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IFAST Prototyping Activity

REX **R**esonant **EX**traction Improvement

Work Package 5 Task 3

Steering Committee Meeting/ 14th December 2023

Peter Forck & Rahul Singh (GSI) on behalf of the consortium

iFAST

Challenge for slow Extraction from Synchrotrons

Slow extraction: Gentle beam excitation at **third** order resonance

Beam physics: Extraction as 'slow losses' for 1 … 10 s

- Particle crosses stability boarder sequentially
- Exponential amplitude growth during 'transit time'

  ≈ 50 … 1000 turns to reach septum for extraction

Problem: Sensitivity to any **unintended** resonance condition, e.g.:

- Change of tune: unintended quadrupole current ripple
- Stochastic amplitude excitation of 'knock-out' extraction

Mitigation research within IFAST-REX:

1. Beam physics:

Reduction of beam sensitivity by non-standard excitation methods

⇒ Extensive simulation of extraction process

2. Technical installations:

- Improved power supplier for magnets
- Improved transverse excitation for knock-out extraction

⇒ Non-standard current measurement and rf-excitation control

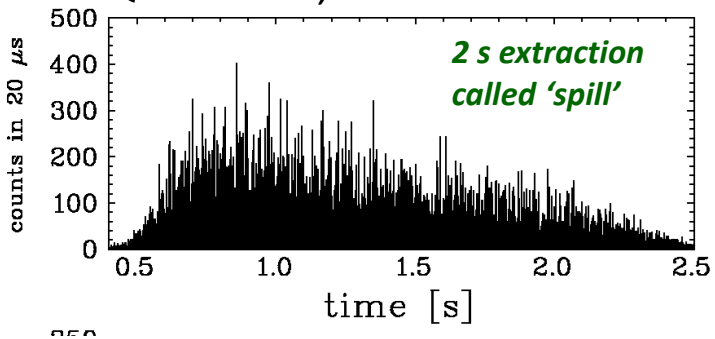
3. Validation:

- Experimental validation at the facilities

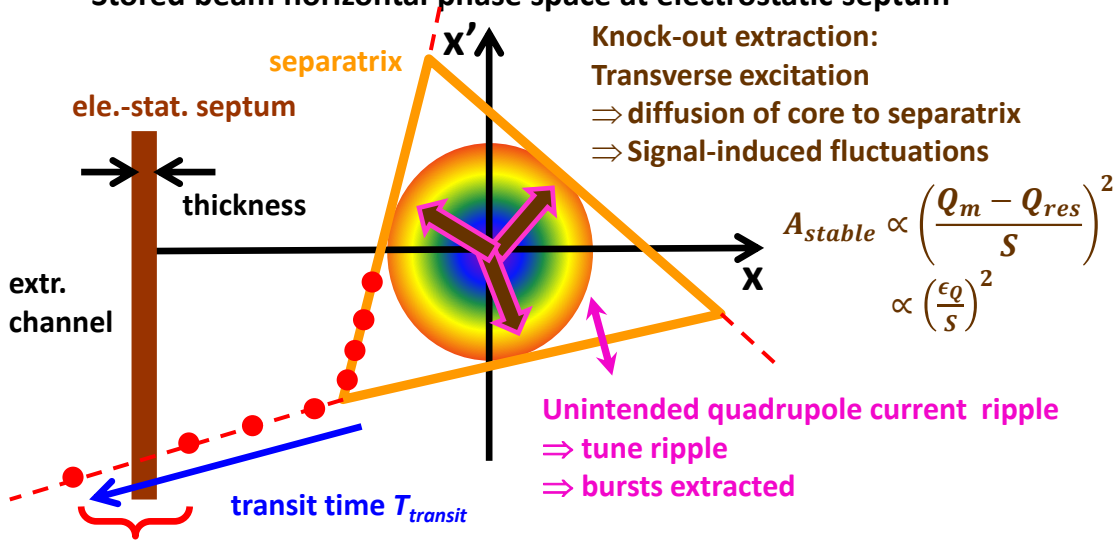
⇒ Tailored improvements for IFAST-REX facilities

***Example*:** C^{6+} at 300 MeV/u at GSI

Quad. scan, un-bunched beam



Stored beam horizontal phase space at electrostatic septum



Knock-out extraction:
Transverse excitation
⇒ diffusion of core to separatrix
⇒ Signal-induced fluctuations

