12TH INTERNATIONAL ORGANIZATION OF CHINESE PHYSICISTS AND ASTRONOMERS ACCELERATOR SCHOOL

OCPA-2025

KHAOYAI, NAKHON RATCHASIMA, THAILAND | 29 JULY - 7 AUGUST 2025

Synchrotron Light Sources in Thailand

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Outline

- Synchrotron Light Research Institute (SLRI)
- Siam Photon Source I (SPS-I)
- Siam Photon Source II (SPS-II)

Synchrotron Light Research Institute (SLRI)

Vision

A Center of Excellence in Synchrotron Light Technology to Support the Country's Development of Economy and Quality of Life of the People

Mission

- Research on Synchrotron and Utilization of Synchrotron
- Provide Services of Synchrotron and Synchrotron Technology
- Promote the Transfer and Learning of Synchrotron Technology

SLRI History

1996 — National Synchrotron Research Center (**NSRC**) project approved

1998 — Installation of major parts from SORTEC (Japan)

2001 — First light from **1-GeV** storage ring

2003 — Opened to users

2005 — **1.2-GeV storage ring** upgraded

2008 — NSRC has transformed to **SLRI**

2010 — Installation of insertion device **U60**

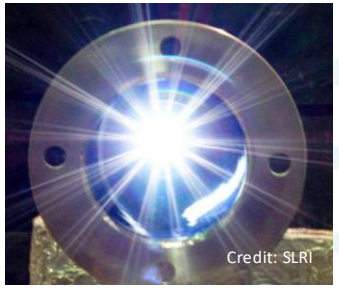
2012 — Implementation of **Fault-Tolerant Control**

2014 — Installation of insertion device **MPW** and **SWLS**

2015 — **RF cavity** upgraded

2016 — **1.2-GeV booster** upgraded

2018 — **Full energy** injection and installation of **SMPW** upgraded



- ***New Synchrotron***
- ***Accelerator Applications***
- ***Other high impact projects***

Synchrotron Core Tech

CORE

- **SPS-I**
- **SPS-II**
- **LINAC Applications**
- Accelerator Mass Spectrometry
- Synchrotron Proton Therapy

SPS-II

Synchrotron Tech

- Green Hydrogen
- EUV
- Brain
- CO_2 Capture
- Semiconductor

Research & Applications

BL Development

Beamline

Applications

Food · Medical · Energy · Archeology · AI

PM 2.5 · Carbon Neutral · Green Environment · Digital

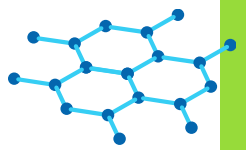
Technology Transfer

DLC

- Carbon capture
- Food packaging
- Petroleum

Graphene

- Carbon neutral
- Environment



Food & agriculture

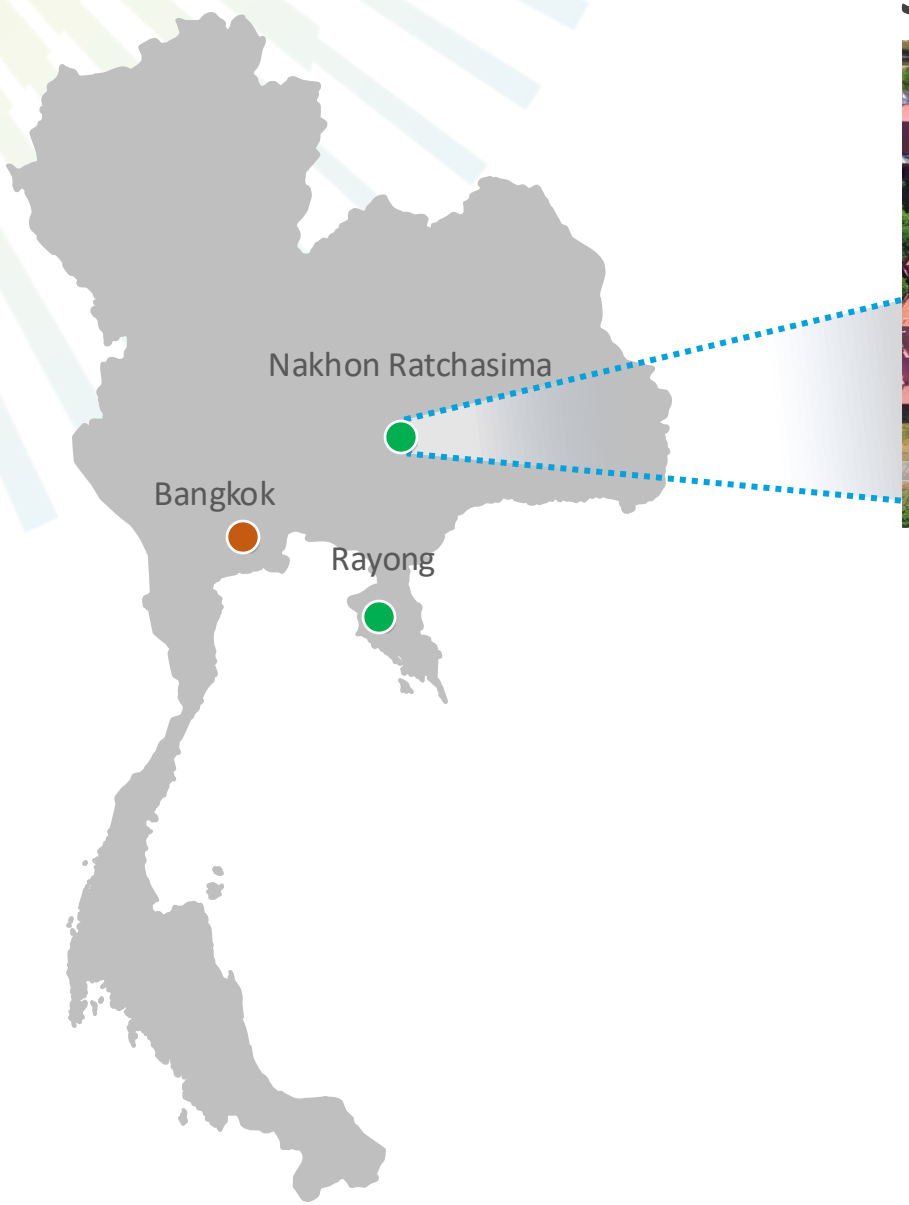
- Social Green Health

Biomedical

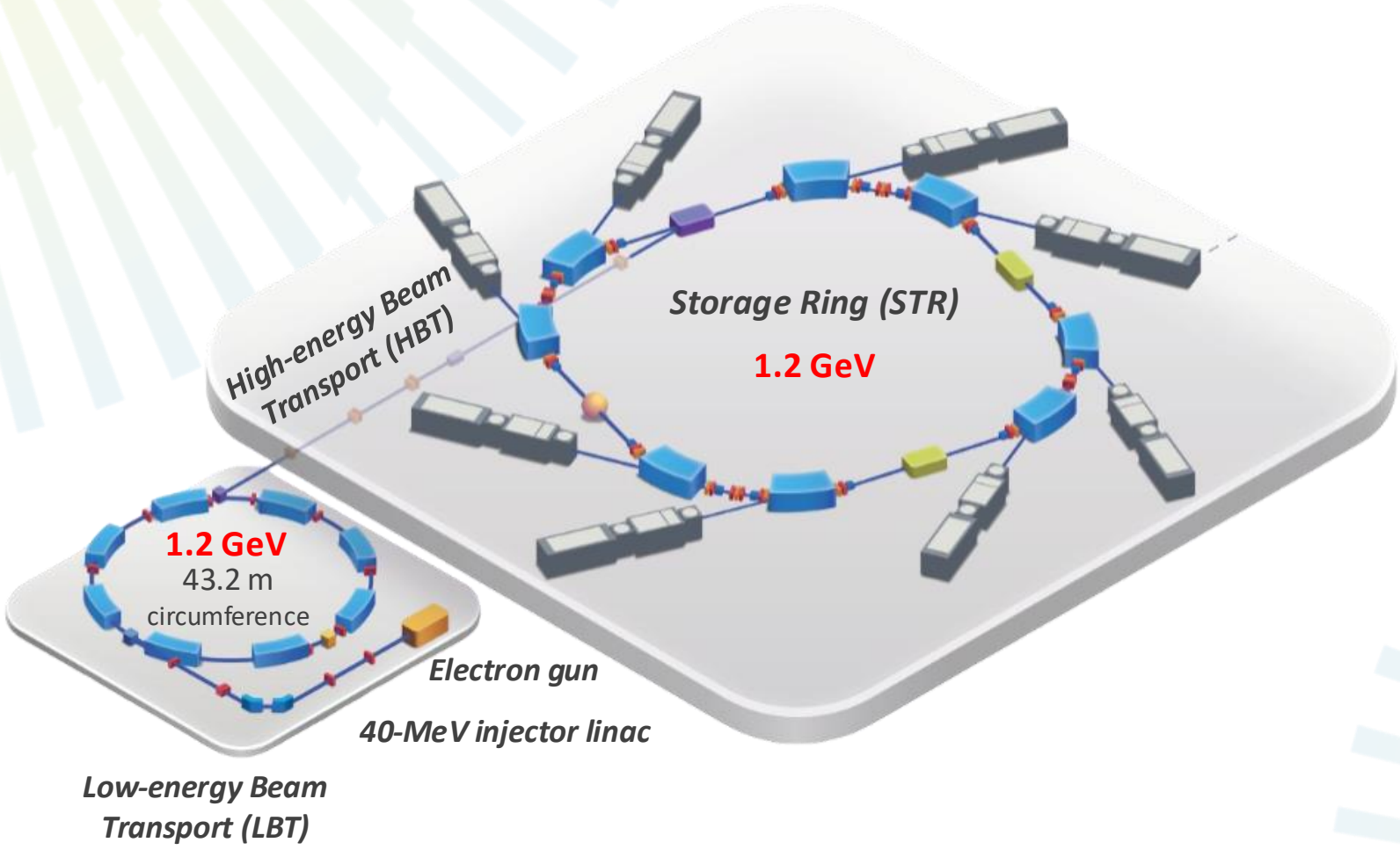
Encapsulation

Archeology

Siam Photon Source I (SPS-I)

