

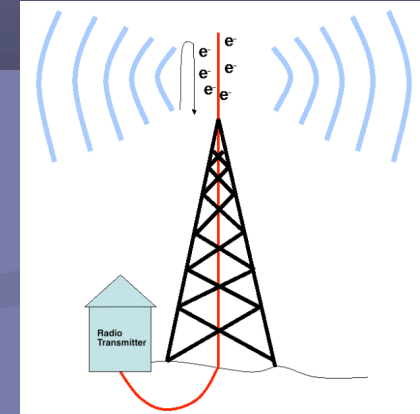
Işınım Kaynakları İçin Benzetim Programları I: SPECTRA

Yrd. Doç. Dr. Zafer Nergiz
Niğde Üniversitesi, Fizik Bölümü

Yüklü Parçacıklarda Işıma

- İvmeli hareket yapan yüklü parçacıklar ışıma meydana getirirler.

Antenlerde değişken akım artıp azalırken radyo dalgaları yayınlar

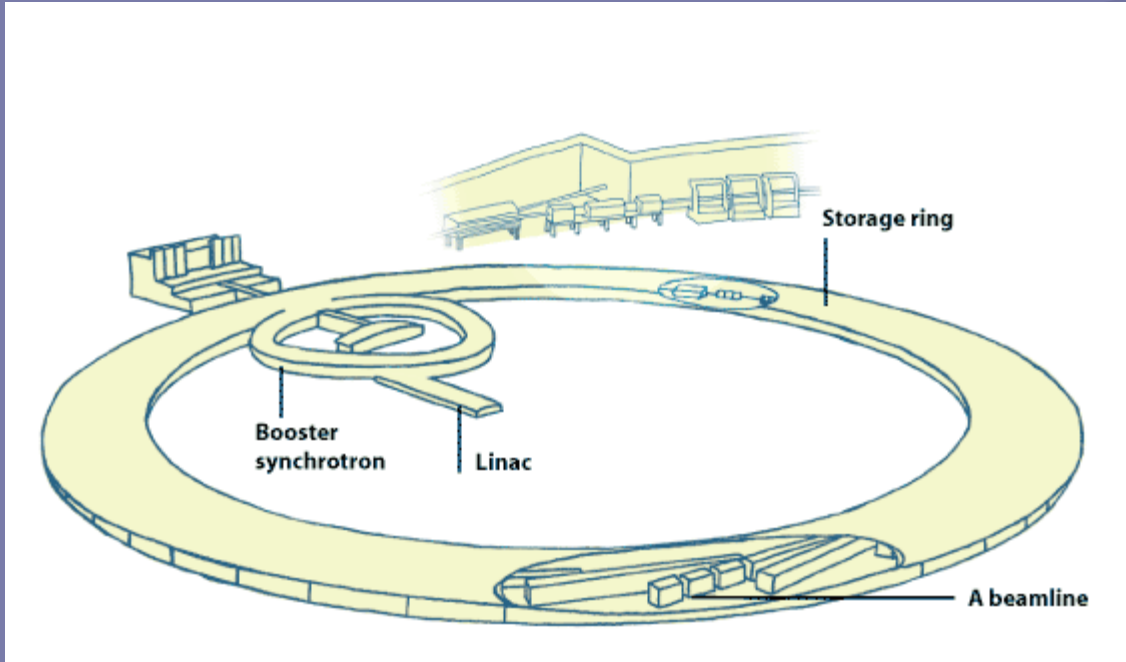


Bremstrahlung (frenleme ışınımı)
ışımasında çekirdekle etkileşen elektron
ışıma yapar

Sinkrotron Işıması

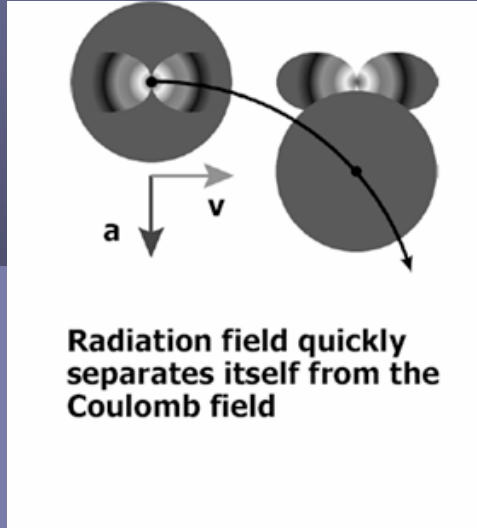
Sinkrotron ışıması, yüklü parçacıklar radyal olarak ivmelendirildiklerinde (dairesel bir yörüngede hareket ettiklerinde) yayınlanırlar

İlk olarak 1947 yılında New York'ta 70 MeV'lik General Elektron Sinkrotron'unda gözlenmiştir.



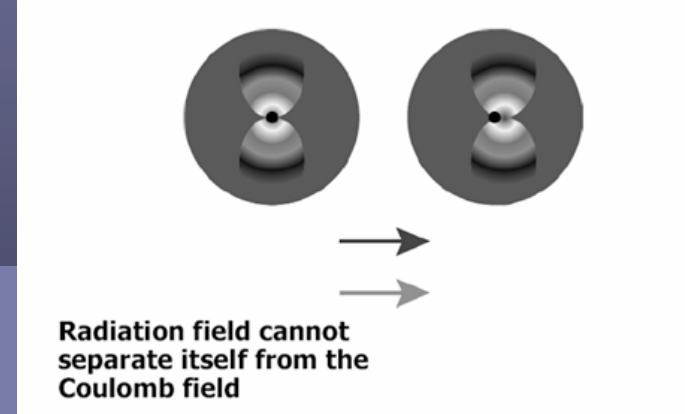
Boyuna ve Enine Hızlandırırma

Enine Durum



$$P_{\perp} = \frac{2}{3} r_e m c^3 \frac{(\beta\gamma)^4}{\rho^2}$$

Boyuna Durum

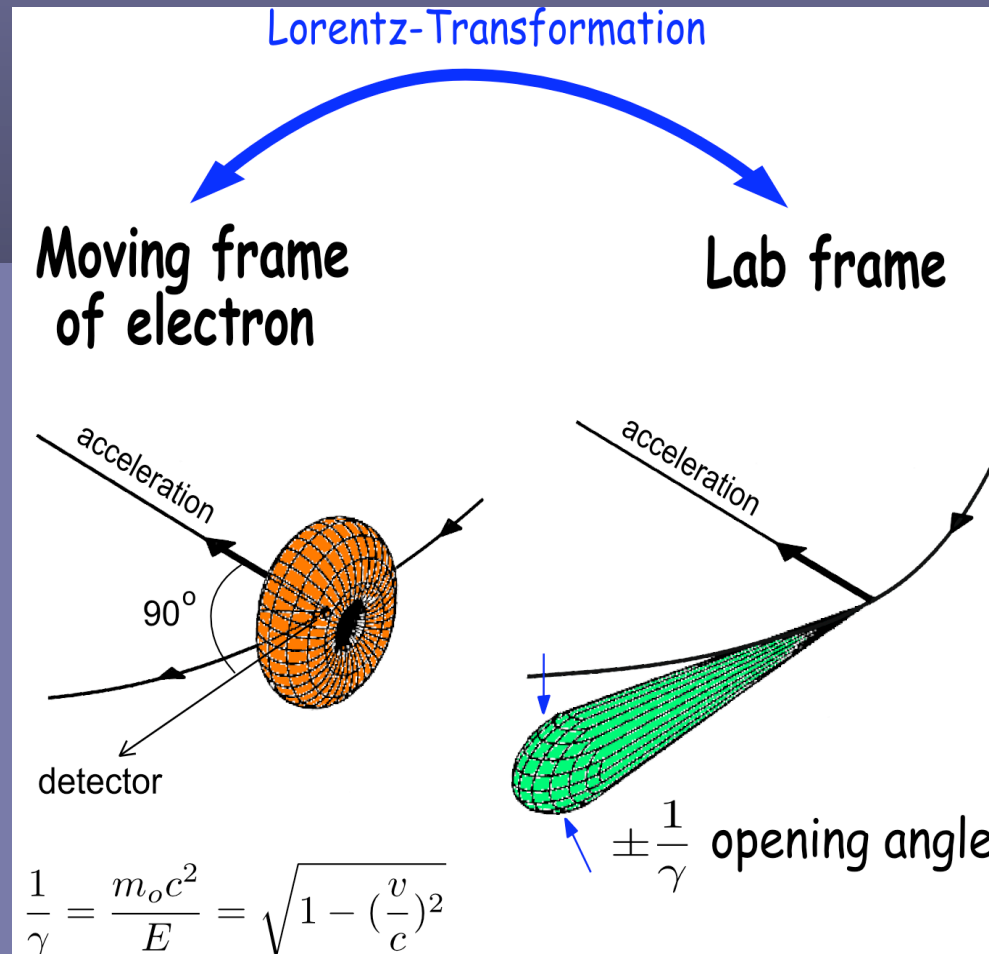


$$P_{\parallel} = \frac{2}{3} \frac{r_e}{mc} \left(\frac{d p_{\parallel}}{dt} \right)^2$$

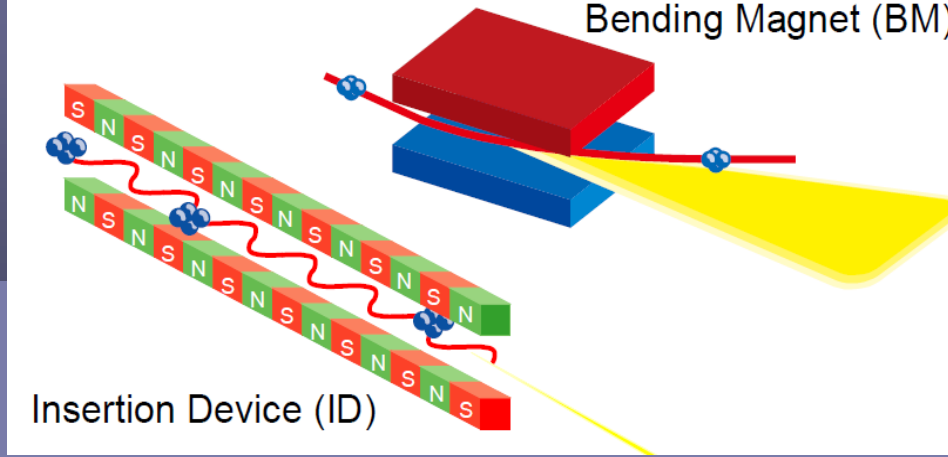
İhmal edilebilir.

