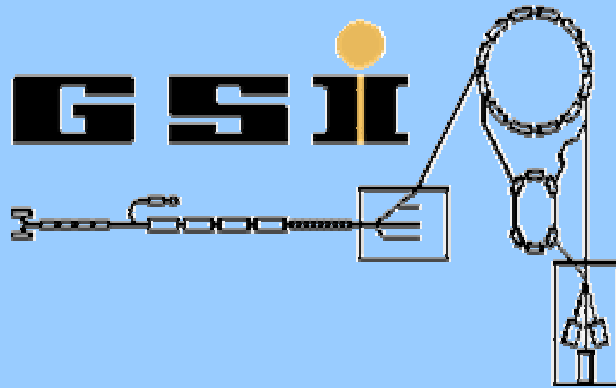
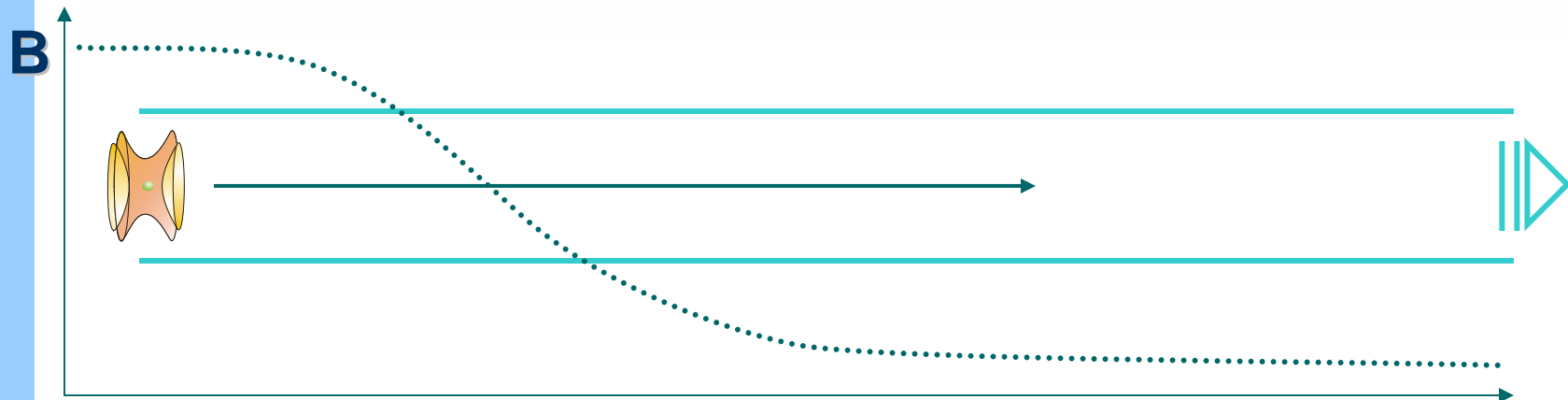
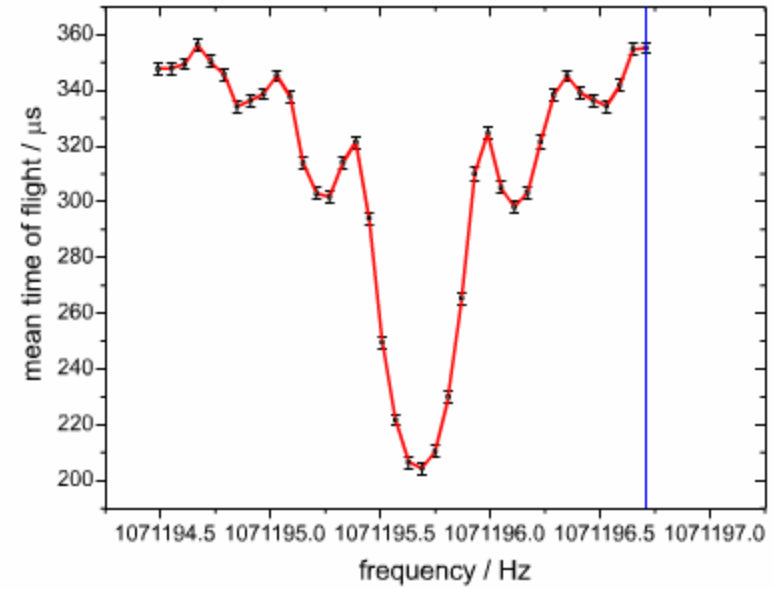
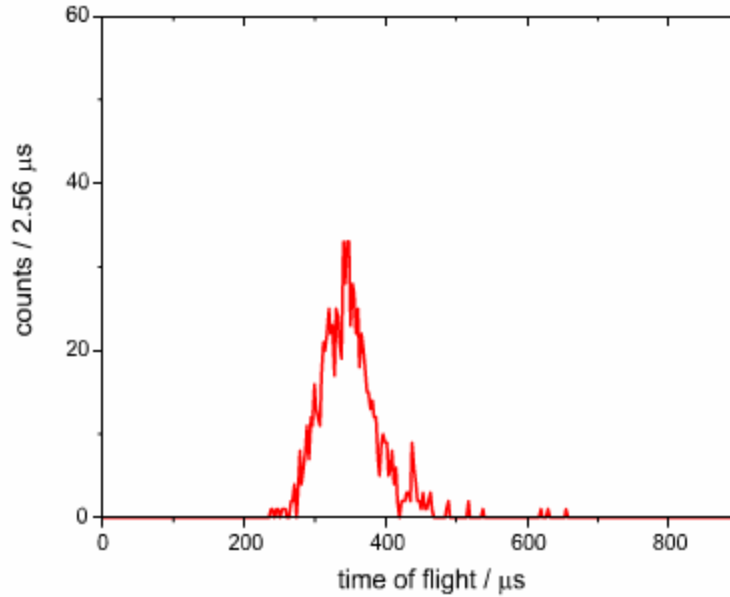


