ECFA panel for instrumentation

Els Koffeman (Nikhef Amsterdam & UvA)

Mandate of the panel [2014]

Nikhef

- Help to create a coherence of the global R&D effort by encouraging synergy between different activities and advising funding agencies.
- Overview the European effort for detector R&D
  - Both items remain in suspense but the committee is willing to work on them, with conjunction with other players (concluding remarks)

Y.Karyotakis (chair)

D.Eckstein (scientific secretary)

E. Koffeman

G. Mikenberg

H.G. Moser

T. Sumiyoshi

C. Padilla

A. White

R. Brenner

M. Diemoz

Introduction [PANEL 2014]

Previous panel was active until 2014.Panel focussed on LC activities and reviewed the following projects:

Calorimeters : High granularity electromagnetic and hadronic calorimeters:

Si and Scintillator ECAL
digital and analog Hcals.

Forward calorimeters :

FCAL and luminosity

Trackers :

LCTPC with various read-outs

Vertex Detectors :

DEPFET and CMOS technologies

PANEL 2017

- **Chair Els Koffeman**, KM3NeT technical coordinator, Professor University of Amsterdam on instrumentation in particle physics
- **Scientific secretary is Doris Eckstein** (DESY)
- Ex officio Arielle Catai, ICFA R&D panel chair

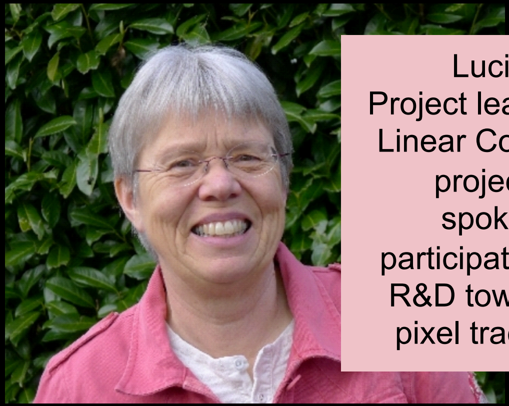
And ….

Arno
Straessner
ATLAS LAr Calorimeter
Upgrade Co-Convener
(2009-2016) and ATLAS LAr
Electronics Upgrade Co-Project
Leader (from 2017); Professor
for Experimental Particle
Physics at TU Dresden

Phill Allport
ATLAS Upgrade Coordinator.
Director Birmingham Instrumentation
laboratory for Particle physics and
Applications (BILPA).

Laurent Serin
Senior physicist
ar LAL Orsay
Liquid Argon
electromagnetic
calorimeter
Phase2 upgrade
project
of a High
Granular Timing
Detector, and
IN2P3/CNRS
national contact
for ATLAS

Sylvia dalla Torre
INFN senior physicst; fundamental
research in hadron physics; gaseous and
RICH detectors;
RD51 (MPGD) co-spokesperson; for 7
years director of INFN-Sezione di Trieste



Lucie Linssen
Project leader of CERN's
Linear Collider Detector
project, CLICdp
spokesperson,
participation in detector
R&D towards a silicon
pixel tracker for CLIC.

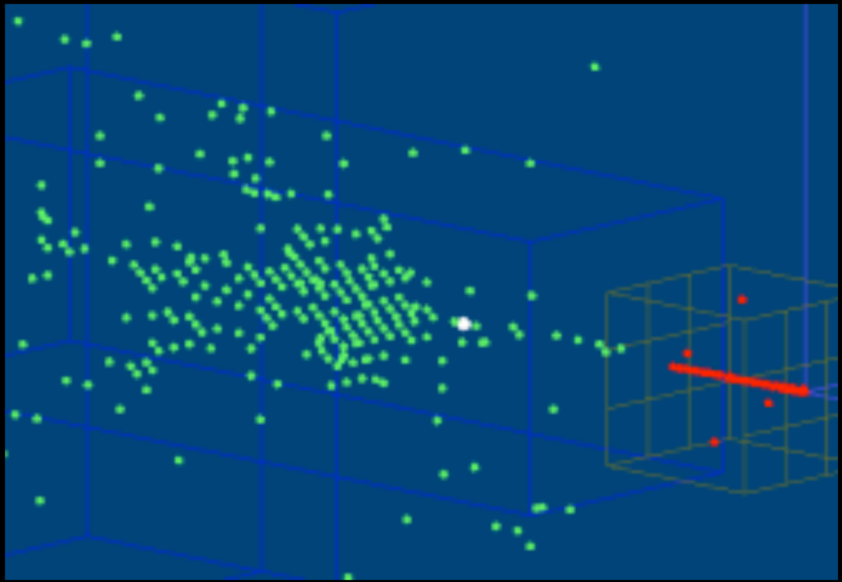
Our ambition "make R&D shine"

- REWARD YOUNG TALENT
- Continue to act as review panel
  - Attract (young) external reviewers
  - First plan is a request for the review of Calice

- Connect with existing review boards
- Explore new roles
  - Assist reviewing process of ATTRACT program in contact with Marcus Nordberg
  - Review R&D for Astroparticle Physics Experiments
  - National/regional R&D activity in Europe
- Initiate R&D discussion for EU strategy on particle physics

