Welcome - Overview of the Gamma Factory Study initiative - Yellow report where do we stand

CERN Gamma Factory group meeting

March 2019

Mieczyslaw Witold Krasny
LPNHE, CNRS-IN2P3 and University Paris Sorbonne, CERN BE-ABP division,

Gamma Factory initiative (Sept. 2016)

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Presented at the PBC Workshop, September 2016

by

Mieczyslaw Witold Krasny

LPNHE, Pierre et Marie Curie University – Paris

...for the executive summary see: e-Print: arXiv:1511.07794 ***[hep-ex]***

Gamma Factory study group members (March 2019)

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Today:
64 scientists
20 institutes
9 countries

GF study group is open to everyone willing to contribute to this initiative!

Three principal domains of activities
and their coordination

As we have passed the threshold of 50 group members (November 2018) , it became natural to segment our on-going activities into the three already well defined and well established domains, and into several on-going "incubator phase" studies.

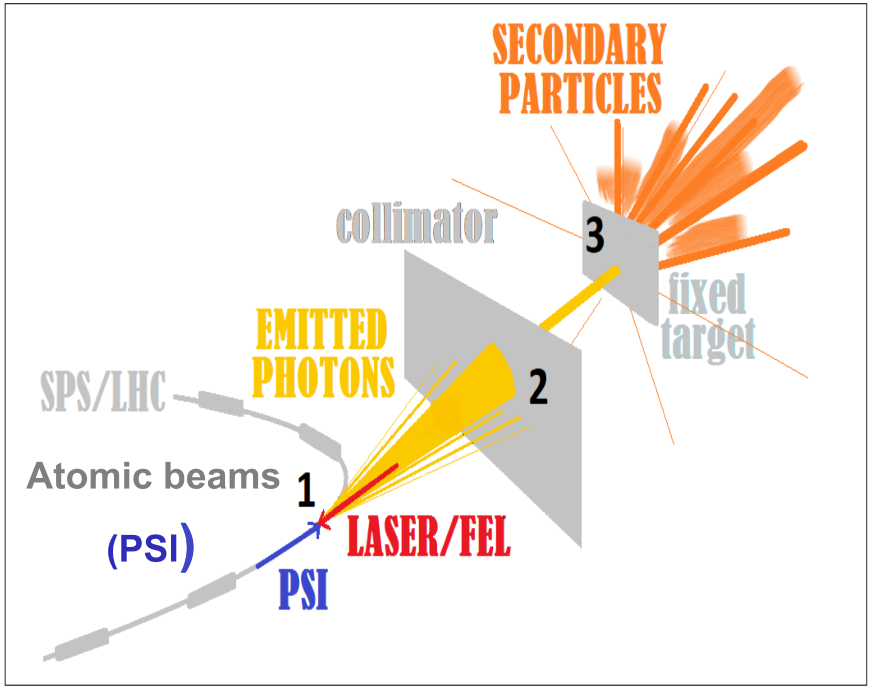
Reyes Alemany Fernandez is coordinating all the activities of the preparation and running of PSI beams at CERN and the analysis of their results — including the implementation of the new stripper(s), beam collimation aspects, storage ring vacuum conditions, etc…

Brennan Goddard is coordinating the Conceptual Design Studies for our PoP experiment, and the preparation of the LOI for the SPSC.

Alexey Petrenko is coordinating the development of the Gamma Factory software, in both its beam dynamics and cooling aspect, and the gamma beam production aspects

… they have organised and will chair the corresponding sessions of this meeting…

Gamma Factory research tools:
primary and secondary beams



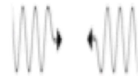
primary beams:

- **partially stripped ions**
- **electron beam (for LHC)**
- **gamma rays**

secondary beam sources:

- **polarised electrons,**
- **polarised positrons**
- **polarised muons**
- **neutrinos**
- **neutrons**
- **vector mesons**
- **radioactive nuclei**

collider schemes:



$\gamma - \gamma$ collisions,
E_{CM} = 0.1 – 800 MeV

$\gamma - \gamma_L$ collisions,
E_{CM} = 1 – 100 keV

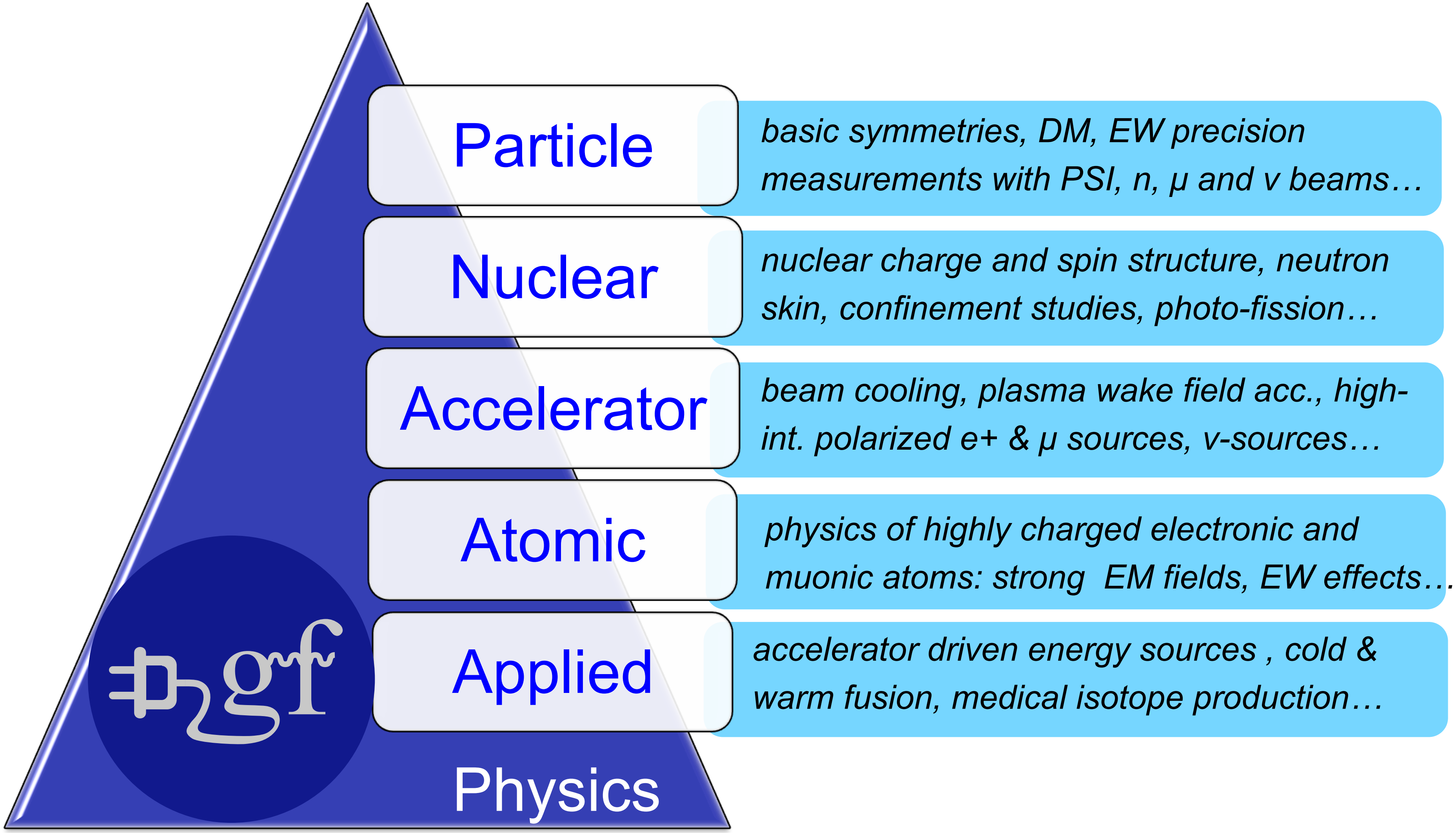
γ–p(A), ep(A) collisions,
E_{CM} = 4 – 200 GeV

A leap in production efficiency, intensity and purity

Gamma Factory beam intensity targets

- ***Highly-ionised, highly-charged atoms*** – *new at relativistic energies.*
- ***Photons*** – *up to factor of **10^7** gain in **intensity** w.r.t. present **gamma** sources.*
- ***Polarised positrons*** – *up to factor of **10^4** gain in **intensity** w.r.t. KEK **positron** source.*
- ***Polarised muons*** – *up to factor **10^3** gain in **intensity** w.r.t. to PSI **muon** source (**low emittance** beams → **muon collider**, high purity neutrino beams).*
- ***Neutrons*** – *up to factor of **10^4** in flux of primary **neutrons** per 1 kW of driver beam power.*
- ***Radioactive ions*** – *up to a factor **10^4** gain in intensity w.r.t. to e.g. ALTO.*

