Report on ICHEP2024

Accelerator Design Meeting - July 25th, 2024

K. André

Agenda - I

- Accelerator sessions: 4 on Thursday and 2 on Friday
  - Accelerators: Physics, Performance, and R&D for future facilities
- Present and approved accelerator facilities
- Panel discussion on Future colliders
- ~~Future facilities and advances in accelerator technologies~~
- FCC integrated program and R&D in accelerator technologies

Agenda - II

	Status of the CEPC Project	Haijun Yang	Club D	08:30 - 08:48
09:00	ILC and CLIC Project Status and Plans	Jenny List	Club D	08:48 - 09:06
	Highlight from SuperKEKB Beam Commissioning after Upgrading during Long Shutdown	kyo shibata	Club D	09:06 - 09:24
	FCC-ee Collider Design Overview	Kevin Andre	Club D	09:24 - 09:42
	The R&D Roadmap towards ERL-based particle physics colliders	Jorgen D'Hondt	Club D	09:42 - 10:00
10:00	PERLE and bERLinPro, two key accelerator projects as pathfinders for future ERL based HEP colliders	Walid KAABI	Club D	10:00 - 10:15
	Coffee break		Foyer Floor 2	10:15 - 10:45
	Physics Program for Super Tau-Charm Facility	Haiping Peng	Club D	10:45 - 11:00
11:00	Accelerator design and R&D efforts for Super Tau-Charm Facility	Prof. Jingyu Tang	Club D	11:00 - 11:15
	Study status of Beam Backgrounds and MDI Design at the CEPC	Haoyu Shi	Club D	11:15 - 11:30
	Status of HALHF - a concept for a hybrid asymmetric linear Higgs factory	Brian Foster	Club D	11:30 - 11:45
	Progress in the center-of-mass energy calibration and monochromatization at FCC-ee	Aurelien Martens	Club D	11:45 - 12:00
12:00	A crystal-based positron source for lepton colliders	Nicola Canale	Club D	12:00 - 12:15
	R&D for positron sources at high-energy lepton colliders	gudrid moortgat-pick	Club D	12:15 - 12:30

	Status and prospects of the HL-LHC project	Hector Garcia Gavela	Club D	14:30 - 14:48
15:00	HL-LHC Crab Cavities & Future Prospects	Rama Calaga	Club D	14:48 - 15:06
	The electron cloud challenge for the HL-LHC	Lotta Mether	Club D	15:06 - 15:24
	Present and future beam collimation: challenges and solu	Dr Stefano Redaelli		
	New baseline layout of the CERN Future Circular hadron-.	Gustavo Perez Segurana		
	Exhibition free guided tour (I)		Foyer - Winter Garden	15:30 - 16:00
16:00	The High-Field Magnet Programme: Magnet R&D for FCC-	Bernhard Auchmann		
	Coffee break		Foyer Floor 2	16:15 - 16:45
	Significant upgrades of magnetic horn system for J-PARC neutrino beamline towards 1.3 MW beam power	Tetsuro Sekiguchi		
17:00	High intensity upgrades for fixed-target experiments at CERN	Johannes Bernhard	Club D	17:03 - 17:21
	Update on TWOCRYST: the feasibility of double-crystal fixed-target experiments at the LHC	Pascal Hermes	Club D	17:21 - 17:36
	EIC Electron Injector Systems Overview	Vahid Ranjbar	Club D	17:36 - 17:54
18:00	The LHeC and FCC-eh experimental program	Jorgen D'Hondt	Club D	17:54 - 18:12

Agenda - III

Time	Title	Speaker	Location	Slot
	Atomic Layer deposited thin coatings for Secondary Electron Emission yield optimization	*Mathieu Lafarie*	*Club D*	08:30 - 08:45
	Compact online scintillation spectrometer and dosemeter for LWFA sources	*Benoit Lefebvre*	*Club D*	08:45 - 09:00
09:00	Compact Electron Linacs for Research, Medical, and Industrial Applications	*Laurence Matthew Wroe*	*Club D*	09:00 - 09:15
	The ICMuS2 Project: Production of a Multi-GeV Muon Beam using Laser Wakefield Acceleration	*Dr Anna Cimmino*	*Club D*	09:15 - 09:30
	Optimizing Mu2e Experiment: Beam Shadowing with Channeling in Bent Crystals for Enhanced Extraction Efficiency	*Marco Romagnoni*		
	The new High Intensity and Brightness Beams at PSI: Status and prospects	*Angela Papa*	*Club D*	09:45 - 10:00
10:00	nuSTORM: neutrino physics on the path to the muon collider	*M. Paul Bogdan Jurj*	*Club D*	10:00 - 10:15
	Coffee break		*Foyer Floor 2*	10:15 - 10:45
	Machine-detector interface design for a 10-TeV muon collider	*Daniele Calzolari*	*Club D*	10:45 - 11:03
11:00	Muon Collider Progress	*Donatella Lucchesi*	*Club D*	11:03 - 11:21
	Final Cooling with Thick Wedges for a Muon Collider	*Daniel Fu*	*Club D*	11:21 - 11:39
	Transverse Collective Effects studies for a Muon Collider	*David Amorim*	*Club D*	11:39 - 11:57
12:00	Physics Potential, Accelerator Options, and Experimental Challenges of a TeV-Scale Muon-Ion Collider	*Darin Acosta*	*Club D*	11:57 - 12:15

