Future Light Source in Thailand

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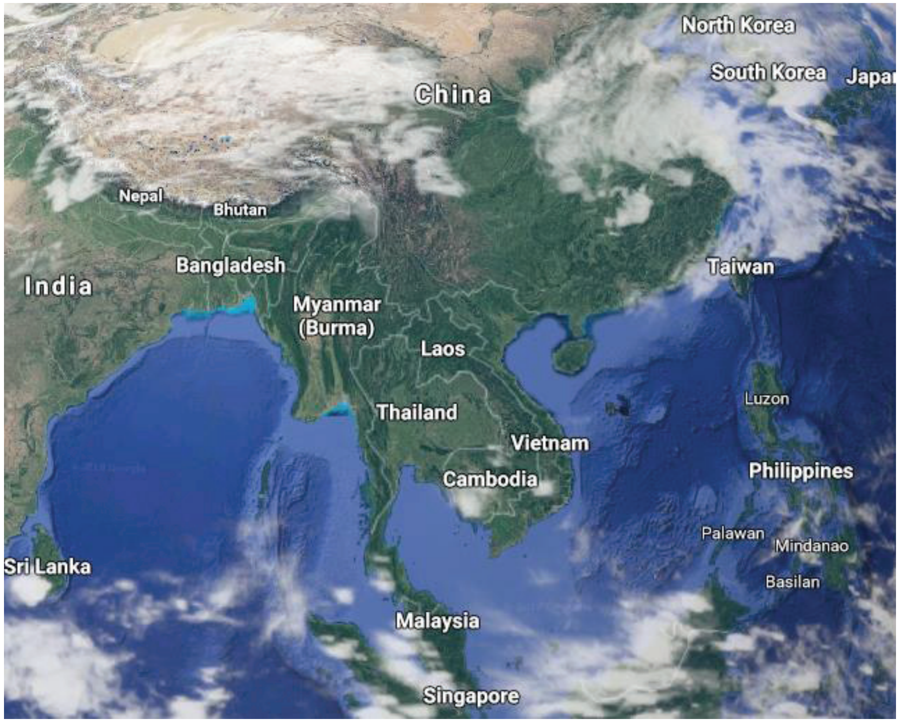
On behalf of SLRI Accelerator Division
Synchrotron Light Research Institute (SLRI)
Thailand

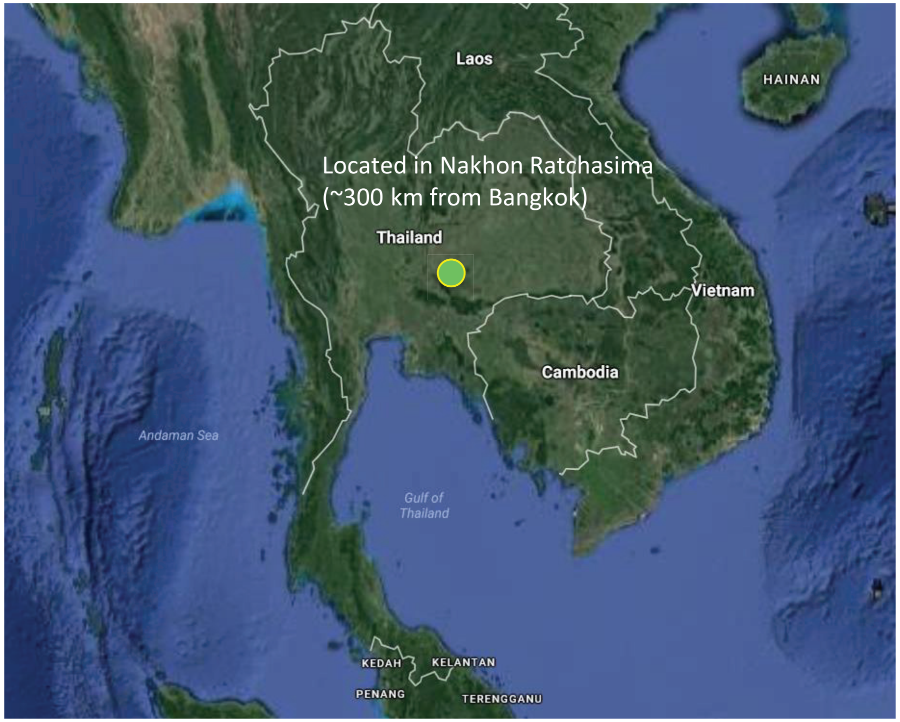
FLS2018, 5-9 Mar 2018, Shanghai

Outline

- Siam Photon Source
- New synchrotron
- Lattice Design
- Injector Design
- Some R&D at SLRI
- Conclusion

Siam Photon Source (SPS)





- Siam photon source (SPS) organised by Synchrotron Light Research Institute (SLRI).
- The 1st and only Thailand's synchrotron light source and the largest in South East Asia.
- Major parts were transferred from SORTEC, Japan in 1996.
- Beam service started in 2003.

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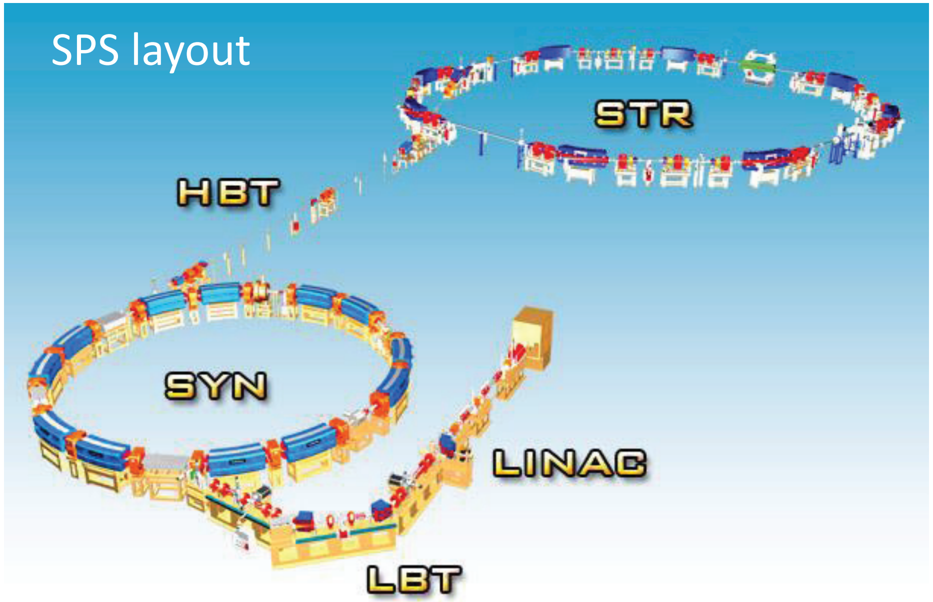
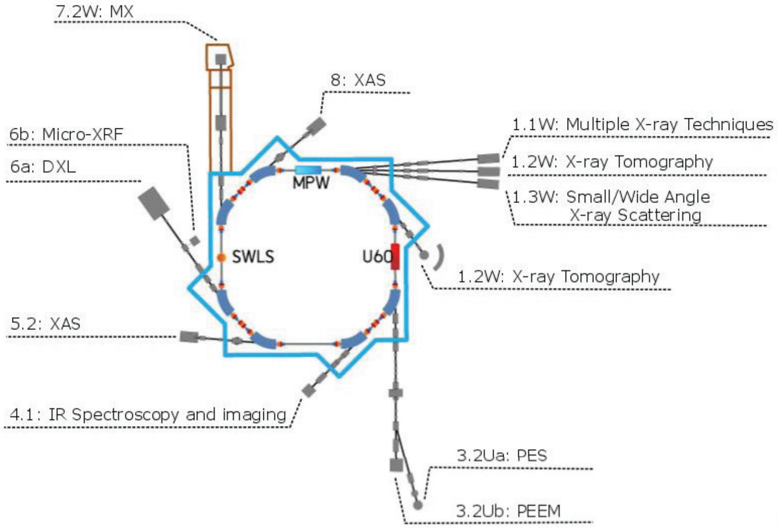
Siam Photon Source (SPS)



