Status of the Super-FRS

M. Winkler

Annual NuSTAR Meeting

GSI, March 5 – 7, 2014

Outline

1) Super-FRS Layout (Full Version)
2) Status of Civil Construction
3) Update on the Energy Buncher
4) Status on Super-FRS Components
5) Summary

Layout off the Super-FRS (Full Version)

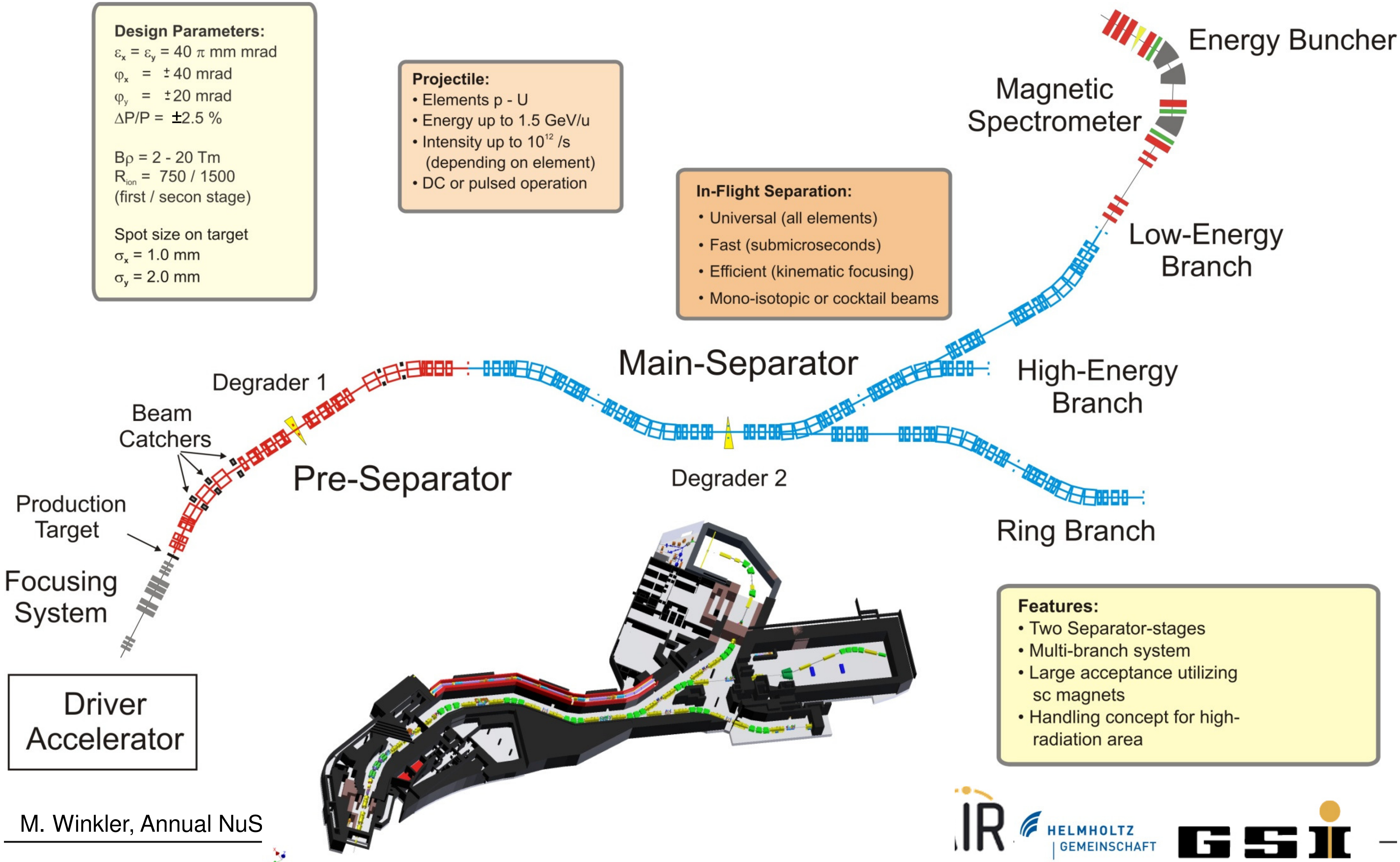
Design Parameters:
$\varepsilon_x = \varepsilon_y = 40\ \pi$ mm mrad
φ_x = ± 40 mrad
φ_y = ± 20 mrad
$\Delta P/P$ = ±2.5 %

