Cold Linac NPM status

Forum diags ESS at Lund

November 20th 2018

CEA Saclay: P. Abbon, F. Belloni, F. Benedetti, G. Coulloux, C. Lahonde-Hamdoun, P. Le Bourlout, P. Legou, Y. Mariette, J. Marroncle, J.P. Mols, V. Nadot, L. Scola

ESS Lund: C. Thomas (NPM Project Leader)

IPHI team for her collaborative spirit

Outline

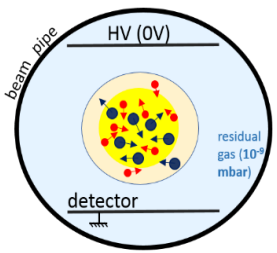
What since last diagnostics forum?

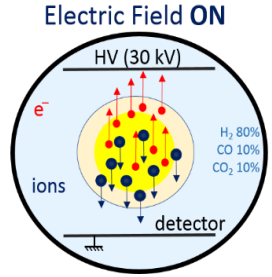
- First beam test at IPHI
- Working meeting at ESS
- Second beam test at IPHI

Analysis in progress for CDR

Toward CDR

Planning





NPM: Non invasive Profile Monitor

IPM: Ionization Profile Monitor

First Beam test at IPHI

Feb. 13th to April 12th 2018

IPHI: (Injecteur de Protons à Haute Intensité or Proton Injector at High Intensity)

Proton beam accelerator at CEA Saclay

- 3 MeV - I_p<100 mA – up to cw
- RF = 352 MHz
- Injector: 95 keV

Life is a long, but a quiet river…

Delays

Component deliveries with important delays

- Most of then were postponed by few weeks, even months wrt the delivery date
  the worst: last MCP received on January 4th 2018 (ordered on 29/6/17)

Vacuum: Problem with a leakage vacuum detector

Etc.

➔ No time to test MCPs in laboratory, just an overlook on CCD cameras, HVs, Faster (strips)…

Installation on IPHI (Feb. 13th 2018)

Kind of IPHI commissioning: working for the first time with an inner diagnostics. Starting data taking completely blind, but a FC, 2 ACCTs upstream and downstream the RFQ and BPMs not connected

- Problem with HVs (sparking)
- impossibility to work with Photonis pMCP, we gave up in mid March, send it back to Photonis and recovered it July 11th 2018 → finally no beam test with a 2nd pMCP!

DAQ, FEE & CS

Caramel and Syroco: delivered at Saclay by LPC Caen (end 8/17)

Adaptation card for signal read-out

Cameras

- NPM (2): Epics development
- FPM (1): brought by Cyrille Thomas
- Scintillating screen: Iphi

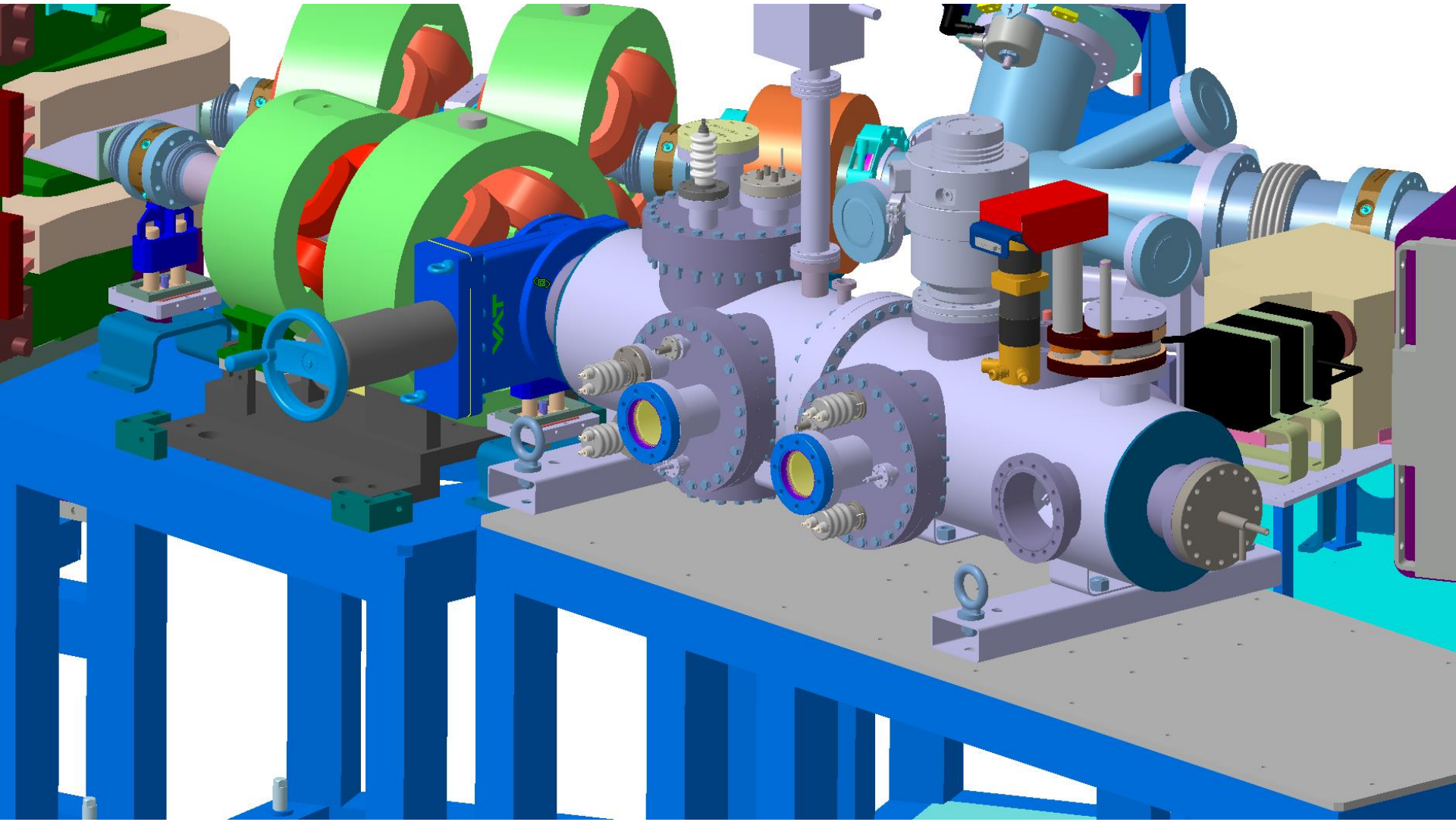
ISEG HVs: ±6, -15/+15 and -30/+30 kV delivered

- potentiometer for MCP gain
- Connection boxes for vHV

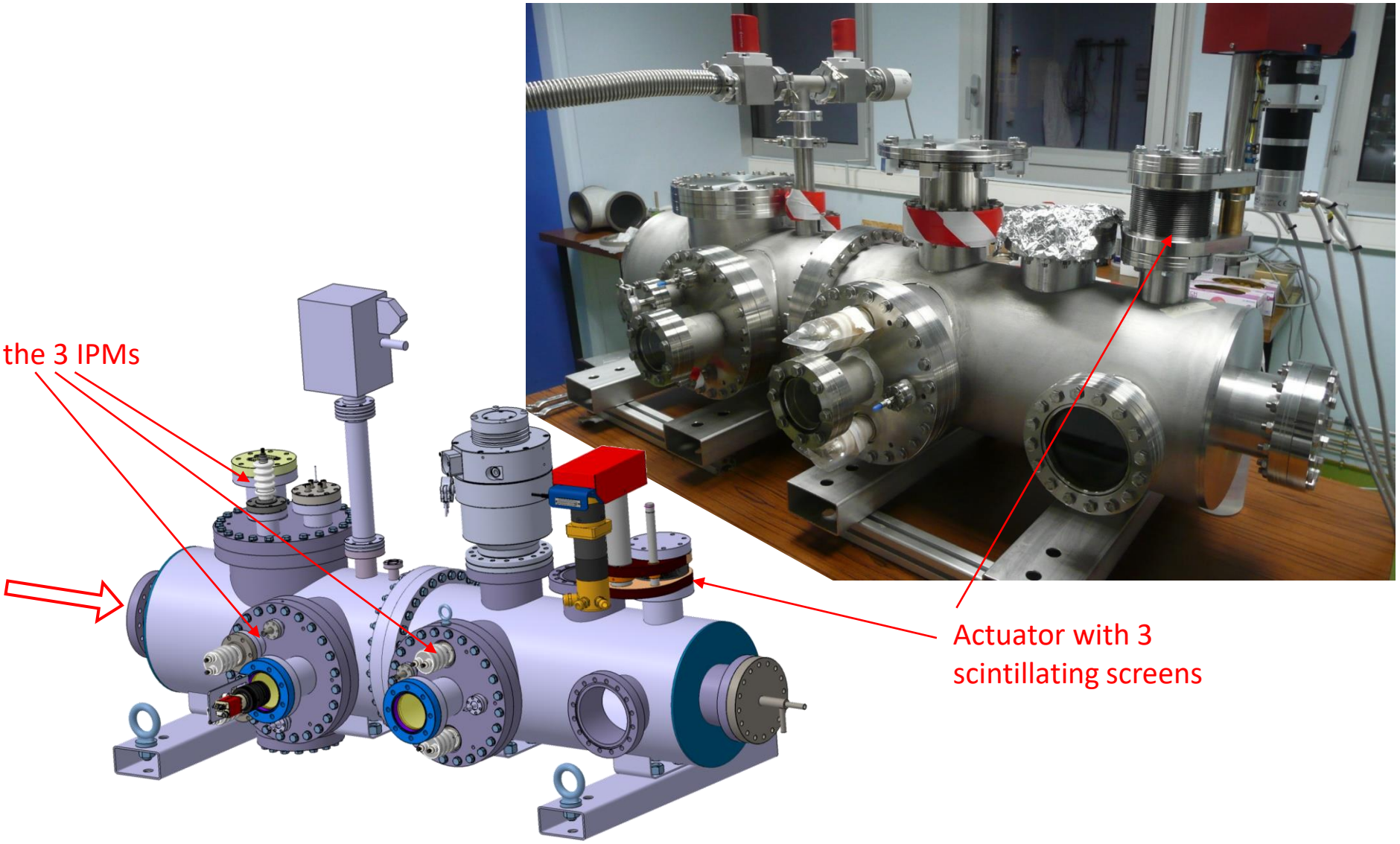
Motor for moving scintillating screen: GeoBrick is installed and checked.

