# SPS Ionization Profile Monitor - experience from 2012/2013

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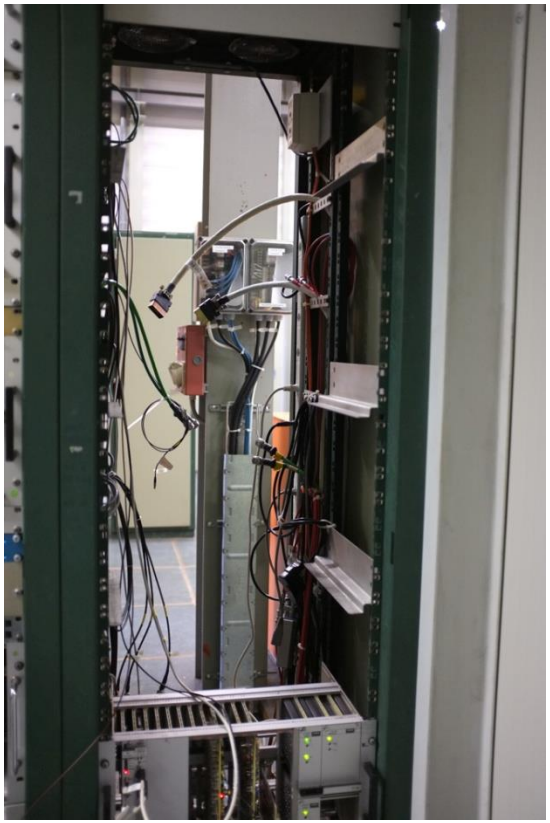
# Outlook

- Looking back – renovation and expectations
- Noise problem
- Measurements on February 12$^{th}$, 2013
- Magnetic field issue
- LS1 activities

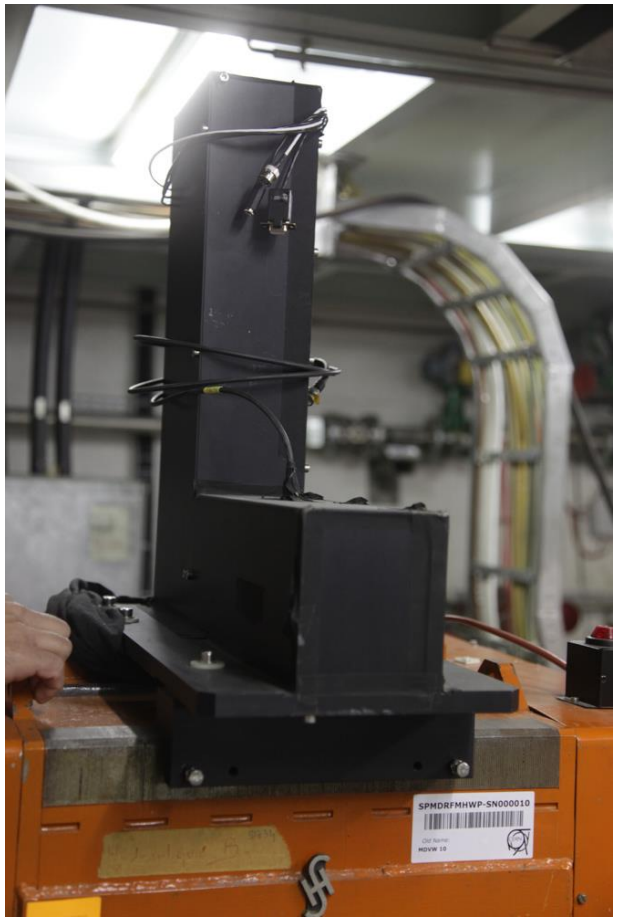
# Renovation

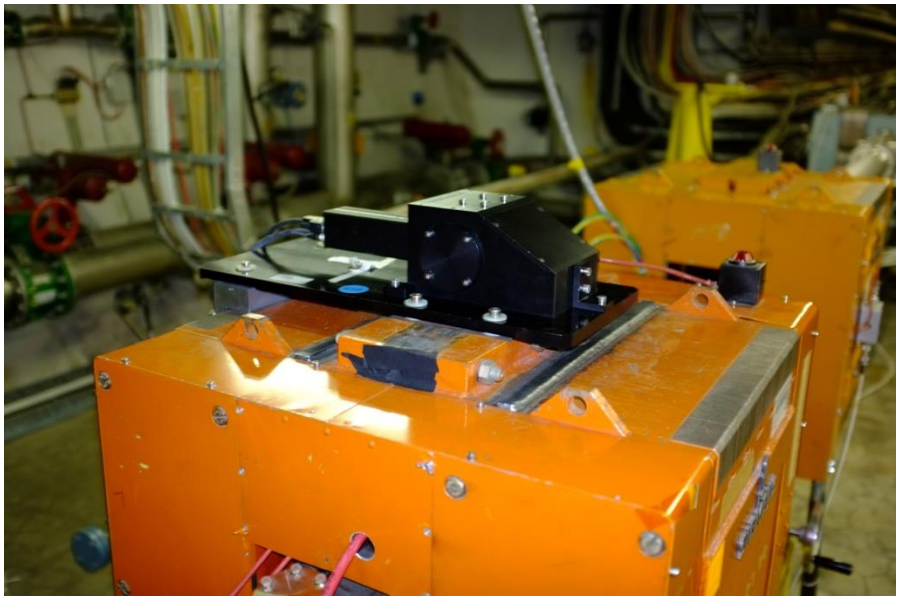
- During winter TS 2011/2012 SPS IPM was renovated:
  - MCPs exchanged (vacuum opened)
  - Electronics (surface and tunnel) exchanged to the same as in LHC
  - Optical systems and cameras exchanged to the same as in LHC
- System ready: end of May 2012,
- it supposed to work as it works on LHC!