Dairesel hızlandırırma Işıma Gücünü çok büyük ölçüde artırmaktadır. Bu olay dairesel hızlandırıcılara ciddi bir enerji limiti koymakla beraber, sinkrotron ışınım kaynaklarının yapılmasına olanak tanımaktadır.

Sinkrotron Işımasının Açısal dağılımı



Sinkrotron Işınımı Kaynakları



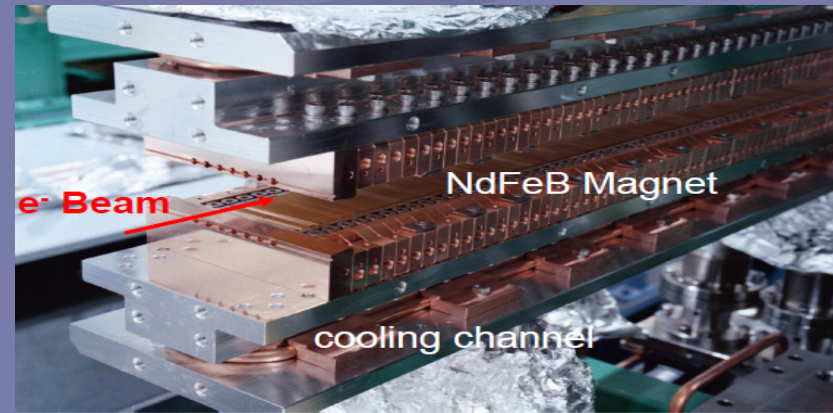
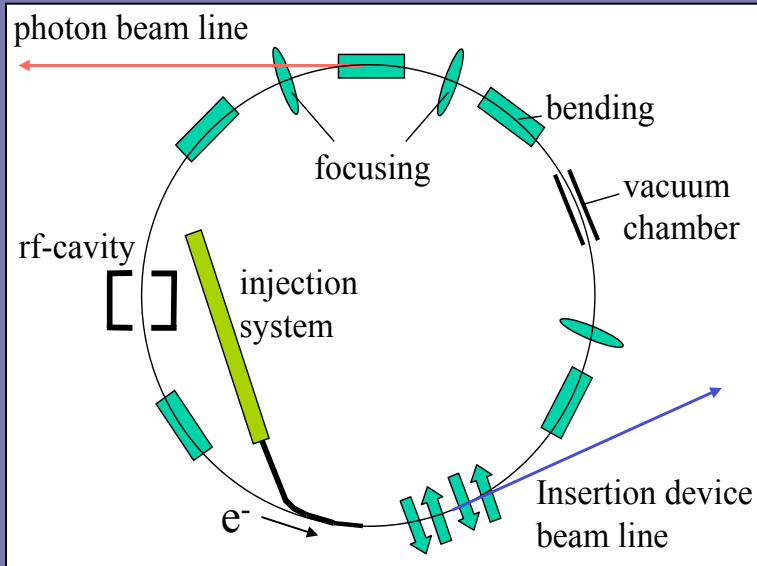
Eğici Magnet: Dairesel hızlandırıcıların zaten var olan elemanlarıdır. Parçacıkları sabit manyetik alan ile dairesel yörüngede tutarlar.

Işınım Aletleri (Insertion Devices)

Eğici magnetler arasında ayrılmış boş bölgelere ışınım üretmek için yerleştirilirler.

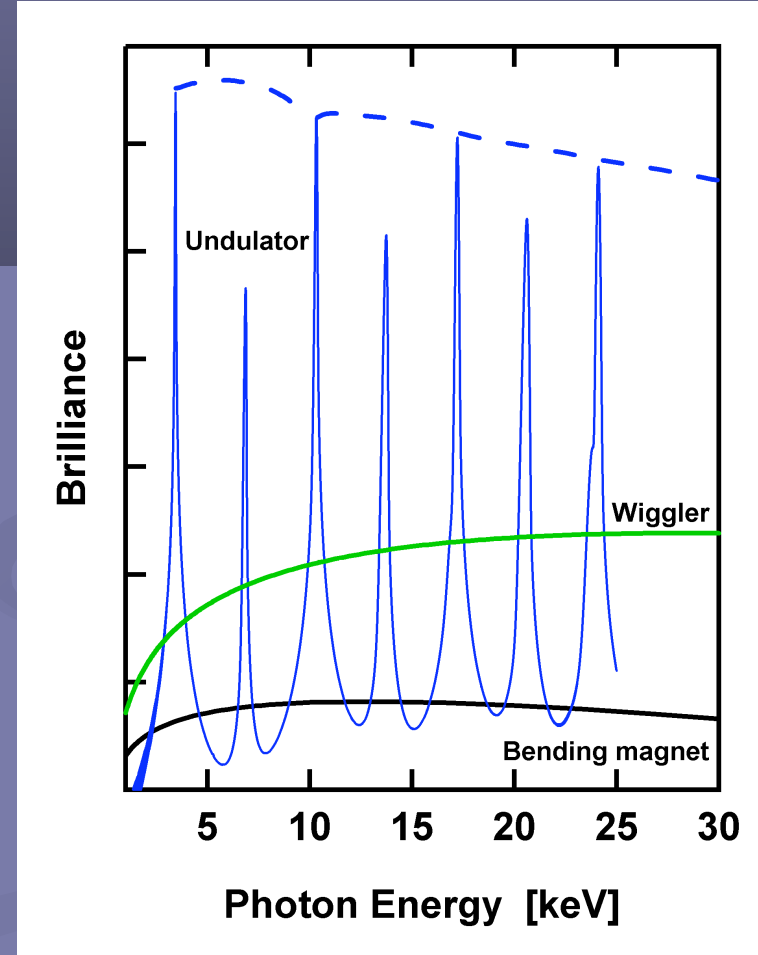
Elektron demetini periyodik olarak hareket ettirecek periyodik manyetik alan üretirler.

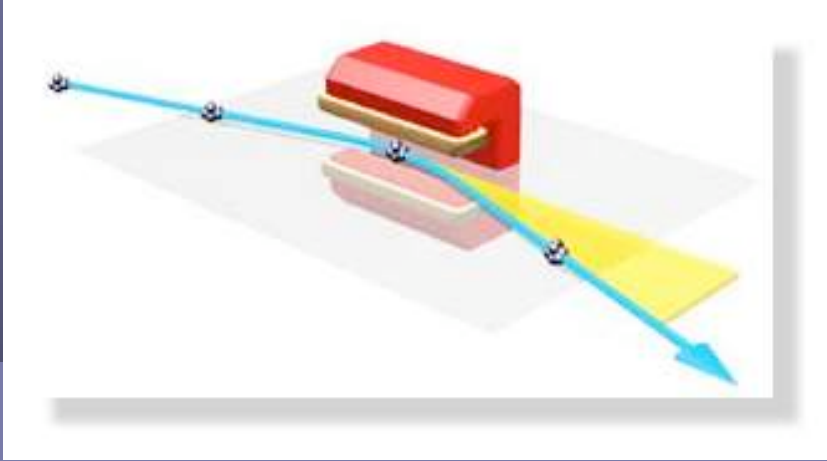
Wiggler (Zigzaglayıcı) ve Undulatör (Salındırıcı) olarak sınıflandırılırlar.



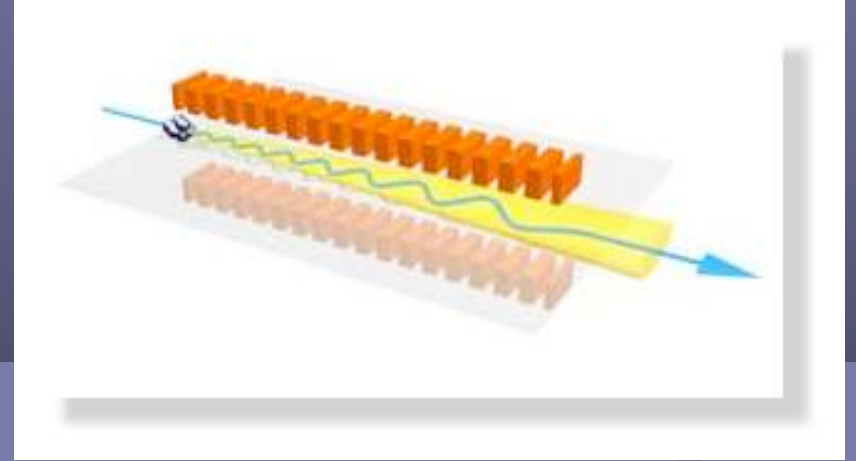
Salındırıcılar: Elektronlar zayıf manyetik alanla periyodik olarak salındırılırlar. Parçacıklar, dalgaboyu periyodik hareketin γ^2 'ye oranı olacak şekilde periyodik pikler şeklinde oluşurlar

Zigzaglayıcılar: Elektronlar kuvvetli manyetik alanla periyodik olarak salındırılırlar. Burada parçacıkların hareketi tam sinüsel değildir. Foton Spektrumu Kritik foton enerjisine kadar süreklidir. Spektrum Infrared'de hard x-ray bölgesine kadar uzanır.





