E-JADE is a Marie Sklodowska-Curie Research and Innovation Staff Exchange (RISE) action, funded by the EU under Horizon2020

E-JADE

Mid-Term Review

LHC consolidation, upgrades and R&D for future hadron machines

Steinar Stapnes/ WP 1

This project is funded by the European Union under Grant Agreement no. 645479

CERN scientific roadmap

Full exploitation of the LHC:

- Run 2 started last year → goal this year is L=10^{34} at √s =13 TeV, ~25 fb^{-1}
- building upgrade of injectors (LIU), collider (HL-LHC) and detectors (Phase-1 and Phase-2)

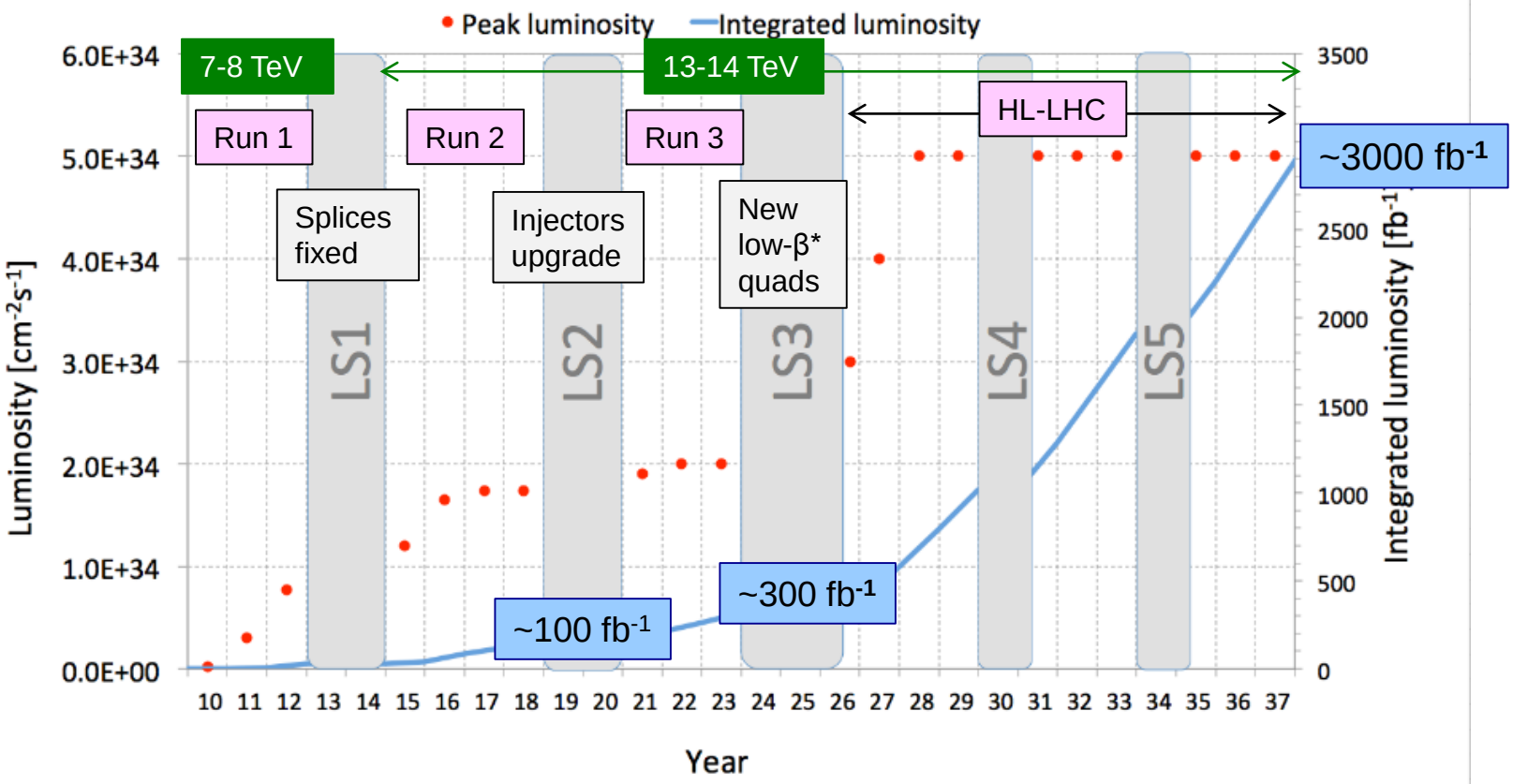
Diversity programme serving a broad community:

- ongoing experiments and facilities at Booster, PS, SPS and their upgrades (ELENA, HIE-ISOLDE)
- participation in accelerator-based neutrino projects outside Europe (presently mainly LBNF in the US) through the CERN Neutrino Platform

Preparation of CERN's future:

- vibrant accelerator R&D programme exploiting CERN's strengths and uniqueness (including superconducting high-field magnets, AWAKE, etc.)
- design studies for future accelerators: CLIC, FCC (includes HE-LHC)
- future opportunities for scientific diversity programme (new)

LHC and HL-LHC



LHC is today's most powerful collider → full exploitation ($\sqrt{s}$ ~ 14 TeV, 3000/fb) is mandatory:

- ❑ If new physics discovered in Run 2-3:
  → first detailed exploration of new physics with well understood machine and experiments while building next accelerator
- ❑ If no new physics in Run 2-3:
  → extend direct discovery potential by ~ 20-30% (up to m ~ 10 TeV)

In either case: measure H couplings to few percent (including 2nd generation: Hμμ)

CERN-KEK Committee, 10th meeting (Draft agenda)

30 Jul 2015, 14:00 → 21:00 Europe/Zurich

60-6-015 - Room Georges Charpak (Room F) (CERN)

Rudiger Voss (CERN)

Thursday, 30 July 2015

14:00 → 14:05 Welcome — 5m
Speaker: Rudiger Voss (CERN)

14:05 → 14:15 Opening Remark — 10m
Speaker: Masanori Yamauchi (KEK)

14:15 → 15:05 CERN Fellow Reports — 50m
Speakers: Akira Miyazaki (CERN) , Hideyuki Oide (CERN) , Yuta Takahashi (Nagoya)
20150728_review... | miyazaki_annual ... | yuta_CERNJapan...

15:05 → 15:20 ATLAS Upgrades — 15m
Speaker: Kazunori Hanagaki (Osaka University (JP))
150730_CERN-KE...

15:20 → 15:40 LHC Upgrade — 20m
Speaker: Lucio Rossi (CERN)
Rossi_LHC Up 10... | Rossi_LHC Up 10...

15:40 → 16:00 Progress on IR Superconducting Dipole Magnet R&D for HL-LHC — 20m
Speaker: Tatsushi Nakamoto
20150730D1_Na... | 20150730D1_Na...

16:00 → 16:20 KEK Participation in the LHC Injector Upgrades — 20m
Speaker: Chihiro Ohmori
2015KEK Particip... | 2015KEK Particip...

16:20 → 16:40 Coffee Break — 20m

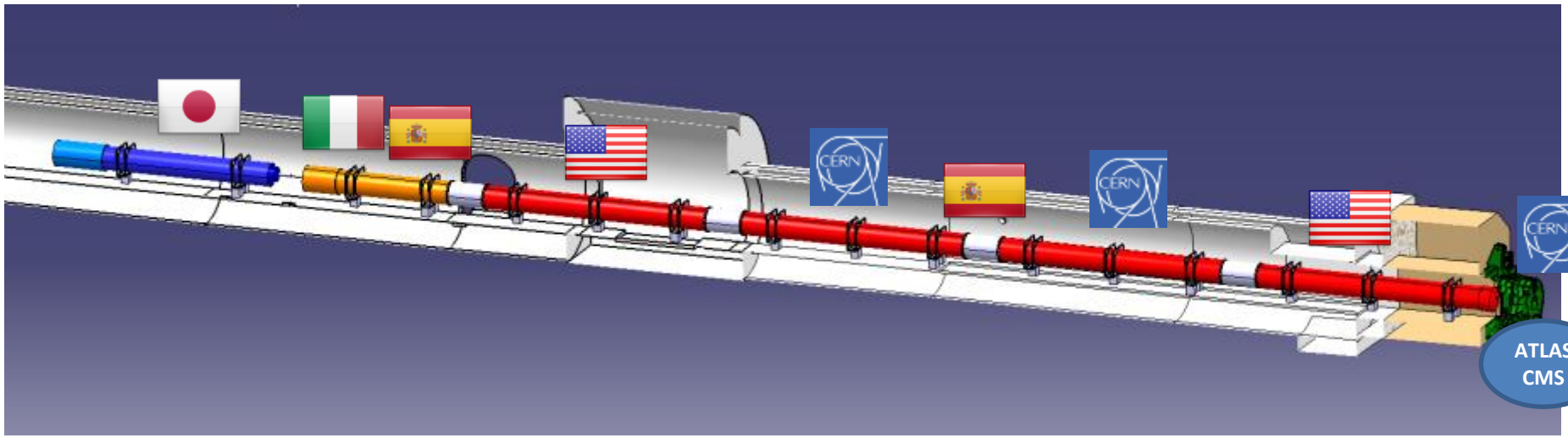
16:40 → 17:00 X-band and other development — 20m
Speaker: Seiya Yamaguchi (KEK)
CKC2015_yamag... | CKC2015_yamag...

