Present:
Daniel Schoerling
Steve Hancock
Gianluigi Arduini
Stephan Maury
Elias Metral
Wolfgang Bartmann
Luc Sermus
Gerard Tranquille
Pavel Beloshitskii
Tommy Eriksson
Thomas Zickler
Simone Gilardoni
Walter Oelert
Francois Butin
Thomas Zickler
Brennan Goddard
Olav Berrig

G.Tranquille explained that the ELENA Beam Physics and Performance Committee meeting was created to establish the technical details of the ELENA accelerator. One of the outcomes would be the Technical Design Report (TDR). The meetings would take place once every two weeks.

P. Belochitskii (slides) then outlined the progress on the design of ELENA. We are presently in the first design phase, where the important task is to identify possible designs that fulfill our constraints (these possible designs will in the following be called: candidates).
The most important factors to take into consideration:

1) Space constraint. ELENA is placed within the AD hall. The cranes must be able to reach most of the positions within ELENA, in order to install heavy magnets.
   There must be enough space for beam instrumentation and the electron cooler. In order to get enough space, also the platform with the kickers needs to be removed.
2) Electron cooler:
   Get physical space.
   Have appropriate Twiss parameters at the electron cooler:
   - Beta-functions
   - Dispersion
3) Choice of working point. Because of the large Laslett space charge tune shift the tune can move to resonance. We must therefore be able to move the tunes away from the most dangerous resonances.
4) The length of the AD is quantified. It must be a fraction of the length of the AD because of bucket to bucket beam transfer e.g. 1/6 = 30.4 m
5) Possibility of a second extraction.

S.Maury: The SPSC board recommended an extra extraction to the research board in June 2010 (Note: The research board has recommended to the departments that the 2'nd extraction is an option – nothing more than this)

6) Control of chromaticity. A special important aspect is the pole-face angles of the bending magnets, called E1 and E2. Another important aspect is the fringe fields.
7) Non-linearities will only be analyzed for the candidate designs, because they take long time to perform.
8) Finacial constraints (Note: The financial constraints were not explicitly mentioned during the meeting, but they are important and favor simple solutions)

S.Gilardoni: Why not use a rectangular layout?
P. Belochitskii: A rectangular machine makes injection and extraction lines more complicated. A ring with 6 bending magnets (=6-fold machine) give more space for equipment.
S.Gilardoni: But this means that you will have stronger stray fields?
P. Belochitskii: Yes, but the tunes can be controlled better. Also the beta functions will have bigger dynamic range in a 4-fold machine.
G.Arduini: How many bunches are transferred from the AD to ELENA?
P. Belochitskii: One bunch
G.Arduini: Why is the circumference limited?
P. Belochitskii: The main reason is the limited physical space in the AD hall.
G.Arduini: Is the 1/n criteria for the ELENA length a strong constraint?
P. Belochitskii: Maybe lower priority constraint
S. Hancock: Yes, it is a low priority constraint, but the 1/n constraint gives easy frequency synchronization between AD and ELENA, but it can done for an arbitrary circumference as well.

P. Belochitskii explains that it is better to have a ring with 6 bending magnets (6-fold machine) than a ring with 4 bending magnets (4-fold machine), because it gives less integrated focusing from the bending magnets. To relax the focusing from the bending magnets, we increase their length, thus leaving more space for other equipment. Less space in a 4-fold machine for other equipment.

S.Maury: What is the length of the straight section, in the 4-fold configuration?
P. Belochitskii: About ~22m/4 i.e. about 5-6 m
S.Maury: If we are worried about too low magnetic fields, as in a LEIR type machine where we have 400 Gauss, we can reduce the length of the magnets and thereby increase the fields.
T. Zickler: Something in between 400 of 490 Gauss is not a big thing for us. The minimum field is not an argument for the magnet group. This is not a strong argument.

P. Belochitskii outlines two different types of 6-fold lattices:

- 3 sections with three quadrupoles

- 4 sections with three quadrupoles – plus – three straight sections.

The quadrupoles can be placed in two configurations, either as a triplet (i.e. closely spaced) or evenly spread out.

