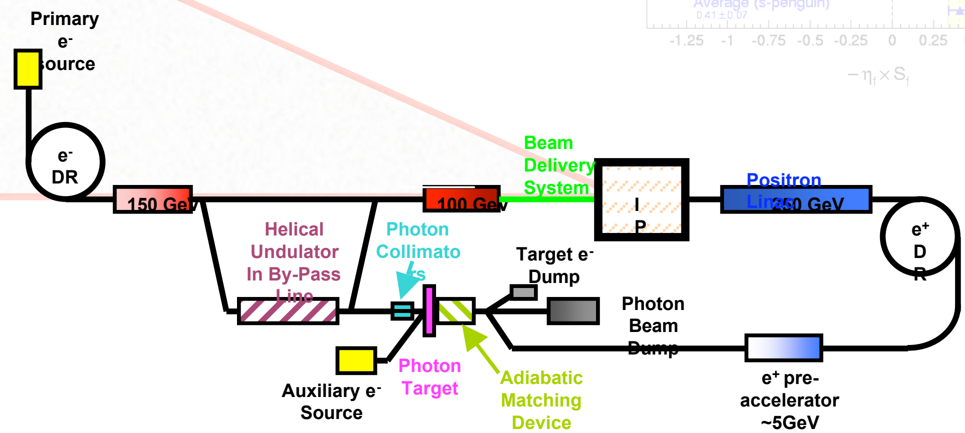
Positron Source Issues



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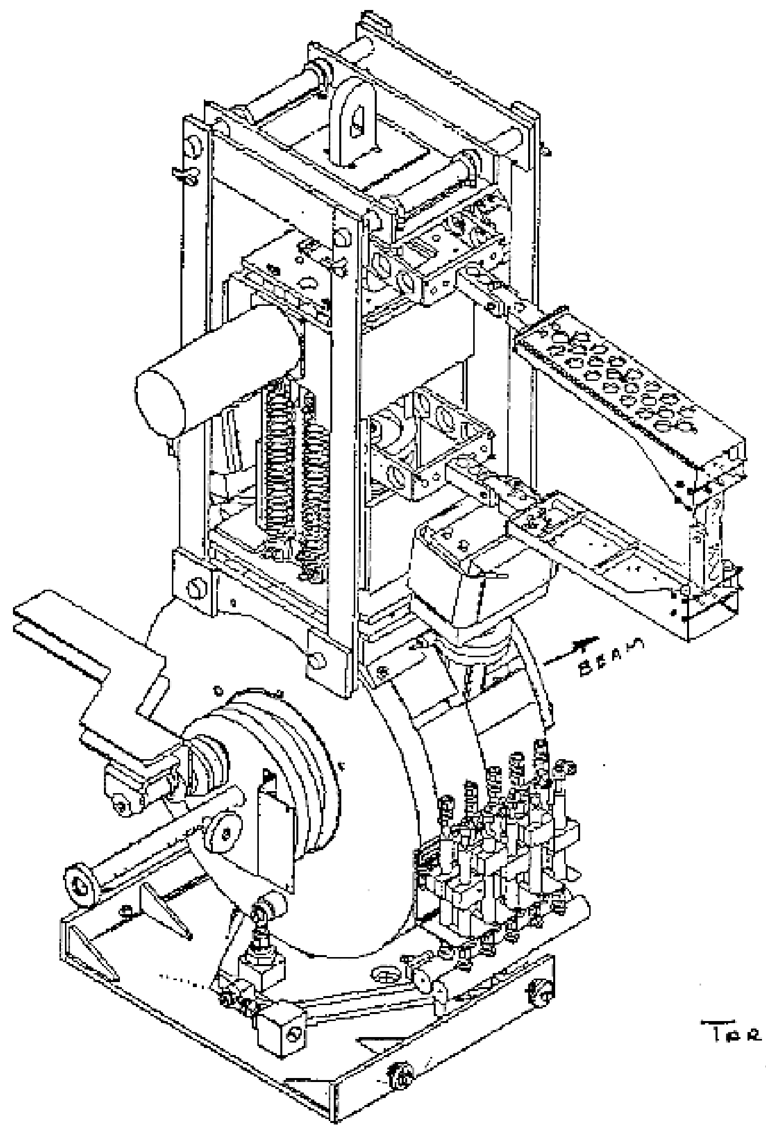
Positron Sources

- ! *Caveat:* I know nothing about positron sources, so I'm just going to act as a placeholder on this issue until we can get someone more knowledgeable on the subject.

