Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

DAΦNE run for SIDDHARTA-2

Catia Milardi
on behalf of the DAΦNE Team

60th Scientific Committee Meeting Nov 16th, 2020

DAΦNE Team

Laboratori Nazionali di Frascati:

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International partners :

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Outline

DAΦNE since the last SciCom

- *What happened since last SciCom*
- *Development and Consolidation activities*
- *Main Ring Optics development*
- *CCAL-T Luminometer update*
- *General considerations*
- *Plans*

Plan from the past SciCom

DAFNE-BTF-SIDDHARTA:

- Up to the first week of March the operations were in full swing and following pretty closely the plan that had been agreed upon during the midterm meeting.
- However, triggered by the lock-down and the changed boundary conditions, the lab involved all relevant stakeholders in a discussion for redefining the main plan, that takes into account the safety-related limitations of DAFNE operations and that gives priority to the BTF restart.
- More concretely, PADME should receive beam towards the end of June/beg. of July, after a period of ~7 weeks (increased compared to the original schedule because of the special working conditions) for restarting the LINAC operations.
- Then PADME should run during summer, maybe even in August (to be seen how much the meteorological and consequently environmental conditions will allow for this), up to September.
- All this moves the start of the SIDDHARTINO run to October, followed immediately by the SIDDHARTA run up to the end of 2020 and continued throughout 2021.
- All involved parties agreed to this plan and also the SC considers this to be a justified and reasonable change of baseline. The SC also takes note of the very clear and strong commitment of the lab to complete the PADME and SIDDHARTA programs.

DAΦNE Operations

DAFNE operations for SIDDHARTINO did not restart on October 2020

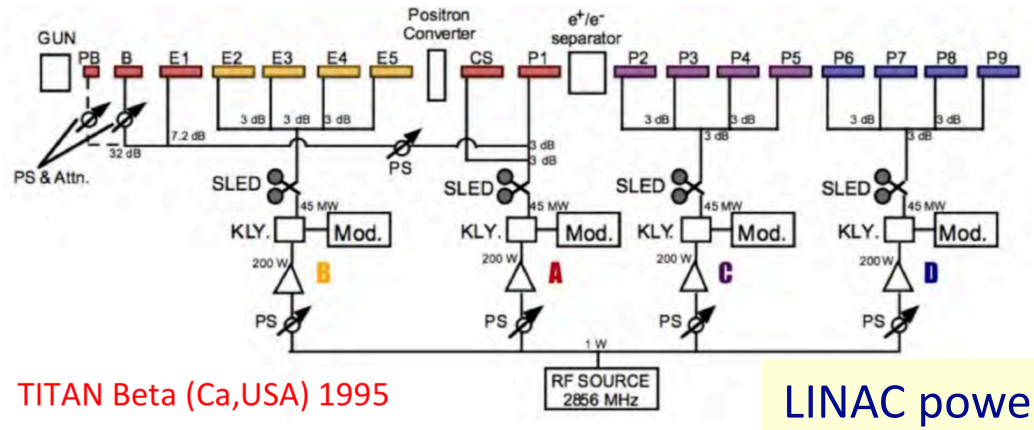
This decision has been made by the LNF management relying on several objective facts:

LINAC performances

PADME experiment data-taking requirements

new pandemic surge

LINAC Performances



TITAN Beta (Ca,USA) 1995

LINAC power distribution

On March 12th when the experimental activities in the LNF have been stopped, the LINAC of DAFNE was recovering from a sequence of faults mainly concerning the RF plant C.

Several Consolidation activities went on during the lockdown:

vacuum gauge on the elbow of the RF plant C was replaced
on May 27th a ceramic load on the RF plant B was replaced
mid July new GUN PULSER installed
……

LINAC operations restarted on June 8th

After a conditioning period interleaved with several mending interventions:

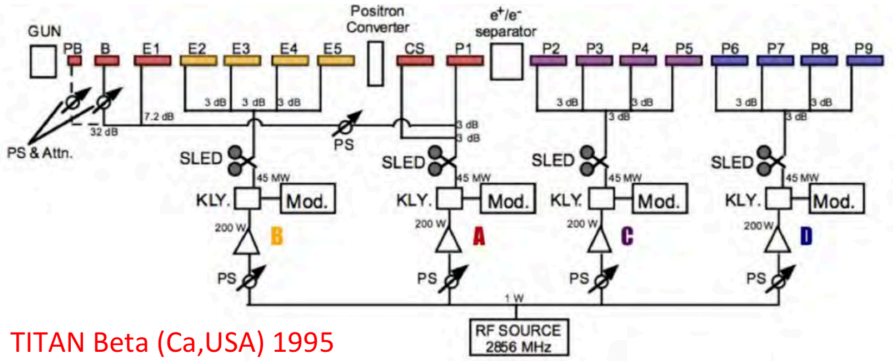
on August 8th the thyratron of the RF plant A was replaced
end of June an additional conditioning system was installed in the RF plant tunnel ..

LINAC achieved optimal vacuum conditions and rather stable operation with RF plant C operating at ~24 MW (~35 MW are required for DAFNE operation)

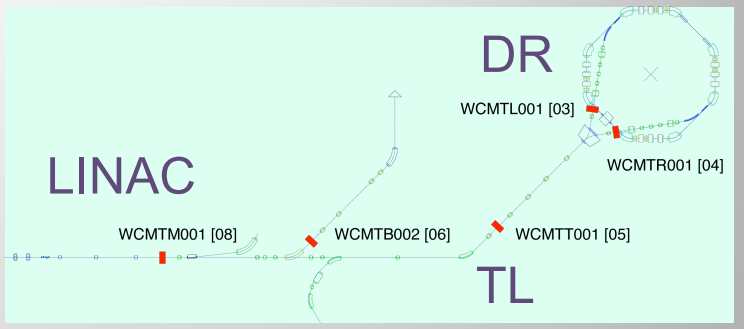
In October stability was improved by removing the bypass on the elbow of the RF plant C
mid October the thyratron of the RF plant C was replaced
….

However it was not clear if LINAC could deliver a 510 MeV e^+ beam to DAΦNE

e^+ Beam Injection Test



TITAN Beta (Ca,USA) 1995



October 21-22

The program was to inject the beam in the DAΦNE DR, for this reason all the subsystems of the DR and of the TL were switched on
LINAC was tuned to accelerate 10 nsec long e^- pulse from the gun

Test outlined the possibility of transporting a rather high e^+ beam current, ~ 20 mA, but only up to a maximum energy of the order of E = 495 MeV.
Not enough to inject in the DR

