Update of the European Strategy for Particle Physics

Status report

K.Desch, University of Bonn, Bad Honnef 16/11/2012

Strategy Process

The European Strategy Group (ESG)

The remit of the ESG is to establish a **proposal** for an Update of the medium and long-term European Strategy for Particle Physics, for approval by the Council. It is proposed that the proposal will take the following elements into account:

The Update of the European Strategy for Particle Physics shall in particular aim at:

enhancing the visibility of existing European particle physics programmes;

increasing collaboration among Europe's particle physics laboratories, institutes and universities;

promoting a coordinated European participation in global projects and in regional projects outside Europe;

encouraging knowledge transfer to other disciplines, industry, and society.

The proposal shall include a review of the implementation of the 2006 Strategy, as well as of the structures and procedures currently in place with regard to the Strategy.

The proposal **shall outline priorities following a thematic approach, with special emphasis on future large infrastructures/projects, including preparatory steps for a next project at CERN after LHC in a global context**, and consider time scales and resources. **It shall also consider possible future participation by CERN in experiments outside the Geneva Laboratory as part of the Strategy implementation.**

The proposal shall comprise a series of ordered and concise statements of 1-2 lines each, or 1-2 pages in total followed by more detailed presentations that shall not exceed 25 pages.

http://europeanstrategygroup.web.cern.ch

European Strategy Group ESG

- Member States
- Austria Prof. A.H. Hoang
- Belgium Prof. W. Van Doninck
- Bulgaria Prof. L. Litov
- Czech Republic Prof. J. Chyla
- Denmark Prof. J.J. Gaardhoje
- Finland Prof. P. Eerola
- France Prof. E. Augé
- Germany Prof. S. Bethke
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- Norway Prof. A. Read
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- Portugal Prof. G. Barreira
- Slovakia Dr L. Sandor
- Spain Prof. F. del Aguila
- Sweden Prof. B. Asman
- Switzerland Prof. K. Kirch
- U.K. Prof. J. Butterworth
-
- CERN Director General Prof. R. Heuer
-
- Major European National Laboratories
- CIEMAT C. Lopez
- DESY J. Mnich
- IRFU Ph. Chomaz
- LAL A. Stocchi
- NIKHEF F. Linde
- LNF U. Dosselli
- LNGS S. Ragazzi
- PSI L. Rivkin
- STFC-RAL J. Womersley
-

- Strategy Secretariat Members
- Scientific Secretary (Chair) Prof. T. Nakada
- SPC Chair Prof. F. Zwirner
- ECFA Chair Dr M. Krammer
- Repres. EU Lab. Directors' Mtg Dr Ph. Chomaz
-
- **Invitees**
- Candidate for Accession
- Romania Dr S. Dita
- Associate Member in the pre-stage of Membership
-
- Israel Prof. E. Rabinovici
- Observer States
- India Prof. T. Aziz
- Japan Prof. Sh. Asai
- Russian Federation Prof. A. Bondar
- Turkey Prof. Dr M. Zeyrek
- United States Prof. M. Shochet
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- EU Dr R. Lecbychová
- ApPEC Dr S. Katsanevas
- Chairman FALC Prof. Y. Osaka
- Chairman ESFRI Dr B. Vierkorn-Rudolph
- Chairman NuPECC Prof. A. Bracco
- JINR, Dubna Prof. V. Matveev
-
- Scientific Assistant Prof. E. Tsesmelis

34 members + 13 invitees

Preparatory Group ESPG

- **Strategy Secretariat Members**
- Prof. T. Nakada Scientific Secretary (Chair)
- Prof. F. Zwirner SPC Chair
- Dr M. Krammer ECFA Chair
- Dr Ph. Chomaz Repres. EU Lab. Directors
-
- **SPC**
- Prof. R. Aleksan (FR)
- Prof. P. Braun-Munzinger (DE)
- Prof. M. Diemoz (IT)
- Prof. D. Wark (UK)

- **ECFA**
- Prof. K. Desch (DE)
- Prof. K. Huitu (FI)
- Prof. A. P. Zarnecki (PL)
- Prof. C. De Clercq (BE)
-
- **CERN**
- Dr P. Jenni
-
- **ASIA/AMERICAS**
- Prof. Y. Kuno (Asia)
- Prof. P. McBride (Americas)
-
- Prof. E. Tsesmelis Scientific Assistant

16 members

ESPG working „groups“

1. Physics at High Energy Frontier: P.Jenni, M. Diemoz, K. Desch, P. McBride, M.Krammer
2. Strong Interaction Physics: P. Braun-Munziger, A. P. Zarnecki
3. Flavour Physics and Symmetries: T. Nakada, Y. Kuno
4. Physics of Neutrinos: D. Wark
5. Astroparticle Physics, Gravitation and Cosmology: C. De Clerc, P. Chomaz
6. Accelerator Physics: R. Aleksan
7. Particle Physics Theory: F. Zwirner, K. Huitu
8. Large Infrastructures: P. Chomaz, P. McBride

ESG organisational working groups

- 1) Mandate and organisational structure for the Council for the European Strategy and its implementation (to be handled by the President's Group);
- 2) Organisational structure for European participation in global projects, including the role and definition of the National Laboratories and the CERN Laboratory in the European Strategy;
- 3) Relations with external bodies, in particular EU-related issues;
- 4) Knowledge and technology transfer, relations with industry;
- 5) Outreach and education.

Time line

Summer 2011	Process started
02/2012	Call for submissions from community
08/2012	161 submissions received (from national communities, labs, experiments, groups, individuals – including statement from KET)
09/2012	Krakow symposium
15/10/2012	Additional community input (o(10))
11/2012	Finalize Briefing Book for ESG
12/2012	Present Briefing Book to ESG
20-26/01/2013	ESG Drafting Session (Erice)
03/2013	Finalization of Strategy by Council
22 or 23/05/2013	Adoption of Strategy by Council in Brussels – coinciding with EU council ministers meeting including outreach event (EU parliament)

Krakow symposium

- 10-12 September
- Close to 500 participants (+ webcast)
- Plenary talks on all working group topics + much room for discussion

http://espp2012.ifj.edu.pl

Outcome →

A lot (positive) has happened!

