C-BAND HIGH POWER AMPLIFIER KLYSTRON DEVELOPED FOR LINEAR ELECTRON ACCELERATORS

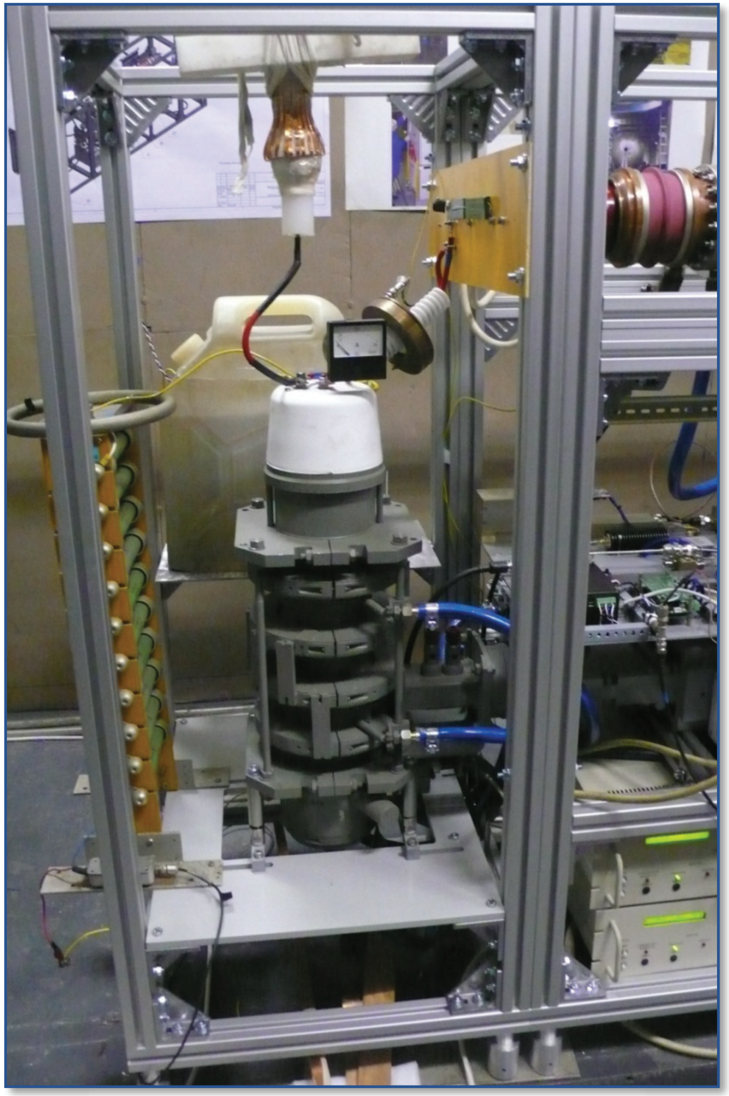
Yury Paramonov

RuPAC 2018, Protvino

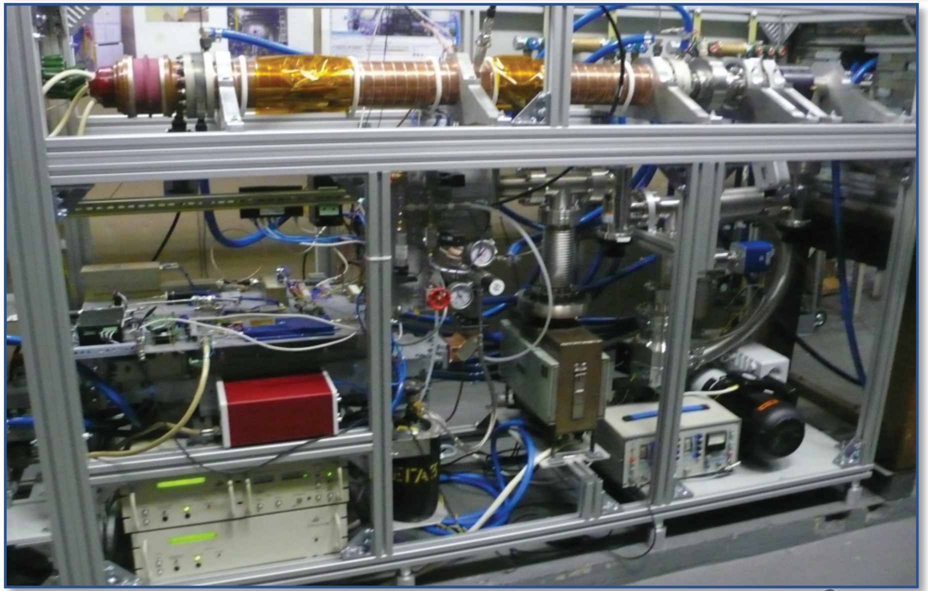
MICROWAVE TUBES FOR LINEAR ACCELERATORS

	Magnetron	CW klystron	Pulsed klystrons				
	MI-470	KU-399	KIU-40	KIU-111	KIU-147	KIU-147A	KIU-168
Center frequency, MHz	1885	2450	991	2450	2450	2856	2856
Output pulse power, MW	10	-	4.7	5	5	6	6
Output average/CW power, kW	30	25	70	5	25	25	5
Cathode voltage, kV	50	10	65	50	50	52	52
Number of electron beams	1	18	6	40			
Focusing	solenoid	permanent magnets	solenoid	permanent magnets			

LINEAR ACCELERATOR UELR-10-15 FOR STERILIZATION



Beam Energy, MeV	5 – 10
Electron Beam Average Power, kW	1 – 15
Pulse Repetition Rate, Hz	up to 400
Scan Length, mm	400 – 600
Scan Frequency, Hz	1 – 30
Microwave Tube	Klystron KIU-147A
Modulator	Solid State



C-BAND HIGH POWER AMPLIFIER KLYSTRON

Main parameters

Frequency –	5712 MHz
Cathode voltage –	45 kV
Pulse cathode current –	150 A
Output pulse power –	3 MW
Quality factor –	300 - 1000;
Focusing –	permanent magnets

Analogs

Type	efficiency, %	Mode
VKL-8271	50.0	140 kV, 125A, 2.5 MW (2.4)
VKL-8301	50.0	130 kV, 160 A, 10.0 MW (3.5)
VKS-8262D	40.0	130 кV, 105 A, 5.5 MW (2.2)
VKC-8313 (5712 MHz)	35.0	120 кV, 79 A, 3 MW (1.9)
TH-1801 (L, MBK, 6 beam) 2016	40.0 (60.0)	120 кV, 132 A 10 MW (3.2)

MAX efficiency (60 – 70%)

MAGIC2-D Simulations of High Efficiency Klystrons using the Core Oscillation Method

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Igor Syratchev
CERN
Geneva, Switzerland

Andrey Yu. Baikov
Moscow University of Finance & Law
Moscow, Russia

Richard Kowalcyzk
SLAC National Accelerator Laboratory
Menlo Park, California, United States

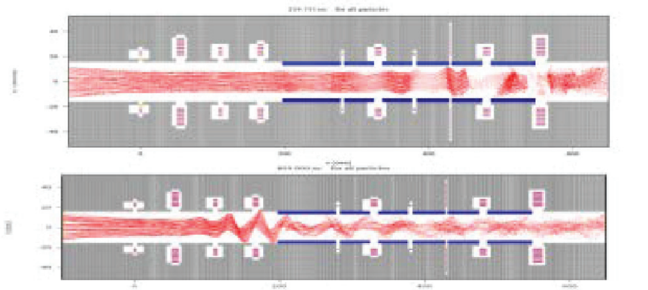

Fig. 5 - Simulation of beam breakup due to 6.7 GHz mode (top) and 4.2 GHz mode (bottom).

20MWp High-Efficiency L Band Multi-Beam Klystron for CLIC Drive Beam

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rodolphe.marchesin@thalesgroup.com

Comparison of 6 MW S-band pulsed BAC MBK with the existing SBKs

Igor Guzilov[1], Oleg Maslennikov[1],Roman Egorov[2], Igor Syratchev[3], Valeriy Kobets[4], Anatoly Sumbaev[4]
[1]JSC "Vacuum device's basic technologies", Moscow, 117342, Vvedenskogo str.,3,k.1, Russian Federation,
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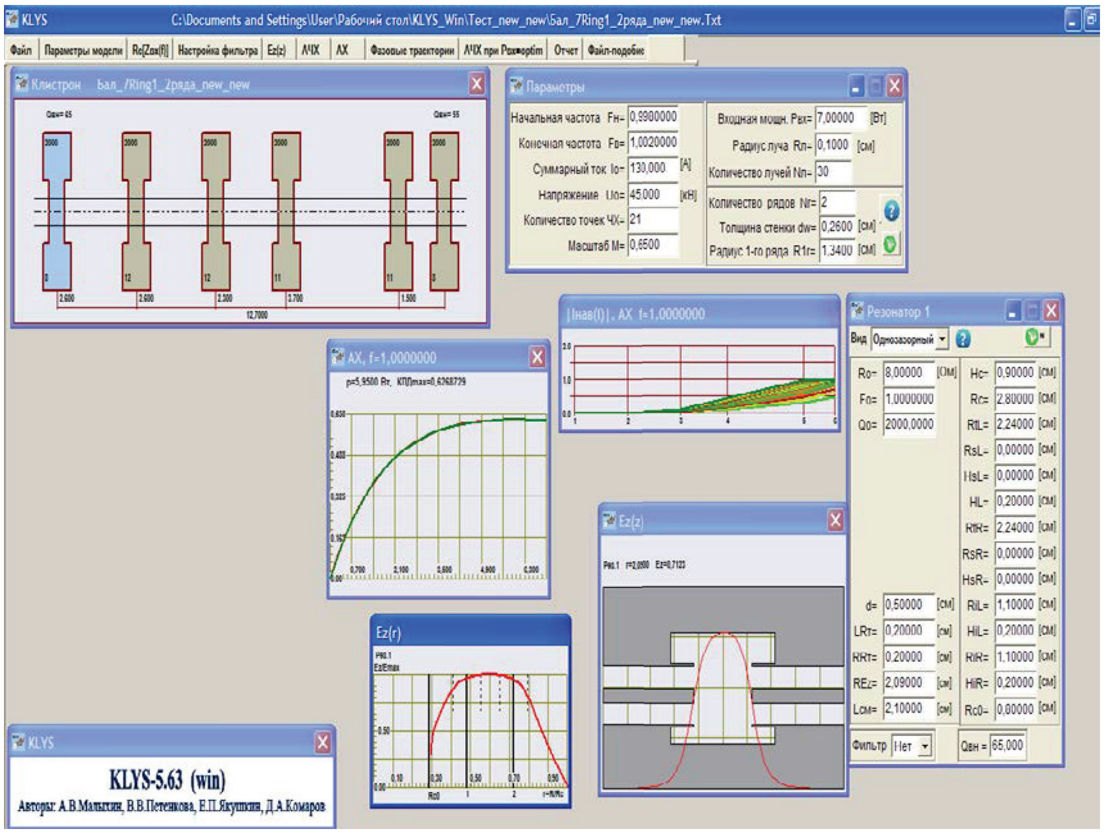
[3]CERN, CH-1211, Geneva 23, Switzerland
[4]JINR, Moscow region, Dubna, Joliot-Curie, 6, Russian Federation
email: iag@bk.ru

