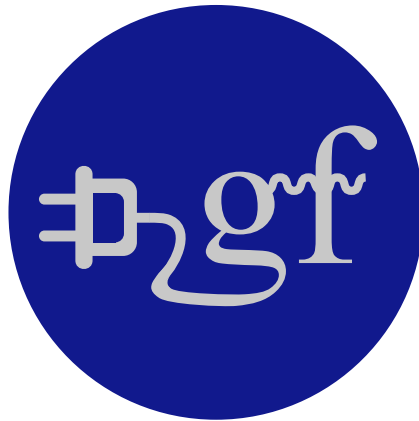


**Welcome** - Overview of the Gamma  
Factory Study initiative - **Yellow report**  
**where do we stand**



**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)

*E.G. Bessonov, Lebedev Physical Institute, Moscow, Russia; D. Budker<sup>†</sup>, Helmholtz Institute, Johannes Gutenberg University, Mainz, Germany; K. Cassou, K. Dupraz, A. Martens, F. Zomer, LAL Orsay, France; P. Czodrowski, Department of Physics, University of Alberta, Edmonton, Canada; O. Dadoun, M. W. Krasny\*, LPNHE, University Paris VI et VII and CNRS–IN2P3, Paris, France; M. Kowalska, A. Petrenko, CERN, Geneva, Switzerland; W. Placzek, Jagellonian University, Krakow, Poland; Y. K. Wu, FEL Laboratory, Duke University, Durham, USA; M. S. Zolotarev<sup>†</sup>, Center for Beam Physics, LBNL, Berkeley, USA.*

<sup>†</sup> Initiative supporter

\* Contact person: e-mail: [krasny@lpnhe.in2p3.fr](mailto:krasny@lpnhe.in2p3.fr)

*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](https://arxiv.org/abs/1511.07794) [hep-ex]

# Gamma Factory study group members (March 2019)

A. Abramov<sup>1</sup>, S.E. Alden<sup>1</sup>, R. Alemany Fernandez<sup>2</sup>, P.S. Antsiferov<sup>3</sup>, A. Apyan<sup>4</sup>, H. Bartosik<sup>2</sup>, E.G. Bessonov<sup>5</sup>, N. Biancacci<sup>2</sup>, J. Bieroń<sup>6</sup>, A. Bogacz<sup>7</sup>, A. Bosco<sup>1</sup>, R. Bruce<sup>2</sup>, D. Budker<sup>8</sup>, K. Cassou<sup>9</sup>, F. Castelli<sup>10</sup>, I. Chaikovska<sup>9</sup>, C. Curatolo<sup>11</sup>, P. Czodrowski<sup>2</sup>, A. Derevianko<sup>12</sup>, K. Dupraz<sup>9</sup>, Y. Dutheil<sup>2</sup>, K. Dzierżęga<sup>6</sup>, V. Fedosseev<sup>2</sup>, N. Fuster Martinez<sup>2</sup>, S. M. Gibson<sup>1</sup>, B. Goddard<sup>2</sup>, A. Gorzawski<sup>13,2</sup>, S. Hirlander<sup>2</sup>, J.M. Jowett<sup>2</sup>, R. Kersevan<sup>2</sup>, M. Kowalska<sup>2</sup>, M.W. Krasny<sup>14,2</sup>, F. Kroeger<sup>15</sup>, D. Kuchler<sup>2</sup>, M. Lamont<sup>2</sup>, T. Lefevre<sup>2</sup>, D. Manglunki<sup>2</sup>, B. Marsh<sup>2</sup>, A. Martens<sup>9</sup>, J. Molson<sup>2</sup>, D. Nutarelli<sup>9</sup>, L. J. Nevay<sup>1</sup>, A. Petrenko<sup>2</sup>, V. Petrillo<sup>10</sup>, W. Płaczek<sup>6</sup>, S. Redaelli<sup>2</sup>, S. Pustelny<sup>6</sup>, S. Rochester<sup>8</sup>, M. Sapinski<sup>16</sup>, M. Schaumann<sup>2</sup>, M. Scrivens<sup>2</sup>, L. Serafini<sup>10</sup>, V.P. Shevelko<sup>5</sup>, T. StoeHLker<sup>15</sup>, A. Surzhikov<sup>17</sup>, I. Tolstikhina<sup>5</sup>, F. Velotti<sup>2</sup>, G. Weber<sup>15</sup>, Y.K. Wu<sup>18</sup>, C. Yin-Vallgren<sup>2</sup>, M. Zanetti<sup>19,11</sup>, F. Zimmermann<sup>2</sup>, M.S. Zolotorev<sup>20</sup> and F. Zomer<sup>9</sup>

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<sup>4</sup> A.I. Alikhanyan National Science Laboratory, Yerevan, Armenia

<sup>5</sup> P.N. Lebedev Physical Institute, Russian Academy of Sciences, Moscow, Russia

<sup>6</sup> Marian Smoluchowski Institute of Physics, Jagiellonian University, Kraków, Poland

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<sup>8</sup> Helmholtz Institute, Johannes Gutenberg University, Mainz, Germany

<sup>9</sup> LAL, Univ. Paris-Sud, CNRS/IN2P3, Université Paris-Saclay, Orsay, France

<sup>10</sup> Department of Physics, INFN-Milan and University of Milan, Milan, Italy

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<sup>13</sup> University of Malta, Malta

<sup>14</sup> LPNHE, University Paris Sorbonne, CNRS-IN2P3, Paris, France

<sup>15</sup> HI Jena, IOQ FSU Jena and GSI Darmstadt, Germany

<sup>16</sup> GSI, Helmholtzzentrum für Schwerionenforschung, 64291 Darmstadt, Germany

<sup>17</sup> Braunschweig University of Technology and Physikalisch-Technische Bundesanstalt, Germany

<sup>18</sup> FEL Laboratory, Duke University, Durham, USA

<sup>19</sup> University of Padua, Padua, Italy

<sup>20</sup> Center for Beam Physics, LBNL, Berkeley, USA

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.*

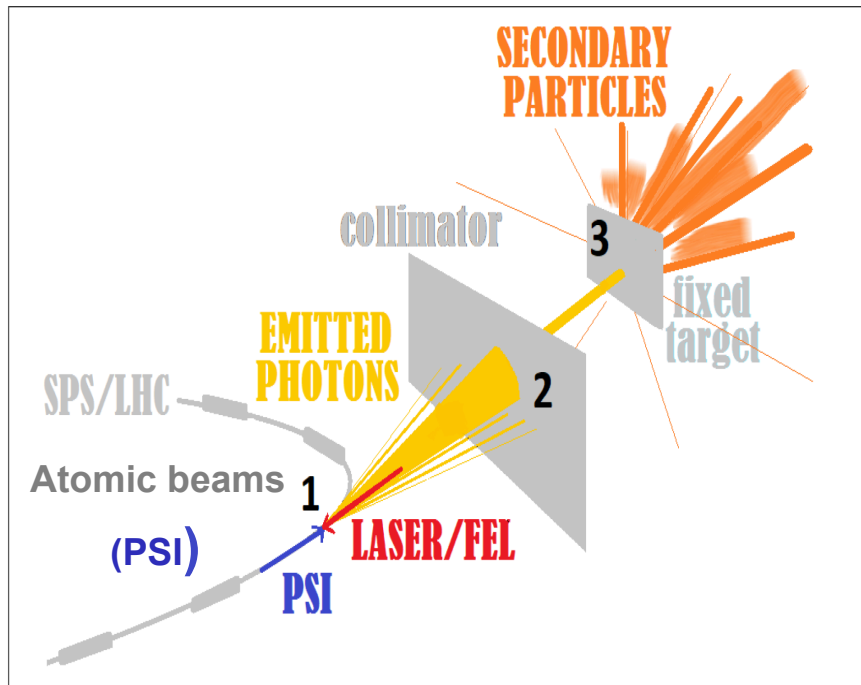
**Reyes Alemany Fernandez** is coordinating all the activities of the preparation and running of PSI beams at CERN and the analysis of their results — including the implementation of the new stripper(s), beam collimation aspects, storage ring vacuum conditions, etc...

