# Solid State Detectors
# Poster Session Summary #I
# System Construction and Operation

Petra Merkel – Fermilab

14th Pisa Meeting on Advanced Detectors

La Biodola, Isola d'Elba, Italy

May 29, 2018

# Tracker Systems

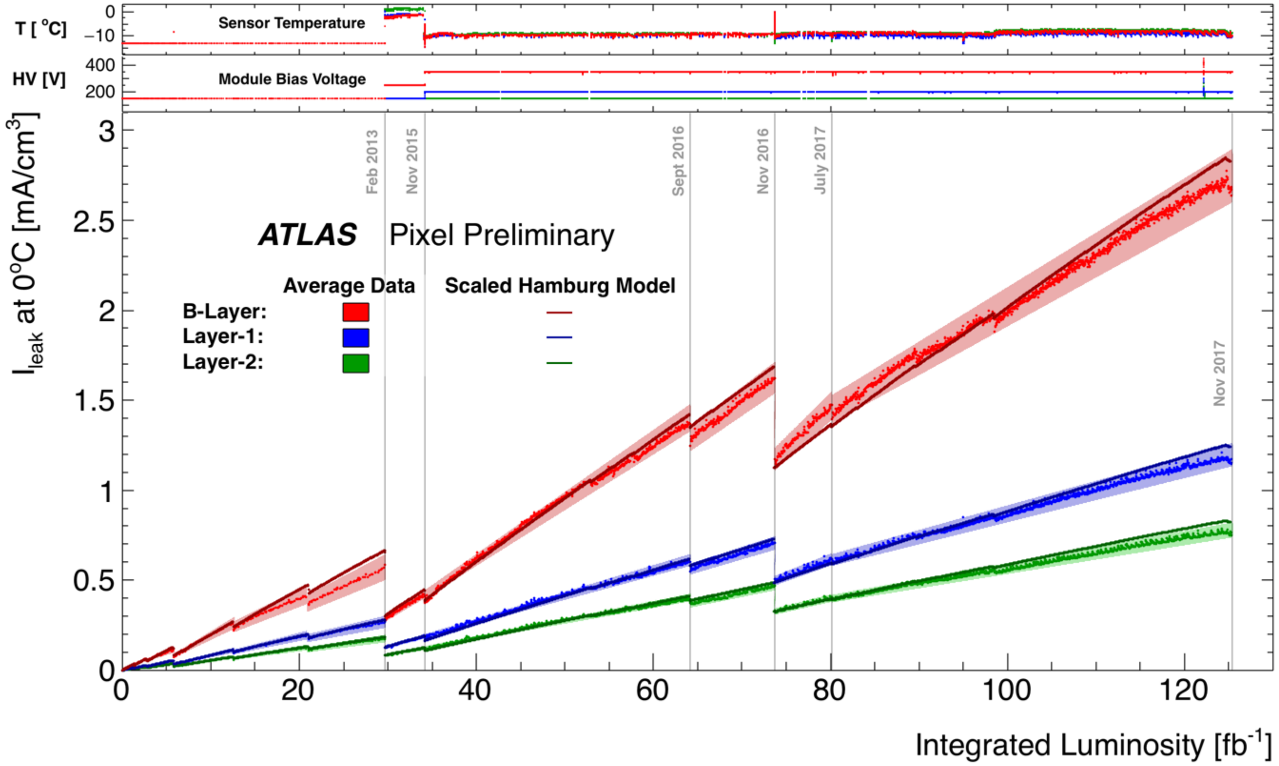
- Operational Experience and Performance with the ATLAS Pixel detector at the LHC – Aidan Grummer,
- Performance and Operation of the CMS Phase 1 Pixel Detector – Lea Caminada, PSI and University of Zurich
- ATLAS ITk Strip Detector for High-Luminosity LHC – Edoardo Rossi, DESY
- The Belle II Silicon Vertex Detector – Richard Thalmeier, HEPHY Vienna
- DEPFET pixel detector situated on Belle II experiment – Christian Wessel, University of Bonn
- The XAFS Fluorescence Detector System based on 64 Silicon Drift Detectors for the SESAME Synchrotron Light Source – Alexandre Rachevski, INFN Trieste
- A feasibility test run for the MUonE project – Giovanni Ballerini, MIB
- Searching for a dark photon with PADME at LNF: status of the active diamond target – Federica Oliva, LE
- Development and Commissioning of the 30 ps time resolution MEGII Pixelated Time detector – Paolo Walter Cattaneo, PV
- Precision Timing Capabilities of Silicon Pad Sensors in the CMS HGCAL – Florian Pitters, CERN
- Status of the vertex detector program of the CBM experiment at FAIR – Philipp Klaus, Goethe University Frankfurt
- The Gigatracker detector of the NA62 experiment at CERN SPS – Luca Federici, CERN
- Technology Experience in the Construction of Silicon Tracker Detectors for Space Experiments – Maria Movileanu, PG

# Operational Experience with and Performance of the ATLAS Pixel Detector at the Large Hadron Collider

Aidan Grummer
On Behalf of the ATLAS Collaboration

- The performance of the LHC has exceeded expectations for instantaneous luminosity and has been presenting a challenge to the operation of the ATLAS Pixel Detector in terms of radiation damage.
- Thanks to a number of hardware and software upgrades the Pixel Detector continues to provide tracking with high efficiency to the ATLAS experiment.
- The current Pixel Detector configuration is adequate until the end of LHC Run 2.

- Average leakage current data and predictions in the three Pixel Detector Barrel Layers

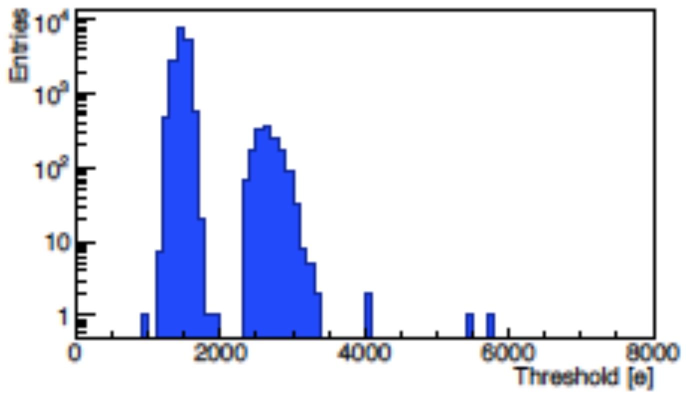


# Performance and Operation of the CMS Phase 1 Pixel Detector

Lea Caminada (PSI / University of Zurich) on behalf of the CMS Collaboration

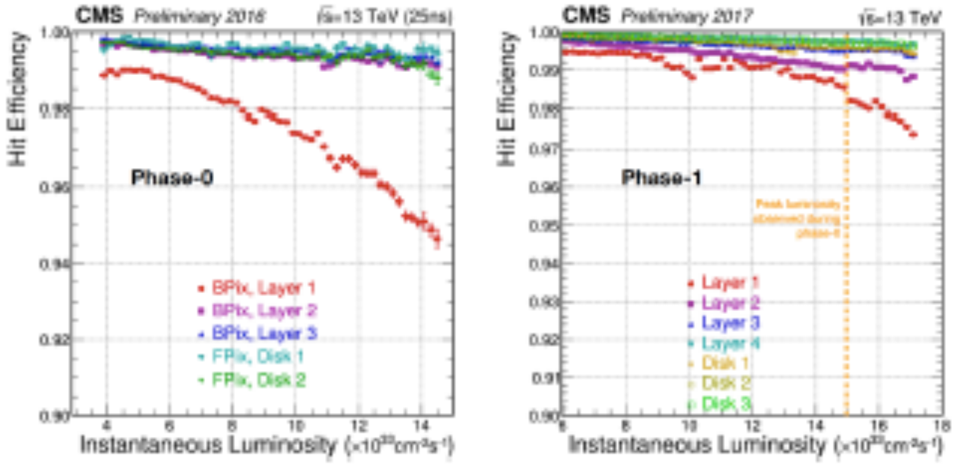
- The CMS pixel detector provides high-precision tracking at LHC
- The CMS Phase 1 pixel upgrade system has been installed in winter 2016/17 and features important improvements regarding rate tolerance, efficiency and resolution
- The CMS Phase 1 pixel detector recorded its first collision data during 2017
- An issue with the DCDC converter modules used to power the detector required an unforeseen intervention at the end of the run(67 (1184) converters failed; still under investigation)
- All repair work was completed successfully in time for data taking in 2018
    - Active channels increased from 95.7% to 97.8%

## Threshold and Noise



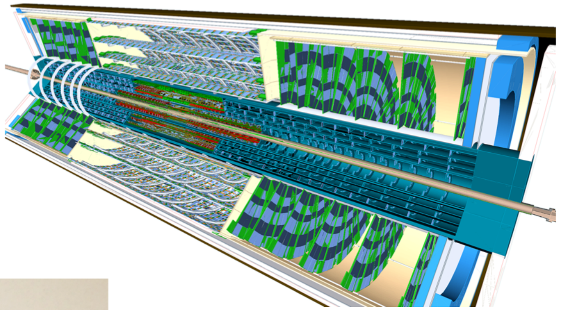

- Mean threshold of 1800e with noise of ~150e for outer barrel layers and endcap disks
- Mean threshold of 2600e for innermost barrel layer (different readout chip)

- Resolution of about 10(30)um in the transverse(longitudinal) direction
- Dynamic inefficiency at high inst. luminosity significantly reduced

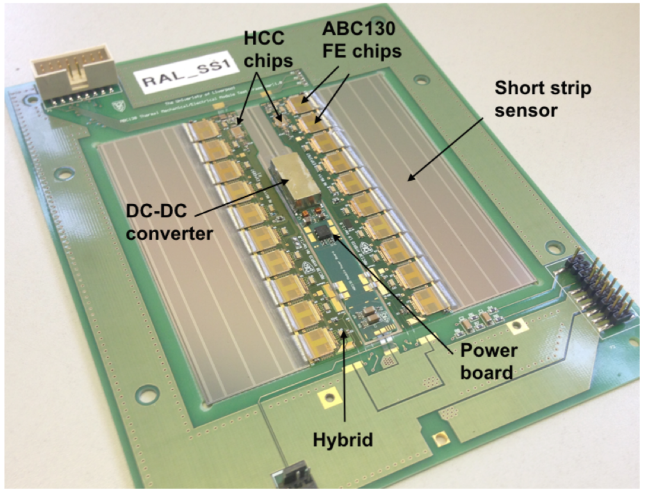


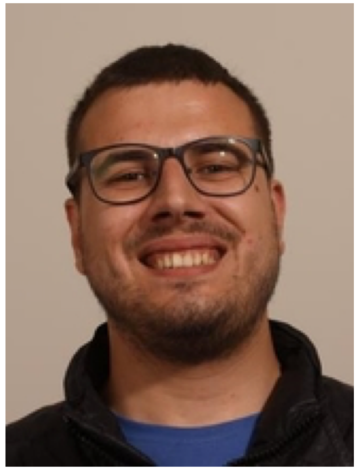
# ATLAS ITk Strip Detector for the High-Luminosity LHC

Edoardo Rossi (DESY) on behalf of the ATLAS ITk Collaboration

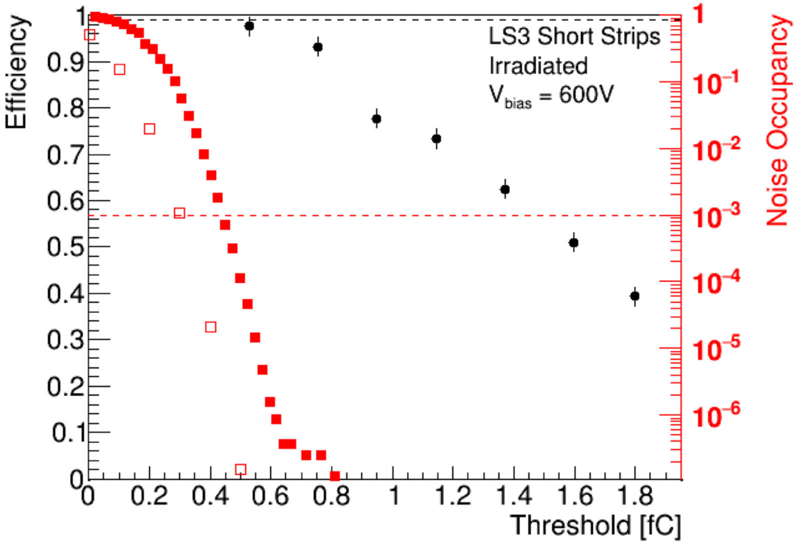


The HL-LHC will start operations in 2026 and will have an instantaneous luminosity about 4 times the maximum expected in the LHC. Because of increased pile-up and radiation, the ATLAS Inner Detector will be replaced by the Inner Tracker (ITk), an all silicon detector.



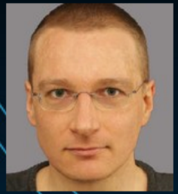
The ATLAS ITk Strip Detector will have an active area of about 165m2 and about 165M channels, it will be 6m long and with a radius of about 1m with respect to the current Inner Detector, the radiation length (material budget) has been decreased significantly and the performances have been maintained or improved. Moreover, thanks mainly to new silicon technology, the radiation hardness of the strip Detector has been substantially improved .




Every component has passed through an extensive prototyping phase. In particular, several full-sized modules have been tested and the performances are within expectations. A prototype module has also been fully irradiated and then tested, proving that modules will guarantee good operations until the end-of-lifetime of the HL-LHC.

