

# **Report on “Radiation Test Programme for the ATLAS Opto-Electronic Readout System for the SLHC”, ATL-PA-MN-0001.**

**Review of ID R&D proposals**

**15.09.2009**

**K.K. Gan**

**The Ohio State University**



# Institutes on ATL-PA-MN-0001

- **Academia Sinica, Taiwan**
  - P.K Teng, Minglee Chu
- **Jozef Stefan Institute (JSI), Ljubljana**
  - I. Mandic, G. Kramberger
- **Ohio State University, USA**
  - K.K. Gan
- **University of Oklahoma (OU), USA**
  - P. Skubic
- **Oklahoma State University, USA**
  - F. Rizatdinova
- **University of Oxford, UK**
  - T. Huffman, C. Issever, A. Weidberg
- **Southern Methodist University (SMU), USA**
  - Jingbo Ye

# Objectives of ATL-PA-MN-0001

1. determine performance of the current OE devices
2. determine performance of custom-made components
3. determine SEU cross section @ GBits/sec rate

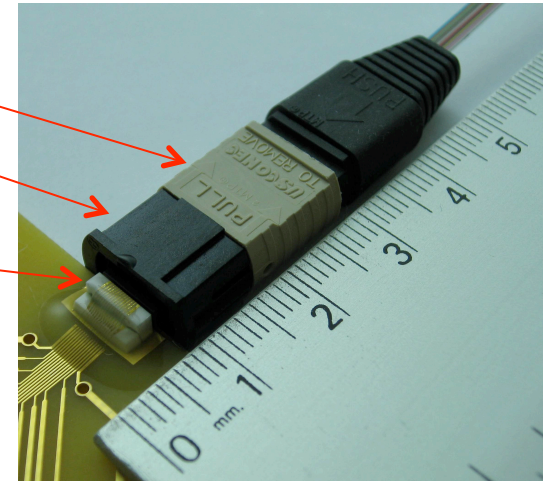
# 850 nm VCSEL Irradiation

- 2006-8:
  - ◆ ~2 VCSEL arrays were irradiated to SLHC dosage
  - ◆ AOC 2.5 Gb/s (obsolete), 5 Gb/s, 10 Gb/s
  - ◆ ULM 5 Gb/s, 10 Gb/s
  - ◆ Optowell 2.5 Gb/s
- 2009:
  - ◆ AOC 10 Gb/s
  - ◆ goal: 20 arrays
  - ◆ actual: 6 arrays due to manufacturer problem
  - ⇒ need to irradiate a sample of 20 arrays in 2010

MPO connector

MPO adaptor

Opto-pack



# 850 nm PIN Irradiation

	Gb/s	Responsivity (A/W)	
		Pre	Post
GaAs			
ULM	4.25	0.50	0.09
AOC	5.0	0.60	0.13
Optowell	3.125	0.60	0.17
Hamamatsu G8921	2.5	0.50	0.28
Si			
Taiwan	1.0	0.55	0.21
Hamamatsu S5973	1.0	0.47	0.31
Hamamatsu S9055	1.5/2.0	0.25	0.20

- Irradiated 2 arrays or several single channel devices for each type
- Hamamatsu devices have low bandwidth but more radiation hard
- Irradiated 20 Optowell arrays in August 2009
- Plan to irradiate a sample of 20 AOC arrays in 2010

# Milestone of ATL-PA-MN-0001

- Mid 2008: Choose set of optimum components for the ATLAS Inner Detector opto-electronic readout system at the SLHC.
  - **This shifted. Expect it to be reached in 2 years.**
- Timeline was too optimistic.
- Other developments caused this timeline to be obsolete in many respects.

# Developments Since the Submission of Proposal

- Activities of this report are embedded within the JOINT ATLAS/CMS optoelectronic working group.
  - Cigdem Issever and K.K. Gan (ATLAS), Francois Vasey (CMS)
  - Proposal A Subgroup “**Lessons Learned**”
  - Proposal B Subgroup “**Radiation Guidelines & Coordination**”
  - Proposal C Subgroup “**Reference Link**”
  
- Large fraction of the effort within “Versatile Link Project”
  - ATLAS/CMS readout link project
  - **Baseline for upgrade**
  - Members: **CERN, FNAL, Oxford, SMU**
  - Associate Members: Academia Sinica
  - See T. Huffman’s talk
  
