Magnetic Field measurement of the S-2S D1 magnet

@SNP School 2016

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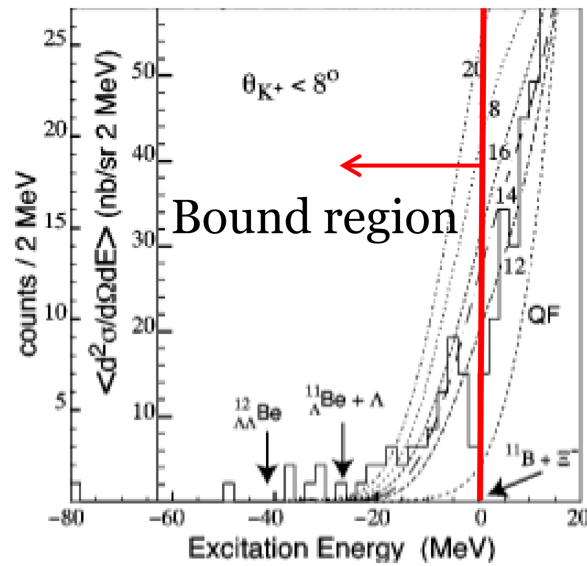
- Introduction
- Study of operation characteristics S-2S D1 magnet
- Field map measurement of S-2S D1 magnet

Study of Xi-hypernuclei

- What can we know from Ξ-hypernuclei ?
  - baryon-baryon interaction(Ξ-N, Λ-Λ)
  - role of multi-strangeness system in NS core
- Spectroscopic study via the $^{12}C(K^-,K^+)$ reaction
  - BNL-E885 experiment
    - Suggested existence of $^{12}{}_{\Xi}Be$
    - Estimated V_{Ξ} and dσ/dΩ
      - V_{Ξ}～-14 MeV
      - dσ/dΩ =89±14nb/Sr (θ<8°)
  - J-PARC E05 pilot run (2015)
    - SKS was used as the spectrometer for K+
    - Better missing mass resolution achieved
    - Observe significant excess in bound region

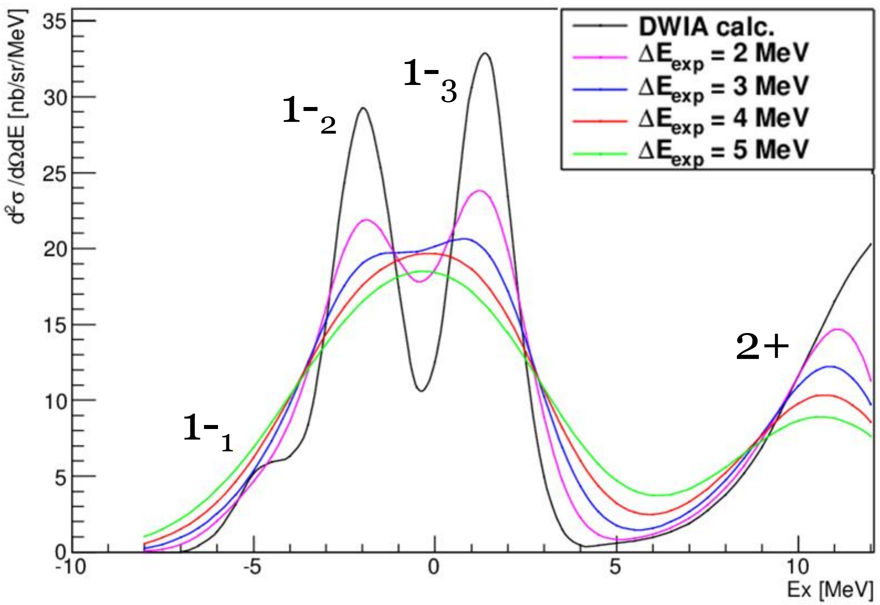


P. Khaustov et al., PRC 61 (2000) 054603

→Latest result will be presented in NSMAT 2016 ! (by S.Kanatsuki)

Why do we aim for better resolution ?