# EVA inside

Frank Herfurth



# EVA – what do we want to know?



# TOF – "MIKE" Function

$$\rho_{\pm}(\omega_{RF}, t) = e^{-\frac{\delta}{2}t} \cdot e^{i\frac{1}{2}(\omega_{RF}-\omega_c)t} \cdot \left\{ \rho_{\pm}^0 \cosh(\omega_B e^{i\theta} t) \mp \frac{1}{2} \frac{\rho_{\pm}^0 [\gamma\omega_c + i(\omega_{RF}-\omega_c)] + \rho_{\mp}^0 k_{RF}^{\pm}}{\omega_B e^{i\theta}} \sinh(\omega_B e^{i\theta} t) \right\}$$

- radii depend on radio frequency

$$E_{rad}(\omega_{RF}, t) = \frac{E_{rad}^+}{2} \left( \rho_+(\omega_{RF}, t) \cdot \omega_+ \right)^2 + \frac{E_{rad}^-}{2} \left( \rho_-(\omega_{RF}, t) \cdot \omega_- \right)^2$$

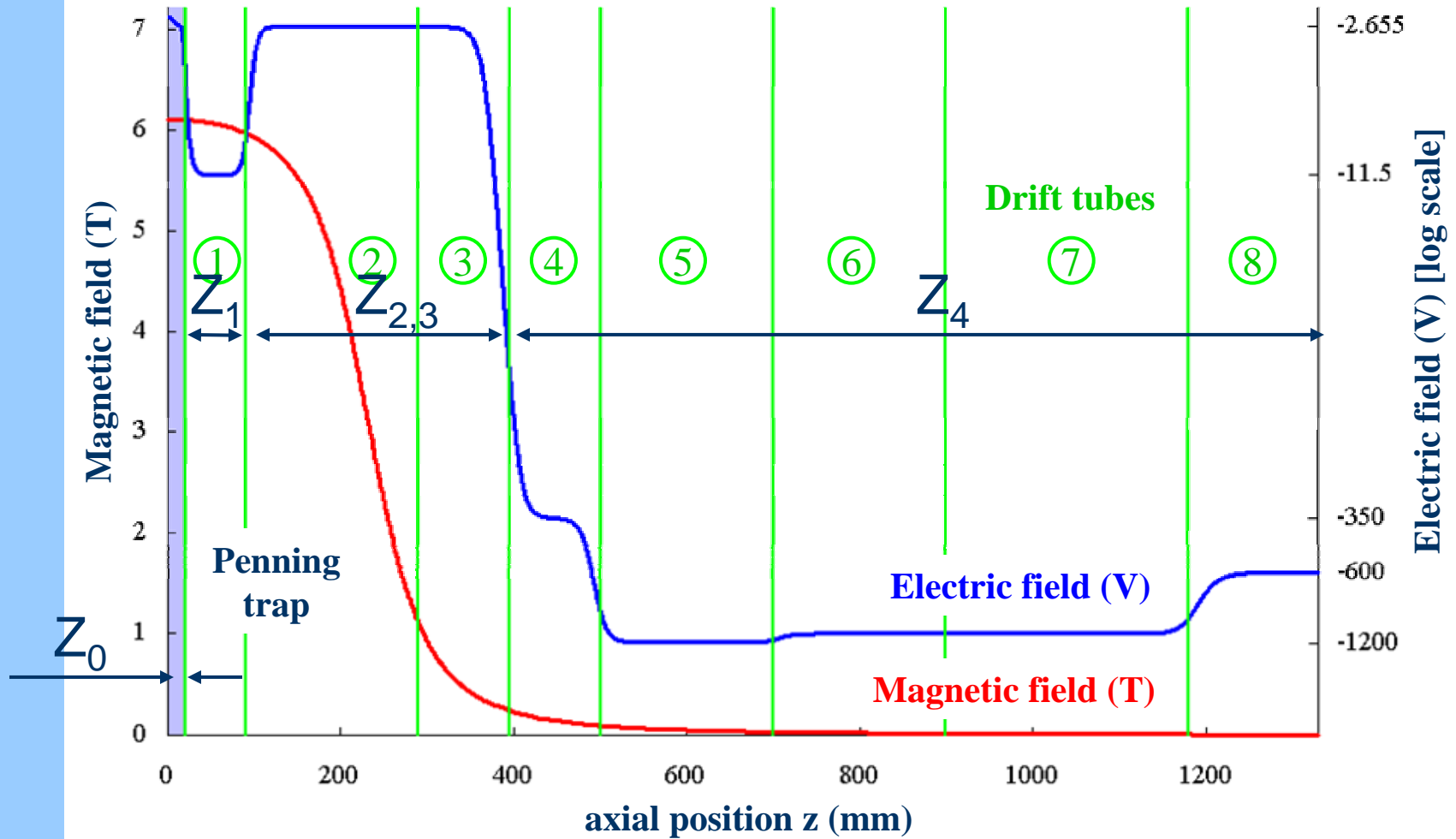
- Energy depends on radii

$$TOF(\omega_{RF}) = \int_{z=0}^{z_{detector}} \sqrt{\frac{m}{2 \left( E_0 - q \cdot V(z) - \mu(\omega_{RF}) \cdot B(Z) \right)}} dz$$

- time of flight depends on:  
total Energy  $E_0$ , electric  $V(\mathbf{z})$  and magnetic Field  $B(\mathbf{z})$

