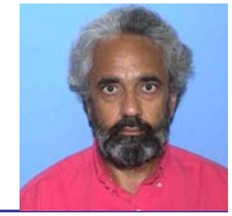
RDR Update

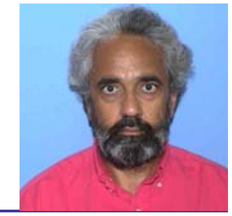


Vinod K. Bharadwaj

SLAC

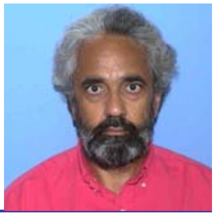
September 10, 2007

Reference Design Report



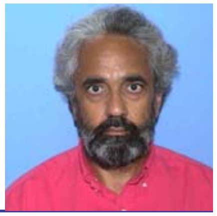
- ILC RDR had multiple roll-outs
  - Early draft presented in Beijing in Feb 07 (missing sections)
  - Fairly complete draft in Rome (FALC) in July 07
  - Complete draft in Korea in August 07
  - Authors added until end of August 07
  - Sent to printers September 4, 2007
- ILC RDR is a four volume set http://www.linearcollider.org/cms/
  - Vol. I Executive Summary – 77 pages
  - Vol. II Physics at the ILC – 149 pages
  - Vol. III Accelerator – 339 pages
  - Vol. IV Detectors – 209 pages
- Authors – 1816 authors from 325 institutions
  - 10 pages for Author names and 12 pages for institutions

Positron Source - TOC

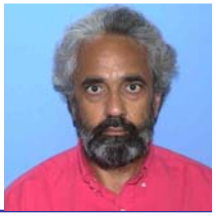


Vol. III, Chapter 2, Section 3 – 15 pages

Positron Source – LOF, LOT



Positron Source Layout



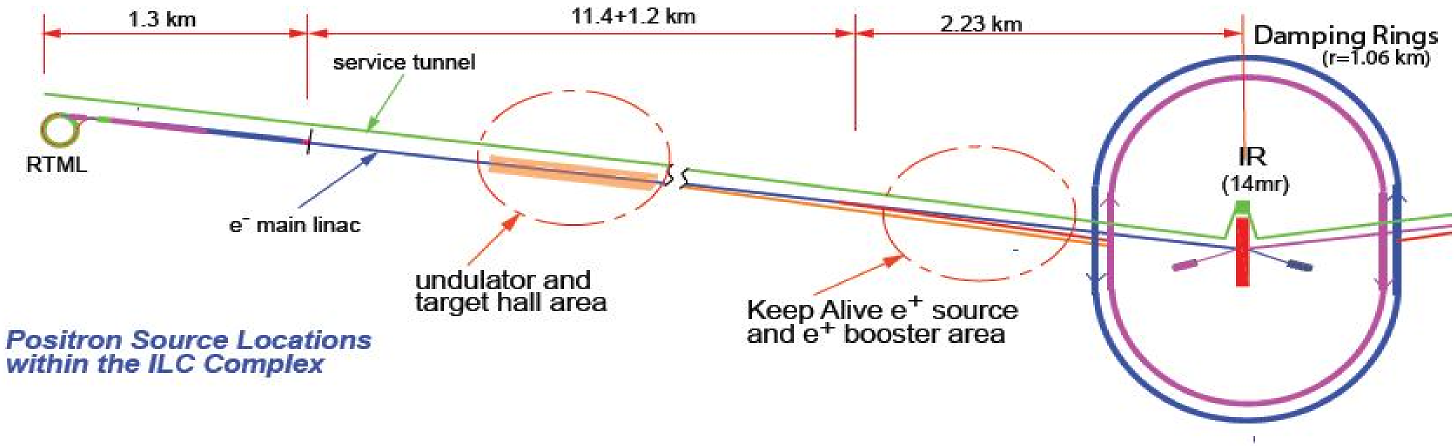


FIGURE 2.3-1. Layout of the Positron Source in the ILC

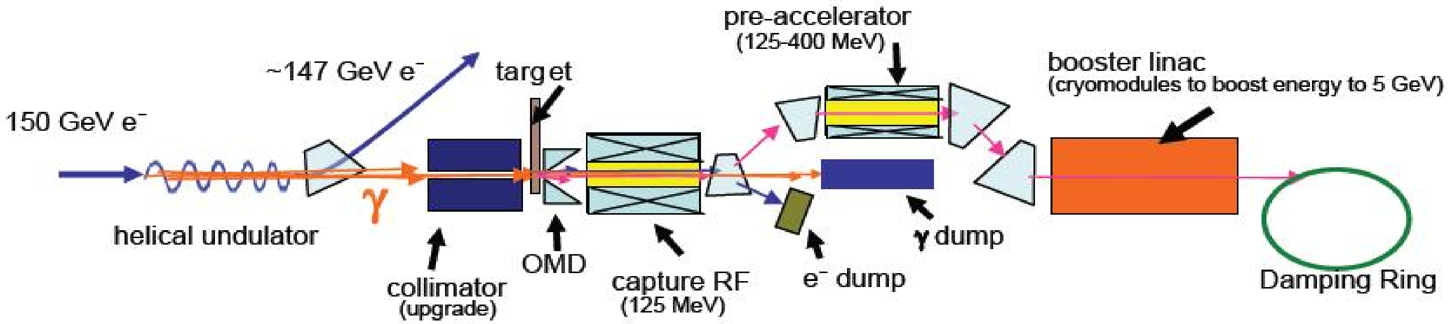
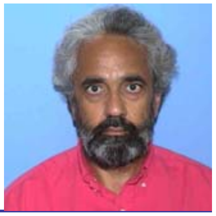