Test of a BAC Klystron

R. Kowalczyk, A. Haase, E. Jongewaard, M. Kemp and J. Neilson
SLAC National Accelerator Laboratory
Menlo Park, CA

A. Jensen
Leidos
Billerica, MA


KLYS
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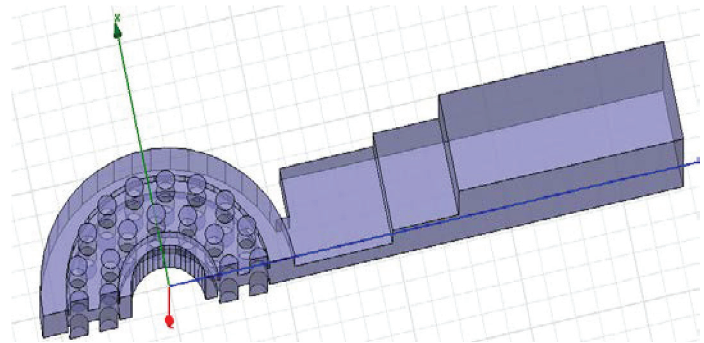
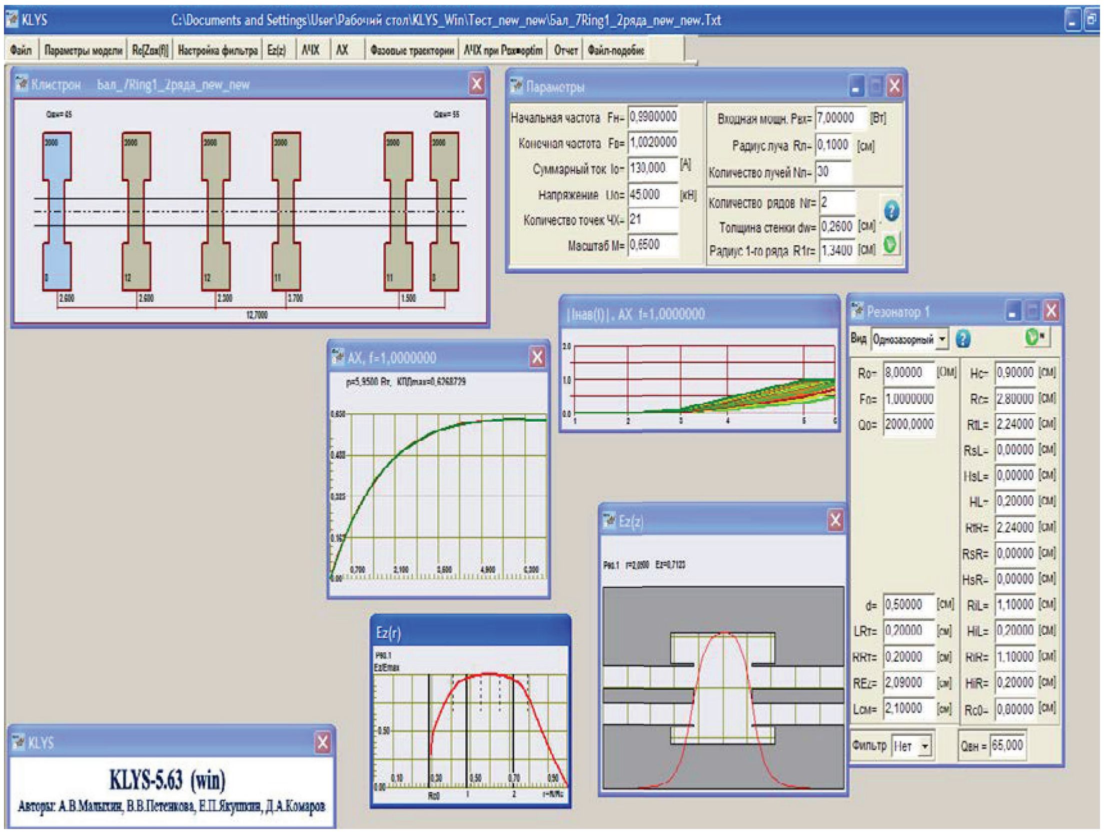
Файл
Параметры модели
Настройка фильтра
АЧХ
АХ
Фазовые траектории
Отчет
Клистрон бал_7Ring1_2ряда_new_new
Параметры
Начальная частота Fн= 0,9980000
Конечная частота Fв= 1,0020000
Суммарный ток Io= 130,000 [А]
Напряжение Uo= 45,000 [кВ]
Количество точек ЧХ= 21
Масштаб M= 0,6500
Входная мощн. Pвх= 7,00000 [Вт]
Радиус луча Rл= 0,1000 [см]
Количество лучей Nл= 30
Количество рядов Nr= 2
Толщина стенки dw= 0,2600 [см]
Радиус 1-го ряда R1r= 1,3400 [см]
АХ, f=1,0000000
Резонатор 1
Вид Однозазорный
Ro= 8,00000 [Ом]
Fo= 1,0000000
Qo= 2000,0000
Hc= 0,90000 [см]
Rc= 2,80000 [см]
RtL= 2,24000 [см]
RsL= 0,00000 [см]
HsL= 0,00000 [см]
HL= 0,20000 [см]
RtR= 2,24000 [см]
RsR= 0,00000 [см]
HsR= 0,00000 [см]
d= 0,50000 [см]
LRt= 0,20000 [см]
RRt= 0,20000 [см]
REz= 2,09000 [см]
Lсм= 2,10000 [см]
RiL= 1,10000 [см]
HiL= 0,20000 [см]
RiR= 1,10000 [см]
HiR= 0,20000 [см]
Rc0= 0,80000 [см]
Фильтр Нет
Qвн = 65,000
Ez(z)
Ez(r)
KLYS
KLYS-5.63 (win)
Авторы: А.В.Малыхин, В.В.Петенкова, Е.П.Якушкин, Д.А.Комаров



Design


KLYS
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Файл
Параметры модели
Настройка фильтра
Ez(z)
АЧХ
АХ
Фазовые траектории
Отчет
Клистрон
Параметры
Начальная частота Fн=
Конечная частота Fв=
Суммарный ток Io=
Напряжение Uo=
Количество точек ЧХ=
Масштаб M=
Входная мощн. Pвх=
Радиус луча Rл=
Количество лучей Nл=
Количество рядов Nr=
Толщина стенки dw=
Радиус 1-го ряда R1r=
Резонатор 1
Вид
Одноазорный
Фильтр
Нет
Ez(z)
Ez(r)
KLYS
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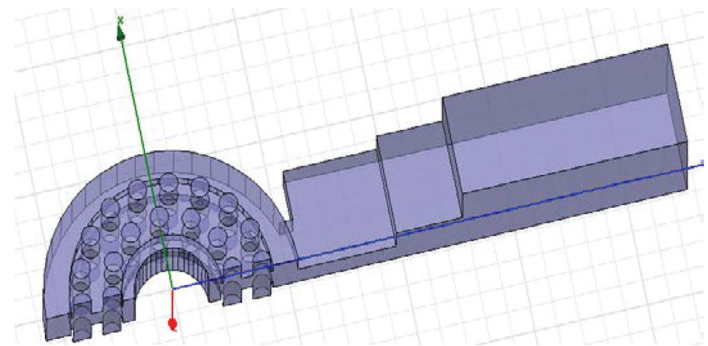
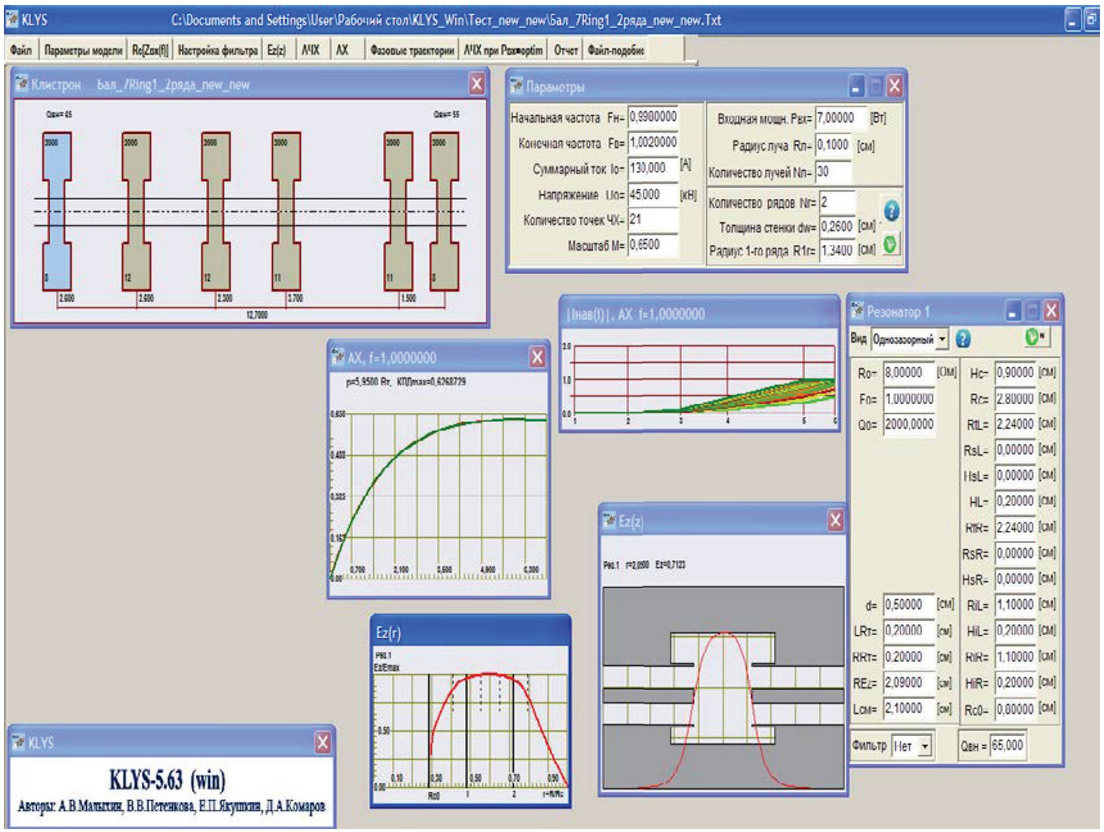
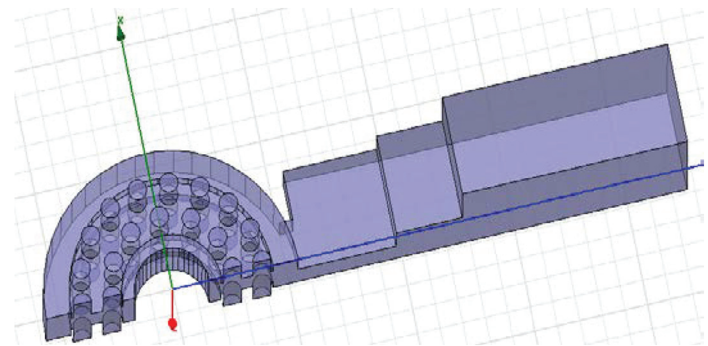