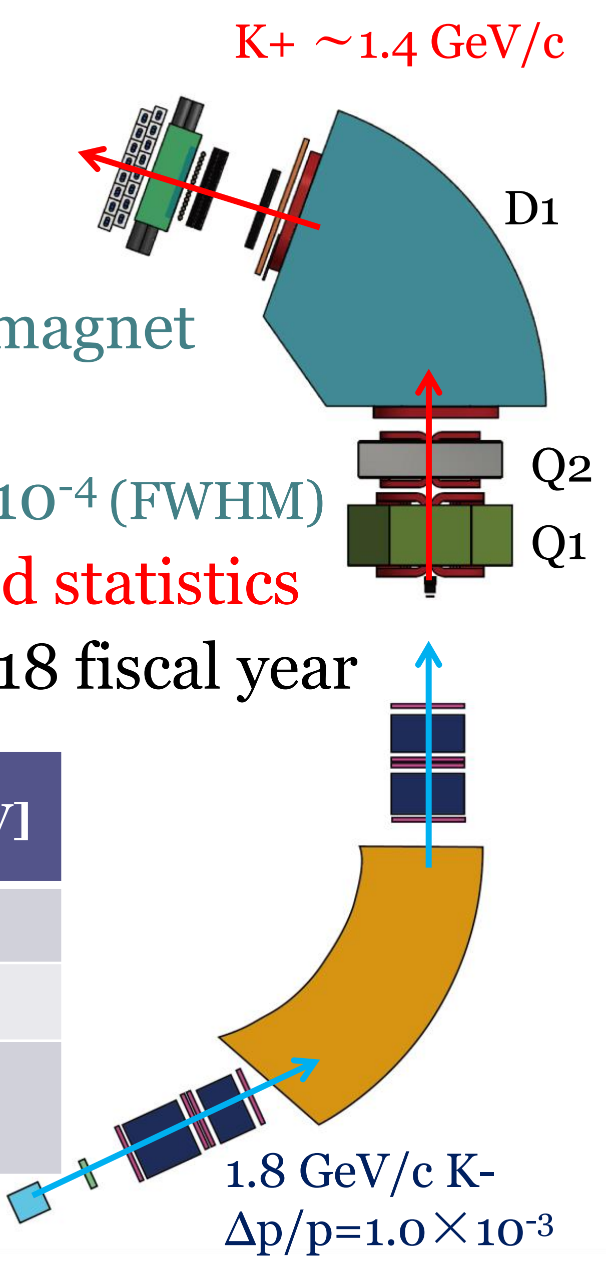
- To observe Ξ-hypernuclear state definitely as peak(s) in missing mass spectra
- To resolve excited states of Ξ-hypernuclei
  - Key to verify shell model and baryon-baryon interaction model
  - ΔE<2 MeV is essential



$^{12}_{\Xi}$Be production cross section calculated with DWIA (for ESC08a interaction)
T. Motoba and S. Sugimoto, NPA 835 (2010) 223

J-PARC E05 with S-2S

- New spectrometer S-2S (**S**trangeness **-2 S**pectrometer)
  - Consists of two Q magnets and D magnet
  - Acceptance ～60 msr
  - Momentum resolution $\Delta p/p = 5 \times 10^{-4}$ (FWHM)
  - →better missing mass resolution and statistics
- will be installed K1.8 beamline ～2018 fiscal year



	Acceptance [mSr]	Peak counts	ΔM[MeV]
BNL E885	50	42(θ<8°)	14
E05 (pilot)	110	39	7
E05 With S-2S	60	100	2

Significance of Magnetic Field Measurement

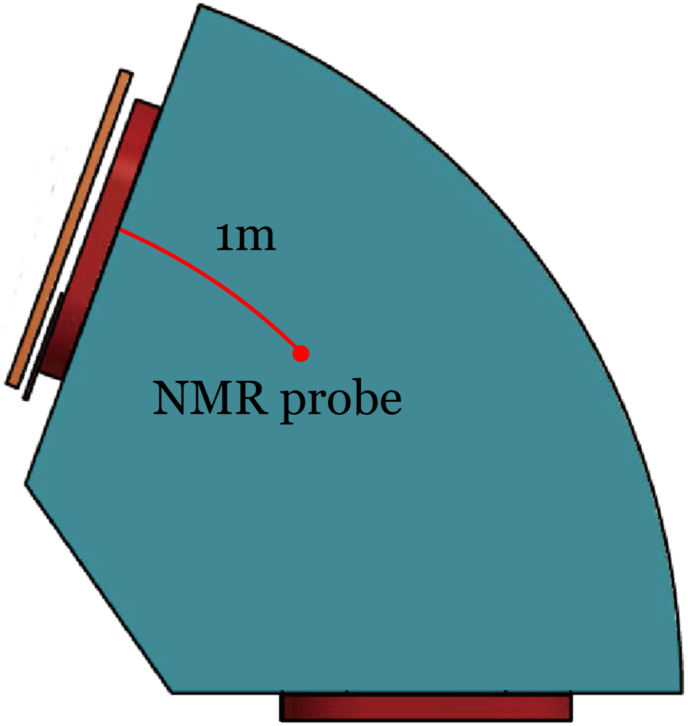
- We will use calculated magnetic field for analysis
  - The difference between calculated magnetic field and real one may make momentum resolution worse.
- Optimizing B-H curve and 3D-model, we make calculated magnetic field accurate.
  - As for the field map of the Q magnets, the consistency has been confirmed within +/-0.1%.
- For S-2S D1 magnet, we study operation characteristics and measure magnetic field map.

