IPHC Institut Pluridisciplinaire Hubert CURIEN STRASBOURG

UNIVERSITÉ DE STRASBOURG

Belle II

PICSEL GROUP

PHYSICS WITH INTEGRATED CMOS SENSORS AND ELECTRON MACHINES

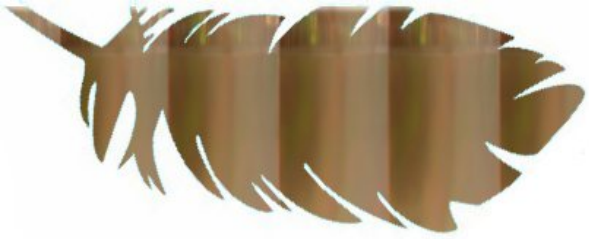
The PLUME project and interest for BEAST II

Jerome Baudot (baudot@in2p3.fr)

for the PICSEL group and the PLUME collaboration

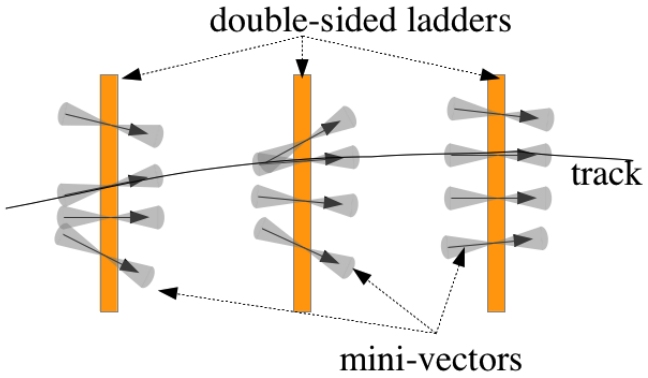
IPHC-Belle II meeting,
2013 October 24

- Motivations for double-sided layers
- PLUME current achievements
- PLUME prospect
- Potential for BEAST II

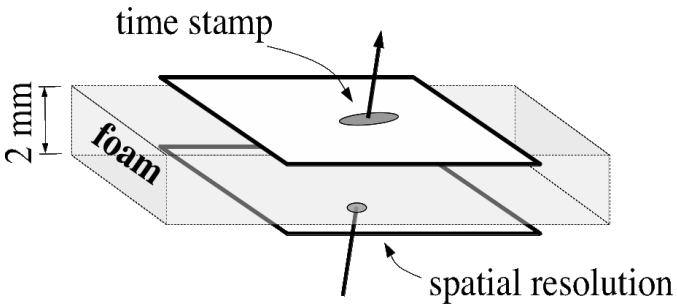


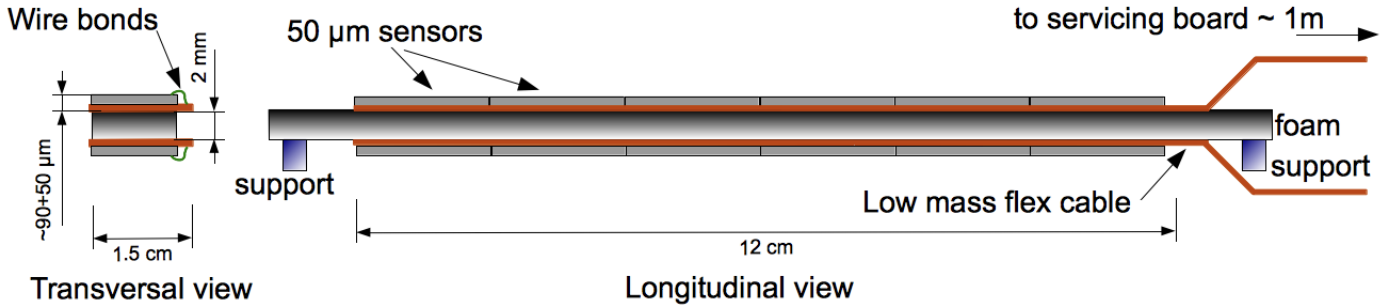
Why going double-sided?