- Some parts of the effort also within GBT project

# Sub-group A: Lessons Learned and to be Learned from LHC

- Published as ATLAS/CMS note
  - **Lessons learned** by ATLAS/CMS
  - Comparison/summary of **Costs**
  - **Quality** of installed links
  - Plans for **long-term monitoring**
  - Discussion **technology choices**
  - **Recommendations for SLHC**
- 
- Subgroup will monitor LHC
    - draw conclusions for SLHC

<https://edms.cern.ch/document/882775/3.8>

Joint ATLAS/CMS NOTE

ATL-COM-ELEC-2007-001

CMS-IN-2007/066



Joint ATLAS-CMS Working Group on Opto-Electronics for SLHC

Report from Sub-Group A  
Lessons Learned and to be Learned from LHC

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# Sub-Group B: Radiation Guidelines/Coordination

<https://edms.cern.ch/document/882783/2.6>

Joint ATLAS/CMS NOTE

- Agreement on radiation guidelines for SLHC
  - ATLAS Strip
  - ATLAS Pixel
  - ATLAS LAr
  - CMS
- Covers
  - Lasers
  - p-i-n
  - Fibres
  - LLD
  - TIA-LA
  - SERDES ASICs
- Group meets 1-2/ year
  - Coordinate and communicates radiation plans of CMS/ATLAS groups



Joint ATLAS-CMS working group on  
optoelectronics for SLHC

Report from sub-group B  
Optical System Irradiation Guidelines

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*CERN, Geneva, Switzerland*  
Todd Huffman, Cigdem Issever, Tony Weidberg  
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Jingbo Ye  
*Department of Physics, Southern Methodist University*  
Pat Skubic, Rusty Boyd  
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# Sub-Group C: Link Evaluation and Test Procedures

<https://edms.cern.ch/document/882784/2.0>

Joint ATLAS/CMS NOTE

- Embedded within in the Versatile Link Project
- Aims:
  - Develop test procedures
  - Develop common test bench
  - Ensure comparability of test results of different groups



Joint ATLAS-CMS working group on  
optoelectronics for SLHC

Report from sub-group C  
Optical Link Evaluation Criteria  
and Test Procedures

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# Summary

- ATL-PA-MN-0001 submitted 2005, approved 2006
- Timeline & milestones too optimistic
- Most institutes on the proposal are still active on OE R&D
- Important developments since 2006
  - Foundation of JOINT ATLAS/CMS OE group
    - Communication on lessons learned
    - Agreed radiation guidelines and coordination
    - Development of a reference link
  - Foundation of the Versatile Link project (baseline for upgrade)
  - GBT project
- Objectives of ATL-PA-MN-0001 are carried out now mainly by
  - VL and GBT
  - Ohio, Oklahoma, Oklahoma State, and Academia Sinica on VCSEL/PIN radiation-hardness
- Project should be taken off the list given these developments

