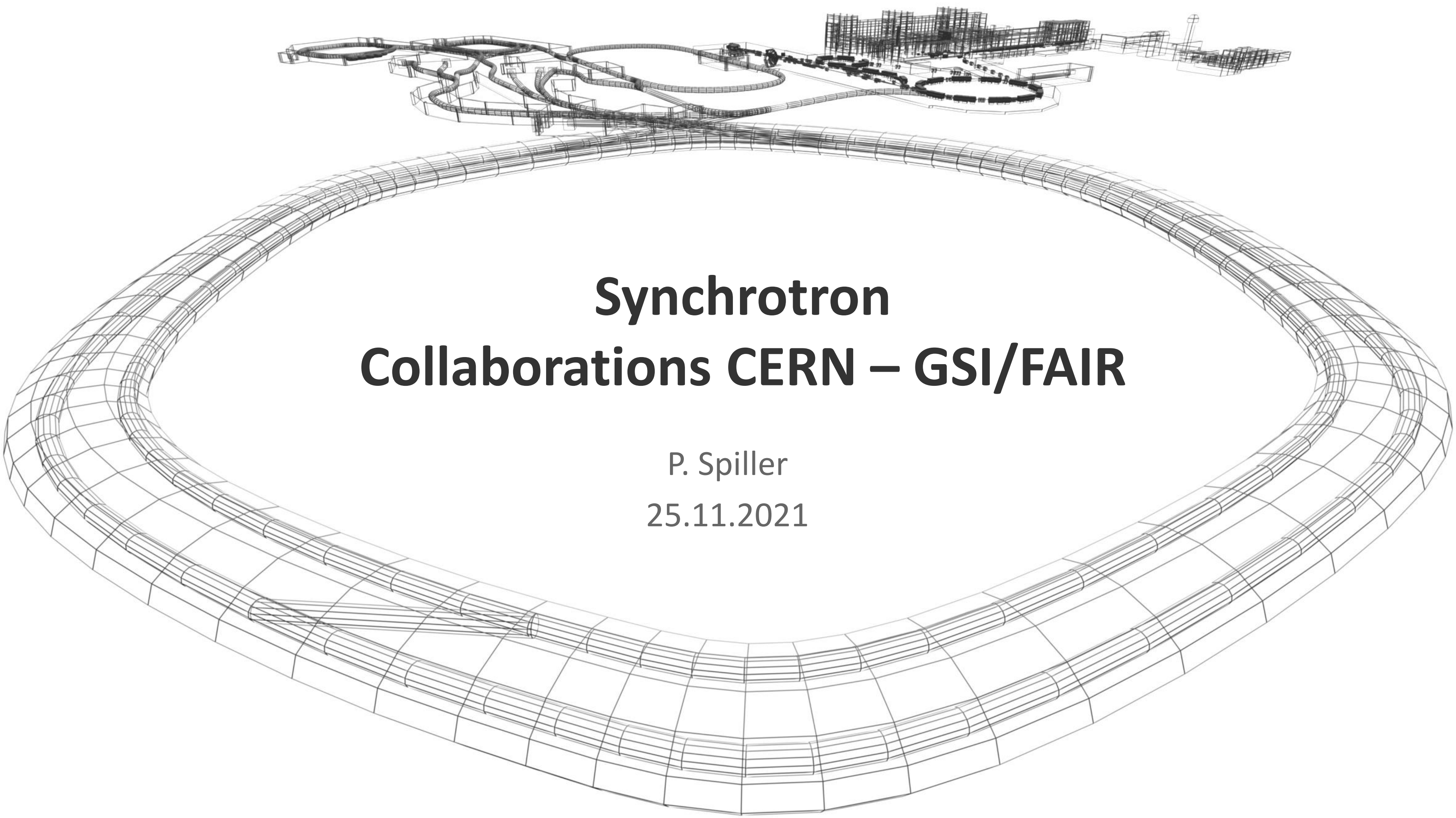


Synchrotron
Collaborations CERN – GSI/FAIR

P. Spiller

25.11.2021

TFS System/KO Exciter

R21.11 Continue to investigate technical details of a transverse feedback system for SIS100, including reserving space in the ring for pickups and kickers for feedback systems with appropriate phase advances.

