FCC Special Technologies WP3 (Beam Transfer Challenges) Summary

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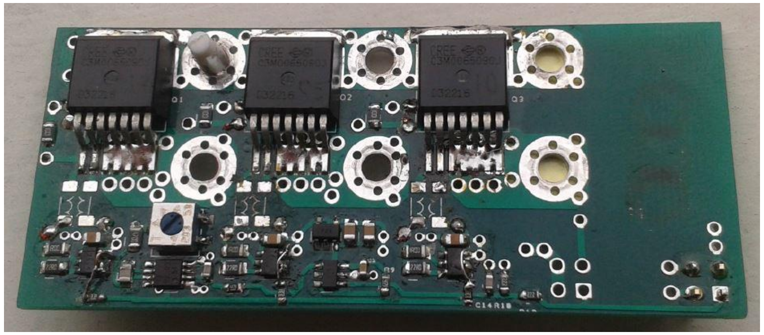
Special Technologies WP3
BEAM TRANSFER CHALLENGES

- WU 3.1: Kicker Generator with Solid State Switch Technology;
- WU 3.2: Kicker Magnet R&D
- WU 3.3: Septum Magnet R&D
- WU 3.4: Fast Electronics, Triggering and Switch Controls

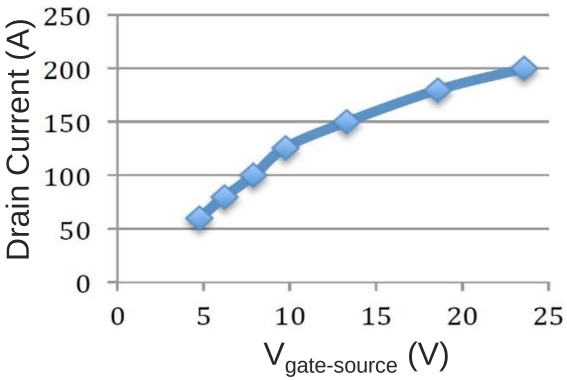
WU 3.1: Kicker Generator with Solid State Switch Technology

Two options for Solid State Switch Technology, both with modular design, under consideration:

- Activity 1: Marx Generator Concepts (ISEL & EPS, Portugal):
  - Application for funds under Portugal 2020 program unsuccessful in 2016: reapplying May 2017. Nevertheless, EPS continuing with R&D;
    - Characterization of SiC MOSFETS ongoing;



Three parallel SiC MOSFETs



    - Current sharing studies for parallel SiC MOSFETs;
    - Currently designing 2-3 Marx stage assembly for testing at full current.
    - Note: supplied a high-repetition rate Marx generator for high repetition-rate breakdown studies.

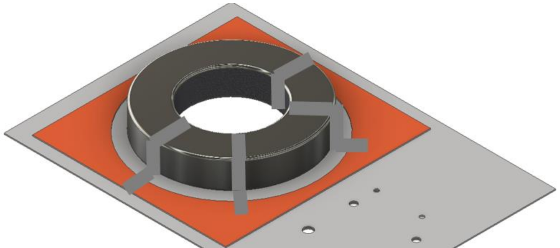
WU 3.1: Kicker Generator with Solid State Switch Technology

➢ Activity 3: Inductive Adder Prototype Development:

		Start
General IA system analysis and basic **parameter definition**	✓	
Setup of **test environment**	✓	
Evaluation and characterization of **critical components**	✓	
a) insulation gap material	✓	
b) magnetic core material	✓	
c) Semiconductor switches and driver circuits	✓ *	
d) HV pulse capacitors	✓	
Selection of **prototype components**	✓	
Production of **PCB** and **mechanical parts** for prototype layers		5/2017
Assembly of prototype layers		9/2017
Test and measurements on prototype layers		11/2017
Design update and production of **full scale prototype**		4/2018
Validation of full scale prototype		9/2018

WU 3.1: Kicker Generator with Solid State Switch Technology

- Activity 2: Advances in pulsed power generators and switch technology:
  - Magnetic pulse compression
    - High rate of rise current – ongoing studies



Example pulse compression stage

  - High reliability switch topologies
    - No progress – low priority
  - Faraday effect fast Current Transformer (expressed interest to ETHZ) – very promising for measurement of fast pulsed current with high precision
    - ETHZ plan to start a PhD project focussing only on the current sensor: there may be a chance for ETHZ to obtain SNF funding for such a project starting in 2018.

