RICH news
• RADIATOR GAS ACTIVITY

• NEW PHOTON DETECTORS
So far: \( \text{C}_4\text{F}_{10} \) from 3M
- 3M has stopped production (known)

The 2017 problem:
- Last batch from 3M: bad = unknown contaminants, not removable with the cleaning procedure
- RICH operated with a mixture of \( \text{C}_4\text{F}_{10} & \text{N}_2 \)

Moreover, the monochromator system (transparency measurements in UV) failed in Summer 2017
- Now FIXED: work in last Winter shutdown

Way-out baseline as in September 2017:
- New radiator gas: \( \text{C}_4\text{F}_8\text{O} \rightarrow \) new gas system
- \( \text{C}_4\text{F}_8\text{O} \) - studied for BTEV, ALICE RICH upgrade
- \( \text{C}_4\text{F}_8\text{O} \) – physical (included optical) properties ~ \( \text{C}_4\text{F}_{10} \)
THE EFFECT in RUN 2017

- Indicative figures to appreciate the size of the effect
- From the data analysis exact figures we will extract exact figures

Normalization:
The usual filling at 95% level
MONOCHROMATOR SYSTEM
- New PMTs with new wavelength-shifter coating
- Optical components cleaned
- Electronics refurbished, some new components
  → Now properly working

Understanding the BAD gas
- High-tech gaschromatography
  → The presence of extra polluting components, not detected before, in the last 3M batch is confirmed
MARKET SURVEYING with target $C_4F_8O$ and $C_4F_{10}$

- 3M (US) confirmed no production of $C_4F_{10}$ or $C_4F_8O$
- Airgas (US, now property of Air Liquide): no offer
- SynQuestLab Inc. (GB): no offer
  - they provided $C_4F_8O$ to ALICE
- F2 Chemicals (UK) can provide $C_4F_{10}$ also in large amounts
  - at a cost ~ double the previous 3M one

→ We purchased 2 samples from 2 different production batches (20 kg each) from F2 Chemicals
  - For initial studies and characterization

→ After marked surveying, change of the baseline option:
  $C_4F_{10}$ with present gas system requiring extraordinary maintenance
  - To be confirmed after studying the small-size samples
**F2 CHEMICALS SAMPLES**

F2 Chemicals sample w/o filtering
(5% C4F10, 95% N2)

F2 Chemicals sample applying filtering
(100% C4F10)

Sample 1

Filtered bad gas (for comparison)

NEVER SO PURE!  BEST FROM THE PAST ➔
Gas Chromatography @ CERN

<table>
<thead>
<tr>
<th>Peak</th>
<th>Bouteille 1</th>
<th>Bouteille 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (C2F6?)</td>
<td>nd</td>
<td>0.000</td>
</tr>
<tr>
<td>2 (C3F8)</td>
<td>0.025</td>
<td>0.045</td>
</tr>
<tr>
<td>3 (C3F6)</td>
<td>0.011</td>
<td>0.001</td>
</tr>
<tr>
<td>4 (C4F10)</td>
<td>99.964</td>
<td>99.954</td>
</tr>
</tbody>
</table>

C3F6 (double liaison)

Comparison “bad gas” - Sample 1:
No sulfur components identified in F2 Chemical gas!
CONCLUDING ABOUT THE GAS

- **C4F10 from F2 Chemicals is fine**
- **Premature to estimate the rate of the cleaning losses**
• **RADIATOR GAS ACTIVITY**

• **NEW PHOTON DETECTORS**
STATUS OF THE NEW PHOTON DETECTORS

- **DETECTOR ELECTRICAL STABILITY:**
  - Active Surface: 95% electrically fully stable
    - thanks to HV segment studies and related implementation
    - instabilities related to THGEMs

- **RESITIVE MM by discrete elements (original architecture)**
  - Extremely stable at gains > 200 (MM layer only)
  - All current sparks induced by THGEM sparks

- **OVERALL HYBRID DETECTOR PERFORMANCE**
  - Gain: ~15 k
  - Spark rate < 1/h in all the 4 detectors
  - Spark recovery time ~ 10 s

- **NOISE FIGURES:**
  - $<\sigma>$ ~ 900 e- in all the 4 detectors
**UPDATE about NOISE STUDIES**

- **NOISE FIGURES:**
  - $<\sigma> \sim 800$ e- in all the 4 detectors
  - very stable in time
EVENT DISPLAY

6.36 GeV pion

6.4 GeV pion

6.76 GeV pion

more and more details about detector characterization on Wednesday at the analysis meeting
Counts

