The Low Power Option – Some Consequences for ILC Physics

Chris Damerell and Sonja Hillert
RAL and Oxford U

Example Parameter Sets

		nom	low N	lrg Y	low P	High L
N	$\times 10^{10}$	2	1	2	2	2
n_b		2820	5640	2820	1330	2820
$\varepsilon_{x,y}$	μm, nm	9.6, 40	10, 30	12, 80	10, 35	10,30
$\beta_{x,y}$	cm, mm	2, 0.4	1.2, 0.2	1, 0.4	1, 0.2	1, 0.2
$\sigma_{x,y}$	nm	543, 5.7	495, 3.5	495, 8	452, 3.8	452, 3.5
D_y		18.5	10	28.6	27	22
δ_{BS}	%	2.2	1.8	2.4	5.7	7
σ_z	μm	300	150	500	200	150
P_{beam}	MW	11	11	11	5.3	11
Lumi	10^{34}	2	2	2	2	

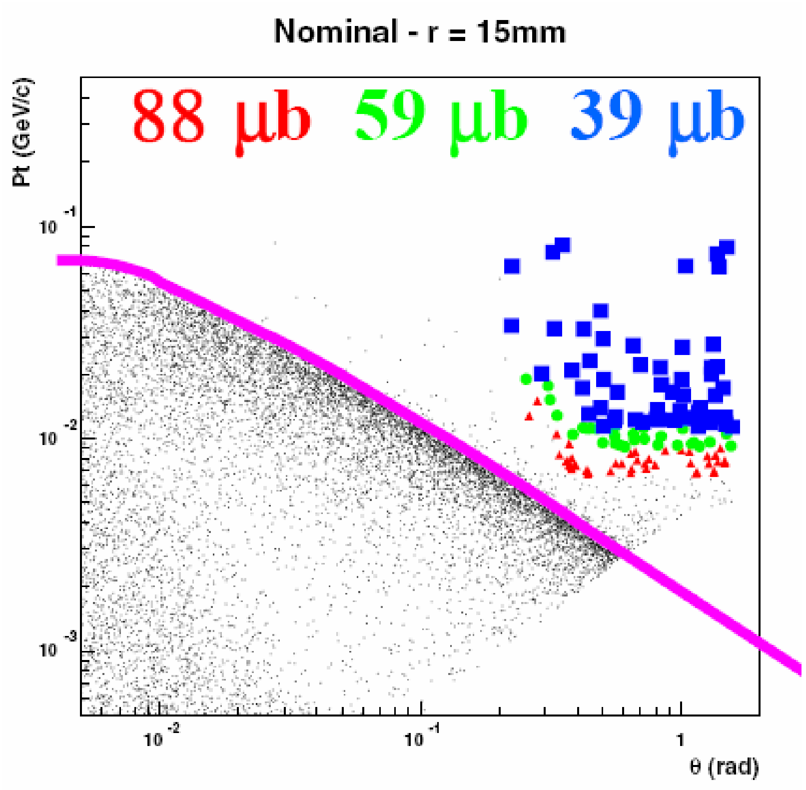
Tor Raubenheimer ALCPG meeting, 5th Oct 2006

