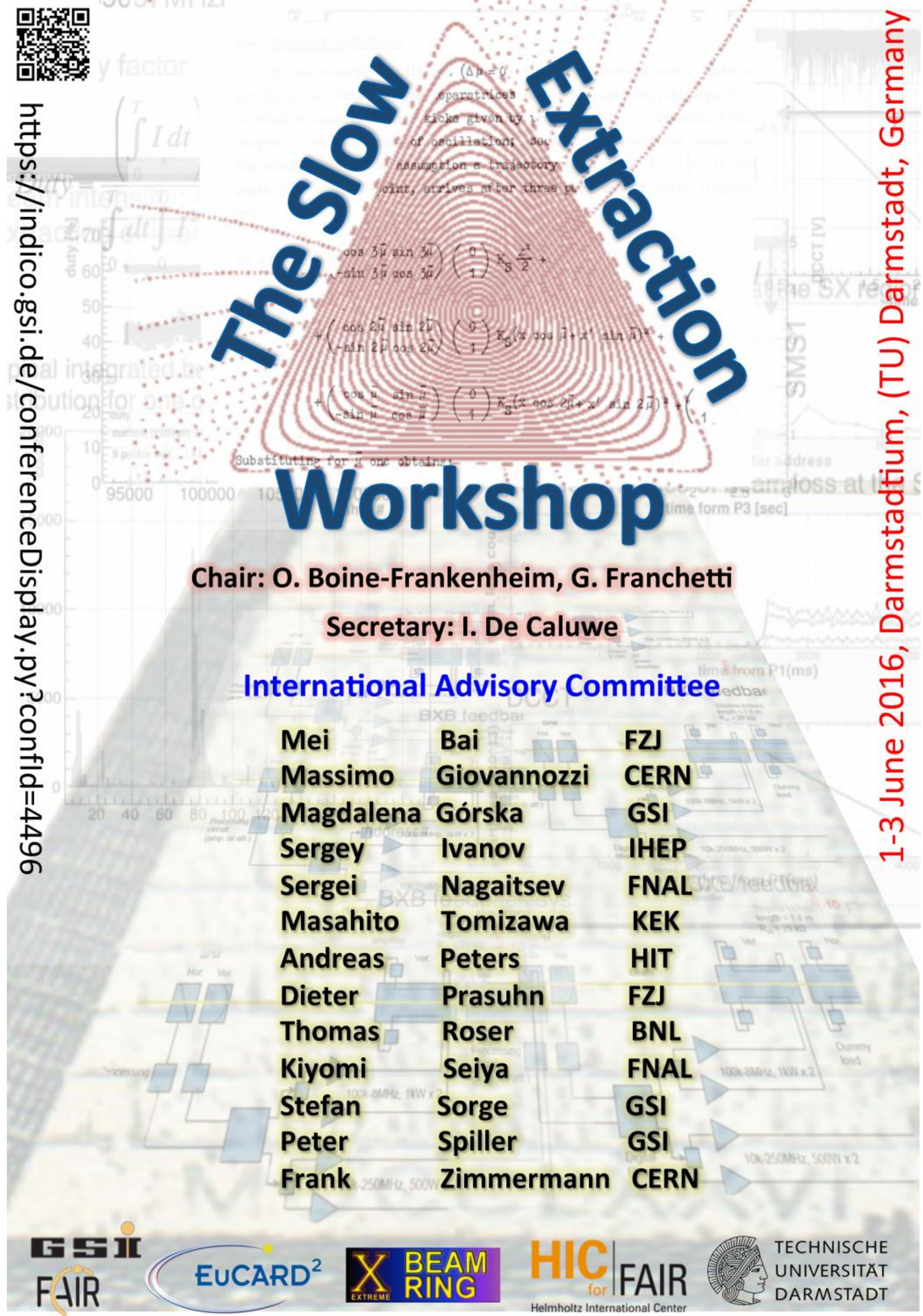
Follow up first workshop + collaborations



Driven by FAIR

Driven by SIS18 experiments

The Slow Extraction Workshop was organized to bright the gap between the user community and accelerator experts.

