PECULIARITIES OF BUNCH SHAPE MEASUREMENTS OF H-MINUS BEAMS IN LINEAR ACCELERATORS

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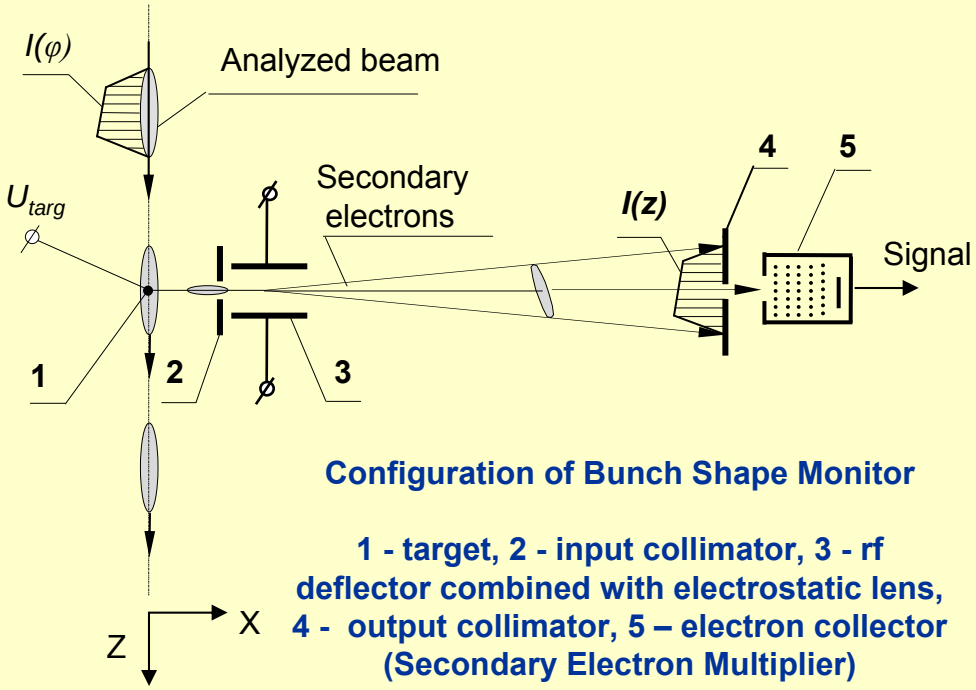
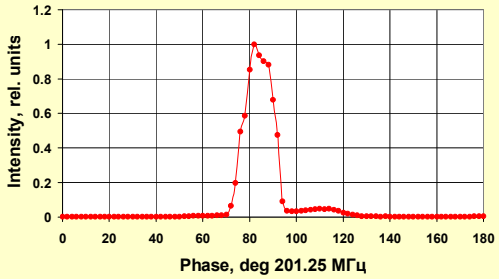


Configuration of Bunch Shape Monitor

1 - target, 2 - input collimator, 3 - rf deflector combined with electrostatic lens, 4 - output collimator, 5 – electron collector (Secondary Electron Multiplier)



Bunch shape measurement of 10 MeV H^- beam (DESY Linac-3)

[5] A. Mirzojan et al. Voprosy Atomnoi Nauki i Tekhniki. V. 4,5 (31,32), Kharkov, 1997, p. 92, (in Russian)

For tungsten $\frac{1}{n\sigma} << \frac{R}{\rho}$

where σ – total electron loss cross section

***n*- number of atoms per 1 cm^3**

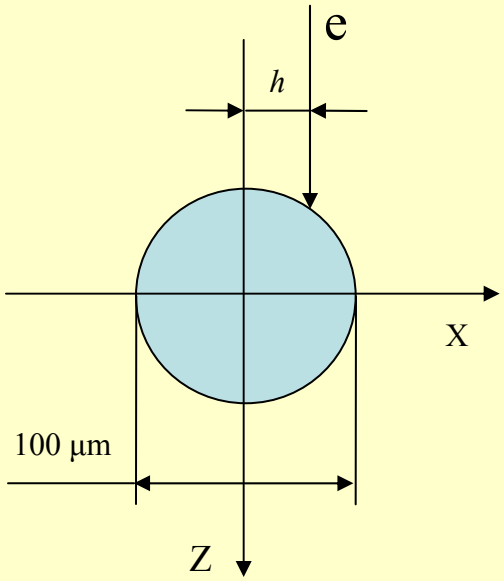
***R* - CSDA range, g/cm^2**

ρ - density

Simulation of interaction of electrons with a target (Geant4)

