The Study of the Quark-Gluon Plasma with the ALICE-LHC Experiment

White Paper proposed for the LASF4RI by the groups from

USP-UNICAMP-UFABC-UFRGS

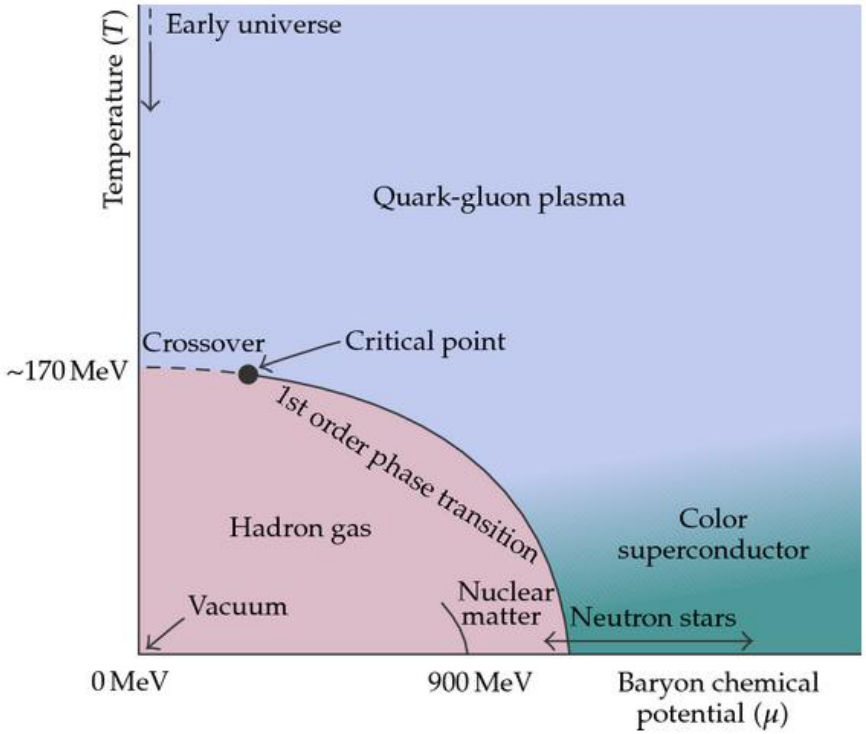
Strong Interactions

Instrumentation and Computing

Scientific Context – The Quark-Gluon Plasma

- *A locally thermally equilibrated state of matter in which quarks and gluons are deconfined from hadrons, so that color degrees of freedom become manifest over nuclear, rather than merely nucleonic, volumes.*
  - (STAR Collaboration's Critical Assessment of the Evidence from RHIC Collisions - 2005)

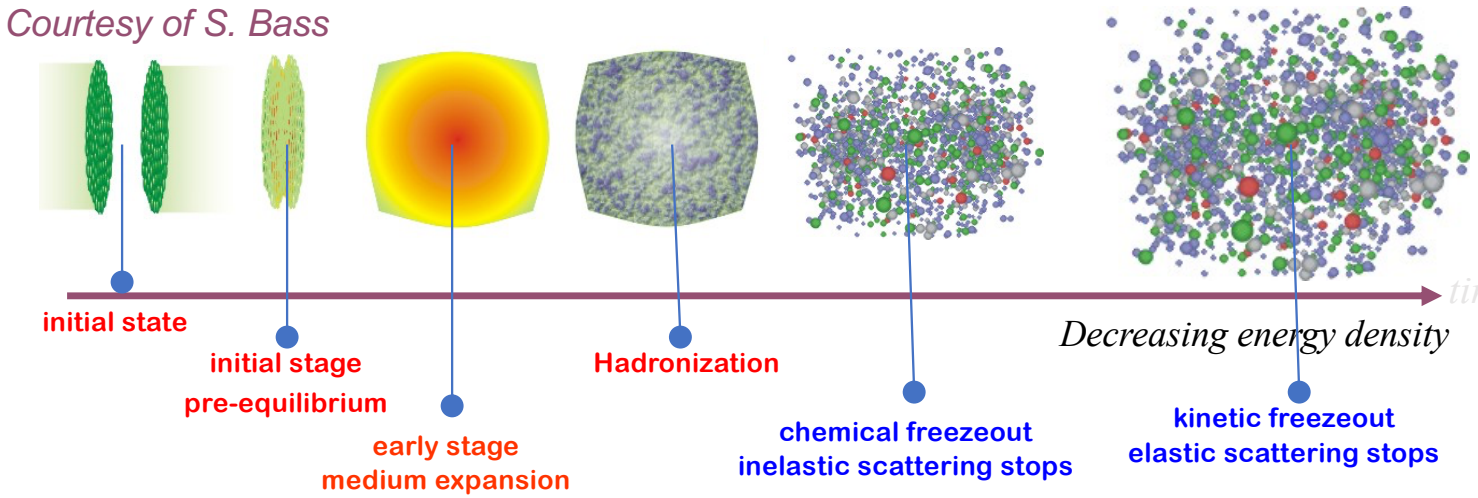
- *It is the simplest form of complex matter that we know of, ..., most directly connected to the fundamental laws that govern all matter in the universe.*
  - W. Busza, K. Rajagopal and W. van der Schee, Ann. Rev. Nucl. Part. Sci. 2018. 68:1–49

