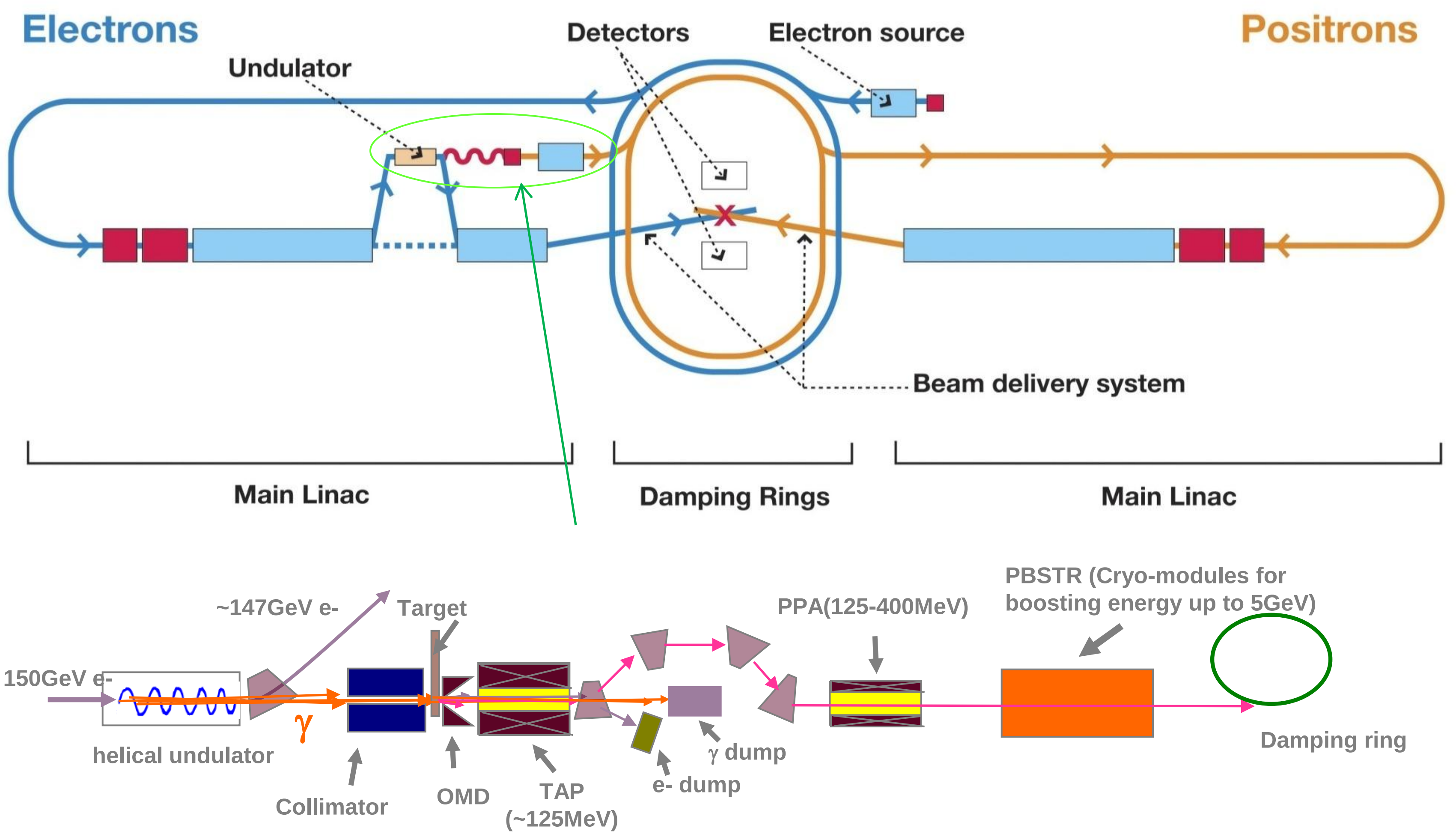
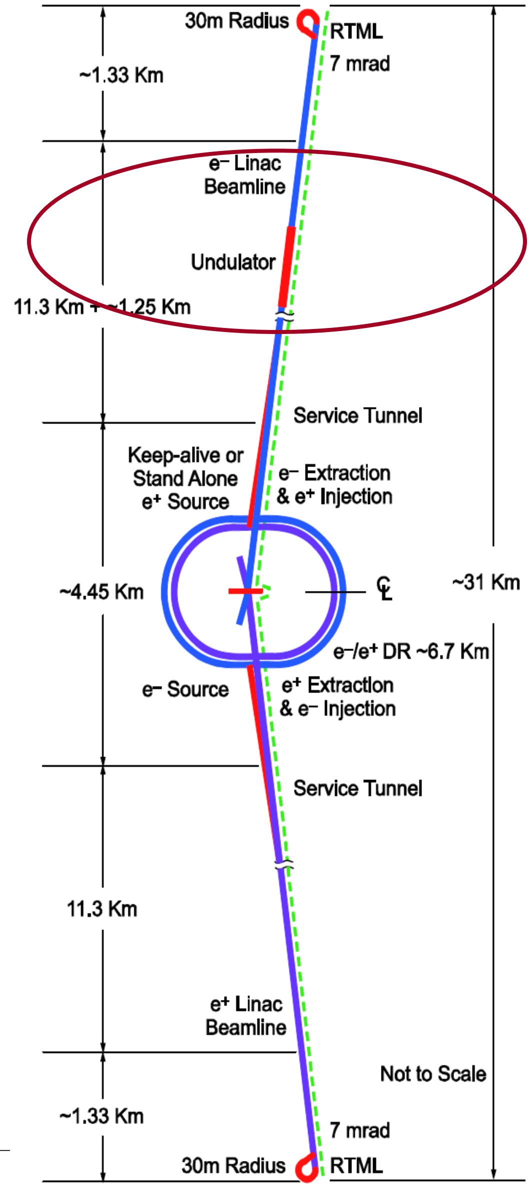
ILC RDR baseline schematic (2007 IHEP meeting)

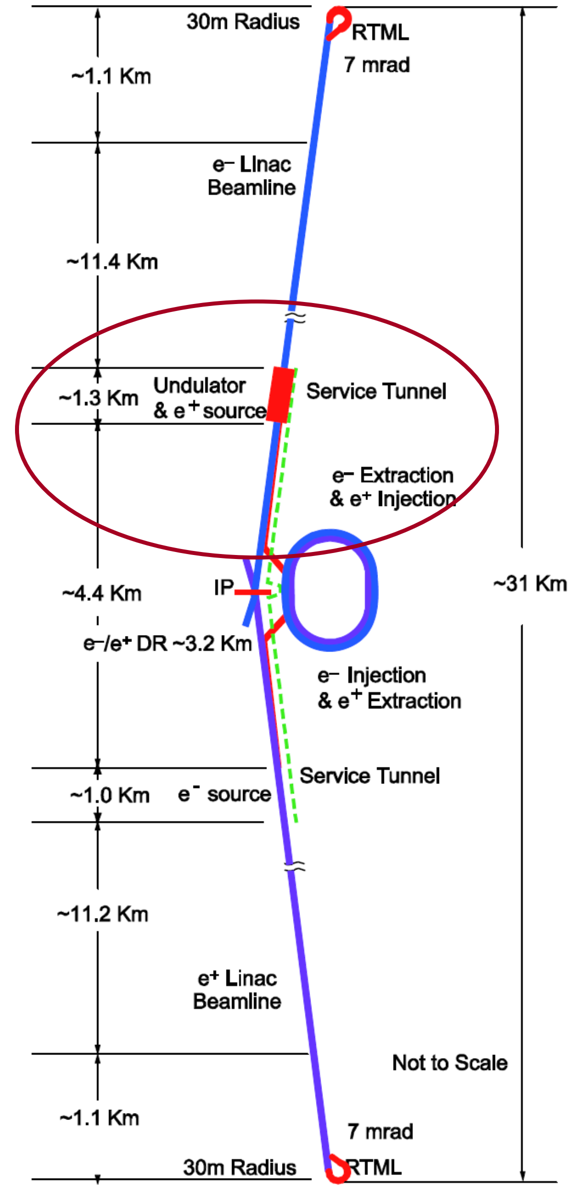


Location of sources at the ILC

RDR:



SB2009 and TDR



TDR Parameters:

- Optimize the positron yields for known technologies:
  - Superconducting helical undulator.
    - Undulator parameter: K=0.92, λu=1.15cm, length reduced from 231m to 147m
  - Capturing magnets
    - Optical matching device: FC is now in TDR baseline instead of ¼ transformer
  - Targets: 0.4 X0 Ti, 1m diameter, 2000 RPM
- Damping ring acceptance
  - Energy spread +/-0.5% => +/- 0.75%
  - emittance_x + emittance_y < 0.09 m-rad emittance_x + emittance_y < 0.07m-rad
- Goal:
  - Achieve yield of 1.5 positrons per electron in the drive beam.
    - 30%.

Summary Parameters

Parameter	RDR	SB2009	TDR	Units
e+ per bunch at IP	2 x 10^10	1 to 2 x 10^10	2x10^10	
Bunches per pulse	2525	1312	1312	
e+ energy (DR injection)	5	5	5	GeV
DR transverse acceptance	0.09	0.09	0.07	m-rad
DR energy acceptance	±0.5	± 0.5	± 0.75	%
e- drive beam energy	150	125-250	150/175/250	GeV
e- energy loss in undulator	3.01	0.5-4.9	3/2.6/2.0	GeV
Undulator period	11.5	11.5	11.5	mm
Undulator strength	0.92	0.92	0.92/0.75/0.45	
Active undulator length	147 (210 after pol. Upgrade)	231 max.	147	m
Field on axis	0.86	0.86	0.86/0.698/0.42	T
Beam aperture	5.85	5.85	5.85	mm
Photon energy (1st harm.)	10	1.1 (50 GeV) 28 (250 GeV)	10/16.2/42.8	MeV
Photon beam power	131	Max: 102 at 150 GeV	63.1/54.7/41.7	kW
Target material	Ti-6%Al-4%V	Ti-6%Al-4%V	Ti-6%Al-4%V	
Target thickness	14	14	14	mm
Target power adsorption	8	8	7/7.2/5	%
PEDD in target			232.5/295.3/304.3	J/cm^3
Dist. Undulator center - target	500	500	500?	m
e+ Polarization	34	22	30	%

Status of the critical hardware components

- 4 meter cryo-module, two 1.7m long RDR undulator. (Completed, STFC/RAL/Daresbury)

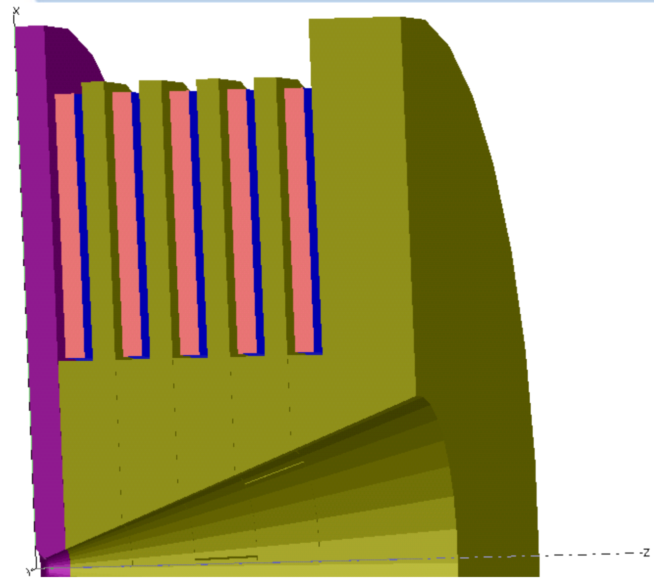
- Target wheel prototype design and test. (Lancaster/Cockcroft/STFC/LLNL)
- Rotating vacuum seal prototype test. (LLNL, Ongoing)
- Capturing RF structure. (SLAC, Completed)
- Flux Concentrator prototype design. (LLNL, New engineering design with water cooling)
- New short period, high K undulator. (Cockcroft/STFC, ongoing), salc/micro=wave).
- Remote handling/target removal engineering design (IHEP, almost done)

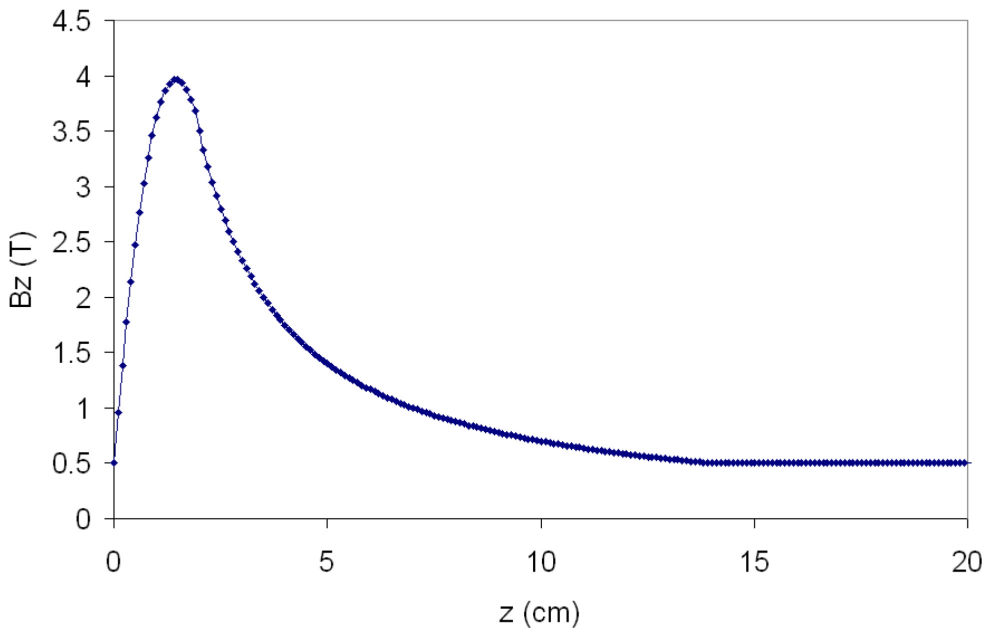
ILC Positron source optimization: Cases Studied:

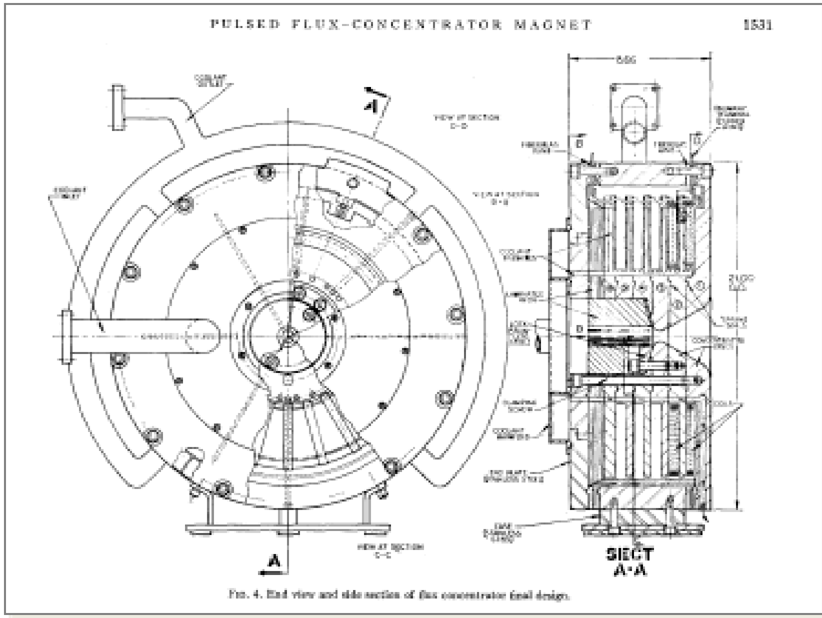
- Common Input Parameters:
  - Undulator parameter: K=0.92, λu=1.15cm
  - Target: 0.4 X0 Ti
  - Drift between undulator and target: 400m
  - Photon collimator: None
- OMD:
  - Flux Concentrator Capturing (137 m long Undulator).
  - Quarter Wave Transformer Capturing (231 m long undulator).
- Undulator Impacts on Drive Beam
  - Energy Spread and,
  - Emittance
- Target Energy Deposition.
- Path toward higher polarizations
  - Photon collimators

A pulsed flux concentrator

- Pulsing the exterior coil enhances the magnetic field in the center.
  - Needs ~ 1ms pulse width flattop
  - Similar device built 40 years ago. Cryogenic nitrogen cooling of the concentrator plates.



