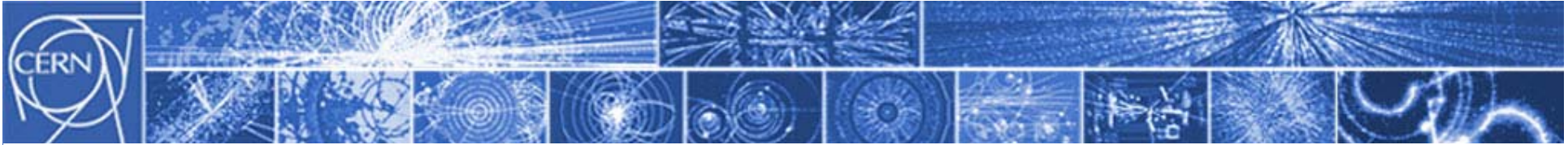


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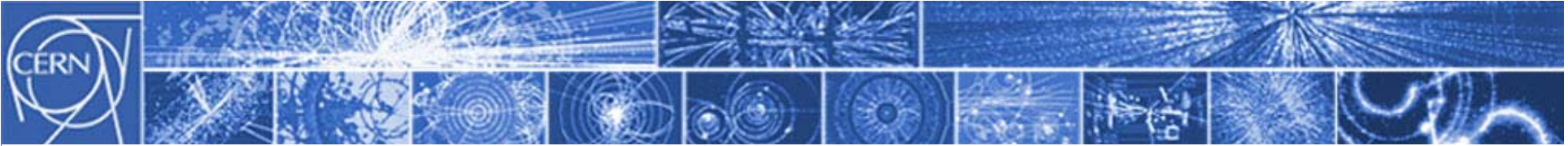
# SPL STUDY & COLLABORATION MEETING

**First SPL Collaboration Meeting  
11-12 December, 2008 -  
CERN**



# OUTLINE

1. Introduction:
  - Motivation for renovating the injectors
  - Description
  - Stages of implementation
  
2. Work Plan of the SPL Study
  
3. Collaboration Meeting
  - Goals
  - Organization



# 1. INTRODUCTION: Motivation

## 1. Lack of reliability:

Ageing accelerators (PS is 48 years old !) operating far beyond initial parameters

⇒ **need for new accelerators designed for the needs of SLHC**

## 2. Main performance limitation:

Excessive incoherent space charge tune spreads  $\Delta Q_{SC}$  at injection in the PSB (50 MeV) and PS (1.4 GeV) because of the high required beam brightness  $N/\varepsilon^*$ .

$$\Delta Q_{SC} \propto \frac{N_b}{\varepsilon_{X,Y}} \cdot \frac{R}{\beta\gamma^2}$$

with  $N_b$  : number of protons/bunch

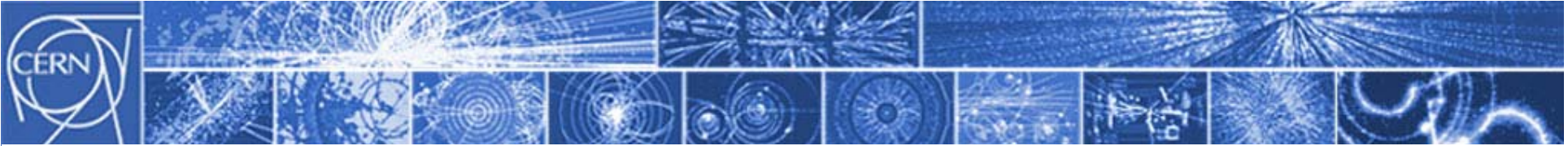
$\varepsilon_{X,Y}$  : normalized transverse emittances

$R$  : mean radius of the accelerator

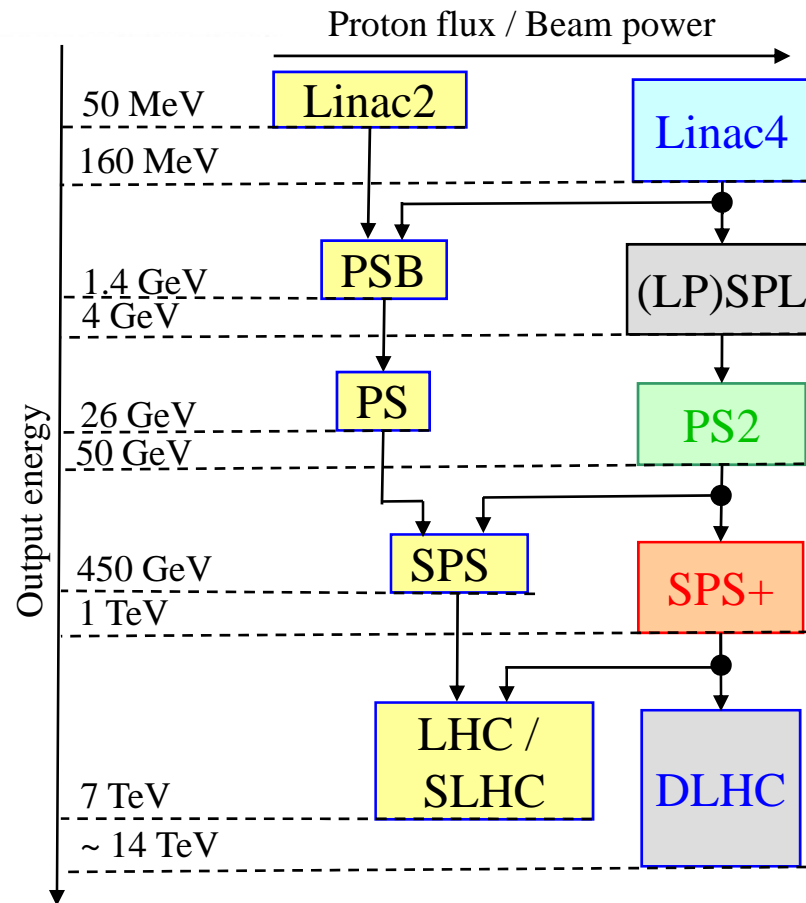
$\beta\gamma$  : classical relativistic parameters

⇒ **need to increase the injection energy in the synchrotrons**

- Increase injection energy in the PSB from 50 to 160 MeV kinetic
- Increase injection energy in the PSB from 25 to 50 GeV kinetic
- Design the PS successor (PS2) with an acceptable space charge effect for the maximum beam envisaged for SLHC: => injection energy of 4 GeV



# 1. INTRODUCTION: Description (1/2)



(LP)SPL: (Low Power)  
Superconducting Proton  
Linac (4-5 GeV)

PS2: High Energy PS  
(~ 5 to 50 GeV – 0.3 Hz)

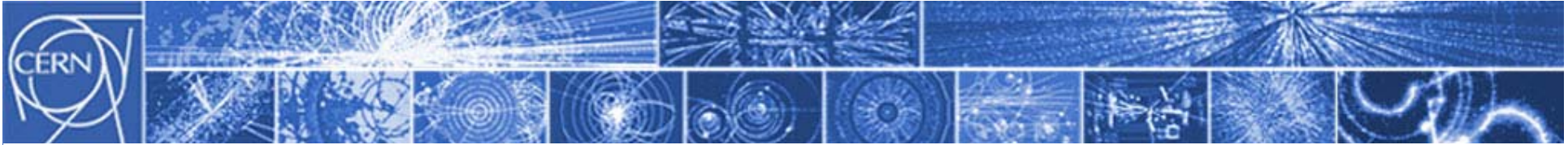
SPS+: Superconducting SPS  
(50 to 1000 GeV)