$B\rho$ = 2 - 20 Tm
R_{ion} = 750 / 1500
(first / secon stage)

Spot size on target
σ_x = 1.0 mm
σ_y = 2.0 mm

Projectile:
- Elements p - U
- Energy up to 1.5 GeV/u
- Intensity up to 10^{12} /s (depending on element)
- DC or pulsed operation

In-Flight Separation:
- Universal (all elements)
- Fast (submicroseconds)
- Efficient (kinematic focusing)
- Mono-isotopic or cocktail beams



Features:
- Two Separator-stages
- Multi-branch system
- Large acceptance utilizing sc magnets
- Handling concept for high-radiation area

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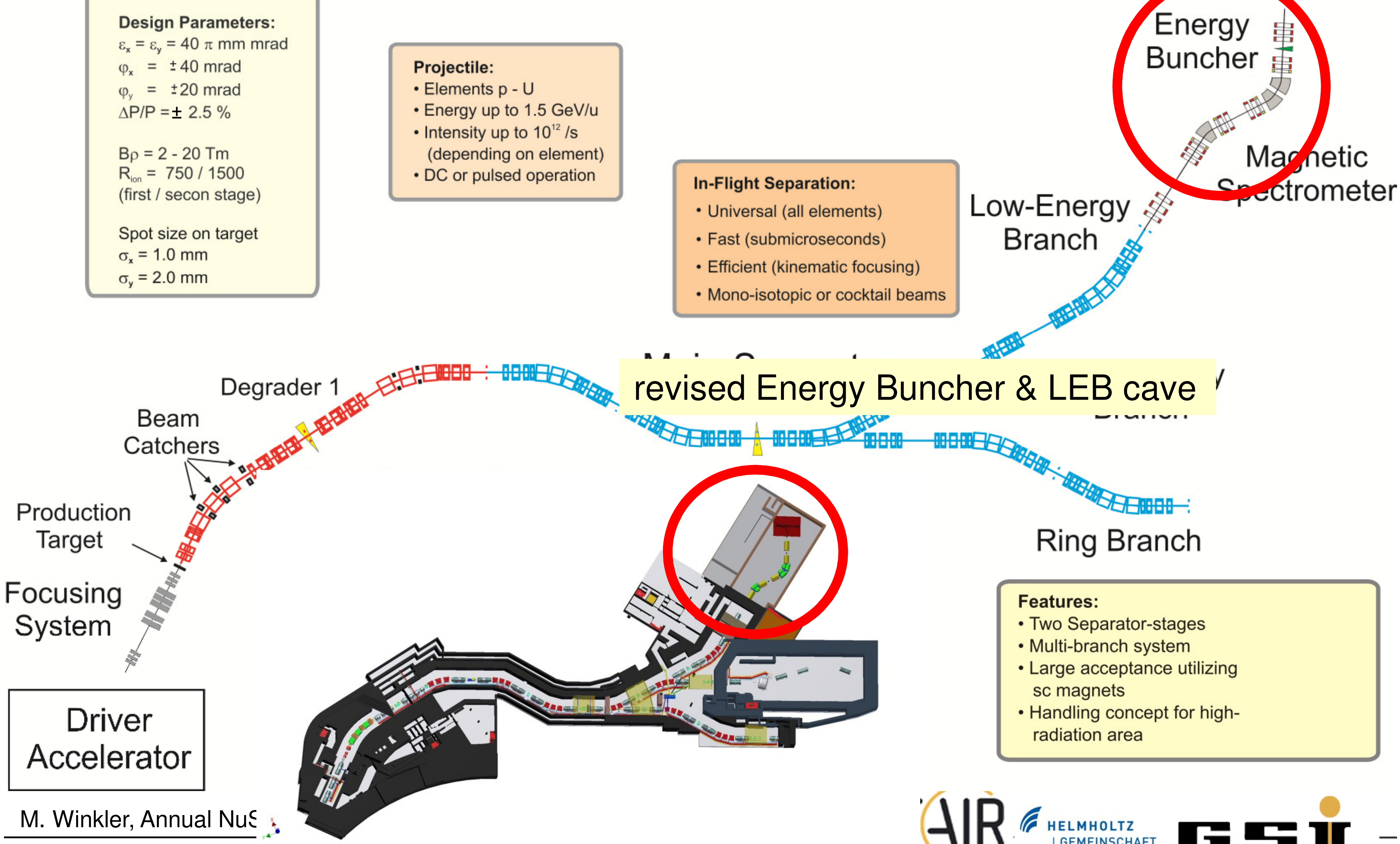

