SUMMIT

SMART SPECIALIZATION STRATEGY | PRAIA DA VITÓRIA AZORES 2024

INOVAÇÃO COM PROPÓSITO

A Ciência e a Engenharia ao serviço da transferência de Conhecimento

O caso da Física de Particulas

Patrícia Gonçalves LIP/IST

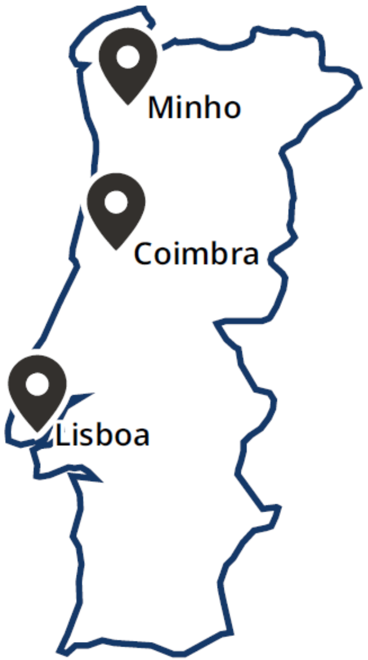
patricia@lip.pt

GOVERNO DOS AÇORES | VICE-PRESIDÊNCIA DO GOVERNO

LIP

Laboratório de Instrumentação e Física Experimental de Partículas

- O LIP é o laboratório de referência em Portigal para a Física de Partículas e suas aplicações e é responsável pela ligação ao CERN
- O LIP existe para a descoberta das leis fundamentais do Universo, garantindo a plena participação da comunidade científica portuguesa neste esforço, e para partilhar este conhecimento com a sociedade
- LIP é nacional, com polos em Lisboa, Coimbra e Braga, em estreita colaboração com as Universidades locais

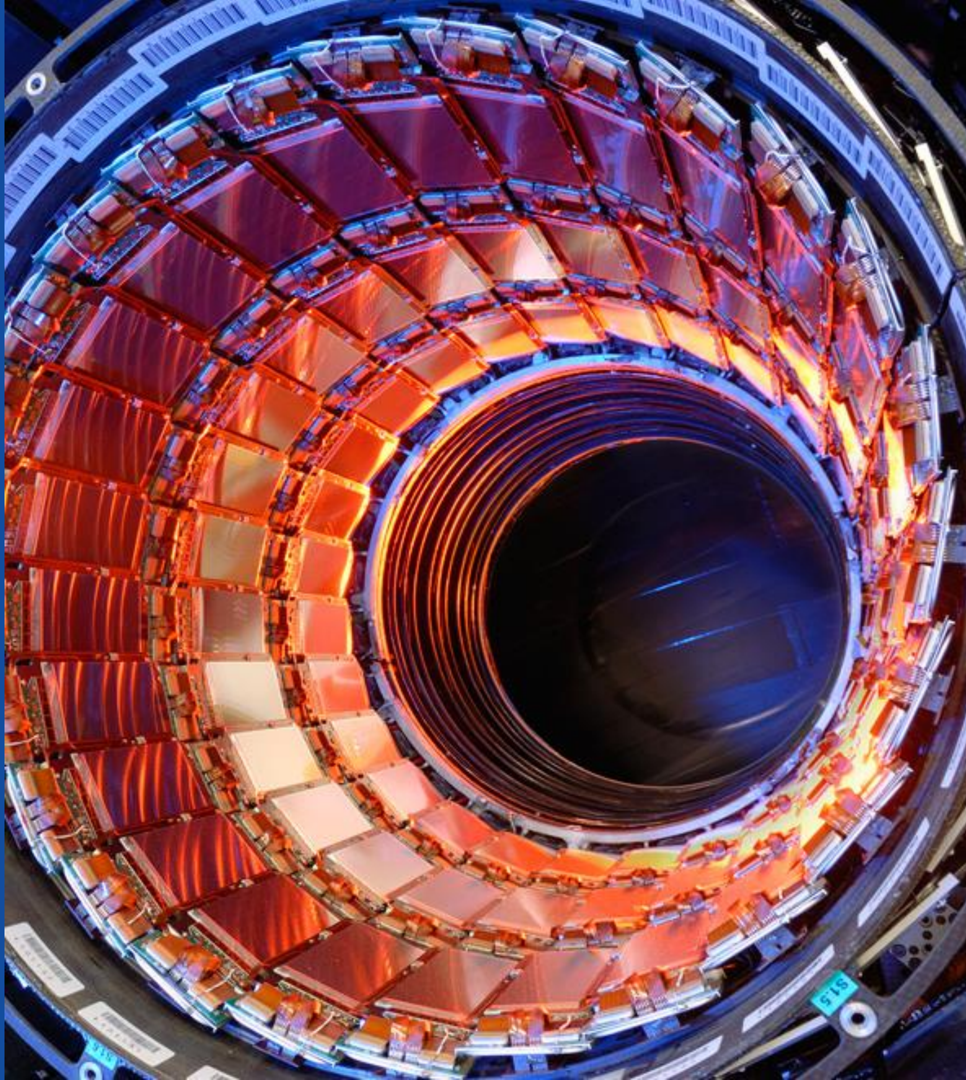


The Large Hadron Collider (LHC)

Na fronteira da tecnologia

- Os aceleradores e detectores de física de partículas estão entre os dispositivos mais complexos construídos pela humanidade

- É necessário desenvolver tecnologias inovadoras para operar estas máquinas.



Tecnologias da Física de Partículas

- Interação da radiação com a matéria:

  Aplicações à saúde

- Detectores e Instrumentação:

  Novos Materiais, eletrônica...

