Review of Optical Matching Systems for Positron Beam

Chenghai XU
LAL/Orsay and IHEP/Beijing

Thanks to Robert CHEHAB, Vladimir STRAKHOVENKO, Guoxi PEI, Alessandro VARIOLA, Olivier DADOUN , Freddy POIRIER, Alessandro VIVOLI, Irina CHAIKOVSKA

Outline

- Introduction
- AMD
- QWT
- Lithium lens

Introduction

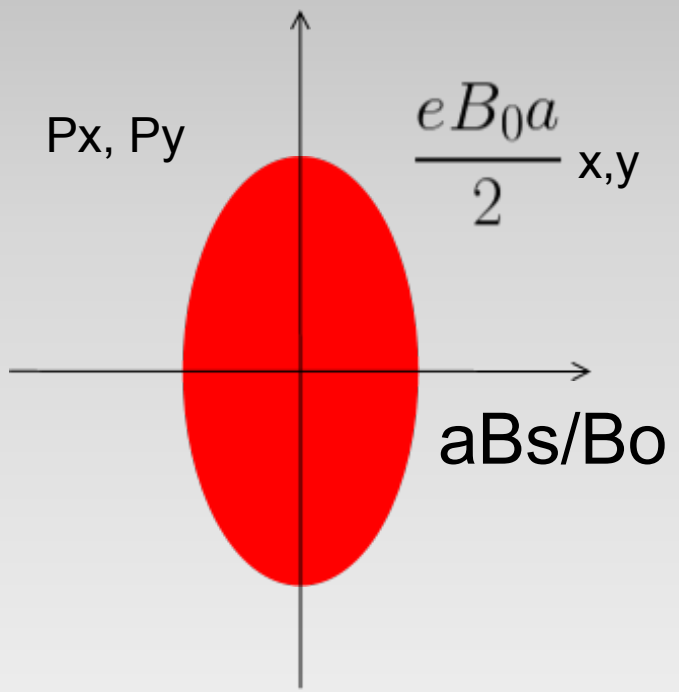
- Necessity of a good matching (yield & emittance): the transverse emittance in the e+ preaccelerator is essentially determined by the matching system.
- Simulation of different OMD using GEANT4 code: the magnetic field law as the accelerating electric field are introduced in GEANT4; results are concerning accelerating distances of 1 to 3 meters.
- The positron source considered here is an hybrid source using channeling in crystals: output data from crystals are gathered from V.Strakhovenko's program.
- The emphasis is put on CLIC and some examples related to ILC are also presented.

QWT – Quarter Wavelength Transformer

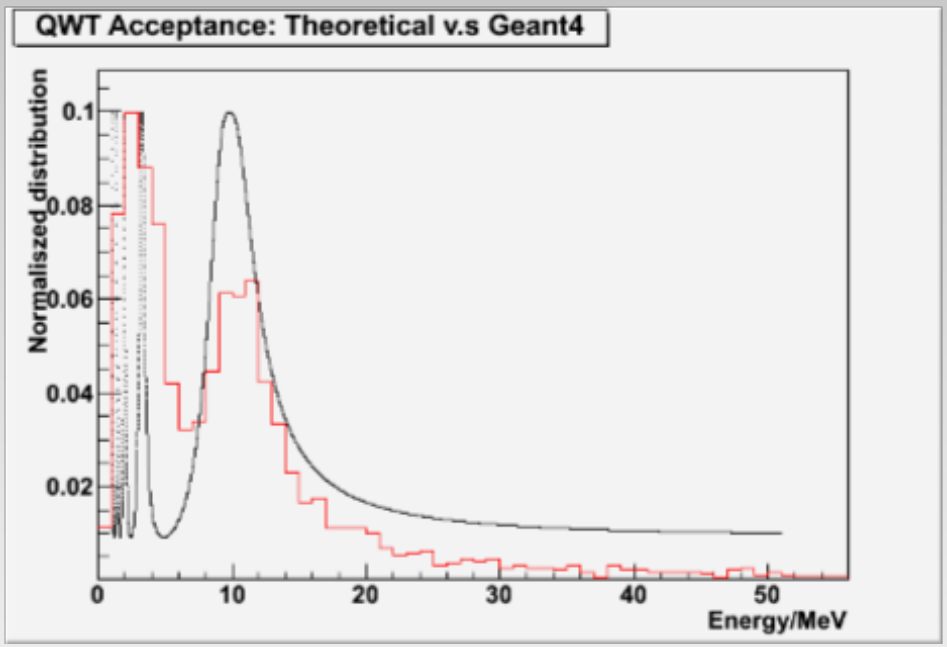
Features:

1. Large momentum acceptance: $(eB_0a/2)(1+B_s/B_0)$
2. Small geometrical acceptance: $a(B_s/B_0)$
3. Narrow energy acceptance
4. Restricted bunch lengthening due to short solenoid length

QWT Acceptance

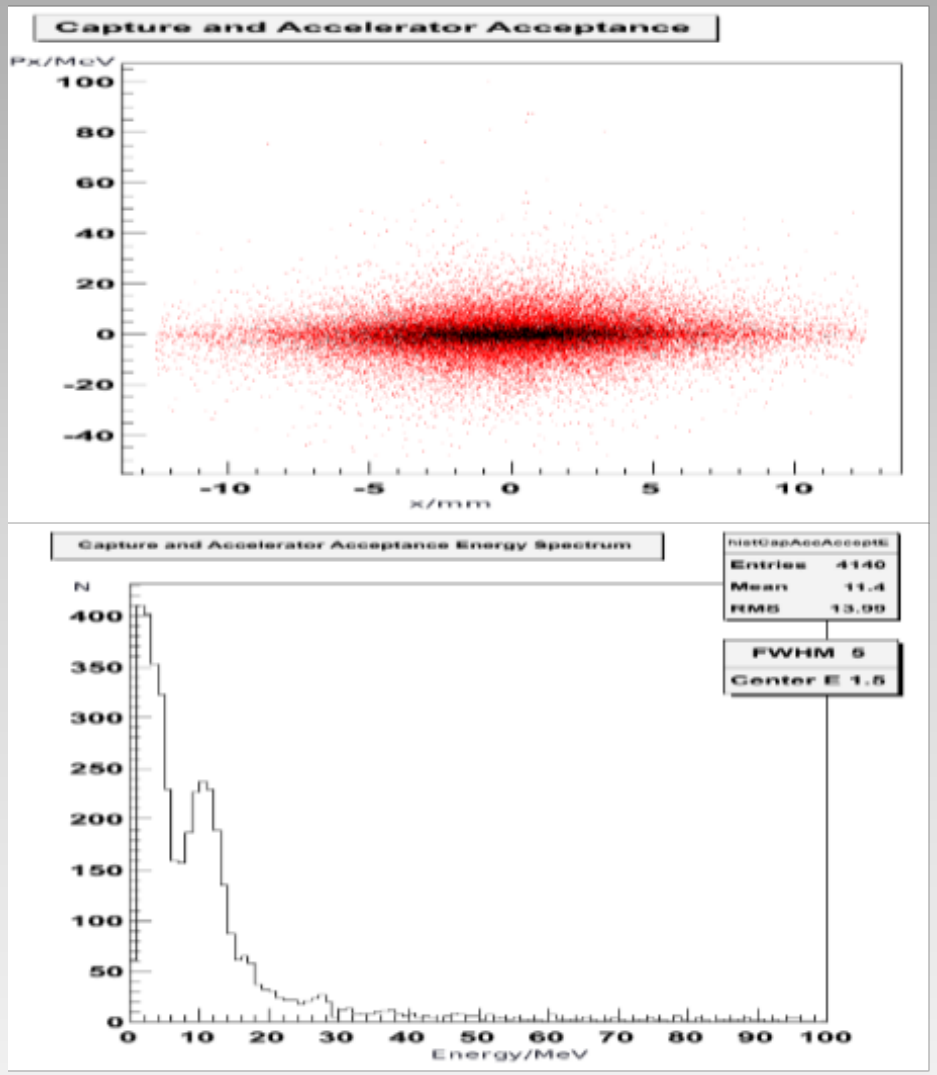


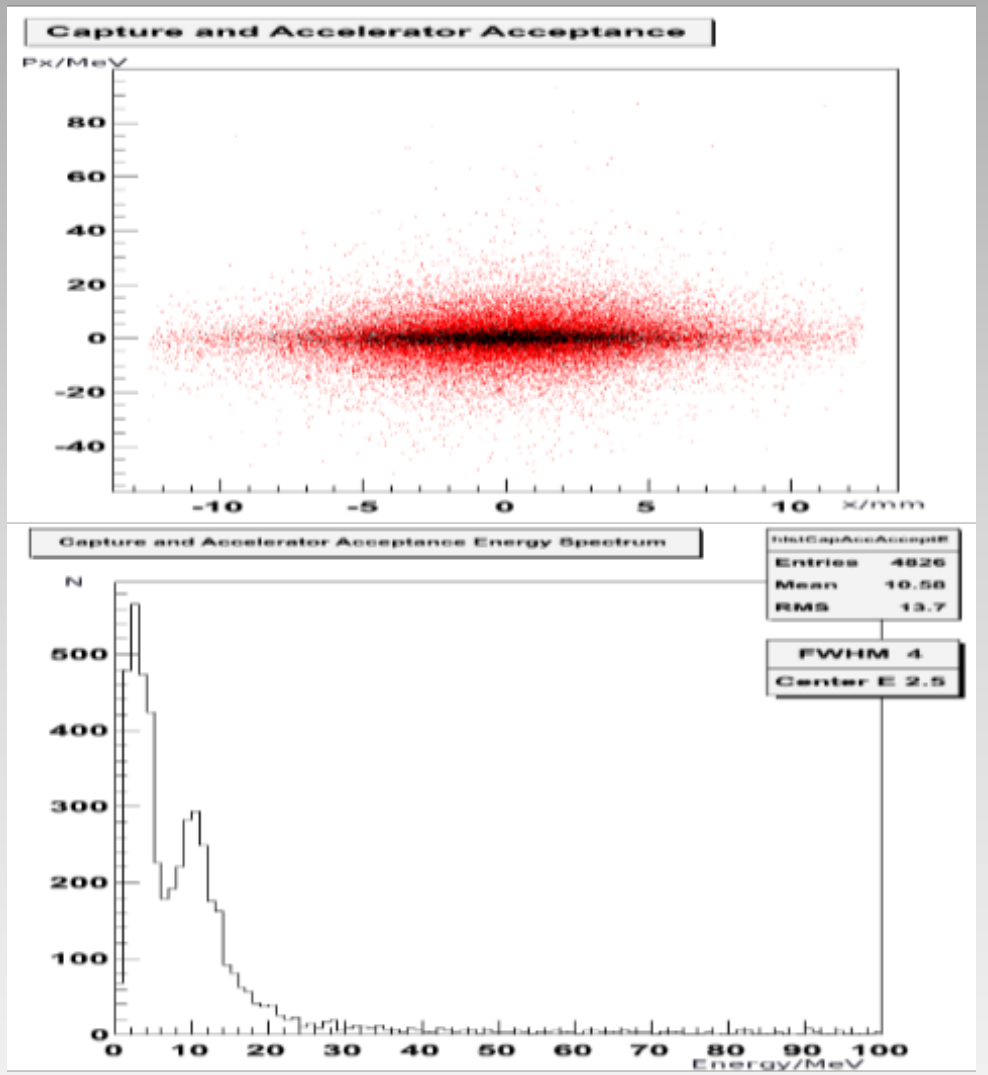
Transverse acceptance
Momenta are canonical
P=e**A**+m**V**



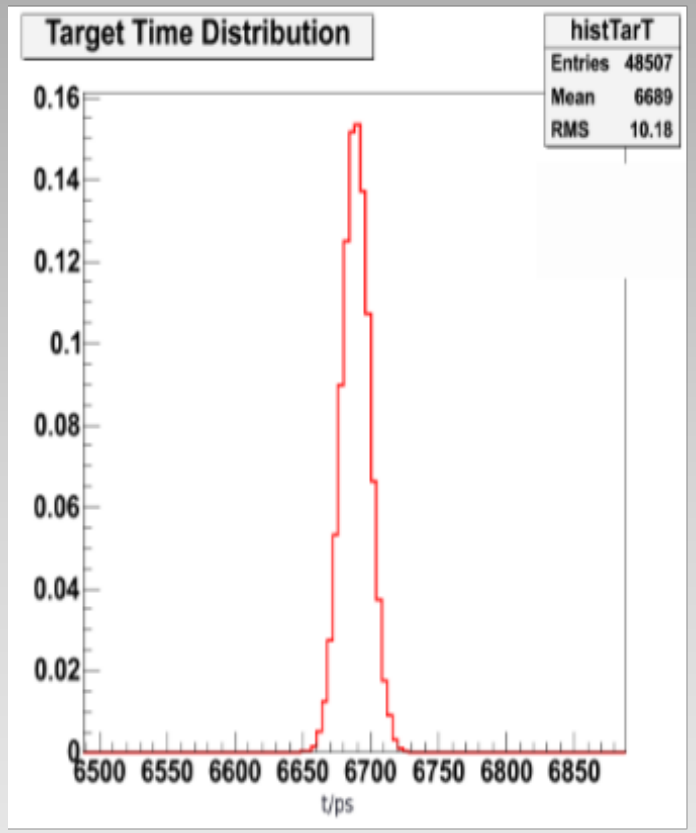
Accepted energy spectrum; in black: analytical and in red: simulations

