Review of ALERT 2016

Emanuel Karantzoulis

With contributions from: R. Bartolini, D. Einfeld, R. Nagaoka,
A. Andersson, P. Tavares and R. Geometrante.
Special thanks to Y. Papaphilippou and all participants for
stimulating and interesting remarks during discussions.

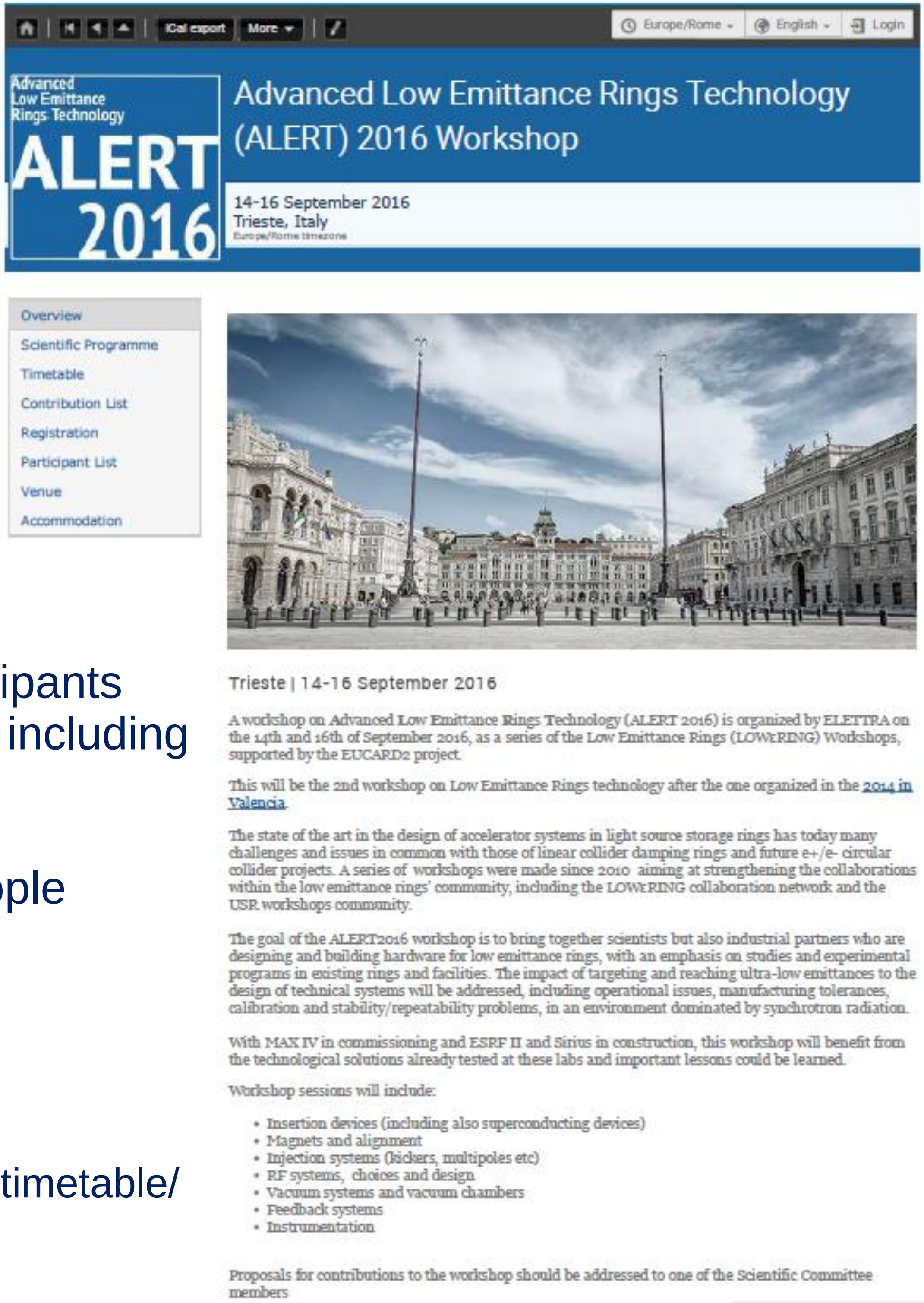
Elettra
Sincrotrone
Trieste

The scope of the workshop was to bring together Research institutes – Industries

There were 67 registered participants from Asia, Europe and America including 15 from the industry

In total with locals about 75 people

N-2 talks (missing 2) on:
https://indico.cern.ch/event/518497/timetable/



Advanced Low Emittance Rings Technology (ALERT) 2016 Workshop

14-16 September 2016
Trieste, Italy
Europe/Rome timezone

Trieste | 14-16 September 2016

A workshop on Advanced Low Emittance Rings Technology (ALERT 2016) is organized by ELETTRA on the 14th and 16th of September 2016, as a series of the Low Emittance Rings (LOWεRING) Workshops, supported by the EUCARD2 project.

This will be the 2nd workshop on Low Emittance Rings technology after the one organized in the 2014 in Valencia.

The state of the art in the design of accelerator systems in light source storage rings has today many challenges and issues in common with those of linear collider damping rings and future e+/e- circular collider projects. A series of workshops were made since 2010 aiming at strengthening the collaborations within the low emittance rings' community, including the LOWεRING collaboration network and the USR workshops community.

The goal of the ALERT2016 workshop is to bring together scientists but also industrial partners who are designing and building hardware for low emittance rings, with an emphasis on studies and experimental programs in existing rings and facilities. The impact of targeting and reaching ultra-low emittances to the design of technical systems will be addressed, including operational issues, manufacturing tolerances, calibration and stability/repeatability problems, in an environment dominated by synchrotron radiation.

With MAX IV in commissioning and ESRF II and Sirius in construction, this workshop will benefit from the technological solutions already tested at these labs and important lessons could be learned.

Workshop sessions will include:

- Insertion devices (including also superconducting devices)
- Magnets and alignment
- Injection systems (kickers, multipoles etc)
- RF systems, choices and design
- Vacuum systems and vacuum chambers
- Feedback systems
- Instrumentation

Proposals for contributions to the workshop should be addressed to one of the Scientific Committee members

Motive and Aims

Research centres cannot produce everything and should also help industries in R&D

The scope of the workshop was to focus and identify the areas of collaboration with industry trying to answer:

At what/where sector are the needs / opportunities for R&D?

What / where are the capabilities for R&D?

Are there any and how can we fill the gaps?

How to improve the interaction / communication?

Initiate discussions

Potential

Institutes → better accelerators (science and tech.)
Industries → financial return

Low Emittance Rings ~2018-2028
(beyond MAX IV – ESRF-EBS – SIRIUS)

APS-U, ALS-U, ELETTRA 2.0, SLS II, PETRA IV, HEPS, DLS II, SOLEIL, ANKA, …
(Iran, Mexico, Thailand, African LS, …)
CepC, FCCee

100-200 Meuros (acc only) each → ~1 B€
200-500 Meuros (inc. beamlines) each → ~2 B€

Technical challenges and R&D needed

Magnets (static and pulsed)

IDs

Vacuum

RF

Mechanical engineering

Diagnostics, Electronics (e.g. BPMs, feedbacks)

Going boldly to the limits (or not?)