On deviated line

Profile measurement on Y direction for avoiding dispersive plane!



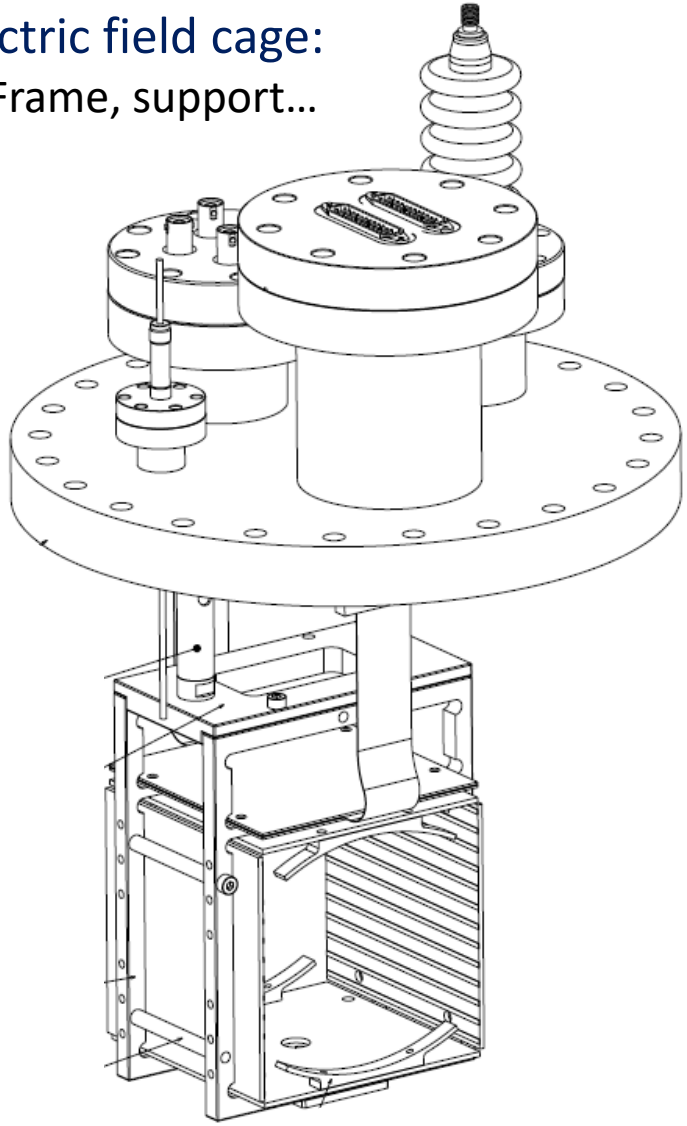
Design/test bench

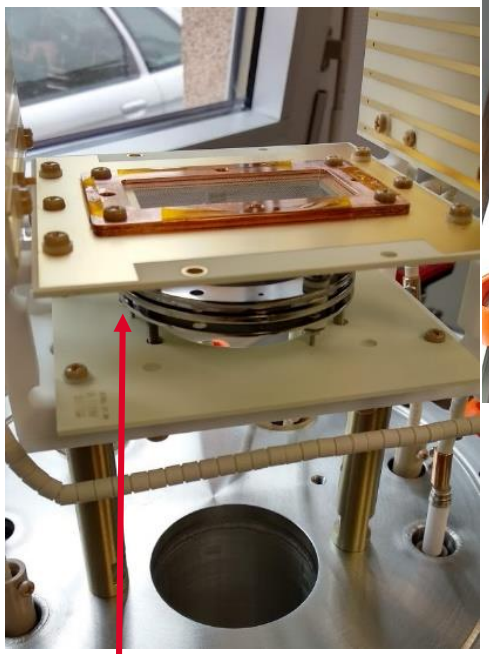


IPM

Electric field cage:

Frame, support…

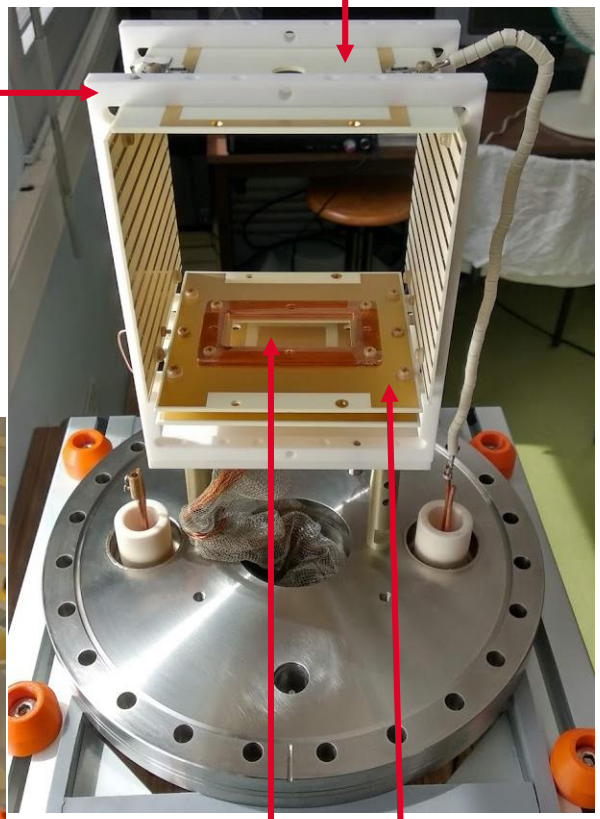




MCP

cathode

Macor©
frame

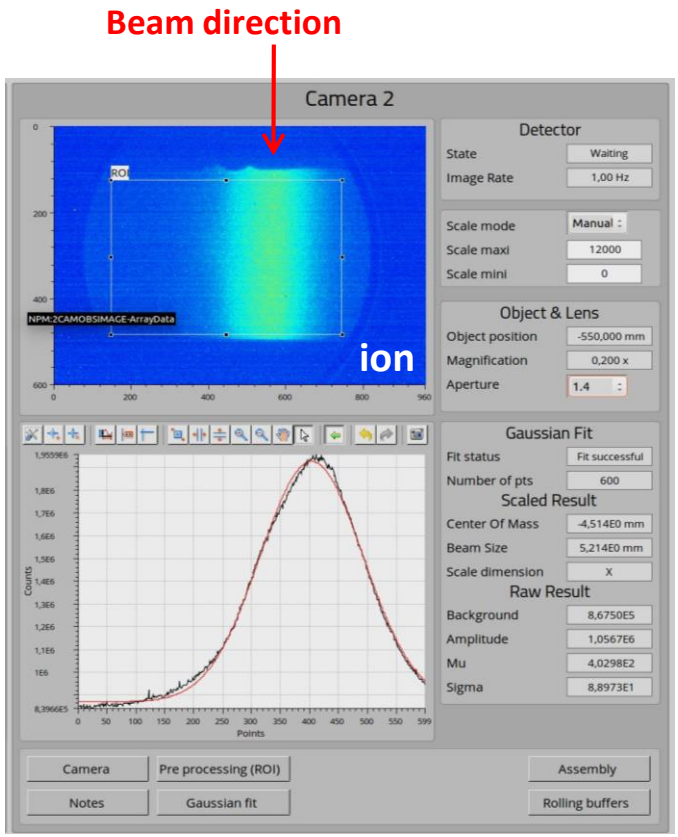


strips

anode

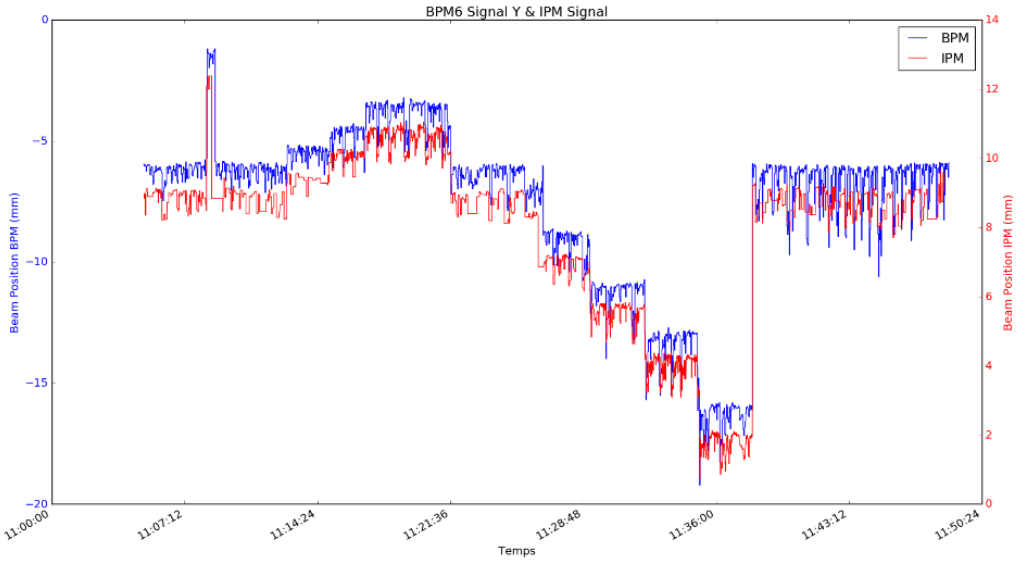
1st beam!