Relation of electron and ion energies $W_e = W_i \, m_e / m_i$

W_i, MeV	W_e, keV
10	5.44
100	54.4
1000	544



h= 0μm, 1μm, 2μm….. 49μm

N=100000 for each *h*

For negative *h* - symmetry

Results of simulation

(Red lines – electrons, green lines – photons)

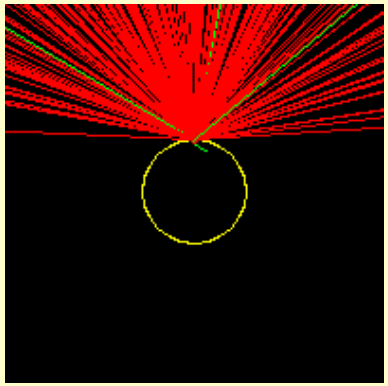
h=0 μm

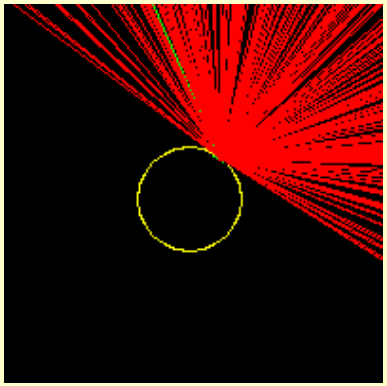
h=30 μm

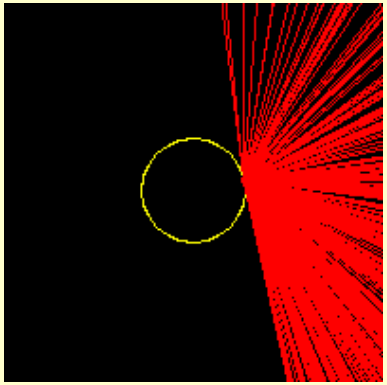
h=49 μm

W=54.4 keV

(100 MeV)







W=163.2 keV

(300 MeV)

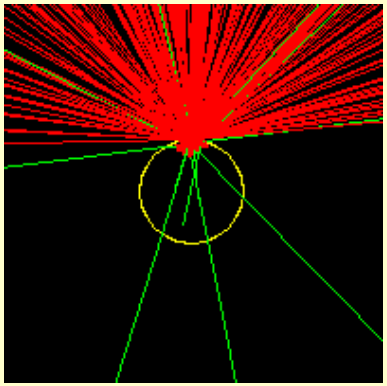
W=326.4 keV

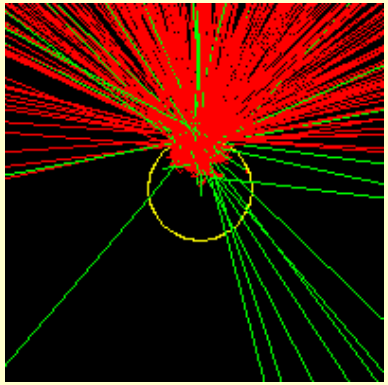
(600 MeV)

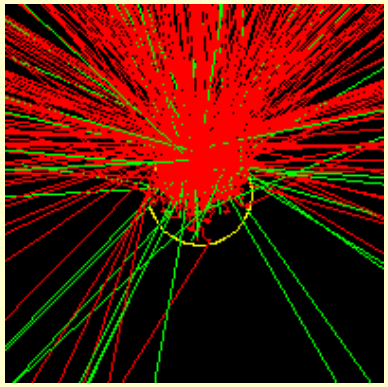
W=544 keV

(1000 MeV)

