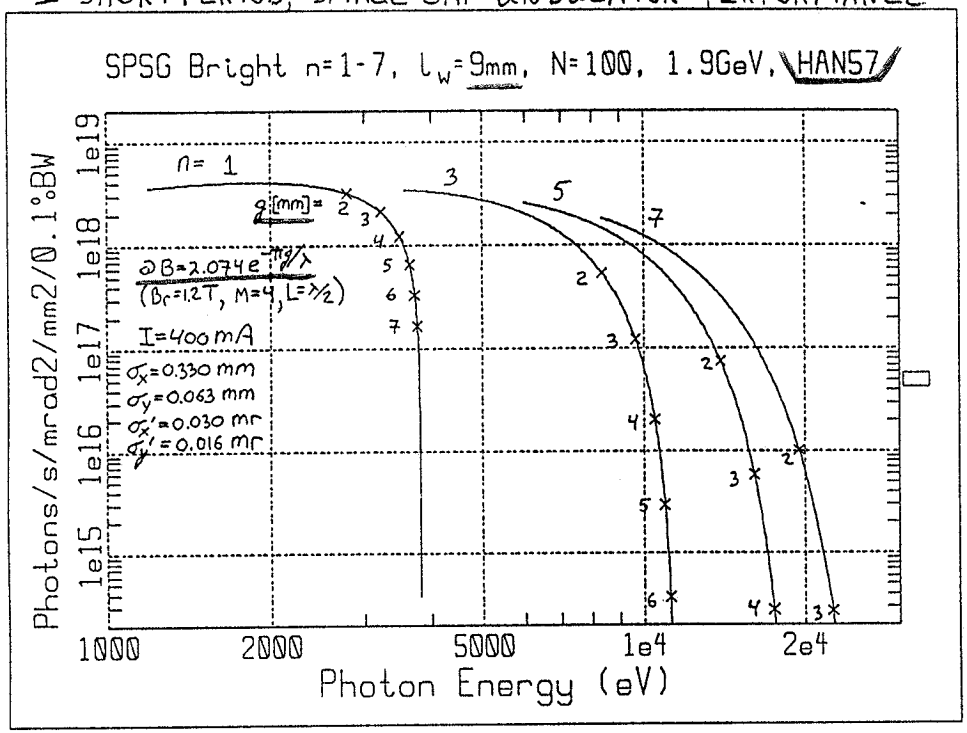
17TH ADVANCED BEAM DYNAMICS WORKSHOP ON
FUTURE LIGHT SOURCES

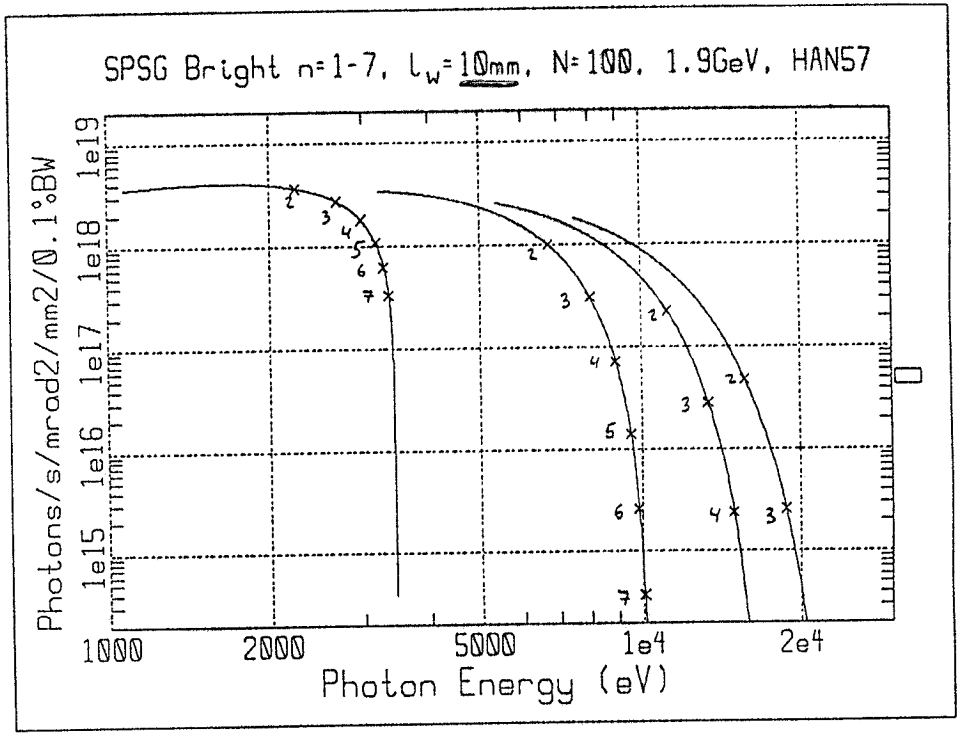
Planning of Small Gap Insertion Devices at the ALS

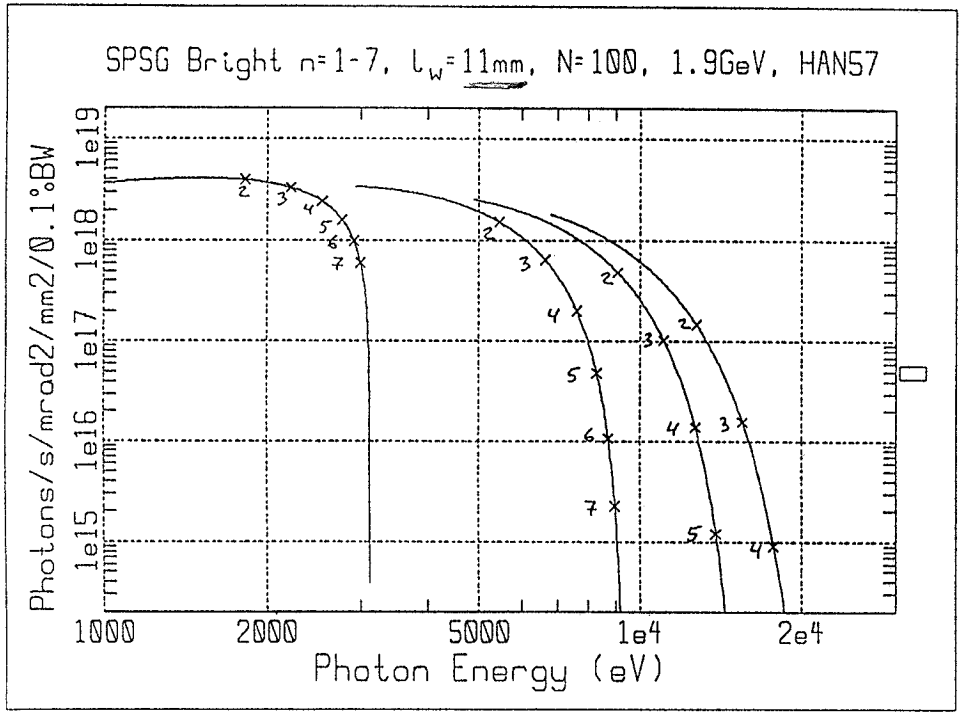
R. Schlueter, E. Hoyer, S. Marks, H. Padmore, D. Plate,
H. Nishimura, D. Robin, H. Zyngier, ALS

