『JLC実験をめざす測定器・加速器開発』

ビームと測定器

素粒子実験シンポジウム、2000年３月３１日

JLC-FFIR グループ，田内利明
http://acfahep.kek.jp/member/subg/ir.html for the members

0. JLC layout and beam parameter

1. Bem delivery system

2. IP layout

3. Support system for QC1 and tungsten mask

4. Background

4.1 muons

4.2 synchrotron radiations

4.3 e^+e^- pairs

4.4 neutron background

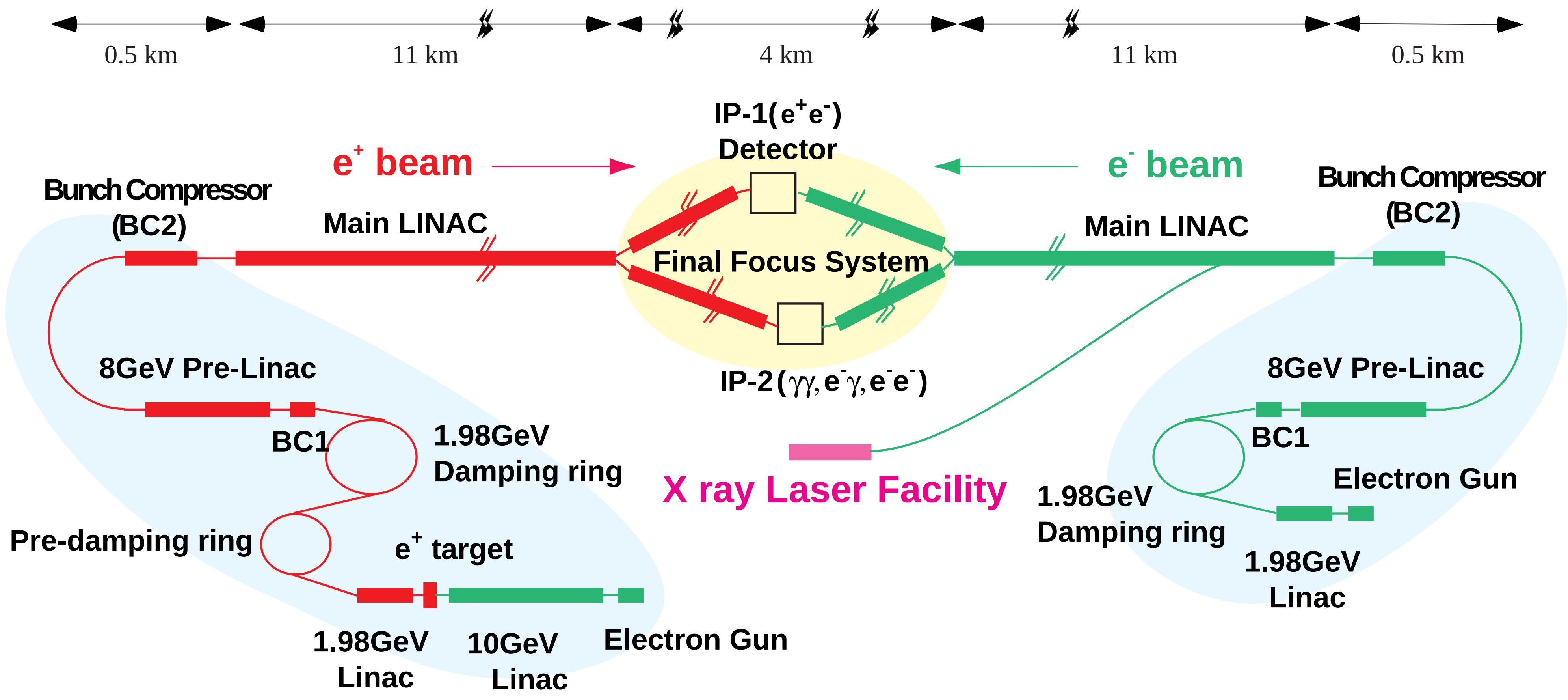
5. Pair monitor for beam size measurement

