DAΦNE Preparation for the SIDDHARTA-2 Run

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on behalf of the DAFNE Team

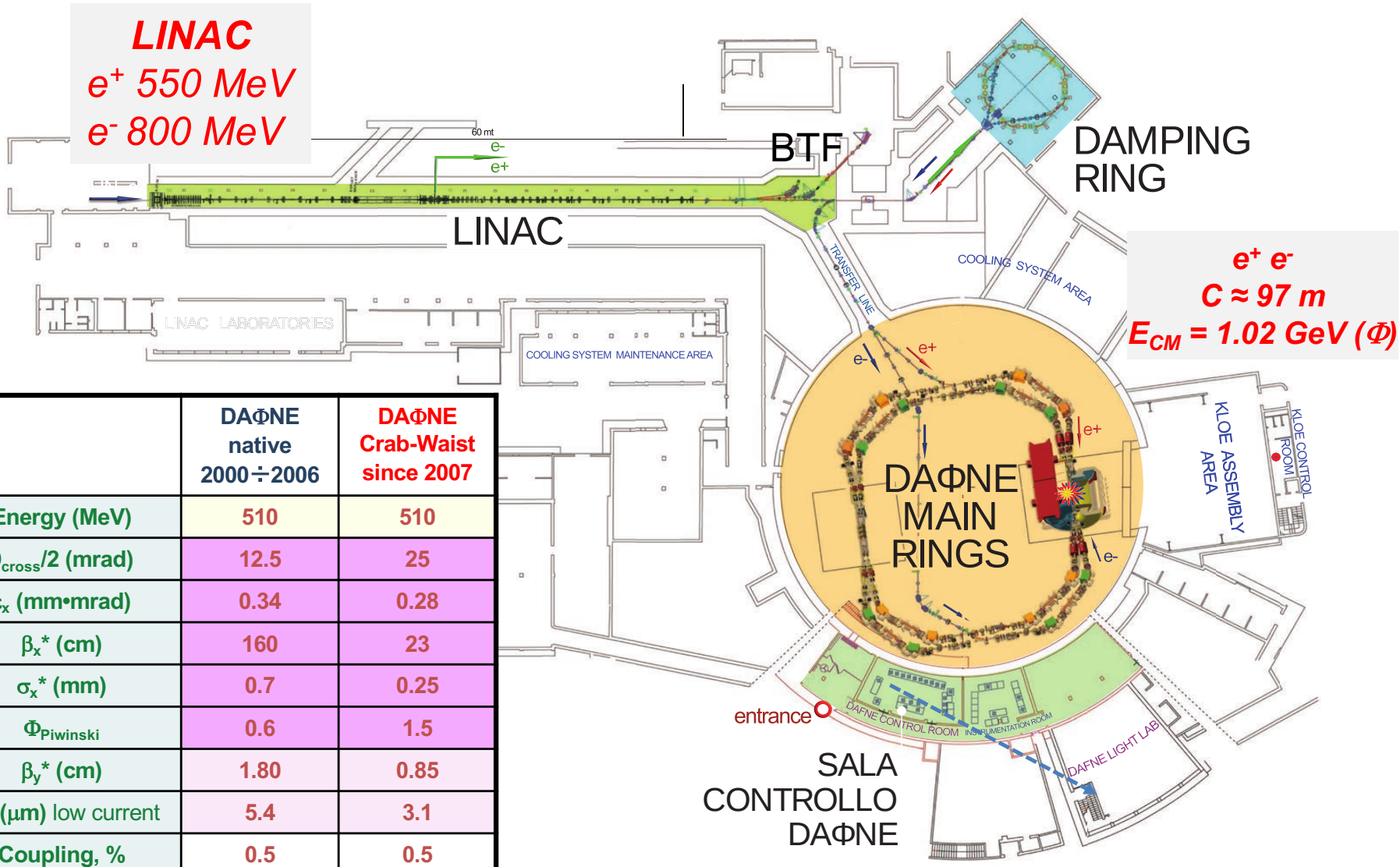
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

57th Scientific Committee Meeting May 9 -10, 2019

Outline

- *DAΦNE overview*
- *PMQDs realization, qualification measurements and optimization*
- *Preparation for the SIDDHARTA-2 run*
- *DAΦNE plan*
- *Conclusions*

The DAΦNE Accelerator Complex



	DAΦNE native 2000÷2006	DAΦNE Crab-Waist since 2007
Energy (MeV)	510	510
$\theta_{cross}/2$ (mrad)	12.5	25
ε_x (mm•mrad)	0.34	0.28
β_x^* (cm)	160	23
σ_x^* (mm)	0.7	0.25
$\Phi_{Piwinski}$	0.6	1.5
β_y^* (cm)	1.80	0.85
σ_y^* (μm) low current	5.4	3.1
Coupling, %	0.5	0.5
Bunch spacing (ns)	2.7	2.7
I_{bunch} (mA)	13	13
σ_z (mm)	25	15
N_h	120	120

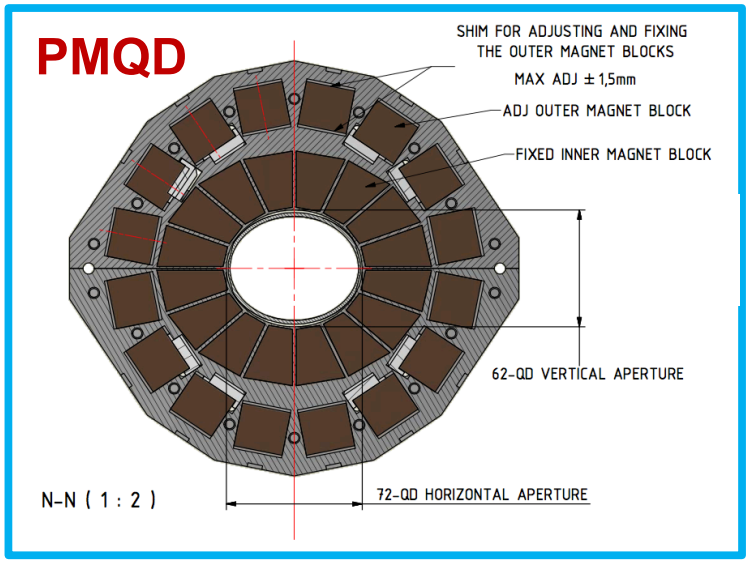
DAΦNE implemented and tested succesfully a new approach to beam-beam interaction: the ***Crab-Waist*** **collision scheme**.

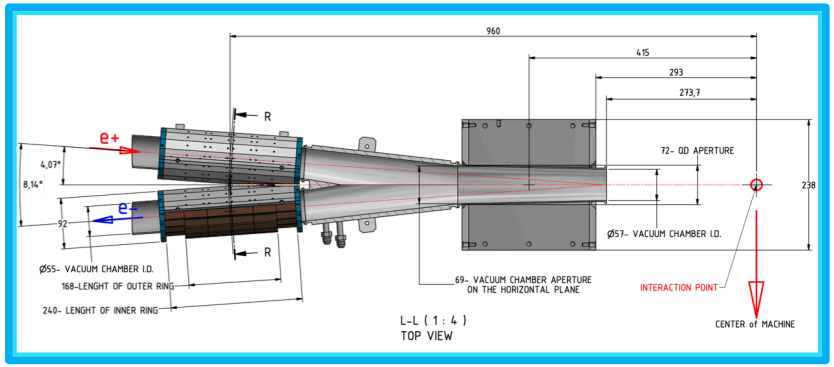
Situation at last SciCom

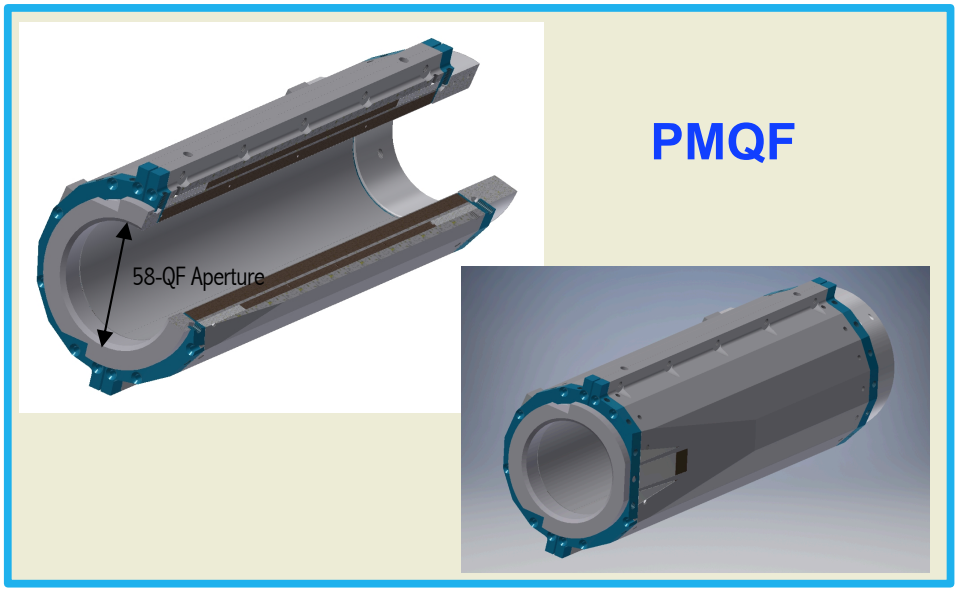
Characterization and Optimization of the PMQDs for the new SIDDHARTA-2 IR

PMQs specifications

New PMQs are Halbach type magnets made of SmCo2:17
PMQs have been designed in collaboration with the ESRF magnet group.





