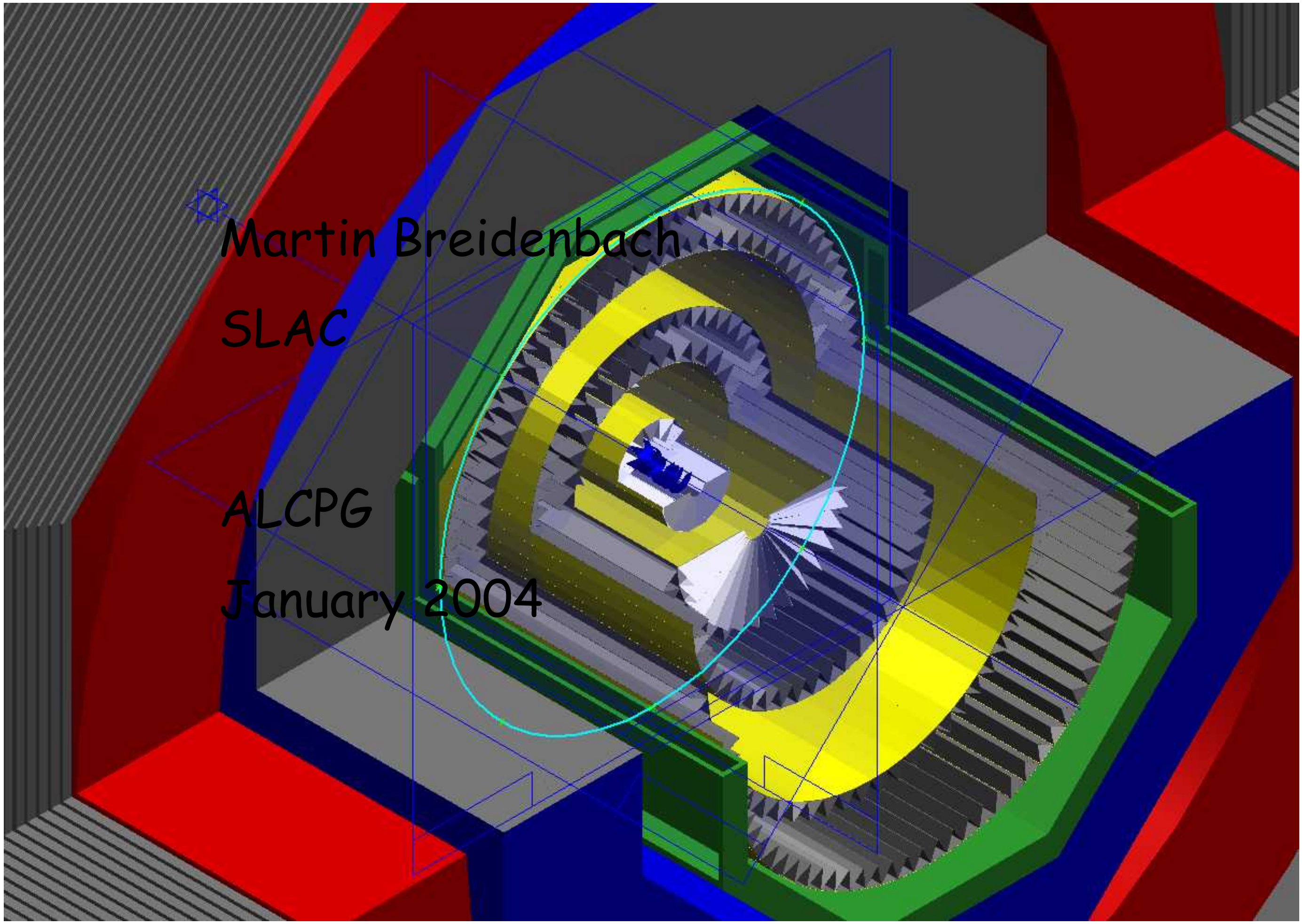
Cold – Warm Considerations for the Detectors



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Cold[1] – Warm[2] Considerations for the Detectors

- Politically Incorrect assessment of issues related to the LC technology choice that affects the detectors
- Mostly questions to be studied in the working groups, rather than conclusions…
- Note that US Cold and US Warm have fewer differences than NLC and TESLA. NLC and TESLA implications were discussed by J. Brau at Jeju in 2002.

