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

ARIES Network ADA on Beam Diagnostics

WP8: Advanced Diagnostics at Accelerators

4th ARIES Annual Meeting, April 21st, 2021

Work-package leader: Peter Forck GSI

Task 2: Diagnostics at hadron LINACs → Peter Forck GSI

Task 3: Diagnostics at hadron synchrotrons → Rhodri Jones CERN

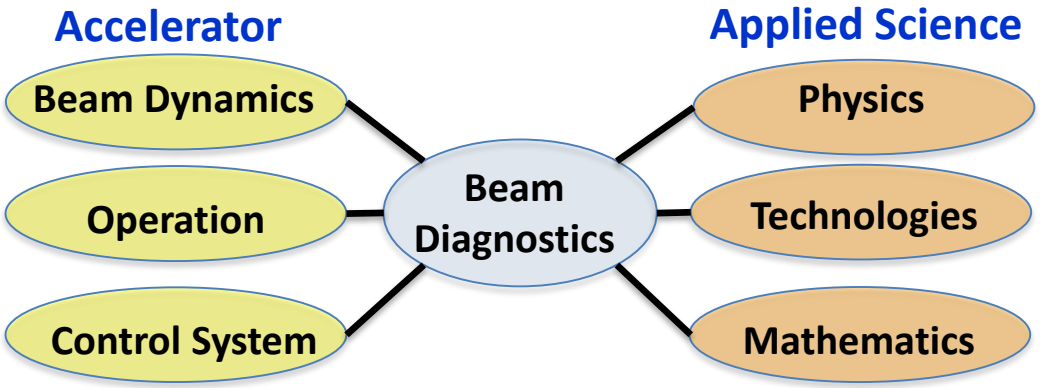
Task 4: Diagnostics at circular light sources → Ubaldo Iriso ALBA-CELLS

Task 5: Diagnostics at linear light sources → Kay Wittenburg DESY

Objective: Network Activity concerning Beam Diagnostics

Requirements for beam diagnostics at novel accelerators:

- Commissioning & enhanced operation of adequate diagnostics
- Instruments are based on different physics and techniques
- Design of diagnostics for novel accelerators



Goal of topical workshops → Focusing of activities at different labs:

- Discussion of requirements, improvements and novel methods of **one** subject
- Meeting of physicists, engineers, technicians from acc. labs, universities & industry
- Inclusion expertise from experts on other fields
- Documentation of state-of-the-art knowledge and realizations
- Face-to-face meetings: Envisaged number of participants is 30 to 50 (or even more...)

→ **Prolongation of WP8 up to end 2021**

ARIES-ADA Topical Workshops previous report periods

#	Date	Org. & location	Title of workshop	# Part.	Task
1	22-24 May 2017	GSI Darmstadt	Simulation, Design & Operation of Ionization Profile Monitors	33	2 & 3
2	29-30 Jan. 2018	ALBA Barcelona	Emittance Measurements for Light Sources and FELs	37	4 & 5
3	14-16 May 2018	CERN Geneva	Extracting Information from electro-magnetic monitors in Hadron Accelerators	32	3
4	25-27 June 2018	DESY Hamburg	Longitudinal Diagnostics at FELs (co-sponsoring)	45	5
5 & 6	12-14 Nov. 2018	ALBA Barcelona	Next Generation Beam Position Acquisition and Feedback Systems Two in one event: hadron - common - electron	84	3 & 4
7	1-3 April 2019	GSI Krakow	Scintillation Screens and Optical Technology for transverse Profile Measurements	49	2, 4 & 5
8	3-5 June 2019	ALBA & ESRF Grenoble	Diagnostics Experts of European Light Sources (DEELS) (co-sponsoring)	33	4

Executed and planed ARIES-ADA Topical Workshops

#	Date	Org. & location	Title of workshop	Task
9	**15-16 June 2020** planed: June 2020	**ELETTRA & ALBA** [Trieste (Italy)]	**Diagnostics Experts of European Light Sources (DEELS)** Online, **57 participants**	4
10	**25-29 Jan. 2021** planed: June 2020	**CIEMAT & GSI** [Segovia (Spain)]	**Experiences during Hadron LINAC Commissioning** Online, **239 participants**	2
11	**21-23 June 2021** planed March 2020	**CERN & GSI** [Oxford (UK)]	**Materials and Engineering for Particle Accelerator Beam Diagnostic Instruments** Online (50 participants registered for March '20)	3 & all
12	**7th July 2021**	**SESAME + ALBA**	**Diagnostics Experts of European Light Sources (DEELS)** Online	4
13	**Nov. 2021**	**CERN**	**FPGA technologies and sustainable development** Online or face-to-face	3 & all

Covid crisis consequences:

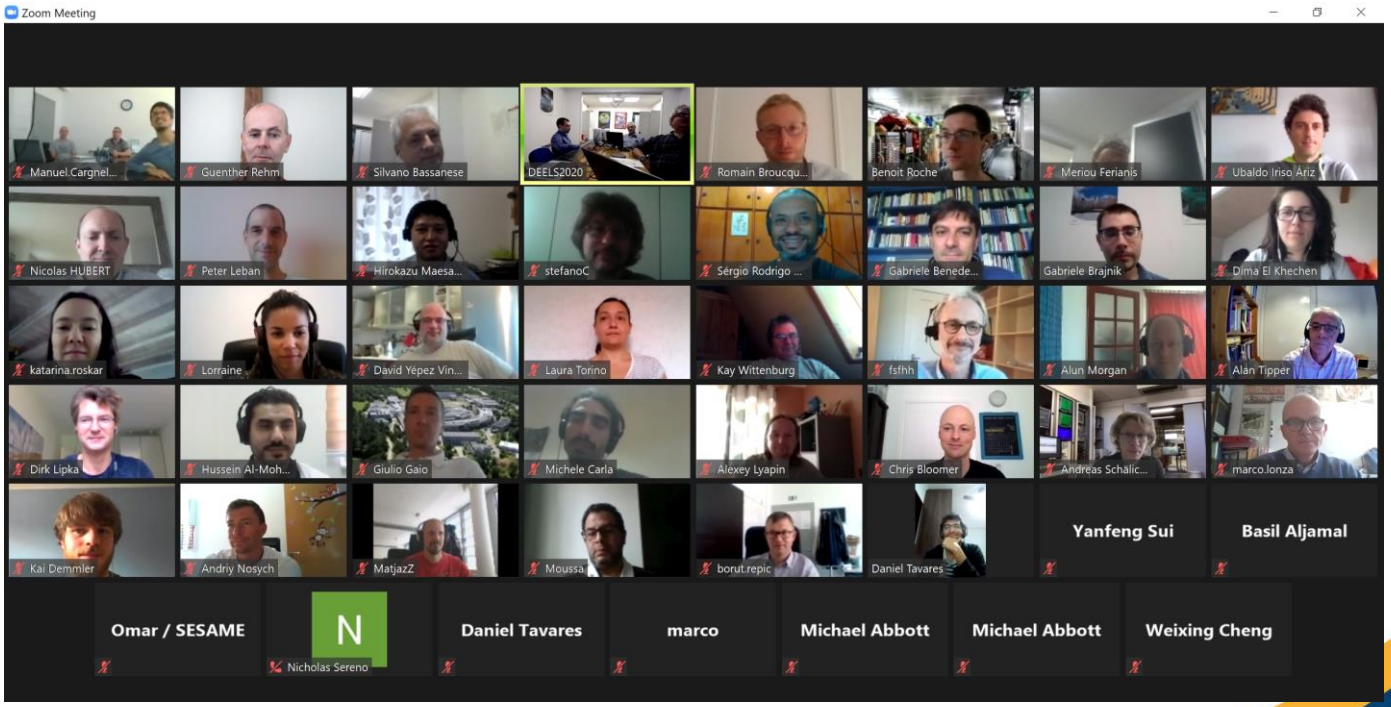
- Workshops executed and planned to reach the commitment in original proposal
- No exchanges of personnel planned presently, but might be reactivated on short note (planned: GSI → Brazilian light source, SESAME → ALBA…..)

Remote Workshop: Diagnostics Experts of European Light Sources (DEELS) 2020

Practical details and statistics:

- **Meeting time:** Tuesday 16th of June, 2020, 9:30 to 17:00 (same as face-to-face planned)
- **Registrations**: total 57, most connected

  Europa: 41 = 72 % | Asia: 5 = 9 % | America: 11 = 19%
- **Talks:** 8 from Europe



Remote Workshop on 'Experiences during Hadron LINAC Commissioning'

Workshop from 25th to 29th of January 2021 organized by CIEMAT (Madrid) and GSI

Remote format with the aims:

- Common efforts by experts on **instrumentation**, beam **dynamics** and **operation**
- Review experiences from commissioning to early operation
- Review initially formulated requirements and final usage of instrumentation
- Executed versus planned efforts to reach final specification
- Explore the balance between detailed measurements on a test bench and fast commissioning