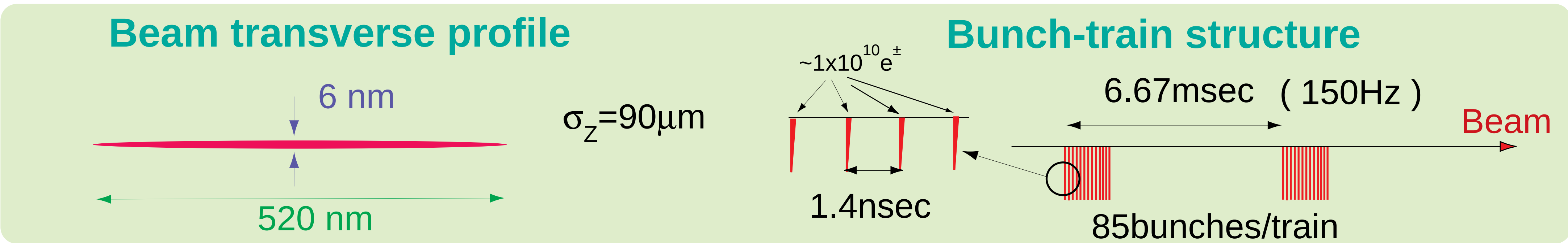
6. Luminosity monitor and Active mask

7. Dump line

8. Future Plan

Schematics of JLC accelerator complex

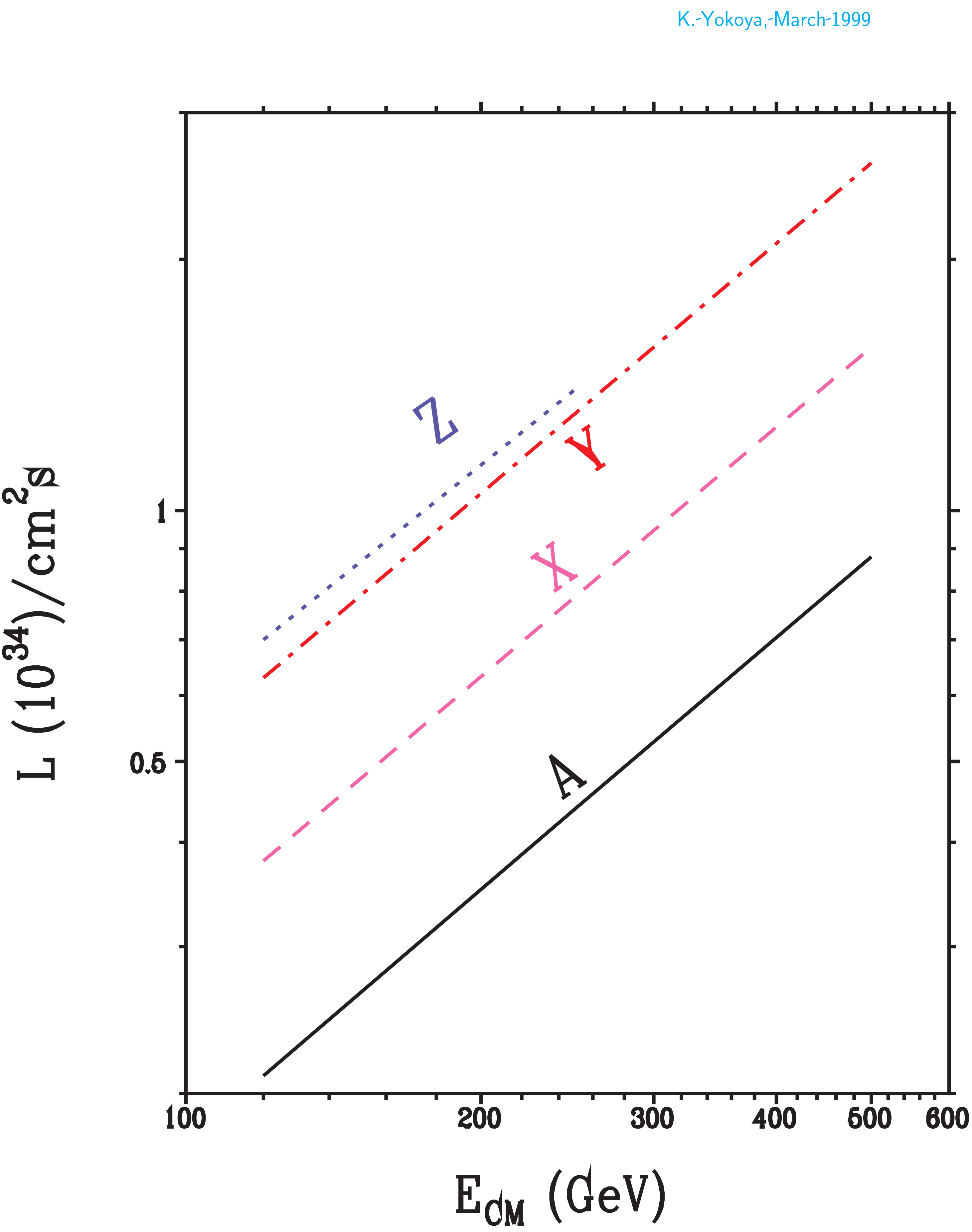




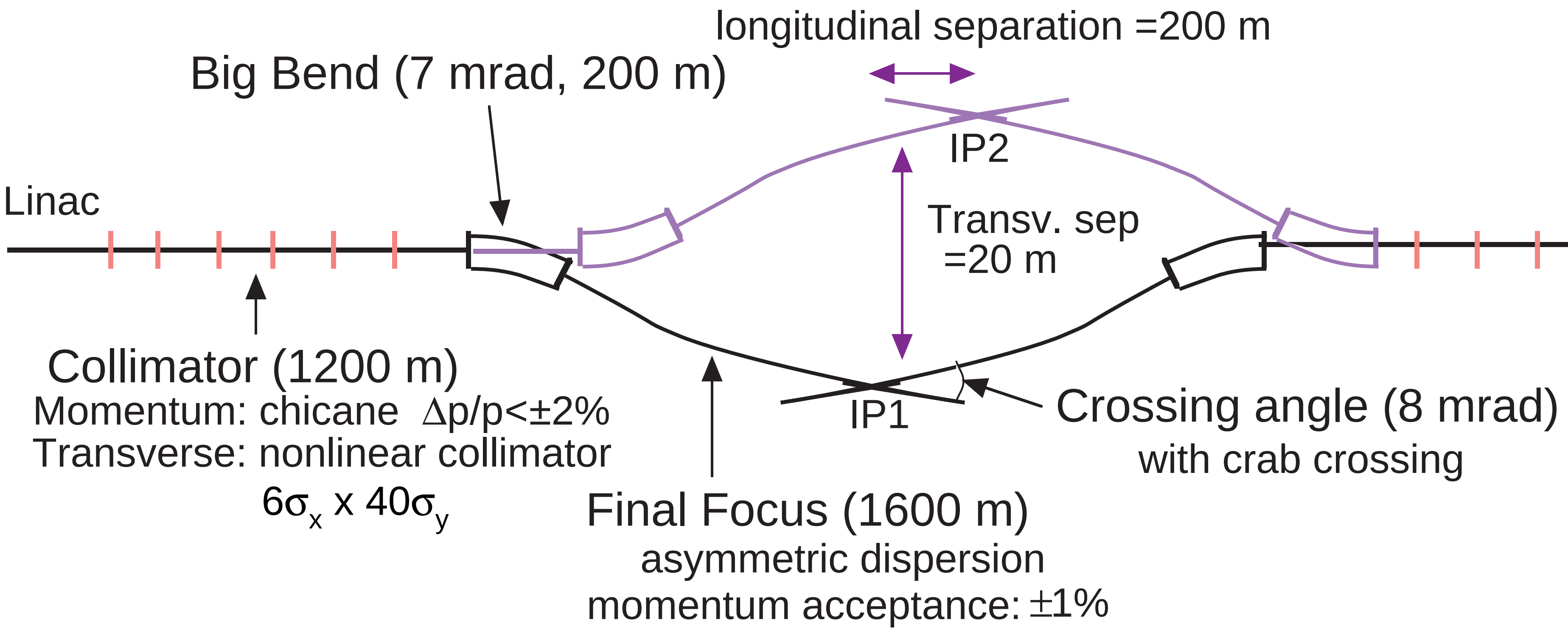
K. Yokoya, March 1999

500GeV (CM) Hi-Lum Parameters of JLC

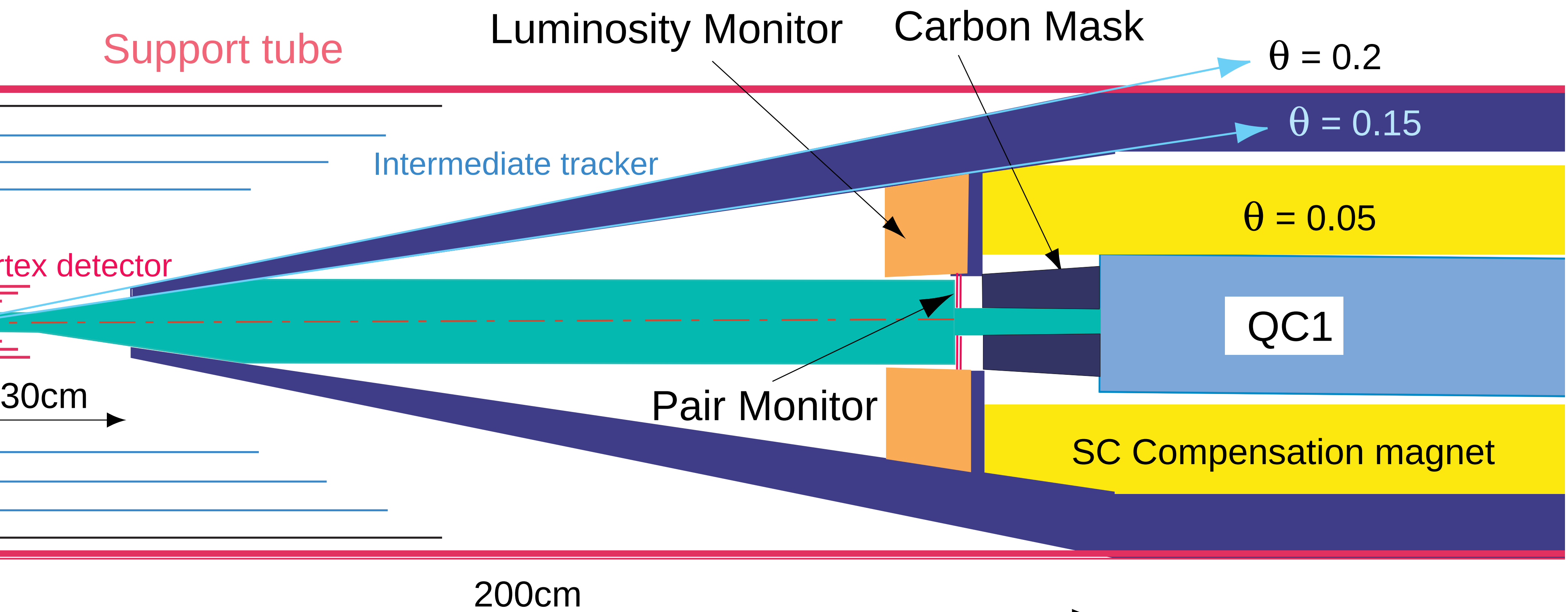
		A	X	Y
Luminosity	$10^{34}/cm^2 s$	0.88	1.57	2.61
Nominal Lum.[3)]	$10^{34}/cm^2 s$	0.63	1.08	1.75
Bunch Population	10^{10}	0.75	0.55	0.70
No. of bunches/pulse		95	190	190
Bunch separation	ns	2.8	1.4	1.4
Linac length/beam [7)]	km	5.21	5.54	5.97
AC power(2 linacs)	MW	117	126	136
Beam power/beam	MW	4.28	6.28	7.99
Loaded gradient [4)]	MV/m	57.6	54.2	50.2
Bunch length σ_z	μm	90	80	80
$\gamma\varepsilon_x$ (DR exit)	10^{-6} m	3	3	3
$\gamma\varepsilon_y$ (DR exit)	10^{-6} m	0.03	0.02	0.02
$\gamma\varepsilon_x$ (IP)	10^{-6} m	4	4	4
$\gamma\varepsilon_y$ (IP)	10^{-6} m	0.06	0.04	0.04
Cavity align. tol. [6)]	μm	15	18	14
β^*_x	mm	10	6	6
β^*_y	mm	0.1	0.1	0.1
IP beam size σ^*_x	nm	286	222	222
σ^*_y	nm	3.15	2.86	2.86
Diagonal angle σ^*_x/σ_z	mrad	3.18	2.77	2.77
Disruption param D_x		0.094	0.102	0.130
D_y		7.64	7.89	10.04
Pinch enh. H_D [5)]		1.38	1.45	1.49
Υ_{ave}		0.136	0.146	0.188
δ_{BS}	%	4.42	4.39	6.67
n_γ		1.07	1.01	1.28



K.-Yokoya,-March-1999
L (10^34)/cm^2 s
1
0.5
Z
Y
X
A
100
200
300
400
500
600
E_CM (GeV)



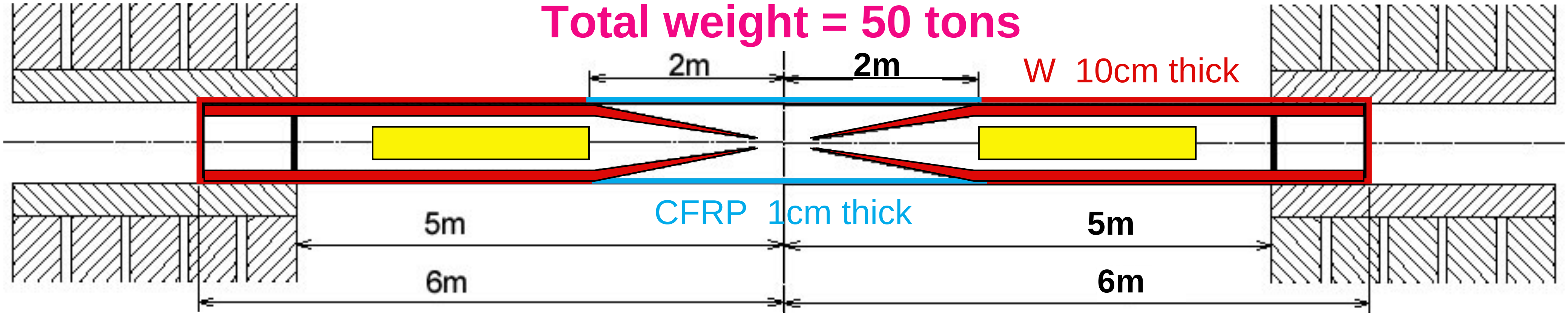
JLC: Beam Delivery System



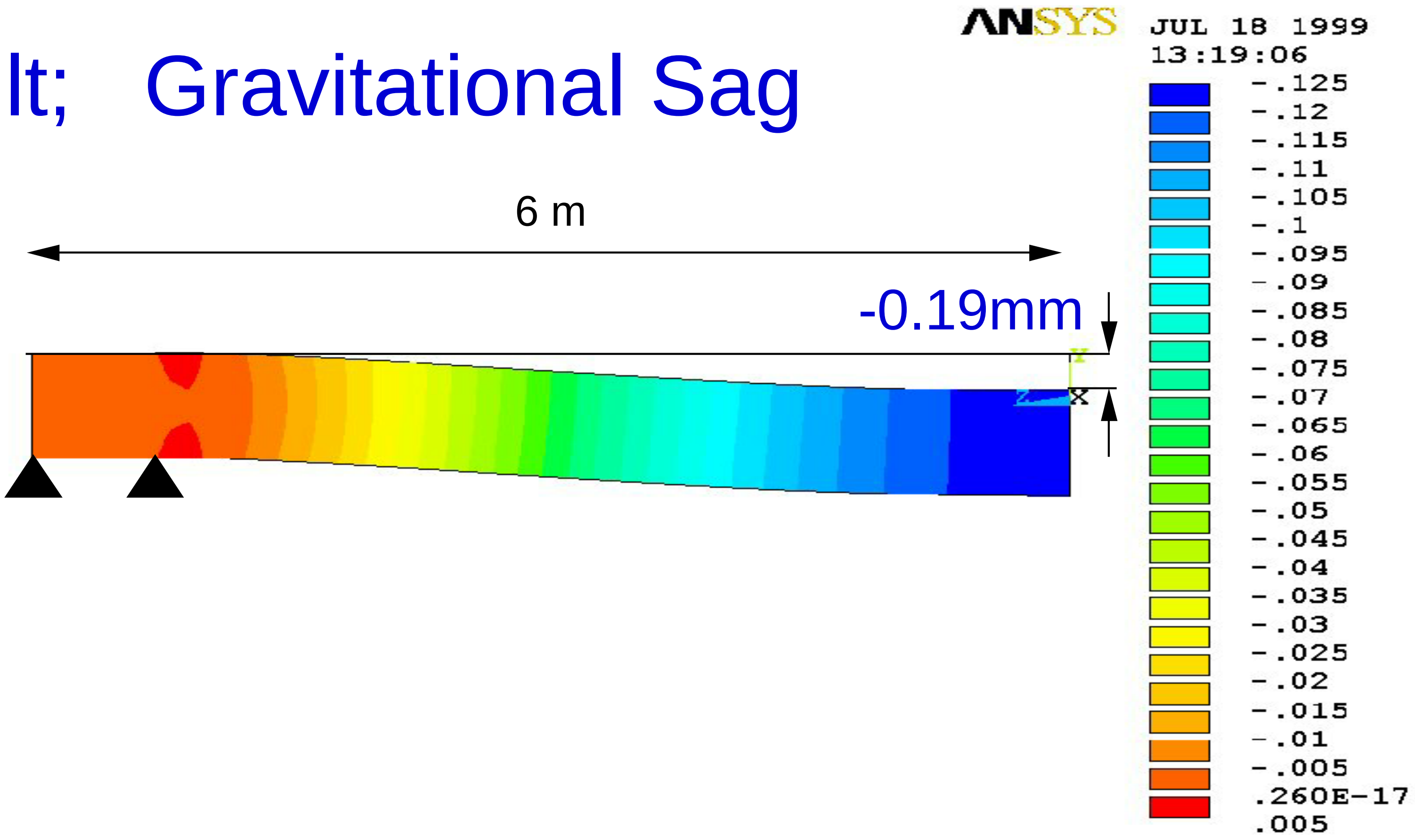
Support tube
Luminosity Monitor
Carbon Mask
θ = 0.2
θ = 0.15
Intermediate tracker
θ = 0.05
rtex detector
QC1
30cm
Pair Monitor
SC Compensation magnet
200cm

