NPAS 2017 Projects

The projects in the course deal with different accelerator facilities used for different purposes. The aim with the projects is that you in a group study and go deeper into one facility and that all students, via presentations of the projects, gain a better overview of different facilities, techniques and science

Each group should choose and review one facility taking the perspective of Accelerator Technology and terminology that we are developing in the course.

In addition you should look into the purpose/science at the facility, but not make this become the main topic. You should try to compare to other facilities and other technologies and don’t be afraid of making your own conclusions, which of course can be questioned. If you want to study the chosen facility with the calculation tools and methods used in the course (accelerator physics, synchrotron radiation,…) you are welcome to do so, but it is not a requirement.

The project should be presented on Tuesday 22 August as a PowerPoint (or similar).

All group members should be active in all parts of the project: planning, information gathering, analysis, presentation preparation and presentation.

There is not much scheduled time for these projects, but you are supposed to finalize them as “homework”.

If you run into problems, please contact any of the teachers that you feel can help you with that specific question.

*- Good luck!*

# NPAS2017 – Project #1

**A synchrotron radiation facility**

(Several groups can take this project, with a different facility)

Describe a facility trying to take an “accelerator” view. This means that it is more important to give a picture of the different accelerators, their performance and technical solutions. As the focus here is synchrotron light it is also important to discuss how the light is produced and with what characteristics. Do not go too far into applications, especially if they are not very unique.

Facilities to choose from (if you do not have a better idea yourself!):

Some hints!

Sirius at LNLS is a hard competitor to MAX IV technology soon to be up running.

ESRF, APS and Spring-8 have interesting upgrade plans.

(The Korean lab might be a little more challenging to find information about.)

1. ESRF, Grenoble: <http://www.esrf.eu/>
2. Soleil, Paris: <https://www.synchrotron-soleil.fr/>
3. Diamond, Oxford : <http://www.diamond.ac.uk/>
4. Astrid I and II, Århus: <http://www.isa.au.dk/>
5. NSLS II, Brookhaven, US : <https://www.bnl.gov/nsls2/>
6. APS, Argonne, US : <http://www.aps.anl.gov/>
7. Australian light source, Melbourne : <http://synchrotron.org.au/>
8. LNLS, Campinas, Brazil : <http://lnls.cnpem.br/en/>
9. Spring-8, Japan : <http://www.spring8.or.jp/en/>
10. Pohang Light Source, Korea : <http://pal.postech.ac.kr/paleng/>
11. SSRF, Shanghai, China : <http://ssrf.sinap.ac.cn/english/>

A collection of information about SR light sources can be found here:

<http://www.lightsources.org/>

The main accelerator conference series is IPAC published at the JACOW web site. Here you can find a lot of (unstructured) information about the facilities. Search within the IPAC series with some “smart” key words.

<http://www.jacow.org/Main/Proceedings?sel=IPAC>

# NPAS2017 – Project #2

**FEL facility**

(Several groups can take this project, with a different facility)

Describe a facility trying to take an “accelerator” view. This means that it is more important to give a picture of the different accelerators, their performance and technical solutions. As our focus is synchrotron light it is also important to discuss how the light is produced and with what characteristics. Do not go too far into applications, especially if they are not very unique.

Facilities to choose from (if you do not have a better idea yourself!):

Some hints!

EU XFEL is the giant European X-ray FEL just up running.

SwissFEL is soon to be operating, with some ingenious technical solutions.

LCLS was the first real X-ray machine and now has an interesting upgrade program (LCLS-II).

(The Korean lab might be a little more challenging to find information about.)

1. FLASH, Hamburg : <http://flash.desy.de/>
2. EU XFEL, Hamburg : <http://www.xfel.eu/>
3. FERMI at ELETTRA, Trieste : <http://www.elettra.eu/lightsources/fermi.html>
4. LCLS, Stanford : <https://lcls.slac.stanford.edu/>
5. SACLA, Japan : <http://xfel.riken.jp/eng/>
6. SwissFEL, Switzerland : <https://www.psi.ch/swissfel/>
7. PALFEL, Pohang, Korea : <http://pal.postech.ac.kr/paleng/>

A collection of information about SR lightsources can be found here:

<http://www.lightsources.org/>

The main conference series for FELs is the FEL conference (<http://www.jacow.org/Main/Proceedings?sel=FEL>) , and much information is also found in the IPAC conference series (<http://www.jacow.org/Main/Proceedings?sel=ipac> ).