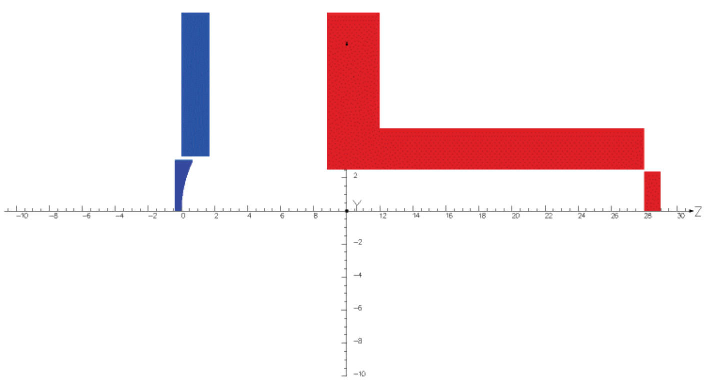
Design



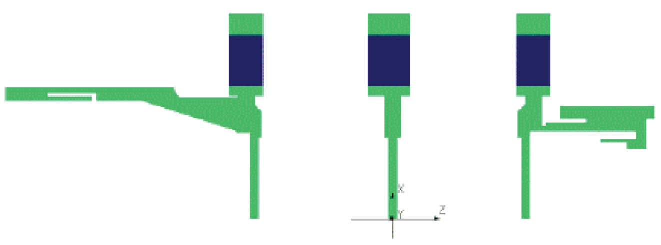
Modeling output/input cavity



Electron gun

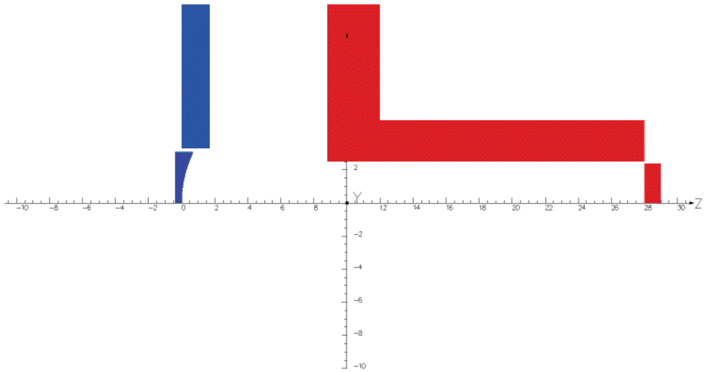


Focusing system

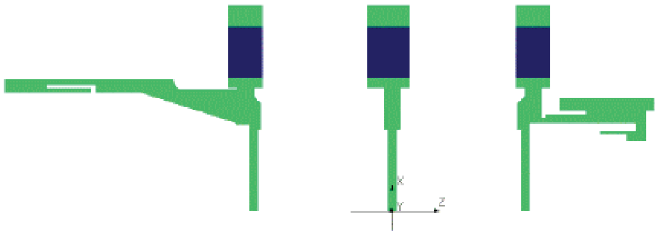


Calculation electron gun

Electron gun



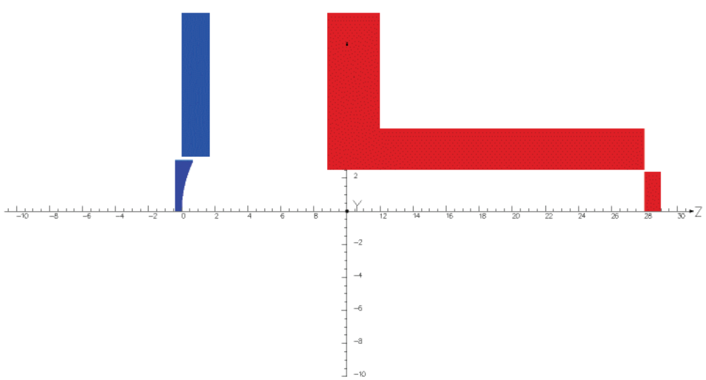
Focusing system



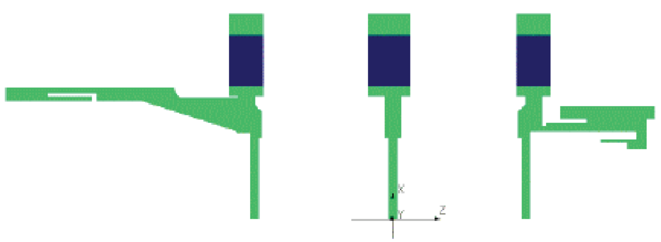
Calculation electron gun

Calculation focusing system

Electron gun



Focusing system

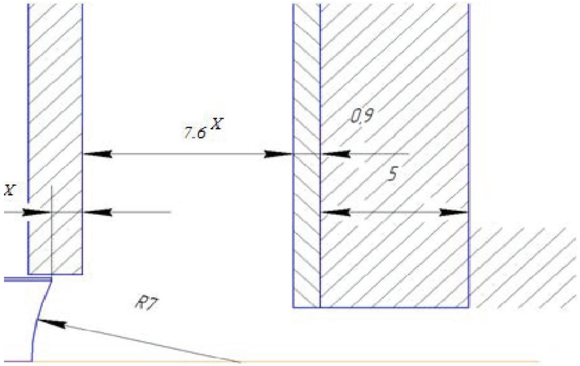


Calculation electron gun

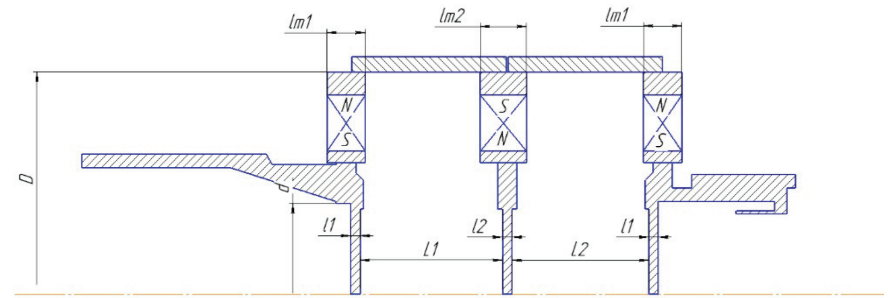
Preliminary design

Calculation focusing system

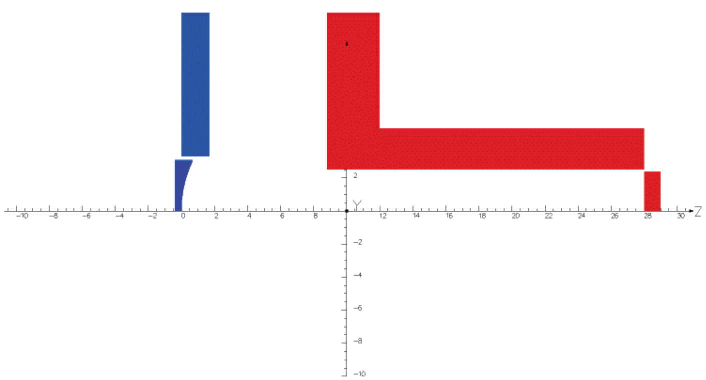
Electron gun



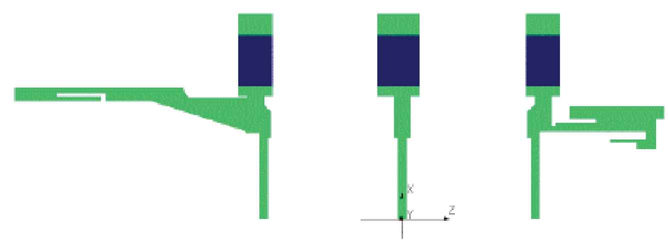
Magnetic system



Electron gun



Focusing system

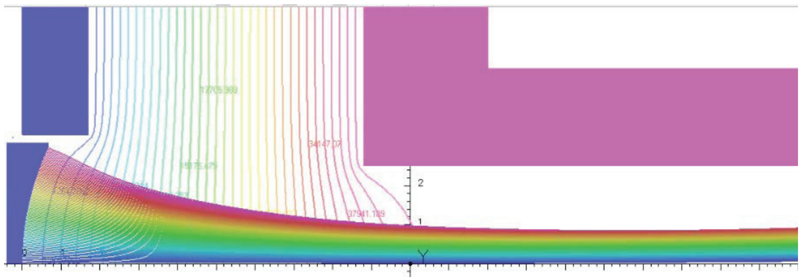


Calculation electron gun

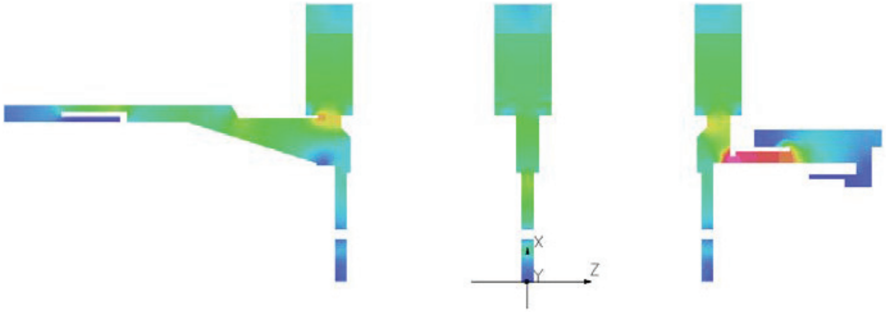
2D design

