



Welcome !!  
to oPAC Workshop on BLMs  
*Carsten P. Welsch*



# What is oPAC ?



- Optimization of Particle Accelerators
  - 23 ESRs
  - >30 Partner Institutions
  - 6 M€



[www.opac-project.eu](http://www.opac-project.eu)

**OPAC**

**OPEN POSITIONS  
WITHIN THE  
OPAC PROJECT**

The optimization of the performance of any particle accelerator critically depends on an in-depth understanding of the beam dynamics in the machine and the availability of simulation tools to study and continuously improve all accelerator components. It also requires a complete set of beam diagnostic methods to monitor all important machine and beam parameters with high precision and a powerful control and data acquisition system.

Within the oPAC project these aspects will be closely linked with the aim to optimize the performance of present and future accelerators that lie at the heart of many research infrastructures.

The network is currently aiming to recruit a pool of talented, energetic, strongly motivated, early stage researchers with a degree in physics, electrical engineering or a closely related field. Possibilities for enrolling into a PhD program exist. Women are especially encouraged to apply.

**Deadline for applications:**  
March 9<sup>th</sup> 2012

Each researcher will benefit from a wide ranging training program that will take advantage of both local and network-wide activities, as well as of schools, conferences, and workshops. Excellent salaries will be offered. Most positions are for starting in summer 2012.

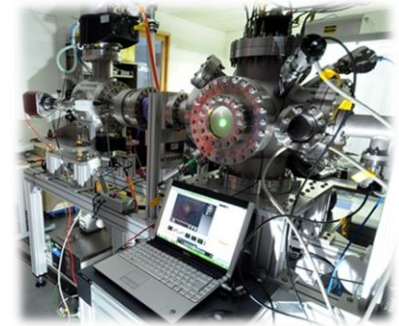
You will find more information about oPAC, all research projects and the application details at:  
<http://www.liv.ac.uk/opac>

Contact and further detail:  
Prof. Carsten P. Welsch  
Cockcroft Institute of Accelerator Science and Technology  
University of Liverpool  
Department of Physics  
L69 7ZE Liverpool, UK  
[carsten.welsch@quasar-group.org](mailto:carsten.welsch@quasar-group.org)

This project is funded by the European Union under contract PITN-GA-2011-295495

# Why needed ?

- Well suited as cross-sector collaboration is key to our research.
- Essentially all large-scale experiments require international cooperation

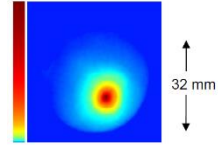


- Research area needs significantly more trained accelerator experts;
- Few universities in EU provide structured courses – oPAC drives innovation in researcher training

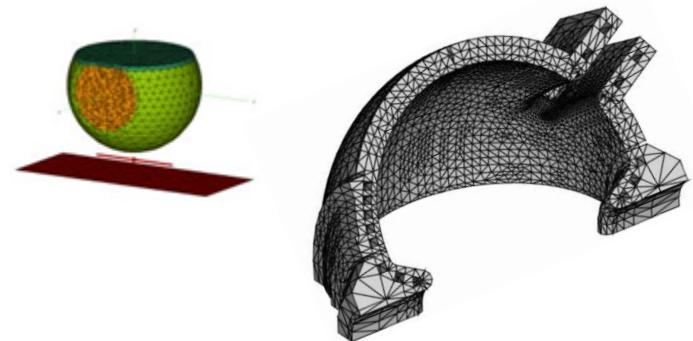


- Development of designs for possible LHC upgrade options
- Advanced beam physics problems at light sources
- Optics and lattice design studies for the interaction region design of the LHC experimental insertions
- LHeC as a future upgrade option of the LHC
- Simulation studies into halo generation in high brightness hadron beams
- Studies into beam loss patterns at ESS
- Design and development of resonant structures as Schottky noise detectors for various frequencies
- Optimization of the layout of the LHC collimation system
- Improvement of the understanding of non-linear beam dynamics effects in light sources

- Beam halo monitor development
- Optimization of beam instrumentation for light sources
- Cryogenic SQUID-based beam current monitor
- Beam Loss Monitors for use in Cryogenic Environments
- Methods for measuring the beam profile in high intensity beams
- Laser-wire beam profile monitor for measuring the transverse beam profile of an H- beam
- Optimization of  $^{10}\text{Be}$  detection
- Design a detection system for verifying a 3D method of image reconstruction for Intensity Modulated Radiotherapy Treatment (IMRT)



- Included in essentially all R&D projects, plus:
- Development of a simulation suite based on the multilevel fast multipole method
- Development of a GPU-based PIC solver



- Links all R&D projects, plus:
- Adaptation of existing open-source control systems from compact accelerators to large scale facilities
- Improvement of the process to identify the needs for accelerator instrumentation



- Objective: Train the next generation of accelerator experts in **best possible way**
- Provide them with **ideal skills basis** for their future careers
- Promote **collaboration** and cross sector exchange
- **Secondments** to under how R&D works at different places

➡ Motivation: *Ideal* Training.





