Some features of the data processing in the time-of-flight mass-spectrometry of heavy ions

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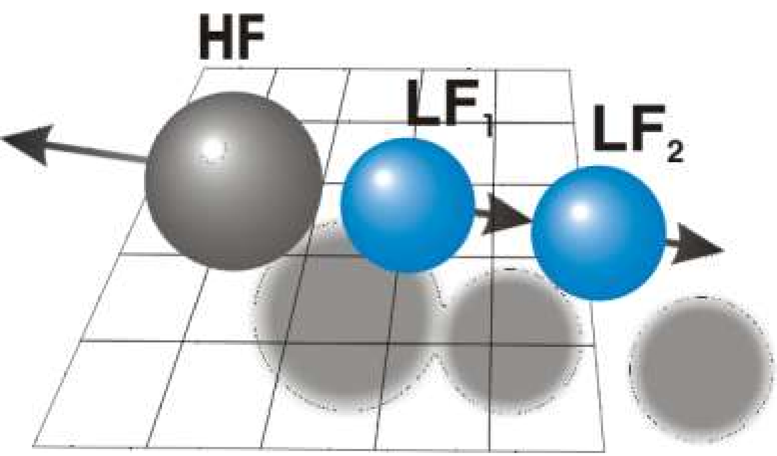
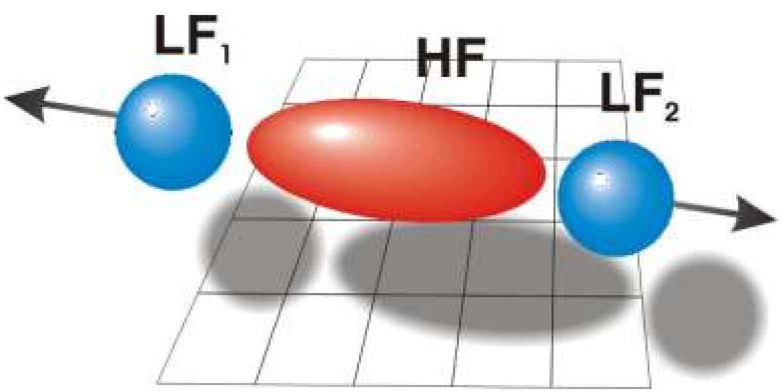
Setting of the physical problem

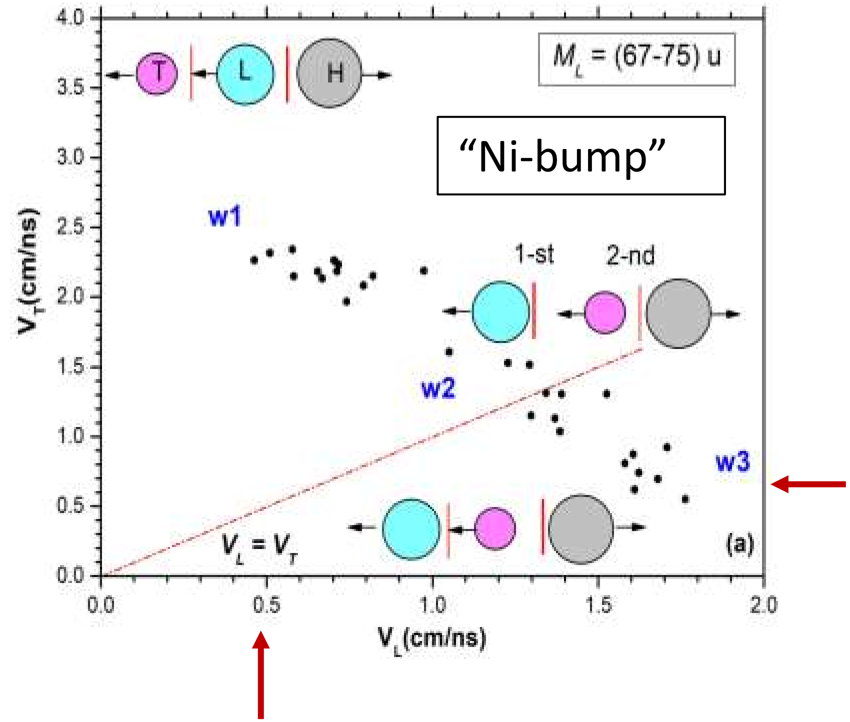
Collinear Cluster Tri-partition (Multy-Cluster Decay)

