Overview of AMS Hardware Developments

Tues Aug 26 10:35 (25 min)

• ePTOF - Efficient Particle Time-of-Flight
• ADQ1600, Custom data acquisition card
• AMS DAQ Software
• PM2.5 Lens
• Capture vaporizer
• Auto tuning software for mass spectrometer
• Pfeiffer pump system
Efficient Particle Time-of-Flight

ePTOF

Application of a higher throughput chopper wheel

Performance enhancements in size resolved measurements with the AMS

ARI/Tofwerk
(J. Jayne, J. Kimmel, R. Knokumuss, M. Cubison, M. Gonin)

CU/Boulder
P. Campuzano Jost, D. Day & Weiwei Hu, Harald,
Donna, Jose
Size measurement in the AMS

Single slit chopper limits throughput to 2%
Typical AMS pTOF Size Distribution

$dM/d\log(Dva)$ (µg m$^{-3}$)

Dva (nm)

- ORG
- NO3
- SO4
- NH4
- Chloride

030707_smps.png
Multi-slit wheel for 50% aerosol throughput

Deconvolution procedure to obtain size information

- 3-phase brushless DC motor
- velocity regulated by closed loop control

4-positions
open, closed, blocked, chop

Richard Knochenmuss - Tofwerk
ePTOF Hardware

6 systems in use

Next controller version will support remote control
ePTOF Controller Mounted on HTOF AMS
300 nm NH$_4$NO$_3$ Raw Data

Recorded with multi-slit wheel

One chopper rotational period, 381 TOF extractions
300 nm NH4NO3 Data De-Multiplexed

Time in Segment dimension

D:\aCIMS\Chopper_Sequence\PAM_Dataplot2.pxp
Mini-AMS PTOF & ePTOF resolution comparison (24.5cm flight path)

ePTOF has higher resolution - 127 bit sequence
→ 1/127 = 0.78% (effective slit width)

Florian, Phil Dec 2013
Compares Single-slit (1%) to Multi-slit

a-Pinene + OH, ~10 µg/m³, 2 min data

m43 ion

multislit chopper
mz43 sharpness=5, denoise=5

singleslit chopper
mz43 x100 (smooth=2)
ePToF Summary

- Acquisition mode is implemented in DAQ5 and Squirrel
- Still targeting acquisition that is ePTOF all the time (always get size, only a small reduction in net MS duty cycle).
- Still evaluating de-noising and sharpness functions.
- Characterization paper this winter (CU), still improving timing.
New Data Acquisition Card
SP Devices ADQ1600

• Fast ADC with extended range, 14 bit, 1.6 GS/sec
• Replaces AP240 (8 bit, 1 GS/sec; now discontinued)
• Custom firmware (Tofwerk-SPD collaboration)
• PCIe and USB-3 versions (for all Tofwerk TOFs)
New Data Acquisition Card
SP Devices ADQ1600

• Supports ePTOF application.

• Single particle – Event Trigger mode (*no support for LS module*)

• With improved thresholding algorithm and extended dynamic range we expect better detection of SI and improved quality of PMF results

• Not recommended to run under Windows XP

• 10+ systems in use
ToF-AMS DAQ

Joel Kimmel

Aerodyne Research | TOFWERK AG
What is DAQ5?

Development of DAQ4 has ended
• Only DAQ 4.0.24 and .36 are supported. Anybody running earlier versions is encouraged to upgrade.

DAQ5 is a major overhaul to accommodate the many AMS configurations that are now possible and new modes of operation
• AP240/ADQ, TPS1/TPS2, mini-AMS
• ePToF, Event Trigger, auto-tuning software

Maintains much of DAQ4 structure and appearance to ease transition for users
• Menu file structure, major windows, HDF file structure

Now in use on 10 to 15 AMSs
• Most are mAMS, ADQ, or TPS2
• 2 or 3 are AP240 beta testers
• Expect broad release for all in next year
### DAQ5