Parameter	Value
Energy	1.2 GeV
Stored current	150 mA
Emittance	41 nm-rad
Lifetime @ 100 mA	12 hours
Circumference	81.3 m
Injection energy	1.0 GeV



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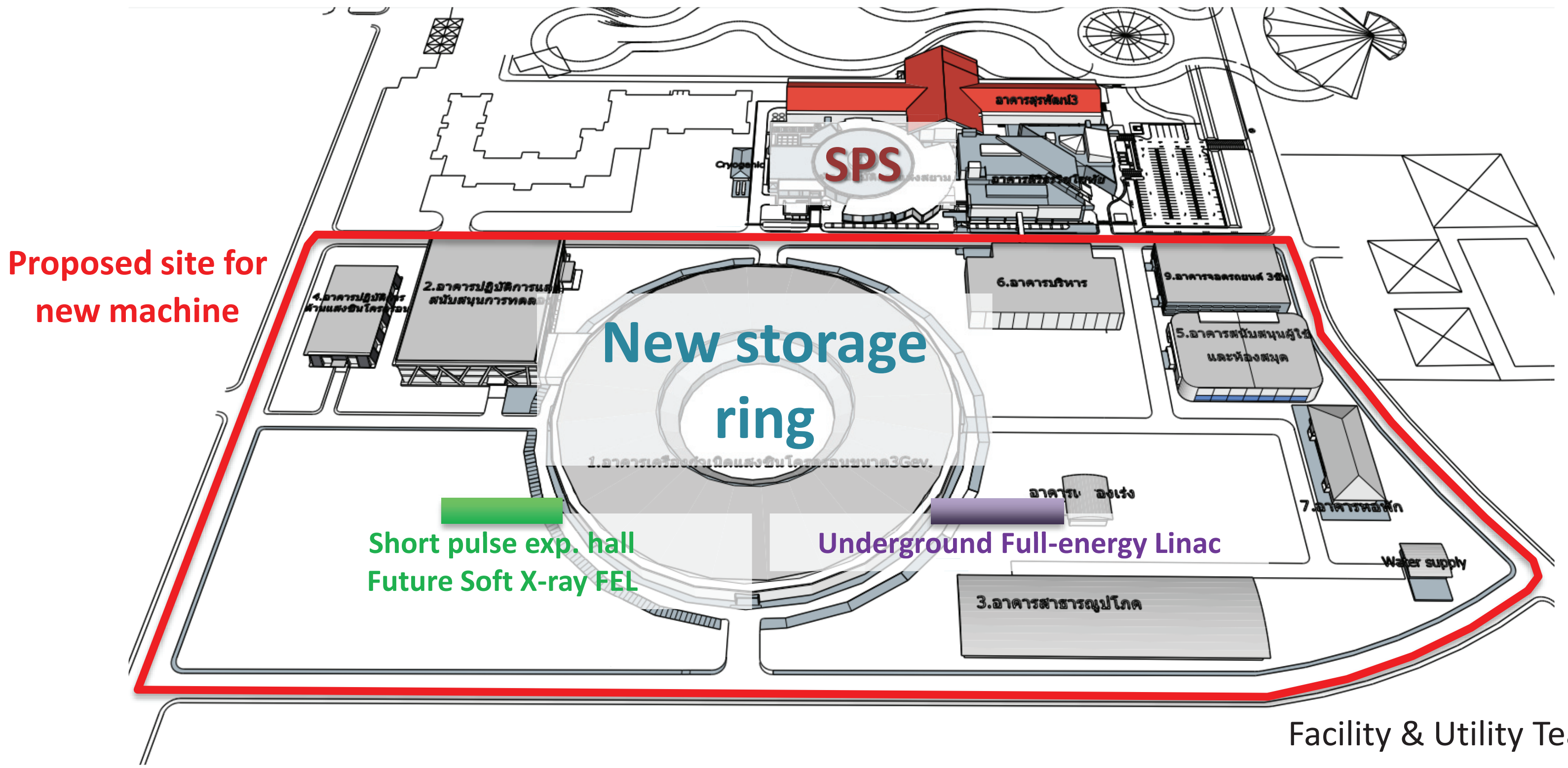
Thailand's Future Light Source: SPS-II



Facility & Utility Team

- Higher electron beam energy
- Larger storage ring
- Full-energy Linac injector for extra usages and future upgrade of SX-FEL

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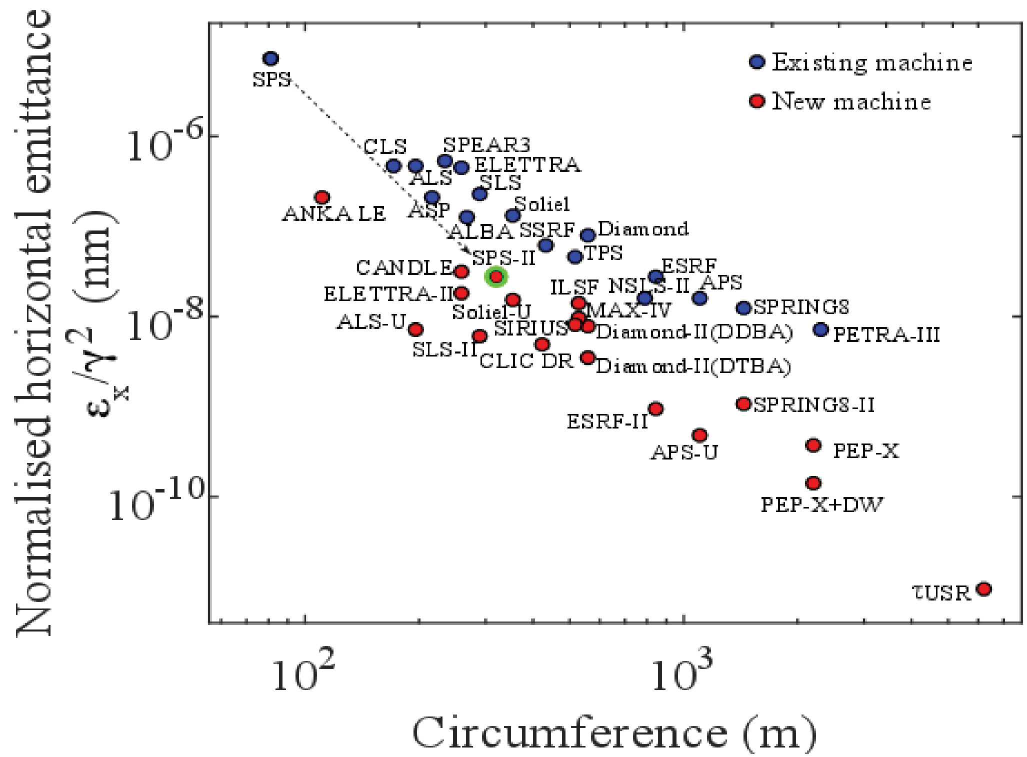
Design Requirements