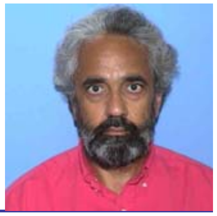
FIGURE 2.3-2. Overall Layout of the Positron Source



Nominal Source Parameters

TABLE 2.3-1
Nominal Positron Source parameters († upgrade values).

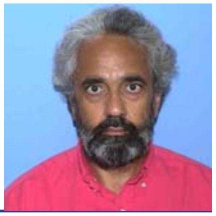
Beam Parameters	Symbol	Value	Units
Positrons per bunch at IP	n_b	2×10^{10}	number
Bunches per pulse	N_b	2625	number
Pulse repetition rate	f_{rep}	5	Hz
Positron energy (DR injection)	E_0	5	GeV
DR transverse acceptance	$\gamma(A_x+A_y)$	0.09	m-rad
DR energy acceptance	δ	$\pm$ 0.5	%
DR longitudinal acceptance	A_l	$\pm3.4 \times \pm25$	cm-MeV
Electron drive beam energy	E_e	150	GeV
Electron beam energy loss in undulator	ΔE_e	3.01	GeV
Positron polarization †	P	$\sim$60	%



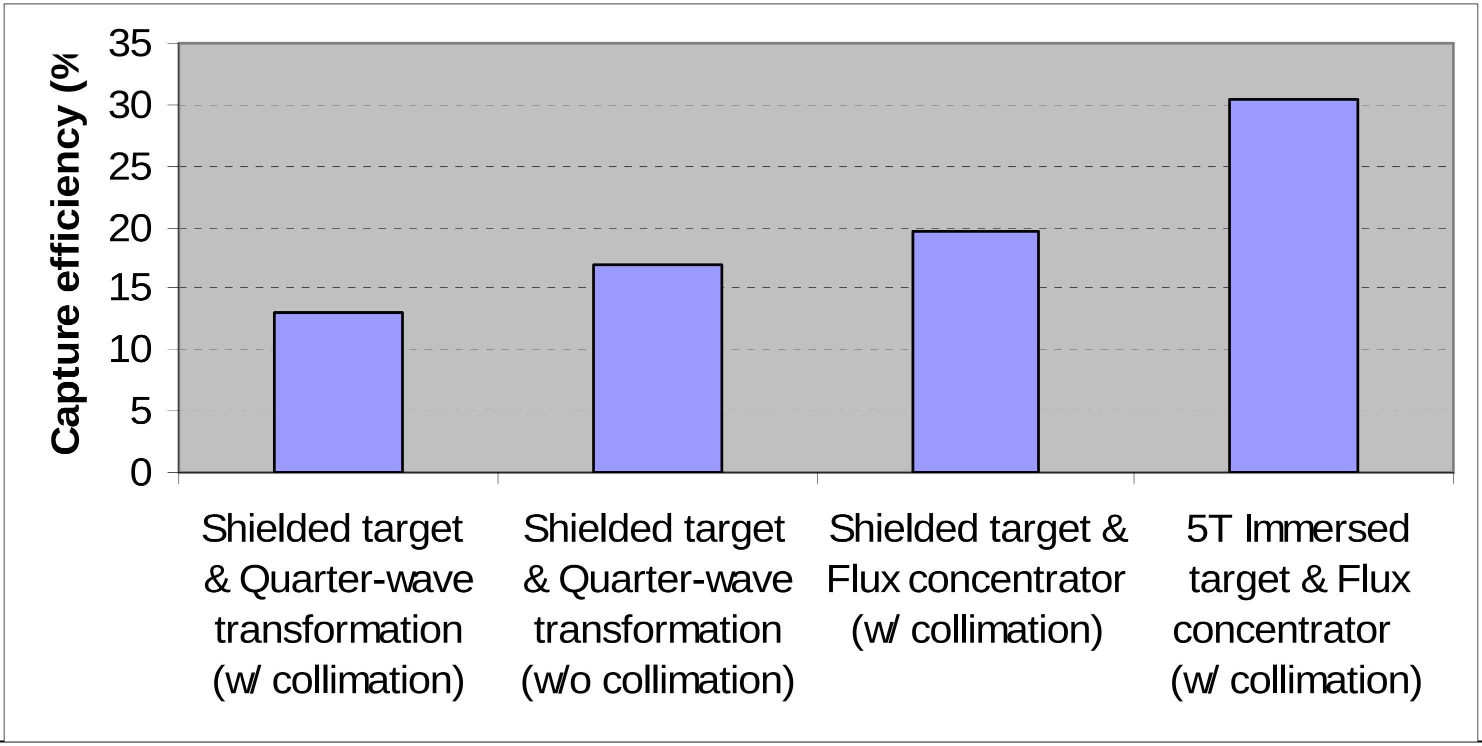
RDR to EDR

- RDR “proof-of-principle” design – know how to design or get around any issues.
- EDR needs a realizable design now so that system engineering can be done in the next three year and a sturdy mechanism to introduce any changes
- In good shape
  - optics, most beamlines, most magnets
  - NCRF
  - Undulator design
  - SCRF (if it works for ILC … we can even use XFEL cavities)
- Needs work
  - Target & capture