# Renovation – surface electronics



# Renovation – optical systems and cameras



# Last time I spoke about it…

MSWG, September 14th, 2012:

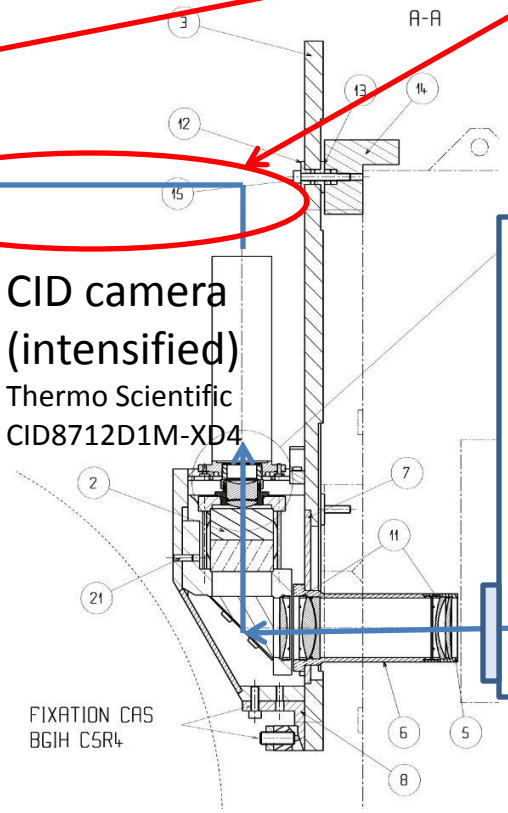
- *initially signals observed (in analog channel), but then disappeared*
- *suspected: camera communication problem (as in LHC)*
- *also one camera intensifier broken*
- *hope to solve during TS3*
- *during TS3: faulty vertical corrector magnet exchange*
- *logging to DB will be done once system functional*

# Signal distortion

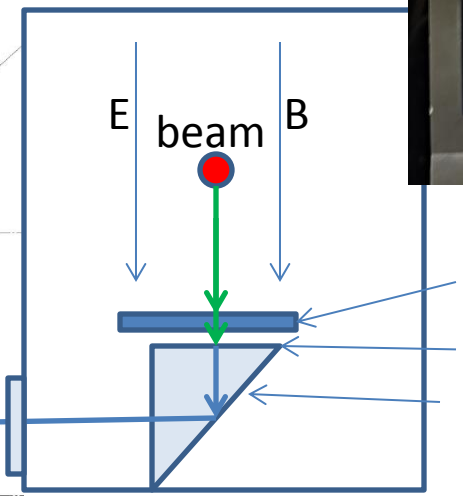
Frame grabber

SPS: picking up a huge noise on video signal correlated with beam type/intensity

~180 m




CID camera (intensified)
Thermo Scientific
CID8712D1M-XD4





2012.10.02

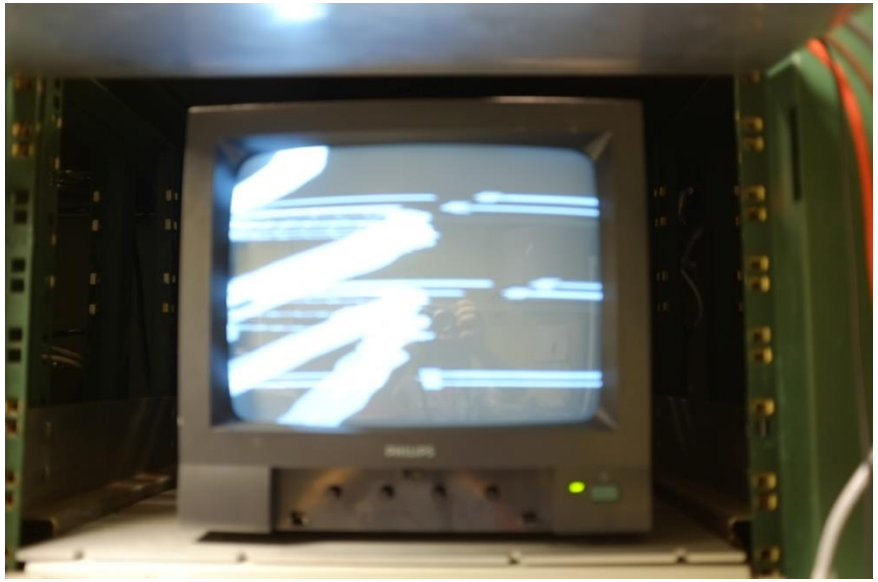
MCP
Phosphor
Prism

Video amplifier

Optical system

View port

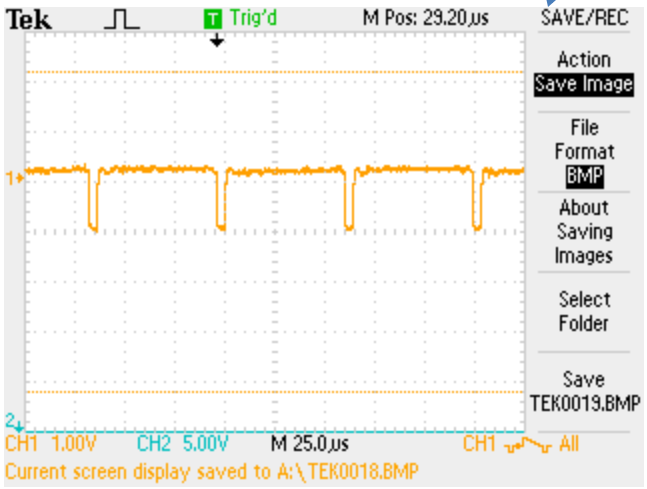
# Signal distortion

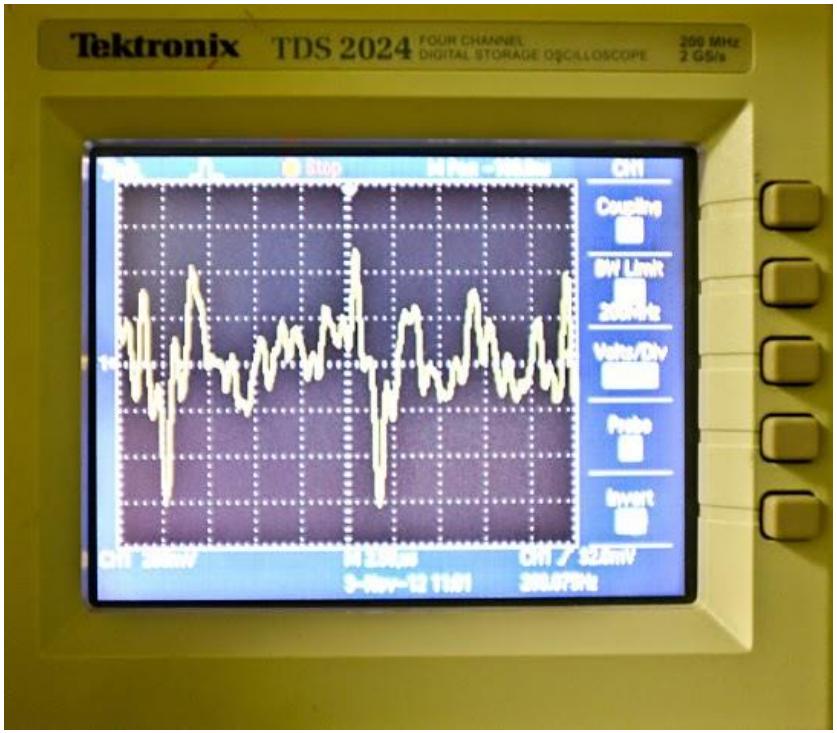


Noise seemed to be linked to beam presence and maybe intensity, not to the magnetic cycle…

