

# J-PARC BL01 チョッパー分光器「四季」

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総合科学研究機構東海事業センター(CROSS東海) 利用研究促進部

## Chopper Spectrometer 4SEASONS

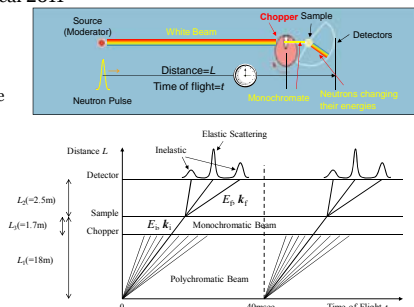
- Chopper-type time-of-flight inelastic neutron scattering instrument to investigate dynamics of spins and atoms in condensed matters
  - Middle resolution & High intensity
  - Wide-angle detector coverage & High measurement efficiency
- Research target
  - Novel spin and lattice dynamics in superconductors, quantum magnets, frustrated magnets, dielectric materials, etc. in the range of  $10^0$ - $10^2$  meV.
- Public beamline since fiscal 2011

### Measurement principle

Energy and momentum that are received by sample:

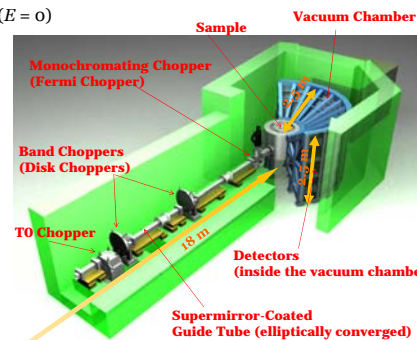
$$E(t) = E_i - E_f(t), Q(t) = k_i - k_f(t)$$

(functions of time)



## Specifications of the Instrument

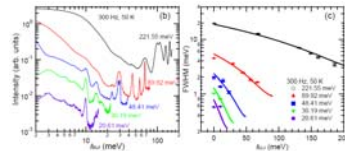
- **Moderator:** Coupled, liquid H<sub>2</sub> (BL01)
- **Flight paths:** L<sub>1</sub> = 18 m (moderator-sample), L<sub>2</sub> = 2.5 m (sample-detector), L<sub>3</sub> = 1.7 m (Fermi chopper-sample)
- **Incident energy:** 5 < E<sub>i</sub> < 300 meV
- **Energy resolution:** ΔE/E<sub>i</sub> > 5% (E = 0)
- **Detector:** <sup>3</sup>He PSD
  - 16.4 atm, φ3/4" × 2.5 m
  - -35° - +55°; horizontal
  - (-+130°; final state)
  - -25° - +27°; vertical
- **Sample environment:** 4K CCR



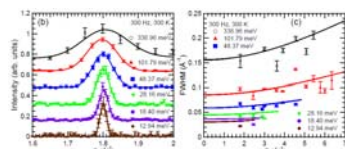
## Energy and Momentum Resolutions: Measurements and Calculations

K. Iida et al., Suppl. of J. Phys. Soc. Jpn., to be published

(Left) Inelastic scattering profiles of C<sub>6</sub>H<sub>12</sub>S at T = 50 K measured with several E<sub>s</sub>.  
(Right) Measured and calculated energy resolutions.



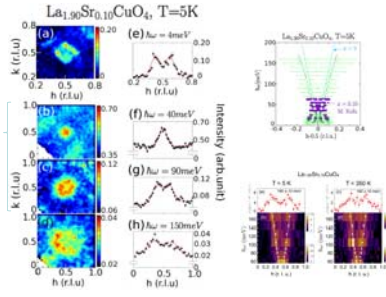
(Left) Elastic scattering profile of Al<sub>2</sub>O<sub>3</sub> at room temperature measured with several E<sub>s</sub>.  
(Right) Measured and calculated momentum resolutions.



## Recent Scientific Outputs

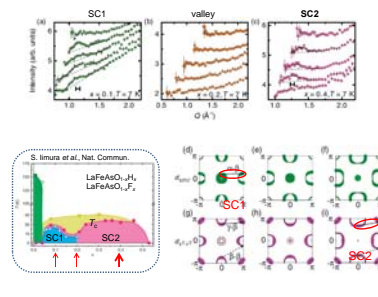
### Magnetic excitations in the cuprate oxide superconductor La<sub>1.90</sub>Sr<sub>0.10</sub>CuO<sub>4</sub>

K. Sato et al., J. Korean Phys. Soc. **62**, 1836 (2013)  
K. Sato et al., JPS Conf. Proc., to be published



### Magnetic excitations in electron-doped iron pnictide superconductors LaFeAsO<sub>1-x</sub>D<sub>x</sub>

S. Iimura et al., Phys. Rev. B **88**, 060501(R) (2013)



## Recent Updates and Problems

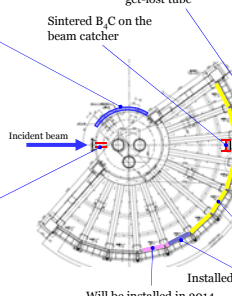
### Background

Still high background exists at high E<sub>i</sub> and low angle

Upgrades several shielding parts



Sintered-B<sub>2</sub>C inside the collimator

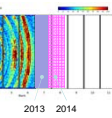


Will be installed in 2014

### Detectors

Increase the number of the <sup>3</sup>He detectors

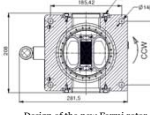
+29 pieces in 2013  
+30 pieces in 2014



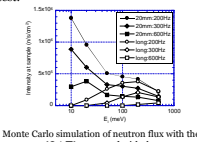
2013 2014

### Choppers

- To chopper
  - High-speed (50 Hz) operation is still unavailable, which sacrifices the neutron flux at high energies (E<sub>i</sub> > ~100 meV).
- Fermi chopper
  - The maximum rotation speed is limited to 350 Hz, which degrades the resolution at high energies.
  - It will be replaced by the new chopper rotor. The available flux is expected to much increase with this rotor.
  - In addition, a new supermirror-coated Fermi chopper will be installed, which enhances the flux in the multi-E<sub>i</sub> measurements.
  - Both the chopper will be installed in the end of fiscal 2013 or until summer in 2014 at latest.