  - Target hall & remote handling
  - Positron beam collimation, photon collimation before target, photon collimation in undulator
  - 150 GeV chicane
    - Magnetic design optimization
    - Upgrade path
    - Effect on electron beam – both bends and undulator
  - NCRF works at low power levels
- More details
  - Spin preservation
  - Collimation needs and collimator design
  - Detailed parameters sets, detailed designs, system design
  - Coordination with other systems
- Alternate designs
  - Resources do not allow us to carry all designs and all ideas forever

Target & Capture

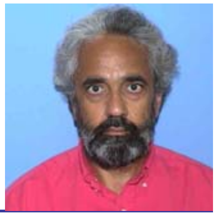


- Best capture – immersed target & "adiabatic field"
- Target must move to survive
- What is the optimum photon beam spot size
- Target damage calculation
- Are we considering safety factors properly

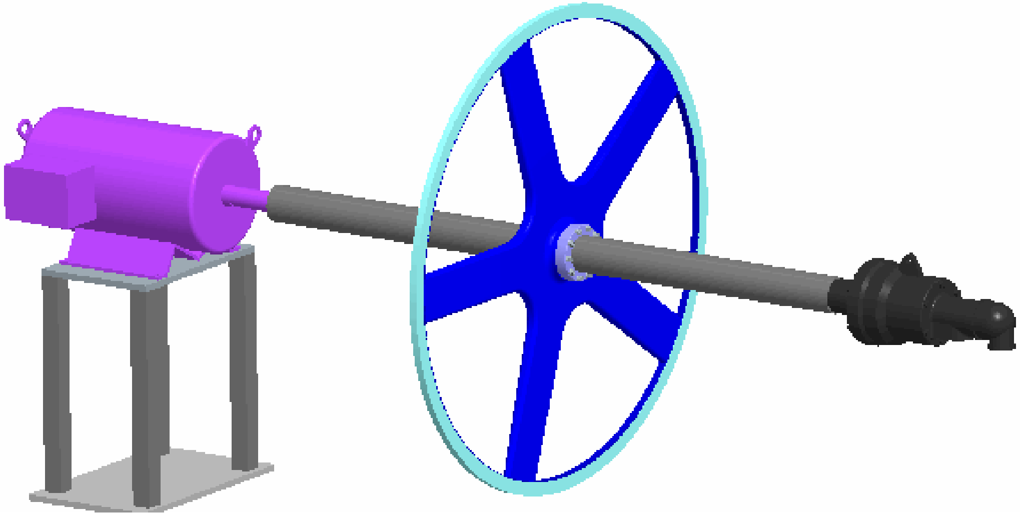


FZ, YN, WL

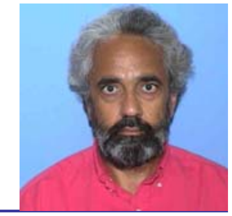
Target



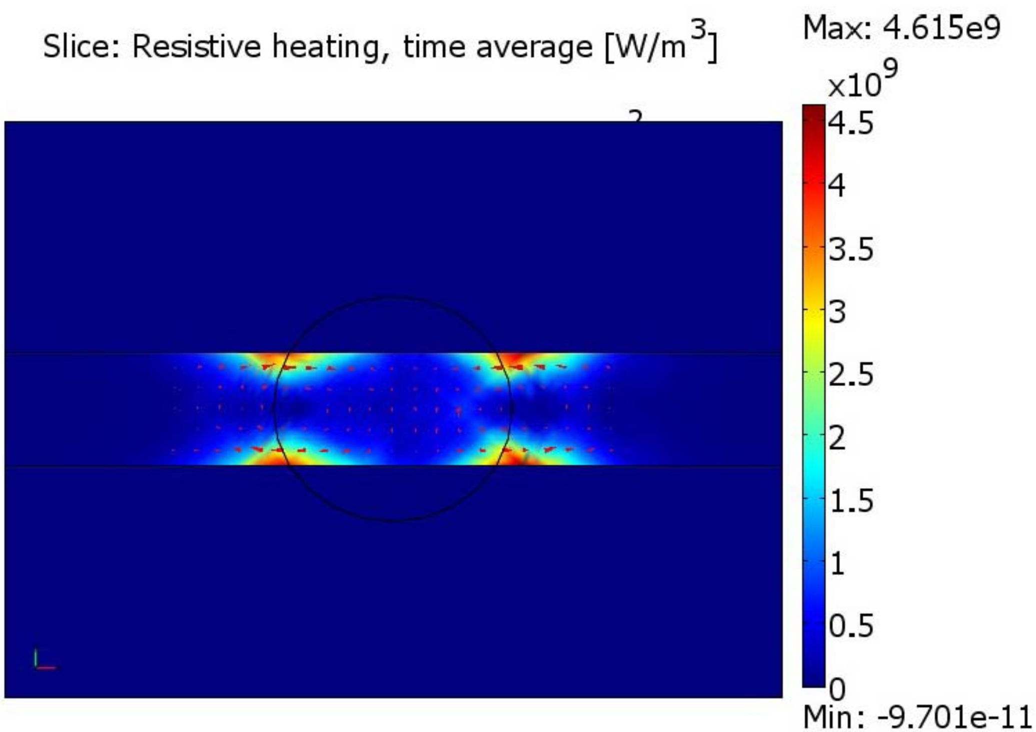
- Target
  - 100 m/s rim speed
  - 1-m wheel
  - 1.4 cm
  - Ti-6%Al-4%V
  - 8% heat deposition
- Stress from motion , stress from heating
- Vacuum seals that allow water flow and rotation
- Magnetic fields & moving metal



