Document Type	Analysis report
Document Number	ESS-0680910
Date	February 2, 2019
Revision	1
State	Preliminary
Confidentiality Level	Internal
Page	1 (17)

Towards cNPM manufacturing

	Name	Role/Title
Owners	Jacques MarroncleIRFU, CEA Saclay	in-kind system lead cNPM / Beam Diagnostics Engineer
	Francesca Belloni, IRFUIRFU, CEA Saclay	in-kind collaborator cNPM / Post-doc
	Florian Benedetti, IRFU, CEA Saclay	in-kind collaborator cNPM / PhD Student
	Cyrille Thomas, BOPD, ESS	System Lead NPMs / Beam Diagnostics Engineer
Reviewer	Subject matter expert who reviewed the report	Role/Title
Approvers	Peter Jacobsson	Head of ES&H Division
	Günter Muhrer	ESS shield design coordinator
	System owner	Role/Title of the system owner
Distribution list	Name	Role/Title
	Name	Role/Title

Abstract

the abstract

Contents

1 Scope

In the in-kind framework between ESS and France, one contract of CEA Saclay consists in providing 5 NPMs for measuring non-invasively the transverse profiles of the beam in the cold part of the accelerator. The distribution of the cNPMs is as follow: 1 in the Spoke section, 3 in the MBL and 1 in the HBL.

This report describes firstly the scenario proposed to manufacture the NPMs detailing all the steps for cleaning, assembling, testing, surveying, packaging before sending them to ESS. A mechanical improvement on the flange system holding the IPMs will be proposed for facilitating maintenance and earning in reliability. MCPs are at the heart of the IPM, but they are submitted to ageing effects and may suffer also of hard radiation environment which will be raised. Interfaces are listed showing an issue with another systems which need to be settle. Work to be done or resume are described for preparing the NPM building prior to launch the production. Finally, the procurement plan, the identified risks and the planning will ended this report.

2 Glossary

Table 1: Glossary with the used acronymes.

IPM:	Ionization Profile Monitor
LWU:	Linac Warm Unit
MBL & HBL:	Medium and High Line
NPM:	Non invasive Profile Monitor. 1 NPM is made of 2 IPMs rotated by 90 with respect to each of them (cNMP means cold NPM)
pMCP:	MultiChannel Plate with a phosphorescent screen
RGA:	Residual Gas Analyzer
VC:	vacuum chamber

3 Scenario for NPM delivery

We make the hypothesis that all pieces are manufactured and available in our laboratory (building 534 / room 43) and that IPMs will be mounted by pairs. This scenario is divided into 4 steps.

3.1 Quality Assurance and Qualification Tests

3.1.1 Cleaning

In building 534, there are two rooms with ultrasonic bath in each: in room 1 there is also a flushing pure water pipe while in room 40 there is a clean tent with a laminar air flux. Cleaning will be done on both rooms depending on the item size. After taking out all the necessary parts, including flanges (without MCP) to build 2 IPMs, we will place all of them in ultrasonic baths with specific detergent (EC260, pH 7.1). Once done, all items are dried in room 40, under the laminar air flux.

By using a conductivity-meter, we have also the possibility to check the quality of the rinsing water.

3.1.2 Assembling

An IPM is shown on Fig. 1 with its squared cage (100mm side) where the beam passes through it. Above is the bracket of the pMCP. Two flanges are mounted with a glass window on the top viewport allowing the signal read-out reaching the CMOS camera. High voltages feedthroughs, sight brackets for alignment are shown on the CF150.

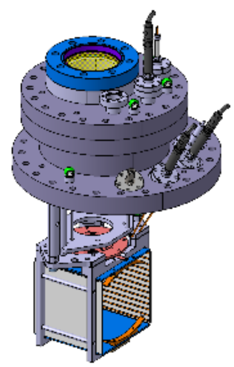


Figure 1: IPM unit mechanical assembly.

In case of asymmetric IPM, a potential up to 30 kV may be applied on the electrode plate which imposes to make connection very thoroughly for avoiding sparks. When both IPMs are assembled, there are inserted in the vacuum chamber, each one in a CF200 viewport flange. All IPMs are similar, but to take into account the geometry, one is rotated by 180° wrt to the other one.

The VC will be baked-out in order to reach a very low pressure inside 10^{-9}-10^{-8} mbar range; an ionic pump may be added to our pumping system.

When a reasonable pressure is achieved, qualification tests can start.

3.1.3 HV qualification

The goal is to apply between 20 to 30 kV without spark until the current is stable. Several dismounting-mounting operations have to be foreseen during this phase, to set differently the copper connections for instance.

The highest achieved HV, the current and the pressure measurements will be part of the IPM qualification.

3.1.4 MCP qualification

As shown on Fig. 2, there is a cylinder which insure the interface between inner VC vacuum and the outer atmospheric pressure. Such systems allow insertion of a β^- radioactive source inside each IPM, with which the MCP functionning can be test as well as the gain behavior versus the applied HV.

The MCP gain curve will be part of the IPM qualification.

