The Positron Source

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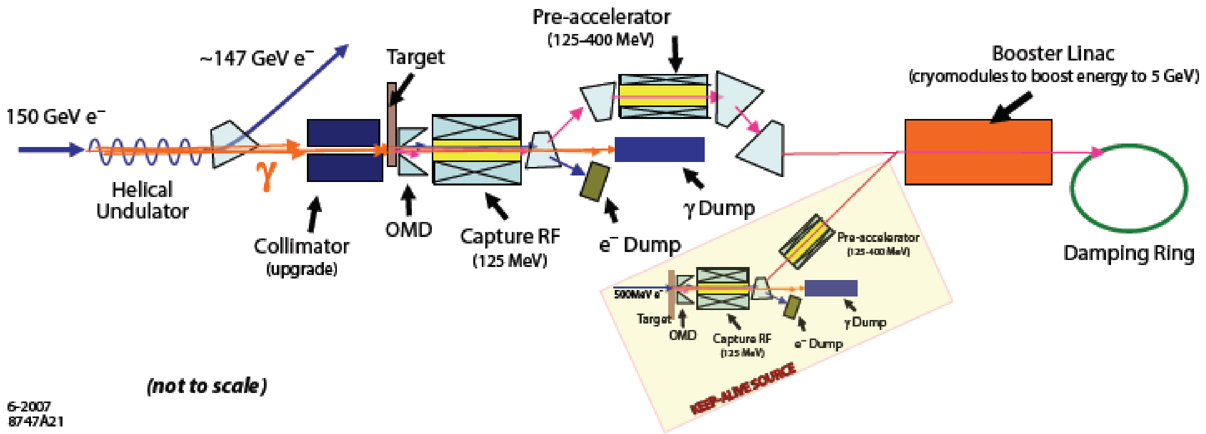
The Baseline Source



	SLC	ILC
Positrons per Bunch	3.5×10^{10}	2×10^{10}
Bunches per Macropulse	1	2625
Macropulse Rep Rate (Hz)	120	5
Positrons per second	**4.2×10^{12}**	**2.6×10^{14}**

The Baseline Source

The undulator based source was selected because it offered the greatest certainty of meeting the required positron source design specification. In comparison with a “conventional” source:

- **Lower absorbed power in the target**
- **Lower target rotation speed, single target feasible**
- **Positron yield much less sensitive to beam size jitter on the target**
- **An order of magnitude fewer neutrons generated and less activation of the target system**
- **Positron capture more efficient due to higher phase space density**
- **An order of magnitude lower power dumped in the RF Capture section due to beam losses**
- **Lower sensitivity to DR acceptance changes**
- **Upgrade to polarized positrons straightforward**

From the BCD

Non-critical Issues

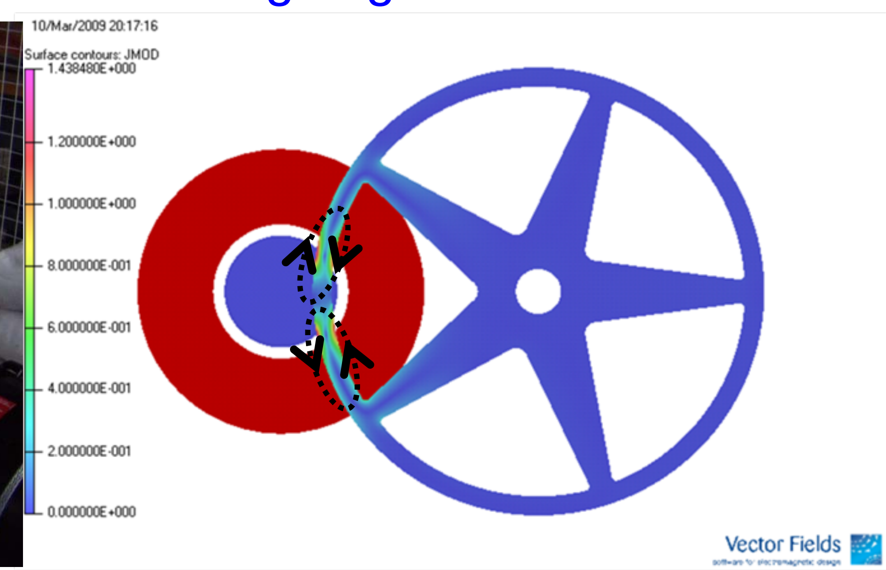
- Undulator
  - **RDR parameters demonstrated with full scale prototype**
  - **Still work to do on alignment, etc and beam test should be carried out early in ILC build**
- Collimation
  - **Engineering needed but no show stopper expected**
- Capture RF & Pre-accelerator
  - **SW prototype constructed, challenging but feasible**
- Dumps
  - **Engineering needed but no show stopper expected**
- Booster Linac
  - **Non-standard SC modules, Engineering needed**