Calculation focusing system

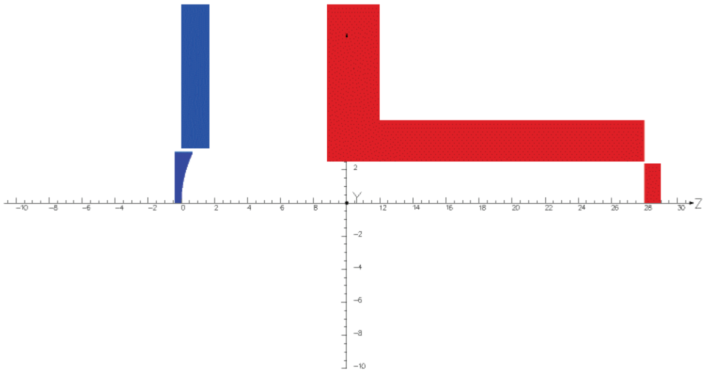
Electron gun



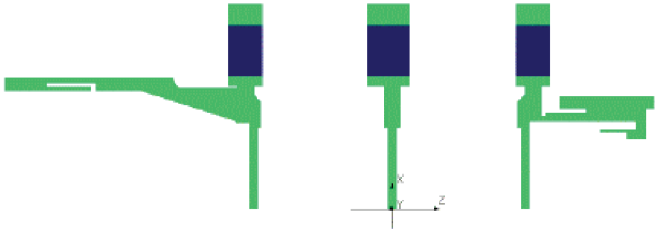
Focusing system



Electron gun



Focusing system

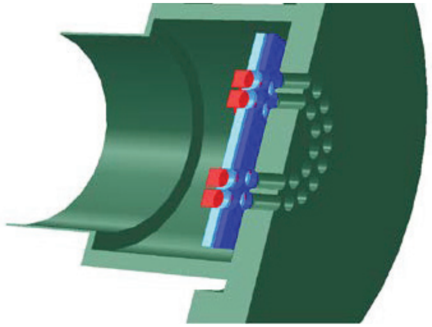


Calculation electron gun

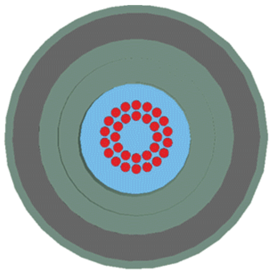
3D design

Calculation focusing system

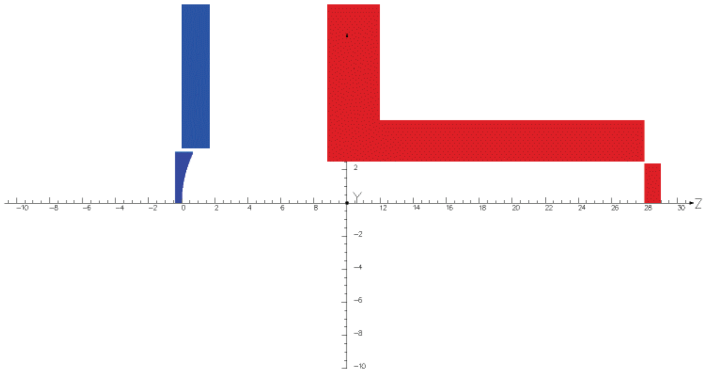
Electron gun



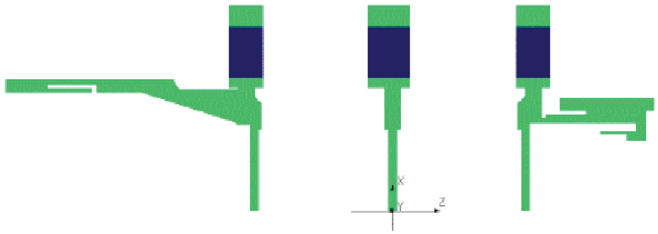
Multi-beam focusing system

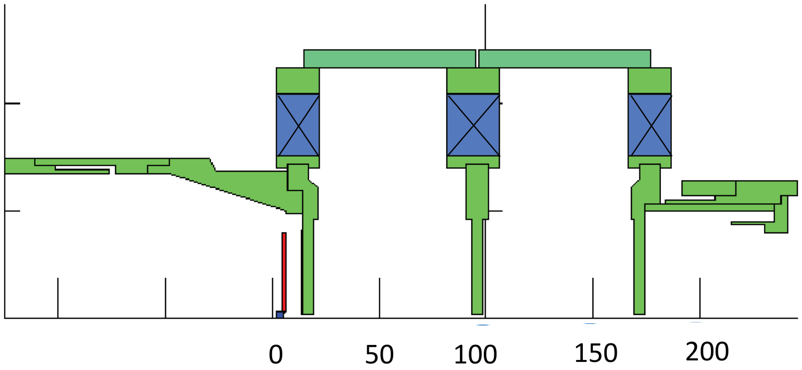


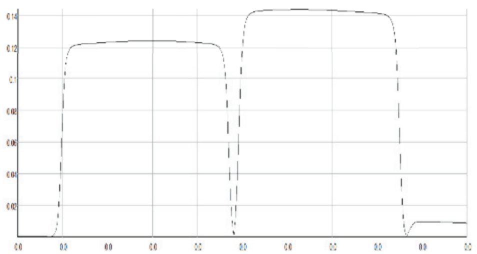
Electron gun

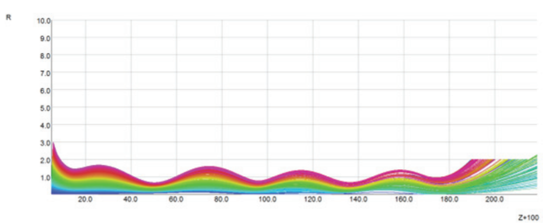


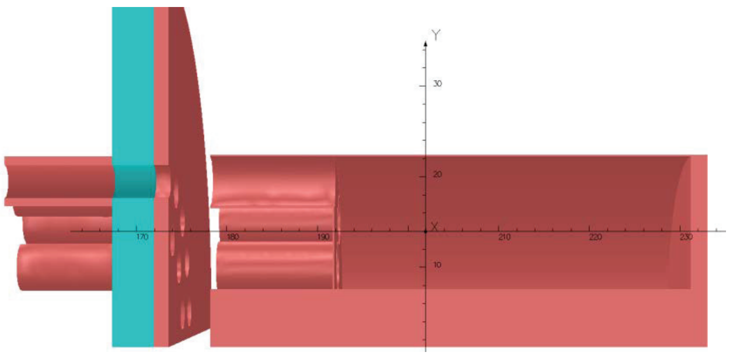
Focusing system

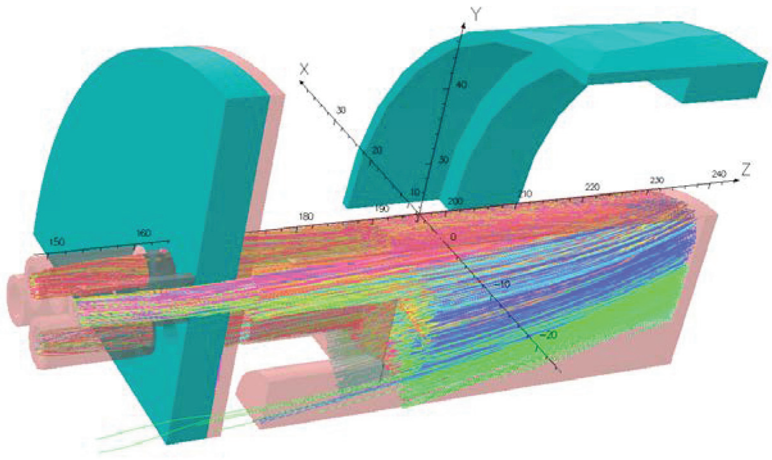



0
50
100
150
200

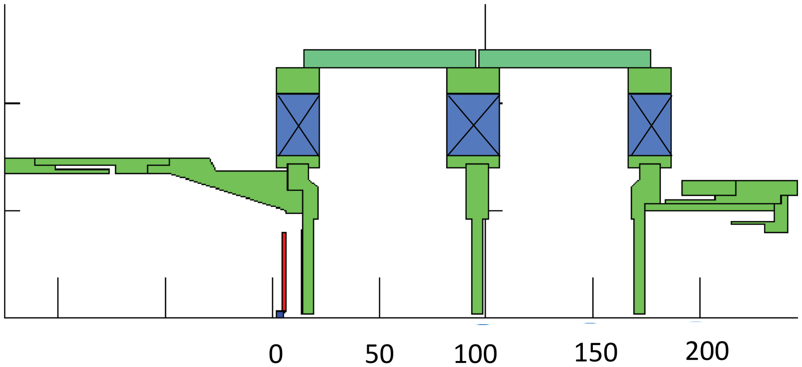


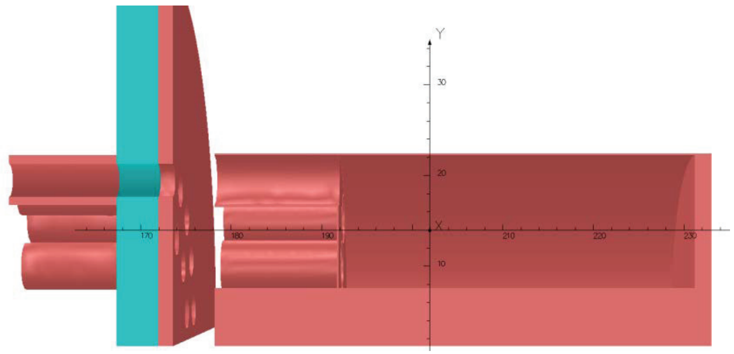

R

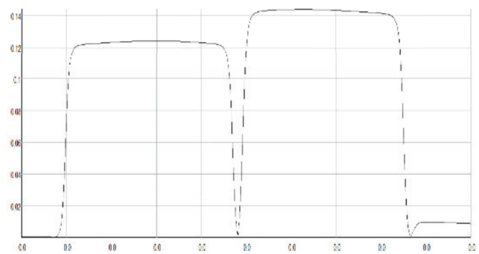


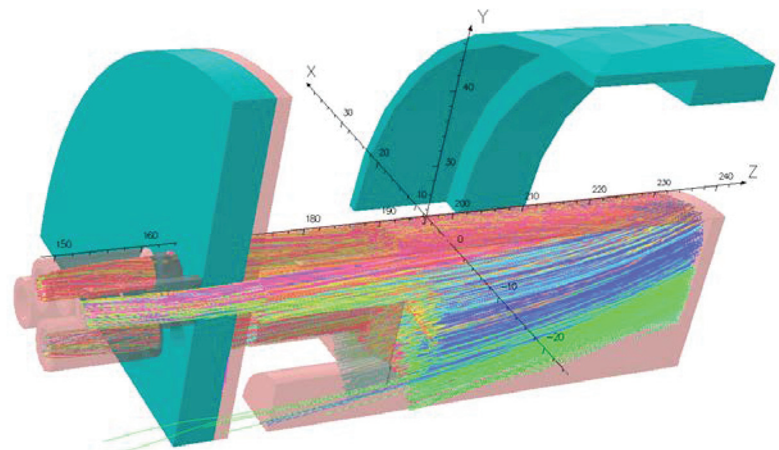

Y
X
Z

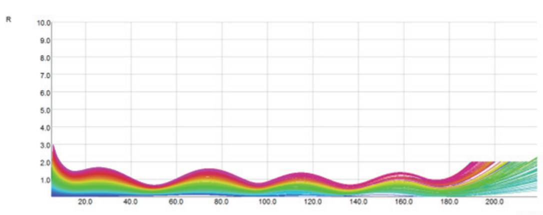