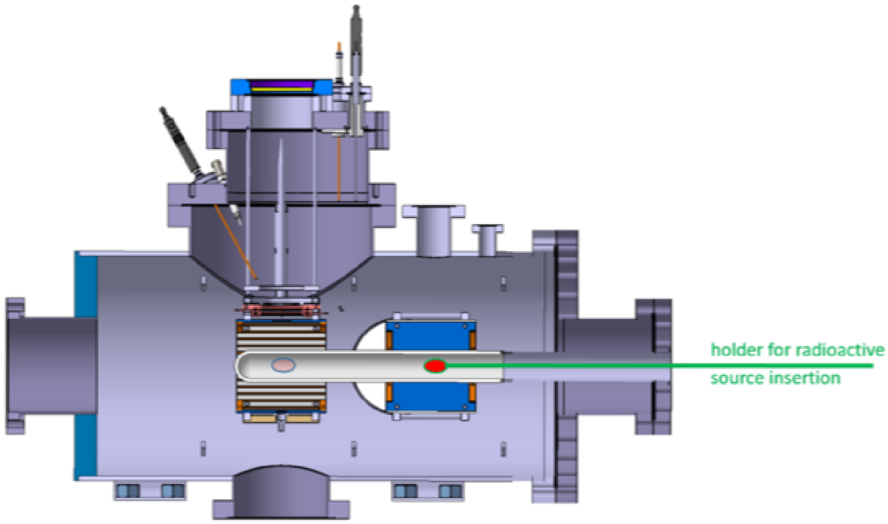


Figure 2: VC test with a tube kept at atmospheric pressure, in which a β^{-}radioactive source can be inserted without vacuum breaking. That will allow MCP characterization by measuring their gain curve for instance.

3.1.5 RGA (Residual Gas Analyser) qualification

It is of the most importance to measure the ougassing of our IPMs which should be compliant with the ESS requirement for avoiding problems with the surrounding cryomodules. Therefore, at this stage we propose to improve the vacuum with a new bake-out operation followed with a ionic pumping and when ready, we will proceed to RGA measurement.

The RGA curve will be part of the IPM qualification.

3.2 IPM Alignment

Since during the previous test, particularly for HVs, we may be faced to dismount partly IPM, meaning alignment has to be done after the previous tasks. Therefore IPMs are dismounted and brought to the DACM[1] Building.

About 4 or 5 alignment sights are fixed on the CF200 flange (see Fig. 3), defined as a reference frame which will allow later on to locate the IPMs in the ESS framework.

Indeed there are few crosses which have to be engraved on MPS plate for the CMOS camera coordinates and also crosses on the plate with the aperture for ionization by-products passage.

This alignment work will be done with an optical bench in the MCP axis and with a tracker laser in the perpendicular plane (depth).

Alignment measurements will be part of the IPM qualification.

3.3 Last cleaning and storage

To comply to ESS cleanliness rules, IPM should have to be cleaned following ISO 5 requirements. Except the MCP, we will plunge the entire IPM in a large ultrasonic bath with detergent (TDF4, pH 13.5). Aside there is a rincing station on duckboard, with filtered and deminarilized water which can flush on IPMs.

[1]Département des accélérateurs, de cryogénie et de magnétisme

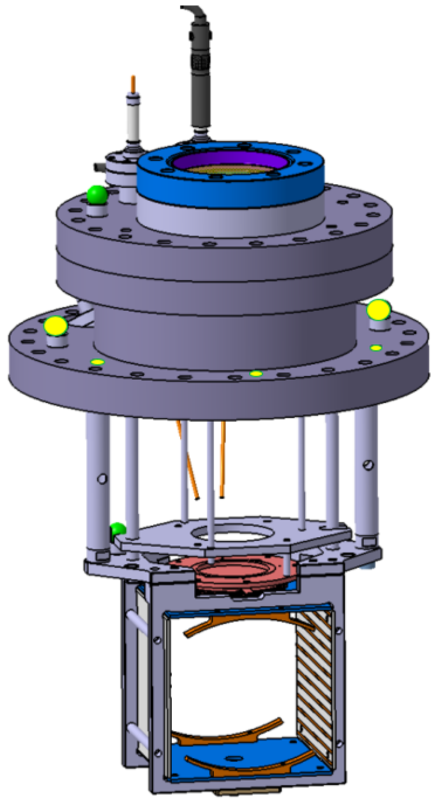


Figure 3: CF200 with 2 sight targets and 3 H7G6 (Φ=0.5”) calibrated holes (yellow).

Then, IPM will be transported (around 50m) entirely drawn in a box filled of pure water up to the ISO 5 cleanroom tent equipped with a laminar air flow.

Note that same cleaning processes have to be followed to the storage boxes.

Once inside the ISO5 tent, the storage box and the IPMs, will be fixed with specific tooling to keep them in the laminar air flux the needed time following clean drying conditions. When IPM will be dried, MCP must be assembled. Pure filtered nitrogen will be blowed until the free particle counter achieves the ISO 5 criteria values.

The first IPM can be inserted on a side of the storage box and slow vacuum pumping can start. As soon as the second IPM is ready, the storage box is slowly filled with pure filtered N_2. The opposite side of the box can be carefully open allowing the mounting of the second IPM. The slow pumping down can start.

For MCP, it is recommended to store them below 10^{-2} mbar. For avoiding any problem we plan to use a new primary dry pump enabling pumping for 5 storage boxes in series.

3.4 Packaging and transport

For IPM storage, we plan to design cylindrical vacuum chamber with a CF200 flange at both ends. Once thoroughly cleaned, the IPMs will be mounted on each end. In this way, a storage box will correspond to a NPM equipping a LWU with X and Y profilers (see Fig. 4).

