LIGHT07 SUMMARY

E.LORENZ

- WHAT'S ABOUT THE LIGHT XX WORKSHOPS
- THE PARTICIPANTS
- ONE MAIN SUBJECT: THIS TIME G-APDS
- THE OTHER SUBJECTS: PMTS, XTALS, ELECTRONICS, OTHER DETECTORS
- WHERE AND WHEN WILL BE THE NEXT LIGHT XX?

WHAT ABOUT THE LIGHT XX WORKSHOPS

- IT‘S NOT A CONFERENCE, IT‘S A WORKSHOP WHERE PEOPLE COME TOGETHER RATHER INFORMALLY TO DISCUSS SOME ISSUES OF THE LATEST DEVELOPMENT IN SPECIFIC PHOTOSENSORS.

- COMBINATION OF TALKS AND DISCUSSIONS (LONG COFFEE PAUSES AND MEALS FOR MORE DISCUSSIONS IN SMALL GROUPS)
- NO FIXED DATES , ARRANGED MORE WHEN SOME GROUP THINKS A NEW SUBJECT HAS REACHED A LEVEL OF IMPORTANCE TO BRING TOGETHER COLLEAGUES FOR EXCHANGE OF IDEAS, CONTACTS WITH INDUSTRY (INDUSTRY GETS PLENTY OF TIME TO REPORT ON THEIR STATUS, PROBLEMS, INTEREST ECT.)
  COMPLEMENTARY TO THE BEAUNE PHOTON DETECTOR CONF. (PD XX CONF.)
  NORMALLY ONLY FOR A RELATIVELY SMALL GROUP 40-50 PEOPLE

LIGHT 07

1. 23-28.9. 07
2. 41 PARTICIPANTS (2 DID NOT SHOW UP ON SHORT NOTICE)
3. 25 FROM RESEARCH INSTITUTES, 14 FROM INDUSTRY
4. PROGRAM MAINLY ON G-APDS AND SPECIALIZED PMTS
5. 4 GENERAL OVERVIEW TALKS
6. LOW LIGHT LEVEL SENSOR APPLICATIONS AND NEEDS
7. OVERVIEW SEMICONDUCTOR LIGHT DETECTORS (APDS AND G-APDS)
8. OVERVIEW ON APPLICATIONS IN ASTROPARTICLE PHYSICS
9. OVERVIEW ON PET WITH EMPHASIS ON MEDICAL ASPECTS

   WE MISSED THE HEP CALORIMETRY USER COMMUNIUTY

1. 13 TALKS ON DEVELOPMENTS AND SPECIFIC APPLICATIONS OF G-APDS
2. 8 TALKS ON PMT DEVELOPMENTS AND APPLICATIONS
3. 3 INTENSE DISCUSSIONS
4. AMONGST 1, 2. : EIGHT TALKS FROM INDUSTRY
5. 3 POSTERS

THE MAIN SUBJECT OF THIS WORKSHOP

THE GEIGER MODE-APD: A NEW PHOTON DETECTOR
WITH SOME UNUSUAL QUALITIES
ALREADY AT THE LAST BEAUNE CONF. THE G-APD
BECAME THE HIGHLIGHT BUT THAT TIME MUCH MORE
DOUBTS IF THIS DEVICE WOULD EVER FLY

THE SEAFARERS AND THE BRITISH/SWISS BANKERS
SITUATION

WE NEVER HAD A DEVICE AT HAND
THAT IS SO COMPACT, CAN DETECT SINGLE PHOTONS
RUNS AT SUCH A LOW VOLTAGE AND PRODUCES
SUCH BIG SIGNALS
NEVERTHELESS MANY PARAMETERS NOT STABLE
OR EVEN NOT KNOWN
BUT WE MAKE RAPID PROGRESS

