KRATTA

KATANA

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NUSYM17, GANIL
Caen, 4-7.09.2017

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Outline

• Main characteristics and properties
• Performance
• Some results
• Possible improvements
KRATTA

KRAków Triple Telescope Array
Active elements

PD1 + CsI1 = SCT (Single Chip Telescope) [G. Pasquali et al. NIMA 301(91)101]
Performance

Pulse shape analysis

Time [FADC channels]

Amplitude

Light Component in PD1

Ionization Component of PD1

SCT after decomposition

PD0 vs PD1

PD0 Amplitude

PD1 Amplitude

Mode of current signal PD0

Raw SCT ID map

ID map for particles stopped in the first photodiode
Background reduction in long CsI(Tl) crystals

J. Łukasik et al., EPJ Web of Conf. 88, 01017 (2015)
\[
\Delta E_{\text{CsI1}} \text{ [channels]}
\]

\[
E_{\text{CsI2}} \text{ [channels]}
\]
p, d, t, stopped in CsI2
p, d, t punching through CsI2
Analyze p, d, t, punch-through segments increase energy range

rough energy/nucleon calibration from “1/ΔE” ->
E/A ~ Z^2/ΔE for punching through Z=1

but
no mass resolution and weak energy resolution

using punch through segments would allow to increase the upper energy threshold for t from ~130 AMeV to ~200 AMeV.
KRATTA

Energy/nucleon spectra for p, d, t

... a work in progress ...
After some “stretching, rotating, projecting…” (a'la Tassan-Got, using Range-Energy tables etc) a work in progress...

... it is not excluded that it might be possible to obtain a very, very rough identification and energy calibration for p, d, t punching through CsI2
and where are the pions?
INDRA@GSI (Feb/Mar 99) C+Au @ 1 AGeV, 166°, 13.2 msr

SILI_17_GG_vs_CSI_17_H

KRATTA@GSI (May 11) Au+Au @ 0.4 AGeV, 66°, 4 msr

mod34

Csl1 [channels]

Csl2 [channels]
KRATTA@GSI (May 11) Au+Au @ 0.4 AGeV, 26°, 4 msr
Au+Au @ 400 AMeV

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UrQMD + Clustering + GEANT4

DE-E [channels]  DE-E [MeV]
Au+Au @ 400 AMeV

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UrQMD + Clustering + GEANT4

\[ \pi^+ \]

DE-E [channels]

DE-E [MeV]
Au+Au @ 400 AMeV

KRATT A

UrQMD + Clustering + GEANT4

π−

DE-E [channels]

DE-E [MeV]
\[ \pi^+ \rightarrow \mu^+ + \nu_{\mu}, \quad \tau_{\pi} \approx 26 \text{ ns}, \quad E_{\mu} = 4.12 \text{ MeV}, \quad R_{\mu}^{\text{plastic}} \approx 1.2 \text{ mm} \]

\[ \mu^+ \rightarrow e^+ + \nu_e + \bar{\nu}_{\mu}, \quad \tau_{\mu} \approx 2.2 \mu\text{s} \]
π⁻ capture/disintegration

π⁻ + A → A' + n, p, d, t, α, ... “star events”
π⁻ + p → n + π⁰ → 2γ + n pionic atom τ < 1 ps
π⁻ → μ⁻ + ν_μ τ_π ≈ 26 ns, E_μ = 4.12 MeV, R_{μplastic} ≈ 1.2 mm
μ⁻ → e⁻ + ν + ν_μ τ_μ ≈ 2.2 μs
μ⁻ + p → n + ν_μ muonic atom
some candidates for $\pi^+$ in KRATTA

Measured waveform

derivative

Time [10 ns/bin]
KRATTA @ GSI (Au+Au at 400 AMeV, 2011)
ASY-EOS Experimental Setup
Flows of light charged particles in Au(400 MeV/u) + Au reactions: KRATTA vs FOPI results

Fourier decomposition of the azimuthal distributions with respect to the reaction plane \( (\phi_R) \):

\[
\frac{dN}{d(\phi - \phi_R)} = \frac{N_0}{2\pi} \left( 1 + 2 \sum_{n \geq 1} v_n \cos n(\phi - \phi_R) \right)
\]