SLHC: “Superluminosity” LHC  
(up to  $10^{35} \text{ cm}^{-2}\text{s}^{-1}$ )

DLHC: “Double energy” LHC  
(1 to ~14 TeV)

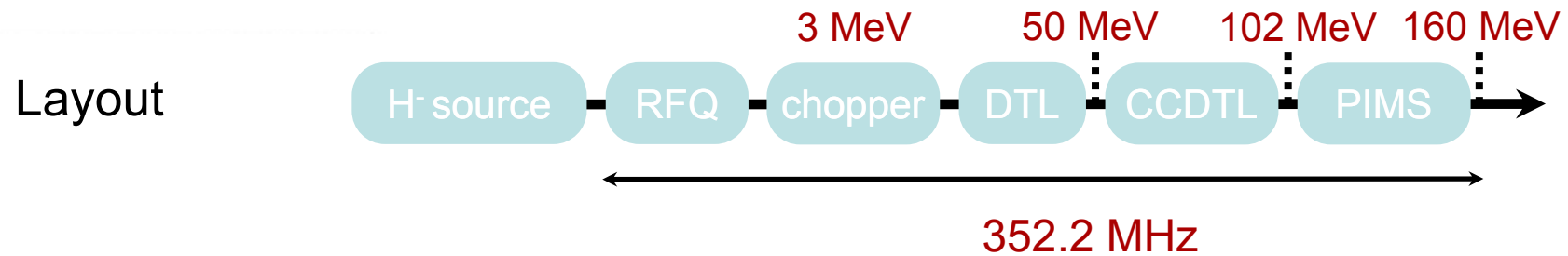






# 1. INTRODUCTION: Stage 1 (1/2)

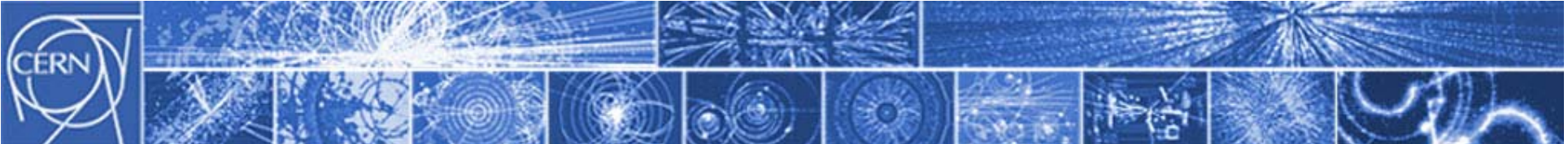
## LINAC4



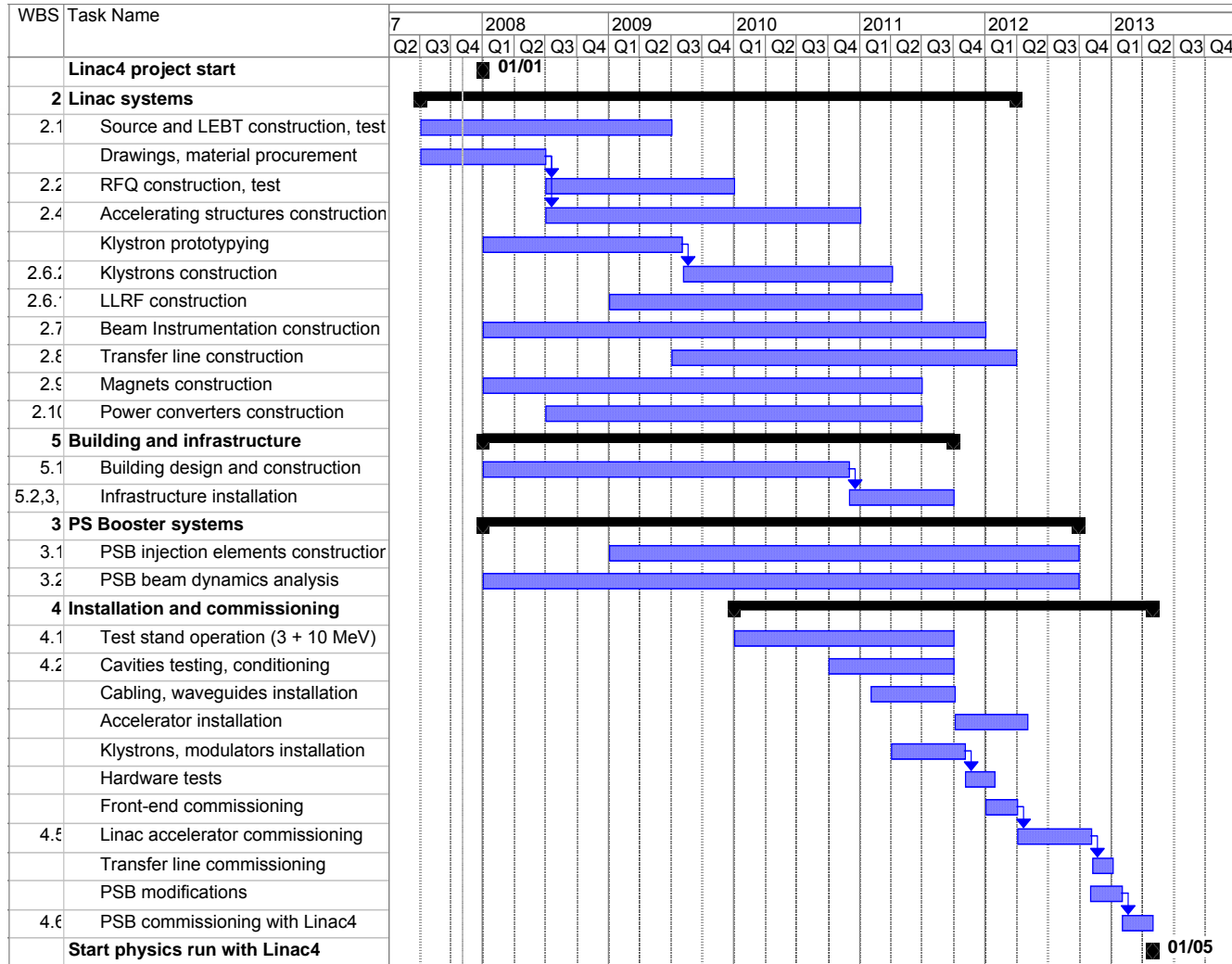
Beam characteristics

Ion species	H <sup>-</sup>
Output kinetic energy	160 MeV
Bunch frequency	352.2 MHz
Max. repetition rate	1.1 (2) Hz
Beam pulse duration	0.4 (1.2) ms
Chopping factor (beam on)	62%
Source current	80 mA
RFQ output current	70 mA
Linac current	64 mA
Average current during beam pulse	40 mA
Beam power	5.1 kW
Particles / pulse	1.0 10 <sup>14</sup>