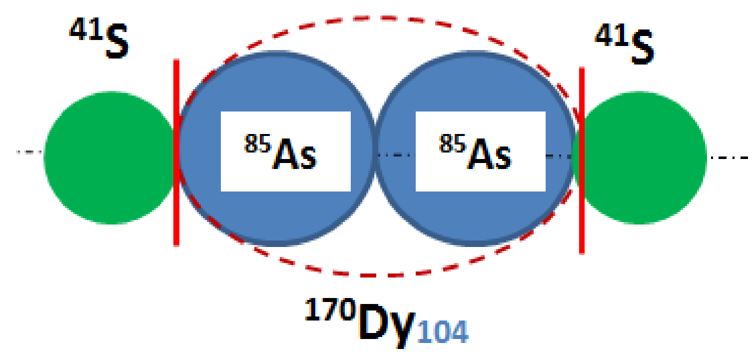




Vide range of heavy ions masses, energies and velocities

Actually find

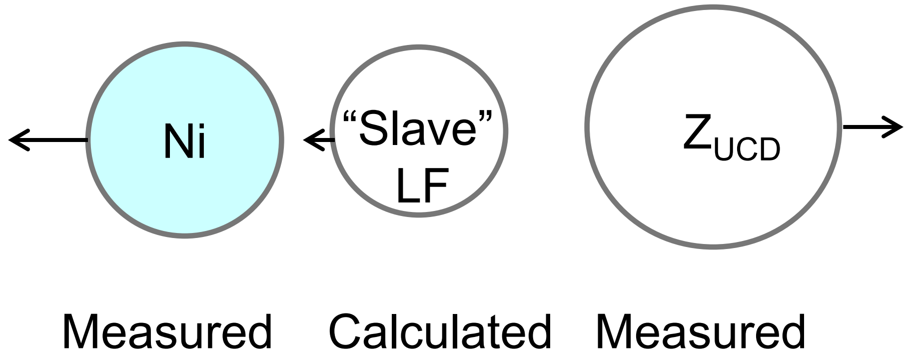




Method of analysis of the missing mass data

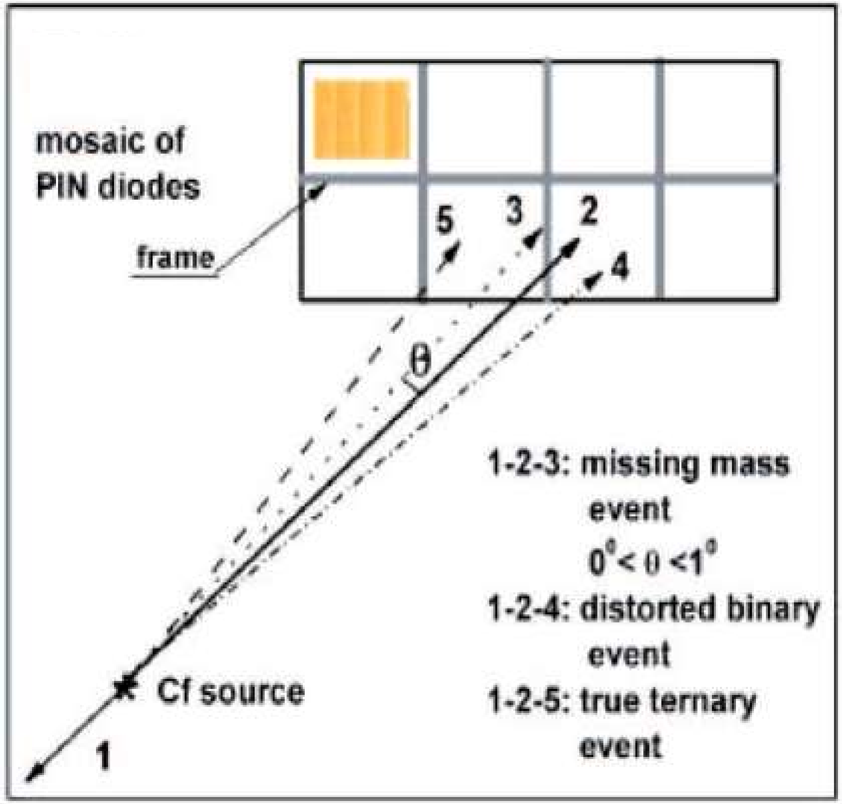
$Z(HF) = Z_{UCD}(M(HF))$

$M(LF) = 252 - M(HF)$
$Z(LF) \;= 98 – Z(LF)$
$V(LF)$ - momentum conservation law



Comparing velocities with the fission ones
one could put forward the ideas on the decay scenarios

Registration of the collinear fragments in the mosaic of PIN diodes



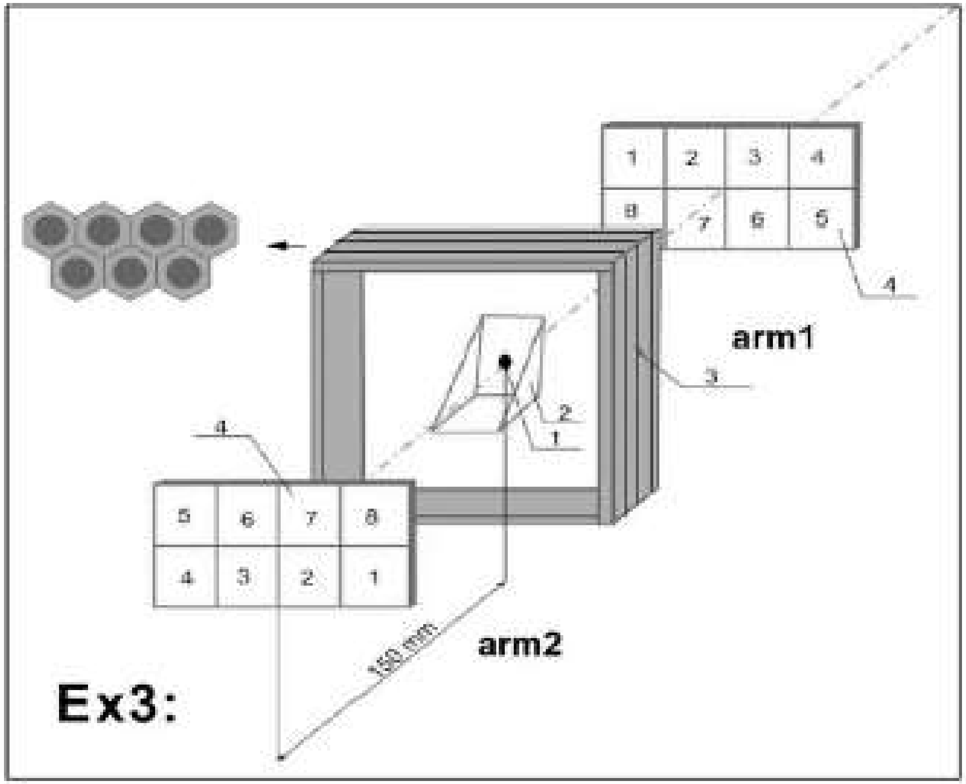
The geometry in Ex3 with the PIN diodes. Hitting the mosaic by a fork of fragments can give rise to three different types of events. Blocking can occur if the opening angle of the fork lies in the range 0◦ < < 1◦ (missing-mass event marked as 1-2-3). Both fragments of the fork can hit the same PIN diode (event 1-2-4). If > 1◦ the fragments forming the fork can be detected in two different PIN diodes (true ternary event 1-2-5).

