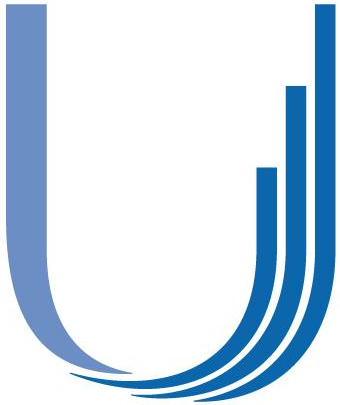


LHC Injectors Upgrade

LHC Injectors Upgrade

Challenges in Beam Instrumentation

Rhodri Jones (BE/BI)

CERN

Introduction

BE-BI started a consolidation program for the beam instrumentation of the injector chain several years ago

The target at that time was to replace obsolete parts to ensure the availability of our systems in the coming years

These developments were not directly linked to performance issues or any requests for improvement

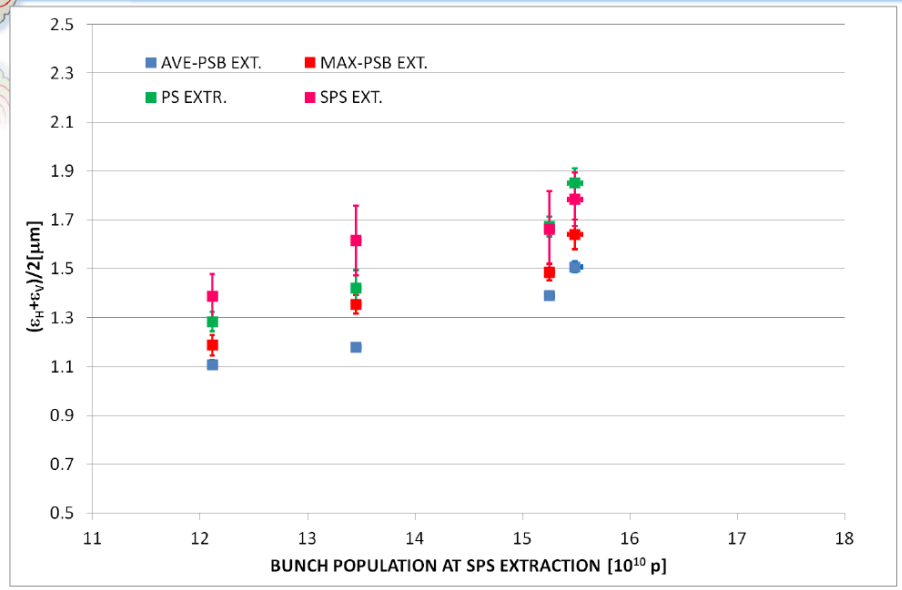
The LIU project now adds many new requirements

- Accurate, reliable measurement of emittance
  - for more intense & smaller beams
  - on a bunch by bunch basis
- Measurement of ghost & satellite populations
- Trajectory measurements in all machines
- Good localisation in time and space of beam losses
- ……

Measurement of Beam Size

Recent LMC summary on injector emittance measurements (G. Arduini)

Summary injectors



Summary

- We are now operating in a regime of ~constant brightness:
  - Certainly true for PSB (ring 1 excepted)
  - Less evident for PS and in particular SPS were blow-up is observed during the ramp but no evident sign of instability
  - Investigations ongoing but would significantly profit of more powerful diagnostics:
    - Continuous profile measurement
    - Bunch-by-bunch profiel diagnostics
  - Now that the LHC is well served in terms of instrumentation we should get the long awaited upgrades of the instrumentation in the injectors!

- Much work already done to calibrate, understand & optimise the existing wirescanner systems
- For maybe first time emittance measurements between accelerators shows expected increase from one accelerator to the next
- Error bars now small except for SPS at top energy
- If smaller differences in emittances need to be determined for optimisation a reduction of systematic errors is required

Current Wirescanner Limitations

Accuracy

Limited by complex mechanics needed for high speed

Fits on asymmetric tails/baseline on some users

Resolution

Small beam size requires improved wire position resolution

Dynamic range

Settings depend on operator input

Rather low signal for pilot beams

Scan speed

Limited operationally to 15 [m/s]