- **Tracking / Alignment**
  - Measurement redundancy
  - Improvement (1/√2) of σ(point)
  - Shallow angle pointing
    - additional constraint for track finder
    - Beneficial when high background
      - Originally proposed for ILC by GLD concept



- **Overcoming technical limits**
  - Opposing constraints σ(time) vs σ(spatial)
    - Technology limits ➡ compromise
  - Split time/spatial constraints on different sides
    - Requires very thin sensors CMOS Pixel Sensors





The PLUME collaboration

Pixelated Ladder using Ultra-light Material Embedding

University of BRISTOL

J.Goldstein (joel.goldstein@bristol.ac.uk)

- Mechanical design
  stiffener, supports
- Stability measurements
- Modules mounting on ladders

DESY

I.Gregor (ingrid.gregor@desy.de)

- Simulations (FEA)
- Ladder mock-up & thermal measurement
- Power pulsing tests

IPHC
Institut Pluridisciplinaire Hubert CURIEN STRASBOURG

J.Baudot (baudot@in2p3.fr)

- Low-mass cable design & test
- Sensors mounting on modules
- Electrical tests
- Readout & DAQ
- Cooling system
- Test beam infrastructure & analysis

Synergy with

- IKF – Frankfurt
  MicroVertex – CBM
- LBNL – Berkeley
  PXL - STAR

PLUME-1 (2010/2012)

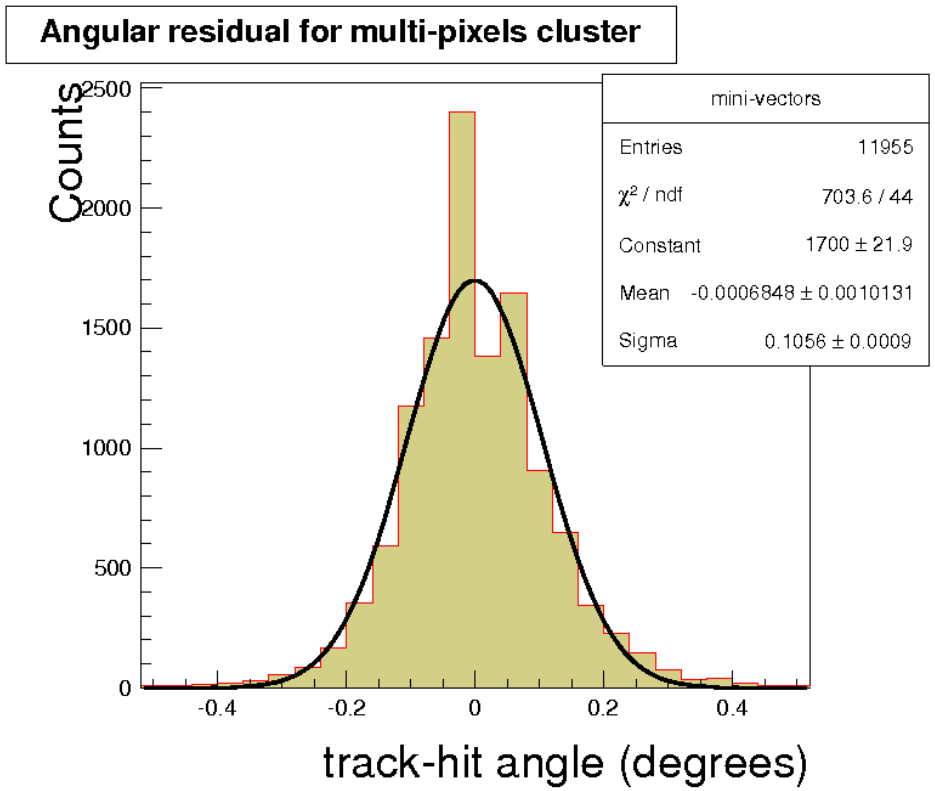
- **Goals**
  - Focus on electrical functionality with 6 sensors
  - Address the assembly & characterization chains