# V(z)

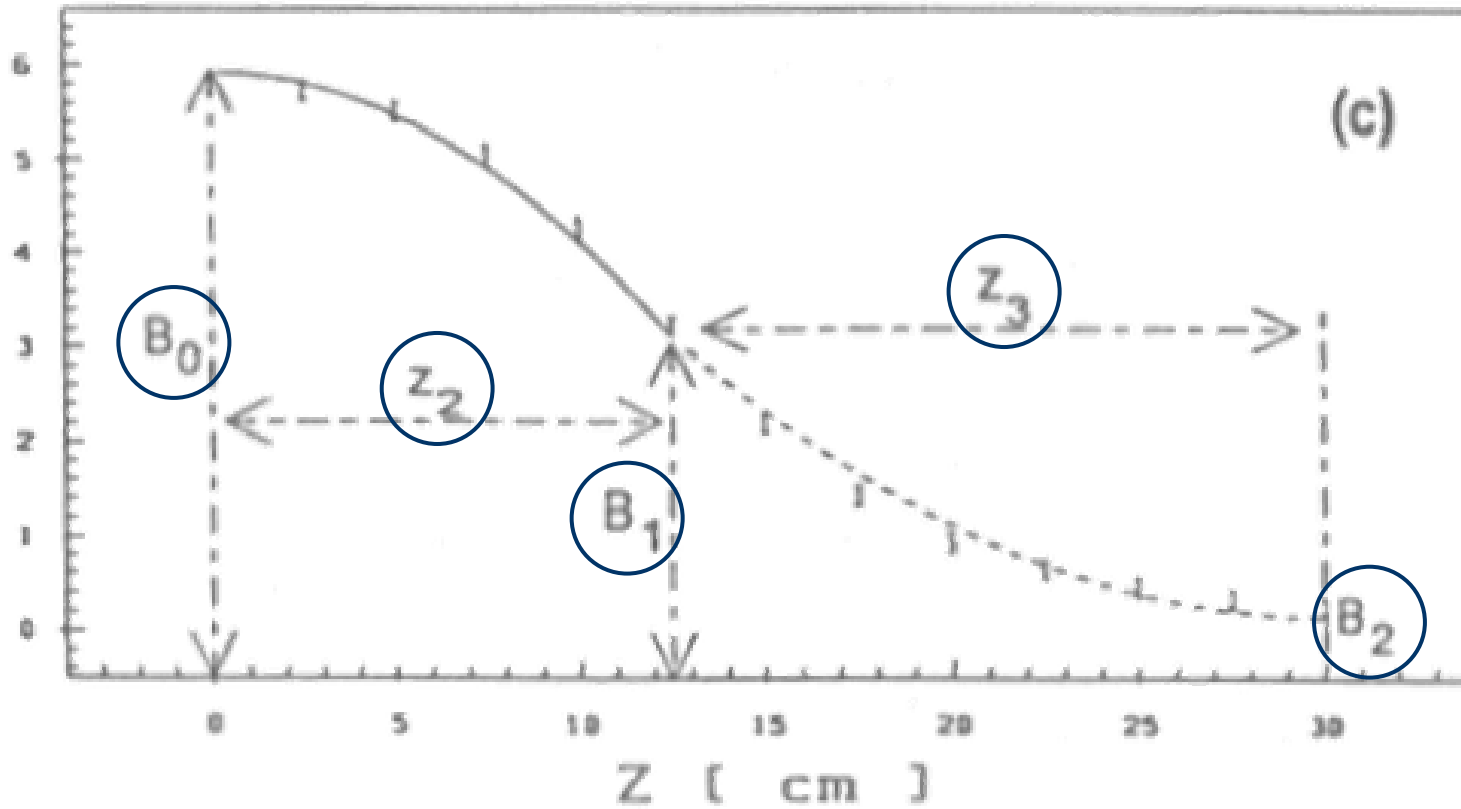
Magnetic and electric field in the precision trap and the drift tubes of ISOLTRAP



# B(z)



Aproximate B(z) by two parabolas





# Setup dependent Parameters

- Z0 - dist. trap center to first drift tube (in m)
- Z1 - length of first drift tube (in m)
- Z2 - length of second drift tube (in m)
- Z3 - length of third drift tube (in m)
- Z4 - length of other drift tubes to detector (in m)
- V1 - potential at first drift tube (in eV)
- V4 - beam potential (in eV)
- $\nu_m = \nu_m$  - magnetron frequency (in Hz)
- B0 - magnetic field at trap center (in T)
- B1 - curvature parameter of magnetic field (in T)
- B2 - curvature parameter of magnetic field (in T)



