LAMPS experiment
-Status & Plan -

Lee Jong-won for LAMPS collaboration
RAON

• First Heavy-ion accelerator for basic science in KOREA
• Operation start from end of 2021 / 2022

\[
\begin{align*}
U^{79} : & \quad 200 \text{ MeV/u} \quad 8.3 \text{ pμA} \\
Xe^{54} : & \quad 251 \text{ MeV/u} \quad 11 \text{ pμA} \\
O^{8} : & \quad 320 \text{ MeV/u} \quad 78 \text{ pμA} \\
p : & \quad 600 \text{ MeV} \quad 660 \text{ uA}
\end{align*}
\]

- Driver Linac
- Post accelerator
- ISOL system
- IF system
- Experimental facility

Diagram showing the layout of RAON with labeled components.
**LAMPS – Physics**

- Nuclear symmetry energy at high density
  - Using rare isotope beam
  - Various beam energy
  - Various collision system
- Ratio of mirror nuclei & $\pi^-/\pi^+$
- Isospin diffusion parameter
- Collective flow
- Dipole emission
- Energy range
  - $18.5 \text{ MeV/u} < E_{\text{beam}} < 250 \text{ MeV/u}$
- Example of reactions
  - $50, 54\text{Ca} + 40\text{Ca}, 68, 70, 72\text{Ni} + 58\text{Ni}, 106, 112, 124, 130, 132\text{Sn} + 112, 118, 124\text{Sn} \ldots$

**RAON is best facility for LAMPS**

“LAMPS” is Large Acceptance **Multi-Purpose** Spectrometer

**Measureable parameters**
- Particle ratios: $n/p, 3H/3\text{He},$ etc.
- Pion ratio ($\pi^-/\pi^+$)
- Collective flow
- Electric dipole emission
LAMPS detector system

From IF

 Beam drift chamber

 Starting counter

 Solenoid Magnet

 Target 1T

 TPC

 Barrel TOF

 Forward TOF

 Neutron Detector Array

 ~1 m

 12 m
Status & Plan @ ATHIC 2018

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<td>Target/TOF detector</td>
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Upstream detectors

Upstream vacuum chamber
Starting counter
BDC
Upstream vacuum chamber

- Two detectors, Starting counter and Beam drift chamber, will be placed in vacuum chamber
- Positions of SC and BDC can be adjusted using servo powered mounting stage
- Almost ended production, will be installed in LAMPS beam line in 2021
Starting counter (SC)

**Features**

- Scintillator + MPPC (SiPM) + 4 movable veto scintillators
- Thin scintillator (0.2mm): High rate heavy ion beam, suppress energy loss.
- MPPC(SiPM) array: Near solenoid magnet, increase light yield. Working in vacuum (cooling)
- Movable veto system: Select beam size.
- Two layer: Measure energy/timing of beam particle
- VME multi hit ADC / TDC readout electronics
SC performance

1. All detector component designs were done. Detector construction will be end in 2021.

2. Performance test was done with RI sources ($\alpha$, $\beta$) and two times of 100 MeV proton beam test

3. Estimated two SC integrated timing resolution was $\sim$70 ps.
Beam drift chamber

**Features**

- XX’YY’/ Module, 2 modules for beam particle tracking
- Position resolution 253 µm (Proto type) -> goal 100 µm
- 2.5 mm wire-wire interval
- ASD board + VME TDC readout
- Proto type was built & tested.
- Will operate in vacuum chamber -> Under design
BDC Plan

We plan to make another prototype BDC for several test till early 2022. BDCs for LAMPS experiment will be produced in the first half of 2022.
Spectrometer

Solenoid magnet
TPC
Barrel/Forward TOF
Solenoid magnet

Features
- Field Intensity: upto 1T
- Field uniformity $\Delta B/B : 1.8 \% \ (MC)$, Measurement undergoing
- Inner radius: 1.6 m
- Placed in LAMPS experiment hall for commissioning & field map measurement
**Time projection chamber (TPC)**