- **Conventional Source or Polarized Source**
  - ***Conventional source***: collide e- with a target, magnetically separate e+ from other particles produced.
  - **Polarized source** -- 2 basic types:
    1) Use **undulator** on high-energy (~50 GeV or greater) e- beam, direct the resulting photons onto a target (then magnetically separate the e+ e- pairs produced).
       - ! *Requires very high-energy (> ~50 GeV) e- beam to produce sufficient e+.*
    2) Compton-scatter (any energy > ~50 MeV) e- beam with a **laser**, direct the resulting photons onto a target (then magnetically separate the e+ e- pairs produced).
       - ! *Requires several very powerful lasers, Fabry-Perot cavities in order to produce enough positrons.*

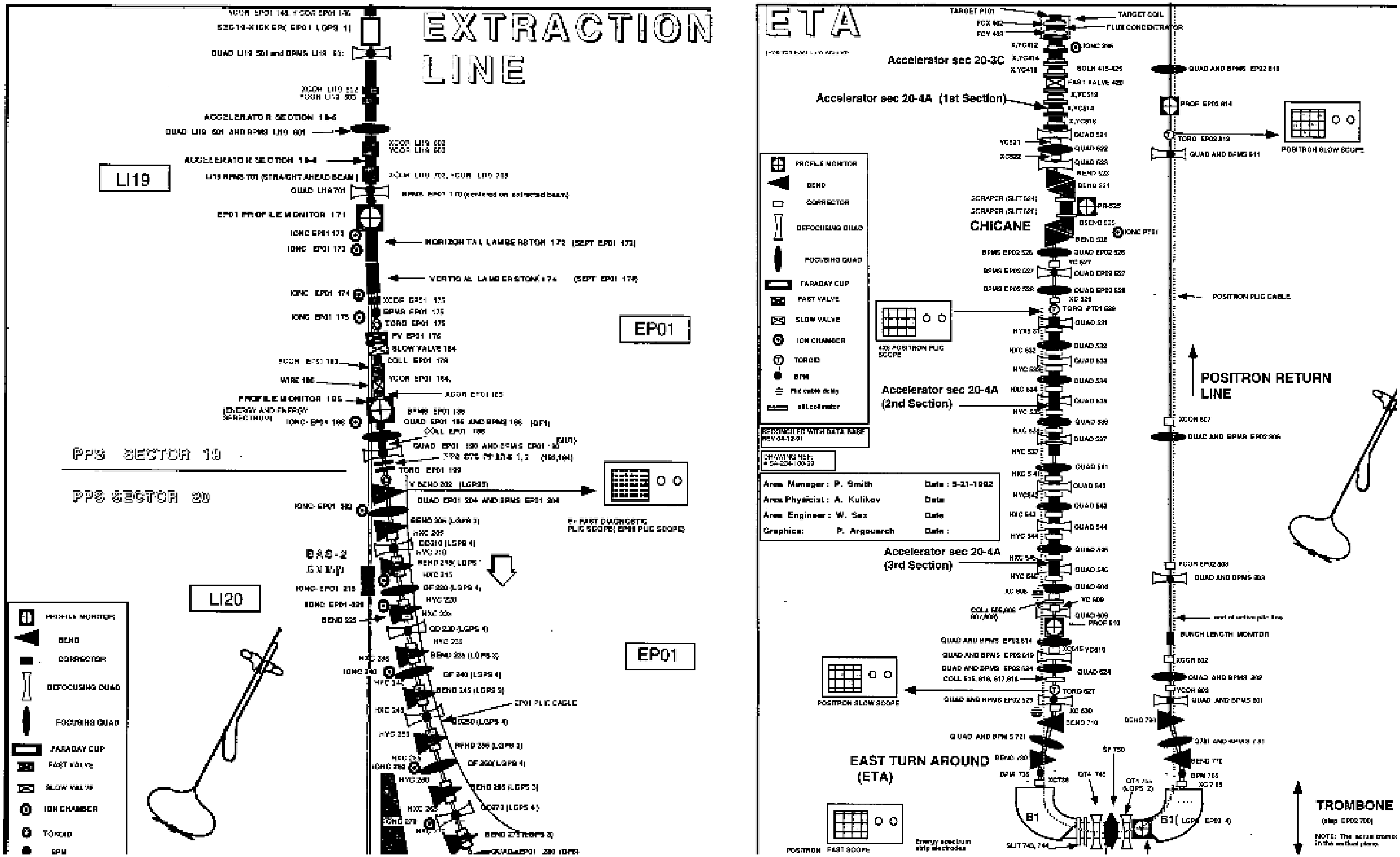
The SLAC Linac Positron Source

