





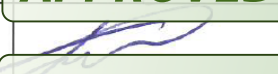


## Requirement Specifications for BL4N Extraction Probe

Document Type: Requirement Specification

Release: 1

Release Date: 2016-06-20

Author(s): Y.-N. Rao

Name	Role	Scope	Signature	Date
Y.-N. Rao	Author	Design	 <b>APPROVED</b>	June 17 / 2016
R. Baartman	Reviewer	Design	 <b>APPROVED</b>	20 June 2016
I. Bylinskii	Reviewer	Design	 <b>APPROVED</b>	17-JUN-2016
V. Verzilov	Reviewer	Design	 <b>APPROVED</b>	6/17/2016
R. Laxdal	Approver	Design	 <b>APPROVED</b>	20-JUN-2016

I. BYLINSKII FOR  
R. LAXDAL

*Note: Before using a copy (electronic or printed) of this document you must ensure that your copy is identical to the released document, which is stored on TRIUMF's document server.*

Requirement Specification for BL4N Extraction Probe		
Document: 133054	Release No: 1	Release Date: 2016-06-20

**History of Changes**

<b>Release Number</b>	<b>Date</b>	<b>Description of Changes</b>	<b>Author(s)</b>
1	2016-06-20	First Release	Y.-N. Rao

# 1 Abstract

The Beam Line 4 North (BL4N) extraction probe is spec'ed in this document in terms of probe's locus, stripping foil assembly's geometrical shape, size and vertical motion range.

## 2 Objective

The BL4N shall deliver proton beam from the 500 MeV cyclotron to the ARIEL target. This note describes the specification of BL4N extraction probe, covering probe's locus, stripping foil assembly's geometrical shape, size and vertical motion range.

## 3 Top Level Requirements

**RS1.** The BL4N shall be solely used to provide proton beam from the extraction port #4 of TRIUMF cyclotron to the ARIEL target [1]. As such, it's required [2] that the energy range of the beam extracted be the same as that of the existing BL2A, that is, between 475 and 500 MeV. Over this energy range, the stripping foil must be positioned such that the reference trajectories of the extracted beam come in through the cross-over point of the combination magnet, and exit out of the axis of the combination magnet with zero degree angle and then go straight down to the beamline.

*Rational:* With zero degree angle exit out of the combination magnet axis, the beam properties and beam line optics appeared to be fully understood, but not at all in the case of angling exit of  $-5^\circ$ . This was shown in the old BL4 days [3].

**RS2.** The extraction 4N (Ex4N) probe shall support extraction of beam intensity up to  $200 \mu\text{A}$ .

*Rational:* There is a plan to build a  $200 \mu$  beam dump on a straight extension of the vault section of BL4N. This will be used for the cyclotron high intensity tuning. Note that the extraction 1 (Ex1) ever had  $200 \mu\text{A}$  extracted down to BL1A with a 0.625" wide and  $4.00 \text{ mg/cm}^2$  thick C-foil; this happened on 2010-Oct-27's beam development shift for about 2 hours.

**RS3.** In order to save on R&D effort, the Ex4N probe shall replicate the existing extraction 2A (Ex2A) probe design and be built based on the set of Ex2A drawings [4].

*Rational:* The Ex4N probe shall operate over the same energy range as Ex2A probe, thus has a similar operating envelope. The Ex2A probe was built after Ex1 probe, so all of the lessons learned went into the design [5]; it has been running steadily and reliably.

## 4 Specific Requirements

**RS4.** The Ex4 probe shall be installed into the cyclotron original Ex4 probe port.

*Rational:* This configuration supports the beam extraction pass down to the BL4N extraction port. Note: The Ex4N probe's interface with the cyclotron port has been modified from original configuration with the vacuum gate valve relocated to outside of the main magnet yoke.

**RS5.** The Ex4N stripping foil's locus shall be such that the proton beam over the entire energy range from 475 to 500 MeV shall be extracted out of the combination magnet axis with zero degree angle. Table 1 lists the required locus coordinates [7].

*Rational:* The zero degree angle exiting is natural, and barely caused any struggling to the beam line tuning and optics modeling in the old BL4 days, as opposed to the case of  $-5^\circ$  angling exit.

**RS6.** The Ex4N shall follow the current operation mode between Ex2A and Ex1A, that is, by radial shadowing of the foils to achieve desired split of beam intensity; while in the vertical direction these foils are fully intercepting the circulating beam. This suggests that the Ex4N foil shall replicate the existing ones for the Ex1A and Ex2A (as shown [8] in Fig.1; these two are identical) in terms of the foil assembly's shape, size and materials and vertical motion distance.

*Rational:* The current 1A and 2A extraction foil's assembly works well in regards to the foil's lifetime in mA-hours, contamination release, extracted beam quality and stability.

**RS7.** The Ex4N probe controls shall be modernized.

*Rational:* The existing extraction probes controls is out of date and soon may lack of an adequate support from the Controls Group.

**RS8.** The foil absolute positioning accuracy, adjustment step precision, position read-back resolution shall be similar to that of existing 1A and 2A probes.

*Rational:* Existing 1A and 2A probes mechanical precision is adequate for the intended purpose.