**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:



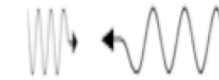
- polarised electrons,
- polarised positrons
- polarised muons
- neutrinos
- neutrons
- vector mesons
- radioactive nuclei

## collider schemes:



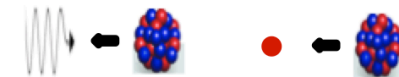
$\gamma\text{-}\gamma$  collisions,

$$E_{\text{CM}} = 0.1 - 800 \text{ MeV}$$



$\gamma\text{-}\gamma_L$  collisions,

$$E_{\text{CM}} = 1 - 100 \text{ keV}$$



$\gamma\text{-}p(A)$ ,  $e p(A)$  collisions,

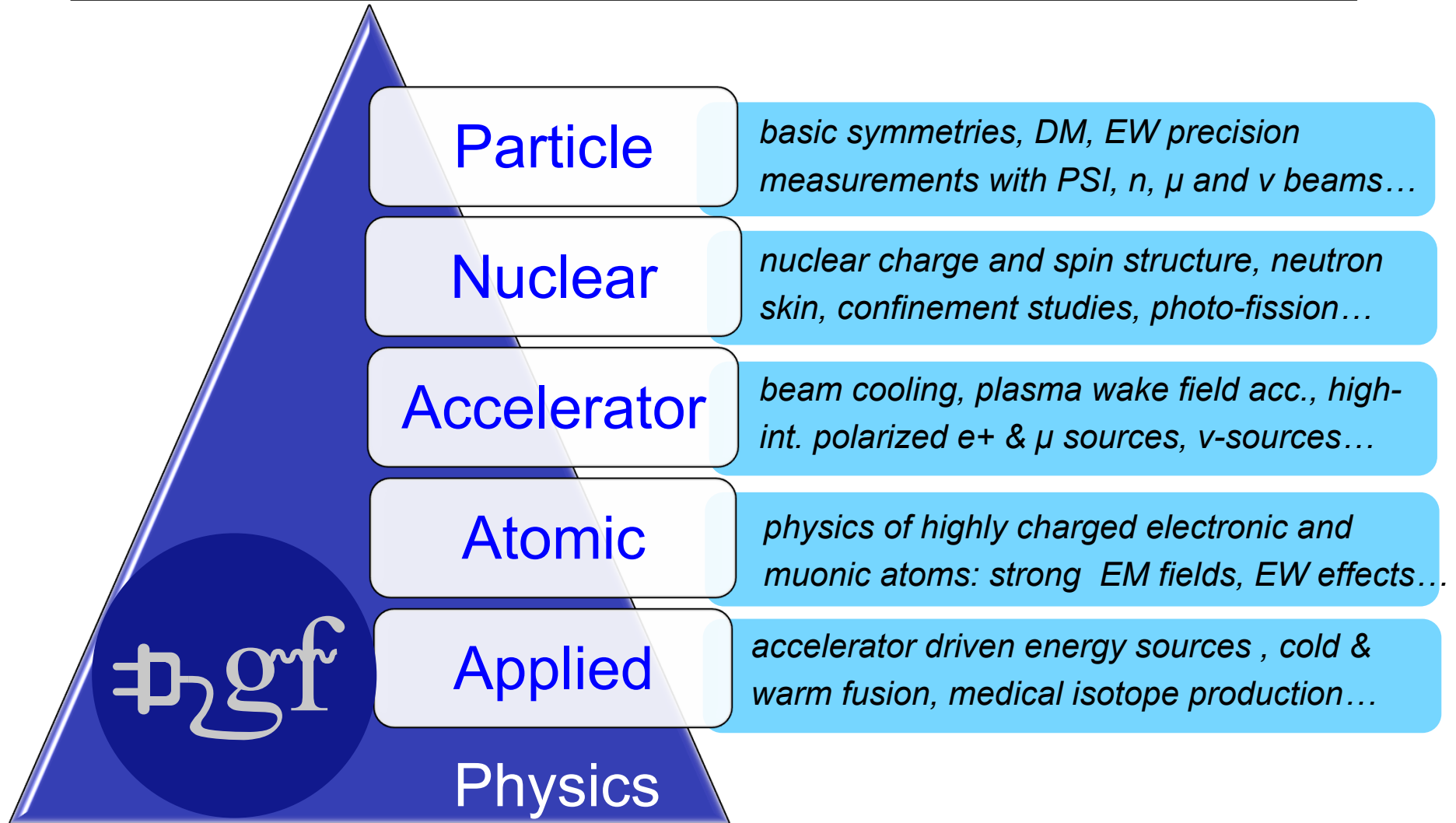
$$E_{\text{CM}} = 4 - 200 \text{ GeV}$$

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:

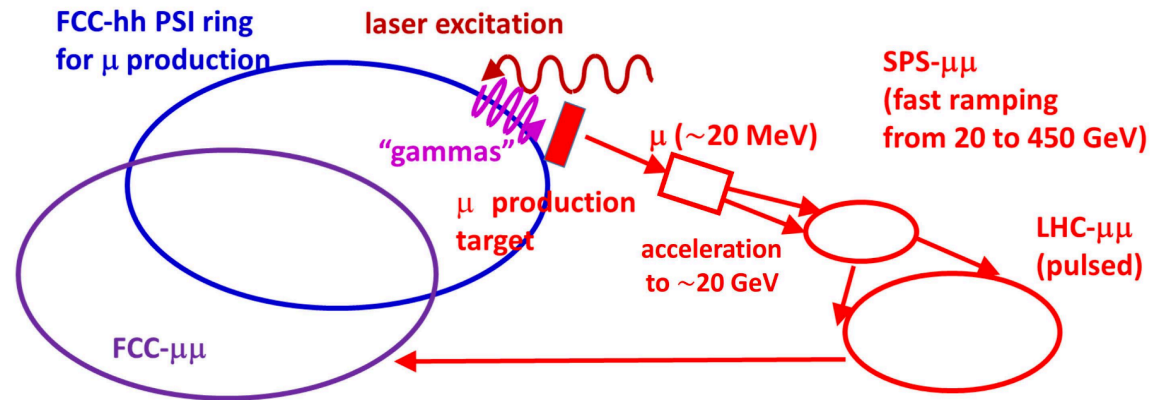
- Low emittance lepton source for muon collider and muon beam based neutrino factory
- Precision EW physics at the LHC with isoscalar beam
- An applied physics example



