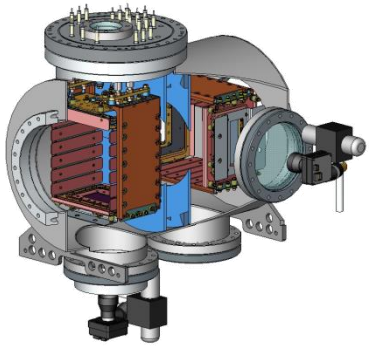
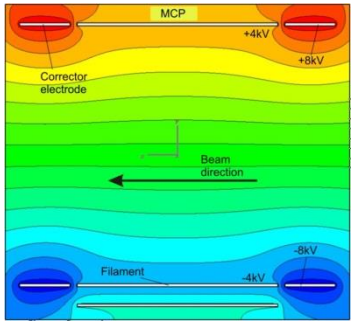
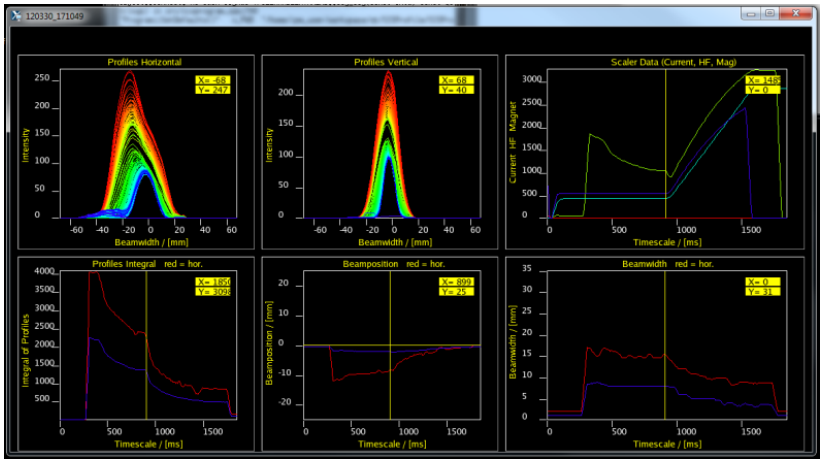
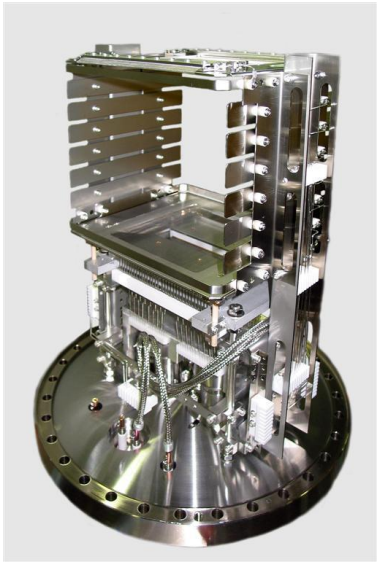




Experience with IPMs measurement in GSI

T.Giacomini, P.Forck, GSI, Darmstadt, Germany

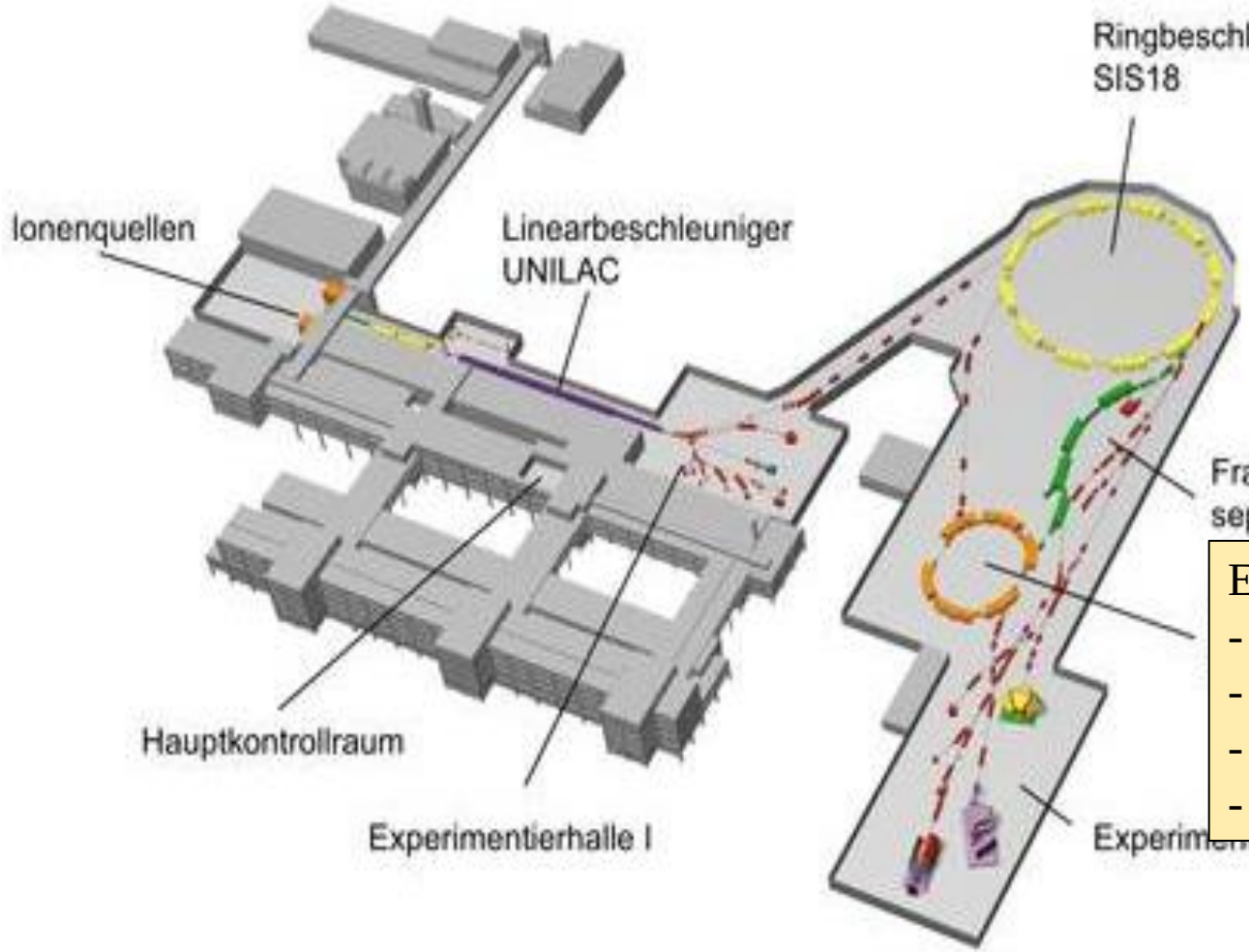




Overview

- IPMs in GSI rings
- Application of GSI IPMs (who use them and what for exp.)
- Beam profiles
- Different IPM readouts / designs
- Current and future IPM developments at GSI for FAIR.

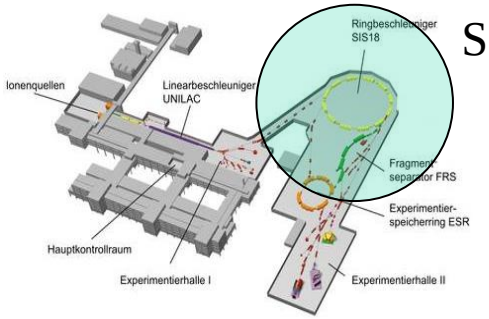
GSI IPMs in Rings – SIS & ESR



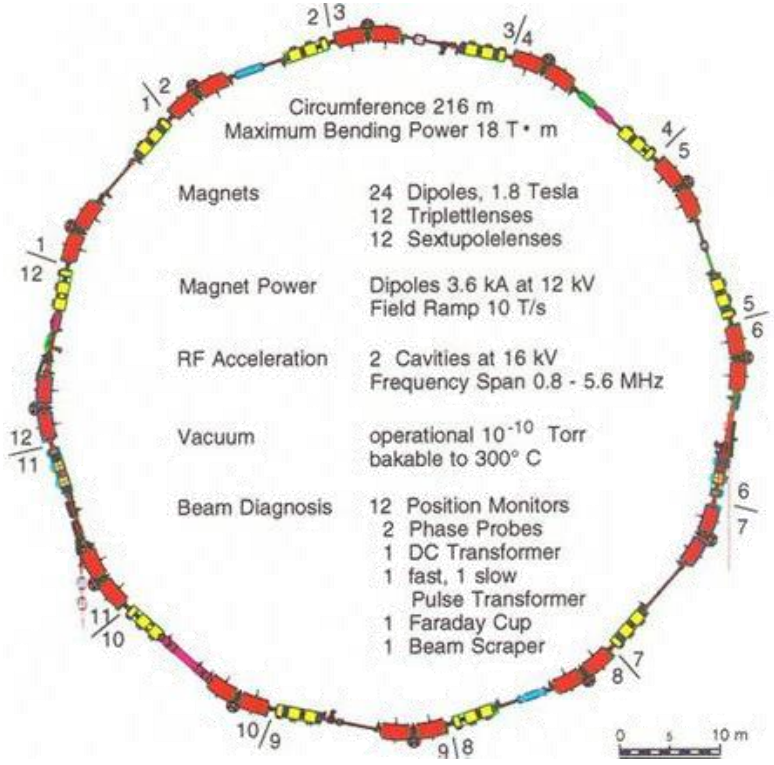
SIS18 IPM:
- MCPs
- Wire array,
- MUX
- ADC
- VME - Crate

ESR IPM:
- MCPs
- Phosphor screen P47
- CCD camera readout
- PC

IPM Design for SIS18



SIS18



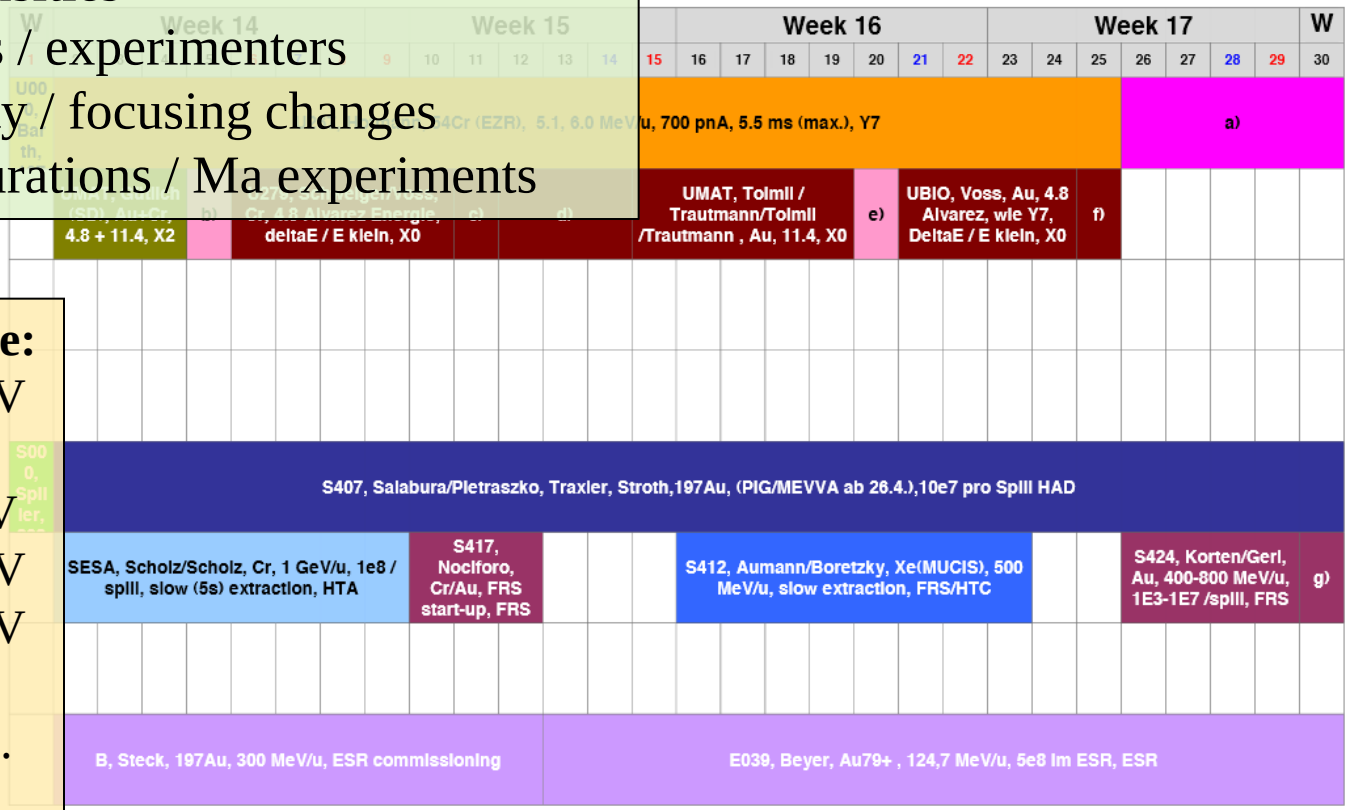
SIS18 parameter:

-circumference	216	m
-periodes	12	
-bending power	18	Tm
-inject. energy	11.4	AMeV
-extr. en. (U78+)	1	AGeV
-extr. en. (p)	4.7	AGeV
-Ions per cycle	1.3×10^{11}	(Ne, Ar)
-Ions per cycle	1×10^{10}	(U28+)
-Ions per cycle	10^{8} - 10^{10}	typ.
-frequ. / time	217 kHz / 4.6 µs	@ inj.
	1.2 MHz / 0.8 µs	@ 1GeV
-vacuum	10^{-11}	mbar
-electron cooler		
-multi turn injections		
-slow / fast extraction		