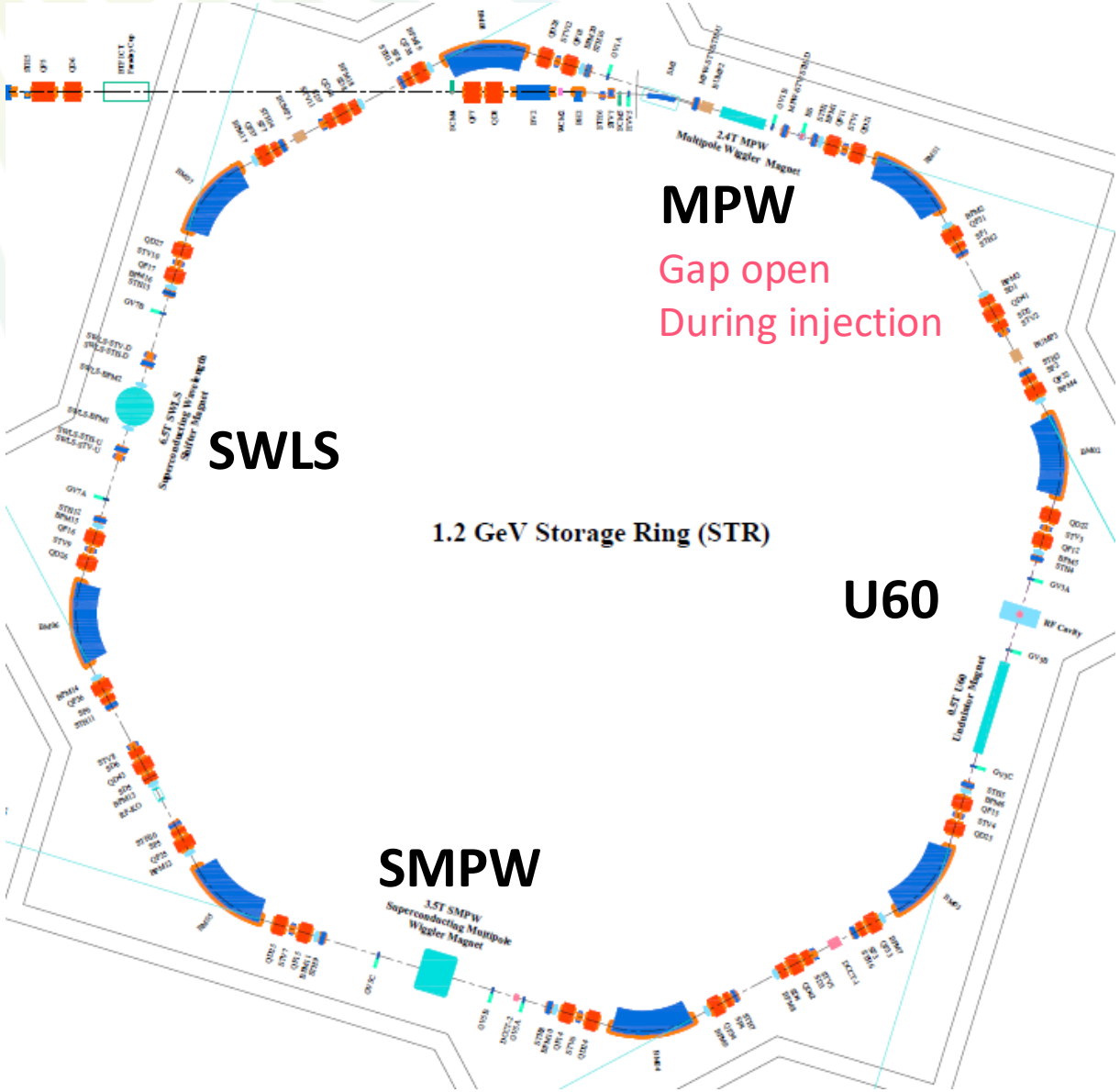


SPS-I accelerator



Parameters	SPS
Circumference (m)	81.3
Energy (GeV)	1.2
Relativistic factor γ	2348.34
Emittance ε_{x0} (nm·rad)	41.0
Nat. energy spread σ_E (%)	0.066
Nat. chromaticity ξ_x/ξ_y	-8.7/-6.4
Tune Q_x/Q_y	4.75/ 2.82
Momentum compaction α_c	1.70e-2
Damping times hor./ver./long. (ms)	10.7/9.8/4.7
Damping partition number $J_x/J_y/J_\delta$	0.92/1.0/2.0 8
Straight/circumference	0.33
Energy loss per turn from dipole U_0 (MeV)	0.066
RF frequency (MHz)	118
RF voltage (MV)	0.3
Harmonic number	32
Overvoltage V/U_0	4.5
Synchronous phase (degree)	167.29
Synchrotron tune	0.00460
Nat. bunch length (mm)	29.03
Nat. bunch duration (ps)	96.8

SPS-I Beamlines



Insertion devices (IDs)

U60 : Undulator

MPW : Multipole wiggler

SWLS : Super conducting wavelength shifter

SMPW: Super conducting multipole wiggler

Operation modes based on IDs

```
Operation Mode Selection:
  [1] Bare Ring
  [2] 2IDsMPW (U60 + MPW 2.2T)
  [3] 2IDsSWLS6.5 (U60 + SWLS 6.5T)
  [4] 3IDsSWLS6.5 (U60 + MPW 2.2T + SWLS 6.5T)
  [5] 3IDsSWLS4.0 (U60 + MPW 2.2T + SWLS 4.0T)
  [6] 3IDsSMPW3.5 (U60 + MPW 2.2T + SMPW 3.5T)
  [7] 4IDs (U60 + MPW 2.2T + SWLS 6.5T + SMPW 3.5T)
```

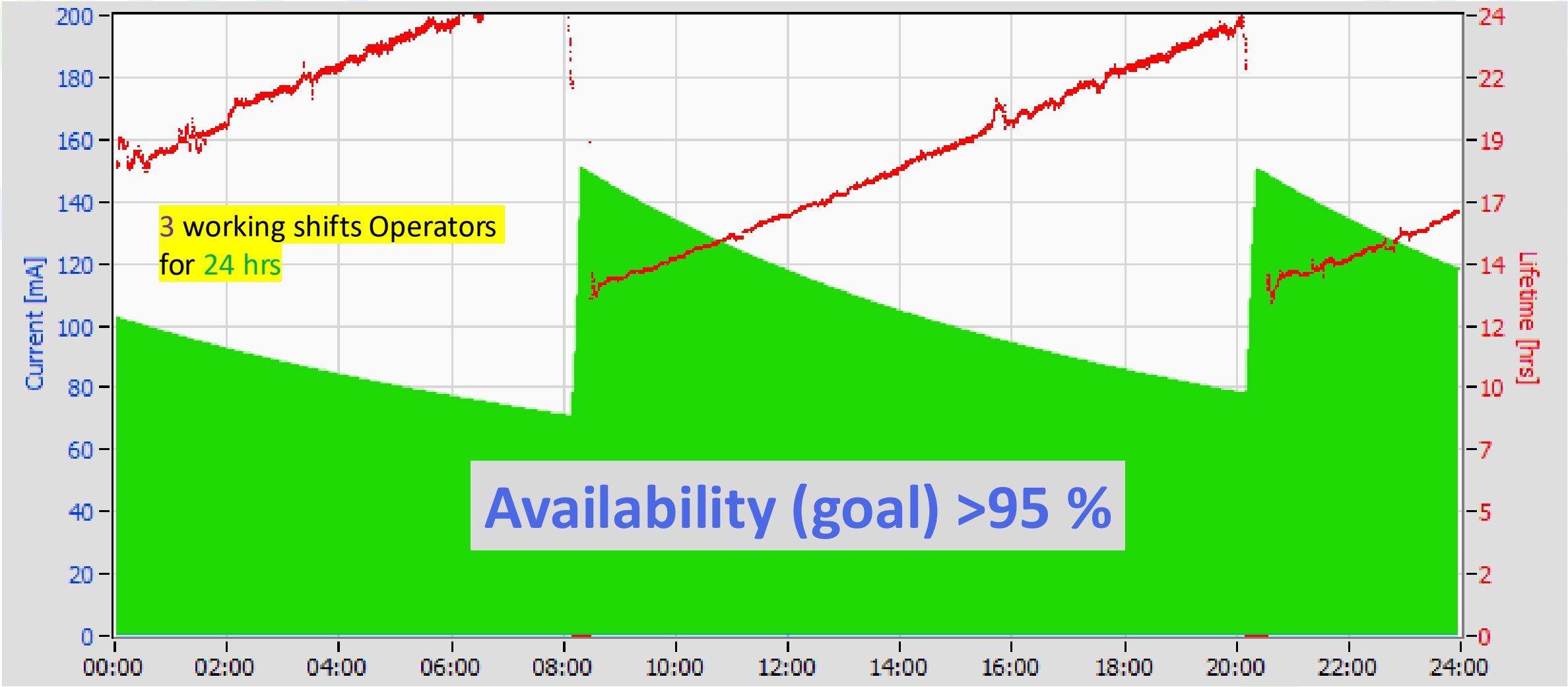
Parameters	U60	MPW	SWLS	SMPW
Peak field (T)	0.55	2.2	6.5	3.58
Number of main poles	80	9	1	12
Pole width (mm)	96	70	139	115
Good field region (mm) ΔB/B < 0.1%	±6	±5	±15	±25

