
CERN

Amorphous carbon thin film coating of the SPS beamline: evaluation of the first coating implementation.

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Amorphous carbon thin film coating of the SPS beamline

1. Motivation
2. Carbon coatings to mitigate e-cloud
3. Implementation strategy
4. The coating setup
5. Results
6. Summary

1. Motivation

- SPS beam parameters

Beam structure 25 ns, 4x72b	**P (GeV/C)**	**N_b (10^{11})**
Nominal for LHC	450	1.2
High Luminosity LHC (HL-LHC)	450	2.3

Performance will be limited by instabilities due to electron cloud

1. Motivation

How to mitigate e-cloud?

- Clearing electrodes.
- Axial magnetic fields to keep secondary electrons close to the wall.
- Decrease the Secondary Electron Yield (SEY) of the beam pipe walls.

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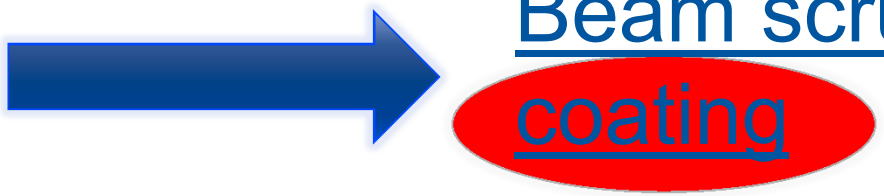

1. Motivation

LIU-SPS Scrubbing Review 8-9TH September 2015: Conclusions and Recommendations

W. Fischer (BNL, review chair), Y. Suetsugu (KEK), K. Cornelis, J.M. Jimenez, M. Meddahi, F. Zimmermann (CERN)

Recommendation

Use a staged, partial deployment of aC coating to reach performance target:

- Take benefit of the impedance reduction activities to coat the corresponding elements (Quads and SSS)
- Replace any miss-functioning magnets by one with a aC coated chamber
- Make aC coating of MBB dipoles the baseline, until there is high confidence that scrubbing alone can establish LIU and HL-LHC performance goals
- Investigate feasibility of replacing standard drifts by coated chambers, with low impact

The following implementation timeline can be used:

(E)YETS:

- Pilot run (1 arc) for QF+SSS aC coating and impedance reduction;
- MBB coating for limited cells;

W. Fischer, et. al. " LIU-SPS Scrubbing Review: Conclusions and Recommendations", CERN 8-9 September 2015, CERN EDMS LIU-PM-RTP-0023

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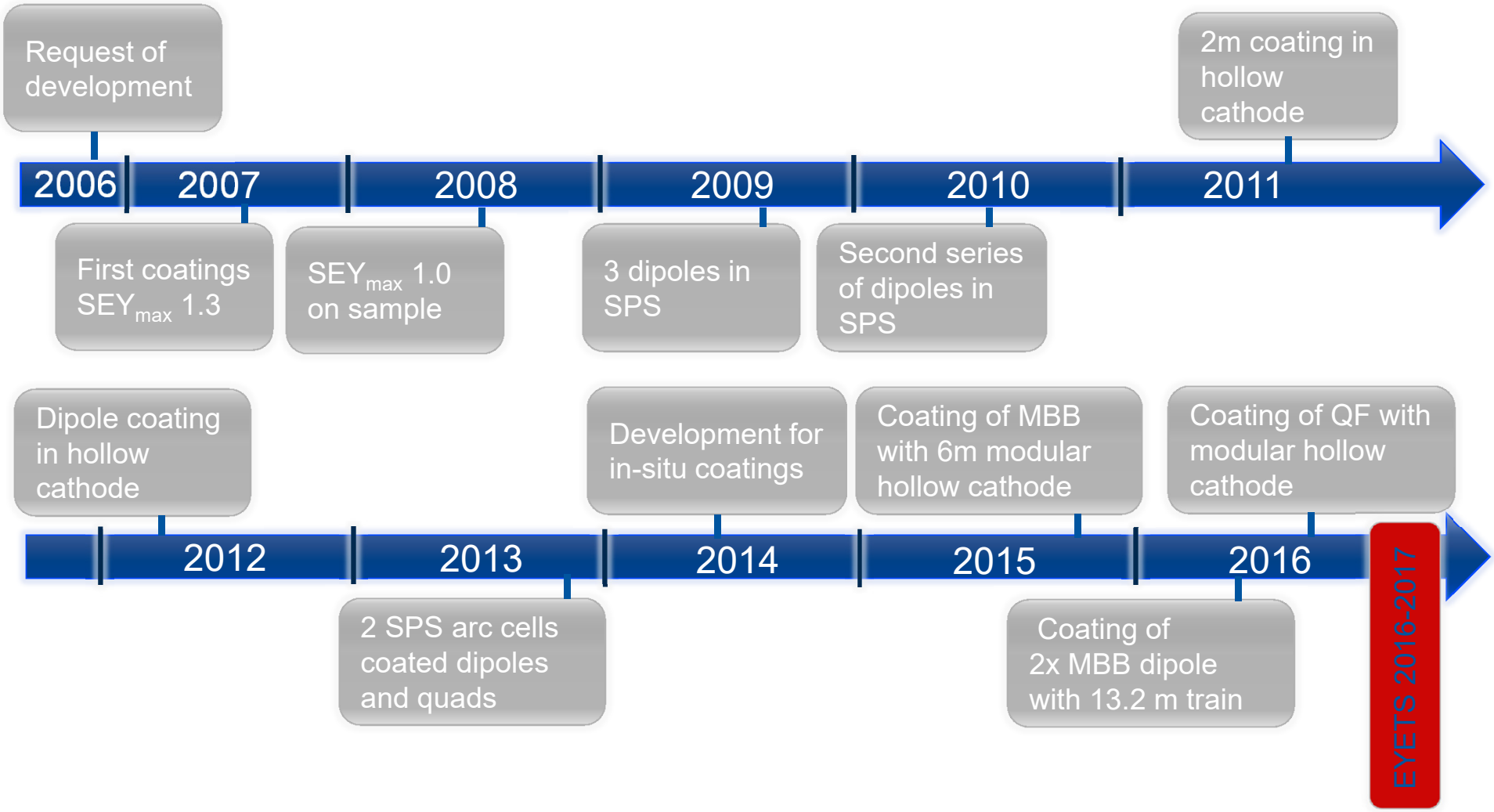
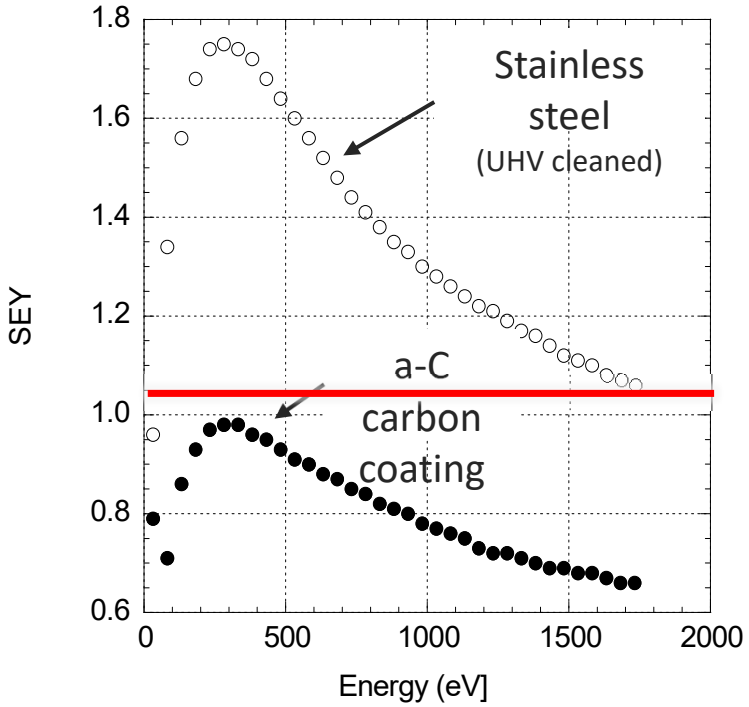
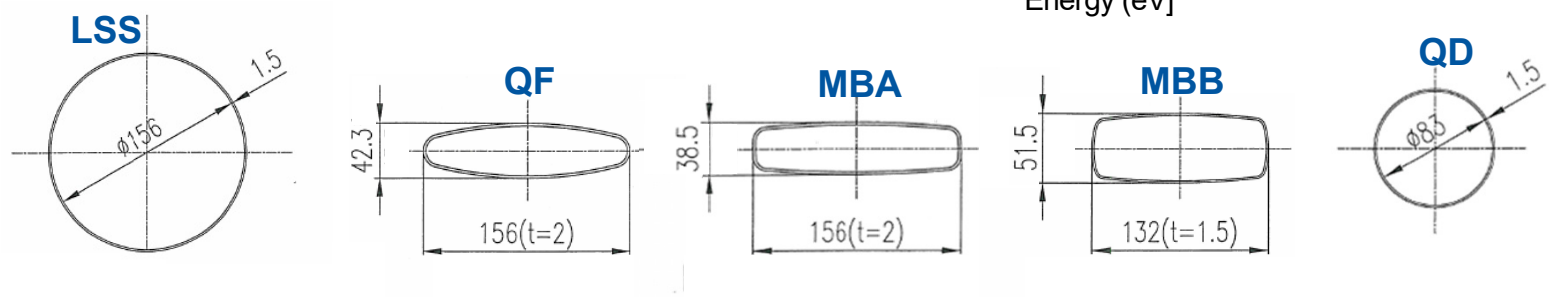
2. Carbon coatings to mitigate e-cloud