GSI SIS18 Operation

SIS18 Operation:

- different sorts of ions from different sources alternately in the SIS18 accelerated
- different beam intensities
- different consumers / experimenters
- requests for intensity / focusing changes
- short experiment durations / Ma experiments



SIS18 operation example:

Au	200	AMeV
Cr	1	AGeV
Xe	500	AMeV
Au	400-800	AMeV

more during machine exp.
5-6 experiments parallel

GSI IPMs Users

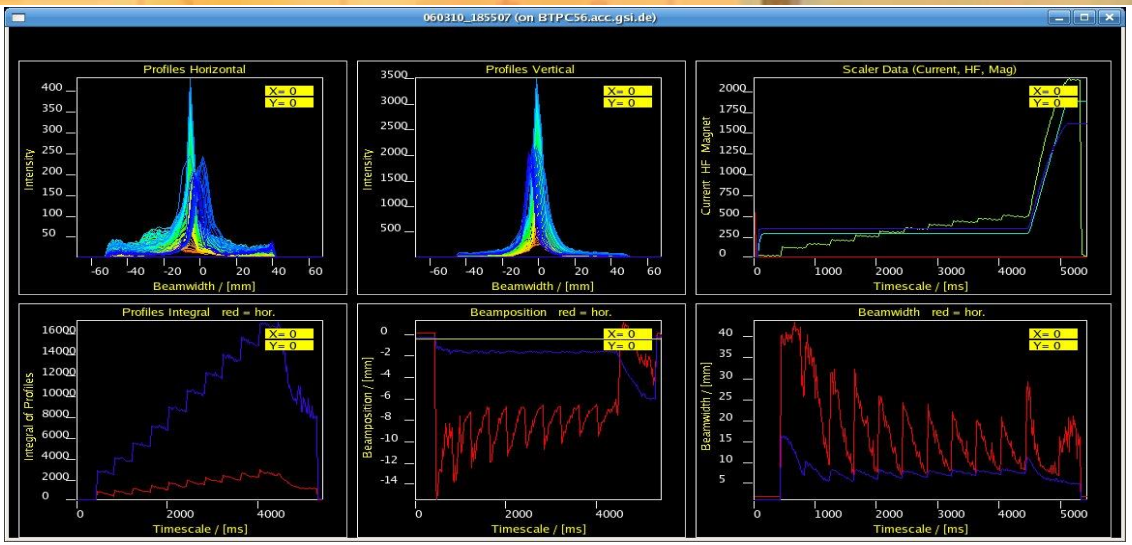
IPM Users:

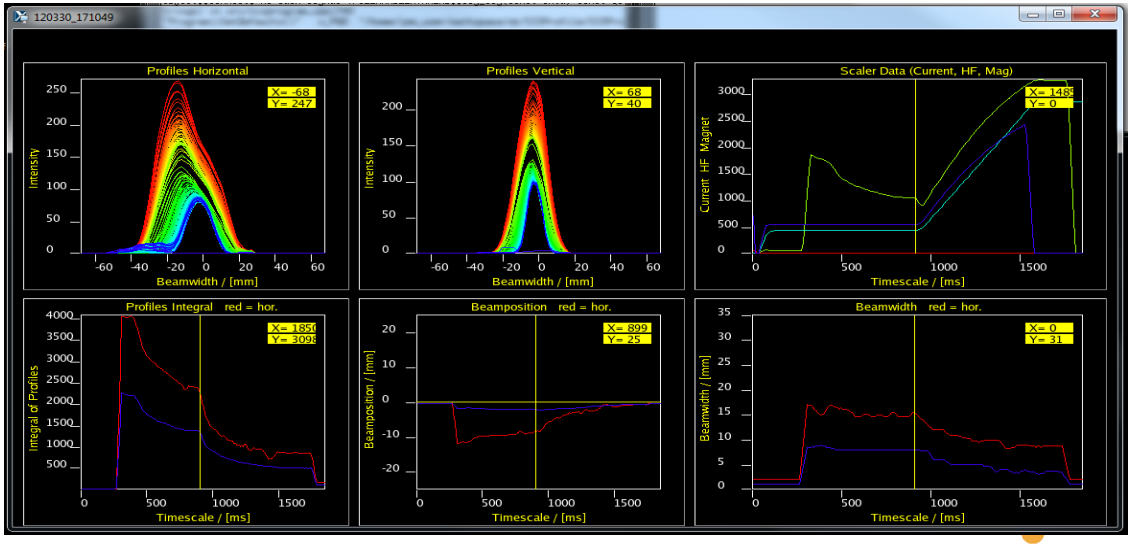
Operators:

- set up different ion sorts
- check beam width by time
- cooling optimization
- injection optimization

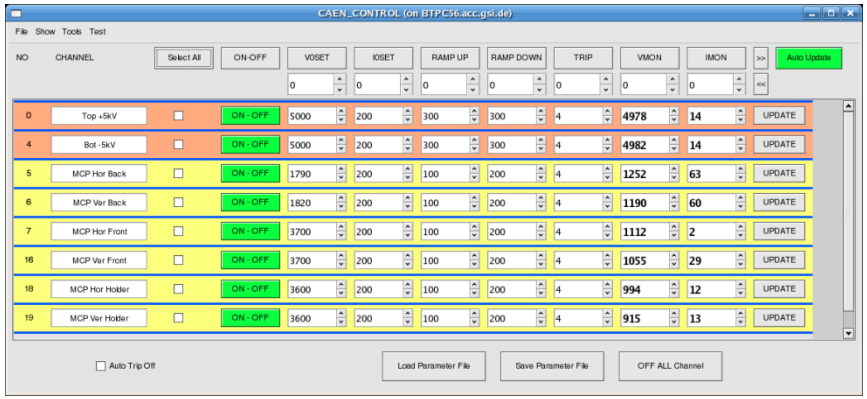
Machine Experimentators / PhD Students:

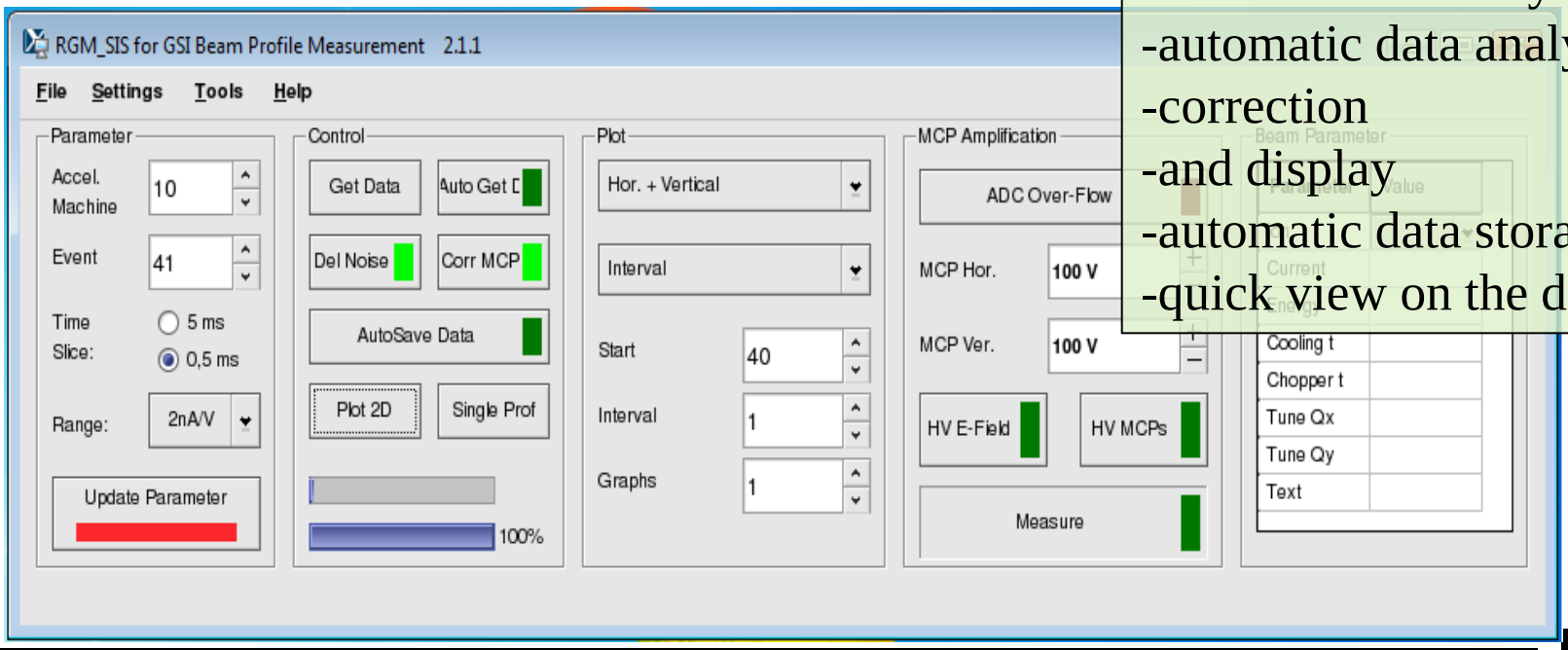
- accelerator physics
- varying beam intensities
- tune changes
- resonance crossings
- emittance exchanges
- beam excitations
- cooling effects





GSI IPMs User Requests



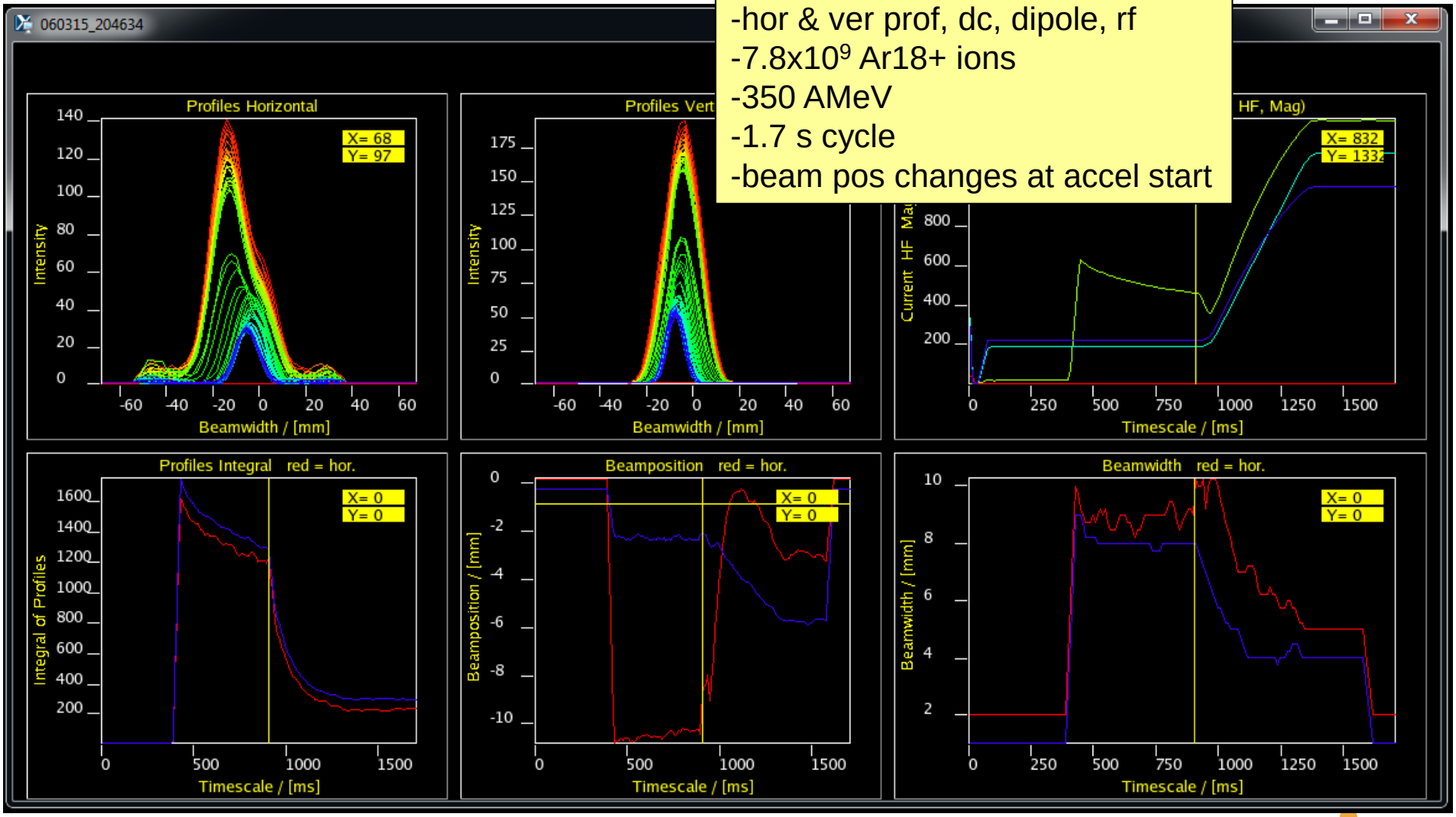


Expected Functions:

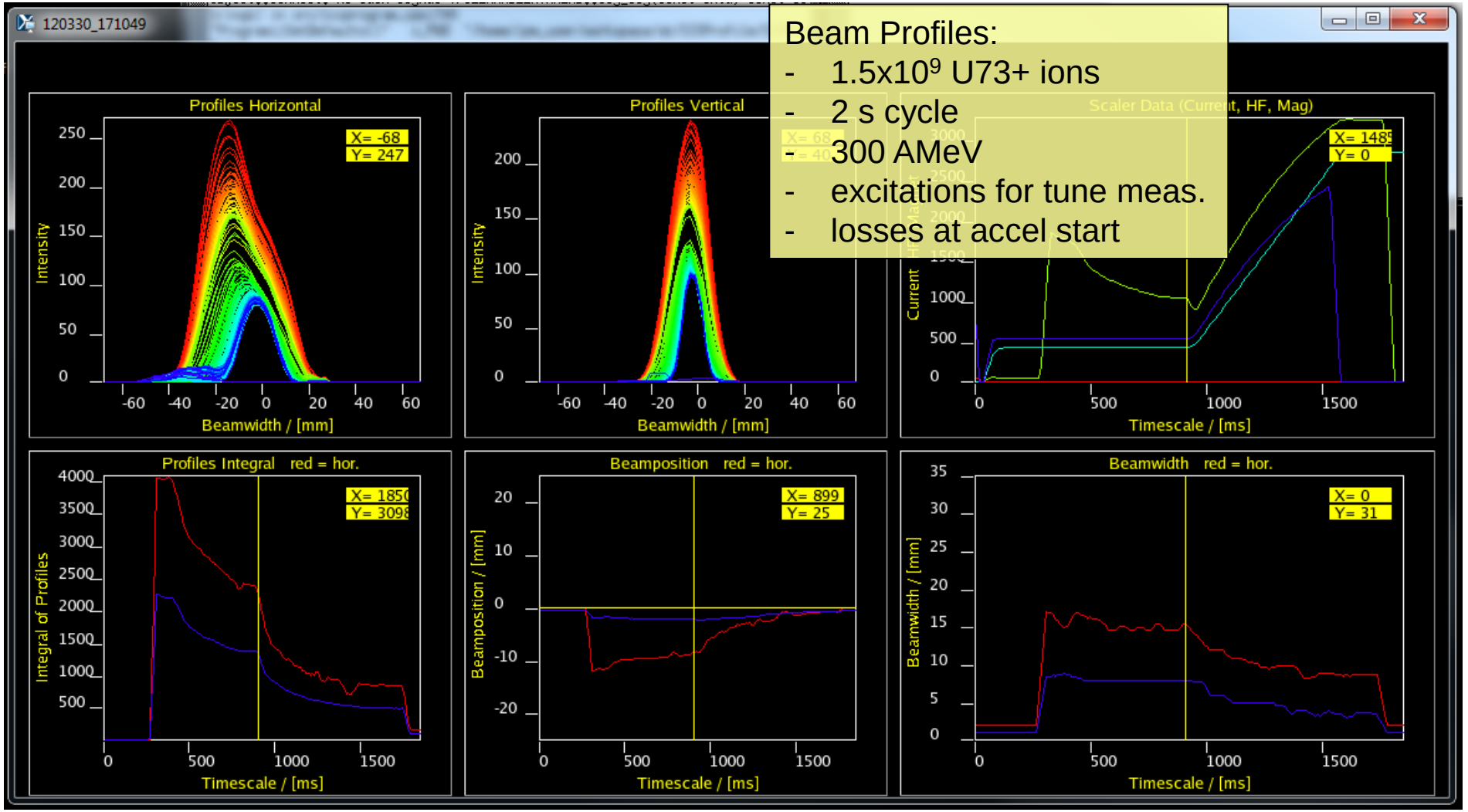
-switch on the IPM
-push one button
-adjust MCP Voltage
-get beam profiles
-measure the full cycle
-automatic data analysis
-correction
-and display
-automatic data storage, network
-quick view on the data

IPM @ SIS18 / Wire Array

Beam Profiles:
-hor & ver prof, dc, dipole, rf
-7.8×10^9 Ar18+ ions
-350 AMeV
-1.7 s cycle
-beam pos changes at accel start



IPM Data of a full cycle in one look

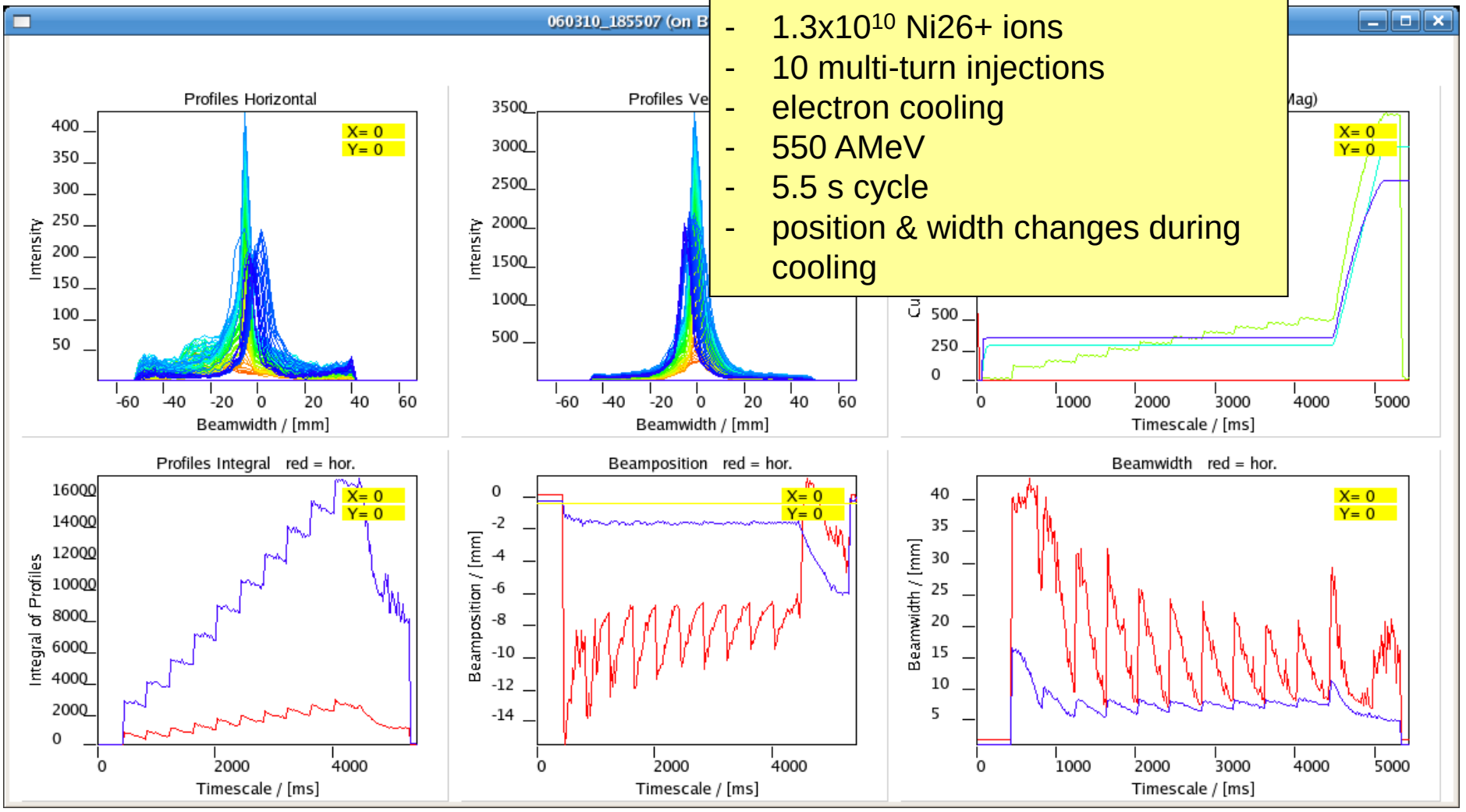


Beam Profiles:

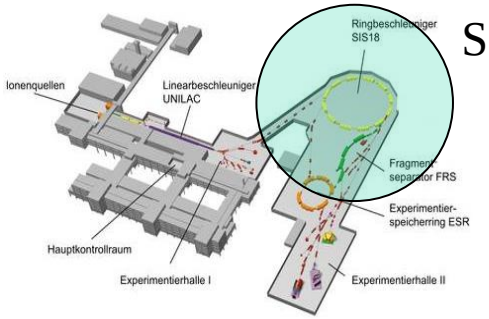
- 1.5×10^9 U73+ ions
- 2 s cycle
- 300 AMeV
- excitations for tune meas.
- losses at accel start

IPM @ SIS18 / Wire Array

Beam Profiles:
- 1.3x10^{10} Ni26+ ions
- 10 multi-turn injections
- electron cooling
- 550 AMeV
- 5.5 s cycle
- position & width changes during cooling

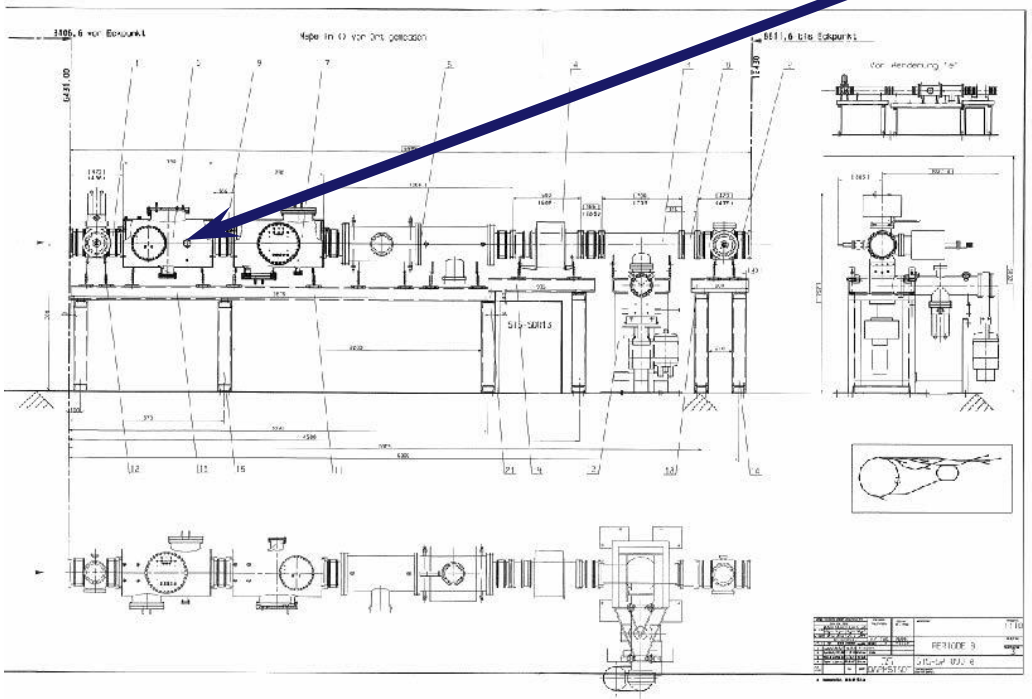


IPM @ SIS18 / Wire Array

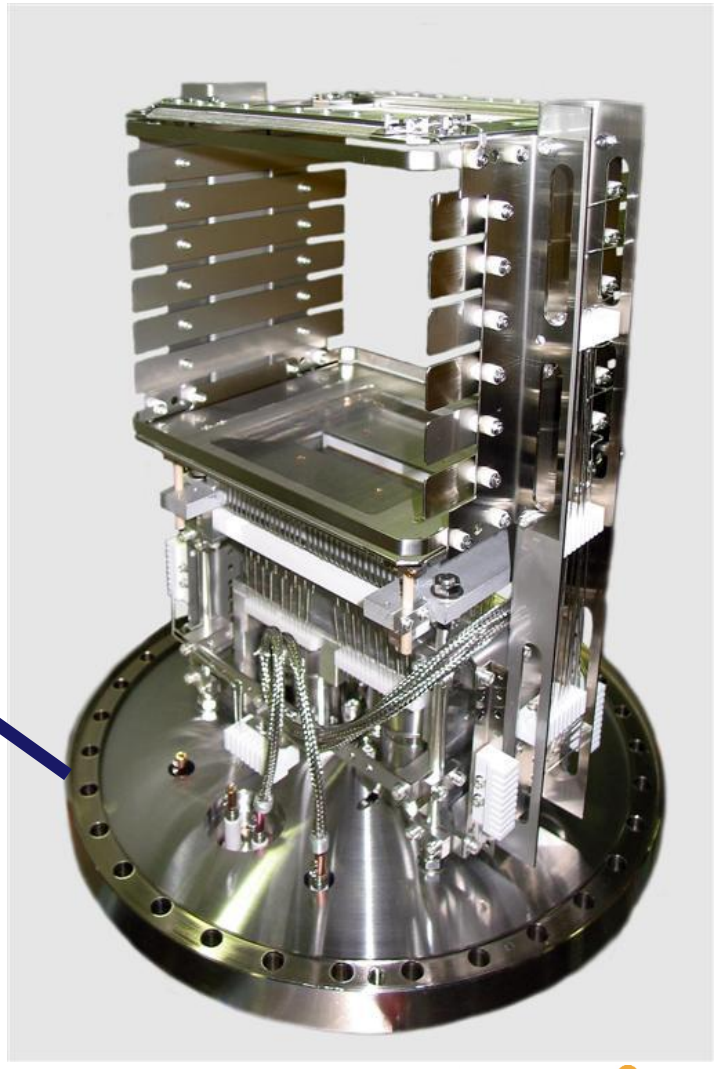


SIS18

SIS18 Section:
-each IPM in a vacuum tank of 1 m length
-wire array readout
-GSI amplifiers beside the IPMs
-each wire MUX to ADC
-1 ADC per profile / 100 Hz

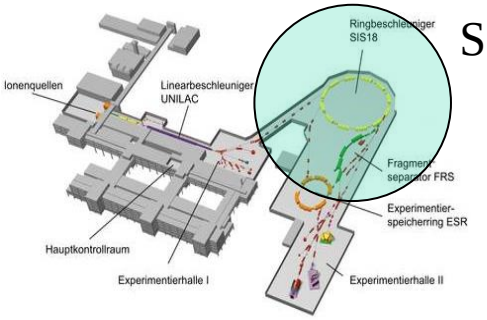


IPM @ SIS18 / Wire Array



-	Flange COF	300	mm
-	e-box opening	200 x 180	mm^2
-	E-field	60 (±5.4 kV)	kV / m
-	cycle time	1 – 16	s (inject. –> extract.)