Eğici magnet ışması

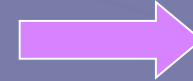


Wiggler ışması

$$K = 0.934 B_0(T) \lambda_p$$



$K > 3$

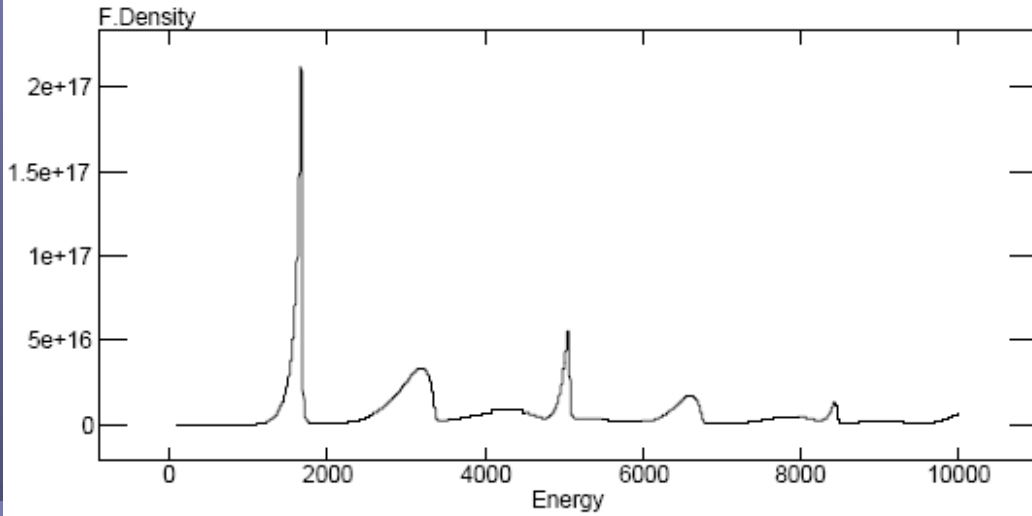


wiggler

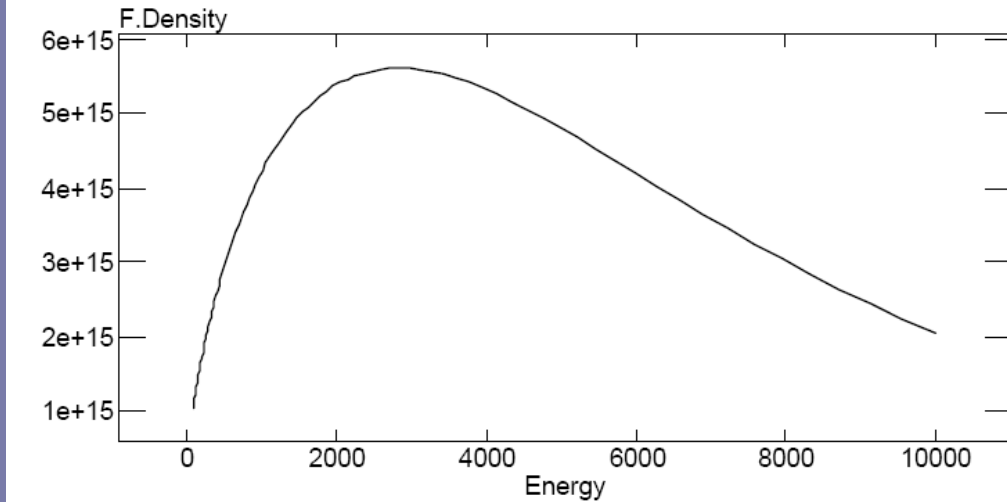
$K < 3$



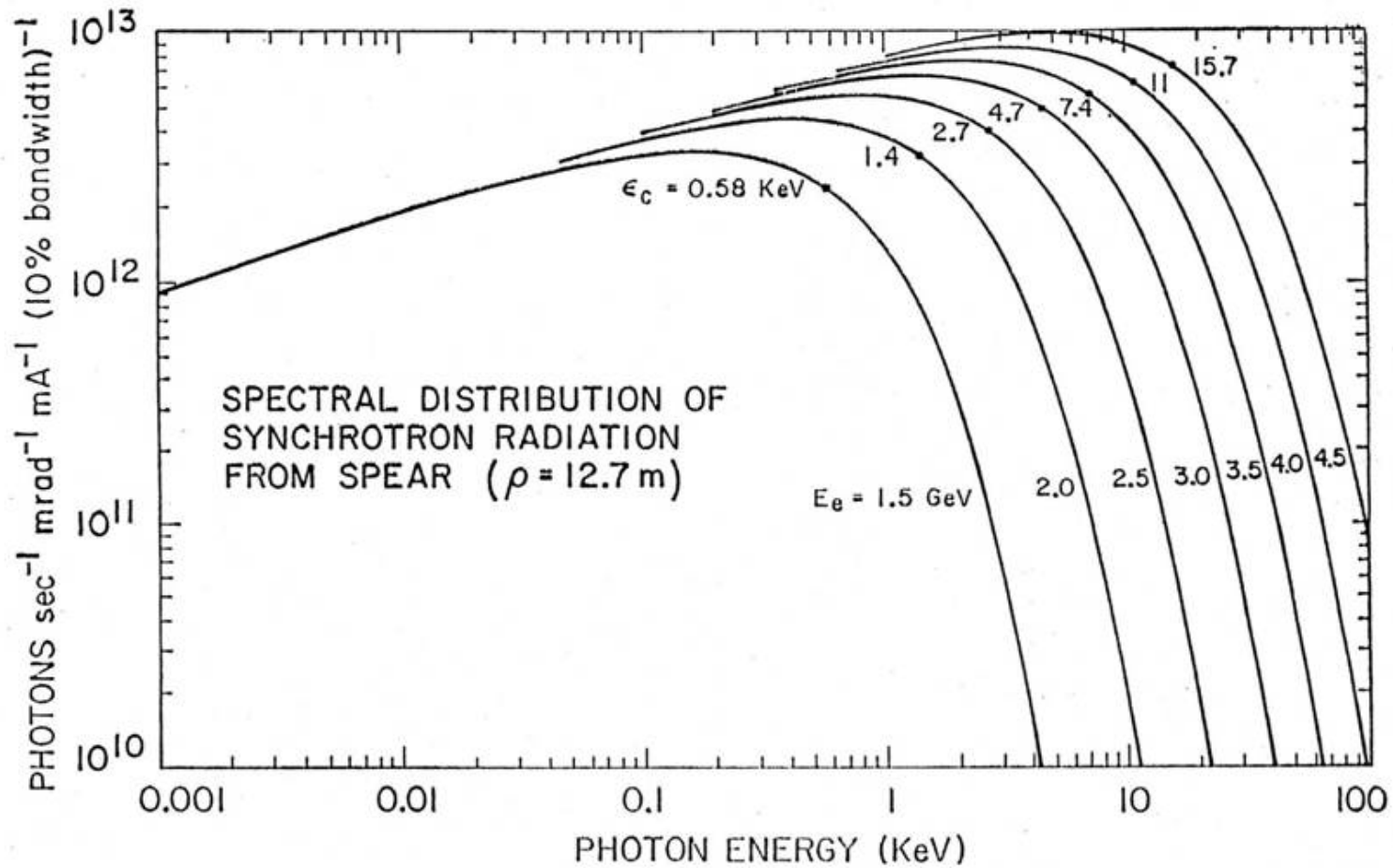
undulator



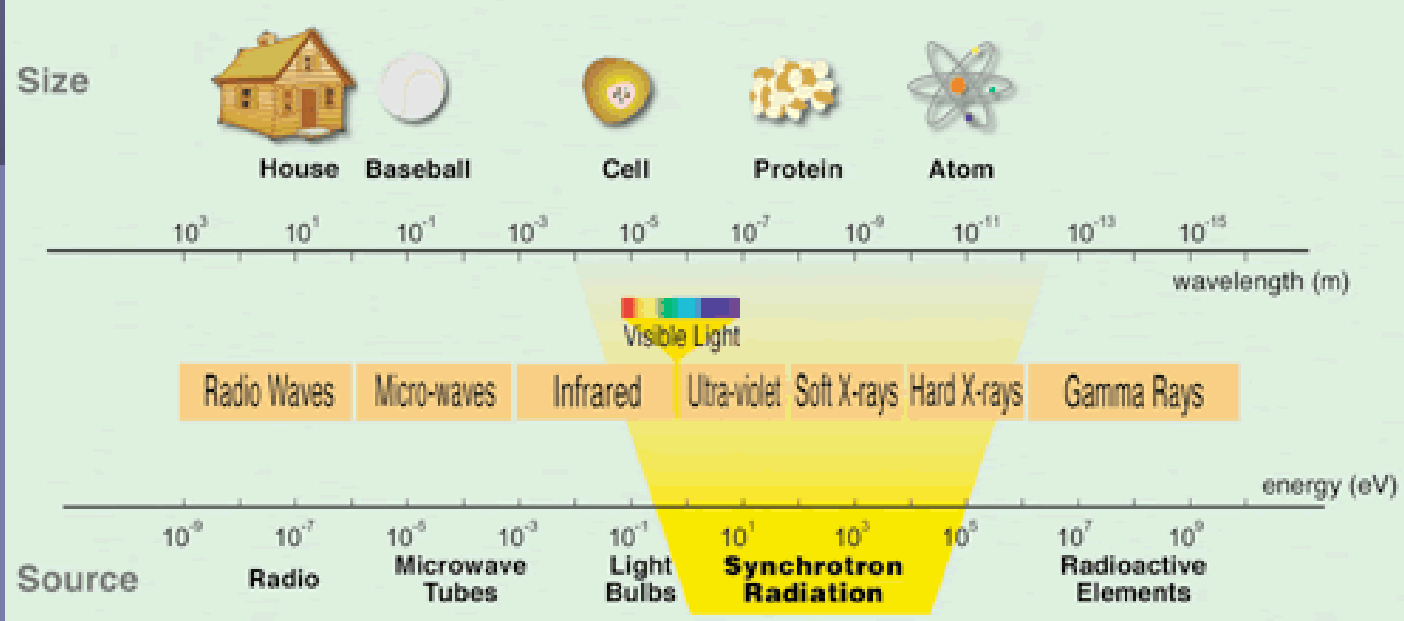
Undulator ışması



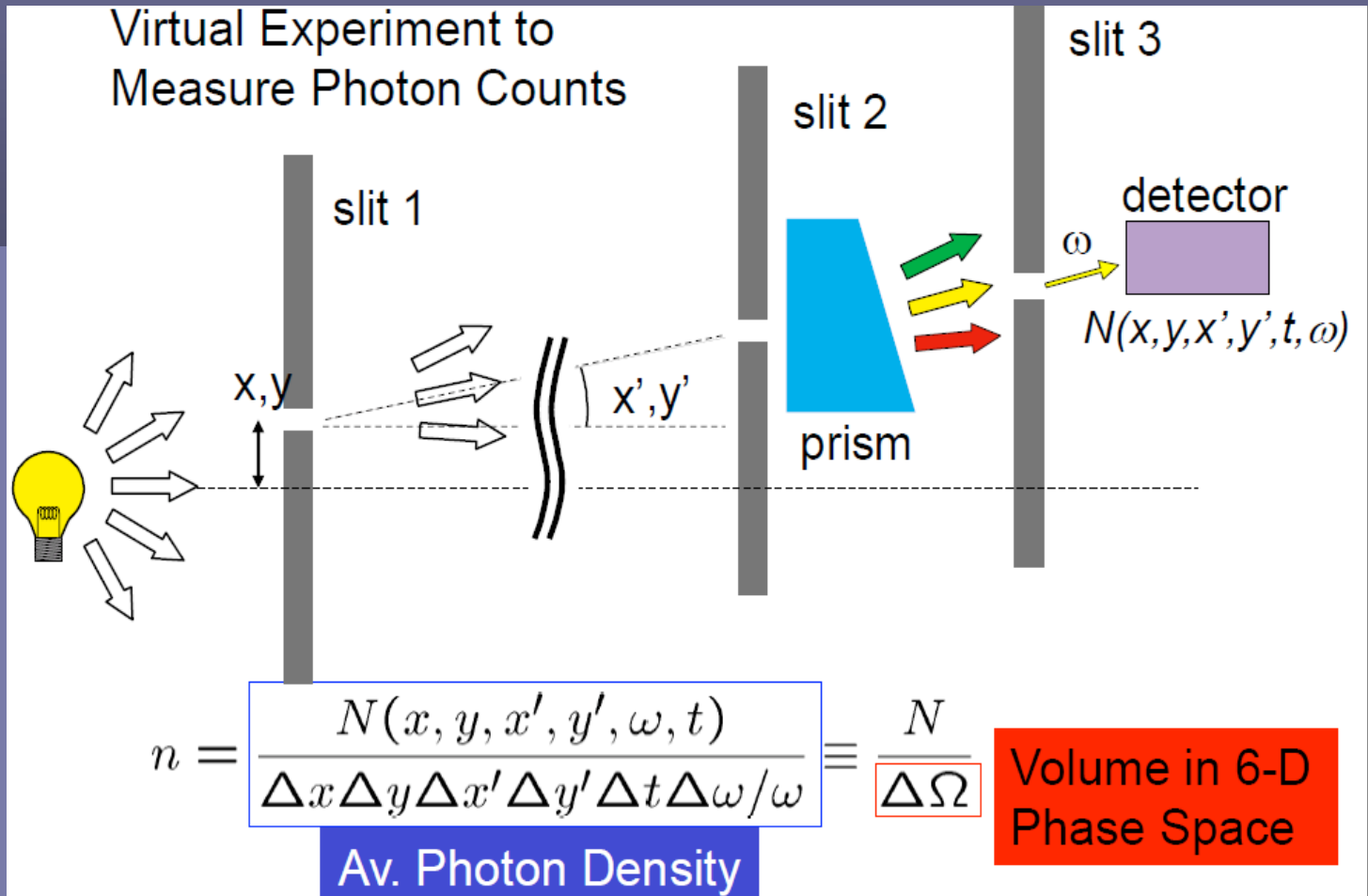
Wiggler ışması



The Electromagnetic Spectrum



Virtual Experiment to Measure Photon Counts



Brilliance (Parlaklık)

Parlaklık (photons/sec/mm²/mrad²/0.1%B.W.) 6 boyutlu faz uzayında foton yoğunluğu olarak tanımlanır.

$$B = \lim_{\Delta\Omega \rightarrow 0} n = \frac{d^6 N(x, y, x', y', t, \omega)}{dx dy dx' dy' dt d\omega / \omega}$$

Açısal Akı Yoğunluğu
photons/sec/mrad²/0.1%B.W



$$\frac{d^2 F}{dx' dy'} = \iint B dx dy$$

Toplam Akı (photons/sec/
0.1%B.W)



$$F = \iiint B dx dy dx' dy'$$

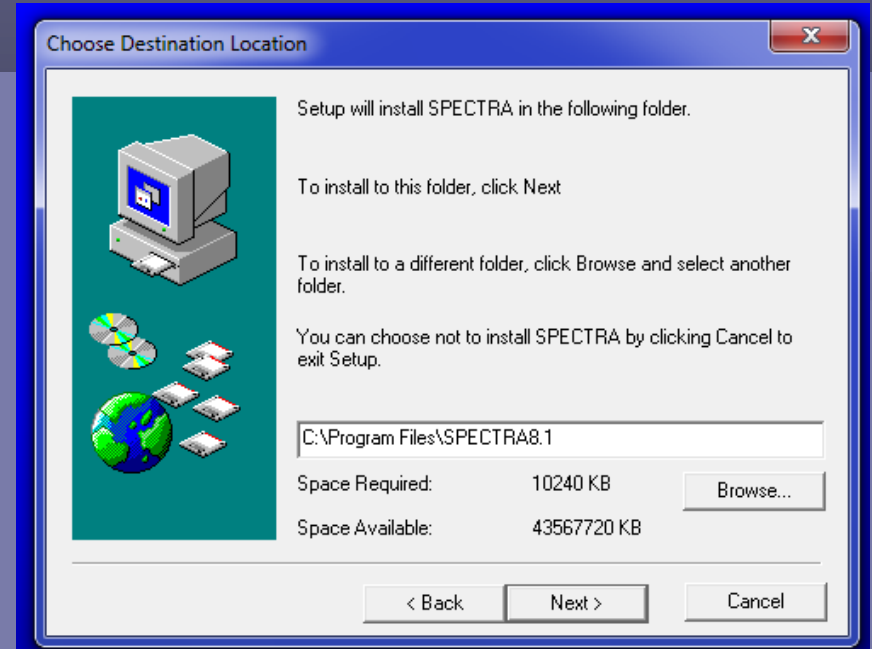
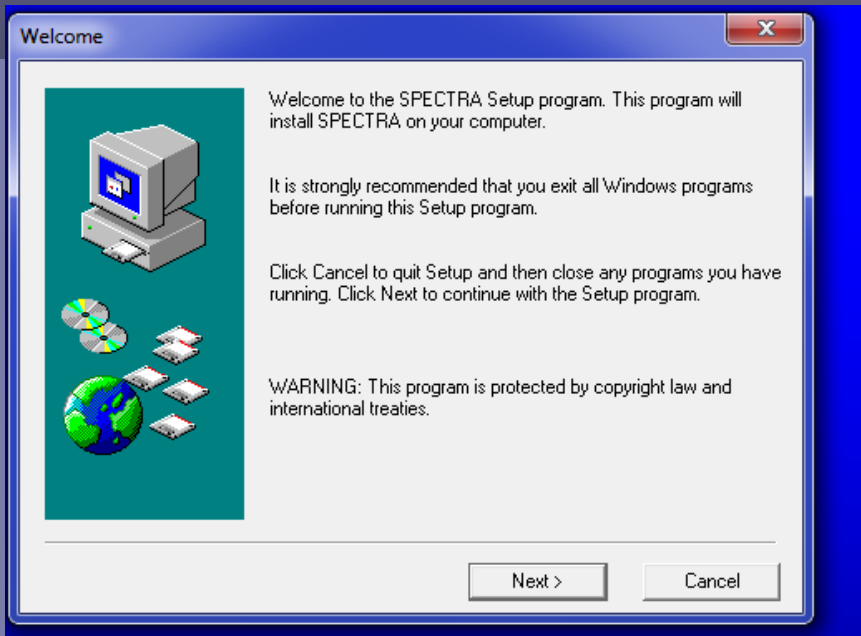
SPECTRA

- Sinkrotron Işınım kaynaklarında undulatör, wiggler ve eğici magnetlerden üretilecek ışınımın özelliklerini belirlemede kullanılır.
- Spring-8'den T. Tanaka ve H. Kitumura tarafından yazılmıştır.

<http://radiant.harima.riken.go.jp/spectra/>

Programın kurulması

spectra_win.exe'ye Çift tıkla>NEXT->NEXT->NEXT