# BackUP Slides

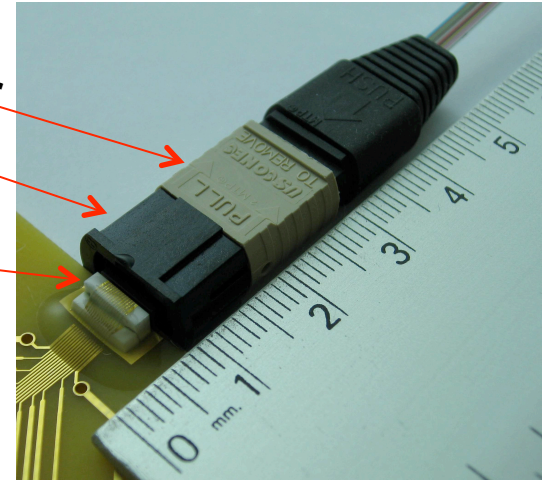
# 850 nm VCSEL Irradiation

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  - ◆ AOC 2.5 Gb/s (obsolete), 5 Gb/s, 10 Gb/s
  - ◆ ULM 5 Gb/s, 10 Gb/s
  - ◆ Optowell 2.5 Gb/s
  - ◆ insufficient time for annealing during irradiation
- 2008:
  - ◆ ~2 VCSEL arrays
  - ◆ AOC 5 Gb/s, 10 Gb/s
  - ◆ Optowell 2.5 Gb/s
- 2009:
  - ◆ AOC 10 Gb/s
  - ◆ goal: 20 arrays
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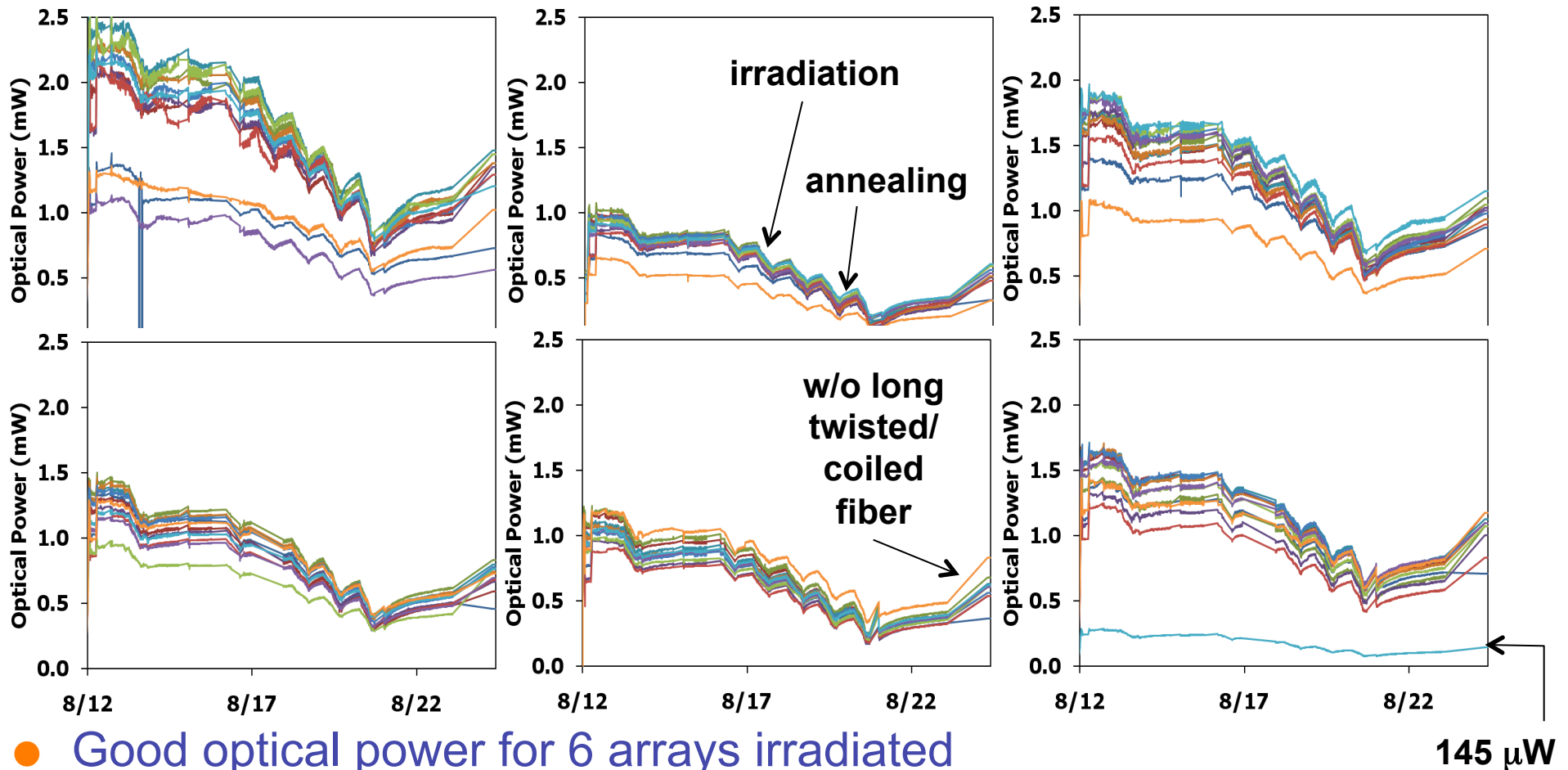
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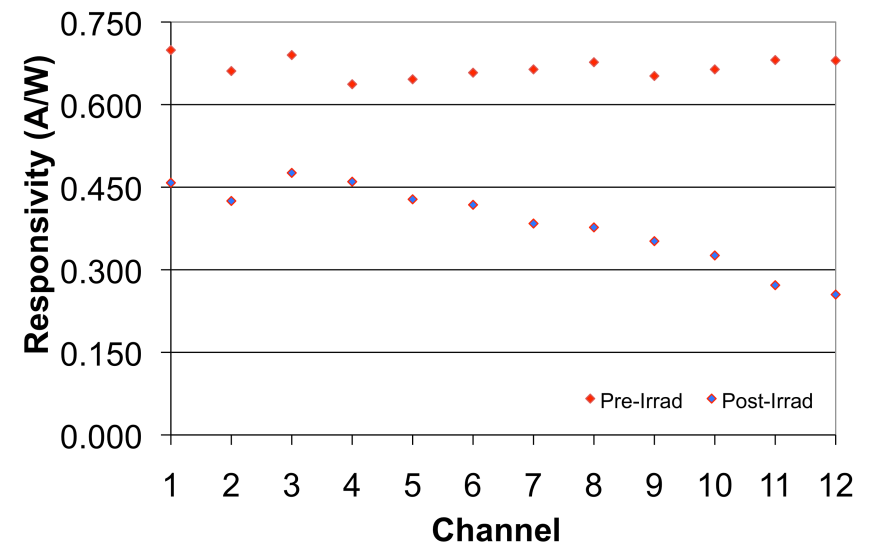
# AOC 10 Gb/s VCSEL



