

Crab Waist at DAΦNE: the accelerator experience

Dmitry Shatilov

in coordination with team members DAΦNE

FCC-ee (TLEP) Joint Accelerator-Physics Vidyo meeting
CERN, 29 June 2015

----- Messaggio originale -----

Oggetto: Crab Waist with KLOE-2 detector

Data: 2015-02-06 10:40

Mittente: Mikhail Zobov <Mikhail.Zobov@Inf.infn.it>

Destinatario: Frank Zimmermann <Frank.Zimmermann@cern.ch>

Cc: Catia.Milardi@Inf.infn.it, E.B.Levichev@inp.nsk.su, Michael

Benedikt <Michael.Benedikt@cern.ch>

Dear Frank,

we have learned that some people in the FCC Collaboration do not believe that the crab waist works in DAFNE with the detector solenoidal magnetic field.

We categorically disagree with this statement.

Both numerical simulations including the complete nonlinear lattice with the detector solenoid and our experimental experience at DAFNE clearly confirm that the crab waist works!

The results of the numerical studies will be presented at IPAC2015, while now I am sending you a couple of slides explaining the current situation.

The first thing that started working reliably was the crab waist.

1. Slide 1:

it is clearly demonstrated that by increasing the strength of the crab sextupoles the beam sizes decrease and luminosity grows. This is seen on both the luminosity monitors: the DAFNE gamma monitor and the KLOE detector monitor.

2. Slide 2:

Up to now we have reached 1.8×10^{32} . As shown this luminosity is already higher than that previously achieved with KLOE and FINUDA detectors and it was reached at much lower beam currents and with less bunches.

The work is in progress to improve the luminosity. Even during the SIDDHARTA run (no detector solenoidal field) it took us 1.5 years to obtain the nominal luminosity. Now the interaction region is much more complicated.

Not the crab waist, but other beam dynamics issues limit the presently achieved luminosity such as e-cloud, single bunch instability etc. Unfortunately, DAFNE complex also has many technical faults.

The following two Slides show you just two examples of REAL reasons presently limiting the luminosity:

3. Slide 3:

In order to decrease the effect of the e-cloud in the same lattice we have collided 10 bunches (shorter train) instead of 100 and we have obtained 2.55×10^{31} per bunch in 10 bunch operation instead of 1.7×10^{32} per bunch in 100 bunch operation.

4. Slide 4:

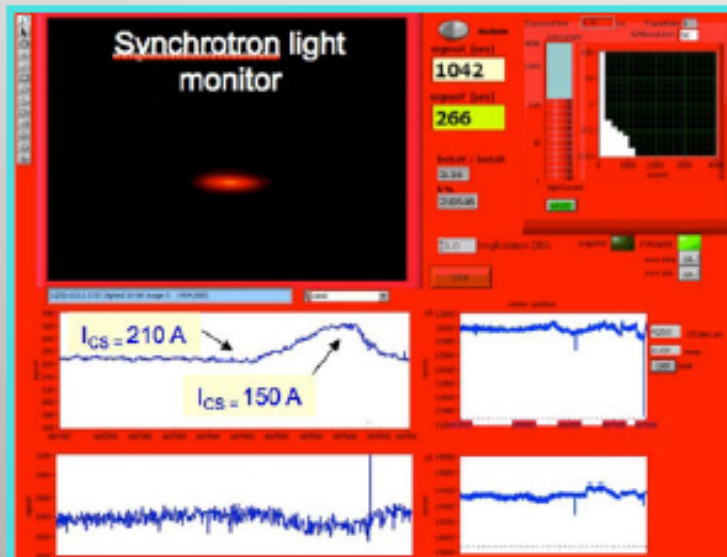
above 8-10 mA per bunch the transverse beam sizes (and also longitudinal energy spread) start to grow even without beam-beam collision. We attribute this single bunch effect to the increased beam impedance of the vacuum chamber: new damp kicker, smaller distance between strips in the injection and transverse feedback kickers etc. We believe that we can increase the instability threshold by increasing the lattice momentum compaction factor. The respective studies have been successfully performed in the past.