- Obtain the assessment of the board on different aspects of CALICE activities, get suggestions for future improvement:
  - The current role of CALICE in the HEP R&D environment, including assessment of the current extent and limitations of the scope of the collaborationactivities, which is focussed on, but not limited to linear collider applications
  - The organisation and operation of CALICE, including collaboration structure, goals, timescales and risks, and the representation to the outside, for example inconferences and publically available material
  - The quality and scope of CALICE results and publications, and the level atwhich the technical solutions followed are state-of-the art

Spokesperson Frank Simon
Contactperson panel Lucie Linsen



We started ambitious with taxonomy

Nikhef

Technique	1.1 (hadron collider)	1.2 (lepton collider)	1.3 (lepton-hadron)	1.4 (fixed target)	Comment
1.a (Si) Vertexing (& Lumi/FP)	Rad-hard (pp) Low mass (AA) Data rate (pp)	Low mass Fine pitch Time stamp	Fine pitch Low mass	Fast R/O Fine pitch Radiation	Monolithic devices incorporate electronics. Time structure dictates on-detector R/O.
1.b Inner track (Si)	Area/cost Radiation (pp)	Low mass Area/Cost	Area/cost	Radiation	Can be few $10^{15} n_{eq}/cm^2$ radiation levels
1.c Track gas (inlc muons)	Area/cost Hit rate, aging	Volume (TPC)	Area/cost Hit rate	Hit rate	Industrialisation of gas micro-pattern detectors
1.d Sci Fibre	Radiation incl photodetectors			Efficiency	Photodetector radiation hardness
1.e Scint Calo	Radiation Granularity	Granularity EM Resolution	Granularity EM Resolution	EM Resolution	Timing for ToF or pile-up mitigation
1.f Calo L-noble	Charge collection time	EM Resolution	EM Resolution	EM Resolution Speed	Rate capabilities
1.g HG-Calo	Area/cost Resolution	Area/cost	Area/cost EM Resolution	EM Resolution	Particle Flow Analysis (EM Resolution?)
1.h Calo homogenous	Radiation Granularity	EM Resolution Granularity	EM Resolution Granularity	EM Resolution Granularity	Timing for ToF or pile-up mitigation
1.i Fast Timing (Si, gas, scintillator)	Radiation, Speed, Rate Area/cost	Time stampArea/cost	Area/cost	Speed Sensitivity	Primary vertexing. Time of Flight for lower momenta PID
1.k Particle ID RICH	Volume Area/cost	Volume Area/cost	Volume Area/cost	Volume Area/cost	Efficiency for single photo-detection
1.o FE Electronics & Interconnect	Radiation Cost/channel # Power	Channel #, Power, fine-pitch	Cost/channel #, Power	Speed/ data volumes	Prototyping costs for deep-sub-micron engineering runs
1.p Data links (incl opto-electronics)	Radiation Cost/channel # Low mass	Channel # Low mass	Channel # Low mass	Speed/ data volumes	How to exploit commercial developments?
1.q Mech, cool, services	Low mass, reliable, stable	Low mass, reliable, stable	Low mass, reliable, stable	Low mass, reliable, stable	Large-scale magnet systems
1.r TDAQ + Computing	Cost, Speed Commercial Solutions	Cost Channel #	Cost, Speed Commercial Solutions	Speed/ data volumes	Is Moore's Law safe forever?

See Phil Allport EPS 2017

R&D at CERN

Nikhef

- Significant part of R&D in our field is embedded in CERN experiments and a (limited) number of R&D programs
  - Soure CERN Greybook

RESEARCH PROGRAMME

LHC
SPS
PS
AD
ISOLDE Facility
Irradiation Facility
Neutrino Platform
GRADE
CTF3
R&D

Name	Synonym	Title
RD-18	CRYSTAL CLEAR	R&D on scintillation materials for novel ionizing radiation detectors for High Energy Physics, medical imaging and industrial applications
RD42		Development of Diamond Tracking Detectors for High Luminosity Experiments at the LHC
RD50		Development of Radiation Hard Semiconductor Devices for Very High Luminosity Colliders
RD51		Development of Micro-Pattern Gas Detectors Technologies
RD52		Dual-Readout Calorimetry for High-Quality Energy Measurements
RD53		Development of pixel readout integrated circuits for extreme rate and radiation
UA9	CRYSTAL	