# ,Success stories' (EC)

- Fellow R&D
- Researcher skills training
- Dissemination and Outreach
- Project Coordination & Management



➡ Also recognized as ,best practice' by HEA, UKRO, etc.

# Stay tuned !!



- URL: <http://www.opac-project.eu>

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Search

oPAC

About us

Network Structure

Projects

Vacancies

News

Events

Dissemination

Press

Downloads

Links

EU Project T.E.A.M.

Contact

Part of the School of Physical Sciences

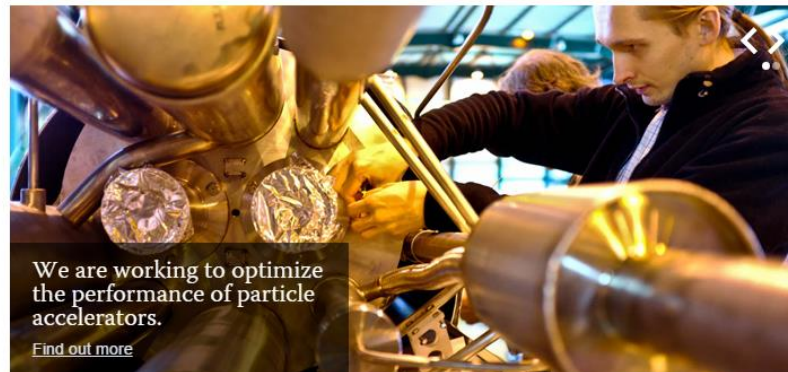
We are working to optimize the performance of particle accelerators. Find out more

Welcome to oPAC

The optimization of the performance of any Particle Accelerator (oPAC) is the goal of this new network within the FP7 Marie Curie Initial Training Network (ITN) scheme.

OPAC

Facebook Twitter



## Our Network

We work with the leading research centres, universities and industry partners.

Find out more

## News

oPAC's bid for the Academy Awards

A particle accelerator made of Lego bricks

Breaking the ice with DFSIRFF

LASERS AND ACCELERATORS FOR SCIENCE & SOCIETY SYMPOSIUM

Liverpool Convention Centre, June 20<sup>th</sup> 2015 (p.m.)

Particle accelerators have numerous applications across many fields including medicine, electronics, environment and energy.

As the limits of performance are reached new methods for particle acceleration and beam optimisation are needed.

Lasers will play a key role in the development of accelerators by improving the generation of particle beams, increasing the mass acceleration gradient, and reducing beam emittance.

This event is free of charge - advance registration is required.

Registration deadline: May 15<sup>th</sup> 2015

[www.opac-project.eu](http://www.opac-project.eu)

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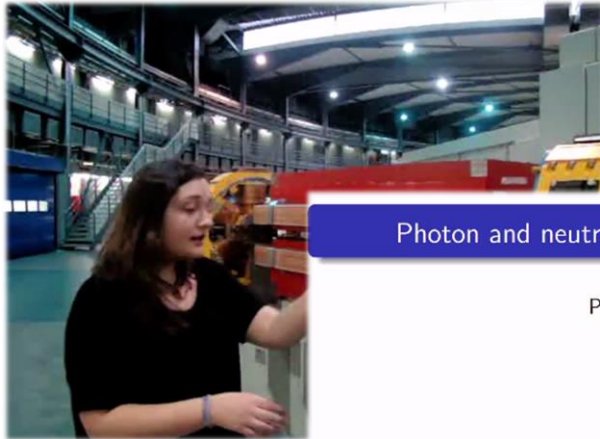
LANET

IOP Institute of Physics



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# Enjoy the movies !



Photon and neutron detection with diamond

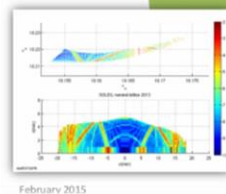
Pavel Kavargin



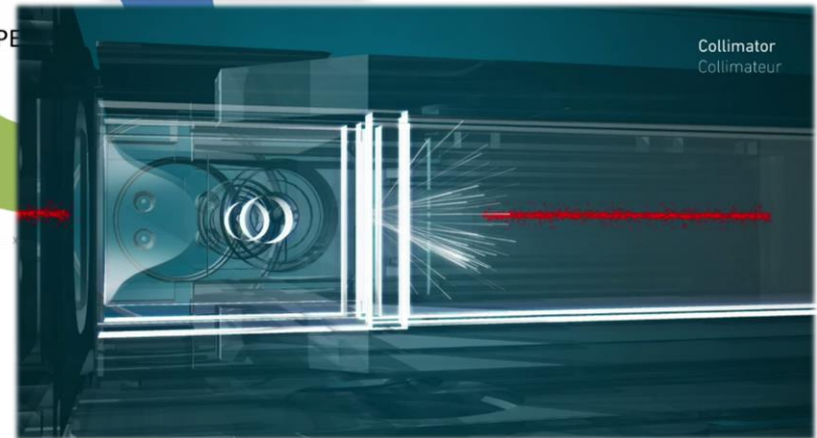
Tools for MOGA



cividec  
instrumentation



EXPE



Examples – many more on  
[www.opac-project.eu](http://www.opac-project.eu)



# Bringing the community together



➔ Still growing - join us !