- Linhas de feixe e aceleradores:

  Aplicação medicina, indústria

- Desenvolvimento de software :

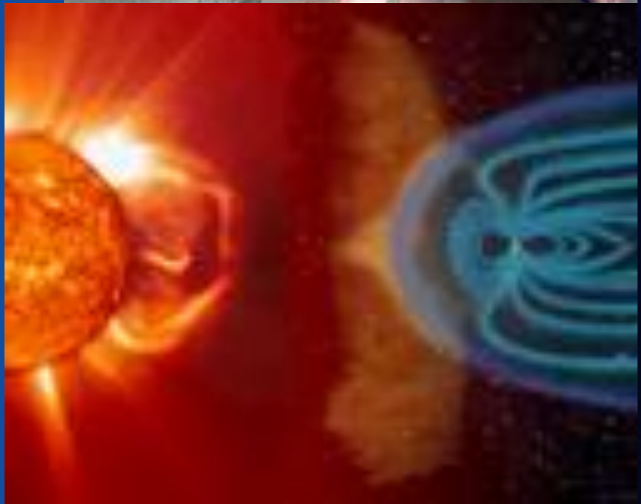
  Controle dos sistemas

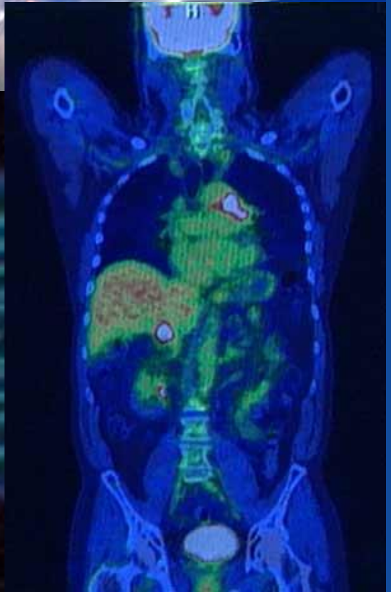
  Simulação de detectores

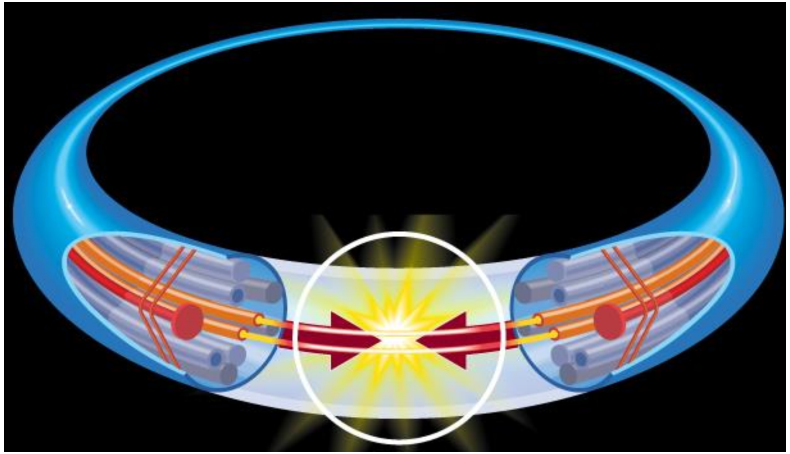
  Análise de dados

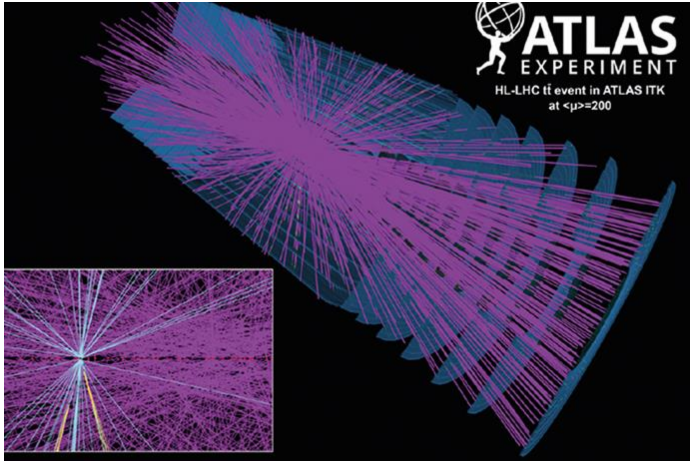
  Algoritmos p reconstrução de sinais /