Moving target: Eddy Current Modeling



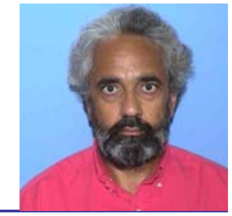
Energy loss is still a challenge



- 150kW @
  - 3.1T
  - 100 m/s
  - 1.5 x 5.5 cm
  - 6.9e5 1/ohm/m
- Scales as expected to
  - 15kW @ 1T
  - May be livable at this field

JG – COMSOL

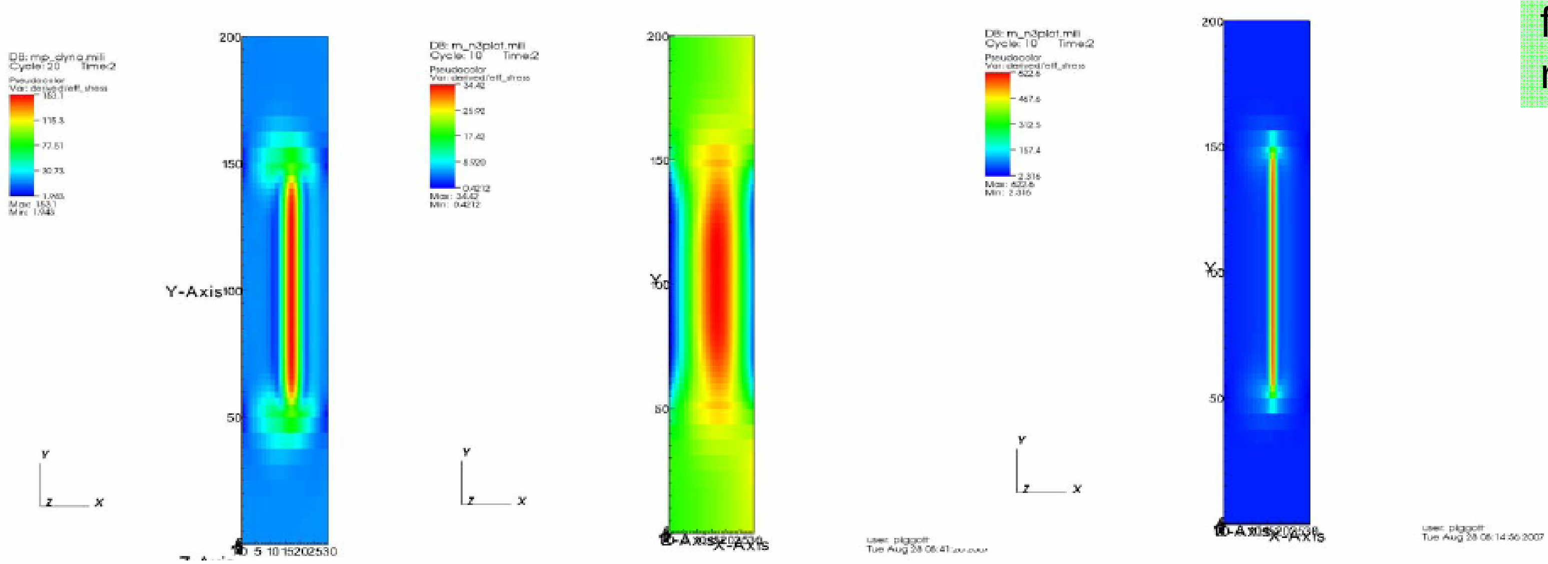
J. Gronberg - LLNL *August 15, 2007 positron target meeting* 6



