ELECTRON-DRIVEN POSITRON CAPTURE SIMULATION FOR ILC

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ABSTRACT

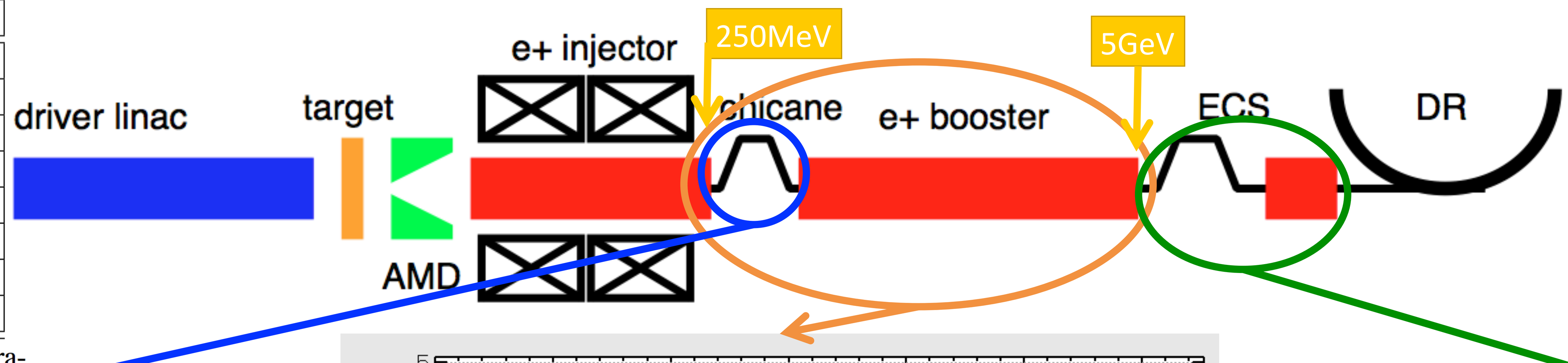
- ILC (International Linear Collider) is a next high-energy physics project to study the Higgs property as detail as possible and new phenomena beyond standard model.
- In ILC, the positron beam is produced by converting gamma rays from undulator radiations. To obtain gamma rays as undulator radiation, the electron beam for collision (more than 100 GeV) is used.
- This positron generation scheme is a totally new approach.
- We propose an ILC positron source based on the conventional electron driven scheme for the backup.
- Electron-driven positron capture is simulated from the positron production to the positron DR (Damping Ring), to demonstrate that an enough amount of positron can be generated and captured with a controllable heat load on the target (3.0×10^{10}).

SUMMARY

- We perform a start-to-end simulation for the electron driven ILC positron source. According to the simulation, 3.0×10^{10} positron per bunch is obtained with PEDD 27 J/g which is below the practical limit by SLC, 35 J/g.
  - The spot size on the target: 4 mm (RMS)
  - Driver electrons per bunch: 2.3×10^{10}
  - AMD – peak field: 5 Tesla, aperture: 8 mm
  - solenoid in injector: 0.5 Tesla
  - The booster linac is a hybrid of L-band and S-band structures.
  - ECS optimizes the capture efficiency.
  - The beam chicane to remove electrons and positrons with a large energy deviation has a limited impact on the capture efficiency.
- The effect of beam loading, especially in the positron injector will be carefully studied, because the beam loading in the positron injector can be heavy by electrons.

Parameter	Value	Unit
Drive Beam energy	6.0	GeV
Beam size	4.0	mm (RMS)
AMD peak field	5.0	Tesla
RF Gradient	25	MV/m
Injector L-band RF aperture	20	mm
Booster L-band RF aperture	17	mm
Booster S-band RF aperture	10	mm
Solenoid	0.5	Tesla

Table 1: A typical parameter set. Aperture is given in radius.



