IR Geometries & Constraints on Forward Detectors

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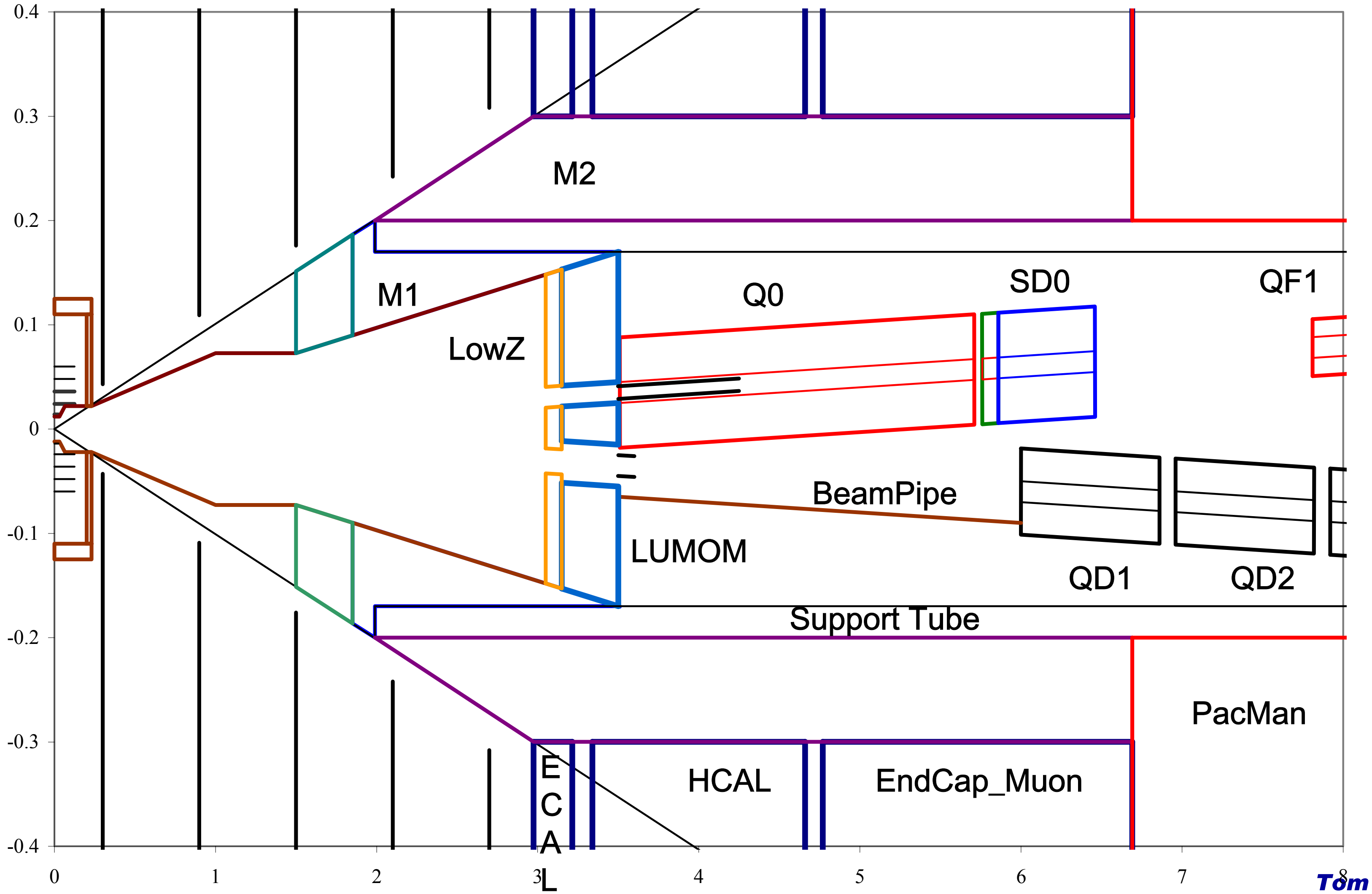
Motivation

- Despite MIB comments from yesterday ECFA BDIR group is still studying physics impact of hole in forward acceptance due to crossing angle and any possible loss of physics sensitivity due to pile-up in any sub-detector as relevant input to the ITRP
  - e- ID in LUMON
  - $\gamma\gamma \rightarrow$hadrons backgrounds in the central calorimeters
- This session designed to give audience a chance to (re)learn what is fundamental from what is a design choice
- You have heard it all before

LD IR Layout



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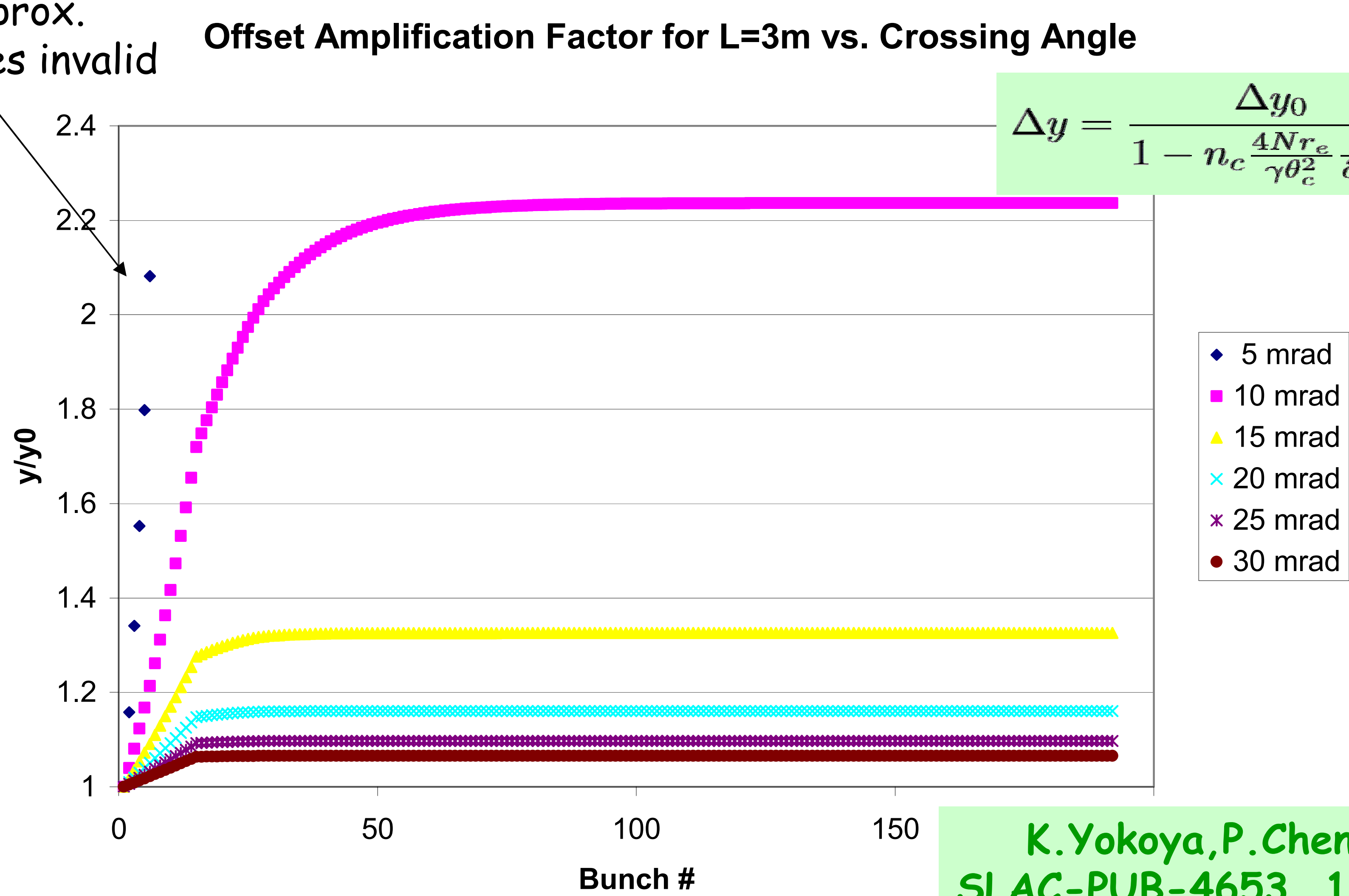
Crossing Angle

- Warm LC requires non-zero crossing angle
- Cold LC can choose zero or non-zero angle
- Minimum angle set by:
  - Need to avoid parasitic collisions and beam-beam induced jitter (20 mrad)
  - Need enough transverse space for QD0 magnet, given
    - L* (a semi-free parameter) (3.51m)
    - Exit aperture at LUM (2.0 cm)
    - QD0 bore size (1.0 cm)
    - Design choice that exit beam goes outside of QD0
- Maximum angle set by
  - Estimated performance ($\Delta\phi$) of Crab Cavities on either side of IP that rotate bunches (~40 mrad)
  - Beam optics effects:
    - ε growth due to SR in QD0 goes as $(B_s L^* \theta)^{5/2}$

