LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

CLIC e+ capture studies for the baseline

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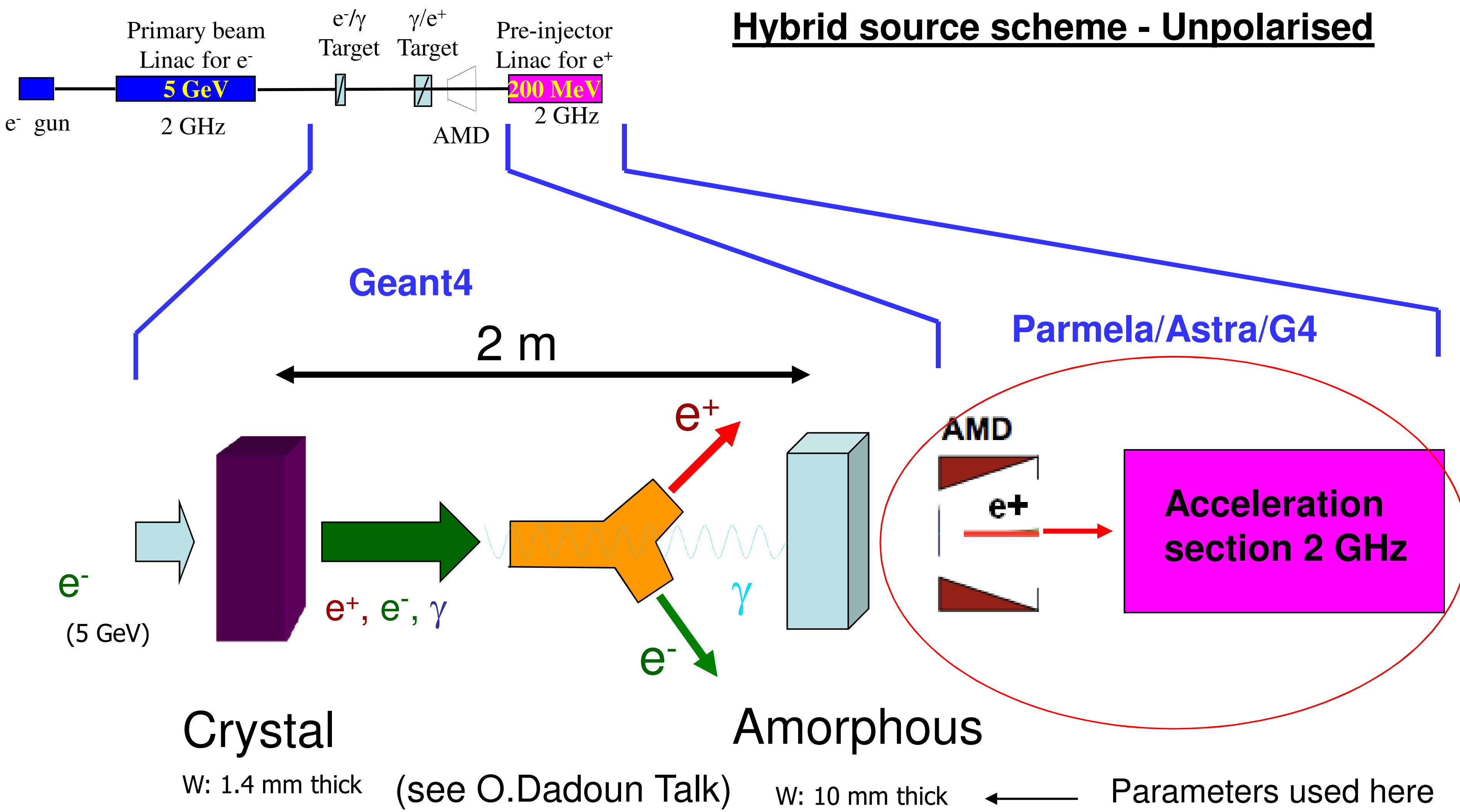
CLIC Positron Production Scheme