# This Workshop...



- An exciting program has been put together by our Fellows
- Engage in discussions – find out about new technologies, latest designs and advanced machine protection schemes

**OPAC** Topical Workshop on Beam Loss Monitors

15-16 September 2016  
Residencia d'Investigadors, Barcelona  
Europe/Zurich timezone

Search

Overview  
Registration  
**Timetable**  
Contribution List  
Speaker List  
Call for Abstracts  
View my Abstracts  
Submit Abstract  
Venue  
How to get there

Ricardo Torres - oPAC Project Manager  
ricardo.torres@cockcroft...

**Timetable**

Thu 15/09 | Fri 16/09 | All days

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14:00	Introduction and Welcome	Carsten Welsch
	Residencia d'Investigadors, Barcelona	14:00 - 14:30
	Beamloss detector development at the ESRF	Friederike Ewald
	Residencia d'Investigadors, Barcelona	14:30 - 15:00
15:00	Fibre BLM studies in the Australian synchrotron	Maria Kasinidou
	Residencia d'Investigadors, Barcelona	15:00 - 15:30
	<b>Coffee Break</b>	
	Residencia d'Investigadors, Barcelona	15:30 - 16:00
16:00	Diamond Beam Loss Monitors	Erich Griesmayer et al.
	Residencia d'Investigadors, Barcelona	16:00 - 16:30
	In vacuum Diamond Sensor Scanners for Beam Halo Measurements at ATF2	Shen Liu
	Residencia d'Investigadors, Barcelona	16:30 - 17:00
17:00	Collaborative work and funding opportunities	Carsten Welsch
	Residencia d'Investigadors, Barcelona	17:00 - 17:30



**BLMs**  
Indispensable Tools for  
Accelerator  
Operation & Optimization

# Looking back 4 years...



- Workshop @ CERN
- IndicoID: 243 336
- Several talks about
  - Monte Carlo;
  - machine protection;
  - detector technologies



**OPAC**

**Grand Challenges in Accelerator Optimisation**

**CERN, Switzerland: 26<sup>th</sup>/27<sup>th</sup> June 2013**

**Speakers include**

Green and Compact Magnet Technology for Optimisation of Particle Accelerators  
*Dr. Gianni Rogier Hübner, CEO, CERN*

Challenges of High Intensity Accelerators  
*Dr. Misha Lindfors, Head of Accelerator Division, ESS*

Research on Ultra-short Timescales – FELs  
*Dr. Daniel Rührig, SLAC*

Laser Acceleration – Towards Highest Gradients  
*Prof. Luis Rosi, Director, CLPU*

Unravelling the Secrets of the Universe  
*Dr. Richard Hawkins, CERN*

Accelerators are key instruments for fundamental research, health and industry applications. International collaboration is very important for their continued optimisation.

This two-day international workshop will provide an overview of the current state of the art in beam physics, numerical simulations and beam instrumentation and highlight existing limitations. It will discuss research and development being undertaken and ambitions to further improve the performance of existing and future facilities.

In addition to invited talks, there will be industry displays and a special seminar covering recent LHC discoveries. All participants will have an opportunity to contribute a poster.

This event is open to all and free of charge. Advance registration is required; places are strictly limited.

Full details and registration:  
[www.opac-project.eu](http://www.opac-project.eu)

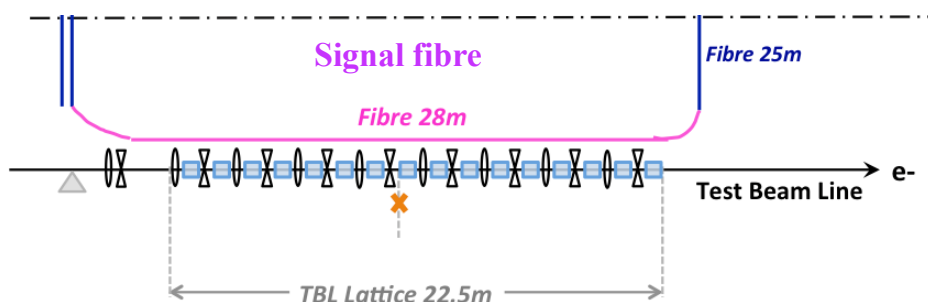
Contact:  
Prof. Dr. Carsten P. Welsch  
Associate Director  
Cockcroft Institute / University of Liverpool  
[c.p.welsch@liverpool.ac.uk](mailto:c.p.welsch@liverpool.ac.uk)

This project is funded by the European Union under contract PITN-GA-2011-289485.