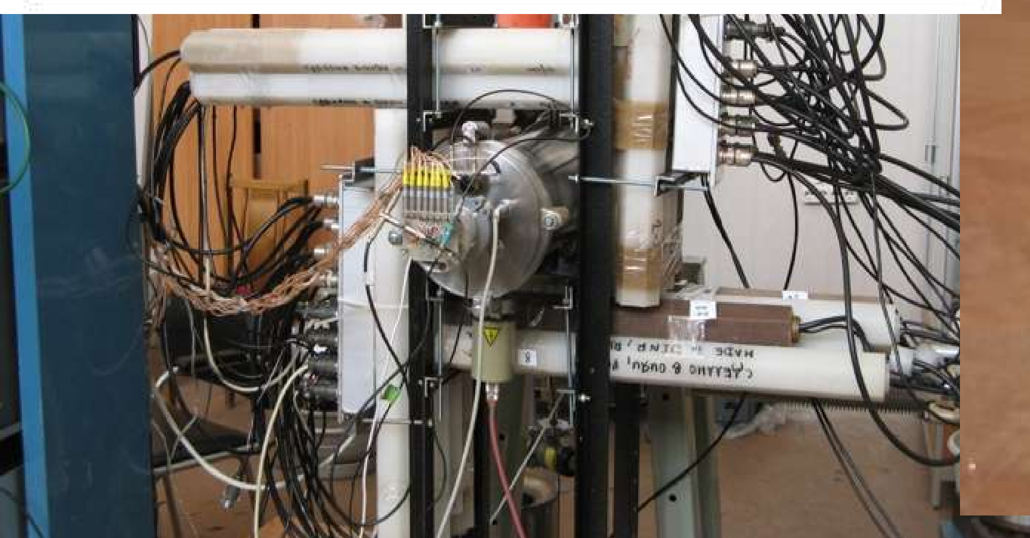
Off-line analysis of the rare events

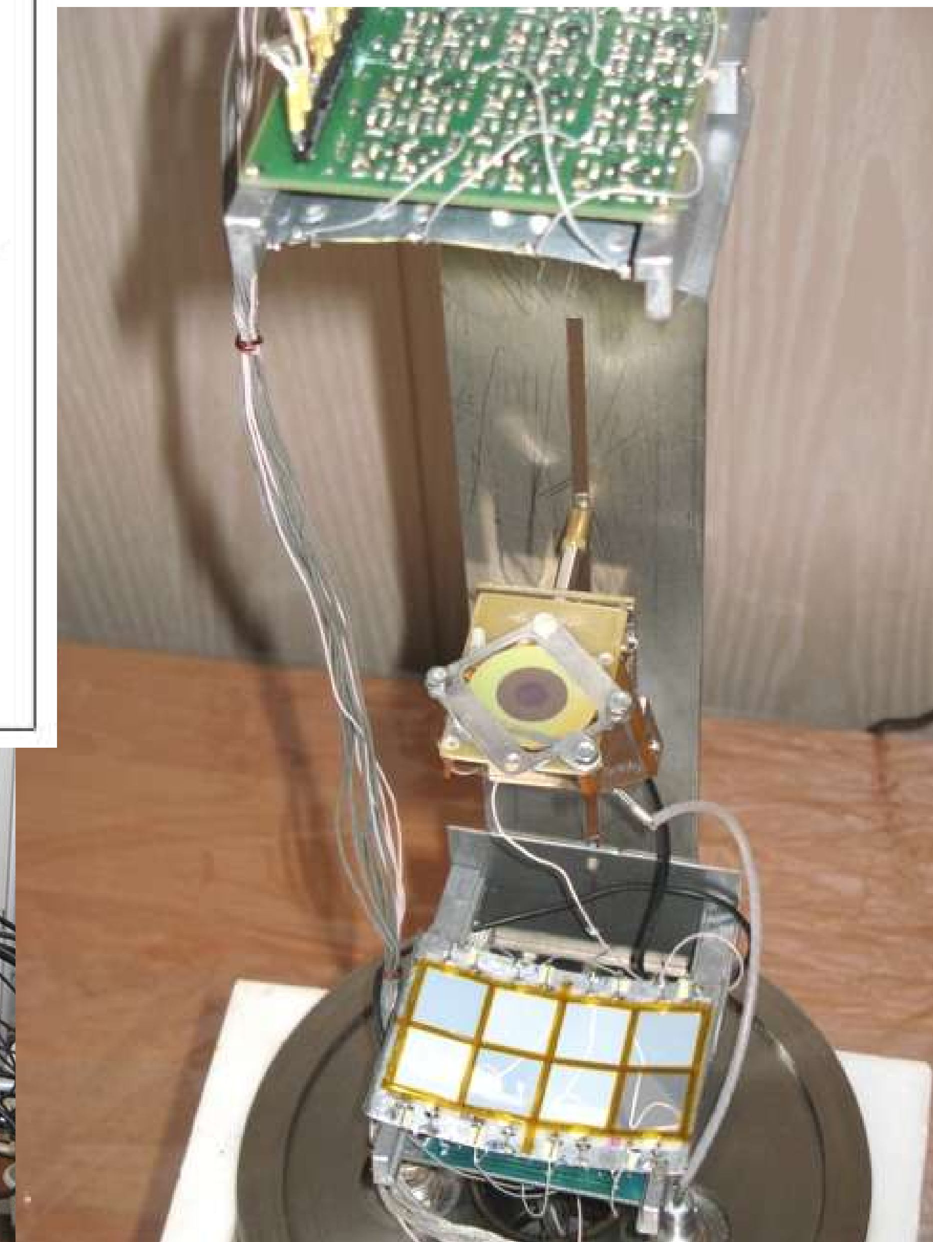
Flash-ADC - 5 GHz sampling rate
200 psec per point