Energy Deposition

Spot Size Comparisons- von Mises Stress

Larger spot size better for many reasons



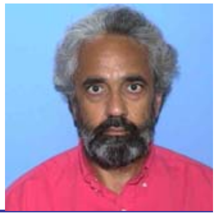
Sigma=1.7 mm
σ_{max}= 153.1 MPa

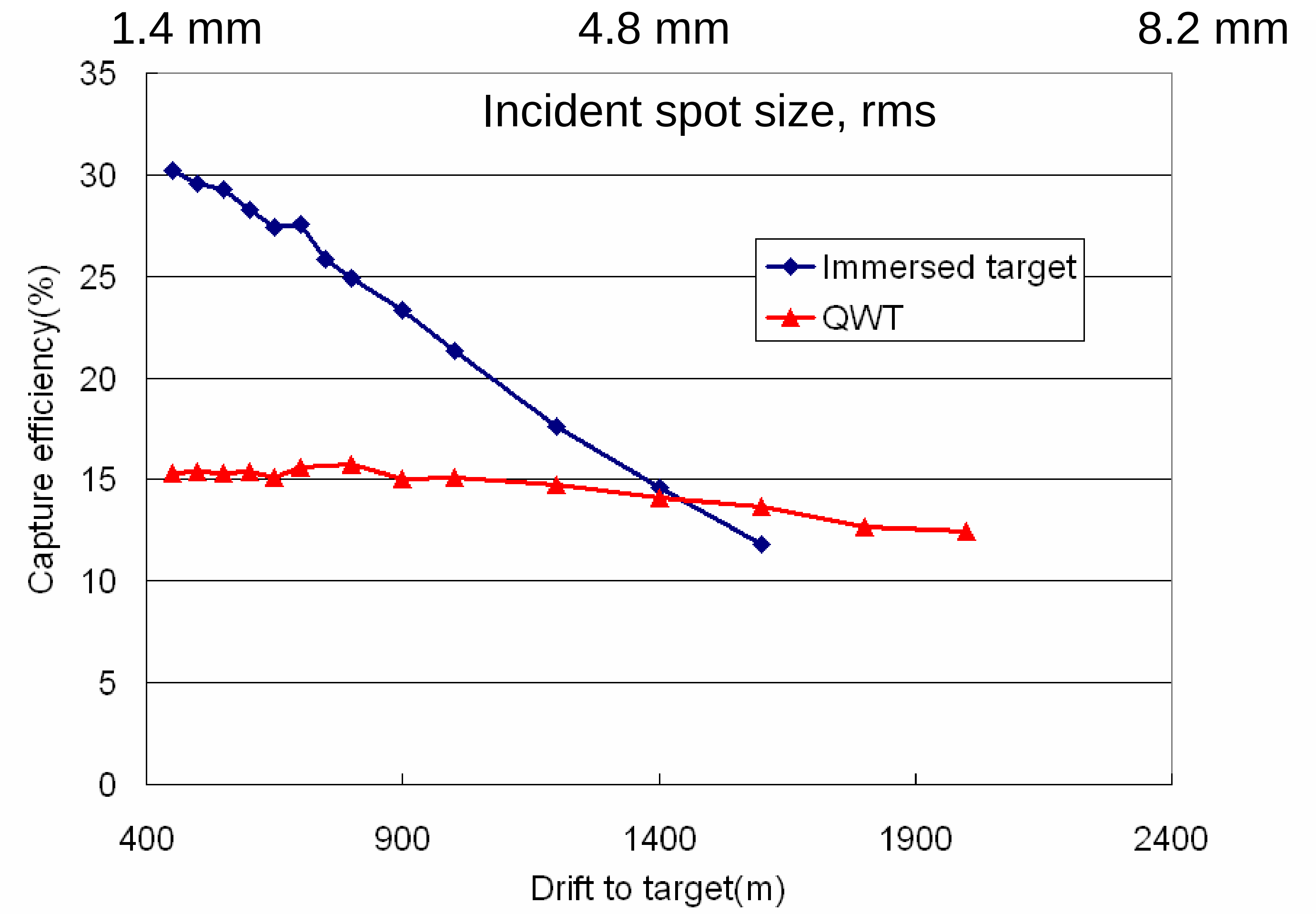
Sigma=3.4 mm
σ_{max}= 34.42 MPa

Sigma=0.85 mm
σ_{max}= 622.6 MPa

TP

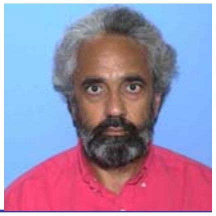
Spot size & Capture Efficiency





Nominal RDR spot size 0.75 mm

WL



¼ λ XMFR Studies

Ti-alloy and W-Re Target Energy Deposition Numbers

W. Liu, T. Piggott, and J. C. Sheppard

Rev. 7: August 24, 2007

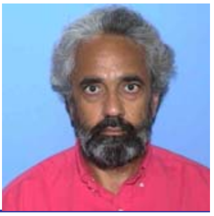
Assuming a gaussian transverse spatial distribution of undulator photons incident to a spinning target annulus of Ti-alloy, what are the values for the deposited energies, energy densities, stresses, and peak and average temperature rises in the target? How do these values change with variations in the incident beam energy and size and tangential target velocity? What is the "safe" engineering limit of the incident beam intensity?

