

APEX: recombination studies

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Radiative recombination of ions was extensively studied experimentally. Perfect agreement between measurements and theoretical prediction for the recombination coefficient was found in a wide range of relative energies between the electrons and ions ($>10\text{meV}$).

However, in the region of extremely small relative energies (which is the region typically used for electron cooling), the measured recombination coefficient for experiments with bare ion was found significantly higher than predicted by standard theory of radiative recombination.

At RHIC during LEReC setup in 2019 the recombination enhancement **was observed first time without continuous** solenoidal field. The goal of this experiment is the systematic study beam losses due to recombination for different energy offsets and energy spread.

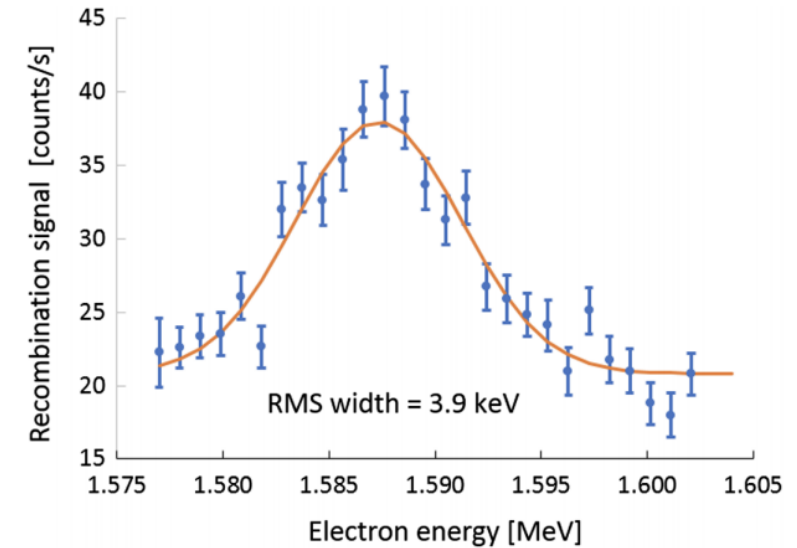
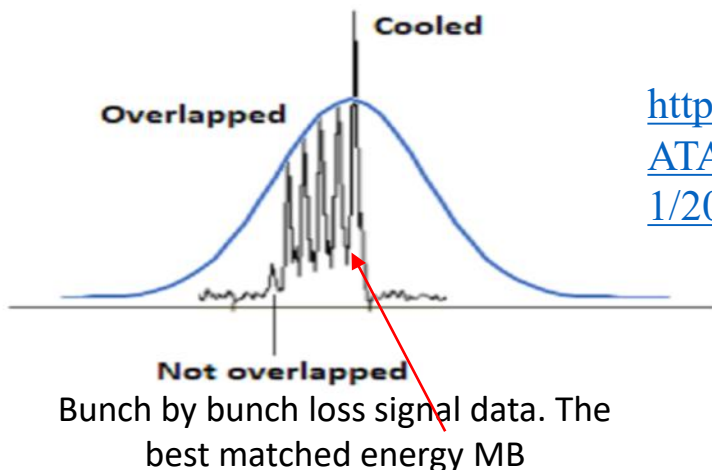


FIG. 7. The recombination signal (blue dots) dependence on beam energy (as measured by spectrometer) during the scan. The error bars for each point represent the rms of the recombination signal at each energy setting averaged over two scans. RMS width of the measured trend is calculated from Gaussian fit of the data (orange solid line).