(since previous strategy process 2005/06)

- LHC up and running!
- Discovery of a Higgs-like boson
- No direct evidence for NP yet (significantly extended direct & indirect limits)
- Θ_{13} large → CPV in neutrino sector accessible

Updated strategy has to reflect this

High Energy Frontier: key issues

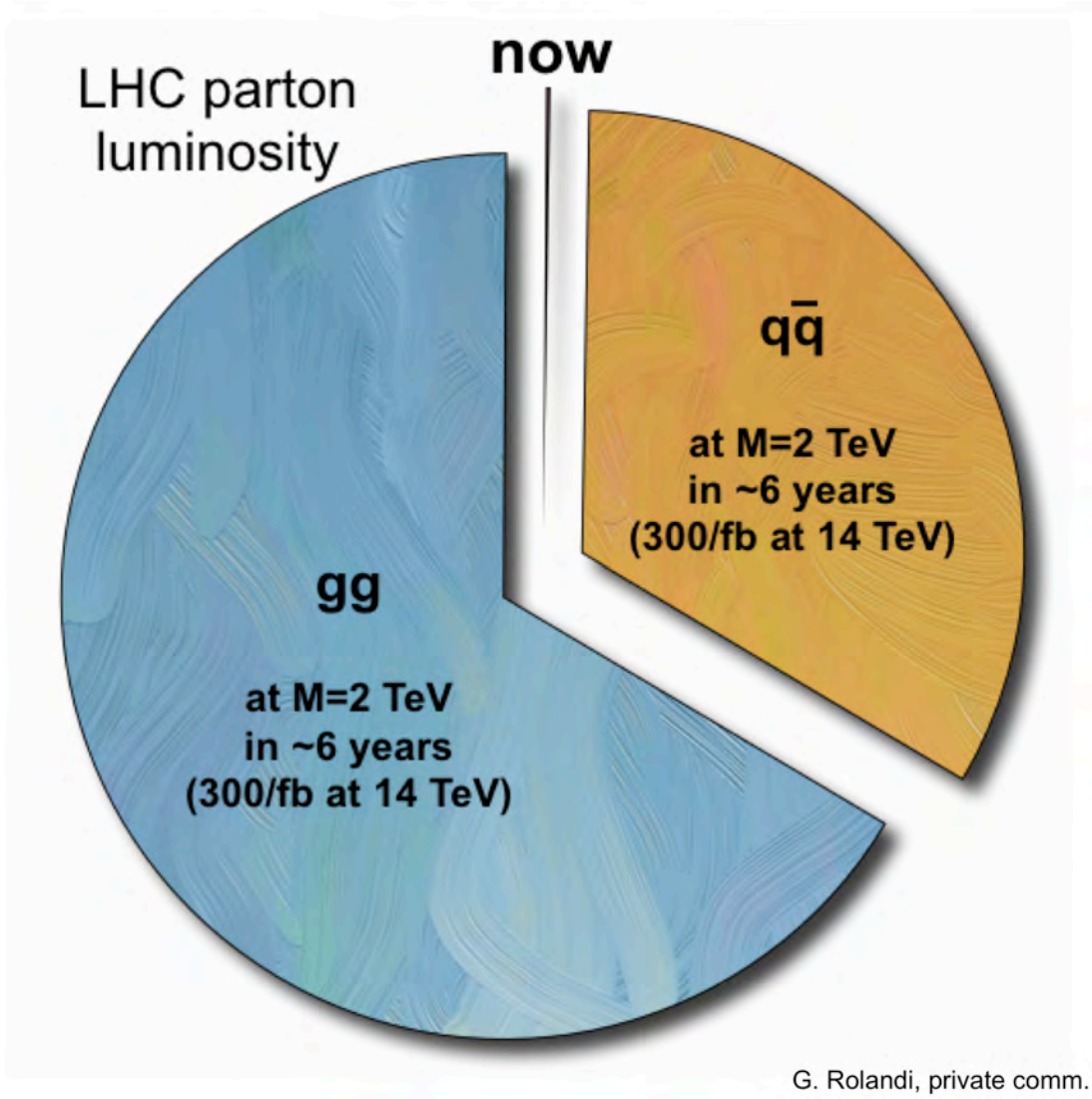
- Upgrade of LHC („HL-LHC“): goal 1000- 3000 fb^{-1} by 2030 ?
- Initiative from Japan: ILC as global project ?
- „The next HEF machine at CERN“
  - what type (pp, e^+e^-, $\mu^+ \mu^-$)?
  - when to decide?
  - accelerator R&D: yes, but how much, on what?

Proton proton colliders

Facility	Years	Ecm [TeV]	Luminosity [10^{34} $cm^{-2}s^{-2}$]	int Luminosity [fb^{-1}]	Comments
nominal LHC	2014-2021	14	1-2	300	
HL-LHC	2023-2030	14	5	3000	luminosity levelling
HE-LHC	>2035	26-33	>2	100-300 / yr	dipole fields 16-20 T
V-LHC		42-100			new 80 km tunnel