Time	Title	Speaker	Location	Slot
	Present and approved accelerator facilities	*Sergei Nagaitsev*	*Congress Hall*	12:15 - 12:40
15:00	Panel discussion on Future Colliders	*Florencia Canelli et al.*	*Congress Hall*	14:45 - 16:00
16:00	Future facilities and advances in accelerator technologies	*Rende Steerenberg*	*Congress Hall*	16:00 - 16:25

Highlight from SuperKEKB Beam Commissioning after Upgrading during Long Shutdown 1 (LS1)

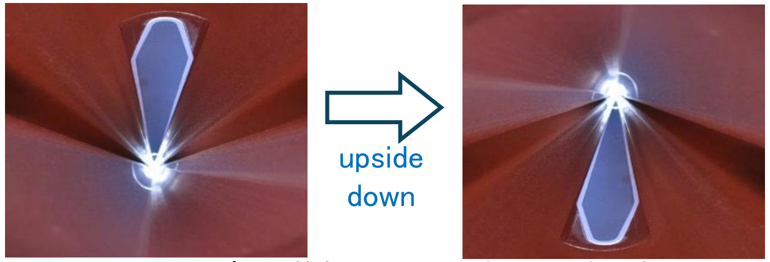
ICHEP 2024

18th July 2024

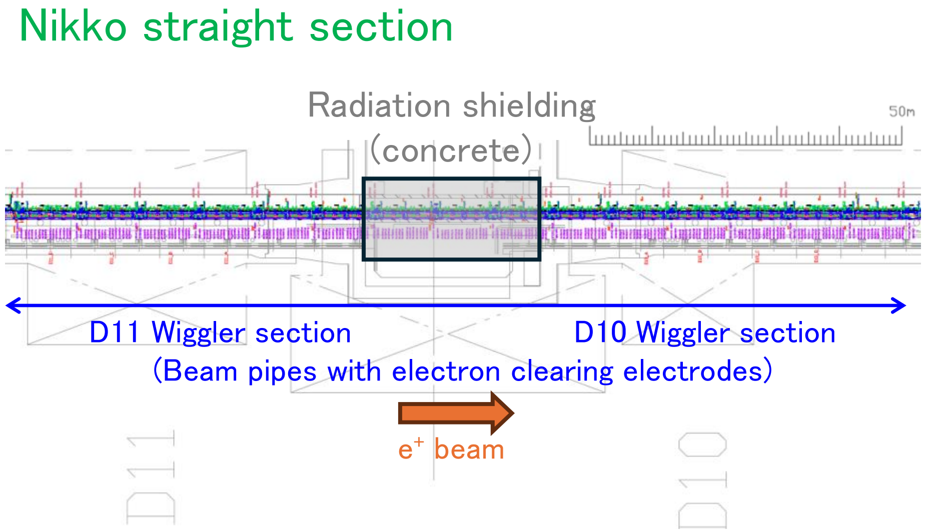
Kyo Shibata (KEK Accel. Lab. & SOKENDAI)

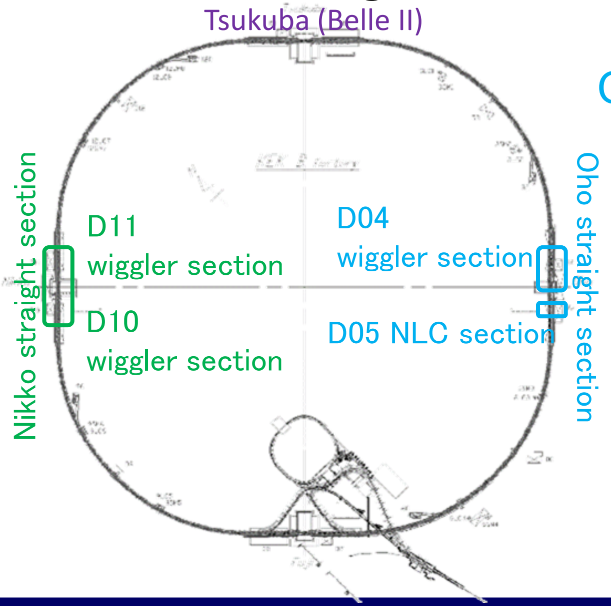
On behalf of the SuperKEKB and Belle II Commissioning Group