- General (physical) Specification of TFS System completed by V. Kornilov 02.2020
- Technical layout and design postponed because of priorisation on day-one items.
- Presently, no WPL assignment yet.
  TransFAIR FZJ ?
  Start required in Q1/22.

- Collaboration for technical specification with CERN (Wolfgang Höfle)

Table 2: General parameters of TFS for SIS100

System Operation	multi-sampling per bunch (damping of intra-bunch oscillations)
Bandwidth: low border (-1 dB)	15 kHz
Bandwidth: upper border (-1 dB)	32 MHz
Pick-Up signal implementations	• 2 pick-ups • 1 pick-up • n turns combined • normalized / unnormalized
Sampling Rate	• fixed-f_S: 16 ns (62.5 Msps) or • $f_S = 240 f_0$: 26.7 ns–15 ns (37.4 Msps–66 Msps)
Total Signal Jitter	max. 1 ns
Low-Pass Filter	32 MHz, 50 dB
Notch Filter	50 dB at $(n f_0 \pm 0.05 f_0)$
Kicker Power	kick per turn $\Delta\theta = 16\,\mu$rad
BTF functionality	
Remotely Adjustable	• lattice settings; variable along the cycle • kick phase (antidamping, reactive) • pick-up signal implementations • kicker gain; variable along the cycle • low-pass filter • pick-up amplifier gain • fast switch

Requirements for SIS100 TFS system

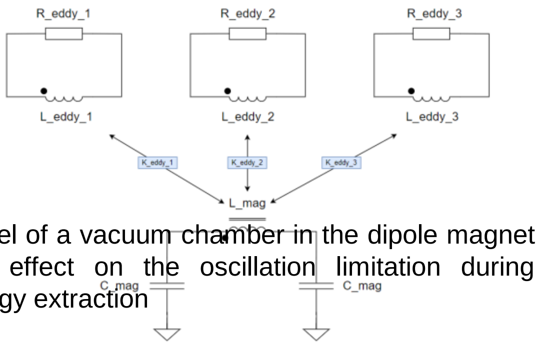
Table 2: Specifications for the TFS

Min. delay (β=1)	630 ns (60ns)
Max. delay (β=0.16)	4800 ns (402ns)
Min. step	~ 1 ns
Frequency range of the analog signal	20 kHz – 40 MHz
Impedance	50 Ω
Dynamic range	> 60 dB

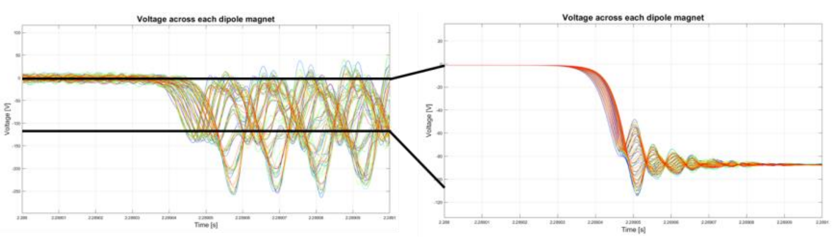
Key parameters of SIS18 TFS system

Transient Effects in SIS100 Simulation by STEAM Group

- Collaboration duration: 2 years (1.03.2020 – 28.02.2022)
- Resources: 1 FTE (Dr. Dimitri Delkov funded by GSI) + support of STEAM group
- Scope and Status (simplified):
  - Creating electrical models of the SIS100 main circuits including energy extraction circuits, grounding and simplified power converters (missing transfer function of the quadrupole magnet which will be measured in Dec. 2021) 80%
  - SIS100 main dipole circuit transient simulation + case study 100%
  - SIS100 main quadrupole circuits transient simulation + case study (waiting for the missing transfer function) 60%
  - 2D mutual inductance calculation for the main bus-bars in the dipole circuit 100%
- Mayor results:
  - DP circuit: initial study revealed high oscillation tendency → installation of parallel resistors across each dipole. After introduction of the vacuum chambers in the model, the oscillations are damped significantly → no R parallel required and no further mitigation action required
  - Same is expected for the quadrupole circuits
  - Case studies in DP: e.g. 1 *R*d does not open → circuit asymmetry but within the voltage limits. Recommendation to introduce a controlled delay between turning on of energy extraction switches in order to always have an optimal order of turning on the 12 energy extraction resistors (circuit asymmetry reduction)
  - 2D mutual inductance simulation → very low coupling between the main bus-bars