Multi-bunch interaction increases static beam offsets if θ_c too small

Approx. becomes invalid



$$\Delta y = \frac{\Delta y_0}{1 - n_c \frac{4Nr_e}{\gamma\theta_c^2} \frac{\partial y'}{\partial \Delta y}}$$

K.Yokoya, P.Chen
SLAC-PUB-4653, 1988

NLC Final Doublet Quad Specs

TRC (2002) 500 GeV Lattice

Magnet	Aperture	Gradient	Rmax if REC	Radial Space	Z_ip	Length
QD0	1.0 cm	141.6 T/m	5.3cm	5.0cm	3.51 m	2.2m
QF1	1.0 cm	80.2 T/m	2.7cm	>7.81cm	7.81 m	2.0 m

Increased LUM aperture decreasing available space

Snowmass 2001 500 GeV Lattice

Magnet	Aperture	Gradient	Rmax if REC	Radial Space	Z_ip	Length
QD0	1.0 cm	144 T/m	5.5cm	5.8cm	3.81 m	2.0m
QF1	1.0 cm	36.4 T/m	2.2cm	>7.81cm	7.76 m	4.0 m

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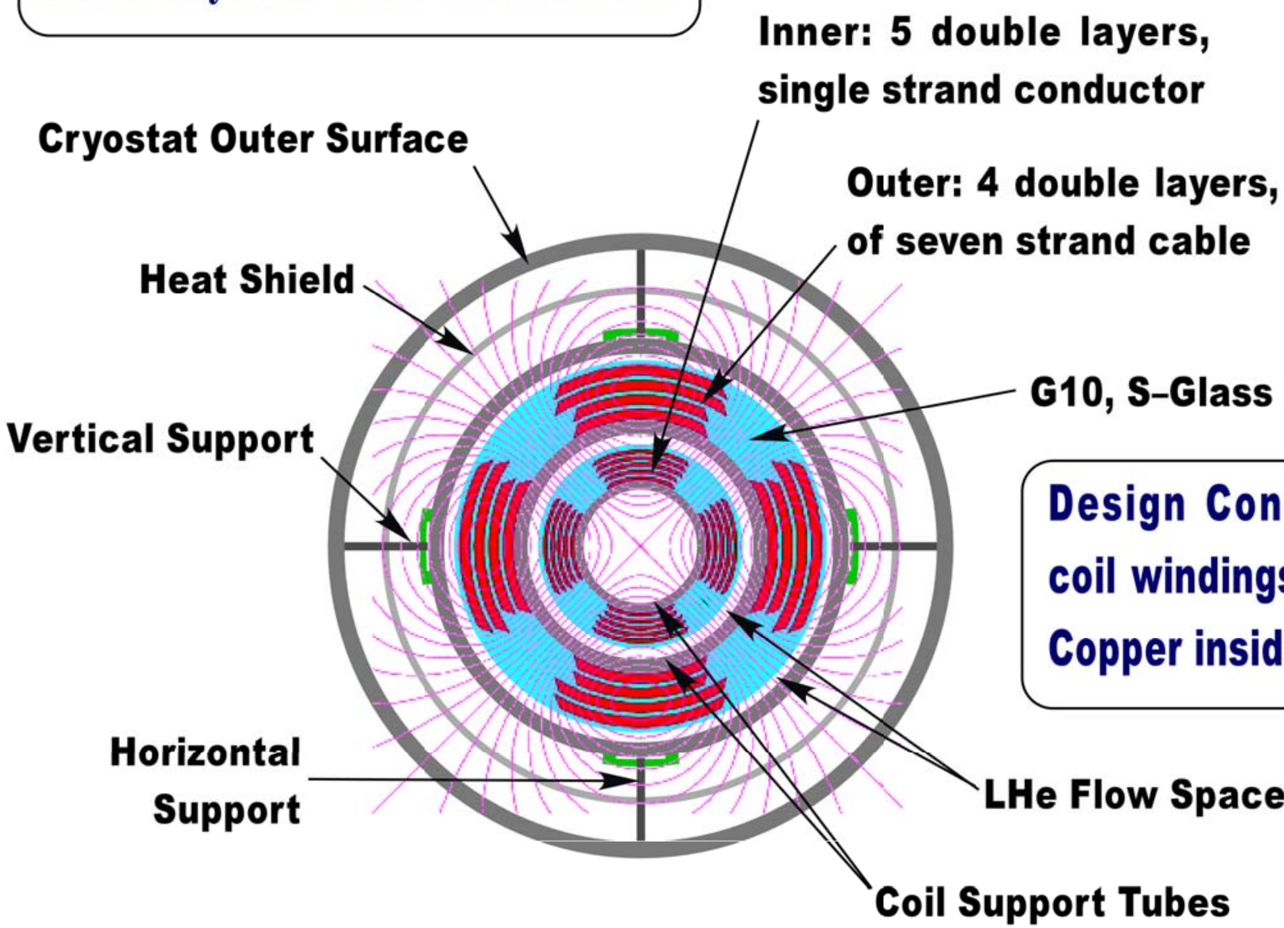
SC Magnet
If r_{in}=10mm, r_{out}=57mm seemed easy

Inner Beam Tube	20 mm ID
Outer Cryostat Tube	114 mm OD



QDO Coil Parameters

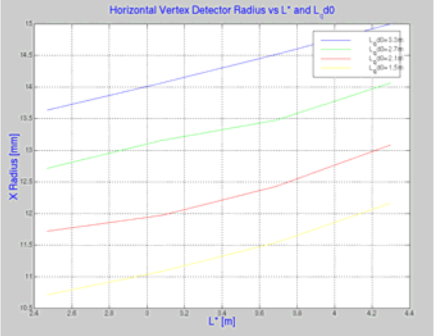
Inner Quad	63 T/m
Outer Quad	81 T/m
Total Quad	144 T/m

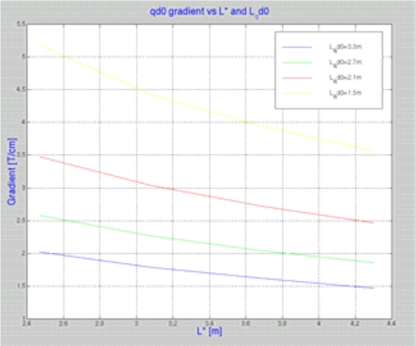
Design Concept: Two independent coil windings. Integrated helium flow. Copper inside inner coil support tube.

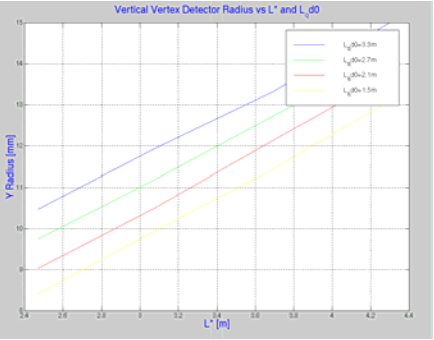
L*=Distance from IP to QD0

- A parameter that can be varied within a range for either design
  - r_vxd, z, length, aperture, gradient of QD0, QF1 all enter
- Motivations for larger L*
  - Move QD0 outside the detector to stable ground
  - Move LUMON further back if pair backsplash a problem
- Note: L* of EXTRACTION LINE now 6m
  - Its z position variable as well
  - Especially valuable as it receives biggest hit from 4 GeV pairs