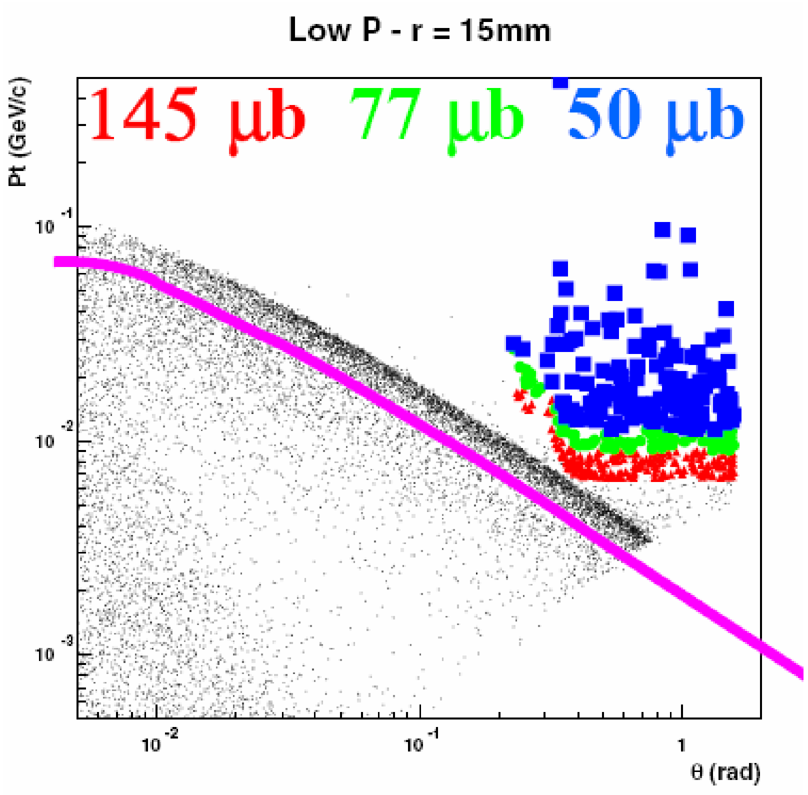
- ‘Low P’ is an association of two independent changes from the nominal design:
  - 2820 → 1330 bunches/train
  - Reduced β* (factor 2 in both x and y) and reduced bunch length

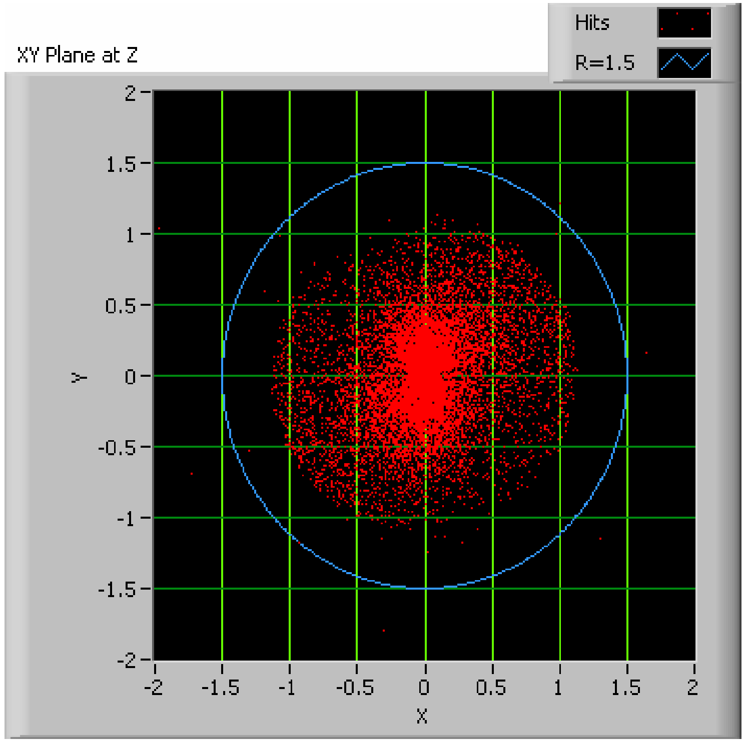
- The first change halves the number of klystrons and provides a cost saving of 2-3%
- The second restores the luminosity to 2×10^{34} $cm^{-2}\ s^{-1}$ at the cost of:
  - increased energy spread (ave E-loss 2.2% → 5.7%)
  - increased beamstrahlung/pair production, pushing the beampipe to larger radius