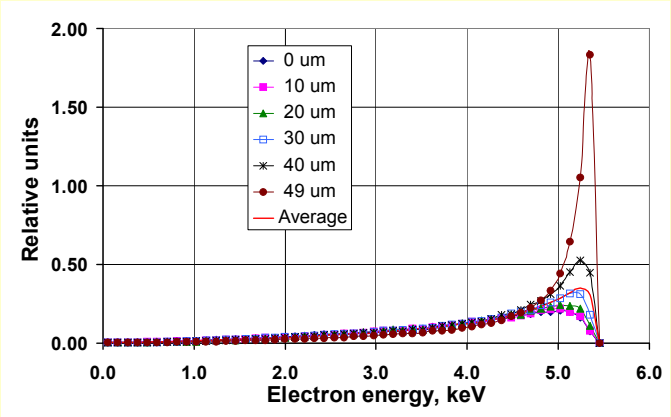
h=0 μm





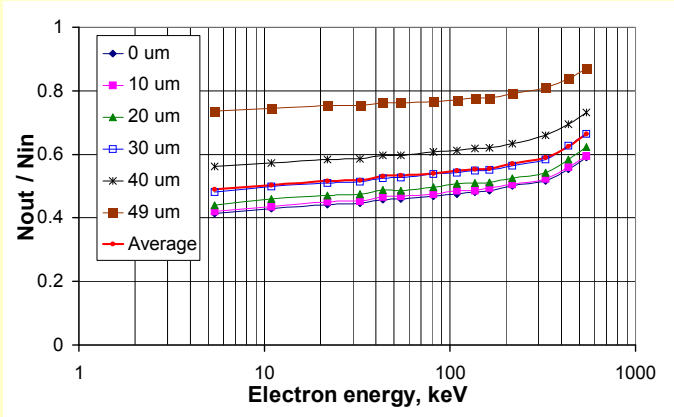


Results of simulation

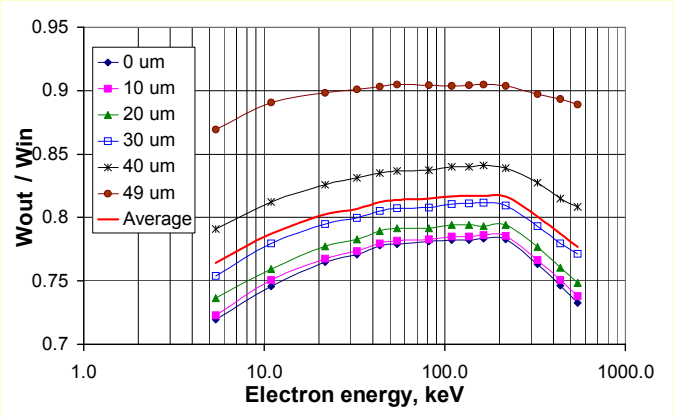


Energy distribution of escaped electrons for different *h*

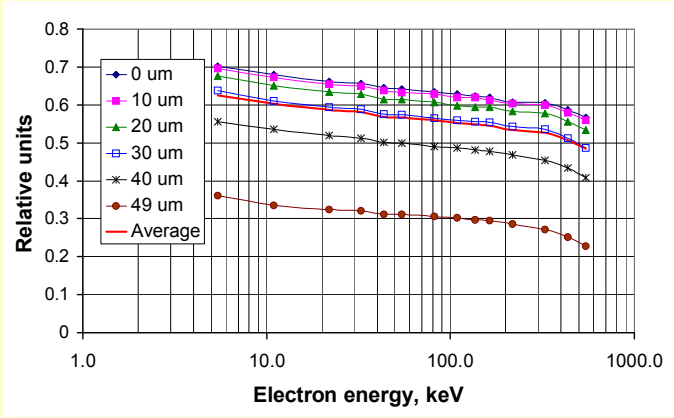
W=5.44 keV(10 MeV)



Fraction of escaped electrons vs input energy for different *h*



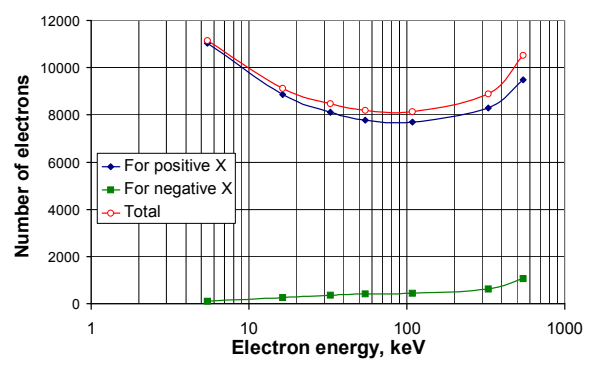
Average energy of escaped electrons normalized by input energy vs input energy for different *h*



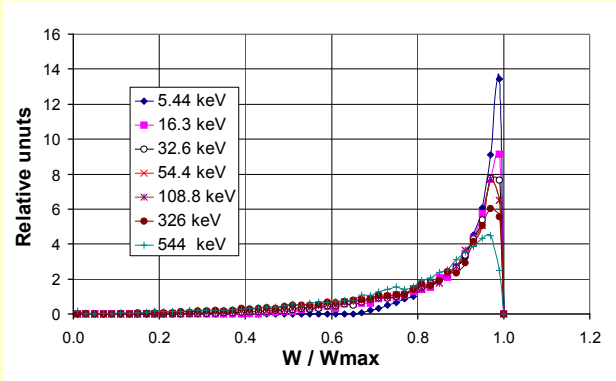
Fraction of energy lost in the target vs input energy for different *h*