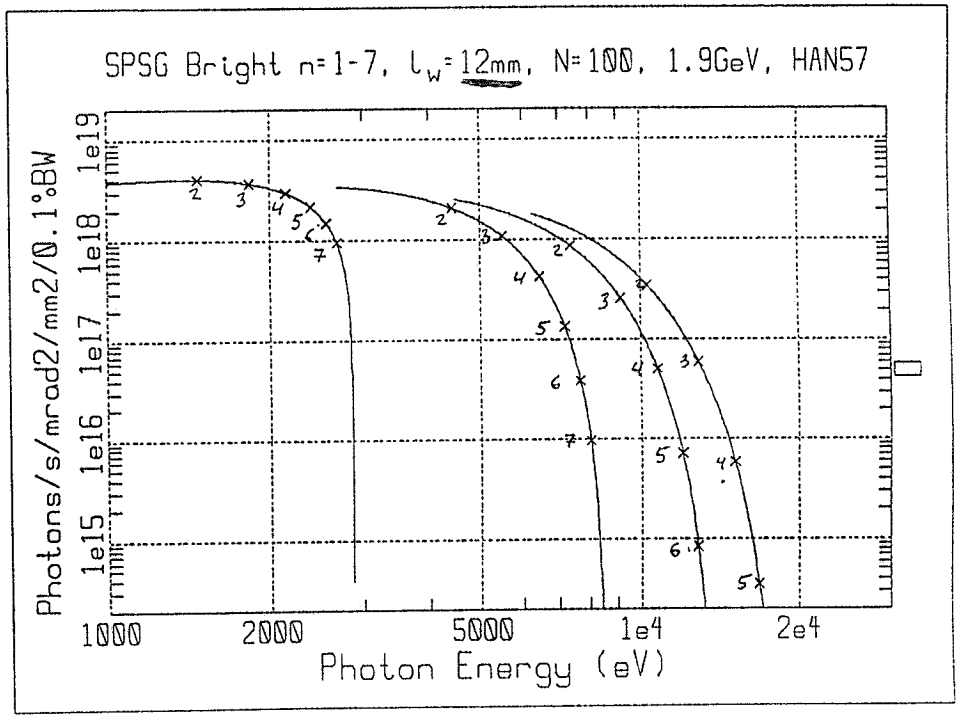
APRIL 6-9, 1999
ARGONNE NATIONAL LABORATORY, ARGONNE, IL U.S.A.

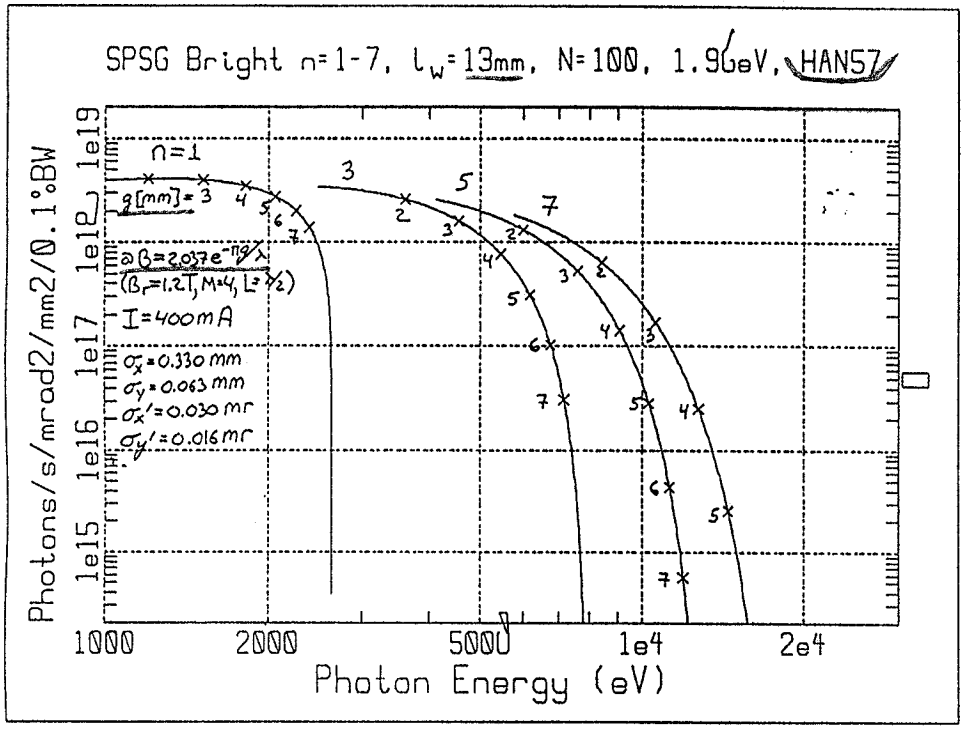
1 SHORT-PERIOD, SMALL GAP UNDULATOR PERFORMANCE

