Future options for optical links

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Options for Optical Links at SLHC

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with input from ATLAS and CMS colleagues

- Margins of existing ATLAS and CMS TK OL
- Options for OL upgrades
- Some proposals
- The joint optoelectronics working group
- Conclusion

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Optical Links for the ATLAS and CMS Trackers

ATLAS

Digital links (40/80Mb/s)

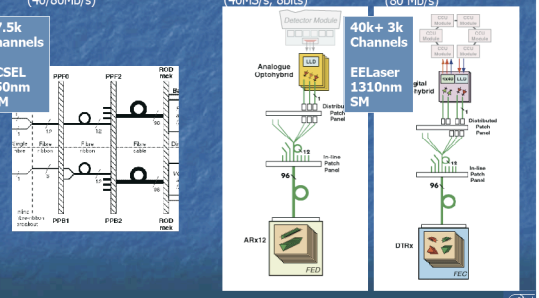
17.5k Channels
VCSEL 850nm MM

CMS

Analogue readout links (40MS/s, 8bits)

Digital control links (80 Mb/s)

40k+ 3k Channels
EELaser 1310nm SM



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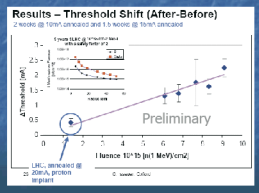
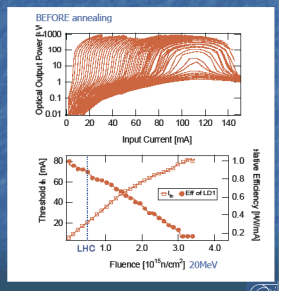
The Optical Link Margins (1: Tx)

- Tx Radiation Hardness
  - Operating point shifts
  - Thermal management becomes crucial
    - Thermal resistance
    - Annealing
  - Compliance voltage





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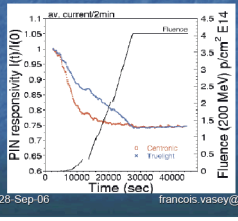
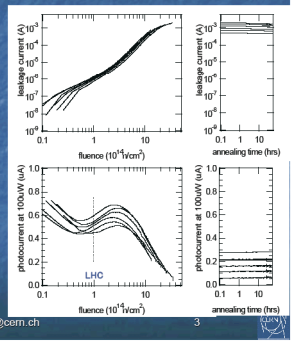
The Optical Link Margins (2: Rx total)

- Rx Radiation Hardness
  - Leakage current damage definitely appears to be 'saturating'
  - Responsivity going to zero
  - No significant annealing
  - Ultimate limit reached





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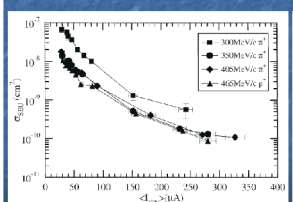
Optical Link Margins (3: Rx SEE)

- Rx SEE cross-section
  - Bit rate dependent
  - Incidence-angle dependent



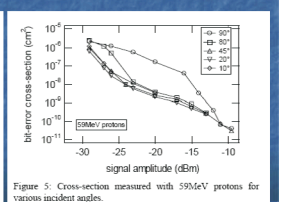


Figure 5: Cross-section measured with 59MeV protons for various incident angles.

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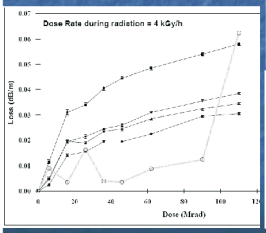
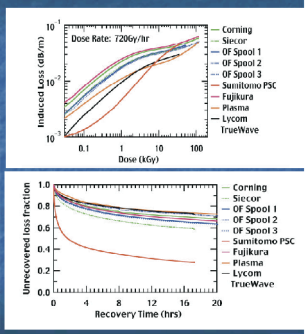
Optical Link Margins (4: fiber)

- Fiber Radiation Hardness
  - (0.05-0.1dB/m)
  - To be reconfirmed





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Optical Link Margins (5: link)

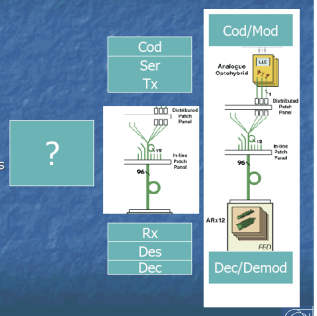
- Fiber Capacity
  - ATLAS SIMM: 50-80 MHz·km
  - ATLAS GRIN: 1000 MHz·km
  - CMS SISM: >>10GHz·km
- Electronics
  - Binary 40/80MBps
  - Analogue 100MHz
  - Digital 80MBps
- Geometry
  - 18cm from beam axis
  - 20cm from beam axis

Margins for operation at SLHC (6: summary)

- Tx and Rx need careful study
  - Are we reaching the limit?
  - Rx SEE sensitivity to be mitigated
- Fiber
  - Radiation tolerance probably OK
  - Capacity increase OK in SM, NOT OK in SIMM, OK in GRIN
- Electronics
  - Generalized Bottleneck
- Geometry
  - Possibility to move away from beam axis to gain margin against radiation damage
- Good overall agreement between ATLAS and CMS observations