SPS-I Machine Operation

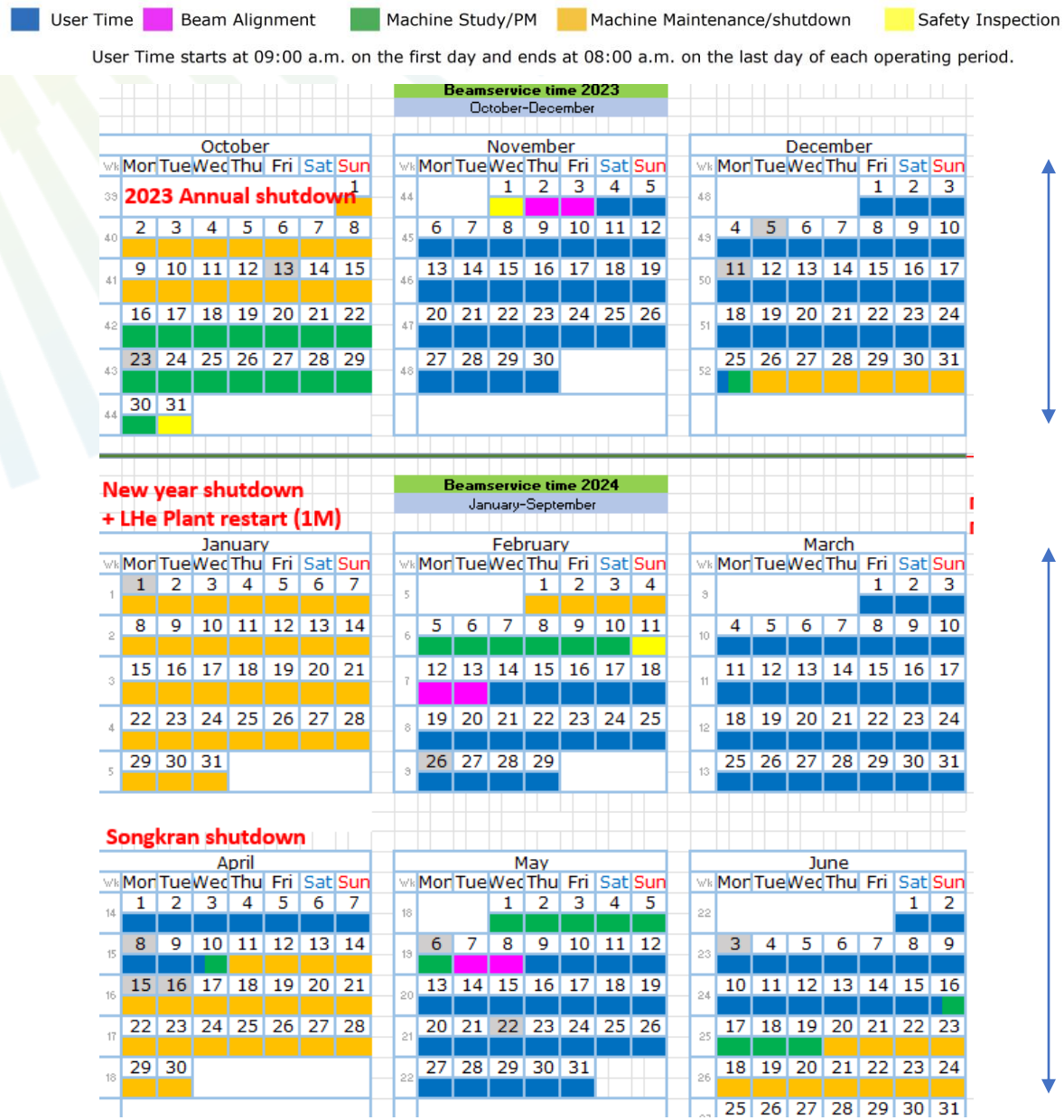
> 23 hrs/day Beam time

Decay mode operation

Beam injection: 2 times/day



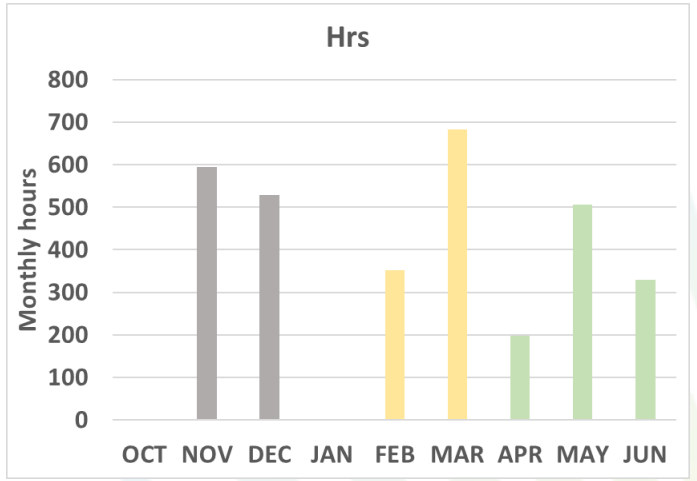
SPS-I Operation History



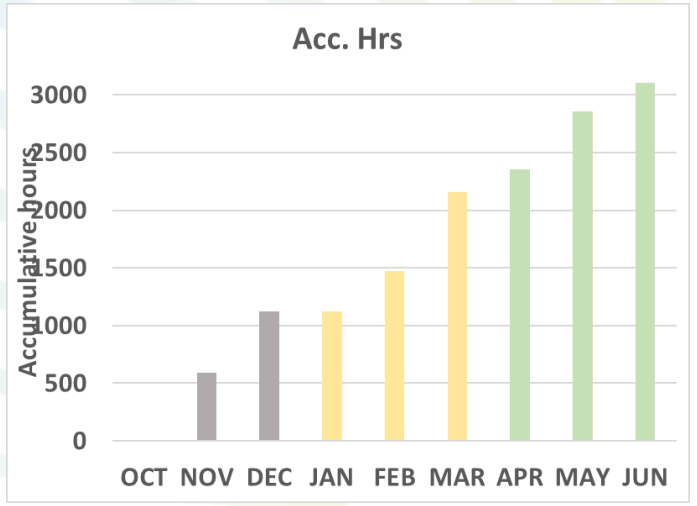
MODE 2
MPW

MODE 4
MPW+SWLS

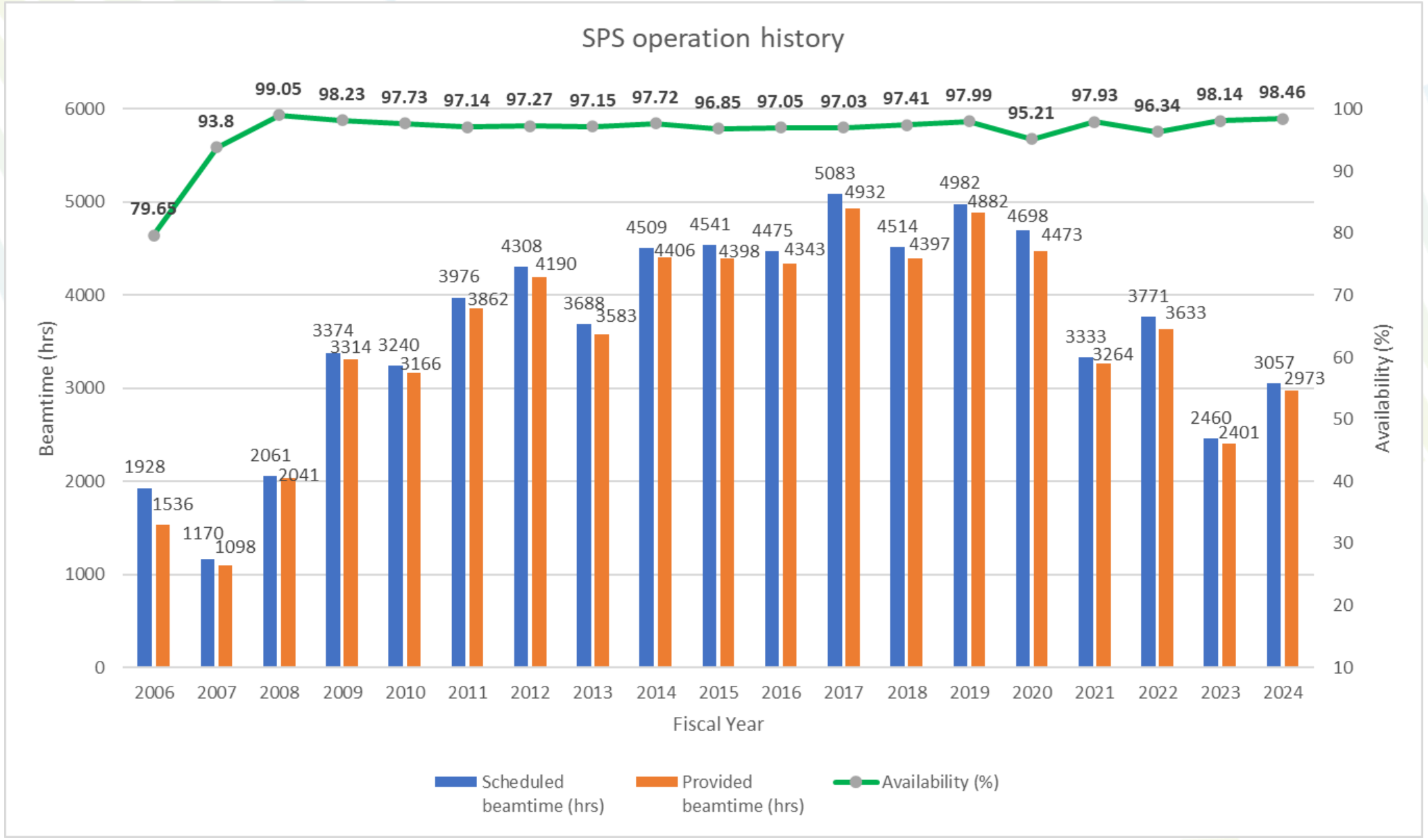
Monthly beam service hour

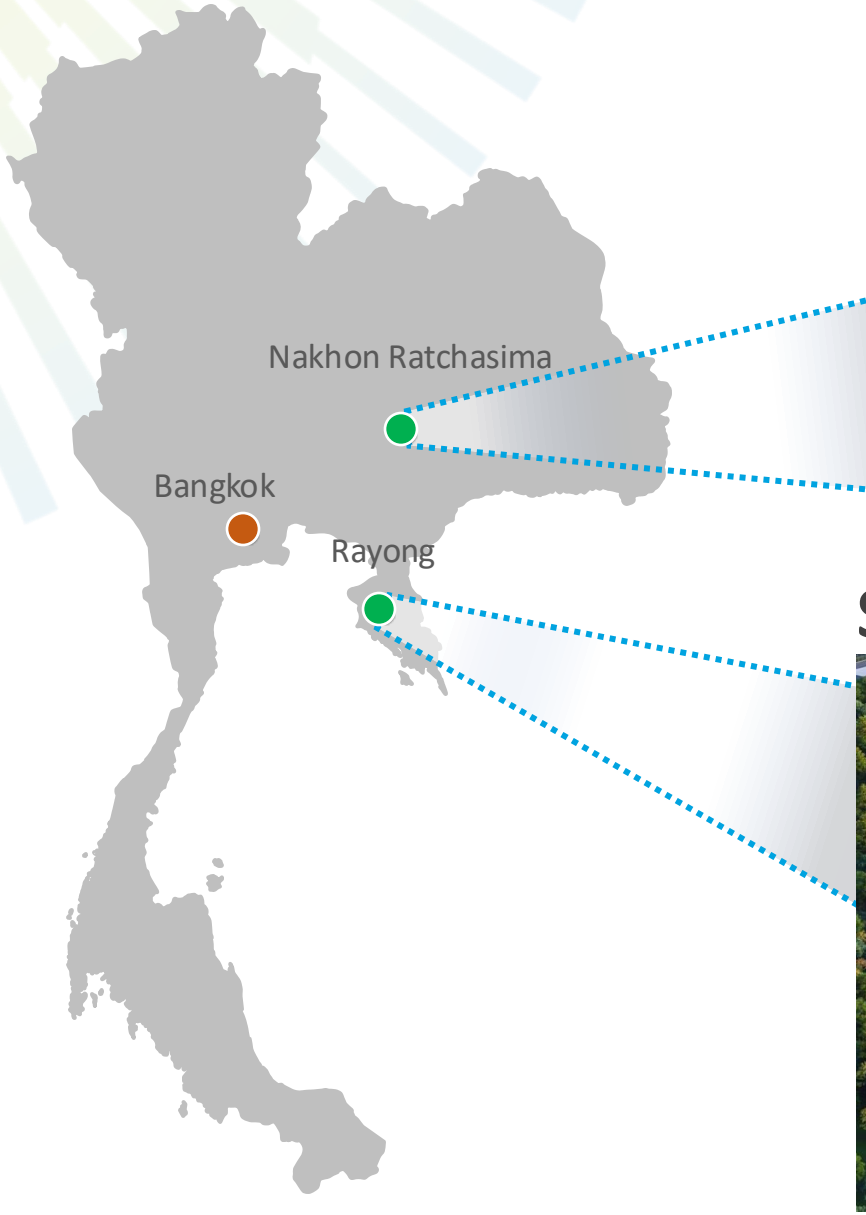


Accumulated service hour



SPS-I Operation History





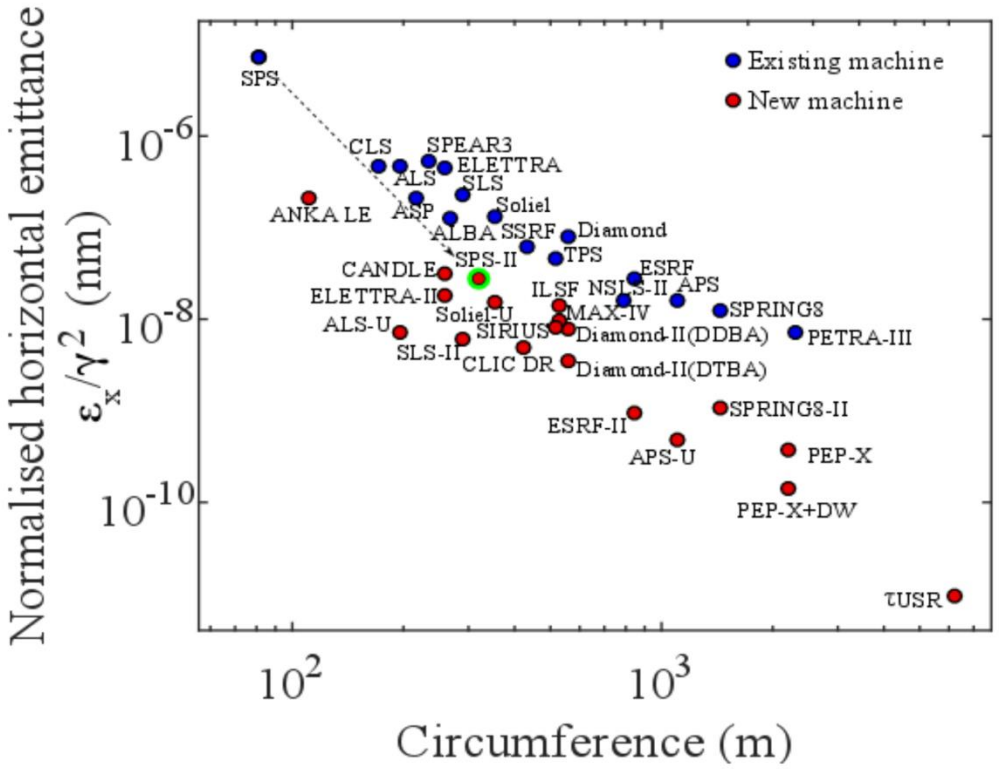
Siam Photon Source I (SPS-I)

