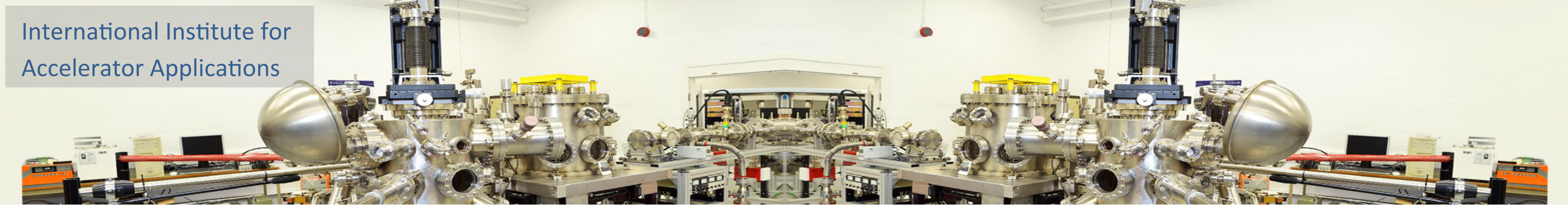
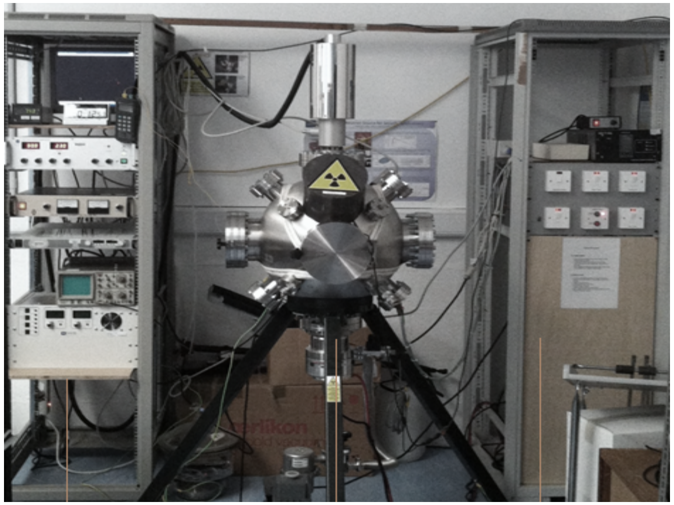
Seviour, Rebecca

Photonics, Particle Accelerators and beyond the Standard Model



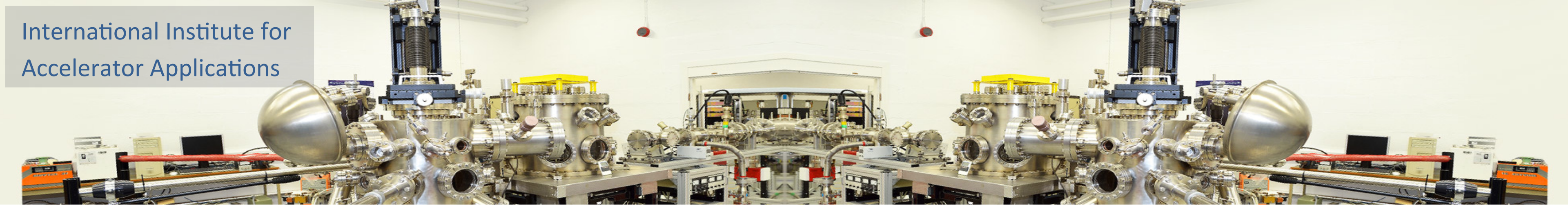
Photonics, Particle Accelerators and beyond the Standard Model

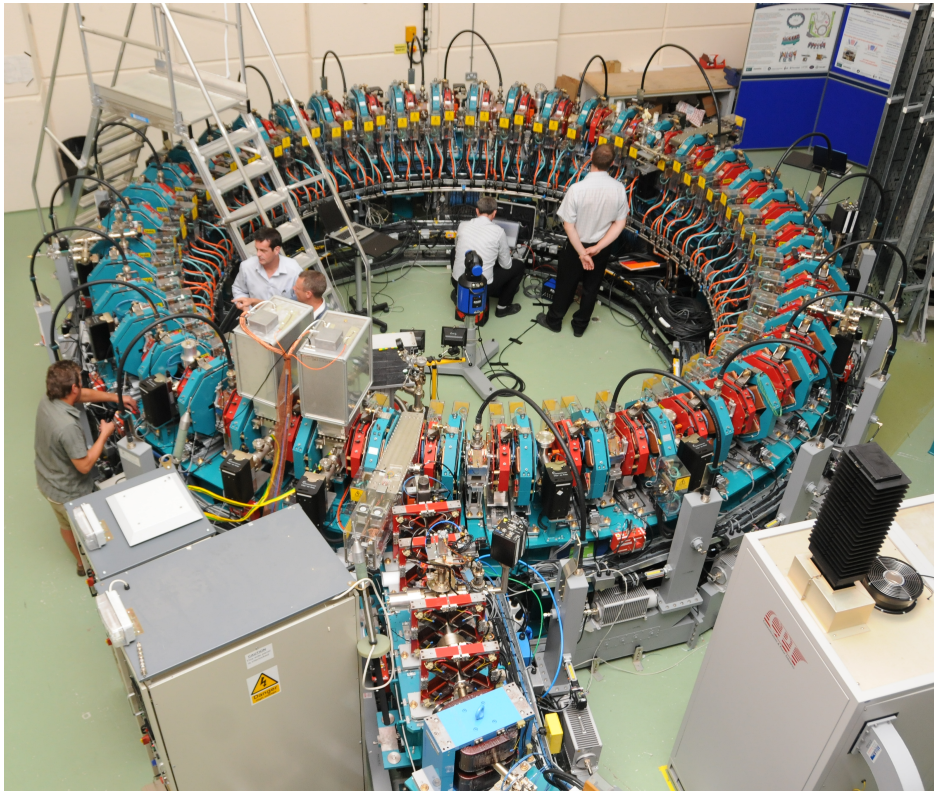


Prof Rebecca Seviour

International Institute for Accelerator Applications

University of Huddersfield





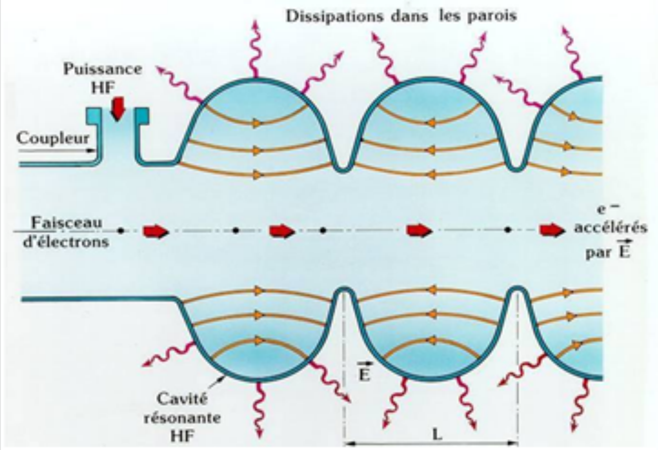
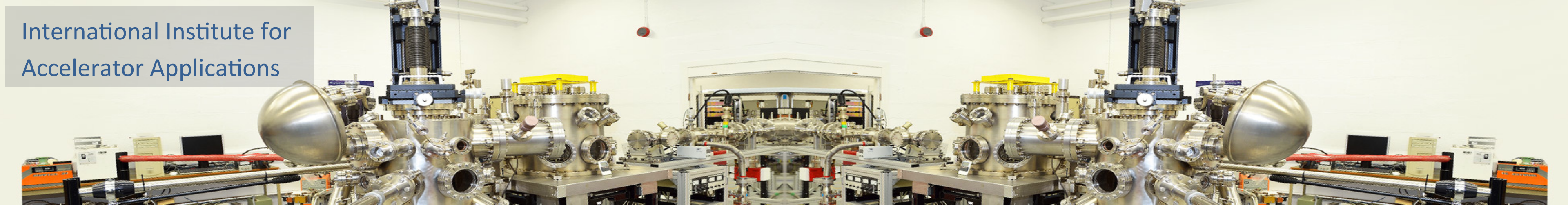
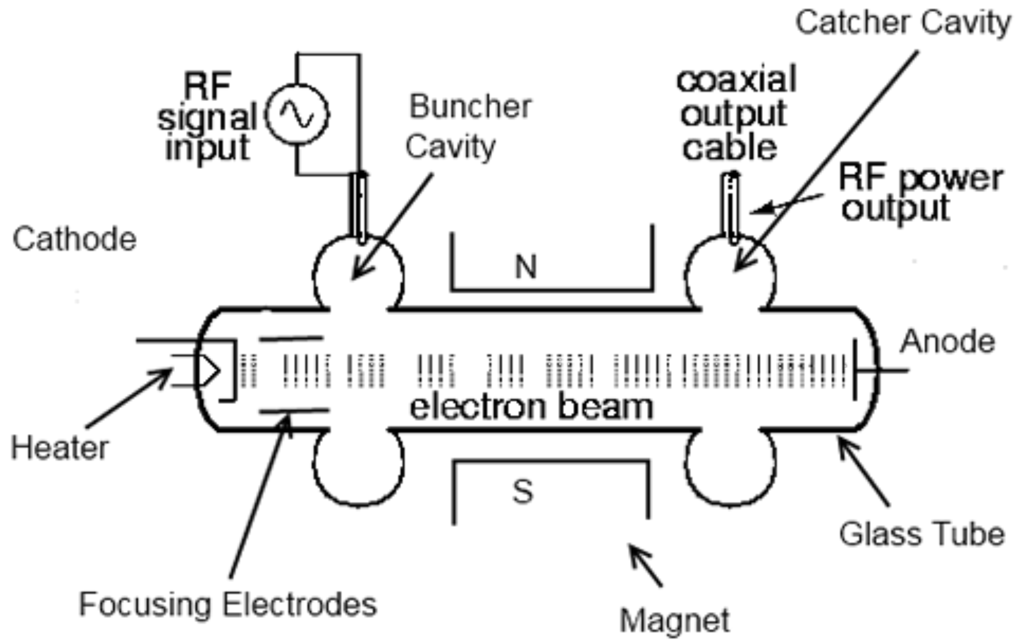
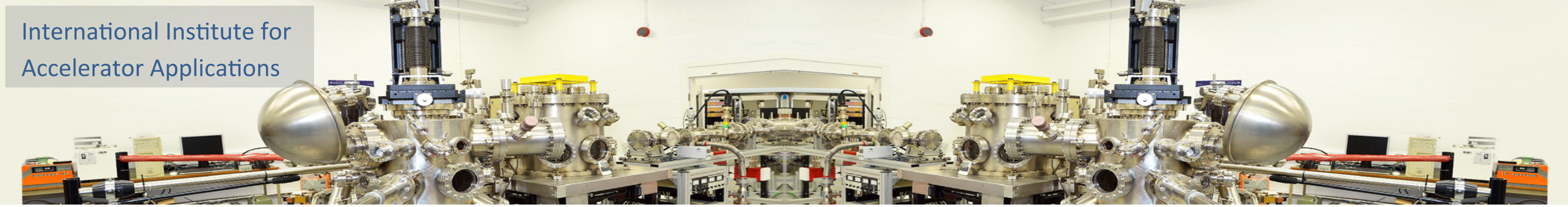
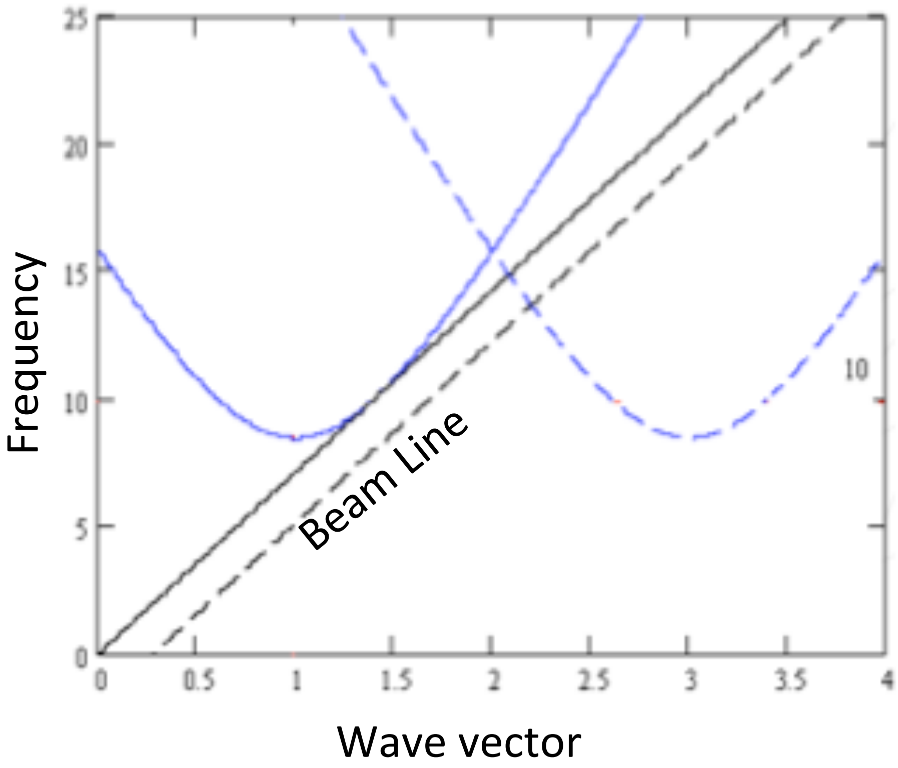


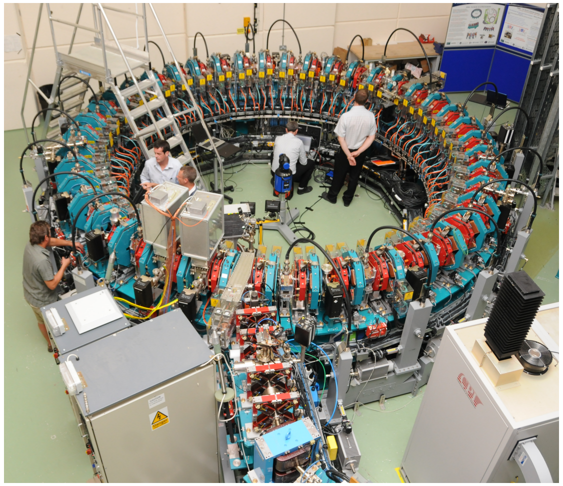
Figure 1 Schéma de la distribution du champ électrique dans une cavité résonnante



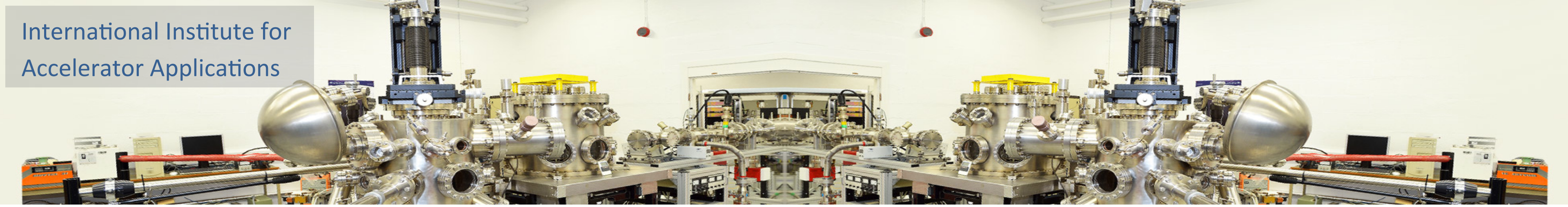

Catcher Cavity
RF signal input
Buncher Cavity
coaxial output cable
RF power output
Cathode
N
Anode
electron beam
Heater
S
Glass Tube
Focusing Electrodes
Magnet

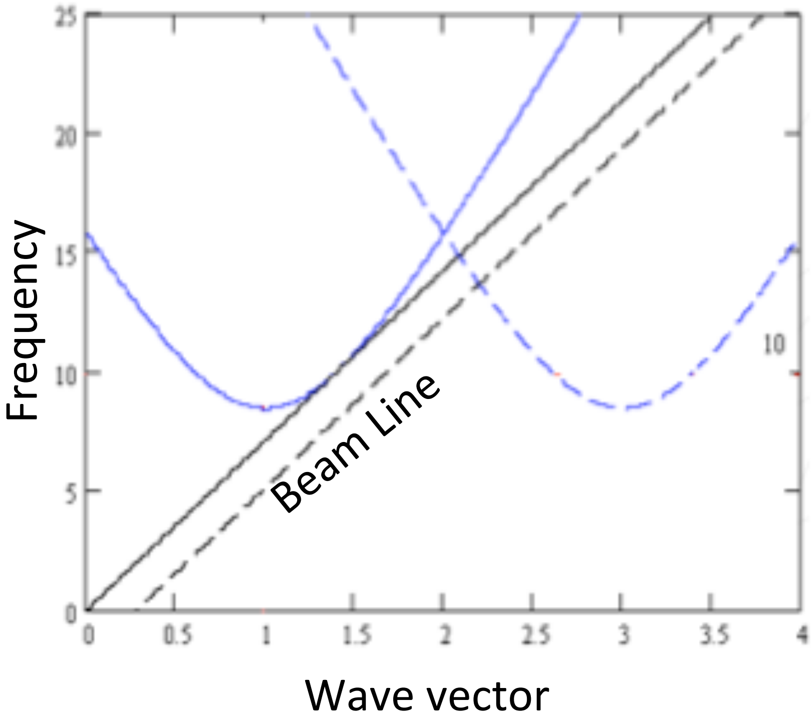


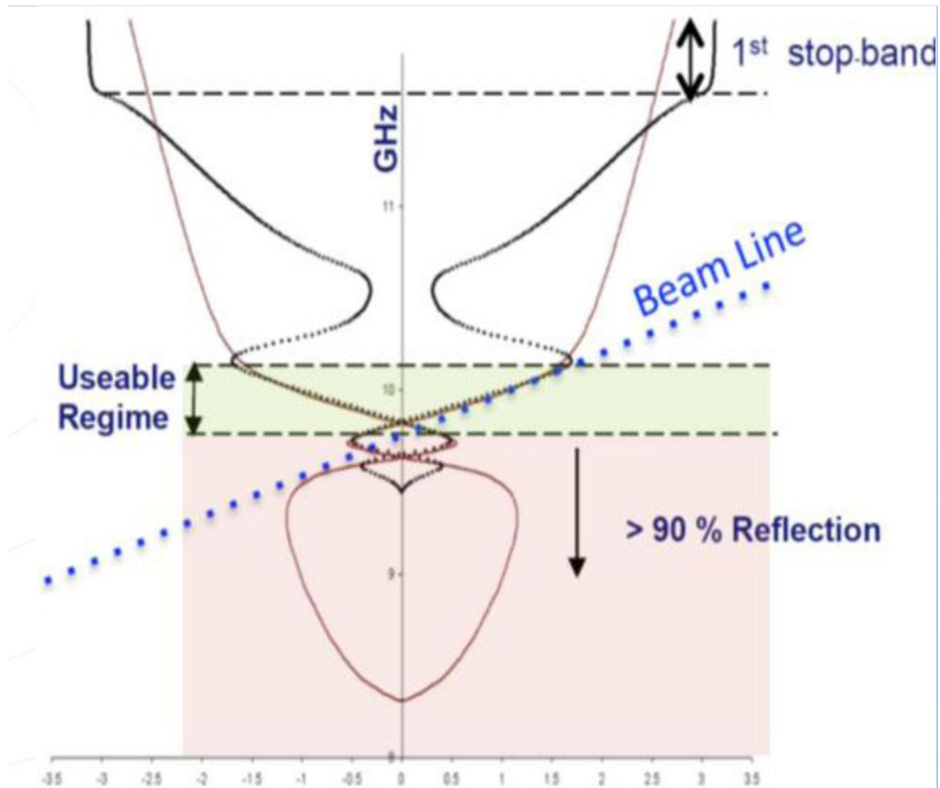


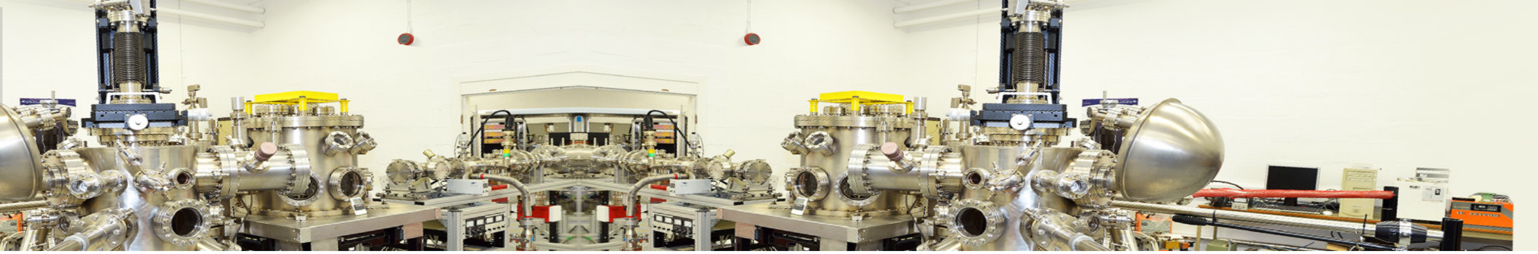


$$\hat{D} = \epsilon_0 \hat{E} + P = \epsilon \hat{E}$$
$$\hat{B} = \mu_0 \hat{H} + M = \mu \hat{H}$$

