Effect of Geometric and L* Changes on Vertex Detector

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Motivation

Original SiD L^* was 3.5m (SiDLOI3); in interest of a common ILD/SiD L^*, we have explored the effect of increasing this to 4.1m

Also, interest in effects/necessity of anti-did field in light of new BeamCal plug region designs

Explored effect on Vertex Detector occupancy

May be *fait accompli* at this point but worth noting the effect.

Tools

GEANT4 implemented via SLIC geometry wrapper

Geometry implemented with LCSIM GeomConverter package

SLCIO output analyzed within LCSIM framework

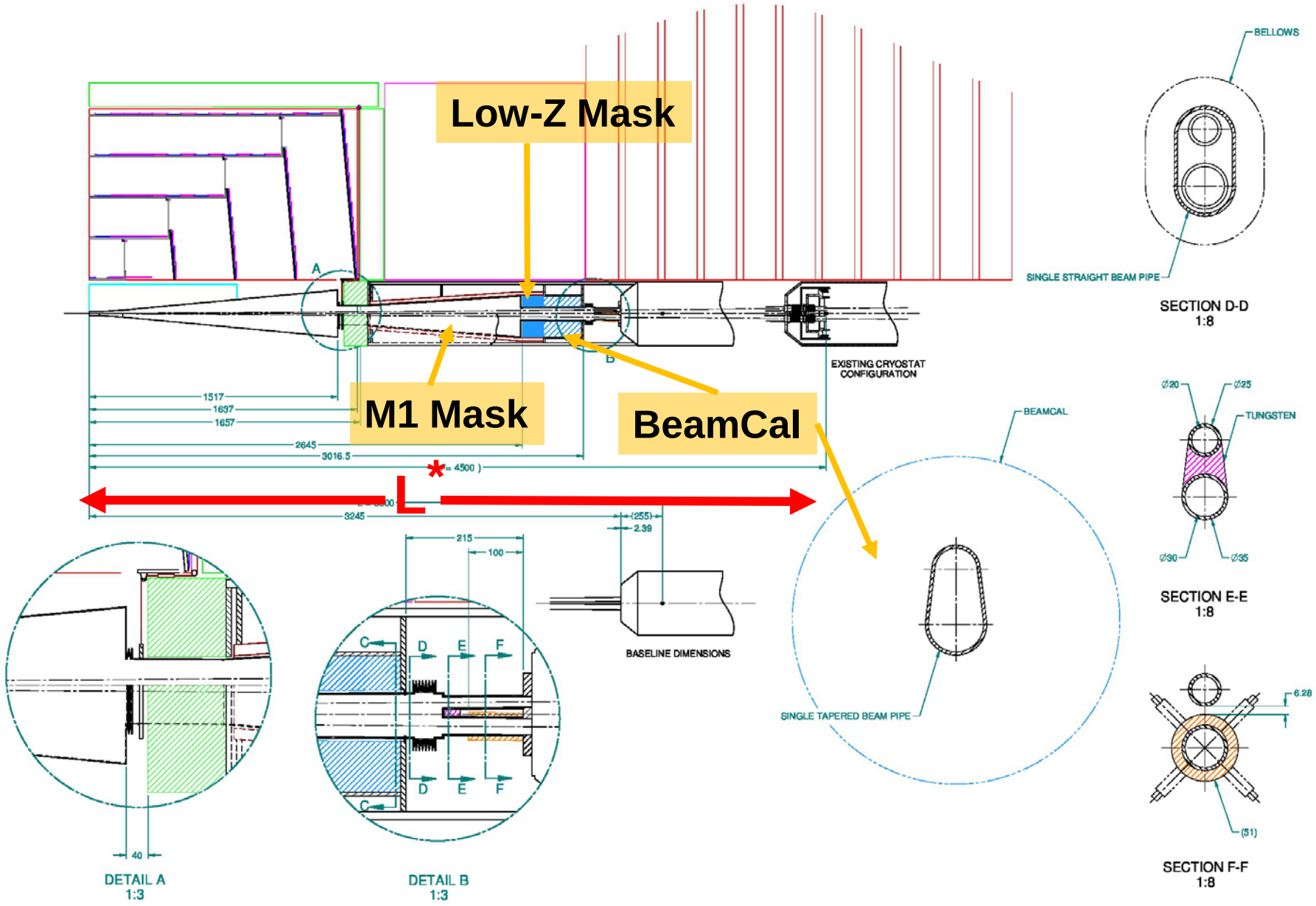
Note: the pairbackground stdhep files were provided by Anne Schuetz (DESY), and were simulated on the GRID by Jan Strube (PNNL)

Geometry Clarifications

Interaction Region has been realigned to be concentric about the outgoing beampipe

Shifting in L* means moving BeamCal and Forward Low Z mask, and lengthening the Forward M1 mask

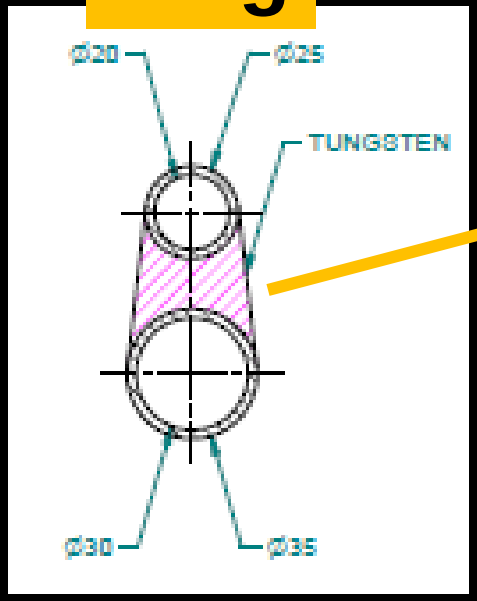
IR Layout


Low-Z Mask
M1 Mask
BeamCal
EXISTING CRYOSTAT CONFIGURATION
BASELINE DIMENSIONS
BEAMCAL
SINGLE TAPERED BEAM PIPE
BELLOWS
SINGLE STRAIGHT BEAM PIPE
SECTION D-D
1:8
TUNGSTEN
SECTION E-E
1:8
SECTION F-F
1:8
DETAIL A
1:3
DETAIL B
1:3
10-27-11

