

Gas detector lab in view of present and future colliders

Outline

- Institutes and person-power
- Expertise
- Proposal
- Future perspectives
- Possible unfoldings
- Costs, timescale and funding sources

Institutions

- Rio de Janeiro State University
 - 5 faculties
 - + 1 post-docs
 - + 2 PhD Students
- Amazonas State University
 - 1 faculty



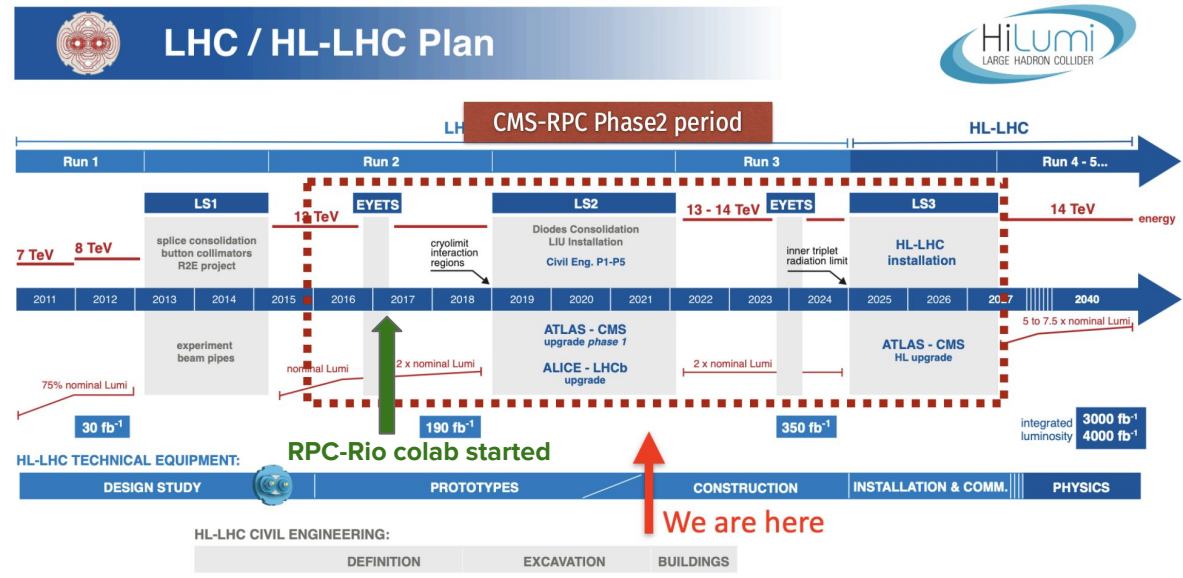
External collaborators:

- Gabriella Pugliesi (Bari)
- Salvatore Buontempo (Naples)
- Roumyana Mileva (Bulgaria)
- Mehar Ali Shah (Pakistan)
- Andres Cabrera (Colombia)
- Michael Tytgat (Ghent)
- Davide Piccolo (Frascati)



Actively collaborating to the
LHC-CMS-RPC Project, since 2017.

LHC-CMS-RPC



RPC-Rio @ LHC-CMS-RPC project:

- Operation
- Certification
- Data Quality Monitoring
- R&D for Phase-2 upgrades
- Offline Software
- Online Software
- Data Acquisition System
- Longevity Studies
- Hardware Maintenance

Proposal

- Gas detector are a widely used technology due to its cost and versatility.
 - At LHC: ATLAS, CMS and ALICE.
 - Future colliders: ILC and FCC.
 - HEP community still have much interest in this kind of technology.
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- **Explore synergies between institutes and researchers to build gas detector labs.**
 - **Take profit of the already established expertise on R&D and operation of RPCs at LHC-CMS.**
 - **Install a gas system that allow R&D on different gas compositions and mixtures.**
 - **Install electronics and DAQ systems, compatible with LHC current standards, to take profit of the group experience.**
 - Other detectors (drift based and GEMS) could be explored.