Non-critical Issues

- Auxiliary Source
  - **Depends on specification. Few % intensity should be ok, much more than this may make it critical.**
- Beam Transport
  - **No show stoppers expected**
- Remote Handling Area
  - **Engineering needed but no show stopper expected**
- Polarimeters
  - **No show stoppers expected**

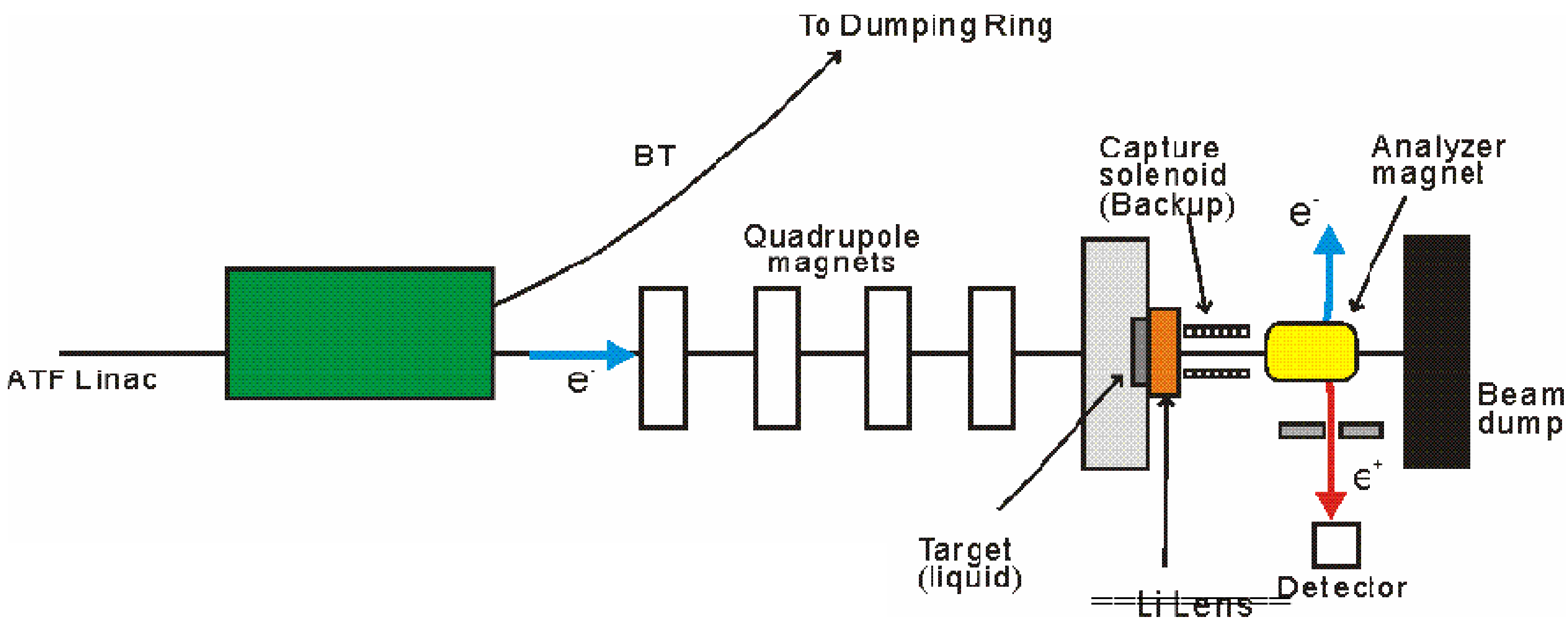
Critical Issues

- Target
  - **Rotating titanium wheel**
    - Eddy current heating (~ 5kW for 1T)
    - Photon beam heating
    - Pressure shock waves
    - Cooling/vacuum/radiation resistance
    - Prototype exists and Eddy current effects will be carefully measured and quantified/benchmarked
    - Analysis of pressure shock waves ongoing