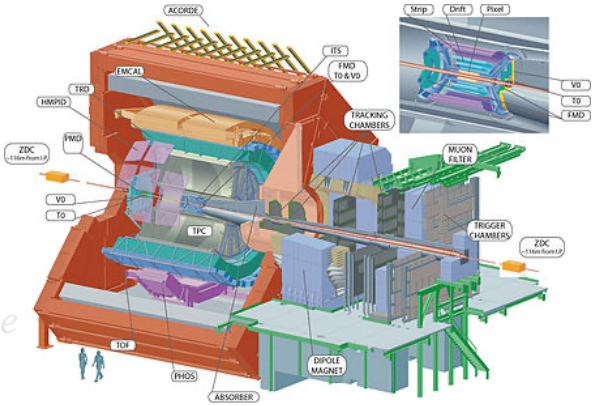


Adv.High Energy Phys (2011) 259025

Scientific Context

- Relativistic Heavy Ion Collisions and the ALICE-LHC experiment
- Extract **the properties of the QGP** from the understanding of the dynamics of these collisions
  - Strangeness → Bulk properties
  - Hard probes (jets and heavy quarks) → QGP tomography



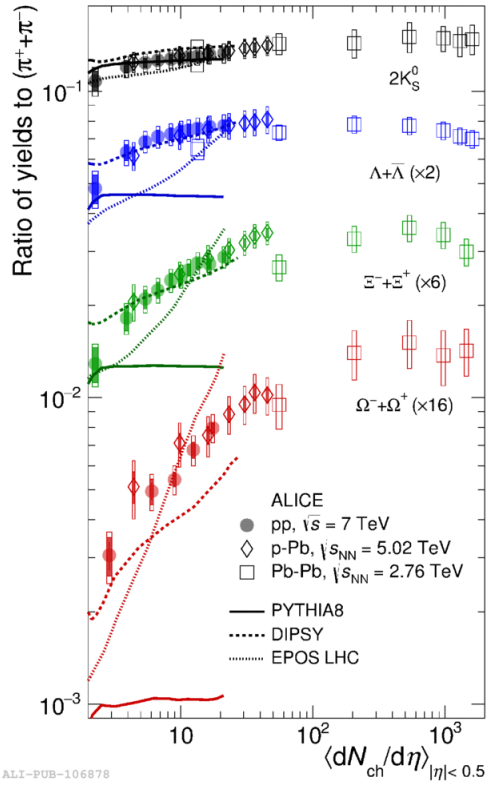


Objectives

- Contribute to the study of the Quark-Gluon Plasma through a relevant participation in the ALICE-LHC experiment
  - Physics analysis
  - Development of state-of-the-art instrumentation