Table 5.2.0.1 Positron Source Specifications	
EXTRACTION	
Electron Scavenger Pulse	
Energy	33 GeV
Intensity	5.0×10^{10} e^-/pulse
Size (1 σ)	0.6 mm
Pulse energy	264 Joules/pulse
Pulse rate	180 Hz
Power	47 kW
Target	
Material	90% Ta – 10% W
Length	6 radiation lengths = 24 mm
Energy deposited in target	53 J/pulse
Pulse temperature rise	380°C
Max. pulse temp.	580°C
Max. compressive stress	32,000 psi
Power deposition	9 kW
Steady-state temp.	200°C
Positron Beam at Target	
Energy range	2 – 20 MeV
Transverse emittance (invariant)	2 mm × 2.5 MeV/c = 0.01 m-radians
Yield (e^+/e^- in.)	2.5
Beam Properties at End of Sector 1	
Energy	1.21 GeV
Energy spread	2% full
Transverse emittance	4.2×10^{-8} m-radians



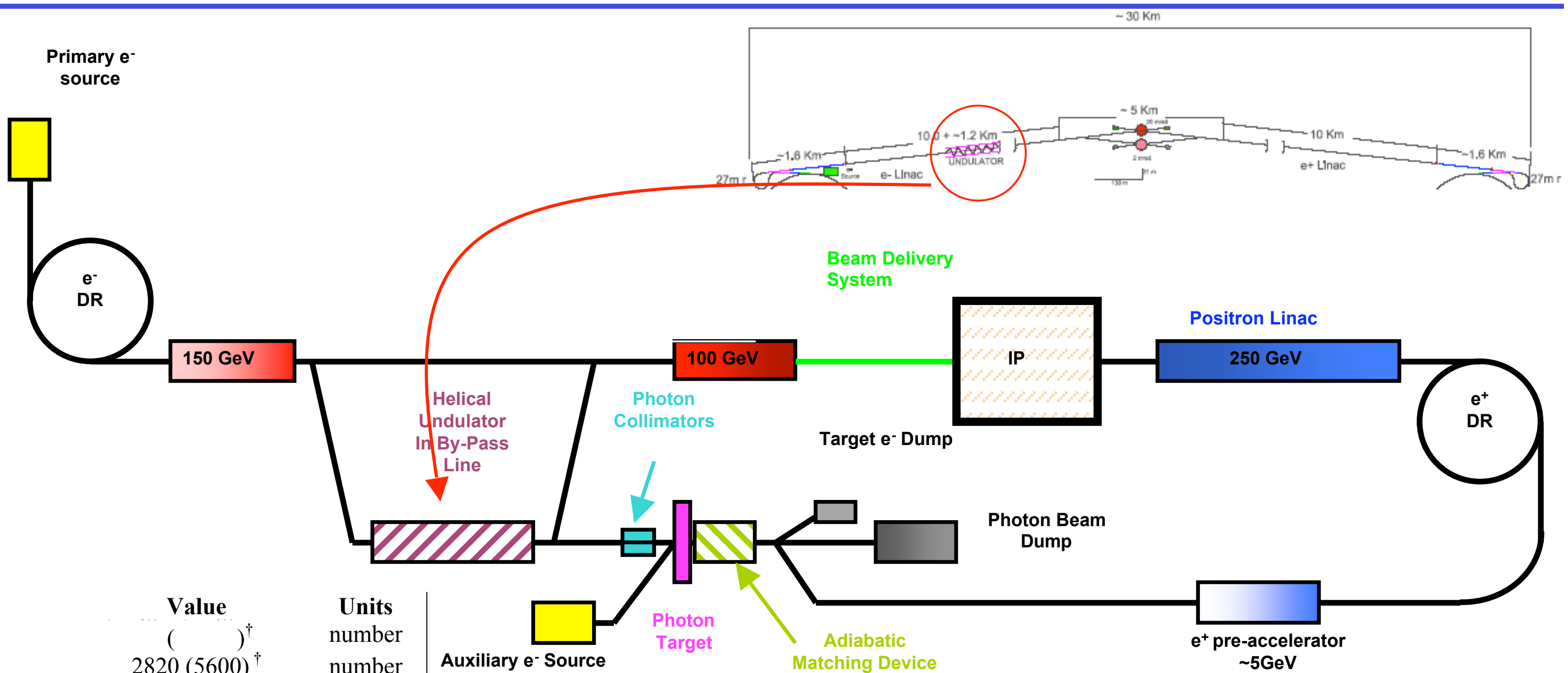
From Stan Ecklund,http://www.slac.stanford.edu/pubs/confproc/nkpslc97/nkpslc97-004.html