2. Carbon coatings to mitigate e-cloud

Machine element	Fraction of the machine	Multipacting threshold (SEY)
MBA dipole magnet	32.8 %	1.60
MBB dipole magnet	35.0 %	1.40
QF quadrupole magnet	4.8 %	1.30
QD quadrupole magnet	4.8 %	1.05
LSS	4.1 %	1.20



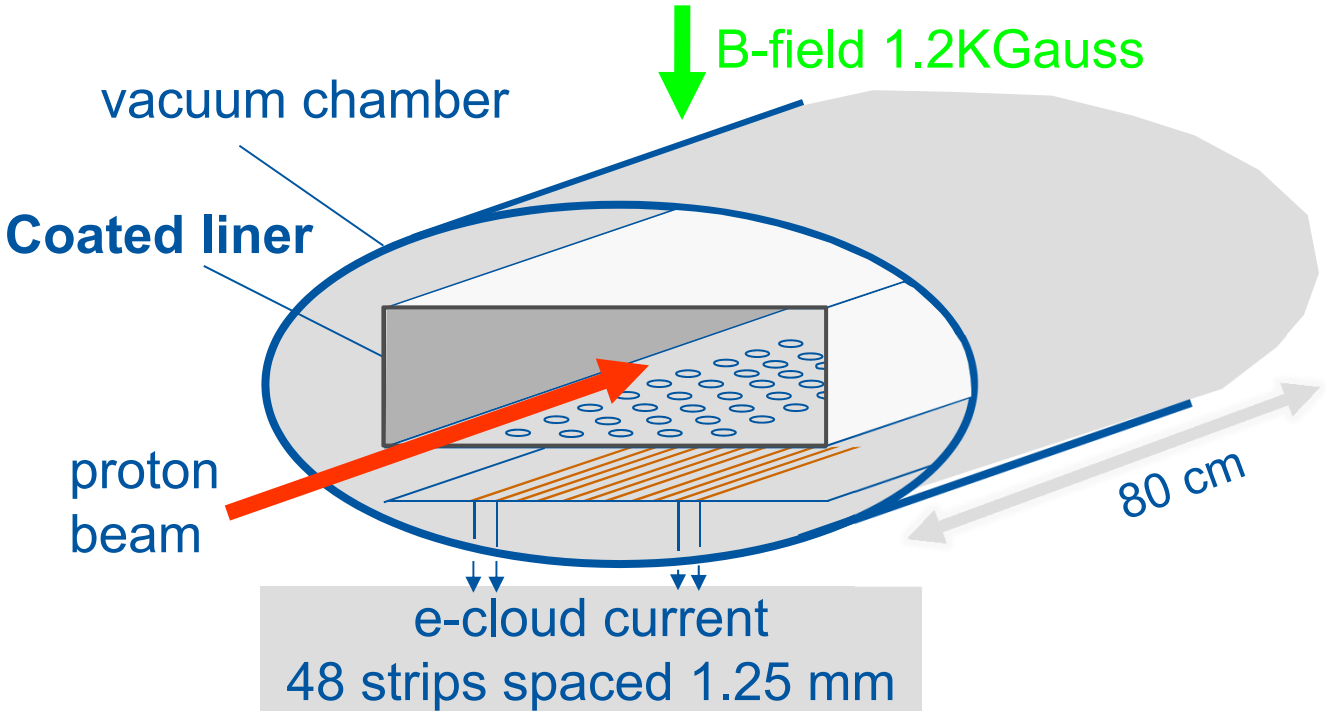


Results of PyECLOUD simulations, courtesy of A. Romano, G. Iadarola, G. Rumolo and K. Li