Experimental setups

COMETA= COrrelation Mosaic E-T Array





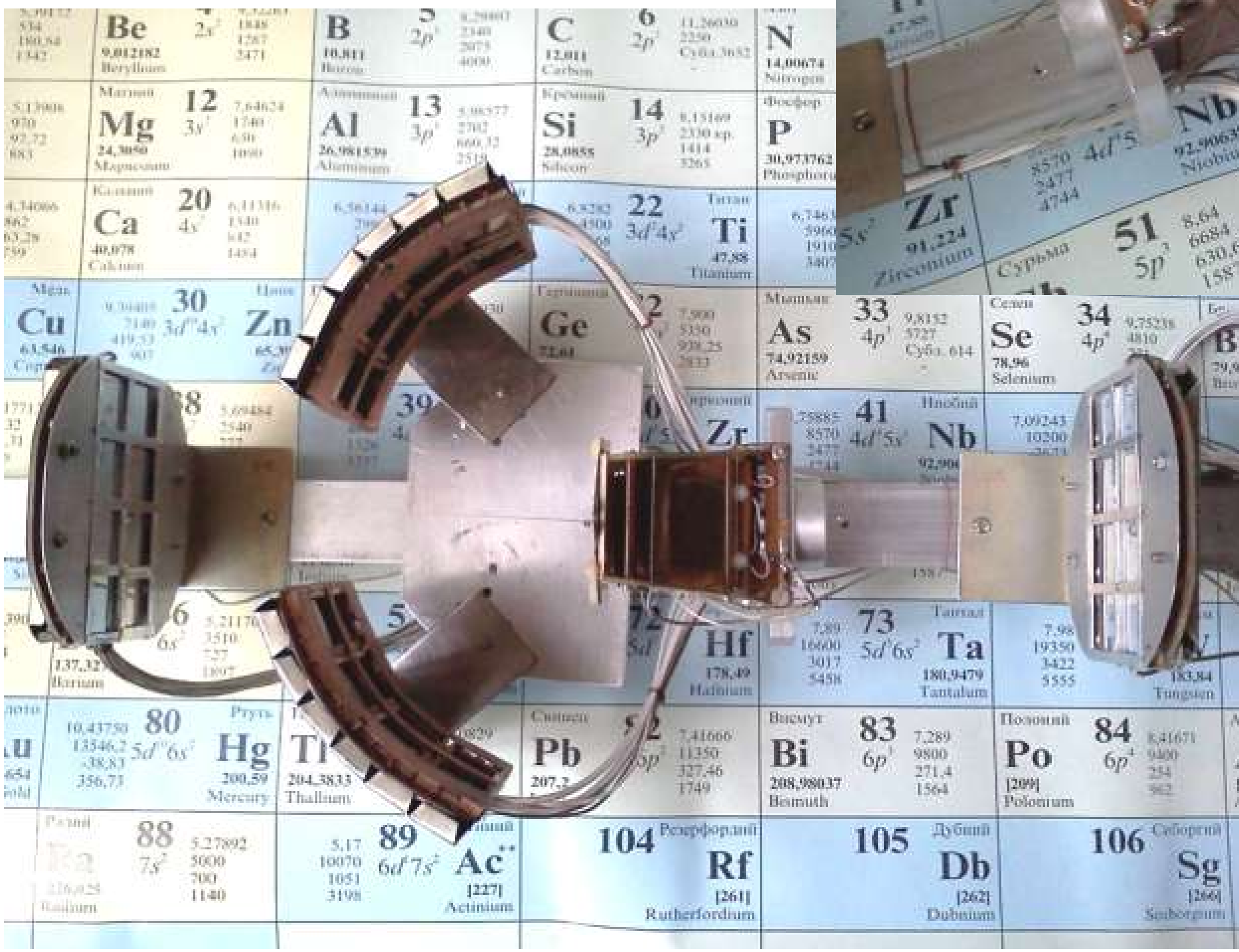


COMETA-2 setup,

PIN-diodes 120˚& MCP

neutron belt 28 ^{3}He counters

Summer 2011



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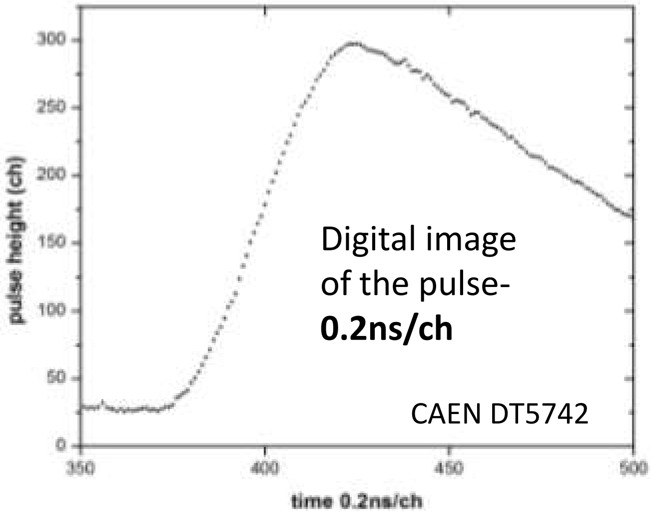
Improvement of the data processing algorithms

