

# Study for ep Instability in High Intensity Proton Ring (E-Cloud Effects in the KEK PS and the JHF project)



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KEK and JAERI

- ECE simulation for the JHF rings
- SEY
- E-cloud in the KEK-PS

# Parameters of E-cloud simulation

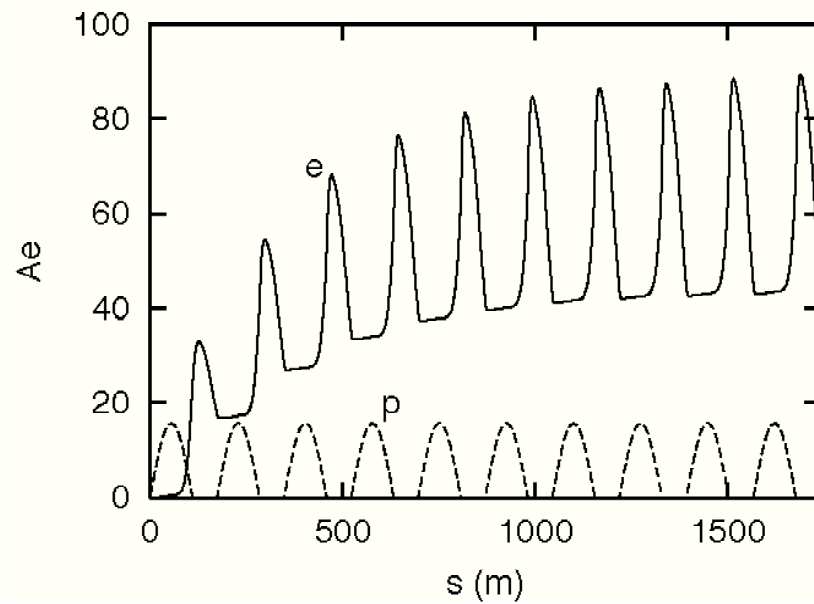
Basic parameters of the proton rings

Variable	symbol	Joint project				PSR	ISIS	AGS
		3GeV RCS		50GeV MR				
		inj.	ext.	inj.	ext.			
circumference	L(m)	348.3	348.3	1567.5	1567.5	90	163	800
Lorentz factor	$\gamma$	1.4	4.0	4.0	50.9	1.85	1.07	2.5
Bunch population	$N_p(\times 10^{13})$	4.15	4.15	4.15	4.15	3	1.25	1.2
Number of bunches	$n_b$	2	2	8	8	1	2	6
Harmonic number	h	2	2	9	9	1	2	6
Rms beam size	$\sigma_r(\text{cm})$	1.9	1.2	1.1	0.5	1.0	3.8	0.7
Bunch length	$l_p(\text{m})$	110	82	82	16	65	60	68
Rms energy spread	$\sigma_E/E(\%)$			0.7	0.25			
Slippage factor	$\eta$	-0.48	-0.047	-0.058	-0.0013	-0.187		-0.146
Synchrotron tune	$Q_s$	0.0058	0.0005	0.0026	0.0001	0.0003		0.0017
Beam pipe radius	R(cm)	12.5	12.5	6.5	6.5	5	8	5