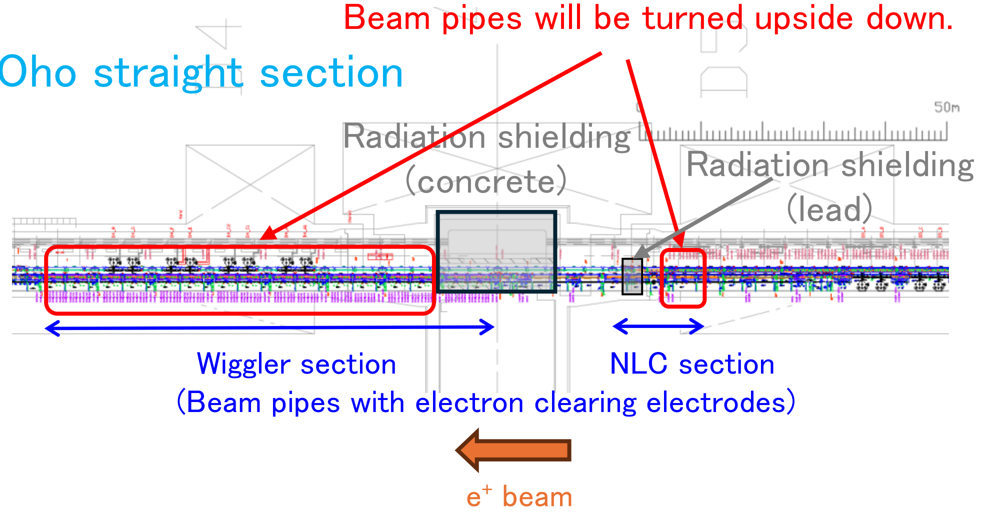
Sudden Beam Loss (SBL) #3



- Countermeasure against SBL during summer shutdown
  - Turning beam pipes with electron clearing electrode upside down
    - 15/50 beam pipes will be turned upside down. (56 m/185 m = 30 %)
    - Oho straight section : 13/16 beam pipes (D04 wiggler section) and 2/4 beam pipes (D05 NLC section) will be turned upside down.
      - It takes over 1 month to turn 13 beam pipes upside down at D04 wiggler section.
    - Nikko straight section : 30 beam pipes at Nikko wiggler section will not be turned upside down.
  - Visual check and dust cleaning of beam pipes which will not be turned upside down.
  - Knocking as many beam pipes (with electron clearing electron or groove structure) as possible.