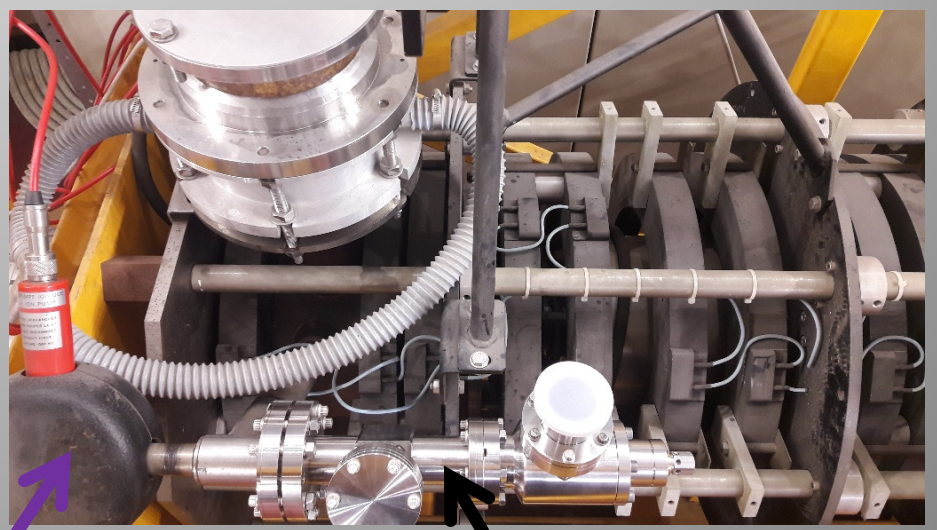
During the test a vacuum leak of the order of $3*10^{-8}$ [mb•l/s] was detected on a flange downstream the SLED of RF plant C

The frequent faults involving vacuum components led to the decision to replace all the vacuum gauges serving the DAΦNE LINAC RF plants

Spare MRs Klystron Vacuum Leak Sealing

DAΦNE RF system includes 4 Klystrons 2 installed on the MRs RF plants, and 2 spare devices.
Since ~5 years ago some of the klystrons started to have vacuum leaks on the klystron body

- 2 klystrons have then been repaired
- on Nov. 20th, a spare klystron had the same vacuum fault
- Since the klystron parts are welded, in order to access the vacuum tube it is necessary to:
  - cut the copper tube near one of the two klystron ion pumps
  - insert a special vacuum chamber with a metallic valve
  - perform the leak test and vacuum seal with Silicon based sealant
  - pump and switch on the klystron ion pumps



Power Supplies

Mending:

5 power modules of large PSs

Several control panels

Spare parts acquisition

Water cooled transistor bars for the Danfysic PSs of the Damping Ring

New control panels for Danfysic PSs

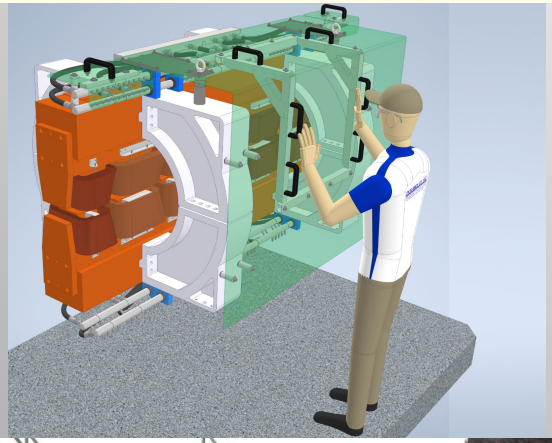
Screens for MRs Wigglers

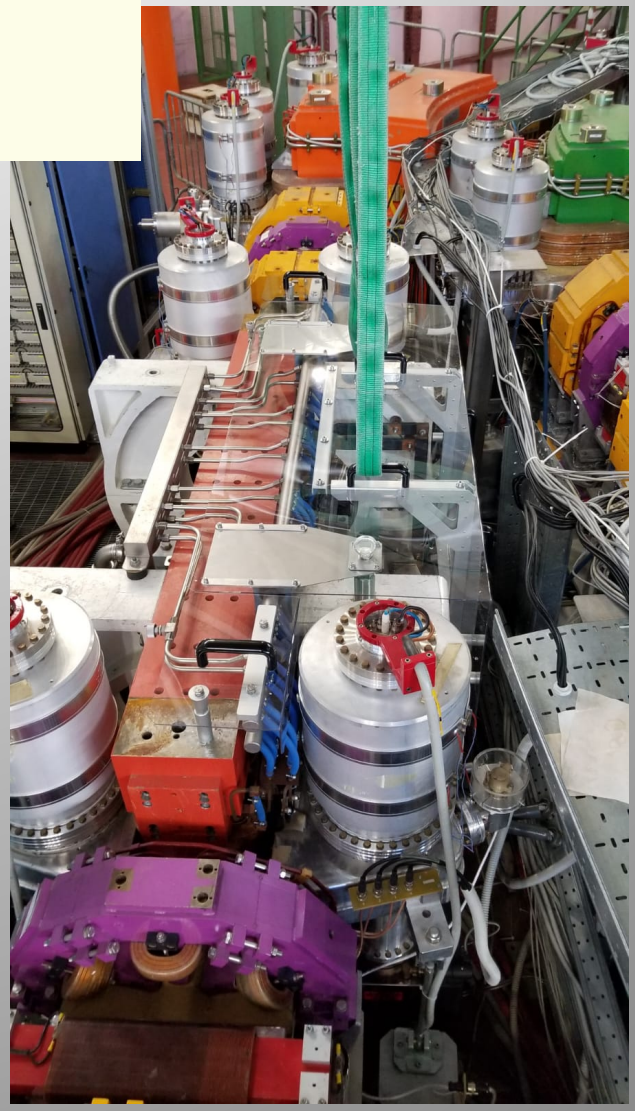
Plexiglass screens have been designed and installed on the eight MRs Wigglers in order to prevent:

injury

water leakage related damages to vacuum parts,

diagnostics components and electronic equipment





Feedback Systems

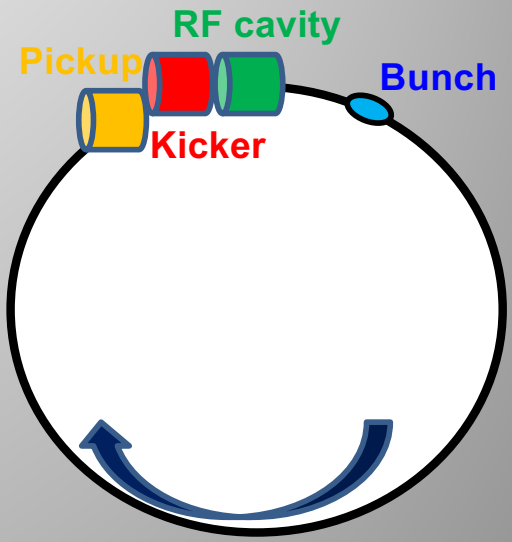
250 W Power Amplifier of the longitudinal e^+ FBK has been repaired in house

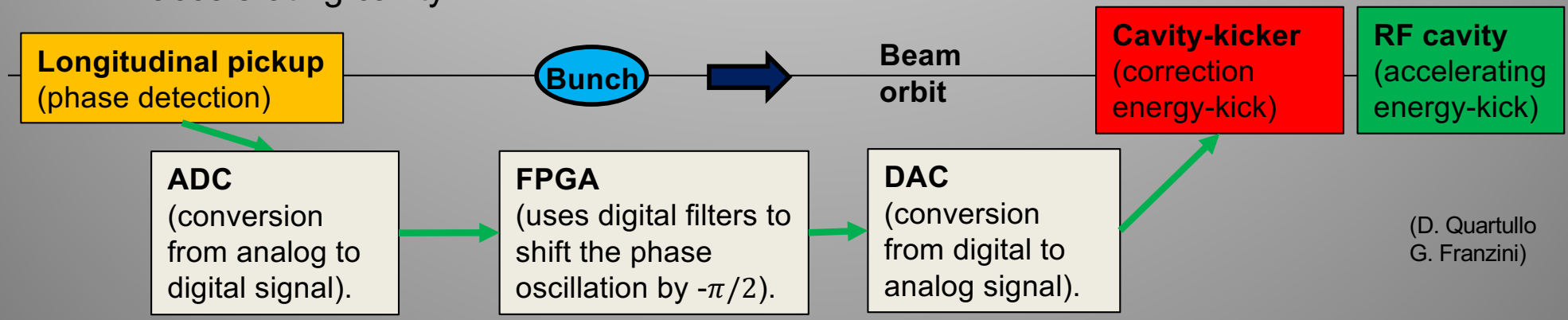
500 W Power Amplifier for a possible second horizontal FBK in MRp has been repaired and sent back to LNF

Feedback survey and simulations

- A **complete survey of the DAFNE feedback system** is ongoing.
  - Detailed schematics of all the hardware components were produced.
  - Analysis of the feedback signal processing is underway, in order to highlight possible critical aspects of the system and find possible improvements for the future.

