Applications of Compton ring to nuclear waste analysis

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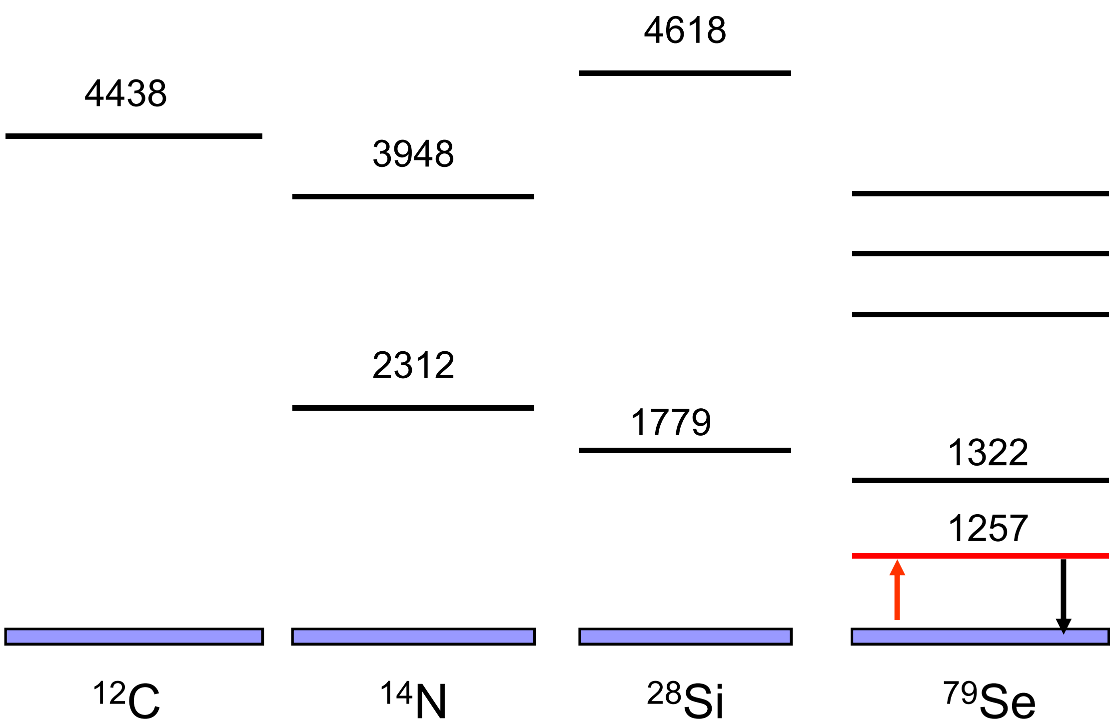
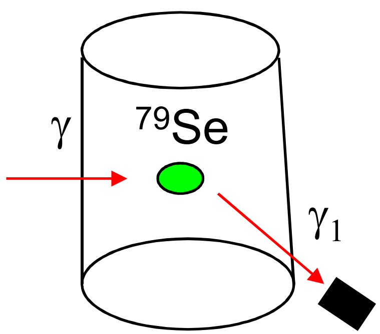
Nuclear Resonance Fluorescence





Pictured by R.Hajima, JAEA

Compton Ring for Nuclear Resonance Fluorescence

$\varepsilon_{\gamma\ max} \approx 4\ \gamma^2\ \varepsilon_{las}$

ε_{las} = 2.33 eV (YAg "green" laser),

$\varepsilon_{\gamma\ max} \approx 4500$ keV → $\gamma \approx 700$, E_e = 170 - 350 MeV,

$N_\gamma > 10^{13}\ \gamma$ / s (10^9-10^{10} ph/s/keV) !!!