# Signal distortion

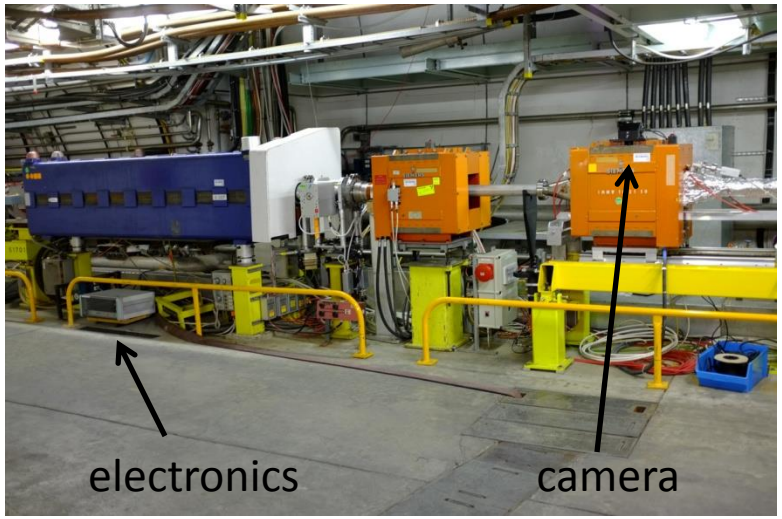
- Signal with beam
- Signal in the lab

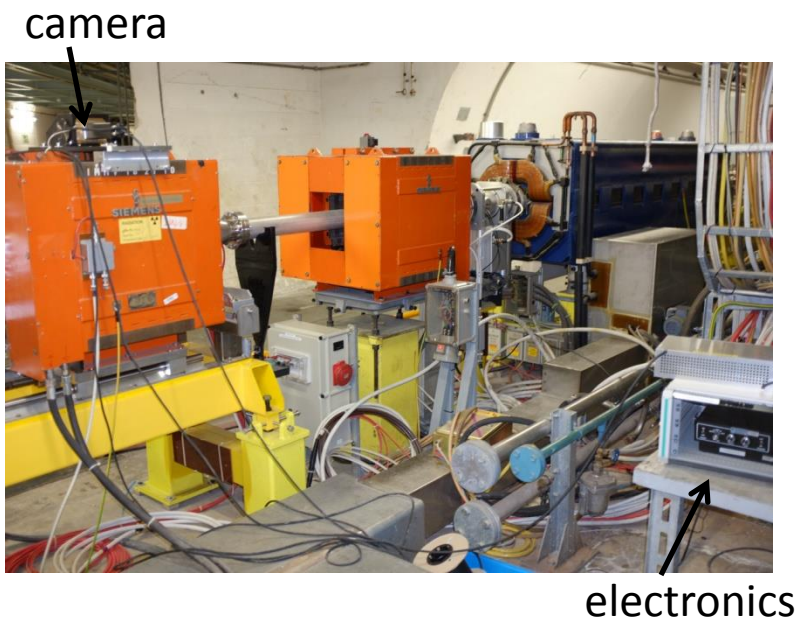


# Signal distortion - remedy

- Cable shielding, moving electronics away from the beam and exchange of video signal amplifier



# Measurements on February 12th

- Only vertical IPM was working
- Signal seen before on LHCION, idea was to explore it
- **SFTMD and LHC2 also measured!**
- 40 scans with scanner 416V
- IPM was very stable, but not calibrated so the analysis is not tuned: no filtering on video, no tilt correction, etc.
- no camera gain control
- WS data: LoggingDB, IPM data: root files on VM
- Synchro WS-IPM: ±5s (my guess)

# Optics functions

**Q20:**

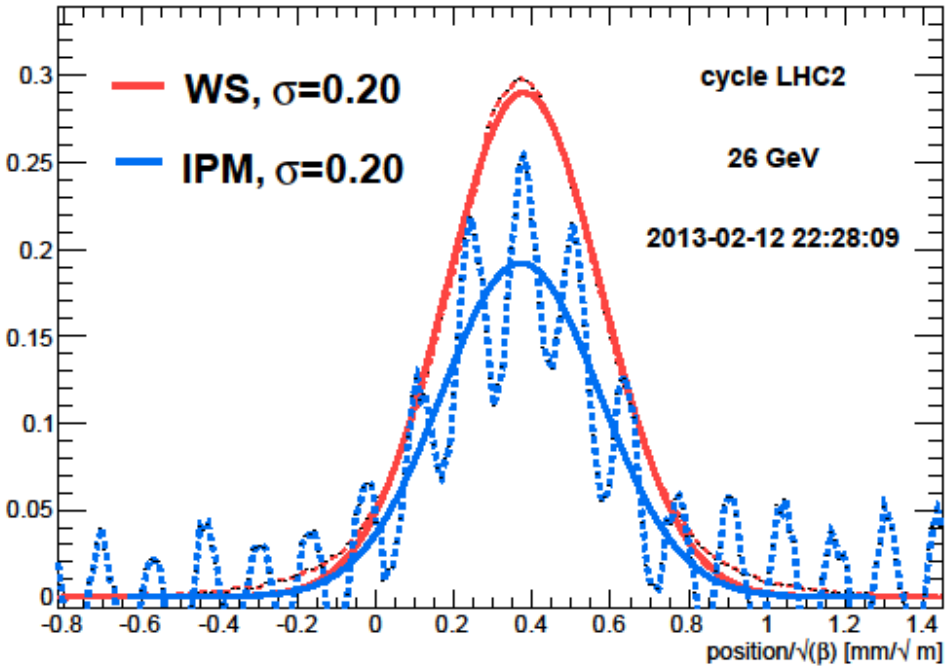
| | WS 416 | IPM |
|---|---|---|
| $\beta_V$ | **71 m** | **517(V): 91 m** |
| $\beta_H$ | 49 m | 516(H): 88 m |