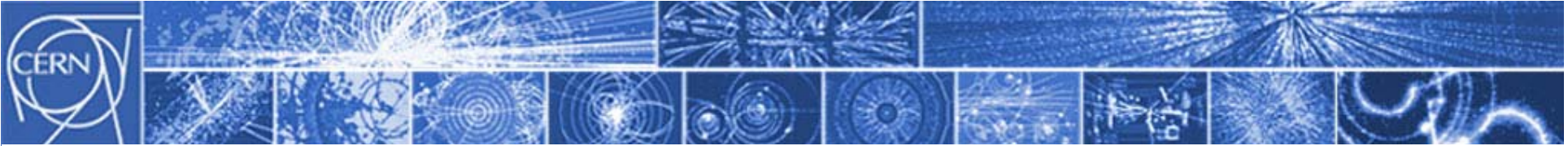


# 1. INTRODUCTION: Stage 1 (2/2)



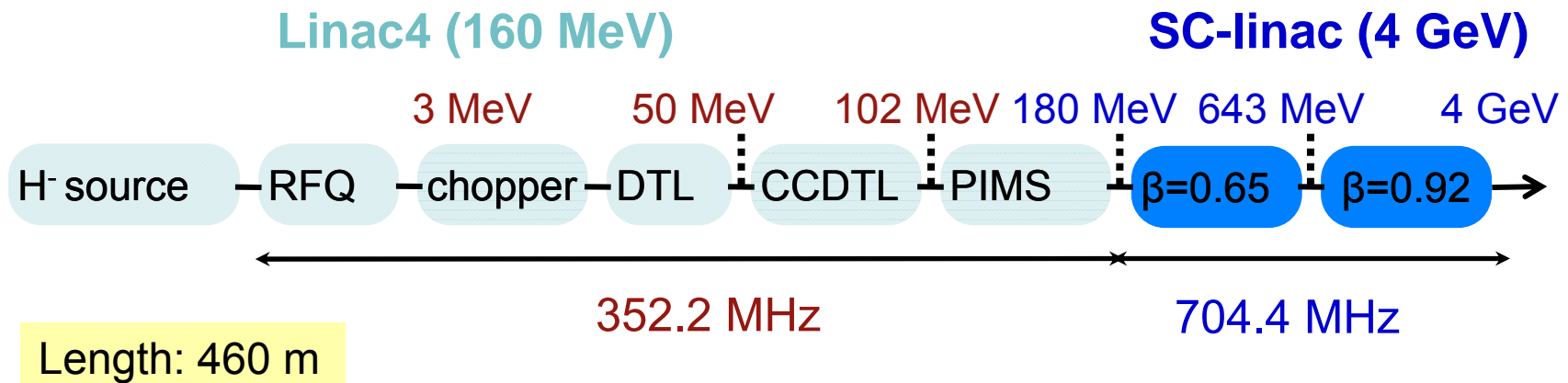
**Milestones**

- End CE works: December 2010
- Installation: 2011
- Linac commissioning: 2012
- Modifications PSB: shut-down 2012/13 (6 months)
- **Beam from PSB: 1rst of May 2013**



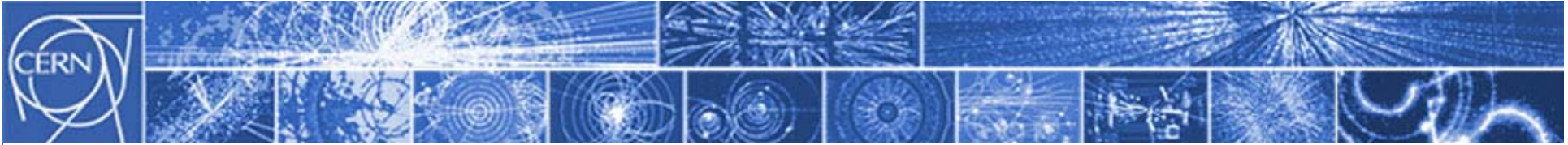
# 1. INTRODUCTION: Stage 2 (1/4)

## LP-SPL



LP-SPL beam characteristics	Kinetic energy (GeV)	4
	Beam power at 4 GeV (MW)	0.16
	Rep. period (s)	0.6
	Protons/pulse ( $\times 10^{14}$ )	1.5
	Average pulse current (mA)	20
	Pulse duration (ms)	1.2





# 1. INTRODUCTION: Stage 2 (2/4)

**PS2** main characteristics compared to the **present PS**

	<b>PS2</b>	<b>PS</b>
<b>Injection energy kinetic (GeV)</b>	4.0	1.4
<b>Extraction energy kinetic (GeV)</b>	~ 50	13/25
<b>Circumference (m)</b>	1346	628
<b>Maximum intensity LHC (25ns) (p/b)</b>	$4.0 \times 10^{11}$	$\sim 1.7 \times 10^{11}$
<b>Maximum intensity for fixed target physics (p/p)</b>	$1.2 \times 10^{14}$	$3.3 \times 10^{13}$
<b>Maximum energy per beam pulse (kJ)</b>	1000	70
<b>Max ramp rate (T/s)</b>	1.5	2.2
<b>Cycle time at 50 GeV (s)</b>	2.4	1.2/2.4
<b>Max. effective beam power (kW)</b>	400	60



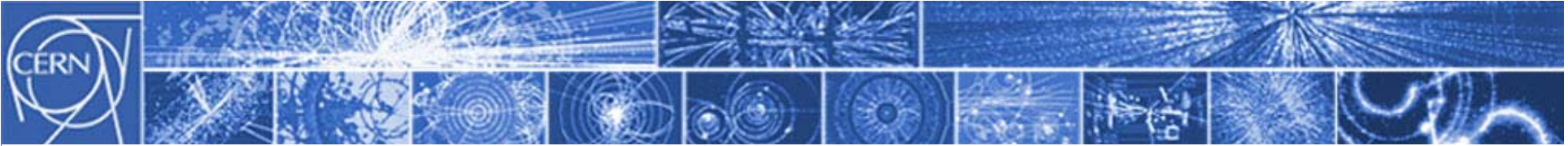
# 1. INTRODUCTION: Stage 2 (3/4)

Construction of LP-SPL and PS2 will not interfere with the regular operation of Linac4 + PSB for physics. Similarly, beam commissioning of LP-SPL and PS2 will take place without interference with physics.

ID	Task Name	Start	Finish	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	<b>SPL + PS2</b>	<b>Mon 1/7/08</b>	<b>Mon 7/3/17</b>												
2	Design	Mon 1/7/08	Wed 6/1/11												
3	SPL Construction	Mon 1/2/12	Fri 1/1/16												
4	SPL beam commissioning	Mon 6/1/15	Fri 12/2/16												
5	PS2 construction	Mon 1/2/12	Fri 4/1/16												
6	PS2 beam commissioning	Mon 4/4/16	Fri 12/2/16												
7	SPS modification	Fri 11/4/16	Fri 5/5/17												
8	SPS beam commissioning	Mon 5/8/17	Fri 6/30/17												
9	Start operation for physics	Mon 7/3/17	Mon 7/3/17												