Gamma Factory research potential



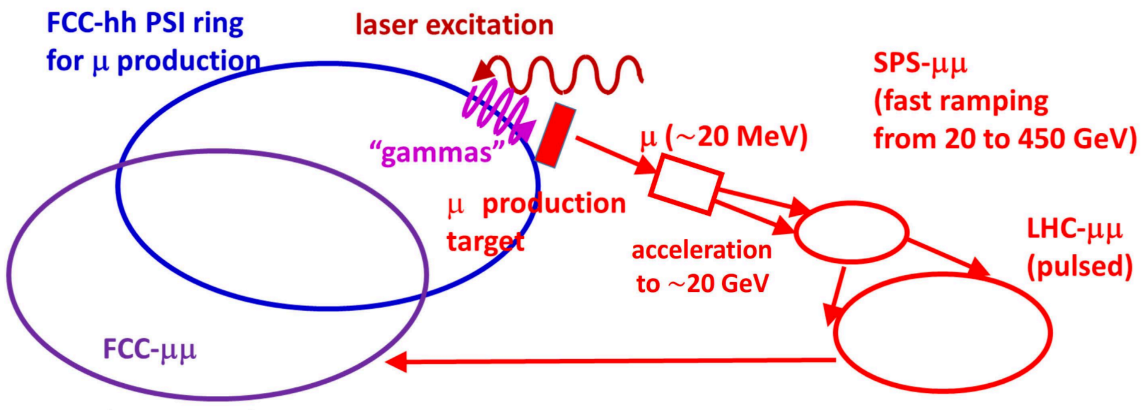
Diverse and exciting research programme in many branches of science

Three examples illustrating the Gamma Factory research potential:

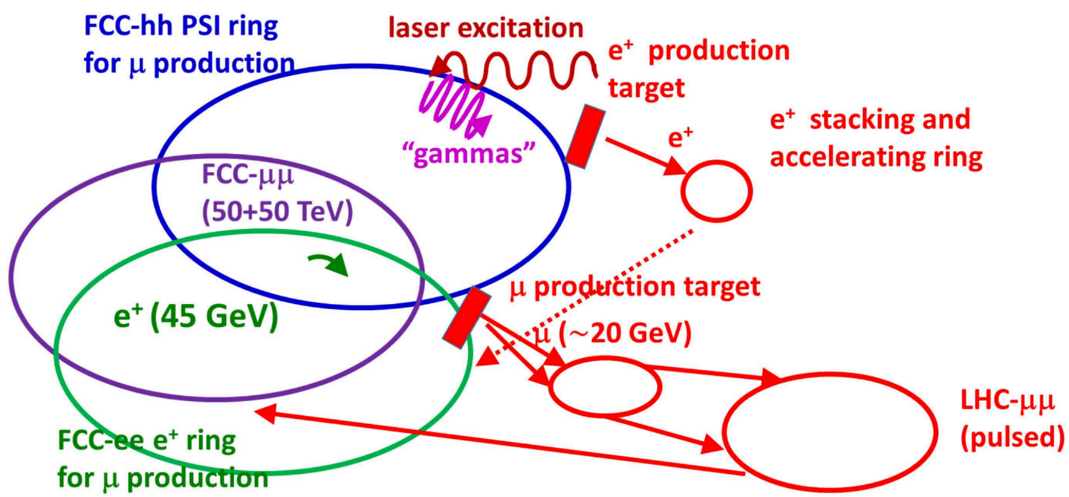
- Low emittance lepton source for muon collider and muon beam based neutrino factory
- Precision EW physics at the LHC with isoscalar beam
- An applied physics example