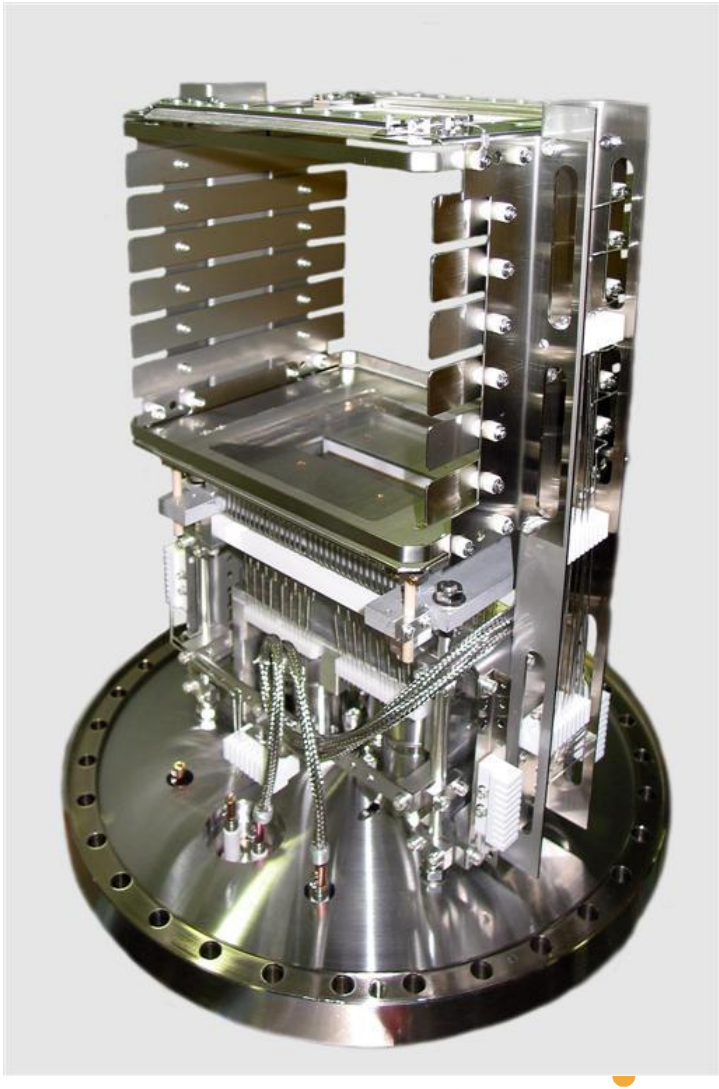
IPM @ SIS18 / Wire Array



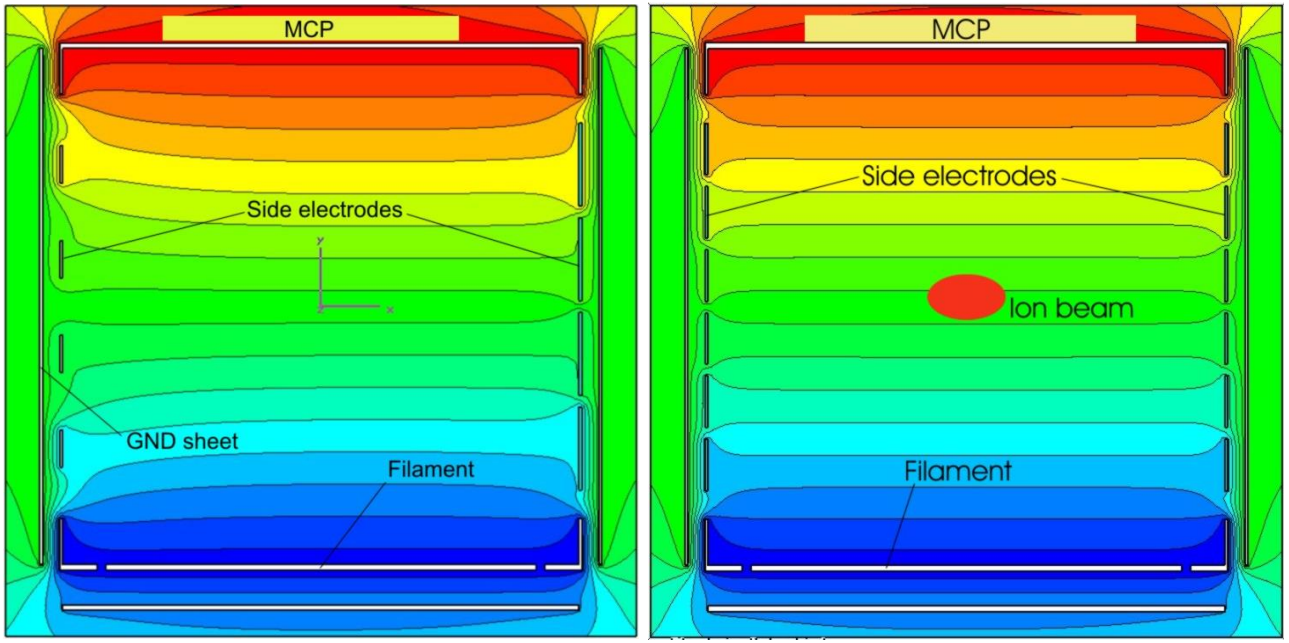
SIS18

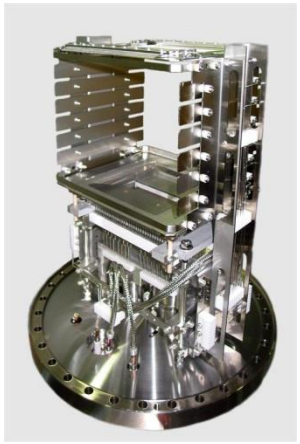
SIS18 IPM:

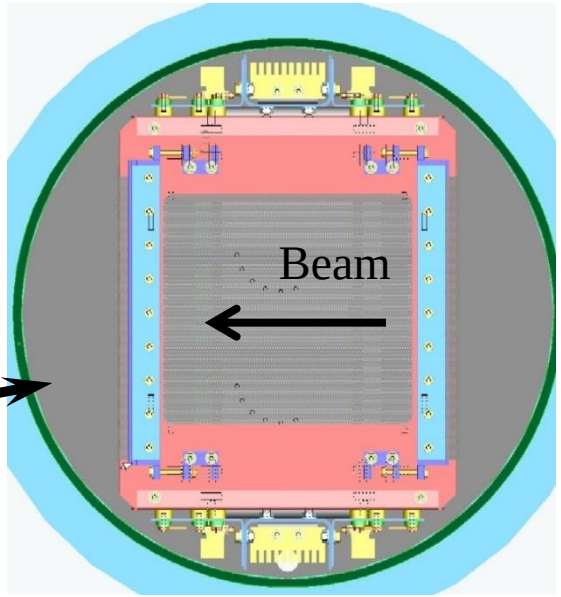
-	Profile rate	100	Hz (100hor & 100ver)
-	MCP active len	26	mm
-	MCP pore size	12.5	µm
-	MCP resistance	~ 100	MOhms / per plate
-	Wires / IPM	64	
-	Wire pitch	2.1	mm
-	Wire diameter	1.5	mm
-	beam width	60 – 1	mm within s
-	poor spatial resolution		



IPM @ SIS18 / E-Field



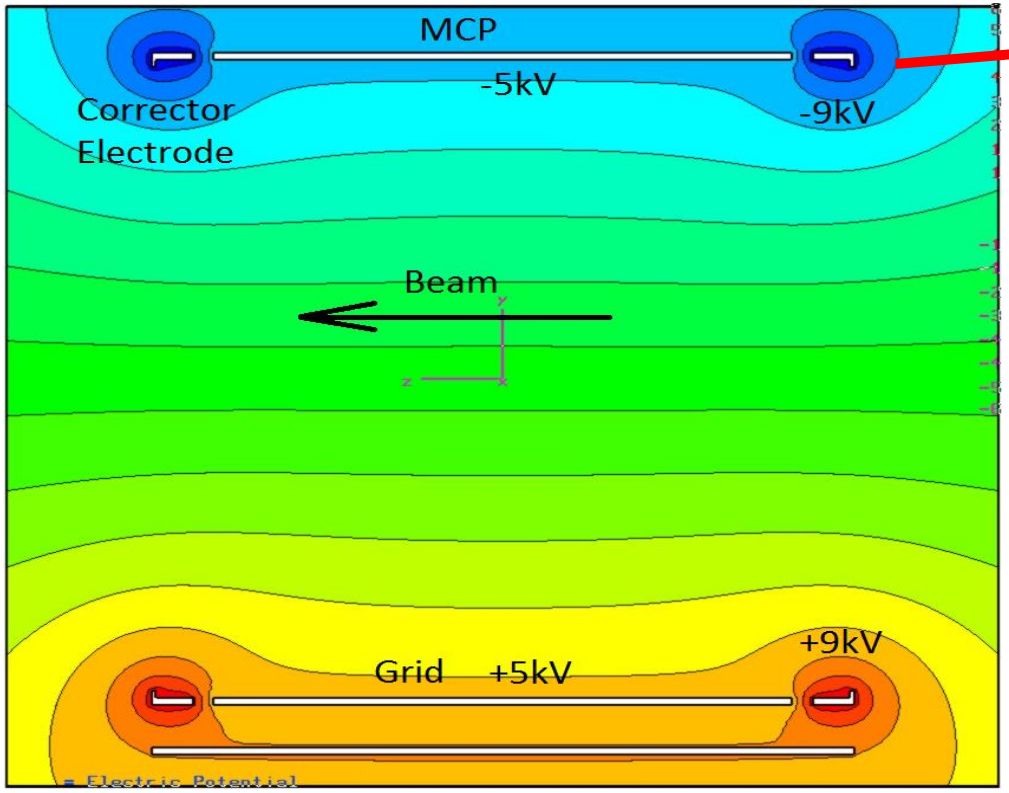


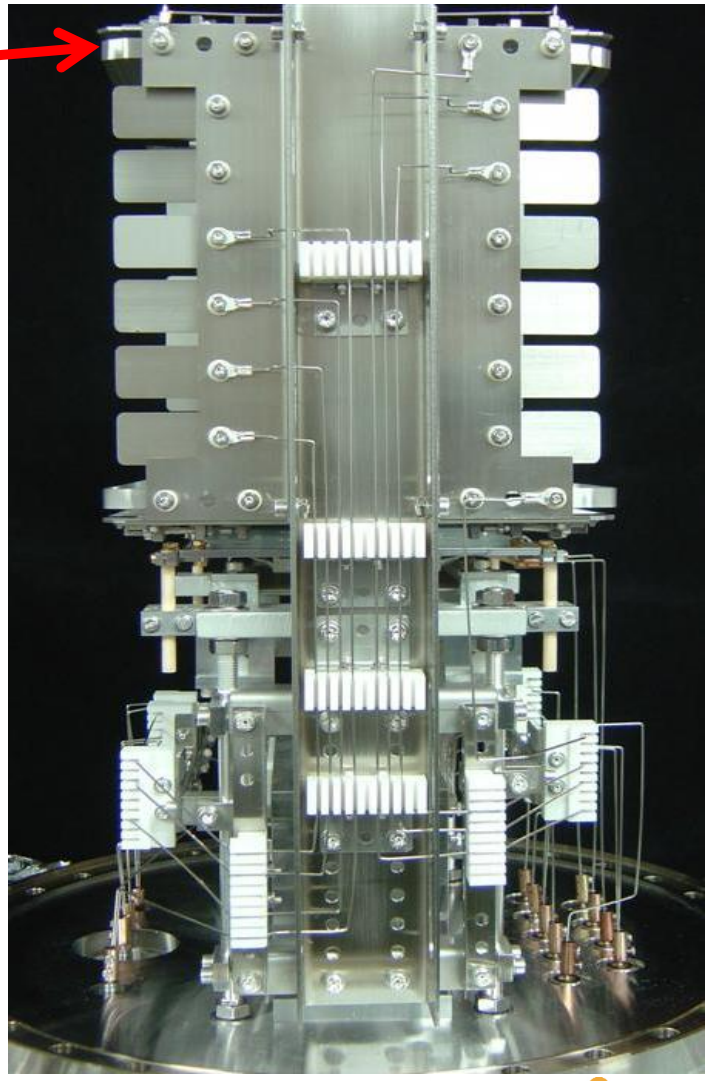


Gaps between side electrodes, large and small.

Design image, insertion into vacuum tank, optimized for large beam aperture.