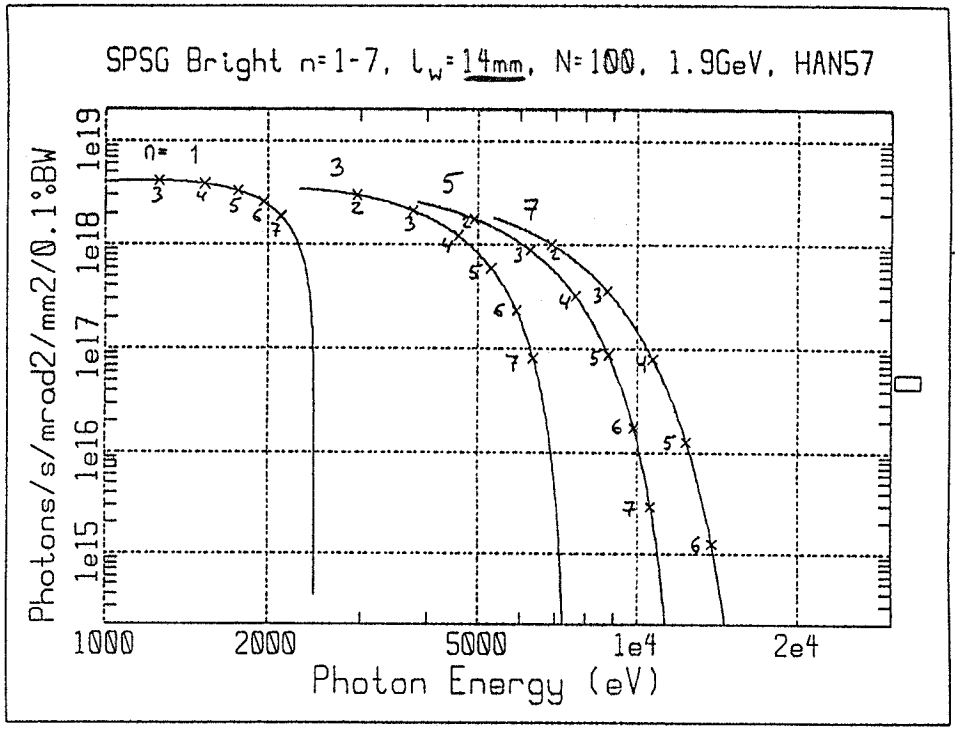


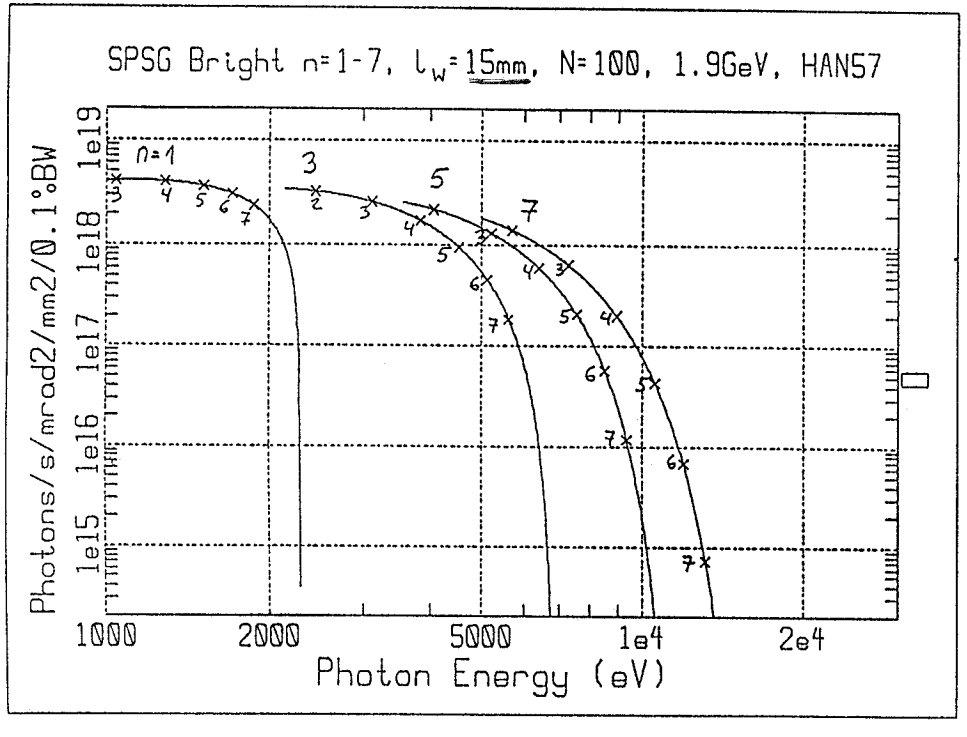


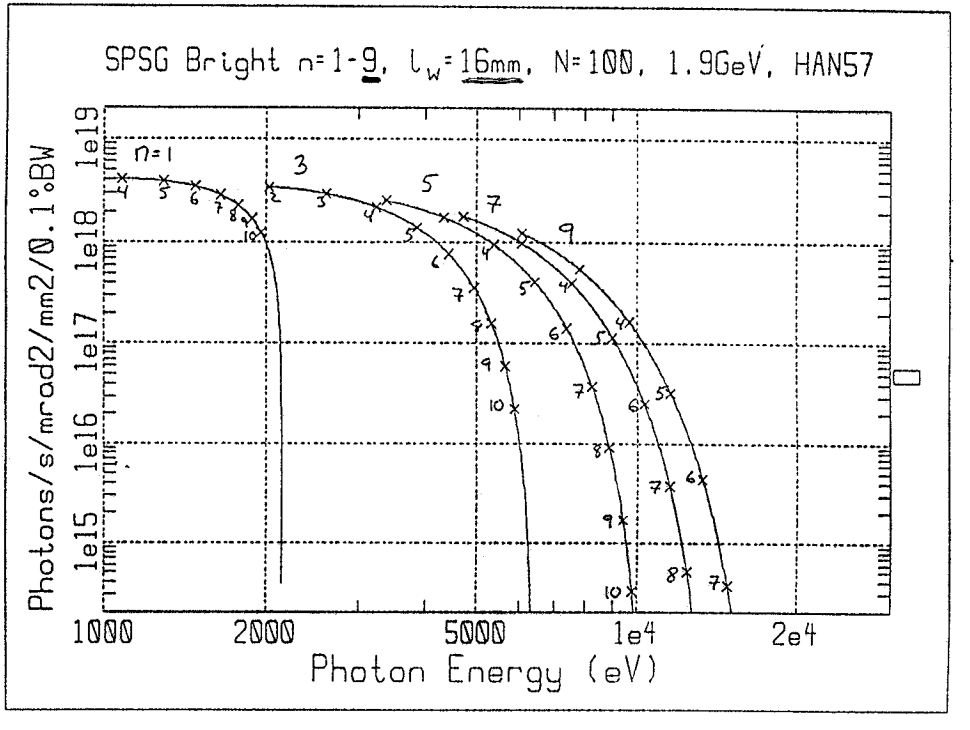


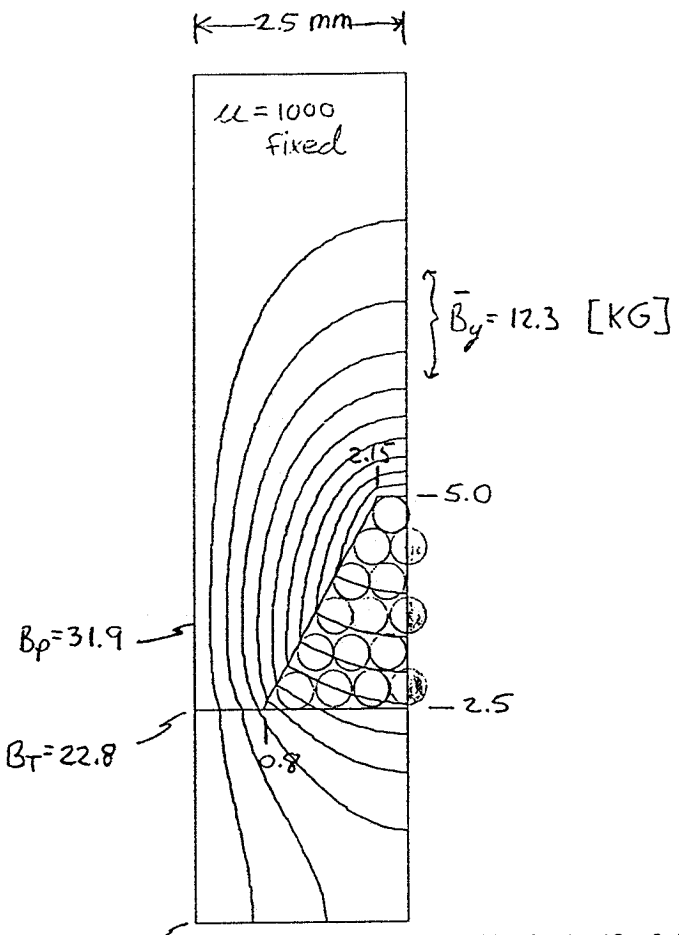



SPSG Bright n=1-7, l_w=13mm, N=100, 1.9GeV, HAN57
n=1
g[mm]=3
σ_x=0.330 mm
σ_y=0.063 mm
σ_x'=0.030 mr
σ_y'=0.016 mr
I=400mA
Photons/s/mrad2/mm2/0.1%BW
Photon Energy (eV)