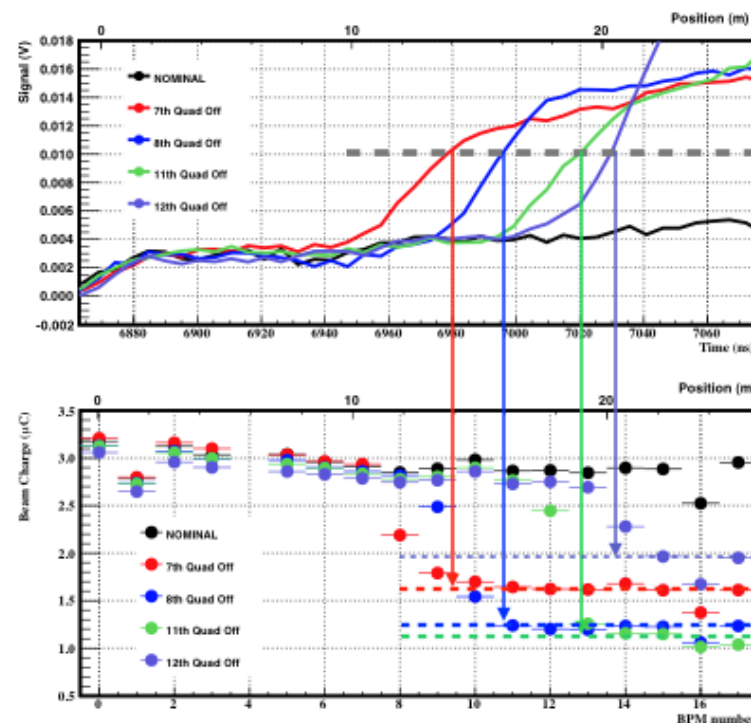
# Resolution w/ Long Pulses

- Optical beam loss monitoring (oBLM) system installed in the Test Beam Line at CTF3
- Demonstrated beam loss location reconstruction with complex pulses (multi bunch, high frequency + long)



**Eduardo Nebot del Busto, Maria Kastriotou**  
“Position Resolution of Optical Fibre-Based Beam Loss Monitors Using Long Electron Pulses”

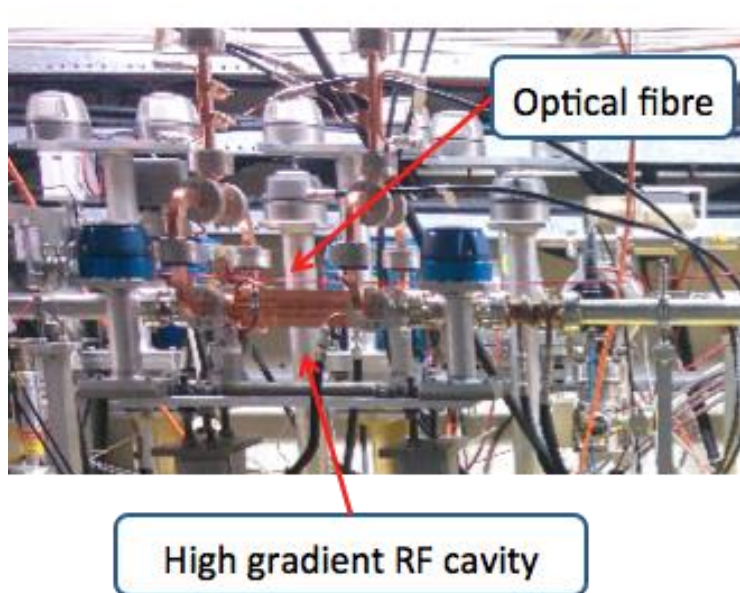
Proc. IBIC15



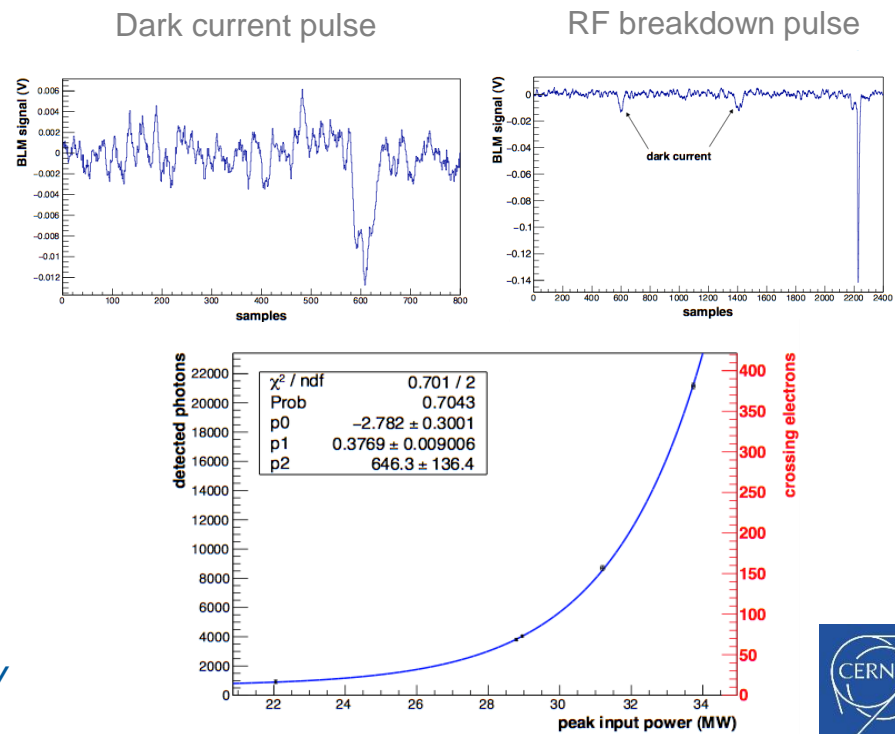


# RF cavity diagnostics

- Studies into sensitivity limitations of oBLMs showed application potential for enhanced RF cavity diagnostics
- Demonstrated **detection of dark current and RF breakdown** induced signals at the “dogleg experiment” in CTF3



