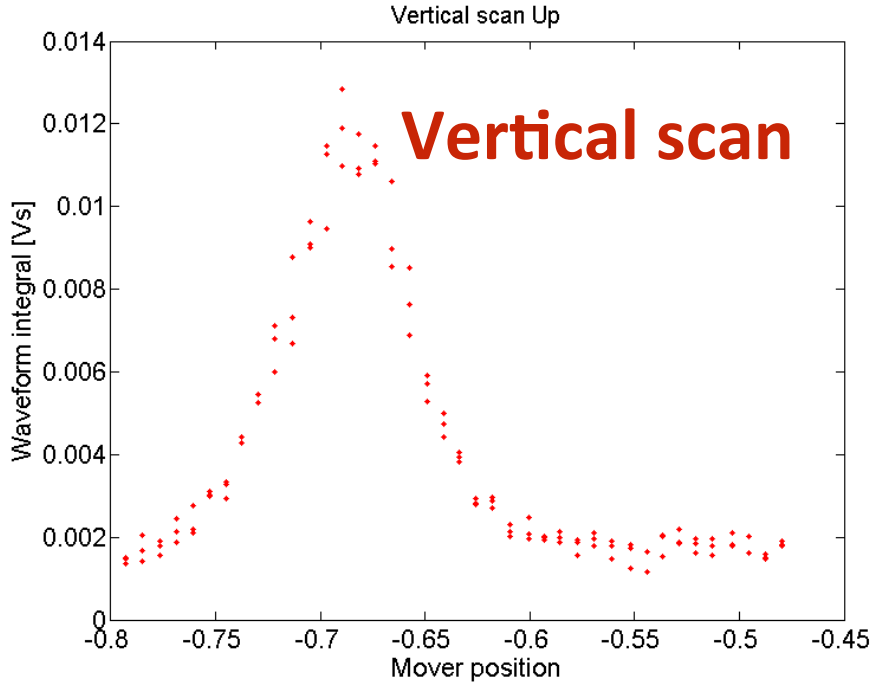
C1 DC50 500 mV/div 1.780 V | C2 DC1M 500 mV/div 220 mV | C3 DC1M 50.0 mV -62.0 mV | C4 DC50 500 mV/div -1.165 V

Tbase -227 ms 50.0 ms/div 1 MS 2 MS/s | Trigger Ext DC Stop -200 mV Edge Negative