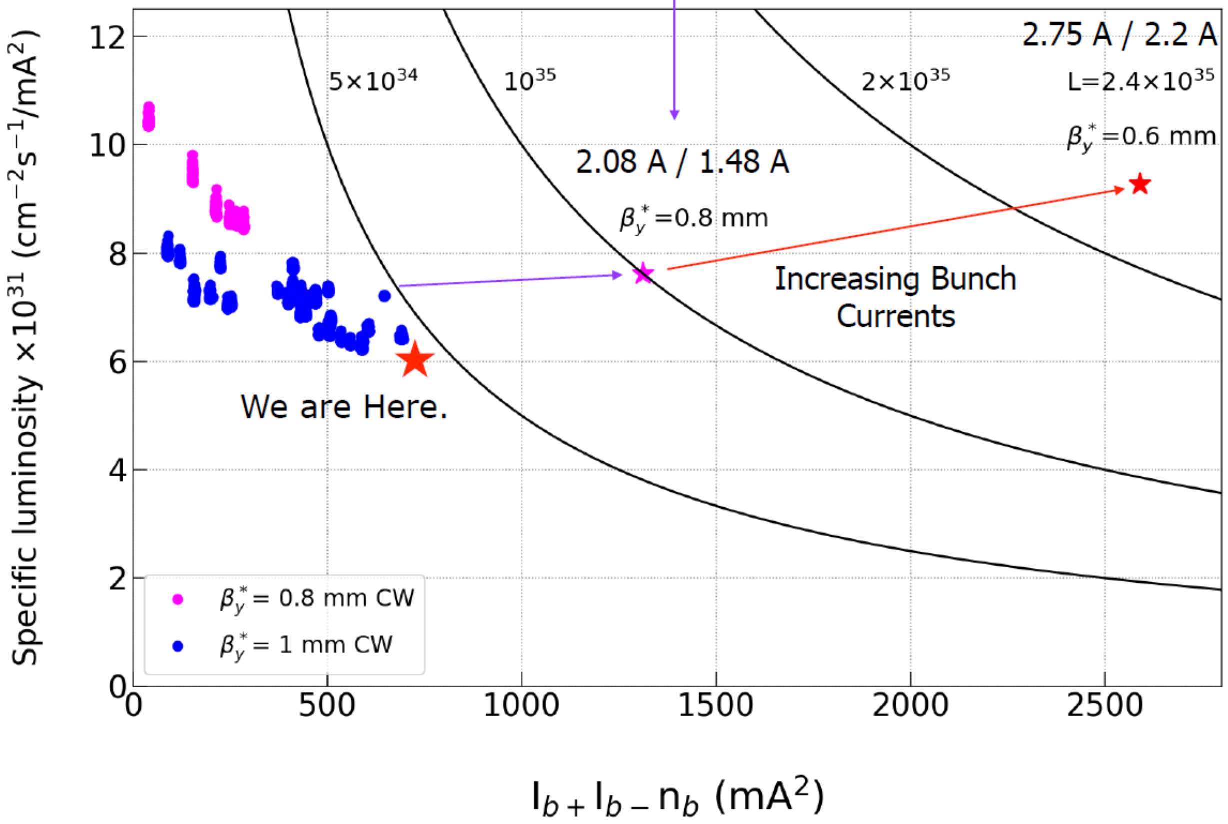


Beyond 10^{35} strategy

Strategy Toward 2.4 x 10^{35} $cm^{-2}s^{-1}$

Y. Ohnishi

$$L_{sp} = \frac{L}{I_{b+} I_{b-} n_b}$$



Summary

- 2024ab run was conducted as scheduled from January 29th to July 1st.
  - First run after Long Shutdown 1
    - NLC system construction, upgrade of HER injection point, etc.
  - Peal luminosity : 4.47×10^{34} $cm^{-2}s^{-1}$
  - Integrated luminosity : 103 fb^{-1}
  - βy^* squeezing : mostly 1.0 mm, finally 0.9 mm
- There are many findings from 2024ab run
  - First demonstration of the effectiveness of the NLC system
  - Improvement of HER injection efficiency at last (30% -> 80%)
  - Still struggle with SBL, but on track to solve it for LER
    - Turning beam pipes with electron clearing electrodes upside down during summer shutdown
  - Also struggle with difficulty to increase beam currents and poor machine stability
- 2024c run will start on October 9th.
  - Operation period : 2 months
    - Extending operation time is difficult due to rising electricity prices.
  - Target luminosity : 1×10^{35} $cm^{-2}s^{-1}$
    - Need to overcome many challenges.

Bando PRIN 2022
e+BOOST
PRIN2022-2022Y87K7X
Funded by
the European Union
NextGenerationEU

A crystal-based positron source for lepton colliders

Prague ICHEP 2024

Nicola Canale

on behalf of F. Alharthi, L. Bandiera, I. Chaikovska , R. Chehab, S. Carsi, D. De Salvador, V. Guidi, V. Haurylavets, G. Lezzani, L. Malagutti, S. Mangiacavalli, P. Monti Guarnieri, A. Mazzolari, V. Mytrochenko, R. Negrello, G. Paternò, M. Prest, M. Romagnoni, A. Selmi, F. Sgarbossa, M. Soldani, A. Sytov, V. Tikhomirov, E. Vallazza

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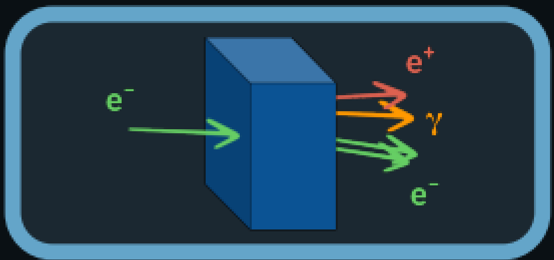
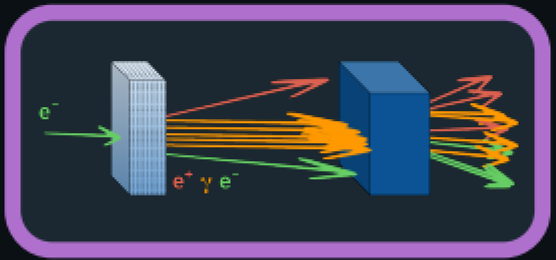
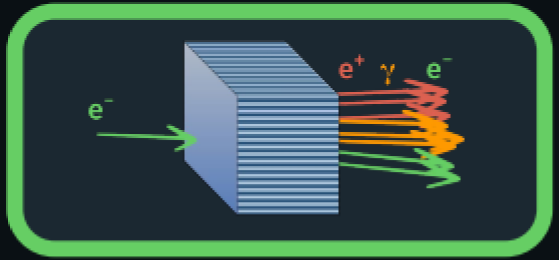
Summary







for 13.5 nC e^+ bunch charge	**Conventional source** *Iryna Chaikovska, FCC Week2024 [2]*	**Hybrid source**	**Single crystal**
e^+ beam energy	6 GeV	6 GeV	6 GeV
e^+ yield @DR	7 N_{e+}/N_{e-}	7.36 N_{e+}/N_{e-} (+5%)	7.87 N_{e+}/N_{e-} (+12%)
Target thickness	17.5 mm (5 X_0)	11.6 + 1.4 mm (~3.7 X_0)	13 mm (~3.7 X_0)
Target deposited Power	1.3 kW	0.88 kW (-32%)	0.89 kW (-31%)
Primary e^- bunch charge	1.93 nC	1.83 nC (-5%)	1.72 nC (-11%)
Target PEDD	6.5 J/g/pulse	6.41 J/g/pulse	6.48 J/g/pulse

The design of a **crystal-based positron source** for the FCC-ee is well-advanced.

