LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

Polarised Positrons for the SuperB Project

Alessandro Variola

Posipol 2009, Lyon - France

Polarised Positrons

- "Chirial" filter for the O(4S)
- Luminosity is constant but σ (so rate…) increases
- Effective polarization (we+wp)/(1+ we wp) for physics - high also for a relative low positron polarization (0.3 -0.4) if electrons are @ 0.8 (~ 0.9)
- Independently if it possible to have both polarised beams it is important to have the degree of freedom to decide who will go in the LER and in the HER
- Electrons is easy (As-Ga super lattice) but positrons => need of circular polarized gammas.

Undulator schemes for the SuperB energy range are out of the game, so what remains:

1) Compton scattering
2) Compton Selection
3) Polarised Bremmstrahlung

+ and -

- Compton +
- 1) High polarization possible (OK for SuperB)
- 2) reduced target heating (no required for SuperB)
- 3) Completely independent from the "main beam" (no required for SuperB)
- 4) R&D running for ILC and CLIC (OK for SuperB)

- Compton –
- 1) Need Compton driver @ high energy (1-2 GeV) = $$$
- 2)Low rate, need stacking strategy

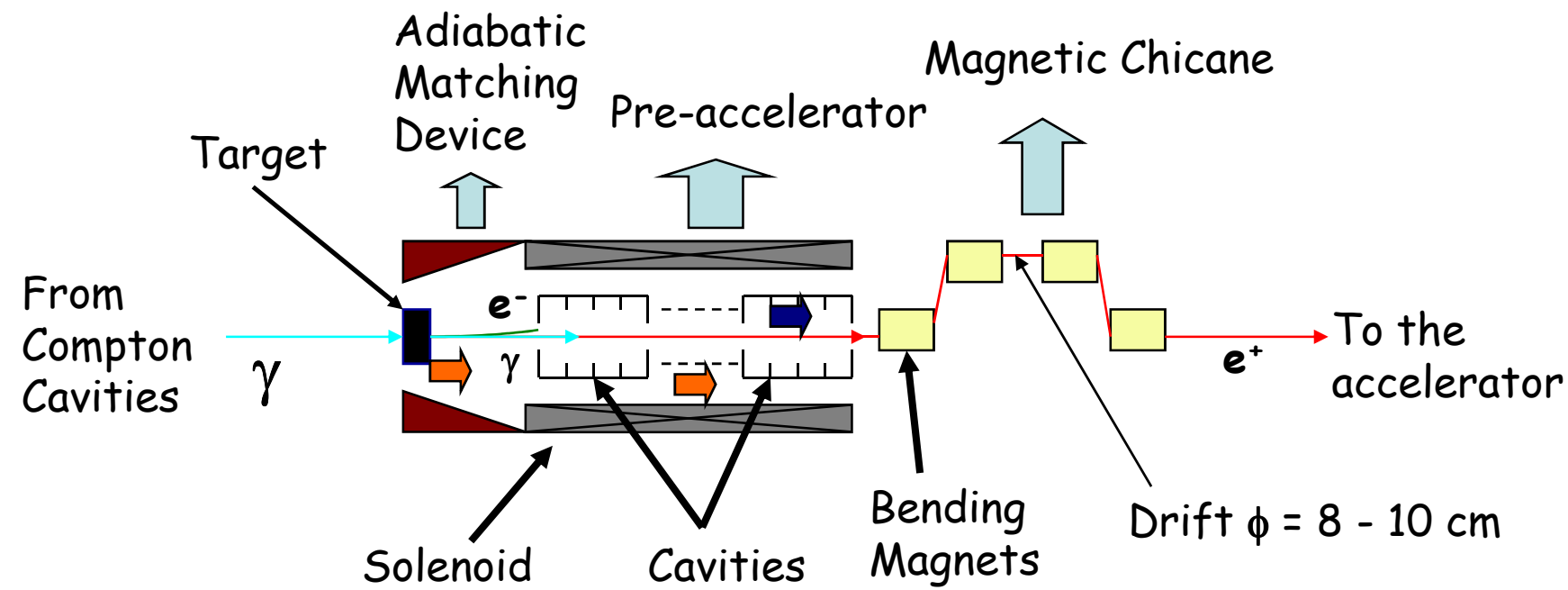
- Selective Compton +
- 1) Easy to implement and low cost (OK for SuperB)

- Selective Compton –
- 1) Needs higher energy (we will show this)
- 2) High power laser to leave the beam cooling

- Polarized Bremmstrahlung +
- 1) Low energy driver required (~ 50 – 40 MeV) (OK for SuperB)
- 2)Sufficient polarisation (linked to the yield) (OK for SuperB)
- 3)Low cost (OK for SuperB)

- Polarized Bremmstrahlung –
- 1) Yield to be evaluated in respect to polarised e- guns performances
- 2) Needs stacking ? Depends form the gun and from the required polarization
- 3) Polarization lower than Compton (Tolerable for SuperB)