Feature №1

Our experimental approach



PHD:

$$E = E_{det} + R(M,E), \quad (1)$$

$$R(M,E) = \frac{\lambda \cdot E}{1 + \varphi \cdot \frac{E}{M^2}} + \alpha \cdot ME + \beta \cdot E, \quad (2)$$

$$E = \frac{M \cdot V^2}{1.9297} \quad (3)$$

$$\longrightarrow \quad G(\{\lambda, \varphi, \alpha, \beta\}, M, V) = 0$$

Combining equation (1), (2) and (3), we obtain:

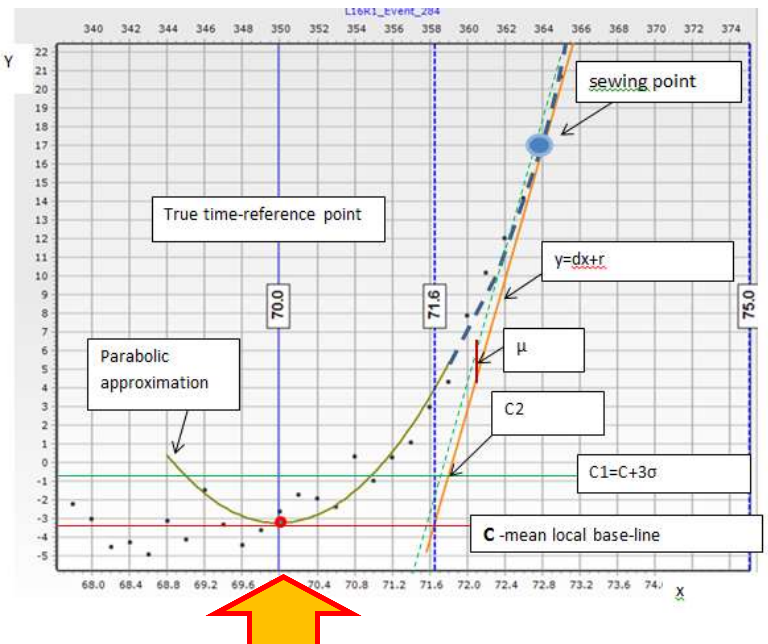
$$G = \frac{MV^2}{k} - [E_{det} + \frac{\lambda \cdot \frac{MV^2}{k}}{1 + \varphi \cdot \frac{V^2}{Mk}} + \alpha \cdot \frac{M^2V^2}{k} + \beta \cdot \frac{MV^2}{k}] = 0,$$

where $k = 1.9297$.

$$\min \quad F = [(<ML_T> - <ML>)^2 + (<MH_T> - <MH>)^2] + \mu \sum_{M_{TE}} \frac{(Y(M_{TE}) - Y_T(M_{TE}))^2}{Y(M_{TE})}$$

PD:

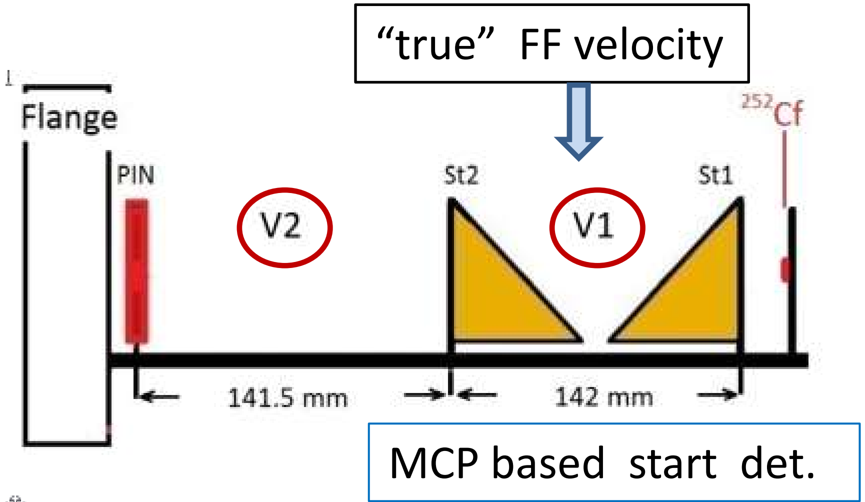
$$\Delta t_p = \gamma \frac{M^{1/6} E^{1/2}}{\;}$$