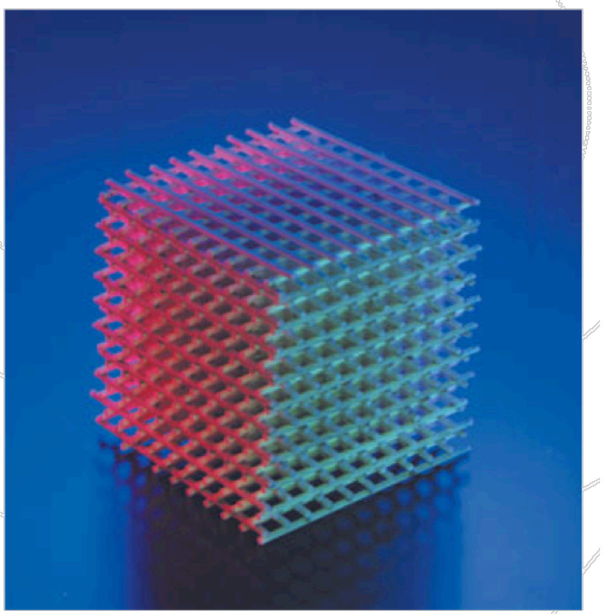



Frequency
Wave vector
Beam Line
10


1st stop band
GHz
Beam Line
Useable
Regime
> 90 % Reflection

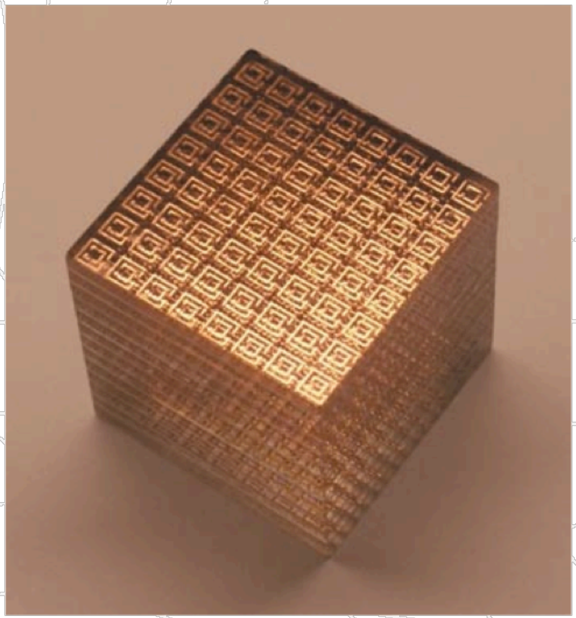


Photonic

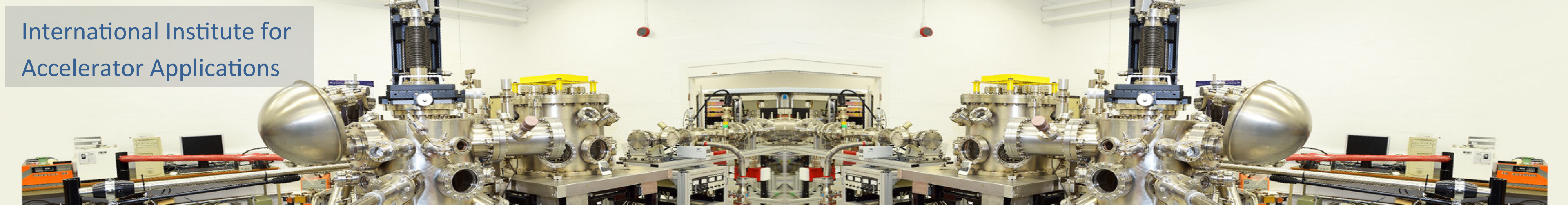


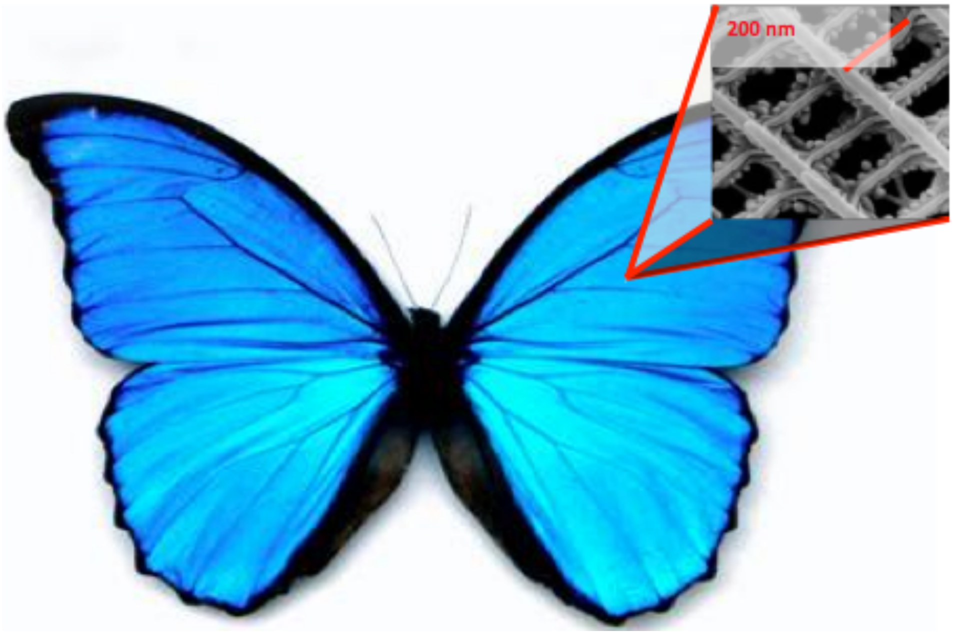
$a \sim \lambda$

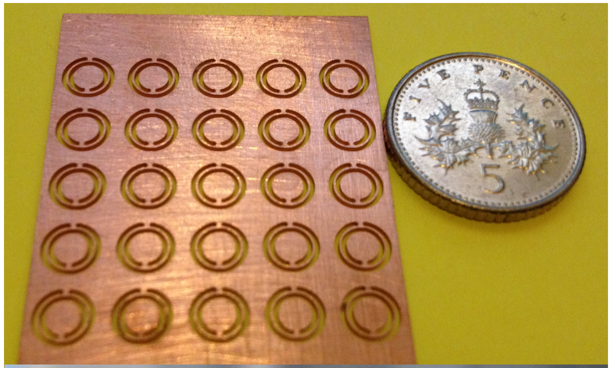
Metamaterial

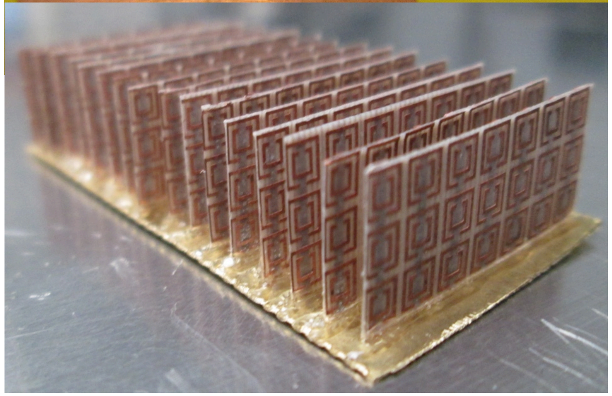


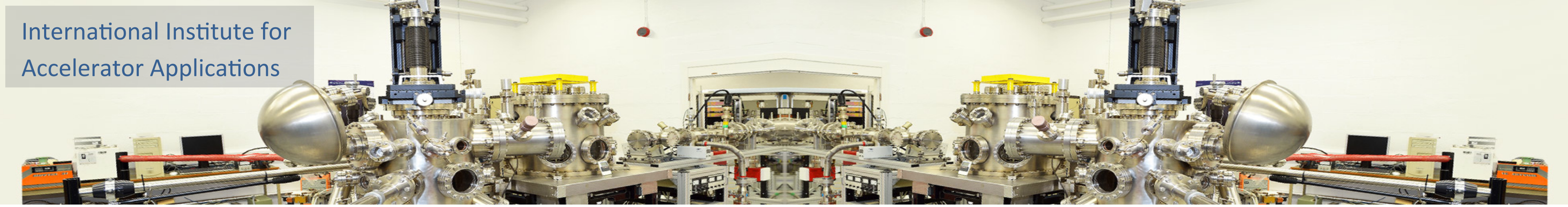
$a \ll \lambda$




200 nm

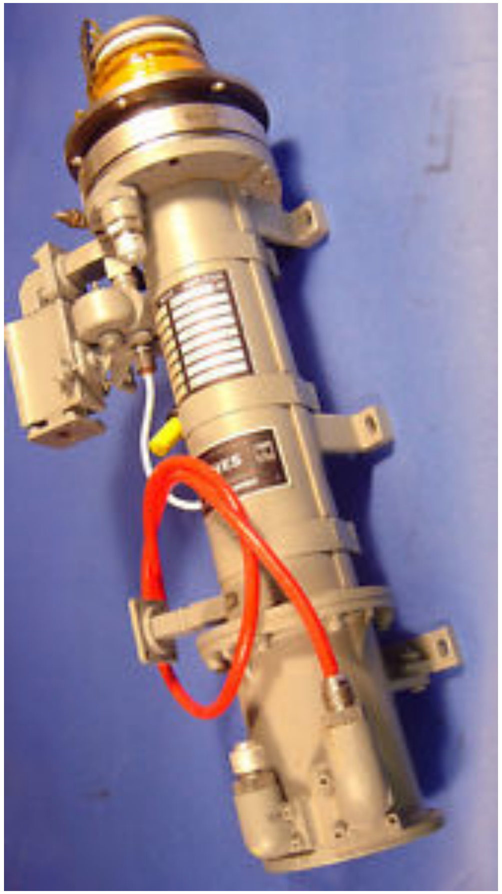


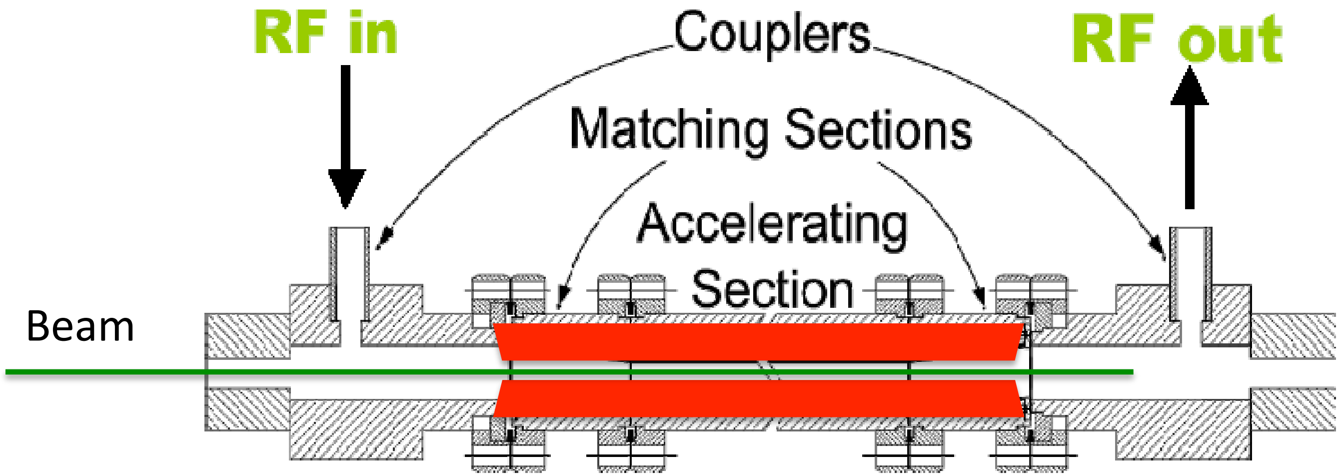


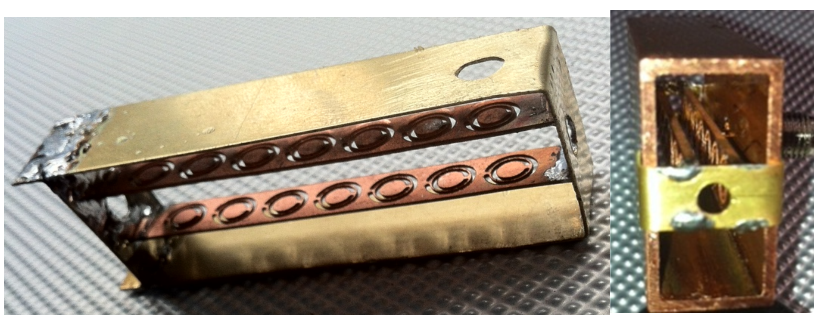


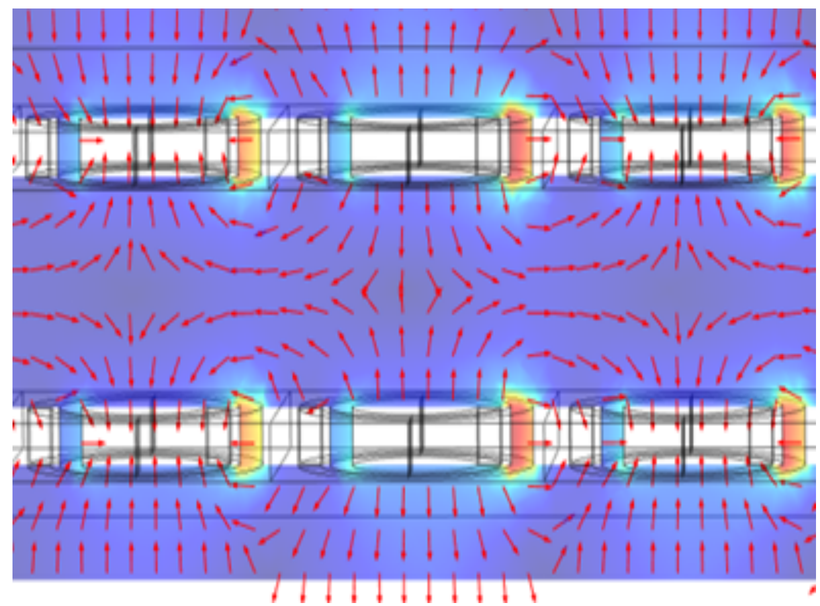
**ERSF 75KW
Solid State RF**

Hughes TWT - RF Tube 100kW

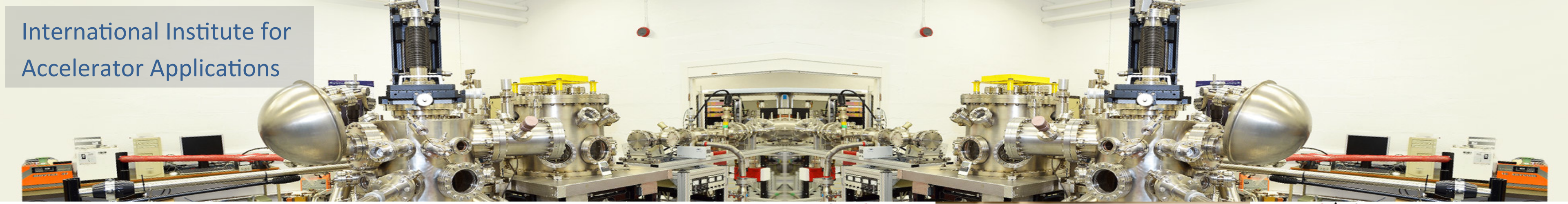








E field 9.6 GHz
π - Mode

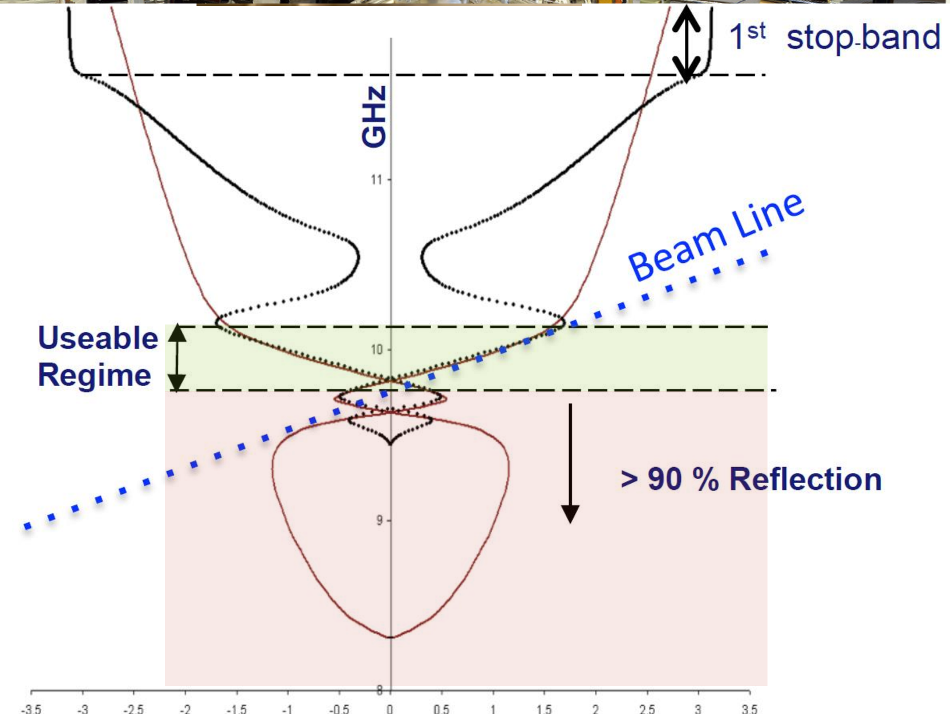


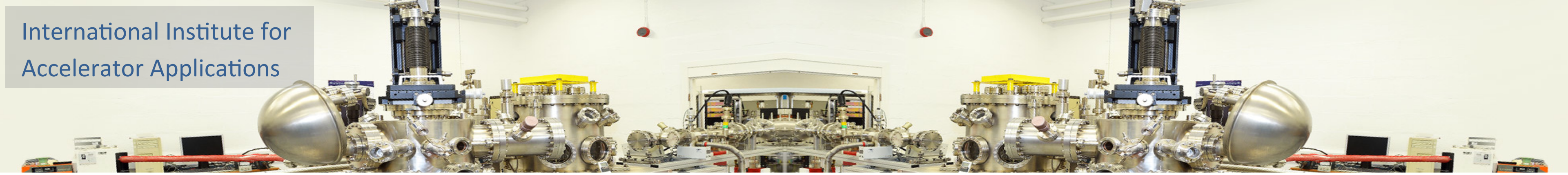
$$\omega = \sqrt{c^2 \left(\gamma_n - \left(\frac{\pi(2n+1)}{p} + \beta_{mm}(f)\frac{\Delta h}{p} \right) \right)^2 \alpha + \omega_c^2}$$

$$\gamma_n = \beta_0 \frac{p+h-\Delta h}{p} + \beta_{mm}(\omega)\frac{\Delta h}{p} + (2n+1)\frac{\pi}{p}$$

$$\alpha = \left(\frac{p}{p+h-\Delta h} \right)^2$$

$$\beta_{mm}(\omega) = c^{-1}\sqrt{\omega^2 \epsilon_r(\omega)\mu_r(\omega) - \omega_c^2}$$





Lorentz's Force Equation

Time changing in $m_0c^2\gamma$ (DC and AC beam energy) is related by the E.v dot product in this equation. The DC beam energy γdc is given by (1+Vdc/511); Vdc is the DC beam accelerating potential. While the AC beam energy exchange (stimulated emission) is calculated through the Madey's theory.