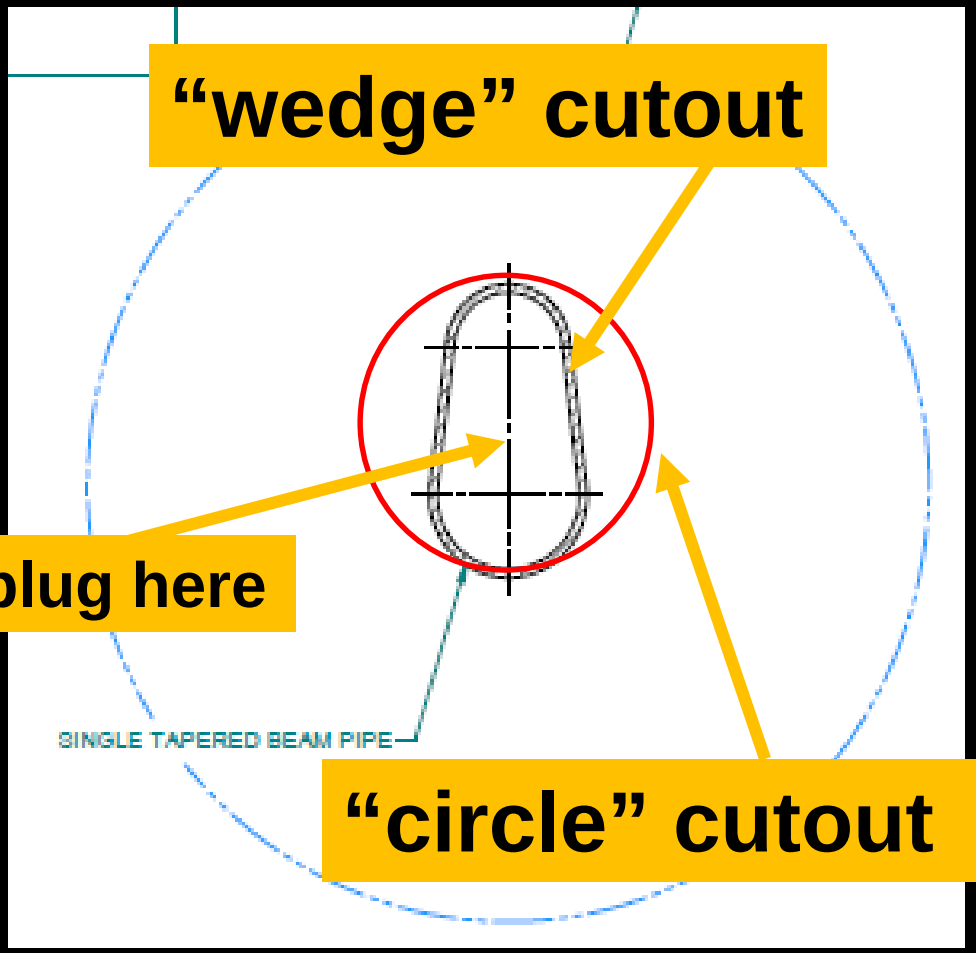
BeamCal Face Geometry Options

- "plugged"
- Wedge cutout
- Circle cutout

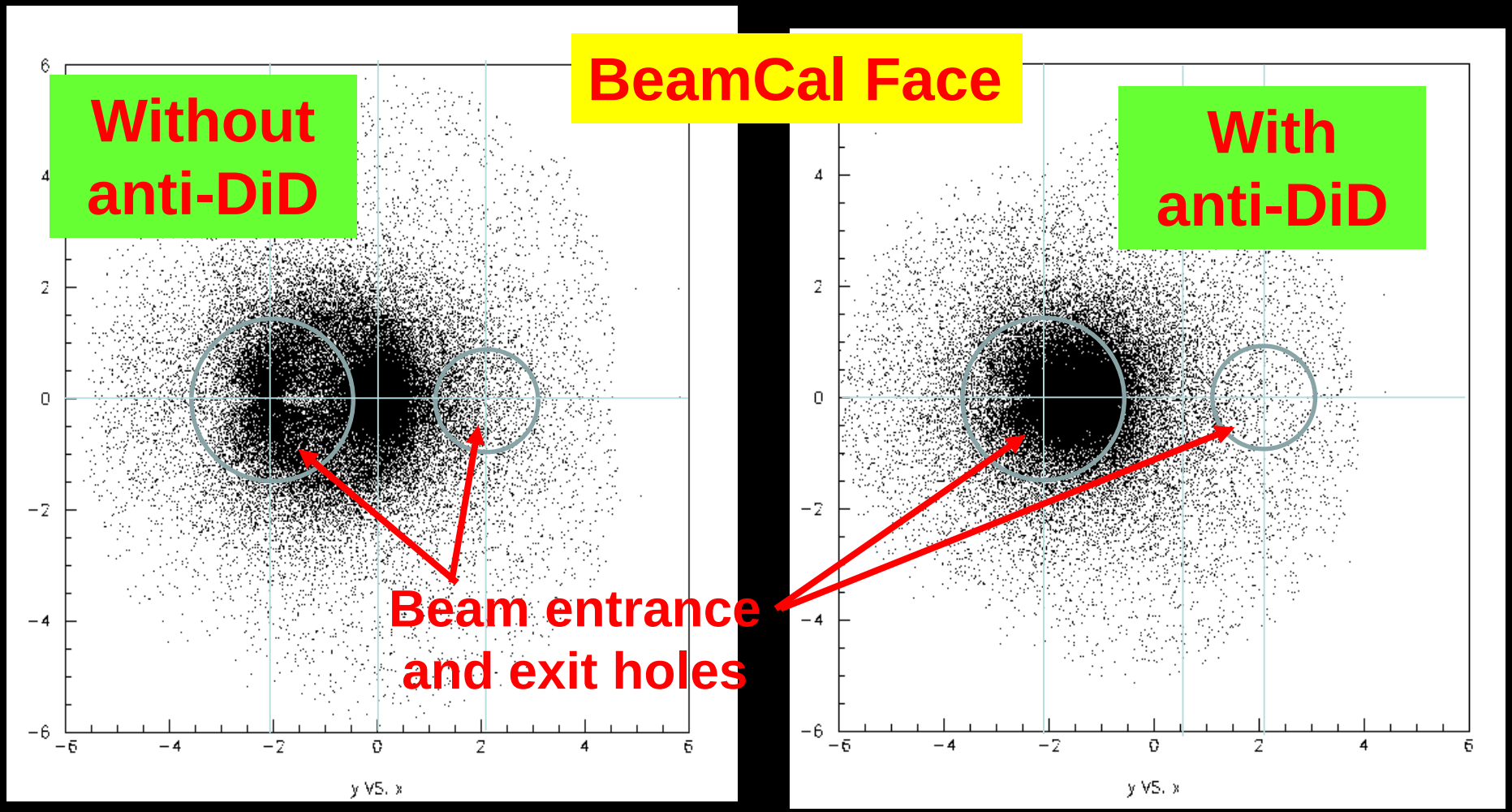
Plug



Insert plug here



Incidence of pair backgrounds on BeamCal with and without “anti-DiD” field



Tom Markiewicz, SLAC

Tom Markiewicz, SLAC

	No DID		AntiDID	
	# Hits	Energy	#Hits	Energy
Out 3cm exit	17.9%	78.4%	81.9%	85.4%
Out 2cm entrance	1.8%	0.4%	0.6%	0.3%
Hit the plug	74.9%	15.2%	6.7%	2.8%
Outside the plug	5.4%	6.0%	10.9%	11.4%

Conclusion:

- The Anti-DID really only helps the plug region between the beam pipes
- Without the plug to create secondaries, VXD backgrounds should be LESS with no Anti-DID and radiation dose to BEAMCAL should be less

This study for a BeamCal at 3m, but as exit hole size will scale with distance, should be true regardless of final layout

Performance Studies

Vertex Detector

Bunch-by-bunch occupancy per layer
Mean occupancy vs phi (barrel) and R (endcap)

BeamCal (Backup Slides)

- Explore efficiency vs. radius for identifying 50 GeV electrons
- For selection for which 10% of beam crossings mistakenly identify an electron
- Factorize into “geometric” (acceptance) and “instrumental” (S/B) efficiency

Configurations Explored

Nominal: L^* = 4.1m; no antiDiD; plug in place

Then, relative to Nominal:

Small L*: L* = 3.5m

AntiDID: Include antiDiD field

Small L* AntiDID: L^* = 3.5m with antiDiD field

Wedge: Remove BeamCal plug

Circle: Remove additional BeamCal coverage as shown in prior slide.

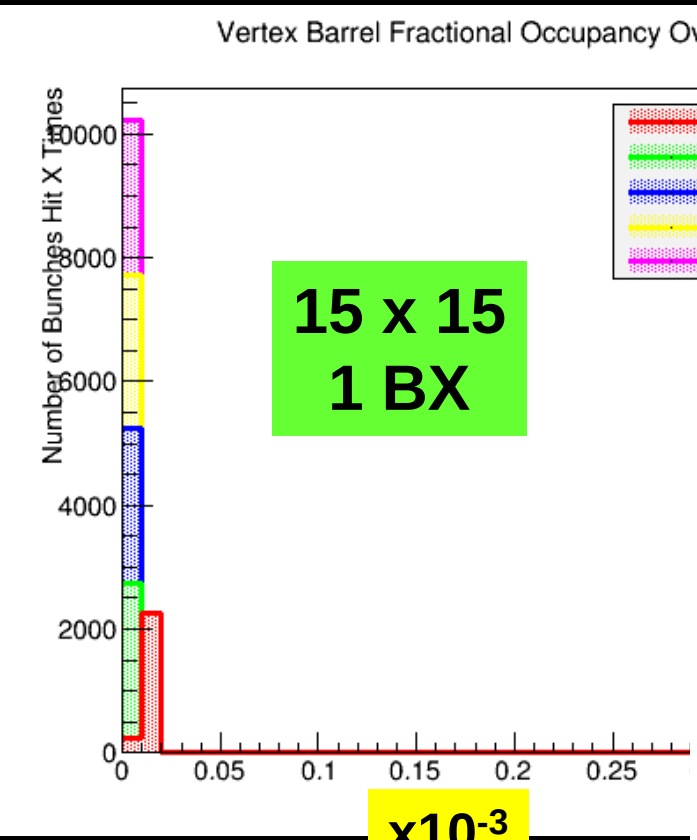
Vertex Detector Configurations

We have studied occupancy as a function of two aspects of the VXD readout architecture

- **Pixel size**
  - **15 x 15 mm^2**
  - **30 x 30 mm^2**
- **Integration time**
  - **1 beam crossing**
  - **5 beam crossings**

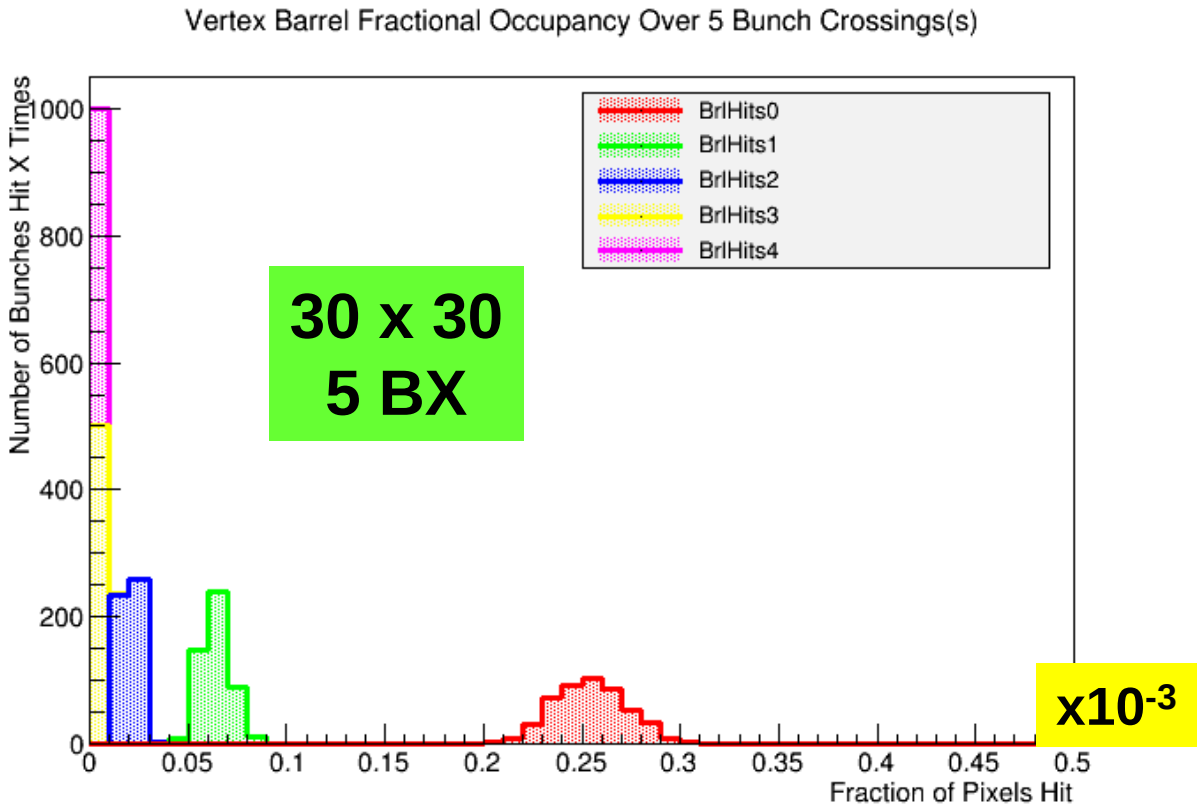
Vertex Detector Results

Nominal IR Geometry Occupancy Distributions (Barrel)