- A **macroparticle code** developed in the 1990s to simulate the **DAFNE longitudinal beam dynamics has been renovated**, with the aim to have an useful real-time tool for the feedback operation.
  - The old Fortran code has been rewritten in Python.
  - The input – output data and plots production have been made much more user friendly.
  - Numerous routines have been added, e.g.
    - Improved analysis of the bunch-by-bunch feedback.
    - Computation of the bunch synchronous-phase taking into account the induced-voltage due to the HOMs in the accelerating cavity.



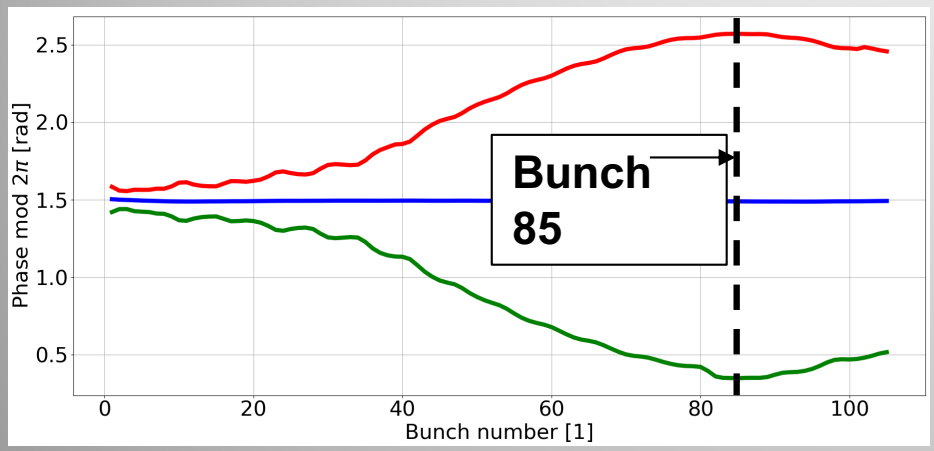


(D. Quartullo
G. Franzini)

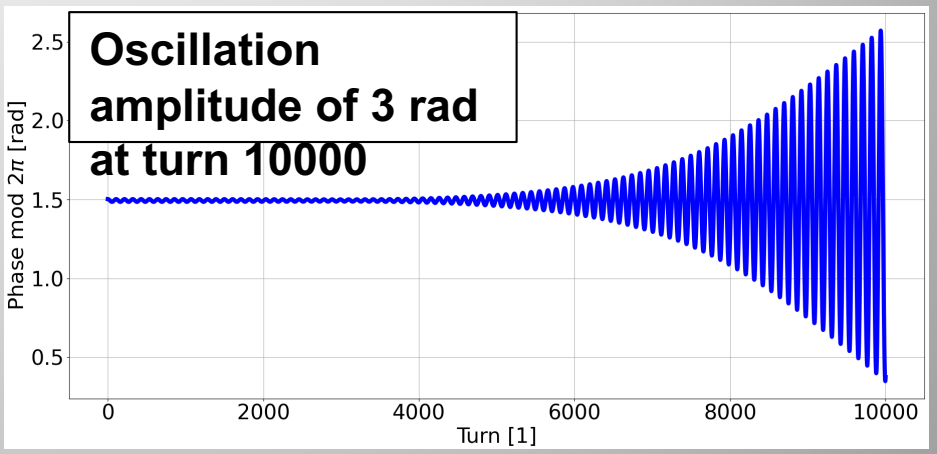
An example of the output of the simulation tool

❑ Updated beam, machine and feedback parameters were implemented within the code.

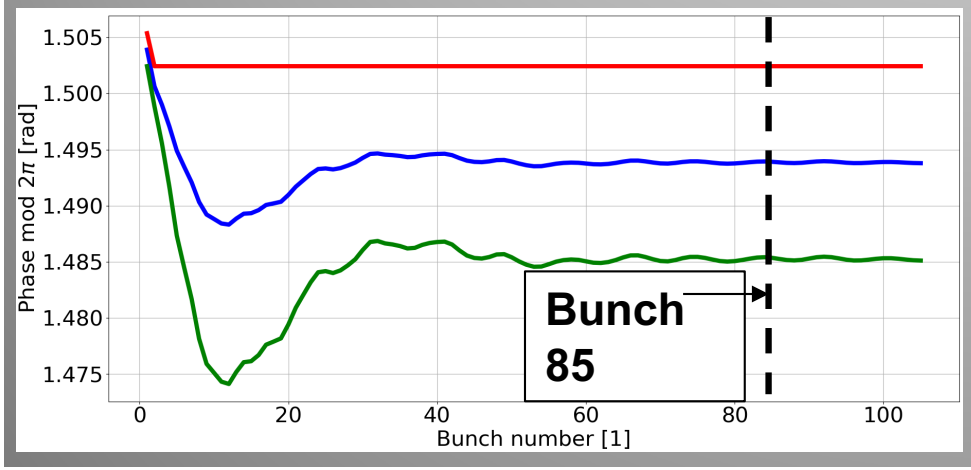
Feedback OFF:
Min, mean and max phase vs bunch number



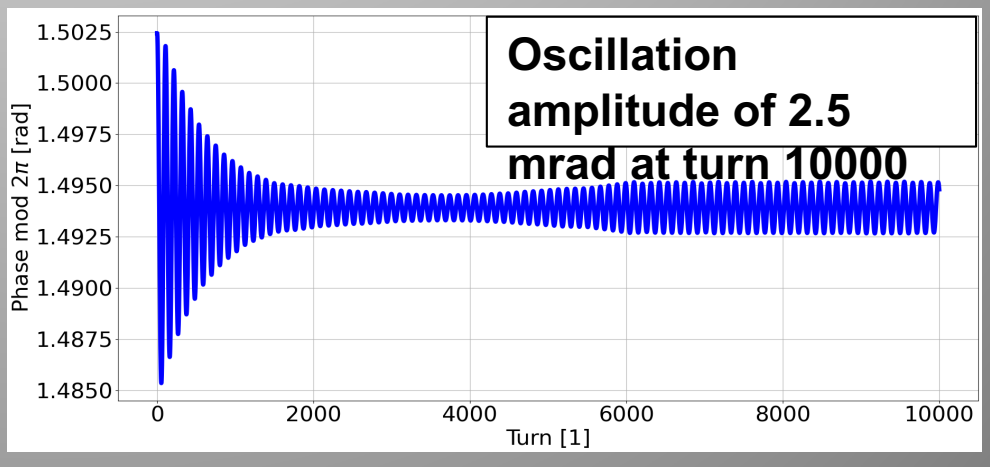
Feedback OFF:
phase evolution of the bunch 85