Compton - examples

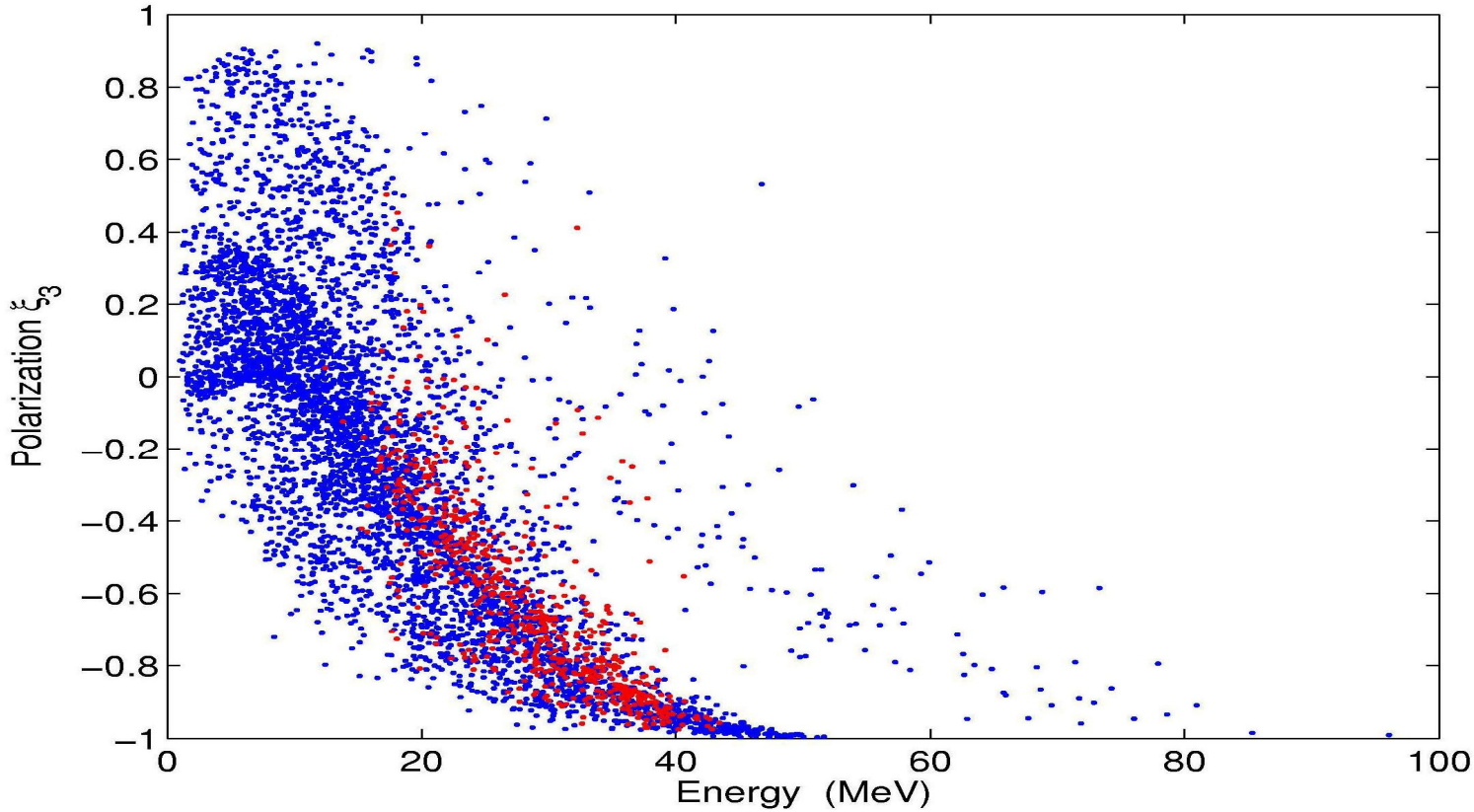


Magnetic field

Electric field

Polarization- Compton

Estimated polarization of accepted positrons at the target 60%



Alessandro Variola
Posipol 2009, Lyon - France

Type	N. γ	Yield e^+/γ %	N. e^+	ε_x π mm mrad	ε_y π mm mrad	ε_z π cm MeV	σ_z cm	σ_E MeV
1.3 / 5 (150 MeV)	$0.67\ 10^{10}$	0.36	$2.39\ 10^{7}$	15	17	1.53	1.67	3.55
1.3 / 5 B. C. (0.3 X0)	$0.67\ 10^{10}$	0.40	$2.66\ 10^{7}$	16	15	2.64	0.28	9.99
1.3 / 5 B. C. (0.4 X0)	$0.67\ 10^{10}$	0.36	$2.42\ 10^{7}$	13	14	2.74	0.28	10.64
1.3 / 5 B. C. (0.5 X0)	$0.67\ 10^{10}$	0.40	$2.69\ 10^{7}$	16	17	2.91	0.28	10.92
1.8 / 5 (180 MeV)	$0.75\ 10^{10}$	0.88	$6.65\ 10^{7}$	19	19	2.15	1.85	5.6
1.8 / 5 B. C. 1	$0.75\ 10^{10}$	0.90	$6.78\ 10^{7}$	17	15	3.89	0.32	12.71
1.8 / 5 B. C. 2	$0.75\ 10^{10}$	0.81	$6.08\ 10^{7}$	14	15	2.51	0.97	5.06

LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

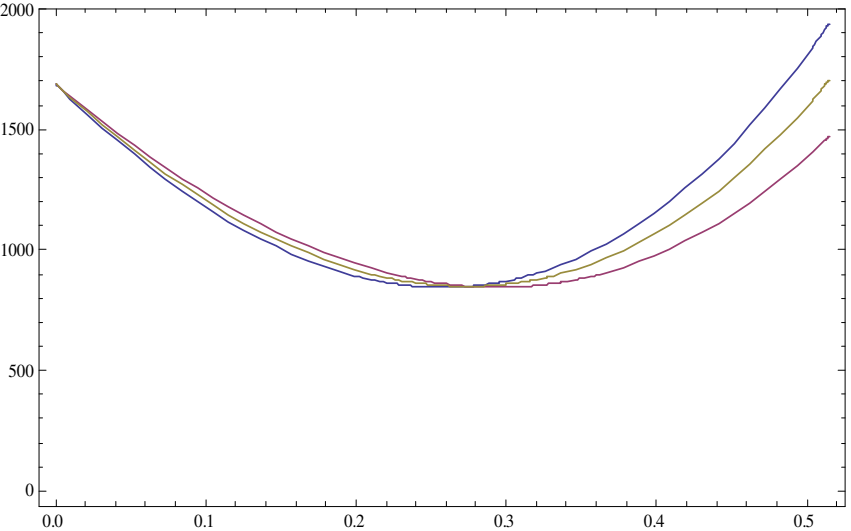
- What can be obtained :
- 1) 100 mJ laser = loss factor 6 so ~ 10exp7 e+ /shot
- For SuperB 2 10^{11} / sec
- 2) frep can be high as 20-80 MHz at the end it is possible to have near three order of magnitude more that the required
- BUT = 6D phase space big and need stacking and a strategy on how to put all them together. SuperB requires low frep injection (max 100 Hz..but 20 better!!!) and single bunch….so stacking requirements are near the ILC ones…..

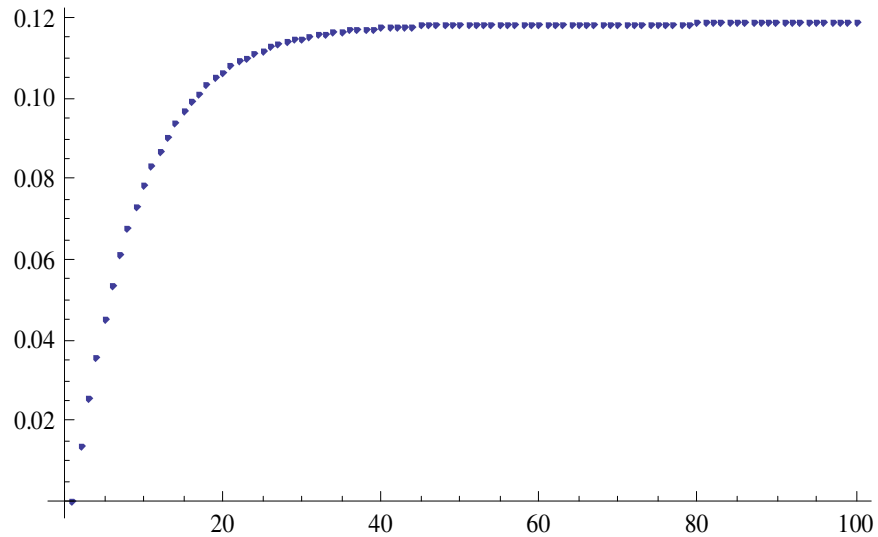
Costs and complexity of the scheme make Compton solution not suitable for SuperB