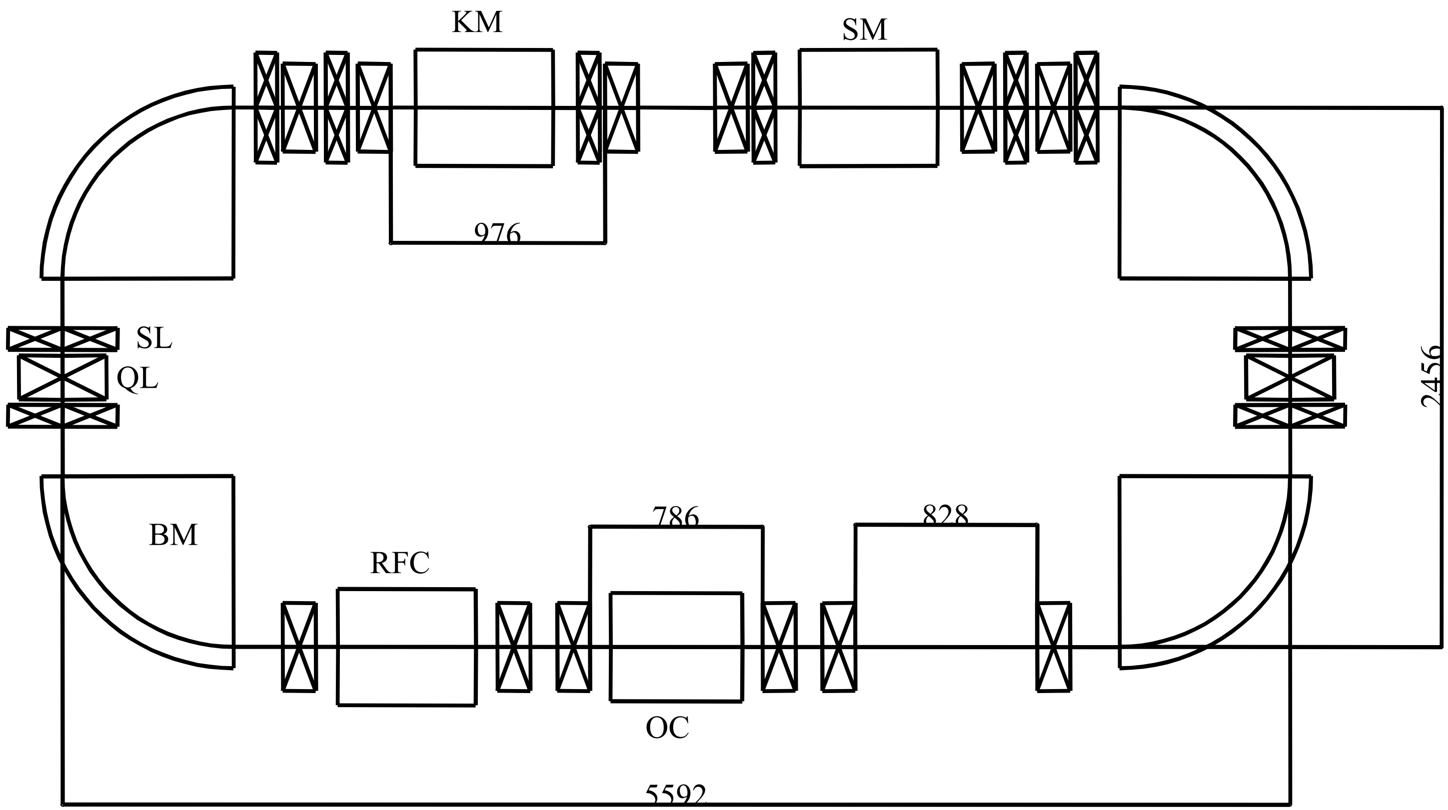
***APPLICATIONS*:**

- nondestructive assay of radioactive nuclides;

- management of nuclear waste;

