Micromegas DHCAL

Status Report and Future Plans
CALICE Meeting
UT Arlington, Texas
12th March 2010

Ambroise Espargilière on behalf of the LAPP group
Outline

• Brief reminder
  – Prototype characteristics
  – Electronic realisations
  – Bulk Micromegas with embedded readout electronics

• Beam tests results
  – Analog readout
  – HARDROC 1-2
  – DIRAC2

• 2010 plans
  – VFE Electronics developments (readout ASIC, spark protection)
  – First m² technological prototype status
  – Beam tests
  – Simulation activities

• Conclusion
Reminder: MICROMEGAS

- MICROMEGAS detector
  - MICRO MEsh GAseous Structure
  - High detection rate
  - Low voltage (all < 600V)
  - Bulk technology
    → Robust, cheap

- Prototype layout
  - 128µm bulk
  - 3 mm conversion gap
  - 2 mm absorber as chamber cover
Reminder: basic performance

- Prototype basic performances (test beam 2008)
  - MIP most probable value: ~20fC (11% r.m.s.)
  - Efficiency > 97%, channel non-uniformity < 1% (1.5fC threshold)
  - Multiplicity < 1.1, chamber non-uniformity < 1.5%
Reminder: Electronics (see C. de la Taille’s talk)

- DIF (Detector Interface) developed at LAPP and ready for mass production
- Recent developments for the new CALICE DAQ:
  - 8B/10B Communication protocols validated (LAPP/LLR)
  - CCC (Clock and Control Card) integration in work at LAPP
Digital Readout

- Bulk MICROMEGAS with embedded Readout electronics
  - HCAL compactness $\Rightarrow$ embedded VFE
  - Install bulk or VFE first? ASICs won’t survive being laminated, Bulk won’t behave well in the soldering oven
  - Solution: VFE first with protection mask for the ASICs

2 types of ASICs considered
- HARDROC, 2 versions (LAL)
- DIRAC2 (LAPP/IPNL)
2009 Beam tests results summary

SEPT 2009: GASSIPLEX

• hadron showers (1-6 GeV, 6 Abs.)

Previous Results

- 2 GeV e⁻ from May TB
- Hadrons 1 GeV
- Ongoing analysis

Number of hits vs. number of absorbers

- 3 fC
- 24 fC

Number of absorbers vs. energy (eV)

- 0 absorber
- 3 absorber
- 6 absorber

12x32 cm² chamber

Ambroise Espargiliere (LAPP)
CALICE meeting at UT Arlington
2009 Beam tests results summary
SEPT 2009 : HARDROC 1

- Threshold $\sim 5\text{fC} \rightarrow$ expect $\sim 90\%$ efficiency or more
- Measurement $\rightarrow 8 - 14\%$ (extremely low !!)

It’s like if the MPV were only $\sim 1\text{fC}$ ($\text{MPV/t} = 0.25$) instead of $\sim 20\text{fC}$
2009 Beam tests results summary
SEPT 2009 : HARDROC 1

• MICROMEGAS signal
  – Fast electron signal (~1 ns)
  – Slow ion signal (~100 ns)
  – ~90% signal due to ions (e-/ions = 1/\ln(Gain) \approx 0.1)

• HARDROC shaping time very short (10-20 ns)
  – electron drift velocity (~50 \mu m/ns)
    → only one mm of gas is seen (2/3 signal lost)
    → the ion tails can’t be seen (~90% of signal lost)
  – HARDROC sees only 0.1 \times 1/3 \times 20fC \approx 1fC as signal MPV
New acquisition software

- X-DAQ left out
- Labview software for calibration, monitoring and data acquisition
- Version for HR1, HR2, DIRAC2
- Version for hybrid readout foreseen
- ~ 100Hz acquisition rate (24 HR2)
2009 Beam tests results summary

NOV 2009: HARDROC 2

- One 32x48 ASU in test box
- Beam profile
- Efficiency very low (as expected with HARDROC) → measurements via « self tracker » or « TPC » mode (1cm gas)
- Many chips were dead (reason not obvious)
2009 Beam tests results summary

