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

Kick-off Meeting CERN, May 4th, 2017

Work-package leader: Peter Forck GSI

Task 2: Beam Diagnostics at hadron LINACs → Peter Forck GSI

Task 3: BD at hadron synchrotrons → Rhodri Jones CERN

Task 4: BD at 3rd gen. light sources → Fancis Perez ALBA-CELLS

Task 5: BD at 4th gen. light sources → Kay Wittenburg DESY

Network Activity concerning Beam Diagnostics

Requirements for beam diagnostics at novel accelerators :

- **Commissioning & enhanced operation of adequate diagnostics is required**
  → novel technologies must be used for high resolution, dynamic range, data rate ...
  → intensive interaction to experts in beam dynamics, operation, control system ...
- **Instruments are based on quite different physical principles and techniques**
  → experts for various technologies at accelerator labs, universities and industry
  → not each accelerator lab recruited the 'right' expert for the required technology
- **Design of diagnostics for novel accelerators**
  → novel ideas or adaption of instruments for new demands

Goal → Focusing of activities at different labs:

- Discussion of urgent requirements and novel methods
- Roadmap for realization
- Recommendations for proper instrument layout and analysis methods

Method → Organization of topical workshops and exchange of personnel:

- Meeting of physicists, engineers, technicians from acc. labs, universities & industry engineers are a major part of a successful technical development
- Education: Meeting of experts and newcomers like PhD students
- Exchange of personnel for common device development & acc. commissioning

Goal concerning Beam Diagnostics

Workshop on actual topics → About four workshops foreseen for each tasks:

Documentation as a very useful documentation concerning state-of-the-art knowledge

Open for everybody → published on ARIES web-site and by personalized announcement

Connections to beam dynamics, operation & industry for hardware and software

Exchange of personnel or invitation of expert typically for 2 to 4 weeks:

Support for design and realization of instruments and methods

Reason for topical workshops:

Beam diagnostics community is very active e.g. conference with 300 participants

Workshops: special topics can't be discussed in detail at conferences

Workshops: one subject can be discussed in detail in connection with other communities

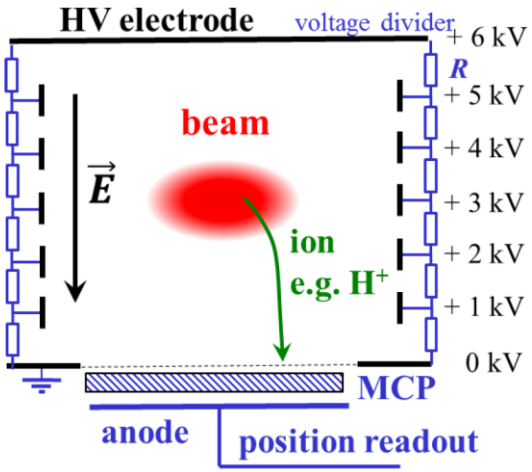
Very good experiences with previous funding programs

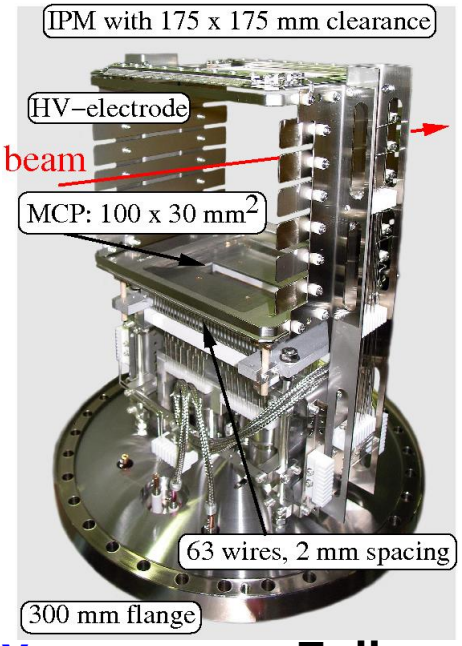
First event for ARIES ADA: Workshop on Ionization Profile Monitor

Ionization Profile Monitor installed in most hadron synchrotrons & LINACs

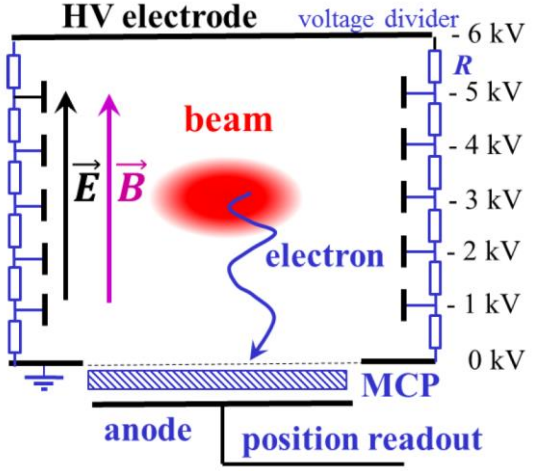
Topic of consideration: **Detail on various hardware, space charge simulation**

