

FUTURE COLLIDERS

SWOT for various projects

- FCC-ee
- CEPC
- LC [Europe]
- LC [Japan]
- Diversification (PP+APP)
- R&D Muon Collider

DISCLAIMER:
This is the result
of an informal
brainstorming
session

28/06/2024 — Stafoverleg
[indico]

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Nikhef

SWOT

STRENGTHS characteristics of the project that give it an advantage over others

WEAKNESSES characteristics that place the project at a disadvantage relative to others

OPPORTUNITIES elements in the environment that the project could exploit to its advantage

THREATS elements in the environment that could cause trouble for the project

The next slides are based on the input of the three first rounds. All rights reserved.

STRENGTHS At CERN; high lumi at Higgs, tera-Z , multiple IPs (redundancy); Clear upgrade path, FCC-hh; we know how to build it; continuation of expertise; attracts talents long term.

WEAKNESSES Cost (hh even more); environment, soil disposal; limits diversification, future options; coordination across CH/F, governance; limit to beam E; only 1 location possible; no polarisation; hard to sell to public; magnets for hh unproven;

OPPORTUNITIES long-term continuation; great for Europe; Flagship at CERN, secures its future; Magnet R&D (hh); lower cost for Europe; concrete plan for 60 years.

THREATS Cost; late; CEPC; If it fails it's the end of HEP; HL-LHC needs to end; political risk; hard to sell to other fields, threat to other funding; energy consumption; sustainability; lose talents;

See also FCC

STRENGTHS Cheaper; earlier; simple approval process; *ZH* at the start; saves us money; competition with Europe;

WEAKNESSES openness, communication, collaboration, data access; CERN/Europe leadership loss; can they do it?; limit to beam E; political climate; travel; sustainability; no flagship at CERN; Positive relation with China; new direction for CERN; Cross-check of results if FCC; more funding free in Europe;

OPPORTUNITIES Earlier timeline; Lower cost for Europe;

THREATS (Geo)political; End of HEP in Europe, CERN leadership; Not accessible; What if it fails?;

LINEAR COLLIDER IN EUROPE

STRENGTHS Higher energy, polarisation; feasible; neutrino programme; physics at low and high lumi; upgradable, CLIC/wakefield; fits CERN budget; different R&D programme;

WEAKNESSES Single IP; lower lumi below $t\bar{t}$; no feasibility study; Energy limited: low discovery potential; R&D needed for CLIC; too little R&D for LC

OPPORTUNITIES Great physics, innovation in Europe; lower cost; flagship for CERN; cheaper option; accelerator developments; extendable in length

THREATS CERN DG; FCC; HEP ends elsewhere;

[B]

See also LC-Europe.

STRENGTHS Good to have a collider in Asia; They have expertise in e^+e^- ; open to collaboration; fills gap between HL-LHC and FCC

WEAKNESSES No flagship at CERN? Travel/sustainability; Is it still timely?

OPPORTUNITIES Political stability; second large facility in the world; Not our money; participation through CERN; relationship with Japan; opens floor for muons;

THREATS Lack of (inter)national enthusiasm; Japanese politics; stops HEP in Europe; Smaller physics programme than FCC; FCC; smaller community; Upgrades may not happen;

DIVERSIFICATION

STRENGTHS Broader community; boost for APP; viability for CERN; detector R&D; more attractive to funding agencies; good for public opinion; better for other experiments;

WEAKNESSES ET is too different; too many different projects; lose technology at CERN; diverting resources; lose CERN as hub, political leverage; no access to high energy frontier;

OPPORTUNITIES any hint will provide arguments for next facility; focus on AI, quantum; Quantum sensing; links to other fields; Find new physics in new ways, axions; revolution in ν ; multiple locations; collaboration PP/APP;

THREATS FCC leaves no money; Loss of flagship programme; loss of collab. big science; threat to CERN; projects too small to make an impact;

[B]