H.Yamaoka, 2nd ACFA-LC, Seoul, Nov.,1999

Support Tube **(80cmϕ x 12m)** Analysis by ANSYS



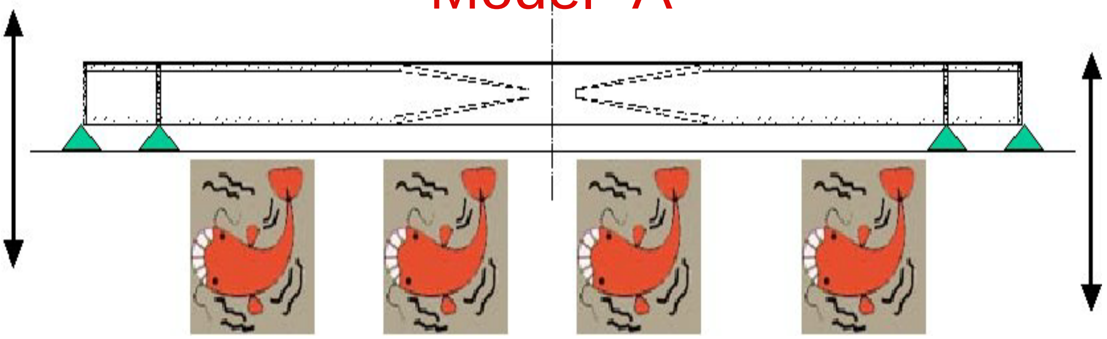
Result; Gravitational Sag



H.Yamaoka, 2nd ACFA-LC, Seoul, Nov.,1999

Spectrum Analysis by ANSYS

Model -A



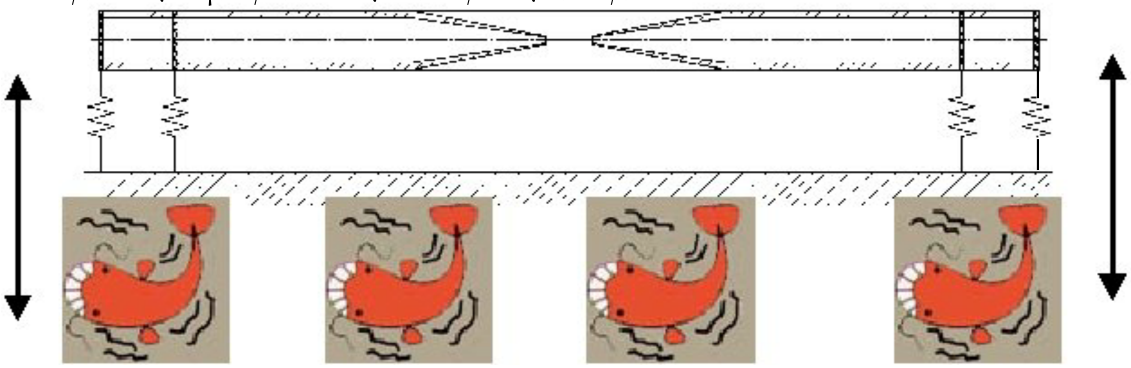
Input

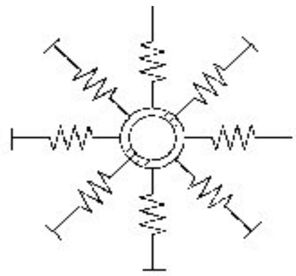
Ground Motion at Tsukuba exp. hall

Hz	µm
0.003	3.0
0.1	1.0
1.0	0.01
3.0	0.005

、3μ
m/3mHz、1μm/100mHz、10nm/1Hz、5nm/3Hz

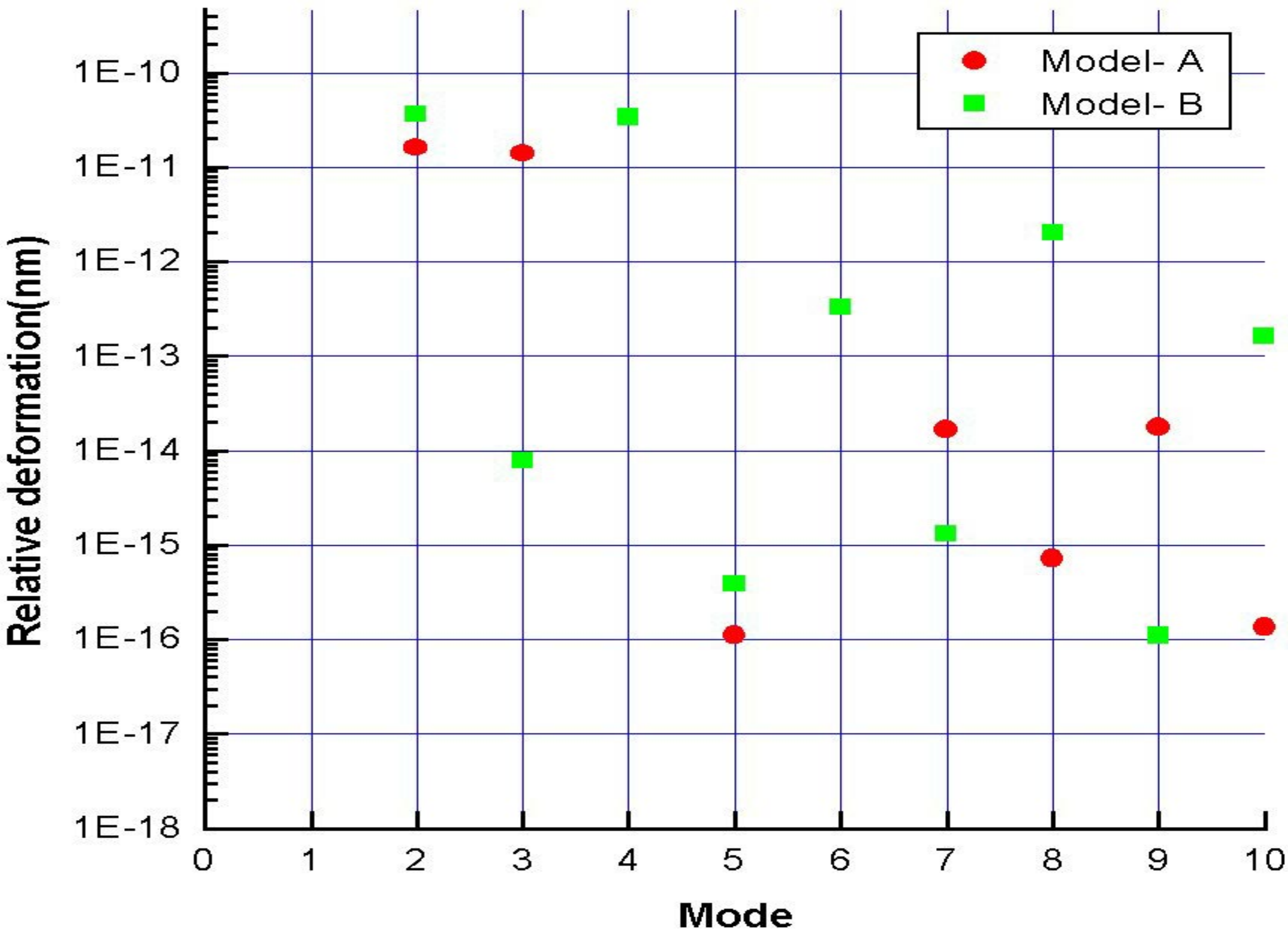
Model -B





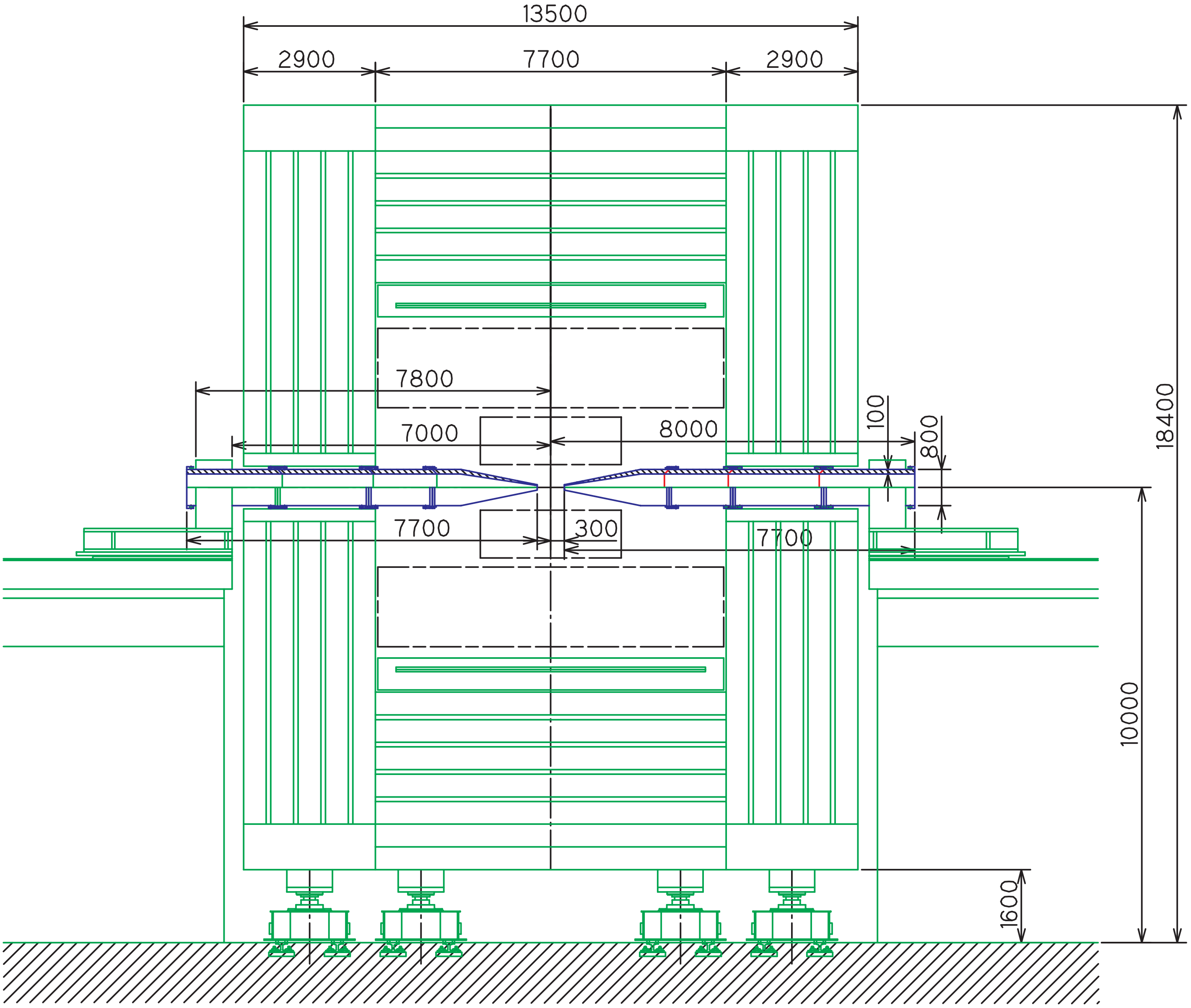
Freq. 15Hz

Result; Relative displacemet between ± 2 m



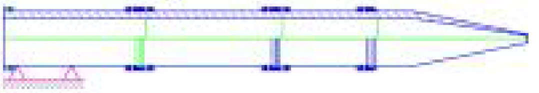
H.Yamaoka, 1/27,2000

Structure of JLC detector at B=3Tesla

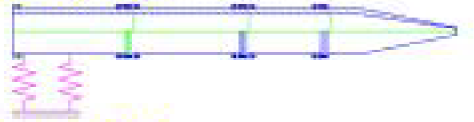


Summary

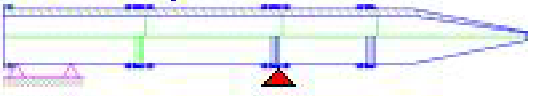
(Model-1A)



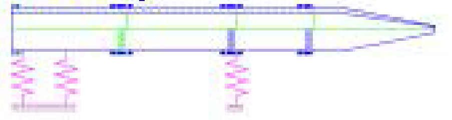
(Model-1B)



(Model-2A)



(Model-2B)



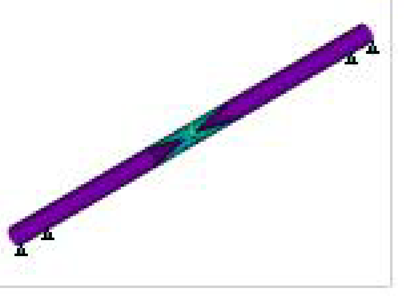
		Model-1A	Model1-B	Model-2A	Model-2B
Deformation(mm)		1.6	-	0.09	-
Stress(MPa)		23	-	5	-
Natural frequency(Hz) (Vertical)	1st mode	17	15	71	15
	2nd Mode	81	38	179	54
	3rd mode	173	105	202	93
Harmonic response(nm) @QC1		8.0	8.0	0.2	6.0
Spectrum analysis(nm) @QC1	1st mode	6.5	2.0	4.3	2.7
	2nd Mode	-1.7	1.1	0.2	0.2
	3rd mode	-0.4	0.1	1.9	0.002

Deformation is too large!!

Further studies

- How much is the relative position between QC1?
- How support the masks at iron structure?

  → Deformation due to the magnetic force.



- Support configuration

  CFRP → High young's modulus (150GPa → 900GPa)

  Masks → Other materials

  → We may not need to support at iron structure.

Backgrounds

(1) Muons

10^7 muons/trains at the collimators

Assuming 0.1% flat beam-tail, 10^{-3}(tail) x 10^{10}(beam)x10^2(bunch)=10^9electrons/train would hit the collimators.

Tolerance: One muon in $16 \times 16 \times 16 m^3$ at IP

(2) Synchrotron radiations in FF-system.

collimation is important: 6 σ_x x 40 σ_y

(3) e^+e^- pairs created in collisions

number of pairs	25,000 / bunch
average energy	4 GeV ($E_e > 3MeV$)
total energy	100 TeV / bunch

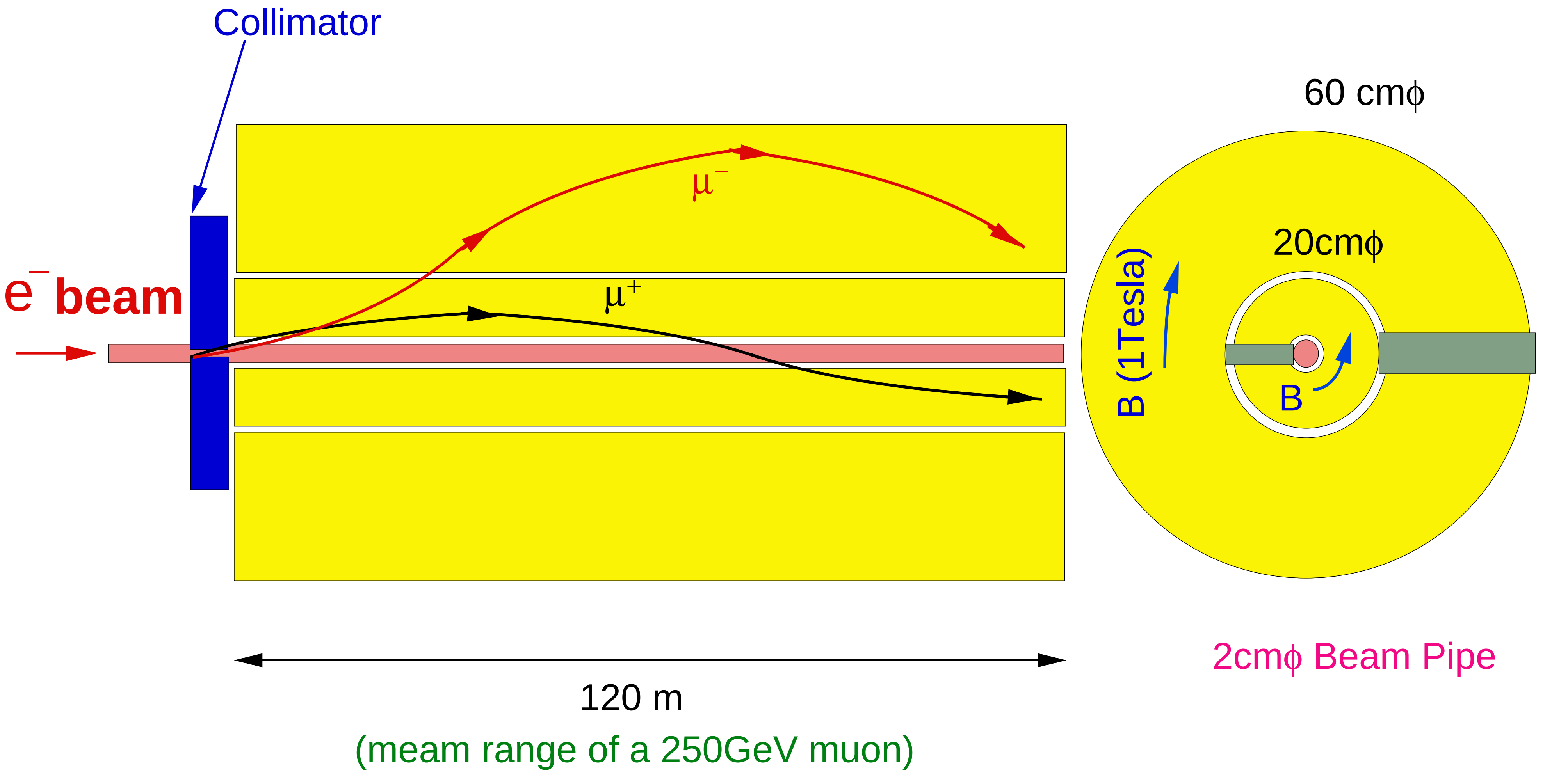
signals for pair monitor for E_e = 300 ~ 500MeV

(4)neutrons (1 neutron/100MeV)