S-2S D1 magnet

- Gap volume: $800 \times 320 \times 3650$ [mm^3]
- Maximum central magnetic Field : 1.475 [T]
- Maximum current: 2500 [A]

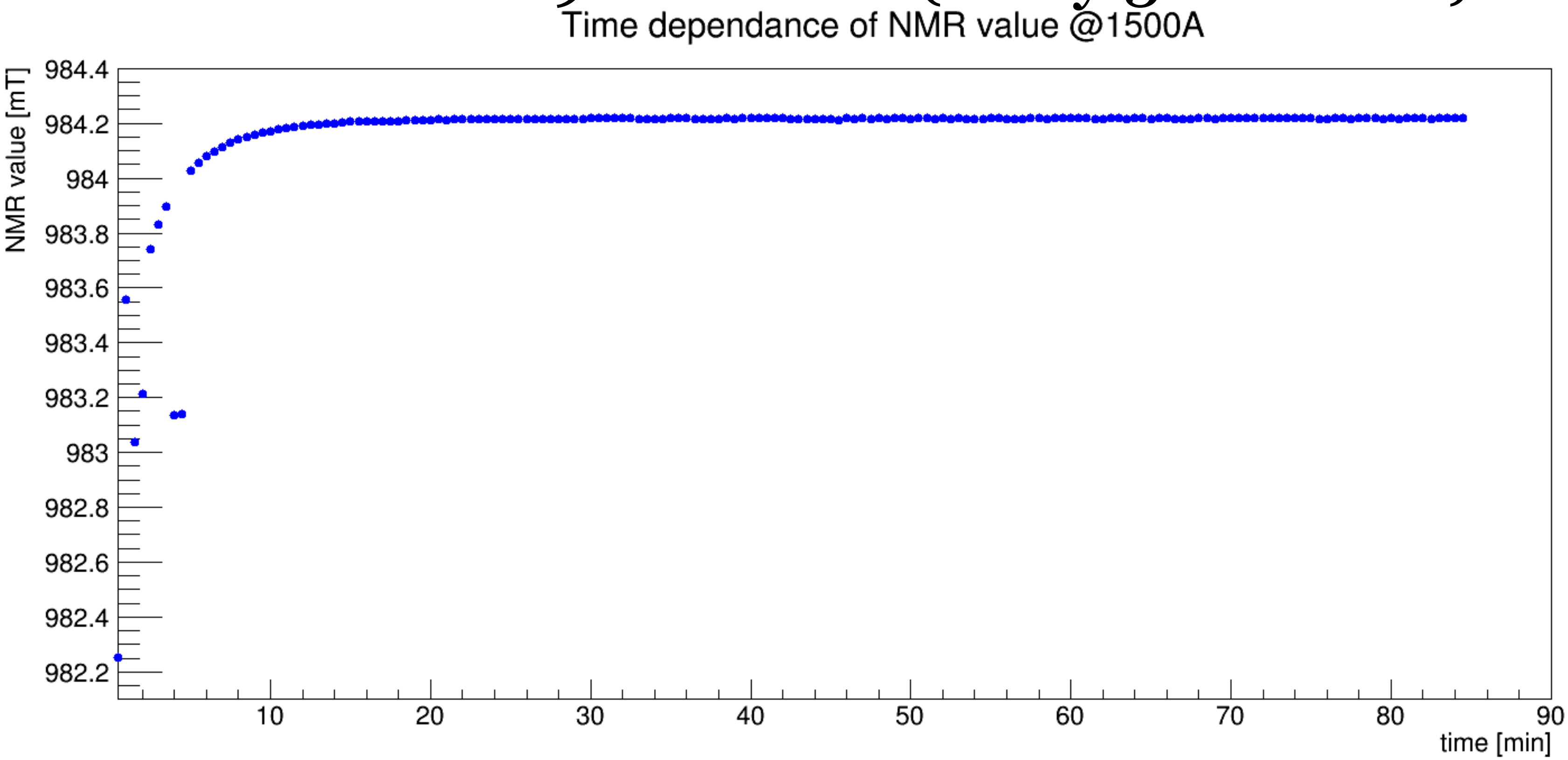
study of operation characteristics S-2S D1 magnet

- We put NMR probe in D1 magnet
  - NMR is also used to correct calculated field map and measured one with Hall-probe
- We take data for
  - Long-term stability
  - Excitation curve
  - Hysteresis