There are other several problems to overcome. So we are working!

Best regards, Mikhail and Catia.

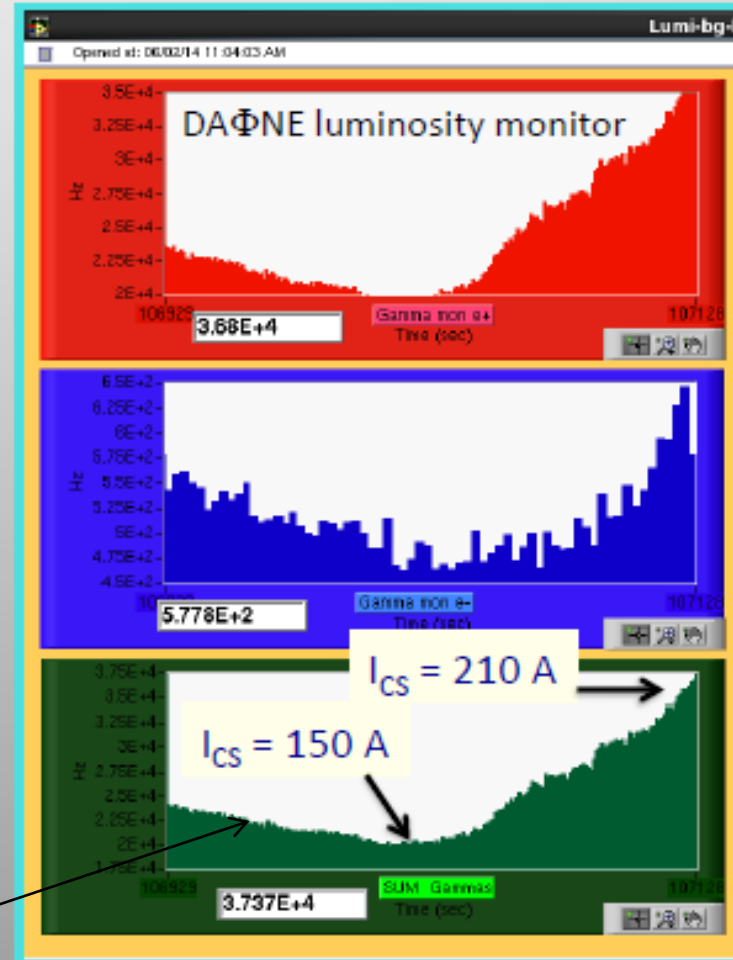
Crab-Waist Sextupoles

Crab-Waist Sextupoles effectiveness has been tested on the e^+ ring

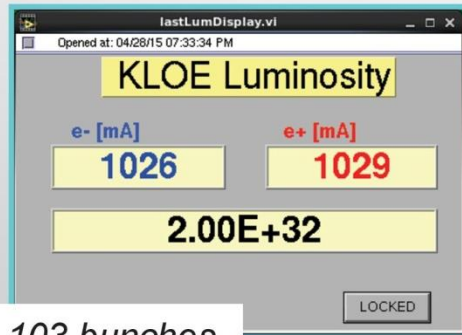


Crab-Waist Sextupoles strengths are 30% and 50% lower than the nominal ones for e^+ and e^- respectively.