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http://www.cadops2.bnl.gov/elogs/entryList.jsp?DATABY=day&ELOG=LEReC_2019&DATE=04/11/2019&DIR=none#968776

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Summary of April 2019

- It seems that bunch by bunch loss rate near recombination monitor location is well correlated with:
 - Presents of electrons
 - Energy of electrons
- For this RHIC/LEReC parameters the loss rate was about 10-15 events/minute.
- The energy dependance distribution of the losses looks not exactly Gaussian.
 - Should try to scale with ion bunch intensity to get more accurate curves

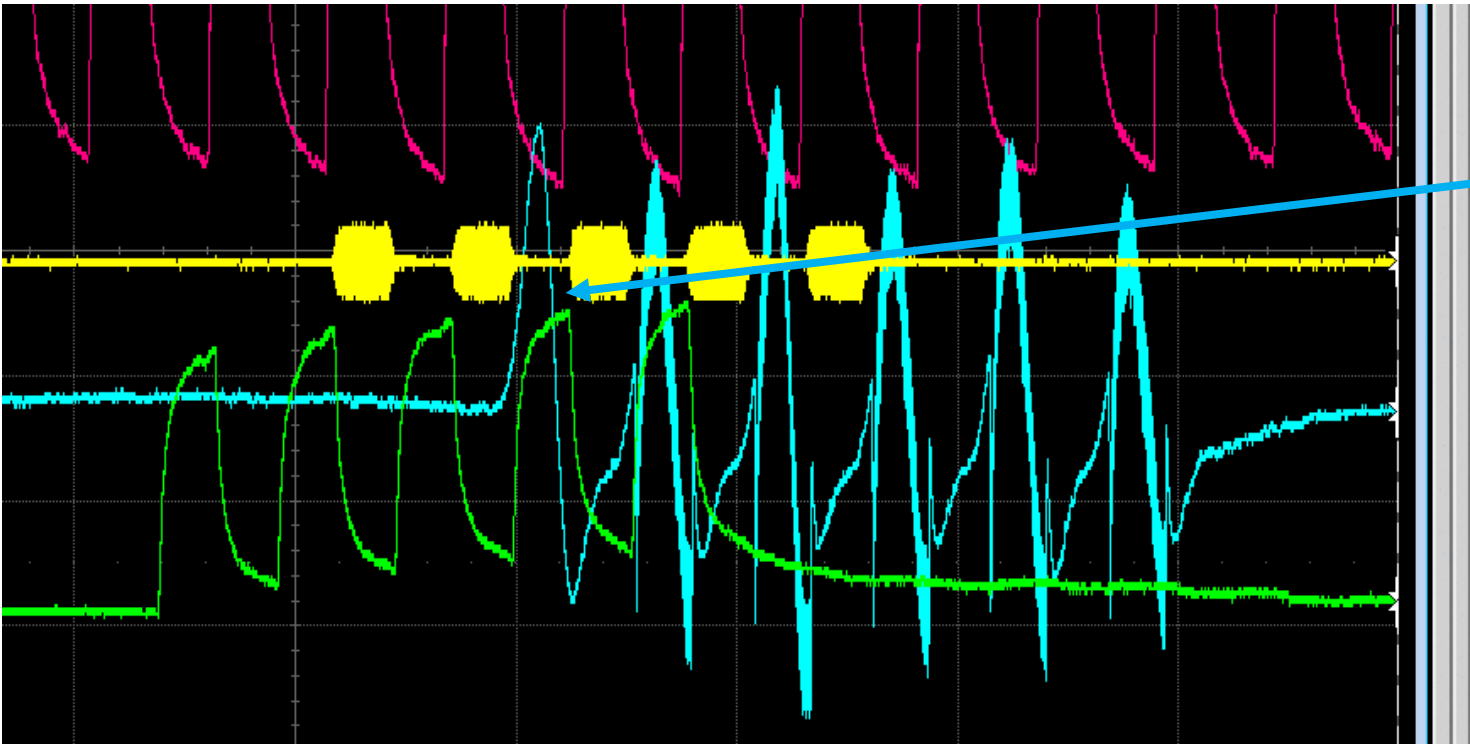
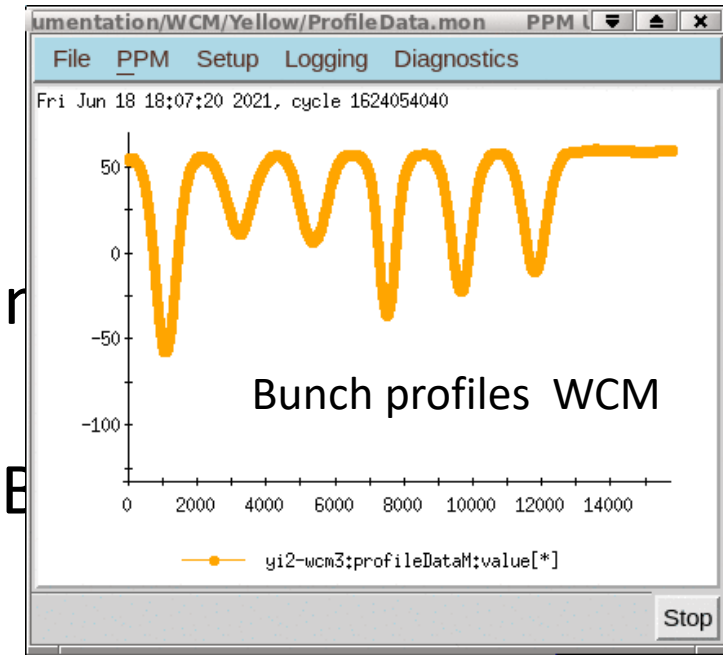
Plan for next APEX June 2021:

- Use more intensity per bunch RHIC and LEReC
- Try LEReC 76kHz mode with 6MB (or 10MB if possible)
- Preferable configuration: several bunches in RHIC and 1 less LEReC Mbunches.
- Question
 - Should we setup Au19-4GeV-25m or try with Au21? **No new/old lattice**
 - Let's try local bump, instead.

RHIC/LEReC setup:

On June 18

- We used regular RHIC lattice with and without local bunching
 - 6 bunches per store with intensity $0.4-1.5e9$ per bunch
- For LEReC we used regular 5 MB with 3 and 2nC per MB
 - beam loading per MB 3.3keV. charge 3nC per MB

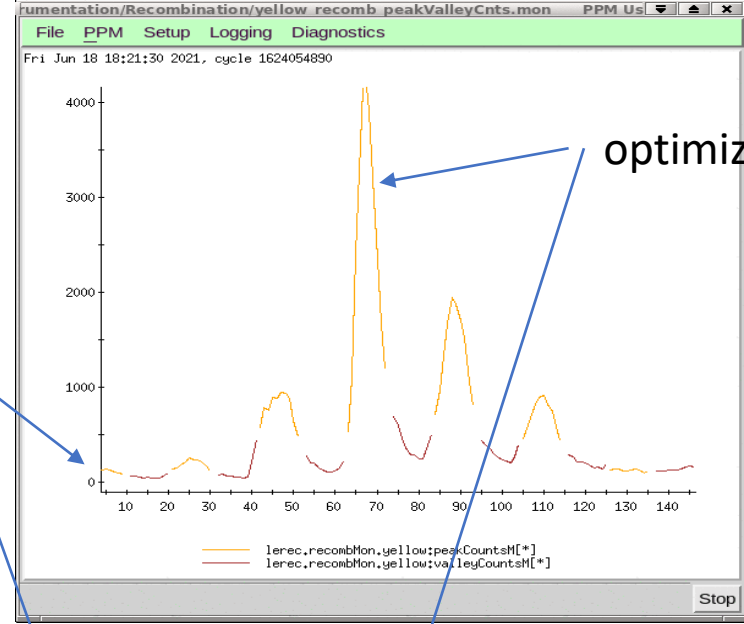
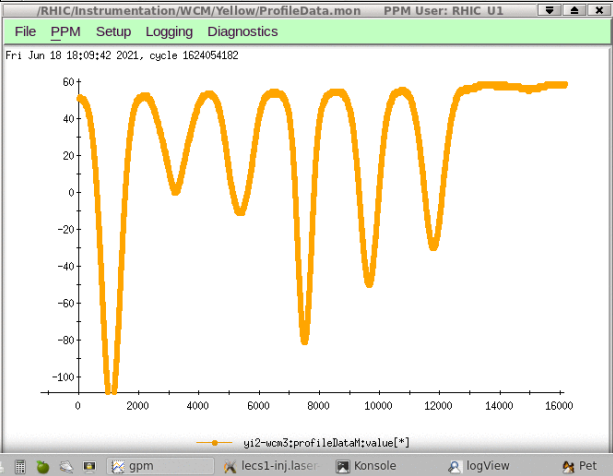
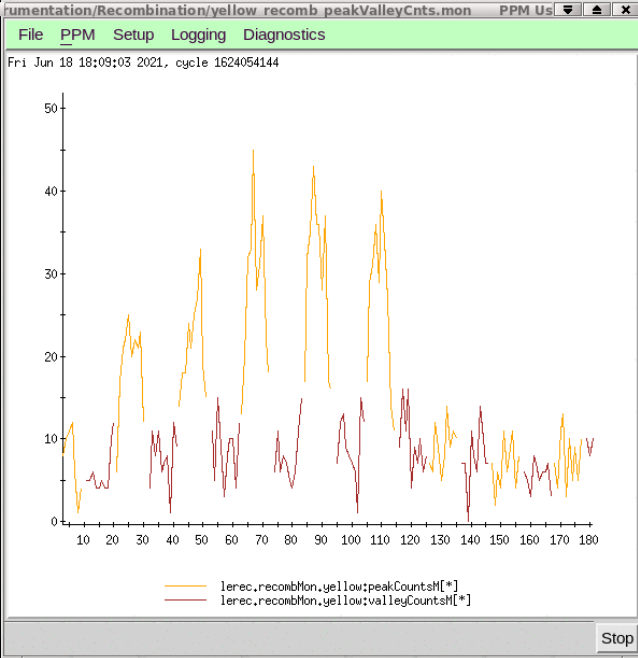