MUON COLLIDERS



STRENGTHS low synchrotron; new technology; low running cost; NP opportunity; Higgs pole and high energy; staging possible; KT; small; coupling to 2nd generation; highest priority for US; excitement from ECR; synergies with HL-LHC for timing; R&D lower cost;

WEAKNESSES Not yet proven; neutrino radiation; no flagship at CERN (?); uncertain timeline and costs;

OPPORTUNITIES Excitement for the field; CERN has infrastructure for R&D; Links with Fermilab; new technologies; neutrino source; innovative; sellable to public; sustainable; smaller; challenging but clear goal;

THREATS at Fermilab; ν flux and local politics; high risk; takes to big; In Europe delays due to HL-LHC; may not work; competition Europe/USA;

[B]

LEP 3 OR LHC 2

STRENGTHS cheap; still acceptable radiation at ZH , multiple experiments; short gap after LHC; bridge to long term

WEAKNESSES sync. radiation; lower lumi; large energy needs; Higgs self coupling out of reach?

OPPORTUNITIES Forces diversification; magnet developments for pp

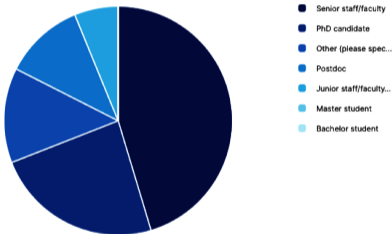
THREATS old tech.

Survey

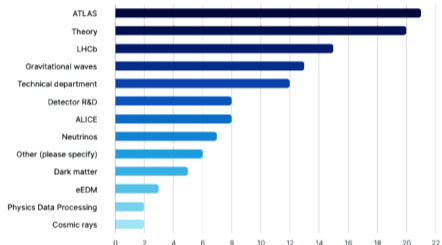
SURVEY

Response statistics: 98 replies

4. I am a



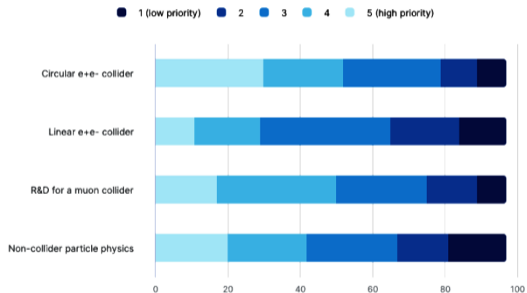
5. I am part of the following group(s)



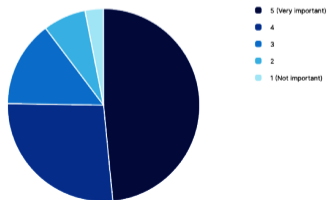
We will not correlate these groups with the responses, except for splitting responses into staff/non-staff.

SURVEY

1. For the upcoming European strategy update, to what extent should Nikhef prioritize



2. How important is it that the next collider is built in Europe?



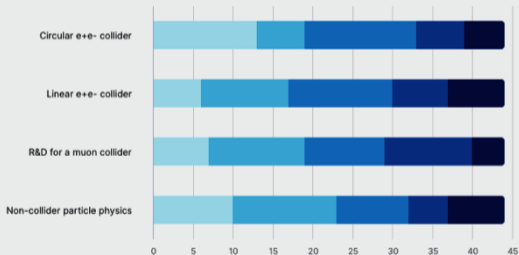
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SURVEY (STAFF ONLY)

1. For the upcoming European strategy update, to what extent should Nikhef prioritize

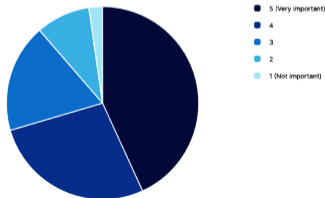
Senior staff responses only

1 (low priority) 2 3 4 5 (high priority)