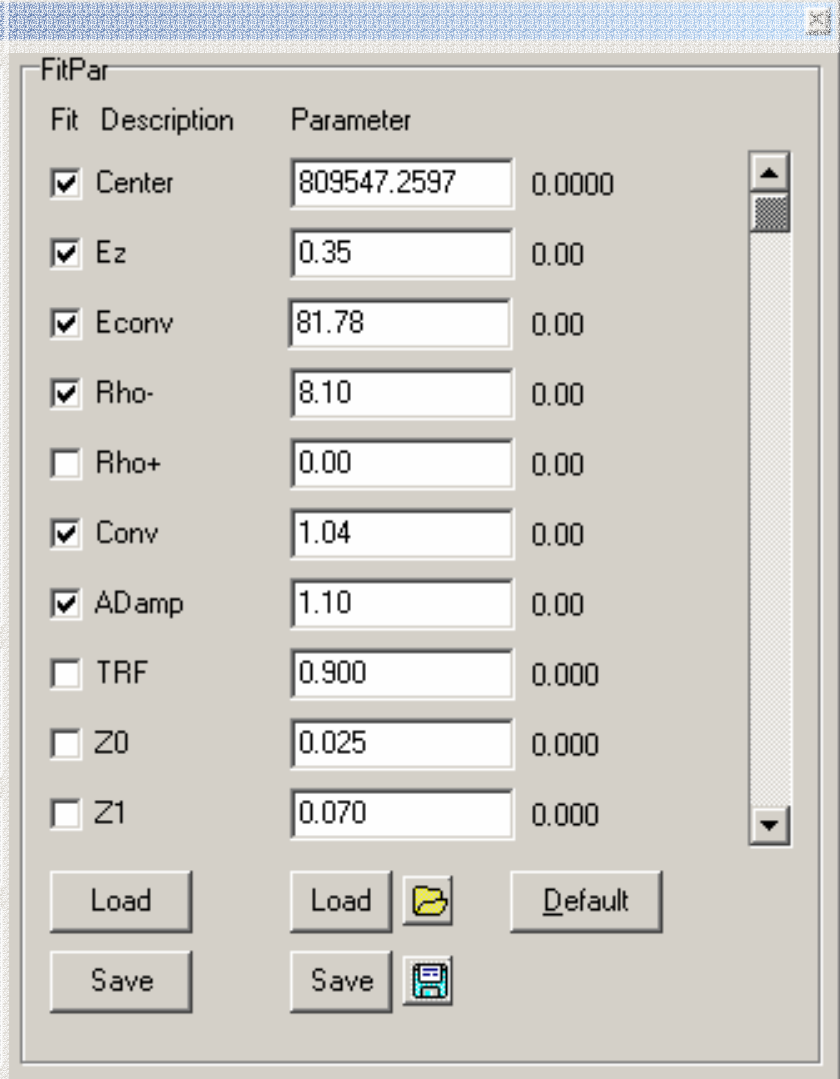
# Parameters that change with "time"

- Center – center frequency (Hz)
- EZ - axial energy during ejection (in eV)
- EConv – energy in the conversion region ( $Z_{2,3}$ )
- RhoP - initial magnetron radius (in mm)
- RhoM - initial reduced-cyclotron radius (in mm)
- Conv - number of conversions
- Damp - damping coefficient  $\delta$  (in 1/s) 
$$\delta = \frac{q}{m M_{ion}} \frac{1}{T/T_N} \left( \frac{P}{P_N} \right)$$
- TRF - excitation time (in s)

# Parameters in EVA control (F1)

## Remarks:

- parameters that should be fitted do not like to start with "0".
- don't try to fit to many at once.

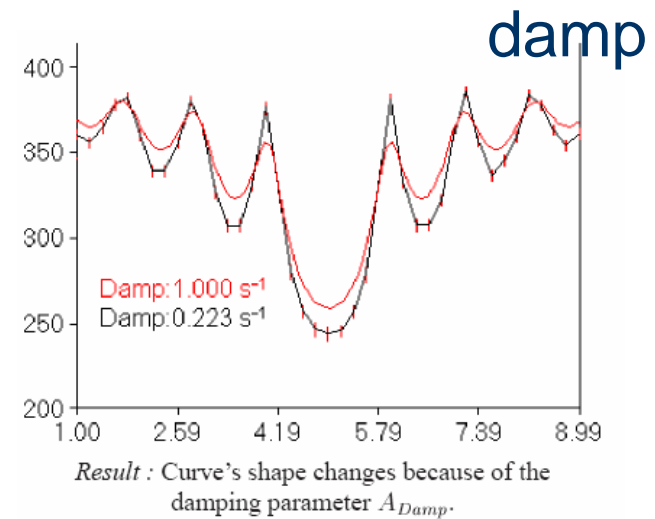
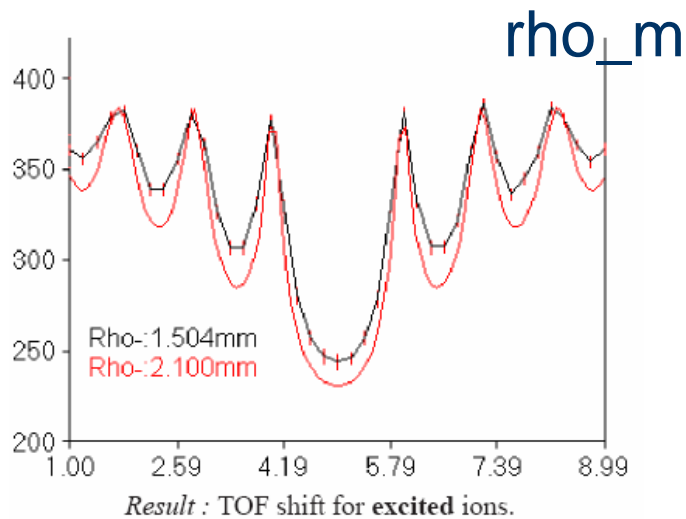
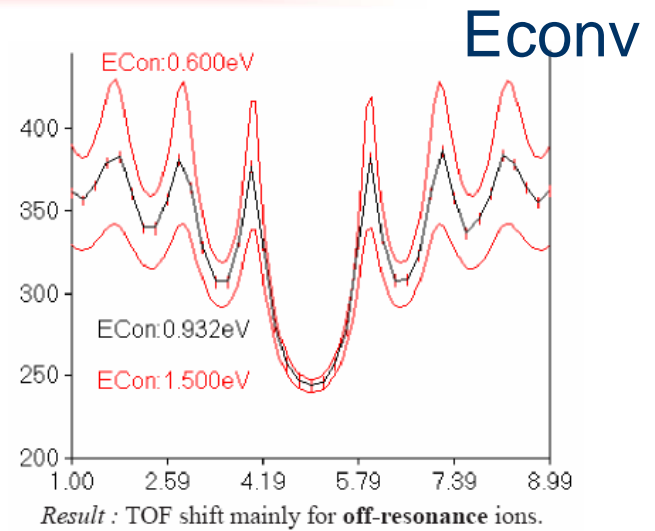
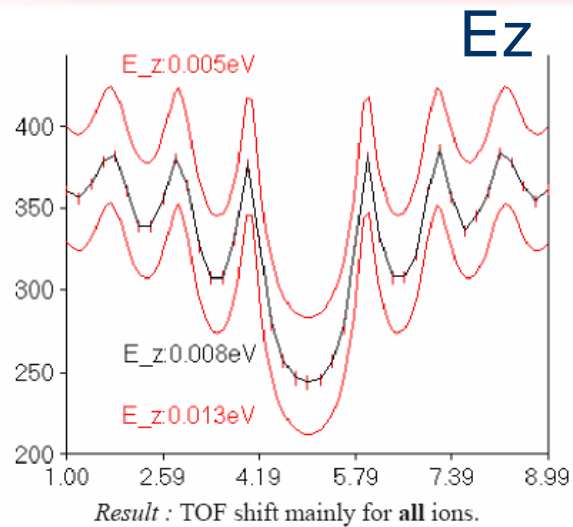