General Session

Highlights from MAX IV commissioning and operation , Pedro Tavares (MAX IV)

ESRF II , Dieter Einfeld (ESRF)

Sirius and Sirius magnets ,James Citadini (LNLS)

BESSY-VSR-Project , Martin Ruprecht (BESSY)

All below 0.3 nm rad

Sirius Budget (2016)

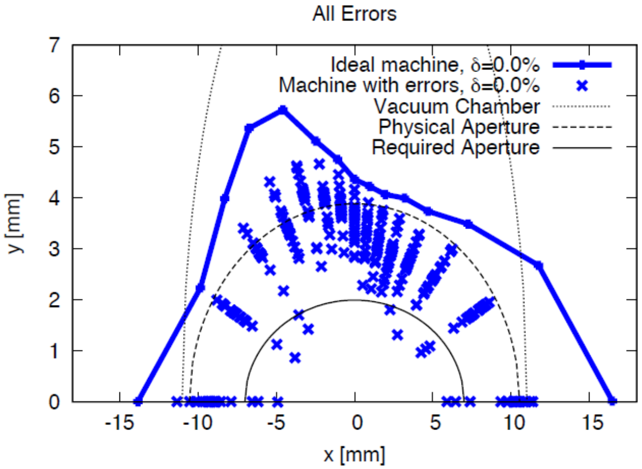
Accelerators	94 M €
13 beamlines	133 M €
Building	200 M €
Human Res	53 M €
Total	480 M € (Not all money given)

3 years to produce 200 magnets 1 year to produce 800 magnets
Full NEG-ed chamber
Coating system in the facility
Partnership LNLS/WEG for magnets
NdFeB with 15 μm parallel surface for Superbends
Booster dipole (with quadrupole and sextupole components)

ESRF, High gradient quads
91 T/m gradient, 388 – 484 mm length
12.7 mm bore radius, 11 mm vertical gap, +/- 20 μm pole accuracy

Also DLG and DQ1: 1.028 m, 0.57 T, 37.1 T/m
Schedule margin 2-3 months

Compact designs: are *compact components key to achieving low emittance in recent designs – can the trend going to continue even further ?*



MAX IV inj. efficiency > 80%
V DA as predicted, H DA should also be measured

BESY-VSR double 3HC to create short and long bunches
RF voltage at 1.5 GHz 20 MV
RF voltage at1.75 GHz 17 MV
(Nb cavities)
Effective bunch length (rms) 1.7 ps

Technical challenges and R&D needed

Insertion devices

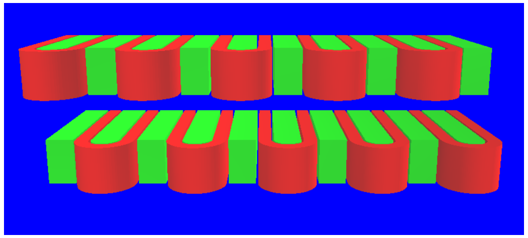
Super-conducting Undulators at ANL, Joel Fuerst (ANL)

Planar superconducting undulator with neutral pole:

test results of the prototype, Nikolay Mezentsev (BINP)

Fixed gap undulators and performance, Bruno Diviacco (Elettra)

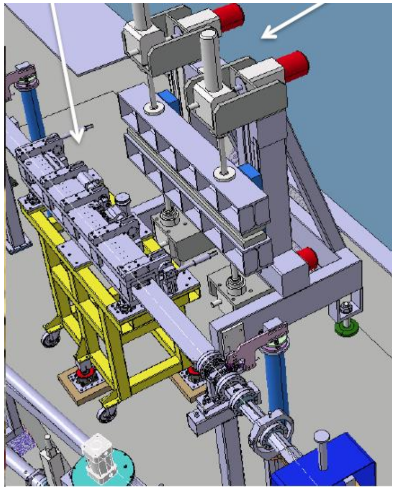
Use of materials of superconductivity (NbTi/Cu, NbSn/Cu) has considerable advantage against permanent magnets



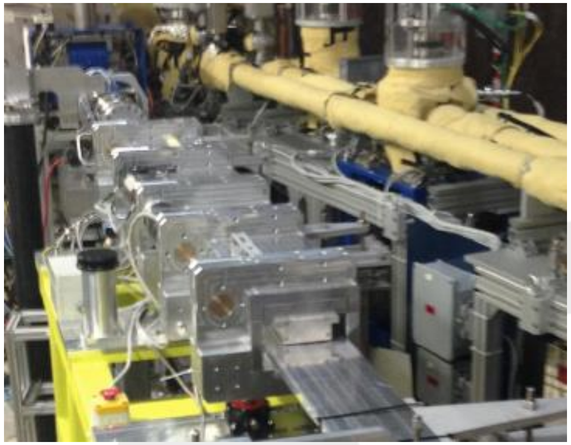
Long-term (3 -4 year) ANL goal is to develop a vendor for “turn-key” SCU production
Several subsystems on existing SCUs (1.67 T) were fabricated in industry from ANL designs:
–Vacuum vessel
–Thermal shields
–Liquid helium reservoir
–Magnet cores
Cryostat evolution: better thermal performance, improved alignment, smaller, cheaper, possible LHe-free cooling..

Parameter	Symbol	Design	Measured	Units
Nominal on-axis, peak field (at 80% short-sample limit)	$\lvert B_0 \rvert$	1.67	1.6657	T
Nominal peak undulator parameter (at 80% short-sample limit)	K_0	3.26	3.260	-
Nominal excitation current (at 80% short-sample limit)	I_0	~600	588	A

Design features of superconducting windings and assembly of the magnet allow to hope for significant increase in accuracy of manufacture and decrease of cost of a magnet.
The quantity of windings is twice decreased.
It is easy to provide mass production, high quality of pole fabrication, control of key dimensions and quality for every pole



APU has many advantages

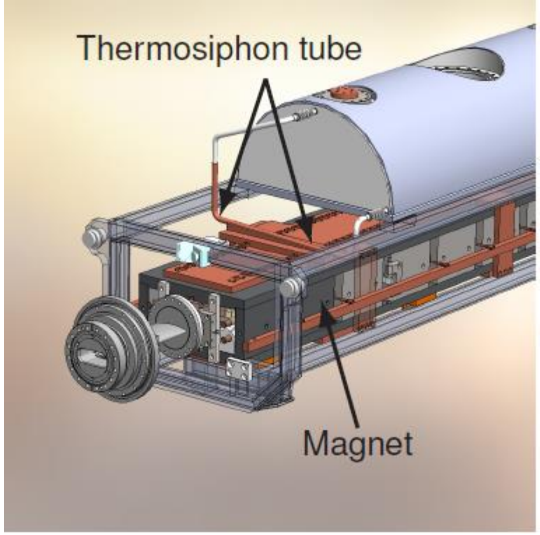


Technical challenges and R&D needed

Insertion devices (from Magnets & alignment session)

NbTi wiggler tests at ANKA ,Axel Bernhard (ANKA)

CLICDW Design: Conduction cooling
The Nb-Ti CLIC damping wiggler prototype with conduction cooling modular design has passed Factory and Site Acceptance Tests and is installed in the ANKA storage ring cryogenic system: performance outstanding
KIT-CERN-BINP collaboration



CPMUs vs SCUs vs In-Vacs vs APD
EPUs
DELTA

NbTi – NB_3Sn

Field (phase errors)
Shimming and correction techniques
Radiation hardness
Cost

New SC devices without He bath

Technical challenges and R&D needed

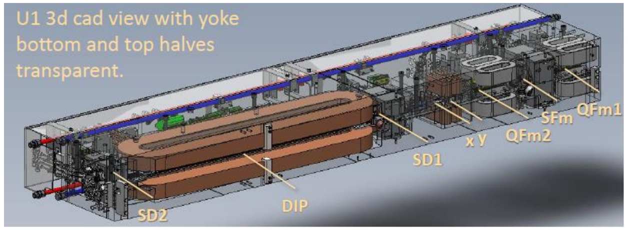
Magnets

MAX IV 3 GeV ring magnet, Martin Johansson (MAX IV)

Magnets for DDBA and lessons learned for Diamond-II ,

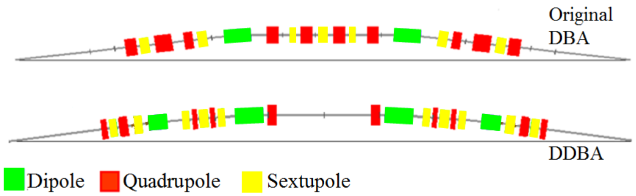
Abolfazl Shahveh (Diamond)

Magnets for Elettra 2.0, Davide Castronovo (Elettra)

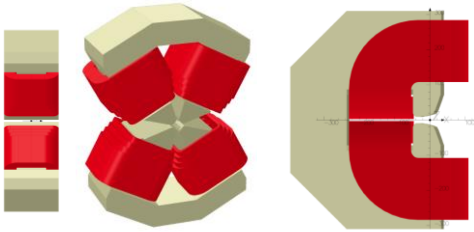

U1 3d cad view with yoke bottom and top halves transparent.