- 1. US Cold. Based on TESLA linac, but more site independent.
- 2. US Warm. Similar to NLC. X Band.
- Both described in (but don't see the ~suppressed) USLCSG LC Technology Comparison Study

Detector Relevant Parameters

Parameter	Warm Ref	Cold Ref	Warm Upgrade	Cold Upgrade
Beam E [GeV]	250	250	500	500
$\mathcal{L}_g$ [$10^{33}cm^{-2}s^{-1}$]	14	14	22	23
$\mathcal{L}$ [$10^{33}cm^{-2}s^{-1}$]	21	26	31	38
Bunches/Train	192	2820	192	2820
Rep Rate [Hz]	120	5	120	5
e^-/bunch [10^{10}]	0.75	2	0.75	2
σ_y (IP) [nm]	3.0	5.7	2.1	4.0
H_D	1.46	1.77	1.41	1.68
$N\gamma$	1.2	1.5	1.2	1.6
δ_E [%]	4.6	3.0	8.2	5.9
$\Theta_{crossing}$ [mrad]	20	20	20	20

Classes of Issues

- Rather evident – e.g. train structure and bunch charge.
- Possibly misunderstood – e.g. crossing angle.
- Irrelevant – e.g. e^+ polarization.
- Likely unknowable – e.g. Energy and Luminosity

The Trains

- Cold: 2820 bunches every 337 ns at 5 Hz. $N=2.0\times10^{10}$
  - Quite plausible to read and clear most detectors in interbunch period.
  - Quite unlikely to usefully power cycle electronics in interbunch period. Can power cycle between trains.
- Warm: 192 bunches every 1.4 ns at 120 Hz. $N=0.75\times10^{10}$
  - Read and clear between bunches probably impossible for most detectors. Some measurement of track time within train likely.
  - Power cycling same as Cold.

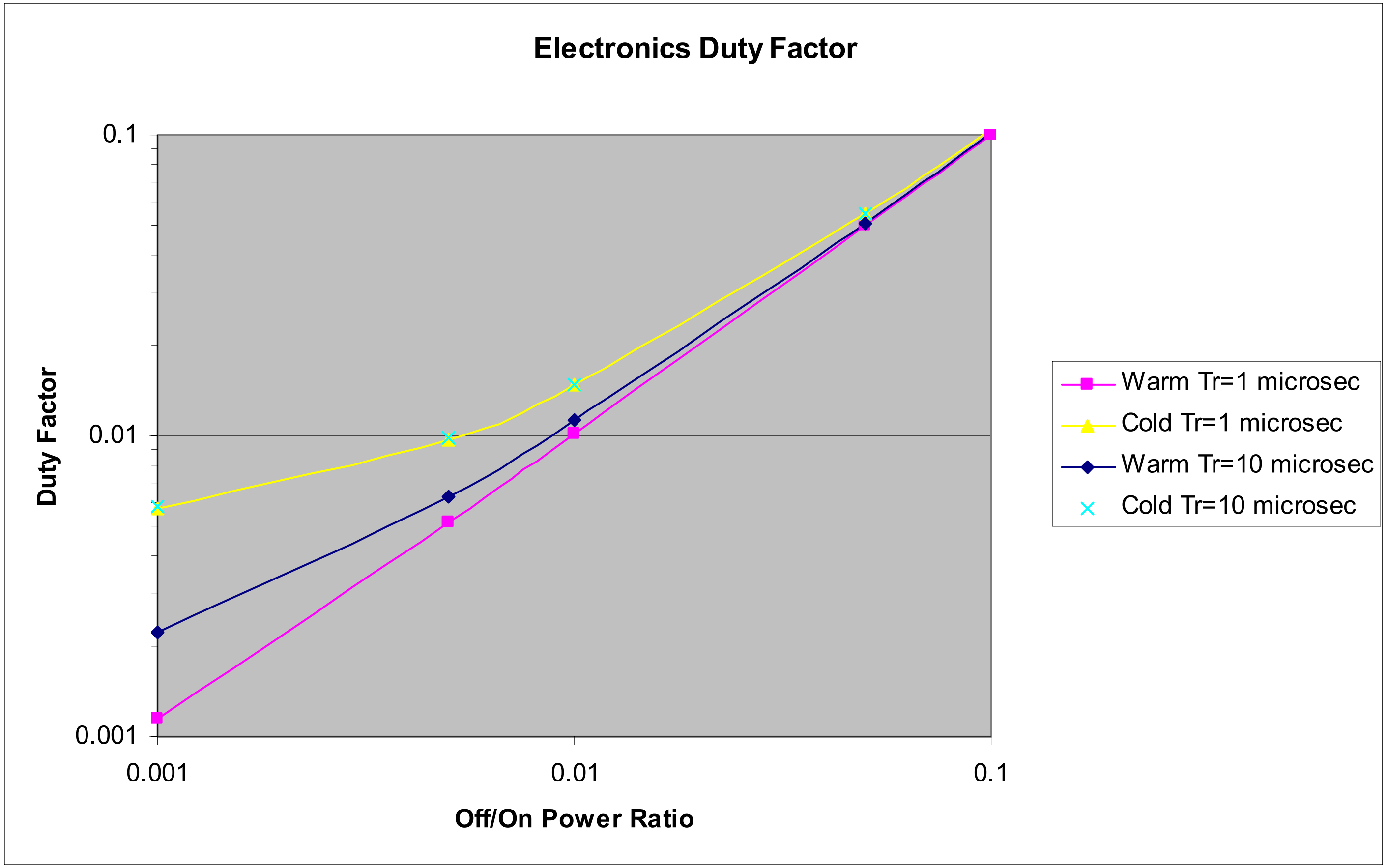
  - Duty Factor
  - Event pile up
  - Electronics implications