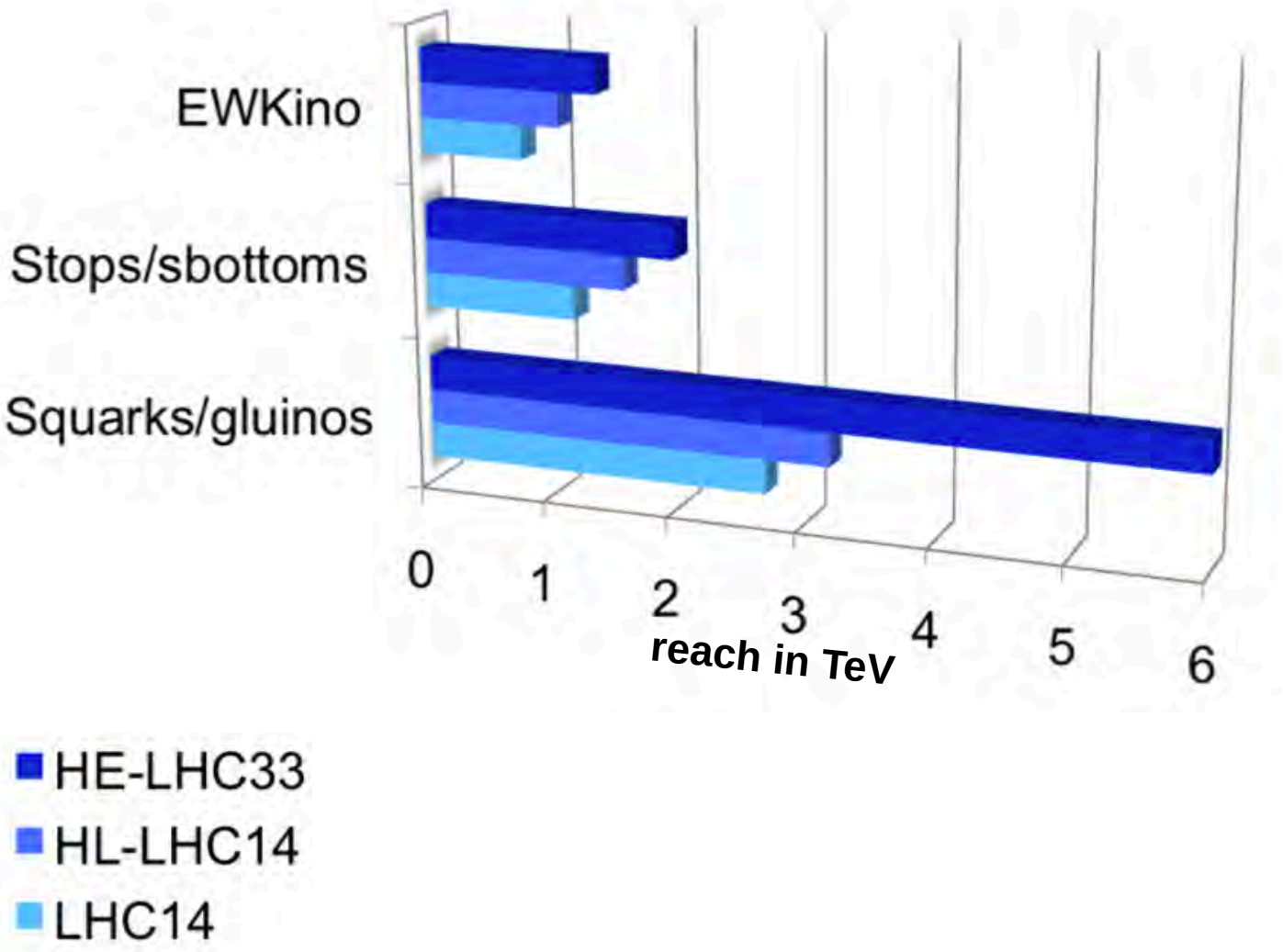
T.Wyatt, Krakow

LHC: the best is yet to come

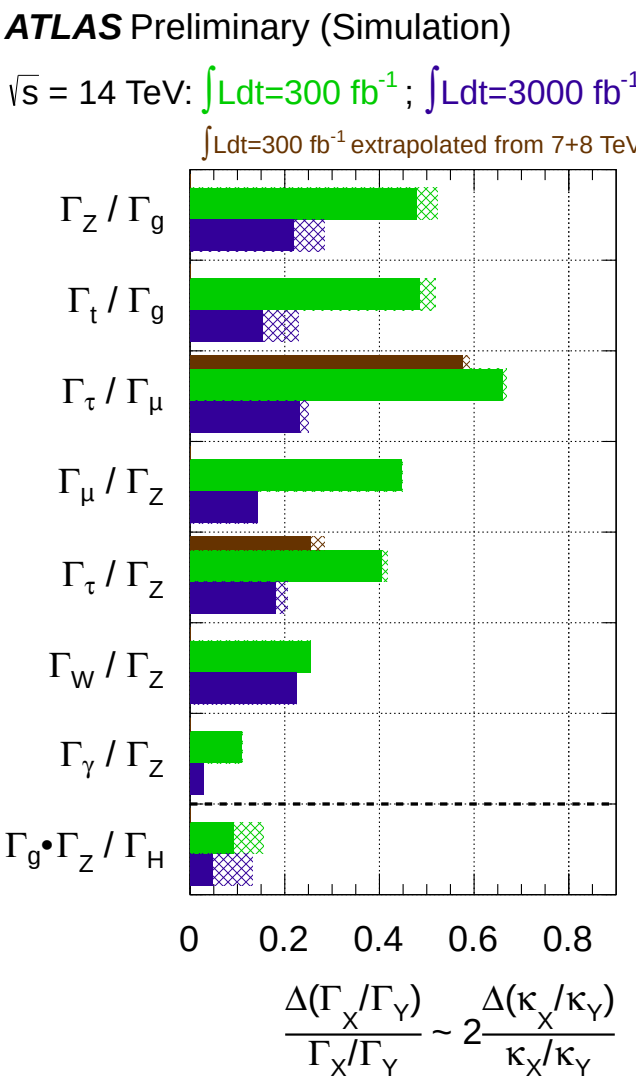


G. Rolandi, private comm.

Motivation for HL-LHC(1)



Motivation for HL-LHC(2)



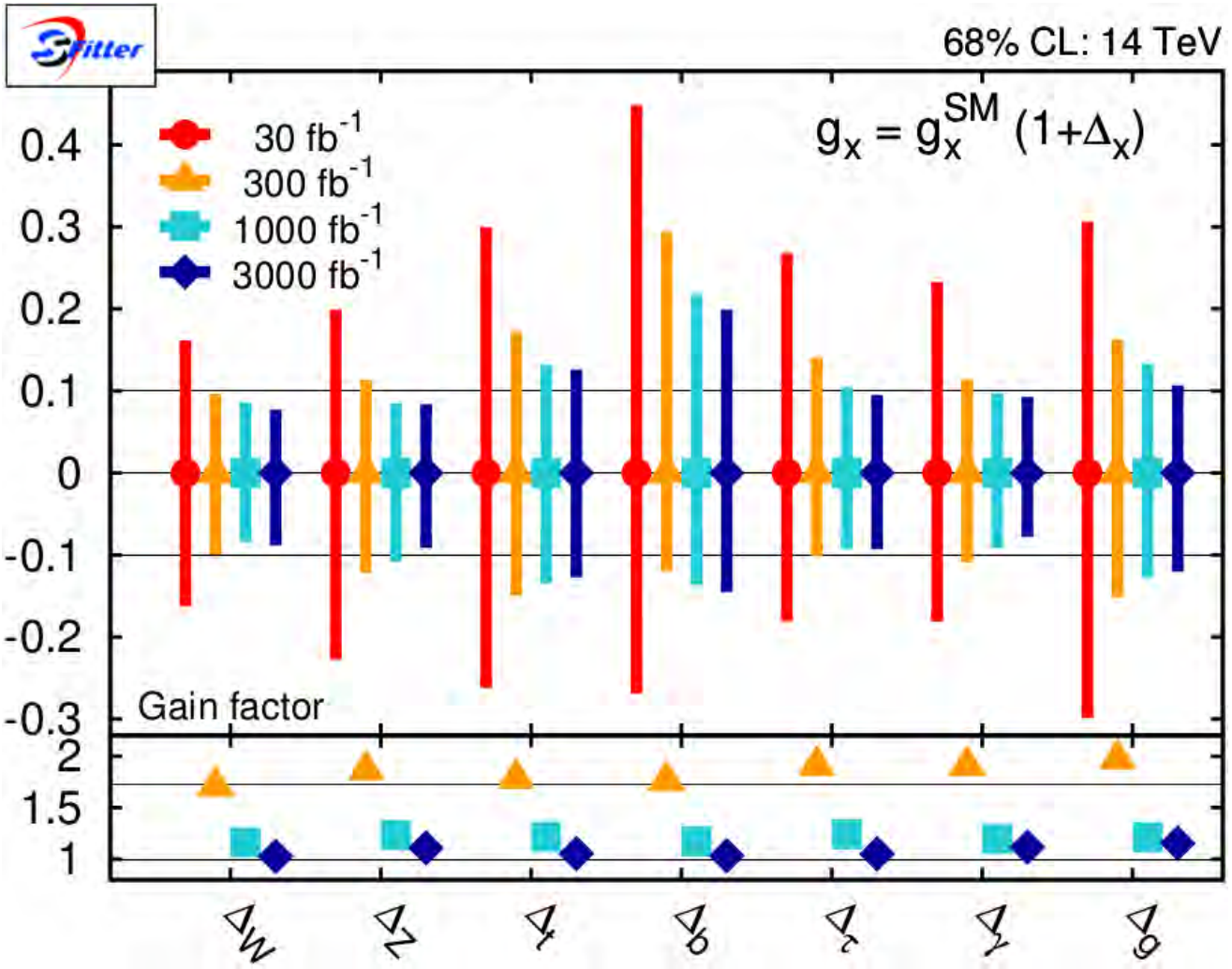
CMS

Coupling	Uncertainty (%)			
	300 fb^{-1}		3000 fb^{-1}	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2
κ_γ	6.5	5.1	5.4	1.5
κ_V	5.7	2.7	4.5	1.0
κ_g	11	5.7	7.5	2.7
κ_b	15	6.9	11	2.7
κ_t	14	8.7	8.0	3.9
κ_τ	8.5	5.1	5.4	2.0