**DAQ5 controls the new variety of hardware configurations**

User interface adjusts based on combination of components in use

<table>
<thead>
<tr>
<th></th>
<th>DAQ4</th>
<th>DAQ5</th>
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</thead>
<tbody>
<tr>
<td>AP240</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Slow Board</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>TPS1</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>MS, PToF, FMS</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Light Scattering</td>
<td>X</td>
<td>?</td>
</tr>
<tr>
<td>Delayed implementation</td>
<td></td>
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<tr>
<td>New ADC</td>
<td></td>
<td>X</td>
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<tr>
<td>ePToF</td>
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<td>X</td>
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<tr>
<td>mini-AMS</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>TPS2</td>
<td></td>
<td>X</td>
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<tr>
<td>Event Trigger</td>
<td></td>
<td></td>
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<tr>
<td>Single Particle Mode</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Auto-tuning</td>
<td></td>
<td>X</td>
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</tbody>
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*Can be used without AMS DAQ; DAQ5 will have dedicated interface*
All new AMSs are delivering with the SP Devices ADQ1600. It is also available as an upgrade. 10-15 units now in use.

<table>
<thead>
<tr>
<th></th>
<th>AP240</th>
<th>ADQ</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Speed</strong></td>
<td>1 GS/s</td>
<td>1.6 GS/s</td>
</tr>
<tr>
<td><strong>Resolution</strong></td>
<td>8-bit (254)</td>
<td>14-bit (16384)</td>
</tr>
<tr>
<td><strong>Thresholding</strong></td>
<td>Record samples that are above threshold</td>
<td>Record samples that are above threshold and adjacent samples</td>
</tr>
<tr>
<td></td>
<td>For many single ions, this means AP240 records only the peak, while ADQ records peaks and edges</td>
<td></td>
</tr>
<tr>
<td><strong>Event Trigger Mode</strong></td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>ePToF Mode</strong></td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
• Downloads
  • Release Notes
• Manual
• FAQs
  • Updated with real questions!
• jkimmel@aerodyne.com
  • Always available for questions and suggestions
Capture Vaporizer
and
Particle Bounce
Particle Bounce

Ideal scenario
Vaporization on 1\textsuperscript{st} collision

Positive Ion Mass Spectrometry

Flash Vaporization

Reduced ion production

Particle Bounce
Collection Efficiency

Standard Vaporizer 600C

\[ \text{NH}_4\text{NO}_3 \]

\[ (\text{NH}_4)_2\text{SO}_4 \]

“calibration”

CE = 22%
Improved CE of AS with new capture vaporizer
76%
Capture Vaporizer pTOF Traces SO4 and NO3
Sulfate is broadened as expected

300 nm 620C
Particles entering Capture Vaporizer more m30 and broader than m46
SO4 is broadened as expected

- m64
- m48
- Sig_p30_R15430
- Sig_p46_R15430
Mass spectrum shows a larger fraction of Org is going into m/z 44

Two side-by-side QACSM systems sampling ambient aerosol
Summary of Capture Vaporizer

• Mostly applicable to ACSM since pTOF is distorted (as expected).
• The device works, all the mass is recovered, CE=1
• Need to carefully evaluate fragmentation patterns.
• Data set from SOAS to be presented (Weiwei, CU)
  • Side-by-side comparison of HTOF w/CV and HTOF w/standard vaporizer
New TOF Power Supply

TPS2 system

- Giraffe (2U)
- TPS2 (3U)
First Pfeiffer Turbo AMS
Replaces Agilent Turbos
Automatic TOF tuning by Thuner

One button simultaneous tuning of multiple TOF (and User) voltages.

- TOFWERK software package (.net, dll)
- Commercial algorithms (Umetrics MODDE)
- Compatible with any Tofwerk TOF

Tofwerk: Manuel Hutterli, Fredrik Östlund, Christian Tanner
Thuner - Simultaneous optimization of signal intensity and resolution

Quad 2 (BSQ) and Primary Beam Voltages

Sensitivity

Resolution
PM2.5 Lens Transmission

We have a design, still learning how to make multiple copies