The best for the IPM transportation is to keep them under vacuum. For safety reason, we will keep NPM in vacuum around 10^{-2} mbar during storage phase, and will slowly come back lightly above atmospheric pressure with N_2 gas for transportation. As soon as the boxes are delivered at ESS, slow pumping down has to be done to achieve a 10^{-2} mbar vacuum. Each storage box will

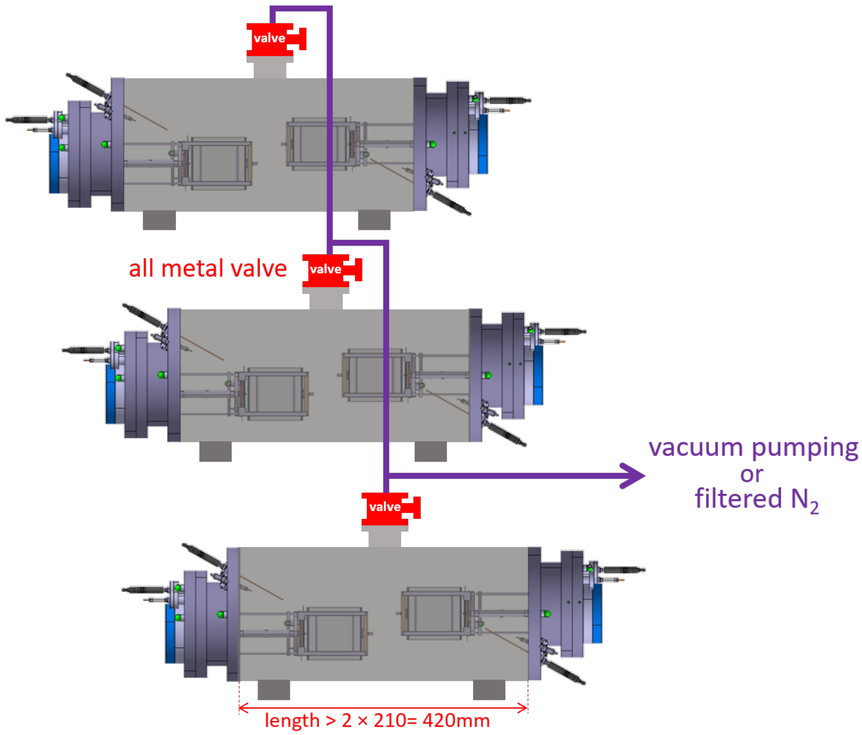


Figure 4: Storage boxes and the pumping system.

be equipped with an all metal valve in order to vent the box at ESS reception.

All boxes have to be wrapped in a way to absorb vibrations, which are particularly harmful for free particle purpose. A mechanical study has to be done to calculate the resonances of the system and to overcome them through a specific cradle or support. Shock and tilt sensors will be attached to the parcel for checking transportation conditions.

3.5 IPM reports

During this long process, few data will be collected and will represent the qualification datasheet of each IPM. Assuming that all of them can be done, there are listed below:

- The highest achieved HV IPM with the consumption current and the pressure
- Using the β^- source for the MCP gain curve
- The RGA response
- The alignment coordinates of IPM crosses wrt the external sight targets
- The free particle measured with the specific monitor

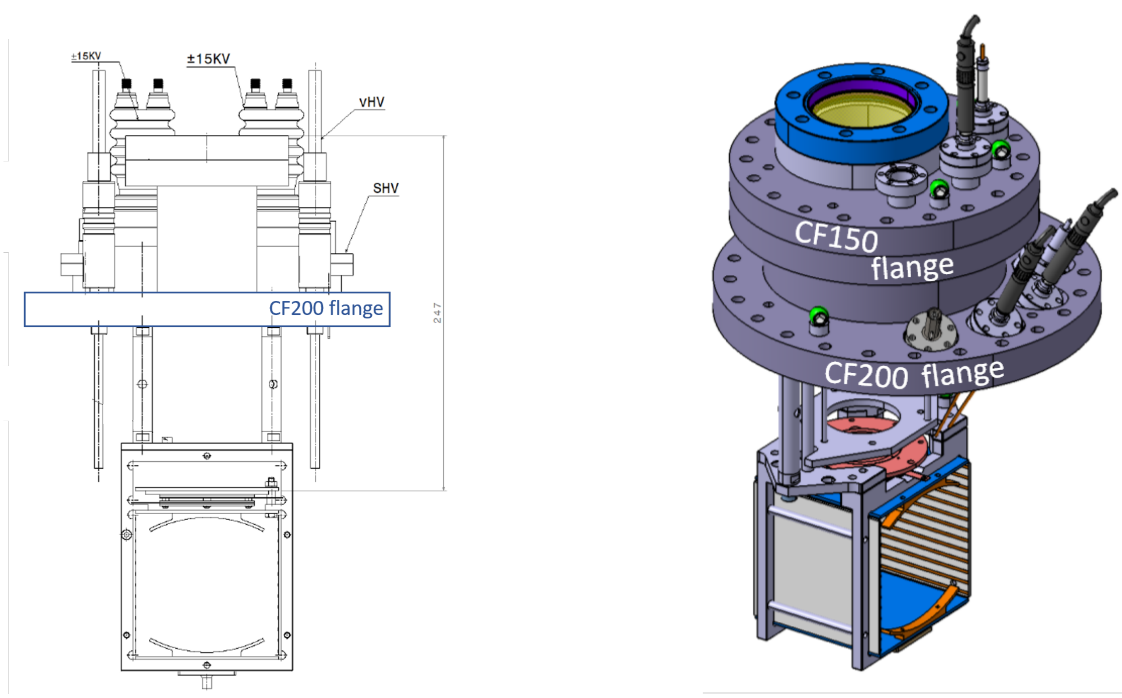
The quality of the IPM manufacturing is more or less summarized in such datasheets.

We are also thinking to measure the impedance of the IPM degraders which may indicate for instance if, during the transport, conductive pieces are still connected when checked at ESS.