NEXT STEPS: **integration studies** and **beam tests** with potential **proof-of-principle** at P^3 experiment @ PSI

Present and approved accelerator facilities

Sergei Nagaitsev

EIC Technical Director
Brookhaven National Laboratory

23 July 2024

Colliders – Important considerations

- Energy
- Luminosity
  - Target density in collider >10 orders of magnitude lower than in fixed target
- Interaction Region design
  - Detector space
  - Experimental background
  - Forward particles
  - …

Also

- Cost
- Reliability
- Flexibility (energy, species for ion colliders)
- Energy efficiency / operating cost
- …

Colliders	Species	E_{cm}, GeV	C, m	$\mathcal{L}$, 10^{32}	Years	Host lab, country
AdA	e^+e^-	0.5	4.1	10^{-7}	1964	Frascati/Orsay
VEP-1	e^-e^-	0.32	2.7	5×10^{-5}	1964-68	Novosibirsk, USSR
CBX	e^-e^-	1.0	11.8	2×10^{-4}	1965-68	Stanford, USA
VEPP-2	e^+e^-	1.34	11.5	4×10^{-4}	1966-70	Novosibirsk, USSR
ACO	e^+e^-	1.08	22	0.001	1967-72	Orsay, France
ADONE	e^+e^-	3.0	105	0.006	1969-93	Frascati, Italy
CEA	e^+e^-	6.0	226	0.8×10^{-4}	1971-73	Cambridge, USA
ISR	pp	62.8	943	1.4	1971-80	CERN
SPEAR	e^+e^-	8.4	234	0.12	1972-90	SLAC, USA
DORIS	e^+e^-	11.2	289	0.33	1973-93	DESY, Germany
VEPP-2M	e^+e^-	1.4	18	0.05	1974-2000	Novosibirsk, USSR
VEPP-3	e^+e^-	3.1	74	2×10^{-5}	1974-75	Novosibirsk, USSR
DCI	e^+e^-	3.6	94.6	0.02	1977-84	Orsay, France
PETRA	e^+e^-	46.8	2304	0.24	1978-86	DESY, Germany
CESR	e^+e^-	12	768	13	1979-2008	Cornell, USA
PEP	e^+e^-	30	2200	0.6	1980-90	SLAC, USA
$Sp\bar{p}S$	$p\bar{p}$	910	6911	0.06	1981-90	CERN
TRISTAN	e^+e^-	64	3018	0.4	1987-95	KEK, Japan
Tevatron	$p\bar{p}$	1960	6283	4.3	1987-2011	Fermilab, USA
SLC	e^+e^-	100	2920	0.025	1989-98	SLAC, USA
LEP	e^+e^-	209.2	26659	1	1989-2000	CERN
HERA	ep	30+920	6336	0.75	1992-2007	DESY, Germany
PEP-II	e^+e^-	3.1+9	2200	120	1999-2008	SLAC, USA
KEKB	e^+e^-	3.5+8.0	3016	210	1999-2010	KEK, Japan
VEPP-4M	e^+e^-	12	366	0.22	1979-	Novosibirsk, Russia
BEPC-I/II	e^+e^-	4.6	238	10	1989-	IHEP, China
DAΦNE	e^+e^-	1.02	98	4.5	1997-	Frascati, Italy
RHIC	p, i	510	3834	2.5	2000-	BNL, USA
LHC	p, i	13600	26659	210	2009-	CERN
VEPP2000	e^+e^-	2.0	24	0.4	2010-	Novosibirsk, Russia
S-KEKB	e^+e^-	7+4	3016	6000*	2018-	KEK, Japan
NICA	p, i	13	503	1*	2024(tbd)	JINR, Russia
EIC	ep	10+275	3834	105*	2032(tbd)	BNL, USA

Present (7) [VEPP-4M to S-KEKB]

Approved [NICA, EIC]

(adapted from [Shiltsev and Zimmermann, 2021]).

