This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement No 730871.

Rings with Ultra Low Emittance (RULε)
Report from WP7

ARIES 2nd Annual Meeting, Budapest, April 9th 2019

R. Bartolini, John Adams Institute (UOXF) DLS/SESAME

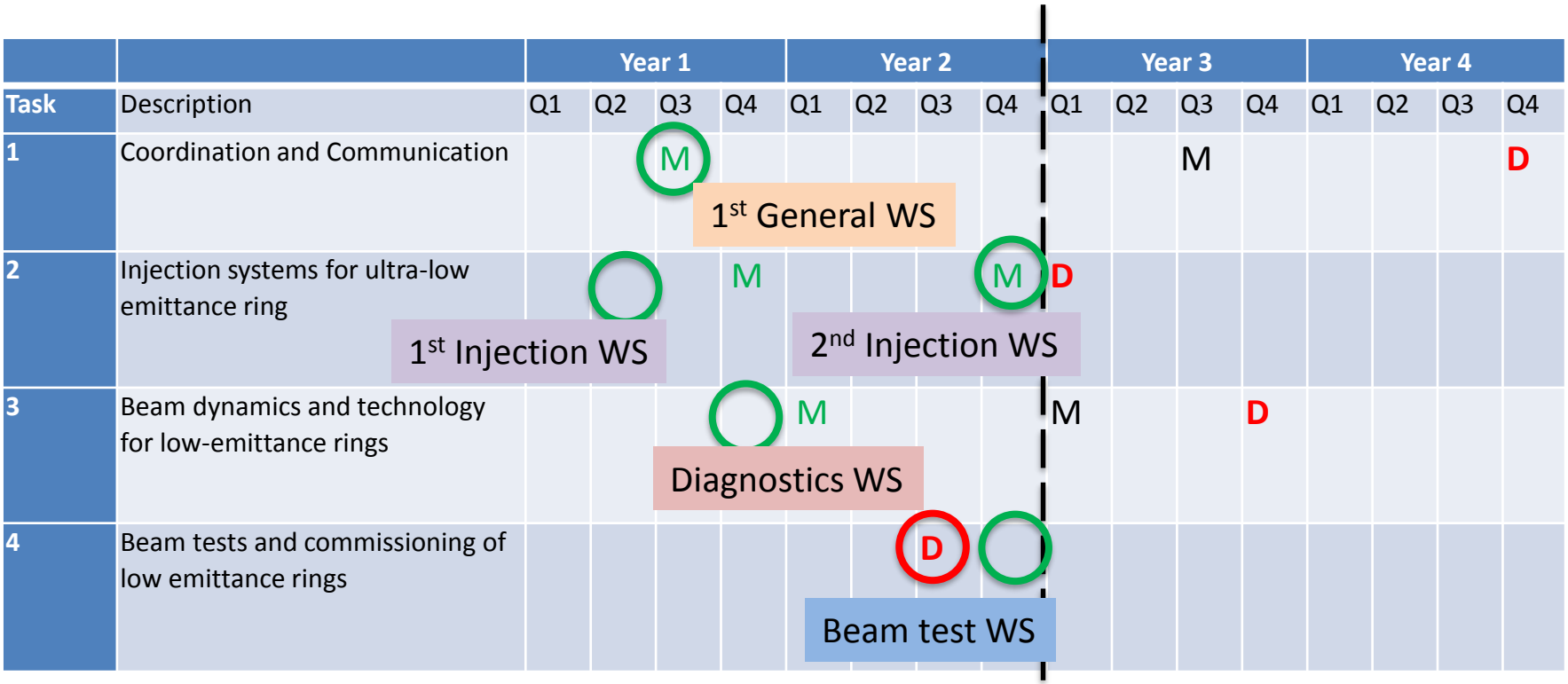
WP7: Rings with Ultra-Low Emittance (RULε)-NA

Fostering **networking** activities, exchange of ideas and staff in the accelerator community involved in **design, construction and operation of ultra-low emittance rings** (light sources, HEP: damping rings and colliders)