- cath2

Entries: 155658
Mean: 47.68 ± 0.1207
RMS: 47.64 ± 0.08357
Underflow: 0
Overflow: 0
Integral(w): 1.557e+05
χ² / ndf: 294.1 / 147
Prob: 7.051e-12
p0: 3081 ± 41.0
p1: 0.02127 ± 0.00014

- cath4

Entries: 108330
Mean: 42.63 ± 0.142
RMS: 46.73 ± 0.1004
Underflow: 0
Overflow: 0
Integral(w): 1.083e+05
χ² / ndf: 244.8 / 147
Prob: 7.381e-07
p0: 1845 ± 31.9
p1: 0.02147 ± 0.00018

Counts

- cath11

Entries: 82923
Mean: 30.33 ± 0.1247
RMS: 35.91 ± 0.08817
Underflow: 0
Overflow: 0
Integral(w): 8.292e+04
χ² / ndf: 205.3 / 147
Prob: 0.001087
p0: 1149 ± 29.4
p1: 0.02463 ± 0.00028

- cath13

Entries: 89187
Mean: 42.69 ± 0.1589
RMS: 47.46 ± 0.1124
Underflow: 0
Overflow: 0
Integral(w): 8.919e+04
χ² / ndf: 232.4 / 147
Prob: 9.052e-06
p0: 1430 ± 27.5
p1: 0.02077 ± 0.00020

Jura

ADC channel

14104.8 ± 91.7048
13976.1 ± 117.162
12178.6 ± 137.194
14441.7 ± 137.984
GAIN MWPC (for comparison)

Counts

**cath0**

- Entries: 23030
- Mean: $17.11 \pm 0.06605$
- RMS: $10.02 \pm 0.0467$
- Underflow: 0
- Overflow: 0
- Integral(w): $2.303e+04$
- $\chi^2$/ndf: 67.67 / 38
- Prob: 0.002151
- p0: $8312 \pm 378.4$
- p1: $0.1154 \pm 0.0019$

ADC channel

**cath1**

- Entries: 102234
- Mean: $17.73 \pm 0.03029$
- RMS: $9.732 \pm 0.02142$
- Underflow: 0
- Overflow: 0
- Integral(w): $1.032e+05$
- $\chi^2$/ndf: 126.4 / 38
- Prob: $2.007e-11$
- p0: $3.144e+04 \pm 6.265e+02$
- p1: $0.1098 \pm 0.0007$

**cath8**

- Entries: 107536
- Mean: $17.61 \pm 0.03044$
- RMS: $9.986 \pm 0.02152$
- Underflow: 0
- Overflow: 0
- Integral(w): $1.076e+05$
- $\chi^2$/ndf: 68.54 / 38
- Prob: 0.001732
- p0: $2.987e+04 \pm 6.261e+02$
- p1: $0.1082 \pm 0.0007$

**cath9**

- Entries: 29809
- Mean: $17.76 \pm 0.05835$
- RMS: $10.07 \pm 0.04126$
- Underflow: 0
- Overflow: 0
- Integral(w): $2.981e+04$
- $\chi^2$/ndf: 86.4 / 38
- Prob: $1.242e-05$
- p0: $8643 \pm 322.8$
- p1: $0.1086 \pm 0.0012$

**Counts**

- **cath0**: $2513.18 \pm 32.85$
- **cath1**: $2736.69 \pm 16.6713$
- **cath8**: $2772.15 \pm 18.007$
- **cath9**: $2763.67 \pm 31.781$
GAIN STABILITY vs TIME

GAIN EXTRACTED FROM SINGLE PHOTON AMPLITUDE SPECTRA

Gain stabilization using global p, T

Individual chamber gain stabilization

Global corrections: \( \sigma/\text{mean} \approx 7\% \)

Individual corrections: \( \sigma/\text{mean} \approx 4\% \)

**Graphs and Data**

- **Gain vs Time**
  - Effective Gain
  - Date: 7/24/2017 to 11/1/2017

- **Gain Stability**
  - Mean = 15.42 ± 0.896
  - Sigma = 572.88 ± 111.54

- **Histograms**
  - Entries: 15/18 ± 0.936
  - Mean = 15.18 ± 0.888
  - Sigma = 572.88 ± 111.54

**Additional Notes**

- Compass TB, 3/9/2018
- Rich News
- Silvia Dalla Torre
NEW ALGORITHM:
Taking into account the binomial nature of the distribution when using “half rings”

\[ N(\theta_\text{Ch}) = p_0 \cdot \sin^2 \theta_\text{Ch} + p_1 \cdot \theta_\text{Ch} \]