  Machine learning

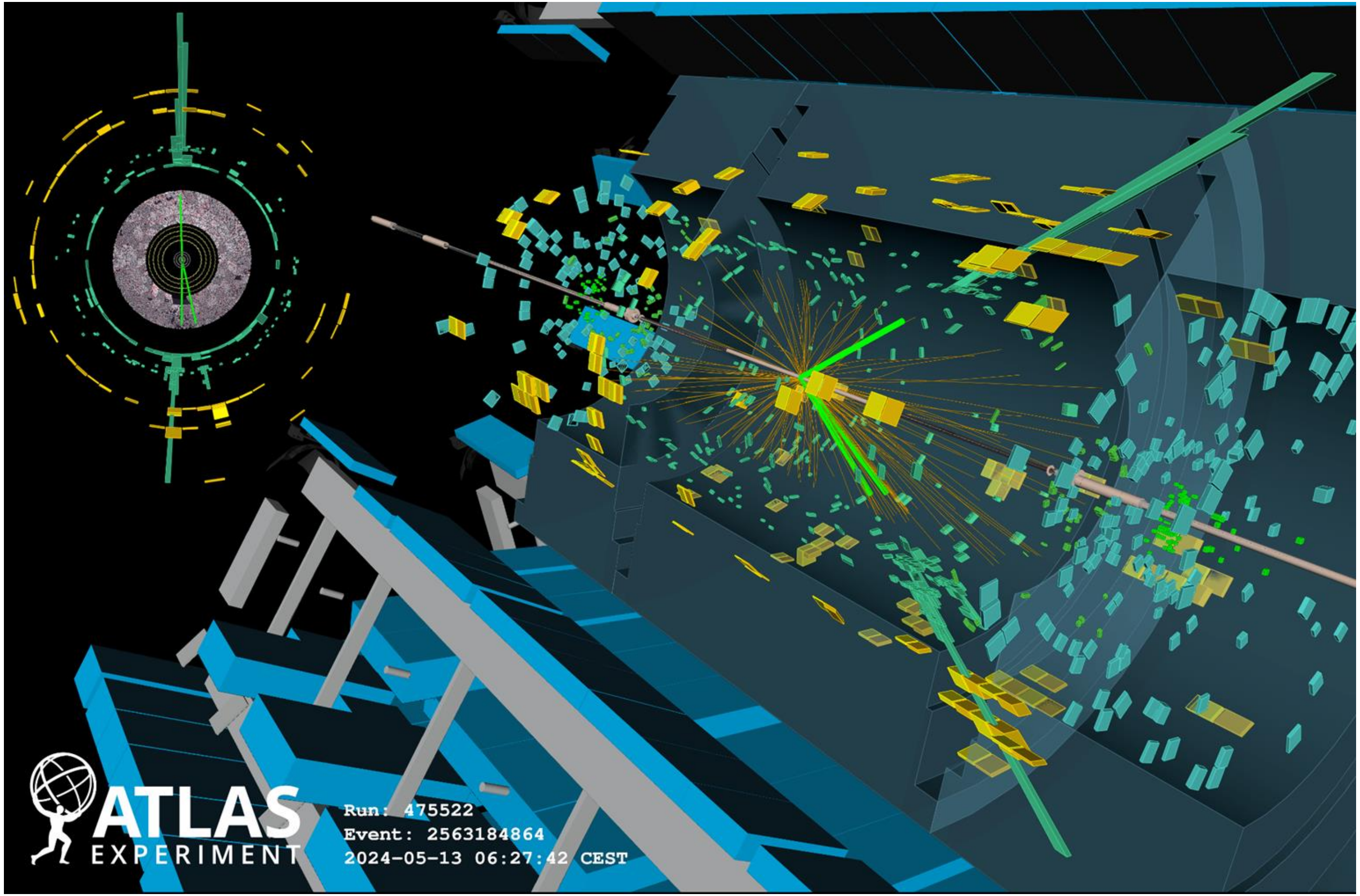








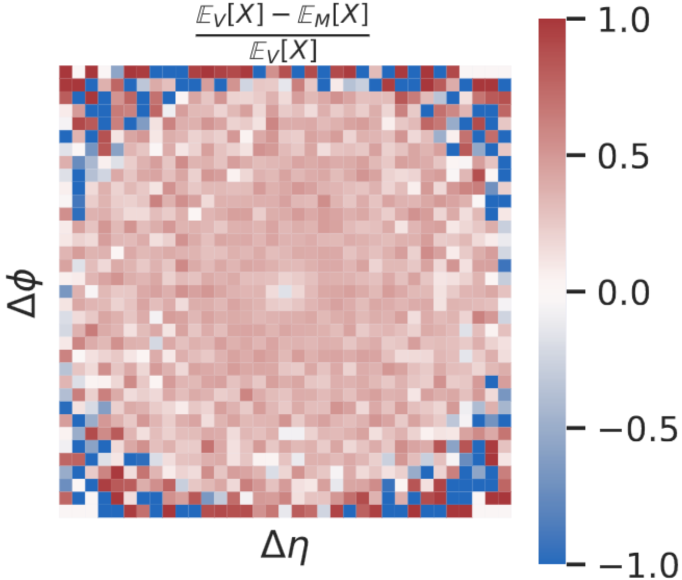
- Feixes de protões colidem **40 milhões** de vezes por segundo.
- **100,000,000** canais de electrónica para detectar e gravar os sinais da passagem das partículas produzidas na colisões.
- **10,000 TB** de dados por ano (por experiência)