SPECTRA 8.1 - C:\Program Files (x86)\SPECTRA8.1\prm\lhec\storage_ring.prm

File Select Calculation Run Open Utility Configuration Help

Accelerator Specification

Storage Ring

Bunch Shape: Gaussian Energy Spread 0.0011

Electron Energy (GeV)	8	$\beta_x(m)$	24	α_x	0
Average Current (mA)	100	$\beta_y(m)$	5.8	α_y	0
Circumference	1435	$\eta_x(m)$	0	η_x'	0
Bunches	2436	$\eta_y(m)$	0	η_y'	0
σ_z (mm)	20				
Peak Current (A)	1.17505	$1/\gamma(\mu rad)$	63.8749		
Natural Emittance (m.rad)	5.9e-9	$\sigma_x(\mu m)$	375.7	$\sigma_x(\mu rad)$	15.66
Coupling Constant	0.003	$\sigma_y(\mu m)$	10.12	$\sigma_y(\mu rad)$	1.744
$\epsilon_x(m.rad)$ 5.882e-09	$\epsilon_y(m.rad)$ 1.765e-11	$\gamma\sigma_x'$	0.2451	$\gamma\sigma_y'$	0.02731

Light Source Description

Linear Undulator

Link Gap & Field
 Segmented Undulator
 Special Magnet Setup

Gap Value	20	$\sigma_r(\mu m)$	2.19789	$\sigma_r(\mu rad)$	3.08254
B(T)	0.26105	$\Sigma_x(\mu m)$	375.741	$\Sigma_x(\mu rad)$	15.9562
Periodic Length (cm)	3.2	$\Sigma_y(\mu m)$	10.353	$\Sigma_y(\mu rad)$	3.54184
Total Length (m)	4.5	$\epsilon_{1st}(peak:eV)$	14525		
Number of Periods	140	$\epsilon_{3rd}(peak:eV)$	43642.4		
K Value	0.78	Flux _{1st}	4.11454e+14		
$\epsilon_{1st}(eV)$	14562.7	Brilliance _{1st}	4.74079e+19		
		Peak Brilliance	5.57064e+20		
		Bose Degeneracy	0.00014334		
		Total Power (kW)	1.23622		

