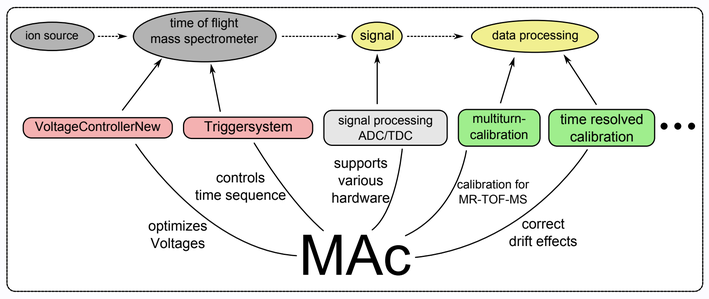
# MAc, Software for data acquisition and hardware control of time-of-flight mass-spectrometers

Julian Bergmann[1], Alexander Pikhtelev[2], Samuel Ayet San Andres[3], Timo Dickel[1,3], Jens Ebert[1,4], Hans Geissel[1,3], Christine Hornung[1], Johannes Lang[1], Wayne Lippert[1], Christian Lotze[1], Wolfgang Plaß[1,3], Ann-Kathrin Rink[1] and Christoph Scheidenberger[1,3]

[1] JLU Gießen, Deutschland — [2]Institute of Energy Problems of Chemical Physics, Russian Academy of Sciences, Moscow, Russia — [3]GSI Darmstadt, Deutschland — [4]TU Darmstadt, Deutschland

## 1. MAc Software




- ➔ data acquisition
- ➔ data evaluation
- ➔ hardware control

**Features:**

+ ADC/TDC for large dynamic range
+ time sequence controller
+ multi-reflection calibration
+ voltage optimizer
+ time resolved calibration
+ spectra accumulation
+ automatic peak detection
+ import/export various file formats
+ data operations (e.g. smoothing)

## 2. Enlarging dynamic range using TDC and ADC simultaniously.

**TDC:**

+ detection of single Ions
− dead time effect

**ADC:**

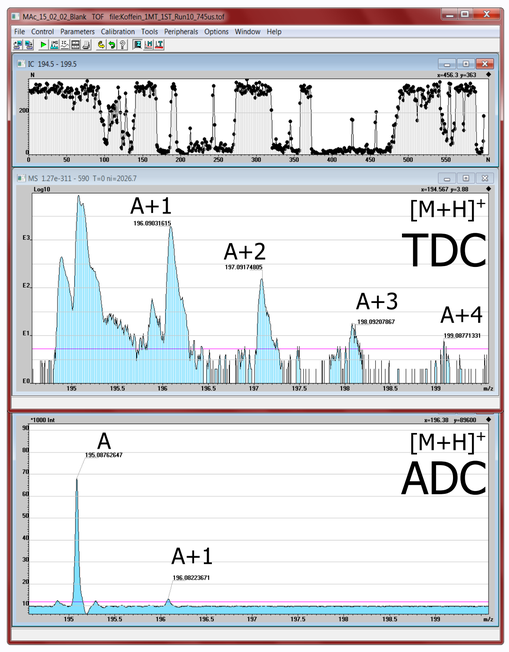
+ detection of high signal rates
− low intensity signals lost

**Combined:**

+ dynamic range > 4 Orders of magnitude
+ detection of high and low signal rates

**MAc:**

- ➔ common user Interface
- ➔ common calibration
- ➔ common file format and analysation tools




