

Instrumentation for flavour

Input for GDR-InF discussion

Introduction

- The purpose of this survey is to know which kind of instrumentation technology is developed in the French labs where intensity frontier experiments are conducted. This can help in identify potentiality and synergies in view of future projects.
- The focus is on the technologies used or planned to be used for experiments at the intensity frontier, but other competences of your lab that could be of interest should be described too.
- Please provide 3 slides maximum per labs, answering the questions listed in the template provided and adding any other information/example that you consider relevant for the discussion.
- Thanks a lot for your collaboration.

CEA/IRFU/DPhN-DEPIP

- Gaseous tracking detectors with [Micromegas](#)
 - Was: Compass
 - Is: CLAS12 (JLAB, 12 GeV electron beam on hadron targets), barrel detector around silicon tracker for slow recoiling protons or high-mass production
 - Will: Electron-Ion Collider, TPC read-out plane

your lab involved in ?

Yes, on all levels, EIC kind of CDR being prepared

CEA/IRFU/DPhN-DEPIP

- Silicon CMOS tracking detectors
 - Was: R&D (also application for particle physics and others)
 - Is: ALICE Muon-Flavour Tracker (silicon discs in front of muon absorber, ALPIDE chip)
 - Will: to be seen, stay at LHC for heavy-ions, at the moment LHCb considered most seriously

your lab involved in ?

Yes, no chip design, but most levels of overall system aspects/services and integration (tbc)

LPC Caen

- **Ultracold neutron detectors** (counters) and associated electronics
 - Was: detectors for nEDM, based on lithium scintillators
 - Is: R&D on gaseous scintillator detector to count ultracold neutrons
 - Will: build the neutron detectors for n2EDM

LPSC Grenoble

- **Ultracold neutron detectors** (position sensitive)
 - Was: R&D for position sensitive ultracold neutron detectors
 - Is: R&D for position sensitive ultracold neutron detectors
 - Will: not sure

- **Atomic magnetometry**
 - Was:
 - Is: R&D on mercury magnetometry
 - Will: Build the n2EDM comagnetometer

LAL Orsay

LHCb

Was : electronics (front end + control boards + L0) of ECAL/HCAL.
Simulation + Neutral reconstruction.

Is : electronics (front end + control boards) of ECAL/HCAL.
Reconstruction of calorimeter objects.

Will : Luminometer, calorimeter electronics pour Upgrade II + simulation

Belle II :

Was: cooling ARICH, Luminometre.

Is : Upgrade DAQ, HLT development

Will :

LPNHE PARIS

LHCb

Is : Back-end electronics for SciFi (programming firmware of the FPGA)

Reconstruction software for tracking with different architectures (CPU, GPU), integrated in completely software trigger

Will : Discussions ongoing for upgrade-II

Discussions ongoing for Codex-b, that could imply mechanics design and DAQ.

Some other competences of the lab :

- Circuit memoire associative for tracking (ATLAS FTK)
- ASICS en technologie CMOS (DAMIC, LSST)
- Capteurs silicium (ATLAS ITK, ILD, HGTD)
- CCD ultrasensibles (DAMIC)

IPHC Strasbourg

- Newly created IN2P3 platform on **CMOS pixel sensors**
 - [Was] 2-decade long experience
 - Sensors: RHIC/STAR-vertex, ALICE-Inner-Tracker-1&2, various smaller-size app.
 - Integration: Ultra-light prototype detector modules (PLUME) for ILC
 - Construction: modules for ALICE-Inner-Tracker-1&2
 - [Is] Sensors for CBM-vertex, ALICE-Inner-Tracker-3
 - [Will] Future e+e- colliders
 - On-going sensor R&D
 - Technology: 65 nm process, stitching for large area
 - Performance: sub-nanosecond timing, ΔE measurement, spatial resolution $\lesssim 3\mu\text{m}$
- Contributions to the Intensity Frontier with
 - [Was] Plume modules for background characterisation during Belle II phase 2 (2018)
 - [Is/Will] Sensors for possible Belle II vertex detector upgrade

LPC Clermont

LHCb

Was : readout of preshower (PS) detector (optical fibers, MaPMT, electronics, ASIC, cooling system) and trigger electronics for PS/SPD and Level-0 Decision Unit. Monitoring, calibration, simulation, reconstruction of calorimeter objects.

Is : electronics (front end, ASIC) of Scintillating fiber detectors (SciFi) and its cooling system (thermal exchange studies). Installation and commissioning of SciFi.

Will : discussions on upgrade II on-going

LAPP Annecy

LHCb

Was: electronics

- Trigger validation board for the calorimeters (full design + firmware for FPGA).
- Firmware for the calorimeter back-end board (Tell1)).
- Operation, Monitoring, calibration, simulation, reconstruction of calorimeter objects.

Reconstruction of calorimeter objects.

Is: electronics

- Coordination of the back-end board (PCIe40) firmwares for the LHCb collaboration: firmware-architecture design and development of the common parts of the firmwares for the back-end board for all sub-detectors. Development environment under Gitlab and continuous integration tools, scripts development, technical assistance, documentation.
- Calorimeter-specific firmware for the back-end board.

Reconstruction of calorimeter objects.

Will : discussions on upgrade II on-going

CPPM - Trigger & DAQ

Fast and high throughput **DAQ** (*High-speed links, macro FPGA*)

LHCb:

- Past: L0-muon trigger for LHCb, search for high-pT muons @ 40 MHz
- Present: PCIe40, DAQ boards for LHCb (+Alice, Belle II, mu2e, ...)
 - read-out full detector @ 40 MHz, output bandwidth 40 Tbits/s,
 - 100 Gbits/s per board to CPU through PCIe
- Future: DAQ for LHCb upgrade II ?
 - output bandwidth 400 Tbits/s
 - intermediate step with 400 Gbits/s to CPU for 2024 (PCIe40++) ?

Also in preparation: DAQ for ATLAS-LAr upgrade phase 2 (LASP board)

CPPM - Pixels

Long history of CPPM with [pixel detectors](#) (DELPHI, ATLAS) - know-how in detector assembly and chips R&D (*micro-electronics, mechanics*)

LHCb:

- Current: Cooling for pixel-detector with micro-channels
 - small R&D to investigate the potentiality of such developments at CPPM
 - encouraging prospects but still a lot to learn
 - synergy with other labs in Marseille and experiments at CPPM + other IN2P3 labs ?
- Future:
 - Micro-channel for LHCb-VELO U2 ???

Belle II:

- present/future: CMOS developpement for replacement of vertex detector (one contribution to the prospective IN2P3 with IPHC)