Laboratory (BNL, CERN, FERMILAB, J-PARC), medical facilities (HIMAC, HIT, MIT, NIRS).

- Austria: 2 (EBG MedAustron, TU Wien)
- Germany: 37 (FZJ, U. Jena, U. Frankfurt, GSI, HIT, MIT, TUD, U. Bonn)
- Italy: 2 (U. Bologna, CNAO)
- Japan: 2 (NIRS, KEK)
- Russia: 1 (IHEP)
- Switzerland: 7(CERN)
- USA: 2 (BNL, FNAL)

1. Experiments
2. Experience and issues from GSI
3. Experience from USA
4. Experience from Japan
5. Experience from Russia
6. Medical facilities
7. Electrons and crystals
8. Theory
9. CERN experience
10. FZJ experience

NUSTAR
(NUclear STructure Astrophysics and Reactions)

Experimenters reported experience during operation with the fragment separator with slowly extracted ion beams from SIS-18: A coarse spill structure with spikes with up to 100 times the average spill intensity and that about **50 % of measurement time intervals of the detectors with duration of 100 microseconds are without particle**. → the detector acceptance is reduced by a factor 3-5 and a strongly smoothed spill structure would be desirable.

HADES/CBM
(High Acceptance Di-Electron Spectrometer / Compressed Baryonic Matter)

Spill structures with duration of about a millisecond but also delta peaks within the detector integration time leading to unnecessary load of the detector and, hence, reducing event rate and detector lifetime.

CERN SPS fixed-target experiments — **This workshop**

Mu2e collaboration at FERMILAB — **Next workshop**

experimentalists are interested in micro and nanosecond spill structure

medical facilities the requirement of smooth spills structure concerns the millisecond scale

From the accelerator “people” point of view:

Are the experimentalists expecting an impossible beam ?

Lack a common framework does not allow a straightforward comparison of the spill quality from several institutions (laboratories or medical facilities).

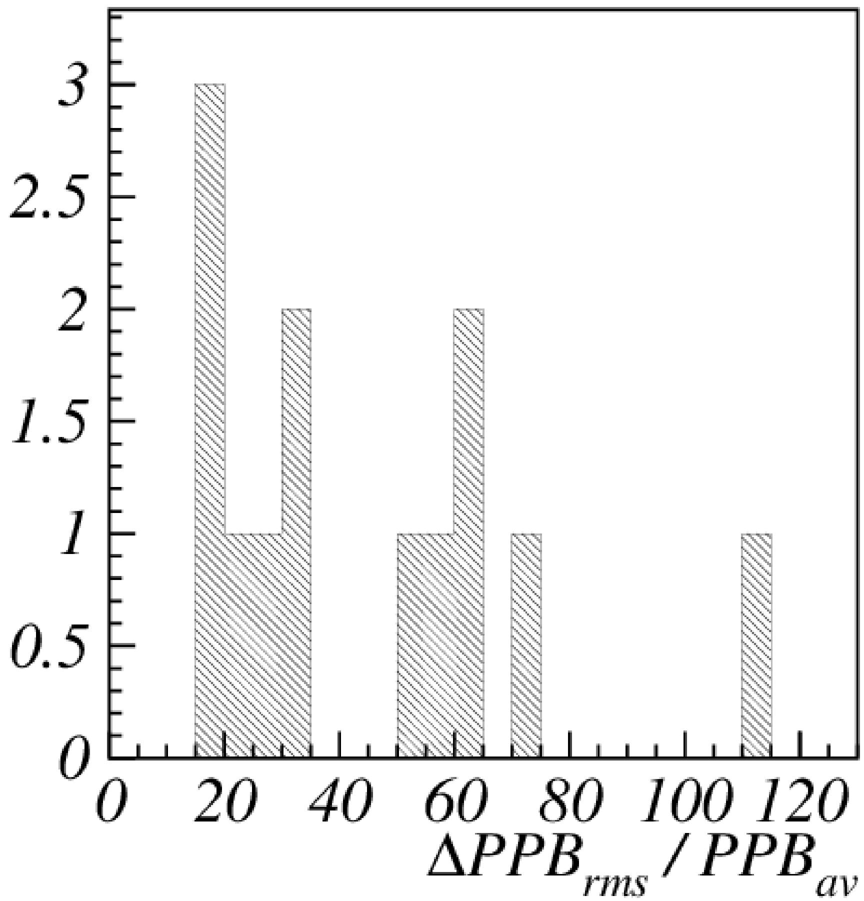
→ Given the high diversity of slow extraction schemes it was decided to compare spill structures of several institutions

