Meeting attivita' INFN nel progetto EuroCirCol

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24/05/2016

Motivazione

- Incontro informativo
- discussione sull'attivita', collaborazione, sinergie
- Attivita' diverse ma intrecciate tra loro, e ad altri progetti futuri (ad. es. LHC-HL, LHC-HE)
- proposta: incontri ~ 1-2 volte/anno

INFN @Eurocircol

- WP3: Experimental Insertion Region Design
  - Task 3.3: Design machine detector interface (STFC, INFN and CERN)

- WP4: Cryogenic Beam Vacuum System Conception
  - task 4.4: study vacuum stability at cry.temp.
  - task 4.6 meas. on cryog. beam vacuum system prototype

- WP5: High-Field Accelerator Magnet Design
  - task 5.4 develop e.m. design
  - task 5.5 develop mechanical engineering design
  - task 5.6 device quench protection concept

INFN @EuroCirCol

- WP3: Experimental Insertion Region Design
- WP4: Cryogenic Beam Vacuum System Conception
- WP5: High-Field Accelerator Magnet Design

		WP4	WP5
TASK	WP3	4.4 4.6	5.4 5.5 5.6
PM	30	94	36

	WP3	WP4	WP5
TASK	3.3 (STFC, INFN, CERN)	4.4 (INFN,CERN) 4.6 (KIT,INFN,CERN)	5.4(INFN,CIEMAT,UT) 5.5 (CIEMAT, CEA, INFN, UT, UNIGE) 5.6 (TUT, INFN)

WP3:
Experimental Insertion Region Design

STFC(UK)

Task 3.3: Design machine detector interface (**STFC**, INFN and CERN)
STFC will coordinate this task and will study the machine detector interface to ensure that the collider design is consistent with the detector performance. In particular, STFC will determine the required apertures for the detector and integrate detector components into the interaction region optics as required, e.g. foresee a detector to determine the total luminosity. Together with CERN, STFC will evaluate the impact of the debris from the collimation system on the interaction region and will optimise this system together with task 3.5. INFN and STFC will study the impact of synchrotron radiation emitted by protons on detector and machine components in the interaction region and develop mitigation techniques. The colliding beams in the interaction point produce a large amount of debris that can destroy the magnets close to the detector. CERN will simulate this source of radiation and develop shielding concepts to protect the machine in close collaboration with optics design work in task 2.2 (Interaction region lattice design). Space constraints for experimental detectors will be derived and documented as part of the overall baseline design parameters (task 1.5).

Deliverables:

D-3.3: Preliminary EIR design including optimized lattice deck Annotated beam optics and lattice files with specifications of the required magnet parameters (strengths and apertures) including consolidated position and element characteristics. Specification of the required magnet types and quantities including magnet field quality specifications.	44

WP4:
Cryogenic Beam Vacuum System Conception

Task 4.4: Study vacuum stability at cryogenic temperature (INFN, CERN)

INFN Frascati will determine vacuum stability and adsorption isotherms at different cryogenic beam-screen operating temperature ranges (**D-4.1**). It will perform complementary studies on beam-induced stimulated desorption phenomena by photons, electrons and ions. These studies rely mainly on experimental samples and require beam-screen prototypes supplied by CERN.

D-4.1: Analysis of vacuum stability at cryogenic temperature Description of simulation environment and assumed input parameters. Description of samples and existing prototypes used as baseline. Documentation of vacuum stability and adsorption isotherms at different beam-screen operating temperature ranges from simulations and laboratory tests.	22

WP4:
Cryogenic Beam Vacuum System Conception

Task 4.6: Measurements on cryogenic beam vacuum system prototype (**KIT**, INFN, CERN)
KIT will be responsible for the "beam qualification" of the beam-screen prototype supplied by CERN (**D-4.2**). The goal is to determine synchrotron radiation heat loads and photo-electrons generation inside the beam-screen prototype. This beam-screen will be qualified with beam by installing the CERN COLDEX[36] experiment in the ANKA synchrotron ring and exposing the beam-screen prototype to significant levels of synchrotron radiation, comparable to the operation conditions at the hadron collider. CERN delivers to ANKA premises the COLDEX experiment together with all documents required to define and create the machine-COLDEX interfaces. ANKA will assist for the installation and integration of COLDEX carried out by CERN and INFN. INFN will commission the experiment and perform the measurements under CERN advice.

