First look at the RICH Prototype test beam data

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## OUTLINE

- Setup description
- Data sample
- Calibration procedure
- Event selection
- > Preliminary results
- ≻ Next steps
- Conclusions

## **EXPERIMENTAL SETUP**

### H8 Experimental area





1192 mm

165 mm

≤

530 mm

83 mm

### **DATA SAMPLE**

- Data sample taken 18/10-19/10 (WC quality, event shift...)
- Proton, <sup>3</sup>He, A/Z=2 runs selected
- Maximum 50k events/run processed

| llew.                  | Matsushita |       | 1.03  | 2x10 mm |       |       |         |                 |
|------------------------|------------|-------|-------|---------|-------|-------|---------|-----------------|
|                        | RUH        | DAY   | INIT  | EIID    | DRIFT | B\rho | #EVENTS | BEAM TYPE       |
|                        | 292        | 18/10 | 06:58 | 08:00   | 417.4 | 40    | 171135  | A/Z=2           |
|                        | 295        | 18/10 | 11:45 |         | 417.4 | 11    | 52000   | P               |
| New                    | Matsushita |       | 1.05  | 2×10 mm |       |       |         |                 |
|                        | RUII       | DAY   | INIT  | EIID    | DRIFT | B\rho | #EVENTS | BEAM TYPE       |
|                        | 302        | 18/10 | 15:35 |         | 375   | 13    | 39961   | P               |
|                        | 304        | 18/10 | 16:15 |         | 375   | 9     | 16390   | A/Z=2           |
|                        | 308        | 18/10 | 19:24 | 19:53   | 375   | 40    | 85023   | A/Z-2 / Q15-0.2 |
| Novosobirsk-hydrophil. |            |       | 1.03  | 30 mm   |       |       |         |                 |
|                        | RUH        | DAY   | INIT  | EIID    | DRIFT | B\rho | #EVENTS | BEAM TYPE       |
|                        | 310        | 18/10 | 21:24 | 21:40   | 417.4 | 40    | 74252   | A/Z-2           |
|                        | 312        | 18/10 | 21:54 | 21:59   | 417.4 | 30    | 71690   | A/Z=3/2 He3     |
|                        | 313        | 18/10 | 22:09 | 22:26   | 417.4 | 13    | 33688   | P               |
| Novosobirsk-hydrophob. |            | 1.03  | 30 mm |         |       |       |         |                 |
|                        | RUH        | DAY   | INIT  | EIID    | DRIFT | B\rho | #EVENTS | BEAM TYPE       |
|                        | 285        | 17/10 | 23:00 |         | 417.4 | 40    | 117737  | A/Z=2           |
|                        | 325        | 19/10 | 07:16 | 07:25   | 417.4 | 13    | 30546   | P               |
|                        | 326        | 19/10 | 07:33 | 07:43   | 417.4 | 30    | 132132  | A/Z=3/2 He3     |
|                        | 327        | 19/10 | 07:54 | 08:     | 417.4 | 40    | 118633  | A/Z-2           |
| 014                    | Matsushita | U.    | 1.03  | 3x10 mm |       |       |         |                 |
|                        | RUH        | DAY   | INIT  | END     | DRIFT | B\rho | #EVENTS | BEAM TYPE       |
|                        | 319        | 19/10 | 02:55 | 03:13   | 417.4 | 13    | 35310   | 2               |
|                        | 320        | 19/10 | 02:32 | 03:36   | 417.4 | 30    | 130557  | A/Z=3/2 He3     |
|                        | 321        | 19/10 | 03:46 | 04:25   | 417.4 | 40    | 135225  | A/Z-2           |
|                        |            |       |       |         |       |       |         |                 |

## **PMT CALIBRATION**

> Pedestals: 5 pedestal runs along the selected period



### **PMT CALIBRATION** > Gain: 5 data runs along the selected period LED calibration vs. Offline calibration Single p.e. spectrum: channel 100 Led run gains events 150.0 / 67 2 2/ndf Testbeam LED spectrum 158.6 Constant m 160 Test beam LED calibration 180 Offline spectrum 0.6443 Mean channels/; 140 100 Cosmic runs LED calibration 0.5771E-01 Sigma 160 Offline calibration 140 10 120 100 80 80 60 10 60 40 40 20 20 0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2 80 100 120 140 160 180 20 40 50 100 150 200 60 0 250 ADC counts above pedestals Gain (ADC counts) Offline gain/ led run gain Gain Gain stability σ gain channels/3.2 255 200 175 150 ∾ <sup>160</sup>ſ 80 ID 1000 counts for single p.e. ID 1000 5 140 1584 Entries 1584 Entries 70 channel 100 59.24 Mean 28.29 Mean 60 RMS 18.81 RM\$ 8.598 50 125 80 40 100 60 30 Protons runs 75 40 20 ADC Helium runs 50 20 10 25 Mean 9<u>E</u> 10 2<sup>日</sup> 100 120 140 160 180 40 60 80 20 290 295 300 305 310 315 320 325 330 30 40 60 50 70