Design of the new Fermi rotor



Monte Carlo simulation of neutron flux with the new rotor (●●) compared with the present rotor (○○).  
M. Nakamura and R. Kajimoto, Suppl. of JPSJ, to be published

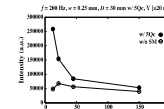
### Radial Collimator

Suppress the multiple scattering by sample environment (Under trial use)



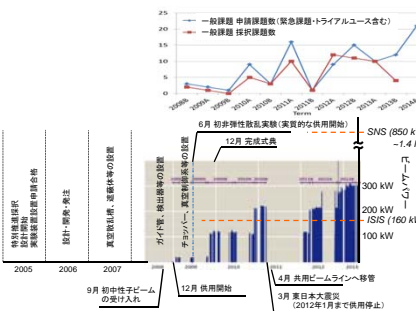
### Continuously Rotating Crystal Measurement

Makes the 4D Q-ω mapping more convenient (Under development)



Monte Carlo simulation of neutron flux available by the Fermi chopper with (●) and without (○) supermirror.  
M. Nakamura et al., Nucl. Instr. Meth. A (2013), to be published  
K. Ikuchi et al., J. Phys. Soc. Jpn. **82**, S4069 (2013)

## History, Proposals, and Publications



Categories of beamtime

Category	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
(1) 一般利用										
(2) 重点課題利用										
(3) トライアルユース利用										

### Publications

- "Inelastic neutron scattering study of the magnetic fluctuations in Sr<sub>2</sub>RuO<sub>7</sub>," K. Iida et al., Phys. Rev. B **84**, 060402(R) (2011).
- "Magnetic excitation spectra of superconducting Ca-Fe-Pt-As system," M. Sato et al., J. Phys. Soc. Jpn. **80**, 093709 (2011).
- "s<sub>±</sub>-like spin resonance in the iron-based nodal superconductor BaFe<sub>2</sub>(As<sub>1-x</sub>P<sub>x</sub>)<sub>2</sub> observed using inelastic neutron scattering," M. Ishikado et al., Phys. Rev. B **84**, 144379 (2011).
- "Neutron scattering of iron-based superconductors," S. Shamoto et al., Physica C **471**, 639 (2011) (proceedings of ICMS2010).
- "Inelastic neutron scattering on iron-based superconductor BaFe<sub>2</sub>(AsP)<sub>2</sub>," M. Ishikado et al., Phys. Conf. Series **340**, 012075 (2012) (proceedings of ECNS2011).
- "Dynamical Spin Susceptibility Studied by Inelastic Neutron Scattering on LaFeAsO<sub>1-x</sub>F<sub>x</sub>," M. Sato et al., J. Phys. Conf. Series **400**, 022105 (2012) (proceedings of LTP26).
- "On the superconducting pairing mechanism of Fe-based systems—Is it new or well-known?," M. Sato and Y. Kobayashi, Solid State Commun. **152**, 668 (2012) (Special Issue on Iron-based Superconductors).
- "Study of magnetic excitation spectra of several Fe-pnictide systems," M. Sato et al., J. Phys. Conf. Series **400**, 022105 (2012) (proceedings of LTP26).
- "High-energy magnetic excitations in underdoped La<sub>1-x</sub>Sr<sub>x</sub>CuO<sub>4</sub>," K. Sato et al., J. Korean Phys. Soc. **62**, 1836 (2013) (proceedings of ICM2012).
- "On the superconducting symmetry of Fe-based systems—impurity effect studies and neutron scattering measurements—," M. Sato et al., J. Korean Phys. Soc. **62**, 1726 (2013) (proceedings of ICM2012).
- "Temperature dependence of spin excitations in the frustrated spin chain system CuGeO<sub>3</sub>," M. Fujita et al., J. Phys. Soc. Jpn. **82**, 084708 (2013).
- "Switching of intra-orbital spin excitations in electron-doped iron pnictide superconductors," S. Iimura et al., Phys. Rev. B **88**, 060501(R) (2013).
- "Anisotropic spin excitations in spin-Peierls CaCuO<sub>2</sub>," K. Ikeuchi et al., J. Korean Phys. Soc. **63**, 333 (2013) (proceedings of ICM2012).
- "Inelastic neutron scattering study of phonon anomalies in La<sub>1-x</sub>Sr<sub>x</sub>NiO<sub>2</sub>," R. Kajimoto et al., J. Phys. Conf. Series, to be published (proceedings of APCC2013).
- "On the superconducting symmetry of Fe-based systems—impurity effects and microscopic magnetic behavior—," M. Sato et al., Suppl. of J. Phys. Soc. Jpn., to be published (proceedings of APCC12).
- "Temperature dependence of spin fluctuations in underdoped La<sub>1-x</sub>Sr<sub>x</sub>CuO<sub>4</sub>," K. Sato et al., JPS Conf. Proc., to be published (proceedings of SCES2013).

## Instrument Group

- JAEA
  - R. Kajimoto, M. Nakamura, Y. Inamura
- CROSS
  - K. Kamazawa, K. Ikeuchi, K. Iida, M. Ishikado (Technical support group)

