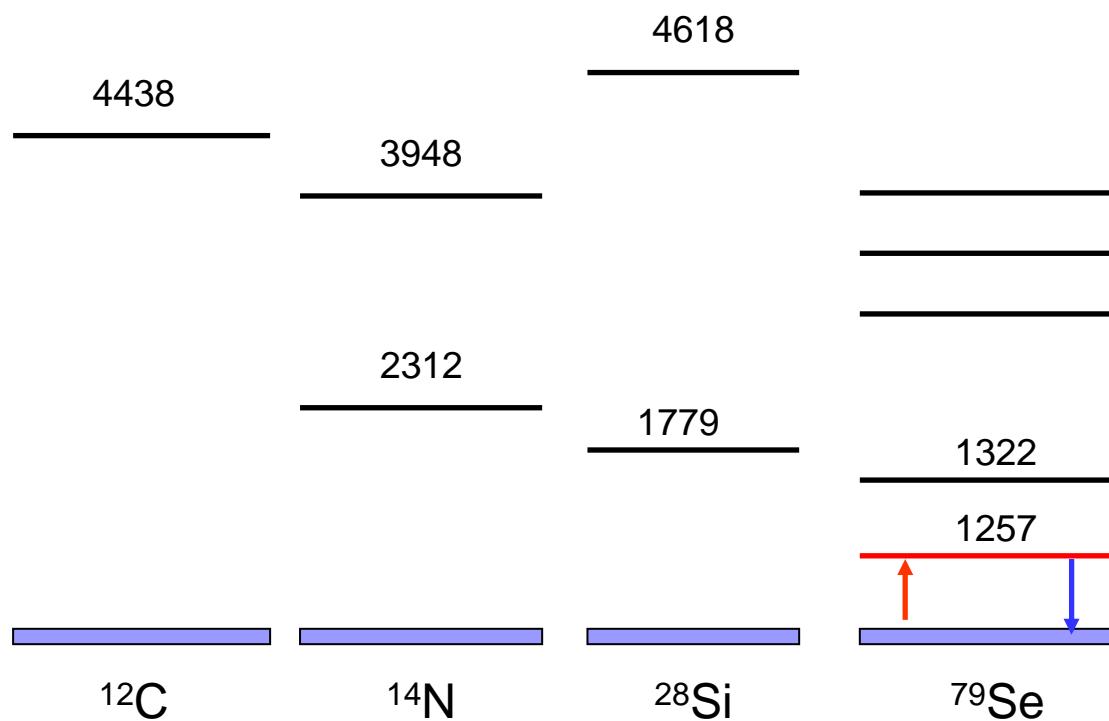


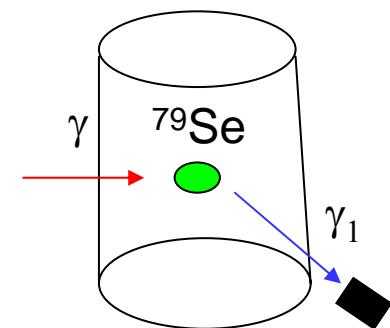
Compact Compton Ring for Nuclear Waste Management

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Nuclear Resonance Fluorescence