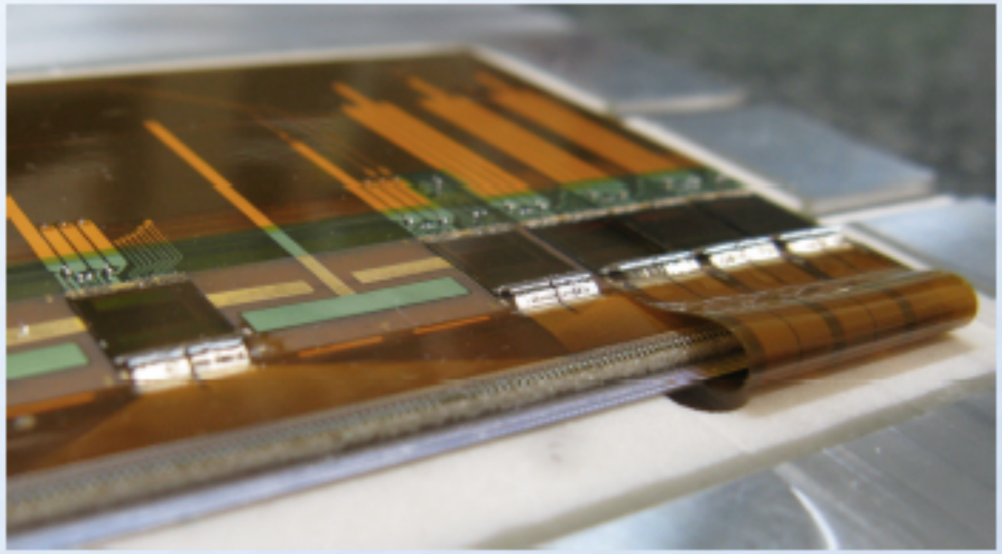
# The Belle II Silicon Vertex Detector

Main author and poster presenter:
Richard Thalmeier

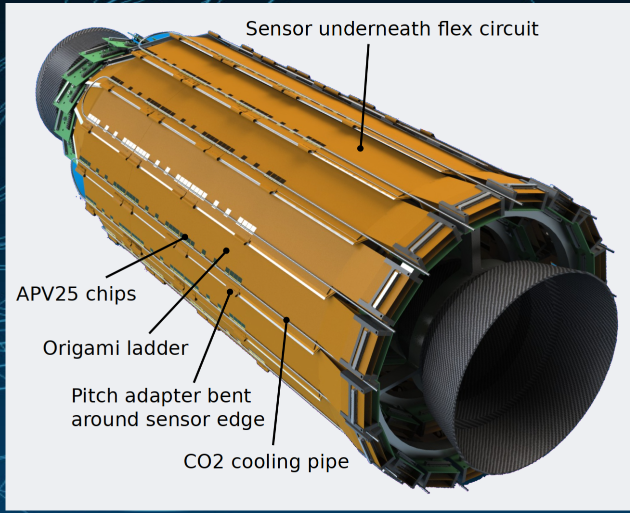


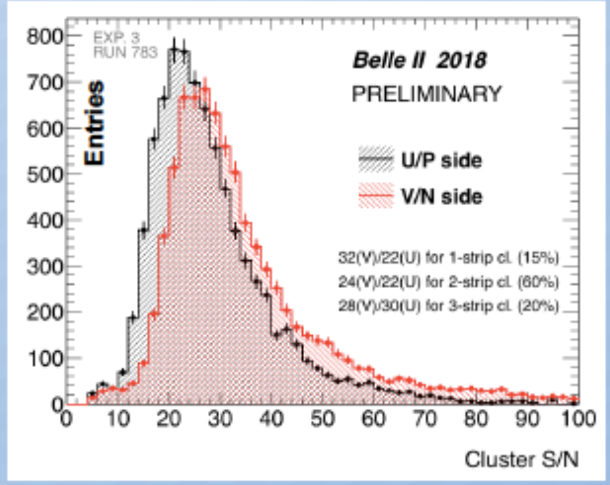
**Co-Authors: (Belle-II SVD Collaboration)**
K. Adamczyk, H. Aihara, C. Angelini, T. Aziz, V. Babu, S. Bacher, S. Bahinipati, E. Barberio, Ti. Baroncelli, To. Baroncelli, A. K. Basith, G. Batignani, A. Bauer, P. K. Behera, T. Bergauer, S. Bettarini, B. Bhuyan, T. Bilka, F. Bosi, L. Bosisio, A. Bozek, F. Buchsteiner, L. Bulla, G. Caria, G. Casarosa, M. Ceccanti, D. Cervenkov, S. R. Chendvankar, N. Dash, G. De Pietro, S. T. Divekar, Z. Doležal, D. Dutta, F. Forti, M. Friedl, B. Gobbo, K. Hara, T. Higuchi, T. Horiguchi, C. Irmler, A. Ishikawa, H. B. Jeon, C. Joo, J. Kandra, N. Kambara, K. H. Kang, T. Kawasaki, P. Kodyš, T. Kohriki, S. Koike, M. M. Kolwalkar, I. Komarov, R. Kumar, W. Kun, P. Kvasnicka, C. La Licata, L. Lanceri, S. C. Lee, J. Lettenbichler, J. Libby, T. Lueck, M. Maki, P. Mammini, A. Martini, S. N. Mayekar, G. B. Mohanty, S. Mohanty, T. Morii, K. R. Nakamura, Z. Natkaniec, Y. Onuki, W. Ostrowicz, A. Paladino, E. Paoloni, H. Park, F. Pilo, A. Profeti, I. Rashevskaya, K. K. Rao, G. Rizzo, Resmi P. K., M. Rozanska, J. Sasaki, N. Sato, S. Schultschik, C. Schwanda, Y. Seino, N. Shimizu, J. Stypula, J. Suzuki, S. Tanaka, G. N. Taylor, R. Thomas, T. Tsuboyama, S. Uozumi, P. Urquijo, L. Vitale, S. Watanuki, M. Watanabe, I. J. Watson, J. Webb, J. Wiechczynski, S. Williams, B. Würkner, H. Yamamoto, H. Yin, T. Yoshinobu, L. Zani

The most notable feature of this detector is the "chip-on-sensor" concept, which minimizes the distance of the signal propagation from the double-sided silicon detector strips to the readout chips and thus reduces noises from strip capacitance.



Chip-on-sensor (completed)



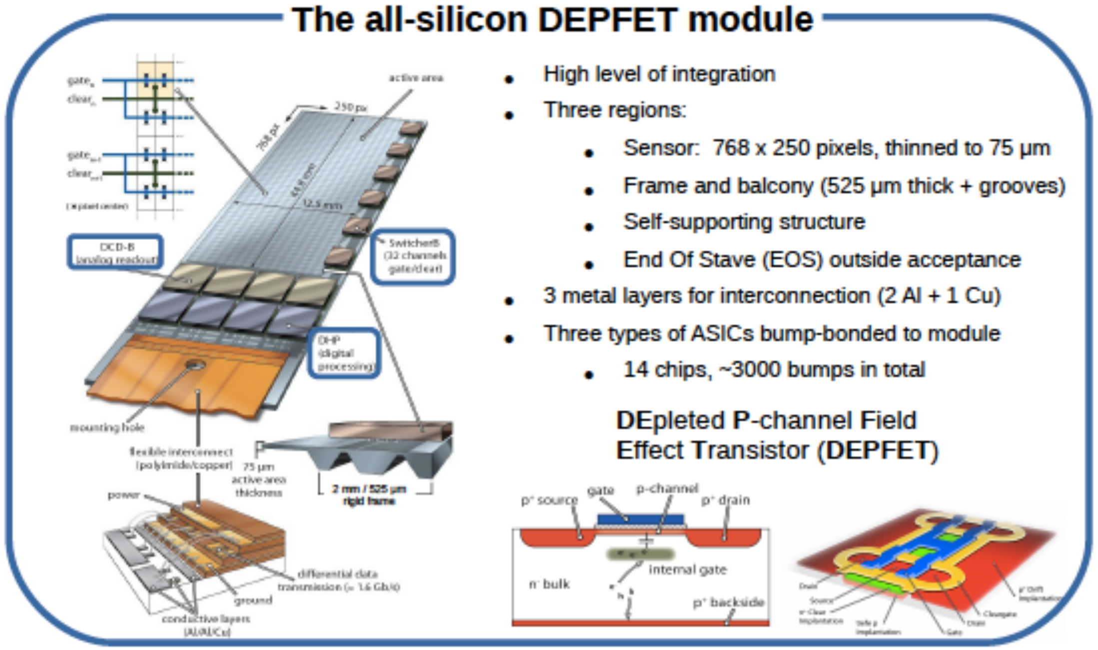




Signal to noise ratio

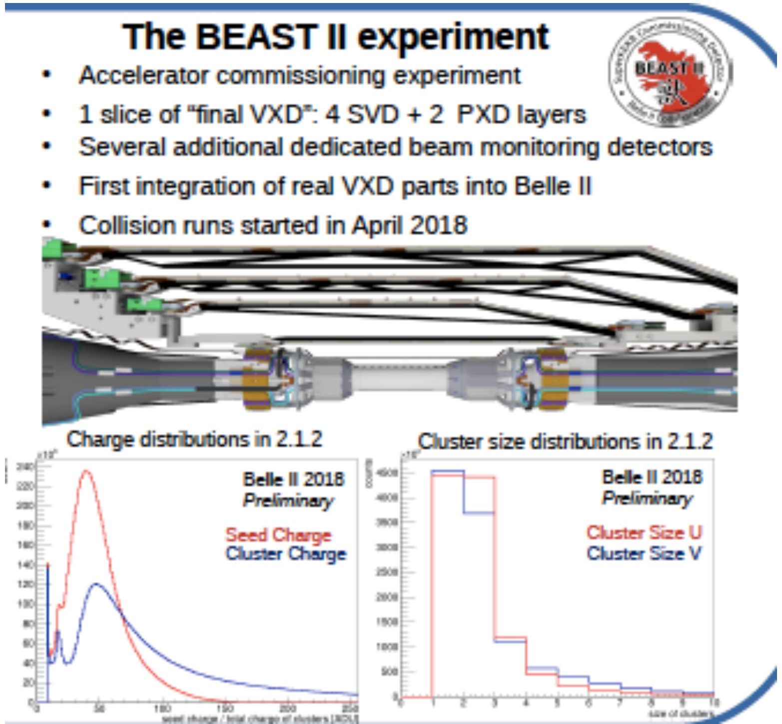
Precise hit time determination needed to remove off-time hits from beam background

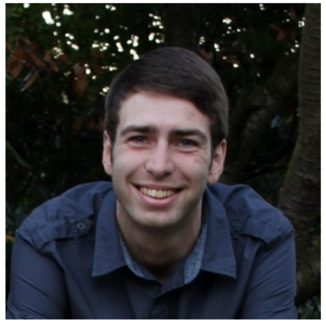
# DEPFET Pixel Detector in the Belle II Experiment

The Belle II Pixel Detector (PXD) is the first HEP pixel detector based on DEPFET technology.
The Belle II experiment started recording first electron-positron collisions in April 2018.
This presentation gives an overview on the complete PXD system, which consists of 40 DEPFET modules, as well as DAQ and DQM systems, including an online data reduction scheme.




Currently phase 2 of the Belle II experiment is taking place with 4 PXD sensors.
The purpose of which is background estimation to create a safe environment for the
operation of the complete PXD with 40 modules starting early in 2019.



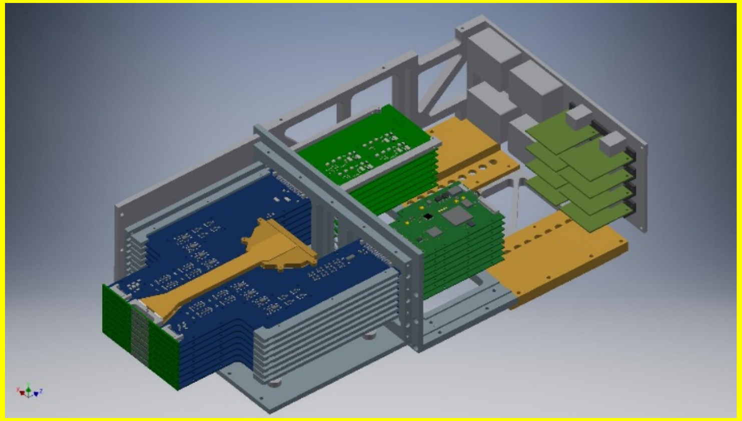
Presenter / Author:
Christian Wessel,
University of Bonn

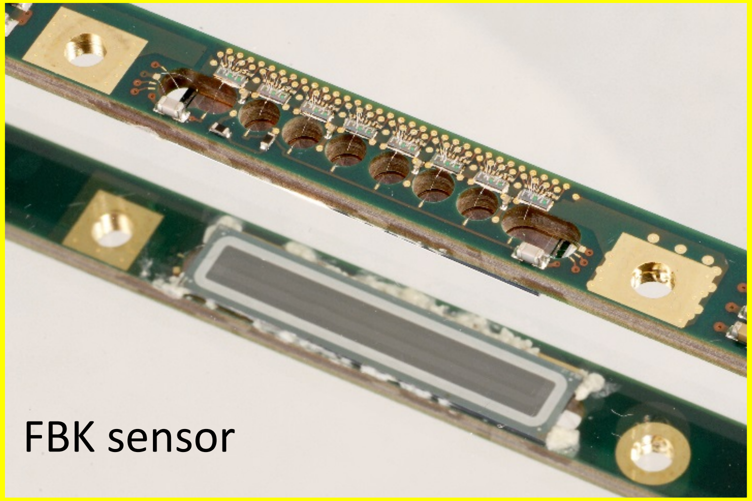
# The XAFS Fluorescence Detector System based on 64 Silicon Drift Detectors for the SESAME Synchrotron Light Source

*A. Rachevski[1], M. Ahangarianabhari[2,5], G. Aquilanti[3], P. Bellutti[4,11], G. Bertuccio[2,5], G. Borghi[4,11], J. Bufon[3,1], G. Cautero[3,1], S. Ciano[1], A. Cicuttin[6,1], D. Cirrincione[7,1], M. L. Crespo[6,1], S. Fabiani[8,9], F. Ficorella[4,11], M. Gandola[2,5], D. Giuressi[3,1], Kasun Sameera Mannatunga[6,10,1], F. Mele[2,5], R. H. Menk[3,1,12], L. Olivi[3,1], G. Orzan[1], A. Picciotto[4,11], M. Sammartini[2,5],*

*I. Rashevskaya[11], S. Schillani[3,1], G. Zampa[1], N. Zampa[1], N. Zorzi[4,11] and A. Vacchi[1,7]*