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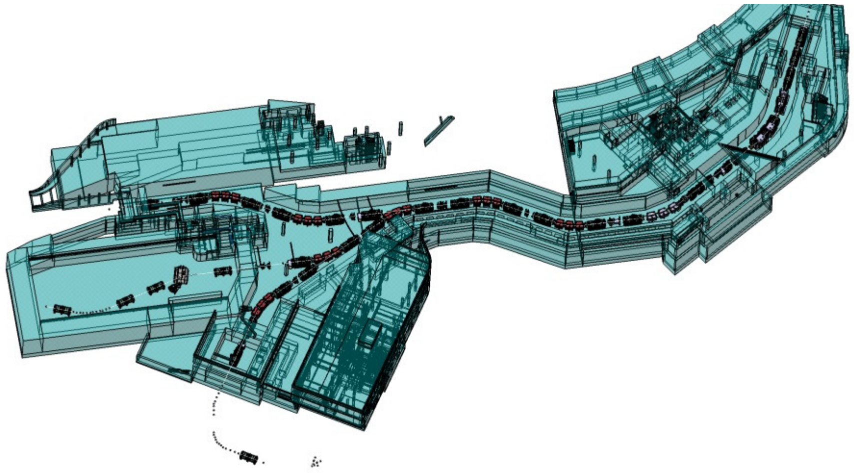
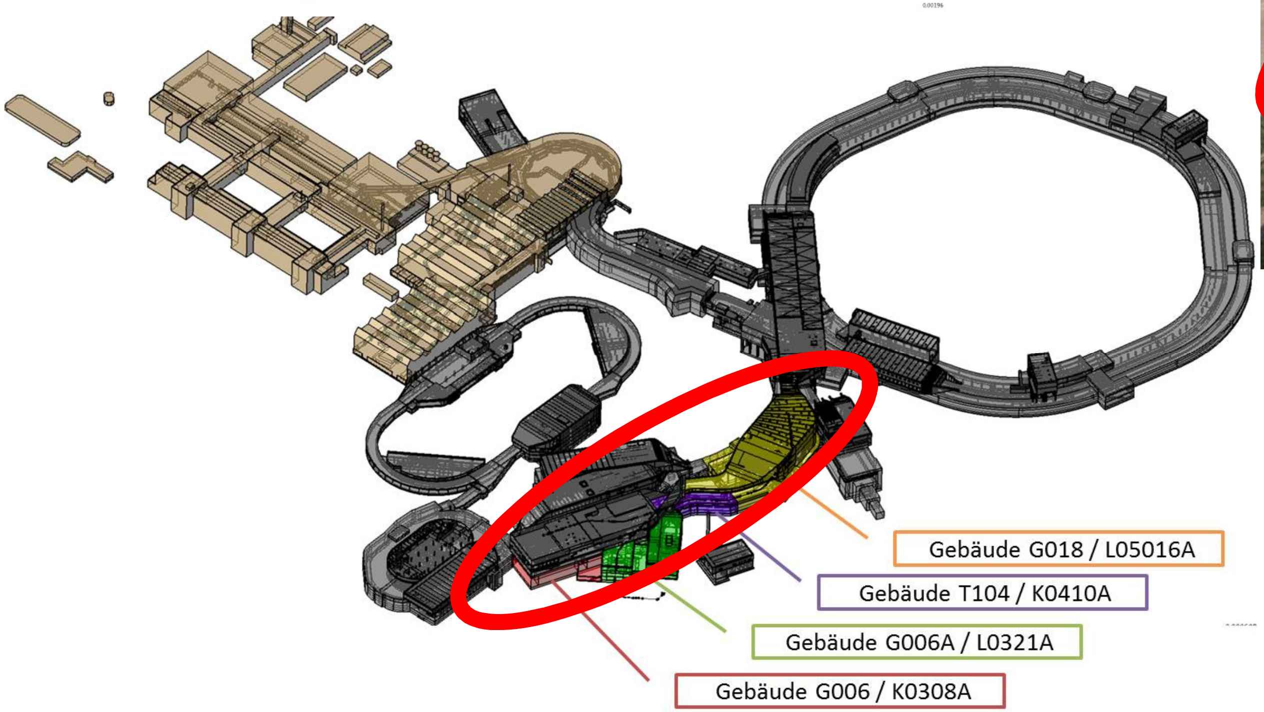
FAIR CC Today