D-4.2: Measurements of vacuum chamber at light source Description of the test setup and the measurement conditions including any aspects that may have an impact on the quality of the raw data and analysis. Set of raw data, associated calibration data and relevant environment operation data. Preliminary summary of the analysis, discussion of the results and conclusions.	28

KIT(Germany): Karlsrhue

WP5:
High-Field Accelerator Magnet Design

UT(OLANDA)

Task 5.4: Develop electromagnetic design (INFN, CIEMAT, UT)
Optimise the coil and magnet configuration (**D-5.1, D-5.2**), to obtain good electromagnetic performance of the preferred magnet conceptual design in close interaction with the mechanical design (task 5.5) and quench protection (task 5.6). CIEMAT and INFN will work jointly on the electromagnetic design and optimization. CIEMAT will design the overall coil cross section and INFN will contribute analysis of field quality and transient effects. UT will provide an experimental database of DC and AC magnetization that serves as input to cross section optimisation of coil, ends, iron, non-linear and transient effects.

D-5.1: Overview of magnet design options Description of relevant design options to be considered for further detailed studies. Summary of the relative merits, requirements, constraints and impacts of each of the options. Classification of the options according to merits and realization risks.	17
D-5.2: Identification of preferred dipole design options and cost estimates Detailed description of the preferred baseline design with its expected performances. Analysis of the individual merits and risks of the different, initial design options and justification for selection. The deliverable includes expected field levels, field errors and a cost estimate, which serve as input for the arc design consolidation. A summary of the technical expert advisory committee review is included. Description of requirements, constraints and impacts on environment, ancillary systems, arc, interaction region and cryogenic beam vacuum system.	26

WP5:
High-Field Accelerator Magnet Design

Task 5.5: Develop mechanical engineering design (**CIEMAT**, CEA, INFN, UT, UNIGE)
The forces in a 16 T accelerator dipole are unparalleled, calling for novel mechanical designs and good knowledge of the engineering margins. CIEMAT and CEA will jointly develop the coil and structure concepts. CIEMAT, CEA and INFN Genova will run 2D and 3D stress analysis of the components and assemblies with CEA focussing on the coil, CIEMAT and INFN looking at the overall structure and magnet assembly. UT will provide design limits for the stress- and strain behaviour of the cables, based on experimental data collected from relevant cable samples. UNIGE will provide design limits for the stress- and strain behaviour of superconducting strands and will provide results from experiments carried out with samples. This task is performed in close interaction with electromagnetic design (task 5.4) and quench protection (task 5.6). The work is direct input to **D-2.1** and **D-5.4**.

D-2.1: Overview of arc design options Description of arc design options and collider layouts to be taken into consideration for further detailed studies. Summary of the relative merits, requirements, constraints and impacts of each of the options to be considered. Classification according to estimated value and realization risk.	12
D-5.4: Manufacturing folder for reference design dipole short model Collection of all drawings, material and element specifications, assembly procedures. Calculation files indicating relevant design and analysis notes. Quantity and cost indications for materials and components required for production. Production quality requirements with tolerances.	46

WP5:
High-Field Accelerator Magnet Design

TUT(FINLANDIA)

Task 5.6: Devise quench protection concept (**TUT**, INFN)
Protection of a long 16 T accelerator dipole may be a limiting factor to magnet performance. It is important to review and assess detection and protection methods and to propose a robust concept. This work will be performed jointly by TUT and INFN L.A.S.A. Milano. Both partners will simulate various quench initiation and propagation cases based on the selected magnet design. TUT will cover the extrapolation to a string of magnets. This task requires close interaction with electromagnetic design (task 5.4) and mechanical design (task 5.5). This work is direct input to the CDR (**D-1.7**).