25mm aperture.
Have the magnet suppliers do as much as possible, for example all field measurements.

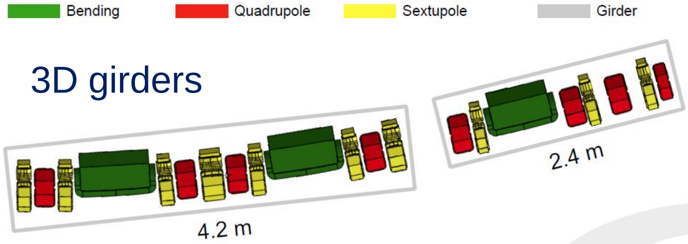
- The “magnet blocks” are an alignment concept that relies on the accuracy of CNC milling and 3D coordinate measurement machines, techniques which are available at large number of machining subcontractors.
- As opposed to stretched wire alignment, which is typically only available at a few accelerator labs.
- With only a limited amount of prototyping done by MAX-lab before purchasing the production series, the “R&D” of finding out what mechanical tolerances were actually achievable for these magnet blocks was essentially done by our suppliers.



Gradient Dipole: B=0.8 T and G=14.4T/m
The good field region is X: ± 10 mm Y: ± 4mm
Quadrupoles designed to reach max G=70 T/m
Bore radius 15 mm
Attempt to reach 20um pole accuracy with precision milling proved challenging
Dipoles: Aligned mechanically using a laser tracker target +/-50 um
Multipoles: Aligned magnetically using stretch wire bench on complete girder target +/- 25 um



Bore radius 26 mm
B=0.8 T G < 15 T/m
GQ < 50 T/m
With Lp=Lm
All air-cooled



3D girders

Technical challenges and R&D needed

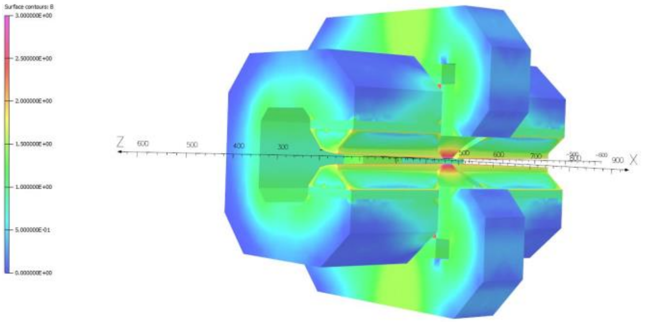
Magnets & alignment

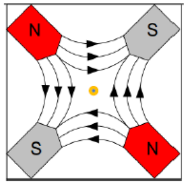
Dipoles with longitudinally variable field for CLIC damping rings ,Manuel Dominguez (CIEMAT)

NbTi wiggler tests at ANKA ,Axel Bernhard (ANKA)

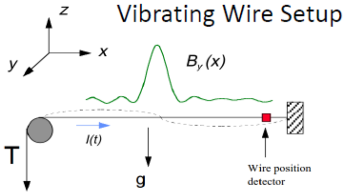
Vibrating wire method and hall probe measurements for combined function magnets (DQ) alignment, Alexander Temnykh (Cornell)

Permanent magnets are the best choice to provide a fixed field: no power consumption and very compact. (1-1.7 T, 11 T/m and LG)
Taking into account:
Temperature variation in the tunnel will be as low as ±0,1ºC
Sm-Co radiation tolerance is higher than Ne-Fe-B
Low radiation expected, but higher in the low field sections (magnet ends)
The permanent magnet volume and weight reduction using Ne instead of Sm goes up to 45%.
The cost of Neodymium magnets is lower than SmCo.
pointing towards the use of:
Ne-Fe-B magnets in the high field region
Sm-Co magnets in the low field regio
NO specific temperature compensation Interaction with CERN





Field is “zero” on magnetic axis, straight geometry


Vibrating Wire Setup

The technique is based on the excitation of the harmonics of a wire vibration by Lorenz forces between current in a wire and the surrounding magnetic field.
It was used on many occasions : Cornell, BNL, SLAC, etc
Precision of magnetic axis localization in respect to wire ~1micrometer or better

Using Vibrating Wire and Hall probe magnetic field measurement techniques, quadrupole and combined function magnets (DQ) can be magnetically surveyed and placed in required **position in respect to girder fiducials with precision better than 20 microns.**

Technical challenges and R&D needed

Magnets and magnets&alignment

High gradient and small bore apertures (how high and how small can we go?)
Review tolerance requirements – how good do magnets really need to be ?

Complex dipoles (DQ, DL)
Permanent magnets for achieving very large gradients ?
Cost-effective series production of permanent magnets

Precision machining (poles, mating surfaces, …)

Measurements (stretched wire with small bores)
Alignment (in situ)

Technical challenges and R&D needed

Beam transfer systems

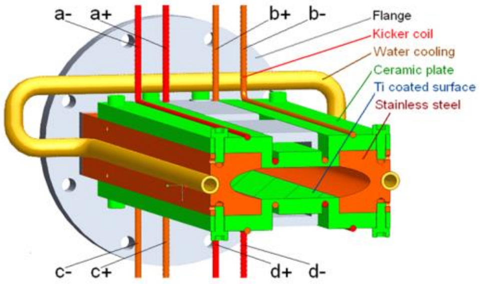
Production of round beams, Peter Kuske (HZB - BESSY)

Development of Multipole Injection Kicker for SOLEIL and MAX IV, Pierre Lebasque (Soleil)

Stripline kicker development at ALS ,Cristoph Steier (LBL)

Transient studies of the stripline kicker for beam extraction from the CLIC damping rings ,Carolina Belver Aguilar (CERN)

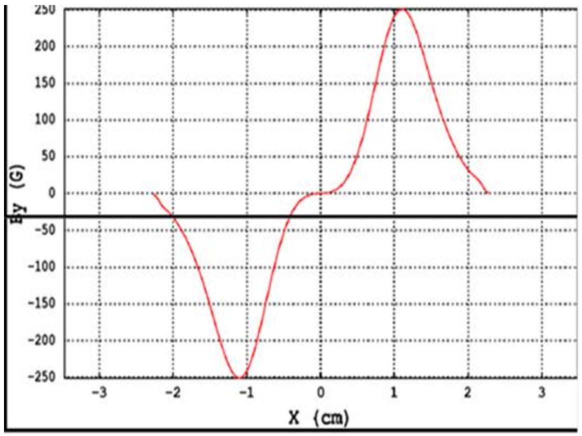
Inductive adders ultra-stable kicker pulse generation, Janne Holma (CERN)



Round beams using skew quad by exciting
coupling resonance at 100 kHz
4 methods presented
Other methods like using solenoids?