Comparison for different capture efficiencies:

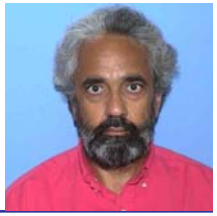
Table 5:

Parameter					Units
Target Material	TiAlV	TiAlV	TiAlV	TiAlV	
Incident Spot Size	1.7	1.7	1.7	1.7	mm
Capture Efficiency	13	16	20	30	%
Number of photons per electron	577	469	375	250	γ/e^-
Undulator Length	303	246	197	131	m
Average power deposition	20	16	13	9	kW
Peak temperature rise	117	95	76	50	^{0}K/pulse
Peak compressive stress, TE	113	92	74	49	MPa

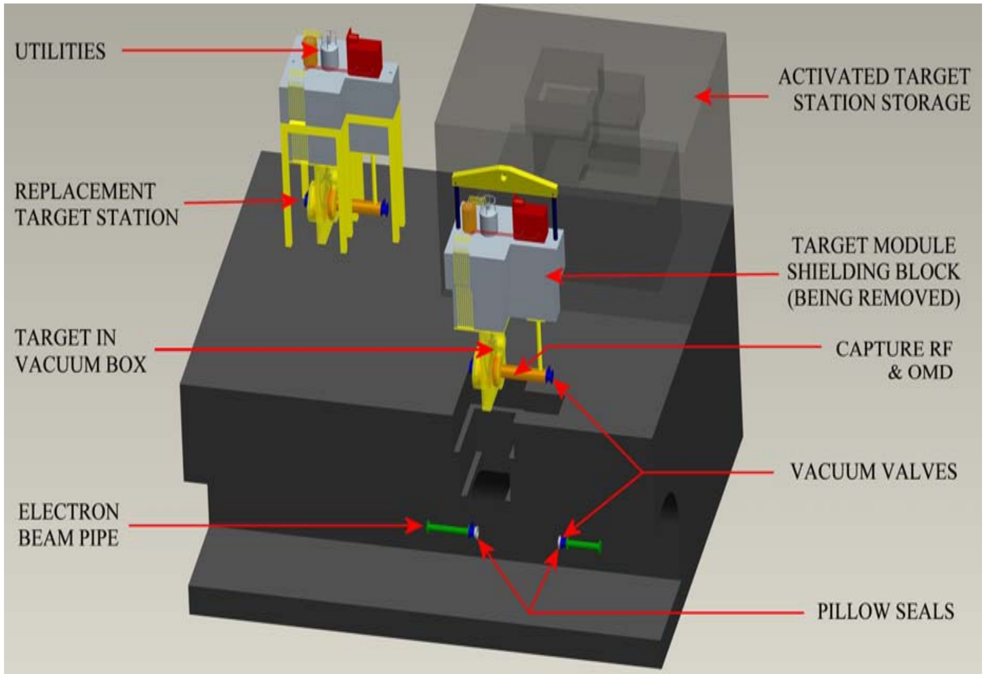
Target Hall/Remote Handling

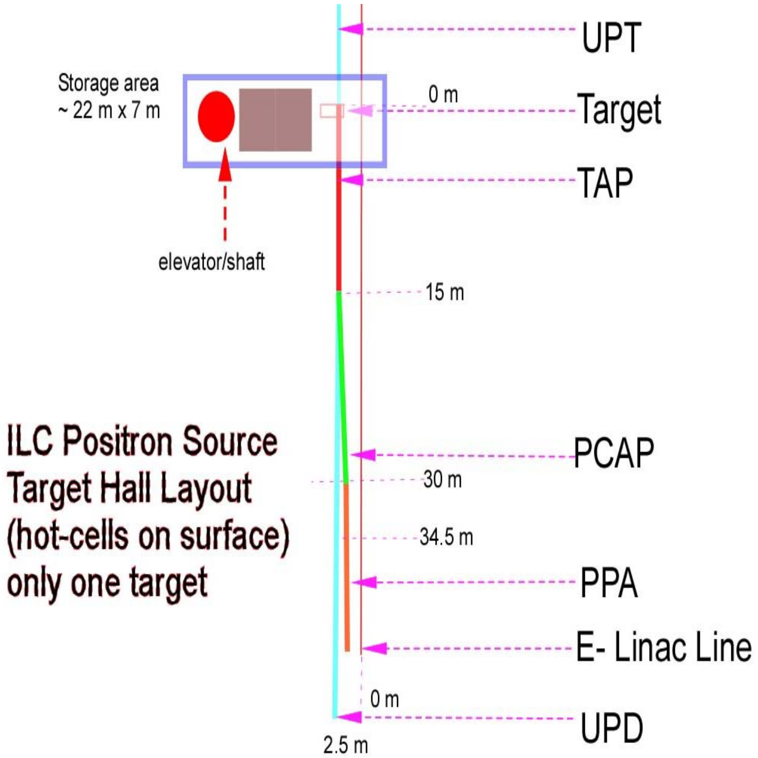


- Target hall
  - How big
  - How much underground
- Do we need remote handling?
  - Target hall activation field
    - We have some numbers for the target (100 R/hour range)
    - Need to do much more realistic calculation for the whole setup. Exercise useful for other questions (SC solenoids around the RF?)
  - Do other ILC facilities need radioactive mechanical work and is there any overlap
- Collaboration with ORNL for RH design?
  - SNS (Graeme Murdoch - Nuclear Facilities Development Division, Deputy Director & Engineering Group Leader)
    - To busy to help in design, can help with reviews etc.
    - (they are trying get ORNL LDRD funds for rotating target!)
  - Nuclear Science and Technology Division (Tom Burgess – Fuels, Isotopes, and Nuclear Materials/Remote System Group)
    - Help with design, need to be funded at some level