Electron beam path analysis



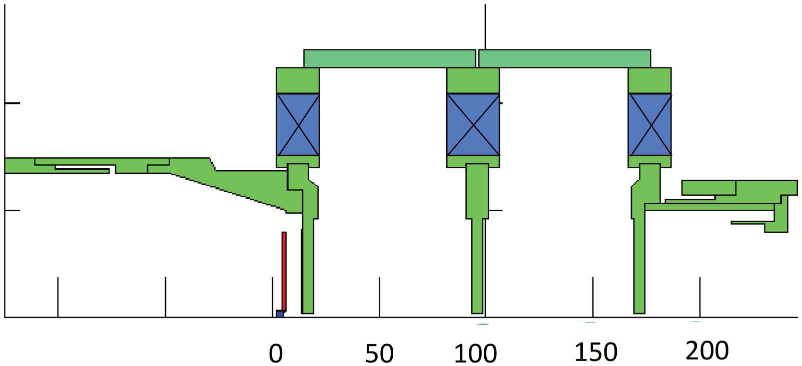


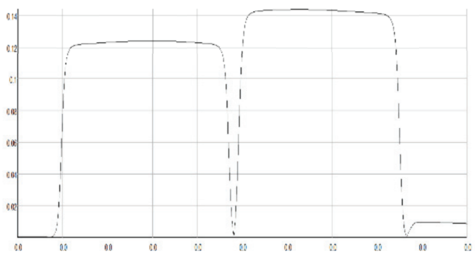


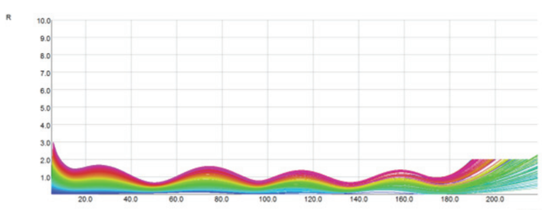




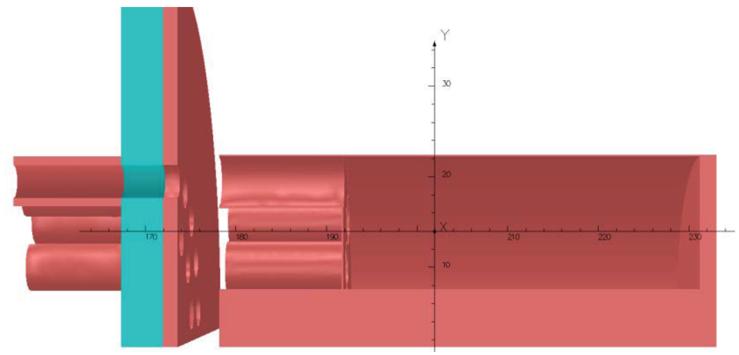
Electron beam path analysis

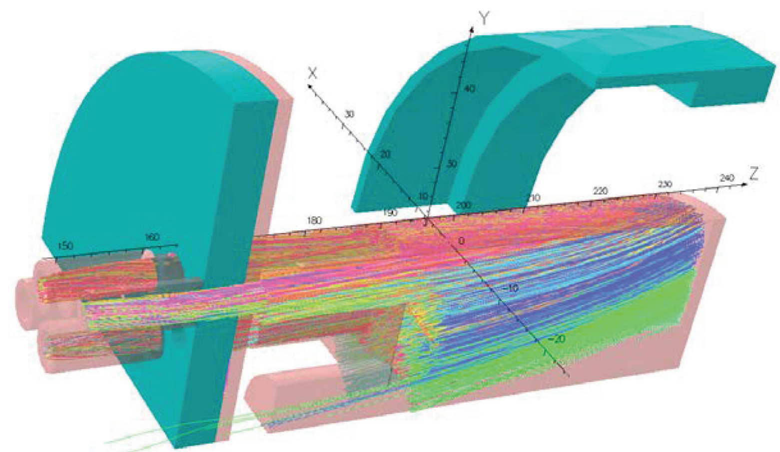






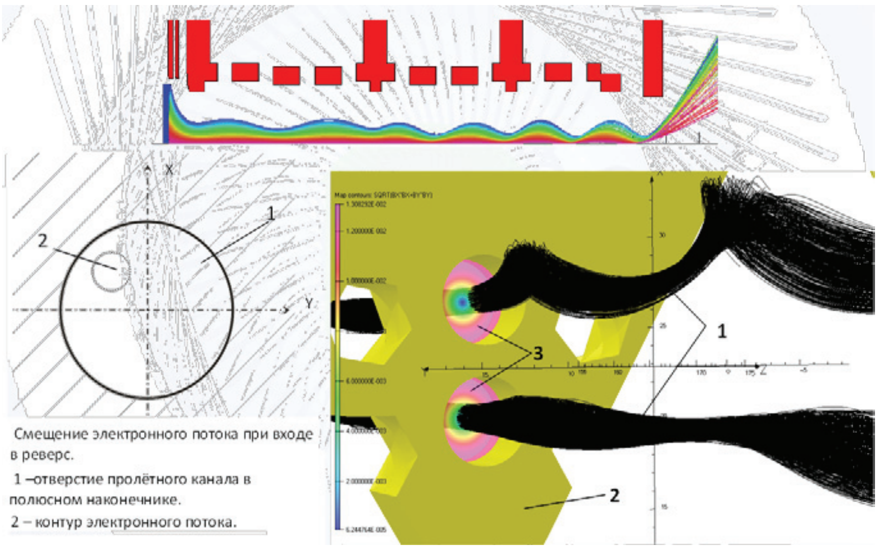
Collector calculation



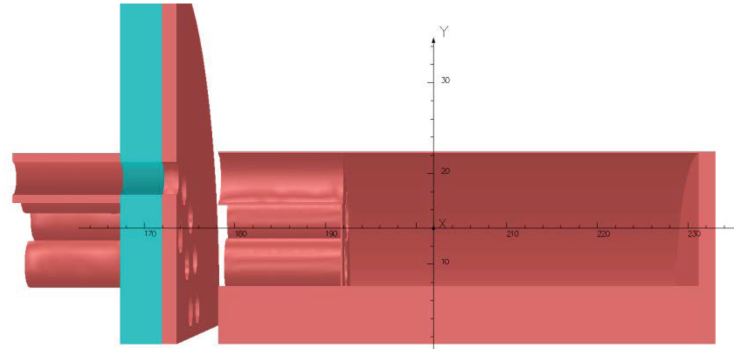


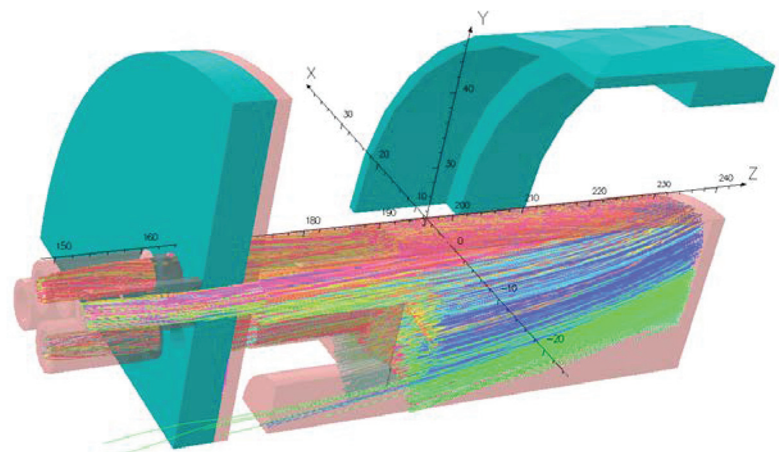
Electron beam path analysis

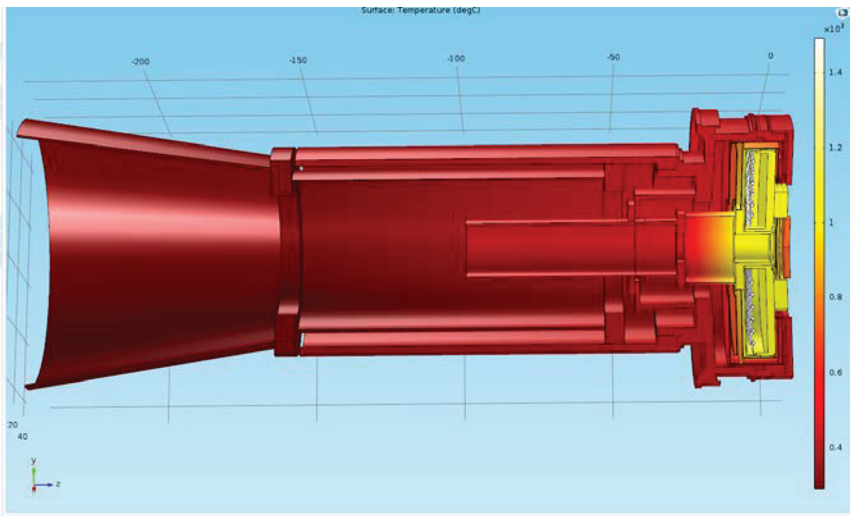
3D calculate multi-beam system

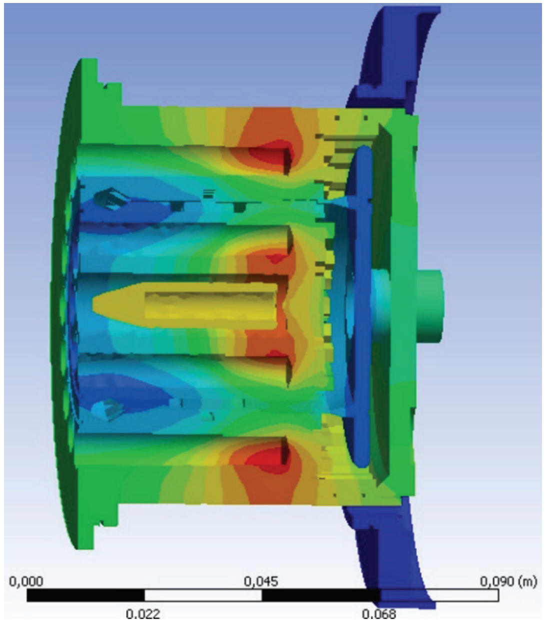


Collector calculation






Surface: Temperature (degC)
x10³
-200
-150
-100
-50
0
1.4
1.2
1
0.8
0.6
0.4
20
40
y
z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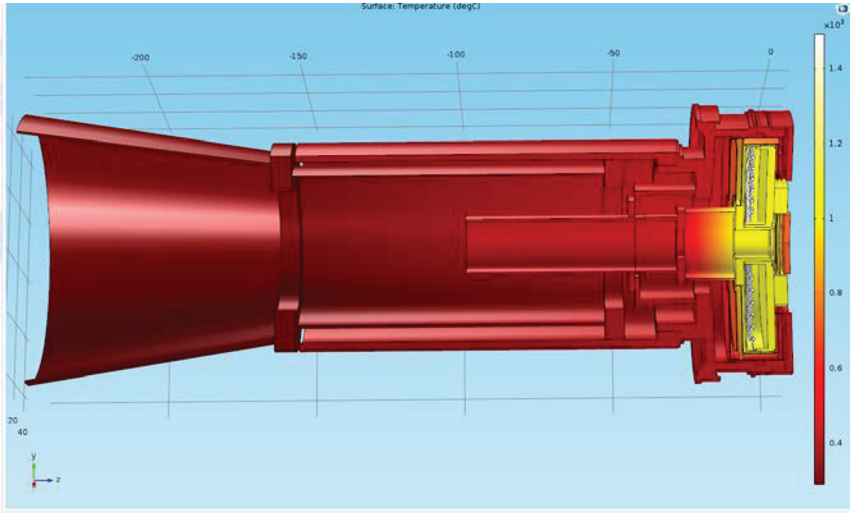
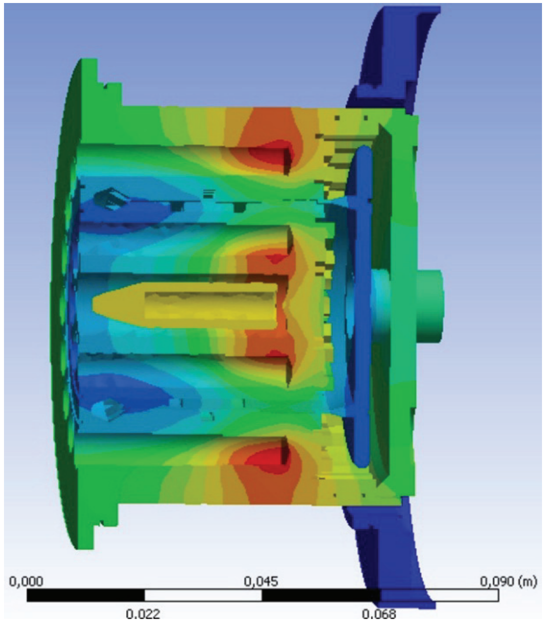
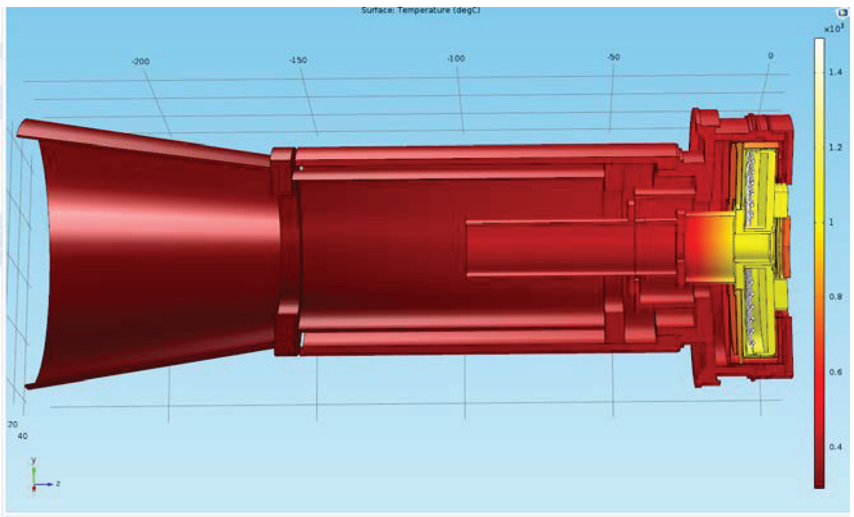
0,045
0,090 (m)
0.022
0.068