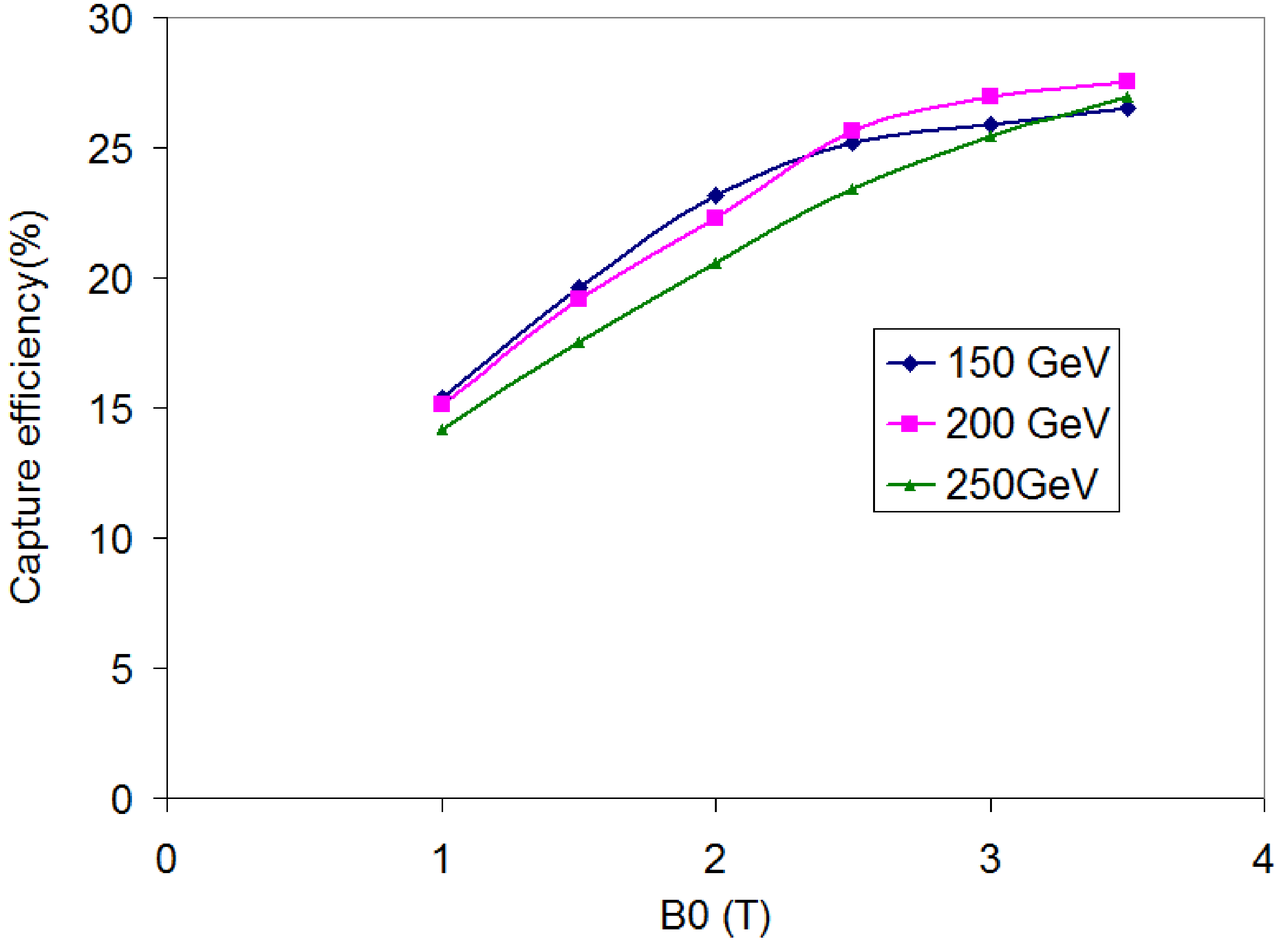




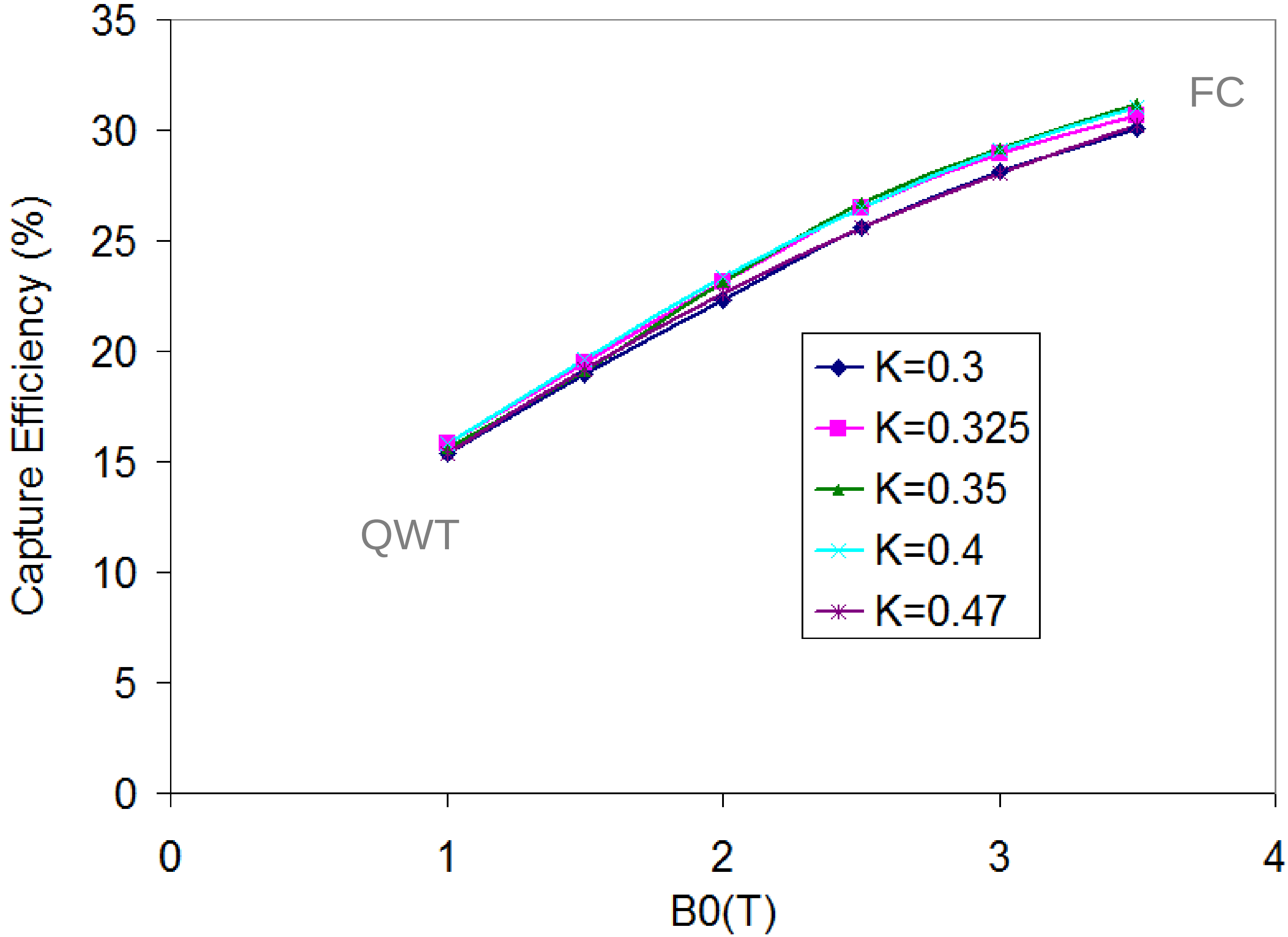
Conditions

- RF: 15MV/m for 1^{st} meter and 8MV/m for the rest
- OMD: FC, varying B0 with fixed length of 14cm
- Capture evaluated at ~125MeV

