From: Fedurin, Mikhail
Sent: Wednesday, July 22, 2015 12:58 PM
To: Fedotov, Alexei
Cc: Miller, Toby; Shaftan, Timur; Seletskiy, Sergei; Gassner, David M; Thieberger, Peter; Minty, Michiko; Fischer, Wolfram; Blaskiewicz, Michael M; Pinayev, Igor; Kayran, Dmitry; Kewisch, Jorg; Tuozzolo, Joseph E; Smith, Kevin S; Michnoff, Robert J; Montag, Christoph; Hoffman, Caitlin
Subject: Re: LEReC Instrumentation Meeting

Alexei and Toby,
Thank you for presentation. Here is my comments/suggestions:

1) I am agree that 1E-3 accuracy in dipole field profile in magnet at 180 gauss level will be a challenge.
a) you can do it with Hall probe if use well temperature compensated and calibrated one with effort to stabilize temperature in surrounding environment.
b) you can use NMR probes. It should not sense temperature change, NMR capsule has a size that make it sensitive to field homogeneity which should be not be a problem at 180 gauss filed level, on other side such a low field may be a hard thing for probe accuracy.
c) if magnet mapping will be difficult you can go with stretched wire method. set up ratio of "current in wire"/"wire tension" appropriate for beam energy and find filed (ps current) for required bending angle.

2) I think beam profile and position can be monitored during operation with OTR BPM that in self not a foil but well cooled metal plate at 45 degree to the beam. Cooling system for that BPM at 100kW heat load have to be designed, but keeping in mind that heat from beam power may not be a big issue because its not constant load, its depend how long you keep that BPM inserted. AT 1.6MeV backward OTR radiation from 45 degree mirror may need special optic setup for camera, but i saw in your instrumentation OTR BPM with foil for single bunch measuremnts, so you may already have everything ready.

This 45 degree OTR BPM will be inserted in to operational beam and absorb full beam power - this can be used for charge measurements too, just need to integrate Faraday cup in it. In this case you could measure beam position, profile and charge of operational beam at the same time

3) Energy collimator i mentioned during talk may be implemented after redesign of beam optic in dispersion section. At collimator place you will need horizontal beam size as small as possible and dispersion as big as possible, so beam size from dispersion will have big domination over betatron size. It may require an effort and a few additional convenient type quadrupoles. May be a theme for good project later

Regards,
Mikhail

From: Shaftan, Timur
Sent: Wednesday, July 22, 2015 11:09 PM

Hi Alexei,

Thank you for inviting us to this interesting meeting.
Below I offer some of my impressions and opinions focusing on the project diagnostics.
With best regards,
Timur.

· The LEReC accelerator is a ~90 m long beamline that contains tens of focusing and RF devices and is designed to operate in two modes of operations: without and with energy recovery. In addition, two modes of intensity operations (with low- and high repetition rate) are foreseen that should help with speedy commissioning. Diversity of LEReC operating modes calls for careful assessment of quantities and capabilities of various diagnostics devices suited to measure beam properties under various operating conditions (different intensities, different beam envelopes, evasive / invasive types). Every operating scenario should be assessed and equipped with diagnostics devices separately so to avoid major changes in the machine built-out as the project progresses.

· It is prudent to base specification of the machine beam diagnostics on the outcome of the detailed beam dynamics analysis. Plotting transverse and longitudinal beam envelopes on the same plot together with dispersion could help to position the diagnostics devices in most appropriate and economic way. In general, diagnostics stations should be positioned at the locations prior and after machine subsystems that capable of changing beam envelopes or impacting the beam intensity.

· Analysis of the beam dynamics should address uncertainty with the beam initial conditions out of the gun. The value of energy spread (5E-4 at 1.6 MeV) required for the ion cooling corresponds to 800 eV and seems hardly realistic. Especially the energy spread, which appears to be the main factor controlling the ion cooling rate, need to be analyzed and scenarios with larger intrinsic energy spread should be assessed. Effects of beam timing and intensity jitters should receive careful attention to make sure that the diagnostics will be capable of robust measurements of off-energy / off-axis beams.