Calculation of thermal deformations in electron gun

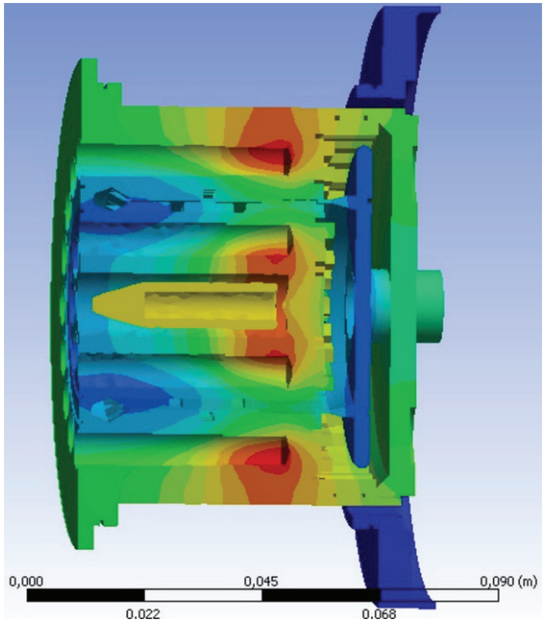




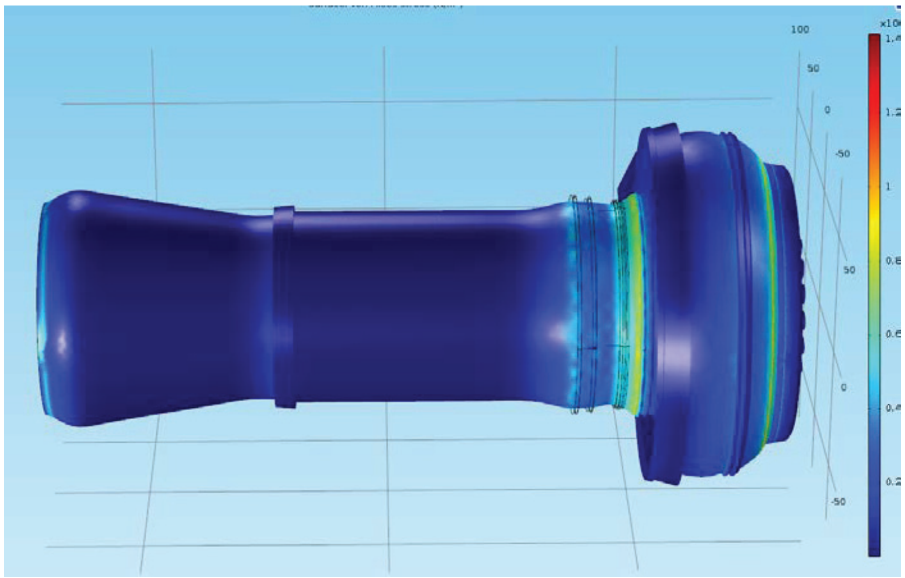
Calculation of thermal deformations in electron gun



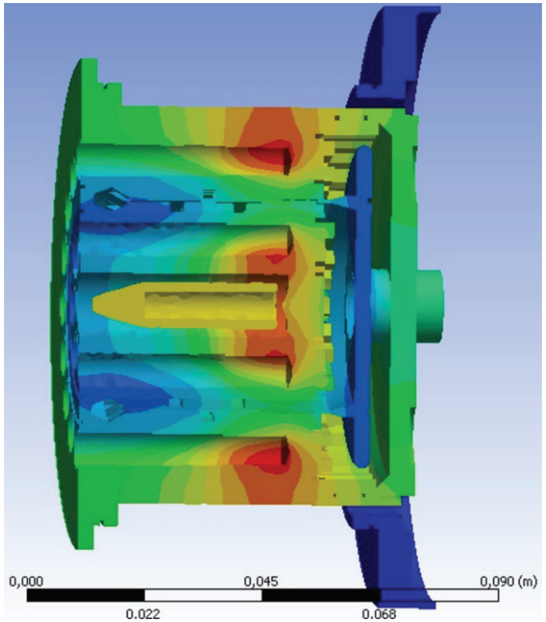
Calculation of thermal deformations in collector



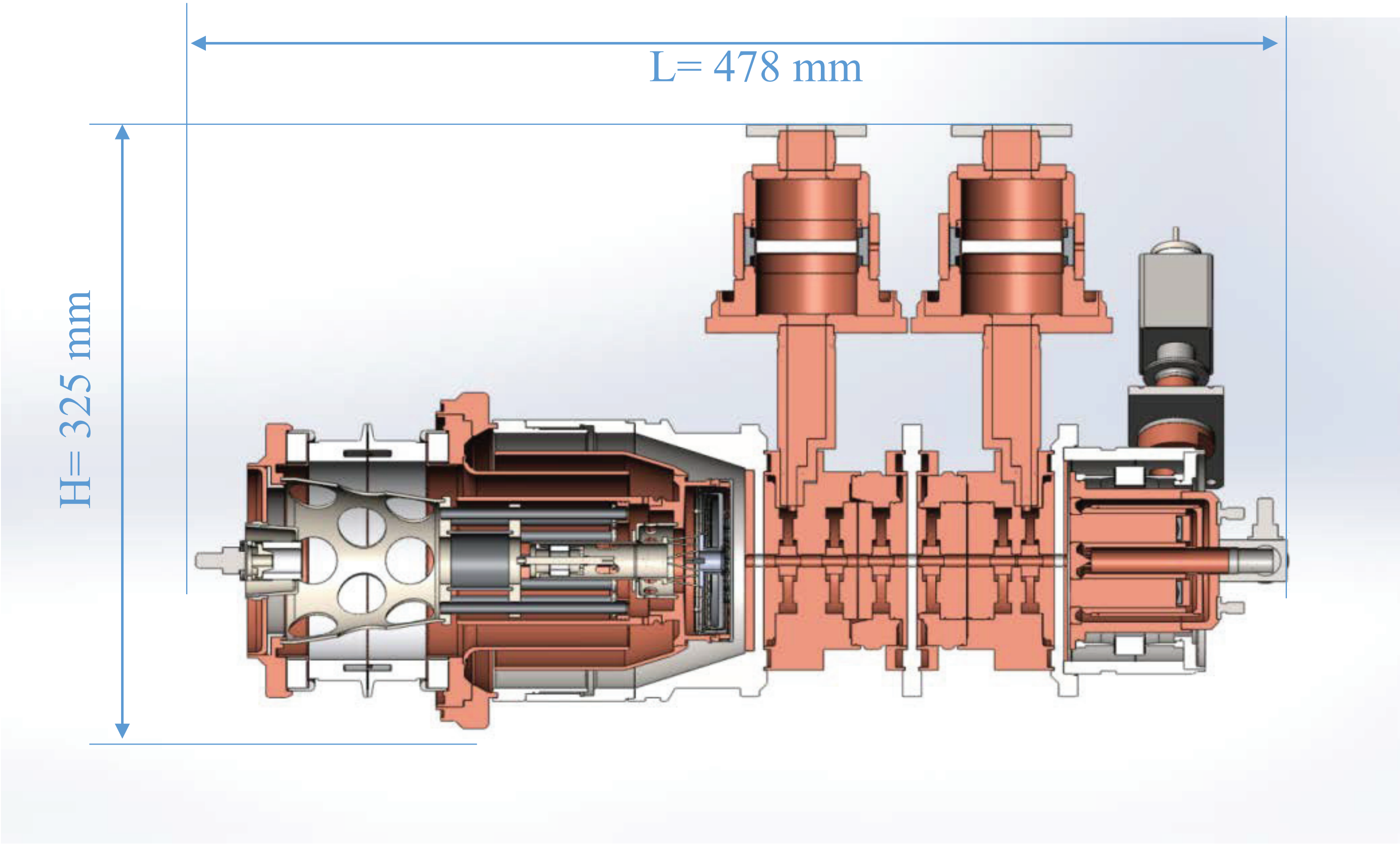
Calculation of thermal deformations in electron gun



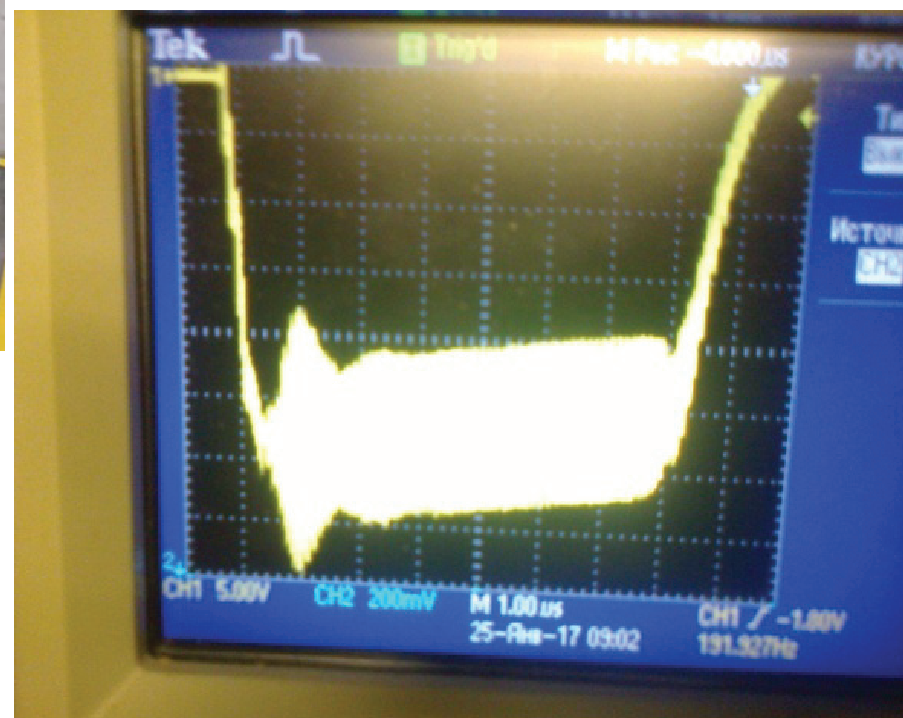
Calculation of thermal deformations in collector



Solid model

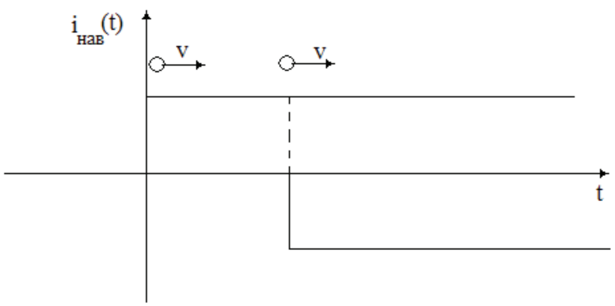


First test



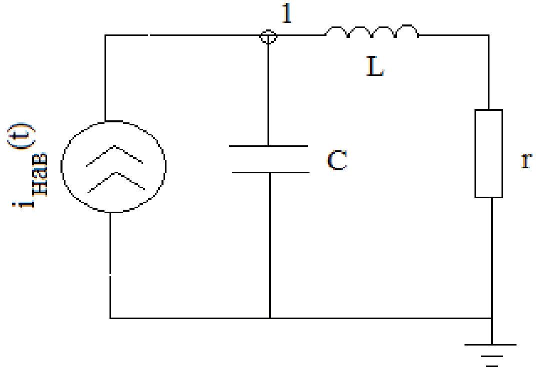
Analytical model

$$i_{ind}(t) = \frac{q \cdot v}{d} \cdot \left(\eta(t) - \eta(t - \tau)\right)$$



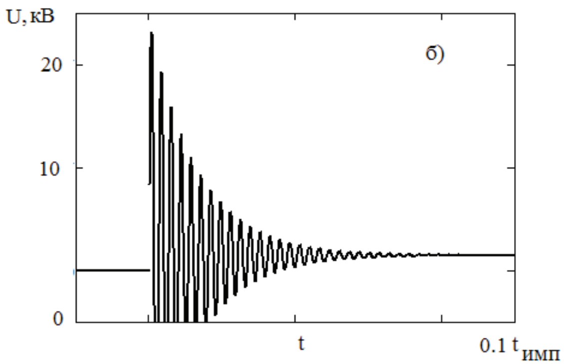
induced current

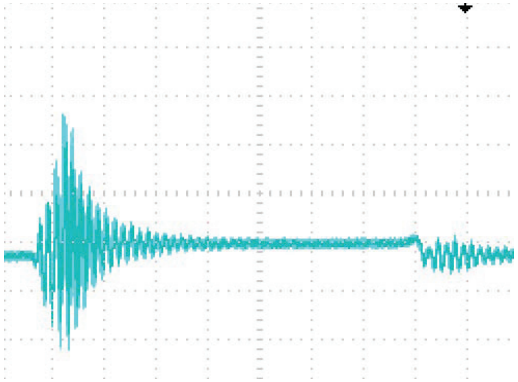
$$\varphi_1(s) \cdot \left(s \cdot C + \frac{1}{r + s \cdot L} \right) = I(s)$$