2. Carbon Coatings to mitigate e-cloud

Electron cloud current in the SPS with an electron cloud detector

The B-field of 1.2 kGauss corresponds to the field of the SPS dipoles at injection energy (26 GeV)



C. Yin Vallgren et al. “Amorphous Carbon Coatings for the Mitigation of Electron Cloud in the CERN SPS” Phys. Rev. ST Accel. Beams 14, 071001 (2011)

2. Carbon Coatings to mitigate e-cloud

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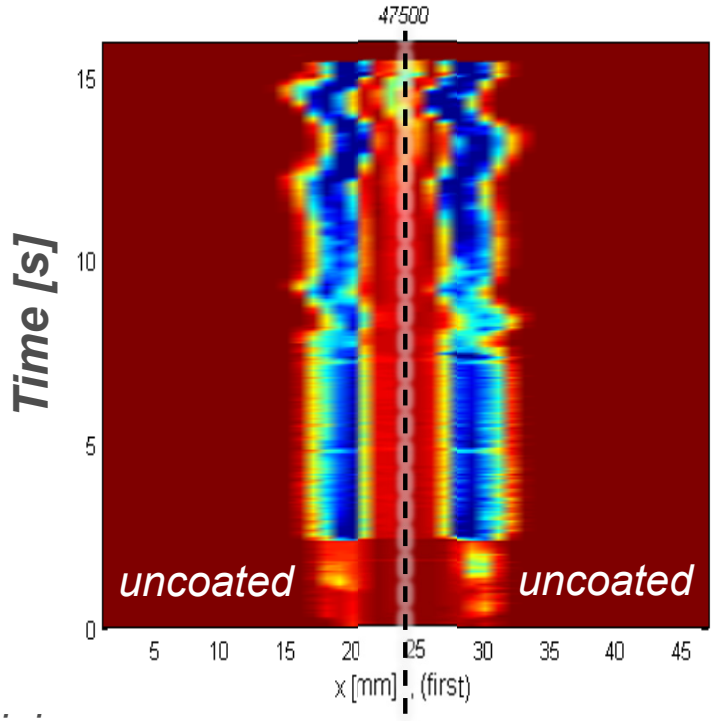
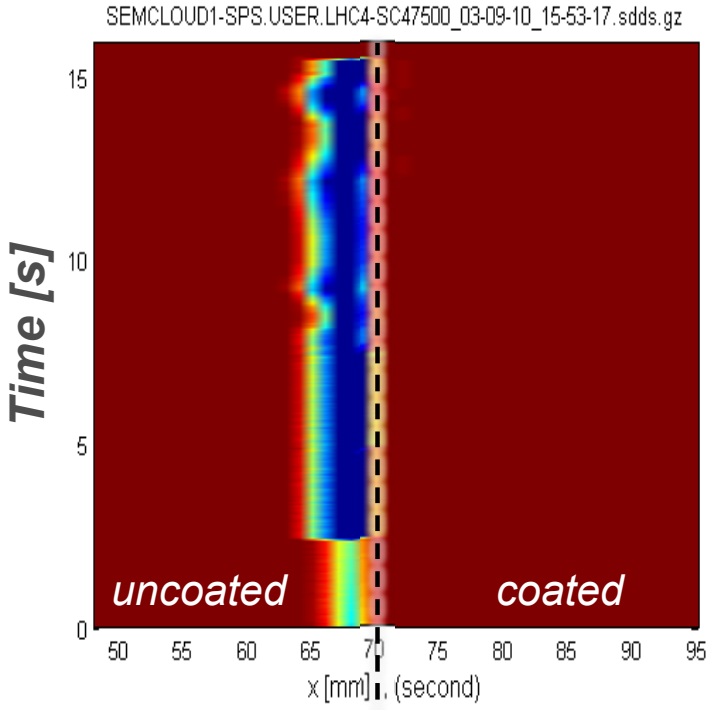
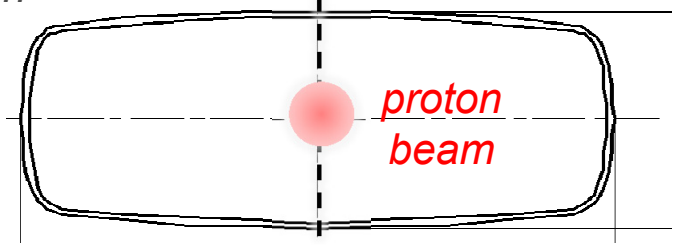
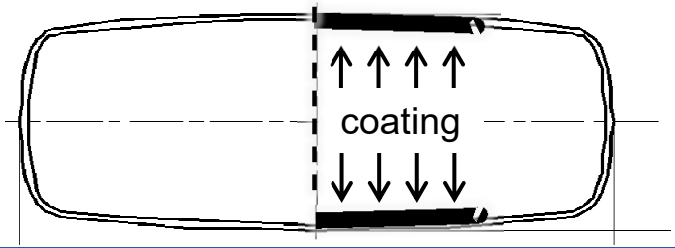