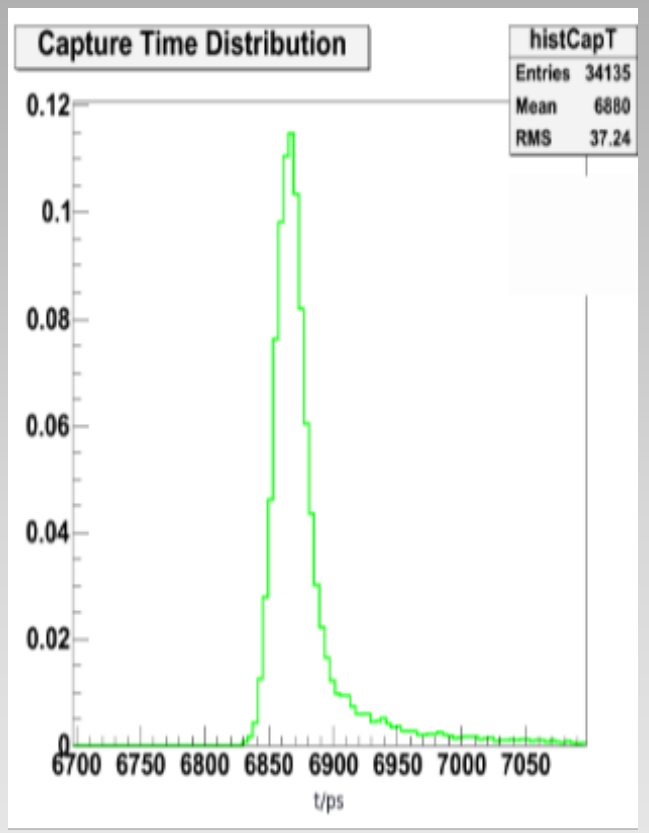
Results

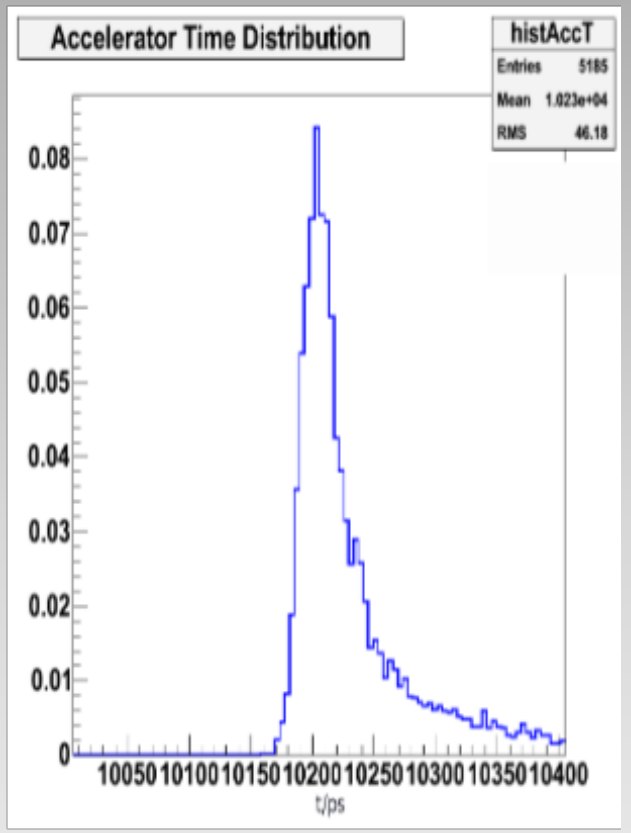




CLIC Case Acceptance : Left L=35mm Bo=3T, Right L=52mm, Bo=2T

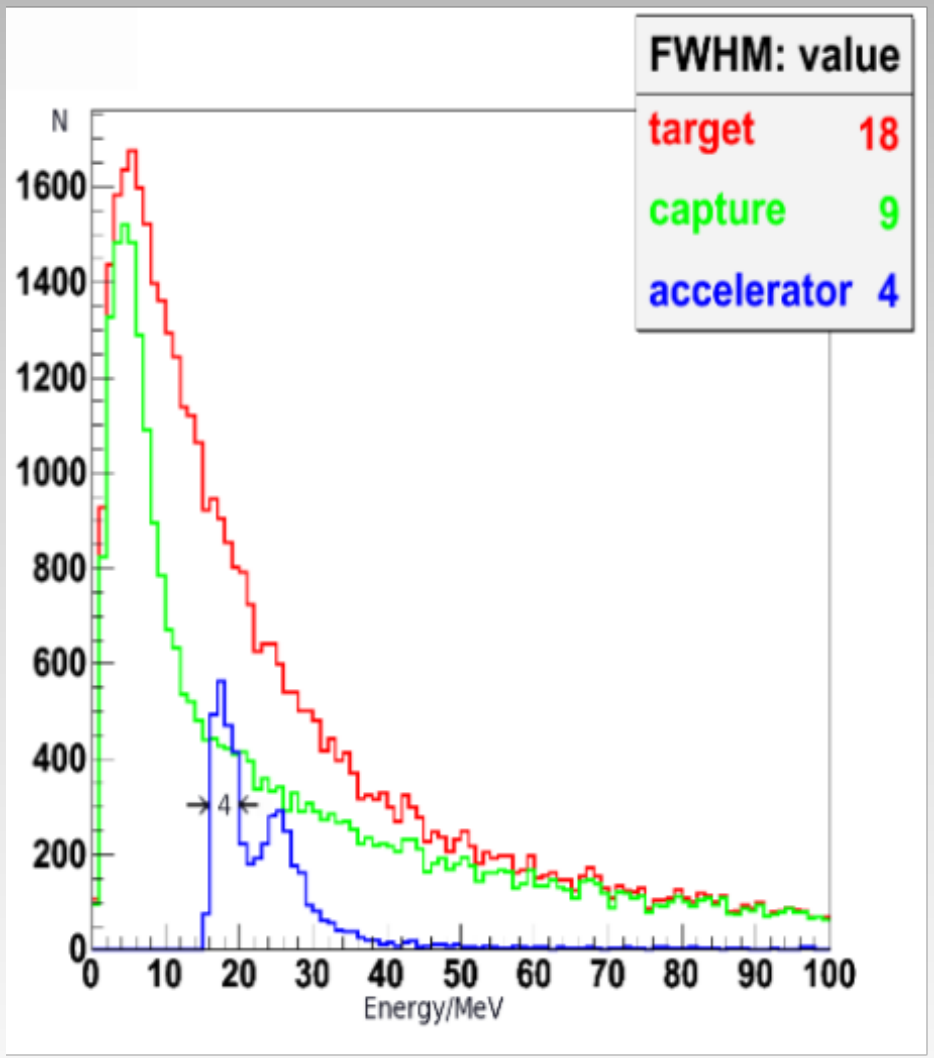






CLIC Case, QWT Time distribution L=52mm, Bo=2T

Yield for QWT L=52mm, Bo=2T CLIC case



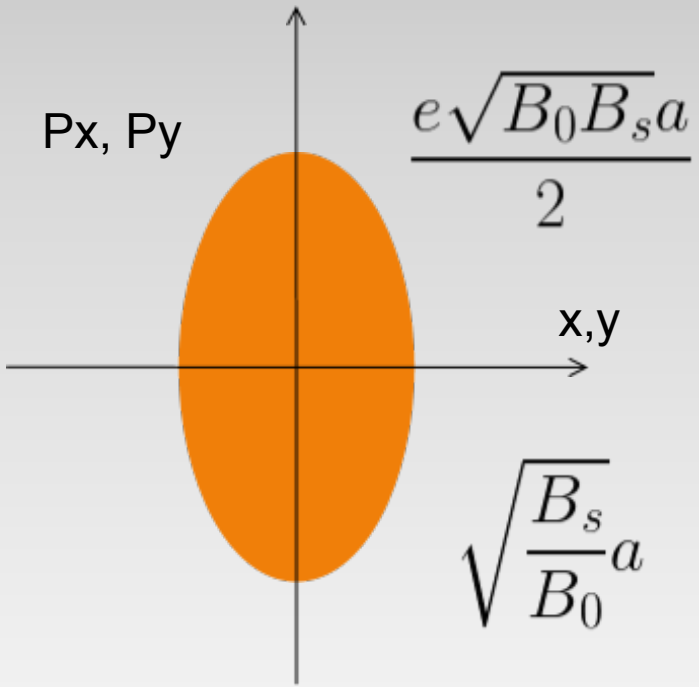
Position	Yield	<100Mev
Target	8.08	7.08
QWT	5.89	4.89
Accelerator	0.96	0.80

AMD – Adiabatic Matching Device

Features:

1. Moderate momentum acceptance: $e[B_0B_s]^{1/2}a$
2. Large geometrical acceptance: $a[B_s/B_0]^{1/2}$
3. Large energy acceptance
4. Important bunch lengthening due to long enough solenoid (adiabatic tapering)