Simulation of electron motion in BSM channel

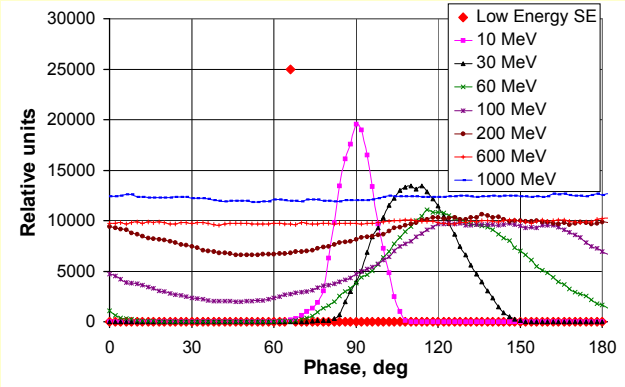
In these simulations parameters of the detectors are taken from [9]



Number of electrons passed through input BSM collimator (input electron number $5 \cdot 10^6 + 5 \cdot 10^6$)



Energy distribution of electrons passed through input BSM collimator



Response functions for different energies

$$\Phi(\varphi) = \int_{\psi} K(\varphi,\psi) F(\psi) d\psi$$

Measured distribution

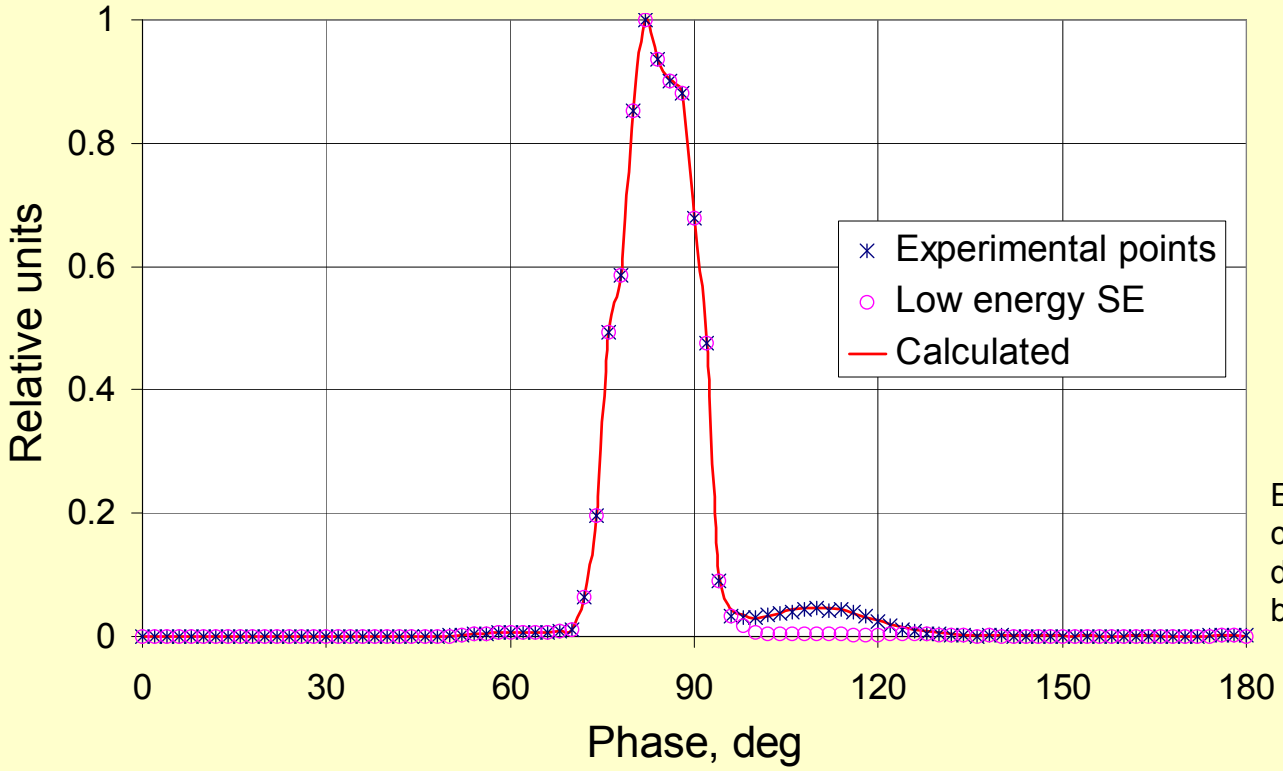
Response function

True distribution