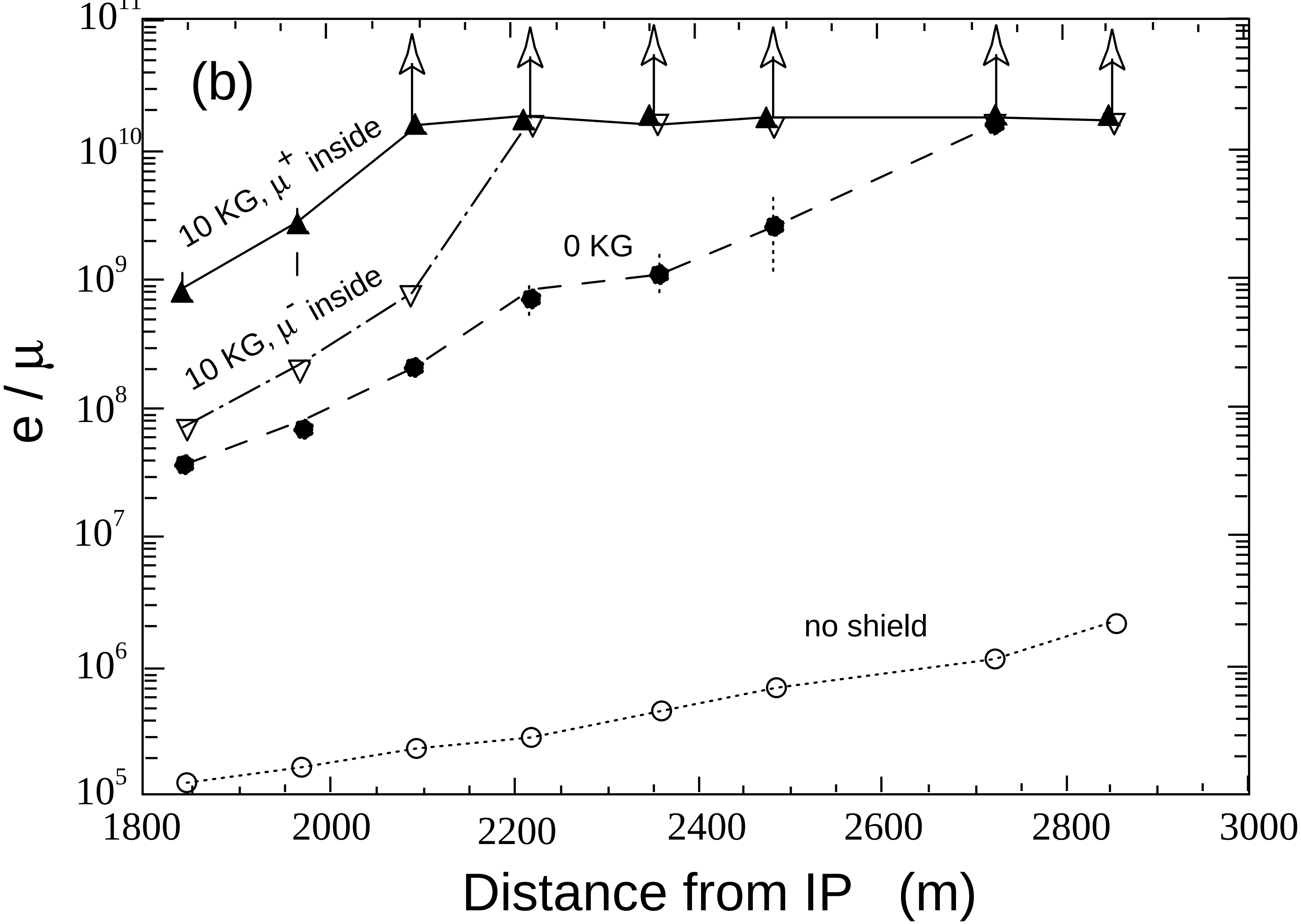
pairs at QC1 and masks	~30 TeV / bunch
	3×10^5neutrons / bunch
beamstrahlung photons	340 kW (4%x2)
	2×10^{16} neutrons / sec

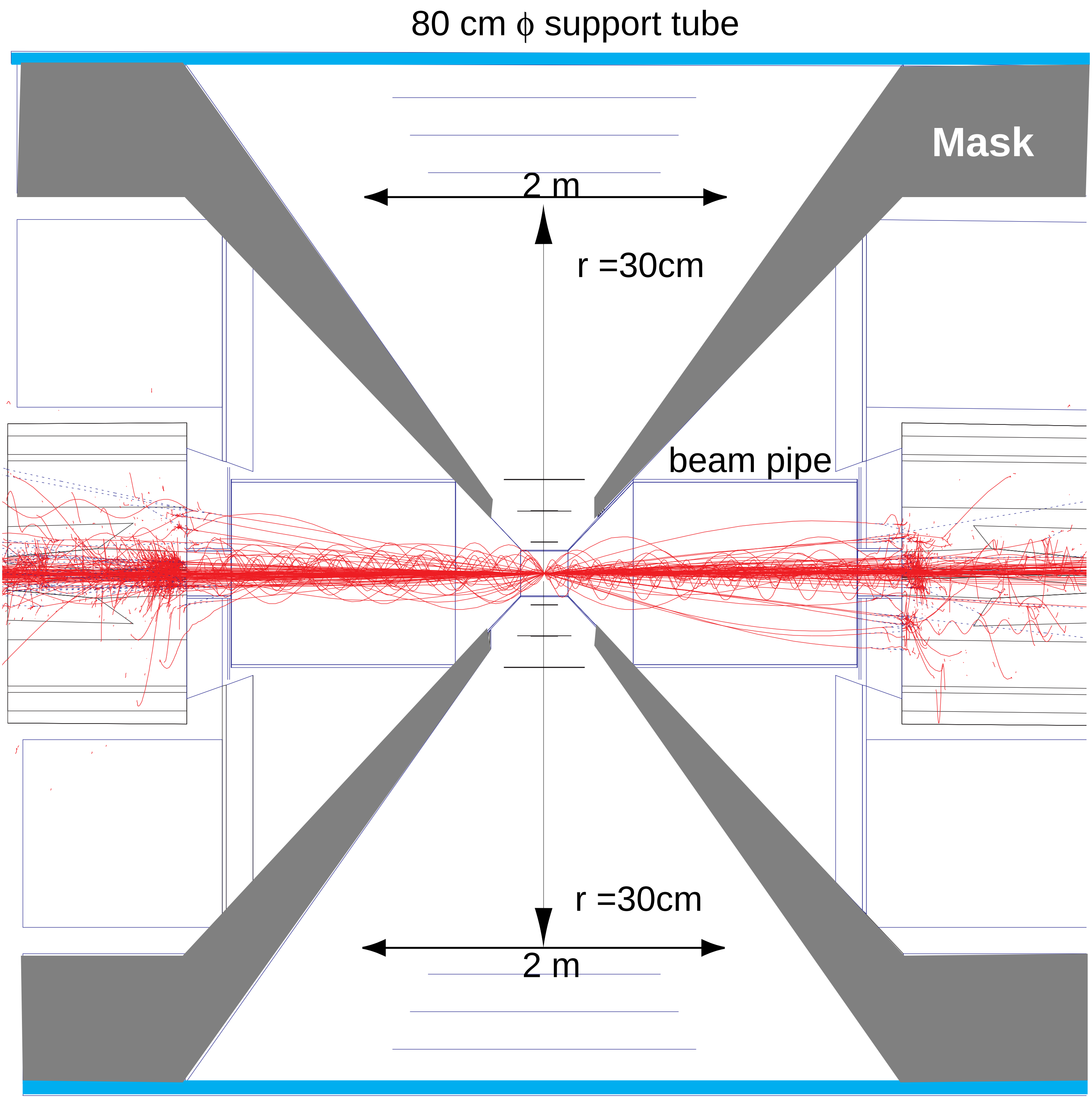
disrupted beam in dump line

Muon Attenuator



Y.Namito, ISG3, SLAC, Jan.1999

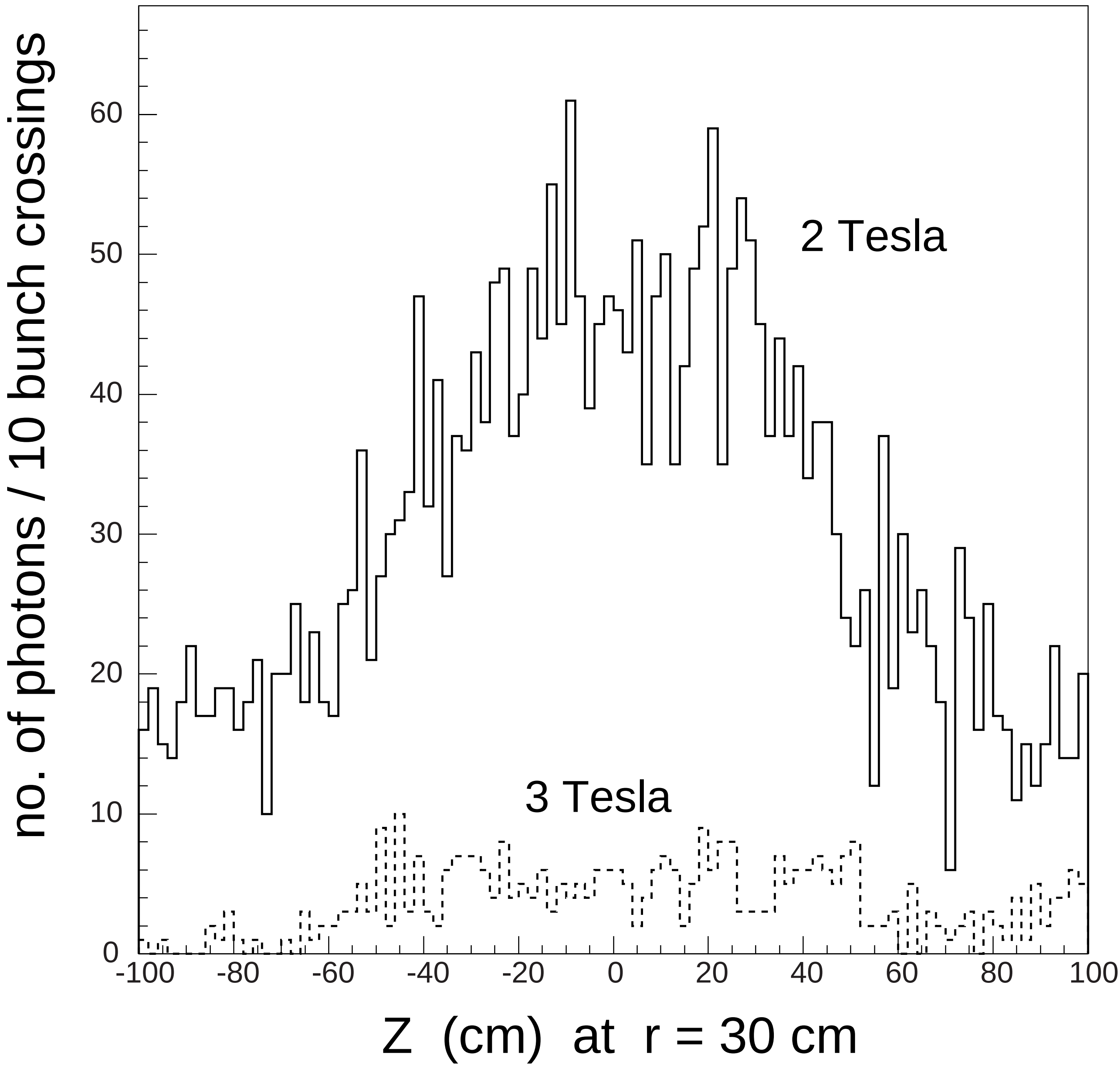




1/100 bunch and E_γ>100MeV, E_e>10MeV for display purpose

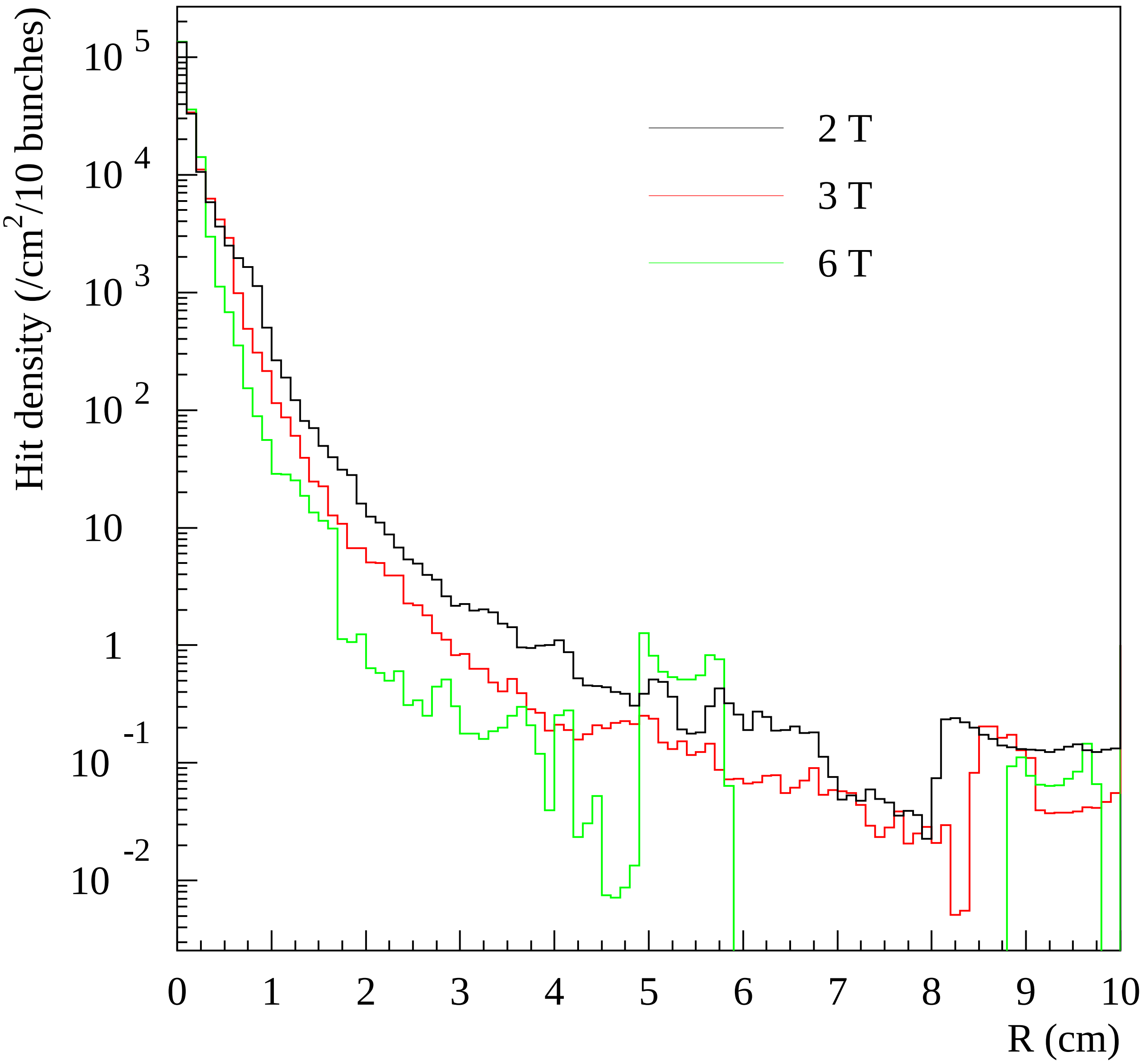
JIM simulation for E_γ>10keV, E_e>200keV