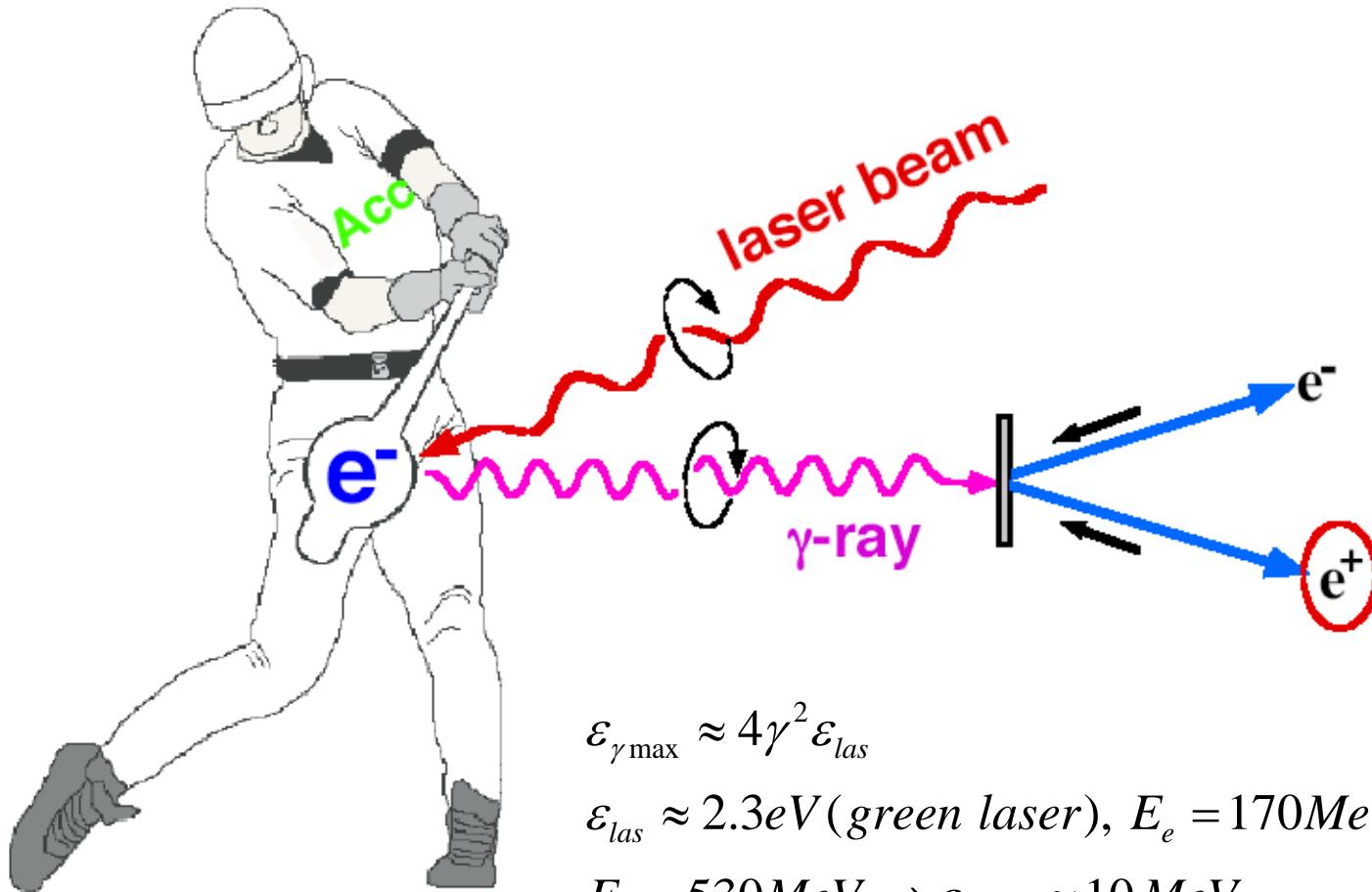


Nuclear waste



Pictured by R.Hajima

Compton scattering



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

$\varepsilon_{\text{las}} \approx 2.3 \text{ eV} (\text{green laser}), E_e = 170 \text{ MeV} \Rightarrow \varepsilon_{\gamma \text{ max}} \approx 1 \text{ MeV},$