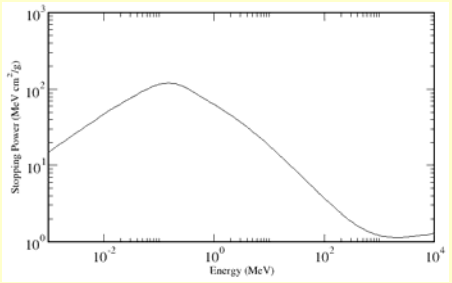
$$\Phi(\varphi) = F(\varphi) + \alpha \int_{\psi} K(\varphi,\psi) F(\psi) d\psi$$

Measured distribution with low energy SE

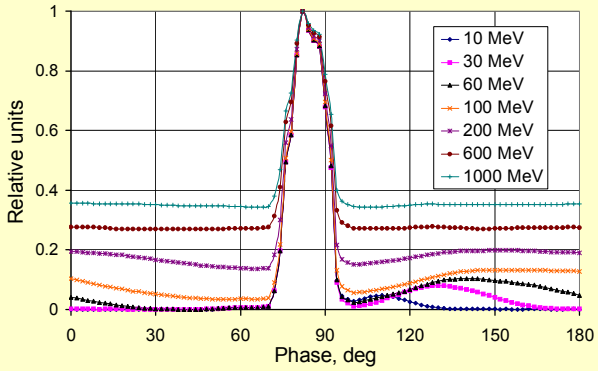
Scaling factor



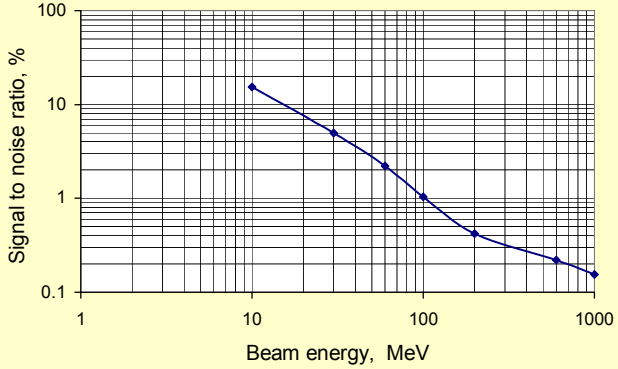
Experimental [5] and calculated longitudinal distributions of 10 MeV beam



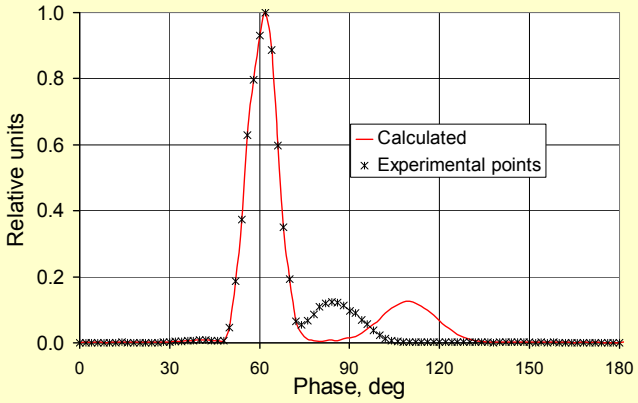
Electronic stopping power in tungsten vs proton energy



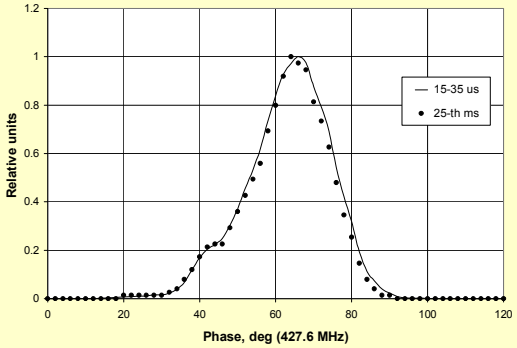
Prediction of experimental longitudinal distributions behavior at different energies