**FT:**

| | WS 416 | IPM |
|---|---|---|
| $\beta_V$ | **64.7 m** | **517(V): 90.3 m** |
| $\beta_H$ | 36.5 m | 516(H): 24.0 m |

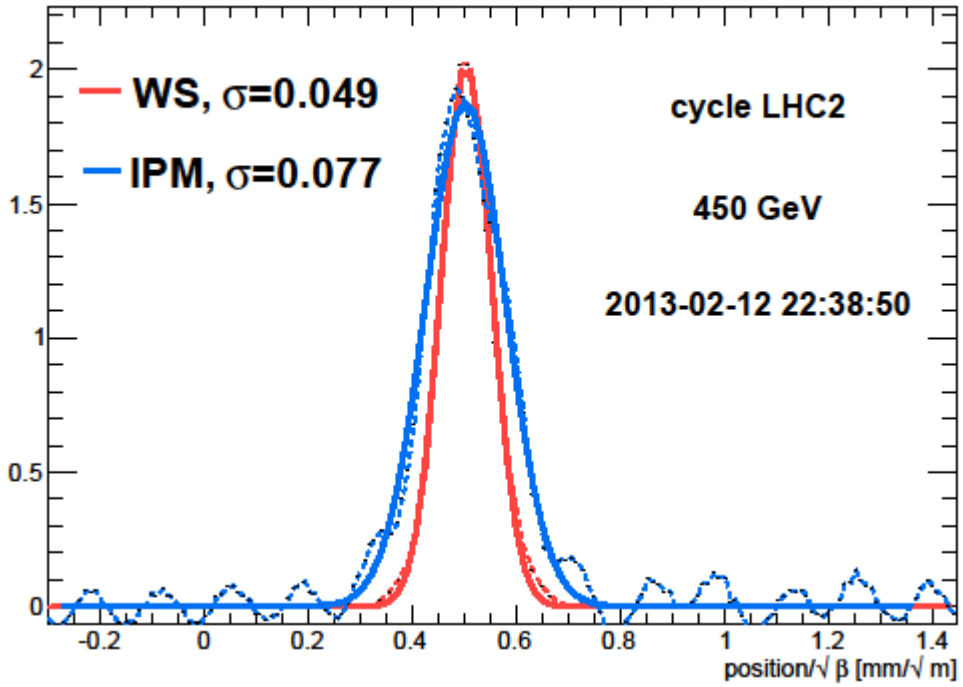
+ BGI calibration: 0.1 mm/pixel

# LHC2 at 26 GeV




WS: scan IN
Emittance (WS) = 1.05 µm
Beam size in IPM = 1.93 mm

# LHC2 at 450 GeV

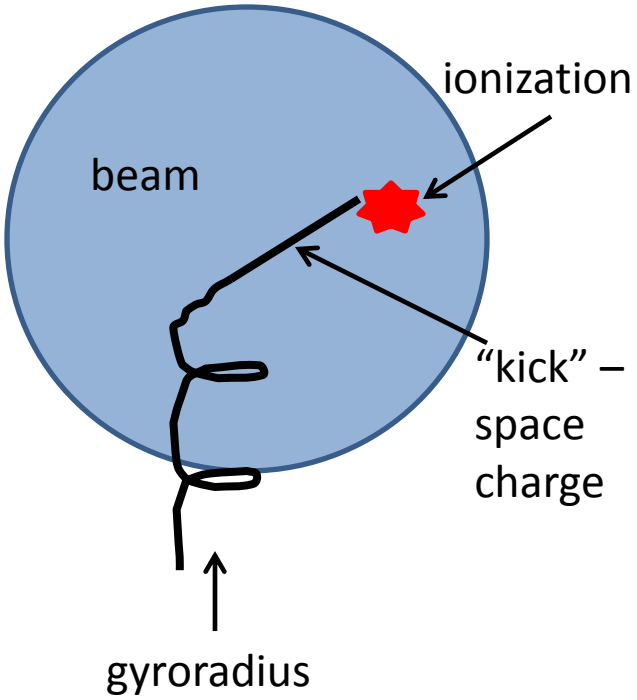



WS: scan IN
Emittance (WS) = 1.13 µm
Beam size in IPM: 0.46 mm

<u>Disagreement because:</u>

- lack proper calibration, camera gain control, etc
- BUT there might be also contribution from beam space charge and too weak magnetic field…

# Magnetic field issue




- Electron movement in presence of beam field is complex!
- Electron velocities and space charge distorts the profile **– visible for small beams**!
- increase of magnetic field cures both effects

  **(0.2T→ 1T)**
- simulations – Marcin Patecki (ongoing):

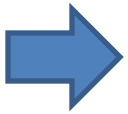
  Proceedings of IPAC13, MOPWA034
- analytical estimations Giuliano Franchetti (GSI)
- Pierre Thonet – stronger magnets

# Magnetic field issue

<u>For which beam we need to increase magnetic field?</u>

From LHC simulations- no significant effect for:

- 450 GeV beam
- β=200 m
- ε=1.5 μm



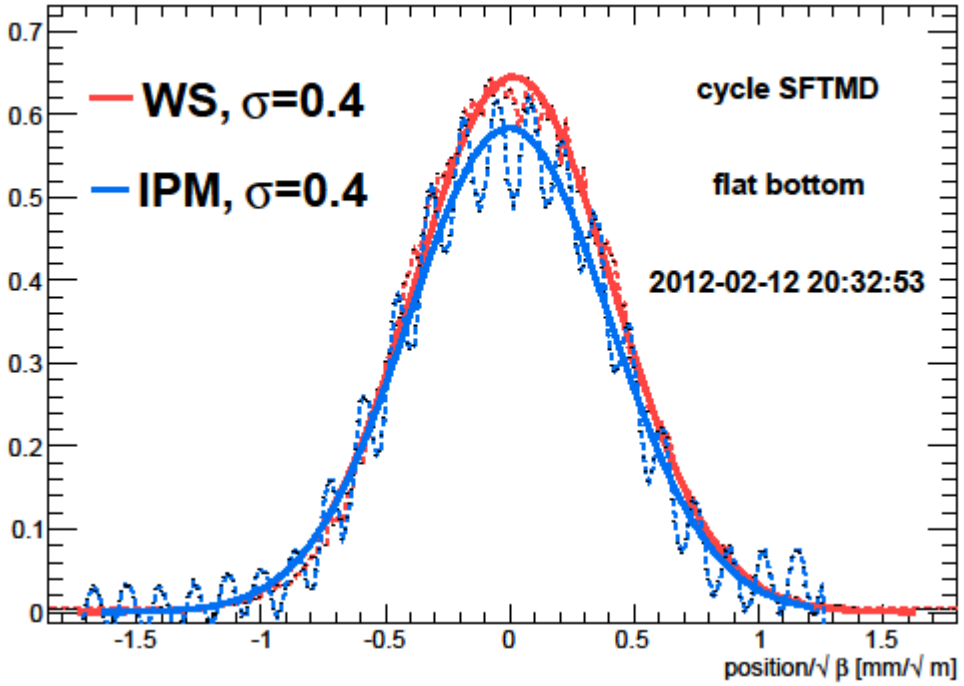
In SPS:

- β = 90 m
- therefore **ε = 3.3 μm**

<u>But:</u>

- to be checked by simulations
- SPS is pulsing machine so it is easier to develop a correction procedure
- overlap of operational intensities with wire scanner

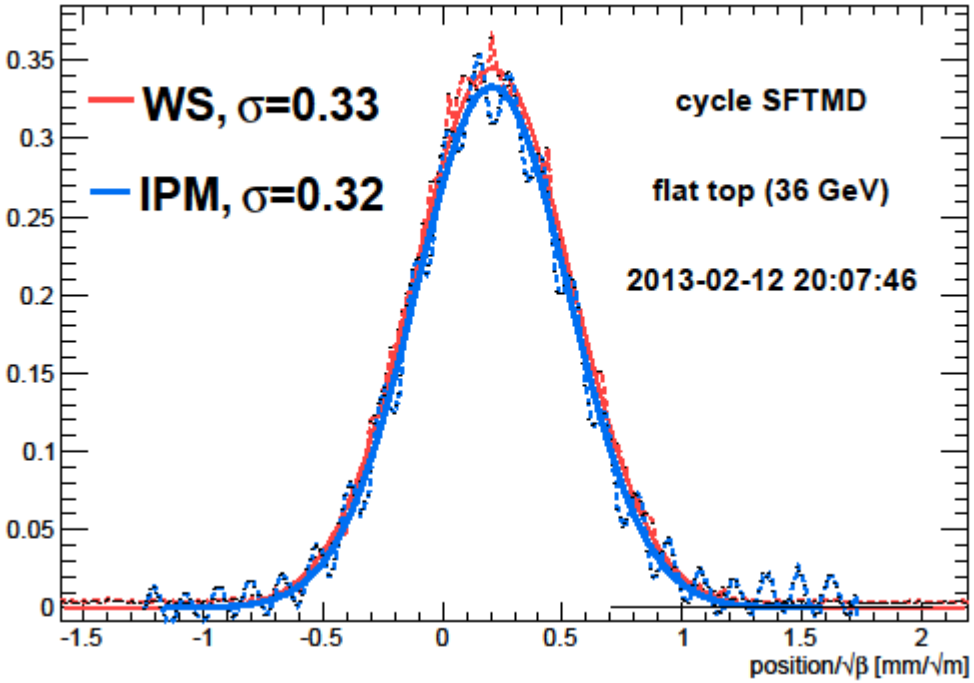
# SFTMD at injection




WS: scan IN

Good agreement!

# SFTMD at extraction




WS: scan IN

Good agreement!

# LS1 improvements

1. **Construction of new detectors, exactly the same as in LHC**
   - Ceramic electrodes
   - Modern design
2. Exchange of cables (short ones), tunnel cable shielding, testing, camera communication
3. **Change from current 2-corrector scheme to single corrector one**:
   - Tested with beam in February
   - Powering scenario which assures cycling mode proposed by Gilles Le Godec

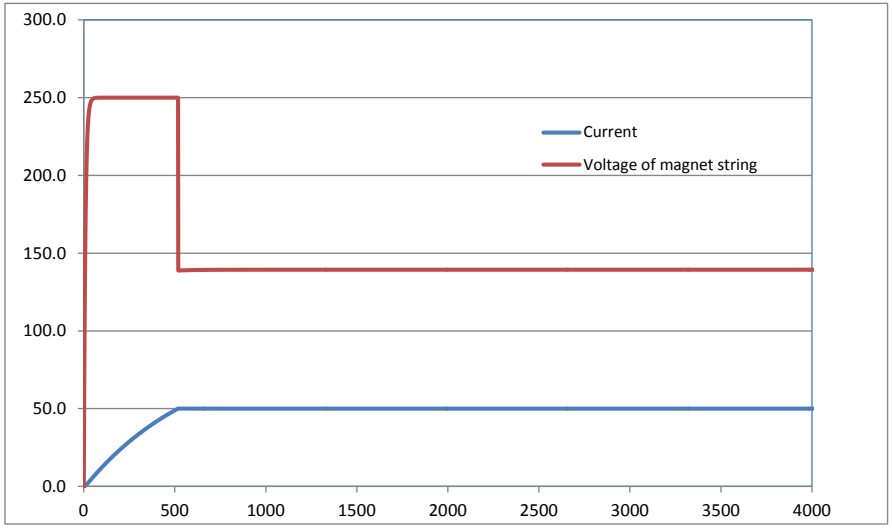
safe operation

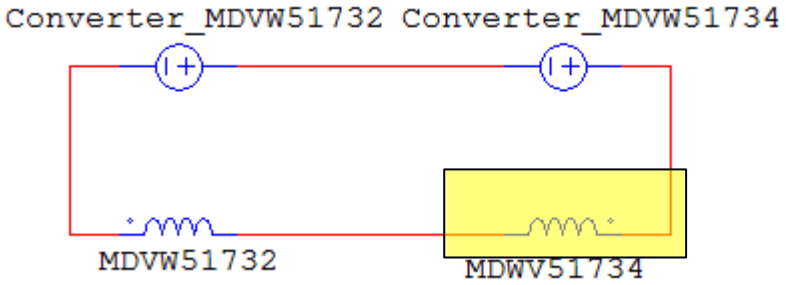
4. Studies ongoing to understand MCP issues
5. Synchronization with machine (bunch-by-bunch)

