Optical Link Layout Options

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November 4, 2008

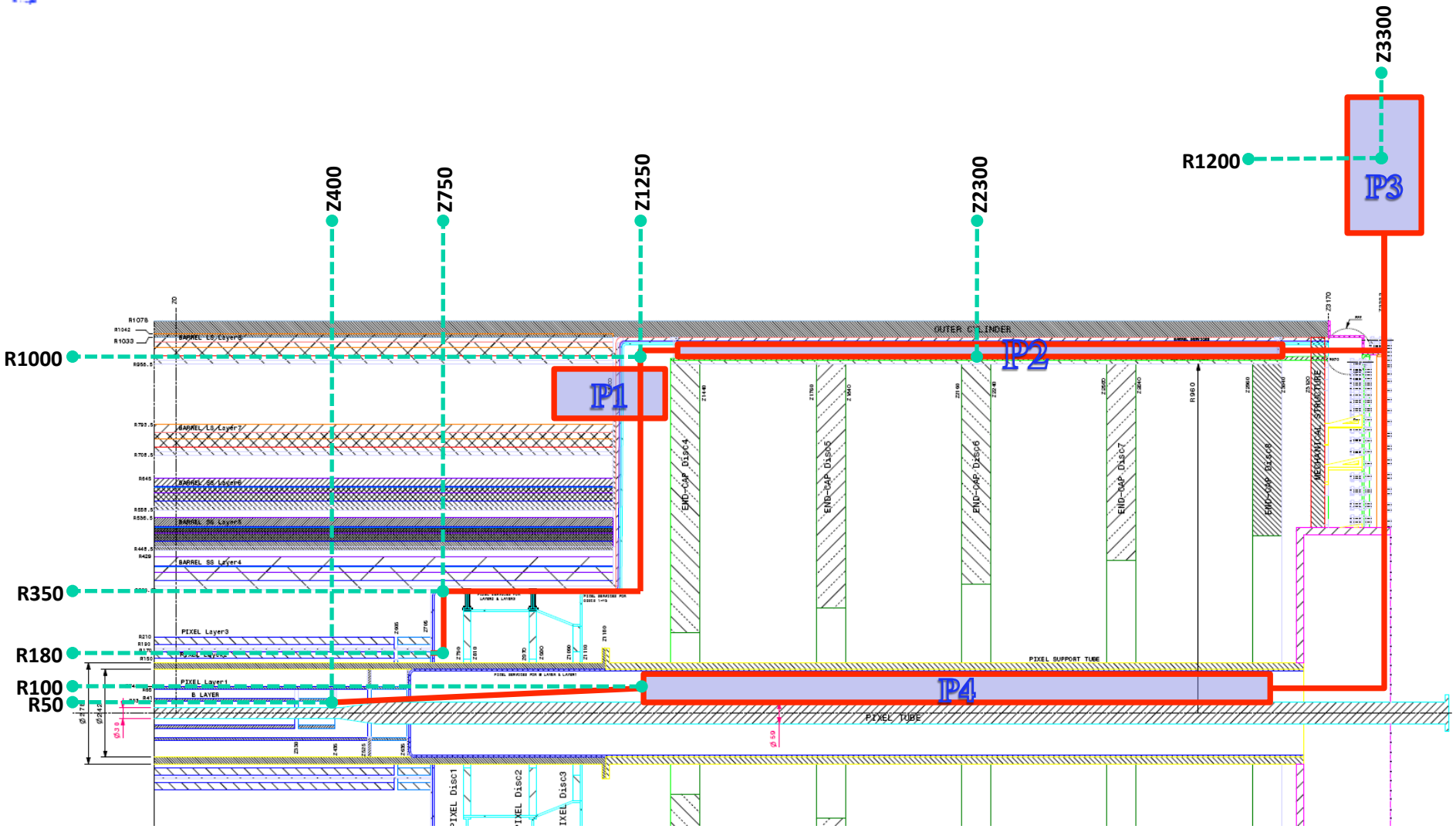
Outline

- Introduction
- Possible optical-link locations
- Predictions of degradation in fibers
- Predictions of degradation in VCSEL/PIN
- Summary