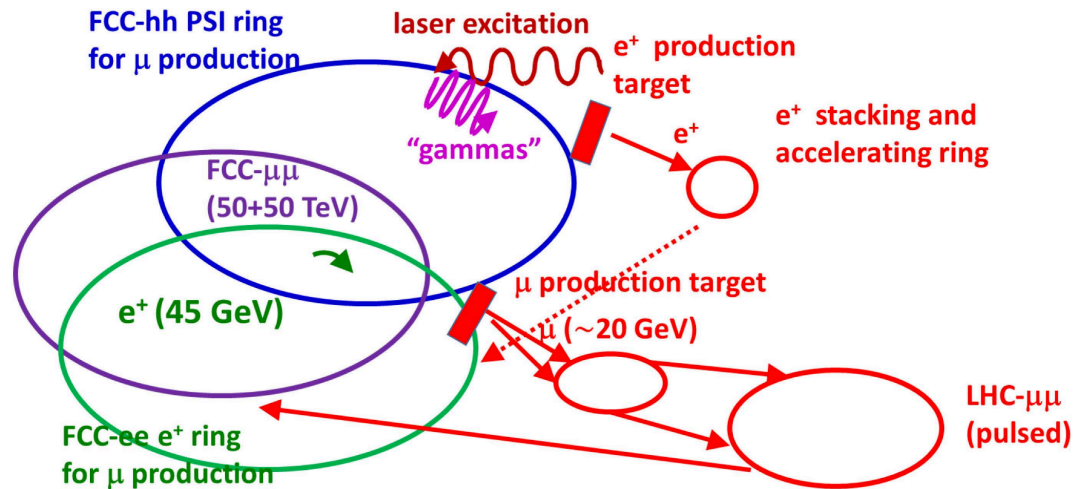


## F. Zimmermann – Muon collider workshop, 2018 - Padova

100 TeV  $\mu$  collider FCC- $\mu\mu$  with FCC-hh PSI  $\mu^\pm$  production

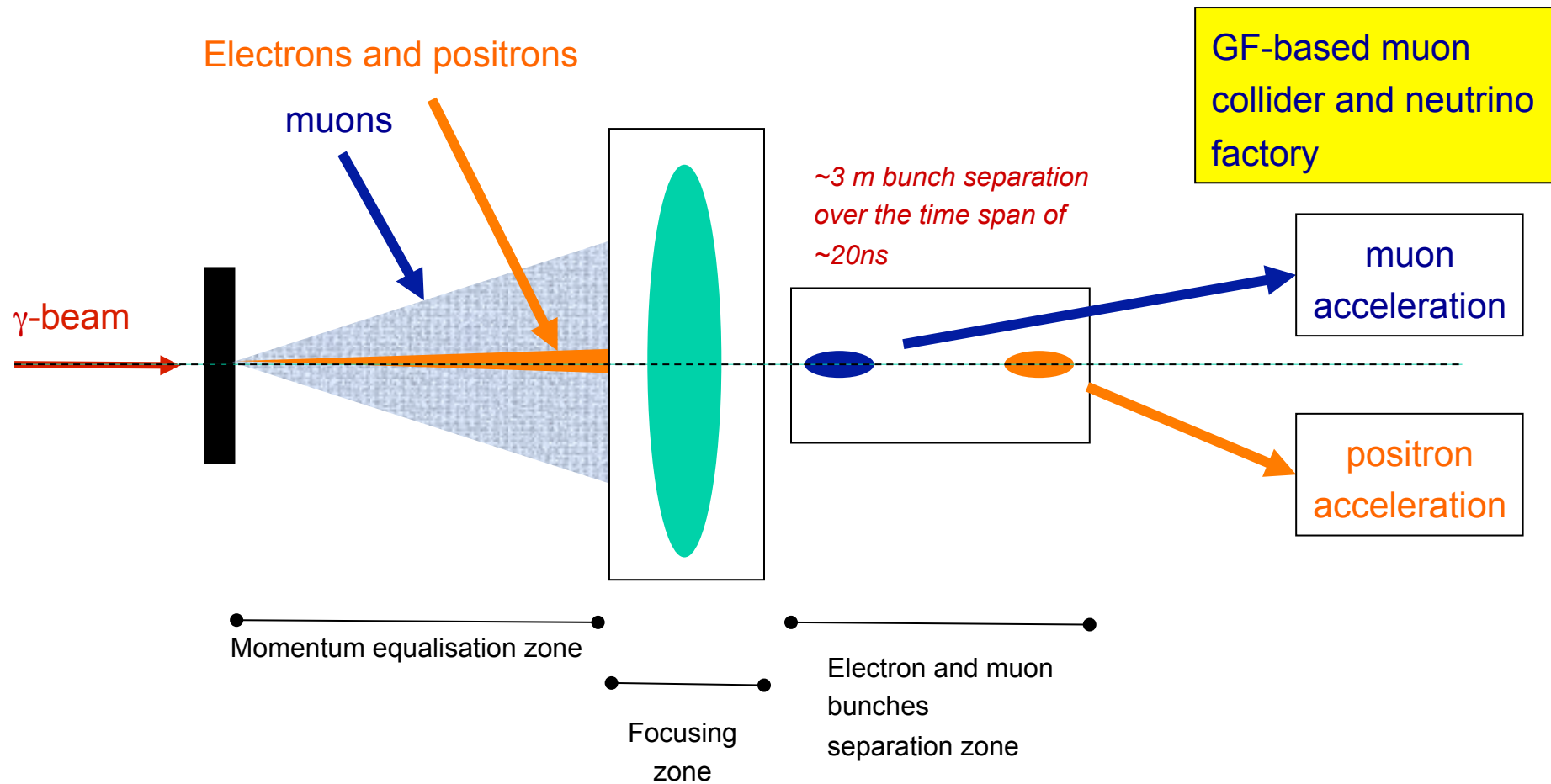


100 TeV  $\mu$  collider FCC- $\mu\mu$  with FCC-hh PSI  $e^+$  & FCC-ee  $\mu^\pm$  production

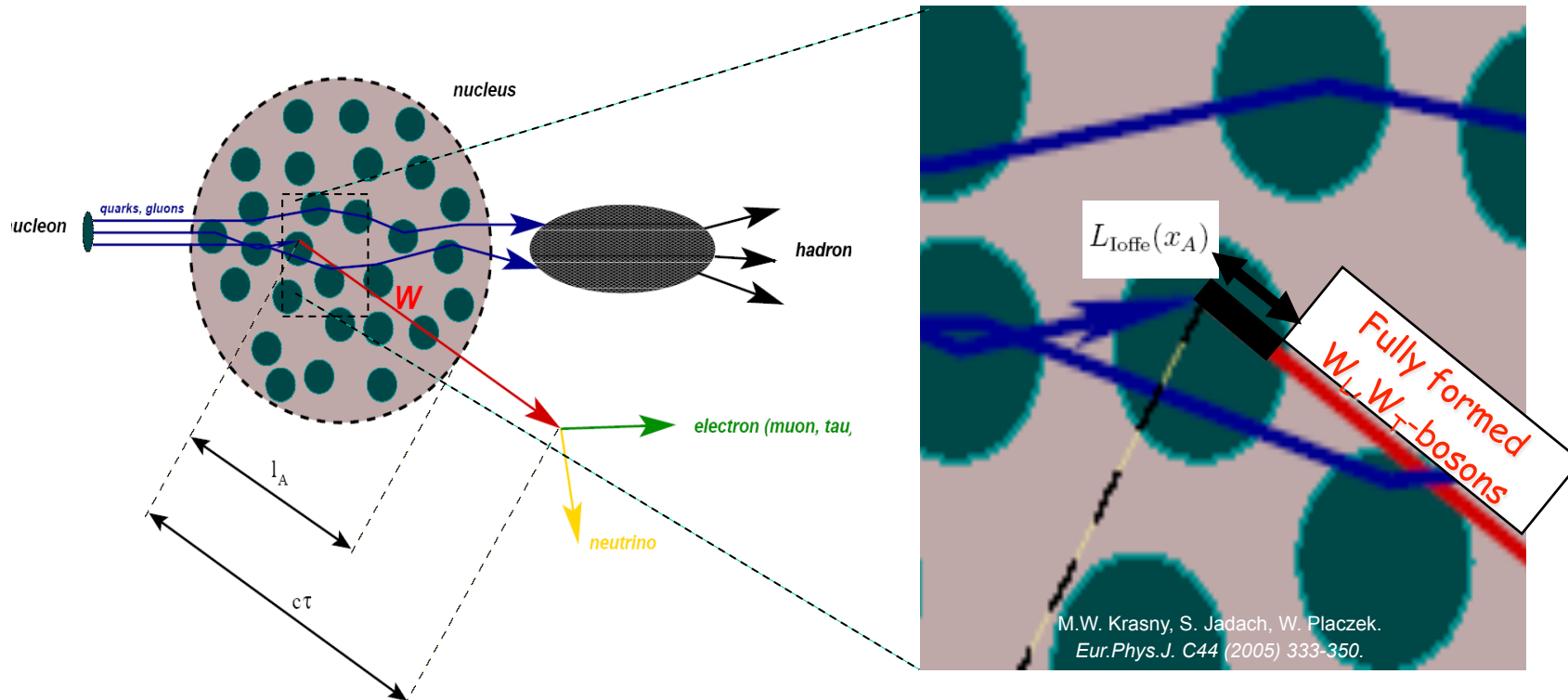


# initial ideas...

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

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

Formation lengths of W-boson

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

# Luminosity requirements for precision EW physics at the LHC

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