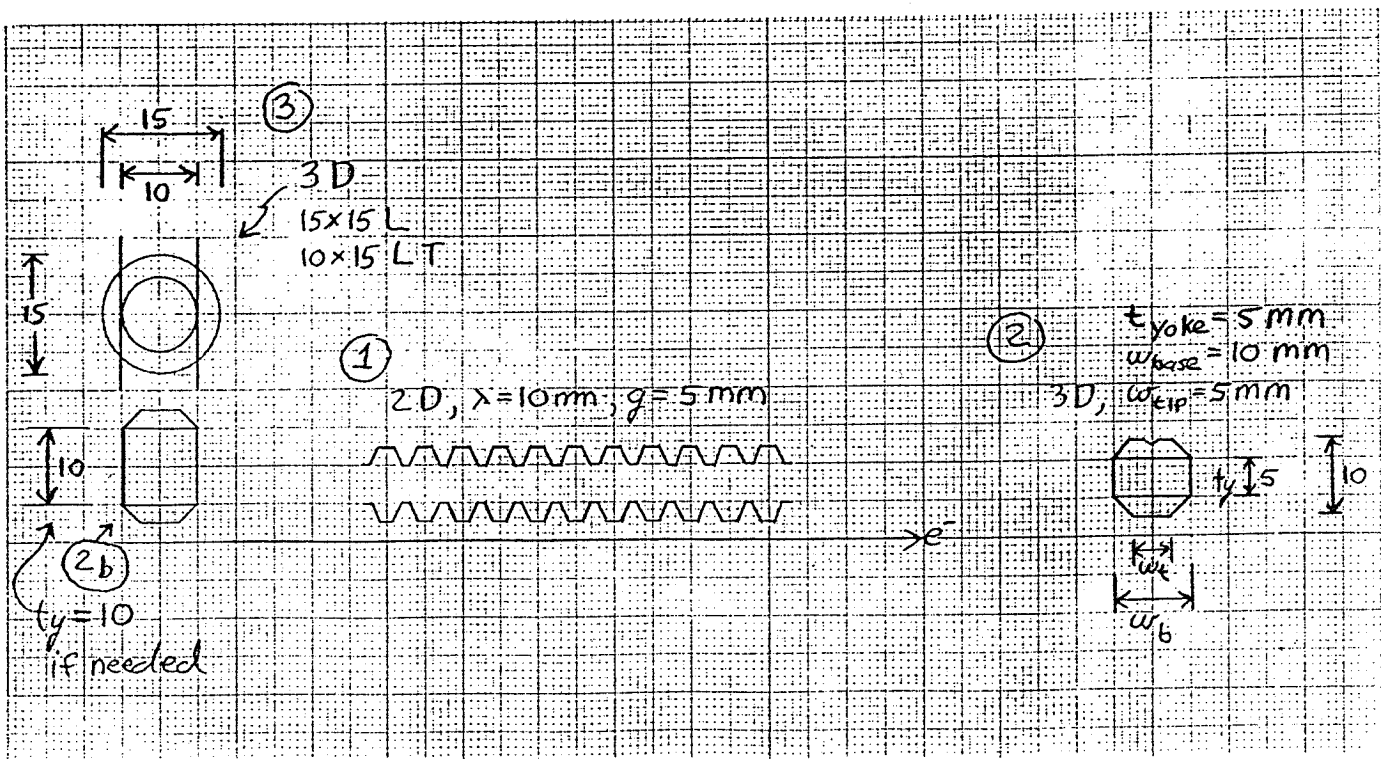

SPSG Bright n=1-7, l_w=14mm, N=100, 1.9GeV, HAN57
n=1
Photons/s/mrad2/mm2/0.1%BW
Photon Energy (eV)


SPSG Bright n=1-7, l_w=15mm, N=100, 1.9GeV, HAN57
n=1
Photons/s/mrad2/mm2/0.1%BW
Photon Energy (eV)


SPSG Bright n=1-9, l_w=16mm, N=100, 1.9GeV, HAN57
n=1
Photons/s/mrad2/mm2/0.1%BW
Photon Energy (eV)



I = 2700 A in 13½ turns of 200 A each (≈ 85% of quench)



(S. MARKS)

Bending\Magnet Brightness

$$\mathcal{B} = \frac{d^2\mathcal{J}}{d\theta d\psi} \Bigg/ 2\pi\left[\left(\sigma_x^2 + D^2\sigma_\varepsilon^2 + \sigma_r^2\right)\left(\sigma_y^2 + \sigma_r^2 + \frac{\varepsilon_y^2 + \left(\gamma_y\sigma_r^2\right)^2}{\sigma_\psi^2}\right)\right]^{1/2}$$

Parameter values for all cases:

1.9 GeV, 0.4 A

$\varepsilon_x = 6.4\times10^{-9}$ m-rad, $\varepsilon_y = 1.9\times10^{-10}$ m-rad

At Bending Magnet - B2

Nominal parameter values:

$B_0 = 1.34$ T

$\beta_x = 0.855$ m, $\beta_y = 1.458$ m

$D = 0.120$ m, $\gamma_y = 0.694$ m^{-1}

B_0 [T]	β_x [m]	β_y [m]	$\mathcal{B}$ @10 KeV	$\mathcal{B}$ @15 KeV	$\mathcal{B}$ @20 KeV
1.34	0.855	1.458	7.29×10^{14}	2.25×10^{14}	6.24×10^{13}
2.00	0.855	1.458	1.42×10^{15}	7.22×10^{14}	3.33×10^{14}
3.00	0.855	1.458	1.98×10^{15}	1.42×10^{15}	9.17×10^{14}
3.00	0.855	1.00	2.39×10^{15}	1.71×10^{15}	1.11×10^{15}
3.00	0.855	0.50	3.38×10^{15}	2.42×10^{15}	1.57×10^{15}
3.00	0.855	0.20	5.35×10^{15}	3.82×10^{15}	2.48×10^{15}
3.00	0.20	0.20	6.33×10^{15}	4.52×10^{15}	2.93×10^{15}
4.50	0.20	0.20	7.12×10^{15}	6.33×10^{15}	5.13×10^{15}