„Scenario 2“ = divide theo errors by two
+ scale syst. errors with √L

- Need effective Lagrangians and fix total width to observed width
- Systematics and theory uncertainties crucial

Motivation for HL-LHC(3)



T.Plehn, D.Zerwas, M.Rauch et al - preliminary

Motivation for HL-LHC(4)

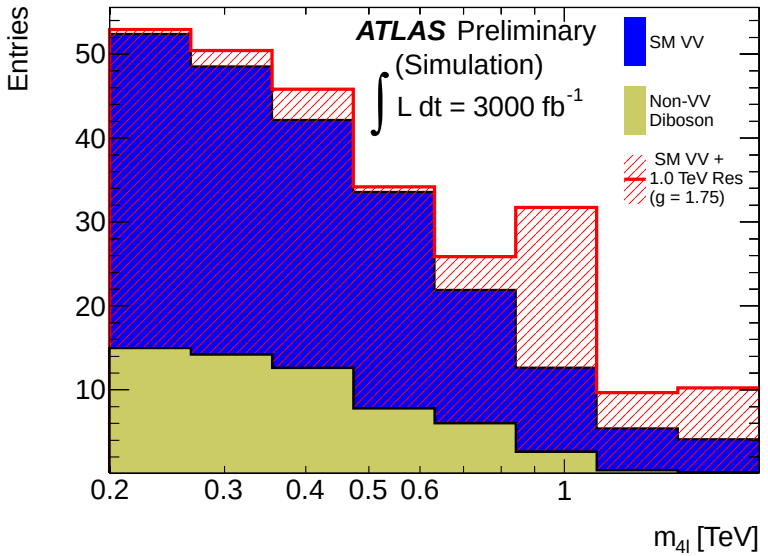
Higgs self-coupling:

ATLAS: bbγγ S/B 15/24 events for 3000 fb^{-1}

(may be 30% on g_{HHH} for both expts and including channels not yet studied ???)

$W_LW_L \rightarrow W_LW_L$:

model	300 fb^{-1}	3000 fb^{-1}
$m_{resonance}$ = 500 GeV, g = 1.0	2.4σ	7.5σ
$m_{resonance}$ = 1 TeV, g = 1.75	1.7σ	5.5σ
$m_{resonance}$ = 1 TeV, g = 2.5	3.0σ	9.4σ



e^+e^- colliders

	ILC	ILC	ILC	CLIC	CLIC	CLIC	LEP3
√s [GeV]	250	500	1000	500	1500	3000	240
Luminosity [10^{34} $cm^{-1}s^{-1}$]	0.75	1.8	4.9	1.3	3.7	5.9	1 per IP
>0.99 √s fraction	87%	58%	45%	54%	38%	34%	100%
polarization e^-	80%	80%	80%	80%	80%	80%	-
polarization e^+	30%	30%	20%	>50%?	>50%?	>50%?	-
beam size σ_x [nm]	729	474	335	100	60	40	71000
beam size σ_y [nm]	7.7	5.9	2.7	2.6	1.5	1	320
Power [MW]	128	162	300	235	364	589	200

T.Wyatt, Krakow

ILC physics goals

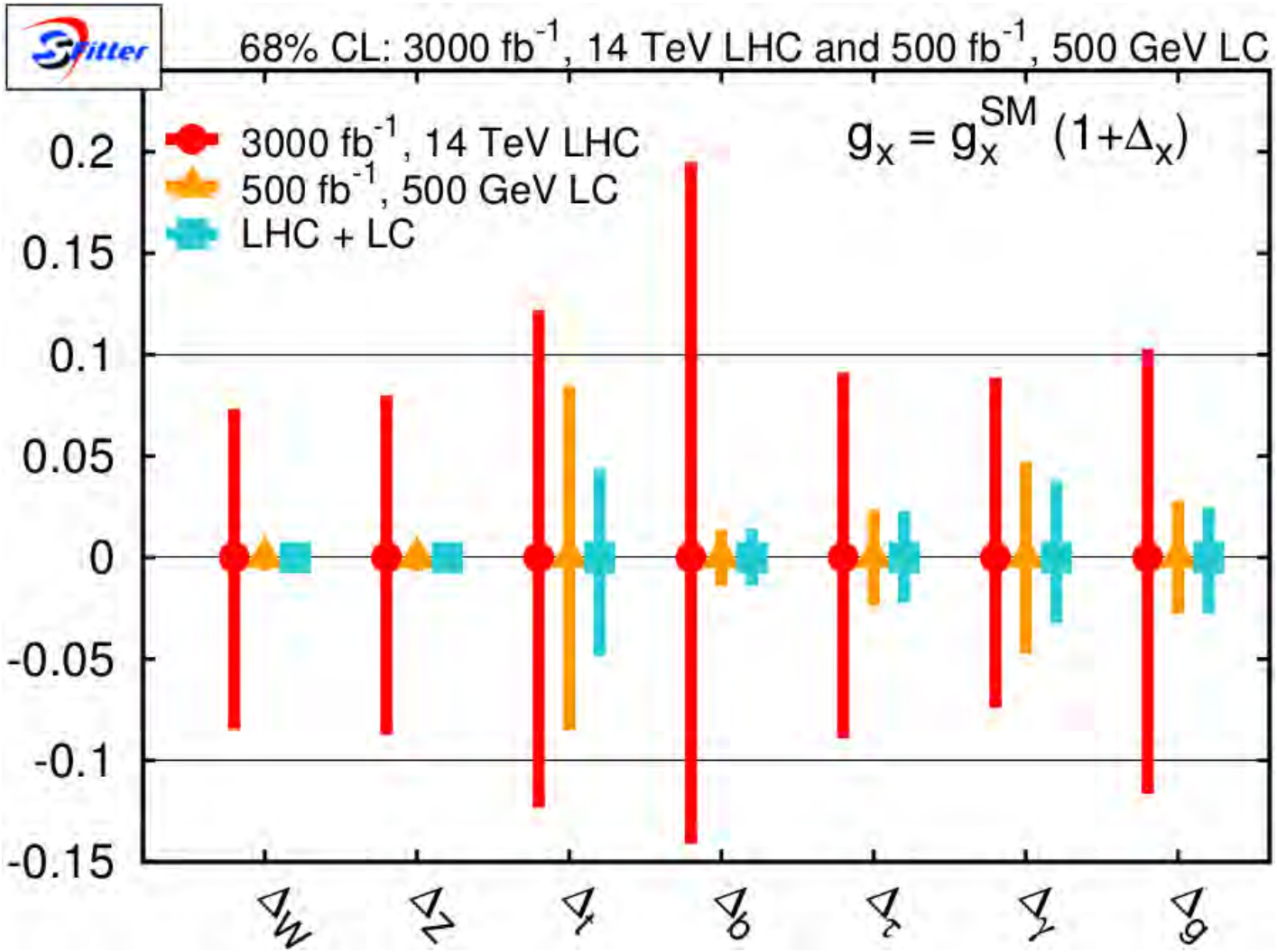
- Study the new boson in a model independent way (qualitative difference to (HL)LHC)
- Precise & complementary measurements of the top quark
- Precision measurements of SM processes (sensitive to EWSB, NP) e.g. TGC, QGC
- Study directly NP (found or not-found at LHC)