$$m_0c^2 \frac{d}{dt} = -\mathbf{E}$$

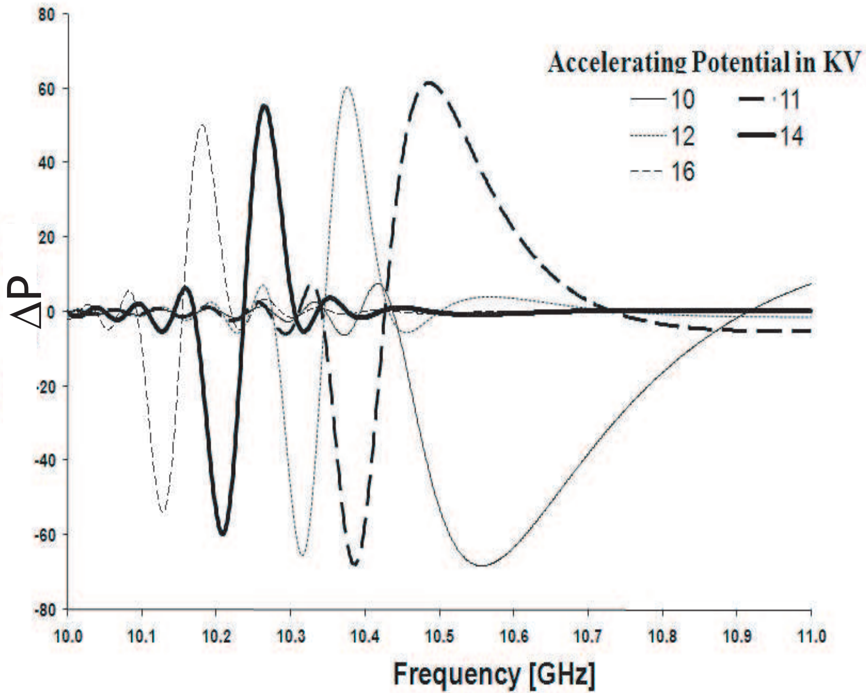
$$m_0c^2 \frac{d}{dt}{}_1 = -\mathbf{E}{}_0$$

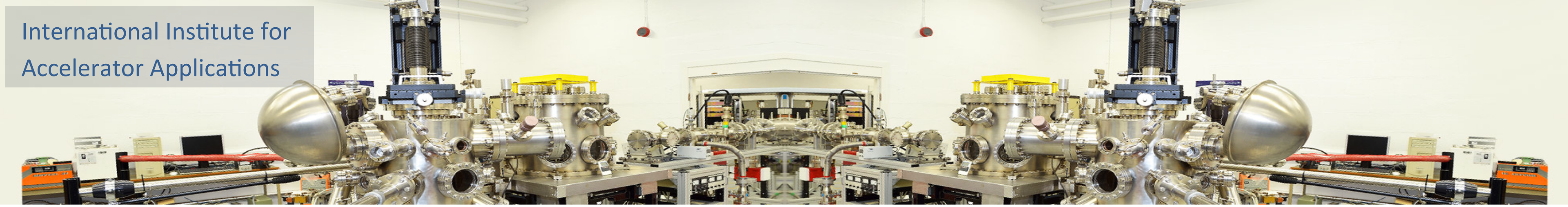
1st order perturbation >> Spontaneous emission

$$\langle \Delta\gamma_2 \rangle = \frac{1}{2}\frac{d}{d}\langle \Delta\gamma_1{}^2 \rangle$$

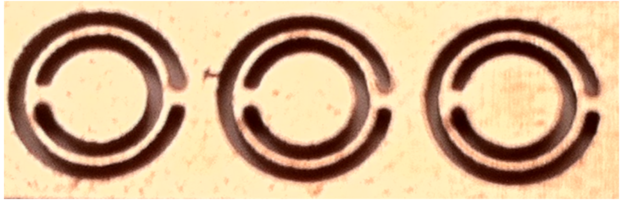
2nd order perturbation >> Stimulated emission

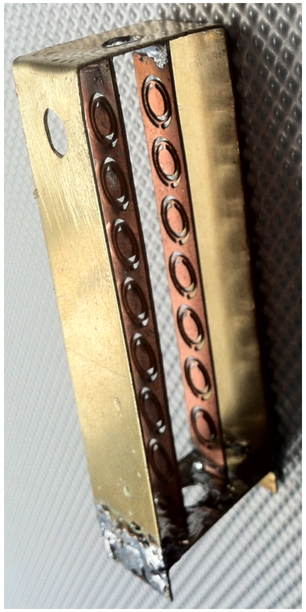
$$\frac{\Delta P_{out}}{P_{in}} = \frac{-\frac{1}{2}\frac{d}{d\gamma}\langle \Delta\gamma_1{}^2 \rangle m_0c^2 \frac{I}{e}}{P_{in}}$$

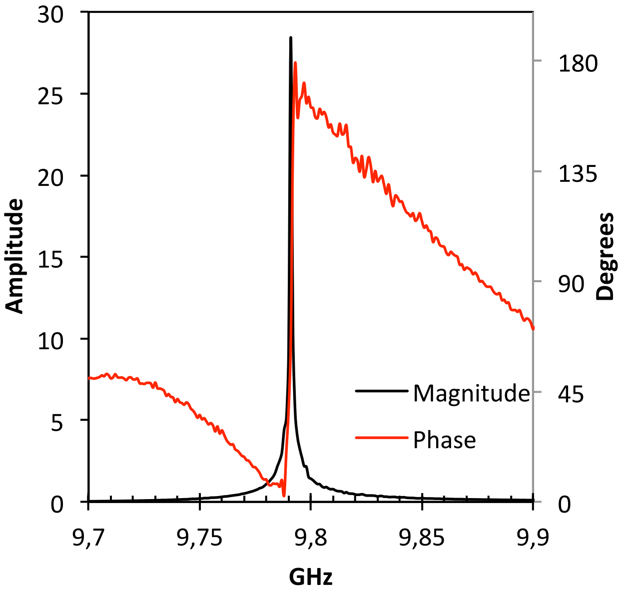




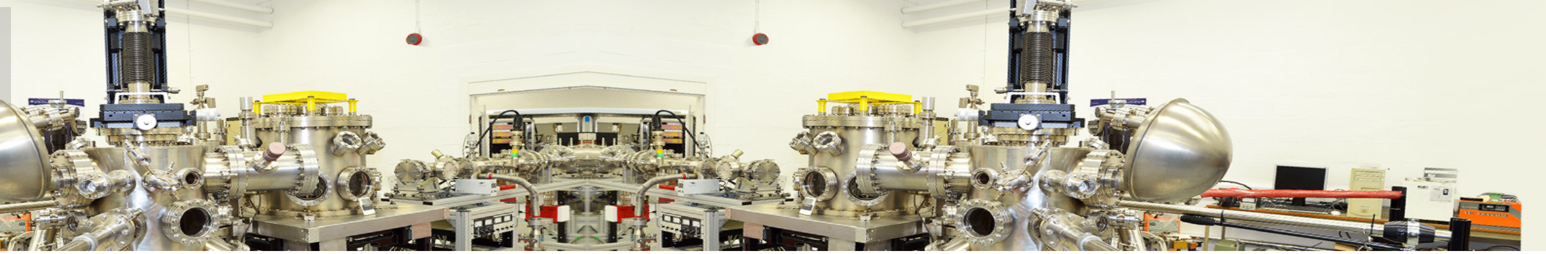
Complementary **S**plit **R**ing **R**esonator

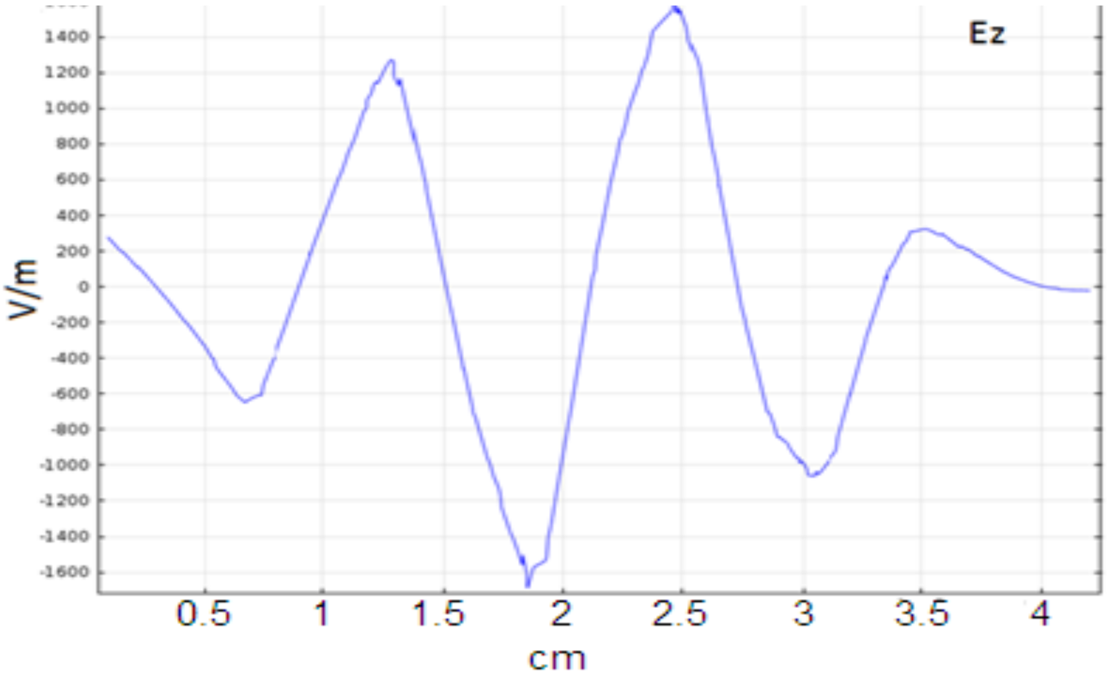


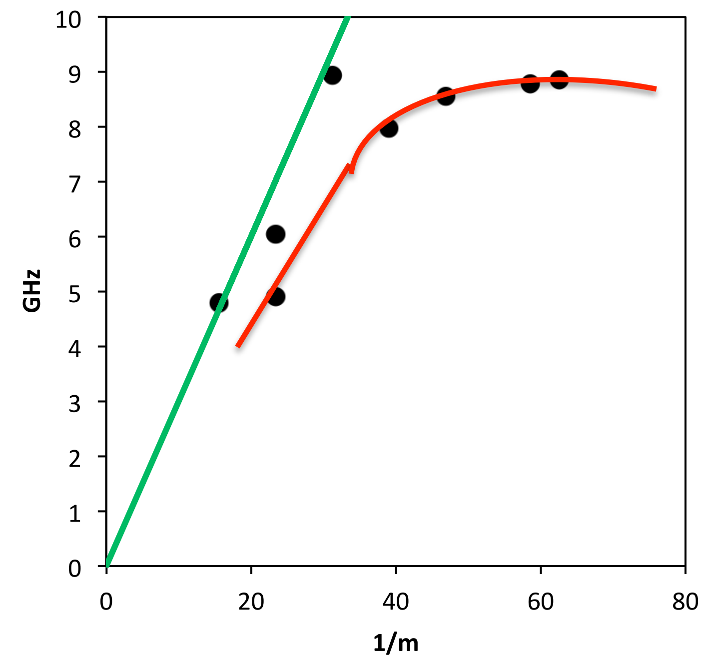




Transmission through CSRR interrupting waveguide.



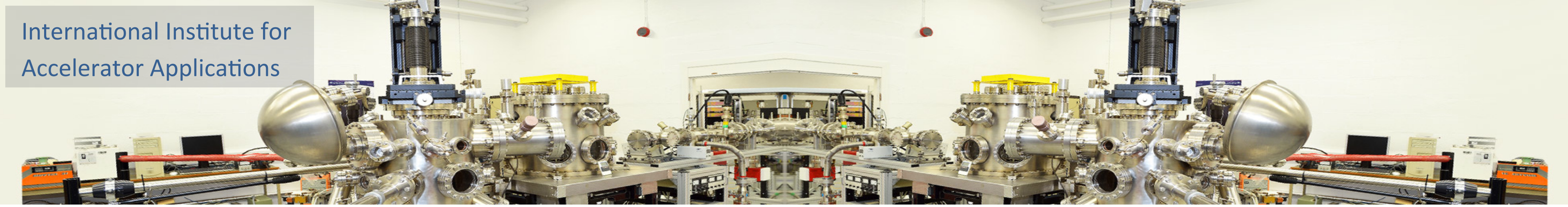


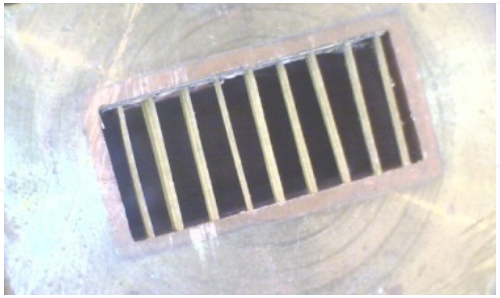


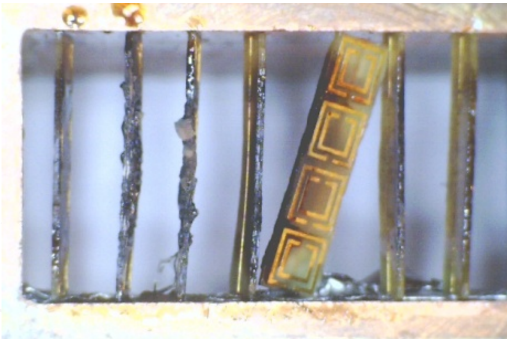
- 1.6 KeV/m Acc gradient

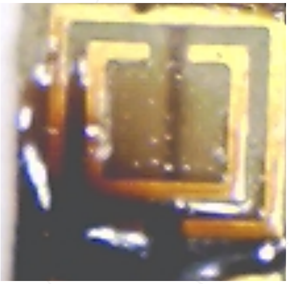
- About 1/5 of the gradient to a comparable pill box resonator

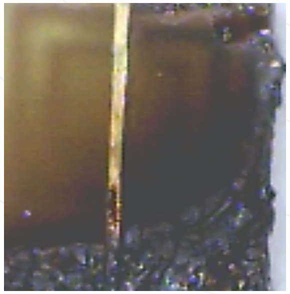
Dispersion relation extracted, black dots, with the light line shown in green.

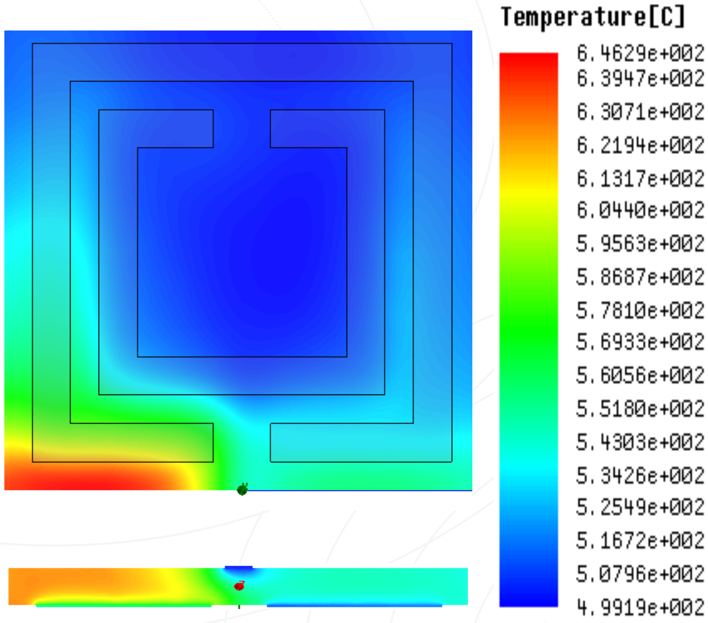


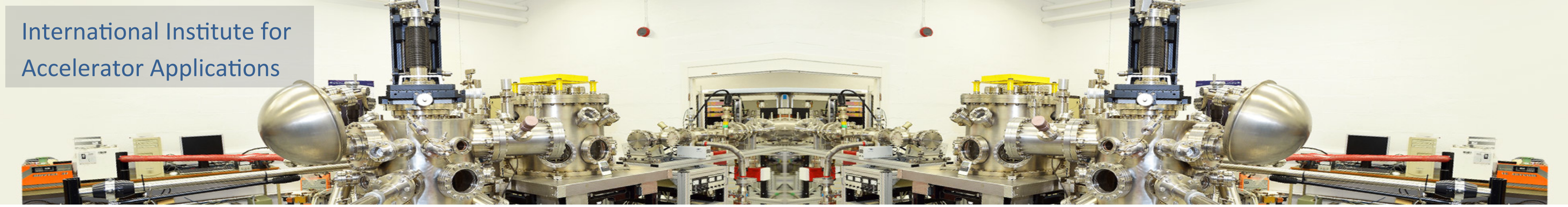


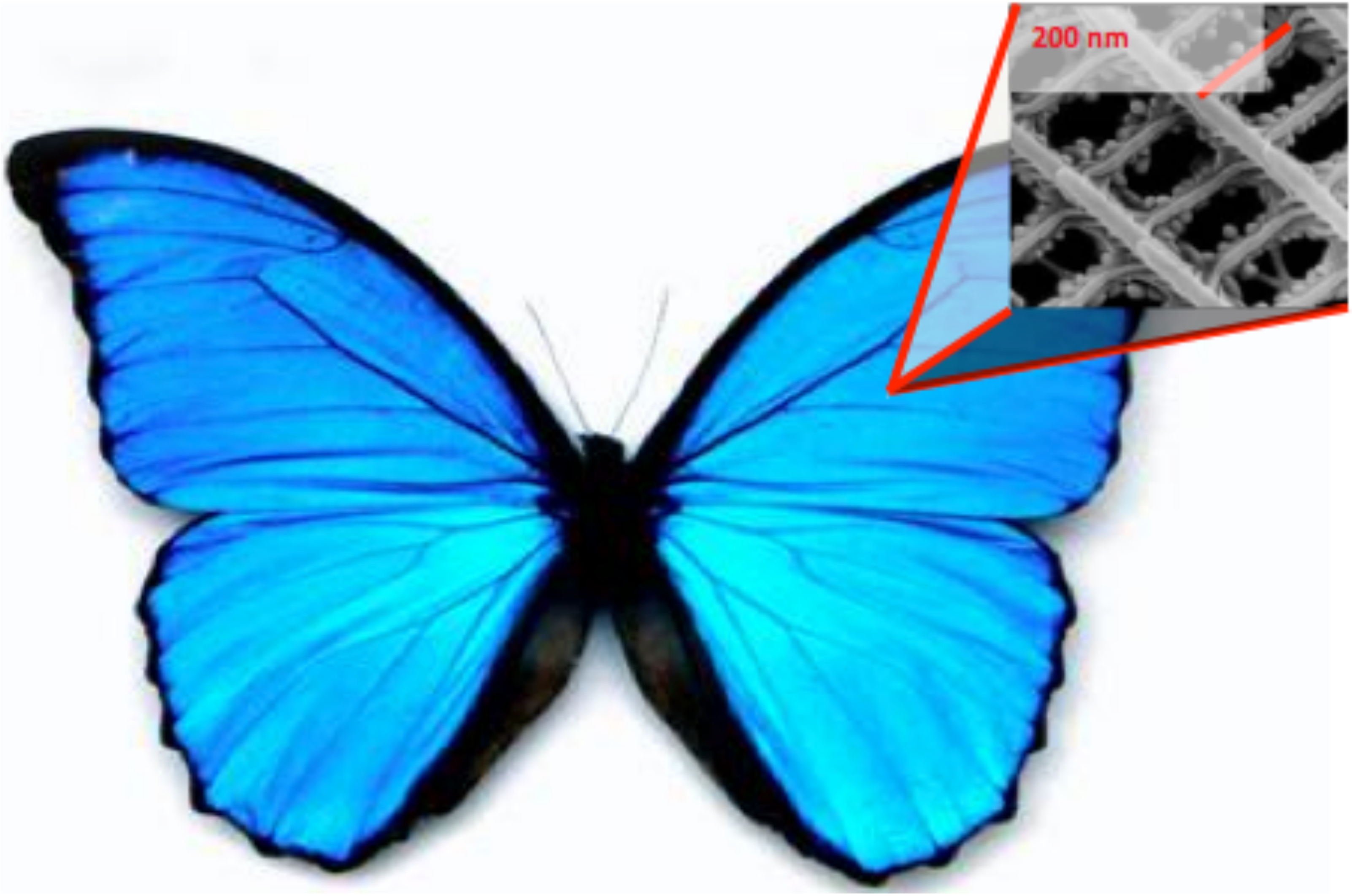


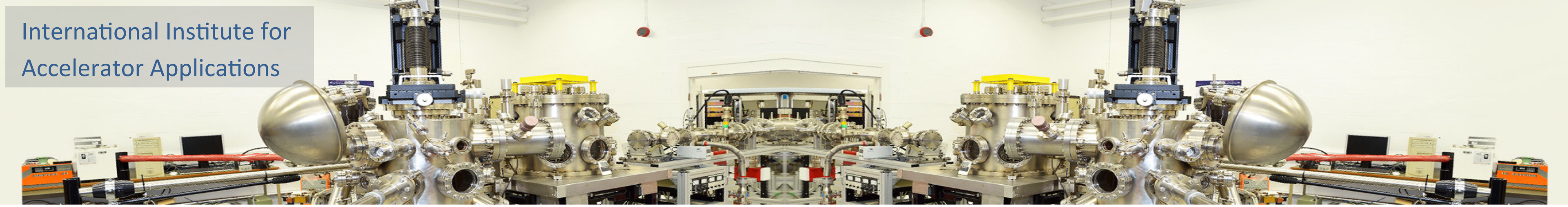





Temperature[C]
6.4629e+002
6.3947e+002
6.3071e+002
6.2194e+002
6.1317e+002
6.0440e+002
5.9563e+002
5.8687e+002
5.7810e+002
5.6933e+002
5.6056e+002
5.5180e+002
5.4303e+002
5.3426e+002
5.2549e+002
5.1672e+002
5.0796e+002
4.9919e+002