Hybrid source scheme - Unpolarised

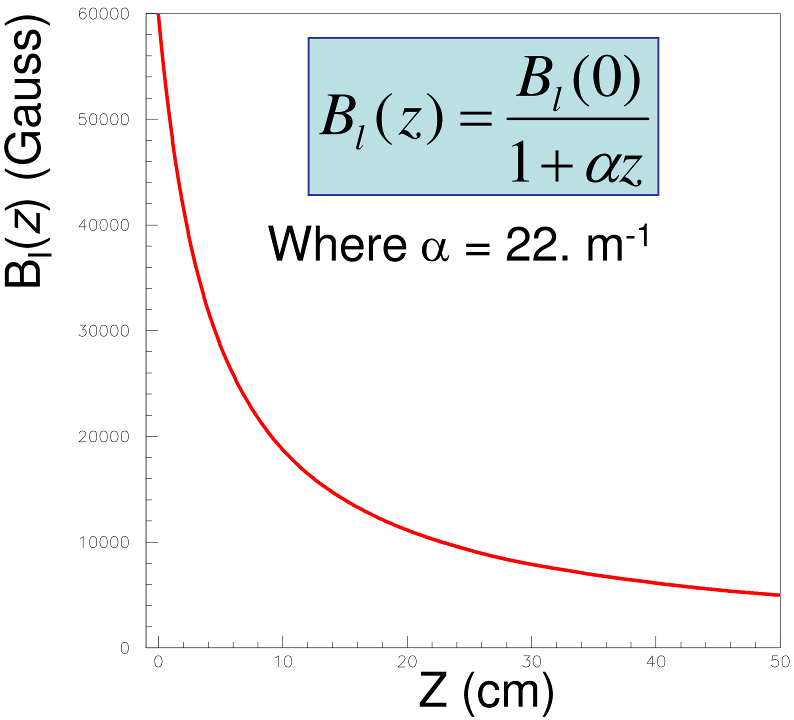


Goal of the present study

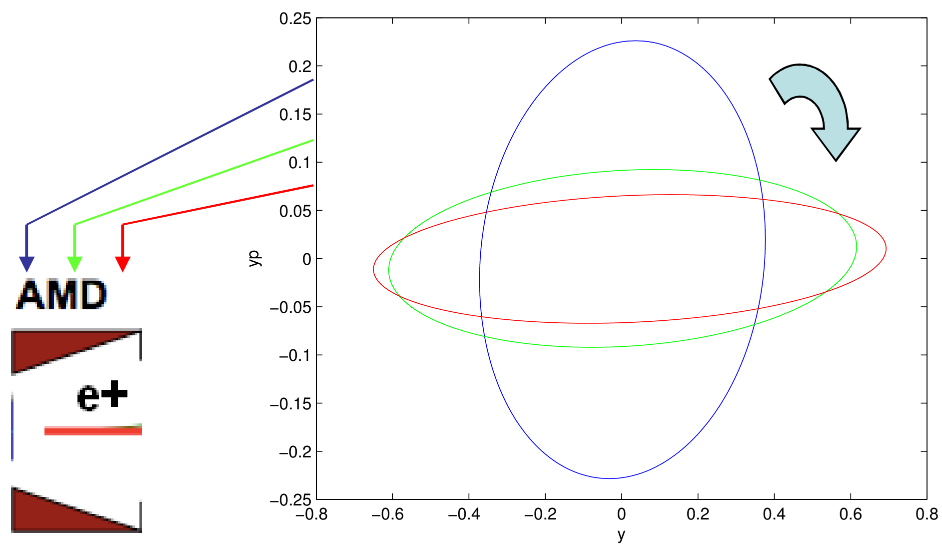
- Optimisation of the positron capture along the Adiabatic Matching Device (AMD) and Accelerating Capture Section (ACS) up to 200 MeV
- Benchmarking between the various simulation codes in use: Parmela, Geant4, Astra

The AMD

- The Adiabatic Matching Device is based on a slowly decreasing magnetic field system which collect the positrons after the target.
- AMD has a wide momentum range acceptance (with respect to systems such as Quarter Wave Transformers)
- The AMD for the CLIC baseline is 50 cm long with a longitudinal field B_l starting at $B_l(0)$=6T decreasing down to B_l(50cm)=0.5T such that