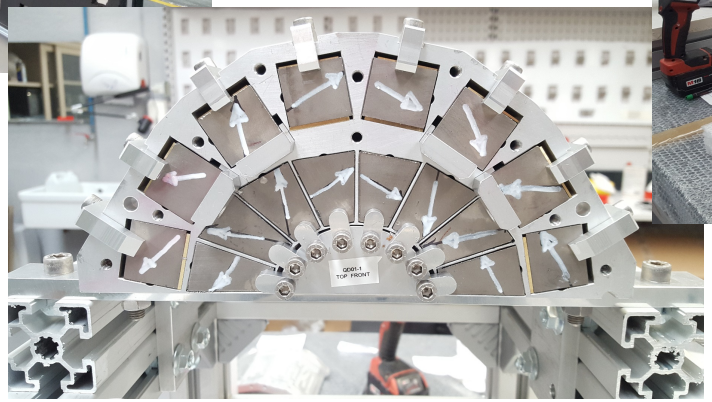


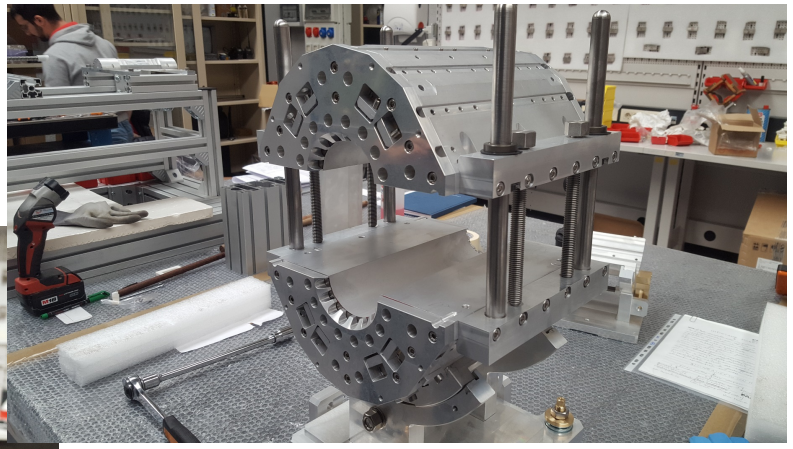
	PMQD	PMQF
Beam Pipe Aperture H-V (mm) at IP (I row) and at Y (II row) side	57 69 - 55	54
Inner Apert. With Case H-V (mm)	72 - 62	58
Outer Diameter H-V (mm)	238 - 220	95.6
Mech. Length Inner-Outer (mm)	220	168 - 240
Nominal Gradient (T/m)	29.2	12.6
Integrated Gradient (T)	6.7	3.0
Good Field Region (mm)	±20	±20
Integrated Field Quality |dB/B|	5.00E-4	5.00E-4
Magnet Assembly	2 halves	2 halves

PMQD Assembly at LNF

- PM blocks delivered at LNF on Dec 20th
  512 blocks for PMQDs and 1024 for PMQFs plus spares
- Cases started to be delivered to LNF on Jan 15th 2019
- Mechanical qualification
- Assembly by using custom developed tools
- PMQD1 upper half completed on Jan 24th 2019
- PMQD1 closed on Jan 30th 2019

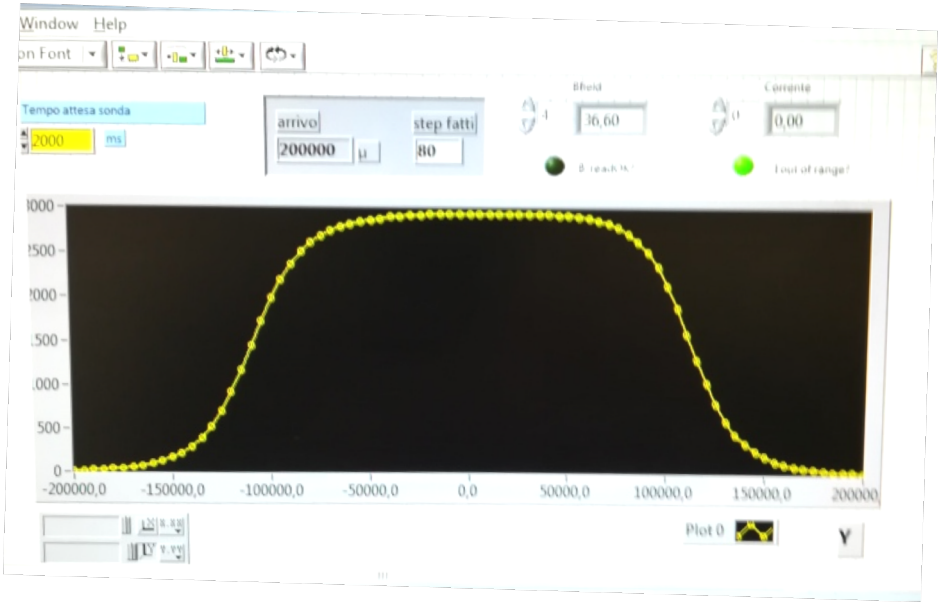
- Feb. 1st 2019 both PMQDs ready for preliminary magnetic characterization

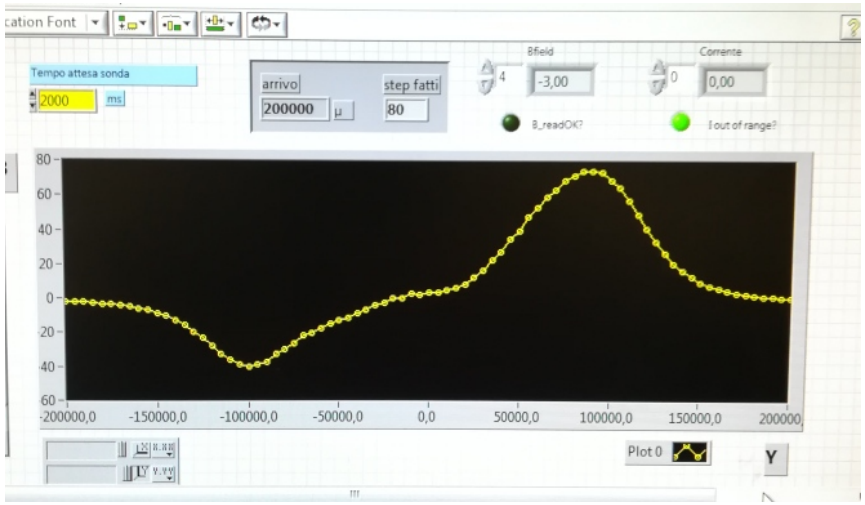




PMQD Magnetic Measurements at LNF

Hall probe preliminary measurements





Leaving for Grenoble (on Feb. 5th)

Magnetic Characterization at Grenoble

Stretched wire measurement outlined:

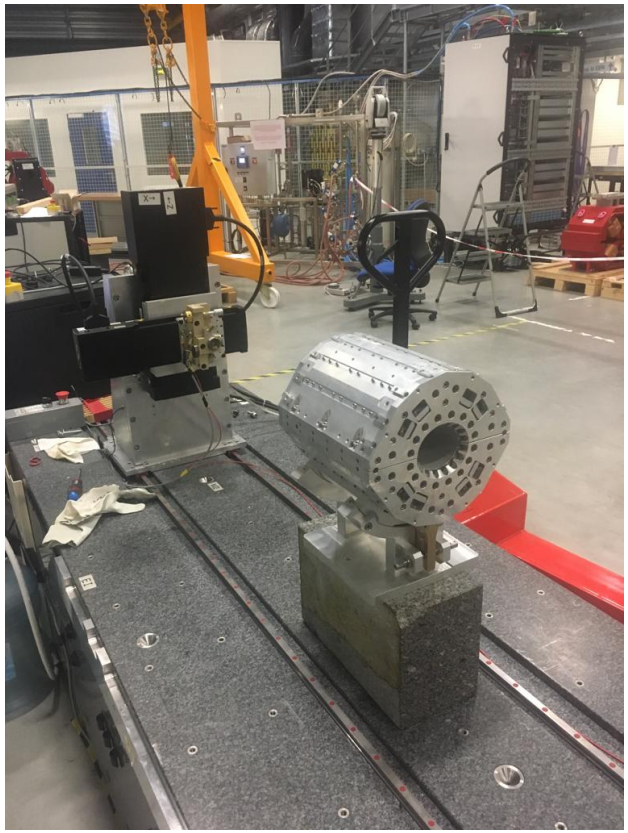
- a slight difference in the integrated gradient strength wrt the nominal value 6.55 T (**6.64 T**)
- some multipole strengths out of specification

multipole terms were comparable for the two PMQDs:

Skew Sextupole
Octupole
Dodecapole

Measurements done on two different benches and analyzed by using different approaches returned the same results

Benchmark the RADIA code with measurements



Magnetic Characterization at Grenoble

Waiting for the vibrating wire measurements after the umpteenth frantic shift of 2-3 hours required to open, disassembly, shim, and close the PMQD again.

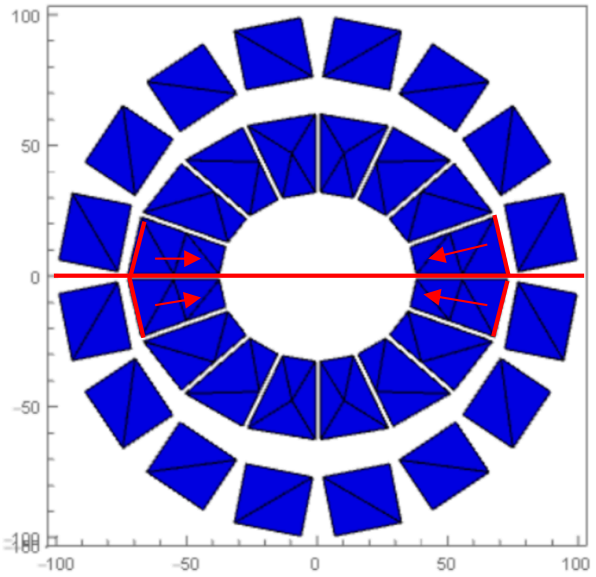
(From the left: L. Pellegrino, M. Vannozzi, and C. Milardi, LNF; J. Chavanne, and G. Le Bec, ESRF. G. Sensolini captured the moment!)

Magnetic Characterization at Grenoble

(on Feb. 25th 2019)

Largest part of the imperfections have been recovered by:

- machining the two halves of the PMQD cases in order to remove 200 micron of Al from the bottom of each half case
- shimming four lines, the first and the last for each PMQD half, in the inner wedge ring by adding 200 μ thick shims in order to move the wedges inward



Fine optimization can be done by tuning the position of the outer blocks

PMQD Normal Multipoles Tuning

Relying on simulations:

- 200 μ thick shims inserted on the sides outlined in yellow
- 100 μ thick shim added between the two case halves on both sides

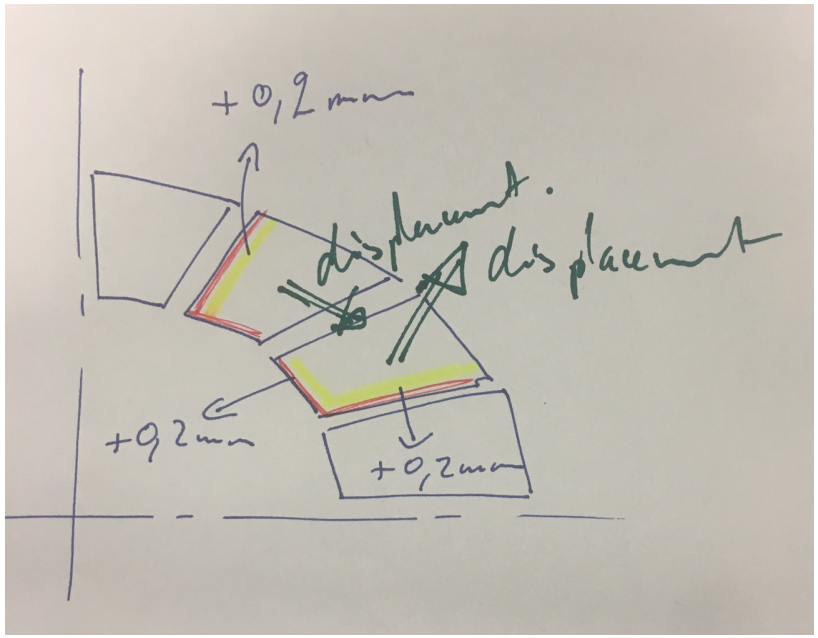


Table1:bnNorm_20mm,anNorm_20mm,...

Unused

Point	bnNorm_20mm	anNorm_20mm	anNorm_20mm
0	-1.43116	18.8631	19.0341
1	10000	54.0269	54.0314
2	-1.14889	-6.2003	-6.13922
3	-0.449526	-7.81696	-7.80919
4	-2.54913	2.52048	2.51761
5	0.374998	4.97588	4.93123
6	-1.82423	-0.825834	-0.794584
7	-1.06677	-0.057609	-0.0389705
8	0.250973	0.921782	0.912823
9	1.32602	0.227595	0.22886
10	0.117723	-0.0458886	-0.0562637

Mainly to correct the 12-pole term

PMQD Skew Multipoles tuning

(Feb 25th 2019)

Relying on simulations

- All the inner blocks are moved in each sector according to the drawing

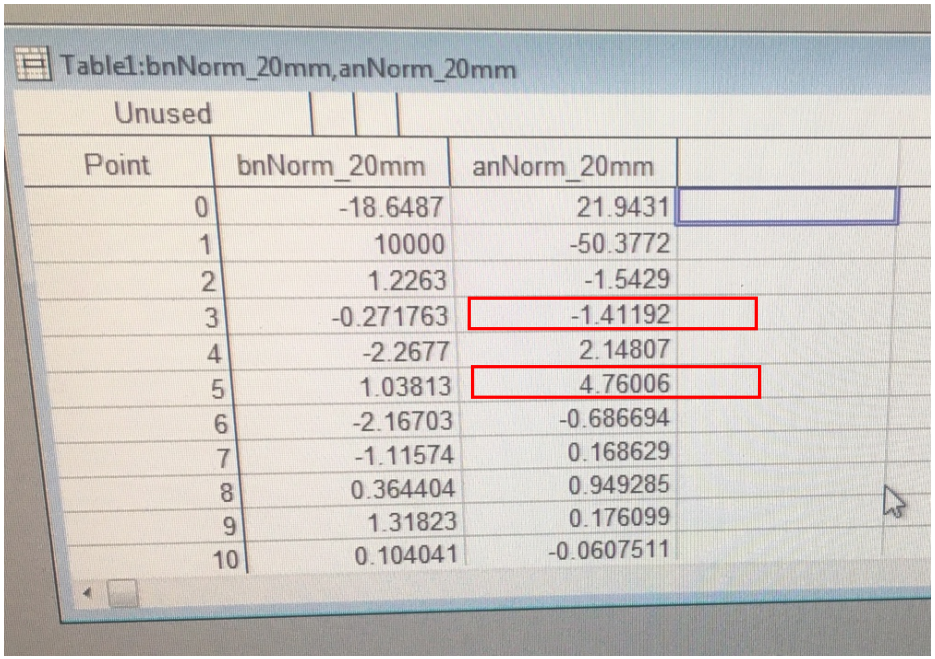
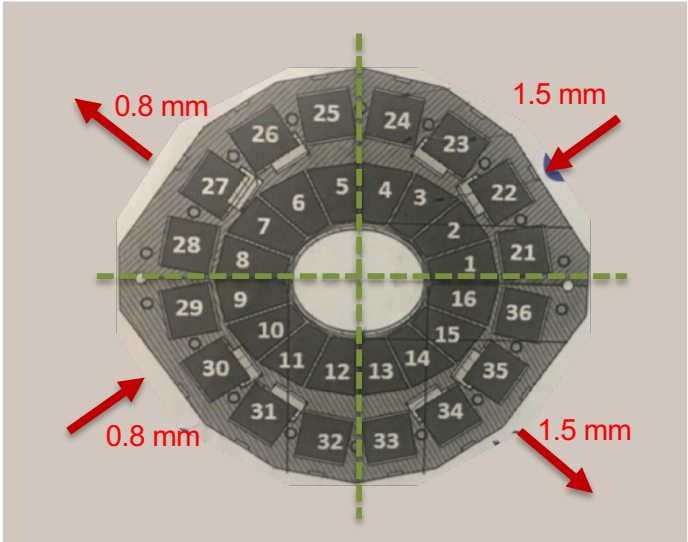


Table1:bnNorm_20mm,anNorm_20mm

Unused

Point	bnNorm_20mm	anNorm_20mm
0	-18.6487	21.9431
1	10000	-50.3772
2	1.2263	-1.5429
3	-0.271763	-1.41192
4	-2.2677	2.14807
5	1.03813	4.76006
6	-2.16703	-0.686694
7	-1.11574	0.168629
8	0.364404	0.949285
9	1.31823	0.176099
10	0.104041	-0.0607511



PMQD Final Measurement and Qualification

(Mar 6th 2019)

The magnets were shimmed in order to optimize the field quality in a 20 mm radius region at the magnet centre.