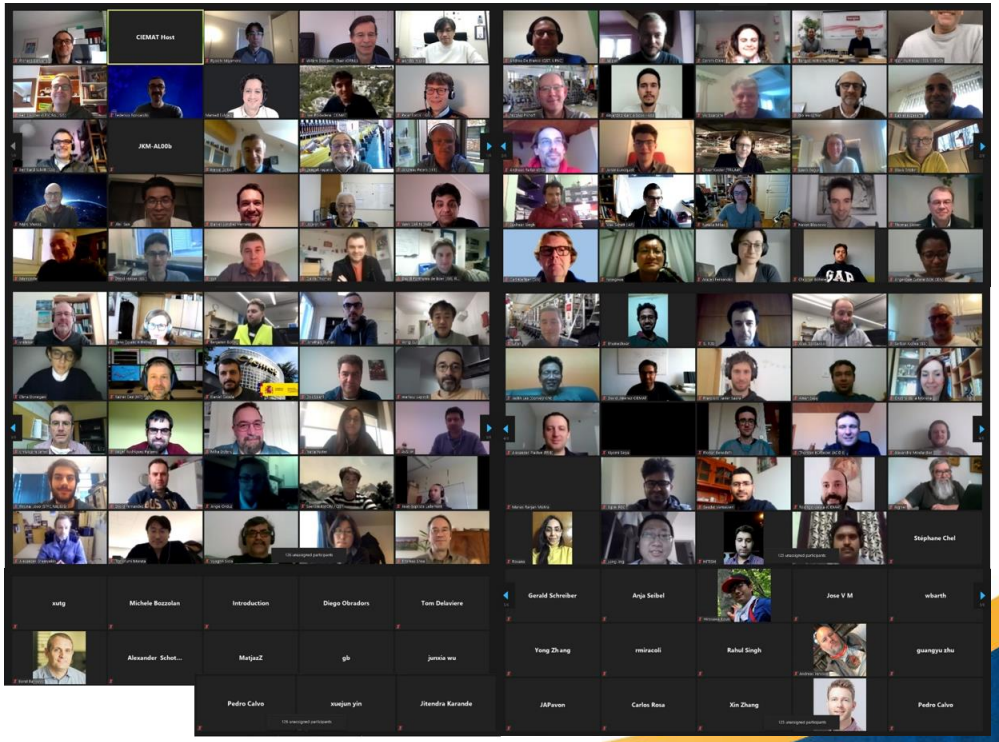
- **Registrations**:

Europa: 154 = 70 %

Asia: 47 = 21 %

America: 19 = 9%

total: 239



Many proton and ion LINACs are presently realized world wide

Remote Workshop on 'Experiences during Hadron LINAC Commissioning'

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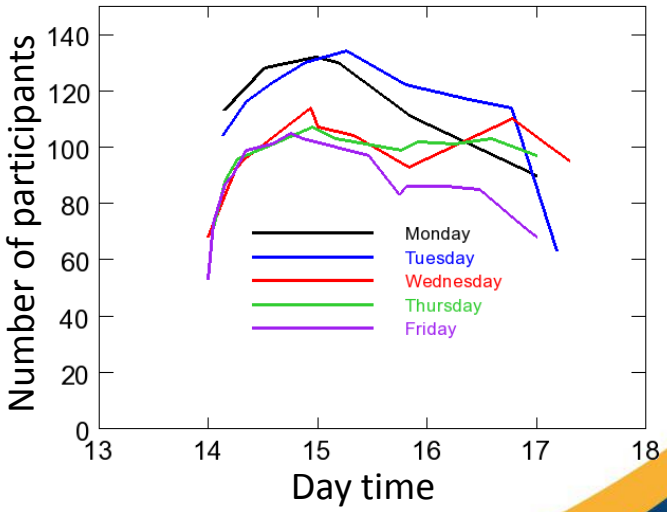
- Review experiences from commissioning to early operation
- Review initially formulated requirements and final usage of instrumentation
- Executed and planned to reach the commitment in original proposal
- Explore the balance between detailed measurements on a test bench and fast commissioning

Practical details and statistics:

- Meeting time: Monday to Friday from 14:00 to 17:15 ETC
  2 x 3 talks + discussion per day
- **Registrations**: total 239
  Europa: 154 = 70 % | Asia: 47 = 21 % | America: 19 = 9%
  Industry: 36 participants = 15 %
- **Talks:**
  Europa: 18 = 60 % | Asia: 5 = 17 % | America: 7 = 23%
- About 100 people connected in parallel,
  many contribution to discussion (even on Friday 90 attendees)