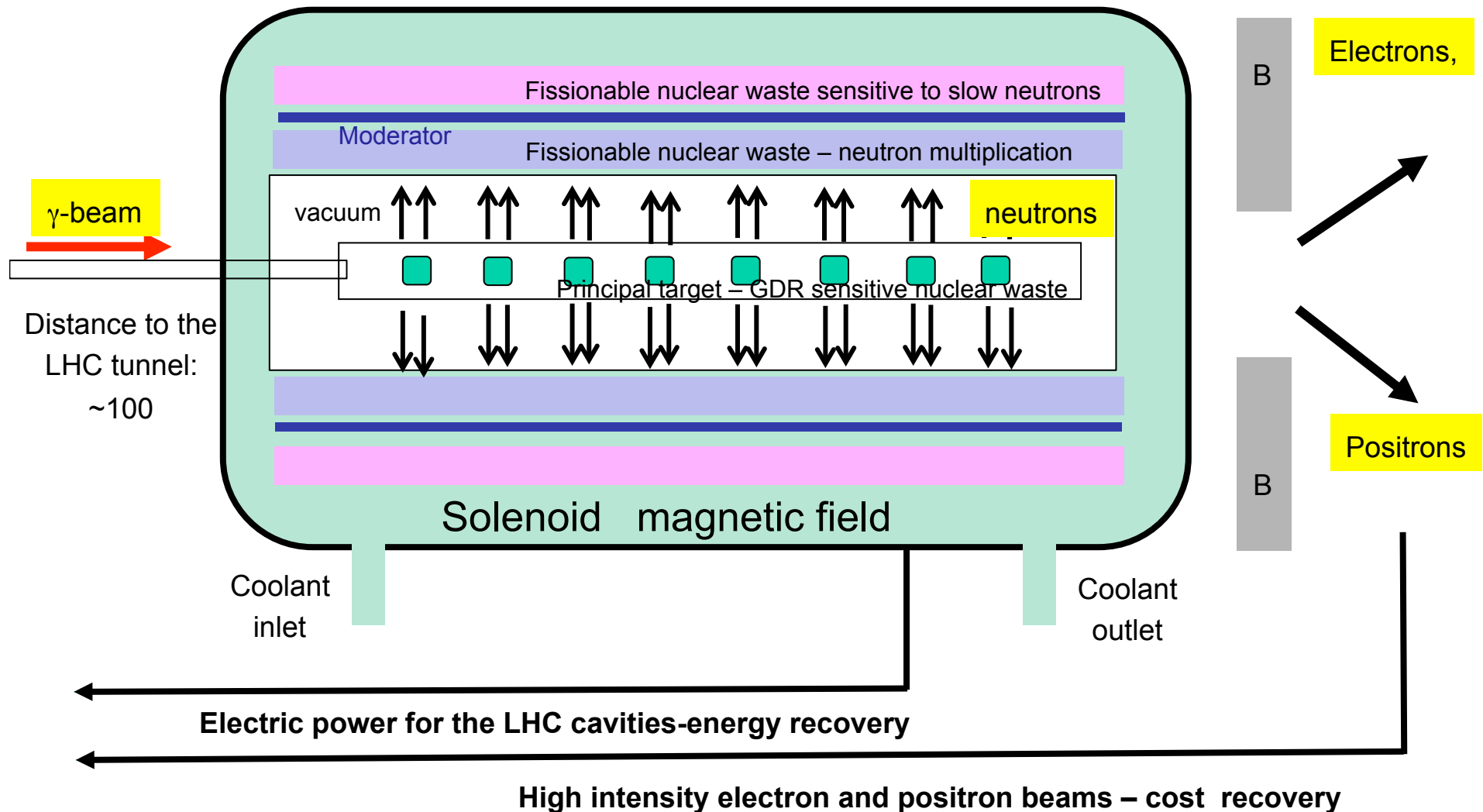
already sufficient for a large fraction of the precision measurement programme with isoscalar beams (e.g. for the  $M_W$  measurement).

Example:  $L_{CaCa} \sim 0.6 \times 10^{30} [1/(\text{cm}^2\text{s})]$  – feasible for  $2 \times 10^9$  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

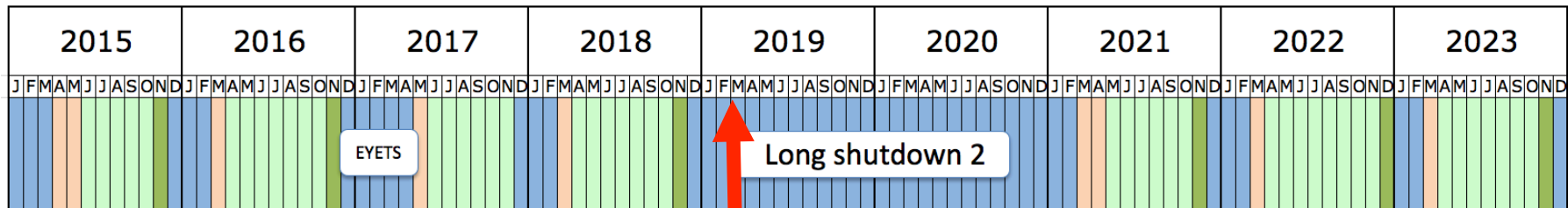
# ... an idea of the secondary positron beam producing station with sustainable research -- the electric power and cost recovery



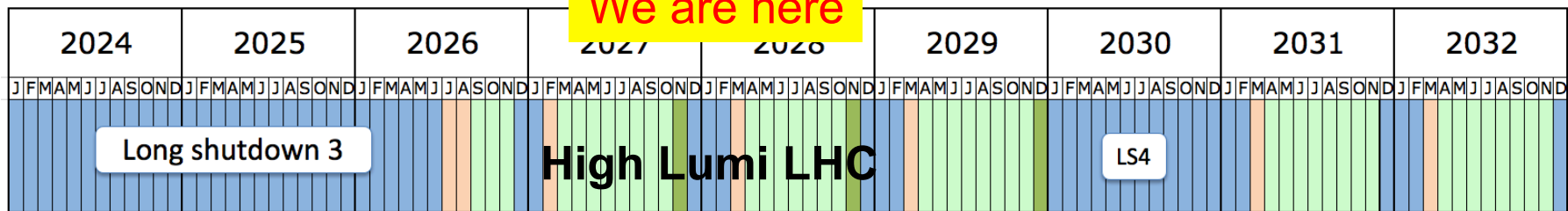
# A path from the GF initial ideas to the GF research project -- three constraints --