SPECTRA 8.1 - C:\Program Files (x86)\SPECTRA8.1\prm\lhec\storage_ring.prm

File Select Calculation Run Open Utility Configuration Help

Accelerator Specification

Storage Ring

Bunch Shape: Gaussian

Electron Energy (GeV) 8

Average Current (mA) 100

Circumference 1435

Bunches 2436

σ_z (mm) 20

Peak Current (A) 1.17505

Natural Emittance (m.rad) 5.9×10^{-9}

Coupling Constant 0.003

ϵ_x (m.rad) 5.882×10^{-9} ϵ_y (m.rad) 1.765×10^{-11}

Beamline

Accelerator

Light Source

Calculation Control

Source Type

Solve Equation of Motion

Duplicate

Change Name

Delete

Untitled

Linear Undulator

Vertical Undulator

Helical Undulator

Elliptic Undulator

Figure-8 Undulator

Wiggler

EMPW

Bending Magnet

Asymmetric Figure-8 Undulator

Multipole Field

Field Mapping

Periodic: User Defined

User Defined

Light Source Description

Linear Undulator

Link Gap & Field

Segmented Undulator

Special Magnet Setup

Gap Value 20

B(T) 0.26105

Periodic Length (cm) 3.2

Total Length (m) 4.5

Number of Periods 140

K Value 0.78

ϵ_{1st} (eV) 14562.7

σ_r (μ m) 2.19789 σ_r (μ rad) 3.08254

Σ_x (μ m) 375.741 Σ_x (μ rad) 15.9562

Σ_y (μ m) 10.353 Σ_y (μ rad) 3.54184

ϵ_{1st} (peak:eV) 14525

ϵ_{3rd} (peak:eV) 43642.4

Flux_{1st} 4.11454×10^{14}

Brilliance_{1st} 4.74079×10^{19}

Peak Brilliance 5.57064×10^{20}

Bose Degeneracy 0.00014334

Total Power (kW) 1.23622

SPECTRA 8.1 - C:\Program Files (x86)\SPECTRA8.1\prm\lhec\storage_ring.prm

File Select Calculation Run Open Utility Configuration Help

Acc Energy Dependence ▶ Brilliance
 Sto Spatial Dependence ▶ Partial Flux ▶
 Bu K Dependence ▶ Total Flux
 Ele Power@Fixed Point
 Av Near Field ▶
 Cir Coherent Radiation ▶

Bunches 2436
 σ_z (mm) 20
 Peak Current (A) 1.17505
 Natural Emittance (m.rad) 5.9e-9
 Coupling Constant 0.003
 ϵ_x (m.rad) 5.882e-09 ϵ_y (m.rad) 1.765e-11

Energy Spread 0.0011

β_x (m)	24	α_x	0
β_y (m)	5.8	α_y	0
η_x (m)	0	η_x'	0
η_y (m)	0	η_y'	0

$1/\gamma$ (μ rad) 63.8749
 σ_x (μ m) 375.7 σ_x (μ rad) 15.66
 σ_y (μ m) 10.12 σ_y (μ rad) 1.744
 $\gamma\sigma_x'$ 0.2451 $\gamma\sigma_y'$ 0.02731

Light Source Description

Linear Undulator

Link Gap & Field
 Segmented Undulator
 Special Magnet Setup

Gap Value	20	σ_r (μ m)	2.19789	σ_r (μ rad)	3.08254
B(T)	0.26105	Σ_x (μ m)	375.741	Σ_x (μ rad)	15.9562
Periodic Length (cm)	3.2	Σ_y (μ m)	10.353	Σ_y (μ rad)	3.54184
Total Length (m)	4.5	ϵ_{1st} (peak:eV)	14525		
Number of Periods	140	ϵ_{3rd} (peak:eV)	43642.4		
K Value	0.78	Flux _{1st}	4.11454e+14		
ϵ_{1st} (eV)	14562.7	Brilliance _{1st}	4.74079e+19		
		Peak Brilliance	5.57064e+20		
		Bose Degeneracy	0.00014334		
		Total Power (kW)	1.23622		

SPECTRA 8.1 - Untitled

File Select Calculation Run Open Utility Configuration Help

Accelerator Specification

Storage Ring

Bunch Shape: Gaussian Energy Spread 0.0011

Electron Energy (GeV) 8 $\beta_x(m)$ 24 α_x 0

Average Current (mA) 100 $\beta_y(m)$ 5.8 α_y 0

Circumference 1435 $\eta_x(m)$ 0 η_x' 0

Bunches 2436 $\eta_y(m)$ 0 η_y' 0

σ_z (mm) 20

Peak Current (A) 1.17505 $1/\gamma(\mu rad)$

Natural Emittance (m.rad) 5.9e-9 $\sigma_x(\mu m)$

Coupling Constant 0.003 $\sigma_y(\mu m)$

$\epsilon_x(m.rad)$ 5.882e-09 $\epsilon_y(m.rad)$ 1.765e-11 $\gamma\sigma_x'$

Light Source Description

Linear Undulator

Link Gap & Field

Segmented Undulator

Gap Value 20 $\sigma_r(\mu m)$

B(T) 0.26105 $\Sigma_x(\mu m)$

Periodic Length (cm) 3.2 $\Sigma_y(\mu m)$

Total Length (m) 4.5 $\epsilon_{1st}(pea)$

Number of Periods 140 $\epsilon_{3rd}(pea)$

K Value 0.78 Flux1st

$\epsilon_{1st}(eV)$ 14562.7 Brilliance

Peak Bri

Bose De

Total Po

Energy Dependence - Brilliance

Observation

Observation Point in Angle

Distance from the Source (m) 30

Initial Energy (eV) 10000

Final Energy (eV) 50000

Energy Pitch (eV) 30

$\theta_x(\mu rad)$ 0

$\theta_y(\mu rad)$ 0

$\epsilon_{1st@\theta_{x,y}}(eV)$ 14562.7

Easy Calc. > -1 eV

Auto Pitch: Rel. Difference 0.5

Filtering Generic Filter

Convolution

Numerical Conditions

Zero Emittance

Zero E-spread

Accuracy Level 1

Output File Settings

Print Header

Print Unit

Suffix dc0

Flux Density (photons/sec/mr²/0.1%B.W)

Brilliance (photons/sec/mr²/0.1%B.W)

PL(s1/s0)

PC(s3/s0)

PL45(s2/s0)

1-|PL|

spectra [Uyumluluk Modu] - Microsoft PowerPoint

sterisi Gözden Geçir Görünüm

Eylem Metin Üstbilgi WordArt Tarih

SPECTRA 8.1 - Untitled

File Select Calculation **Run** Open Utility Configuration Help

Accelerator Specificati
Storage Ring | Create Process
Import List
Start Calculation

Bunch Shape: Energy Spread 0.0011

Electron Energy (GeV)	8	$\beta_x(m)$	24	α_x	0
Average Current (mA)	100	$\beta_y(m)$	5.8	α_y	0
Circumference	1435	$\eta_x(m)$	0	η_x	0
Bunches	2436	$\eta_y(m)$	0	η_y	0
σ_z (mm)	20				
Peak Current (A)	1.17505	$1/\gamma(\mu rad)$	63.8749		
Natural Emittance (m.rad)	5.9e-9	$\sigma_x(\mu m)$	375.7	$\sigma_x(\mu rad)$	15.66
Coupling Constant	0.003	$\sigma_y(\mu m)$	10.12	$\sigma_y(\mu rad)$	1.744
$\varepsilon_x(m.rad)$ 5.882e-09	$\varepsilon_y(m.rad)$ 1.765e-11	$\gamma\sigma_x$	0.2451	$\gamma\sigma_y$	0.02731

Light Source Description

Linear Undulator |

Link Gap & Field
 Segmented Undulator

Gap Value	20	$\sigma_r(\mu m)$	2.19789	$\sigma_r(\mu rad)$	3.08254
B(T)	0.26105	$\Sigma_x(\mu m)$	375.741	$\Sigma_x(\mu rad)$	15.9562
Periodic Length (cm)	3.2	$\Sigma_y(\mu m)$	10.353	$\Sigma_y(\mu rad)$	3.54184
Total Length (m)	4.5	$\varepsilon_{1st}(peak:eV)$	14525		
Number of Periods	140	$\varepsilon_{3rd}(peak:eV)$	43642.4		
K Value	0.78	Flux _{1st}	4.11454e+14		
$\varepsilon_{1st}(eV)$	14562.7	Brilliance _{1st}	4.74079e+19		
		Peak Brilliance	5.57064e+20		
		Bose Degeneracy	0.00014334		
		Total Power (kW)	1.23622		

Energy Dependence - Brilliance

Observation |

Observation Point in Angle

Distance from the Source (m) 30

Initial Energy (eV) 10000

Final Energy (eV) 50000

Energy Pitch (eV) 30

$\theta_x(\mu rad)$ 0

$\theta_y(\mu rad)$ 0

$\varepsilon_{1st}@\theta_{x,y}(eV)$ 14562.7

Easy Calc. > -1 eV

Auto Pitch: Rel. Difference 0.5

Filtering Generic Filter

Convolution

Numerical Conditions

Zero Emittance
 Zero E-spread
Accuracy Level 1

Output File Settings

Print Header
 Print Unit
Suffix dc0

Flux Density (photons/sec/mr²/0.1%B.W
Brilliance (photons/sec/mr²/0.1%B.W
PL(s1/s0)
PC(s3/s0)
PL45(s2/s0)
1-|PL|

Storage Ring

Bunch Shape: Gaussian Energy Spread: 0.0011

Electron Energy (GeV)	8	$\beta_x(m)$	24	α_x	0
Average Current (mA)	100	$\beta_y(m)$	5.8	α_y	0
Circumference	1435	$\eta_x(m)$	0	η_x'	0
Bunches	2436	$\eta_y(m)$	0	η_y'	0
σ_z (mm)	20				
Peak Current (A)	1.17505	$1/\gamma(\mu rad)$	63.8749		
Natural Emittance (m.rad)	5.9e-9	$\sigma_x(\mu m)$	375.7	$\sigma_x(\mu rad)$	15.66
Coupling Constant	0.003	$\sigma_y(\mu m)$	10.12	$\sigma_y(\mu rad)$	1.744
$\epsilon_x(m.rad)$	5.882e-09	$\gamma\sigma_x'$	0.2451	$\gamma\sigma_y'$	0.02731
$\epsilon_y(m.rad)$	1.765e-11				

