DAΦNE run for SIDDHARTA-2

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on behalf of the DAΦNE Team

64th Scientific Committee Meeting November 14th, 2022

DAΦNE Team

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On leave / retired

Outline

- *Machine Operation overview*
- *SIDDHARTA-2 run*
- *Machine studies*
- *Preparation for next run*
- *Conclusions*

Operations Overview

DAΦNE operations for SIDDHARTA-2 restarted on April 8th

Collisions ready by the end of April

Energy save operation mode adopted

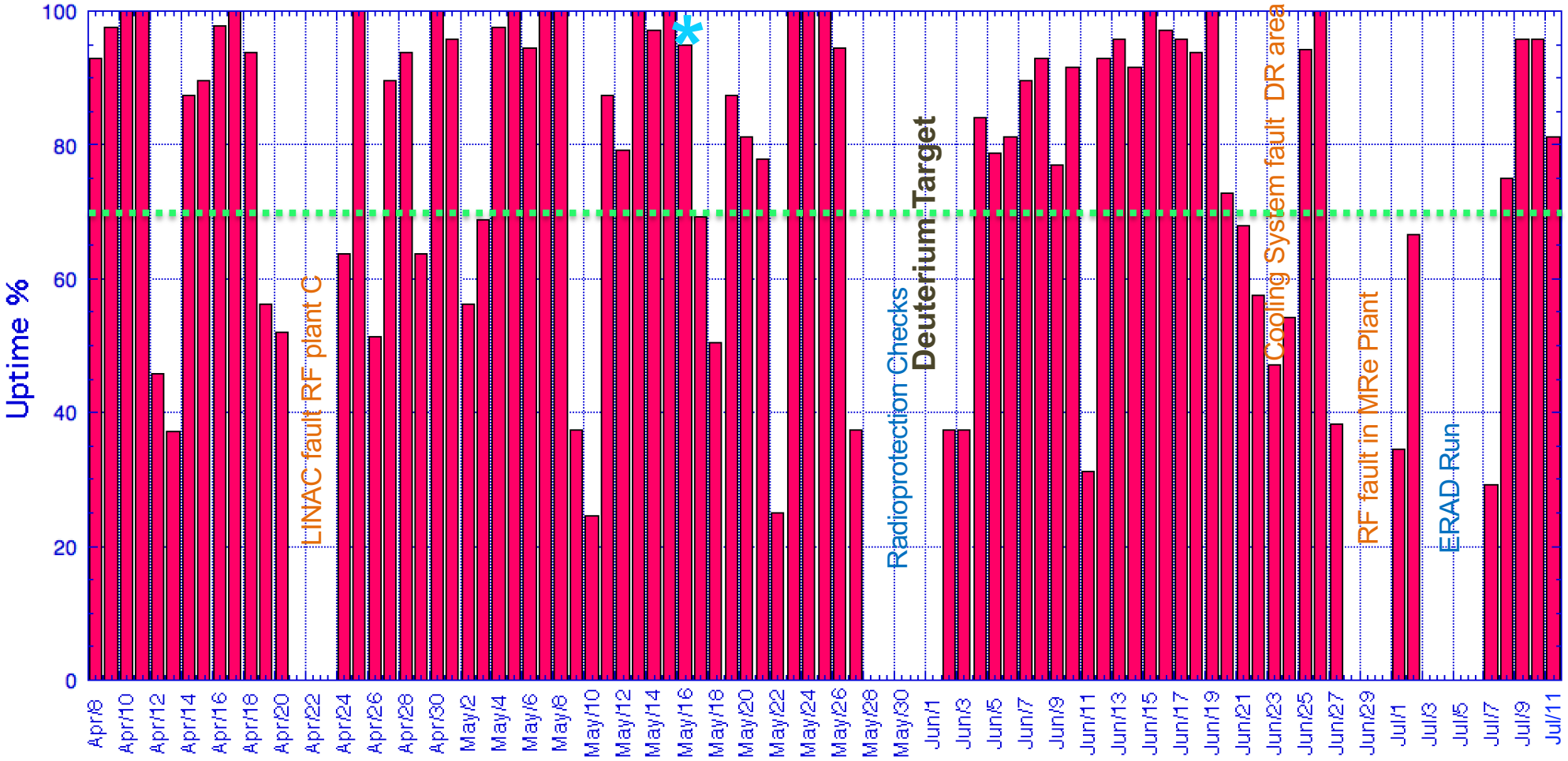
Previous SciCom on May 16th 2022

DAΦNE shutdown on July 11th in advance wrt the schedule, including 4 days LINAC operation for the ERAD experiment

DAΦNE LINAC resumed operations on September 19th to prepare the setup for the PADME run.

Uptime

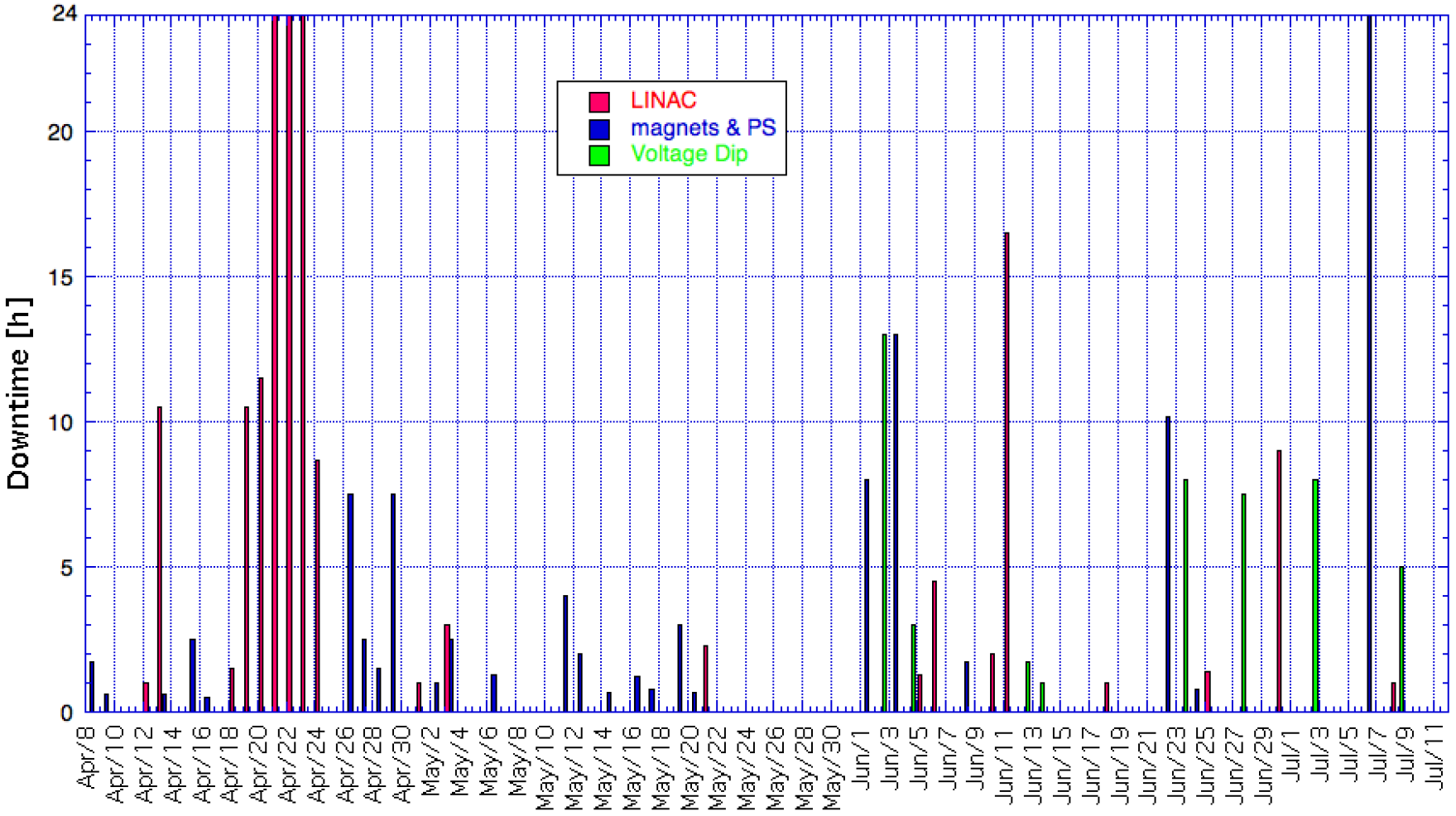
Average uptime during SIDDHARTA-2 Run (April 8th Jul 11th) has been ~ 72 %



Uptime is defined as the daily time percentage the collider has been storing beams in collisions.

