Using Event Trigger Panel for IE/AB and Transmission Curve Calibrations

Benjamin Nault + Jimenez Group

AMS User's Meeting, Portland

October 21st - 23rd, 2016

Take Away Points—ET is a Powerful Tool for AMS IE and Transmission Curve Calibrations

- ET reduces the calibration time for IE calibrations
  - This is especially important for IE calibrations out in the field
  - This also provides Lens Transmission checks with each calibration
- ET can be utilized for Lens Transmission Curve calibrations with less uncertainty than mass transmission curves

Typical Methods to Calibrate AMS IE with NH_4NO_3

Well covered by Ed Fortner and John Jayne in 11th[1] and 14th[2] Users Meeting

CPC Mass Calibration

1) Relies on mass measured by AMS with mass measured by CPC
2) Many errors can be introduced by uncertainties with CPC, DMA, lens alignment, doubles, etc.

Single Particle Calibration

1) Relies on detecting the number of ions from a single particle
2) Avoids errors introduced by CPC and CPC Mass Calibrations
3) Need low number conc. of NH_4NO_3 (150 – 250 particles/cc)
4) Typically use 400 nm, but can use anything between 300 – 450 nm

1. http://cires1.colorado.edu/jimenez-group/UsrMtgs/UsersMtg11/Jayne_Calibrations.pdf
2. http://cires1.colorado.edu/jimenez-group/UsrMtgs/UsersMtg14/ed_AMS_Calibrationsuser2013.pdf

The Way Single Particle (SP) is Measured Depends on the Data Acquisition Card Used for your System

AP240 (old data acquisition card) vs ADQ (new acquisition card)

- Old card is old; therefore, not as fast as the new ADQ
- For SP with old card, data had to be transferred from card to computer; then, card had to wait for next event
- For ADQ, the ADQ goes into SP mode to store all single particle events and then data is transferred (faster & more events)
- For ADQ, custom firmware from Tofwerk that makes SP faster
- ADQ needs less signal to run, so the SI is lower **Important for comparisons**

The Way Single Particle (SP) is Measured Depends on the Data Acquisition Card Used for your System

AP240 (old data acquisition card) vs ADQ (new acquisition card)

- Old card is old; therefore, not as fast as the new ADQ
- For SP with old card, data had to be transferred from card to computer; then,

ADQ IS BETTER FOR SP

then data is transferred (faster & more events)

- For ADQ, custom firmware from Tofwerk that makes SP faster
- ADQ needs less signal to run, so the SI is lower **Important for comparisons**

Using Old Data Card for Single Particle IE Cals

Pros:

- Do not need to use CPC to measure IE
- Can use CPC to compare CPC and BFSP counts
- Ability to spot check 1 point on lens transmission curve

Cons:

- Take 45-60 minutes to get enough statistics (e.g., > 300 events)
- Ability to only spot check 1 point on lens transmission curve
- One data file per event

Using Old Data Card for Single Particle IE Cals

Pros:

Do not need to use CPC to transmission curve

Cons:

Take 45-60 minutes to get enough

Older Card = Slower Acquisition = Slower Cal & Less Points

Using New Data Card for Single Particle IE Cals → Event Trigger!!

Pros:

- Do not need to use CPC to measure IE
- Can use CPC to compare CPC and ET counts
- Ability to spot check 1 point on lens transmission curve

Advantages compared to Old Card:

- Take ~15 minutes to get enough statistics (e.g., > 1000 counts)
- Can do multiple lens transmission curve points in same amount of time as old card
- One data file for entire run

Con:

- Cannot be used to calibrate capture vaporizers
- Similar to prior SP cals, can't use ET to calculate NH4 RIE

Using New Data Card for Single Particle IE Cals → Event Trigger!!

Pros:

Do not need to use CPC to transmission curve

Advantages compared to Old Card:

Take ~15 minutes to get enough

One data file for entire run

Newer Card = Faster Acquisition = Faster Cal & More Points

Con:

Cannot be used to calibrate capture vaporizers

Similar to prior SP cals, can't use ET to calculate NH4 RIE

Comparison of Old Card vs New Card IE Calibration on Same Day

Old Card SP Calibration Values
**NOTE: After correcting for different SI values between old and new card

- IE = 2.07×10^{-7}
- **IE/AB = 7.25×10^{-13}**

New Card SP Calibration Values

- IE = 2.22×10^{-7}
- **IE/AB = 7.42×10^{-13}**

ADQ needs less signal to run, so the SI is lower **Important for comparisons

Comparison of Old Card vs New Card IE Calibration on Same Day

Old Card SP Calibration Values

New Card SP Calibration Values

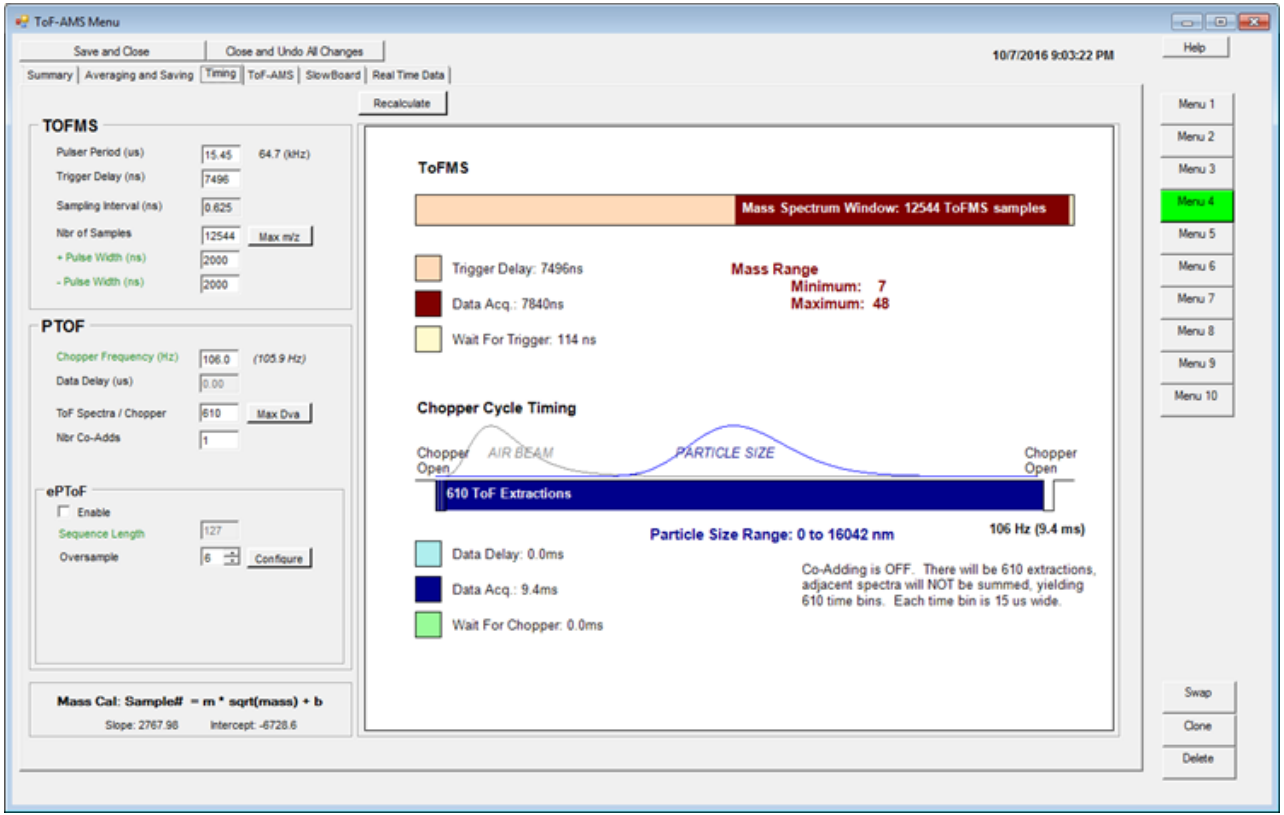
**NOTE: After correcting for

The two methods typically agree to within 5% when comparing IE/AB and correcting for the difference in the SI values between the two cards.