Power Cycling

- Why: Limiting power makes possible elimination of liquid cooling systems in sensitive areas of the detector, reducing multiple scattering and photon conversions. Cool electronics is also more reliable.

- Assume 10 μsec settling time. Assume "off"/"on" = 1% power. Then duty factor =
  - Warm 0.011
  - Cold 0.015
- No significant difference. Difference grows if "off"/"on" gets smaller…

Electronics Duty Factor



Pileup

- Vertex Detector:
  - Warm: Integrate entire train, readout ~standard[1] CCD's between trains. Note that warm integrates ~1/3 luminosity (and background) during full readout cycle than cold with 50 MHz column parallel CCD's.
  - Cold: Must readout in modest number (~350 @ 50 MHz) of bunches. Need column parallel CCD or other very fast technology. Doable, but complex.
  - RF Pickup vulnerability: If shielding inadequate to EMP - (SLD VXD3 had problems despite considerable effort) easy warm fix is to delay readout until microseconds after beam is gone; this is not a cold option.
  - 1. Need 20 readout nodes on 2x12 cm CCD. SLD VXD3 had 4.

Pileup, Continued

- TPC's
  - Drift time is 5-10 μsec/cm. For a 2 m ½ length TPC, this is 20-40 μsec, or the entire warm train, or 60-120 cold bunches. (Mike Ronan).
  - By coincidence, the integrated luminosity during the drift time is ~the same. But sorting tracks to bunches will be easier with cold.

Pileup, Continued

- Si Strip Detectors
  - Cold should be fairly easy to separate bunches.
  - Warm unlikely to resolve within train, especially if aggressively keeping material out of tracking volume.
  - Probably not too important because of high probability of good time tag in Si-W EMCal.

Pileup, Continued

- Si-W Calorimeters
  - SiD is studying calorimeter with readout chip bump bonded to large area pixellated detector. Preliminary simulation indicates rather good timing tag capability for warm. (David Strom, this workshop).
  - Bunch ID should be quite easy for cold.
  - Specialized small area calorimeter for extreme forward direction should permit readout for each bunch (warm). Not easy, but doable.

Pileup, continued

- Straws
  - Should have full readout capability warm or cold.

Backgrounds (Naïve Look)

	US SC 500	US SC 1000	US NC 500	US NC 1000
Lum/bc ($x10^{34}$)	1.8	2.7	0.90	1.4
Nγ	1.5	1.6	1.2	1.3
Coherent Pairs/bc	4.6×10^{-34}	6.9×10^{-11}	4.5×10^{-11}	7.3×10^{-1}
Inc Pairs/bc	3.7×10^{5}	5.0×10^{5}	1.2×10^{5}	1.73×10^{5}

- Backgrounds are probably high risk area, but US Cold/Warm differences above are probably small compared to the errors.
- Accelerator people claim tails are at 10^{-6} of core and they can handle 10^{-3}. What have they missed? (!!)