Feedback ON:
Min, mean and max phase vs bunch number

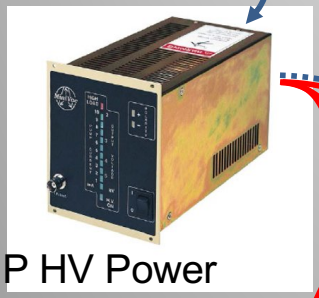


Feedback ON:
phase evolution of the bunch 85

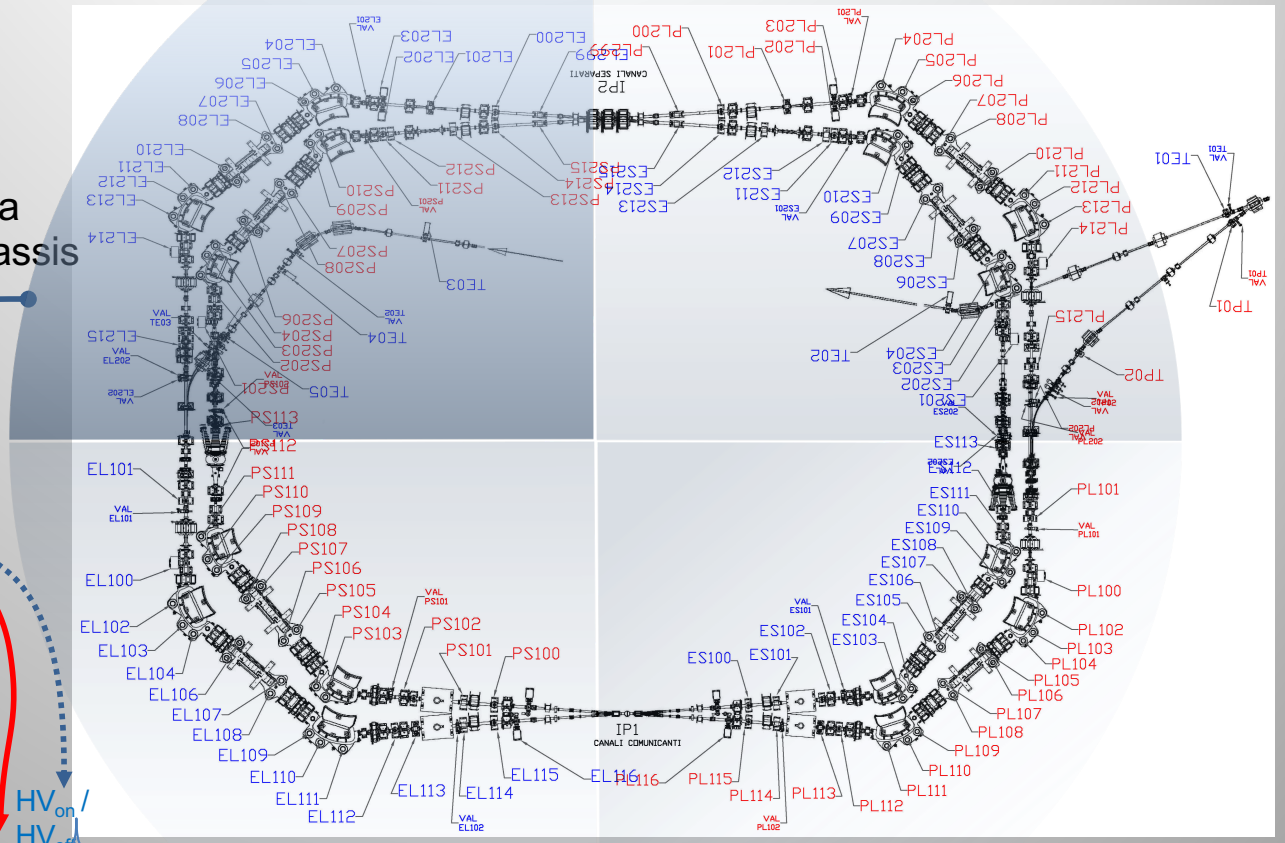


Diagnostic & Control: new DAQ system for DAFNE Sputter Ion Pumps (SIP)

All **SIP** HV power supplies of **each machine arch** are connected to a CompactDAQ chassis



SIP HV Power Supply



HV_{on} / HV_{off}

I_{low} I_{high} HV

CompactDAQ chassis & modules

- already employed on other systems
- powerful SW drivers provided
- native integration in LabVIEW®

Computing centre

LabVIEW control program running on remote virtual machine

POWERED BY LabVIEW

oVirt

Diagnostic & Control upgrades

Facing the obsolescence of some devices (no longer produced or in end-of-life)

> DAQ system of Main Rings DCCT current monitors

Old VME Digital Voltmeters have been replaced with Agilent Voltmeters controlled through Ethernet. Control program has been rewritten and moved from VME processor to remote virtual machine.

> Injection kickers pulse monitoring

In order to improve the injection efficiency, signals from fast pulsed magnets are now elaborated and stored on a dedicated digitizer, on a pulse-by-pulse basis, to monitor any amplitude or phase variation.

Systems being redesigned...

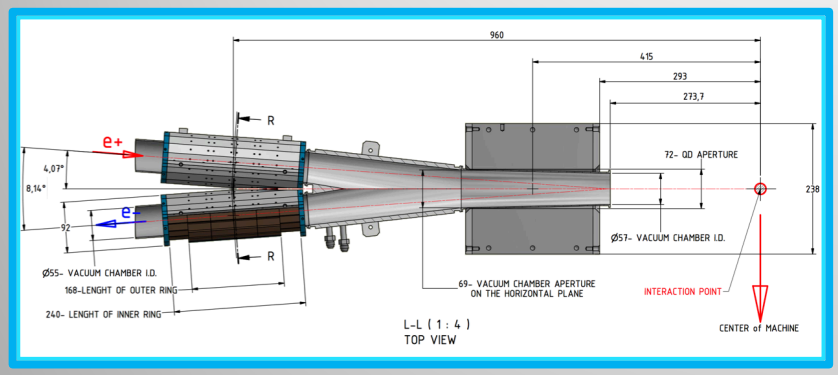
> Main Ring orbit acquisition system

A brandnew system based on CompactRIO® – able to acquire both analog signals from Bergotz modules and digital data from Libera® BPM modules – is under study. The hardware necessary for the realization of a pilot system has already been purchased.

> Timing dispatcher

The timing dispatcher is a crucial system for all DAFNE operations.
It is necessary to replace the timing sequence generator which is still on an old VME bus embedded processor.
The new system will be built on the CompactRIO® platform with RT Linux controller + FPGA. It will provide the generation of the timing sequences as well the distribution of the relative coded information throughout the accelerator.