- ❑ *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 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.*

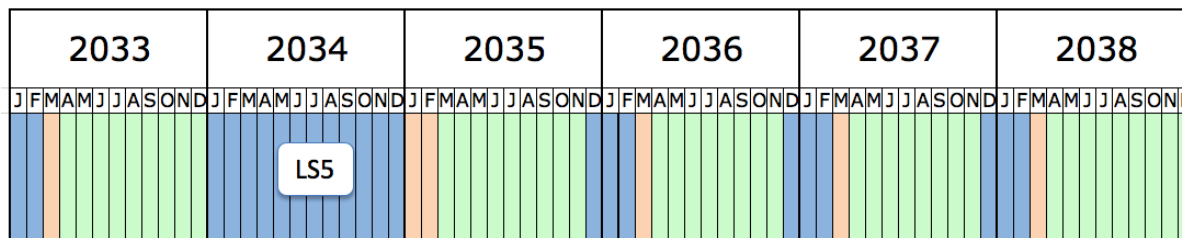
# LHC run schedule



We are here



Start of the LHC-based GF research programme



- Shutdown/Technical stop
- Protons physics
- Commissioning
- Ions

# 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

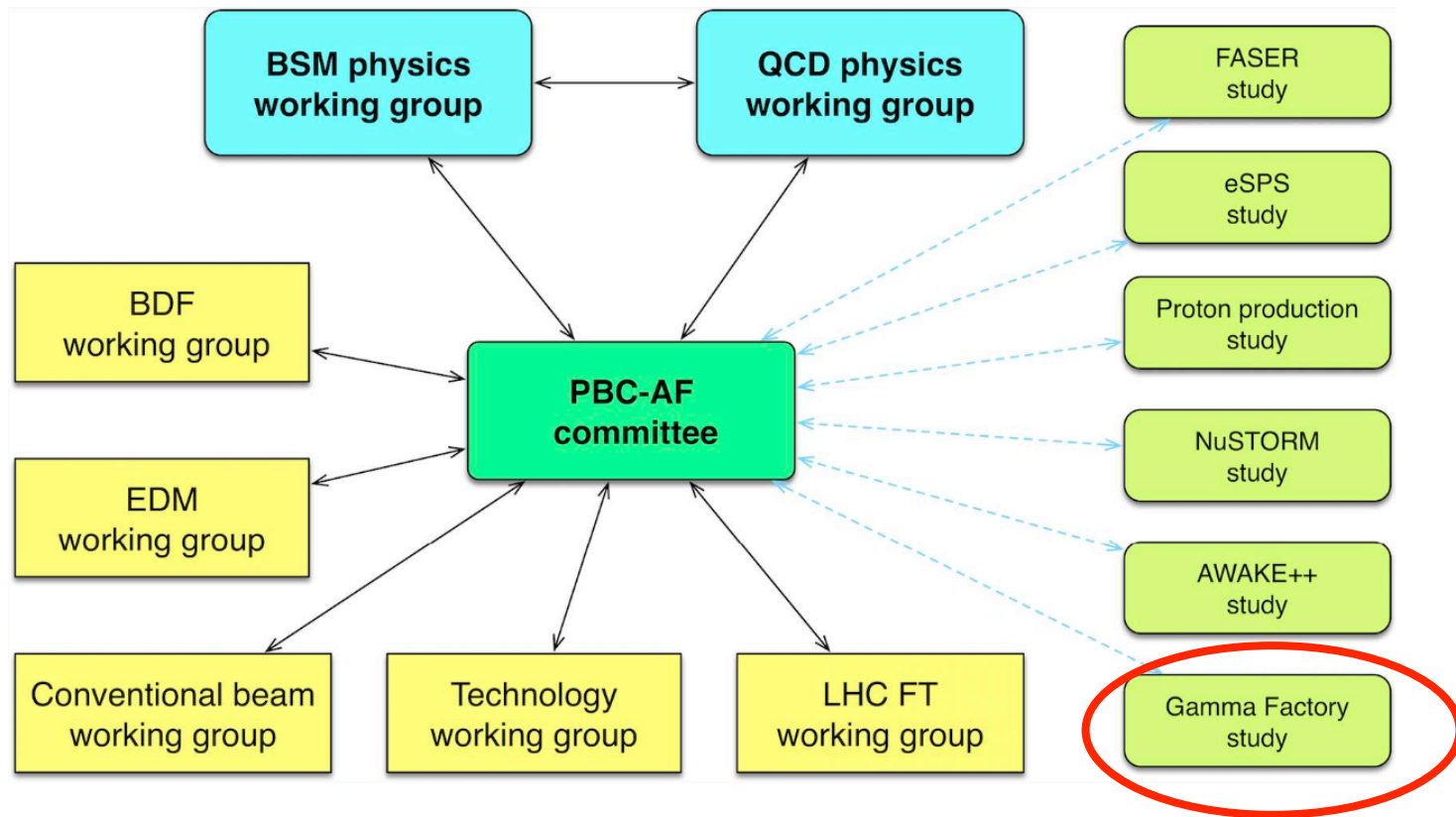
*The Gamma Factory initiative ([arXiv:1511.07794 \[hep-ex\]](https://arxiv.org/abs/1511.07794)) was endorsed by the CERN management by creating (February 2017) **the Gamma Factory study group**, embedded within *the Physics Beyond Colliders (PBC) studies framework*:*

## **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
<b>Preparation for the future</b>	<b>39.1</b>	<b>27.0</b>	<b>35.2</b>	<b>40.5</b>	<b>35.5</b>	<b>36.0</b>	<b>213</b>	<b>35</b>	<b>36</b>	<b>39</b>	<b>97</b>	<b>106</b>	<b>527</b>
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
<b>Scientific diversity activities</b>	<b>33.1</b>	<b>28.1</b>	<b>28.2</b>	<b>22.4</b>	<b>21.3</b>	<b>20.9</b>	<b>154</b>	<b>20</b>	<b>20</b>	<b>20</b>	<b>19</b>	<b>19</b>	<b>251</b>
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.