200 nm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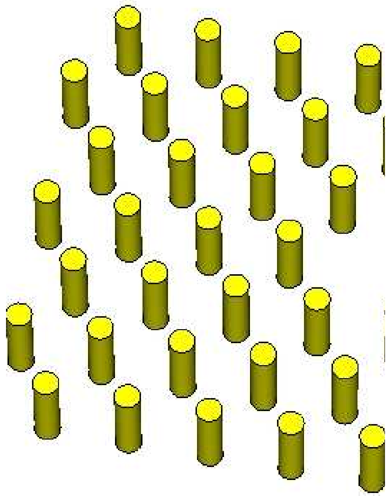
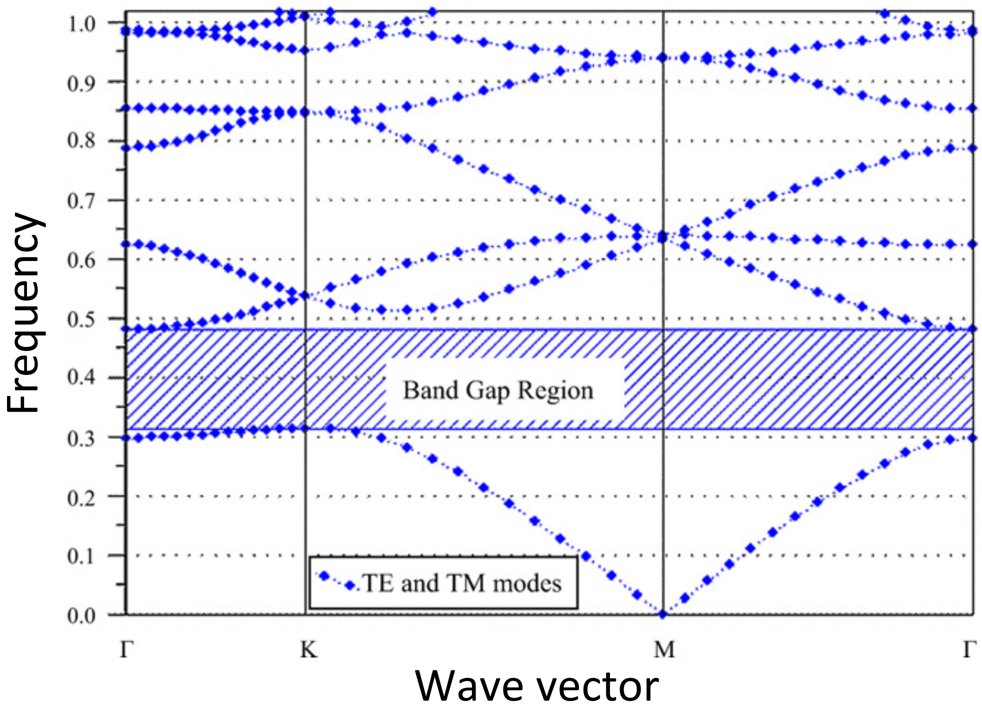
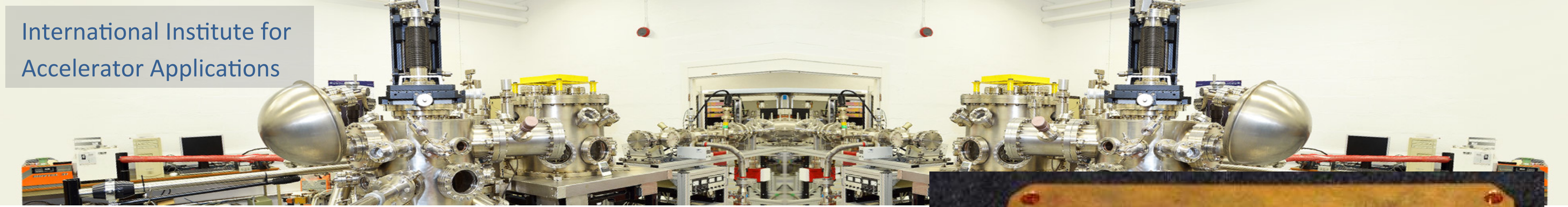
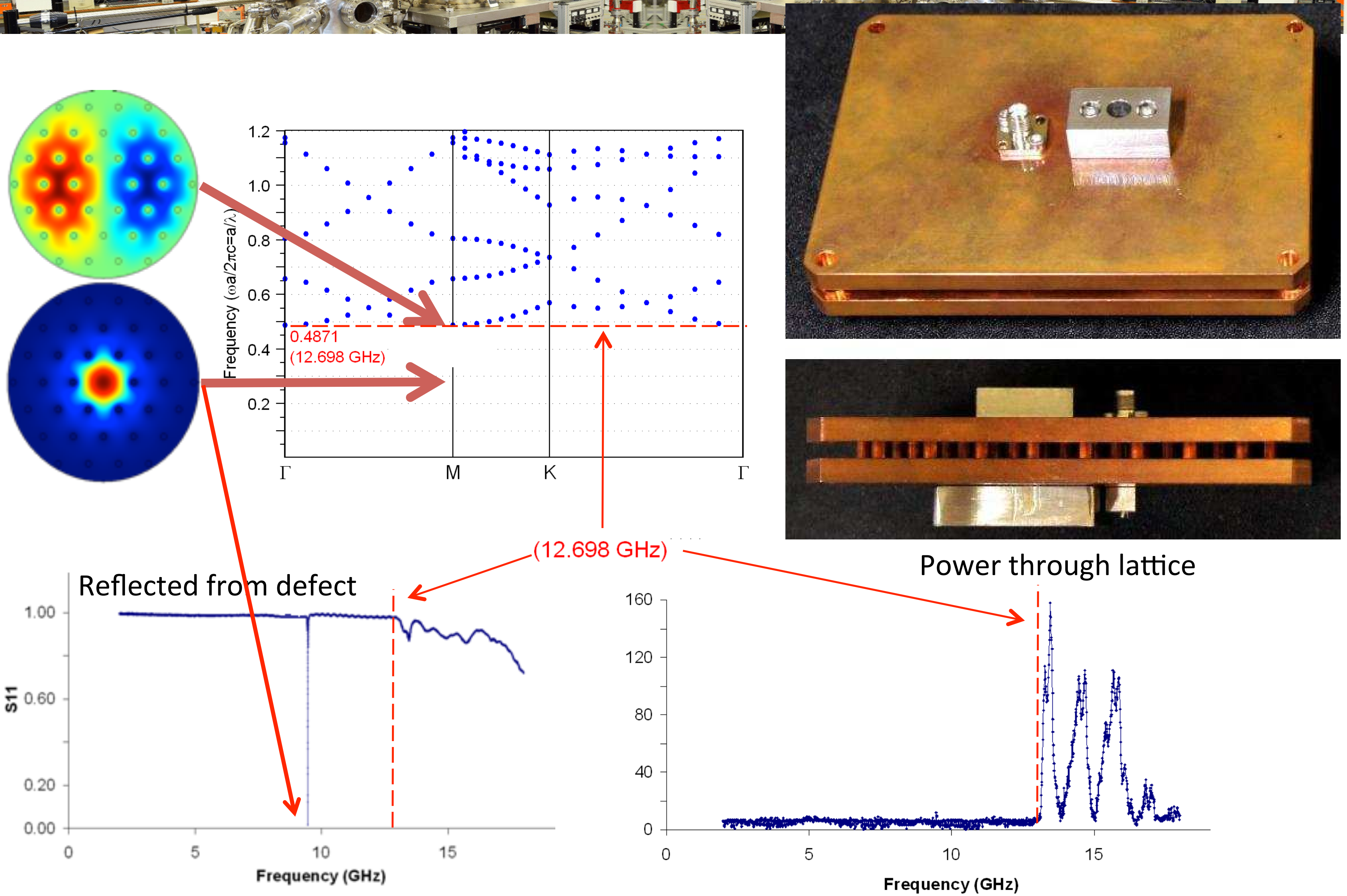
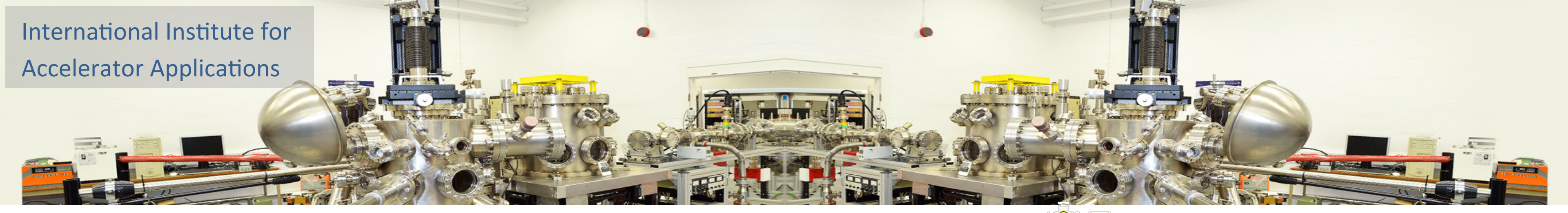
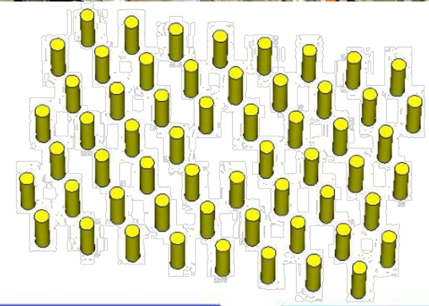


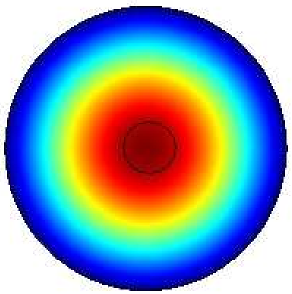

1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Frequency
Band Gap Region
TE and TM modes
Γ
K
M
Γ
Wave vector

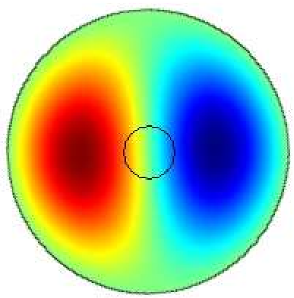

International Institute for
Accelerator Applications


1.2
1.0
0.8
0.6
0.4
0.2
Frequency (ωa/2πc=a/λ)
Γ
M
K
Γ
0.4871
(12.698 GHz)
(12.698 GHz)
Reflected from defect
1.00
0.60
0.20
0.00
S11
0
5
10
15
Frequency (GHz)
Power through lattice
160
120
80
40
0
0
5
10
15
Frequency (GHz)