Ion detection mode:





Electron detection mode:



Workshop on 22nd to 24th of May at GSI Darmstadt

- 25 participants
- General compilation on IPM realization
- Exchange of novel ideas
- Common code development

. Follow-up of a workshop March 2016

First event for ARIES ADA: Workshop on Ionization Profile Monitor

Code for space charge broadening by beam's space charge

Status March'16: Each laboratory has its own code with special application & restriction
Exchange concerning underlying physics and software realization

Initialization of common code development on initiative of M. Sapinski GSI

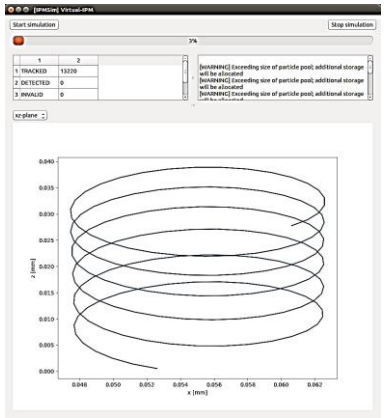
- Relevant physics included
- Open code with extension possibilities
- Appropriate GUI for input & output
- Web-site for discussion:
  twiki.cern.ch/twiki/bin/view/IPMSim/

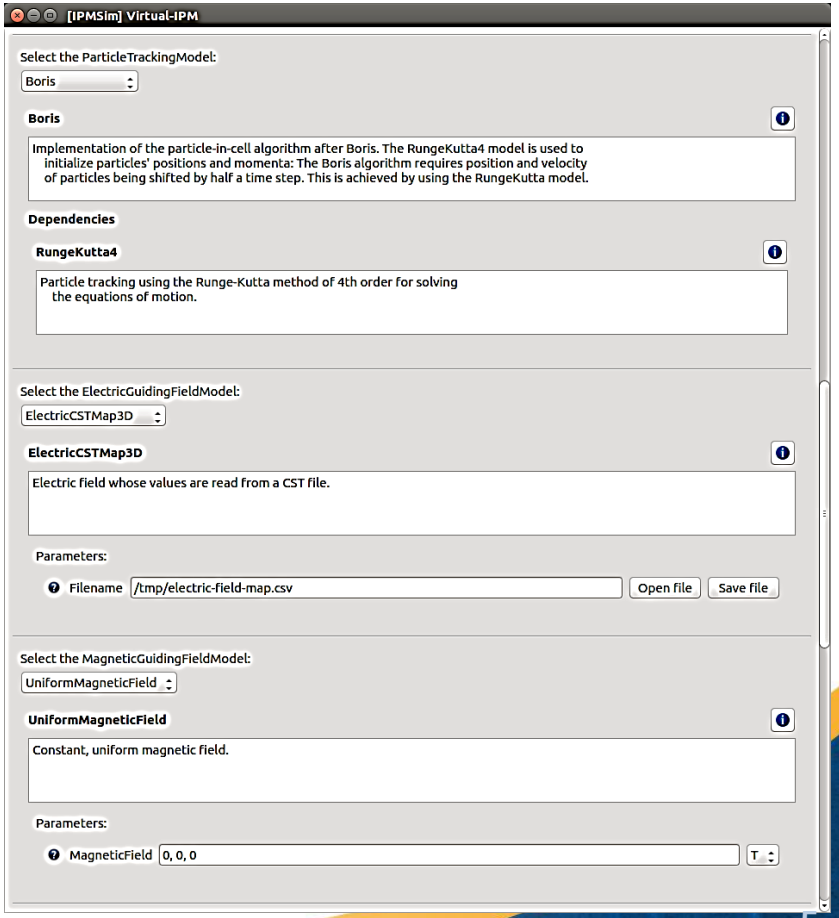
Present participants for code development:

CEA/Saclay, CERN, ESS, FNAL, GSI, J-PARC, RAL

Further interest by:

BINP, BNL, CAS (China),
Cockcroft, FZ-Jülich, SNS



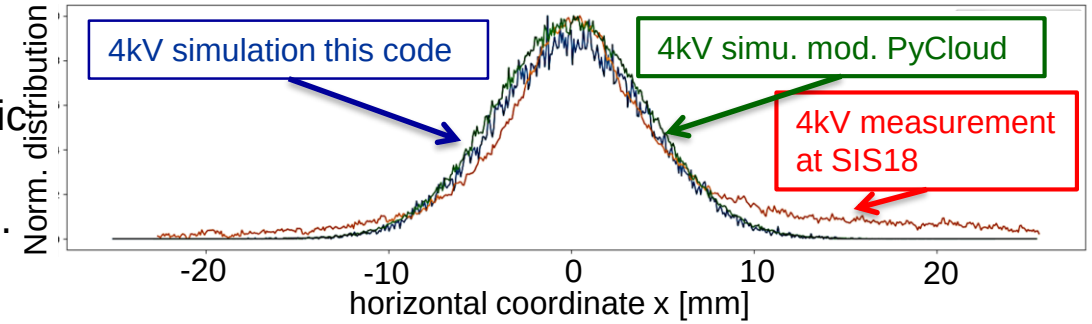


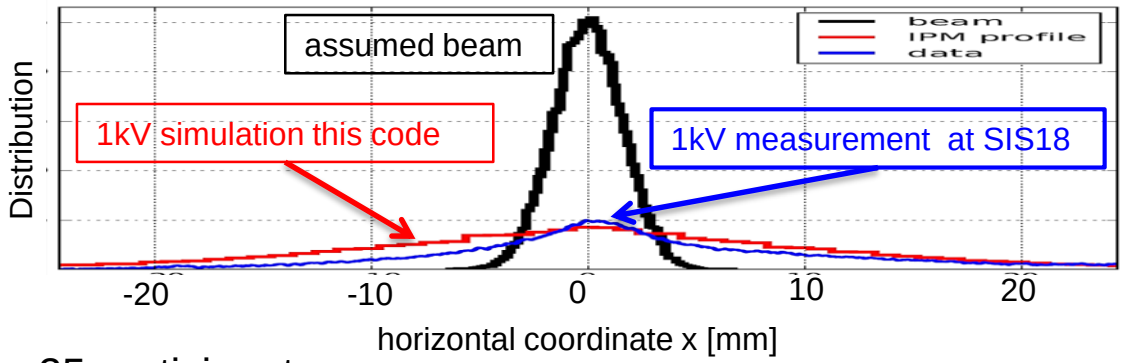
First event for ARIES ADA: Workshop on Ionization Profile Monitor

Common, generic code for space charge broadening by beam's space charge

Results: Code benchmark & comparison to measurements

Beam at GSI synchr. : 10^9 Xe^{43+} at 600 MeV/u, $\sigma_{bunch} \approx$ 10 m $\Rightarrow$ 2d calc.





Code includes:

- Application for **LINACs**
  i.e. short bunches, non-relativistic
- Application for **synchrotrons**
  i.e. long bunches, rel. $\Rightarrow$ 2d calc.
- Various bunch shapes
- Homogeneous $\vec{E}$ & $\vec{B}$ fields
  or input from CST etc. maps
- Realistic e^- generation: $\frac{d^2\sigma}{dE \cdot d\theta}$
- Different methods for tracking
- Meaningful GUI

Workshop 22nd to 24th of May:

- Presentation to larger audience, 25 participants
- Compilation of worldwide realization and usage of IPMs
- Motivation for benchmarking of code and common usage
- Discussion on possible extension of code and new ideas

$\Rightarrow$ Accelerator Research and Innovation for European & **Worldwide** Science: ARIE**WS**

Task 2: Advanced Instrumentation for hadron LINACs

Hadron LINACs uses high gradient acc. and based on complex beam dynamics
Goal: Emittance conservation, low losses but critical matching requirements
Task leader: GSI

- **Implementation of high precision position, profile and phase measurements**
  BPMs: Precise position and phase measurement, design of electronics & signal processing,
  In collaboration with electron accelerators as of Task 4 and 5
  → **workshop 'Next generation BPM systems' with Task 3 at CERN**
- **Non-invasive longitudinal and transverse profile and halo measurements**
  Methods of non-invasive profile measurement, partly common subject with Task 3
  → **workshop 'Experiences and Simulation for IPMs' with Task 3, May 2017 at GSI**
  Extension for halo determination and matching conditions
  Methods of reliable emittance determination
  → **workshop 'Transverse & longitudinal emittance measurement' May 2019 at GSI**
  → **workshop 'Scint. screen, OTR screen and rad-hard cameras' with Task 2 at CERN**
- **Automated methods for beam matching between cavities**
  Methods of transmission control
  Design of feedback or feed-forward loops using non-invasive measurement results
  Design of optimized algorithms