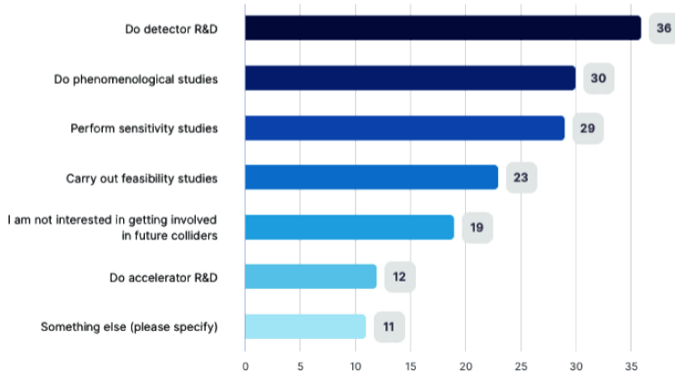
2. How important is it that the next collider is built in Europe?

Senior staff responses only



SURVEY

3. If you would like to get more involved in future colliders, how would you like to do that?



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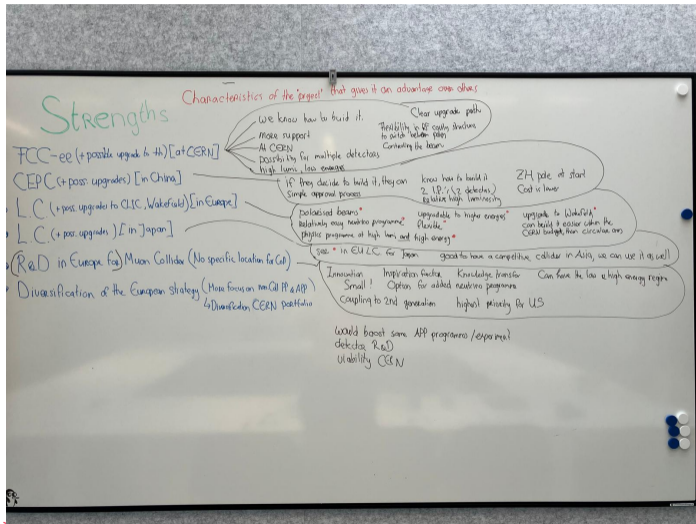
Conclusion

Thanks for participating!



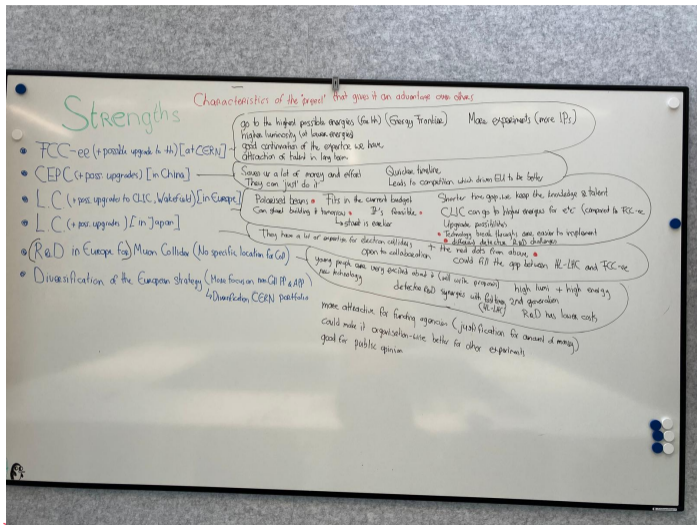
Backup

STRENGTHS



[B]

STRENGTHS



[B]