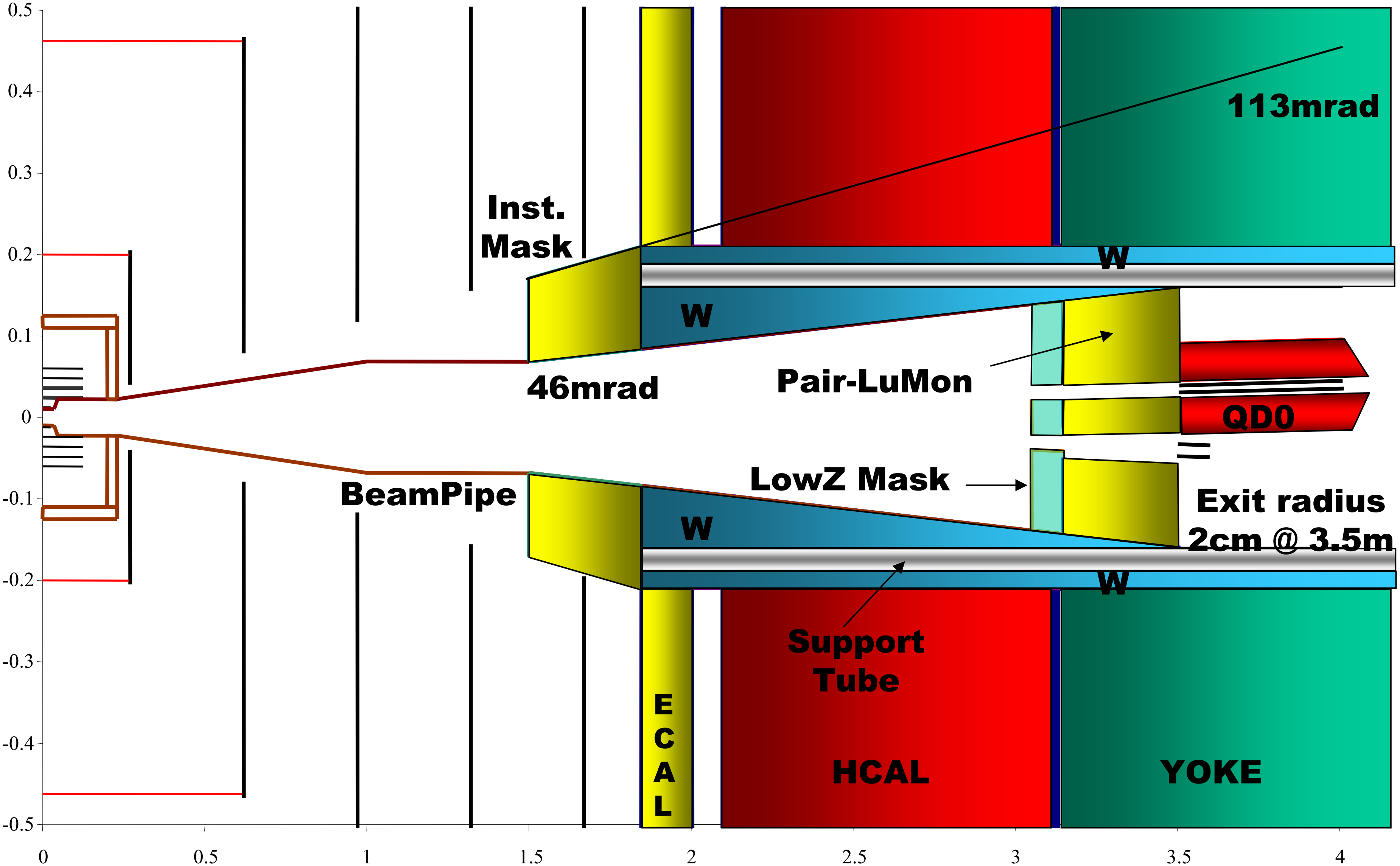
Warm Cold Independent

- Polarized e^+. Either design can use undulator source. US Cold and Warm both use (non-polarizing) undulators.
- Experience indicates that commissioning might be easier with a conventional e^+ target. A design is being developed that will work for cold…(John Sheppard)