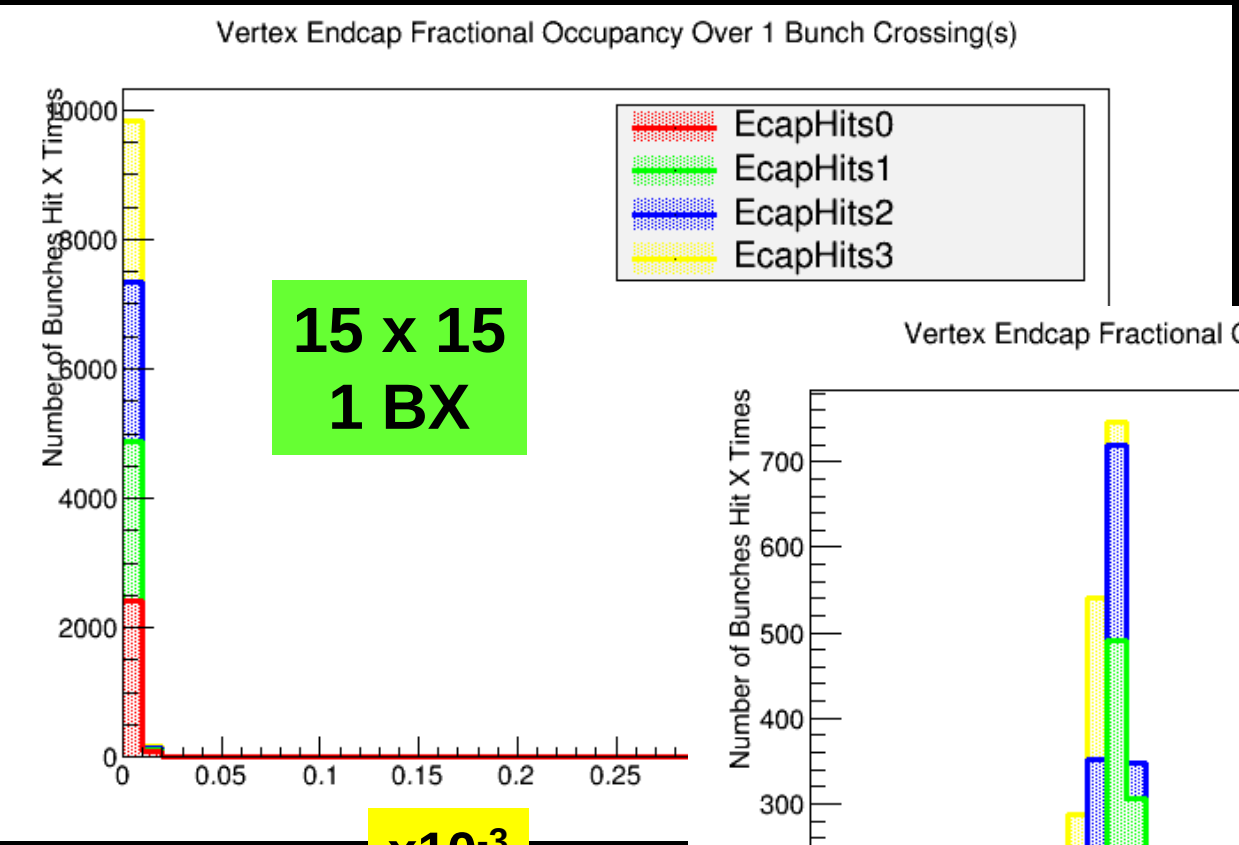
15 x 15
1 BX

Stacked histograms!



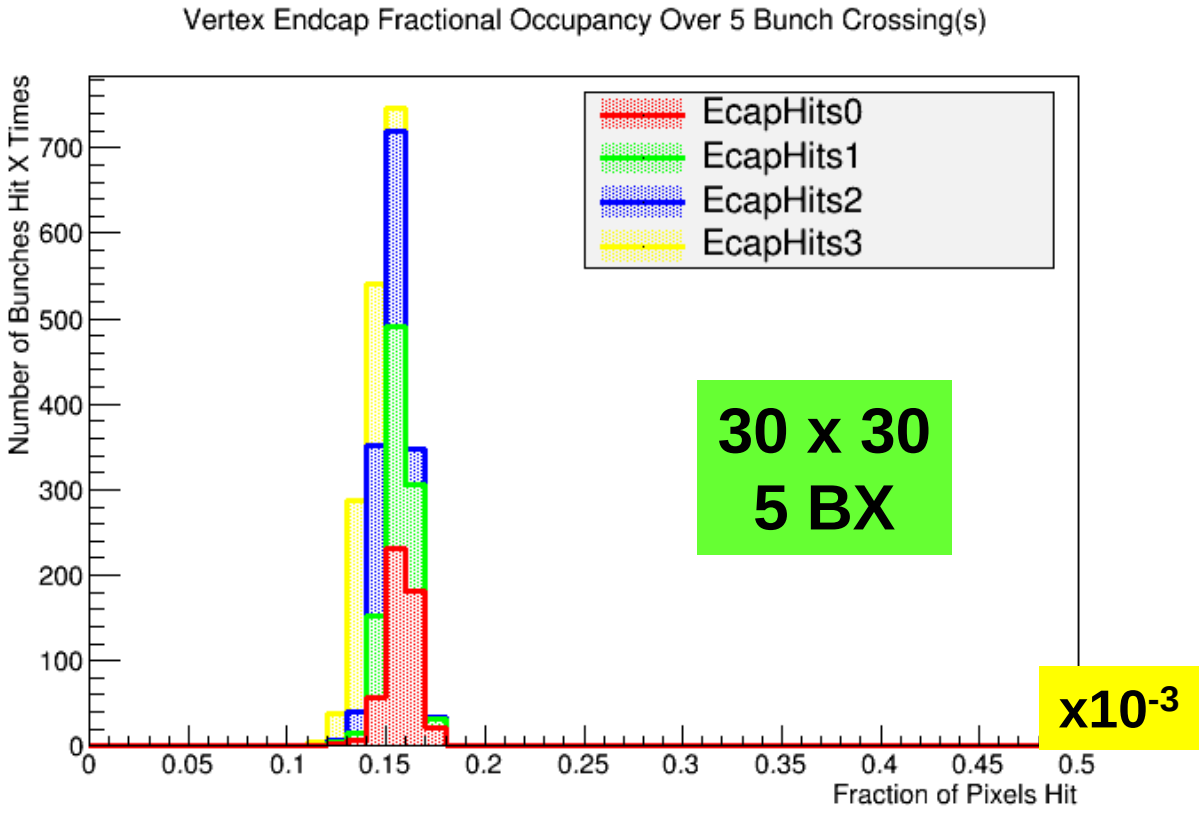
30 x 30
5 BX

Nominal IR Geometry Occupancy Distributions (Endcap)



15 x 15
1 BX

Stacked histograms!



30 x 30
5 BX

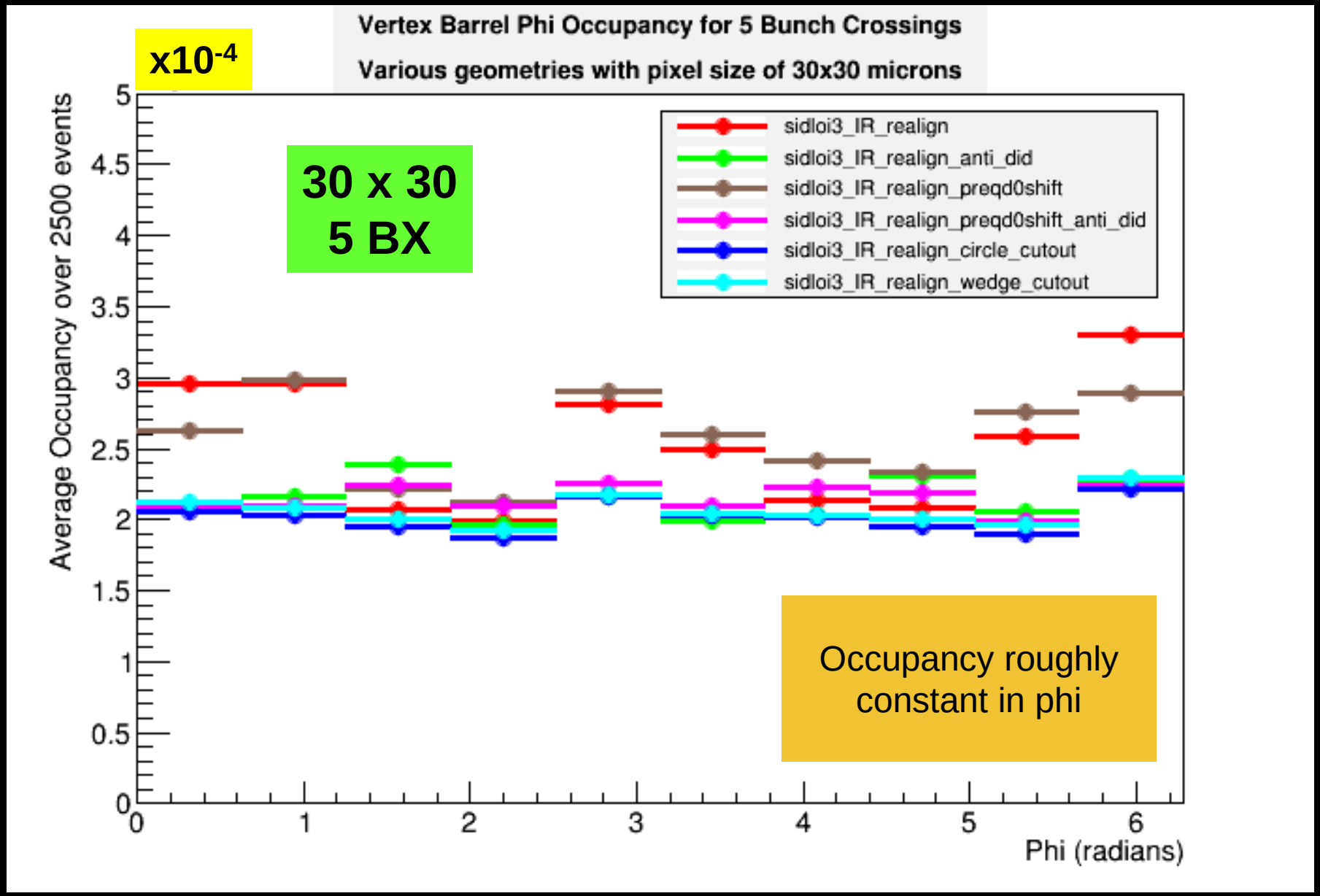
We note that:

- Pulse-by-pulse variation is small
- Occupancy only appreciable for largest pixel size (30x30) and greatest integration time (5 Bx)
- Inner layer (0) dominates occupancy in barrel
- Inner layer (0) characteristic of occupancy in endcap

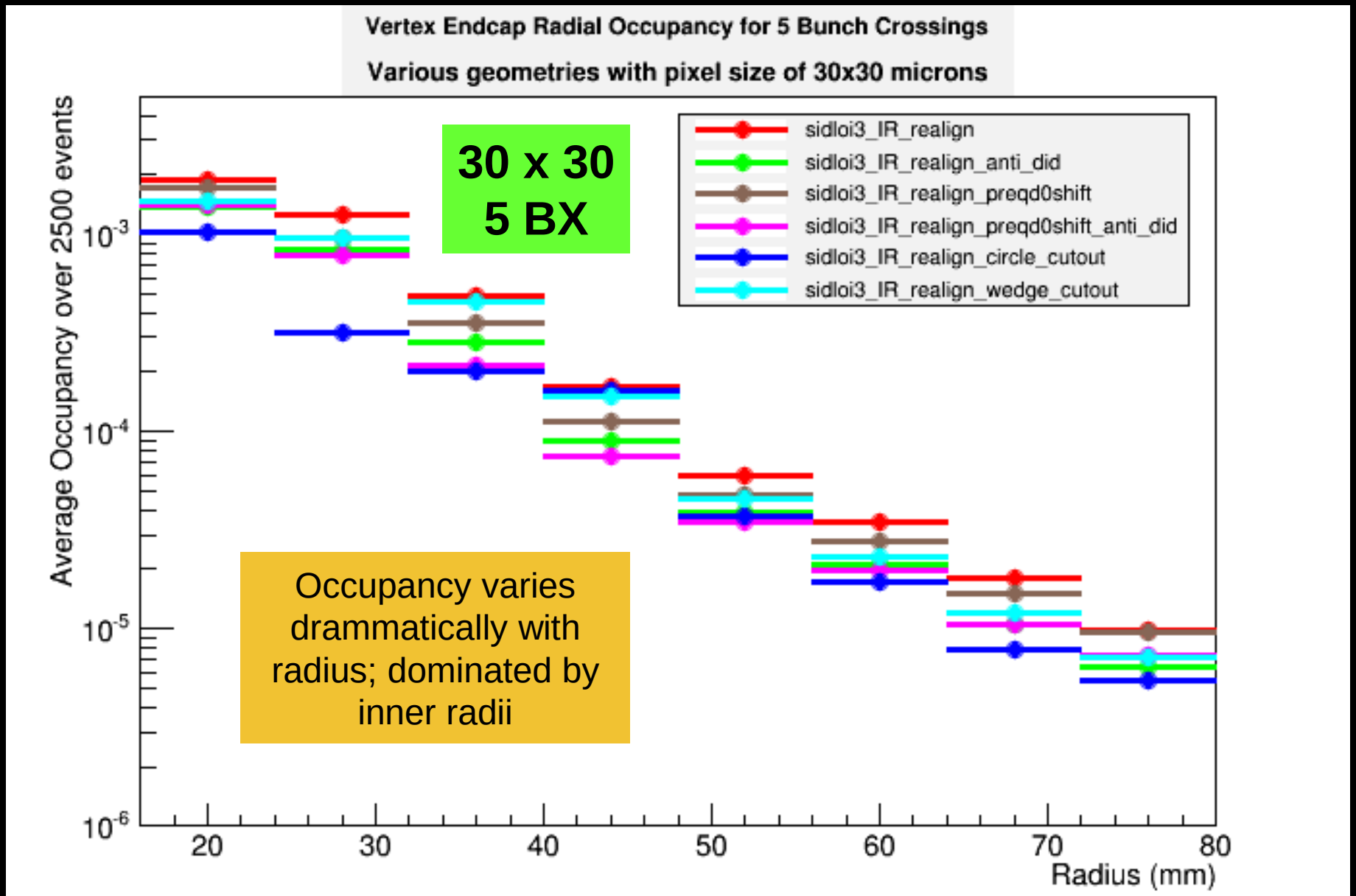
→Study IR configuration dependence with layer 0 (both endcap and barrel) for 30x30 pixel integrating over 5 Bx.