Table 2. Multipoles of the QD0 magnets, expressed at 20 mm radius and normalized to the quadrupole component

	QD0-1				QD0-2		
n	Component	Normal	Skew	n	Component	Normal	Skew
1	Dipole	–	–	1	Dipole	–	–
2	Quadrupole	10000	–	2	Quadrupole	10000	–
3	Sextupole	0.4	3.4	3	Sextupole	1.2	−1.5
4	Octupole	−1.8	−2.4	4	Octupole	−0.3	−1.4
5	Decapole	3.9	−5.1	5	Decapole	−2.2	2.1
6	Dodecapole	0.3	4.4	6	Dodecapole	1.0	4.8
7	14-pole	0.2	−0.4	7	14-pole	−2.2	−0.7
8	16-pole	0.7	1.7	8	16-pole	−1.1	0.2
9	18-pole	−0.6	0.3	9	18-pole	0.4	0.9
10	20-pole	−0.7	0	10	20-pole	1.3	0.2

New PMQDs

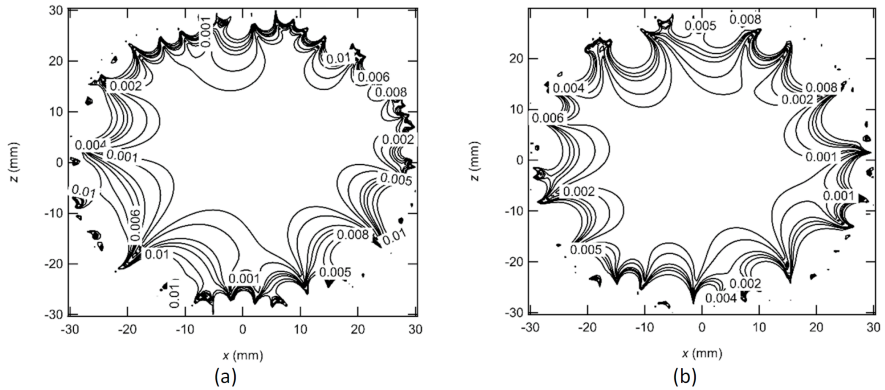
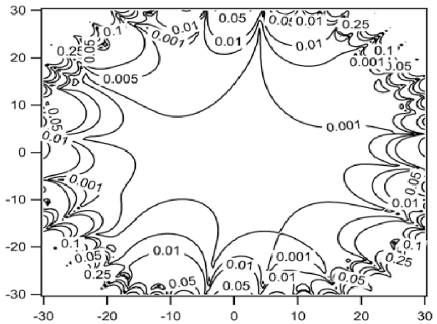
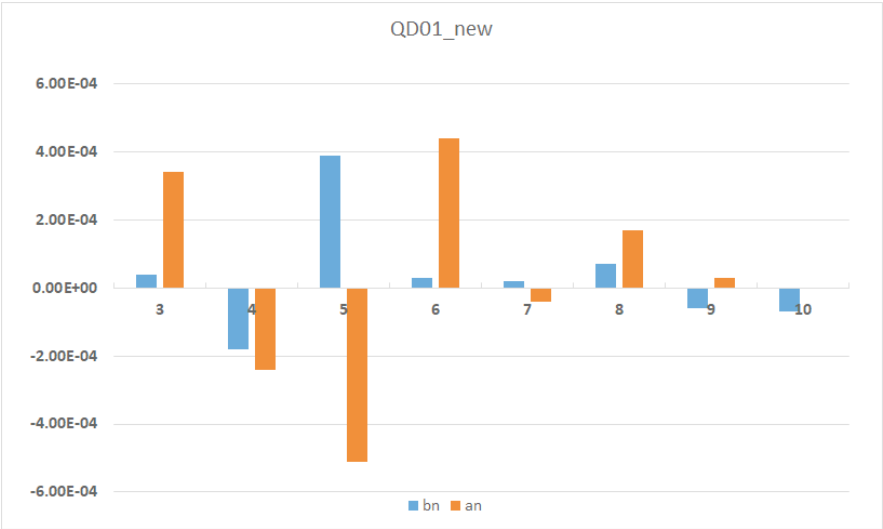


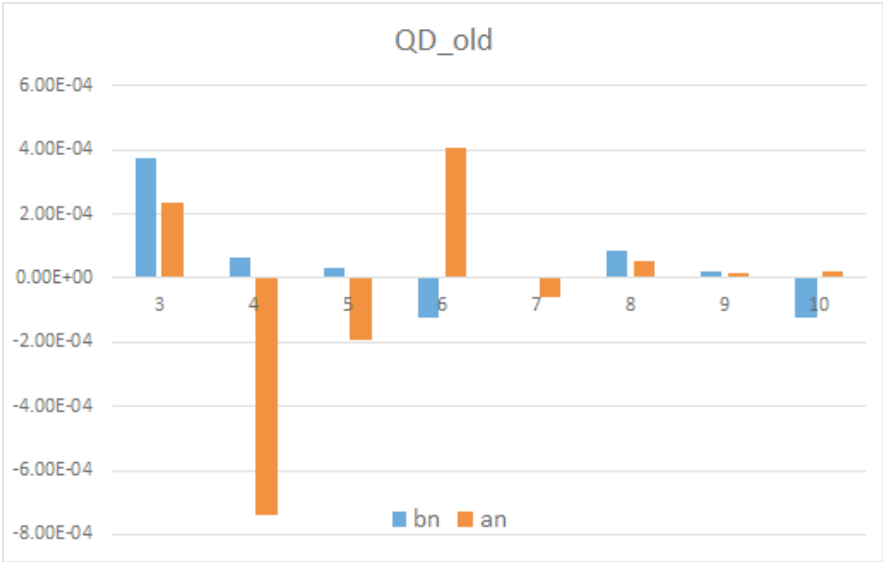
Figure 3. Gradient homogeneity contour plots for the QD0-1 (a) and QD0-2(b) magnets. The inner contour corresponds to gradient inhomogeneities below 0.001.

