New Accelerator Projects

J.P.Delahaye/CERN

Focusing on High Energy Colliders (> 10 GeV!)

Not covering nuclear physics, photon science, LBL neutrinos,…

Apologies to ESS, FAIR, XFEL, etc…..

Thanks to the (many) experts who kindly provided me (consciously or not) with updated information and slides:

R.Aleksan, B.Barish, R.Bailey, M.Biagini, O.Boine-Frankenheim, O.Bruning, E.Colby, W.Fischer, B.Foster, M.Harrison, S.Holmes, R.Garoby, M.Giorgi, G.Hanson, M.Izawaki, J.Jowett, M.Klein, JP.Koutchouk, P.Lebrun, V.Litvinenko, K.Long, M.Masuzawa, T.Roser, L.Rossi, D.Schulte, G.Trubnikov, B.Tschirhardt, K.Yokoya, A.Wagner, F.Zimmermann,

Taking advantage of (but not summarising)
Session 14 (24/07/10) "Future Machines and Projects"

Co-chairs: K.INSOO, M.SHOCHET, S.STAPNES

B.BARISH: The Global Design Effort for the International Linear Collider

B.FOSTER: Governance of the International Linear Collider Project

D.SCHULTE: CLIC Progress and Status

E.COLBY: Present Limits and Future Prospects for Dielectric Acceleration

P.KOOIJMAN: Status of KM3NeT

M.GIORGI: The SuperB Project

M.IWASAKI: The SuperKEKB accelerator status

G.TRUBNIKOV: The heavy ion collider project NICA/MPD at JINR/Dubna

M.KLEIN: The Large Hadron Electron Collider (LHeC) Project

B.TSCHIRHART: Project-X at Fermilab

K.LONG: The International Design Study for the Neutrino Factory

G.HANSON: The Research and Development Program towards an Energy-Frontier Muon Collider

R.BAILEY: LHC machine upgrades

Conclusion: Personal Remarks

- Large number of ambitious accelerator projects with promising performances in the near (and short term) future
  - Towards energy and/or luminosity frontiers
  - Complementary aspects of various particles species
- High Energy Physics requirements extremely demanding with challenging parameters
  - Entering into the new territories: TERASCALE
  - High Energy or/and High (Integrated) Luminosity
  - High performance, high availability, long lifetime, luminosity leveling….

Creative and Strong R&D

New projects more and more challenging:

- Larger, more powerful, more expensive not an option
- Technology above present standard

Innovative ideas and breakthrough on novel technologies = key for HEP adventure

- Innovation and imagination = a MUST!
- Previous presentation

Aggressive R&D imperative

- Beam and Technology related
- Cost and power consumption mitigation
- Ambitious Test Facilities to address feasibility

Global Collaborations

- More and more time and (M&P) resources required from first ideas to project proposal
  - Launch R&D early,
  - Explore ALL possible options of schemes and technologies (anticipating future Physics requests)
  - Realistic status & schedule estimates:

    preserve credibility & make reasonable plans
- Global Collaboration mandatory from the R&D phase to construction and operation
  - Best use of limited resources & available expertise
  - Inspired from successful collaborations on Detectors

Plea for a Global Coordination (initiated by ICFA)

Global strategy of new accelerator projects in truly world-wide collaboration:

- Defining all various Projects and Technology options worth exploring
- Global teams made of world-wide experts taking advantage of synergies to address common issues (generic R&D) of various projects
- Preparing together plethora of project proposals to cover Physics Landscape: ready for window opportunity
- Collaborative/Competition: Experts in Collaboration, Technology & Projects options in Competition
- Joining resources on (few) selected projects

Conclusion

Future HEP Projects (beyond LHC) will be:

GLOBAL!

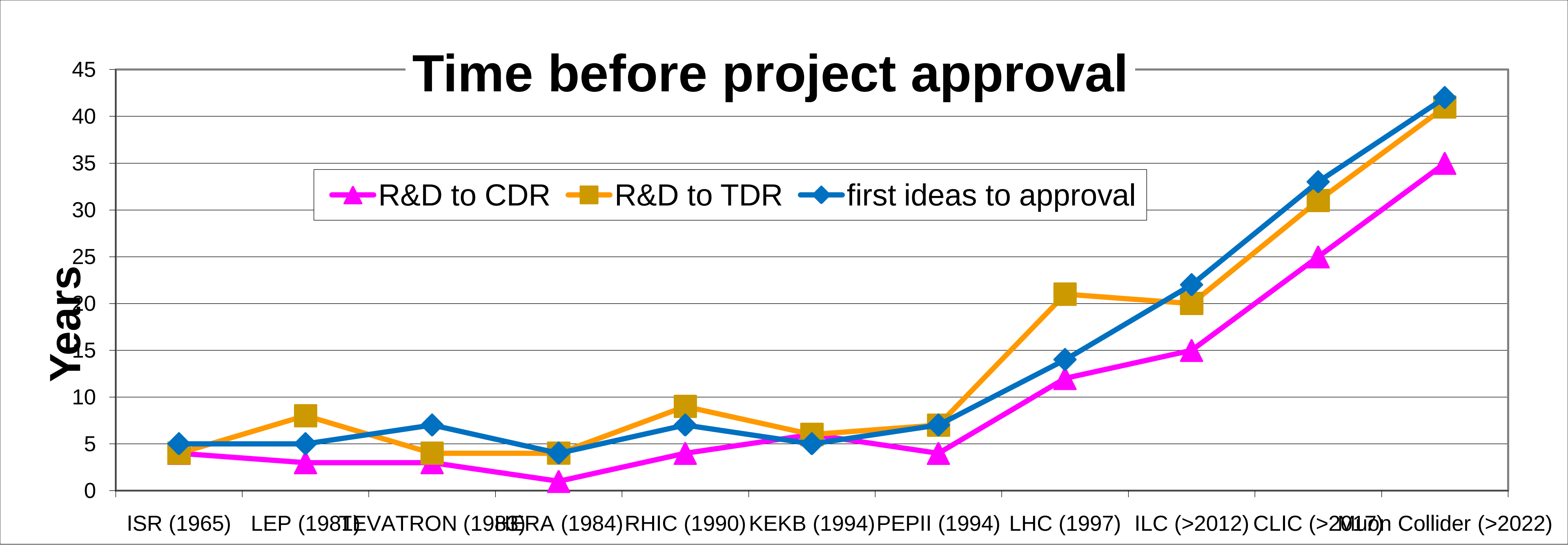
Collaborations!

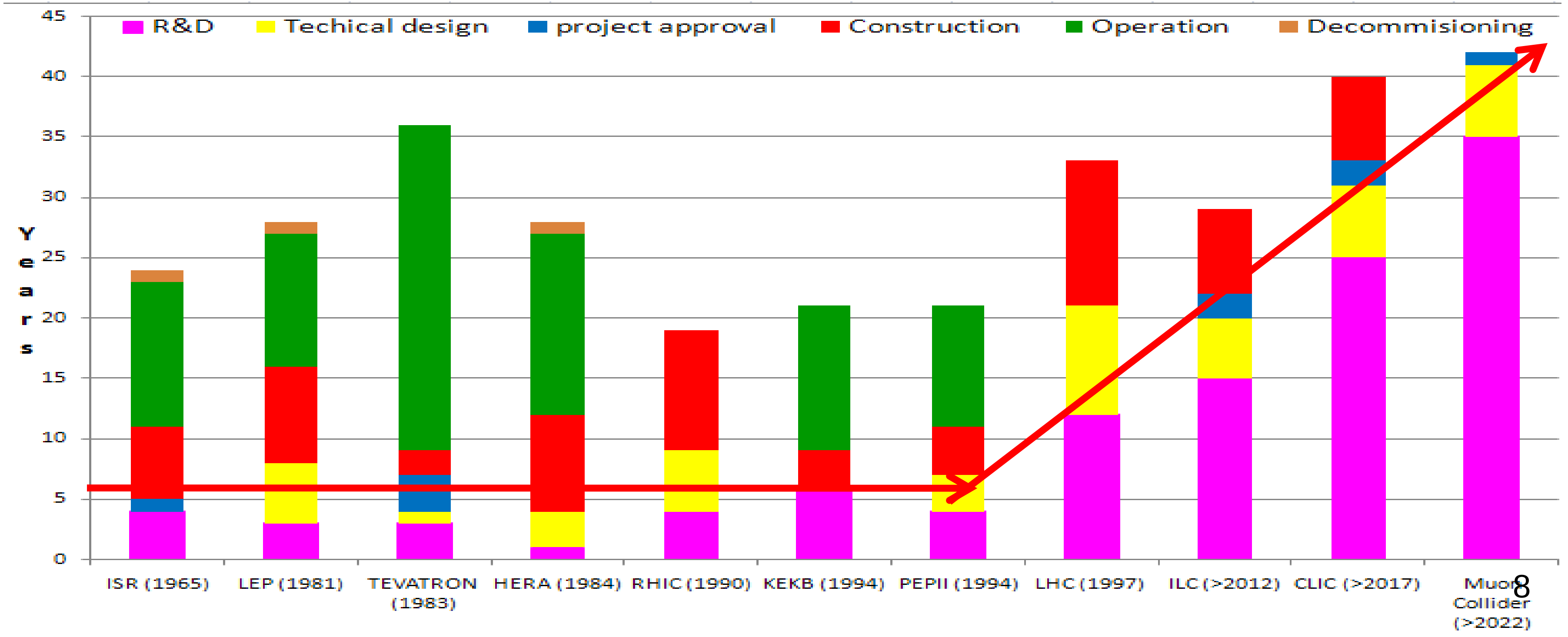
Innovative ideas and technology breakthroughs

R&D, R&D , R&D

Globally Coordinated Strategy

or will not be!

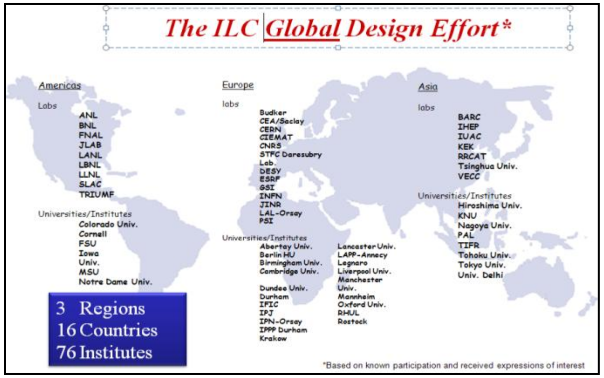

Time before project approval
Years
R&D to CDR
R&D to TDR
first ideas to approval
45
40
35
30
25
20
15
10
5
0
ISR (1965)
LEP (1981)
TEVATRON (1983)
HERA (1984)
RHIC (1990)
KEKB (1994)
PEPII (1994)
LHC (1997)
ILC (>2012)
CLIC (>2017)
Muon Collider (>2022)

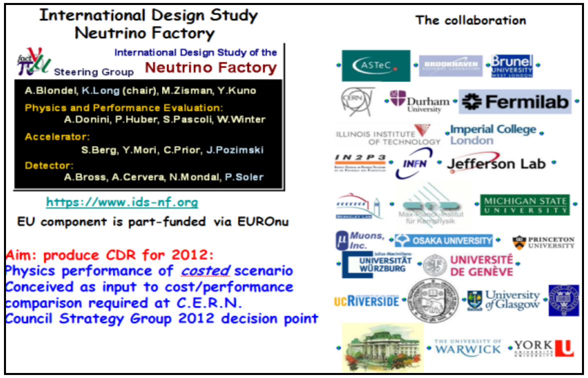

R&D
Techical design
project approval
Construction
Operation
Decommisioning
Years
45
40
35
30
25
20
15
10
5
0
ISR (1965)
LEP (1981)
TEVATRON (1983)
HERA (1984)
RHIC (1990)
KEKB (1994)
PEPII (1994)
LHC (1997)
ILC (>2012)
CLIC (>2017)
Muon Collider (>2022)

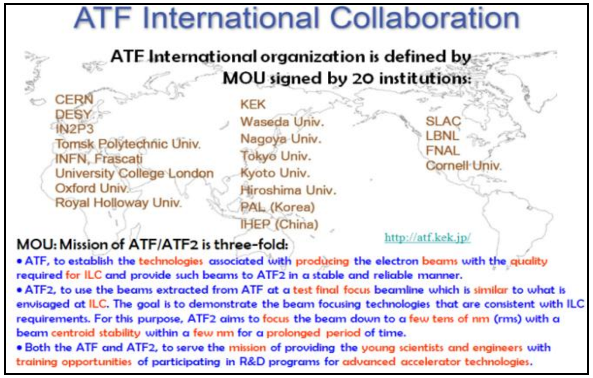
Synergies between projects: Generic R&D

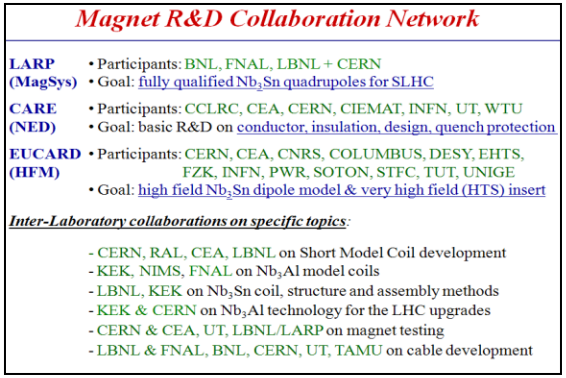
R&D/Projects		Test Facilities	Protons			Ions			Electron-Hadrons			B Factories		Linear Colliders				Muons & Neutrinos		
			HL-LHC	HE-LHC	LHiC	NICA	RHIC II	FAIR	LHeC	eRHIC	ELIC	Super KEKB	SuperB	ILC	CLIC	PFWA LWFA	Dielec-tric Acc	Muon Collider	Neutrin Factory	Project X
	Coordination		CERN	CERN	CERN	DUBNA	BNL	GSI	CERN	BNL	JLAB	KEK	LNF	GDE	CLIC coll	SLAC/LBl	SLAC?	MAP	NF Coll	FNAL
Electron cloud	Cornell?	CESR-TA	X	X		X	X		X	X		X	X	X	X					X
SC magnets (High Field, Fast Cycling, Super-Ferric, Wigglers)	Magnet R&D network?	CERN, FNAL, GSI	HF	HF/FC	HF	SF		FC				HF	HF		W					
Super-Conducting RF	TESLA Tech coll	FLASH, NML, STF, XFEL					X		X	X		X		X				X		X
High field NC Structures	?	CTF3, SLAC, KEK													X				X	
Low emittance generation	CLIC/ILC WG?	ATF1										X	X	X	X	X	X			
Nanometer beam focusing	ATF coll	ATF2	X									X	X	X	X	X	X			
Alignment and stabilisation	?	AlignTF, StabTF					X		X	X	X	X	X		X	X	X			
RF power source high efficiency	?		X	X	X									X	X			X		X
High beam power generation&handling	?	SNS, PSI	X	X								X	X	X	X	X	X	X	X	X
Collimation & targets high power beams	?	HRad,HARP,MERIT	X	X	X							X	X	X	X			X	X	X
Cooling (Electron, Coherent, Stochastic)	?	RHIC				S,E	S		C	C	E									
Ionisation cooling	?	MICE,MTA, MuCool																X	X	
crab cavities	?	KEKB	X						X	X	X			X	X					
Plasmas	LBL, SLAC	BELLA, FACET														X				
Lasers	LBL, Ec. Polyt	BELLA, LULI												X	X	X	X			
Drive beam generation	CTF3 collab	CTF3, FACET													X	X	X			
Beam dynamics simuations	?	Test benches	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Beam Instrumentation	?		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Beam based feedbacks	?					X	X			X	X	X	X	X	X					
Energy recovery linacs	CEBAF?	CEBAF, BNL R&D ERL							X	X	X									
Nanobeam scheme (LPA & Crab waist)	B Fact collab?	DAFNE	X									X	X							
Positron generation	?									X	X	X	X	X	X					
Polarisation	?					X	X		X	X	X		X	X	X					
Dynamic vacuum	?			X	X	X	X			X	X	X	X		X					

Global Collaborations (Examples of)









European Commission supported Coordination of Accelerator R&D

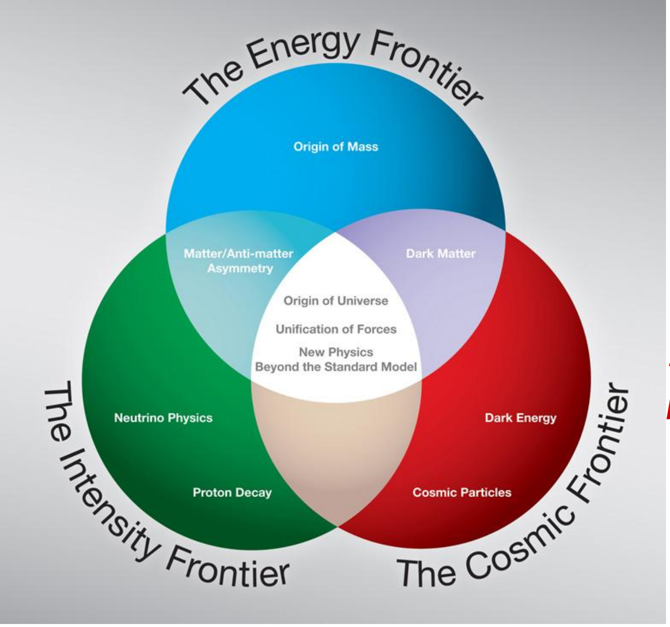
SEVENTH FRAMEWORK PROGRAMME

Tiara

coordination & support of European distributed R&D Infrastructure and joint R&D programme

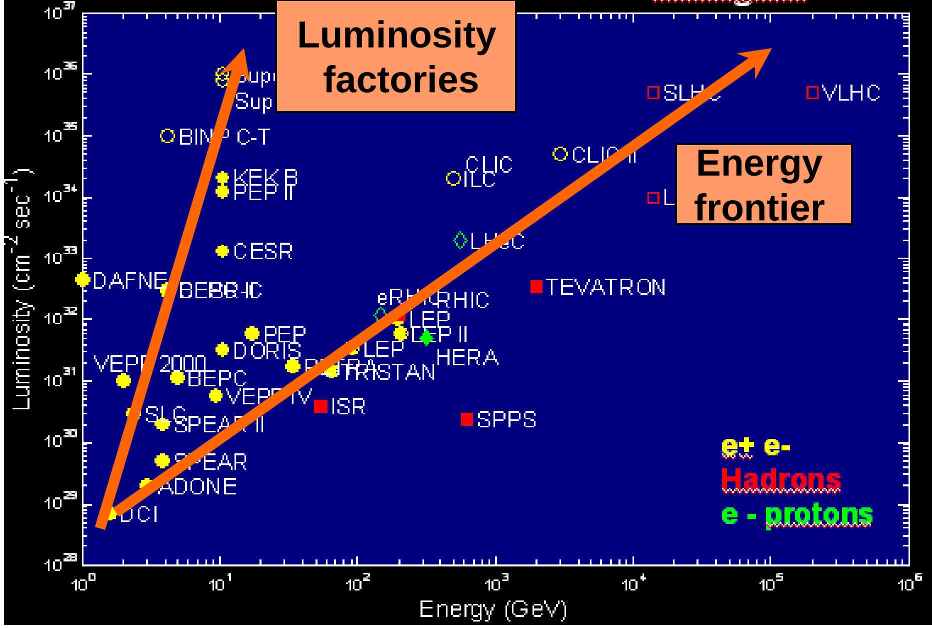
Starting end 2010: http://www.eu-tiara.eu