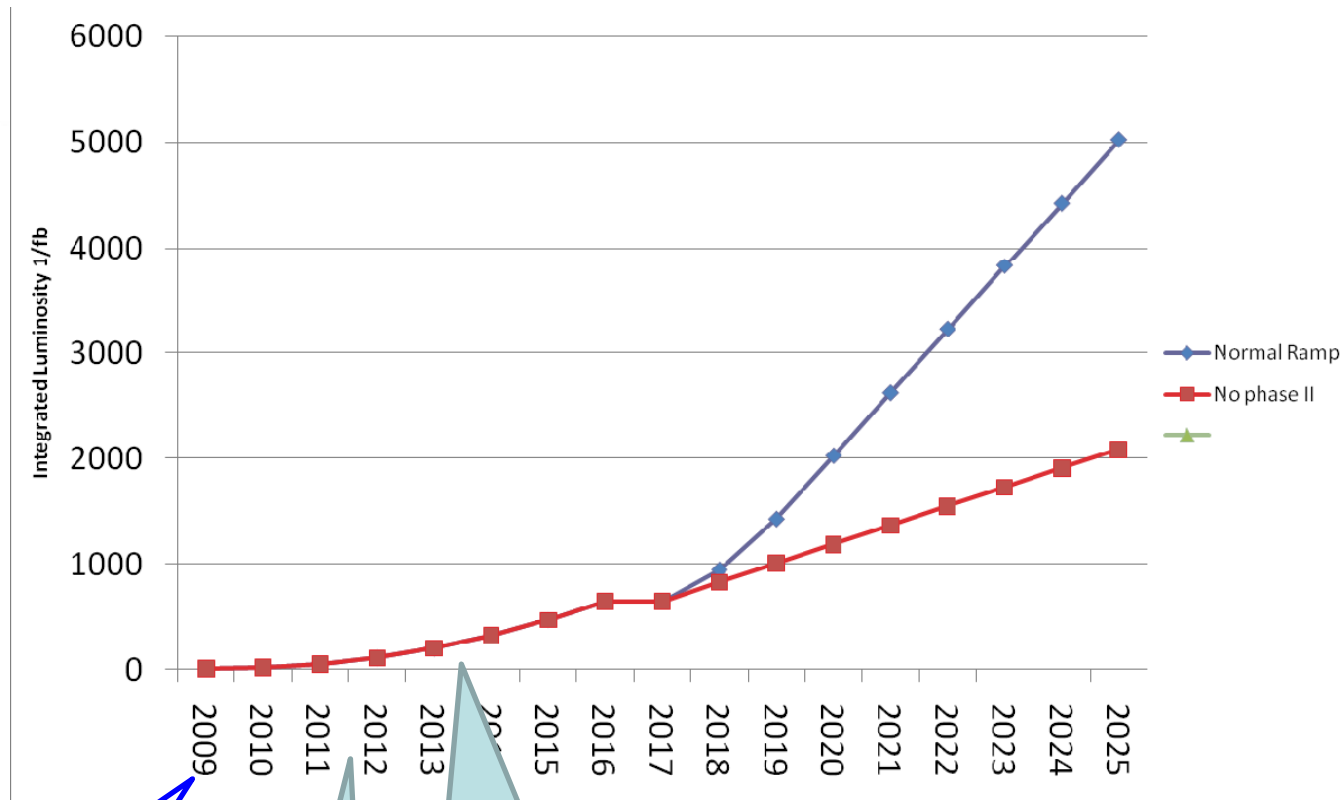
## Milestones

- Project proposal: June 2011
- Project start: January 2012
- LP-SPL commissioning: mid-2015
- PS2 commissioning: mid-2016
- SPS commissioning: May 2017
- **Beam for physics: July 2017**



# 1. INTRODUCTION: Stage 2 (4/4)

Integrated luminosity in LHC...

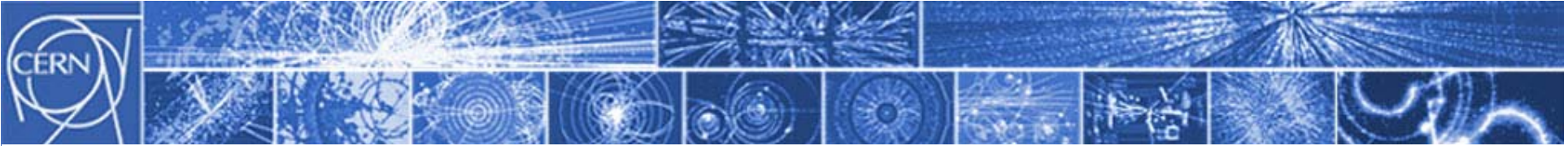


Early operation

Collimation phase 2

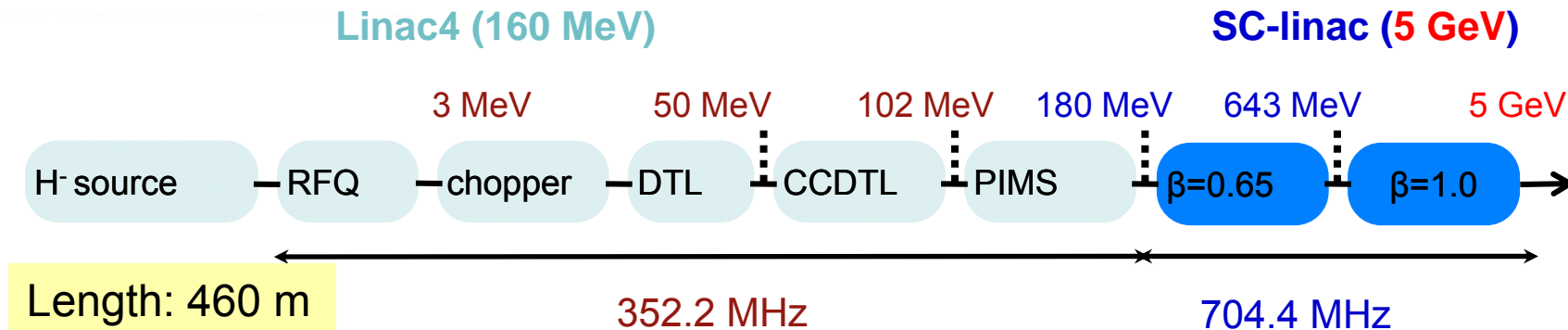
Linac4 + IR upgrade phase 1





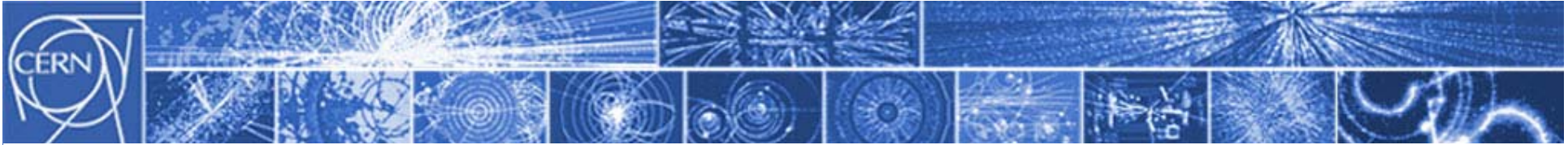
# 1. INTRODUCTION: Stage 3 (1/2)

## HP-SPL



HP-SPL beam characteristics

	Option 1	Option 2
Energy (GeV)	2.5 or 5	2.5 and 5
Beam power (MW)	3 MW (2.5 GeV) <u>or</u> 6 MW (5 GeV)	4 MW (2.5 GeV) <u>and</u> 4 MW (5 GeV)
Rep. frequency (Hz)	50	50
Protons/pulse (x 10 <sup>14</sup> )	1.5	2 (2.5 GeV) + 1 (5 GeV)
Av. Pulse current (mA)	20	40
Pulse duration (ms)	1.2	0.8 (2.5 GeV) + 0.4 (5 GeV)