Storage ring:

- 3GeV
- Medium size ~ 300 m circumference
- Horizontal emittance < 1 nm·rad
- High capacity

Booster

- 3GeV Linac injector
- Length < 150 m
- Norm. hor. emittance < 10 µm·rad
- High capability:
  - Ring injection
  - Short bunch generation



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DTBA cell

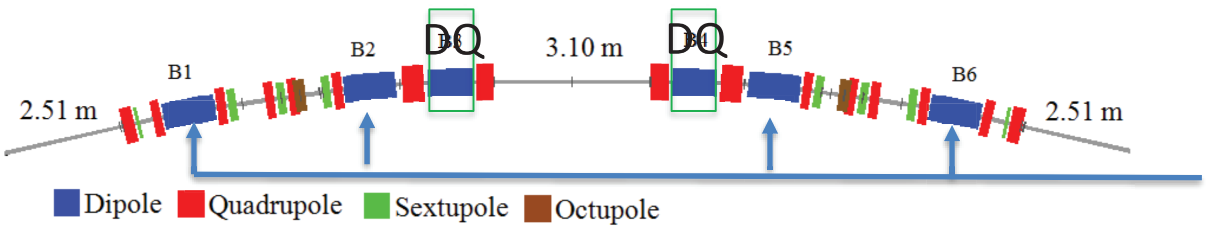
DTBA (Double Triple Bend Achromat)