Target Hall/Remote Handling

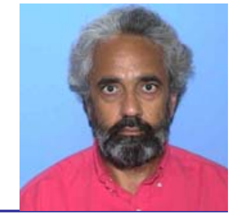


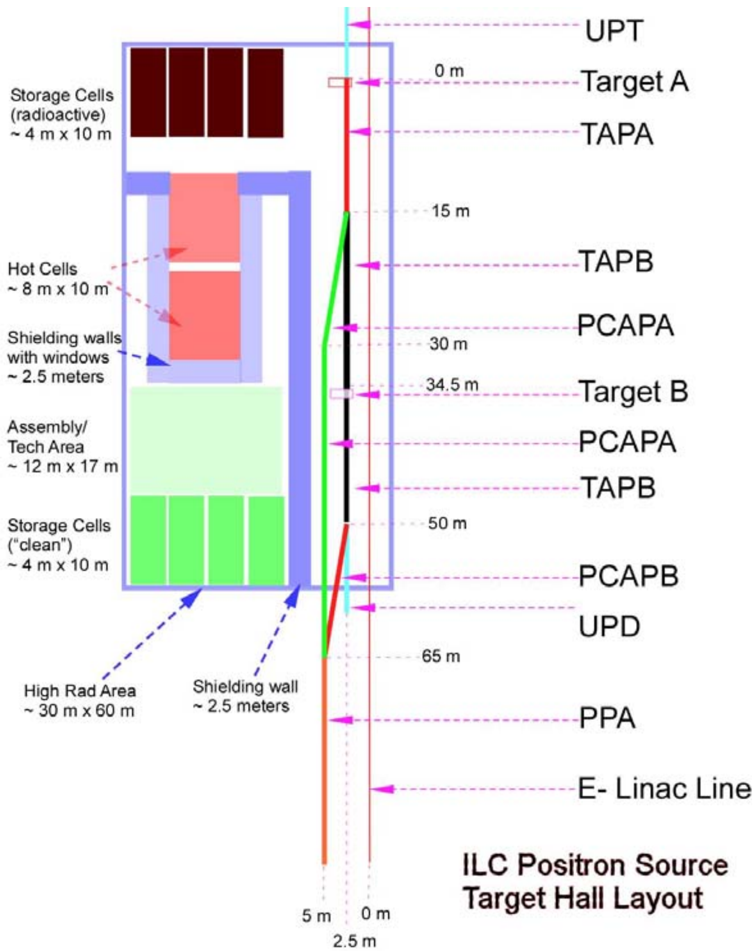


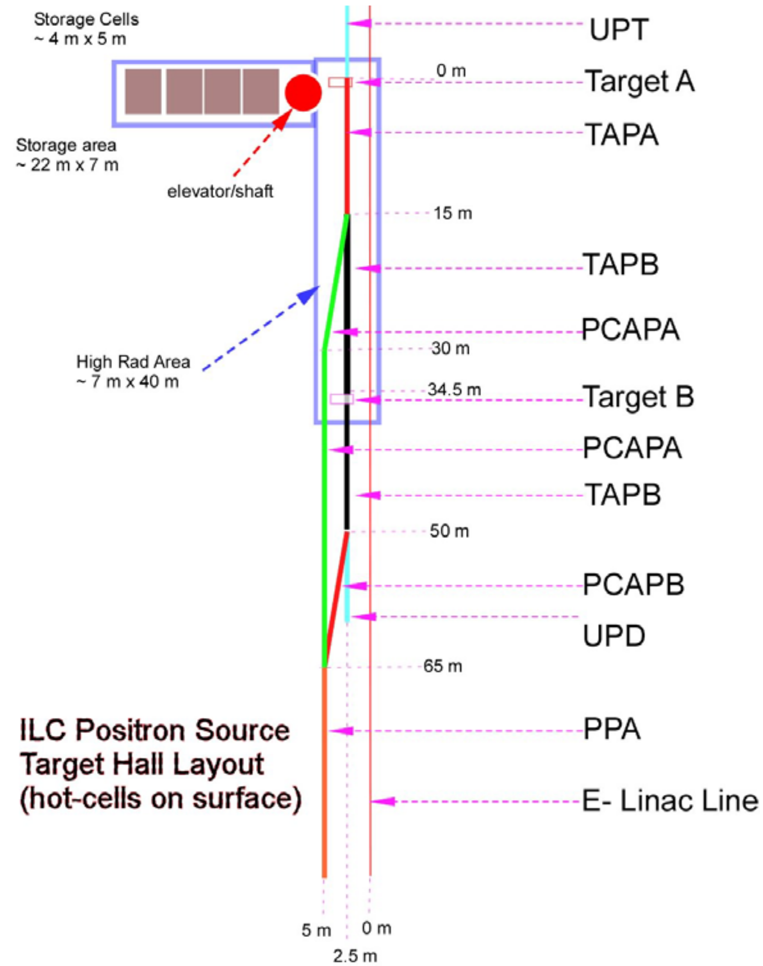
Target station deep underground
Excavation costs volume dependent