R&D embedded in experiments

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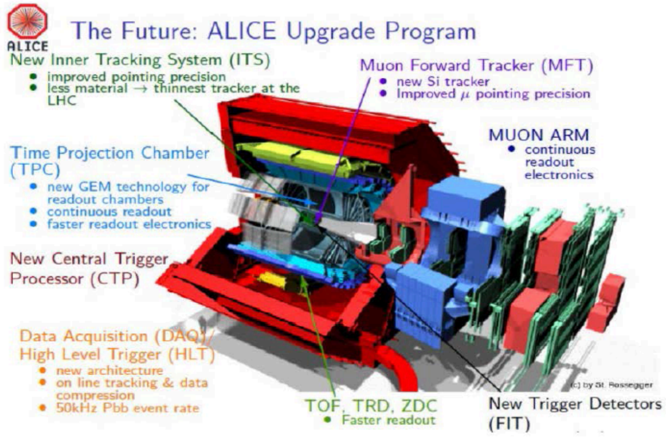
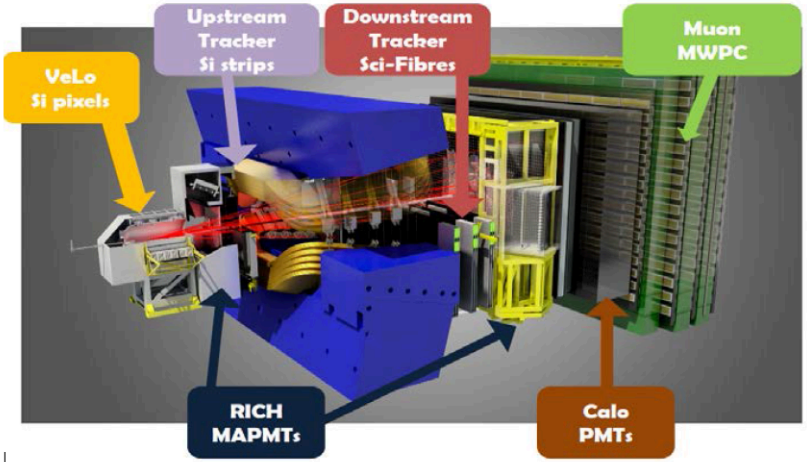
https://indico.cern.ch/category/4863/

ALICE: Phase-I Upgrades



LHCb: Phase-I Upgrades



CMS: Phase-II Upgrades

http://cds.cern.ch/record/2055167/files/LHCC-G-165.pdf?version=4

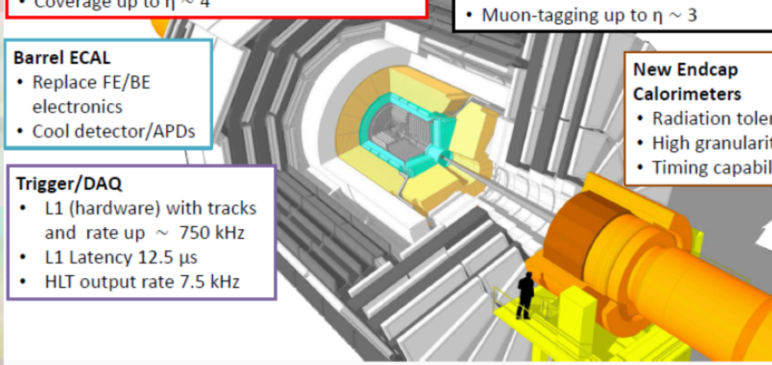
New Tracker
- Radiation tolerant - high granularity - less material
- Tracks (P_T>2GeV) in hardware trigger (L1)
- Coverage up to η ~ 4

Muons
- Replace DT and CSC FE/BE electronics
- Complete RPC coverage in forward region (new GEM/RPC technology)
- Muon-tagging up to η ~ 3

Barrel ECAL
- Replace FE/BE electronics
- Cool detector/APDs

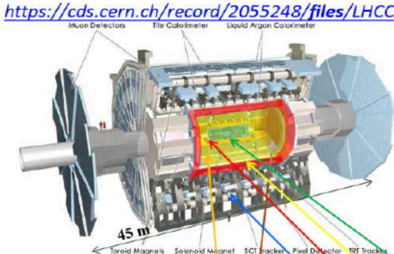
New Endcap Calorimeters
- Radiation tolerant
- High granularity
- Timing capability

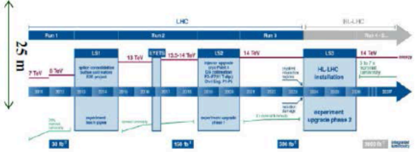
Trigger/DAQ
- L1 (hardware) with tracks and rate up ~ 750 kHz
- L1 Latency 12.5 μs
- HLT output rate 7.5 kHz



ATLAS: Phase-II Upgrades

https://cds.cern.ch/record/2055248/files/LHCC-G-166.pdf





Phase-1 Upgrade	Phase-2 Upgrade
L = 2e34 (μ~60) int L = 200 fb⁻¹	L = 7.5e34 (μ~200) int L = 3000 fb⁻¹
• New Muon Small Wheel (NSW) • Fast Track Trigger (FTK) • TDAQ Phase-1 • LAr Calorimeter Electronics • ATLAS Forward Protons (AFP)	• All new Tracking Inner Detector (ITk-Strip/Pixel) • Calorimeter Electronics Upgrade • Forward Timing Detector • Muon System Upgrade • TDAQ Phase-2