- Task 7.1. Coordination and Communication (R. Bartolini, UOXF)
- Task 7.2. Injection Systems for U-LER (R. Bartolini, UOXF, M. Boege, PSI)
- Task 7.3. Technology for ultra low emittance rings
  (Y. Papaphilippou, CERN, M. Biagini, INFN, R. Nagaoka, SOLEIL)
- Task 7.4. Beam tests and commissioning of U-LER (A.S. Mueller, KIT-ANKA)

  - Workshop on Injection held at PSI in April 2019 → **MS36 (in m24)**
  - Beam tests at ANKA-BESSY with SOLEIL-PSI → **D7.1 (in m18)**
  - Workshop on Beam tests and commissioning at KIT **(task 7.4)**
  - Prep. for Workshop on “small aperture accelerators” (M37, due m27)

WP7 RULε: milestones and deliverables



Summary of Milestones:

MS33, MS34, MS35 – ok in 2018

MS36: workshop on injection

MS37: workshop on technology

Summary of Deliverables:

D7.1: report on first beam tests

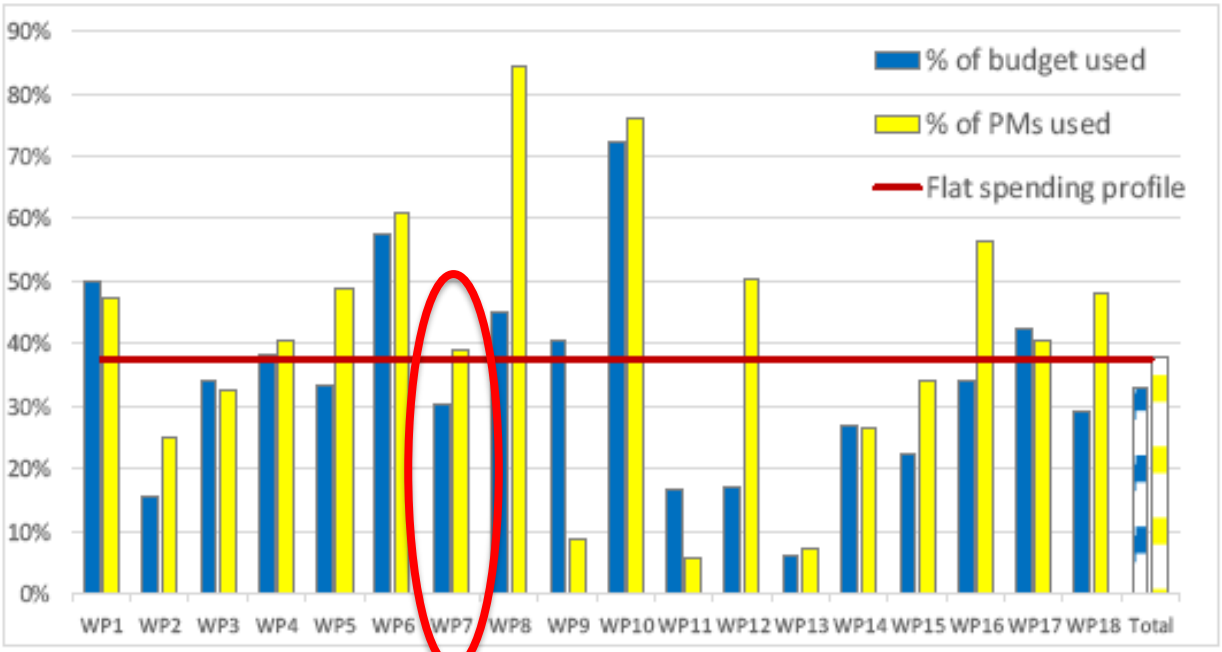
D7.2: report on injection (April 19)

Upcoming MS38 general workshop D7.3 and D7.4 (reports)

Status of WP7 – *Ring for Ultra-Low Emittance*

Overview of ARIES finances at M18 (end October)