* 63rd Scientific Committee

Main Downtime source



LINAC has been operated at 25 Hz

Voltage Dip became relevant for the first time

Ring Working Point

Latest working point adopted during the SIDDHARTINO data taking and corresponding to the best signal to noise ratio measured so far is:

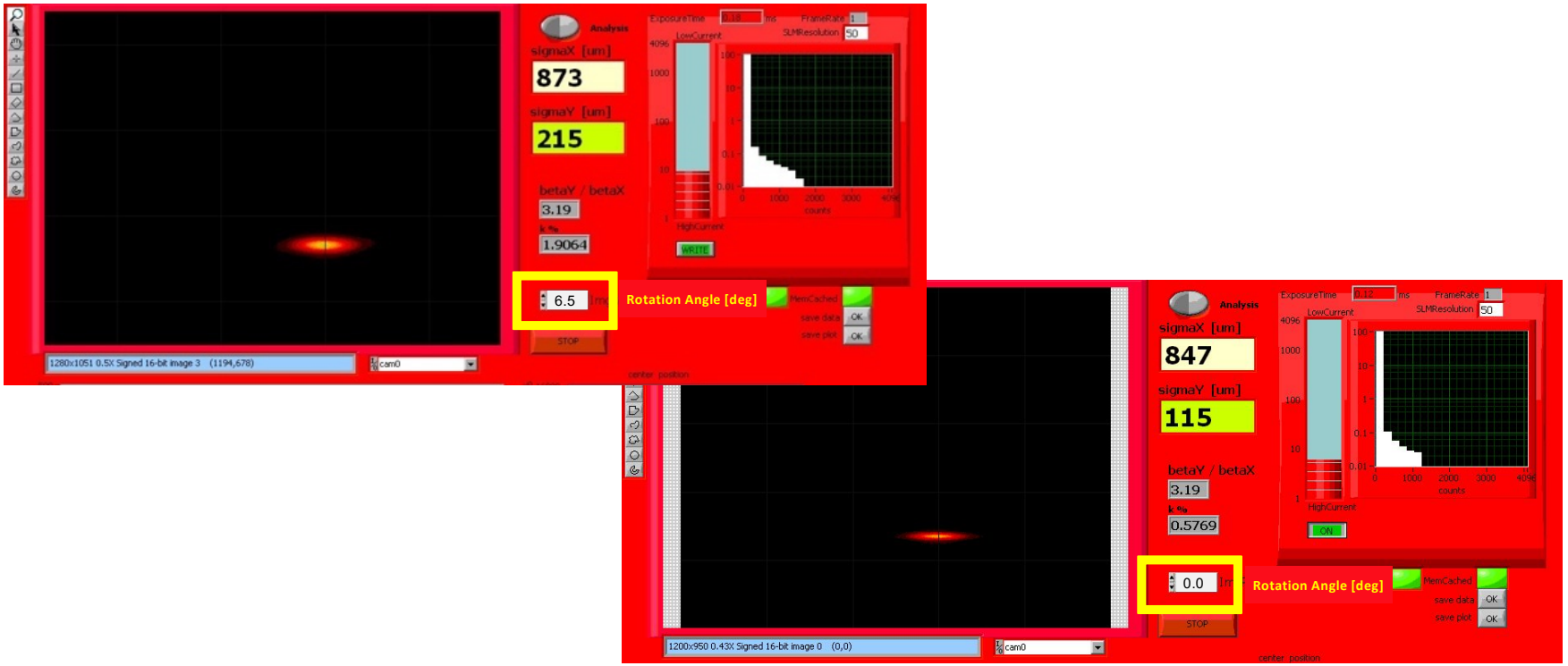
$Q_x^- = 0.1082$ $Q_y^- = 0.1533$

$Q_x^+ = 0.0972$ $Q_y^+ = 0.1648$

Crab-Waist Sextupole strengths are still 55% of the nominal value.

Betatron Coupling Optimization in MRp

Linear ring betatron coupling



Betatron Coupling as measured at the SLM was considerably reduced:

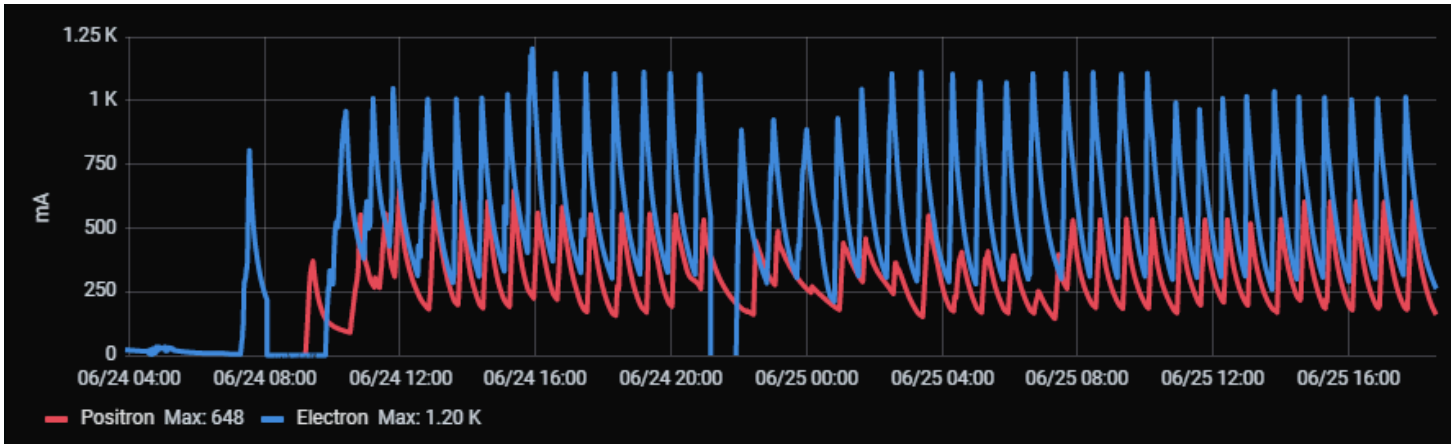
- σ_y almost halved,
- **tilt angle** zeroed,
- κ reduced by more than a factor 3

Coupling components in the steering magnets Response Matrix became negligible.

Electron Beam Dynamics

Electron Beam

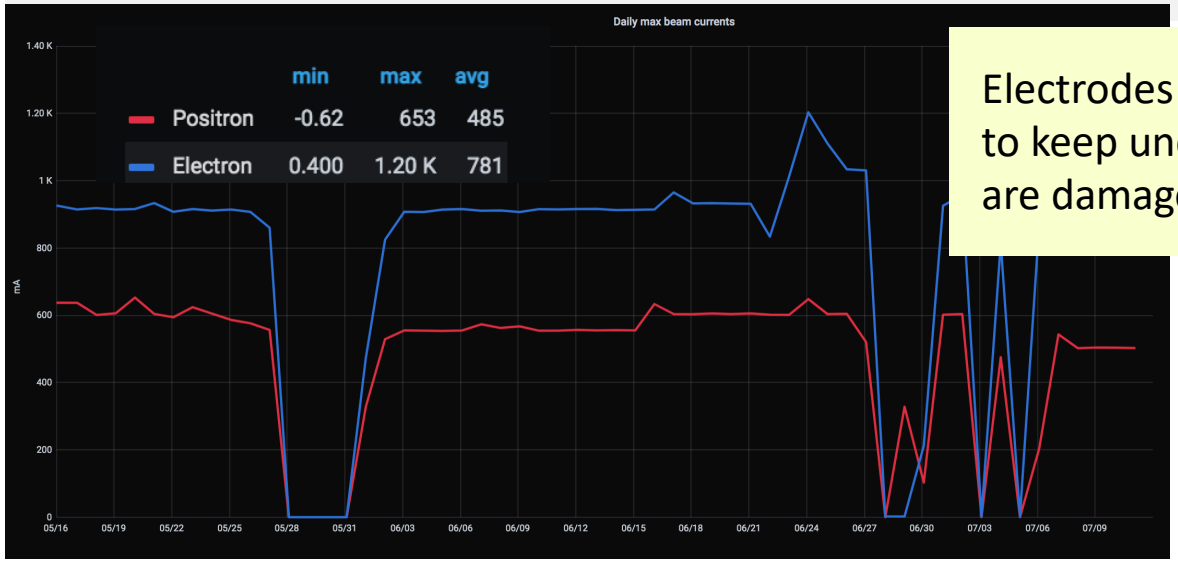
- A sudden beam loss was observed with a threshold in the range 600 - 900 mA stored in 105 bunches,
- no signal useful for diagnostics were detected from feedback and/or BPMs,
- the effect was cured by tuning the low-level RF feedback of the RF cavity in the electron ring.