PMQFs for the IR low-β



	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

PMQDs have been completed on schedule;

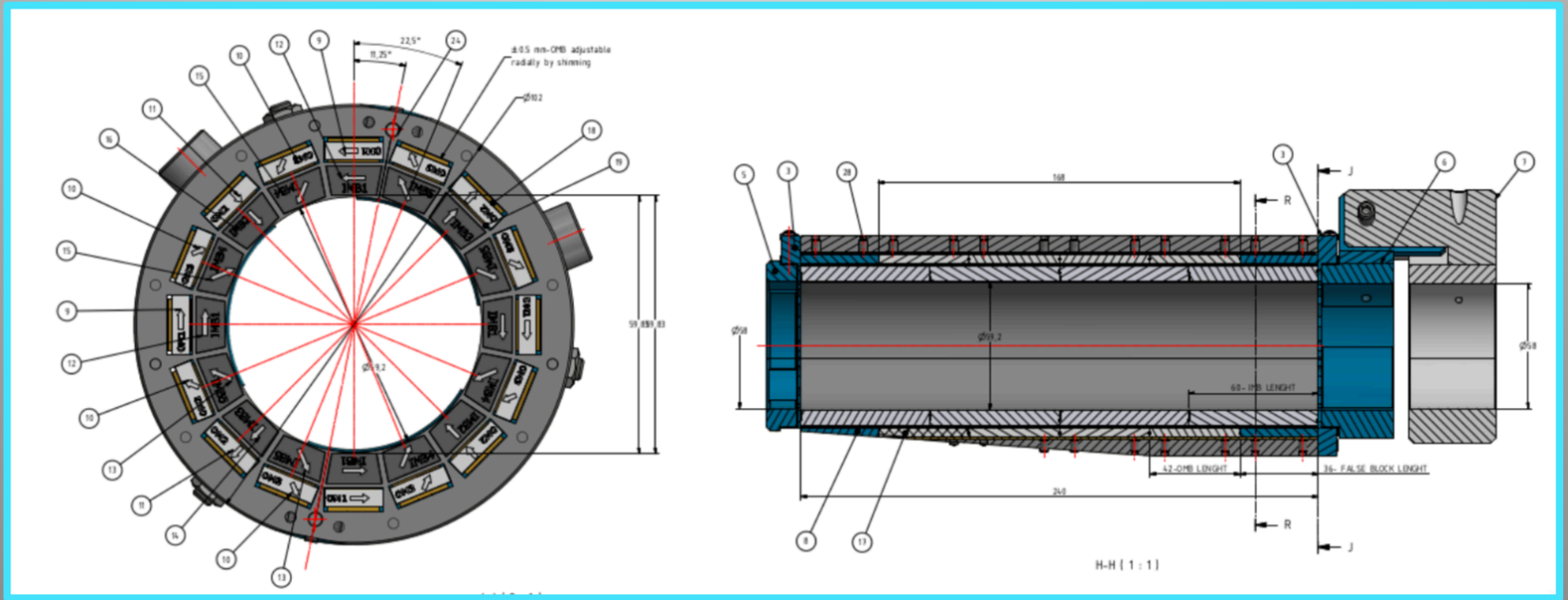
they have improved magnetic properties w.r.t. the old quadrupoles;

they provide larger acceptance for the beams.

PMQFs Update

PMQFs realization has been considerably slowed down by delays in the delivery of the case and by the lockdown

- ***Beginning July 2019* PMQF cases arrived at LNF**
  - machining was necessary to fix some imperfections
  - PMQF assembly and first qualitative characterization by Hall probe system
- ***End of July 2019* first PMQF shipped to ESRF**
  - First measurements outlined a significant difference between the integrated gradient and its nominal value coming from an error in the length of the PM blocks of the inner ring
  - Inner PM blocks have been cut at LNF, PMQFs have been reassembled and measured by SWM system to verify they had the proper integrated field
- ***End February 2020* PMQFs have been shipped to ESRF for characterization and tuning.**



PMQF First Optimization

Present status

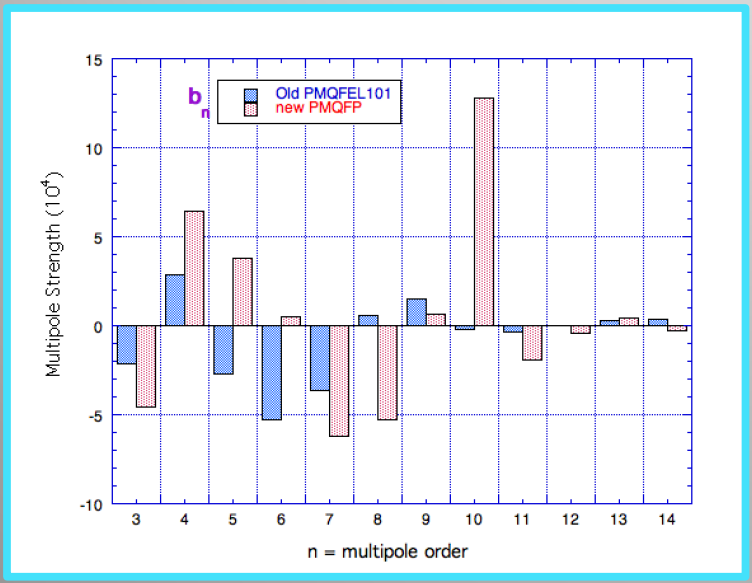
New PMQFs have all the required integrated gradient (G = 3.019 T)

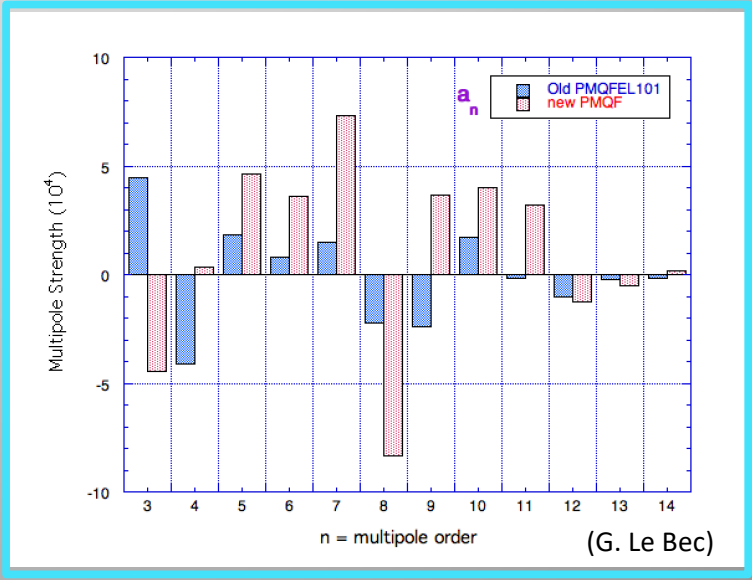
*The **20-pole** component has been reduced by changing the number of PM blocks in the outer rows (+1 block in the even rows, -1 block in the odd rows), but it is still out of specifications*

In general old PMQF have multipole components smaller than the new devices

Presently we are cutting some PM blocks in four parts to be used to shim the magnets

Restrictions imposed by the pandemic did not help the optimization process, in fact during the PMQD tuning the presence of our group at ESRF has been essential in achieving magnet specifications, well and quickly