S. Gilardoni: Why do you limit yourself to three quadrupole families? Can you add more quadrupole families?
P. Belochitskii: There is no physical space for these
S. Gilardoni: Did you compute the structural resonances? (i.e. a resonance that appear because of a field imperfection in one of the magnets, which will excite the beam with an ever increasing amplitude)
P. Belochitskii: Not yet; no non-linear effects have been studied at this stage of the project.

P. Belochitskii discusses the choice of tunes. He emphasizes that enough flexibility must be available to move the tunes away from resonances. Also the solutions must not be too sensitive to changes of the pole-face angles.

S. Gilardoni: The choice of tunes also depends on the dispersion in the cooler?
P. Belochitskii: Yes, also because of the beta-functions. In the AD we run with 0.45 and in Stockholm 0.3 was tested. The main criterion is to leave space for the Laslett tune shifts.
E. Metral: What is the maximum space charge tune shift do you allow?
P. Belochitskii: 0.1
S. Gilardoni: In order to have the preferred Twiss functions and dispersion at the electron cooler, is it possible to put the electron cooler inside an insertion (Note: An insertion have fixed beta-functions at the start and end)
P. Belochitskii: No, ELENA is too small to accommodate insertions.

P. Belochitskii lists the different design candidates and looks at the effect of pole-face angles on the solutions. He notes that he does not like the sensitivity to the chromaticity, and for some solutions there is no good space for extra sextupoles, because there is no good separation between horizontal and vertical beta-functions.

S. Gilardoni: Are you using MADX or PTC for the simulations?
P. Belochitskii: I use MAD8
S. Gilardoni: If you are sensitivity to the E’s, how can you use MAD8?
P. Belochitskii: I plan to use PTC (Note: PTC is a very precise version of MADX).
G. Tranquille: How sensitive are you to the pole-face angles and can you correct the chromaticity?
P. Belochitskii: Most of the solutions with 4 sections with three quadrupoles can correct the chromaticities. 3 families of quadrupoles does not give flexibility for corrections.

P. Belochitskii looks at the different aspects of the extractions. He notes that all lengths are magnetic lengths, which are shorter than the actual magnets.

T. Zickler: We should also remember that when the magnets are close, there is crosstalk between the magnets. Also the instrumentation could give extra crosstalk.
G. Arduini: You have studied the sensitivity to the pole-face angles, have you also studied the sensitivity to other errors e.g. quadrupole errors?
P. Belochitskii: The first part of the design is to select possible solutions exclusively for linear optics. Sensitivities will be analyzed in detail for a few selected design candidates.
S. Maury: What if you put the kicker on the other side of the triplet?
P. Belochitskii: If you put the kicker upstream of the defocusing quadrupole or triplet, then we have to increase the apertures of these quadrupoles significantly; compared to the other quadrupoles in the machine. This solution would be more expensive – especially taking into account that we need extra power supplies. It is also difficult for commissioning. I do not like to have a special construction of the quadrupoles, which is adapted to the extraction. In the AD we have specially constructed quadrupoles and had big problems them.

P. Belochitskii emphasizes that a big kicker angle should not be a problem for ELENA, because the time interval between consecutive bunches is big enough for the ripple to disappear.

P. Belochitskii examines how to estimate the beam emittance which will give us the dimensions of the vacuum chambers (i.e. acceptance)
P. Belochitskii: According to Thomas Zickler it is difficult to keep a 10^{-4} field homogeneity in the bending magnets. Careful studies should be performed to see if we can relax this requirement. One big problem is that when we measure the emittance in the AD, it varies from day to day. The emittance in AD can vary from 1 π to 15 π. When we decelerate, the emittance will increase to about 15 π to 45 π.