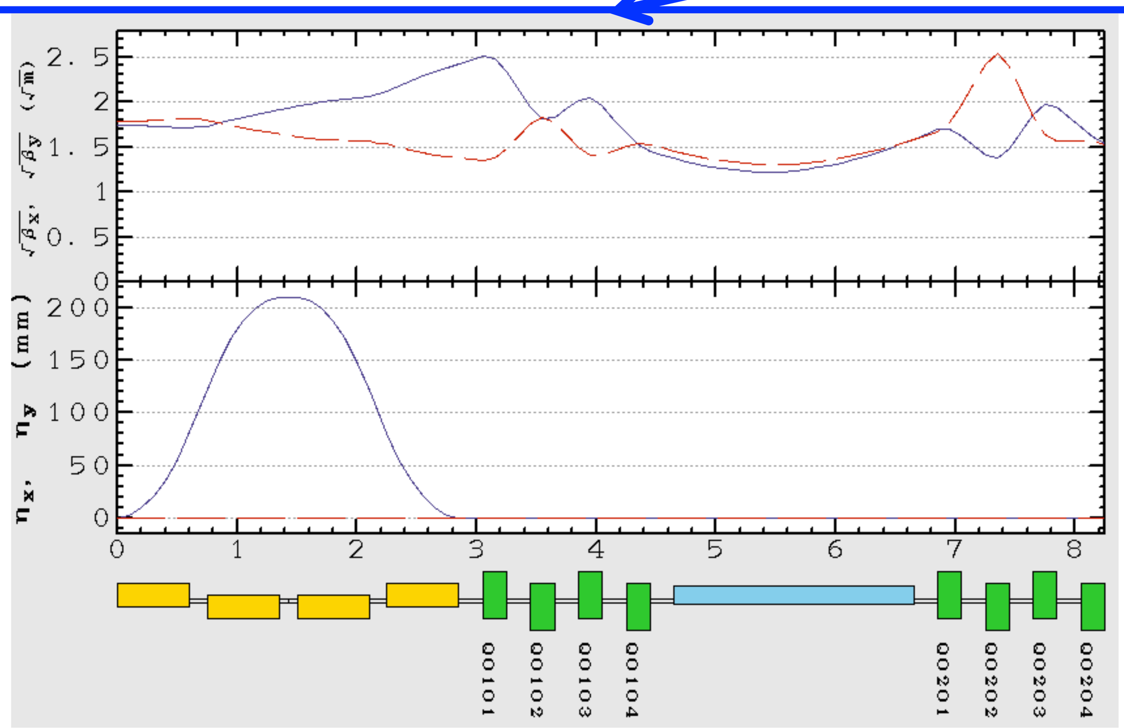
e^- target requirement:

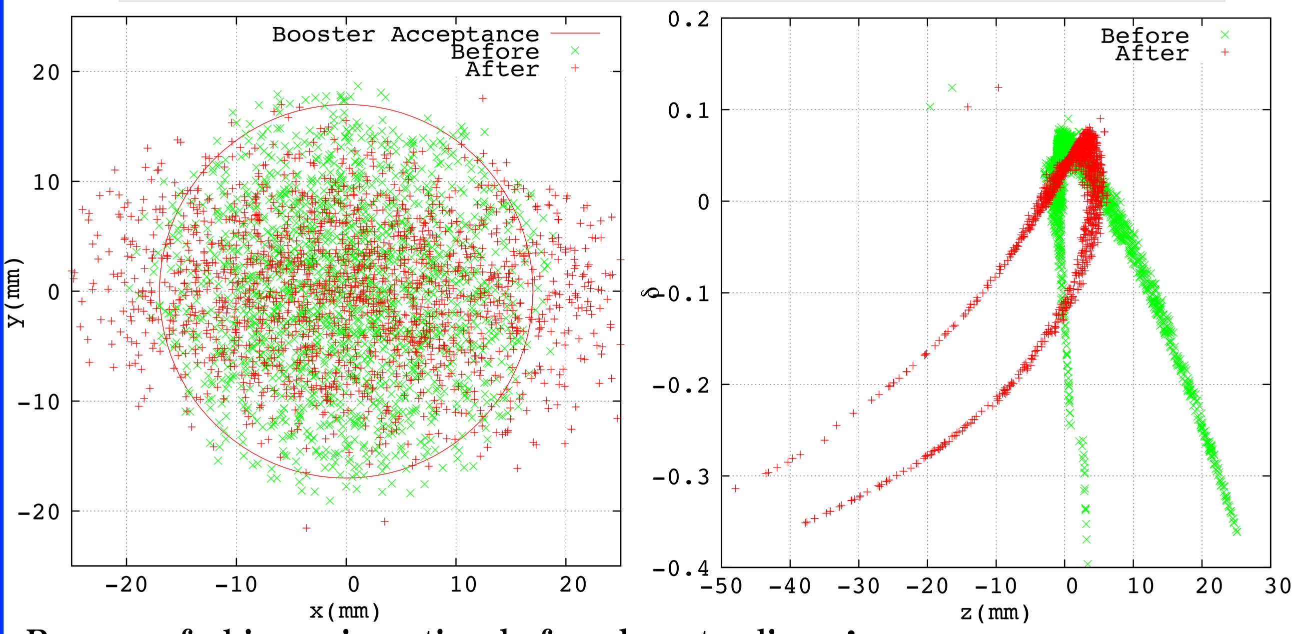
PEDD < 35 J/g

DR aperture:

$$\gamma A_x + \gamma A_y < 0.07 \text{ m}$$

$$z < \pm 35 \text{ mm}, \ \delta < \pm 0.75\%$$

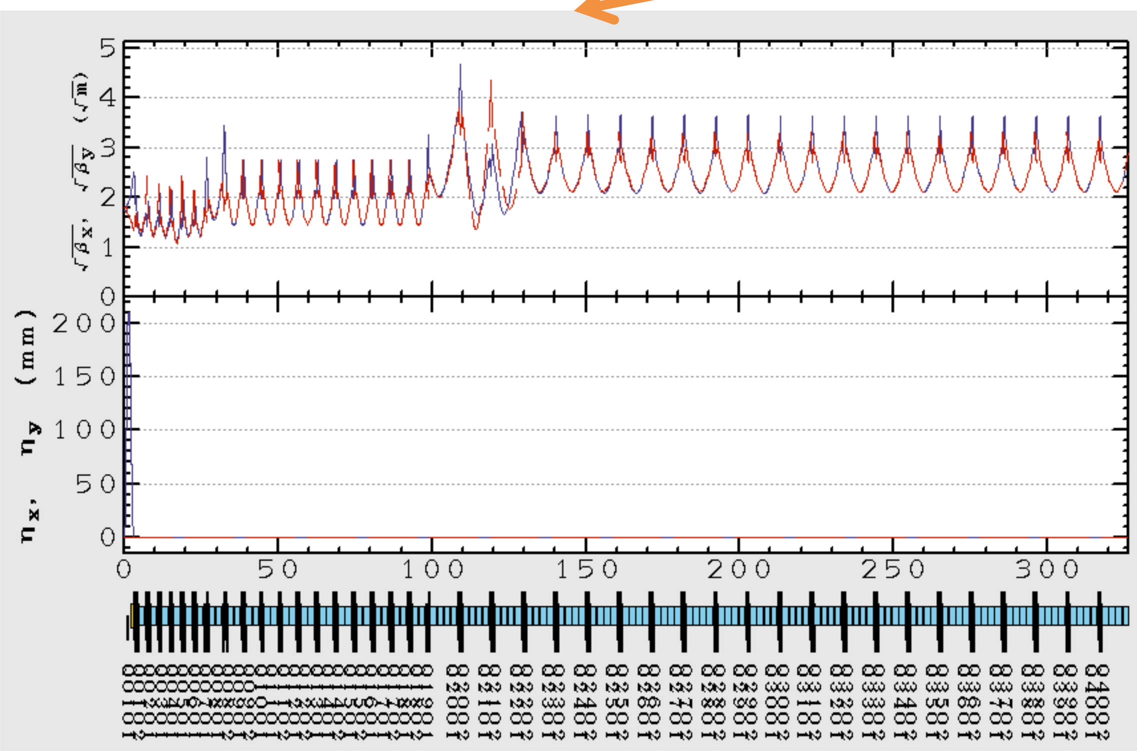




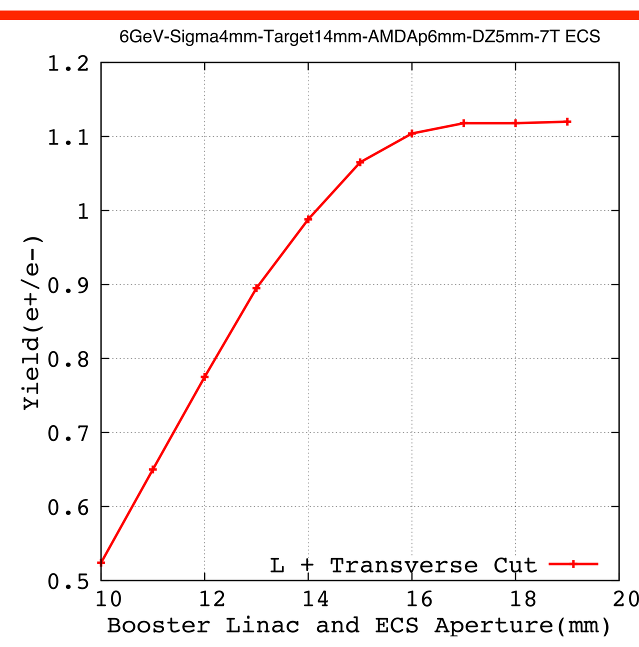
Reason of chicane insertion before booster linac :

- Removing electrons from the beam as soon as possible.
- Removing positron with a large energy deviation as soon as possible.
- On the other hand, the capture efficiency for the positron will be affected if the chicane is placed at the lower energy region.

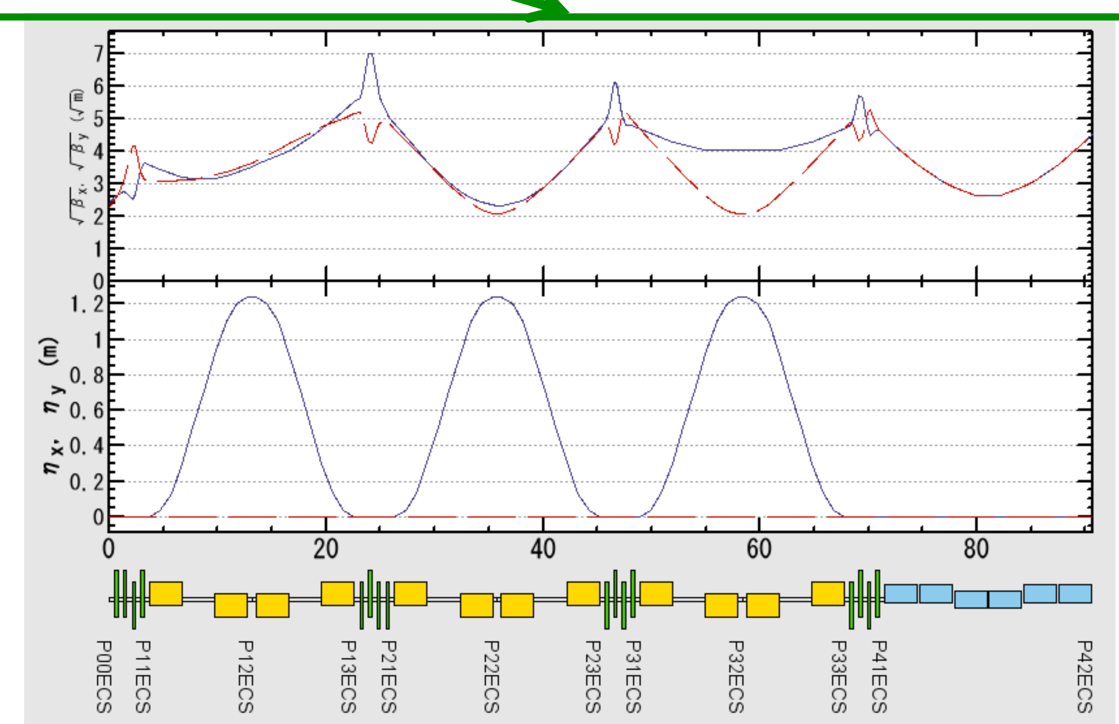
Capture efficiency is slightly improved with the chicane.