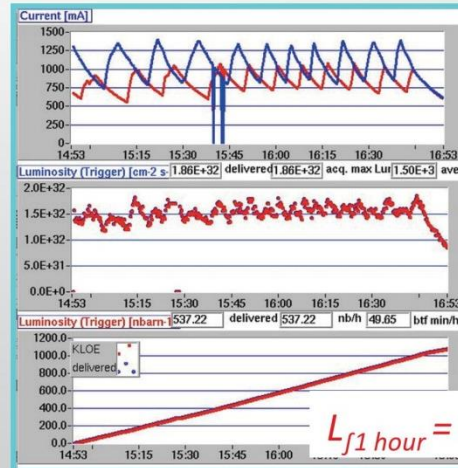
KLOE Detector monitor



Peak Luminosity



103 bunches



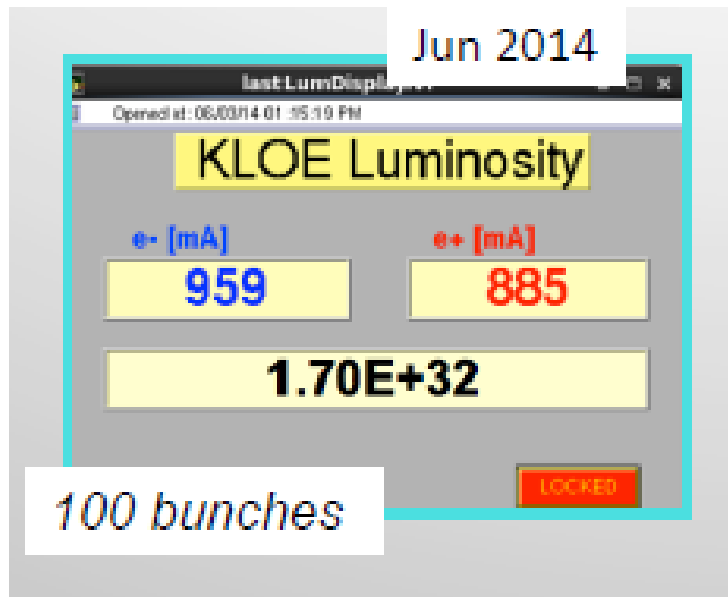
$L_{f1 \text{ hour}} = 0.54 \text{ pb}^{-1}$

| | DAΦNE CW upgrade SIDDHARTA (2009) | DAΦNE KLOE (2005) | DAΦNE (CW) KLOE (2012) | DAΦNE (CW) KLOE-2 (2014) |
|---|--------------------------------------|----------------------|---------------------------|-----------------------------|
| $L_{\text{peak}} \text{ [cm}^{-2}\text{s}^{-1}\text{]}$ | $4.53 \cdot 10^{32}$ | $1.50 \cdot 10^{32}$ | $1.52 \cdot 10^{32}$ | $2.0 \cdot 10^{32}$ |
| $I^- \text{ [A]}$ | 1.52 | 1.4 | 0.93 | 1.03 |
| $I^+ \text{ [A]}$ | 1.0 | 1.2 | 0.72 | 1.03 |
| N_{bunches} | 105 | 111 | 100 | 103 |

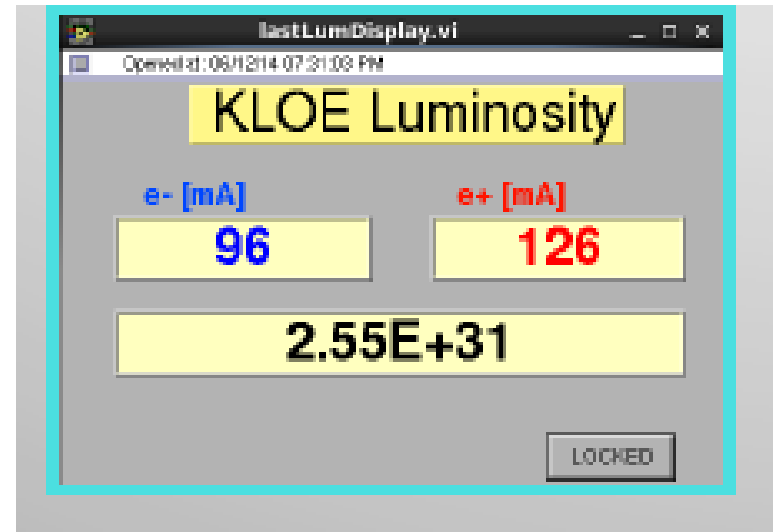
L_{peak} exceeds by a **33%** the best luminosity ever achieved, at DAΦNE, during operations for an experimental apparatus including high field detector solenoid.

