Progress on the HypHI project at GSI

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for the HypHI collaboration

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Production of Hypernuclei

- Coalescence of $\Lambda$ in projectile fragments
- $(\pi^+,K^+)$ reactions in projectile fragments

$NN \rightarrow \Lambda KN$: Energy threshold $\sim 1.6$ GeV
- Heavy ion beams with $E > 1.6$ A GeV needed
  - Stable heavy ion beam at GSI
  - Stable heavy ion beam at FAIR
  - RI-beam from FRS and super-FRS
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H. Bando et al., NPA 501 (1989) 900
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Relativistic hypernuclei

- **Large Lorentz factor** $\gamma (>3)$
  - Effective lifetime: Longer by the Lorentz factor
    - 200 ps $\rightarrow$ 600 ps at GSI
    - 200 ps $\rightarrow$ 4 ns at FAIR

- **Hypernuclear separation and spin precession**
  - Can be feasible with 20 Tm at 20 A GeV
  - Large spin precession in magnetic fields
    - 225 degrees with free-$\Lambda$ magnetic moment
    - 205 degrees with 8.8% reduction due to the kaon exchanging current
Hypernuclear landscape with HypHI

Known hypernuclei
Hypernuclear landscape with HypHI

**Phase 1 (2009-2012) at GSI**
Proton rich hypernuclei

**Known hypernuclei**
10^4 /week
10^3 /week
Hypernuclear landscape with HypHI

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Phase 2 (2012-) at R3B/FAIR
Neutron rich hypernuclei

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Phase 3 (201X-) at FAIR
Hypernuclear separator
With hypernuclear separator
Magnetic moments
Hypernuclear landscape with HypHI

Phase 0 experiment:
Demonstrate the feasibility of precise hypernuclear spectroscopy with heavy ion beams
$^6$Li beam at 2 A GeV on $^{12}$C target

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Hypernuclear separator

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With hypernuclear separator
Magnetic moments

T.R. Saito, Kaga-Onsen, 29th – 31st
Phase 0 experiment

Beam: $^6\text{Li}/^{12}\text{C}$ at 2 A GeV
Target: $^{12}\text{C}$ 8 g/cm$^2$
Fiber detectors

- Daisuke Nakajima and Banu Oezel

- Fiber: 0.83 mm diameter (0.59 mm position granularity)
- PMT: HAMAMATSU H7260KS MOD
- Discriminators: from KaoS collaboration

Construction

- TR0x and TR0y: Done and tested
- TR1x and TR1y: Done and tested
- TR2y: Done and tested
- TR2x: To be done by the end of October
- Holding structure: To be done in November

Readout

- TR0: TDC by VUPROM and QDC
- TR1 and TR2: TDC by VUPROM
Fiber detectors

Test experiments

- March 2007: prototypes with $^{12}$C and $\pi^+$ beams
- September 2007: prototypes with light fragments produced by $^{58}$Ni beams
- August 2008: TR0x, TR0y, TR1y and TR2y with $^{6}$Li beams
TOF-start

Olga Borodina and Sebastien Bianchin

Plastic fingers with
  • BC420 plastic scintillators
  • HAMAMATSU R7400-06 MOD

Test experiment
  • August 2008: prototypes with $^6$Li beam

Construction
  • To be done by February 2009
TOF+

- Olga Borodina, Sebastien Bianchin and Christophe Rappold

- Scintillators: BC408 45 x 25 x 10000 mm³
- PMT: H7415 MOD

- Test experiments
  - September 2007: 3 prototypes
  - August 2008: 7 prototypes

- Time resolution: 357 ps FWHM for MIP
- Position resolution: 18 % FWHM for MIP

- Construction: to be done by the end of 2008
ALADiN TOF wall

- Olga Borodina and Sebastien Bianchin

Existing (very) old TOF wall from the ALADiN collaboration

Works done
- Repair and test of all modules
- Replacing all bases by new ones
- Electric insulation

Commissioning
- March 2009: ALADiN TOF month
Drift chambers

- Daisuke Nakajima, Banu Oezel and Yue Ma

- From KEK

- Constructing the laboratory in cave C

- Repair works and commissioning
  - To be done by March 2009
Trigger electronics

Christophe Rappold, Shizu Minami, Jan Hoffmann, Nik Kurz and Wolfgang Ott

VUPROM

- VME logic modules with FPGA and DSP
- Prototype VULOM: tested in March and September 2007 with beams
- VUPROMs: tested in August 2008 with $^6$Li beams
- 80 modules have been already produced
Secondary vertex trigger

Christophe Rappold and Shizu Minami

With fiber detectors and VUPROM

Test experiment
- August 2008: with TR0y, TR1y and TR2y, $^6$Li beams
- Analysis in progress
Z=1,2 trigger

Christophe Rappold and Shizu Minami

Selecting events with Z=1 and Z=2 particles registered in TOF+

Mean timer and triggers with discriminator modules from RCNP

Test experiments
- September 2007: for principles
- August 2008: with RCNP discriminators and VUPROMs

![Graph of Signals form a digital scope]

![Correlation-2_ch chart]

Z=1,2 trigger

Christophe Rappold and Shizu Minami

Selecting events with Z=1 and Z=2 particles

Mean timer and triggers with discriminator modules from RCNP

Test experiments
- September 2007: for principles
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Monte Carlo simulations and event reconstruction

- Christophe Rappold

- New tracking algorithm with Hough transformation

- Vertex resolutions
  - X and y: ~ 2 mm FWHM
  - Z: ~ 25 mm FWHM

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Monte Carlo simulations and event reconstruction

Christophe Rappold

New tracking algorithm with Hough transformation

Invariant mass resolutions
- $^3\Lambda$H: 3.0 MeV RMS
- $^4\Lambda$H: 3.6 MeV RMS
- $^5\Lambda$He: 3.6 MeV RMS
Other detectors considered

- LAND neutron detector
- NMWD neutron channel
- With the LAND collaboration

TOF wall
- For $\pi^+$ measurements
- With the LAND collaboration
Plan for 2009

**Commissioning**
- Fiber detector: January - March
- TOF+: January - March
- Drift chamber: January - March
- ALADiN TOF wall and TOF-start: March

**Test experiment**
- Fiber detector and Tracking trigger
  - February in cave C
  - February in MAMI C???

**Phase 0 experiment is planned!!!**
- June/July
Do we have to consider hypernuclear excitation?

- Produced hypernuclei must go through the thick target
  - Average mean thickness: 4 g/cm²

- Produced hypernuclei are excited to the resonance states via Coulomb/nuclear excitation

- Total excitation probability
  - 0.02 % /mb
  - Typical excitation cross section: 100-1000 mb → 2-20 %

- Decay channel, example
  - $^5_\Lambda$He*:
    - $p + ^4_\Lambda H \rightarrow p + \pi^- + ^4\text{He} : 33\%$
    - $\Lambda + ^4\text{He} \rightarrow \pi^- + p + ^4\text{He} : 33\%$
    - $n + ^4_\Lambda \text{He} \rightarrow n + \pi^- + p + ^3\text{He} : 33\%$