Colliders e⁺e⁻ (factories): VEPP-2000, VEPP-4M, BEPC-II, DAΦNE, SuperKEKB

[Reported numbers, not design]

	DAΦNE	VEPP-2000	BEPC-II	VEPP-4M	SuperKEKB
Start of operation [year]	1999	2010	2008	1994	2018
Species	e^+e^-	e^+e^-	e^+e^-	e^+e^-	e^+e^-
Circumference [m]	97	24	238	366	3016
Beam energy [GeV]	0.51	1	1.89 (2.474 max)	6	4 / 7
CoM energy [GeV]	1.02	2	3.78 (5.56 max)	12	10.58
Average beam current [mA]	800 / 1250	160	851	80	1400 / 1000
Peak luminosity [10^{30} $cm^{-2}s^{-1}$]	453	50	1000	20	3810
Focus	Φ meson	u,d,s interactions	tau-charm	Υ(1S) meson	B meson

Brookhaven National Laboratory

[PDG, Tables 32.1, 32.3;
Q. Qin, "Overview of the low energy colliders", proceedings eeFACT2016, Daresbury (2016)]

Colliders e+e-

Ongoing discussion concerning DAFNE's future:

In the next future DAFNE might be used for short periods, 4-5 months per year.

DAFNE Synchrotron Light Facility could be also operated.

DAFNE LINAC will continue to power two **Beam Test Facility lines.**

This plan requires a minimal refurbishment of the accelerator complex that can also be implemented progressively

Maintaining DAFNE infrastructure operative could be also very much synergic with Future CERN developments in the lepton colliders field.

Status and upgrade of BEPC-II discussion:

Increase luminosity by factor 3 and energy up to 2.8 GeV.

Requires: double beam power, optics upgrade and new high field magnets. Commissioning planned for January 2025.

Parameters	Design	Achieved	
		BER	BPR
Beam energy (GeV)	1.0-2.1, 1.89	0.92-2.47, 1.89	0.92-2.47, 1.89
Beam current (mA)	910	950	950
Bunch number	93	118	118
Beam-beam parameter	0.04	0.041	
β_x^*/β_y^* (m)	1.0/0.015	1.0/0.0135	1.0/0.0135
Lum. ($\times 10^{33}$cm^{-2}s^{-1})	1.0	1.1	

BEPC parameters

SuperKEKB:

During Long Shutdown 1: Improvements of the Belle II detector and the SuperKEKB accelerator.

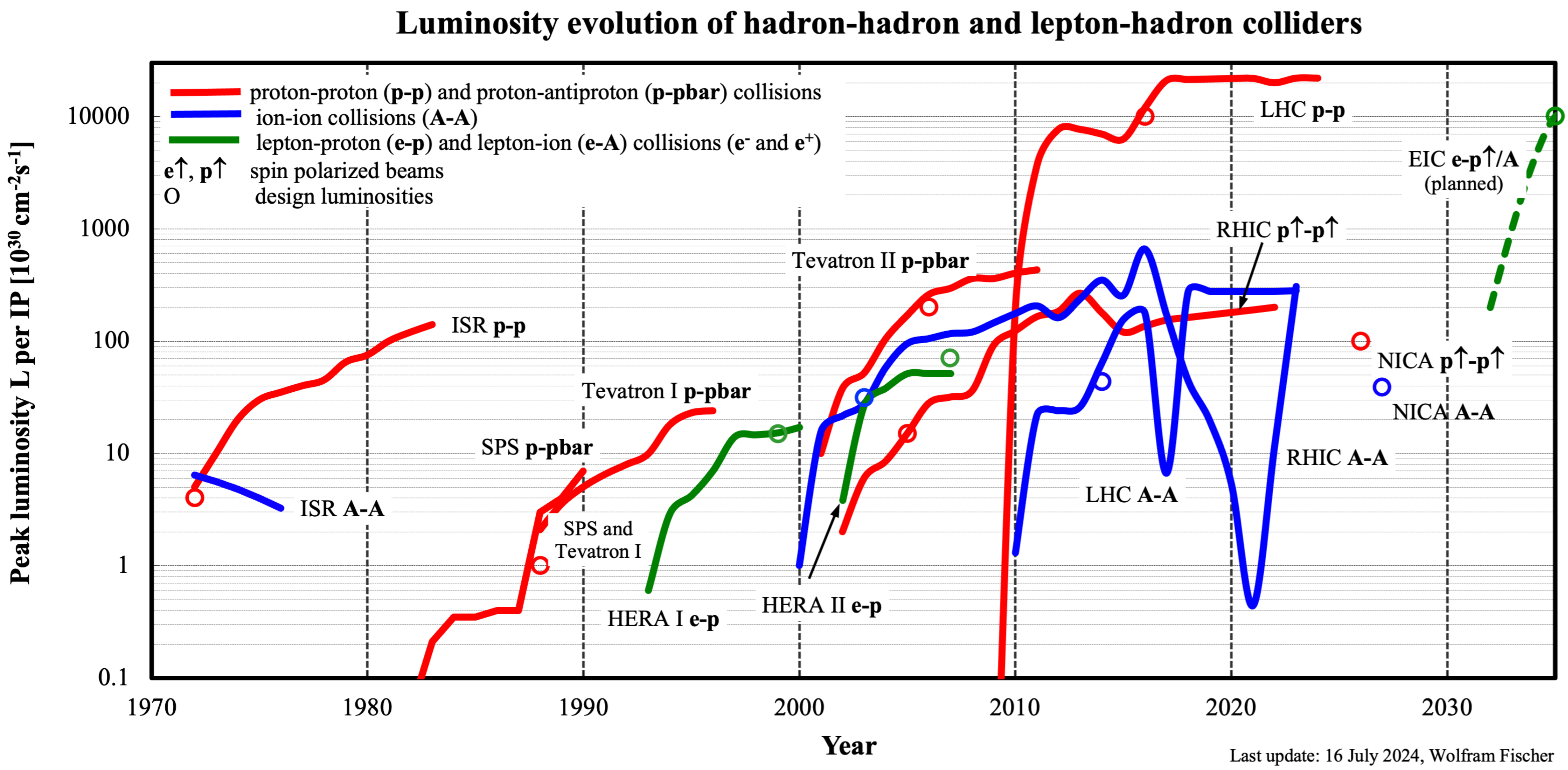
Countermeasures to sudden beam loss should be implemented during summer maintenance period.