From PR1 Financial Section – these plots will be presented and discussed at the Governing Board meeting in Budapest

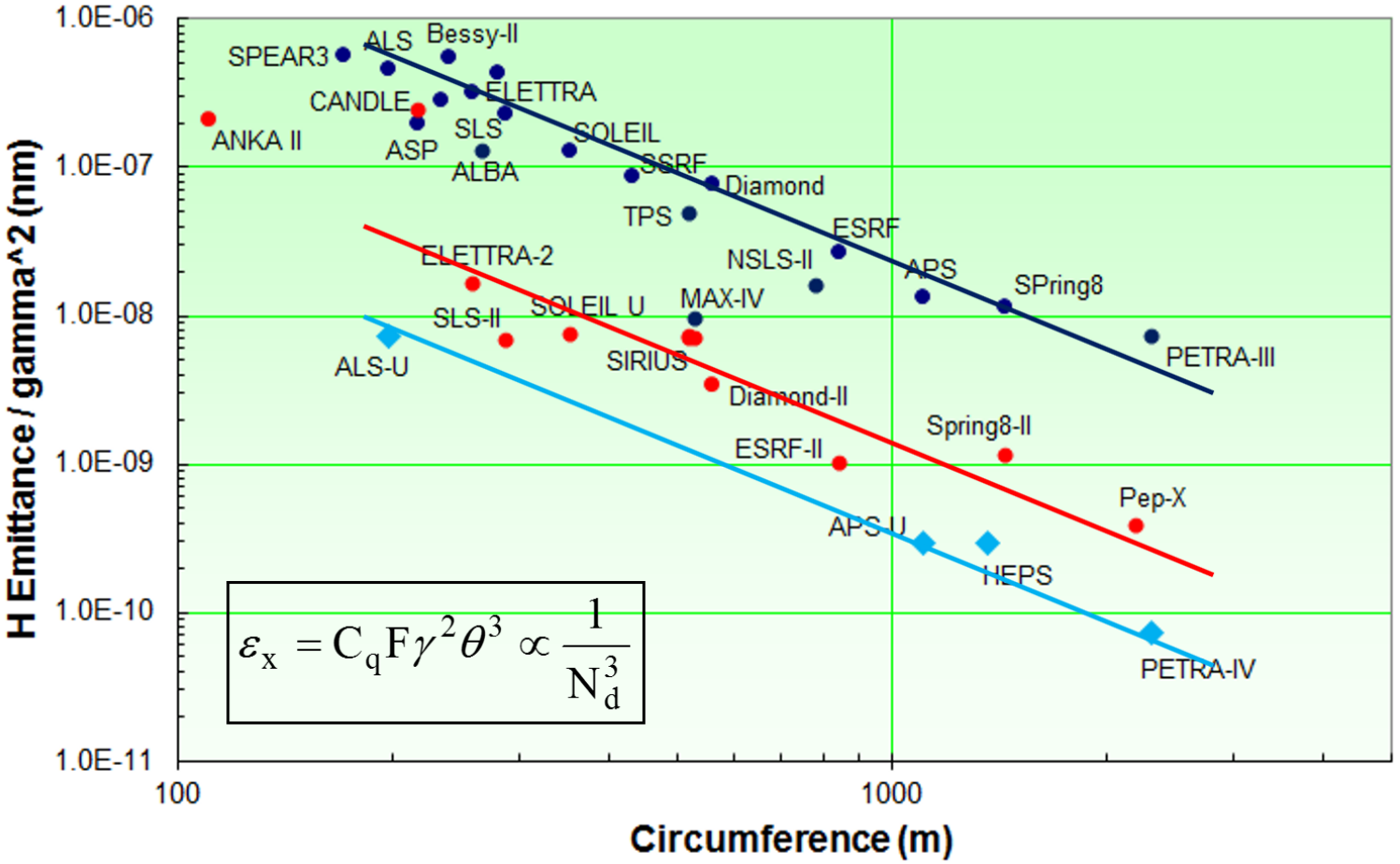


Underspending (<20%):
WP13
WP11
WP9 (personnel)
WP12 (budget)

Overspending (>60%):
WP10
WP8 (personnel)
WP6

Utilisation of man-power and resources for WP1 to WP18 during P1. The resources cover the full costs incurred by the beneficiaries (EC contribution + matching funds, including overheads) and are shown as percentage of the estimated total man-power and budget for the complete duration of the project.