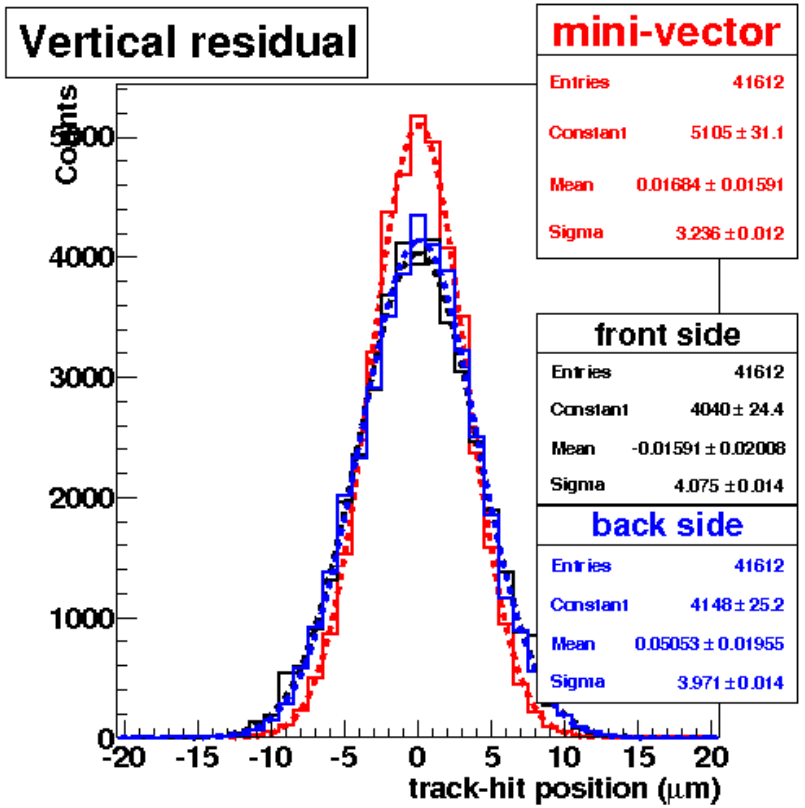
- **Ladder key features**
  - 2x6 MIMOSA 26, pitch 18.4 μm, thinned down to 50 μm
  - 2x low mass cables, 140 μm thick including 2x20 μm copper
  - 1x spacer, SiC foam at 8% density
  - ➡ 8M pixels with 115 μs readout-time, 10 g, 0.6 % X_0
    hit rate > 10^6 $cm^{-2}s^{-1}$
  - Air cooled at ≈3 m/s

- **Characterizations**
  - 2 functional ladders produced in 2011
  - Thermal measurements: Tmax on pixel ~50°C
  - Mechanical planarity: within 20 μm
  - Vibration estimation:
  - Beam test: see next slide

PLUME-1 beam test

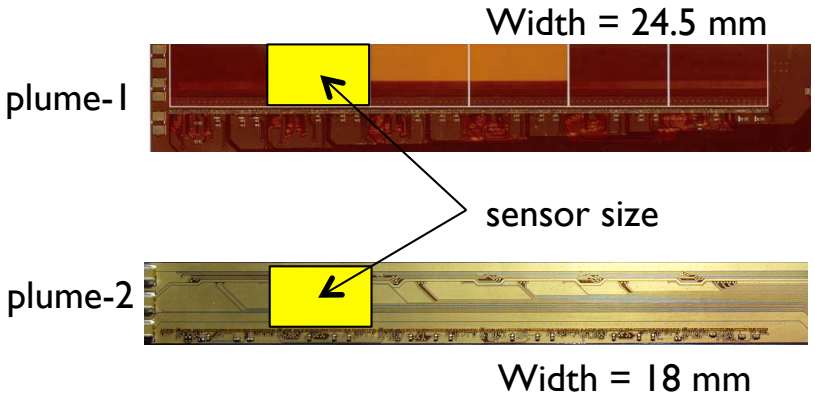
- **Conditions**
  - SPS beam π 120 GeV
  - Pixel telescope with single MIMOSA 26 per plane
- **Results at normal incidence**
  - σ (point) ≈ 3 μm
  - σ (angle) ≈ 0.1°





PLUME-2 (2012/2014)

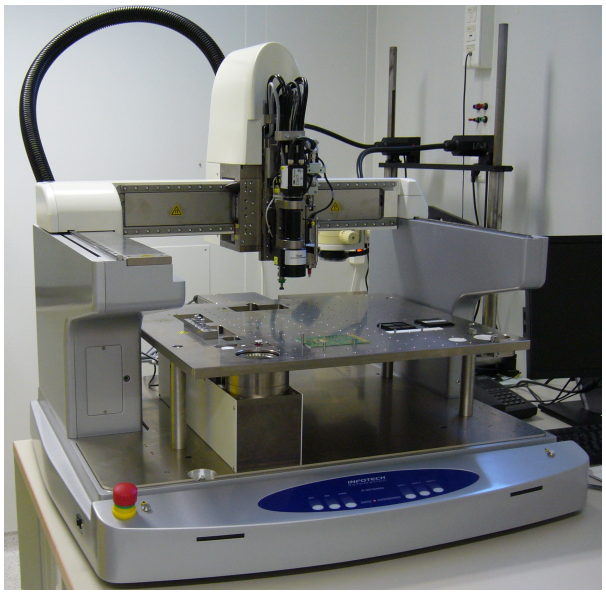
- **Goals**
  - Focus on minimal material budget
  - Small production (≲10 ladders)