Target luminosity is 1x10^{35} cm^{-2}s^{-1} for this year.

Colliders hh and eh: RHIC, LHC, EIC, NICA

Nuclotron-based Ion Collider fAcility

	RHIC **pp** (actual)	**LHC** **pp** (actual)	**RHIC** **AA** (actual)	**LHC** **AA** (actual)	**EIC** **ep, eA** (design)	**NICA** **pp, dd, AA**
Start of operation [year]	2001	2009	2000	2010	2032 (planned)	2025 (planned)
Species	p↑+p↑ (polarized p)	p+p	p↑+Al, p↑+Au, d+Au, h+Au, O+O, Cu+Cu, Cu+Au, Zr+Zr, Ru+Ru, Au+Au, U+U	Pb+Pb, p+Pb, Xe+Xe	e↑+p↑ to e↑+U (polarized e,p, He-3)	p↑ d↑ A
Circumference [km]	3.8	26.7	3.8	26.7	3.8	0.5
Beam energy [GeV]	255	6500	100 A	2560 A	5-18 / 40-275	1 – 4.5
CoM energy [GeV]	510	13000	200 A	5120 A	28-140 (e↑+p↑)	4 – 11
Average beam current [mA]	257	510	224 (Au+Au)	24 (Pb+Pb)	2500 / 1000	
Peak luminosity [10^{30} $cm^{-2}s^{-1}$]	245	2100	0.015 (Au+Au)	0.006 (Pb+Pb)	10000 (e↑+p↑)	
Spin polarization	55-60%	0	0	0	70% e,p,h	



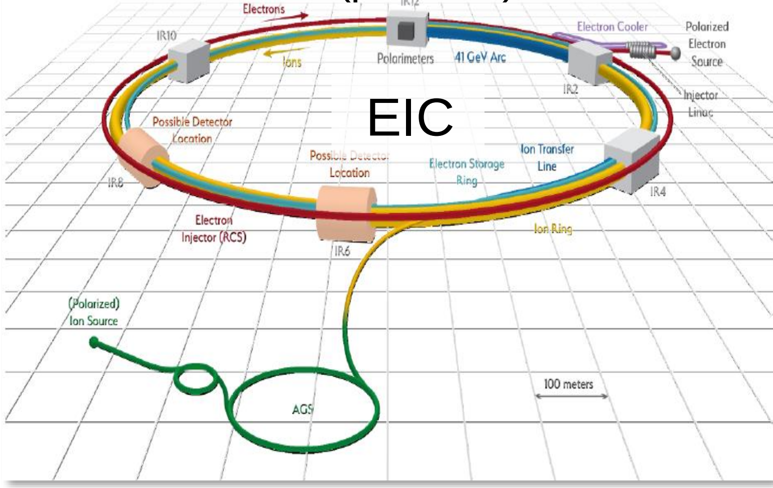
variations in AA luminosity
due to energy/species

Brookhaven National Laboratory

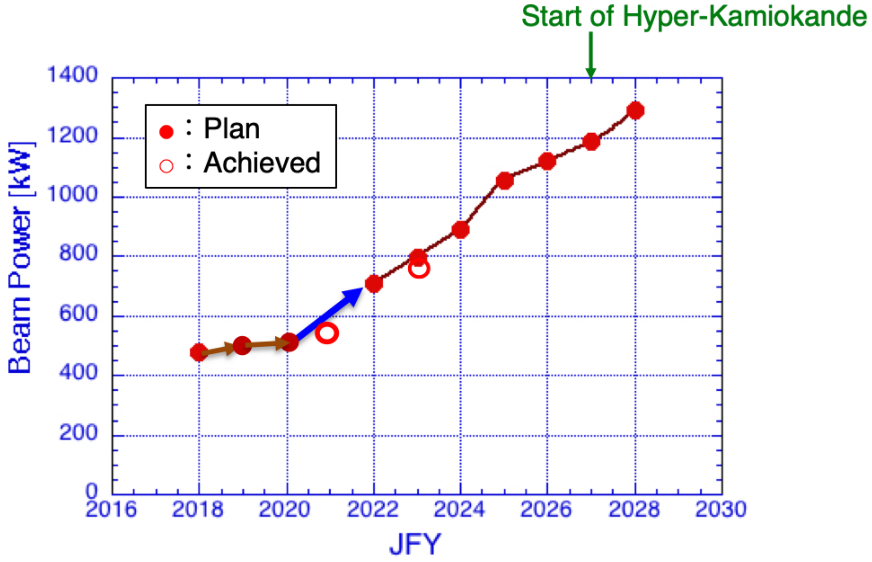
Summary – present accelerators and approved facilities