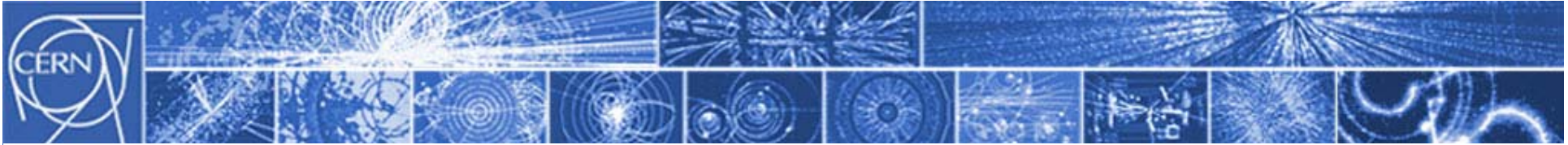


## 1. INTRODUCTION: Stage 3 (2/2)

**Additional option initiated in September 2008 (LHeC workshop in Divonne): use the  $\beta=1$  part of the SPL for multi-pass acceleration of  $e^+/e^-$  for LHeC...**

In any case, any upgrade beyond stage 2 (LP-SPL):

- will depend upon the approval of major new physics programmes [Radioactive Ion beams (EURISOL-type facility) / Neutrino factory / LHeC].
- will be mostly implemented during a series of ordinary shutdowns
- **is unlikely to be in operation before 2020**



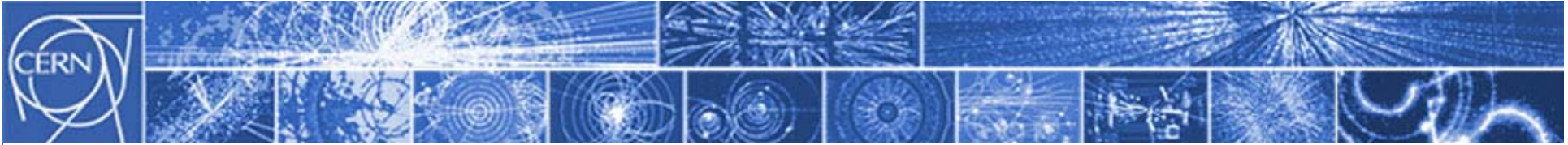
## 2. WORK PLAN OF THE SPL STUDY (1/3)

- **Linac4 is in construction at the correct location for becoming the SPL front-end (Beam for physics in 2013)**
- **Project proposals (TDR + cost estimates) for LP-SPL and PS2 are due for mid-2011**

### **Main technical issues for the SPL project proposal:**

- **Design optimization (layout, beam loss and collimation...),**
- **Detailed options and modes of operation**
- **Design and test of prototype sc cavities at 704 MHz (25 MV/m @  $\beta=1$ ),**
- **Design and assembly of a full cryomodule (8 cavities),**
- **Design of the high power RF distribution scheme and prototyping of key components,**
- **Design of architecture and algorithm of operation of the LLRF,**
- **Analysis and documentation of safety and environmental impact,**
- **Preparation of Civil Engineering documents for tender.**





## 2. WORK PLAN OF THE SPL STUDY (2/3)

### **Other technical issues:**

- LLRF,
- Beam instrumentation,
- Ion source,
- Klystron modulator.

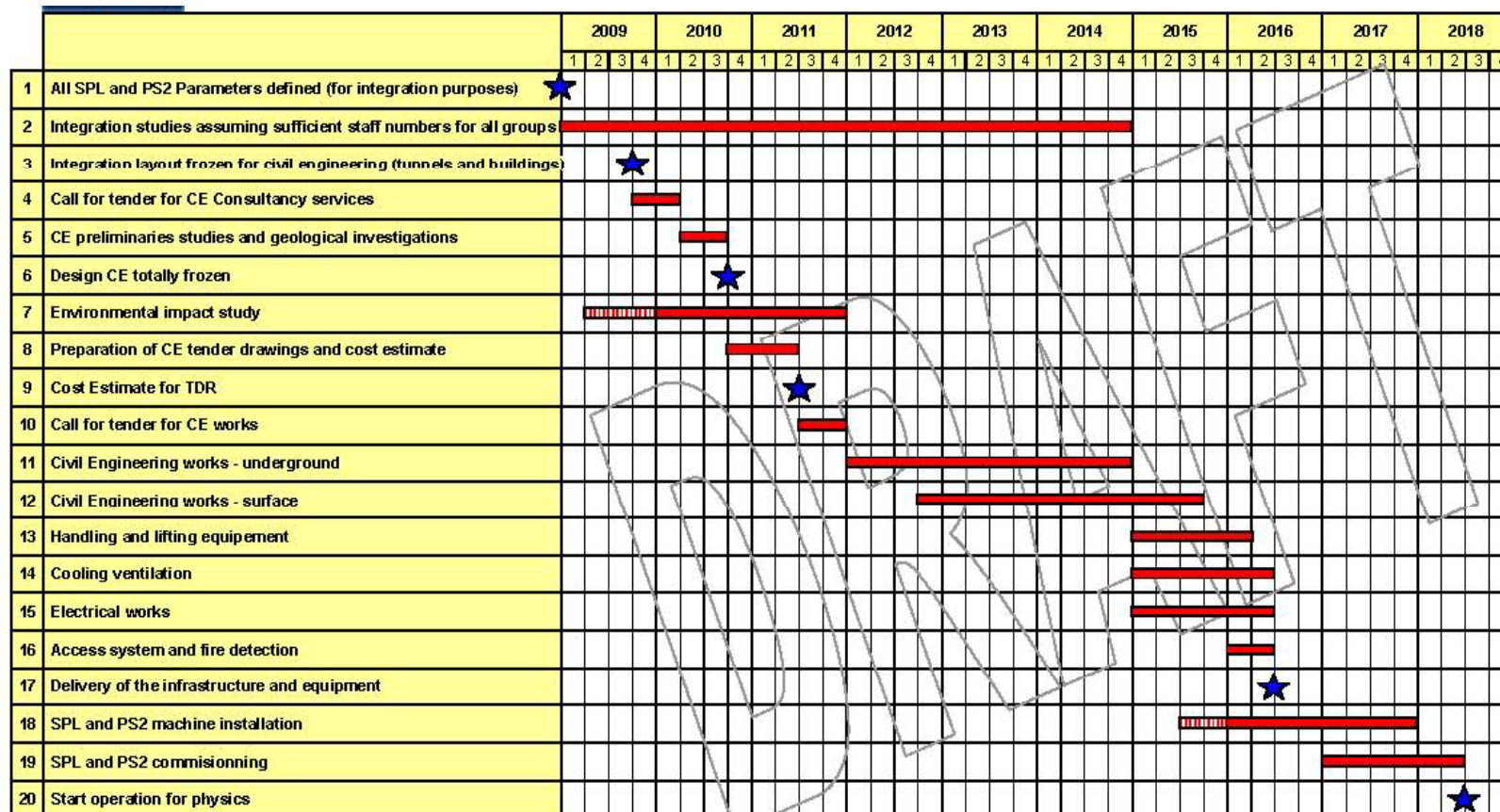
### **Other concerns:**

- Implement a 704 MHz high power RF test place with 2 K capability
- Upgrade CERN competences and capabilities in SRF.

