HEPS Injection (Gang Xu)

With antibend & ID Case (Circonference=1360.4m)

\( h=756, \ E_0=6000, \ \alpha_0=1.35\times10^{-5}, \ U_0=4.5, \ \Phi=\pi, \ h_0 \alpha_0 \ E_0 \delta_{acc}=0.03, \ V_{acc}=\delta_{acc}^2 \ \Phi, \ \varphi s=\pi \)

\( \Delta t=2.14\text{ns} \) between injecting and circulating beam (center to center)

If considering effect of GolfClub \( \Delta t=2.4\text{ns} \)

**RF gymnastics for long. acc. & swap-out with BR for acc.@high E**

- **Challenge of “swap-out” injection**: a full charge injector
  - “Charge recovery” in the booster at 6 GeV

- **Two high-energy transport lines**

- **Three 7BA arcs in between**

- **RF Modulation --- elegant tracking**
  - **Phase Modulation**
    - Modulation amplitude: 0.1 rad;
    - Modulation frequency: ~26 kHz, corresponding to 2 times synchrotron oscillation frequency;

- **Element-By-Element**

  Transmission is only 84%
**Diamond-II: Injection**

- 1 mm thick
- ~2 mm for injected beam
- Requirements on injected beam:
  - 3.5 GeV
  - Emittance in range 10-30 nm.rad
  - Bunch length in range 20-40 ps

**Proposal is to use ‘anti-septum’ storage ring injection scheme**

- Off-axis accumulation
- Standard 4-kicker bumps for stored beam
- Kicker 3 contains thin (1 mm) ‘anti-septum’ plate
- Appears like a drift space for injected beam
- Separation of stored / injected beams ~ 3mm

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Septum</th>
<th>Kicker</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnetic Length</td>
<td>1.67 m</td>
<td>0.6 m</td>
</tr>
<tr>
<td>Bend angle</td>
<td>148.4 mrad</td>
<td>9.3 mrad</td>
</tr>
<tr>
<td>Bend radius</td>
<td>11.3 m</td>
<td>64.5 m</td>
</tr>
<tr>
<td>Magnetic field</td>
<td>1.04 T</td>
<td>0.18 T</td>
</tr>
<tr>
<td>Pulse shape</td>
<td>Full-sine</td>
<td>Half-sine</td>
</tr>
<tr>
<td>Pulse duration</td>
<td>160 μs</td>
<td>6 μs</td>
</tr>
<tr>
<td>Rep rate</td>
<td>5 Hz</td>
<td>5 Hz</td>
</tr>
</tbody>
</table>

*C. Gough, M. Alba, IPAC’17, MOPIK104

**New Booster: Installation Strategy**

- From Linac
- 1.73 m
- New booster
- LTB
- 1.85 m
- Existing tunnel > 4.0 m wide

**Diamond-II: Accumulator (Ian Martin)**

Build new BR for use as AR @ low E
Injection for SLS-II (Masamitsu Aiba) $A_z$ & anti-septum for off-axis @ low beta

**Results:**

- Observation of "Golf-club acceptance" was clearly observed.
- Good agreement with simulation except for $V_f=2.0$ MV.
- Given that the observed discontinuity of bucket this is attributed to a fragile transverse acceptance at large momentum deviation (more argument in next slide).

**Anti-septum + Longitudinal injection**

- Short pulse kicker can be placed at the next straight section.
- "One-arc dynamic aperture" must be large enough.
- Anti-septum injection = Quasi-on-axis injection → Reasonable kick angle, $\sim 1$ mrad for $\beta_x = 4$ m.

**Baseline injection scheme (1)**

- Anti-septum wall thickness can be 1 mm.
  - Stray field is excited at the other side of stored beam after injection beam passes.
  - Enough for mechanical stiffness.
  - Injection into $\sim 5$ mm aperture is possible.
Observations & Discussions

- Diamond has decided to optimize 6BA brightness through energy increase (3→3.5 GeV) rather than emittance decrease (160 pm rad @ 3.5 GeV in 561 m) → should help with IBS and Touschek
  - Does this only work for Diamond users (~20 keV)?
  - For other projects: can users’ demands only be satisfied by minimizing emittance?
- Different types of RF gymnastics proposed for longitudinal injection (SOLEIL, HEPS, PLS-II)
- Lots of experience in proton machines, but in light sources what is there beyond Peter's/Masamitsu's measurements on BESSY-II? Where do we take confidence from?
- What about effect of transients?
  - ALS with only modest 3HC tuning & 10% gap → 20 deg transient ~ 120 ps
  - In 4GSRs: gaps might be shorter, use active HCs and/or FBs
- No matter if we do on-axis or off-axis, we need short-pulse kickers (developments need to start well ahead of projects)
  - Low frequency helps (100 MHz → 20 ns kicker pulses)
  - Short-pulse kickers allow for single-bunch injection → 1/h perturbation → injection becomes much more transparent regardless of
  - On the other hand, (short) gaps will likely remain necessary → trains remain an option → do flat-top requirements preclude short rise/fall times?
- Longitudinal accumulation appears to be much more robust compared to transverse accumulation, but will our machines still offer enough MA to enable it going forward (Bob Hettel: “If you have DA MA left you haven't pushed your lattice hard enough”)

*Note: The asterisks (*) are not part of the text and are placeholders for formatting.*