WP7 RULε: present landscape



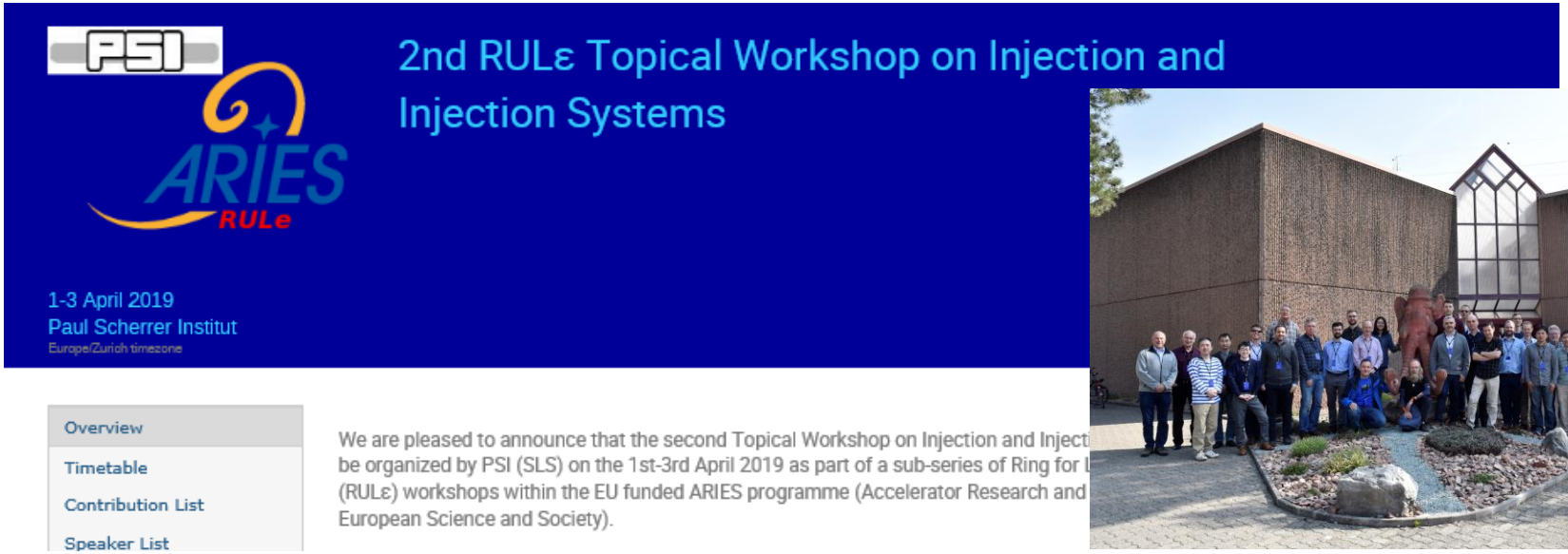
DBA/DTA

MBA + technology

On-axis inj. + technology

WP7 RULε: 2nd injection workshop (PSI)

2nd Topical Workshop on **Injection and Injection Systems**
(PSI, Villigen, 1-3 April 2019)



35 participants; M. Boege (PSI) Chair

- Review of existing injection schemes: transient and operation issues
- Novel injection schemes for ultra low emittance rings
- Hardware development, ongoing and proposed R&D

Agenda, attendance list on Indico

https://indico.psi.ch/event/6972/

Injection in ultra-low emittance rings

Main goals:
Injection in **small apertures** (6D, DA, MA), for **transparent top-up** (injection transient), with **high injection efficiency** (reduce losses for low radiation dose and PM demagnetisation)