WHERE DO WE STAND

AROUND 4-5TH YEAR OF THE TYPICAL DEVELOPMENT CYCLE OF ≈ 8 YEARS

EXPLORATION OF TECHNOLOGY
I COUNTED MORE THAN 20 DIFFERENT DESIGNS
NOISE REDUCTION ONGOING
OPTICAL CROSSTALK GETS MOSTLY UNDER CONTROL
1x1 mm^2 DESIGNS MOST COMMON CONSTRUCTION
FIRST 2.5x2.5, 3x3 AND 5x5 mm^2 PROTOTYPES AVAILABLE
5x5mm^2 (B.DOLGOSHEIN) and 10x10 mm^2 ON THE HORIZON

COMPARISON OF THE SITUATION WITH PIN PHOTODIODE AND APD DEVELOPMENTS AT THE SAME EQ. TIME (4-5 Y IN THE 8 Y CYCLE)

THE BIG POTENTIAL OF THE CMOS TECHNOLOGY

INTEGRATION OF PHOTON DETECTORS INTO COMPLEX ELECTRONICS NOW POSSIBLE WITH BASICALLY THE SAME PROCESS (NOT POSSIBLE WITH PMTS OR APDS). WE HAVE NOT YET CONSIDERED THIS IMPORTANT ISSUE.

WHEN DOES THE CONSOLIDATION PHASE SET IN?

SOME FACTS ABOUT G-APD PRODUCTION
ORIGINALLY 3 ACTIVITIES IN RUSSIA
NOW AT LEAST 8 COMPANIES MAKING PROTOTYPES
(BUT TRANSITION TO SERIES PRODUCTION NOT SO EASY.
WHAT ARE THE MARKET PROSPECTS ??? TO START SERIES PRODUCTION
CAN A REASONABLE PROFIT BE MADE?
WILL NEVERTHELESS THE PRICES DROP FAST ENOUGH TO ATTRACT MORE CUSTOMERS
WHEN DOES THE PRODUCTION TECHNOLOGY BECOME MATURE
WHERE ARE ALL THE CUSTOMERS THAT WANT G-APDS?)

THE STANDARDISATION PROBLEM (TOO MANY PARAMETERS ONE CAN TURN ON)
P-ON-N, N-ON P, FRONT SIDE /BACKSIDE ILLUMINATION?
MEAN PDE, PEAK PDE AT WHICH WAVELENGTH,
SIZE, CELL SIZE, ACTIVE AREA FRACTION, DYNAMIC RANGE
GROOVES OR NO GROOVES, WHICH GAIN,
OVERVOLTAGE RANGE, OPERATION VOLTAGE
NOISE, OPERATION TEMPERATURE
STABILITY OF OPERATION PARAMETERS
CELL DEADTIME, RECOVERY, LINEARITY/ SATURATIONS
LINEARITY
RADIATION DAMAGE
HIGHLY CORRELATED PARAMETERS
THE POTENTIAL USERS SHOULD SOON UNIFY ON SOME BASIC TYPES AND CONFIGURATIONS (EXAMPLE IN PIN PHOTODIODES: MOST APPLICATIONS USE THE 3X3 mm^2 BLUE ENHANCED PIN DIODE AS STARTING BASE FOR THE APPLICATIONS.

WHERE WEARE MAKING PROGRESS IN UNDERSTANDING G-APDS

RADIATION DAMAGE (D.RENKER): DAMAGE IS VERY SIMILAR AS IN NORMAL APDS
BUT NOT ALL PROCESSES WELL UNDERSTOOD.
MORE RESEARCH NEEDED.
PDE NEARLY NOT AFFECTED, NOISE VERY MUCH AFFECTED
G-APDS ARE NOT SUITED FOR ENVIRNONEMTS AS IN LHC OR EQ. ‚HOT' ENVIRONMENTS
WE STILL NEED TO UNDERSTAND RADIATION DAMAGE OF HIGH Z RELATIVISTIC PARTICLES (PERHAPS SHOW STOPPER IN SPACE APPLICATIONS ?)
10^8 Neutrons/mm^2 prevent MPPCs from proper working

Displacement damage cannot be avoided. The dark count damage constant is $(3.5\pm0.5)*10^{-3}$ Hz/%/neutron. Only a reduction of the contributing volume can keep the dark counts in a tolerable range (D. Renker).