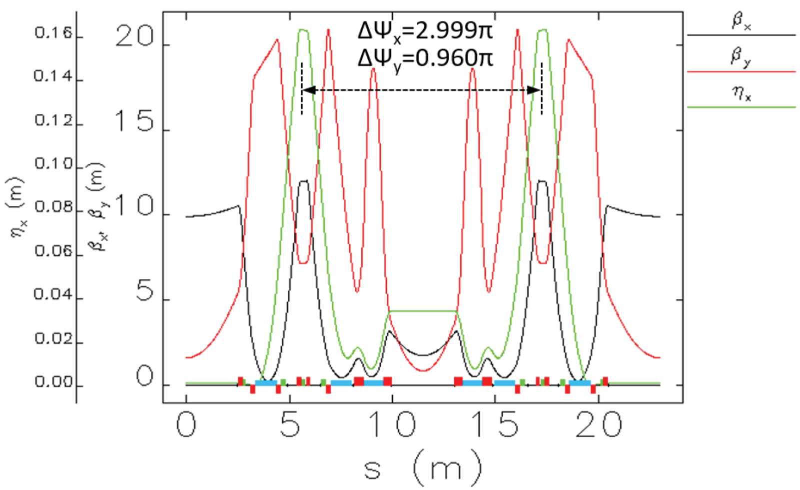
Original Diamond upgrade study

4 Normal dipoles & 2 Combined fn. dipoles (DQ)

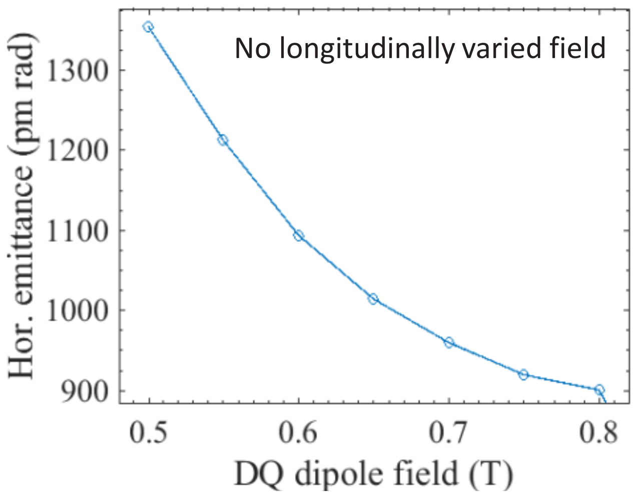
14 Cell -> RING

28 straights in total





Local dispersion bump and
chromaticity correction
Odd-pi phase advance trick



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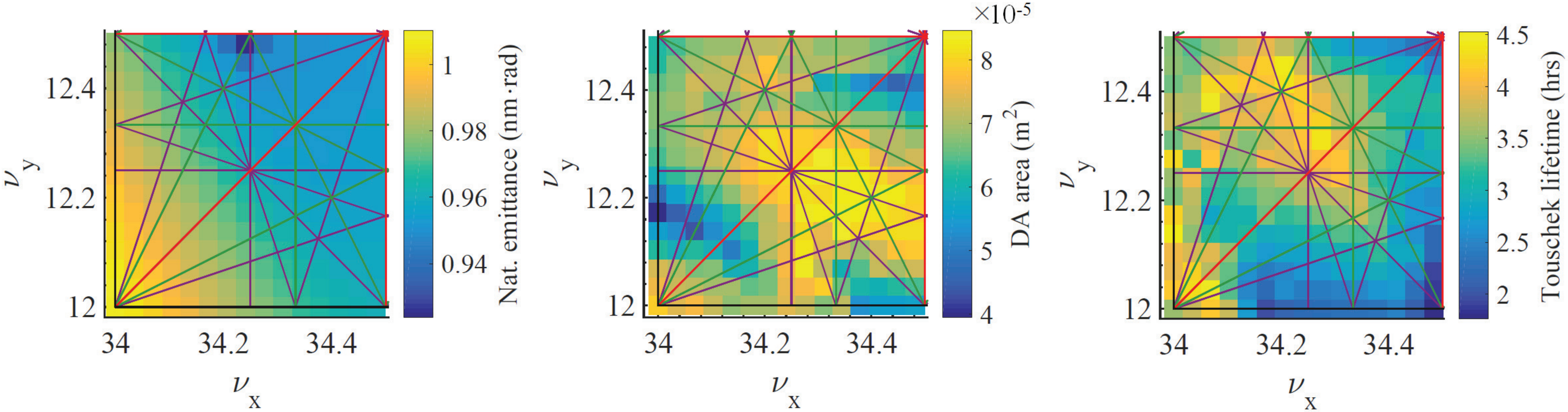
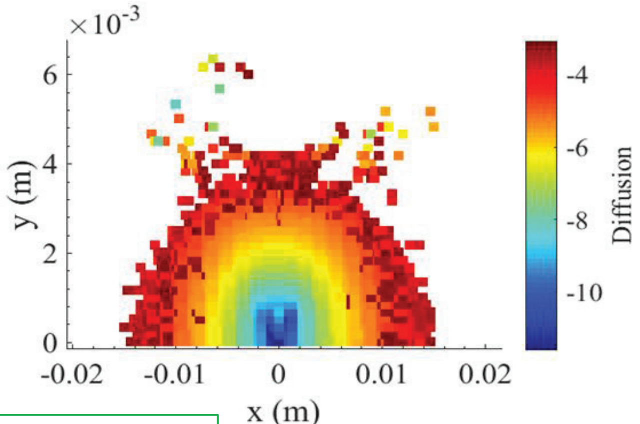
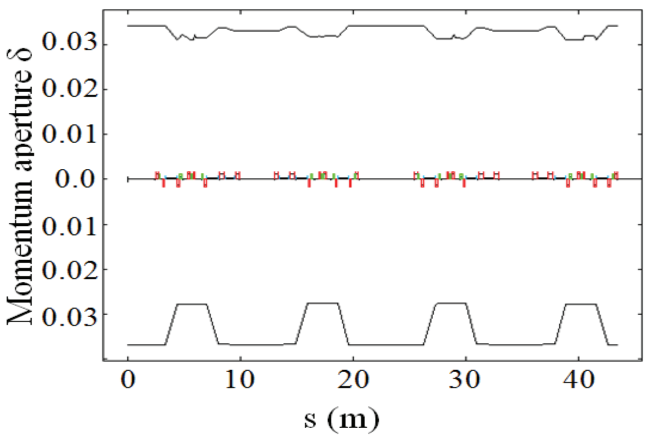
DA, MA optimization

Tune scan







Vrf 2.2 MV

RFfreq 500 MHz

500 Bunches

300 mA

BL ~ 3mm

Coupling 0.8 %

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Storage Ring parameters

Parameters	SPS	SPS-II
Circumference (m)	81.3	**321.3**
Energy (GeV)	1.2	**3.0**
Relativistic gamma 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	**-64.3/ -77.5**
Tune Q_x/Q_y	4.75, 2.82	**34.24/ 12.31**
Momentum compaction α_c	1.70e-2	**3.18e-4**
Damping times hor./ver./long. (ms)	10.7/9.8/4.7	**9.5/ 11.1/ 6.1**
Straight/circumference	0.33	**0.35**
Energy lost per turn from dipole U_0 (MeV)	0.066	**0.577**
RF frequency (MHz)	118.00	**500.12**
RF voltage (MV)	0.3	**2.2**
Harmonic number	32	**536**
Overvoltage V/U_0	4.5	**3.8**
Synchronous phase (degree)	167.29	**164.77**
Synchrotron tune	0.00460	**0.00438**
Nat. bunch length (mm)	29.03	**2.854**
Nat. bunch duration (ps)	96.8	**9.5**

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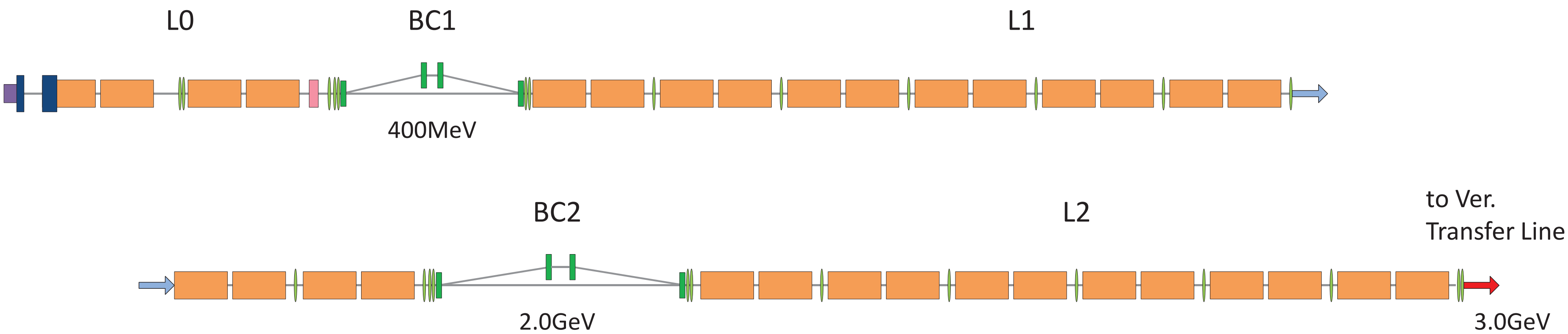
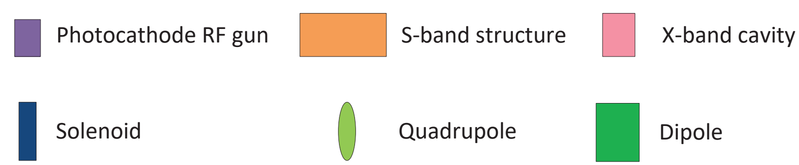
Injector Design





32 high gradient S-band
G = 35-38 MV/m

N. Juntong
WEP1WD03

Parameters	Value
Total injector length	< 150 m
Electron beam energy	3.0 GeV
Repetition rate	60 Hz
Normalised emittance ε_{nx}	< 10 µm·rad
Energy spread σ_E	< 0.1 %
Bunch charge	0.1-1 nC
Bunch length for storage ring injection	< 10 ps (3 mm)
Bunch length for short pulse experiment	100-200 fs (30-60 µm)

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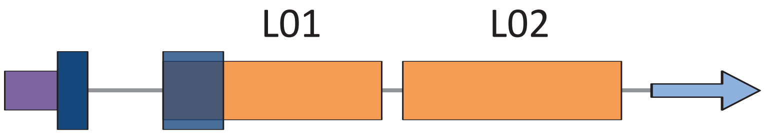
Pre-injector Simulation



- RF photo gun

Parameters	Value
Model	Based on LCLS RF photo gun
Cathode material	Cu
Nominal peak field	120 MV/m
Frequency	2856 GHz
Repetition rate	60 Hz
Number of cells	1.6
Beam energy at gun exit	~5.7 MeV
Energy spread at gun exit	~0.3%
Bunch length for ring injection	10 ps (3 mm)
Bunch length for short pulse	100-200 fs (30-60 μm)

