LHCb RICH Upgrade

Current LHCb RICH Configuration
RICH Upgrade Motivation

- Amount of recorded data limited by trigger rate ⇒ upgrade the electronics to 40MHz trigger rate
- RICH HPD have embedded FE electronics limited at 1MHz ⇒ replace
- Luminosity increase from 4 to 20 $10^{32}$ cm$^{-2}$s$^{-1}$
  - ⇒ Degradation due to high occupancy
    - Change the design
  - ⇒ Aerogel material improves the tagging performance
    - remove

![Diagram of RICH electronics and data visualization](image)

![Graph showing SSK Effective Efficiency Comparison](image)

Peak occupancy ~33%

Lumi20
Integrated luminosity for Run 2

- Luminosity projection based on experience in Run 1 and updated schedules:

- Ideally collect 10 fb\(^{-1}\) before LS2, thus another 7 fb\(^{-1}\)
- Attractive to extend Run 2 by \sim\) one year or so
- Note, however that the LHCb expected system lifetime (trackers) at 10 fb\(^{-1}\)
RICH Options

“RICH2019”

“TRIDENT”
Purpose of the review meeting

RICH upgrade geometry design: 3 options

1) Retain current RICH-1 & RICH-2 geometry
   - This option is much less preferred on grounds of reduced performance.

2) Re-design RICH-1 with new optical system
   - We have now converged on a vertical configuration

3) Single RICH: “TRIDENT” concept
   - Innovative design, possibly with improved performance over alternative

Today we need to converge on a solution to which the RICH group should reach consensus.
RICH2019 concept

Current detector plane

New detector plane

3/7/13
RICH2019 performance

<table>
<thead>
<tr>
<th>RICH Kaon ID</th>
<th>RICH1-Optics-Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Geometry</td>
<td>2 $10^{32}\text{cm}^{-2}\text{s}^{-1}$</td>
</tr>
<tr>
<td>Current Geometry</td>
<td>10 $10^{32}\text{cm}^{-2}\text{s}^{-1}$</td>
</tr>
<tr>
<td>Current Geometry</td>
<td>20 $10^{32}\text{cm}^{-2}\text{s}^{-1}$</td>
</tr>
<tr>
<td>RICH2019 Geometry</td>
<td>20 $10^{32}\text{cm}^{-2}\text{s}^{-1}$</td>
</tr>
</tbody>
</table>
INFN Involvement in the RICH

- Design of front-end electronics (CLARO chip) [MI Bicocca, FE]
- PhotoDetector Module Assembly [GE]
- PDM mechanical superstructure, cooling, magnetic screening, extraction system [PD]
- MaPMT characterization [MI, FE, PD]
- Simulation [PD]
Padova Involvement: Mechanics

Superstructure

Sistema di convogliamento del flusso di B
Padova involvement: calibration of PMT response

- Idea by G.Collazuol
  - Use the dy12 pin to inject a charge signal on each pixel anode
  - Generate the signal using a 1V step function signal
- The response to the charge injection on dy12 is equivalent to a single photon signal
- With our setup (HV=1000V) and a wide bandwidth voltage amplifier the response to a single photon is
  - Pulse height=\(~60\text{mV}\)
  - FWHM=\(~1.3\text{ns}\)
- Check the uniformity of the response as a function of the position of the pixel
- Can be done with HV=0
Padova Involvement: MaPMT

- Shield optimization
- Characterization
- ~5k MaPMT → automated setup in various institutions
Padova Involvement: Simulation

Cherenkov Photons propagation time

Δt[ns]

HPD sensor hits
# Milestones

<table>
<thead>
<tr>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>30/09/2013</td>
<td>Prototype Elementary Cell operating in the lab with readout board and prototype mechanics.</td>
</tr>
<tr>
<td>31/07/2014</td>
<td>Fully functional and complete prototype of a photo-detector module (PDM).</td>
</tr>
<tr>
<td>31/12/2014</td>
<td>Mechanics and front-end chip boards preproduction completed and qualified.</td>
</tr>
<tr>
<td></td>
<td>Prototype supporting structure.</td>
</tr>
<tr>
<td>31/07/2015</td>
<td>Final design and qualification of EC, PDM and supporting structure.</td>
</tr>
<tr>
<td>31/12/2015</td>
<td>Mechanics and front-end boards production completed and qualified.</td>
</tr>
<tr>
<td>31/12/2016</td>
<td>50% of EC, PDM and supporting structure assembled and tested.</td>
</tr>
<tr>
<td>31/12/2017</td>
<td>Mechanics and front-end chip production completed and qualified</td>
</tr>
<tr>
<td>30/04/2019</td>
<td>Upgraded RICH installed and commissioned, ready for data taking</td>
</tr>
</tbody>
</table>
Servizi e richieste 2014