Capture Efficiency for RDR Undulator with Different Drive Beam Energy

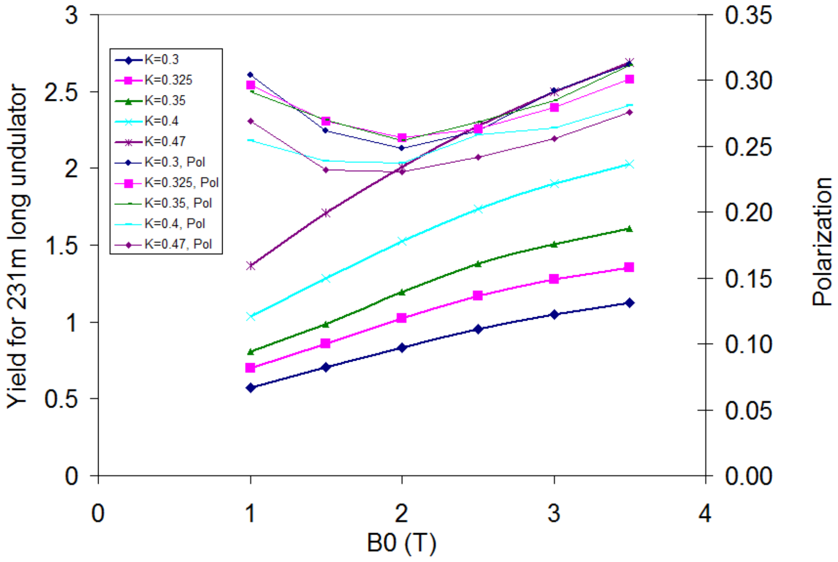


Capture Efficiency for 250 GeV Drive Beam with Different K of Undulators

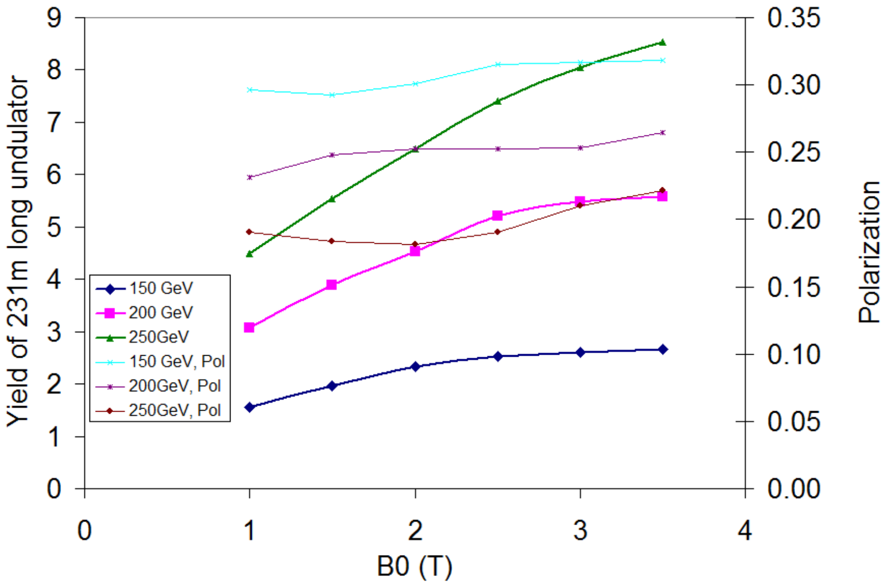


Yield and Pol

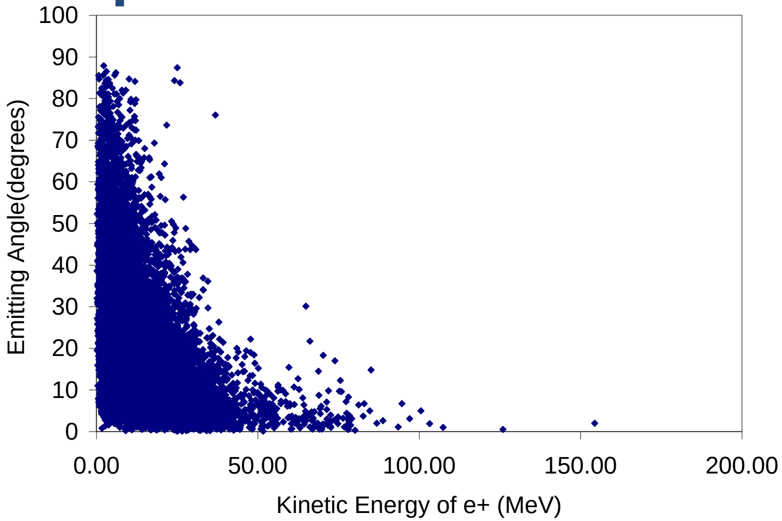
250GeV drive beam

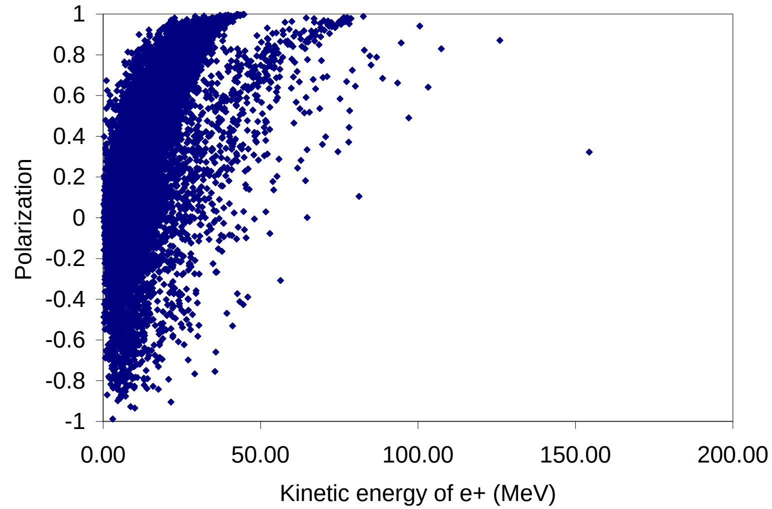


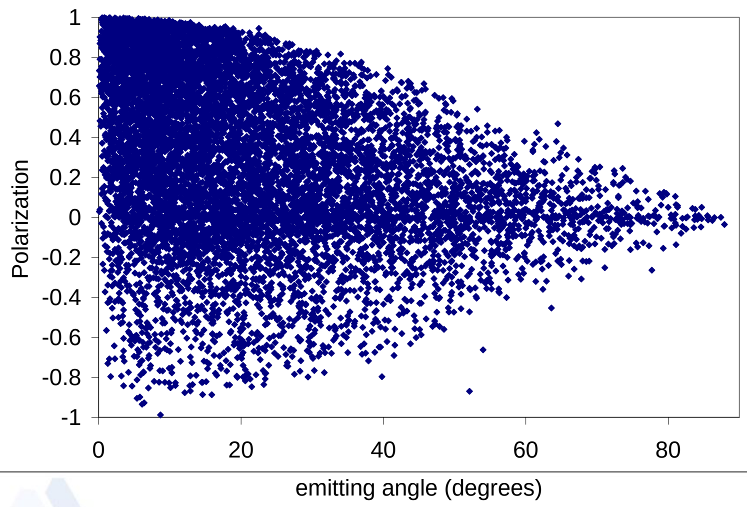
RDR with different drive beam



Explanation of Pol-B0 relation

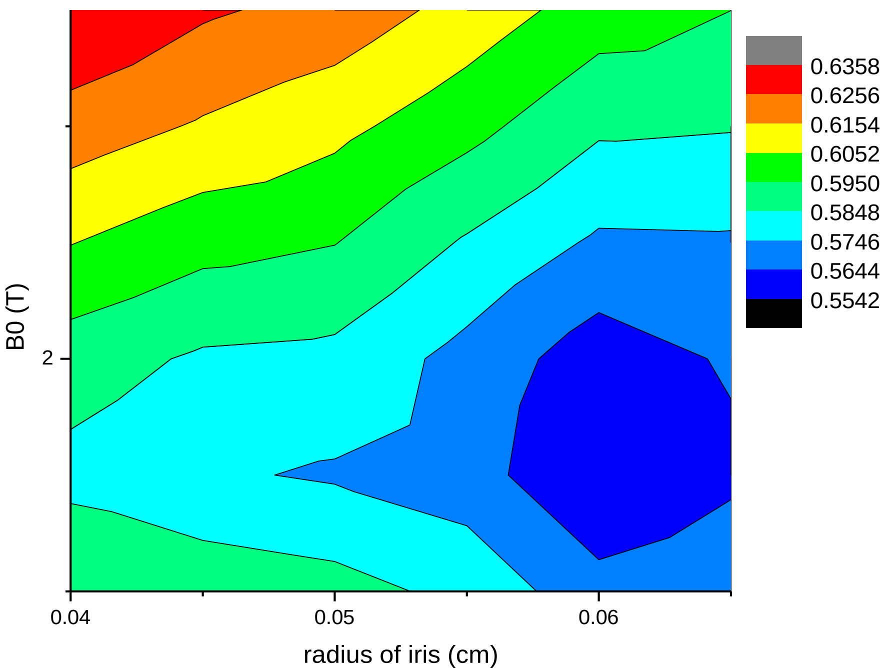


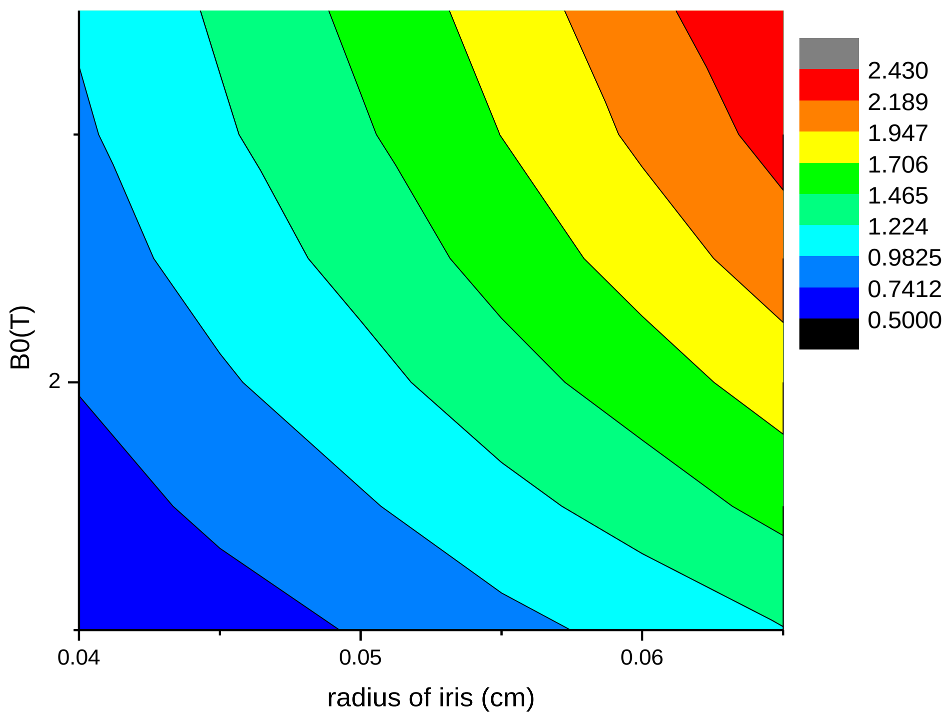




- As displayed in the plots, particles with lower energy tends to have bigger emitting angle and lower polarization.
- When B0 get smaller, more lower energy particles will pass through the barrier created by the ramping up of B field and being captured. Meanwhile, more particles with higher energy but bigger angle will escape the capture as the field get weaker. That's why lowering B0 will lower the polarization of captured beam initially.
- When B0 get even smaller, the low energy and bigger emitting angle particles will escape the capture and then the captured positron beam polarization starts going up

RDR undulator, 250GeV 60% Pol. possibility





With FC having B0 ~2.5T, 60% polarization and 1.5 yield can be achieved with photon collimator having an iris of ~0.55mm in radius using 231m RDR undulator

Yield Calculations Using RDR Undulator Parameters (137 meter and FC without photon collimators)

Drive beam energy	Yield	Polarization	Required Undulator Length for 1.5 Yield	Emittance Growth X/Y for 1.5 Yield*	Energy Spread from Undulator for 1.5 Yield
50 GeV	0.0033	0.42	Very long		
100 GeV	0.2911	0.39	685 m		
150 GeV	1.531	0.34	137 m	~ -2.5%/-1.6%	0.17%
200 GeV	3.336	0.27	61 m		
250 GeV	5.053	0.23	40 m	~-1%/-0.4%	0.18%

* No Quads misalignment included.