WU 3.2: Kicker Magnet R&D

PhD student commenced in August 2016:

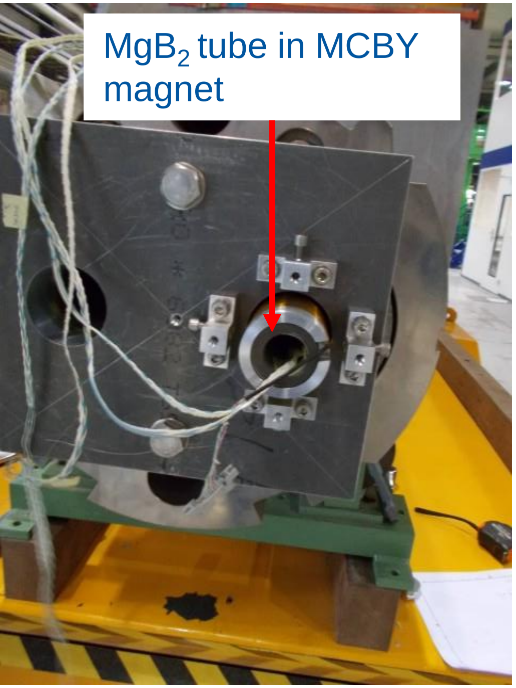
		Start
Definition of key parameters for FCC injection kicker magnets, in parallel with the specification of the pulse generators	✓	
Confirmed need for a beam screen to shield ferrite yoke, for anticipated beam spectrum	✓	
Develop the beam screen to achieve: ➢ adequately low, broadband, beam coupling impedance; ➢ fast field rise and fall times; ➢ acceptable high voltage behaviour.		5/2017
Construct a prototype beam screen for installation in existing magnet (first prototype MKI?).		8/2018
Test the prototype in the laboratory: beam impedance measurements and high voltage tests.		2/2019

WU 3.3: Septum Magnet R&D

		Start
Lambertson based solution (presented at FCC week 2016**)**	✓	
Massless septa	✓	Optimization ongoing
Superferric solutions: ➢ Stealth topology proposed by Texas A&M University (P. McIntyre) ➢ Truncated half cosine with iron orbiting beam screen by GSI (K. Sugita)		Ongoing Currently a low priority for GSI
Superconducting Shield (SuShi) – in collaboration with the Wigner Institute (HU) ➢ MgB2 solid tube; ➢ HTS (GdBCO) tape wound on Cu tube carrier; ➢ Nb/Ti/Nb/Cu multi layer sheet, to be formed into a tube prior to testing.	Tested In test	Ongoing

WU 3.3: SuShi Septum

- First MgB2 prototype tested in February 2017 in SM18 up to 2.6 T;
- Second GdBCO prototype currently being tested at SM18;
- Third Nb/Ti/Nb/Cu multilayer sheet currently in production. Delivery foreseen for May; prototyping ongoing regarding shaping techniques.

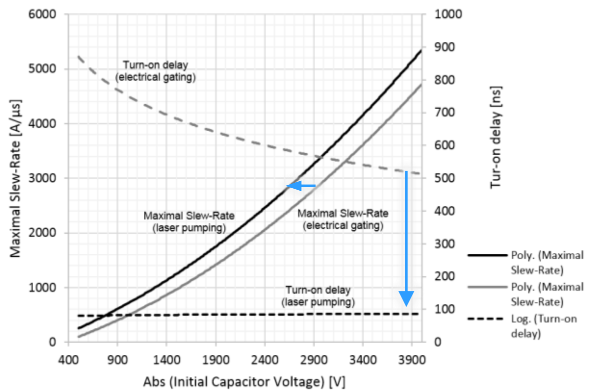


PRAB paper published on SuShi topology: https://journals.aps.org/prab/abstract/10.1103/PhysRevAccelBeams.20.041002
Publications being prepared on the first test results.