L* Optimization
P.Raimondi
~2001



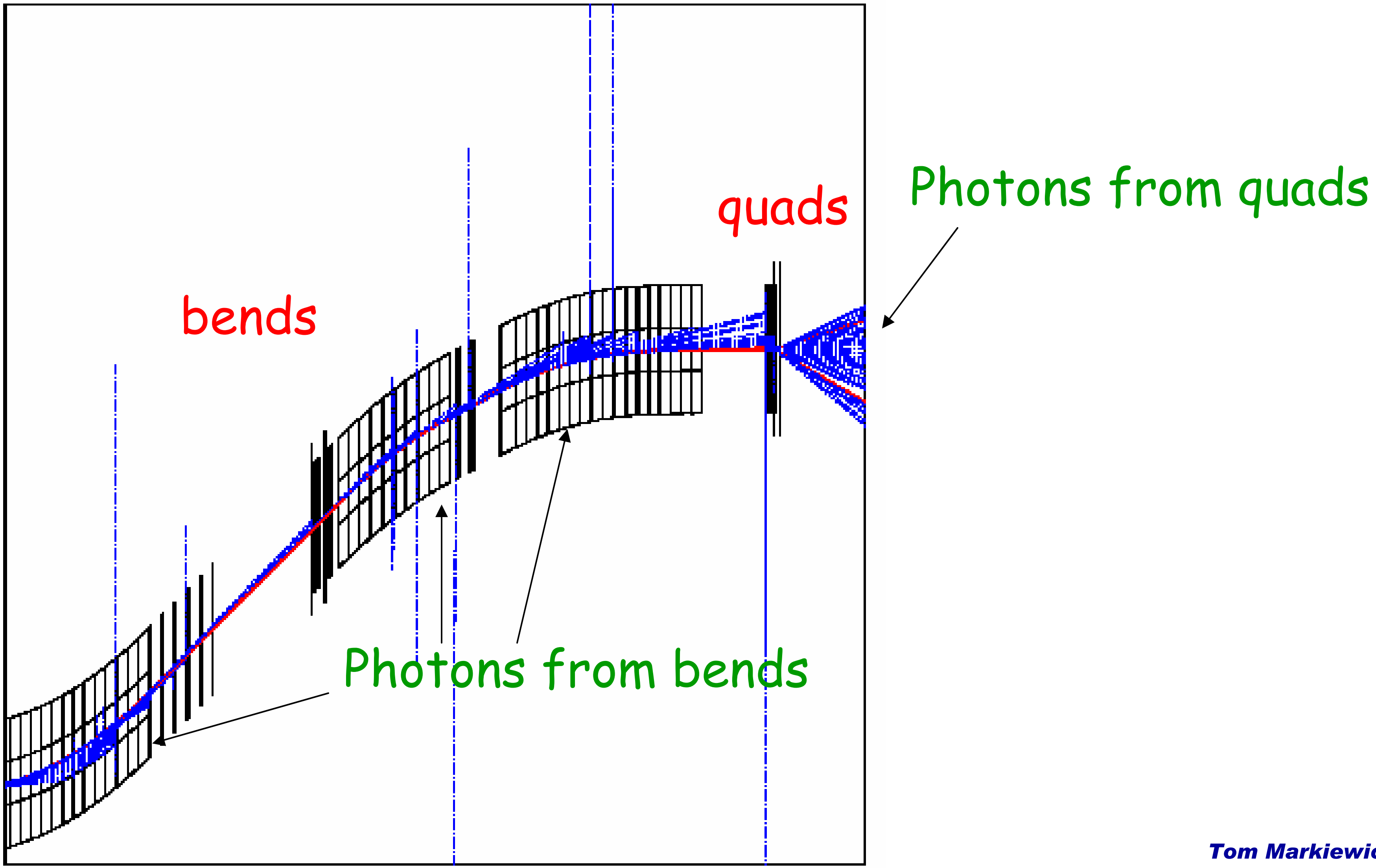




Exit Aperture at LUM
Beam Pipe Radius at IP

- Same issues for warm vs. cold choice
- Set by (arbitrary?) design requirement that ALL Synchrotron Radiation Leaves IP
  - Collimation system design & performance
  - Magnitude and distribution of non-gaussian beam halo
  - Level of aggression in setting collimators and resultant
    - beam jitter amplification due to collimator wakefields
    - muon production
  - Level of conservatism
    - Worst beam conditions system must safely handle
  - Advantage in reducing albido from splattered e+e- pairs in having the high Z LUM at a larger radius than the low Z albido absorber

Synchrotron Radiation



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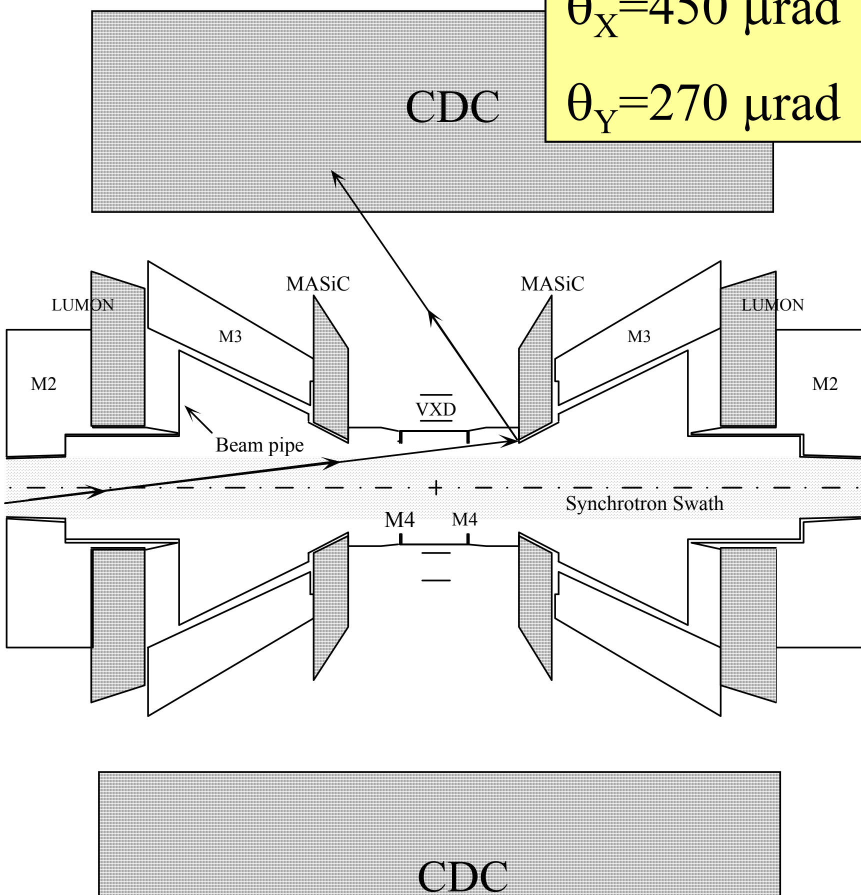
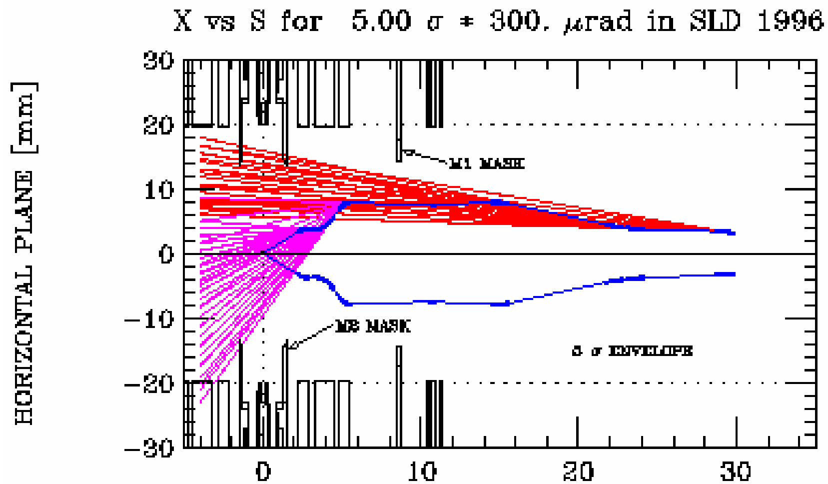
At SLD/SLC SR WAS THE PROBLEM