Positron Beam Dynamics

Positron Beam

- At DAΦNE he maximum positron beam intensity is determined by ***e-cloud*** induced effects,
- presently positron beam exhibit a ***threshold around 650*** *mA* where a fast horizontal instability appears,
- *threshold was* ~ 800 mA during SIDDHARTINO run, FBK optimization is crucial,
- this kind of instability is compatible with the fact that the main contribution to the e-cloud density comes from the four wiggler magnets installed in each ring,
- beam pipe venting for machine upgrade and/or new interaction region installation caused evident memory effects leading to progressively threshold reduction on the long term.

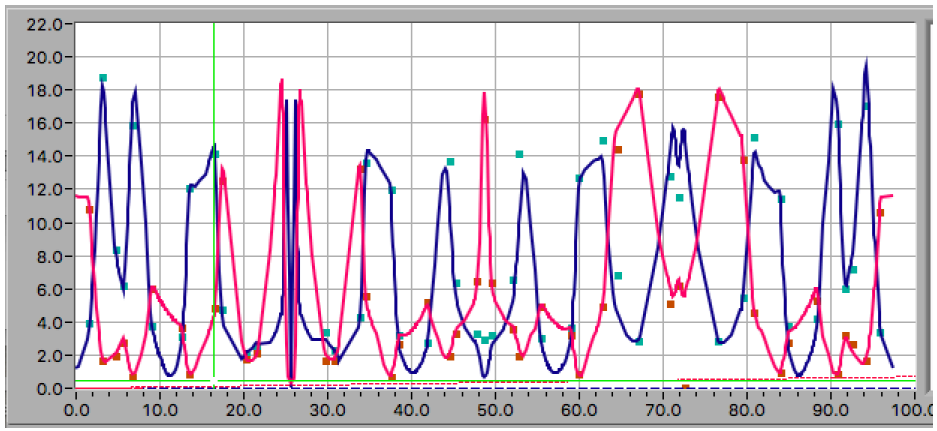


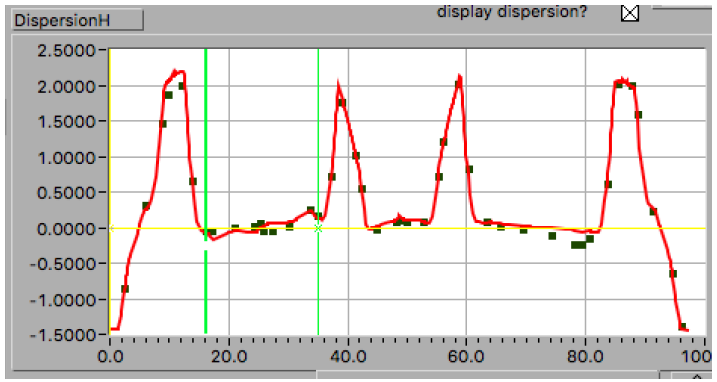
Electrodes successfully used in the past to keep under control e-cloud effects are damaged.

MRs Optics Characterization

Before ending the run Main Ring linear and non-linear optics has been fully characterized by measuring:

- betatron oscillation amplitudes,
- tunes,
- Dispersion,
- first and second order chromaticities.





Such measurements will be used as a reference for the next run, as well as for checking and optimizing ring optics.

Energy Scan

C.M. energy has been studied by varying the frequency of the main ring RF cavities

$$-\alpha_c \frac{\Delta p}{p} = \frac{\Delta f_{RF}}{f_{RF}}$$

In the range

$-15\ \text{KHz} \leq f_{RF} < 15\ \text{KHz}$

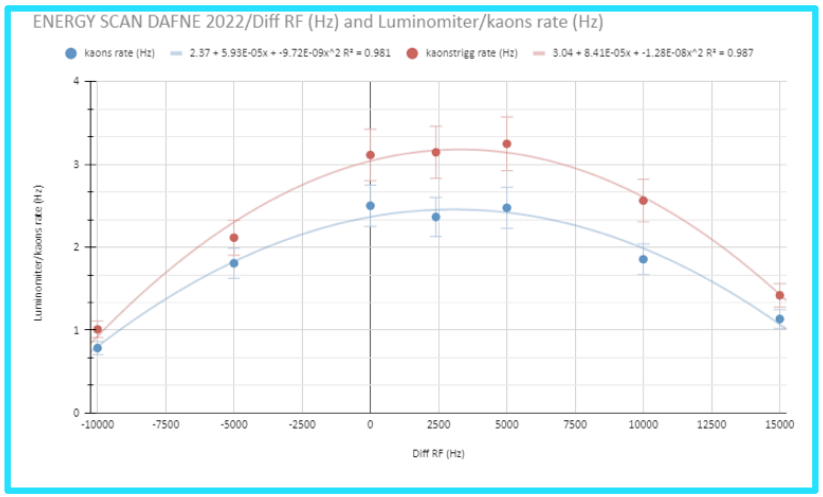
Corresponding to an energy variation per beam

$-1.09\ \text{MeV} \leq E < 1.09\ \text{MeV}$

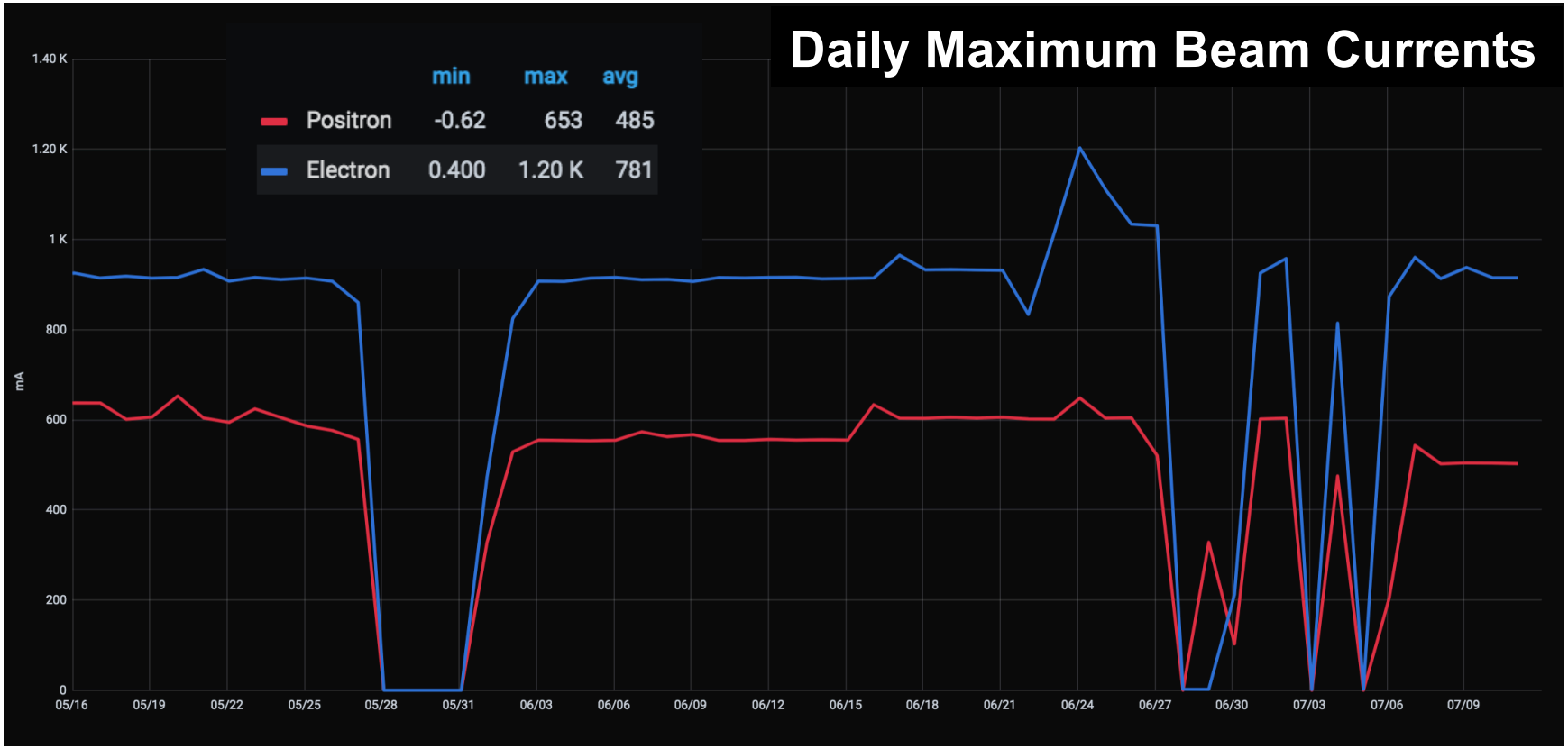
Collisions are almost centered on the peak of the Φ resonance