AMD Acceptance L=50cm, Bo=6T CLIC Case



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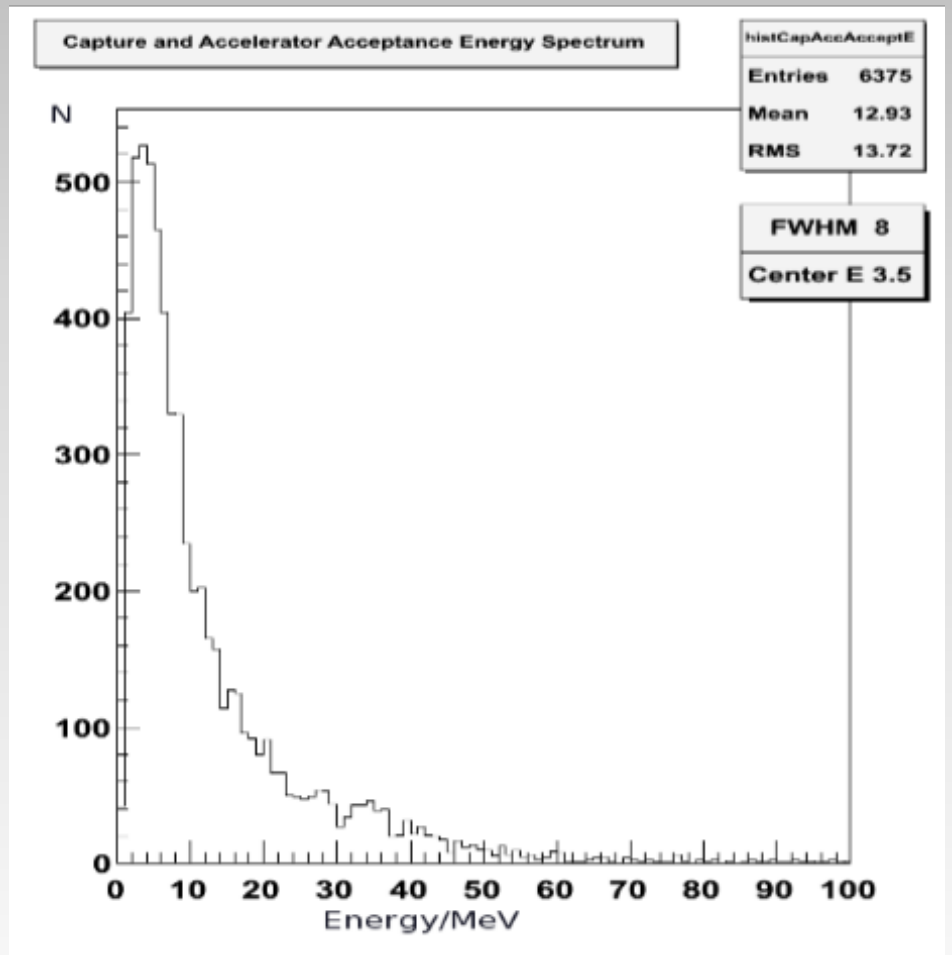
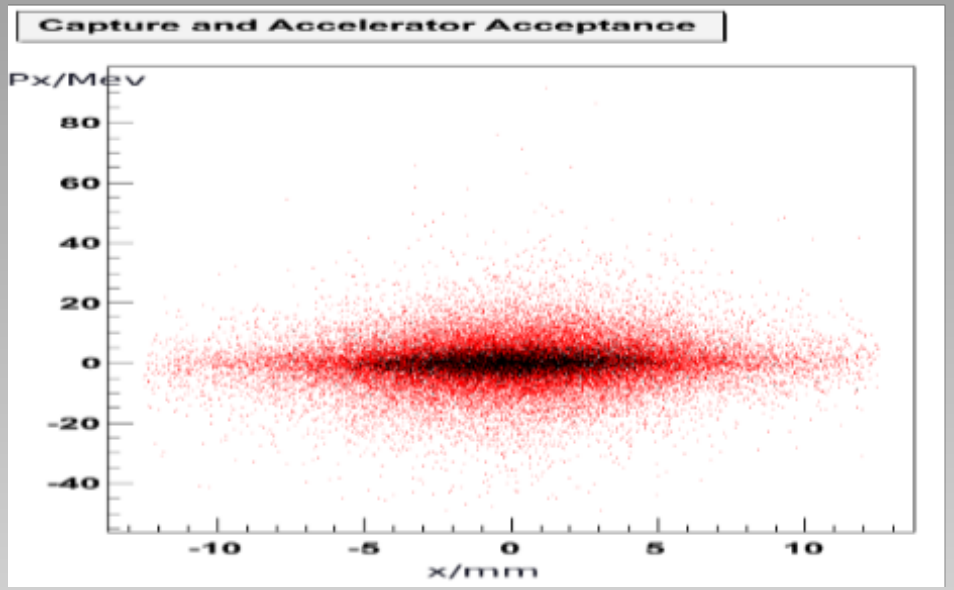
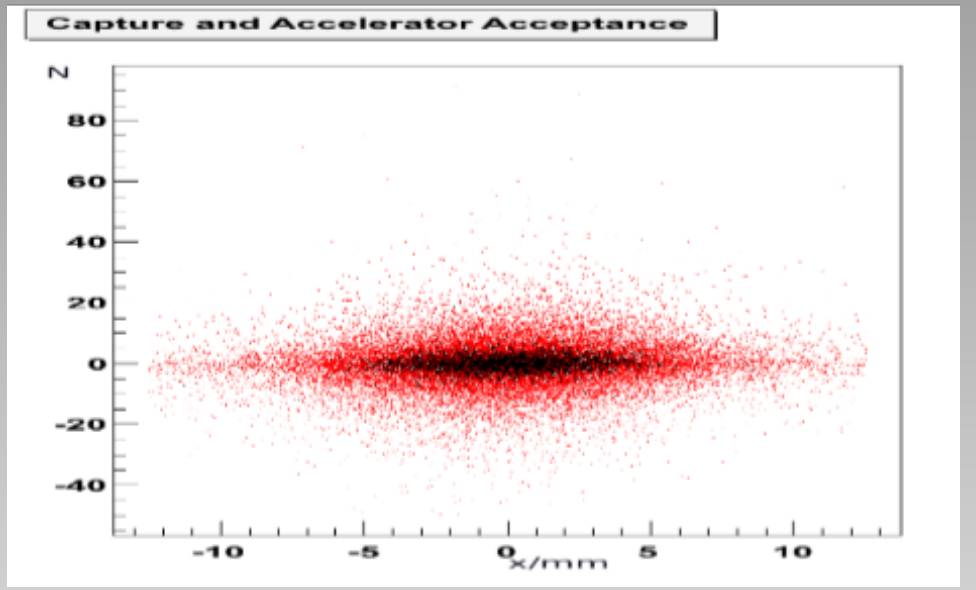
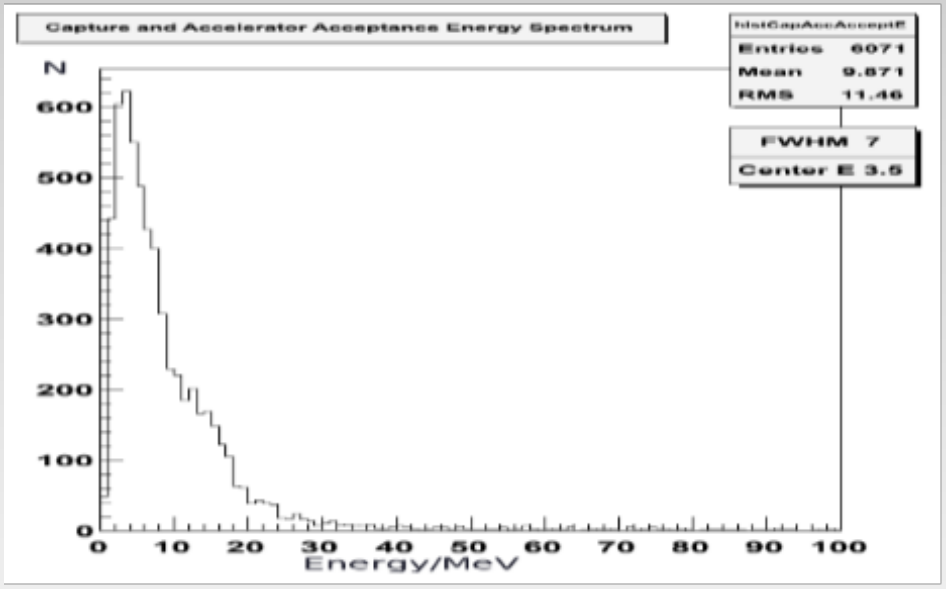
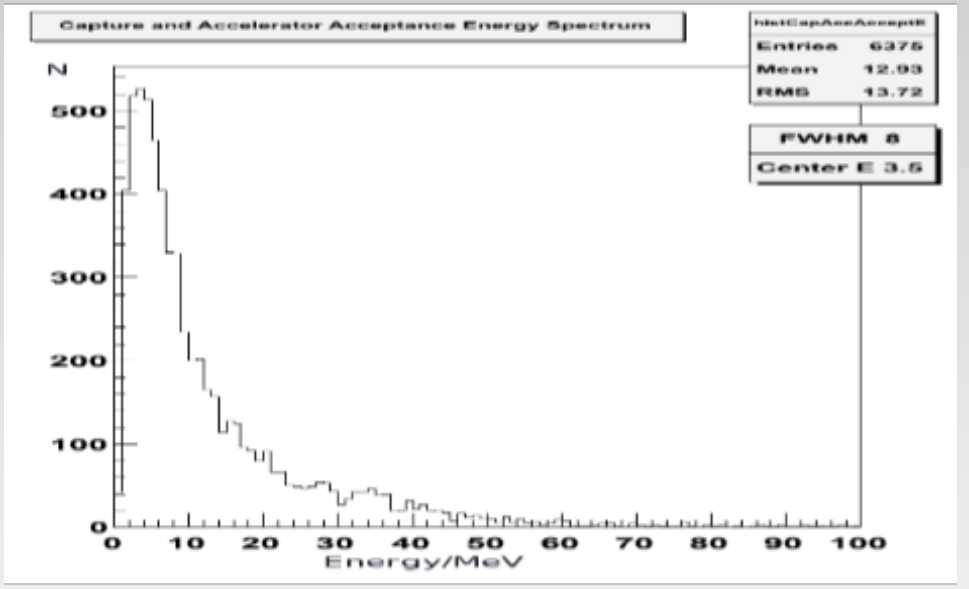