More investigation needed to consolidate

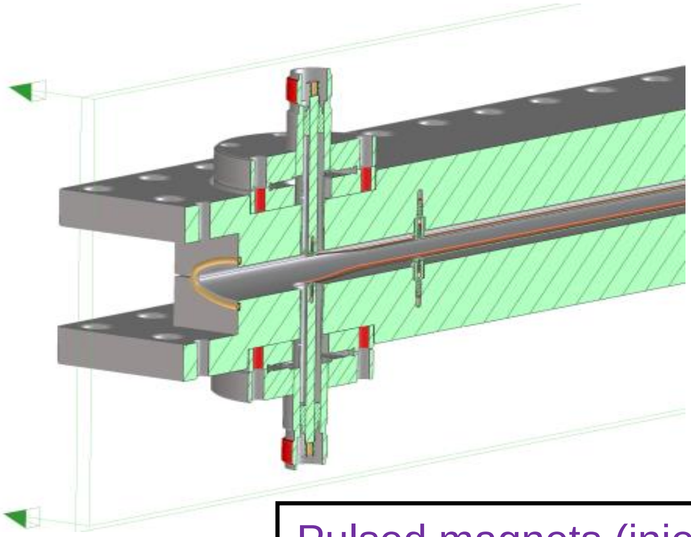
Technical Approach	Injection	Emittance control	Complexity
Radial Damping Wigglers	off-axis	yes	large
Möbius Accelerator	on-axis	no	moderate
Resonance Excitation	off-axis	(no)	moderate
On Coupling Resonance	off-axis, tune shift with ampl.	(no)	trivial



Very challenging , high accuracy required (e.g. 10um in wire position) In delay due to some external company

Technical challenges and R&D needed

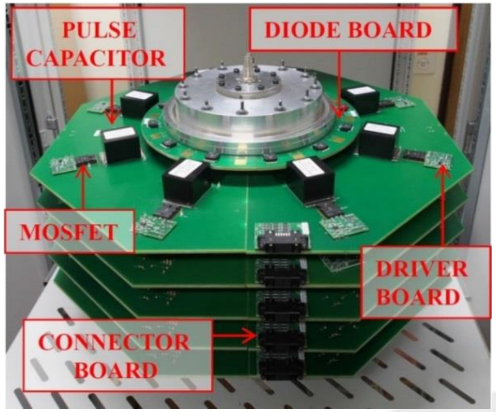
ALS On-axis swap-out injection
Building 6 mm gap stripline kicker for test in ALS (<10 ns rise/fall time) using inductive adders



CLIC also studies stripline extraction kickers using inductive adders with rise time 100 ns and very flat-top of 1μs (stable deflection angle)

Inductive Adders for CLIC

±0.02 % (± 2.5 V) requirement for the **flat-top stability** of ±12.5 kV, 160 to ~900 ns pulse is an extremely demanding specification! **However the pulse power modulators for CLIC DR kicker systems are very probably feasible with inductive adder technology.**



Pulsed magnets (injection in small apertures)

Kickers for swap out

- rise time (1-few ns)
- flattop (10^{-4})

Kicker for top-up

- 4 equal pulses

Non-linear kickers -> difficulties with tolerances

CW skew quadrupole

Technical challenges and R&D needed

RF technology related contributions

- MAX IV RF Systems --- Lars Malmgren (MAX IV)
- Conceptual Design of a 2 GHz RF System for the CLIC DRs --- Alexej Grudiev (CERN)
- State-of-the-art RF solid state amplifiers --- Massamba Diop (SOLEIL)
- Experience and future trends of Harmonic RF systems --- John Byrd (LBNL)

100 MHz with Rohde & Schwarz 60 kW CW solid state liquid cooled amplifiers based on two 30 kW transmitters / amplifiers with additional power combiner

CLIC	1 GHz	2 GHz, **no train interleaving after DR**
Classical RF system based on the NC ARES-type cavities	Baseline P_{RF} = 3.8 MW; L = 32 m; Cavity design: OK	Alternative 2.0 P_{RF} = 5.9 MW; L = 48 m; Cavity design: ok?
Classical RF system based on the SCC cavities	Alternative 1.1 P_{RF} = **0.6** MW; L = 108 m; Cavity design: **ok?**	Alternative 2.1 P_{RF} = **0.6** MW; L = **800** m; Cavity design: **NOT OK**
RF system with RF frequency mismatch	Alternative 1.2 P_{RF} = **1.3** MW; L = **16** m; Cavity design: **OK**	Alternative 2.2 P_{RF} = 2.1 MW; L = 24 m; Cavity design: OK
"A-la-linac" RF system with strong input power modulations	Alternative 1.3 P_{RF} = 3.3 MW; L = **8** m; Cavity design: **OK**	Alternative 2.3 P_{RF} = 5.8 MW; L = **12** m; Cavity design: **OK**

High efficiency (65%), redundancy, modularity, low phase noise, MTBF > 1y

Technical challenges and R&D needed

	Active	Passive
NCRF	- Requires input coupler - Requires RF source and controller - Can reach optimum BL at any current - Multiple cavities	- Lower cost - Only “optimum” bunch lengthening at most at a single high current (maybe nowhere) - Higher total R/Q for transients - Multiple cavities
SCRF	- Requires SC infrastructure - Requires input coupler - Requires RF source and controller - Can reach optimum BL at any current - Lower R/Q for transients - One or two cells	- Requires SC infrastructure - Never reaches optimum BL (always 90 deg phase) - Lower R/Q for transients - One or two cells

NC or SC RF?

High RF frequencies,
Low RF frequencies

RF sources:

Low Frequency (50-200 MHz) offers several technology options at the right power range. SSPA favored.

High Frequency (>1.5 GHz) available at the 10 kW range in SSPA format. Higher power sources more rare.

RF cavities:

High frequency cavities (>1.5 GHz) exist. NC have large power densities and are limited to ~10 kW/cell. HOM-damped SC cavities exist but typically limited by input power coupler. Is the small beam pipes of 4GLS hinting towards higher frequency cavities?

Most HOM-damped designs exist in the 350-500 MHz range. HOM-damping for low frequency cavities can still be optimized. How much HOM damping is needed with Landau cavities in use?

Almost all of the machine diagnostic/auxiliary systems

depend on choice of RF frequency. The practical optimum

frequency depends on many factors.

SS amplifiers vs klystrons (list in talks)
modularity – low phase noise – cost
efficiency – failure rate

Choice of frequency
100 MHz – 500 MHz – higher (e.g. 2 GHz)
Larger cavities (100 MHz) might have long conditioning times
Larger machines may benefit from lower rf. freq.
instead smaller machine may benefit from
higher rf. Frequency -> Reducing size longitudinally

How to fight IBS and improve lifetime? HCs

Special harmonic cavities
e.g. VSR concept
cryomodule design – HOM reduction

Technical challenges and R&D needed

Some points learned from the presentations and raised during the discussions *(notes from R. Nagaoka)* :

- High gradient RF voltage using the superconducting multi-cell cavities *à la* BESSY-VSR may be a good effective means to provide much higher intensity short photon pulses with a high repetition rate in storage rings. → Compatibility with low emittance/Suppression of HOMs must be further pursued.

- SSPAs (Solid State Power Amplifiers) are becoming explosively the new RF power source in modern accelerators after the pioneering and successful development and experiences made at SOLEIL. Their effective operating range in frequency is rapidly increasing. There was also a counter argument that Klystron lifetime is also not said to be comparatively short. However, there is a clear trend that the number of Klystron manufacturers is decreasing.