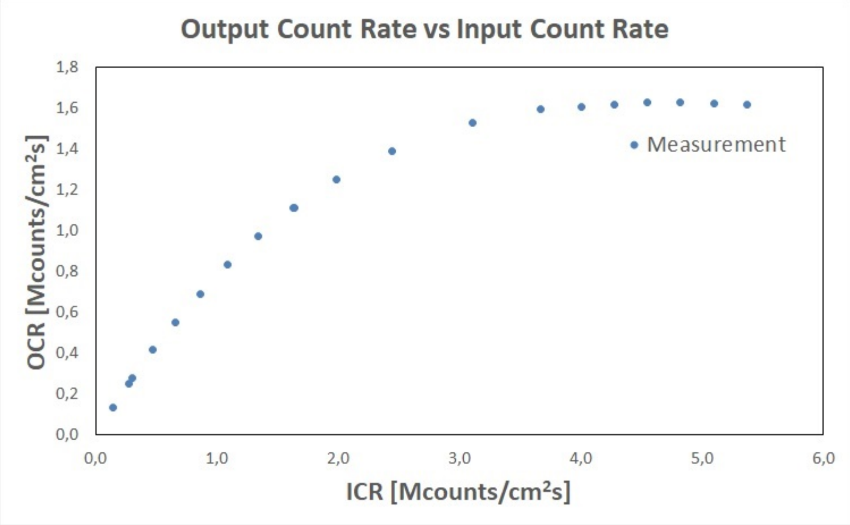
*1) INFN Trieste, Italy, 2) Politecnico di Milano, Italy, 3) Elettra-Sincrotrone Trieste, Italy, 4) Fondazione Bruno Kessler, Trento, Italy, 5) INFN Milano, Italy, 6) ICTP MLab, Trieste, Italy, 7) Dipartimento di Matematica ed Informatica, Università di Udine, Italy, 8) INAF-IAPS, Roma, Italy, 9) INFN Roma Tor Vergata, Italy, 10) University of Sri Jayewardenepura, Department of Physics, Colombo, Sri Lanka, 11) TIFPA – INFN, Trento, Italy, 12)Department of Medical Imaging, University of Saskatchewan, Saskatoon, SK S7N 5A2, Canada*





FBK sensor

**The Fluorescence Detector System based on 64 SDDs custom designed for the SESAME XAFS beamline (Amman, Jordan) is a state-of-the-art instrument. It has a total collimated sensitive area of 499 mm$^2$, with the capability of reaching a maximum count-rate of at least 8 Mcps. The energy resolution confirmed by the beam test at XAFS beamline of the ELETTRA Sincrotrone, is below 150 eV FWHM @5.9 keV for all channels with the detector cooled to 10 °C. One module of the new multi-cell system operating with a peaking time of 0.9 µs produces an Output count-rate (OCR) of 1600 kcounts/s·cm$^2$ after the pile-up rejection (see figure to the right).**




Energy resolution the same for single SDD cell and for 8 SDD module

# A feasibility test run for the MUonE project

Giovanni Ballerini
(gio.ballerini94@gmail.com)
on behalf of the MUonE collaboration

Modern measurements of the muon anomalous magnetic moment g-2 stand more than 3-4σ away from the Standard Model prediction: **hint of new physics?**

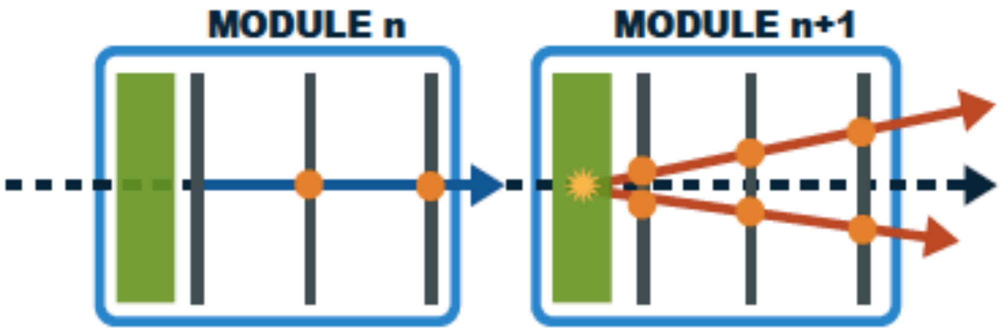
The **MUonE project** aims to measure the Hadronic Leading Order (**HLO**) contribution to the muon g-2 by scattering high energy (**150 GeV, from CERN-SPS beam**) muons off the atomic electrons of a low-Z target through the elastic process **μ+e → μ+e**

To exploit the kinematical correlation of the μ - e collision
⊖ need for **precise measurements in a as thin as possible detector**

A **modular target** is foreseen, consisting of **60 low-Z layers** each sandwiched in layers of Si-microstrip detectors

In April-May 2018 a reduced experimental setup was installed, running parasitically on the beamline behind the **COMPASS** experiment

**→ find more on the experimental setup & the Daq system on the poster ←**




PM2018

14th Pisa Meeting

# “Searching for a dark photon with PADME at LNF: status of the active diamond target”

**Federica Oliva on behalf of the PADME Collaboration**

The **PADME experiment**[1] at the DAΦNE Beam-Test Facility (BTF) will search for the dark photon production in the annihilation $e^+e^- \to \gamma A'$ using the intense positron beam hitting a diamond target.

## A target for PADME?

### ACTIVE TARGET

The missing mass resolution improves with the spatial resolution on the beam-target interaction point, needed to measure the direction of the photon

### DIAMOND TARGET

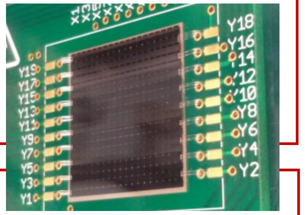
Low Z (=6) improves Signal/Background

BACKGROUND $e^+N \to e^+N\gamma$

$e^+e^- \to \gamma\gamma(\gamma)$

$$N(A'\gamma) \propto N(\gamma\gamma) \propto Z \qquad N_{brem} \propto Z^2$$

Two Active Diamond Targets **2 × 2 cm²** area and **100 µm thickness** with 19X+19Y strip (1mm pitch) electrodes assembled: one with metallic strips (produced directly by Applied Diamond) and one with graphitic strips (produced by means of an excimer laser ArF in the L3 Laser Laboratory in Lecce ).



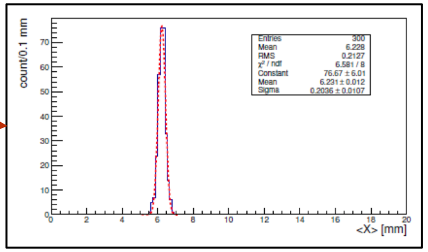

**Active Diamond Target DCS, DAQ and mechanical support in vacuum ready**

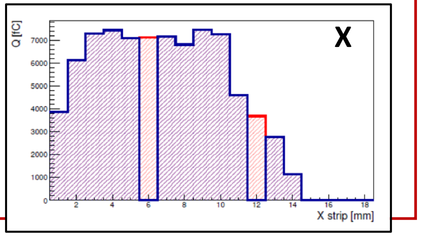
The **very first prototype** with graphitic strips was tested and characterized in November 2015 during a beam test at the BTF (LNF), using the e± beam of the *DAΦNE Linac* [2] .

**2 × 2 cm² area, 50 µm thickness**
**18x18 strips 1mm pitch**

**spatial X resolution ≈ 0.2 mm**
**spatial Y resolution ≈ 0.3 mm**
**Charge Collection Distance ≈ 11-12 µm**
**X-Y beam profiles reconstructed**
**good time resolution (0.7ns)**

**X Charge Centroid Distribution**





[1]M. Raggi and V. Kozhuharov, *“Proposal to Search for a Dark Photon in Positron on Target Collisions at DAΦNE Linac”*, Adv. High Energy Phys., 2014;

[2]The Active Target PADME group, *“Performance of the diamond active target prototype for the PADME experiment at the DAΦNE BTF”*, NIM A 898 105–110 (2018).



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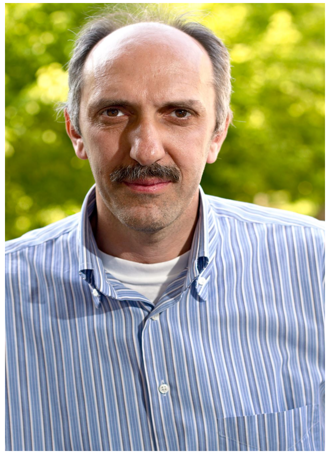
**For more info on the PADME experiment:**
http://www.lnf.infn.it/acceleratori/padme/
https://web.le.infn.it/padme/

**TURN THE DARK ON!**

# Development and commissioning of the 30 ps time resolution MEG II Pixelated Time Detector

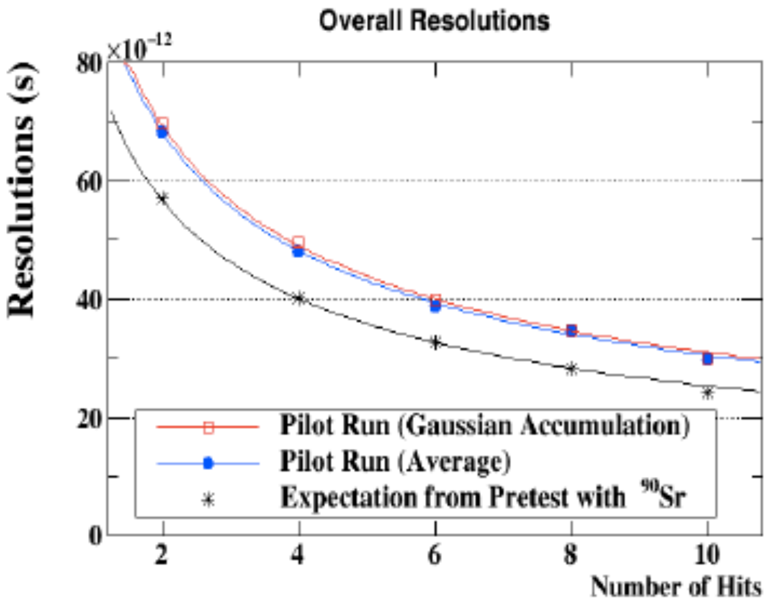


P. W. Cattaneo[a], G.Boca[a,b], F.Gatti[c,d], M.DeGerone[c], M.Nakao[e], M Nishimura[e], W.Ootani[e], M.Rossella[a], Y.Uchiyama[e], M.Usami[e]

(a) INFN Pavia, (b) University of Pavia, (c) INFN Genova, (b) University of Genova, (e) The University of Tokyo

The experiment MEG II is designed to improve by an order of magnitude the current sensitivity reached by MEG $4.2\times10^{-13}$ on the search for $\mu^+\rightarrow e^+\gamma$ decay. A crucial part of MEG II is a pixelated Timing Counter (pTC) that was developed to measure the positron timing with increased accuracy. The pTC is segmented into 512 small scintillation counters. Since the positron time is measured independently by several counters (~9 on average), the timing resolution improves significantly. We constructed and installed the pTC and performed commissioning runs at piE5 beam line in PSI during 2016 and 2017. The analysis performance is checked by MC and the timing resolution of 33.7 ps (at 8 hits) is obtained with commissioning run data.

(Degraded performance with multiple hits to be understood)




Tested with $^{90}$Sr all counters

$\sigma_{single\_countter+ele}$=96 ps

$\sigma_{single\_countter}$=80 ps

With mutiple hits $\sigma$=38.5 ps (in MEG 76 ps)

Additional contribution $\sigma$=53 ps under investigation.
After averaging multiple hit only a few ps degradation.

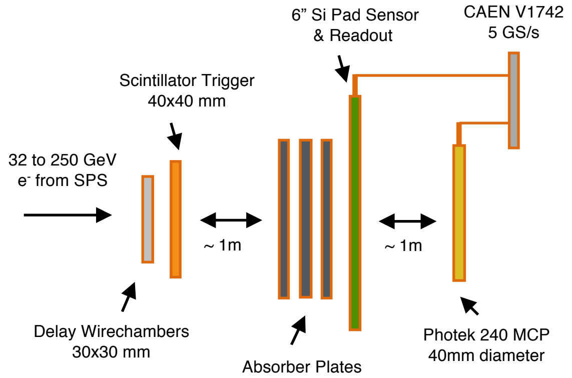
Scintillator readout with SiPMs

# Precision Timing Capabilities of Silicon Pad Sensors in the CMS HGCAL

by Florian Pitters

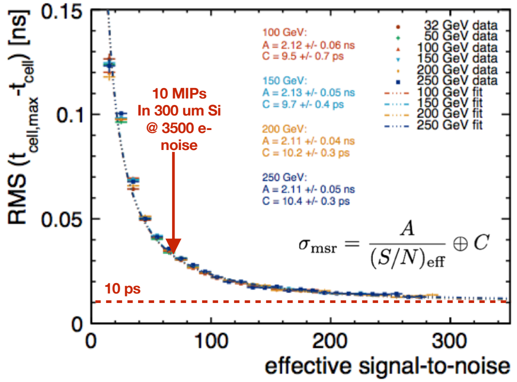
A CMS HGCAL prototype silicon pad sensor with dedicated readout used to sample electromagnetic showers

- Probe intrinsic limit on time resolution for these sensor
  —> 10 ps reached
- Probe uniformity of reachable time resolution across multiple pads
  —> excellent uniformity found



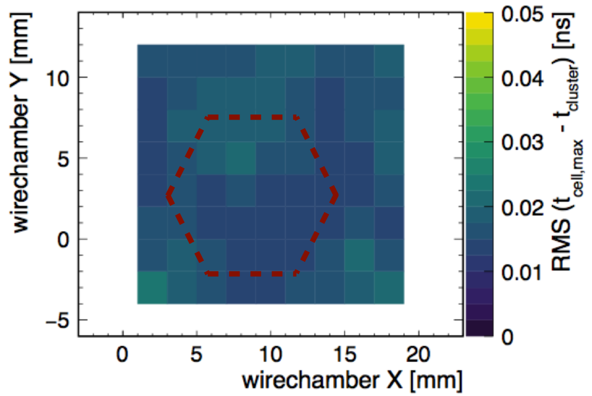

**Experimental Setup:**

- HGCAL prototype silicon pad sensor
- Custom read-out optimised
- Waveform sampling at 5 GS/s
- Time differences between adjacent pads and relative to the MCP




**Uncertainty vs. S/N:**

- Well modelled by a two parameters
- Jitter term from mostly risetime and sampling rate
- Constant term of 10 ps mostly from readout electronics