Model of a vacuum chamber in the dipole magnet and effect on the oscillation limitation during energy extraction



Radiation Hard Electrostatic Extraction Septa

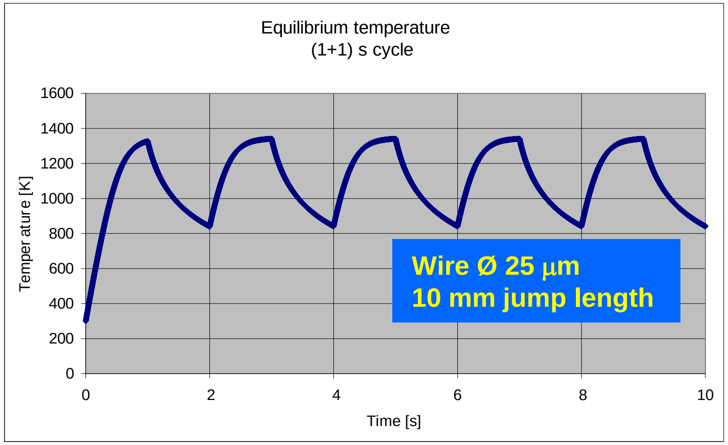
The baseline SIS100 electrostatic extraction septum has a conventional design (wire septum).
However, the high specific energy deposition at full Uranium intensity can not be covered by this design.

Communication/exchange of concepts and idea for alternative E- septa designs.

CERN contact: Bruno Balhan, Jan Borburgh

Electrostatic wire septum

U at 2.7 GeV/u, cycle 1+1s, 5×10^{11} ions



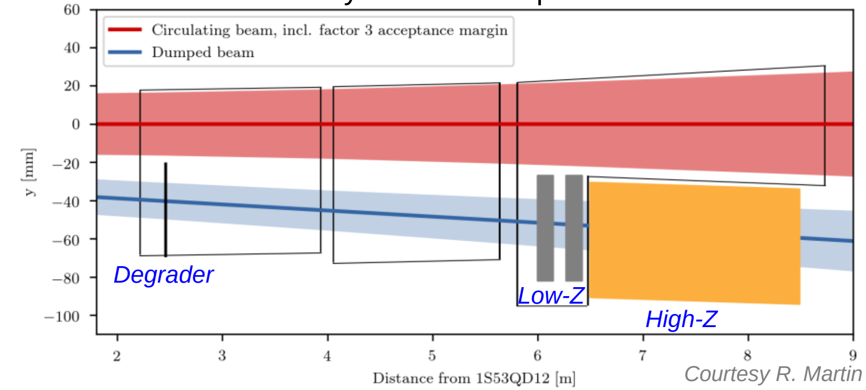
Heat load simulations for the W-Re wires

SIS100 Emergency Beam Dump

- Function
  - Protection of SIS100 machine and experimental equipment from damage by beam
  - Essential part of Fast Beam Abort System (FBAS)
  - Beam extraction during 50us by fast kickers
- Main challenges
  - Very different energy loss characteristics of protons and heavy ions (dE/dx ~ Z^2)
  - Peak energy deposition about 7 kJ/cm^3
- Design concept
  - Split dump into low-Z and high-Z part for absorption of heaviest ions (U^{28+}) and protons
  - Low-Z part in XHV beam vacuum, high-Z in air
  - Degrader to increase beam size at dump
- Collaboration interests
  - Simulation tools and strategies for dump design
  - Material properties of known low-density carbon materials for use in thermo-mechanical simulations
  - Estimation of damage thresholds from simulations
  - XHV properties of low-density carbon materials
  - Material choice for beam exit windows