- Training of future generation of scientists

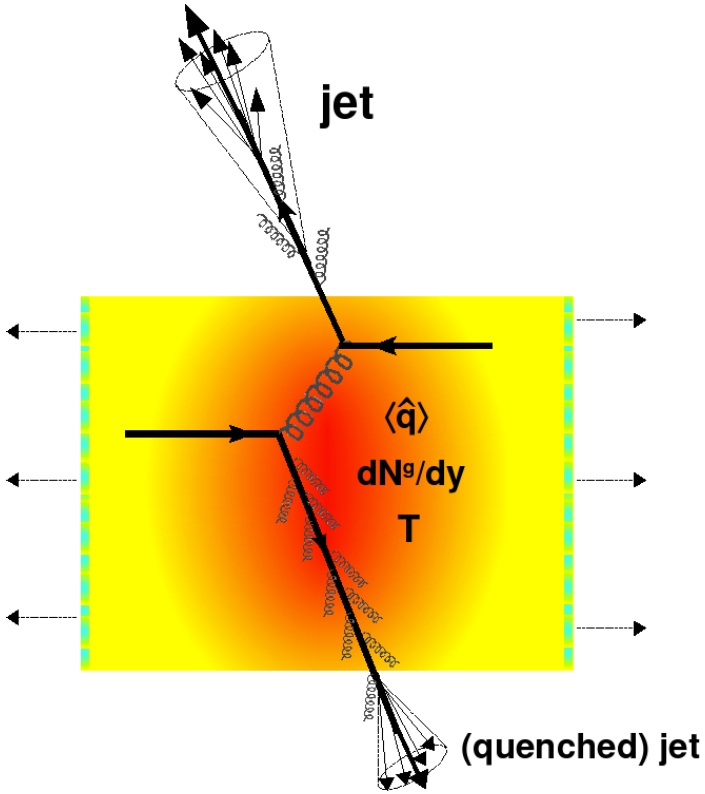
Methodology – Bulk Properties



ALICE, Nature Phys. 13, (2017) 535

- Strangeness Enhancement is one of the originally proposed signatures of the QGP
  - $m_s \sim T_c$
- Recently, it was observed in pp data, where no QGP expected.
  - Models fail to describe observed enhancement
- Analyze the production of strange hadrons, K_0, Λ, Ξ and Ω, with **higher statistics** for collisions of Pb-Pb, p-Pb and pp

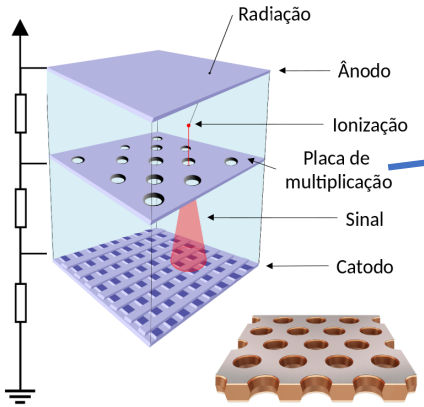
Methodology – Hard Probes

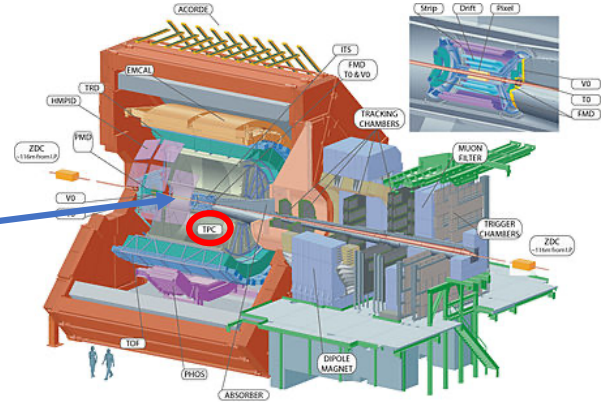


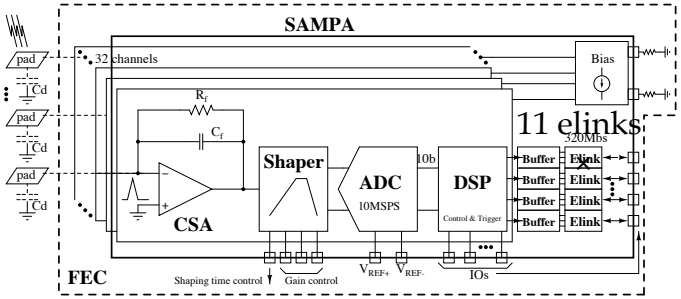
- Hard scattering of partons during the collision
- Excellent probe of the medium properties due to energy loss
  - The strategy is to look for jet structure modifications (quenching)
- Study with **higher statistics** jets originated from heavy quarks, through open and quarkonia states in central and forward rapidities