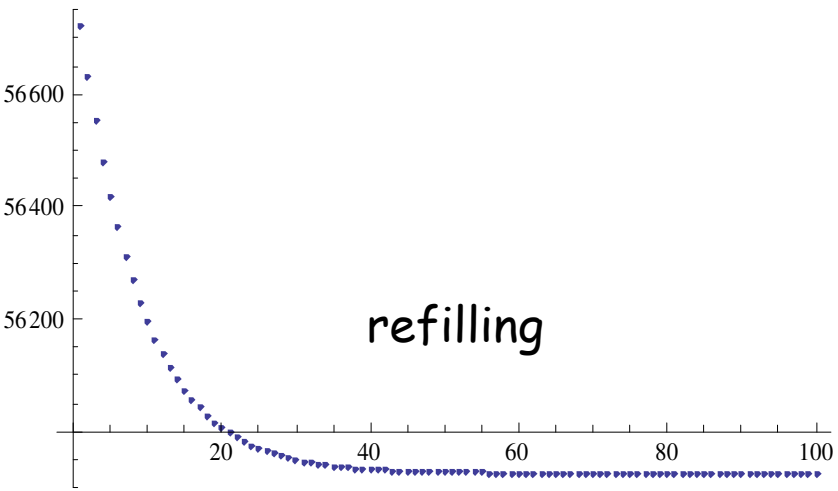
Selective Compton

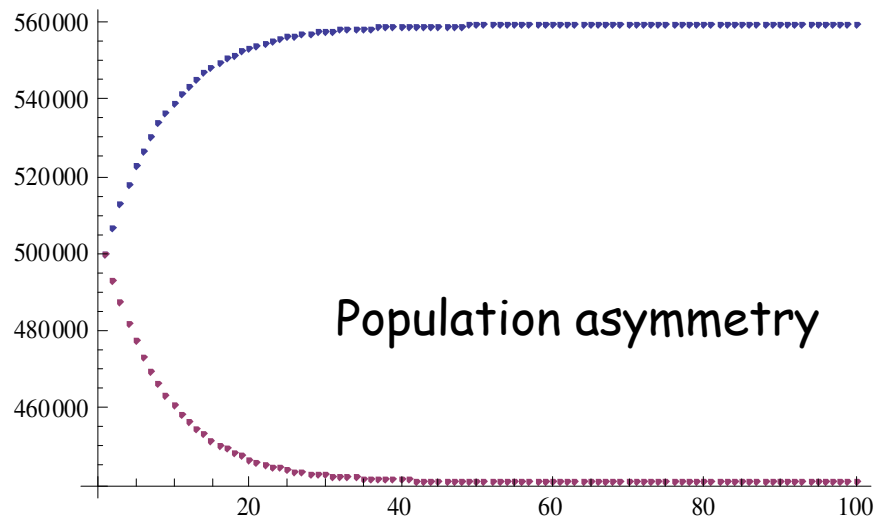
- Difference in cross section for up and down spins (like for polarimetry…)
- Energy recoil
- Dispersive line => selection
- Refilling with 50%/50% up and down
- Statistic selection

