Development of Stripline-type Beam Position Monitor System for CSNS-II

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Abstract

As part of the CSNS-II upgrade, the H^- LINAC beam energy will be increased from 80 MeV to 300 MeV using superconducting cavities. To accurately measure beam position, phase, and energy, stripline-type Beam Position Monitors (BPM) are essential. The shorted-type stripline BPM was chosen for this upgrade due to its excellent S/N ratio and rigid structure. As space is limited in the LINAC's SC section, the BPMs must be embedded in the quadrupole magnet. Two prototypes, with inner diameters of 50 mm and 96 mm, were designed using numerical simulation codes and manufactured for beam testing. This poster details the simulation, design, and beam test results of the prototype BPMs for CSNS-II.

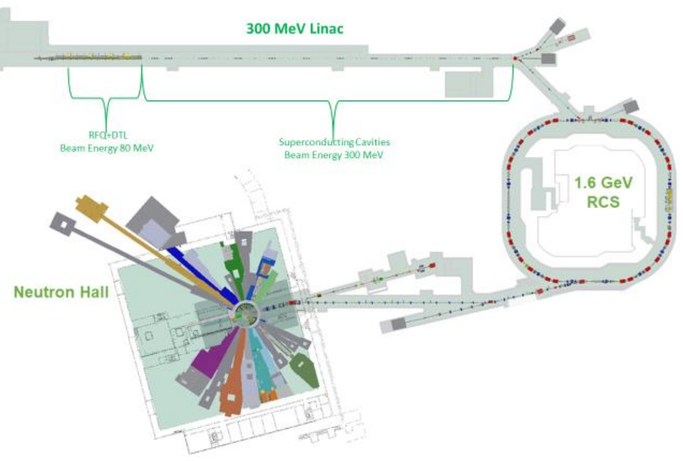
Introduction

- **The China Spallation Neutron Source (CSNS) is one of the major scientific facilities in China, constructed to deliver intense pulsed neutron beams for diverse scientific research and industrial applications**
- **The CSNS accelerator complex comprises an injector LINAC that accelerates the H^- beam to 80 MeV, 1.6 GeV RCS and tungsten target**
- **The power of the beam will be increased to 500 kW for CSNS-II**
- **The beam energy in the Linac will be raised from 80 to 300 MeV**
- **To ensure precise measurement of beam position, phase, and energy in the new superconducting section of the Linac, a new stripline-type Beam Position Monitoring (BPM) system is crucial**

The shorted-type stripline Beam Position Monitor (BPM) has been selected for this upgrade

- **Excellent signal-to-noise ratio**
- **Rigid structure**

Parameters	CSNS	CSNS–II	Units
Beam Power	100	500	kW
Injection Energy	80	300	MeV
Bunch Frequency	324	324/648	MHz
Bunch length	20	8	ps
Ring Circumference	227.92	227.92	m
Extraction Energy	1.6	1.6	GeV
Repetition Rate	25	25	Hz
Number of Bunches	2	2	
Beam Intensity	1.56×10^{13}	7.8×10^{13}	ppb

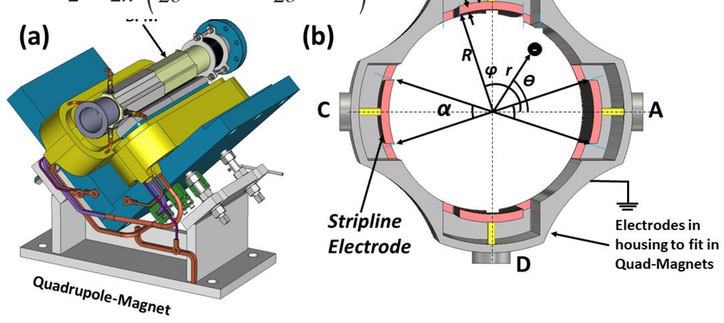


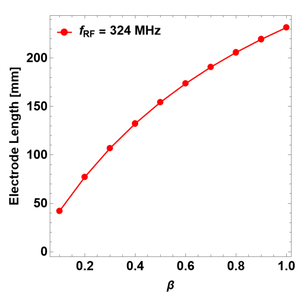
Development of Stirpline-type BPM for CSNS-II

Principle:

- The passage of a charged particle induced image current on a stripline is proportional to the distance between the electrode and the beam, beam intensity, the electrode's opening angle, and the stripline's length.

$$V(t) = \frac{Z_{strip}}{2}\frac{\alpha}{2\pi}\left(\frac{e^{-t^2}}{2\sigma^2} - \frac{e^{\left(t-l\left(\frac{1}{c}+\frac{1}{v}\right)\right)^2}}{2\sigma^2}\right) I_0$$