Photon Background



Vertex detector hit density in stronger B fields

cos θ < 0.9



Background tolerance

(1) CDC 10 % occupancy / train

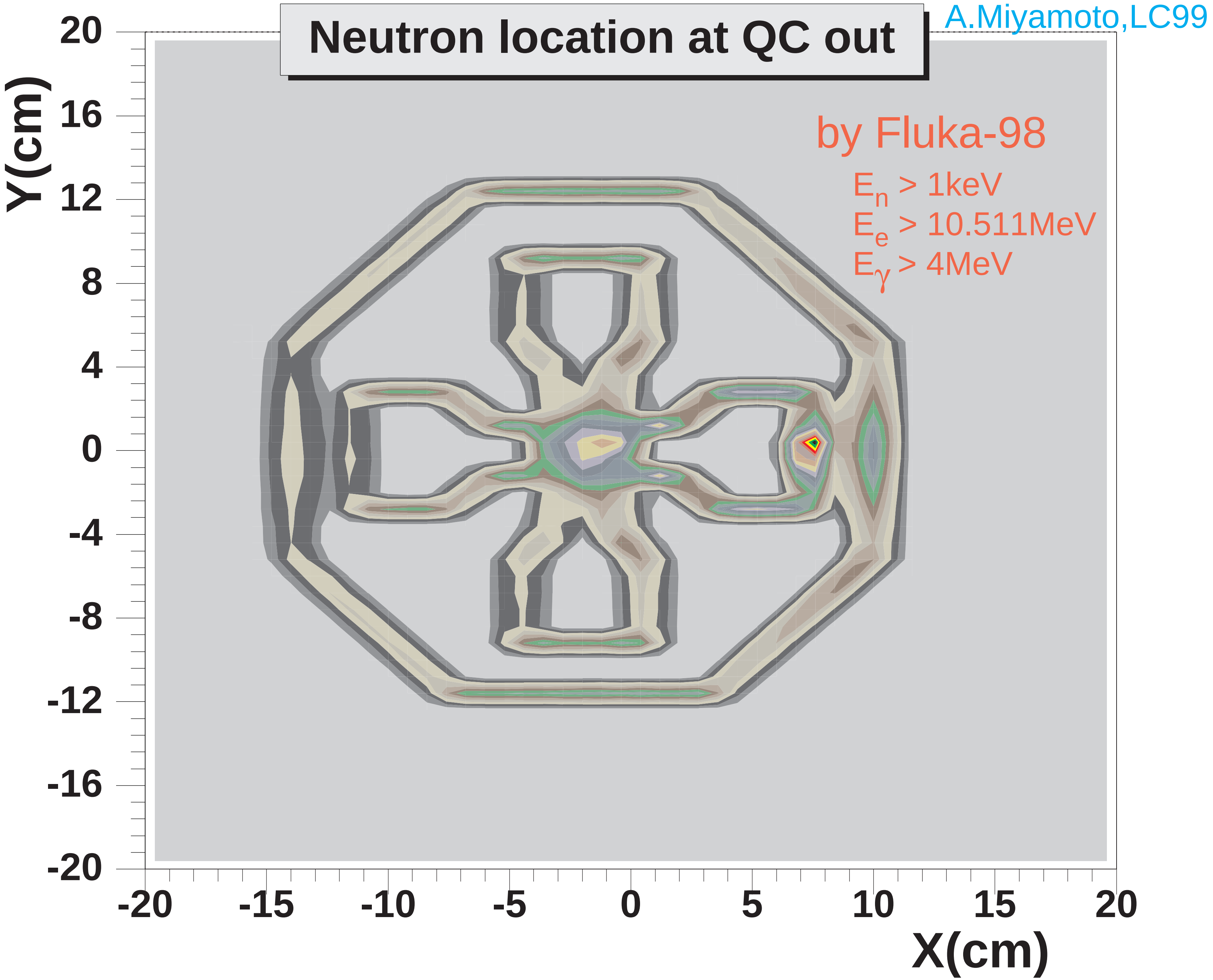
r_{min} \ B	2 tesla	3 tesla
2.5 cm hit#/train	1.2 k (2.4 k)	0.12 k (0.37 k)
1.8 cm		0.72 k
1.5 cm hit#/train	4.2 k	2.6 k

(2) VTX 1hit / mm^2 / train

r_{min} \ B	2 tesla	3 tesla
2.5 cm hit#/mm^2/train	0.9 (2.8)	0.4 (1.0)
1.8 cm		1.6
1.5 cm hit#/mm^2/train	4.3	3.6

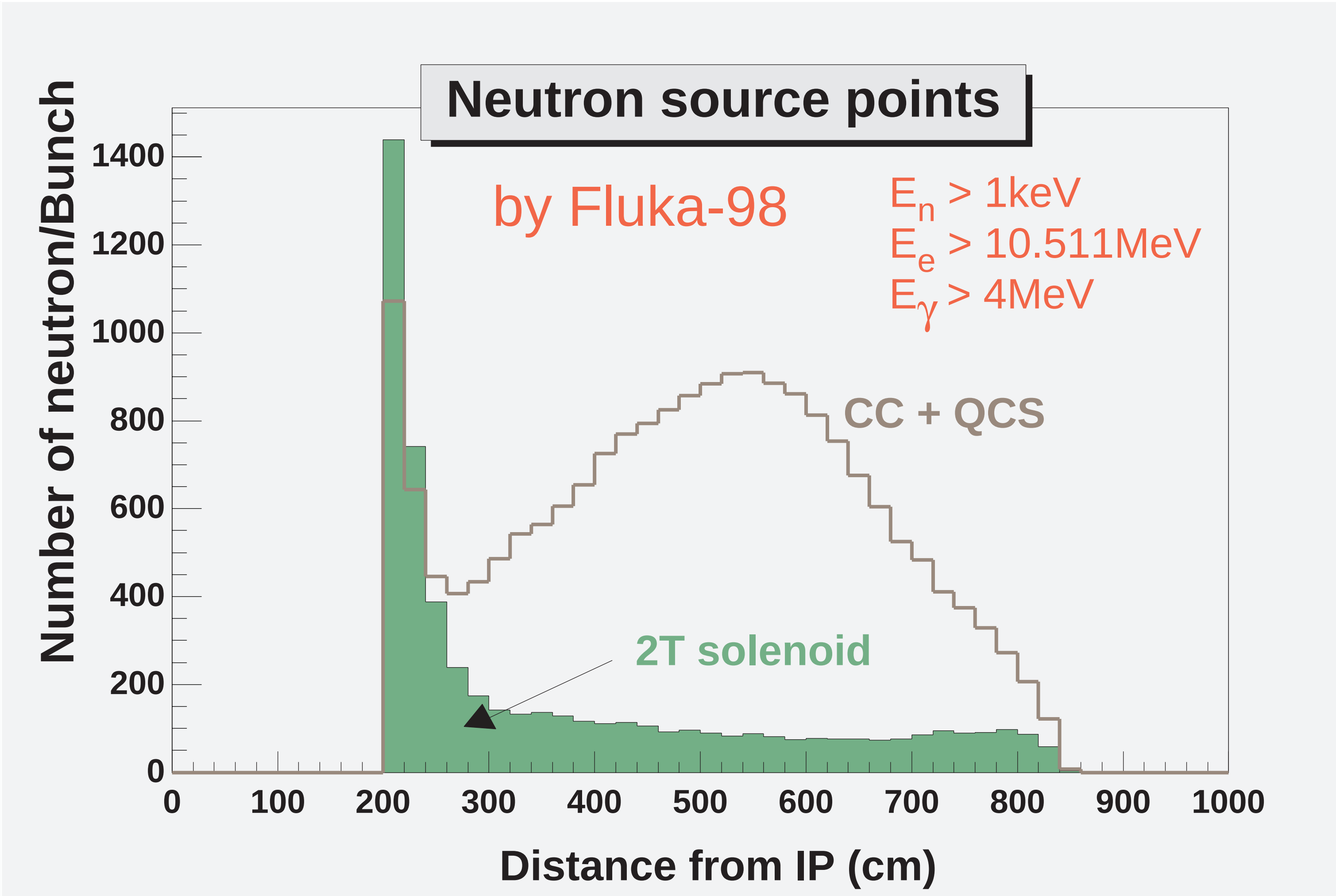
Values in ( ) are those of JLC-Y (high luminosity).

4,3 and 2cmϕ beam pipes for r_{min}=2.5,1.8 and 1.5 cm, respectively.



Neutron location at QC out
A.Miyamoto,LC99
by Fluka-98
E_n > 1keV
E_e > 10.511MeV
E_γ > 4MeV
Y(cm)
X(cm)
20
16
12
8
4
0
-4
-8
-12
-16
-20
-20
-15
-10
-5
0
5
10
15
20

A.Miyamoto, LC99, Oct.,1999



A.Miyamoto, LC99, Oct.,1999

Summary of Neutron Background in VTX

			Neutron yield at IP($/cm^2$ /year)
e^+e^-:	Old (GEANT)		$3 x 10^7$
	New(Fluka98) w 2T solenoid		$5 x 10^7$
	New(Fluka98) w. CC and QC		$7 x 10^7$
beamstrahlung: from beam dump(340kW) (300m from IP)		Old(GEANT)	$1 x 10^7$
		New(Fluka98)	$2.5 x 10^7$

Statistical error of new estimate is roughly a few x 10^7 (guess)

New estimatebased on Fluka98 is well below the requirement,

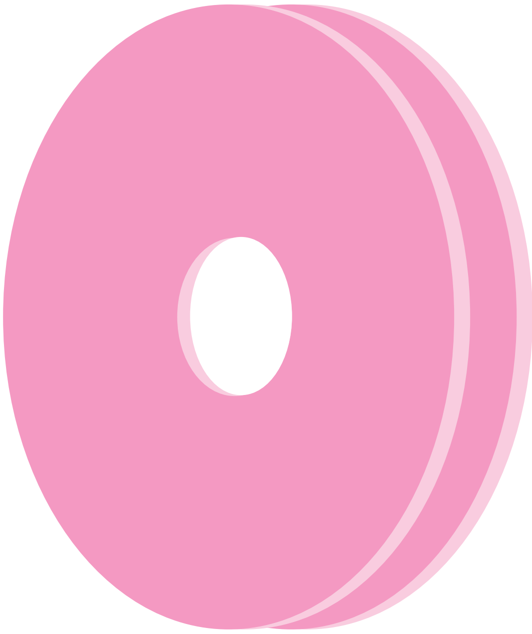
$< 1.5 x 10^{10}$ n/cm^2

for the CCD vertex detector

Neutron background from other sources in dump line are under study.

Pair Monitor

as a beam profile monitor



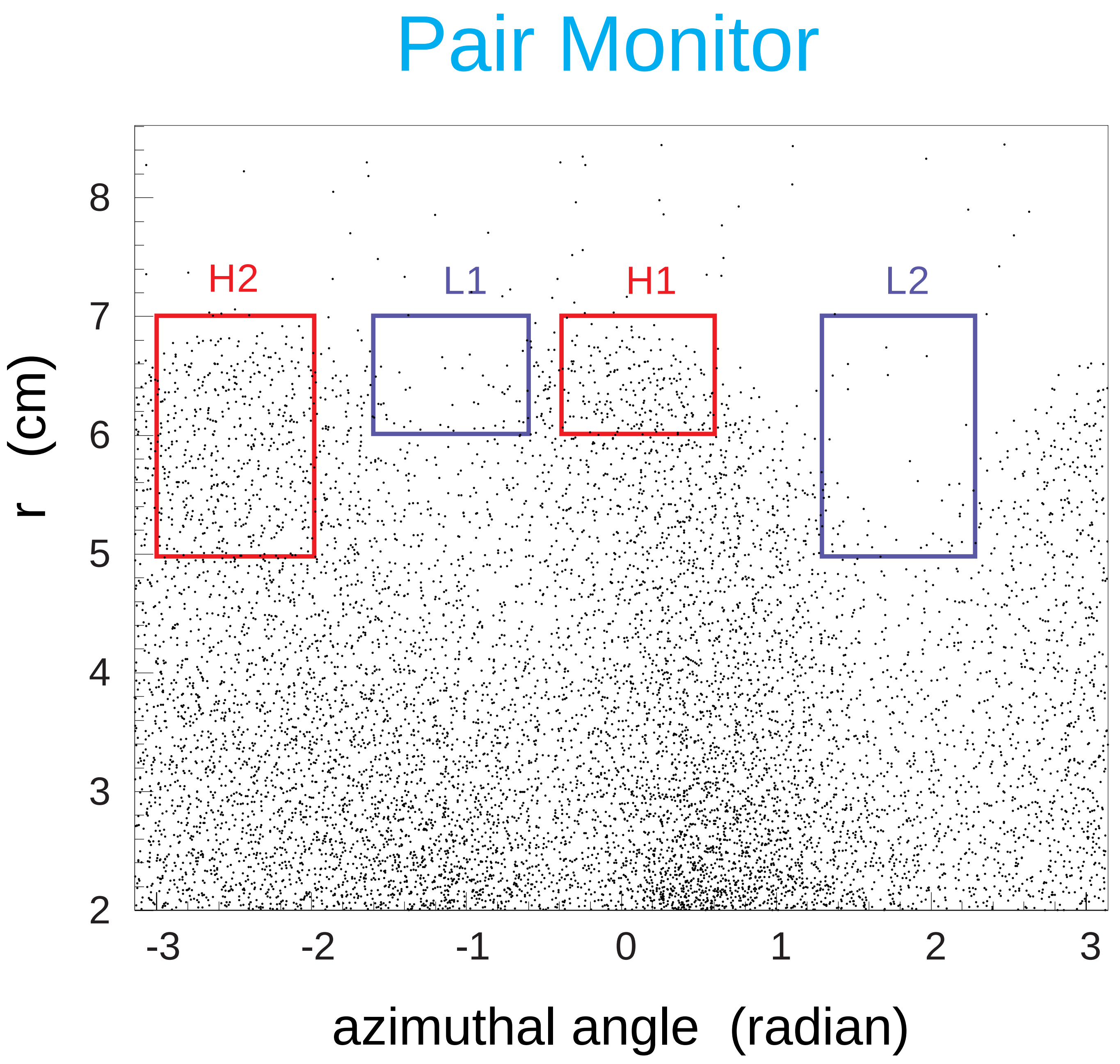
Active Pixel Sensor

double layer of silicon disks

pixel size	100 x 100 μm^2
thickness	300 μm
inner radius	2 cm
outer radius	8.5 cm
location (z)	176 and 177 cm from IP