In terms of: azimuthal dependence in barrel; radial dependence in endcap

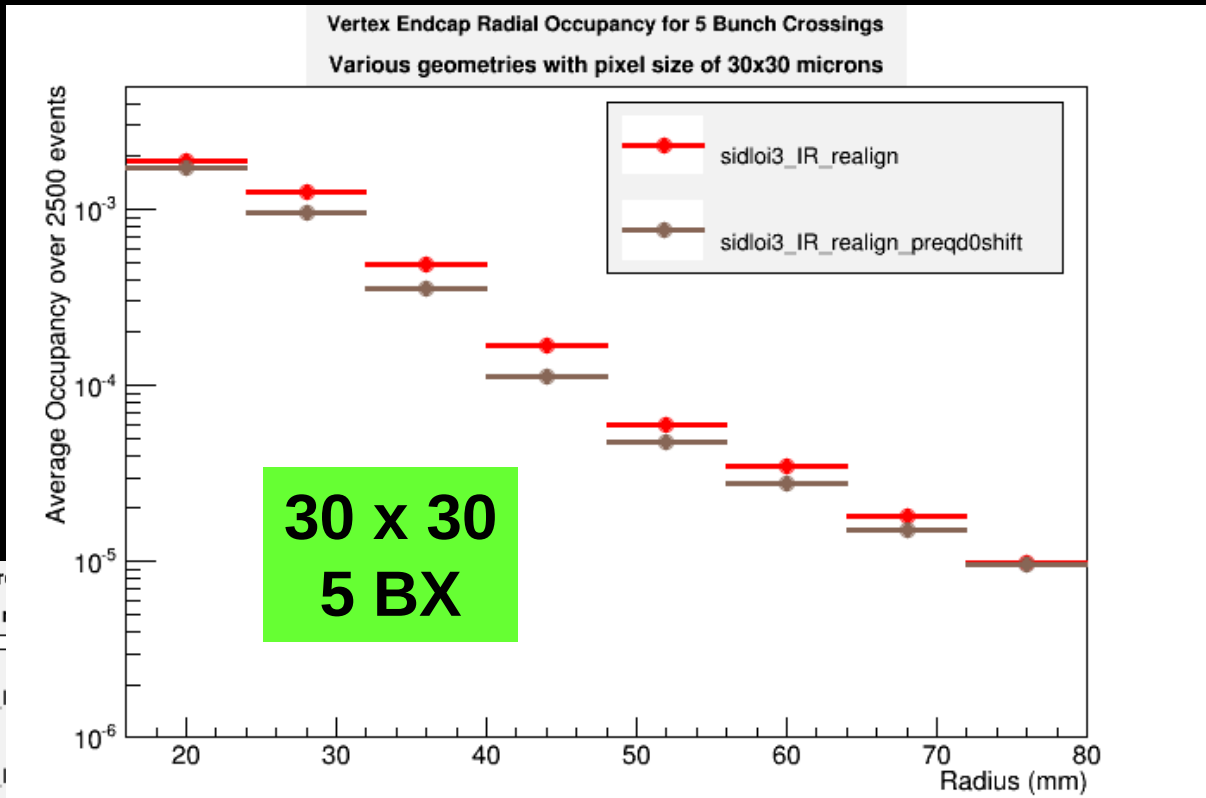
Barrel: Mean Occupancy vs. Phi

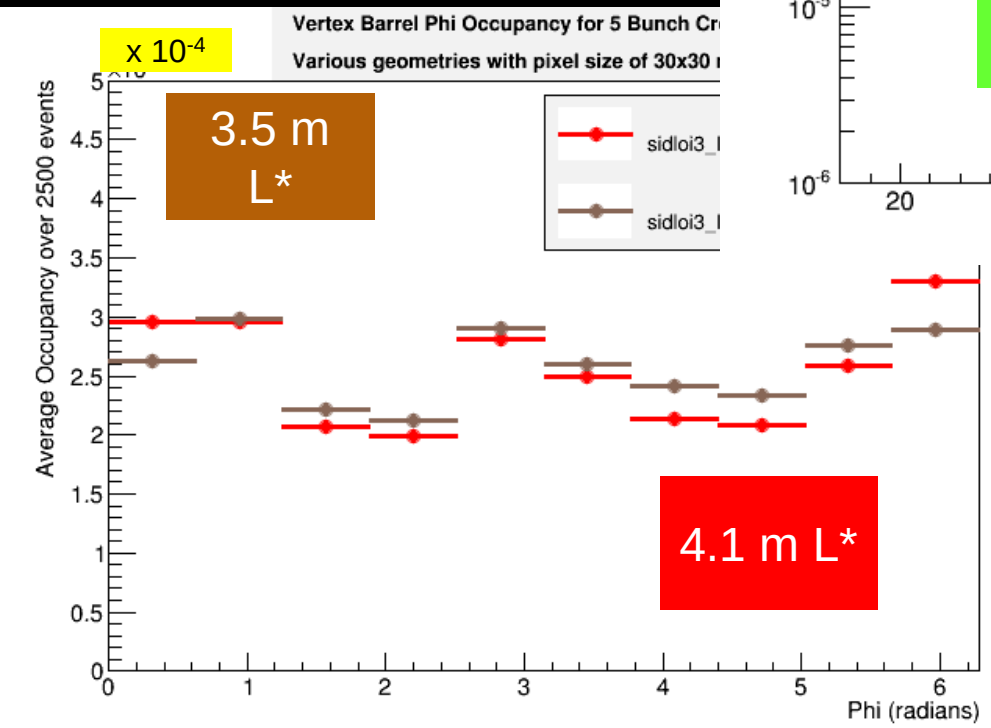


Endcap: Mean Occupancy vs. R



Vertex Occupancy Dependence on L* Configuration

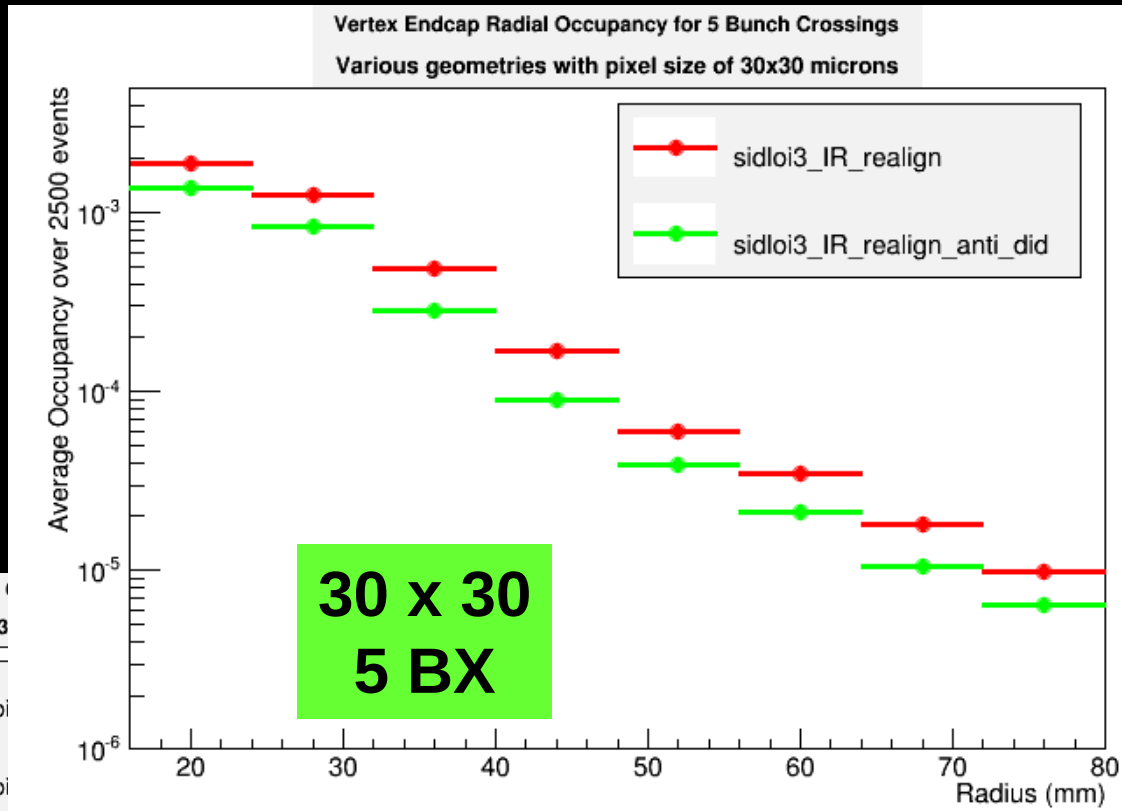


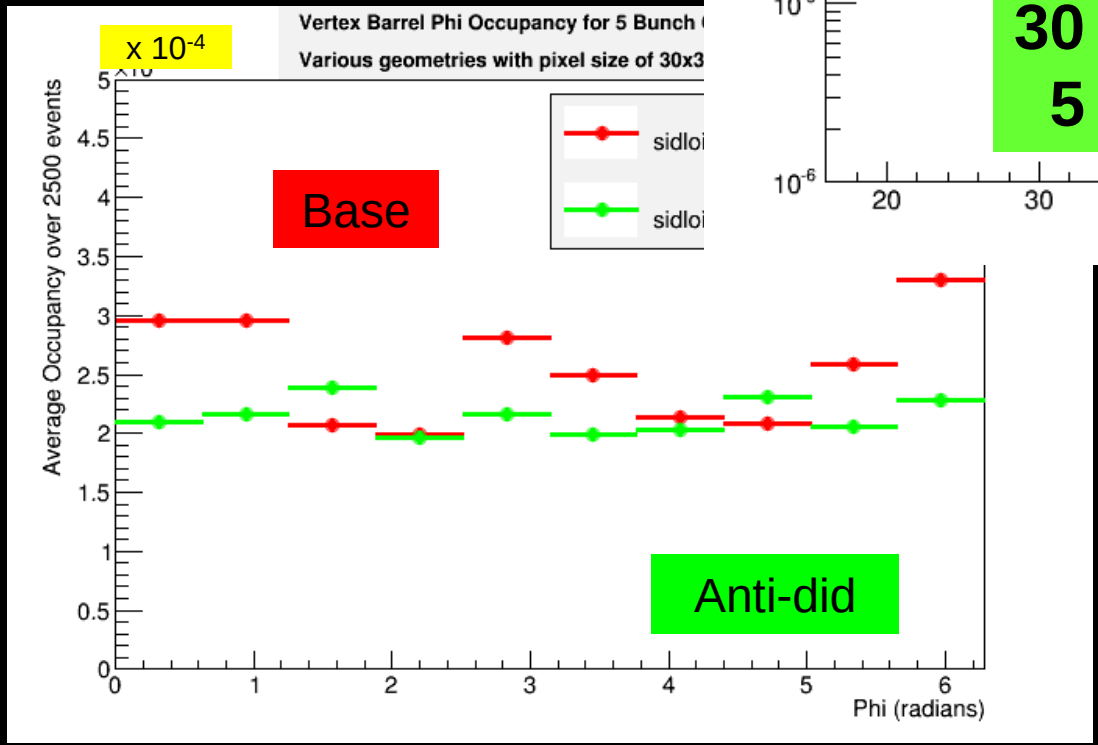


L* occupancy differences appear to depend on backscatter deflection angle

Vertex Occupancy Dependence on Anti-did Field

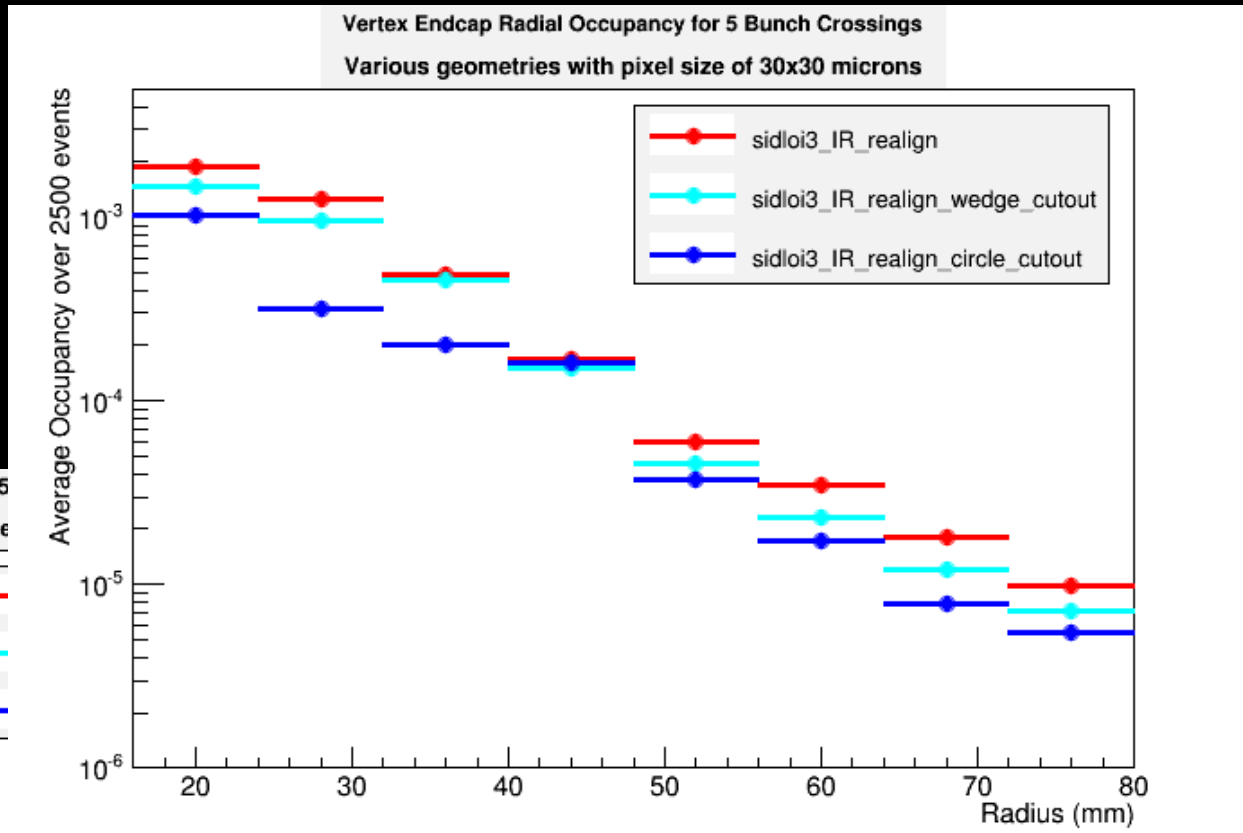
Plug is in place!