Critical Issues

- Target
  - **Possible alternative is Liquid metal target**
    - Window survivability
    - Cavitation in liquid metal
    - R&D study to be carried out at KEK, including beam tests with ATF linac (but will still need to extrapolate results)



Critical Issues

- Optical Matching Device
  - **Flux Concentrator**
    - Long pulse length
    - High field (field on target)
    - Power supply
    - Engineering to handle cooling & forces
    - Previous example suggests should be feasible
    - Little active design so far for ILC but ramping up now

Parameter	Brechna	ILC	Units
Field Strength	10	7	T
Pulse Length	40	1	ms
Repetition Rate	1/3	5	Hz

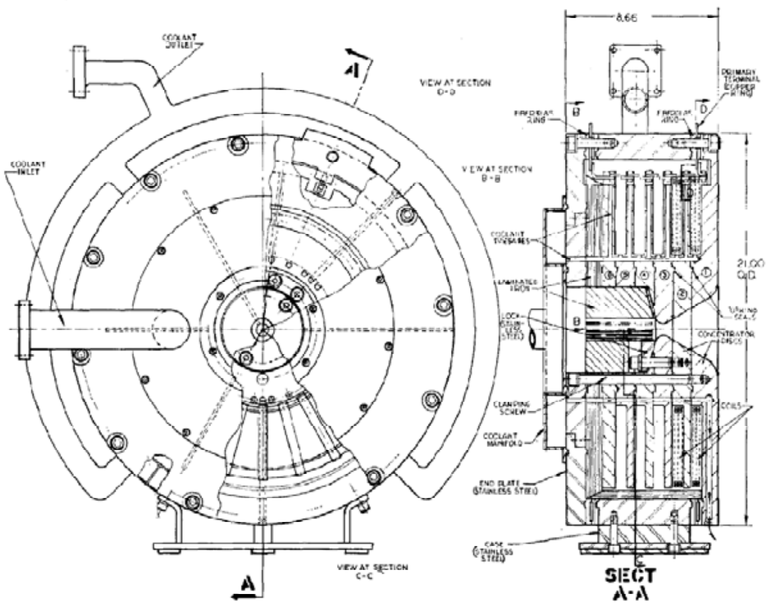


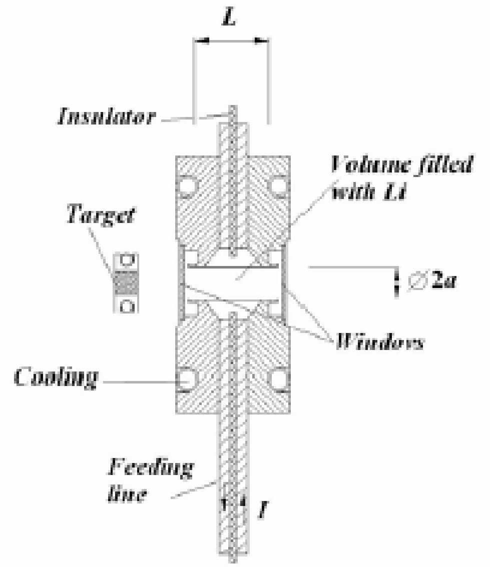
Fig. 4. End view and side section of flux concentrator final design

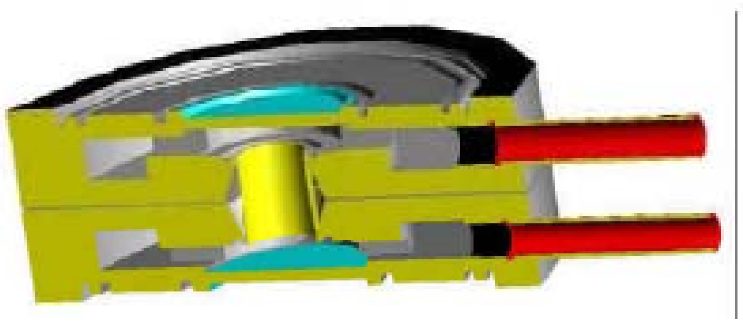
Critical Issues

- Optical Matching Device
  - **Alternative #1 is Quarter Wave Transformer**
    - DC system
    - Simple solenoid arrangement
    - Low field on the target
    - Lower capture efficiency
    - No show stopper, no need for R&D
    - Would require ~40% longer undulator, more power to handle