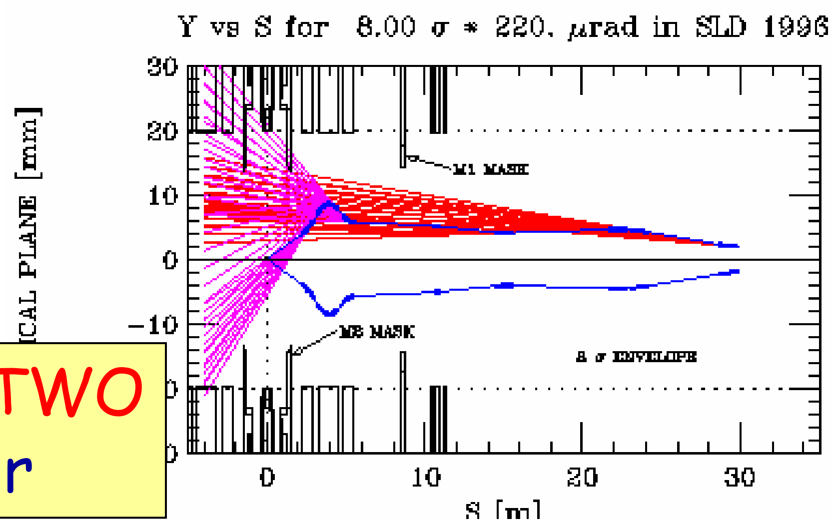
θ_X=450 μrad

θ_Y=270 μrad





SR Fans from Halo in Final Focus



Photons need a minimum of TWO bounces to hit a detector

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SR at Warm/Cold LC

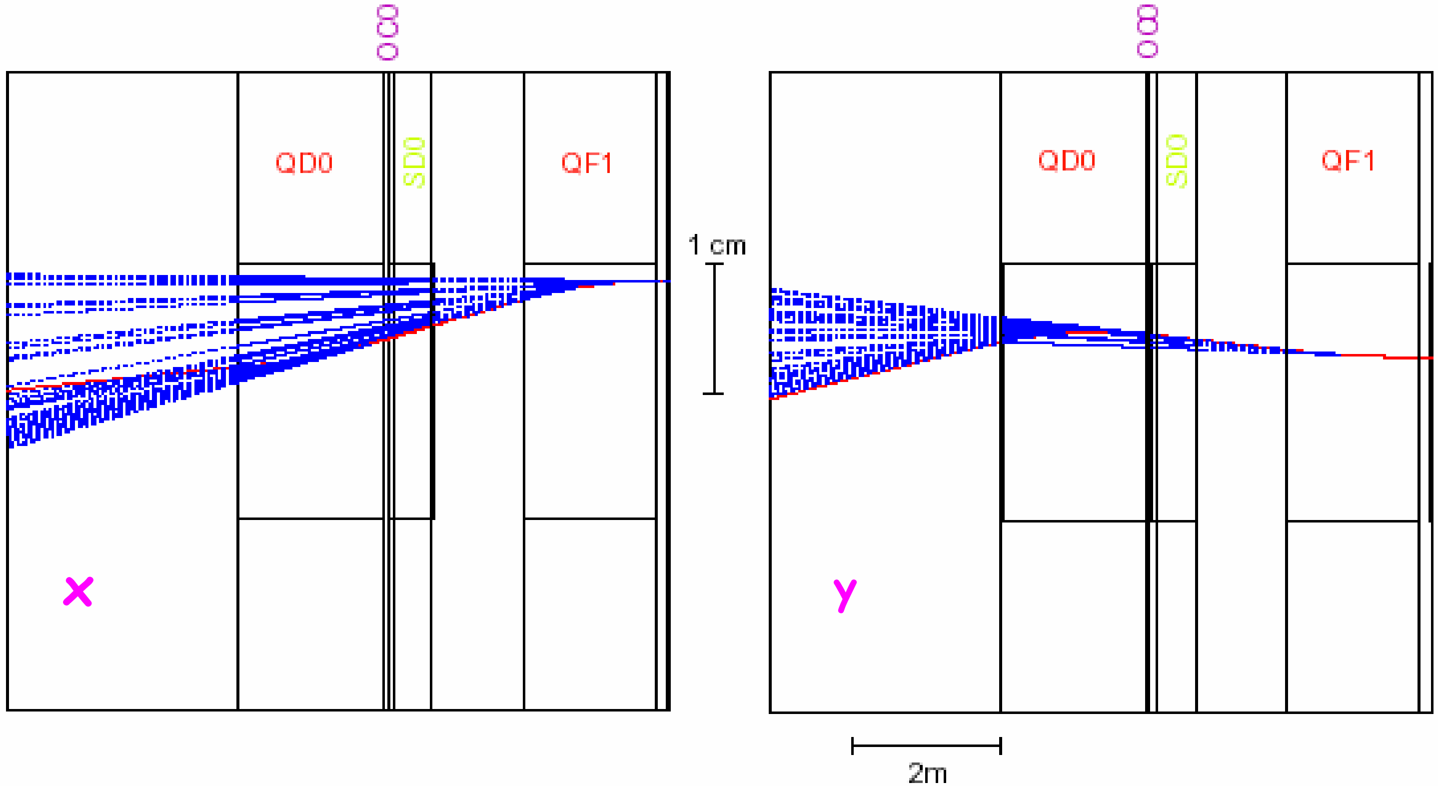
θ_X=30.3 μrad

θ_Y=27.3 μrad

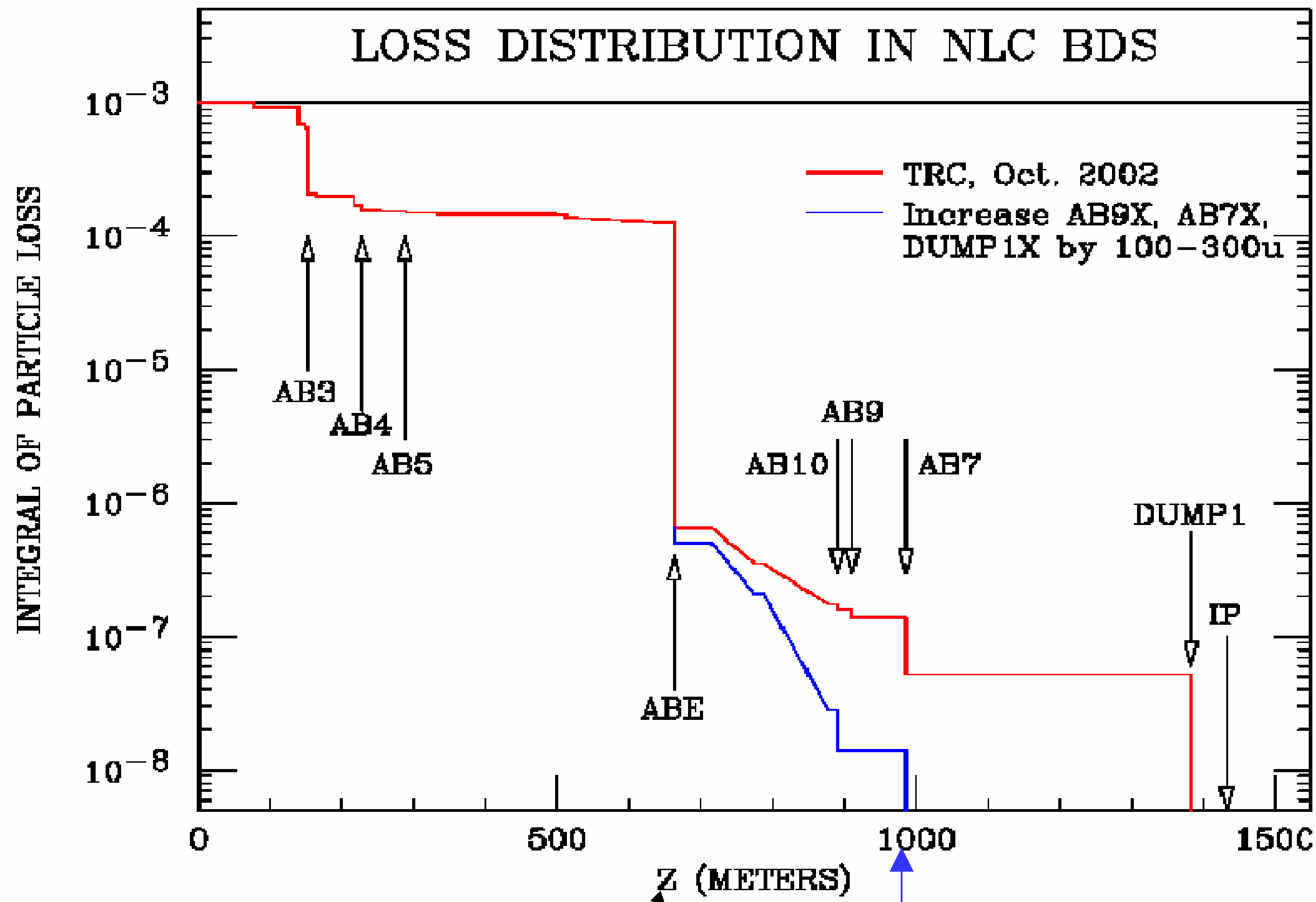
Design Criteria: NO Photons hit beampipe at IP or LUM