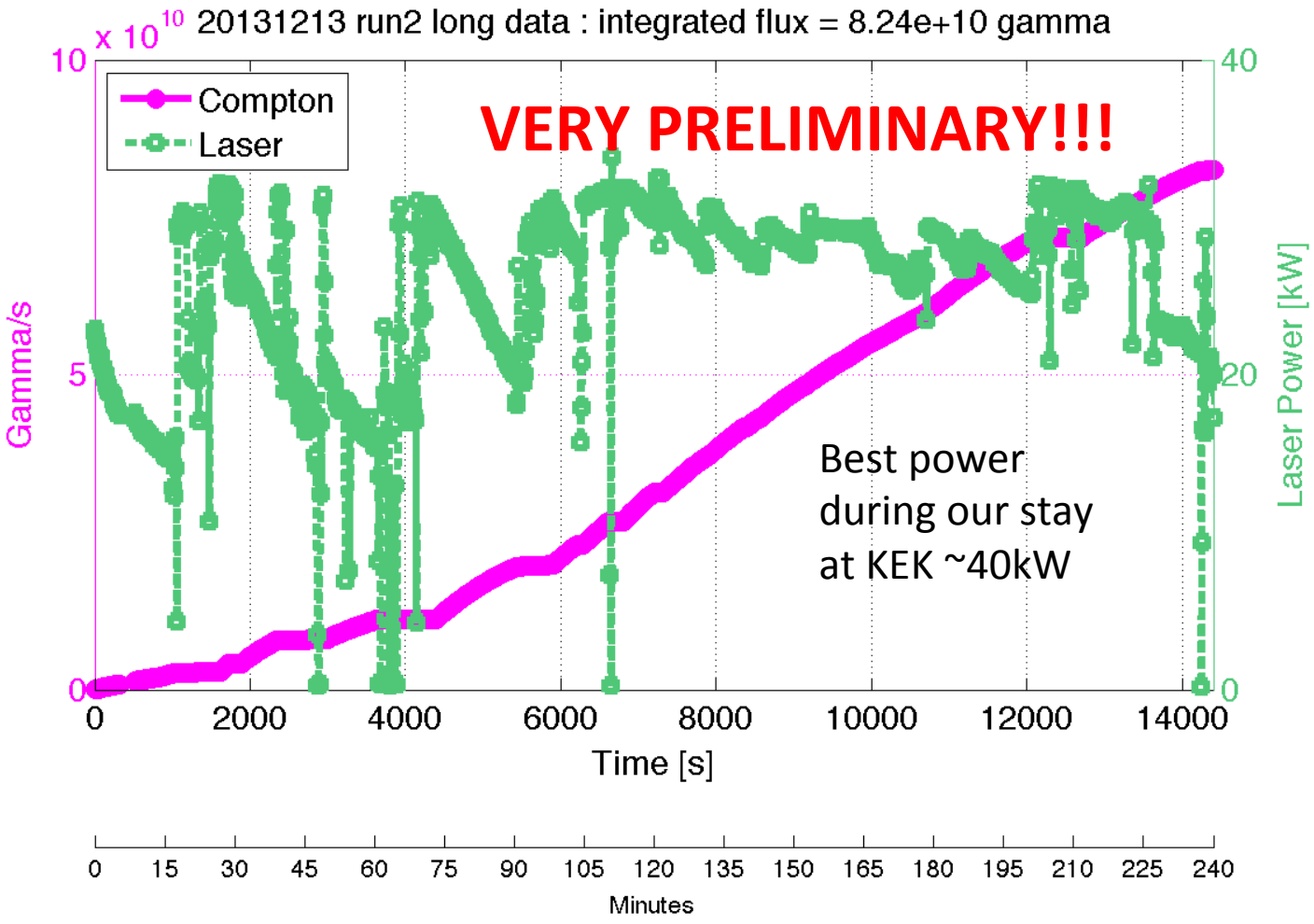
Position and phase scans





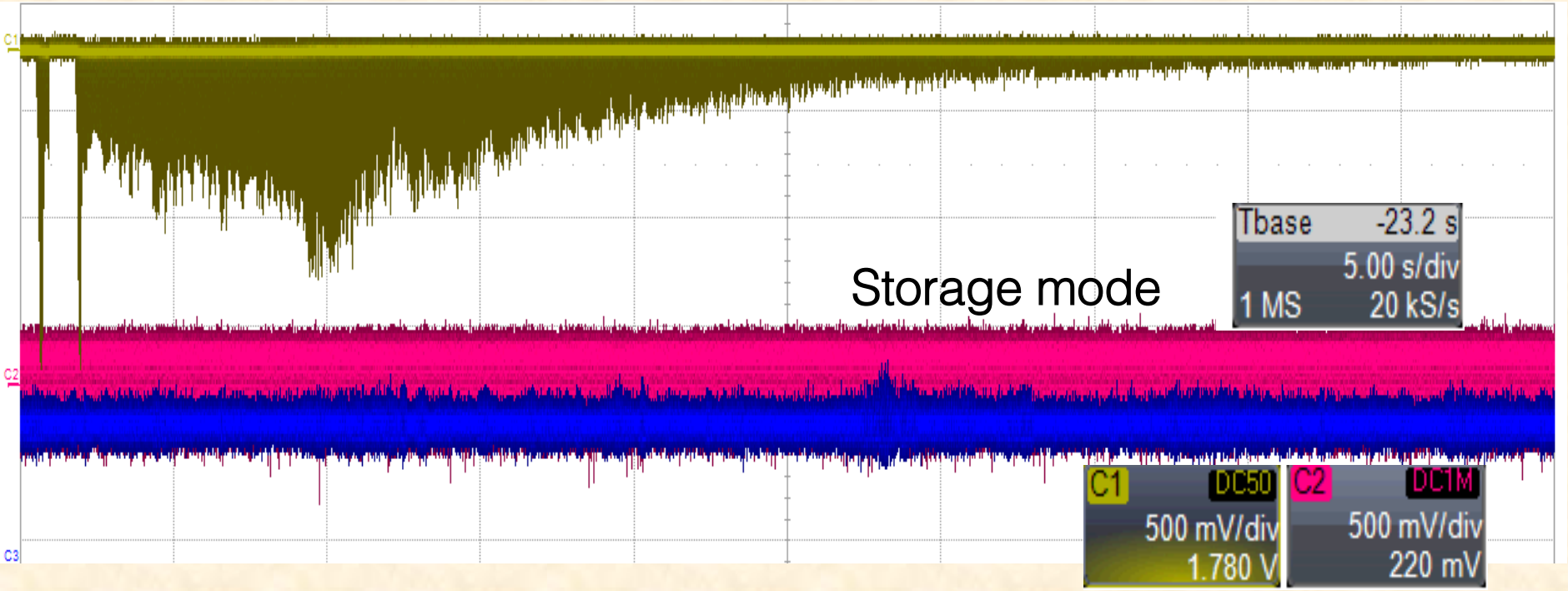


Long run with high power

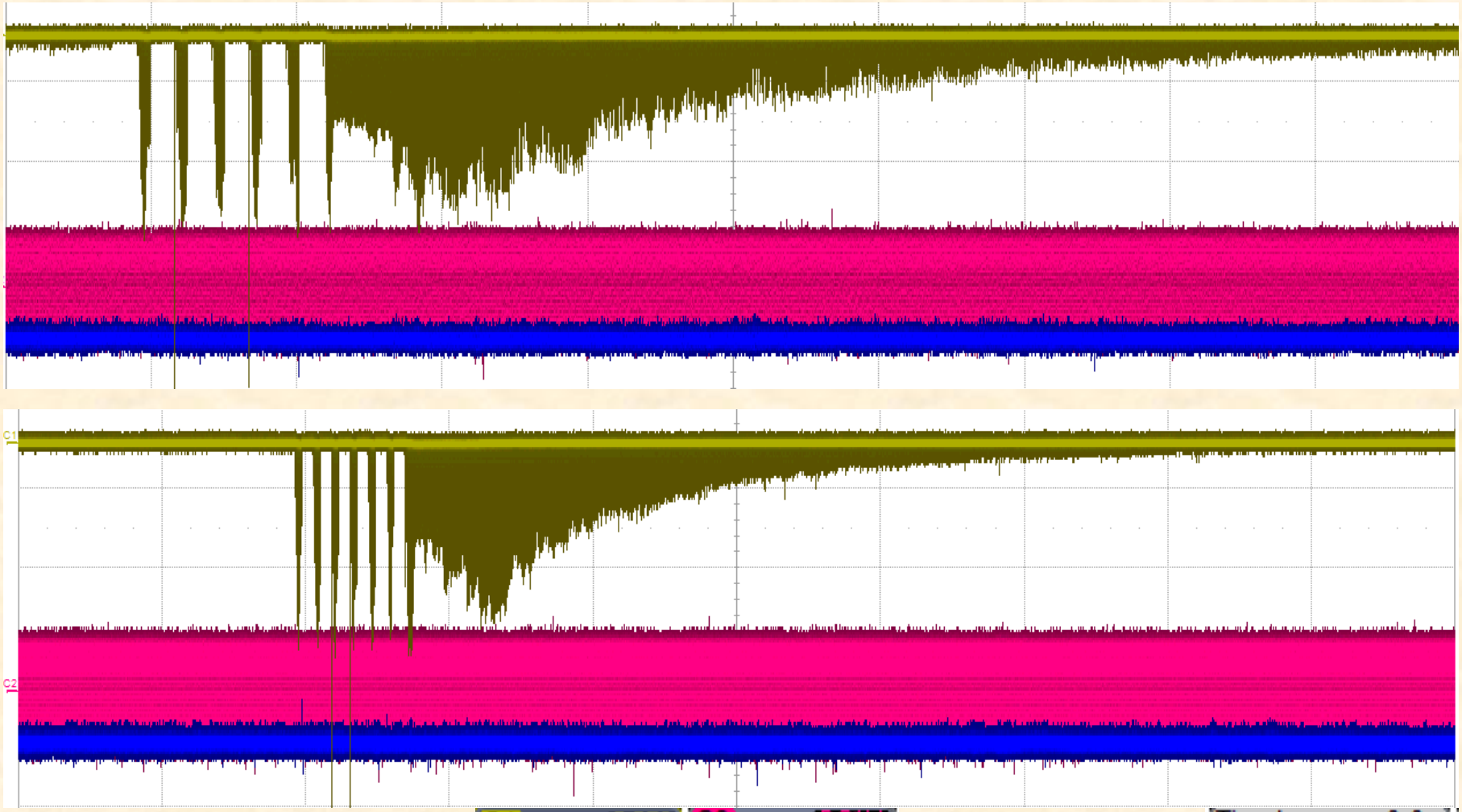


Long beam storage

- We did use long storage period to study flux stability and impact on the beam lifetime.
- In storage mode we observed an expected « peak » in Compton flux after ~7s at full laser power.