# Proposed Hardware configuration

**Scenario #5**

- Two existing converters rated 125V/125A in a serial configuration (Master/slave) with two magnets in series,
  - Current reference = variable di/dt (max voltage is used, no control of the current during ramp up),
  - Max requested current = 50A,
  - Total Load (magnet + cables) resistance @45°C = 2.79Ω,




➔ **Rise time = 0.517 second**

**This configuration is relevant**

# Conclusions (I)

1. SPS IMP renovated during 2011-2012 winter TS and spring months
2. Long fight with noise problem – stable operation in February 2013
3. IPM in SPS will be operational after LS1
4. (Because of MCP ageing it is not “switch on and forget” device)
5. Data from February analyzed – most challenging LHC beam (ε=1 μm)
    - Obviously not a very good data, calibrations/synchronization missing
6. For this beam there might be an issue from too weak magnetic field

   (but OK for other beams and also we can probably correct for it)
7. Improvements foreseen during LS1:
    - Reconfiguration of magnets and powering system

# Conclusions (II)

1. PS IPM will NOT be installed during LS1
2. We are investigating this and electron scanner
3. It seems that there is a solution for magnetic field (Dominique Bodart)
4. Radiation is an issue, we would like to go to non-optical readout system
5. We think we could install a device before LS2

# Acknowledgements

Many people help/contribute to this project:

Ana Guerrero, Karel Cornelis, Joel Adam,

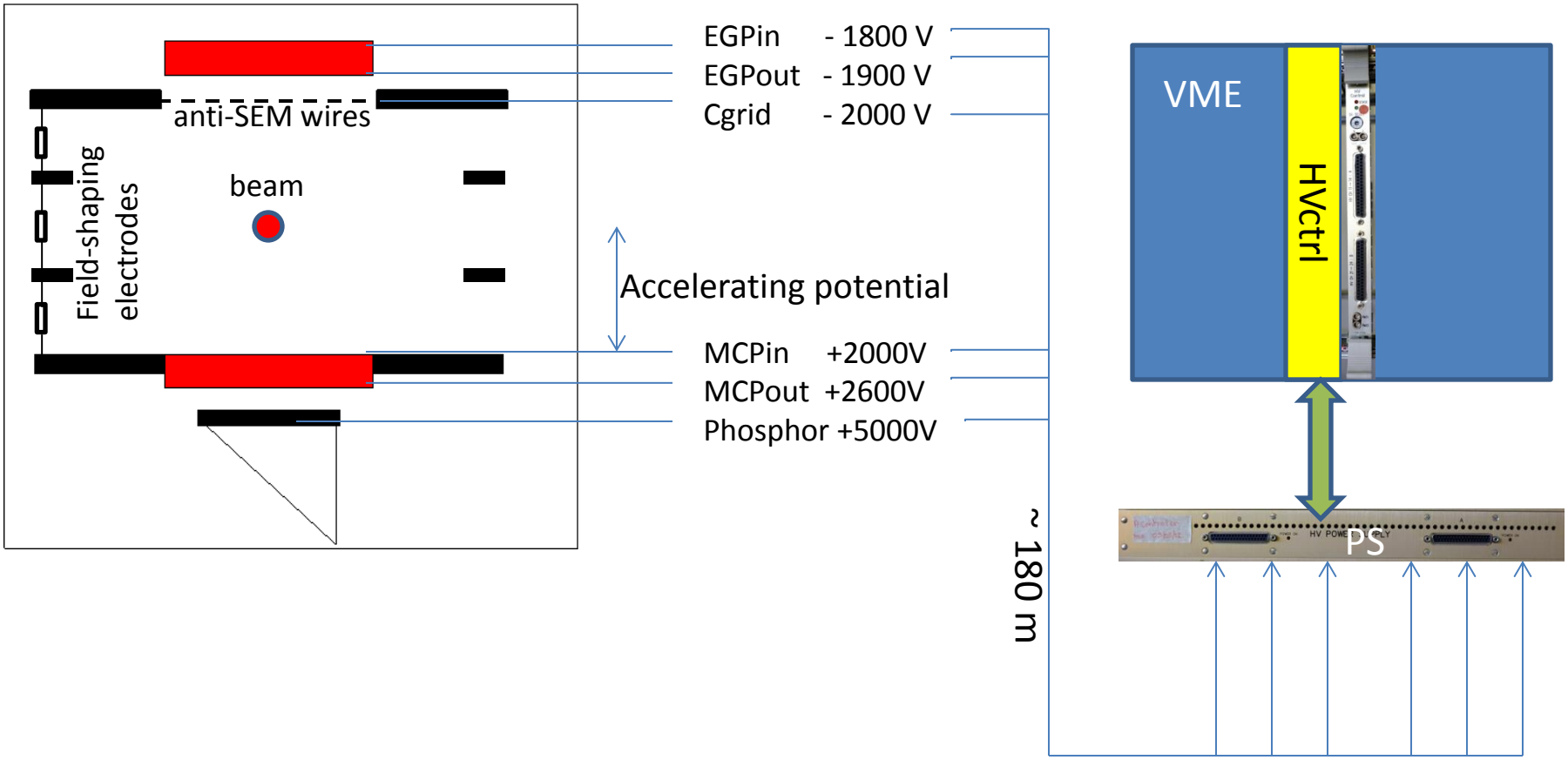
Stephane Burger, Jeremie Bauche, Gilles Le Godec,