BUT 4 GeV @ sharp acceptance very difficult to do…



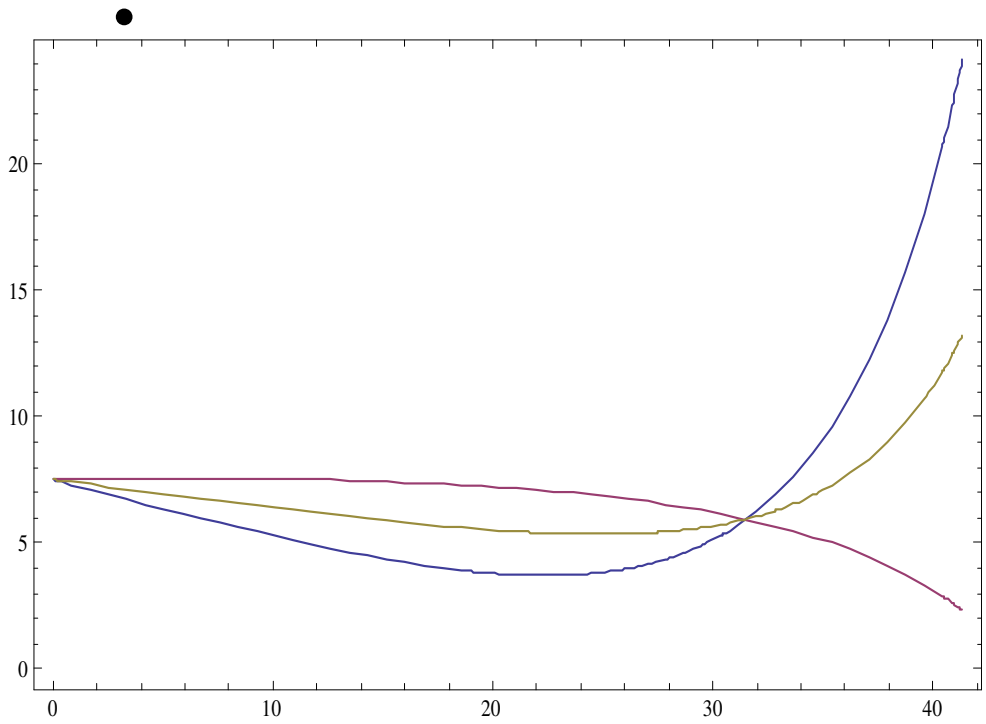


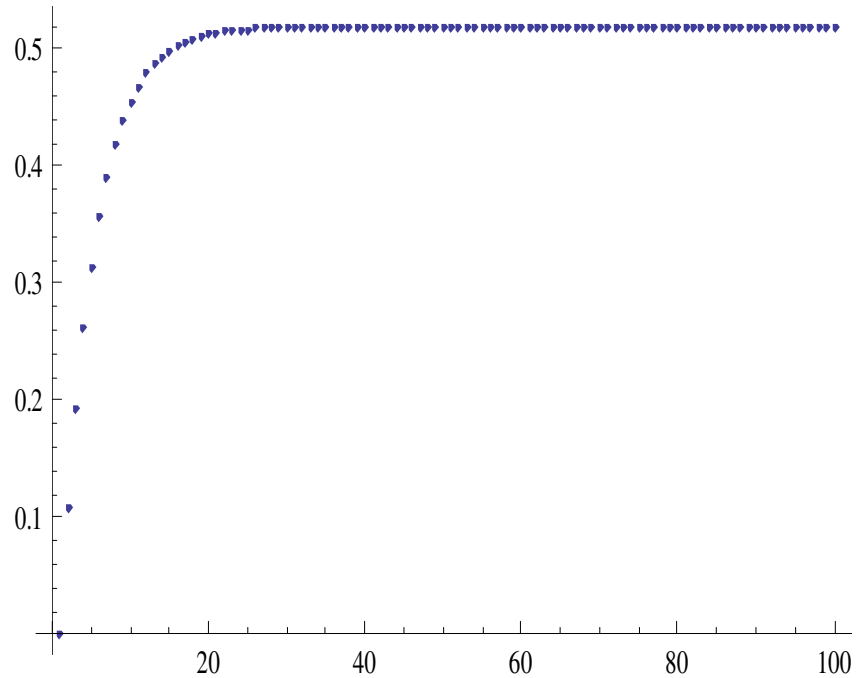




Alessandro Variola
Posipol 2009, Lyon - France

…60 GeV @ sharp acceptance





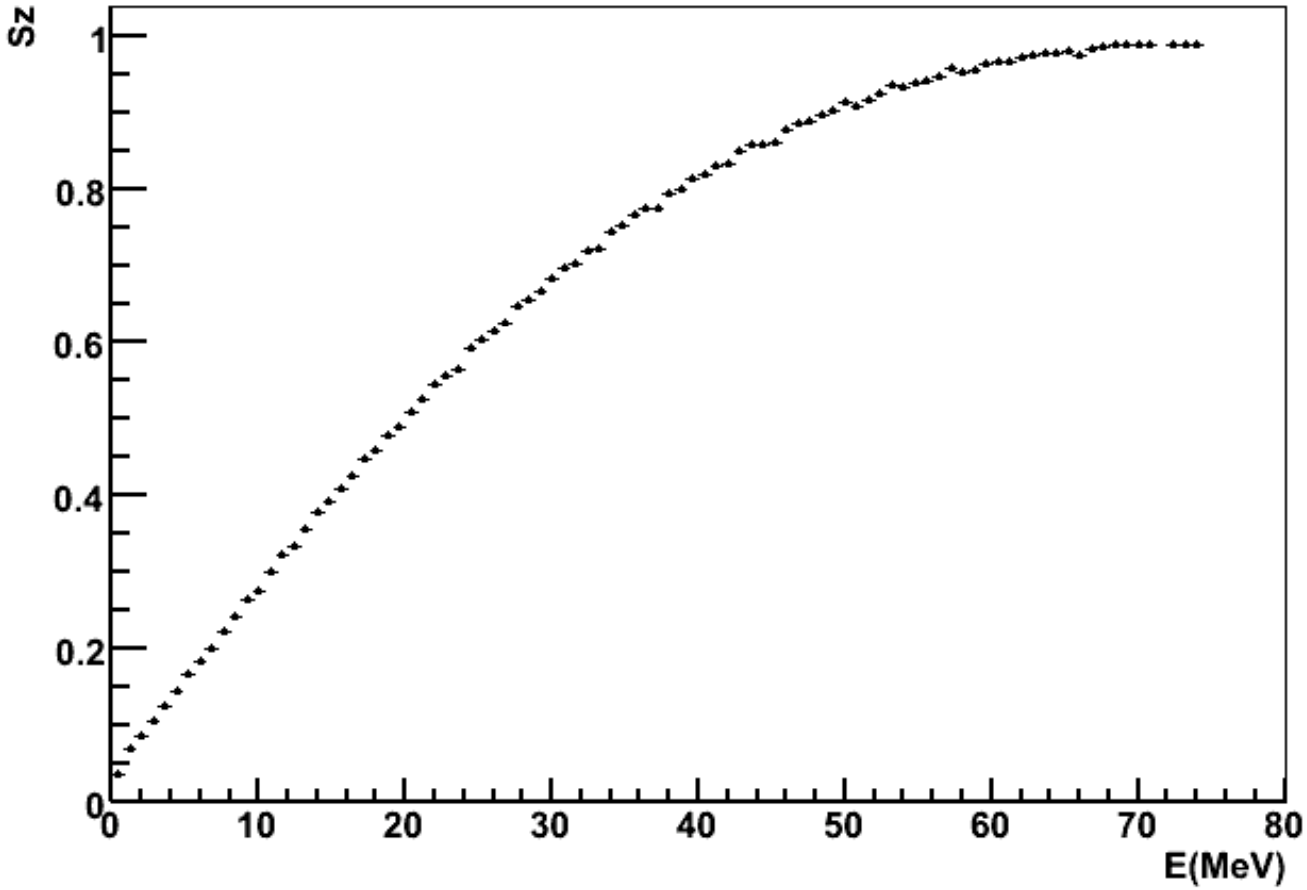
- Feasible sharp acceptance (4/5 ecut)?
- Anyway also if feasible pol = 0.1%....(BEST CASE)
- I think that this is not the good method for SuperB …

Polarised Bremmstrahlung

- Polarised electrons beams on amorphous target
- Polarised gammas -> polarised pairs
- High energy population is polarised
- Conflict between the Schiff spectrum and the requirement in yield….
- Average deposited energy .. not a problem, PEDD to be checked (SLAC gun = 15nC/pulse…)!!!

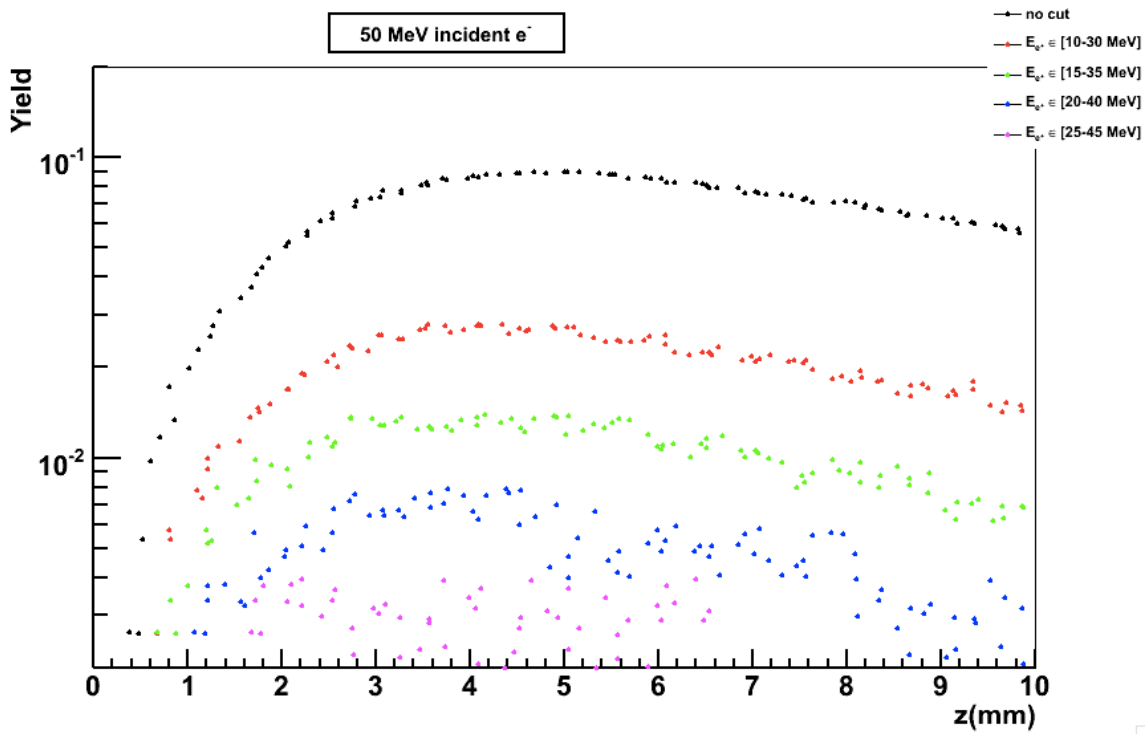
Two cases are analysed : drive beam = 50 and 80 MeV