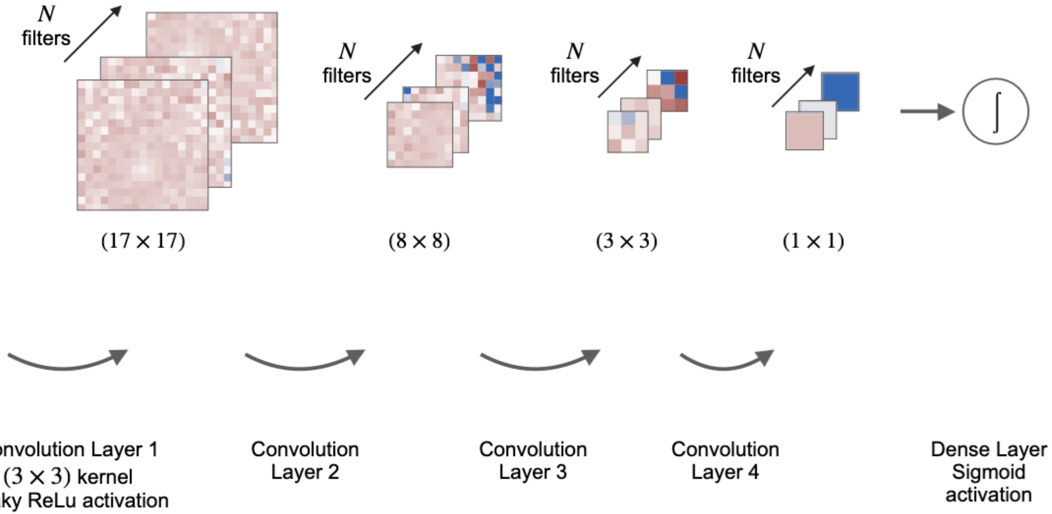

ATLAS
EXPERIMENT
Run: 475522
Event: 2563184864
2024-05-13 06:27:42 CEST

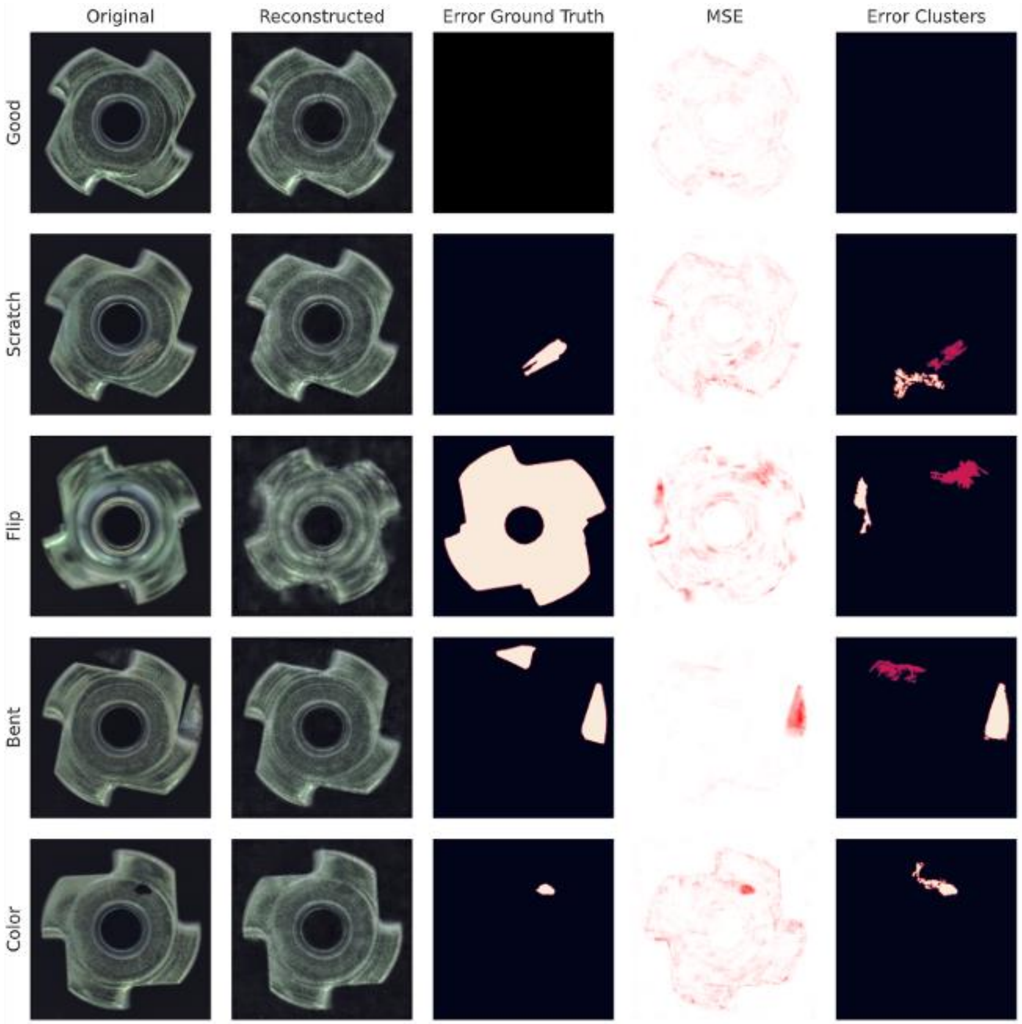
Classificação de imagens no LHC

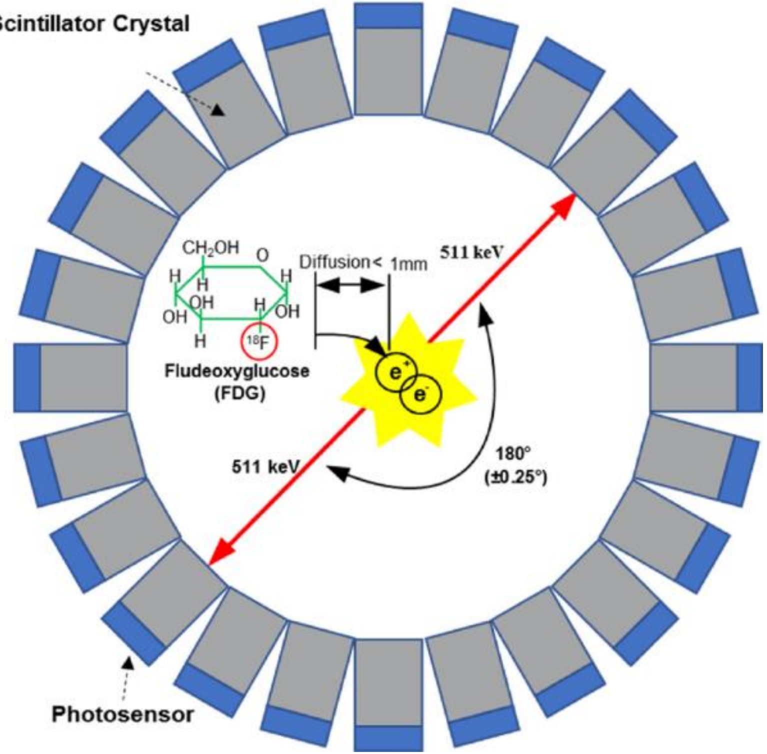
[Deep Learning for the classification of quenched jets](#)
Liliana Apolinário, Nuno F. Castro, M. Crispim Romão, José Guilherme Milhano, Rute Pedro, F.C. R. Peres
JHEP 11 (2021) 219

Classificação automática de imagens (com deep learning)






Original
Reconstructed
Error Ground Truth
MSE
Error Clusters
Good
Scratch
Flip
Bent
Color