4 IPM mechanics: proposition of a new flange option

During the tests done at IPHI, we used a simple CF200 flange to support the IPM (Fig. 5a). For the manufacturing of the IPM, we thought that 2 independent flanges CF200 and CF150 (Fig. 5b) will ease the assembling process and also the maintenance. This later configuration presents the following advantages wrt the former one:

- Once the complete IPM set is mounted on the LWU VC, alignment can be done by measuring all sight pods on the CF200. Then, if MCP has to be removed (unscrew the CF150), the IPM cage linked to the CF200 stays fixed. MCP can be changed but, no alignment are necessary. We just have to measure with the CMOS camera the 4 crosses which will be engraved on the electrode plate back. This new configuration is compliant with a better reliability of the IPM since the MCP change may be done quickly, with no impact on alignment. Furthermore, the CF150 flange with its MCP bracket, HV viewports is quite light and can be easily operated.
- For assembling the whole IPM, it is more convenient to prepare first the CF200 and all its belonging items, and then the CF150 ones. It allows minimizing the MCP in oxygen atmosphere.
- The IPMs X and Y are similar: while X is centered on the CF200 LWU viewport, Y is shifted by 36 mm to its CF200 axis. The trick for mounting both IPMs, is to rotate the CF150 by 180 wrt the CF200 flange. This is of great interest for manufacturing purpose.



(a) (b)

Figure 5: IPM with a CF200 flange on which all viewports are mounted (a); CF150 on which all MCP items are mounted independently to the fixed CF200 flange (b).

Figure 6 illustrates this point with bottom views of the MCP (red) and its bracket mounted on the CF150 flange (left) while the IPM cage (blue) is sustained on the CF200 flange (center), but shifted by 36 mm for Y profile and 0 mm for X. After 180 rotating of X CF150, and assembly of both flanges, results are presented on the right column.

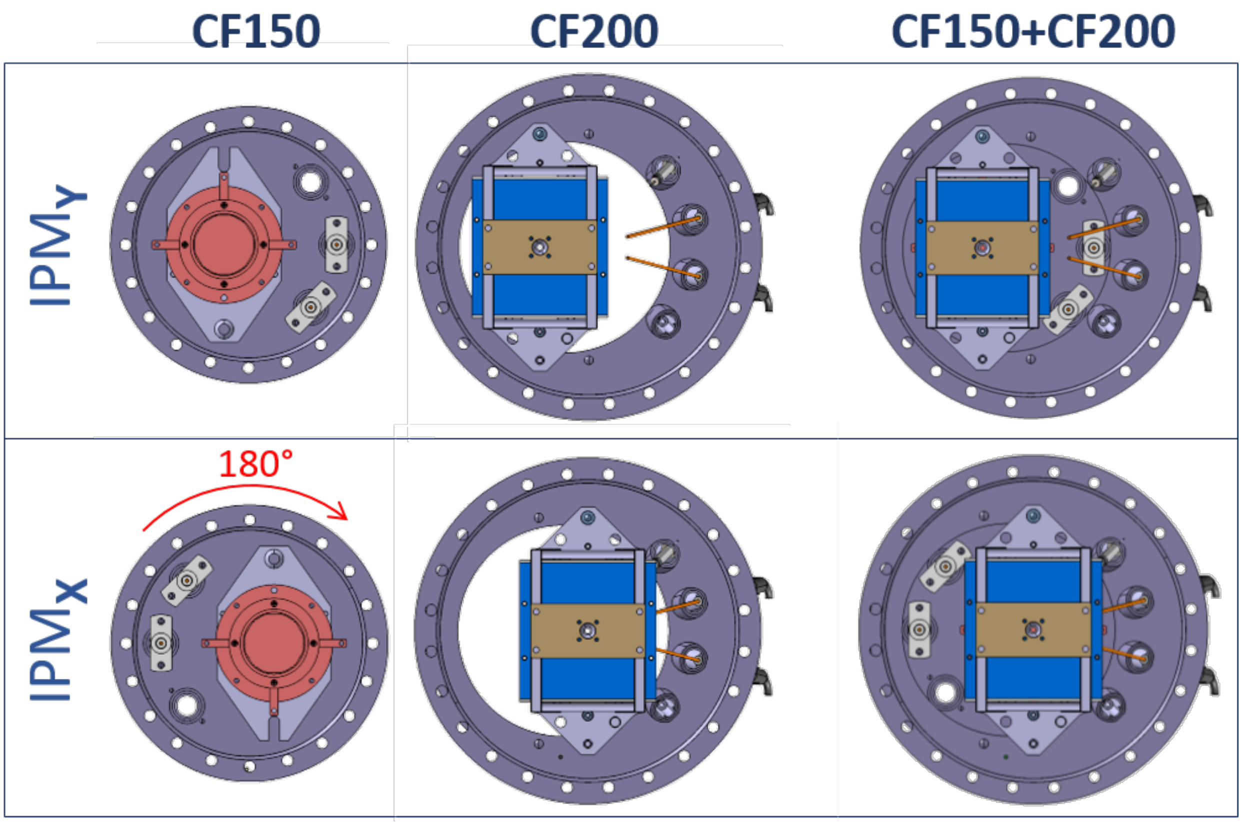


Figure 6: CF150 and CF200 flanges with their assemblies are shown on the top row for profiler on Y direction. Same things on the bottom row for the X projection

5 Read-out system: MCPs and CMOS cameras

5.1 MCP choice

The experimental tests done at IPHI has demonstrated that MCP is mandatory to extrapolate the measured signal to the expected signal at ESS conditions. During our tests, we used single chevron MCP with a phosphorescent screen. In such a case where CMOS cameras are installed directly on the glass viewport, extrapolation shows that the MCP gain was enough for measuring a transversal beam profile every ESS pulse beam. Unfortunately, the vault radiation calculations are not enough accurate to decide if the CMOS camera will be or not enough radiation-hard to sustain the radiation background (at least 1 to 10 Gy/h, for 1 W/m losses[2]), but losses should be around 0.01W/m![3] If it is not the case, a fiberscope of few meters long will be used to put the CMOS at remote distance, which may reduce drastically the light signal.