**Cluster timestamp vs impact position**

- Cluster timestamp via weighting of timestamps from multiple pads
- Red hexagon indicates central pad
- Excellent uniformity across multiple pads

# STATUS OF THE VERTEX DETECTOR PROGRAM OF THE CBM EXPERIMENT AT FAIR

## PM2018 - 14TH PISA MEETING ON ADVANCED DETECTORS

*Philipp Klaus‡ for the CBM-MVD collaboration*

Work supported by BMBF (05P15RFFC1), HIC for FAIR and GSI

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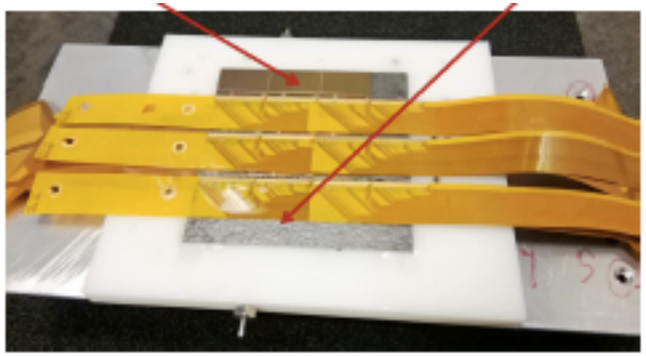


*Prototype 2 based on 500 μm thin TPG support*

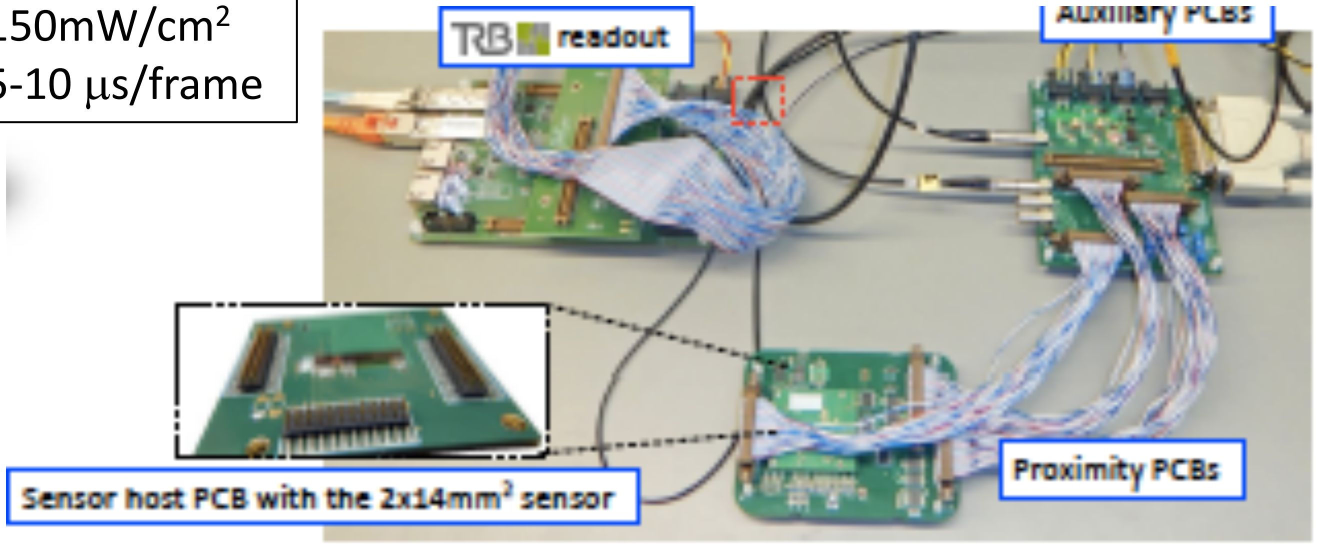
50μm CMOS sensors on TPG carrier for heat transfer to actively cooled Al heat sink

Targeted material budget reached and vacuum compatible sensor and FPC integration demonstrated

150mW/cm$^2$
5-10 μs/frame

Control System of the CBM-MVD based on EPICS is being developed and tested in the lab, including Docker virtualization and a web based dashboard

First prototype sensor for the MVD expected to meet the harsh CBM experiment running conditions now undergoing testing



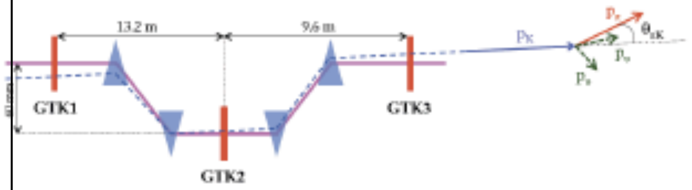

Focus: AC vs DC in-pixel architecture performance, priority encoder, amplification, radiation tolerance

# The Gigatracker detector of the NA62 experiment at CERN SPS

G. Aglieri Rinella[a], D. Alvarez Feito[a], R. Arcidiacono[b], C. Biino[b], S. Bonacini[a], A. Ceccucci[a], S. Chiozzi[c], E. Cortina Gil[e], A. Cotta Ramusino[c], J. Degrange[a], L. Federici[a*], M. Fiorini[c,d], E. Gamberini[a], A. Gianoli[c], J. Kaplon[a], A. Kleimenova[e], A. Kluge[a], A. Mapelli[a], F. Marchetto[b], E. Migliore[b], E. Minucci[e], M. Morel[a], J. Noël[a], M.Noy[a], L. Perktold[a], M. Perrin-Terrin[g], P. Petagna[a], F. Petrucci[c],d, K. Poltorak[a], G. Romagnoli[a], G. Ruggiero[f], B. Velghe[e], H. Wahl[c,d].

[a]CERN, Geneva, Switzerland; [b]INFN Sezione di Torino, Torino, Italy; [c]INFN Sezione di Ferrara, Ferrara, Italy; [d]Università degli studi di Ferrara, Ferrara, Italy; [e]Université Catholique de Louvain, Louvain-la-Neuve, Belgium; [f]Lancaster University, Lancaster, UK; [g]Centre de physique des particules de Marseille, Marseille, France

NA62 designed to measure highly suppressed $K^+ \rightarrow \pi^+ \nu \overline{\nu}$

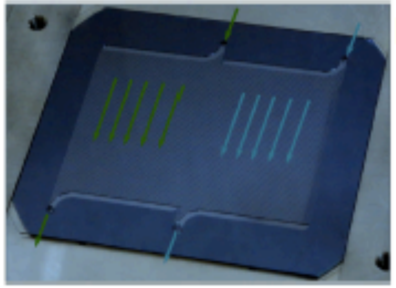


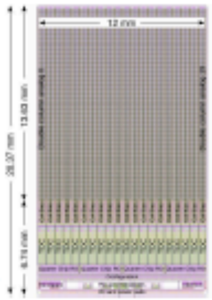

Silicon hybrid detector made of 3 station operating in vacuum at -25°C and biased up to 300V

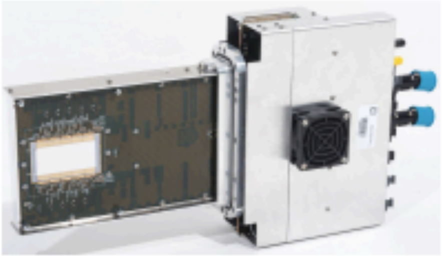
Exposed to a 75Gev/c charged particle beam at 1.3MHz/mm$^2$

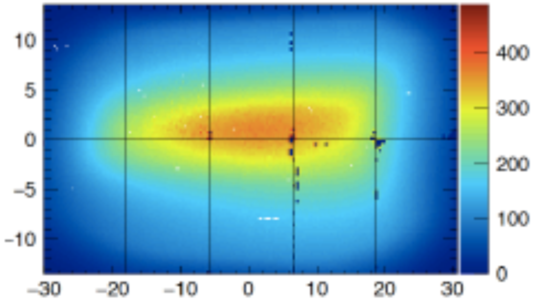
First application in HEP of μ-channels cooling plate

35 W/station





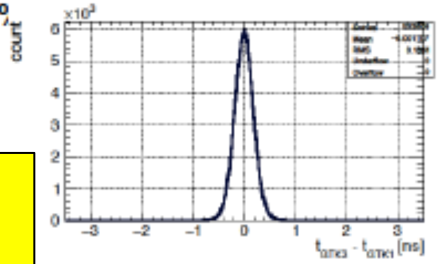




Stations need to be replaced every 100 days

10 Read Out Custom ASICs per Station
high speed output link
4x3.2Gb/s serializers each

- Very low material budget (X/X0 ~0.5% per station)
- High precision in momentum (σ(pK)/pK ~0.2%)
- High precision angle (σ(θK) ~16 μrad)
- 300 × 300 μm2 pixel size
- High time resolution (< 200 ps on single hit)



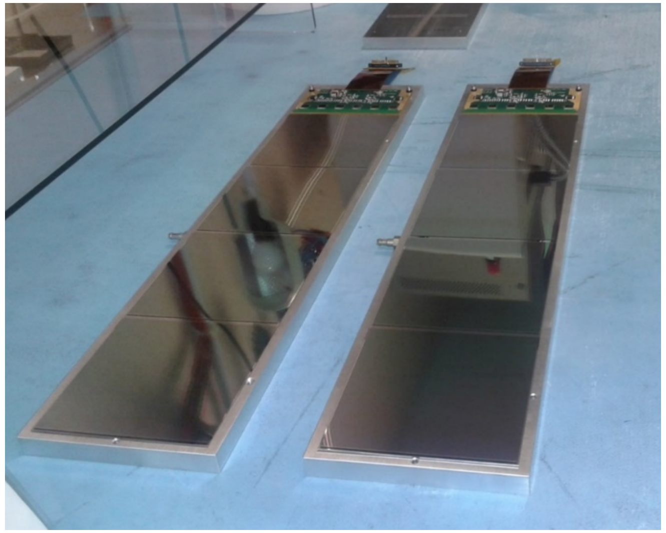
Better than expected performance

# Technological Experience in the Construction of Silicon Trackers Detectors for Space Experiments

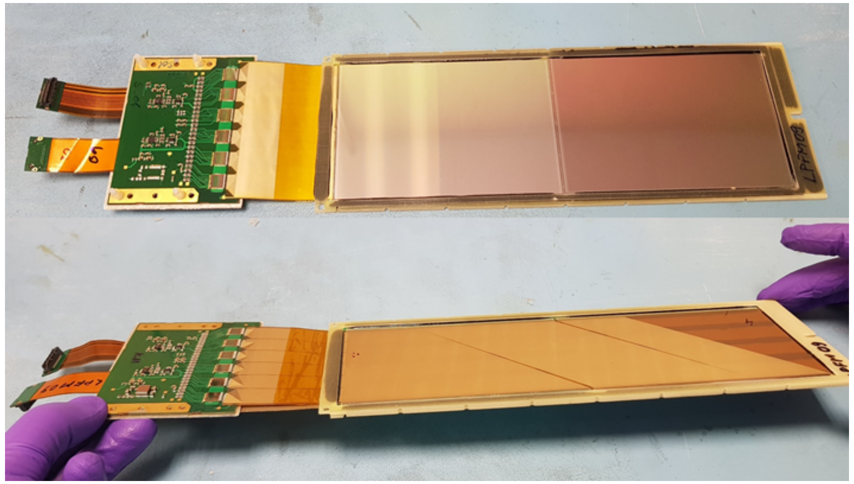
Maria Movileanu-Ionica

INFN Sezione di Perugia, Via A.Pascoli, 06100 Perugia, Italy

The Silicon Trackers for DAMPE and CSES/LIMADOU experiments have been designed and built following the very stringent requirements typically to the space experiments such as: resistance to the mechanical stress during launch (vibrations and shocks), thermo-mechanical stability in a large temperature range, low power consumption, low weight, traceability of the quality of the components through documentations on design, tests, assembly, and integration, reliability under space conditions.



DAMPE single side silicon detectors



LIMADOU double side silicon detectors

For each experiment the Thermo-Mechanical Model, Engineering Qualification Model and Flight Model have been built and completely tested in conformity with the requests from the space environmental conditions.

In the present work are presented the technological choices for the construction and test of the DAMPE and, respectively CSES/LIMADOU silicon tracker and the assembly quality results. The space qualification tests done on both trackers are presented and some Quality Assurance issues followed for both trackers assembly are mentioned.

# Quality Control/Quality Assurance

- Development of an automated and programmable characterization system for silicon multi-strip sensors – Geetika Jain, Delhi University
- Advanced optical quality assurance of the silicon microstrip sensors of the CBM STS detector – Evgeny Lavrik, University of Tuebingen

# Development of an automated and programmable characterization system for silicon multi-strip sensors

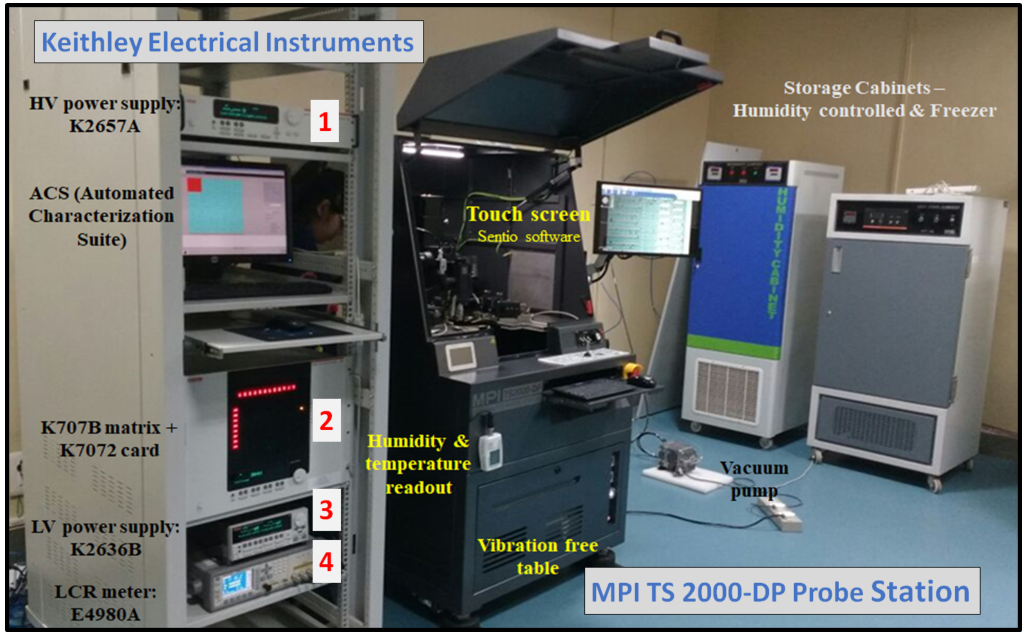
Geetika Jain, Chakresh Jain, Ajay Kumar, Abhijeet Sisodia, Mansi Saxena, Surabhi Sharma, Ashutosh Bhardwaj, Kirti Ranjan
Centre for Detector & Related Software Technology, Department of Physics & Astrophysics, University of Delhi, INDIA

## Tracker system constitutes mostly of silicon sensors

To maintain physics performance in radiation environment
→ Stringent constraints on sensor tolerance criteria
→ Also difficult to replace faulty sensors, if any

## Motivation for Development of System

Crucial to 'Quality Assure' the sensors!
→ University of Delhi motivated to develop an Automated & Programmable Characterization System.