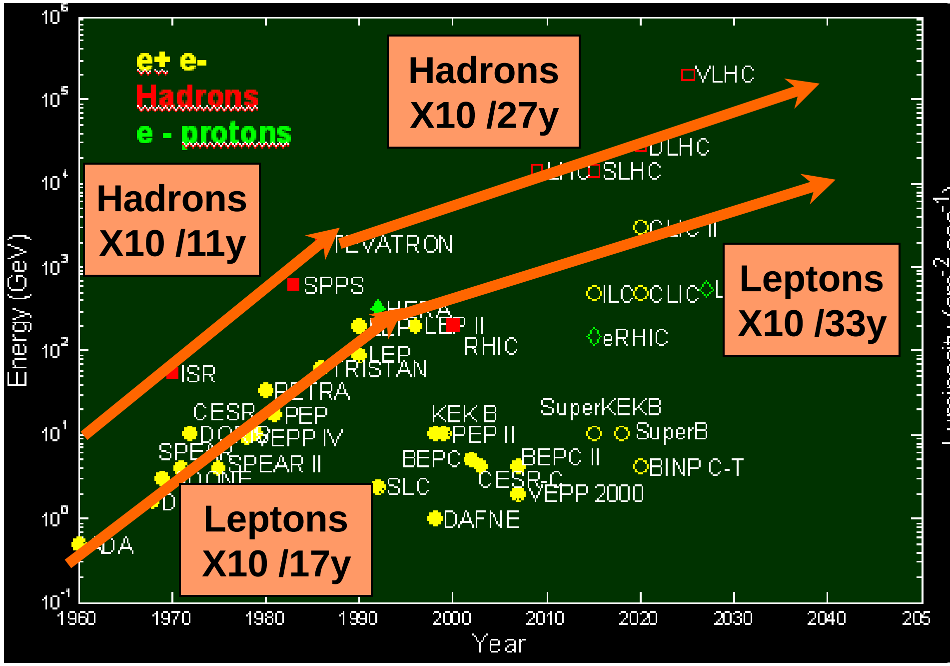
Integrated Activity:EUCARD *http://eucard.web.cern.ch/EuCARD/*

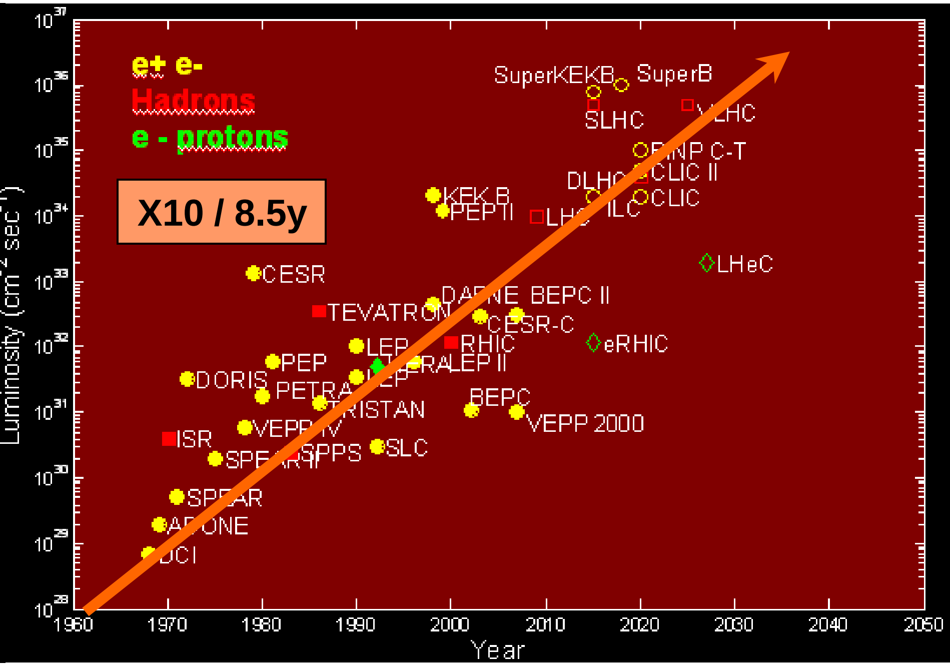


Trends of HEP facilities

Courtesy of M.Biscari EPS-HEP09







Towards Energy frontier

Towards Luminosity frontier

Complementary facilities of various particle species

Hadrons/Hadrons

Species	Present	Future
Protons	TEVATRON	LHC HL-LHC VL-LHC
Ions	RHIC	RHIC II LHiC

Leptons/Leptons

Frontier	Present	Future
Energy	~~LEP~~	ILC CLIC Muon Collider
Lumin	KEKB ~~PEPII~~	SuperKEK SuperB

New Physics

Hadrons/Leptons

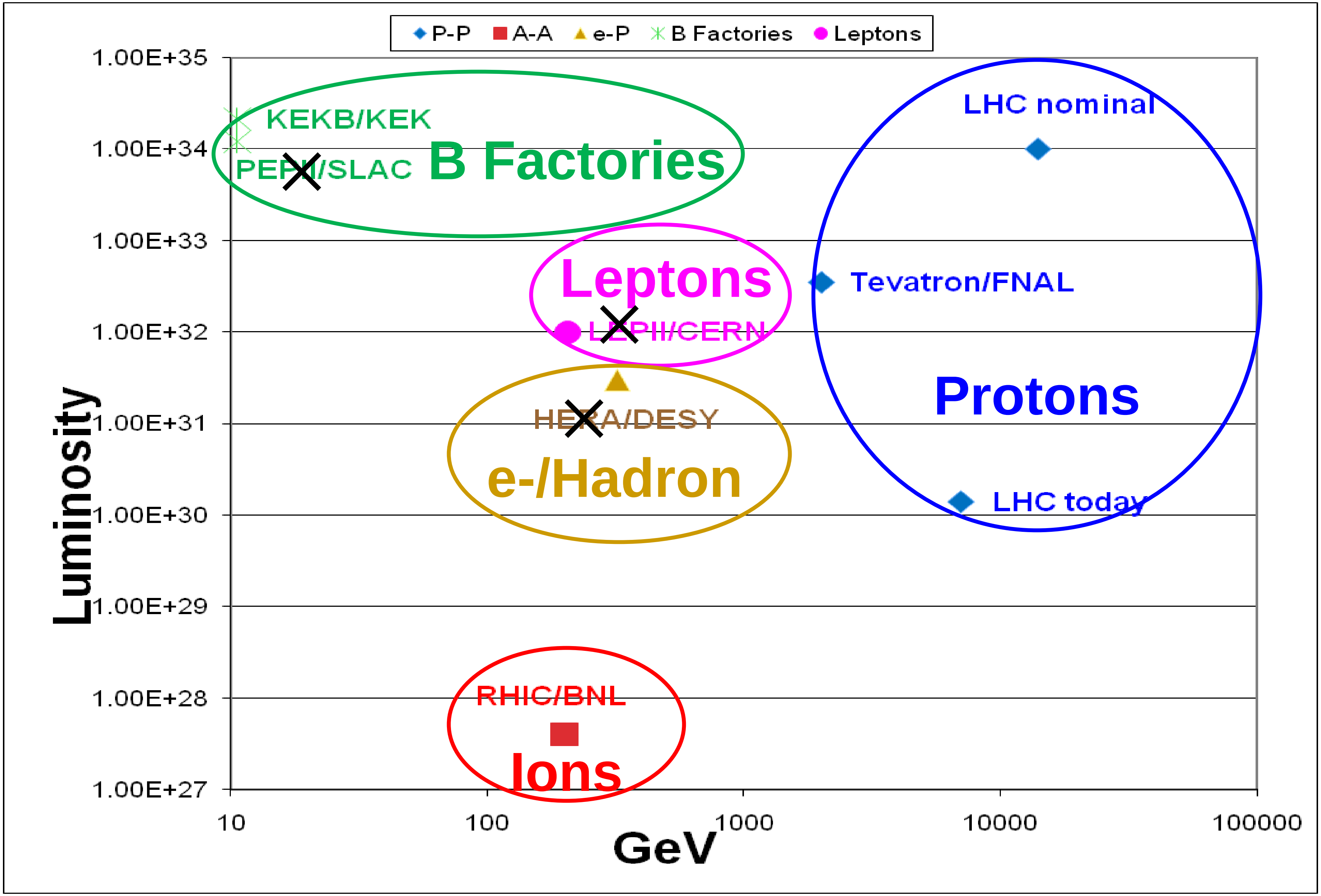
Species	Present	Future
Energy	~~HERA~~	LHeC
Lumin.		ELIC ERHIC

Neutrinos

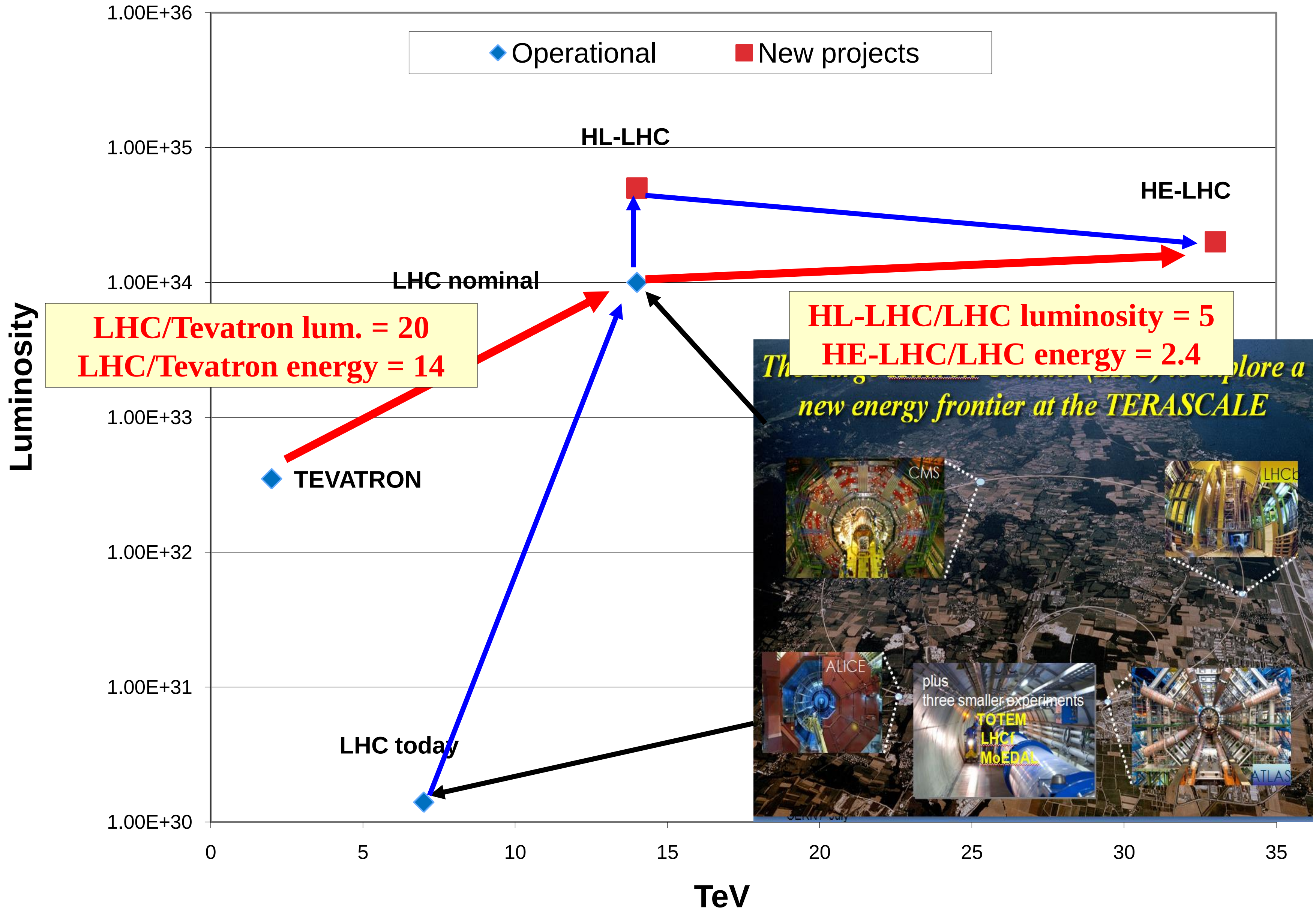
Present	Future
Super- Kamiokande MINOS CNGS	LBNE/Project X Neutrino Factory

12

Present HEP colliders at Energy/Luminosity frontiers



Proton Colliders @ High Energy Frontier

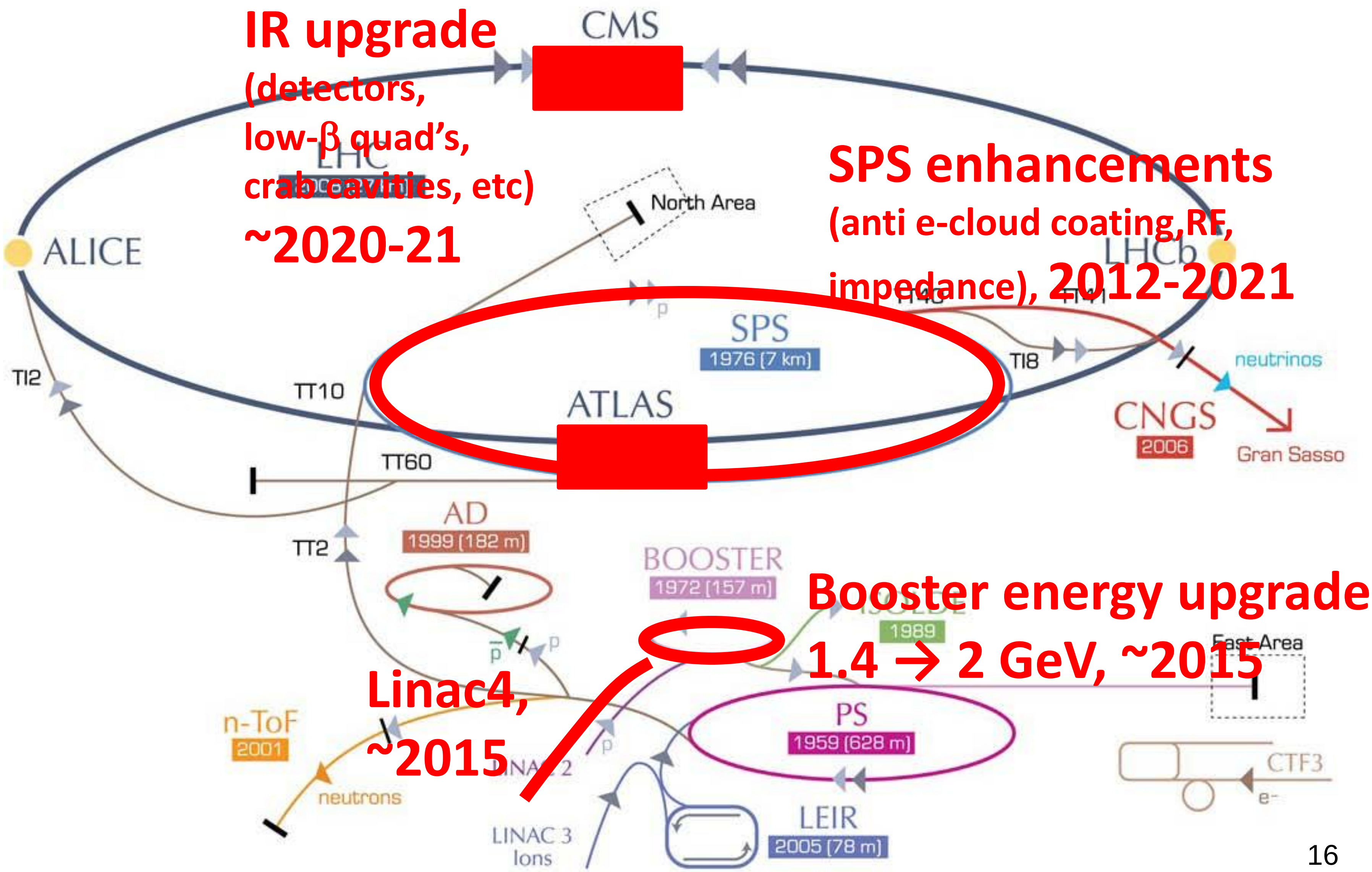


LHC parameters evolution

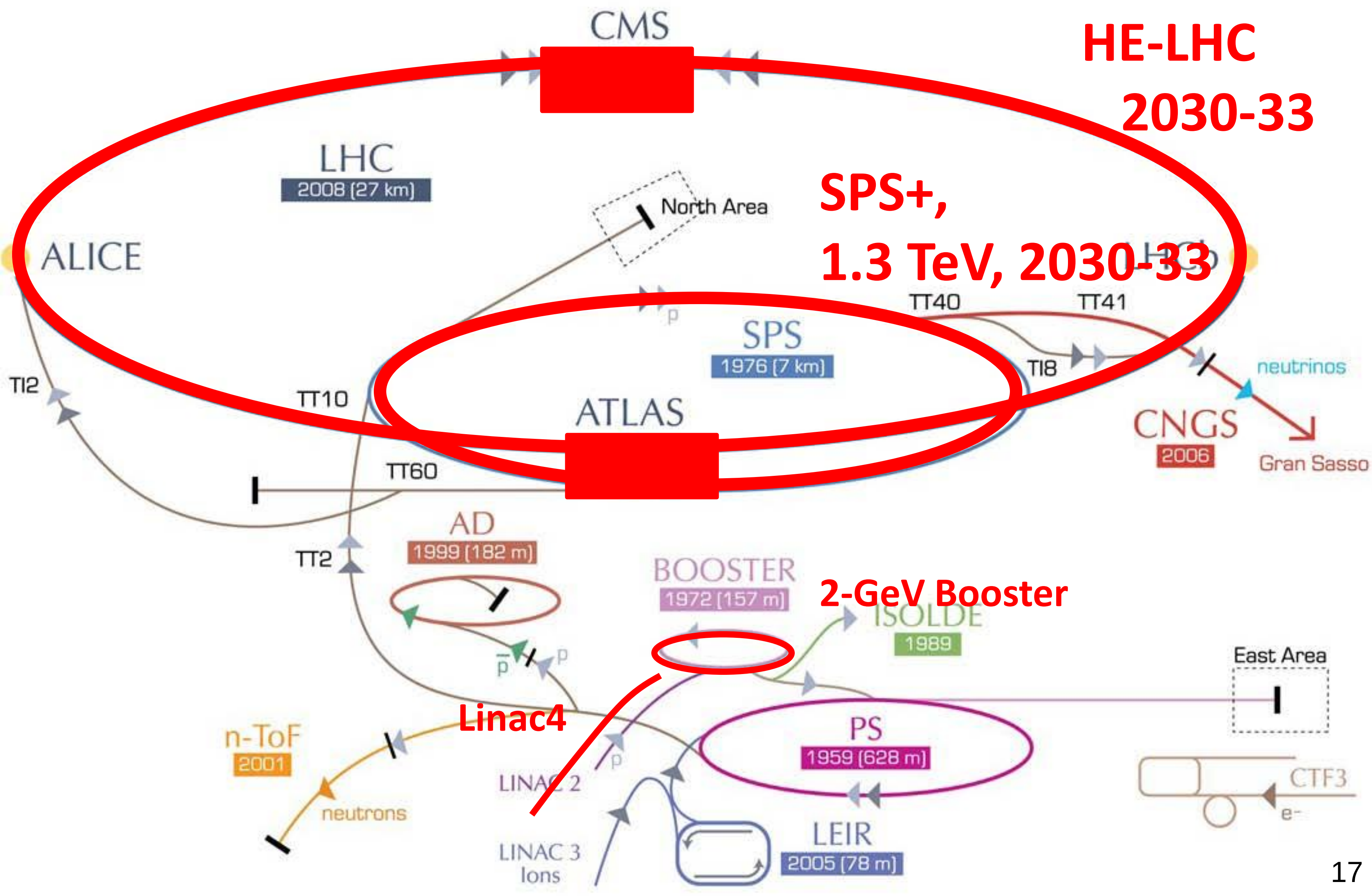
Nominal *High-Luminosity* *High-Energy*

	LHC	HL-LHC	HE-LHC
Collision energy [TeV]	14	14	33
Peak/leveled luminosity [10^{34} cm^{-2}s^{-1}]	1.0	7.9/5.0	2.0/2.0
integrated luminosity per year (1900h) [fb^{-1}]	57	250	100
events per crossing	19	150	76
# bunches / beam	2808	2808	1404
bunch population [10^{11}]	1.15	1.7	1.29
Beam current [A]	0.58	0.86	0.32
Luminosity leveling	no	θ_c , V_{crab} or β^*	$\varepsilon_{x,y}$
initial transverse normalized emittance [μm]	3.75	3.75	3.75 (x),1.84 (y)
number of IPs contributing to tune shift	3	3	2
maximum total beam-beam tune shift	0.01	0.01	0.01
IP beta function [m]	0.55	0.14	1.0 (x), 0.43 (y)
full crossing angle [μrad]	285 (9.5 $\sigma_{x,y}$)	0 (509)	175 (12 σ_{x0})
dipole field [T]	8.33	8.33	20
dipole coil aperture [mm]	56	56	40-45
stored beam energy [MJ]	362	504	479
SR power per ring [kW]	3.6	5	62.3
longitudinal SR emittance damping time [h]	12.9	12.9	0.98
luminosity lifetime [h]	23	4	13