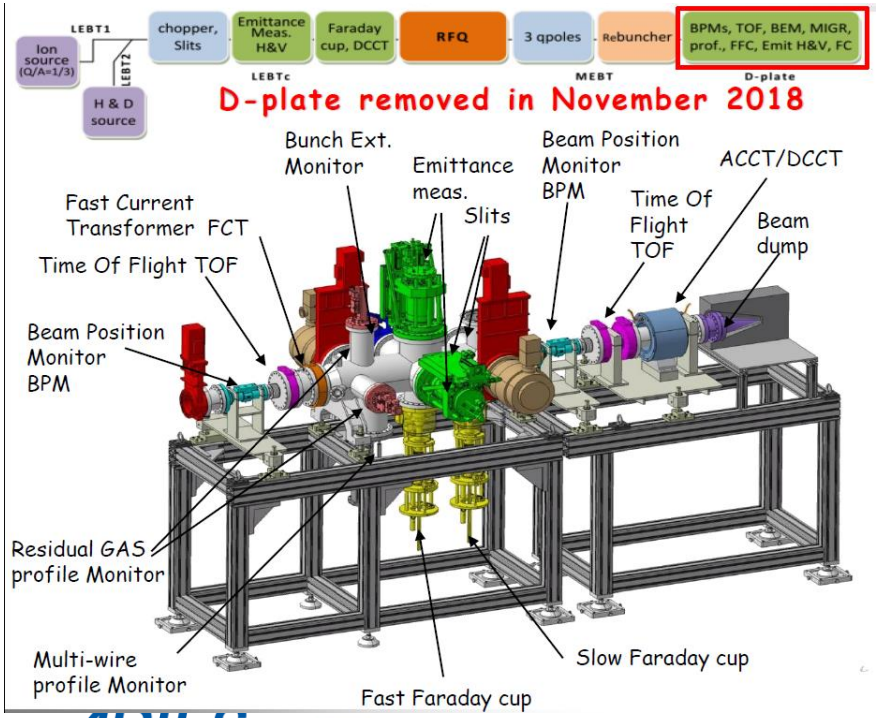


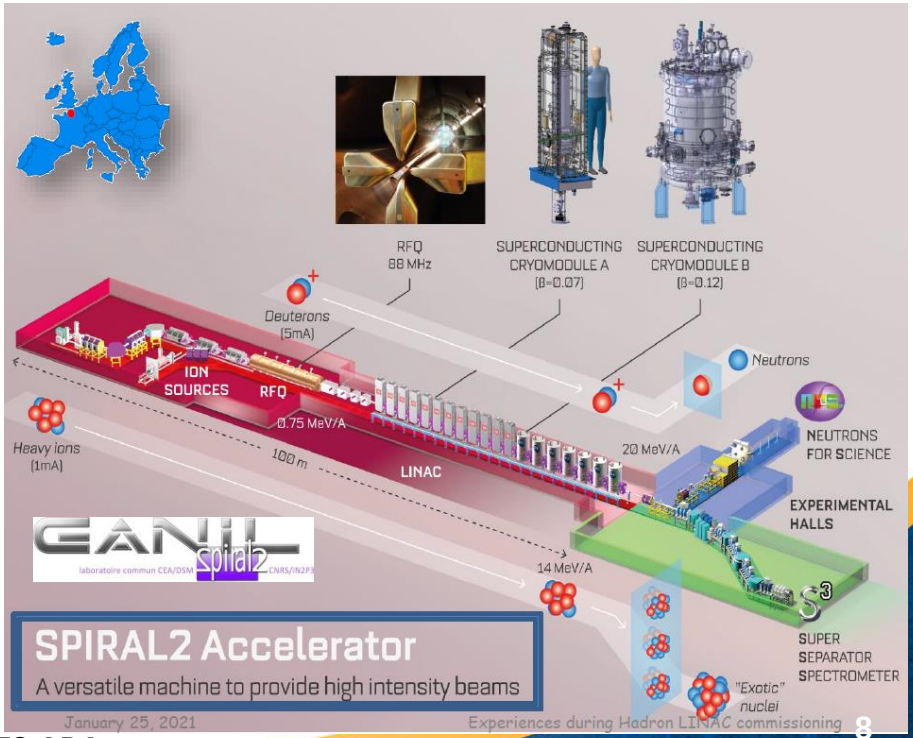
D-Plate & stepwise Commissioning ↔ final Instrumentation

Observation: Some facilities do detailed stepwise commissioning, e.g. Sprial2, other installed large parts of the DTL in one step.

- Stepwise commissioning in particular of versatile ion LINACs; RFQ parameter are crucial
- Measured during stepwise commissioning: transverse emittance, bunch shape and long. emi.
- Wish list from beam dynamics & operation: Test simulation, but often insufficient operation time
- However, installation time is very restricted and does not allow for detailed meas.