- Lowering the main RF frequency f_{RF} cannot always be a solution in fighting against IBS and reduced Touschek lifetime, as reduces the number of buckets and so increases the bunch current.
  - Machine specificity such as the machine energy, circumference and foreseen filling modes must be taken into account in evaluating the pros and cons.
  - Large machines having the margin to sacrifice the number of buckets may profit by decreasing f_{RF}.
  - Higher f_{RF} may enhance beam-induced heating due to widened bunch spectra
  - Generally, there are constraints due to components dependence on f_{RF}

- Active lengthening of a bunch using harmonic cavities may be a common effective means of combatting the IBS, reduced Touschek lifetime and even fighting against collective instabilities for future ultra low-emittance rings not intending to produce short bunches. The choice of superconducting versus normal conducting requires careful machine-dependent comparisons

Technical challenges and R&D needed

Feedback systems and Enginneering

Fast orbit Feedback for ESRF-EBS, Benoit Roche (ESRF)

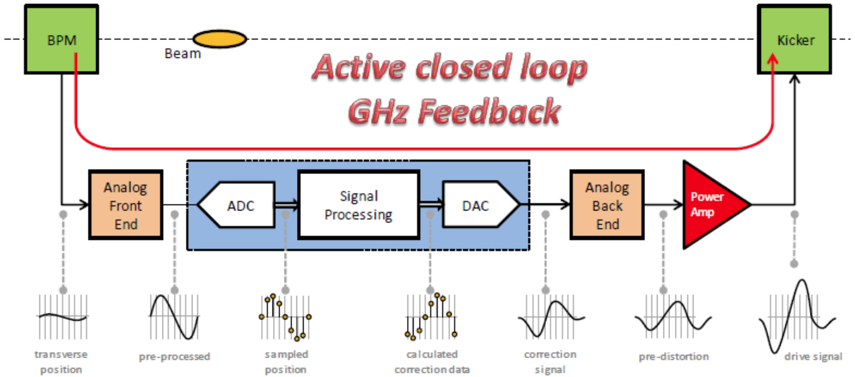
Application of wide-band feedback systems for low emittance rings , John Fox (SLAC)

Engineering for DDBA and lessons learned for Diamond-II , Nigel Hammond (Diamond)

Risk assessment for the ESRF II , Dieter Einfeld (ESRF)

For the ESRF-EBS, beam stability requirements are comparable with ESRF (roughly same vertical beam size, below micron)
Requires 320 bpm and 288 (96 fast) correctors having fast and slow FB. 10 kHz acquisition no big changes

Wideband Intra-Bunch Feedback

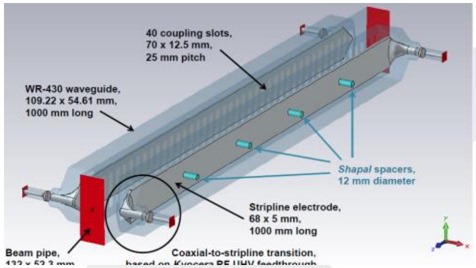


- Pickup - provides moment (charge*position)
- Analog Front End - Δ and Σ
- GHz Bandwidth, equalization

- 4 - 8 GS/s DSP
- Orbit rejection, processing gain
- Tailored gain vs. phase for damping

- Back End - RF drive to power stages, equalization
- Kickers - converts RF to transverse kick
- Timing, Synchronization, Diagnostics

1 GHz Wideband Slot-line kicker development CERN-INFN-LFN-LBL-SLAC collaboration



Technical challenges and R&D needed

Feedback systems and Enginneering

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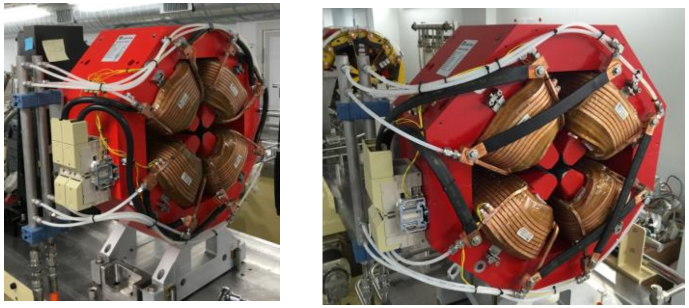


Manufacturing Errors and Overlaying Bake out Cabling. Additional spacer required to separate cable route from water cooling tube route etc...

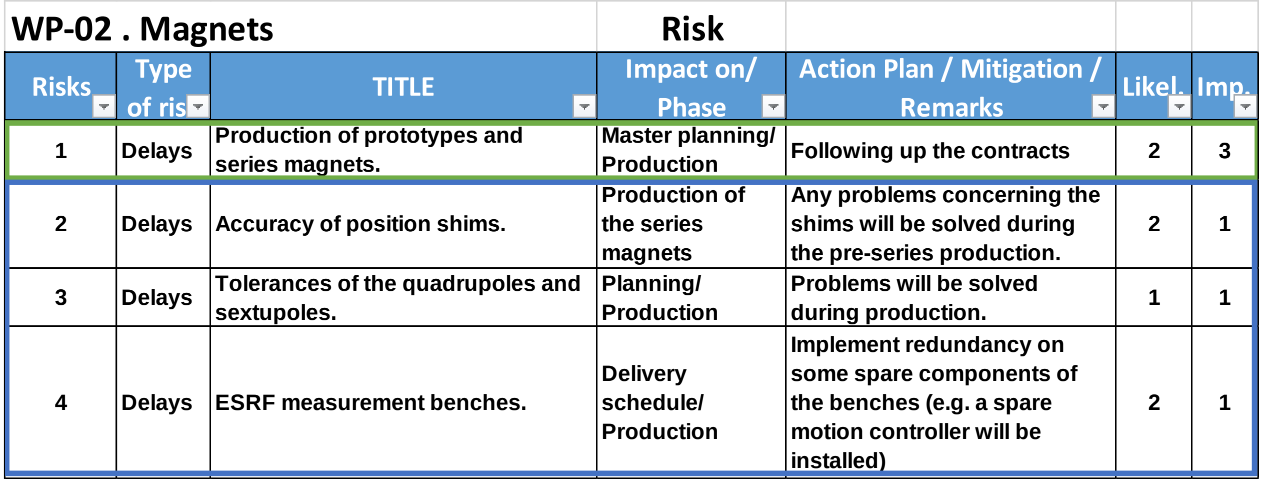
- Physically separate magnet alignment, vessel construction and cabling areas. Or build in flexibility to change a single area from temperature controlled to clean and then general.
- Appoint a **Girder Assembly Supervisor** devoting 100% of his/her time to setting priorities, resolving conflicts and maintain tidiness of area during the girder assembly.
- Employ full time ‘Expeditor staff’, or a ‘Third Party Inspection Agency’ to monitor progress and quality control at major suppliers premises.
- Include cable routes in the CAD model, especially routing approaching cable terminations. Don’t forget the vessel bake-out cabling.
- Carry out design development for flange alignment and seal design for RF continuity.
- Carry out trials of metal joining processes in conjunction with component design.

Mechanical engineering
- MAX IV blocks concept
- Precision girder machining (20 um over 3-5 m)
  - T-slot keyways vs dowels