Siam Photon Source II (SPS-II)

Siam Photon Source II (SPS-II)

Parameters	SPS	SPS-II
Circumference (m)	81.3	327.6
Energy (GeV)	1.2	3.0
Relativistic factor γ	2348.34	5870.85
Emittance ε_{x0} (nm·rad)	41.0	0.96
Nat. energy spread σ_E (%)	0.066	0.077
Nat. chromaticity ξ_x/ξ_y	-8.7/-6.4	-69.1/ -69.7
Tune Q_x/Q_y	4.75/ 2.82	34.21/ 12.37
Momentum compaction α_c	1.70e-2	3.24e-4
Damping times hor./ver./long. (ms)	10.7/9.8/4.7	9.8/11.3/6.1
Damping partition number $J_x/J_y/J_\delta$	0.92/1.0/2.08	1.15/1.0/1.84
Straight/circumference	0.33	0.35
Energy loss per turn from dipole U_0 (MeV)	0.066	0.578
RF frequency (MHz)	118	499.654096
RF voltage (MV)	0.3	2.2
Harmonic number	32	546
Overvoltage V/U_0	4.5	3.8
Synchronous phase (degree)	167.29	164.77
Synchrotron tune	0.00460	0.00446
Nat. bunch length (mm)	29.03	2.9
Nat. bunch duration (ps)	96.8	9.7

- Larger ring → More beamlines (~ 21)
- Higher beam energy → Higher photon energy
- Lower emittance
  + Higher current → Higher flux and brightness

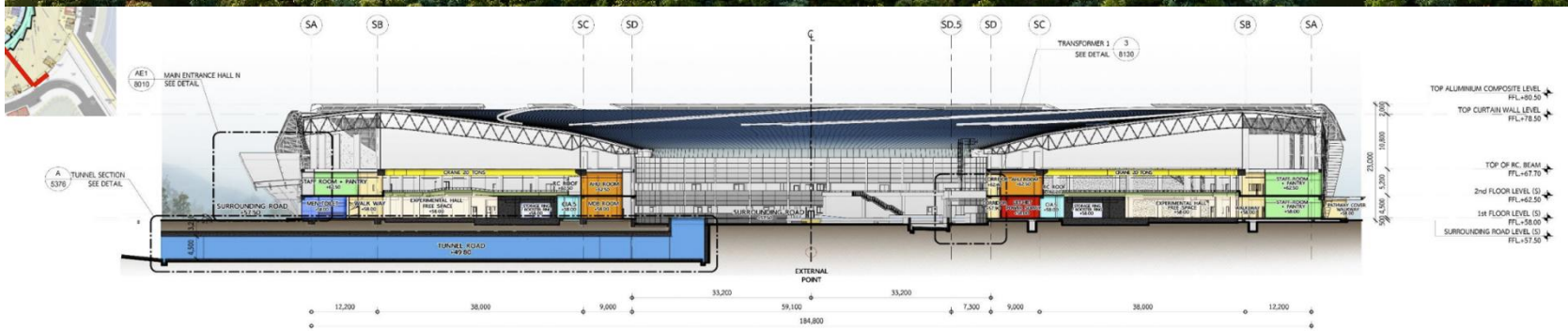


Siam Photon Source II (SPS-II)

Will be located in The Eastern Economic Corridor of Innovation (EECi), Rayong.

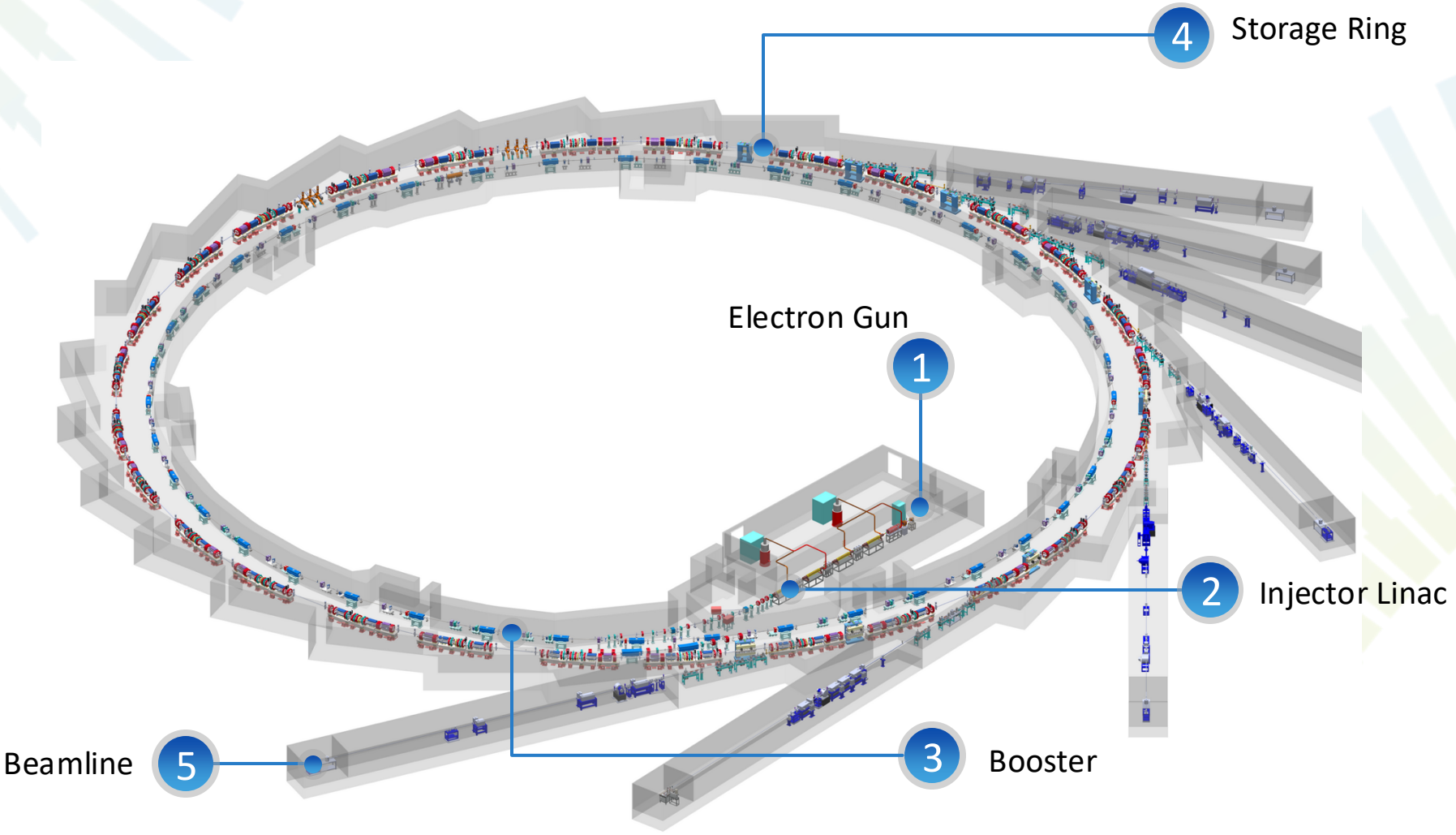
SPS-II Facility

Redesigning synchrotron building (inc. structural foundation)



Design includes a solar cell rooftop capable of providing 2 MW of power

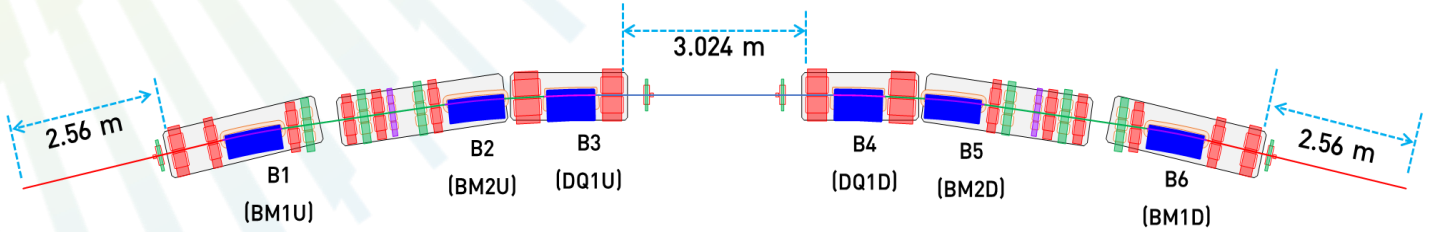
SPS-II Machine Layout



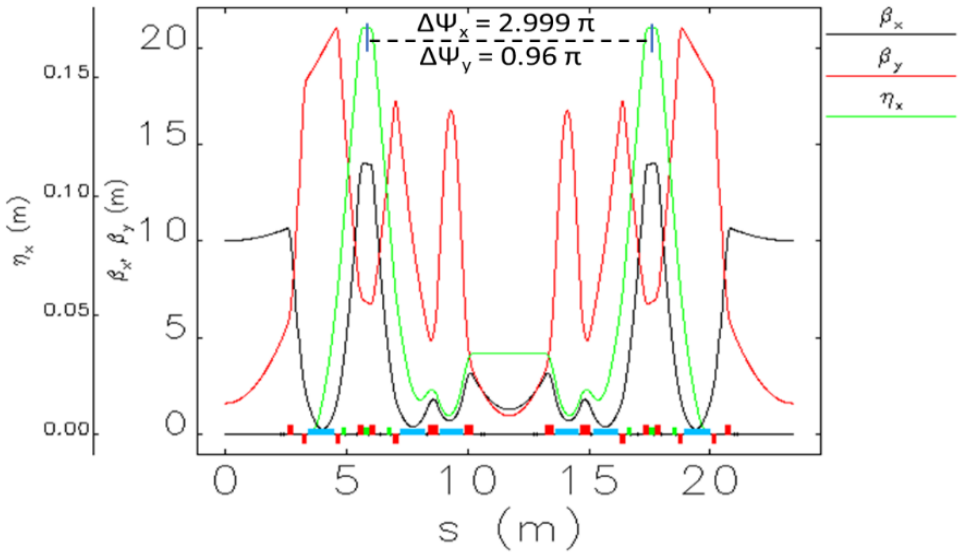
based on beam injection with **Non-Linear Kicker (NLK)** to storage ring