HL-LHC – LHC modifications



HE-LHC – LHC modifications



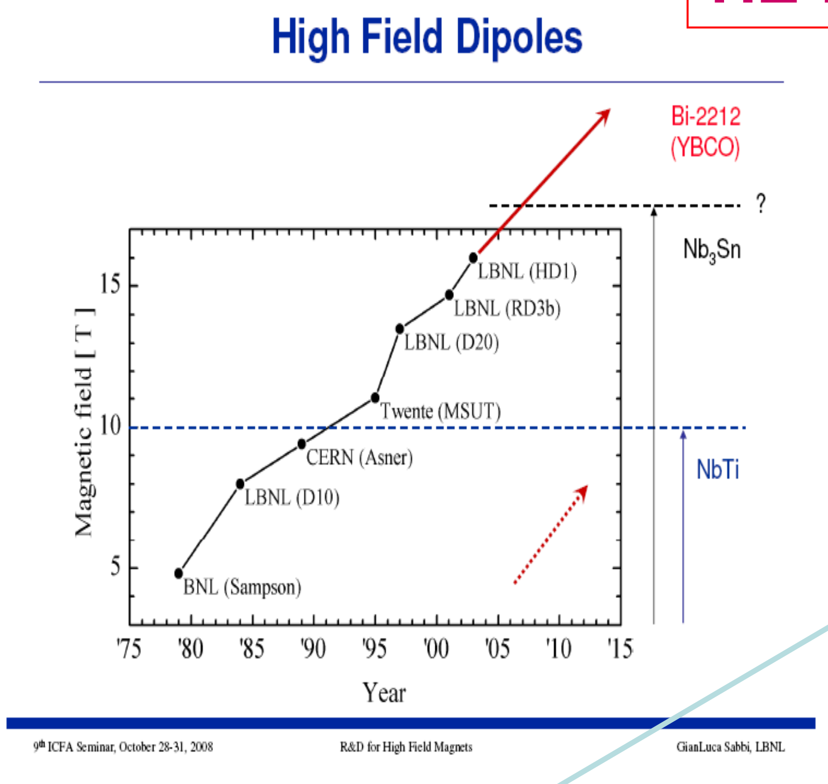
LHC upgrade issues and R&D

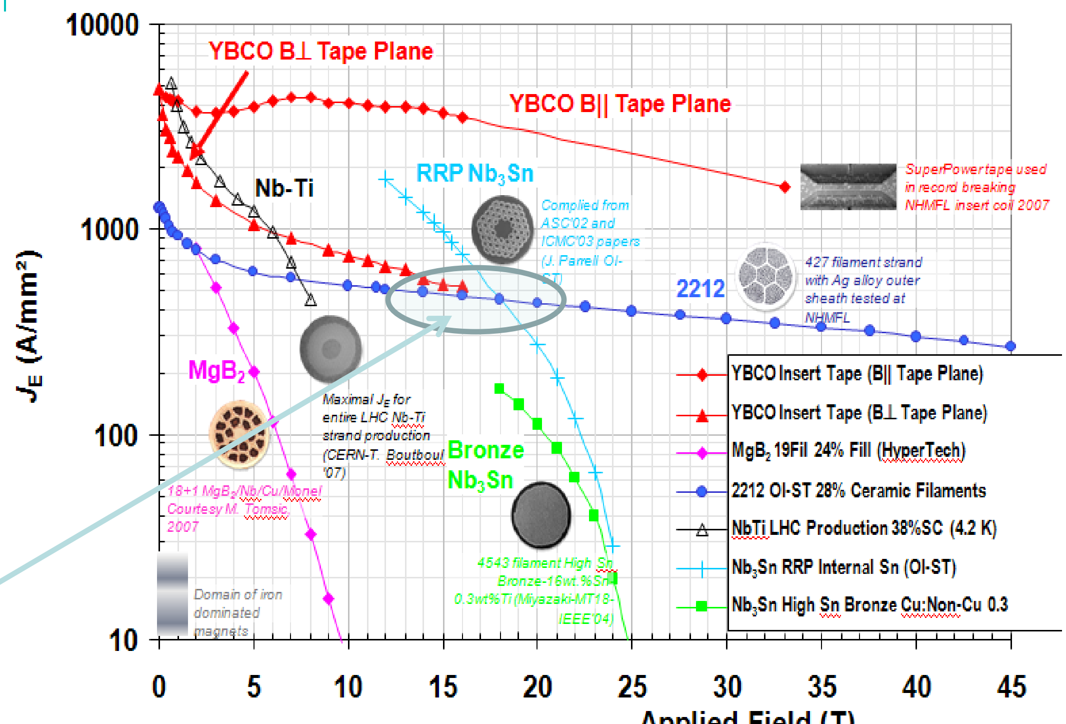
Issues	High Luminosity LHC	High energy LHC
Super-Cond. quadrupoles	15 T for low beta @IR	for IR and Ring
Super-Conducting dipoles		20 T (Nb3Sbn, HTS)
Fast cycling SC magnets		For 1.3 TeV injector
Mini beta operation	Chromatic correction and large aperture of matching section	Cryogenic handling of SR heat load
Crab cavities	Novel compact design compatible with machine protection	
Machine protection (500 MJ beam power)	Collimation with high effic, & reliability, low impedance	Cryogenic handling of SR heat load
Luminosity leveling	Control q_c , V_{crab} or b*	Control emittances
Dynamic vacuum		Synchrotron radiation

High Field Super-Conducting magnet R&D

LHC upgrades

- **HL-LHC:L = 5 10^{34}** → Low β quads(15T)
- **HE-LHC:** E_{cm} = 33 TeV → Dipoles (20T)

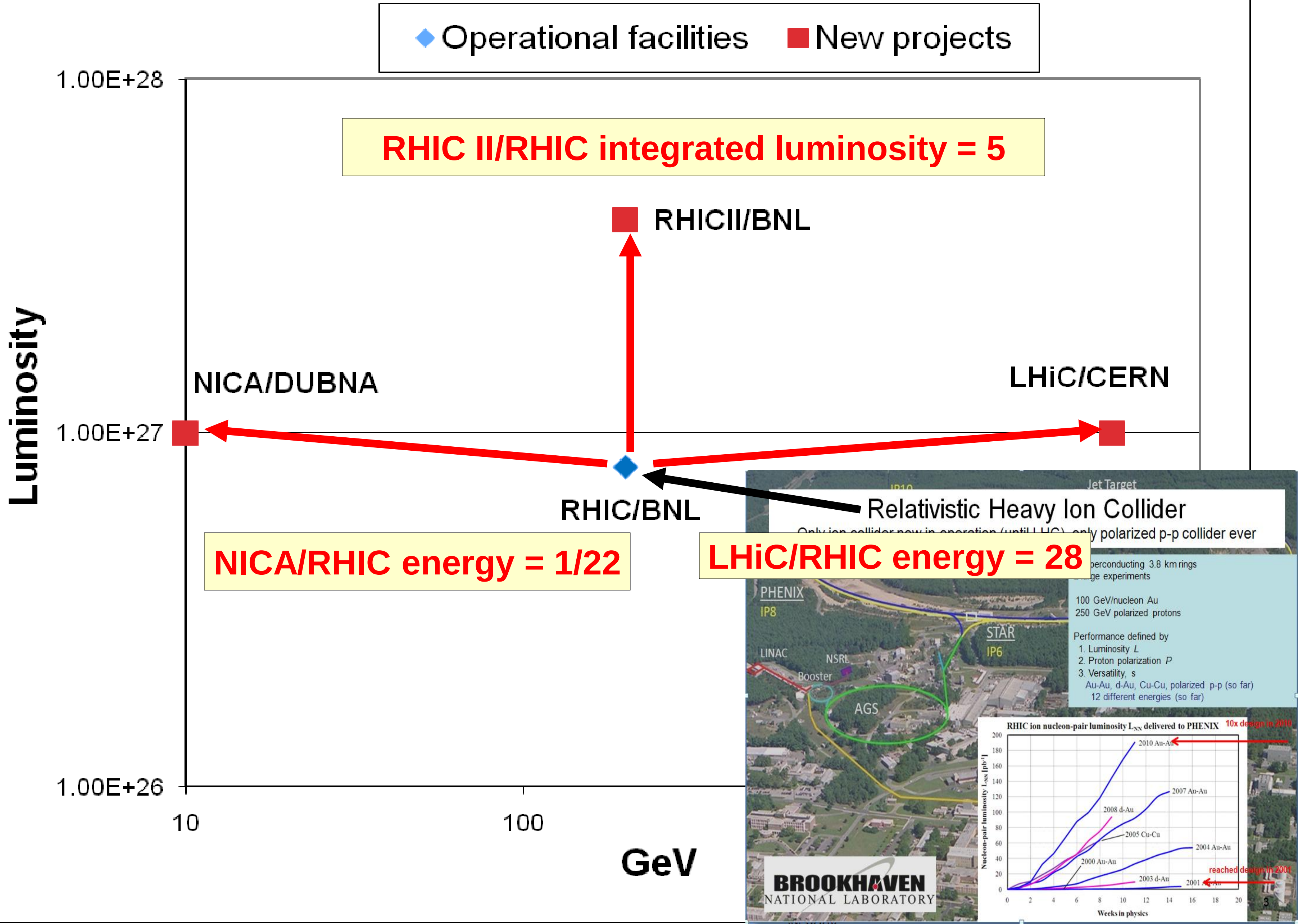




15 to 24 T Possible Super-conductors: Nb_3Sn existing up to 17-18 T
High Temperature SC : Bi-2212 (existing) or YBCO (small tapes only)

Promising but lots of R&D

Ion Colliders



Ions Colliders Parameters

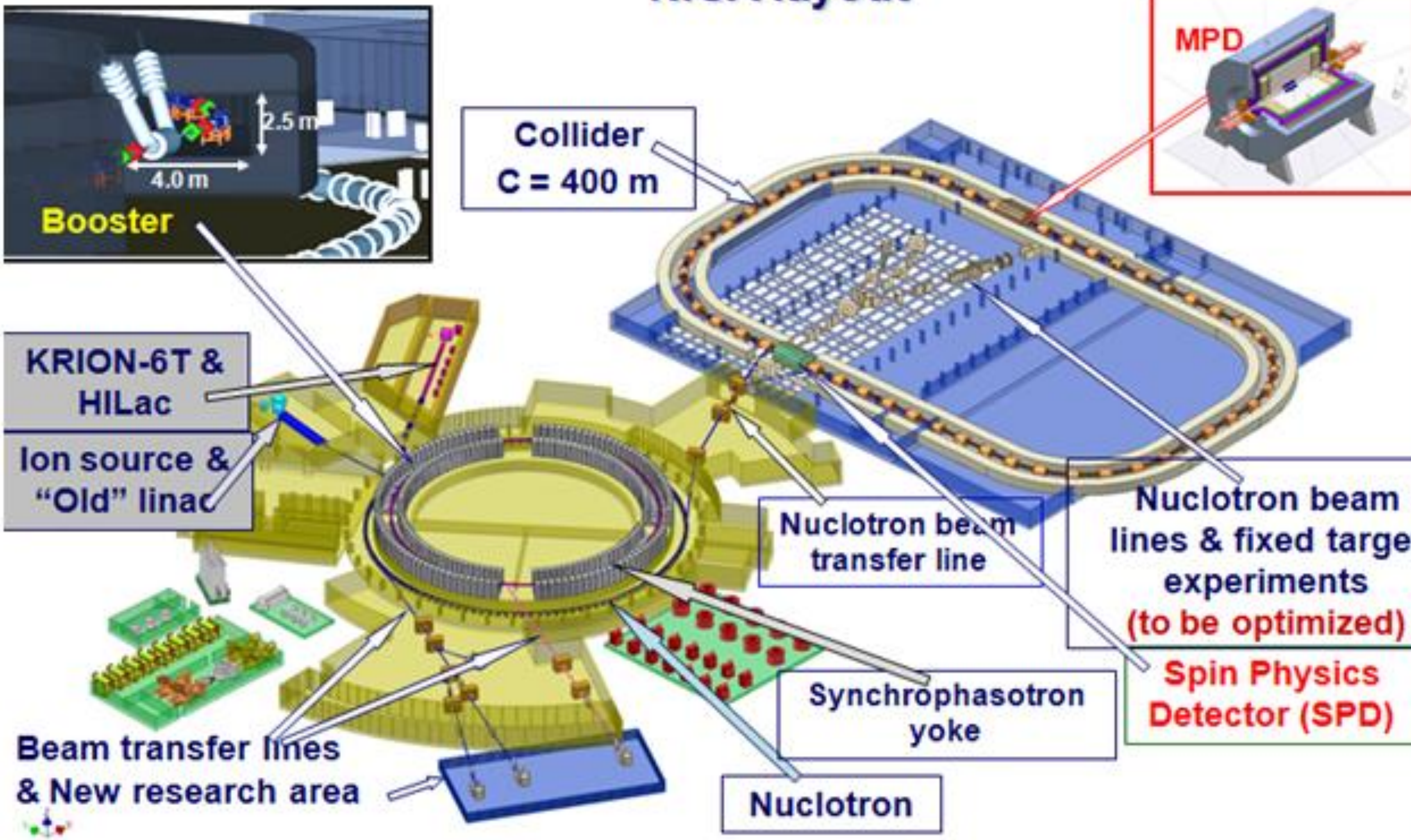
	Parameters	NICA	RHIC II	LHiC
Ions	Energy (GeV/Nucleon)	1-4.5	100	2760
	Luminosity (10^27)	1	4	1
	Ions	Au-Au	Au-Au	Pb-Pb
	Number bunches	34	111	592
	Ions/bunch (10^7)	100	100	7
	Emittances H/V ([μm]	30/0.03	2.5	1.5
	Stored energy (MJ)		0.4	3.8
Protons	Energy(Gev/Nucleon)	12-25	250	Later?
	Luminosity (10^30)	1.1	300	?
	Polarisation (%)	70	70	0

Major issues of Ions Colliders

<table>
<tr><th>Issues</th><th>NICA</th><th>RHIC II</th><th>LHiC</th></tr>
<tr><td>Peak Luminosity and Luminosity lifetime</td><td colspan="2">Intra-beam scattering</td><td>Beam losses from EM interactions</td></tr>
<tr><td>Intensity limits</td><td></td><td></td><td>Nuclear reactions in collimators</td></tr>
<tr><td rowspan="2">Remedies</td><td colspan="2">Stochastic cooling with bunched beams</td><td rowspan="2">New “cryo-collimators”</td></tr>
<tr><td>High voltage elect. cooling</td><td></td></tr>
<tr><td>Efficient and high quality magnets</td><td>Super -ferric SC magnets</td><td></td><td></td></tr>
<tr><td>Effective energy scan</td><td>Flexible lattice</td><td></td><td></td></tr>
</table>

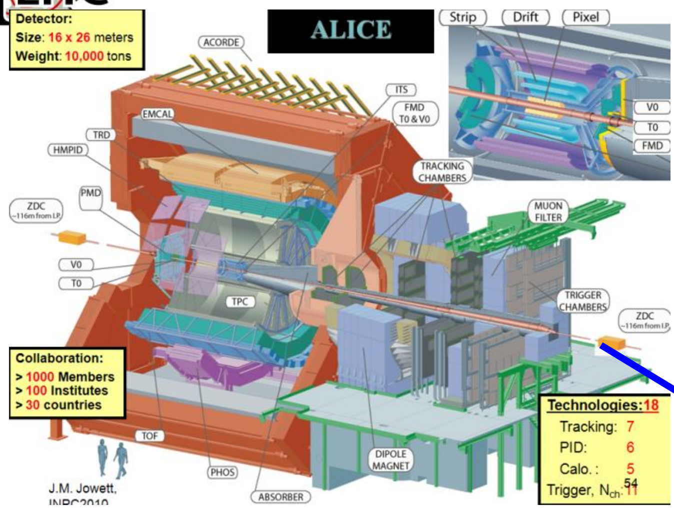
Nuclotron-based Ion Collider fAcility (NICA) at JINR

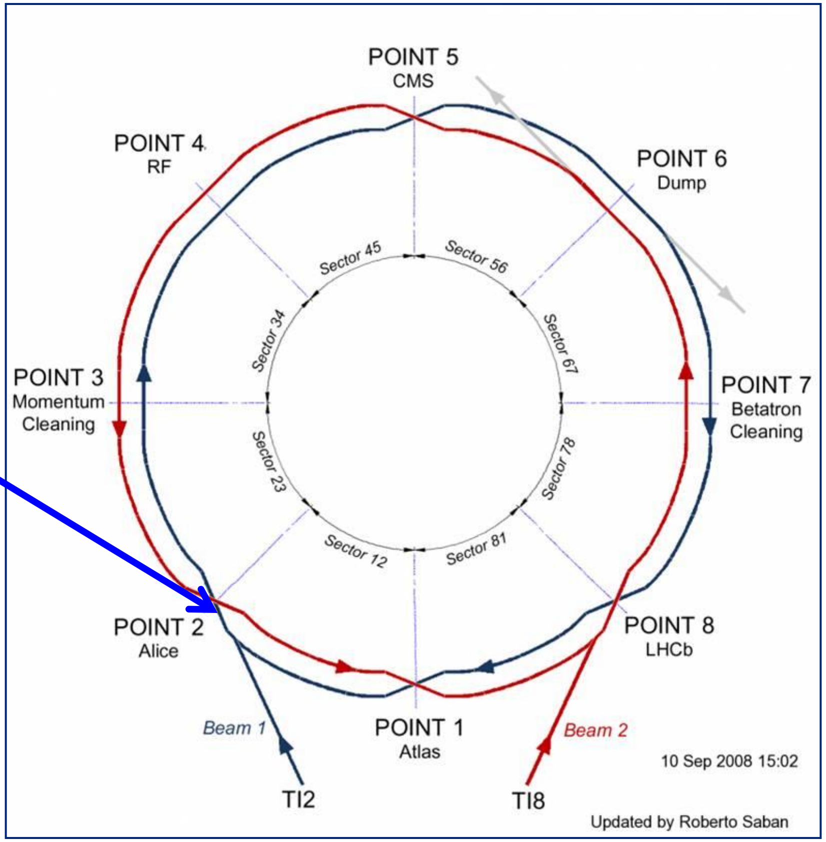
NICA layout



All rings (Booster, Nuclotron and Collider) are superconducting synchrotrons based on 2 Tesla super-ferric magnets (Nuclotron technology);