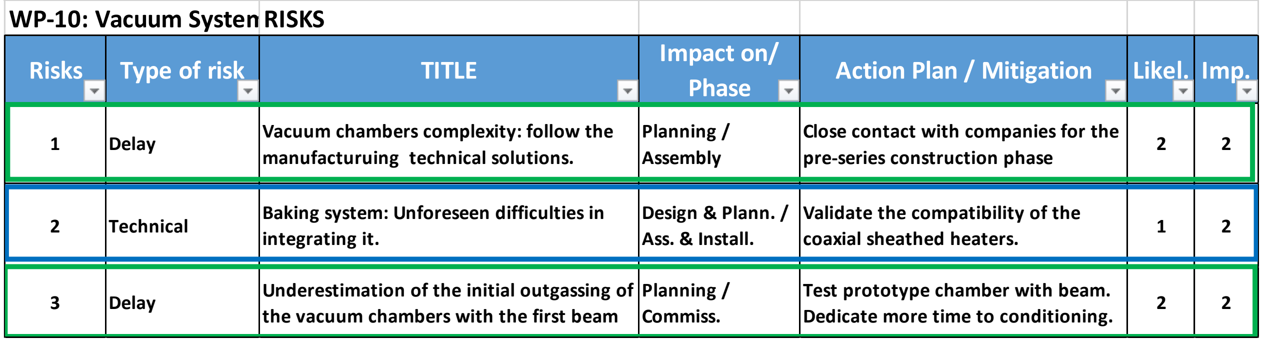
- Girder motion
  - movers
  - by-hand

- high precision movement in monochromators
- narrow band-pass filter

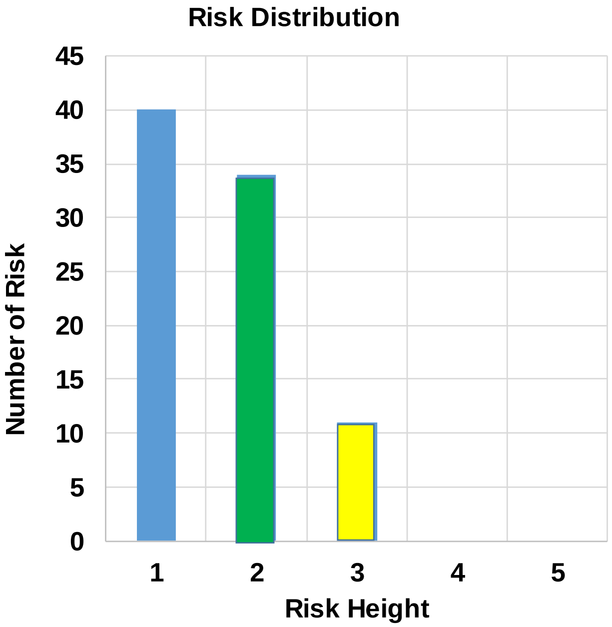
Risk Analysis



WP-02 . Magnets			Risk			
Risks	Type of ris	TITLE	Impact on/ Phase	Action Plan / Mitigation / Remarks	Likel.	Imp.
1	Delays	Production of prototypes and series magnets.	Master planning/ Production	Following up the contracts	2	3
2	Delays	Accuracy of position shims.	Production of the series magnets	Any problems concerning the shims will be solved during the pre-series production.	2	1
3	Delays	Tolerances of the quadrupoles and sextupoles.	Planning/ Production	Problems will be solved during production.	1	1
4	Delays	ESRF measurement benches.	Delivery schedule/ Production	Implement redundancy on some spare components of the benches (e.g. a spare motion controller will be installed)	2	1



WP-10: Vacuum Systen		RISKS				
Risks	Type of risk	TITLE	Impact on/ Phase	Action Plan / Mitigation	Likel.	Imp.
1	Delay	Vacuum chambers complexity: follow the manufacturuing technical solutions.	Planning / Assembly	Close contact with companies for the pre-series construction phase	2	2
2	Technical	Baking system: Unforeseen difficulties in integrating it.	Design & Plann. / Ass. & Install.	Validate the compatibility of the coaxial sheathed heaters.	1	2
3	Delay	Underestimation of the initial outgassing of the vacuum chambers with the first beam	Planning / Commiss.	Test prototype chamber with beam. Dedicate more time to conditioning.	2	2



The highest risks are “delays” with 28 tasks and “technical” with 11 tasks.

But sometimes delays are due to “technical”

Technical challenges and R&D needed

Diagnostics, Instrumentation and coating

Ultra-low vertical emittance measurements in the Australian Light Source , Mark Boland (Australian Synchrotron)

Conceptual design of X-ray interferometer for extremely apparent small beam size in FCC-ee and beam halo measurement with coronagraph for HL LHC , Toshiyuki Mitsuhash (KEK)

Ultra-short bunch length diagnostics , Axel Bernhard (KIT-ANKA)

Laser engineered surfaces , Amin Abdolvand (Dundee University)

Experience with coating of low gap chambers , Roberto Kersevan (CERN)

Vaccuum and other Key technologies and engineering

MAX IV 3 GeV ring vacuum system ,Marek Grabski (MAX IV)

Vacuum systems for DDBA and lessons learned for Diamond-II, Matthew Cox (Diamond)

>>> Experience and future trends of Harmonic RF systems , John Byrd (LBL)

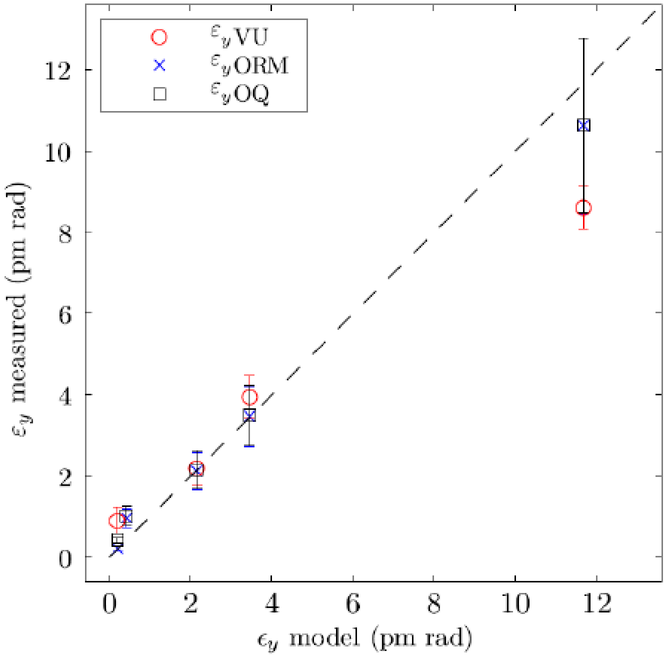
Transverse and horizontal beam size diagnostics with visible SR , Åke Andersson (MAX IV)

Particle Accelerator Components’ Metrology and Alignment to the Nanometre scale (PACMAN) , Michele Modena (CERN)

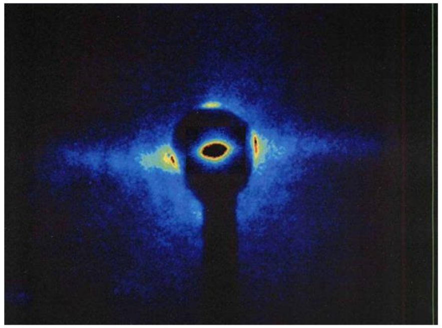
Technical challenges and R&D needed

Good method and lattice model to reduce the coupling and hence the vertical emittance { need to improve ultra low emittance measurements.

Good success with measuring ultra low vertical emittances using undulator spectra and interferometry (from a 140 m long beam line)

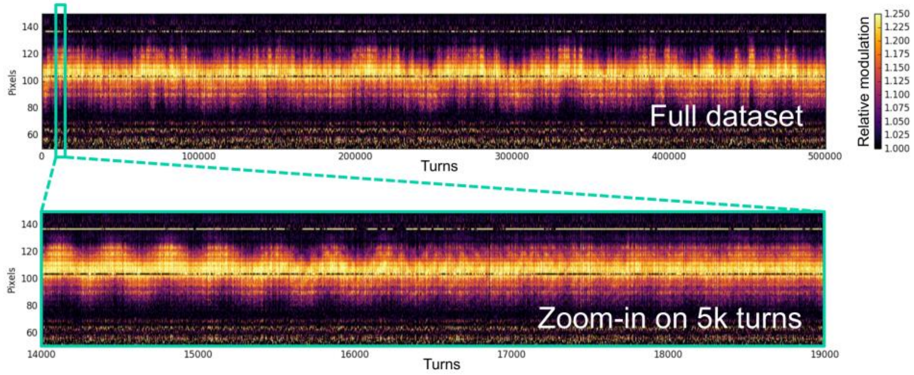


Halo observation by using the coronagraph in HL LHC and single and double slit interferometry