SPS-II Storage Ring

DTBA (Double Triple Bend Achromat) Lattice



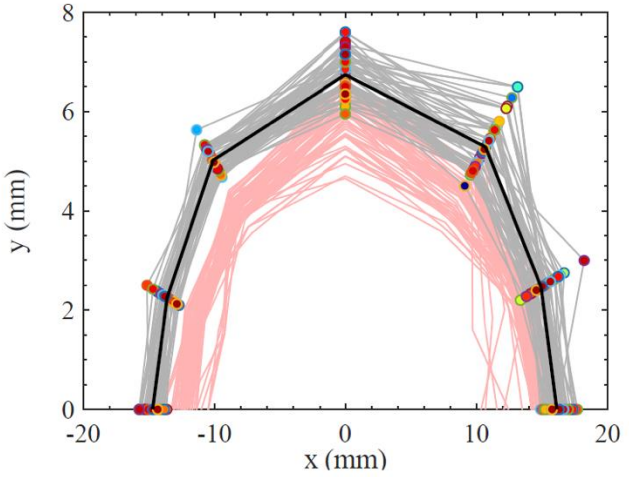
14 Cells -> 28 straights in total



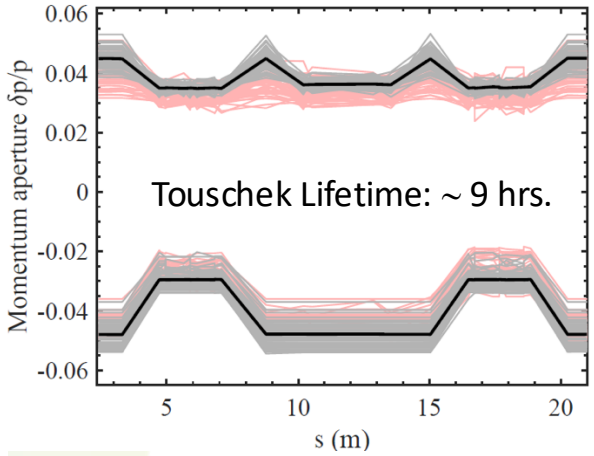
Design Concept:

- DTBA lattice: to adopt MBA with an extra straight section in each cell.
- Emittance ~ 1 nm·rad
- Space usage > 35%
- 14 DTBA cells -> 28 straight sections.
- The chromaticity is corrected locally in the dispersion bumps.
- The odd π phase advance between dispersion bumps are for nonlinear driving term cancellation.

Credit: T. Pulampong



With multipole errors and misalignment after correction

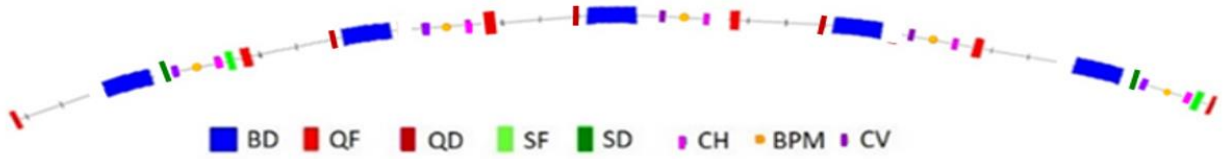


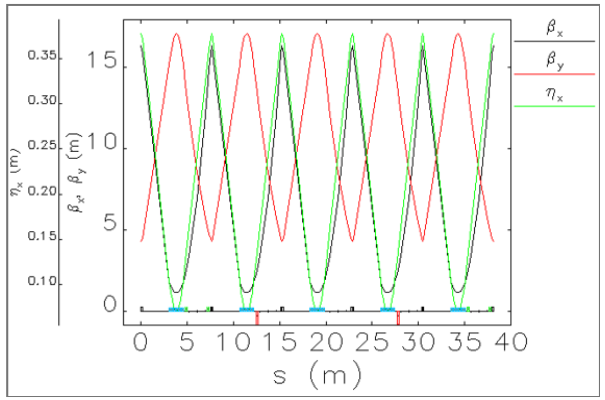
Optimized solution (grey)

SPS-II Booster

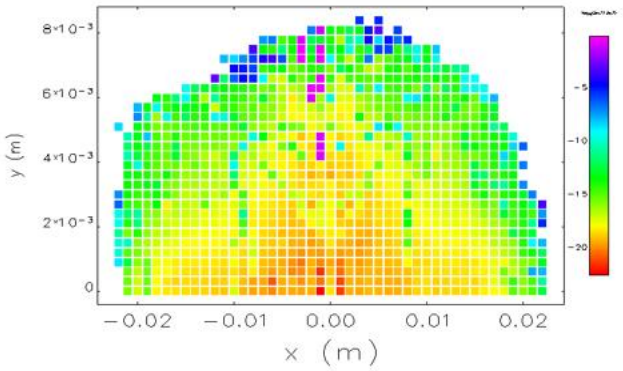
- Achieve a low emittance of 5.89 nm-rad to ensure clean injection into the storage ring.
- Implement an energy ramping cycle with a 2-Hz repetition rate.
- Apply a sinusoidal pattern for the energy ramping process.
- Operate with a beam current of 2 mA.

38.25 mm (8 super-periods)



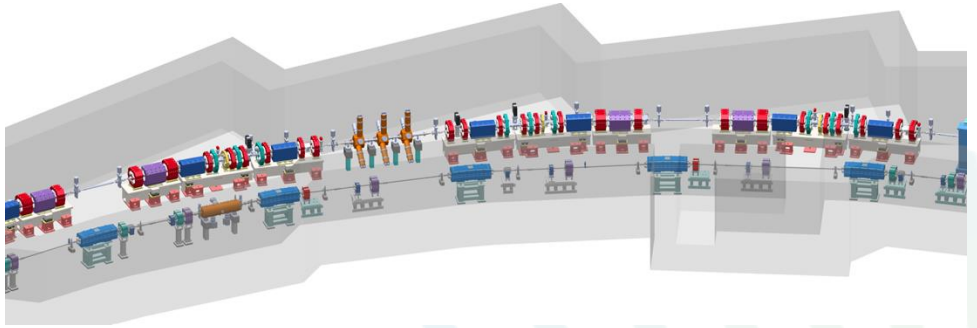


With multipole errors and misalignment after correction



Credit: S. Jummunt

Concentric Booster

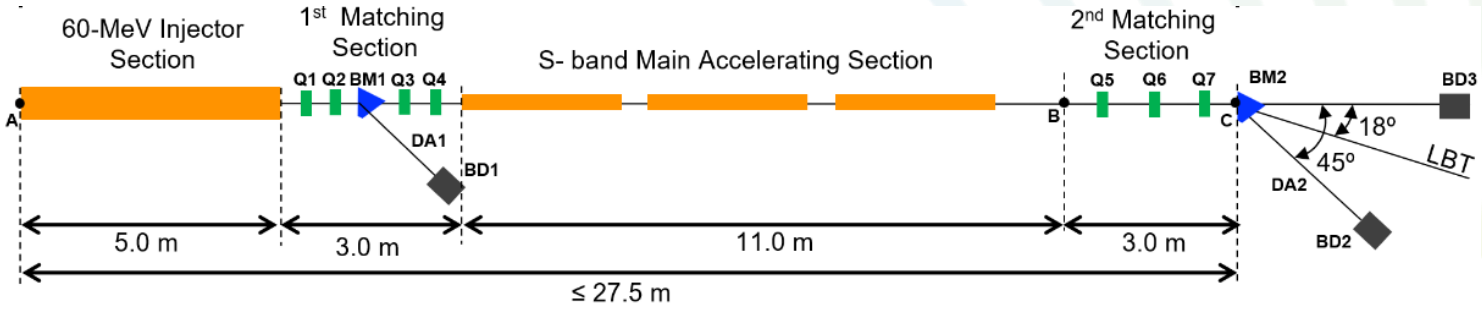


Parameter	Detail
Circumference	306.00 m
Beam energy	3.0 GeV
Relativistic factor (γ)	5870.85
Emittance	5.89 nm-rad
Nat. energy spread	0.091 %
Nat. chromaticity (ξx/ξy)	-23.63/ -10.31
Tune (ν_x / ν_y)	14.71/5.61
Momentum compaction (α_c)	1.671×10^{-3}
Energy loss per turn (U_0)	0.75 MeV
RF frequency	499.654096 MHz
Harmonic number	510
Beam current	2 mA
Repetition rate	2 Hz

SPS-II Injector Linac

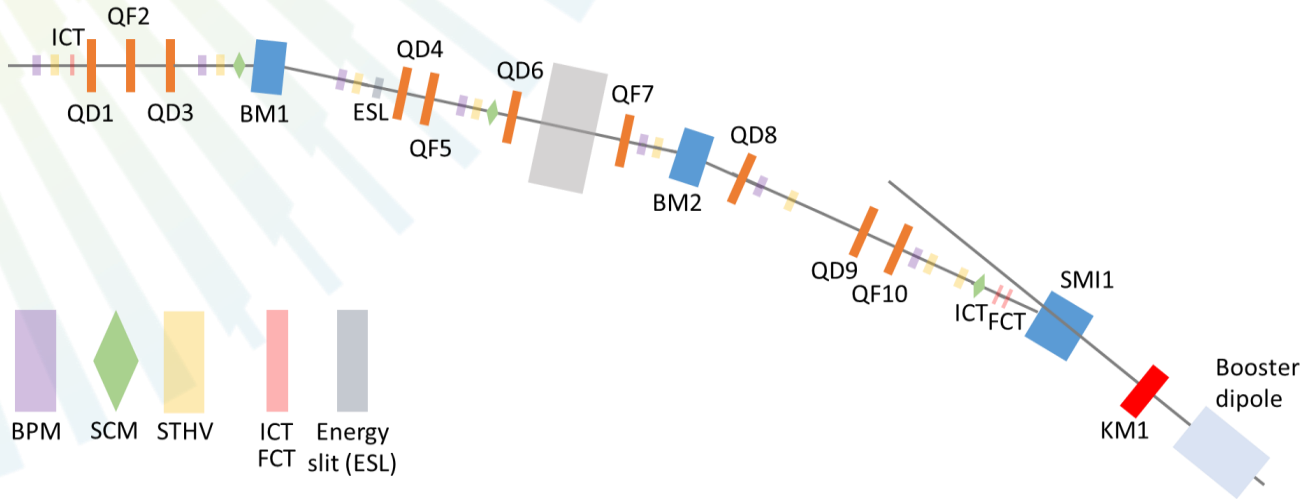
Parameters	Detail
Total length	≤ 27.5 m
Beam height	1.5 m
Operation mode	Single bunch mode (SBM)
RF frequency of bunchers	238 and 476 MHz
RF frequency of accelerating structures	2856 MHz
RF macro-pulse length (FWHM)	< 1 ns
RF macro-pulse repetition rate	1-5 Hz (adjustable)
Charge in single bunch	≥ 1.5 nC
Single bunch purity	Better than 1%
Final beam energy	250-270 MeV
Final normalized emittance (1σ)	≤ 50 π mm·mrad
Final energy spread (rms)	≤ 0.5%
Final beam position error	Within ±0.5 mm
Pulse-to-pulse energy variation (rms)	≤ 0.25%
Pulse-to-pulse beam position variation (rms)	≤ 0.2 mm
Pulse-to-pulse jitter	≤ 100 ps