The SLAC Linac Positron Source



From Stan Ecklund, http://www.slac.stanford.edu/pubs/confproc/nkpslc97/nkpslc97-004.html

The ILC Positron Source



Parameter	Value	Units
Positrons per bunch	( )†	number
Bunches per pulse	2820 (5600)†	number
Pulse Repetition Rate	5	Hz
Positron Energy	5	GeV
Electron Drive Beam Energy	150	GeV
Electron Drive Beam Energy Loss	3.23	GeV
Undulator Period	10	mm
Undulator Strength	1	-
Undulator Type	Helical	-
Undulator Length (unpolarized source)	100	m
Photon Energy (1st harmonic cutoff)	10.7	MeV
Max Photon Beam Power (unpolarized source)	147	kW
Target Material	Ti-6%Al-4%V	-
Target Thickness	0.4	r.l.
Max Target Absorption	11	kW
Incident Spot Size on Target	0.75	mm, rms
Positron Polarization (upgrade)	60	%

† Low Q Parameters

- Main ILC positron source uses a helical undulator in a bypass at the 150 GeV point in e- linac to produce photons, which pair-produce in a thin (0.4 radiation lengths) target (mostly vanadium), producing ~80% polarized positrons.
- Convenient due to presence of high-energy e- beam. Drawbacks (not too major): requires most of e- linac to be functioning in order to produce e+, e+ "only" 80% polarized, radiation near undulator.

SuperB Parameters & Issues

- The requirement for a 150 GeV e- beam for the main ILC e+ source is, of course, a show-stopper for using a similar system at SuperB, however.
- Fortunately, the ILC is also likely to have an additional "keep-alive" conventional e+ source that can produce **at least 10%** of the e+ required for nominal ILC running.

Parameter	**LEB**	**HEB**
Beam Energy (GeV)	4	7
Number of bunches	10000	10000
Collision freq/bunch (Hz)	120	120
IP energy spread (MeV)	6	8
Particles /bunch x 10^{10}	10	10
Time betw. collisions (μsec)	8.3	8.3
β_y* (mm)	0.57	0.57
β_x* (mm)	22	22
Emittance (x/y) (nm)	0.7/0.002	0.7/0.002
σ_z (mm)	0.3	0.3
Lumi enchancement Hd	1.00	1.00
Crossing angle(mrad)	0	0
IP Horiz. size (μm)	4	4
IP Vert. size (μm)	0.024	0.024
Horizontal disruption	1.5	0.8
Vertical disruption	180	90
Luminosity ($x10^{34}/cm^2/s$)	100	100