**Maria Kastriotou, et al.**, “RF cavity induced sensitivity limitations”, Physics Procedia (2015)



# oBLM Performance



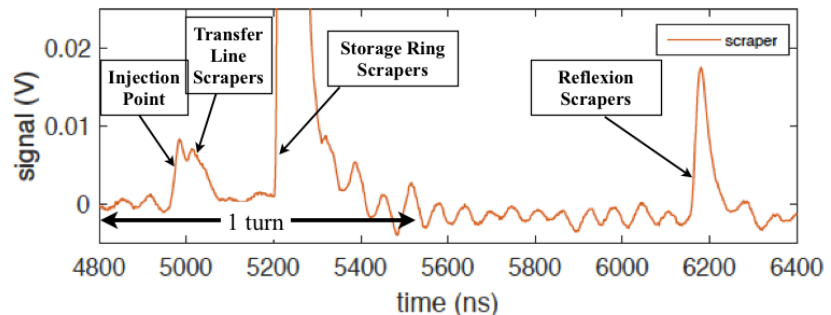
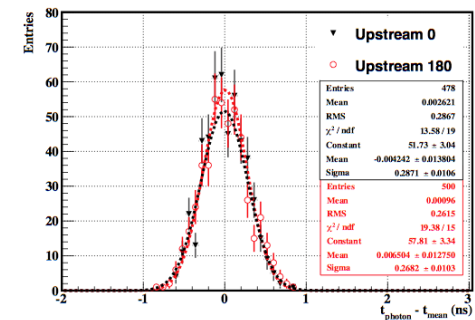
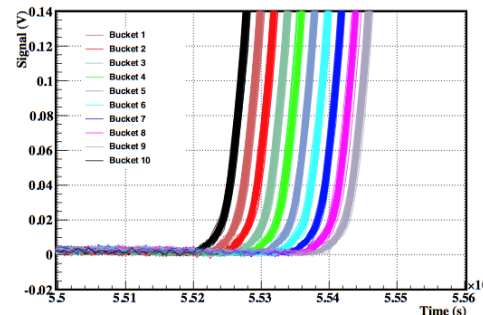
- Demonstrated superior time resolution and loss pattern reconstruction capability

**Eduardo Nebot del Busto, et al.**

*“Position Resolution of Optical Fiber-based Beam Loss Monitors Using Long Electron Pulses”*

Talk @ IBIC15, Melbourne

- Potential for high sensitivity sensor

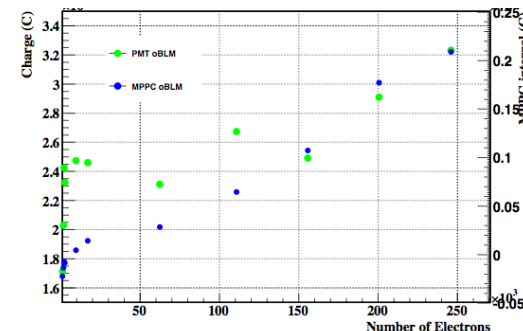


Down to  $\sim 10^4$  lost electrons

**Eduardo, Maria**

*“Measurement of Beam Losses Using Optical Fibers at the Australian Synchrotron”*