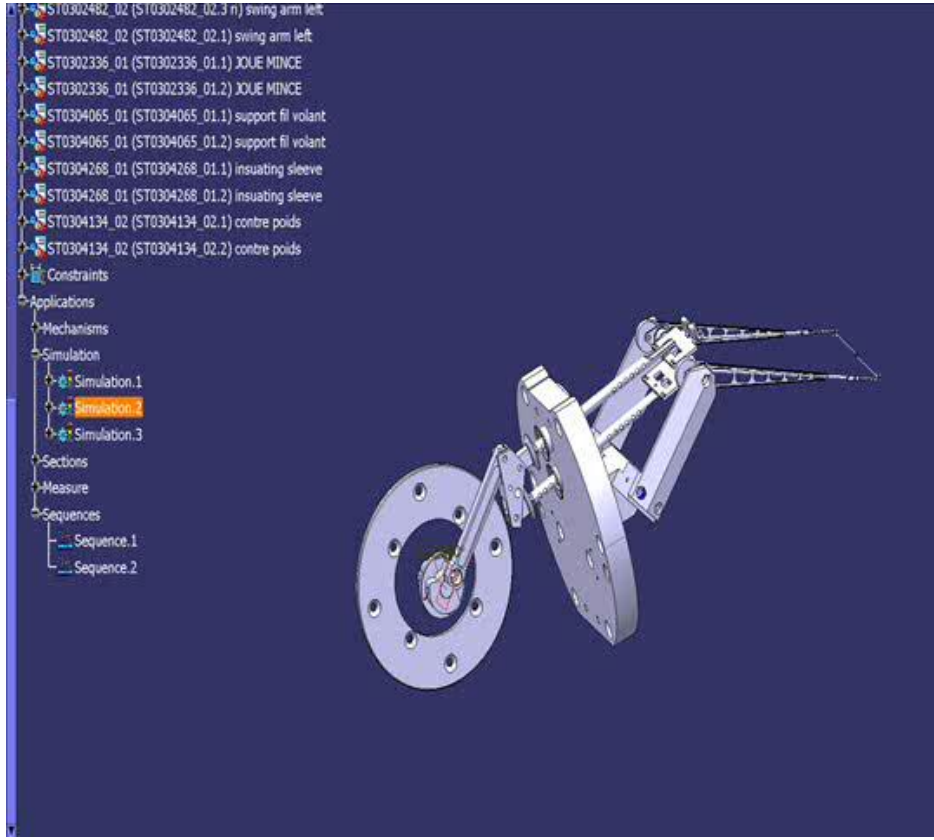
Premature bellow fatigue

5’000 scans in the PS (new bellows being tested)