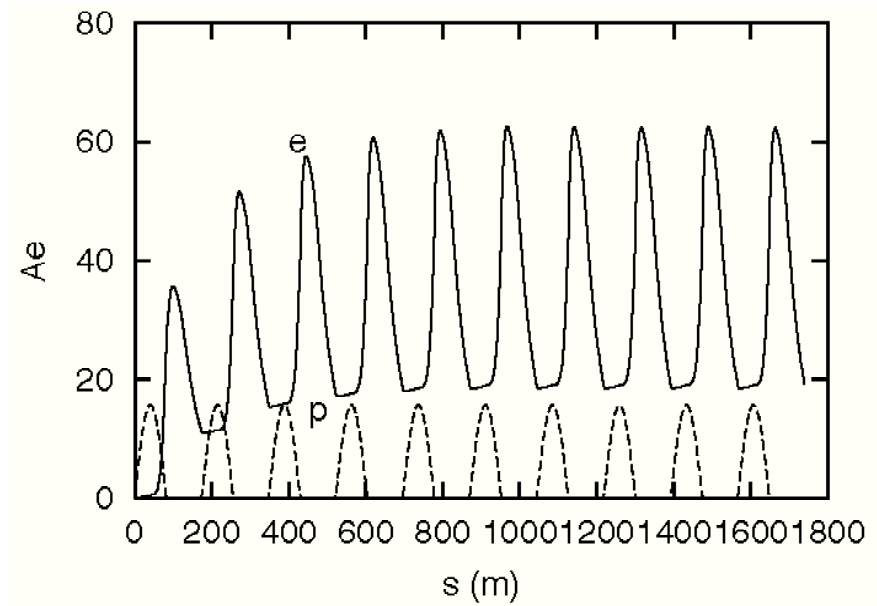
# Estimation of E-cloud

JHF 3 GeV RCS

@injection



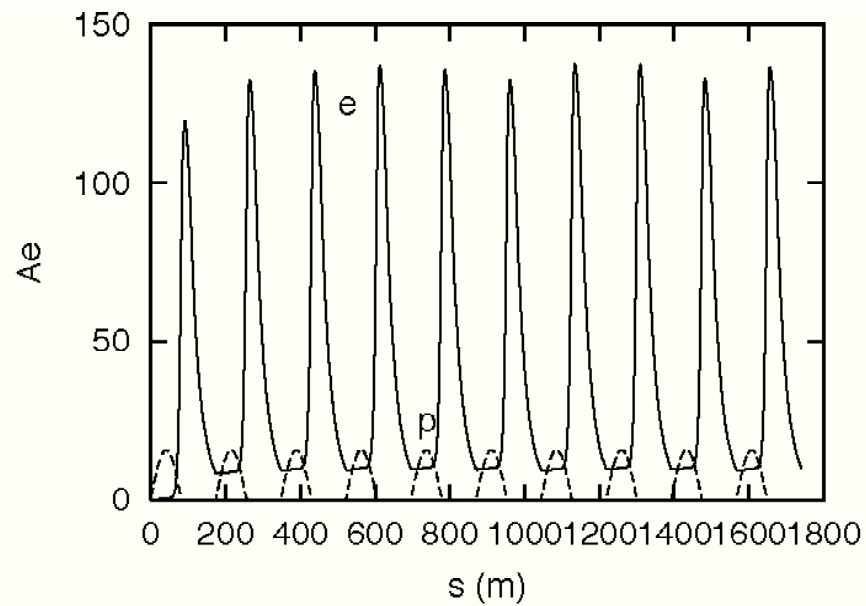
@extraction



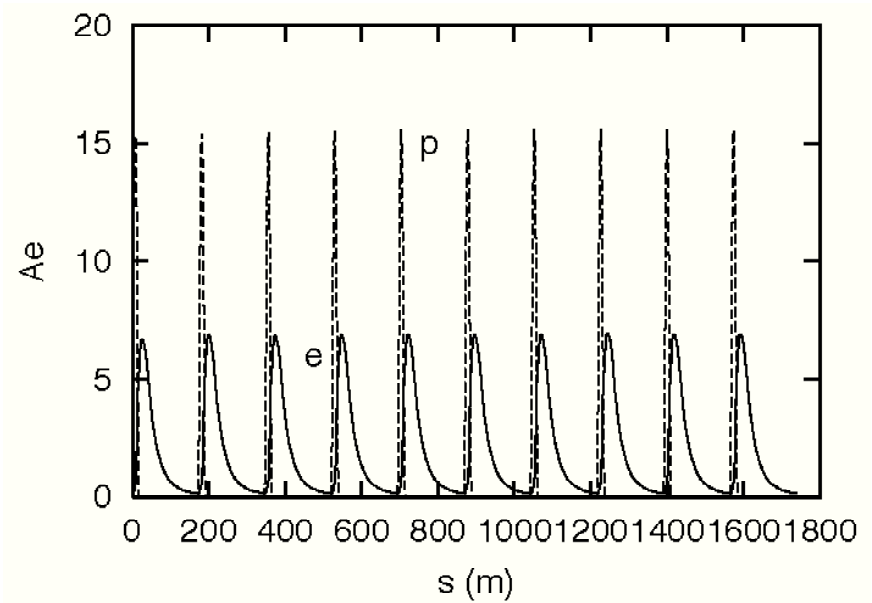
# Estimation of E-cloud

JHF 50 GeV MR

@injection

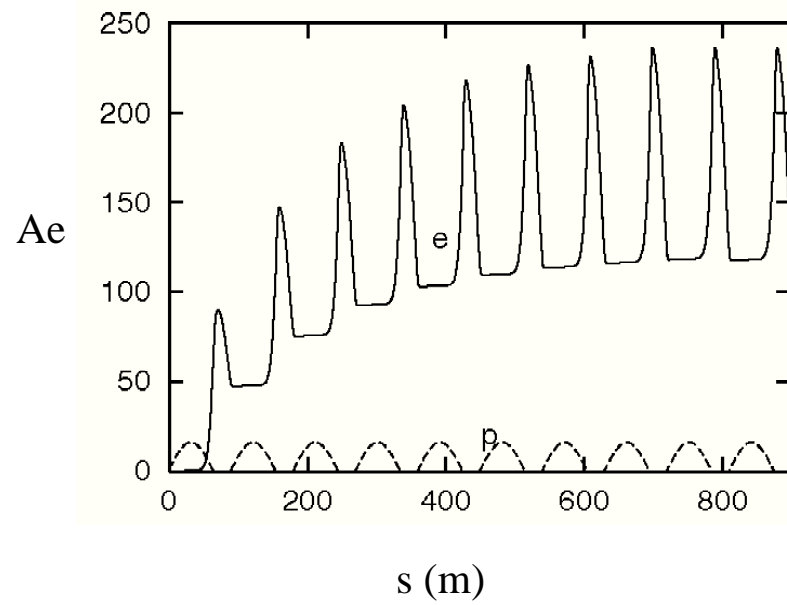


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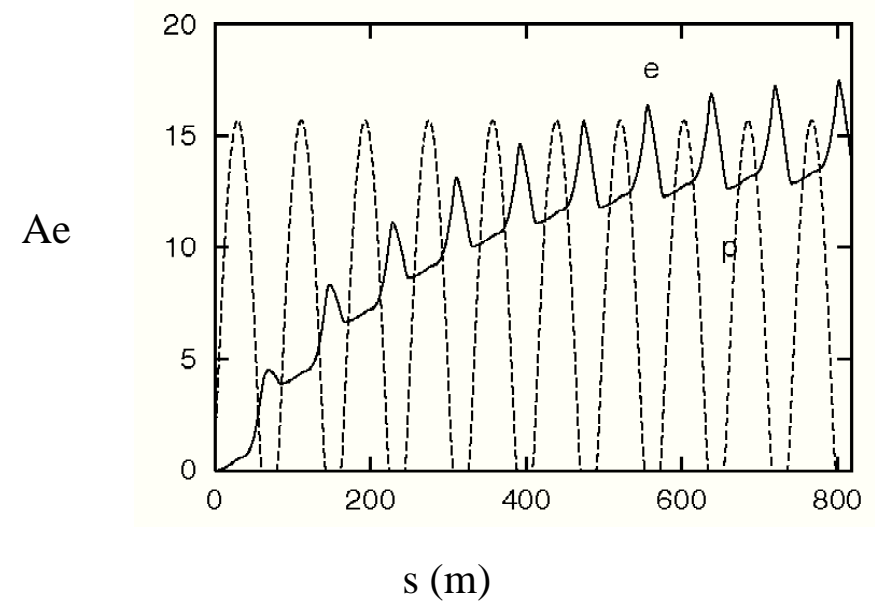


# Estimation of E-cloud

PSR