Introduction

- Important to fix the location of opto components early
  - affect mechanical layout
  - affect design of electronics
    - long distance electrical transmission requires development of radiation-hard electronics for pre-emphasis of signal
  - ⇨ evaluate degradation of opto components at various possible locations

Potential Pixel Opto-Board Locations



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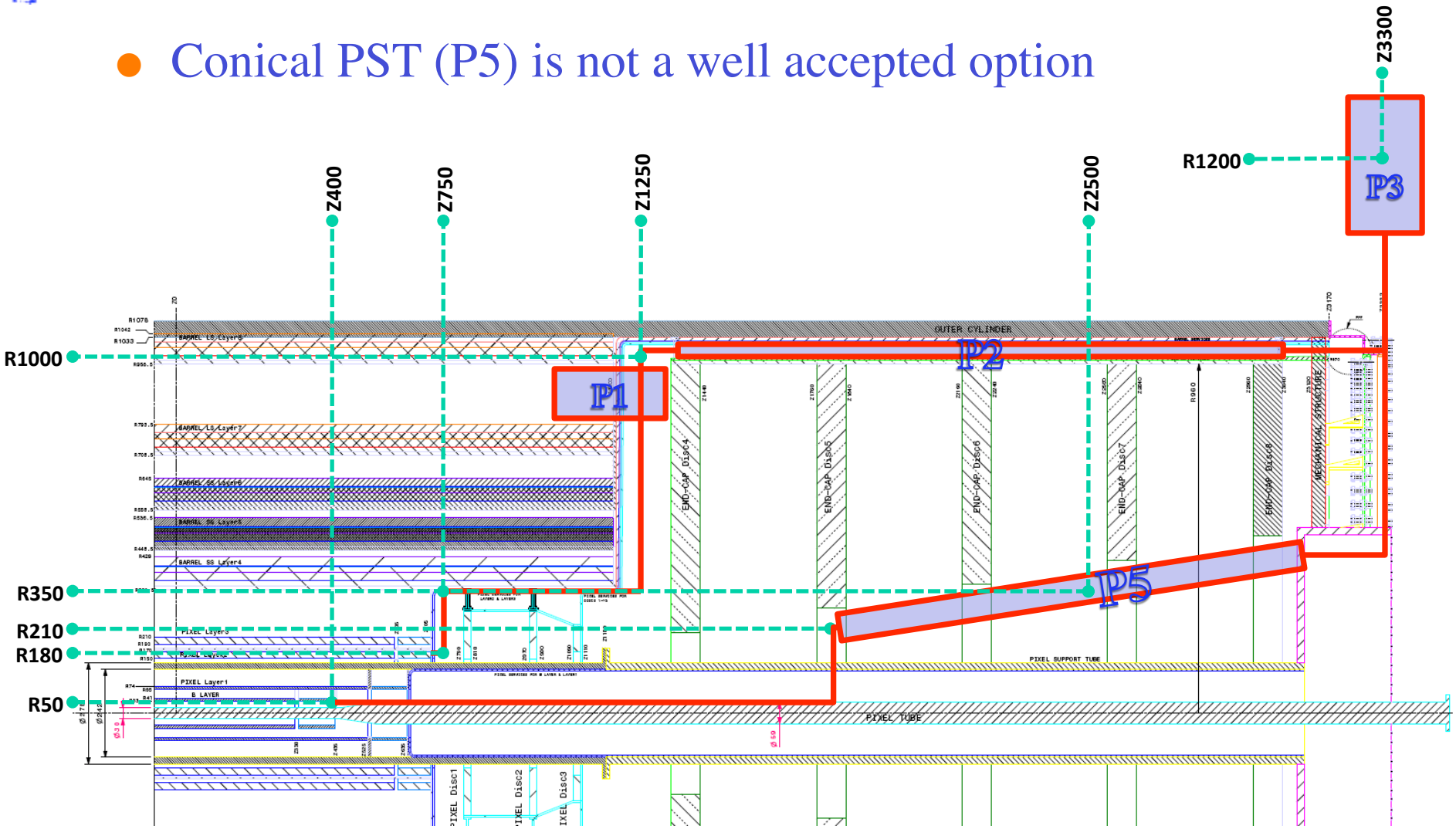
Potential Opto-Board Locations for conical PST