- UV laser (converted from IR)

Parameters	Value
Wavelength	~ 260-270 nm
Repetition rate	60 Hz
Longitudinal pulse shape	Uniform
Transverse pulse shape	Uniform

- Solenoid

Parameters	Value
At gun:	
Axial field	< 0.3 T
Effective length	14 cm
At L01:	
Axial field	< 0.2 T
Effective length	0.8 m

- S-band booster

Parameters	Value
Frequency	2856 GHz
Structure length	3 m
Peak gradient	40 MV/m

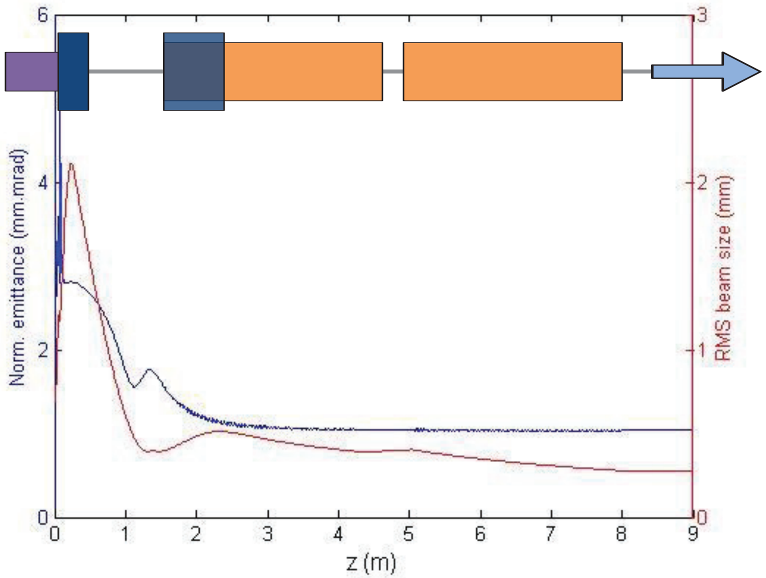
- ASTRA* simulation

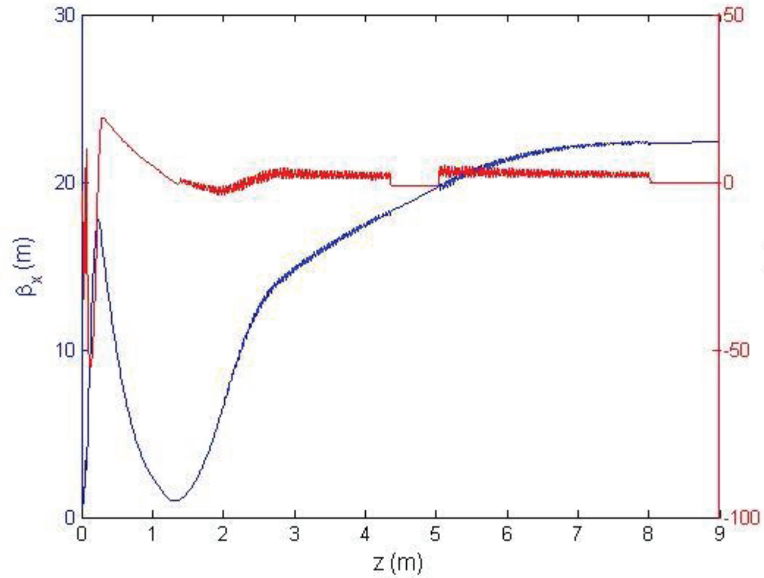
Parameters	Value
Bunch charge	1 nC
At cathode:	
Long. charge distribution	Uniform
Tran. charge distribution	Uniform