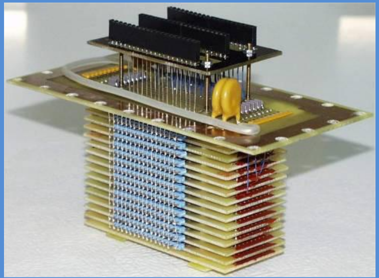


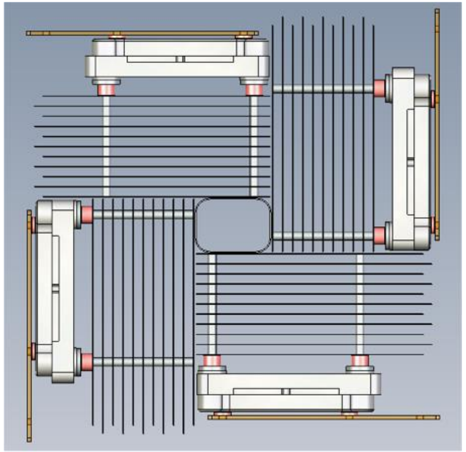
Positron Emission Tomography

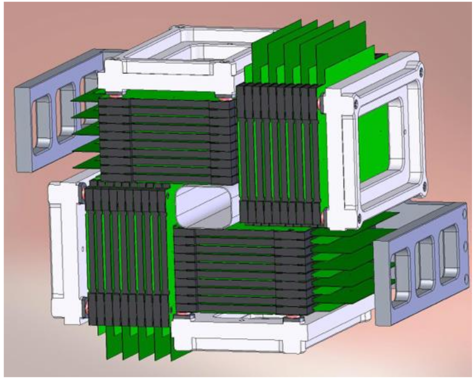
RPC based PET imaging

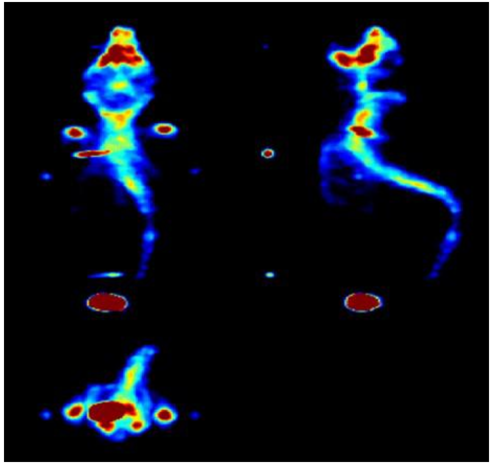
Small animal PET

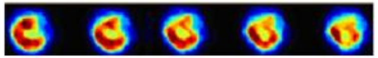
- Hundred of mice examined for biology research
- > three years of routine use
- **0.52 mm spatial resolution**
- **low cost**



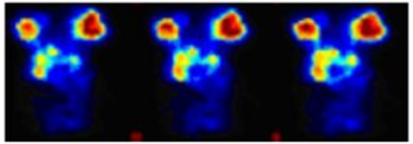




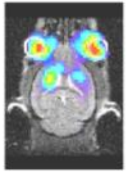




Live heart transaxial section with ^{18}FDG



Harderian glands and left striatum with ^{11}C-raclopride



Co-registration with MRI

Phys. Med. Biol.66(2021)065016 (https://doi.org/10.1088/1361-6560/abe558)

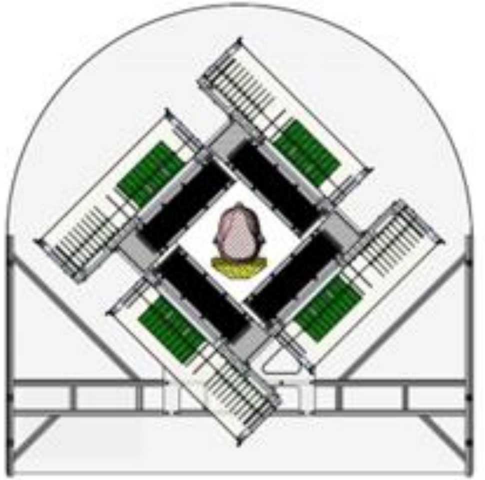
RPC based PET imaging

Human brain PET

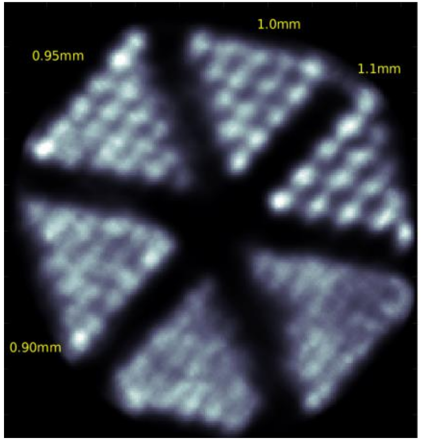
Diagnosis and investigation of diseases of the central nervous system by allowing to resolve small brain structures

Construction of a tomograph for Human brain imaging with the requirements:

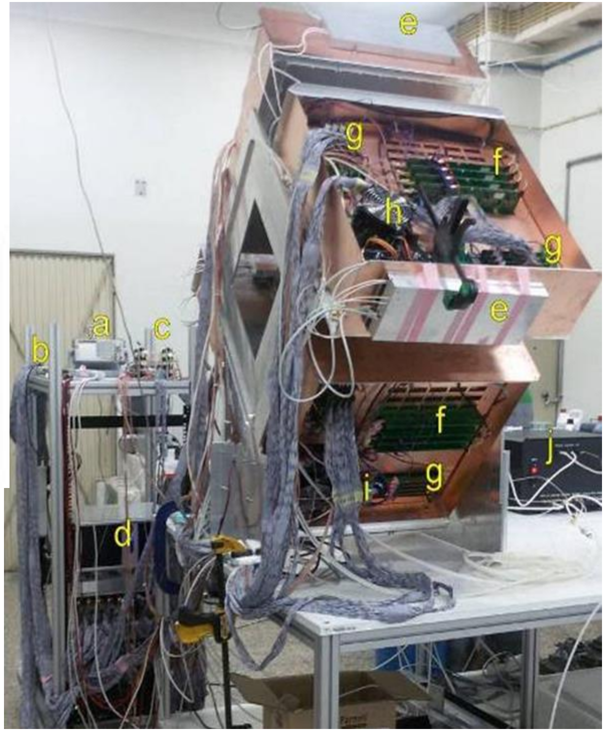
- Spatial precision < 1 mm
- Timing precision < 300 ps
- Solid angle coverage > 50%
- Sensitivity of the order of 0.1 %



Radial resolution < 1mm (above the state-of-the-art)



Data taken on the final scanner with a "Derenzo" or "hot-rod" phantom with ^{18}F.