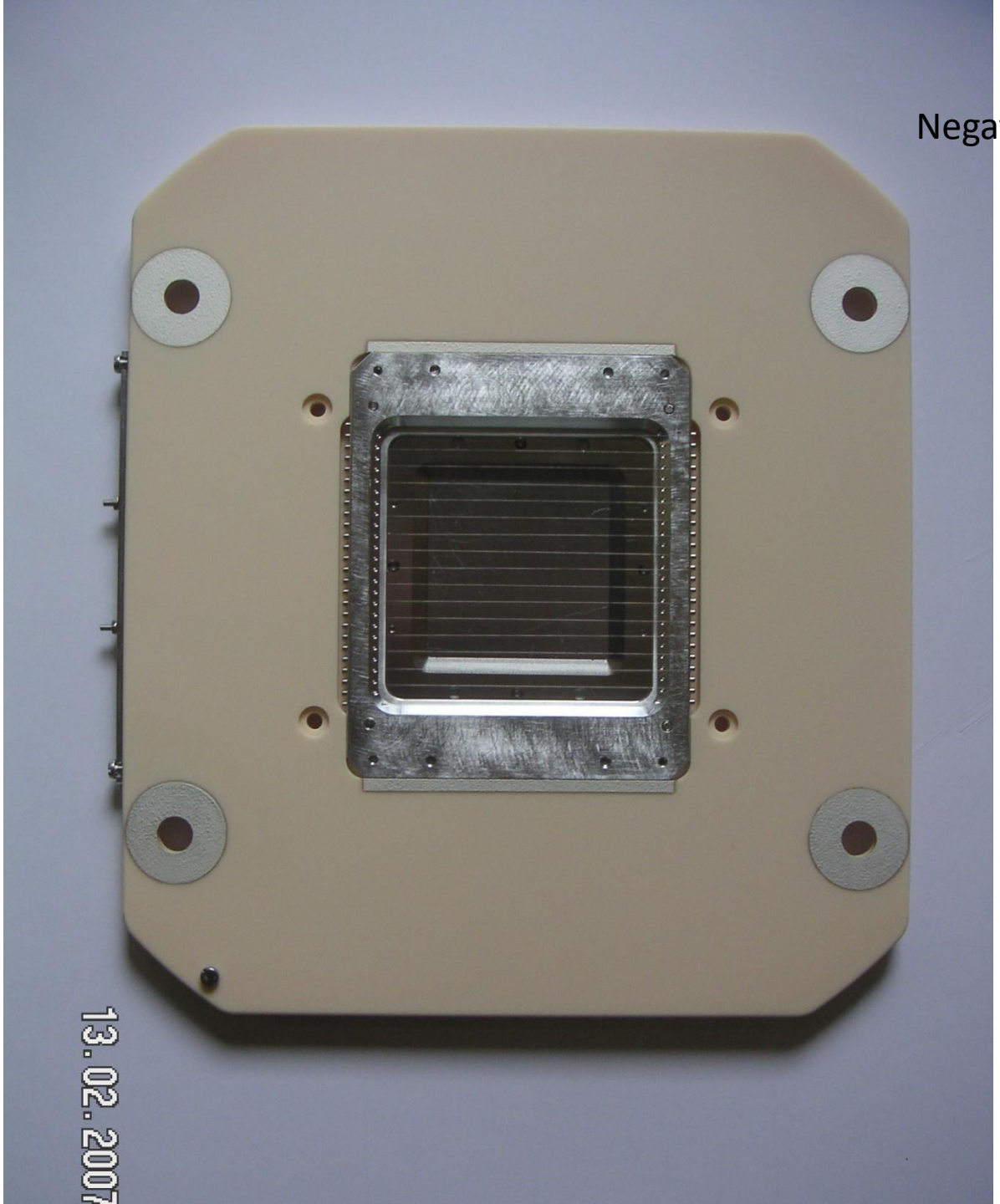
Marcin Patecki, Pierre Thonet, Giovanni Iadarola