Mini-hall concept

Target Hall/Remote Handling

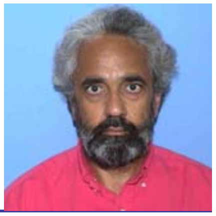






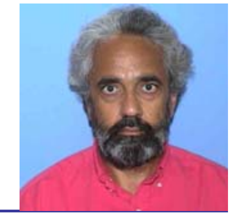
Maybe we will need more area underground

Collimation



- Not really mentioned in RDR
- Only 10-30% of the beam coming out of the target is captured in the damping rings
- We need a system of collimators to localize beam loss and activation
- Better to collimate at lower energies
- Some collimation optics have been designed
  - How much more work is needed for optics design
  - Can we cross-check anything
  - Do we need R&D to make any of the collimators
  - What are the minimum feasible losses in the DR
  - Do the DR’s have any loss requirements
- Photon collimation
  - Before target
  - Inside the undulator

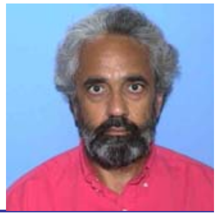
150 GeV Chicane



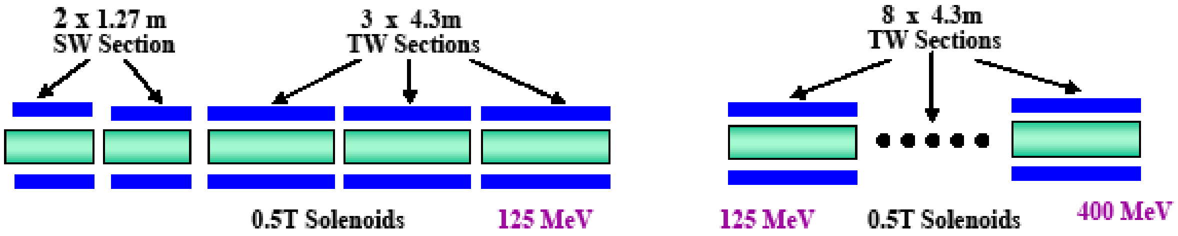
- Nominal design
  - Undulator parallel to linac line
    - 2.5 meter offset
      - needed for target station
      - needed for beam dump
    - Total length > 1200 meters for a few hundred meter undulator
      - 2.5 meter offset achieved with 250 meter arcs ~ 10mr bend
    - Electron beam quality going through chicane is OK
      - Need to quantify all the beam effects
      - Beam energy upgrade problematic
- Are there alternative designs that are better
  - Non-parallel undulator line
  - Do we really need 2.5 meter offset
- How do we upgrade in energy
  - Scale bends
  - New location

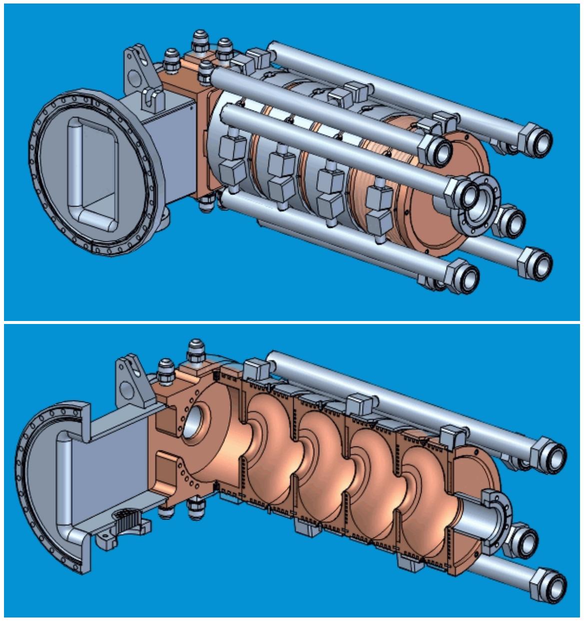
Location	start	end	length
	(meters)	(meters)	(meters)
End of 150 GeV linac	0	0	
MPS + matching	0	237.804	237.804
Bypass bend-to-bend	237.804	486.624	248.82
Bypass emit meas	486.624	540.624	54
Bypass extra before U	540.624	577.894	37.27
Undulator region	577.894	868.654	290.76
Bypass extra after U	868.654	905.914	37.26
Bypass bend-to-bend	905.914	1154.734	248.82
Bypass matching to L	1154.734	1177.966	23.232
Emittance measurement	1177.966	1232.344	54.378
Acceleration for Und loss	1232.344	1376.344	144

NCRF



- Short (SW)prototype designed and built
  - Need to do high power testing





Structure Type	Simple π Mode
Cell Number	11
Aperture 2a	60 mm
Q	29700
Shunt impedance r	34.3 MΩ/m
E_0 (8.6 MW input)	15.2 MV/m

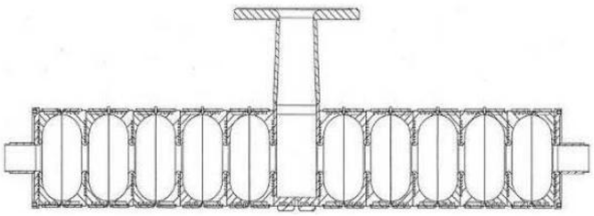


Figure 3: 11–cell SW structure.