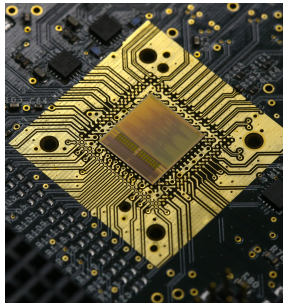
Current Status and Expected Challenges

- **ALICE Upgrade for LHC Run-3**
- Time Projection Chamber (TPC)
  - Need to operate the TPC at 50 kHz (a factor 100 increase)
  - New Readout
    - Gas Electron Multiplier (GEM)
  - New Electronics
    - Continuous readout
    - SAMPA chip



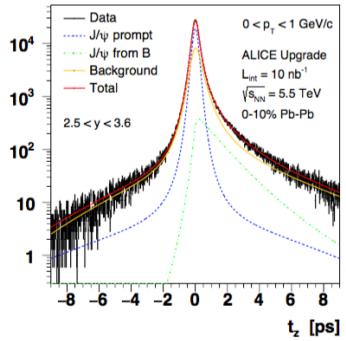


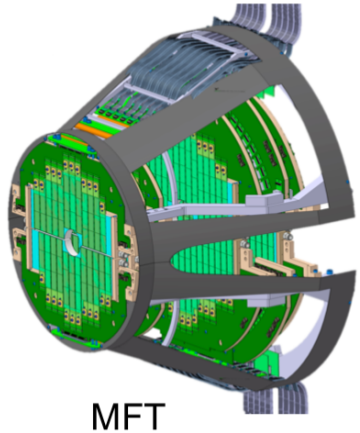




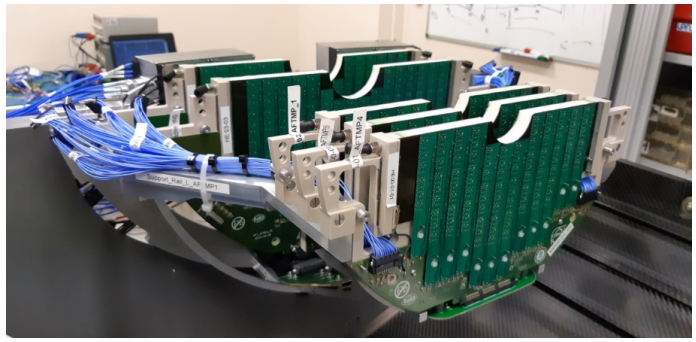
Current Status and Expected Challenges

- **ALICE Upgrade for LHC Run-3**
- Muon Forward Tracker (MFT)
  - New Silicon detector: 936 ALPIDE (ALICE Pixel Detector) sensors
  - Refine vertexing capabilities for the ALICE Muon Spectrometer
  - Improve measurements of charmonia at low p_T to define suppression/ recombination in deconfined medium