Local gas detector lab

Local lab activities and its possible unfoldings:

- Characterization of RPCs with new eco-friendly gas mixtures
 - RPC performance with R134a alternatives
 - RPC performance with SF6 alternatives
- Construction of gas detectors (e.g. RPC) for future experiments.
- Development of local person-power and expertise for current and future activities.
- R&D and characterization of DAQ and electronics for future detectors.
 - Aligned with the group current activities on CMS DAQ (current and future system).

Other labs with similar context

Ghent (Belgium) - Assembly and validation for CMS Phase-2 Upgrade



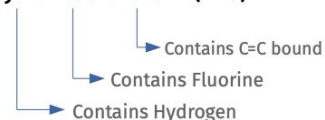
KODEL (Korea) - Construction and validation for CMS Phase-2 Upgrade



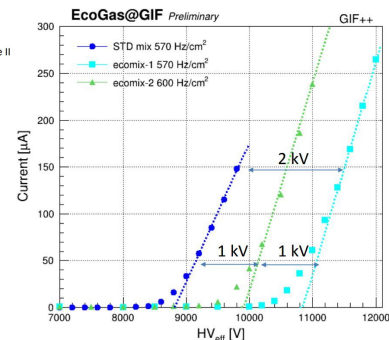
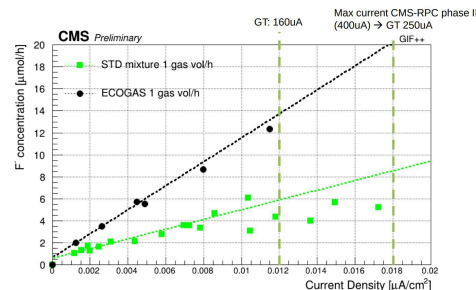
Eco Gas Studies

- **Collaboration (since 2019) with different groups and institutes: CMS-RPC, ATLAS-RPC, EP-DT, ALICE-MTR, LHCb, SHiP.**
- CERN is pushing the LHC experiments to replace the $C_2H_2F_4$, as it has a high global warm potential (GWP) ~ 1430 , with gases with lower GWP.
- Goal of the collaboration: Characterization of HFO-Based gas mixtures with LHC-like background.
- Detectors with different technologies and shared parts: CMS-RPC WebDCS, CMS Mechanics Trolley, EP-DT Gas System, EP-DT Monitoring tools.

Hydro-Fluoro-Olefin (HFO)



RPC	Gap type
CMS-GT	2 mm, double gap
CMS-K	1.4 mm, double gap
ALICE	2 mm, single gap
EP-DT	2 mm, single gap



Results

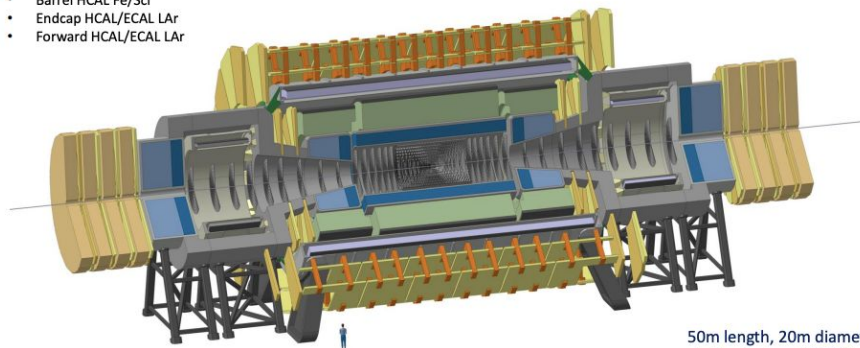
- HFO-based gas mixture chosen to be tested: HFO 35 %, CO_2 60 %, iC_4H_{10} 4 %, SF_6 1 %.
- No clear sign of aging so far.
- Detector working point found 1 kV higher than the standard gas mixture.
- Stable ohmic current, while some increase and/or fluctuation (under study) is visible at working voltage.
- Ongoing studies: (F^- production, rate scan studies, long term monitoring).
- Test beam 2021: First beam test on the setup to be done this year \rightarrow Study of rate, cluster size, efficiency.