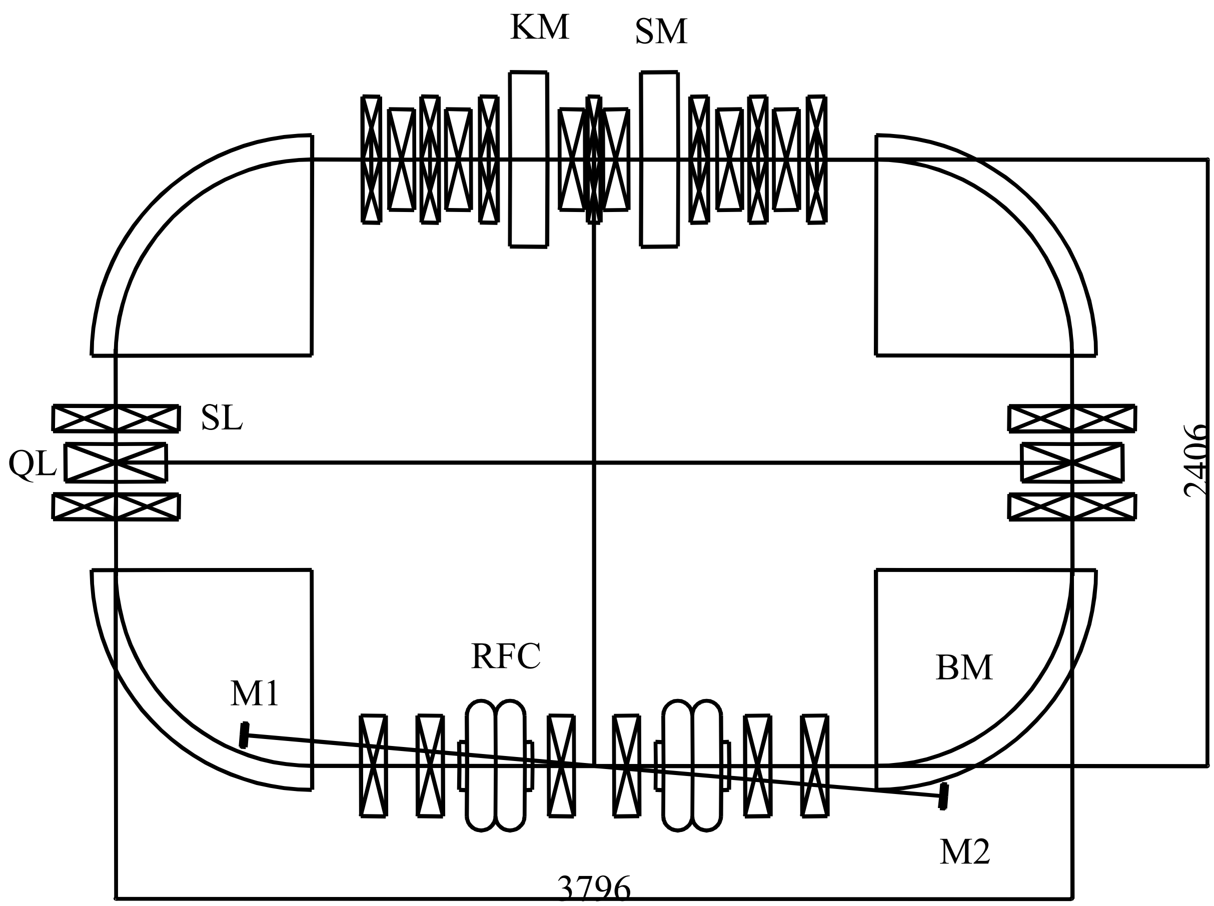
- advanced safeguard technologies of non-proliferation