Both are published at the JACOW web site. Here you can find a lot of (unstructured) information about the facilities. Search within each series with some “smart” key words.

# NPAS2017 – Project #3

**Spallation Sources - SNS**

The Spallation Neutron Source is located at the Oak Ridge National Laboratory in Tennessee, USA. Just like the ESS it is a user facility that produces neutrons with by using a particle accelerator.

In this project you should study the SNS from an accelerator scientist's point of view, remembering the topics we discuss during the school. Here are some questions to get you started:

* What does it look like (layout, dimensions)?
* What are its characteristics? E.g. Beam parameters, magnetic lattice structure, etc.
* What are the particular challenges of this machine?
* Choice of technology for RF, magnets, diagnostics, vacuum...?
* How does it differ from the ESS?

Literature tips:

<https://neutrons.ornl.gov/sns>

<https://journals.aps.org/prab/abstract/10.1103/PhysRevSTAB.3.080101>

***Phys. Rev. ST Accel. Beams 3, 080101 (2000) - Low-loss design for the high-intensity accumulator ring of the Spallation Neutron Source***

*journals.aps.org*

This paper summarizes the low-loss design for the Spallation Neutron Source accumulator ring [``Spallation Neutron Source Design Manual'' (unpublished)]. A hybrid lattice consisting of FODO arcs and doublet straights provides optimum matching and flexibility for injection and collimation. For this lattice, optimization focuses on six design goals: a space-charge tune shift low enough (below 0.15) to avoid strong resonances, adequate transverse and momentum acceptance for efficient beam collimation, injection optimized for desired target beam shape and minimal halo development, compensation of magnet field errors, control of impedance and instability, and prevention against accidental system malfunction. With an expected collimation efficiency of more than 90%, the uncontrolled fractional beam loss is expected to be at the 1e-4 level.

<https://arxiv.org/pdf/physics/0008212.pdf>

<http://accelconf.web.cern.ch/AccelConf/hb2016/papers/moam4p40.pdf>

# NPAS2017 – Project #4

**Spallation Sources – J-PARC**

The KEKB is a particle accelerator located at the KEK laboratory in Tsukuba, Japan. J-PARC is a collider with a quite specific purpose, and has some unusual aspects.

In this project you should study the J-PARC from an accelerator scientist's point of view, remembering the topics we discuss during the school. Here are some questions to get you started:

* What does it look like (layout, dimensions)?
* What are its characteristics? E.g. beam parameters, magnetic lattice structure, etc.
* What are the particular challenges of this machine?
* Choice of technology for RF, magnets, diagnostics, vacuum...? Motivation?
* What makes it special compared to other particle colliders?

<https://www.kek.jp/en/Facility/ACCL/KEKBRing/>

<https://lib-extopc.kek.jp/preprints/PDF/1990/9024/9024024.pdf>

<http://accelconf.web.cern.ch/accelconf/p95/ARTICLES/TAG/TAG11.PDF>

<https://accelconf.web.cern.ch/accelconf/PAC2009/papers/we6pfp043.pdf>

<http://accelconf.web.cern.ch/AccelConf/IPAC10/papers/weoamh02.pdf>

# NPAS2017 – Project #5

**Proton-therapy accelerators in Scandinavia**

In Uppsala in Sweden, a proton cancer-therapy facility has recently started operation (<http://www.skandionkliniken.se/en/>) and a comparable facility is being built in Aarhus, DK (<http://www.auh.dk/om-auh/afdelinger/dansk-center-for-partikelterapi/>) to treat first patients in 2018. Both facilities are based on a 250 MeV cyclotron accelerator, one normal-conducting from IBA, <https://iba-worldwide.com/proton-therapy>, the other a superconducting from Varian, <https://www.varian.com/oncology/solutions/proton-therapy>.

In the project, you are requested to describe such a proton-therapy facility with emphasis on accelerator aspects you have met in the lectures like energy, current, rf frequencies, dose, ranges etc. The descriptions should also be quantitative as possible, where you provide the formula's, data and methods used.

More details can be found on www, in particular <http://www.jacow.org/Main/Proceedings?sel=IPAC>.