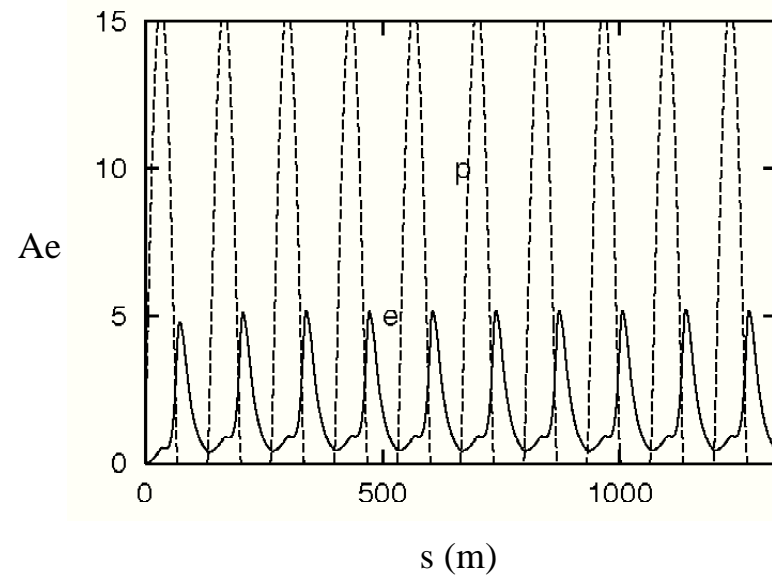


ISIS



# Estimation of E-cloud

AGS



# Estimation of stability

Electron cloud build-up of the proton rings

Variable	Joint project				PSR	ISIS	AGS
	3 GeV RCS		50 GeV MR				
	inj.	ext.	inj.	ext.			
Ae(bottom)	42.0	18.0	9.4	0.13	118	12.9	0.42
Ae(peak)	87.6	62	136	6.9	236	17.5	5.18
$\eta$ (bottom)	0.020	0.0067	0.0035	0.00001	0.034	0.003	0.0001
$\eta$ (peak)	0.042	0.023	0.05	0.0005	0.067	0.005	0.0015