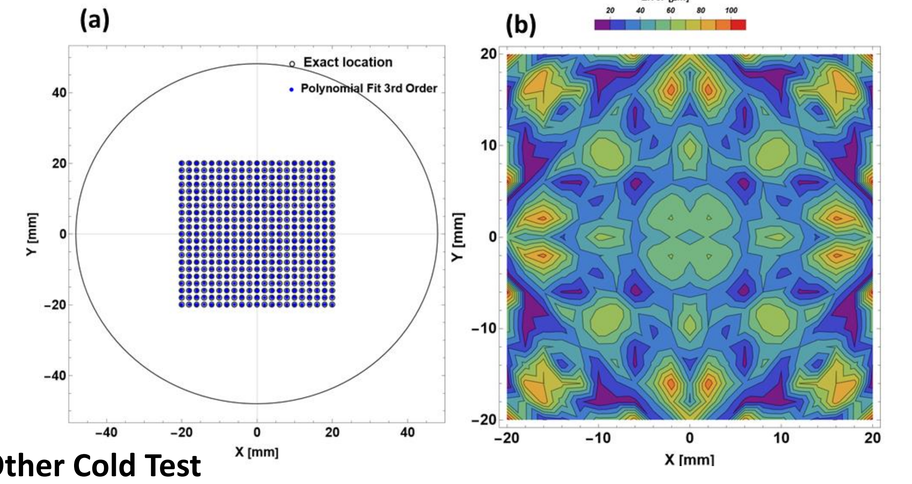


Parameters	T1	T2	T3	T4
Opening Angle	36.12	25.3	40.0	54.0
Stripline Length	143.6	183.2	183.2	231.5
Stripline Thickness	2.0	2.0	2.0	2.0
Inner Diameter	50.0	96.0	96.0	52.0
Quad Embed	Yes	Yes	No	No

Parameters	Values
Position Accuracy	1% of R
Position Resolution	50 µm
Phase Accuracy	1 Degree
Phase resolution	0.2 Degree
Meas. Range	R/2

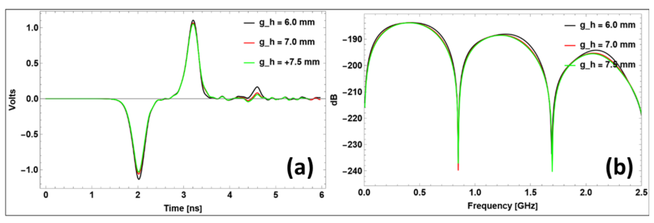
Position Characteristics:

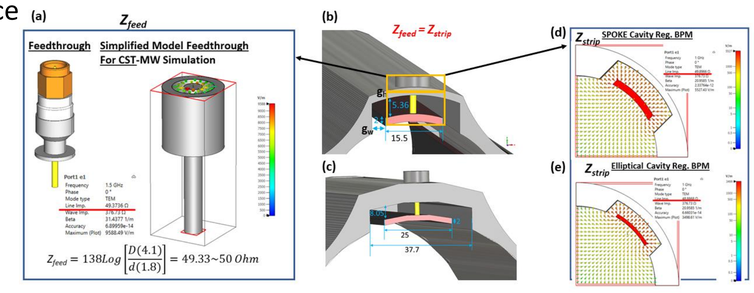
- The position characteristics of proto-type BPMs were evaluated using the wire calibration system. The 3rd order polynomial fit was used to correct the beam position non-linearities
- The spoke cavity region BPMs maximum absolute error of 40 µm
- The elliptical cavity region BPM error 48 µm
- Which is less than the 1% of half of the radius



Impedance Matching:

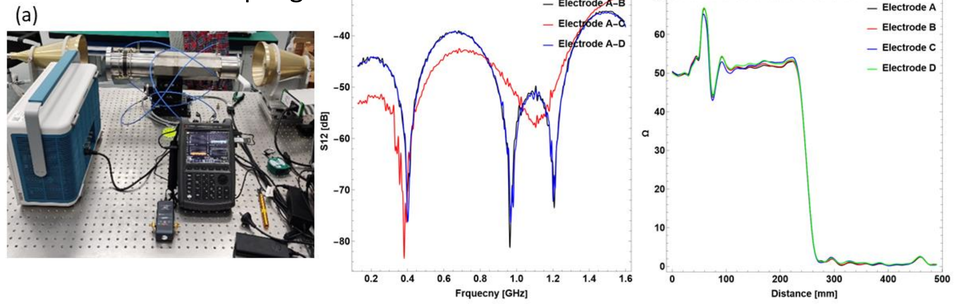
- The impedance of cables, feedthrough, and electrodes must be matched to avoid signal reflection and deformation
- Stripline electrode optimized for the 50 Ω impedance