Study of novel injection schemes:

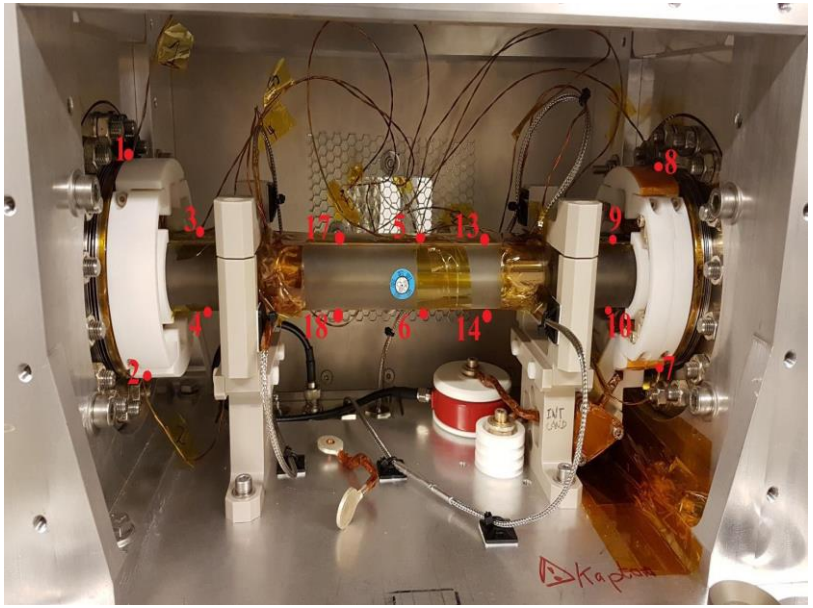
Off axis injection with anti-septum: SLS-II, Diamond-II
allows ~ 3mm separation of injected and stored beam; but nonzero transient
Off axis injection with NLK: Bessy-II, MAX-IV)
ok at MAX IV – heating issues – difficult to build

On axis longitudinal injection schemes: off-energy (SLS-II, SOLEIL, HEPS, …)
an impressively large number of variants (see later on beam tests)
Swap out injection: APS-U, ALS-U, HEPS, Petra-IV, …
allows extremely pushed lattices – need fast kickers and demanding injector

Hardware development:

New kickers (MIK) and fast kicker pulsers: e.g. 20 kV- 10 ns;
New boosters for low emittance or Linac injectors
Accumulators rings for swap-out injection: injection of full charge per bunch

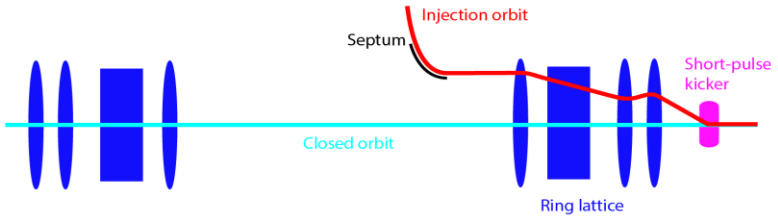
Some highlights of the workshop

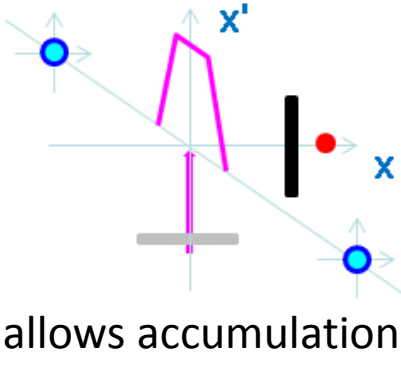


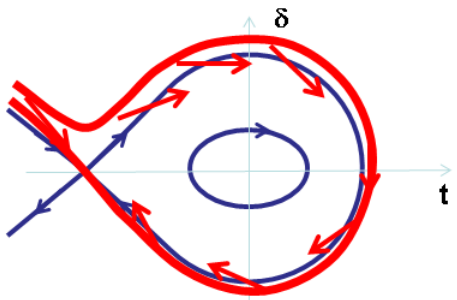
MIK SOLEIL-MAX IV
Injection efficiency 90 %
Residual perturbation < 10 um