$\Delta E_{CM} \sim 0.4\ \text{MeV}$

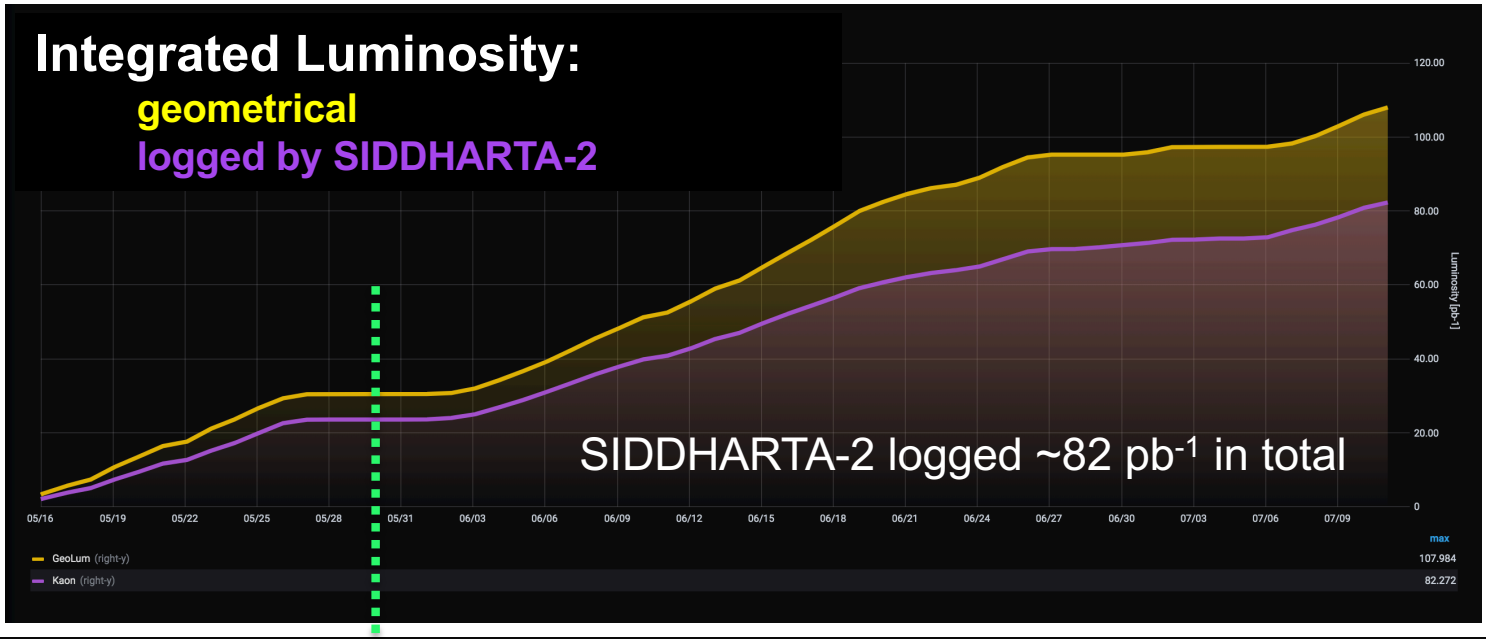
More rigorous data analysis is under way

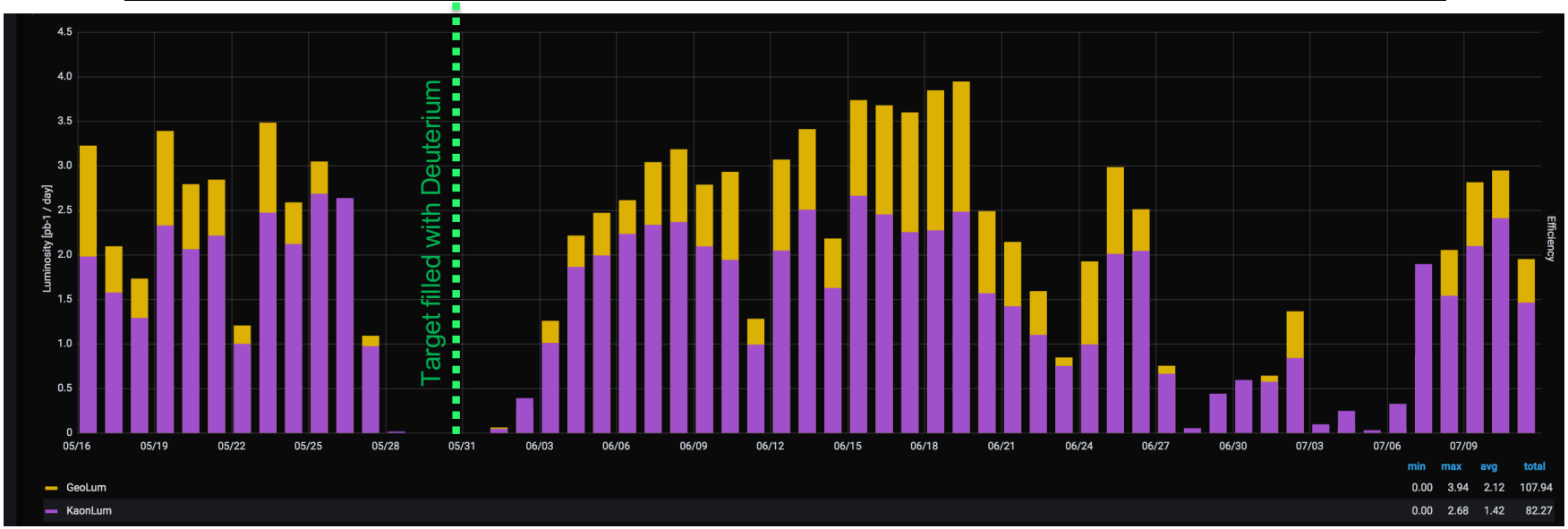


Daily Beam Current Trends



Data Delivery (May 16th – Jul 11th)





Background

Average ratio between ***Kaon Trigger rate*** and ***SDD normalized rate***.
Kaon/SDD was considerably improved mainly by scrapers optimization, and by working point fine tuning.
Kaon/SDD is still considerably lower than the reference value achieved during the SIDDHARTINO run which was above 30%.

DAFNE Consolidation for Next Run

LINAC: mending program already presented, it's important to recover full efficiency of the four RF plants and restore 50 Hz operation mode.

Magnets and PS:

general maintenance program,
clean-up some fake alarm coming from specific PS families,
special intervention on the cooling system of the DR PSs,
mending electronic components of the TL pulsed dipoles PS
trying to improve reliability of the TL steering magnet PSs

ControlSystem:

Finalize the service procedure which scans devices checking alarms and faults (Hunter Dog),
update the now derelict temperature probe control system,
upgrade of the DR closed orbit measurement.