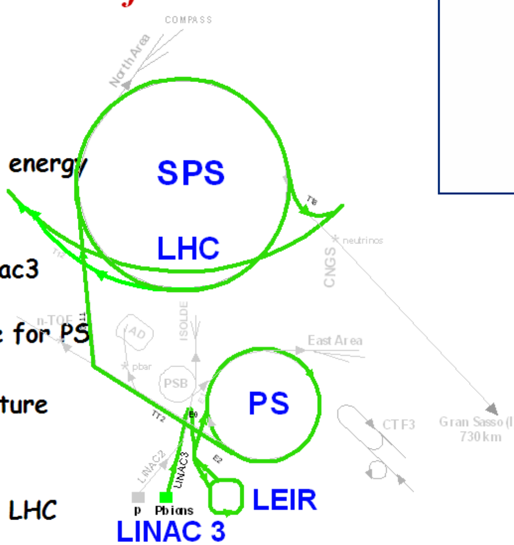
Large Hadron Ion Collider (LHiC)





LHC Ion Injector Chain

- ECR ion source (2005)
  - Provide highest possible intensity of Pb^{29+}
- RFQ + Linac 3
  - Adapt to LEIR injection energy
  - strip to Pb^{54+}
- LEIR (2005)
  - Accumulate and cool Linac3 beam
  - Prepare bunch structure for PS
- PS (2006)
  - Define LHC bunch structure
  - Strip to Pb^{82+}
- SPS (2007)
  - Define filling scheme of LHC

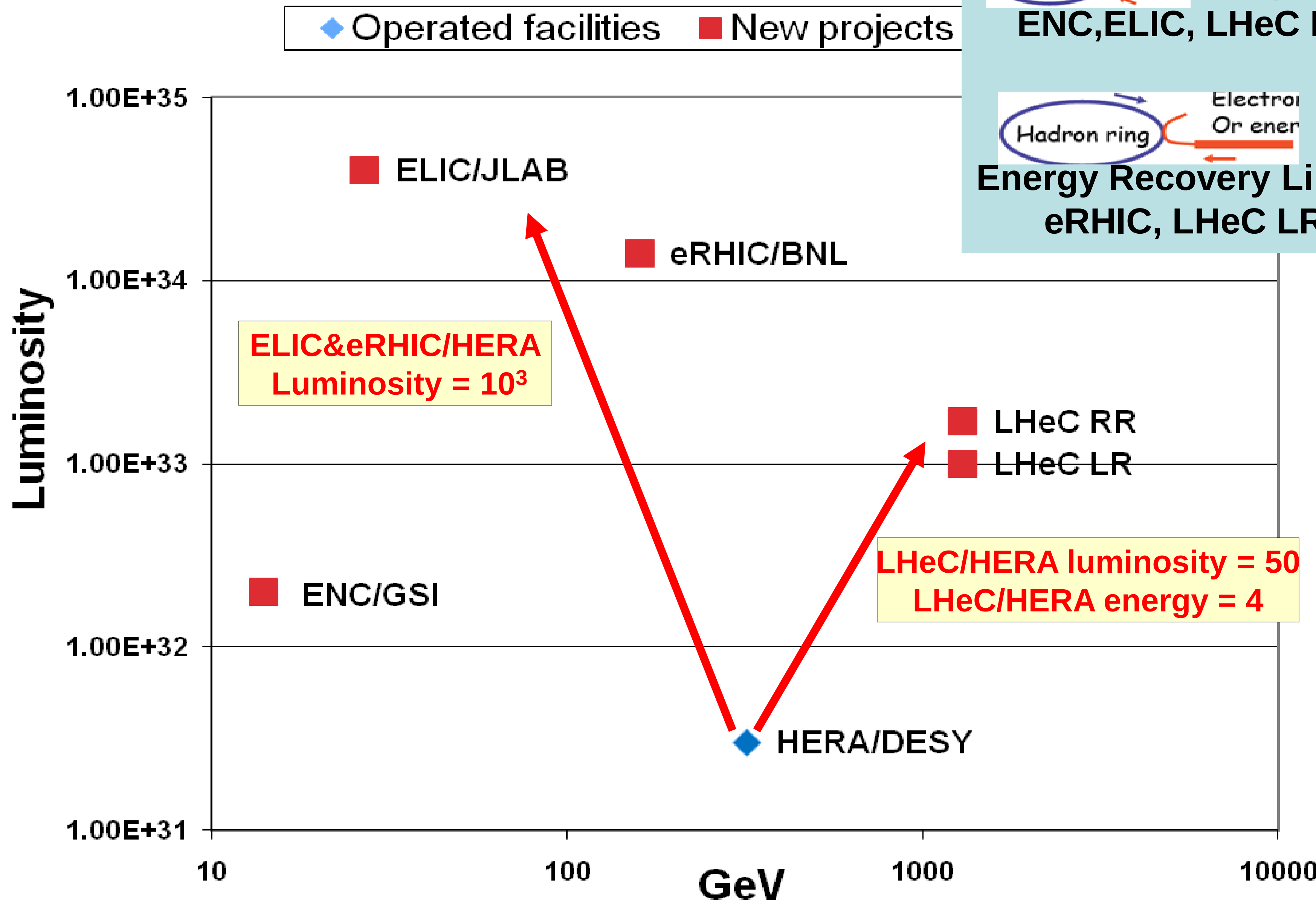


1 month/year for heavy-ion program (Starting Nov 2010)

- **initially $^{208}Pb^{82+}$- $^{208}Pb^{82+}$**
- **Later p-Pb, lighter A-A…**

Review @IPAC10
V.Litvinenko/BNL

Hadron-Lepton Colliders

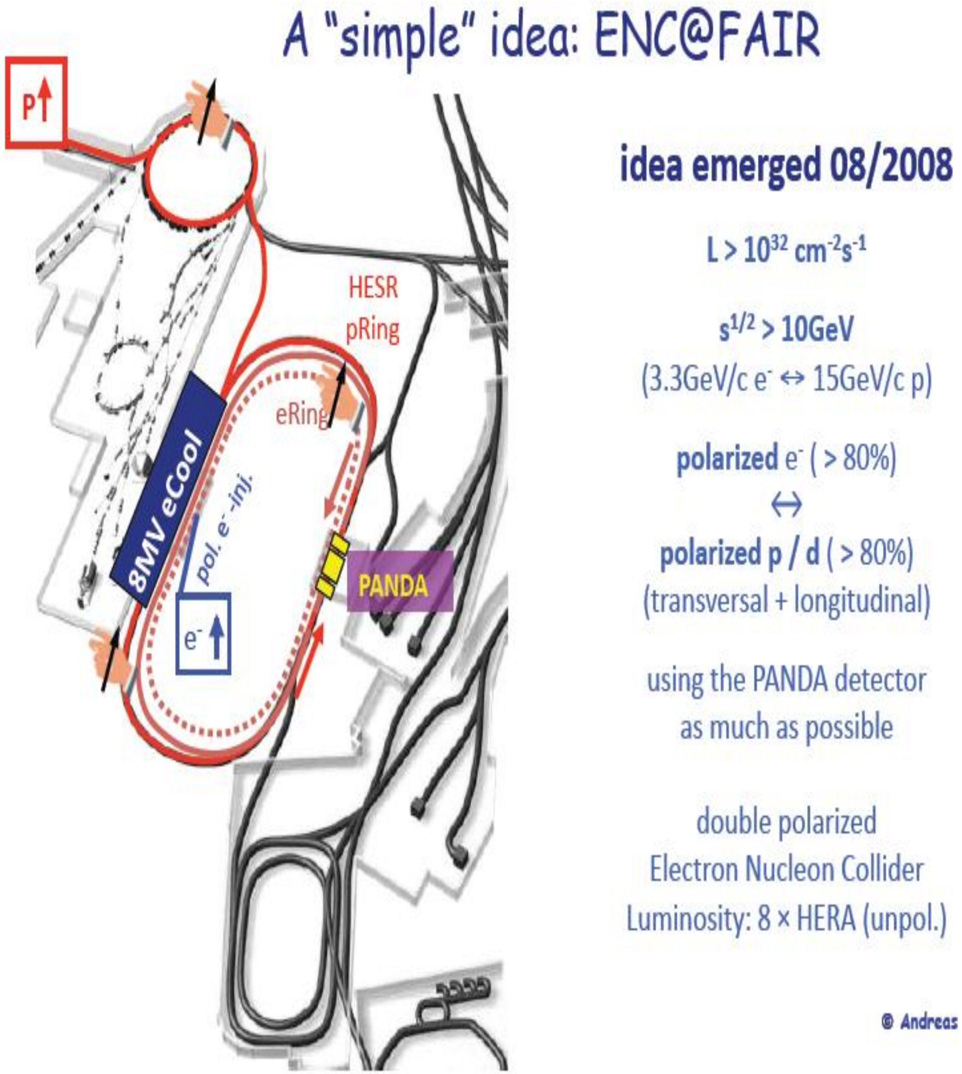


Two options for e-:

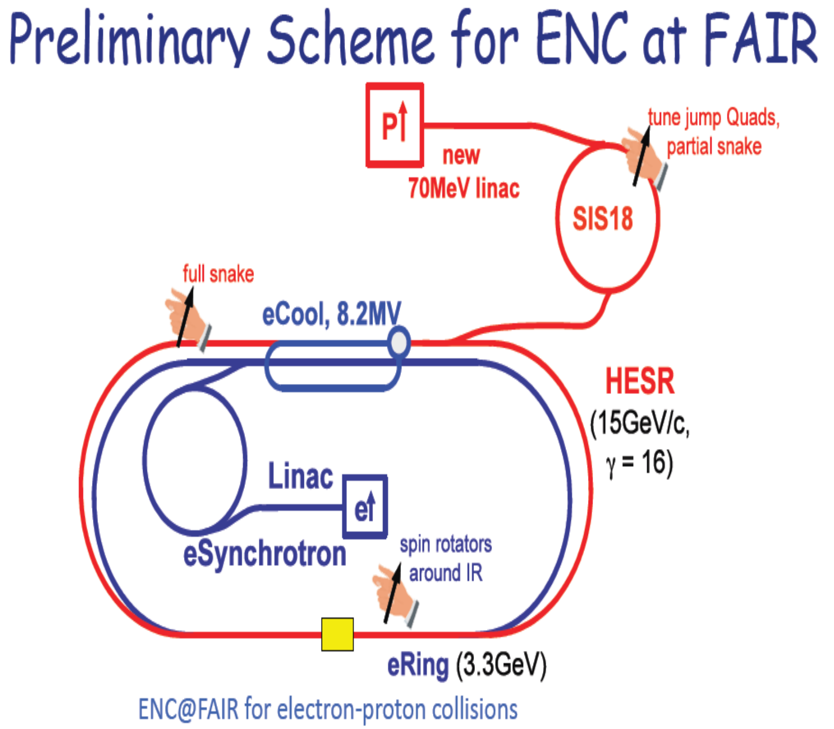
Ring:
ENC,ELIC, LHeC RR

Energy Recovery Linac:
eRHIC, LHeC LR

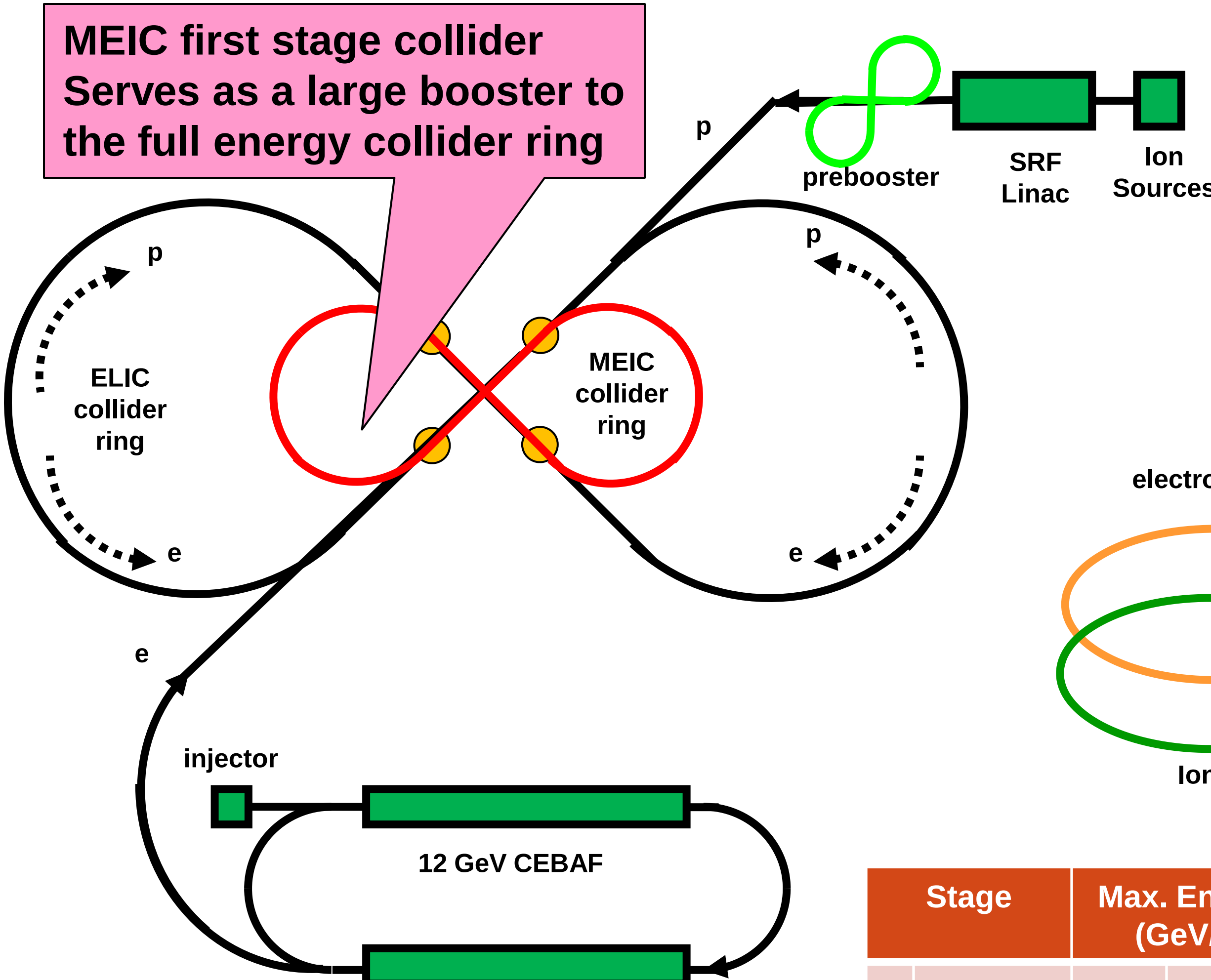
ENC @ FAIR



Taking advantage of the “existing” FAIR / HESR 15 GeV proton ring

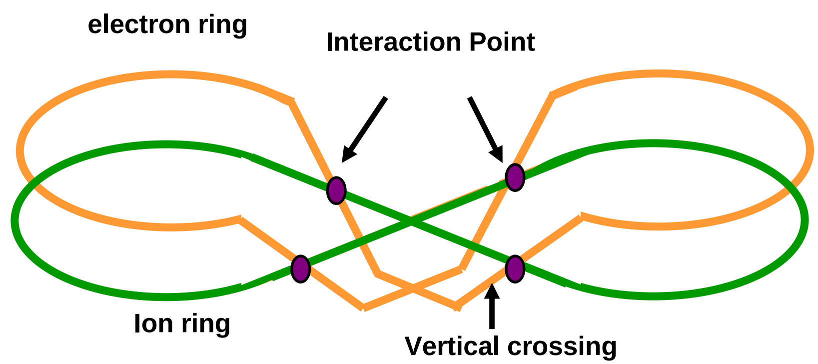


ELIC at JLAB



Taking advantage of the existing CEBAF 12 GeV electron accelerator

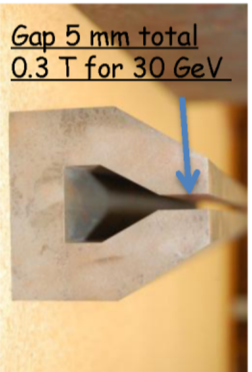
Circumference	m	1800
Radius	m	140
Width	m	280
Length	m	695
Straight	m	306



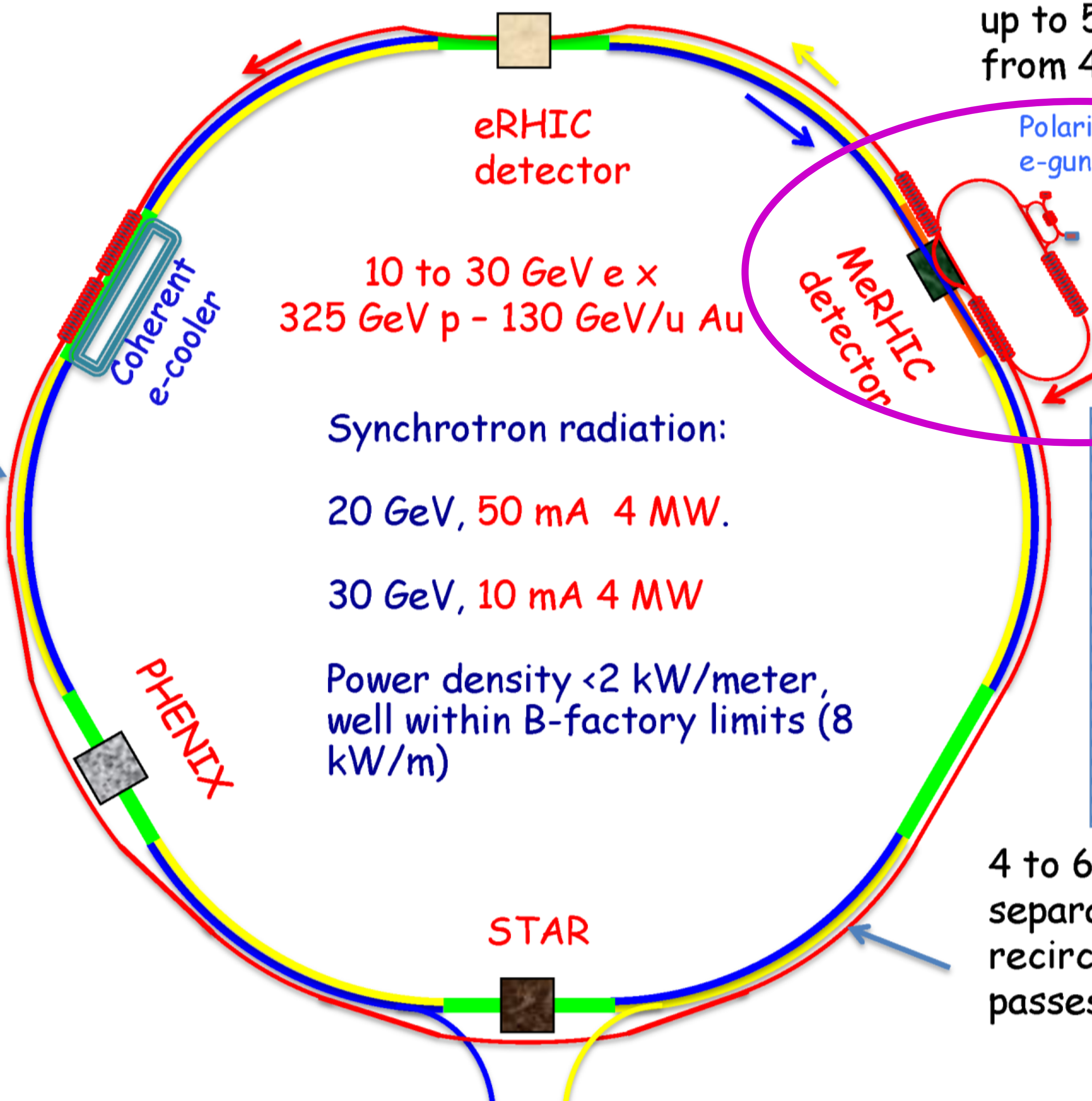
Stage	Max. Energy (GeV/c)		Ring Size (m)		Ring Type		IP #
	p	e	p	e	p	e	
Low	12	5 (11)	630		Warm	Warm	1
Medium	60	5 (11)	630		Cold	Warm	2
High	250	10	1800		Cold	Warm	4

eRHIC @ BNL

Taking advantage of the existing RHIC 130 GeV/u Au ring



2 x 200 m SRF linac
up to 5 GeV per pass
from 4 to 6 passes



10 to 30 GeV e x
325 GeV p – 130 GeV/u Au

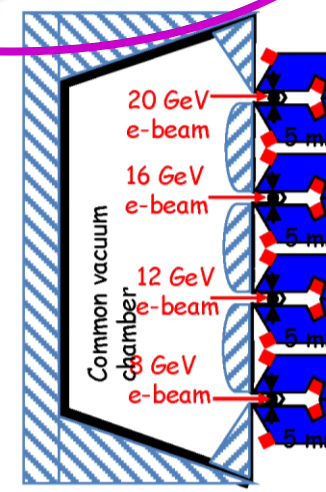
Synchrotron radiation:

20 GeV, 50 mA 4 MW.

30 GeV, 10 mA 4 MW

Power density <2 kW/meter, well within B-factory limits (8 kW/m)

First stage
4 Gev e- X
250 GeV p
100 GeV/u Au

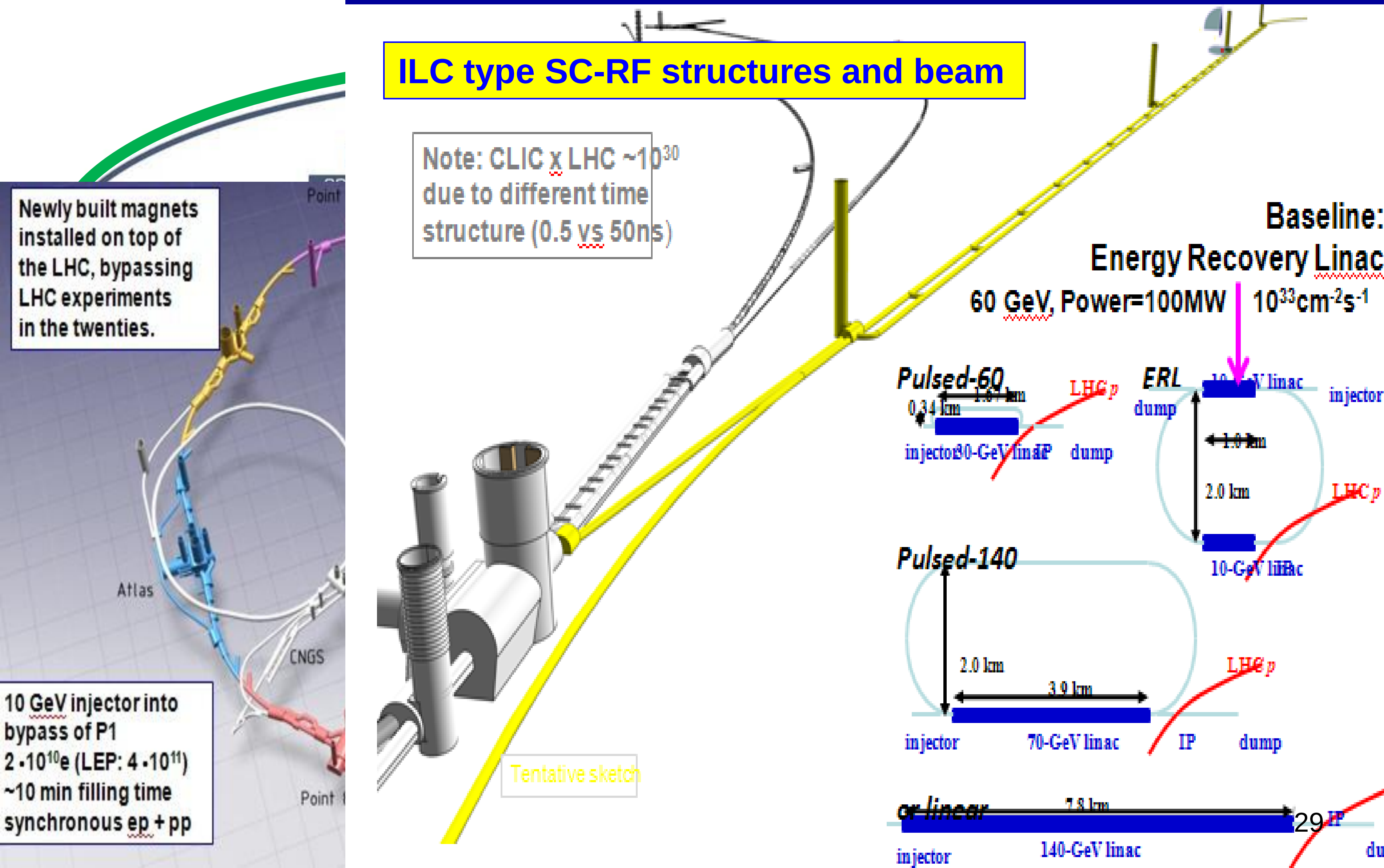


Possibility of 30 GeV low current operation

4 to 6 vertically separated recirculating passes

LHeC – Two options

Taking advantage of the existing LHC proton ring
7 TeV (to 16.5 TeV in HE)



Hadron-Lepton Collider Parameters

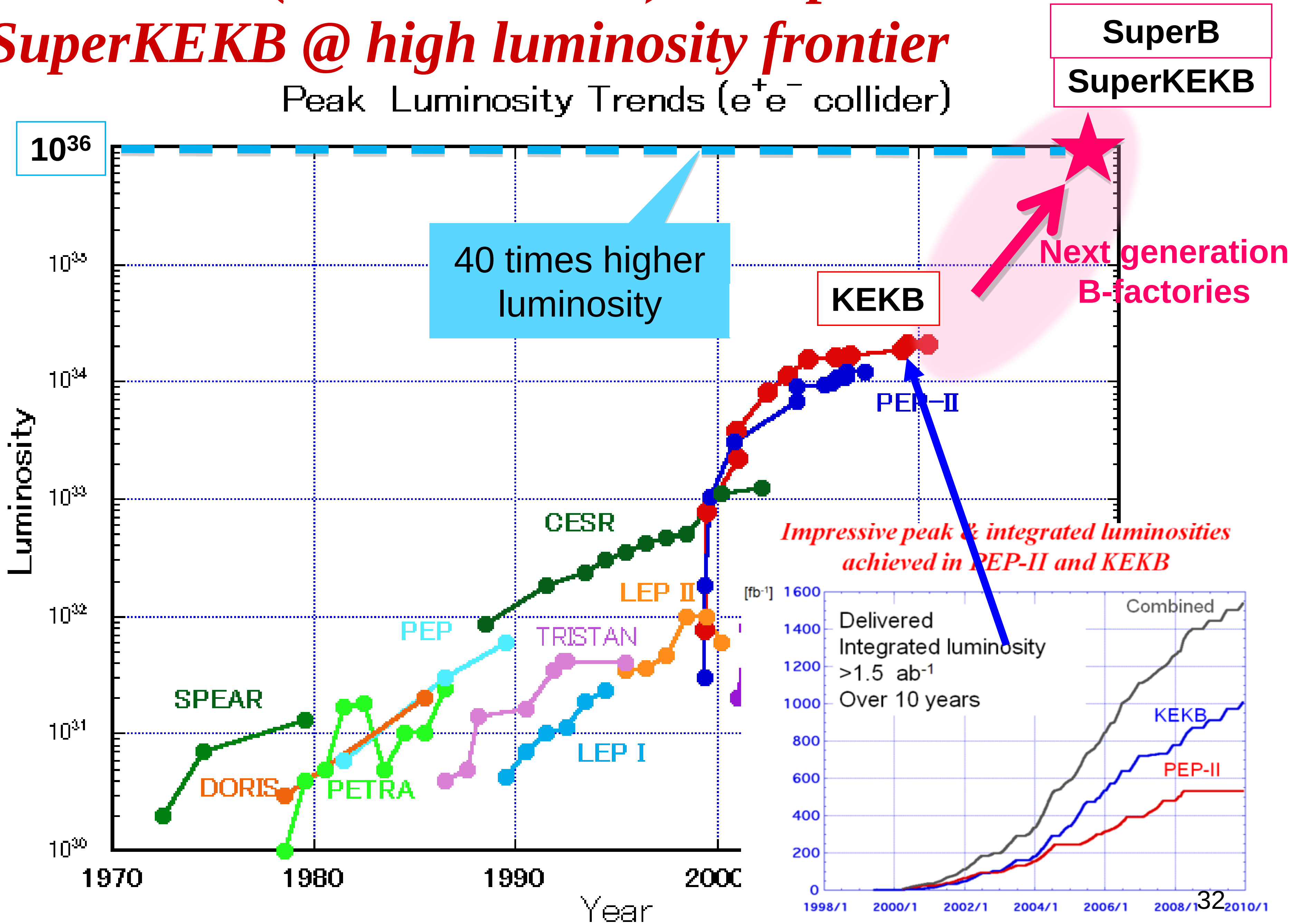
Parameters	ENC	ELIC	eRHIC	LHeC	
option	RR	RR	LR	RR	LR
P-A/e- energy [GeV]	15/3.3	60/3	325/20	7000/60	7000/60
√(S) [GeV]	14	27	160-102	1296	1296
luminosity [10^{32} $cm^{-2}s^{-1}$]	2	400	140	17	10
P/e- polarization [%]	80/80		70/80	/40	/90
P/e- bunch popul. [10^9]	5.4/23	11/60	200/24	170/26	170/2.0
P/e- bunch length [mm]	0.3/0.1	5	49/20	/10	/0.3
P/e- bunch interval [ns]	19		74	25-50	25-50
P/e- tr. emit. $ge_{x,y}$ [μm]		0.8/75	1200/25000	3.75/580,290	3.75/50
IP beam size $s_{x,y}$ [μm]				30, 16	7
full crossing angle [mrad]				0.93	0
geometric reduction H_{hg}				0.77	0.91
Energy Recovery efficien.	-	-	94?	-	94%
average current [mA]		860/4800	420/50	131	6.6
tot. wall plug power[MW]				100	100

Main Accelerator Challenges

In red -increase/reduction beyond the state of the art

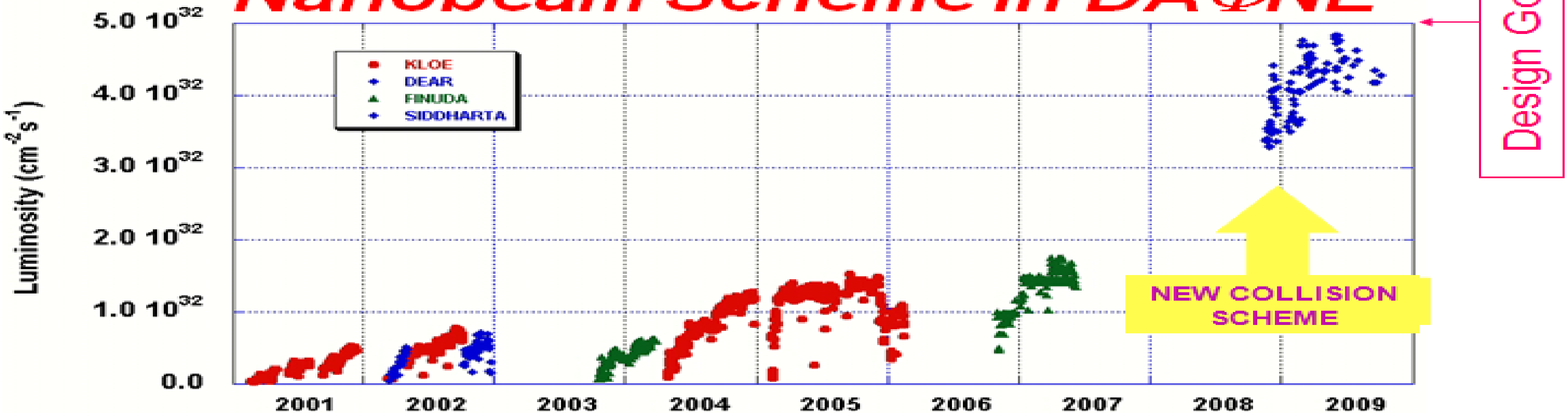
ENC at FAIR	ELIC at JLaB	eRHIC at BNL	LHeC at CERN Ring-Ring	LHeC at CERN Linac-Ring
	β*=0.5 cm 50x reduction	Polarized electron gun - 50x increase	Depolarization at the top energy	Polarized e⁻ source
8 MV, 3 A magnetized electrostatic (Voltage*2, Current*6)	HE Electron Cooling – [illegible]	Coherent Electron Cooling – New concept	Energy reach beyond 70 GeV for leptons	Potential 10x gains from cooling, but need special CeC
Investigation of large beam-beam tune shift in space charge dominated regimes	High current recirculating ring with ERL-injector New concept	Multi-pass SRF ERL 5x increase in current 30x increase in energy	Synchrotron radiation losses in the arcs	Multi-pass SRF ERL 5x increase in current 30x increase in energy 3-4x in # of passes
Crab crossing (compliance with acceptance of PANDA)	Crab crossing 5x the angle New for hadrons	Crab crossing New for hadrons	Crab crossing New for hadrons	Crab crossing New for hadrons
	Polarized ^3He production		By-passes	Totally new tunnel
Limited space for electron ring	Never explored beam-beam parameter range 3-4x in ξ	Understanding of beam-beam affects New type of collider	Complexity of the sharing tunnel with LHC	Very challenging to have e+ source
Polarization life time in electron ring (lattice considerations)	[illegible]	β*=5 cm 5x reduction		Using crossing angle to avoid SR in IR
Space charge limits beam dynamics, Bunching (1→200)	Sub-nsec kicker with MHz rep-rate 50x shorter pulses	Multi-pass SRF ERL 3-4x in # of passes	Need new injector	
	Figure-8 ring spin dynamics New concept	Feedback for kink instability suppression Novel concept	Synchrotron radiation in the IR	

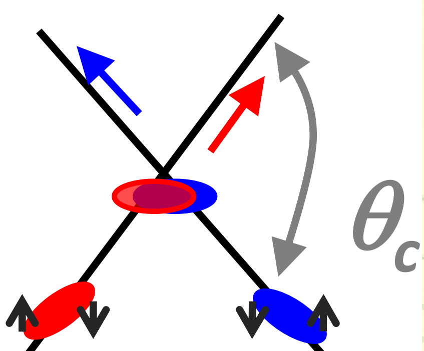
B Factories (PEPII&KEKB) to SuperB and SuperKEKB @ high luminosity frontier



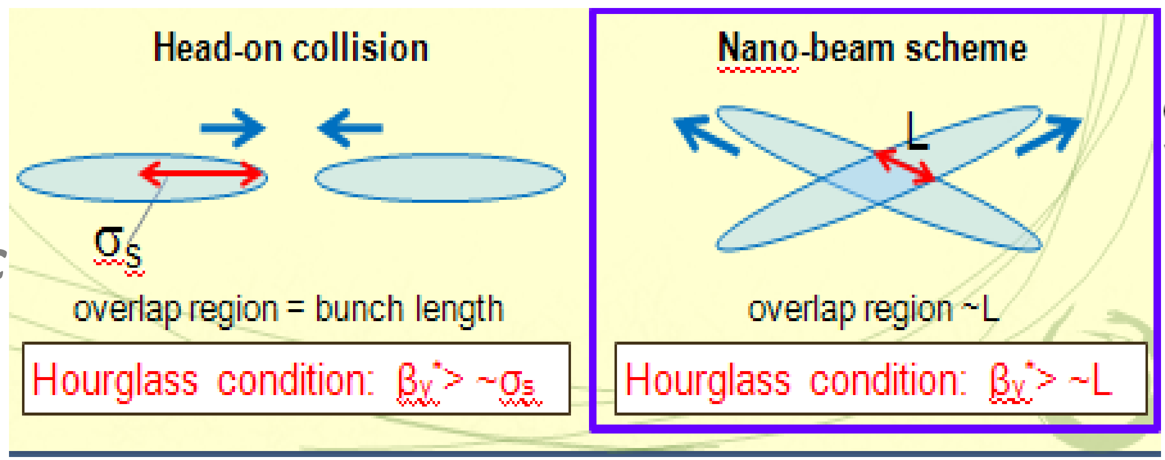
Novel "nanobeam scheme" (P.Raimondi/LNF)

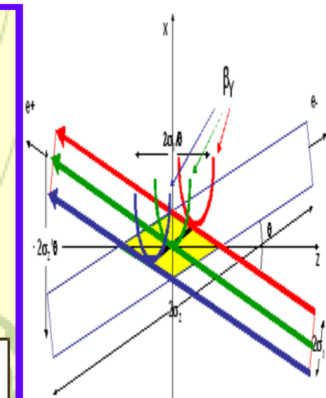
Successful demonstration of Nanobeam Scheme in DAΦNE





Crab-crossing KEKB





Major parameters B Factories

		SuperB (Baseline)		SuperKEKB	
Parameter	units	HER (e+)	LER (e-)	HER (e-)	LER (e+)
Circumference	m	1258.4		3016.3	
Energy	GeV	6.7	4.18	7	4
X angle (full)	mrad	66		83	
β_x at IP	cm	2.6	3.2	2.4	3.2
β_y at IP	cm	0.0252	0.0206	0.041	0.027
ε_x	nm	2.0	2.41	2.4	3.1
Emittance ratio	%	0.25	0.25	0.35	0.40
σ_z (full)	mm	5	5	5	6
I	mA	1892	2410	2620	3600
σ_x at IP	µm	7.211	8.782	7.75	10.2
σ_y at IP	µm	0.035	0.035	0.059	0.059
ξ_x		0.0021	0.0033	0.0028	0.0028
ξ_y		0.0978	0.0978	0.0875	0.09
Luminosity	$cm^{-2}\ s^{-1}$	$1x10^{36}$		$0.8x10^{36}$	

Next Generation B-factories IPAC10

KEKB to SuperKEKB : current status

- KEKB operation finished at 9:00 am June 30, 2010

- SuperKEKB budget is partially approved
  - Damping ring : 580M yen (~5.8M$) (FY2010)
  - Special budget "Very Advanced Research Support Program"
    1B yen (~100M$) (FY2010-2012)