Finally, beam appears on March 1st 2018!



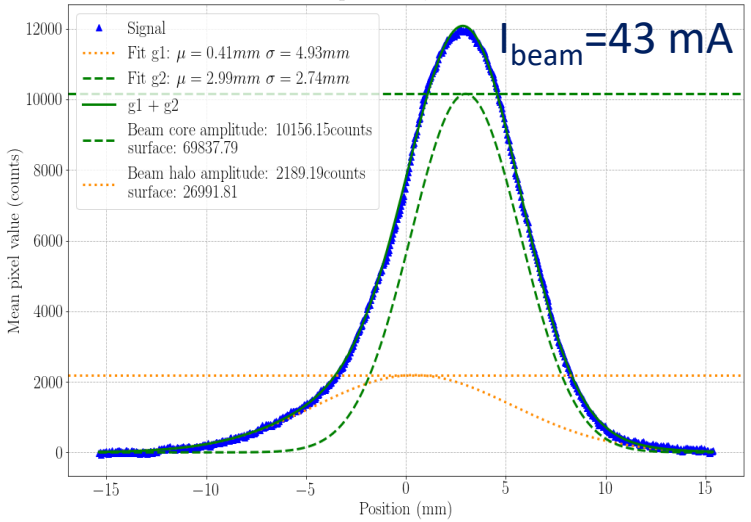
but… it appears clearly that beam was moving top/bottom by few mm, and comes back regularly (several seconds)…
…like electric charging / discharging materials!

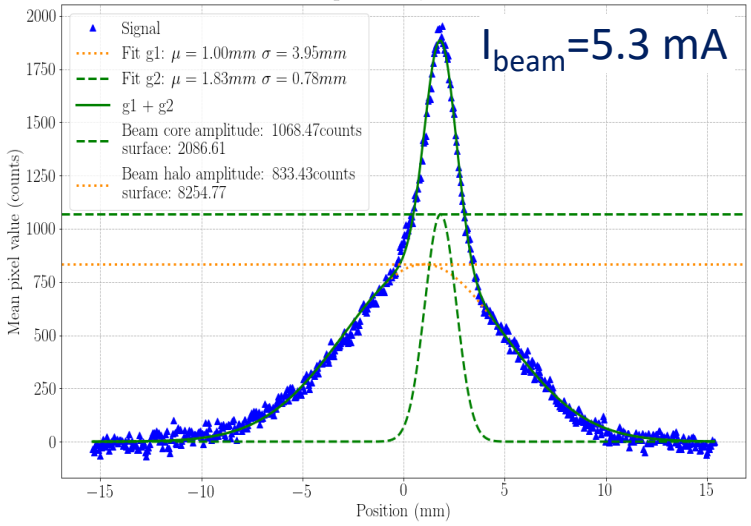
1 or 2 weeks later, BPMs were connected →

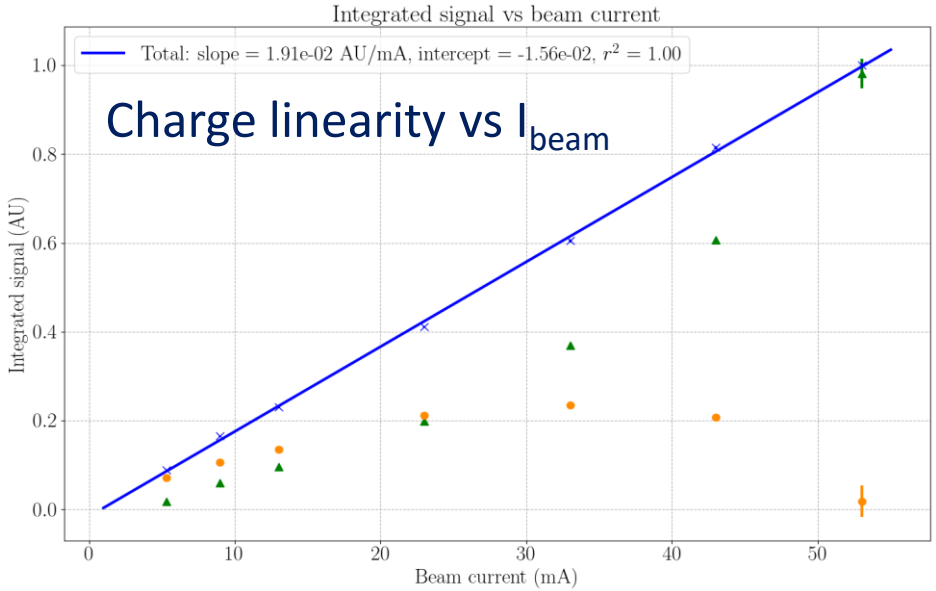


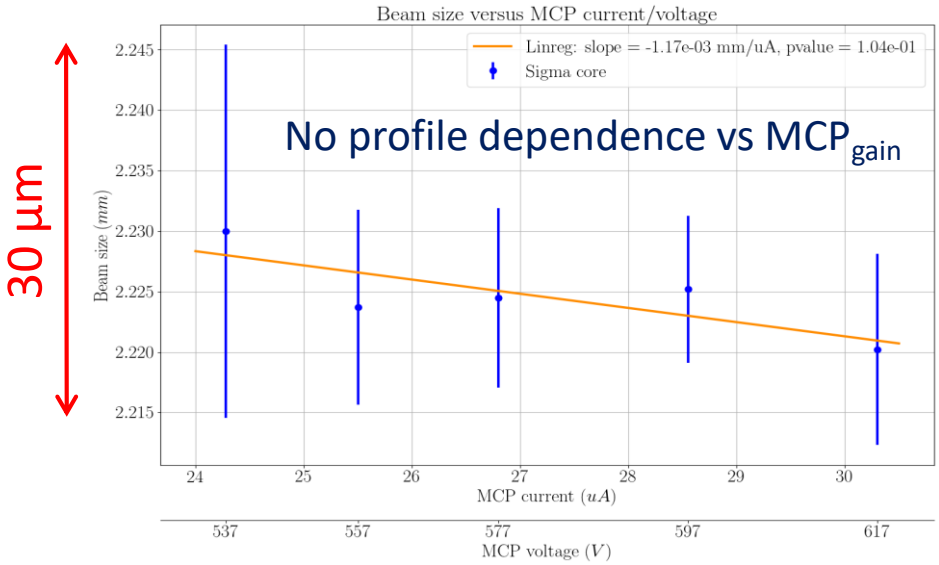
pMCP (Hamamatsu) + CCD

Double Gaussian fit







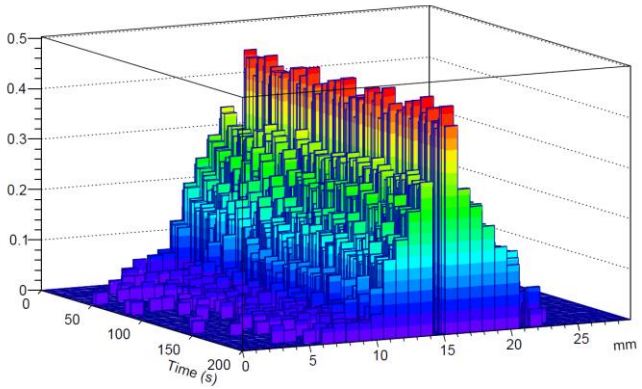


MCP and constant strips

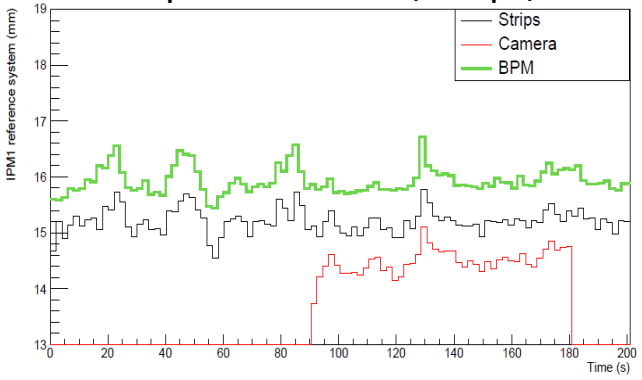
MCP (Hamamatsu) + constant strips

Read-Out: D. Etasse et al., Faster system
LPC Caen, France.

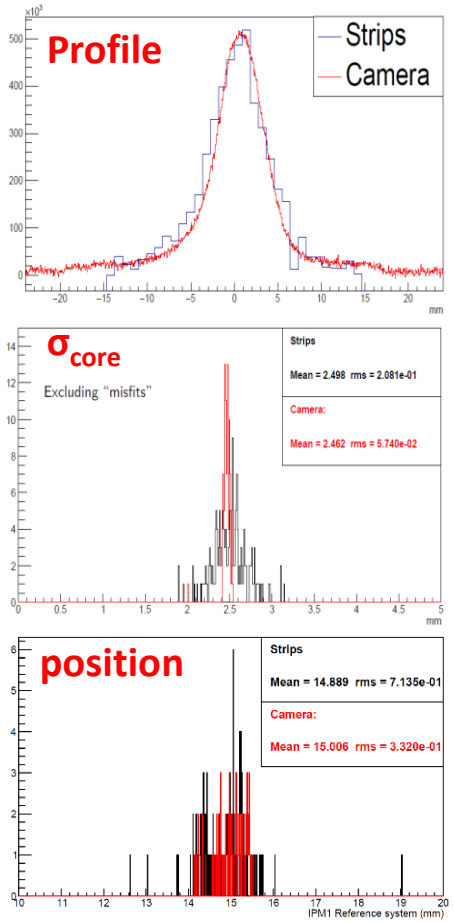
I_{beam} = 32mA - 10^{-7}mbar - Δt=100μs (1Hz) - σ≈3.3mm