Critical Issues

- Optical Matching Device
  - **Alternative #2 is Lithium lens**
    - Liquid metal
    - BN Window survivability
    - Cavitation in liquid metal
    - Design for ILC more mature than Flux Concentrator
    - Liquid metal target studies at KEK may help with window & cavitation understanding





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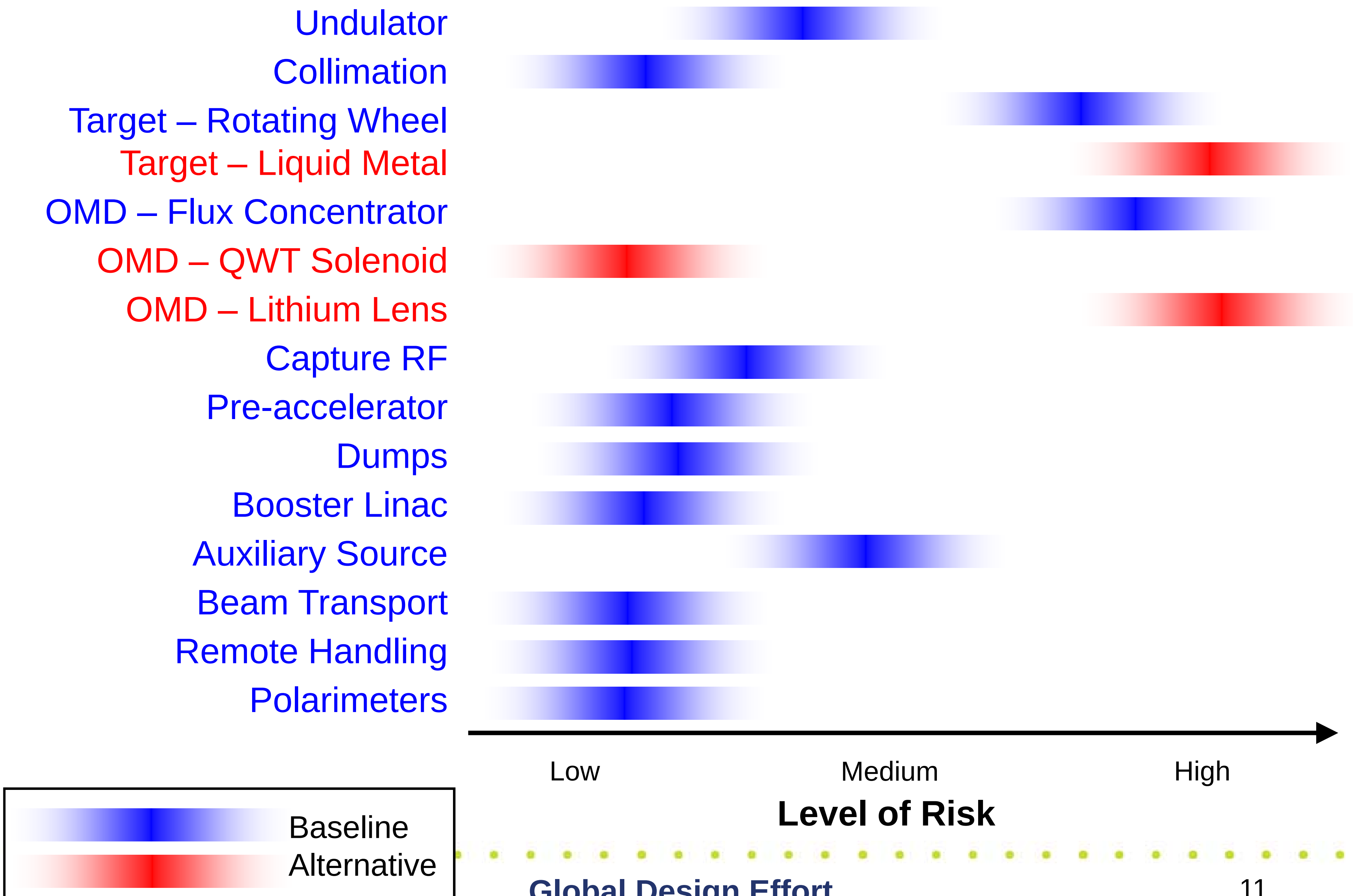
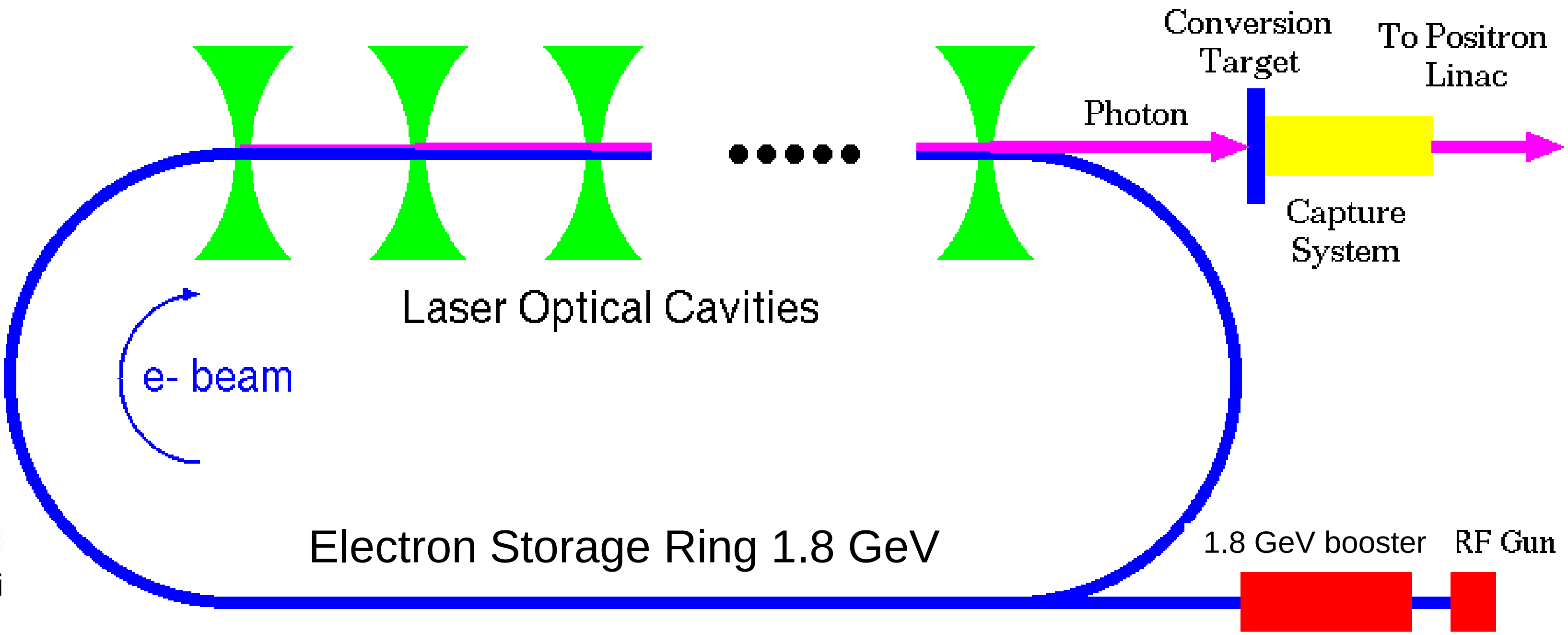
Critical Issue Summary