- **IE/AB = 7.25×10^{-13}**
- **IE/AB = 7.42×10^{-13}**

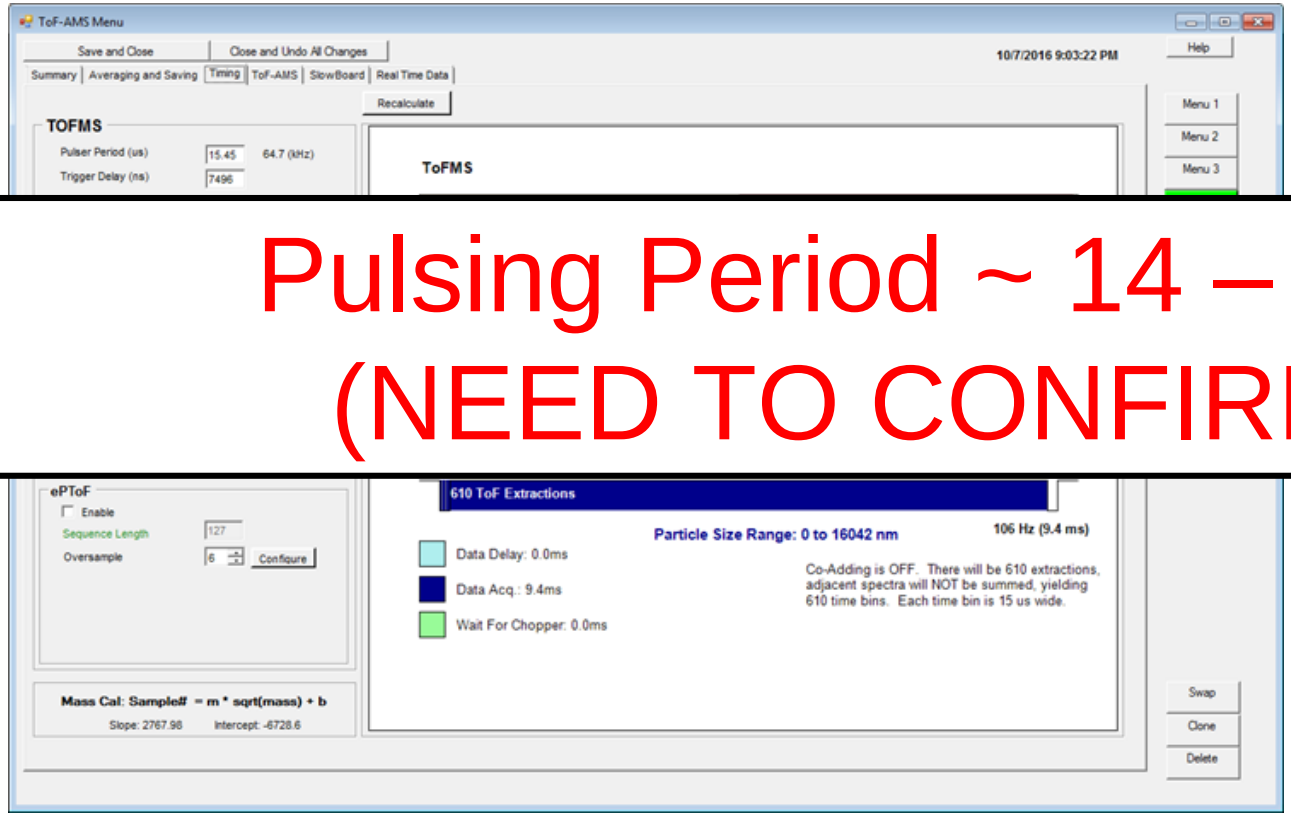
ADQ needs less signal to run, so the SI is lower **Important for comparisons

Setting the Pulsing Period for the Maximum Signal



The pulser period (~14 – 16 μs) for ET needs to be squeezed (max m/z=48) in order to measure full single event profile profile of NH_4NO_3 while minimizing evaporation loss during the measurement.

Setting the Pulsing Period for the Maximum Signal

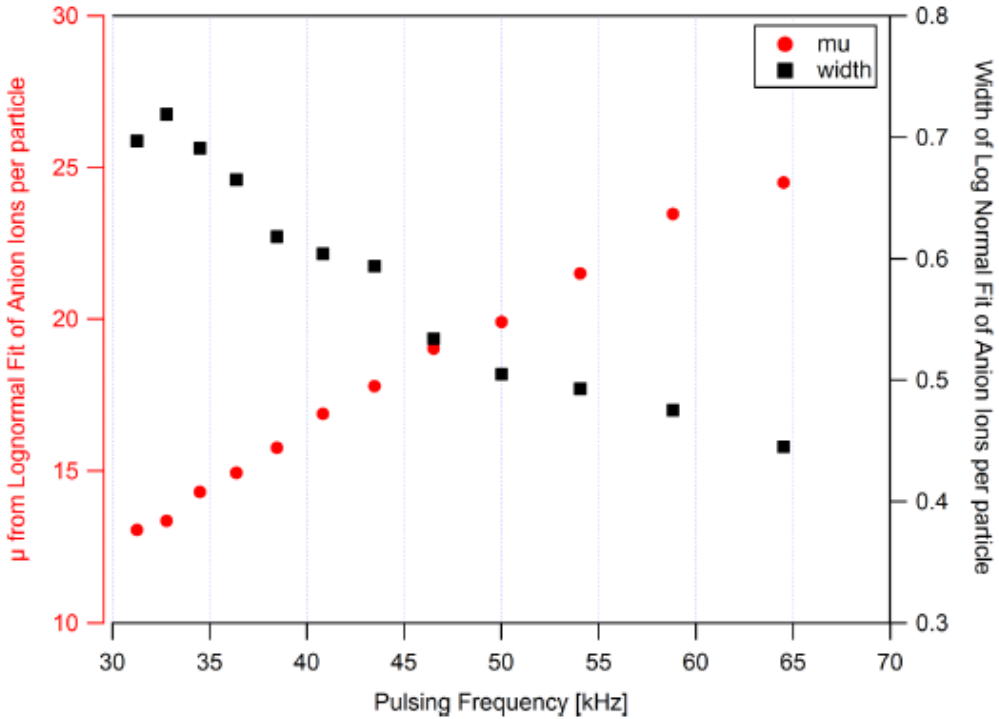


The pulser period (~14 – 16 µs) for ET needs to be

Pulsing Period ~ 14 – 16 µs (NEED TO CONFIRM!!!)

loss during the measurement.

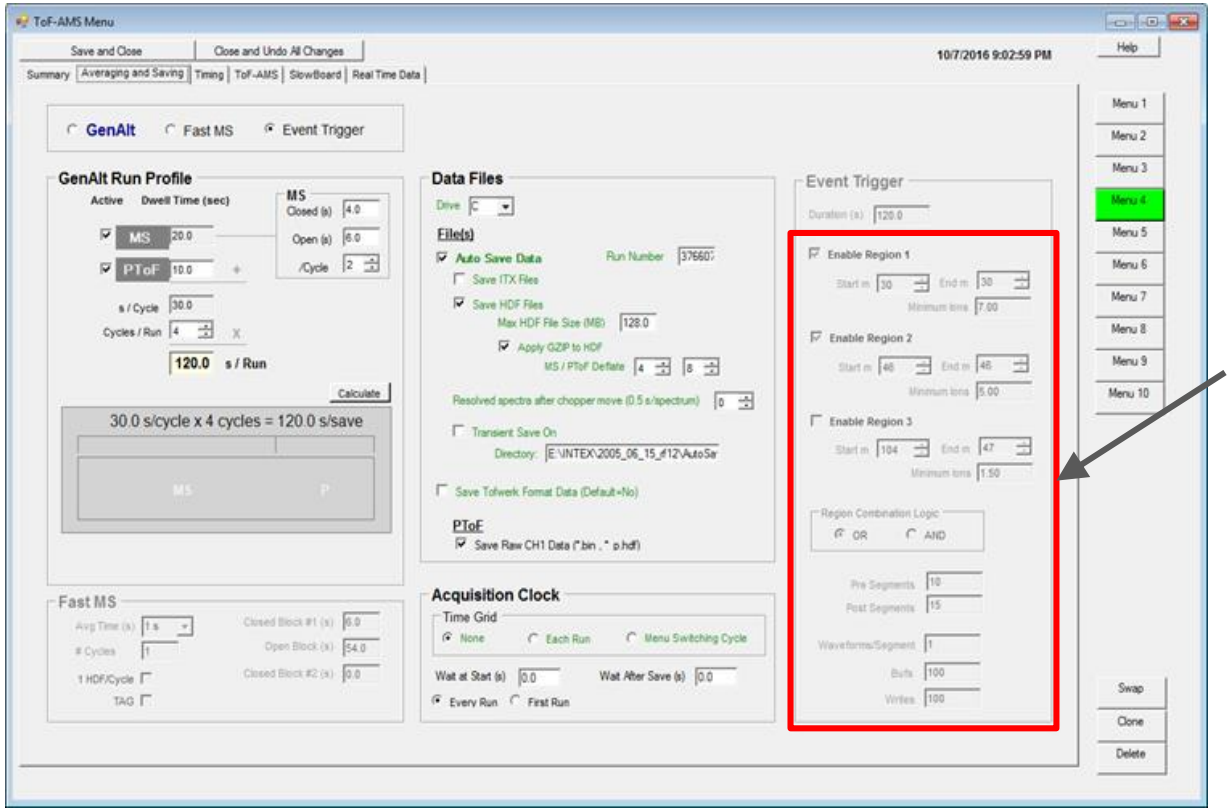
Pulsing Frequency Impacts the Width and Ions Per Particle



Increasing the pulsing frequency leads to more ions per particle and decrease in the distributions.

From Schoder and Sueper 6th AMS Clinic, 2015: http://cires1.colorado.edu/jimenez-group/UsrMtgs/clinic_2015/EventTriggerPanelIntroductionandDiscussion.pdf

Setting Up ET for Calibrations (IE or Lens Transmission Curve)



This is where you set-up the ion thresholds for your ET Cal prior to running the cals.

BOTTOM LINE: Find settings the minimize false counts (ideally, < 30 counts during blank run) while maximizing number of events measured.

Exact details covered in appendix slides for later.

Setting Up ET for Calibrations (IE or Lens Transmission Curve)

Set-up for the calibration has been explained in numerous other presentation[1,2,3,4].