STRENGTHS

Strengths Characteristics of the "green" that gives it an advantage over others

- FCC-ee (+ possible upgrade to fh) [at CERN]
 - Strong Higgs programme
 - Possible opportunity to upgrade to hh - search higher energies, LHC physics programme, discovery machine
 - Flagship at CERN
 - Consolidates CERN as the place for HEP
 - multiple IPs
 - substantial budget
- CEPC (+ poss. upgrades) [in China]
 - Fastest realisation
 - No financial risk
 - Strong Higgs programme
- L.C. (+ poss. upgrades to CLIC, Wakefield) [in Europe]
 - The upgrade possibilities
 - Higgs programme
 - No BDRS-stitching
 - Shoekel-harrel (less environmental impact / more sustainable)
 - To higher energies
 - Polarised beams
 - Can be a lot cheaper than FCC-ee
 - at least 10 years
- L.C. (+ poss. upgrades) [in Japan]
 - Stimulates the Japanese economy in the North
 - You keep the PP community alive worldwide
- (R&D in Europe for) Muon Collider (No specific location for CE)
 - Both discovery machine and Higgs factory
 - Provides a path to yet higher energies
 - Collisions are cleaner (than H)
 - Something new
 - More attractive for students
 - High gain
 - Drives technological innovation
 - at least 10 years
- Diversification of the European strategy (More focus on non-GIL PP & NP)
 - Diversification CERN portfolio
 - not all eggs in one basket
 - you can do it step by step, you can already do something with a smaller budget
 - keeps a broad scientific community
 - More flexible than with one big flagship
 - will not interfere with the HL-LHC programme

[B]

STRENGTHS

Strengths

Characteristics of the 'project' that gives it an advantage over others

- FCC-ee (+ possible upgrade to tt) [at CERN]
 - Guaranteed future for CERN (not coming 100 years)
 - High energy (PP) 4 or 8 IP's
 - Broad physics programme
 - High luminosity
 - Outreach for massive tunnel construction
 - Technological feasible
- CEPC (+ poss. upgrades) [in China]
 - Not one money, but lot of returns
 - Can be realised quicker (future for younger generation)
 - Slightly more realistic (less time, start at the 40-pole), more practical
 - Chinese technology for non-based (pp merged) (Wu version)
- L.C. (+ poss. upgrade to CLIC, Wakefield) [in Europe]
 - Physics programme (polarised beams) • cheaper solution
 - Can start quicker • Can gradually put in more money to go to higher energies
 - Technology utilisation by ion industry
- L.C. (+ poss. upgrade) [in Japan]
 - something during our building of FCC-ee
 - Doesn't cost us money
- (R&D in Europe for) Muon Collider (No specific location for Coll)
 - If can do everything exciting technology lot of research to do guaranteed future for CERN
 - Highly Factory + discovery machine can be sold to the public
 - lot of technology you can bring to industry • outreach and funding via smaller footprint
 - cheaper fundamental shift of technology to the next level
 - Risk mitigation discovery potential increases
 - cheap, diverse, low-risk
- Diversification of the European Strategy (More focus on non-Gal IP & AP)
 - ↳ Diversification, CERN portfolio

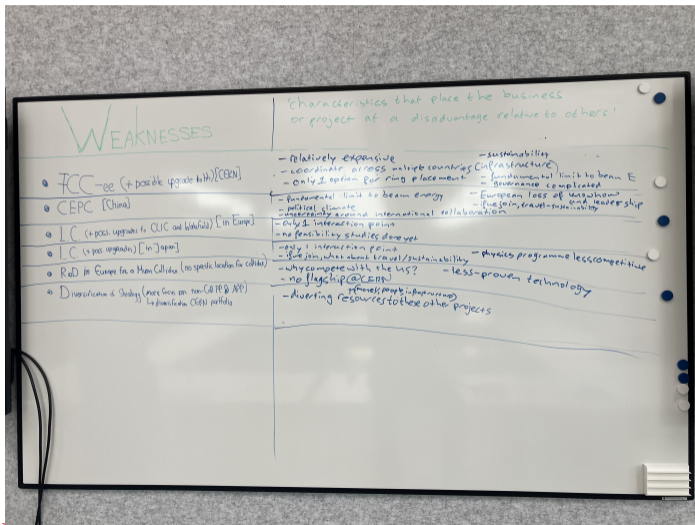
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WEAKNESSES