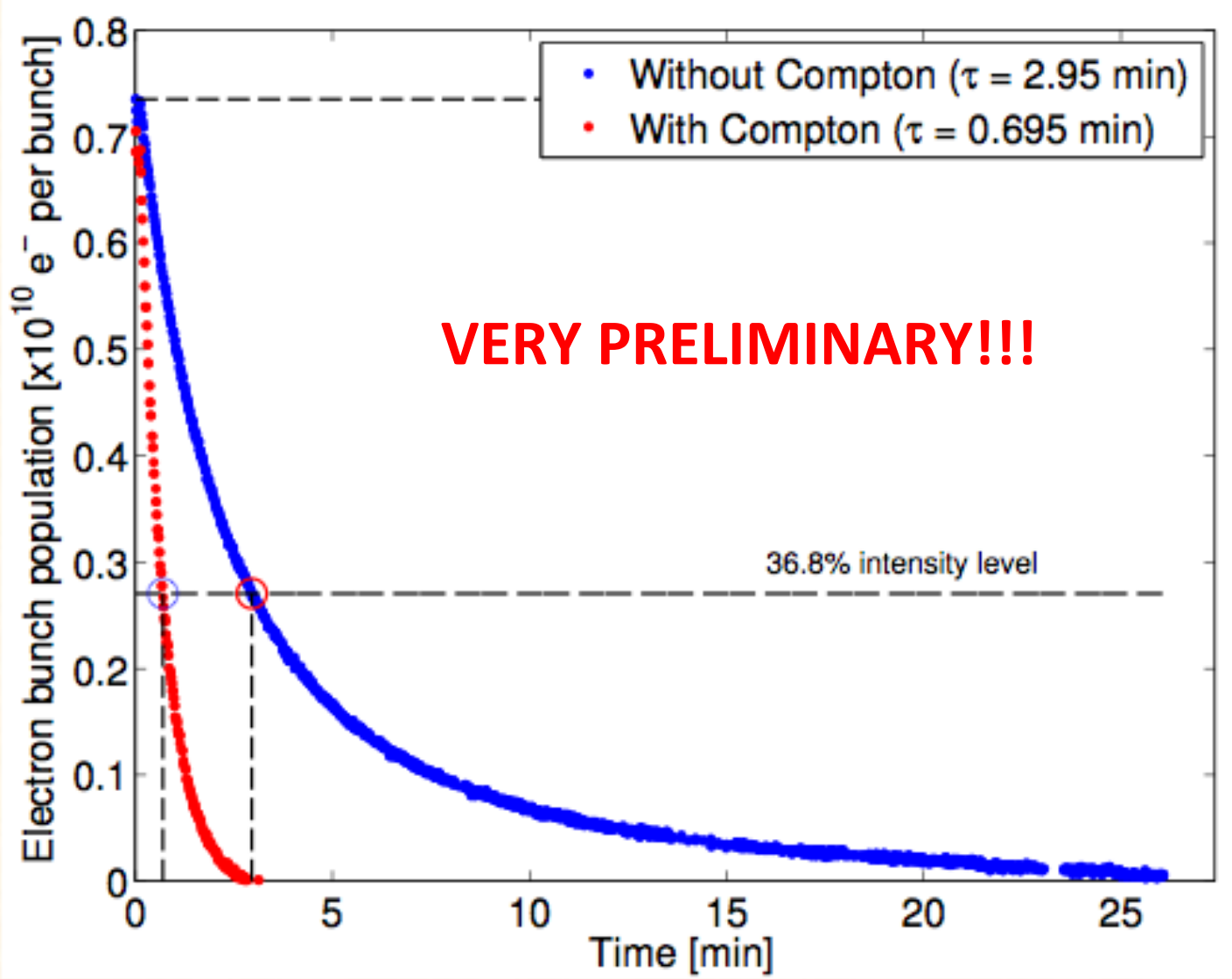


Other examples

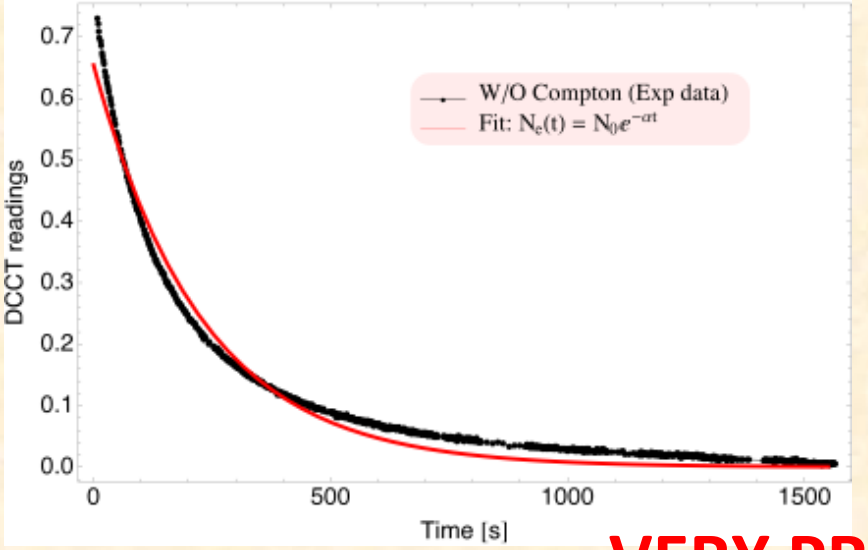


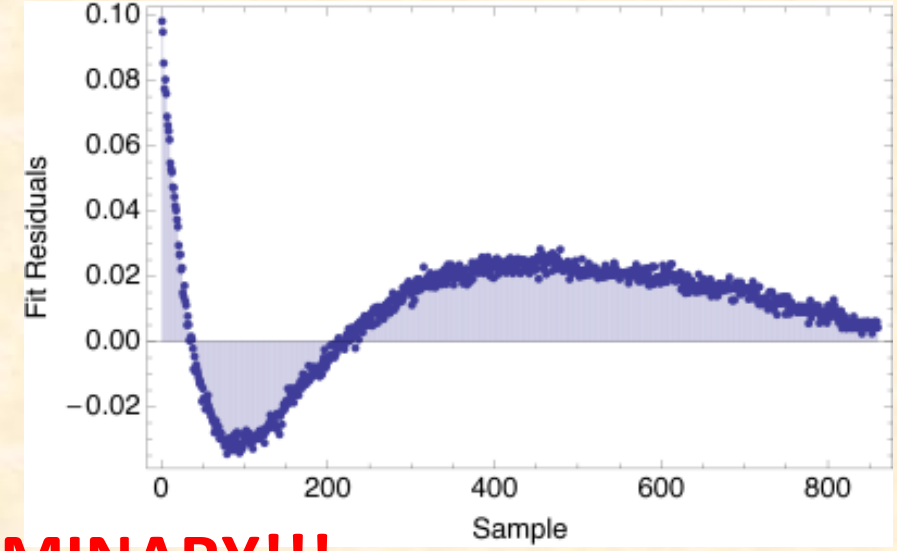
Storage mode

Beam lifetime decrease