Bottom line:

1. Make sure to have an initially low concentration (< 250 particles/cc without dilution)
   -This ensures that you are measuring 1 particle at a time
   -This minimizes doubles

2. Make sure particles are dried

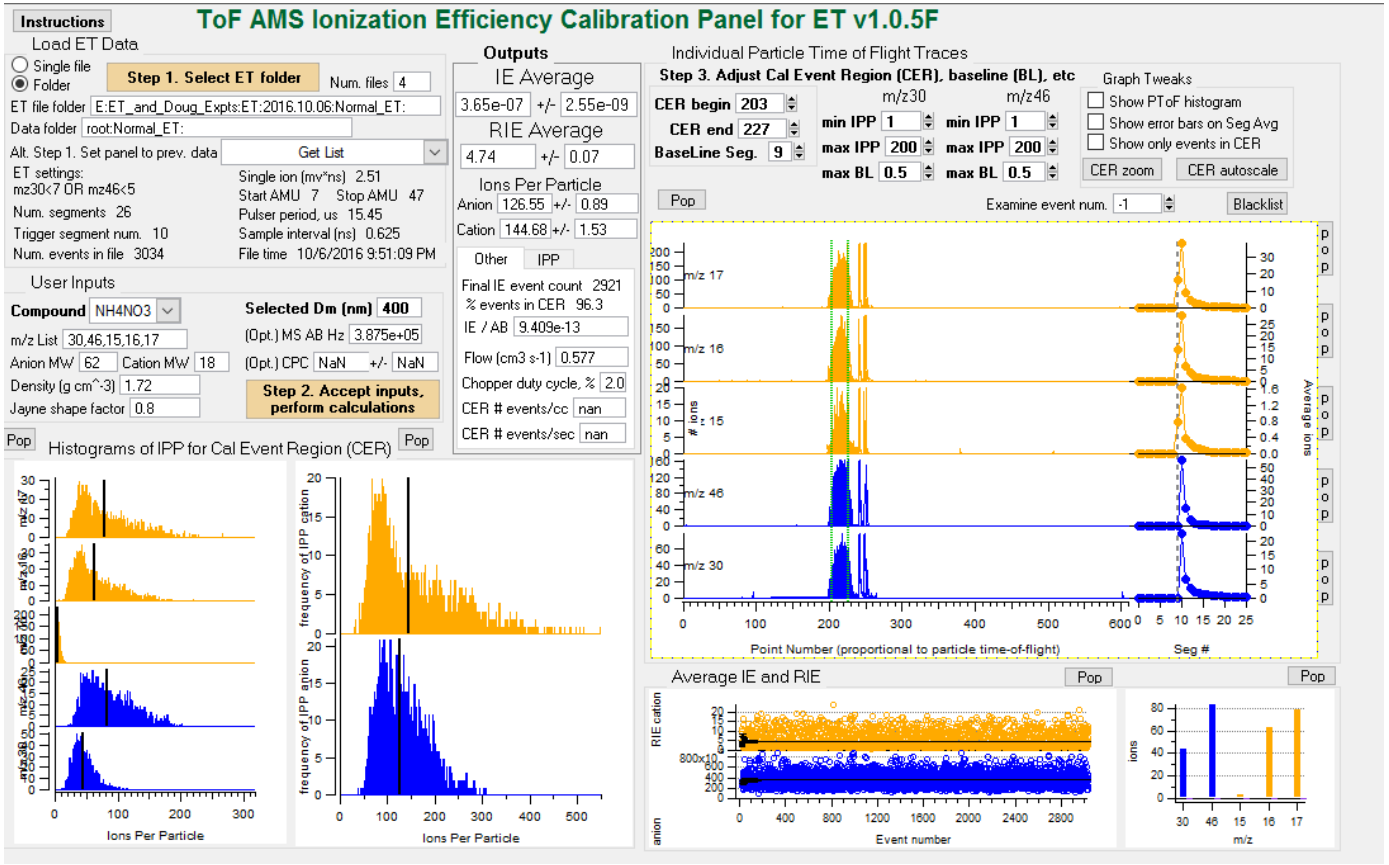
3. Make sure you have the shortest line possible to minimize evaporative loss

1. http://cires1.colorado.edu/jimenez-group/UsrMtgs/UsersMtg11/Jayne_Calibrations.pdf
2. http://cires1.colorado.edu/jimenez-group/UsrMtgs/UsersMtg14/ed_AMS_Calibrationsuser2013.pdf
3. http://cires1.colorado.edu/jimenez-group/UsrMtgs/EUCAARIClinic2010/PSI-IECalibration.pdf
4. http://cires1.colorado.edu/jimenez-group/UsrMtgs/UsersMtg7/ie_cal_tutorial.pdf

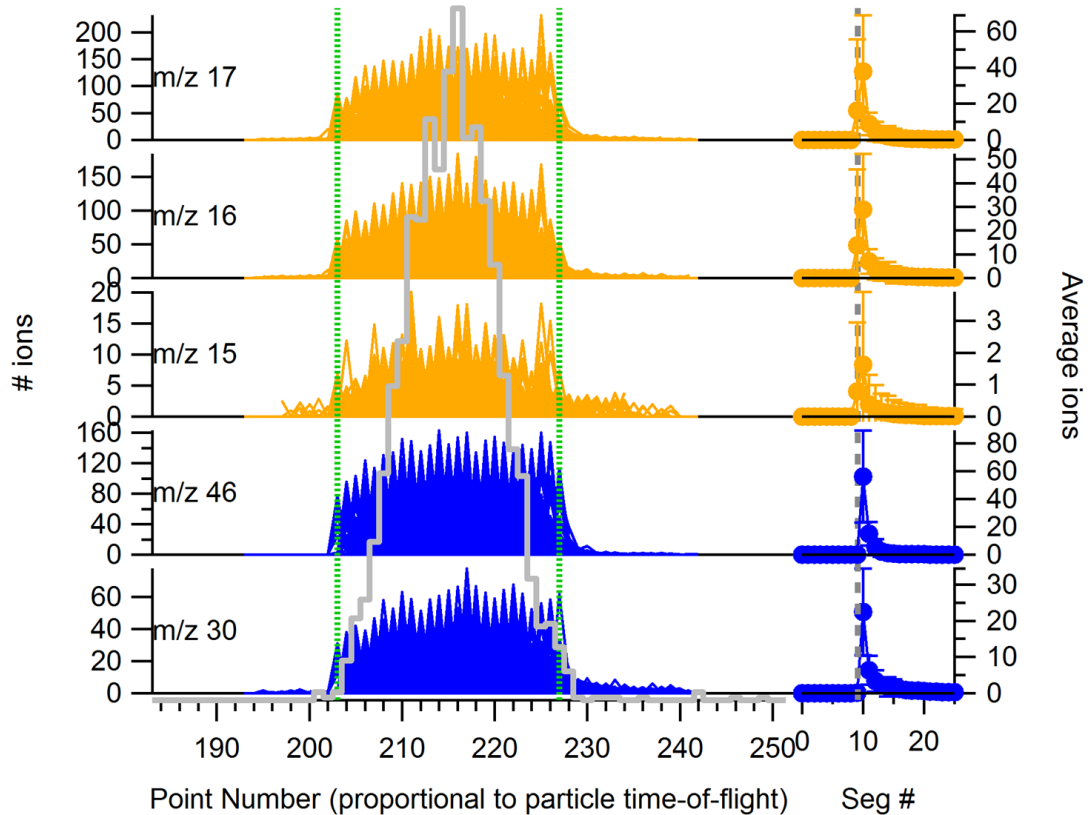
Analyzing ET for Calibration (IE or Lens Transmission Curve)

NOTE: The background for our ET (IPP < 50) is extremely low because we use a cryogenic pump.

Typically, the background for IPP < 50 will be much higher.



After Removing Doubles, Finding the Proper CER, Etc., Your Final Results Should Look Something Like This



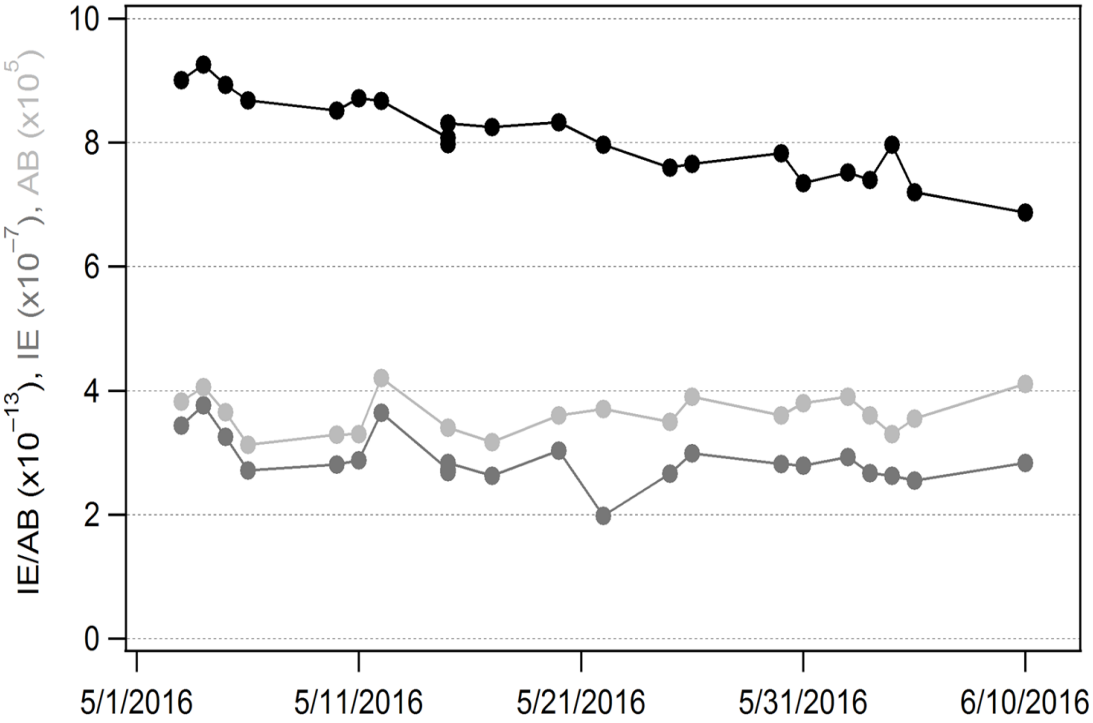
NOTE: Green line is near the edges of the PToF (grey) line, which indicates the events that are being used for the IE Calibration.