Scintillators emit luminescence light when excited by nuclear radiation/high-energy particles

Can be organic (crystal, liquid, plastics), inorganic, gases

Technology used in many applications involving particle detection

- Nuclear medicine/imagiology (eg. PET/CT scanner,…)
- Homeland security
- Research in Nuclear/Particle Physics
  (eg. LHC/CERN experiments: ~10 tons of plastic scintillators)

New Scintillators and fibres

LIP R&D on new plastic scintillators

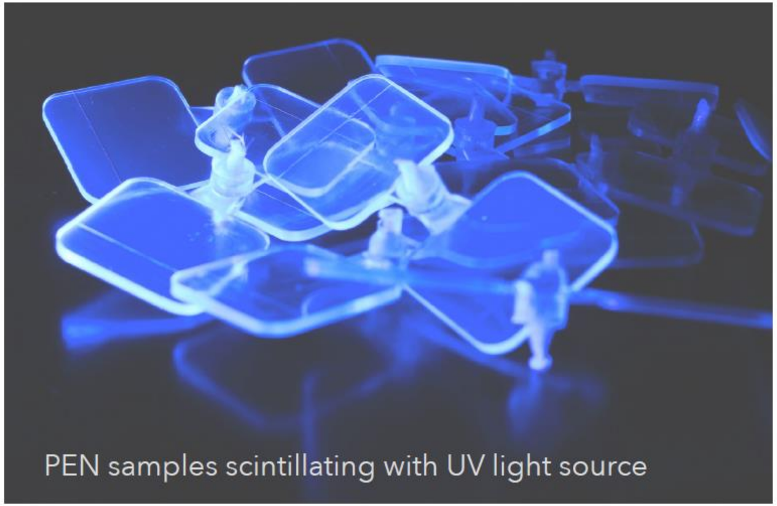
Exploratory R&D on new plastic scintillator materials

- Collaboration between LIP and Institute for Polymers and Composites (IPC), University of Minho
- National funding by FCT: 50k€
- Set up a scalable manufacturing technique
- Scintillator samples produced by injection moulding at IPC
- Optical and scintillator characterisation at LIP

Mid-term goals and landscape

- Production of scintillators for detector prototype in construction with CERN
- Collaboration with polymer and mould industry to demonstrate mass-scale production capability
- Formation of a new international scientific collaboration to pursuit ECFA R&D needs (including R&D on scintillators)

Production of 30x30x2mm^3 PEN and PET samples by injection moulding.



PEN samples scintillating with UV light source

Contact: rute@lip.pt

Application Example: microdosimetry

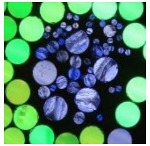
Development of tissue equivalent detectors using scintillating plastic optical fibres able to reach a cell level radiation field dose description.

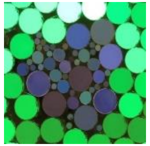
SPOF dosimeter : A large field detector with a resolution determined by the fibre cross section for radiometry and radiobiology experiments.

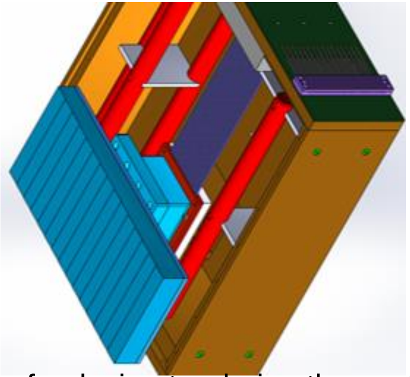
Microdosimeter : Optical characterization of micrometric scale fibres under development in a collaboration with C2TN.

Other applications : Radiation monitoring

Working with commercial fibres

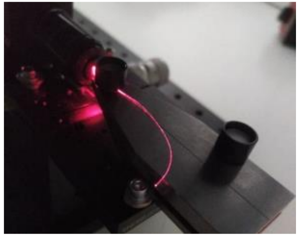


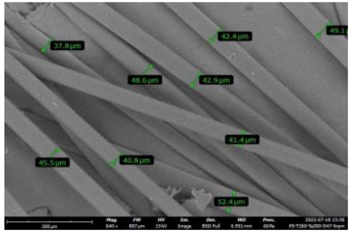




Development of a dosimeter during the past few years now being tested

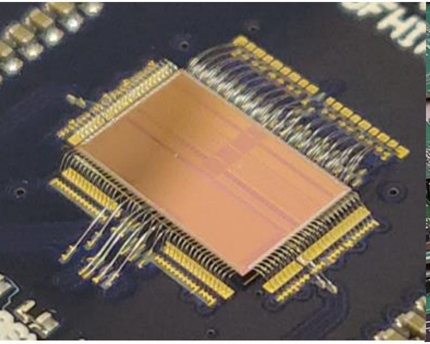
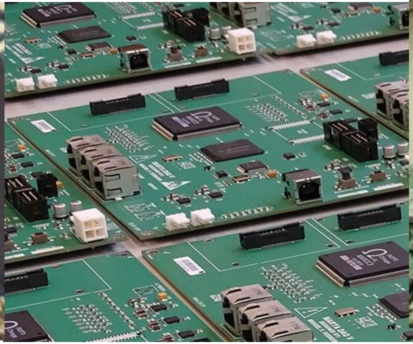
Developing micrometric fibres with C2TN