(IP) x' < 570 μrad = 19 x 30.3 μrad y' < 1420 μrad = 52 x 27.3 μrad

(LUM) x' < 520 μrad = 17 x 30.3 μrad Y' < 1120 μrad = 41 x 27.3 μrad



NLC Collimation System Designed to Make Detector Free of Machine Backgrounds



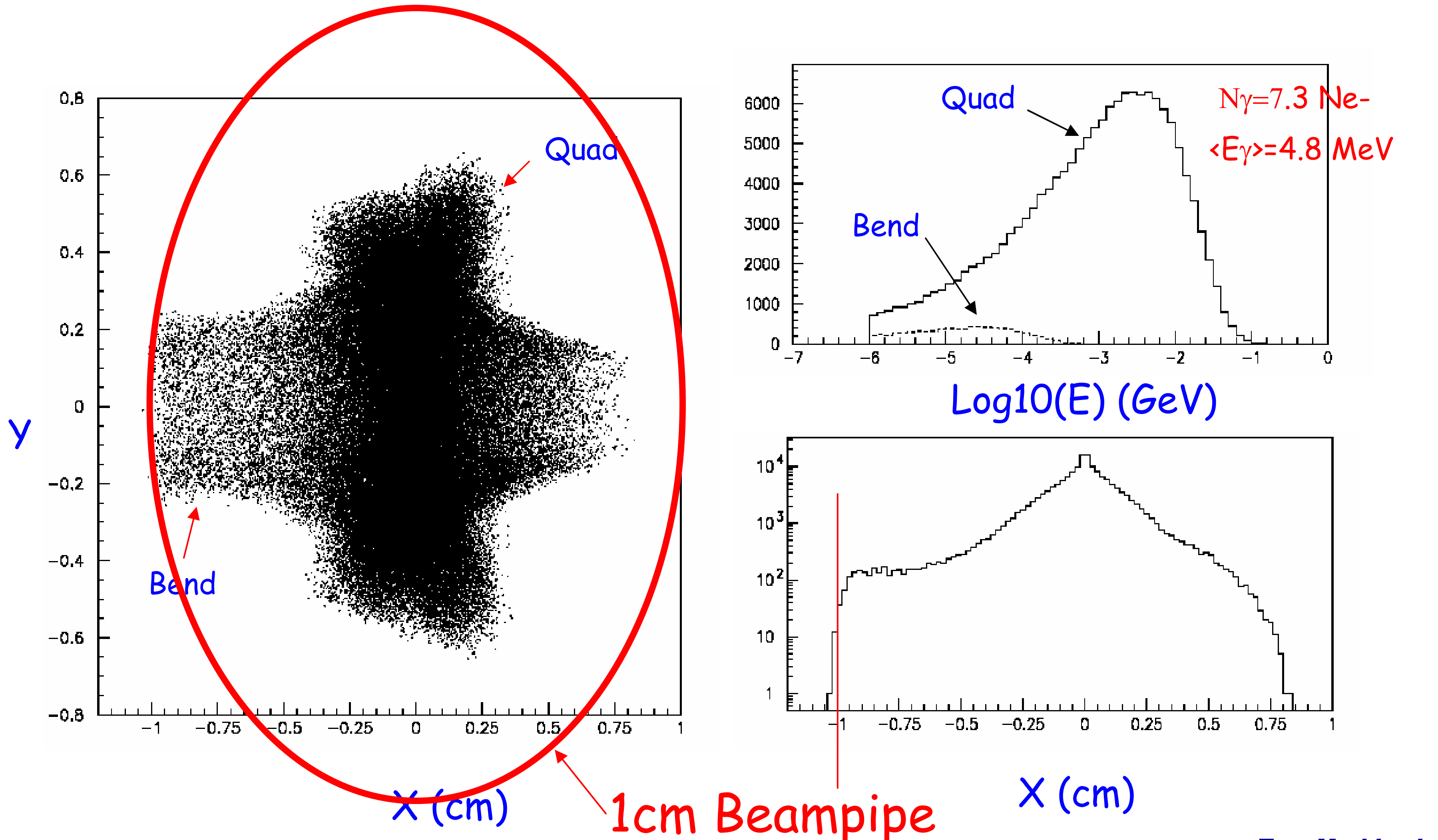
E=250 GeV

N=1.4E12

0.1% Halo distributed as 1/X and 1/Y for $6<A_x<16\sigma_x$ and $24<A_y<73\sigma_y$ with $\Delta p/p=0.01$ gaussian distributed

Last Lost e- 1000m from IP

SR at IP due to Halo



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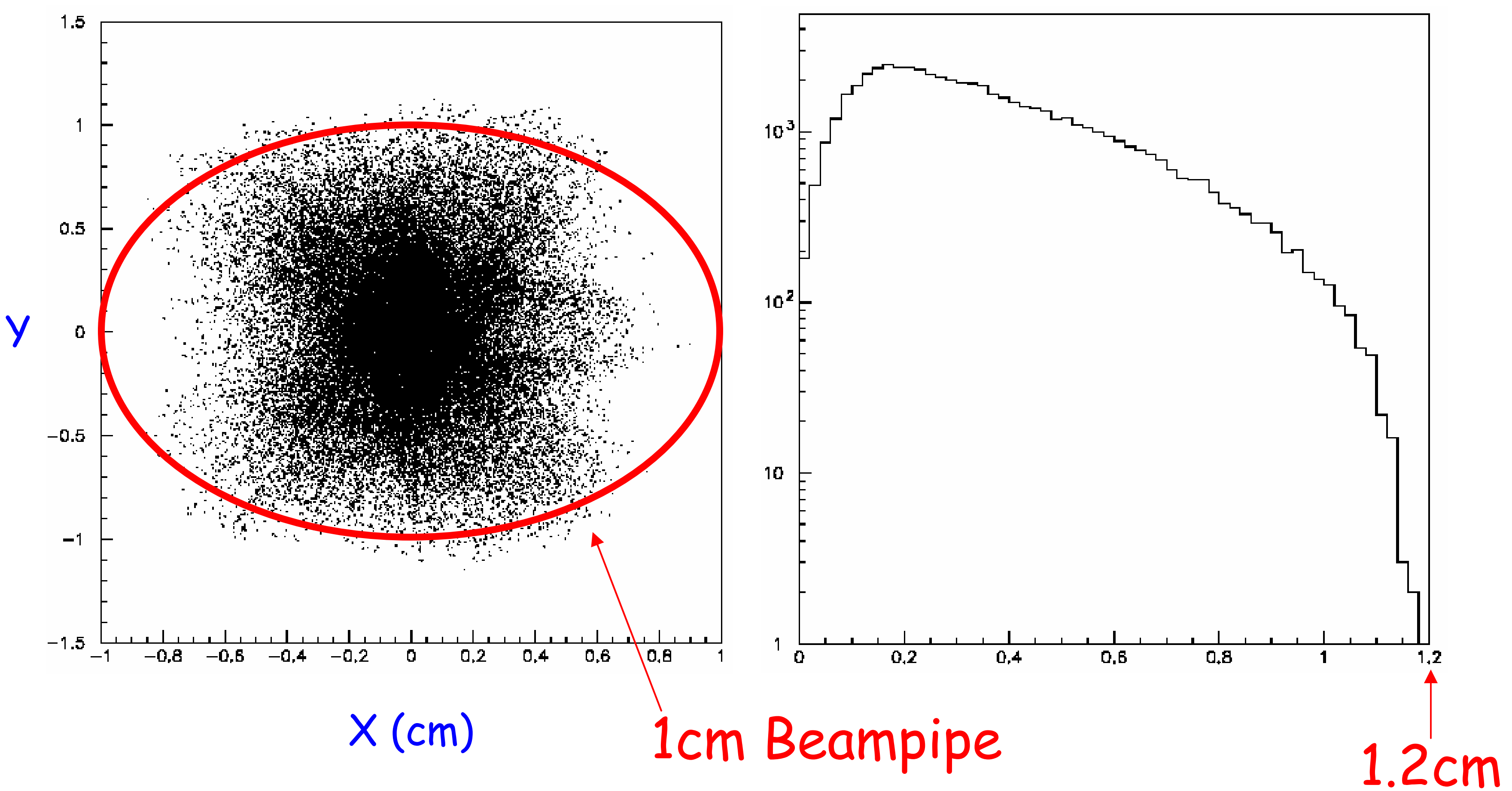
Quad SR at z=-3.15m

Set Low Z Mask aperture at 1.2cm



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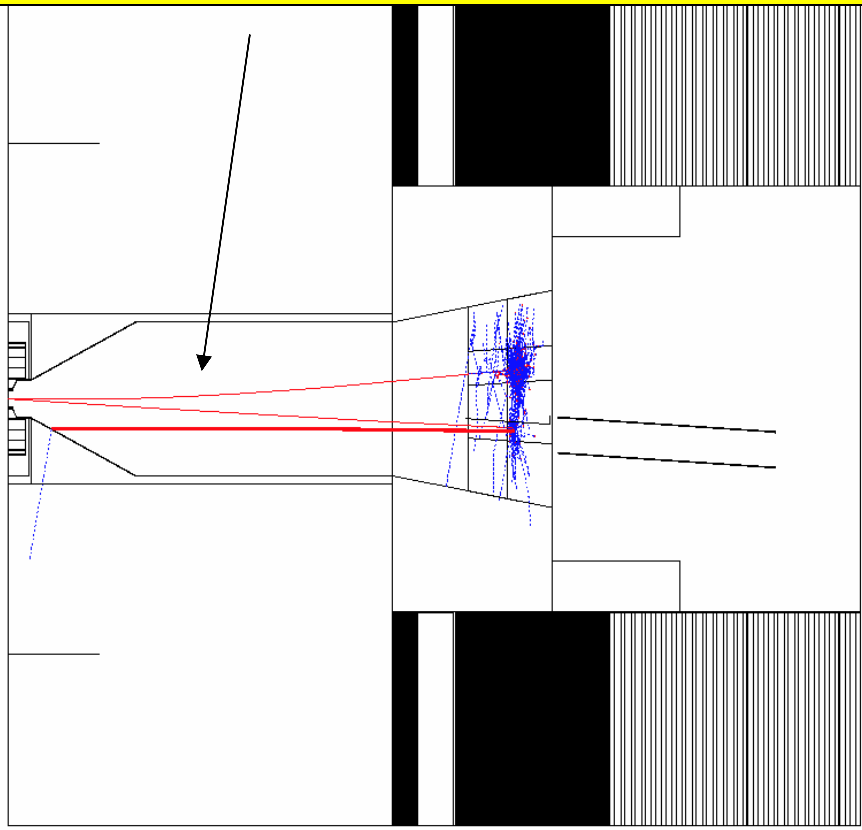
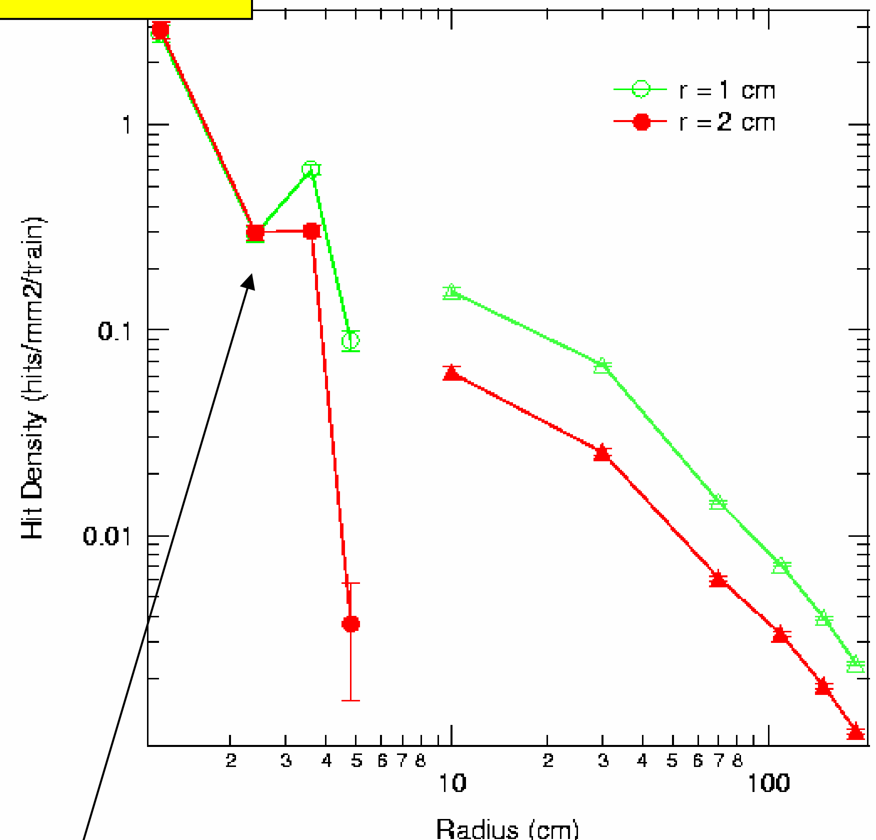
If LUM Aperture 1cm→2cm Hit Density r>3cm improves