Also, note that doubles (see prior slide) are removed.

ET Provided the Ability to Measure the IE/AB after Each Flight during KORUS-AQ (2016) and ATom (2016)

Added the calibration system to our flight rack in order to have the ability to calibrate IE/AB after each flight during our last two campaigns.

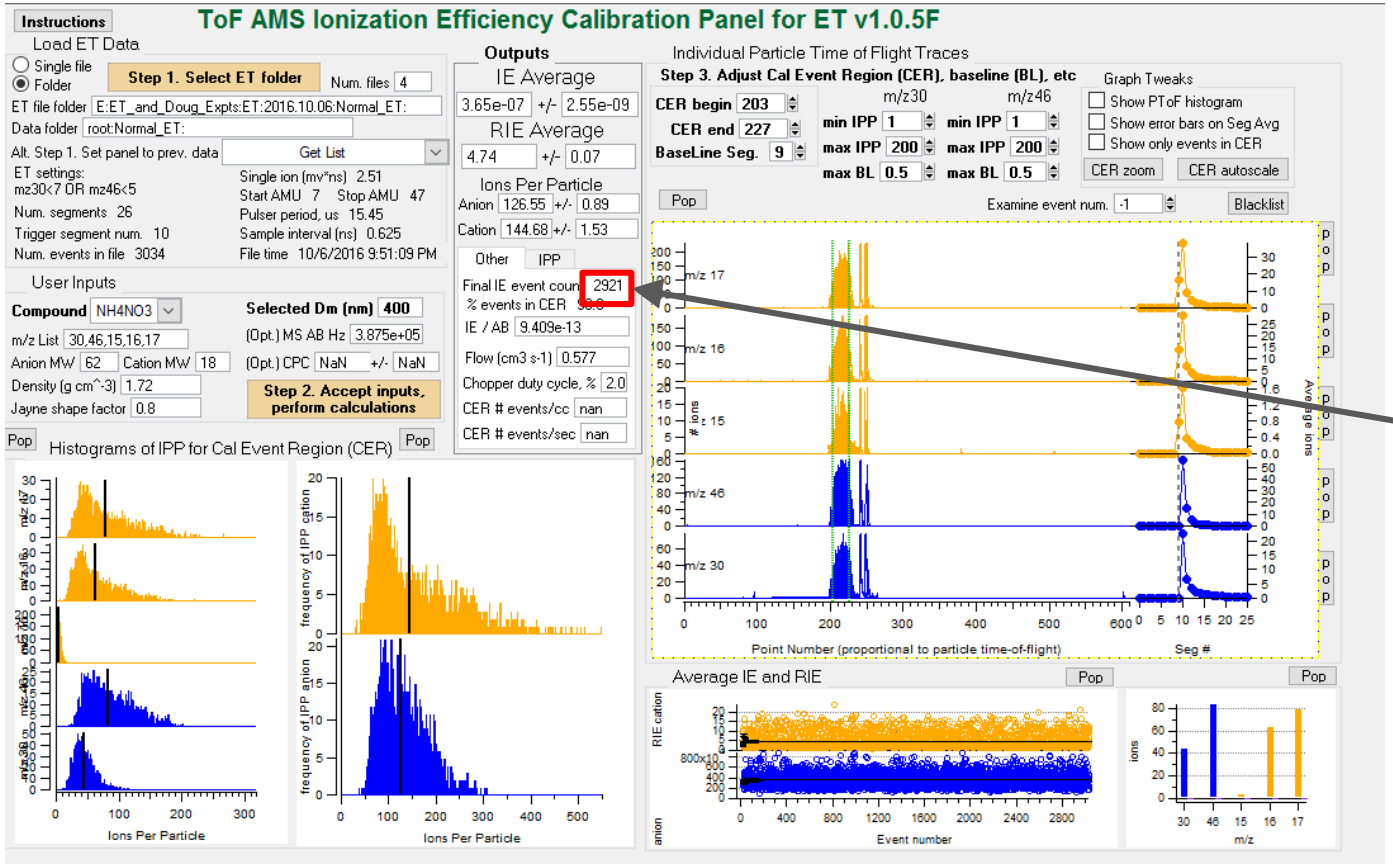
ET Provided the Ability to Measure the IE/AB after Each Flight during KORUS-AQ (2016)



During KORUS-AQ, we had a total of ~20 IE/AB calibrations.

~17 of these calibrations occurred after one of the research flights, during the 2 hours provided after landing.

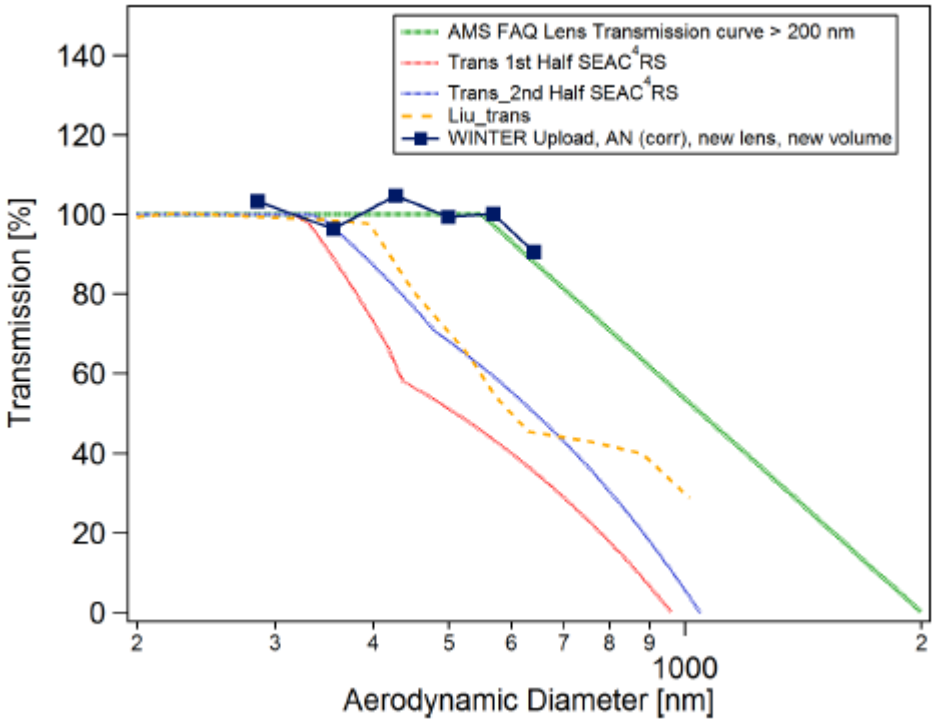
Analyzing ET for Calibration (IE or Lens Transmission Curve)



Finally, you can use the Final IE event count with the flow rate (make sure to document down the flow rate during the calibration) along with sampling time (how long you ran ET) and duty cycle (2%) to calculate the particles/cc sampled.

This value should be used as a spot check on the transmission of particles or to create a transmission curve.

The Need to Do Lens Transmission Curves



From Campuzano-Jost 6th AMS Clinic, 2015: http://cires1.colorado.edu/jimenez-group/UsrMtgs/clinic_2015/06-20-2015_PCJ_Lens_Transmission_issues_v2.pdf

The transmission curve should constantly be checked and verified.

Even during a campaign, as shown to the left, the transmission curve can change.

Also, the transmission curve of a specific instrument may not be close to the theoretical transmission curve (green); therefore, the actual curve needs to be known.

ET provides opportunities for spot checking the transmission during each calibration and a total check, with the only uncertainties stemming from counts and flow rate (vs. uncertainties in flow rate, counts, “Jayne factor”, particle size, etc.)

The Need to Do Lens Transmission Curves

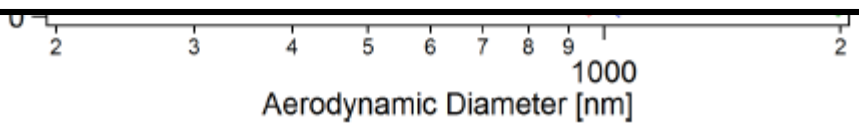
The transmission curve should constantly be checked and verified.

Recall:

(1) Since ET requires low particle conc. (< 250 particles/cc), doubles are minimized (lens transmission curve worst enemy!!!!)!!!

(2) ET Panel provides the ability to remove any doubles.

(3) Doubles are typically <5% of the particle counts; therefore, the comparison of counts (ET) to counts (CPC) is not impacted the same way doubles impact CPC mass lens transmission curves.