At Insertion Straight

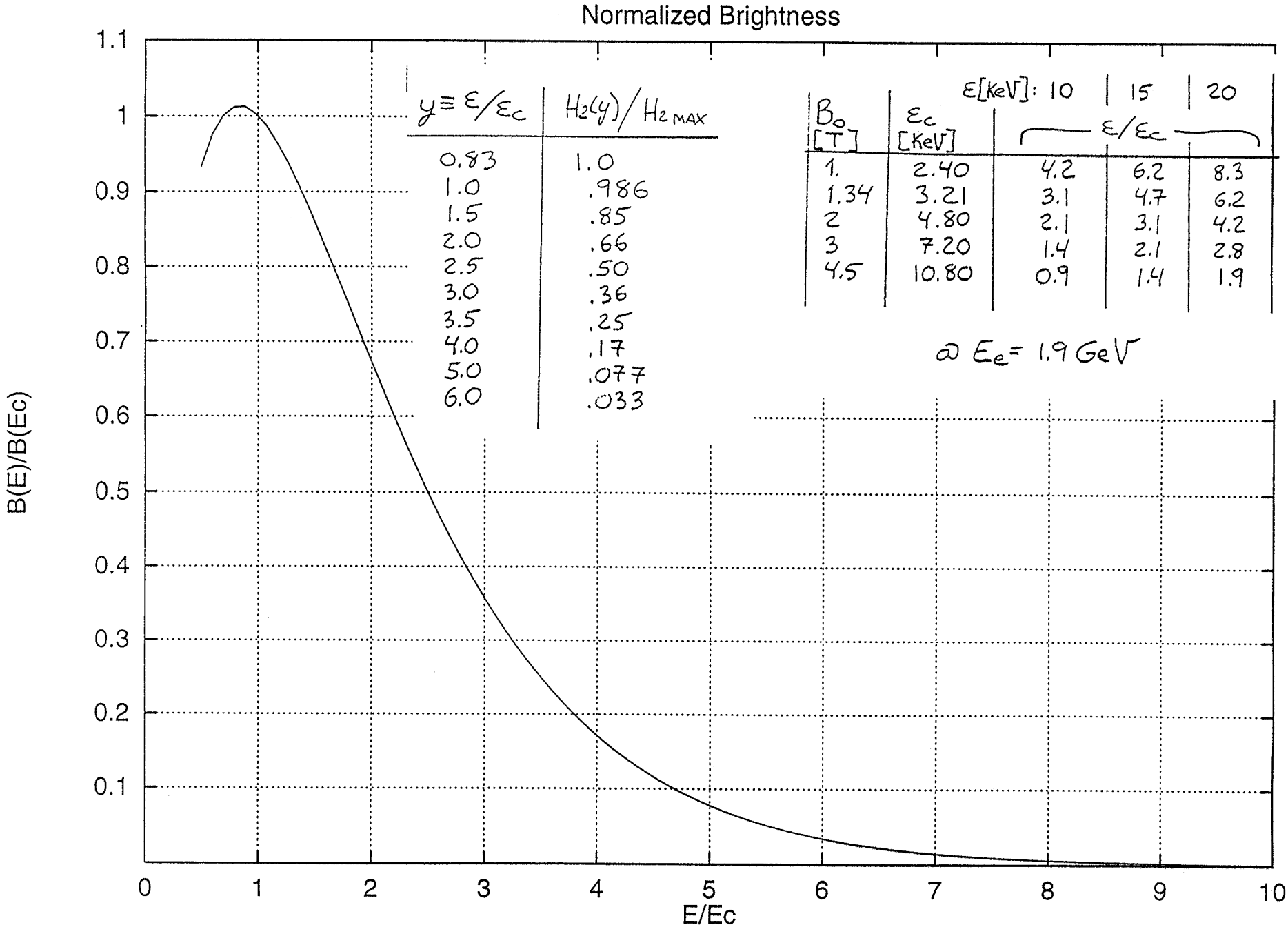
Nominal parameter values:

$B_0 = ?$

$\beta_x = 11.209$ m, $\beta_y = 4.226$ m

$D = 0.0$ m, $\gamma_y = 0.237$ m^{-1}

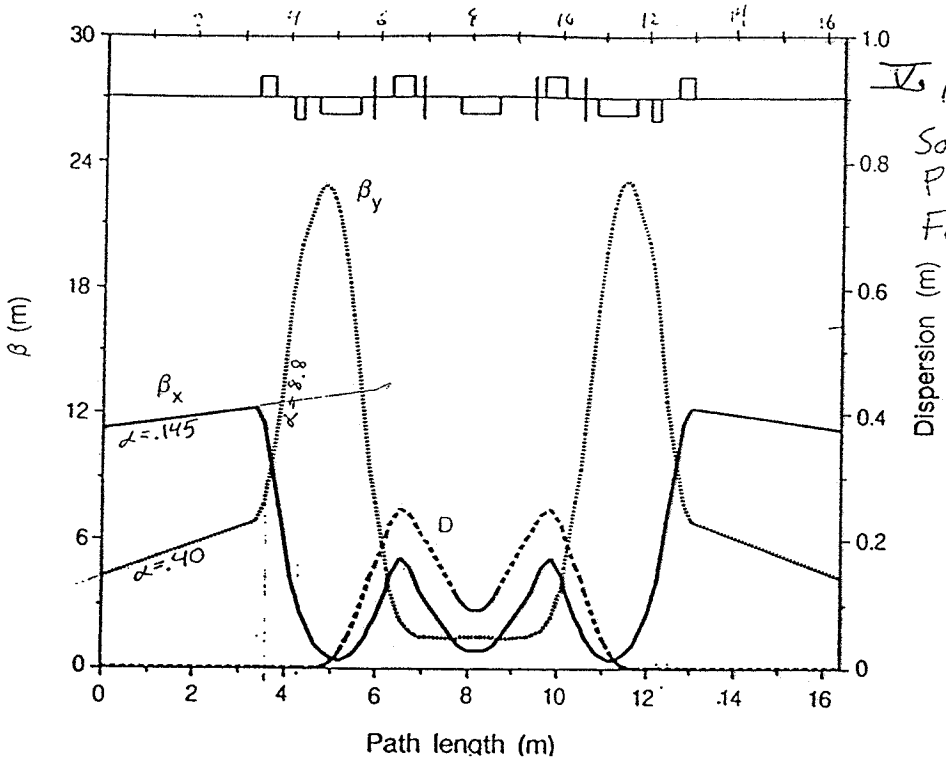
B_0 [T]	β_x [m]	β_y [m]	$\mathcal{B}$ @10 KeV	$\mathcal{B}$ @15 KeV	$\mathcal{B}$ @20 KeV
2.00	11.209	4.226	3.75×10^{14}	1.91×10^{14}	8.83×10^{13}
2.00	5.00	2.00	8.17×10^{14}	4.17×10^{14}	1.92×10^{14}
2.00	1.00	1.00	2.58×10^{15}	1.32×10^{15}	6.07×10^{14}
2.00	0.20	0.20	1.29×10^{16}	6.59×10^{15}	3.04×10^{15}
3.00	0.20	0.20	1.81×10^{16}	1.29×10^{16}	8.37×10^{15}
4.50	0.20	0.20	2.03×10^{16}	1.81×10^{16}	1.47×10^{16}



$y \equiv \varepsilon/\varepsilon_c$	$H_2(y)/H_{2\,MAX}$
0.83	1.0
1.0	.986
1.5	.85
2.0	.66
2.5	.50
3.0	.36
3.5	.25
4.0	.17
5.0	.077
6.0	.033

B_o [T]	ε_c [KeV]	ε[KeV]: 10	15	20
		$\varepsilon/\varepsilon_c$		
1.	2.40	4.2	6.2	8.3
1.34	3.21	3.1	4.7	6.2
2	4.80	2.1	3.1	4.2
3	7.20	1.4	2.1	2.8
4.5	10.80	0.9	1.4	1.9

@ E_e = 1.9 GeV



β_x, β_y Source Placement Focusing

$$\sigma = \sqrt{\varepsilon\beta} \; ; \; \sigma' = \sqrt{\varepsilon\gamma} \; ; \quad \gamma = \frac{1+\alpha^2}{\beta} \; ; \quad \alpha = -\frac{1}{2}\frac{d\beta}{ds}$$

① β_x in bend @ $\varepsilon_x = 6.4\cdot10^{-9}$, $\beta_x = .855m \Rightarrow \sigma_x = 74\mu$