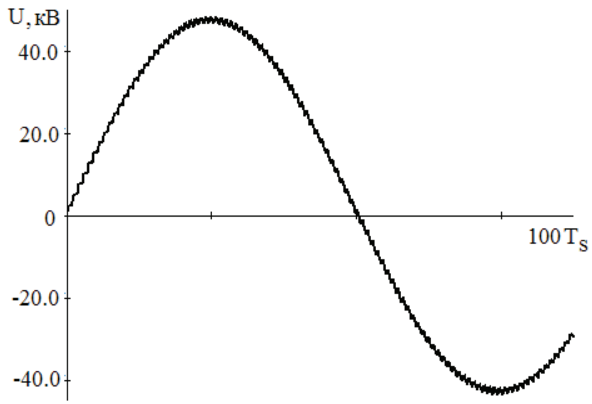
equivalent circuit

Results



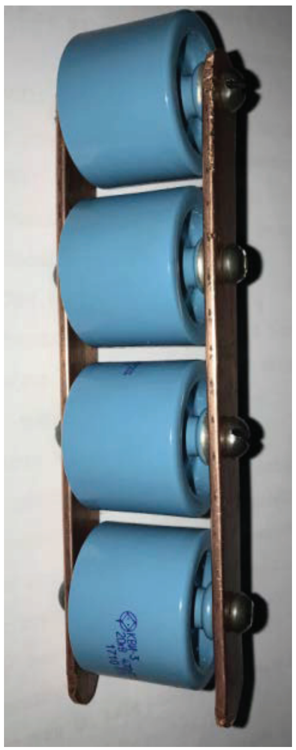


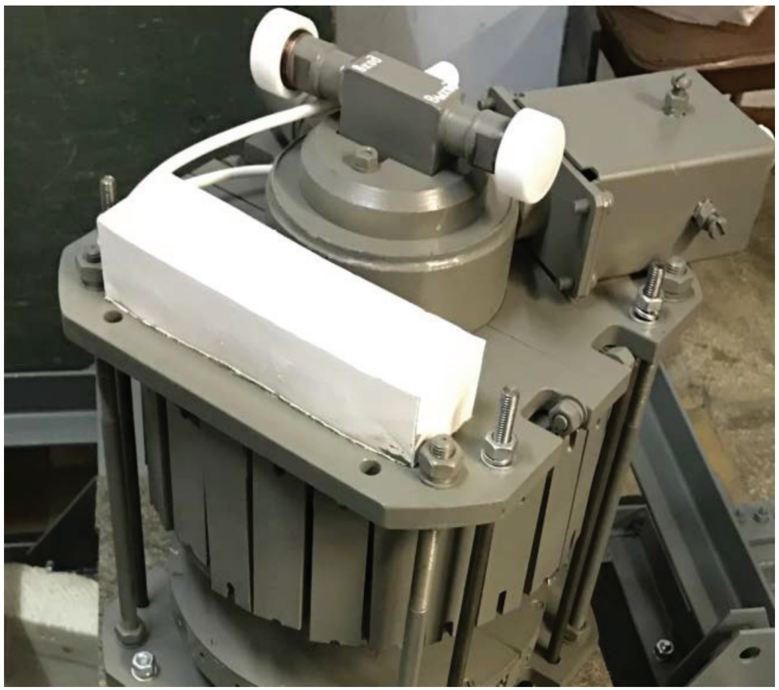
Induced current in static mode

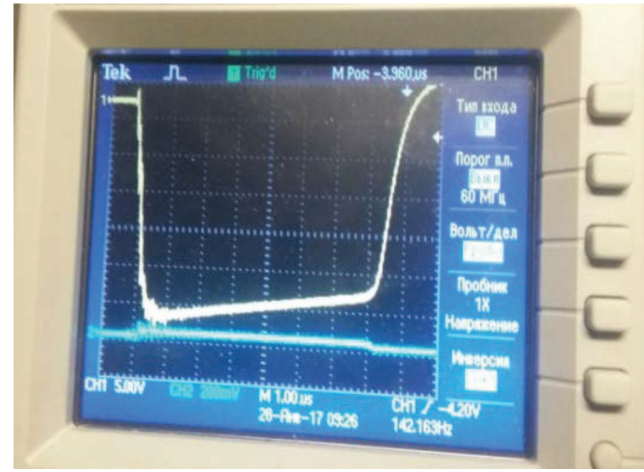


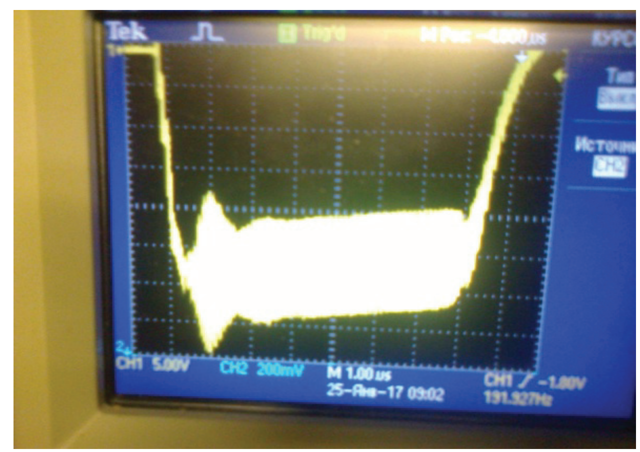
Induced current in dynamical mode

Effect of external electrical circuits

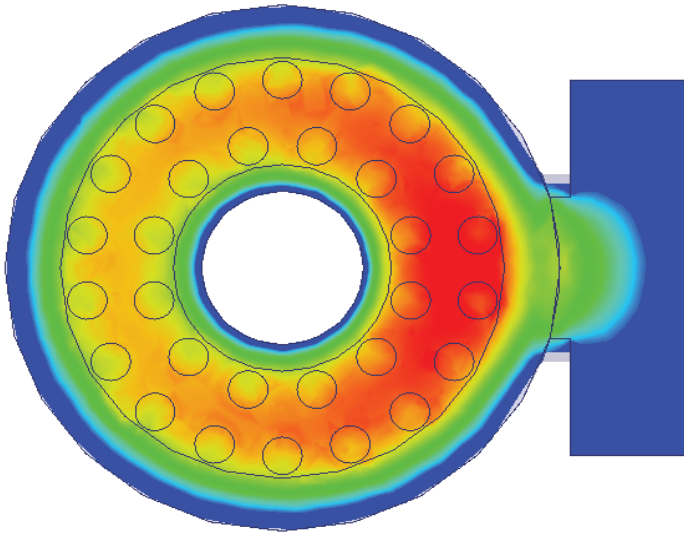


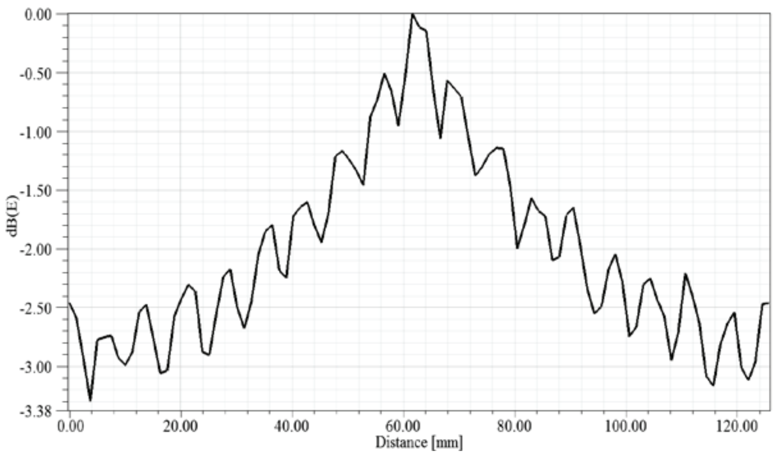


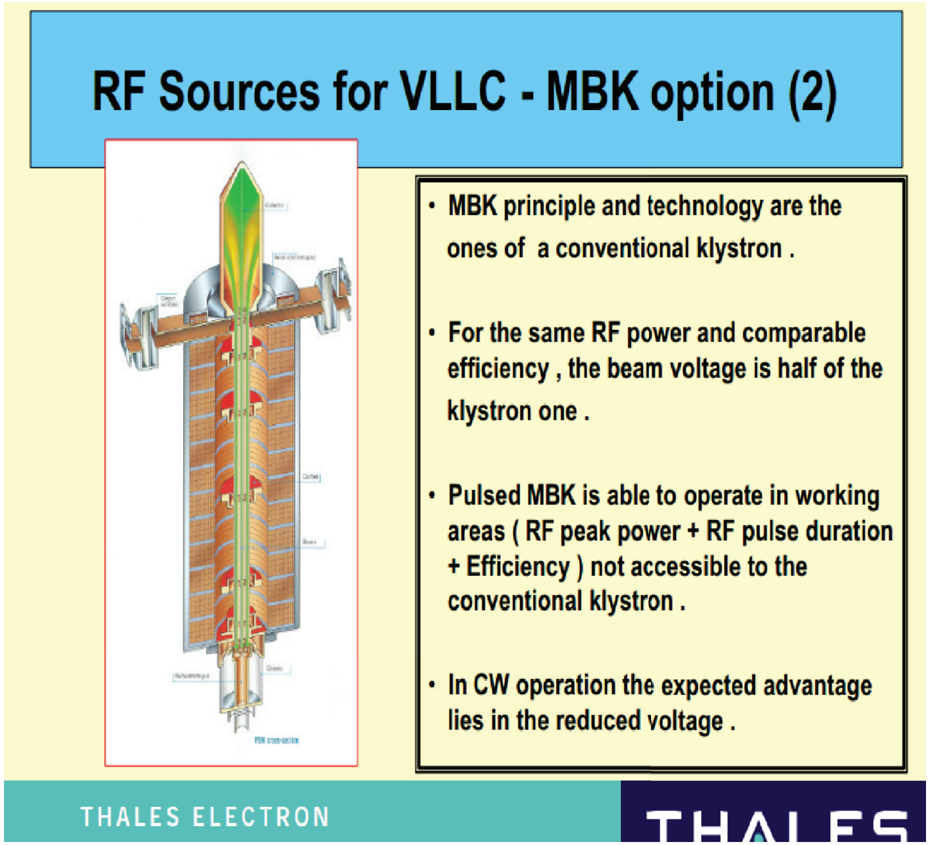




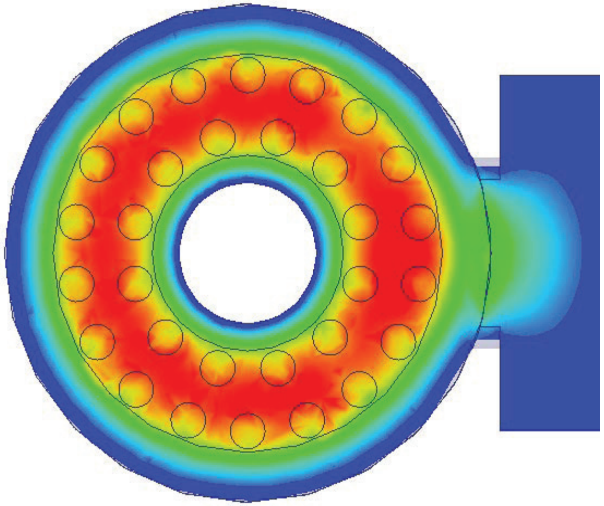
Optimization of the output cavity

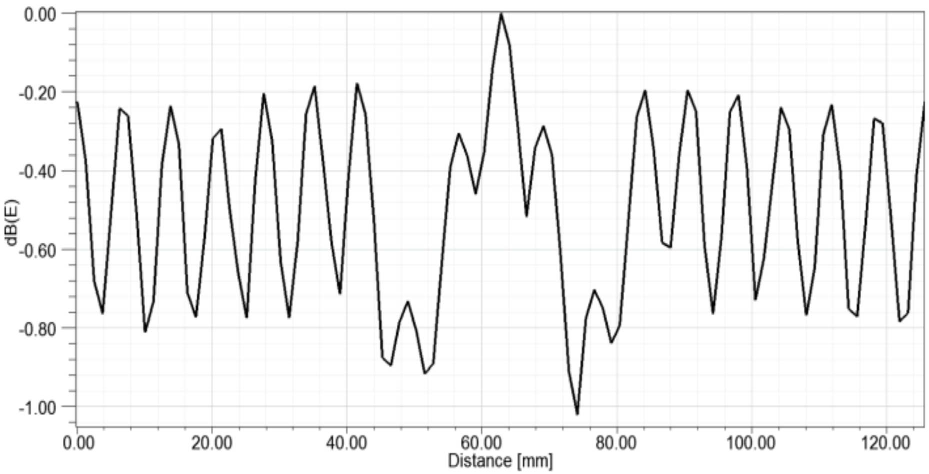


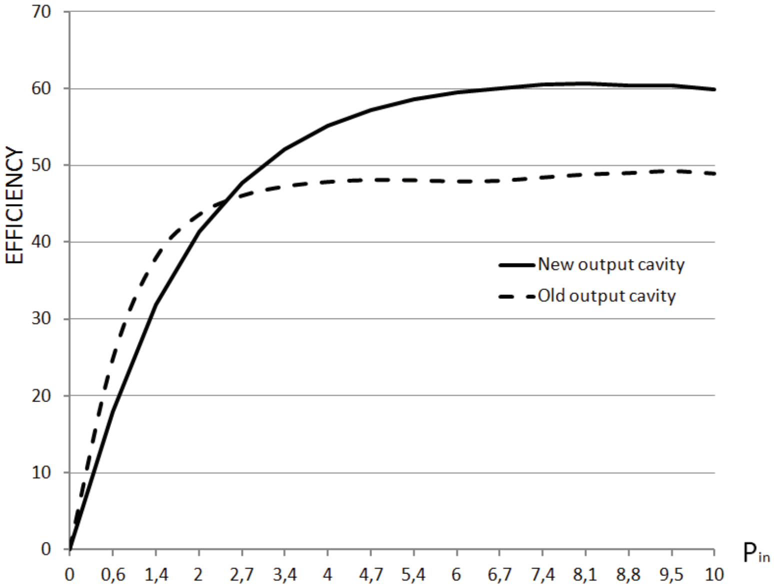




Optimization of the output cavity