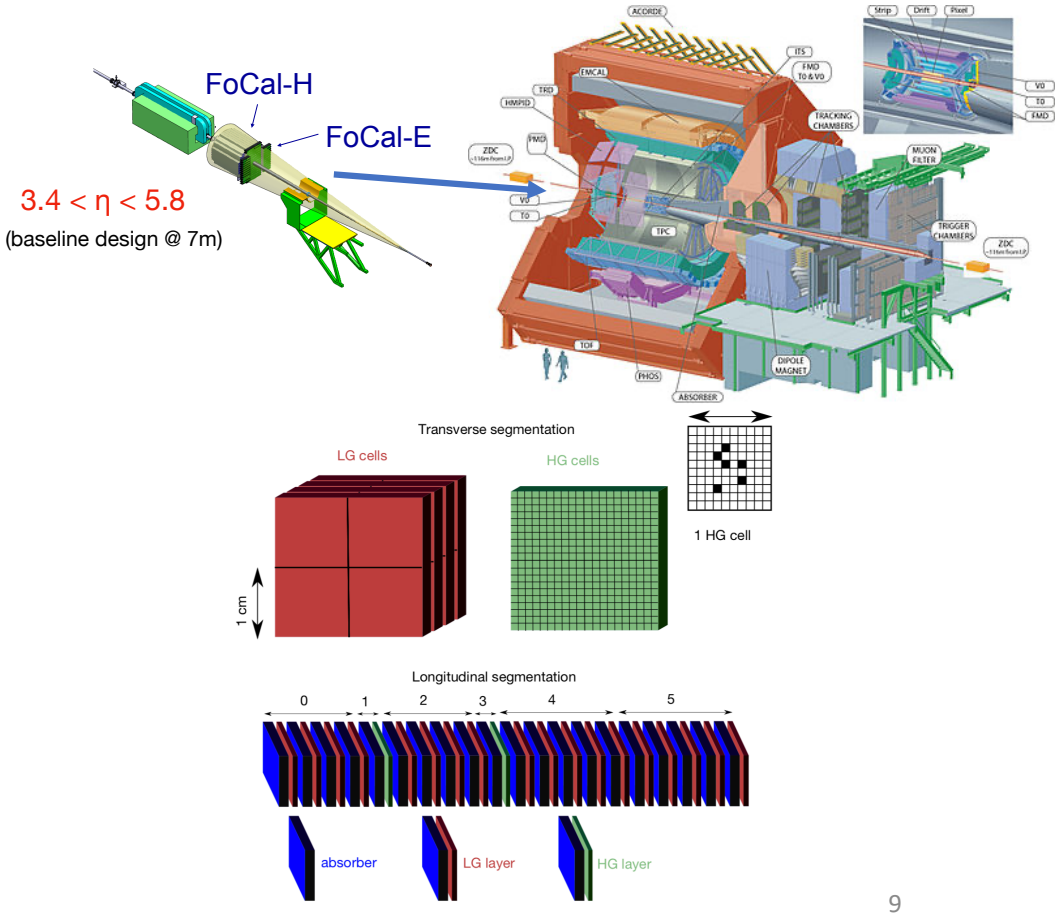


MFT

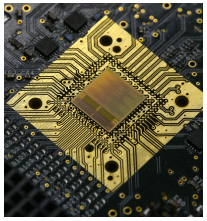


Current Status and Expected Challenges

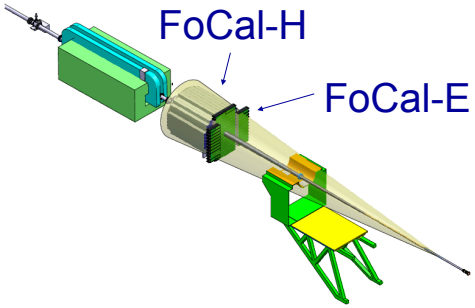
- **ALICE Upgrade for LHC Run-4**
- Forward Calorimeter (FoCaL)
  - Quantify nuclear modification of the gluon density at small-x
  - Explore jet quenching at forward rapidity
  - Electronics for LG Layers (Pad Si Detectors) in thee FoCal-E
  - First common project of all Brazilian groups in ALICE!

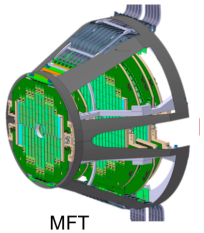


Timeline



Data Analysis





MFT

Construction and Operational Costs

- Maintenance and Operation Fees
  - M&O-A: in 2020 is 78,059 CHF for 10 Scientists
  - M&O-B: around 20,000 CHF per year

- Contribution for the ALICE TPC Aging Studies
  - Estimated budget for this part is of approximately 180,000 CHF, not including costs with human resources

- Contribution for FoCal LG Layers (Si Pad Detectors) Readout System
  - FoCal pad layers readout system is estimated in 500,000 CHF and the current proposal is to share such cost (around 50%) with the LPSC group

Computing requirements

- Fair share of Brazilian groups for the ALICE computing effort is ~2%
  - SAMPA cluster, hosted in the Universidade de São Paulo, has 2408 CPU cores (18.7 kHS06 of processing power) and 0.85 PB of storage

- Expected 20% grown per year of demanding computing power and storage until 2025

- **Very basic requirement for a relevant participation in this collaboration!**

Closing Remarks

- White paper brings all Brazilian groups working in the ALICE Collaboration together
- Explore several overlapping physics interests within the groups
- Common instrumentation project: the new Forward Calorimeter
- Opens the possibility for further collaboration among the groups in the future
- **New collaborations with other ALICE groups in Latin American are most welcome!**