Old PMQD



Comparison between New and Old PMQDs



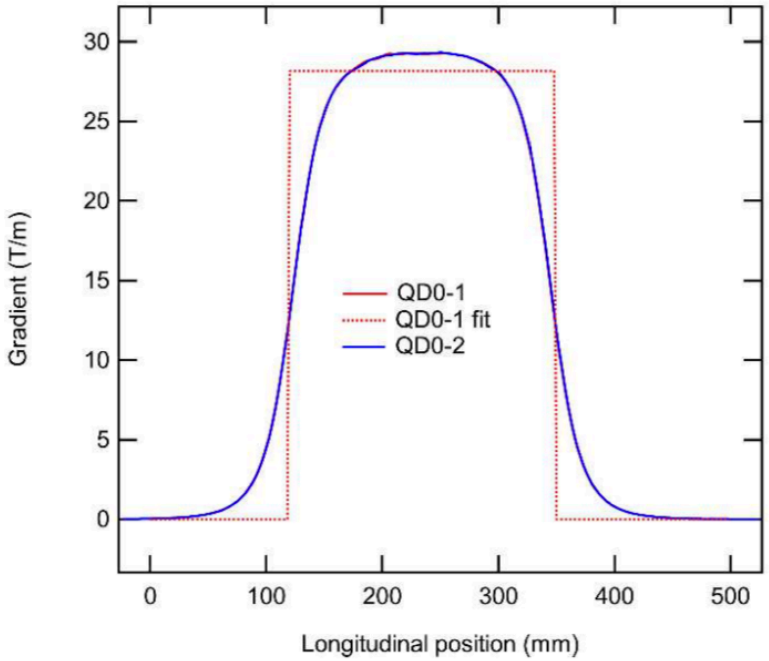


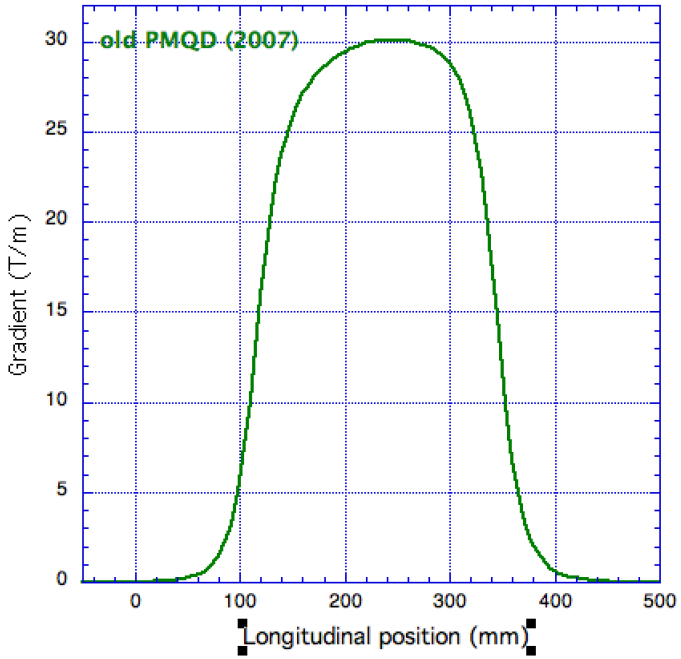
Relevant reduction of the:

- 6-pole and 12-pole normal component
- 8-pole skew component

Gradient Longitudinal Profile

Longitudinal profiles of the gradient for the two new PMQDs. The two curves are perfectly superposed. The dotted line represents the best fit for a hard-edge model. The best fit is obtained with L = 231 mm.





Change in the gradient is the same as for the old PMQDs in the range ± 0.02 mm, while it is less steep for wider intervals

Painful notes about PMQFs

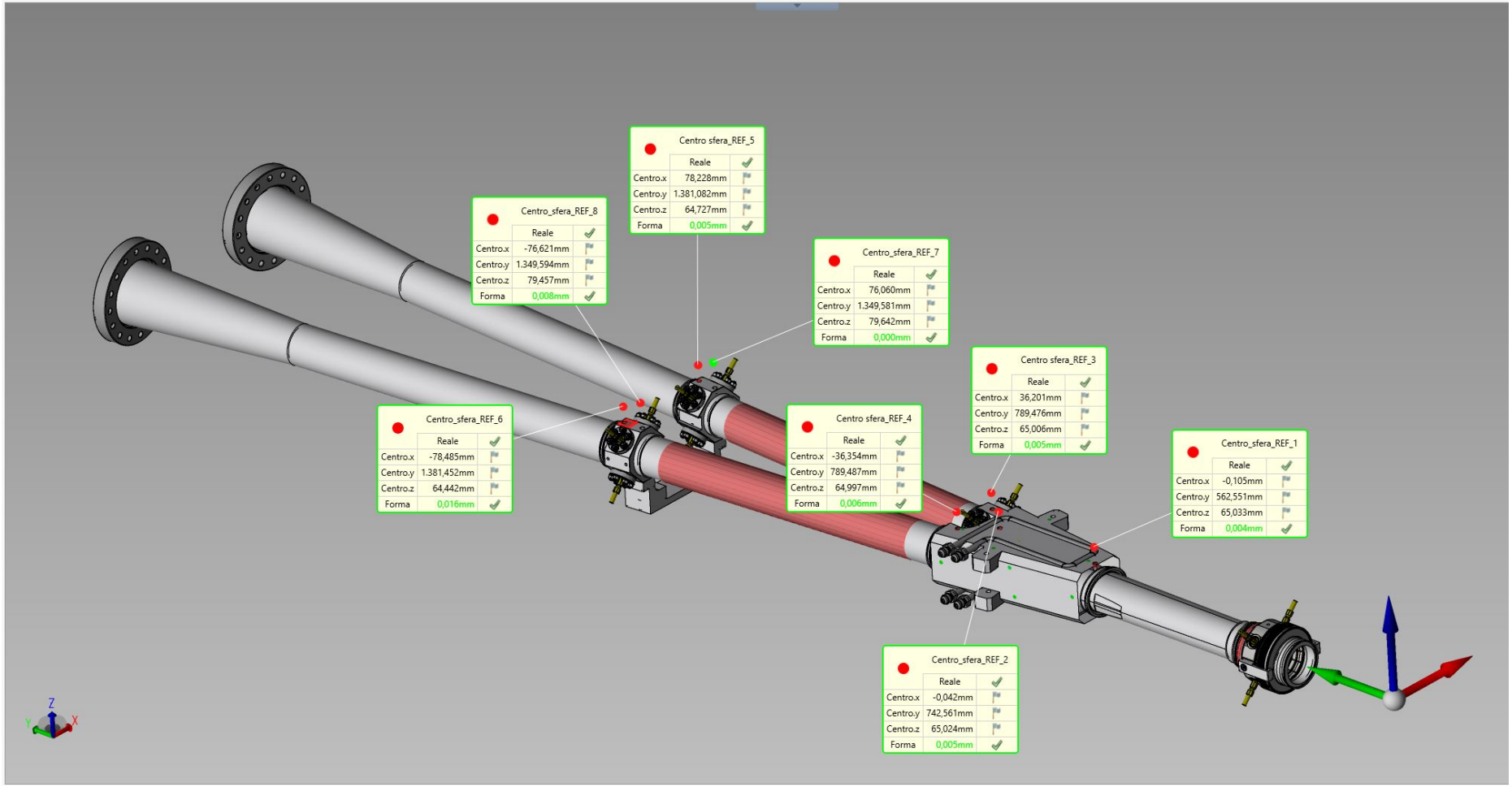
- Order for the cases placed at CECOM on November 13th 2018
- Delivery foreseen within 60 days
- Failure of the EDM machine not yet fixed
- Still not delivered.
- **Old PMQF1s temporarily mounted in its stead**