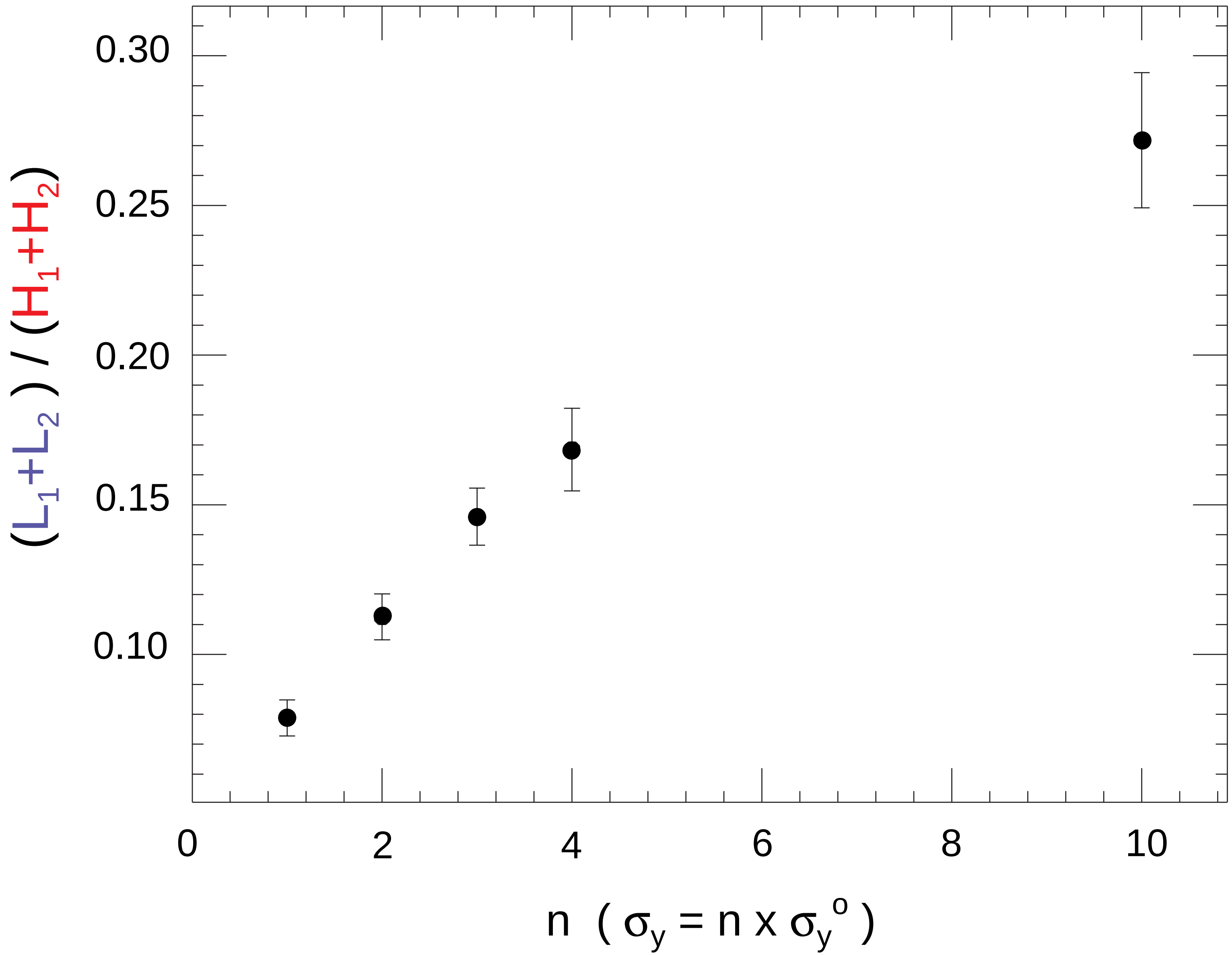
Measurement:

position and energy deposit



Pair Monitor
H2
L1
H1
L2
r (cm)
2
3
4
5
6
7
8
-3
-2
-1
0
1
2
3
azimuthal angle (radian)

Pair Monitor



Pixel Beam Profile Monitor for Linear Collider

A. Miyamoto, Y. Sugimoto, T. Tauchi, K. Yokoya
High Energy Accelerator Research Organization (KEK)

G. Alimonti, T. Browder, C. Kenney, S. Olsen, S. Parker,
M. Rosen, K. Travelsi, G. Varner, H. Yamamoto
The University of Hawaii

1 Introduction

At linear colliders, it is expected that a large number of e^-e^+ pairs are created by the QED process $\gamma\gamma \to e^+e^-$ where γ may be off-shell or near-on-shell[1]. Depending on the number of off-shell photons involved, they are classified as Landau-Lifshitz (both off-shell), Bethe-Heitler (one of them is off-shell), and Breit-Wheeler (both near-on-shell). These pairs are predominantly created along the beamline, and acquires p_t kick by the electromagnetic field of the on-coming bunch. As long as the pair is relativistic and the direction is the same as the co-moving bunch, the net force due to the co-moving bunch $\pm e(\vec{E} + \vec{\beta} \times \vec{B})$ cancels out ($\vec{\beta}$ is the velocity of the pair particle in unit of c). One then only needs to consider the effect of the on-coming beam (Figure 1).

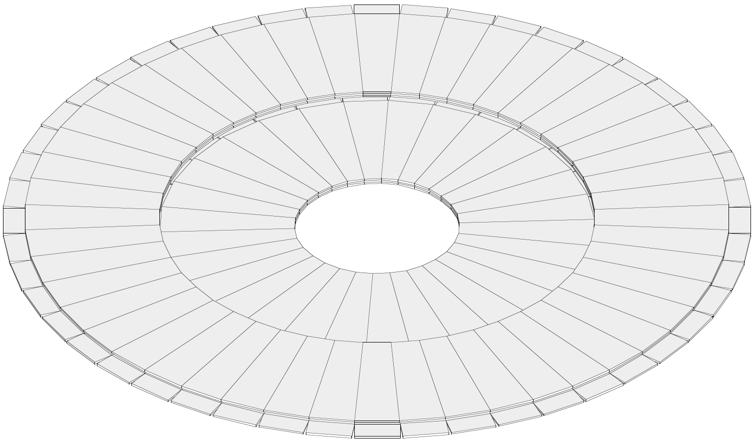
Typical parameters of the bunch is $\sigma_x/\sigma_y/\sigma_z = 260\text{nm}/3\text{nm}/80\mu\text{m}$, and the number of particles per bunch N is $\sim 10^{10}$. If we assume a rectangular beam of $2\sigma_x \times 2\sigma_y \times 2\sigma_z$ with uniform charge density and $\sigma_y \ll \sigma_x$, this creates

$$E(\text{dyne/esu}) = B(\text{gauss}) = \frac{\pi e N}{2\sigma_x \sigma_z} \sim 3.6 \times 10^7 \qquad (1)$$

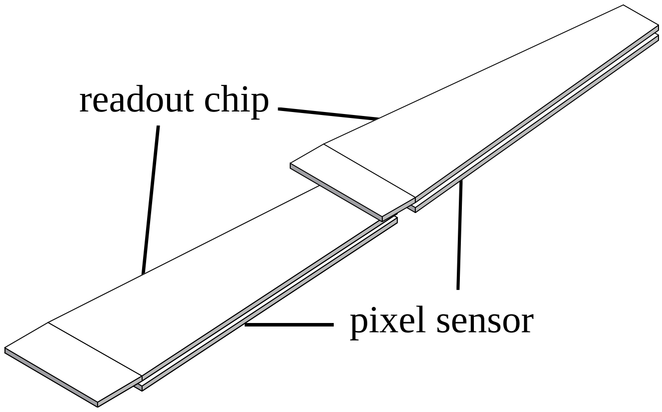
just above or below the on-coming bunch in the laboratory frame. For the typical value of $p = 300$ MeV/c, the curvature due to both E and B fields is about 170μm which can be compared to the bunch length of 80μm. If the charge of the particle and the on-coming bunch are opposite sign, the created particle would undergo a number of oscillations around the beam plane and the net p_t acquired will be small. On the other hand, if the particle and the

Pixel Beam Profile Monitor

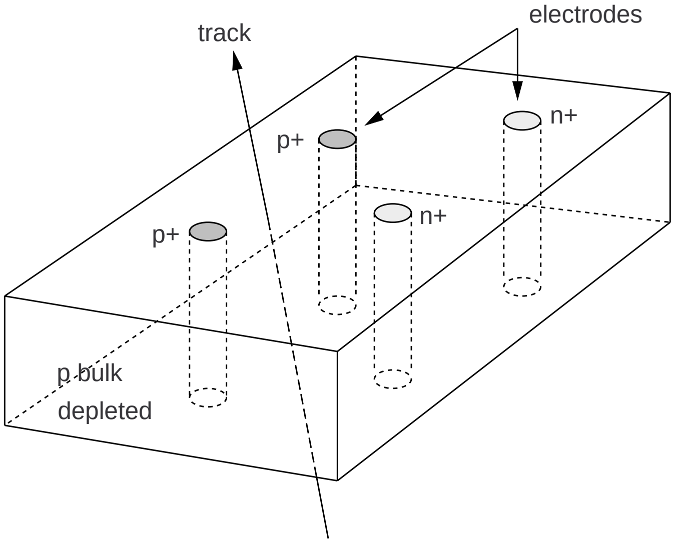
H. Yamamoto et al., University of Hawaii



The sensor arrangement; the top side faces the IP.



One 'segment' ; the bottom side faces the IP.



Schematic diagram of the 3D pixel concept

3D Pixel

1. Fast charge collection

   < 1 nsec :bunch separation

2. Radiation hard

   >>50kRad/year,10^7n/cm^2/year

3. Flexible geometry

4. Active edge

Luminosity Monitor and Active Mask

(1) Luminosity monitor

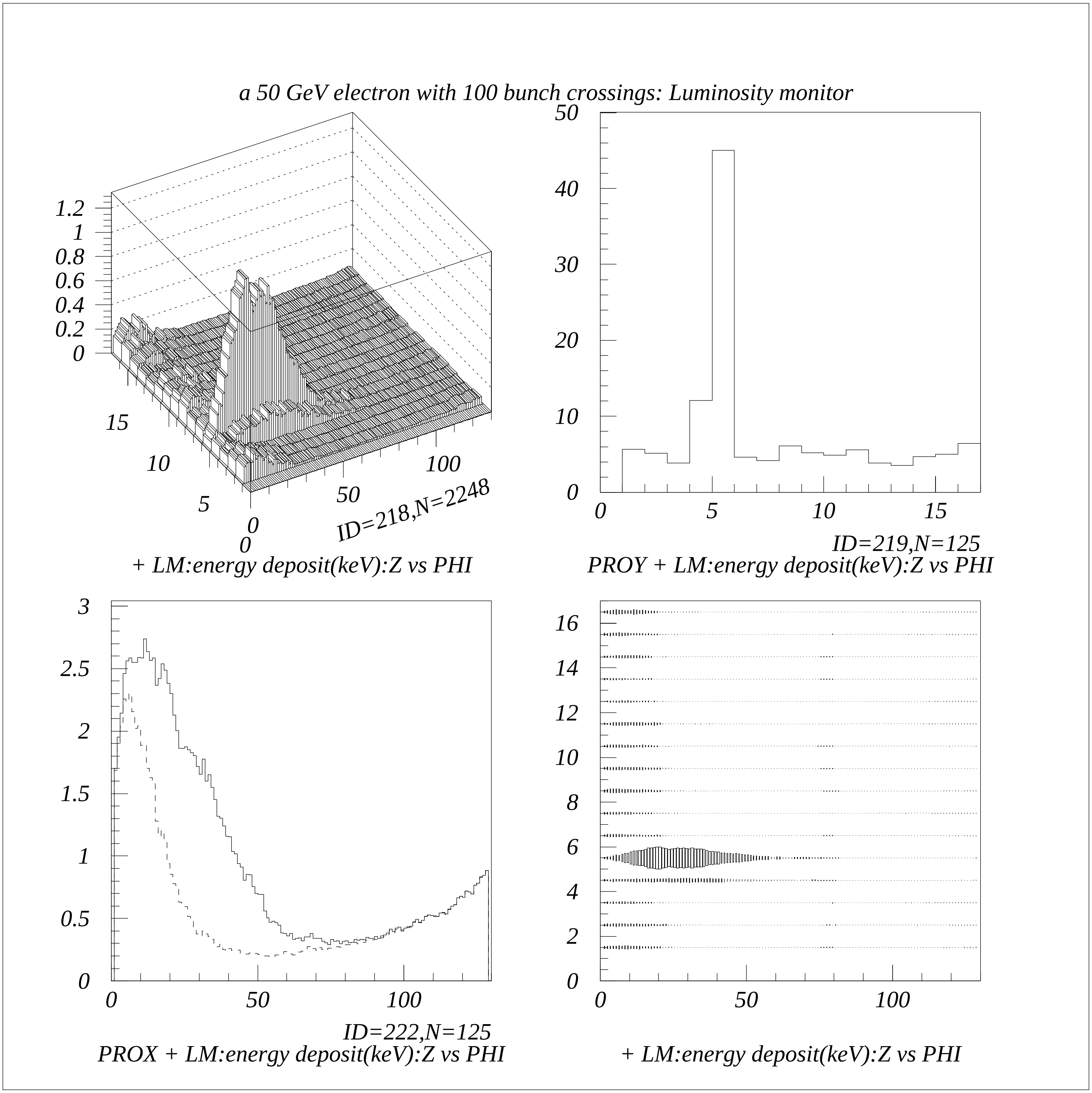
geometrical acceptance:
$163 < z < 178$ cm and $0.05 < \theta < 0.15$ rad.
made of tungsten only in this study
segmentation:

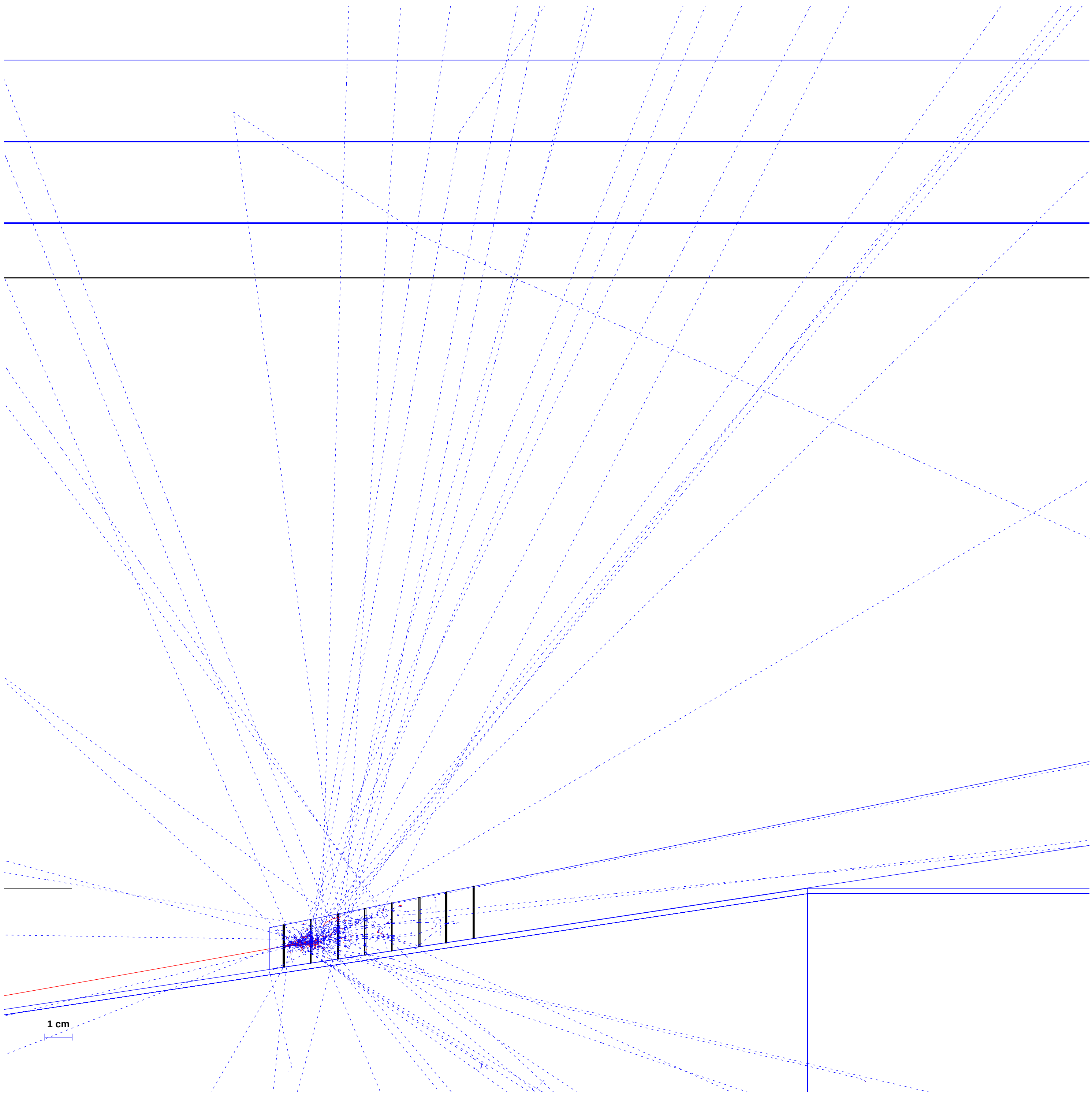
r	32 divisions	$\Delta r \sim 5$mm
ϕ	16 divisions	$\Delta\phi \sim 3.2 - 9.7$ cm
z	128 divisions	$\Delta z \sim 1.17$mm

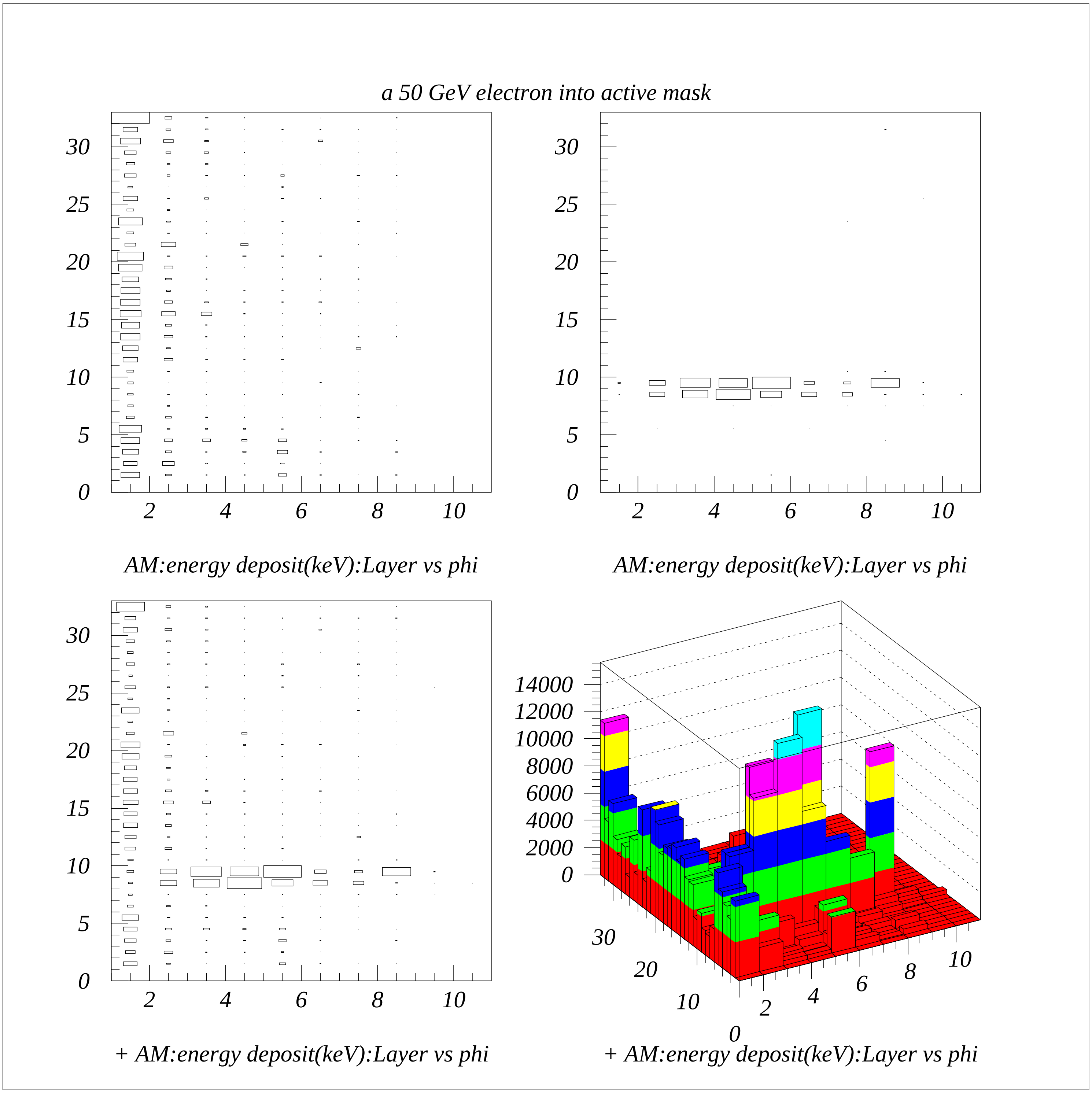
(2) Active mask (front part of conical mask)

geometrical acceptance:
$30 < z < 37.5$ cm and $0.15 < \theta < 0.20$ rad.
made of tungsten(W) and silicon pad(Si,200μm^{t})
5mm^{t}W/Si/(1cm^{t}W/Si)^{7} 8 layers
segmentation:

r	8-10 divisions	$\Delta r = 2$mm
ϕ	32 divisions	$\Delta\phi \sim 0.9 - 1.2$ cm


a 50 GeV electron with 100 bunch crossings: Luminosity monitor
ID=218,N=2248
+ LM:energy deposit(keV):Z vs PHI
ID=219,N=125
PROY + LM:energy deposit(keV):Z vs PHI
ID=222,N=125
PROX + LM:energy deposit(keV):Z vs PHI
+ LM:energy deposit(keV):Z vs PHI

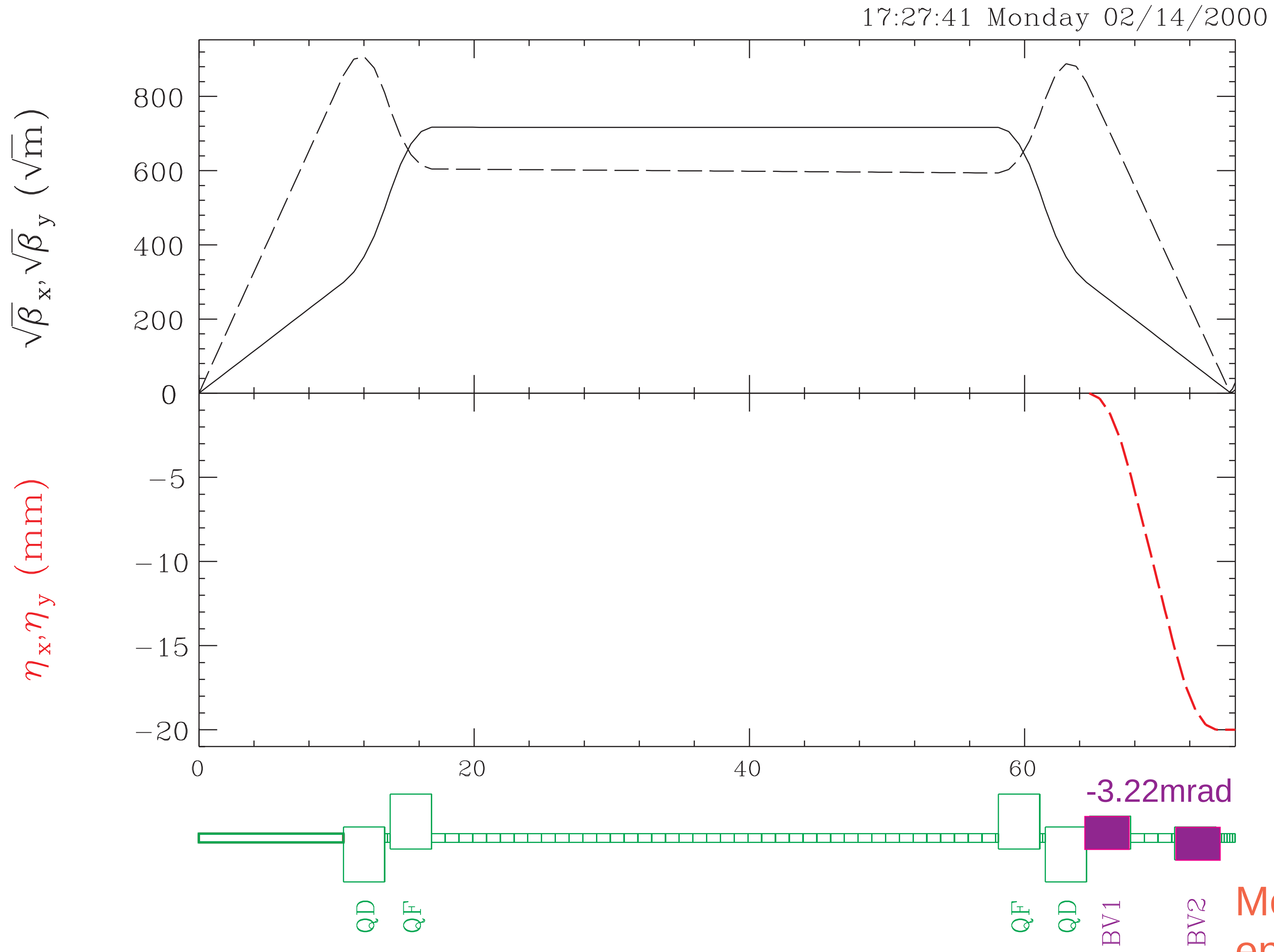

1 cm



a 50 GeV electron into active mask
AM:energy deposit(keV):Layer vs phi
AM:energy deposit(keV):Layer vs phi
+ AM:energy deposit(keV):Layer vs phi
+ AM:energy deposit(keV):Layer vs phi

Optics of Dump Line (1 st version)