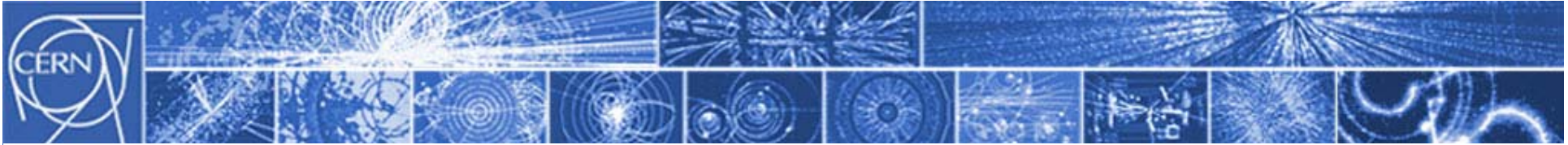


## 2. WORK PLAN OF THE SPL STUDY (3/3)

Recent planning by Civil Engineering shows that time is very short...



Notes: The 3 years between the first item, "all parameters defined", and the starting of the CE Works is extremely challenging  
 The planning for EL, CV, HE, ... works needs to be approved by various TS corresponding Groups  
 The planning for items 19 to 20 results from preliminary discussions with R. Garoby and F. Gerigk  
 Except new FTE, the first financial commitment for either project will be item 5 (~ 1 MCHF). We will try to present the financial commitment planning before end 2008



### 3. COLLABORATION MEETING: Goals

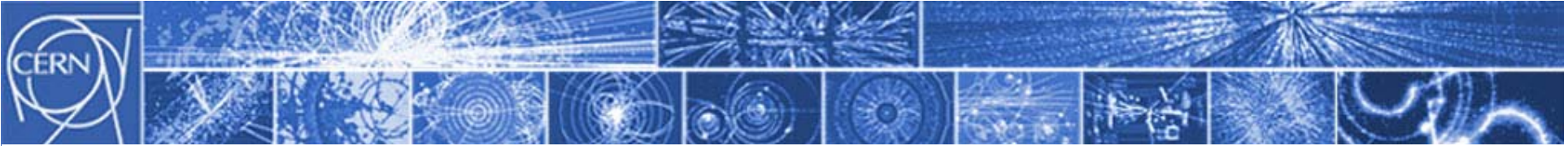
*First meeting of the SPL Collaboration on December 11-12, 2008 at CERN*  
<http://indico.cern.ch/conferenceDisplay.py?confId=44821>

*Remark: H<sup>-</sup> ion source, modulators and beam instrumentation are deliberately not on the agenda of this meeting.*

#### **MEETING GOALS:**

- to review specifications and technical choices + to set deadlines for decision on pending questions,
- to define the precise contribution of each partner (deliverables and planning) and the interactions between partners (names of persons in charge, exchange of information/hardware, planning of meetings, ...),
- to propose how to demonstrate 25 MV/m ( $\beta=1$ ) and 19 MV/m ( $\beta=0.65$ ) before mid-2011
- to list untreated subjects and collect suggestions for addressing them,
- to organize the collaboration (Constitution?),
- to define the dates of the main meetings until end of 2009.





### 3. COLLABORATION MEETING: Organization (1/5)

#### **WORKING GROUPS:**

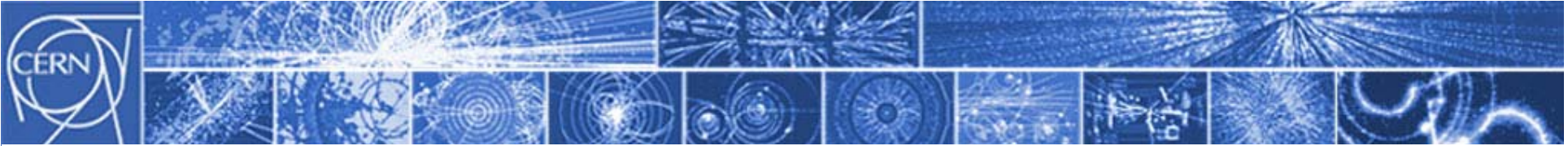
The mandate of the working groups is to fulfill the meeting goals on a subset of subjects.

**WG 1:** High power RF equipment (RF distribution, amplitude/phase modulators, circulators, loads...)

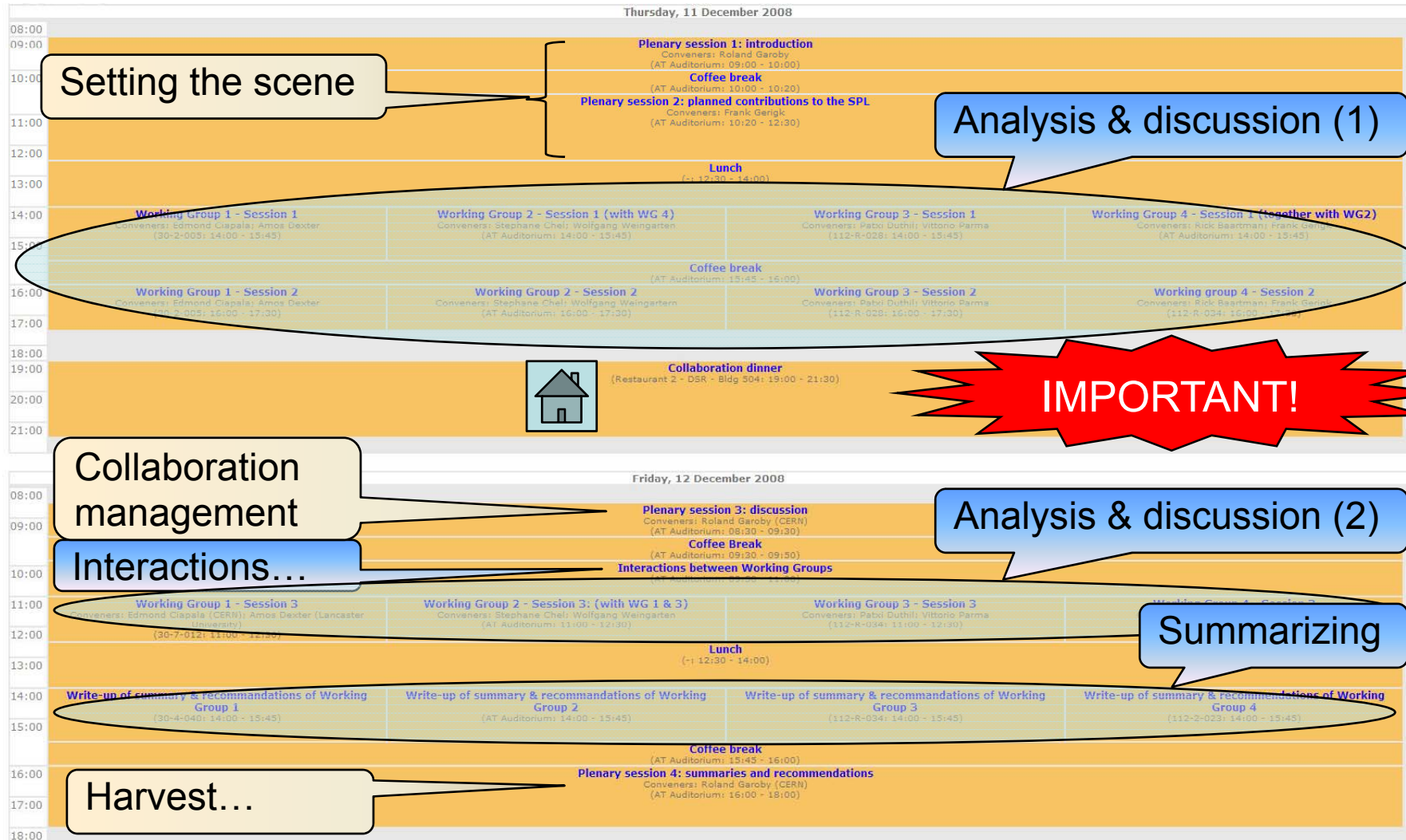
**WG 2:** Cavity design (Geometric beta, high power coupler, HOM damper/coupler, tuner...) and construction (Manufacturers, processing facilities, low power RF tests...)