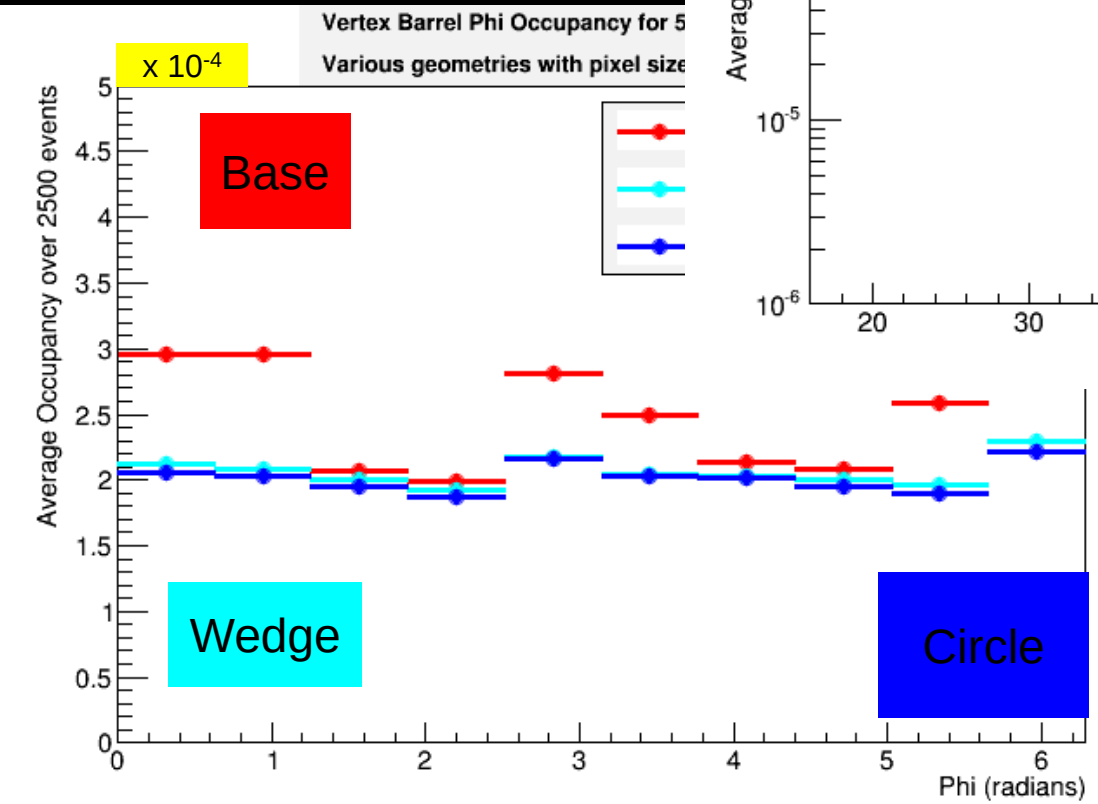




Anti-did field generally improves occupancy in barrel and thoroughly improves occupancy in endcap

Occupancy Dependence on Plug Geometry





As expected, occupancy gets progressively lower as more of the BeamCal plug is cut away

Summary

Occupancy always less than 2x10^-3; general less than $2x10^{-4}$

Small dependence on L*

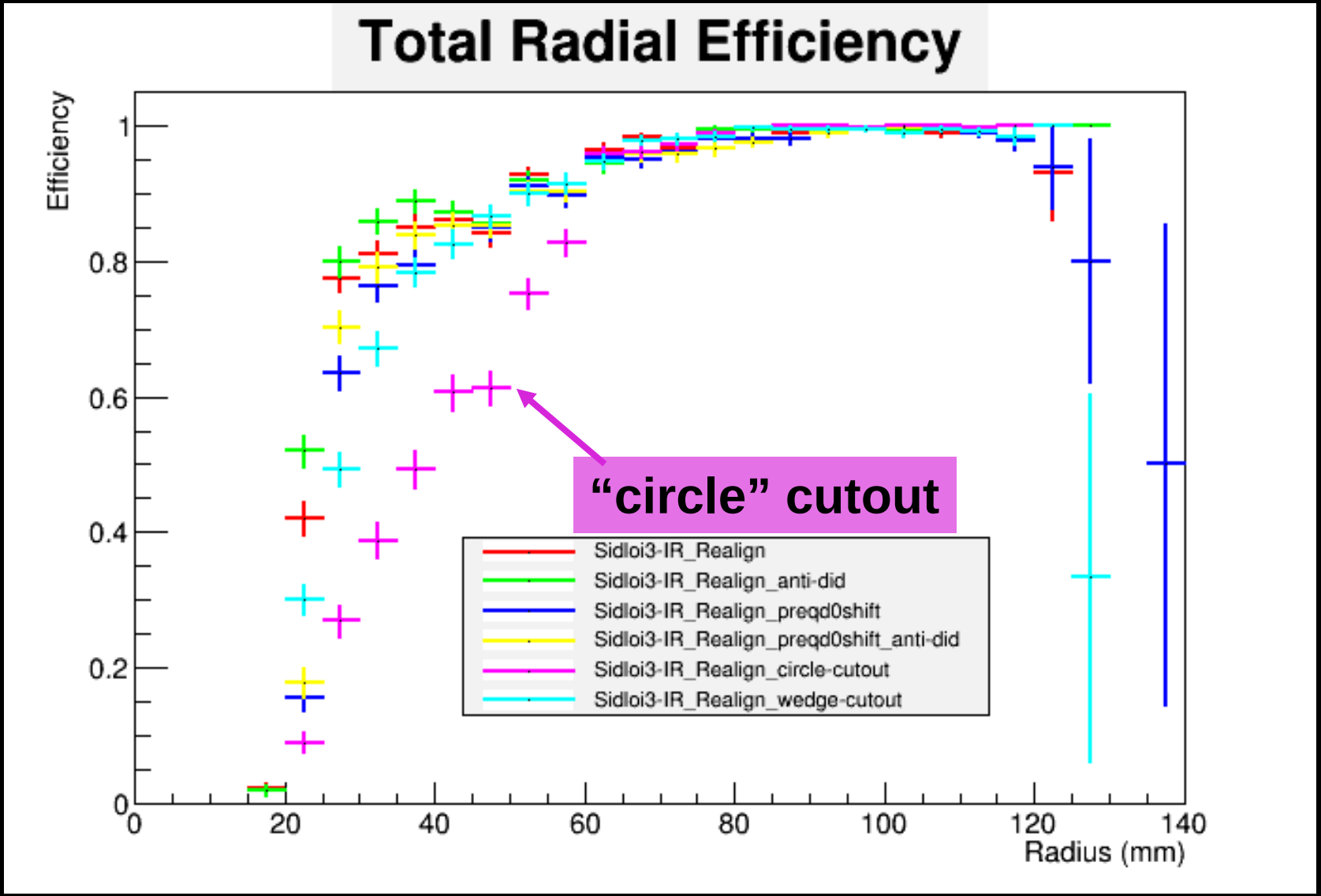
With plug in place, anti-did improves occupancy