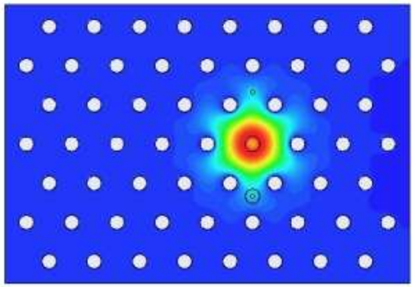


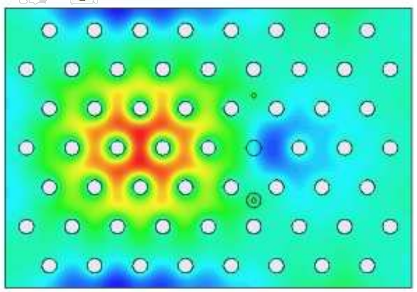




f_0 = 9.532 GHz
Q_{ohmic} = 3850

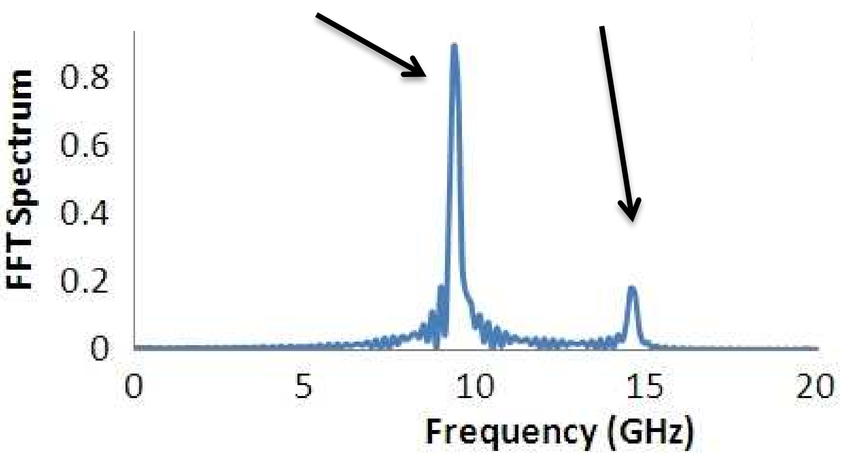
f_1 = 14.82 GHz
Q_{ohmic} = 4600

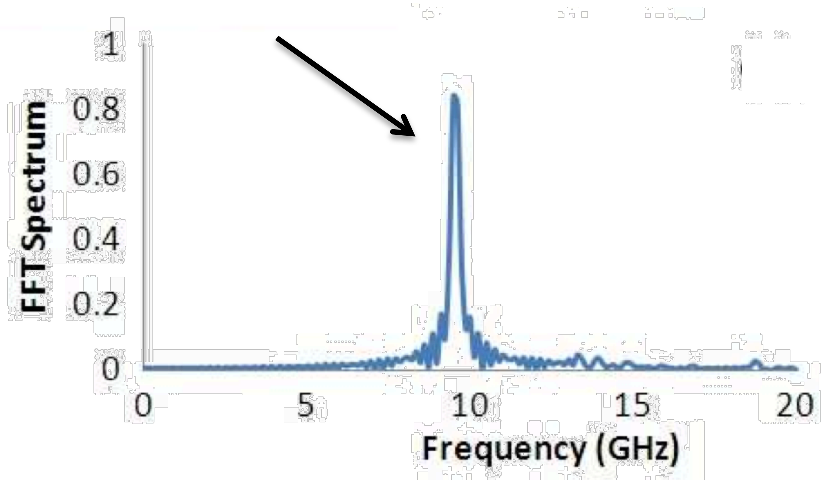


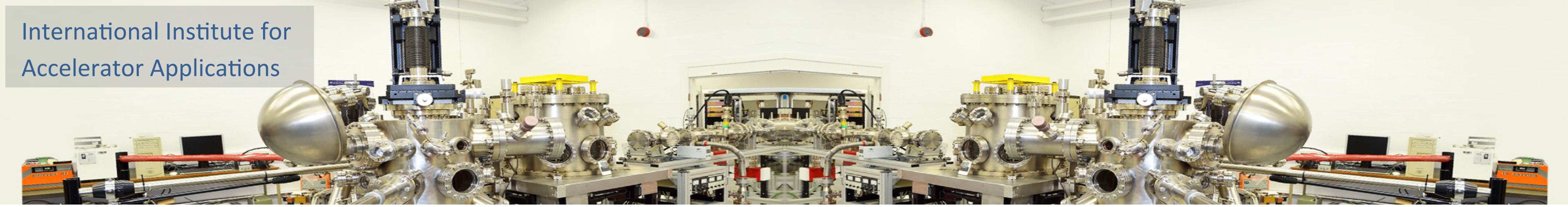


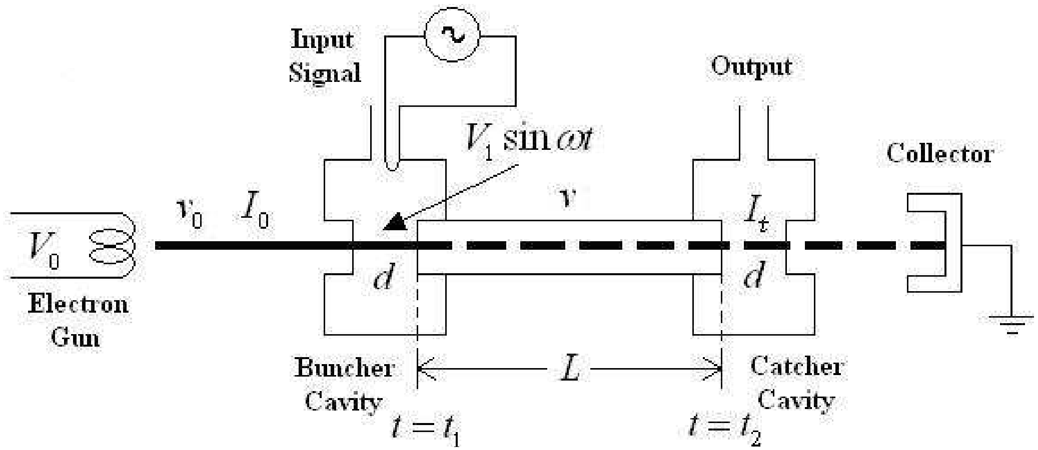
f_0 = 9.532 GHz
Q_{total} = 3200

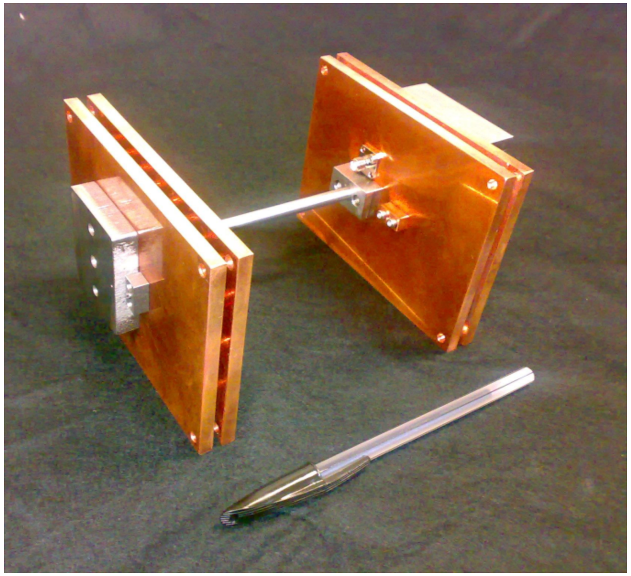
f_1 = 13.03 GHz
Q_{total} = 205

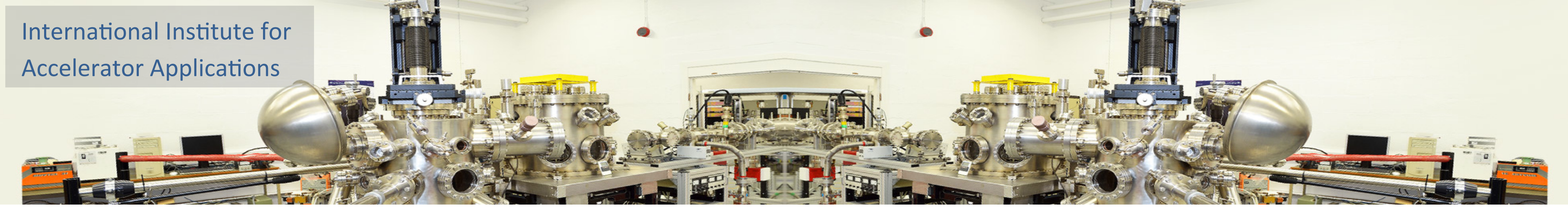


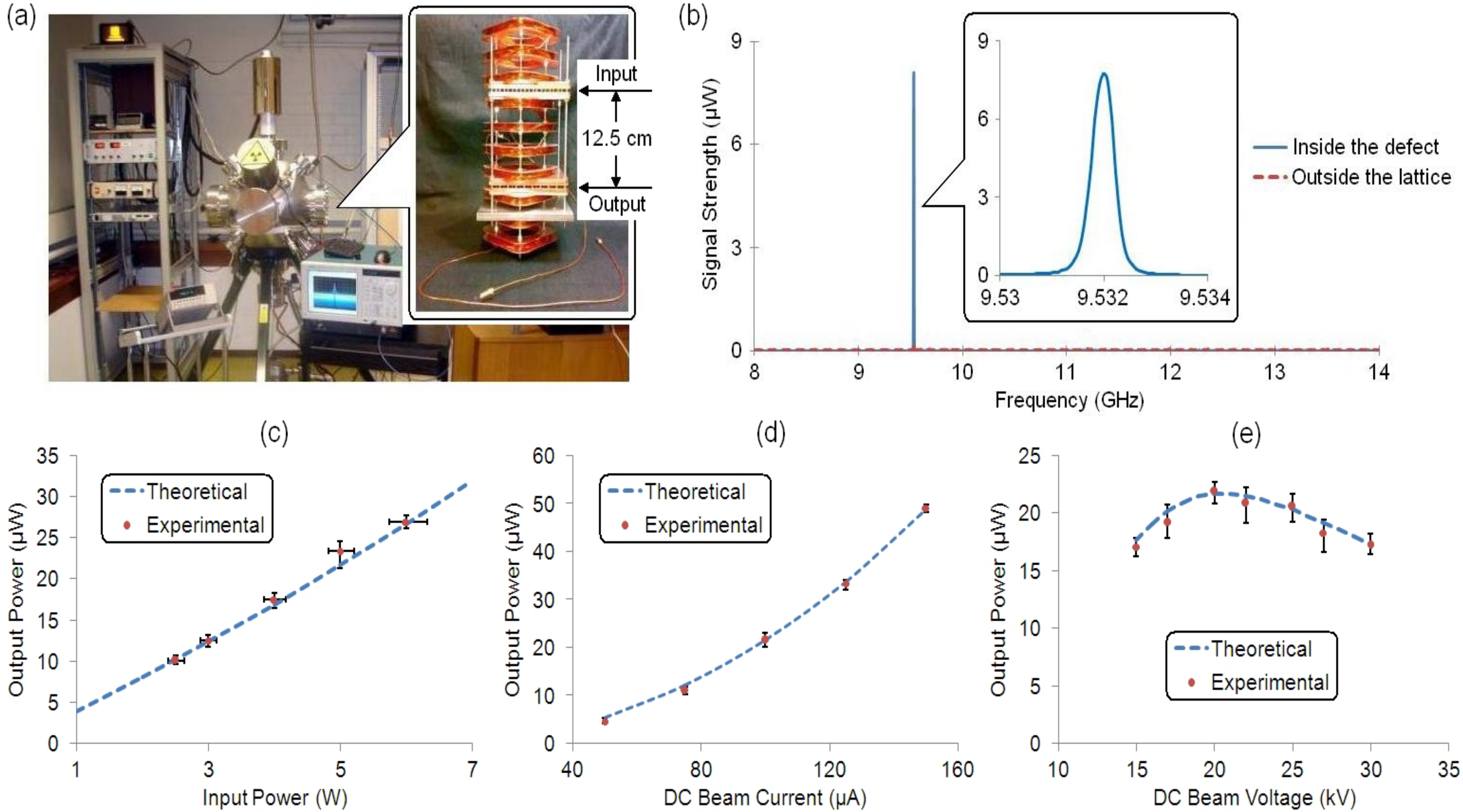





Input Signal
Output
$V_1 \sin \omega t$
Collector
v_0
I_0
v
I_t
V_0
d
d
Electron Gun
Buncher Cavity
L
Catcher Cavity
$t = t_1$
$t = t_2$







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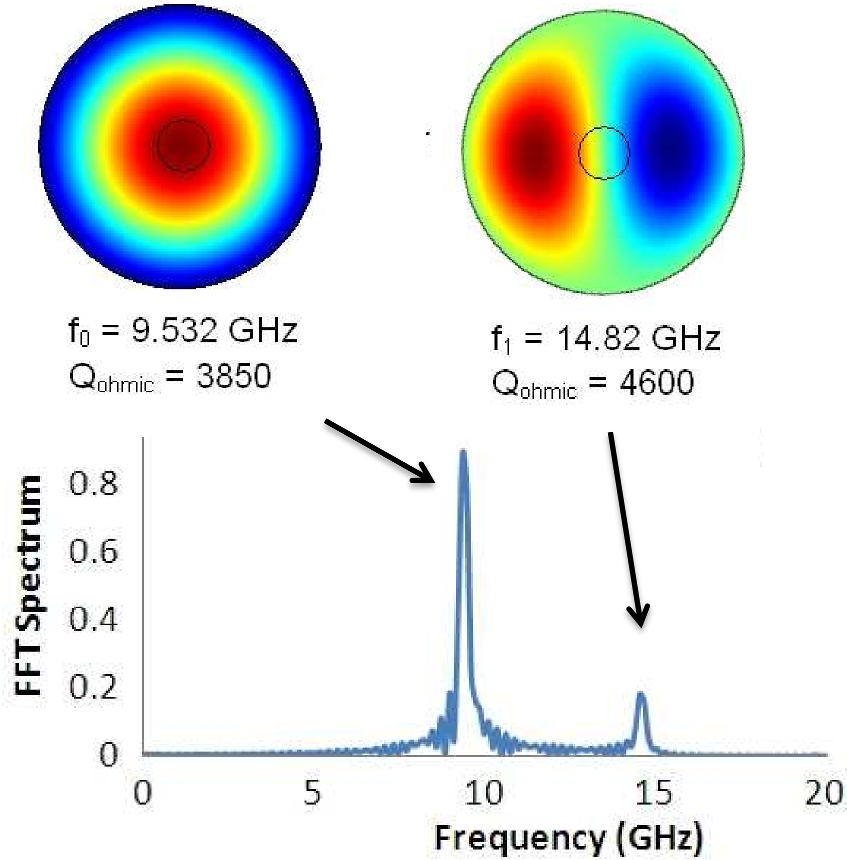
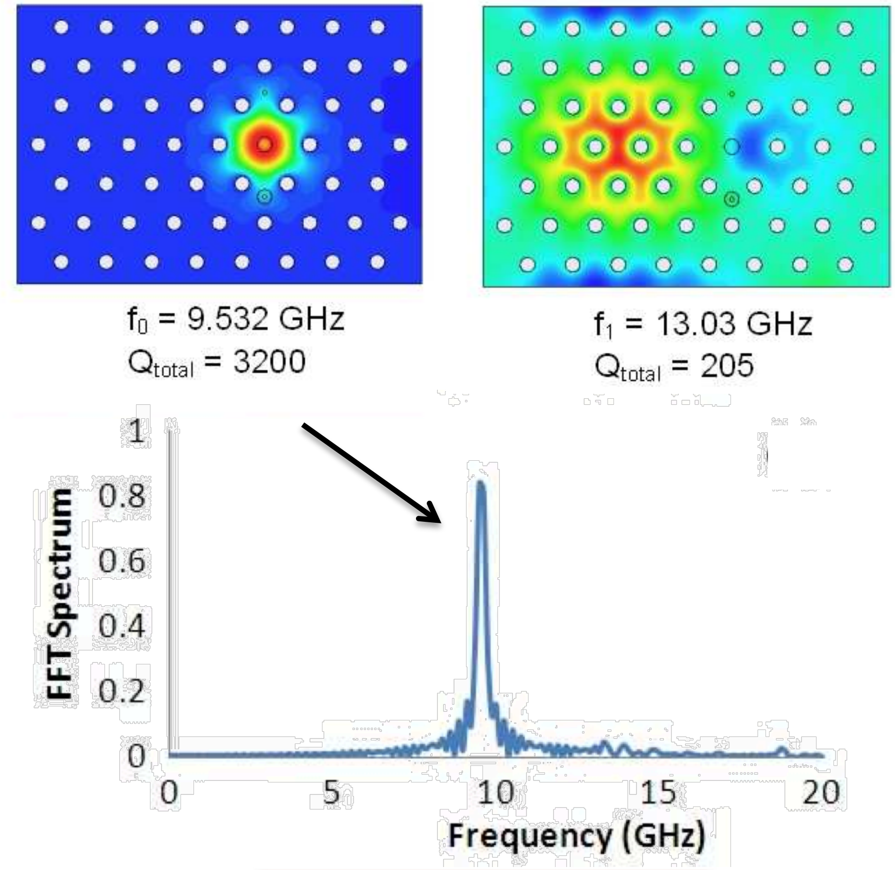
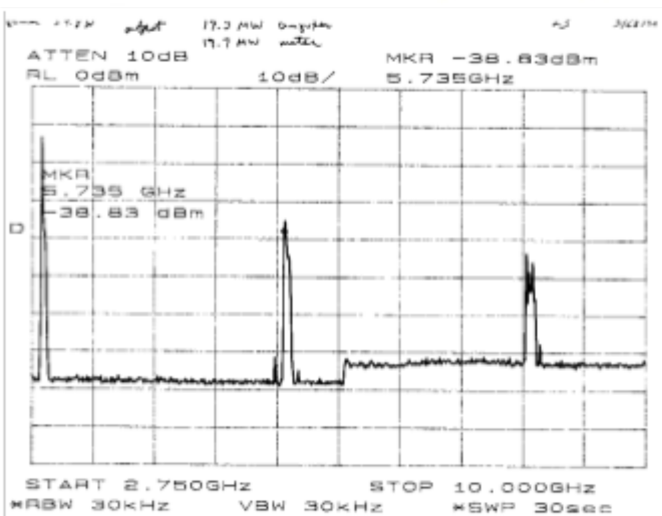
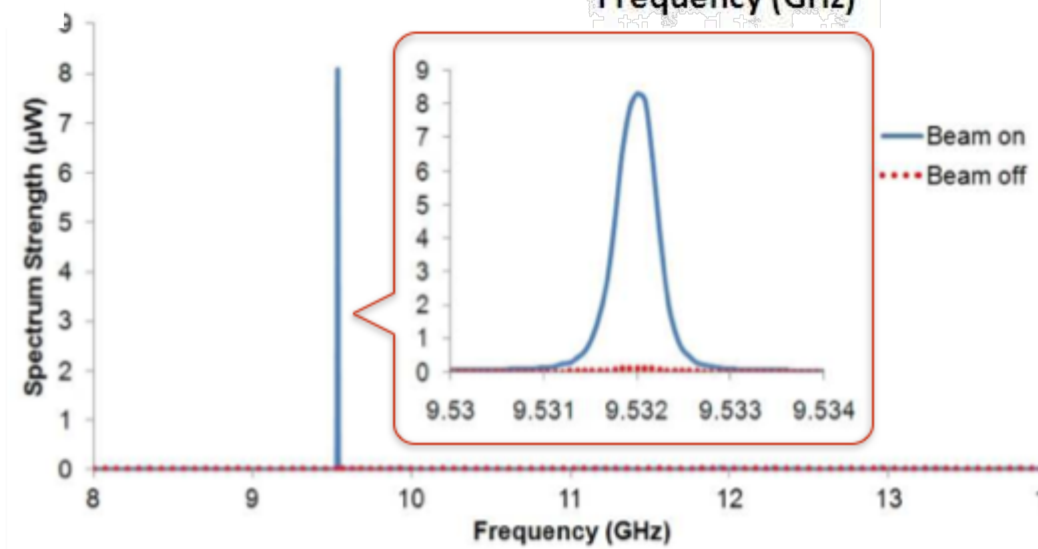
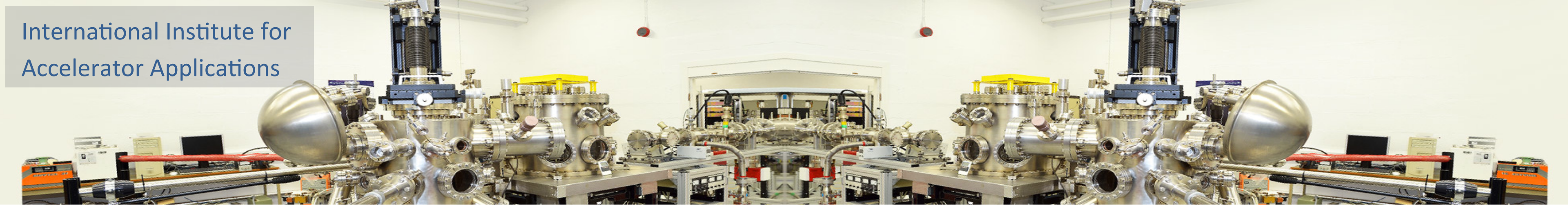