Albido from pairs making hits in VXD





L1 & L2 of VXD Unchanged
Improvements for outer detectors

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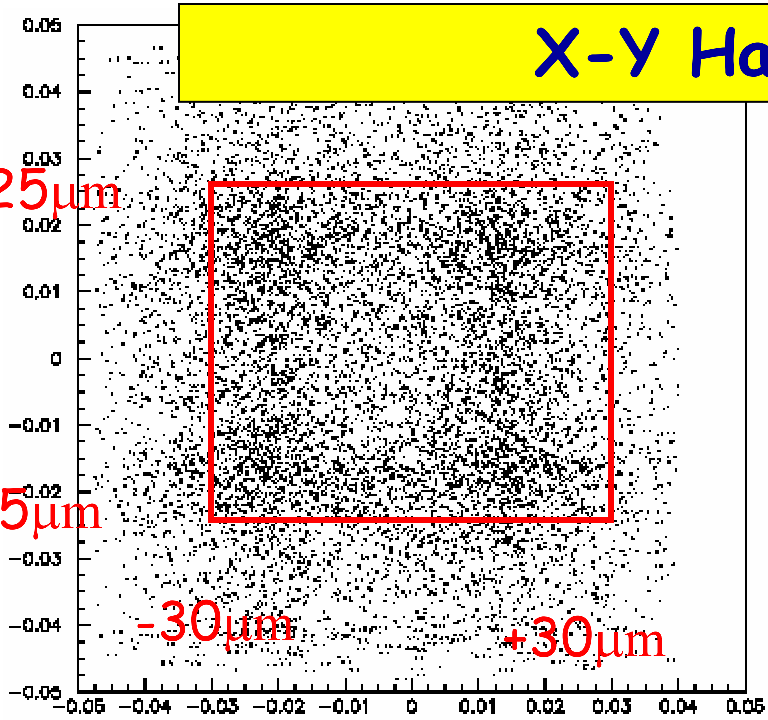
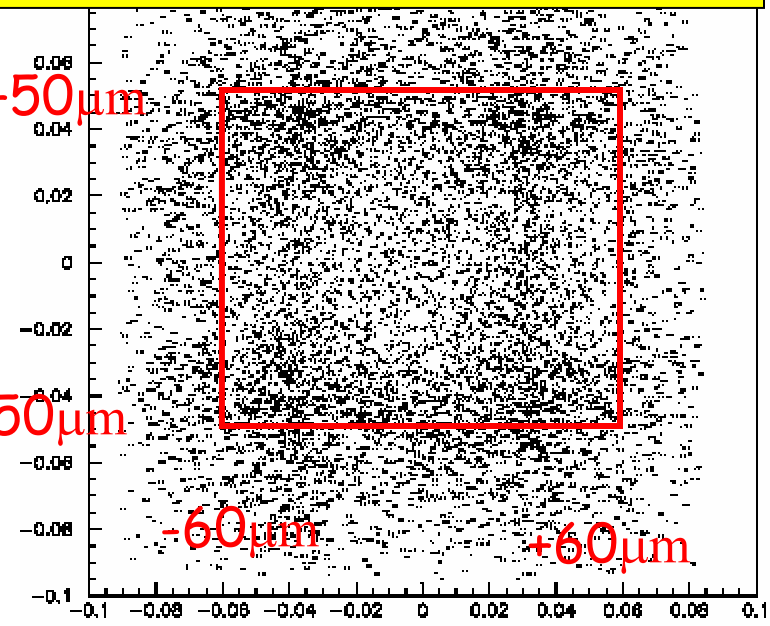
Study Non-Optimal Running Conditions

Open Collimators x2 & Broaden Halo x2 so that 10^{-5} of beam is lost on SR Dump at IP

X-Y Halo at Spoiler #3





Design

$\pm 30\mu m \times \pm 25\mu m$

$6\sigma_x < A_x < 16\sigma_x$

$24\sigma_y < A_y < 73\sigma_y$

$\pm 60\mu m \times \pm 50\mu m$

$12\sigma_x < A_x < 32\sigma_x$

$48\sigma_y < A_y < 146\sigma_y$

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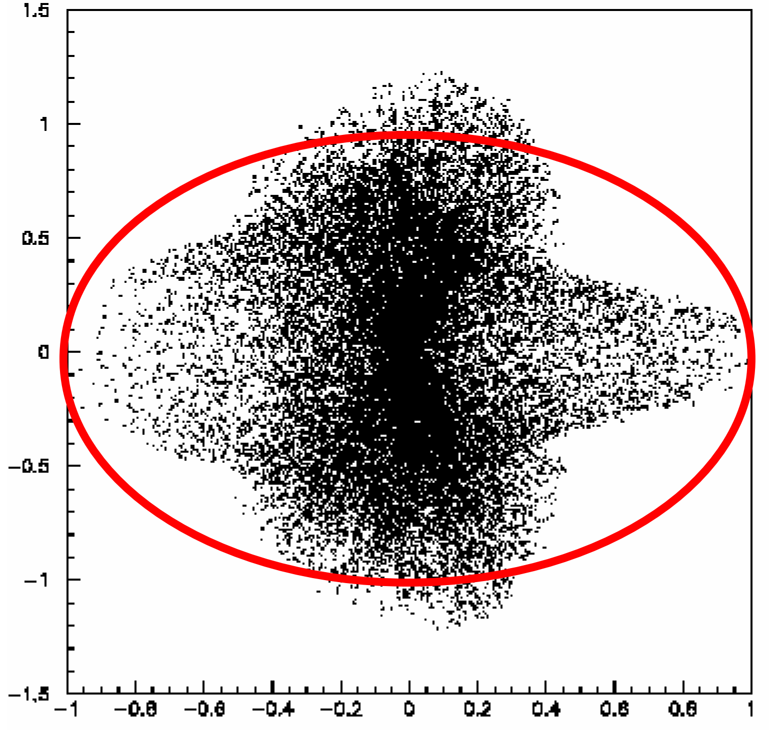
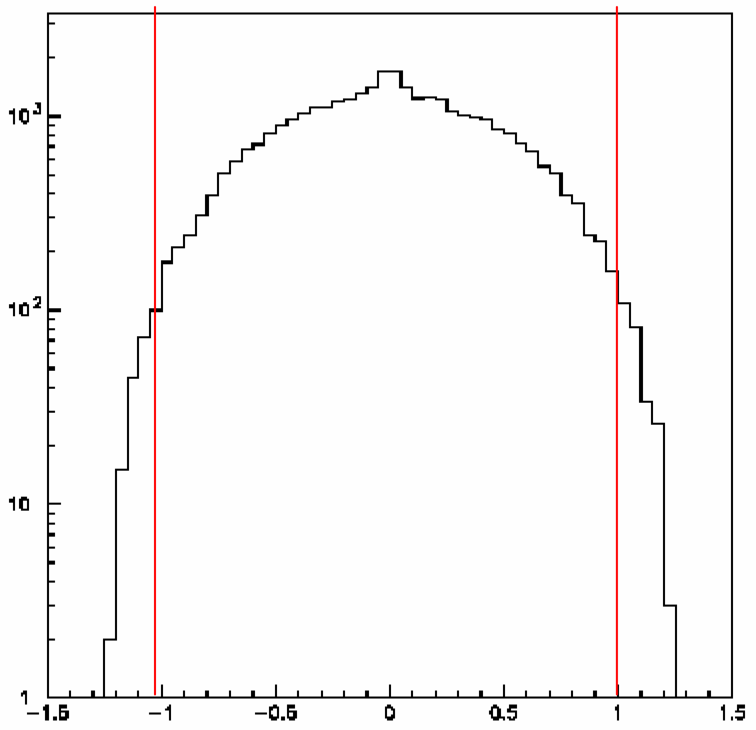
SR at IP in “1000x worst case” Study