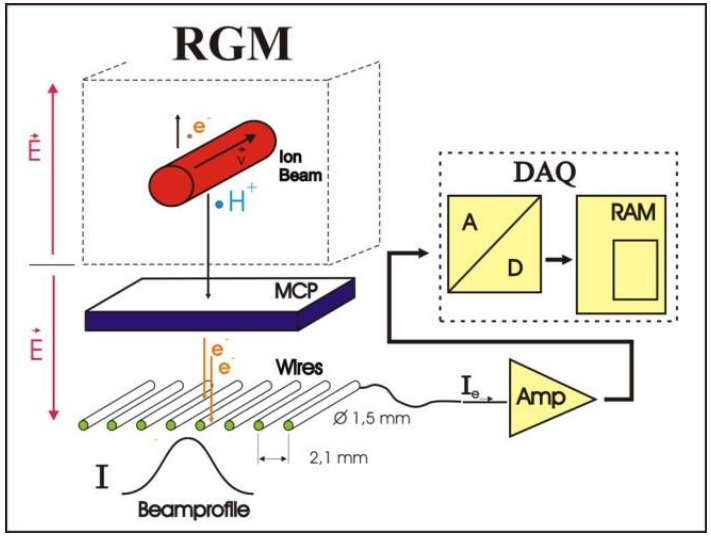
IPM @ SIS18 / E-Field

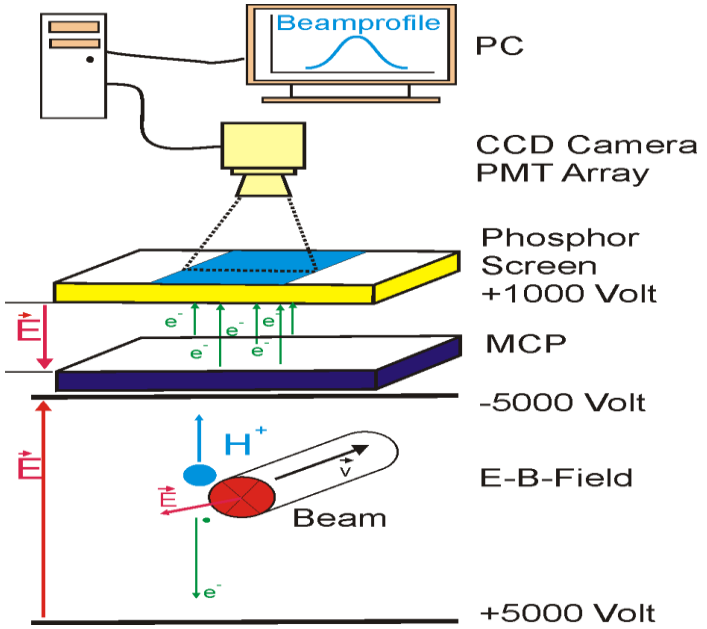




- Corrector electrodes to reduce the longitudinal e-field components Ez.
- Due to vacuum conditions and bakeout each HV electrode individual feedthrough

IPM Types @ GSI





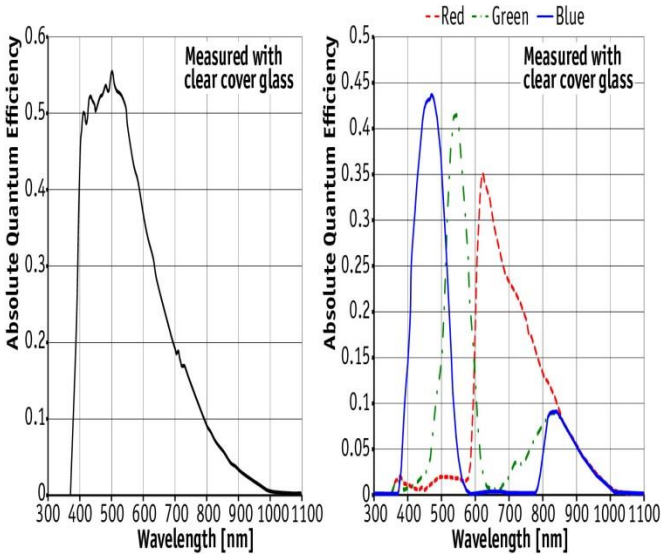
SIS18 IPM:
-wire array-64
-beam width: 60 – 1 mm

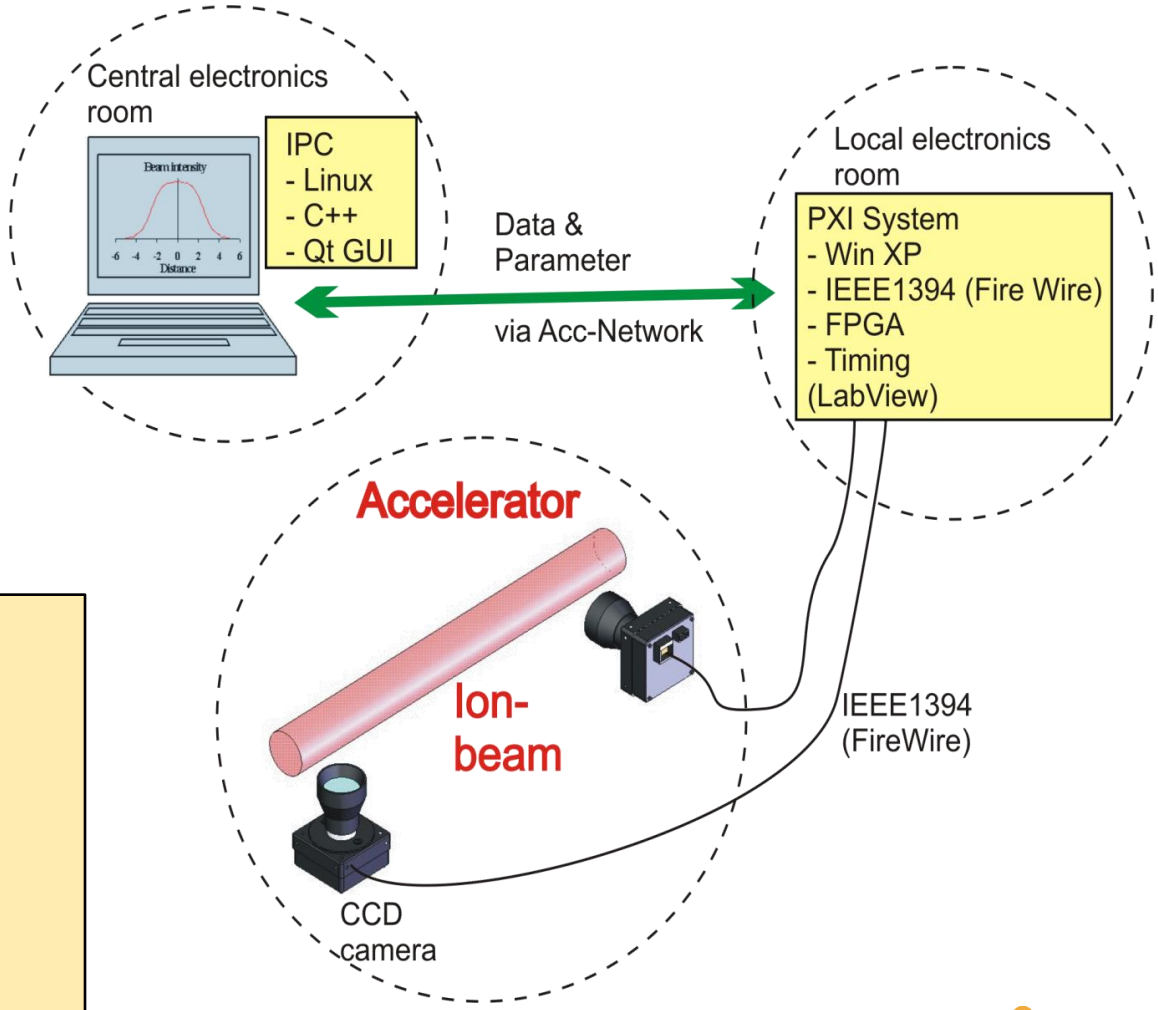
Wire readout disadvantages:
-less spatial resolution
-1 dim. readout
-Channel calibration by hand

Optical readout by digital Camera

-Measure image 2 dim.
-Spatial resolution < 200 µm
(dep. on MCP width to pixels)
-image corrections
-standard software tools

IPM @ GSI / Camera





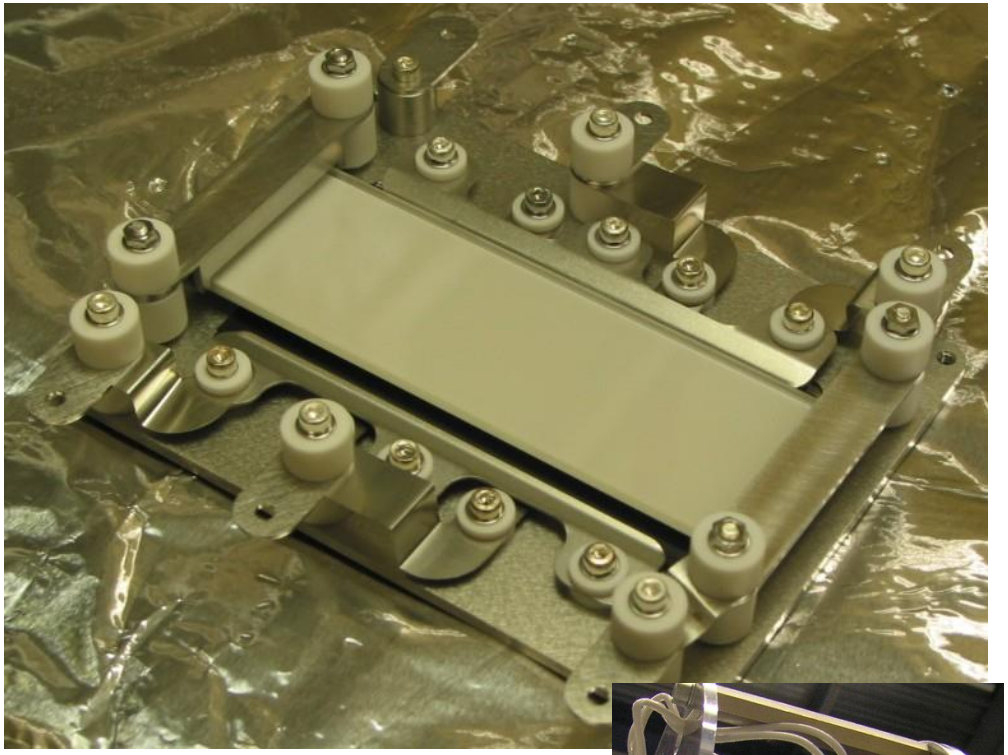
Optical readout by digital Cameras

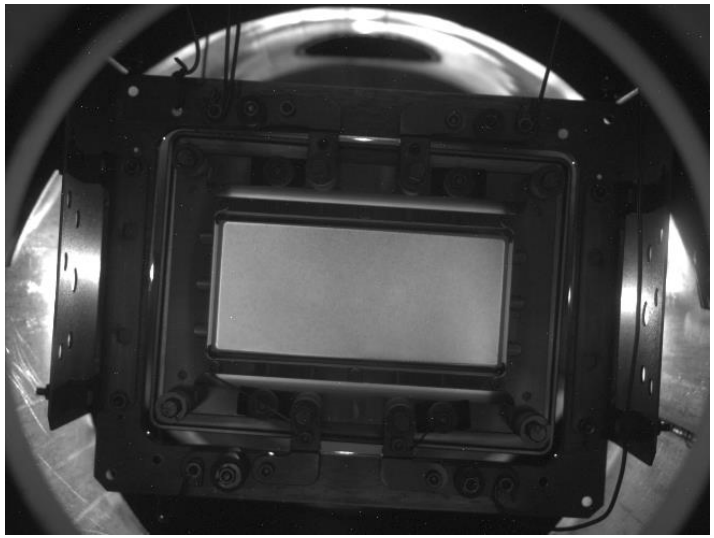
- 2 digital cameras
- standard computer technology
- CCD cameras 200 frames / s
- Integration time 1µs -> s

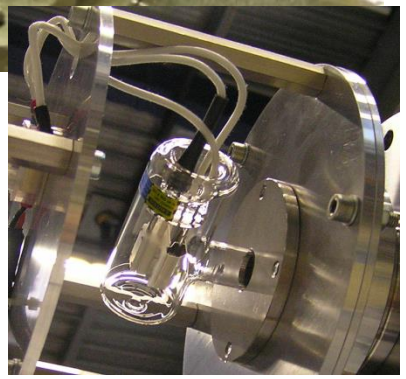
IPM @ GSI / Camera

MCP – PH – Assembly

- MCP – Ph shape ideal rectangular,
- large width ~ 100 mm
- length 40 mm
- P47, 100ns decay time
- MCPs ~ 100 MOhms