D-1.7: Preliminary Conceptual Design Report (CDR) The preliminary CDR serves the CB to recommend to the CERN Council subsequent technical R&D activities for a pre-project phase. This version of the CDR is part of a set of documents being prepared for the next European Strategy for Particle Physics Update.	**47**

WP3

Parameters

We have two preliminary parameter sets

- Beam current is the same
- But luminosity differs

$$\mathcal{L} \propto \frac{N}{\epsilon} \frac{1}{\beta_y} N n_b f_r$$

They have the same current but the ultimate set has more challenging collision parameters

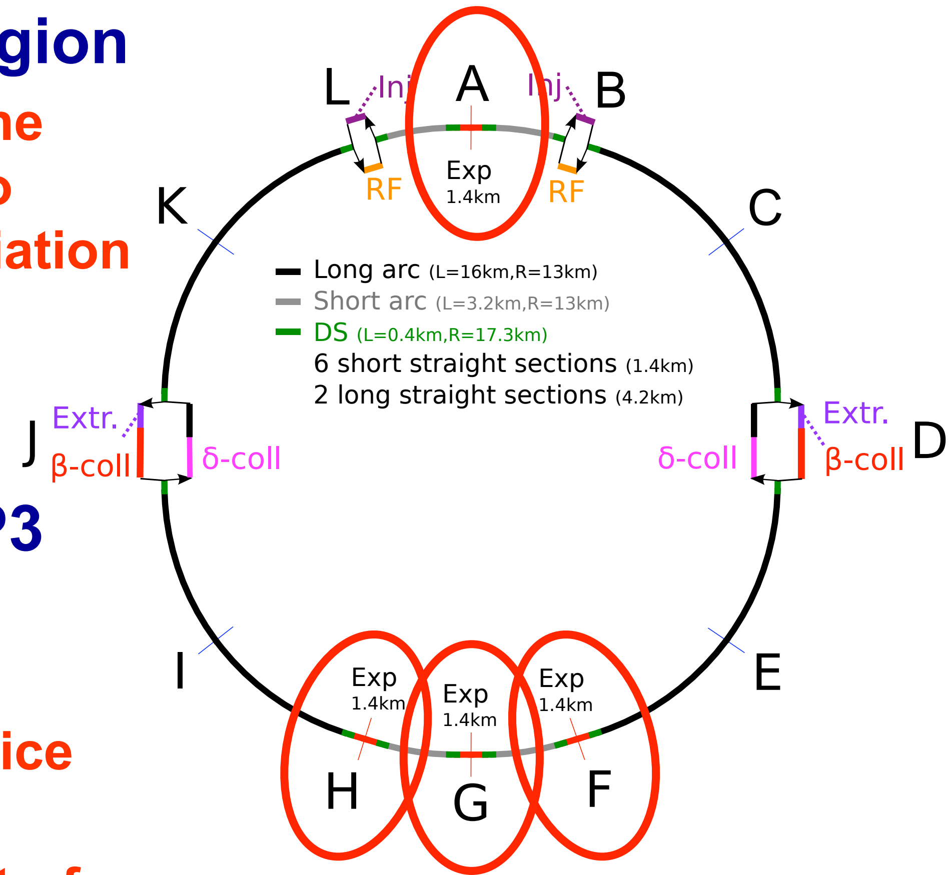
The “baseline” in EuroCirCol should be capable to run with the **ultimate** parameters

Slide from Daniel Schulte

	FCC-hh Baseline	FCC-hh Ultimate
Luminosity L [$10^{34}cm^{-2}s^{-1}$]	5	20-30
Background events/bx	170 (34)	<1020 (204)
Bunch distance Δt [ns]	25 (5)	
Bunch charge N [10^{11}]	1 (0.2)	
Fract. of ring filled η_{fill} [%]	80	
Norm. emitt. [μm]	2.2(0.44)	
Max ξ for 2 IPs	0.01 (0.02)	0.03
IP beta-function β [m]	1.1	0.3
IP beam size σ [μm]	6.8 (3)	3.5 (1.6)
RMS bunch length σ_z [cm]	8	
Crossing angle [σ’]	12	Crab. Cav.
Turn-around time [h]	5	4

Tasks

- **Experimental Interaction Region**
  - **The main goal is to optimise the luminosity per beam current to ensure that beam induced radiation does not compromise the experiments or affect collider operation**
- **Tasks of EuroCirCol EIR WP3**
  - **Coordination**
    - **JAI/Oxford (lead), CERN, task 3.1**
  - **Develop interaction region lattice**
    - **JAI/Oxford (lead), CERN, task 3.2**
  - **Design of machine detector interface**
    - **CI/Manchester (lead), INFN, CERN, task 3.3**
  - **Study of beam-beam interaction**
    - **EPFL (lead), CERN, task 3.4**