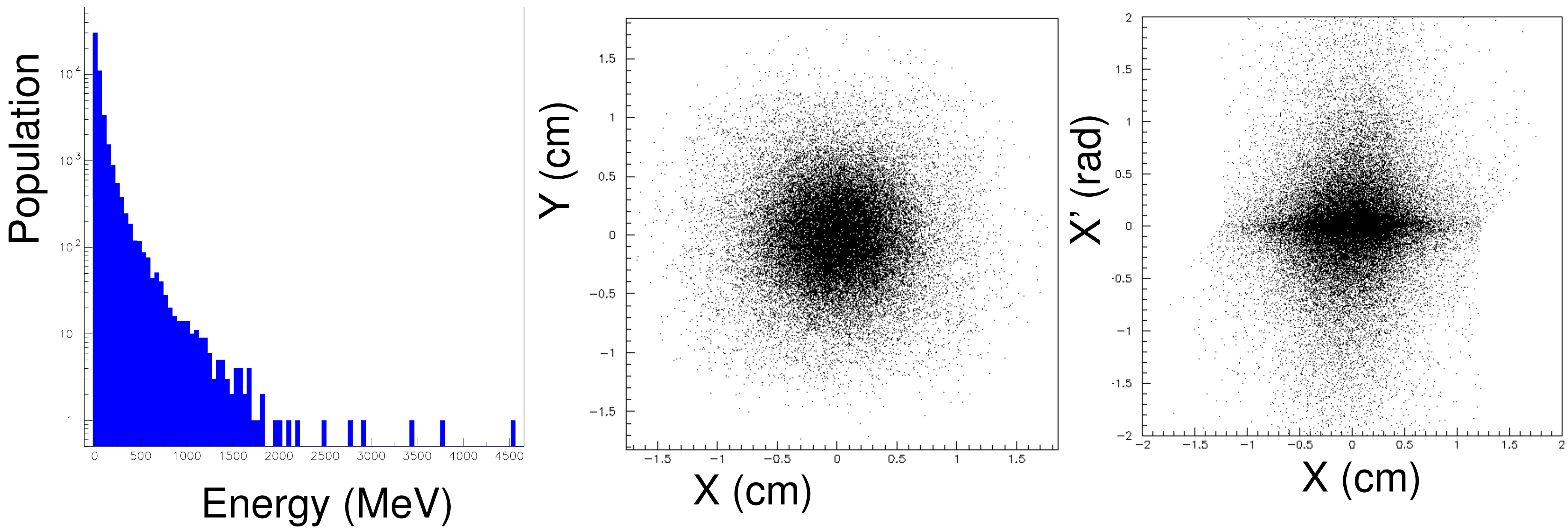


Transverse emittance in AMD is rotated and compressed:



