RESULTS OF PARMELA SIMULATIONS OF THE CAPTURE SECTION WITH PHOTONS FROM 10 LASER CAVITIES

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Some new simulations of the Capture Section have been performed taking as input particles the photons contained in the file gamma3.dat.gz given to us by Omori-san who performed CAIN simulations.

After extracting coordinates, momenta and polarizations (only the 2nd component of the Stokes parameters) of the photons (106,402 photons in total) we have proceeded to correct the coordinates of each photon taking into account the 40 m drift between the collision points (all normalized at S=0, according to Omori's instructions) and the target.

Then we have made a simulation with EGS4 with polarization implemented, using as incident particles the photons above and as target we used an amorphous tungsten target of thickness = 0.4 X_0 (= 1.4 mm), obtaining 5171 positrons produced.

Then we have taken the polarized positrons produced and after cutting positrons with an angle bigger than 45 degrees to the propagation axis ($P_z/P > 0.707$), we have used the positrons left (4,000 in total) as input particles for our PARMELA simulation.

Here are some details of the Capture Section :

AMD

Length = 0.50 m

Initial Magnetic Field : 6 Tesla

Final Magnetic Field (at 0.5 m from the target) : 0.5 Tesla

Pre-accelerator (Solenoid)

Length = 55.2 m
N. of cavities = 79
Distance between cavities = 13 cm

The cavities used are 1,280 MHz 4 cells cavities of length 56.84 cm and peak electric field of 7 MV/m and aperture of radius = 20 mm. In Fig. 1 a plot of the electric field in one of these cavities is shown. The mean energy of the beam at the exit of the solenoid is about 150 MeV.

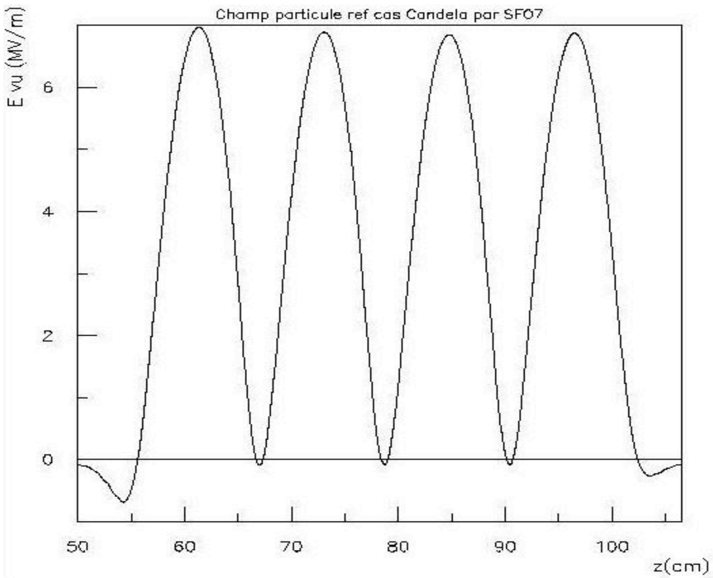
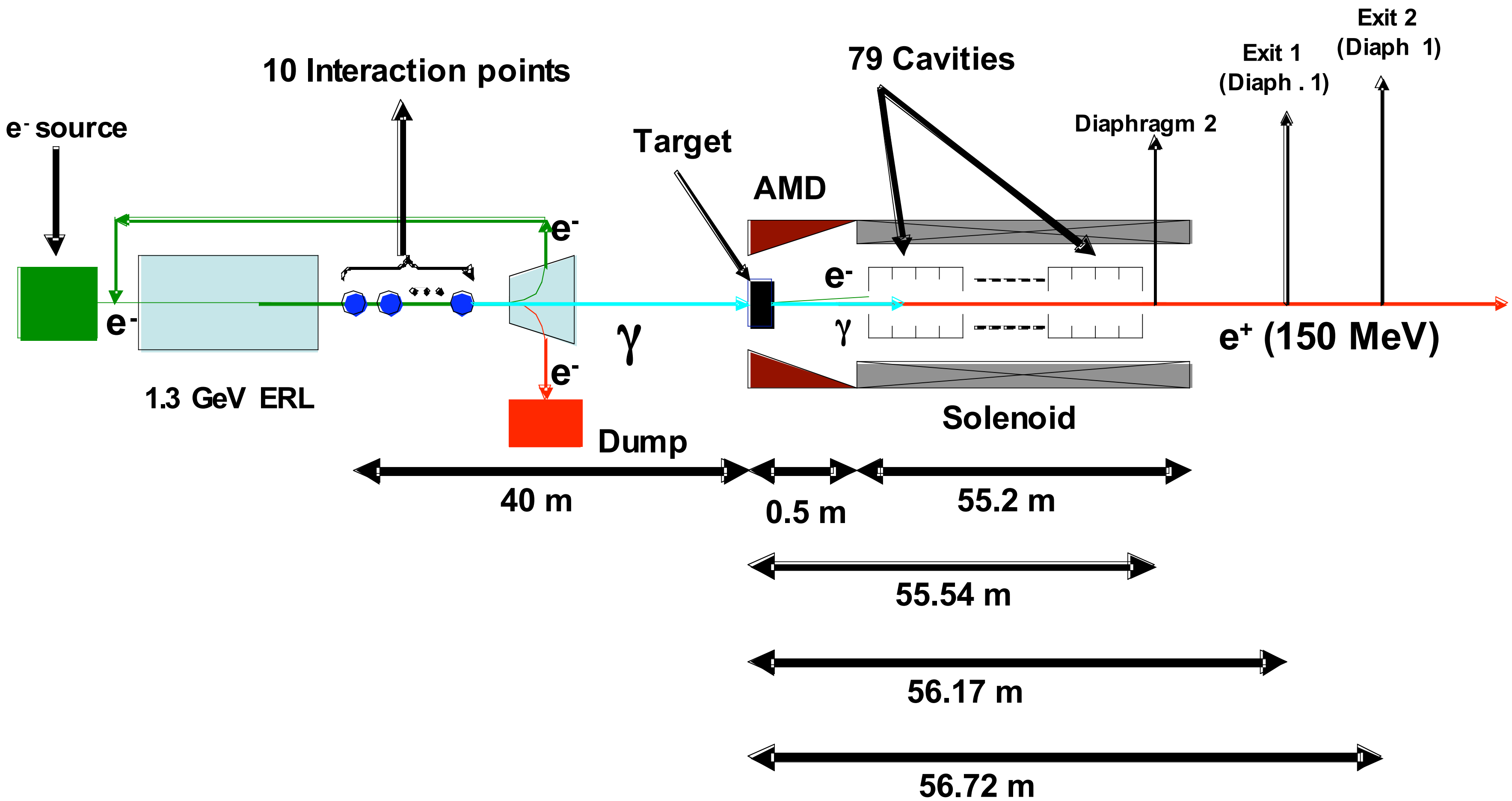