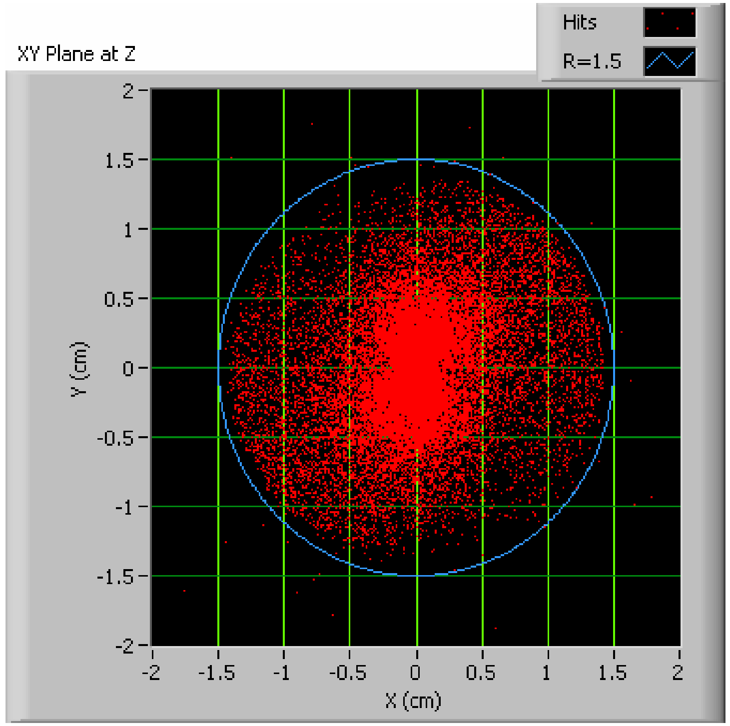
- This procedure to increase **L** could be applied to the nominal parameters (it is approximately the High L option), so it should be considered on its merits

- **Pair production for these and other options was presented at Snowmass 2005 by Cécile Rimbault, and published in Phys.Rev.ST Accel.Beams 9:034402,2006**