Compton Ring with Short Optical Cavity

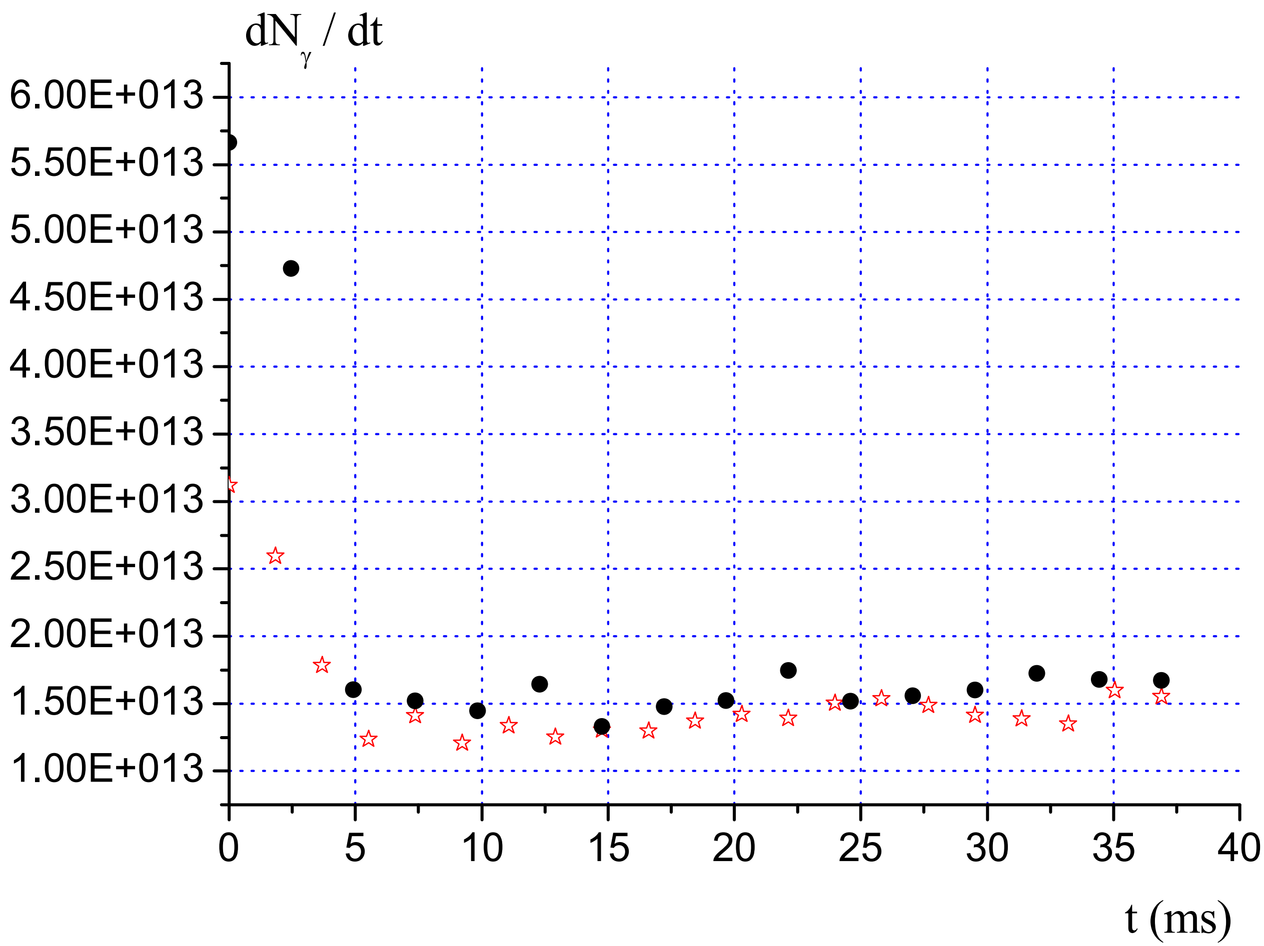


BM are bending magnets; QL quadrupoles; SL sextupoles; KM, SM kicker-and-septum magnets; OC optical cavity. Circumference C=14.76 m