ILC keep-alive e+ source

From John Sheppard:

- Nominally the keep-alive source need only produce 10% of the required ILC positrons. But there is also a design for a conventional keep-alive source that can produce the full intensity (using a 5 GeV e- beam):

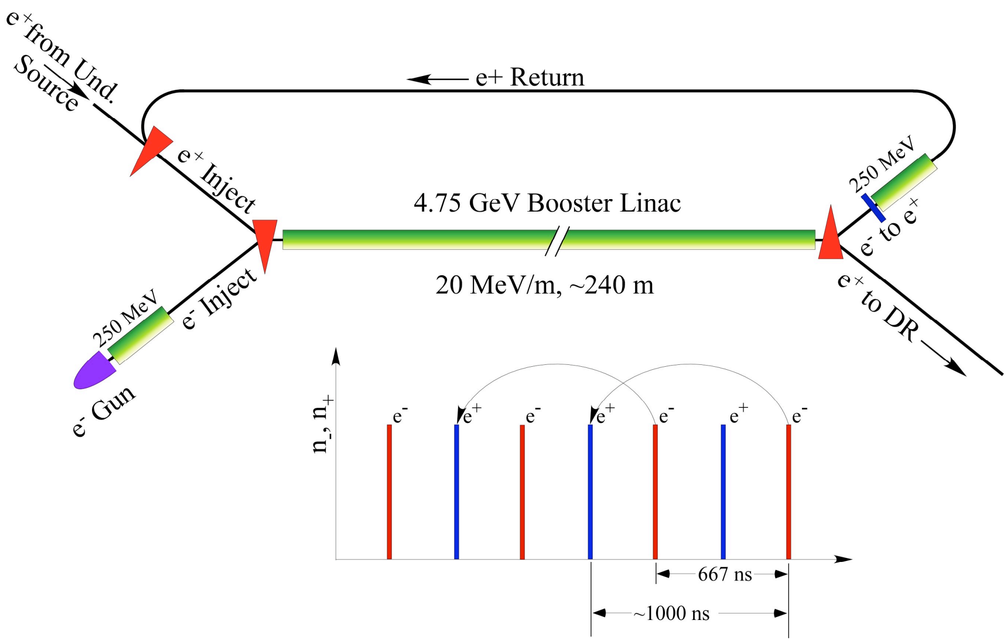
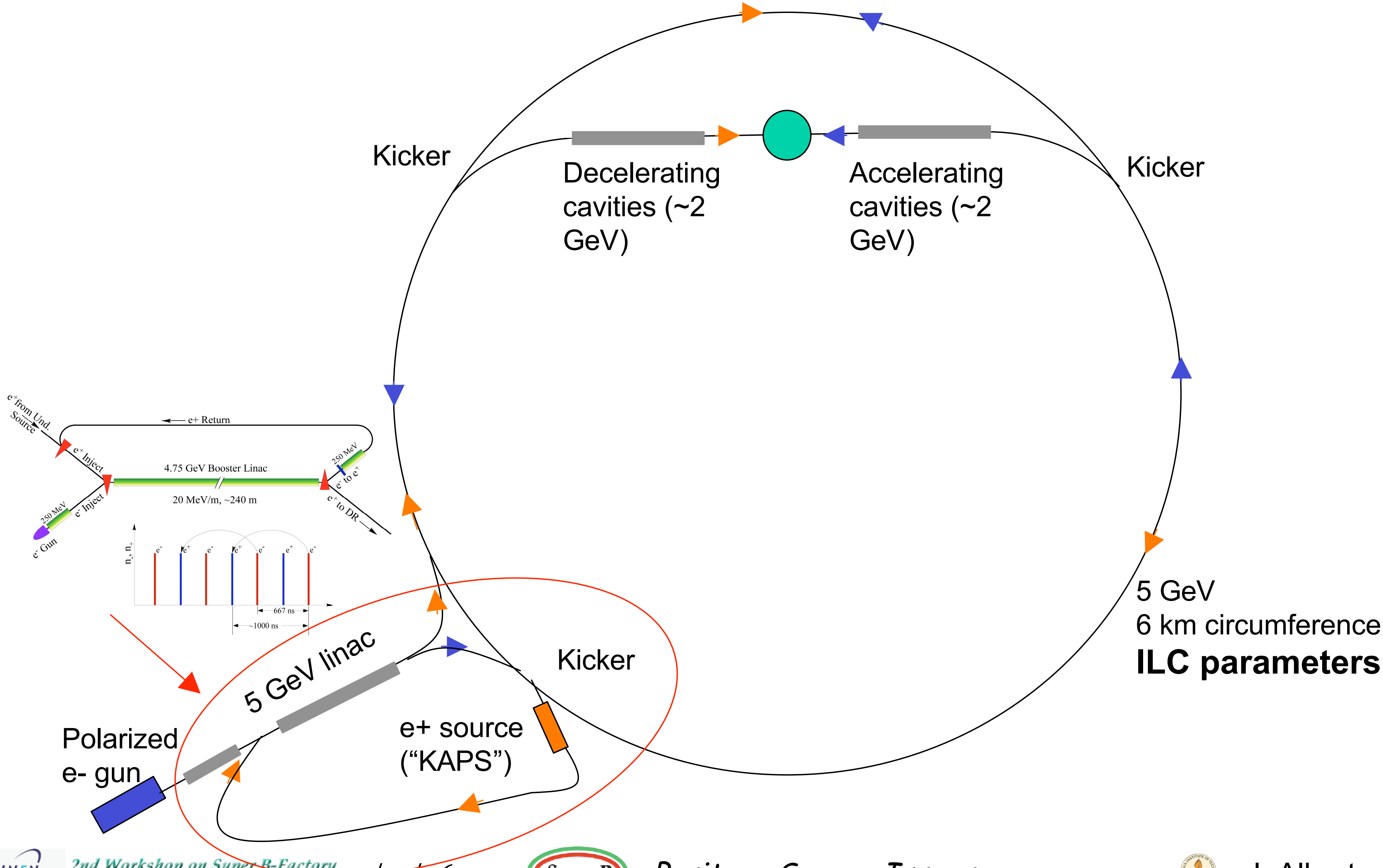