Profile positions: CCD/Strips/BPM



Comparison MCP+strips/CCD



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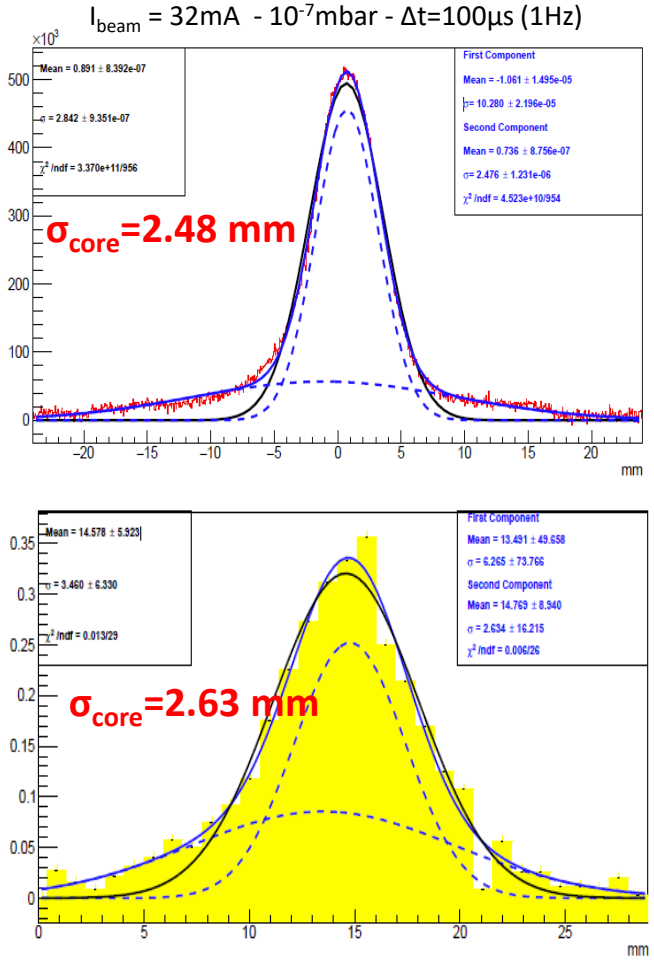


Toward a second IPHI test

First IPHI test results were presented at Lund during a Working Meeting on July 18th

Requested more time to study particularly:

- Space charge effect: σ_X for applying SC algorithm (Francesca & Cyrille)
- Interferences between two IPMs with perpendicular electric field ($\overrightarrow{E_X}$, $\overrightarrow{E_Y}$)
- Electric field homogeneity
- Reducing sparking
- Extrapolation IPHI data to ESS → feasibility
- Read-Out choice: more data have to be taken with strip RO
- Etc.

Therefore, the test bench was a bit different

- IPM1 in X direction (≠width strips), IPM2 (Y-Photonis pMCP) and IPM3 (constant width strips)
- Grids in front of RO (thin mesh)

Second Beam test at IPHI

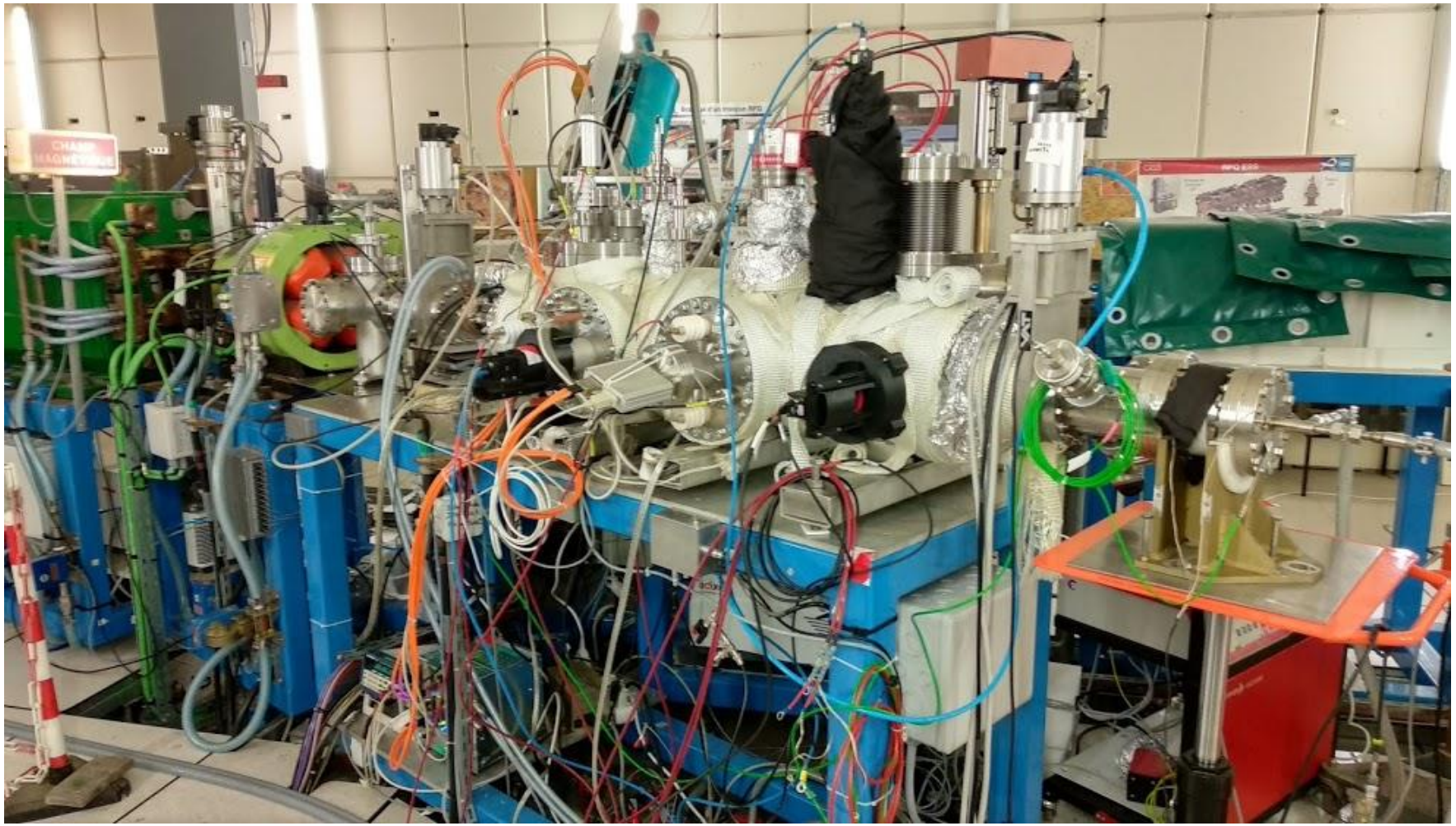
Sept. 10th … Oct. 19th 2018, with few days

IPHI: (Injecteur de Protons à Haute Intensité or Proton Injector at High Intensity)

Proton beam accelerator at CEA Saclay

- 3 MeV - I_p<100 mA – up to cw
- RF = 352 MHz
- Injector: 95 keV

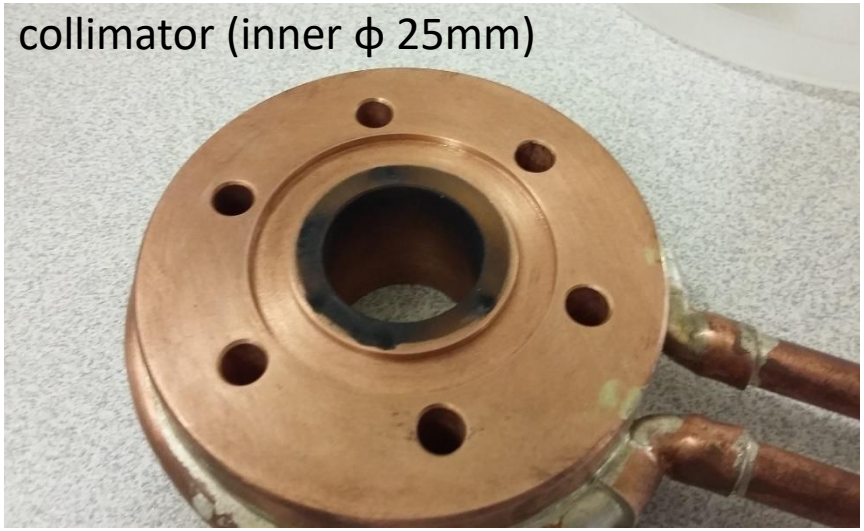
On IPHI deviated line



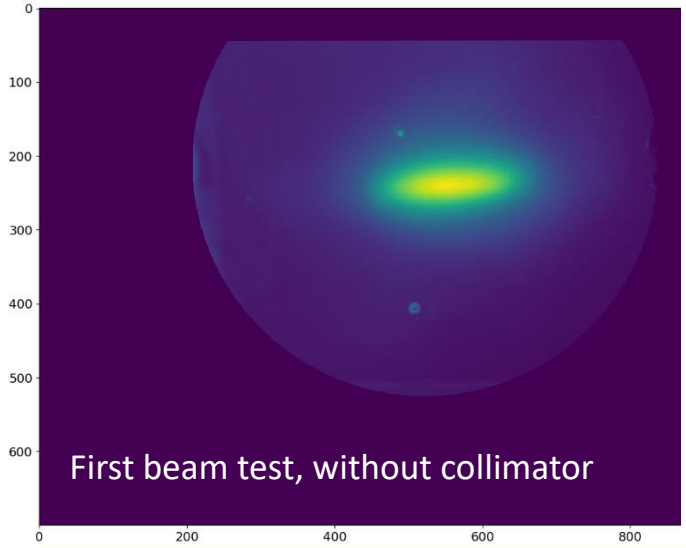
Preamble

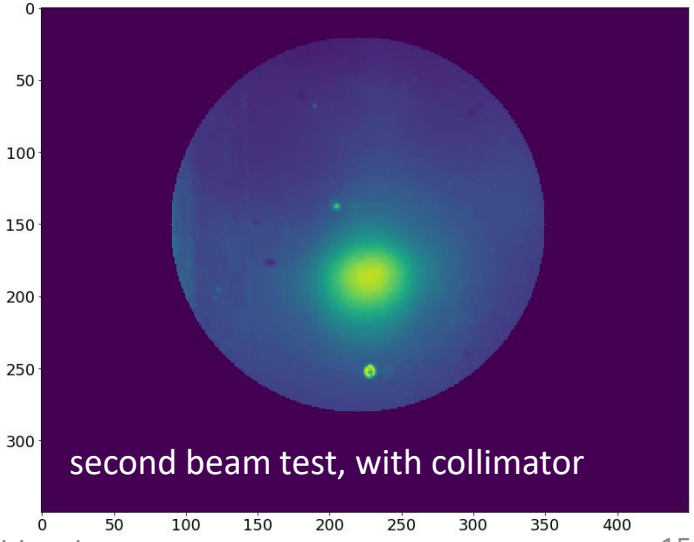
During Sept. 10th to Oct. 19th, we share the beam with other teams. Devoted time to NPM was about 2 weeks

Beamline was assembled to test a BPM of ESS Bilbao upstream to the NPM test bench. In order to protect the BPM (electrodes), a water cooling collimator with a 25 mm aperture was mounted upstream the BPM. Lot of electron background was generated.