Fig 1. Electric field intensity on the axis of a cavity.

At the end of the simulation the beam parameters have been taken at two different points of the transport line: the first (named Exit 1) located at 56.17 m after the target (namely 47 cm out of the solenoid) and the second at 56.72 m after the target (102 cm out of the solenoid).
Below it's shown a scheme of the Capture Section simulated.

Scheme of the Capture Section (up to 150 MeV)



Three different studies have been performed with the particles at both the exit points. In the first study only particles inside a transversal circle of given radius have been considered and their transversal normalized rms emittance and Yield have been calculated. Then this radius has been varied from 2 cm to 0.4 cm and transversal normalized rms emittance and Yield have been calculated for the resulting particles. This study has been done to simulate the effects of putting a diaphragm at the exit of the solenoid. Yield has been calculated as ratio between the number of particles left and the number of photons hitting the amorphous target (namely 106,402).

A second study has been performed by putting 2 diaphragms, one at point 55.54 m after the target, right after the last accelerating cavity and the other at the exit point as before. The radii of the diaphragms have been kept equal. This study has been made in order to see a reduction of the transversal emittance of the beam, by cutting particles with large transversal angles.

A third study has been made by selecting the particles at the exit points of the simulated line. Particle falling outside of a selected interval of energy has been cut and longitudinal rms emittance of the remaining particles has been calculated. The energy interval has been centered around 160 MeV, which resulted to be the peak of the energy spectrum of the particles.

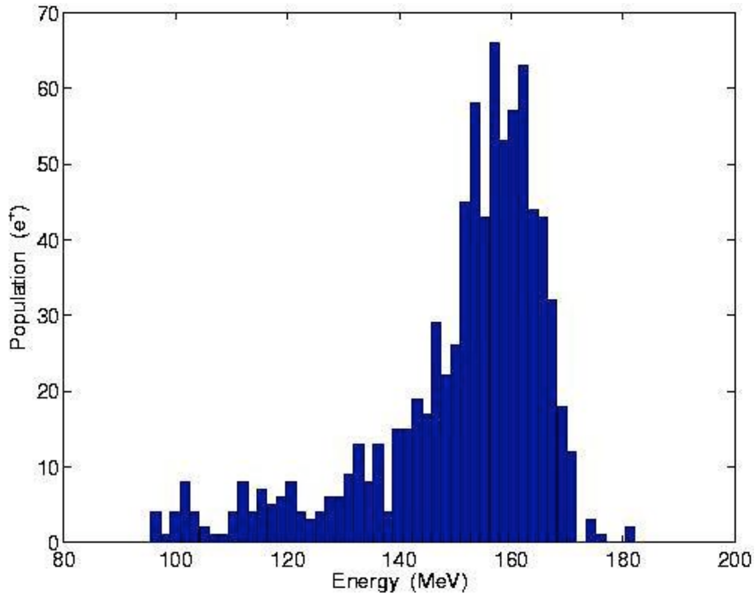


Fig.2 Energy Spectrum of the positrons at the exit points.