From Campuzano-Jost 6th AMS Clinic, 2015: http://cires1.colorado.edu/jimenez-group/UsrMtgs/clinic_2015/06-20-2015_PCJ_Lens_Transmission_issues_v2.pdf

calibration and a total check, with the only uncertainties stemming from counts and flow rate (vs. uncertainties in flow rate, counts, “Jayne factor”, particle size, etc.)

The Power of ET for Lens Transmission Curve Calibrations

(1) Since ET requires low particle conc. (< 250 particles/cc), doubles are minimized (lens transmission curve worst enemy!!!!)!!!

(2) ET Panel provides the ability to remove doubles.

(3) Doubles are typically <5% of the particle counts; therefore, the comparison of counts (ET) to counts (CPC) is not impacted the same way doubles impact CPC mass lens transmission curves.

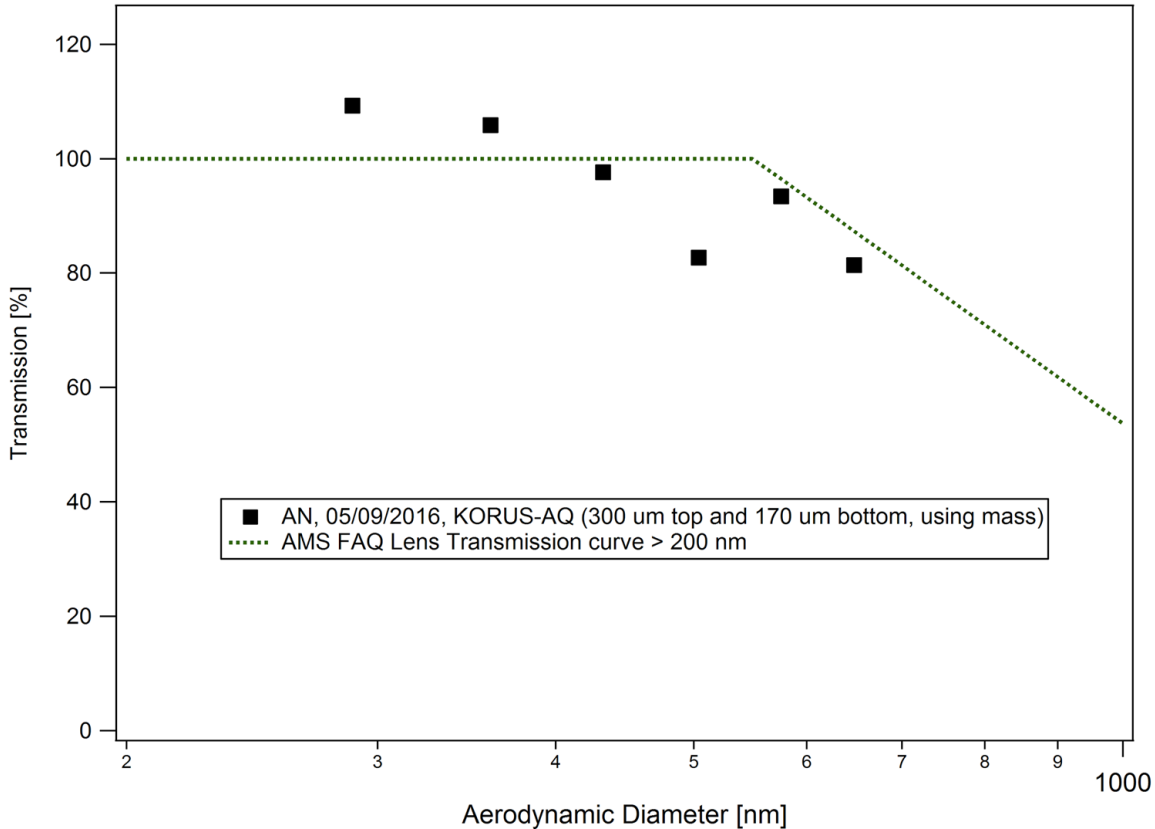
The Power of ET for Lens Transmission Curve Calibrations

(1) Since ET requires low particle conc. (< 250 particles/cc), doubles are

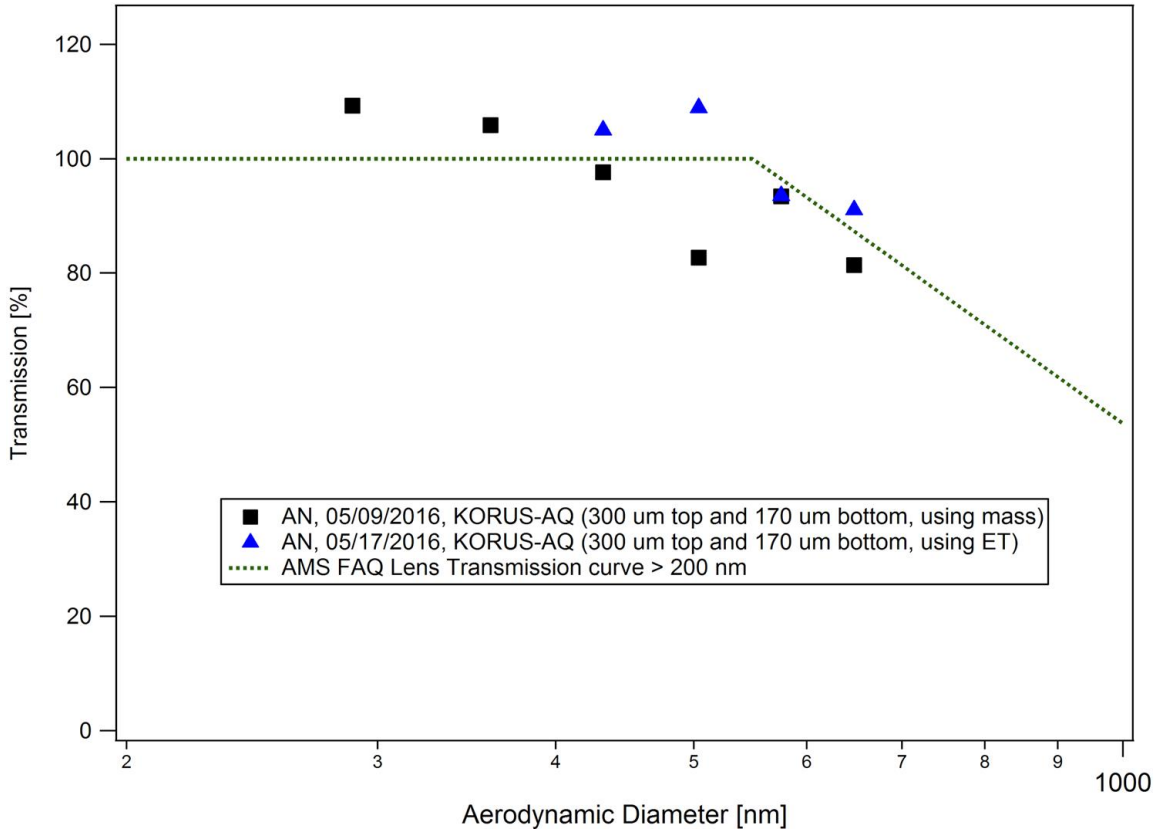
ET Makes Lens Transmission Curves Easy!!

counts (ET) to counts (CPC) is not impacted the same way doubles impact CPC mass lens transmission curves.

Lens Transmission Curve: Comparing Mass to ET



Lens Transmission Curve: Comparing Mass to ET



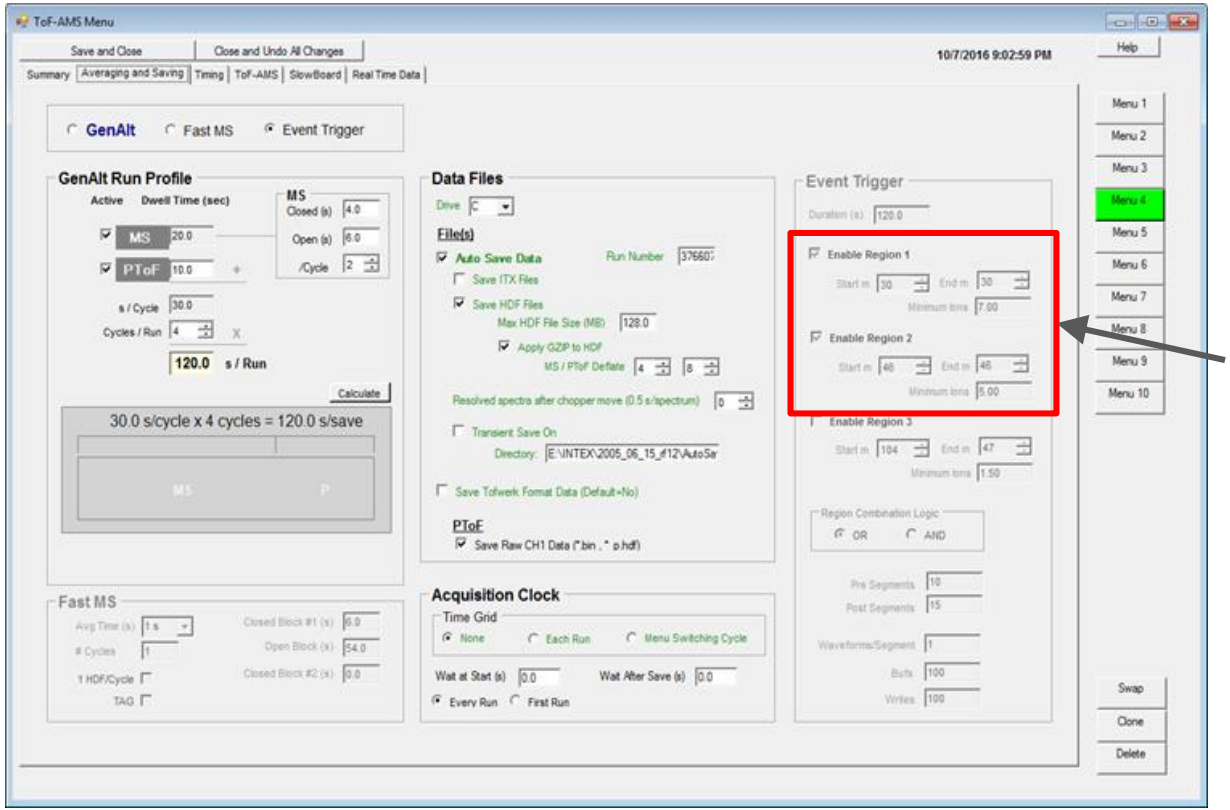
ET is a Powerful Tool for AMS IE and Transmission Curve Calibrations

- ET reduces the calibration time for IE calibrations
  - This is especially important for IE calibrations out in the field
  - This also provides Lens Transmission checks with each calibration
- ET can be utilized for Lens Transmission Curve calibrations with less uncertainty than mass transmission curves

Thank you! Questions?