Vacuum Chamber and Installation Activity

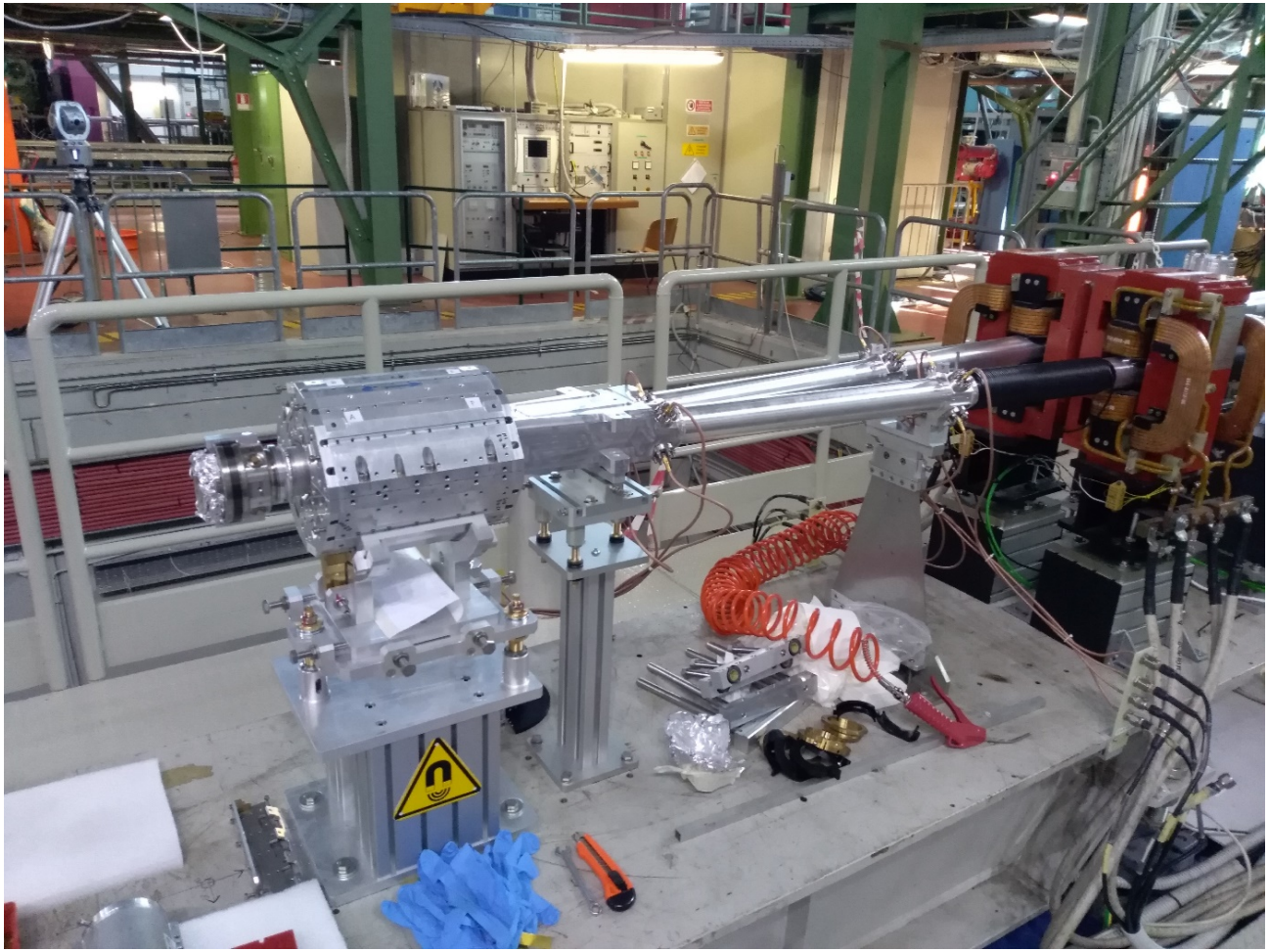
Interaction Region Installation Work

- 5 Dec -21 Feb: simulation and design of the cooling collar necessary to weld the SIDDHARTA-2 carbon fiber reinforced thin chamber
- 22 Feb: welding tests @ CECOM
- 2 Jan: Y vacuum chambers delivery @LNF
- Y Chambers dimensional check and qualification @ LNF
- Mounting and pre-aligning of the Y chambers, QD0 and QF1magnets.
- 18 Mar: ready for the Y chambers welding to the IP thin chamber, BUT:
  - The welder from CECOM (who did the weld test) suffered a injury to his hand!
  - After some days of waiting, we asked Tecnoalarm to send another welder
  - 25 Mar: first attempts to welding, but the beads leak!
  - 28 Mar: the Y chambers with the thin chamber removed as a whole with a special support designed to put the assembly upside down.
  - 29 Mar: final welding and leak test.
- PMQD0s and PMQFs closed, others iron magnets and luminometers mounted and aligned.
- ***19 April: final IR alignment check***.