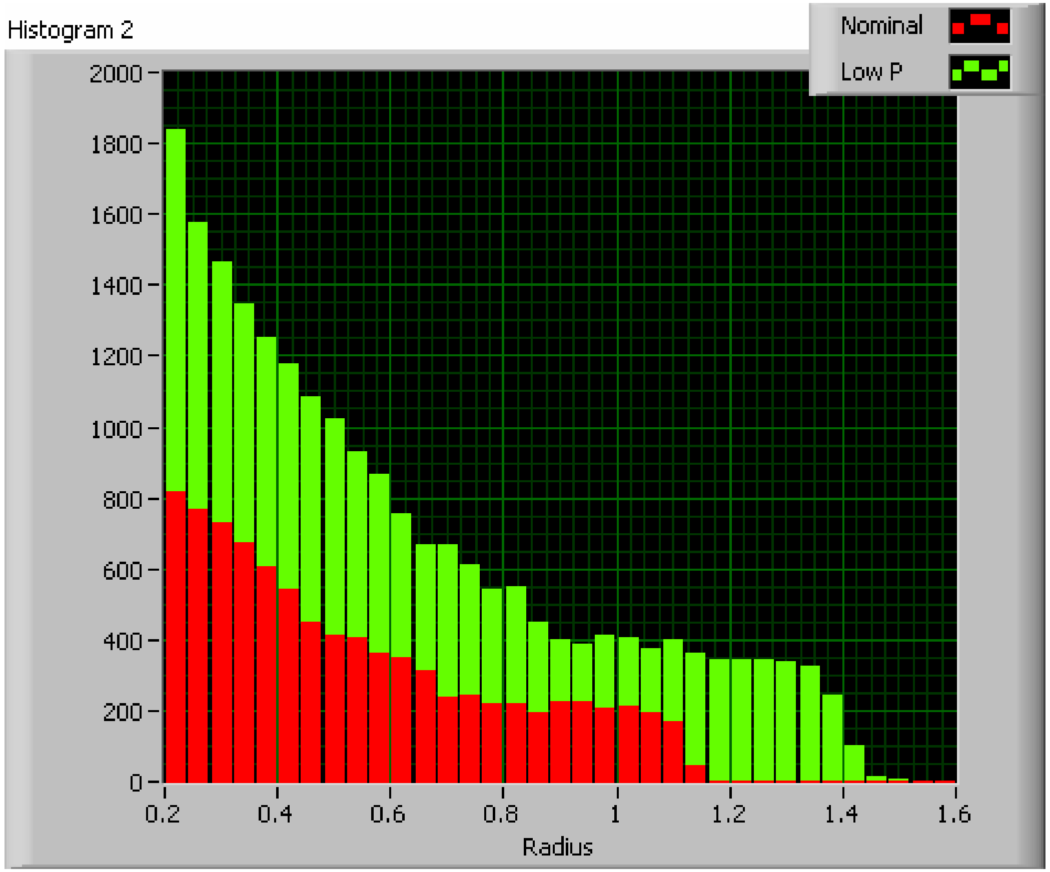








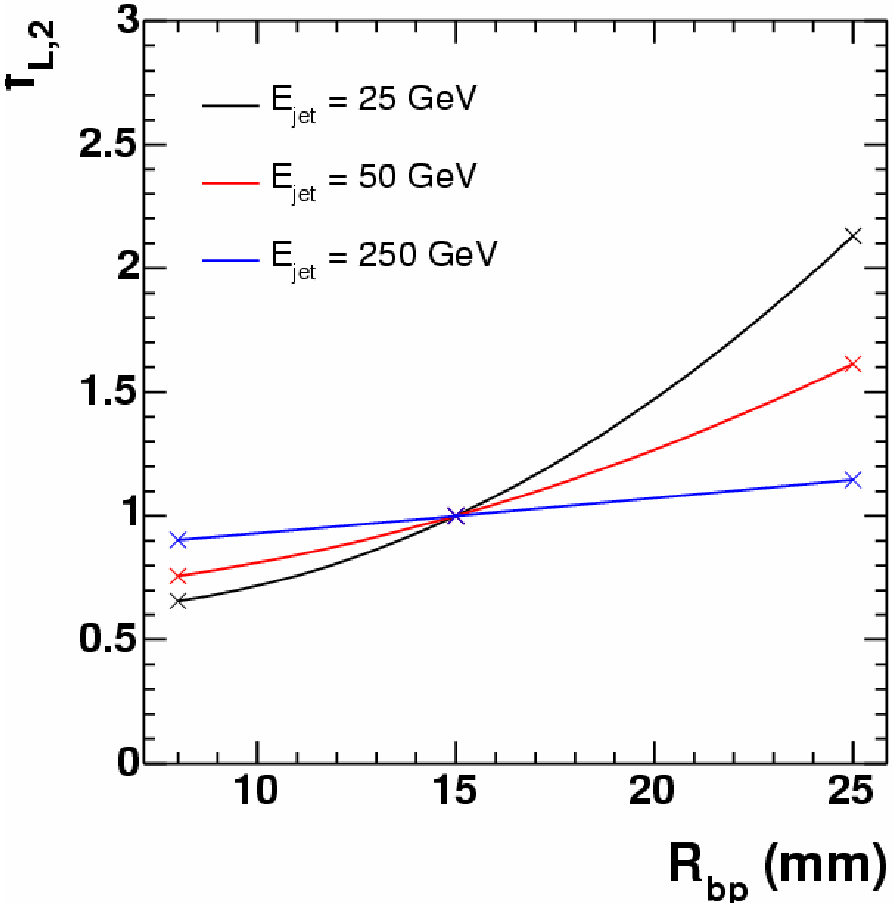
- Nominal and low P, 4 T, |z| = 8 cm
- CAIN simulation, 1 bunch, 64k electrons (nominal), 159k electrons (low P)
- Very preliminary results from Tim Woolliscroft (Liverpool U)
- Interesting to see the deviations from azimuthal symmetry in the pair envelope at the end of the cylindrical pipe



- Nominal and low P, 4 T, |z| = 8 cm, radial distribution (cm)

- If R_{bp}(min) is 15 mm for nominal FF (stable since Obernai, 1999, Nick Walker), this suggests we need R_{bp} ~ 18 mm for low P

2-jet luminosity factors



Plot shows the 'irreducible limit' from low momentum tracks ambiguous between IP and decay chain

R_{min} for layer 1 depends on which technology will work (~R_{bp} for chronopixels, larger for other options)

Radius limit for time integrating detectors comes from hit density on layer 1:

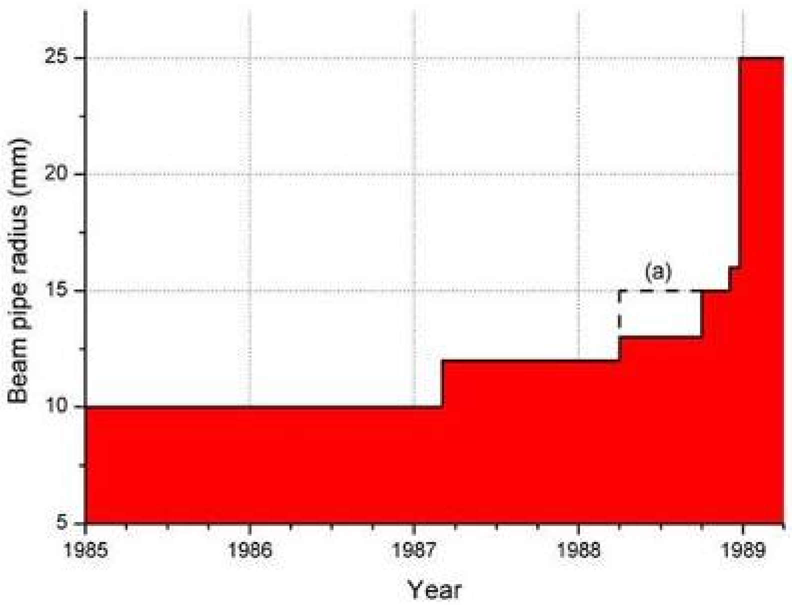
[tracks fitted to layer 2 having unacceptable level of ambiguous hits within the extrapolated ellipse on layer 1]

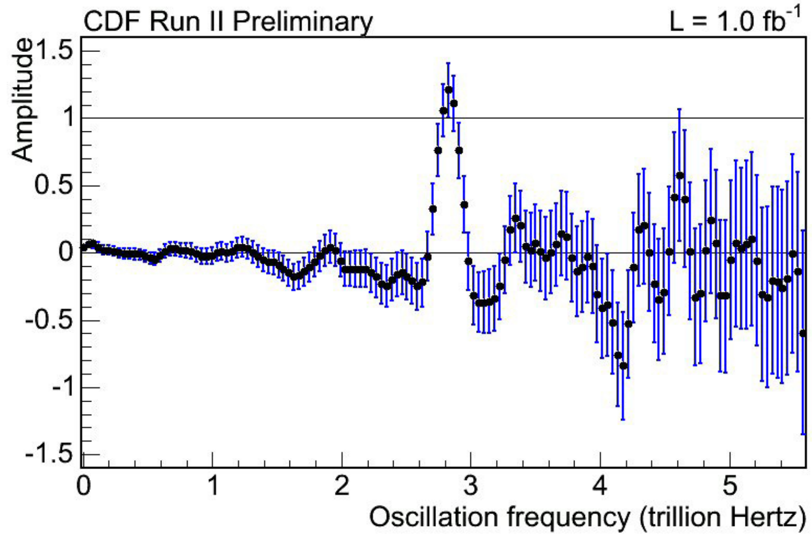
These limits will be evaluated by the ILC vertexing community with full M/C simulation and reconstruction, for different assumed technologies

Largest uncertainty by far: which technology can be made to work without creating a small furnace at the heart of the ILC detector?

This may not be known for 2-3 years. For ~50 μs sensitive time, Nom → Low P inflates Layer 1 Rmin 16 → 24 mm

Consequences of a swelling beampipe!





CDF's beautiful result – Sept 2006

Some will see increasing R_{bp} as 'progress'. However, this cost SLD the measurement of B^0_s mixing, who knows what further physics, and delayed the mixing measurement by 8 years. Similar story from LEP …

Interim Conclusions

- **Advantage of factor 2 luminosity gain for low β* option is roughly cancelled for processes where vertex charge for moderate energy jets is required, for detectors with timing resolution ~50 μs**
- **Increased energy spread will further weaken this option for some physics processes**
- **However, for physics that requires neither of these, this luminosity gain will be useful**
- **How to decide? Maintain flexibility; maybe LHC results will provide guidance …**
- **Our opinion: processes such as e+e- → t tbar nu nubar *will* be important at ILC**
- **Independent of β*, let's hope that the penalty in ILC luminosity by factor 2, for 2-3% cost saving, can be avoided by the international community**