Extra Slides for Discussion/Upload

Setting Up ET for Calibrations (IE or Lens Transmission Curve)



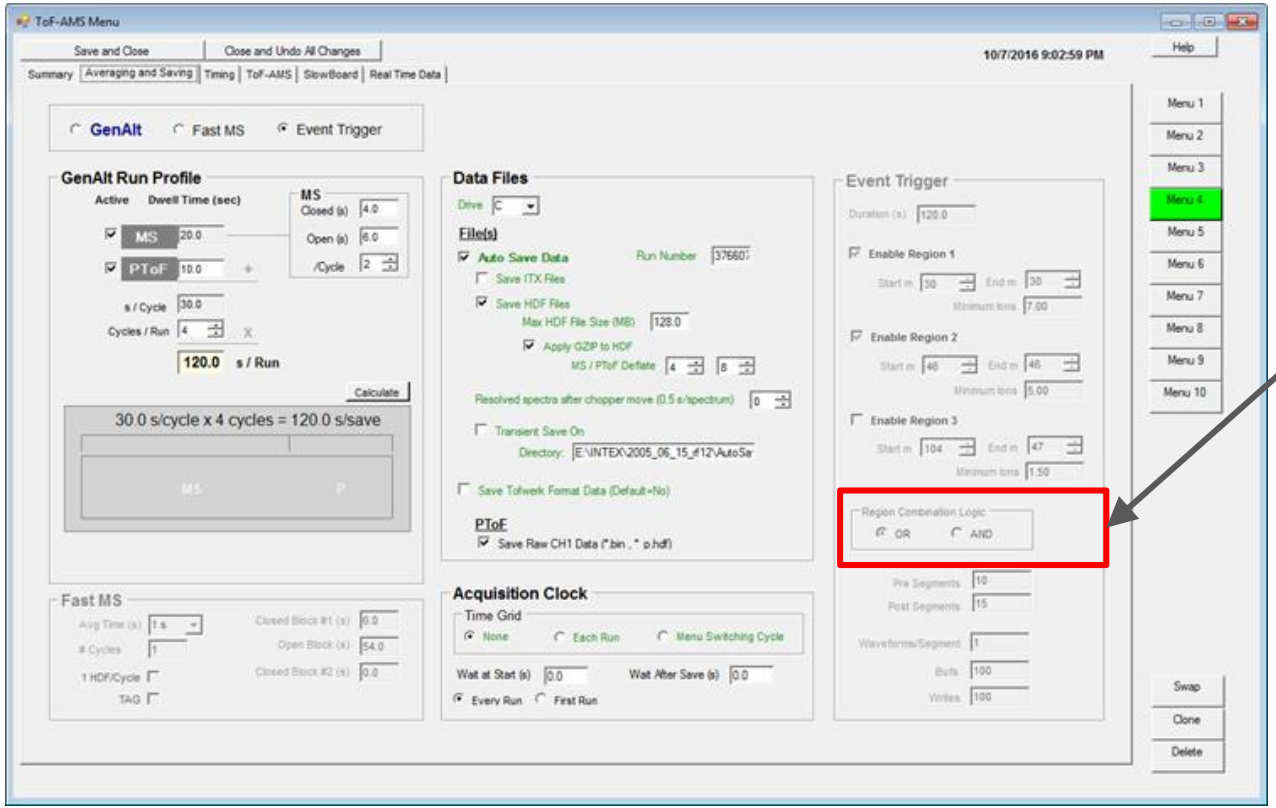
This is where you set your baseline for events.

If you set the minimum ions low, you start counting false events, which can be seen when you are doing a blank (and comparing values vs. CPC).

If you set the minimum ions too high, you start missing events (again, can be seen in comparison vs. CPC).

Ideally, the minimum ions should be set so that you have < 10 particles/cc (< 30 events in a run) during a blank.

Setting Up ET for Calibrations (IE or Lens Transmission Curve)

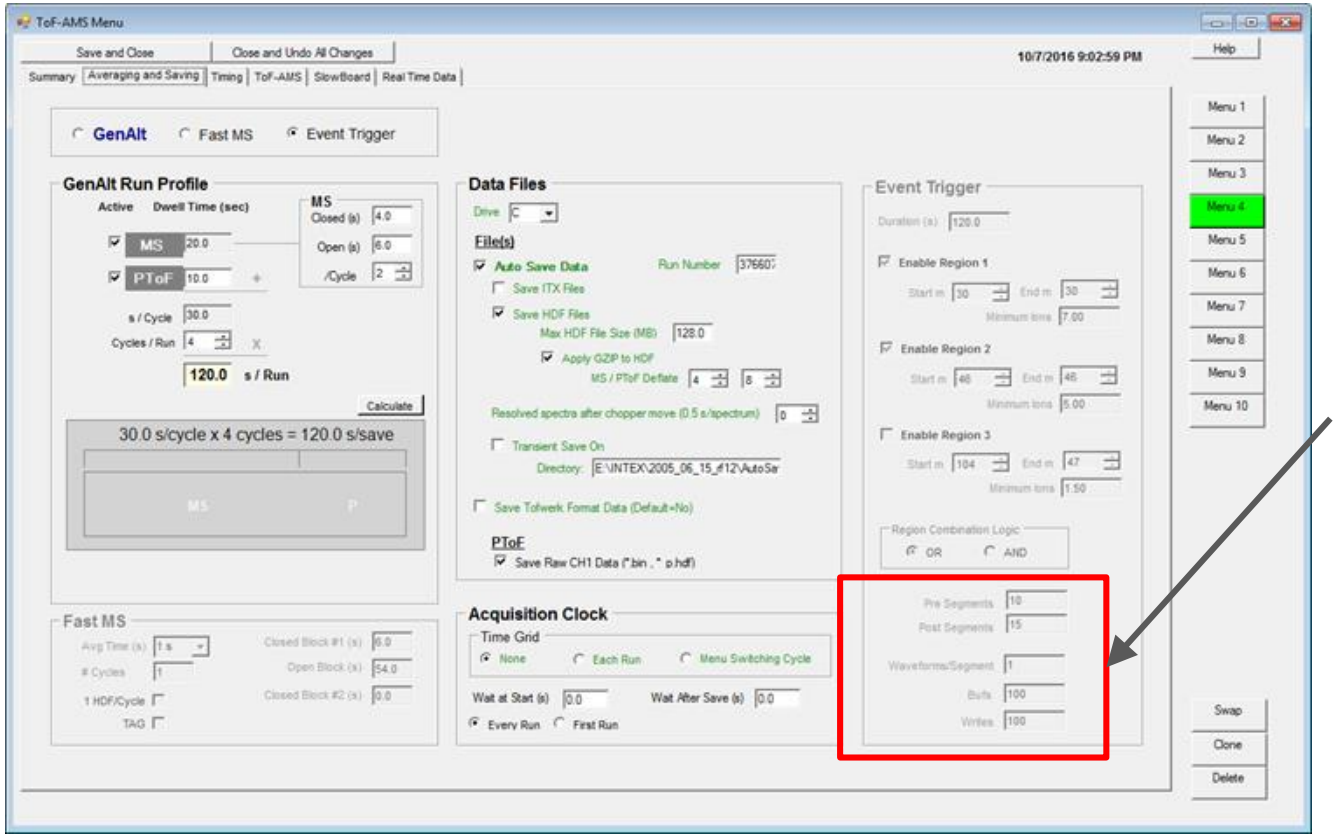


This is where you set logical restrictions for the minimum ion count.

Selecting AND can lead to a too strict minimum ions and missing events.

With OR and the right minimum ion threshold (prior slide), we can get a false event count of ~10 particles/cc in 120 sec (< 30 events in that time).