**Example: Coffein ($10^{-4}$ mol/l)**

**TDC** (top):
+ A+1 to A+4

**ADC** (bottom):
+ A and A+1

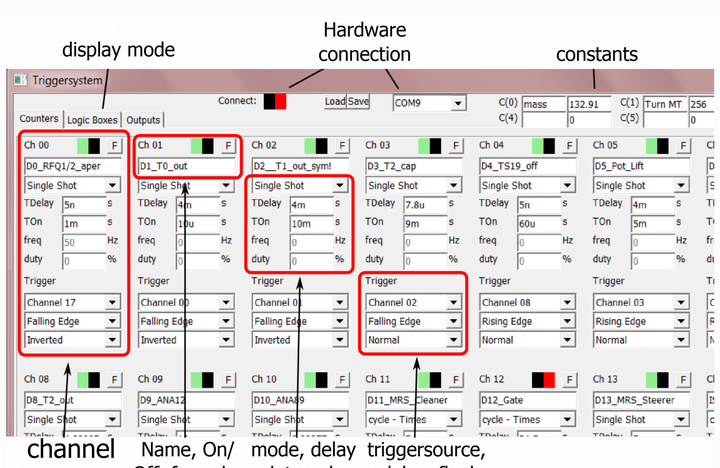
| Device | Isotope | MAc | Literature | rel. Deviation |
|---|---|---|---|---|
| ADC | m195 / m196 | 9,374 79 | 9,457 79 | 0,008 78 |
| TDC | m196 / m197 | 11,7599 | 11,7515 | $7{,}1480 \cdot 10^{-4}$ |
| | m197 / m198 | 5,629 95 | 19,1104 | 0,705 40 |
| | m198 / m199 | 3,404 73 | 33,768 | 0,899 17 |

Excelent Isotop distribution

unresolve Isobars

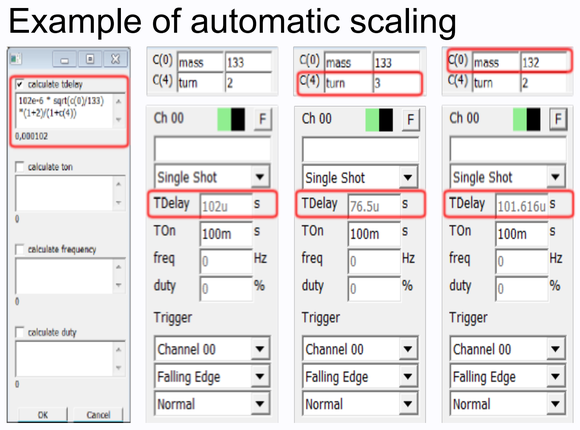
## 3. Time Sequence controller

- ➔ controls time sequences for traps, electrodes etc.
- ➔ multiple modes to set delays and duty cycles




+ link triggers for 32 channels to each other or up to 16 logic channel combinations
+ use formulars to calculate delay and duty cycles
  + link to other channel's times
  + use up to 8 constants
+ set times can be used in other MAc parts
  - ➔ calibration

Example of automatic scaling



## 4. Multiturn Calibration

Calibration Formular

$$m = a\frac{(t-t_0)^2}{(1+b\cdot N)^2}$$

$$a = \frac{2q\cdot U}{l_{detec}^2} \qquad b = \frac{l_{turn}}{l_{detec}}$$

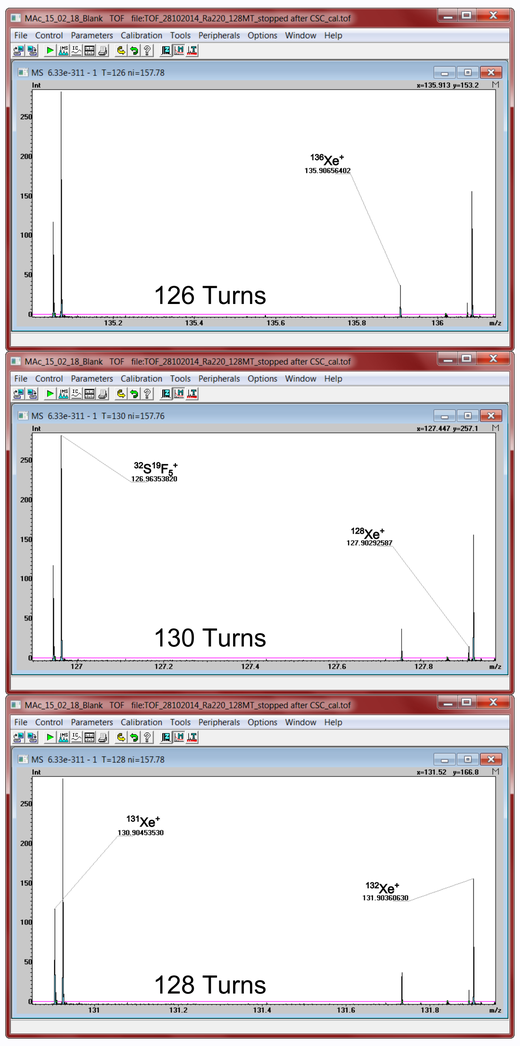
$t_0$: electronic delay time

+ ≤3 calibrants ➔ analytical
+ >3 calibrants
  - ➔ least square deviation minimizer
+ uses time sequence controller for trap extraction time
+ use and display for different turns in multiturn calibration
+ mass range greatly increased