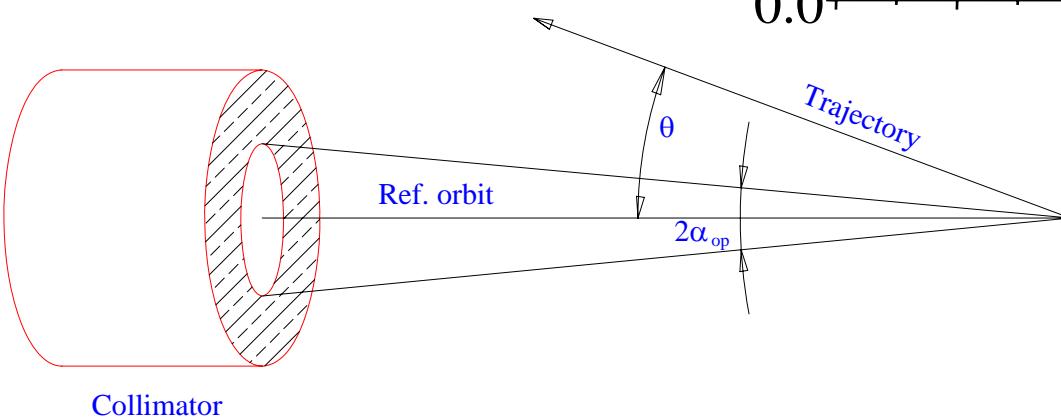
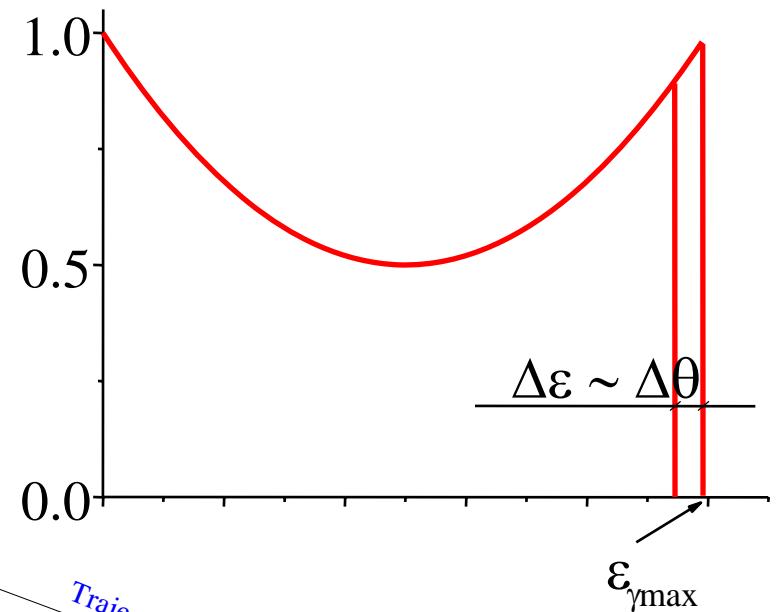
$E_e = 530 \text{ MeV} \Rightarrow \varepsilon_{\gamma \text{ max}} \approx 10 \text{ MeV}$

Pictured by T.Omori

Compton scattering

$$\varepsilon_\gamma \approx \frac{2\gamma^2(1+\cos\varphi)\varepsilon_{las}}{1+\gamma^2\theta^2} \approx \frac{\varepsilon_{\gamma\max}}{1+\gamma^2\theta^2}$$

$$\frac{\Delta\varepsilon_\gamma}{\varepsilon_{\gamma\max}} = \frac{2\gamma^2\theta^2}{1+\gamma^2\theta^2}$$