Long-term stability

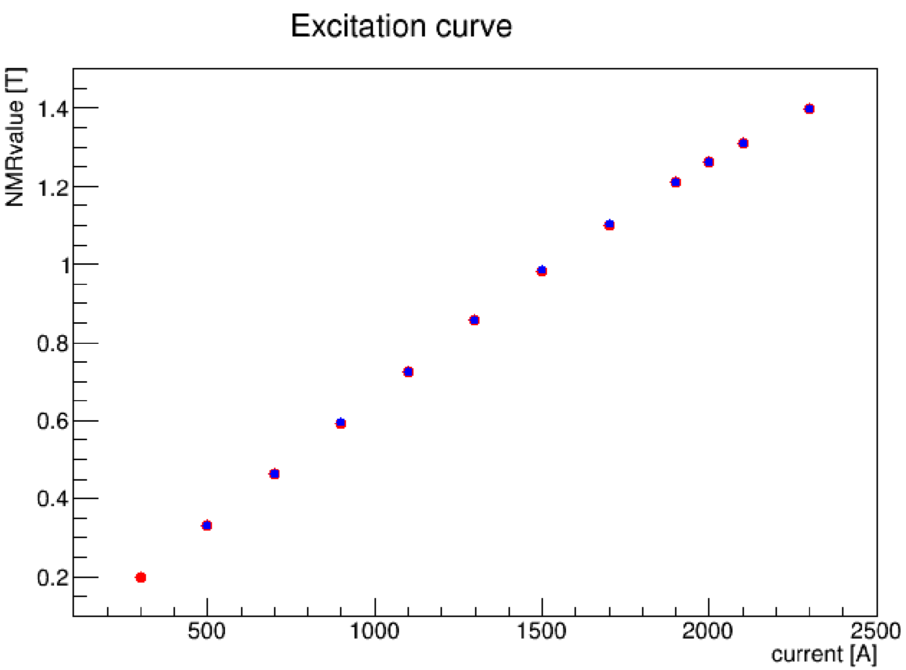
- From excitation @1500A, we had taken NMR data for about 90minutes. (every 30seconds)

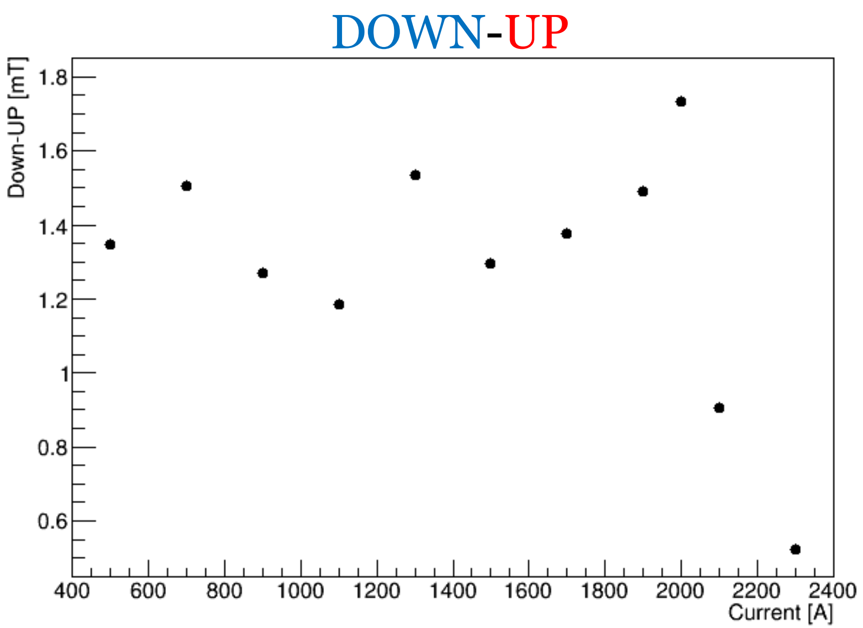


- 10 minutes after excitation, NMR value becomes very stable. (σ= 1.6μT)

Excitation and hysteresis curve

- Changing current and taking value of NMR
- 0A→300A→500A→・・・→2500A (UP)
- 2500A→2300A→・・・→500A→0A (DOWN)
- 0A→1100A→1500A→2000A (UP2)