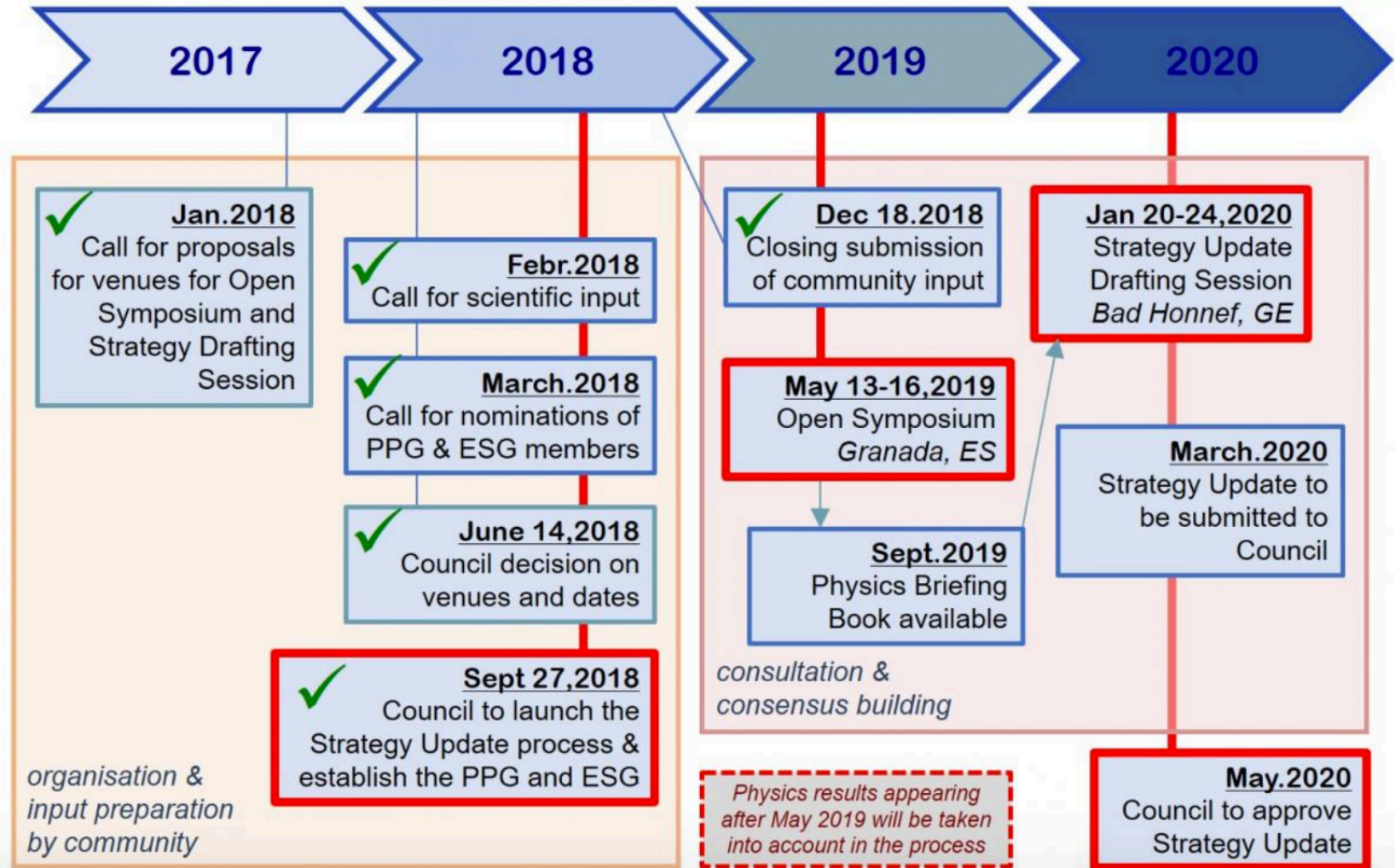
Individual (major) projects require dedicated approval: e.g. HL-LHC

from *Fabiola Gianotti's presentation*

# Process



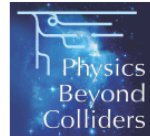
## European Particle Physics Strategy Update



# Gamma Factory group EPPSU contributions

## Gamma Factory for CERN

EPPSU COMPREHENSIVE OVERVIEW

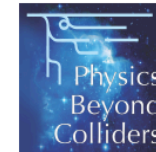


### Abstract

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.***
- 
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 than 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



*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/meriamerberboucha/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.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:

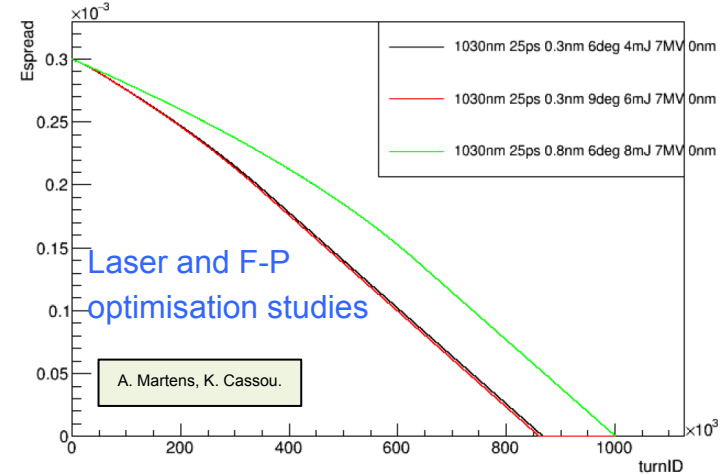
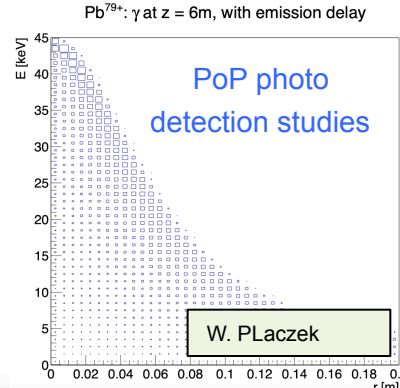
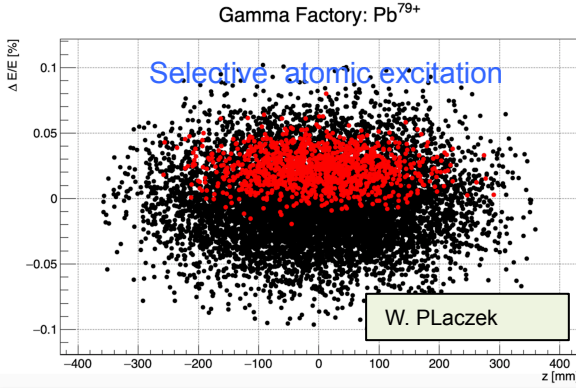
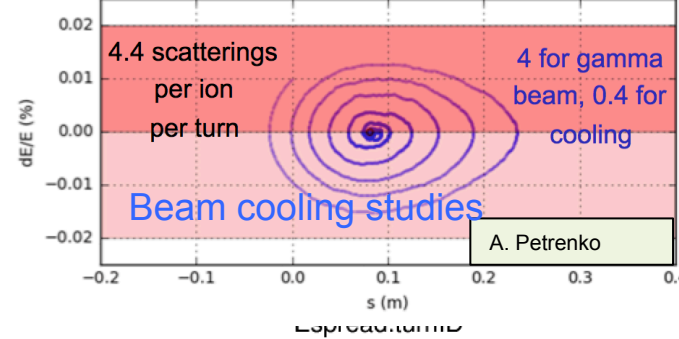
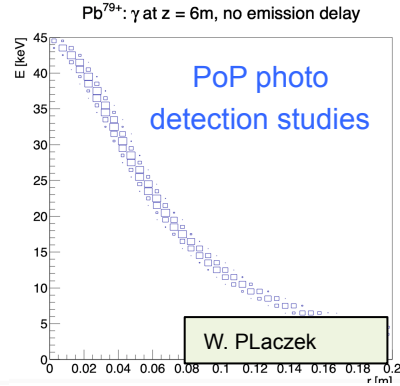
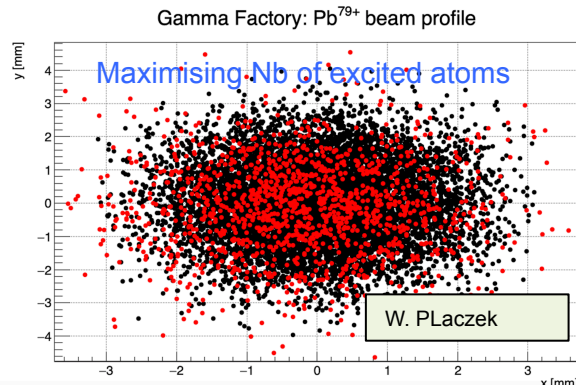
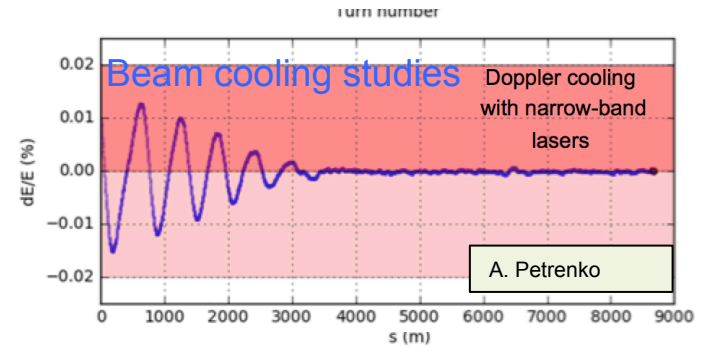
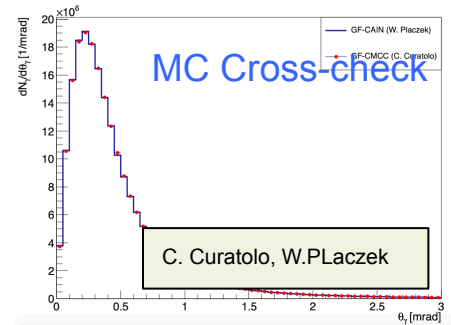
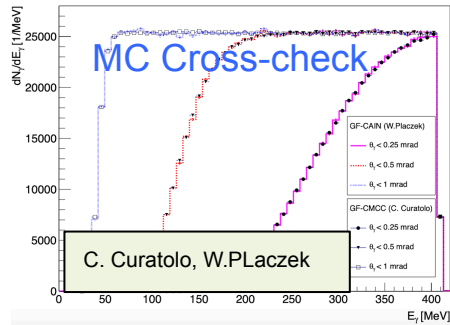
The successful **Gamma Factory** beam tests, with the **Xe+39**, **Pb+80** and **Pb+81** beams, over the year 2017 and 2018 involved dedicated work of the operation teams of the: **Ion source, Linac, PS, SPS, LHC, the BE, EN groups** responsible for the installations of the GF strippers, vacuum teams,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