F. Zimmermann – Muon collider workshop, 2018 - Padova

100 TeV μ collider FCC-μμ with FCC-hh PSI μ± production

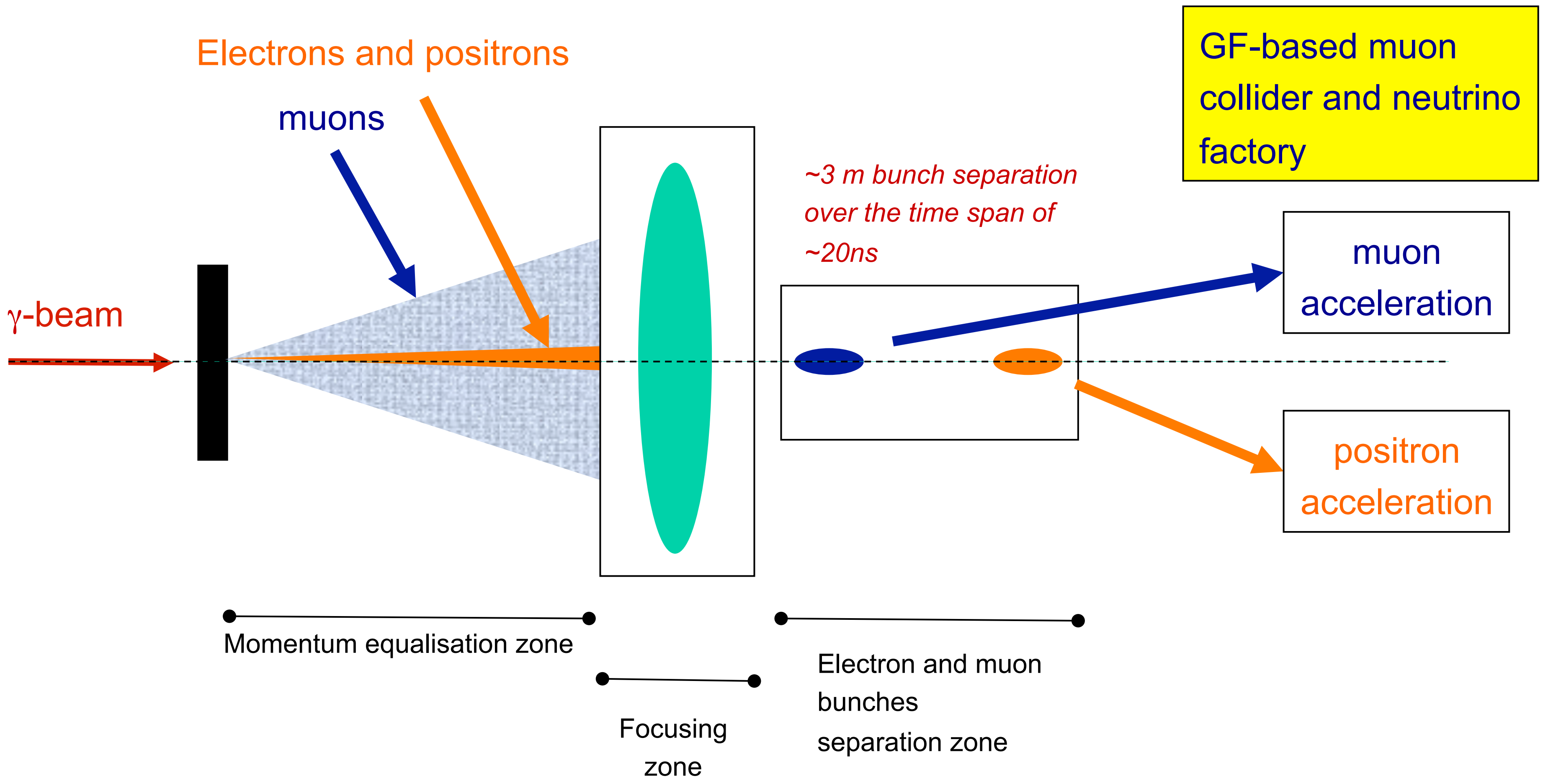


100 TeV μ collider FCC-μμ with FCC-hh PSI e+
& FCC-ee μ± production

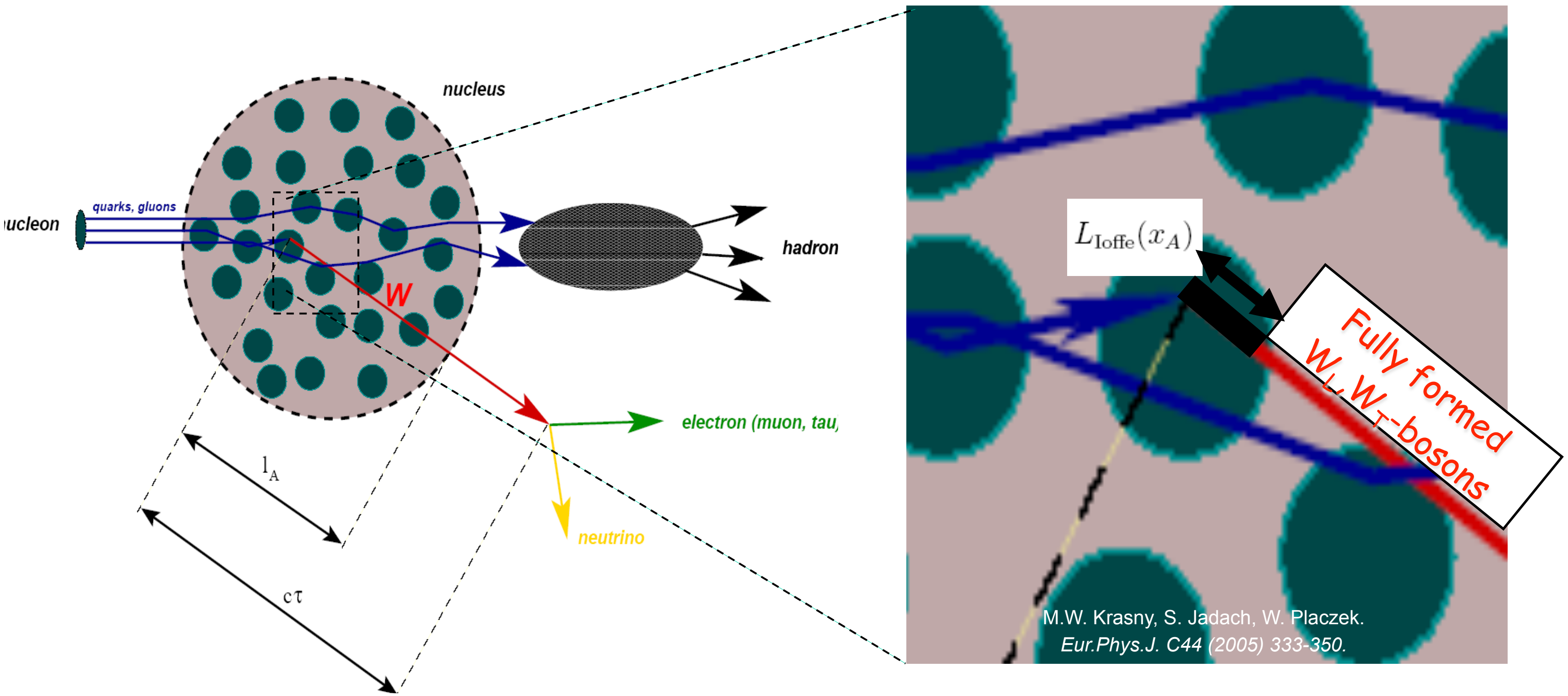


initial ideas…

software tools are being developed -- talk of V. Ivantchenko at this meeting)



Propagation of transversely and longitudinally (Higgs modes) polarized W-bosons in vacuum and matter



Quantum uncertainty of the Longitudinal position of W-production

$$L_{\mathrm{Ioffe}}(x_A) = \frac{1}{2M_A x_A}$$

Formation lengths of W-boson

$$\delta z = \gamma_W / M_W$$

Luminosity requirements for precision EW physics at the LHC

- $L_{AA} \sim 0.1\ L_{pp}/A^2$

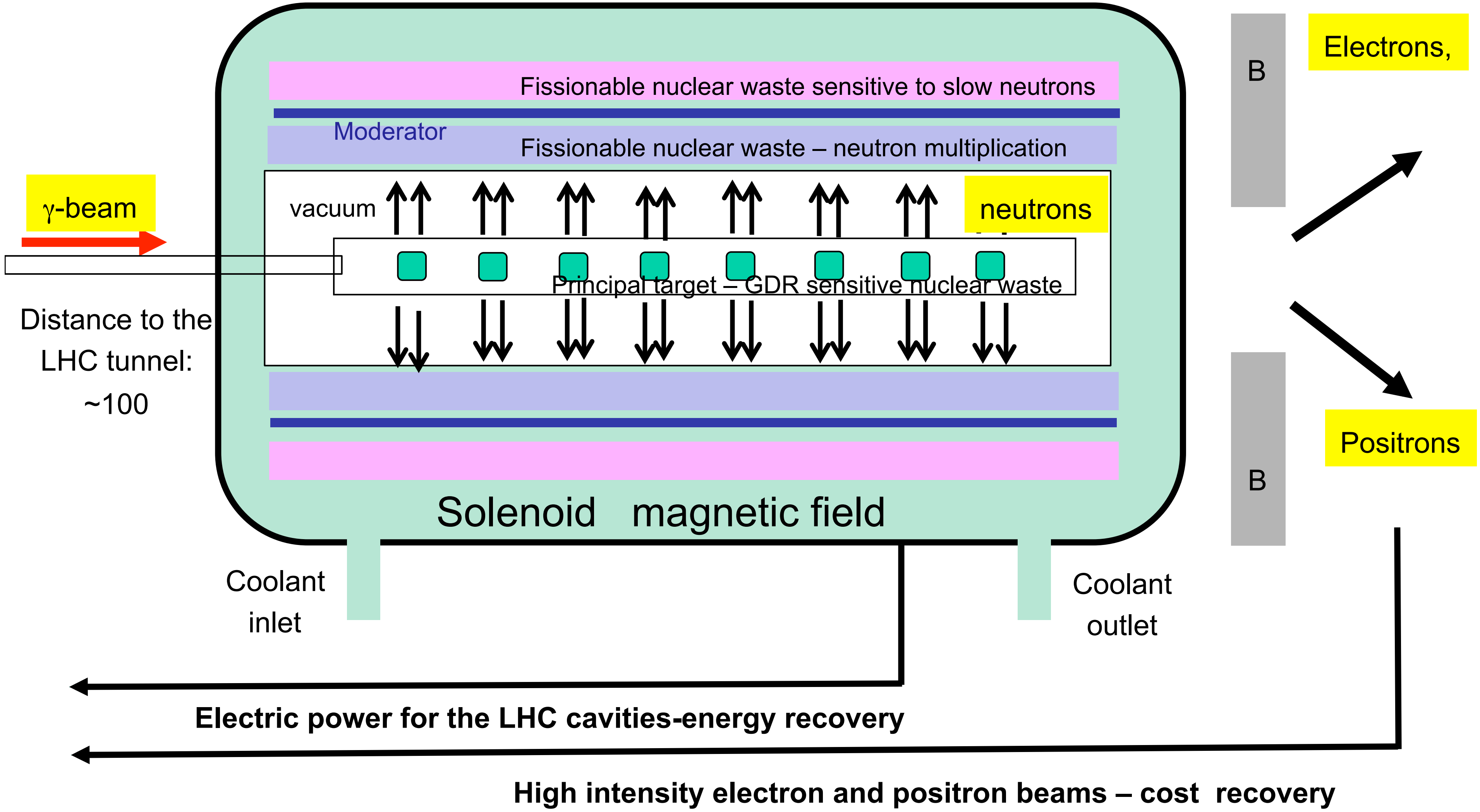
already sufficient for a large fraction of the precision measurement programme with isoscalar beams (e.g. for the M_W measurement).

Example: $L_{CaCa} \sim 0.6 \times 10^{30}$ [1/(cm^{2}s)] – feasible for 2×10^9 Ca ions/bunch at the SPS exit? (D. Manglunki et al Proceedings of IPAC2016, Busan, Korea)

How to achieve such a goal:

Laser Doppler cooling of isoscalar PSI at the SPS followed by an electron stripping in the SPS-LHC transfer line and (if necessary) optical stochastic cooling at the LHC

… an idea of the secondary positron beam producing station with sustainable research -- the electric power and cost recovery