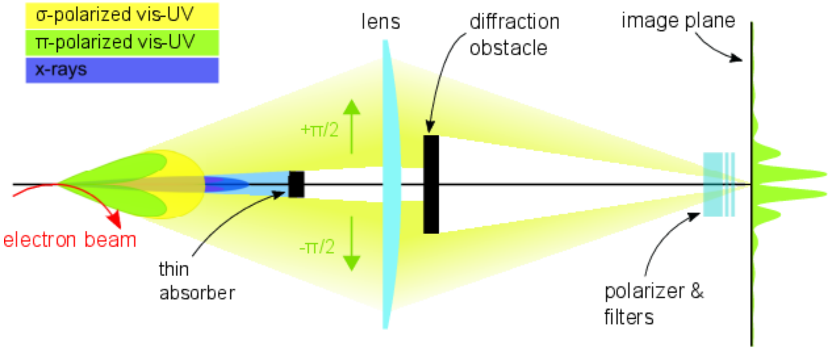


method	**wavelength**	**measurable minimum beme size in angular diameter in μrad**	**Corresponding size in 100m in μm**	**Corresponding size in 1000m in μm**
Visible light imaging	500nm	50	500	5000
X-ray pinhole	0.1nm	0. 5	50	500
FZP imaging Of soft X-ray	0.35nm	0.3	30	300
Visible light interferometry	400nm	0.47	47 (resolution 5)	470
Visible light Interferometry with imbalance input	400nm	0.2 (scaled) No measurement	20	200
Coded aperture	0.3nm	0.5 0.1 (estimation) No measurement	50 10	500 100
X-ray Interferometry (new method)	0.1nm	0.01	1	10μm

Technical challenges and R&D needed



Emitt. Meas via beam size using diffractometer
Measuring up to 2-3 um beam sizes



Investigation of the Micro-bunching instability in Short-Bunch Operation
Fast acquisition 900 kHz (1imag/um)
Using THz and EO methods
spectral decoding long. Phase space
detail: development of sub structures

Diagnostics-Electronics
- stability (> 100Hz)
- integration with beam-lines

Measurement of small size beams (still valid the 10% rule?)
- also from dipole, or V undulators

BPMs
- high accuracy in different conditions,
  - e.g. t-b-t, single bunch, low current (rf bpms?)

Feedback systems
- LMFB, TMBF
- intra-bunch train

THz detectors and electro-optical crystals are used to a large extent for short pulse resolution ->Industry co-operation?

Technical challenges and R&D needed

Vaccuum, coating and other Key technologies and engineering

Laser engineered surfaces , Amin Abdolvand (Dundee University)

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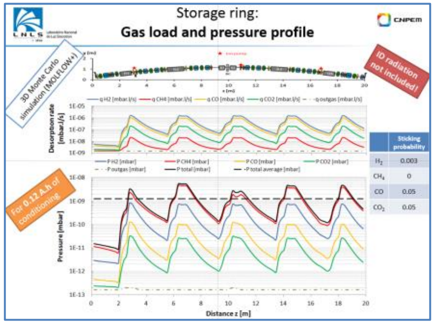


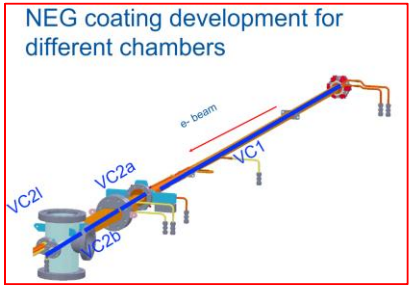
Storage ring:
Gas load and pressure profile

3D Monte Carlo simulation (MOLFLOW+)

ID radiation not included!

For 0.12 A.h of conditioning

	Sticking probability
H_2	0.003
CH_4	0
CO	0.05
CO_2	0.05



NEG coating development for different chambers

Laser engineered surfaces.

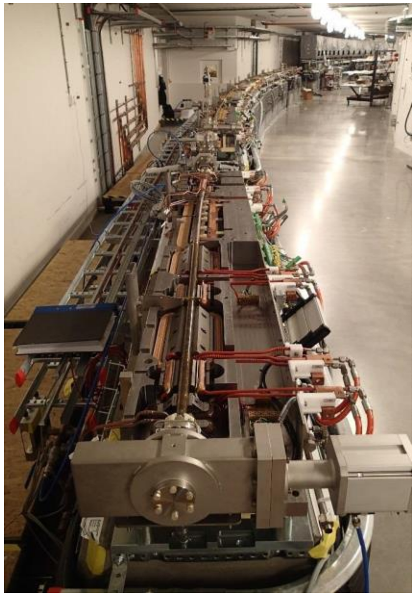
A number of accelerator physics problems can be alleviated by treatment of the vacuum surfaces, like secondary electron yields, secondary photon yields that can be substantially decreased. Emissivity of in-vacuum materials can be increased etc.

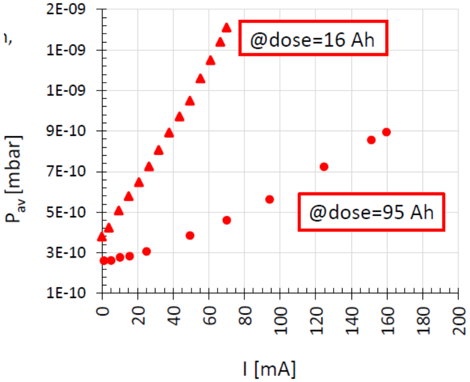
1. In the new machines **the whole vacuum system has become a “low-gap chamber”,** not only the IDs. Some novel ideas have surfaced which ask for **extremely small diameter chambers**, less than 10 mm ID, and for this kind of designs **there is no alternative to NEG-coating**: the specific conductance of a 10 mm circular profile is about 0.9 l·m/s for CO.
2. For out-of-vacuum IDs, there is no alternative to NEG-coating, other than using some “expensive” design like the chamber-antechamber solution used at APS, where “expensive” means needing a lot of ancillary longitudinal space for installing a lumped absorber and tapers, reducing the space available to IDs.
3. The Vacuum Surfaces and Coating group of CERN has been heavily involved in the fabrication of MAX-IV vacuum chamber, namely “the most difficult ones”, i.e. those for which industry was not ready to bid and get a contract, too risky

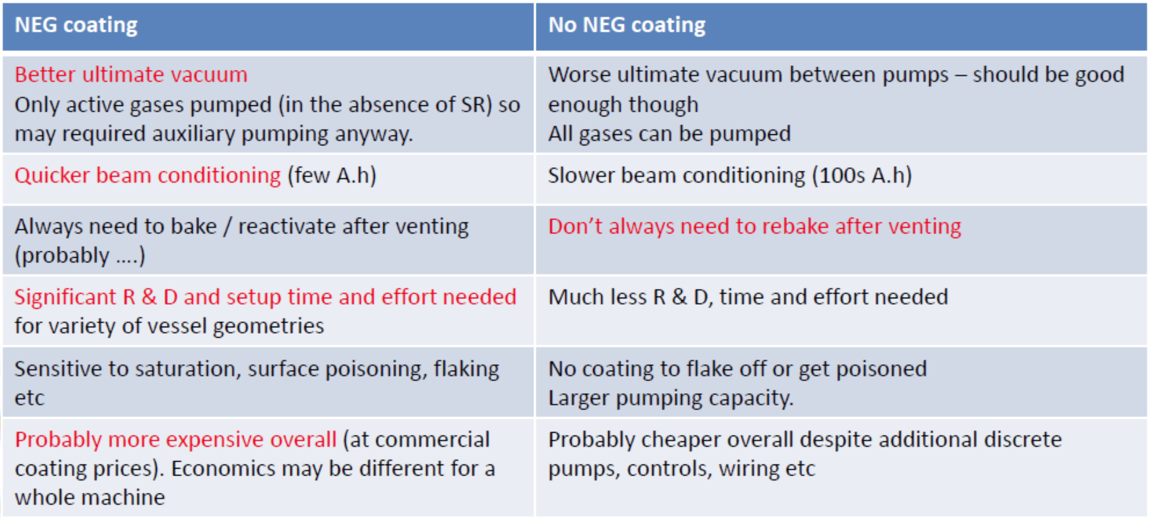
Technical challenges and R&D needed

NEG coated OFS Copper (almost all) (6 km of vacuum pipe coated)

Replace entire vacuum system (basically 18 x 27 mm ellipse internal) for one cell (17.35m) (copper OFS alloy and 316 LN (stainless steel) Installation + beam conditioning in a working machine with ≤ 8 weeks downtime.