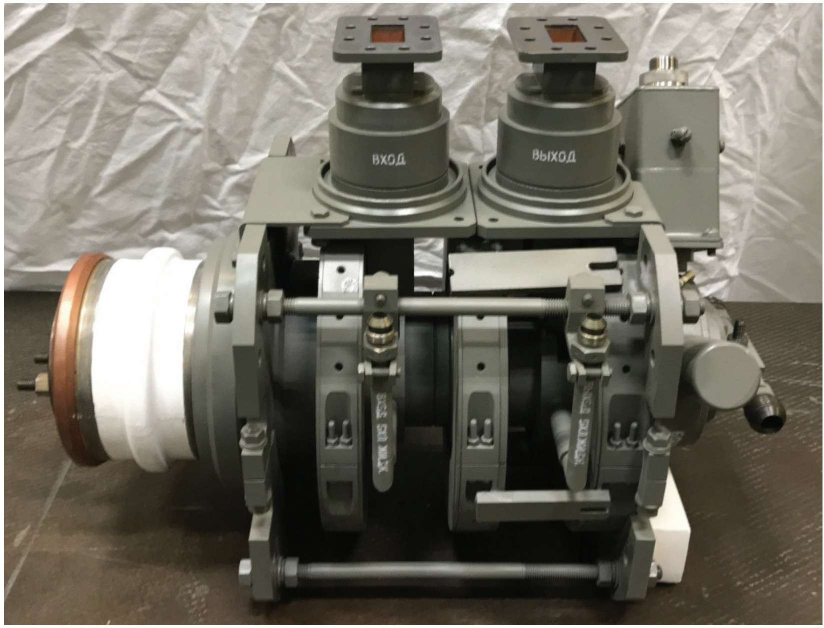


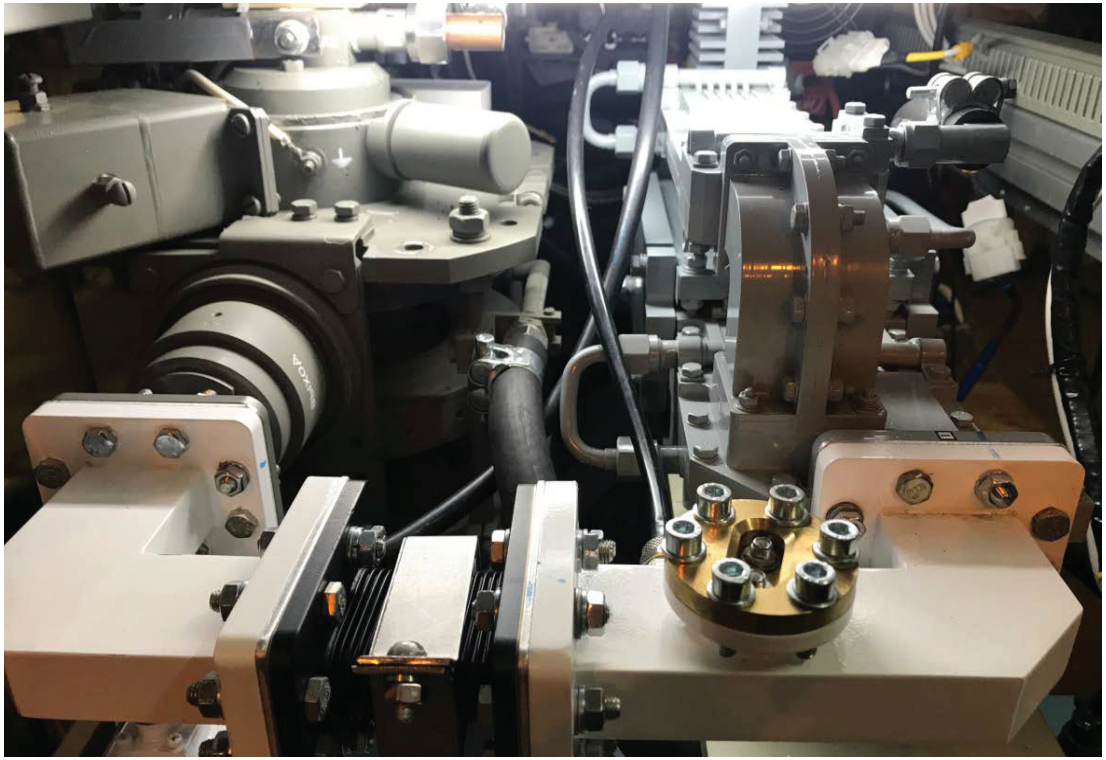


Conclusion

KILYSTRON KIU-271

Frequency –	5712 MHz
Cathode voltage –	45 kV
Pulse cathode current –	150 A
Output pulse power –	3,2 MW
Quality factor –	300 - 1000;
Focusing –	permanent magnets
Length -	478 mm

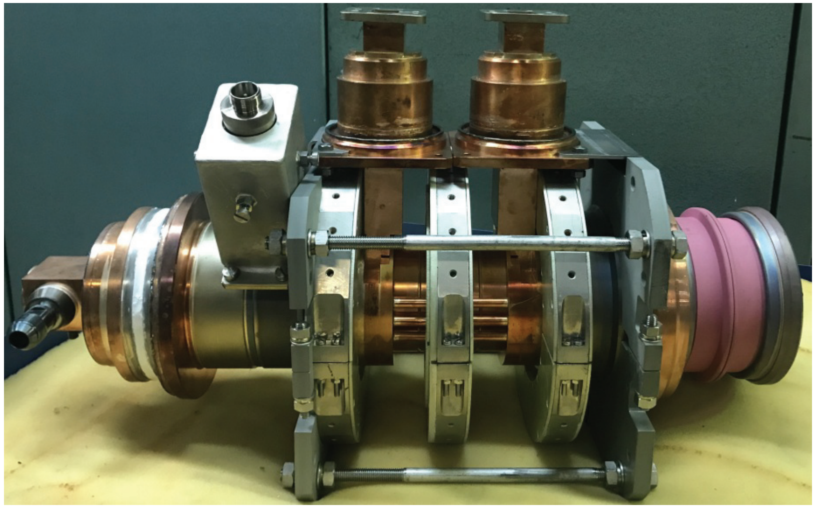


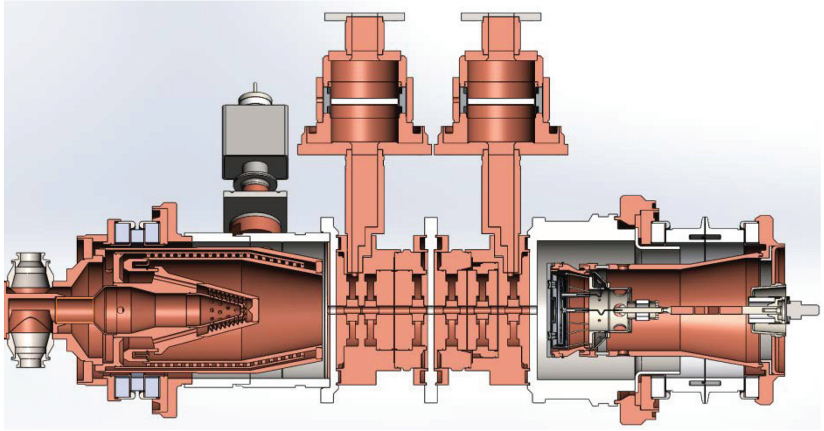


Conclusion

KLYSTRON KIU-273

Frequency –	5712 MHz
Cathode voltage –	45 kV
Pulse cathode current –	150 A
Output pulse power –	3,4 MW (+200 kW)
Quality factor –	300 - 1000;
Focusing –	permanent magnets
Length -	548 mm (+70 mm)





Thank You!

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