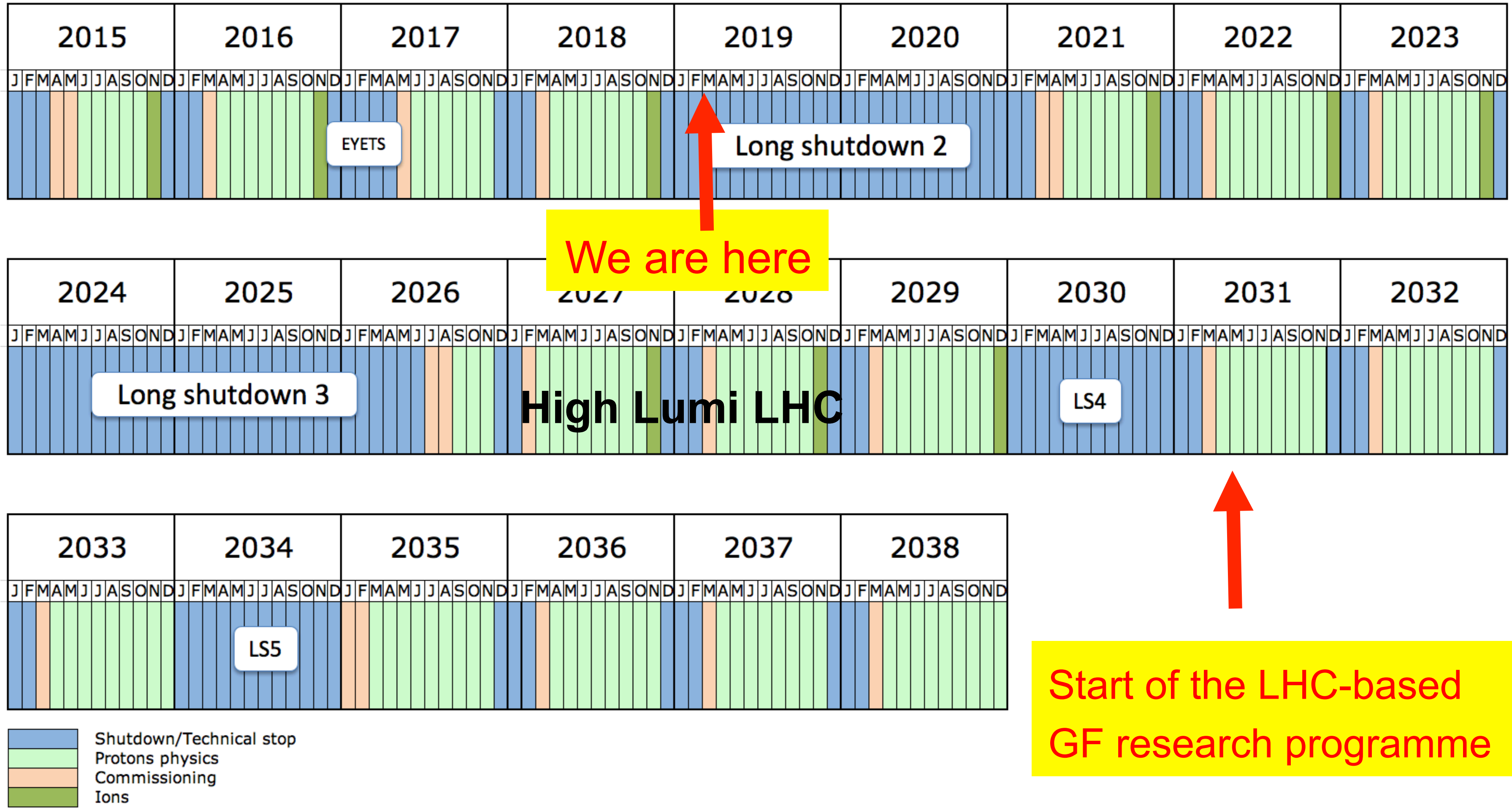
A path from the GF initial ideas to the GF research project
-- three constraints --

- *The GF programme can be realised at CERN by using its present accelerator complex infrastructure, including the LHC – it must fit to the long term plans of of CERN.*

- *The GF programme can only be realized as an interdisciplinary project (collaboration of accelerator, particle physics, nuclear physics, atomic physics and applied physics communities) – first ever attempt going in this direction.*

- ***We (the Gamma Factory study group) have to demonstrate, quantitatively, based on detailed simulations and the dedicated R&D studies, its research potential.***

LHC run schedule



The opportunity window for the Gamma Factory research programme

- *The **next** CERN **high-energy frontier** project may take **long time** to be approved, financed and built.*

- *If the **present** LHC **research programme** reaches **earlier** its discovery **saturation** (no further physics gain by extending its running time), a strong **need** will arise for a **novel** programme which could **re-use** ("co-use") the **existing** CERN facilities (including the LHC) in **ways** and at **levels** that were **not** necessarily **thought** of when the machines were **designed**.*

- ***Gamma Factory** research programme could potentially fulfil such a role. It could exploit **the existing**, **world unique opportunities** offered by the CERN accelerator complex and its scientific infrastructure **(not available elsewhere**).*

- ***It requires an extensive R&D to prove its feasibility. The R&D timeline is tight to be ready, at the time when such a need arises…***

PBC as a "start-up cradle" for the Gamma Factory study group activities

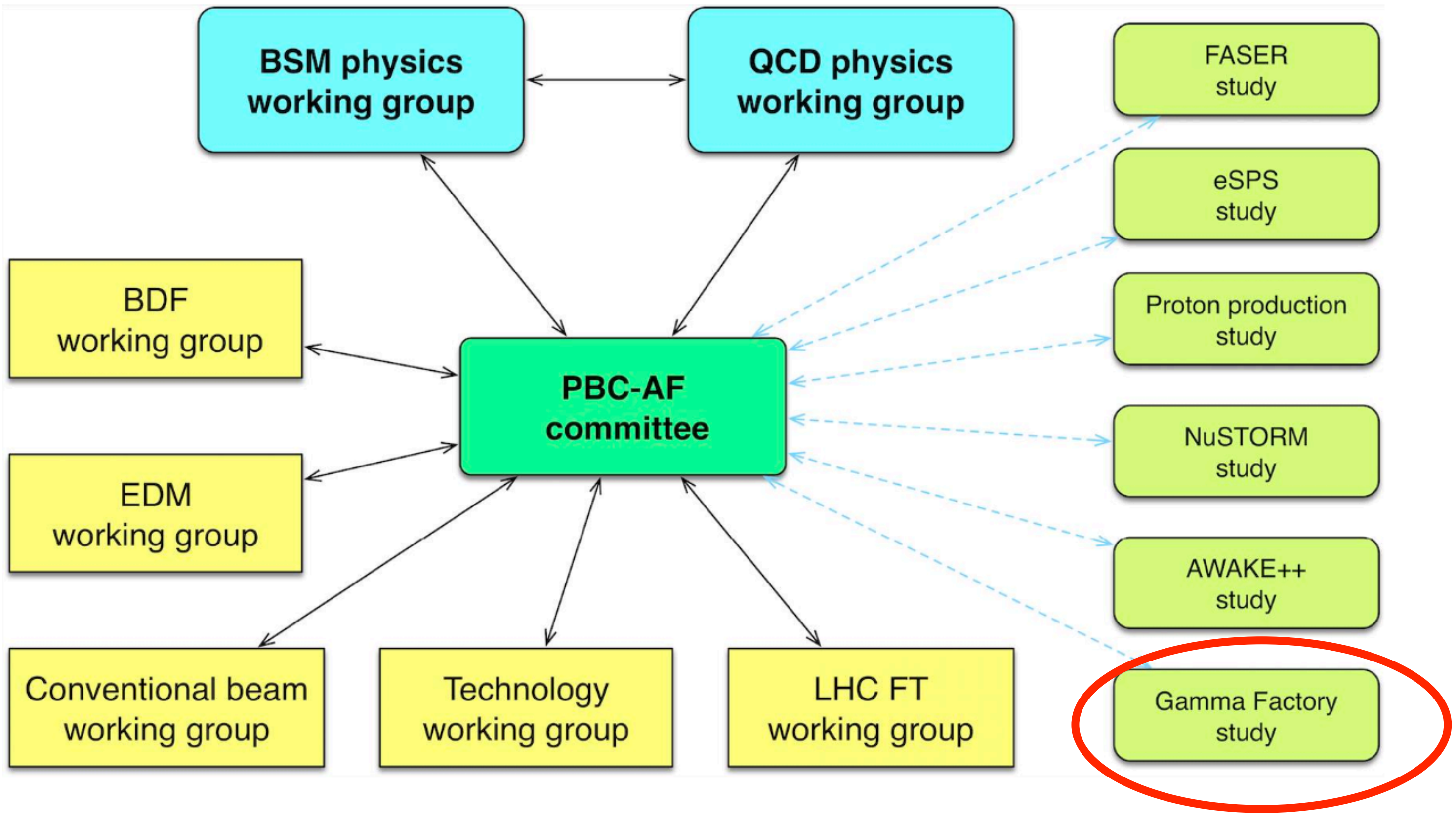
The Gamma Factory initiative (arXiv:1511.07794 [hep-ex]) was endorsed by the CERN management by creating (February 2017) ***the Gamma Factory study group****, embedded within the Physics Beyond Colliders (PBC) studies framework:*

Mandate of the "Physics Beyond Colliders" Study Group

Conveners: J. Jaeckel, M. Lamont, C. Vallee

CERN Management wishes to launch an exploratory study aimed at exploiting the full scientific potential of its accelerator complex and other scientific infrastructure through projects complementary to the LHC and HL-LHC and to possible future colliders (HE-LHC, CLIC, FCC). These projects would target fundamental physics questions that are similar in spirit to those addressed by high-energy colliders, but that require different types of beams and experiments.

The PBC groups



Funding profile

It is expected that the group will continue its activity throughout the ESPP process, which will be completed in May 2020, so as to follow up the development of the various studies and provide any additional input the ESPP may need.