Types of Compton based sources

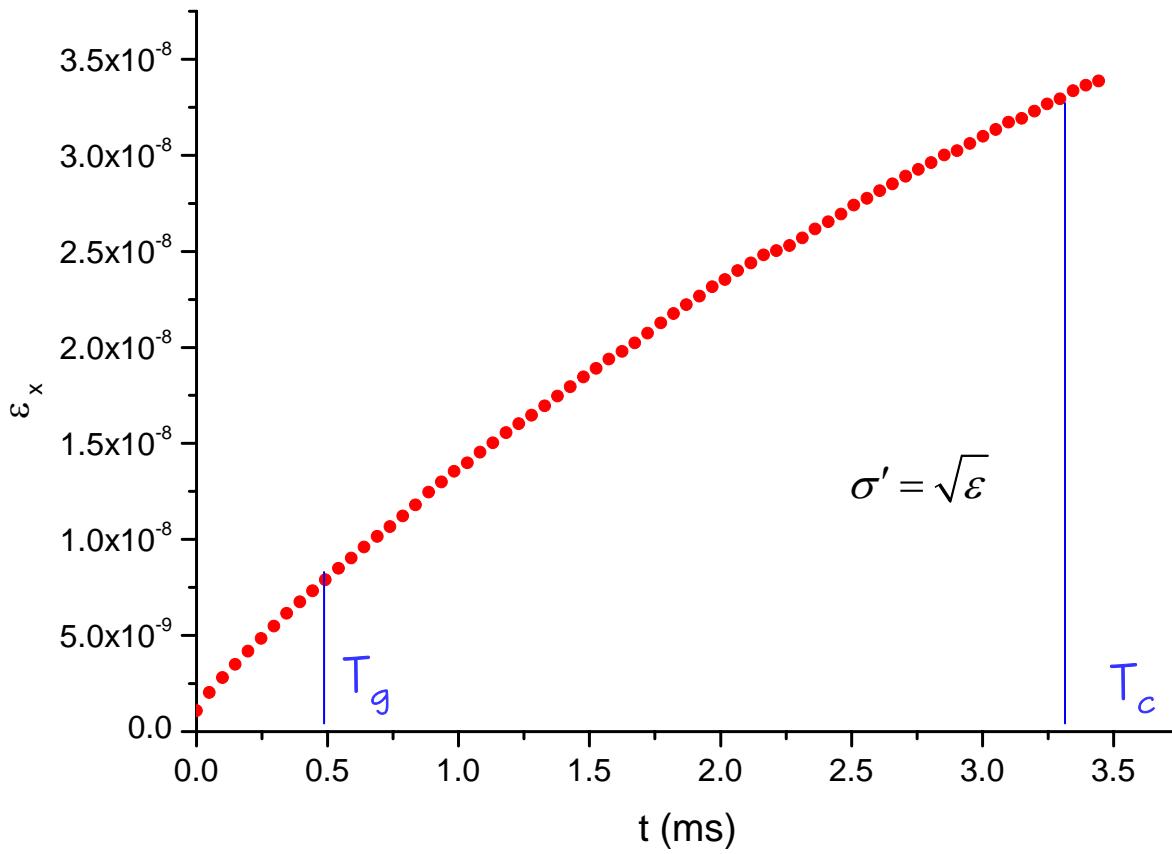
1. Linac, energy recovery linac:

- Low emittance – advantage
- Low energy spread – advantage
- Low mean current – significant disadvantage