SR distribution ~2x wider in y at IP with direct hits unless BP >1.25cm





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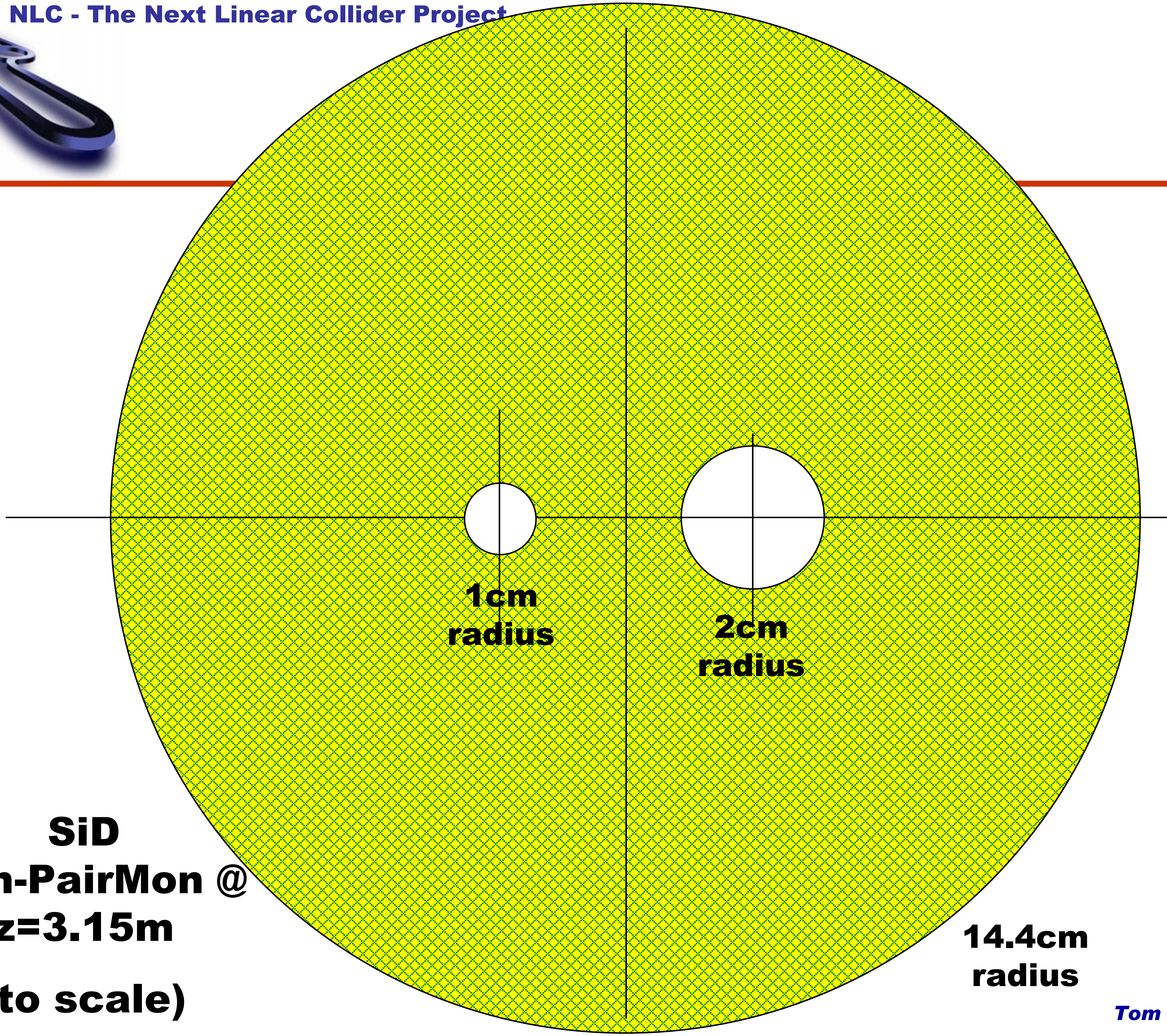


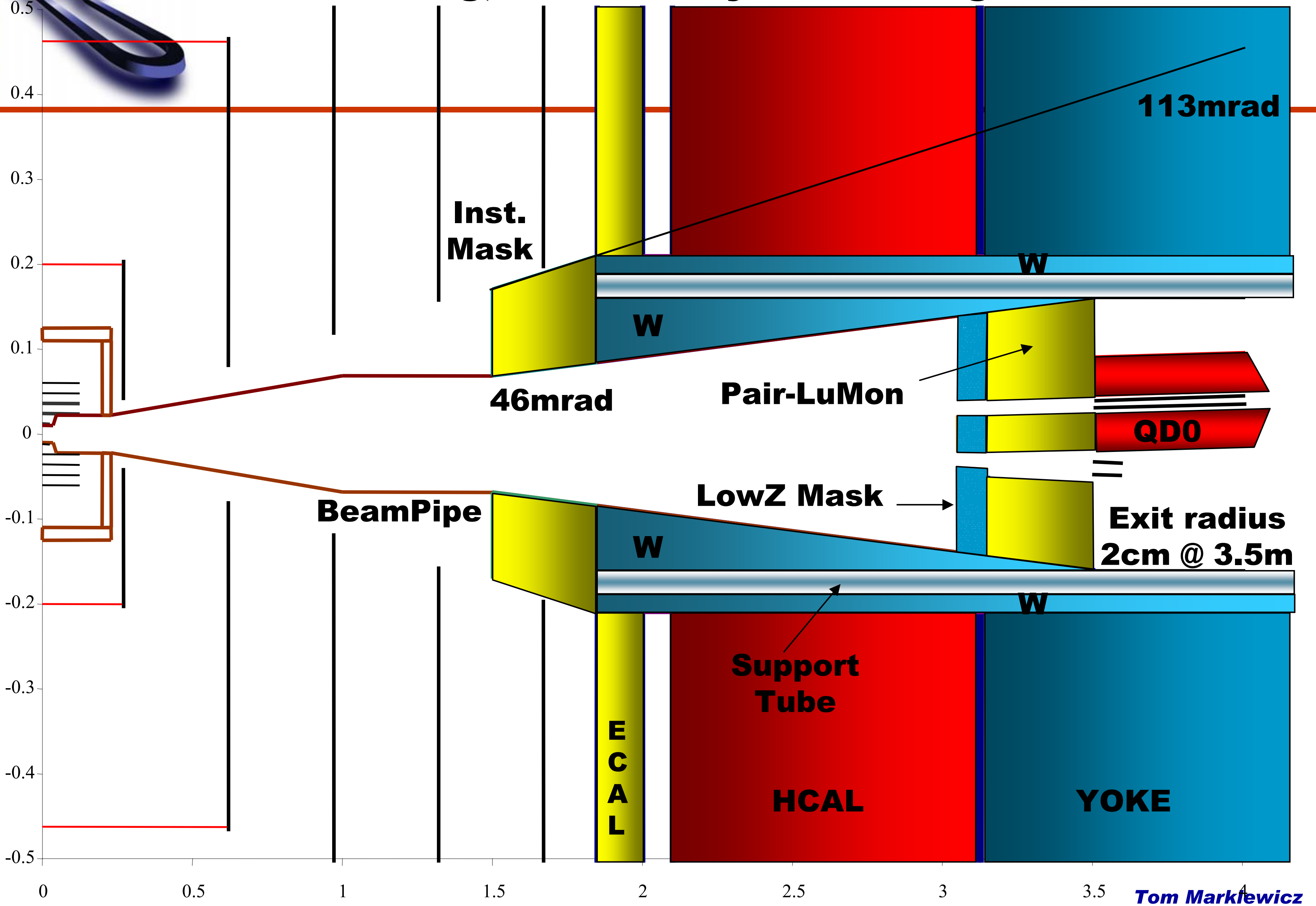
SiD
Lum-PairMon @
z=3.15m

(to scale)

Junctions between ECAL & Instrumented Mask & Pair/Lumon

- Not fundamental to warm/cold choice
- LD & SiD pictures have not had proper review for either engineering or physics
- SiD Design Points
  - Vibration sensitive QD0 magnets supported in ~20cm radius cantilevered tube with 3cm wall
  - Tube carries weight of Instrumented mask, Pair/Lumon and any non-cylindrical W masking WHEN DETECTOR OPEN
  - WHEN DETECTOR CLOSED, non-QD0 weight transferred to cylindrical W mask permanently inside detector
  - 35cm thick Instrum.Mask & SiD z_Ecal=1.85m define z_mask=1.5m
  - Add conic W masking to maintain ~6-10cm shielding LUM to Detector
- LD:
  - keep z_mask=1.5m so distance to Lum is same as for SiD
  - 10cm cylindrical W mask & appropriate conic W shielding up to LUM