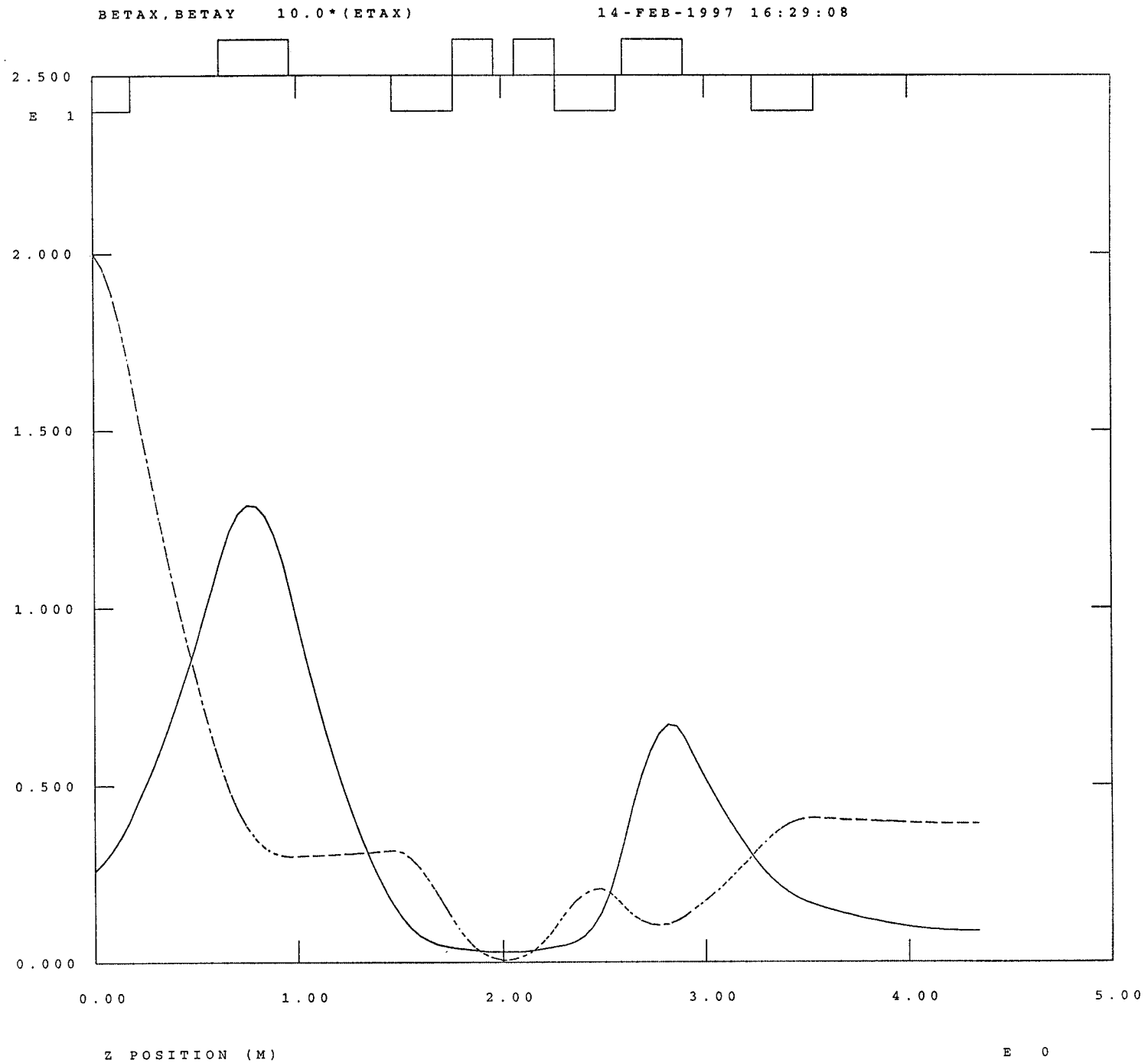
@ $D = .12m$, $\sigma_\varepsilon = 8\cdot10^{-4} \Rightarrow D\sigma_\varepsilon = 96\mu$

$\therefore$ No point in reducing β_x in center bend; just look for opportunity in D=0 section

② β_y: $\theta_{ph} \approx 1/\gamma = 269\mu rad$ @ 1.9GeV; it would pay off to reduce β_y such that $\sigma_{y'} \approx \theta_{ph} \Rightarrow$ @ $\varepsilon_y = 1.9\cdot10^{-10}$ $\beta_y^* = .00263\,m$

@ $\varepsilon_y = 1.9\cdot10^{-10}$ + $\alpha \approx 0$:

	1D	OUTER BEND	CENTER BEND					
β_y^*	4.2256	22	1.45	1	0.1	0.01	0.00263	[m]
$\sigma_{y'}$	6.7	2.9	11.4	13.8	44	138	269	[μrad]
σ_y	28.3	64.6	16.6	13.8	4.36	1.38	0.707	[μm]


BETAX,BETAY 10.0*(ETAX) 14-FEB-1997 16:29:08
2.500
E 1
2.000
1.500
1.000
0.500
0.000
0.00
1.00
2.00
3.00
4.00
5.00
Z POSITION (M)
E 0

```
TITLE &
"MAD deck als-lb7
!
! DATE AND TIME:   14/02/97  16.20.18
!
! FILE:            LB7.MAD

!
PI: CONSTANT = 3.14159265359
TWOPI: CONSTANT = 6.28318530718
DEGRAD: CONSTANT = 57.295779513082
RADDEG: CONSTANT = 0.01745329252
E: CONSTANT = 2.718281828459
EMASS: CONSTANT = 0.51099906E-3
PMASS: CONSTANT = 0.93827231
CLIGHT: CONSTANT = 2.99792458E8
L1 := 0.259404526566
L2 := -0.368938944466
QDA: QUADRUPOLE, L=0.187, K1=-4.0
D2: DRIFT, L=0.4345
QFA: QUADRUPOLE, L=0.344, K1=5.8
DB1: DRIFT, L=0.5
QLB1: QUADRUPOLE, L=0.3, K1=-10.29974
DB2: DRIFT, L=1.0E-5
QLB2: QUADRUPOLE, L=0.2, K1=6.4656
DB3: DRIFT, L=1.0E-5
DW: DRIFT, L=0.05
QLB3: QUADRUPOLE, L=0.2, K1=4.0
DB4A: DRIFT, L=0.0
QLB4: QUADRUPOLE, L=0.3, K1=-16.848093803938
DB4: DRIFT, L=0.4+L2
QLB5: QUADRUPOLE, L=0.3, K1=12.172657974323
DB5: DRIFT, L=0.08+L1
QLB6: QUADRUPOLE, L=0.3, K1=-3.42573232
DB6: DRIFT, L=0.6987-L1-L2
LB: LINE=(QDA,D2,QFA,DB1,QLB1,DB2,QLB2,DB3,DW,DW,QLB3,DB4A,QLB4,DB4,QLB5,DB5,&
QLB6,DB6)
RETURN !
```

3/97

Issues re low β design:

* dynamic aperture $(25_x, 10_y) \rightarrow (10_x, 5_y)$
  hard to inject?

* β_x vs β_y tradeoff

* Δ between the 2 low-β sections

* Quad strengths / capabilities / r_i / spacing

* open gap? or always turned on?