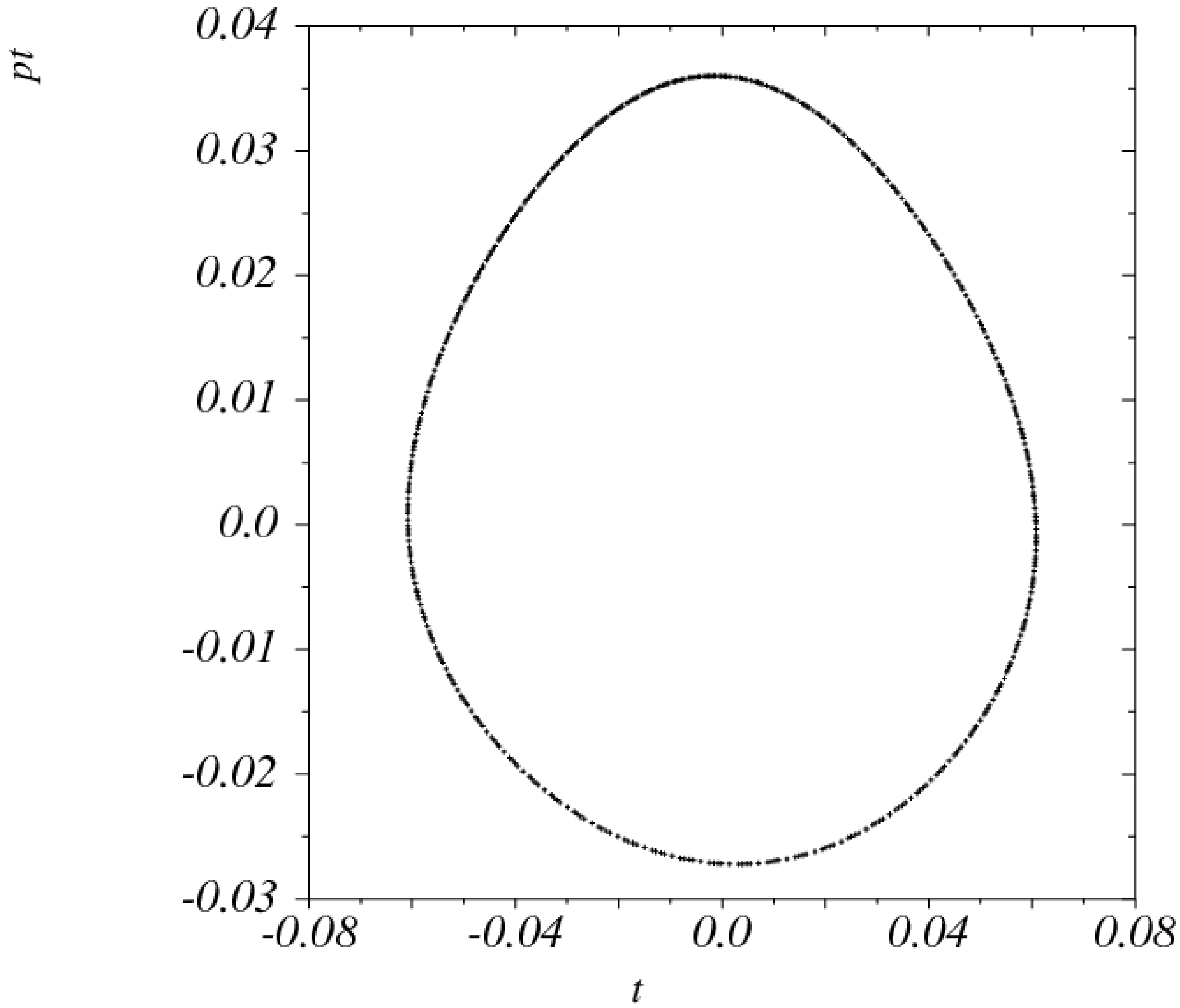
Compton Ring with Long Optical Cavity



M1, M2 are mirrors of optical cavity. Circumference C=11.06 m