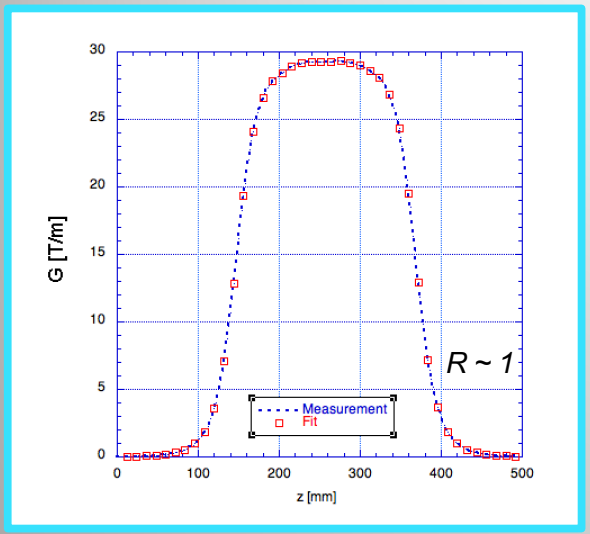




(G. Le Bec)

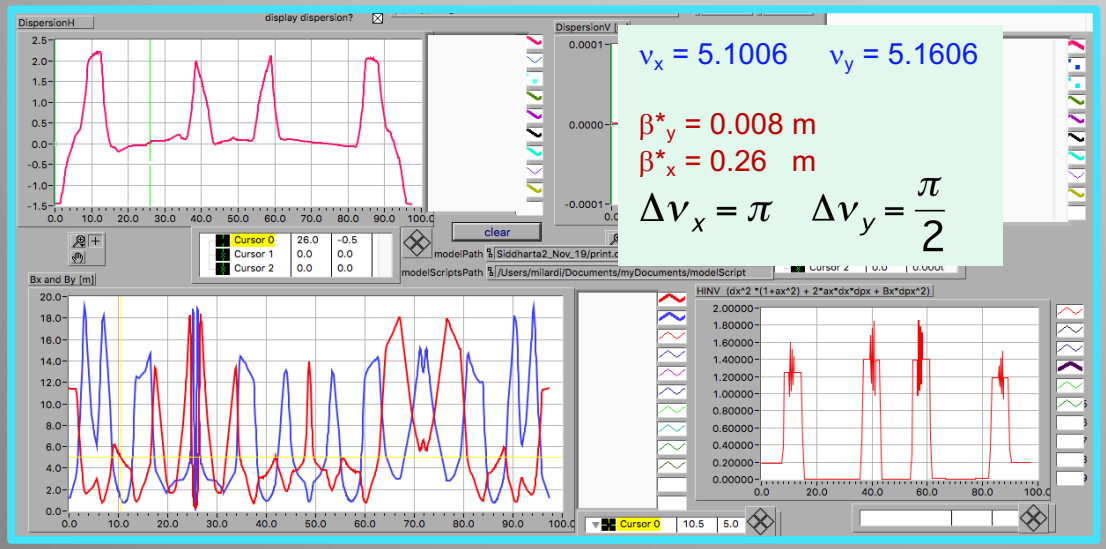
It should also be pointed out that the new PMQFs are not essential, as the PMQDs, for the success of the SIDDHARTA-2 run

PMQD Slice Model for the MRs Optics



- Each PMQD is described by 42 slices;
- each slice consists of a 12 mm long drift element centred around a thin multipole having b_{2i} and b_{1i} components;
- b_{2i} accounts for the focusing effect of the PMQD, it is obtained from an ad hoc fit of the longitudinal gradient profile measurements
- b_{1i} describes the dipole component coming from the beam passing off axis in the PMQD

$$b_{1i} = dx_i \cdot \vartheta \cdot b_{21} \cdot cst \qquad (cst=1)$$



$\nu_x = 5.1006 \quad \nu_y = 5.1606$

$\beta^*_y = 0.008$ m

$\beta^*_x = 0.26$ m

$$\Delta\nu_x = \pi \quad \Delta\nu_y = \frac{\pi}{2}$$

As expected linear optics is not affected by the new PMQD model

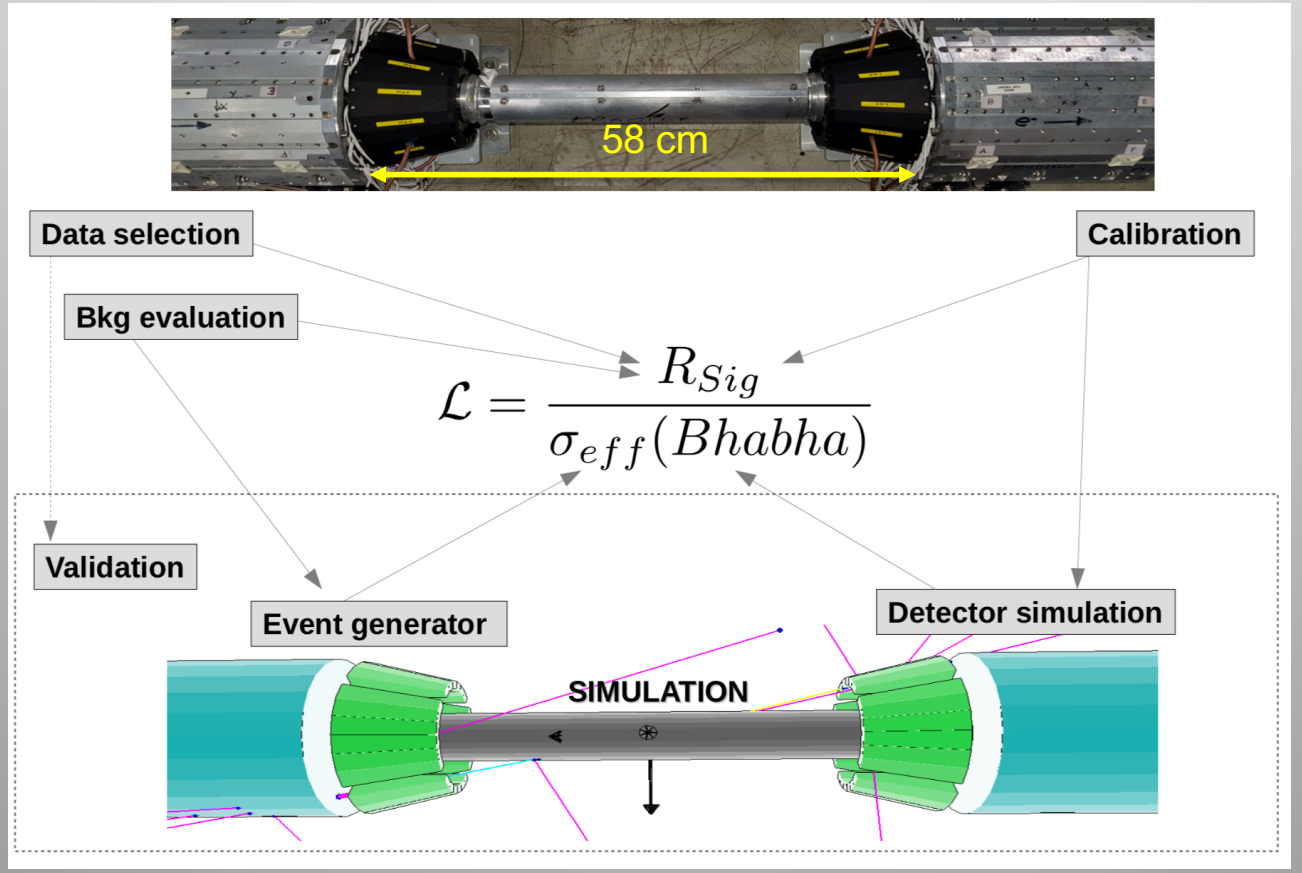
It is mainly relevant to perform non-linear *beam dynamics and background numerical simulations*.