WU 3.4: Fast Electronics, Triggering and Switch Controls

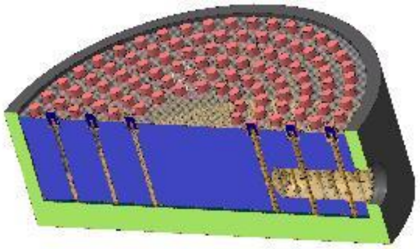
		Start/Comment
Cooperate with other groups at CERN with radiation hardened electronics experience to evaluate future control and triggering solutions		Ongoing
Study and test possible solutions to mitigate degradation by radiation.	X	Not identified as a priority
Studies of laser triggered thyristors ongoing: ➢ light diffusers studies; ➢ Construct a test-bench for high-power laser-pumped thyristor triggering		Ongoing Ongoing Mid-2017
Develop an Artificial Intelligence prototype by using the logged data of an existing kicker installation		Ongoing

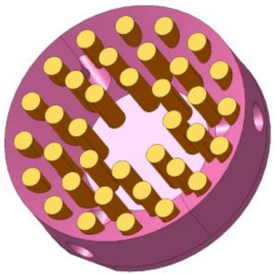
WU 3.4: Fast Electronics, Triggering and Switch Controls



Laser triggered thyristor:

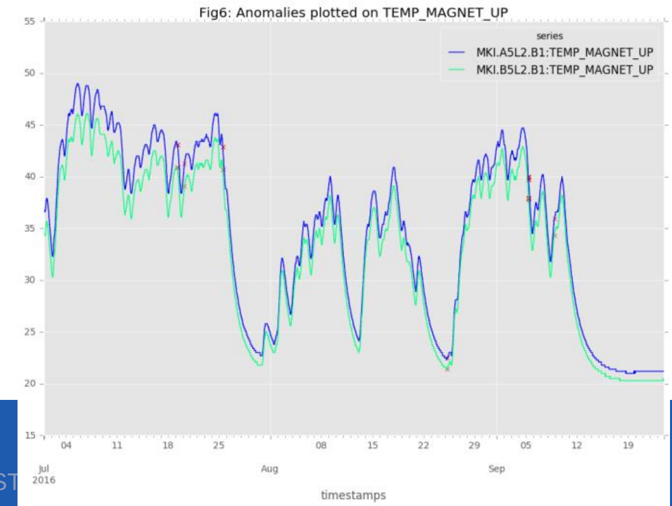
- Advantages shown by modified COTS thyristor
- Building proof-of-concept test bench, in-house laser diffuser being prototyped
- Low inductance thyristor clamp designed

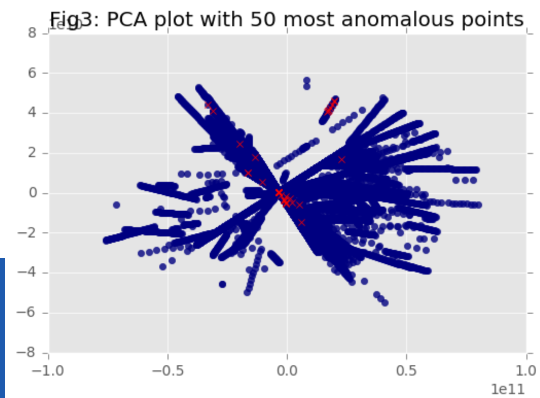


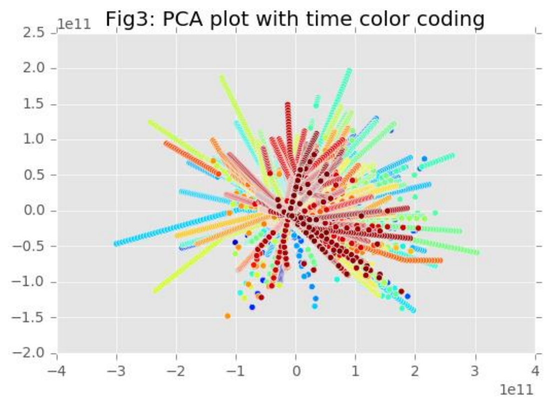


Anomaly detection by using Artificial Intelligence (AI) algorithms:

- Multi-year collaboration with University of Leuven (EDMS 1752095); master-student started 09/2016
- Presently focus on LHC Injection system
- Currently: anomaly classification and ranking