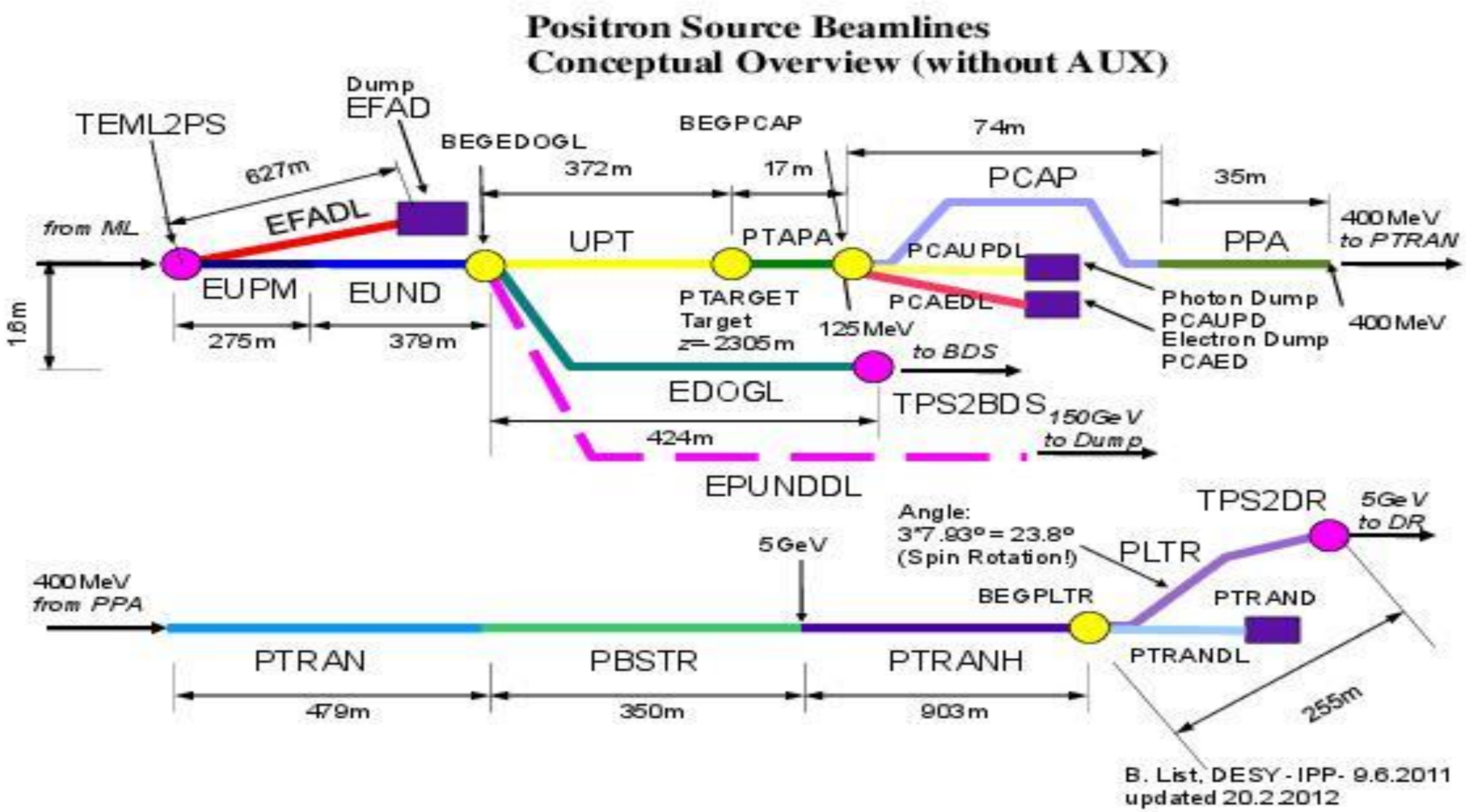
Emittance growth due to BPM to Quad misalignments
-- From Jim Clark's report

Table 2 Summary of the vertical emittance growth results due to BPM to quadrupole misalignments.

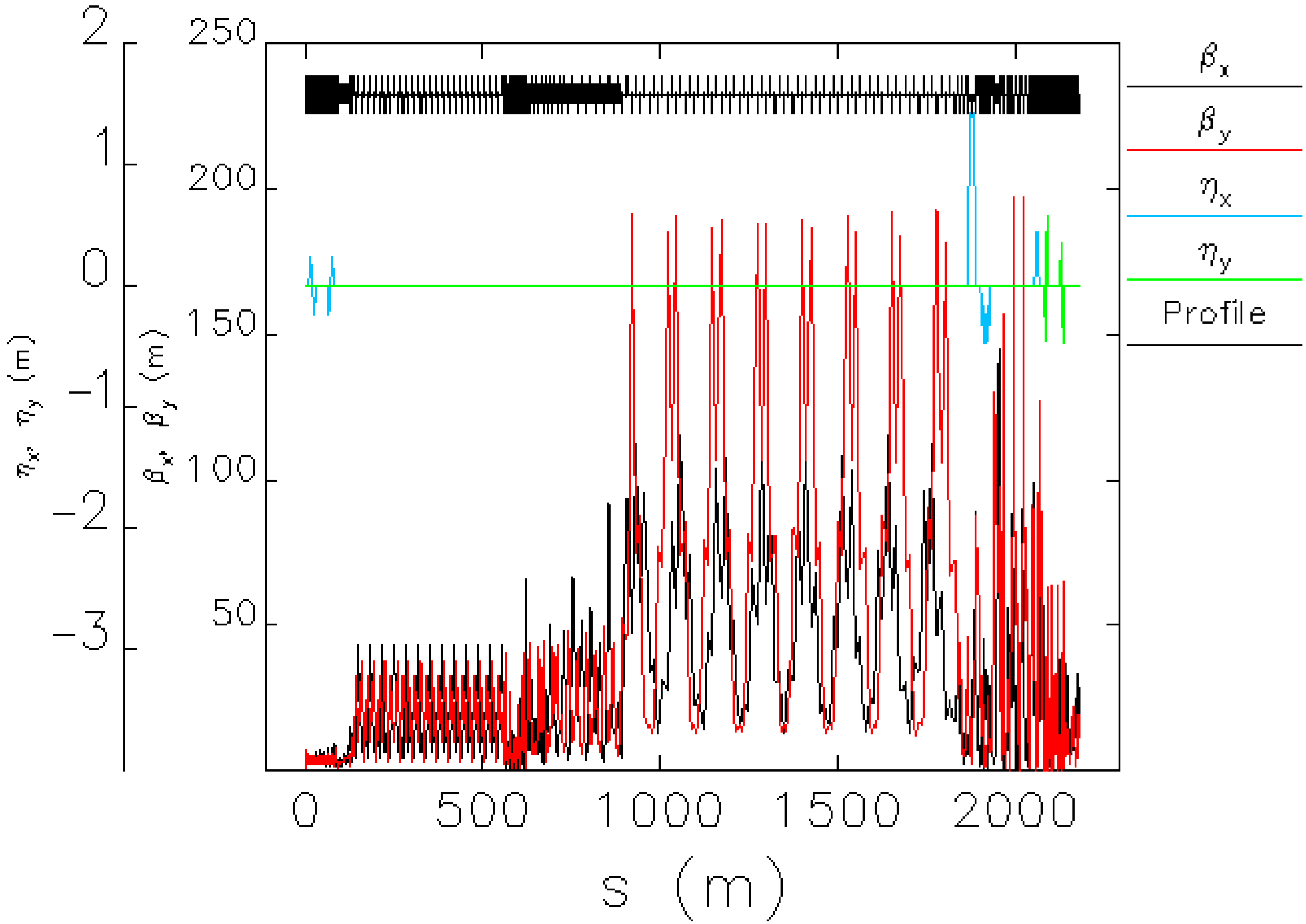
	BPM to quadrupole Error (μm)	Vertical emittance growth (%)	Correction algorithm
ANL	20	5	None
Daresbury	10	8	SVD
Daresbury	20	15	SVD
Kubo	10	2	Kick minimisation
Schulte	10	5	Dispersion free
Schulte	10	10	Dispersion free (restricted energy range)
Schulte	30	10	Kick minimisation