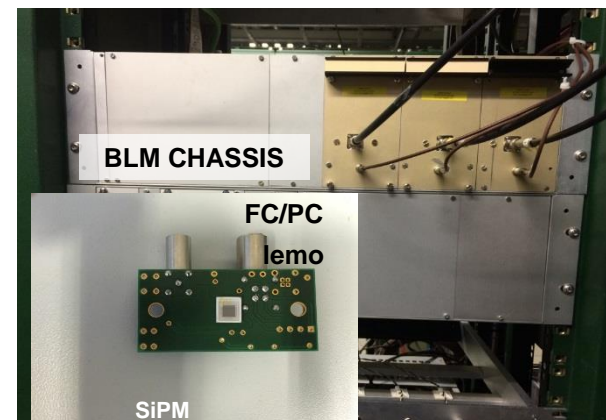
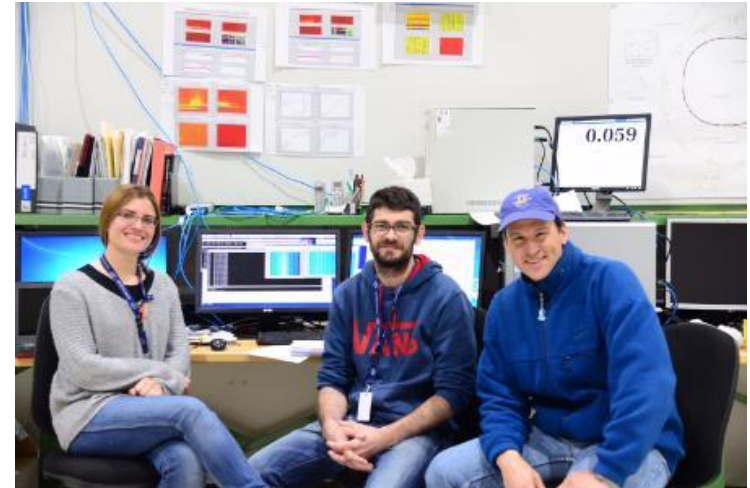
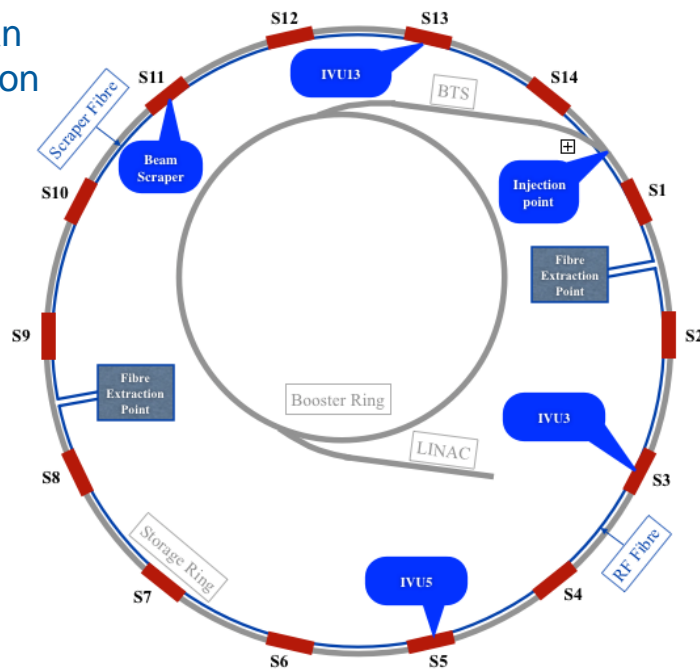
Proc. IBIC14



# System Test Down Under

- Storage ring (216 m) covered by two SiO<sub>2</sub> multi mode optical (Cherenkov) fibers
- Optical readout based on SiPMs

Australian  
Synchrotron



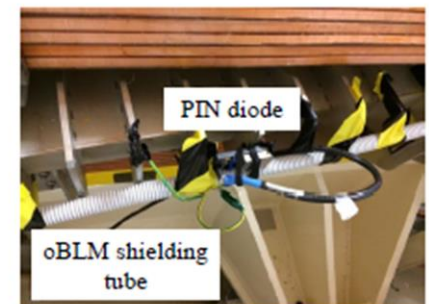
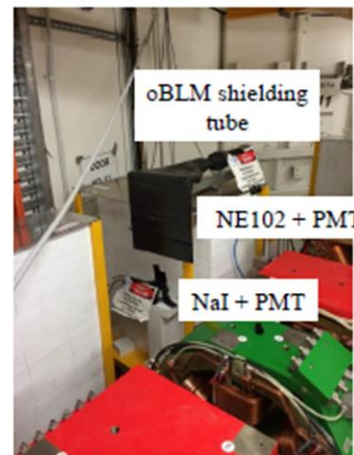
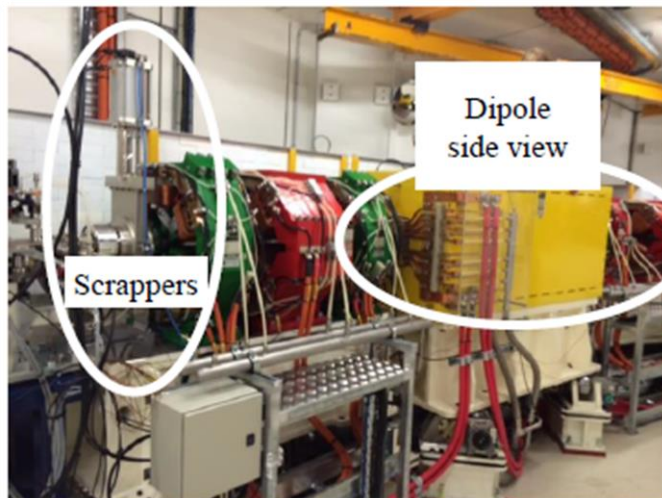
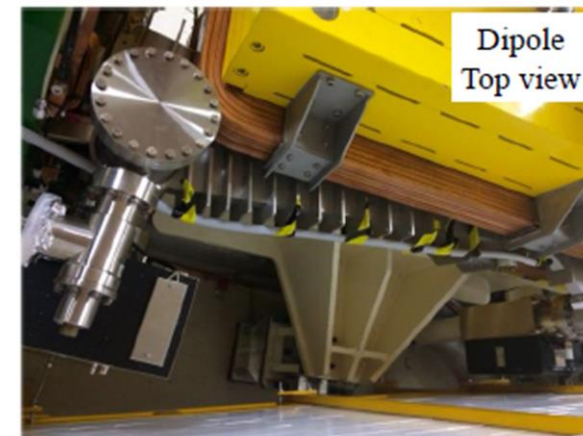
Work supported by the Royal Society