(in MCHF, 2018 prices, rounded off to 0.1 MCHF until 2023, 1 MCHF thereafter)	Revised 2018 Budget	2019	2020	2021	2022	2023	Total 2018-2023	2024	2025	2026	2027	2028	Total 2018-2028
Preparation for the future	**39.1**	**27.0**	**35.2**	**40.5**	**35.5**	**36.0**	**213**	**35**	**36**	**39**	**97**	**106**	**527**
Linear collider studies (CLIC, ILC, detector R&D)	*16.2*	*15.3*					*31*						*31*
Future Circular Collider study	*16.8*	*8.1*					*25*						*25*
High-energy frontier			*21.6*	*28.0*	*28.0*	*28.0*	*106*	*28*	*28*	*28*	*80*	*90*	*360*
Proton-driven plasma wakefield acceleration (AWAKE)	*4.1*	*2.6*	*1.4*	*1.0*	*0.7*	*0.7*	*10*	*0*	*0*	*0*	*0*	*0*	*11*
Physics Beyond Colliders study	*2.1*	*1.0*	*1.0*	*1.0*	*1.0*	*1.0*	*7*	*1*	*2*	*5*	*10*	*10*	*35*
R&D for future detectors			*11.2*	*10.4*	*5.8*	*6.3*	*34*	*6*	*6*	*6*	*6*	*6*	*65*
Scientific diversity activities	**33.1**	**28.1**	**28.2**	**22.4**	**21.3**	**20.9**	**154**	**20**	**20**	**20**	**19**	**19**	**251**
CERN Neutrino Platform	*12.4*	*13.3*	*12.1*	*6.7*	*6.6*	*6.6*	*58*	*7*	*6*	*6*	*7*	*7*	*90*
R&D (incl. EU support) for accelerators	*20.7*	*14.8*	*16.2*	*15.6*	*14.7*	*14.3*	*96*	*13*	*13*	*13*	*12*	*12*	*161*

Mike Lamont

The EPPSU context

The European Particle Physics Strategy Update (EPPSU) is the process by which every ~ 7 Years the European particle physics community updates the priorities and strategy of the field.

First ESPP in 2006; first update in 2013; next update 2020.

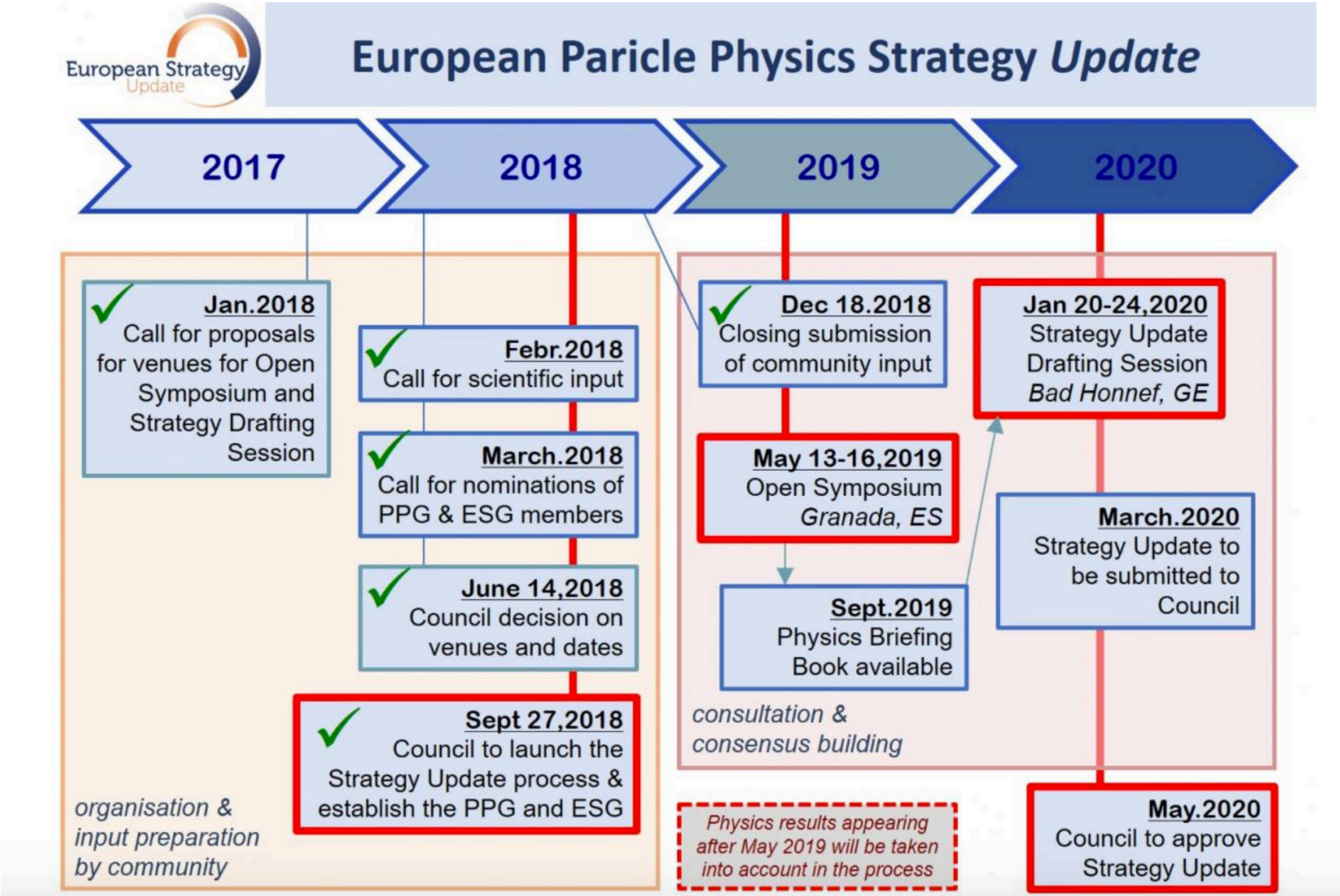
Bottom-up process involving the community. Driven by physics, with awareness of financial and technical feasibility.

Scientific input includes: physics results from current facilities from all over the world; physics motivations, **design studies and technical feasibility of future projects**; results of R&D work.

The Strategy is adopted by the CERN Council.
Individual (major) projects require dedicated approval: e.g. HL-LHC

from *Fabiola Gianotti's presentation*

Process


European Strategy Update
European Paricle Physics Strategy Update
2017
2018
2019
2020
Jan.2018
Call for proposals for venues for Open Symposium and Strategy Drafting Session
Febr.2018
Call for scientific input
March.2018
Call for nominations of PPG & ESG members
June 14,2018
Council decision on venues and dates
Sept 27,2018
Council to launch the Strategy Update process & establish the PPG and ESG
organisation & input preparation by community
Dec 18.2018
Closing submission of community input
May 13-16,2019
Open Symposium
Granada, ES
Sept.2019
Physics Briefing Book available
consultation & consensus building
Jan 20-24,2020
Strategy Update Drafting Session
Bad Honnef, GE
March.2020
Strategy Update to be submitted to Council
May.2020
Council to approve Strategy Update
Physics results appearing after May 2019 will be taken into account in the process

Gamma Factory group EPPSU contributions

Gamma Factory for CERN

EPPSU COMPREHENSIVE OVERVIEW

Abstract

This contribution discusses the possibility of creating novel research tools at CERN by producing and storing highly relativistic atomic beams in its high-energy storage rings, and by exciting their atomic degrees of freedom by lasers to produce high-energy photon beams. Their intensity would be, by several orders of magnitude, higher than those of the presently operating light sources, in the particularly interesting gamma-ray energy domain reaching up to 400 MeV. In this energy domain, the high-intensity photon beams can be used to produce secondary beams of polarised electrons, polarised positrons, polarised muons, neutrinos, neutrons and radioactive ions. The atomic beams, the photon beams and the above secondary beams are the principal research tools of the proposed Gamma Factory. New research opportunities in a wide domain of fundamental and applied physics can be opened by the Gamma Factory scientific programme.

Gamma Factory for CERN

EPPSU ADDENDUM

Submitted December. 2019

The Gamma Factory study group milestones

1. ***Production**, **acceleration** and **storage** of **"atomic beams"** at CERN accelerator complex.*

2. ***Proof-of-Principle** (PoP) experiment in the SPS tunnel.*

3. ***Development** "ab nihilo" the requisite Gamma Factory **software tools**.*

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4. ***Realistic assessment** of Gamma Factory **performance figures**.*

5. ***Physics highlights** of Gamma Factory based **research programme**.*

6. *Gamma Factory **TDR**.*

News

Accelerators

Xenon beams light path to gamma factory

On 14 September, CERN injected a beam of partially ionised xenon atoms into the Super Proton Synchrotron (SPS) and kept it circulating for a short period. The successful demonstration, carried out by the SPS operations and radio-frequency teams, is the first of a series of experimental steps to explore the feasibility of a gamma-ray source with an intensity several orders of magnitude higher that those currently in operation.

Earlier this year, CERN's accelerator complex demonstrated its flexibility by producing a beam of fully ionised xenon atoms for the fixed-target experiment NA61, which studies the physics of strong interactions. Profiting from this achievement, the gamma-factory study group – which is part of CERN's Physics Beyond Colliders study – requested dedicated beam tests with partially ionised xenon atoms in the SPS. The beam was composed of xenon nuclei carrying 15 out of the 54 electrons present in the

M Brice/CERN

The SPS, pictured during a recent technical stop, was loaded with beams of partially ionised xenon atoms in September.