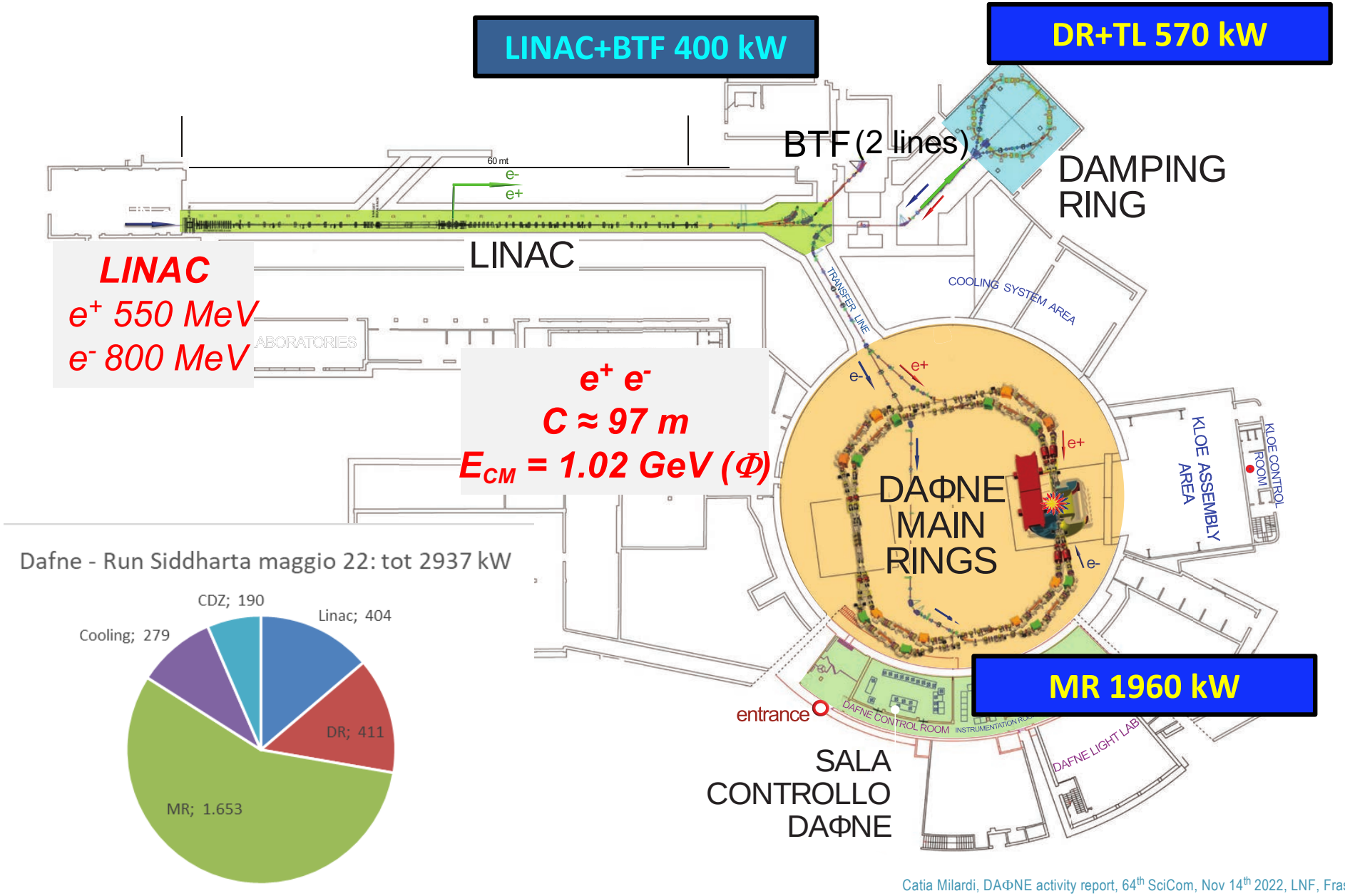
Vacuum:

temperature probe refurbishment
Vacuum gauge PS maintenance

Cooling systems:

general maintenance, and well defined maintenance calendar for the run

DAΦNE Power Load



DAΦNE Power Demand Trend

WIGGLER: reduced gap, lower pole field, pole shaped;
Septa: reduced gap, and new coils;
MR RF plant: power limitation;
Cooling: control system revanping.

Cryo Plant off

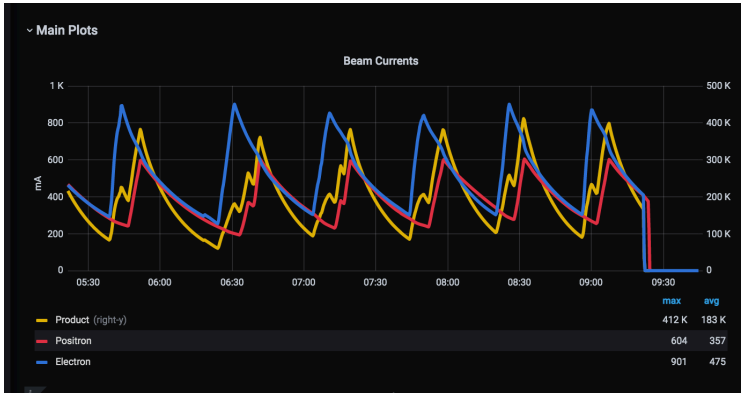
Anno	Pdafne [MW]	€/MWh	Costo 24 h run	
2000	5,63	82,60	€ 11.167	
2001	5,32	92,21	€ 11.772	
2002	5,66	90,68	€ 12.313	
2003	5,66	91,67	€ 12.447	
2004	5,20	95,09	€ 11.867	
2005	5,98	97,73	€ 14.026	Kloe
2006	5,54	116,21	€ 15.465	Kloe + Finuda
2007	4,30	118,70	€ 12.250	Finuda + Siddharta
2008	4,10	144,15	€ 14.185	Siddharta
2009	4,30	127,84	€ 13.193	
2010	3,60	136,01	€ 11.751	
2011	3,35	152,76	€ 12.282	KLOE
2012	3,35	180,61	€ 14.521	
2013	3,30	185,86	€ 14.720	
2014	3,35	176,11	€ 14.159	
2015	3,35	158,49	€ 12.743	
2016	3,35	163,55	€ 13.150	
2017	3,35	155,61	€ 12.511	
2018	3,35	156,38	€ 12.573	
2019	2,90	169,15	€ 11.773	
2020	2,90	155,19	€ 10.801	
2021	2,90	222,33	€ 15.474	Siddharta

(Data from R. Ricci)

Energy Saving Proposal

Characteristic timescale of the Injection process:

e^- injection	~ 6 min
Commutation	~ 3min
e^+ injection	~ 6 min
costing in collision	***~ 24 min***
total	39 min



DR and TL PSs account for 14% of the DAΦNE total power demand,
these devices **might be set at almost to zero current during costing** ~ 20 min
saving more than 45% of their power need: **200 kW**.

Benefit: ~ **7%** energy save in terms of DAΦNE total power demand.
Costs: automatic procedure should be developed in the CS GUI in order to implement the new operation mode.
Drawbacks: continuous thermal excursion maight affect magnetic field reproducibility. Test and cooling system tuning are required before the run.

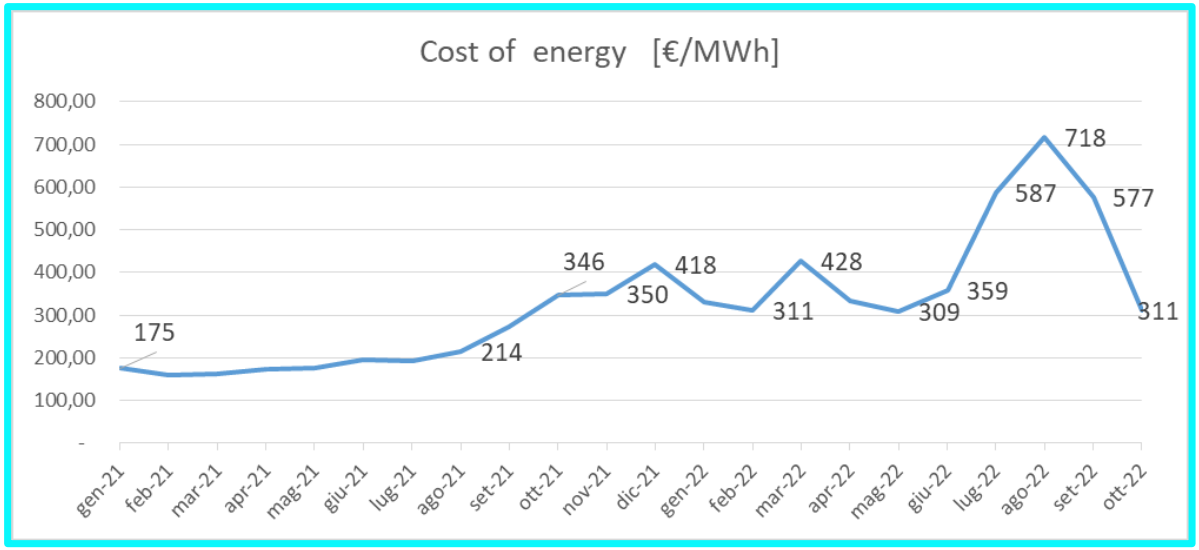
A more modest energy save, ~ **1.3 %** of the DAΦNE total power demand, can be obtained only setting to ~ zero all the PS involved in the commutation process after e+ injection.

Further energy save could come from optimization of the DAΦNE ancillary subsystems.