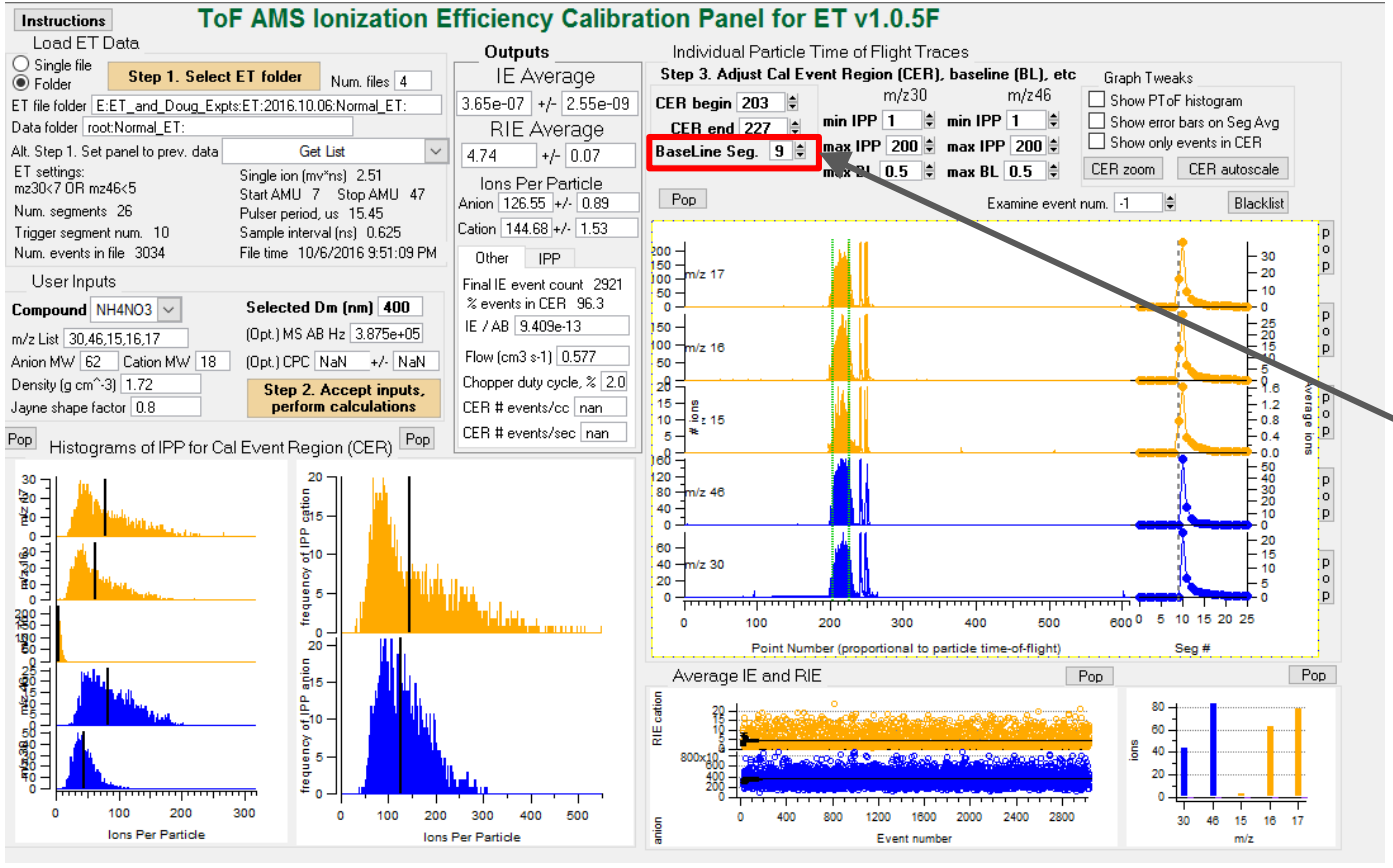
Setting Up ET for Calibrations (IE or Lens Transmission Curve)



Still under development.

Currently, to calibrate with ET, the settings should be Pre Segments = 10, Post Segments = 15, and Waveforms/Segment = 1.

Analyzing ET for Calibration (IE or Lens Transmission Curve)

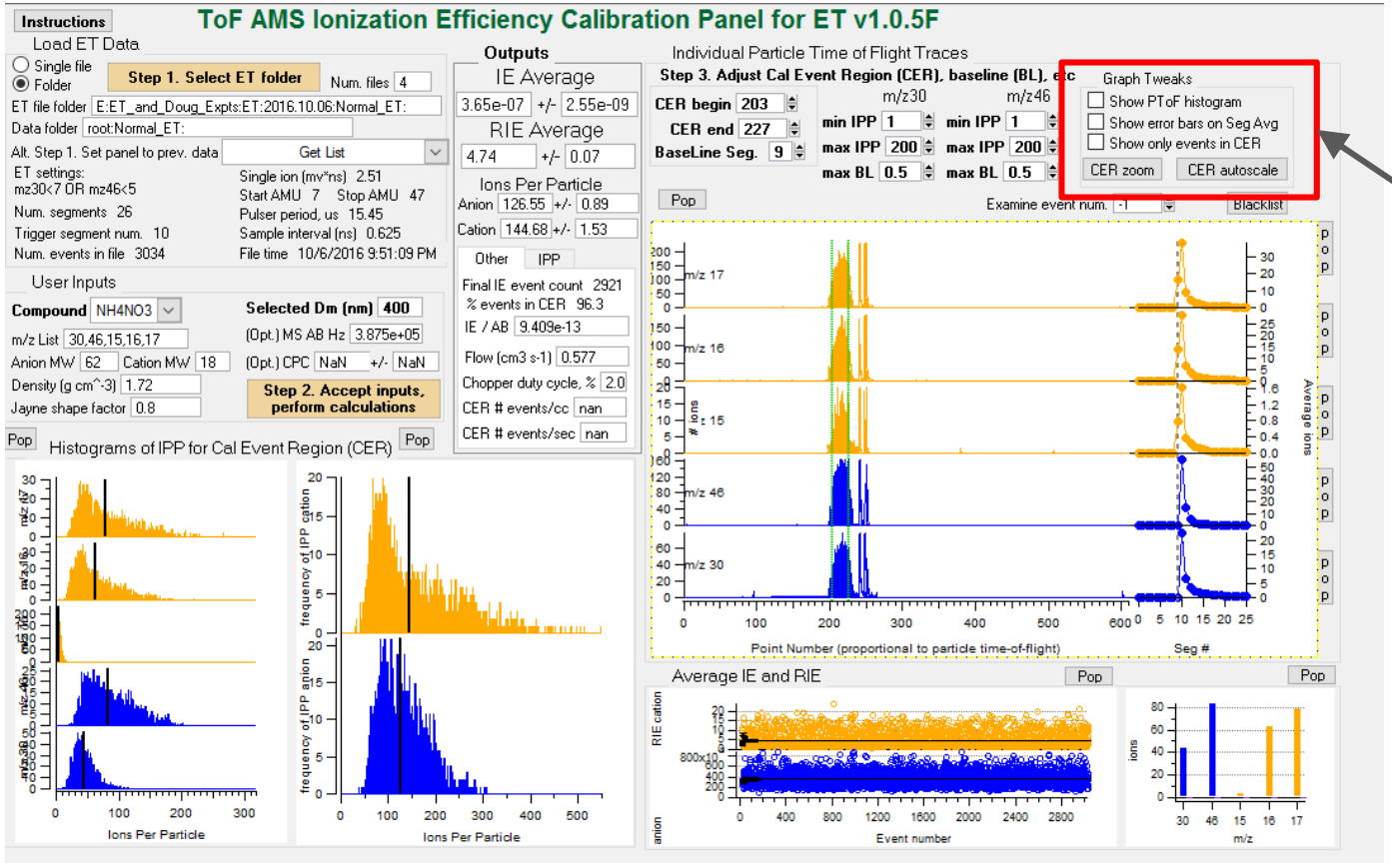


One new feature to ET analysis, compared to BFSP, is the BaseLine Segment.

The baseline segment refers to which segment number events started.

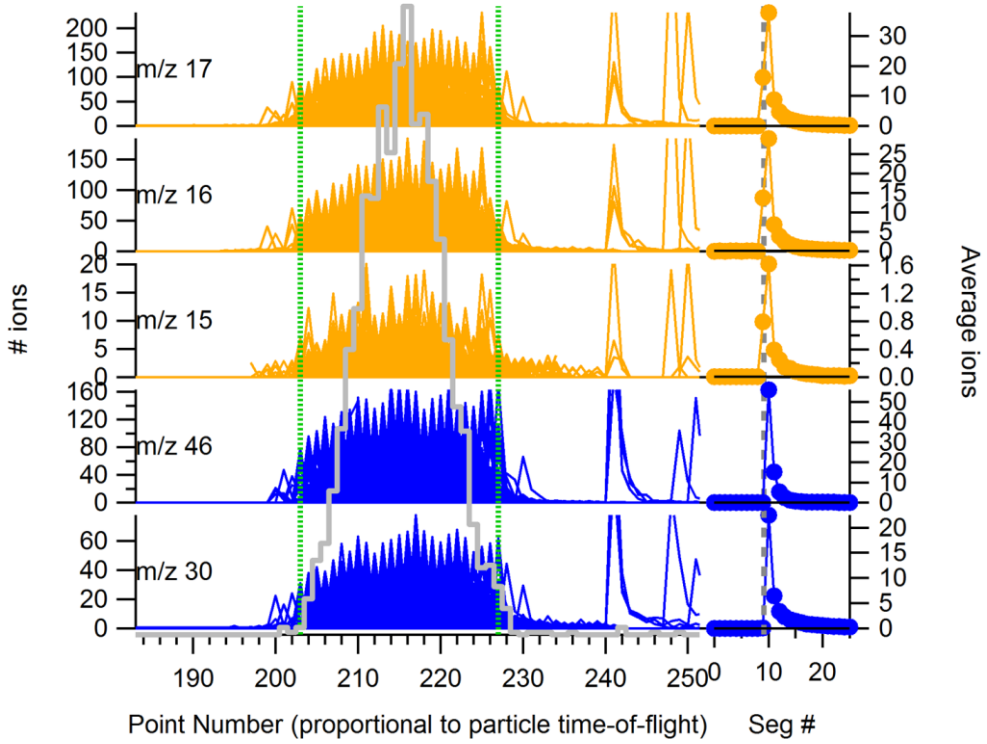
Typically, values < 9 are associated with noise, but this value should be confirmed by each user.