Conceptual Layout

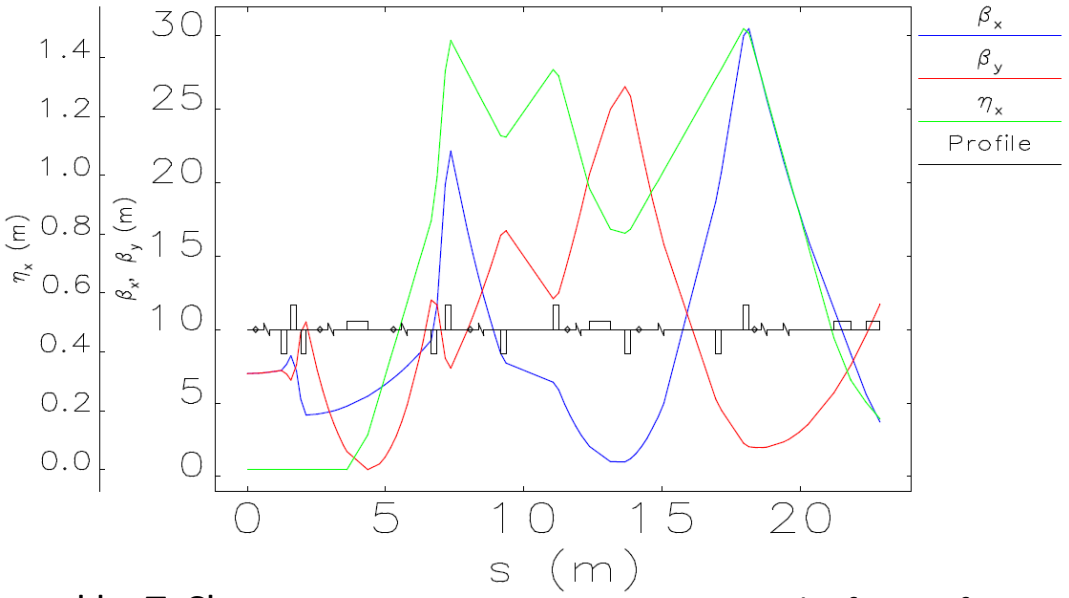


- High energy beam → Small emittance + Low energy spread
- Inject at higher energy → Simplify booster requirements

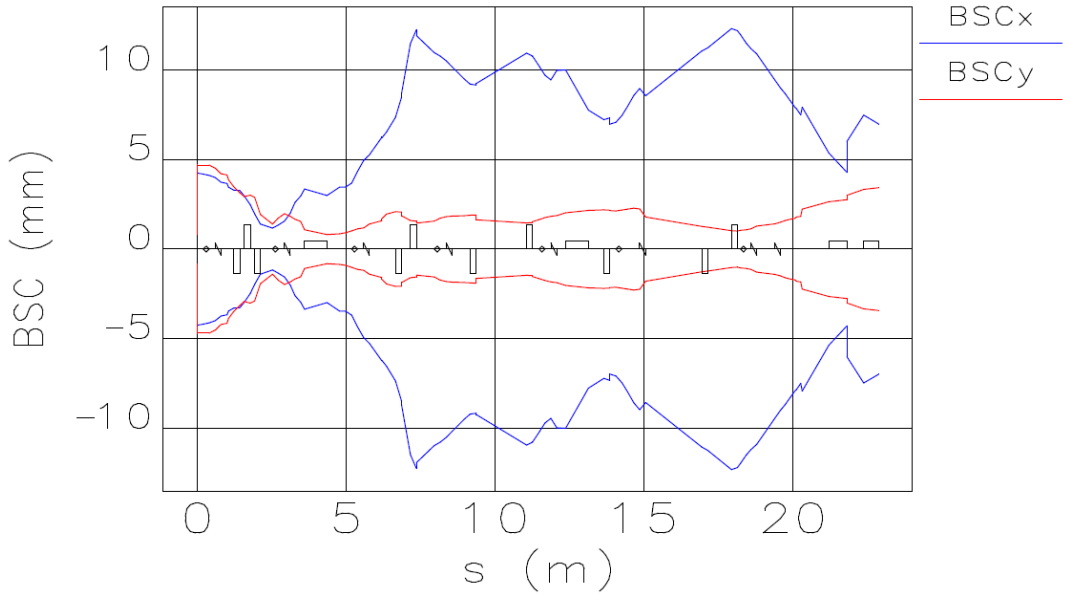
SPS-II Low-Energy Beam Transport Line (LBT)



- Space and layout are limited by booster circumference.
- Design based on linear beam optics.
- Sufficient correctors and beam diagnostics are required.



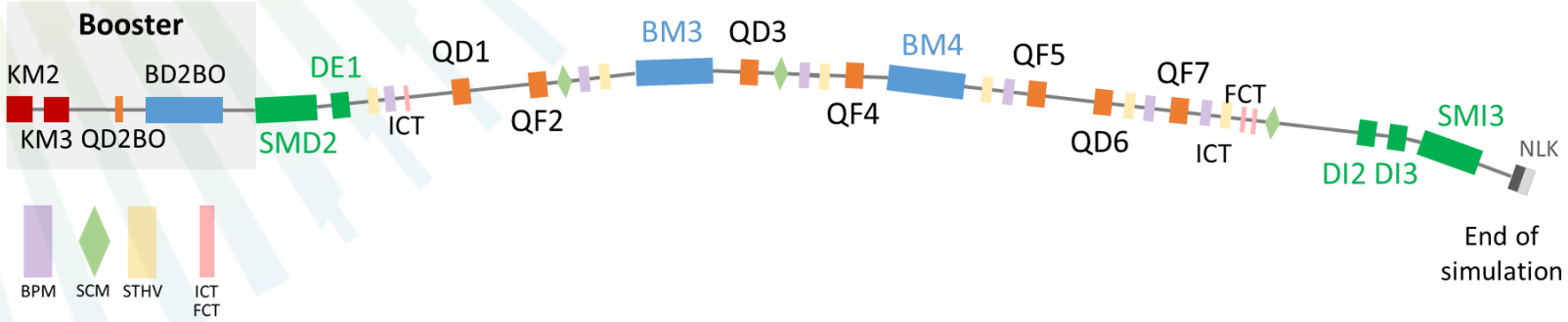
Beam stay clear



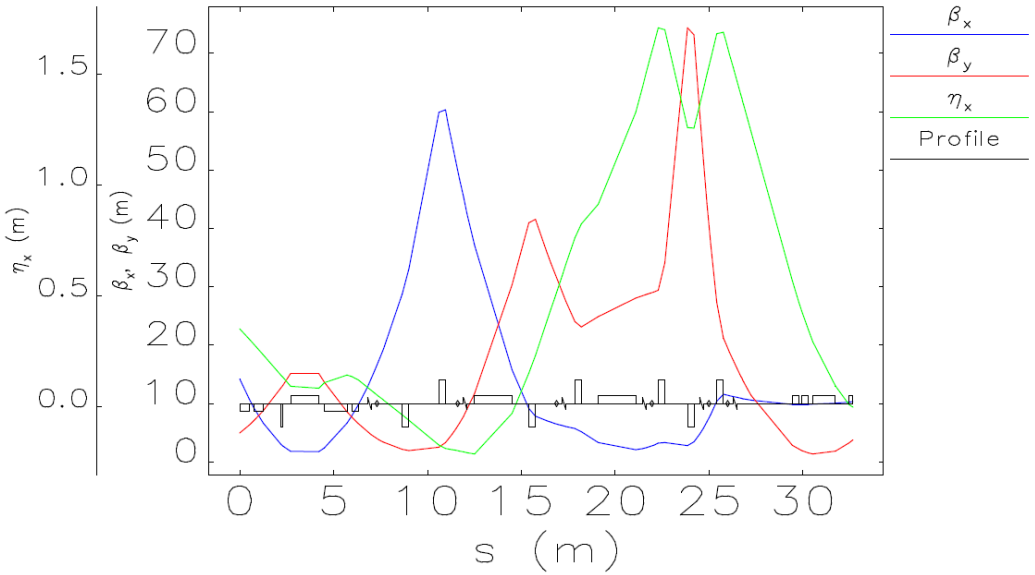
Designed by T. Chanwattana

Results from reference case with $\beta_{x,y} = 7$ m, $\alpha_{x,y} = 0$

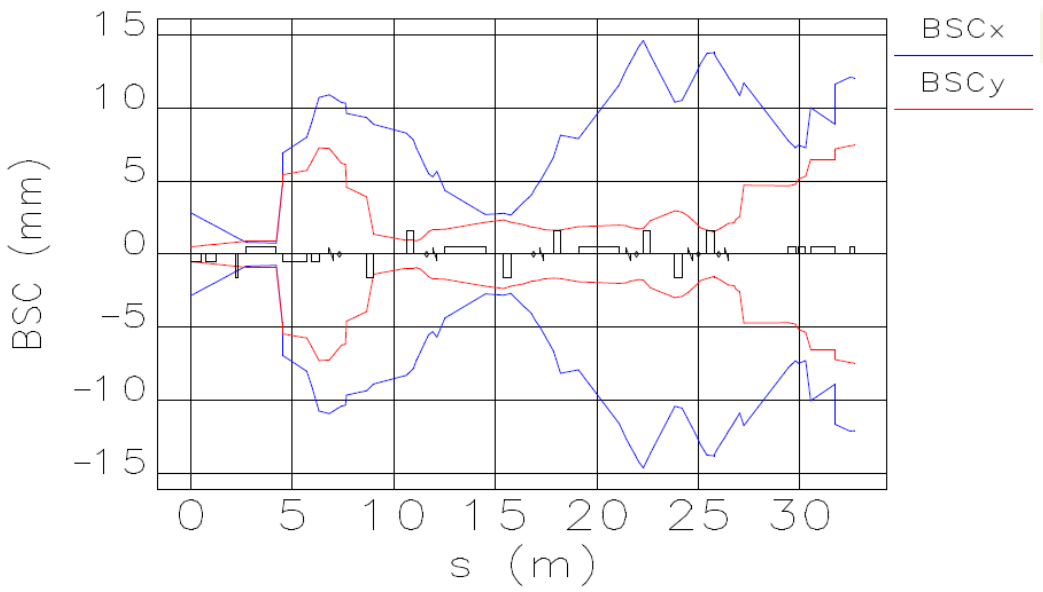
SPS-II High-Energy Beam Transport Line (HBT)



- Design based on linear beam optics.
- Space, especially closer to the storage ring, is limited according to magnet arrangement.