Task 3: Advanced Instrumentation for Hadron Synchrotrons

The intensity limit should be reached for regular operation

Goal: Prevention of instabilities, emittance con., low losses, precise beam control

Task leader: CERN

- **Design of next generation, high performance BPM systems**

  High precession and accuracy, large data handling and analysis, common subject to Task 4

  Determination of lattice functions

  Feedback systems for position on large time scale, tune, chromaticity

  → **workshop 'Extracting information from ele-mag. monitors' at CERN**

  → **workshop 'Next generation BPM systems' at CERN**

- **Non-invasive transverse profile and halo measurements**

  Comparison of technologies for various gas based monitors, common subject to Task 2

  Design of electro-optical methods and synchrotron light monitors

  → **workshop Experiences and Simulation for IPMs' with Task 2, May 2017 at GSI**

  → **workshop 'Scint. screen, OTR screen and rad-hard cameras' with Task 2 at CERN**

- **Monitors for improvement and control concerning beam instabilities**

  Correct monitoring, interpretation and control of possible instabilities

  Damping of coupled- or intra bunch instabilities with appropriate feedback

  Close collaboration with beam dynamics experts, common subject to Task 4

  → **workshop 'Extracting information from ele-mag. monitors' at CERN**

Task 4: Advanced Instrumentation for 3rd Generation Light Sources

3rd generation synchrotrons aim for significant emittance reduction, higher stability
Goal: Prevention of instabilities, achievement of stability requirements and resolution

Task leader: ALBA

- **Implementation of precision orbit determination & closed orbit feedback**

Requirements for high stability down to 1 % of beam size

Closed orbit feedback with 100 nm accuracy and 1 kHz bandwidth, common subject to Task 3

Inclusion of xBPM at beam lines into feedback system

Design of feedback loops, common subject to Task 3 & 5

→ workshop 'Instabilities and Feedback Systems ' June '18 at ALBA, with task 3

→ workshop 'Beam Dynamics Requirements for BPMs ' June '19 at ALBA, with task 3&5

- **Improvement of methods for transverse & longitudinal profile**

Implementation of optical interference & x-ray technologies, connection to industrial partners

Fast observation of longitudinal profiles matching and possible instabilities control

→ workshop 'Ultra Low Emittance Measurements ' in autumn '17 at ALBA

→ workshop 'Beam Loss Monitor System' June '20 at ALBA

- **Methods of impedance determination to prevent for beam instabilities**

Monitoring, interpretation and control of possible instabilities with appropriate feedback

→ workshop 'Instabilities and Feedback Systems ' June '18 at ALBA, with task 3

→ co-funding of workshop for Diagnostics Expert of European Light Sources DEELS '20

Task 5: Advanced Instrumentation for FELs

For FELs have extreme beam parameters & novel diagnostics must be used
Goal: Precise measurement of beam parameters, alignment issues, reproducibility
Task leader: DESY

- **Design of high precision position monitoring and feedback system**
  Demands for high precession position measurements with short pulses
  Position feedback down to bunch-by-bunch basis
  → **workshop 'Bunch-by-bunch beam stabilization in FELs' in Dec. '19 at PSI**
  → **workshop 'Beam emittance preservation' in Dec. '20 at DESY together with Task 4**
- **Short bunch length measurement and synchronization**
  Improvement of electro-optical monitors fs time resolution, synchronization for acc.& users
  Experiences related operation (even by non-experts) of complex instrumentation
  → **workshop 'Synchronization with femtosecond accuracy ' in Dec. '17 at DESY**
  → **workshop 'Bunch length measurement' in Dec. '18 at DESY**
- **Reliability monitoring and interlock generation**
  Monitors for pulse-by-pulse evaluation of beam parameters for reproducibility statements
  Design and operation of automated beam parameter control and interlock generation

Summary: Advanced Diagnostics at Accelerators

Workshop on actual topics→ About four workshops foreseen for each tasks:

Typical number of attendance: 20 to 35 worldwide experts

Documentation as a very useful documentation concerning state-of-the-art knowledge

Open for everybody → published on ARIES web-site and by personalized announcement

Connections to beam dynamics, operation & industry for hardware and software

Exchange of personnel or invitation of expert typically for 2 to 4 weeks:

Support for design and realization of instruments and methods

Everybody is welcome to propose an actual topic and contribute to the efforts and the success of common research. Please contact us!

Thank you for your attention!