[2]ESS-0060208 note, L. Tchelidze et al., May 2017
[3]A. Jansson et al., Overview of ESS Beam Diagnostics, IBIC 2012, Tsukuba, Japan.

Furthermore, we know that MCPs are sensitive to ageing, meaning that they permanently lose sensitivity when submitted to radiations, which is minimized at lower gain. Therefore, for all these reasons we decide to install a double stacked MCP with a phosphorescent screen.

5.2 MCP ageing

During IPHI tests, we used a LED source (350nm, 5mW, but going down to 150nm) while MCP sensitivity is below about 180nm. We expected to compensate the low LED rate at low wavelength with the high power source, but we failed. That should have been an interesting solution using optical fiber and low size items in the quite crowded LWU location.

Later on, we would like to check if it is really hopeless. Indeed, the fact we did not see the light may come from the parasitic light coming from other viewport.

Anyway, we propose to develop a software solution to follow up the sensitivity evolution. The idea is to take data weekly or monthly in nominal beam conditions devoted to operation called calibration runs. Then an automatic analysis may follow-up the pixel response evolutions versus time by comparison between these runs. It is expected a higher decreasing sensitivity for pixels submitted to higher intensity, as the ones located in front of the beam center. Pixel correction factors can be evaluated by levelling the pixel responses over consecutive runs. Once determined, the Pixel mapping will be used for "rescaling" MCP gain by software.

5.3 MCP with camera at remote distance

In the case where the radiation background should shorten the MCP lifetime down to a year, it would be necessary to set a camera at remote distance in a shielded area. Two solutions are investigated to transport the image over up to 10 m, where the camera can be shielded in the bottom of the nearby Stub. The solution to get a camera detecting single events, i.e. an ion hitting the MCP is been studied at ESS. A more detail document can be found in CHESS with the reference ESS-0680911. The document presents two alternative imaging systems: the first one using a fiberscope and lenses is sketched on Fig. 7, while the other one based on 2 mirrors and an objective lens can be seen on Fig. 8.

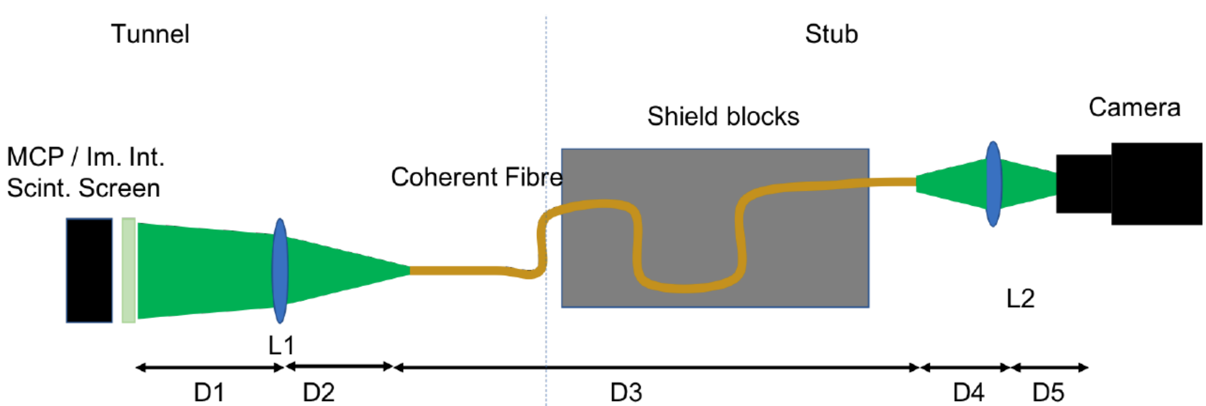


Figure 7: Fiberscope image transport for remotely CMOS camera.

At a first order evaluation of the system transmission, one can start by selecting the focal lens required to make conjugate images. For the lens L1, the magnifications for the MCP is set, so as the geometrical aperture coupling light into the fibre.

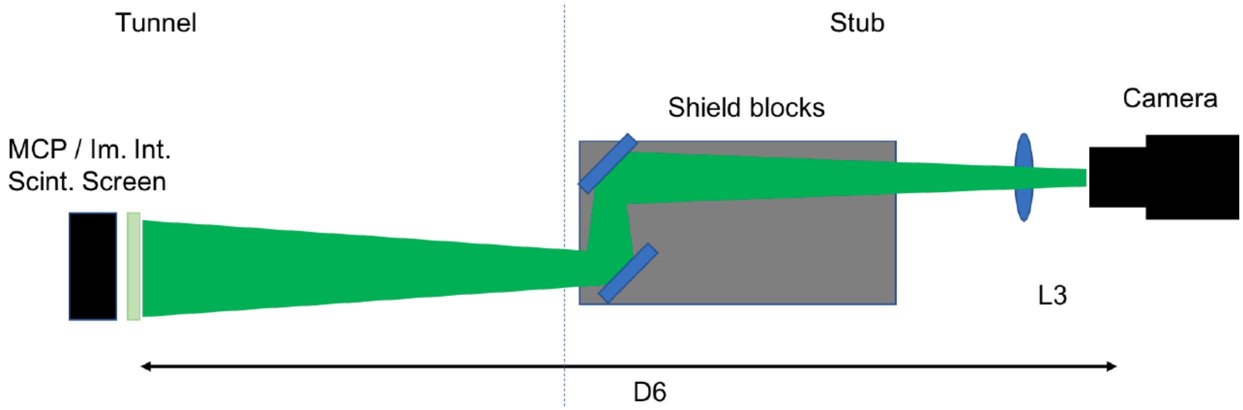


Figure 8: Miror image transport for remotely CMOS camera

The MCP is 40 mm diameter and the fiber diameter is 2 mm. The geometrical transmission T of the lens to the fiber is defined by the aperture of the lens, called the F-number or F#, the focal lens, F and the distance between the screen and the lens, D1:

$$T = \frac{1}{2}(1 - cos(\theta)) \quad (1)$$

with $\theta = arctan\left(\frac{F/F\#}{2D}\right)$

The geometrical transmission for 0.5 numerical aperture of the fiberscope is about $3 \cdot 10^{-5}$ while it is a factor 4 below for the second system. Such an attenuation encourages to purchase stacked double MCP for increasing the output light.