Cyan trace is signal from BPM in the cooling section
1st RHIC bunch is not overlapping with LEReC bunches
5 followed bunches are overlapped with LEReC bunches

Bunch by bunch recombination loss signal

With local bump

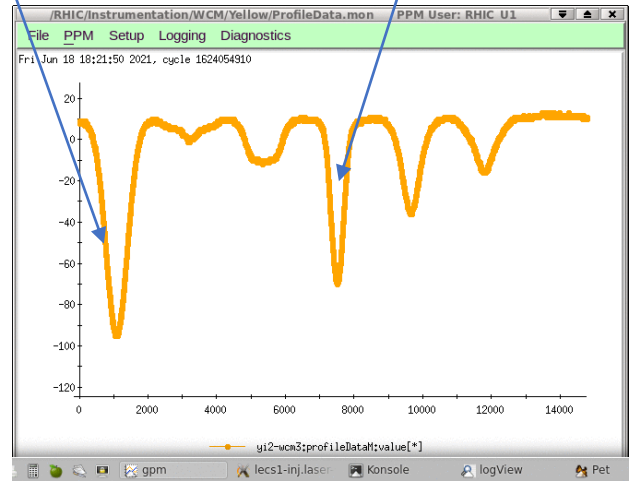
Without local bump



Non interacted bunch #1

optimized energy

WCM profiles



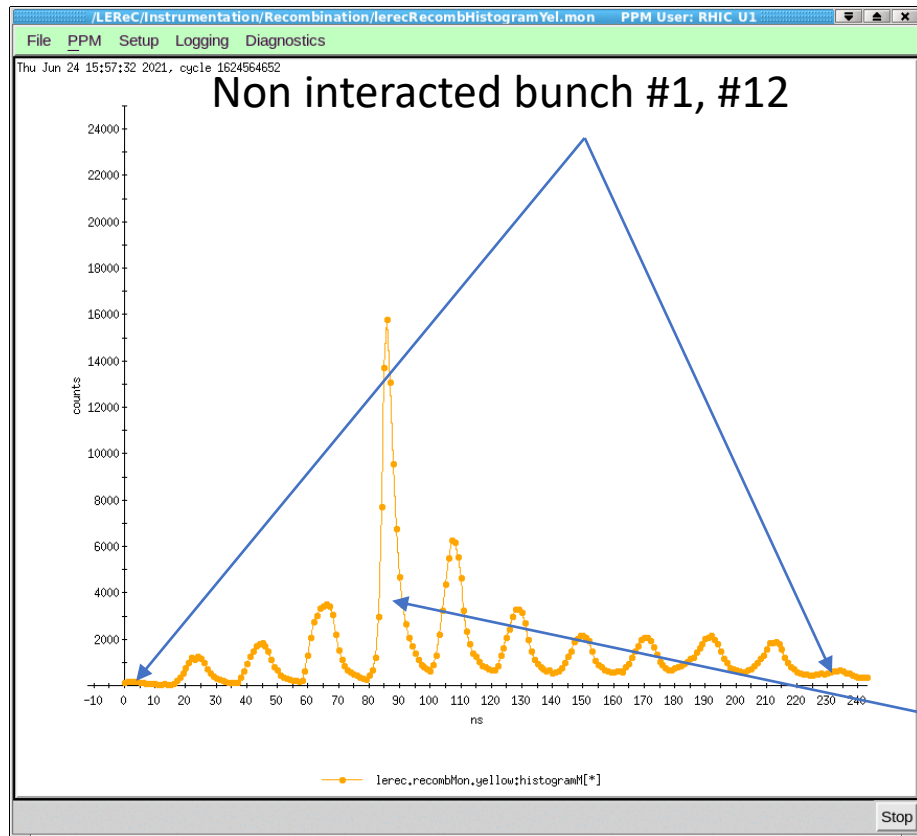
APEX June 23

We used regular RHIC lattice with local bump:

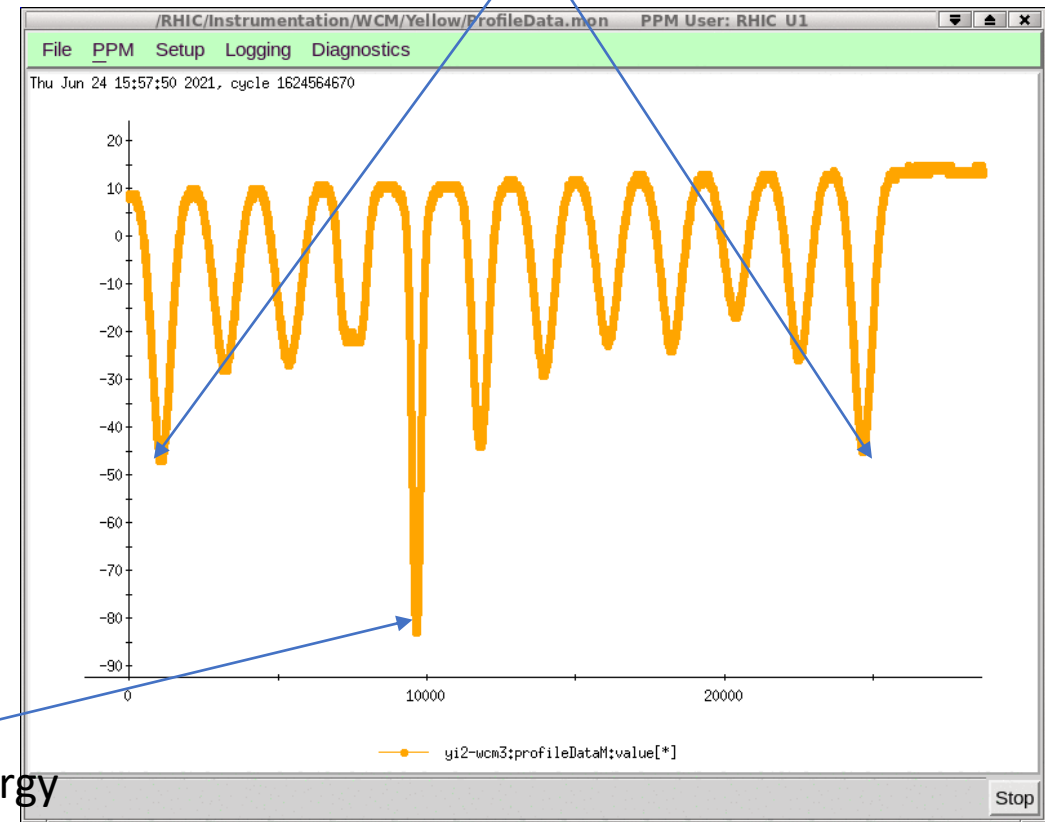
12 bunches per store with intensity $0.4\text{-}1.5 \times 10^9$ per bunch