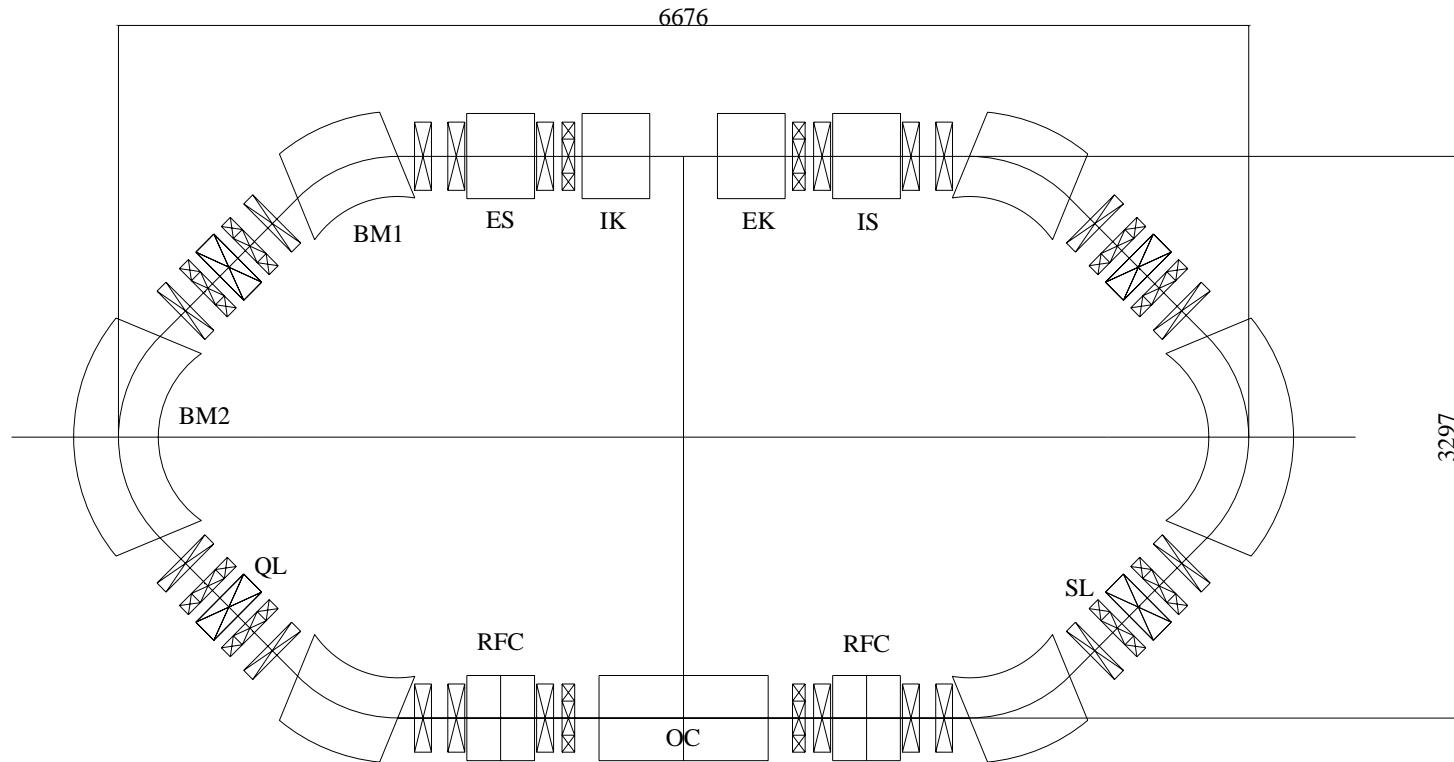
2. Compton storage ring :

- Quite low emittance – (dis)advantage
- Large energy spread – disadvantage
- Large mean current – significant advantage