D-Plate at **Spiral2** from Christophe Jamet



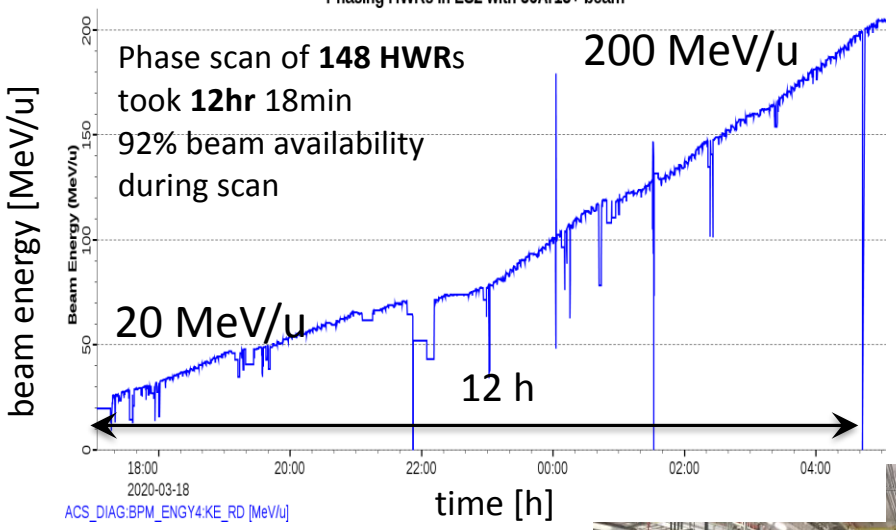


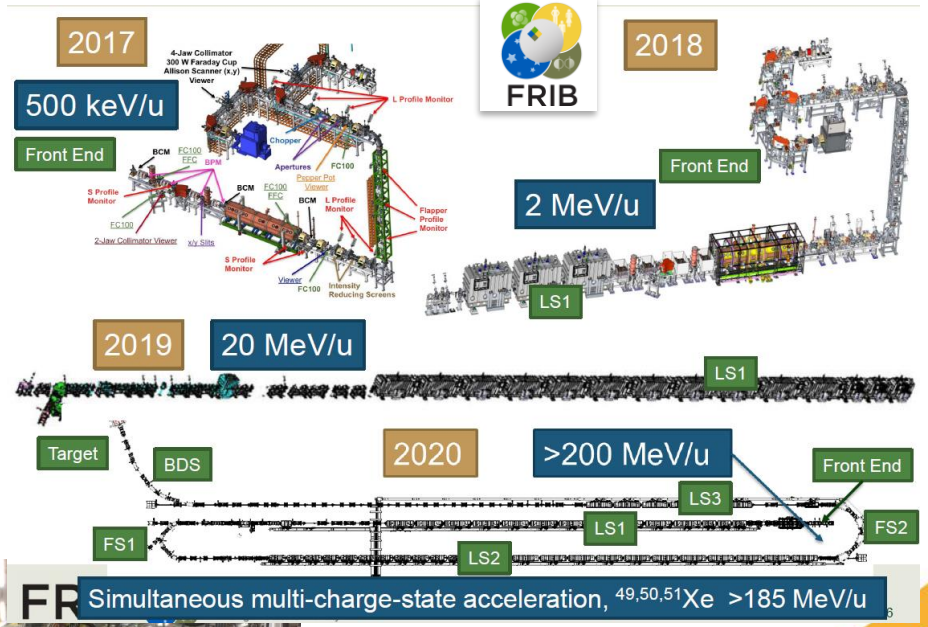
D-Plate & stepwise Commissioning ↔ final Instrumentation

Observation: Some facilities do detailed stepwise commissioning, other installed large parts of the DTL in one step, e.g. FRIB.

- Only few steps at FRIB: Source & LEBT; RFQ, DLT up to 20 MeV/u, 200 MeV/u
- Only few intermediate measurements ⇒ 'empirical settings' aided by automatisms
- Acceleration achieved by automated phase scan
- Ongoing commissioning