*K. Floettmann, ASTRA, http://www.desy.de/~mpyflo/

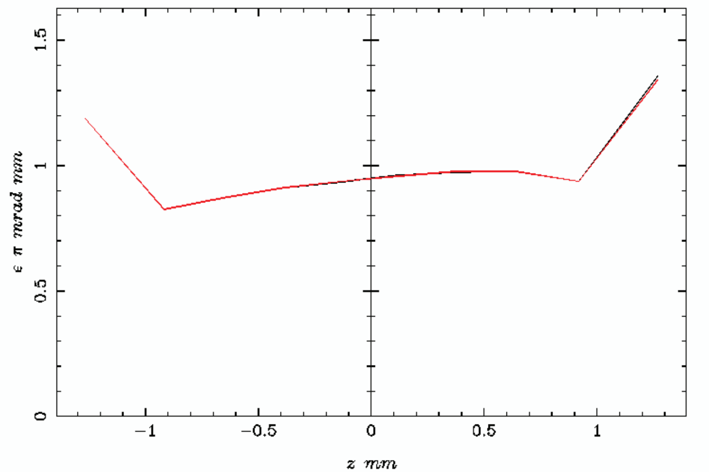
Pre-injector Simulation

- Pre-injector Use conventional S-band column with high gradient < 40 MV/m

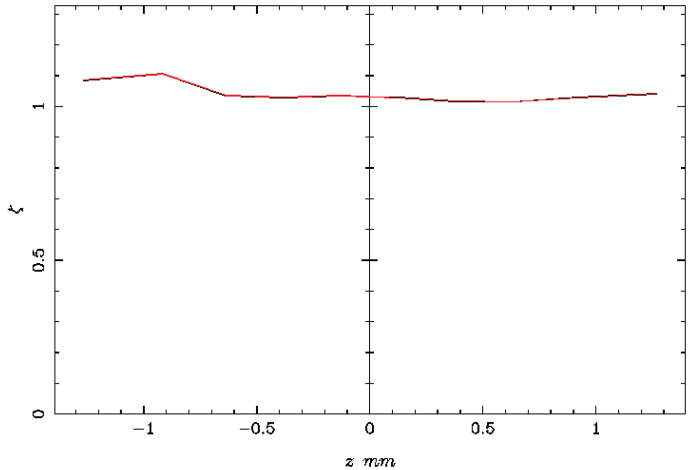




Slice emittance

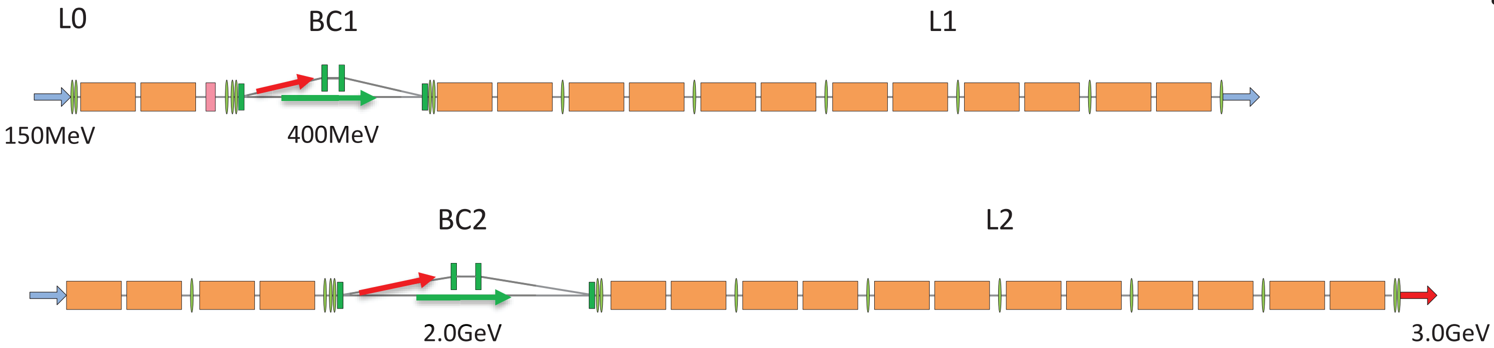


Mismatch parameter



Main Linac Simulation

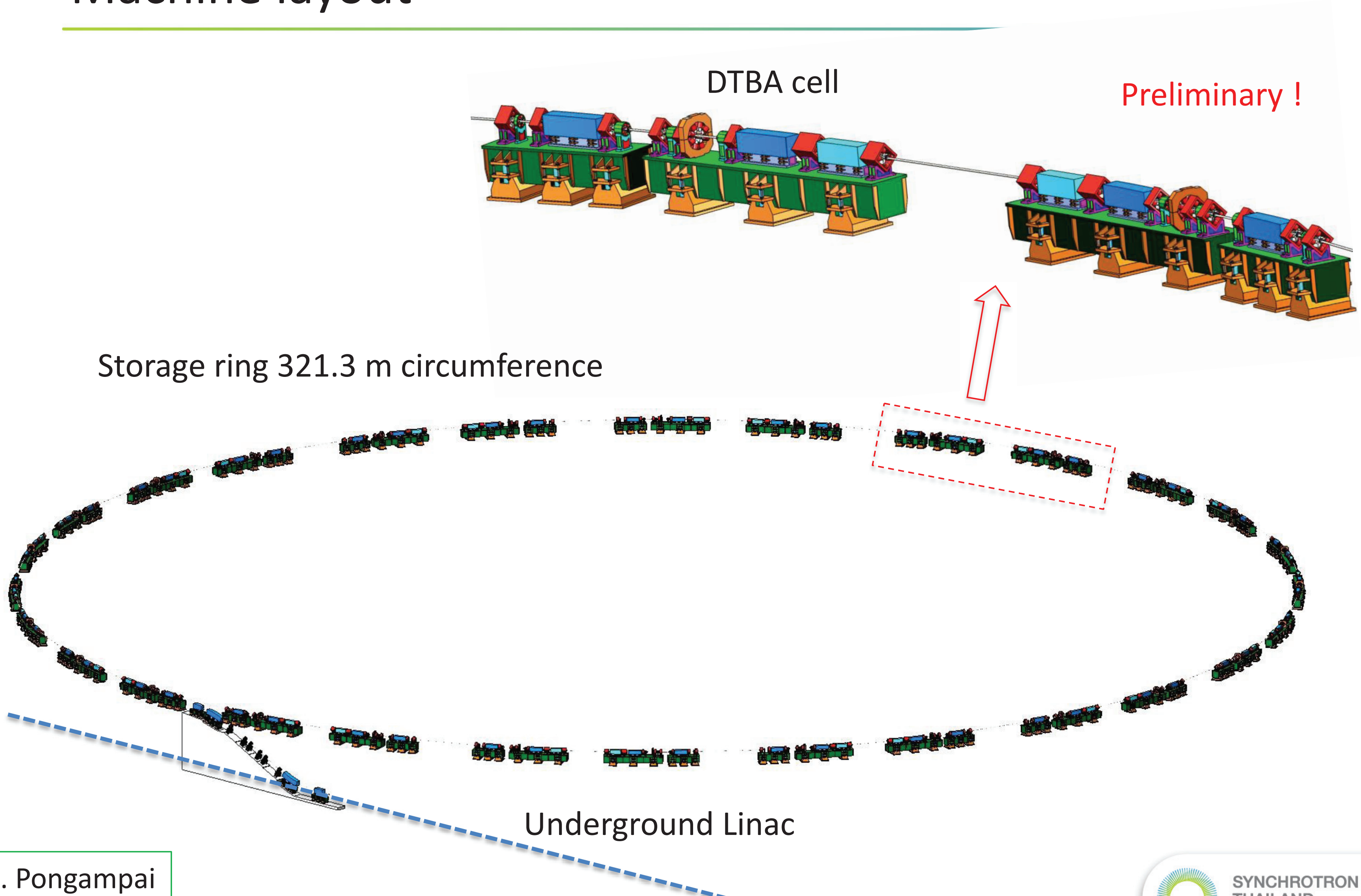
Simulation with elegant*



Parameters	Ring injection	Short bunch
Bunch charge (nC)	1	1
Normalised emittance $\varepsilon_{nx}/\varepsilon_{ny}$ (µm·rad)	1.0 / 1.0	7.1 / 1.0
Emittance ε_x / ε_y (nm·rad)	0.16 / 0.16	1.11 / 0.16
Energy spread σ_E (%)	0.09	0.12
Final rms bunch length (µm)	780	59
Final rms bunch duration (ps)	2.6	0.2
Final peak current	35 A	3.2 kA
Compression factor BC1 / BC2	1 / 1	4.8 / 2.8
BC bending angle (°)	0 / 0	3.5 / 3.5
S-band gradient (MV/m)	38	38
L04 phase (°)	-30	-30
X-band cavity gradient G (MV/m)	43	43
X-band cavity phase	-90	-110

*M. Borland, elegant, APS LS-287, (2000).

Machine layout



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Magnets summary

Design parameters	D0	DQ	QD	QF1	QF4	QF6	QF8
Effective length (m)	1.0	0.85	0.162	0.215	0.162	0.412	0.328
Number of magnets	56	28	84	28	56	28	28
Dipole field (T)	0.87	**0.6**	0	0	0	0	0
Quadrupole field (T/m)	0	**27.1**	51	45	44	**60**	50
Sextupole field (T/m^2)	0	0	0	0	0	0	0
Octupole field (T/m^3)	0	0	0	0	0	0	0
Vertical gap (mm)	40	---	---	---	---	---	---
GFR (mm)	17	8	17	17	17	8	8
Field quality in GFR	3×10^{-4}	1×10^{-2}	5×10^{-4}	5×10^{-4}	5×10^{-4}	5×10^{-4}	5×10^{-4}