See Phil Allport EPS 2017

R&D at CERN

- GRADE

RESEARCH PROGRAMME

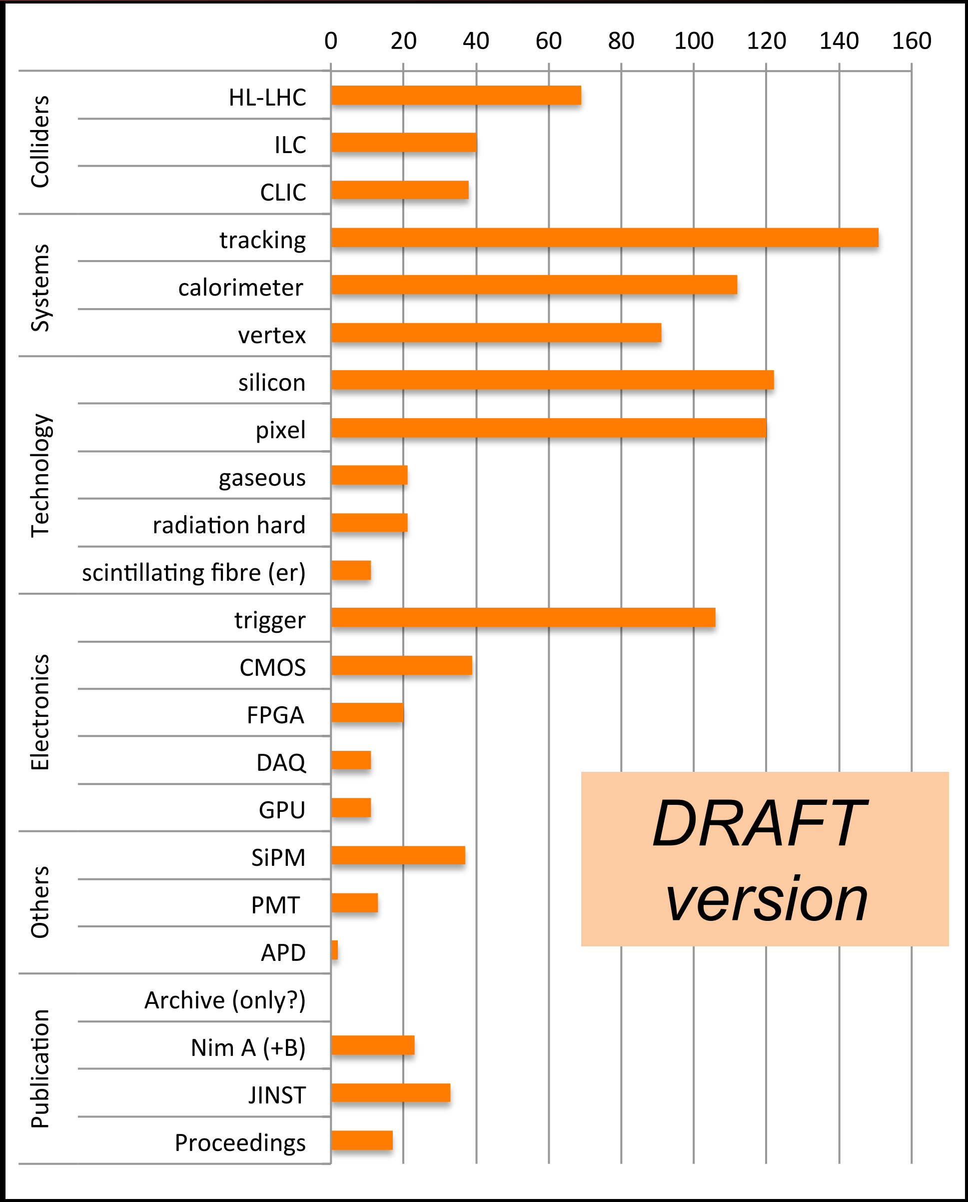
LHC
SPS
PS
AD
ISOLDE Facility
Irradiation Facility
Neutrino Platform
GRADE
CTF3
R&D

Name	Synonym	Title	Date of Approval
GR02	TT-PET	Thin Time-Of-Flight PET project	08-06-2016
GR03	AUGMENT	generic R&D and augmented reality techniques	08-06-2016
GR04	HEALTH	detectors for health and safety	08-06-2016
GR1	SIMPLE	Silicon Photo Multipliers for Generic Detector R&D	09-12-2015

Make R&D shine (again)