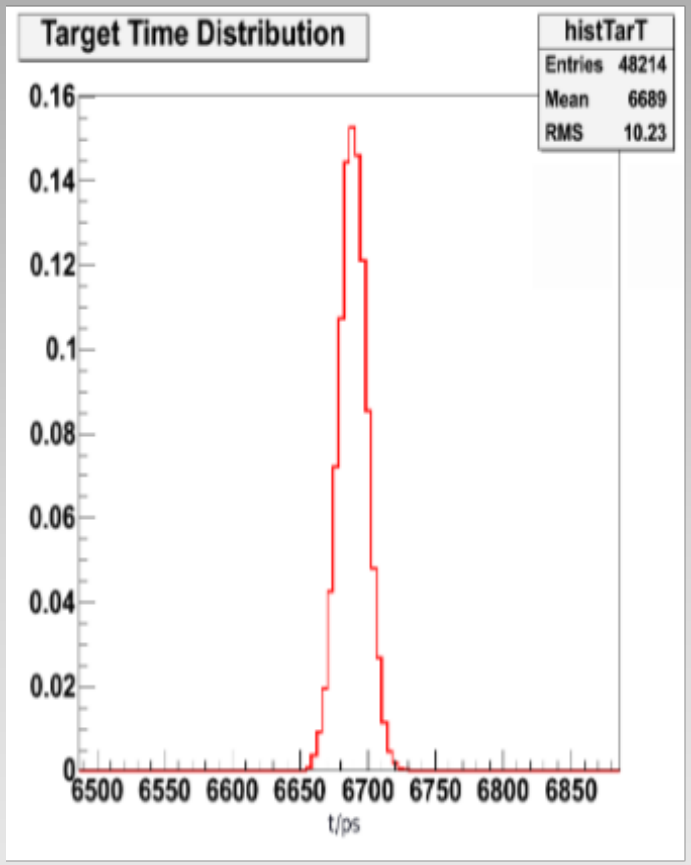


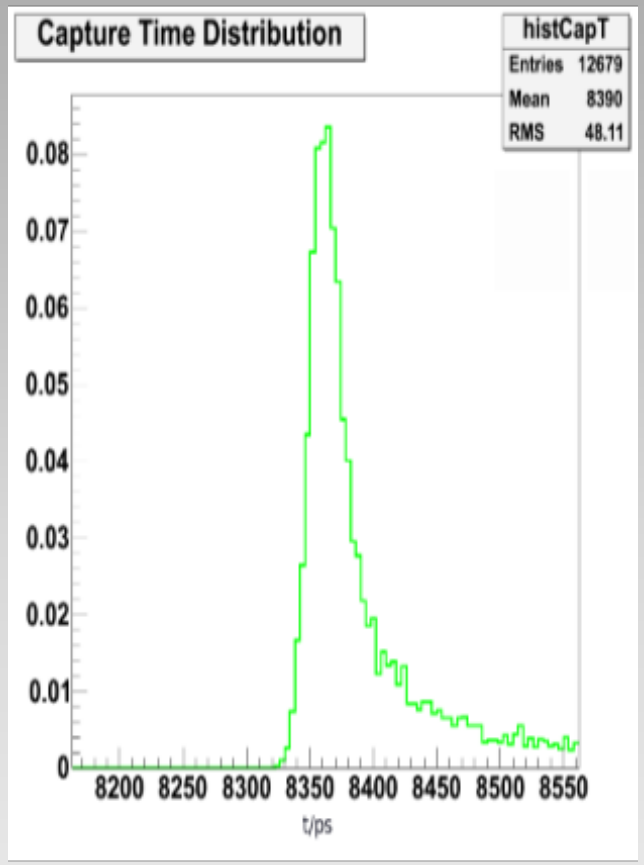


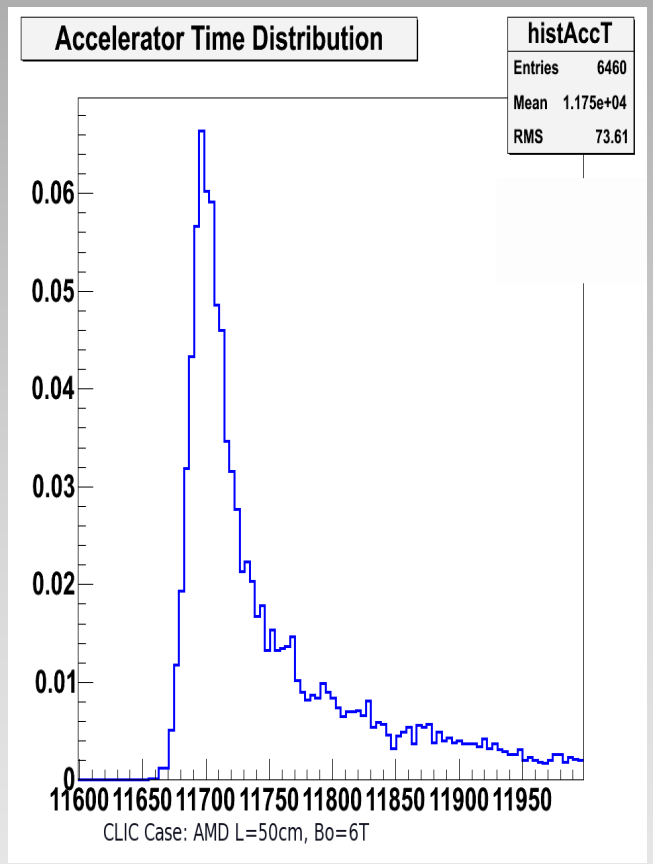




CLIC Case AMD Acceptance : Left L=20cm Bo=6T, Right L=50cm, Bo=6T



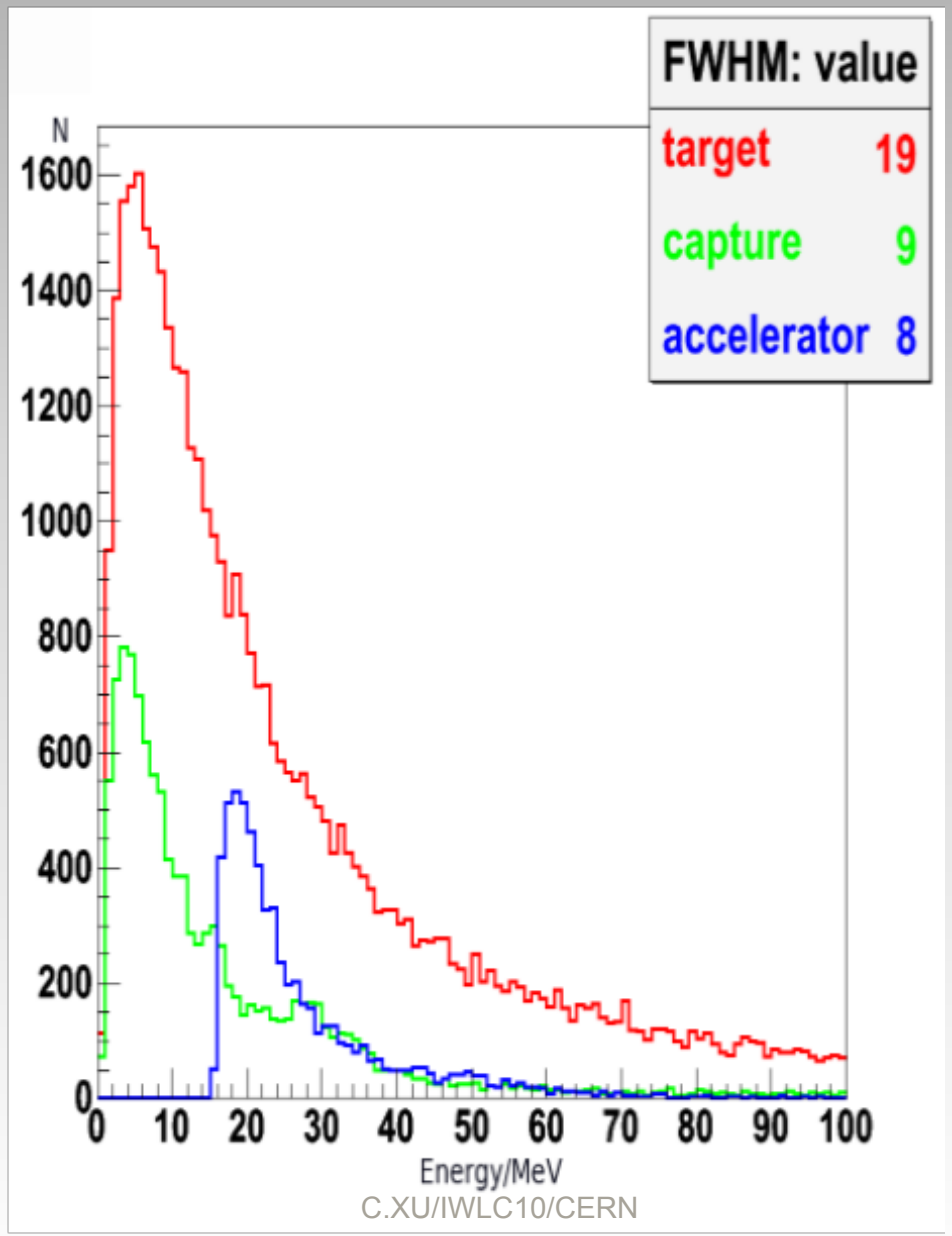




CLIC Case, AMD Time distribution L=50cm, Bo=6T

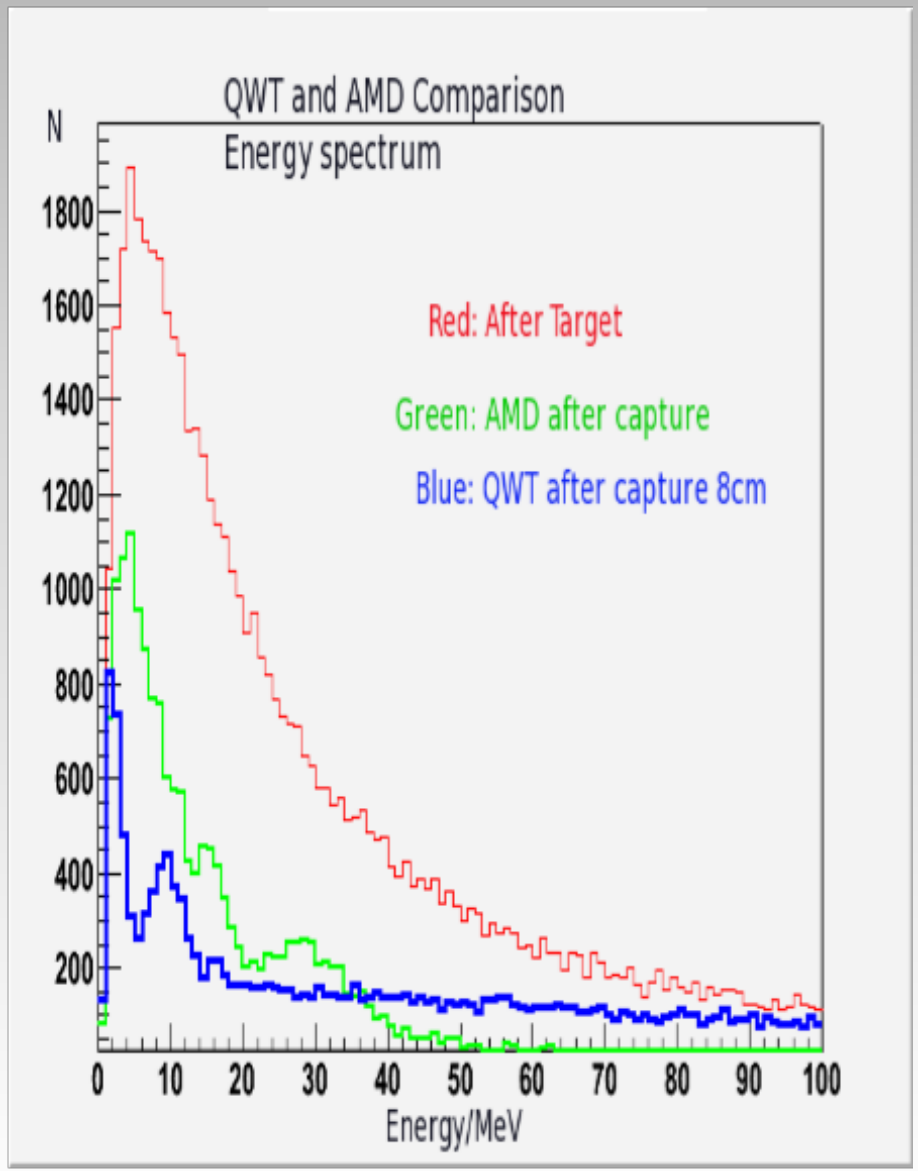
Yield for AMD L=50cm, Bo=6T CLIC case

Position	Yield	<100Mev
Target	8.04	7.05
AMD	2.29	1.96
Accelerator	1.15	1.06



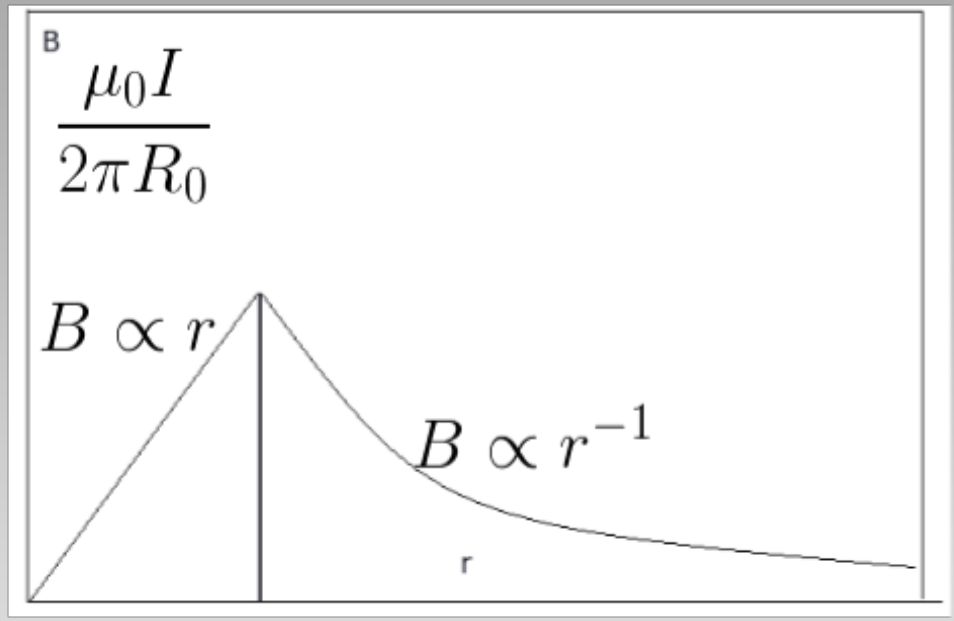
Comparison Between QWT and AMD

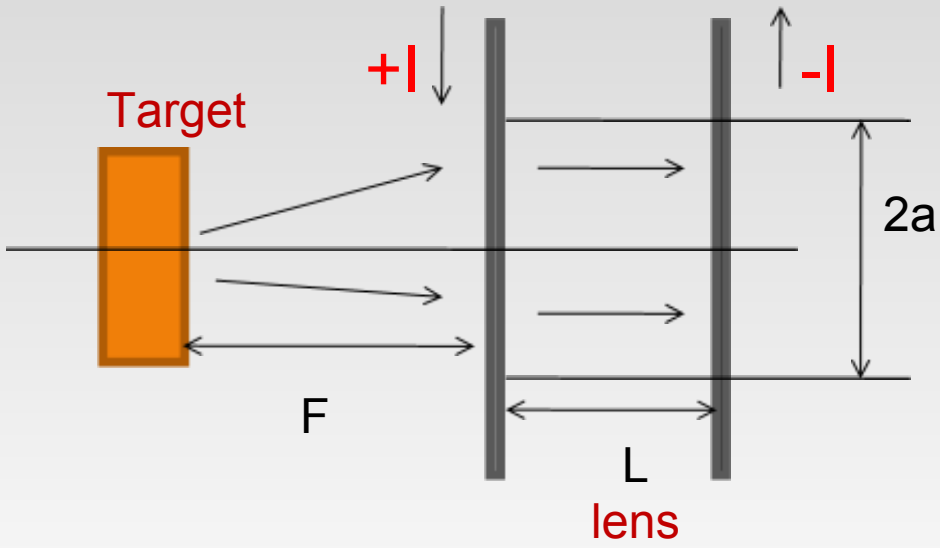
Yield comparison		
	AMD Bo=6T L=50cm	QWT Bo=2T L=52mm
Target	8.04	8.04
Capture	2.29	5.89
Accelerator	1.15	0.96



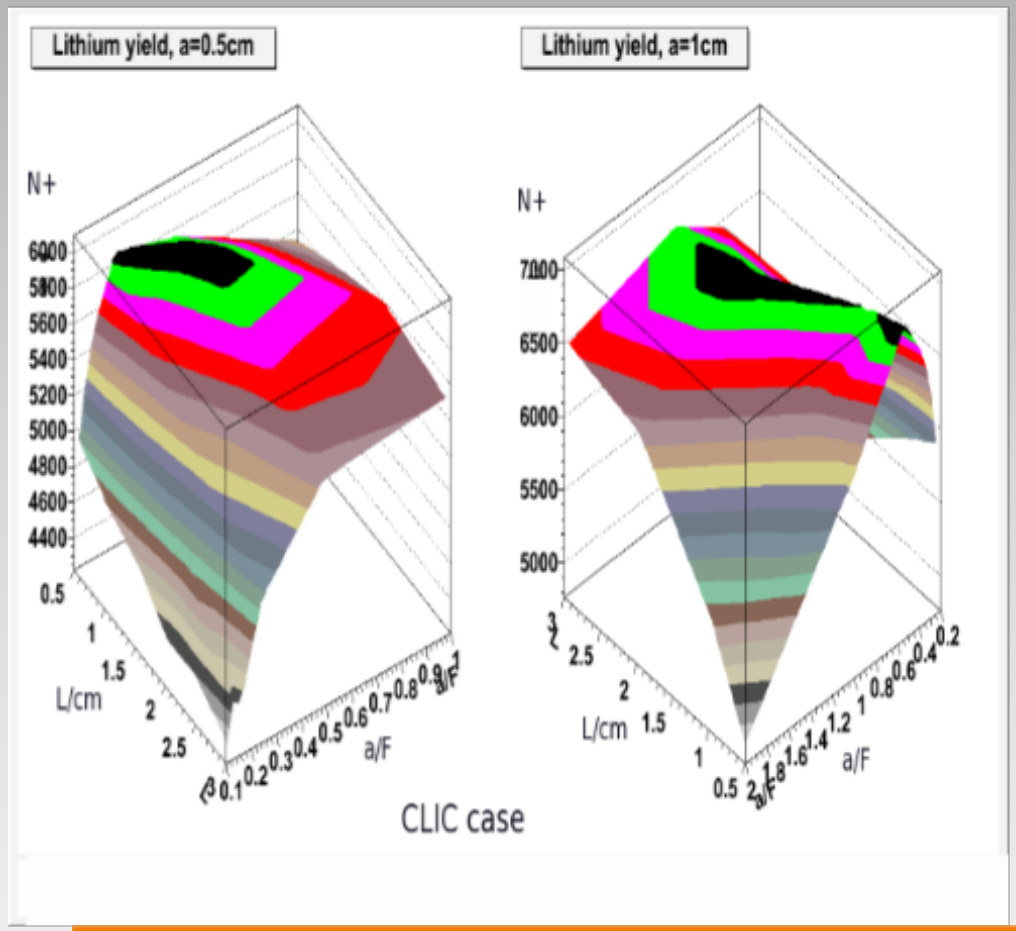
Lithium lens

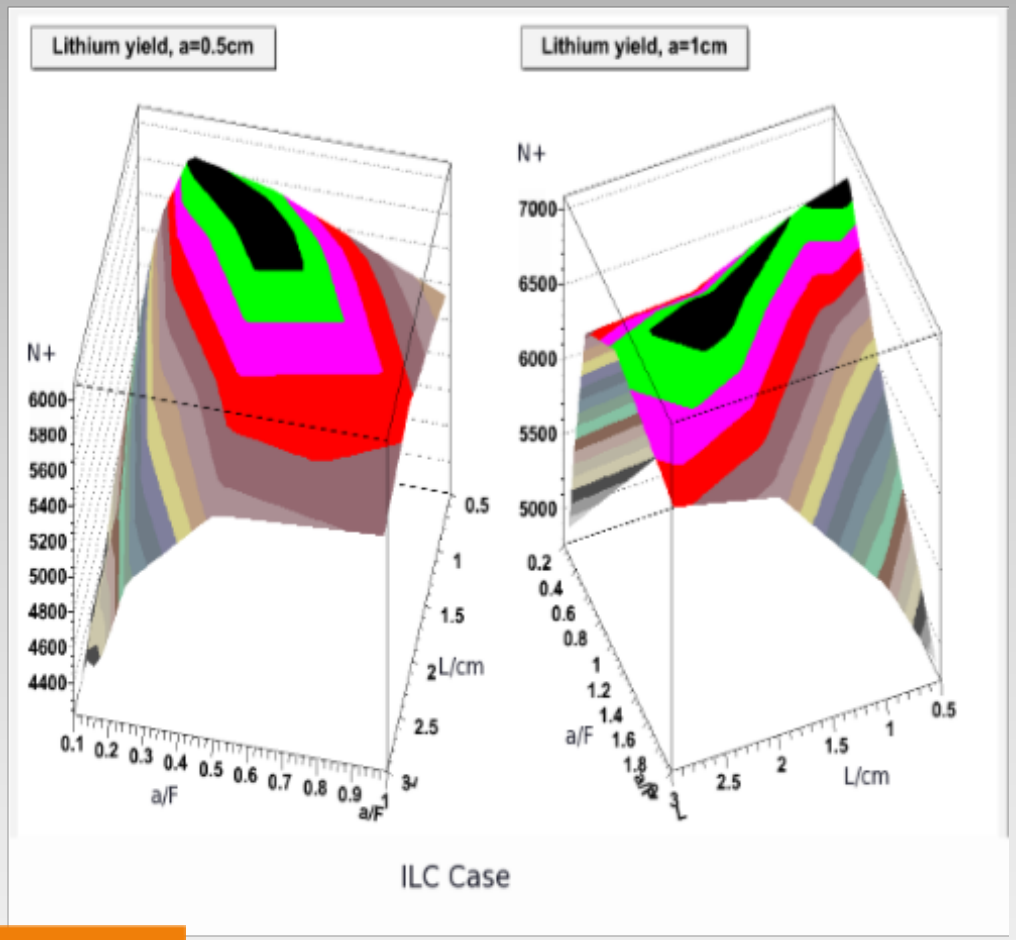
- Features
- 1. Acts like a QWT: reduces strongly the angle by focusing at infinity, for particles for which the distance between the target and the lens is equal to the focal length.
- 2. The lithium lens focuses positrons and defocuses electrons.
- 3. Problem of multiple scattering: lengths limited to few cm.
- 4. The plasma lens acts identically.