GENERAL ADVICE: MAKE ACTIVE VOLUME AS SMALL AS POSSIBLE

OPTICAL CROSS-TALK: NEW INFO FROM N.OTTE. ≈ 3 ‚EFFICIENT' PHOTONS /Gain= 10^5
EFFICIENT PHOTONS: PHOTONS BETWEEN 1.1 AND 1.6 eV
NOW GOOD MODELLING POSSIBLE (WE NEED A PAPER)

G-APD UNIFORMITY: GENERALLY HIGH (N. GODINOVIC...)

THE CURRENT POTENTIAL USER COMMUNITY

A) ASTROPARTICLE PHYSICS: GROUND-BASED CHERENKOV TELESCOPES FOR VHE GAMMA ASTRONOMY (E.L.)

B) HEP EXPERIMENTS DETECTING CHERENKOV RINGS (P. KRIZAN)
A HIGH PDE (> THAN IN PMTS) IS OF KEY IMPORTANCE. GAIN, OPT CROSS TALK, NOISE SECONDARY
AFTER FIRST SUCCESSFUL PROTOTYPES NEED FOR MANY m^2 AREA
BUT COST AN ISSUE

C) HEP: WLS/SCI FIBER DETECTORS: CONDITIONS EASIER COMPARED TO CHERENKOV LIGHT DETECTION. PROJECTS MORE ADVANCED ALREADY A ‚MARKED' VISIBLE
NOTE: PMTS LOOSE OUT FOR 1x1 mm^2 AREA DETECTORS

D) IN WAITING STATUS: SPACE APPLICATIONS, EXAMPLE S-EUSO > 10 m^2AREA

NUCLEAR MED. APPLICATIONS: PET/NMR
BOTH SMALL ANIMAL PET AND CLINICAL PET (BRAIN, HEART, CANCER, DRUG DEV.)
WE NEED
SOME PROOF OF CONCEPT DEMONSTRATORS
THE PRICES MUST GO DOWN
RELIABLE SERIES PRODUCTION
NEED MATRIX PRODUCTION (E.POPOVA, P.HUGHES)

NEXT STEPS: INTEGRATED ELECTRONICS ON SAME CHIP (LARGE, UNIQUE POTENTIAL) (RMD, (E. POPOVA))

SOME COMMENTS ON PET DEVELOPMENTS WITH G-APDS

- LARGE CELL NR/mm^2 NEEDED
- PDE LESS AN ISSUE
- OPT. CROSSTALK, NOISE LESS AN ISSUE
- GAIN LESS AN ISSUE
- THE READOUT (HIGH MULTIPLEXING) VERY IMPORTANT, NOT DISCUSSED
- TIMING IMPORTANT BUT ONE WANTS ≈ 300 psec RESOLUTION

- COMPARED TO PREVIOUS PMT AND APD DEVELOPMENTS:
  MUCH FASTER PROGRESS WITH G-APDS!!
  511 KeV RES. ≈ 10-13%, TIMING ≈ 600-800 psec
  CONFIRMED BY MANY TESTS
  (G.LLOSA, B. DOLGOSHEIN, RMD, P. KRIYAN, N.OTTE, P.HUGHES
  A. TADDY, ...)

WE MISS LARGE SCALE NON R&D APPLICATIONS

FLUORESCENCE SPECTROSCOPY
GENERAL RADIATION MONITORS (CONTROL SMUGGLING RADIOACTIVE MATERIALS)
OPTICAL COMMUNICATION APPLICATIONS
LIDARS
MANY MORE APPLICATIONS RELYING ON CHEAPOR SMALL PHOTON DETECTORS.
.