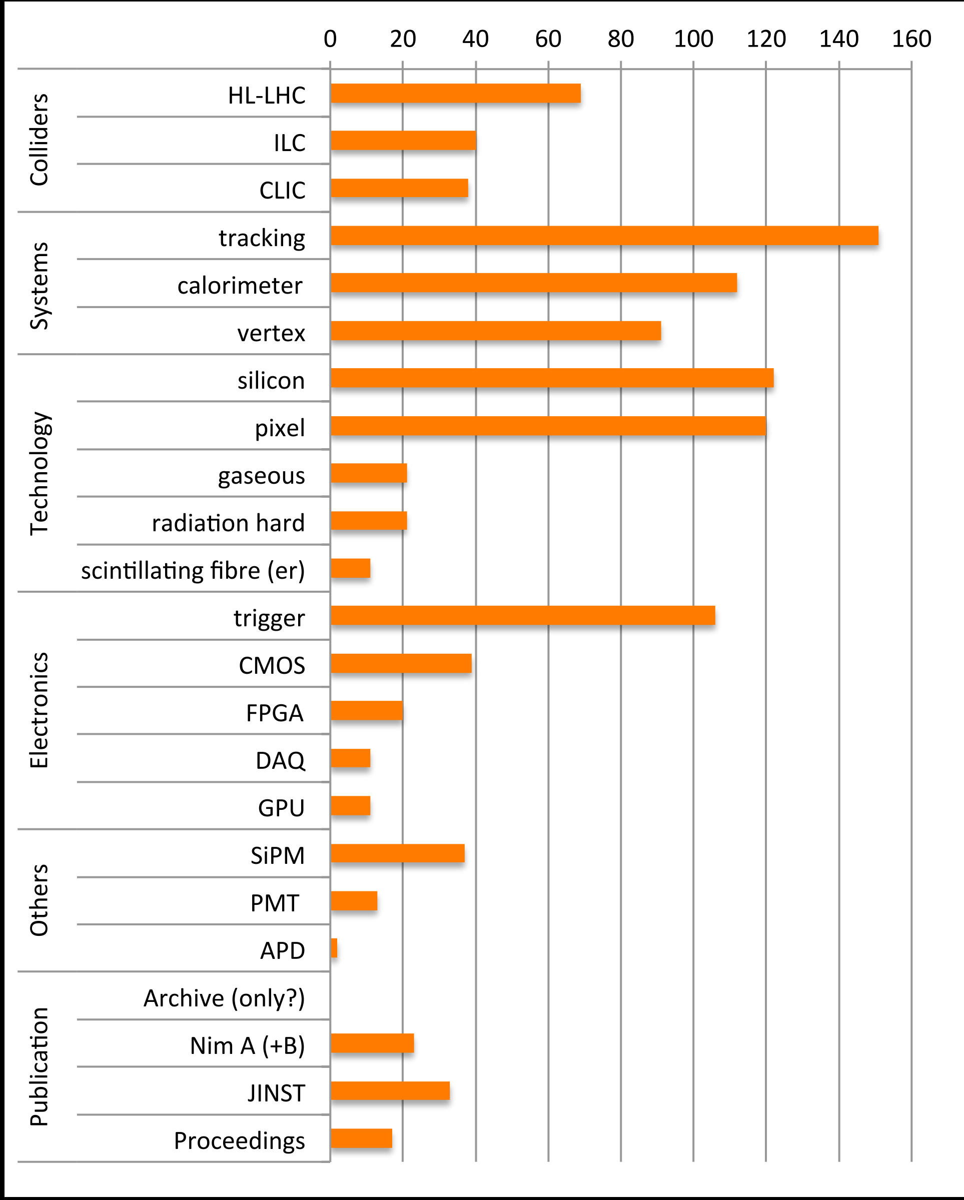
- I performed a small analysis on what we published in 2017
- Few percent of total number of publications is on R&D

- DISCLAIMER
  - Some terms are not unique and no correlations are counted. Source is SPIRES database.
  - Publication distribution is given for the search term "silicon"



Make R&D shine (again)

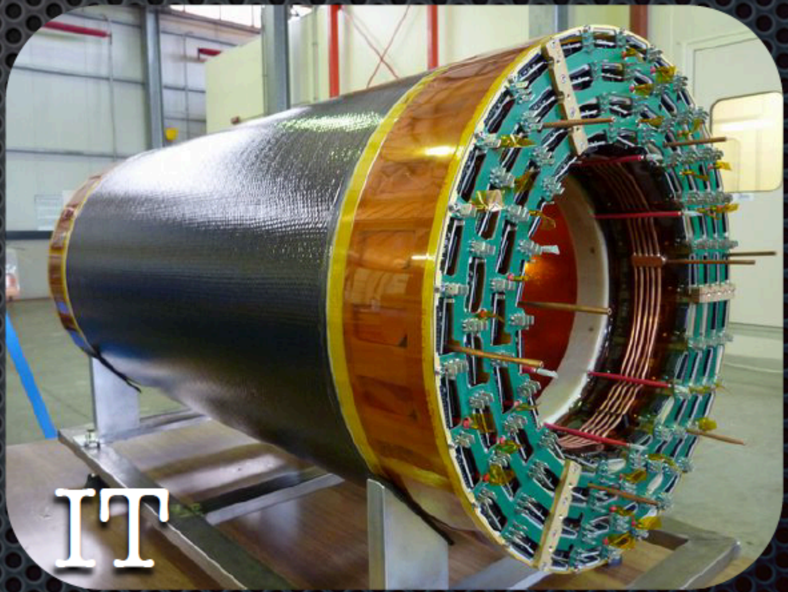
- The number one topic of 2017……
- “ FAST” (>200 hits)
- <u>Personal Concern</u>
  - The impact factor of JINST and NIM are not so high