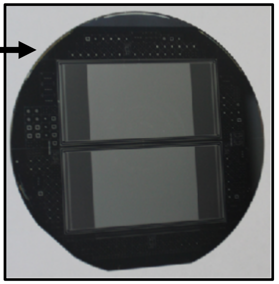



## Some 'Highlights' of the System

(i) EM shielded, dark measurement chamber
(ii) Motorized chuck movement in XYZ$\theta$
(iii) 2 micro-positioners attached to chuck to maintain reverse bias condition
(iv) Control over temperature & humidity
(v) Voltage capability of 1.5 kV
(vi) Measuring range: Current (pA-mA), Capacitance (pF-µF)
(vii) Interfacing through 'Automated Characterization Suite'

## Sensor Tested on System:

Bharat Electronics Limited, **India fabricated** p-on-n, poly-silicon resistor biased & AC-coupled



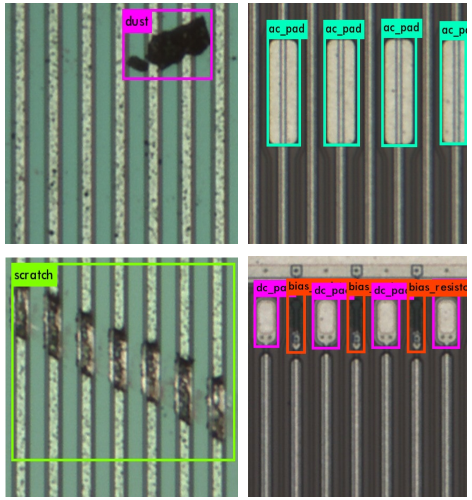
## Silicon Multi-Strip Parameters to be monitored

**Environmental conditions (#2) :** Temperature, Humidity
**Global Measurements (#2) :** Total Leakage Current, Backplane Capacitance
**Strip Parameters (#4) :** Strip Leakage Current, Poly-silicon Resistance, Dielectric Current, Coupling Capacitance
**Inter-Strip Scans (#2) :** Inter-strip Resistance, Inter-strip Capacitance

Evgeny Lavrik, for the CBM Collaboration

University of Tübingen, Germany

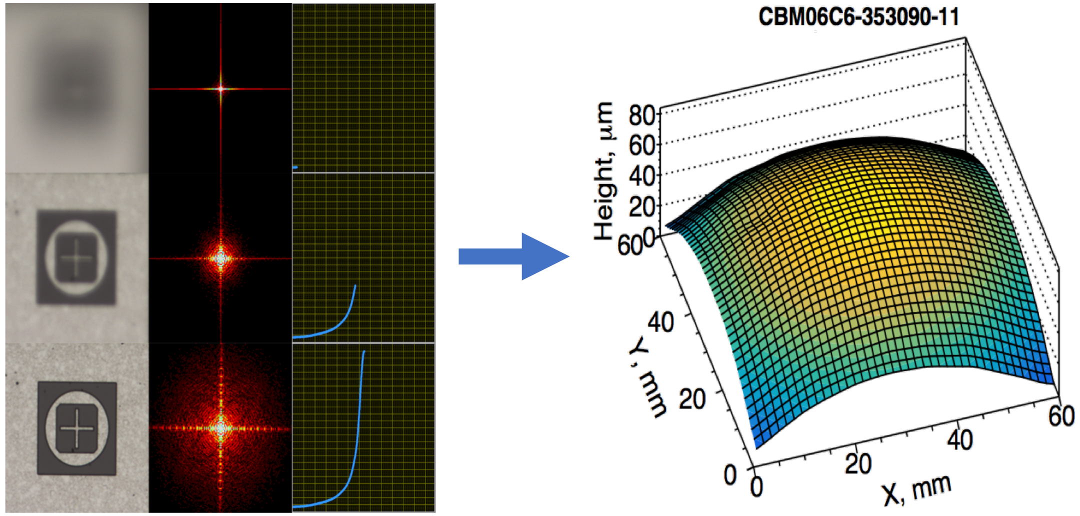
# Advanced optical quality assurance of the silicon microstrip sensors of the CBM Silicon Tracking System




Machine vision and machine learning algorithms to:

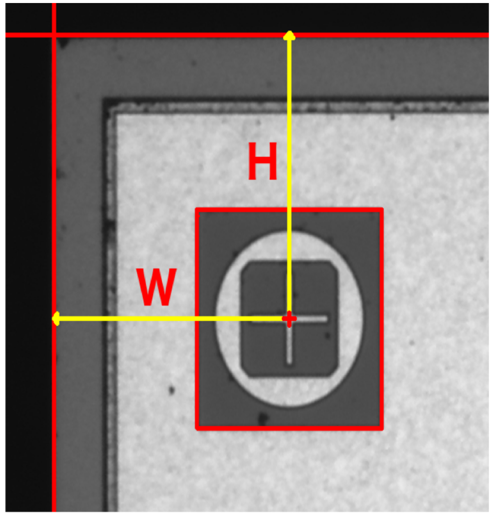
- recognize
- classify
- assess severity
- extract context

of the surface defects




High precision contactless height measurements with motorized focus or Z-stage with FFT

Allows to reconstruct and inspect 3D structure of the object such as sensor warp




Various other metrology measurements such as:

- Edge parallelism
- Cut quality
- Sensor thickness

# Cooling

- Advancements and plans for LHC upgrade detector thermal management with CO2 evaporative cooling – Paola Tropea, CERN
- ATLAS "Baby-DEMO" – Lukasz Zwalinski, CERN
- Progress Towards the Development of Cooling Demonstrator of the CBM Silicon Tracking System – Kshitij Agarwal, Eberhard Karls Universitaet Tuebingen
- R&D on CO2 cooling using a silicon Microchannel substrate for the LHCb VELO – Vinicius Franco Lima,

# Advancements and plans for LHC upgrade detector thermal management with $CO_2$ evaporative cooling

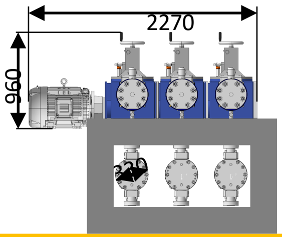
P. Tropea, J. Daguin, D. Giakoumi, N. Koss, P. Petagna, H. Postema, D. Schmid, L. Zwalinski, B. Verlaat

ATLAS & CMS upgrades: $CO_2$ cooling for tracking & timing detector + CMS endcap calorimeter:

- down to -40 C at the detector
- up to 500 kW per experiment
- Space & reliability constraints

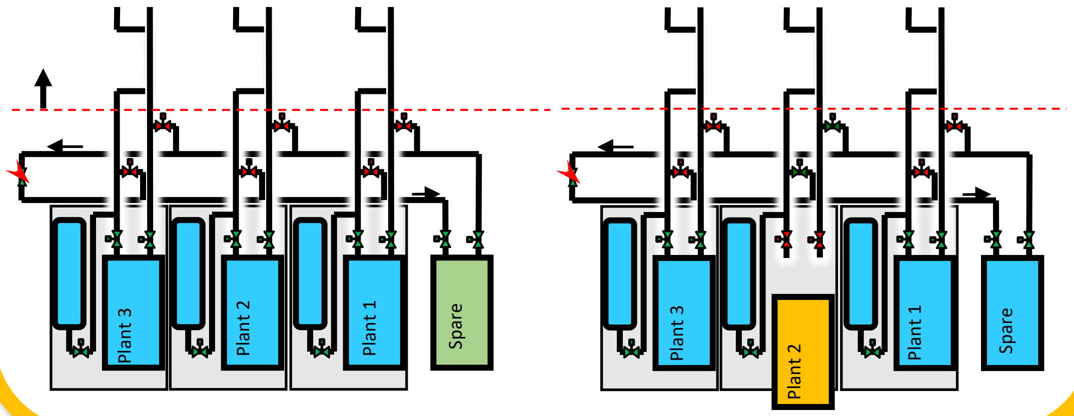
COMMON APPROACH & PLANT DESIGN!

NEW: 50-70 kW cooling units (based on market survey)

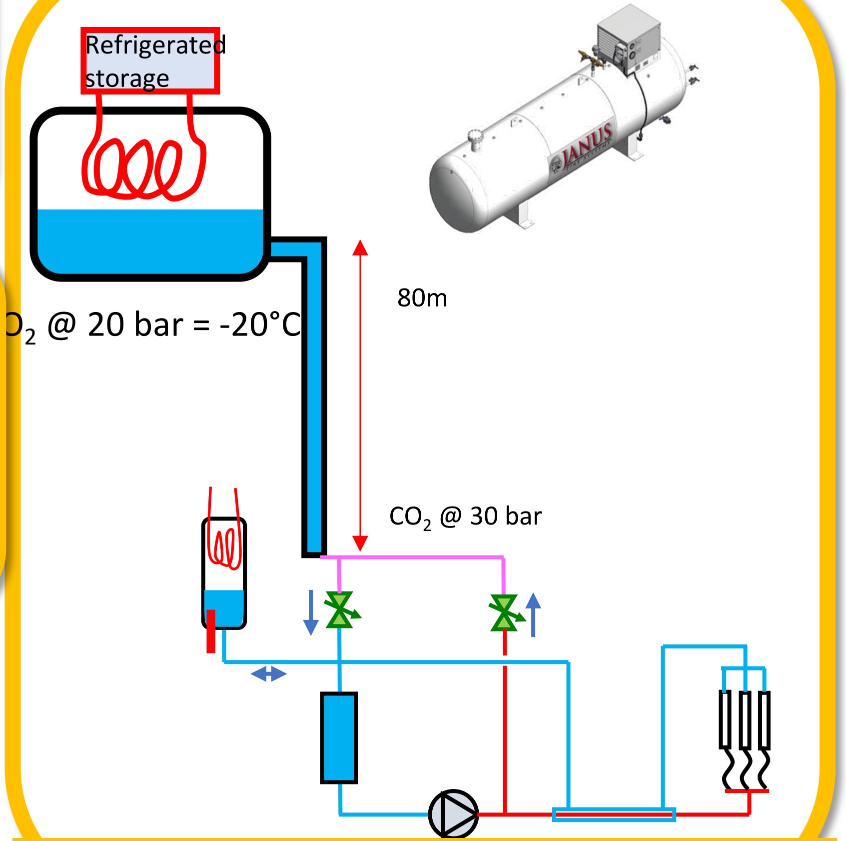



NEW: R744 ($CO_2$ in transcritical cycle) as primary system

ANY SYSTEM (IDENTICAL OPERATION x ALL PLANTS): Spare plant runs cold over the spare manifold for direct kick-in (IBL method)




- R&D to adapt industrial solutions to HEP needs
- enhanced availability for irradiated Si needed
- -45°C evaporation temp reached




NEW: 2PACL CIRCUIT with SURFACE STORAGE

# ATLAS Baby-DEMO


**Authors:** L.Zwalinski[a], K.Bojdol[d], C.Bortolin[a], D.Chmielewski[i], P.Dziurdzia[a], D.Giakoumi[a], J.Godlewski[h], I.Ilyashenko[g], M.Kalinowski[c], R.Kantor[c], L.Klimczyk[e], T.Kuczek[c], M.Marziani[k] ,B.Niezgoda-Zelasko[c], R.Puppo[b], C.Rossi[b], B.Verlaat[a], S.Vogt[f], A.Volpe[b], J.Witek[j]

[a]CERN CH-1211 Geneva 23, Switzerland
[b]INFN e Universita Genova, Via Dodecaneso 33, 16146 Genova,Italy;
[c]Cracow University of Technology, Warszawska 24, 31-155 Kraków, Poland
[d]PONAR ul. Wojska Polskiego 29, 34-100 Wadowice, Poland
[e]HYDROAUTOMATYKA Sp. z o.o., ul. Kościuszki 25, 32-620 Brzeszcze, Poland
[f]Max-Planck-Institut fuer Physik, Föhringer Ring 6, D-80805 Munich, Germany
[g]Petersburg Nuclear Physics Institut PNPI, 1, Orlova roscha mcr., Gatchina, Leningrad region, 188300, Russia
[h]Institute of Nuclear Physics PAN, ul. Radzikowskiego 152, 31-342 Kraków, Poland
[i]DARCLIM Chłodnictwo I Klimatyzacja 31-867 Kraków, os. 2 Pułku Lotniczego 3, Kraków, Poland
[j]CEBEA 32-700 Bochnia, ul. Krasińskiego 29, Poland
[k]University of Cape Town , Private Bag X3, Rondebosch 7701, South Africa


## R&D for ATLAS ITk low temperature $CO_2$

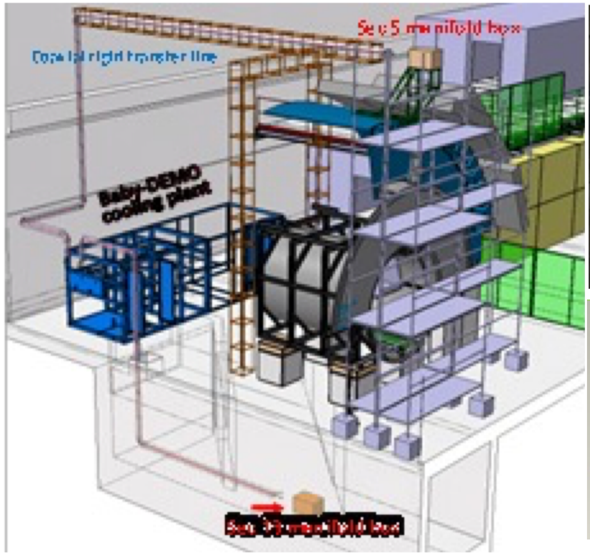
**Program time span for the first results**: Dec 2017

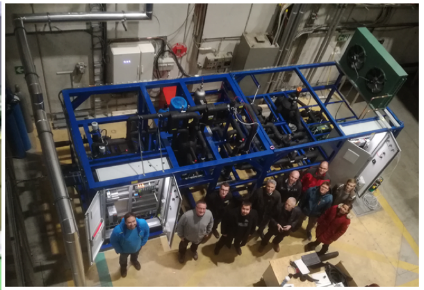
**Goals**:

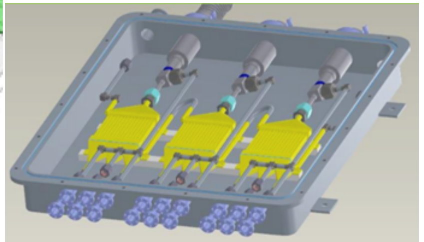
- Provide input to the Pixel TDR about **minimum attainable cooling temperature** by the end of 2017 as it will have an impact on technological choices for the detector sensing elements.