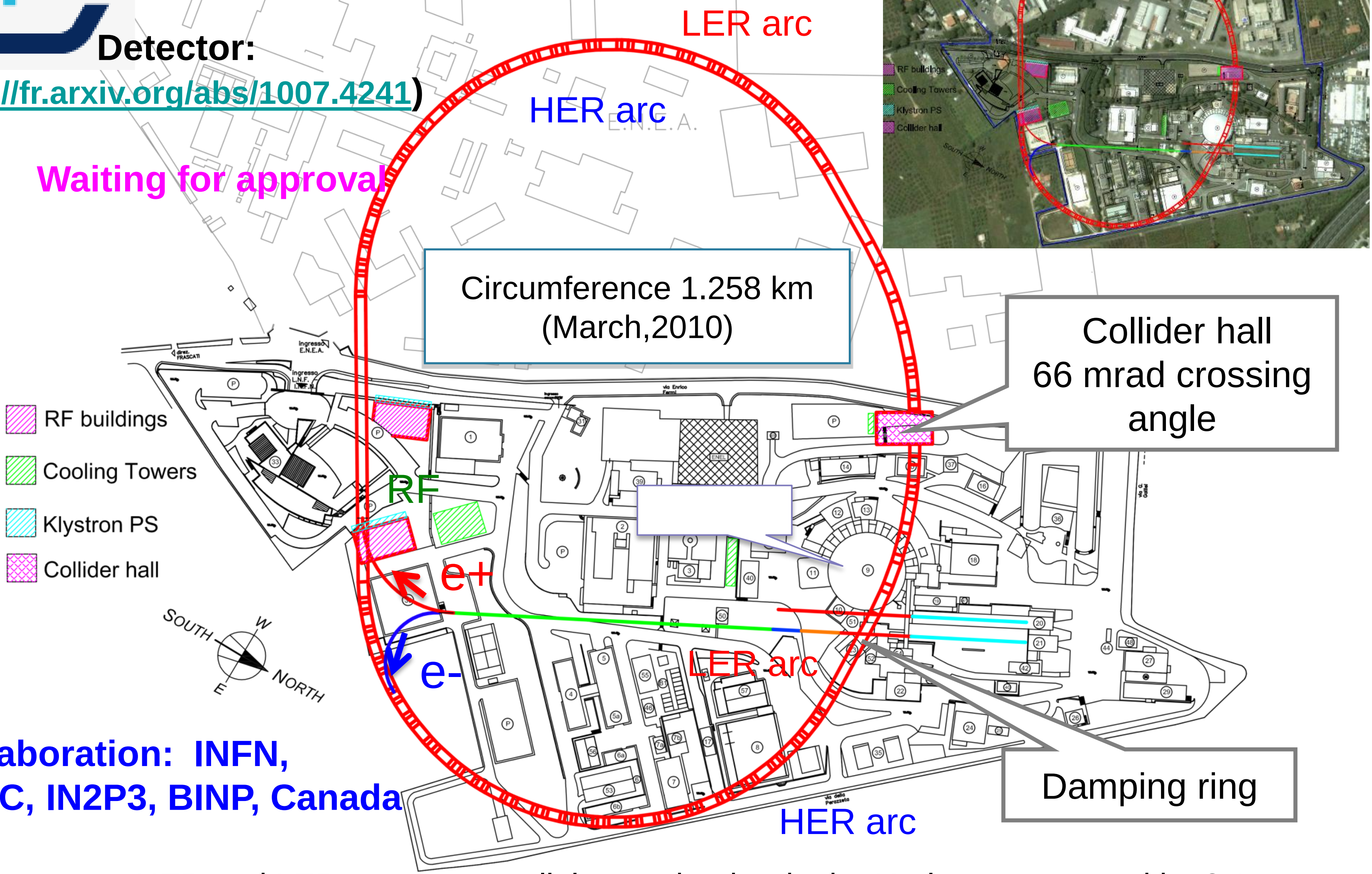
→*Start construction (FY2010-2013)*

SuperB at Frascati

CDR in 2009: http://arxiv.org/abs/0709.0451

Detector:
http://fr.arxiv.org/abs/1007.4241)

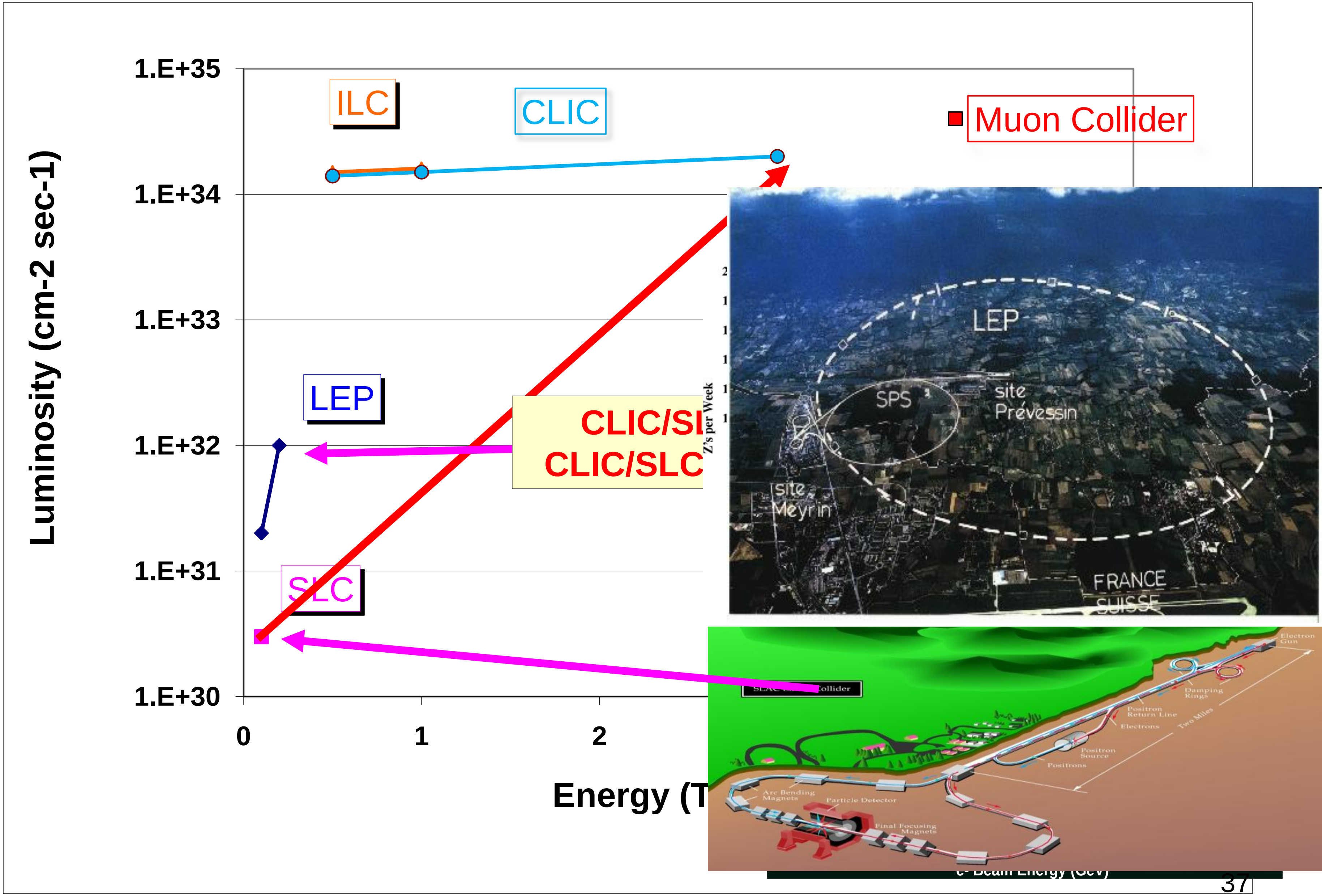
Waiting for approval



Collaboration: INFN, SLAC, IN2P3, BINP, Canada

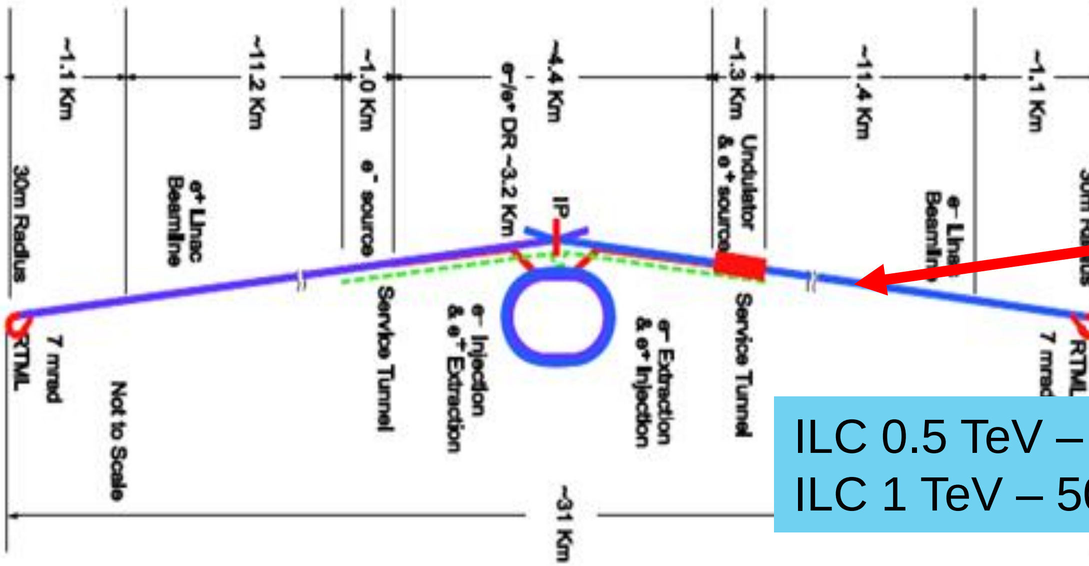
HER and LER arcs are parallel to each other in the H-plane, separated by 2.1 m.

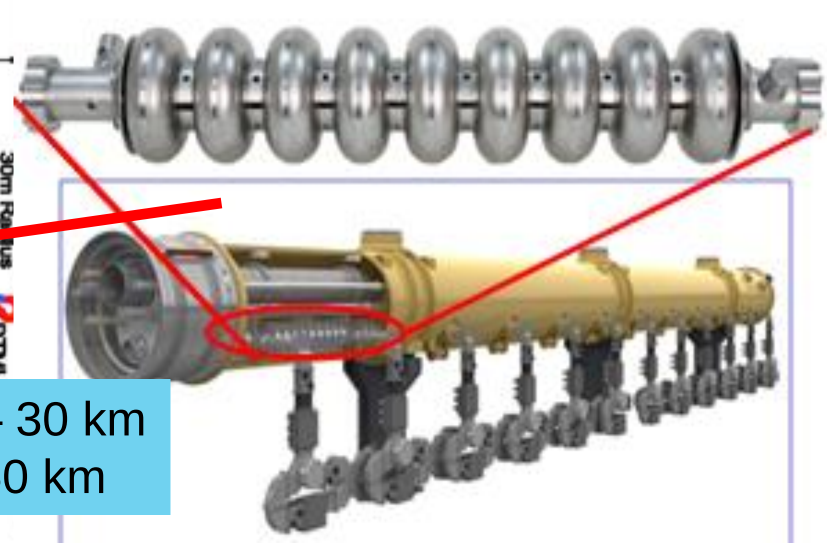
Lepton Colliders at the Energy Frontier



Linear Collider layouts

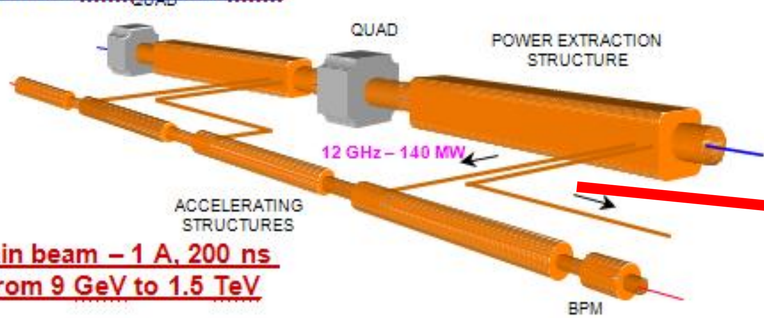
http://www.linearcollider.org/cms   http://clic-study.web.cern.ch/CLIC-Study/



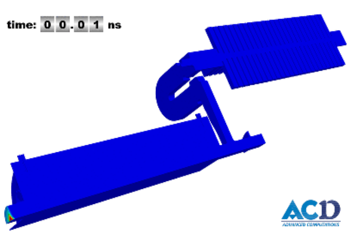


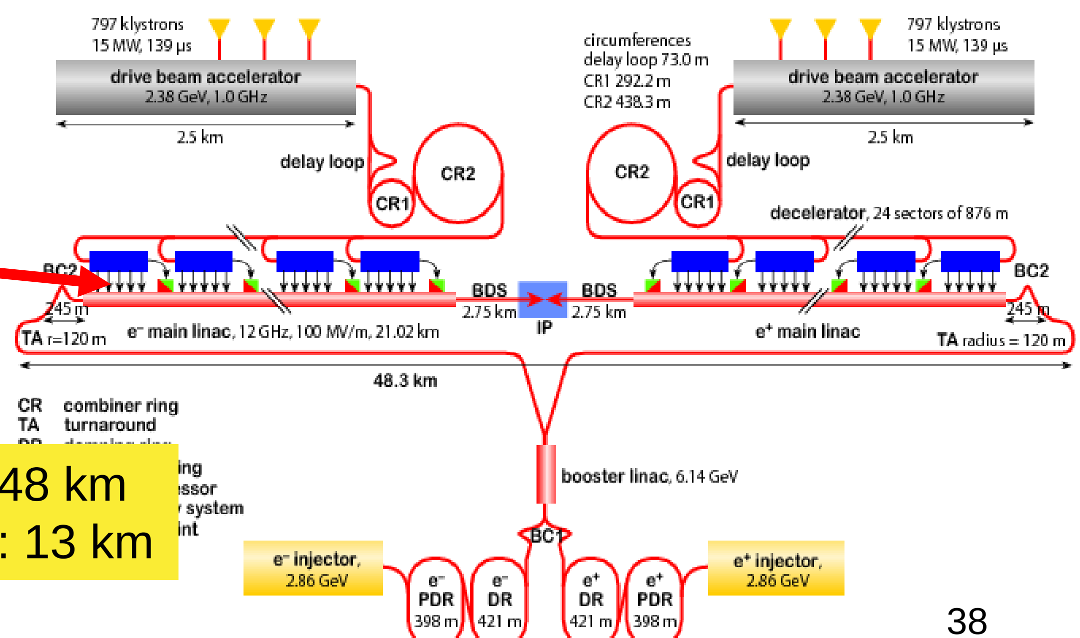
ILC 0.5 TeV – 30 km
ILC 1 TeV – 50 km

Drive beam - 95 A, 300 ns
from 2.4 GeV to 240 MeV



Main beam – 1 A, 200 ns
from 9 GeV to 1.5 TeV





CLIC 3 TeV: 48 km
CLIC 0.5 TeV: 13 km

Linear Collider main parameters

Technology	ILC	CLIC	
Centre-of-mass energy (GeV)	500	500	3000
Total (Peak 1%) luminosity (10^{34})	2.0(1.5)	2.3(1.4)	5.9(2.0)
Total site length (km)	31	13.0	48.3
Loaded accel. gradient (MV/m)	31.5	80	100
Main linac RF frequency (GHz)	1.3 (Super Cond.)	12 (Normal Conducting)	
Beam power/beam (MW)	20	4.9	14
Bunch charge (10^9 e+/-)	20	6.8	3.72
Bunch separation (ns)	176	0.5	
Beam pulse duration (ns)	1000	177	156
Repetition rate (Hz)	5	50	
Hor./vert. norm. emitt ($10^{-6}/10^{-9}$)	10/40	4.8/25	0.66/20
Hor./vert. IP beam size (nm)	640/5.7	202 / 2.3	40 / 1
Hadronic events/crossing at IP	0.12	0.19	2.7
Coherent pairs at IP	10	100	$3.8\ 10^8$
Wall plug to beam transfer eff	9.4%	7.5%	6.8%
Total power consumption (MW)	216	129.4	415

Status and major issues of Linear Colliders

ILC

- 0.5 TeV upgradable to 1 TeV
- Mature SC-RF technology (TESLA- Flash- XFEL)
- CDR in 2007, TDR in 2012
- Global Intern. collaboration & organisation (GDE)

CLIC

- extension in multi-TeV range
- Novel scheme of Two Beam Acceleration (TBA): CTF1,2,3
- CDR in 2011, TDR in 2016
- Multi-lateral Int. Collaboration of 38 volunteer Institutes

Extremely fruitful collaboration between CLIC and ILC
Taking advantage of common issues and great synergies

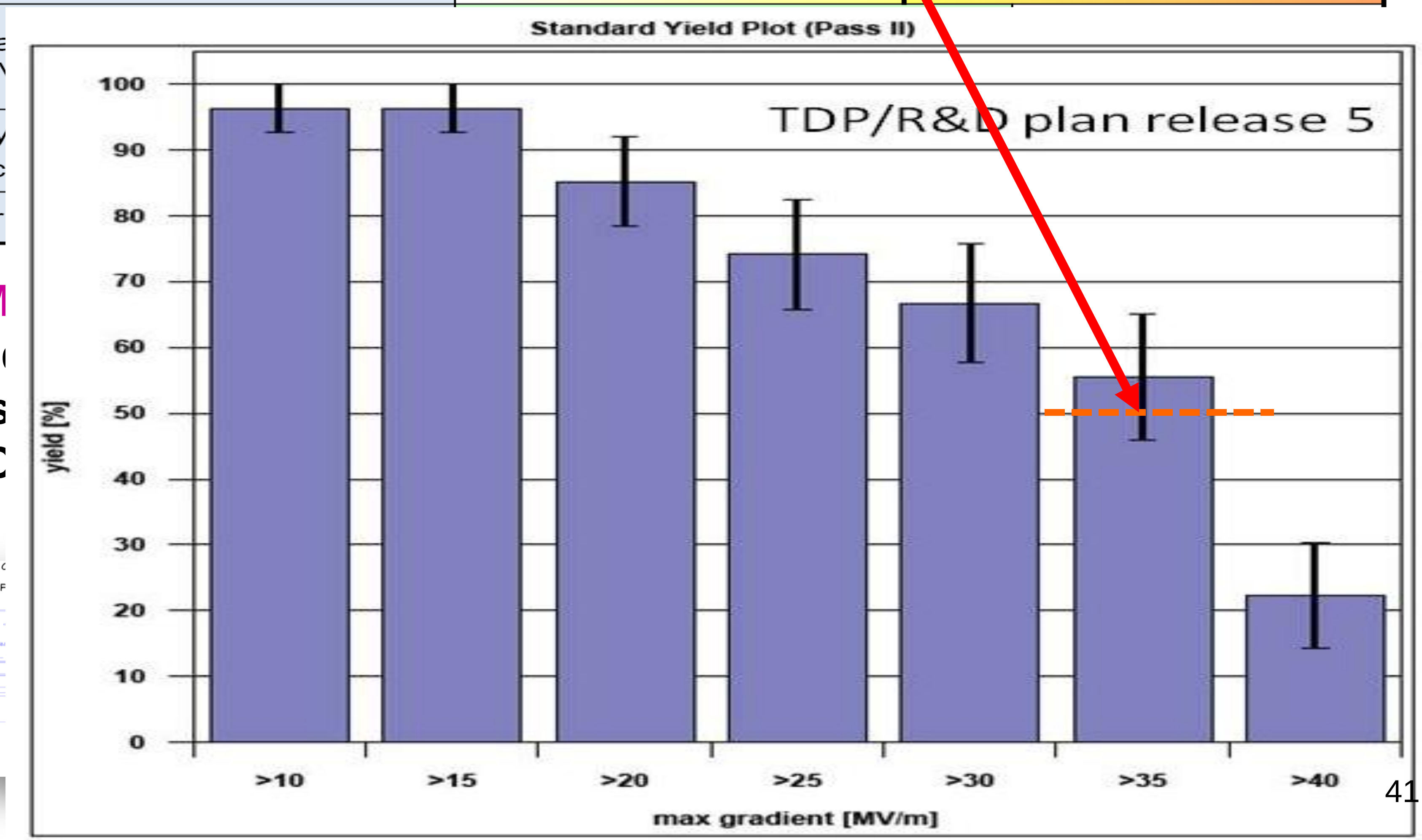
Common IWLC Workhop (18-22/10/2010 @ CERN)

Towards single Linear Collider community and….