Removing plug entirely provides 20-40% reduction in occupancy

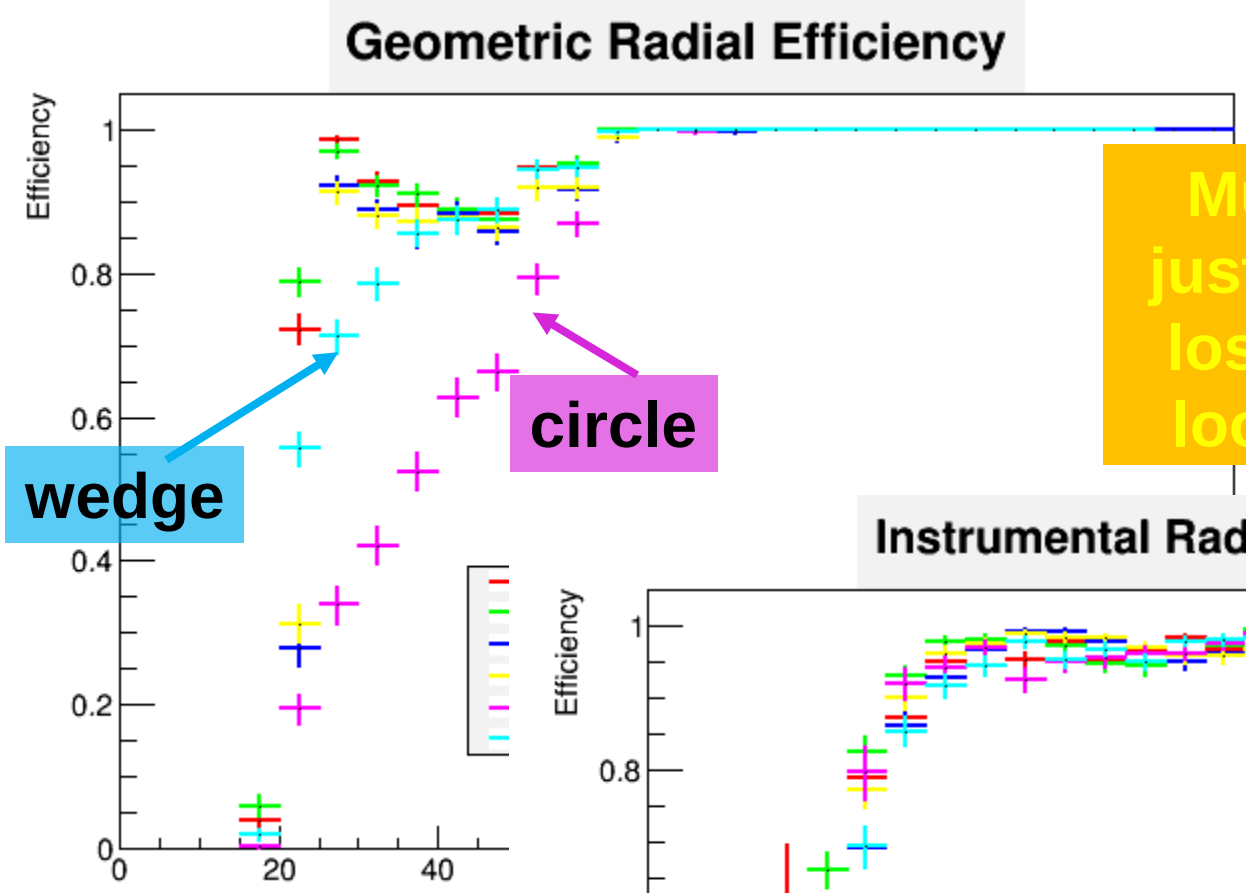
Backup

BeamCal Results

BeamCal Efficiency vs. Radius



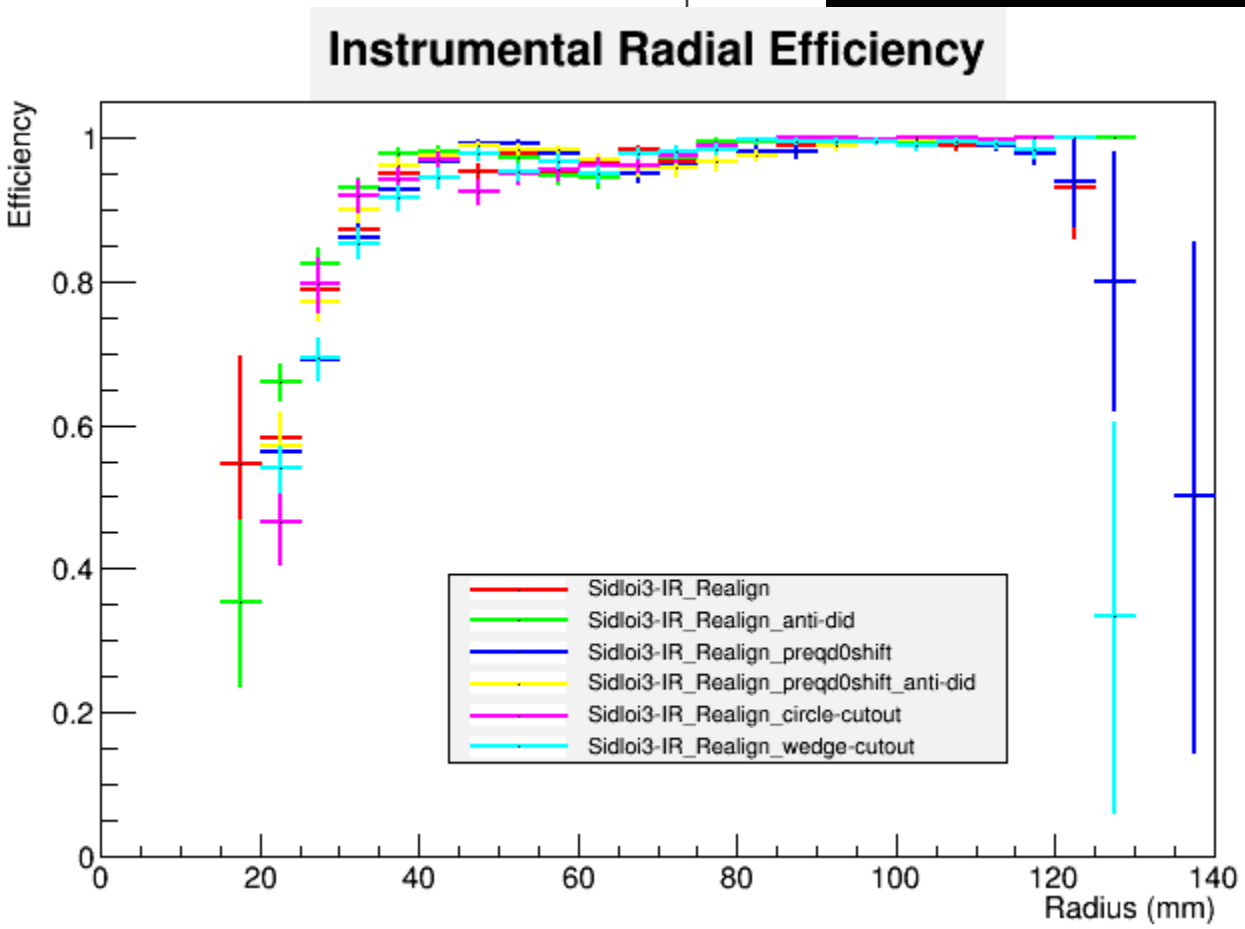
Difference due solely to loss of coverage?



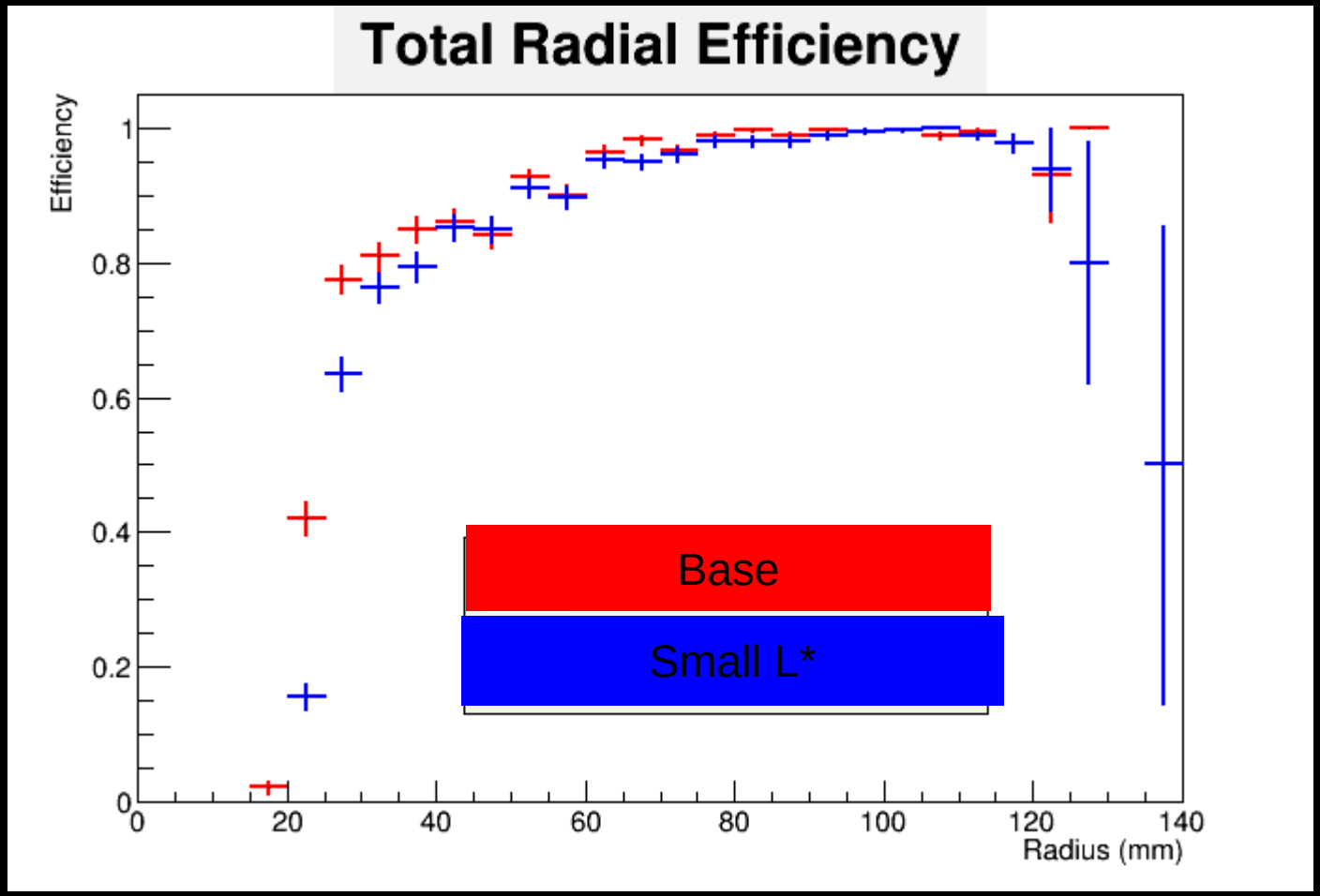
wedge

circle

Much of effect does just seem to be due to loss of coverage, but look in more detail…