→ EWSB sector as gateway to NP

ILC – Higgs: far beyond LHC potential

- Model-independent g_{HZZ} (~1%) (250 or 350)
- Total width (350 or 500)
- Absolute BR´s (including cc,gg) (250 or 350)
- Absolute g_{Htt} (500 +)
- Self coupling g_{HHH} (also not easy at any LC) (500, ... 1000)
- CP even-odd admixtures
- Invisible and light-flavour decays

ILC - Higgs

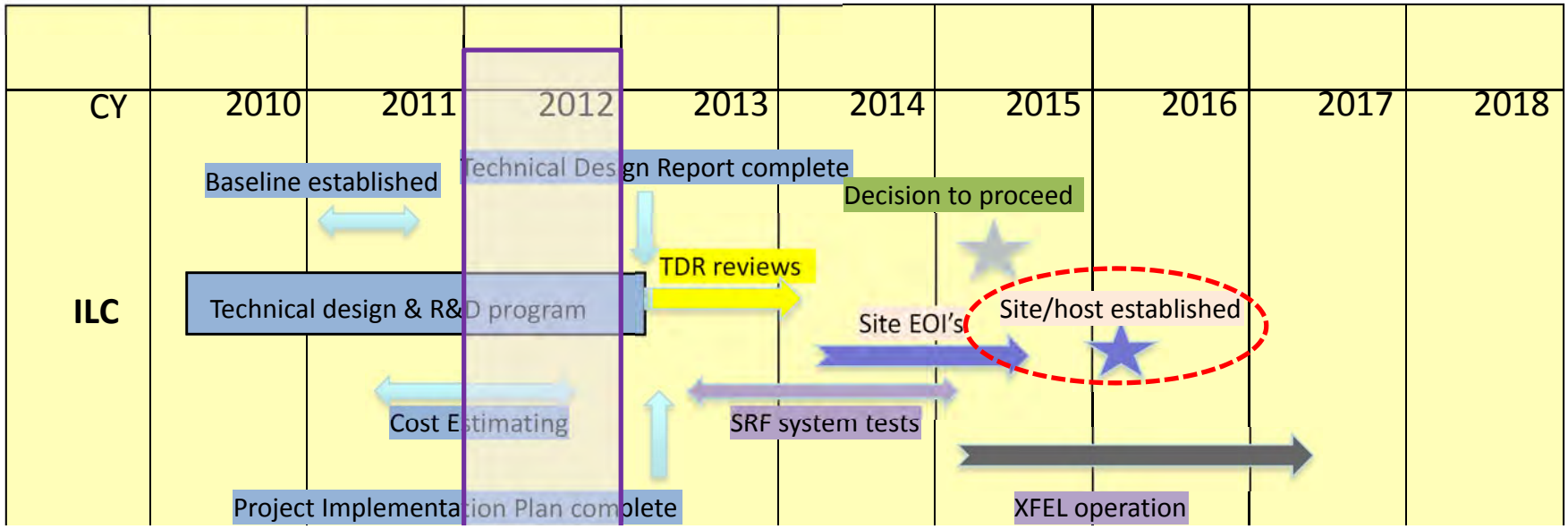


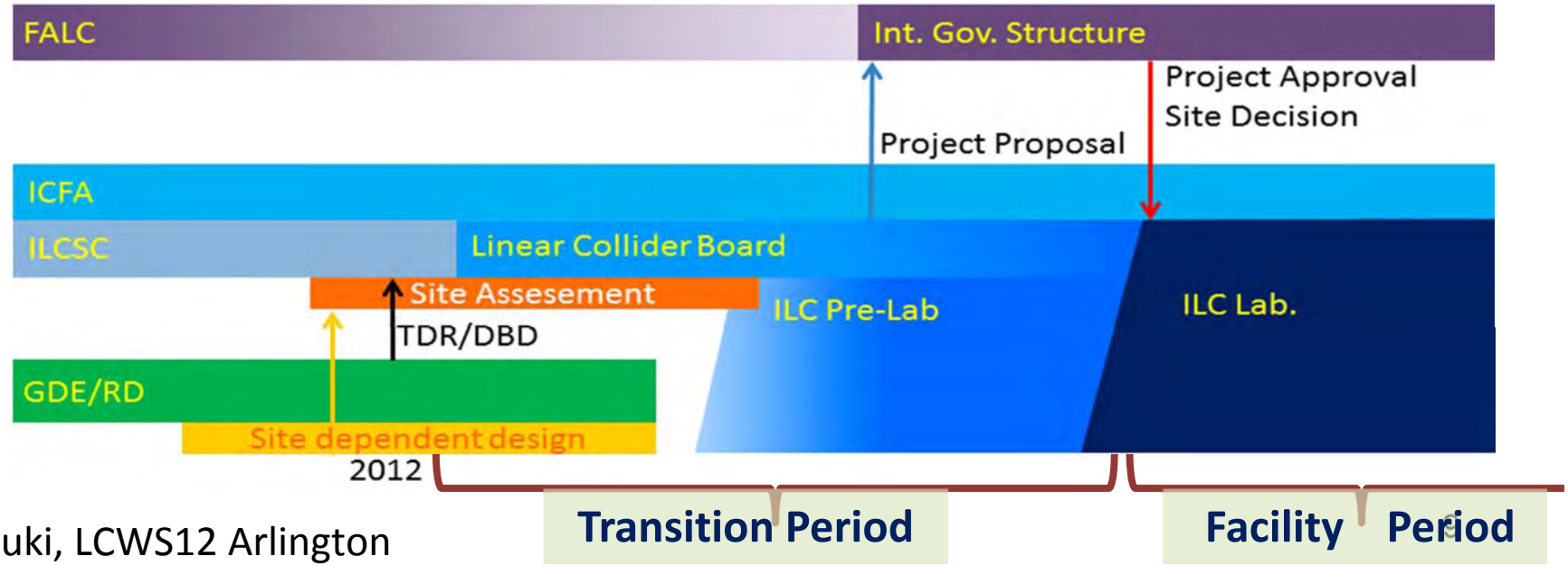
T.Plehn, D.Zerwas, M.Rauch et al - preliminary

ILC Plan in Japan

- Japanese HEP community proposes to host ILC based on the "staging scenario" to the Japanese Government.
  - ILC starts as a 250GeV Higgs factory, and will evolve to a 500GeV machine.
  - Technical extendability to 1TeV is to be preserved.
- It is assumed that one half of the cost of the 500GeV machine is to be covered by Japanese Government. However, the share has to be referred to inter-governmental negotiation.