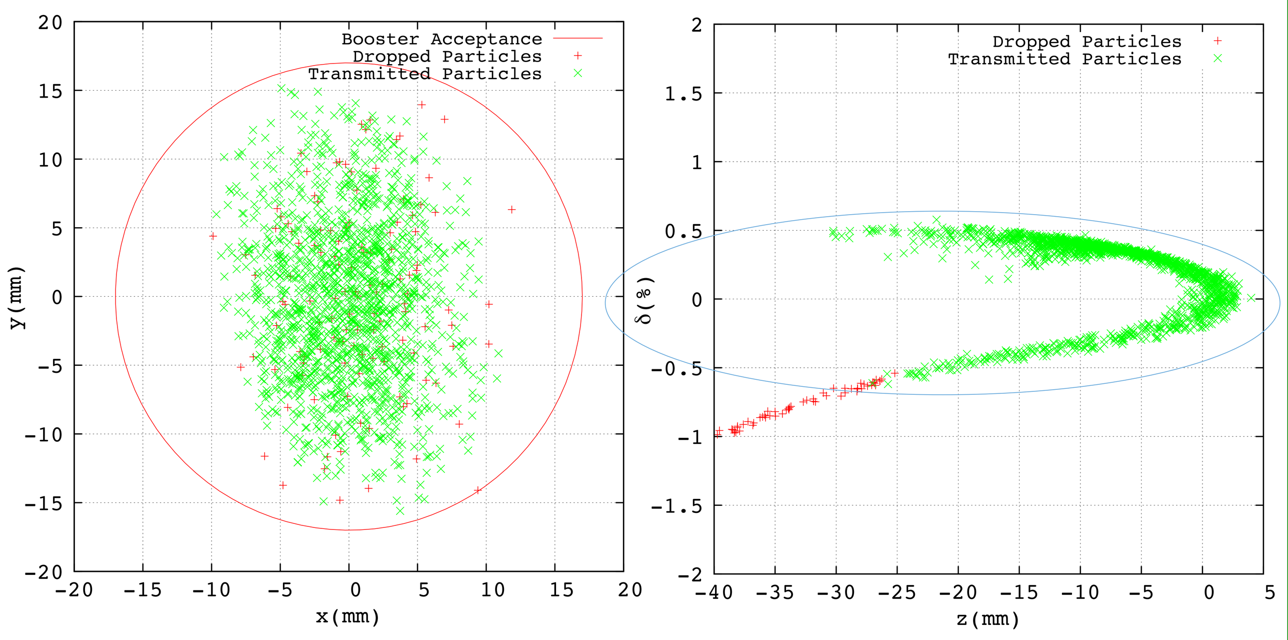


$$\text{Yield:} = \frac{\text{number of } e^+ \text{ in DR aperture}}{\text{number of } e^- \text{ as driver}}$$