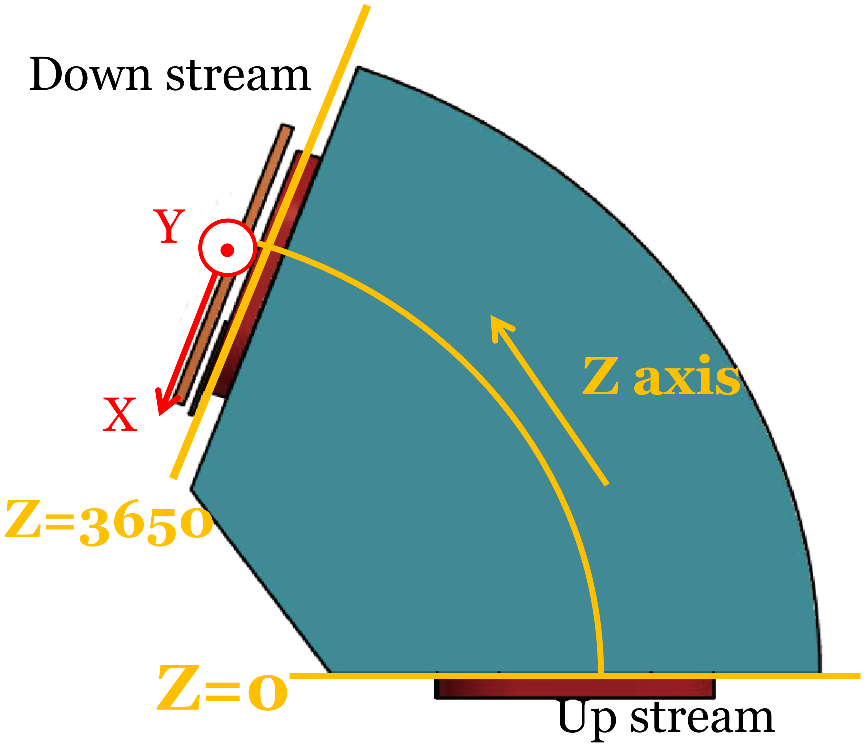


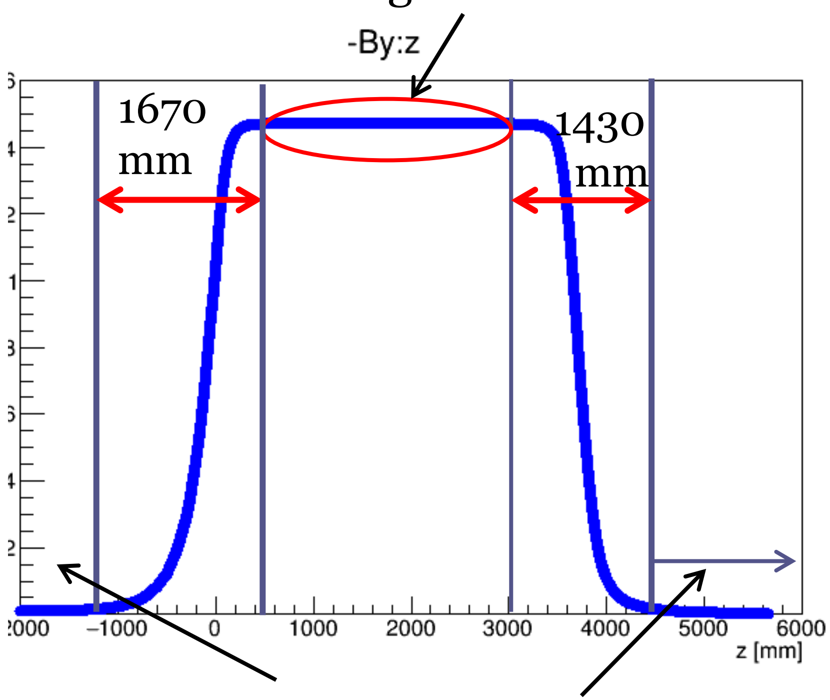


NMR value of “UP2” correspond with “UP” within 0.05 %.
→hysteresis effect is enough small.