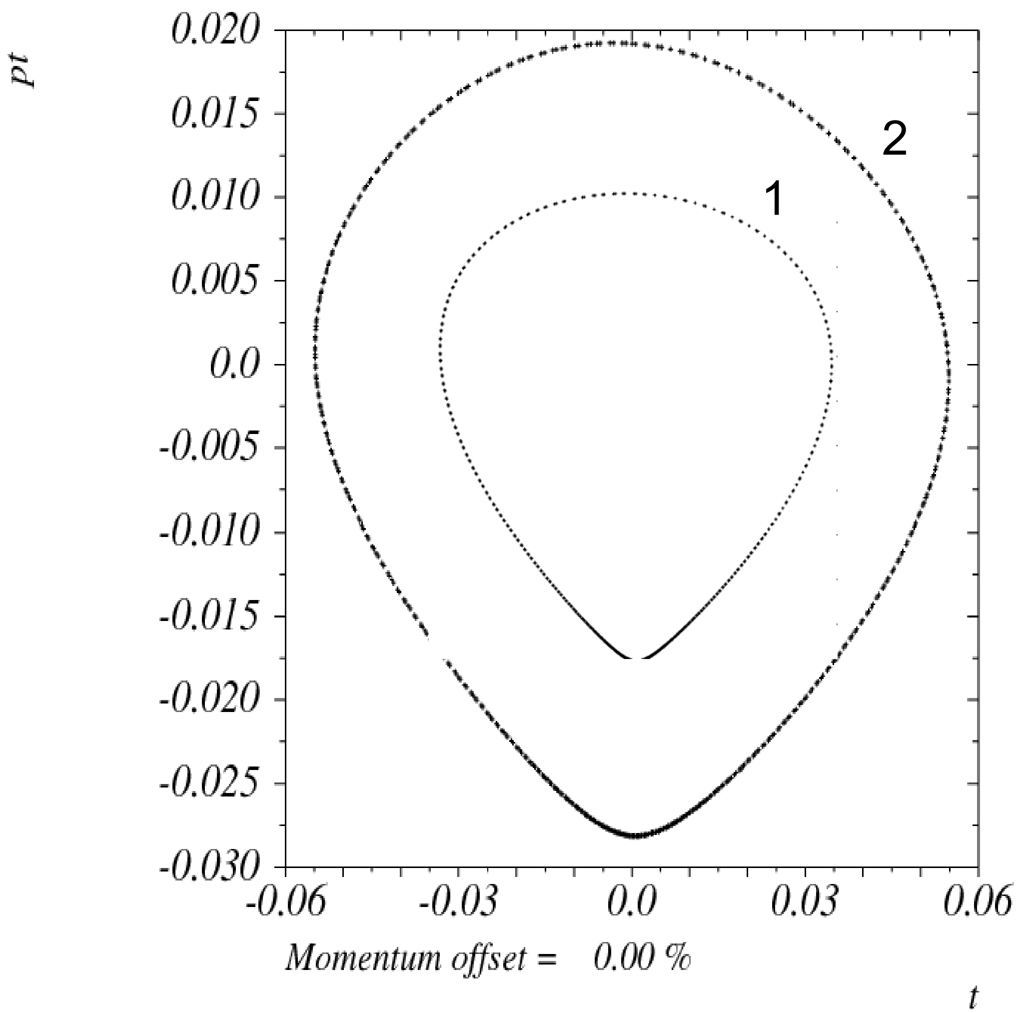


Compton beam intensity at W_{las}=20 mJ. Circles and stars correspond to long and short rings