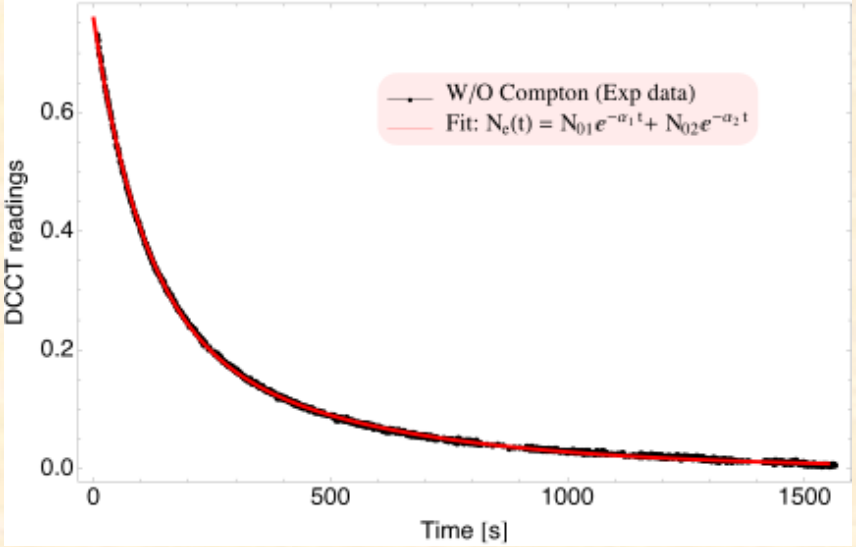


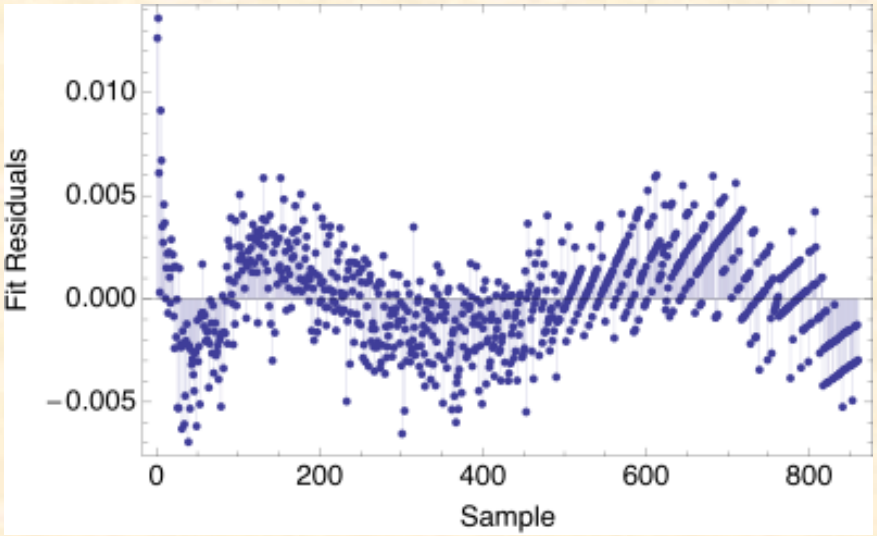
Lifetime without Compton



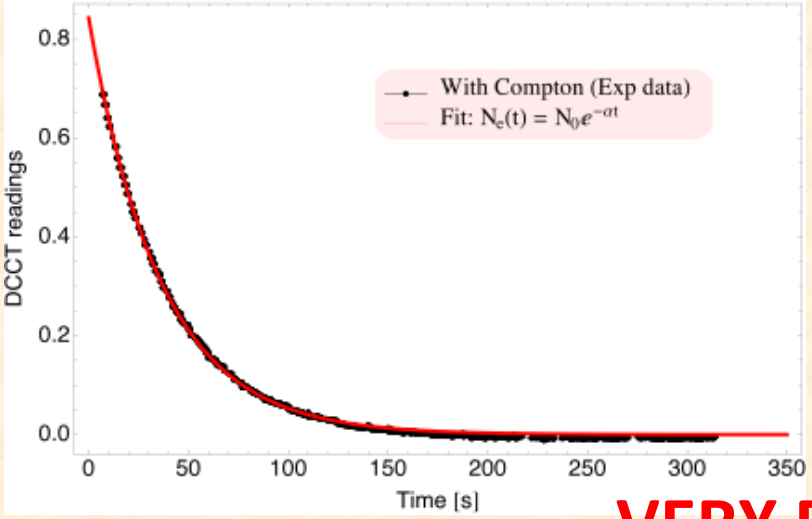


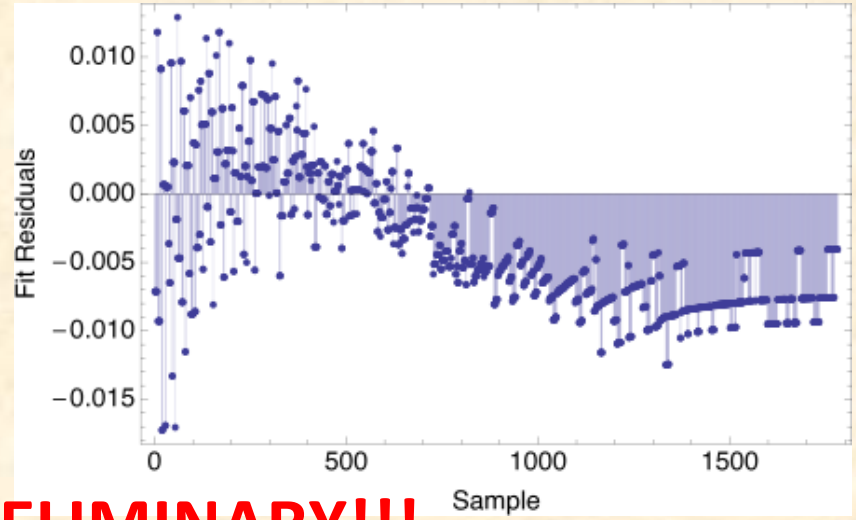
VERY PRELIMINARY!!!