The team:

- **IR Work Package**
  - Development of the EIR lattice
    - JAI/Oxford (lead), CERN, task 3.2
    - PhD student started Oct 2015
    - Two PostDocs: started in Jan and Feb
      - { OPTICS }
      - { OPTICS / ENERGY DEPOSITION }
  - Design of machine detector interface
    - CI/Manchester (lead), INFN, CERN, task 3.3
    - One PostDoc just hired in Manchester, topic:
      - { MDI }
    - One PostDoc just hired in INFN, topic:
      - { MDI }
  - Study of beam-beam interaction
    - EPFL (lead), CERN, task 3.4
    - PostDoc started in Aug 2015

CERN: Rogelio Tomas, Roman Martin, Andy Langner

JAI/OX: Andrei Seryi, Emilia Cruz Alaniz, Jose Abelleira Fernandez, Leon van Riesen-Haupt

JAI/RHUL: Laurie Nevay (BDSIM expertise liaison)

CI/Manchester: Rob Appleby, PDRA just hired

CERN: Francesco Cerutti, Maria Ilaria Besana, Helmut Burkhardt

INFN: Manuela Boscolo, Francesco Collamati

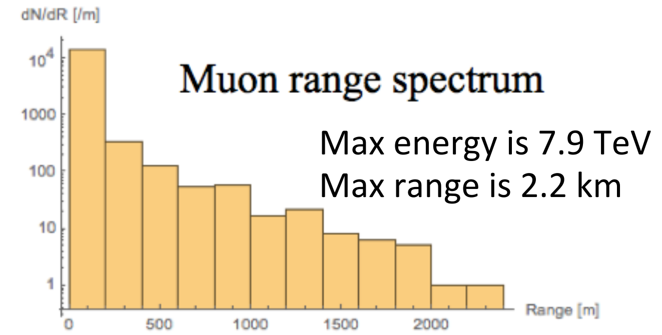
EPFL: Javier Barranco, Jorge Patrik Gonçalves

CERN: Tatiana Pieloni, Xavier Buffat

MDI – cross-talk between IRs

- **Preliminary study of**
  - **Inelastic protons through beam pipe vacuum (i.e. optics)**
  - **Elastic protons through beam pipe vacuum (i.e. optics)**
  - **Muons travelling through rock from IPA to IPB (analytical estimations)**

More details in the talk of Rob Appleby



- **Preliminary conclusions (some)**
  - **Inelastic protons – around 40 protons per BX (ultimate) with 0.1mm spot size from IPA to IPB – may cause some background**
  - **Elastic protons – lead to some emittance growth**
  - **Muons – do not expect much muons arriving through rock**
    - **Can muons be guided by tunnel walls?**
    - **need to check by FLUKA or similar code**
- **Ongoing study of SR in IR**
  - **Tools developed, results to be presented soon**

H. Burkhardt, M. Boscolo, F. Collamati

EuroCirCol : Activities on WP3 Task 3.3 (CI/Manchester, INFN, CERN)

- **Task 3.3** Design machine detector interface
  - Ensure that collider design is consistent with the detector performance
  - Determine the required apertures for the detector
  - Integrate detector components into the IR optics
  - Evaluate impact of debris from collimation system on IR
  - Optimise IR system together with other relevant tasks
  - **Study the impact of synchrotron radiation on IR and develop mitigations**
  - Study colliding beams debris in IR and develop shielding concepts

Synchrotron Radiation in FCC-hh:
Study the impact of synchrotron radiation on IR and develop mitigations

1 post-doc F. Collamati (INFN) hired on 1st March 2016 (just started)
work in collaboration with H. Burkhardt (CERN)

Application of SR tools to FCC-hh, like: **MDISIM**

MDISIM is based on three main steps and uses existing standard tools:

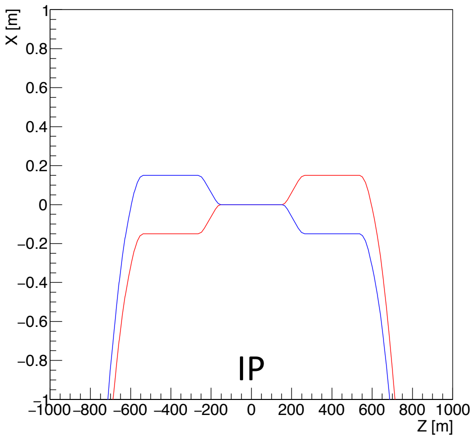
1 MAD-X : Read machine lattice description, generate twiss, survey and geometry files.
2 ROOT Visualization of the geometry and analytic estimates including calculation of synchrotron radiation. Export geometry.
3 GEANT4 Import geometry. Detailed simulation of the passage of particles through materials.