P. Belochitskii shows the ELENA cycle, it has three momentum plateaus:

- Injection (100 MeV/c)
- Intermediate cooling (35 MeV/c)
- Extraction (13.7 MeV/c)

T. Zickler: What is the rise time toward injection? Within 10 seconds or maybe below a second?
P. Belochitskii: It is longer than a second.
S. Maury: I am wondering about the acceptance. With the decrease in energy the acceptance will increase from 15 π, by a factor 3, to 45 π. We also need to include the fluctuation of the orbit. Maybe 45 π is not enough? Or, maybe 15 π in the AD is too pessimistic?
P. Belochitskii: I care about intensity. We cannot keep the entire beam within 10 π in AD, but most of the beam can be kept below 10 π. We cannot define precisely the amount of beam within 10 π, because the emittance varies during the year. After the beam transfer to ELENA, due to possible mismatch, emittance can grow up to 12 π. During deceleration there will be an increase

of adiabatic blow-up whereby the emittance grows to 36 π. With acceptance of 50 π we have good margins also for non-adiabatic emittance increase. I think 50 π is a reasonable choice for acceptance.

G.Tranquille: We need to work more on alignment between the anti-proton beam and the electron beam in the AD in order to obtain less than 10 π emittance.
T.Eriksson: Will we get a new electron cooler for the AD?
G.Tranquille: Yes, if you will provide the money!
S. Gilardoni: Did you include orbit deviations?
P. Belochitskii: There are no errors included, but I put margins for everything.
S. Gilardoni: About injection oscillations – What about transverse damper to reduce them?
P. Belochitskii: We will think about this.

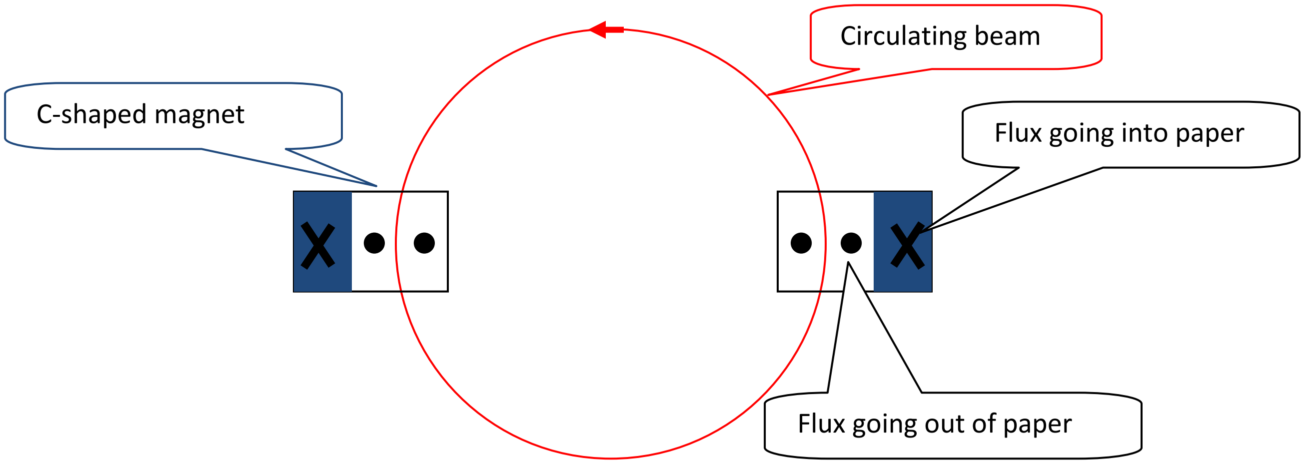
P. Belochitskii Introduces the 26m ELENA ring with only 4 bending magnets (i.e. a 4-fold machine).

W.Bartmann: You do not want to use more quadrupoles families? I do not mean more HW but only more knobs, more power supplies. (Note: Instead of having one power supply for a triplet, maybe we could power the quadrupoles individually. As Simone suggested, having many quadrupole families, which give flexibility in correcting chromaticity, etc.)
P. Belochitskii: I did not look at this option
W.Bartmann: From your tables, maybe you could get appropriate dispersion and limits to the beta-functions with individual powered quadrupoles?
P. Belochitskii: It is true; I did not look at machines without periodicity, because in this case we get magnets with large apertures. I plan to look to add trims on the quadrupoles to better control the beta-functions and dispersion at the electron cooler.