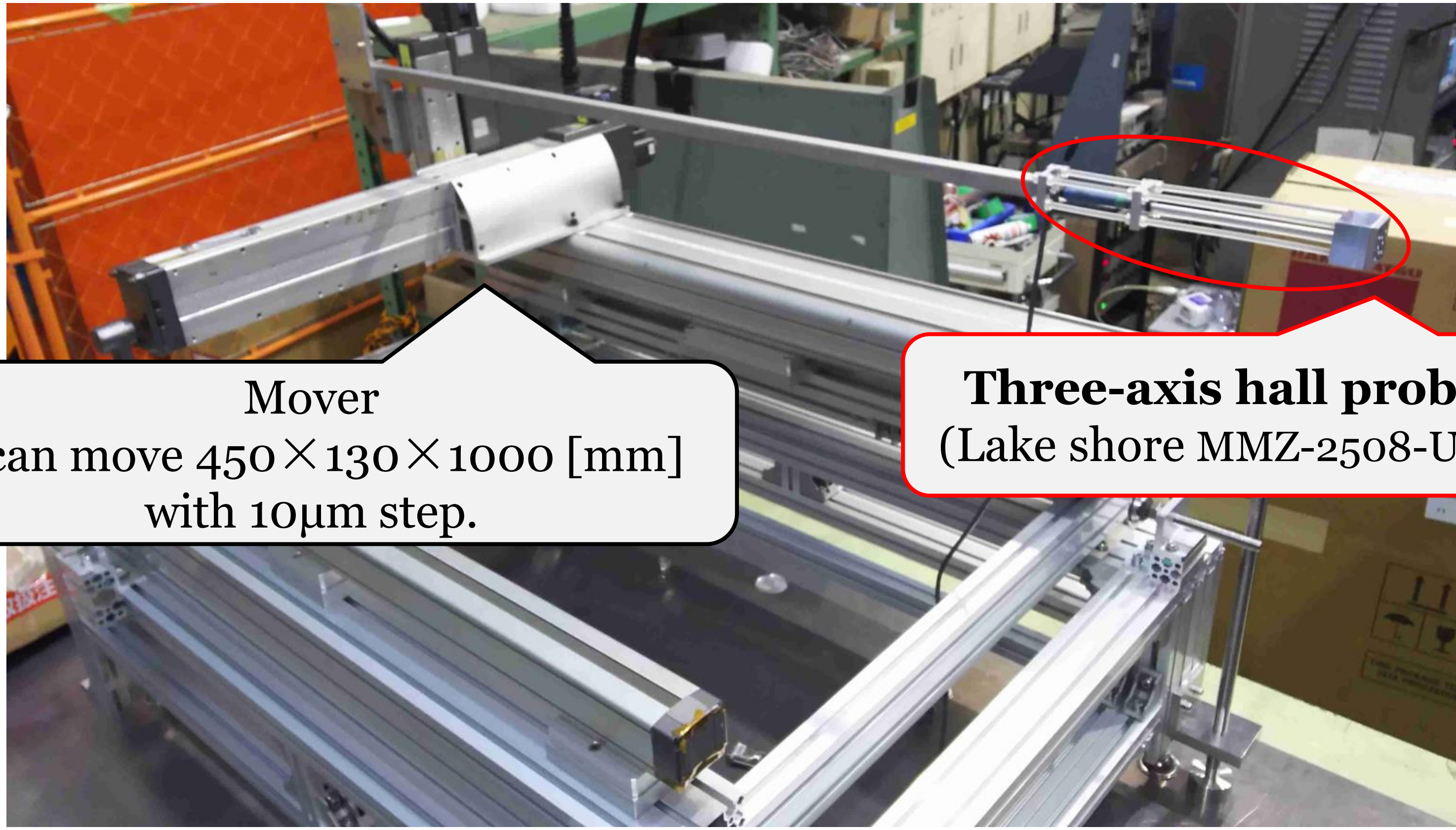
Consideration of field mapping volume

- 800mm×320mm×1700mm for each side (up stream, down stream)
- Step:50 mm× 20 mm × 50 mm





Field mapping system



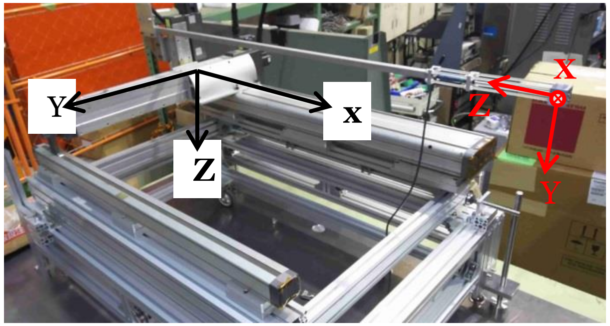
Mover
It can move 450×130×1000 [mm]
with 10μm step.

Three-axis hall probe
(Lake shore MMZ-2508-UH)

- To cover whole mapping area, we change position of this system 12 ways for each side of magnet.

Transformation between coordinates

- Defined three coordinates
  - "probe coordinates"
    - Measured (B_x,B_y,B_z)
  - "mover coordinates"
    - Position of probe (x,y,z)
  - "S-2S coordinates"
    - (x,y,z), (B_x,B_y,B_z) of calculated magnetic field



- To compare two magnetic field maps, transform measured value to S-2S coordinates.

$(x_{meas},y_{meas},z_{meas})$

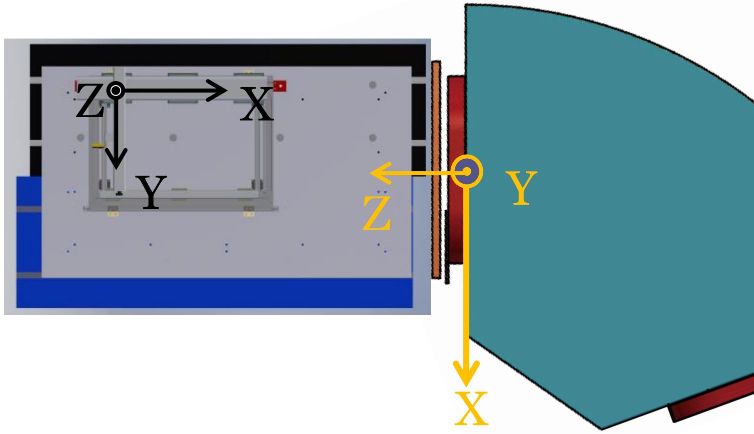
Parallel shift and
Change axis labeling
according to survey