Beam prints on interceptive scintillating screen.

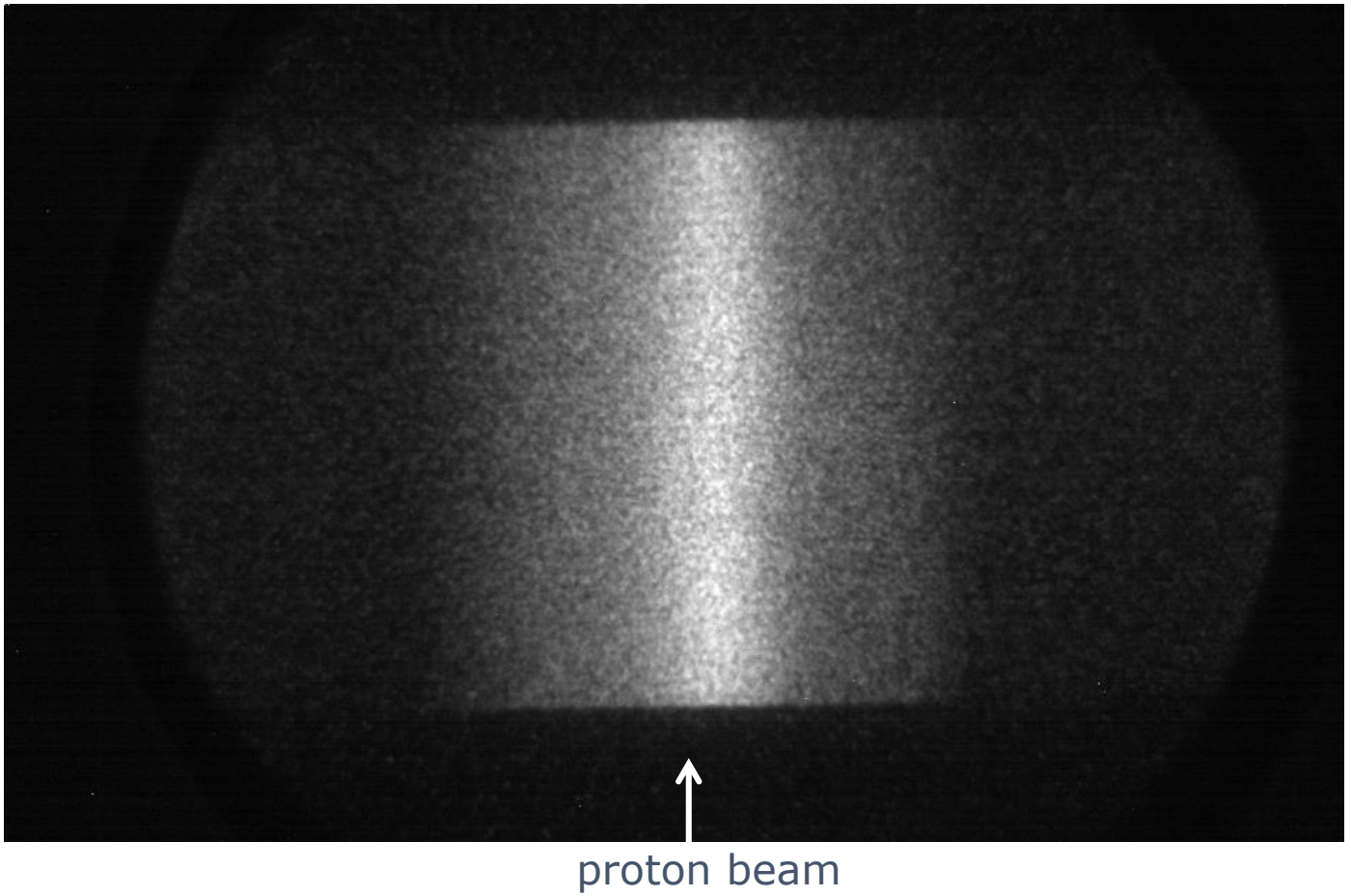




First beam

First beam was delivered on September 14 → the profile was directly measured

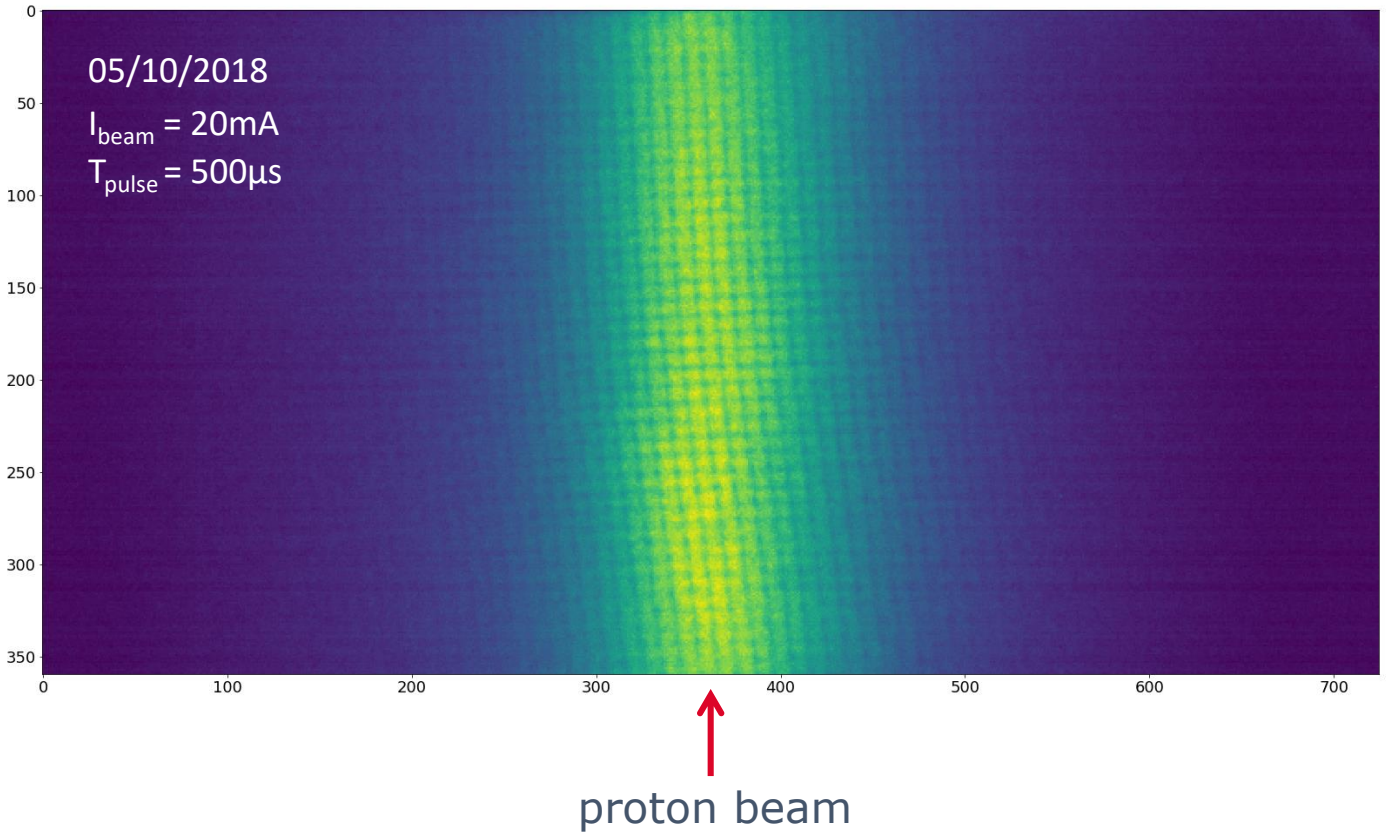
Reminder: it took 2 weeks for the 1st beam test!