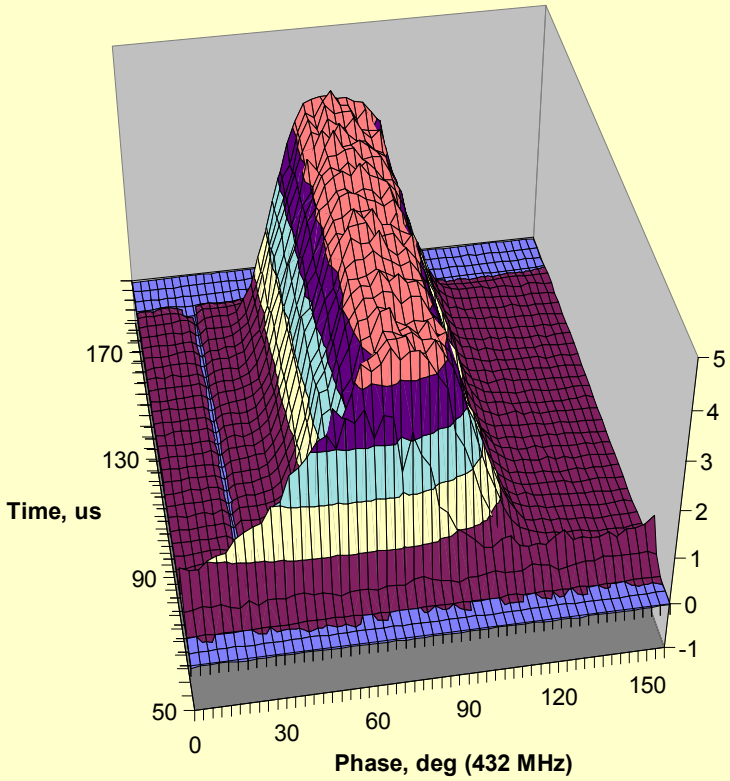
Prediction of integrated signal to noise ratio behavior



Experimental [5] and calculated longitudinal distributions of 30 MeV beam (Integrated signal to noise ratio = 4.4)