Future detectors (colliders)

FCC-hh Reference Detector

- 4T, 10m solenoid, unshielded
- Forward solenoids, unshielded
- Silicon tracker
- Barrel ECAL LAr
- Barrel HCAL Fe/Sci
- Endcap HCAL/ECAL LAr
- Forward HCAL/ECAL LAr

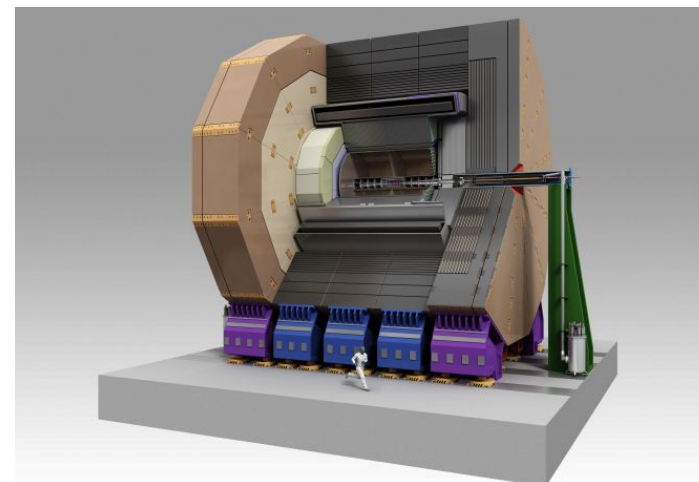


50m length, 20m diameter
similar to size of ATLAS

Muon system reference: Drift Tubes + RPC

<https://doi.org/10.1140/epjst/e2019-900087-0>

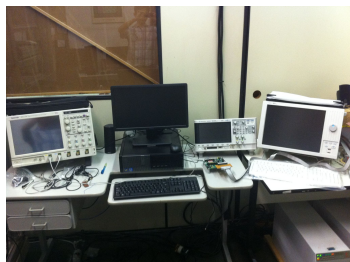
ILC reference detector: ILD and SiD



Hadronic Calorimeter reference: RPC based

<https://arxiv.org/abs/1306.6329>

Present Infrastructure - Starting point



Laboratório de Física Nuclear e Altas Energias (LFNP) @ UERJ

100 m²

Eletrônica modular padrão VME, NIM e CAMAC:

2 Crates NIM;

1 Crate CAMAC;

1 Crate VME;

1 Crate misto VME-NIM;

Módulos de amplificação de sinais multicanais (NIM);

Módulos discriminadores (NIM, CAMAC);

Unidades lógicas (NIM, CAMAC)

Módulos temporizadores duplos e quádruplos (NIM, CAMAC);

Digitalizadores de carga QDC (CAMAC, VME);

Digitalizadores de tempo TDC (CAMAC, VME);

Contadores (NIM, CAMAC, VME)

Conversores de padrão digital (NIM, VME);

Fontes de alta tensão (NIM, Mainframe CAEN).

Osciloscópio Agilent 650 MHz de banda.

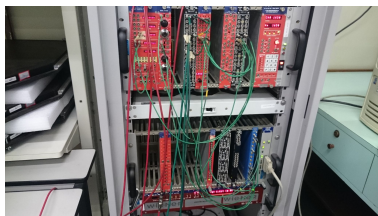
Osciloscópio Tektronix 1 GHz de banda.

Geradores de sinais arbitrários Agilent e Tektronix. -

Analisador lógico Agilent.

Analisador lógico Keysight com gerador de padrão. -

Gerador de pulsos óticos BNC (400 nm).



Detectores:

- 12 Detectores cintiladores de 40 x 40 cm².
- 2 Detectores cintiladores de 10 x 10 cm².
- 3 Detectores a gás streamer 50 x 8 cm².