Some issues with heating prompted a careful analysis of thermal effects (110 C)
better with HC and longer bunches (60 C)
Next MIK will have a large coating thickness 0.8 um to 3.5 um (amorphous coating)
Now routinely used in MAXIV injection

Longitudinal injection scheme M. Aiba (PSI), underpins many variants







Fast kicker between RF bucket allows accumulation: capture in the golf club

F. Perez: progress with experimental tests of CLIC damping ring stripline kickers at ALBA

Task.7.4: beam tests and commissioning

Topical workshop on **beam tests and commissioning of LER**
(KIT, Karlsruhe, 18-20 February 2019)

81 participants; A.S. Mueller (KIT) Chair

- Review of commissioning strategies
- Installation and commissioning of subsystems
- Ongoing and proposed R&D, collaboration and best practises

Agenda, attendance list on Indico

https://indico.cern.ch/event/772326/overview

Task 7.4: commissioning of LER

Review the commissioning experience:

MAX IV experience – still the first and only LER - lesson learned P. Tavares

Main commissioning issues were relate to simple problems that risked to slow down progress rather than fundamental issues

- polarity inversion
- short circuited pole face stripes – poor isolations
- misplaced thermal switches on coils – no temperature information (ILK)
- misaligned vacuum chamber
- chamber hot spot

All emphasised the need for adequate preparation:

High level software and diagnostics readiness

Subsystem testing:

use final control system for commission and be ready with the relevant software

Do not want surprises when you start the commissioning …but one cannot foresee everything.

Task 7.4: commissioning strategies

Review of commissioning strategies:

Commissioning strategies not too dissimilar from 3rd generation light sources:

- First turn steering
- sextupole – RF on
- multi-turn > stored beam (diagnostics with multi-turn capabilities)
- orbit, BBA, LOCO (re-alignment)

Much attention given to the preparation for commission – Fast commissioning (<3 months)

- commissioning simulations – ESRF-EBS and APS-U, ALS-U

Not only for “automated” commissioning

- i.e. a series of scripts to measure and correct beam trajectory – orbit – optics

but Beam Based correction strategies are included in the definition of the tolerances on the machine elements misalignments

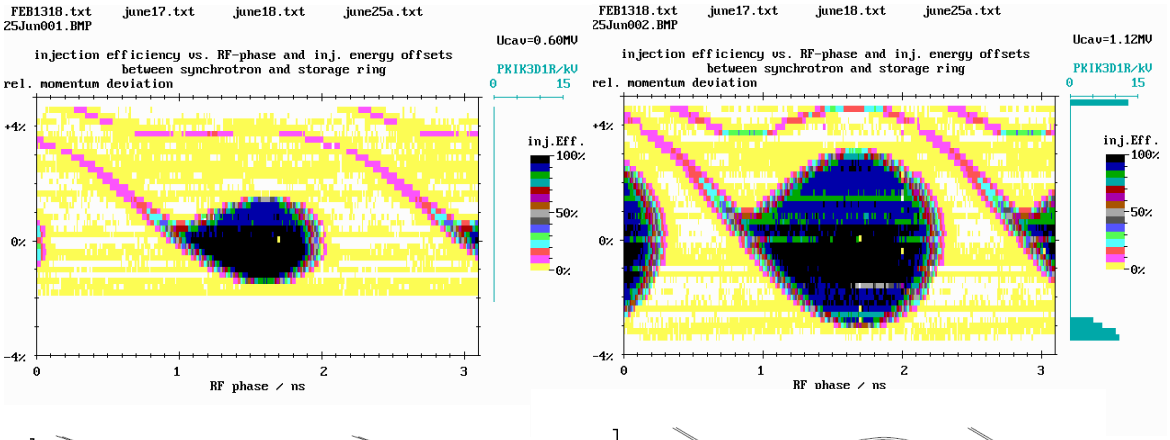
e.g. error tables defined for diamond would fail to find a closed orbit in ~70% of cases while a pre correction of trajectory reduces the failure to ~5%. Avoid over-specifying the tolerances!