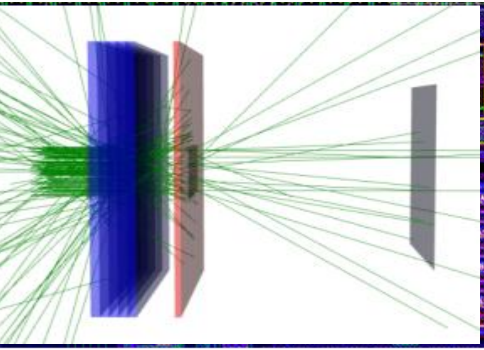
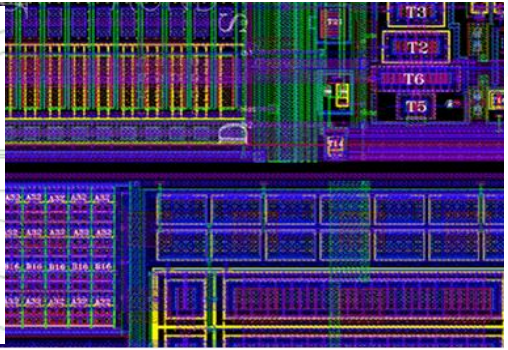




Starting development of crystal based detectors Al2O3 able to reach a nanometric dosimetry scale

contact: João Gentil (gentil@lip.pt)

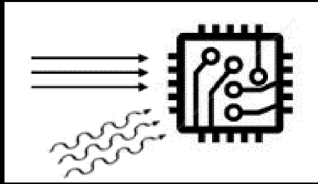





Electronics and computing

Development of large-scale computing infrastructures

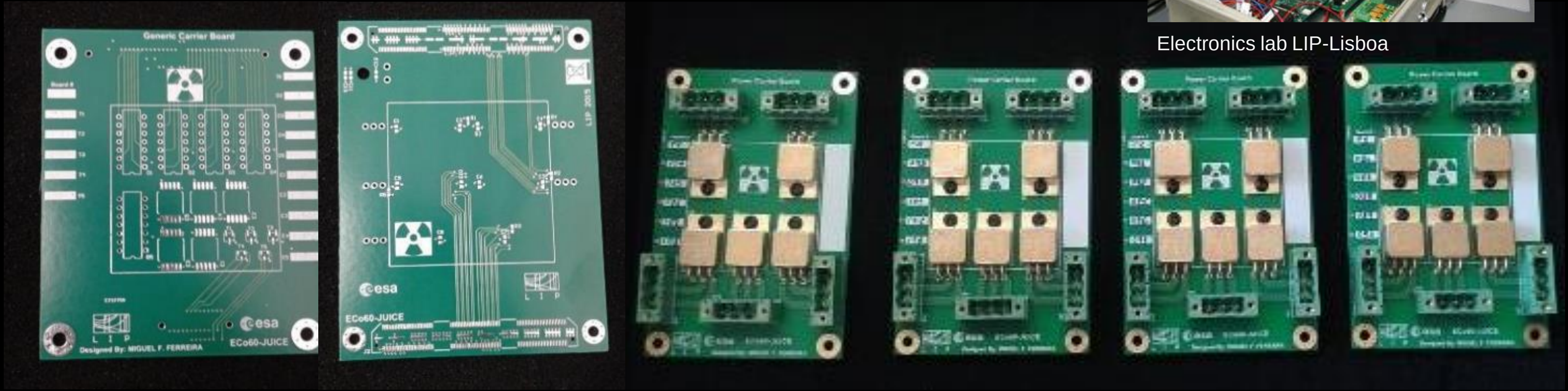
Data acquisition electronics

Test, Characterization and Radiation Hardness Assurance of EEE components

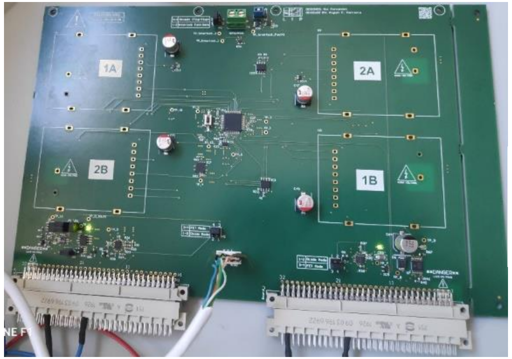


- Electronics
- Instrumentation
- Beam-lines

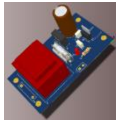
Electronics lab LIP-Lisboa



ESA AO 3-13975/13/NL/PA - ECO-60: Verification of Co-60 testing representativeness for EEE components flown in the Jupiter electron environment



Electronics for ATLAS
Electronics for High Voltage systems

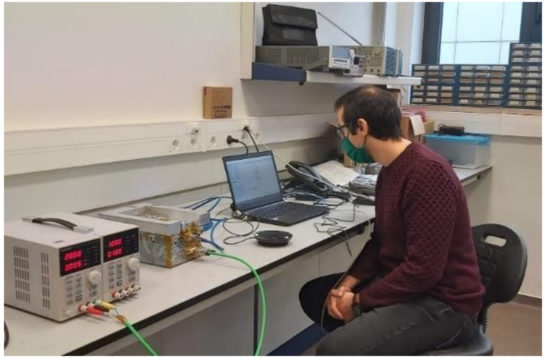


Electronics for The Pierre Auger Observatory
Autonomous, low power station.
Solutions for RPC detectors operating in Argentina pampa
Slow control and integrated DAQ

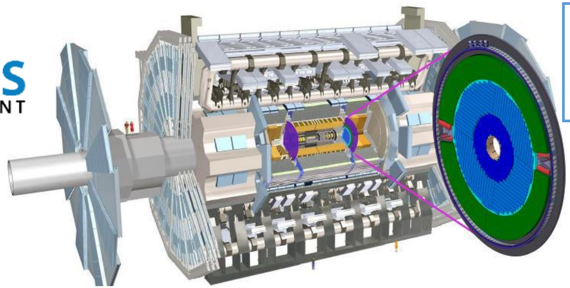
Qualification of components for European Space Agency