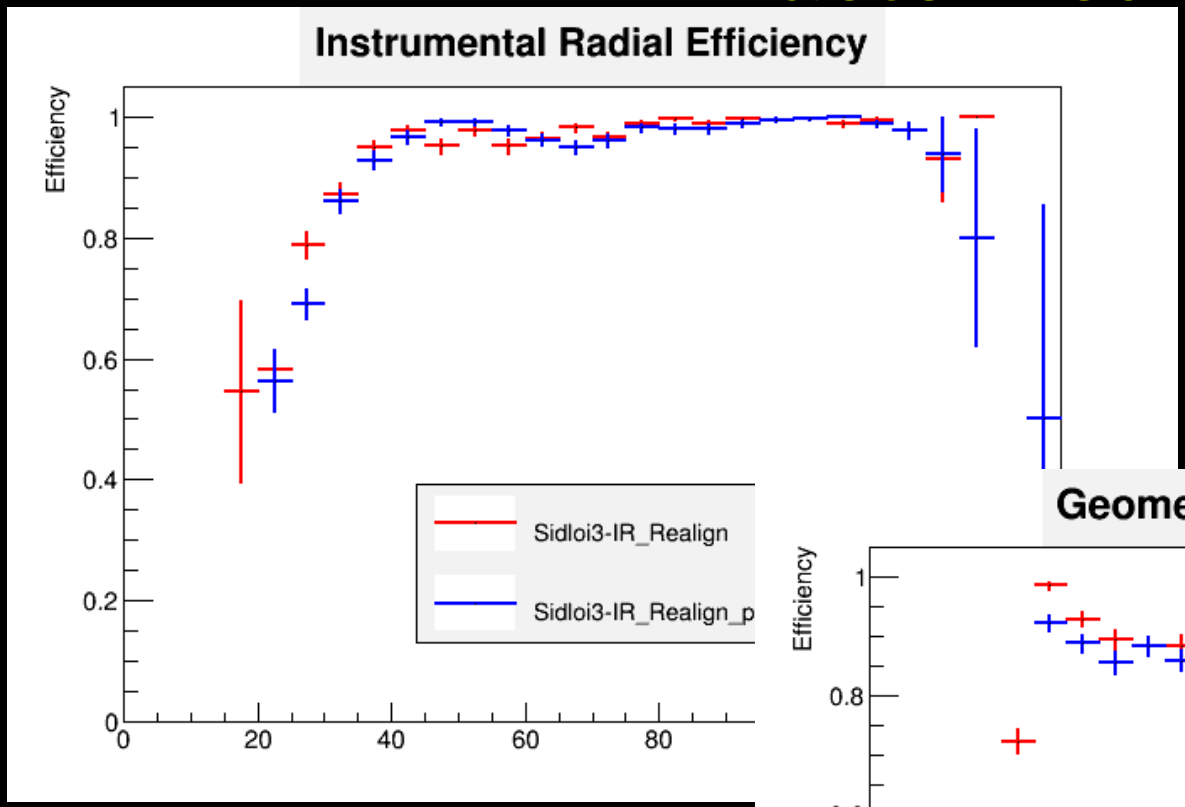


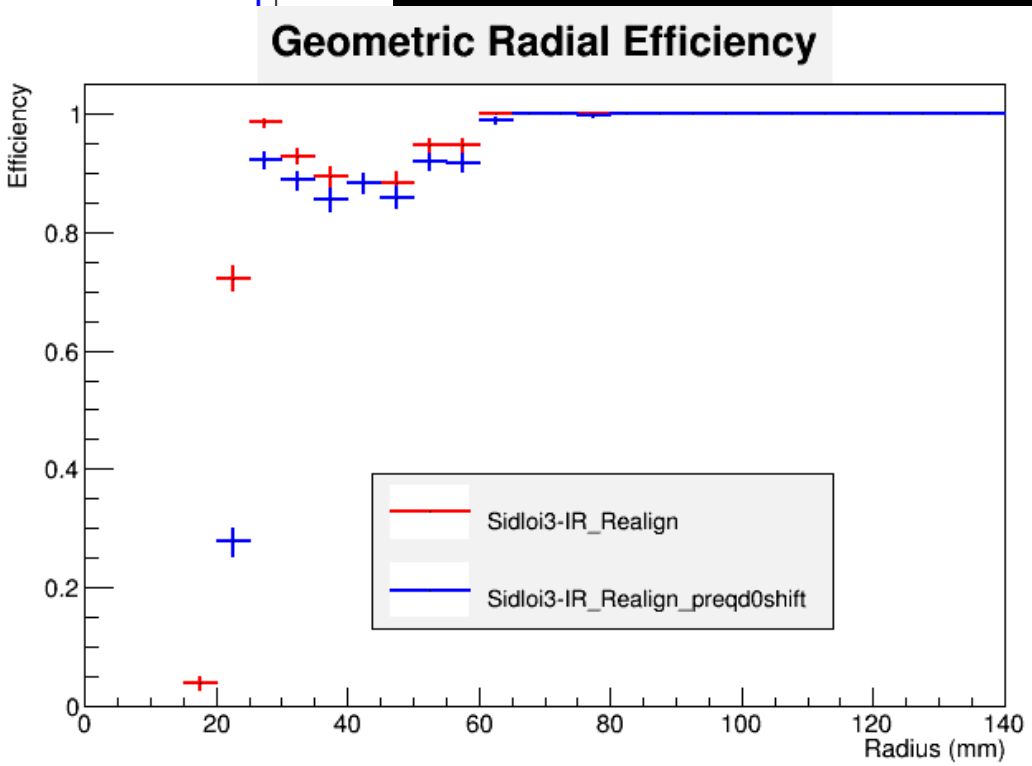
BeamCal Efficiency L* Dependence



larger L* consistently displays higher efficiency

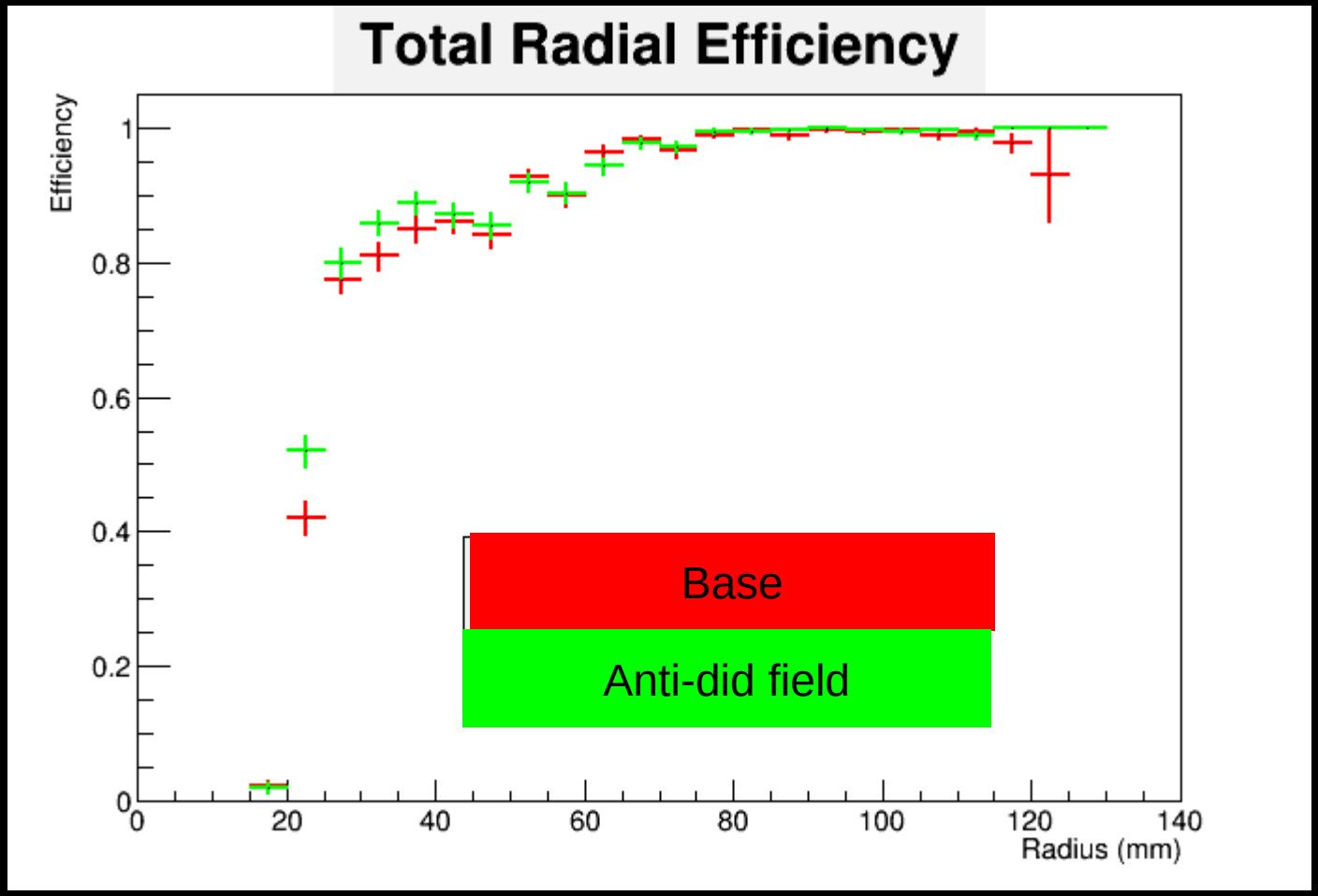
BeamCal Efficiency L* Dependence Factorized



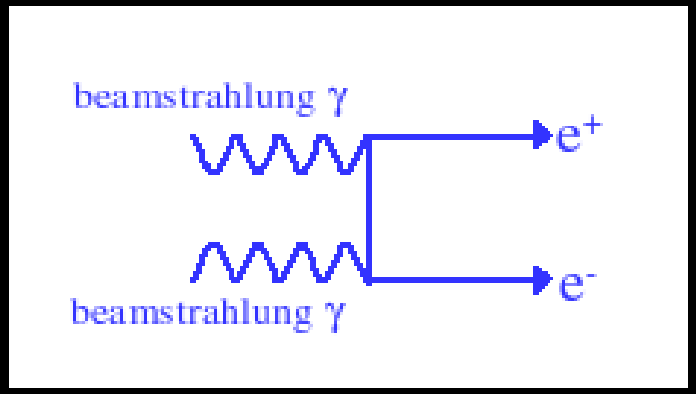


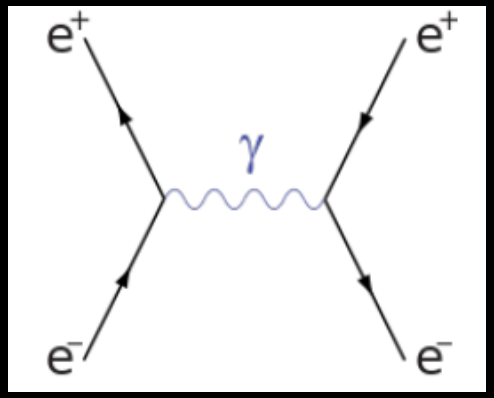
Difference is largely geometric

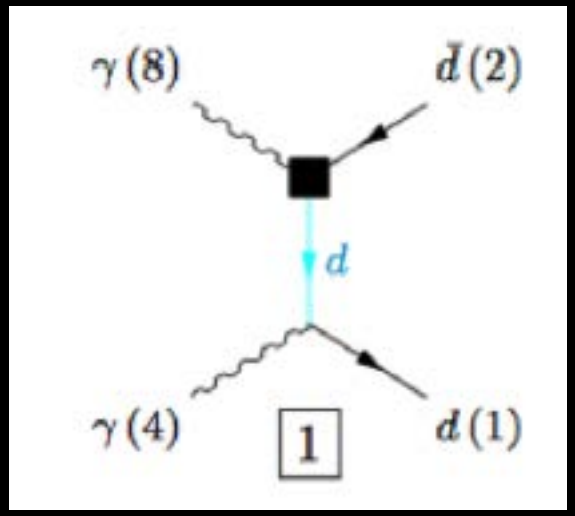
BeamCal Efficiency anti-did Dependence

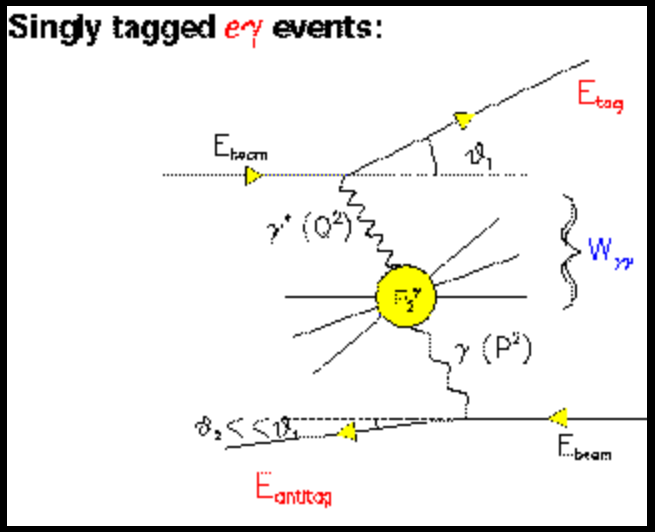


anti-did field does improve efficiency with plug in place


beamstrahlung γ
e+
e-
beamstrahlung γ


e+
e+
γ
e−
e−


γ (8)
d̄ (2)
d
γ (4)
1
d (1)


Singly tagged eγ events:
E_tag
E_beam
ϑ1
γ* (Q²)
W_γγ
γ (P²)
E_beam
E_antitag

KPix Buffer Depth Study (incremental occupancy rates)