The fiber attenuation is an important value to take into account. For instance, for silica fibers, this can be as low as a few dB per km. We intent to used plastic coherent fibers. The material used is PMMA. This material is rather cheap, and it presents good optical quality and rather good transmission, typically 0.5dB/m at 500 nm. However, a full characterisation of the system with the selected fiber will have to be done in order to prove and demonstrate the performance of the system. Lenses transmissions can be close to 100% with anti-reflection coating.

5.4 Camera selection and requirements

We used during our beam test at IPHI the CMOS camera model Blackfly FLIR BFLY-PGE-23S6M-C with a sensor Sony IMX249. Nevertheless, as we are aware that ESS has already developed and implemented software on platform for GiGE camera, we propose to choose one product which will fulfill our requirements with the recommendations of ESS experts. These requirements are the following:

- Large pixel size, > 5.86µm, with the possibility to bin them together x2 or more,
- Pixel numbers: 2.3 Mpix are enough,
- Speed acquisition should above 14Hz

For more details on the tested camera, see file ”Prototyping, design and test results of the cNPM” chapter 1

During the prototype tests the supports of the cameras were manufactured with a 3D printer using plastic materials. It is made of a fixed part which is attached to the CF200, while a mobile chariot on which the camera is fixed may be set at the right position wrt the focal plane tuning. This gave a good feedback for the design of the final optical imaging system for the cNPM.

The optical imaging is not finalized yet. However, there is enough time between the CDR and the delivery of the IPM units to design, test and procure the final optical imaging for the cNPM.

6 Interfaces

6.1 LWU

There are two types of LWU devoted to the cold NPM: the one which are in the Spoke section and those in the MBL and HBL section. The former are shorter than the later. The test bench designed at Saclay for IPHI beam test is divided in 2 parts, where the upstream one is similar (in dimensions) to the MBL & HBL. We were never informed that 2 LWU types have to be considered and unfortunately we discovered this in Dec. 2018. Moreover, for electric field uniformity purpose each IPM has to be flanked by two grounded surfaces (LWU wall or disk) set at 33mm from IPM sides. Below are summarized the results of our discussions with Daresbury STFC (provider of LWU and managed by Paul Aden):

- Spoke LWU: STFC kindly accepts to move both CF200 viewports, as well as the lugs holding the disks. We got a step file, which fits our requirements.
- MBL and HBL LWU: nothing to move, but the lugs. We did not receive the step file and therefore, we did not check it. Anyway, STFC is aware about that.

To be done: establish a Change Request to insure that modifications are all taken into account and to define who take in charge the lugs (welding) and the disks (design, manufacturing and mounting) and check if all items are located at their expected locations with their expected shapes.

6.2 Cables, Control system ...

There is an interface between cables (power supplies, signal and control) between the IPMs and the electronic cabinets (FEE, HV power supplies, data acquisition system and control system).

Control system: for monitoring HVs feeding IPMs (15 to 30 kV), CMOS cameras and MCP. For MCPs, a specific setting has to be implemented for adjusting their gains. All these operations have to be done remotely from a GUI where operators can proceed. ”Calibration runs” for following up the MCP gain evolution must be also done from this platform.

Data acquisition system: it consists to register data when beam is working, store and analyze (on-line) to deliver beam profile information like the mean values and their sigma (with and without fit) and also the time evolution of these parameters. DAQ must work at least at 14 Hz.

HVs for powering IPMs are provided by ISEG (a priori already used at ESS). A reflection is in progress about the possibility to work IPMs in Symmetric mode with a HV module equipped with 4 channels (for instance Model EHS 4y 200x, 20 kV, 0.4 mA). Such module would allow tripping all its channels as soon as one tripped, avoiding sparking between IPM electrode and MCP, which will reinforce the reliability.

7 To be finish or resume

7.1 MCP ageing follow-up

As already written, we failed using a LED light source for this purpose. We propose to develop a software correction, but we would appreciate to resume this activity in laboratory. LED is a quite simple technique which deserves to be investigated. We may plan to find a light source better adapted, but we can also imagine to put a thin electro-emissive foil able to produce electrons extracted by the IPM electric field; it has to be compliant with cleanliness cautions.

7.2 Choice between Asymmetric or Symmetric IPM mode

Refer to paragraph 7.2

7.3 Beam background

We receive data from Beam Physics group by end of Dec. 2018. We try to analyze them in January 2019 but unsuccessfully by lack of time and also due to missing information or misunderstanding on the processing way.

After the CDR, study will be resume for evaluating the profile shape of the out of beam particles (see document ”Prototyping, design and test results of the cNPM”, paragraph XX)

8 To be done for building IPMS

8.1 Mechanics

Alignment: design and manufacture a bracket for fixing the IPM on the optical bench (see section 4.2).

IPM item drying: tools as well as brackets are required to hang them in the laminar air flux (see section 4.1.1 and 4.3).