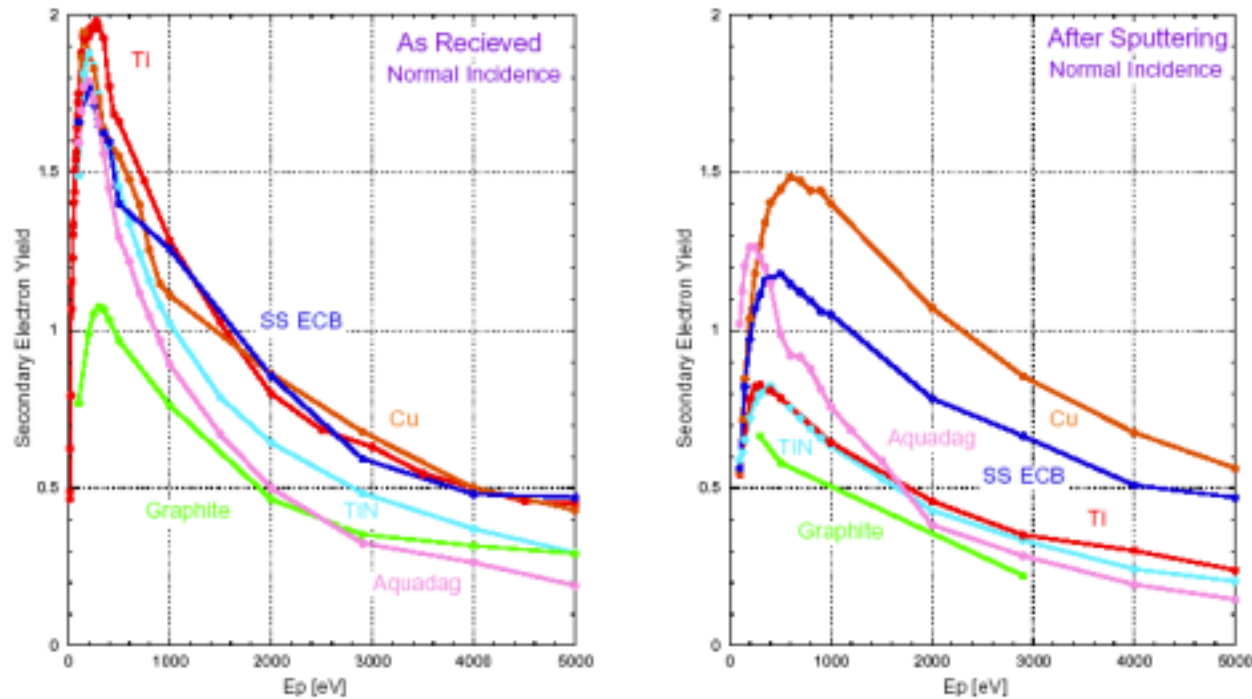
# Estimation of stability

Wake field and stability for electron cloud instability

Variable	Joint project				PSR	ISIS
	3 GeV RCS		50 GeV MR			
	inj.	ext.	inj.	ext.		
$Z(\omega_e)_L/Q$ (M $\Omega$ /m)	0.11	0.088	0.21	0.006	0.17	0.002
$Z(\omega_e)_H/Q$ (M $\Omega$ /m)	0.22	0.30	3.0	0.30	0.34	0.003
$\omega_e l_p / c$	134	185	185	261	83	15
$U_L$	0.08	0.23	0.11	0.02	1.6	0.10
$U_H$	0.16	0.81	1.5	1.1	3.2	0.17

# SEY measurements

- Chamber material
  - Secondary electron emission from metals and graphites / S. Kato and M. Nishiwaki



Dependence of secondary electron yields on a primary electron energy at the surfaces as-received and after sputtering.