Fit	Description	Parameter	
<input checked="" type="checkbox"/>	Center	809547.2597	0.0000
<input checked="" type="checkbox"/>	Ez	0.35	0.00
<input checked="" type="checkbox"/>	Econv	81.78	0.00
<input checked="" type="checkbox"/>	Rho-	8.10	0.00
<input type="checkbox"/>	Rho+	0.00	0.00
<input checked="" type="checkbox"/>	Conv	1.04	0.00
<input checked="" type="checkbox"/>	ADamp	1.10	0.00
<input type="checkbox"/>	TRF	0.900	0.000
<input type="checkbox"/>	Z0	0.025	0.000
<input type="checkbox"/>	Z1	0.070	0.000

Buttons: Load, Save, Load (with folder icon), Save (with floppy icon), Default



# Some examples



*courtesy of C. Yazidjian*

# More settings

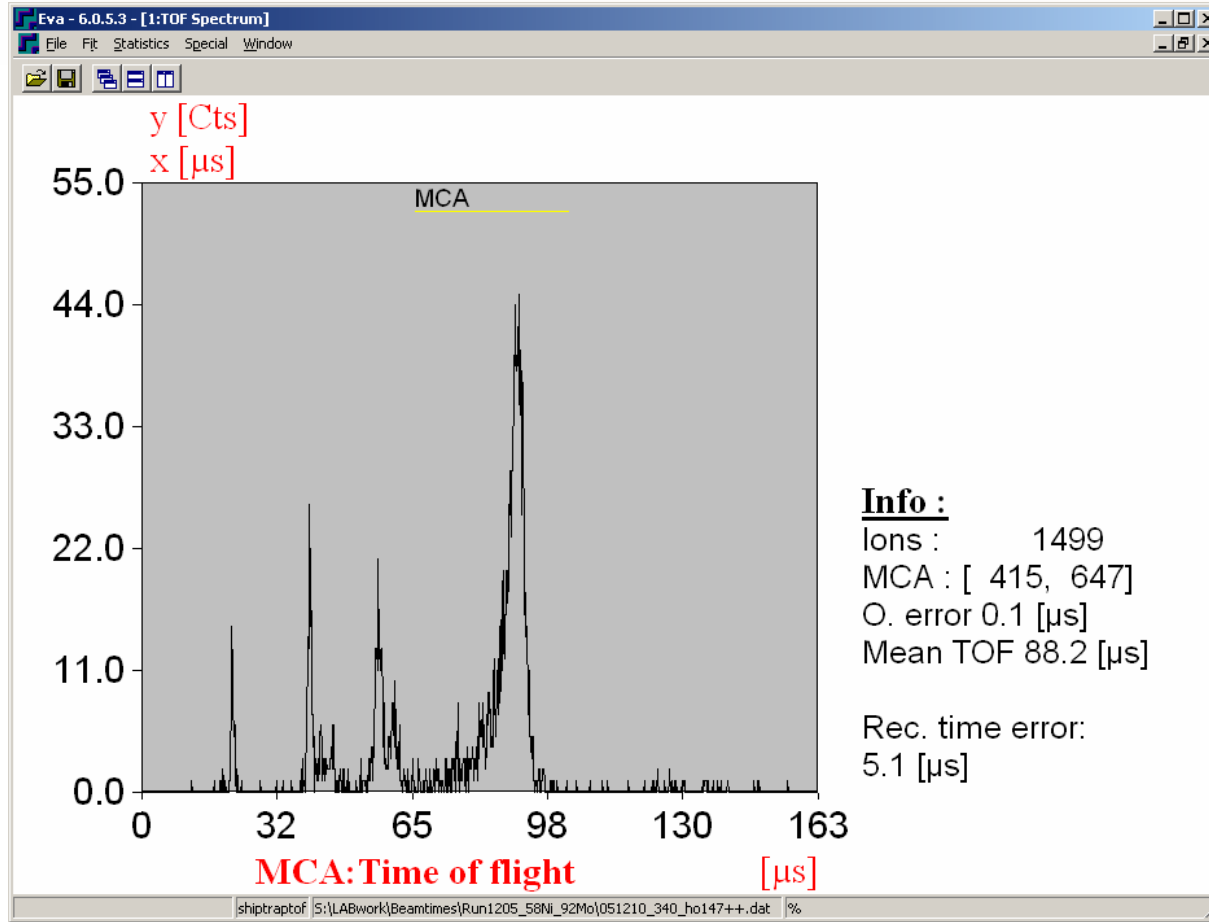
- scans per fit – evaluation of data with time/scan
- ions per shot = z-class
- TOF error
  - stat: standard deviation for each scan step = recom. time error
  - sys: deviation for mean TOF determination between different scans
- Sum statistics – evaluation of data with time for low statistics