From Reviewers Report

....
The main ring optics require the development of a lattice model for the new PMQFs, once the magnetic measurements are available. Background simulations might also be performed. The DAFNE program has to deal with the well-known lack of dedicated manpower and it is not clear that everything specified in the plan can be tackled.
…

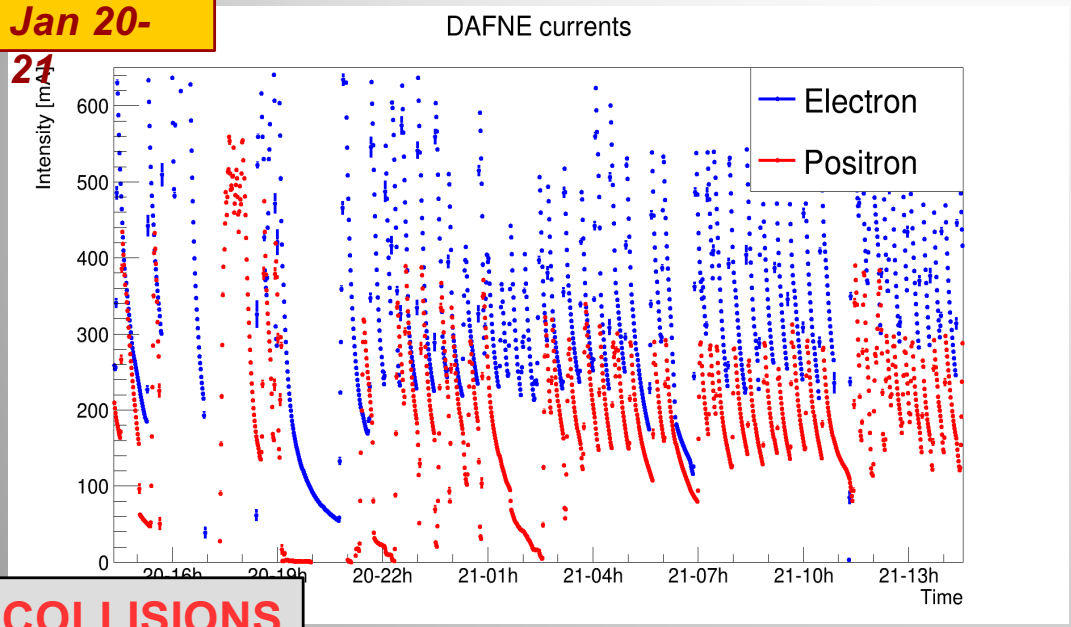
PMQFs tuning is in progress
A more accurate PMQD model has been implemented in the MRs optics
Background simulations have not been done

CCAL-T Luminometer

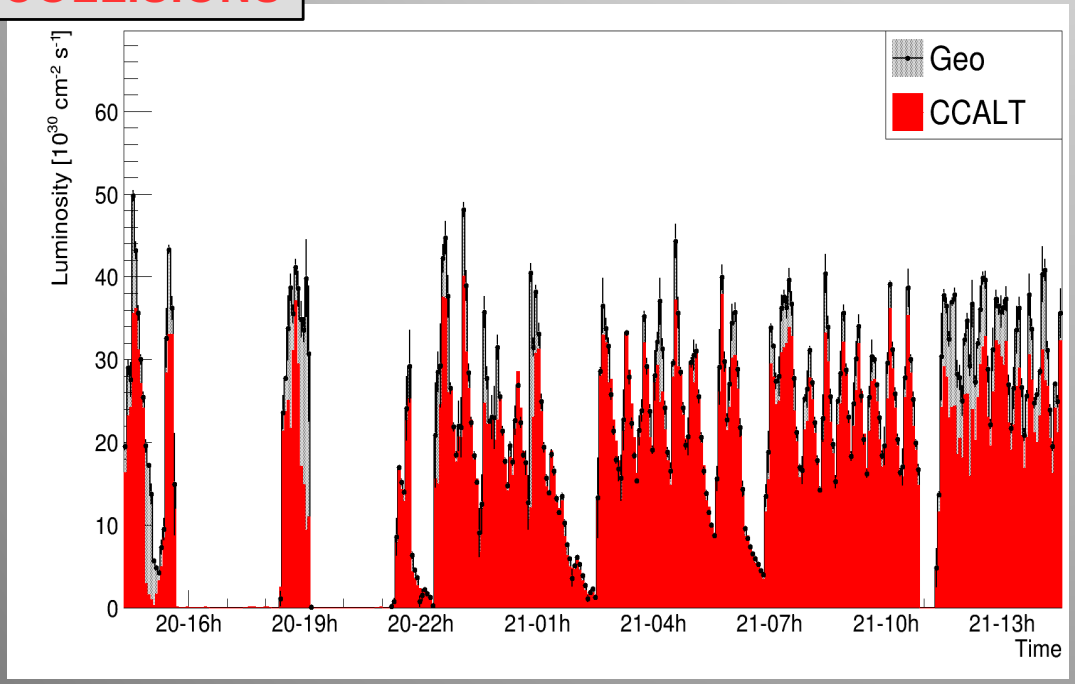


Luminosity Measurements Updates

Jan 20-21



COLLISIONS



Analysis improvement:

- Refined time calibration
- Energy scale calibration
- Single channel efficiency
- Background rejection

- The effective cross section has been increased including more sector in the signal selection.