Out of the target/ Simulation Input for the AMD

Typical particles distribution

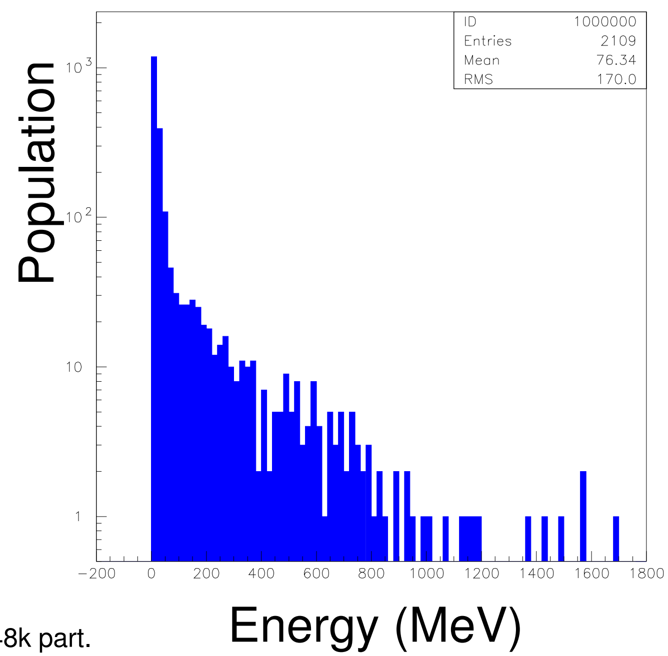


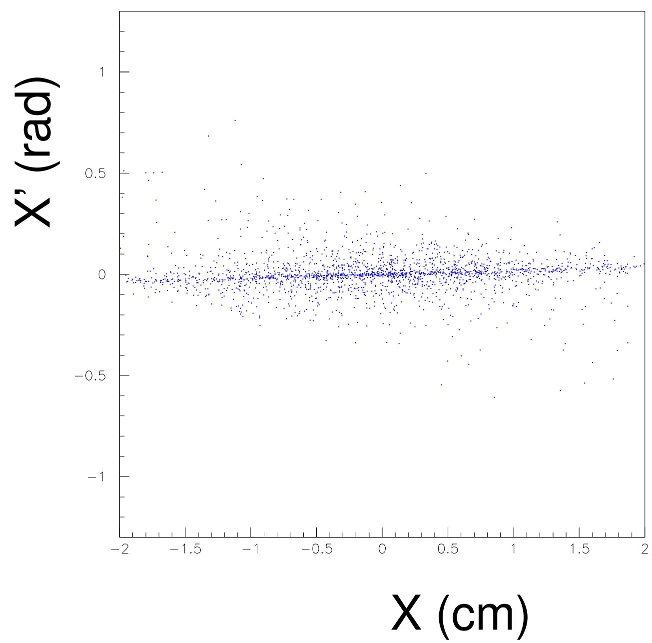
Nb of particles	<E> (MeV)	$\sigma_{E\ rms}$ (MeV)	$\sigma_{X\ rms}$ (cm)	$\sigma_{X'\ rms}$ (rad)
48851	50	110	0.39	0.34

AMD Simulation / Parmela

- Parmela (fortran based tracking code for particles modified at LAL):
  - It includes
    - Longitudinal field Bz defined by coils (at the present time the coils values have been provided by R. Roux - LAL)
    - Radial field Br calculated according to Maxwell-equations (derivation up to the 3rd order)

Nb of particles*	<E> (MeV)	$\sigma_{E\ rms}$ (MeV)	$\sigma_{X\ rms}$ (cm)	$\sigma_{X'\ rms}$ (rad)
9000	74.6	170.04	0.85	0.15





*sample of the 48k part.

Ongoing Benchmark AMD

- 3 different simulation codes are being used to study the AMD (6T – 50 cm) and ACS:
  - Astra, Geant4, Parmela

First seed for e+ distribution in front before AMD

Software	Acceptance of AMD only	E_x mm.mrad	E_y mm.mrad	<E> (MeV)	$\sigma_{E\ rms}$ (MeV)	$\sigma_{z\ rms}$ (mm)
Astra	25.2%	502	508	70.6	176.6	10.0
Parmela	23.5%	582	600	70.6	172.2	9.5

Acceptance = Number of particles in / Nb of particles out in %

New set (with new seed) of e+ distribution

Soft.	Accept.	$\sigma_{X\ rms}$ (cm)	$\sigma_{X'\ rms}$ (rad)	<E> MeV	$\sigma_{E\ rms}$ (MeV)
G4* with Br	28.6%	0.86	0.098	65.0	170.1
Parmela	23.6%	0.85	0.093	74.6	170.0

* radial fields have been included

Geant4 → O.Dadoun PSCSim Simulation code, Parmela→ LAL's Parmela

AMD Outcome

- AMD studies indicate a >20% positron capture.
- Slight differences found between simulation code results
  - Carefull check of the tracking of particles in AMD needed?
- The benchmark has opened the door to an interface between Parmela & G4 (not standard though)
- Note: the Parmela longitudinal magnetic field simulation was build up by hand with coils. This is a semi-qualitative method, that does not profit form a automatisation process. Therefore, modifying the AMD parameters is not trivial and has to be crosschecked everytime.
  - An automatic algorithm* is now being devised to possibly widen AMD studies (field? / length?), facilitate further benchmark and which could also be used later for field tolerances studies.