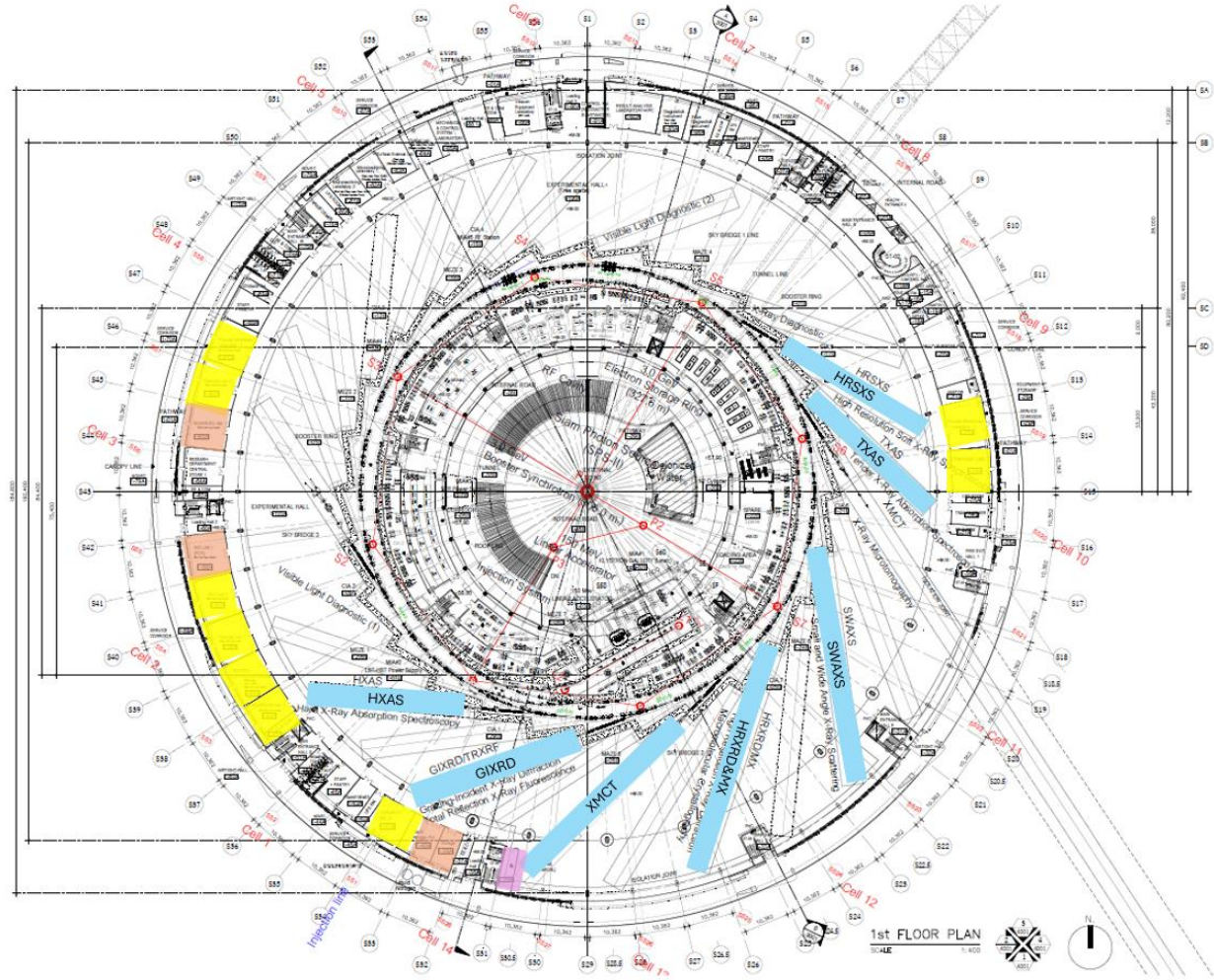
Beam stay clear



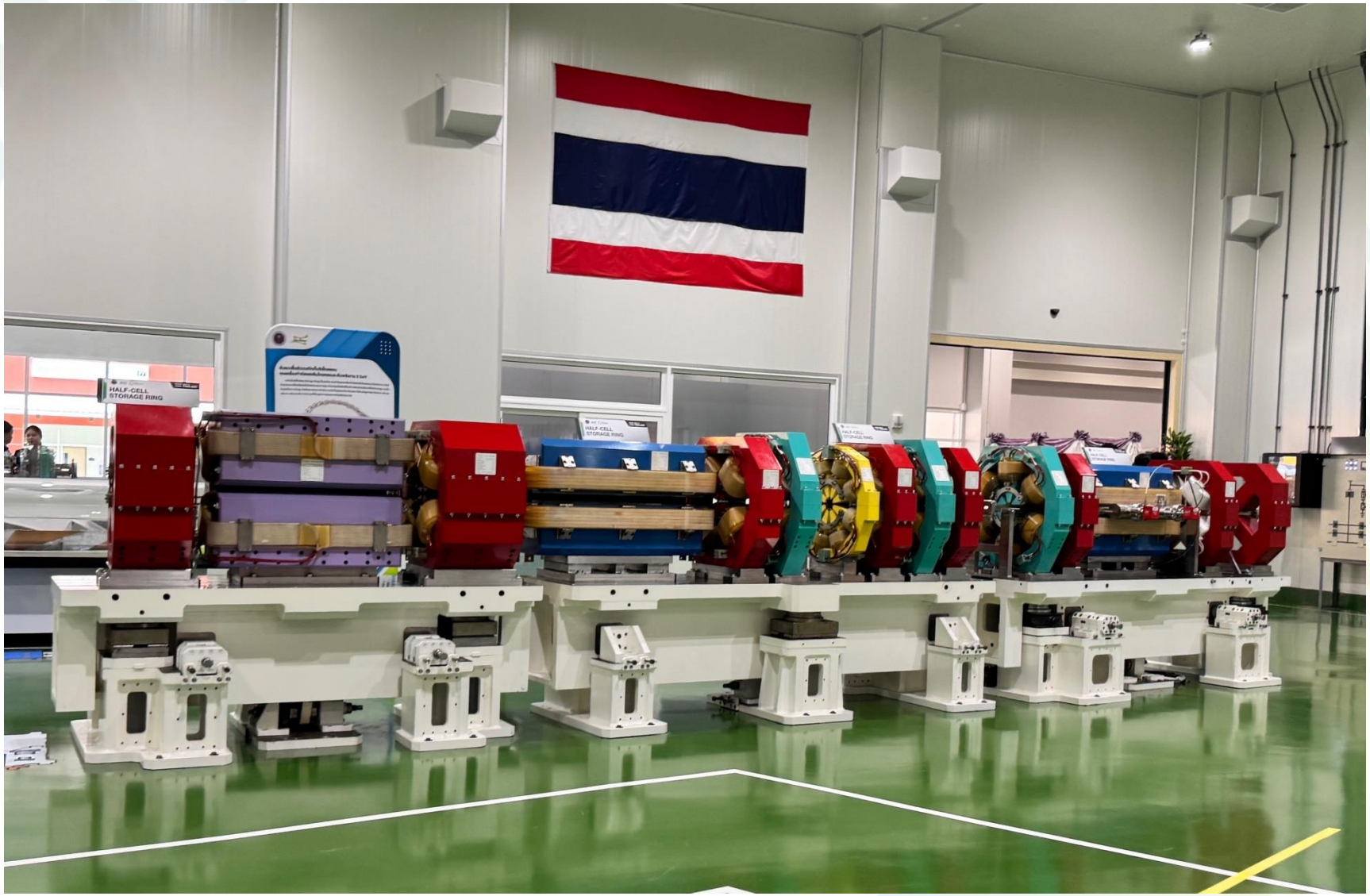
Designed by T. Chanwattana

SPS-II Phase-I Beamlines

Beamline	Technique	IDs	Energy range
TXAS	Tender X-ray absorption spectroscopy	IVU23	1.8-13 keV
HXAS	High X-ray absorption spectroscopy	IVU18	6-35 keV
XMCT	X-ray microtomography	MPW	10-60 keV
HRXRD/MX	High resolution X-ray diffraction & Macromolecular crystallography	IVU18	9-27 keV
SWAXS	Small & wide-angle X-ray scattering	IVU20	8-20 keV
GIXRD/TRXRF	Gazing-incidence X-ray Scattering and Total Refection Fluorescence	IVU18	8-28 KeV
HRSXS	High resolution soft X-ray spectroscopy	EPU58	90 eV-2.5 keV



SPS-II R&D

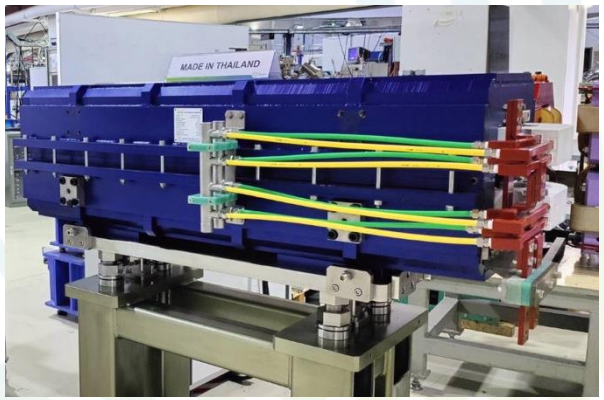


SPS-II R&D: Magnet Prototype

Storage ring magnets prototype

- ✓ **Manufacturing:** 15 magnets (9 types) successfully fabricated.
- ✓ **Tolerance Verification:** Fabrication and assembly tolerances confirmed within ±20 µm (pole profile).
- ✓ **Coil Testing:** Resistance, inductance, and temperature rise tests meet all specifications.
- ✓ **Field Quality:** Magnetic field measurements completed on 11 of 15 magnets. Pole-end chamfering is in progress.
- ➢ **Design Improvements:** New mechanical design was implemented on 2 magnets, resulting in improved magnetic field quality.
- ➢ **Repeatability Checks**: Repeatability of magnet assembly and deformation check to be initiated soon.

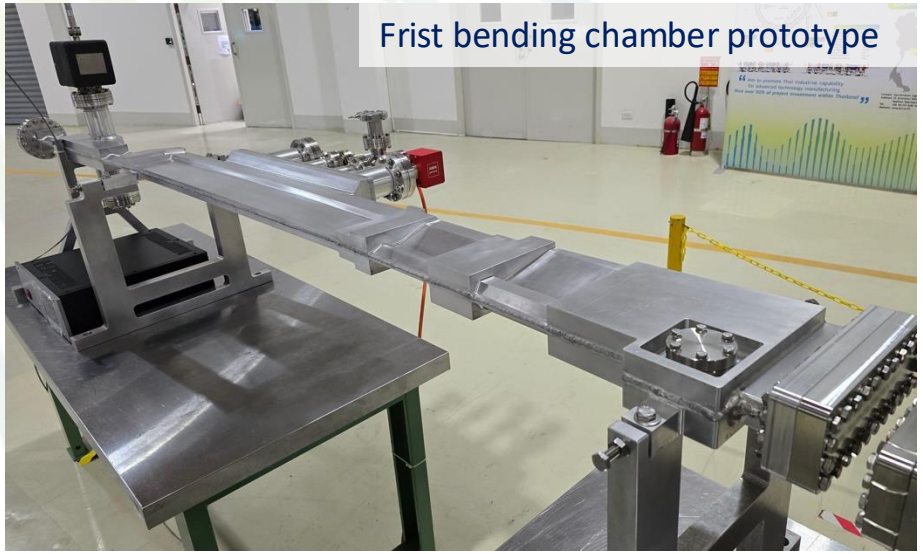
Booster magnets prototype



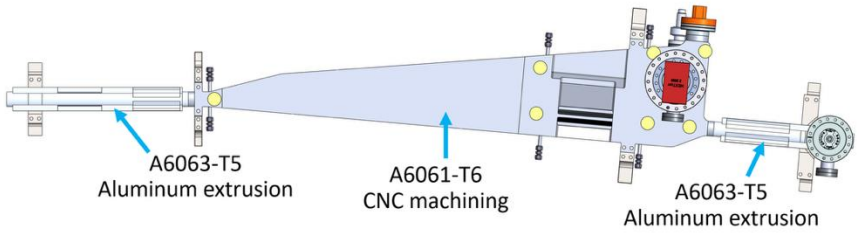
- ✓ **Manufacturing:** 5 magnets (5 types) successfully fabricated.
- ✓ **Tolerance Verification:** Fabrication and assembly tolerances confirmed within ±25 µm(pole profile).
- ✓ **Coil Testing:** Resistance, inductance, and temperature rise tests meet all specifications.
- ➢ **Field Quality:** Testing in progress
- ➢ **Design Improvements:** Not yet started
- ➢ **Repeatability Checks**: Not yet started