	SD1	SD2	SF2	OF1	COR
Effective length (m)	0.14	0.14	0.14	0.09	0.1
Number of magnets	28	28	56	28	28
Dipole field (T)	0.057	0.057	0.057	0	0.08
Quadrupole field (T/m)	0.72	0.72	0.72	0	0
Sextupole field (T/m^2)	2,030	1,140	1,450	0	0
Octupole field (T/m^3)	0	0	0	72,000	0
Vertical gap (mm)	---	---	---	---	100
Bore radius (mm)	24	24	24	30	---
GFR (mm)	16	16	16	16	16
Field quality in GFR	3×10^{-3}	3×10^{-3}	3×10^{-3}	5×10^{-3}	1×10^{-2}

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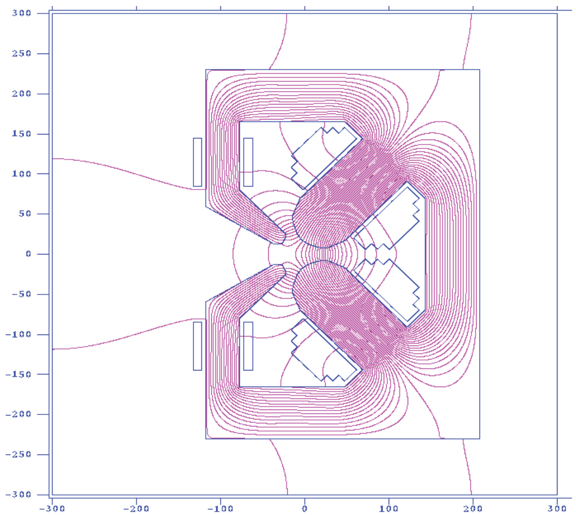
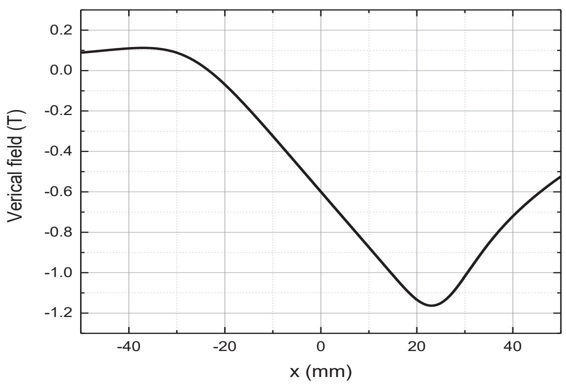
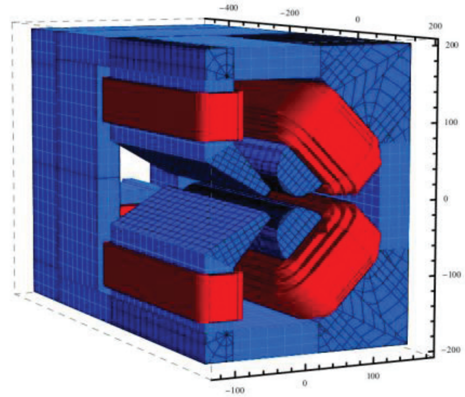
Magnet design

- Combined fn. Dipole DQ

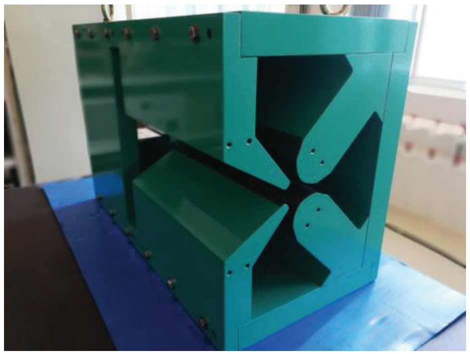


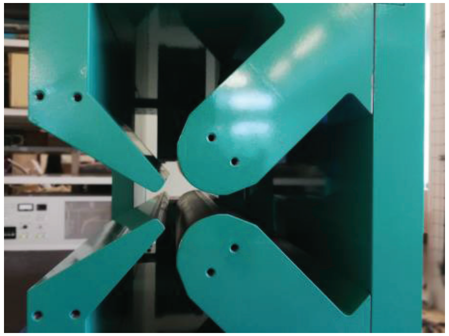


In-house DQ prototype



Precise machining with Wire EDM





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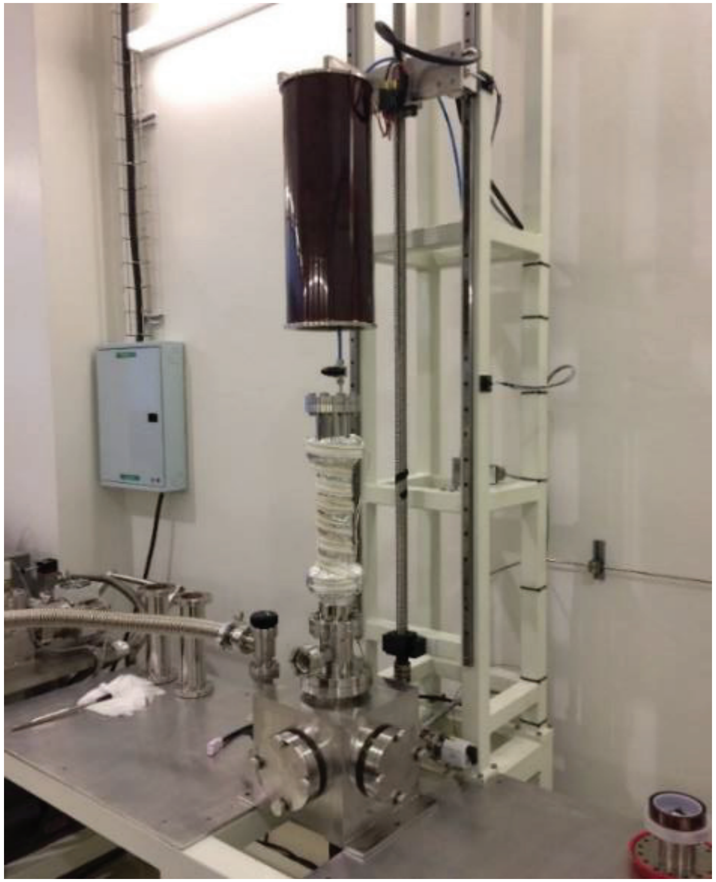
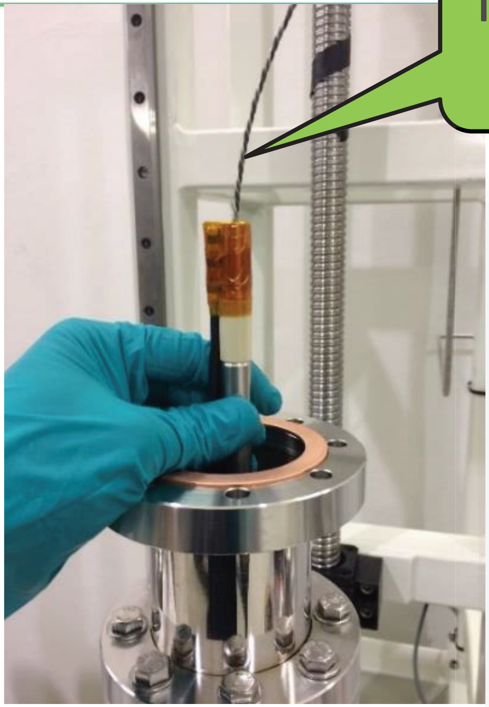
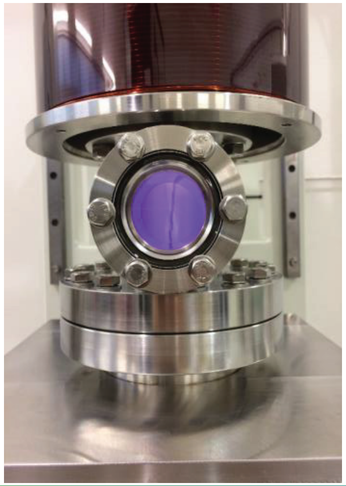
NEG coating R&D program