Light Source Description

Linear Undulator

Link Gap & Field

Segmented Undulator

Gap Value	20	$\sigma_r(\mu m)$	2.19
B(T)	0.26105	$\Sigma_x(\mu m)$	375
Periodic Length (cm)	3.2	$\Sigma_y(\mu m)$	10.3
Total Length (m)	4.5	$\epsilon_{1st}(peak:eV)$	
Number of Periods	140	$\epsilon_{3rd}(peak:eV)$	
K Value	0.78	Flux _{1st}	
$\epsilon_{1st}(eV)$	14562.7	Brilliance _{1st}	
		Peak Brilliance	
		Bose Degener	
		Total Power (k	

Energy Dependence - Brilliance

Observation

Observation Point in Angle

Numerical Conditions

ro Emittance

ro E-spread

Accuracy Level 1

File Settings

int Header

int Unit

dc0

ensity (photons/

ce (photons/sec

(s0)

(s0)

s2/s0)

SPECTRA: Result Viewer

Select Data Name: C:\Program Files\SPECTRA8.1\deneme1

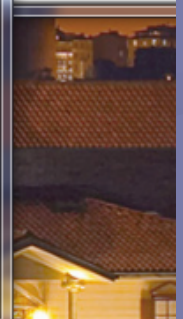
Select X Axis: Energy

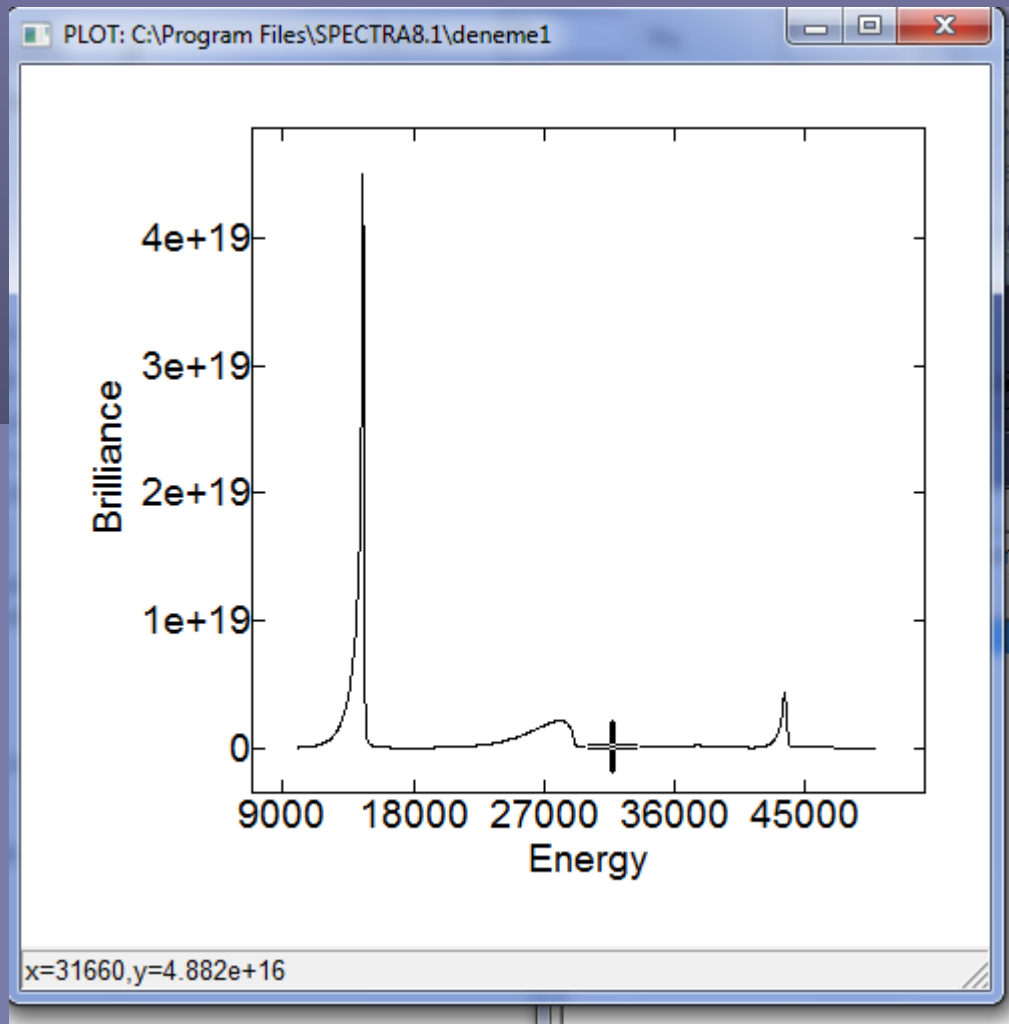
Select File Name: deneme1.dc0

Select Y Axis:

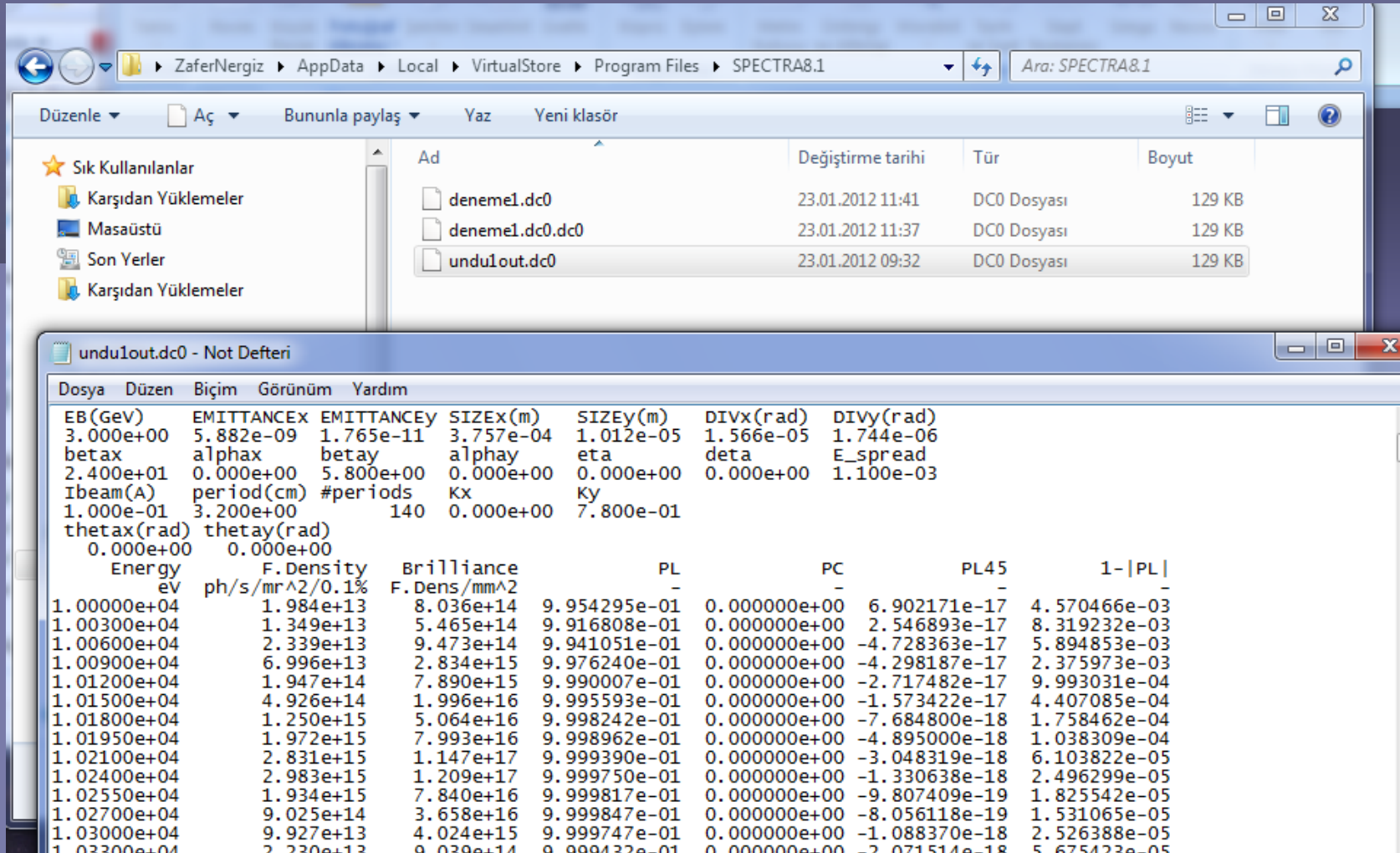
- Energy
- F.Density**
- Brilliance
- PL
- PC
- PL45
- 1-|PL|

Plot Import Clear Close



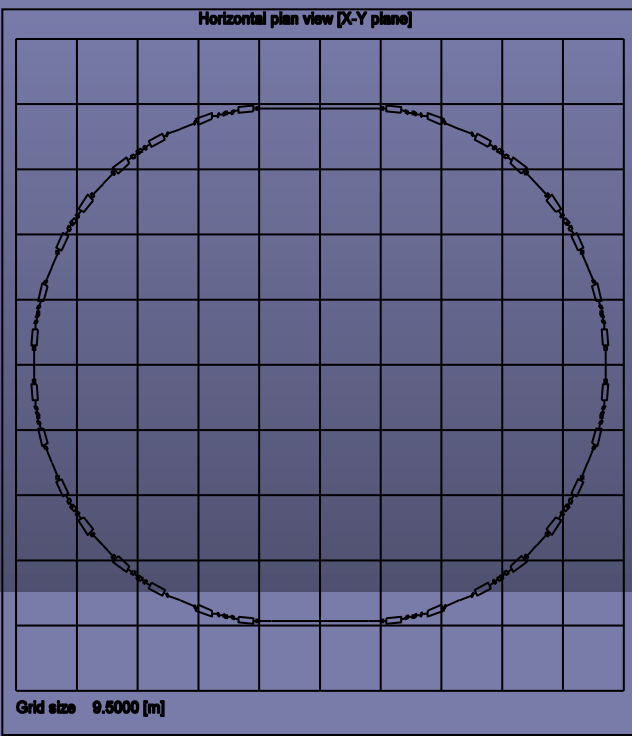


Datalar sizin programfiles'da sizin belirlemiş olduğunuz dosyaya kaydolur. Çeşitli sonuçlar farklı grafik programları yardımı ile çizdirilebilir.