Extrapolate to 55.2 mrad, number of photon = 12.9
First part of the function = 10.3 ± 0.4
Second part of the function = 2.6 ± 0.3

**Table:**

<table>
<thead>
<tr>
<th>Entries</th>
<th>Mean</th>
<th>RMS</th>
<th>( \chi^2 / \text{ndf} )</th>
<th>( p_0 )</th>
<th>( p_1 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>116</td>
<td>39.52</td>
<td>13.04</td>
<td>19.19 / 16</td>
<td>3384 ± 118.0</td>
<td>46.34 ± 4.90</td>
</tr>
</tbody>
</table>
\[ \text{QE}_{\text{det2}} / \text{QE}_{\text{det4}} = 1.10 \]

\[ \text{Nph.s}_{\text{det2}} / \text{Nph.s}_{\text{det4}} = 1.06 \]
MPGD-based photon detectors ACCOMPLISH THEIR MISSION

- From the characterization exercises:
  - stable gain and large gain
  - resolution as expected
  - good number of detected photoelectrons

Technological achievement - for the FIRST TIME:

- single photon detection is accomplished by MPGDs
- THGEMs used in an experiment
- MPGD gain > 10k in an experiment
A fully reliable RICH needed for the 2021 run and the future physics with our spectrometer

THEREFORE

We have submitted a request to INFN to complete the photon detector upgrade equipping with hybrid MPGD-based PDs the side part of RICH-1
A FULLY RELIABLE RICH, A MUST FOR THE 2021 RUN

- **K-identification** for flavor separation in D data (as for the p data)
  - For p data: identified single h and identified h-couples

- Relevance of reinforcing the later RICH domain to have good efficiency at large $x_{Bj}$: here the cross-section is small!

- The RICH: a key-ingredient for a large range of COMPASS physics
  - See also the next two slides

- More homogeneous photon-detector system

- Refurbishing the existing detectors is in any case work and costs

- A robust RICH for the future physics program with the spectrometer
  (spectroscopy, exclusive reactions with polarized target, anti-matter production)
physics with muon beam and PID

completed analyses:

longitudinally polarised targets

- flavour separation of helicity distributions – d and p
- gluon polarisation from open charm muoproduction

"unpolarised" targets

- D* and D Meson Production
- Multiplicities of charged pions (d)
- Multiplicities of charged kaons (d)
- K− over K+ multiplicity ratio (d)

transversely polarised targets

- Collins and Sivers asymmetries for pions and kaons – d and p
- Dihadron asymmetries with PID – d and p
- Λ polarisation transfer – d and p

2016/17 analysis Meeting, August 30, 2018

A. Martin
ongoing analyses (2016 and 2017 data):

unpolarised p target

  Azimuthal asymmetries

  \( P_T \) distributions

  Multiplicities of charged pions and kaons

Exclusive Vector Meson production

future analyses (2021 data):

transversely polarised d target

  Collins and Sivers asymmetries

  Other single hadron asymmetries

  Dihadron asymmetries

  \( \Lambda \) polarisation transfer

Exclusive Vector Meson production
COMPLETING THE RICH UPGRADE

NOW

MWPC | HYBRID | HYBRID | MWPC
MWPC | MAPMT | MAPMT | MWPC
MWPC | MAPMT | MAPMT | MWPC
MWPC | HYBRID | HYBRID | MWPC

> 2018

HYBRID | HYBRID
HYBRID | MAPMT | MAPMT | HYBRID
HYBRID | MAPMT | MAPMT | HYBRID
HYBRID | HYBRID

COMPASS TB, 3/9/2018
RICH news
Silvia DALLA TORRE
Concerning acceptance, the most demanding item in COMPASS physics: (SI)DIS

Analysis performed on 2010 data: corner cut at DDD level

- Tracks in RichOne
- Photon Hits

Full Detector

- $Q^2 > 1$
- $x > 0.1$

CORNERS not in Reconstruction

Overall loss is 1.2%
**Data selection**

- Very simple Likelihood selection
  - Standard DIS cuts
  - $z > 0.1$
  - Momentum in the range between 2 GeV/c and 50 GeV/c
  - First selection of the maximum likelihood among the e, mu, pi, K and p (normalized to the background likelihood)
  - Likelihood cuts:
    - $\frac{L_{\text{max}}}{L_{\text{bck}}} > 1.2$
    - $\frac{L_{\text{max}}}{L_{2\text{nd max}}} > 1.05$
Results – Effect of RICH with no CORNERS

Overall loss is 1.2%
Results – Effect of RICH with no SIDES

Overall loss is 5%, but 30% at large $x$