K.Kubo

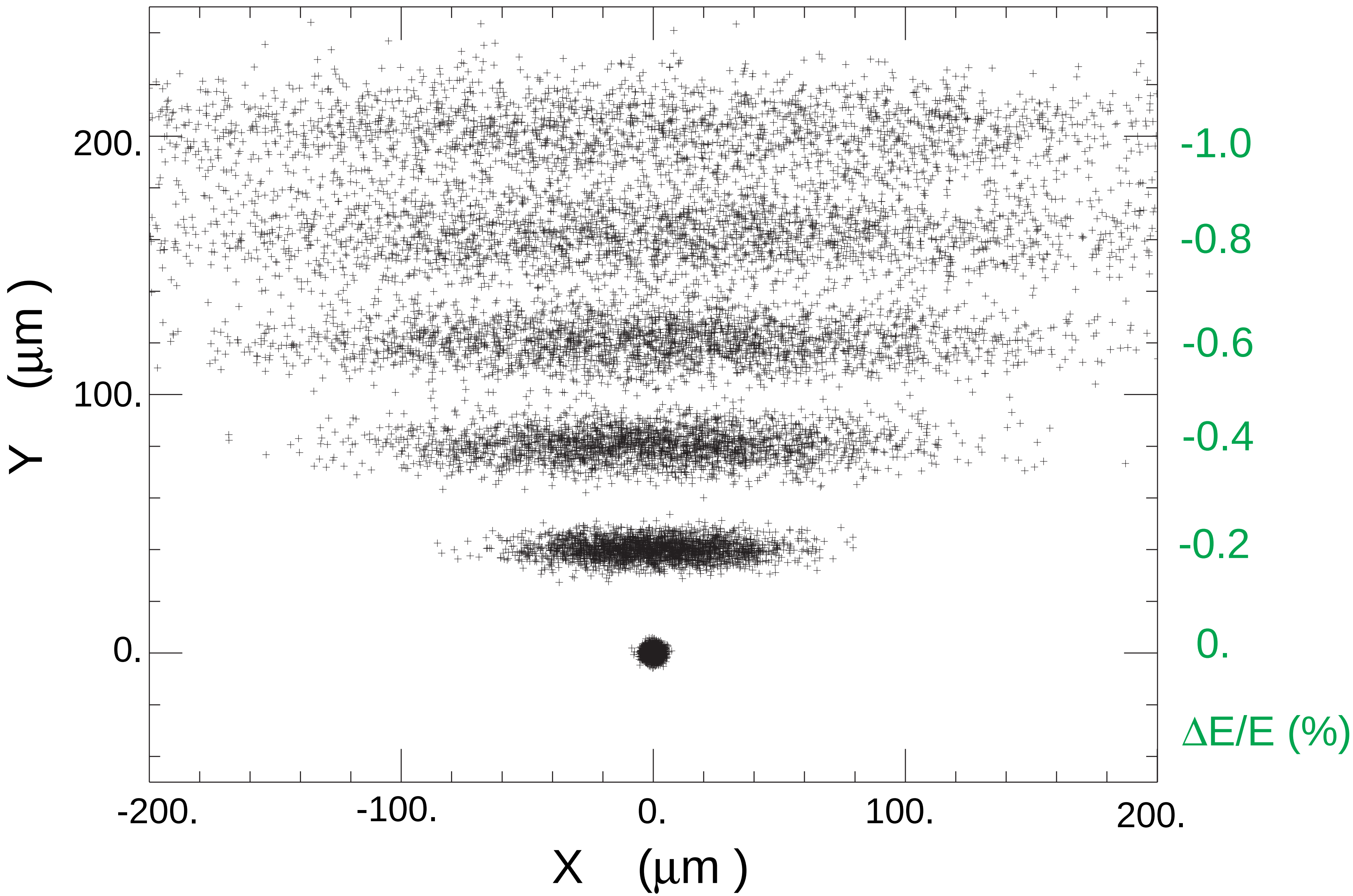


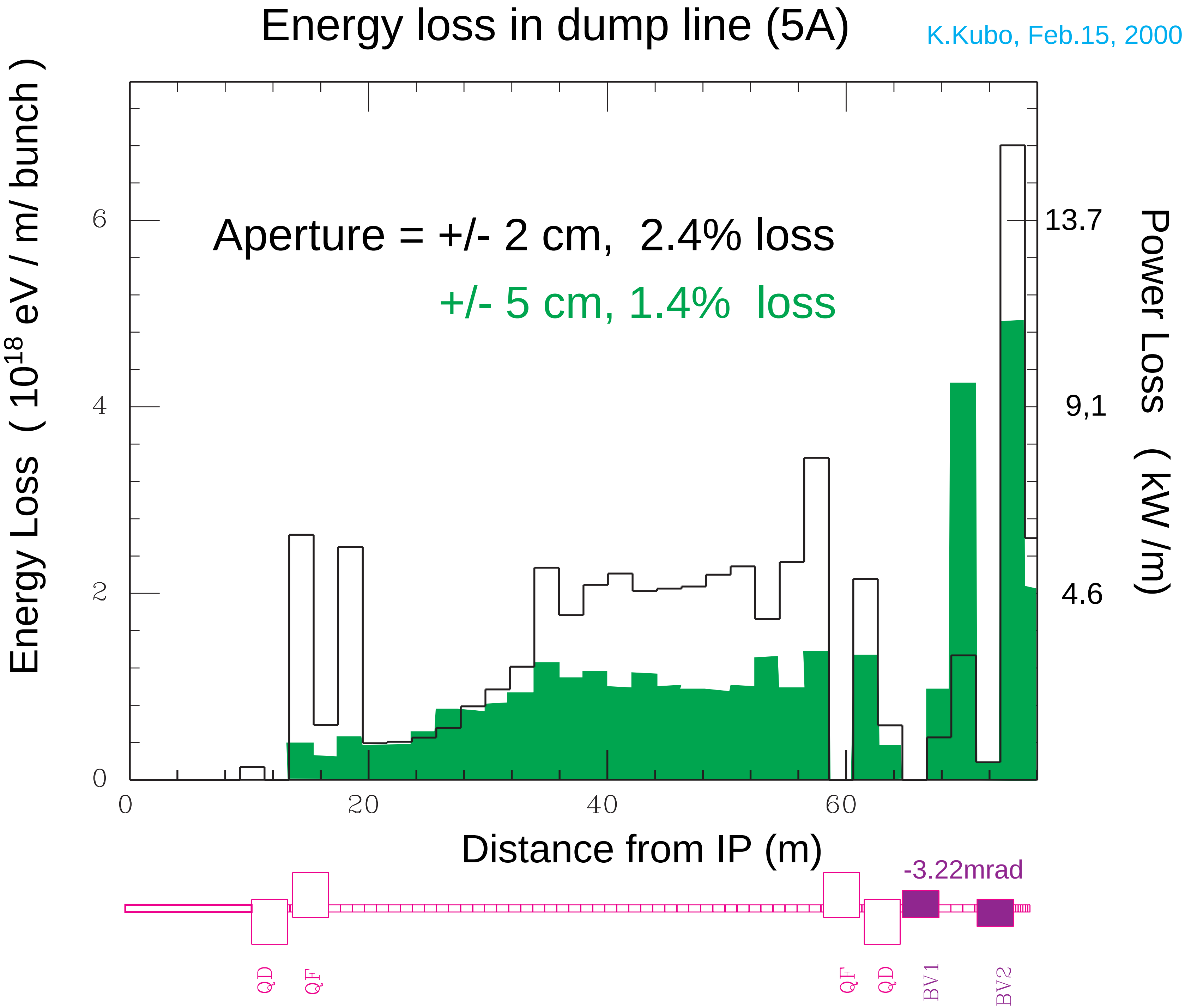
2nd focus point

Measurements of energy distribution polarization

K.Kubo, Jan.2000

Vertical dispersion at 2nd IP in dump line

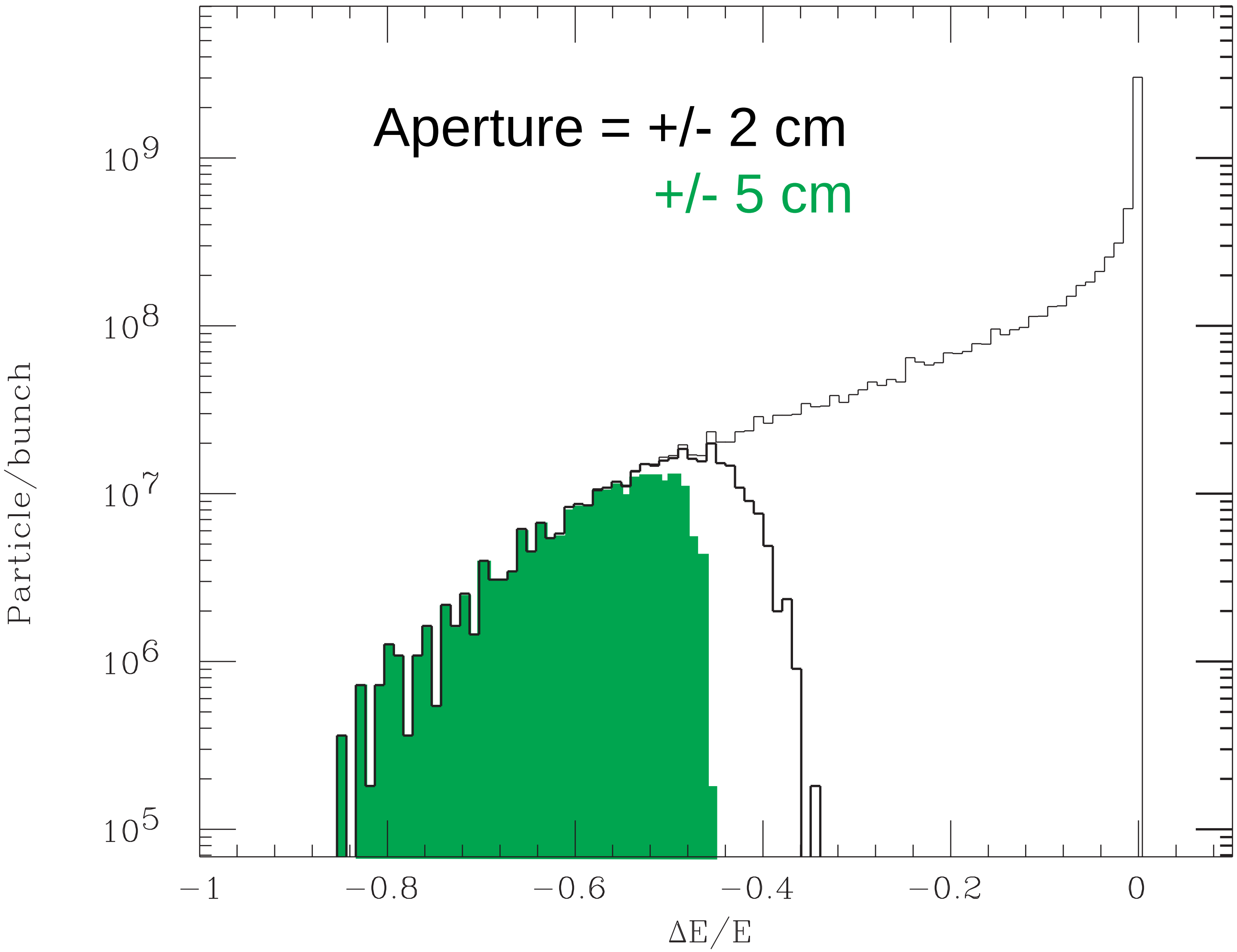




Energy loss in dump line (5A)
K.Kubo, Feb.15, 2000
Aperture = +/- 2 cm, 2.4% loss
+/- 5 cm, 1.4% loss
Energy Loss (10^{18} eV / m/ bunch)
Power Loss (kW /m)
0
2
4
6
13.7
9,1
4.6
0
20
40
60
Distance from IP (m)
-3.22mrad
QD
QF
QF
QD
BV1
BV2

Particle loss in dump line (5A)

K.Kubo, Feb.15, 2000



Future Plan

1. IP layout will be optimized for the high luminosity upgrade.

   JLC-Y : 1.4nsec bunch spacing,
   190 bunches/train
   stronger beamstrahlung effects

2. "Pre-linac" collimation scheme must be established.

It means collimation before the main linac.
It may simplify the collimation system and the muon protection.

3. Superconducting QC1 is seriously considered.

The design shall be based on experiences of LHC-QC magnets, adding new features of correction magnets near the beam line for nano-meter beams.
Prototype of QC1 must be necessary.

4. More detailed study on the support system will be pursued with respect to ground motions.

Prototype system must be constructed to verify our estimations.

5. Background studies will continue based on detailed simulations with up-to-date geometries, especially for the neutron background.

6. The realistic design of the pair monitor shall be promoted by a collaboration between University of Hawaii and KEK. It will be finalized in this autumn.

7. R&D of active mask and luminosity monitor will be initiated by National Taiwan University group.

8. The "actual" dump line must be designed in order to control beam losses for the neutron backgrounds.
Experimental methods must be established for measurements of beam energy spread and polarization.

9. All efforts should be concentrated for the first draft of the CDR in this autumn.

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Beam Delivery and Interaction Region Workshop 2000

Welcome to the BDIR2000 Web Site.

Goals of the Workshop

- to bring together those people who are either currently active in Beam Delivery System research and development or those who are interested in getting involved;
- to identify the technical challenges of such systems;
- identify those aspects that
  - are considered to have technical solutions;
  - have partial technical solutions and still need some work - or better ideas;
  - have currently either only a conceptual solution, or no solution at all;
- identify areas of mutual common ground where collaboration would be beneficial;
- form a plan for further (collaborative) work beyond the workshop.

Organisation

The workshop will be held at Daresbury Laboratory, near Warrington in the UK,
from Monday 3rd July 2000 to Wednesday 5th July 2000.

The workshop fee is £100.00. This will cover:

- Transport between hotels and Daresbury Laboratory
- Reception buffet on Sunday night
- Workshop Dinner on Tuesday night
- Lunch on Monday, Tuesday, Wednesday
- Copies of the Proceedings

The deadline for registration and for payment of the workshop fee is **31 May 2000**.
See the registration page for payment details.