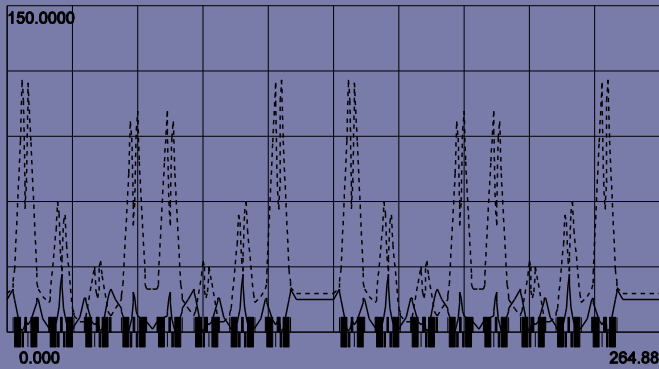


The screenshot shows a Windows file explorer window with the address bar set to 'ZaferNergiz > AppData > Local > VirtualStore > Program Files > SPECTRA8.1'. The search bar contains 'Ara: SPECTRA8.1'. The file list shows three files: 'deneme1.dc0' (129 KB, DC0 Dosyası, 23.01.2012 11:41), 'deneme1.dc0.dc0' (129 KB, DC0 Dosyası, 23.01.2012 11:37), and 'undu1out.dc0' (129 KB, DC0 Dosyası, 23.01.2012 09:32). Below the file explorer, a Notepad window titled 'undu1out.dc0 - Not Defteri' is open, displaying a table of data.

Dosya	Düzen	Biçim	Görünüm	Yardım		
EB(GeV)	EMITTANCEX	EMITTANCEY	SIZEx(m)	SIZEy(m)	DIVx(rad)	DIVy(rad)
3.000e+00	5.882e-09	1.765e-11	3.757e-04	1.012e-05	1.566e-05	1.744e-06
betax	alphax	betay	alphy	eta	deta	E_spread
2.400e+01	0.000e+00	5.800e+00	0.000e+00	0.000e+00	0.000e+00	1.100e-03
Ibeam(A)	period(cm)	#periods	Kx	Ky		
1.000e-01	3.200e+00	140	0.000e+00	7.800e-01		
thetax(rad)	thetay(rad)					
0.000e+00	0.000e+00					
Energy	F. Density	Brilliance	PL	PC	PL45	1- PL
eV	ph/s/mr^2/0.1%	F. Dens/mm^2	-	-	-	-
1.00000e+04	1.984e+13	8.036e+14	9.954295e-01	0.000000e+00	6.902171e-17	4.570466e-03
1.00300e+04	1.349e+13	5.465e+14	9.916808e-01	0.000000e+00	2.546893e-17	8.319232e-03
1.00600e+04	2.339e+13	9.473e+14	9.941051e-01	0.000000e+00	-4.728363e-17	5.894853e-03
1.00900e+04	6.996e+13	2.834e+15	9.976240e-01	0.000000e+00	-4.298187e-17	2.375973e-03
1.01200e+04	1.947e+14	7.890e+15	9.990007e-01	0.000000e+00	-2.717482e-17	9.993031e-04
1.01500e+04	4.926e+14	1.996e+16	9.995593e-01	0.000000e+00	-1.573422e-17	4.407085e-04
1.01800e+04	1.250e+15	5.064e+16	9.998242e-01	0.000000e+00	-7.684800e-18	1.758462e-04
1.01950e+04	1.972e+15	7.993e+16	9.998962e-01	0.000000e+00	-4.895000e-18	1.038309e-04
1.02100e+04	2.831e+15	1.147e+17	9.999390e-01	0.000000e+00	-3.048319e-18	6.103822e-05
1.02400e+04	2.983e+15	1.209e+17	9.999750e-01	0.000000e+00	-1.330638e-18	2.496299e-05
1.02550e+04	1.934e+15	7.840e+16	9.999817e-01	0.000000e+00	-9.807409e-19	1.825542e-05
1.02700e+04	9.025e+14	3.658e+16	9.999847e-01	0.000000e+00	-8.056118e-19	1.531065e-05
1.03000e+04	9.927e+13	4.024e+15	9.999747e-01	0.000000e+00	-1.088370e-18	2.526388e-05
1.03300e+04	2.230e+13	9.039e+14	9.999432e-01	0.000000e+00	-2.071514e-18	5.675423e-05



Betatron amplitude functions [m] versus distance [m]



Dispersion functions [m] versus distance [m]



Depolama halkasında



32 adet eğici magnet



4.4 metrelik 14 adet magnetsiz bölge

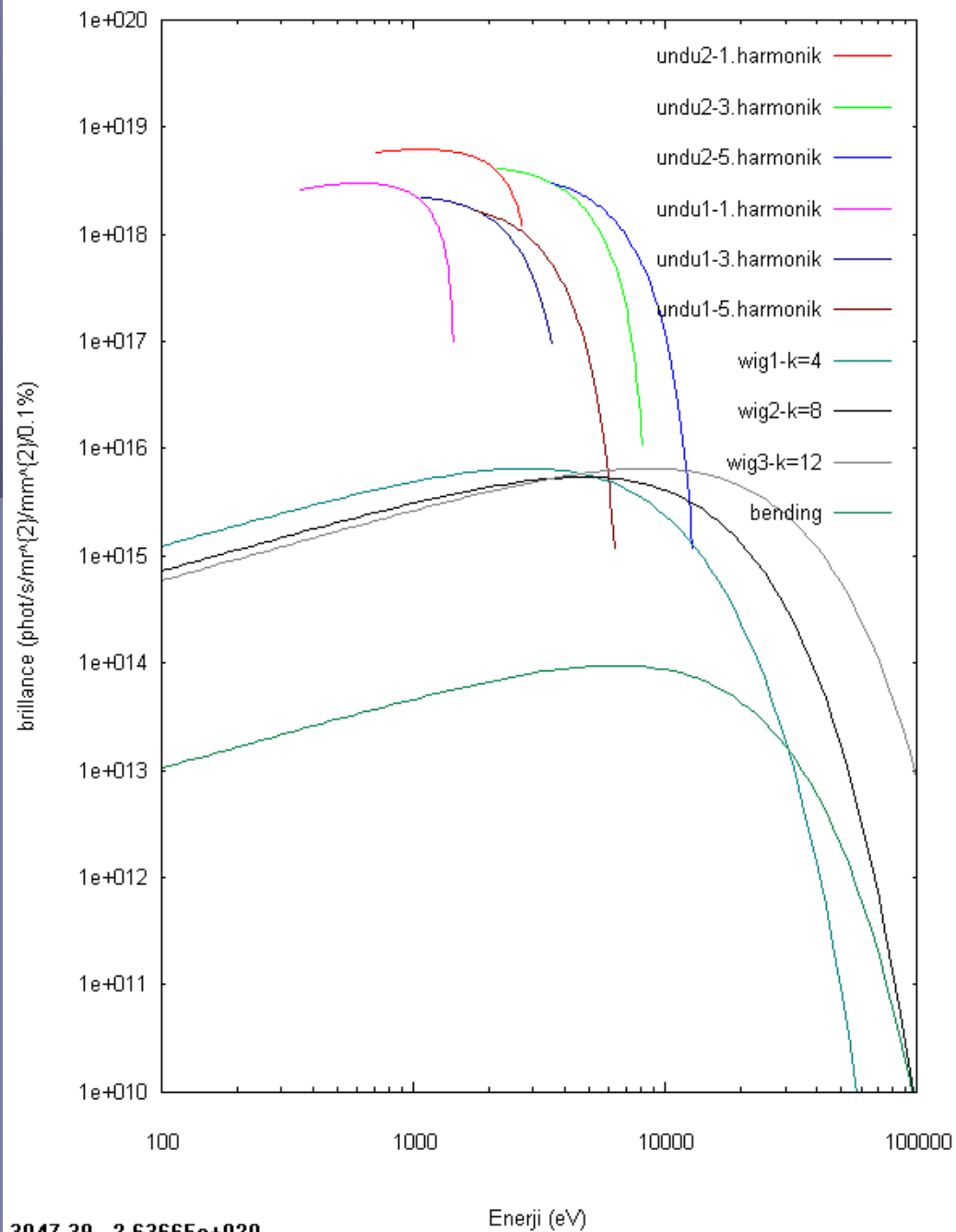
Elektron demeti parametreleri

Enerji (GeV)	3.56
I_{ortalama} (mA)	400
Emittans (nm rad)	8
Betax/Betay (m)	2.5/2.5
D_x/D_y	0.22