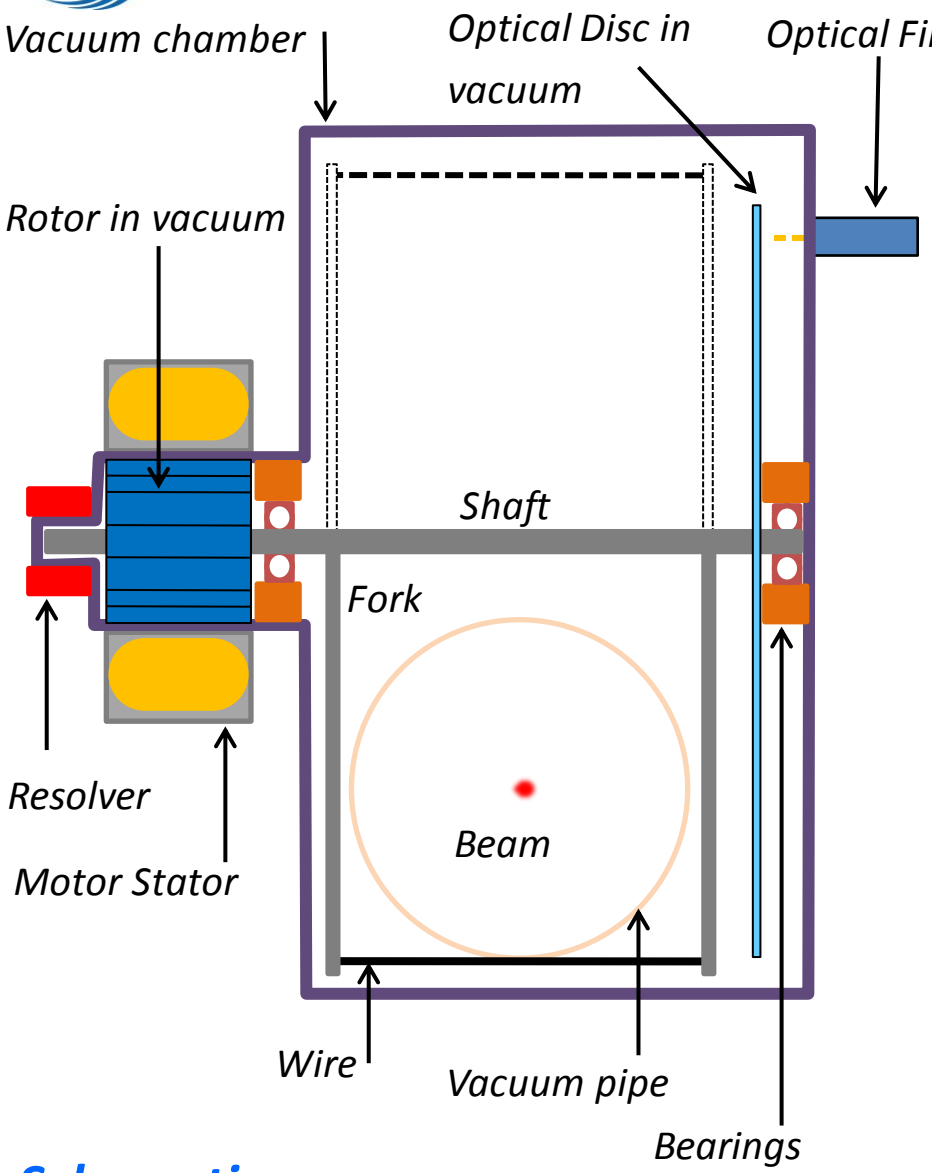
Fast acquisition for bunch by bunch

LHC type being tested in the SPS at the moment

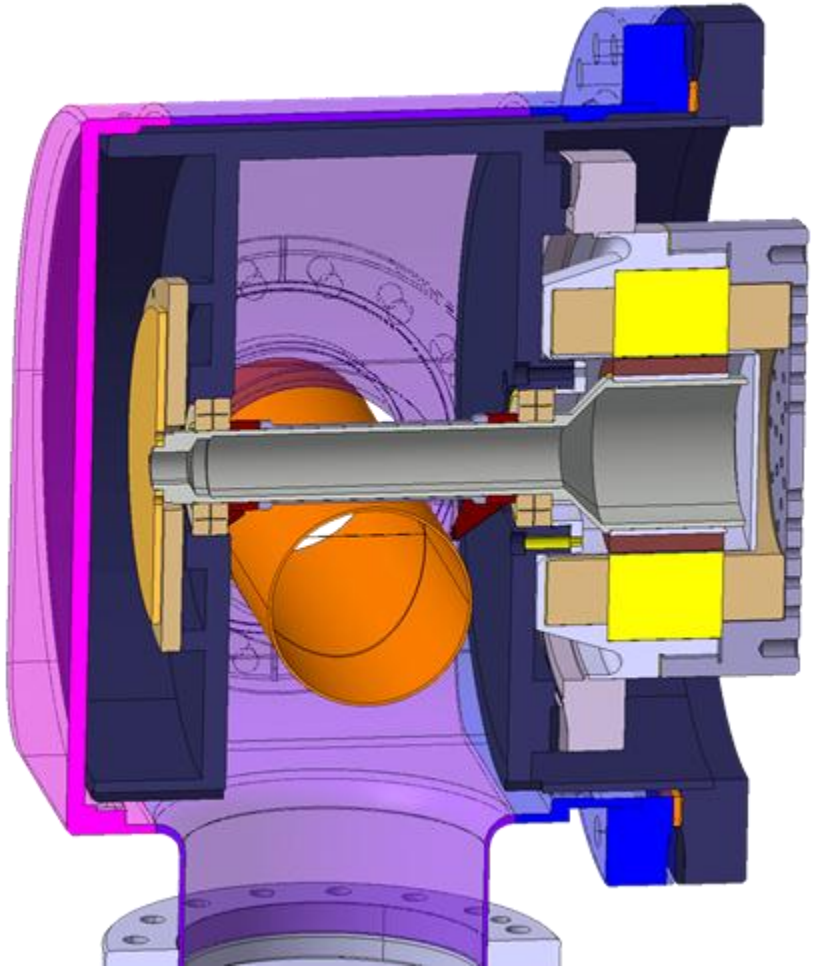
Unavailable for PSB and PS (frev variation)