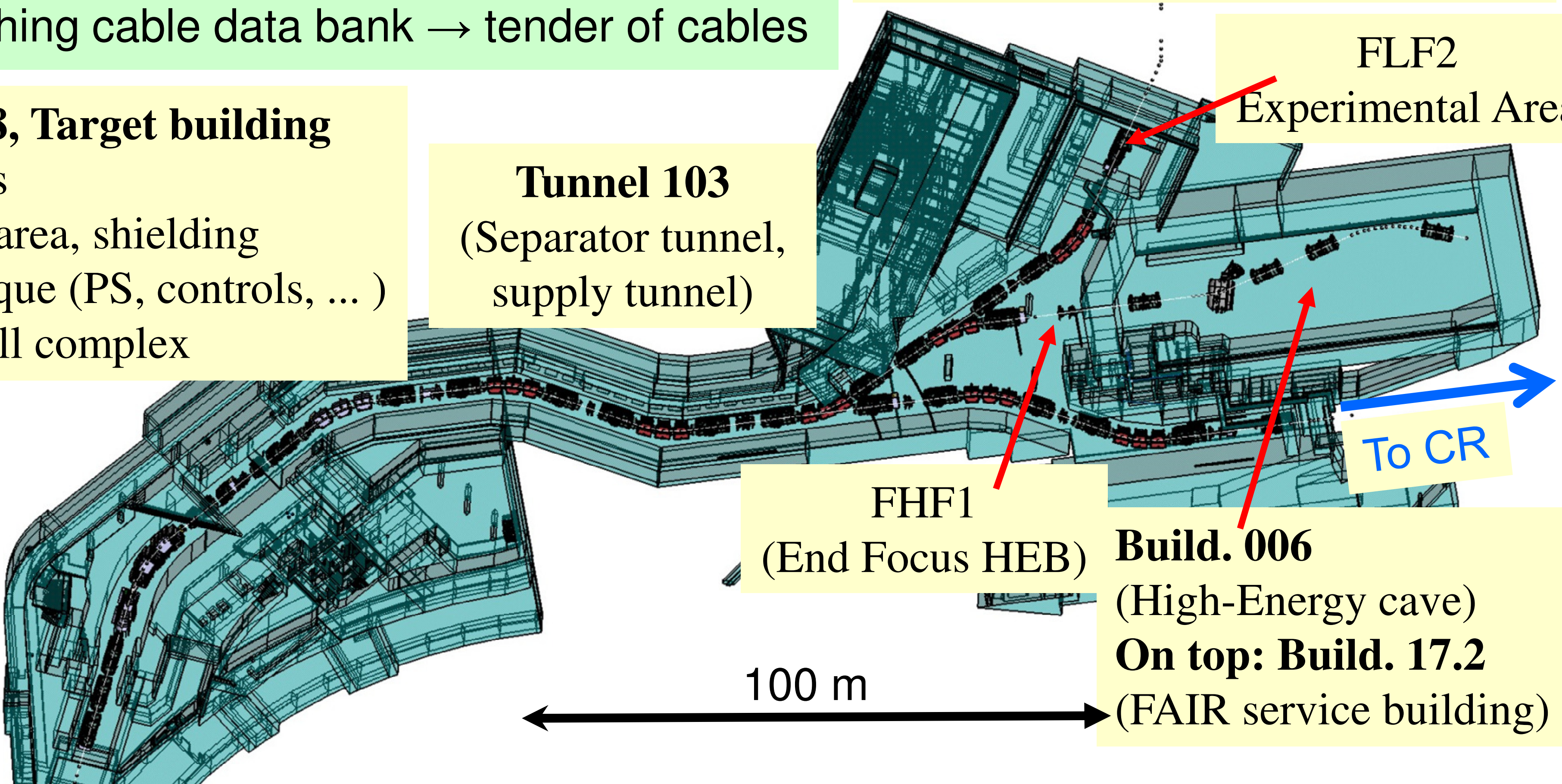


Super-FRS Buildings (MSV)

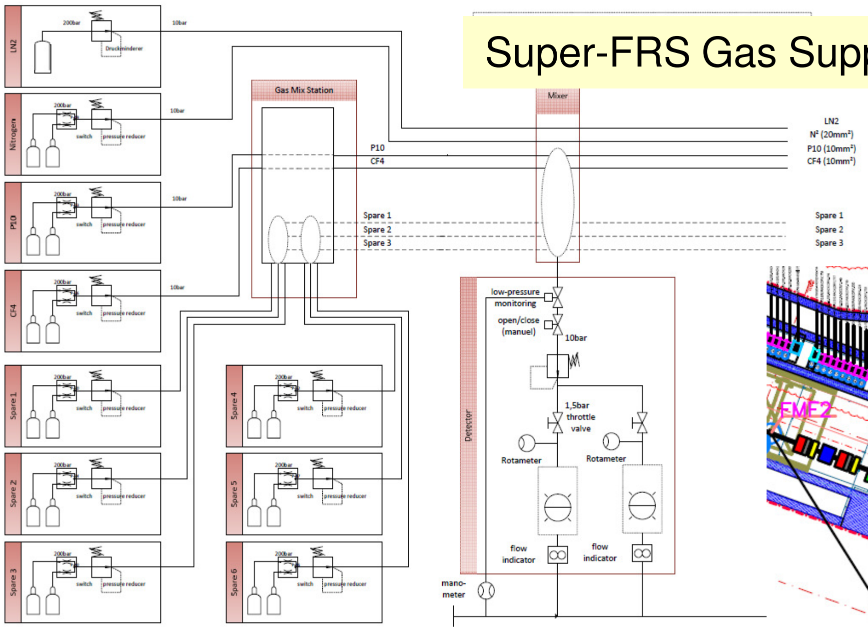
- Basic evaluation completed
- Preliminary planning completed
- Approval planning completed
- Execution planning under approval
- Running: route planning (cable, pipes, cryo)
- Formwork planning & Tendering
- Establishing cable data bank → tender of cables

Build. 006a, Service building
- 3 floors (~2000 m^2)
- Technique (PS, controls, ...)
- Experimental preparation
- Control room, electronics
- Gas supply, gas mixing station
- Main tunnel access

Build. 018, Target building
- 5 floors
- Target area, shielding
- Technique (PS, controls, ...)
- Hot Cell complex