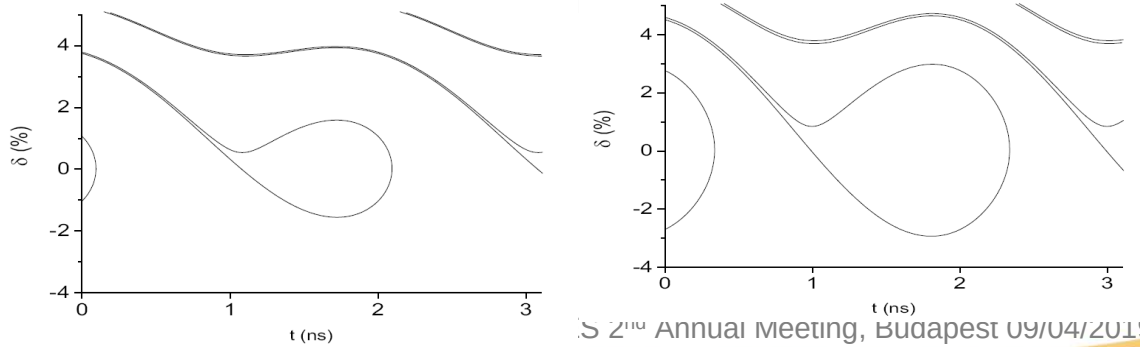
beam tests: off energy injection at BESSY-II

Two machine shifts were performed at the BESSY-II Feb and Jun 2018 by P. Kuske, Ji Li (HZB) and M. Aiba (PSI).

In many longitudinal injection schemes it is important to evaluate the longitudinal acceptance accurately.

Experiment at BESSY-II for accurate measure of the longitudinal acceptance of a ring and compare with the result of numerical simulations.





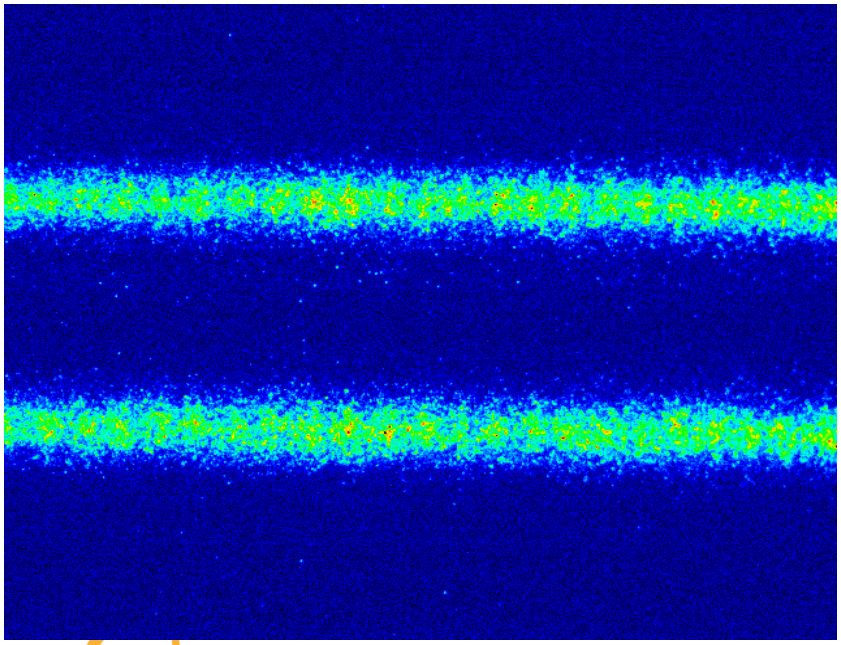
Injection efficiency as a function of off energy and off phase creates a golf club structure that is well replicated by the numerical simulations