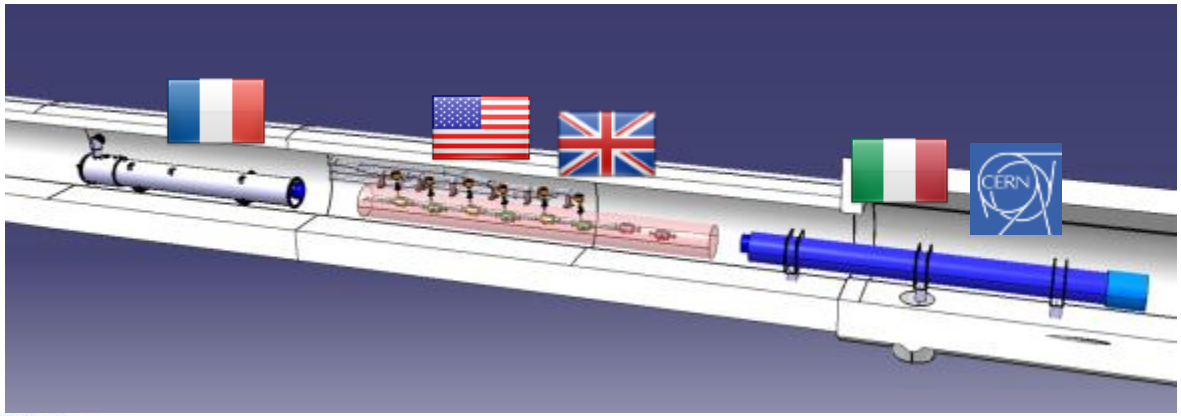
17:00 → 17:20 Linear Collider R&D status in cooperation with CERN and KEK — 20m
Speakers: Akira Yamamoto (H) , Steinar Stapnes (CERN)
CERN-KEK-Com... | CERN-KEK-Com... | CERN-KEK-LC-20...

17:20 → 17:40 FCC-related R&D at KEK — 20m
Speaker: Toru Ogitsu
FCC_Dev_In_Jap... | FCC_Dev_In_Jap... | FCC_Dev_In_Jap...

17:40 → 18:00 Status of CERN-KEK office — 20m
Speakers: Katsuo Tokushuku (High Energy Accelerator Research Organization (JP)) , Steinar Stapnes (CERN)
CERN-KEK-office.... | CERN-KEK-office....

In-kind contribution and Collaboration for HW design and prototypes





CC : R&D, Design and in-kind **USA**

CC : R&D and Design **UK**

Q1-Q3 : R&D, Design, Prototypes and in-kind **USA**
D1 : R&D, Design, Prototypes and in-kind **JP**
MCBX : Design and Prototype **ES**
HO Correctors: Design and Prototypes **IT**
Q4 : Design and Prototype **FR**

Slide from L.Rossi

RF Collaboration for LHC Injector Upgrade

Objectives

- **Consolidation/upgrade of the PSB RF systems** possibly using wideband, multi-harmonic, solid-state driven Magnetic Ally loaded cavities
- Development and installation of **a longitudinal damper in the PS**