FRIB LINAC from Steve Lidia



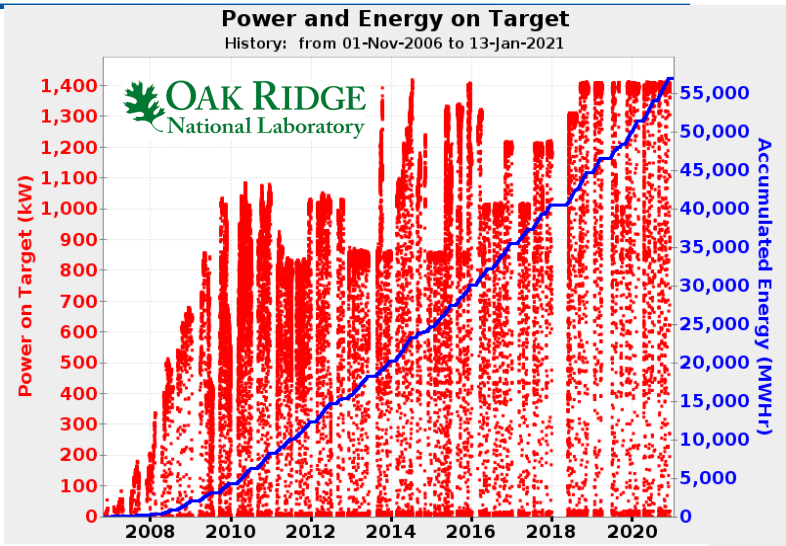


D-Plate & stepwise Commissioning ↔ final Instrumentation

Observation: stepwise com. ↔ fast installation,

Experiences at SNS

- Design values is reached only after many years and 'small step optimization'
- All beam diagnostics were important for improvements
- No clear relation RMS parameters ↔ beam loss



DTL in-line diagnostics at SNS from Alexander Aleksandrov

Instrument	Measured parameter	quantity	Use for commissioning	Use for machine tuning	Use in operation	Use in Beam study
Beam Loss Monitor (BLM)	radiation Ionizing, n	11+12	Yes	Yes	Yes	Yes
Beam Current Monitor (BCM)	beam current	6	Yes	No	No	No
Beam Position Monitor (BPM)	x, y, z position	10	Yes	Yes	No	Yes
Wire scanner (WS)	x, y 1-d profile	6	Yes	No	No	Yes
Differential BCM (DBCM)	In-out beam current	1	No	No	No	No
Faraday Cup with energy degrader (FC)	beam current above energy cutoff	6	Yes	Yes	No	Yes
Laser Emittance Scanner (LES) at SCL only	x,y 2-d emittance; longi. 1-d profile	1	No* added later	No	No	Yes

Longitudinal Emittance Measurement

Observation: At many facilities, the mean energy is measured precisely via ToF by BPMs.

The energy distribution and bunch shape (i.e. long. phase space) is measured rarely.

Mean energy after cavity → important at all facilities:

Time-of-flight along the pulse using BPMs

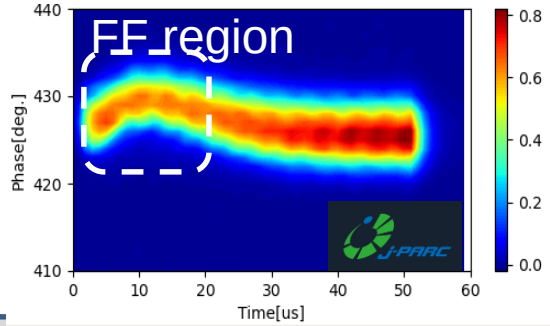
Longitudinal bunch shape measurement

- Bunch Shape Monitor (scanner) is important for beam studies
- Phase space reconstruction using various methods

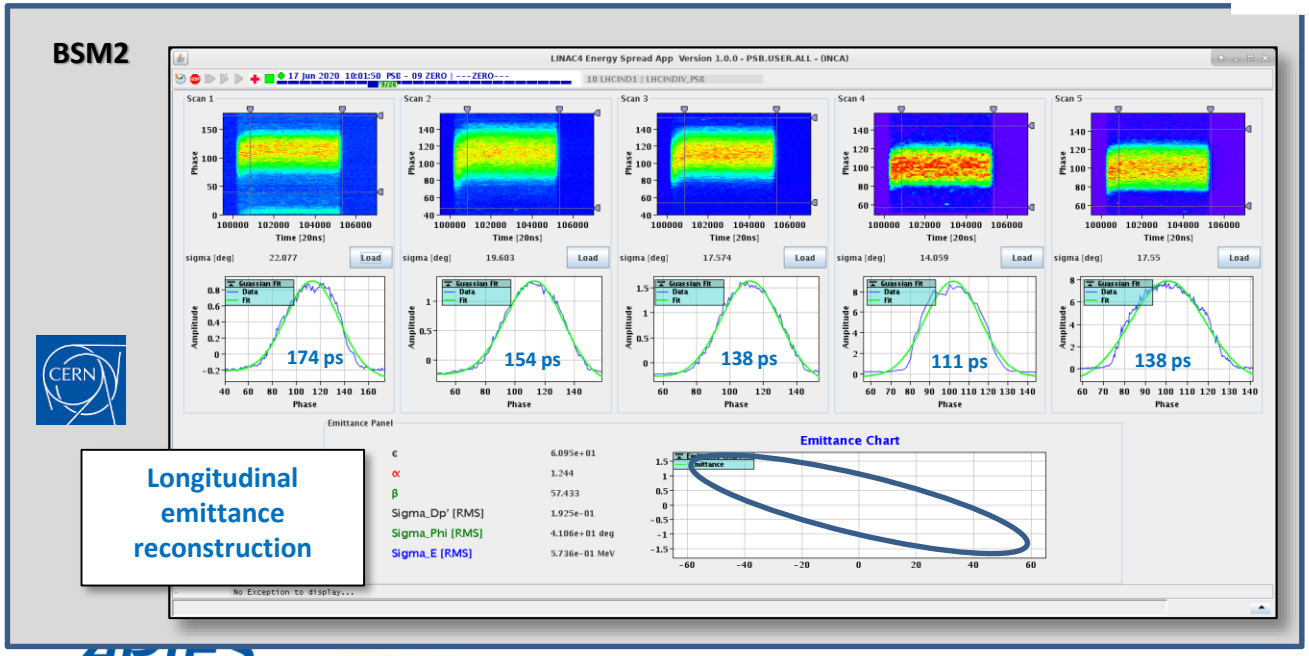
CERN LINAC4 from Jean-Baptiste Lallement and Jocelyn Tan