July 2018: Birth of Atomic Physics research at CERN

symmetry
dimensions of particle physics

topics ▾ follow +

A joint Fermilab/SLAC publication

LHC accelerates its first "atoms"

07/27/18 | By Sarah Charley

Lead atoms with a single remaining electron circulated in the Large Hadron Collider.

https://home.cern/about/updates/2018/07/lhc-accelerates-its-first-atoms
https://www.sciencealert.com/the-large-hadron-collider-just-successfully-accelerated-its-first-atoms
https://www.forbes.com/sites/meriameberboucha/2018/07/31/lhc-at-cern-accelerates-atoms-for-the-first-time/#36db60ae5cb4
https://www.livescience.com/63211-lhc-atoms-with-electrons-light-speed.html
https://interestingengineering.com/cerns-large-hadron-collider-accelerates-its-first-atoms
https://www.sciencenews.org/article/physicists-accelerate-atoms-large-hadron-collider-first-time
https://insights.globalspec.com/article/9461/the-lhc-successfully-accelerated-its-first-atoms
https://www.maxisciences.com/lhc/le-grand-collisionneur-de-hadrons-lhc-accomplit-une-grande-premiere_art41268.html
https://www.symmetrymagazine.org/article/lhc-accelerates-its-first-atoms

Acknowledgement:

The successful **Gamma Factory** beam tests, with the Xe+39, Pb+80 and Pb+81 beams, over the year 2017 and 2018 involved dedicated work of the operation tams of the: Ion source, Linac, PS, SPS, LHC, the BE, EN groups responsible for the installations of the GF strippers, vacuum teams, RF-experts and numerous other individuals.

We (GF-group) acknowledge high quality of their work and and their enthusiasm in making these tests a success story!

What we want to learn/demonstrate with the GF Proof-of-Principle (PoP) experiment at the SPS?

1. *How to **integrate** the **laser and Fabry–Perot** cavity system into the **storage ring** of hadronic beam? (radiation hardness of the laser system, IP for high beam magnetic rigidity beam, beam impedance, vacuum, etc…)*

2. *How to **maximise** the rate of **atomic excitations?***

3. *How to **extract** γ**-rays** from the **collision** zone?*

4. *How to **collimate** the γ**-ray beam**?*

5. *How to **monitor/measure** the flux of outgoing **photons**?*

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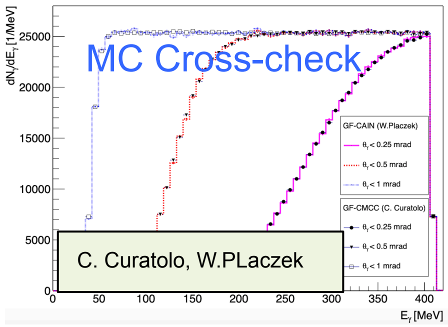
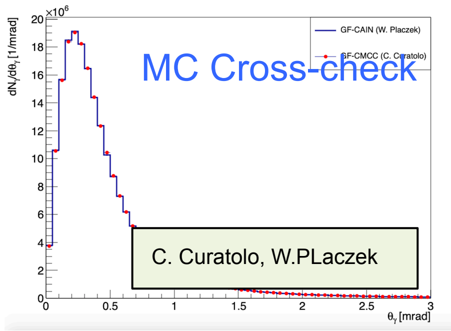
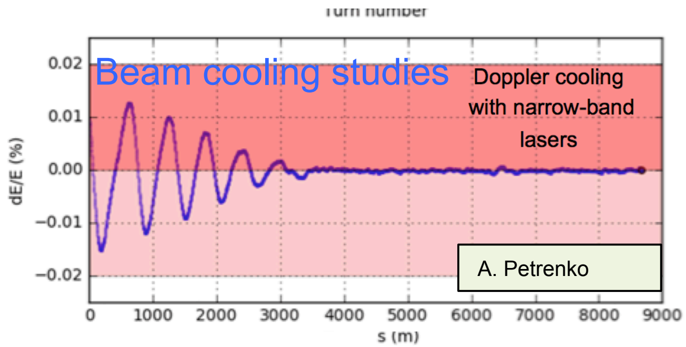
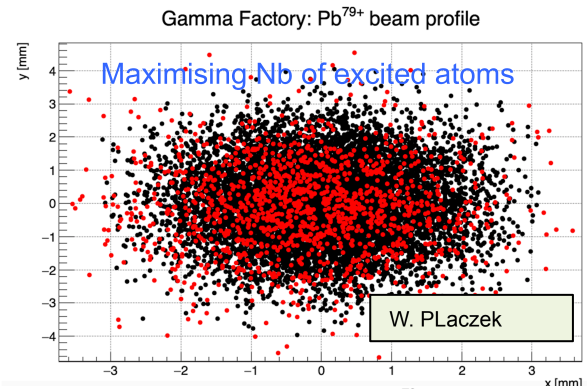
6. *Demonstrate **new cooling** method of **hadronic** beams (Doppler Cooling).*
7. ***Atomic Physics** measurement programme.*