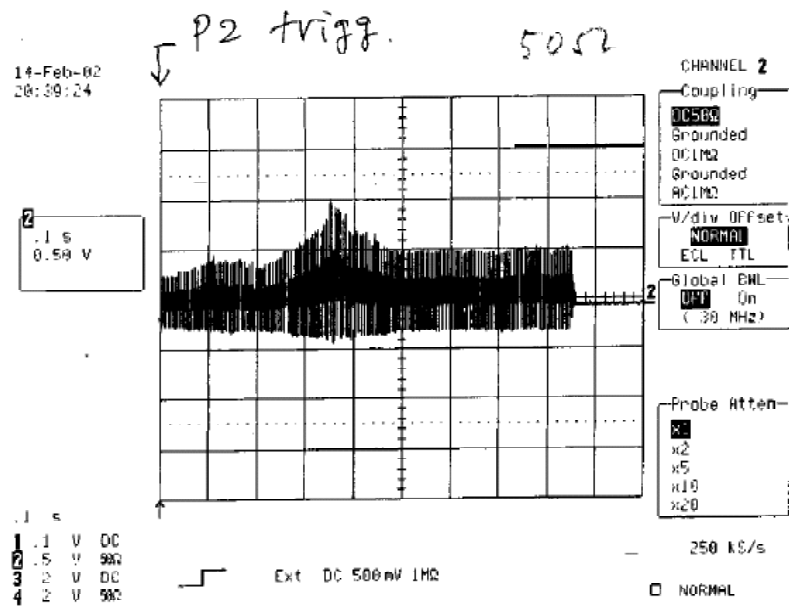
# E-clouds in the KEK-PS



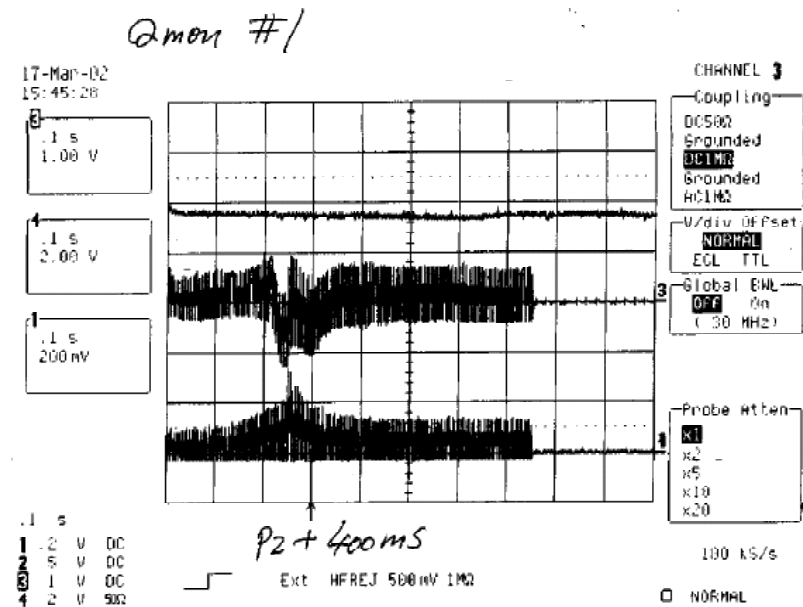
- Motivation
  - Check the validity of the simulation by comparing with experimental results
  - Check the material effects on the e-cloud
- Preliminary measurement in the KEK-PS MR
  - Using electrostatic monitor / exciter

# E-clouds in the KEK-PS (2)

In the 12 GeV MR, charge-up of electrodes are observed  
 After acceleration start (P2), curious baseline shift was observed  
 Beam intensity  $\sim 2.5 \times 10^{12}$  p+/9 bunches



Wall current monitor

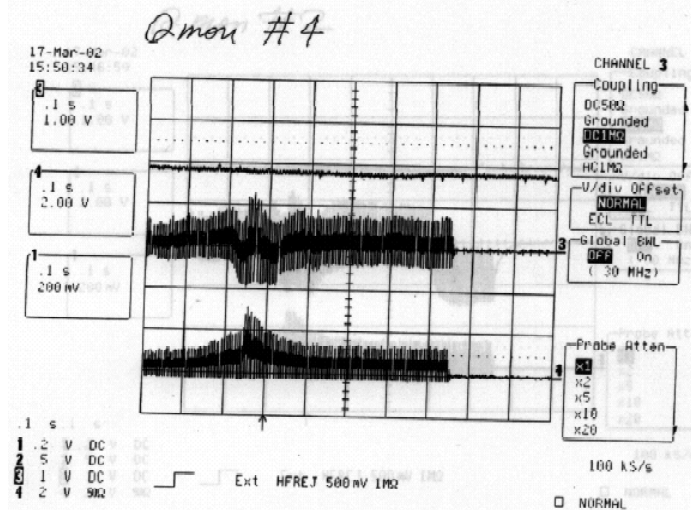
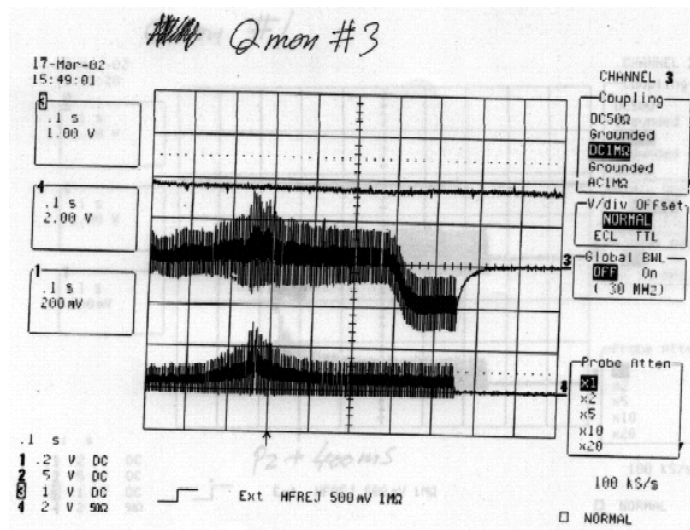
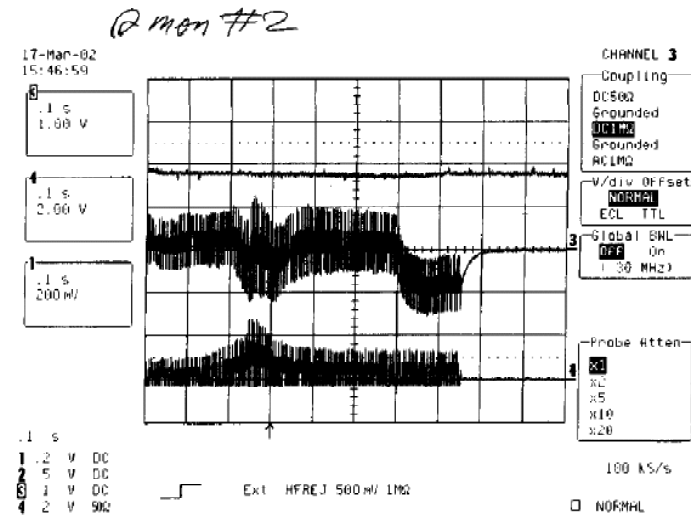