J-PARC bunch shape from Akihiko Miura

Adjustment of the RF-feed forward power



Failure of the RF-feed forward power (example: failure at DTL1, 2 and 3)



Machine Learning and Reconstruction Algorithms

Observation: Machine Learning and reconstruction algorithms are increasingly important

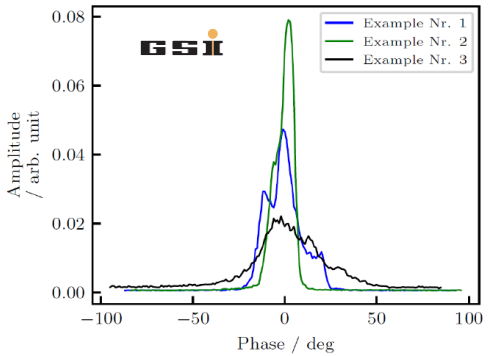
Machine Learning:

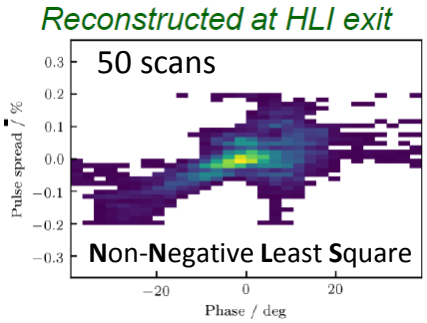
- Machine learning as an operational tool with adaption of existing methods
- Successfully demonstrated, trending technology

Reconstruction algorithm:

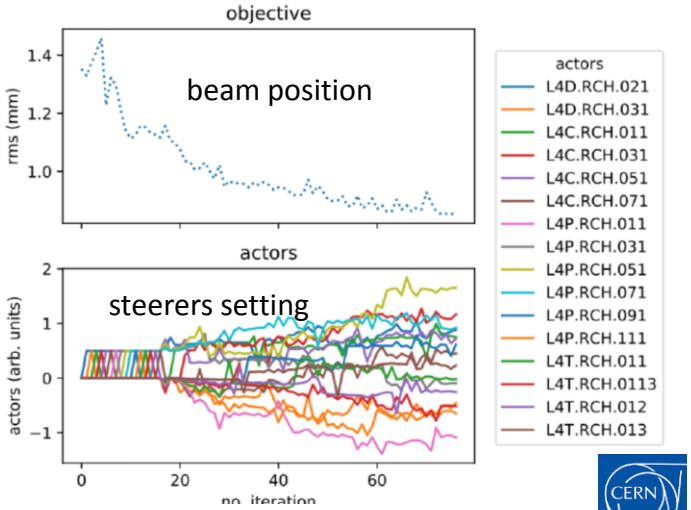
- Measurement for quadrupole or buncher variation reconstruction algorithms for non-Gaussian beams

GSI bunch shape measurement and entrance reconstruction





CERN LINAC4 trajectory optimization from Verena Kain



Conclusion:

- Collection of experiences from almost all hadron LINAC facilities
- Report and documentation of hands-on experiences
- Summary report available

Remote Workshop on 'Experiences during Hadron LINAC Commissioning'

Workshop from 25th to 29th of January 2021 organized by CIEMAT (Madrid) and GSI

Pros of virtual meeting:

- Permanently ≈ 100 participants as no travel is required (expectation for face-to-face meeting ≈ 50 part.)
- Good mixture between experts on instrumentation, beam dynamics and operation
- 45 min final discussion with significant oral contributions
- Maybe: people are keen for workshops related to many cancellations of events in the last year due to Covid
- Afternoon (14-17:30) acceptable in all continents