Results have been reported in the table.

Exit 1 (56.17 m)	Yield e^+/γ (%)	$\gamma (\varepsilon_x+\varepsilon_y) \pi$ (rms) (cm rad)	Yield/Emittance % / (π cm rad)	Radius Diaphragm (mm)
1 Diaph.	0.77	4.94	0.16	20
	0.50	3.42	0.15	11
	0.31	2.41	0.13	7.7
	0.20	1.85	0.11	6.2
	0.10	1.18	0.09	4.1
2 Diaph.	0.77	4.94	0.16	20
	0.50	3.37	0.15	12
	0.30	2.30	0.13	8.4
	0.20	1.70	0.12	6.8
	0.10	1.06	0.10	4.8
Energy selection		ε_z (rms) (π cm MeV)	Yield/Emittance % / (π cm MeV)	Energy interval (MeV)
	0.77	7.34	0.11	87
	0.66	3.90	0.17	50
	0.51	2.33	0.22	20
	0.35	1.58	0.22	12
	0.25	1.12	0.23	8
	0.13	0.61	0.21	4

Exit 2 (56.72 m)	Yield e^+/γ (%)	$\gamma (\varepsilon_x+\varepsilon_y)\ \pi$ (rms) (cm rad)	Yield/Emittance % / (π cm rad)	Radius Diaphragm (mm)
1 Diaph.	0.75	4.79	0.16	20
	0.50	3.40	0.15	12
	0.20	1.75	0.11	6.7
	0.10	1.21	0.08	4.6
2 Diaph.	0.75	4.79	0.16	20
	0.50	3.29	0.15	13
	0.20	1.68	0.12	7.9
	0.10	1.01	0.10	5.9
Energy selection	Yield e^+/γ (%)	ε_z (rms) (π cm MeV)	Yield/Emittance % / (π cm MeV)	Energy interval (MeV)
	0.75	7.25	0.10	87
	0.65	3.89	0.17	50
	0.47	2.19	0.22	18
	0.34	1.58	0.22	12
	0.24	1.12	0.22	8
	0.12	0.60	0.20	4

Remark:

In cases where transversal diaphragms have been used, a calculation of the longitudinal emittance of the final beam has not been performed. In those cases a reduction of the longitudinal emittance is expected because of the reduction of the number of particles, even if such reduction is not expected to be significant, since the particles are not selected according to their energy. As a first approximation then we can consider the longitudinal emittance of the beam in cases with diaphragms to be the same of the beam without selection of the particles, namely 7.34 π cm MeV for Exit 1 and 7.25 π cm MeV for Exit 2.

The same argument can be used for cases where particles have been selected according to their energy. In those cases the transversal rms emittance can be estimated as 4.94 π (cm rad) for Exit 1 and 4.79 π (cm rad) for Exit 2.

For each result the ratio Yield/Emittance has been calculated, in order to give an indication of the number of positrons the system is able to inject for unit area of the damping ring's acceptance.