Upper trace: beam intensity  
 Middle trace: E.S. electrode

# E-clouds in the KEK-PS (3)

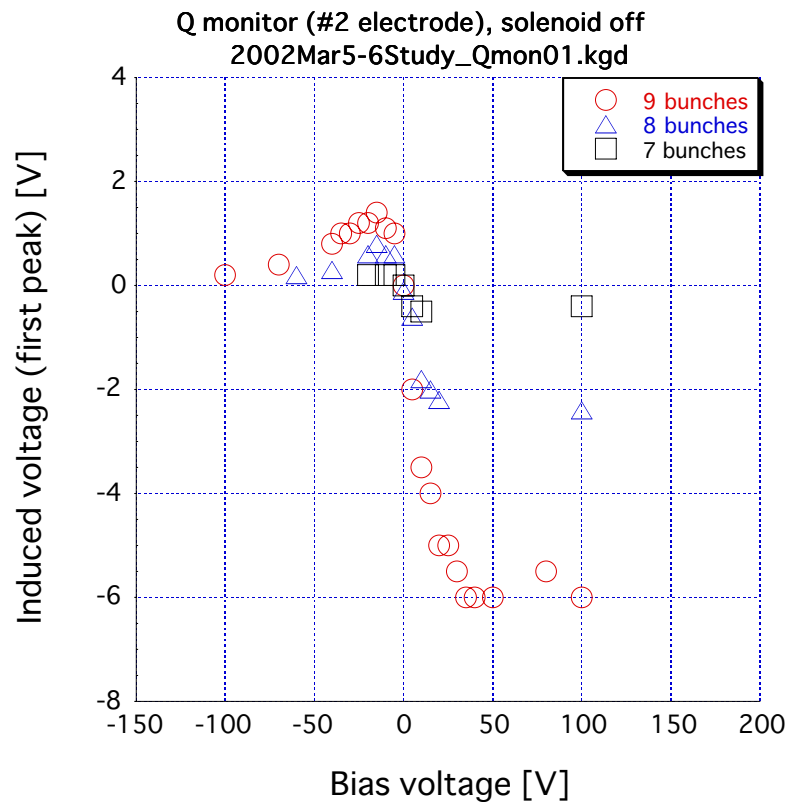
Other electrodes of the same P.U.  
also had baseline shift