* Based on matrix inversion

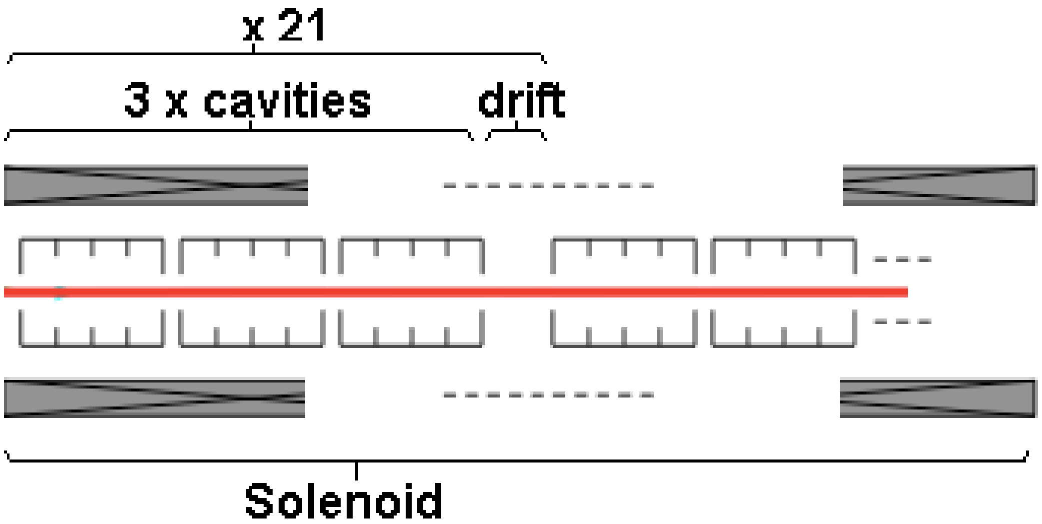
The ACS

- The Accelerating Capture Section has 2 purposes:
  - Accelerating the positrons up to 200 MeV where the bunches can be prepared (e.g. compressed) and reaccelerated for the Damping Rings
  - Minimize the collected positron losses as much as possible