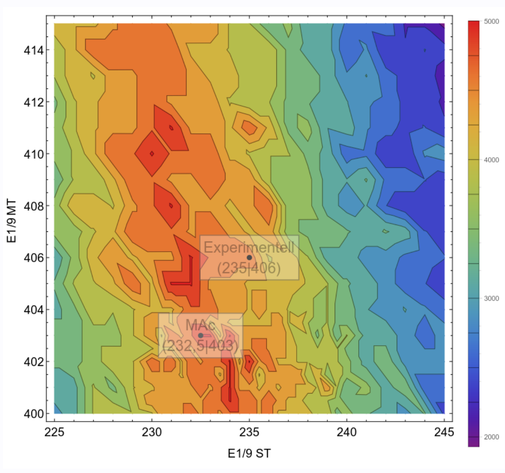
**Example: Xe & SF6**

+ between 126 and 130 Turns
+ precision of online identified masses of $4{\cdot}10^{-7}$

| Time (µs) | Turns | Mass MAc (u) | Mass Lit (u) | $\frac{\text{Lit}-\text{MAc}}{\text{Lit}}$ | Nuklid |
|---|---|---|---|---|---|
| 49,3071469 | 130 | 127,9029259 | 127,9029822 | $4,40 \cdot 10^{-07}$ | $^{128}Xe^+$ |
| 46,5327600 | 126 | 135,906564 | 135,9066657 | $7,48 \cdot 10^{-07}$ | $^{136}Xe^+$ |




## 5. Voltage Optimizer




- ➔ connects to all available power suplies
- ➔ free choice for amount of channels
- ➔ from adjustable MIN to MAX all voltage combinations are testet
- ➔ automatic measurement taken for each combination
  + 20 measurements per minute
- ➔ $R^2$ + a $I^2$ automatically calculated
  + factor a to weight Intensity

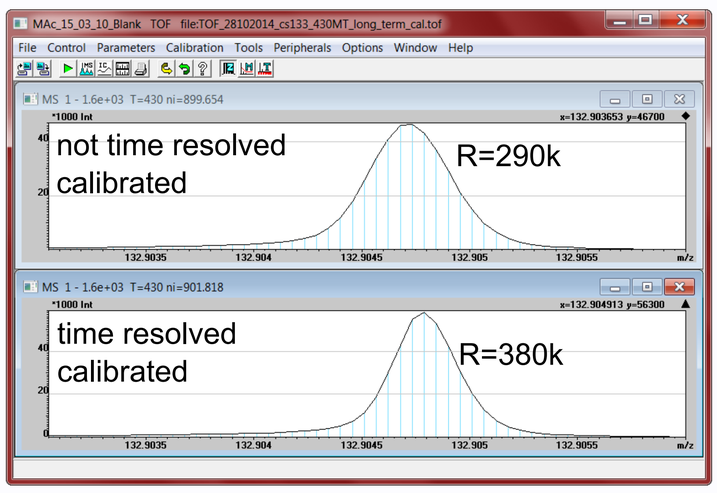
**Conclusion:**

Indespensable for preparing in-situ measurements e.g. for Ambiprobe MR-TOF-MS

## 6. Time resolved calibration

**Problem:**

- voltages can vary during measurement
- thus flight length varies during turns
- mass lines shift in time




**Solution:**

+ each spectra gets calibrated ➔ calibrant stays fixed in mass

**MAc:**

+ automatic detection of calibrant
+ correction of 2000 spectra in under 1 second
+ recalibrated data can be displayed and used inside MAc
+ ideally suited for long term or high resolution measurements

## Poster Information

Euroschool on Exotic Beams 2016
Mainz, Germany, 28 August - 3 September
Participant: Julian Bergmann