Few preliminary results

- Analysis is under progress -

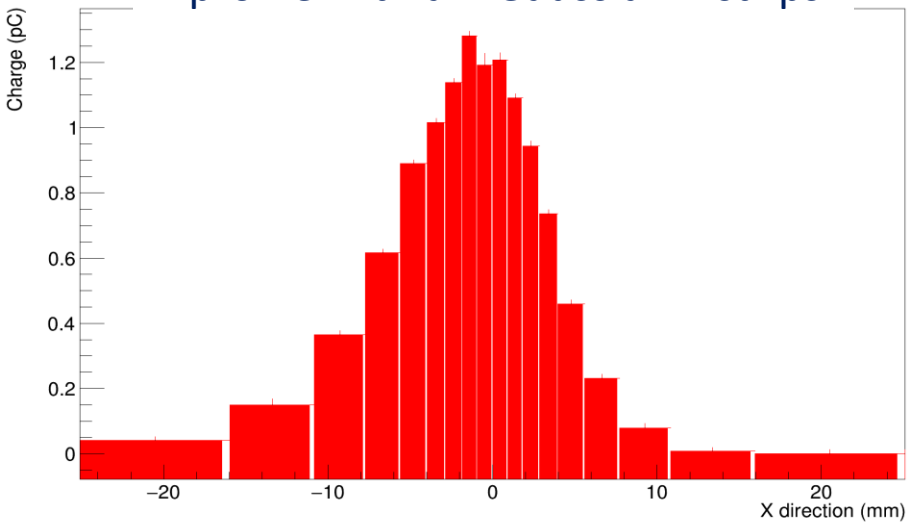
This nice picture gives an idea about the quality of the electric field uniformity



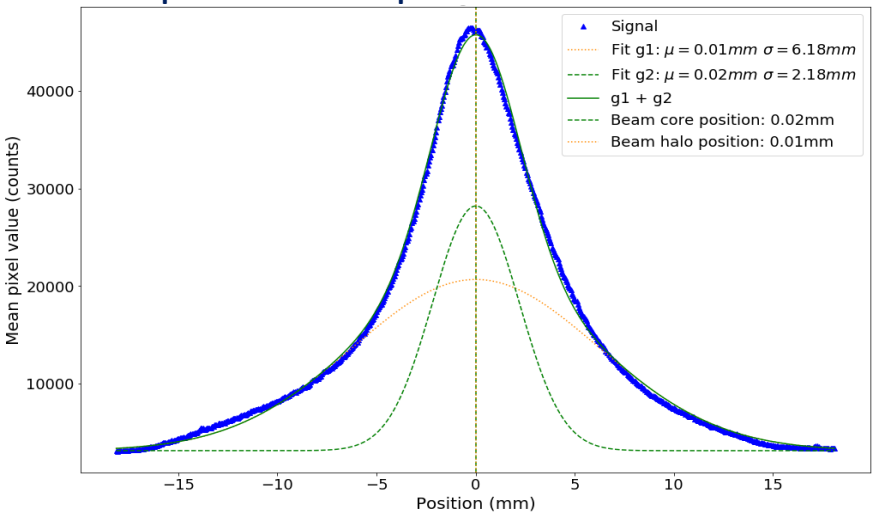
Few preliminary results (2)

05/10/2018: I_{beam} = 20mA and Δt_{pulse} = 500µs

X profile with a « Gaussian » strips



Y profile with pMCP from Photonis



Improvement of HV connection to increase electric field

Analysis under progress:

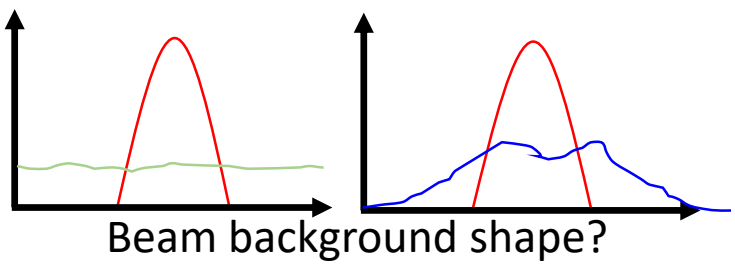
- electron background subtraction → hopeless to work in "electron mode"
- Extrapolation to ESS condition → this time the residual gas pressure was quite low (5 10^{-8} mbar)
- Electric field uniformity
- SC
- Etc.

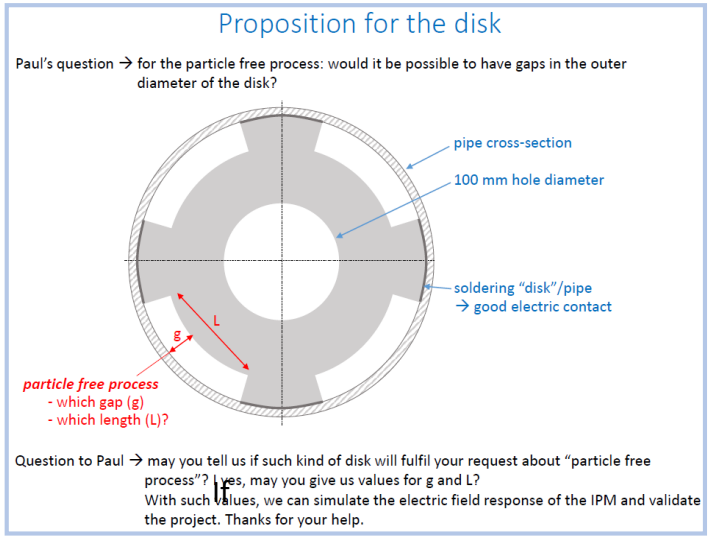
Goal: CDR on Feb. 5th 2019

Toward CDR

To be done

- Background from the beam → calculation by Mamad: important to determine the background which is supposed to pollute profiles
- Change request:
  grounded disks for IPM → Daresbury (letter sent by Cyrille on Feb. 2017)…
  CEA Saclay proposition sent to Paul on April 2018
- Improvement to be done on the final IPM → feedback from our tests and also from CDR