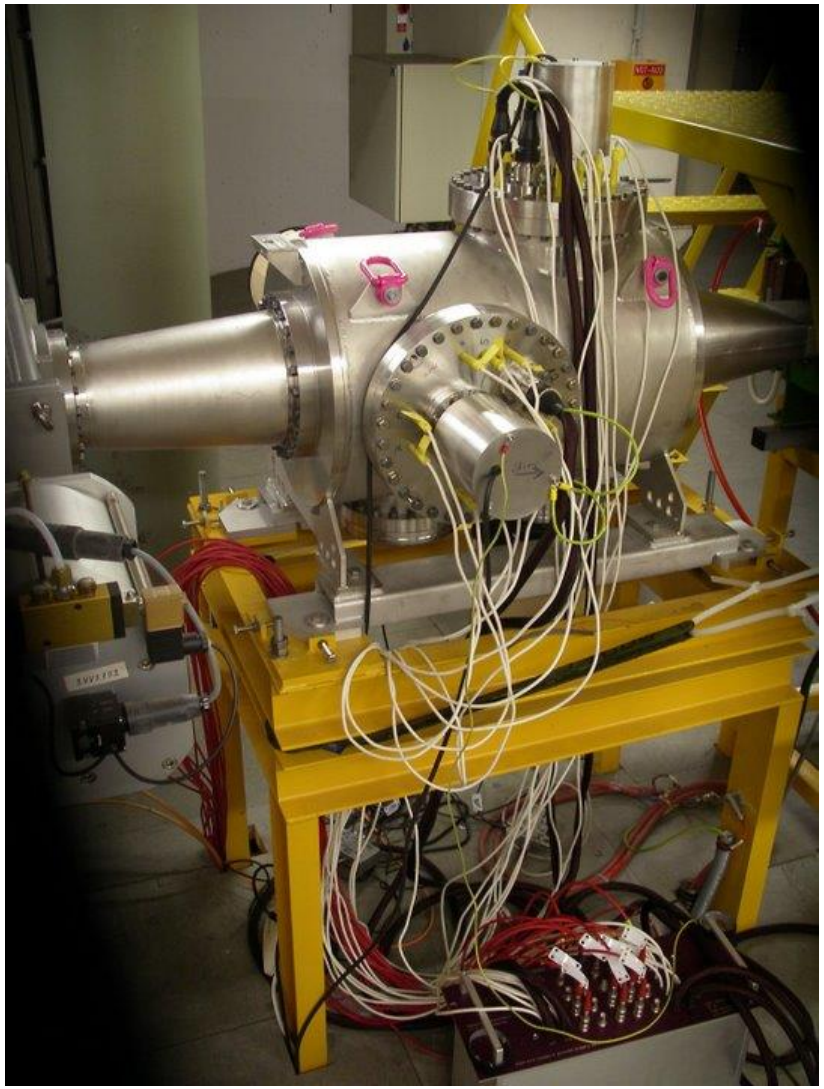


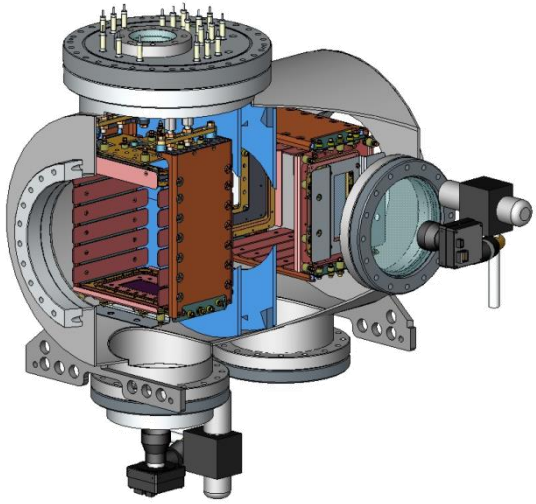




UV light signal for MCP calibration
Deuterium lamp, 115nm

IPM @ COSY FZ-Juelich

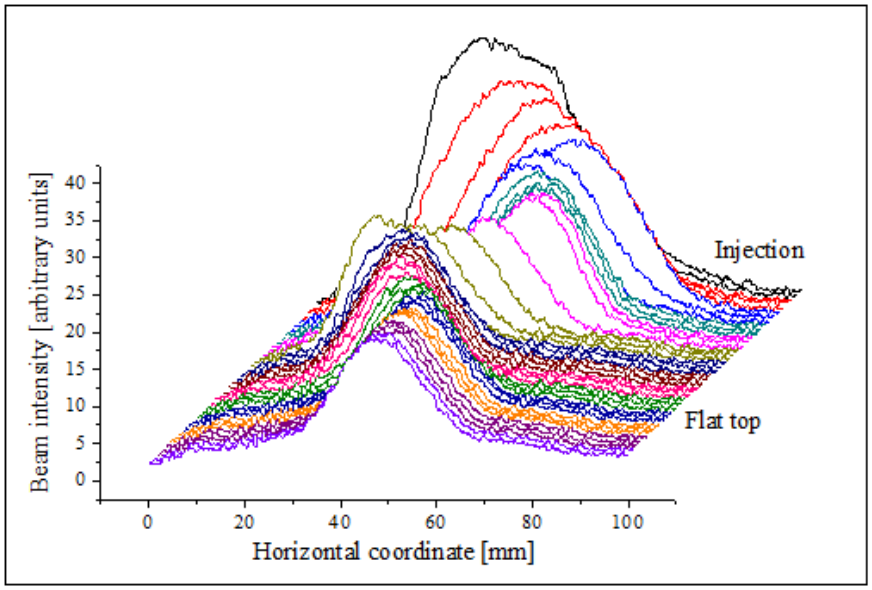




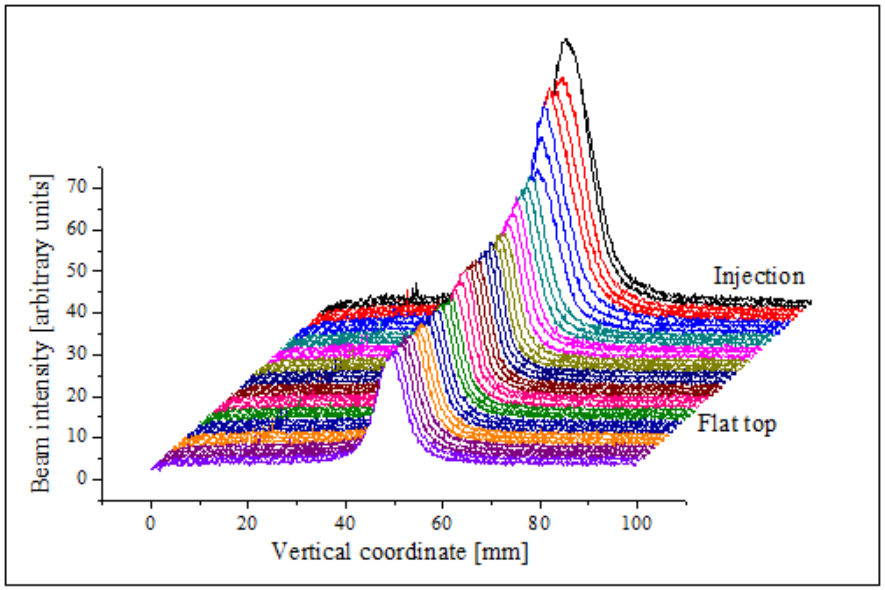
IPM with optical readout installed in COSY@FZ-Juelich

- Protons
- Vacuum tank 0.6 m length
- Main flanges CF250
- Aperture 180 x 180 mm^2

IPM @ COSY FZ-Juelich



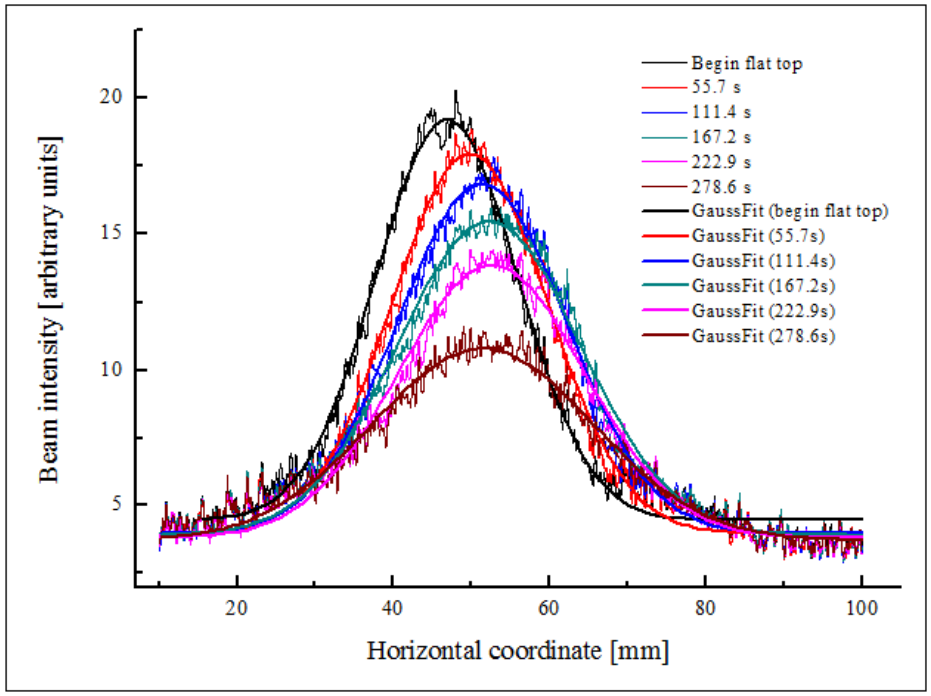
Evolution of the horizontal proton beam profile during injection and acceleration to 1.343 GeV/c. About $3 \cdot 10^9$ polarized protons reached flat top. Time span is 2 s.



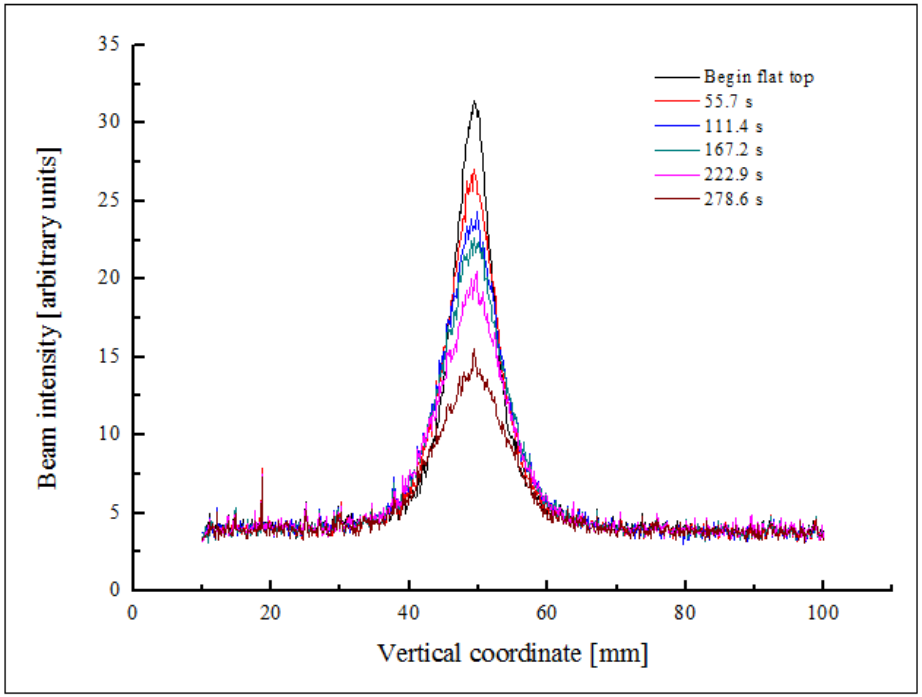
Evolution of the vertical proton beam profile during injection and acceleration to 1.343 GeV/c. About $3 \cdot 10^9$ polarized protons reached flat top. Time span is 2 s.

Data measured in 2009 in COSY@FZ-Juelich and presented at the DIPAC2009 by V. Kamerdziehv, C. Böhme, J. Dietrich, P. Forck, T. Giacomini.

IPM @ COSY FZ-Juelich



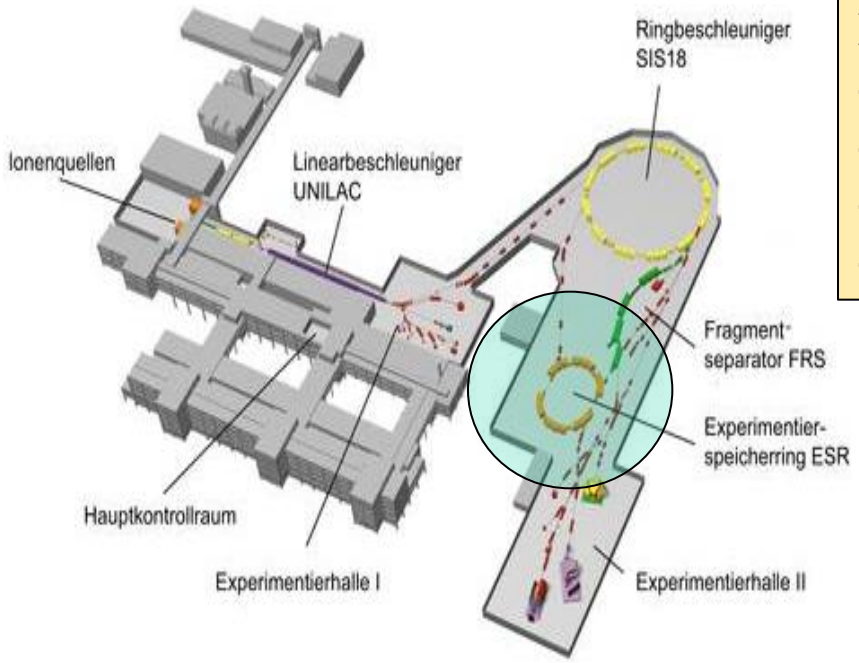
Horizontal profiles of the polarized proton beam at 1.343 GeV/c. The profile measurement started once the flat top was reached.



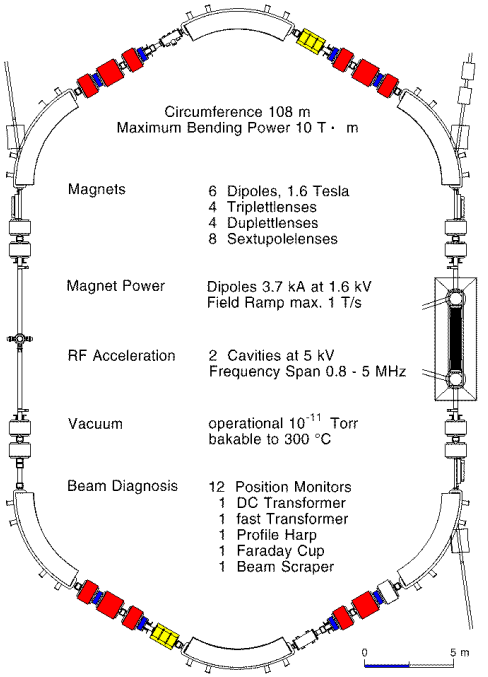
Vertical proton (polarized) beam profiles at 1.343 GeV/c flat top.