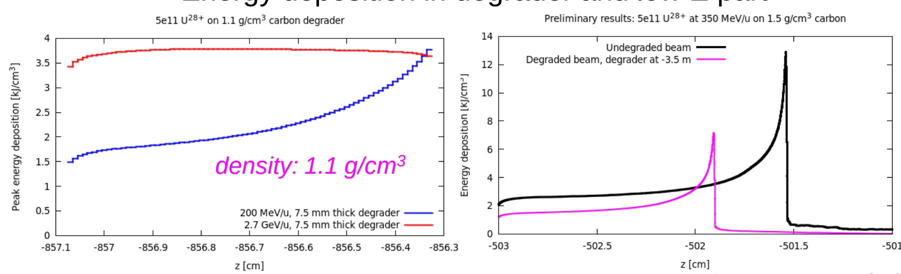
CERN contact: M. Calviani (Head SY-STI-TCD)

Geometry of beam dump section



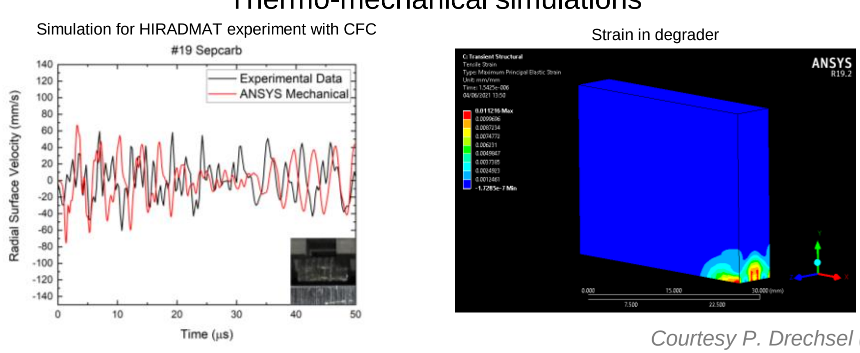
Courtesy R. Martin (GSI)

Energy deposition in degrader and low-Z part



Courtesy R. Martin (GSI)

Thermo-mechanical simulations



Courtesy P. Drechsel (GSI)

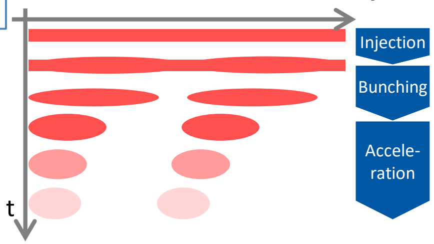
FP7- ARIES – Electron Lens for Space Charge Compensation

ARIES workpackage (IAP, Frankfurt, Univ. Riga, GSI, CERN) has been prolongated and shall be completed with all promissed deliveries until Dec. 31th 2021.

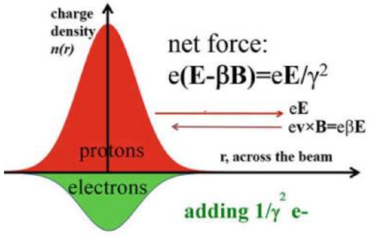
- Motivation: Increasing heavy ion intensities beyond the space charge limit
  - Light ions are space charge limited in SIS18 today
  - Ion source and injector upgrades will push the limits
  - Electron lenses allow to increase intensities by (partial) compensation of space charge
- Roadmap: SC compensation lens for SIS18
  - Requirements on lens
    - Compensation of $\Delta Q_{sc} = 0.2$ for $A/Q \leq 4$
    - 3 Lenses with L = 3.3 m lead to 10 A peak current
    - RF modulation to follow bunch structure
    - Matching or flat transverse profile
  - EU project for RF modulated electron gun (ARIES WP16, partners: CERN, IAP, RTU)
    - Design of grid modulated gun finalized
    - Gun and collector solenoids ordered
    - Magnetic design of interaction solenoid done
    - Preliminary layout of complete lens exists
  - GSI project for manufacturing of prototype lens
    - Required for benchmarking and optimization
    - Ultimately at least three lenses necessary

CERN contact: Adriana Rossi
CERN contribution: Test stand for electron beam. Has been changed since test are conducted at IAP Frankfurt.