- NEG in-house R&D





Twisted Wire Target
(Ti, Zr and V)



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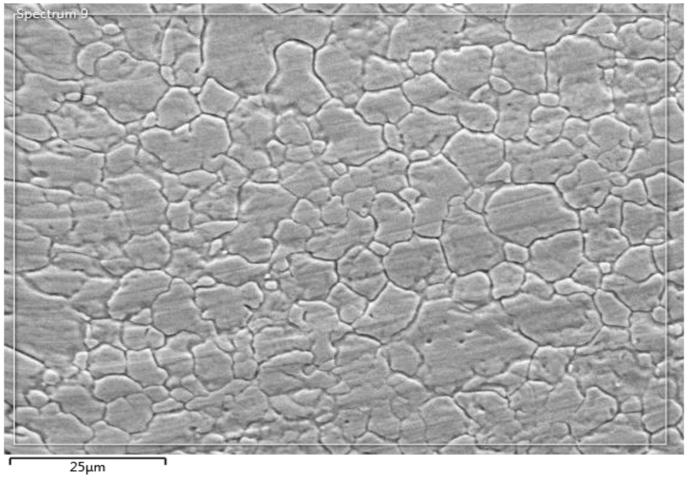
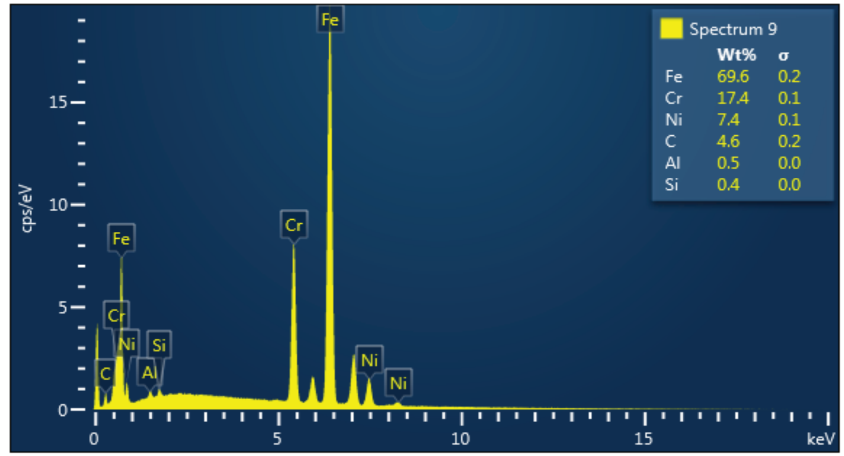
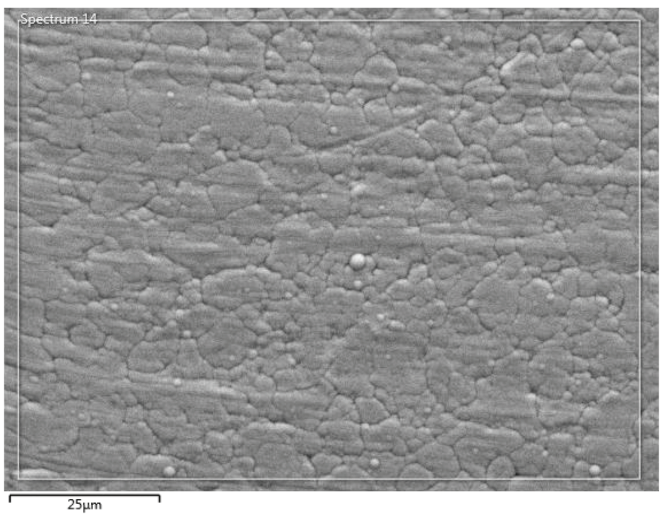
SEM on the surface

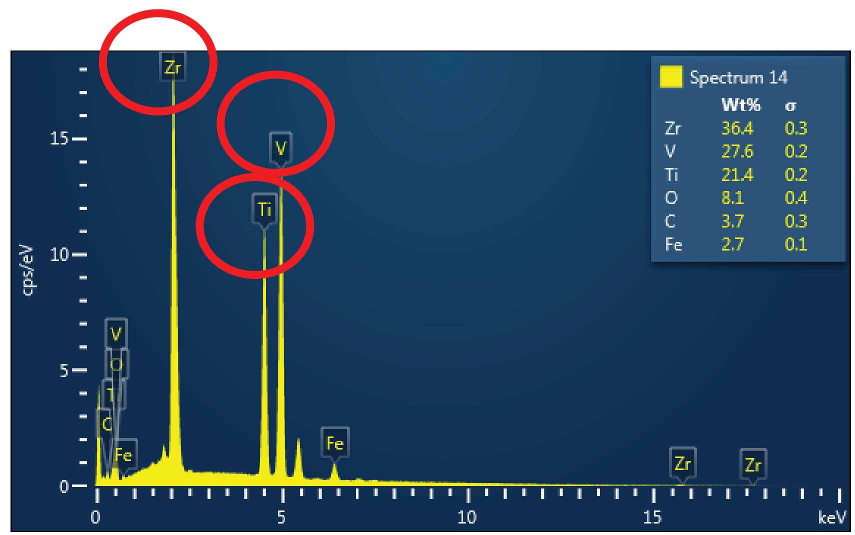
Un-Coat Surface





NEG Coated Surface





Physical Surface

Compositions

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Conclusion

- DTBA is good for us in terms of emittance and straight sections.
- Full-energy Linac injector for short pulse experiment and future upgrade of soft X-ray FEL.
- The project is mostly based on existing technology.
- Government acknowledged the project concept since 2017.
- Project Funding will be considered in April 2018.
- DDR is in progress and should be launched in 2019.
- Magnet and NEG are in R&D process.

Acknowledgement

- Beam dynamics and instrumentation group
- SPS-II DDR team
- Magnet group
- RF group
- Vacuum group
- Diamond AP group

THANK YOU

T. Chanwattana on behalf of SLRI