Beamline Lattice

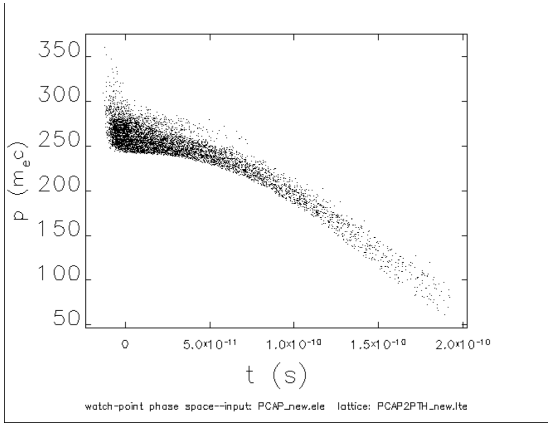
- New lattice design has been done to comply with the new layouts as follow.



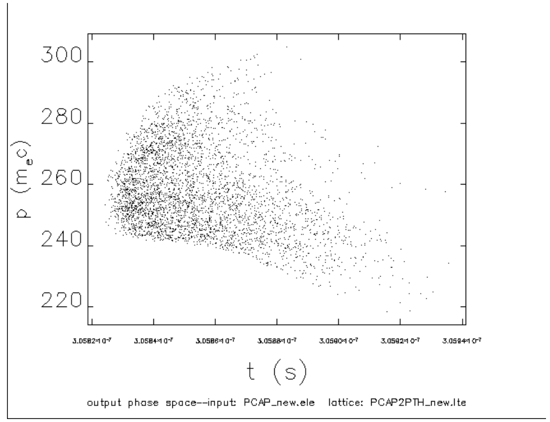
Optics parameter of the new ILC positron source beamline lattice



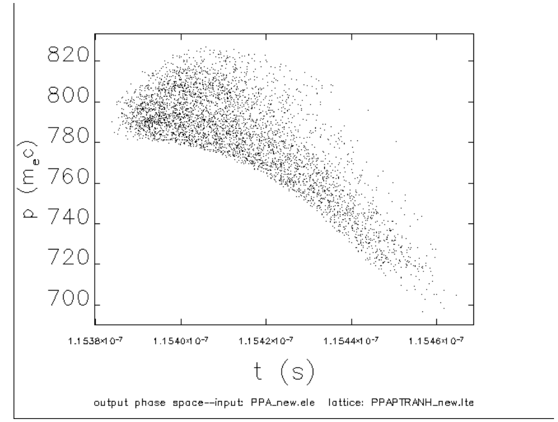
Typical particle distribution at key points



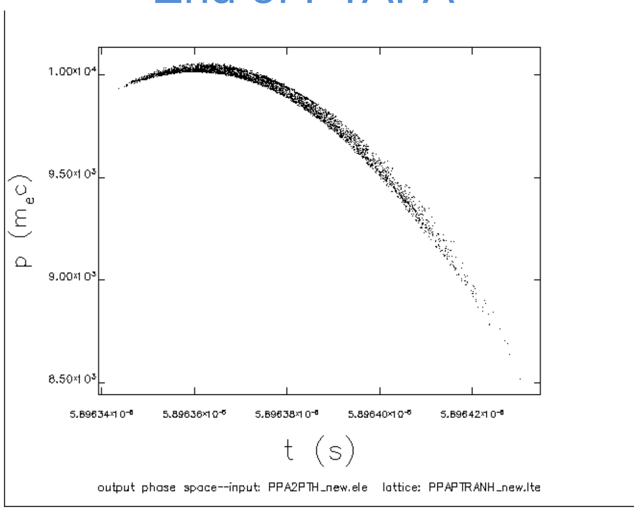
End of PTAPA



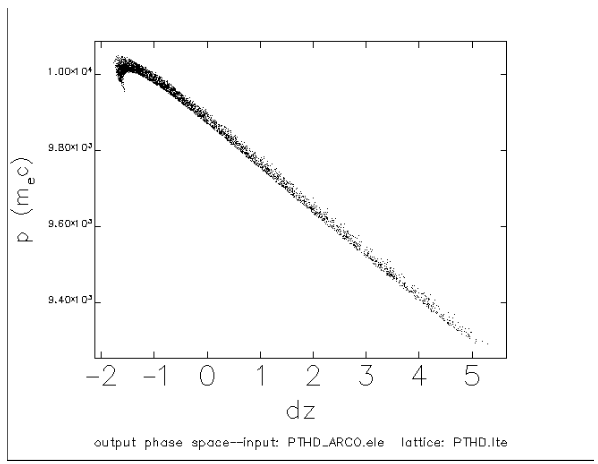
End of PCAP



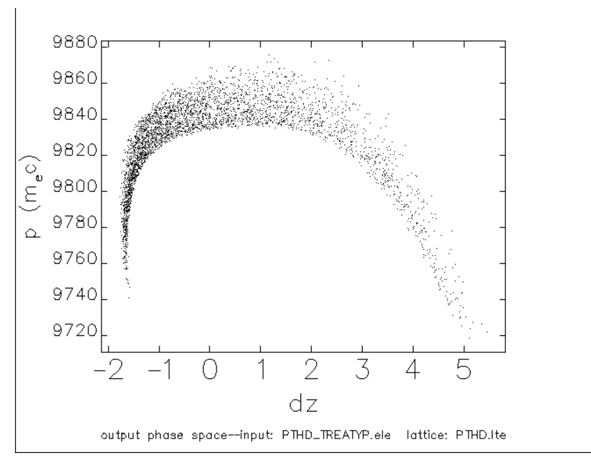
End of PPA



End of PTRANH



Before energy Compressor



At the end of beamline, the treaty point to damping ring

Energy deposition/accumulation on Target

Parameter			Centre-of-mass energy E_{cm} (GeV)				
			200	230	250	350	500
Positron pulse production rate		Hz	5	5	5	5	5
Electron beam energy (e+ prod.)		GeV	150	150	150	178	252
Number of electron bunches	n_b		1312	1312	1312	1312	1312
Electron bunch population	N_+	$\times 10^{10}$	2	2	2	2	2
Required undulator field	B	T	0.86	0.86	0.86	0.698	0.42
undulator period length	λu	cm	1.15	1.15	1.15	1.15	1.15
undulator *K*	K		0.92	0.92	0.92	0.75	0.45
Average photon power on target		kW	91	100	107	55	42
Incident photon energy per bunch		J	9.6	9.6	9.6	8.1	6.0
Energy deposition per bunch (e+ prod.)		J	0.72	0.72	0.72	0.59	0.31
Relative energy deposition		%	7%	7%	7%	7.20%	5%
Photon rms spot size on target		mm	1.4	1.4	1.4	1.2	0.8
Peak energy density in target		J/cm^3	232.5	232.5	232.5	295.3	304.3
		J/g	51.7	51.7	51.7	65.6	67.5