The screenshot shows the 'Eva control' software interface with the following settings:

- Scans per fit:** min 1, max 5
- Ions per shot:** min 1, max 26
- MCA range:** min 66.24, max 103.36
- Z-class analysis:**
  - yes, please
  - z-classes: 3
  - ions/z: 500
  - deteff. %: 35
  - efferr. %: 10
- Use scans:** All 1, Select 2d (list contains 1)
- Use points:** All (list contains 1-14)
- TOF error:** stat 4.00, sys 0.00
- Sum statistics
- Single TOF: 1
- Fit:**
  - No
  - Gauss
  - Mike
  - Mike (2 res)
  - Ramsey (exp)

Buttons: Update, Save ini

# TOF spectrum (Ions/channel vs. t)



Recommended time error =  
Mean quadratic deviation

$$\sqrt{\frac{1}{N-1} \sum_i N_i \cdot (x_i - \bar{x})^2}$$

# Fit the Mike function

- Fitting by minimizing

$$\chi^2 = \sum_{i=1}^N \left( \frac{y_i - y(x_i; a_1 \dots a_M)}{\sigma_i} \right)^2$$

using the "Levenberg-Marquardt" method

- Uncertainty of  $a_m$  by varying  $a_m$  until we find  $\chi^2 = \chi^2 + 1$  and symmetrizing the left and right value.



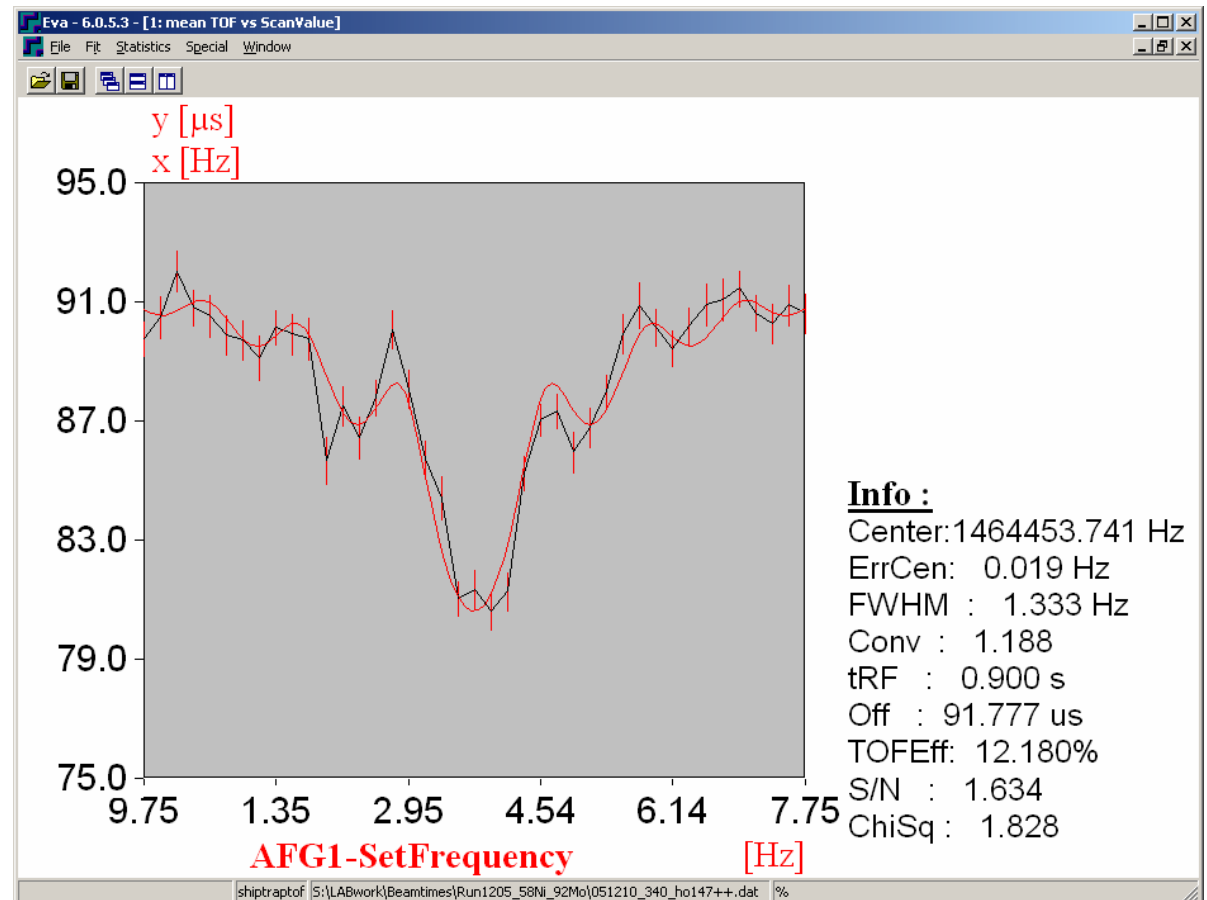
# Fit result

- TOFEff = Off – TOF(Center)

!Mass and fit dependend!