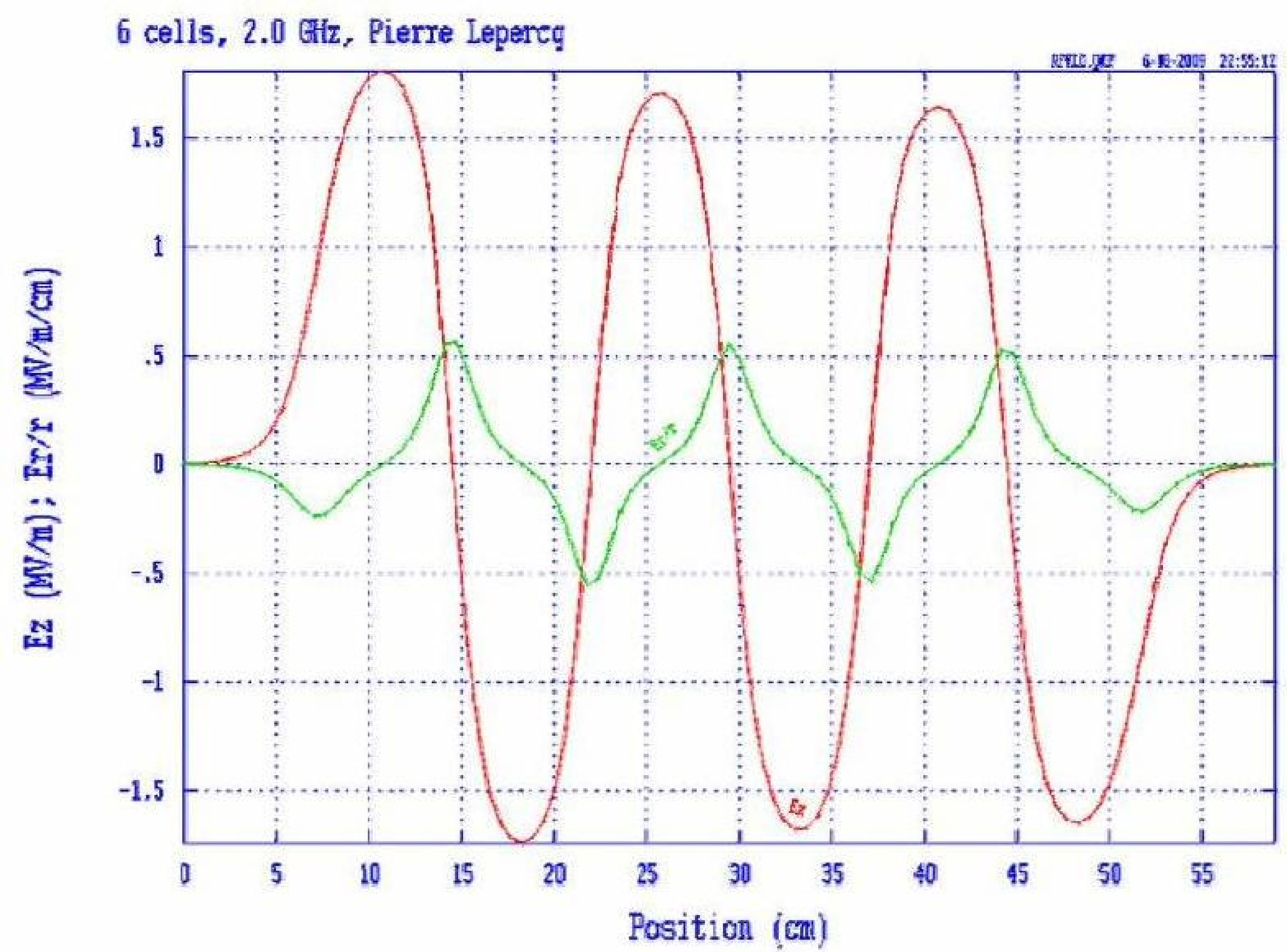
- For this purpose, the accelerating structures are encapsulated within a magnetic field of 0.5 T, provided by a solenoid

The CLIC ACS

- ACS Lattice provided by A. Vivoli:
  - 63 Warm cavities,
  - ~41 m
  - 3 cavities + drift (15 cm)
- Cavities (P.Lepercq):
  - 60 cm
  - 6 cells
  - 2 GHz, r= 2cm, 25 MV/m,
  - Max Energy gain=5.95 MeV
- Phase of cavities (ASTRA ref):
  - 14*3 cav @ 115 deg
  - 6*3 cav @ 225 deg
  - 1*3 cav @ -36 deg