Beam
Cross section



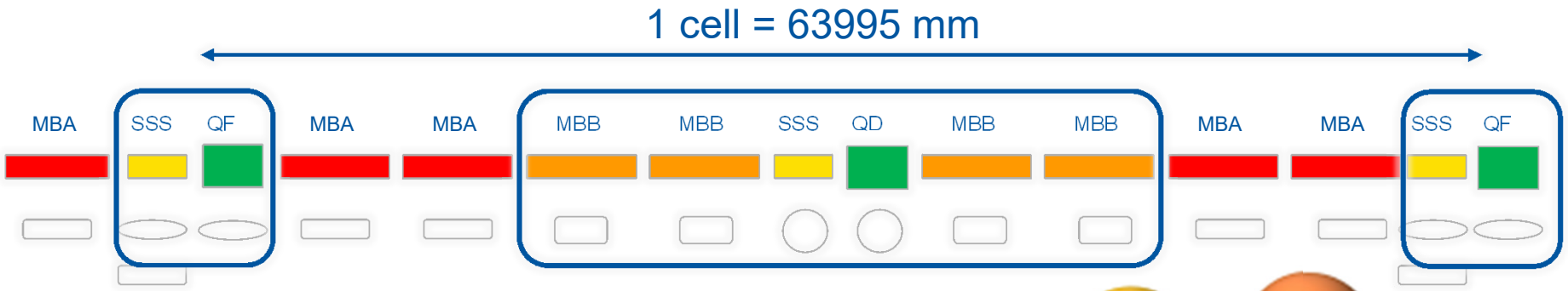


3. Implementation strategy

The Super Proton Synchrotron

3. Implementation strategy

Layout

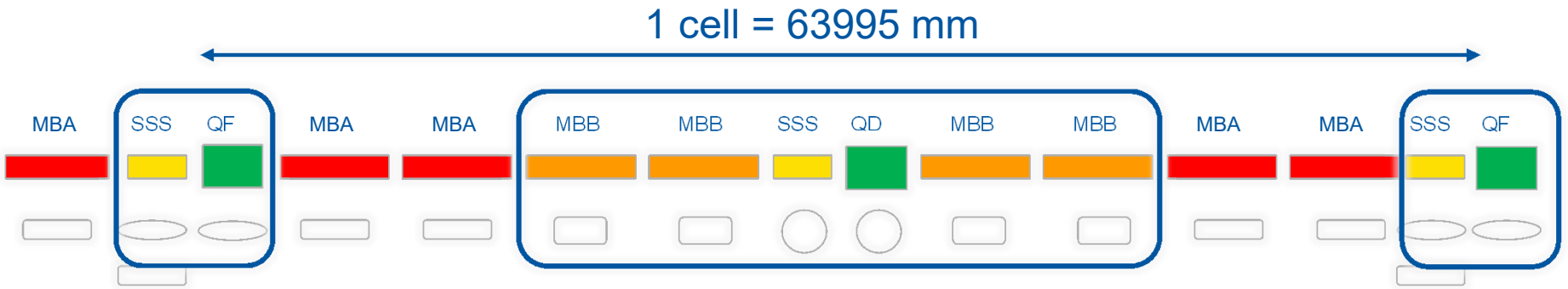


Risk & cost optimisation:

- Ranking components by “e-cloud”

3. Implementation strategy

Layout

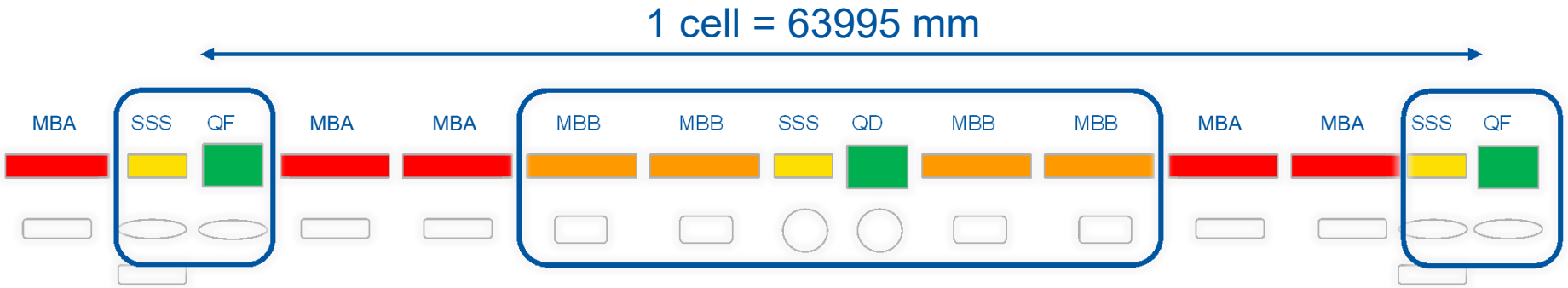


Risk & cost optimisation:

- Ranking components by “e-cloud”
- In-situ coating approach
- Minimize transport/removal of magnets from the tunnel

3. Implementation strategy

Layout



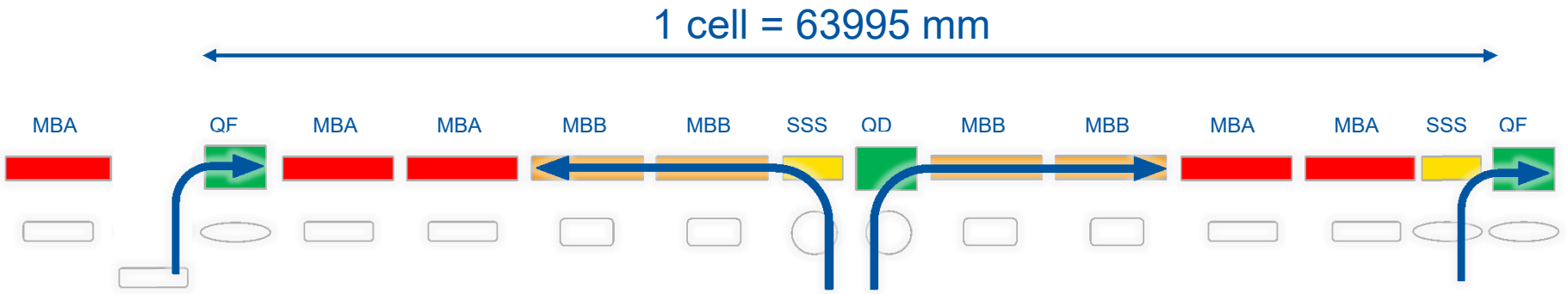
To do list for EYETS 2016-2017

- 4 MBB pairs
- 2 QD's and adjacent SSS
- 9 QF's and adjacent SSS
- LSS of sector 440 (27 m)