- **Improvements**
  - Cable narrower & aluminum traces
    - Mirror version → narrower ladder
  - Spacer thinner: 4% density
  - Automatic placement machines
    - fast & reliable assembly

material budget
0.35 % X_0

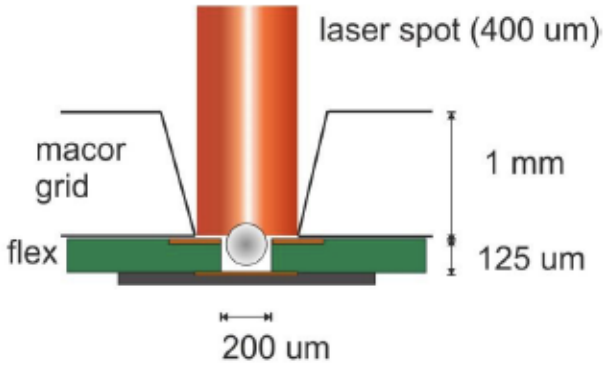
- **Expected schedule & plans**
  - First ladder expected January 2014
    - others ready by end of 2014
  - Mechanical tests Spring 2014
  - Beam test > October 2014



Prospects from ALICE dvpmts

- New sensors
  - Technology 0.18 μm
  - Sensitive layer
    - Highly resisitive > 1-6 kΩ.cm
    - Thickness 18 to 40 μm
  - Radiation tolerance
    - Ionizing dose: > Mrad
    - Non-ionizin dose: > 10^{13} n_{eq}/cm^2
  - Sensor specifications (ALICE-FSBB):
    - Still evolving!
    - Pixel pitch: 22x33 μm2 to 30x44 μm2
      - Expected σ(point) < 5 μm
    - Readout-time: 15 to 35 μs
      - Architecture can go down to 5 μs
    - Hit rate sustainable: > 10^7 $cm^{-2}.s^{-1}$
    - Power dissipation < 100 mW/cm^2
    - Probably 2 submissions
      - FSBB-M in Q1 2014: 35 μs version
      - FSBB-A in Q4 2015: 15 μs version

- New integration
  - Laser soldering ⇔ "cold" bump bonding
  - Avoid wire bonding and pads
    - Decrease overall material budget

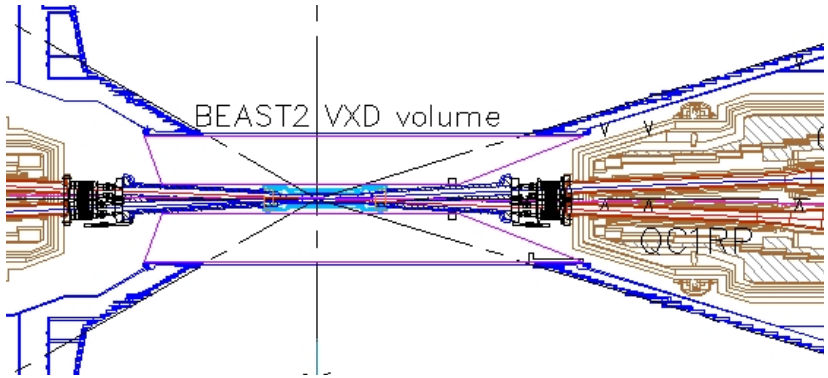


- Potential first mixed-ladder
  - Combining
    - MIMOSA 26: 3 μm spatial resolution
    - FSBB-A: 15 μs readout-time
  - Possible only after mid-2015

PLUME for BEAST II

- The proposal
  - Install one operating ladder
    - In VXD volume
    - For several months operation
  - Measurement:
    - particle rate per pointing angle
    - Available online

- Already available
  - Ladder & services
  - Standalone acquisition system
  - Analysis software (offline type)
  - Full simulation package