Comparison of spill structures

(S. Sorge)

Name, Institution	spill duration	particles in spill	original bin length	Particles Per Bin, av. (orig.) (PPB_{av})	$\frac{\Delta PPB_{rms}}{PPB_{av}}$	Particles Per Bin, av. (1 ms) (PPB_{av})	$\frac{\Delta PPB_{rms}}{PPB_{av}}$ (1 ms)
M. Fraser, CERN	4.0 s	$4.0 \cdot 10^{13}$	0.4 ms	$4.0 \cdot 10^{9}$	0.158	10^{10}	0.157
C. Krantz, MIT	8.0 s	$2.7 \cdot 10^{8}$	0.05 ms	1700	0.25	34000	0.17
K. Brown, BNL (*)	2.4 s	$7.6 \cdot 10^{13}$	0.04 ms	$1.3 \cdot 10^{9}$	0.21	$3.2 \cdot 10^{10}$	0.19
C. Schömers, HIT	5.0 s	$1.5 \cdot 10^{8}$	0.05 ms	1500	0.31	30000	0.21
H. Stockhorst, FZJ (+)	3.5 s	$1.3 \cdot 10^{7}$	1.0 ms	3700	0.28	3700	0.28
S. Ivanov, IHEP	1.3 s	$(2-10) \cdot 10^{12}$	0.04 ms	$(6.0-30.0) \cdot 10^{8}$	0.45	$(1.5-7.5) \cdot 10^{9}$	0.329
P. Forck, GSI (x)	1.5 s	$1.4 \cdot 10^{6}$	0.02 ms	18	0.58	900	0.334
A. Wastl, MedAustron	5.0 s	$1.8 \cdot 10^{10}$	0.02 ms	72000	0.90	$3.6 \cdot 10^{6}$	0.54
K. Brown, BNL (**)	1.6 s	$6.2 \cdot 10^{13}$	0.04 ms	$1.5 \cdot 10^{9}$	0.87	$3.0 \cdot 10^{10}$	0.57
M. Tomizawa, J-PARC	2.1 s	$4.8 \cdot 10^{13}$	0.01 ms	$2.3 \cdot 10^{8}$	0.91	$2.3 \cdot 10^{10}$	0.637
P. Forck, GSI (xx)	2.0 s	$1.1 \cdot 10^{6}$	0.02 ms	11	0.81	550	0.642
P. Forck, GSI (xxx)	2.1 s	$2.1 \cdot 10^{6}$	0.02 ms	20	1.4	1000	0.73
H. Stockhorst, FZJ (++)	3.0 s	$4.3 \cdot 10^{6}$	1.0 ms	1400	1.1	1400	1.1

K. Brown (*) – empty 93 MHz bucket
K. Brown (**) – no empty bucket filtering
H. Stockhorst (+) – stochastic extraction
H. Stockhorst (++) – quadrupole driven extraction
P. Forck (x) – bunched beam, KO extraction
P. Forck (xx) – bunched beam, quadrupole driven extraction
P. Forck (xxx) – unbunched beam, quadrupole driven extraction



Frequency of the “spill structure fluctuations”. The result is that no facility is able to produce a spill structure with relative fluctuation less than 15%. The majority of the spills are in the 15-35% range, and another group of spills is in the 50-80% range.