Emittance growth

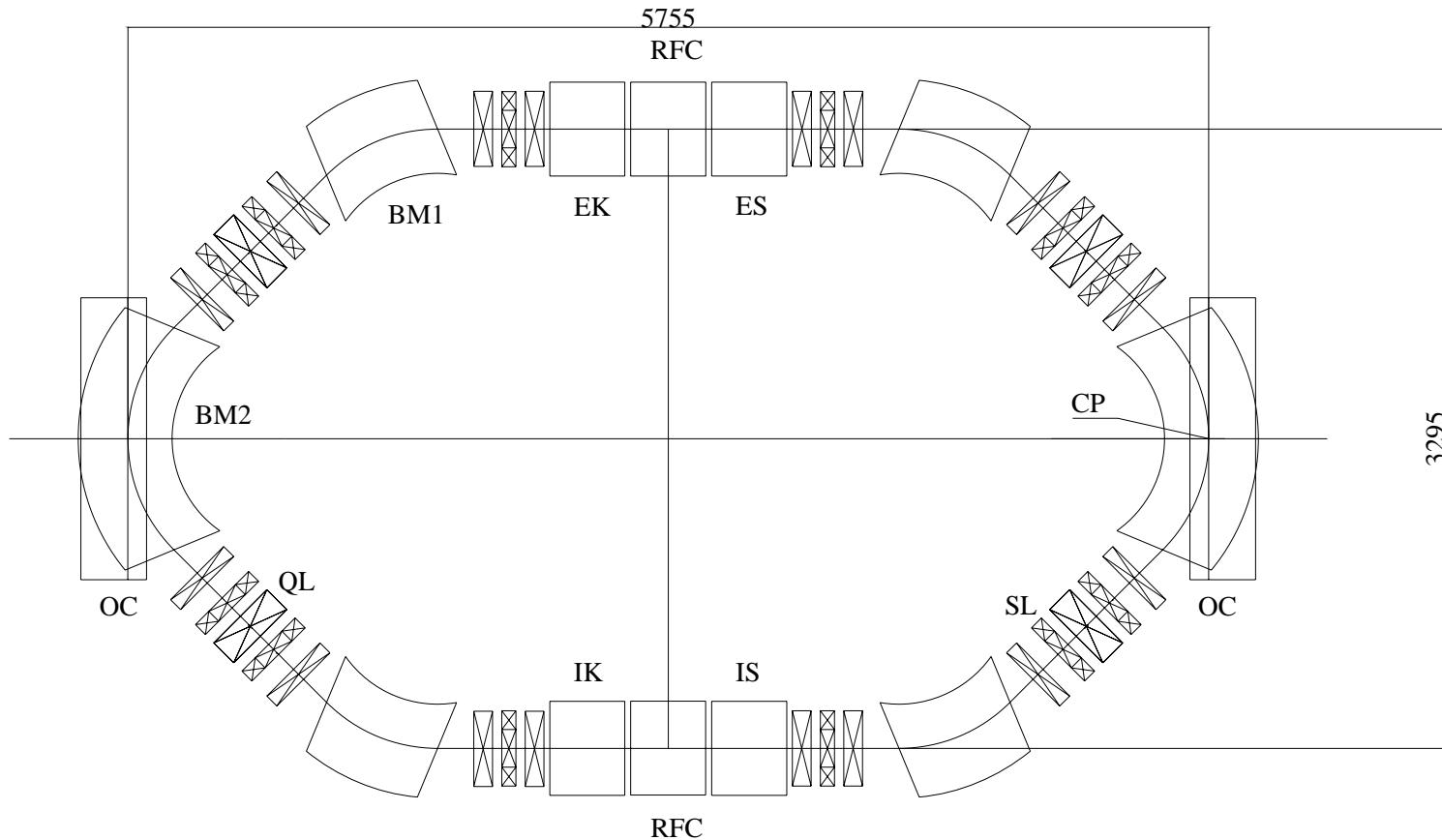


CSR with non-head-on collision



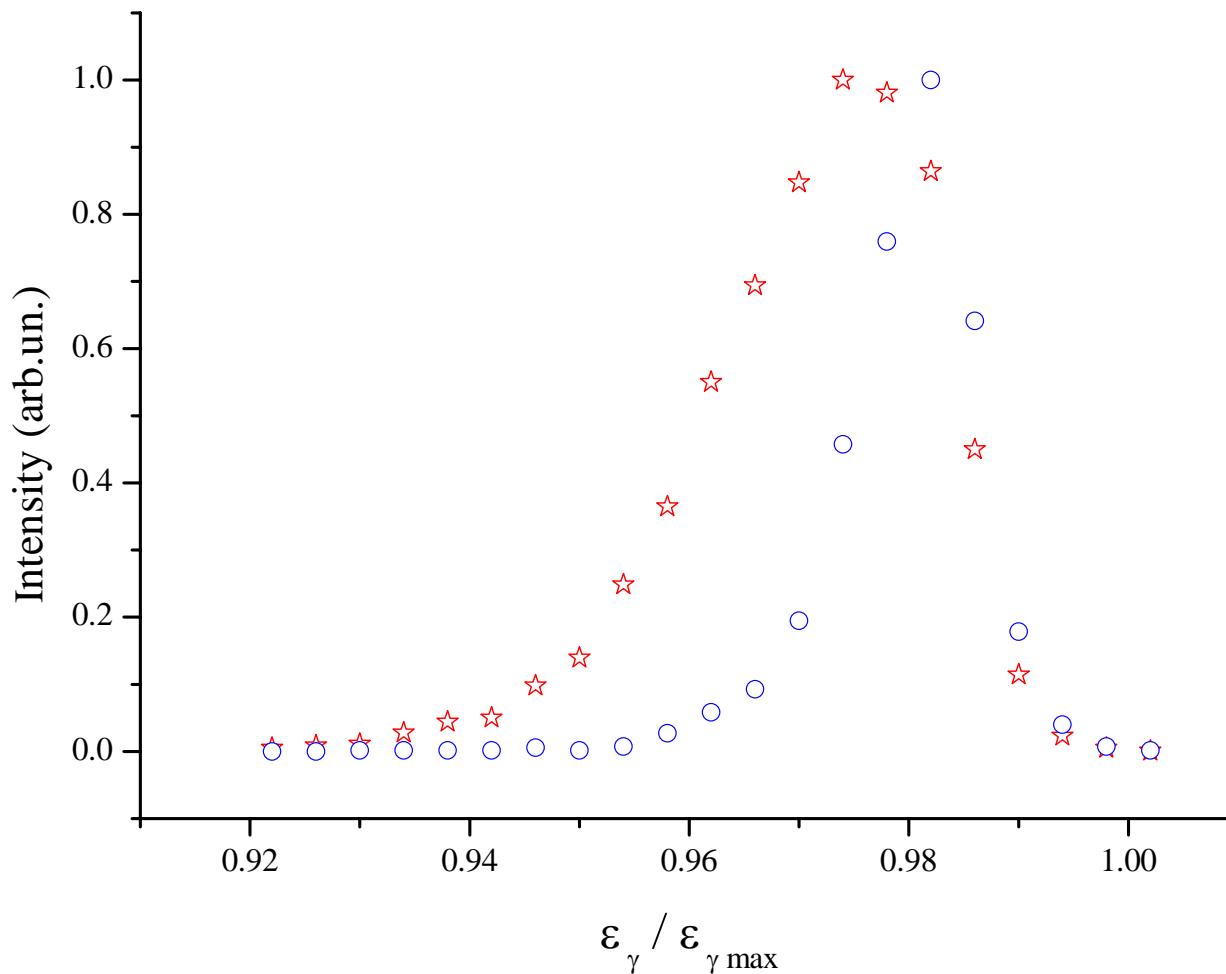
BM1, BM2: bending magnets with bending angle 45° and 90° ;
QL, SL: quadrupoles and sextupoles; RFC: rf-cavities; OC: optical cavity;
IS, IK: injection septum and kicker; ES, EK: extraction septum and kicker.