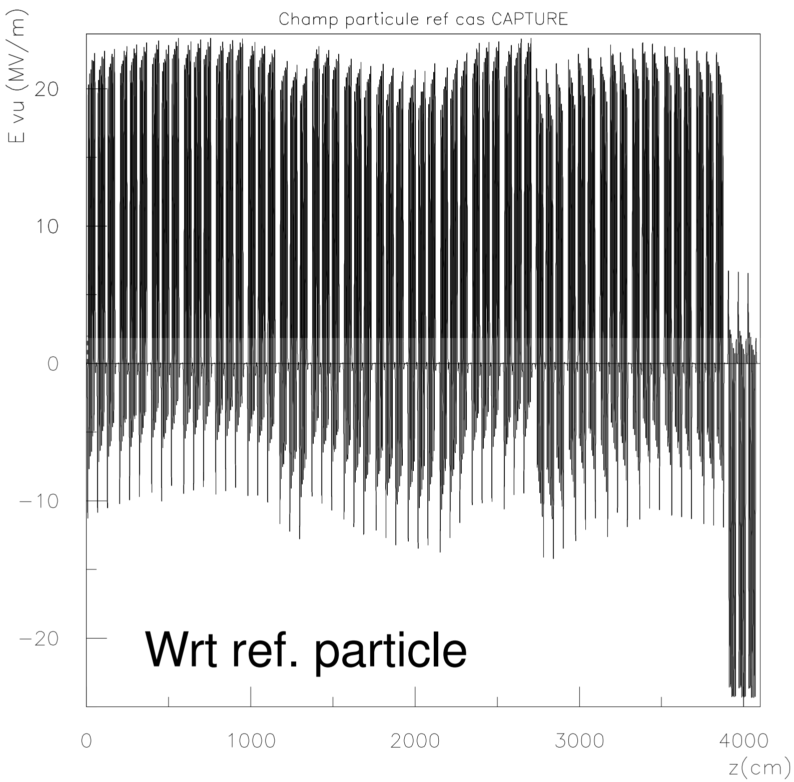


Cavity 2 GHz – 6 Cells

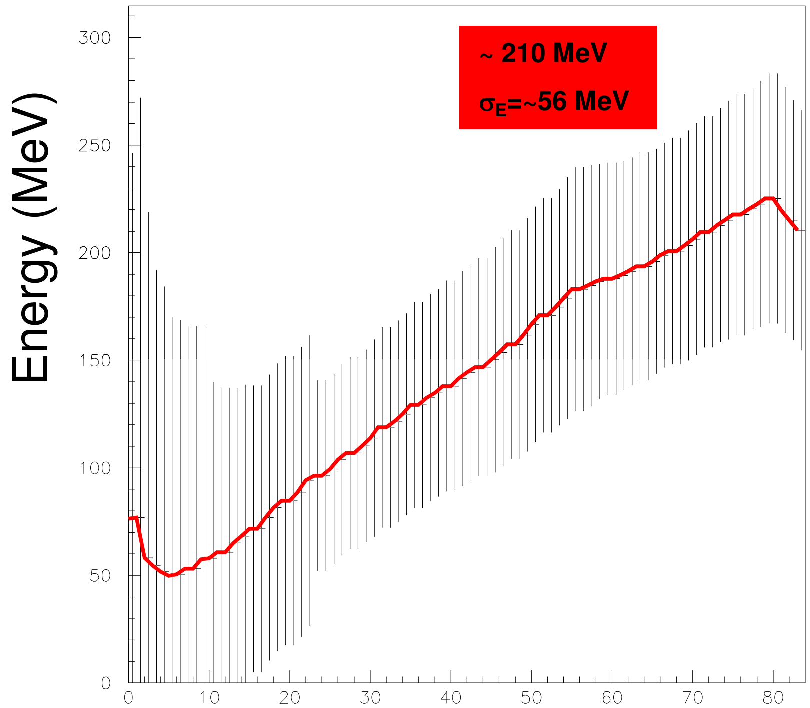


Phase & effect on Energy

Cavities phases



Mean Energy versus element number

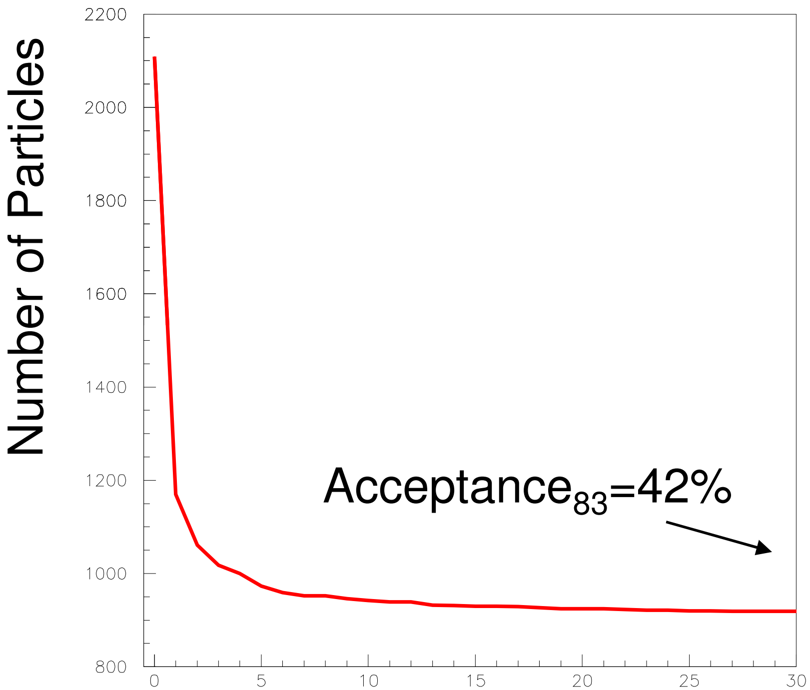


Element along lattice

Choice of phases for the cavities done to limitate the particle loss along ACS

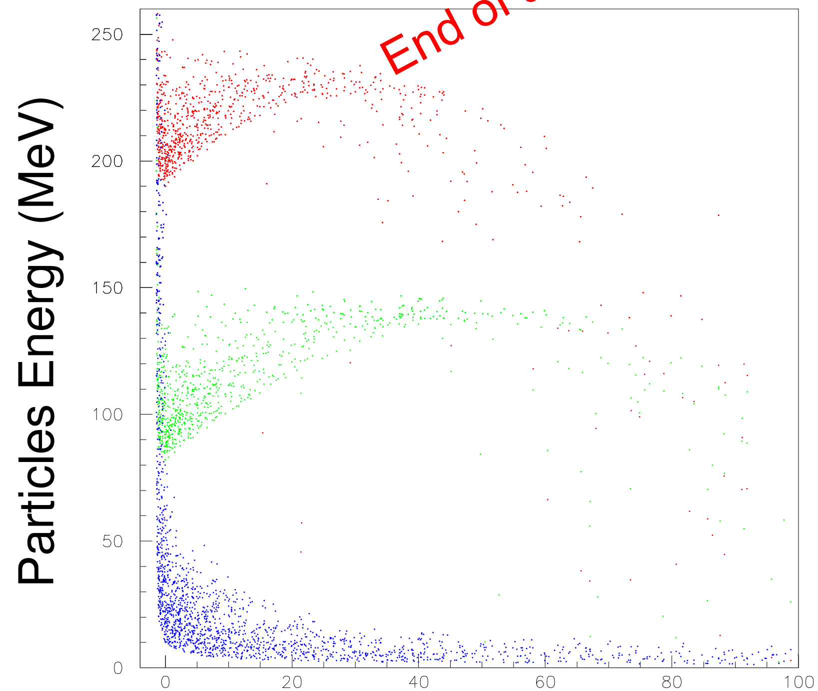
End of the ACS

End of ACS Simulation Result



Element Number

55% of the particles are kept in the 1st cavity



ϕ (degree)

Beg of acc. section

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What Does it give us?

e+/e- yield	AMD yield	ACS yield	Total yield
~8.15	0.23	0.42	~0.8

- Total yield e-/e+= 0.8 with Parmela i.e. with 7.5 10^9 e- / bunch in front of crystal we get ~6. 10^9 e+ / bunch at exit of accelerating section (or 6.7 10^9 at exit for 8.4 10^9 at entrance)

At the present time also slight difference Parmela/ASTRA/G4 for the Yield

A first (and quick) benchmark shows that capture percentage in the first cavities is rather dependant on the code used → Some work needed here

Software	Parmela	Geant4	ASTRA
Accept 1st cav	55%	85%	70%

Acceptance= input nb of particles / output nb of particles (%) for 1st cav.

Conclusion

- With a little bit more than 1nC per e-bunch it is possible to provide 1nC e+ at the end of the capture section. This can take into account a safety factor 2 for the transport and injection to the damping ring and to the collision point.
- Ongoing benchmark between the various codes shows a pretty good agreement (for the adiabatic flux concentrator section).
- Further work needed for the accelerating section.

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Outlook

- → Further optimisation (and work!) on ACS
- → Automatisation of the magnetic field construction in Parmela
- → Larger statistics samples will be used for Parmela
- → Bunch compressor after the accelerating section of 200 MeV