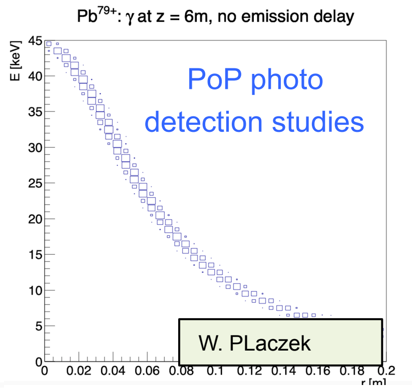
GF software development

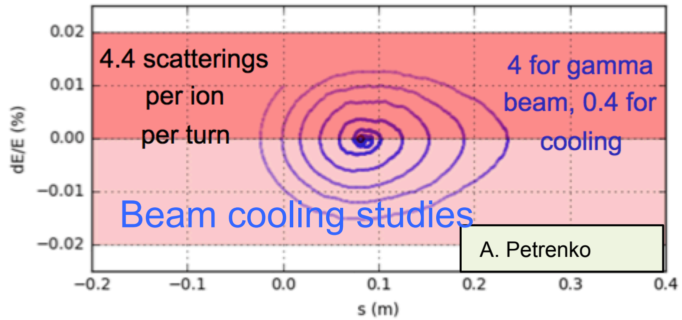


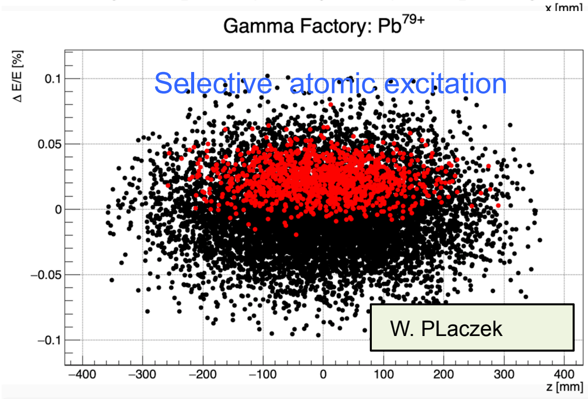


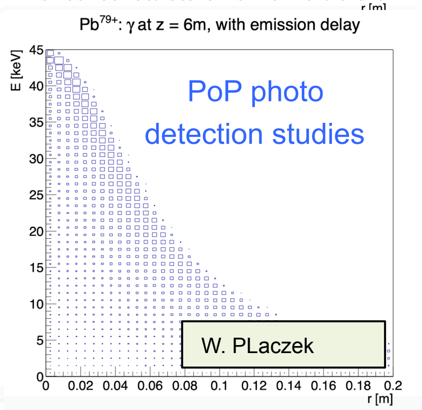


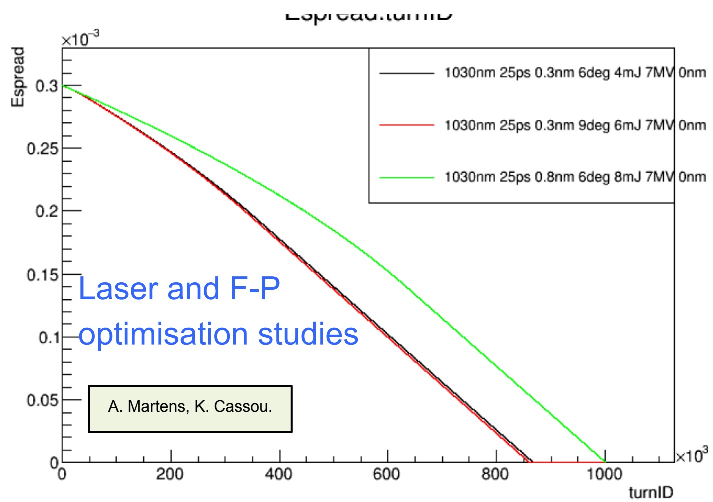






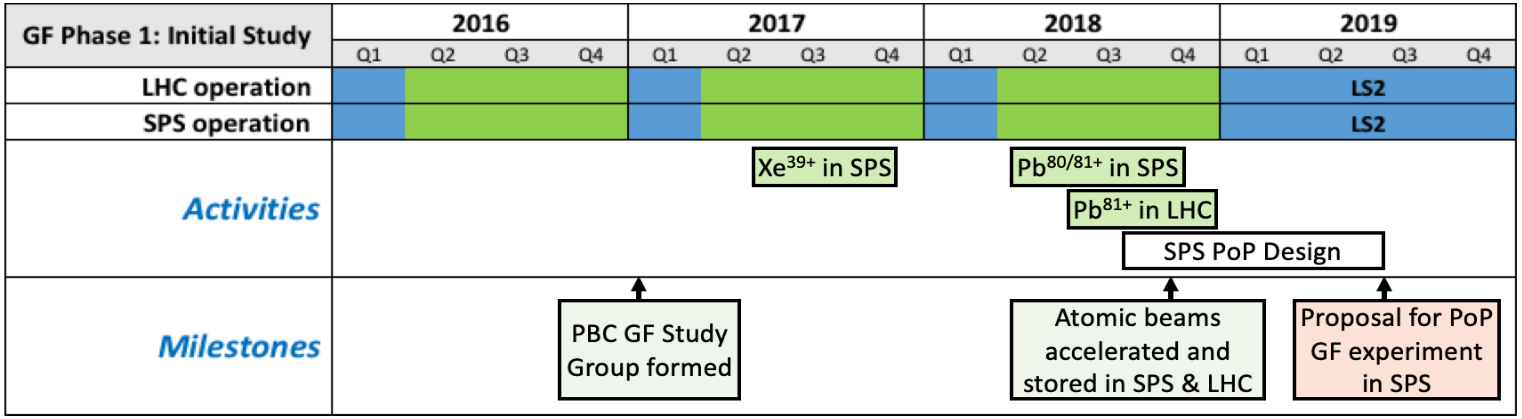




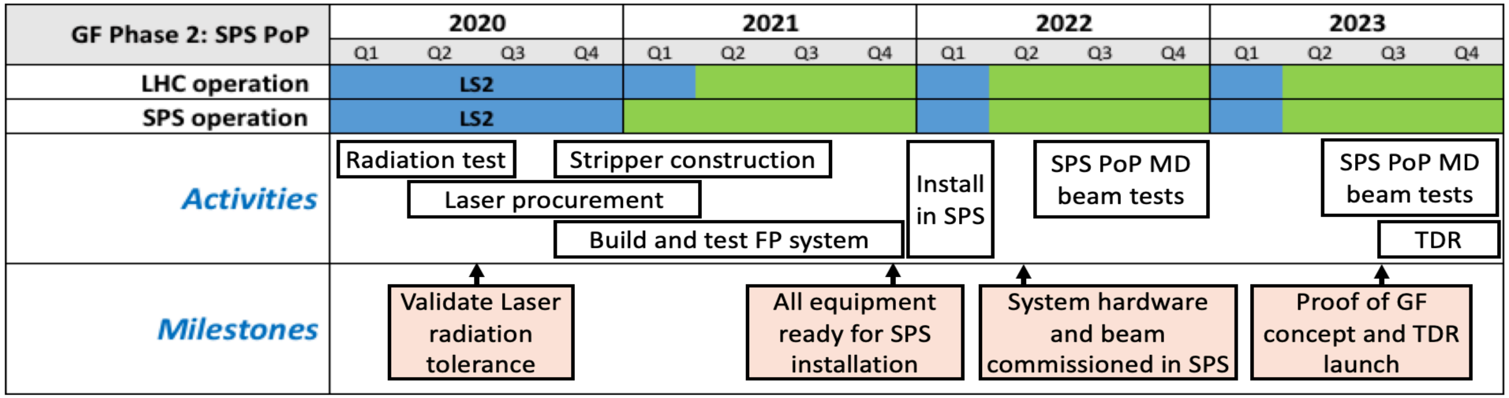


The Gamma Factory studies timeline
(as specified in the GF EPPSU document)

Phase 1 -- Initial beam tests and PoP experiment design



Phase 2 -- SPS PoP experiment and GF performance studies



The Gamma Factory group Yellow Report

1. ***Production***, ***acceleration*** *and* ***storage*** *of* ***"atomic beams"*** *at CERN accelerator complex.*

2. ***Proof-of-Principle*** *(PoP) experiment in the SPS tunnel.*

3. ***Development*** *"ab nihilo" the requisite Gamma Factory* ***software tools****.*

Vol. 1

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4. ***Realistic assessment*** *of Gamma Factory* ***performance figures****.*

5. ***Physics highlights*** *of Gamma Factory based* ***research programme****.*

6. *Gamma Factory* ***TDR****.*

Vol. 2

CERN Yellow Reports: Monographs
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Gamma Factory for CERN

Vol. 1

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Overleaf framework

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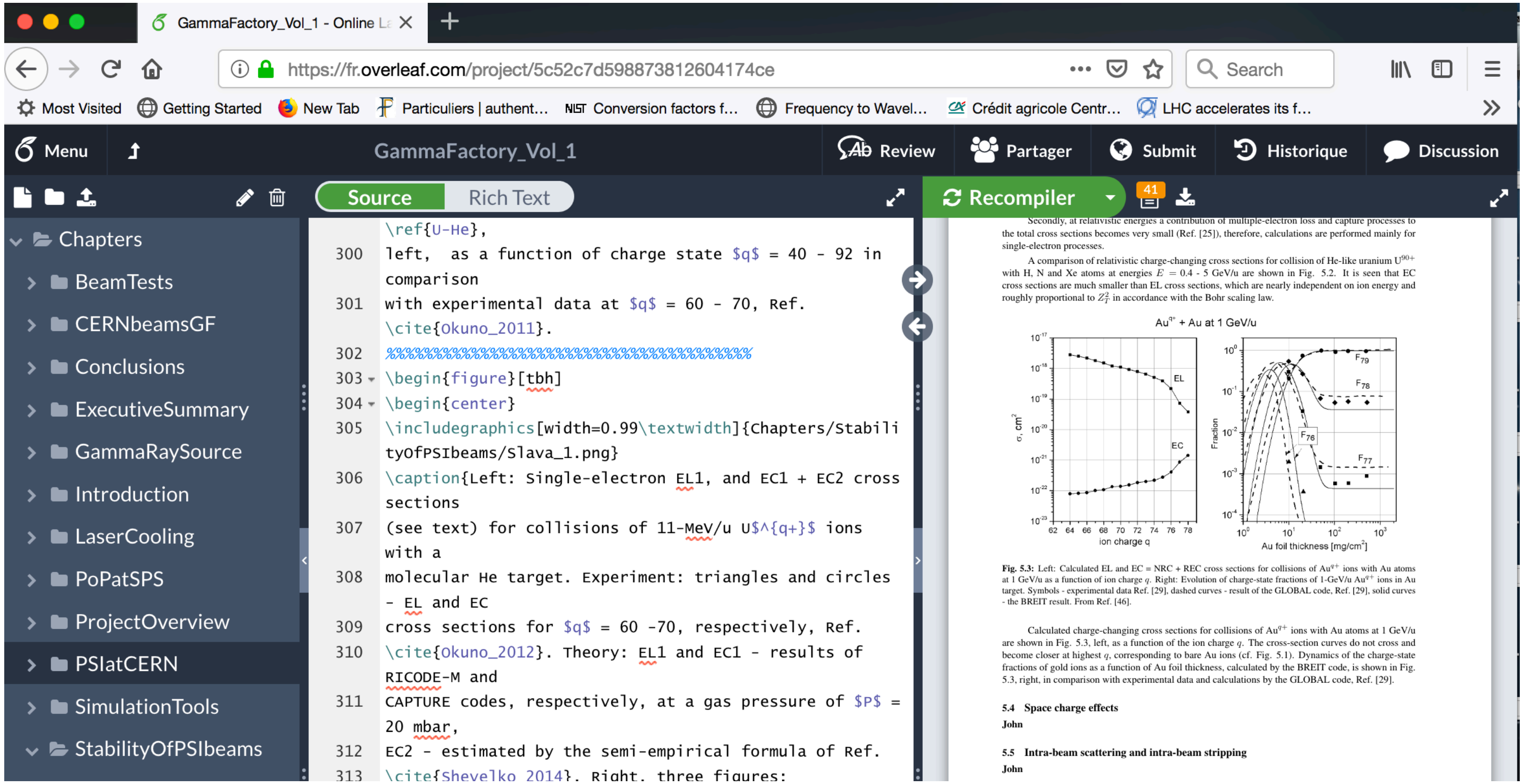