Optimization HR(momentum)=10MeV/c

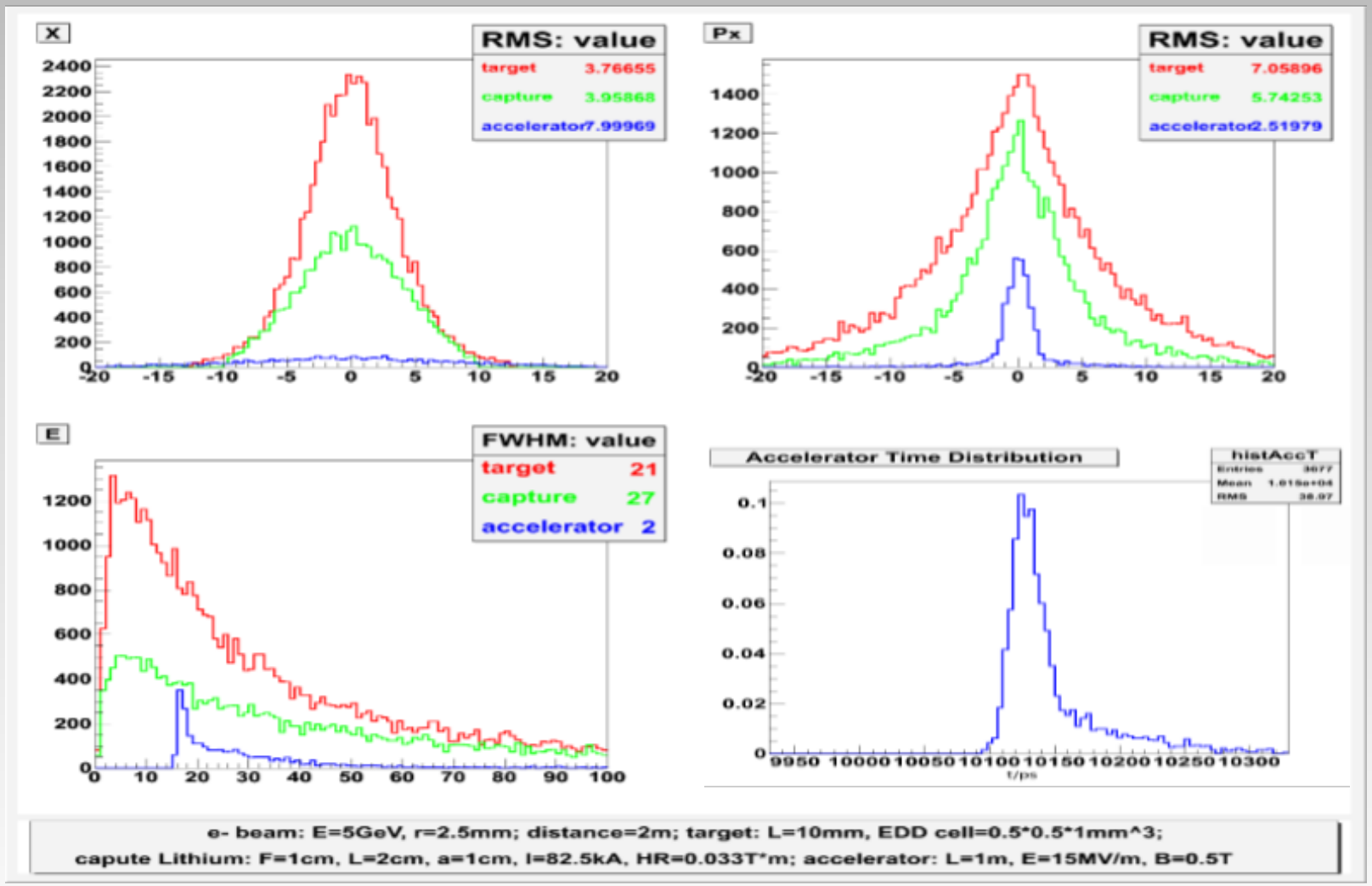




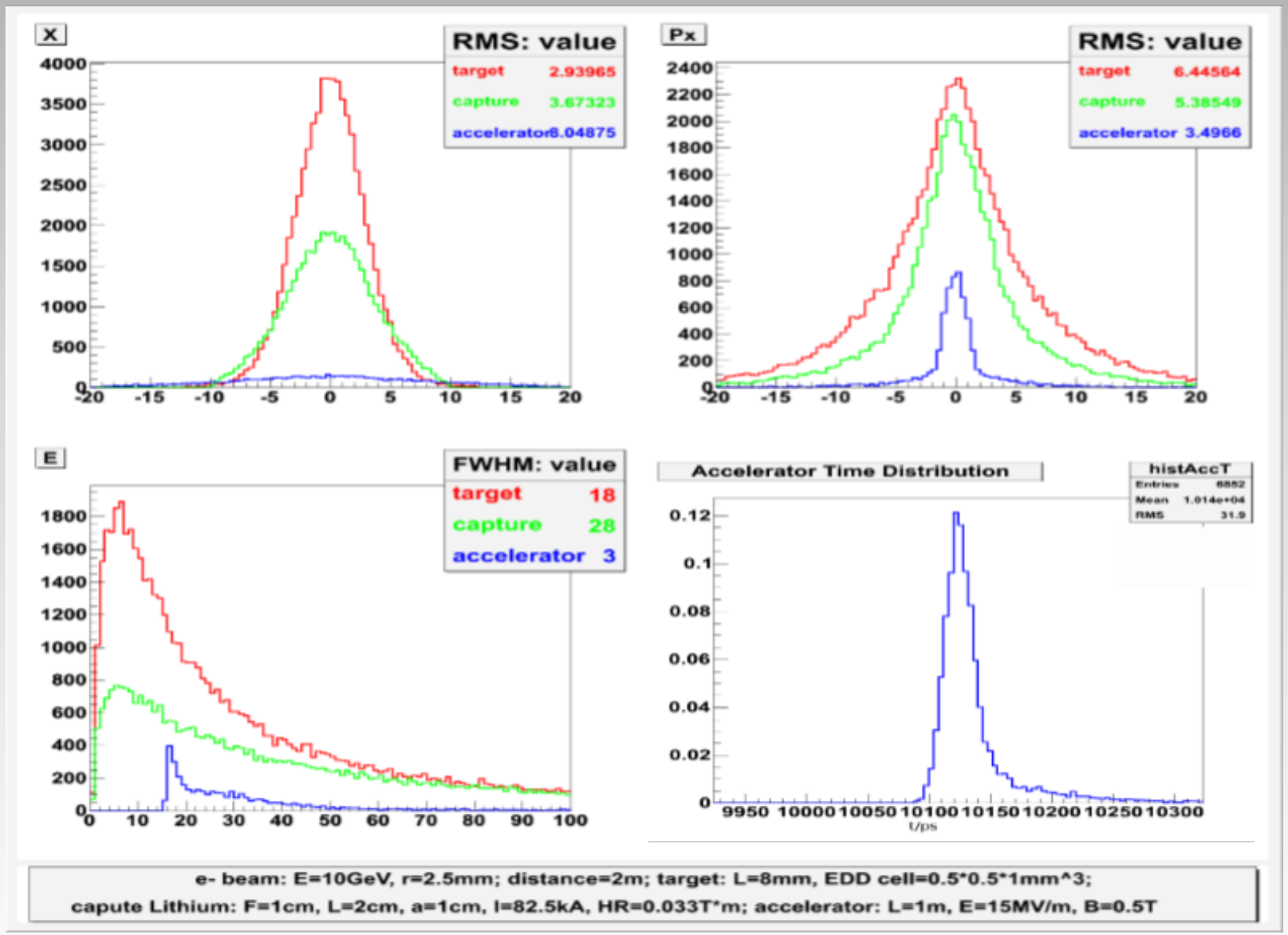
Best parameters:
ILC: a=1cm, L=2cm, F=1cm, I=82.5kA
CLIC: a=1cm, L=2cm, F=1cm, I=82.5kA

