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**IFAST** Prototyping Activity **REX**

**Resonant EXtraction Improvement**

Work Package 5 Task 3

**Steering Committee meeting / 25th of June 2021**

Peter Forck and Rahul Singh, GSI

**Consortium:**
Challenges for slow Extraction from Synchrotrons

Slow extraction: Gentle excitation of a beam third order resonance

Beam physics: Extraction as ‘slow losses’ for 1 ... 10 s
  - Particle crosses stability boarder sequentially
  - Exponential amplitude growth during ‘transit time’
    \[ \approx 50 \ldots 1000 \text{ turns reaching septum and is extracted} \]

Problem: Sensitivity to any unintended resonance condition, e.g.:
  - Change of tune: unintended quadrupole current ripple
  - Change of excitation strength: sextupole current ripple
  - Stochastic amplitude excitation of ‘knock-out’ extraction

Mitigation research within IFAST-REX:

Beam physics: Methods for beam sensitivity reduction
  - Proposal of non-standard excitation methods
  - Extensive simulation of extraction process

Technical installations: Improved power supplier for magnets
  - Improved transverse particle excitation for knock-out extraction
  - Non-standard power converter and rf-amplifier control

Validation: Experimental validation at all facilities
  - Tailored improvements for IFAST-REX participants

Example: \( \text{C}^6^+ \) at 300 MeV/u
  - Quad. scan, un-bunched beam
  - 2 s extraction called ‘spill’

Stored beam horizontal phase space at electrostatic septum

\[ \text{Ion's amplitude growth per turn} \propto T_{\text{transit}} \]

\[ \begin{align*}
  A_{\text{stable}} & \propto \left( \frac{Q_m(t) - Q_{\text{res}}}{S} \right)^2 \\
  \epsilon_Q(t) & \rightarrow 0 \\
\end{align*} \]
### IFAST-REX Working Group Members for initial Phase

#### 1) Development and integration of high dynamic range current measurement device:
- **CERN**: Diogo Alves, Marek Gasior
- **CNAO**: ---
- **GSI**: Rahul Singh, Andrzej Stafiniak
- **HIT**: --
- **MedAustron**: Claus Schmitzer
- **MIT**: --
- **SEEIIST**: Mariusz Sapinski
- **Bergoz**: Frank Stulle

#### 2) Specification and contribution for KO signal generation, exciter and amplifier design:
- **CERN**: Paolo Sota
- **CNAO**: Marco Pullia, Luciano Falbo, Paolo Meliga, Al.Merighetti
- **GSI**: Rahul Singh
- **HIT**: Eike Feldmeier
- **MedAustron**: Claus Schmitzer, Florian Kühteubl, Dale Prokopovich
- **MIT**: Tobias Blumenschein, Andre Rajan
- **SEEIIST**: Elena Benedetto
- **Barthel**: Matthias Barthel

#### 3) Slow extraction simulations:
- **CERN**: Verena Kain, Matthew Fraser, Francesca Velotti
- **CNAO**: Marco Pullia, Luciano Falbo, Paolo Meliga, Al.Merighetti
- **GSI**: Peter Forck, Stefan Sorge
- **HIT**: Cristopher Cortes, Michael Galonska
- **MedAustron**: Florian Kühteubl, Alexander Wastl, Dale Prokopovich
- **MIT**: --
- **SEEIIST**: Rebecca Taylor

#### 4) Spill detector development and analysis:
- **CERN**: Federico Roncarolo (maybe Matthew Fraser)
- **CNAO**: Marco Pullia, Luciano Falbo, Paolo Meliga, A. Merighetti
- **GSI**: Peter Forck, Plamen Boutachkov
- **HIT**: Andreas Peters, Christian Schömers
- **MedAustron**: Dale Prokopovich
- **MIT**: --
- **SEEIIST**: Mariusz Sapinski

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P. Forck, R Singh GSI – IFAST-REX Slow extraction – IFAST 1st Steering Com. Meeting 25th June 2021
### IFAST-REX Working Group 1: Start of Program

**Topic:** Development and integration of high dynamic range current measurement device

**Goal:** Production of extreme large dynamic range current measurement device by company Bergoz

**Methodology:** Detailed specification table produced as steered by GSI and company Bergoz

**Style:** Several Zoom meeting executed

**Status:** Agreement on most items, first design ideas by Bergoz

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>DC current $I_{DC,\text{min}}$</td>
<td>300 A</td>
</tr>
<tr>
<td>DC current $I_{DC,\text{max}}$</td>
<td>10000 A</td>
</tr>
<tr>
<td>By how much can the DC current of a given magnet vary during operation, machine studies,...? This needs to be specified to know the required dynamic range of the HDR-ACT. 10% of peak current (mentioned in next slide)</td>
<td></td>
</tr>
<tr>
<td>AC ripple $f_{AC,\text{min}}$</td>
<td>10 Hz</td>
</tr>
<tr>
<td>AC ripple $f_{AC,\text{max}}$</td>
<td>40000 Hz</td>
</tr>
<tr>
<td>AC ripple $I_{AC,\text{min}}/I_{DC}$</td>
<td>$10^{-7}$</td>
</tr>
<tr>
<td>AC ripple $I_{AC,\text{max}}/I_{DC}$</td>
<td>$10^{-2}$</td>
</tr>
<tr>
<td>Measurement dynamic range</td>
<td>&gt;100 dB</td>
</tr>
<tr>
<td>Measurement resolution $\sigma/I_{DC}$</td>
<td>$10^{-7}$</td>
</tr>
<tr>
<td>Is this resolution also required during magnet current ramp?</td>
<td>No, only during flat-top</td>
</tr>
<tr>
<td>Measurement uncertainty $u_I$</td>
<td></td>
</tr>
<tr>
<td>Including systematic errors (gain error, offset, non-linearity)</td>
<td></td>
</tr>
<tr>
<td>Temperature coefficient $g_T$</td>
<td>??? %/K</td>
</tr>
<tr>
<td>To achieve $10^{-7}$, temperature of all components is an issue</td>
<td></td>
</tr>
</tbody>
</table>
IFAST-REX Working Group 3 and 4: Start of Program

Topic WG3: Slow extraction simulations
First step: Questionnaire for survey
by Florian Kühteubl (MedAustron)

Questionnaire related to:

- General beam parameters
  ⇒ appropriate scaling
- Type of slow extraction
  ⇒ comparison of different methods
- Typical quality and its measurement
  ⇒ experiences of improvements

Comparison of achievements including appropriate scaling e.g. trans. emittance

Status: Part of the answers received

Topic WG4: Spill detector development
Status: Proof-of-principle for fast & rad-hard scintillator counter at GSI
Conclusion:
Collaboration established
Work Group content determined
Work Group 3 and 4: First steps performed
Work Group 1: Detailed design work started

Thank you for your attention