WEAKNESSES	'characteristics that place the business or project at a disadvantage relative to others'
<ul style="list-style-type: none"> • FCC-ee (+ possible upgrade to FCC) [CERN] 	<ul style="list-style-type: none"> - relatively expensive - LH is even more expensive - building ee implies building LH → fixes the future
<ul style="list-style-type: none"> • CEPC [China] 	<ul style="list-style-type: none"> - collaboration with non-Chinese countries? - can they do it? - CERN leadership?
<ul style="list-style-type: none"> • ILC (+ possible upgrades to CLIC and MuonCollider) [in Europe] 	<ul style="list-style-type: none"> - only 2 interaction points - long-term: below \mathbb{E} threshold
<ul style="list-style-type: none"> • ILC (+ possible upgrades) [in Japan] 	<ul style="list-style-type: none"> - what will be the flagship of CERN? - CERN leadership?
<ul style="list-style-type: none"> • ReD in Europe for a Muon Collider (no specific location for collider) 	<ul style="list-style-type: none"> - not yet proven - radiation issues
<ul style="list-style-type: none"> • Diversification of Strategy (more CERN can non-Colliders @ IFF) 	<ul style="list-style-type: none"> - a flagship project is more under risk - too many different projects - less technology focus @ CERN
<ul style="list-style-type: none"> • Diversification CERN portfolio 	<ul style="list-style-type: none"> - lose magnet tech @ CERN

[B]

WEAKNESSES



[B]

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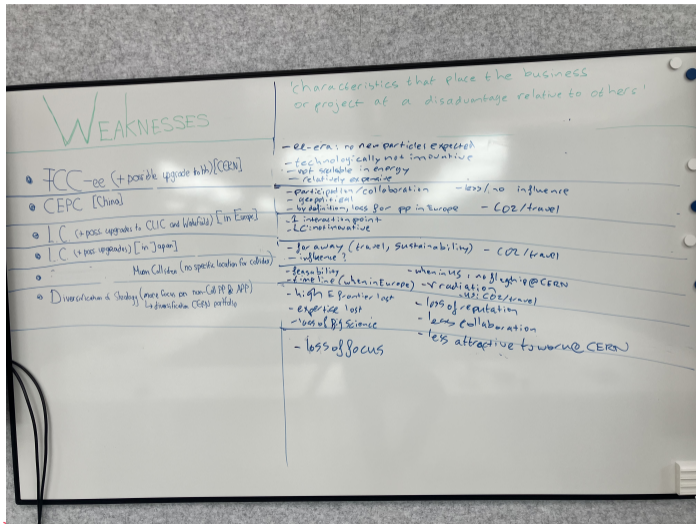
- FCC-ee (+ possible upgrade to h) [CEBN]
- CEPC [China]
- LC (+ poss. upgrades to CLIC and Wakefield) [in Europe]
- LC (+ poss. upgrades) [in Japan]
- RnD in Europe for a Muon Collider (no specific location for collider)
- Diversification & Strategy (more focus on non-Coll. PP @ APP)
↳ diversification CERN portfolio

'characteristics that place the business or project at a disadvantage relative to others'

- no polarised beams
- relatively expensive
- hard to sell to general public (costs, sustainability)
- magnet RnD needed (not proven)
- geopolitical situation — labour conditions
- no flagship @ CERN — Europe/CEBN collaboration with China
- political money, not expertise to China (access to facilities/data)
- Energy limited — CLIC: a lot of RnD needed
- limited discovery potential — LC: little RnD is also not desirable
- Energy limited — no flagship @ CERN
- still ethically? — neutrino regeneration
- feasibility — long timescale (uncertain)
- secure costs
- lose public perception of CERN as the accelerator complex
- lose political leverage
- lose access to high energy frontier