Analyzing ET for Calibration (IE or Lens Transmission Curve)



The other new feature, compared to BFSP, are the Graph Tweaks.

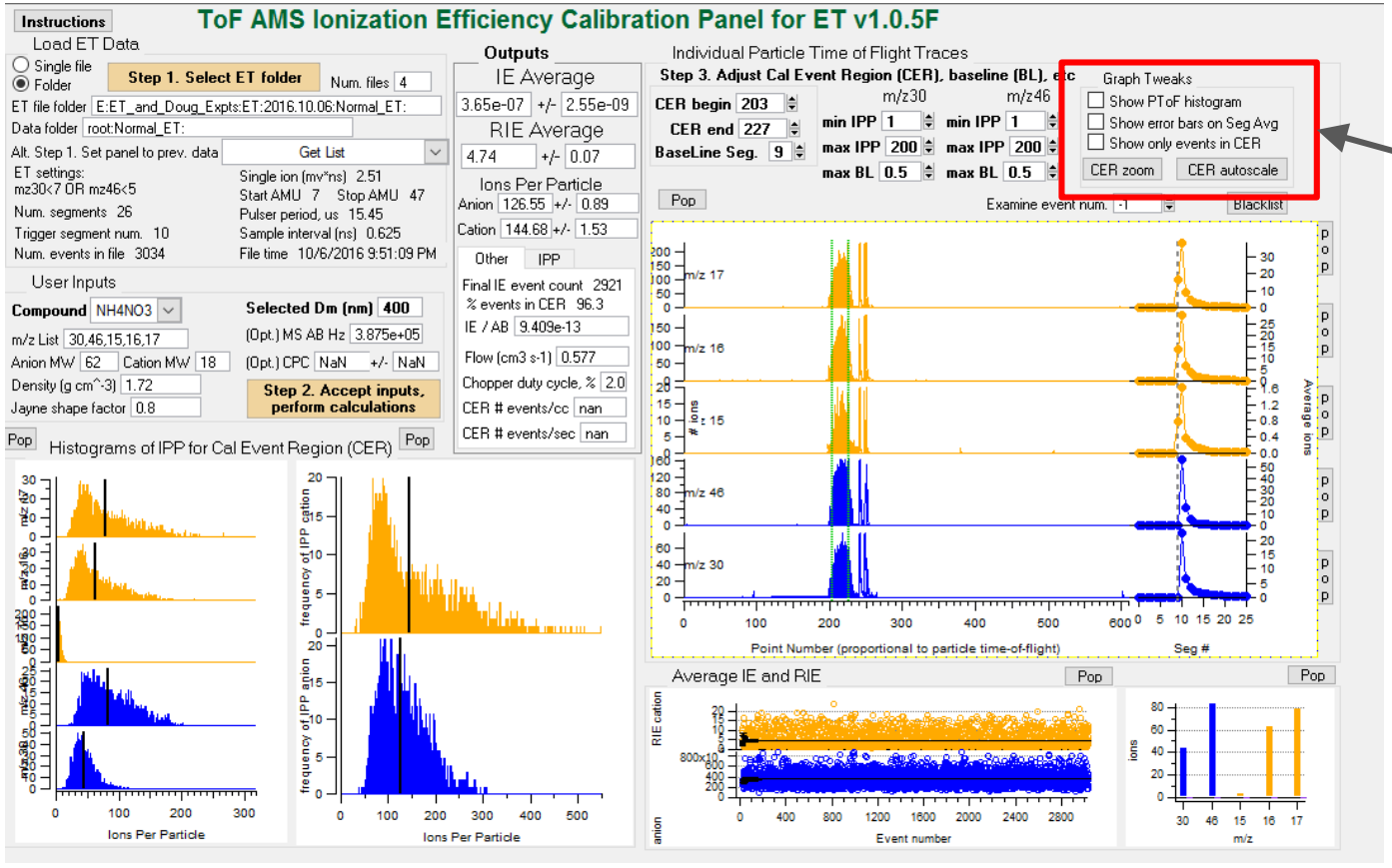
Showing PToF Histogram Box



By selecting the show PToF histogram, a histogram of the PToF during the ET calibration is shown, in grey.

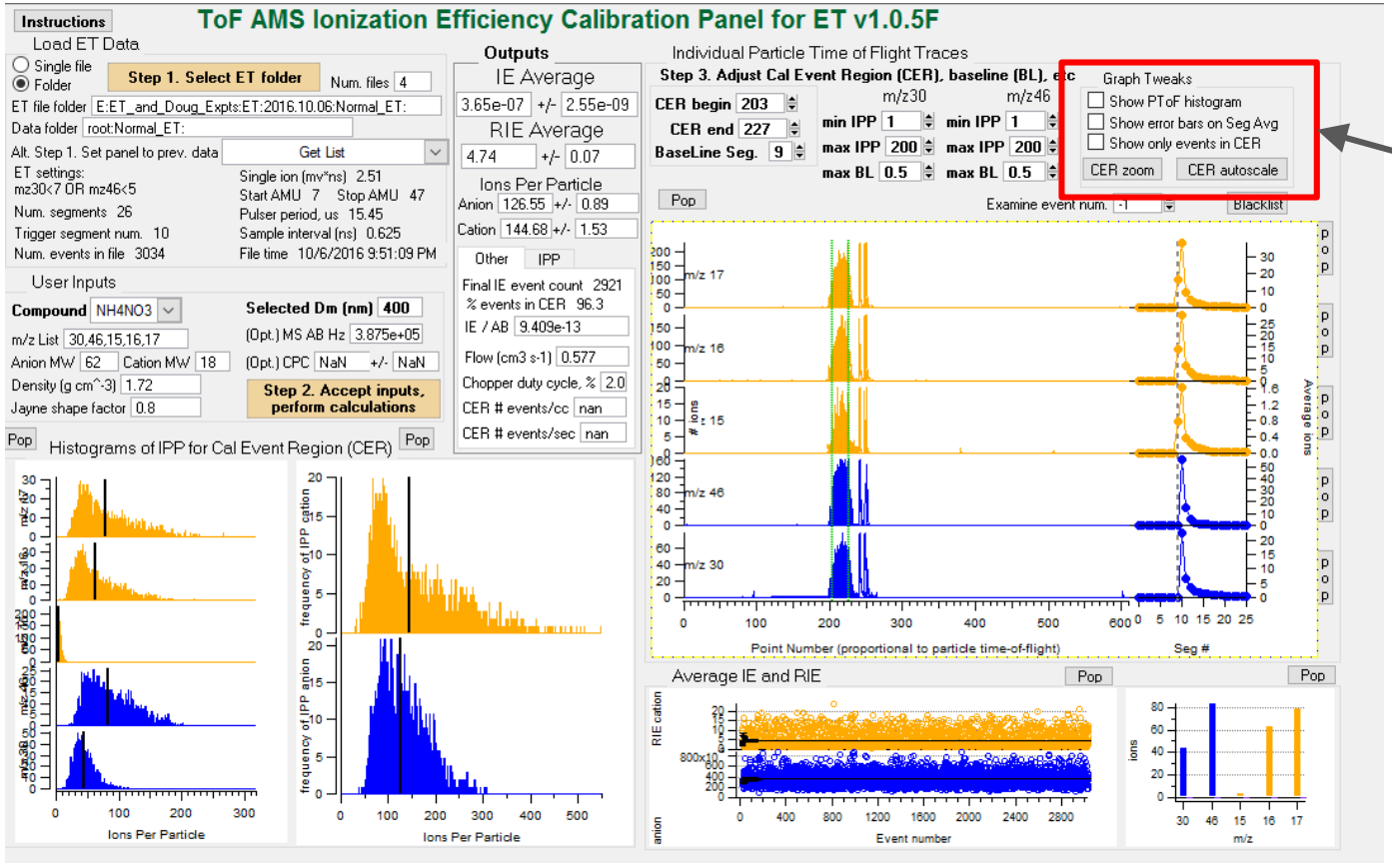
This is provide validation of a normal distribution, without doubles, in your final CER and IPP selection to calculate your IE, IE/AB, Ions Per Particles, and Final IE Event Count.

Analyzing ET for Calibration (IE or Lens Transmission Curve)



The other new feature, compared to BFSP, are the Graph Tweaks.

Analyzing ET for Calibration (IE or Lens Transmission Curve)



The other new feature, compared to BFSP, are the Graph Tweaks.

Extra Slides: How to Convert ET Final Counts to Particles/cc

$$\frac{Particles}{cc} = \frac{Final\ ET\ Counts}{ET\ Aqcuisition\ Time * Flow\ Rate} * (\frac{1}{Duty\ Cycle})$$