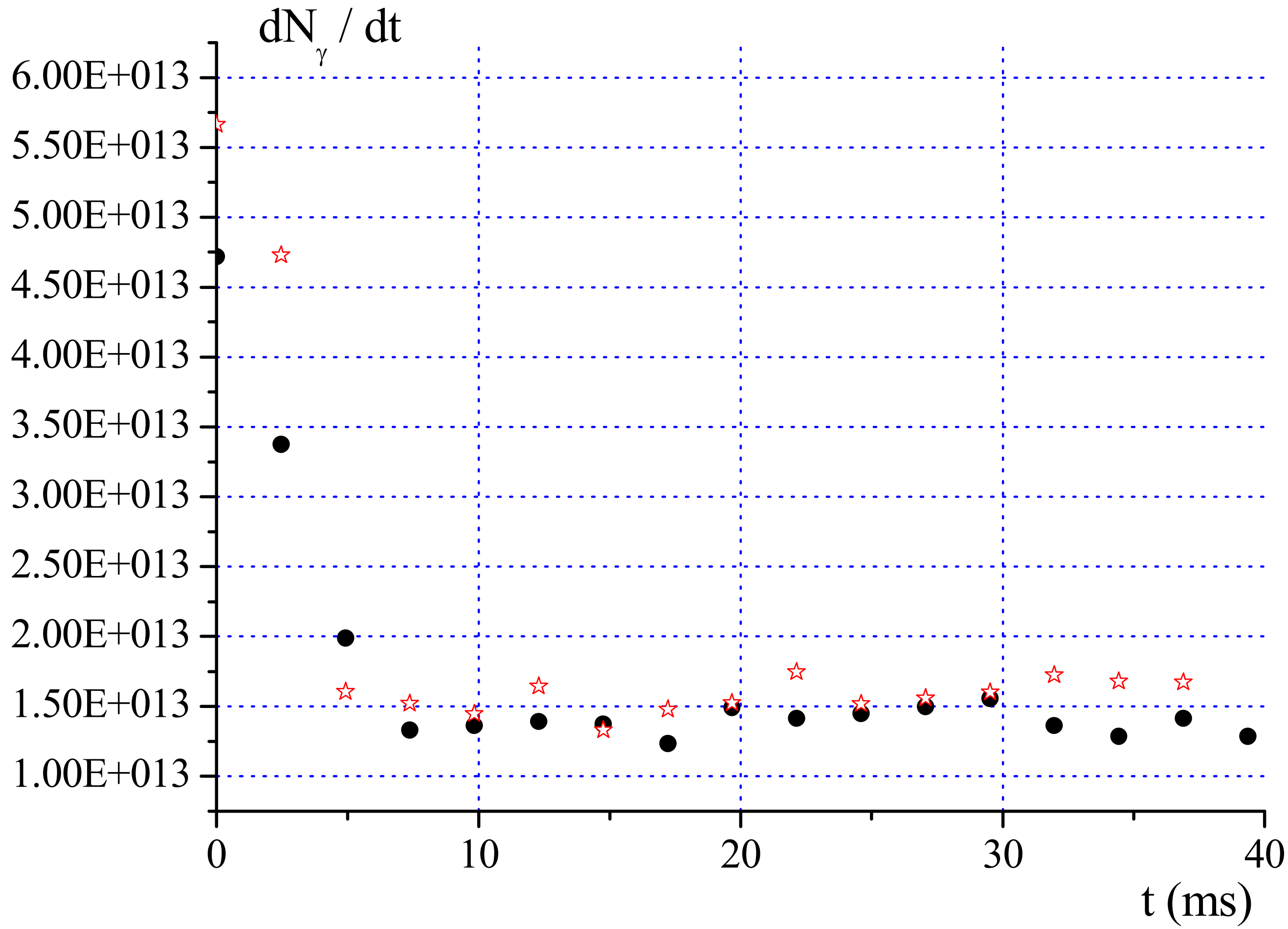


RF acceptance of long ring at momentum compaction α_1 = 0.01

$\sigma_{rf} \approx |\alpha_1 / \alpha_2|$



RF acceptance of short ring at α_1 = 0.01 (1) and α_1 = 0.02 (2)



Compton beam intensity at α_1=0.02 (stars, W_{las}=20 mJ) and α_1=0.01 (circles, W_{las}=10 mJ)

Main Ring&Beams Parameters

Parameter	C=14.760 m	C=11.068 m
Maximal electron energy, MeV	350	350
Maximal gammas energy, MeV (ε_{las}=2.328 eV)	~ 4.3	~ 4.3
Circumference, m	14.760	11.068
Betatron tunes	3.114; 1.199	2.872; 1.230
Harmonics number	64	48
RF frequency, MHz	1300	1300
RF voltage, MV	0.5	0.5
Momentum compaction factor α_1	0.01 - 0.02	0.01 - 0.02
Amplitude functions at IP, m	0.163; 0,120	0.300; 0.150
Crossing angle, degrees	8	5
Bunch number * bunch charge (nC)	8 * 2	4 * 2
Bunch-to-bunch spacing, ns	6.15	9.22
Size of electron beam at IP σ_x, σ_y, σ_s, microns	180; 35; 1000	245; 40; 1000
Laser spot size at IP, microns	30	40
Laser flash energy, mJ	10	2*10
Steady-state gamma-beam intensity N_γ / s	$1.4*10^{13}$	$1.2*10^{13}$

Summary

- High-flux compact gamma-source for nuclear waste management may be realized on base of Compton ring at state-of-the art of technologies;

- Compactness – advantage or disadvantage ?

- Drastic decreasing of gamma-beam intensity. Crab –crossing ? Double chicane ?