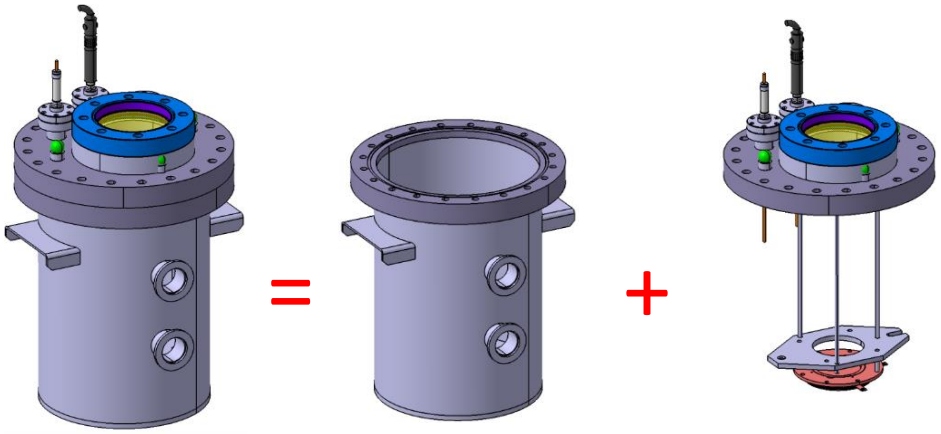


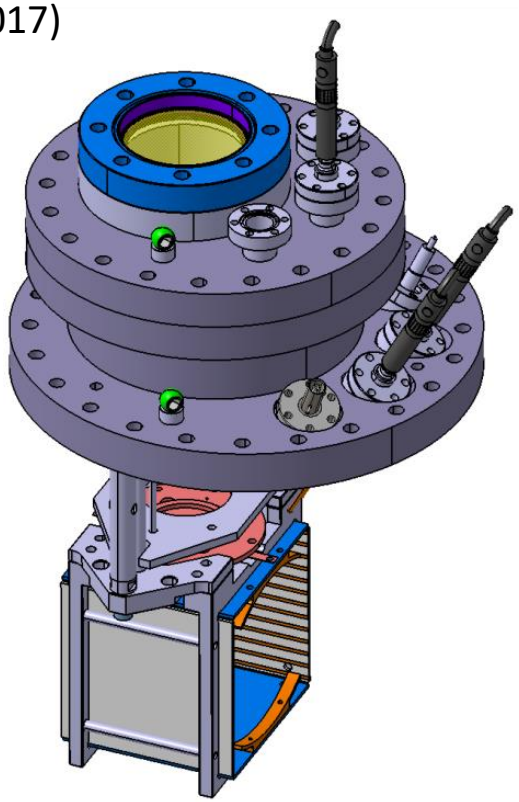


Read-Out

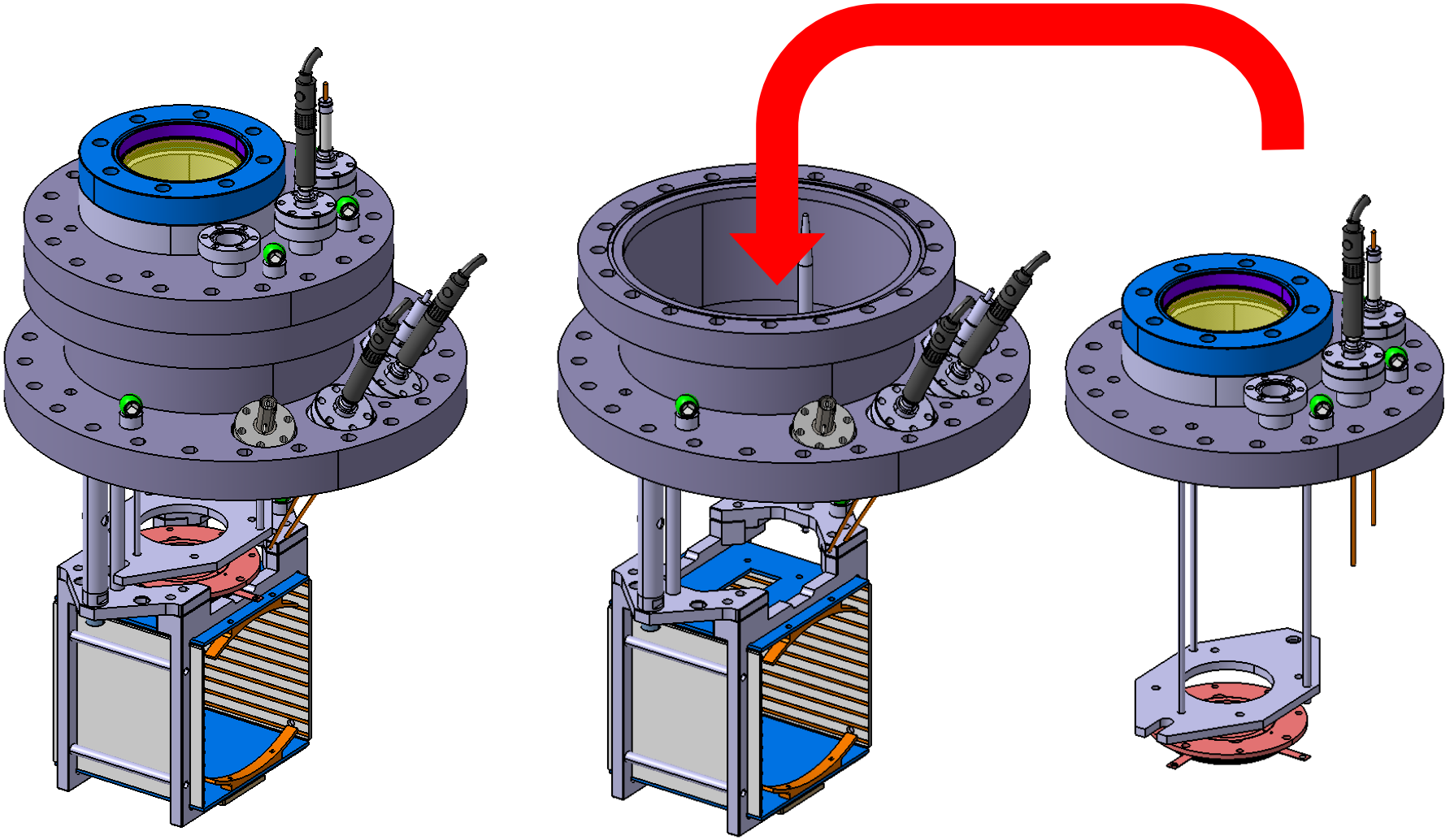
Hypothesis: seems that we are going to choose pMCP + CCD

- CCD: not radiation hard
  - CID camera (less sensitive…)
  - Camera set at remote distance → fiberscope (multi o.f. bundle for imaging) → see Cyrille Thomas who plan to test soon the radiation hardness of cheaper ones
  - Deposited power 1 to 10 Gy/h (Report ESS 00602018 – 1/2017)
- pMCP
  - Follow-up software with reference channels → correction on-line
  - MCP lifetime duration
    - → We learnt that Photonis has developed new MCPs increasing their lifetime
    - → We have proposed a specific assembling in order to replace them quickly and efficiently.

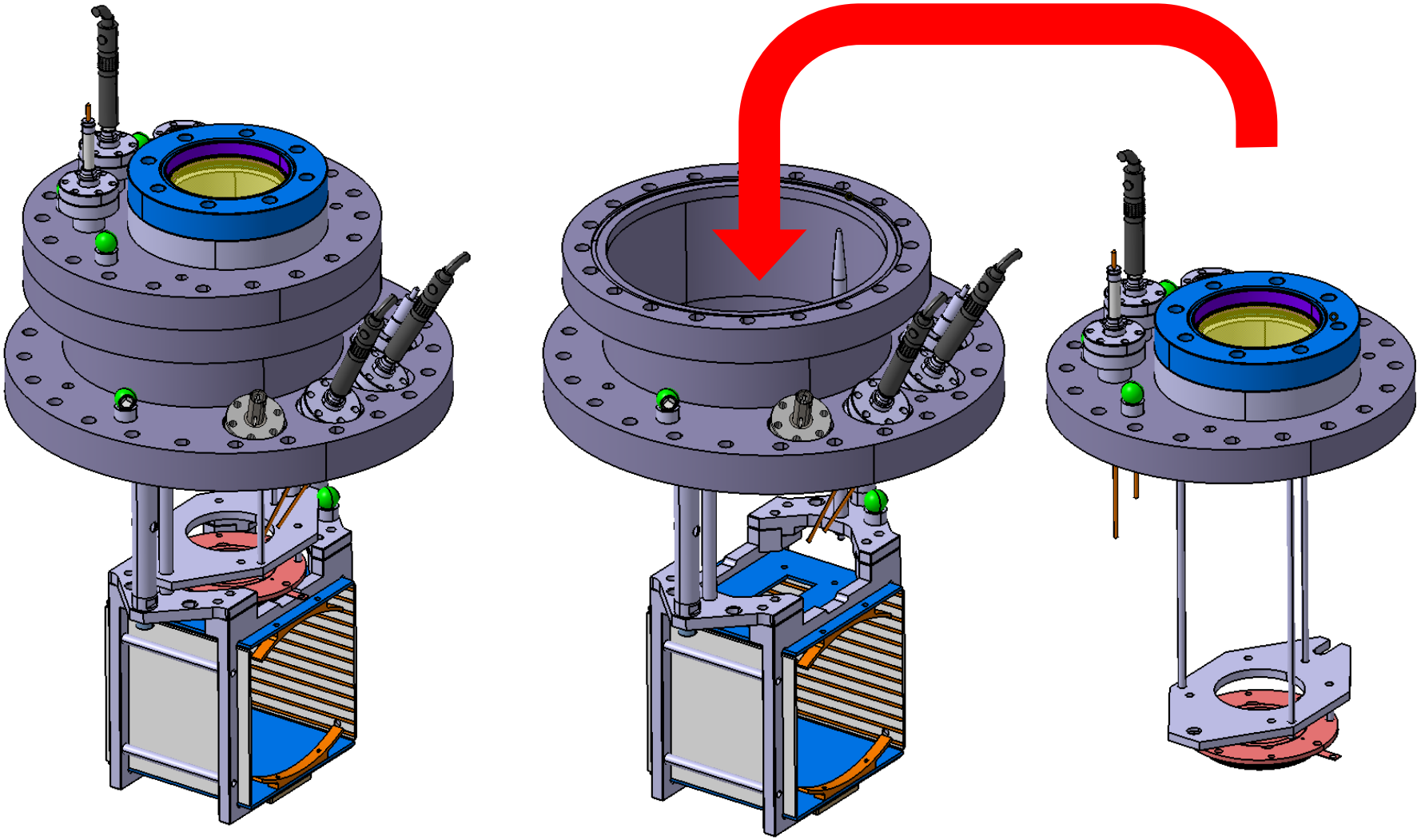




pMCP replacement: IPM_Y



pMCP replacement: IPM_X

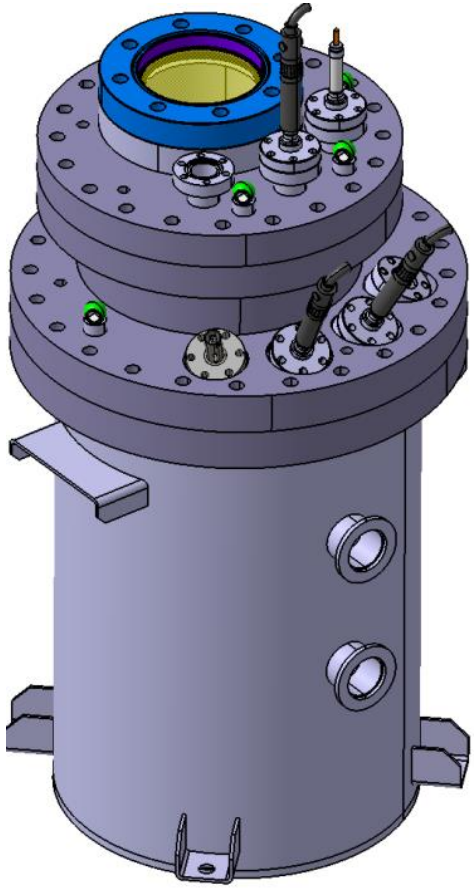


Delivery

IPM assembling, test and validation

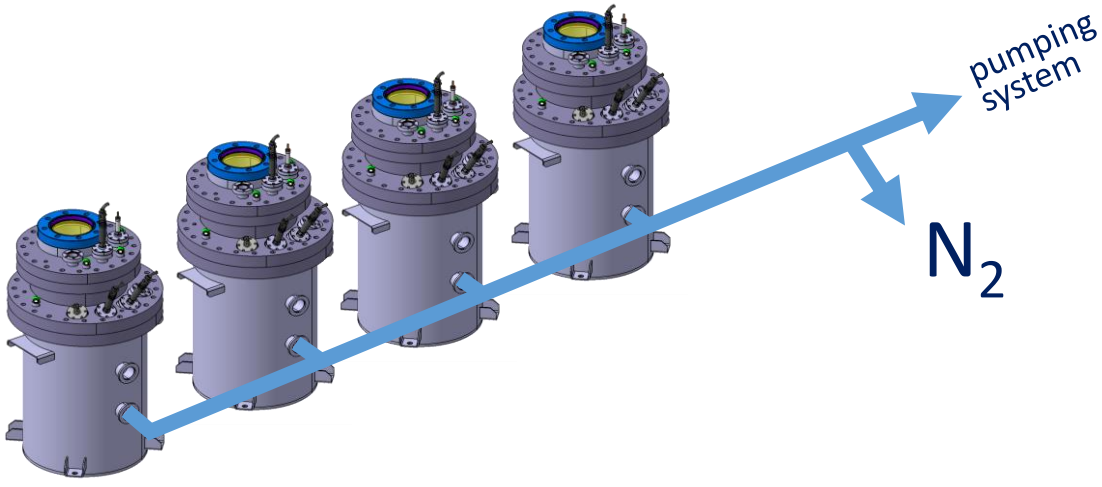
- Assembling in a clean room and test/validation
- Design of a new vacuum chamber, to test:
  - Vacuum pressure 10^{-9} mbar
  - HV sustaining 20, 30 kV
  - RGA (Residual Gas Analyzer) to be compliant with outgassing requirements
  - Check FEE electronics with a β source