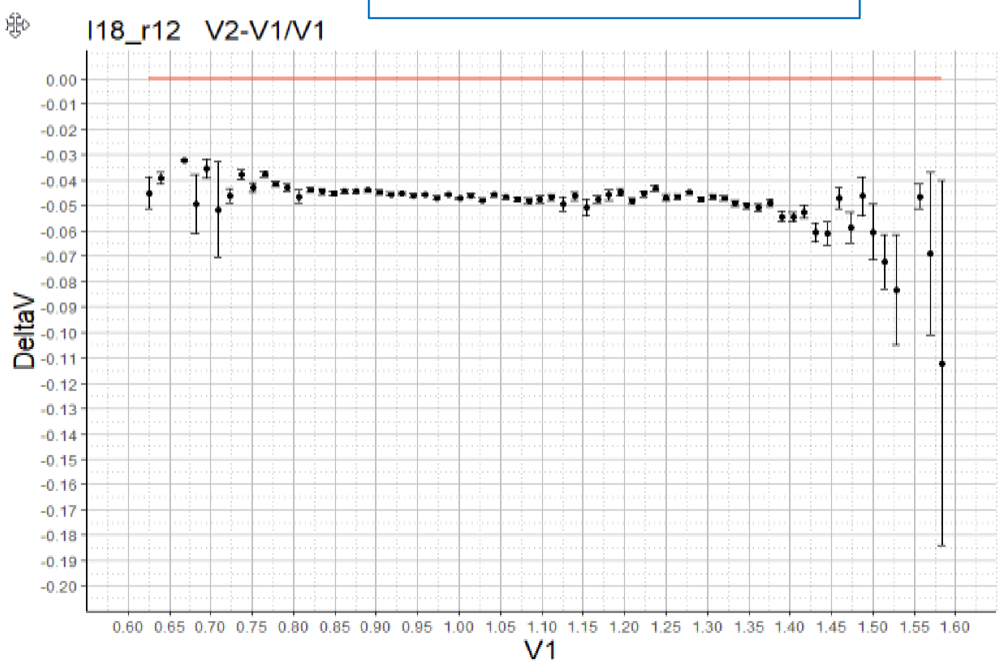


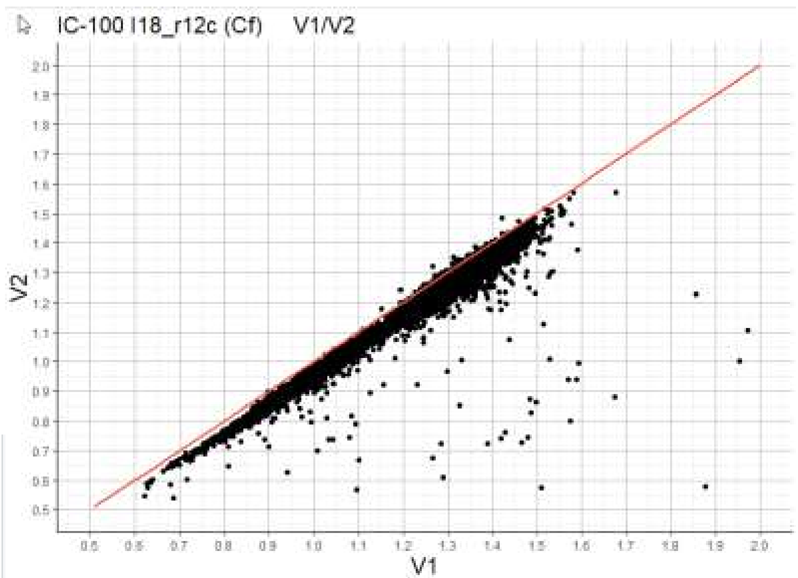
True time reference point

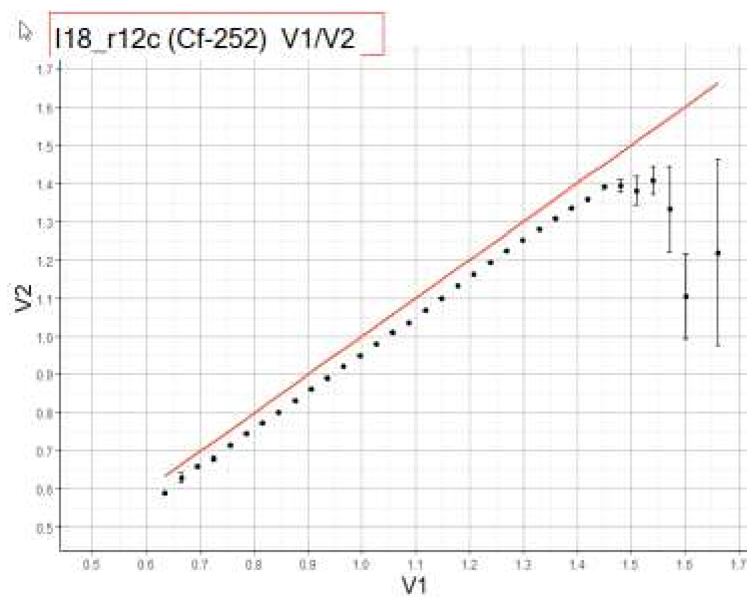
A new off-line method of time-pickoff “sewing-parabola”

Validating of the Sewing-parabola method









Comparison of V1&V2:
good agreement within ~0.5%

Feature №2

Specific approach to the energy spectrometry with PIN diodes

Peculiarity of the CCT experiments : short intervals of the fragments following while the double-hit regime of their detection is extremely desirable .

Providing the double-hit detection mode:

two fragments in the same detector simultaneously

formation of short pulses From PIN diode in the sub-microsecond range, but normally milliseconds formations are adopted (?!)

Sorry for some formulas:

In the classical approach Q~E = $\int_{-\infty}^{\infty} \frac{i(t)}{dt}$ (1)

i.e. the area under the current graph is calculated *i(t)*

Let us show that with an arbitrary response $h(t)$ of the electronic circuit connected to the detector, the area of the output signal S is also proportional to the charge Q.

Then the response of the external circuit U(t) to the current $i(t)$:

$$U(t) = \int_0^t i(r)h(t-r)dr,$$

And

$$S = \int_0^\infty U(t)dt = \int_0^\infty \{\int_0^t i(r)h(t-r)dr\}dt \qquad (2)$$

According to the Fumini theorem:

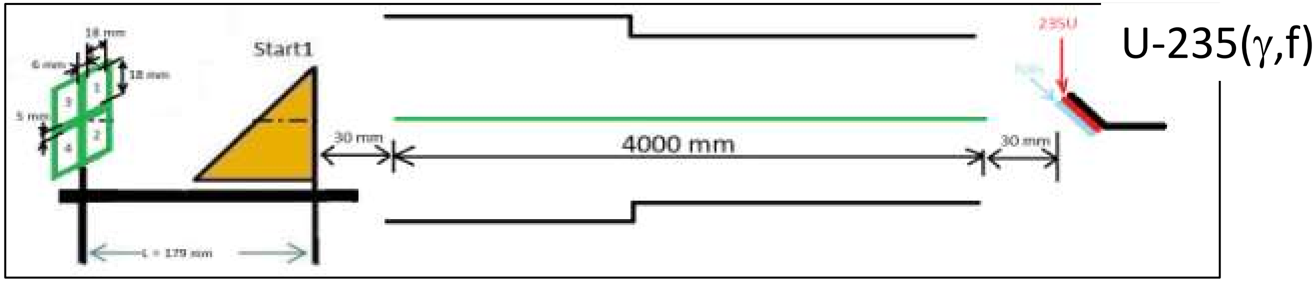
$$S = \int_0^\infty U(t)dt = \int_0^\infty \{\int_0^t i(r)h(t-r)dr\}dt = \int_0^\infty i(r)dr \int_r^\infty h(t-r)dt$$

After replacing the variables in the inner integral, we have:

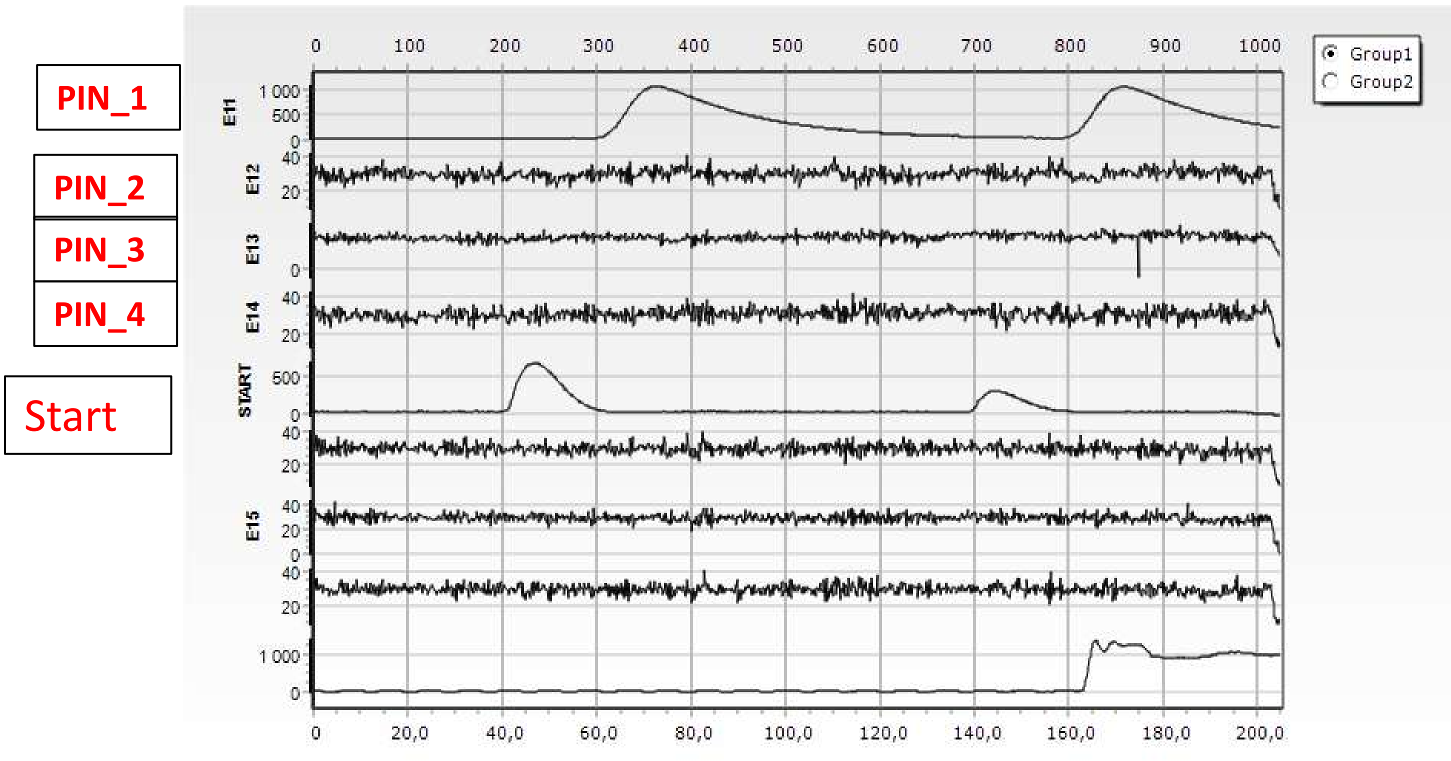
$$S = \int_0^\infty i(r)dr \int_r^\infty h(t-r)dt = \int_0^\infty i(r)dr \int_0^\infty h(z)dz = C\int_0^\infty i(r)dr = C*Q, \qquad (3)$$

where C = const is the area of the response function, and Q is the charge created by the fragment in the detector.

Hot example of the double-hit success



VEGA (V-E Guide based Array) setup at the MT-25 microtrone in FLNR



First simultaneous registration of two CCT partners in one spectrometer arm – direct demonstration of the CCT

Feature №3

Modernization of the PHD parametrization used

Parametrization utilised earlier:

[Mulgin et al., Two-parametric method for silicon detector calibration in heavy ion and fission fragment spectrometry// Nuclear instruments and Methods in Physics Research A. 388, (1997), 254-259]

$$E = E_{det} + R(M,E), \quad (1)$$

$$R(M,E) = \frac{\lambda \cdot E}{1+\varphi \cdot \frac{E}{M^2}} + \alpha \cdot ME + \beta \cdot E\,, \quad (2)$$