Data measured in 2009 in COSY@FZ-Juelich and presented at the DIPAC2009 by V. Kamerdziehv, C. Böhme, J. Dietrich, P. Forck, T. Giacomini.

ESR IPM – Optical Readout



ESR IPM:
- Chevron MCP, Phosphorscreen P47, CCD
- beam width 50 – 1 mm
- beam time s – hours (inject. –> extract.)
- beam profiles 200 / s (200 hor & 200 ver)



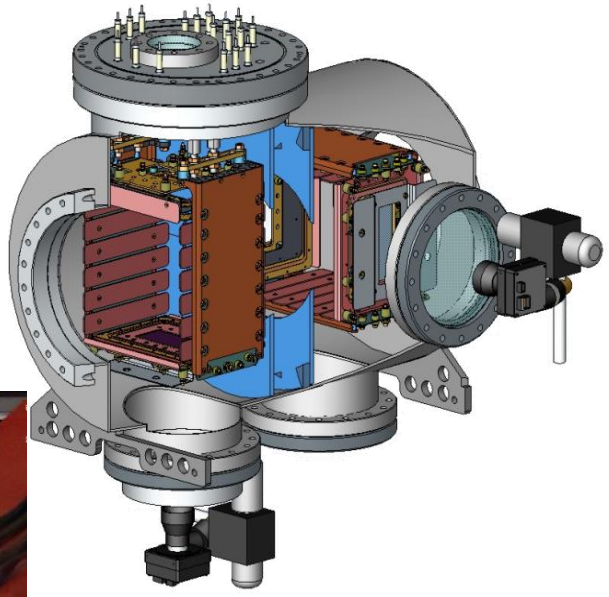
Electron cooler

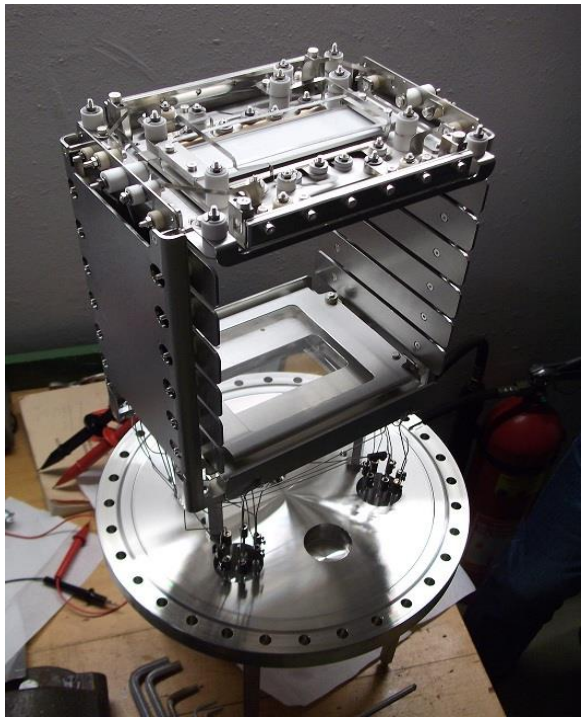
ESR parameter:
- circumference 108 m
- bending power 10 Tm
- ions per cycle 10^8 typ.
- vacuum 10^{-11} mbar
- electron & stochastic cooling

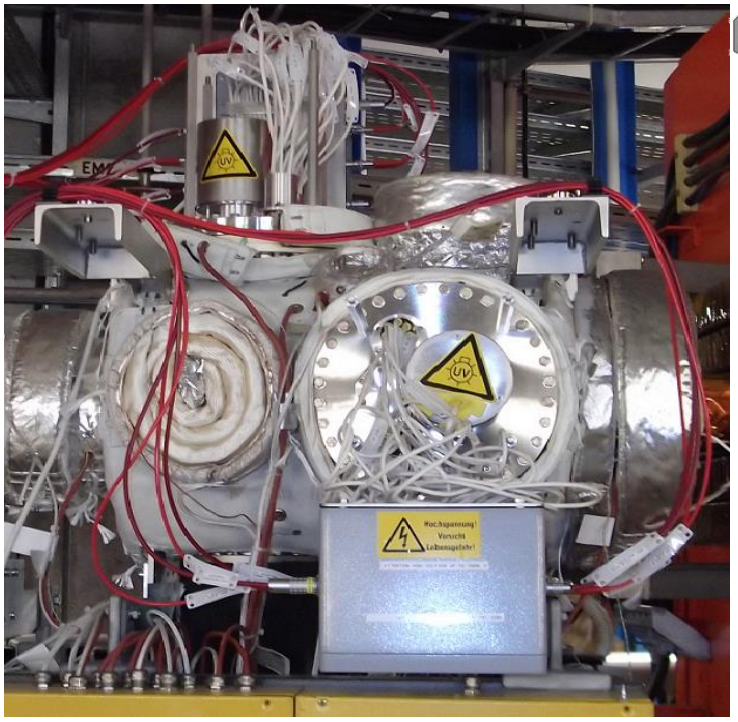
IPM @ GSI / ESR

IPM with optical readout installed in ESR@GSI

- Vacuum tank 0.6 m length
- Main flanges CF250
- Aperture 180 x 180 mm^2

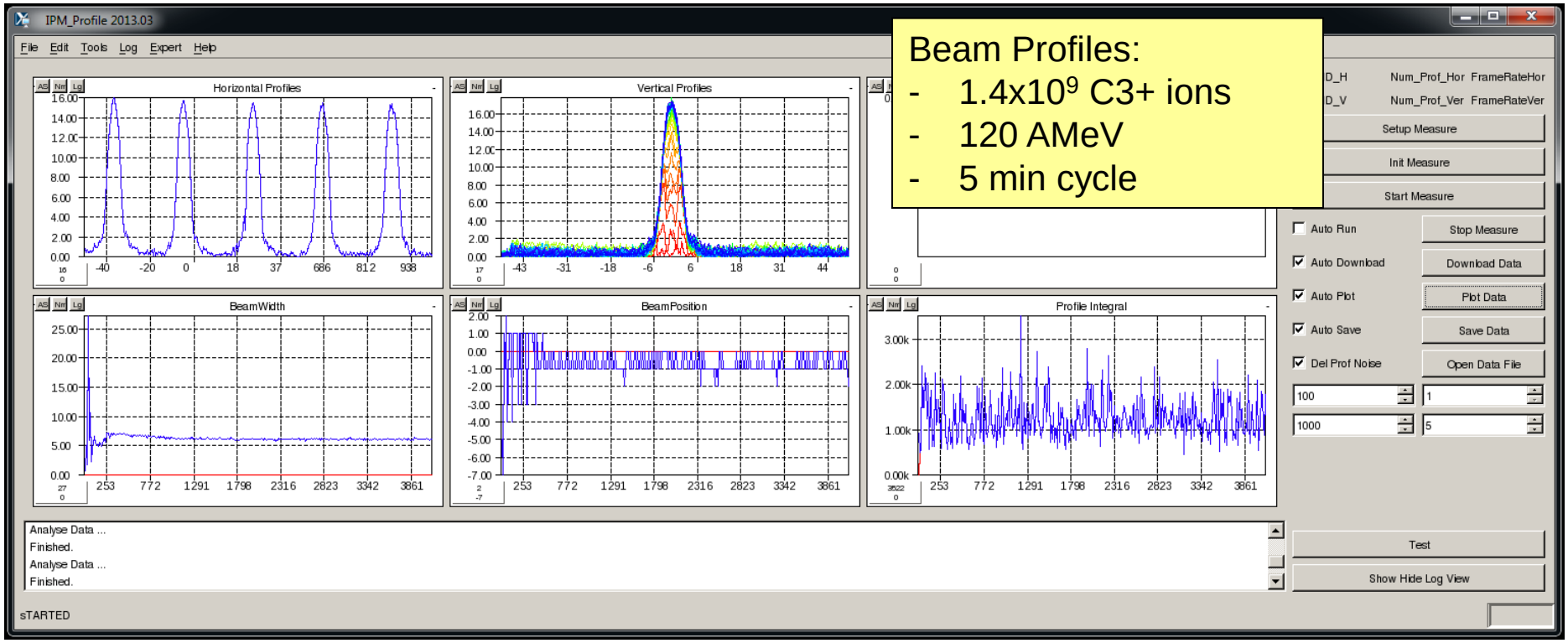






ESR IPM installed with
-heat jacket
-UV lamp
-CCD cameras
-HV

IPM @ GSI / ESR



Beam Profiles:
- 1.4×10^9 C3+ ions
- 120 AMeV
- 5 min cycle

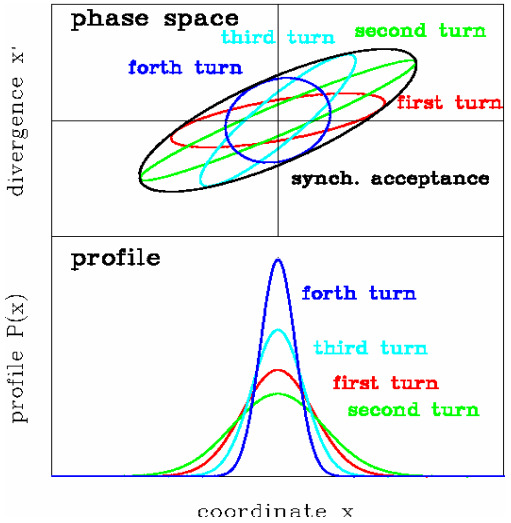
Beam profiles measured with optical IPM in ESR@GSI.

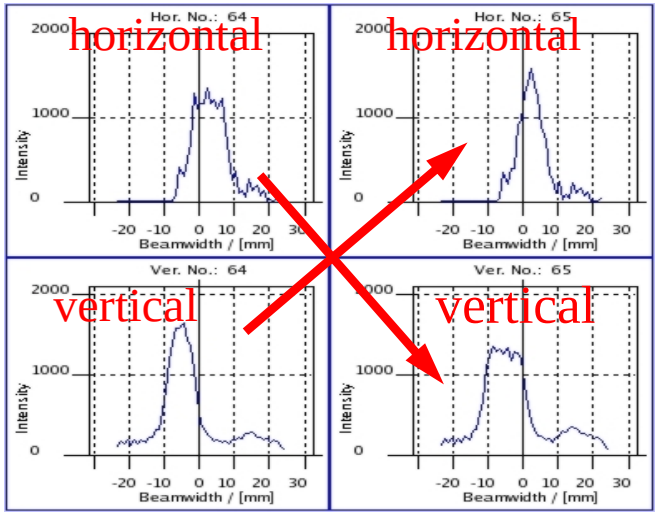
Current developments

Fast beam changes:
-injection mismatches
-emittance exchanges due to coupling of tune resonances between hor & ver phase space

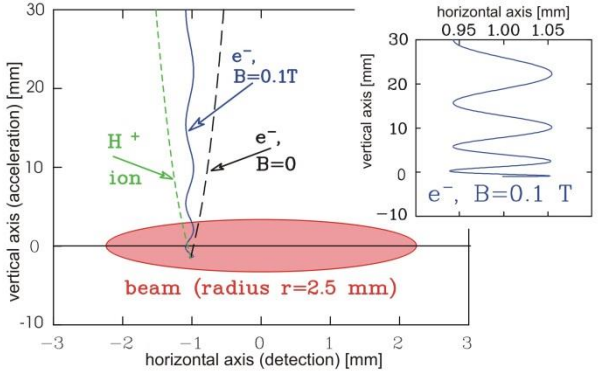
Ambition:
Bunch by bunch readout.
Profile rates of about 5 – 10 MHz

-camera ~ 1000 profiles / s
-via PMT-array or SiPM, prototype avail, not tested yet
-detection of ionized residual gas electrons / not ions
-additional magnetic field in parallel to electric field