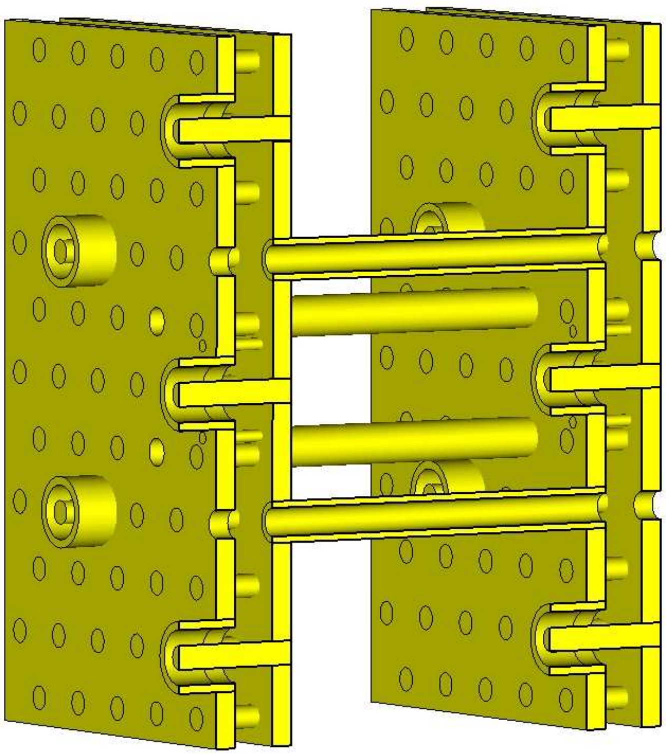


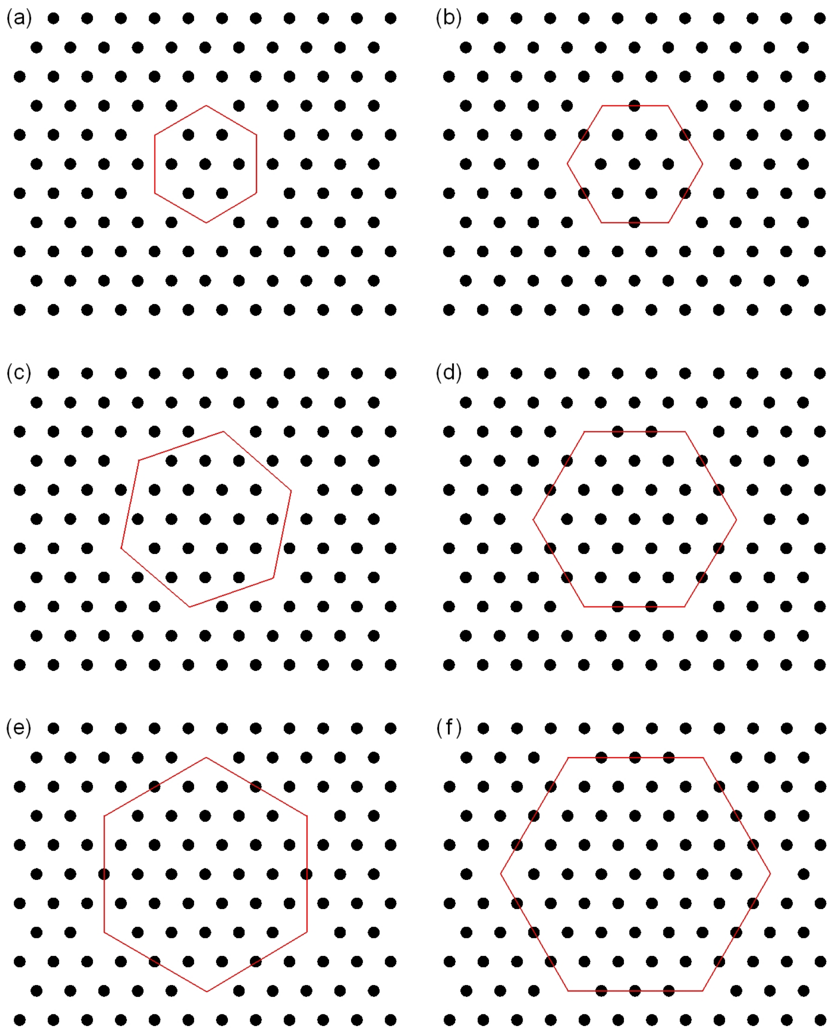


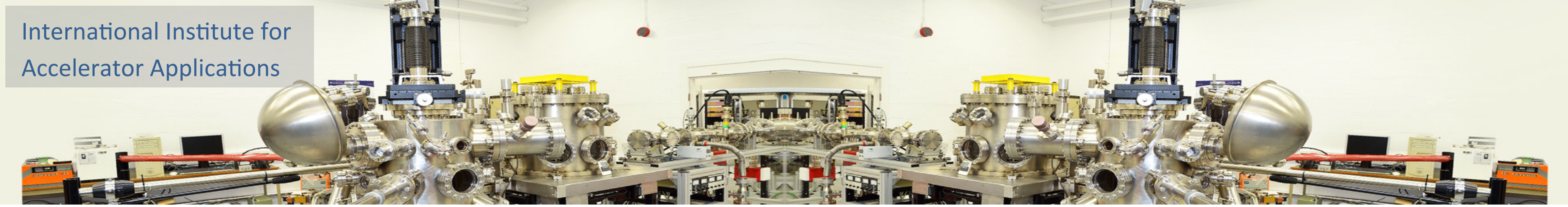
Yoon Kang, Ali Nassiri, IPAC 1998








(a)
(b)
(c)
(d)
(e)
(f)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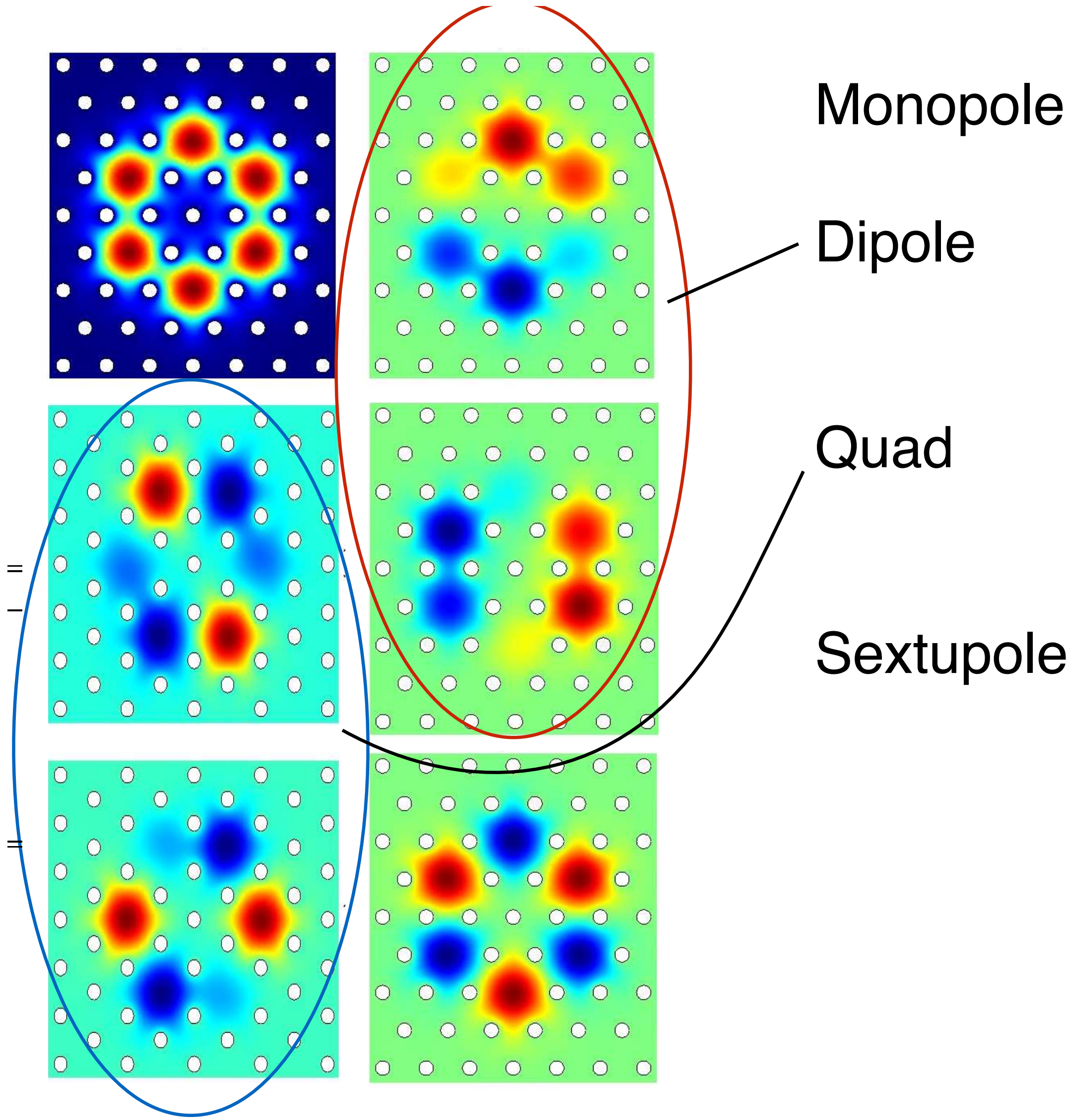
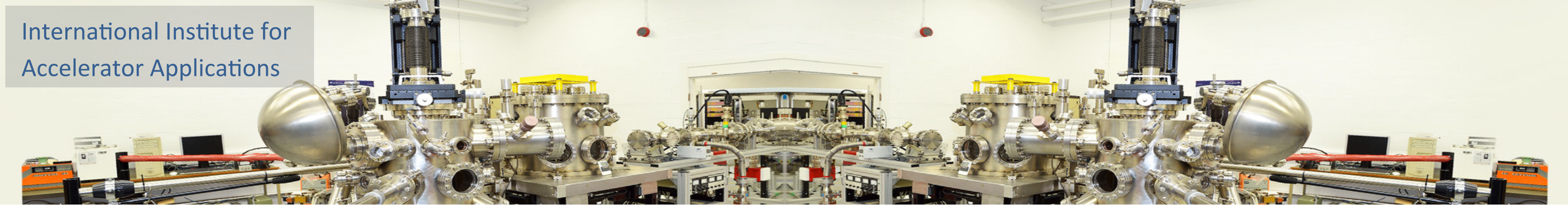
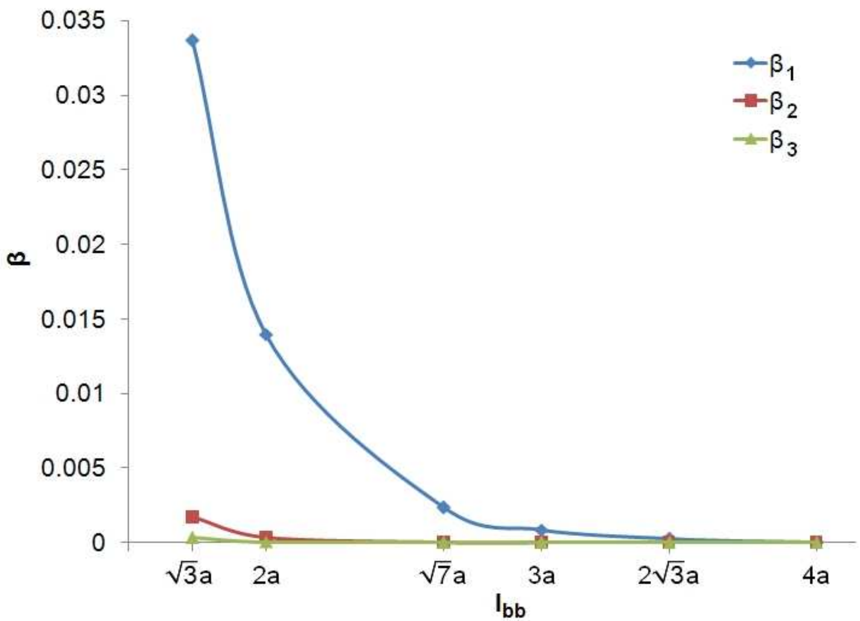
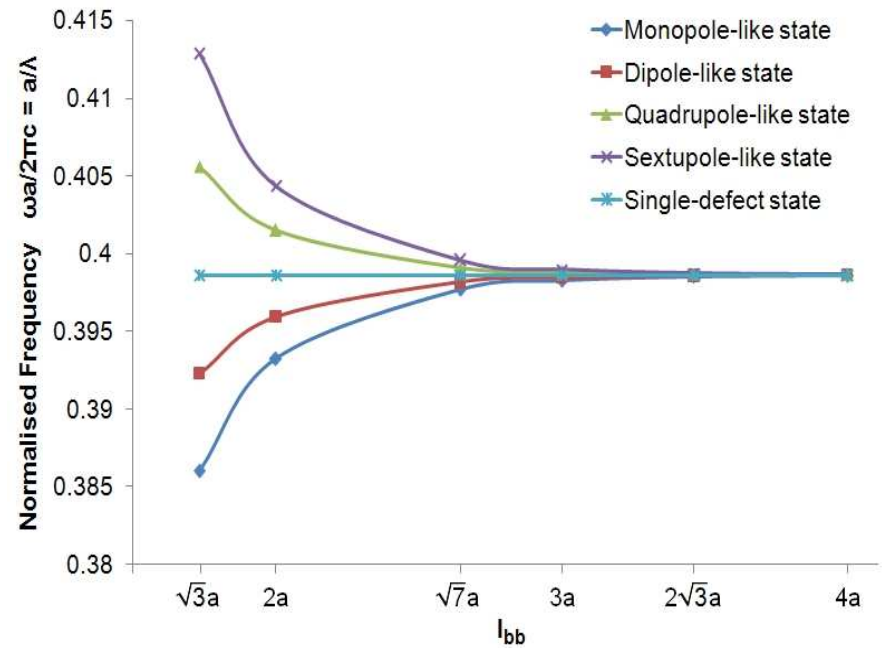

Monopole
Dipole
Quad
Sextupole

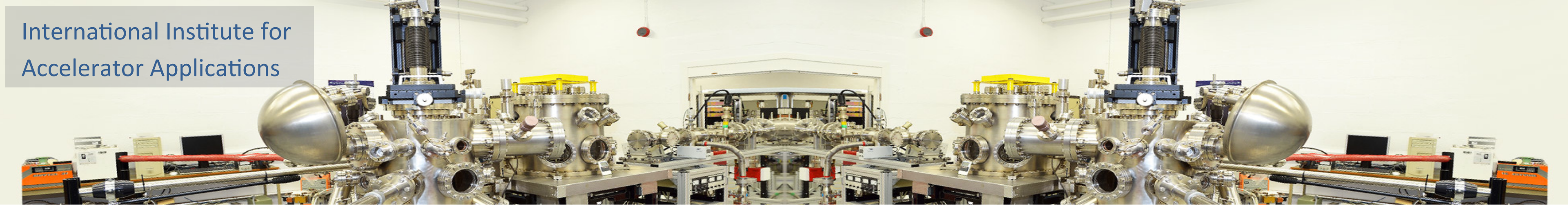


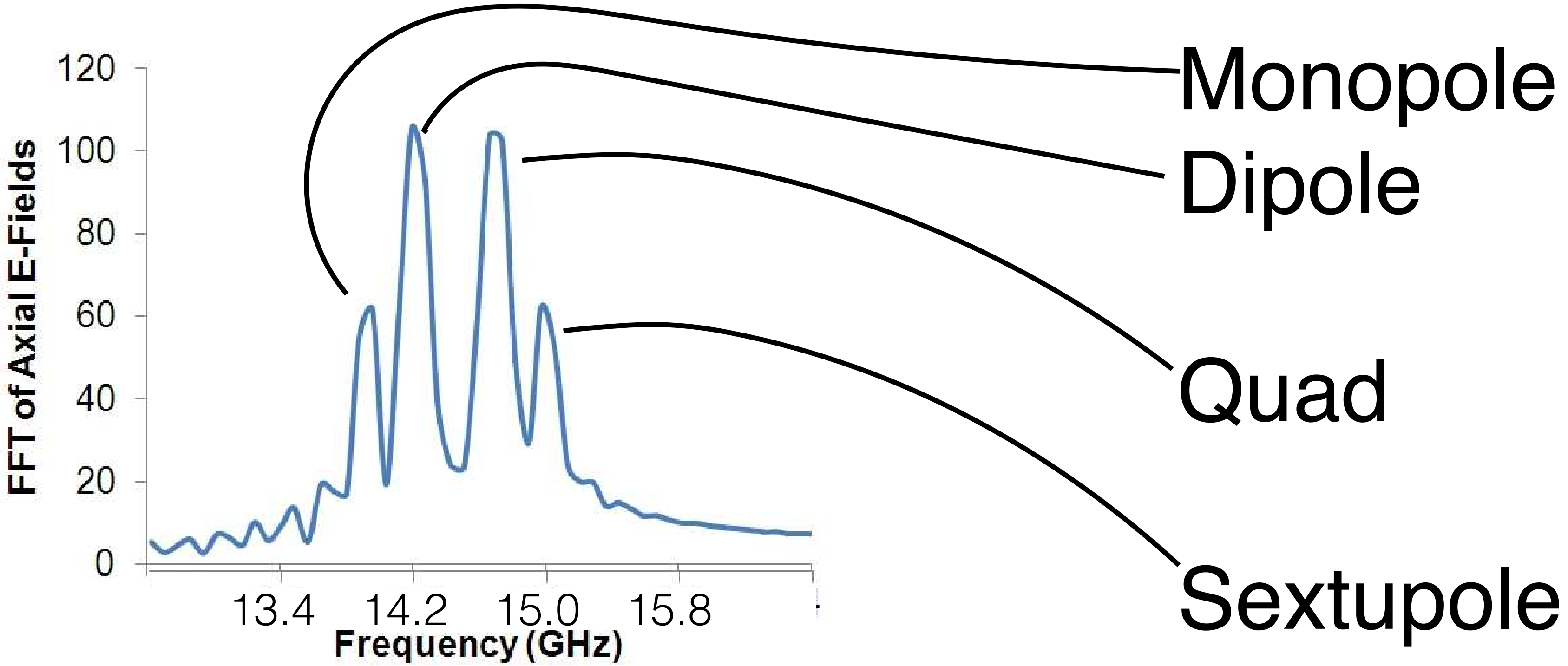
$$
\begin{aligned}
\vec{H}_{ij} &= <\vec{E}_0(\vec{r}-\vec{R}_i)|\hat{O}|\vec{E}_0(\vec{r}-\vec{R}_j)> \\
&= \begin{cases}
(\omega_0/c)^2 = \alpha & (i=j), \text{the same defect} \\
(\omega_0/c)^2\beta_1 & (i\neq j), \text{the first-neighbour defect} \\
(\omega_0/c)^2\beta_2 & (i\neq j), \text{the second-neighbour defect} \\
(\omega_0/c)^2\beta_3 & (i\neq j), \text{the third-neighbour defect}
\end{cases}
\end{aligned}
$$

$$
\begin{vmatrix}
\alpha-\gamma & \tilde{\beta}_1 & \tilde{\beta}_2 & \tilde{\beta}_3 & \tilde{\beta}_2 & \tilde{\beta}_1 \\
\tilde{\beta}_1 & \alpha-\gamma & \tilde{\beta}_1 & \tilde{\beta}_2 & \tilde{\beta}_3 & \tilde{\beta}_2 \\
\tilde{\beta}_2 & \tilde{\beta}_1 & \alpha-\gamma & \tilde{\beta}_1 & \tilde{\beta}_2 & \tilde{\beta}_3 \\
\tilde{\beta}_3 & \tilde{\beta}_2 & \tilde{\beta}_1 & \alpha-\gamma & \tilde{\beta}_1 & \tilde{\beta}_2 \\
\tilde{\beta}_2 & \tilde{\beta}_3 & \tilde{\beta}_2 & \tilde{\beta}_1 & \alpha-\gamma & \tilde{\beta}_1 \\
\tilde{\beta}_1 & \tilde{\beta}_2 & \tilde{\beta}_3 & \tilde{\beta}_2 & \tilde{\beta}_1 & \alpha-\gamma
\end{vmatrix} = 0
$$

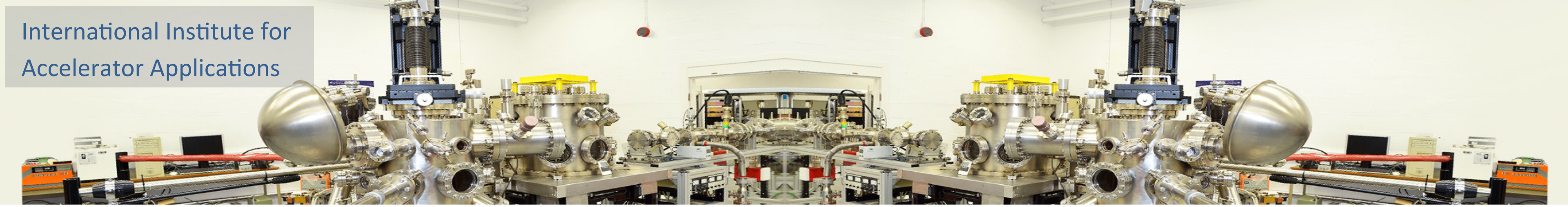


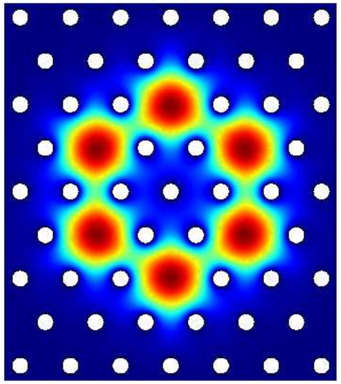


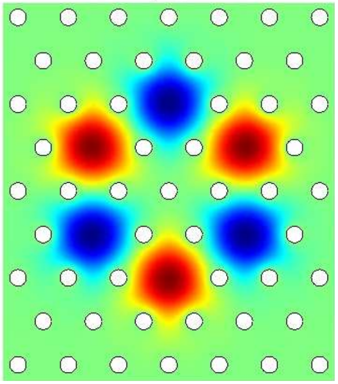


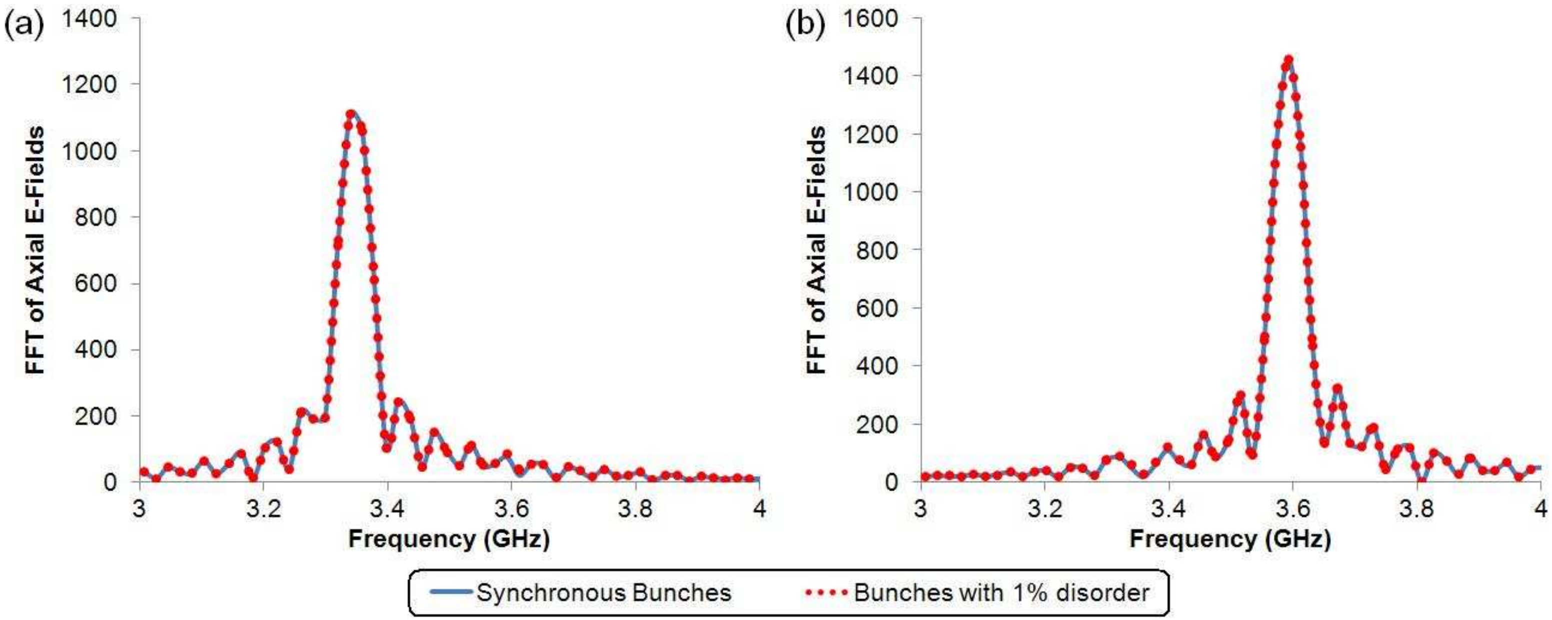


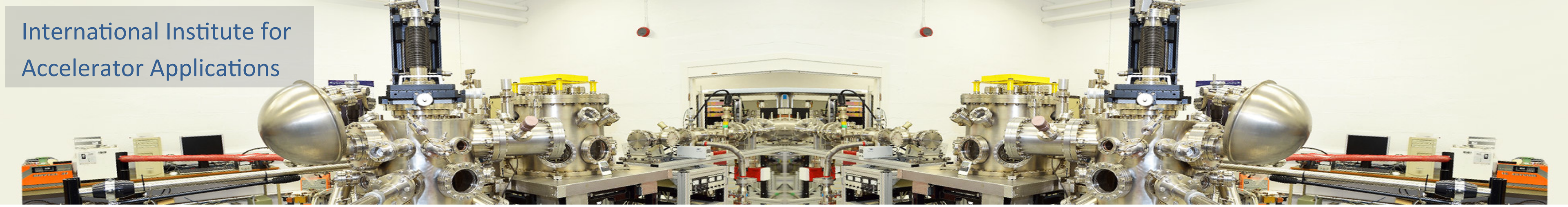
Excitation of one defect



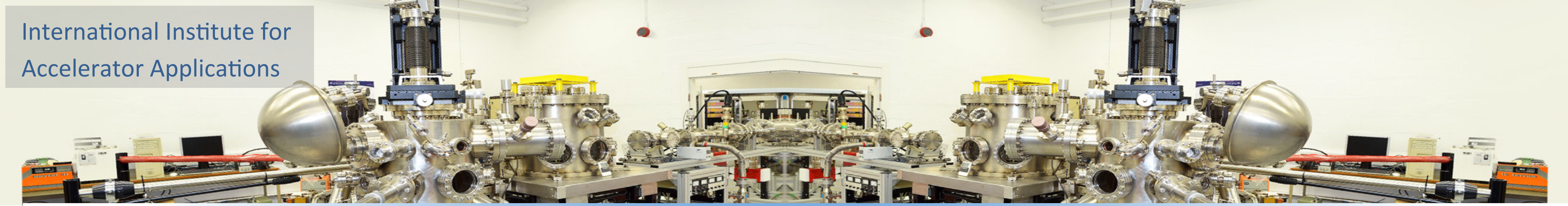


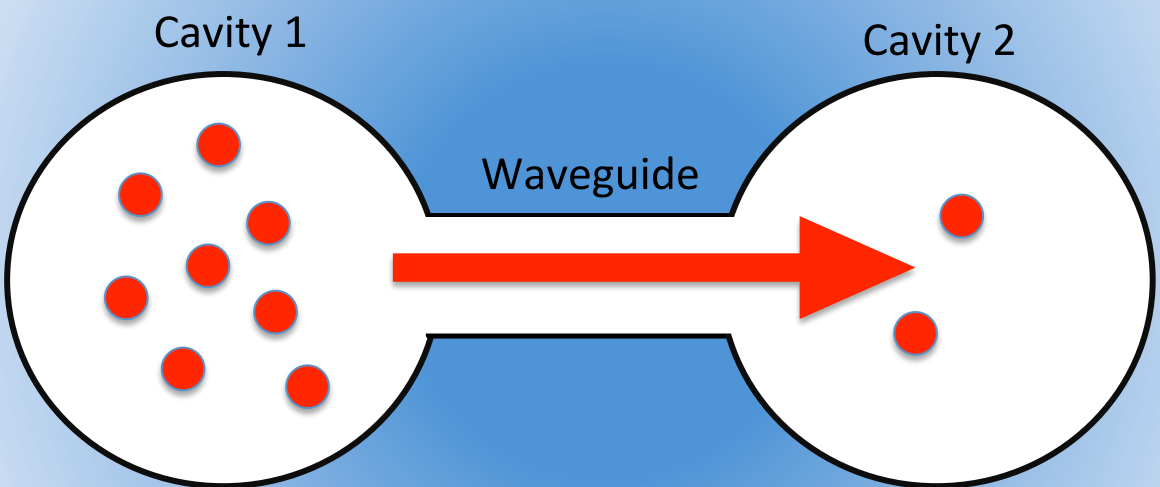



(a)
(b)
FFT of Axial E-Fields
Frequency (GHz)
Synchronous Bunches
Bunches with 1% disorder