Power Cost Trend

Cost of energy @LNF

(VAT not included)



(Data from R. Ricci)

	Power demand [kW]	Energy [kWh]	Cost before crisys	Expected	Costo max 21-22 (aug 22)
cost of energy [€/MWh]			€ 180,00	€ 350,00	€ 418,00

		30 day run			
Dafne RUN x Siddharta	2950	2.124.000	€ 382.320	€ 743.400	€ 887.832
Solo LINAC	350	252.000	€ 45.360	€ 88.200	€ 105.336
LINAC+BTF	400	288.000	€ 51.840	€ 100.800	€ 120.384
Base LNF		750.000	€ 135.000	€ 262.500	€ 313.500

Man Power

Scientific Staff

Man power working on the DAΦNE collider remains an issue.

- Main accelerator topics such as optics and beam dynamics do not have adequate manpower.
- Some topics as for instance background simulations are uncovered.
- Crucial activities as Feedbacks would benefit from additional support.

In the next future:

- a new accelerator physicist will join the group next month,
- a postDoc will arrive at the end of of February 2023.

They both do not have experience in circular collider operation.

Technical Staff

- Another member of the operation group retired.
- New hired young technicians have been involved in operations, but they need training, especially about DAΦNE.

Presently Operation Group provides support to: DAΦNE, BTF1, BTF2, SPARC and TEX.

Conclusions

DAFNE operations aimed at commissioning the new setup of the SIDDHARTA-2 detector have been completed, regardless the non-optimal uptime also due, in some extent, to external adverse circumstances.

Collider performances are still modest even with respect to the SIDDHARTINO run, even though data-delivery has been privileged over machine studies.

Energy saving operation mode does not help in profiting from fine tuning and in understanding collider limitations.

However few machine dedicated runs led to quite relevant improvements:

- **betatron coupling in the positron ring was considerably reduced,**
- **electron beam intensity has been increased up to 1.25 A without any threshold evidence,**
- **Kaon/SDD ratio has been moved from 13% to 20%.**

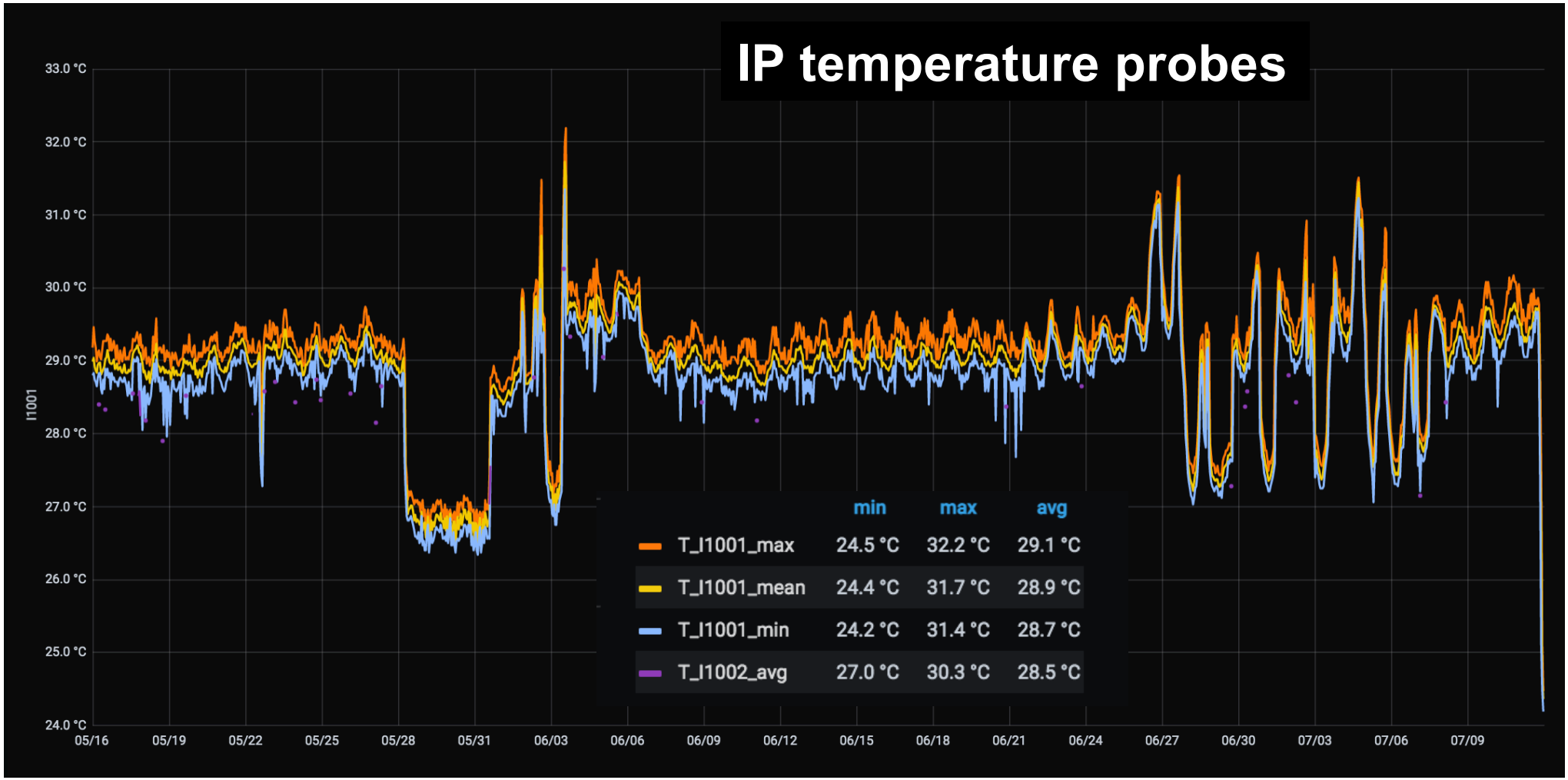
A detailed maintenance and mending plan has been defined in order to assure reliable and efficient operations in 2023.

A comprehensive revision of the DAΦNE power demand is under way.