Core Technology :

- **Wideband Cavity using Magnetic Alloy,Finemet-FT3L**
- Use of **Solid State Amplifiers**

Collaboration activities

- Studies on the PSB multi-gap wideband **cavity-beam interactions**
  - Beam Studies at J-PARC MR during LS1 & PSB
- Study **radiation damage on solid-state RF amplifier**
  - Radiation damage test at J-PARC MR
- Study, design and prototype **a longitudinal damper for the CERN PS**
  - Wideband cavity system to damp the longitudinal coupled bunch instability
- Collaboration on the conceptual design of feed-forward **beam compensation schemes** for FINEMET® cavities
  - J-PARC wideband cavities handles 1E14 ppp in MR with Feed Forward compensation in LS1

WP1

Description of Work

- The LHC accelerator will run at its full energy from 2015 and Japanese researchers participate in operation, analysis and upgrade projects for both accelerator and detectors. R&D on high field magnets and wideband magnetic alloy RF systems is a key ingredient for upgrading the LHC, and its injectors through the LIU project, and for reaching the goals of the High Luminosity LHC project. These studies are also relevant for the J-PARC accelerators and for a potential very large collider as studied in the context of the FCC programme.

Objectives

- Execution of an intensified Japanese programme at LHC in preparation for future accelerator programmes
- Advance the preparation for and execution of the European-Japanese collaboration on the High Luminosity LHC upgrade and associated R&D
- Strengthen the R&D on High field magnets and RF systems for future or upgraded energy- and/or intensity-frontier hadron machines.

WP 1:

- **Tasks:**
  - *Task 1.1: LHC operation and analysis (CERN, KEK & UoT):* Integrate Japanese efforts in operation of LHC machines and detectors at full energy; expected to provide important guidance for future accelerator developments in Europe and Japan.
  - *Task 1.2: The HL-LHC project (CERN & KEK):* Engineering design and validation of two short prototype separation superconducting dipoles (D1) followed by construction preparation, construction and test of the 4 final (plus two spare) D1 dipoles for the upgraded LHC insertion regions. Studies for the crab cavities (CC) for the LHC luminosity upgrade, benefitting from operational experience of CC at KEK.
  - *Task 1.3 High field magnet R&D and preparation of future hadron injectors and colliders (CERN & KEK):* R&D on the viability of HTS magnets of accelerator/collider quality. Enhance the exchange of staff between CERN and KEK in the context of the LIU project and the J-PARC intensity upgrade studies. Technologies of special interest are Wideband Cavities using Magnetic Alloy, Solid State Amplifiers and Low Level RF.