**Features**

- Large acceptance TPC detector $\eta: -0.7$~1.6
- Gas volume: 1.2 m x 1 m octagonal prism shaped
- Drift length: 1.2 m - Drift velocity > 6cm/ms
- Quadrupole GEM system - gain $\sim 10^4$ @ P-20 gas
- Gas vessel: rohacell + G10 sheet - t/X$_0$ $\sim$ 1.45%
- Readout channel: 21,512ch
- DAQ: GET system (88AsAd – 22CoBo – 3mTCA)
TPC production
2019 - 2021

Field Strip

Readout system

Quadruple GEM system

Integration

ATHIC2021
Barrel/Forward TOF

Features

• **BTOF**
  - 48 segmented scintillator bar
  - 5 MPPC array for both side: Light yield, Magnet
  - Timing resolution < 150 ps
  - Position resolution ~3 cm
  - Measure charged particle tof of $\eta$ -0.7 ~ 1.6 (Barrel side)

• **FTOF**
  - 48 segmented trapezoid shaped scintillator
  - 8 and 3 MPPC array for both side: Light yield, Magnet
  - Timing resolution: ~142 ps
  - Position resolution ~ 3 cm
  - Measure charged particle tof of $\eta$ > 1.6 (forward)

Detector construction will be ended in 2021

Under production!

Multi MPPC Board
Neutron detector array

Features

- 160 x \{\text{Thick (10 cm x 10 cm x 2 m) scintillators + 2 PMTs}\} for 4 layers
- 80 x \{\text{Thin (1 cm x 10 cm x 2 m) scintillators + 2 PMTs}\} for VETO
- 2x2 m² detection area, 80 cm thickness
- Neutron detection efficiency/layer: \(\sim\)17\% (65 MeV), 12\% (392 MeV)
- Timing resolution 301 ps (FWHM)
- Position resolution 4.6 cm (FWHM)
- VETO plane for all 4 layers: Flexible setup for increase acceptance. Reduce recoil proton contamination.
- 500 MHz FADC readout for multi-hit suppression
Data readout electronics

All trigger information are sent to LTE, LTE decides to issue trigger based on trigger map. All data readout computers are connected to 10G networks, send data without bottle neck.
Generalized analysis framework (KEBI) is under development.

- Geant4 based
- Track and vertex reconstruction with Genfit2 and RAVE
- > 95% track reconstruction efficiency
- ~3% momentum resolution for proton

Correlation between # of gen. and rec. tracks

Efficiency vs theta

Vertex resolution

Vertex resolution [cm]
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<th></th>
<th>2017</th>
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<th>2020</th>
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<td>Construction</td>
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All detector will be prepared in mid 2022.
## Detector system

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<th>Detector</th>
<th>Type</th>
<th>Role</th>
<th>Performance</th>
<th>Purpose</th>
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<tr>
<td>Starting counter</td>
<td>Plastic scintillator</td>
<td>Time origin, Beam rate, Energy</td>
<td>High rate tolerance ( $10^6$ pps ) Timing resolution 100 ps</td>
<td>Beam diagnostic, $T_0$</td>
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<td>Beam drift chamber</td>
<td>Gas Drift chamber</td>
<td>Beam shape, Interaction point on target</td>
<td>High rate tolerance ( $10^6$ pps ) Position resolution 300 um</td>
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<td>TPC</td>
<td>Gas Time projection chamber</td>
<td>Momentum of Charged particle</td>
<td>Momentum resolution</td>
<td>Charged particle energy/momentum</td>
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<td>Barrel/Front TOF</td>
<td>Plastic scintillator</td>
<td>Energy, Momentum (TOF, charged particle)</td>
<td>Timing resolution 150 ps Position resolution :</td>
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<td>Neutron detector array</td>
<td>Plastic scintillator</td>
<td>Energy, Momentum (TOF, charged particle)</td>
<td>Timing resolution 300 ps</td>
<td>Neutron energy / momentum</td>
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Additional detectors for forward charged particle is under studying.