**WG 3:** Cryomodule and integration (Design, construction, assembly...)

**WG 4:** Beam dynamics and loss management (Collective effects, H- stripping, collimation...)



# 3. COLLABORATION MEETING: Organization (2/5)



Setting the scene

Analysis & discussion (1)

**IMPORTANT!**

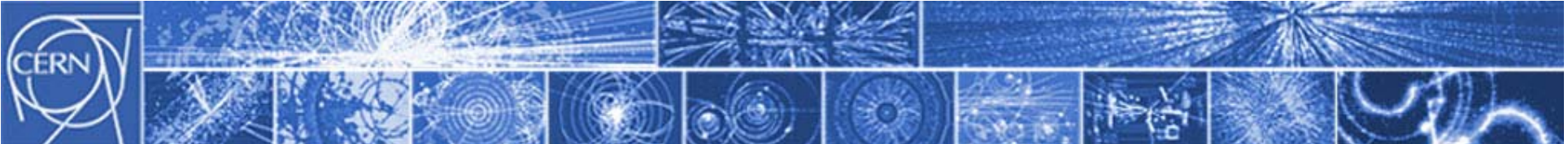
Collaboration management

Interactions...

Analysis & discussion (2)

Summarizing

Harvest...



## 3. COLLABORATION MEETING: Organization (3/5)

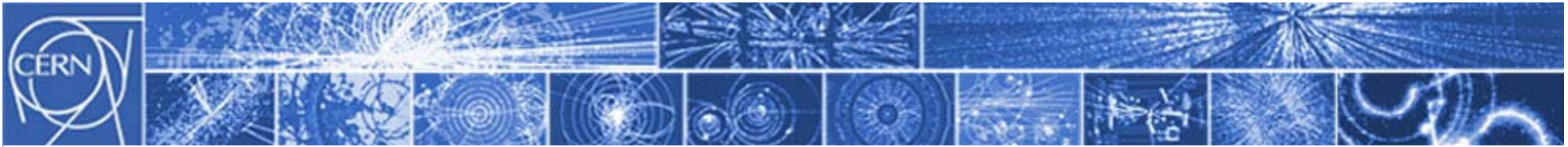
### Plenary session 2: planned contributions to the SPL

**Place:** CERN  
Room: **AT Auditorium**  
**Dates:** Thursday 11 December 2008 10:20  
**Conveners:** Gerigk, Frank

[Contribution List](#) [Time Table](#)

Thursday, 11 December 2008	
10:00	<p>[15] <b>CEA (Saclay) plans</b> by Stephane CHEL (Centre d'Etudes de Saclay (CEA-Saclay)) (AT Auditorium: 10:20 - 10:40)</p> <p>[16] <b>IN2P3 (Orsay) plans</b> by Pabci DUTHIL (IPNO - IN2P3 - CNRS) (AT Auditorium: 10:40 - 11:00)</p>
11:00	<p>[17] <b>TRIUMF plans</b> by Robert LAXDAL; Rick BAARTMAN (AT Auditorium: 11:00 - 11:20)</p> <p>[19] <b>Cockcroft Institute plans</b> by Amos DEXTER (AT Auditorium: 11:20 - 11:40)</p> <p>[20] <b>Stony Brook / BNL plans</b> by Rama Buchi Rao CALAGA; Ilan BEN-ZVI (AT Auditorium: 11:40 - 12:00) </p>
12:00	<p>[21] <b>Explanation/Discussion on the mandates of the working groups</b> by Roland GAROBY (AT Auditorium: 12:00 - 12:30)</p>





## 3. COLLABORATION MEETING: Organization (4/5)

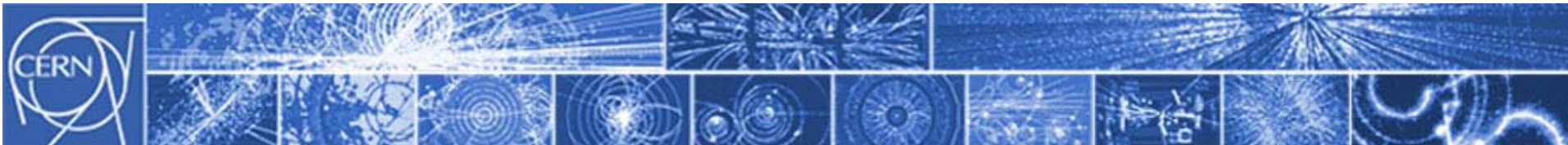
### Plenary session 3: discussion

**Place:** CERN  
Room: **AT Auditorium**  
**Dates:** Friday 12 December 2008 08:30  
**Conveners:** **Garoby, Roland**

[Contribution List](#) [Time Table](#)

Friday, 12 December 2008	
08:00	[23] <b>Organisation of the collaboration (with discussion)</b> by Roland GAROBY (AT Auditorium: 08:30 - 09:00)
09:00	[24] <b>Preliminary feedback from the Working Groups</b> (AT Auditorium: 09:00 - 09:30)





## 3. COLLABORATION MEETING: Organization (5/5)

### Plenary session 4: summaries and recommendations

Place: CERN

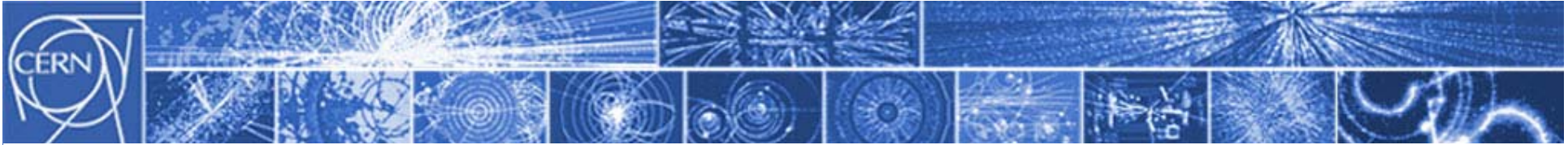
Room: **AT Auditorium**

Dates: Friday 12 December 2008 16:00

Conveners: **Garoby, Roland**

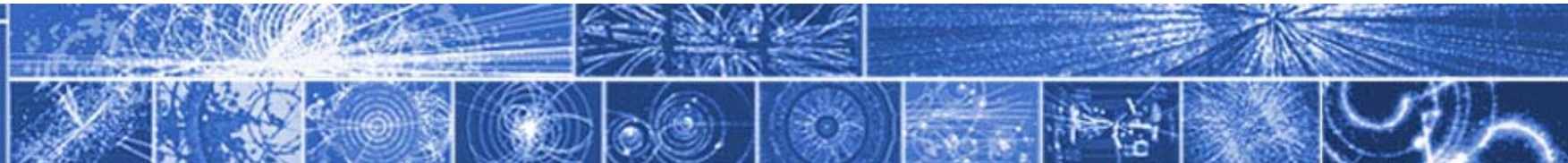
[Contribution List](#) [Time Table](#)