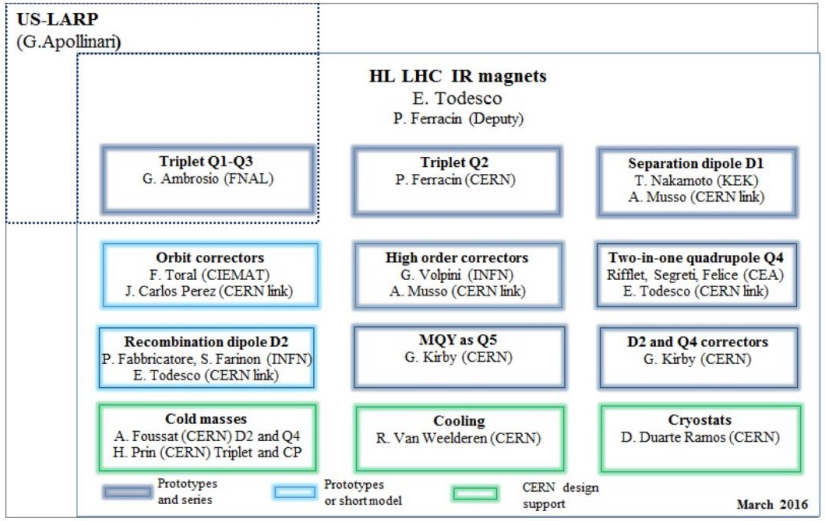
WP 1

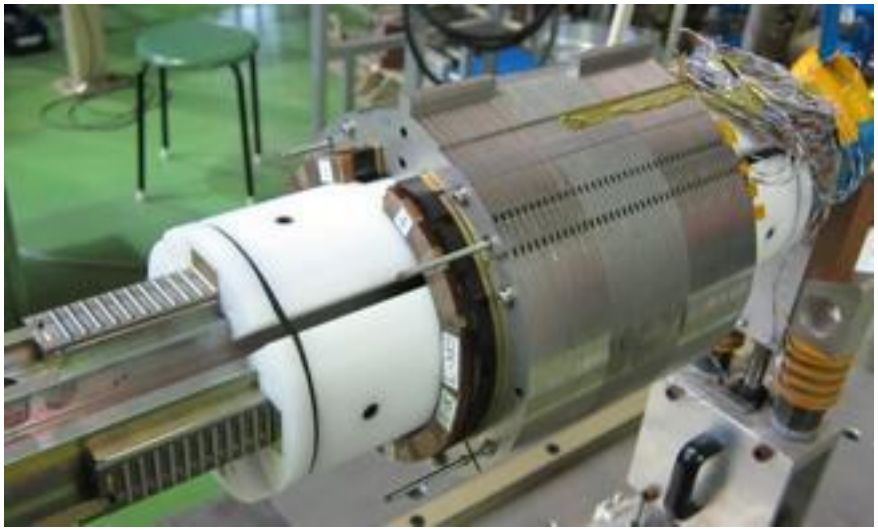
- **Deliverables**
  - *Month 25 Magnets and Gradients:* Report on common R&D results on high field magnets and high gradient structures.
  - *Month 25 Hadrons at high intensity and energy:* Report describing R&D results on FCC and J-PARC related activities.
  - *Month 37 Physics at LHC*: Report covering main findings at LHC with relevance for future energy frontier accelerator projects.
  - *Month 37 HL-LHC:* Status report and final plan of the Japanese contribution to HL-LHC.

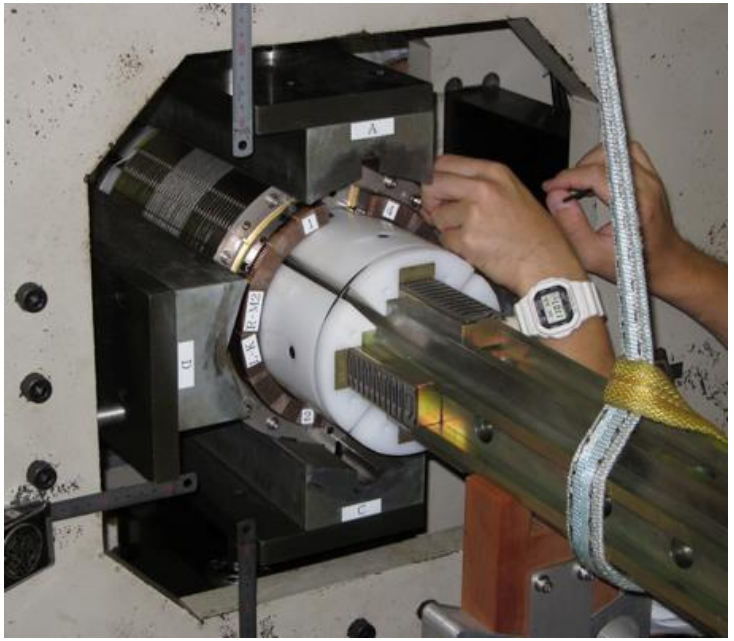
HL-LHC

- Secondments/travels currently mostly linked to preparation (prototyping) of the separation dipoles for HL-LHC
- Testing of 2m prototyping ongoing this week (A.Musso currently at KEK)

Structure







Advantages of Magnetic Alloy (Finemet®) Cavity for PSB/PS Case

RF cavity loaded with magnetic alloy cores

- High field gradient ->
  - Replacement of PSB cavities
  - Enough voltage to damp coupled bunch instability at PS
- Wideband system ->
  - dual harmonic acceleration for PSB
  - compensation of multi-harmonics for PS
- Stable/medium impedance
  - Compact RF system driven by solid state amplifiers
- Multi-cell structure (24-36 cell / PSB ring, 24 is enough)
  - Reduction of down time
- Cost reduction: no bias PS, no tube, no anode PS