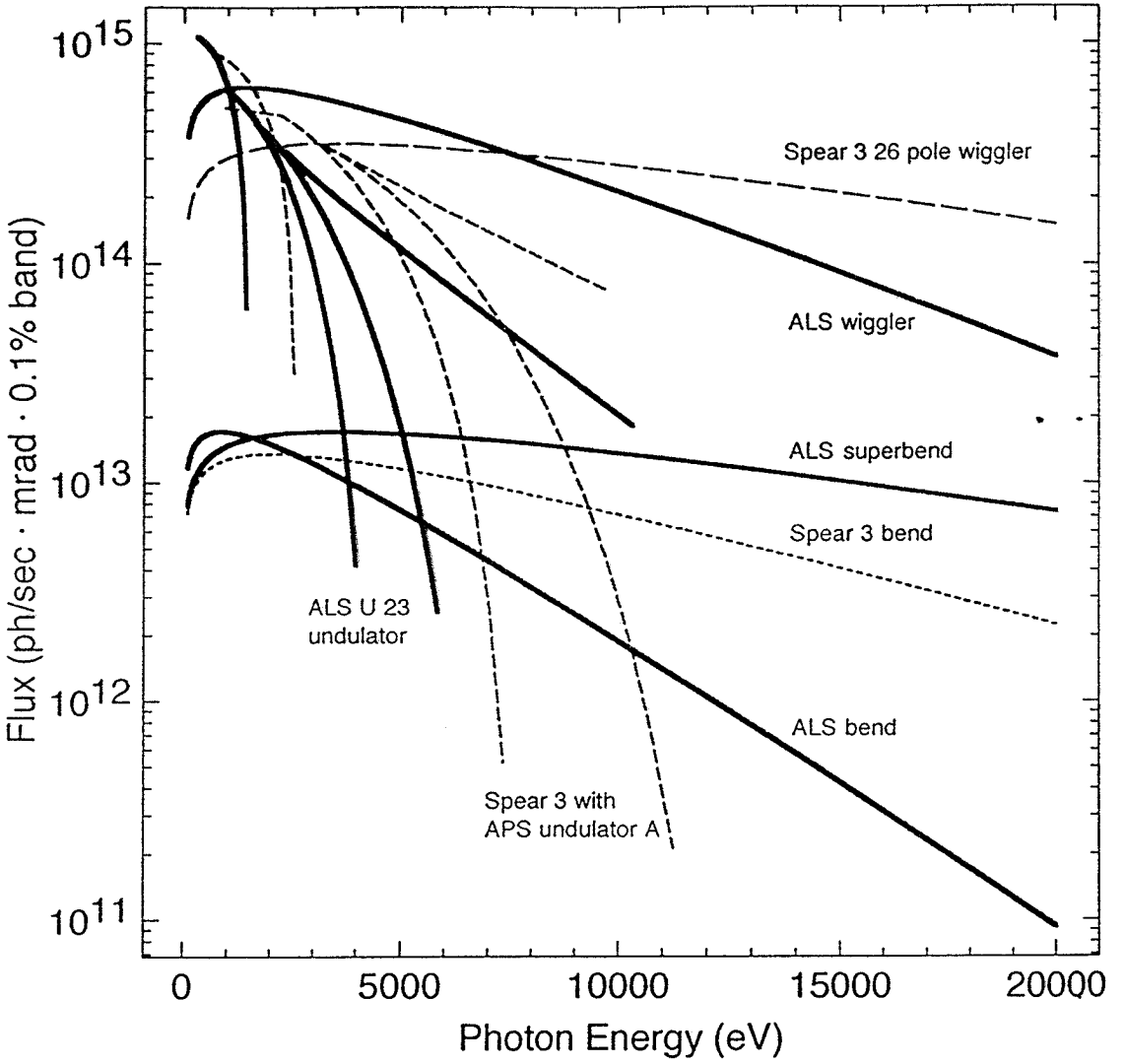


Fig. 9 Flux of ALS and SPEAR3 with additional sources

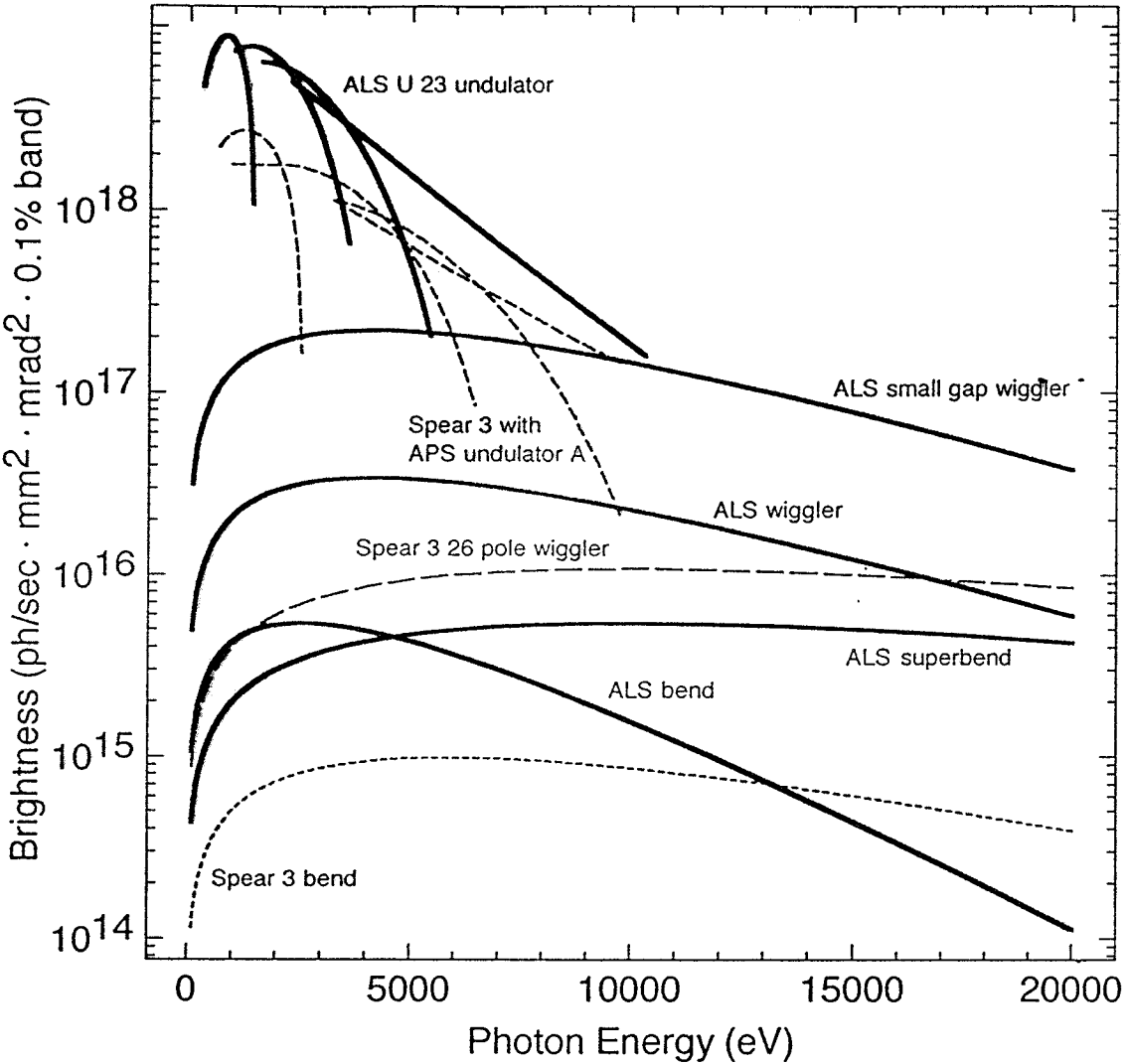


Fig. 10 Brightness of ALS and SPEAR3 with additional sources

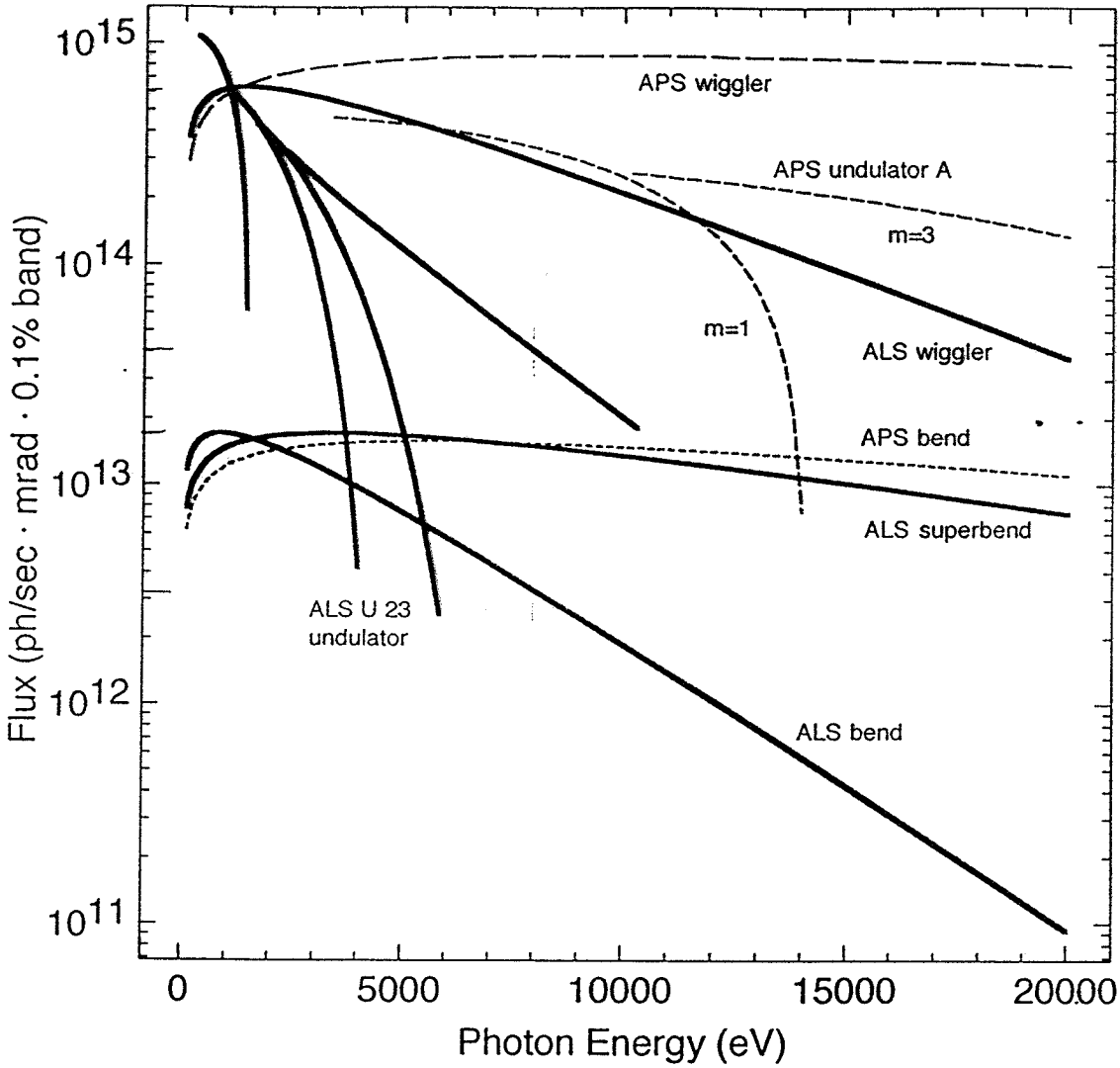