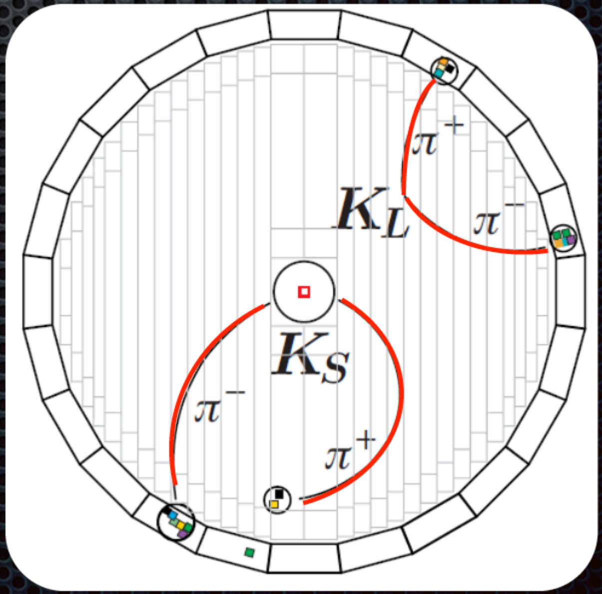


Highlights KLOE 2 DAΦNE

Tracking System

- DC – He-Iso 90-10
  3.7m x 4m Drift Chamber
- Inner Tracker – 4 Cylindrical GEM detectors





Highlights

First tests of a novel radiation hard CMOS sensor process for Depleted Monolithic Active Pixel Sensors

H. Pernegger[a], R. Bates[c], C. Buttar[c], M. Dalla[b], J.W. van Hoorne[a], T. Kugathasan[a], D. Maneuski[c], L. Musa[a], P. Riedler[a], C. Riegel[a], C. Sbarra[b], D. Schaefer[a], E.J. Schioppa[a] and W. Snoeys[a]

− Hide full author list

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Journal of Instrumentation, Volume 12, June 2017

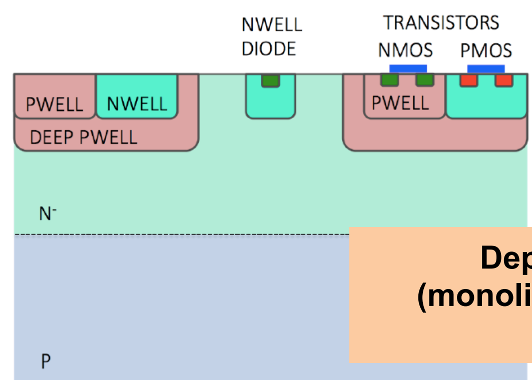

Figure 2. Cross-section of the TJ180 process modification for enhanced depletion.

Depleted MAPS (monolithic active pixel sensors)

Contributors

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HGTD and LGAD R&D beam test crews

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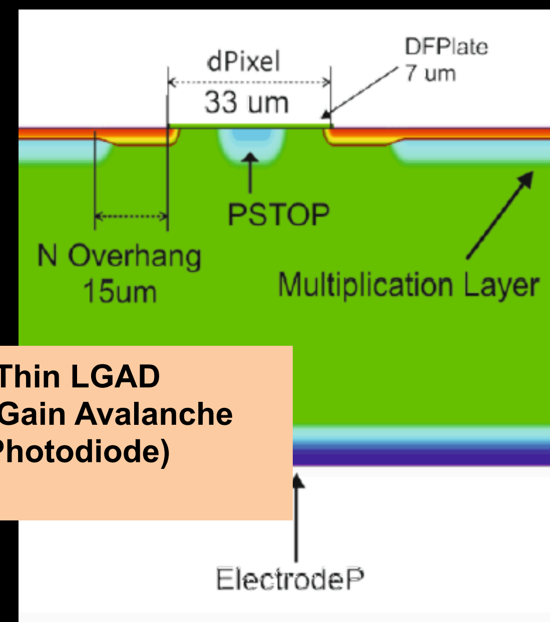
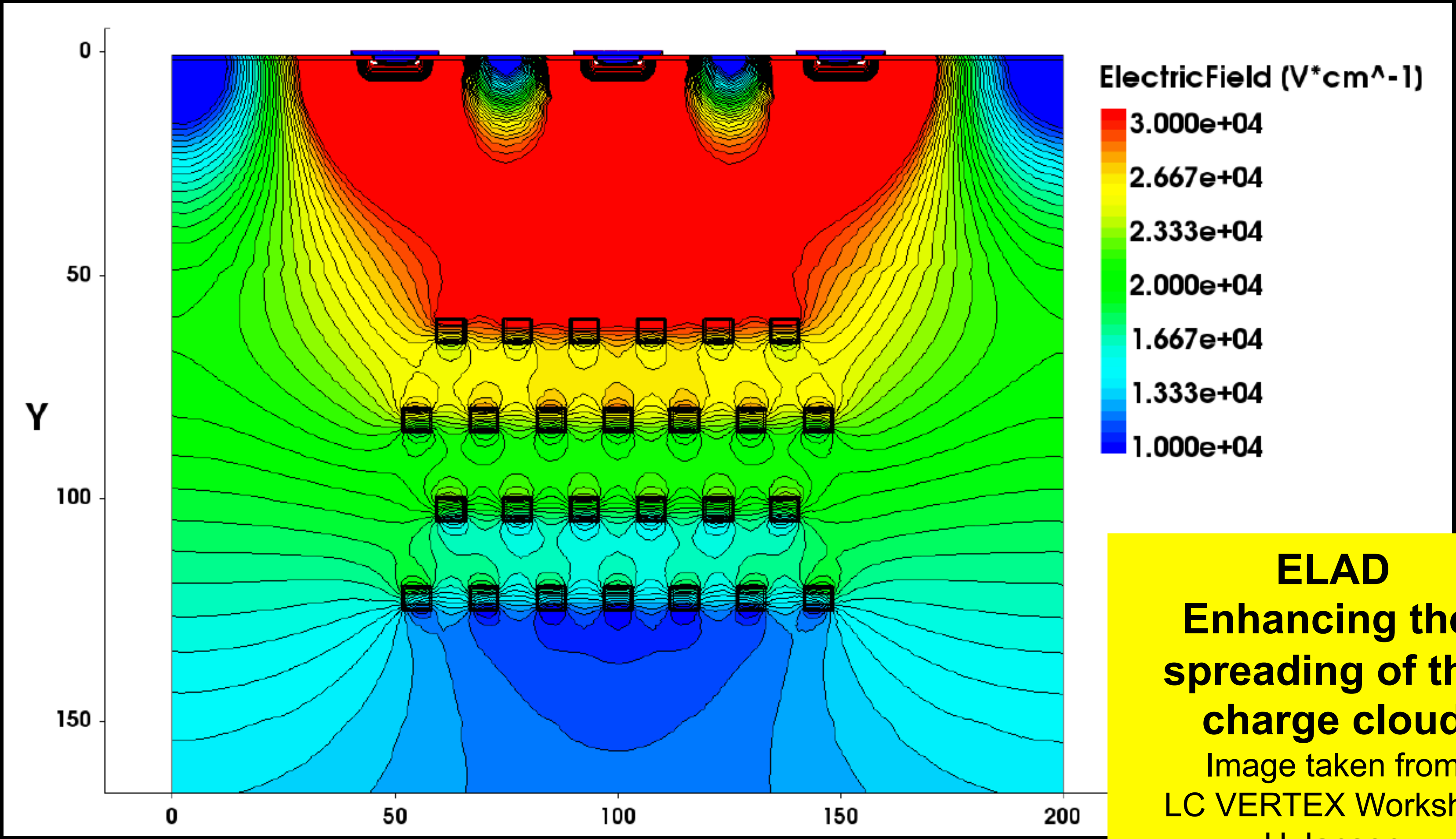
This work was partially performed within the CERN RD50 collaboration.