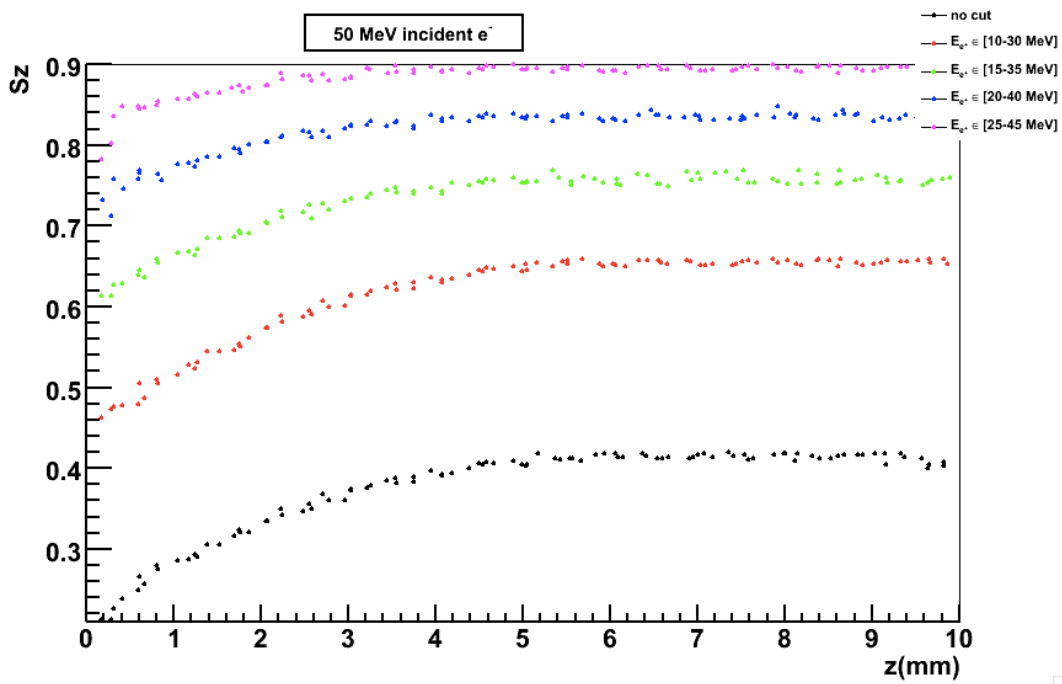
Polarisation vs Energy (for 80 MeV incident beaM – POL 1)



LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

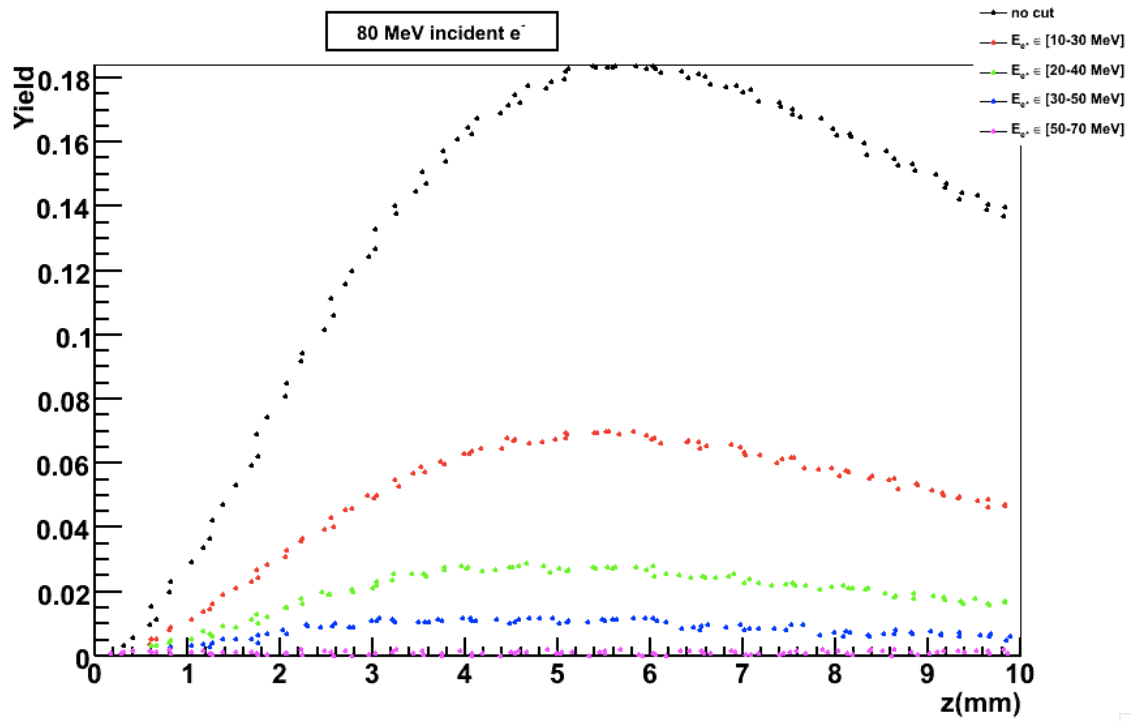
Drive beam
50 MeV

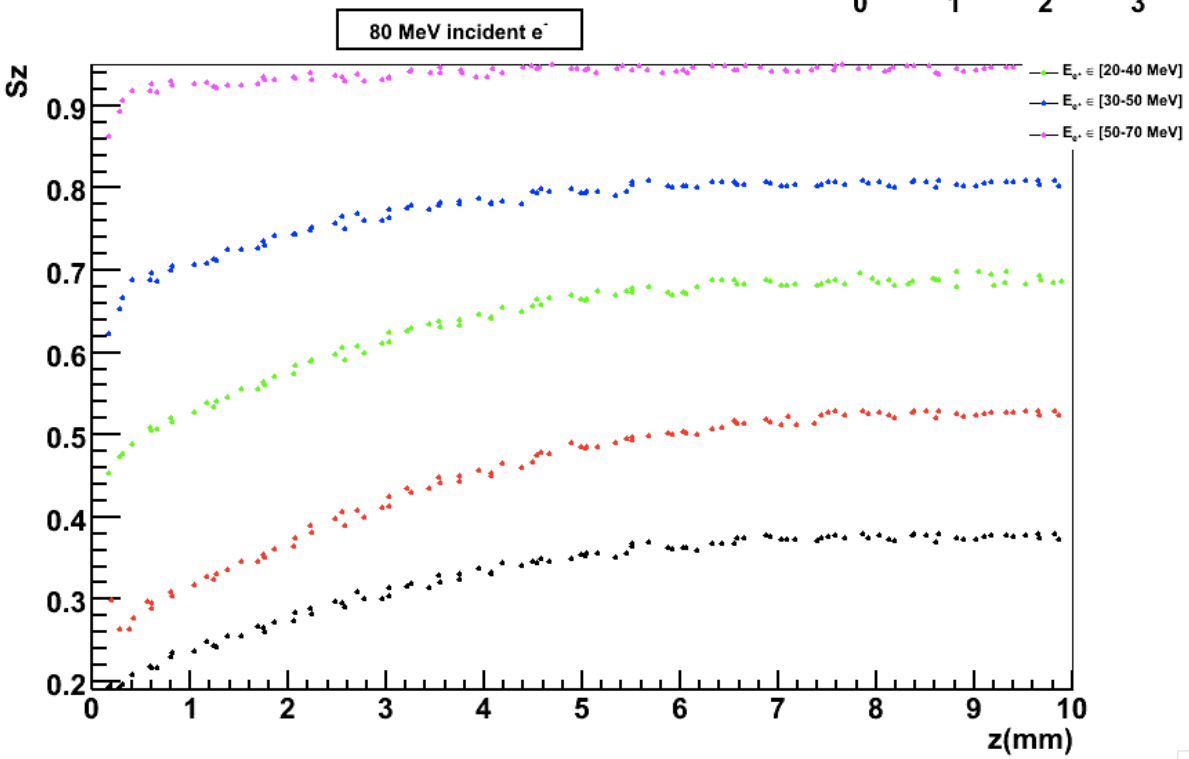




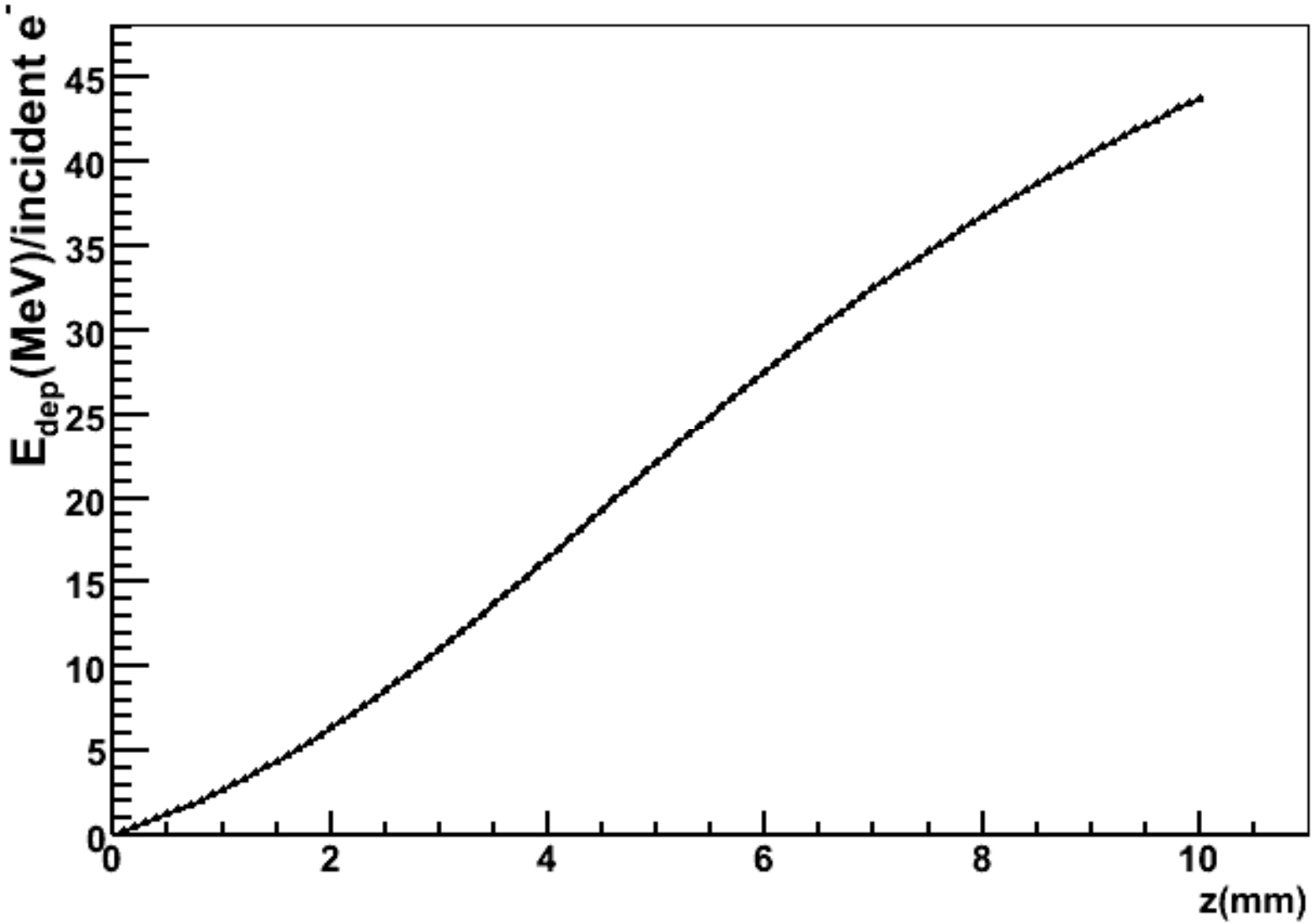
LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

Drive beam 80 MeV



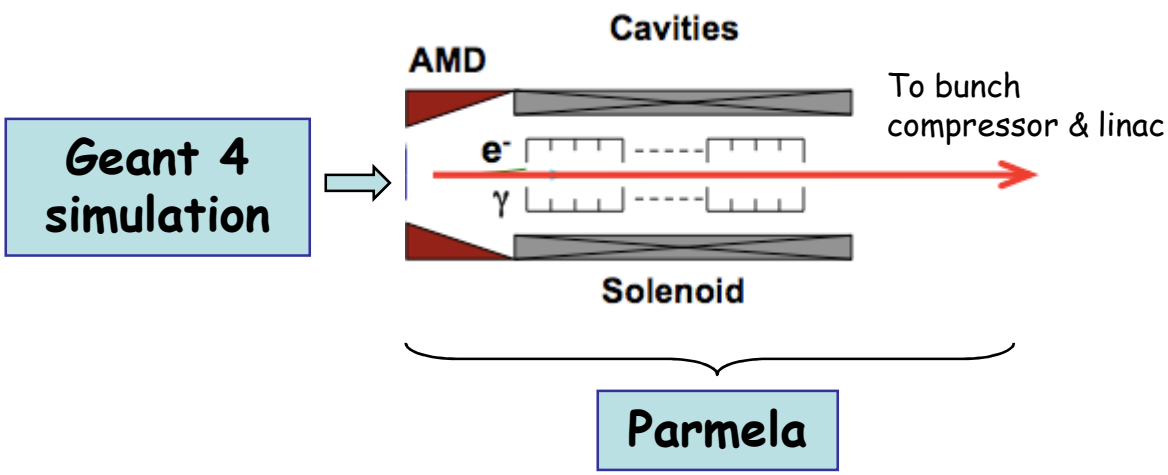


Energy deposition per impinging electron vs target thickness



What about the capture ?