Fig. 11 Flux of the ALS with superbends, a small gap undulator and a small gap wiggler and of the APS

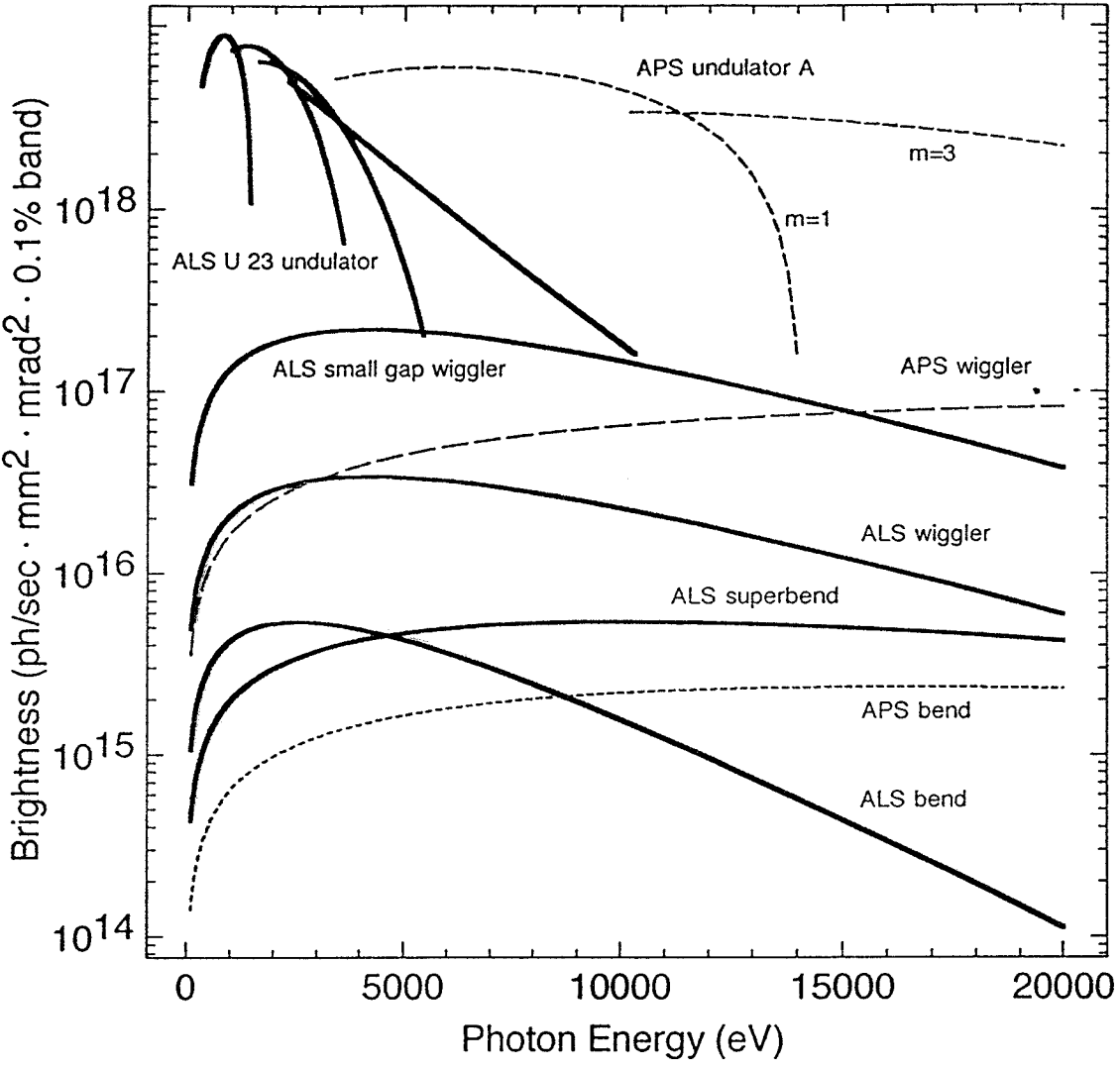


Fig. 12 Brightness of the ALS with superbends, a small gap undulator and a small gap wiggler and of the APS