**Challenges**:

- Demonstration of a typical 2PACL $CO_2$ plant to operate at the lowest temperature ever achieved!
- Investigate capability to reach an operational temperature down to -45'C (at -56'C $CO_2$ freezes & $CO_2$ pumps require to operate safe sub cooling margin).
- The target is to bring on the evaporator temperature down to -40'C or lower, if possible!
- Typical distribution beyond PP2 manifold is required as it is the critical path due to pressure drop.





## Results and Conclusions

The Baby-DEMO was designed, built and commissioned within 1.5 year

The Baby-DEMO system arrived 16 November 2017 at CERN

First circulation achieved 5 December 2017.

Temperature cycle tests with several heat loads from 11-14 December

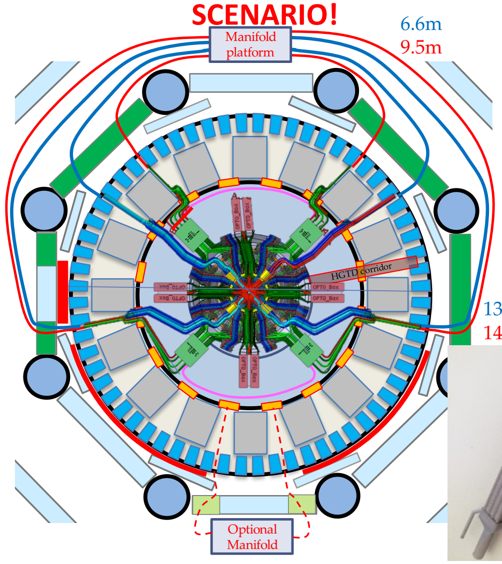
Target achieved at 1st cool down (5kW @ <-40°C at dummy load)

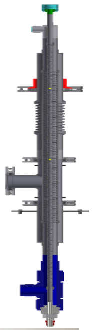
Larger than expected temperature gradients observed in flex lines, 6°C gradient at -40°C dummy load (-46°C accumulator)

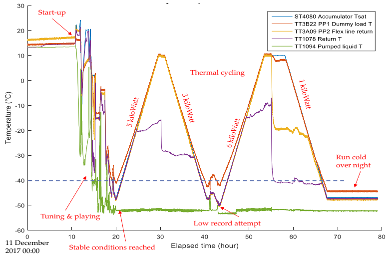
Stable long term operation at -47°C accumulator cooling

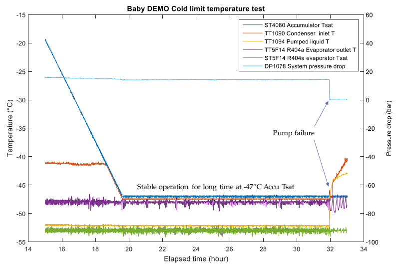
Pump looks not sensitive to low sub cooling failure;

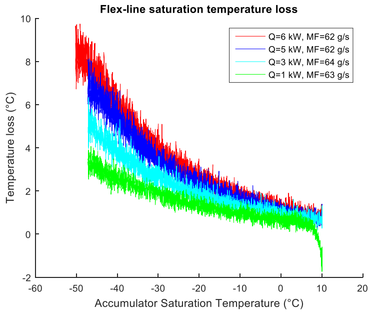
Record low temperature of **-50°C** achieved with manual tricks. **THIS IS NOT AN OPERATIONAL SCENARIO!**

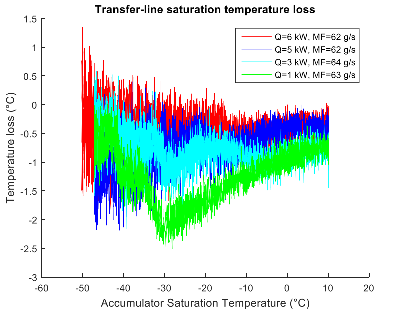




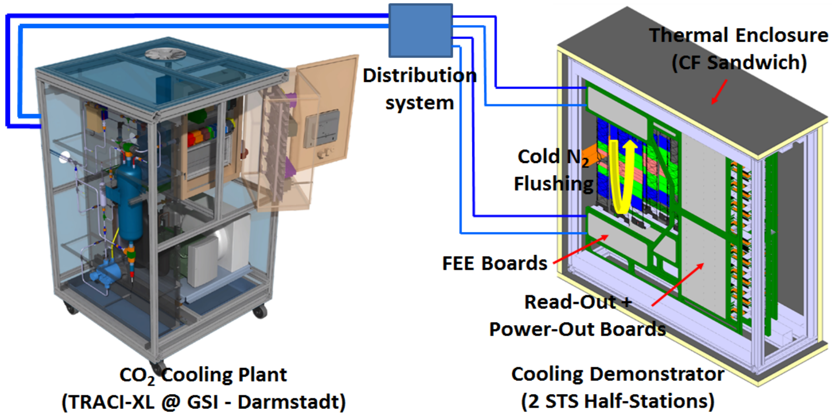



# Progress Towards the Development of Cooling Demonstrator of the CBM Silicon Tracking System

K. Agarwal[1], P. Koczon[2], E. Lavrik[1], H.R. Schmidt[1,2], O. Vasylyev[2] , for the CBM Collaboration

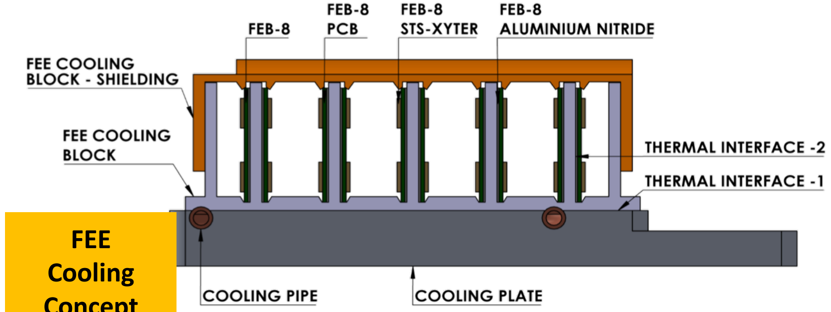
*[1] Eberhard Karls Universität Tübingen, Tübingen, Germany*

*[2] GSI Helmholtz Centre for Heavy Ion Research, Darmstadt, Germany*




**Bi-Phase $CO_2$ cooling at -25°C for FEE (40kW in ~2m³ )**

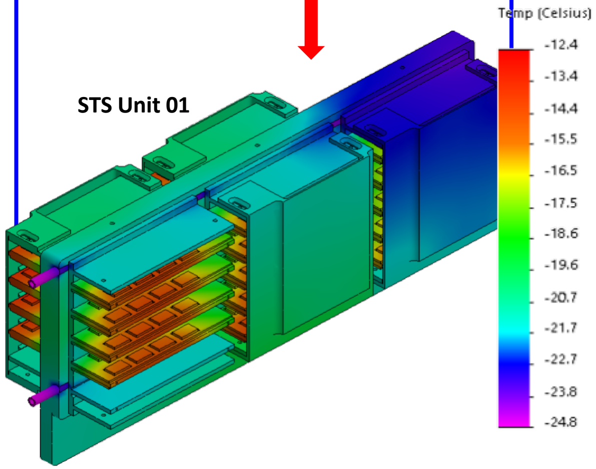
**Forced $N_2$ cooling directly for sensors (aim ≤ -10°C)**




**FEE Cooling Concept**

**T-p v/s L Analysis Flow Pattern Map (MATLAB + REFPROP)** + **Thermal FEA (SolidWorks)**

**Optimal Operation Parameters (Mass Flow, Pressure Drop, Tube geometry, Temp. Gradient etc.)**




**Max. FEE temp. < -10°C 👍**
**Computational Characterization**

**FEE shielding encapsulates higher FEE temp. 👍**

## TIM Optimisation

$T_{H2O}$ = 15°C, $\dot{Q}$ = 160W, Fr = 11.1g/s

| Interface #1 | Interface #2 | Maximum Fin Temp. (°C) | |
|---|---|---|---|
| | | Exp. (PT100) | Thermal FEA |
| Grease | Grease | 29.7 | 32.0 |
| | C-Foil | 29.6 | 32.0 |
| C-Foil | Grease | 33.7 | 32.1 |
| | C-Foil | 33.9 | 32.1 |

**Viscous TIM (grease) is better 👍**
**Relative measurements with $H_2O$**

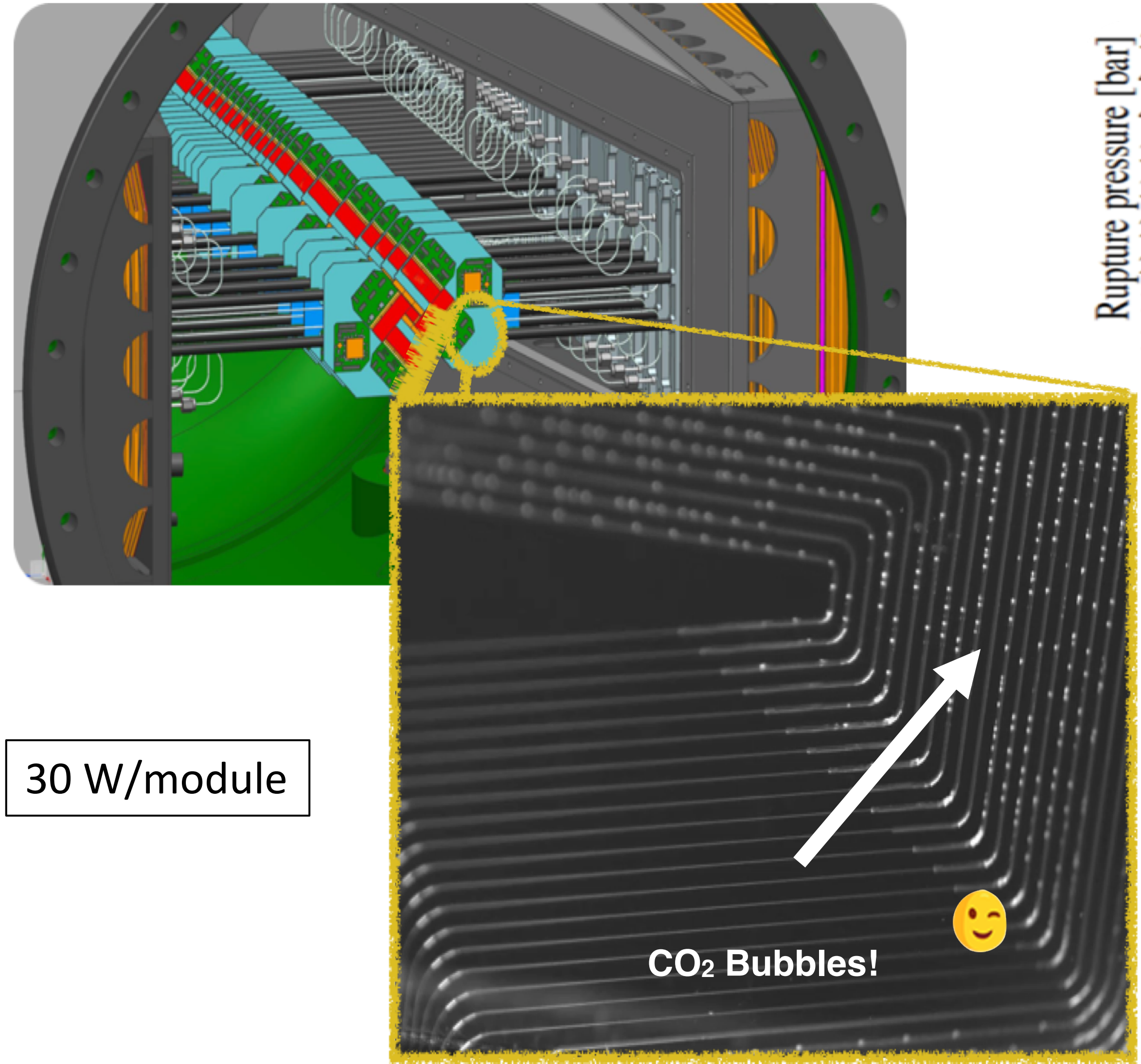
## OUTLOOK

- **Commissioning of demo $CO_2$ cooling plant**
- **Exp. verification of FEE cooling calculations**
- **Thermal characterization of feedthroughs**
- **Mechanical integration, part production → experience from mSTS@SIS18 (Aug-Sep'18)**