$(x_{S\text{-}2S},y_{S\text{-}2S},z_{S\text{-}2S})$

$(Bx_{meas},By_{meas},Bz_{meas})$

Rotation
according to survey
(check ing symmetry
of magnetic field)

$(Bx_{S\text{-}2S},By_{S\text{-}2S},Bz_{S\text{-}2S})$



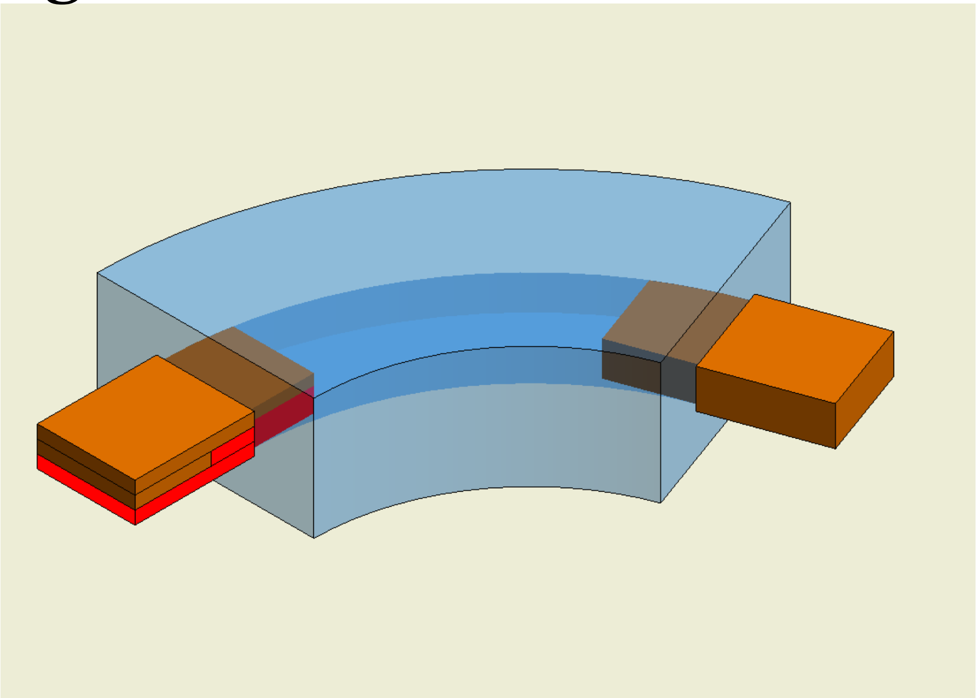
Error evaluation

parameters	Precision	accuracy
position	25μm	125 μm
Angle		0.01 degree
By (NMR)	2.0×10^{-4} %	
Bx,By,Bz(Hall probe)	50μT	0.1 %

- considering these errors in the field map, the total momentum resolution is estimated to be **6×10^{-4} (FWHM)** by simulation.
  - Event generation: Geant4, with calculated map
  - Analyzer :using Runge-Kutta method (when it reads calculated map, these parameters were fluctuated)

Present status

- Progress of measurement



Red・・・completed
Orange・・・To be measured

- About 50 %of down stream side was completed.
- Data analysis just started…

Summary

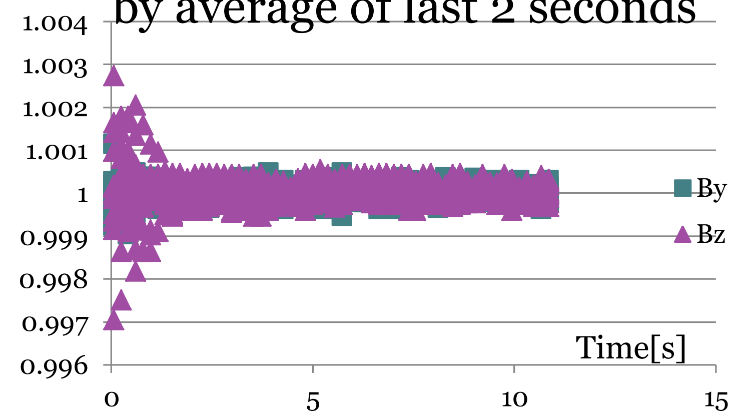
- New generation spectroscopy of Ξ-hypernuclei via the (K^-,K^+)reaction with the S-2S will provide us keys to understand baryon-baryon interactions by achieving unprecedented missing-mass resolution.
- The basic operation performance was studied for the D1 magnet.
- The magnetic field measurement of the D1 magnet is ongoing to check the consistency between the measured and calculated field maps.