Recent detector expertises:

- CASTOR Calorimeter @ CMS
- CMS-Hadronic calorimeter - Front-end upgrade
- CMS-TOTEM Precision Proton Spectrometer (PPS)

Cost estimates and founding

- **Tickets and Travel expenses:** integration between sites and other facilities.
- **Services and Licenses:** Customs, software, construction, mechanicals parts, chemicals (grafite deposition), ...
- **Gas system:** bottles, mixers, humidifiers, control system, connections, assembly.
- **Infrastructure:** renovation, A/C, computing and network.
- **Electronics + DAQ:** Data acquisition system (compatible with LHC standards, e.g. ATCA), HV power system, LV power system, oscilloscope, digitizer, TDC, programmable boards, conectores, interfaces de comunicação, etc.

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Cost estimates per site:

- **Tickets + travel:** 40k Reais
- **Services and Licenses:** 80k Reais
- **Gas system:** 178k Reais
- **Infrastructure:** 192.5k Reais
- **Electronics + DAQ:** 340k Reais

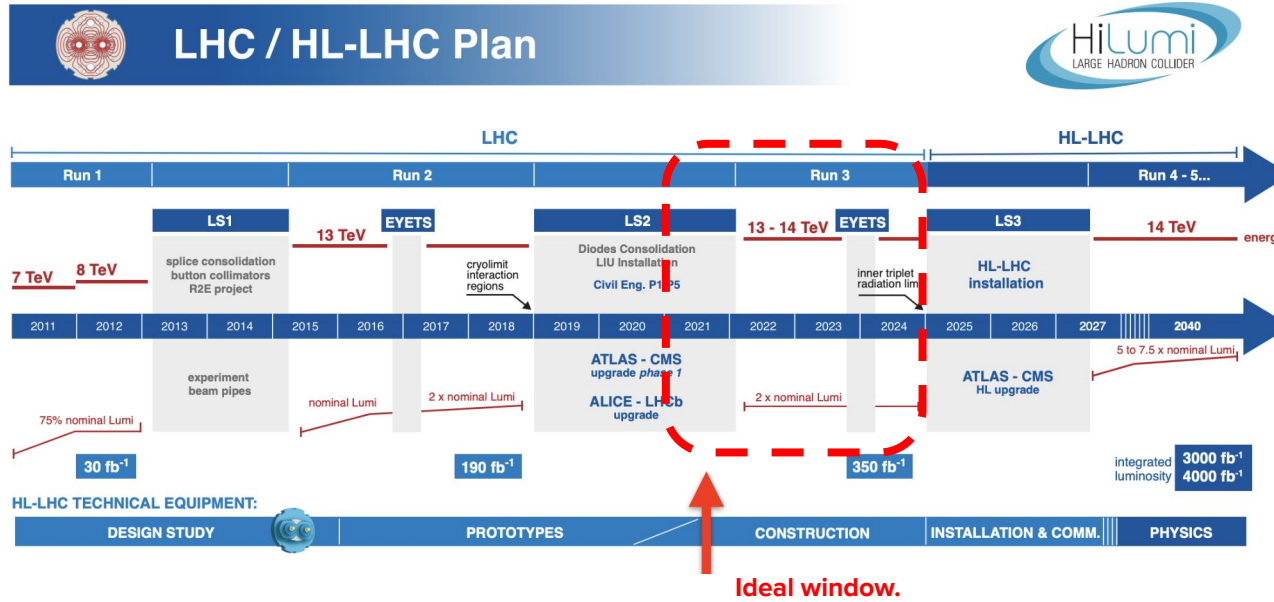
Total: R\$ 830.000,00

Detailed tables are available.

Possible sources of founding:

- **FAPEAM, FAPERJ, CNPq/CAPES, "Lei de Informática" (Amazonas, only).**

Timescale



Summary

- **Collaboration between institutes on gas detectors**
- **Explore the expertise within the institutes on the RPC technology**
- **Build know-how in view of future experiments**
- **Explore different designs, gas mixtures and application on gas detectors**
- **Cost estimates and timescale are presented.**

Obrigado