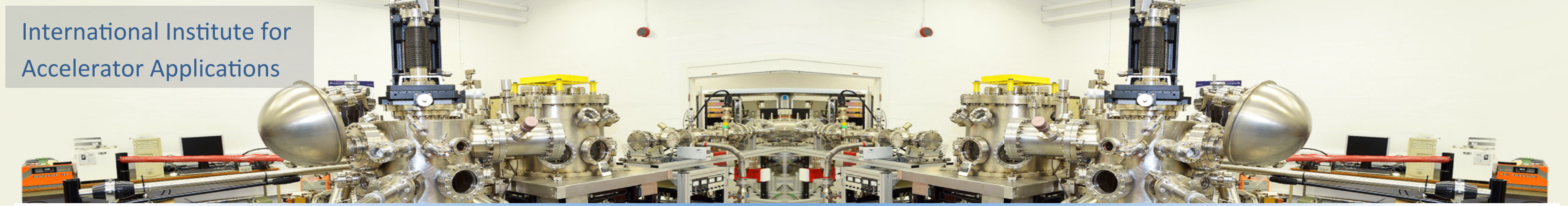


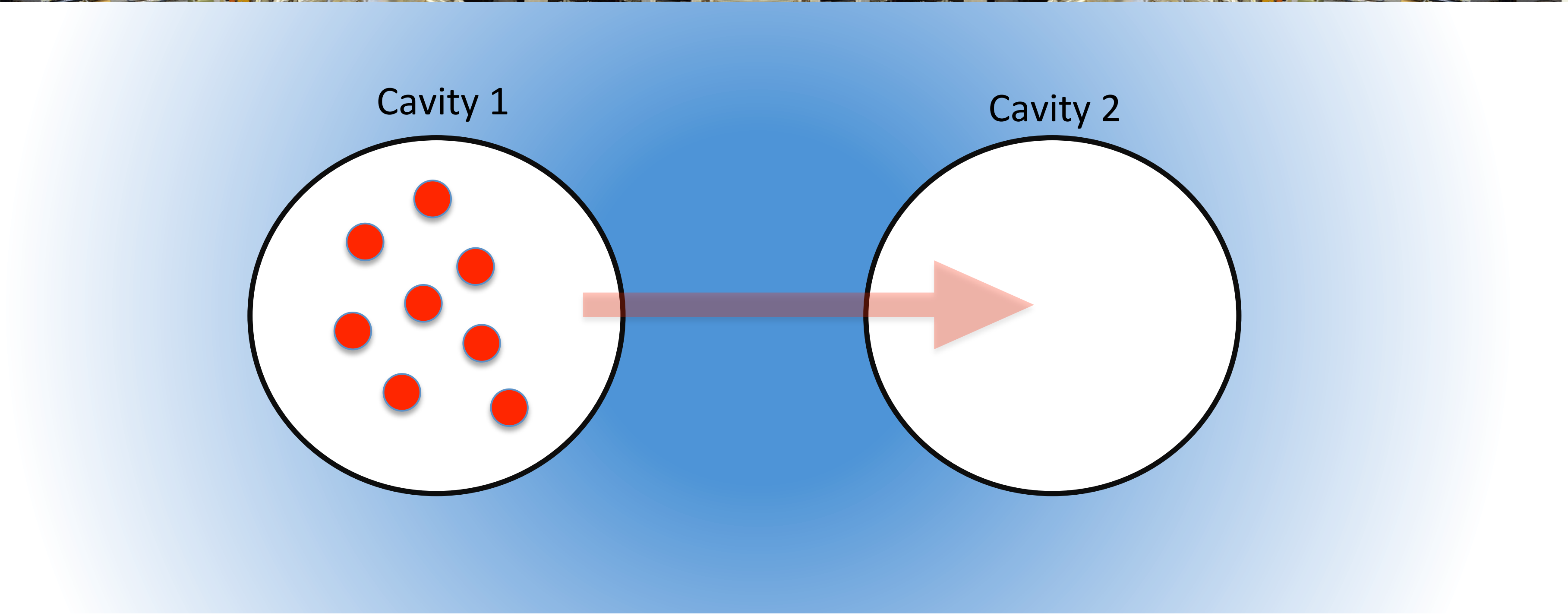
Hidden Sector Photon Searches



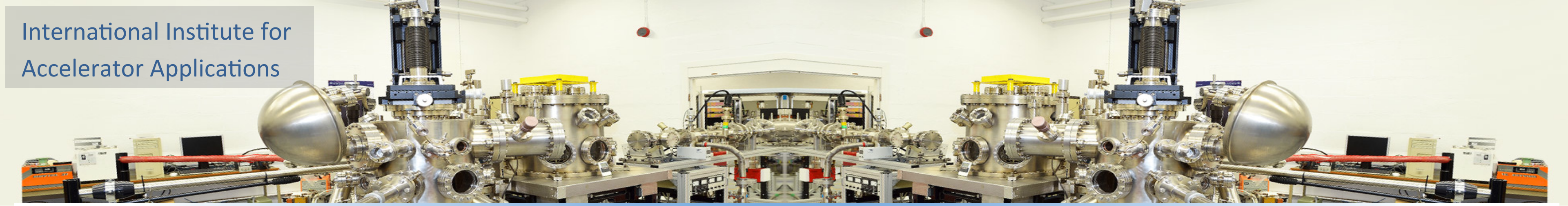


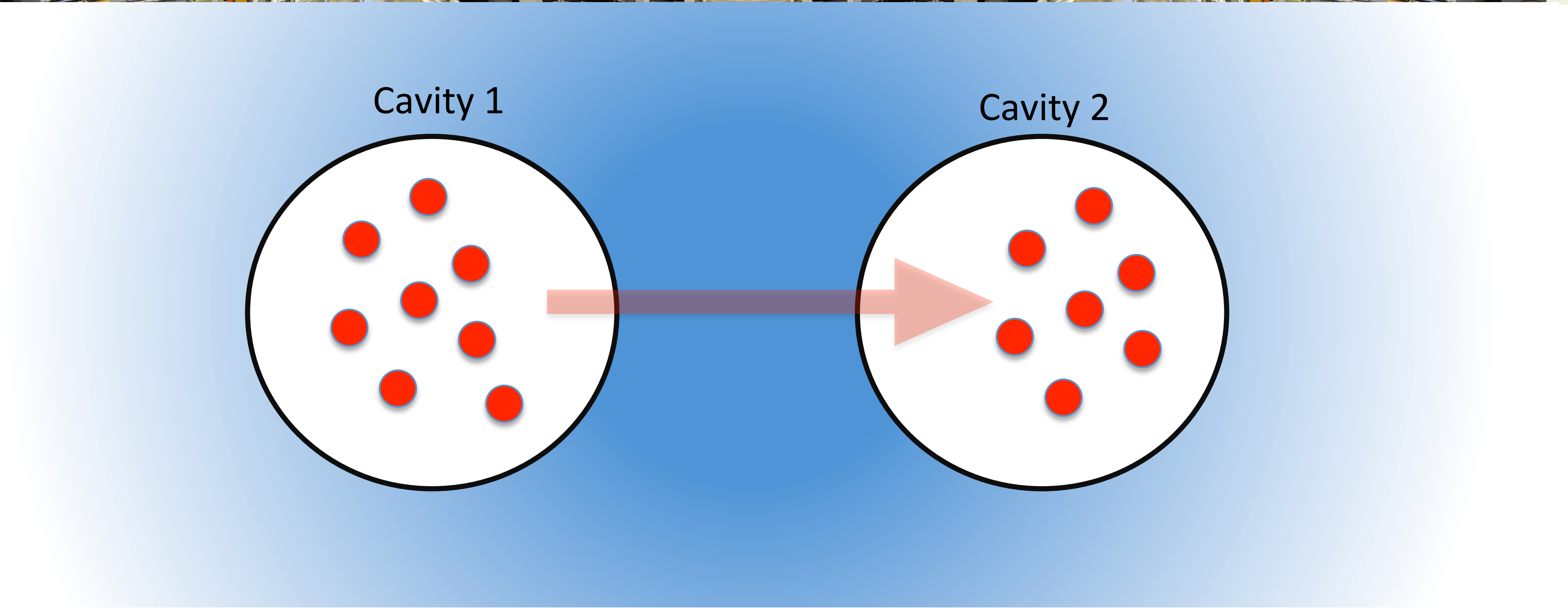
$$\nabla^2 E - \mu \varepsilon_r \varepsilon_0 \omega^2 \frac{\partial^2 E}{\partial t^2} = 0$$



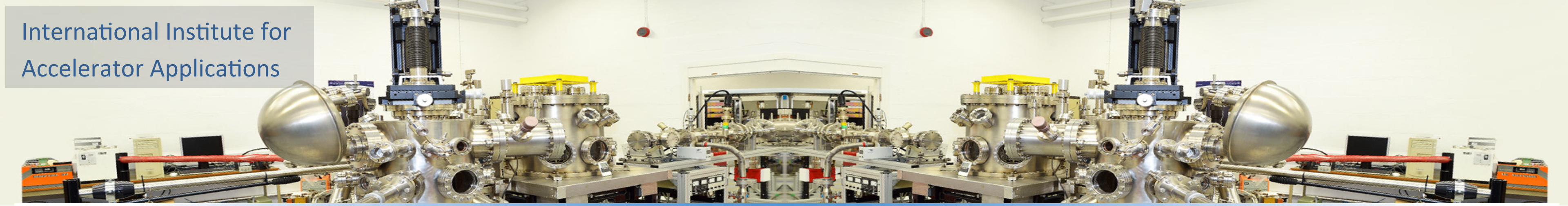


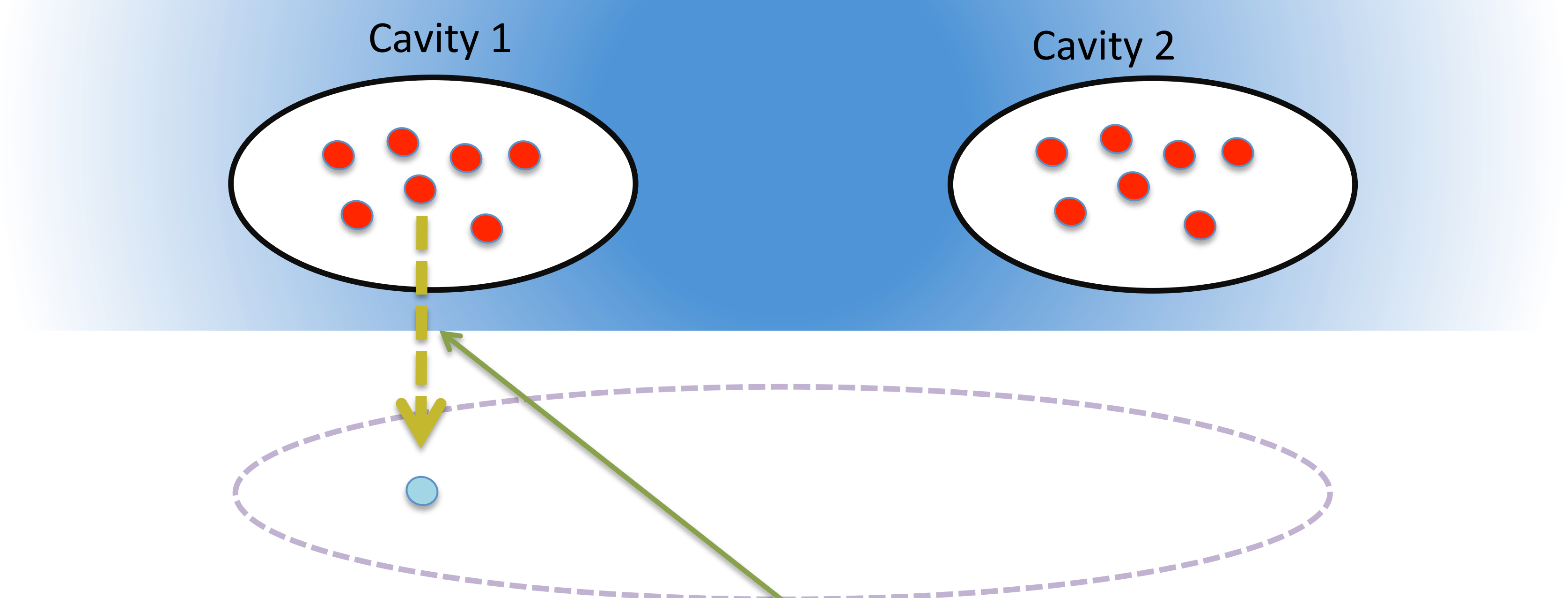
$$\nabla^2 E - \cancel{\mu\varepsilon\varepsilon_0\omega^2} \frac{\partial^2 E}{\partial t^2} = 0$$





$$\mathcal{L} = -\frac{1}{4}F^{\mu\nu}F_{\mu\nu} - \frac{1}{4}B^{\mu\nu}B_{\mu\nu} - \frac{\chi}{2}F^{\mu\nu}B_{\mu\nu} + \frac{m_\gamma^2}{2}B^\mu B_\mu$$





$$\mathcal{L} = -\frac{1}{4}F^{\mu\nu}F_{\mu\nu} - \frac{1}{4}B^{\mu\nu}B_{\mu\nu} - \frac{\chi}{2}F^{\mu\nu}B_{\mu\nu} + \frac{m_\gamma^2}{2}B^\mu B_\mu$$

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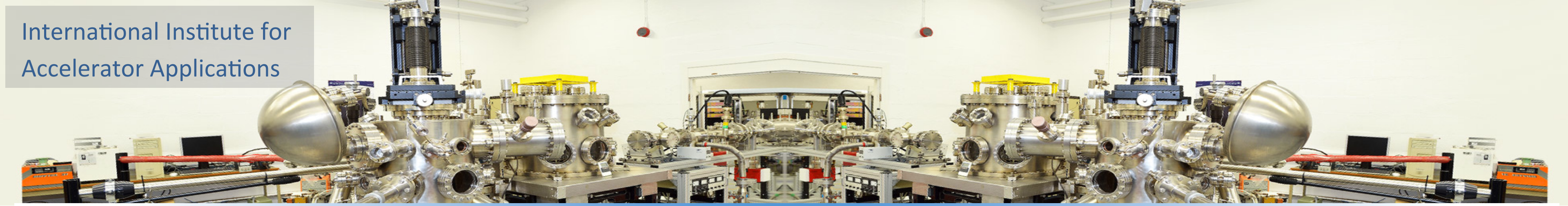
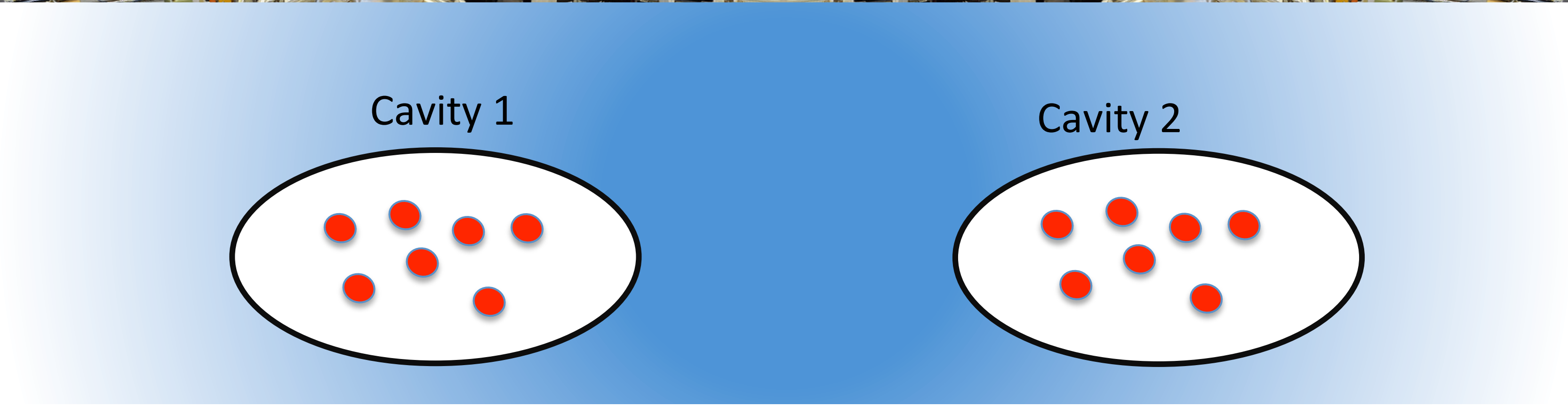
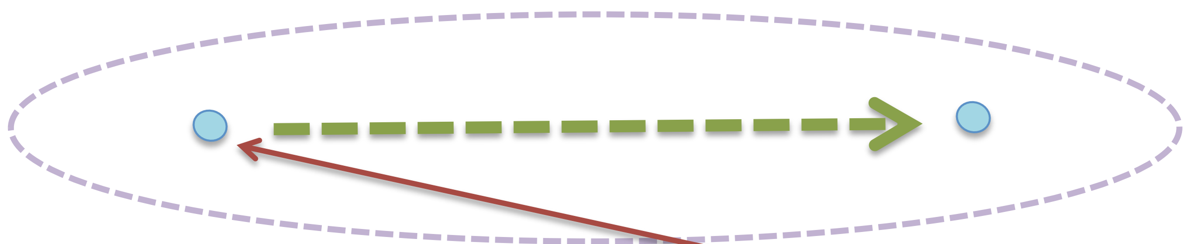
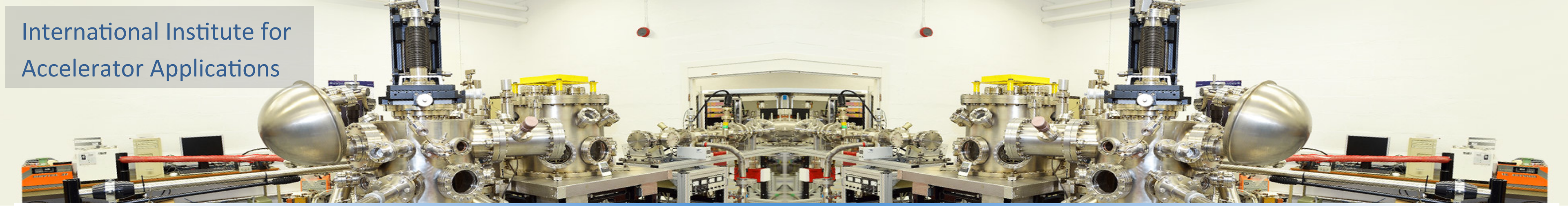
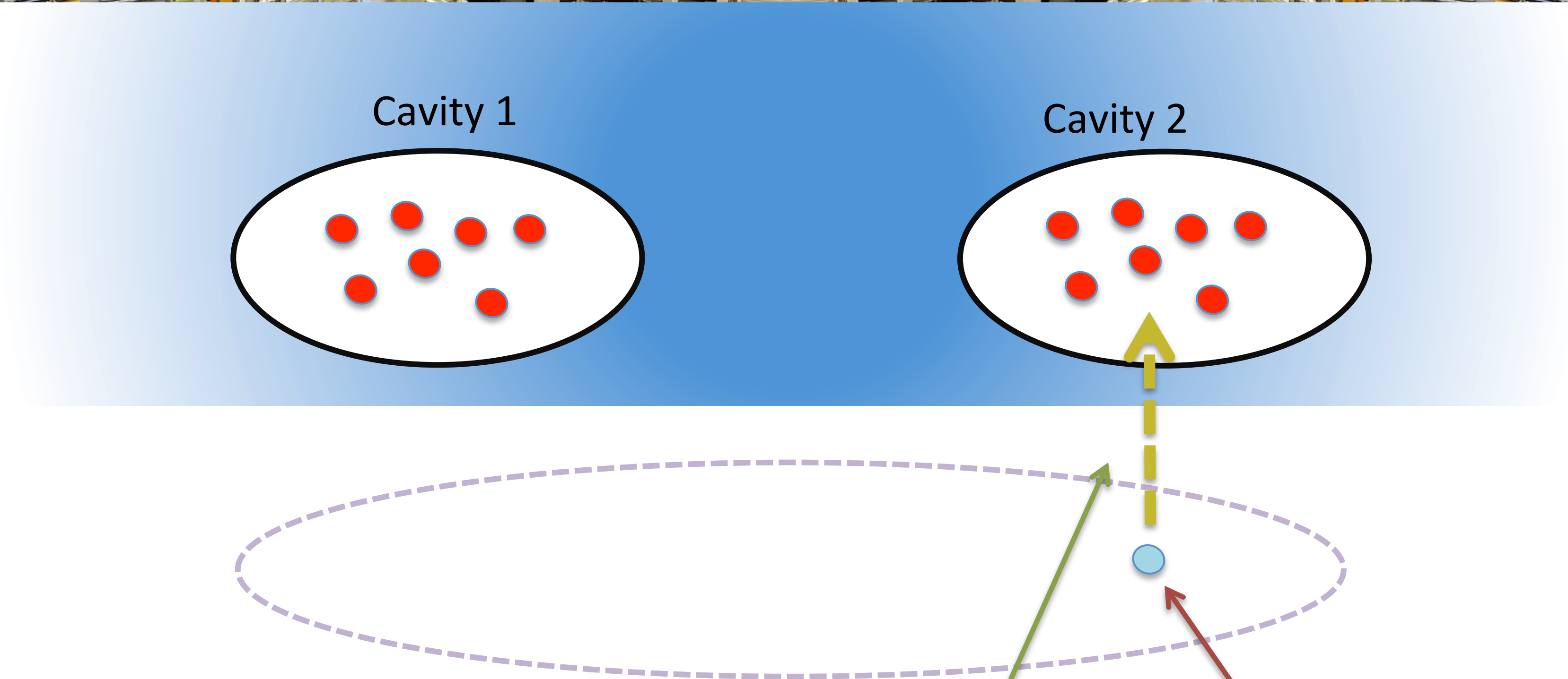