Possibly future joined project based on Physics requests (LHC results) and technology choice as best trade off between performance, maturity, risk, cost, etc….

Successful ILC Super Conducting RF developments in global collaboration

Year	2008	2009	2010	2011	2012
Phase	TDP-1			TDP-2	
Cavity Gradient in v. test to reach 35 MV/m	→ Yield 50%			→ Yield 90%	
Ca MV					
Sy ac					
Pr					



NM

Un

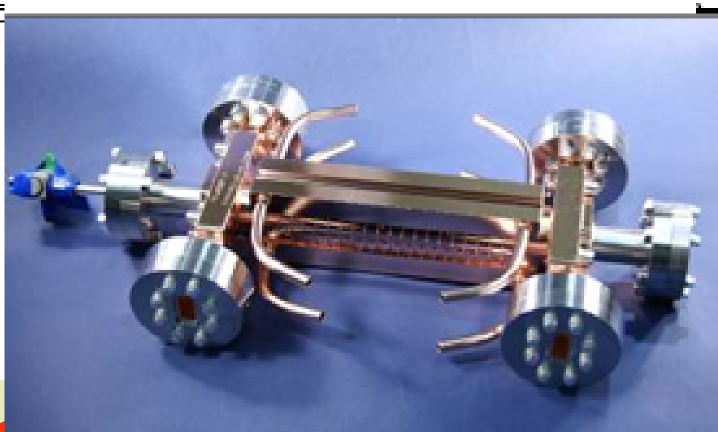
firs

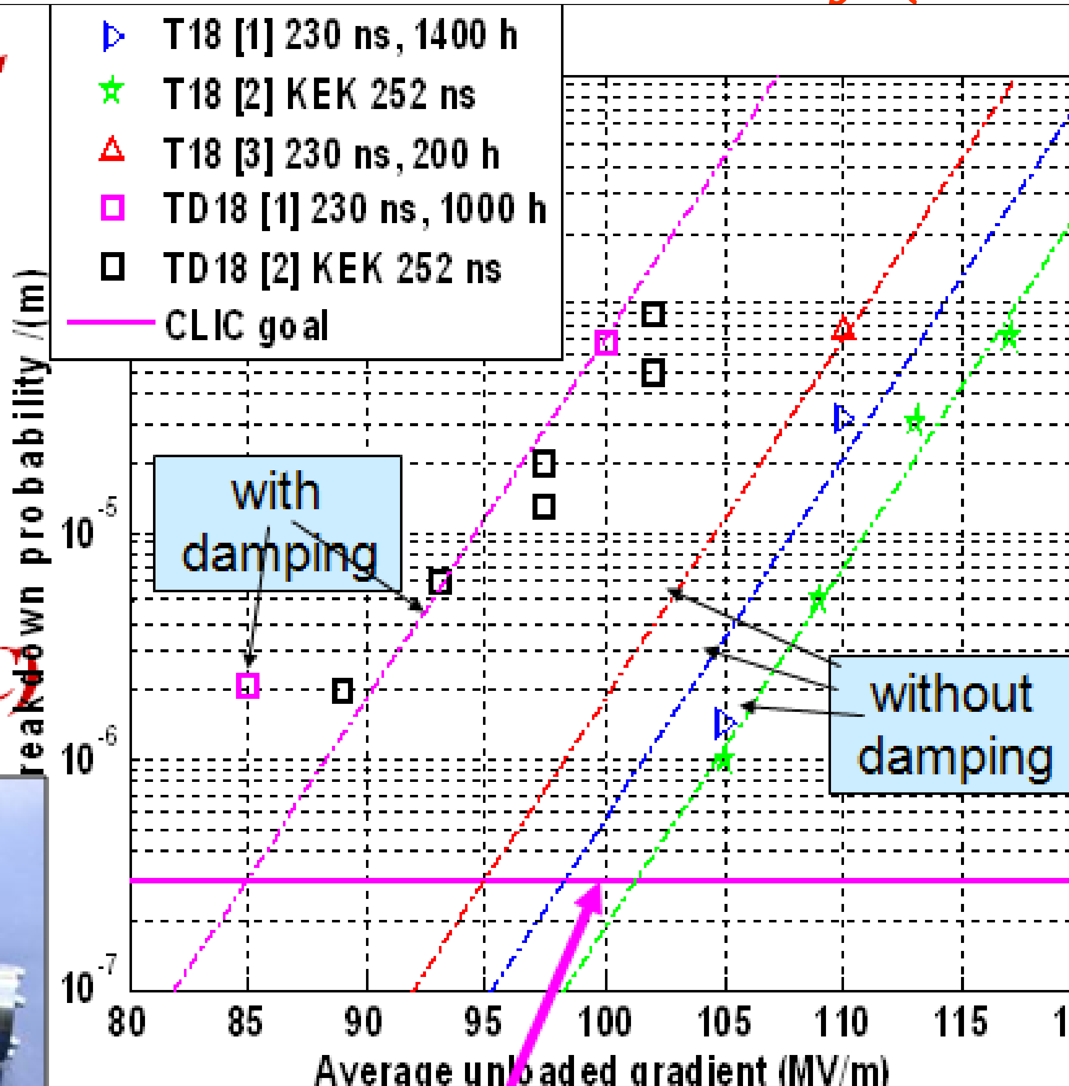
ILC

n

Addressing all major CLIC technology key issues in CLIC Test Facility (CTF3)

Nominal CLIC Accelerating Structure Performance achieved by global collaboration (CERN-KEK-SLAC)

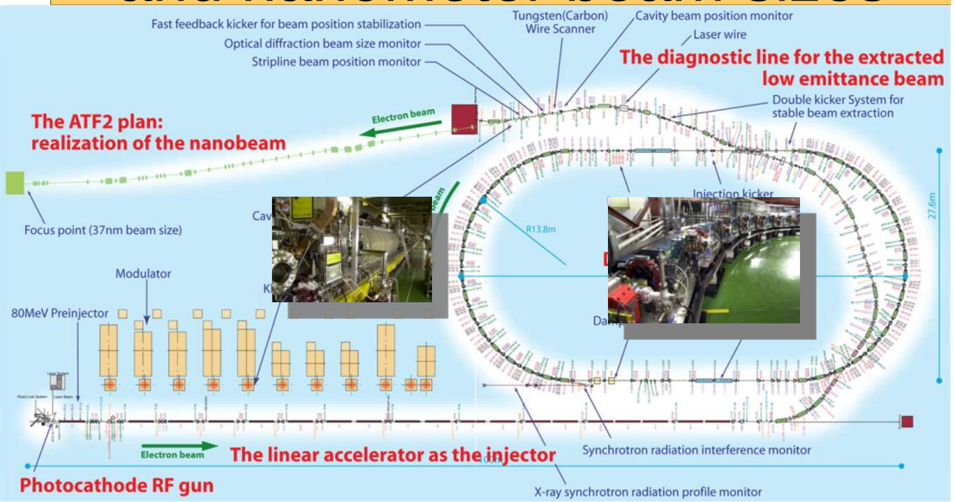


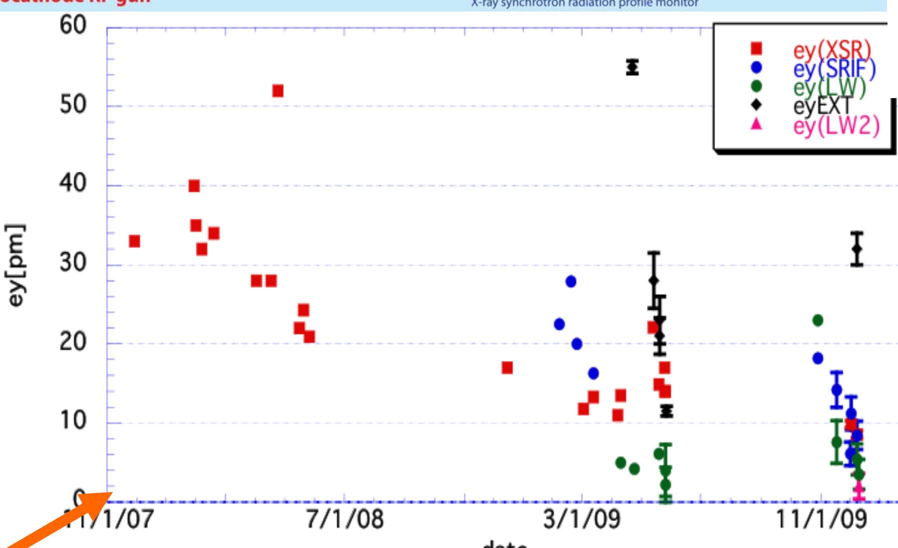


CLIC goal:100 MV/m loaded with BR<3 10-7/m

Test Facilities on Linear Colliders Common Issues

ATF/KEK: ultra low emittance and nanometer beam sizes



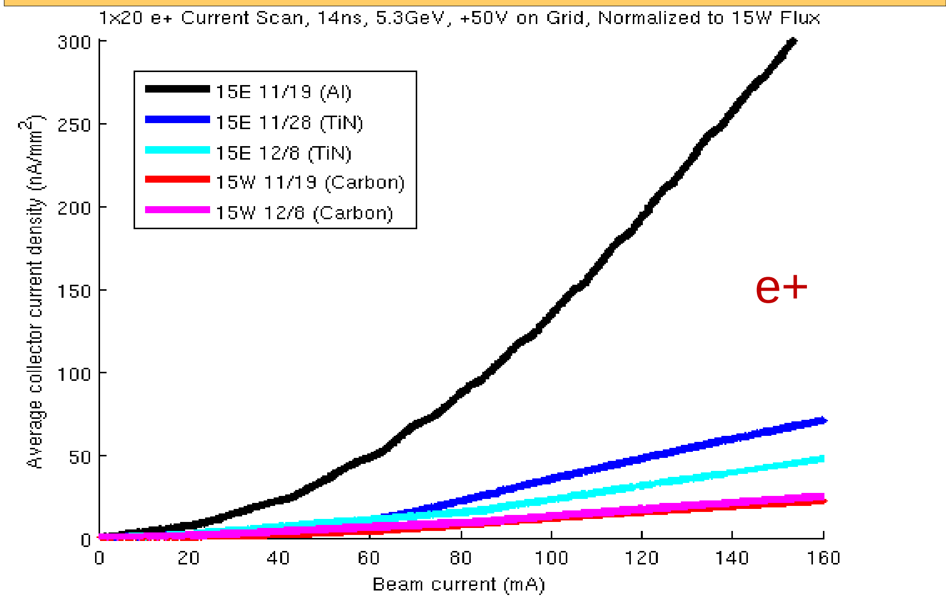


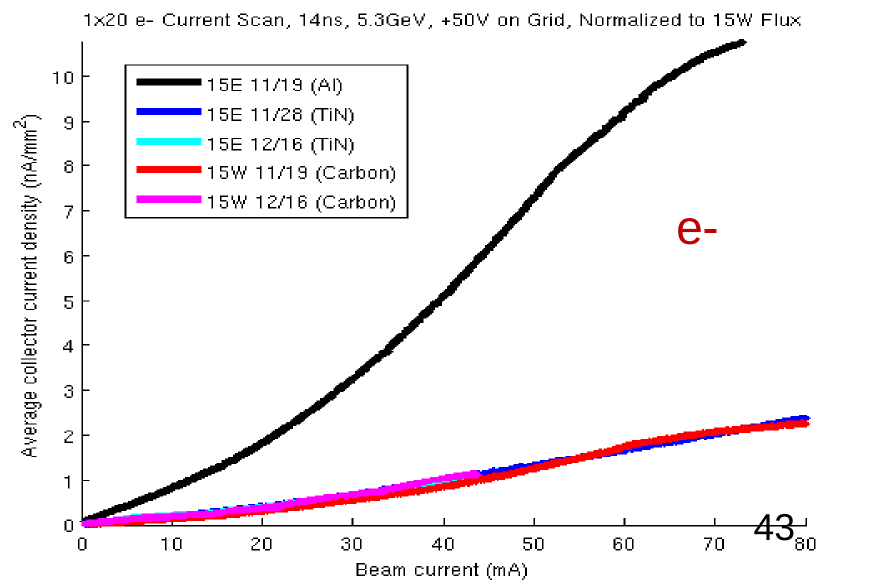
CLIC Damping Ring

2009 spring
I=5-6x10[9]

2009 autum
I=4-5x10[9]

CESR-TA/Cornell:Electron cloud





Muon Collider possible alternative for Multi-TeV Lepton Collider ?

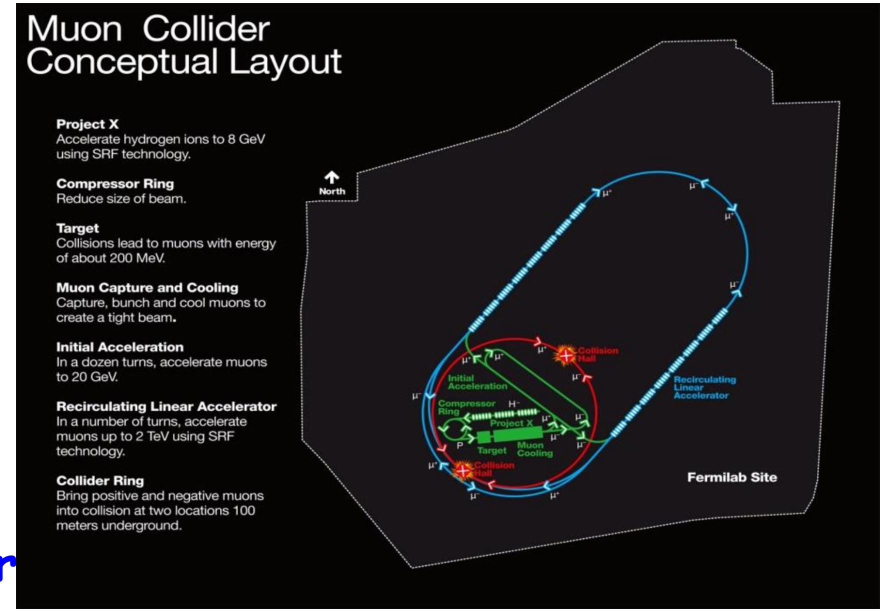
Limited synchroton radiation and beamstrahlung due to high mass:(m_μ / m_e ~ 207)

COST

-COMPACT
- Fits on FNAL laboratory site

-MULTI-PASS ACCELERATION
- Cost Effective

-MULTIPASS COLLISIONS IN A RING (~1000 turns)
- Relaxed emittance requirements & hence relaxed tolerances



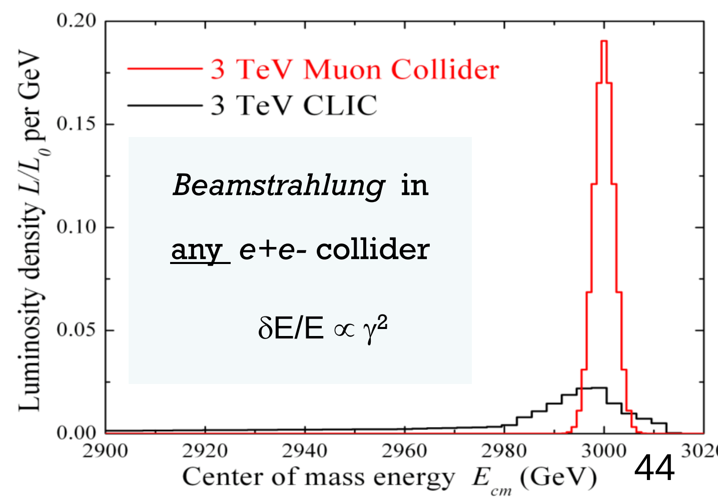
PHYSICS

-NARROW ENERGY SPREAD
- Precision scans, kinematic constr

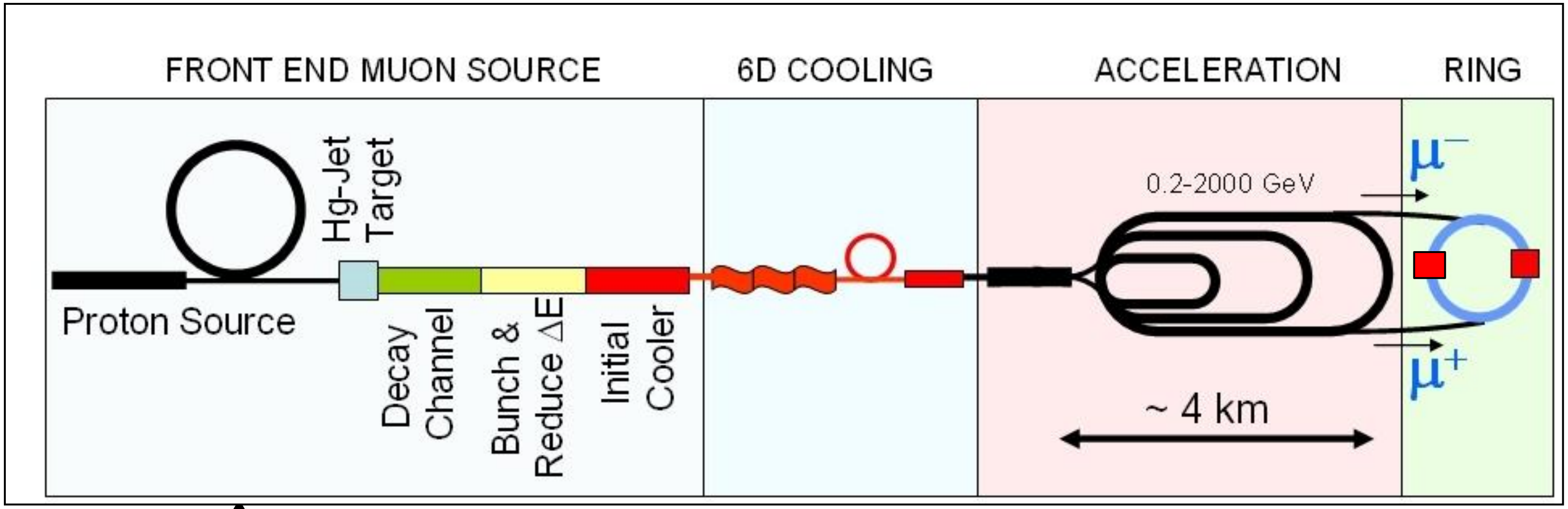
-TWO DETECTORS (2 IPs)