Test Vacuum Chamber:

- A bracket has to be built for carrying the VC with its accessories like the ionic pump which is quite heavy.
- Finalization of the VC with its finger for facilitating MCP and IPM tests with a - source (see section 4.1.4)

Storage Vacuum Chamber: once ready, IPMs will be inserted by pair in a storage VC already mentioned in 4.4.

8.2 Slow pumping

Working for achieving a free particle ISO5 quality requires many precautions and knowledge of experts. One of them is the slow pumping or slow N_2 atmospheric pressure coming back which necessitates to develop a bench with specific filters.

8.3 Others

The IPM cage are made with 4 ceramics plates (Rogers RO4350): on these plates are deposited layers of copper for degraders or for electrode plates. Passivation layers have to be added in order to avoid oxidation of copper. We have to inquire which material can be used to avoid undesirable outgassing molecules.

9 Procurements

Our IPMs are made of numerous small pieces which do not represent huge amount of money. We plan to proceed by call for tender for most of them, except HV for instance.

For avoiding manufacturing defects, we plan to order items in two times: manufacturing a first set (for instance the 4 ceramic plates of the IPM cage) and once done, we will check the dimensions, voltage, resistors, soldering, for some of them outgassing... Then, if results are compliant with our expectation we will give a green light for the rest of the production, otherwise we will discuss with the manufacturer to understand the problem and to correct it. During this period, we can start the manufacturing process at Saclay with the first IPM pair already done allowing saving time.

Few procurements:

- Mechanics: manufactured CF200, CF150 flanges, CF100 glass flanges, frames in Macor, IPM cage brackets, ceramic plates with copper deposits and CMS resistors, brackets, screws (alumina ceramic)...
- Electronics: power supplies (high and Low voltage), HV connectors, double stacked MCPs with phosphorescent screen, copper cables for HV connection to IPM cage (with, or not, ceramic beads), connection boxes for very HV...
- Optics: CMOS cameras, lenses, sight targets...
- Vacuum: tools for slow vacuum pumping, dry primary pump for IPM storage, ionic pump, gas regulating valves, specific filters...
- Personal equipment: lab coats, gloves, shoe covers, mobcaps, masks...

10 Risks

The updated risk table, as it appears in the Risk Portfolio, is summarized below:

Current risks

RR3-PM2 - Owner CEA - Rating: before mitigation=32, after mitigation=8	
”As a result of” ...	Ultra high vacuum and high energy of the proton beam
”There is a risk that” ...	Ratio S/N too low and NPM not reaching expected performance with the foreseen technology
”Resulting in” ...	Another monitoring system to develop Mitigation strategy Trade-of for 2 RO solutions (100%) + Proto tests (2 options on IPHI - end 2018) (50%)
CRR3-PM3 - Owner CEA - Rating: before mitigation=8, after mitigation=4	
”As a result of”...	Lack of space between the cryomodules devoted to NPM
”There is a risk that”...	NPM unable to measure X and Y profiles in the same diagnostic box
”Resulting in”...	bad performance / new concept, but X and Y not measured simultaneously
Mitigation strategy	1 channel instead of 2, but with a rotation system for X and Y profile measurements
RR3-PM4 - Owner CEA+ESS - Rating: before mitigation=32, after mitigation=8	
”As a result of”...	Uncorrelated proton beam can induce ionization at NPM location which imply background noise
”There is a risk that”...	Reduction of Ratio S/N
”Resulting in”...	Extra studies for characterization or another monitoring system, upstream scrapper aperture optimization
Mitigation strategy	Background to be characterized: uniform distribution or not (25%)
RR3-PM6 - Owner CEA+ESS - Rating: before mitigation=32, after mitigation=8	
As a result of	Too weak FEE radiation shielding in the CM support
”There is a risk that”...	Drastic reduction of S/N ratio
”Resulting in”...	no data transferred to DAQ system
Mitigation strategy	Radiation map from ESS (100%) but not accurate enough. Implement shielding in FEE (25%). Experimental data (0%)
RR3-PM7 - Owner CEA+ESS - Rating: before mitigation=16, after mitigation=1	
”As a result of”...	very high voltages (up 30 kV), sparking effects may appear leading to reduce HV for decreasing them
”There is a risk that” ...	Larger distortion (width) of profile measurement due to the Space Charge effect
”Resulting in”...	degradation of profile measurement
Mitigation strategy	Software space charge benchmarking to perform on IPHI (25%) + Software correction developed by Francesca (75%)

For potential hazard, only very high voltages were mentioned. Today, this risk was minimized by using new HV connectors with a surrounding insulator on the female connector cable head,

Transferred risk to ESS

RR3-PM5.1 - Owner ESS - Rating = 32	
"As a result of"...	Vacuum chamber CDR 3wks after NPM kickoff ¿ chamber design as a constraint
"There is a risk that"...	Read Out difficult to integrate in the vacuum chamber design
"Resulting in"...	Vacuum chamber to be modified
Transfer	CEA has notified ESS previously to VC CDR (VC modification proposed)
RR3-PM5.2 - Owner ESS - Rating 32	
"As a result of"...	Vacuum chamber CDR 3wks after NPM kickoff ¿ chamber design as a constraint
"There is a risk that"...	Generation of sparks for very high voltages
"Resulting in"...	Vacuum chamber to be modified
Transfer	CEA has notified ESS previously to VC CDR (VC modification proposed)

Closed risk

RR3-PM1 - Owner CEA	
"As a result of"...	Budgetary or operational reasons (ESS)
"There is a risk that"...	Decision to implement NPM taken too late
"Resulting in"...	Expenses with no concrete use, no conservative measures taken in current design
RR3-PM5 - Owner CEA+ESS	
"As a result of"... LINAC4. Schedule constraints	Proto tests on IPHI
There is a risk that	Full qualification of the NPM prototype not ready for CDR
"Resulting in"...	delaying the CDR to achieve the prototype characterization

which avoid any contact with the male connector fixed on the flanges. Moreover, all connectors with bare ceramics and bare conductor will not be used anymore (see Fig. 9).