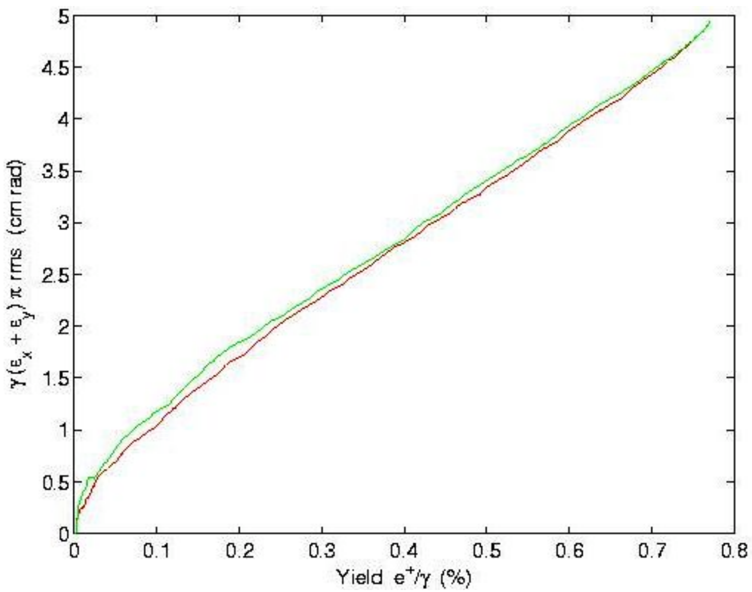


Fig.3 Transversal emittance vs Yield

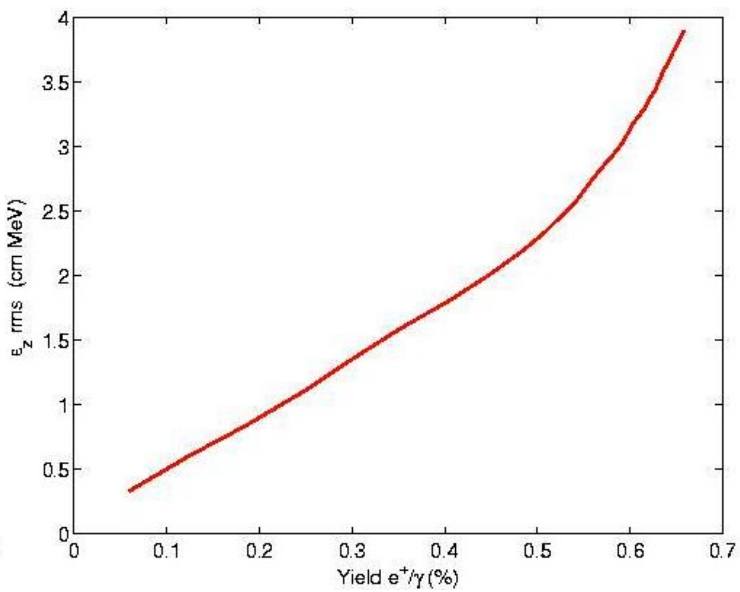


Fig.4 Longitudinal emittance vs Yield

Preliminary observations

- The system with 2 diaphragms can provide the same Yield of the system with one diaphragm with a transversal emittance reduced of a few percents.
- A selection of the particles by transversal diaphragms is not helpful for increasing the number of particles to inject per unit of acceptance area.
- A selection of the particles by energy seems effective in increasing the number of particles to inject per unit of acceptance area.

Remark

Polarization of the beam has been calculated by averaging the polarization of the positrons at the end of the simulation, making the assumption that these positrons maintain at the solenoid exit the same polarization they had at the target. The values of this parameter have been plotted below as a function of the total Yield in the case of energy selection study in Exit 2 as shown below, and it is always between 59% and 73%. For example, the polarization is about 67% for the optimized cut of 18 MeV giving 0.22 (% / MeV cm) as the ratio Yield/Emittance.

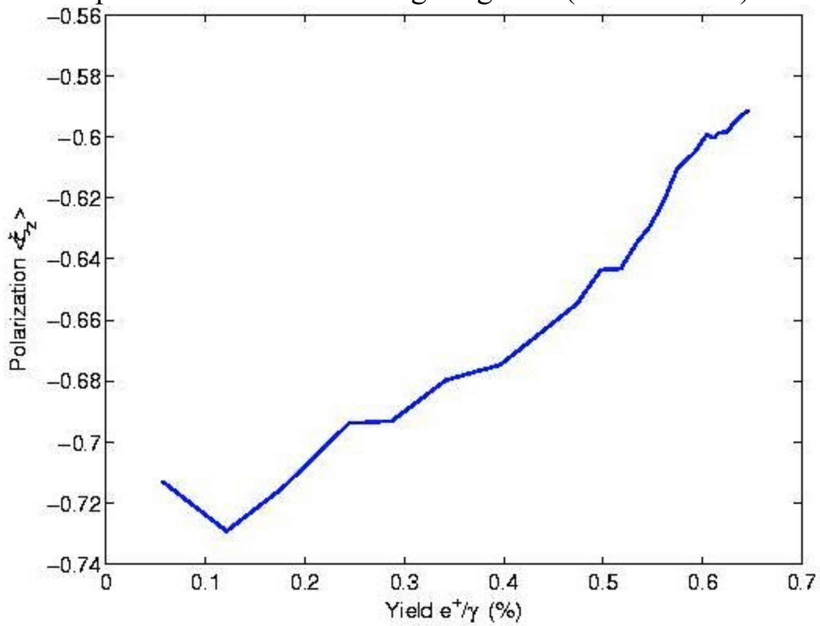


Fig.5 Polarization vs Yield of energy selected particles.

More accurate estimations of the polarization will be studied soon.