Existing RF systems in the PSB

Three systems are presently installed in the machine:

C02

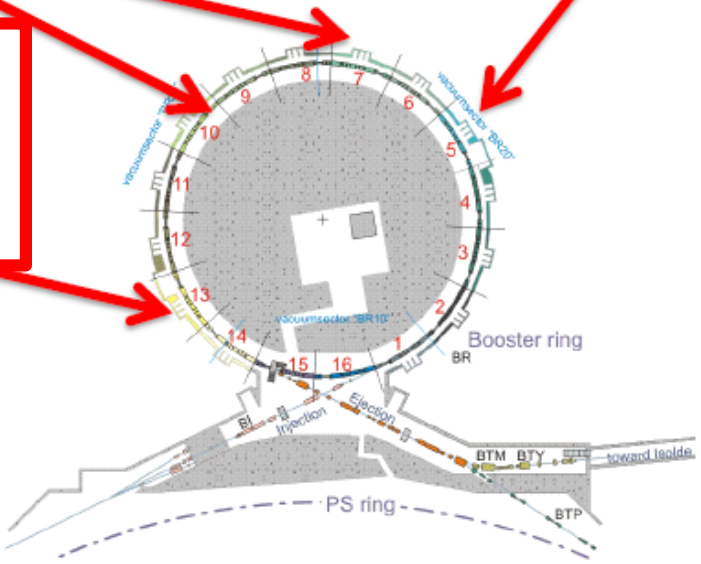
- Frequency range 0.6 (*1.0) – 1.8 MHz
- Gap Voltage 8 kV
- Installed in sections 7L1 and 10L1

C16

- Frequency range 6.0 – 16 MHz
- Gap Voltage 6 kV
- Installed in section 5L1

C04

- Frequency range 1.2 (*2.0) – 3.8 MHz
- Gap Voltage 8 kV
- Installed in section 13L1



Finemet cavities may (will) work as C02 & C04 systems

** Frequency with injection from LINAC4*

M. Poluzzi @ Finemet review

LHC Injector Upgrade

Objectives:
The LHC injectors upgrade (LIU) project aims to prepare the CERN accelerator complex for reliably providing beam with the characteristics required for the high luminosity operation of the LHC. This implies an upgrade of the PSB RF systems including magnetic alloy cavities driven by solid state amplifiers. The cavity system has three different roles; acceleration, the second Harmonic RF and emittance blow-up. Three straight sections of the PSB will be used for these purposes and 340 Magnetic Alloy cores will be needed for the cavities. KEK, who has also committed to the LIU project including design, test and improvement of the PSB RF and PS damper RF systems under the APPENDIX6 to ICA-JP-0103 completed on 31st December 2014, has been developing Magnetic Alloy cavities for twenty years and successfully developed new Finemet®-FT3L cavities for J-PARC MR upgrade. KEK is willing to further contribute to the LIU project based on the knowledge and experience to produce the above mentioned magnetic alloy cores

R&D Status

- Two projects on going (Founded by JST and AMED)
  - JST: Med Field HTS Mag. For Small Acc.; ~1MCHF/y * (5+5)y
  - AMED: Med Field HTS Mag. for Medical Acc.; ~1MCHF/y * 3y
- Several Proposals to JSPS
  - JSPS: Advanced Conductor Development for High Field App.
    - Nb3Sn and HTS; ~3MCHF/y * 5y
  - JSPS: HTS High Field Magnet Development for Future Acc.
    - ReBCO cable; ~2MCHF overall 5y
- Nb3Sn Development Efforts by Private Companies
  - KSL/JASTEC, SH Copper, and Furukawa

Key points

- Projects and tasks nicely on track

- Secondments for LHC operation (task 1)-> talk of K.Tokushuku
- Secondments for task 2 started and will be important in the coming years (follow the dipoles)
- For task 3 the work well underway and agreements are (being) put in place, secondments being defined in more detail. Efforts are being made to making best possible use of EJADE to increase impact.

Thank you very much for your attention!

This project is funded by the European Union under Grant Agreement no. 645479