R&D on a New CERN Vacuum Wire Scanner

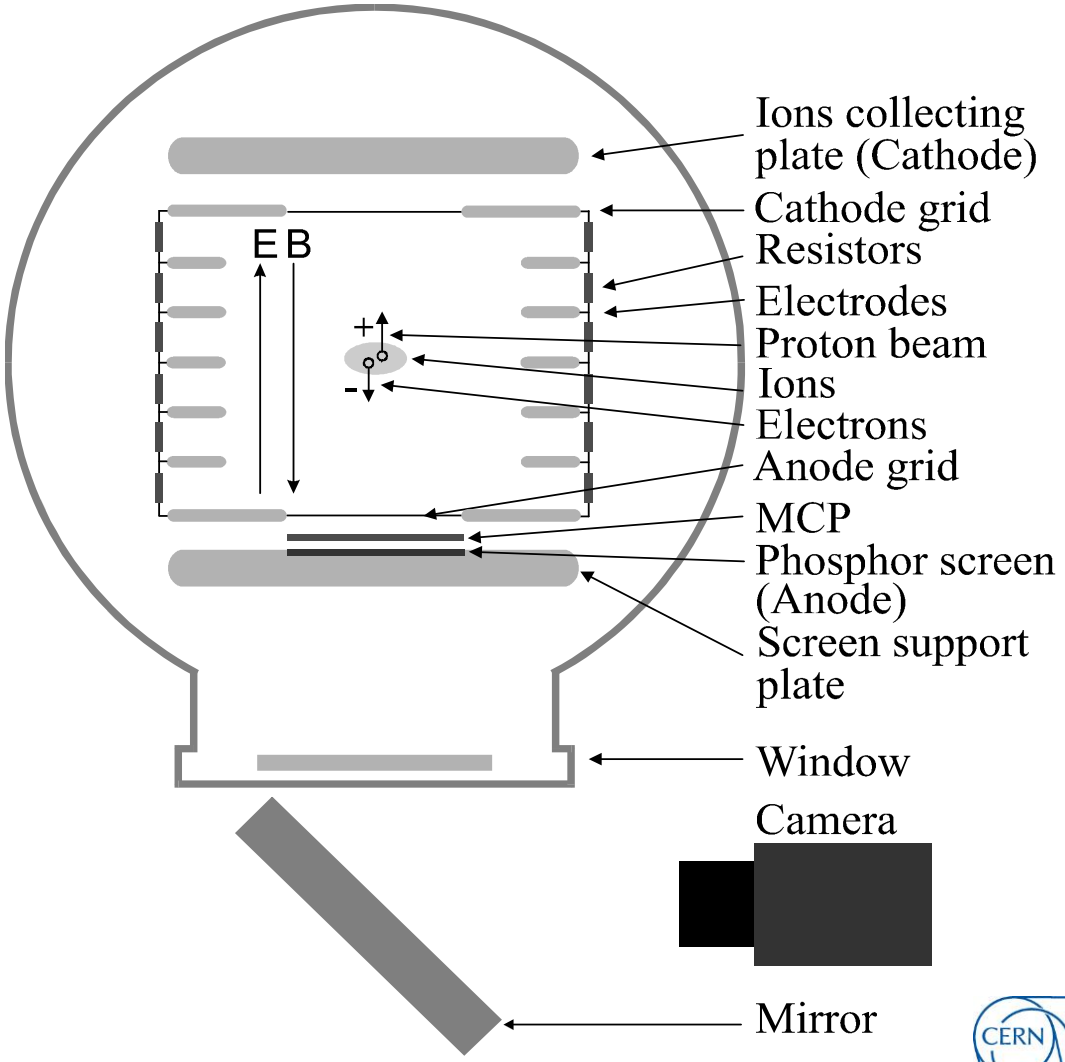


Schematic



3D Mockup

Continuous Beam Size Measurement
Rest Gas Ionisation Monitors



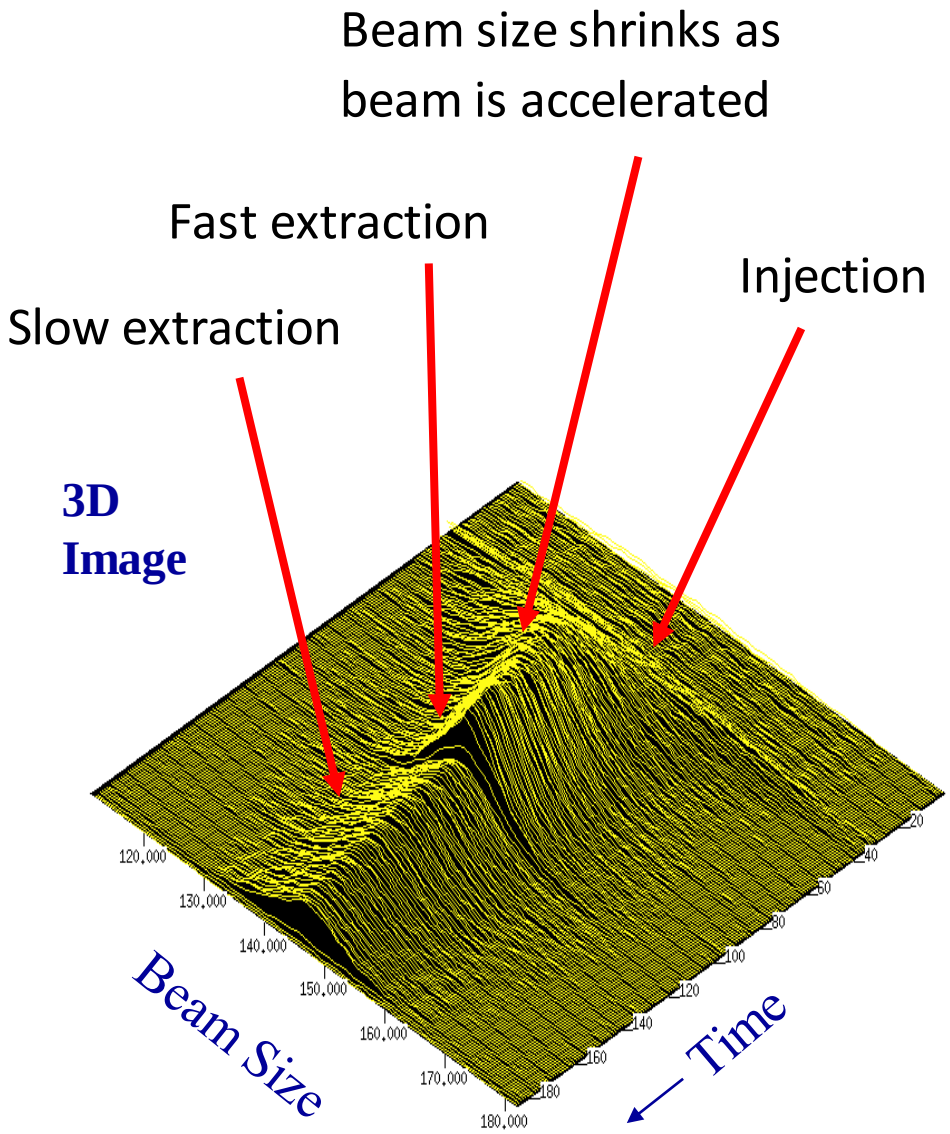
Continuous Beam Size Measurement
Rest Gas Ionisation Monitors

SPS System

- Prototype to be refurbished with LHC type optical readout system
- Aim to test in 2012
- Look at possibility to develop similar system for the PS and possibly PSB

Challenge

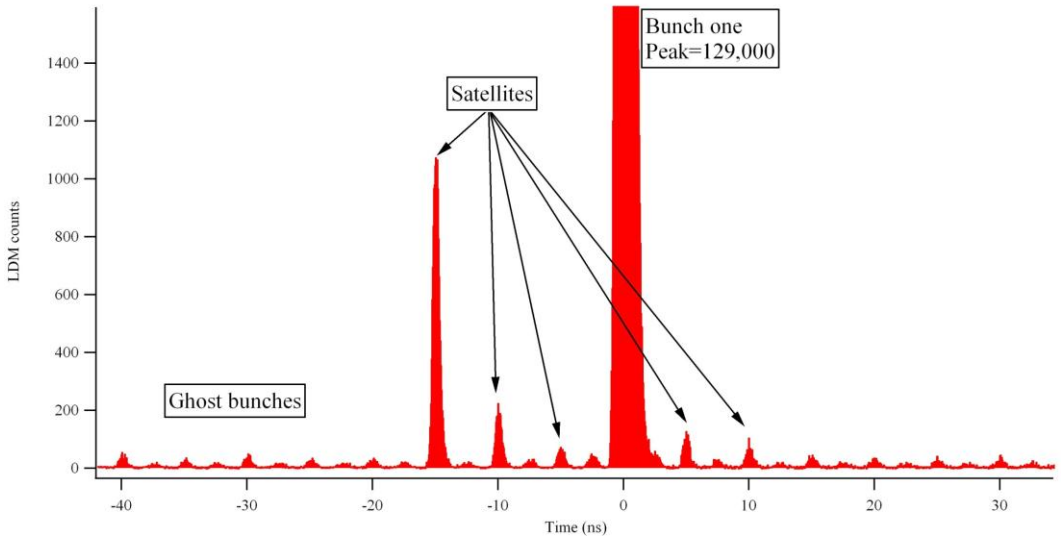
- To understand & optimise the system for different particle energies
- To make this a compact instrument for PS / PSB



Measurement of Satellites

LHC

Longitudinal Density Monitor using synchrotron light & photon counting techniques gives dynamic range of 10^5 with integration over a few minutes



Where do they come from?