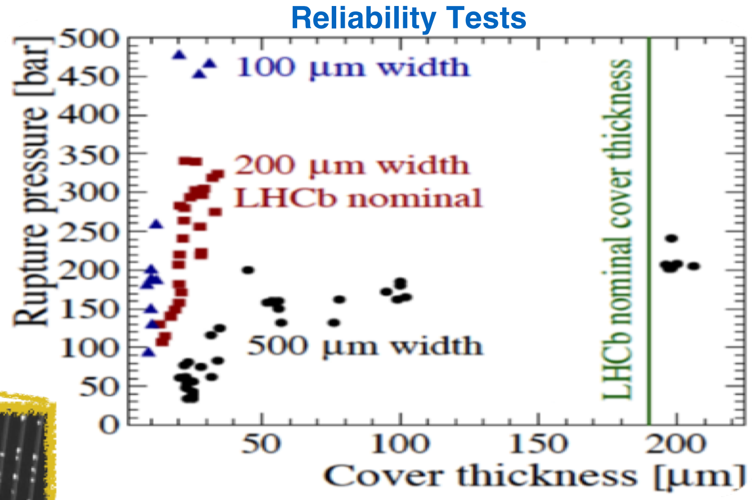
**Sensor cooling tests under realistic conditions (with least additional $X_0$/station)**

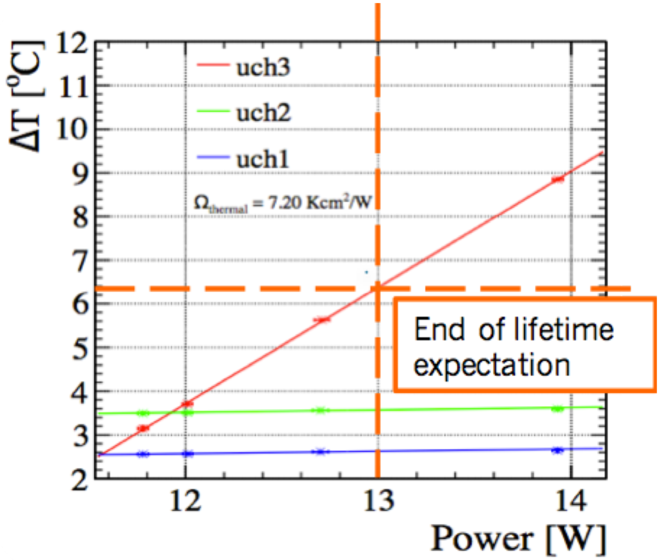
# R&D on $CO_2$ Cooling using a Silicon Microchannel Substrate for the LHCb VELO Upgrade

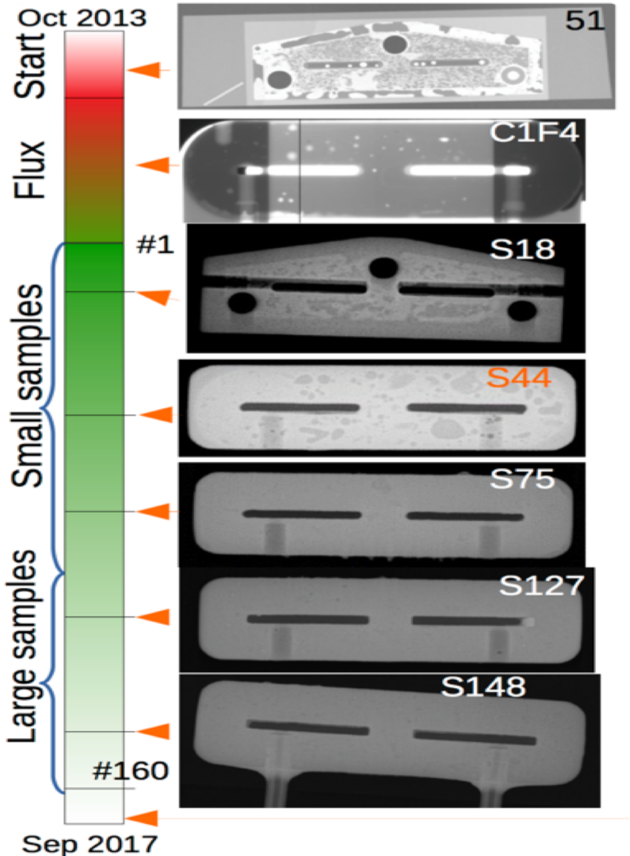

Vinícius Franco Lima
On Behalf of the LHCb VELO Upgrade


30 W/module



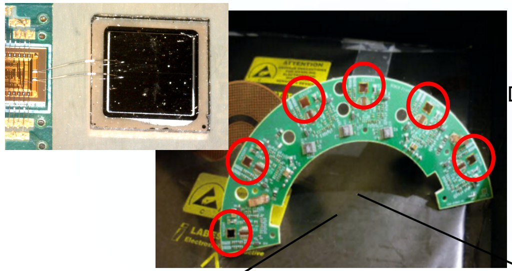
# Beam Monitoring

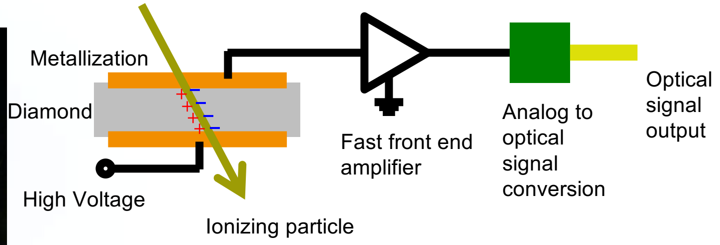
- The new Fast Beam Condition Monitor using diamond and silicon sensors for luminosity measurement at CMS – Moritz Guthoff, DESY
- Development of the proton beam monitor based on the thin diamond crystal for the COMET Experiment – Yuki Fujii, KEK
- Overview of the CMS beam loss monitoring system (BCML) and the performance of the system in 2017 – Vitalii Okhotnikov, Tomsk Polytechnic University
- A fast and quasi-mon invasive muon beam monitoring detector working at the highest beam intensity in the world – Malte Hildebrandt, PSI
- First experience with the Belle II radiation monitoring system based on s-CVD diamonds

# The new Fast Beam Condition Monitor using diamond sensors for luminosity measurement at CMS.

Moritz Guthoff (DESY, Hamburg, Germany)
on behalf of the CMS collaboration

**CVD diamond based particle detector**

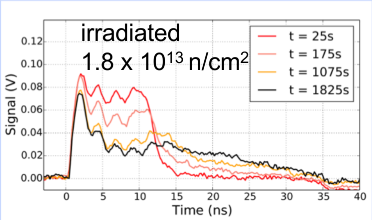


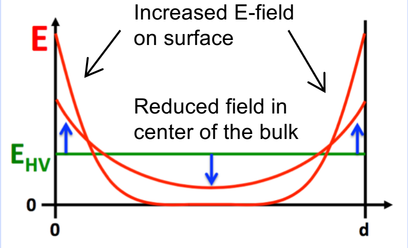



## Original system 2015/16 single-crystal diamonds

HV trips after irradiation at high particle rates.

➢ Unstable operation.



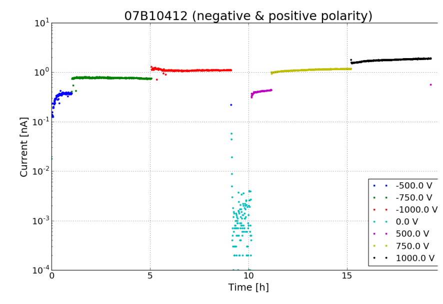



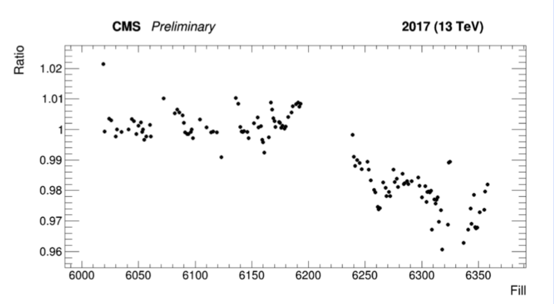

Transient current technique measurements show bulk polarization after irradiation as likely cause for instabilities.

## New replacement 2017/18 poly-crystal diamonds

Stably operation at sufficient HV

➢ Good quality luminosity measurement




pCVD lab tests:
Stable operation at 1000V for many hours

Luminosity 2017:
BCM1F within 2% of reference measurement

# Development of the proton beam monitor based on the thin diamond crystal for the COMET Experiment


Y.Fujii,

KEK, Tsukuba, Japan

yfujiI@post.kek.jp


Diamond based proton beam monitor (PBM) is quite important for COMET to search for the μ-e conversion with a single event sensitivity down to $10^{-17}$.

Since a diamond detector is a brand new technology as for the particle detector, especially for use of the single particle identification, the prototype detector was developed to investigate its precise performance and the technical difficulties. The prototype detector consists of two single crystal diamonds with a uniform square shaped contacts, and a 200μm ultra thin ceramic PCB as shown in Figure1 and Figure2.

According to the measurement using an Am241 (5.5MeV α source), the expected pulse height due to a single proton is calculated to be less than 0.4mV. Therefore the strong noise reduction is essential in order to discriminate the single proton with the prototype detector both online and offline. The measurement of the small number of protons was conducted in the winter of 2018 using this prototype at J-PARC. As a result, we successfully observed the signal due to the small number of protons as shown in Figure3 and the baseline analysis method including the offline noise reduction was developed. However, the measured noise level was around 0.15mV, and it was found that further noise reduction is necessary.

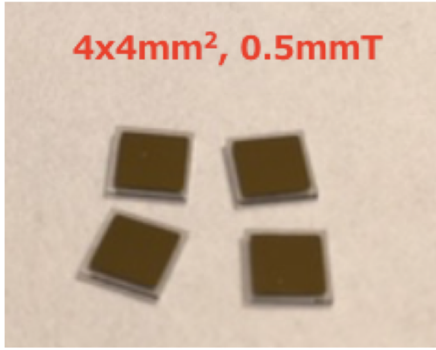



Figure1. Diamond crystals with square shaped metal contacts.

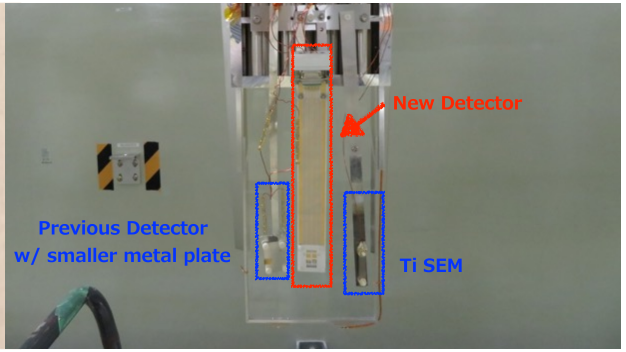



Figure2. A prototype diamond detector based on the special thin ceramic PCB.

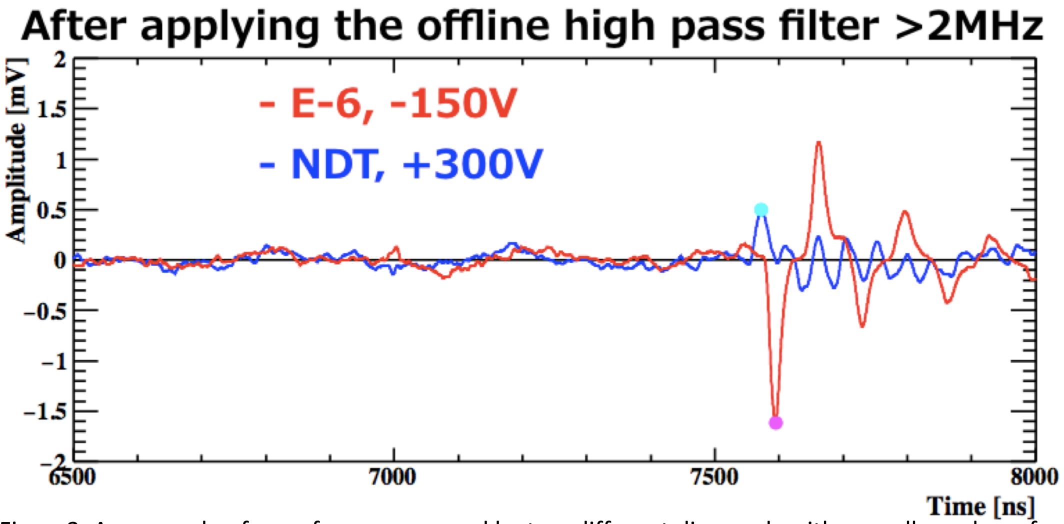
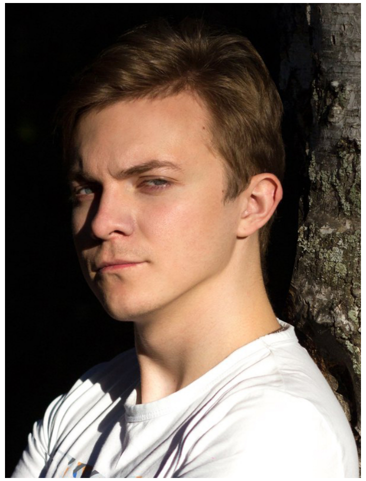



Figure3. An example of waveforms measured by two different diamonds with a small number of protons. One is a CVD (Chemical Vapor Deposition, from Element-6) diamond and other is a HPHT (High Pressure High Temperature, from New Diamond Tech.) diamond.