- S/N =

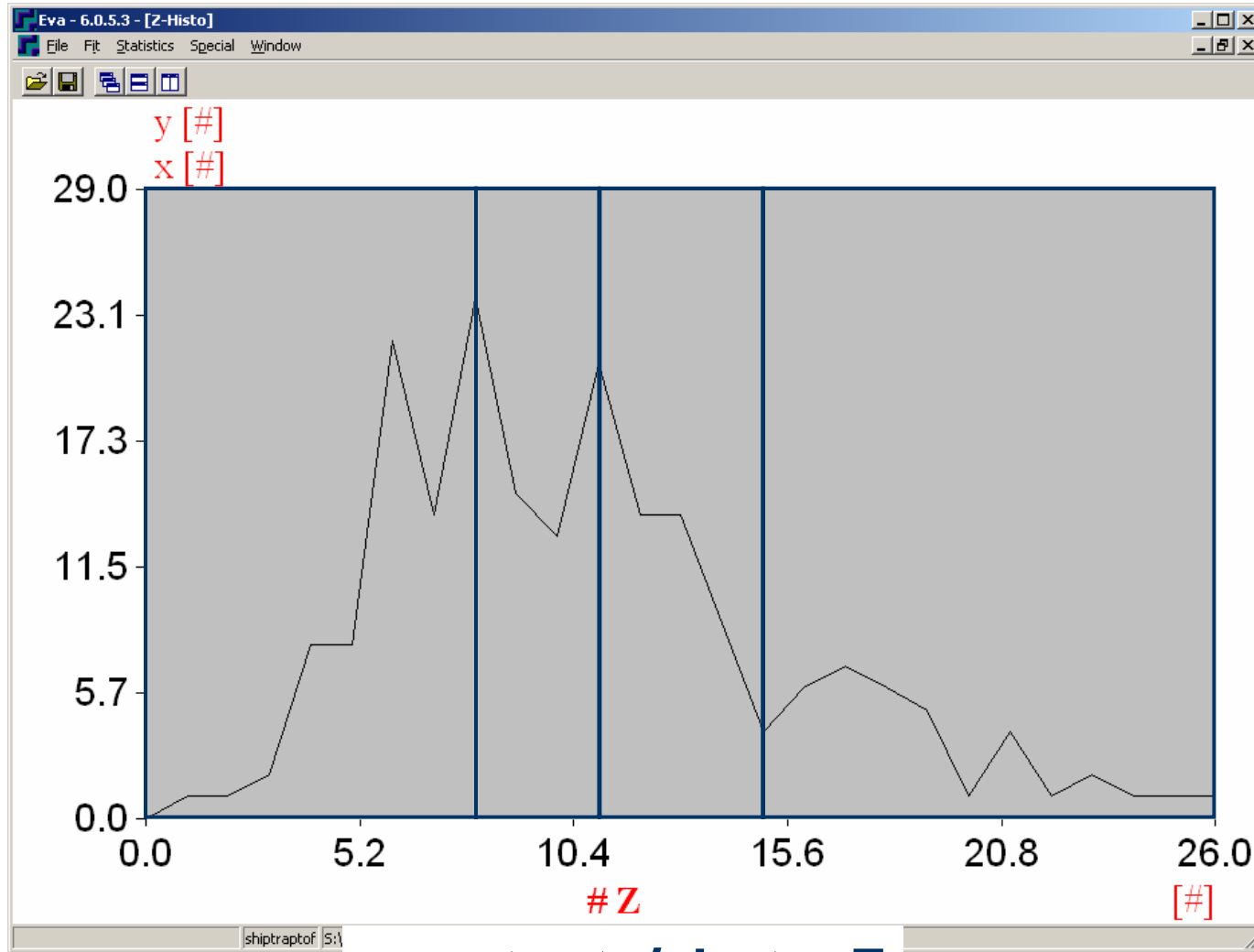
$$\frac{t_{\max} - t_{\min}}{\sqrt{\sigma(t_{\max})^2 + \sigma(t_{\min})^2}}$$