· In particular, including more stations for measuring energy / energy spread / energy jitter should be considered as the energy spread may change along the machine impacting the cooler performance. We support the idea of having compact kicker beamlines to deflect a portion of the high current beam to a beam screen under the assumption that these stations can be made efficient and inexpensive. Cooled copper mirror can reliably serve as a transverse diagnostics for the beam carrying power in the range of ~ten kW. Rich experience from the BINP's microtron-recuperator 300 keV / 2 MeV injector should be taken into the consideration.

· As majority of the beam diagnostics hinges on the BPMs, their sensitivity, noise and accuracy in measurements of the low-energy low-charge beams should be carefully analyzed and optimized. For these BPMs located in the cooling regions one needs to consider additional signals driven by the ion beam and devise a solution as how to separately measure electron and ion beam coordinates and intensities.

· Lastly, the only diagnostics of bunch-to-bunch intensity distributions will follow from the time domain measurements of laser intensity in the photocathode gun. We advise to consider including alternative diagnostics that will enable measurements of electron bunch pattern along the way.

From: Seletskiy, Sergei
Sent: Monday, July 27, 2015 4:02 PM
To: Miller, Toby; Fedotov, Alexei; Shaftan, Timur; Fedurin, Mikhail; Gassner, David M; Thieberger, Peter; Minty, Michiko; Fischer, Wolfram; Blaskiewicz, Michael M; Pinayev, Igor; Kayran, Dmitry; Kewisch, Jorg; Tuozzolo, Joseph E; Smith, Kevin S; Michnoff, Robert J; Montag, Christoph; Hoffman, Caitlin
Subject: RE: LEReC Instrumentation Meeting

Dear Alexei and Toby,

Once again, thank you for inviting us to the meeting. It was very interesting and I, personally, learned a lot .
Here is a couple of points I'd like to make with regard to what we discussed last Tuesday:

While I agree that measuring the absolute energy of the beam with 0.1-0.2 % precision is a challenge I believe that providing the energy stability at 0.0001 level and controlling energy spread at 0.0005 level is even more challenging. I guess my point here is that I would be concerned with achieving such level of stability more than with any other aspect of the project.
The dedicated longitudinal phase space diagnostics is a must. I would definitely proceed with the plans of installing "vertical deflecting cavity – bending magnet" diagnostics beamline. I also agree with Misha's suggestion on using OTR screen there for the full e-train and with Timur's concern about having diagnostics at a single point only, while having 4 RF knobs. If overall impedance budget prohibits installation of even the simplest additional diagnostics ("spectrometer bend"-type) downstream of each RF cavity then it is crucial to prepare a set of realistic simulations showing what longitudinal phase space you expect to observe at the location of your diagnostic beamline when you turn the cavities one by one.
It is critical to know the transverse profile of the e-train in the cooling section. I would consider installing several laser wires there. These are the non-destroyable, precise (<1 um precision) devices that can be used for the full power e-beam and even in the presence of heavy ions in the cooling section. I also believe that the laser wire is not an expensive device unless you need to use something as fancy as Shintake Monitior, which has nm resolution capabilities.

Cheers,

Sergei

	M. Fedurin	T. Shaftan	S. Seletskiy
Diagnostics	#2 measure beam profiles with full-current-compatible OTR	#1 careful assessment of quantities and capabilities of the various diagnostics under different operating conditions #4 use multiple compact kicker beamlines + full-current-compatible OTR (cooled copper mirrors) #5 study and optimize BPMs based on sensitivity, noise and accuracy #6 consider diagnostics for bunch pattern (i.e. bunch-by-bunch)	#2 proceed with vertical deflecting cavity + bend + full-current-compatible OTR #3 include several laser wires in cooling section
General Concerns	#1 measurement accuracy (180 Gauss level) of 180 deg dipole challenging #3 energy collimator after beam optic redesign	#2 diagnostics specs and placement should be based on detailed beam dynamics analysis #3 beam dynamics analysis should address uncertainty in initial conditions from the gun	#1 “more than any other aspect of project…” be concerned with • providing energy stability (1E-4) • controlling energy spread (5E-4)