# Overview of the CMS beam loss monitoring system (BCML) and the performance the system in 2017

Vitalii Okhotnikov (Tomsk Polytechnic University, Tomsk, Russia)
on behalf of the CMS collaboration

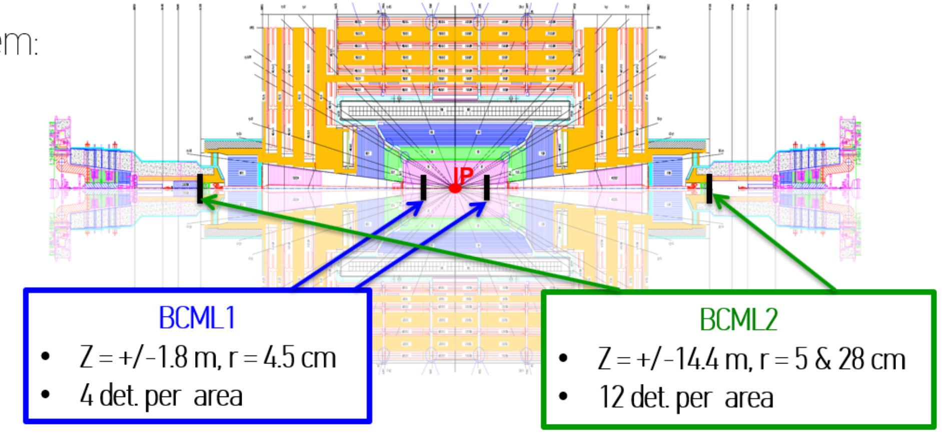
Co-autors: Anne Dabrowski (CERN), David Stickland (Princeton University), Moritz Guthoff (DESY-Hamburg), Maxim Titov (Paris-Saclay), Arkady Lokhovitskiy (University of Canterbury), Stepan Linnik (Tomsk Polytechnic University )

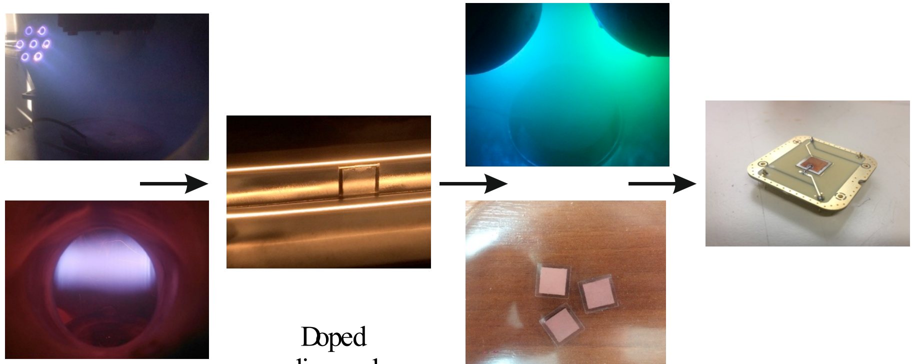


In CMS a beam loss monitoring system (BCML) is in place to protect the CMS Tracker from potentially damaging, high intensity beam loss events. Above a pre-defined detector current the LHC beams are automatically dumped. Detectors for this system require high radiation tolerance for stability over time, sufficient signal over noise at a given particle rate and a linear response up to the abort threshold. Poly-crystalline (pCVD) diamond sensors are used as detectors. Additionally sapphire based and diamond-on-iridium prototype sensors were installed during 2017 to investigate more radiation tolerant detectors. This report discusses - BCML system, as well as promising ways of solving problems with adhesion to the detector's plates by using the diamond surface modification by using doped diamond sublayers

BCML system:

Beam
Condition
Monitor
Leakage



Pretreatment

Doped diamond deposition

Metallization

Mounting in box

# A fast and quasi-non invasive muon beam monitoring detector working at the highest beam intensities in the world

poster presenter:
M. Hildebrandt

*A. Papa[1,2], G. Rutar[1,3], F. Barchetti[1], M. Hildebrandt[1]*
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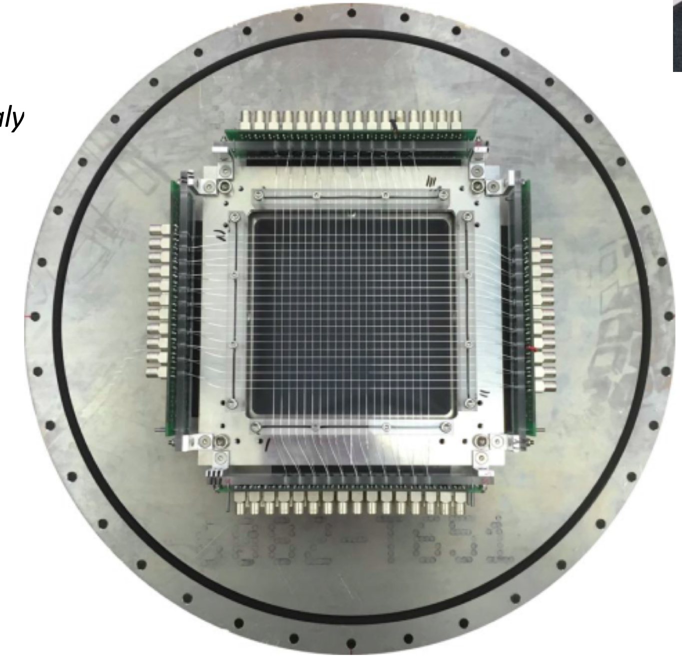


Scintillating fibers + SiPMs

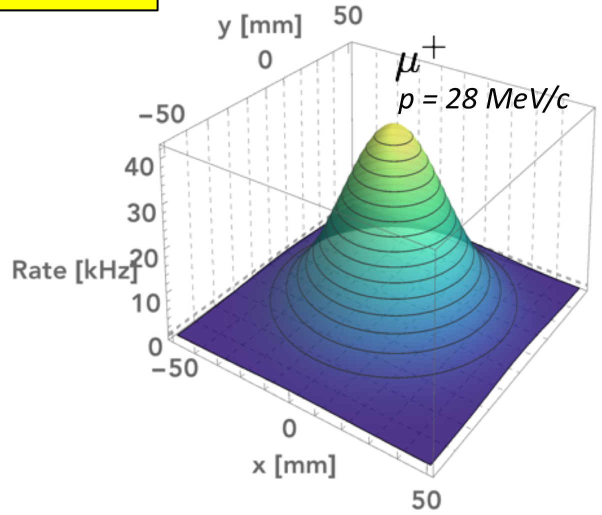
## Detector

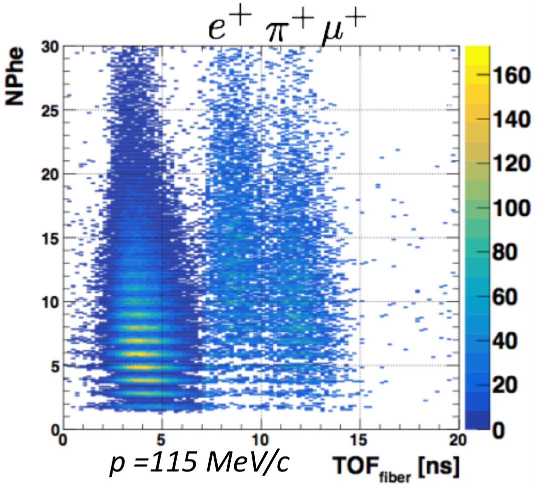
- fibre: SaintGobain double clad, 250μm squared BCF12 with 100nm of evaporated Al coating
- photosensor: Hamamatsu MPPC S13360-1350CS
- DAQ + TRG: waveform digitizer up to 5 GSample/s (DRS4)

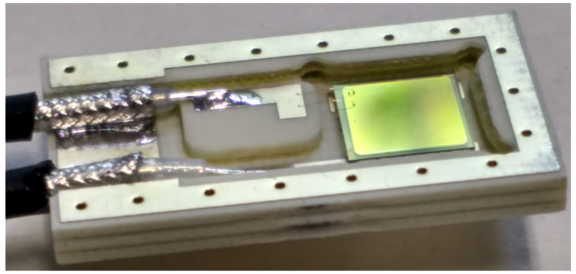
**Can sustain particles rates up to $10^8$ particles/s**

## Results

- full detection efficiency for heavy ionising particles
- high granularity
- high transmission
- fast response
- beam profile and rate in few seconds
- particle ID possible based on TOF



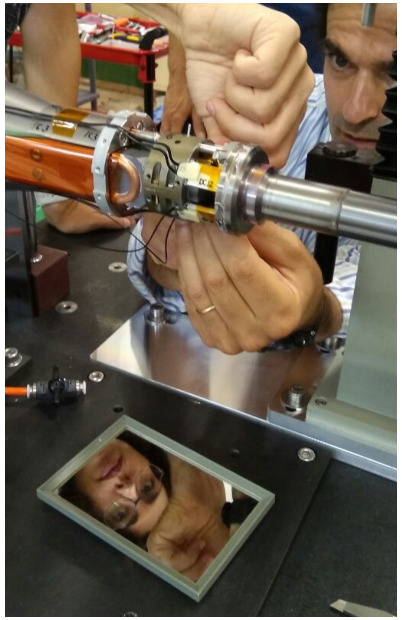





# First experience with the Belle II radiation monitoring based on diamonds


**Lorenzo Vitale on behalf of Belle-II SVD collaboration**

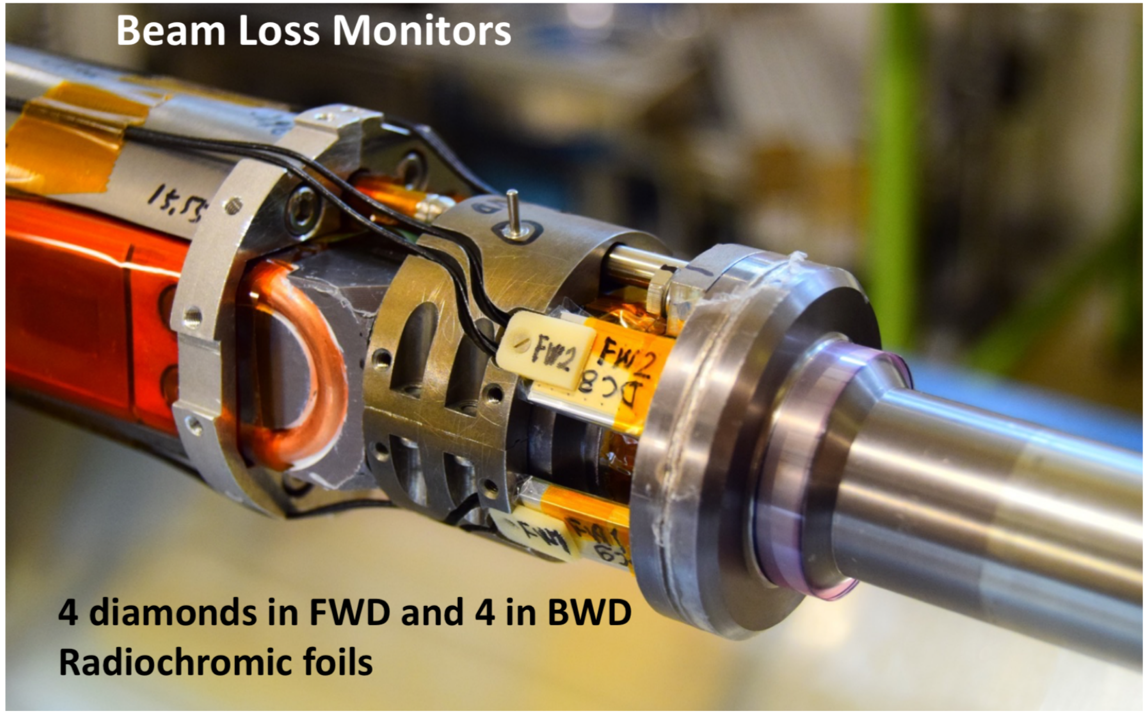
INFN and Univ. Trieste, ITALY

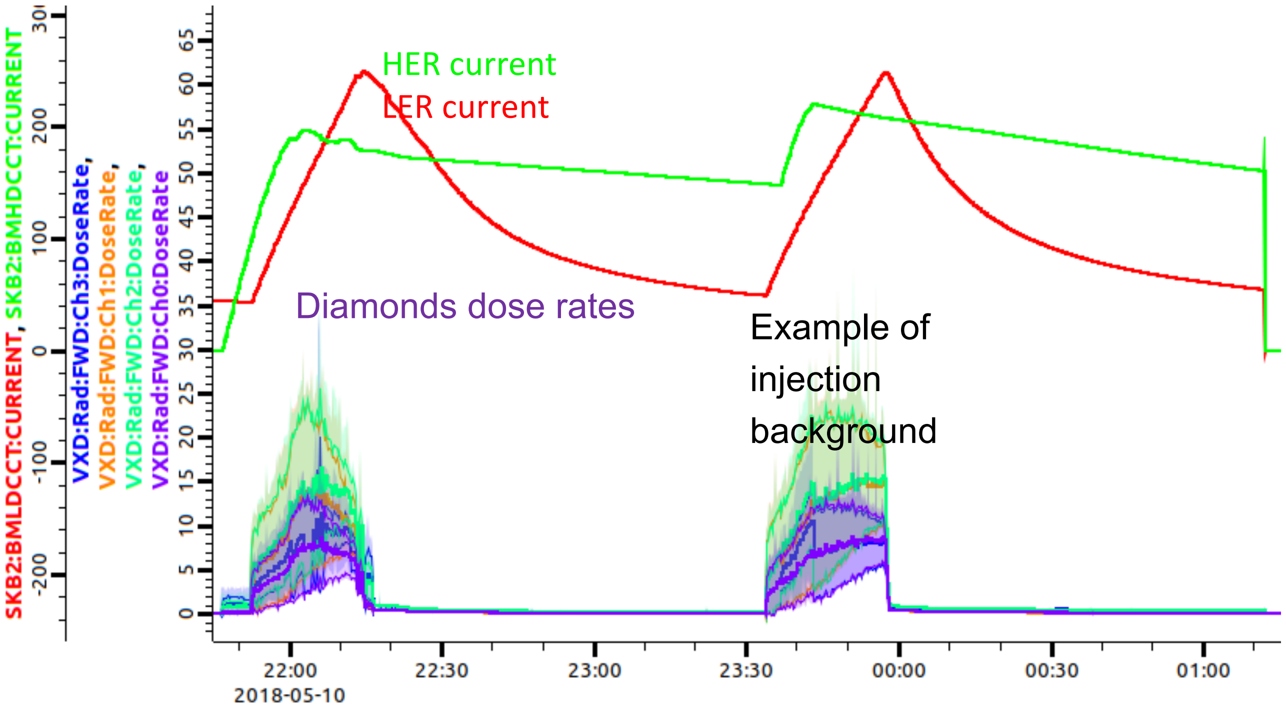



Mar-Jul 2018 commission phase for BELLE II & SuperKEKB

Horizontal sector of vertex detector and innermost radiation monitoring

- 8 diamonds around beam pipe on same locations as for physics phase (20 new diamonds)
- Full functional readout electronics for fast beam abort, real time monitoring of dose rates and integrated dose (10 Hz and 100 kHz sampling)



# Conclusions

A lot of interesting developments ongoing, please go and talk to the poster presenters across the hallway NOW