We (GF-group) acknowledge high quality of their work and 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  $\gamma$ -rays from the collision zone?*
  4. *How to collimate the  $\gamma$ -ray beam?*
  5. *How to monitor/measure the flux of outgoing photons?*
- 
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

GF Phase 1: Initial Study	2016				2017				2018				2019			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
LHC operation													LS2			
SPS operation													LS2			
<i>Activities</i>					Xe <sup>39+</sup> in SPS				Pb <sup>80/81+</sup> in SPS				Pb <sup>81+</sup> in LHC			
									SPS PoP Design							
<i>Milestones</i>					PBC GF Study Group formed				Atomic beams accelerated and stored in SPS & LHC				Proposal for PoP GF experiment in SPS			

## Phase 2 -- SPS PoP experiment and GF performance studies

GF Phase 2: SPS PoP	2020				2021				2022				2023			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
LHC operation	LS2															
SPS operation	LS2															
<i>Activities</i>	Radiation test		Stripper construction		Laser procurement				Build and test FP system				Install in SPS			
									SPS PoP MD beam tests				SPS PoP MD beam tests			
													TDR			
<i>Milestones</i>	Validate Laser radiation tolerance				All equipment ready for SPS installation				System hardware and beam commissioned in SPS				Proof of GF concept and TDR launch			

# 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.**

- 
4. **Realistic assessment of Gamma Factory performance figures.**
  5. **Physics highlights of Gamma Factory based research programme.**
  6. **Gamma Factory TDR.**

# Gamma Factory for CERN

Vol. 1



Editors:

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# Overleaf framework

<https://fr.overleaf.com/project/5c52c7d598873812604174ce>

The screenshot shows the Overleaf web editor interface. The left sidebar contains a navigation menu with folders like 'Chapters', 'BeamTests', 'CERNbeamsGF', 'Conclusions', 'ExecutiveSummary', 'GammaRaySource', 'Introduction', 'LaserCooling', 'PoPatSPS', 'ProjectOverview', 'PSIatCERN', 'SimulationTools', and 'StabilityOfPSIbeams'. The main editor area displays LaTeX source code for a document section on cross sections. The code includes a figure command and a caption. The right sidebar shows a 'Recompiler' button and a '41' notification. The document content includes a figure with two plots and a caption. The first plot shows calculated EL and EC cross sections as a function of ion charge  $q$ . The second plot shows the evolution of charge-state fractions of 1-GeV/u  $Au^{q+}$  ions in Au target as a function of Au foil thickness. The caption explains the figure and compares experimental data with theoretical calculations. The document also includes a section on 'Space charge effects' and 'Intra-beam scattering and intra-beam stripping'.

```
\ref{U-He},
left, as a function of charge state  $q = 40 - 92$  in
comparison
with experimental data at  $q = 60 - 70$ , Ref.
\cite{okuno_2011}.
\begin{figure}[tbh]
\begin{center}
\includegraphics[width=0.99\textwidth]{Chapters/StabilityOfPSIbeams/slava_1.png}
\caption{Left: Single-electron EL1, and EC1 + EC2 cross
sections
(see text) for collisions of 11-MeV/u  $U^{q+}$  ions
with a
molecular He target. Experiment: triangles and circles
- EL and EC
cross sections for  $q = 60 - 70$ , respectively, Ref.
\cite{okuno_2012}. Theory: EL1 and EC1 - results of
RICODE-M and
CAPTURE codes, respectively, at a gas pressure of  $P = 20$  mbar,
EC2 - estimated by the semi-empirical formula of Ref.
\cite{shevelko_2014}. Right. three figures:
```

Secondly, at relativistic energies a contribution of multiple-electron loss and capture processes to the total cross sections becomes very small (Ref. [25]), therefore, calculations are performed mainly for single-electron processes.

A comparison of relativistic charge-changing cross sections for collision of He-like uranium  $U^{90+}$  with H, N and Xe atoms at energies  $E = 0.4 - 5$  GeV/u are shown in Fig. 5.2. It is seen that EC cross sections are much smaller than EL cross sections, which are nearly independent on ion energy and roughly proportional to  $Z^2$  in accordance with the Bohr scaling law.

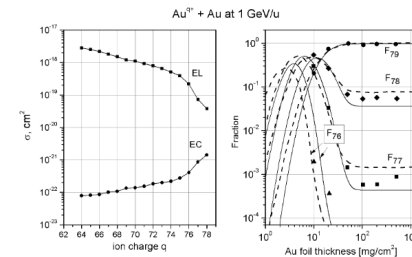


Fig. 5.3: Left: Calculated EL and EC = NRC + REC cross sections for collisions of  $Au^{q+}$  ions with Au atoms at 1 GeV/u as a function of ion charge  $q$ . Right: Evolution of charge-state fractions of 1-GeV/u  $Au^{q+}$  ions in Au target. Symbols - experimental data Ref. [29], dashed curves - result of the GLOBAL code, Ref. [29], solid curves - the BREIT result. From Ref. [46].

Calculated charge-changing cross sections for collisions of  $Au^{q+}$  ions with Au atoms at 1 GeV/u are shown in Fig. 5.3, left, as a function of the ion charge  $q$ . The cross-section curves do not cross and become closer at highest  $q$ , corresponding to bare Au ions (cf. Fig. 5.1). Dynamics of the charge-state fractions of gold ions as a function of Au foil thickness, calculated by the BREIT code, is shown in Fig. 5.3, right, in comparison with experimental data and calculations by the GLOBAL code, Ref. [29].