For LEReC we used regular 10 MBs with 1.3 nC per MB

beam loading 1.4 keV per MB

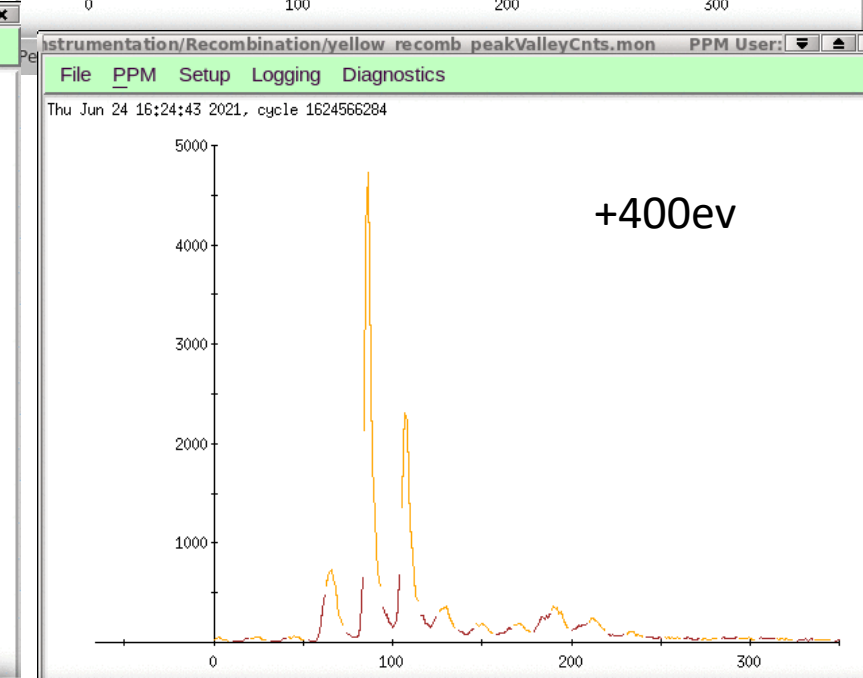
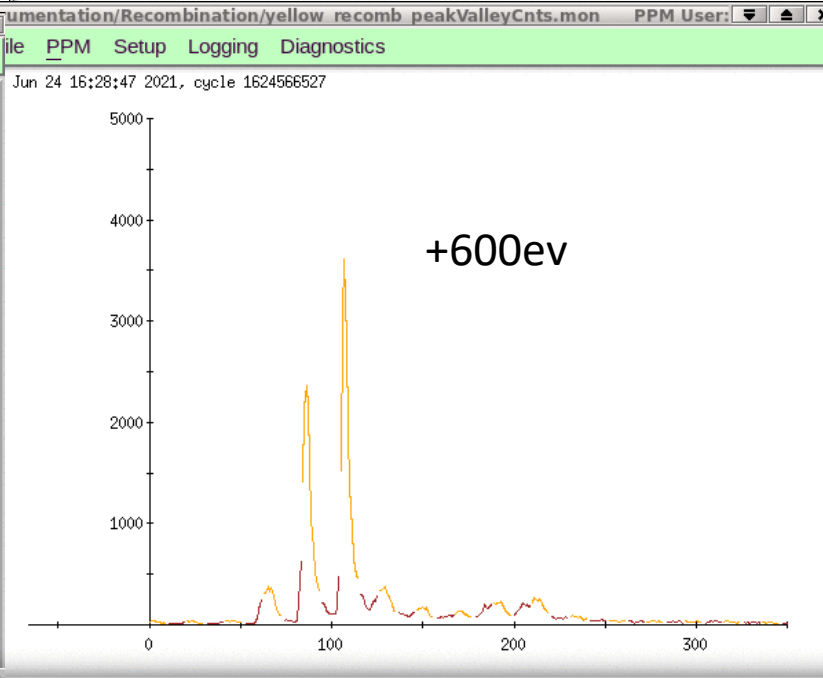
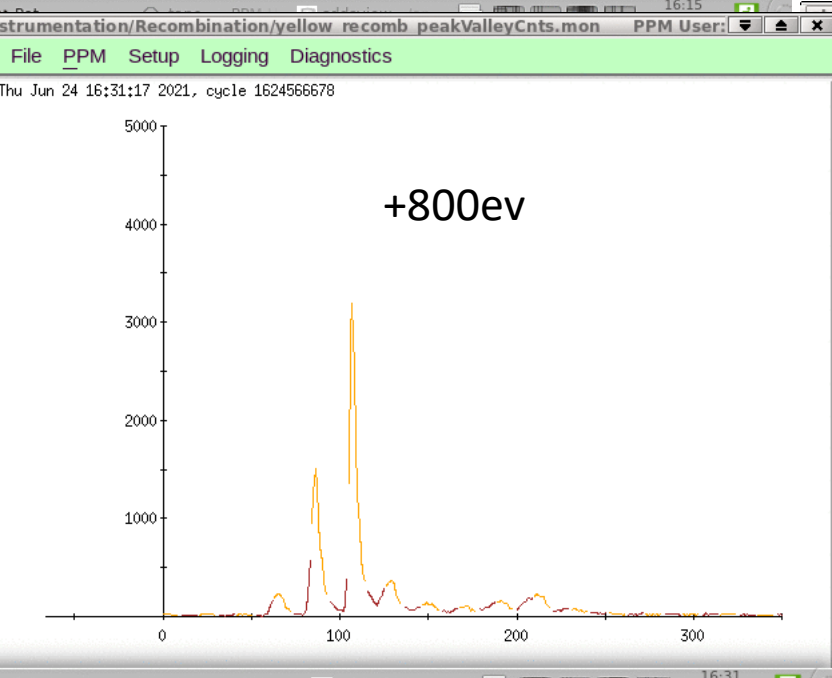
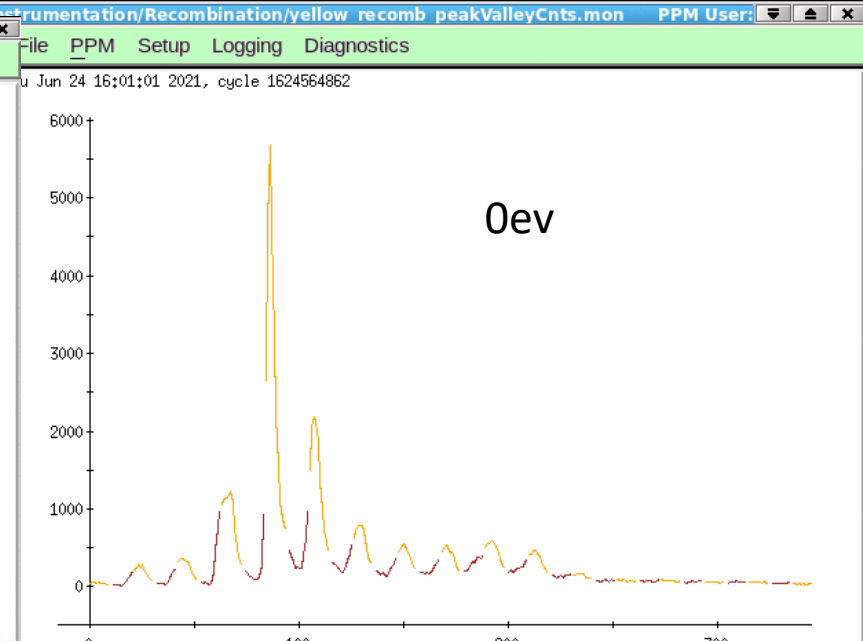