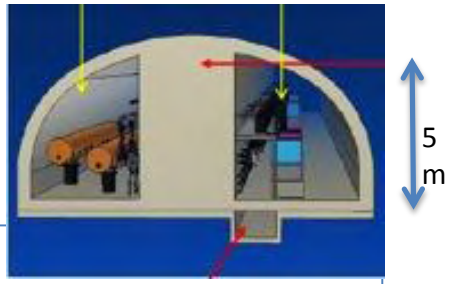
2. ILC Possible Timeline



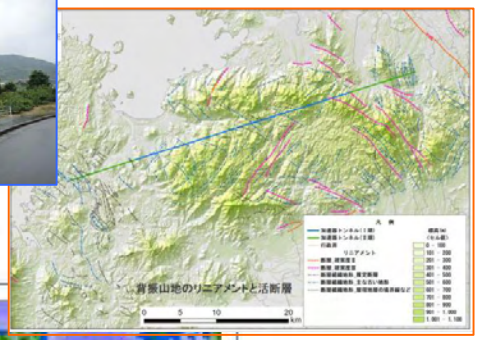


Suzuki, LCWS12 Arlington

Two Candidate Sites in Japanese mountainous locations



- Japanese Mountainous Sites -



SEFURI

FUKUOKA

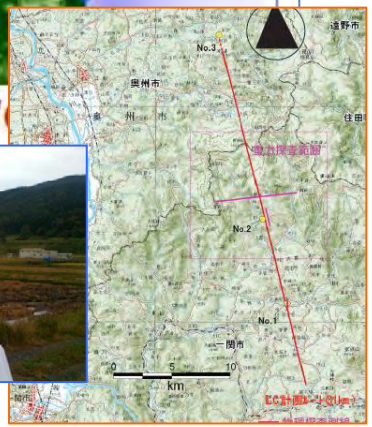
SAGA

KYUSHU district

Site-A KITAKAMI

Tokyo

TOH



- GDE-CFS group visited two candidates sites, Oct. 14 and 15, 2011

Yamauchi, Krakow

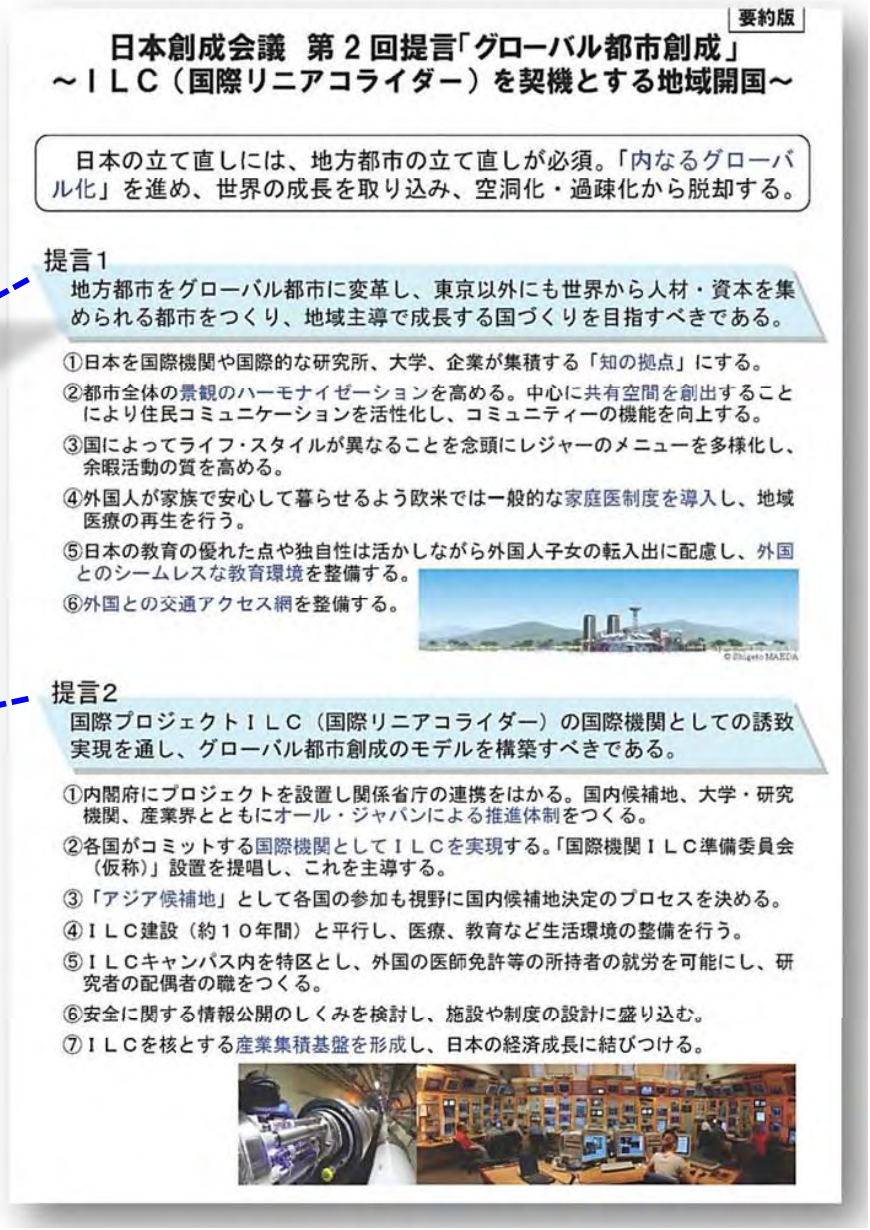
Why ILC in Japan ? : 2

July 12, 2012

Japan Policy Council
Second Recommendations:
Regional Development through Creation of Global Country inside Japan

Realizing a global city that can attract human and financial resources from around the world: Regional development triggered by the International Linear Collider (ILC)

<u>Realizing an international organization for the International Linear Collider (ILC), to push towards reforming regional cities as a role model for the creation of a global country.</u>



要約版

日本創成会議　第２回提言「グローバル都市創成」
～ＩＬＣ（国際リニアコライダー）を契機とする地域開国～

日本の立て直しには、地方都市の立て直しが必須。「内なるグローバル化」を進め、世界の成長を取り込み、空洞化・過疎化から脱却する。

提言１
地方都市をグローバル都市に変革し、東京以外にも世界から人材・資本を集められる都市をつくり、地域主導で成長する国づくりを目指すべきである。

①日本を国際機関や国際的な研究所、大学、企業が集積する「知の拠点」にする。
②都市全体の景観のハーモナイゼーションを高める。中心に共有空間を創出することにより住民コミュニケーションを活性化し、コミュニティーの機能を向上する。
③国によってライフ・スタイルが異なることを念頭にレジャーのメニューを多様化し、余暇活動の質を高める。
④外国人が家族で安心して暮らせるよう欧米では一般的な家庭医制度を導入し、地域医療の再生を行う。
⑤日本の教育の優れた点や独自性は活かしながら外国人子女の転入出に配慮し、外国とのシームレスな教育環境を整備する。
⑥外国との交通アクセス網を整備する。