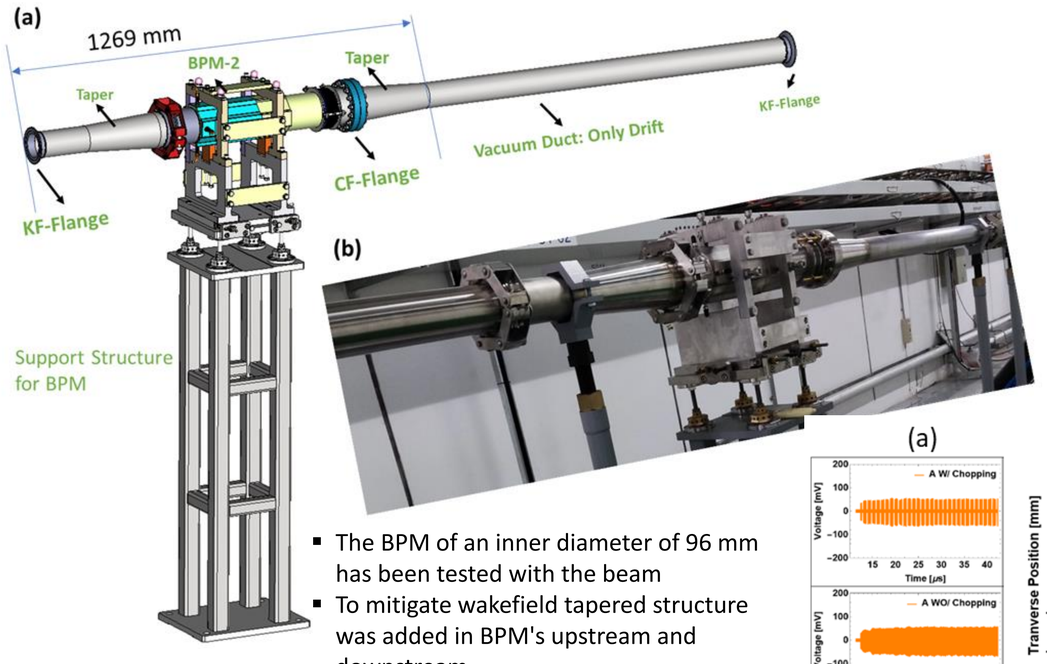
Other Cold Test

- TDR
- Electrodes coupling

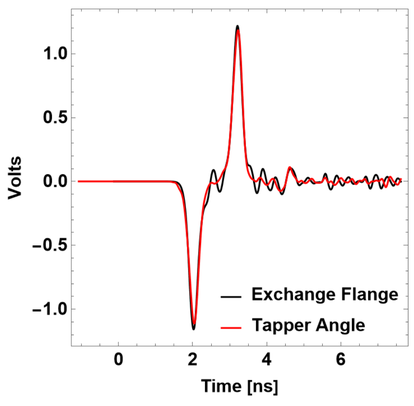


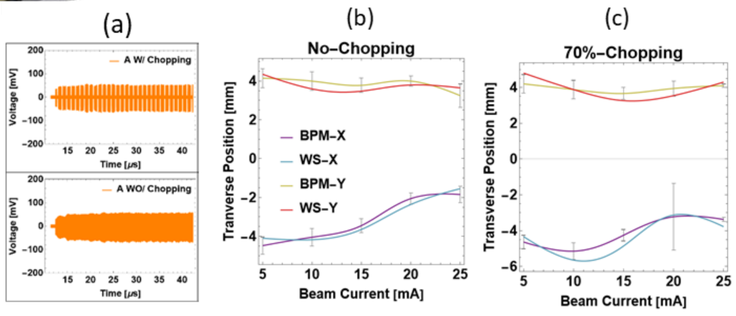
Experiment

Beam Test



- The BPM of an inner diameter of 96 mm has been tested with the beam
- To mitigate wakefield tapered structure was added in BPM's upstream and downstream





Summary

- As a part of the CSNS-II power upgrade the H^- injector Linac beam energy will be increased to 300 MeV
- The stripline-type BPM system has been simulated, and the design and prototype were manufactured.
- The length of the BPM electrodes was optimized according to the beam energy.
- Through numerical simulations, the geometry of the BPM has been optimized to obtain 50 Ω impedance of the electrodes
- Two prototype BPMs were manufactured, and the wire mapping of the BPMs was performed
- The wire test achieved a position accuracy of better than 50 µm.
- One BPM with an inner diameter adequate for the existing beamline was tested with the beam, and the beam transverse position along the injector LIANC was measured.

References

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