Friday, 12 December 2008	
16:00	[25] <b>Summary &amp; recommendations - Working Group 1</b> by Edmond CIAPALA (CERN); Amos DEXTER (AT Auditorium: 16:00 - 16:20)
	[27] <b>Summary &amp; recommendations - Working Group 2</b> by Stephane CHEL (Centre d'Etudes de Saclay (CEA-Saclay)); Wolfgang WEINGARTEN (CERN) (AT Auditorium: 16:20 - 16:40)
	[28] <b>Summary &amp; recommendations - Working Group 3</b> by Patxi DUTHIL (IPNO - IN2P3 - CNRS); Vittorio PARMA (CERN) (AT Auditorium: 16:40 - 17:00)
17:00	[29] <b>Summary &amp; recommendations - Working Group 4</b> by Rick BAARTMAN; Frank GERIGK (AT Auditorium: 17:00 - 17:20)
	[30] <b>Summary on organisation and planning of the collaboration</b> by Roland GAROBY (AT Auditorium: 17:20 - 18:00)



# REFERENCE SLIDES

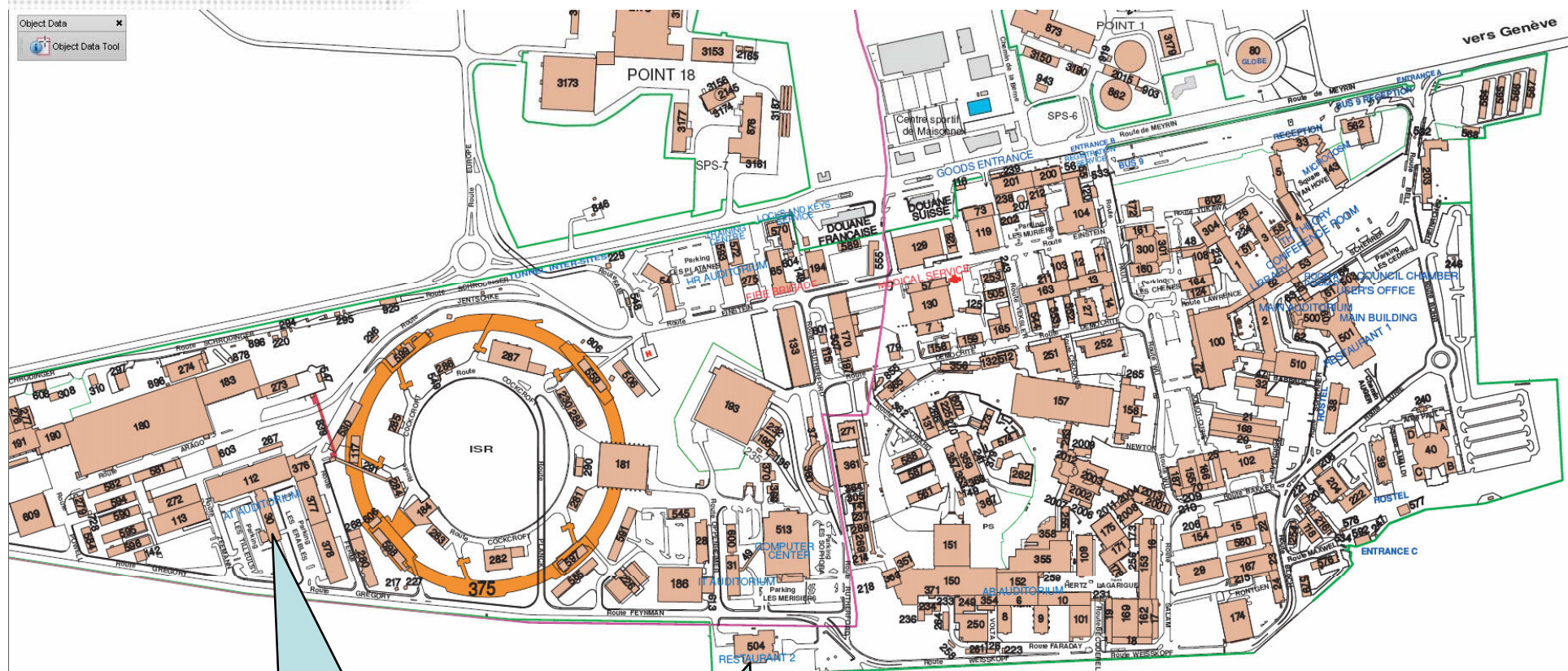




# CERN

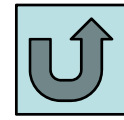
European Organization for Nuclear Research  
Organisation Européenne pour la Recherche Nucléaire

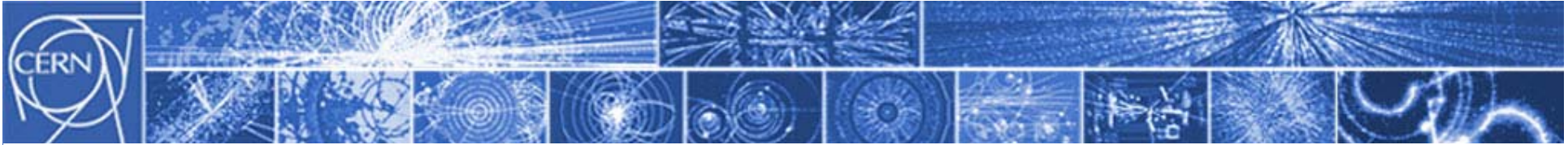
Object Data  
Object Data Tool



AT Auditorium

Restaurant nb.2





## MAIN REFERENCES IN 2008

1. Site Layout of the Proposed New Hadrons' Injector Chain at CERN, CERN-AB-2008-061 PAF ,  
[https://edms.cern.ch/file/964560/1/CERN-AB-2008-061\\_PAF.pdf](https://edms.cern.ch/file/964560/1/CERN-AB-2008-061_PAF.pdf)
2. Upgrade issues for the CERN accelerator complex, CERN-LHC-PROJECT-Report-1110,  
<http://cdsweb.cern.ch/record/1123676?ln=en>
3. Feasibility Study of Accumulator and Compressor for the 6-bunches SPL based Proton Driver , CERN-AB-2008-060,  
<http://cdsweb.cern.ch/record/1125556/files/CERN-AB-2008-060.pdf>
4. Assessment of the basic Parameters of the CERN SPL, CERN-AB-2008-067-BI-RF,  
<http://cdsweb.cern.ch/record/1136901/files/CERN-AB-2008-067.pdf>