Alternative Source – Compton

- The source could use a storage ring, an energy recovery linac, or a linac
- A complete, integrated design does not yet exist for the ILC
- Unlikely to be ready for the rebaseline decision at end of 2009

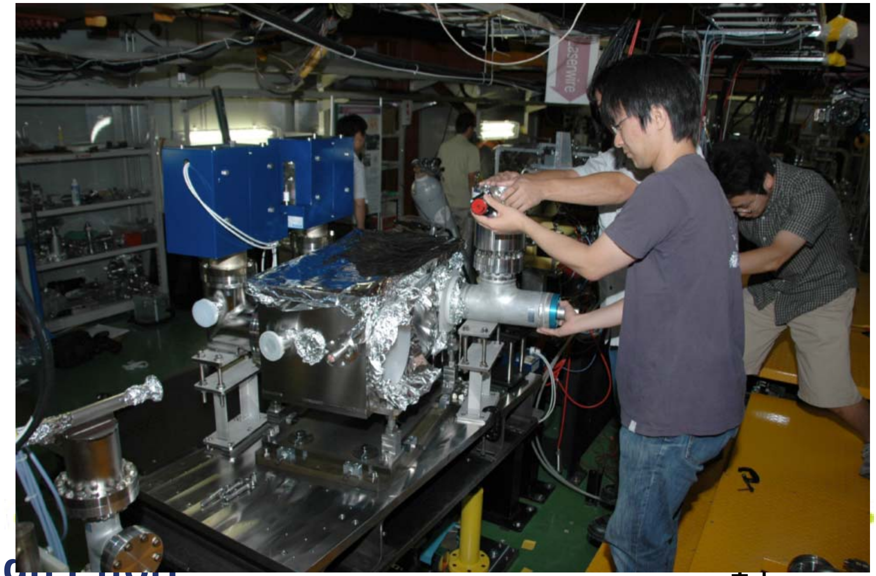


Alternative Source – Compton

- A proof of principle experiment has been successful
- There is active R&D on the source from many collaborators
- The laser system for the ring/ERL scheme is available at the 100W level commercially
- Need ~1kW so probably not a critical issue

Alternative Source – Compton

- Critical Issues Highlighted Only
  - **Laser Stacking Cavity**
    - High enhancement
    - Small laser spot
    - Active feedback
    - Small crossing angle
    - Active R&D plan, beam tests at ATF, plenty still to do!



Alternative – Compton

- Critical Issues Highlighted Only
  - **Positron Stacking**
    - Have to stack to generate enough positrons per bunch
    - Only short time available for stacking so enough time to damp
    - Increase energy pre-compression x3
    - Additional wigglers for faster damping x2
    - Larger RF voltage x 1.5
    - Still get ~3% injection loss
    - Active studies to improve this by modifying DR away from present solution
    - Could add a pre-damping ring perhaps

Alternative – Conventional

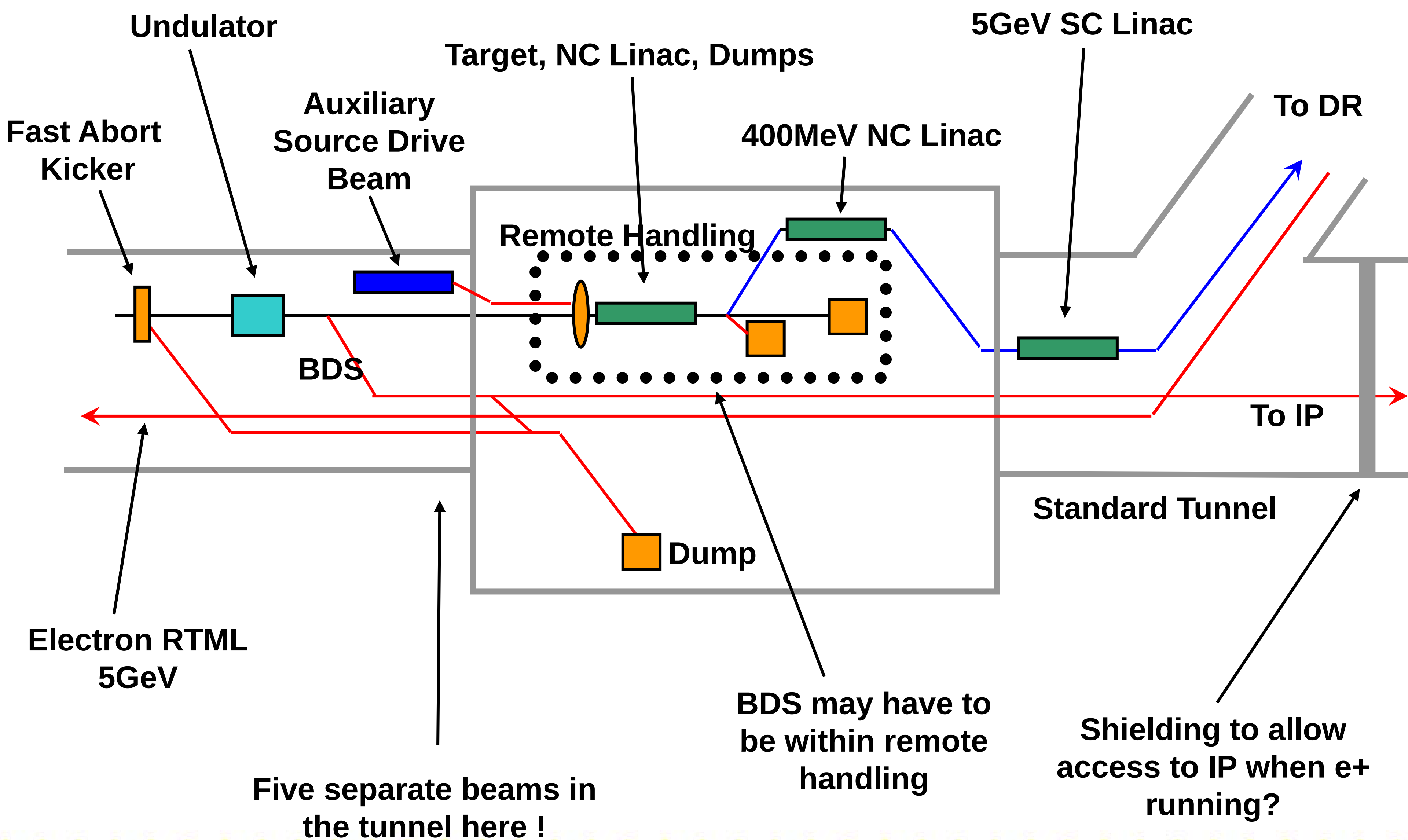
- Consideration is being given to moderate energy electron drive beam, liquid lead target, lithium lens combination
- Critical Issues Highlighted Only
  - **Liquid lead target**
    - Needs to have very high flow rates (~30m/s) and relatively large spot size on the target (~3mm) to avoid boiling of the lead
    - Window survivability
    - Cavitation in liquid metal
  - **Lithium lens**
    - Liquid metal
    - Window survivability
    - Cavitation in liquid metal
- A second scheme using a liquid lead or hybrid target and accumulating in the DR over 63ms is also considered