GENERAL COMMENT: MANY CURRENT OPTOELECTRONICS INSTRUMENTS ARE BASED ON HIGHER LIGHT INTENSITIES: WE ARE NOT YET READY FOR FAST LOW LIGHT LEVEL APPLICATIONS.

THE **MOS** PRODUCTION AND INTEGRATION IN **MOS** ELECTRONICS CHIPS

OPTOELECTRONICS IS CURRENTLY AN EXPLODING AREA OF INSTUMENT DEVELOPMENT WITH A HIGH DEMAND ON MINIATURISATION

THE UNCHALLENGED TERRITORY OF LARGE AREA PHOTON DETECTION: THE LARGE PMTS

USERS:
HEP RESEARCH: NEUTRINO DETECTORS IN WATER, ICE...
MEDICAL: WHOLE BODY SCANNERS...
SECURITY: SURVEY OF NUCLEAR MATERIAL SMUGGLING...

ALL NEED LARGE AREA PMTS, COST IS AN ISSUE
POSSIBLE SOLUTIONS: SMART PMTS (PHOTONIS, LUBSANDORZHIEV, FERENC)
HIGHER QE CATHODES: HAMAMATSU, PHOTONIS
AN IMPORTANT PROBLEM: THE PHOTOELECTRON COLLECTION EFF. (+TIMING)
CLASSICAL DYNODES NOT SO GOOD
-> SMART PMTS , HYBRID PMTS WITH e-BOMBARDED ANODES WITH INTERNAL AMPLIFICATIONS
A SPECIAL CASE : GAASP HPD (T. SAITO) REACHING 50 % QE/PDE
EXCELLENT PERFORMANCE BUT LIMITED LIFE-TIME
AND HIGH PRICE PREVENTS LARGE SCALE APPLICATIONS

THE ISSUE OF HIGHER QE PHOTOCATHODES

RESEARCH HAS A HIGH DEMAND. DRIVE FOR HIGHER QE PHOTOCATHODES

THE POTENTIALLY HIGHER PDE OF G-APDS IS A THREAD FOR THE SMALL (MATRIX) PMTS -INDUSTRY

NOW WE SEE THE FIRST SIGNIFICANT IMPROVEMENTS
HAMAMATSU (SUPER,ULTRA BIALKALI > 40 %QE
PHOTONIS (S-BIALKAL, S^2, S^3) ->55% QE
HAMAMATSU (GAASP) > 50% QE (CONSISTENT PROD.!!)
IS THIS THE END OR THE BEGINNING OF A GENERAL TREND TO IMPROVE THE CATHODES
CAN THE PEAK QE BE SHIFTED BETWEEN 300 AND 500 nm?
CAN THE SPECTRAL RANGE BE WIDENED?
CAN THE COST BE LOWERED?

A BIG HUG AND MANY THANKS TO

SYBILLE

FOR THE EFFICIENT ORGANISATION IN THE BACKGROUND AND ALL THE FRIENDLY HELP AND QUICK FIXES IN
ANY CASE OF A PROBLEM

ALSO MANY THANKS TO THE PERSONNEL OF THE RINGBERG CASTLE

MANY THANKS FOR ALL THE CONTRIBUTIONS BY TALKS AND IN THE DISCUSSIONS

SPECIAL THANKS TO THE INDUSTRY PARTICIPANTS
(MANY MORE DETAILS REVEALED THAN AT BEAUNE)

A PLEA TO:

THE PHYSICISTS: MAKE MORE CONTACTS TO OUR COLLEAGUES IN INDUSTRY DOING DEVELOPMENTS AND UNDERSTAND THEIR CONSTRAINTS
TO OUR COLLEAGUES FROM INDUSTRY: MAKE MORE CONTACTS TO THOSE RESEARCHERS INVOLVED IN DEVELOPMENTS

GOOD BYE, GET HOME SAFELY AND SEE YOU AGAIN AT THE NEXT WORKSHOP