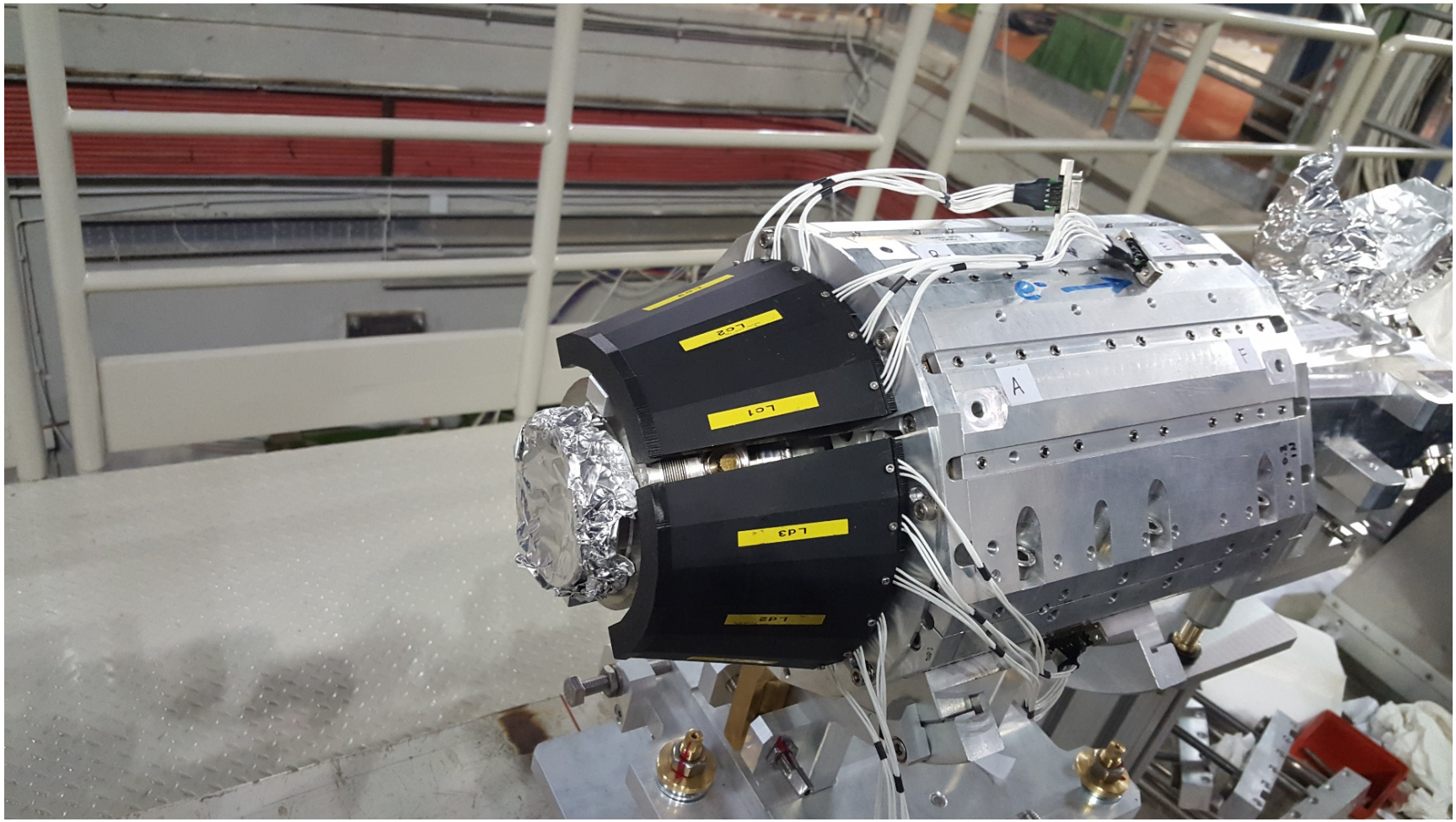
Y-Chamber Qualification at LNF



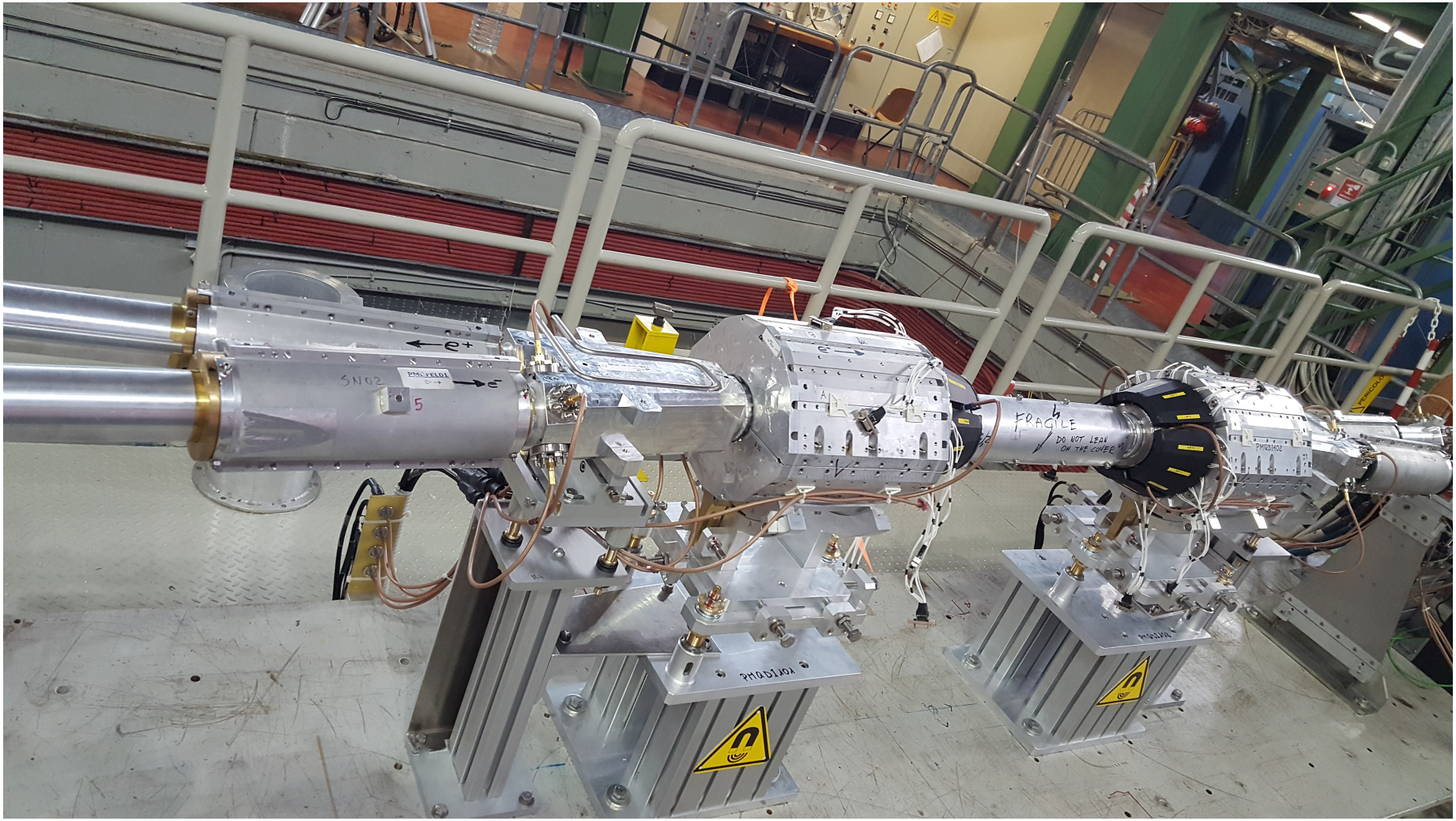
PMQD and Y-Chamber



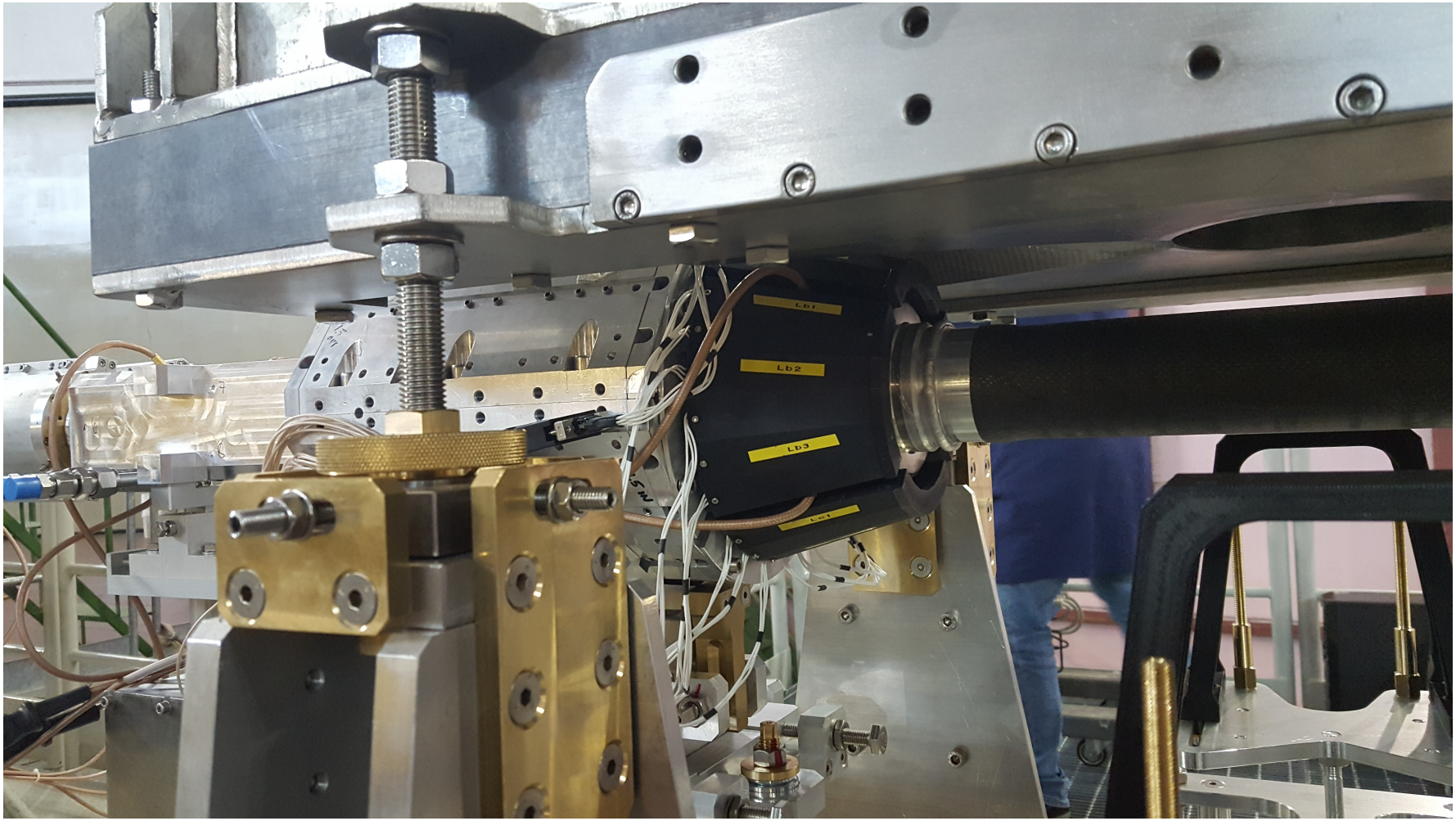
Mounting the luminometer



PMQF in place



SIDDHARTA-2 Support Installed



DAΦNE IR and SIDDHARTA-2

DAΦNE Commissioning

- March 25th Linac test and DAFNE warmup
- April 2nd general blackout switched off all DAFNE subsystems causing damages
- April 4th Safety System tests
- April 13th both beams transported and stored in the DR
- April 18th vacuum valves in the Main Rings opened
- Apr 20th - May 6th a lengthy holiday period …..
- Apr 20th major failure on the transformer of the PS serving the WIGGLERS in MRe

Transformer

As usual the initial stage of commissioning is affected by a high fault rate fairly spread among all subsystems

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Commissioning started in time sharing with other activities: installation, alignment and vacuum. The last ones required ~ 60% of the time

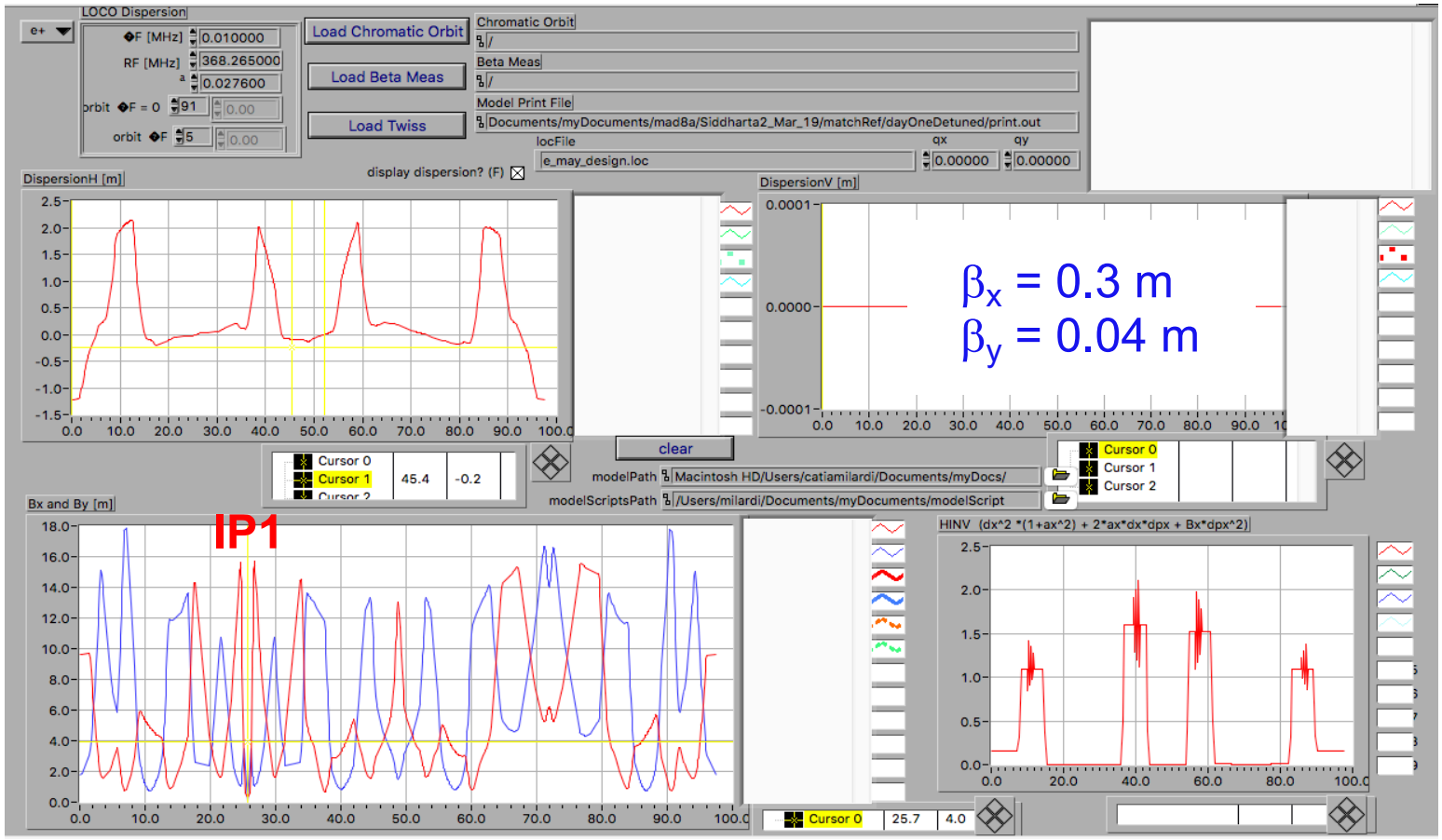
- Apr 20th major failure on the transformer of the PS serving the WIGGLERS in MRe