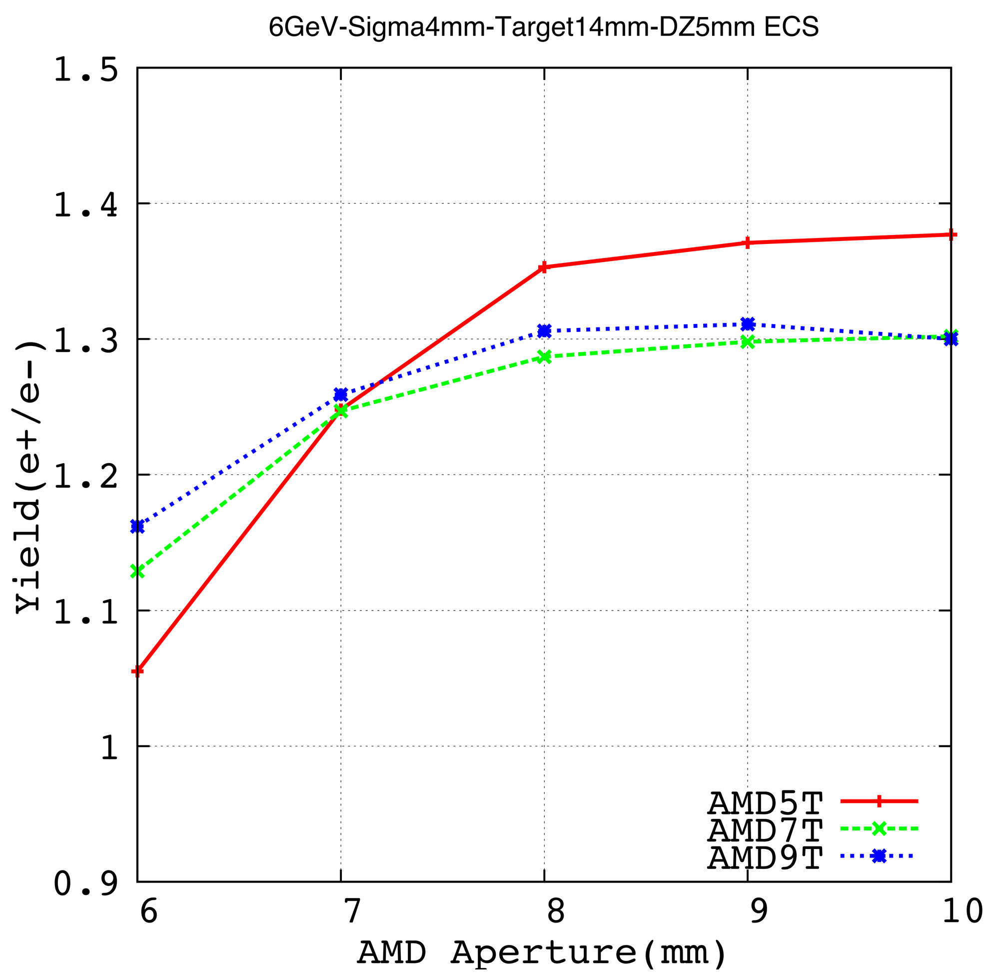


Yield as a function of booster linac aperture shows that the yield is saturated at these aperture larger than 16 mm.