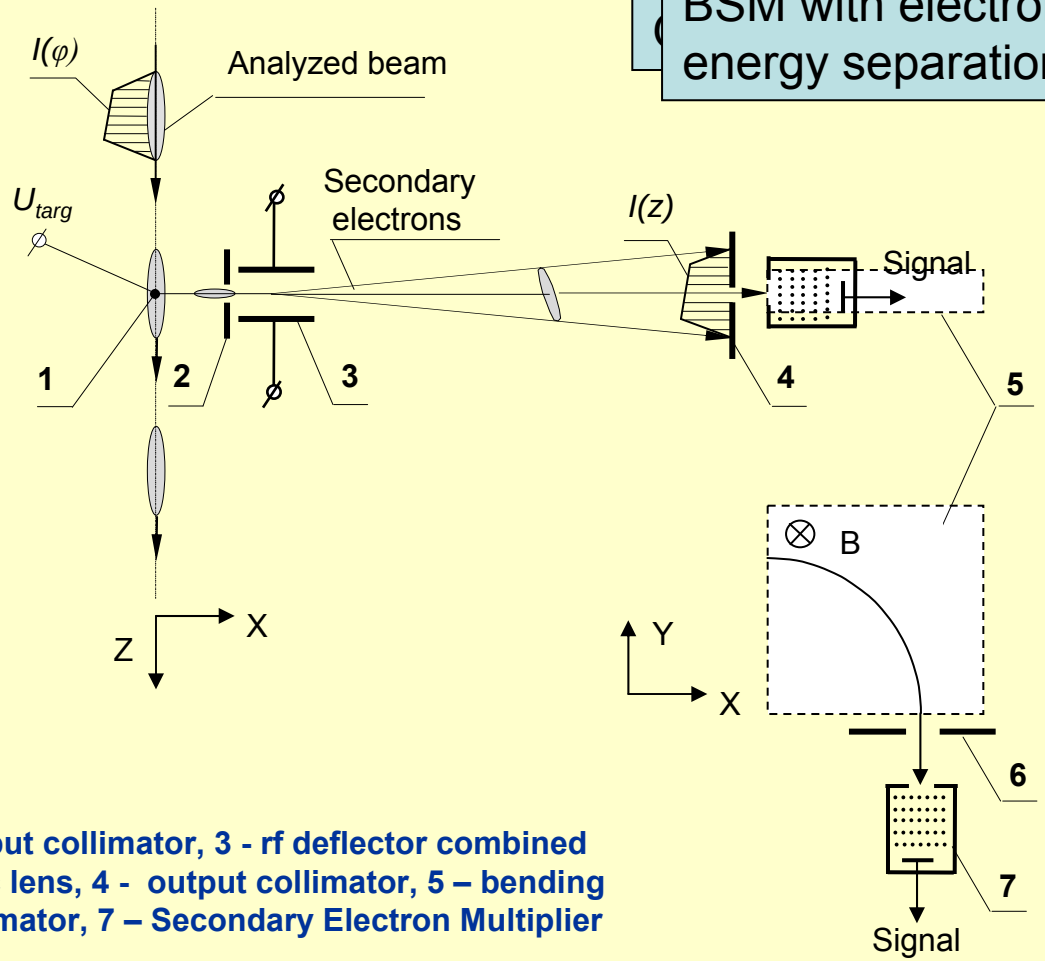


Experimental [3] longitudinal distribution of 2.5 MeV beam



Experimental [4] longitudinal distribution of 3.0 MeV beam

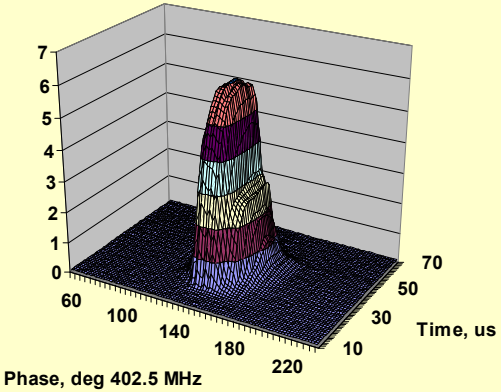
BSM with electron energy separation



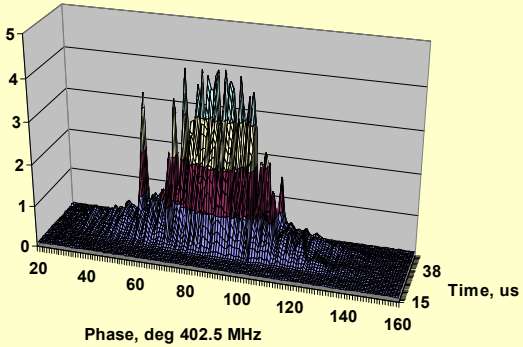
1 - target, 2 - input collimator, 3 - rf deflector combined with electrostatic lens, 4 - output collimator, 5 – bending magnet, 6 – collimator, 7 – Secondary Electron Multiplier

Some experimental results [11,12]

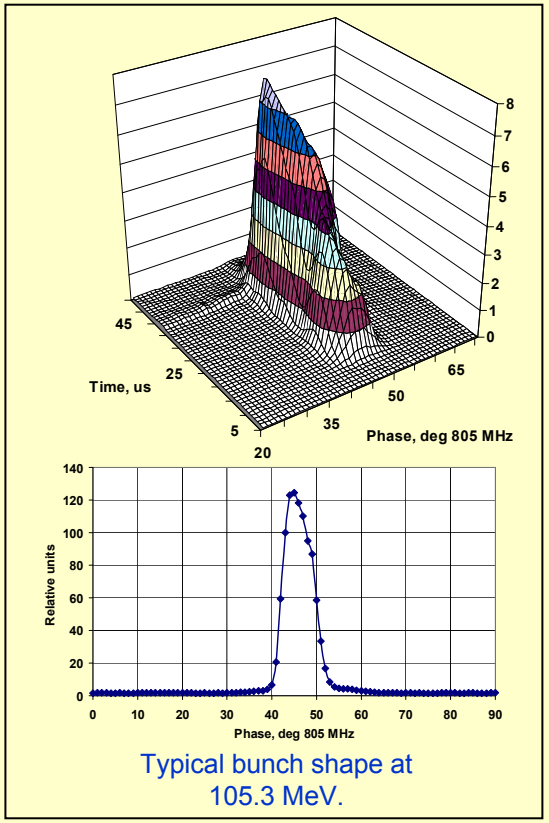
Zero effect of detached electrons is observed in the measurements with electron energy separation



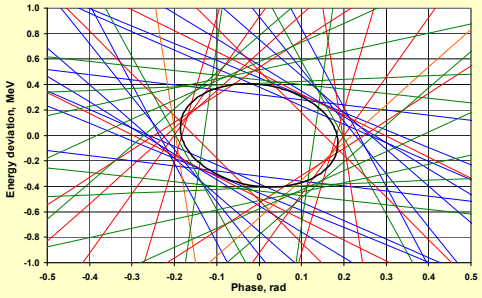
Typical evolution of bunch shape along the beam pulse (at 7 MeV).