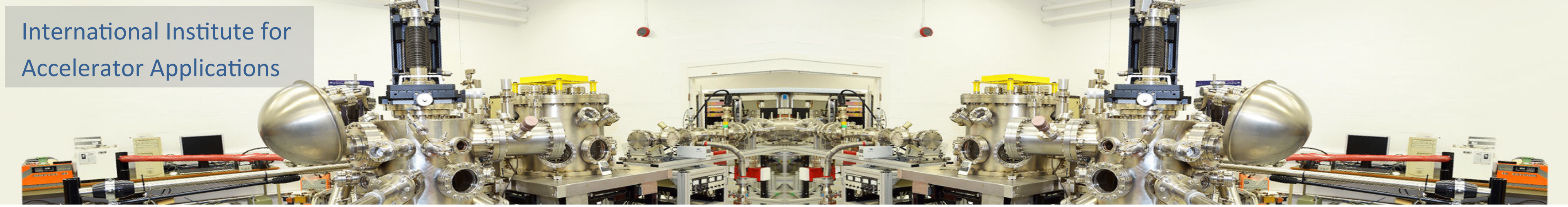


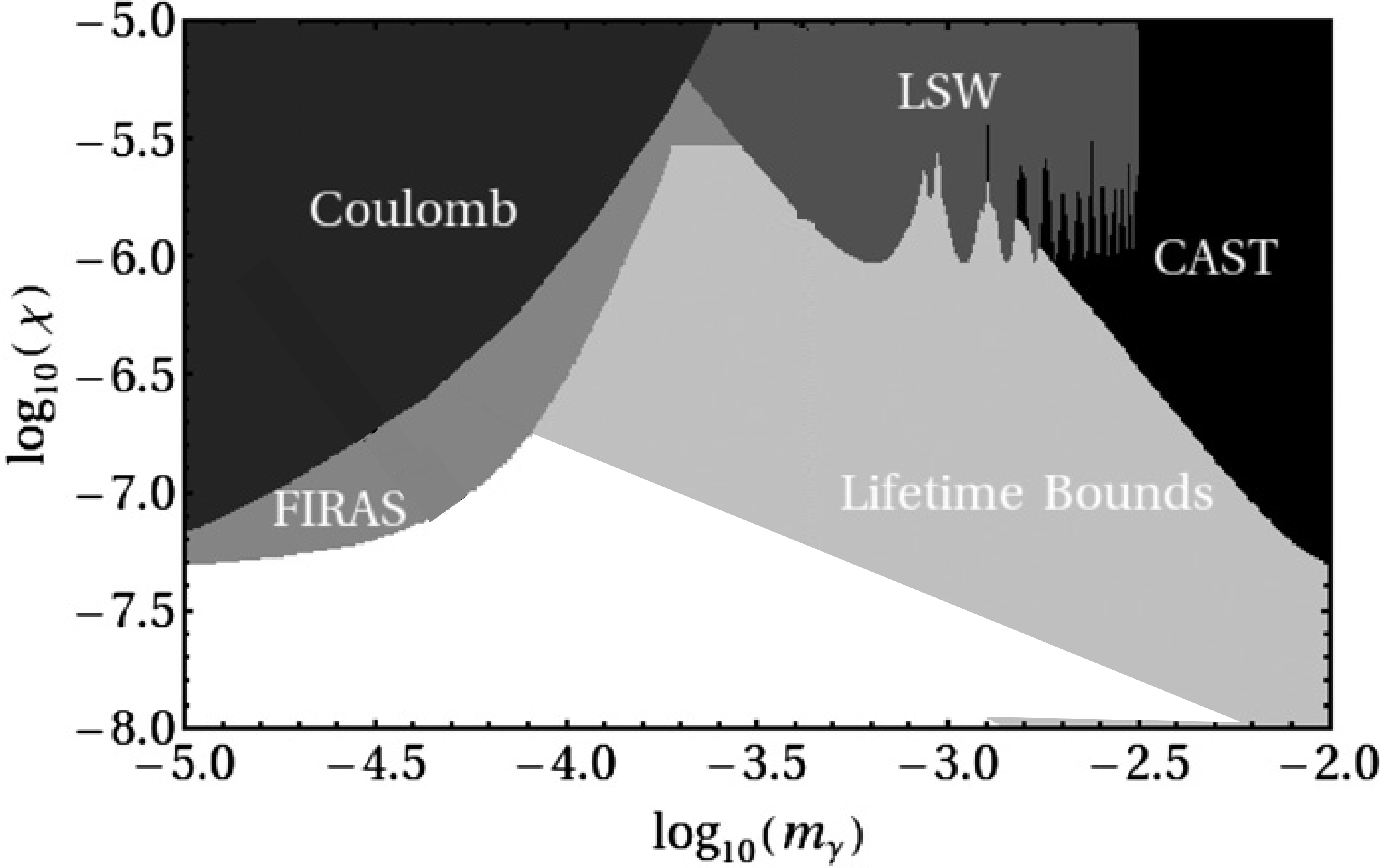
$$\mathcal{L} = -\frac{1}{4}F^{\mu\nu}F_{\mu\nu} - \frac{1}{4}B^{\mu\nu}B_{\mu\nu} - \frac{\chi}{2}F^{\mu\nu}B_{\mu\nu} + \frac{m_\gamma^2}{2}B^{\mu}B_{\mu}$$

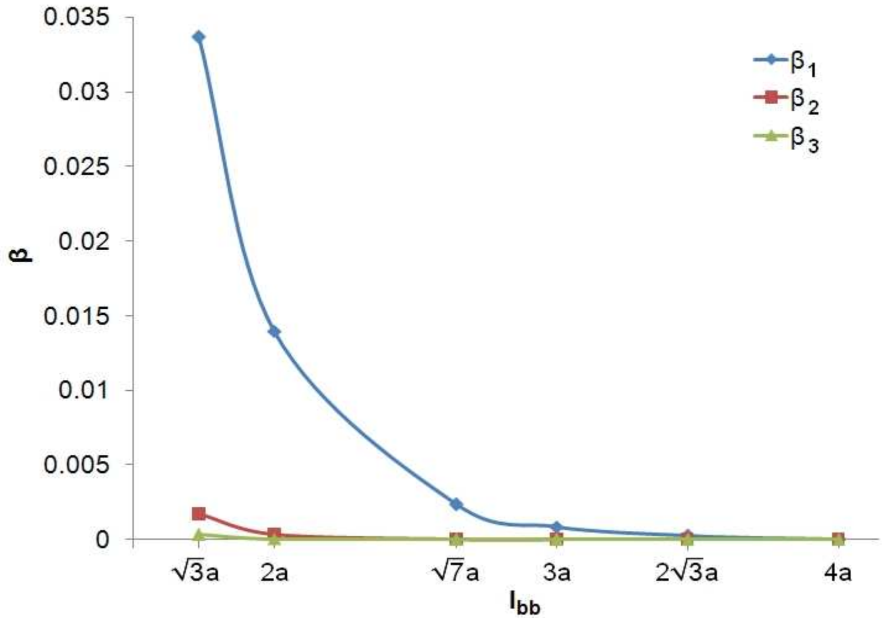


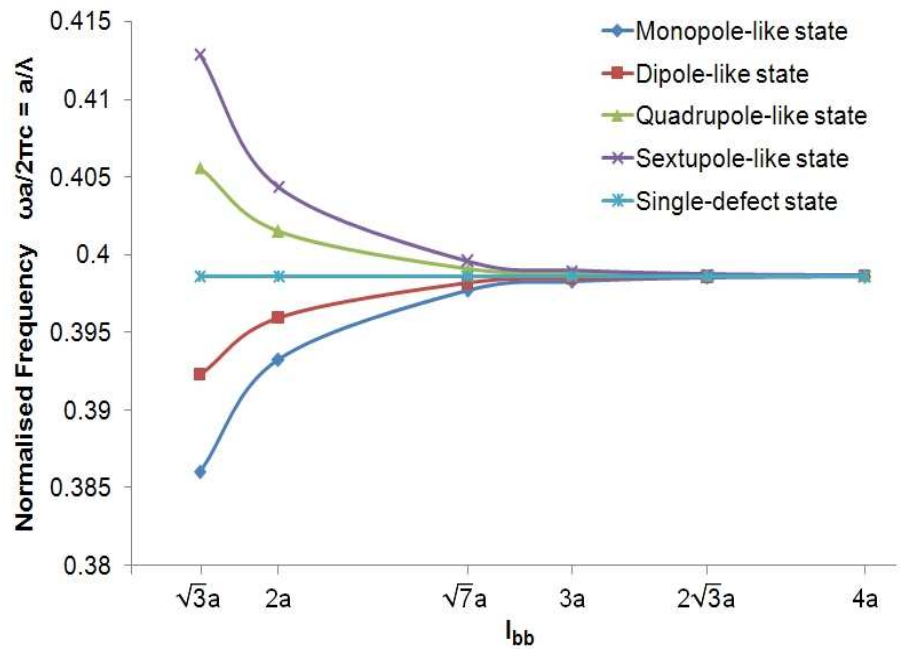


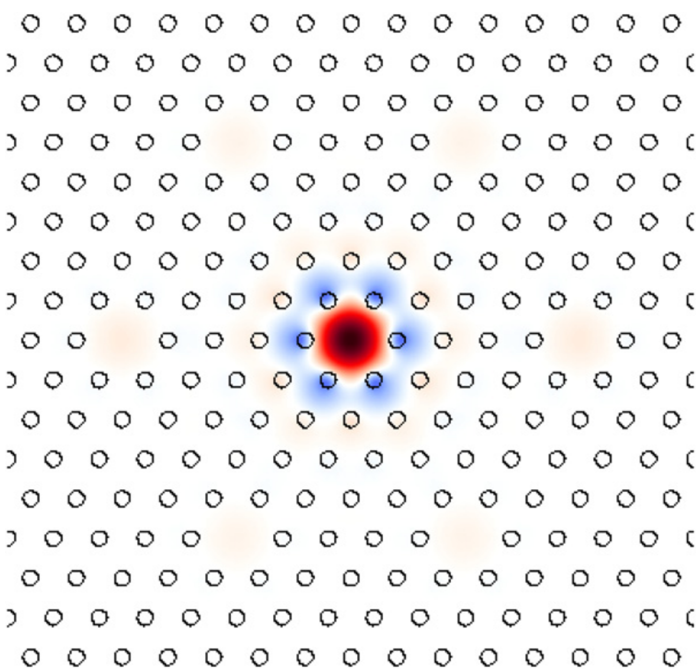
$$\mathcal{L} = -\frac{1}{4}F^{\mu\nu}F_{\mu\nu} - \frac{1}{4}B^{\mu\nu}B_{\mu\nu} - \frac{\chi}{2}F^{\mu\nu}B_{\mu\nu} + \frac{m_\gamma^2}{2}B^{\mu}B_{\mu}$$

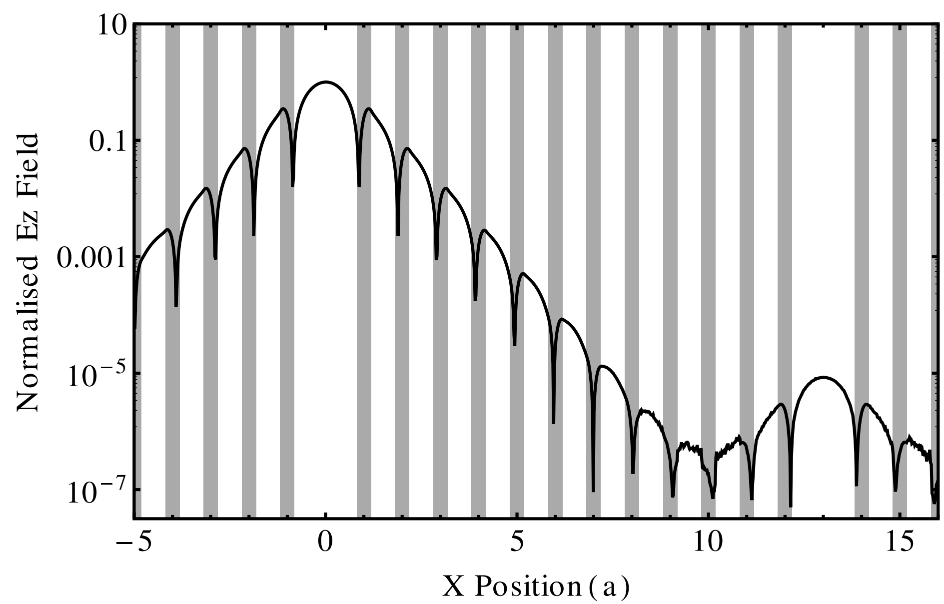



Coulomb
LSW
CAST
FIRAS
Lifetime Bounds
$\log_{10}(\chi)$
$\log_{10}(m_\gamma)$
−5.0
−5.5
−6.0
−6.5
−7.0
−7.5
−8.0
−5.0
−4.5
−4.0
−3.5
−3.0
−2.5
−2.0

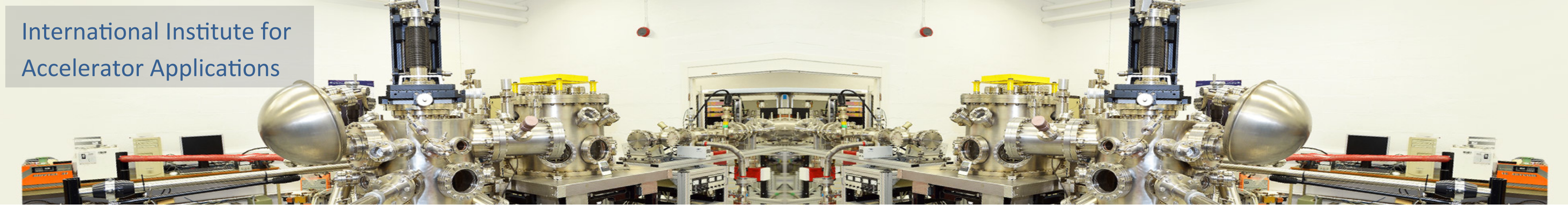


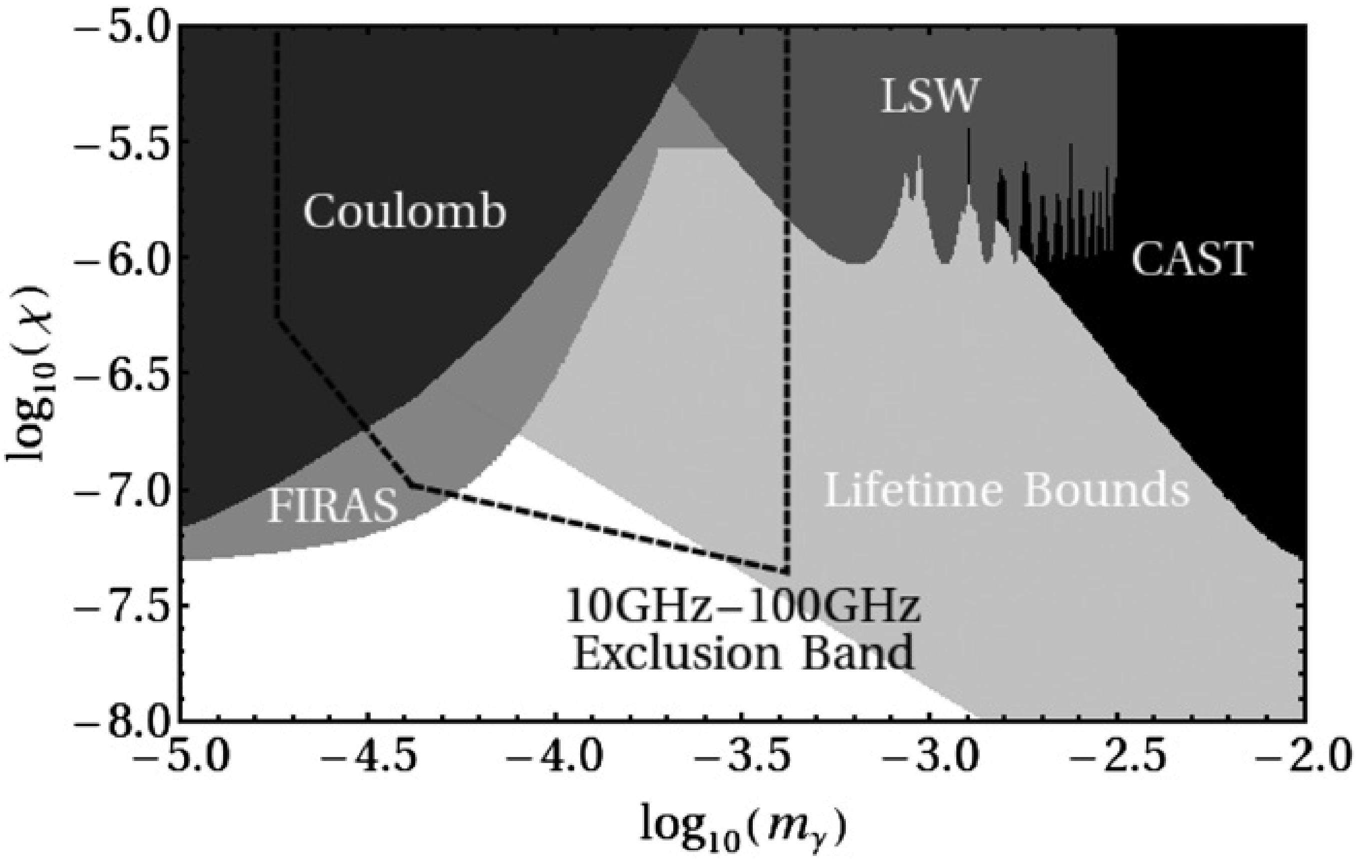






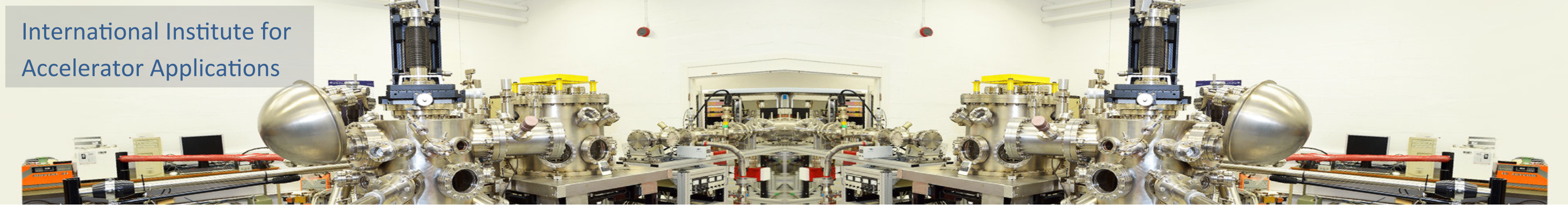
J. Phys. G: Nucl. Part. Phys. **41** (2014) 035005





$$\mathcal{L} = -\frac{1}{4}F^{\mu\nu}F_{\mu\nu} - \frac{1}{4}B^{\mu\nu}B_{\mu\nu} - \frac{\chi}{2}F^{\mu\nu}B_{\mu\nu} + \frac{m_\gamma^2}{2}B^{\mu}B_{\mu}$$

J. Phys. G: Nucl. Part. Phys. **41** (2014) 035005



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UNITED STATES AIR FORCE

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