No clear upgrade to polarized positrons

Minimum Machine

- Undulator moved to the end of the linac
  - **This allows for sharing of infrastructure with the auxiliary source**
  - **Removal of the 1.2km insert at 150 GeV**
  - **Sharing of the tunnel (and shaft) with the BDS**
- The undulator was originally placed at 150 GeV (BCD White Paper) primarily for physics reasons to maintain design luminosity over the full electron energy range

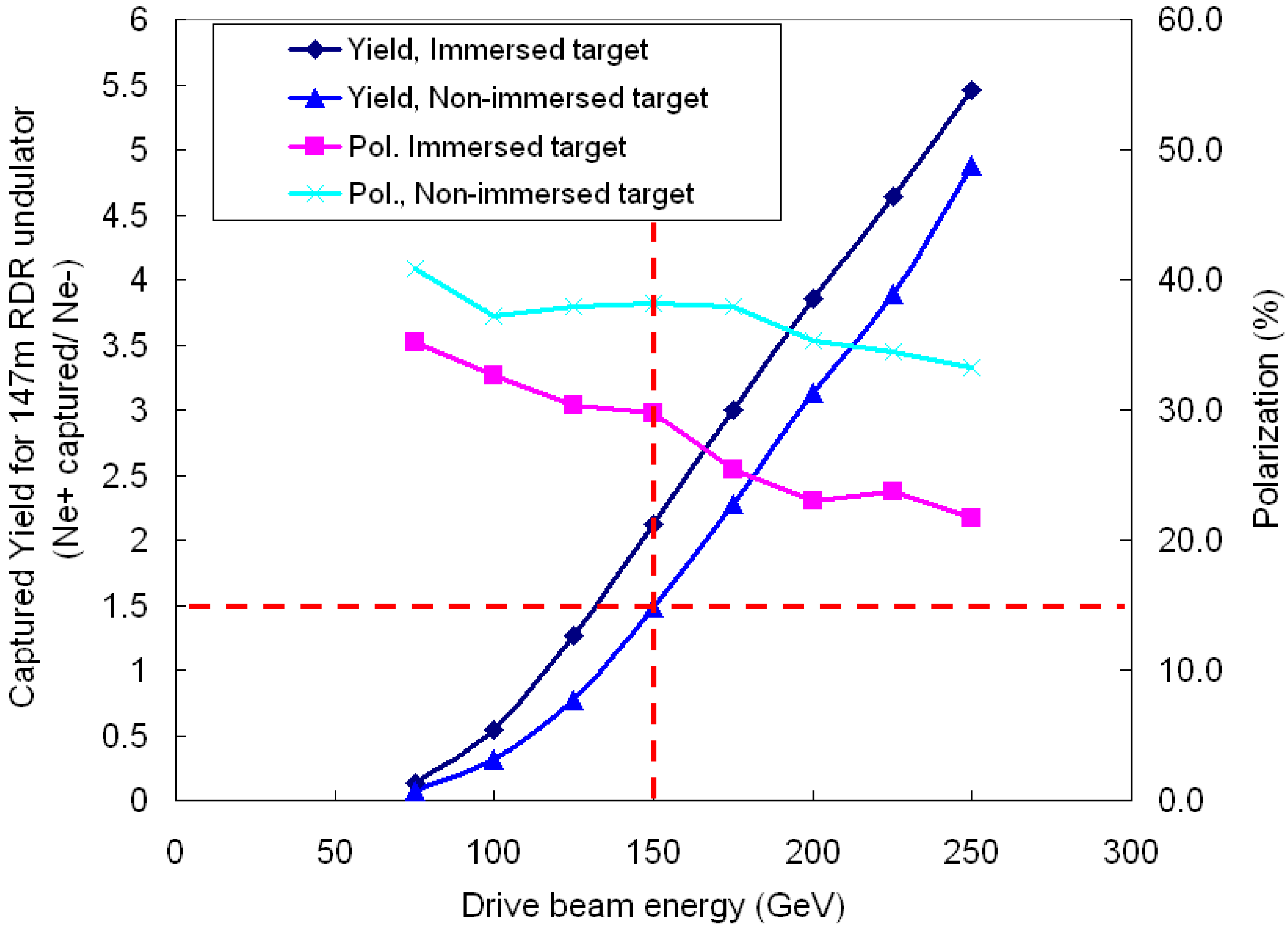
Minimum Machine Layout



Minimum Machine

- With the RDR source, running beyond 150GeV will increase the yield
  - **gives greater safety margin and allows some undulator modules to be turned off**
- Running below 150GeV the yield will fall below 1.5 (unless more modules are installed)

Minimum Machine

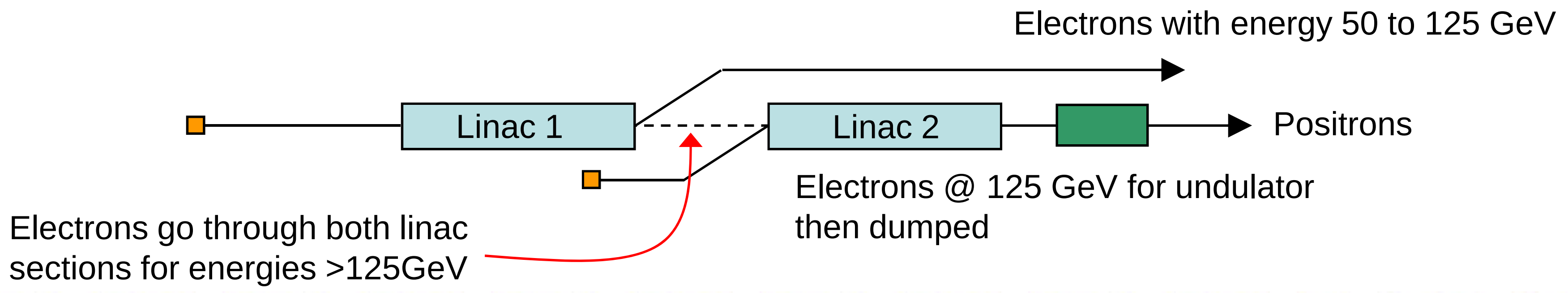


Low Electron Energy Operation

- For calibration purposes (Z-pole) the auxiliary source will be able to provide intensity at the few % level
- At some energy below 150 GeV the yield will fall by a factor of two and ILC could then operate in a pulse sharing mode
  - **Energy crossover depends on installed undulator length**
  - **Positrons are generated at high energy but at half rep rate**
  - **Electrons are transported at the low energy to the IP at half rep rate**
  - **This option gives half the number of bunches at the IP**

Low Electron Energy Operation

- Alternatively, an undulator of length sufficient for 125 GeV operation could be installed
- Then a second injector could be installed at the 125 GeV point in the linac and a bypass line
  - **This would allow one beam to generate positrons at 125 GeV and a second beam (covering 50 to 125GeV) could be transported to the BDS**
  - **No loss in luminosity at any energy**



Minimum Machine

- The source needs to be re-optimised for the undulator at the end of the linac
  - **In general we can say that above 150GeV it will give a higher yield, the issue is how to deal with lower electron energies**
- Parameter space will be examined in more detail during 2009 and operating scenarios explored
- Central region integration will also be studied to assess the impact on the CF&S, BDS, etc

Thanks

I would like to express my thanks to all of the positron source team for providing the material presented here and to the AAP as background material