Table 1: STRIPUBC calculated extraction stripping foil's locus under condition that the beam exits at  $0^\circ$  w.r.t. the combination magnet axis. Note that the origin of the coordinate system is in the center of cyclotron;  $+x$  axis, on which  $\theta = 0^\circ$ , is directing to the right-hand side Dee gap center line while  $+y$  axis is  $90^\circ$  counterclockwise rotation from  $+x$  axis.

p-beam energy (MeV)	$0^\circ$ exit for BL4N			
	r(inch)	$\theta$ (degr)	x(inch)	y(inch)
449.510	302.886	53.501	180.159	243.480
453.506	303.574	53.510	180.530	244.062
457.501	304.268	53.521	180.896	244.654
459.499	304.616	53.527	181.077	244.953
461.497	304.963	53.532	181.262	245.248
463.495	305.310	53.537	181.447	245.543
465.493	305.654	53.544	181.621	245.842
467.490	305.999	53.549	181.805	246.135
469.488	306.343	53.555	181.983	246.431
470.487	306.515	53.560	182.064	246.585
472.485	306.859	53.566	182.242	246.881
473.484	307.032	53.569	182.332	247.030
474.483	307.204	53.573	182.417	247.181
475.482	307.376	53.576	182.506	247.329
477.480	307.719	53.583	182.680	247.627
479.477	308.059	53.590	182.851	247.923
480.476	308.228	53.593	182.939	248.068
481.475	308.396	53.597	183.021	248.216
483.473	308.729	53.601	183.201	248.497
485.471	309.059	53.609	183.362	248.788
487.469	309.386	53.615	183.530	249.071
489.466	309.712	53.620	183.702	249.349
491.464	310.037	53.626	183.869	249.630
493.462	310.361	53.632	184.035	249.910
495.460	310.684	53.637	184.204	250.187
496.459	310.845	53.640	184.287	250.326
497.458	311.006	53.642	184.373	250.462
498.457	311.166	53.645	184.455	250.601
499.456	311.326	53.648	184.537	250.739
500.454	311.486	53.650	184.623	250.874
501.453	311.646	53.653	184.705	251.013
503.451	311.963	53.658	184.870	251.284
505.449	312.278	53.662	185.040	251.551
507.447	312.593	53.666	185.209	251.818
509.445	312.911	53.669	185.384	252.084
511.443	313.233	53.672	185.561	252.353

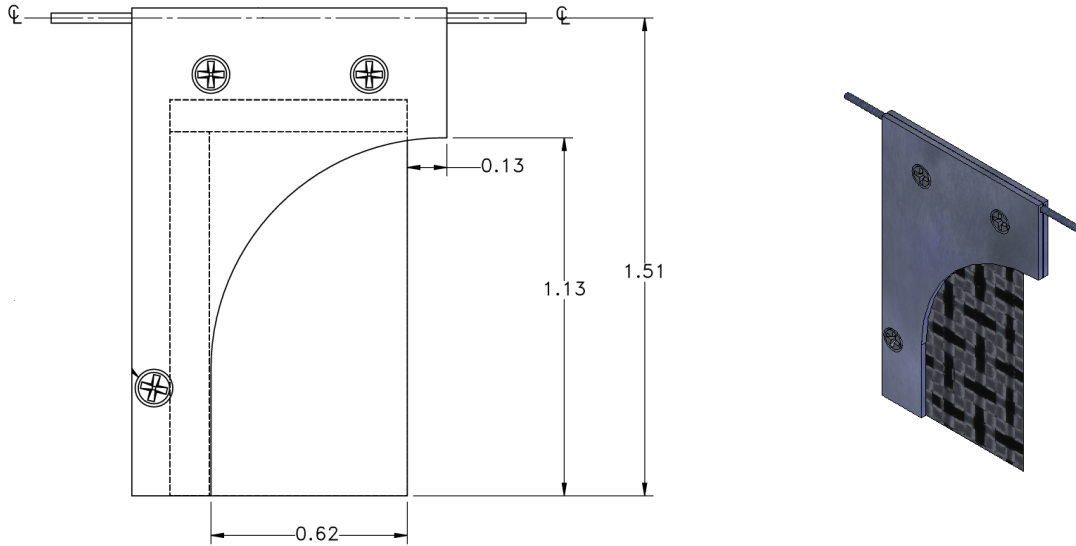


Figure 1: Geometrical shape and size of the current extraction foil's assembly for the Ex1A and Ex2A. The BL4N extraction foil's assembly shall replicate this.

## References

- [1] Y.-N. Rao, R. Baartman, *TRI-DN-13-13: Beam Line 4 North (BL4N) Optics Design*, Document-91008, Release 5, 2015-07-23.
- [2] R. Laxdal, *ARIEL Top Level Requirements-P0342*, Document-118534, Release 2, 2016-02-27.
- [3] S. Yen, Private communication, Dec.17, 2015.
- [4] *10 FOIL SWING ARM, GENERAL INFORMATION EXTRACTION PROBE 2A, PROBE HEAD*, DWG. NO. IEC0050E, REV. A, DEC.'99;  
*OVERAL LAYOUT, BL2A EXTRACTION PROBE*, DWG. NO. IEC0174D, REV. A, 24/OCT/96;  
*PROBE IN PARK POSITION, BL2A EXTRACTION PROBE*, DWG. NO. IEC0191D, REV. A, JAN. 20/07.
- [5] Scott Kellog, *Cyclotron Extraction Probes 1 and 2A – History and Changes*, July 16, 2013.
- [6] Y. Bylinsky, E-mail communication, Nov.14, 2011.
- [7] Y.-N. Rao, *Requirement Specications for BL4N Extraction Stripping Foils Locus*, TRI-BN-16-05, Mar. 1, 2016.
- [8] S. Kellog, *C-FOIL FRAME ASSEMBLY; EXTRACTION 1/2A FOIL ASSEMBLY; EXTRACTION 1/2A PROBE*, DWG. NO. TEC0047, NOV.30/09.