- Simulation performed with Parmela
  - Inputs from Geant 4 simulation for the Bremsstrahlung positron production alternative option



Accelerating structures are ILC-like based on SLC cavity model:

- CW square cavities
- 1.3 GHz
- Aperture: 2.5 cm
- Unit Length: 56.122 cm
- 18 MV/m

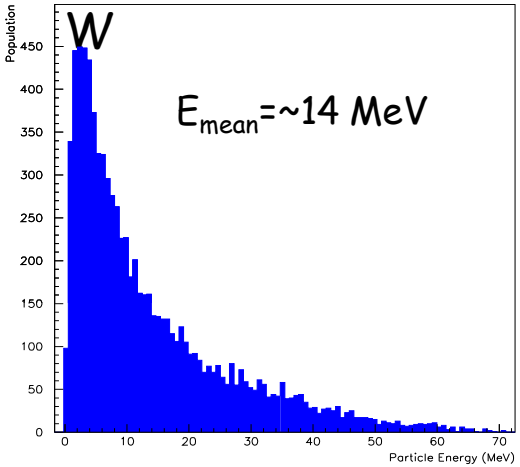
AMD: Adiabatic Matching

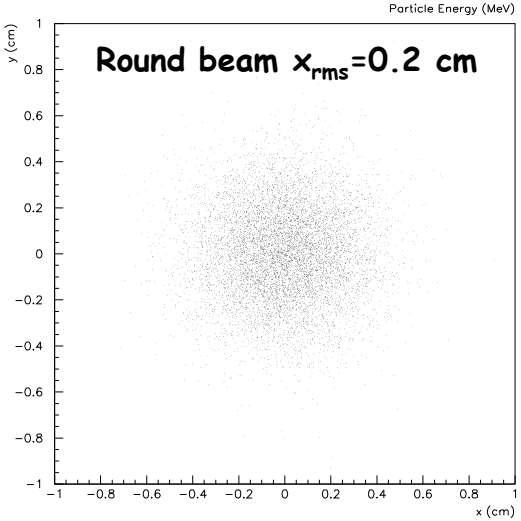
Freddy Poirier – poirier@lal.in2p3.fr

Simulation - Parmela

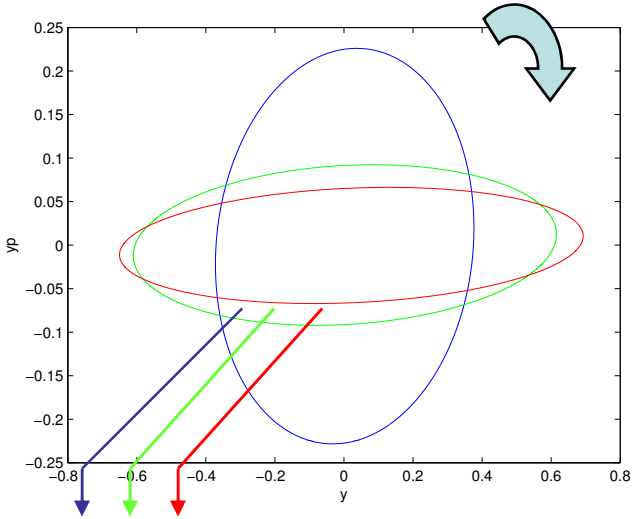
Geant4 inputs

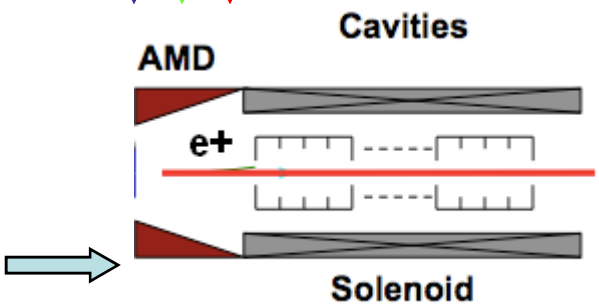
80 MeV – 0.5 mm





Rms vertical emittance in AMD



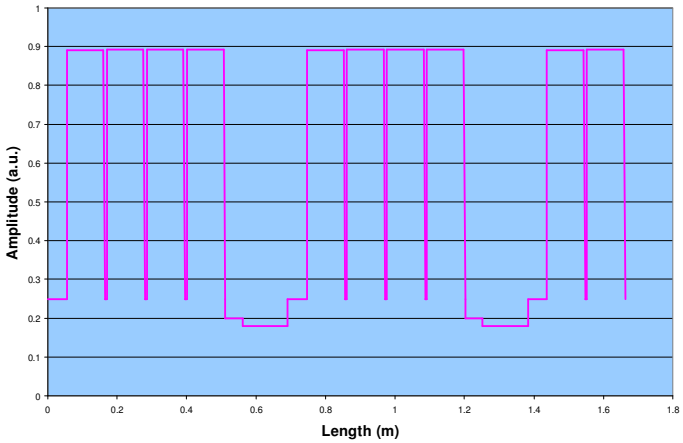


B_{field} max in AMD = 6T

B_{field} in solenoid = 0.5T

Parmela

Cavity structure L Band

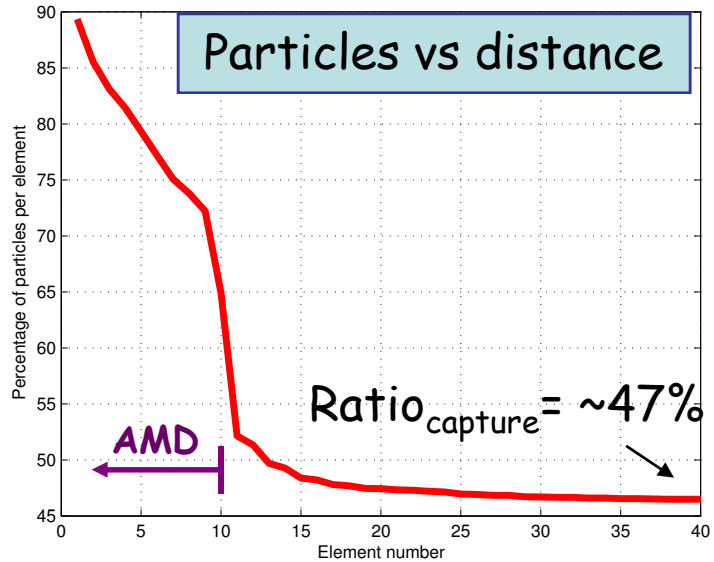


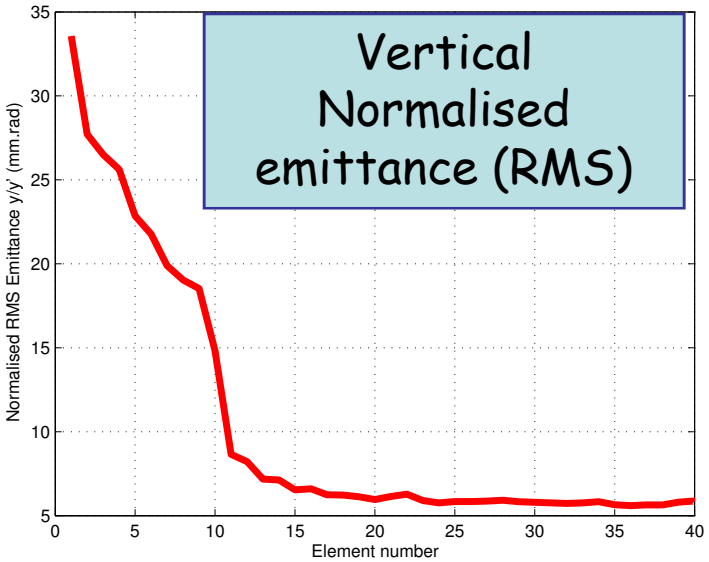
Alessandro Variola
Posipol 2009, Lyon - France