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



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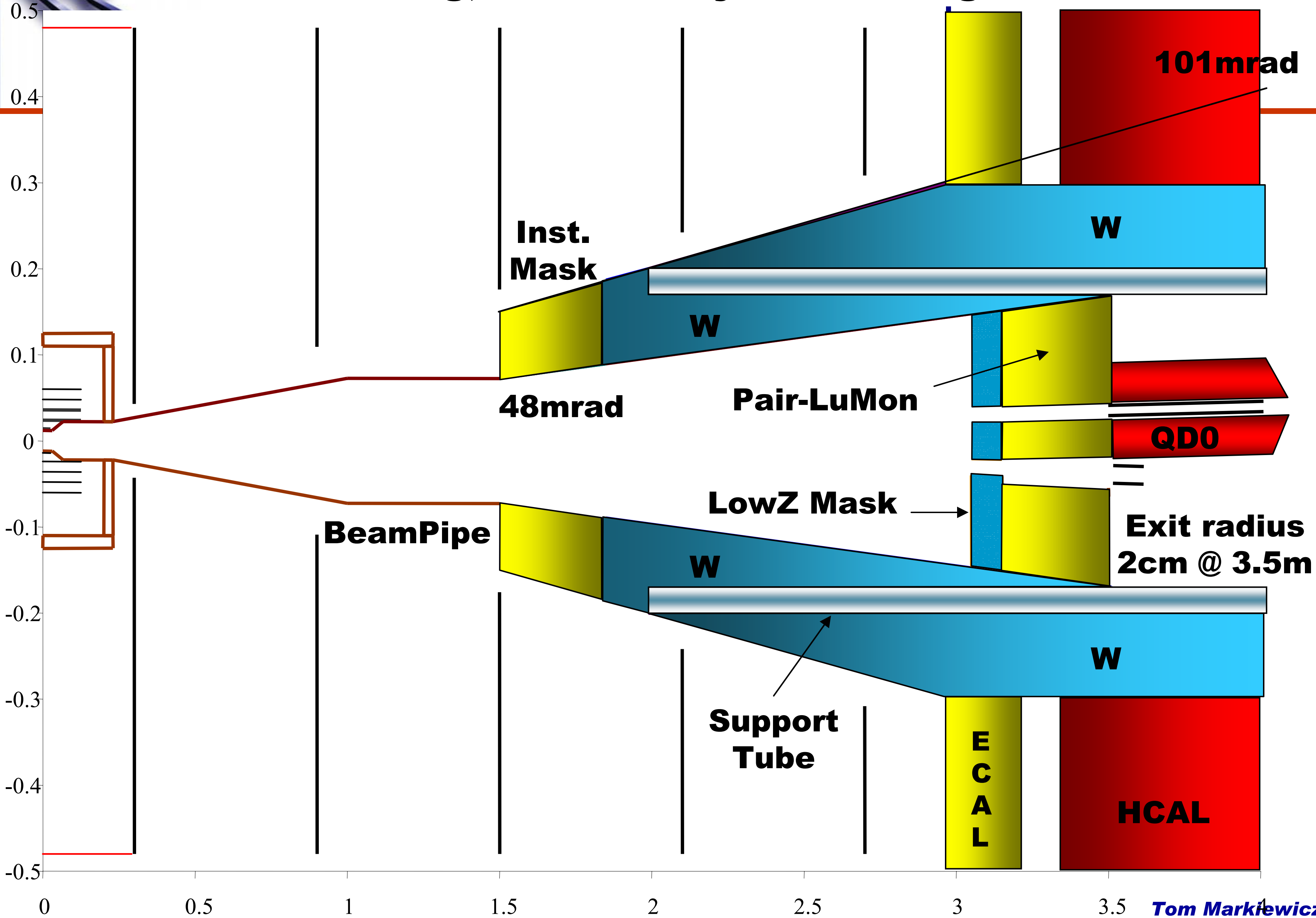
LD Forward Masking, Calorimetry & Tracking 2003-06-01



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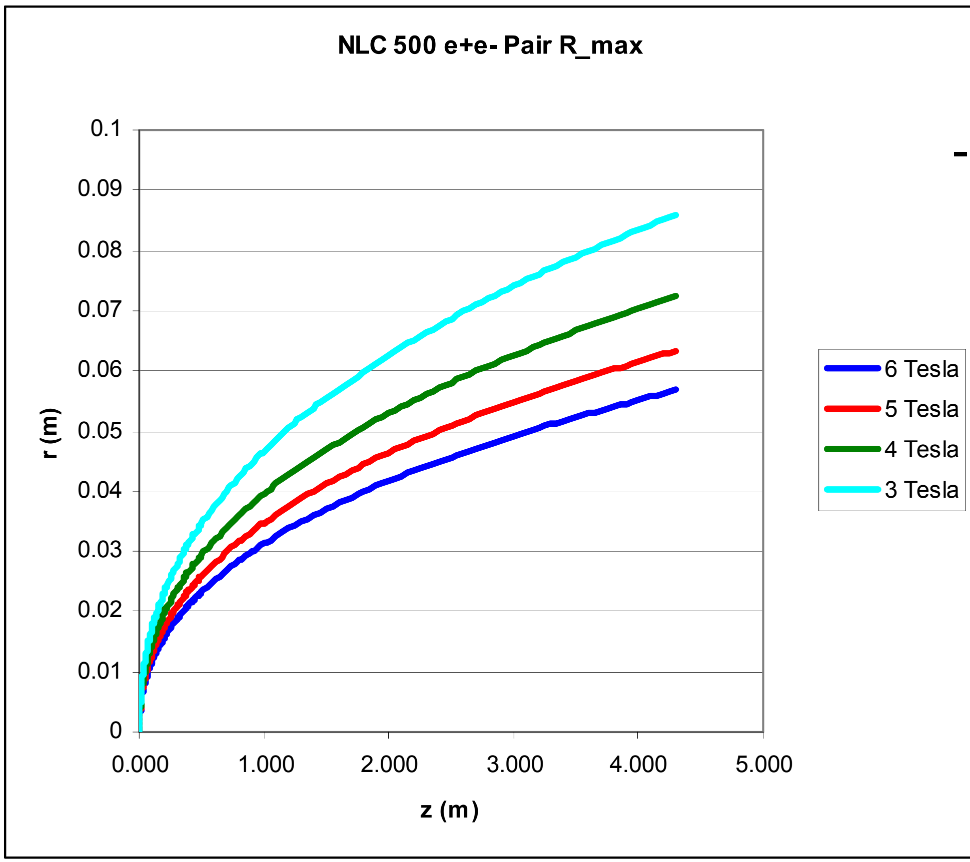
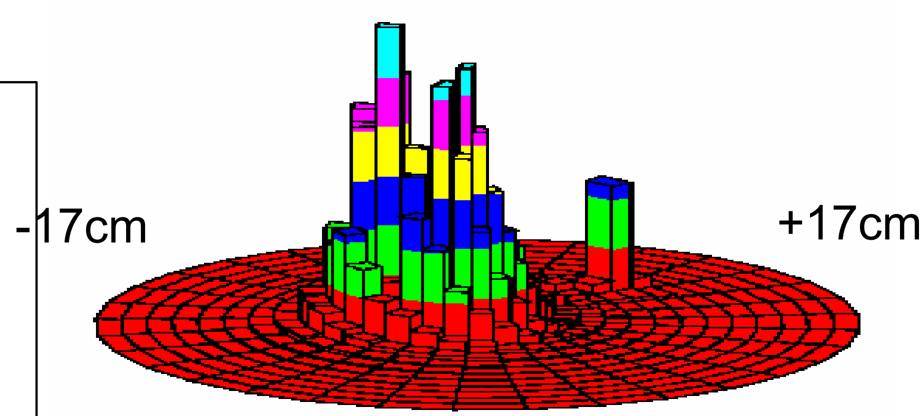
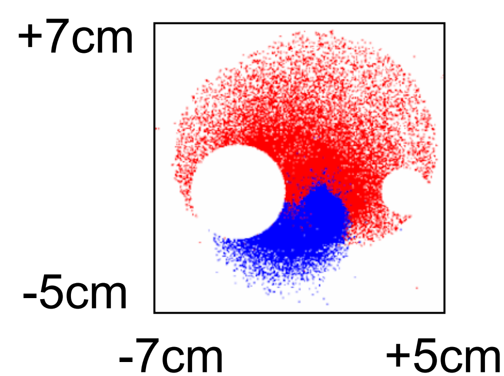
LUMON Hammered with Pairs to r~6-7cm







Dimensions defining Forward Calorimeters

	Large Detector-3 T				Silicon Detector-5 T			
	Ecal	I-Mask	Clean Lumon	Pair Lumon	Ecal	I-Mask	Clean Lumon	Pair Lumon
z (m)	2.975	3.500	3.150	3.150	1.850	3.500	3.150	3.150
r (m)	0.300	0.170	0.075	0.020	0.210	0.160	0.055	0.020
θ_{min} (mrad)	100.5	48.5	23.8	6.35	113.0	45.7	17.5	6.35
θ_{max} (mrad)		100.5	48.5	23.8		113.0	45.7	17.5

Personal Views

- If advertised luminosity is delivered, physics inside of ~25 mrad will be a real bitch for any machine
- I can't believe that either a hole in that region or that pileup in that region should drive technology choice
- I am happy to hear real physics analyses which show otherwise and that are crucial enough to demand a zero crossing angle