• Meccanica
  – 40% M.Benettoni
  – ~9 mesi u. disegnatore
  – ~9 mesi u. officina meccanica
  – Preproduzione superstruttura meccanica: 20KE

• Stazione test MaPMT
  – 33kE a luglio su fondi ex-SuperB (non parte del core LHCb upgrade)
  – 3-6 mesi u. di tecnico elettronico di laboratorio + 0% Flavio per supporto progettazione amplificatori
  – 2 mesi serv. progettazione Elettronica x
    • Amplificatore 64 ch per MaPMT
    • Scheda x circuito iniezione carica

• Completamento stazione su fondi 2014:
  – 5.4kE per HV, 14kE per 2 teste per laser PiLas

• Costruzione apparati: alcuni acquisti anticipati al 2014
  – MaPMT: ~45KE (da discutere lunedì’)

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Backup
Richieste x stazione test (anticipabili al 2013 su fondi ex SuperB)

<table>
<thead>
<tr>
<th>item</th>
<th>quantità</th>
<th>costo</th>
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</thead>
<tbody>
<tr>
<td>Tavolo con smorzamento vibrazioni</td>
<td>1</td>
<td>€ 2,000.00</td>
</tr>
<tr>
<td>assi movimentazione x-y</td>
<td>1</td>
<td>€ 6,000.00</td>
</tr>
<tr>
<td>digitizer caen V1742</td>
<td>1</td>
<td>€ 7,000.00</td>
</tr>
<tr>
<td>dark box + accessori ottici</td>
<td>1</td>
<td>€ 3,000.00</td>
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<tr>
<td>aggiornamento sistema di misura dell’efficienza quantica (fotomoltiplicatore calibro, amplificatore, PC, fibre)</td>
<td>1</td>
<td>€ 5,000.00</td>
</tr>
<tr>
<td>fototubi Hamamatsu R11265</td>
<td>2</td>
<td>€ 4,000.00</td>
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<tr>
<td>costruzione amplificatori</td>
<td>64</td>
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<tr>
<td>bobina di Helmotz</td>
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<td>€ 1,000.00</td>
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<tr>
<td><strong>TOTALE</strong></td>
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In discussione, da finalizzare entro la prox settimana

3/7/13

G.Simi - CdS INFN
# Upgrade tasks

**WP1: Simulation, optimisation & reconstruction**
- 1.1 Optimizing geometrical layout
- 1.2 Optimisation of photon optics
- 1.3 Simulation - Gauss
- 1.4 Pattern recognition and ring reconstruction
- 1.5 Offline monitoring

**WP2: Photon Detectors**
- 2.1 Characterisation of photon detectors
- 2.2 Testbeam verification
- 2.3 Simulation of photon-detector properties
- 2.4 Photon detector production testing
- 2.5 Photon detector monitoring
- 2.6 Magnetic shields

**WP3: Detector Mechanics and Optics**
- 3.1 Mechanical support structure for photon detectors
- 3.2 Mechanical design of RICH structure/ gas enclosure
- 3.3 RICH optics mechanical design
- 3.4 Mirror mounts
- 3.5 Lenses
- 3.6 Seats to beam pipe/exit/entrance windows
- 3.7 Mechanical superstructure for photon detectors and services
- 3.8 Cooling
- 3.9 Optical monitoring and alignment gear
- 3.10 MOCS
- 3.11 RICH installation equipment

**WP4: Electronics Readout & Data Acquisition**
- 4.1 Front-end electronics readout, Claro/MAROC & evaluation
- 4.2 Production of Claro/MAROC cards
- 4.3 Prototype/design and fabricate front-end ("Level-0") readout board
- 4.4 Front-end FPGA firmware & data suppression
- 4.5 Data links and off-detector readout (Tell-40)
- 4.6 HV
- 4.7 LV
- 4.8 Experimental control (ECS)/ readout software/ configuration software
- 4.9 Detector (slow) control (DCS)
- 4.10 Demonstration of the full PID readout chain at 40 MHz (Testbeam)