Injectors

- Do not benefit from synchrotron light (apart from SPS above 400GeV)
- Are not colliders & hence require fast measurements

Challenge

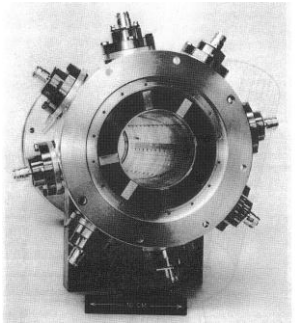
Find technique to allow monitoring of populations at % level within 200 turns

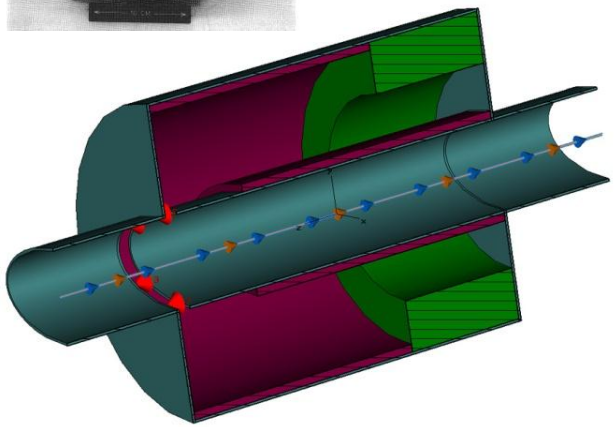
- Would allow further RF optimisation for minimisation
- OR RF tuning to create desired satellites (main v satellite for ALICE)

Measurement of Satellites

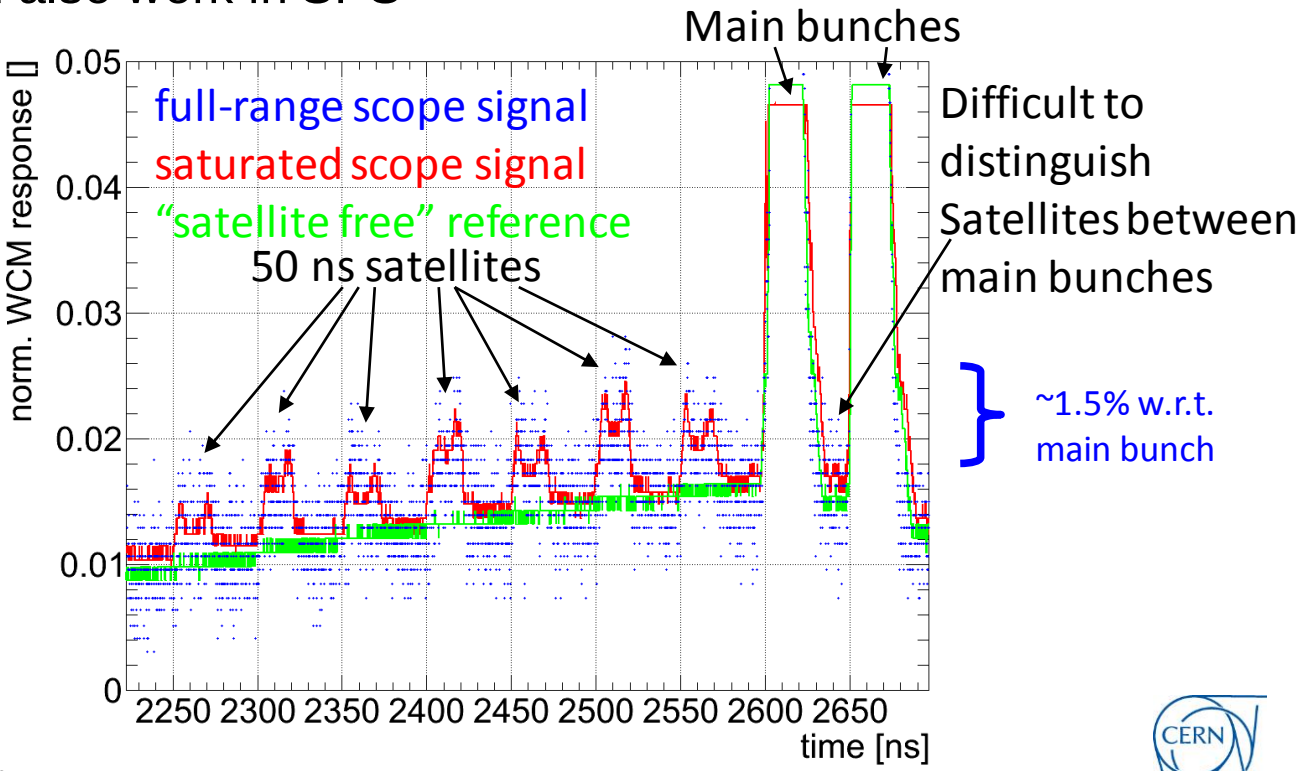
Best Candidate

- Upgrade of the existing PS electromagnetic wall current monitor for improved pick-up response
- Use of fast sampling oscilloscopes combined with significant post processing
  - compensate for reflections, pick-ups response, droop etc.
- Similar solution should also work in SPS





New PS Wall Current Monitor



Measurement of Satellites

Other Possibilities – using optical means

- OTR in PS to SPS transfer lines
  - Use photomultiplier to give time structure in single pass

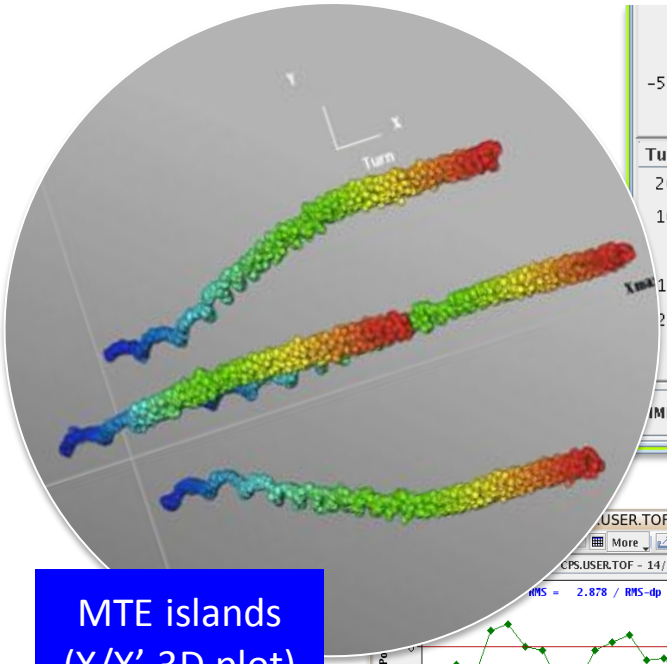
- Upgrade of the existing SPS synchrotron light monitor
  - Synchrotron Light only available above ~400 GeV for protons
  - Needs substantial refurbishing before it is operational again
  - Can equip with
    - CCD camera for transverse measurements
    - Photomultiplier for longitudinal measurements