Black color □ strongest density

Lithium CLIC Case

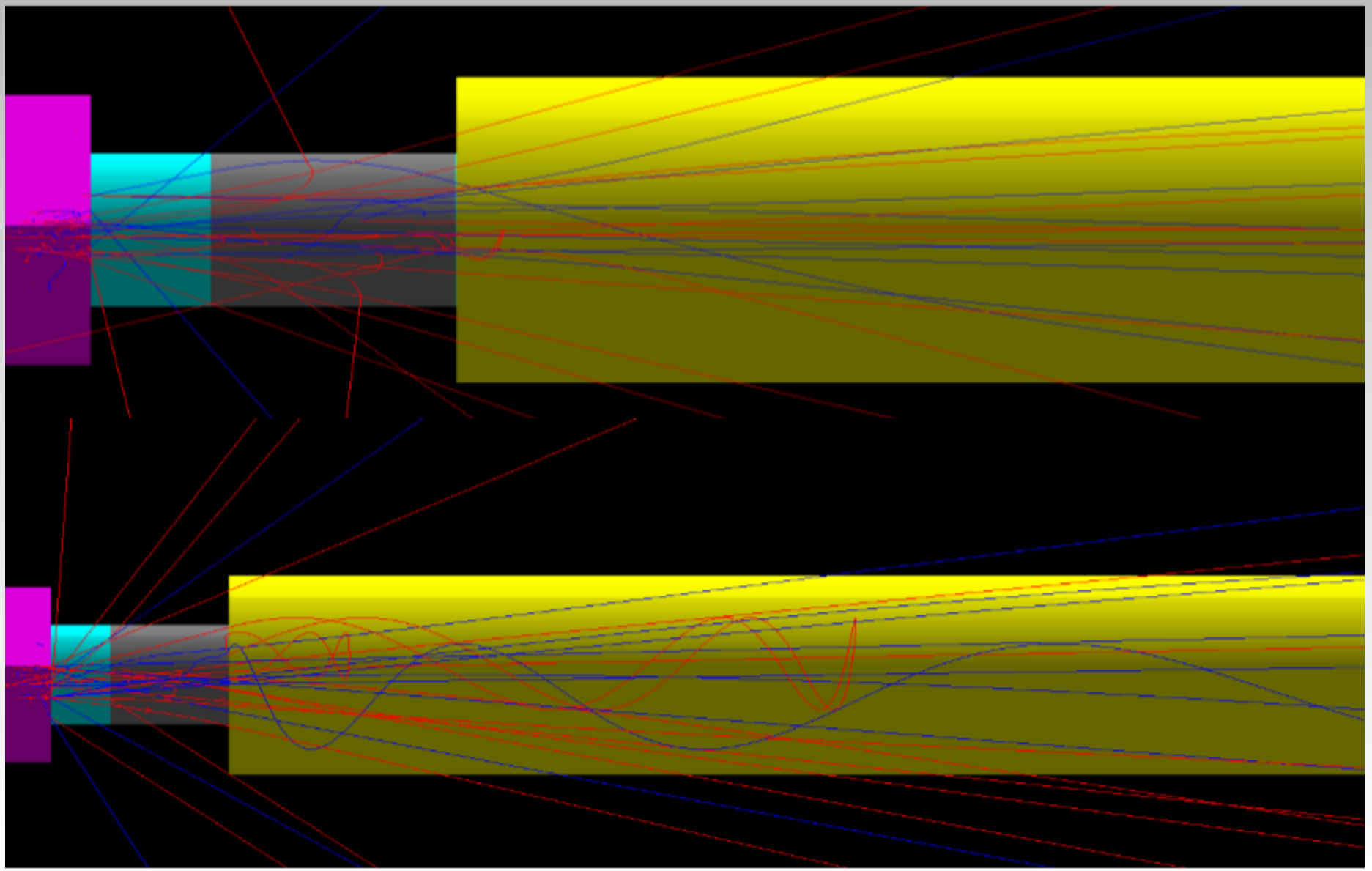


Lithium ILC Case



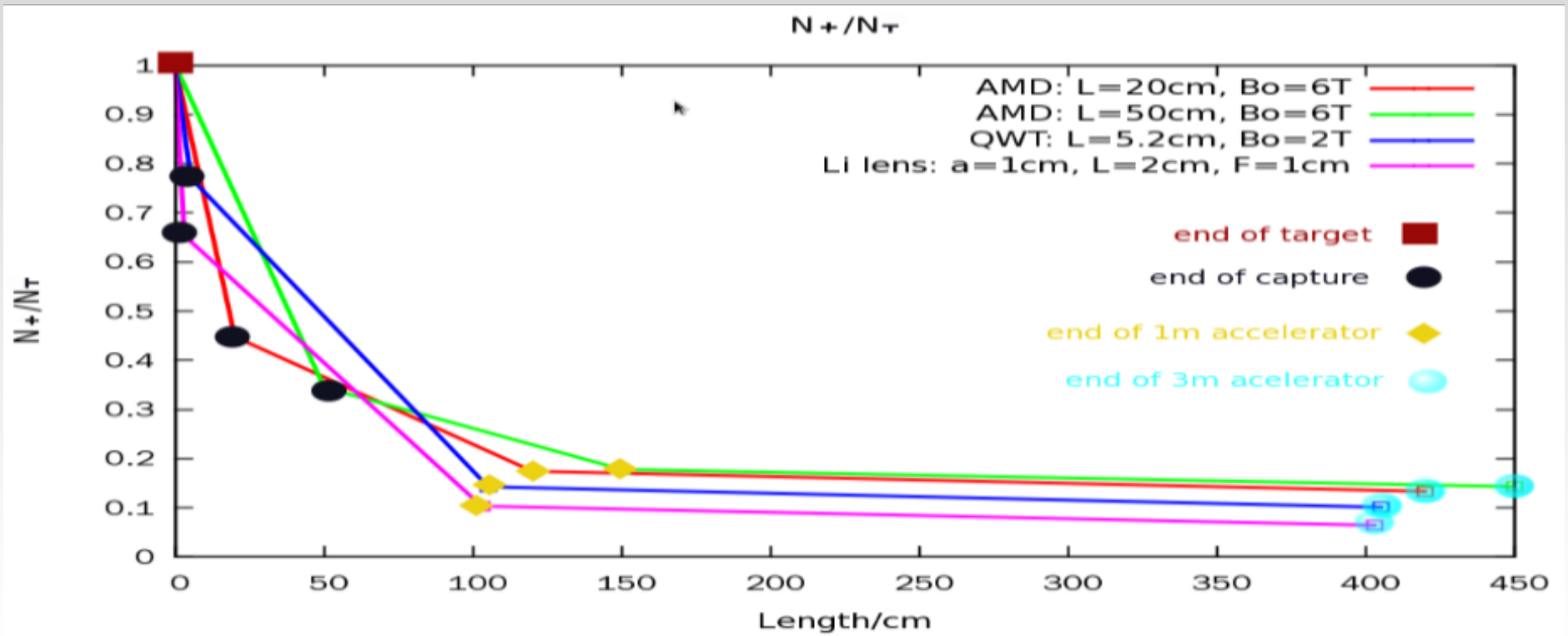
Trajectory (ILC Case)

Red: electron; Blue: positron

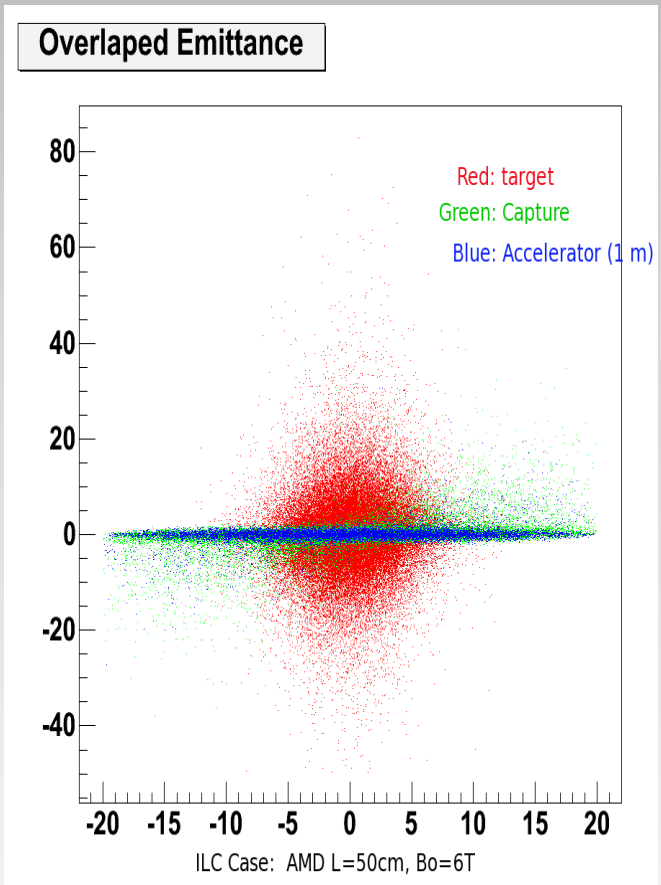


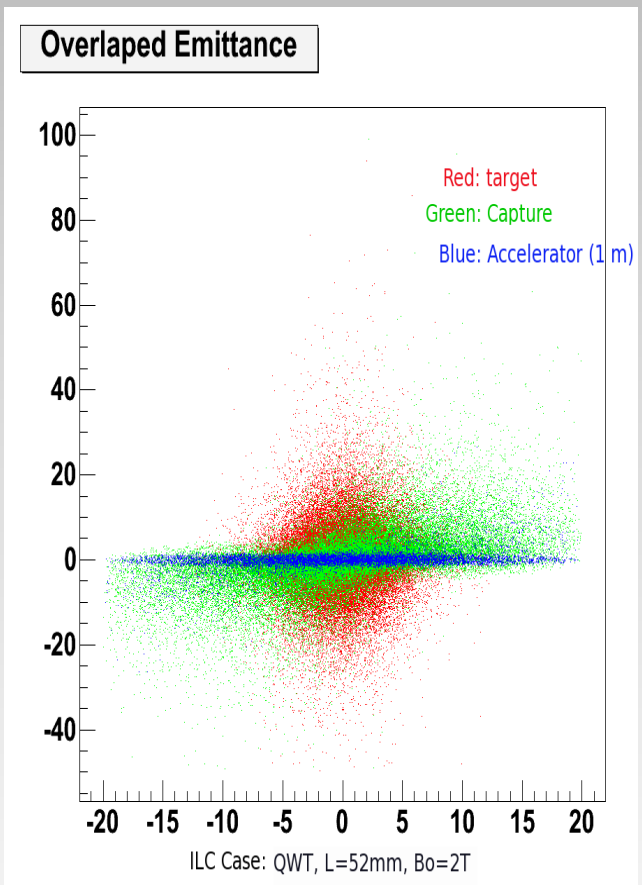
Discussion: Capture Efficiency and yield ILC Case

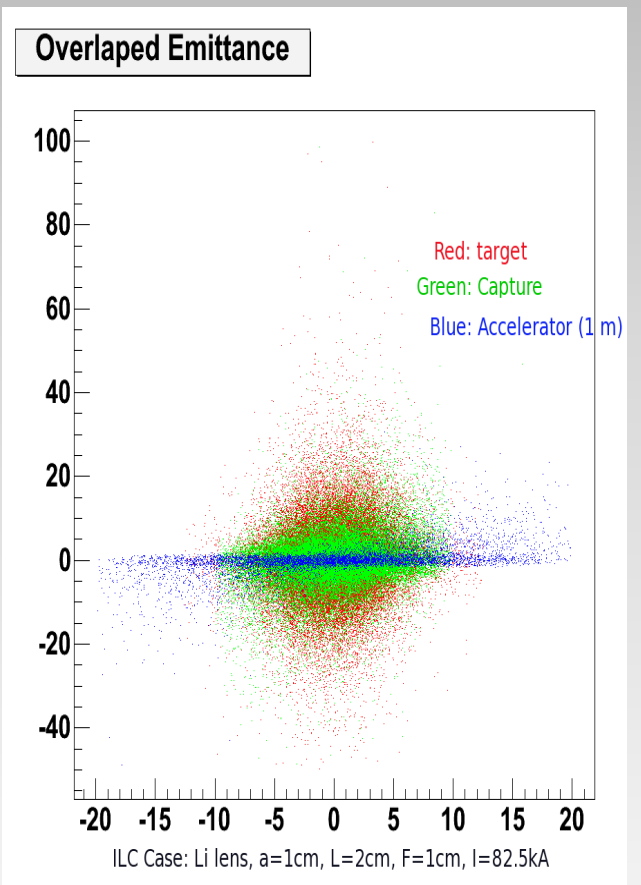
Yield comparison			
	AMD Bo=6T L=50cm	QWT Bo=2T L=52mm	Li lens a=1cm L=2cm F=1cm
Capture	4.59	10.36	8.69
Accelerator 1m	2.37	1.92	1.376
Accelerator 3m	1.90	1.36	0.85