Back up

How long should we wait to take data from the mover moving ?

- When the mover move, the position of hall probe may oscillate and therefore magnetic field will oscillate.
- @1500A
- Moving x±5 cm, y±5cm, z± 5cm(and conposition of these shift) and read hall probe value every 200ms, during 12minutes from moving.
- When we wait two seconds, magnetic field vary within 0.05%.

Magnetic field value normalized by average of last 2 seconds

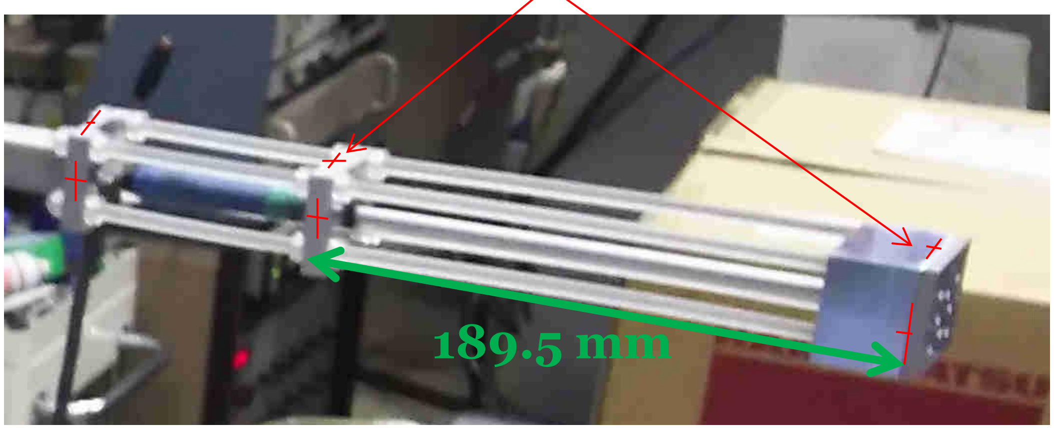


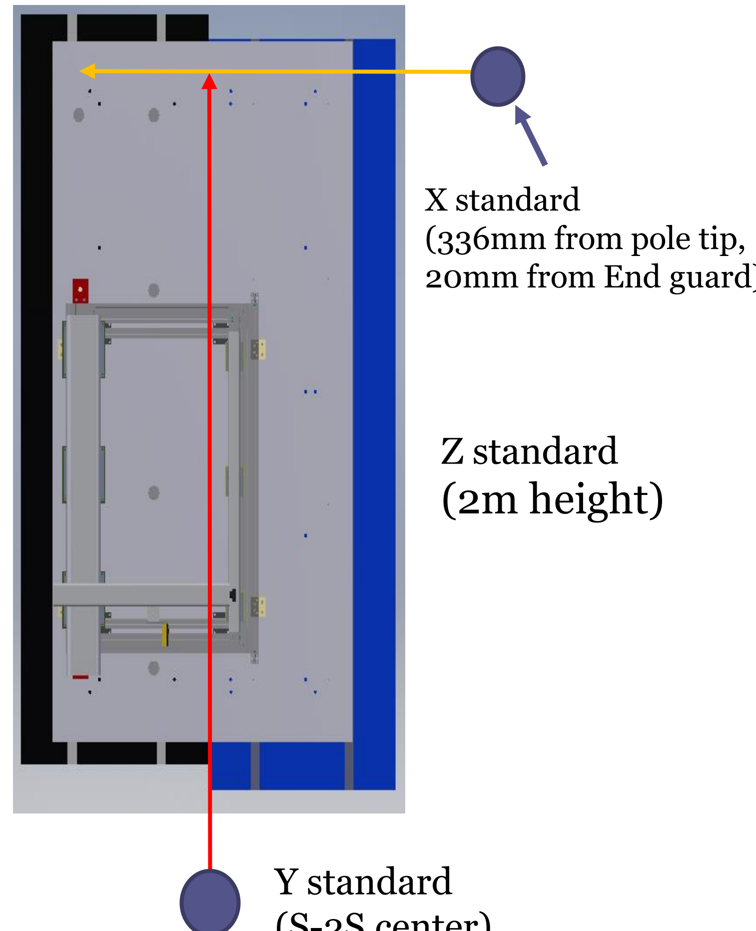
Standard and resolution of survey

- We set two theodolite and level on standard line.
- Move probe to see marking in center of theodolite and record value of mover moved.
- We could resolve 25μm

→angler resolution ∼0.01 deg.

Probe almost fixed this two point





Simulation for error estimate

- Generated K+
  - Momentum 1.3000±0.0975 [GeV/c]
  - Angle θ<10°