Mandate: reach the best spill structure

SE schemes and methods have a large diversity

	Method SE	Motivation	Main issues	Hardt?
CERN	Q sweep, large Q' -1 (-26), debunched	ripple	Beam loss, activation, ripple, stability	No
MIT	RF KO, bunched, Q' -1?	Simplicity, ease of rate modulation	Ripple, pointing/spot stability	No
BNL	Q sweep with large Q' -1 (-5), debunched	Simple, relaible	None	No
HIT	As MIT			
FZJ	3rd order res. Longitudinal noise driven, debunched, finite Q' +3 norm.	Simplicity, reliable, stable, frozen lattice	See noise central freq. at MHz on beam	Yes. Can extract below and above trans.
IHEP	FT: longitudinal noise driven, finite Q' -8? (backup with Q sweep with finite Q'). FB - DC KO.	Spill length, fill FT, ripple	Ripple, BTF	No

	Method SE	Motivation	Main issues	Hardt?
GSI	Q sweep, debunched, large Q’ -1.5 (-6). Will go to RF KO	RF KO for pointing stability,	ripple	No
MedAustron	Betatron core momentum driven, finite Q’ (-4)	Ripple reduction between 0.1-1kHz	No multi energy extraction per spill, ripple	Yes
J-PARC	Q sweep, debunched, low Q’ less than -0.5 unnormalised, DB	High efficiency	Ripple, transverse instability during debunch	Yes
CNAO	Betatron core momentum driven + empty sweeping bucket, finite Q’ -4 unnormalised	Ripple reduction between 0.1-1kHz	Beamloss, no multi energy extraction per spill	Yes
FNAL	2nd integer, Q sweep, high Q’, -10? unnormalised bunched	Aperture?	Efficiency, stability	No
FNAL future	Q sweep, bunched, DB, low Q’ 1 unnormalised	Reliability,	Stability, beamloss	Yes

Criteria for defining collaborations

Common topics/Issues	**Types of collaboration**
Scientific Technical Novel Concepts ……	SE workshops Partnership in studies Joint experimental Campaigns Joint development of hardware MoU between labs and institutions ……

Tentative list of topics/collaborations

topics	Type of collaboration	Who
Spill requirement specification (dA vs f)	Measure today's performance	CERN FT experiments
Comment instrument for high f spill	Joint HW dev & tests	CERN, GSI,
Diffuser for loss reduction	Partnership in studies	CERN, FNAL
Rad hard HW for SE, dielectric, stepping motors	Information exchange,	FNAL, JPARC, CERN, GSI
Carbon anode wires/foils, HT tests	Joint HW dev & tests, exploit existing collaboration	JPARC, CERN, GSI, FNAL
Simulation of SE, losses and spills, code benchmarking, common FoM definitions, suitable code	Partnership in studies, SE WS session, experimental benchmarking	GSI, CERN, BNL, MedAustron, CNAO, HIT/MIT, FNAL

Tentative list of topics/collaborations

topics	Type of collaboration	Who
Use of feedback and feedforward	Partnership in studies, information exchange	CERN, IHEP, JPARC, FZJ, MedAustron, FNAL
Machine learning	Partnership in studies, experiments, ICFA WS in SLAC Feb 2018	Experiments, BNL, CERN, FNAL
SE of bunched beam, or burst mode, with low losses	Partnership in studies	HIT/MIT, CERN
Low activation materials	Joint HW dev& tests	CERN, GSI,
Remote handling	Information exchange, joint HW dev,	FNAL, JPARC, CERN, GSI
Comparison of activation and loss profiles against primary beam energy, also simulations	Information exchange	FNAL, CERN, JPARC, GSI,

Tentative list of topics/collaborations

topics	Type of collaboration	Who
Power supply technologies and input for simulation, plus active ripple correction	Information exchange on HW and performance, joint studies	CERN, GSI, MedAustron
Phase space tomography	Information exchange, algorithms	MedAustron, CERN, GSI,
Crystals for extraction, profile randomising	Joint studies, collaboration	IHEP, UA9, CERN, MedAustron, JPARC
Beam splitting for serving several targets	Information exchange	CERN, IHEP
Beam instrumentation for DC beams	Information exchange, joint HW dev & tests	GSI, CERN, …
Alignment and position monitoring in high rad env.	Information exchange,	GSI, FNAL, JPARC, CERN
Massless/multipole septum for increasing efficiency	Collaboration, joint HW dev, joint studies	JPARC, BNL, CERN, FNAL