Table 1: Positron System Keep Alive Source Parameters:

Parameter	Symbol	Value	Units
Positrons per bunch			number
Bunches per pulse		1410	number
Bunch Separation	T_b	667	ns
Pulse Repetition Rate		5	Hz
Energy	E_0	5	GeV
Keep Alive Conventional Source			
Electron Drive Beam Energy	E_e	5	GeV
Electrons per bunch			number
Electron Drive Beam Power	P_e	136	kW
Target Material	-	W-23%Re	-
Target Thickness	L_t	4.0	r.l.
Target Absorption	-	14	%
Electron Source Option			
Electrons per bunch			number
Electron Drive Beam Power	P_e	227	kW
Bunches per pulse		2820	number
Bunch Separation	T_b	333	ns
Pulse Repetition Rate		5	Hz
Energy	E_0	5	GeV

- This type of design looks promising.

"Concept"


Kicker
Decelerating cavities (~2 GeV)
Accelerating cavities (~2 GeV)
Kicker
e+ Return
4.75 GeV Booster Linac
20 MeV/m, ~240 m
5 GeV
6 km circumference
ILC parameters
5 GeV linac
Kicker
Polarized e- gun
e+ source ("KAPS")

Conclusions

- Conventional positron source would be the simplest & cheapest.
  - If we were to decide we need polarized positrons from the start, then a Compton polarized e+ source would likely be the next option.
- A bypass line on the e- damping ring onto a target would most likely be able produce a sufficient number of positrons.
- More synergy with ILC -- can use an identical/similar positron source as the "keep-alive" conventional e+ source for ILC.
  - ✓ Emittance sufficiently small for ILC.
- Need to determine requirements for injected e+ current.
- If there were possibly also a physical connection to ILC, then could also potentially use / upgrade to use polarized e^+ from the undulator ILC source once the e^- main linac is running.