# NPAS2017 – Project #6

**Future linear colliders - CLIC and ILC**

There are two studies for a future linear electron-positron collider for particle physics studies at the energy frontier. The international linear collider, ILC, and the compact linear collider, CLIC.

The key parameters for a particle collider is: particle type to be collided, center-of-mass energy of collisions, and luminosity. ILC consists of an 250 GeV electron linac and a 250 GeV positron linac. The total length of the machine is 30 km. CLIC consists of an 1.5 TeV electron linac and a 1.5 TeV positron linac, with a total length of 50 km. Both have luminosities of about 1034 / cm2/s.

In this project you should study the key challenges in building a linear collider, from an accelerator scientist's point of view, remembering the topics we discuss during the school.

*First, discuss the differences between LHC and a linear collider.*

Some questions :

* From the particle physics points of view what are disadvantages/advantages of hadron colliders versus lepton colliders?
* What are disadvantages/advantages of circular collider versus linear colliders?
* Both LHC and ILC/CLIC has similar luminosity. Which parameters are pushed in each case?
* What is the average power consumption for LHC, ILC and CLIC? What do you estimate society would think is an acceptable power and energy consumption for a new particle collider. Assume this collider will be the only one of its kind in the world

*Then, discuss the different design choices for CLIC and ILC.*

Possible topics to cover :

* ILC have chosen superconducting RF, CLIC has chosen normal conducting RF. Why?
* Main accelerator physics challenges (high gradient, wake field, intense beams effects, beam-beam, CSR)?
* Main technical challenges (magnets, RF, vacuum?)
* What are the advantages of CLICs drive beam scheme? Describe the scheme.
* Have the two studies reached the same level of "technical maturity", i.e. are they equally ready to start construction if funding would be available overnight?

Some references to start with:

<http://www.linearcollider.org/from-design-to-reality/>

<http://clic-study.web.cern.ch/content/clic-nutshell>

[https://agenda.linearcollider.org/event/6906/timetable/ - 20151027.detailed](https://agenda.linearcollider.org/event/6906/timetable/#20151027.detailed)

- see lectures introduction, ILC and CLIC.

<https://www.linearcollider.org/ILC/Publications/Technical-Design-Report>

- especially introduction/summaries

<http://clic-study.web.cern.ch/content/conceptual-design-report>

- especially introduction/ summaries

# NPAS2017 – Project #7 – (Pauli)

**FFAG**

A Fixed Field Alternating Gradient accelerator, FFAG, is a fairly new accelerator concept. It has similarities both with synchrotrons and cyclotrons.

In this project you should study the FFAG concept and compare it with synchrotrons and cyclotrons from an accelerator scientist’s point of view. Study also the structure and properties of some existing FFAGs.

Some references to start with

<https://cas.web.cern.ch/cas/Austria2015/Lectures/7Thu04/Sheehy.pdf>

<https://accelconf.web.cern.ch/accelconf/IPAC10/papers/thpec090.pdf>

<https://accelconf.web.cern.ch/accelconf/p05/PAPERS/FPAE026.PDF>

# NPAS2017 – Project #8 (Pauli)

**PSI Proton Accelerator**

The PSI high intensity proton accelerator generates a proton beam with 590 MeV kinetic energy and presently

1.3 MW average beam power. The beam is used to produce pions, muons and neutrons.

In this project you should study the PSI Proton accelerator system from an accelerator scientist's point of view, remembering the topics we discuss during the school. Here are some questions to get you started:
What does it look like (layout, dimensions)?

What are its characteristics? E.g. Beam parameters, structure of the accelerators, etc.
What are the particular challenges of this machine?
Choice of technology for RF, magnets, diagnostics, vacuum...?

Some references to start with:

<https://accelconf.web.cern.ch/accelconf/IPAC10/papers/tuyra03.pdf>

<https://accelconf.web.cern.ch/accelconf/abdwhb06/PAPERS/THAZ01.PDF>

<https://www.psi.ch/gfa/FacilityOperationReportsEN/Operation_of_the_PSI_Accelerator_Facilities_2016.pdf>

<https://www2.kek.jp/accl/seminar/file/mike_seidel_PSI_accelerators.pdf>

<http://indico.psi.ch/getFile.py/access?contribId=56&resId=0&materialId=slides&confId=1146>