NOV 2009: DIRAC 2

- Stack of 4 8x8 MICROMEGAS chambers equipped with DIRAC 2
- Only 3 hours commissioning
- 4-fold coincidences immediately observed
- Destructive sparks killed channels one by one after few hours functioning
  - Few data available
  - No time for threshold optimisation
2009 Beam tests results summary

NOV 2009: DIRAC 2

• DIRAC performances
  (no threshold optimisation)

  Multiplicity
  Chamber 1: 1.13 (6fC)
  Chamber 2: 1.11 (6fC)
  Chamber 3: 1.07 (14fC)
  Chamber 4: 1.06 (14fC)

  Efficiency
  Chamber 1: 12 / 27 = 0.4±0.1 (6fC)
  Chamber 2: 14 / 29 = 0.5±0.1 (6fC)
  Chamber 3: 14 / 30 = 0.5±0.1 (14fC)
  Chamber 4: 14 / 30 = 0.5±0.1 (14fC)

  Not corrected for synchronous functioning

Compatible with previous measurements
Digital readout
Conclusions and outlook

• HARDROC 1 and 2 input stage not adapted to MICROMEGAS signal
• DIRAC 2 showed fragility to sparks
• HARDROC showed fragility not fully explained (sparks ? Commissioning ? ... )
• New chip is needed
  – Optimized for MICROMEGAS signal
  – Hardened design against sparks
• Improved external spark protection needed
2010 plans:
VFE Electronics developments

• New input stage developed for the next generation ASIC
  – Optimized for MICROMEGAS
  – Simulations give S/N=10 @ 1fC, noise r.m.s. 0.1fC @80pF
  – Integrable to HARDROC or DIRAC design

• Spark protections
  – PCB to test various protection schemes
  – Spark generator (large capacitance discharging in the PCB)
  – Test of buried components undergoing and promising

Ambroise Espargiliere (LAPP)
CALICE meeting at UT Arlington
2010 plans: 
First technological m² prototype (1)

- Mechanical Prototype validated the assembly procedure (6 dummy ASUs)
- Available ASU for technological prototype
  - 4 ASU with HARDROC2 chips
    (under tests, almost all ready)
  - 1 ASU with HARDROC2b chips
    (PCB in cabling)
  - 1 dummy ASU (6 ASU 32x48 are necessary)
2010 plans:
First technological $m^2$ prototype (1)

- Mechanical Prototype validated the assembly procedure (6 dummy ASUs)
- Available ASU for technological prototype
  - 4 ASU with HARDROC2 chips (under tests, almost all ready)
  - 1 ASU with HARDROC2b chips (PCB in cabling)
  - 1 dummy ASU (6 ASU 32x48 are necessary)
2010 plans:
First technological m² prototype (2)

- All ASU tested between each step
  - Electronics:
    - Return from cabling
    - Return from bulk lamination
    - After bulk cooking
  - Full calibration
  - ⁵⁵Fe and/or cosmics with a test box
- Clean room → naked mesh ASU
  - Perform mesh cooking in air
  - Insert/remove ASU from test box
- m² completion
  → validate full design & processs
2010 plans: Beam tests

• Beam test second half of June 2010 at CERN/SPS/H4
  – $m^2$ tests
    • Test $m^2$ functionnality
    • Measure efficiency, multiplicity and uniformity
      → Use HR1 or DIRAC ministack stack as a telescope
  – DIRAC tests
    • Measure efficiency, multiplicity and uniformity
    • Test power pulsing in magnetic field
    • Spark study

• Beam test mid November 2010 at CERN/PS
  – $m^2$ tests in/behind W structure
2010 plans:
Simulation activities

• Study impact of supporting structure on the HCAL performance
• Projective and non-projective geometries are considered
2010 plans:
Simulation activities

Ambroise Espargiliere (LAPP)
CALICE meeting at UT Arlington
Conclusion

• Project delayed
  – HARDROC 1 & 2 not applicable to MICROMEGAS
  – DIRAC 2 not spark proof

• Main benchmarks:
  – Commissioning of m$^2$ technological prototype
  – Optimized readout chip
  – Upgraded spark protections

• Intensive R&D activities
  – LAPP group is involved in several fields (DIF task force, Mechanical engineering, detector R&D, simulations)
  – Detector R&D highly supported by in2p3