BPM System Upgrades - PS

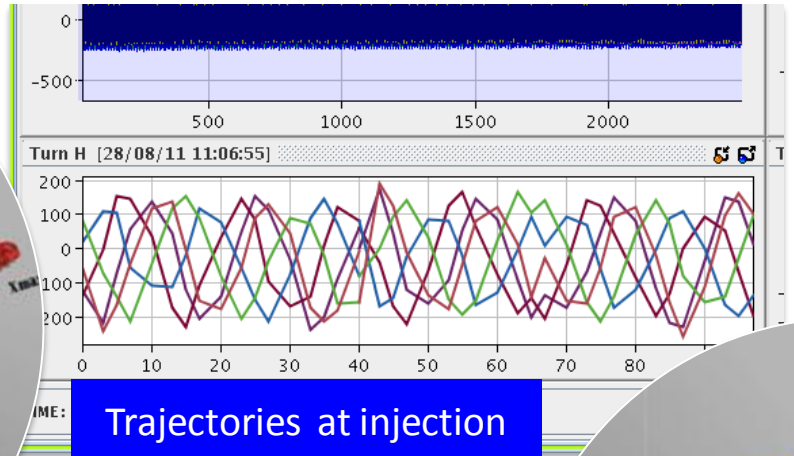
PS System recently upgraded

Now allows bunch by bunch and turn by turn measurements

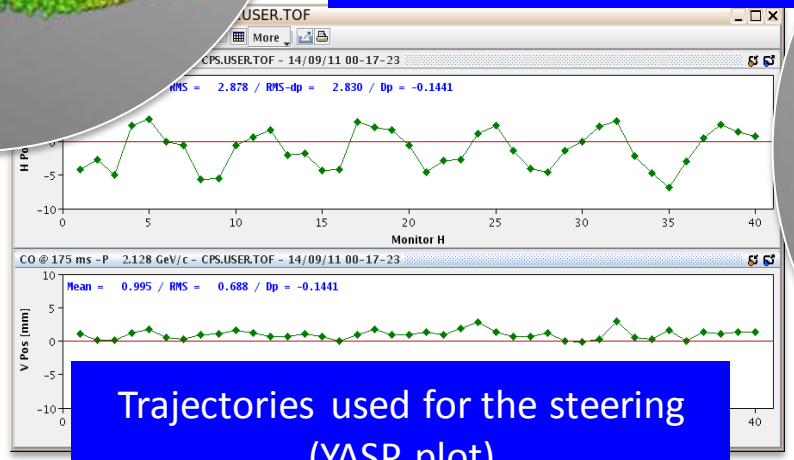
Vital for phase space visualisation and optimisation of critical processes



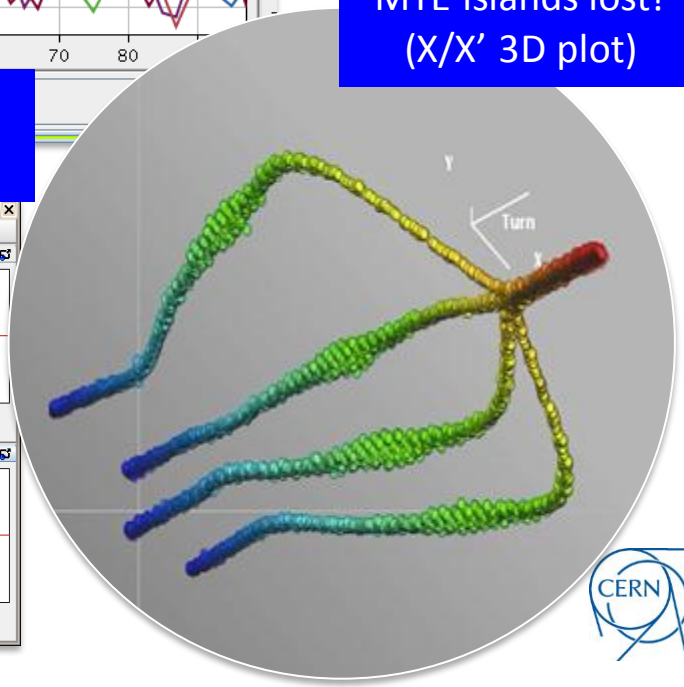
MTE islands
(X/X' 3D plot)



Trajectories at injection
There is a problem…



Trajectories used for the steering
(YASP plot)