# Z-class Analysis

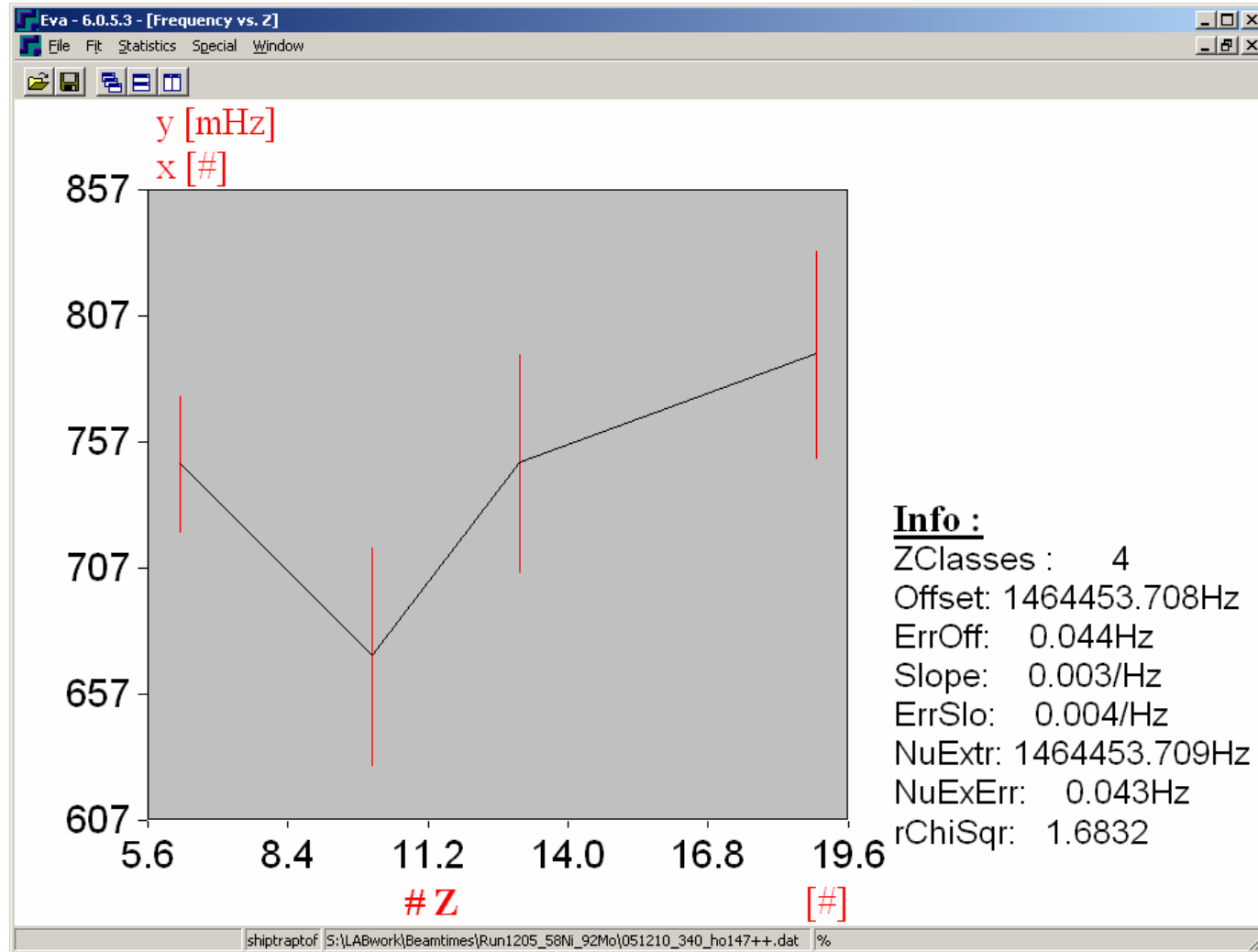
number of events / z



count rate/shot = Z

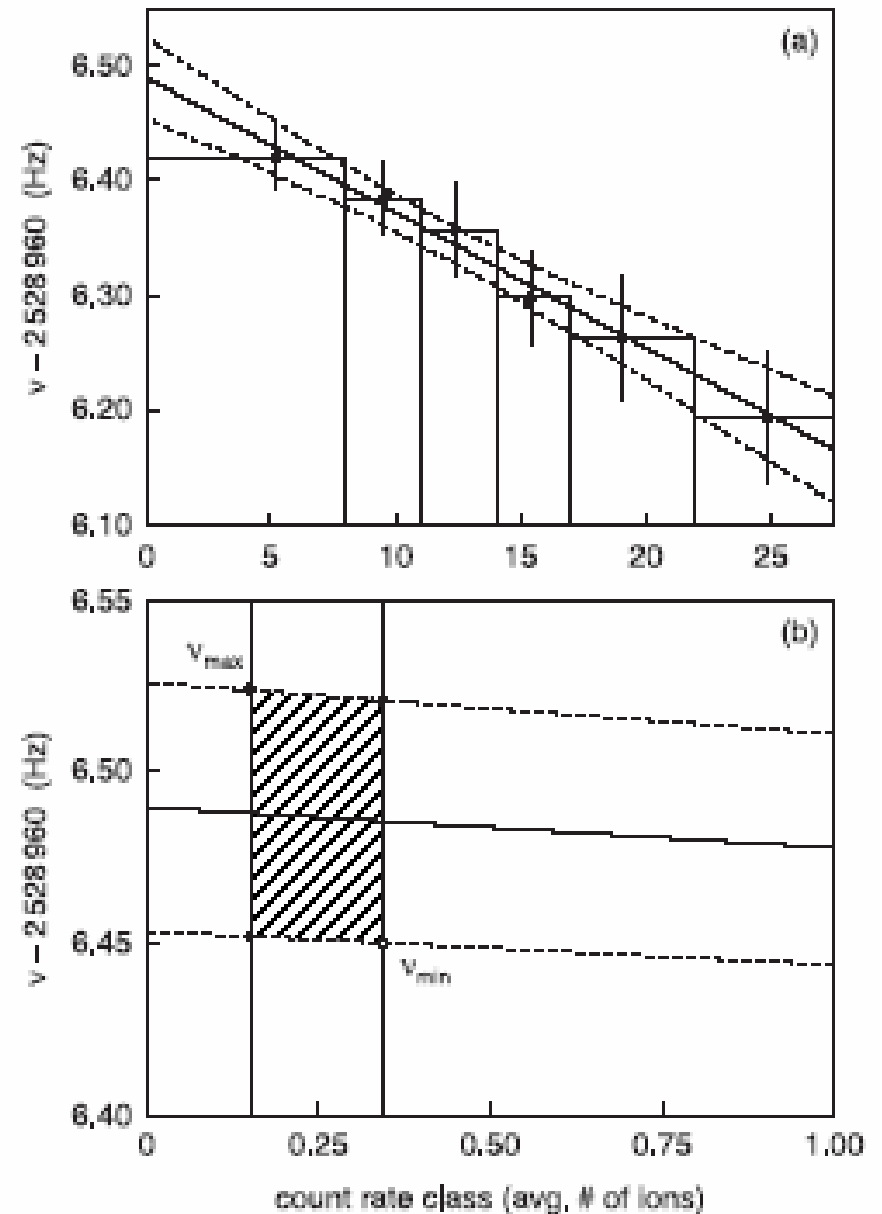


# Z-class Analysis



# Z-class Analysis

- linear extrapolation to one ion in the trap (including detector efficiency)
- should be done for all files





# Results

- Menu->Fit->Write Fit Files (CTRL-s)
- two files are created: `*.ft2` and `*.log`
  - `*.ft2` to be used with SOMA (see Ryan's talk)
  - `*.log` contains more complete information  
(if you want to redo the fit and obtain the same result 😊)
- from z-class analysis: `*z.fit`
  - contains the used z-class breakdown and the parameters of the linear fit