- Present colliders: 5x e^+e^- and 2x hh
  - Low-energy colliders are technology test beds (beam-beam compensation, crab crossing, beam cooling, collimation, …)
  - SuperKEKB (very high *L*) prototype for future e^+e^- colliders, EIC
  - hh colliders – increasing flexibility (energy, species)
- Colliders under construction:
  - BNL Electron-Ion Collider: ~100x HERA luminosity, polarized e,p,He-3 and heavy ions
  - NICA

BNL EIC project – working towards baseline collisions 2032 (planned)



- Present high-intensity machines
  - >1 MW beam power available, ν beams drive increases
  - Synergies with other applications: spallation neutron sources, nuclear physics, Accelerator Driven Systems (ADS)
- Present high-intensity projects:
  - FNAL PIP-II goal: 1.2 MW
  - J-PARC MR goal: 1.3 MW



Future facilities and advances in accelerator technologies

Rende Steerenberg – CERN

With thanks to Mike Lamont and all others from who I ‘borrowed’ material

23 July 2024

Possible future main facilities

Foreseen to start operations within the time frame until 2045:

- **EiC (approved)**
- **FCC-ee**
- **ILC/CLIC**
- **CEPC**
- **CCC**

Beyond 2045:

- **FCC-hh**
- **Muon Collider**
- **SppC**

Other ideas were also presented and discussed at ICHEP-2024:

- Energy Recovery Linac (ERL) based facilities (LHeC, FCC-eh, etc.)
- PERLE and bERLinPro, pathfinders for future ERL based colliders
- Wakefield-acceleration-based muon facility
- Hybrid Asymmetric Linear Higgs Factory (HALHF) partially based on Wakefield acceleration
- Tau-Charm facility in China
- Compact Electron Linacs for Research, Medical, and Industrial Applications

Summary of Rende's slides

- Mostly presented FCC integrated program (ee + hh),
- and the following key technologies:
  - SRF technology R&D, highlighting the new SRF facility at CERN (mid 2029)
  - High field magnet NbTi → Nb_3Sn → HTS, FCC-hh requires higher temperature magnets, current LHC dipoles at 1.8K in FCC would lead to 4TWh, 4 times CERN electric consumption!
  - Briefly covered muon collider as the magnets should have high gradients and survive `high' heat load (5-10kW) and high radiation dose (20-40MGy)

How to further optimise SRF?

Increasing the accelerating gradient

- Reduction in number of cavities, less space required, reduced cryogenic power, reduced RF power distribution,…

Increasing the quality factor Q

- Less power deposited, reduction of cryogenic needs hence reduction in electricity consumption

Using higher temperature superconducting materials

- Could allow RF cavities to run at 4.5K instead of 1.9K as used for high performance Nb cavities – reduced cryogenic needs

Thin film SRF technology offers a pathway to enhance performance and cost-effectiveness

- Substantial R&D required and ongoing.

A new superconducting RF facility at CERN

Purpose:

- R&D on single and multi-layer thin film coated and bulk superconducting cavities
- R&D on higher temperature superconducting cavity materials
- Prototyping and pre-series for FCC-ee
- R&D on the process to maximise throughput, reproducibility and minimise resources

Goal:

- Limit the operational cost of new large projects
- Reduce capital investment in SRF systems

Start operation mid-2029

Concluding Remarks

Multiple, competitive, complementary, and challenging design studies for future facilities are being undertaken

- *The FCC feasibility study will conclude in March 2025, followed by a resource loaded pre-TDR phase*
- *The ESPPU process has been launched and will conclude in 2026, providing direction*

Each generation of facilities pushes the boundaries of technology

- *This requires substantial R&D and collaboration in various key domains*
- *New technological developments can enhance societal well-being and drive economic economic growth*

Studies of future facilities provide a fertile ground for developing new technologies, while currently operational facilities serve as test-beds for these innovations.

- *The HL-LHC will contain with Nb3Sn superconducting magnets, experienced gained will feedback into the R&D*

No new facility can be considered if sustainability is not fully embedded in the design process

Panel discussion on future colliders