\( v_1 \equiv \langle \cos(\phi - \phi_R) \rangle \) directed flow

\( v_2 \equiv \langle \cos 2(\phi - \phi_R) \rangle \) elliptic flow
Charge distribution \( \text{Au}(400 \text{ MeV/u}) + \text{Au} \)

**KRATTA data \leftrightarrow \text{UrQMD predictions}**

- **ASY - SOFT**
- **ASY - STIFF**

**Criteria:**
- \( b < 7.5 \text{ fm} \)
- \( 24^\circ < \text{Ion} < 59.4^\circ \)
- \( 0.7^\circ < \text{lat} < 25.7^\circ \)
- \( 20 < \frac{E_{\text{KIN}}}{A} < 133 \text{ MeV} \)

**Legend:**
- \( \Delta r=2.5 \text{ fm} \Delta p=290 \text{ MeV/c} \quad \gamma=0.5 \)
- \( \Delta r=2.5 \text{ fm} \Delta p=290 \text{ MeV/c} \quad \gamma=1.5 \)
- \( \Delta r=3.0 \text{ fm} \Delta p=100 \text{ MeV/c} \quad \gamma=0.5 \)
- \( \Delta r=3.0 \text{ fm} \Delta p=100 \text{ MeV/c} \quad \gamma=1.5 \)
- Exp.

S. Kupny, PhD thesis, Jagiellonian University, Kraków (2016)
Energy/nucleon

Au(400 MeV/u) + Au

\[ \frac{d^2\sigma}{d\Omega dE} [\text{arb. units}] \]

\[ p, d, t, ^3\text{He}, ^4\text{He} \]

- \( \Delta r=2.5\text{fm} \, \Delta p=290\text{MeV/c} \, \gamma=0.5 \)
- \( \Delta r=2.5\text{fm} \, \Delta p=290\text{MeV/c} \, \gamma=1.5 \)
- \( \Delta r=3.0\text{fm} \, \Delta p=100\text{MeV/c} \, \gamma=0.5 \)
- \( \Delta r=3.0\text{fm} \, \Delta p=100\text{MeV/c} \, \gamma=1.5 \)
- Exp.

\[ b < 7.5 \text{ fm} \]
\[ 24^\circ < \text{lon} < 59.4^\circ \]
\[ 0.7^\circ < \text{lat} < 25.7^\circ \]
t/³He isotope ratios \( (20 < E_{\text{kin}}/A < 133 \text{ MeV}) \)

- \( \text{Au}(400 \text{ MeV/u}) + \text{Au} \)
- \( 5.5 < b < 7.5 \text{ fm} \)
- \( 24^\circ < \Theta_{\text{LAB}} < 62^\circ \)
- \( 20 < E_{\text{kin}}/A < 133 \text{ MeV} \)

\begin{itemize}
  \item \( \frac{y}{y_{\text{proj}}} \)
  \item \( \frac{p_T}{A} (\text{GeV}/c) \)
\end{itemize}
Proton flow \((20 < E_{\text{kin}} < 250 \text{ MeV})\)

\[
\begin{align*}
\nu_1 & \quad 0.2 & \quad 0 & \quad -0.2 \\
0 & \quad 0.2 & \quad 0.4 & \quad 0.6 & \quad 0.8 \\
\nu_2 & \quad 0 & \quad -0.05 & \quad -0.1 \\
0 & \quad 0.2 & \quad 0.4 & \quad 0.6 \\
\end{align*}
\]

\[
\begin{align*}
p_t/A \quad (\text{GeV}/c) & \quad 0 & \quad 0.2 & \quad 0.3 & \quad 0.4 & \quad 0.5 \\
\end{align*}
\]
Deuteron flow \( (20 < E_{\text{kin}}/A < 160 \text{ MeV}) \)

\[
\begin{align*}
\nu_1 & \quad y/y_{\text{proj}} \\
\nu_2 & \quad p_t/A (\text{GeV/c})
\end{align*}
\]
KATANA

Kraków Array for Triggering with Amplitude discrimination
# KATANA main requirements

(\textit{more than just a trigger...})