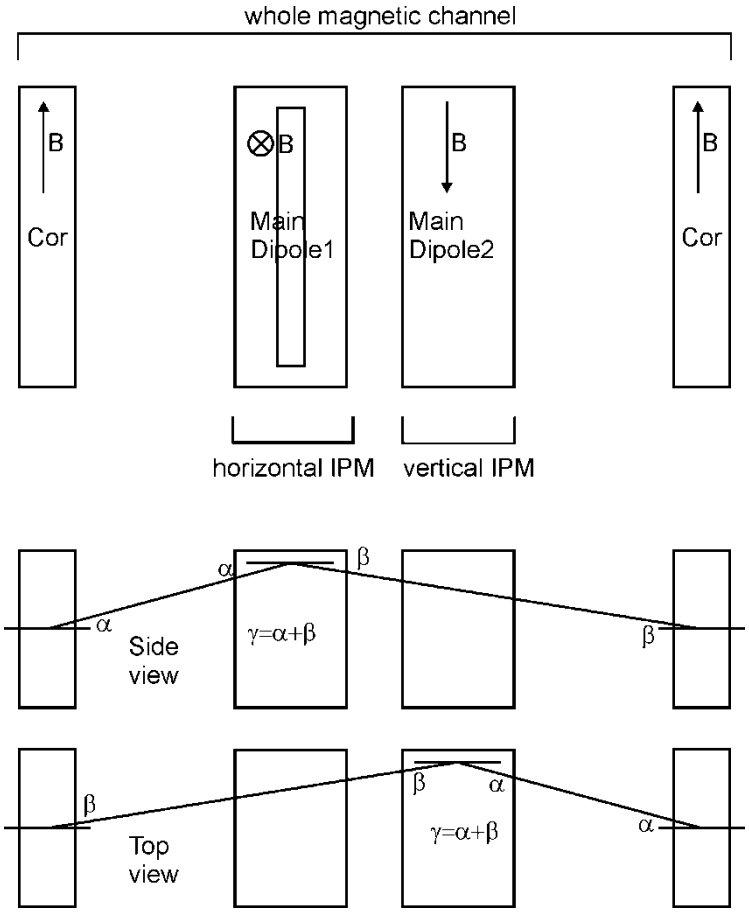




32 ch PMT array

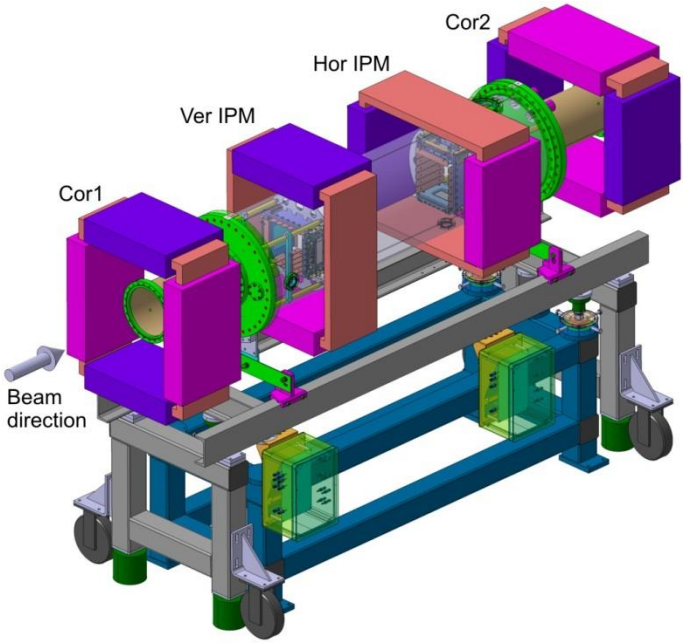


Bunch by Bunch Readout

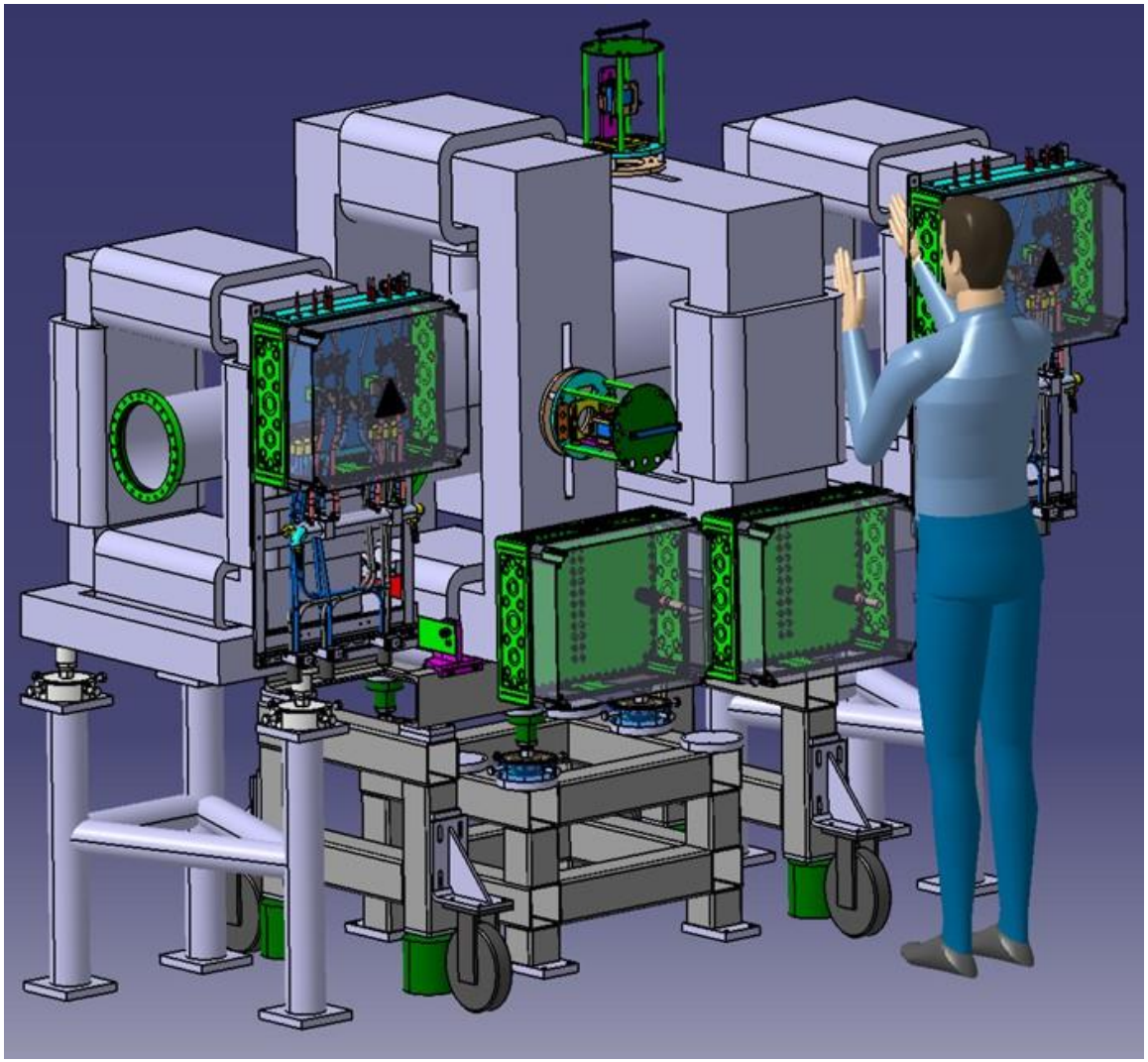


Magnet design

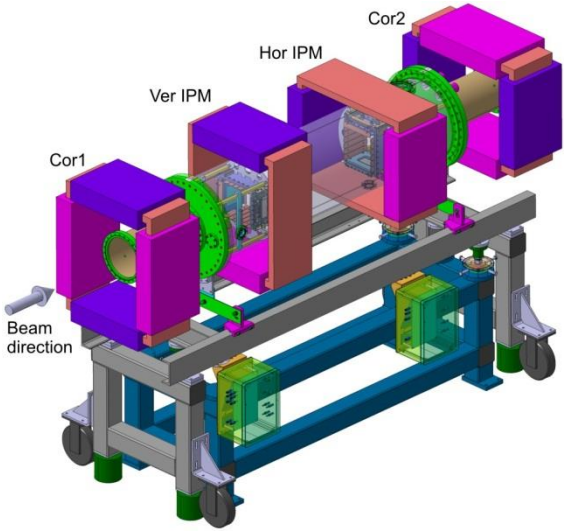
- window frame
- one diagnostic magnet active at time
- length 2.5 m, width 1.6 m
- vacuum parts similar to ESR type
- IPMs are inserted into vacuum tank in beam direction



Bunch by Bunch Readout

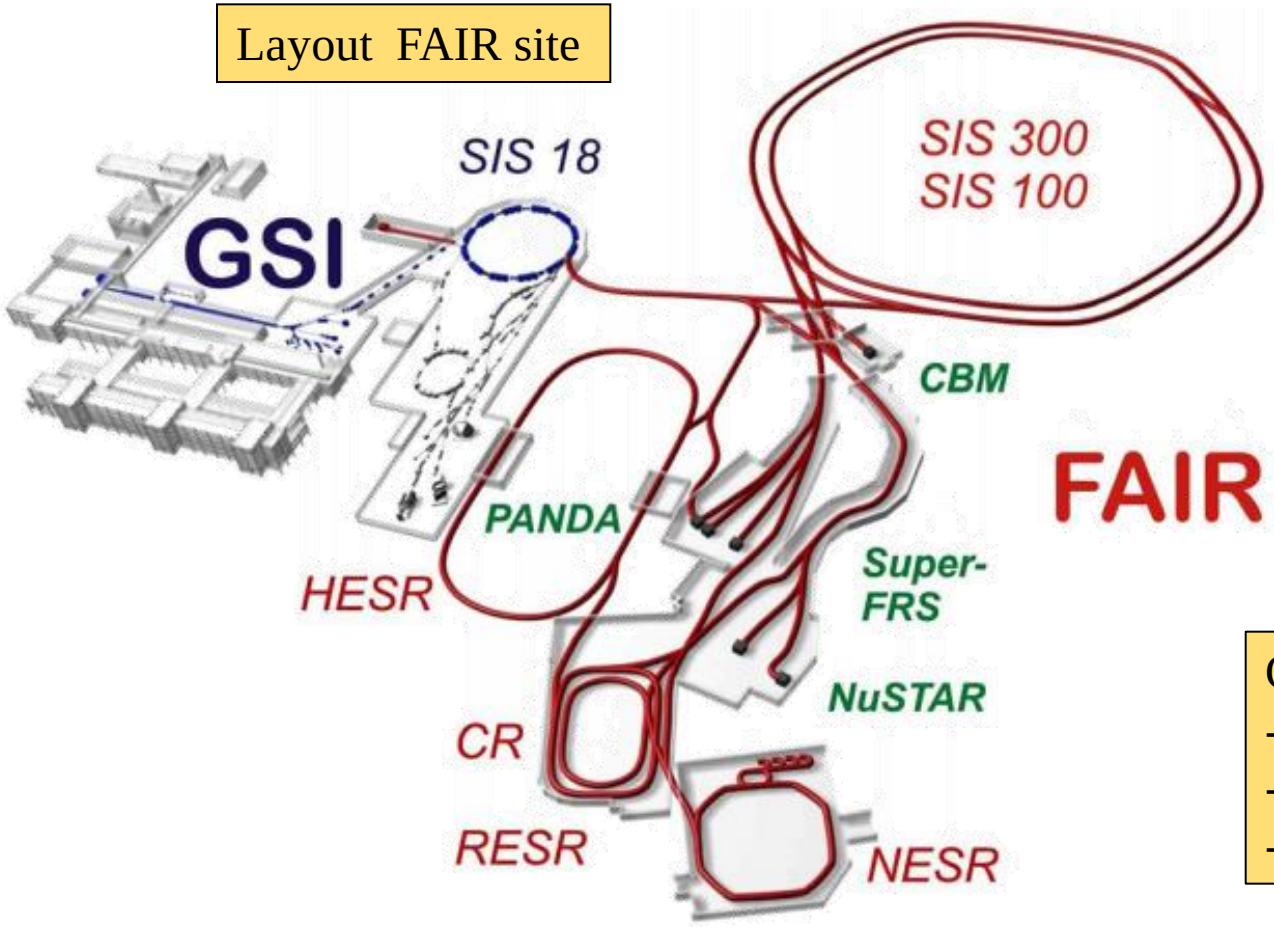


Digital mock up of the final design.
Prototype for FAIR SIS100.
Slits in the yokes for CCD.



IPMs @ FAIR

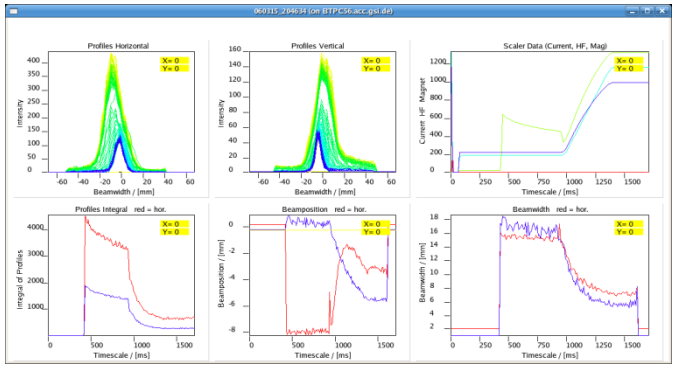
Layout FAIR site

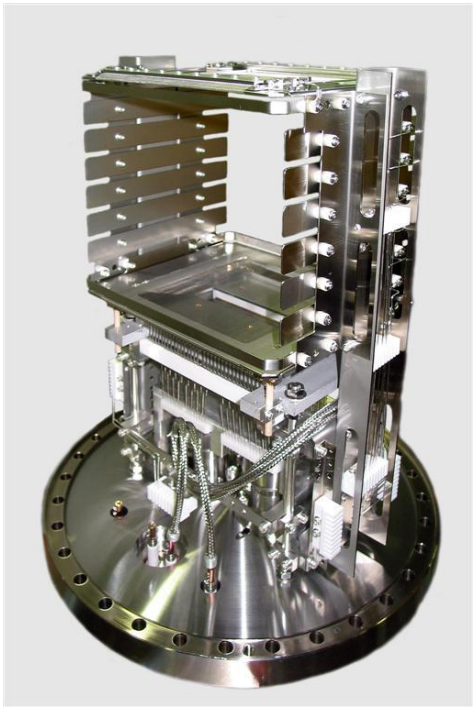


SIS100 IPM:
- 50 mm beamwidth
- Fast readout
- Magnet

CR IPM (Collector Ring):
-400 mm Beamwidth
-CCD camera readout
-no Magnet

Summary





- IPM wire array readout
- Data presentation
- IPM optical readout
- Prototypes for FAIR