NEG coating	No NEG coating
Better ultimate vacuum Only active gases pumped (in the absence of SR) so may required auxiliary pumping anyway.	Worse ultimate vacuum between pumps – should be good enough though All gases can be pumped
Quicker beam conditioning (few A.h)	Slower beam conditioning (100s A.h)
Always need to bake / reactivate after venting (probably ….)	Don't always need to rebake after venting
Significant R & D and setup time and effort needed for variety of vessel geometries	Much less R & D, time and effort needed
Sensitive to saturation, surface poisoning, flaking etc	No coating to flake off or get poisoned Larger pumping capacity.
Probably more expensive overall (at commercial coating prices). Economics may be different for a whole machine	Probably cheaper overall despite additional discrete pumps, controls, wiring etc

Smaller apertures, chamber heating from radiation
NEG coating of vacuum chambers of smaller and smaller transverse dimensions.
NEG or no NEG? -> evidence of fluorescence , old evidence of inductive impedance increase with NEG.
Small chambers with Complex geometries
Polishing of internal surface (low SEY)
Laser ablation
Coating (conducting, e.g. kickers for top-up)

Cost reduction for series production

Novel materials, manufactoring and joining tecniques

PACMAN = a study on **P**article **A**ccelerator **C**omponents' **M**etrology and **A**lignment to the **N**anometre scale, is an **Innovative Doctoral Program network** founded by the European Commission **FP7 Marie Curie Actions**, hosted by **CERN**, providing training to **10** Early Stage Researchers (**ESR**) all enrolled to **PhD** studentship programs.

CLIC Mechanical pre-alignment:

~ 0.2-0.3 mm over 200 m

Active pre-alignment:

14-17 µm over 200 m

Industry presentations

Collaboration with industry

SAES group activity in accelerator technology ,Paolo Manini (SAES Getters SpA)

Strumenti scientifici CINEL: a reliable supplier for products as well as a skillful partner for R&D projects , Riccardo Signorato (CINEL)

SiC MOSFET & Diode Roadmap , Wolfgang Knitterscheidt (eurocomp)

Superconducting undulators ,Cristian Boffo (Babcock Noell GmbH)

KYMA: a success story of technology transfer and strategic partnerships ,Geometrante Raffaella (KYMA)

Tunga Lyft - Installations at MAXIV, Olle Torsteni (Tunga Lyft)

Remarks during discussion

Summary and close out

Summary talk by R. Bartolini

Discussion and close-out

Notes by R. Geometrante

List of facilities and their budget/cost estimates (Europe/USA/Cina…) - see 1st slide

Kickers for top-up
Industry to go back to Klystron?

Power supply and energy saving

Control system and operating software system / integration
Timing and big data coming from beam-lines

Vibrations, temperature control, ionized water

Kicker development for injection to be supported by EU support like PACMAN for alignment

Procurement rules
To choose the most appropriate procedure according to the kind of products

Quality control / visit to the customer

Feedbacks to companies when they are not awarded the contract - lessons learnt useful information for the supplier

Interaction research facilities -industries

Different interaction depending on institutes

- (plain) customer-manufacturer
- (collaborative) R&D collaboration
- (active) knowledge transfer (→ spin off)
- (political) engaging with local industries
- …

Interaction institutes-industries

(plain) customer-manufacturer

Steps

- Specifications
- call for tenders out – bids in – contract placed
- design reviews – production – FATs
- delivery -> mostly in delay

Assume specs are written clearly

- responsibility assigned
- critical quantities to be met identified

Assume manufacturer can deliver

- no major technology unknown

Interaction institutes-industries

customer-manufacturer – issues and improvements

communications

- common design reviews
- monthly report (is there anything better?)
- delays
- expeditors

Complaints from institutes? P. Lebasque's talk, Dieter's talk, (delays..)

Complaints from industries:

- ✓ Procurement rules need revision (should not win always the cheapest)
- ✓ To choose the most appropriate procedure according to the kind of products
- ✓ Quality control / visit to the customer
- ✓ Feedbacks to companies when they are not awarded the contract - lessons learnt useful information for the supplier

Comments

Industry has knowledge and capabilities and customer buys it

Industry is protective of their know-how

Interaction institutes-industries

(collaborative) R&D collaboration

Technology areas missing on both parties

There is the need on both side to work together to develop the technology

Institute is willing to engage with industries at design/prototypes level and R&D from early stages

Both increase their knowledge however attention with intellectual property

There are advantages on both sides

Institute benefits
- Sell knowledge through licensing
- Can avoid time consuming call for tenders
- Can push costs down

Industry benefits
- Can offer high tech product
- Reduce R&D cost
- Better delivery (on time and on budget)
- Sell products to more institutes and customers
- Open up markets worldwide
- Sell knowledge through licensing

Interaction institutes-industries

Active knowledge transfer (KT)

Institute developed knowledge-technology during many years; potential markets exist and the institute is interested in commercialisation (not all of them are)

But no industry is capable or does not exist (globally, locally)

However for various reasons (also political) there is the need to transfer to industry

Financial benefit for the institute

licence a technology

give IPR (intellectual property rights) right to manufacture (right might not be exclusive can be transferred to many industries)

competition → reduce cost

Spin off companies: direct knowledge flow from institute to company that can be extend it to other applications (e.g. CERN incubation centres, Kyma-Elettra, …) or direct(?) financial support (unlikely)

How does KT work? KT is different in different labs, do prototyping together? what can be industrialised?
how to engage with industry? Make them aware of KT?

Different personal approaches; giving away knowledge or not? Which institute want to transfer what?

Institute view? Industry view?

Interaction institutes-industries

engaging with local industries (mostly political)

strengthen/foster national industry with knowledge transfer

(e.g. Brazil WEG, Iran MAPNA)

France spin out (ESRF area)

CERN?

But large projects cannot do everything nationally

- …

Some remarks and advise

According to D. Einfeld

- In general the relationship between the industry and the laboratories is pretty good. The industry wants that you are satisfied with the final product.
- The industry is capable to build all the accelerator components.
- The industry is capable to build systems (injectors) for an accelerator complex.
- For medical applications the industry can build turn key synchrotrons.
- Have also in mind that the industry has to earn some money. They have to pay the salaries for their employees and they have to survive.
- The companies want to have the contract and therefore they promise you a lot of things, sometimes too much. Therefore:
  - Write the “Technical Specifications” for the CFT very careful because it as an appendix a part of the contract. Do not write anything that you do not understand. Take care for the tolerances, use only tolerances which are achievable by the industry.
  - The companies do not provide all the required answer to your specs, there is a need to clarify everything in the negotiation about technical issues. Any unclear point has to be clarified before signing the contract.
- Following up the production of the prototype and the series very carefully.
- Take care of the time schedule, (life is sometimes very complicated).

Final considerations

First meeting to foster discussion and reflect on how to improve the collaboration between research facilities and industries

Consider:

technical challenges and required R&D

what industries are interested what capabilities

where technology transfer can happen

How to foster this exchange?

special committees/individuals

(e.g. industry liaison officers)-> in some labs already exist (Electra, ESRF,..)

Actions:

workshops/networks – invite industries

seconded PhD with EU support (Marie Curie netw.)

Use the PACMAN example for univ + lab +   company collaboration

Thank you for your attention