Transformer

As usual the initial stage of commissioning is affected by a high fault rate fairly spread among all subsystems

Detuned Optics

Low-β and *Crab-Waist* condition relaxed



First Results

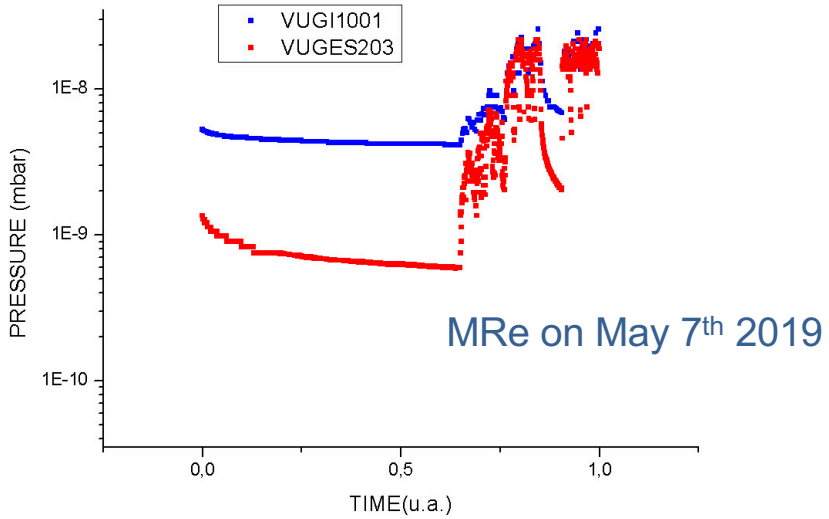
Both beams have been stored in the MRs

$I^- = 24$ mA

$I^+ = 7$ mA

with a lifetime compatible with the vacuum conditions, but suitable for first measurements with the beam

Pressure rises are observed in the sections where new beam pipes have been installed



MRe on May 7th 2019

DAΦNE Preliminary Plan

May 1st - July 8th

DAΦNE collider setup and vacuum conditioning
since mid June test for **BTF2**
DAΦNE-Light beamlines tests (UV, infraRed and XUV)

July 8th - July 29th

PADME acquisition test

August 26th - September 6th

DAΦNE maintenance

September 6th - October 31st

DAΦNE collider setup and vacuum conditioning
acquisition test with the **mini-SIDDHARTA2** setup
DAΦNE-Light X-Ray beamlines setup

November 1st - December 16th

PADME run
safety tests
DAΦNE Main Rings maintenance
installation of the SIDDHARTA-2 final apparatus.. hopefully

Conclusions

The new PMQDs have been build and characterized, they have improved field quality as we wished

DAΦNE commissioning has started

Both beams have been transported and stored in the Main Rings

No major limiting factors have been observed until now

Warning

The DAΦNE Operation Group → **LNF Accelerator Operation Group**
A very positive evolution indeed

The **DAΦNE Operation Group** was taking care of activities on the DAΦNE collider, BTF (only 1 line) and, seldom in crucial context, of the SPARCLab activities.

The **LNF Accelerator Operation Group takes care of the** DAΦNE collider, BTF (2 line), PADME, and systematically of the SPARCLab activities.

Since last year the **Accelerator Operation Group** lost three highly experienced Technicians, one more will retire by the end of next summer.

Warning

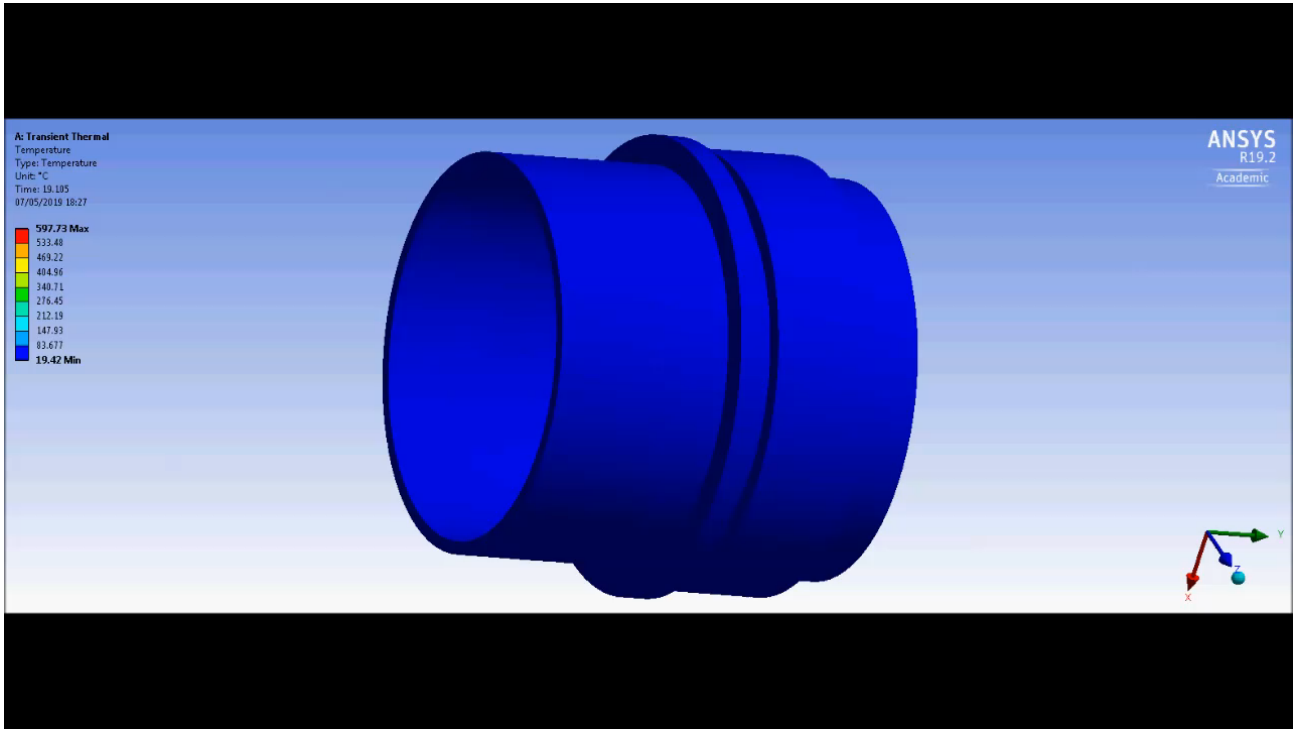
Scientific and Technological activities involving Physicists and Engineers of the AD are growing in number and the people working on DAΦNE collider are becoming less and less

In about one year two more Accelerator Physicists will retire.

Man power is an issue!
Even more in the presence of ambitious plans!

Thank you for your attention

Welding probe simulation with water cooling clamp video clip



Thin chamber welding simulation with water cooling clamp video clip