L* and Vibration Sensitivity

- σ_y (IP) = 3 nm (warm); 5.7 nm (cold)
- Cold bunch spacing is 337 ns; intratrain feedback to correct offsets (and angles) should be straightforward. However, background in the feedback BPM's could be a severe problem, and no relevant R&D seems plausible before commissioning. Actual luminosity (as opposed to offset) feedback may be needed.
- Warm spacing is 1.4 ns; intratrain feedback can help, but delay before correction is noticeable. Warm design expects stabilization from inertial reference or optical anchor.
- Intertrain feedback is at 120 Hz for warm; 5 Hz for cold. Cold with intertrain will not be as effective.
- Detectors for cold or warm will have to be rather careful about mechanical vibration issues, such as cooling.
- L* is a compromise among detector clearances, optical issues affecting luminosity, and "rational" beam stay clears affecting VXD radii. L* does not appear to be a cold/warm discriminator.

SiD Forward Masking, Calorimetry & Tracking 2003-06-01



Tom Markiewicz

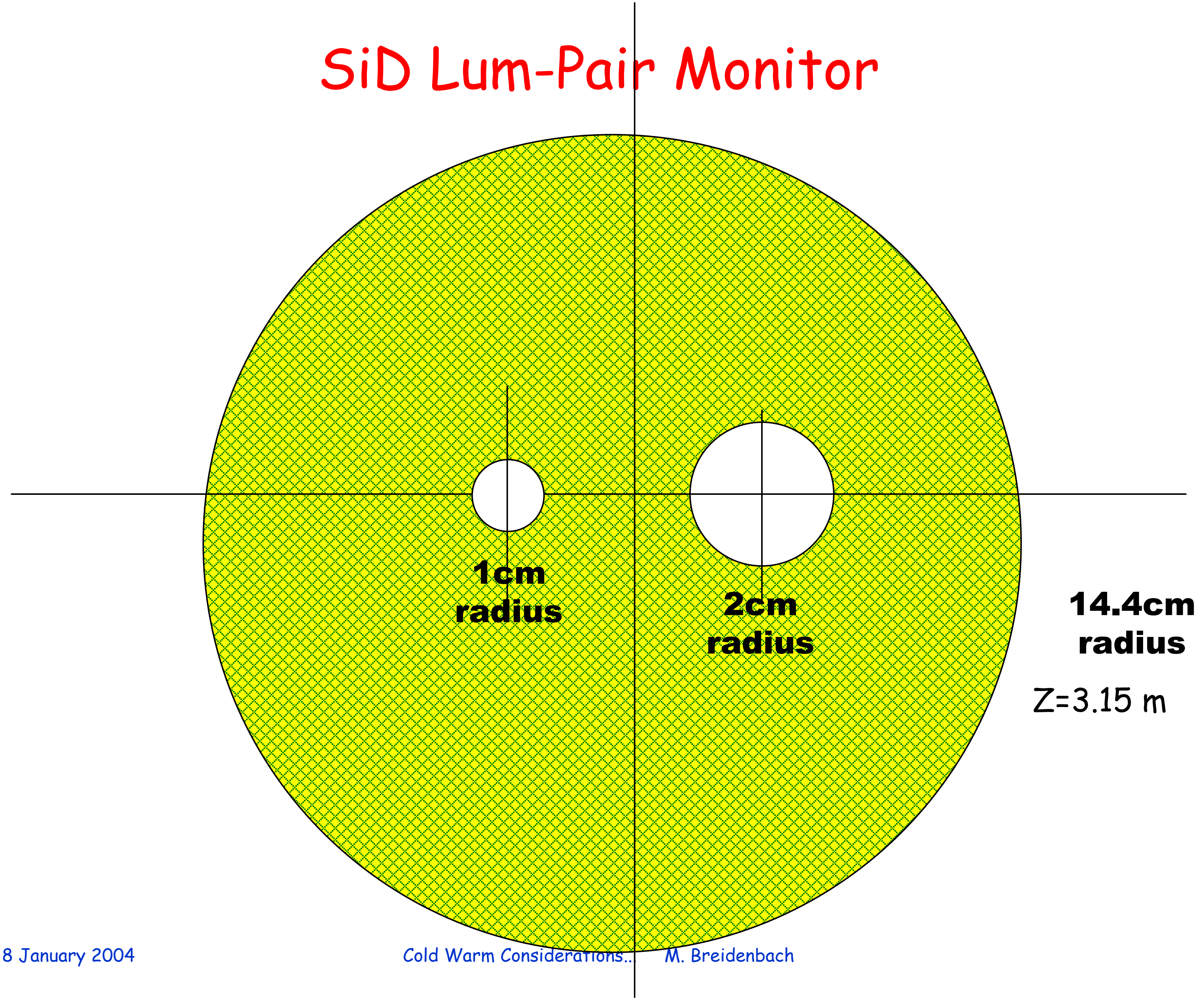
Crossing Angles

- Crossing Angle: Both warm and (U.S.) cold have crossing angles. *[End of discussion!!]*
- Required for downstream beam (LEP) diagnostics. Upgrading to a crossing angle later is ~impossible!
- A crossing angle may well be required for acceptable extraction).
  - Crossing angle does not affect acceptance except for 1 cm Radius entrance hole.
  - Crossing angle has less affect on backgrounds than choice of B field.