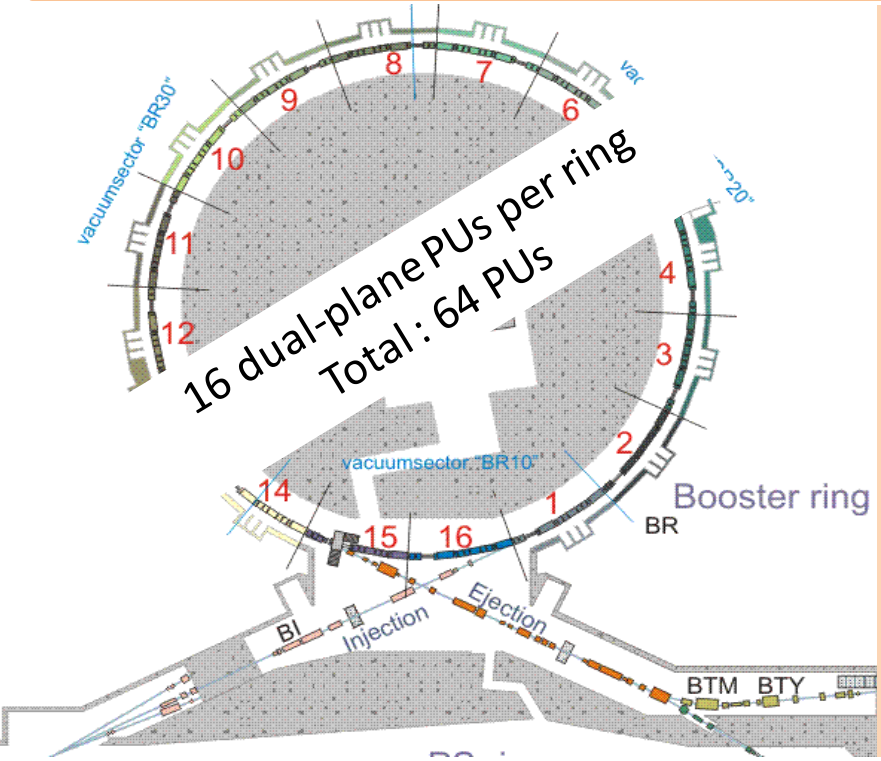


MTE islands lost!
(X/X' 3D plot)

BPM System Upgrades - PSB

Requirements – most coming from connection of LINAC4:

-Bump closure measurement at injection
-Injection steering
-Injection trajectories turn-by-turn over the first ~100-1000 turns
-Resolution / absolute precision : 0.2 mm / 0.3 mm
-Frequency span : 1MHz
-Intensity range 5E9-2E13



STATUS : The present **ORBIT** measurement is obsolete and measures only one ring at a time

BI group proposal :

- Keep monitors
- New Front-end electronics
- New Cables to BOR
- Data processing :
  a) complete trajectories,
  b) orbit,
  c) same as PS, or in-house based on FMC
- Every ring to get own acquisition (no multiplexing)

BPM System Upgrades - SPS

Why the Upgrade?

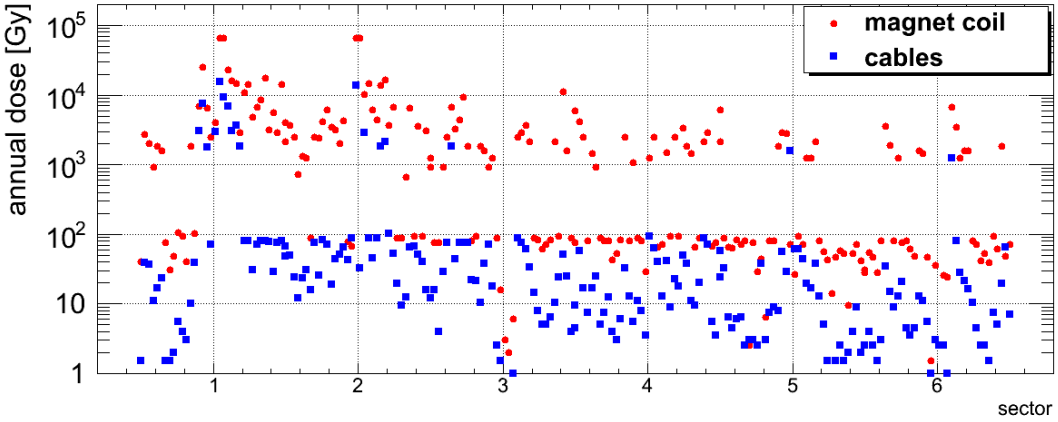
Actual SPS-MOPOS electronic system is:

- Obsolete
- Limited in accuracy
- Noisy for low intensity beams
- Shows filling pattern dependency
- Requires yearly in-situ calibration due to lack of on-line calibration system

Challenges

Elimination of coax cables

- Move to fibre-optics (as for LHC)
- Development of radation tolerant front-end electronics



Logistics

- Installation of fibre-optic network in the SPS tunnel
  - Allows system to be tested in parallel to exisiting system
  - But implies addition of further cabling in an already crowded tunnel

BLM System Upgrade

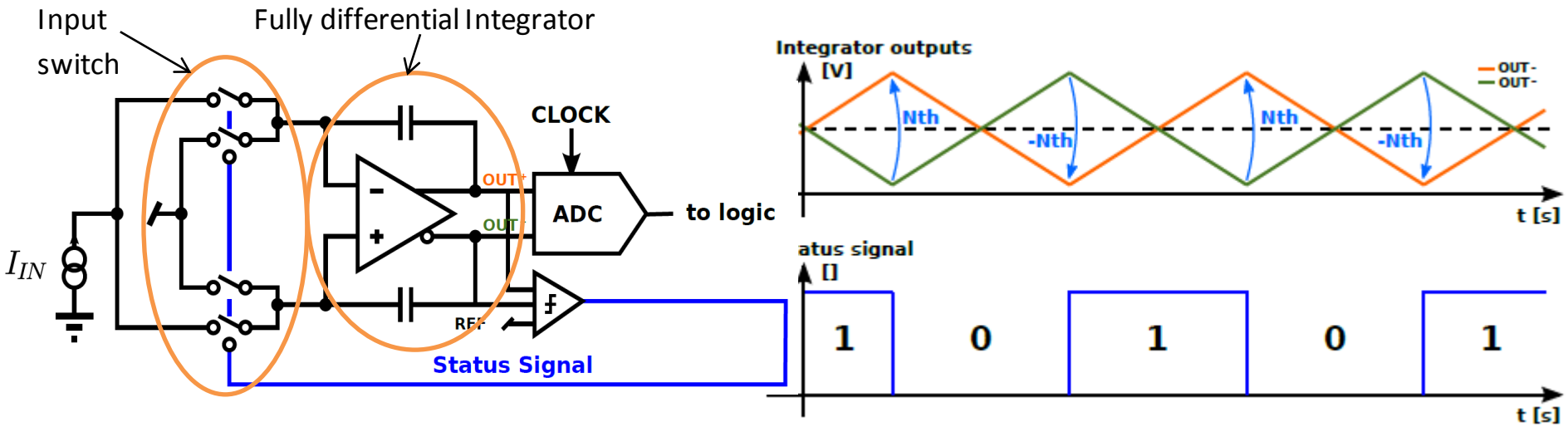
Objective: Replace obsolete system and upgrade performance for LIU