Totalling 33 coating runs

3. Implementation strategy

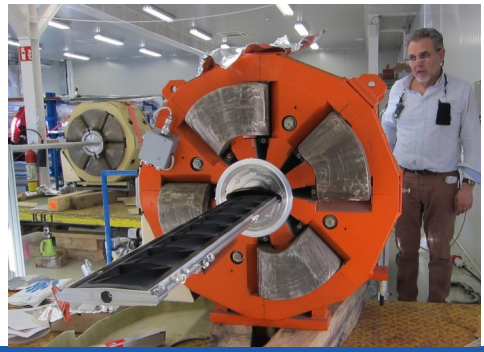
Logistics



Coating lab 1

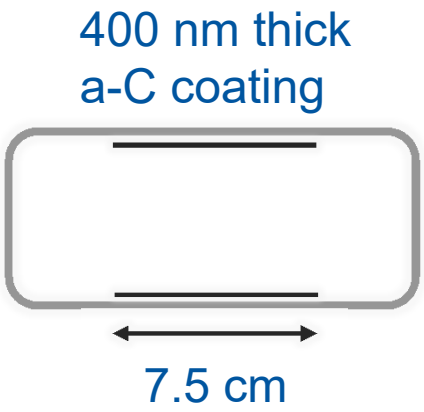
+ new drift tubes

Coating lab 2 (radioactive)



4. The coating setup

MBB hollow cathode train



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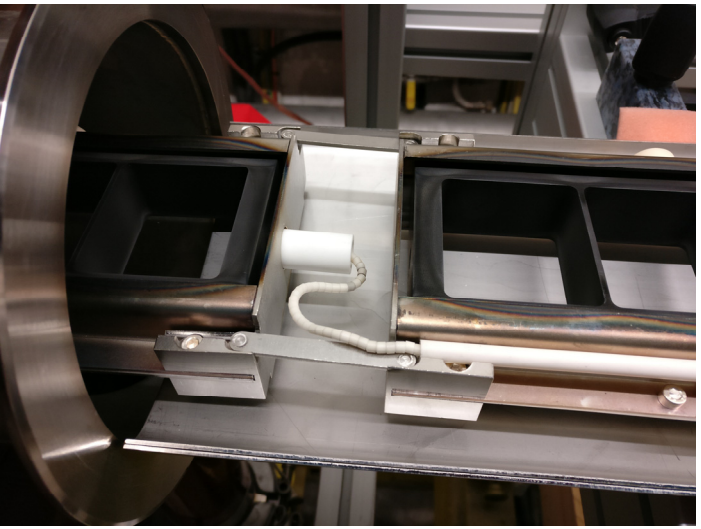
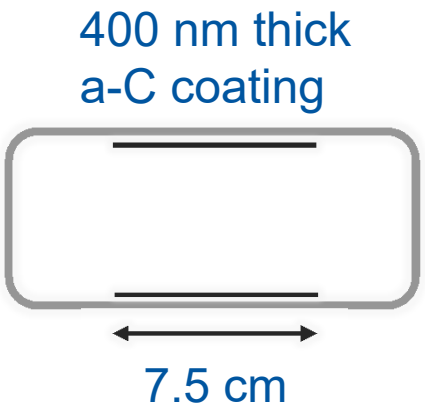
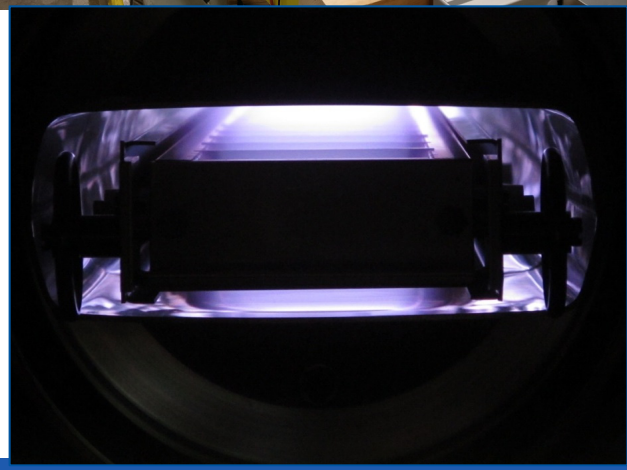




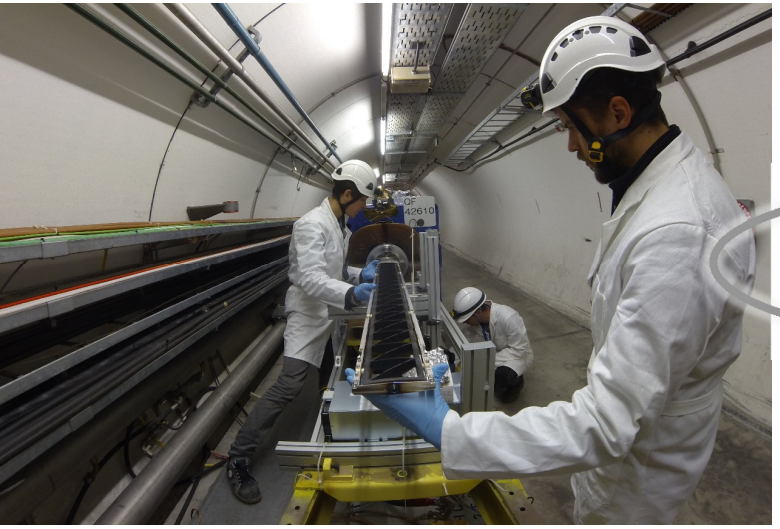
Coating setup

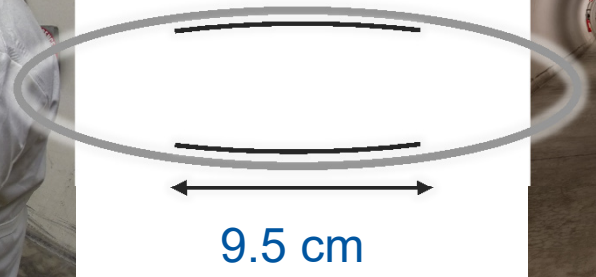


- 13.2 m long modular train for MBB
- 2 power supplies
- Continuous movement back and forward (A = 12 cm) during coating process
- Coating process takes 22 h