- Conical PST (P5) is not a well accepted option



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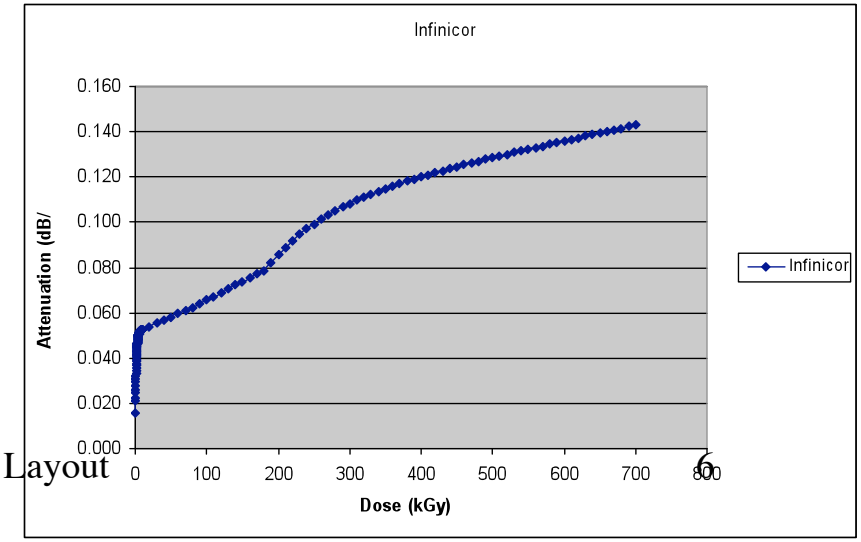
Fiber Losses

- Assume L = 3000 fb^{-1} and damage is mainly due to ionizing dose
- Assumed safety factor:
  - 1.5 for r < 110 cm
  - 5 for r > 110 cm
- Loss calculated for Corning Infinicor GRIN fiber
- Fibers irradiated with gammas from Co^{60} by Jingbo Ye and Todd Hoffman et al.
- Losses due to radiation calculated by Tony Weidberg
- See talk by KK on Wednesday for more details on irradiation



Prediction on Fiber Losses

	Fibre routing (cm)				Length (cm)	**Loss (dB)**
Step	r start	r end	z start	z end		**Infinicor**
1	90	110	120	120	20	**0.017**
2	110	110	120	340	220	**0.122**
3	110	420	340	340	310	**0.131**
4	420	420	340	0	340	**0.012**
5	420	572	0	0	152	**0.002**
6	circumferential step		$\Delta\phi = \pi$, r = 572		1797	**0.005**
7	572	1200	0	0	628	**0.008**
Total					**3467**	**0.30**

Position	1	2	3	4	5
Loss (dB)	0.33	0.22	0.16	0.31	0.28

- Losses for Infinicor GRIN fiber are small for all locations
  - Losses for SIMM fiber are much smaller

Radiation Hardness of VCSEL/PIN

- Radiation hardness of 850 nm VCSEL/PIN has been studied at present opto-board patch panel PP0: r ~ 18 cm, z ~ 1.4 m
  - expected dose for 3,000 fb^{-1}, including 50% safety factor
    - assume displacement damage as proportional to non-ionizing energy loss (NIEL)
    - irradiate with 24 GeV protons at CERN
    - Si: 1.5 x 10^{15} 1-MeV n_{eq}/cm^2 (2.6 x 10^{15} p/cm^2)
      - PIN candidate: Hamamatsu
    - GaAs: 8.2 x 10^{15} 1-MeV n_{eq}/cm^2 (1.6 x 10^{15} p/cm^2)
      - PIN candidates: Hamamatsu, Optowell (?)
      - VCSEL candidates: AOC (5 &10 G), Optowell (?)
- See talk by KK on Wednesday for more details

1310 nm VCSEL

- 1310 nm VCSELs are becoming available
  - radiation tolerance looks encouraging
  - readily available radiation-hard fiber
  - single mode laser is easier to understand
    - no mode hoping as in multi-mode laser
- Need to keep an eye on this development