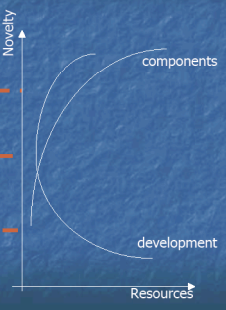
The Options for an Upgrade (1)

- Reuse the existing system
  - Check margins carefully
  - Boost analog link capacity by developing CODEC and MODEM
    - See paper by S. Dris
- Reuse the fiber plant only
  - Develop TRx, SERDES and CODEC
    - See paper by P. Moreira
  - Check compatibility and margins of legacy fiber and connectors
- Start from scratch
  - Possibly using components identical to existing ones
- A combination of the above
  - Geometry dependent system implementation



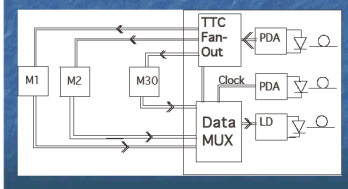
The Options for an Upgrade (2)

- Start from scratch
- Reuse the fiber plant only
- Reuse the existing system



Proposal 1: The ATLAS SCT Straw-Link

- (T. Weidberg, Oxford, Oct 05)
  - 2500 links
  - 2.5Gbps
  - Start from scratch



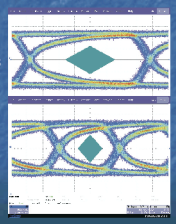
Proposal 2: ATLAS Pixels

- K.K. Gan, Ohio State University
- Reuse existing cable plant
  - 1m micro twisted pair, 8m SIMM fiber, 70m GRIN fiber, 1Gbps

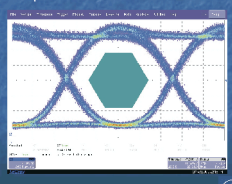
1m40 μTP

0.65Gbps

1.3 Gbps

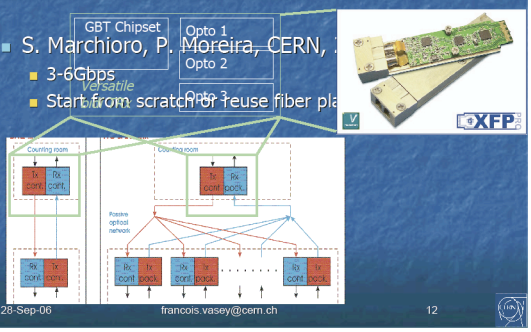


2Gbps 9m SIMM + 20m GRIN



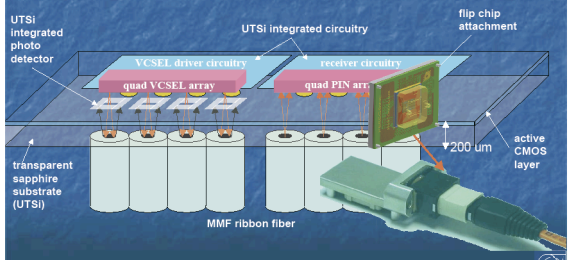
Proposal 3: The versatile bi-directional digital link

- S. Marchioro, P. Moreira, CERN,
  - 3-6Gbps
  - Start from scratch or reuse fiber pla

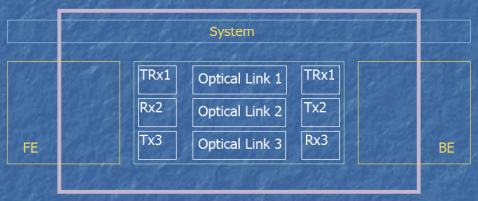


Proposal 4: Flipped OE devices on SoS substrate

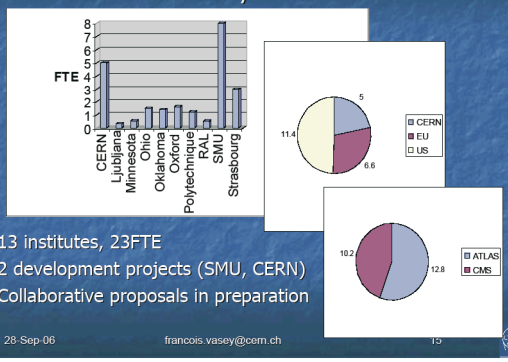
- Ping Gui, Jingbo Ye, SMU, 2005
- Start from scratch or reuse fiber plant



The Joint Optoelectronics Working Group



Joint Optoelectronics Working Group Survey Result



- 13 institutes, 23FTE
- 2 development projects (SMU, CERN)
- Collaborative proposals in preparation

Conclusions

- Options for Optical Links at SLHC are:
  - Reuse existing system (open to CMS only)
  - Reuse fiber plant only (open to CMS and ATLAS Pixels)
  - Start from scratch (possibly using components identical to existing ones).
- Check margins of existing components thoroughly
  - Investigate Laser and PIN diodes in depth
    - Will we reach the total dose limit at SLHC?
  - Draw a line of usability at SLHC, with safety margin.
  - Investigate electronic mitigation techniques (total dose and SEE).
- For new components, concentrate on only very few options.
  - Generic and versatile
  - The joint optoelectronics working group has the potential to coordinate a few parallel projects across experiments.
  - System level aspects to be addressed by the experiments.