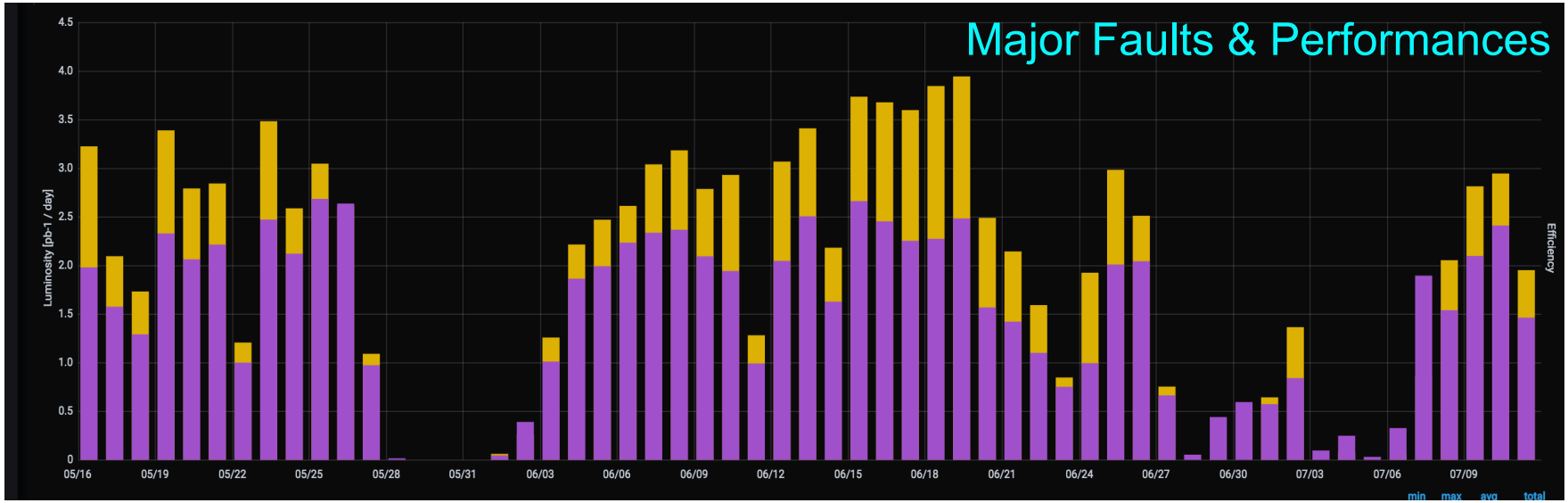
Thank you for your attention

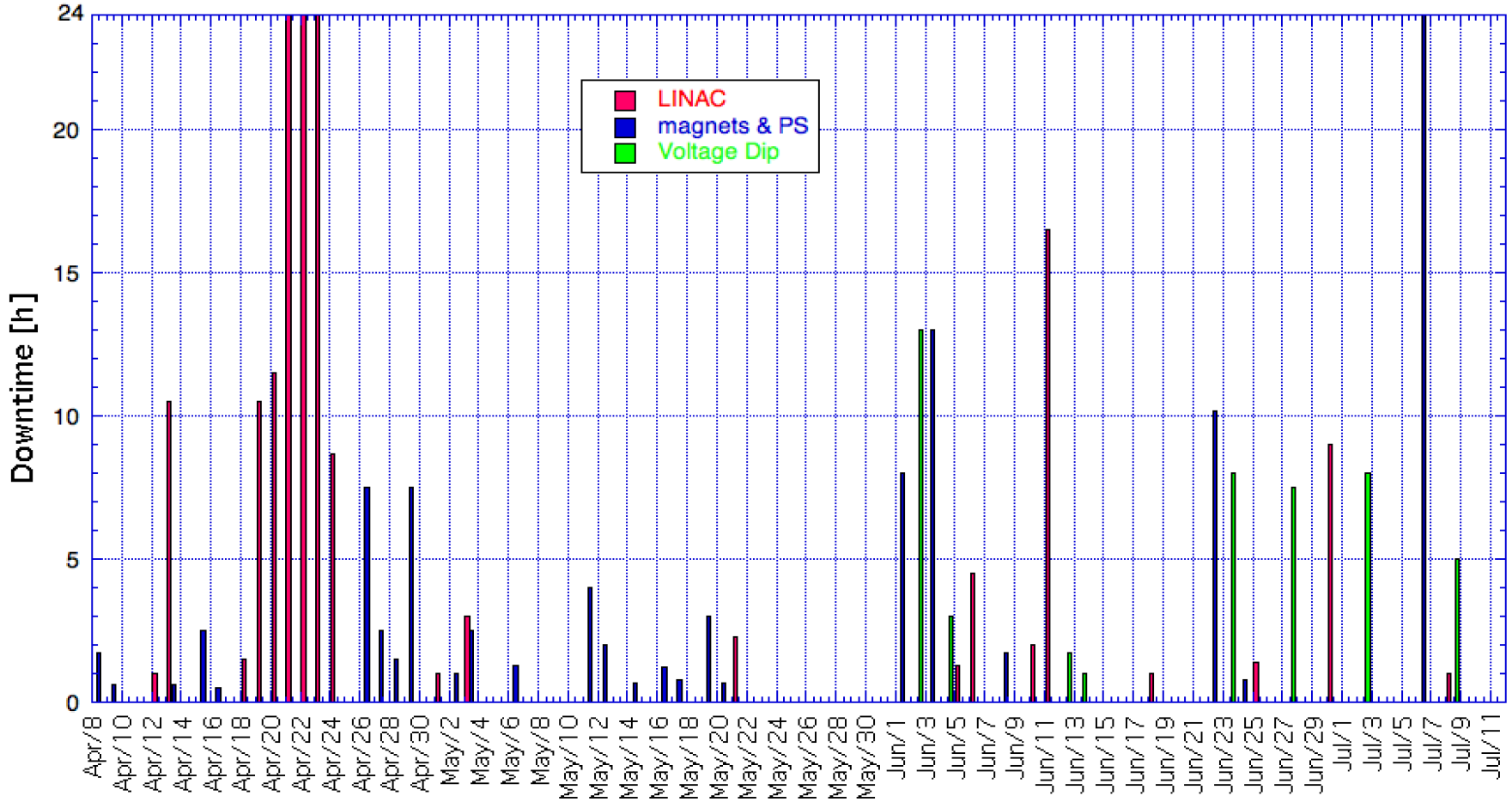
SPARE

IP temperature probes



Major Faults & Performances

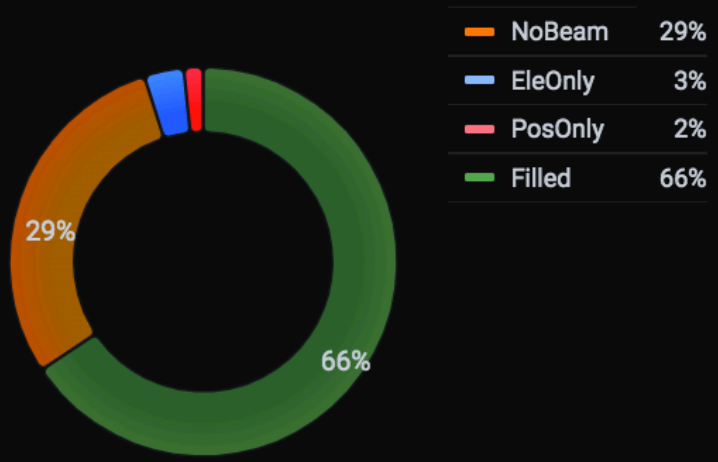




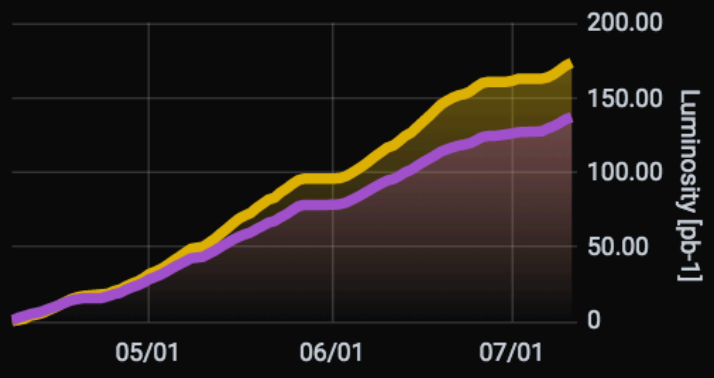
LUMINOMETER / Long-Term trends

SIDDHARTA-2 run (Apr 8th – Jul 11th)

Dafne BeamTime Category

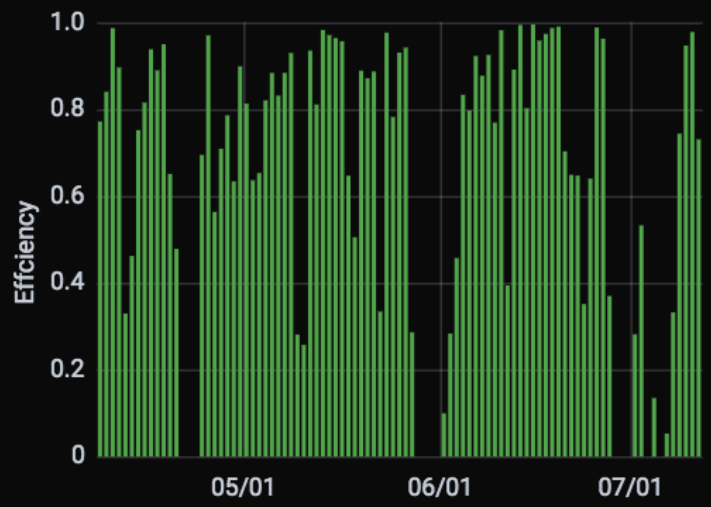


Luminosity Integrated Delivery



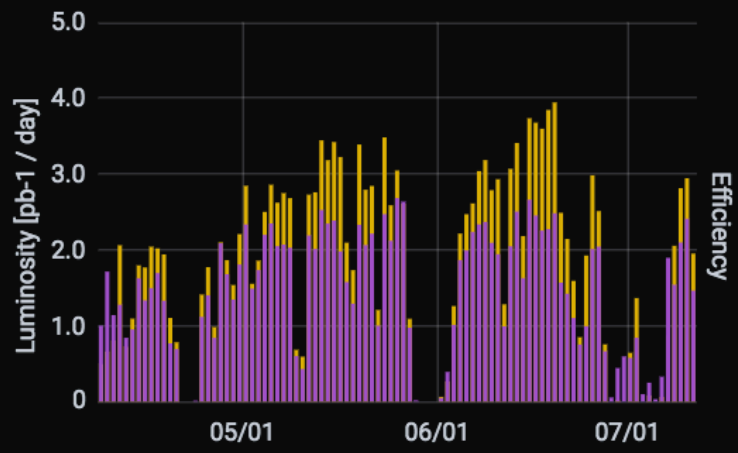
	max
GeoLum (right-y)	173.400
Kaon (right-y)	136.984