- High trigger efficiency for central and semi-central collisions \[\rightarrow\] GEANT4 + UrQMD simulations to test various options and setups
- Fast VETO signal for fragments with $Z>20$ to close the Gating Grid \[\rightarrow\] Fast plastics (BC404) Fast preamps Trigger Box with FPGA logic
- Insensitivity to magnetic field \[\rightarrow\] MPPCs (HAMAMATSU)
- Possibly low position dependence of the signal amplitudes \[\rightarrow\] Wave Length Shifters (BCF-92) for VETO paddles
- Stability and beam time respect \[\rightarrow\] Remote control of discriminator thresholds, bias voltages and temperatures
- Provide data, handle Active Collimator signals \[\rightarrow\] Include trigger detector in DAQ
Determination of the density and momentum dependence of the EOS at supra-saturation densities

Stable and radioactive systems at 300 AMeV

\[ ^{132}\text{Sn} + ^{124}\text{Sn} ; \quad ^{124}\text{Sn} + ^{112}\text{Sn} \]

\[ ^{108}\text{Sn} + ^{112}\text{Sn} ; \quad ^{112}\text{Sn} + ^{124}\text{Sn} \]

Observables:
ratios: \( \pi^-/\pi^+ \), \( n/p \), \( t/3\text{He} \),
flow: \( n, p, t, 3\text{He} \)

Main detectors:
SPIRIT TPC inside SAMURAI
KYOTO + KATANA
NeuLAND
Charge resolution

Taking a single Z “blob” from the upstream chamber and projecting it on KATANA Z calibration we get charge resolution of ~1.8 Z FWHM which is still worse than at HIMAC (~1.3 Z FWHM at Z=54, digital sum) but much better than from the cocktail beam peak (~3.2 Z for run 2350)
Amplitude drop: $\sim 1\% / \text{day}$
Veto efficiency for heavy charges

UrQMD+GEANT4 simulation
Trigger efficiency vs b

UrQMD+GEANT4 simulation
Trigger efficiency vs MUL

UrQMD+GEANT4 simulation
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KRAków Barrel
ASY-EOS II @ FAIR (2019?)

Determination of the density dependence of the EOS at supra-saturation densities

Symmetric and asymmetric systems
\(^{108}\text{Sn}, \, ^{132}\text{Sn}, \, ^{197}\text{Au} \, @ \, 0.4, 1, 1.2 \, \text{AGeV}

Observables:
ratios: n/p, t/\(^3\text{He}, \, \pi^-/\pi^+ (?)
flow: n, p, t, \(^3\text{He}

Main detectors:
NeuLAND, FOPI PlasticWall / ALADIN TOF-Wall;
Trigger/Reaction Plane detector around the target
Trigger/Reaction Plane detector around the target

requirements:

• should cover angles > 30°,
• high segmentation in azimuthal angle,
• high geometrical efficiency,
• low multihit probability,
• fast timing
Trigger/Reaction Plane detector around the target:

- 5 rings of 4x4 mm$^2$ fast scintillating fibers (e.g. BCF-20) read out by SiPMs
- covers angles from 30° to 165°,
- segmentation assures more or less uniform count rates for Au+Au at 1 AGeV,
- geometrical efficiency ~95%
- ~10% of charged particles involved in multihits,
- ~5% multihit probability
- sufficiently large for radioactive beams
- sufficiently small and lightweight not to disturb neutrons
- min radius - 6 cm,
- max radius - 12 cm
- length 43 cm
- 180 segments in forward rings
- 90 segments in backward ring
- 810 channels
UrQMD + clustering: Au+Au 1000 AMeV, 0-10 fm, 200 fm/c

better correlation
hits/segment

krab_bar \{krab\_de>0\}

- Entries: 484802
- Mean: 465.2
- RMS: 242.2

SciFi segment number
1 AGeV Au Au target 40x40x0.5 mm³

geom. efficiency

target shadow
Summary and Conclusions

KRATTA
- good detector performance
- flow parameters consistent with FOPI data
- UrQMD (+ clustering) fails in reproducing isotope ratios
- realistic description of cluster formation needed
- advantages of pulse shape analysis
- attempt to obtain approximate isotopic identification in punch through regions
- attempt to identify pions (at least $\pi^+$)

KATANA
- charge resolution of the VETO paddle: > 1.8 charge units FWHM
- amplitude drop of the central VETO: about 1% per day of the beam time
- trigger efficiency $\sim$100% for MULT KYOTO+KATANA>14

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- design of the multiplicity trigger/reaction plane detector for the ASY-EOS II