Işınım kaynağı parametreleri

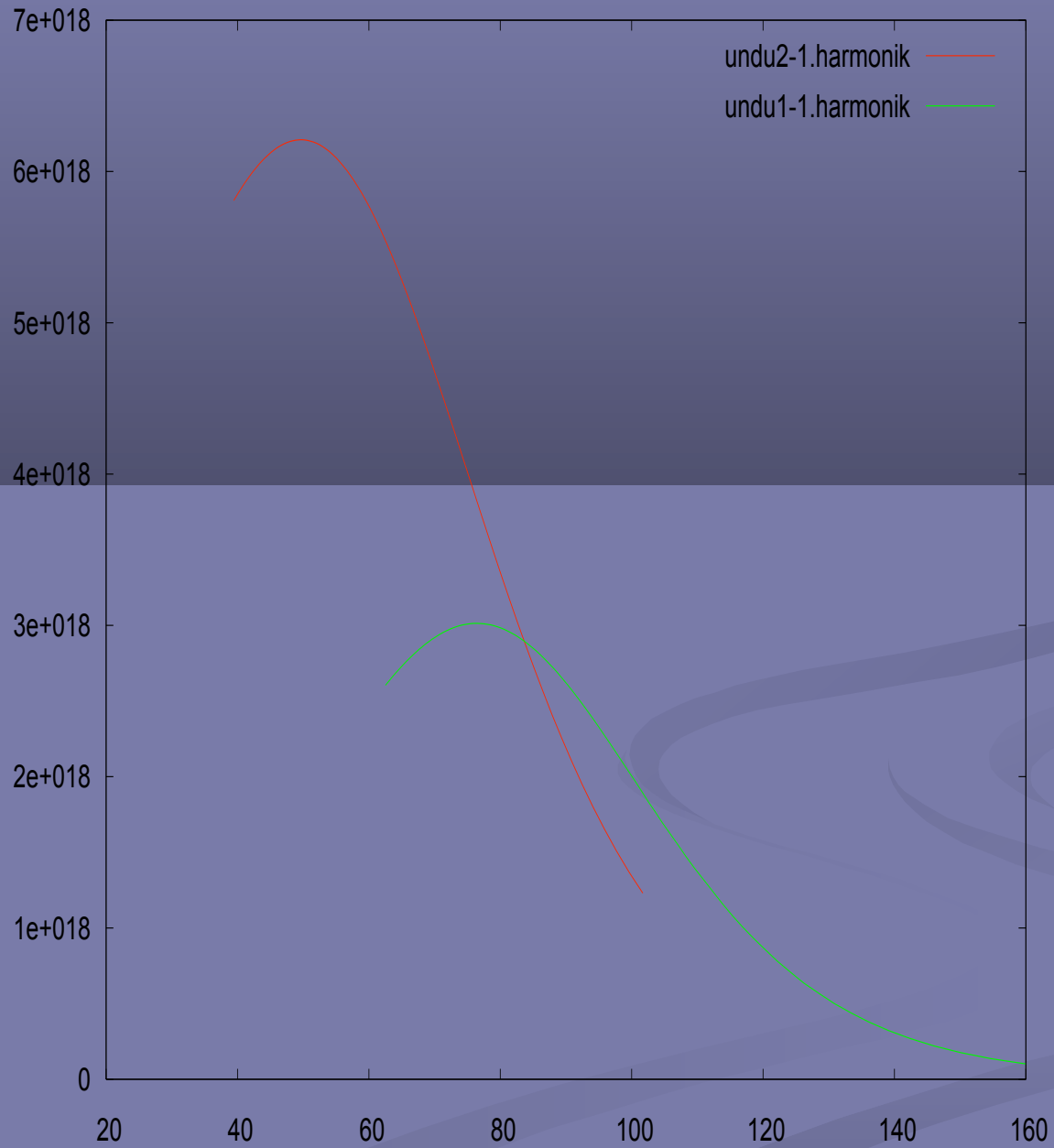
Işınım kaynağı	Wiggler1	Undulator1	Undulator2
Periyot uzunluğu (cm)	10	8	4
Periyot sayısı	35	45	75
Manyetik alan (T)	0.42	0.16	0.32
K değeri	4	1.2	1.2

Wiggler2 için **K=8** ve wiggler3 için **K=12**



3047.39, 2.63665e+020

Enerji (eV)



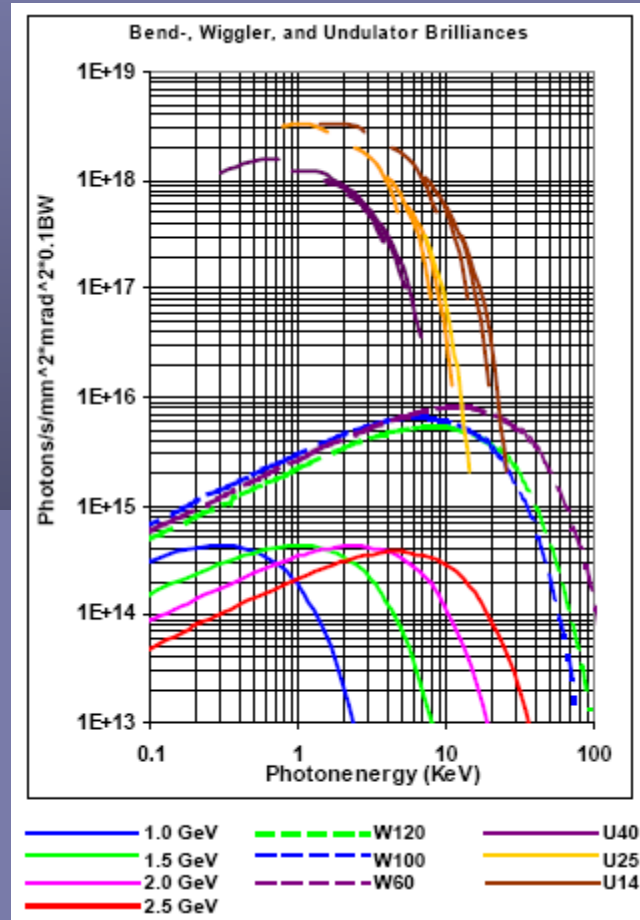
	$E_{1,\text{pik}}$ (eV)	$E_{3,\text{pik}}$ (eV)	Brilliance _{1,pik}	Flux _{1,pik} Foton/s/%1 BW	Total Power (kW)
Undulator1	836	2525	$2.6 \cdot 10^{18}$	$8 \cdot 10^{14}$	0.29
Undulator2	1679	5029	$5.5 \cdot 10^{18}$	$1.4 \cdot 10^{15}$	0.96



Hesaplanan ışınım parametreleri



	E_c (eV)	Total Power (kW)
Wigler1	3489	2.0
Wigler1	5816	5.5
Wigler1	10469	18.0

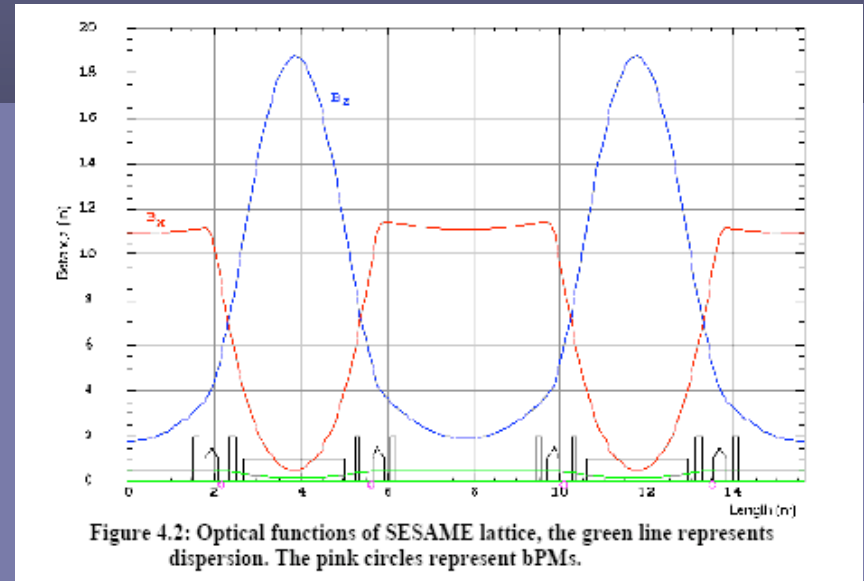


SESAME'de elde edilecek foton parlaklık Spektrumu

UYGULAMA

Table 4.2: SESAME storage ring parameters (without insertion devices).

Parameter	Unit	Value
General Parameters		
Energy	GeV	2.5
Maximum Beam current	mA	400
Circumference	m	124.802
Natural emittance	nm.rad	24.9
Coupling	%	1
Horizontal emittance	nm.rad	24.65
Vertical emittance	nm.rad	0.2465
Horizontal tune		7.217
Vertical tune		5.192
Relative energy spread	%	0.1119
Chromaticity (horizontal)		-13.1
Chromaticity (vertical)		-13.8
Machine Functions		
Horizontal beta functions		
Wiggler / bending / undulator	m/rad	11.12 / 0.483 / 10.9
Vertical beta functions		
Wiggler / bending / undulator	m/rad	1.89 / 18.75 / 1.73
Dispersion function		
Wiggler / bending / undulator	m	0.453 / 0.135 / 0.534
Beam Sizes and Cross Sections		
Horizontal beam size		
Wiggler / bending / undulator	μm	728.6 / 186.3 / 790.9
Vertical beam size		
Wiggler / bending / undulator	μm	21.6 / 68 / 20.6
Beam area		
Wiggler / bending / undulator	mm^2	0.099 / 0.0796 / 0.102
R.F-System (2nd stage)		
Energy loss per turn	keV	580
R.F-power	kW	413
Cavity Shunt impedance	$\text{M}\Omega$	3.4
R.F-cavity voltage	kV	487



- **Uygulama 1.** SESAME’de Eđici magnetlerden elde edilen ışınımın parlaklık spektrumunu 1.5, 2.0, 2.5 GeV elektron enerjileri için bulalım.

Eđici magnetin eđrilik yarıçapı: 5.9565 m

uzunluđu : 2.34 m

2.5 GeV’de B : 1.4 T

$$B(T)\rho(m) = E(\text{GeV})/0.2998$$

Uygulama 2. SESAME’de zigzaglayıcılardan elde edilen ışının parlaklık spektrumunu çizdiriniz.

Table 2.1: Data’s of the wigglers foreseen at SESAME.

Type	B_0	λ_w	N_w	L	K	X_0	X'
W-100	2.0 T	100 mm	24	2.4 m	18.7	0.061 mm	3.8 mrad
W-120	2.5 T	120 mm	20	2.4 m	28.0	0.109 mm	5.7 mrad
W-60	3.5 T	60 mm	30	1.8 m	19.6	0.038 mm	4.0 mrad

Uygulama 3. SESAME’de aşağıda parametreleri verilen salındırıcılarından elde edilecek ışının Parlaklık spektrumlarını çizdiriniz.

$\lambda = 14$ mm, $k = 1-2$, $L = 1.4$ m, $\text{coupling} = \%2$

$\lambda = 11$ mm, $k = 1.4-2.8$, $L = 2.4$ m, $\text{coupling} = \%2$

Kaynaklar

- *Takasha TANAKA Cheiron 2011: Light Source I*
- Sarah Cousineau, Jeff Holmes, Yan Zhang, USPAS, January, 2011
- SESAME web sitesi, Yellow Book