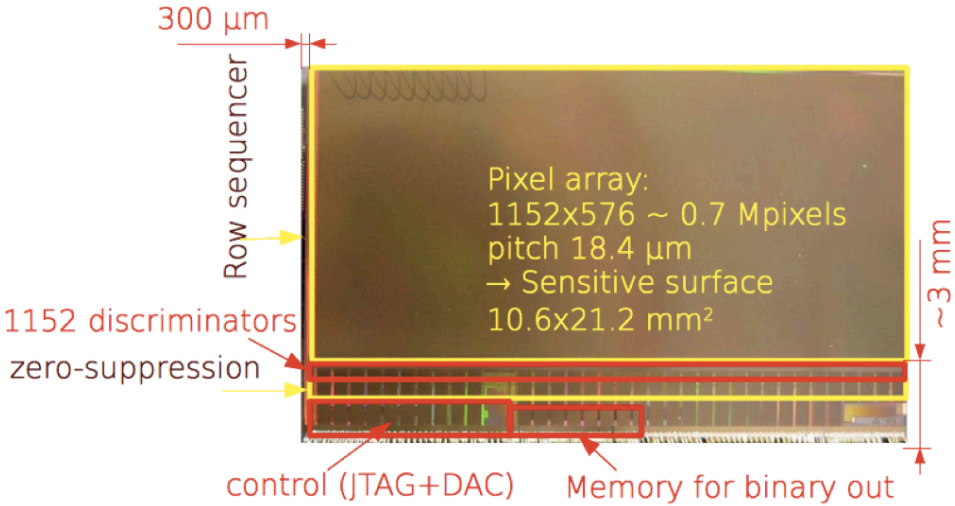


- Work to be done
  - Mechanical support
    - Ladder & service boards
  - Air cooling
  - "Robust" slow control
  - Online histogramming
- Manpower
  - For integration: collaboration with Bonn
  - Slow Control, Online analysis
    - 1 FTE = 1 PhD student / 1 Post-doc / 1 perm.
  - Operation: TBD

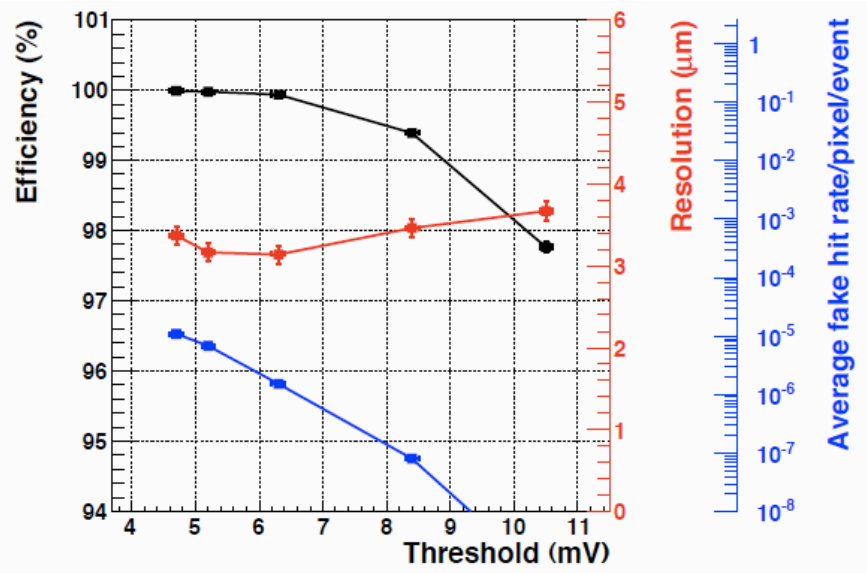
backup

MIMOSA 26

- **Fabrication and specification**
  - Technology 0.35 µm AMS OPTO-process
  - Fabricated in 2009 and 2010
  - Sensitive layer: 14 µm thick, resisitivity > 400 Ω.cm
  - Thinned to 50 µm
  - Operating temperature ~30°C



- **Performances**
  - Rolling-shutter steering
    Readout-time = integration time = 112 µs
  - Binary output
  - Spatial resolution ≃ 3µm
  - Hit rate sustainable > 10^6 $cm^{-2}.s^{-1}$
  - Radiation tolerance validation
    - Ionizing dose: 300 kRad
    - Non-ionizing fluence: 10^{13} n_{eq}/cm^2



Ladder assembly process