Main requests from the experiment:

1. $\pi/K$ separation up to $\sim 60$ GeV/c
2. Large angular acceptance:
   $\pm 250$ mrad (H), $\pm 200$ mrad (V)
3. Minimize materials

Design:

- **Radiator**: $C_4F_{10}$, length: $\sim 3$ m
- **Mirrors**: Spherical, focal length 3.3 m
  Reflectance $> 80\%$ for $\lambda > 165$nm
  Total surface $5.3 \times 4$ m
- **Photon detectors**: MWPC's with CsI photocathodes, out of spectrometer acceptance
  Total surface $5.3 \, m^2$
- **Read-out electronics**: Analog read-out
  83 K channels
  average occupancy 5%
  max data rate 2.5 Gb/sec in spill

Material Budget:

- Gas radiator $C_4F_{10}$ 10.5% $X_0$
- Mirrors 5.5%
- Up/Downstream window 2.0/2.2%
- Mirror mechanics 2.3%

<table>
<thead>
<tr>
<th>Component</th>
<th>% Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>22.5%</td>
</tr>
<tr>
<td>Total (Beam Line)</td>
<td>1.6%</td>
</tr>
</tbody>
</table>
COMPASS RICH-1
Parameters II

Contribution to $\Delta n$:

- **Chromatic Dispersion**: $\frac{\Delta n}{(n-1)} = \pm 1.2\%$
- **C4F10 weight**: $\frac{\Delta n}{(n-1)} = \pm 0.25\%$
- **$\Delta T$ within the vessel**: 
  
  \[ 0.1 \text{ Deg. } \Rightarrow \frac{\Delta n}{(n-1)} = \pm 0.02\% \]
  
  \[ 1.0 \text{ Deg. } \Rightarrow \frac{\Delta n}{(n-1)} = \pm 0.2\% \]
  
  \[ 5.0 \text{ Deg. } \Rightarrow \frac{\Delta n}{(n-1)} = \pm 1.00\% \]

$\rightarrow$ Vessel Thermalized to keep $\Delta T \leq 1$ Deg.
Mirrors and Mirrors Support

Measured by using CERN Reflectometer (CERN/EP/TA1)

Comparison mirror/ext.sample for mirror 8

Spherical, focal length 3.3 m

Total surface 5.6 × 4 m²

Large size: hexagons 52 cm diameter

Good reflectivity down to λ ~ 165 nm

Good roughness
Figure: r.m.s. 1.6 nm

Coating: Al (~80 nm)
2001 Mirror Mounting
Vessel: Installation
Leak test

Flushing the vessel with N₂ (July 2000)

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>Oxygen Content (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10000</td>
</tr>
<tr>
<td>2000</td>
<td>1000</td>
</tr>
<tr>
<td>4000</td>
<td>100</td>
</tr>
<tr>
<td>6000</td>
<td>10</td>
</tr>
<tr>
<td>8000</td>
<td>1</td>
</tr>
</tbody>
</table>

Door (VITON o-ring)

Before intervention: No Leaks
Leaks: 10⁻⁴ leak (lt*mbar/sec)
No Leaks: 10⁻⁴ leak (lt*mbar/sec)

After intervention:

Leak test results show a significant reduction in oxygen content over time, indicating successful flushing.

Graphs illustrate the effectiveness of the intervention in reducing leaks and maintaining the vessel's integrity.
Quartz Windows Transparency

Quartz n. 14

![Graph showing transmission (%)](image)
1.5 tons of \( C_4F_{10} \) (i.e. 20 bottles of 50 l each)

The measurement of the initial transparency shows two categories of bottles:

- 9 “Good Bottles” with a transparency of \( >95\% @ 230\text{nm} \)
  Pre Cleaning OK ~ 1 week; 7% material loss

- 11 “Bad Bottles” with a transparency of \( <70\% @ 230\text{nm} \) probably due to a high contamination of Air (several percents)
  Pre Cleaning OK but several weeks needed and 50% of material loss
  Need of Cryogenic Cleaning to remove \( O_2 \) before starting the standard filtering procedure

The Cryogenic cleaning uses the temperature window in which the \( C_4F_{10} \) is in the liquid phase (at atmospheric pressure) while the \( O_2 \) is still gaseous to remove the it from the bottle. One day (~8h) of cryo-cleaning allows a factor 10-40 of \( O_2 \) reduction.
Gas Radiator II: 
C$_4$F$_{10}$ Cleaning Results

Transparency measured over 5 cm of C$_4$F$_{10}$ in liquid phase (~7m of gas) 
scaled to 5m of gas (mean photon path length in the vessel)
Gas Radiator
$C_4F_{10}$ Gas System

Project and Construction: CERN/ST/CV
Photon Detectors I: Working principle

Basic Geometry: RD26

- 8 Photon detectors (total active surface: 5.3 m²)
  - 2 Active cathodes: double layers PCBs (58×58 cm²) with 5184 pads
  - Double quartz window (each 60×60 cm²)
  - Anode wires supported at mid length by MACOR bars with groves (max. sagitta at working voltage 80 μm²)
CsI photo-cathode ⇒ the photo-cathode must be protected from H₂O and O₂, (our goal: always <100p.p.m.). Always fluxed with dry inert gas.
Photon Detectors III: Problems with 20μm Wires

In y2k run we had problems of breakdowns already at a limited gain. Investigations have shown that the reason is linked to defects of the anode wires.

We have proved that the electrical instability is due to the defects of the wires by increasing the breakdown limits of several factors removing the defects. Two new planes have been produced with different wires!
Read Out:
Basic Design Parameters

Basic parameters:

i. Analog read-out
ii. Total number of channels: 83K
iii. Expected occupancy ~ 5%
iv. Total maximum data flux in spill: 2.5 GB/sec. (at the max. trigger rate of 105 Hz)

Front-end chip: COMPASS-GASSIPLEX

i. Modified version of GASSIPLEX, FE chip developed for RD26:
   Preamplifier + Shaper + Analog multiplexer
ii. Intrinsic dead time: 400nsec/ev.
iii. Peaking time: 1µsec
iv. Noise: \( 585 + \frac{16}{[\text{fC}]} \times \text{C electrons (r.m.s.)} \)
v. Gain: \( \sim 6.5 \text{mV/fC} \)

Front-end Card: BORA BOARD

i. 192 boards for the whole RICH1
ii. It includes: F-E chip GASSIPLEX
   ADC’s
   FIFO’s to decouple F-E and logic stage
   FPGA for logic sequencer, threshold subtraction, zero suppression
   DSP for event packaging and on-board controls
   Optical link
iii. Event processing in \( \sim 10\mu s \)
iv. BORA BOARD (60 cm long) directly mounted on the rear side of the cathode PCB planes
Read Out:
Bora and Dolina Boards