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$$G = \frac{MV^2}{k} - [E_{det} + \frac{\lambda \cdot \frac{MV^2}{k}}{1+\varphi \cdot \frac{V^2}{Mk}} + \alpha \cdot \frac{M^2V^2}{k} + \beta \cdot \frac{MV^2}{k}] = 0\,,$$

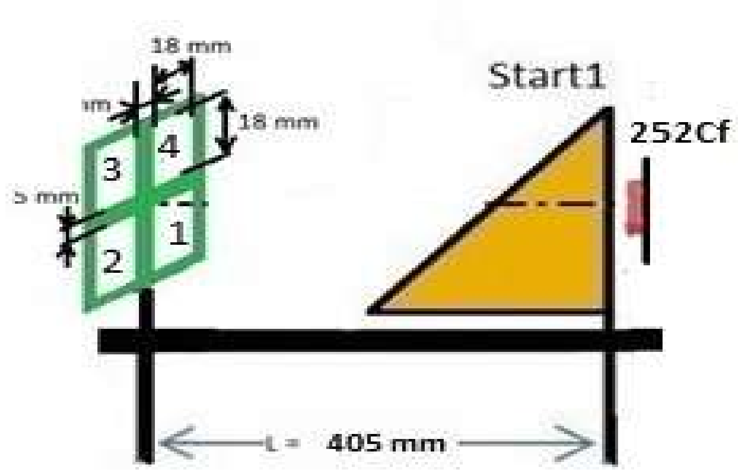
where $k = 1.9297$.

$$\min \quad F = [(<ML_T> - <ML>)^2 + (<MH_T> - <MH>)^2] + \mu \sum_{M_{TE}} \frac{(Y(M_{TE}) - Y_T(M_{TE}))^2}{Y(M_{TE})}$$

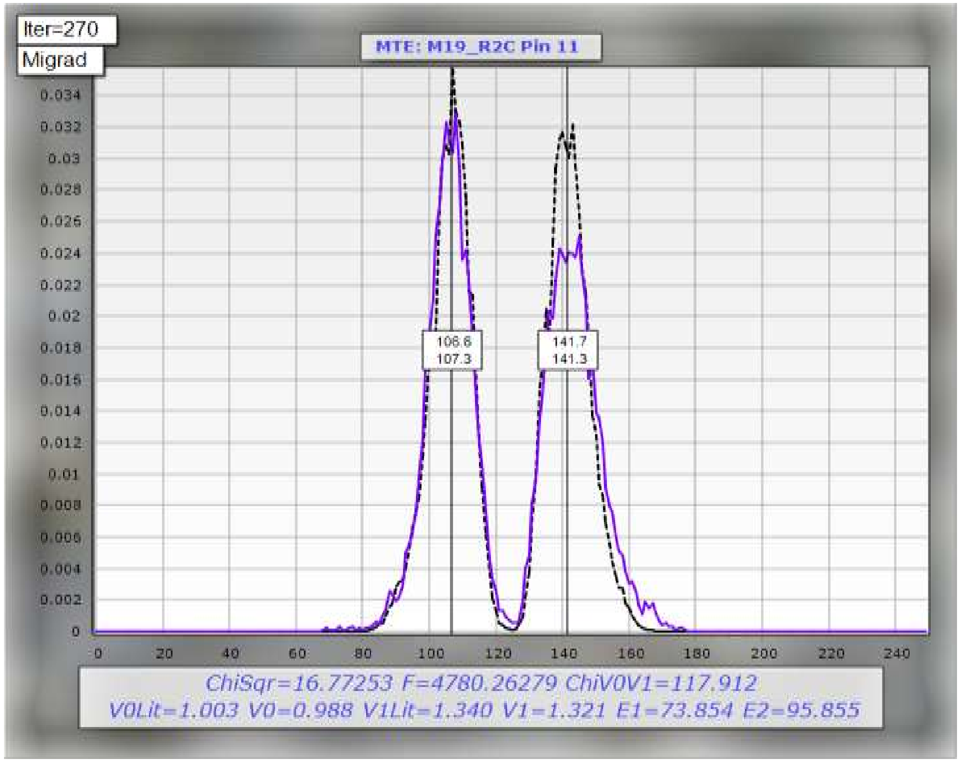
Extended parametrization: $R(M,E) = \frac{\lambda \cdot E}{1+\varphi \cdot \frac{E}{M^2}} + \alpha \cdot ME + \beta \cdot E\,,$ $\longrightarrow$ $\alpha M^{(1+d)} E + \beta M^{f} E$

Motivation: guarantied unbiased position of the mass lines

Testing of the extended PHD parametrization



VEGA detection block



Pin	Vl			VH			ML			MH			D	F
	Vel_{exp}	Vel_{lit}	ΔV	Vel_{exp}	Vel_{lit}	ΔV	$Mass_{exp}$	$Mass_{lit}$	ΔM	$Mass_{exp}$	$Mass_{lit}$	ΔM		
1	1.340	1.321	0.019	1.003	0.988	0.015	107.25	106.6	0.65	141.28	141.7	-0.42	-0.35	0.47
2	1.340	1.33	0.01	1.003	0.994	0.009	107.25	106	1.25	141.28	142	-0.72	-0.53	-0.55
3	1.340	1.32	0.02	1.003	0.983	0.02	107.25	106.6	0.65	141.28	141.9	-0.62	-0.69	0.49
	1.340	1.316	0.024	1.003	0.983	0.02	107.25	106.4	0.85	141.28	140.8	0.48	-0.19	-0.15

Conclusion: additional parameters d &f are significantly different from the previously adopted zero values

Conclusion:

Original hardware and software complexes created in our group proves to be an effective instrument for investigation of the multibody decays. Recent modernization of the data processing algorithms aimed at providing better robustness of the data processing have demonstrated positive results in the latest experiments.

Thank you for attention!