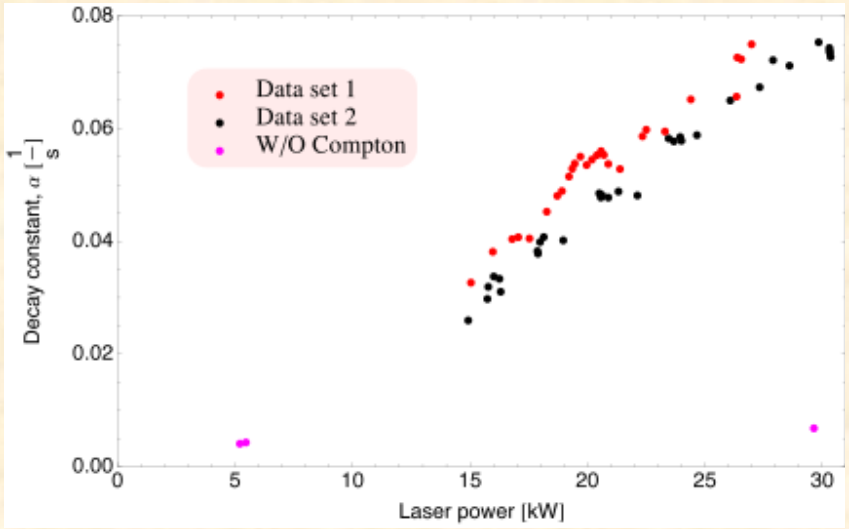
Lifetime with Compton





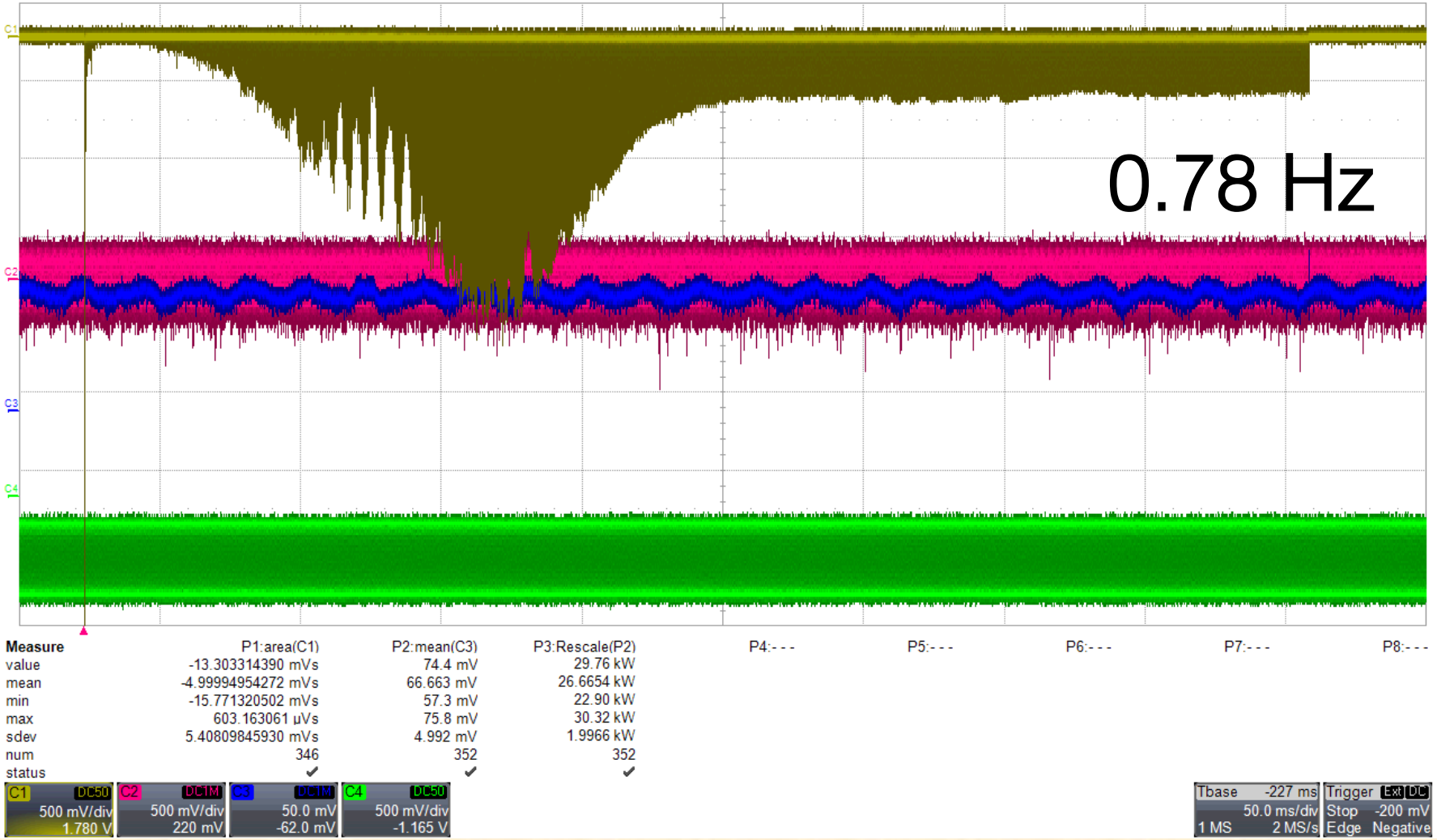
VERY PRELIMINARY!!!