提言２
国際プロジェクトＩＬＣ（国際リニアコライダー）の国際機関としての誘致実現を通し、グローバル都市創成のモデルを構築すべきである。

①内閣府にプロジェクトを設置し関係省庁の連携をはかる。国内候補地、大学・研究機関、産業界とともにオール・ジャパンによる推進体制をつくる。
②各国がコミットする国際機関としてＩＬＣを実現する。「国際機関ＩＬＣ準備委員会（仮称）」設置を提唱し、これを主導する。
③「アジア候補地」として各国の参加も視野に国内候補地決定のプロセスを決める。
④ＩＬＣ建設（約１０年間）と平行し、医療、教育など生活環境の整備を行う。
⑤ＩＬＣキャンパス内を特区とし、外国の医師免許等の所持者の就労を可能にし、研究者の配偶者の職をつくる。
⑥安全に関する情報公開のしくみを検討し、施設や制度の設計に盛り込む。
⑦ＩＬＣを核とする産業集積基盤を形成し、日本の経済成長に結びつける。

Suzuki, LCWS12 Arlington

Federation of Diet Members for promotion of the ILC project

Expand to Suprapartisan Federation

Kickoff Meeting : July 31st, 2008

Vice Chair Hatoyama | Chair Yosana | Secretary Kawamura

~50 members took part in this meeting.

AAA

Advanced Accelerator Association
Promoting Science & Technology

15/Dec./2011

Symposium

Prime Minister Noda

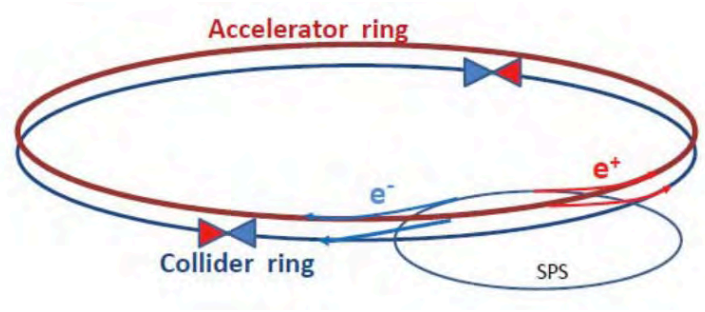
positive reference to the ILC

Suzuki, LCWS12 Arlington

The next HEF machine at CERN

- Circular e+e- collider ?
- CLIC (finished CDR) ?
- HE-LHC (33 TeV) new magnets in LHC tunnel ?
- VLHC (80km tunnel, ~80 TeV – could be used for „TLEP“ (e+e- 350 GeV) before) ?

Circular e^+e^- colliders



E.g., LEP3:

- $\sqrt{s}$ = 240 GeV in the LHC tunnel to produce e^+e^-➔ZH events
- Short beam lifetime (~16 mins) requires two ring scheme
  - Top up injection from 240 GeV "accelerator ring"
  - "Collider ring" supplying 2-4 interaction points L = 10^{34} $cm^{-2}s^{-1}$ per IP
    - Re-use ATLAS and CMS and/or install two dedicated LC-type detectors
- Current design uses arc optics from LHeC ring
  - Dipole fill factor 0.75 (smaller than for LEP)
  - increased synchrotron energy loss (7 GeV per turn)
  - redesign possible?
- $e^{\pm}$ polarization probably not possible at $\sqrt{s}$ = 240 GeV
- In principle space is available to install compact e^+e^- facility on top of LHC ring
  - Is this really feasible?
  - Alternatively wait until completion of LHC physics programme and removal of LHC ring?
- SuperTRISTAN is a proposal for a similar machine in Japan

E.g., TLEP:

- $\sqrt{s}$ = 350 GeV in 80 km LHC tunnel to reach thresholds for top pair and e^+e^-➔$\nu\nu$WW➔$\nu\nu$H

Flavour and symmetries: key issues

- Indirect search for BSM physics complementary to direct search
- LHCb + SuperKEKB well on track
- Not much discussion about Super-B
- Complementary precision programme at low-E (g_μ-2 , LFV searches, rare K-decays, ...)

→ Not much to decide (?)

Neutrino physics. key issues

- Mass hierarchy (normal or inverted)
- CP violation
  → new long baseline experiment(s)
    (US: LBNE – JP: T2HK – EU: LBNO/Laguna)
  which project is best? more than one?
  regional balance? Which detector (LAr vs LSc)?
  synergy with astroparticle physics / proton decay?

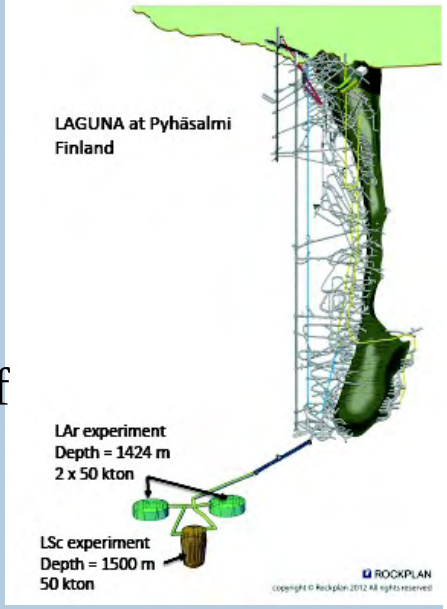
- „Anomalies“ – e.g. sterile neutrino ?
  → new short baseline experiment(s)
    „conventional“ (C.Rubbia proposal) vs. Muon storage ring (NuStorm)

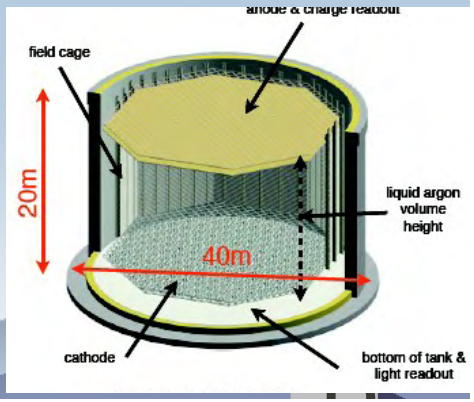
- Long-term goal: neutrino factory

Contribution ID74

LAGUNA-LBNO

- The LAGUNA-LBNO consortium proposes to create a new European underground laboratory at Pyhäsalmi (Finland) at 2300 km from CERN
- The choice is based on scientific, technological and practical advantages of the site
- The laboratory can host a 50+50 kT liquid Argon detector combined with a 50 kT magnetized Fe detector for the detection of beam ν
- The first phase of the incremental program would be the operation of a new ν beam based on SPS (500 kW)
- The project has a rich astroparticle physics program that can be fully exploited together with a 50 kt Liquid scintillator
- Recently submitted EOI to SPSC (230 authors, 51 labs)





