Performance of hadron calorimeter (Projectile Spectator Detector - PSD) at NA61/SHINE experiment

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NA61/SHINE experiment at CERN SPS

NA61/SHINE facility:
- accelerator chain, beam line and detectors
- hadron production spectrometer for h+p, h+A, A+A
- energies: 13 – 150 AGeV/c (400)
- precise measurements of produced particles (charge, mass, momentum)

Physics program at NA61

Hadron calorimeter (PSD) at NA61/SHINE
Hadron calorimeter (PSD) at NA61/SHINE

NA61/SHINE

Ar + Sc @ 150 AGeV/c

tracks reconstructed

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The 3rd ICPPA, 2-5 October 2017, NRNU/MEPhI
Hadron calorimeter (PSD) at NA61/SHINE

Hadron calorimeter PSD at NA61/SHINE

projectile spectators
participants

b
Hadron calorimeter (PSD) at NA61/SHINE

44 modules + 1:
- 16 small: 10cm x 10cm size
- 28 large: 20cm x 20 cm size

(10 sections in 1 module) => ~5.6 int. length

1 short module of 2 sections

450 channels to read-out
Hadron calorimeter (PSD) at NA61/SHINE

<table>
<thead>
<tr>
<th>Name</th>
<th>Zecotek MAPD-3A</th>
<th>Hamamatsu S12572-010P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of pixels</td>
<td>135 000</td>
<td>90 000</td>
</tr>
<tr>
<td>Nominal gain</td>
<td>6 x 104</td>
<td>1 x 105</td>
</tr>
<tr>
<td>Pixel recovery time</td>
<td>1 – 10 μs</td>
<td>10 ns</td>
</tr>
</tbody>
</table>
Hadron calorimeter (PSD) at NA61/SHINE

S.Morozov, on behalf of INR RAS, Moscow

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Mean energy $\rightarrow 158.0$ GeV

1) scale mean deposited energy to 158 GeV (beam energy)
2) apply an iteration procedure of “smoothing”

Mean energy $\rightarrow 158.0$ GeV

Muon spectrum in PSD section

1) muon beam: to equalize response of all PSD sections

Deposited energy in PSD modules

Mean energy $3.49$ GeV

2) proton beam $\rightarrow$ all modules energy calibration

Hadron calorimeter (PSD) at NA61/SHINE

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Hadron calorimeter (PSD) at NA61/SHINE

PSD energy in MIPs

- 20 GeV
- 31 GeV
- 40 GeV
- 60 GeV
- 80 GeV
- 120 GeV
- 158 GeV

NA61 PSD Calibrations

Linearity

Beam Energy, [GeV]

Energy resolution

- $\sigma_E/E_{\text{rec}}$ vs. Beam Energy [GeV]
- $a = 65.7$, $b = 4.2$, $c = 3.1$

158 GeV protons

short module at PSD center

short module the rest of PSD full system

muons

PSD visible energy, GeV

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PSD performance at Ar + Sc beam period

Hadron calorimeter (PSD) at NA61/SHINE

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The 3rd ICPPA, 2-5 October 2017, NRNU/MEPhI
Energy in PSD is ~30 TeV!
Hadron calorimeter (PSD) at NA61/SHINE

A. Senger
Fluka simulation for
Pb beam at rate $5 \times 10^4$ ions /sec

PSD at future (NA61 beyond 2020)

Radiation problem

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Hadron calorimeter (PSD) at NA61/SHINE

Centrality determination with new PSD schematics..

\[ \text{Pb+Pb@29AGeV} + \text{Pb+Pb@150AGeV} \]

\[ \text{PSD1} \]

\[ \text{PSD2} \]

\[ \text{PSD at future (NA61 beyond 2020)} \]

…. and comparison with present PSD
Centrality determination with new PSD schematics.

... and comparison with present PSD
Hadron calorimeter (PSD) at NA61/SHINE

New fast and low noise read-out

ADC64s electronics

64 channels FPGA based read-out board

FEE with new differential outputs

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Hadron calorimeter (PSD) at NA61/SHINE

**TRB3**
- multi purpose time digitization board:
  - 23 ps RMS TDC (FPGAs)
  - up to 256 channels
  - DAQ functionality
  - fast data transfer via gigabit Ethernet

**ToT board** - front-end charge-to-Time-Over-Threshold conversion:
- 8 MMCX inputs → 32 TDC channels on TRBv3 needed
- NINO chip based design
- threshold settings through TRB3 SPI protocol

**PSD at future (NA61 beyond 2020)**

**CBM: 10 MHz trigger rate**

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Hadron calorimeter (PSD) at NA61/SHINE

Summary:

- PSD has been designed and (will be) used at heavy ion experiments

- performance of PSD calorimeter has been tested widely at CERN SPS

- new fast electronics has been developed and tested with PSD:
  1) ADC64s board (JINR, Dubna) + new FEE
  2) ToT board (INR, Moscow) + TRB3 read-out

- future PSD modifications are under discussions now
Backup slides
Hadron calorimeter (PSD) at NA61/SHINE

Energy scan of modules:

beam centered on mod#45 (short) before the center of PSD