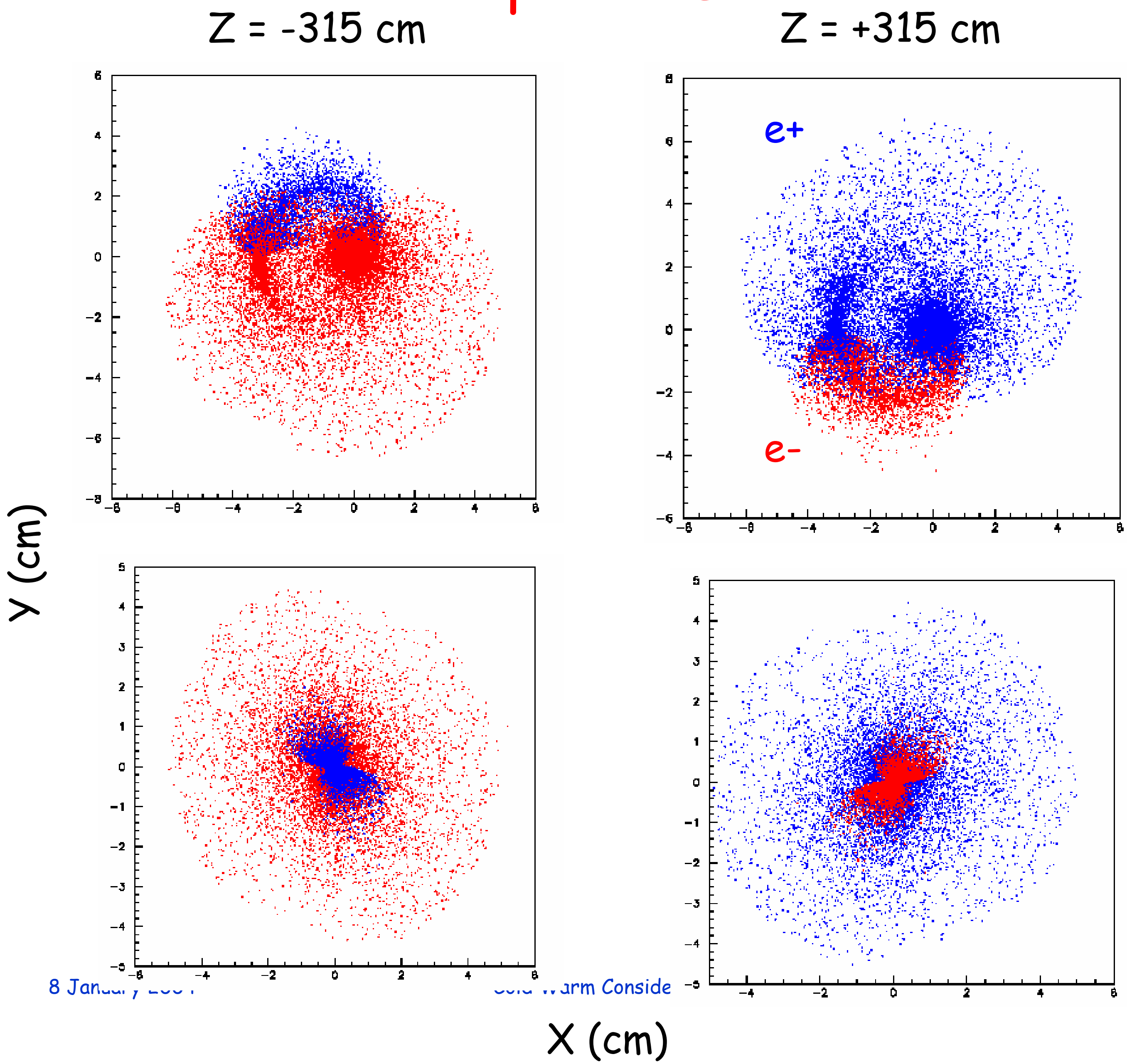
More on Crossing Angles

- The incoming beam line can be quite small, and should be smaller than the beam line through the VXD.
- The outgoing beam line should be set by considerations of the beam divergence and general conservatism.
- If there is no crossing angle (TESLA), than inlet and outlet radii are the same, so VXD desire for small radius implies an aggressive exit radius. A small radius VXD is a happier optimization with a crossing angle.

SiD Lum-Pair Monitor



Pair Spatial Distribution



5 Tesla

20 mr crossing angle

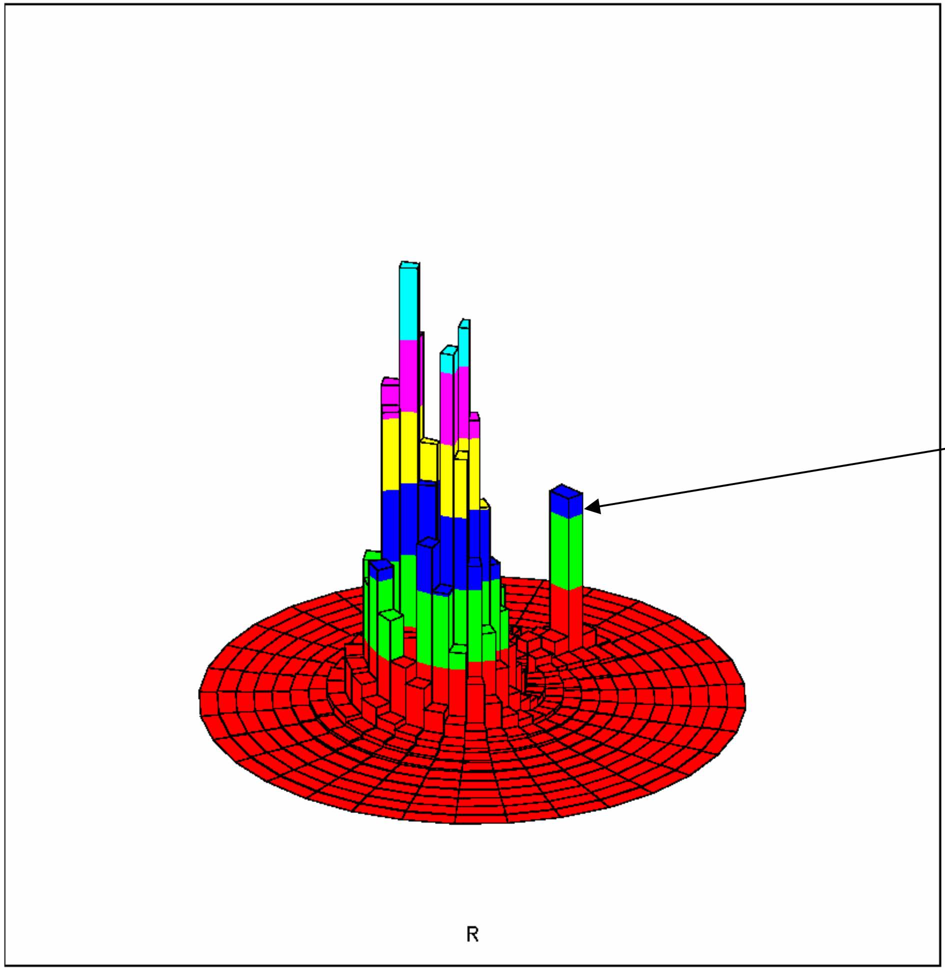
Head-on

Takashi Maruyama

Issues relating to vetos for very forward e's – SUSY searches

- Acceptance: A crossing angle reduces the acceptance by the area of the incoming beamline – (1 cm radius).
- Pileup: One is searching for a 250 GeV e in a sea of perhaps 20 TeV of e+e- pairs. "Cold" samples one bunch easily. "Warm" might sample one or few bunches, but it will require a challenging detector. Since the detector area is tiny, it is plausible. The pair background may be sufficiently statistically stable to allow subtraction, but it probably depends on the pico-details of the bunch structure.