4. The coating setup

QF hollow cathode train



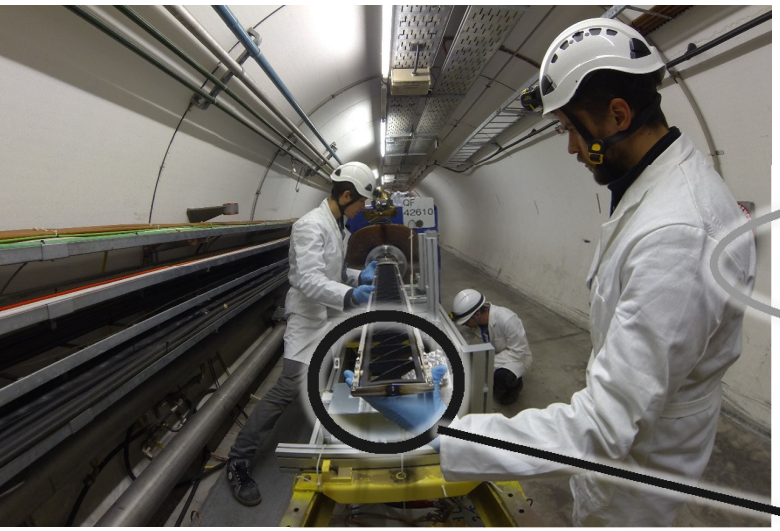


Coating setup

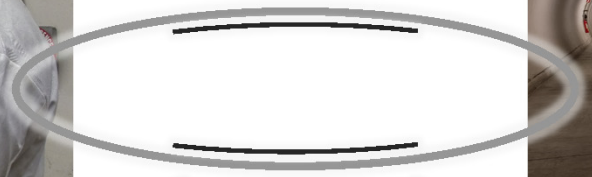
- 3.2 m long modular train for QF
- 1 power supply
- Continuous movement back and forward (A = 12 cm) during coating process
- Coating process takes 22 h

4. The coating setup

QF hollow cathode train



400 nm thick
a-C coating



9.5 cm

Coating setup

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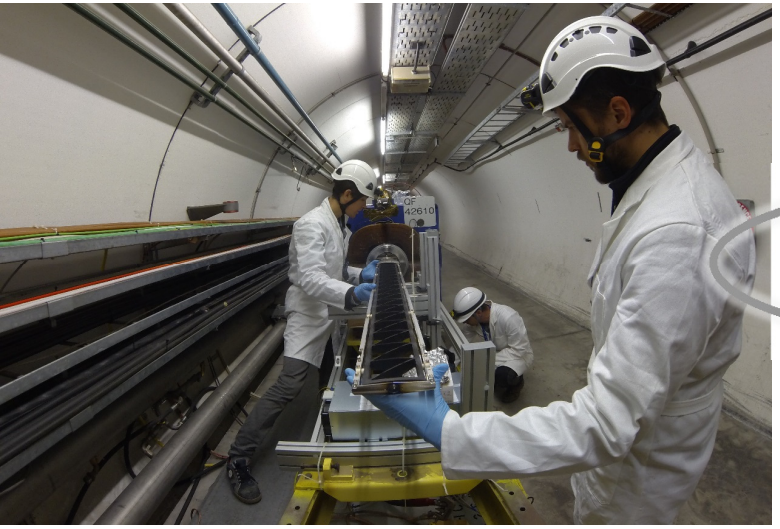
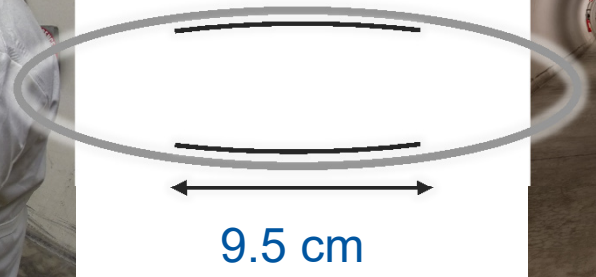
QF hollow cathode train