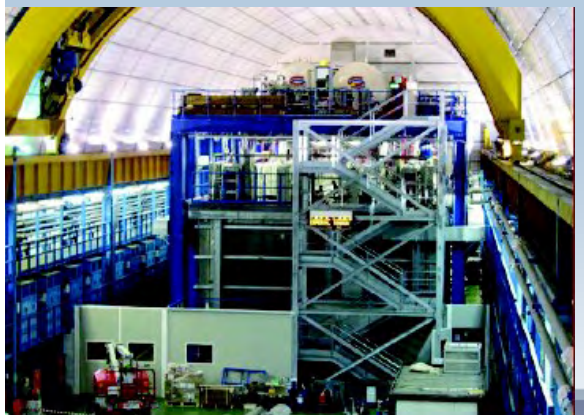
Long baseline projects

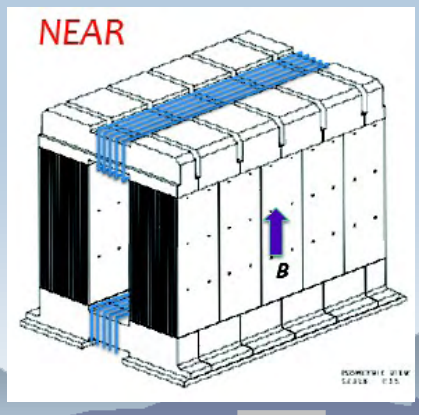
Project	Beam power MW	Fiducial Mass kt	Baseline km	MH	CPV 90%CL, (3σ)	Physics starts	Astrophysical program
LBNO	0.8	20->100	2300	Excellent	71 (44)	2023	Yes
T2HK	0.75	500	295	Little	86 (74)*	2023	Yes
LBNE	0.7	10	1300	OK	69 (43)	2022	No
Lund	5	440	365	Some	86 (70)	>2019	Yes
CERN-Canfranc	0.8-4	440	650	Some	80-88(80)	>2020	Yes

M. Zito, Krakow

Neutrino anomalies: short baseline

- Proposal (SPSC-P-347, 150 authors) of a comprehensive search for new neutrino states around $\Delta m^2 \sim 1eV^2$ using a SPS 110 GeV proton beam in the NA
- with two LAr detectors, at 1600 m (ICARUS T600 now at Gran Sasso) and 300m (T150), supplemented by two spectrometers
- Method : two identical detectors, with imaging properties and complete final state reconstruction





Alternatives: MicroBoone (FNAL), NuStorm (FNAL, proposal, 94 muon decay ring)

Strong Interaction: key issues

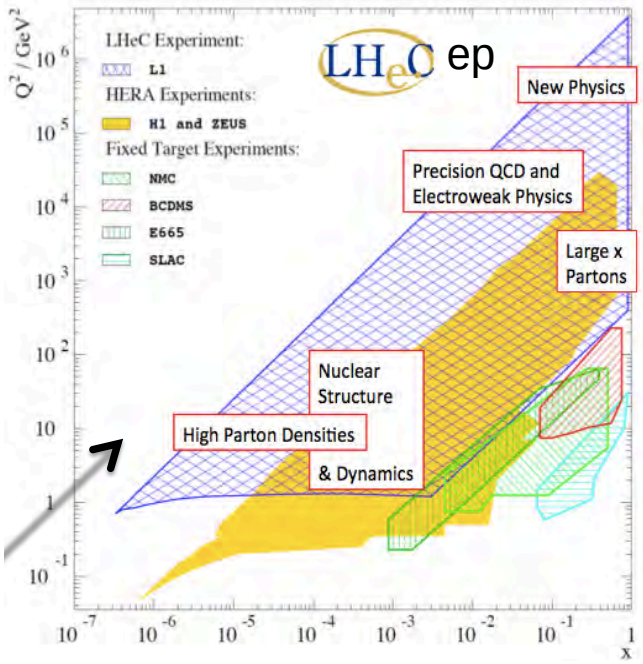
- Continue Heavy Ion Program

  ALICE running (well beyond 2020) ?

  Complementary to FAIR, RHIC, NICA, SPS ?

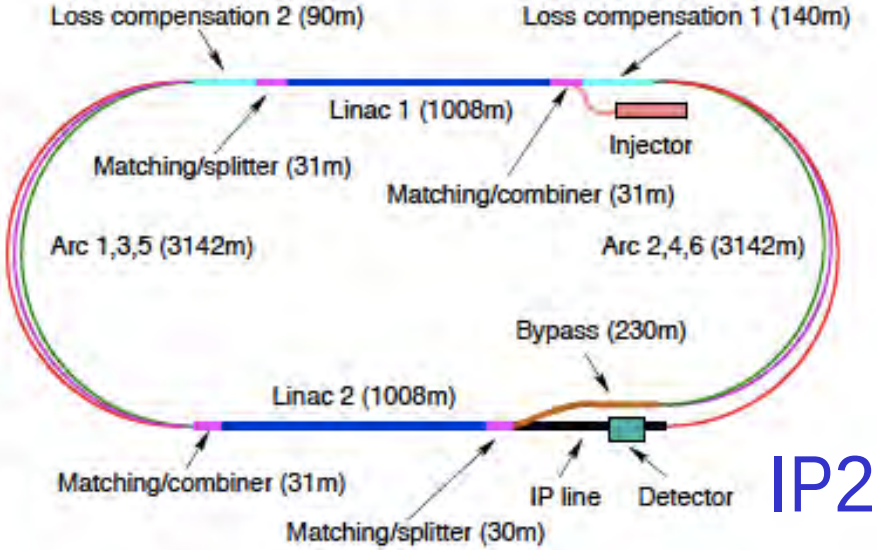
- Proton structure

  LHeC ?



Large Hadron electron Collider (LHeC)

- 60 GeV electron beam colliding with LHC protons (ions) from mid 2020s
- Simultaneous with pp running
- Lumi ~10^{33} $cm^{-1}s^{-1}$ constrained by 100 MW power consumption,
  → ~100 fb-1 integrated
- `Medium scale LHC upgrade'



- Mainly QCD & PDF-focused facility at the ep energy frontier, attacking fundamental questions in QCD and providing a basis for LHC discovery potential near the kinematic limit

- Discovery potential, probing eq, eg vertices, excited leptons …
- Complementary to LHC in Higgs sensitivity (clean WW, ZZ production, bbbar decay, CP properties …)
- Precision electroweak measurements

Accelerator R&D

- Yes! But what priorities?

- CLIC
- High-field magnets
- High-intensity proton drivers, muon cooling, ...
- Plasma wakefield acceleration
  (laser-driven, e-beam driven, p-beam driven)

Strategy process

- Key questions are identified
  - LHC upgrade?
  - ILC@JP?
  - Neutrinos?
  - LHeC?
  - Next HEF machine at CERN?

- No conclusion yet! (but soon...)