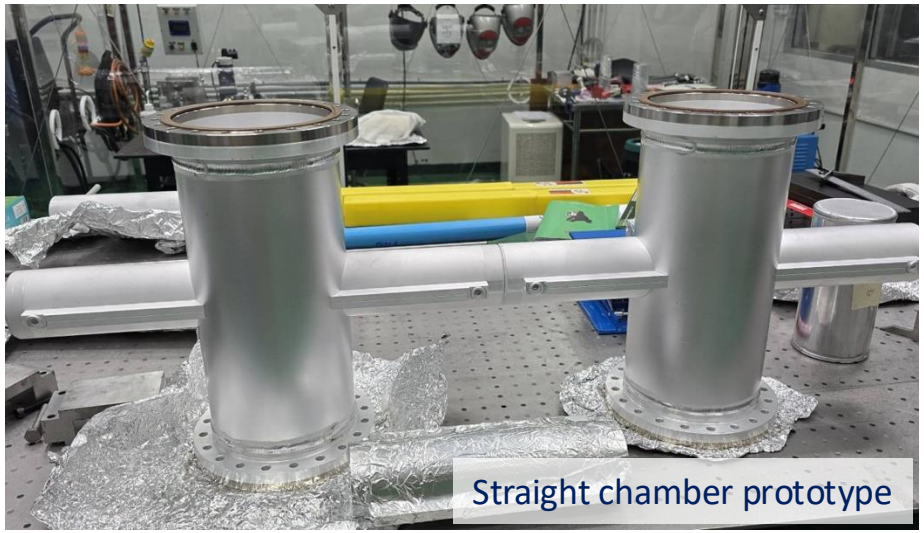
Credit: P. Sunwong and S. Pawanta

SPS-II R&D: Vacuum Prototype


Frist bending chamber prototype

- ✓ **First prototype** of stainless steel and aluminum vacuum chambers completed. Straight sections made from aluminum extrusion; bending sections CNC-machined with oil-less cooling
- ➢ **Ongoing improvement** of aluminum vacuum chamber prototype, focusing on reducing geometry deformation and improving vacuum performance.




Straight chamber prototype

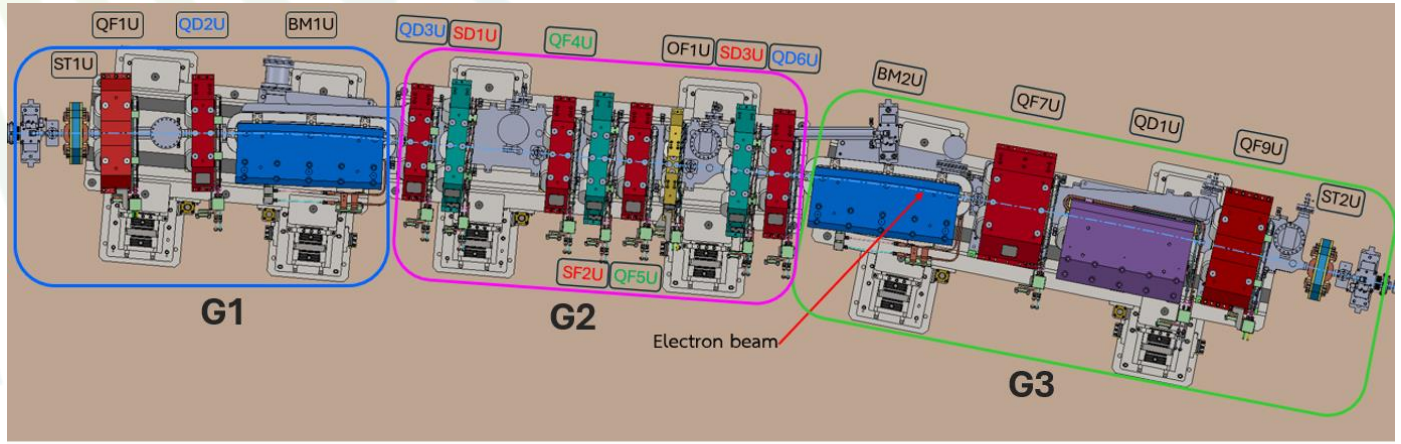

Elliptical and circular tube made from extrusion

High heat load absorber

Credit: T. Phimsen, S. Boonsuya and S. Chitthaisong

SPS-II R&D: Girder Prototype

Dec. 2025 Dec. 2024



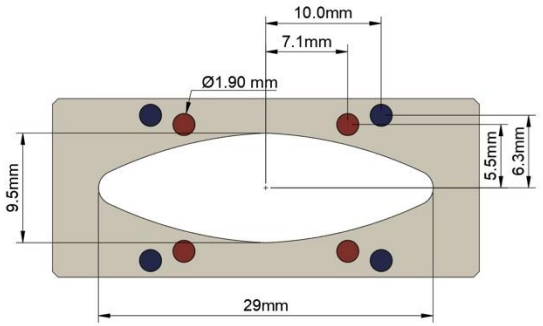
The up-stream half cell lay out

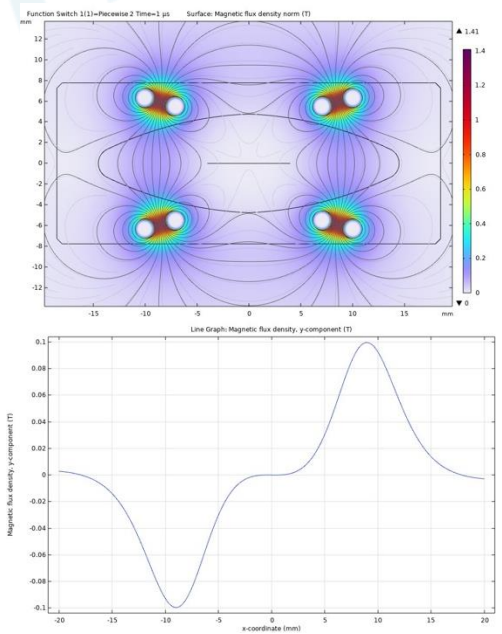
Six girders per cell to install, 84 girder in total

- ✓ Frist G1 girder successfully manufactured
- ✓ Precision machining: top surface alignment grooves verified to meet <15 µm specification, adjustable positioning accuracy within ±5 µm
- ➢ Deformation and vibration testing in progress
- ➢ Ongoing manufacturing of G1 and G2 girders

SPS-II R&D: Kickers and BPM

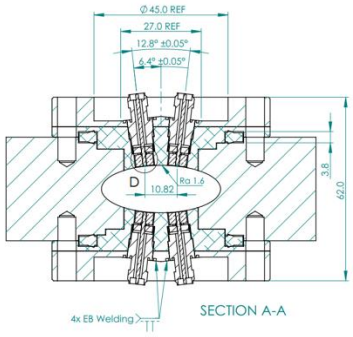
Non-linear kicker (NLK) prototype for the storage ring injection

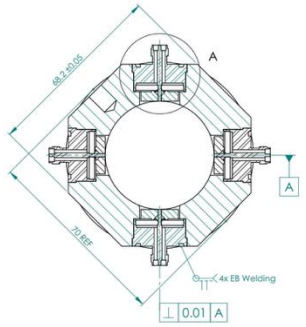




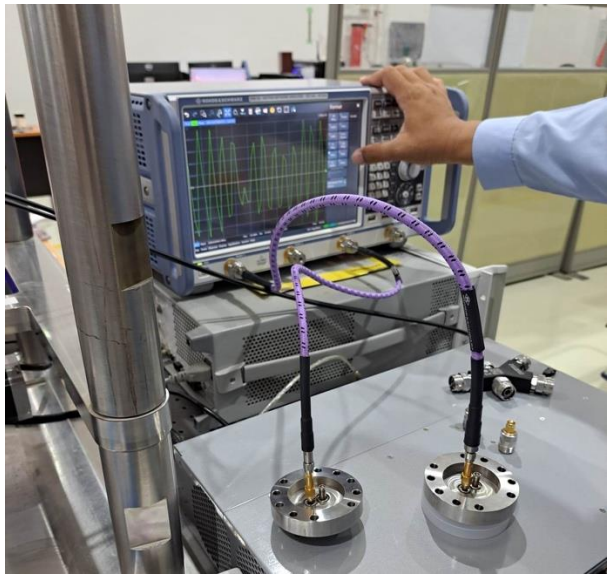
Ongoing development in collaboration with LNLS, SIRIUS

BPM prototype

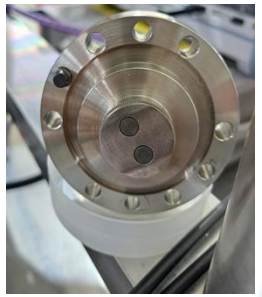




BPM for storage ring



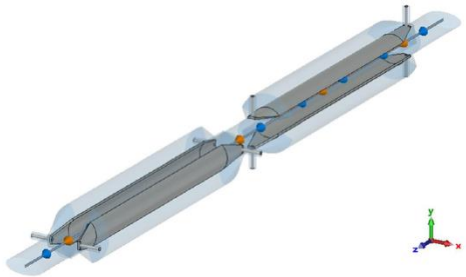
Booster BPM

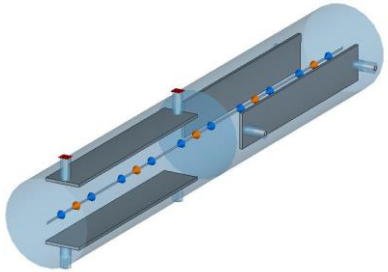


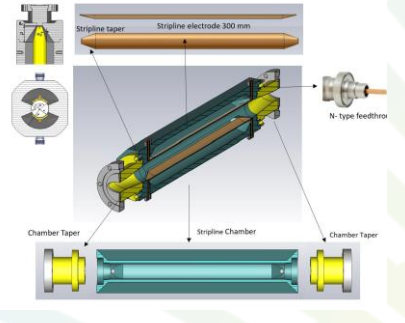
BPM feedthrough manufactured and tested successfully

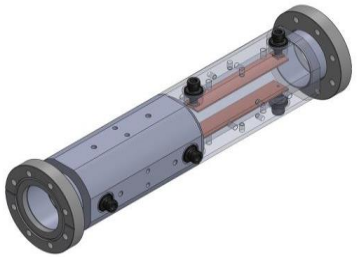
Credit: P. Sudmuang

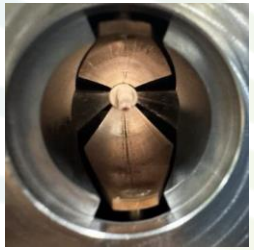
Stripline kicker for tune measurement and bunch by bunch feedback











First stripline kicker manufactured and tested; minor improvements required

SPS-II Project Timeline

Detailed design study & Prototypes

2020

Project endorsed by cabinet

2025

- Submit revised project proposal (final machine design and cost) for cabinet approval
- Complete prototype development

TOR & Bidding

2028

- Start building construction
- Start procurement

Construction & Manufacturing

2029

Complete Lab building construction

2031

Complete building construction

Installation and Comm.

2032

Complete Linac installation & commissioning

2033

Complete machine installation &commissioning

Fine tune lattice corrections

2034

Start user operation


Thank
You