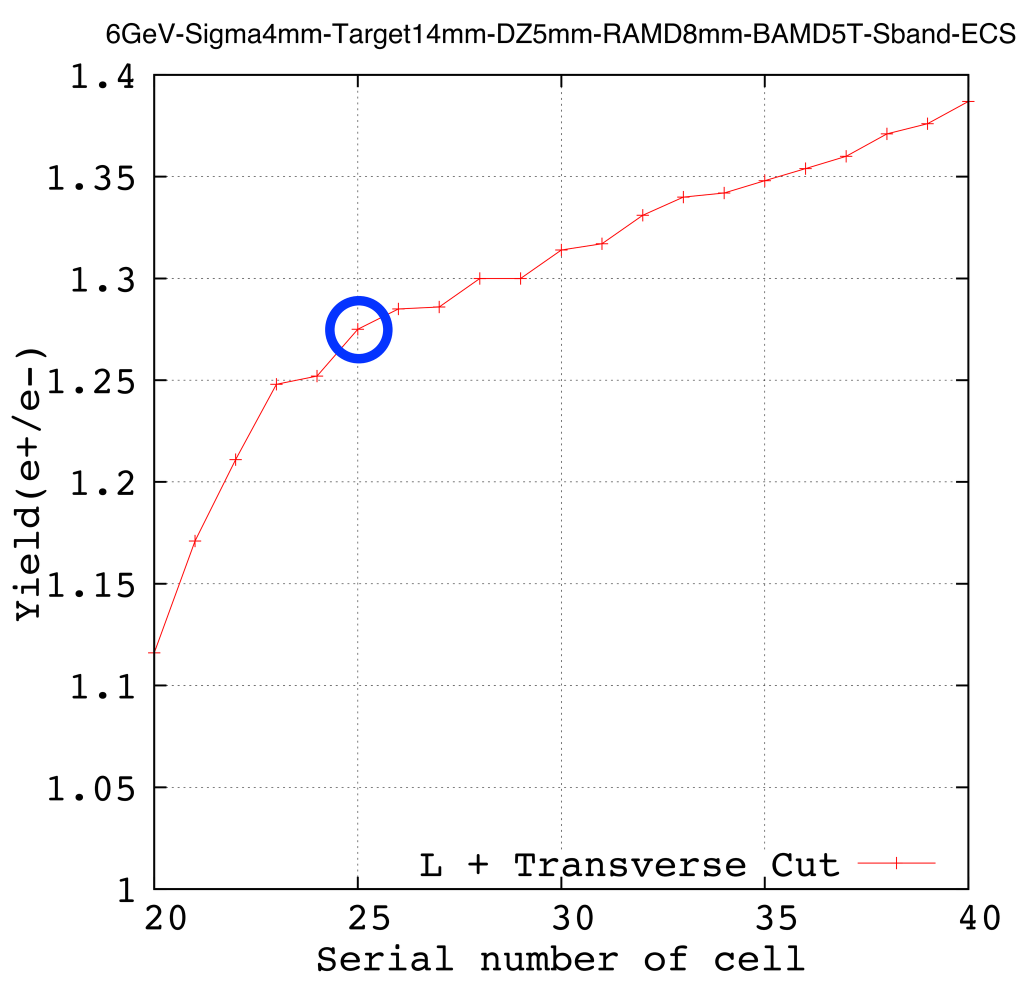




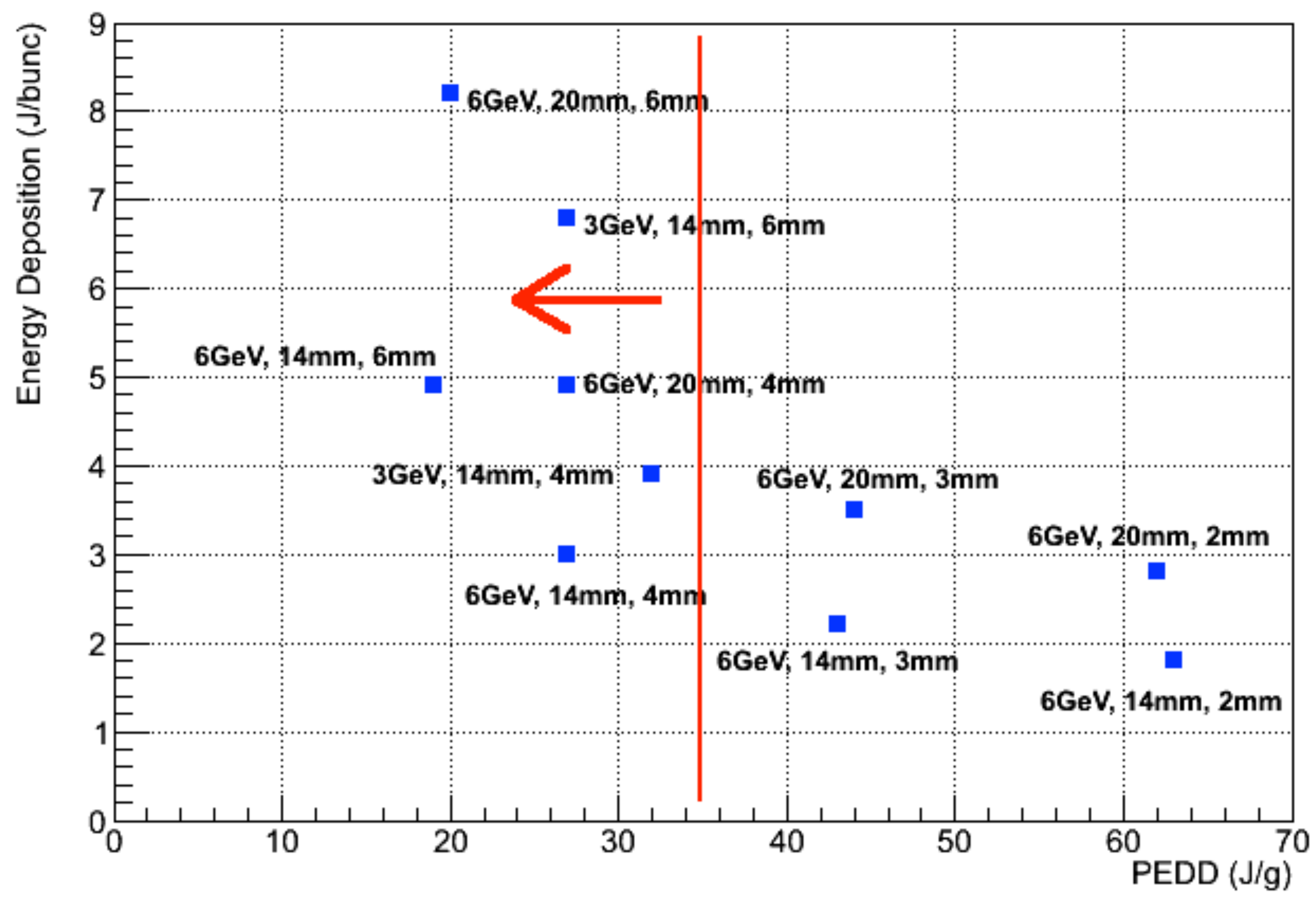
The particle distribution is rotated by 90 deg. with ECS as recognized. Green plots show e+ in DR aperture.



- Yield as a function of AMD aperture for 5 Tesla (red), 7 Tesla (green), and 9 Tesla (blue) peak field.
- AMD aperture lager than 8mm,
- 5 Tesla peak field with 8 mm aperture is an optimum.



- L-band accelerator is more expensive than S-band.
- This yield is estimated when the L-band structures after the cell are replaced with the S-band.
- Number of replacing L-band with the S-band after 26 cells is corresponds to about half number of all RF in booster linac. In this case, yield is 1.28.
- Yield 1.28 is enough for generating 3×10^{10} positrons with 2.3×10^{10} driver electrons.



- These plotted condition is normalized by the number of captured positron, 3.0×10^{10}/bunch.
- PEDD should be less than 35 J/g to prevent any target destruction.
- Lower energy deposition per bunch is better from technical point of view.
- 6 GeV driver beam energy, 14 mm target thickness, and 4 mm rms spot size is the best. In this case, driver electrons per bunch are 2.3×10^{10}.