Delivery efficiency



	min	max	avg	total
Day Efficiency	0	1.00	0.63	60.72

Luminosity Daily Delivery (pb-1)

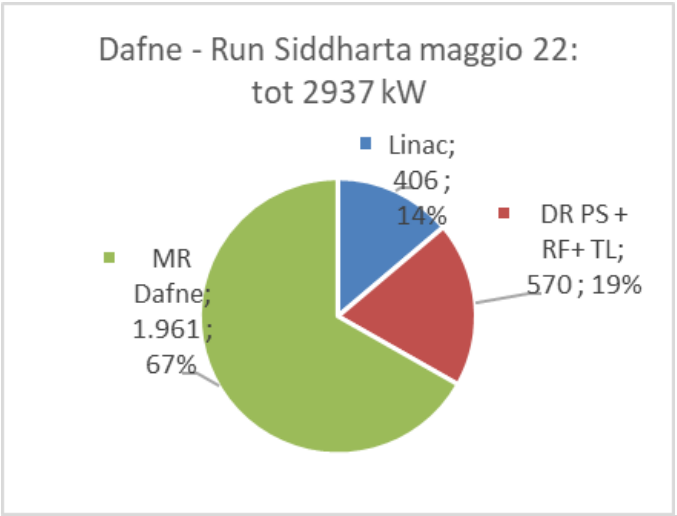


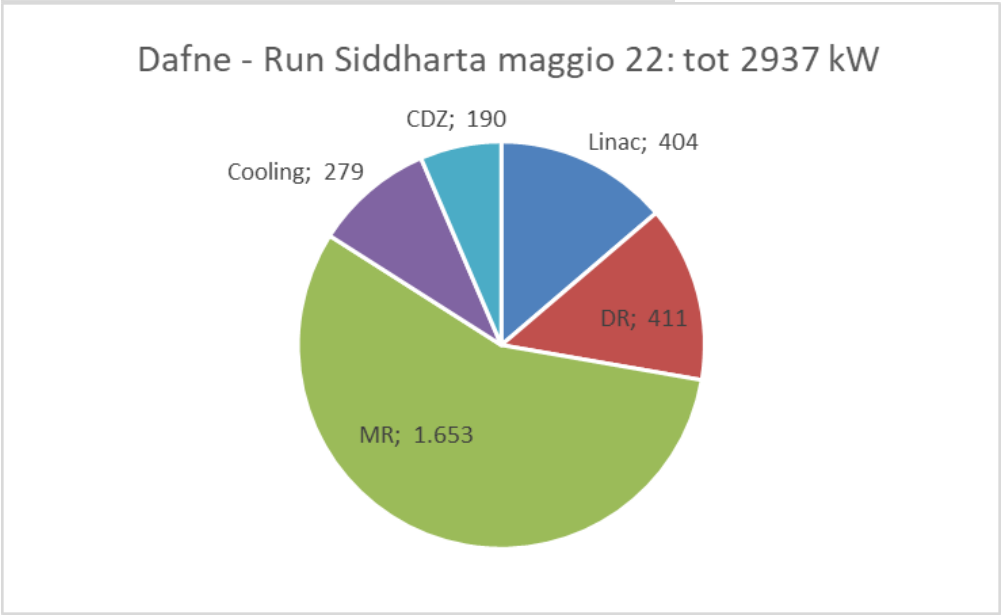
	min	max	avg	total
GeoLum	0.00	3.94	2.02	173.30
KaonLum	0.00	2.68	1.43	136.98

SIDDHARTA-2 run (Apr 8th – Jul 11th)

DAΦNE Power Load

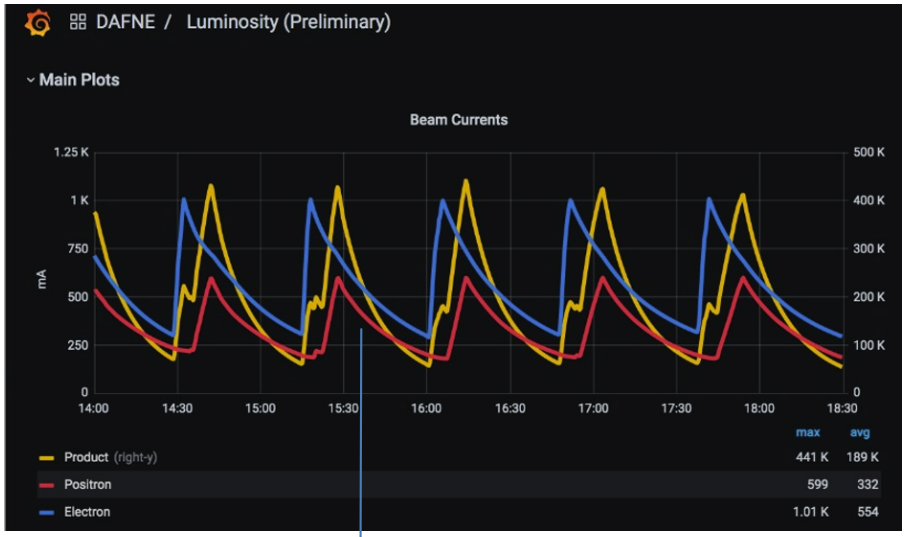
Componenti Acceleratore	kW	**2378**
Linac Modulatori	208	
PS Linac	76	
DR PS + RF+ TL	411	
PS Dafne Cab. 10	1092	
PS Sala conteggio e Dafne	173	
RF MR	388	
BTF	*30*	
Cooling		**369**
Sala pompe Linac	32	
Linac WS	90	
Sala pompe DR (Q2)	69	
Sala pompe Dafne (Q3)	170	
Cooling RF MR (Q4-Q5)	8,4	
Codizionamento		**190**
CDZ Dafne	130	
CDZ DR+ BTF	60	
Tot Dafne Run Siddharta maggio 2021		**2.937**

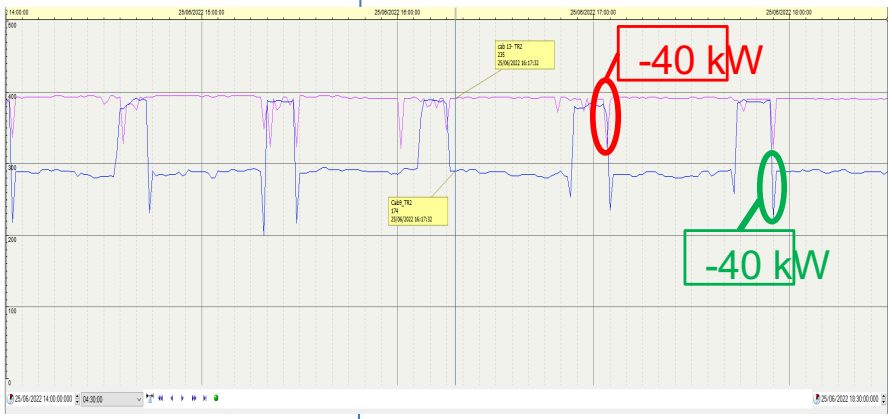




(Data from R. Ricci)

Energy Saving Proposal n. 2





1. St-by of TL PS involved in polarity change

PS involved in e-/e+ switching: 80 kW

Evaluation based on co-relation between injection/AC power demand:
Of the 2 tranformer feeding these PS we observe 80 kW of load reduction during stand-by

Benefit: Reduction of mean power of 40 kW (1,3% of total Power demand – saving of 84 k€/year)

Cost: new procedure of commutation introducing an additional step

Drawbacks: none

Energy Saving Proposal n. 4

3 Wigglers off in each ring
WIGGLERS represent about 26% of the total power demand of the MRs

Benefit: ~ **19%** energy save in terms of DAΦNE total power demand.

Costs:

- Cabling reconfiguration
- 2.5 months for machine studies
- big effort in term of ring optics and beam dynamics development.

Drawbacks:

- success is not guaranteed,
- It will be possible to operate the x-ray SR beam-line.

DAΦNE Activity Plan

- Transfer Lines studies in order to improve Injection efficiency;
- LINAC optimization at 50 HZ;
- Closed orbit refinement an CHV strength minimization in MRs;
- Twiss function measurements in MRs in order to check the optics setup and to further improve the agreement between model and measurements;
- Beam spectra measurements at some BPMs;
- Bunch length, tune measurements, and vertical beam size as a function of bunch current for different RF voltage and for different chromaticity;
- Feedback system measurements and optimization