Hartmut F.-W. Sadrozinski, "Measurements on thin LGAD", RD50 2017



Thin LGAD (Low Gain Avalanche Photodiode)

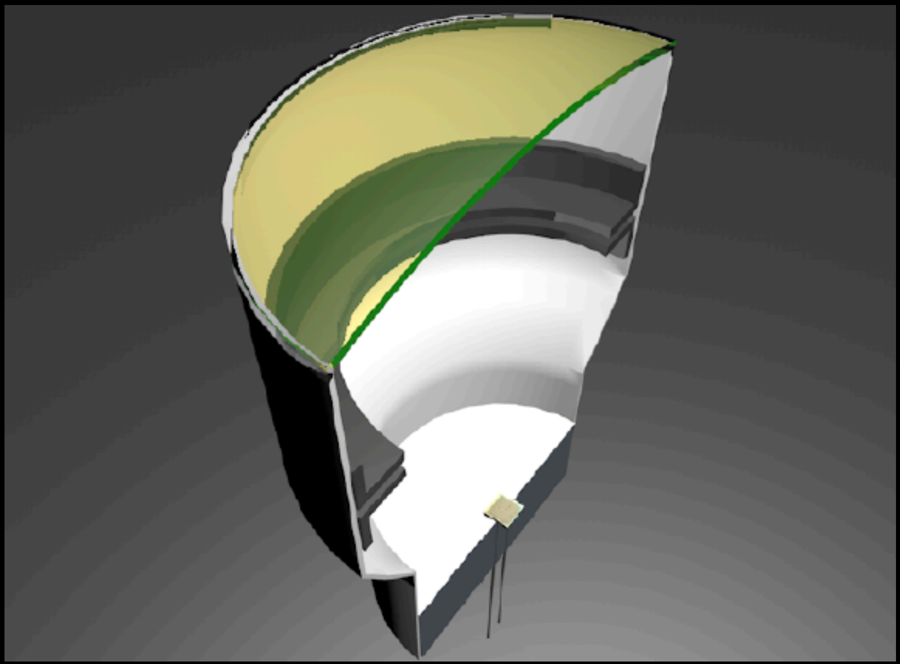
Highlights Novel concept



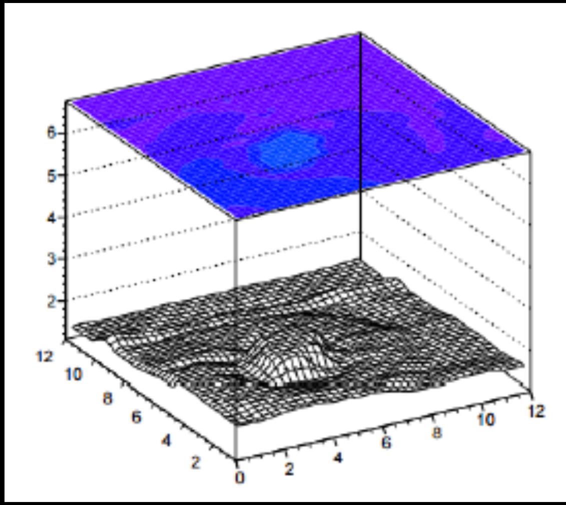
ELAD
Enhancing the spreading of the charge cloud
Image taken from
LC VERTEX Workshop
H.Jansen