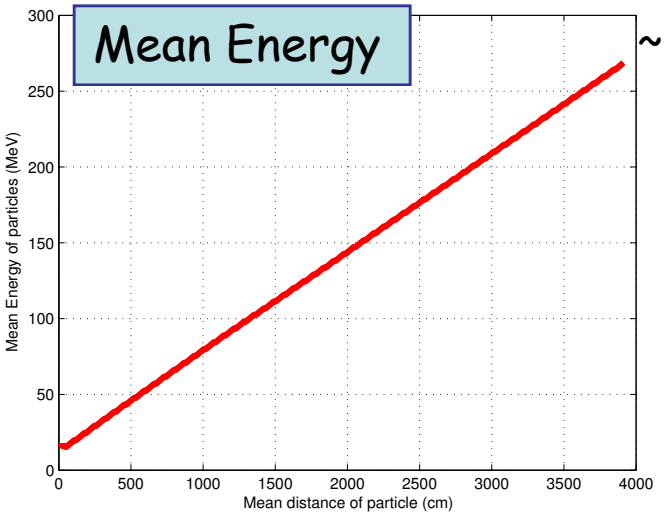
Freddy Poirier – poirier@lal.in2p3.fr

Preliminary: (5000 part.)

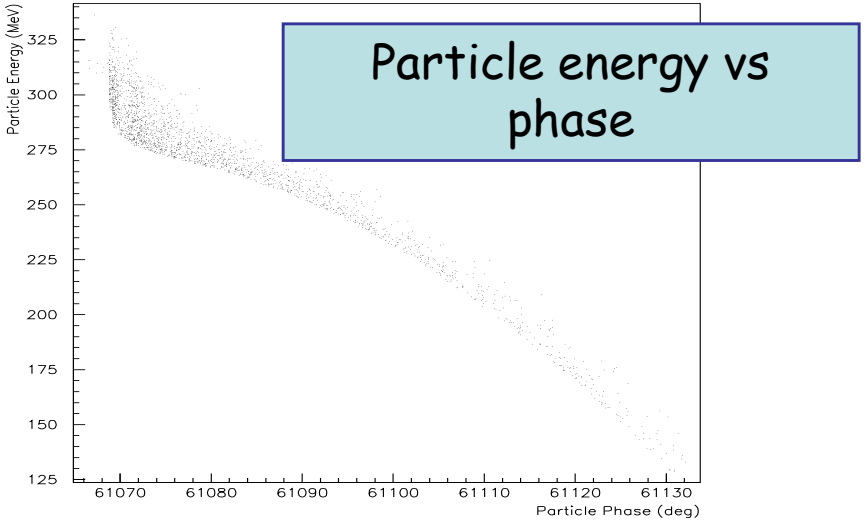
Parmela Results – first optimization







~270 MeV

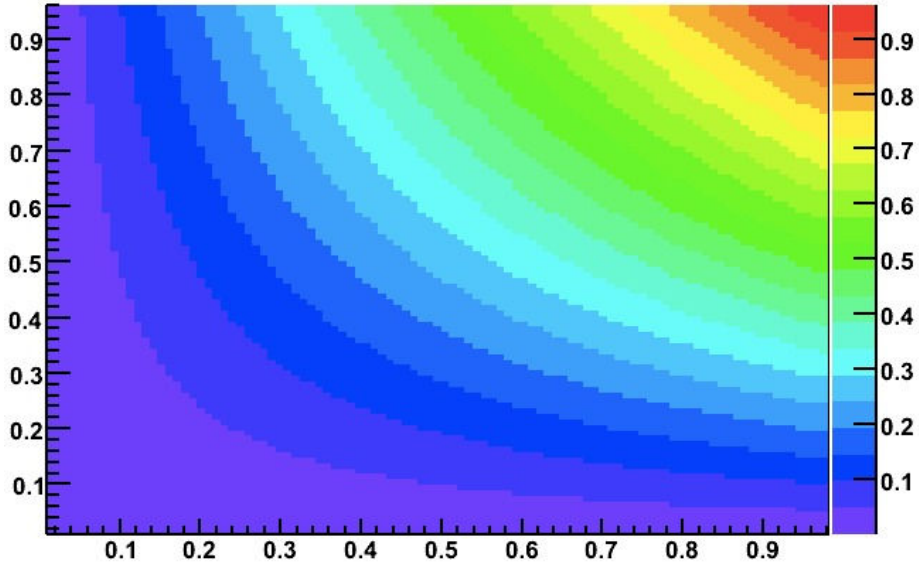


Alessandro Variola
Posipol 2009, Lyon - France

Freddy Poirier – poirier@lal.in2p3.fr

LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

- For SuperB
- @ 80-100 MeV yield => 0.2
- Capture in L Band => 0.5
- Total => 10% (@ ~30% polarization)
- 15 nC (Slac gun) => ~10^{11} e^- /pulse
- 10% => 10^{10}/pulse
- 2 10^{11} @ 20Hz = 10^{10} !!!! IT FITS!!!
- Preliminary considerations…needs fine tuning in capture @ 3 GHz, transport, PEDD but for the moment it works. Moreover it is possible to increase the frep (up to 100 Hz) and the number of bunches per train.



- Conclusion

- Polarised positrons for the superB => $L = 1 + \sigma e^{+} \sigma e^{-}$
- 3 ways explored : Compton, Selective Compton, Polarised Bremmstrahlung
- 1)Feasible but expensive
- 2)Only at higher energy
- 3)VERY PROMISING and quite for free!!!

Stacking Results

N. Injections	σ_z mm	$\sigma_{\delta 0}$	Offset %	Loss %
2550 (80 MHz)	9	10^{-4}	--	80.2
2550 (80 MHz)	4.5	10^{-4}	--	80.1
650 (20 MHz)	9	10^{-4}	1.2	63.7
650 (20 MHz)	9	10^{-4}	0.7	50.0
650 (20 MHz)	9	10^{-4}	0.8	41.8
650 (20 MHz)	9	10^{-4}	0.9	36.7