- Good optical power for 6 arrays irradiated
- ◆ await return of arrays to Ohio State for annealing/characterization
- ⇒ need to irradiate a sample of 20 arrays in 2010

# Results on Optowell PIN Arrays

- 20 Optowell PIN arrays irradiated in August 2009
  - ✓ average responsivity after irradiation:  $\sim 0.3$  A/W
  - ◆ analysis complicated by beam misalignment
    - ⇒ need more detailed study
- AOC plans to release high-speed PIN arrays in 2010
  - ◆ plan to irradiate a sample of 20 arrays



# Timeline/Milestones of ATL-PA-MN-0001

- 2006: irradiate GRIN fibres up and single-mode fibres up at the  $^{60}\text{Co}$  gamma source at INER in Taiwan.
  - Is done now at SCK, Co gamma source (VL project)
- Beginning of 2006: We plan to test VCSELs/PINs at UC Louvain in Belgium with neutrons and the PS at CERN with 24 GeV protons. The tests at the PS will include radiation of opto-boards with pixel receiver/driver chips (0.25 $\mu\text{m}$ ). Single event upset (SEU) cross section of the opto-boards will be determined.
  - Neutron radiation are not carried out yet
  - Proton radiation are done by Ohio, Oklahoma & Taiwan
- Mid 2006: Opto-boards with GOL and QPLL chips and VCSELs/PINs will be irradiated. Total dose effects and SEU cross sections will be determined.
  - We don't have the total dose effect or the SEU cross sections



# Timeline/Milestones of ATL-PA-MN-0001

- End of 2006, Milestone: Determined if VCSELs, Si PIN diodes and fibres are suitable for an upgraded ATLAS inner detector at the SLHC.

- **In progress.**

- 2007 – 2008: Opto-boards with SLHC receiver/driver chip (designed by Ohio State University) and PIN/VCSEL arrays will be irradiated at the PS at CERN (24 GeV protons). Total dose effects and SEU vs PIN current will be measured during irradiation.

- **In progress.**

- 2007 – 2008: Opto-boards with SLHC receiver/driver chip (Single-Chip Solution designed by SMU) will be irradiated and tested. SEU cross sections and total dose effects will be determined.

- **In progress.**

- Beginning of 2008, Milestone: Determined whether custom-made opto-electronic solutions are suitable for an upgraded ATLAS inner detector at the SLHC.

- **Did not happen yet**

# Timeline/Milestones of ATL-PA-MN-0001

- Mid 2007 – Mid 2008: Radiation Tests of Commercial Of The Shelf (COTS) components (lasers, fibres, asics). In case the custom-made devices fail the SLHC dose we plan to search for components produced in industry. We will perform these tests in collaboration with the CMS Inner Detector Readout Group which has extensive experience of COTS.
  - **Focus more on commercial parts and tests are performed within the VL project, Ohio, Oklahoma.**
- Mid 2008, Milestone: Choose the set of optimum components for the ATLAS Inner Detector opto-electronic readout system at the SLHC.
  - **This milestone shifted. Expect it to be reached in 2 years.**
- Timeline was too optimistic.
- Events caused this timeline to be obsolete in many respects.