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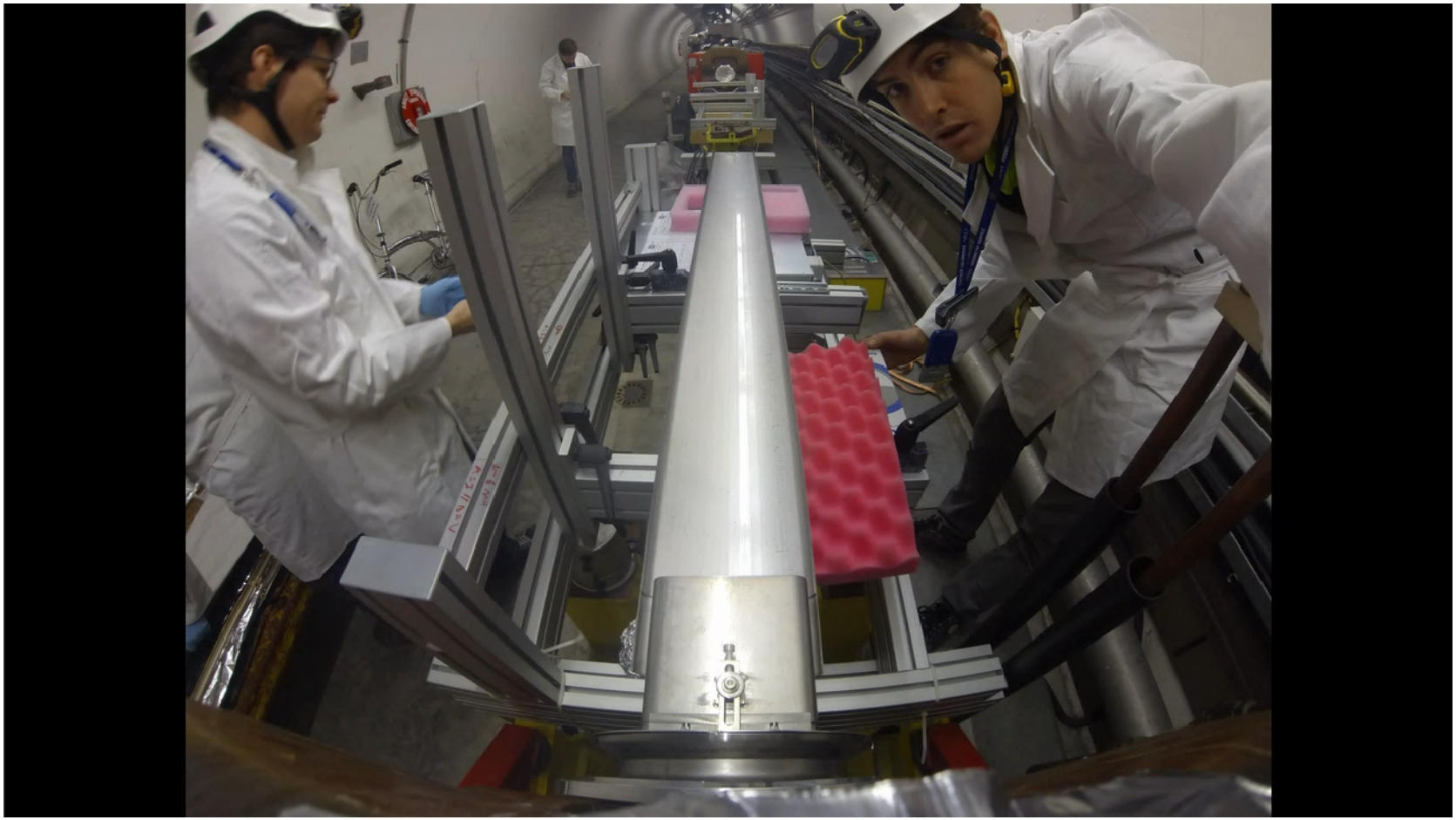
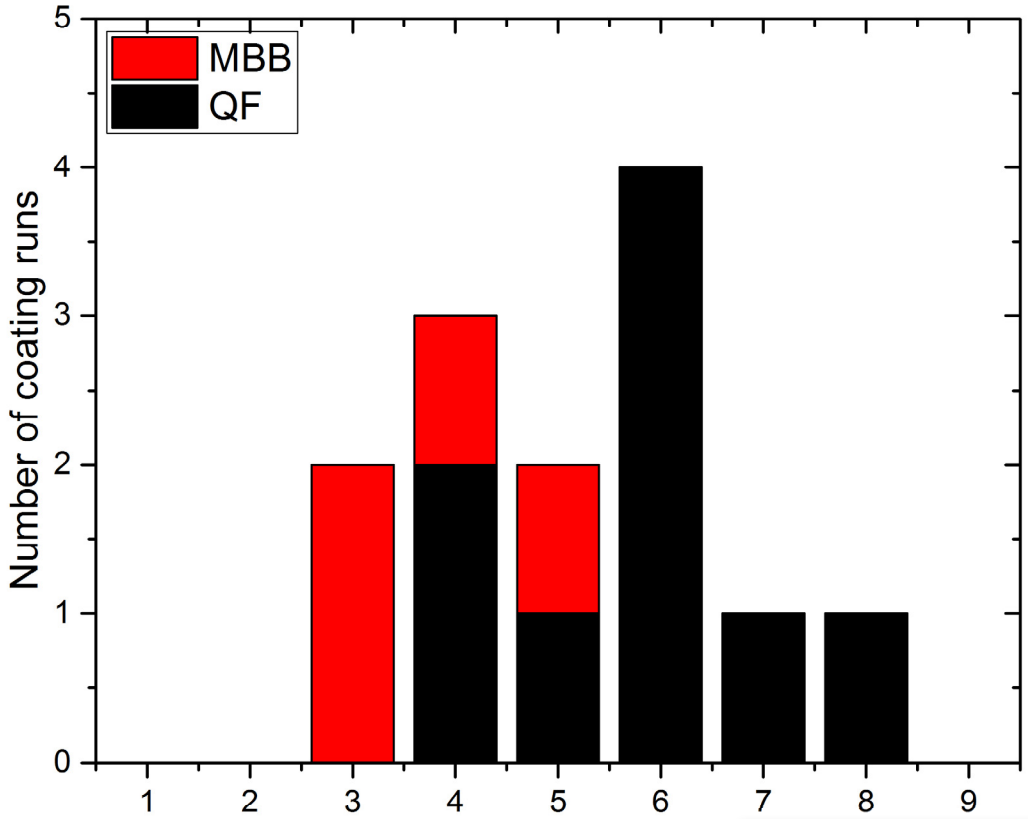