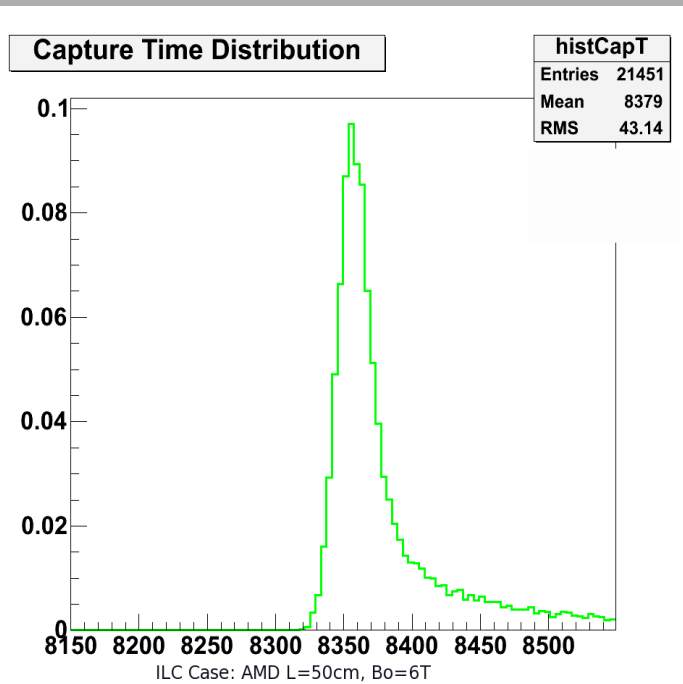
Emittance
ILC Case

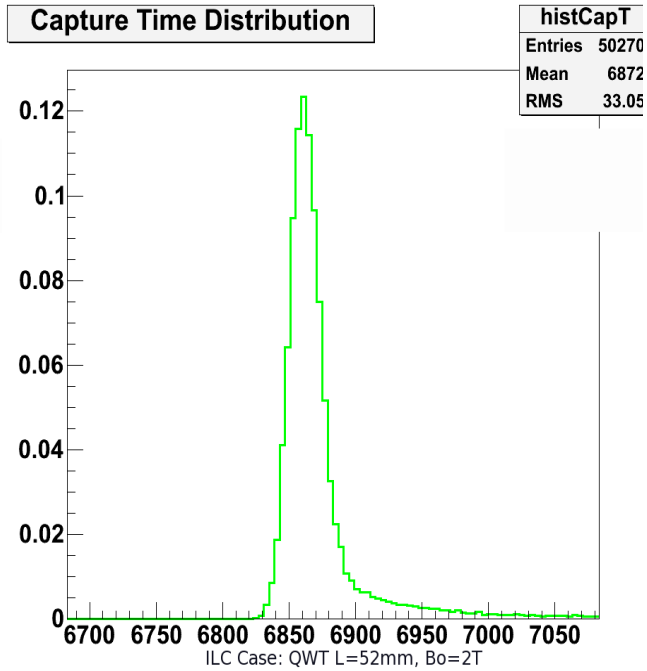


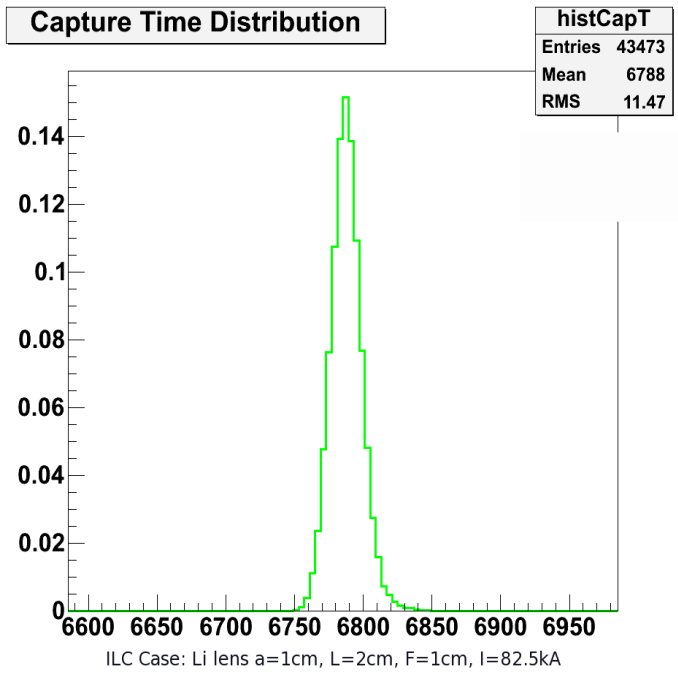


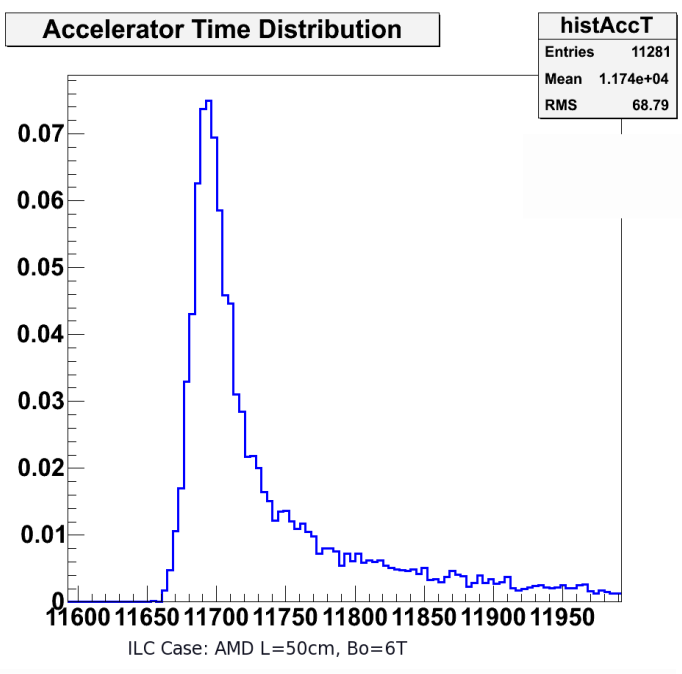


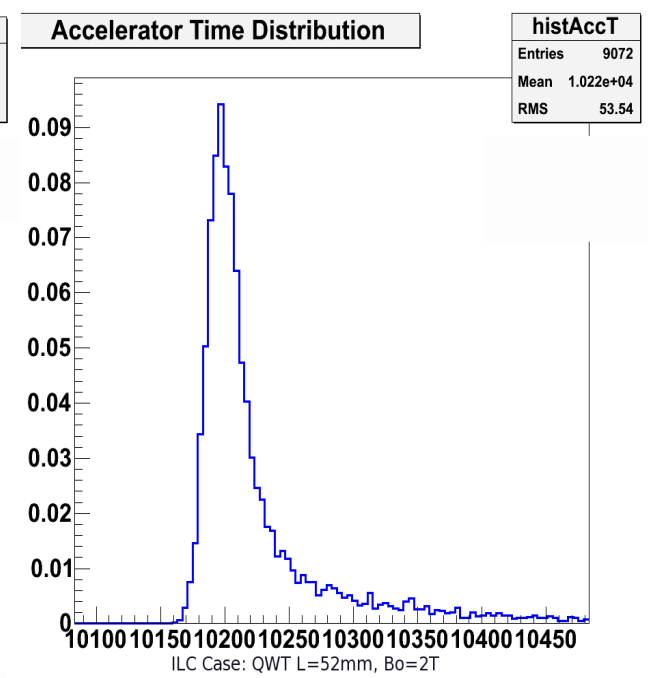
Time Distribution (ILC Case)

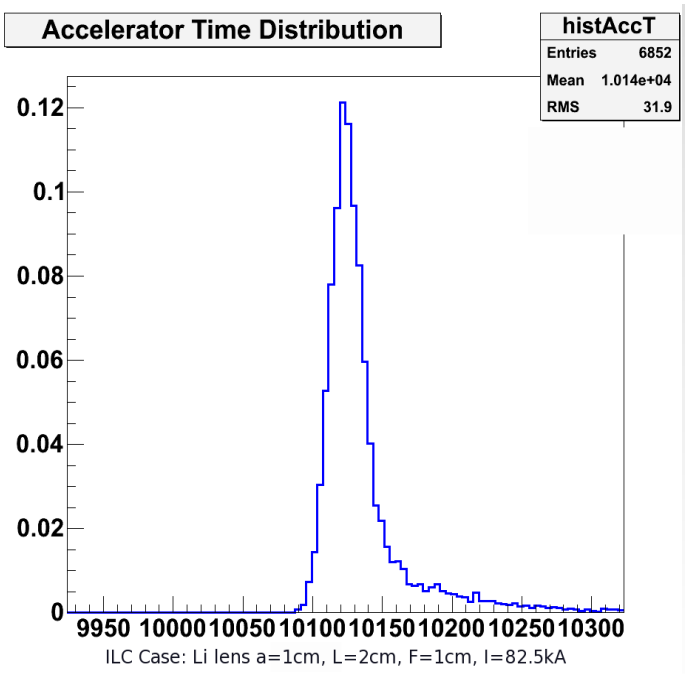












Summary

- Our study concerned three kinds of lenses: QWT, AMD and Lithium lens. We have considered the CLIC case and also the case of ILC. Comparisons between the different lenses for the accepted yields, the emittances, energy spectra and bunch lengths were operated. A figure representing the electron and positron trajectories for the Lithium lens, shows clearly a different behaviour: as expected, for a given current direction, the electrons are more likely ejected than the positrons. Such situation is to be taken into account for very intense beams coming out from the target.

Thank you very much

Additional slides

QWT – Quarter Wavelength Transformer

- Features:

1. Large momentum acceptance $(eB_0a/2)(1+B_s/B_0)$
2. Small geometrical acceptance $a(B_s/B_0)$
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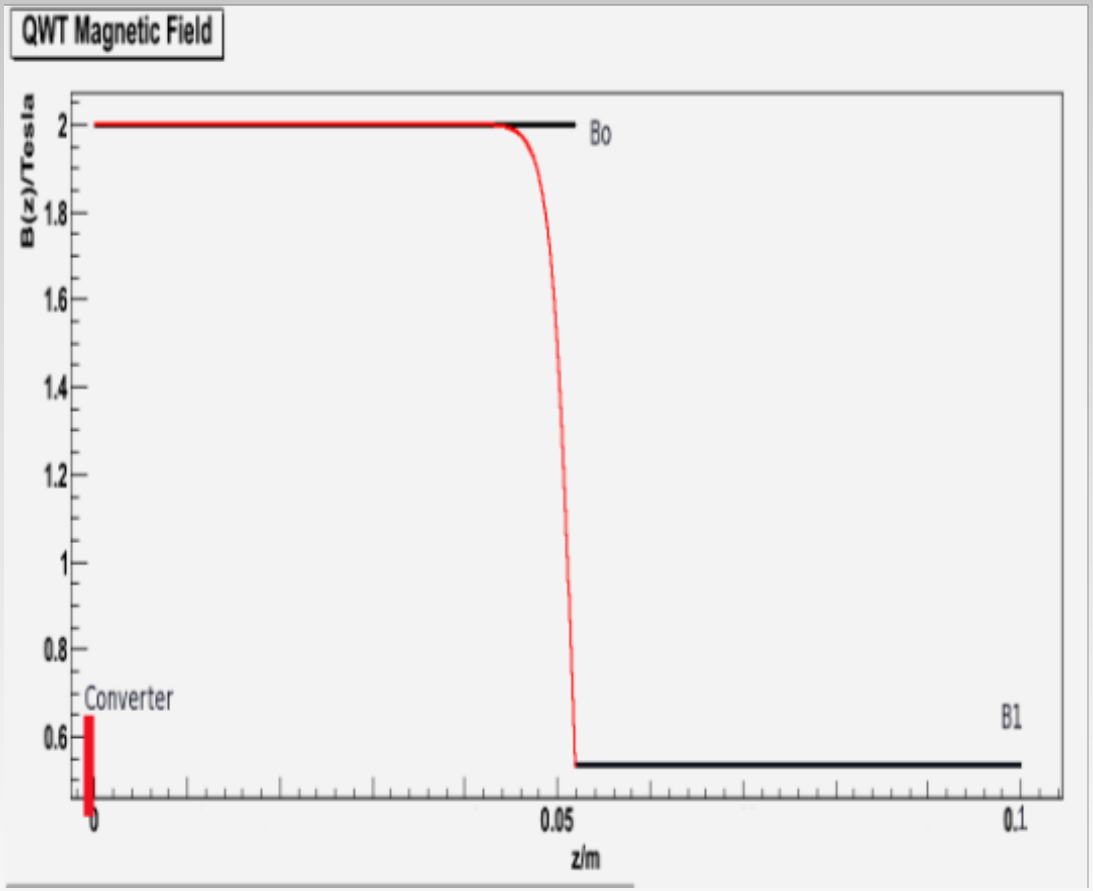

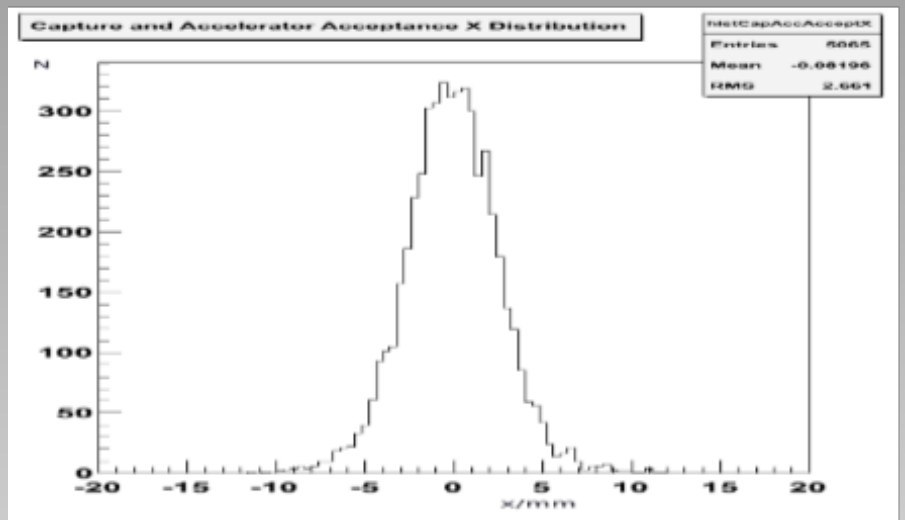

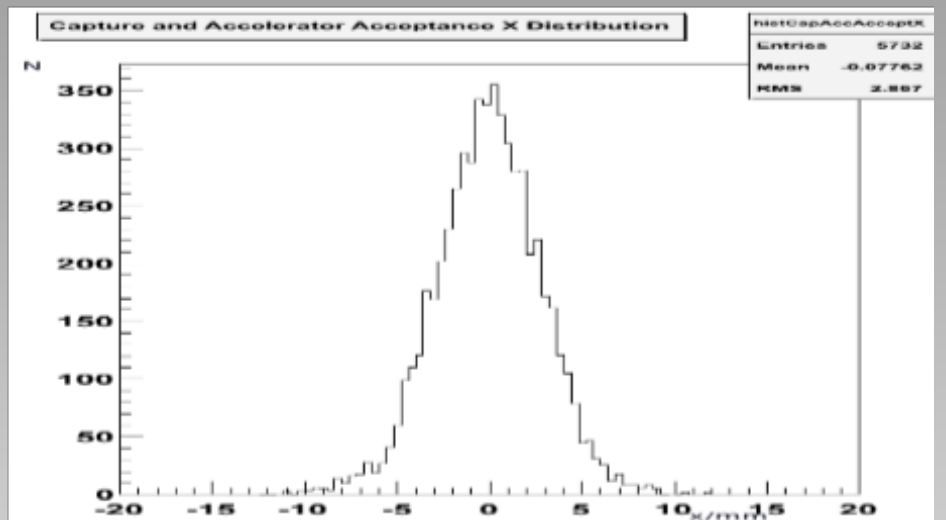

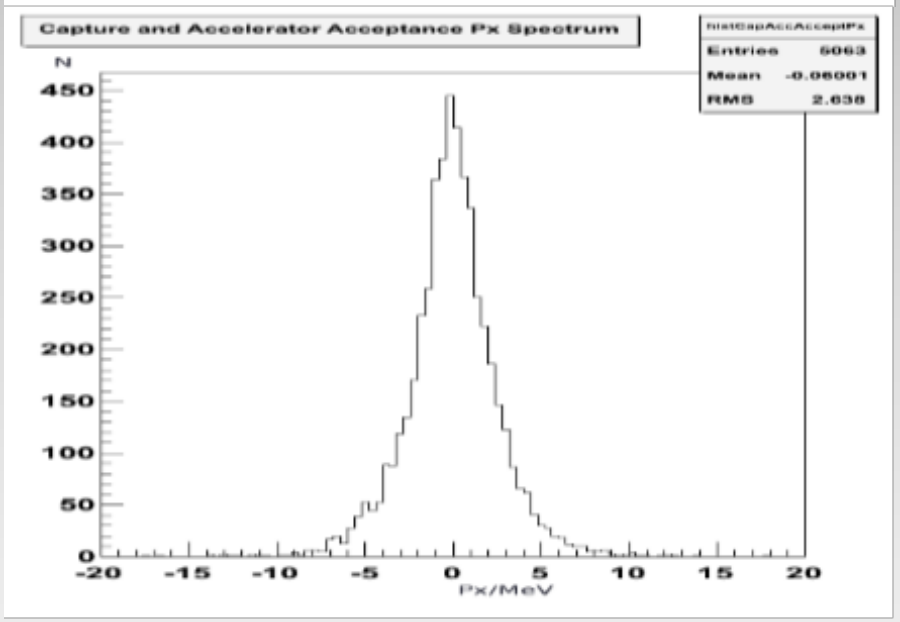

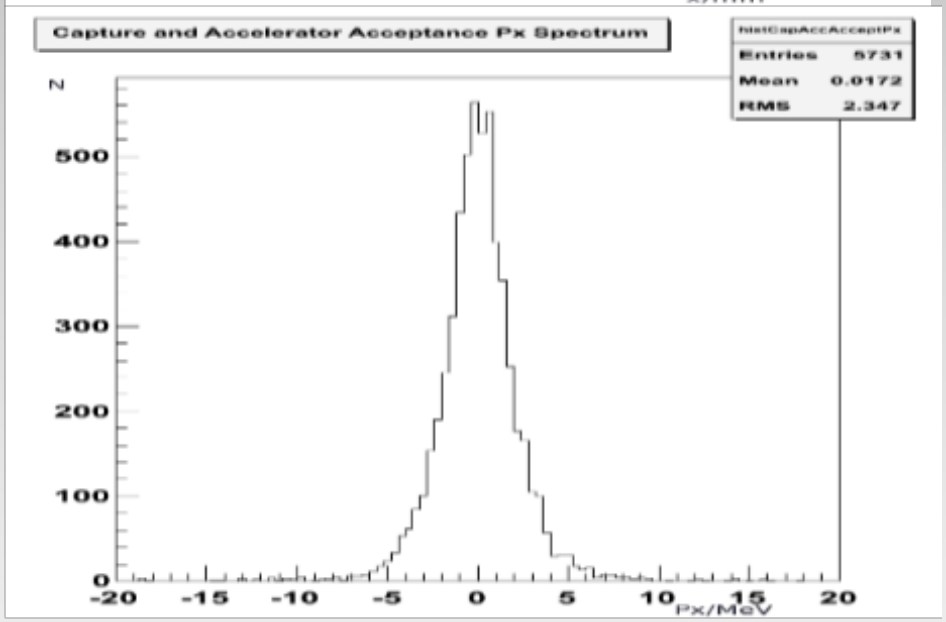

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AMD – Adiabatic Matching Device