# Movie (SFTMD and LHC2)


# SPARE SLIDES

# System: HV cage + PS + control

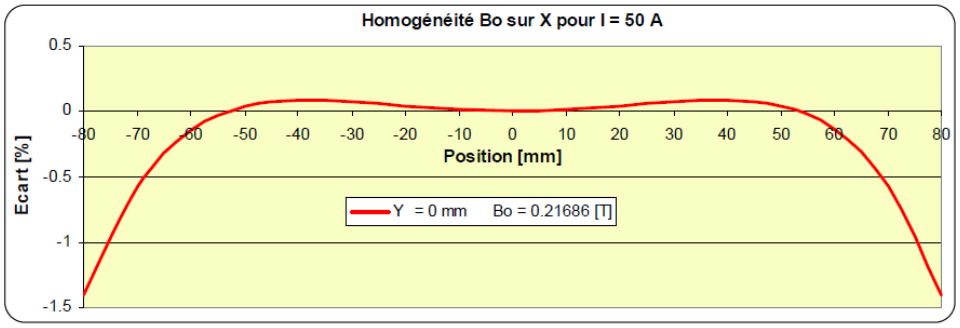




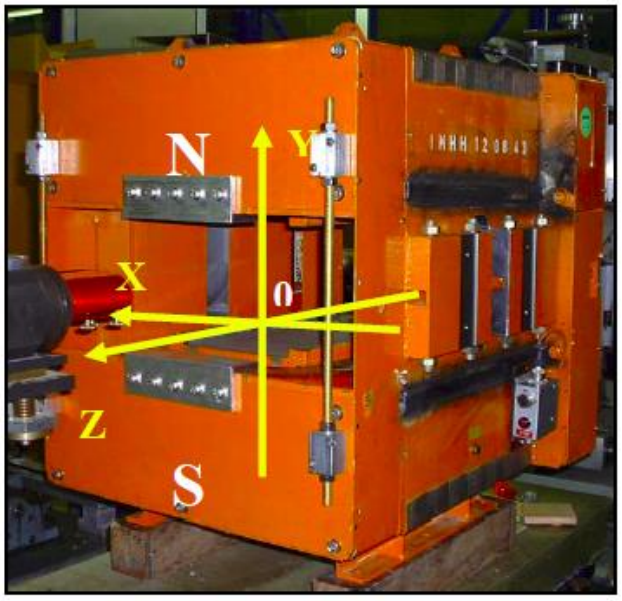

Negative electrode

# System: magnetic field

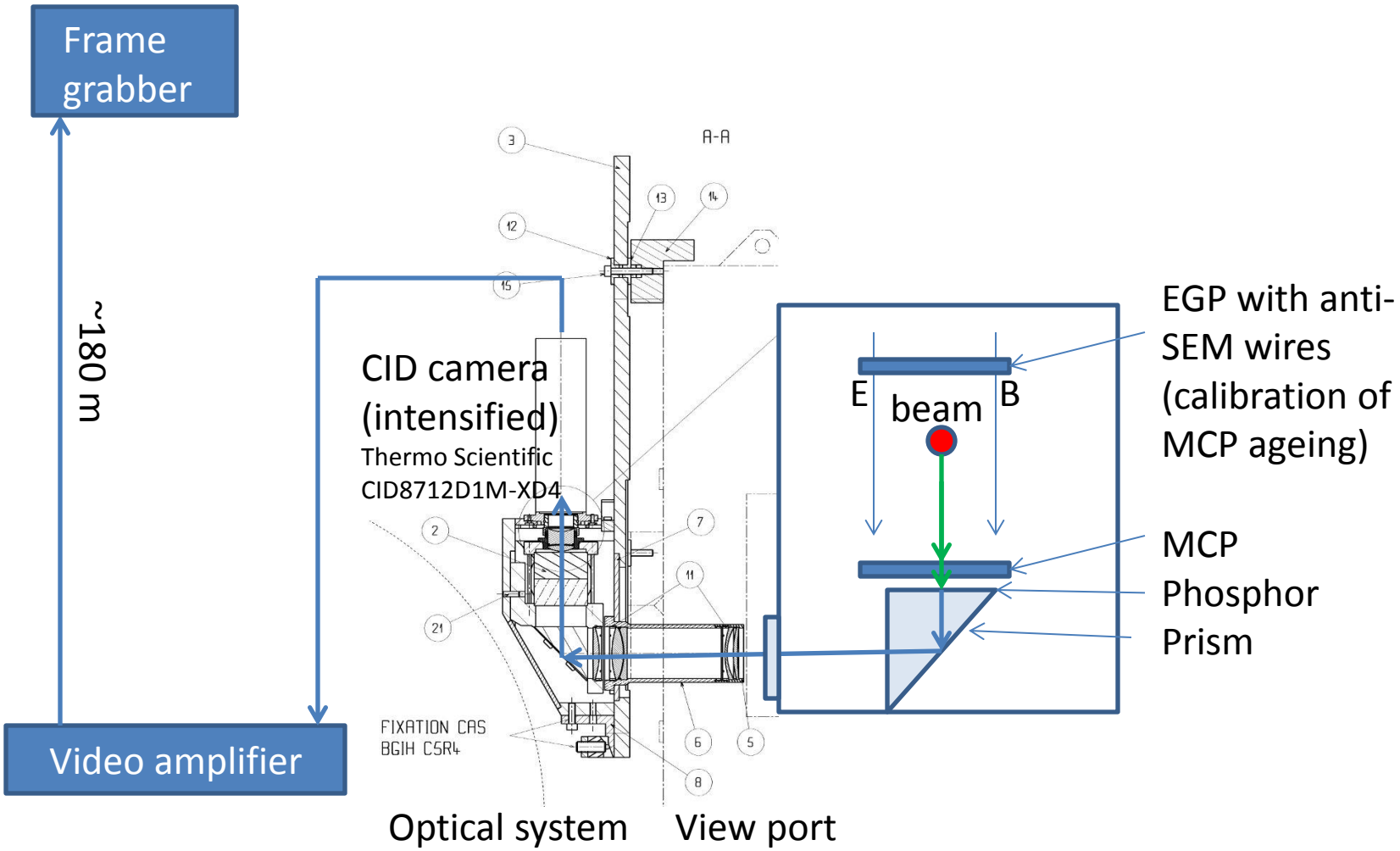
- Magnetic field needed to keep minimize beam space charge effect
- 0.2 T magnets originally from ISR, yoke modified to extract light
- Need to exchange  power converters on SPS magnets  to allow cycling.
- magnets are compensated (ie. 2 magnets/detector/plane in the same circuit)
- length 43 cm
- 20 cm space between poles
- Field quality:




Aimant type IMHH



# System: imaging



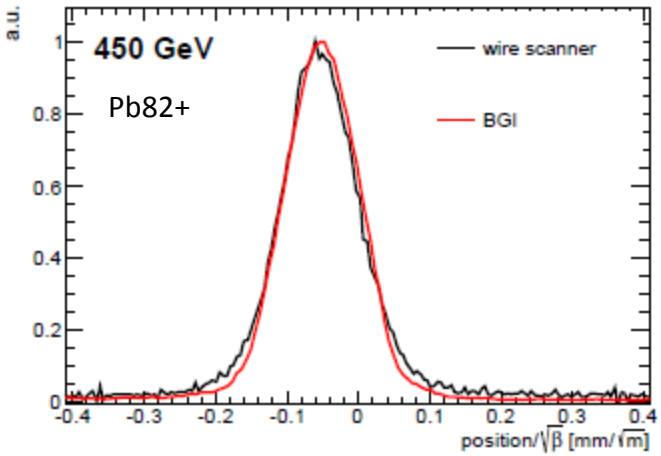
# Hardware failures (other than already mentioned)

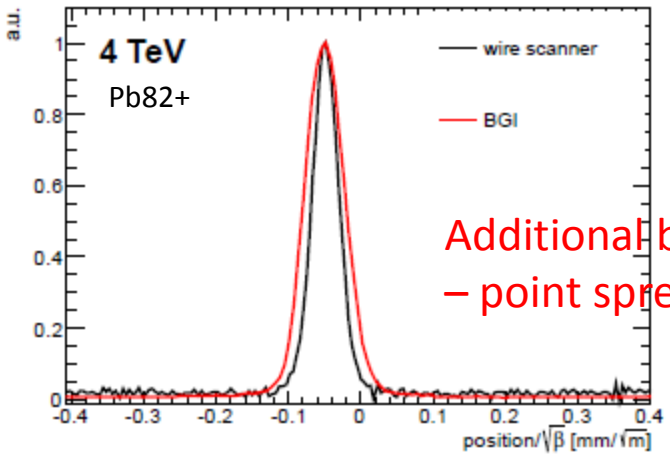
- HV ctrl card – problem with compatibility with VME (linux CPU)
- 5 CID cameras stopped working, in most cases we suspect that intensifier reached MTTF (tbc by ThermoFischer).
- failures of MCPs
  - "conditioning effect" for MCPs
  - too high input electron current might kill MCP
  - abrupt HV change might kill MCP (and dump the beam!)

Killed MCP: creation a conducting channel through the plate: cannot set HV anymore, cannot amplify the signal.

# Cross-calibration (WS, BSRT)

- Because of old MCPs BGI sensitivity starts where WS cannot measure
- But for ions there was an overlap
- BSRT uses cross-calibration with WS, so calibration with BSRT is of "second order".




Additional broadening in BGI – point spread function?

| B2V [m] | WS | BGI |
|---|---|---|
| injection | 418.95 | 217.19 |
| flat top | 451.04 | 225.35 |