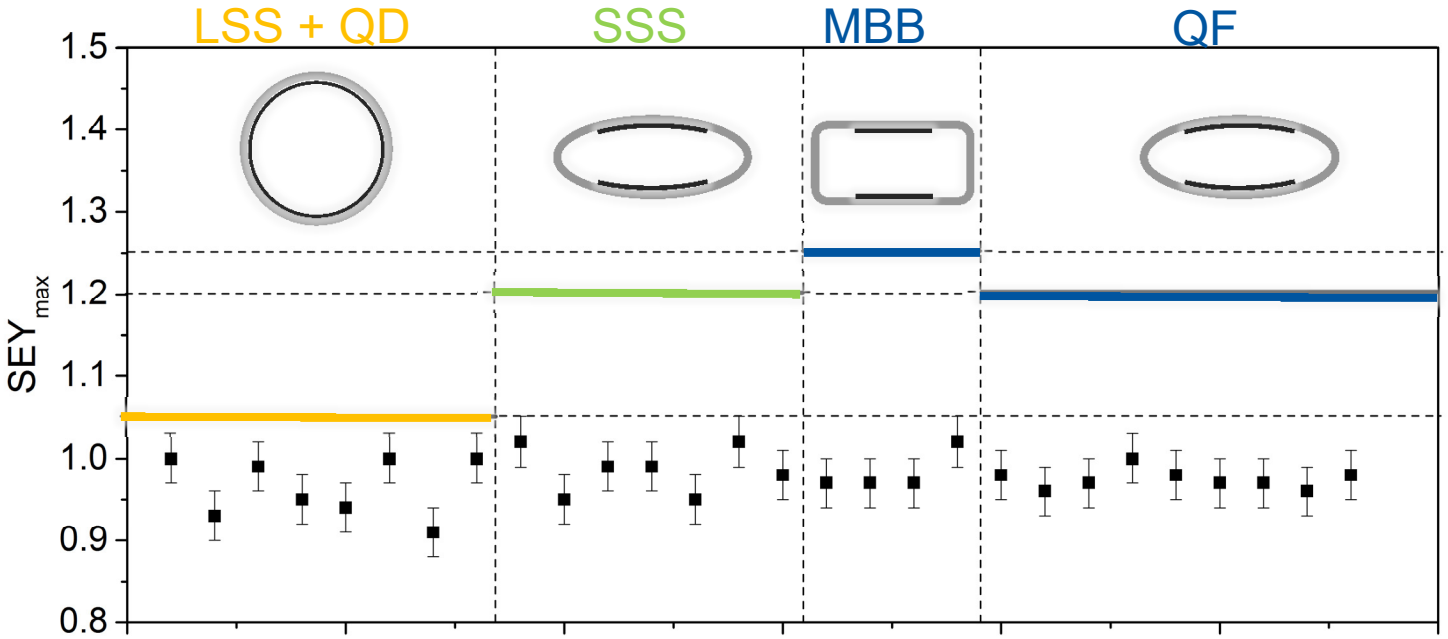
5. Results



Start on Wed 04/01

End on Thu 23/02

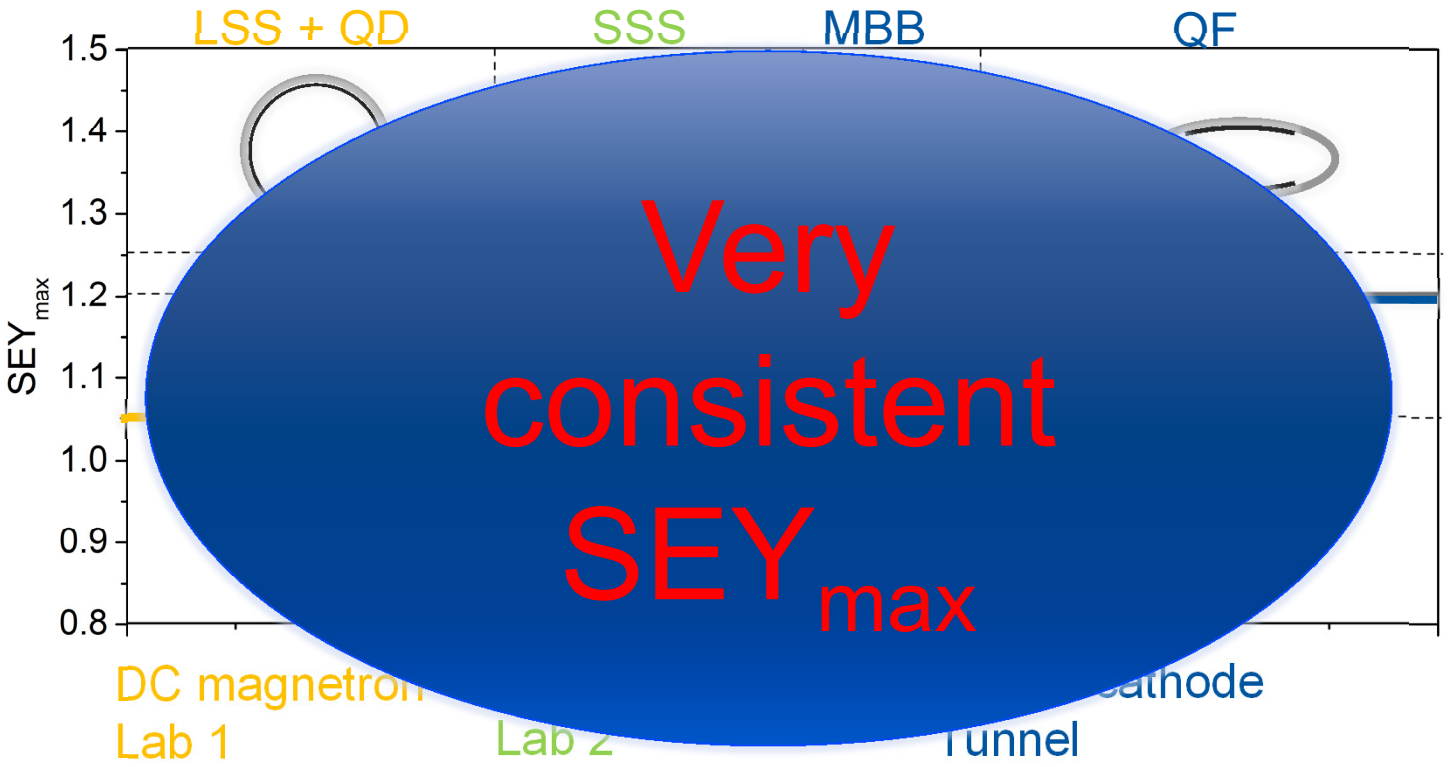
5. Results



	DC magnetron Lab 1	Hollow cathode Lab 2	Hollow cathode Tunnel
$\overline{SEY_{max}}$ =	0.97	0.99	0.98
σ =	0.03	0.03	0.02

accuracy on SEY measurement is ± 0.03

5. Results



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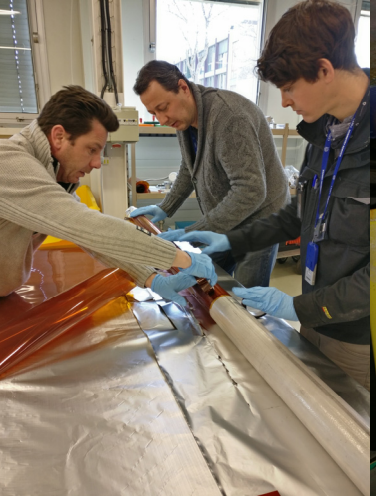
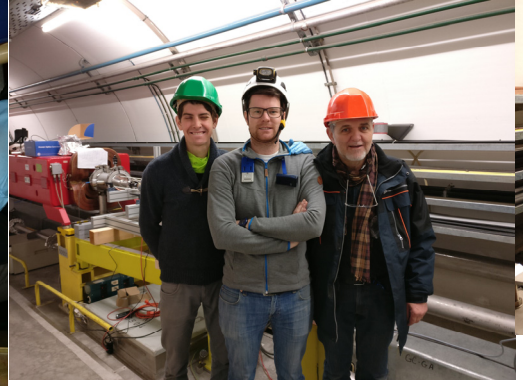
6. Summary

- First successful in-situ coating campaign in Jan & Feb of 2017.
- The a-C coating technique has proved its scalability to an industrial process.
- SPS is running smoothly since 24/04/2017.
- If scrubbing does not mitigate the e-cloud sufficiently, the coating technique is ready for full scale implementation.






Thanks to all teams and