Challenge:

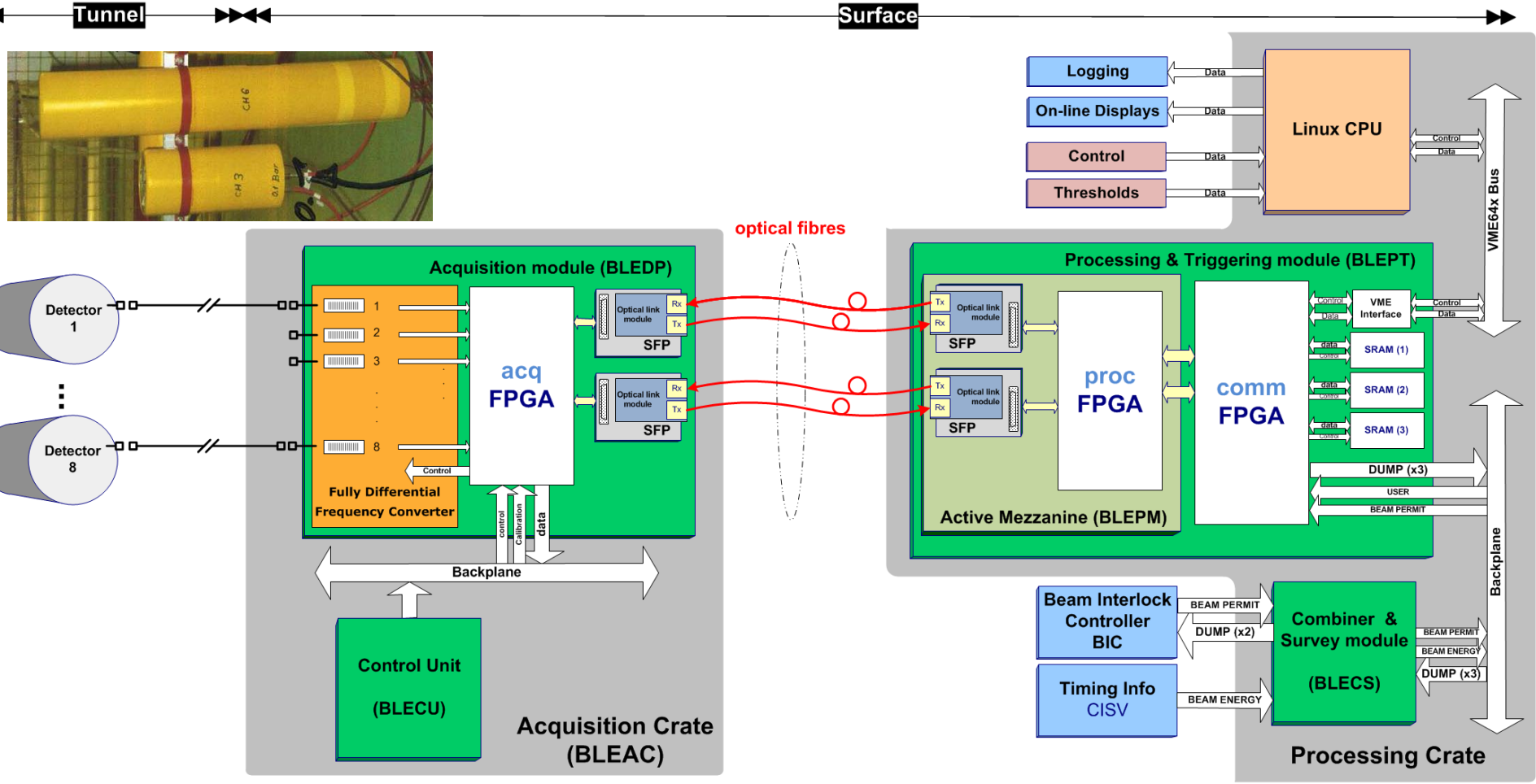
- 7 orders of magnitude dynamic range for 2ms integration window – 1nA to 200mA
- 9 orders of magnitude dynamic range for 1s integration window – 1pA to 200mA

Plan:

- New system based on experience of successful LHC implementation
- Single electronic system capable of taking input from different monitor types
  - LHC type ionisation chambers or smaller version - little ionisation chamber (LIC)
- Develop for LINAC4 & extend to cover whole injector complex
- Add fast detectors (ACEM, Cerenkov or diamond) for bunch resolved measurements



BLM System Upgrade



Schematic Overview of Acquisition System

Summary

The majority of Beam Instrumentation systems in the injectors have, or will, undergo significant upgrades in the coming years

This will be a combination of

Consolidation of old, obsolete or radiation damaged equipment

- Fast BCT electronics standardised all over the PS complex
- New Fast BCT and DCCT in the SPS
- SEM electronics upgraded everywhere
- Renovation of the controls infrastructure

Upgrades linked to enhanced performance required by the LIU project

- A new PSB and SPS orbit and trajectory system
- A new PSB, PS and SPS BLM system
- New WCM in the PS for longitudinal density distribution measurement
- New ionisation profile measurement system in the SPS

In addition there is much R&D to further improve beam instrumentation

- Development of fast, accurate vacuum wire scanners
- Study of feasibility of ionisation profile measurements in the PSB & PS
- ……