Highlights Novel concepts PMT

- PMT with SiPM inside



Full Characterization of the First 1 Inch Industrial Prototype of a New Concept Photodetector

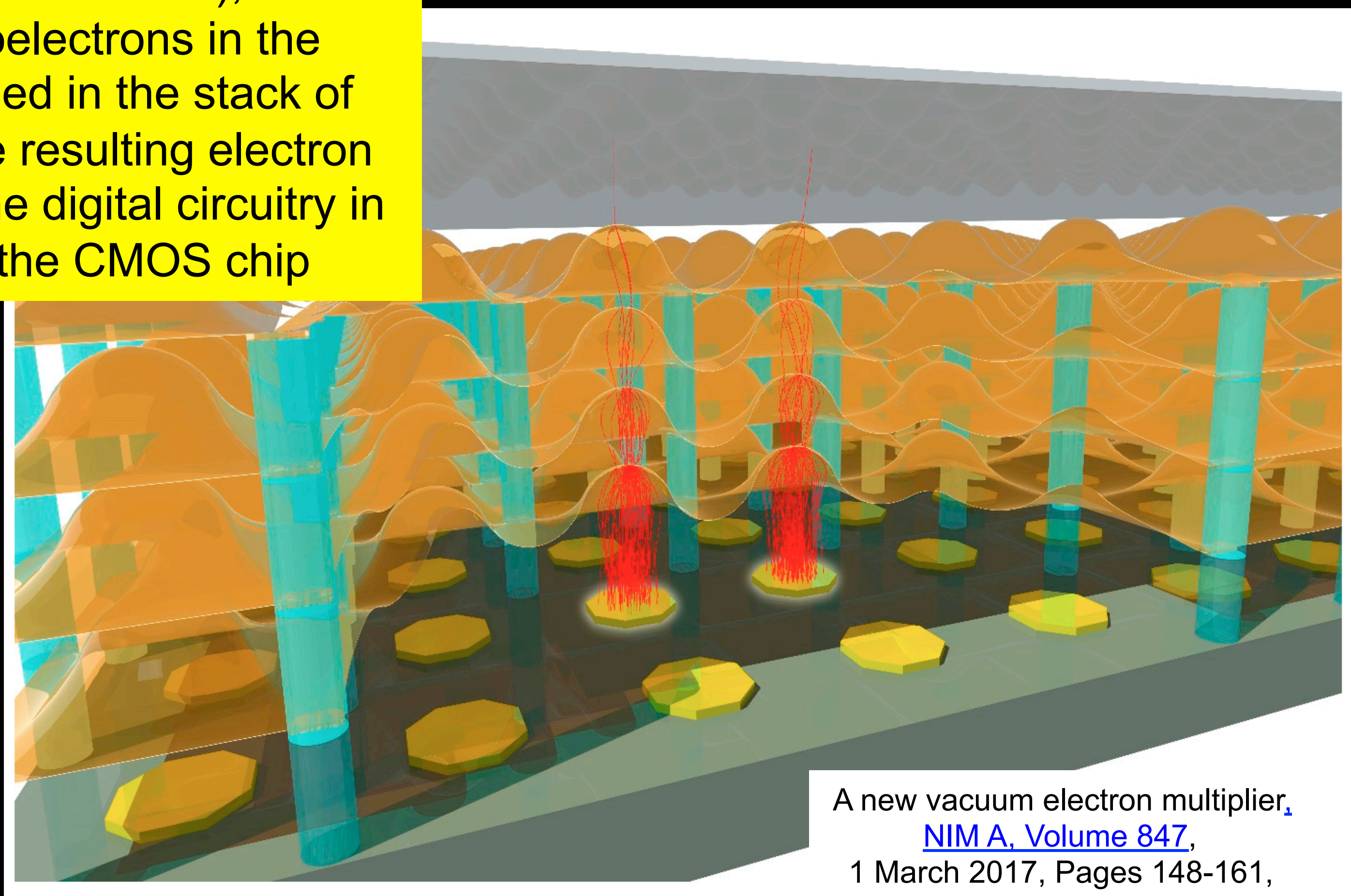


images taken from
High Energy Physics – Experiment (hep-ex)
arXiv:1705.00602 [physics.ins-det]

Highlights Novel concepts PMT on a pixel

Nikhef

The Tipsy detector, for example, is sensitive for individual soft photons (100–1000 eV), which are converted into photoelectrons in the photocathode and multiplied in the stack of transmission dynodes. The resulting electron avalanche is detected by the digital circuitry in the individual pixels of the CMOS chip



A new vacuum electron multiplier, NIM A, Volume 847, 1 March 2017, Pages 148-161, Harry van der Graaf et al.

Summary

- Looking forward to
  - To start Calice new review
  - Prepare for European Strategy
  - Connect with ATTRACT
  - Follow Novel Concepts

- Explore
  - Publication strategy
  - Review R&D in related field (discussion started with APPEC/ several neutrino experiments), Nupecc, GW?