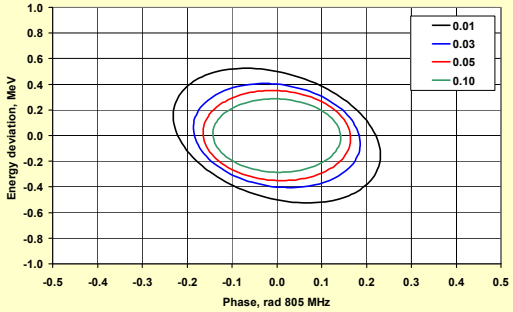
Manifestation of Low Level RF instabilities in Bunch Shape (at 7 MeV)



Typical bunch shape at 105.3 MeV.

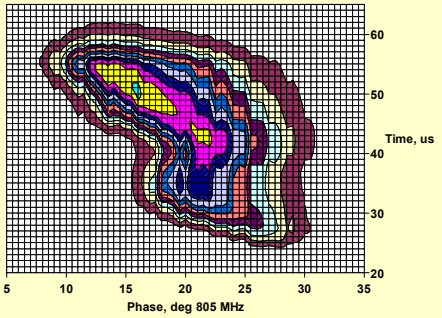


Bunch boundaries transformed to the entrance of CCL #1(97.9 MeV) and an equivalent phase ellipse



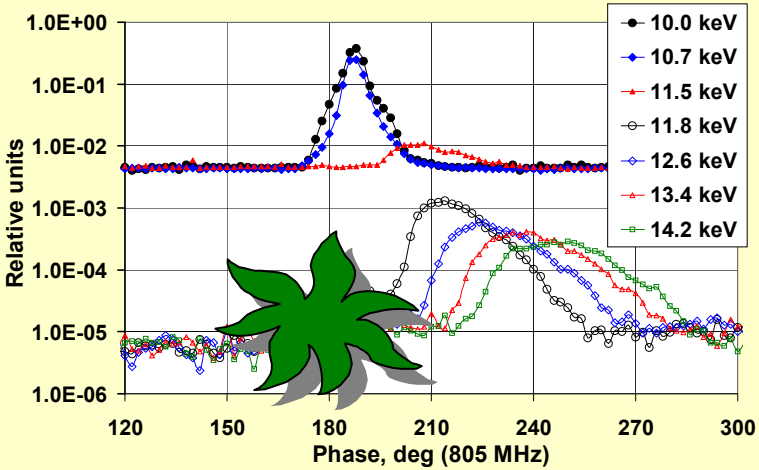
Phase ellipses for different threshold levels

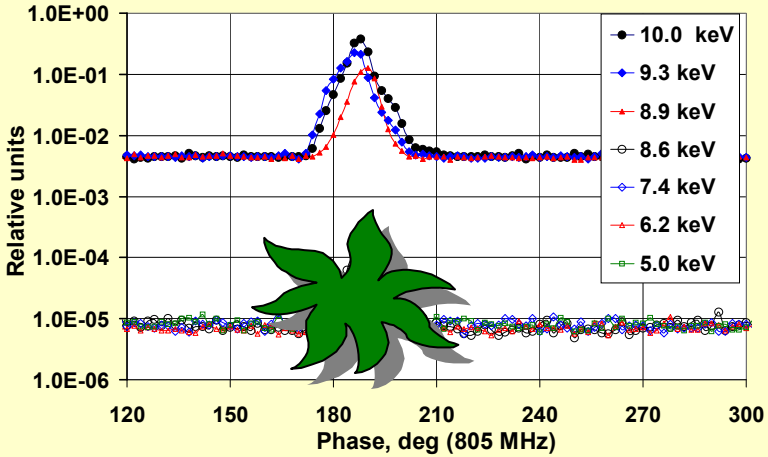
Manifestation of poor beam loading compensation



Search for detached electrons influence

Measurements of longitudinal distribution for different set points of separating magnet





Summary

- The detached electrons distort the results of bunch shape measurements essentially
- However these distortions are efficiently removed using energy separation of the electrons
- Modification of BSM with low energy electrons scanning is desirable with the aim to remove residual gas ionization influence

THE END