CSR with head-on collision



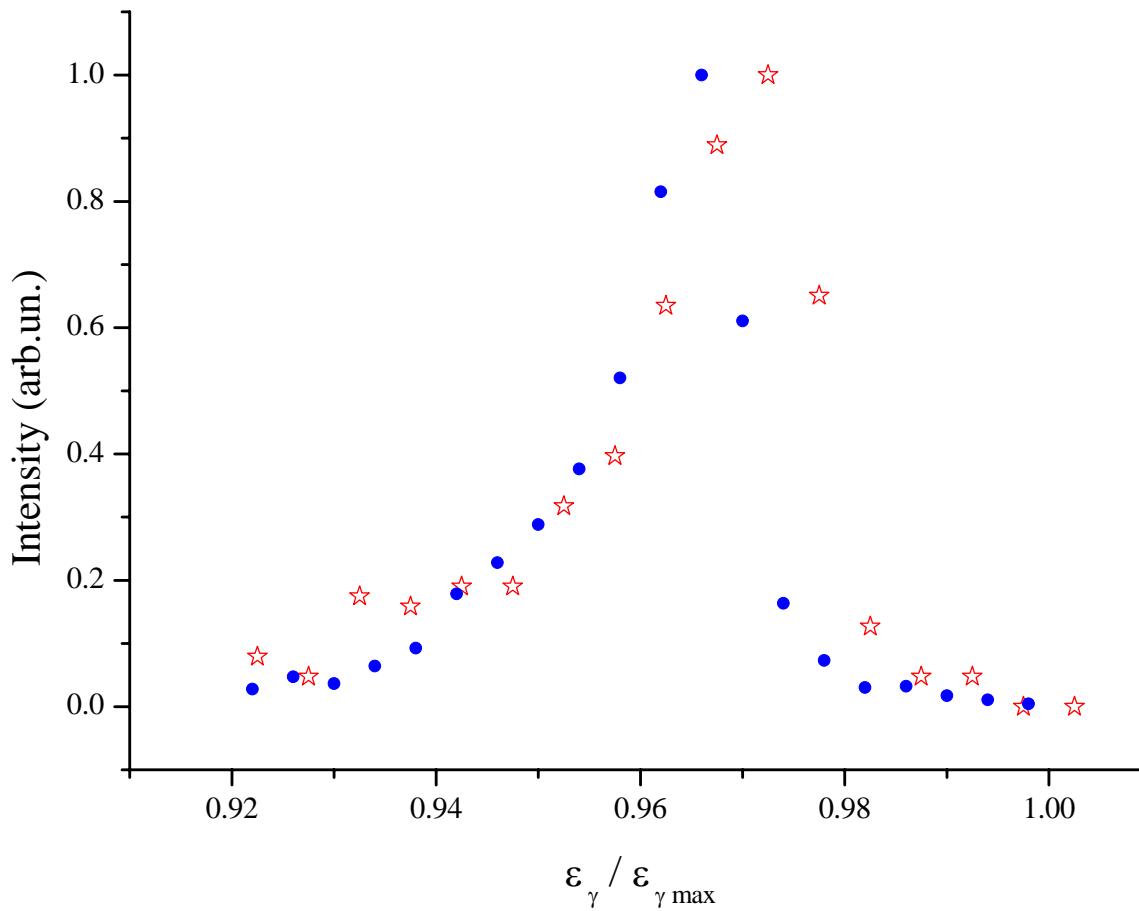
P.Gladkikh. RREPS-2013, Sevan,
Armenia

Collimated spectra



$E_e = 100 \text{ MeV}$, $\Delta p/p = 0.2 \%$, opening angle 0.4 mrad (blue circles),
 0.8 mrad (red stars). Generation time $500 \mu\text{s}$.

Collimated spectra



$E_e = 450 \text{ MeV}$, $\Delta p/p = 0.2 \%$, opening angle 0.1 mrad .
Generation time $500 \mu\text{s}$ (blue circles), 3.33 ms (red stars).

Main ring parameters

Parameter	Value
Electron beam energy range, MeV	90 – 450
Circumference, m	14.760
Bunch number	16
Bunch charge, nC	0.5
Bunch-to-bunch spacing, m	0.923
Bending field, T	1.8
Tunes, Q_x , Q_y	2.866; 1.198
RF voltage, MV	2*0.4
Momentum compaction factor	0.035
Natural emittance at maximal energy, nm*rad	50
Amplitude functions at collision point, m	0.47; 0.52
Laser photons energy, eV	2.328
Laser flash energy, mJ / flash	12-25
Laser waist, microns	30
Gamma – rays energy range, MeV	0.29 – 7.22
Gamma – yield, photons / s / CP	$\sim 1.0 \times 10^{13}$
Spectral density of collimated spectrum, photons / keV / s	$0.8 \times 10^9 - 2 \times 10^{10}$
Collimated spectrum FWHM, %	$\sim 0.5 - 1$

Conclusions

- We propose compact gamma-beam source which joints together advantages of both CSR and ERL schemes.
- The spectrum width is practically determined by the energy spread of the injected electron beam.
- Use of the head-on collision allows us considerably improve the source capabilities.
- At present, such a source does not have an alternative for the nuclear waste management