- As expected with Compton scattering an exponential fit gives the lifetime.
- Clear linear relation between beam lifetime and laser power.
- Reasonnable agreement with predictions.



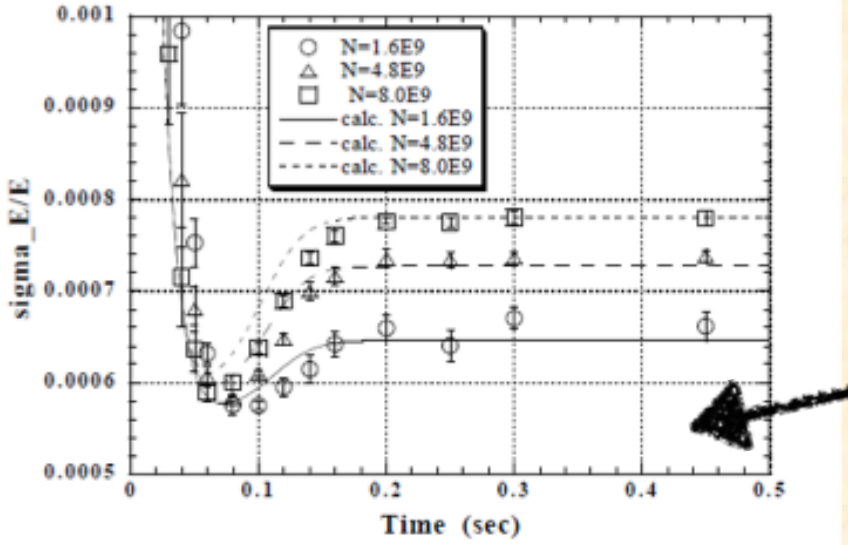
Extra: IBS

- We were also impressed by how well we could see the effect of IBS in our data!



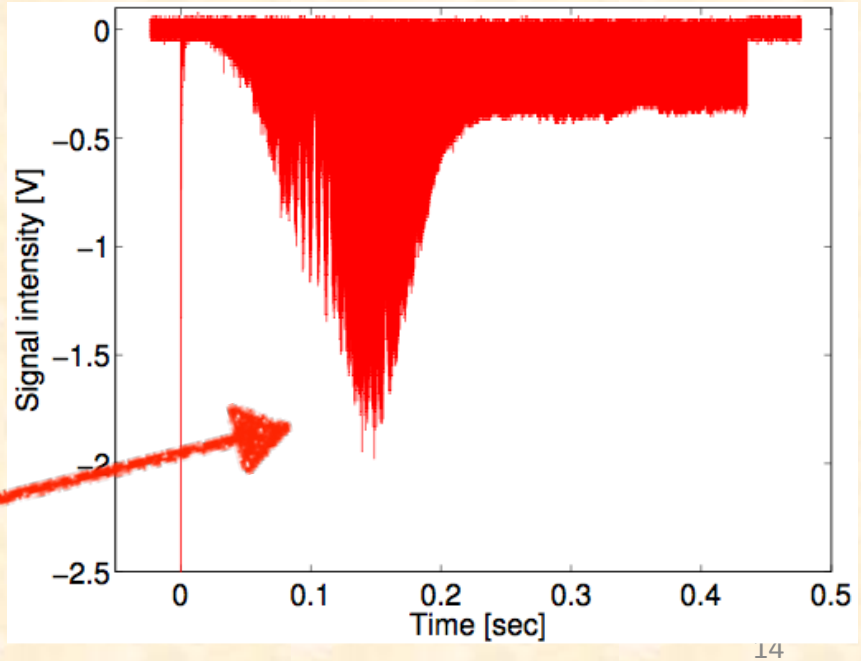
Effect of intrabeam scattering

K. Kubo et al., Phys. Rev. Lett. 88, 194801 (2002).



Measured energy spread as function of time after injection, for three different currents.

Measured Compton signal intensity ~number of scattered gamma rays ~ (electron bunch size at the IP)$^{-1}$ as function of time after injection.