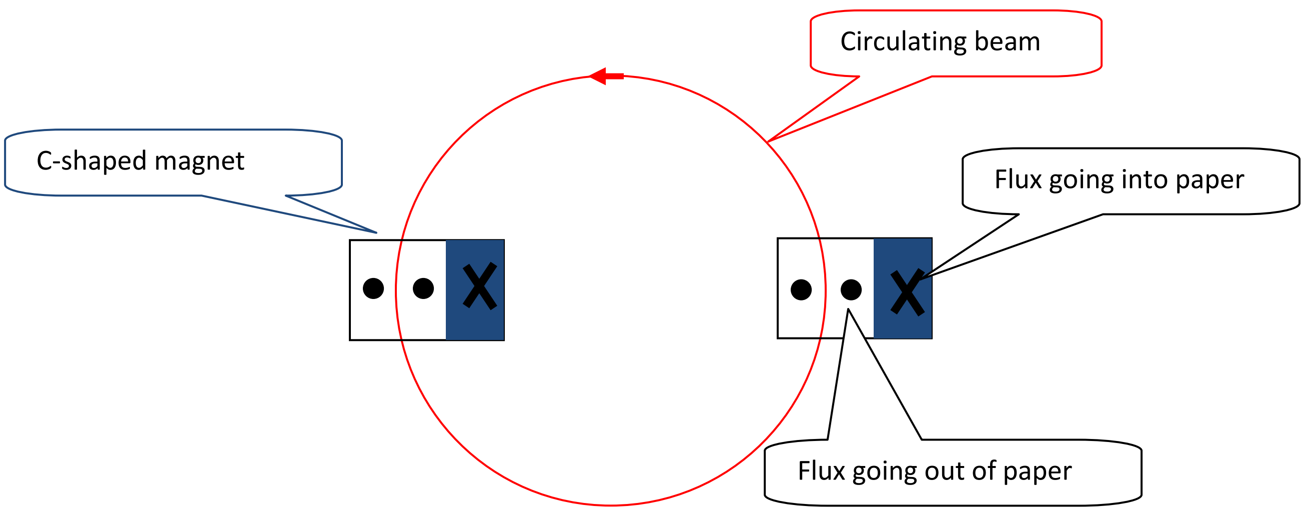
P. Belochitskii The next step is to make an estimation of the space needed for equipment.
S. Gilardoni: How do you measure intensity?

G. Tranquille: We will use the longitudinal Schottky monitor, but we also need a BCT for calibration.
S. Maury: How do you calculate the number of correctors?
P. Belochitskii: They should have about 90 degrees phase separation. 8 is a proper number for a tune of 2.3
S. Maury: Have you enough knobs to control Chromaticity, QH and QV ?
P. Belochitskii: To control the tunes, we have three quadrupole families. To control the chromaticity we have 2 sextupole families – each consisting of two sextupoles.
S. Hancock: Have you investigated if you need to interchange the bending magnets, so that one bending magnet has the yoke on the outside and the next bending magnet has the yoke on the inside. If this is not done, you can create accelerating voltages that are greater than the RF-voltages and the machine gets out of control

(Note from SH: It is an application of Faradays law of induction: $|\mathcal{E}| = \left|\frac{d\Phi_B}{dt}\right|$, The induced voltage is longitudinal, just as the RF-voltage:



In the above design, the total flux inside the ring, is 2 x ½ flux of one magnet.



In the above design, the total flux inside the ring, is ½ - 1 + ½ = **0 flux of one magnet**.)

S. Gilardoni: It is a key aspect of the lattice design in the PS
S. Gilardoni: The PS magnet report is on CDD (Note:
https://edms.cern.ch/file/1151929/1/CERN_Book.pdf
https://edms.cern.ch/file/1151929/1/CERN_Book_2.pdf
https://edms.cern.ch/file/1151929/1/CERN_Book_3.pdf)

S.Maury: Where can we see the slides
G. Tranquille: They are on the web (Note: https://espace.cern.ch/ELENA-BPPC/BPPCmeetings/default.aspx)