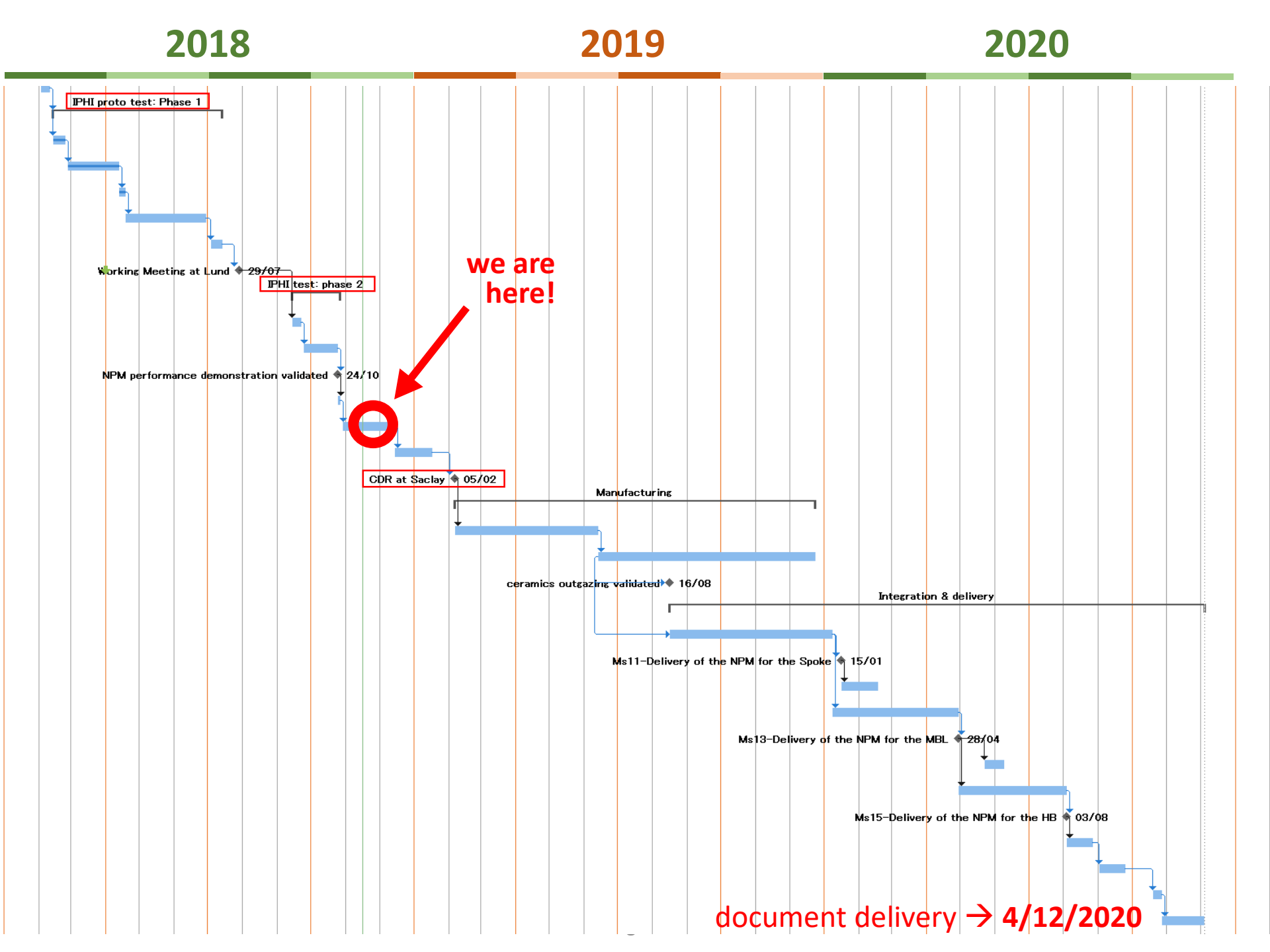
  → Plan to have a meeting with Saclay people working on CM (ok)



IPM storage / sending to Lund

- Storage pot N_2, vacuum




2018
2019
2020
IPHI proto test: Phase 1
Working Meeting at Lund
29/07
IPHI test: phase 2
we are here!
NPM performance demonstration validated
24/10
CDR at Saclay
05/02
Manufacturing
ceramics outgazing validated
16/08
Integration & delivery
Ms11-Delivery of the NPM for the Spoke
15/01
Ms13-Delivery of the NPM for the MBL
28/04
Ms15-Delivery of the NPM for the HB
03/08
document delivery → 4/12/2020

Summary

NPM data taking

- 1st IPHI test → Working Meeting on July 2018 at Lund
- 2nd IPHI test → analysis is in progress for CDR around Feb. 5th 2019
- → Lot of work done, starting from scratch

CDR preparation

- Starting to work on MCP and CCD Read-Out compliant to ESS radiation environment
- Change request: grounded disks
- Improvement of IPM
- Assembling, test and Validation in clean room
- Wrapping of IPM for Lund delivery
- … a long way!

EMU repairing

O. Tuske, N. Misiara, P. Daniel-Thomas

Damage 1: Transportation

Damage 1: happens during the EMU transportation between CEA Saclay (Dec. 8th 2016) and INFN Catania (Dec. 12th 2016)

The bellow of the EMU has been damaged in its wooden box

The wounded undulations of the bellow have been bended back in Catania premises.

Leak test before and after: no leak!

→ ***INFN takes the risk to used it***

ESS will pay for a new bellow
CEA STAFF will make the change as soon as EMU is back to Saclay.

[CEA-ESS-DIA-NC-0001.pdf]

Damage 2: translation problem

Damage 2: once INFN Catania has installed the EMU on the LEBT end, they encountered translation problem on July 21st 2017

The measurement head has crashed into the diagnostic chamber

→ Ceramic connectors bent

→ Collector connectors twisted…

INFN STAFF made the reparation ☺

They fixed it as well as they could to resume test measurement activities.

Damage 3: Thermal problem

Damage 3: during measurements on the proton source beam at Catania, a thermal damage most likely (since no data available) caused by a too much focalized beam onto the EMU beam dump and slit (27/11/2017) induced a scratch on the beam dump and the closure of the slit aperture.

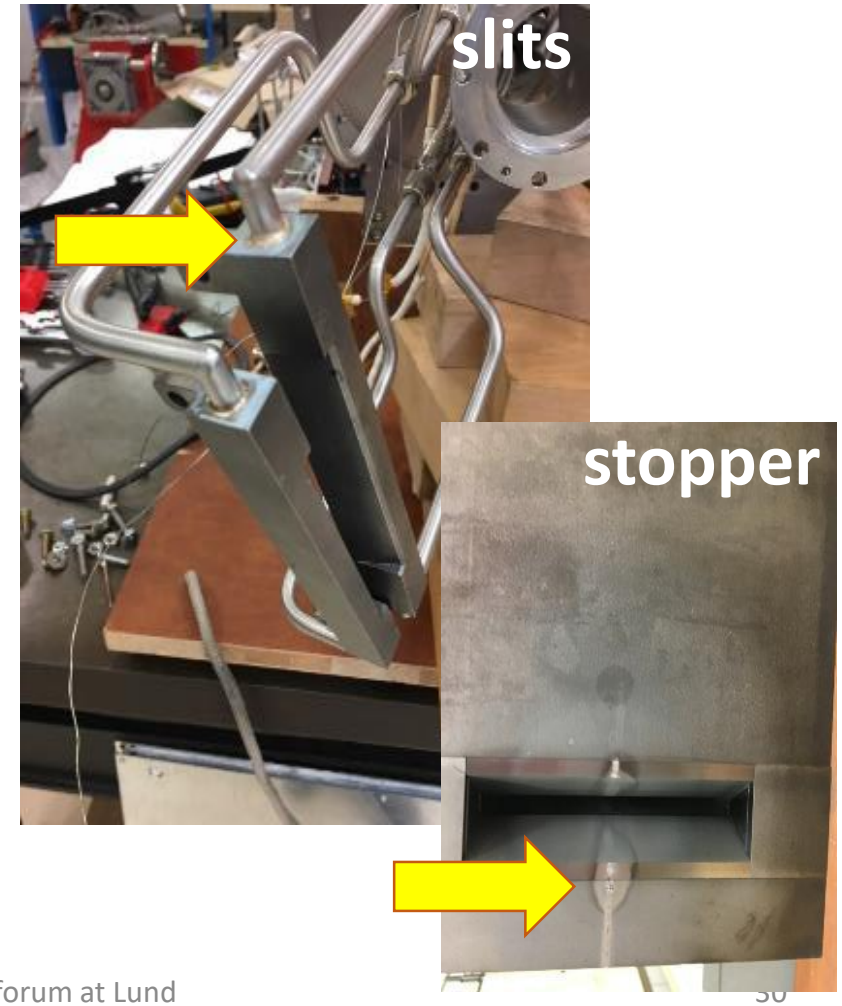
AS no-DATA was send to CEA to explain how this incident occurs, we can only guess that the power density of the beam was much higher than expected / requested.

THE SLITS have been damaged: leaks on pipe/slit brazing…

ESS pays for a new slit
CEA staff installed it freely

The beam STOPPER was marked but still functional

[CEA-ESS-DIA-NC-0023.pdf]



Repairing at CEA Saclay

EMU back to Saclay on November 23rd 2017

Replacing the bellow, the outer shield, the connectors with ceramics.
Removing water pipes with great care for the O-ring joints, connections...
CEA Saclay exchanges the damage slits by its own subsystem
Several tests were done fulfilling the requirements as vacuum and water leaks

→ **Finally, EMU n°2 was sent to Lund on mid-October 2018.**

ESS should refund the slit subsystem

Thank you for your attention