Radiation Dose at Possible Locations

Position	PP0	1	2	3	4	5
10^{14} 1-MeV n_{eq}/cm^2	17	3.0	3.4	4.0	17	8.0

- Radiation doses at 5 possible opto-board locations are comparable or less than that expected at PP0
  - ⇨ PIN/VCSEL candidates will survive the exposure

Comparison of Cable Lengths

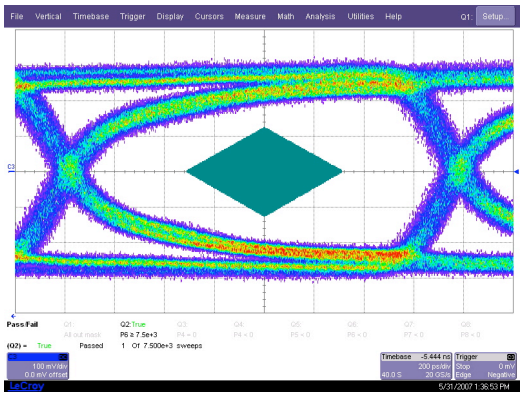
Position	PP0	1	2	3	4	Conical PST 5
10^{14} 1-MeV n_{eq}/cm^2	17	3.0	3.4	4.0	17	8.0
Cable length (m) (inner layers)				4.4	2.4	2.7
Cable length (m) (outer + disks)		2.0	3.2	4.3		
Pre-emphasis for 320 Mb/s			yes	yes		
Pre-emphasis for > 3.2 Gb/s		yes	yes	yes	yes	yes

- No need for pre-emphasis of signal directly from FE's if opto components are located:
  - position 4 for inner layers
  - position 1 for outer layers and disks
- pre-emphasis is needed if signals from FE's are serialized and transmitted at higher speed at end of stave

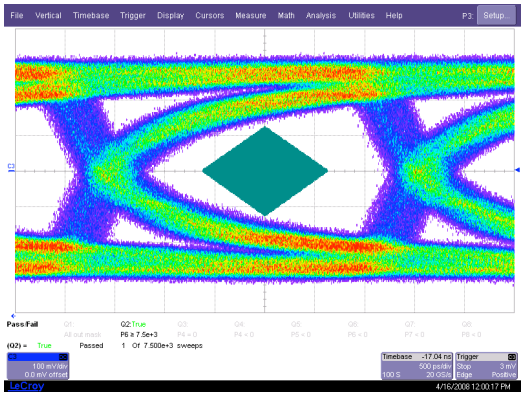
Bandwidth of Micro Twisted Pairs

current pixel cable with 100 μm diameter

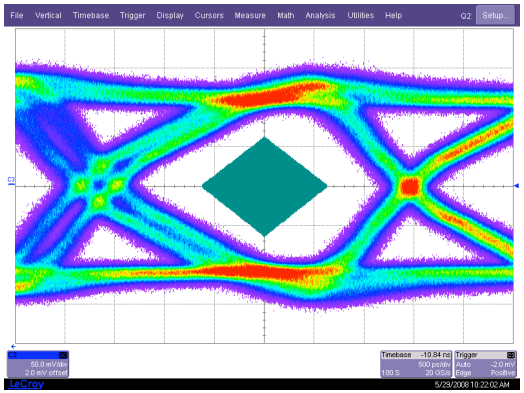
640 Mb/s
1.4 m



320 Mb/s
3 m



320 Mb/s
4 m
Pre-emphasis



- signals can be transmitted at 640 Mb/s up to 1.4 m or at 320 Mb/s up to 3 m
- pre-emphasis of high-frequency components in signal driver to compensate for transmission loss in long cable
  ⇨ can transmit at 320 Mb/s up to ~ 4 m

Summary

- small losses (< 0.33 dB) in GRIN fiber due to radiation damage at five possible opto-link locations
- radiation dose for VCSEL/PIN at five possible locations is comparable or less than that expected at PP0 where radiation-hardness has been evaluated
  - ⇨ VCSEL/PIN will survive at these locations
- positions 4 (inner layers) and 1 (outer layers and disks) require no pre-emphasis of signal directly from FE's