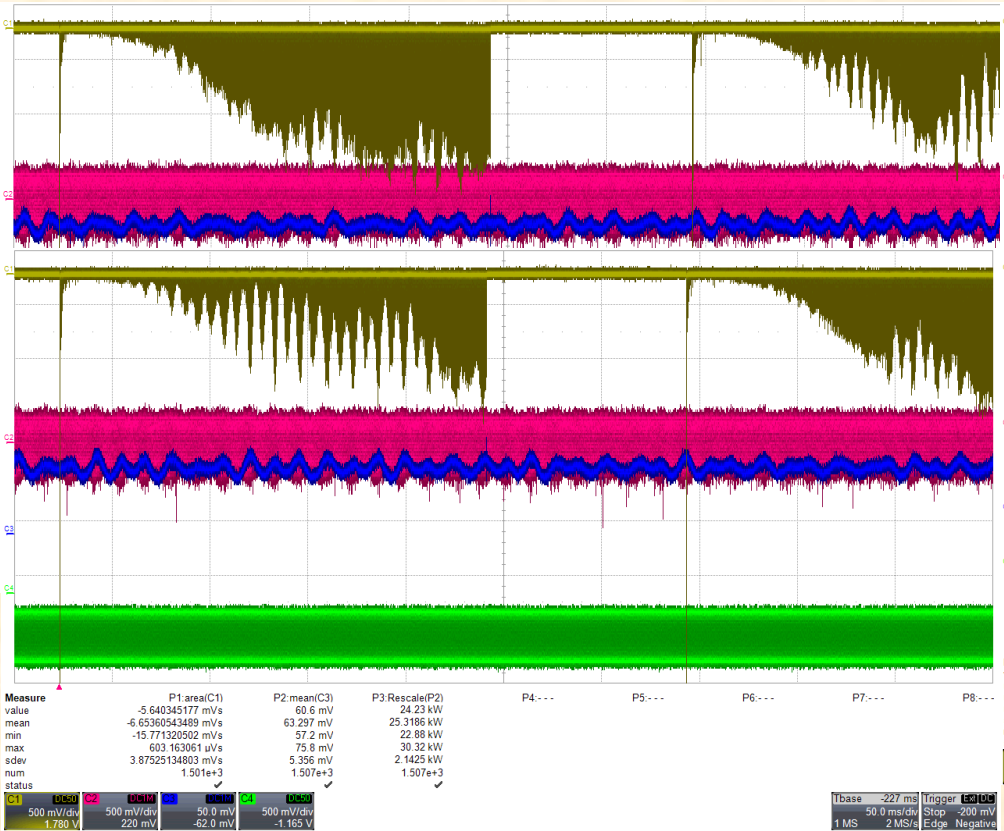


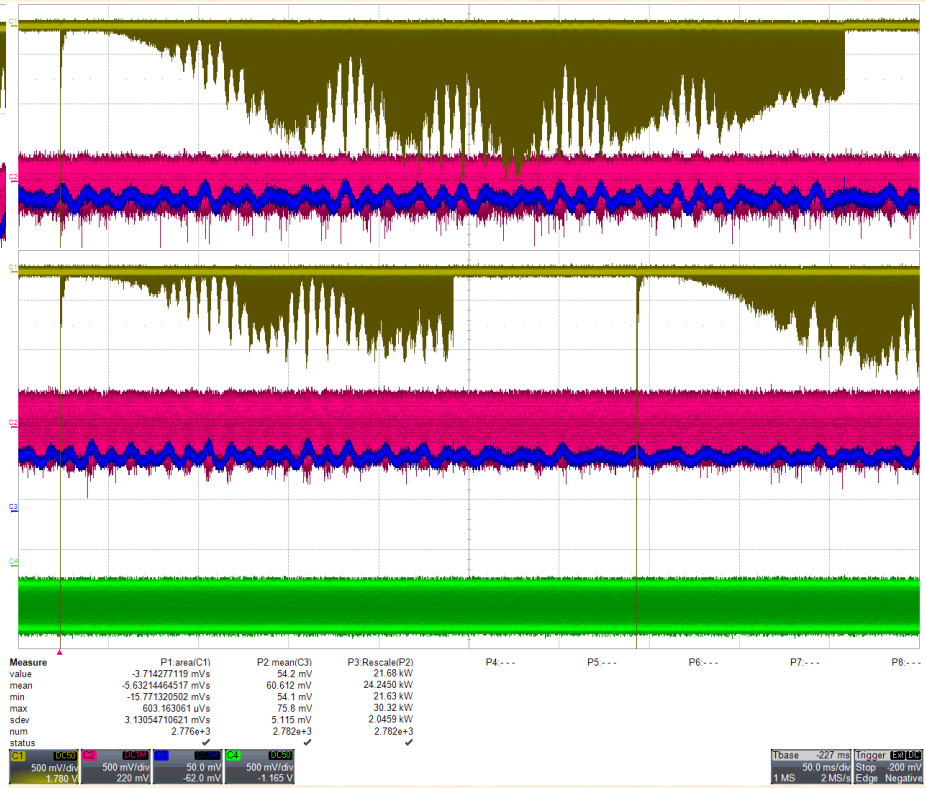
Limitations

- Several effects limited the power stored in the cavity:
  - Thermal effects at the beam compressor (CVBG) & wavefront changes => bad coupling
  - Mirrors thermal deformation => mode changes
  - 80Hz oscillations in the signal (due to a nearby pump?)
- The laser amplifier was able to deliver much more power than what was used because we could not inject more power in the cavity.

80Hz oscillations

- During several shots we observed oscillations in the Compton flux at about 80Hz.
- Oscillations can be present on one shot and much smaller on the next one…
- Partial correlation with an effect on the laser… => Vibrations?
- Effect of a pump?





Outlook and Future plans

- We had a very successful run in December and we are grateful to our ATF colleagues who helped us with this run.
- We are writing a short paper summarizing the results and a longer « technical » paper describing the R&D and the system.
- After the jump in performance by a factor > 100 in flux we have identified several limitations in our system that need to be addressed but such work will be easier to do outside an accelerator tunnel.
- Further R&D at LAL for now => ThomX.

Due to embargo rules with some journals we are careful with the results we circulate until the paper is submitted and accepted.