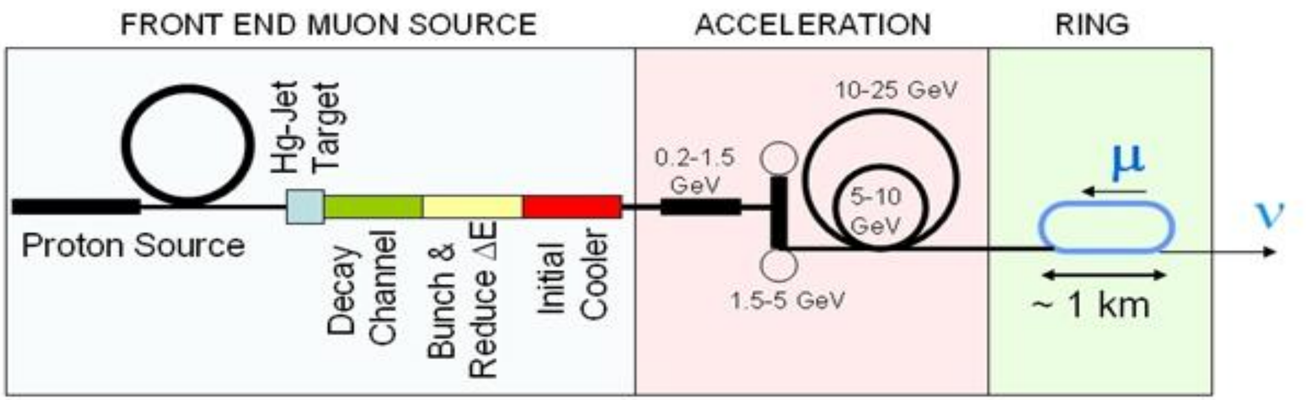
- $\Delta T_{bunch} \sim 10\ \mu s$ … (e.g. 4 TeV collider)
  - Lots of time for readout
  - Backgrounds don't pile up

-$(m_\mu/m_e)^2$ = ~40000
- Enhanced s-channel rates for Higgs-like particles



Muon Collider Schematic



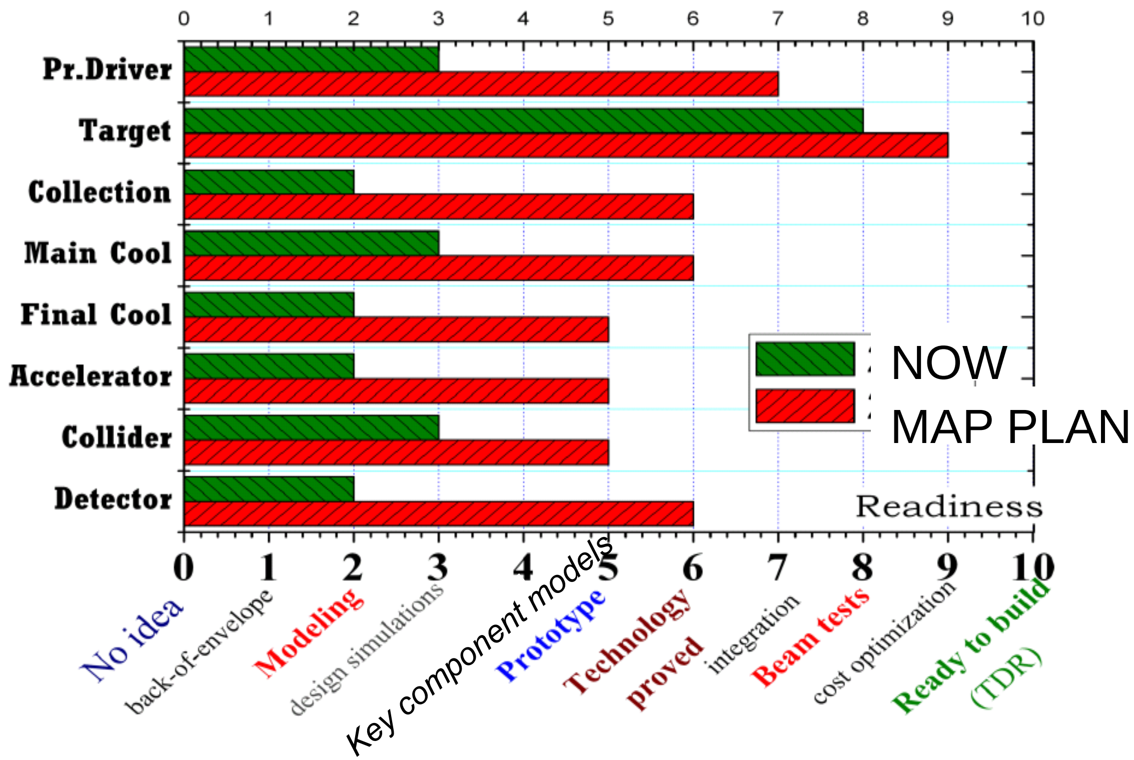


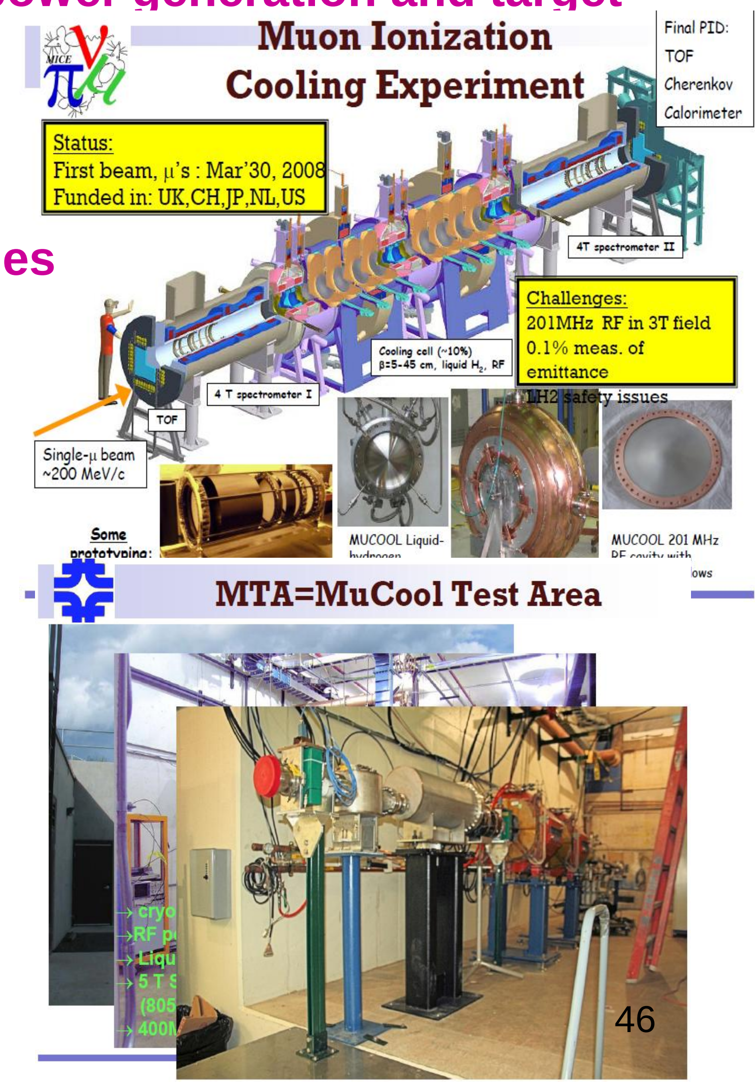
NEUTRINO FACTORY

Neutrino Factory as first possible step towards Muon Collider
Large number of synergies, identical Front End

Muon Collider Issues&Challenges, R&D

- Limited muon lifetime: 2 microsec: ⇨ Race before death!
- Muon generation in large emittance : ⇨ Cooling by 10^5 (6 planes)
  ⇨ MWatts proton beam power generation and target
- Radiations in machine and detectors:
- Novel scheme & technology:
  ⇨ Challenging R&D
  ⇨ Feasibility addressed in Test Facilities

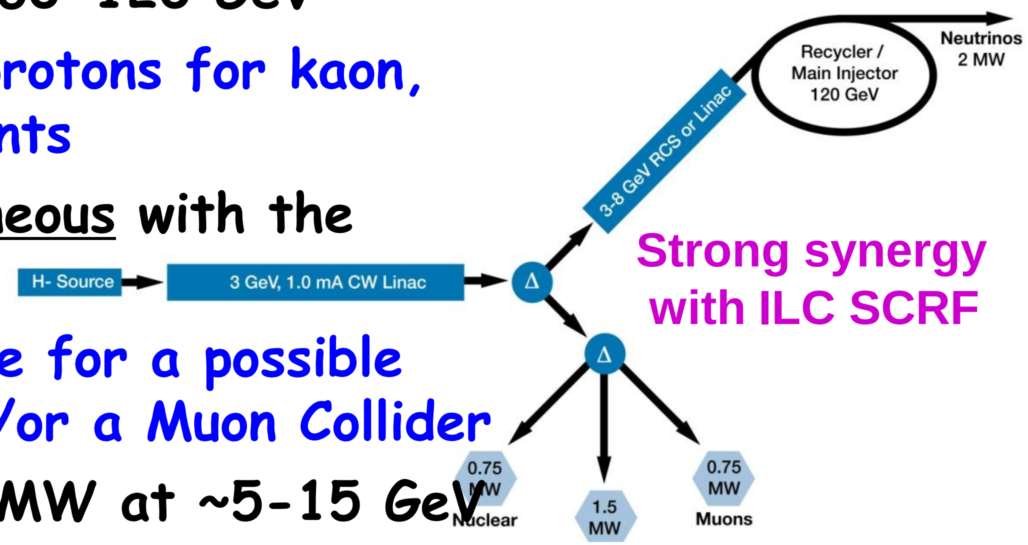




Project X at FNAL: 3 MW proton source

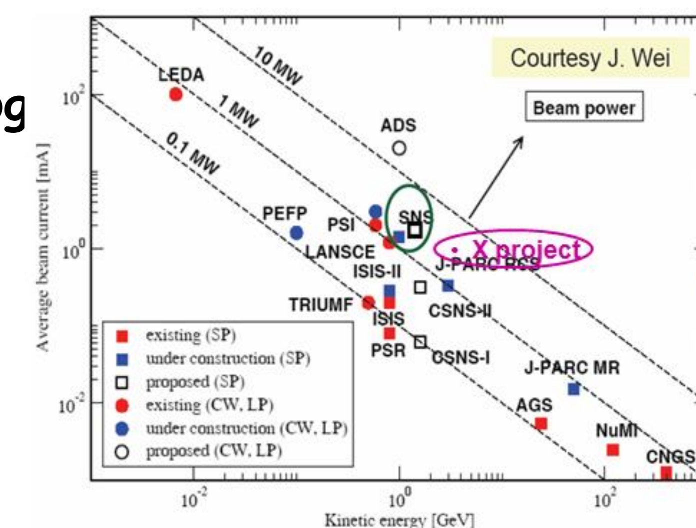
- A neutrino beam for long baseline neutrino oscillation experiments:
  - > 2 MW proton source at 60-120 GeV

- High intensity, low energy protons for kaon, muon, and nuclear experiments
  - >2 MW <u>operations simultaneous</u> with the neutrino program

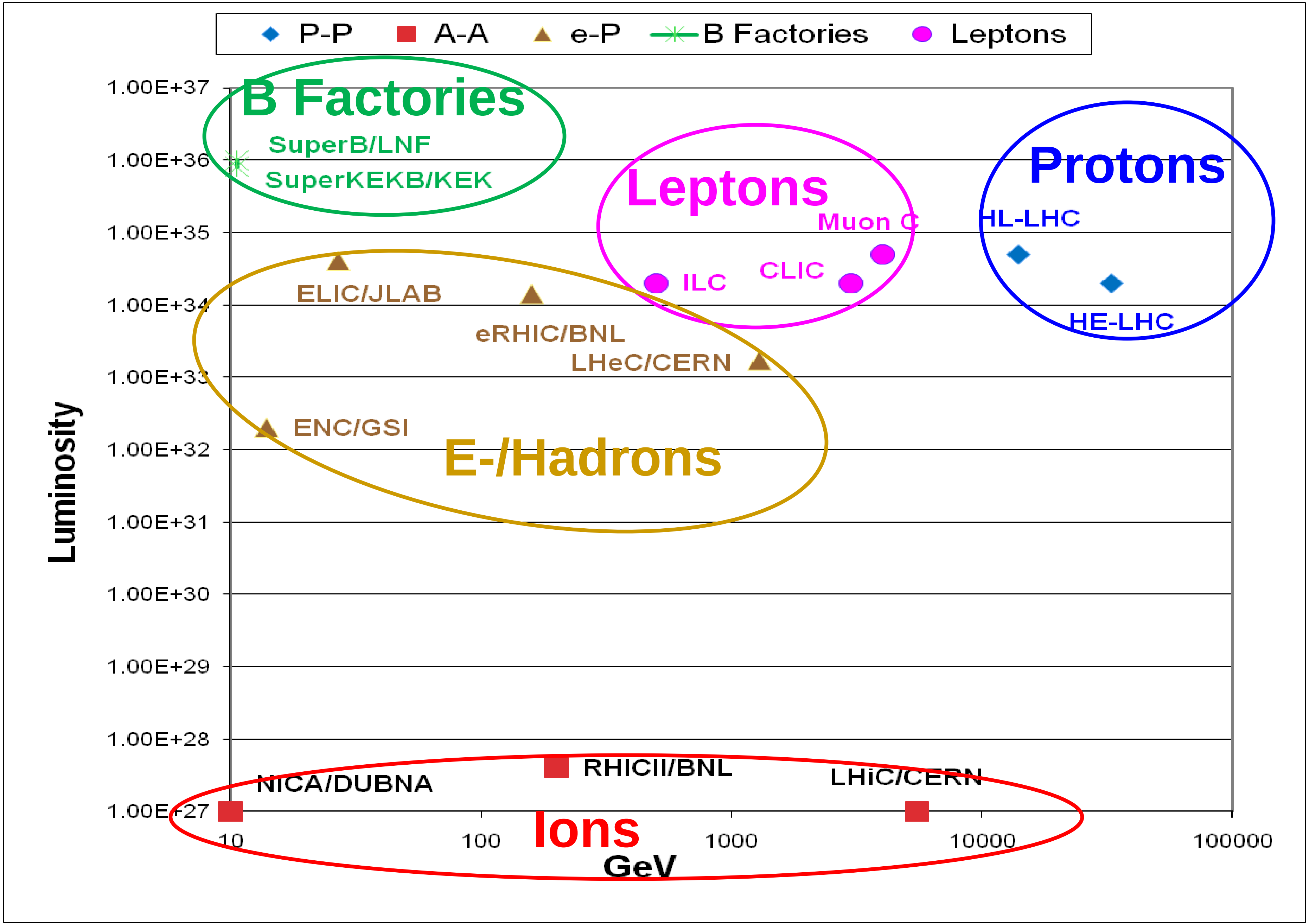


- A path toward a muon source for a possible future Neutrino Factory and/or a Muon Collider
  - Ugrade potential to 2-4 MW at ~5-15 GeV

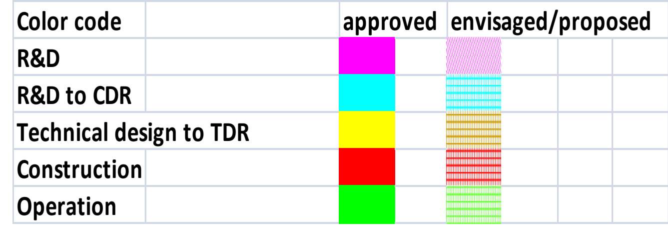
- 3 GeV, 1 mA CW superconducting linac
  - 3 MW beam power for rare processes prog
  - flexible beam provision for multiple users
  - Options for 3-8 GeV acceleration:
  - CS or (1.3 GHz) pulsed linac
  - Main Injector utilized for neutrino prog.



Possible future HEP facilities at Energy/Luminosity frontier

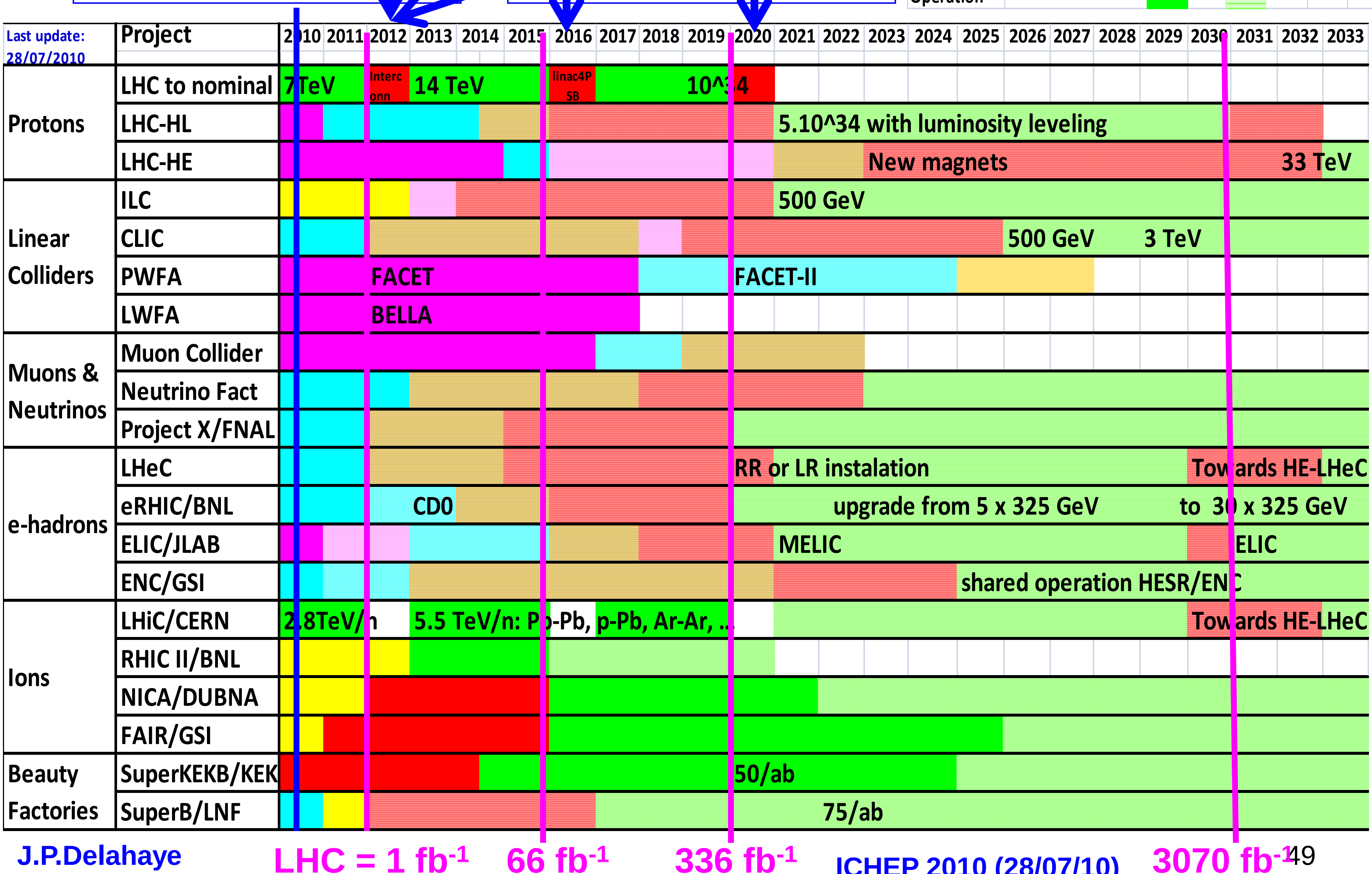


Tentative schedule new projects



European Strategy For Particle Physics

Future facility specif. from LHC Physics?



J.P.Delahaye

ICHEP 2010 (28/07/10)