# Australian Synchrotron



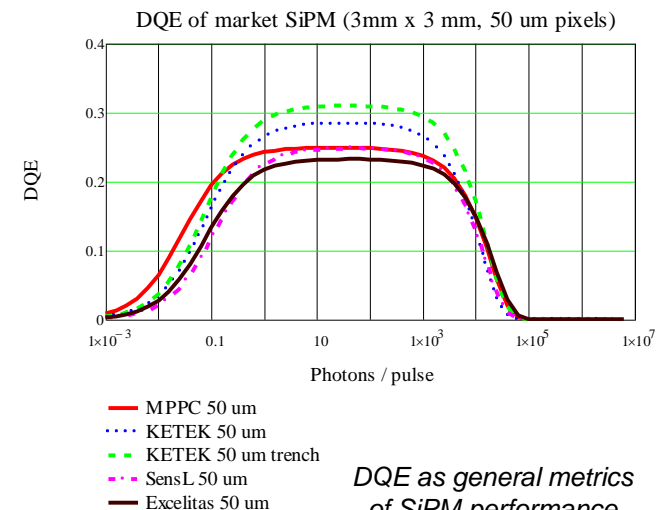
- Installation of several prototypes in the AS
- Two (one) 7 m (5 m) optical fibres with 365  $\mu\text{m}$  (200  $\mu\text{m}$ )  $\text{SiO}_2$  core:
  - Multi Pixel Photon Counter (MPPC)
  - Photon Multiplier Tube (PMT)
  - Avalanche Photon Diode (APD)
- Pin diode, NaI and NE102 scintillators in neighbouring locations for comparison



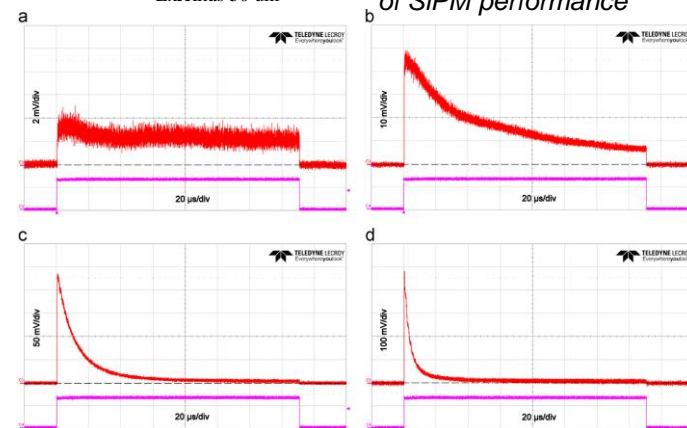


1. Development of analytical model of SiPM time resolution and order statistics with crosstalk. First implementation of probabilistic technique of correlated filtered marked point processes to SiPM modeling.
2. General Metrics. Excess Time Factor approach used to describe inherent photodetector performance in time resolution applying Excess Noise Factor metrics on photon number resolution.
3. Calibration of low gain SiPMs. Using Erlang and Gamma probability distributions, substituting measurements of noisy signals by measurements of time required to accumulate relatively large signal charge.
4. Analysis of multi-photon multi-avalanche processes. Order statistics approach for processing of experimental results carried out for a single SiPM cell.
5. First experimental studies and first analytical modeling of nonlinear transient SiPM response in long intense light pulses. This supports high dynamic range applications of SiPM as BLMs.
6. New method for characterization of dark noise generation process. Uses comparative analysis of dark and photo I-V characteristics of SiPMs in a full range of operating bias voltages.