Semi-automatic testing system for radiation damage

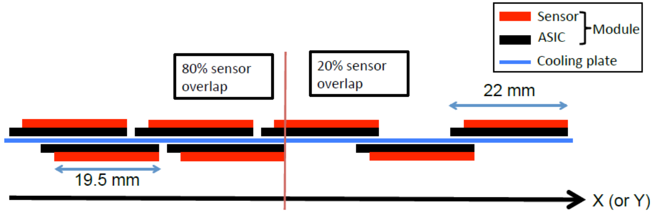
Support for radiation monitoring instruments



A High-Granularity Timing Detector (HGTD) in ATLAS

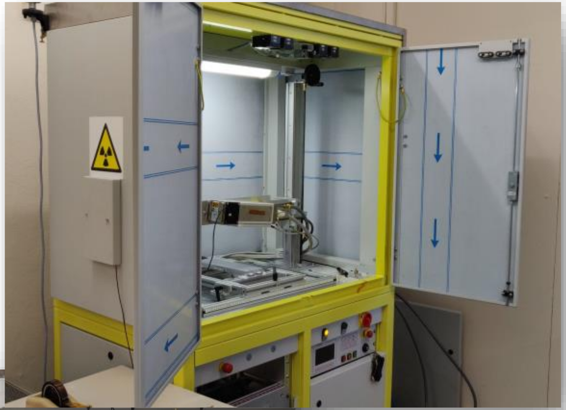


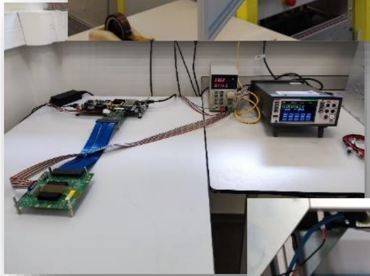
Charged Particle Detector
1.3 mm resolution
30 ps timing resolution

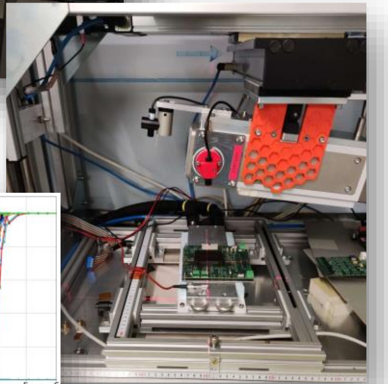


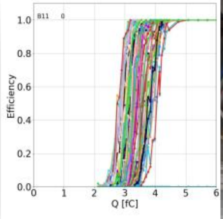
Sensor: LGAD – Low Gain Avalanche Diode
Coupled to ASIC (Appl. Spec. Integrated Circuit

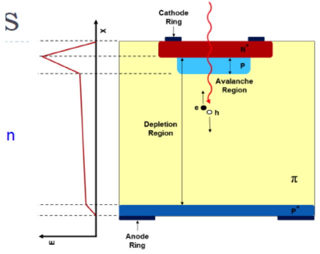
Performance degradation with radiation

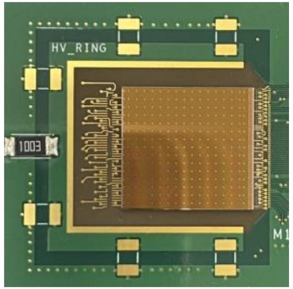












Technology transfer

Electronics degradation with Radiation

Application to particle beams (Medical)

Contact: Pedro Assis (pedro.assis@lip.pt)

Distributed Computing and digital Infrastructures

LIP Computing

R&D projects and infrastructures

EOSC-hub
IBERGRID
EOSC SYNERGY
EUDAT
deep Hybrid DataCloud
egi
EUROPEAN OPEN SCIENCE CLOUD
WLCG Worldwide LHC Computing Grid

Support

OPENCoastS
GBIF biodiversity data portal
LHC data processing
Cosmic rays
Genome data elixir PORTUGAL
Neutrino physics
Computational chemistry
Climate EC-EARTH
...

Knowledge Capabilities

INCD Infraestrutura Nacional de Computação Distribuída

Shared computing and data services for the academic and research communities

LIP | FCT-FCCN | LNEC

PORTUGUESE ROADMAP OF RESEARCH INFRASTRUCTURES – 2020 Update

Software management coordination

Piloting data repositories

HPC and virtualization for machine learning

Cloud for research

IBERGRID coordination

EUDAT national node

European Grid Initiative
pan-European middleware coordination

WLCG –
Worldwide LHC Computing Grid national node

contact: Jorge gomes (jorge@lip.pt)

Transferencia de tecnologia com aplicação a diversos domínios

Exemplos:

- **Eletrónica rápida**
- **Novos materiais**
- **Novos instrumentos** para:
  - à saúde: ex: diagnóstico do cancro (PET) e terapia (aceleradores)
  - à segurança: ex: tomografia de contentores
  - a exploração especial: efeitos da radiação em componentes eletrónicos
- **Algoritmos, deep learning e computação avançada para**:
  - Controlo de qualidade em produção industrial
  - Observação da terra: Ordenamento do territorio, mar
    - ex: alterações da costa, florestas, culturas agícolas

Tecnologias da Física de Partículas

A física de partículas e dos aceleradores é conhecida pelas grandes experiencias de física realizadas em laboratórios de física mundialmente famosos como CERN ou Fermilab.
Nesses institutos, aceleradores de partícula são usados para fazer colidir partículas, permitindo reconstruir, as condições no início do nosso Universo.

Para além de todo o conhecimento fundamental da natureza, a I&D em Física de Altas Energias tem o potencial de contribuir para a sociedade com importantes spin-offs, aplicações e soluções multidisciplinares!