(a) (b)

Figure 9: Old bare conductor able to sustain 30kV (a) and protected HV (b) with model going up to 25kV.

11 Planning

Hereunder is the planning of the NPMs; end of installation of cNPM LWUs is the latest version on ESS CHESS database. These dates are superimposed (green) on the cNPM project planning.

A first glance shows that IPMs will be delivered before the LWU installation completion date for Spoke and MBL. We should be late by 2 months for the HBL.

If actual planning remains, mitigation can be found in the qualification procedure described in paragraph 4. Indeed, with additional manpower the cleaning, assembling and testing (paragraph 4.1) can be done with one assembly while another one will be aligned, cleaned and packed (paragraphs 4.2, 4.3 & 4.4).

Note that there is no spare IPM foreseen.

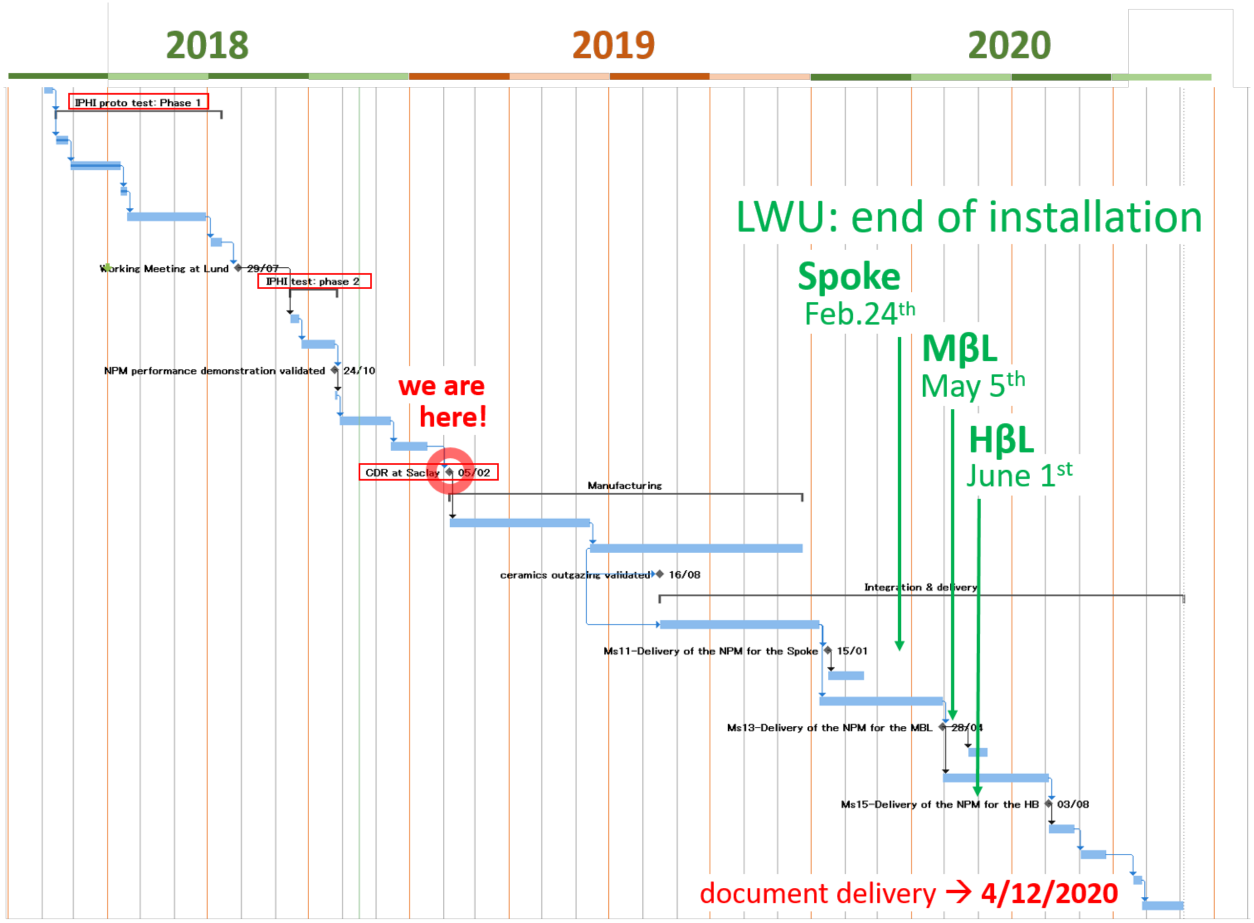


Figure 10: NPM and LWU plannings

12 Conclusion

This report deals with the activities we have to deploy for the manufacturing of 5 cNPM based on the hypothesis that read-out is insured by pMCP and appropriate optical system and camera.

The necessary tasks for starting with a set of IPM items and finishing with the storage of an IPM pair packaged in a storage box is detailed. It follows the recommendations of our CEA experts colleagues who are in charge of few ESS cryomodules design and who, like us, are submitted to cleanliness ISO 5. In the rest of the report, we have tried to cover proposed evolution w.r.t what was done or taken during IPHI test beam. We have also identified a change request concerning LWU which has to be settled.

Finally, Interfaces, procurement procedures, the risk table and the planning are also included. For this later, the planning we have shown at Lund in November 2018 seems to be compliant with the ESS planning of LWU implementations.