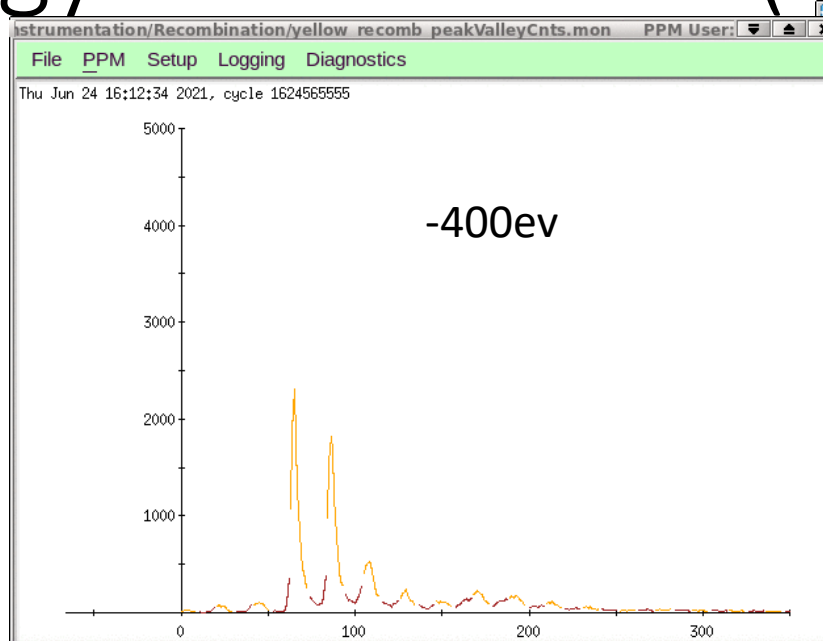
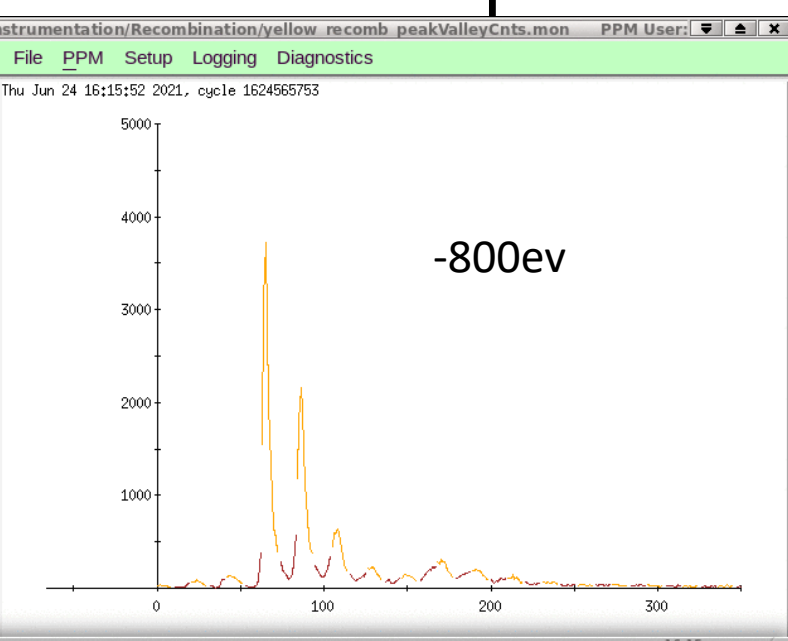


Non interacted bunch #1, #12



Optimized energy

Small steps energy scan $\sim 200\text{eV}$ ($dE/E=1e-4$)



APEX on Recombination studies summary (so far)

- We clearly observed energy dependence recombination signal
- Introducing local bump significantly improved statistic
- Good sets of the data were collected
- Need to finish data analyzes taking to account individual bunches intensity