ADC counts

Run number

ADC counts

### WC CALIBRATION



### WC CALIBRATION

### WC – RICH position residues (4.5 mm):

1. same in x & y axes

### 2. similar to those obtained @ ISN with cosmics (6mm)

(RICH pixel contribution  $\approx 3.5$  mm)



# **SCINT CALIBRATION**

- Good correlation observed btwn SC1 & SC2
- Non linearities in anode & dynode signals
- Scint response calibrated using RICH selection





## **RADIATOR PARAMETERS**

**Optical parameters can be (ambiguously!) tuned from the RICH velocity and charge reconstruction:** 

> $\beta \Rightarrow$  Refraction index (or expansion length)  $Z \Rightarrow$  Clarity (or absorption length)



# **EVENT SELECTION**

- Reconstructed WC-track
- Loose WC-beam and WC-RICH matching
- $N_{USED} > 2$ ,  $N_{EXP} > 2$
- Multi-particle event rejection
  - **Multi-Ring** (Charge/ChargeInRing < 1.75)
  - Multi-Track (ChargeSingleHit < 2.3 x ChargeInRing + 2.7)



87 06

Constan

Ն Նտու

0.986

Mean

Siam

Preselected Selected

10

49.57

0.2290E-05

0.4392E-05

5085.

0.9987

0.6925 E-03

0.994

1.002

1.01

ß

35.31

Constant

0.98

Mean

Siam

Preselected

10

633.3

0.9951

0.1279E-02

0.99

1

1.0

ß

Events/0.0005

10

1

0.96

0.97

**B determination** After selection, tails are mainly coming from multi-particle events and beam contamination

 $\sigma(\beta)/\beta \approx 1.0\%$  : NM 1.03, NV 1.03

135.7

0.3050E-03

0.7309E-04

 $\sigma(\beta)/\beta \approx 1.3\%$  : NM 1.05, OM 1.03, NV 1.04

Events/0.0005 ਫ਼ਰੋ

 $10^{2}$ 

10

0.97

0.978



97 62 / 10

1649.

0.9977 +

243.0

0.1689E-03

Constant

Mean

9

8

7-

5

Nov. hydrophobic 3cm

old Matsu, 1.03 3cm

new Matsu, 1.03 2cm

new Matsu. 1.05 2cm

• Nov. hydrophilic 3cm

### Z determination

Since the rings are completely contained in the PMT matrix, the optimum charge resolution is obtained for every radiator.

 $N_{EXP} \approx 7 : NM 1.05, NV 1.03, NV 1.04$  $N_{EXP} \approx 5 : NM 1.03, OM 1.03$ 



60

### **Z** determination

Although RICH charge peaks are visible up to  $Z \approx 20$ , scintillator charge determination  $\frac{40}{5}$  40 limits a precise determination of RICH charge resolution & confusion for high Z. 20







15

10

5

**Run 285** 

20

A first estimation of the RICH reconstruction efficiency can be derived from the extrapolation of the spectrum of used hits, which can be described to a good approximation by a Poisson distribution.



### **STRANGE EVENTS**

### In $Z_{SCNT}$ =2 sample (A/Z = 2 runs) 2 different types of RICH events:

- Standard Helium ( $N_{HitsInRing} < 40, Q_{HitInRing} \approx 1 \text{ p.e.}$ )
- $N_{\text{HitsInRing}} > 40, Q_{\text{HitInRing}} < 1 \text{ p.e.}$

### Actually, in sample B, Q<sub>hit</sub> spectrum peak is below 1 p.e. !



### **STRANGE EVENTS**

- By comparing with previous trigger we see that the fired pixels in sample B are correlated with high charge hits in the previous event.
- After removing these coincident hits, sample B events show a nice  $Z_{RICH} = 2$  distribution.



### **STRANGE EVENTS**

In the proton runs, we select in every event the pixel with the highest  $Q_{hit}$  ( $Q_{hit}^{max}$ ).

In the next event, the signal of that pixel, when fired, is strongly peaked at  $Q_{hit} < 1$ .

The probability of having a fired hit with low  $Q_{hit}$  increases with increasing  $Q_{hit}^{max}$ .





## **NEXT STEPS**

- Calibration verification (WC, SCNT...)
- Ntuple availability
- **MC production**
- Analysis extension to the full data sample including all the radiators



Additional background rejection and identification capabilities can be obtained by correlating RICH data with Tracker and TOF samples using the common event number.

## CONCLUSIONS

- First look at test beam data agrees with the system expected performances regarding velocity resolution and dynamic range.
- Detailed comparison with simulation is needed to perform the final radiator choice.
- Correlation with TOF and Tracker data may be needed to reject backgrounds and to improve signal selection.
- > Two unexpected effects have been detected:
  - Inconsistent LED/Offline PMT Gain calibration
  - "Persistent signals" in consecutive events