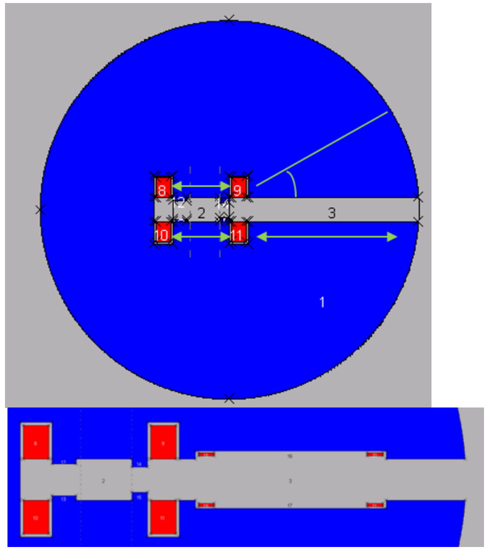




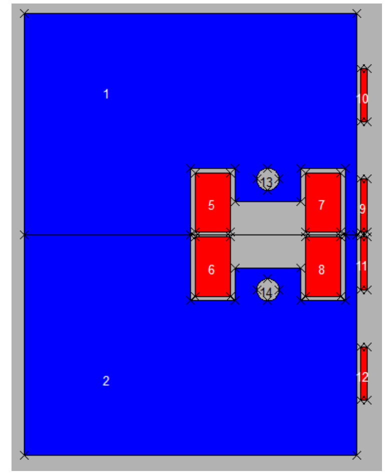
Thank you for your attention

Iron dominated septa

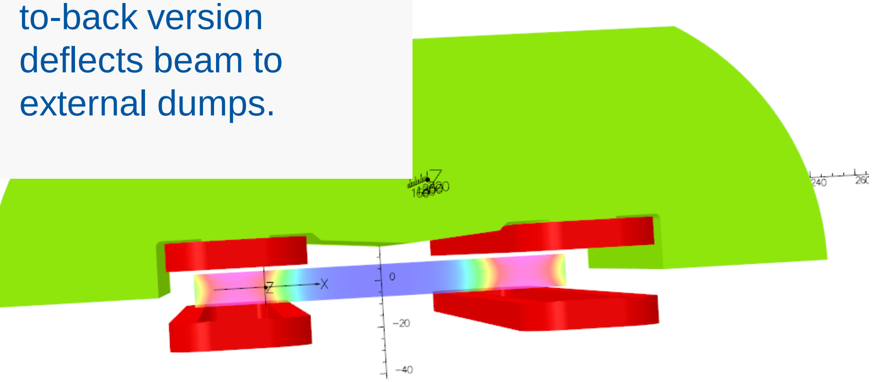
Massless septum:
For extraction:
Proposed a half-open H-dipole (Pacman);
Optimization ongoing:
- Transition “septum” region ≈ 1.5 times the gap height (1.5*26 mm) instead of 25 mm (Baseline)
- B < 2 T and leak field ≈ 1e-5 T



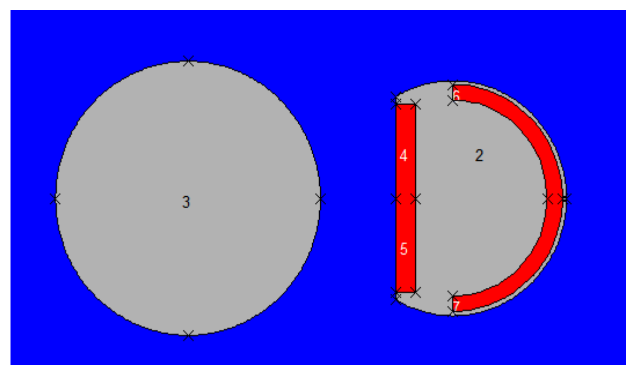
Stealth septum (P. McIntyre)
Benefitting from magnetisation of asymmetric window frame yoke.
Septum conductor forces are taken by thin adjacent yoke leg



Injection (for mis-steered beams): back-to-back version deflects beam to external dumps.



Truncated half cosine theta (GSI):



In need of working collaboration with GSI; slow, as SC septum currently a low priority for GSI