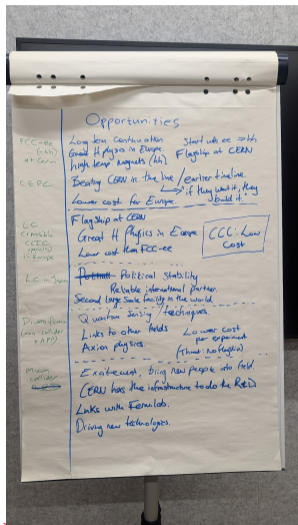
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WEAKNESSES



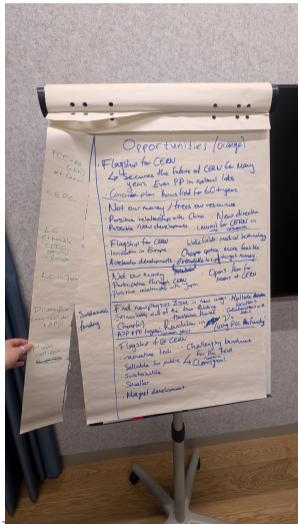
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OPPORTUNITIES



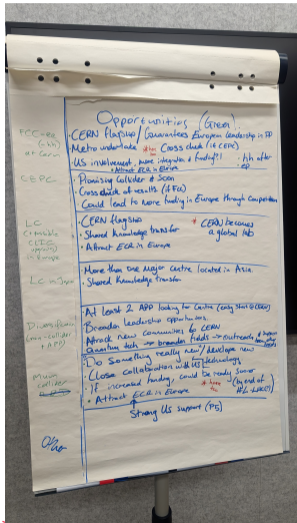
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OPPORTUNITIES



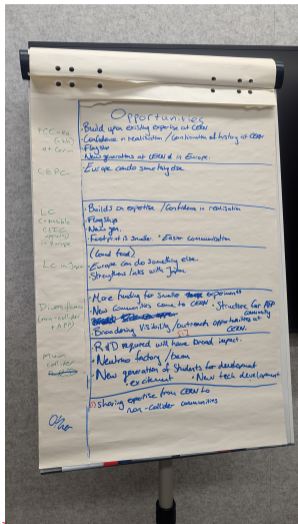
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OPPORTUNITIES



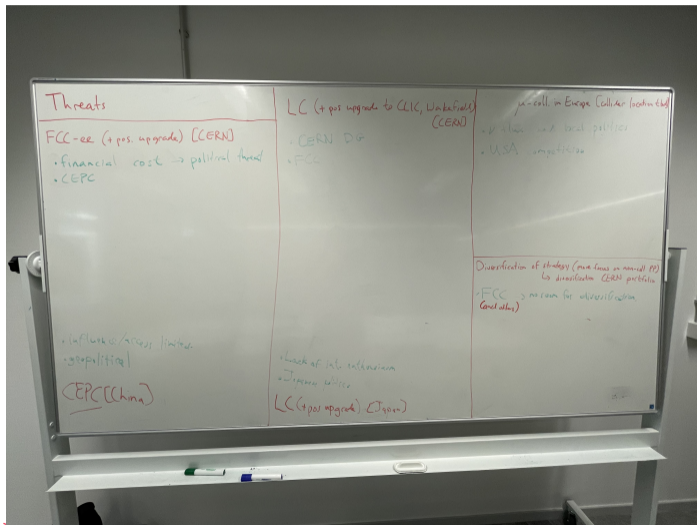
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OPPORTUNITIES



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THREATS



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THREATS

Threats

FCC-ee (+ pos. upgrade) [CERN]

- if it fails (to expensive/pol. problems)
→ end of particle physics
- HL-LHC program (needs to end early)
- CEPC
- political risk
- hard sell to other fields
- threat to funding of other projects
- energy consumption
- environmental (CO₂)

- end of PP in Europe
- not accessible, politics

CEPC (China)

LC (+ pos upgrade to CLIC, Wakefield) [CERN]

- PP elsewhere (US/Japan) stops

Disunity at LHC just
beyond energy of threshold

- Japanese politics
blocks PP in Europe

LC (+ pos upgrade) [Japan]