[Ref. *"Tools for flexible optimization of IR designs with application to FCC"*, IPAC15, H. Burkhardt(CERN), M. Boscolo(INFN-LNF)]

Results for Lattice V.4 with MDISIM

50 TeV protons

critical energy in the range of few keV and within 800 m of IP

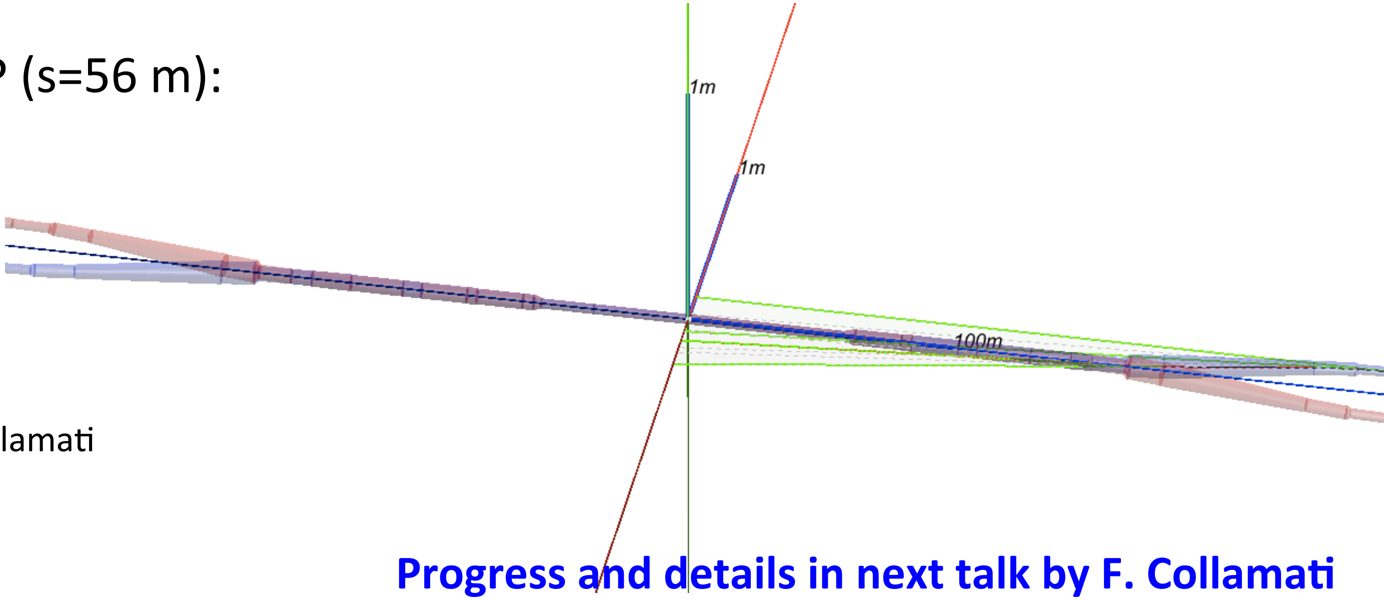


for first two bendings from IP (s=164.7 m, 178.7 m):

- E_{crit} = 3.4 keV
- Power = 0.26 kW
- E_{mean} = 0.991 keV

for first **quad** from IP (s=56 m):

- E_{crit} = 0.1449 keV
- Power = 0.85 W



H. Burkhardt, M. Boscolo, F. Collamati

Progress and details in next talk by F. Collamati

Next Steps

- Update and complete the study of SR for the latest lattice and different with MDISIM
- Complete the SR studies also using GEANT4

- Develop mitigation techniques
- ....