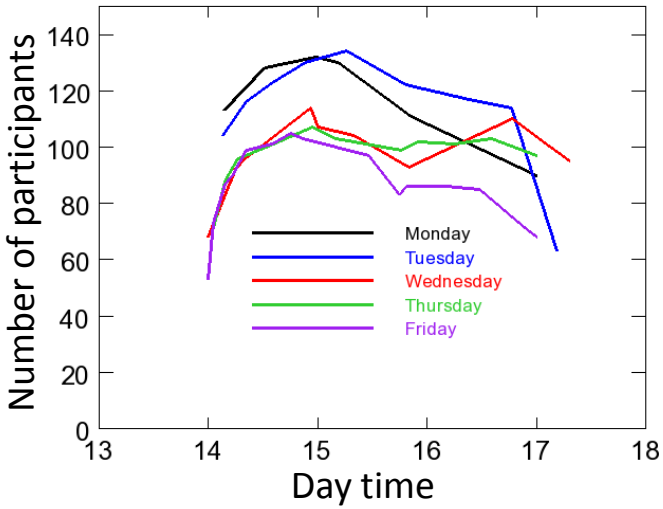
Cons of virtual meeting:

- Much less direct interaction as face-to-face meeting
- No initialization of collaborations
- Not much fun as a group event

239 registrations

Europa: 154 = 70 % | Asia: 47 = 21 % | America: 19 = 9%

Industry: 36 = 15 %



Planned ARIES-ADA Topical Workshops

Materials and Engineering Technologies for Particle Accelerator Beam Diagnostic Instruments

original date March 29th to April 1st, 2020 ⇒ new date remote workshop June 21st to 23rd, 2021

The aims of the Workshop are:

- **Novel materials** and production e.g. ultra-thin wires for wire scanners and SEM-Grid
- **Novel materials** for vacuum installations with improved properties
- **Precise vacuum installations** and drives, e.g. magnetically coupled
- Improved methods for **mechanical development & production**, e.g. 3-d printing
- Review the state-of-the-art in **materials & technology**, intensify collaborations institutes and industry

Organization of workshop in Oxford in March 2020:

- CERN as main organizer (R. Veness), local organizer Oxford university, mech. eng. (D. Eakins)
- 32 talks & company visit 'First Light Fusion Ltd' producing high-level comp. for fusion research
- **50 participants registered, including 7 participants from industry**

Conclusion ARIES-ADA Topical Workshops

Upcoming workshops:

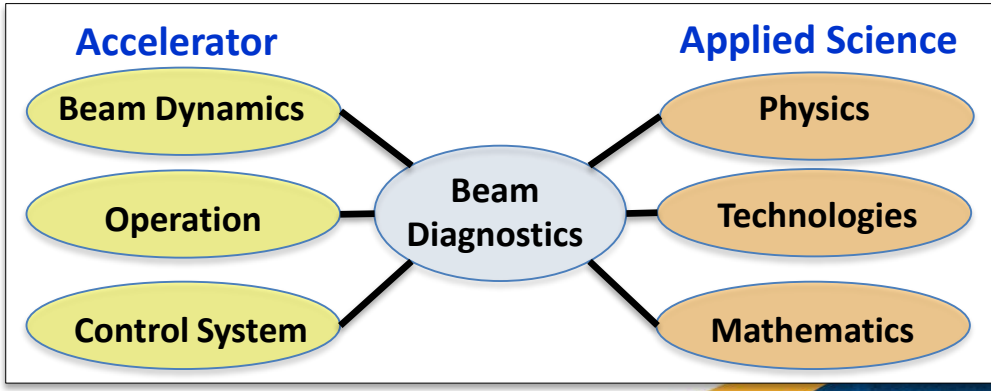
#	Date	Org. & location	Title of workshop	Task
11	**21st-23rd June** planed Mar. 2020	**CERN & GSI** [Oxford (UK)]	**Materials and Engineering for Particle Accelerator Beam Diagnostic Instruments** Online meeting (50 participants registered for March '20)	3 & all
12	**7th July**	**SESAME + ALBA**	**Diagnostics Experts of European Light Sources (DEELS)** Online meeting	4
13	**Nov. 2021** Date Nov.	CERN	**FPGA technologies and sustainable development** Online meeting (or Face-to-Face ?)	3 & all

Deliverables: D8.1-4 - Report on progress in beam diagnostics for hadron LINACs, synchrotrons, circular and linear light sources (M52)

ARIES-ADA program 2017 to 2021:

- Topical workshops on **non-standard** subjects
- Networking within instrumentation community
- Collaboration established by personal contacts
- Exchange of personnel
- COVID crisis as significant hindrance
- Prolongation to end 2021

⇒ **Well recognized by the community**
(e.g. several invited talks at conferences)



Thank you for your attention!