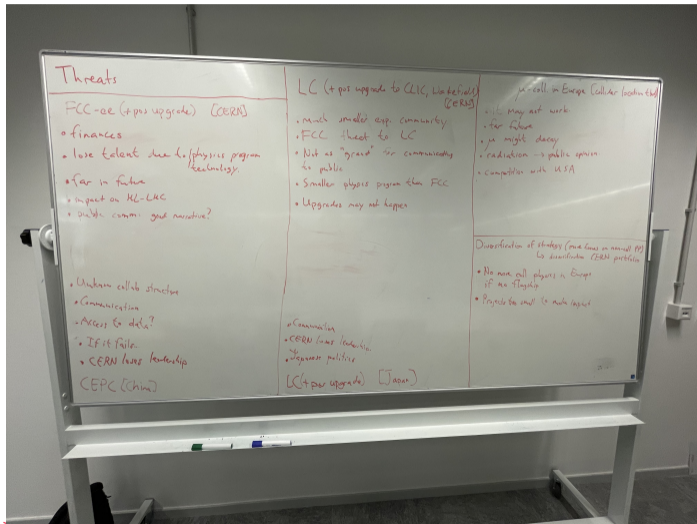
coll. in Europe (collider location that)

- high risk
- takes too long → impact on community.
- In Europe construction delayed by HL-LHC
- In Europe: ν radiation.

Diversification of strategy (move focus on non-coll PP)
↳ diversification CERN portfolio

- Loss of flag ship program
→ lose momentum
- loss of cult by science
- Threat to CERN

THREATS



[B]

THREATS

Threats

FCC-ee (+ pos upgrade) [CBRH]

- decrease of funding from competition with CERN
 - too expensive \leftarrow for governments not supported by public
 - HL-LHC planning*
 - Lack of support of (some of) communities
 - Decreased support for science funding*
 - Possibility for increased industrialism (due to increased data, global lab)
- * may hold for all CERN projects
- Sustainability/power consumption

- Brain drain to CERN
- Political risk
- No transparency: that physics results (CERN [China])

LC (+ pos upgrade to CLIC, Wakefield) [CERN]

- Decreased support for science funding
- Finances: CLIC is still much cheaper

- Feasibility study of tunnel may come back negative

- Brain drain to Japan
- Antiquities

LC (+ upgrade) [Japan]

pos coll. in Europe Collider (contested)

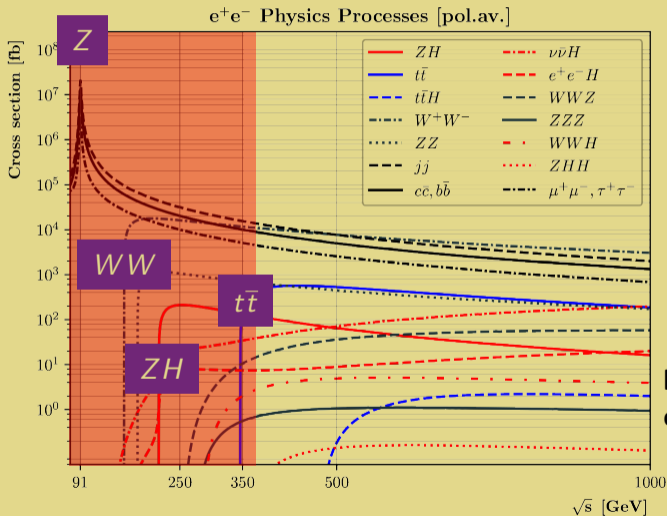
- High risk, may not work
- Medium flux (public perception)
- Significant delay
- Friction with USA
- No plan B

Diversification of strategy (more lines on overall FP) \rightarrow diversification CERN portfolio

- Diversification becomes critical
- Easier to cut

ECFA e^+e^- HIGGS/TOP/EW FACTORY STUDY

circular
colliders



linear
colliders