**Sergey Vinogradov, et al.**, Nucl. Instr. Meth. A (2015), *mult.*



*DQE as general metrics of SiPM performance*



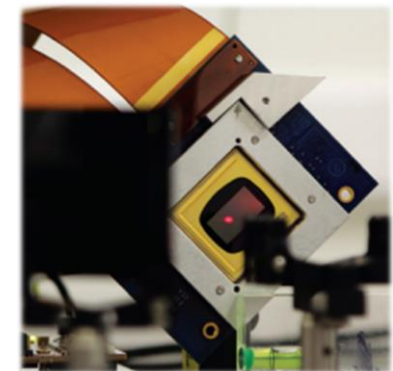
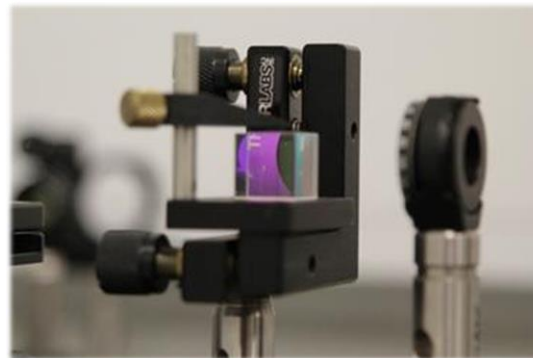
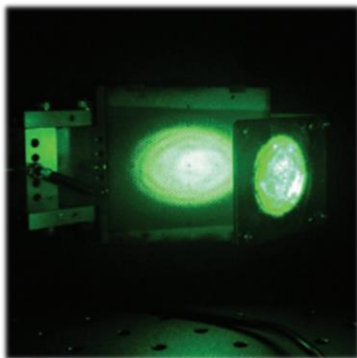
*Transformation of nonlinear transient SiPM responses to long light pulses from low (a) to mid (b, c) and high intensity (d) due to slow pixel recovery*

## ■ Commercialization of beam diagnostics

- Optical sensors
- Beam loss monitors
- Profile measurement
- Machine protection



[www.d-beam.co.uk](http://www.d-beam.co.uk)



# Diagnostics for Beams



- Based on university R&D
- Supported by Enterprise Fellowship
- Benefiting from international links

[www.d-beam.co.uk](http://www.d-beam.co.uk)



# Easy to forget:

- BLMs are essential parts of any accelerators or like source – you simply can't do without them !
- Advantages and disadvantages in using purpose-built monitors vs. commercial solutions
- Enhance performance by optimizing position, range, etc. through supporting simulations
- This workshop: Overview of current technologies, discussion of performance limits and identify R&D requirements and road map !



# Starting now:



- (online) beam monitors
- Improved calorimeters and Si detectors



- Enhanced Monte Carlo codes (FLUKA)
- Systematic studies into e.g. ion effects

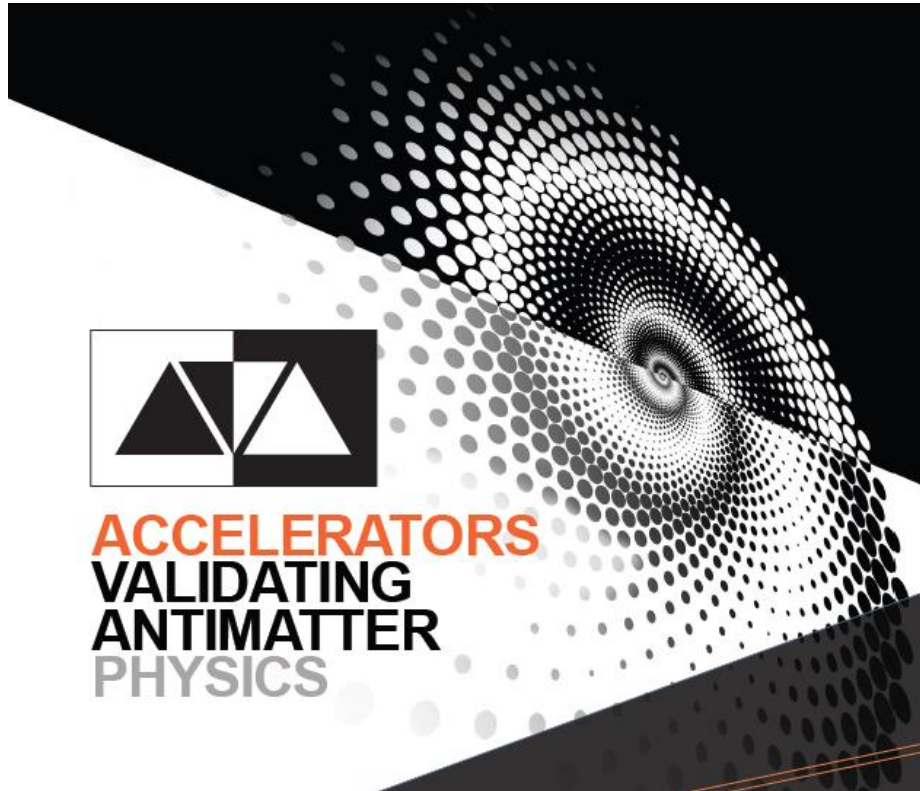


- Common software bus
- Improved beam delivery schemes



# Just approved: AVA

*(Accelerators Validating Antimatter physics)*



- European Network
- Coordinated by CI/Liverpool
- 4 M€ Funding
- Start: 1. January 2017
- 15 Fellowships
- Many schools and workshops



- Better facility design
- New beam handling techniques



- Online diagnostics
- Improved detectors



- Experiments: Novel cooling schemes
- Spectroscopy on antihydrogen.



# Goals of oPAC

- Promote international collaboration
- Provide access to world-class research infrastructures
- Include blue sky and applied research
- Strengthen industry – academia partnership
- Organize workshops and conferences as drivers for knowledge exchange



Be part of it !