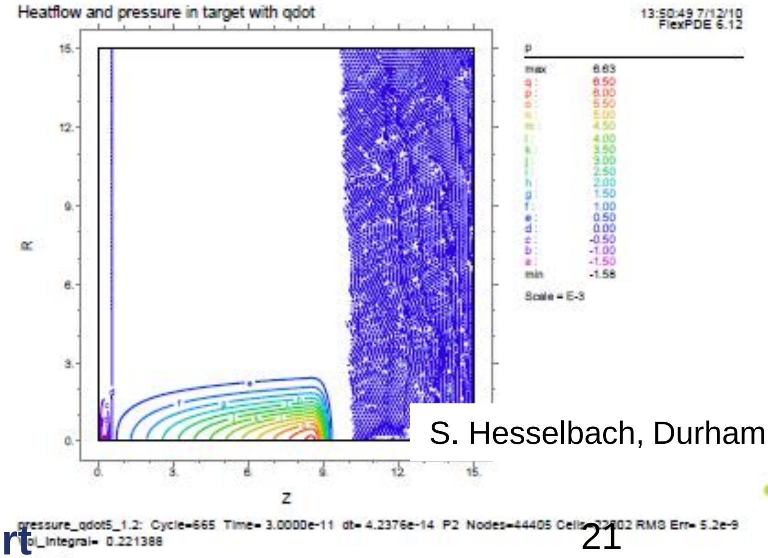
Shockwaves in the target

- Energy deposition causes shockwaves in the material
  - **If shock exceeds strain limit of material chunks can spall from the face**
- The SLC target showed spall damage after radiation damage had weakened the target material.

- Initial calculations from LLNL had shown no problem in Titanium target
- Two groups are trying to reconfirm result
  - **FlexPDE (S. Hesselbach, Durham → DESY)**
  - **ANSYS (L. Fernandez-Hernando, Daresbury)**
  - **No definitive results yet**
- Investigating possible shockwave experiments
  - **FLASH(?)**
  - **https://znwiki3.ifh.de/LCpositrons/TargetShockWaveStudy**


SLC positron target after decommissioning

Contours of P in MPa



S. Hesselbach, Durham

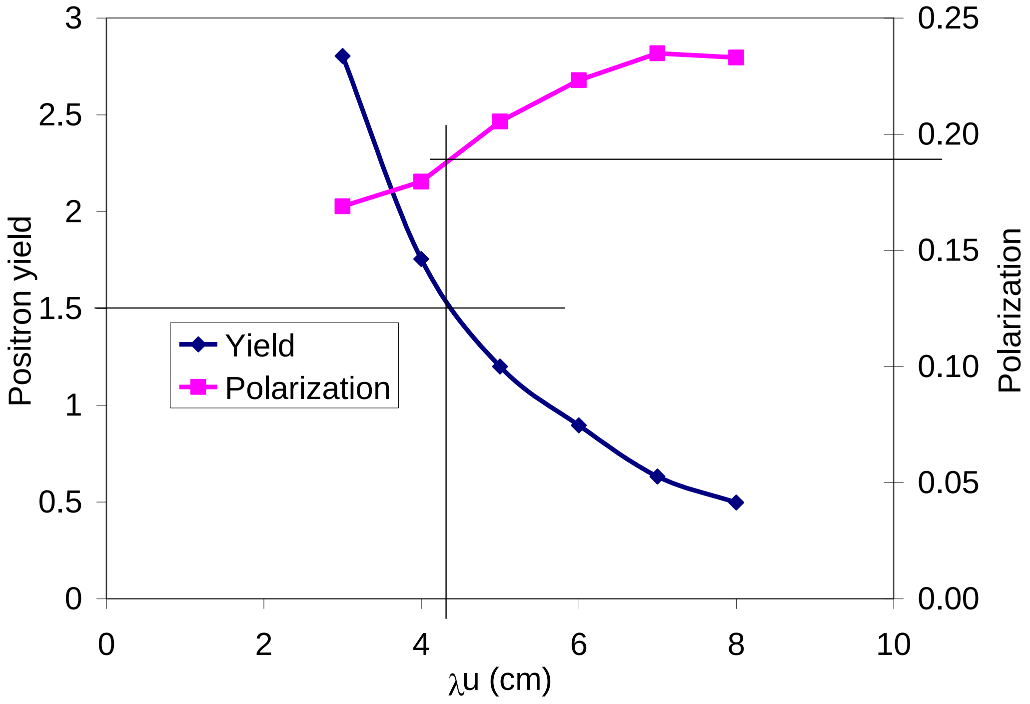
Remote Handling

- Use detailed target, RF, etc model in Fluka – Andriy
  - **Confirmed by IHEP, China**
- Model established –Jia/ IHEP

  Simple design, low cost.
- RH scenarios refined
  - **Changeover times (requirement ties in with lifetime of kit in RH), a day**
  - **Replacement of pillow seals?**
- Pillow seals need R&D
- Engineering design compatible with source layout – IHEP, Xuejun Jia

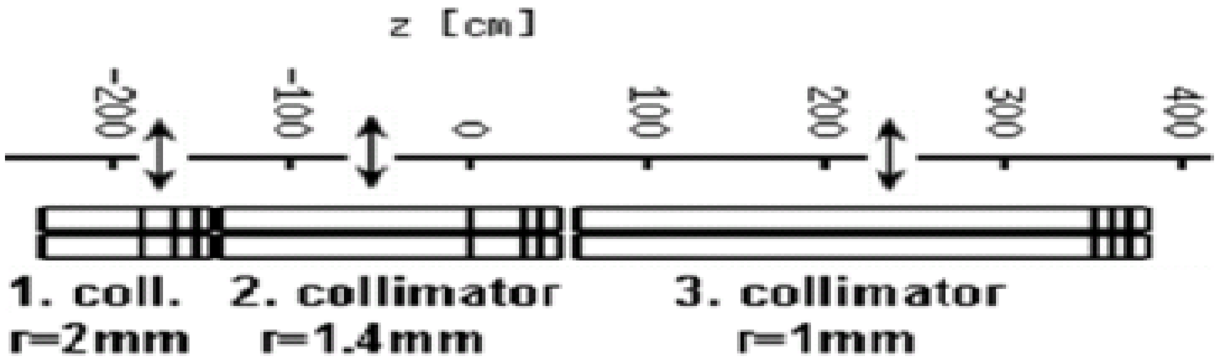
TeV upgrade scenarios

- Scenarios has been Studied by both DESY and ANL
- Proposed K=1, λu=4.3cm



Polarization upgrade

- The lattice/layout of ILC positron source have left enough space for 231m effective undulator length
- With the progress in FC prototyping at LLNL, only 147m long undulator will be needed to produce enough positron intensity without photon collimator. The extra space can be used for additional undulator modules for polarization upgrade
- A multi stage photon collimator conceptual design for polarization upgrade has been done at DESY



Issues with ILC positron sources

- Risk assessments for the e+ system:
  - Undulator (OK, more RD needed for different scenarios other than Baseline)
  - Photon Collimators (good progress made, conceptual design done, need a engineering design)
  - Capturing magnets (design done, prototyping done?)
  - Target (Tested, other engineering issues, OK)
  - Pre-accelerator (done)
  - RH (Engineering design done).
  - Lattice (Done).
- Sources TeV upgrade seems to be OK.

Next for ILC,

- TDR, almost done, will have a collaboration meeting this Friday to go through the write-up.
- At next LCWS , Arlington in October, we will have the final version of TDR submitted.
- Higgs factory source design…