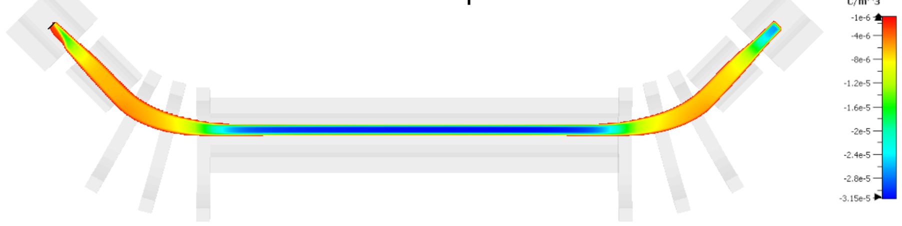
Bunch structure in SIS18 cycle



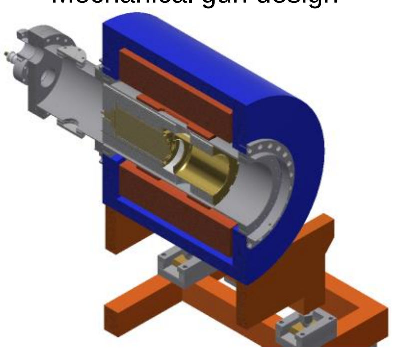
Modulation to match bunch



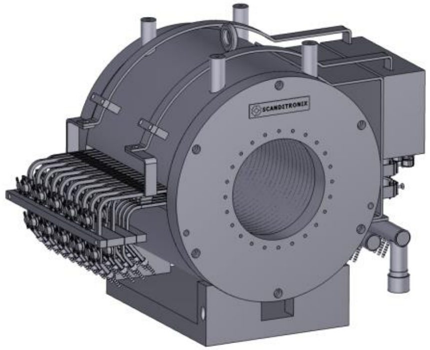
Electron beam transport simulation



Mechanical gun design



3-D model of gun solenoid



FCC: R&D high-field superconducting (extraction) septa

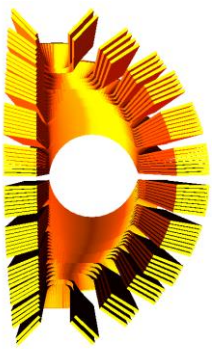
proposed

purpose/benefit

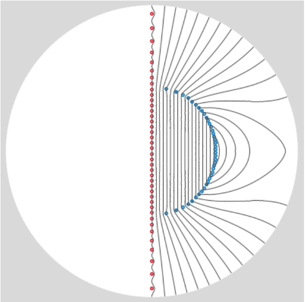
Conventional iron-dominated septa are limited to 2 T field strength. At GSI a cosine-theta septa magnet concept was developed enabling much higher field strength.

Superconducting cosine-theta septa might be used at future accelerators (e.g. FCC, SIS400, medical, …). For feasibility studies the concept must be transferred to an engineering design.

Contribution to FCC week 2015-2019



cosine-theta septa coil



magnetic field

contribution

Add.	GSI		CERN
#x	• Septa concept expertise (comparison Nuclotron – Rutherford)		• Consine-theta expertise (Rutherford cable)
	• Design studies: electromagnetic, cryogenic, mechanical • R&D of critical parts • Prototyping and testing		

- **high interest from both sides** (application in future projects)
- benefit from **complementary expertise**

CERN contact: Jan Borburgh

Other Topics

Expert Reviews:

- Design and Cold Testing of SIS100 Feed Boxes (28.4.2020) (CERN: Hans Quack)
- Interconnection Region Design (Induction in LHe, Mutual Bus Bar Forces, Bus Bar Clamping, Forces by Process Line Bellow and Mechanical Fixations and Support) (planned)