#### 5.4 Space charge effects

John

#### 5.5 Intra-beam scattering and intra-beam stripping

John



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# 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 phase**: (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 Lol 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** 🕒 45m  
Speaker: Mieczyslaw Krasny (Universite Sorbonne Nouvelle Paris III (FR))
- 09:45** **Acceleration and storage of ion beams at CERN.** 🕒 25m  
Speaker: Reyes Alemany Fernandez (CERN)
- 10:10** **Coffee break** 🕒 30m
- 10:40** **Ion sources - present status.** 🕒 30m  
Speaker: Richard Scrivens (CERN)
- 11:10** **SPS and LHC vacuum.** 🕒 50m  
Speaker: Roberto Kersevan (CERN)

# The agenda of the meeting

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

14:00	→ 15:15	<b>PSI beams, cont</b> Convener: Reyes Alemany Fernandez (CERN)	60-6-015 - Room Georges Cha...
14:00		<b>Collimation of PSI beams.</b> Speaker: Roderik Bruce (CERN)	25m
14:25		<b>Optimisation of the stripper foil material and thickness for GF.</b> Speaker: Felix Kroeger	25m
14:50		<b>PSI operation constraints: Run 3 and Run 4.</b> Speaker: Reyes Alemany Fernandez (CERN)	25m
15:15	→ 15:50	<b>Stability aspects of PSI beams</b> Convener: Reyes Alemany Fernandez (CERN)	60-6-015 - Room Georges Cha...
15:15		<b>Beam gas collisions.</b> Speaker: Viatcheslav Shevelko	25m
15:40		<b>Stark effect.</b> Speaker: Mieczyslaw Krasny (Universite Sorbonne Nouvelle Paris III (FR))	10m
15:50	→ 16:20	<b>Coffee break</b>	30m
16:20	→ 17:15	<b>SPS and LHC beam test results</b> Convener: Reyes Alemany Fernandez (CERN)	60-6-015 - Room Georges Cha...
16:20		<b>Xe+39, Pb+80 and Pb+81 tests in SPS</b> Speaker: Simon Hirlander (CERN)	20m
16:40		<b>Pb81+ tests in LHC.</b> Speaker: Michaela Schaumann (CERN)	35m

# The agenda of the meeting

Tuesday afternoon – gamma ray source session. – chaired by Andrey  
software tools development session chaired by Alexey

TUESDAY, 20 MARCH

09:00 → 12:00	Discussion session (Room 4-S-030)	4-S-030
12:00 → 14:00	Lunch Break	2h
14:00 → 17:30	<b>Gamma Ray source</b> Convener: Andrey Surzhikov	60-6-015 - Room Georges Cha...
14:00	<b>Overview of the gamma-ray sources.</b> Speaker: Luca Serafini (INFN-Milan)	35m
14:35	<b>Atomic Physics aspects of the GF software.</b> Speaker: Simon Rochester	35m
15:10	<b>Spatiotemporal and spectral optimisation of the Laser+F-P photon fluxes</b> Speaker: Aurelien Martens (LAL/IN2P3/CNRS)	30m
15:40	<b>Gamma Factory ion beam dynamics</b> Speaker: Alexey Petrenko (Budker Institute of Nuclear Physics (RU))	20m
16:00	Coffee break	30m
16:30	<b>Spatiotemporal and spectral optimisation of FEL photon fluxes.</b> Speaker: Vittoria Petrillo	30m
17:30 → 18:35	<b>Software tools development</b> Convener: Alexey Petrenko (Budker Institute of Nuclear Physics (RU))	60-6-015 - Room Georges Cha...
17:30	<b>Overview and plans</b> Speaker: Alexey Petrenko (Budker Institute of Nuclear Physics (RU))	30m
18:00	<b>PSI driven gamma source – fundamentals.</b> Speaker: Dmitry 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	<b>Semi-Analytical calculations.</b> Speaker: Aurelien Martens (Centre National de la Recherche Scientifique (FR))	25m
09:25	<b>GF-CMCC.</b> Speaker: Camilla Curatolo (INFN - National Institute for Nuclear Physics)	25m
09:50	<b>GF-Cain.</b> Speaker: Wiesiek Placzek (Jagiellonian University)	25m
10:15	<b>Coffee break</b>	30m
10:45	<b>RH code for photon-PSI collisions.</b> Speaker: Siobhan Alden	20m
11:05	<b>Muon pair production Monte Carlo.</b> Speaker: Vladimir Ivantchenko (CERN)	30m
11:35	<b>Discussion on the way forward in the GF software development</b> 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 experiment	60-6-015 - Room Georges Cha...
14:00		<b>Overall concept, stages and procedure.</b> Speaker: Brennan Goddard (CERN)	40m
14:40		<b>SPS accelerator aspects.</b> Speaker: Yann Dutheil (CERN)	20m
15:00		<b>Ion transition parameters and their present uncertainties.</b> Speaker: Andrey Surzhikov	20m
15:20		<b>Photon flux simulations.</b> Speaker: Camilla Curatolo (INFN - National Institute for Nuclear Physics)	20m
15:40		<b>Coffee break</b>	30m
16:10		<b>Impedance guidelines for the SPS</b> Speaker: Aaron Farricker (CERN)	1h
17:10		<b>Bunch dynamic.</b> ¶ Speaker: Alexey Petrenko (Budker Institute of Nuclear Physics (RU))	30m
17:40		<b>Laser system for single bunch, "photon production" option.</b> Speaker: Stephen Gibson (Royal Holloway, University of London)	20m

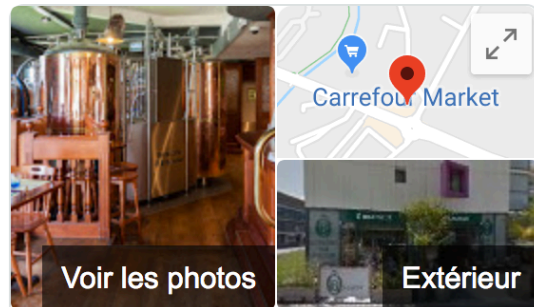
# The agenda of the meeting

Thursday morning – PoP experiment session chaired by Bren and Yann  
(SPS tunnel visit organised by Reyes)

THURSDAY, 28 MARCH

09:00 → 12:50	<b>PoP experiment, cont.</b>	60-6-015 - Room Georges Cha...
Conveners: Brennan Goddard (CERN), Yann Dutheil (CERN)		
09:00	<b>Laser system(s) for single bunch and bunch train (cavity) "cooling proof" options.</b>	40m
Speaker: Dr Kevin CASSOU (LAL/CNRS)		
09:40	<b>Radiation aspects.</b>	40m
Speaker: Ruben Garcia Alia (CERN)		
10:20	<b>SPS-RF - Timing and synchronization.</b>	40m
Speaker: Wolfgang Hofle (CERN)		
11:00	<b>Coffee break</b>	30m
11:30	<b>Photon detection system(s) - photon production and beam cooling observation functions.</b>	40m
Speaker: Thibaut Lefevre (CERN)		
12:10	<b>Experiment Layout and schedule</b>	40m
Speaker: Brennan Goddard (CERN)		
13:00 → 15:00	<b>Lunch Break</b>	2h
15:00 → 19:00	<b>SPS Visit</b>	

# Tuesday dinner



Voir les photos

Extérieur

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[Suggérer une modification](#)

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!**