Contents

The principal goal of this meeting

- *Over the last **2 years** the **Gamma Factory** initial ideas have been transformed into **well-defined** R&D **activities***
- *We have passed the first and **most important milestone**: the **proof** that one can **produce**, **accelerate** and **store atomic beams** in the **CERN accelerator complex...***
- *… and entered its **second phas**e: (1) developing the requisite **software** tools and (2) designing a GF **Proof-of-Principle** experiment at the CERN **SPS**.*
- *We have submitted two **documents** (Comprehensive overview and Addendum) to the **European Particle Physics Strategy Update 2018–2020** and hope that the Gamma Factory will be retained as a possible **future research programme** for **CERN**.*

The principal goal of the meeting

- *Given the the EPPSU timing our main priority now is* ***to document the work*** *which has already been done by the GF study group,* ***e.g. in a form of a CERN Yellow Report***
- ***This a very crucial step on our path from the "GF initiative" to the "GF project" stage.***
- *Such a reference document will be of of help while: (1) applying for grants, (2) preparing conference contributions, (3) preparing the LoI for the GF proof-of-principle experiment and finally (4) for the visibility of our progress - a "sine qua non" condition to trigger the quantitative studies of the GF research goals*
- *The structure of the document and the assignments of the authors of the sections and chapters has been made… initial drafts of several contributions have been written ☺ (…111 pages as of today…)*

One of the principal goal of his meeting is to review were do we stand with the GF YR writing… the agenda of this meeting reflects closely the structure of sections and chapters of the YR.

The Agenda of the meeting

Monday morning – PSI beams session chaired by Reyes

MONDAY, 25 MARCH

09:00 → 12:00 **PSI beams** — 60-6-015 - Room Georges Cha...

Convener: Reyes Alemany Fernandez (CERN)

09:00	**Welcome - Overview of the Gamma Factory Study initiative -Yellow report: where do we stand** **Speaker:** Mieczyslaw Krasny (Universite Sorbonne Nouvelle Paris III (FR))	45m
09:45	**Acceleration and storage of ion beams at CERN.** **Speaker:** Reyes Alemany Fernandez (CERN)	25m
10:10	**Coffee break**	30m
10:40	**Ion sources - present status.** **Speaker:** Richard Scrivens (CERN)	30m
11:10	**SPS and LHC vacum.** **Speaker:** Roberto Kersevan (CERN)	50m

The agenda of the meeting

Monday afternoon – PSI beams session cont. – chaired by Reyes

14:00 → 15:15 **PSI beams, cont** — 60-6-015 - Room Georges Cha...
Convener: Reyes Alemany Fernandez (CERN)

- 14:00 **Collimation of PSI beams.** — 25m
  Speaker: Roderik Bruce (CERN)
- 14:25 **Optimisation of the stripper foil material and thickness for GF.** — 25m
  Speaker: Felix Kroeger
- 14:50 **PSI operation constraints: Run 3 and Run 4.** — 25m
  Speaker: Reyes Alemany Fernandez (CERN)

15:15 → 15:50 **Stability aspects of PSI beams** — 60-6-015 - Room Georges Cha...
Convener: Reyes Alemany Fernandez (CERN)

- 15:15 **Beam gas collisions.** — 25m
  Speaker: Viatcheslav Shevelko
- 15:40 **Stark effect.** — 10m
  Speaker: Mieczyslaw Krasny (Universite Sorbonne Nouvelle Paris III (FR))

15:50 → 16:20 **Coffee break** — 30m

16:20 → 17:15 **SPS and LHC beam test results** — 60-6-015 - Room Georges Cha...
Convener: Reyes Alemany Fernandez (CERN)

- 16:20 **Xe+39, Pb+80 and Pb+81 tests in SPS** — 20m
  Speaker: Simon Hirlander (CERN)
- 16:40 **Pb81+ tests in LHC.** — 35m
  Speaker: Michaela Schaumann (CERN)

The agenda of the meeting

Tuesday afternoon – gamma ray source session. – chaired by Andrey

software tools development session chaired by Alexey

09:00 → 12:00	Discussion session (Room 4-S-030)	4-S-030
12:00 → 14:00	Lunch Break	2h
14:00 → 17:30	Gamma Ray source Convener: Andrey Surzhikov	60-6-015 - Room Georges Cha...
14:00	Overview of the gamma-ray sources. Speaker: Luca Serafini (INFN-Milan)	35m
14:35	Atomic Physics aspects of the GF software. Speaker: Simon Rochester	35m
15:10	Spatiotemporal and spectral optimisation of the Laser+F-P photon fluxes Speaker: Aurelien Martens (LAL/IN2P3/CNRS)	30m
15:40	Gamma Factory ion beam dynamics Speaker: Alexey Petrenko (Budker Institute of Nuclear Physics (RU))	20m
16:00	Coffee break	30m
16:30	Spatiotemporal and spectral optimisation of FEL photon fluxes. Speaker: Vittoria Petrillo	30m
17:30 → 18:35	Software tools development Convener: Alexey Petrenko (Budker Institute of Nuclear Physics (RU))	60-6-015 - Room Georges Cha...
17:30	Overview and plans Speaker: Alexey Petrenko (Budker Institute of Nuclear Physics (RU))	30m
18:00	PSI driven gamma source — fundamentals. Speaker: Dimitry Budker (Mainz University)	30m
18:35 → 20:35	Dinner	2h

The agenda of the meeting

Wednesday morning – software tools development session chaired by Alexey

WEDNESDAY, 27 MARCH

09:00 → 12:00 **Software tools development, cont.** — 60-6-015 - Room Georges Cha...

Convener: Alexey Petrenko (Budker Institute of Nuclear Physics (RU))

09:00	**Semi-Analytical calculations.** **Speaker:** Aurelien Martens (Centre National de la Recherche Scientifique (FR))	25m
09:25	**GF-CMCC.** **Speaker:** Camilla Curatolo (INFN - National Institute for Nuclear Physics)	25m
09:50	**GF-Cain.** **Speaker:** Wiesiek Placzek (Jagiellonian University)	25m
10:15	Coffee break	30m
10:45	**RH code for photon-PSI collisions.** **Speaker:** Siobhan Alden	20m
11:05	**Muon pair production Monte Carlo.** **Speaker:** Vladimir Ivantchenko (CERN)	30m
11:35	**Discussion on the way forward in the GF software development** **Speaker:** Alexey Petrenko (Budker Institute of Nuclear Physics (RU))	25m

The agenda of the meeting

Wednesday afternoon – PoP experiment session chaired by Bren and Yann

14:00 → 18:00 **PoP expriment** — 60-6-015 - Room Georges Cha...

Conveners: Brennan Goddard (CERN), Yann Dutheil (CERN)

14:00	**Overall concept, stages and procedure.** **Speaker:** Brennan Goddard (CERN)	40m
14:40	**SPS accelerator aspects.** **Speaker:** Yann Dutheil (CERN)	20m
15:00	**Ion transition parameters and their present uncertainties.** **Speaker:** Andrey Surzhikov	20m
15:20	**Photon flux simulations.** **Speaker:** Camilla Curatolo (INFN - National Institute for Nuclear Physics)	20m
15:40	Coffee break	30m
16:10	**Impedance guidelines for the SPS** **Speaker:** Aaron Farricker (CERN)	1h
17:10	**Bunch dynamic.** ¶ **Speaker:** Alexey Petrenko (Budker Institute of Nuclear Physics (RU))	30m
17:40	**Laser system for single bunch, "photon production" option.** **Speaker:** Stephen Gibson (Royal Holloway, University of London)	20m

The agenda of the meeting

Thursday morning – PoP experiment session chaired by Bren and Yann

(SPS tunnel visit organised by Reyes)

THURSDAY, 28 MARCH

09:00 → 12:50 **PoP experiment, cont.** — 60-6-015 - Room Georges Cha...

Conveners: Brennan Goddard (CERN), Yann Dutheil (CERN)

09:00	**Laser system(s) for single bunch and bunch train (cavity) "cooling proof" options.** **Speaker:** Dr Kevin CASSOU (LAL/CNRS)	40m
09:40	**Radiation aspects.** **Speaker:** Ruben Garcia Alia (CERN)	40m
10:20	**SPS-RF - Timing and synchronization.** **Speaker:** Wolfgang Hofle (CERN)	40m
11:00	Coffee break	30m
11:30	**Photon detection system(s) - photon production and beam cooling observation functions.** **Speaker:** Thibaut Lefevre (CERN)	40m
12:10	**Experiment Layout and schedule** **Speaker:** Brennan Goddard (CERN)	40m

13:00 → 15:00 Lunch Break — 2h

15:00 → 19:00 **SPS Visit**

Tuesday dinner

A table for 12 was reserved in the O'Brasseur bar for Tuesday dinner (8 PM) (8 people inscribed in the Meeting registration form) - please let me know if you did not inscribe and want to join…

the bar is within a walking distance from CERN

Welcome,

and looking forward to a fruitful

GF meeting!