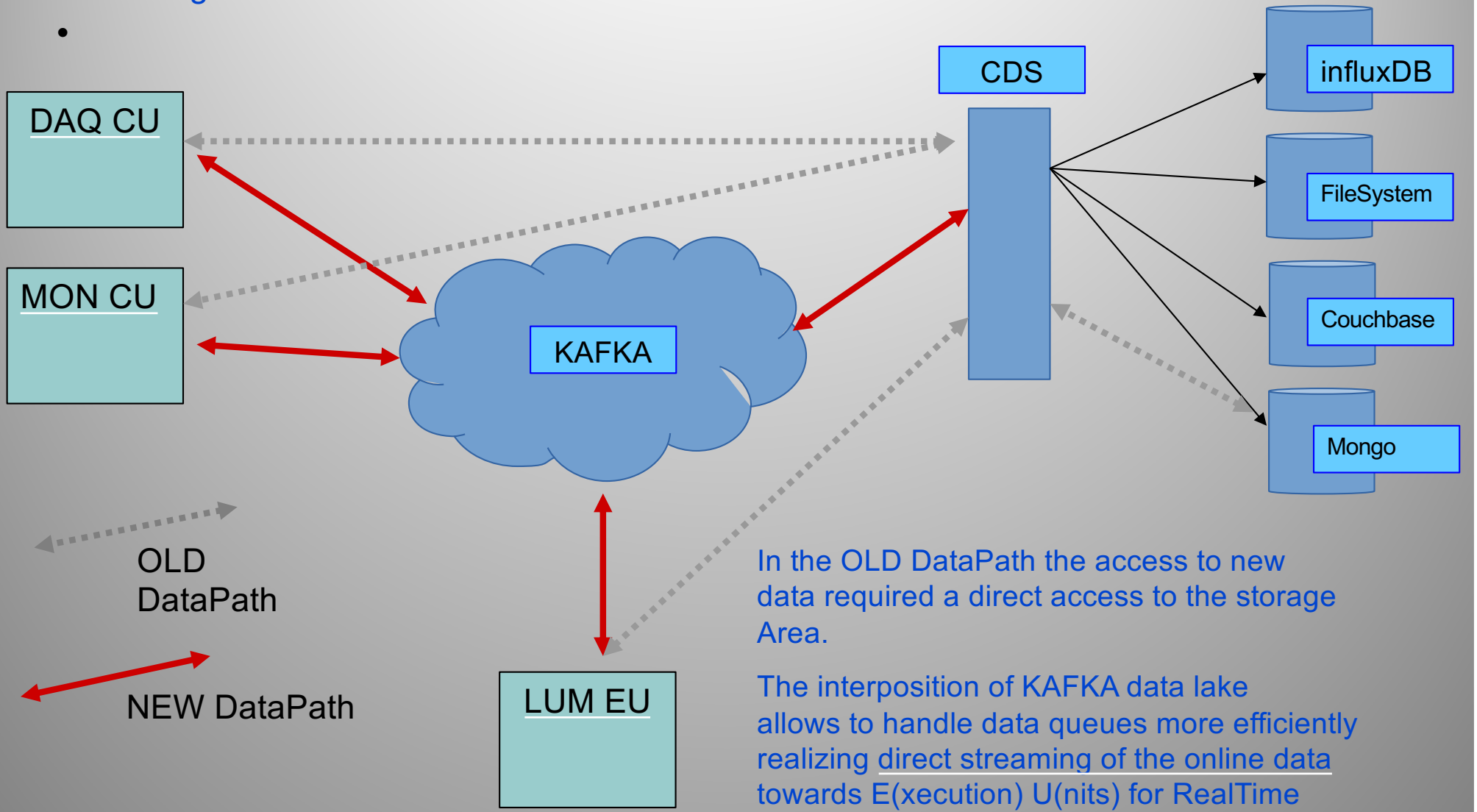
- According to MC the effective cross section for the applied selection is 275.7 nb (was 102 nb in the last SC).

- Counting rate is validated observing runs without collisions.

- Validation of the MC generator and detector response with cosmic ray data still ongoing.

On-Line luminosity monitor

- !CHAOS infrastructure improved to cope with higher data rate exchange and management
-



In the OLD DataPath the access to new data required a direct access to the storage Area.

The interposition of KAFKA data lake allows to handle data queues more efficiently realizing direct streaming of the online data towards E(xecution) U(nits) for RealTime analysis.

DAΦNE Plan

The new LNF plan foresees:

- PADME run should be hopefully completed by the end of November (with 1 week of contingency);
- December should be dedicated to:
  maintaining and consolidating the DAΦNE LINAC in order to recover suitable performances for collider operations
  check all the DAFNE subsystems
- DAFNE operations should resume by January 11th 2021.

DAΦNE Activity Plan

Date	Scheduled Activities	
11/01/21	LINAC setup, TLS warmup	
12/01/21	LINAC setup, TLS warmup	
13/01/21	LINAC setup, TLS warmup	
14/01/21	LINAC setup, MRs and TLS warmup	
15/01/21	LINAC setup, MRs and TLS warmup, Injection test in Acc	
18/01/21	LINAC setup, MRs and TLS warmup, Injection test in Acc, TLs optimization	
19/01/21	LINAC setup, MRs and TLS warmup, Injection test in Acc, TLs optimization	
20/01/21	Injection in the MRs	
21/01/21	Injection in the MRs	
22/01/21	Injection in the MRs, Transverse coupling check in MRe	
25/01/21	Response Matrix acquisition, Reference Orbits optimization in MRe and MRp	
26/01/21	Response Matrix acquisition, Reference Orbits optimization in MRe and MRp, tests with e+ beam about polarities of solenoids.	
27/01/21	Twiss function measurements in MRe	
28/01/21	Twiss function measurements in MRp	
29/01/21	Chromaticity measurements and optimization in MRe and MRp.	
1/02/21	Chromaticity measurements and optimization in MRe and MRp.	

Weekends are the only contingency included in this plan, they could be used for:

- Dynamic vacuum conditioning
- LINAC conditioning (if required)
- Systems optimization (FBKs, collimator, TLs …)
- Luminosity tests in stable conditions.

DAΦNE Activity Plan

Date	Scheduled Activities	
2/02/21	Optics and Collision Bumps check and optimization	
3/02/21	Optics and Collision Bumps check and optimization	
4/02/21	CW-SXTs alignment check in MRe	
5/02/21	CW-SXTs alignment measurements in MRp, CW-SXTs mechanical alignment	
8/02/21	High currents tests and FBKs optimization	
9/02/21	High currents tests and FBKs optimization	
10/02/21	Collisions tests with CW Sextupoles OFF	
11/02/21	CW Sextupoles ON, chromaticity checks in Mre and MRp	
12/02/21	Collisions optimization with CW-SXTs ON, test run with 1 bunch for CCALT	
15/02/21	Collisions optimization with CW-SXTs ON, test run for CCALT	
16/02/21	Collimator optimization, test run for CCALT	
17/02/21	Collisions optimization with CW-SXTs ON, SIDDHARTINO acquisition tests	
18/02/21	High currents tests and FBKs optimization	
19/02/21	High currents tests and FBKs optimization	
22/02/21	Collisions optimization with CW-SXTs ON, SIDDHARTINO acquisition tests	
23/02/21	Collisions optimization with CW-SXTs ON, SIDDHARTINO acquisition tests	
24/02/21	Collisions optimization with CW-SXTs ON, SIDDHARTINO acquisition tests	
25/02/21	Collisions optimization with CW-SXTs , SIDDHARTINO acquisition tests	

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From Reviewers Report

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…

Manpower

Concerning scientific manpower this is the update with respect to the previous SciCom

Qualification	expertise	RC	
Physicist	*Resp. FBK Systems*		Retired on past June
Physicist	*Background simulations*	*	on leave for 1 year
Young Physicist	*Optics and Operations*		will leave by mid Jan. 2021

** Available to work as RC from time to time*

An application call aimed at recruiting one person with experience in the field of optics design is presently suspended due to the new Government dispositions against the pandemic

This position is intended to work on the FCC-ee injection system and on the DAΦNE collider.

Technical Staff

Presently shifts to operate the DAΦNE LINAC for the PADME experiment and SPARC rely on eight crews of tree people, **29 Operators** in total.

To operate DAΦNE we need eight crews of four people, **32 Operators** in total.

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Special thanks are due to the Technical Staff of the Accelerator and Technical Divisions. They worked hard and in a though context to install and mend system components as well as to operate the Accelerators in the LNF.

Conclusions

Regardless of the difficoult situation and amid many restrictions the DAΦNE run for SIDDHARTA-2 has been planned in great detail.

Thank you for your attention