the same condition as before

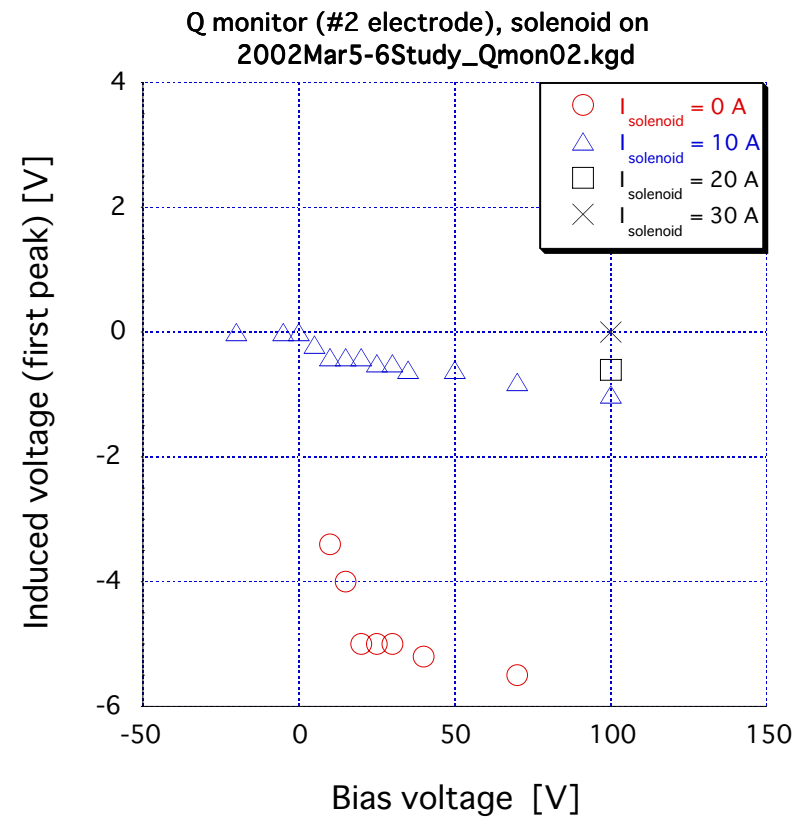


# E-clouds in the KEK-PS (4)

Bias dependence  
with or w/o empty buckets

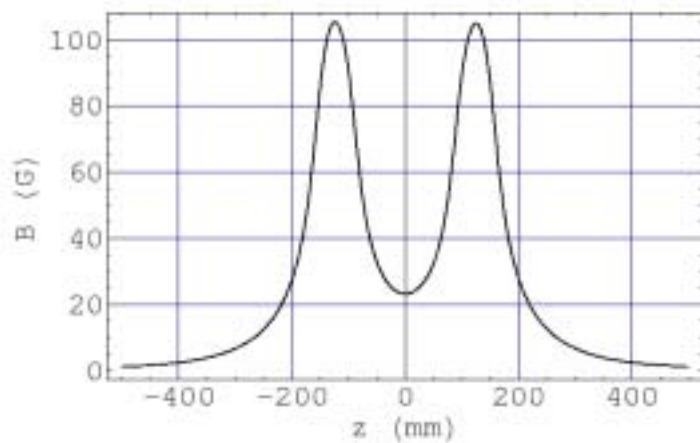
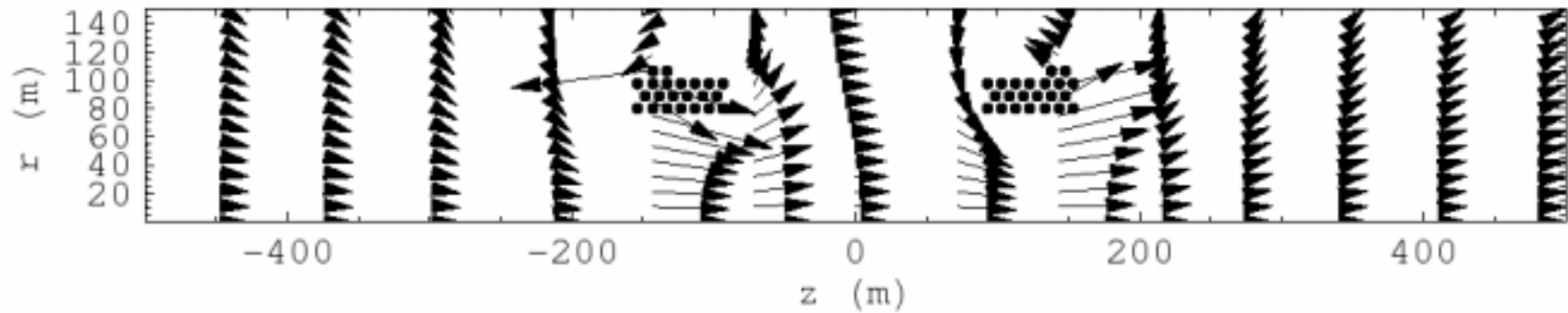


Effects of solenoidal fields  
at 9 bunches (full filling)



# E-clouds in the KEK-PS (5)

Calculated magnetic field at 25 A



Lamor radius at 300 eV  
~23 mm at 25 G

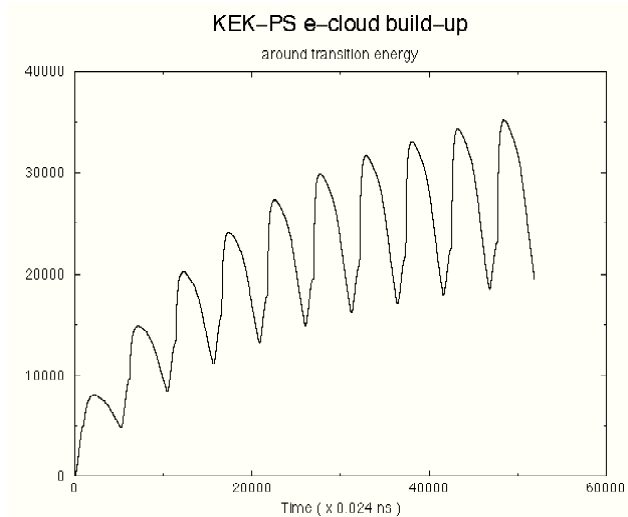
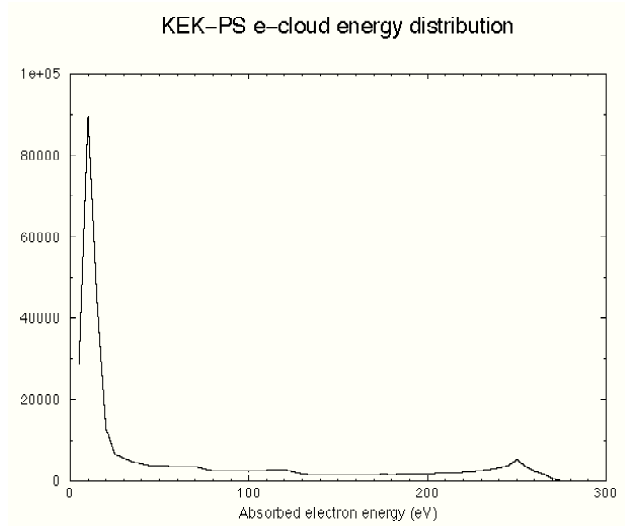
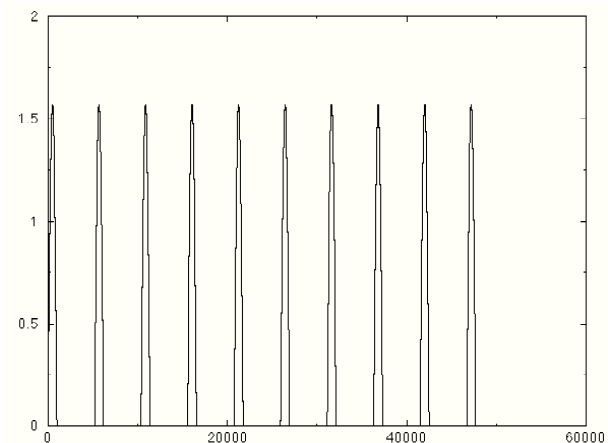
25 A, duct surface