Poor injection efficiency in the golf club due to long bunches from bessy booster

beam tests: with (large) negative alpha

In the past, studies of **low alpha** dynamics were intentionally pursued in the light source storage ring community in the attempt to produce short bunches and CSR, rather than to lower the emittance (**“large” negative alpha** required)

Experiments are needed to investigate the “large” negative alpha operation. The operation might suffers from significant coherent instability, reducing significantly the stored current.



streak camera of first beam injection in negative alpha

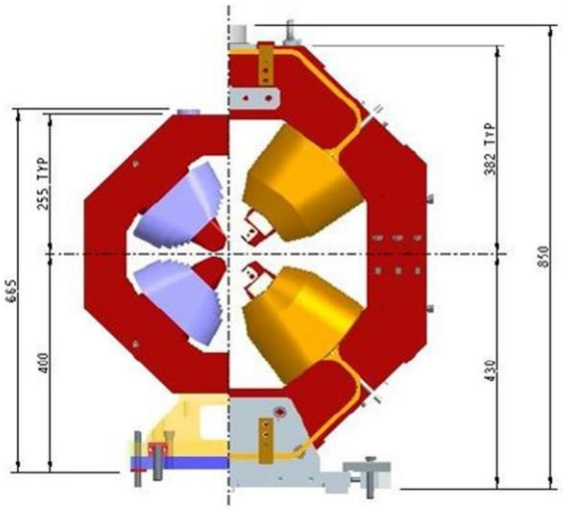
Energy	500 MeV
Alpha	- few 1e-3
Bunch length	~ 50ps FWHM
stored current	2 mA now

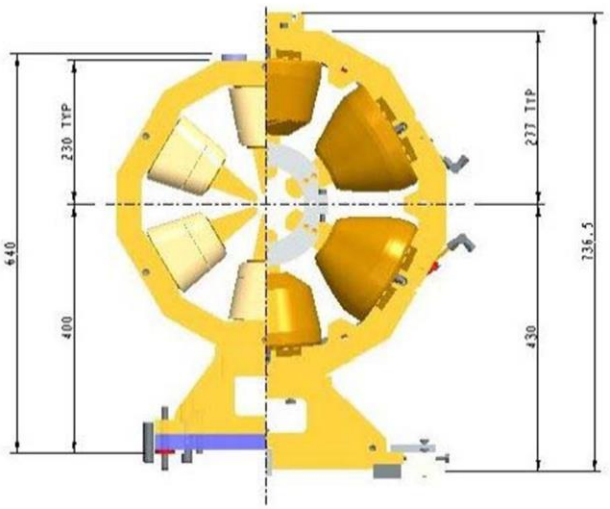
More tests foreseen in April 19
WP11 transnational access in KARA

WP7 RULε: future workshops

Upcoming workshop on technology Task 7.3 with main theme the implication of small aperture accelerators: small bore magnets and IDs operation, vacuum, BPMs, impedance and cures

Diamond DDBA upgrade chamber and magnet cross section





set for 8th July 2019 ALERT in Greece (theme is accelerator with small apertures)
Followed by the general workshop in January 2020 in Frascati

Conclusions and upcoming activities

WP7 activities proceeding according to plan. Workshop attendance in line with previous networks. Interest still high and many project progress have completed the CDRs and are going through the funding chain.

Upcoming activities – (good discussion at the WP7 coordination meeting on Tuesday)

- Next topical workshop … location to be decided. Milestone M37 due in … 2019
- Next general Workshop
  milestone M38 due in m33 – Jan 2020
- Deliverable D7.3 final report on technology
  due in m36 – April 2020
- Deliverable D7.4 final report
  due in m46 – February 2021

Thanks to:

M. Biagini (INFN), M. Boege (PSI), S. Casalbuoni (KIT),
S. Guiducci (INFN), A. S. Mueller (KIT), R. Nagaoka (SOLEIL),
Y. Papaphilippou (CERN), R. Ruprecht (KIT),

and thank you for your attention!