Background presently has been **considerably reduced** especially the component due to the e^- beam

In order to decrease the e-cloud effect we have performed luminosity measurements with a shorter bunch train in the same lattice

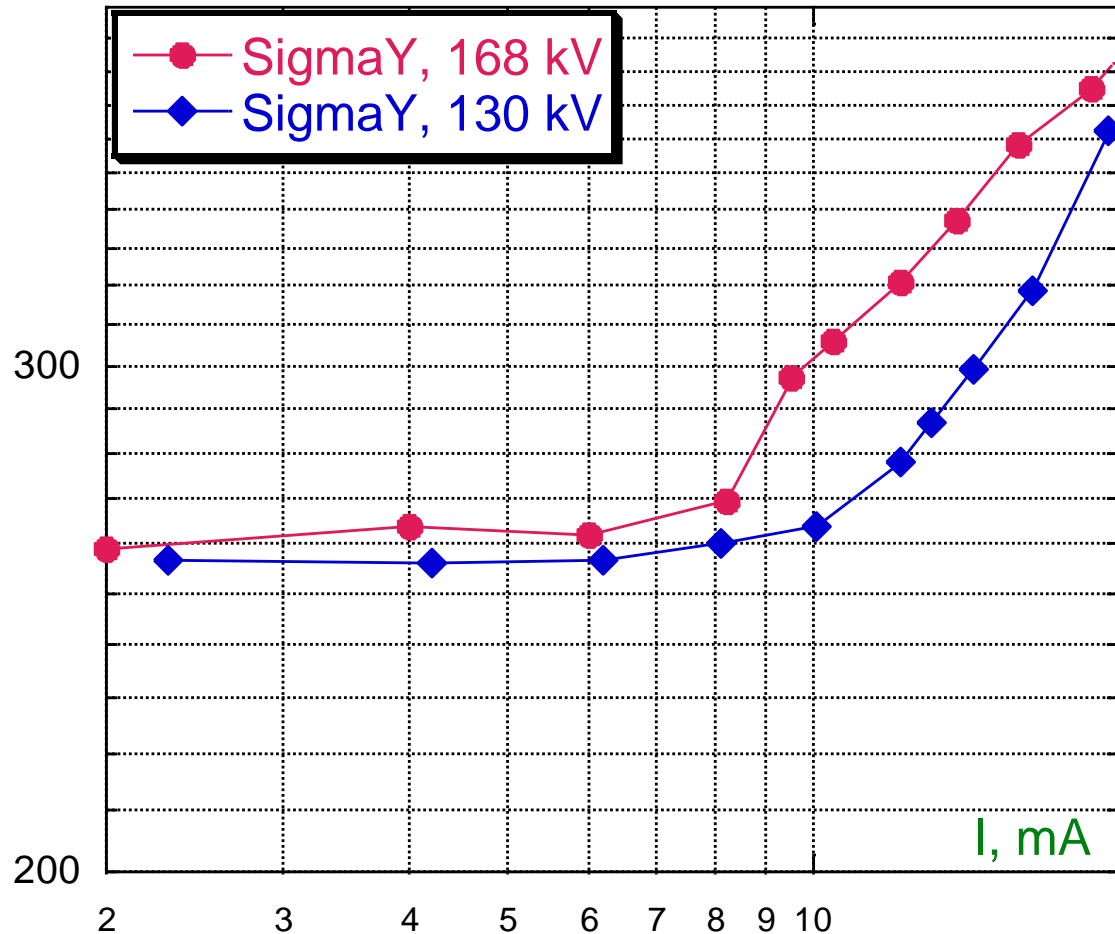


100 Bunches



10 Bunches

Transverse Beam Size Increase without Beam-Beam interaction (26 June 2014)



Conclusion

- Specific luminosity at KLOE-2 is two times higher than at KLOE (2005). The main part of this factor comes from β_y reducing, another part – from crab waist.
- To reveal all the benefits of crab waist, we need the beam parameters (without beam-beam) corresponding to large ξ_y : bunch current ~ 15 mA and small vertical beam size. At present these parameters were not achieved yet, so the effectiveness of crab waist is lower than it could be.
- See the 2nd slide, note the highlighted text.
- There are many other issues, but I do not have enough information and the authority to talk about them.
- Ask Mikhail Zobov & Catia Milardi to present more detailed report. Contact them in advance to decide on the convenient date.