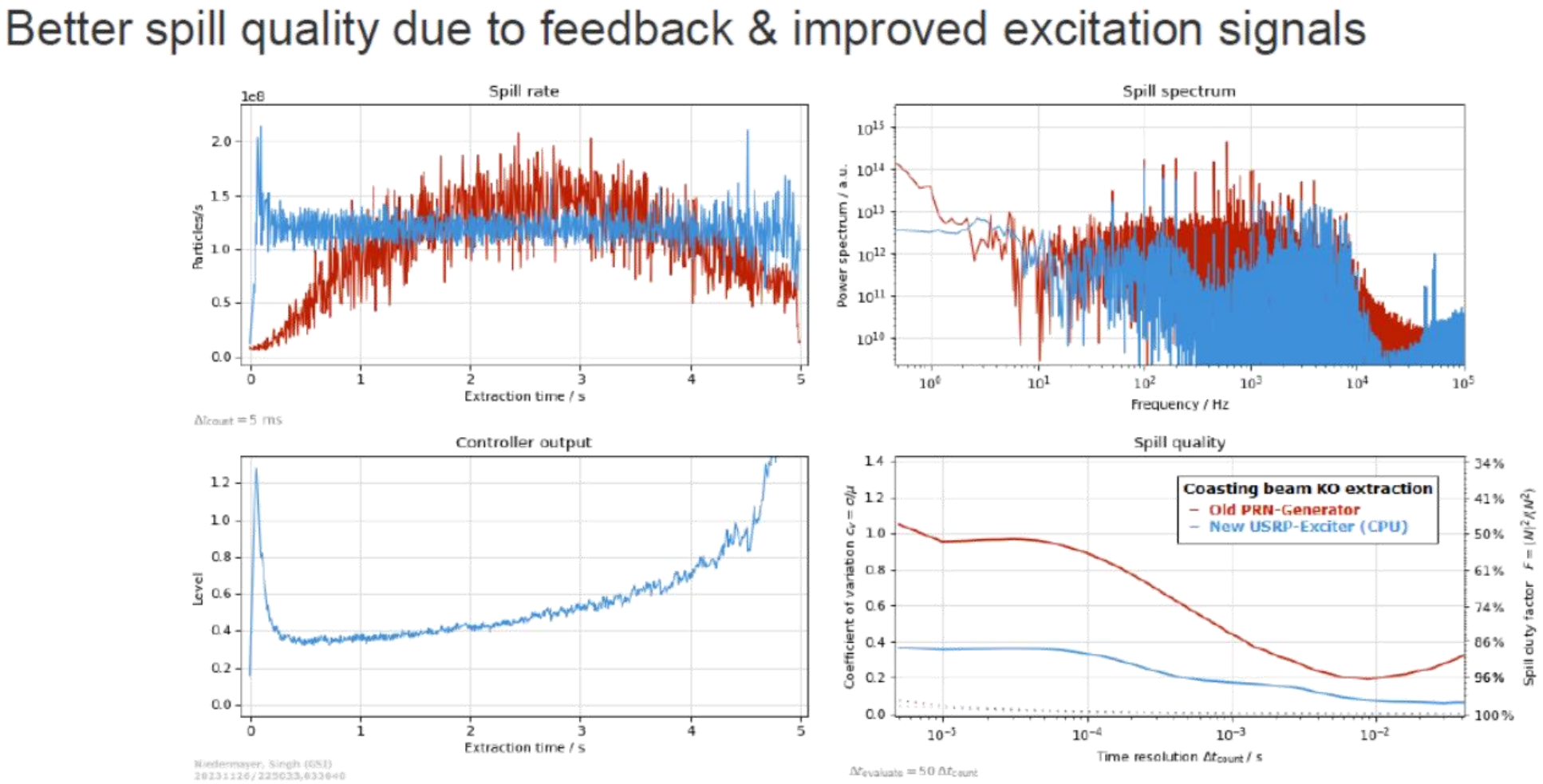
$$A_{stable} \propto \left(\frac{Q_m - Q_{res}}{S}\right)^2 \propto \left(\frac{\epsilon_Q}{S}\right)^2$$

Unintended quadrupole current ripple
⇒ tune ripple
⇒ bursts extracted

Sextupoles: non-linear fields
Ion's amplitude growth per turn
⇔ $T_{transit}$ & x_{step}

Recent Improvements by fast Feedback with novel Technology

Example: GSI knock-out extraction



IFAST-REX Structure: Working Groups

Topic: Workshare structure within the entire project

- **Working Group 1:** Power supplier ripple measurement novel transformer combination
  chair Frank Stulle (Bergoz Instrumentation) ⇒ **technical design ongoing within schedule**
- **Working Group 2:** Optimized rf-amplifier and control of knock-out extraction
  chair Eike Feldmeier (HIT) ⇒ **rf control even <u>better</u> than foreseen, amplifier expected January 2024**
- **Working Group 3:** Simulation and experimental verification for slow extraction
  chair Francesco Velotti (CERN) ⇒ **ongoing within schedule with good communication**
- **Working Group 4:** Innovative detectors and data acquisition for slow extraction
  chair Peter Forck (GSI) ⇒ **ongoing within schedule; presently, no big challenge**

IFAST-REX Structure: Working Groups

Workshop on slow extraction

- Meeting with worldwide experts
- Date: February 12 to 14, 2024
- Location Wiener Neustadt organized by MedAustron

Thank you for your attention!

Are there comments?

SLOW EXTRACTION WORKSHOP

The Workshop aims to bring together the current worldwide developments and innovations in the Slow Extraction techniques from synchrotron accelerators. It will cover three full days and include approximately 60 presentations and discussion sessions as well as posters available during breaks.

February 12 - 14, 2024
Wiener Neustadt, Austria

Information & Registration

Program:
Topics covered in the workshop include:

- Facility overviews
- Spill ripples and beam quality
- Managing extraction efficiency
- Slow extraction hardware and machine protection
- Optimisation and machine learning for slow extraction
- Advanced extraction techniques
- Septa development

Please see the Indico page for the detailed program.

International Organizing Committee:

Kevin **Brown** (BNL)
Peter **Forck** (GSI, co-chair)
Matthew **Fraser** (CERN)
Brennan **Goddard** (CERN)
Vladimir **Nagaslaev** (Fermilab)
Ryotaro **Muto** (J-PARC)
Alessio **Mereghetti** (CNAO)
David **Ondreka** (GSI)
Mauro **Pivi** (MedAustron, co-chair)
Dale **Prokopovich** (MedAustron, chair)
Marco **Pullia** (CNAO)
Christian **Schömers** (HIT)
Masahito **Tomizawa** (J-PARC)
Jiancheng **Yang** (IMP/CAS)