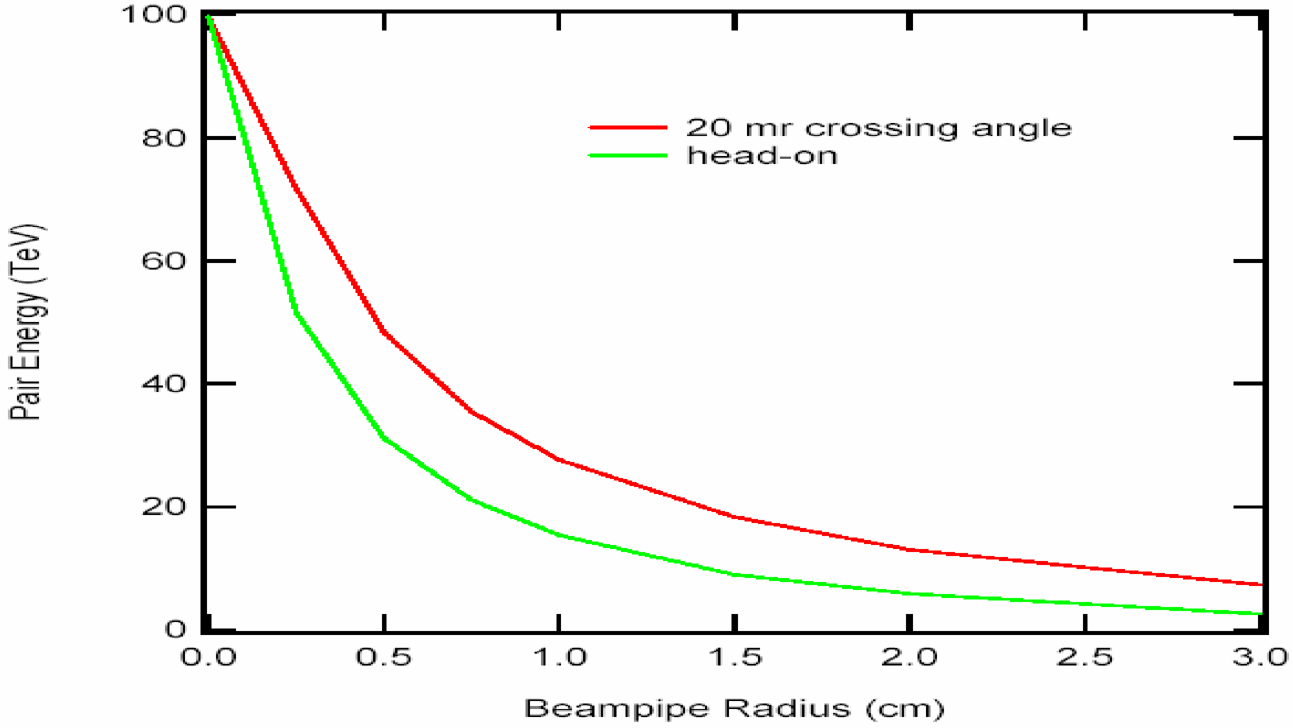
Energy Lego Plot



250 GeV electron

Takashi Maruyama

Pair Energy exiting through Beampipe



Takashi Maruyama

Energy Variability

- NLC was considering permanent magnet final focus quads, but
- US Warm and US Cold are configured with the same superconducting final focus, so
- There should be no difference coming from the Beam Delivery system cold/warm.

Energy and Luminosity

- U.S. Warm and U.S. Cold are both designed as 500 GeV baseline and 1 TeV upgrades.
- It is difficult to see why energy would be a problem as long as there is sufficient overhead in the design. This is not a detector or physics issue!
- The geometric luminosity of both machines is the same. With pinch, cold is higher by 23%.
- Based on SLC experience, it is difficult to see even a factor of two luminosity projections as credible. Critical question is the conservatism of the design – both in the machine physics and reliability. Extremely difficult (impossible???) for experimentalists and theorists to judge.

(My) Conclusions

- "This (the Linear Collider) ain't LEP" John Jaros December, 2003
- The detector can do great physics with either machine
- The detectors will, on balance, be somewhat more challenging for warm, but not sufficiently so as to influence a choice
- I can believe the wise men are wise, but with a few important exceptions, their professional backgrounds seem surprising for what appears an accelerator physics, engineering, and political choice.