# Simulation of e-clouds in the KEK-PS

SEY = 2.1 at 200 eV  
no elastic reflection

~5000 primary e<sup>-</sup> yield/ bunch

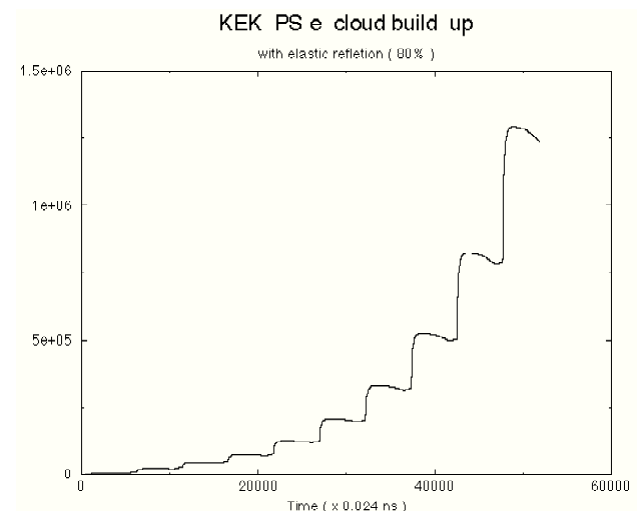
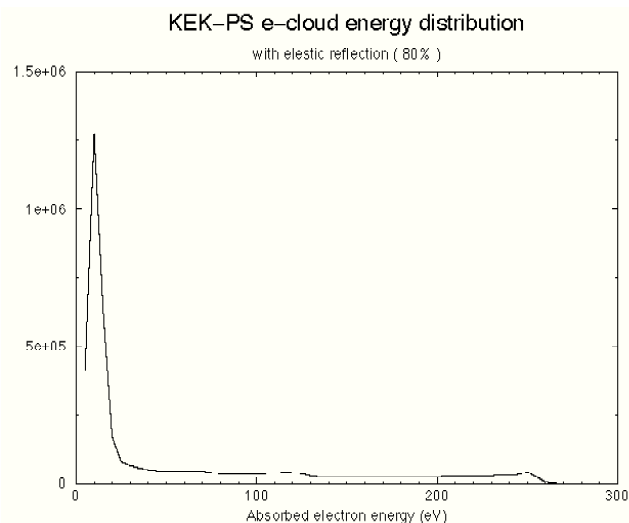
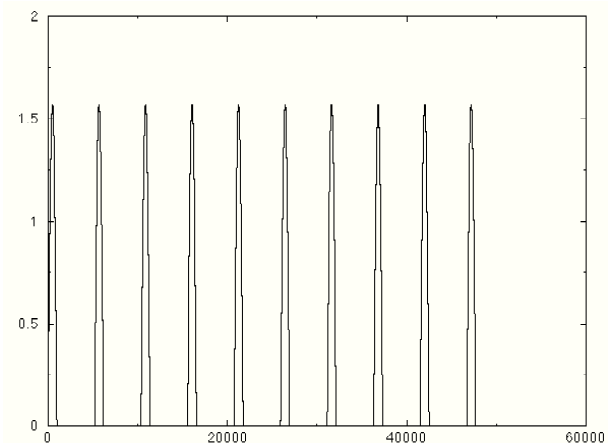
Amplification factor ~ 7



# Simulation of e-clouds in the KEK-PS (2)

SEY = 2.1 at 200 eV  
with elastic reflection (80% at 0eV)

Amplification factor >260  
(not saturated yet)



# Summary



- ECE simulation for the 3 GeV RCS and 50 GeV MR
  - E-cloud build-up was estimated, assuming primary electron yield
  - Estimation: field-free region, SEY=2.1 without elastic reflection
  - Qualitative agreement with observations
  - Need further investigation
- Vacuum system
  - TiN coating on 3GeV RCS vacuum pipe
  - For 50GeV MR vacuum pipe --- coating not yet decided
  - SEY measurement is going on
  - Cure by clearing wires to be examined
- Experiments in the KEK-PS
  - Some signs of e-cloud (?)
  - Dedicated detectors will be installed soon