- Features

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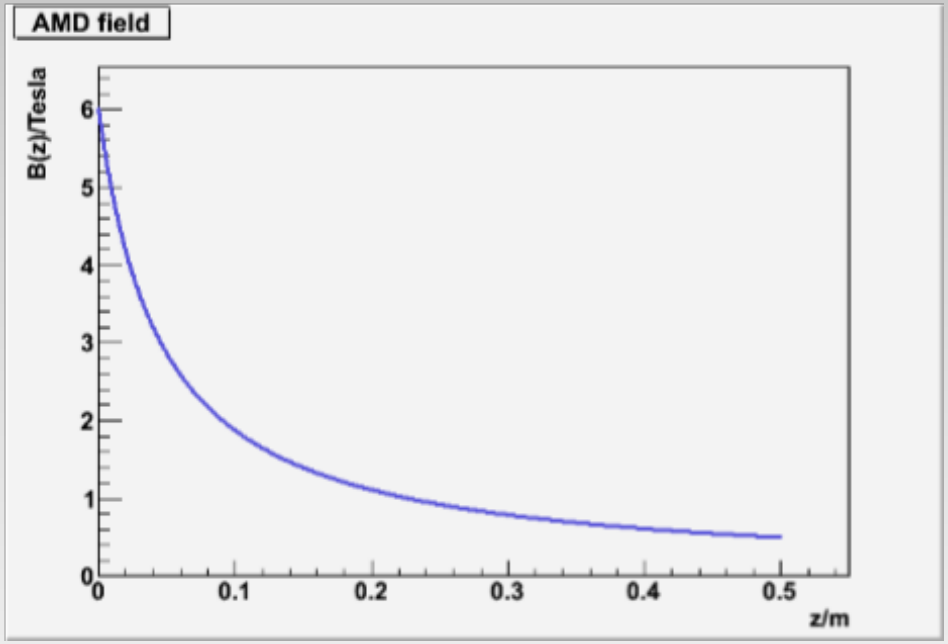
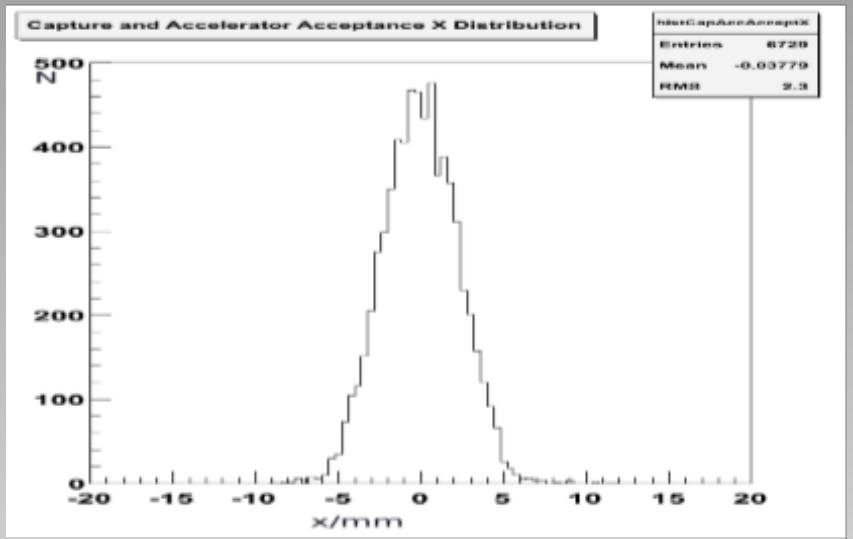
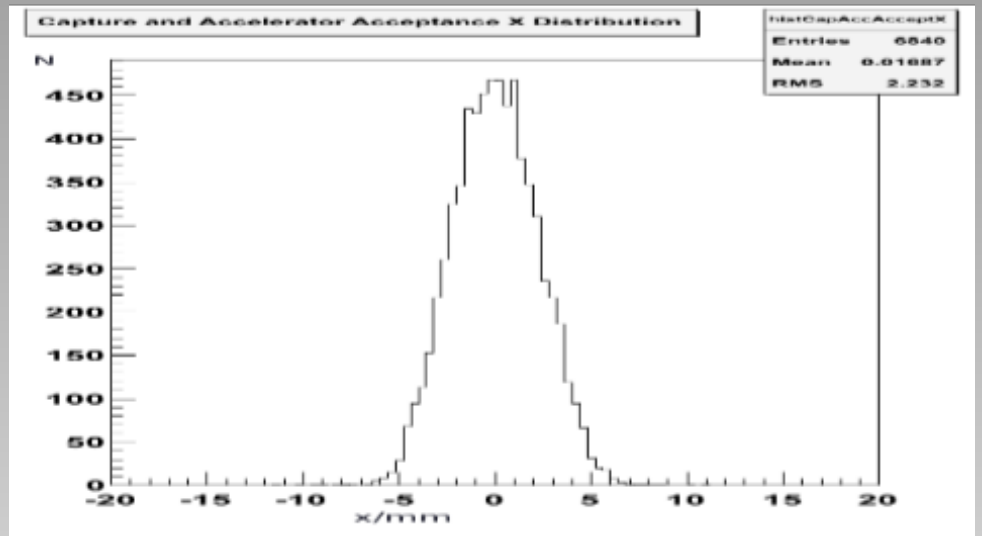
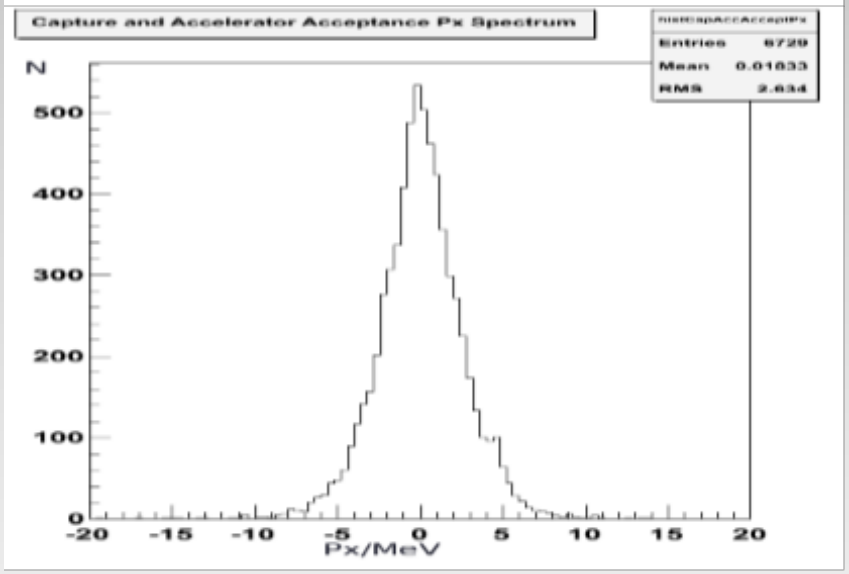
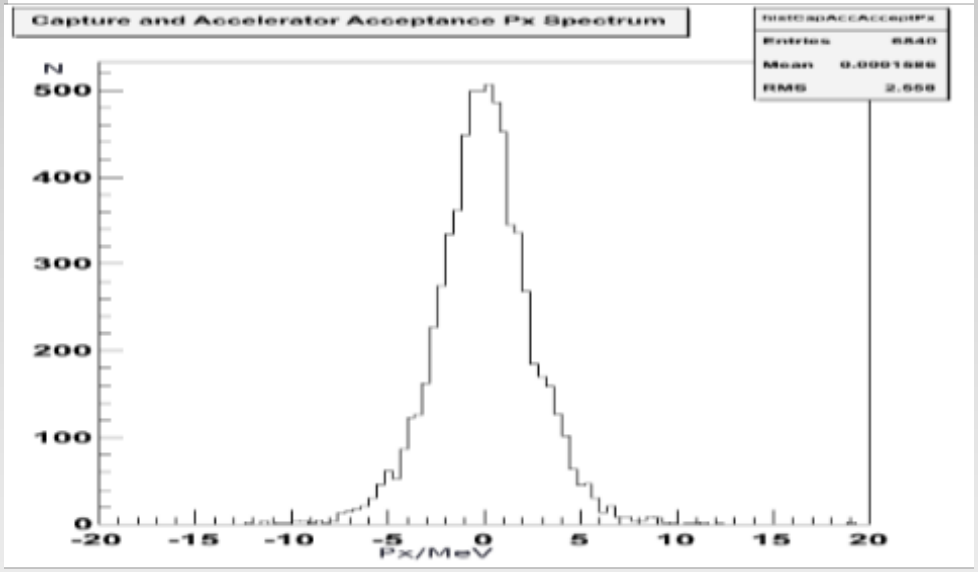




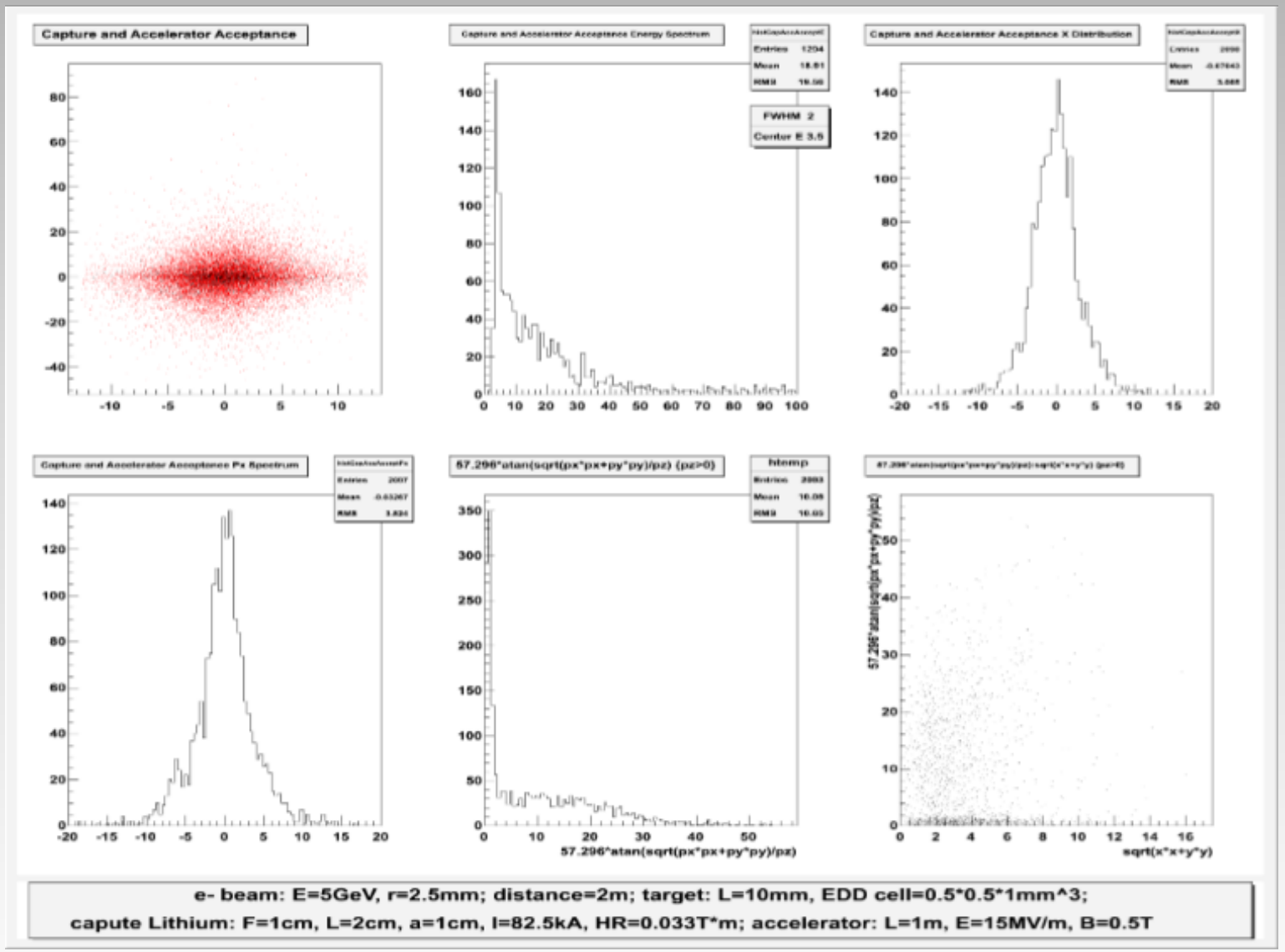






CLIC Case, AMD Acceptance : Left L=20cm Bo=6T, Right L=50cm, Bo=6T

Lithium CLIC Case: Acceptance



Lithium ILC Case: Acceptance