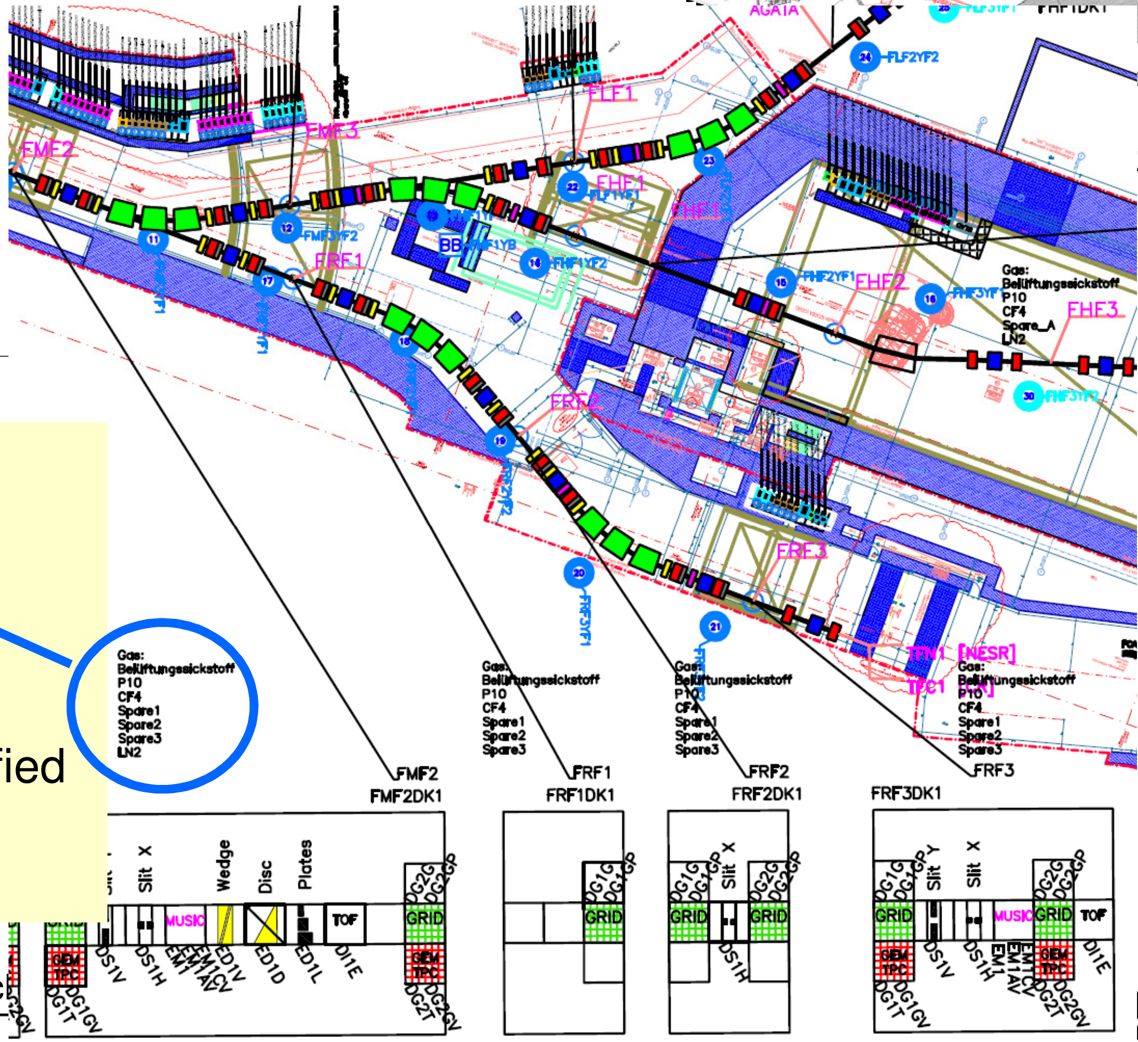


(Detector) Gas Supply



Super-FRS Gas Supply

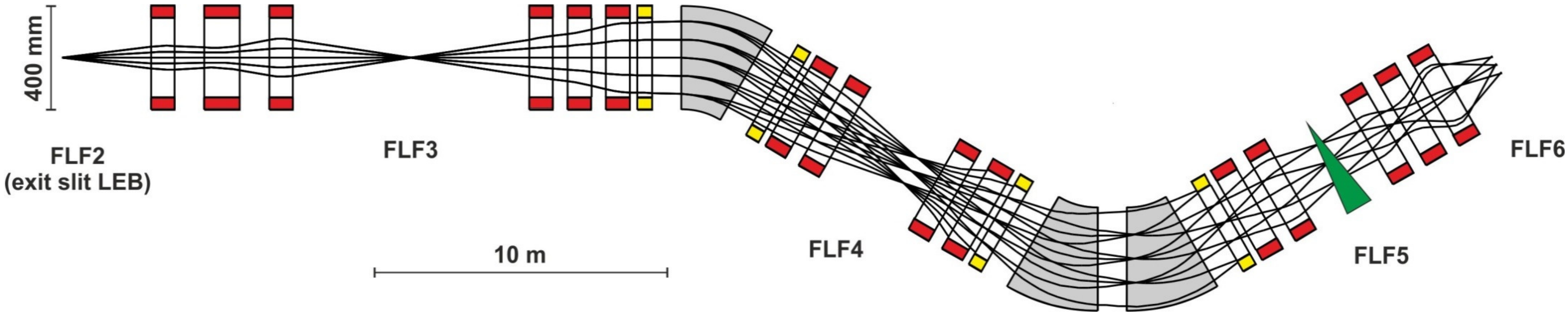
Gas Mixing Station in Build. 6a



- ✓ Standard Beam Diagnostic defined for each focal plane
- ✓ Detector gases defined for each focal plane (separator)
- ✓ Gas storage & mixing station
- Security requirements to be clarified
- LN2 storage available (piping not provided)

Energy Buncher: S-shape layout
(using standard multiplet magnets)

LEB task force
H. Geissel,
J. Winfield et. al

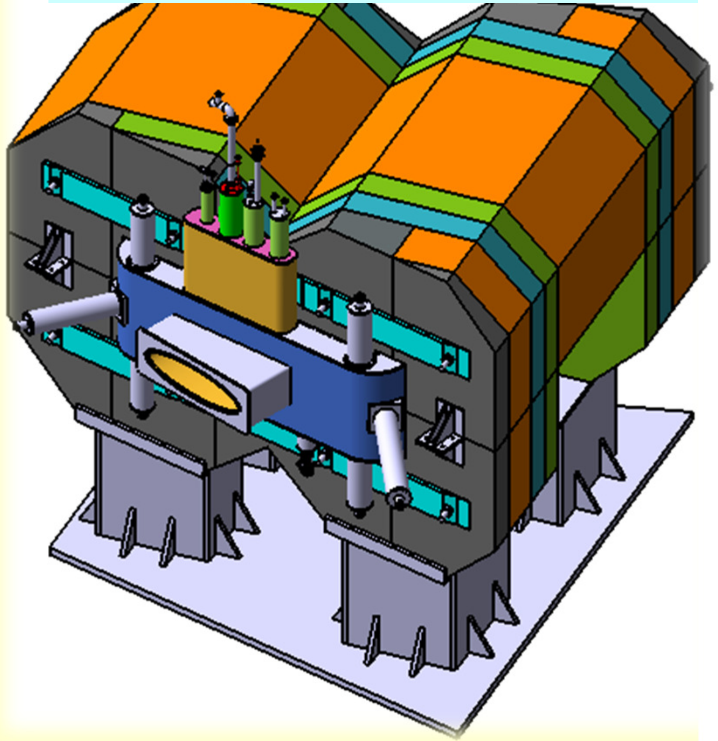


- Flexible operation
  - large acceptance spectrometer
  - high-resolution / energy buncher mode
  - dispersion matching (Main-Separator and EB)
- Intermediate focus at focal plane FLF4
  - ➢ keep overall dispersion in limits
  - ➢ in particular reduce gap size of magnets (use standard multipole magnets)
  - ➢ reduce requirements on monoenergetic degrader at FLF5
  - ➢ reduce technical risks
- Enlarged experimental areas
  - ➢ better matching of detectors / spectrometer performance

Magnets for Energy Buncher

- Magnets are Indian in-kind, revised parameters discussed with VECC
- Maximum beam rigidity: 7 Tm
- 3 dipole units with 30° deflection angle
  - superferric, warm iron, SC coils
  - usable aperture: (x = ±250mm, y = ±70mm)
  - expected weight <80 ton,
  - ➢ cost reduction, easier to handle and to measure
  - VECC is working on the new design
- Multiplet (quadrupole design same as in the separator)
  - superferric, cold iron
  - usable aperture: Ø380 mm,
  - leff: 800 mm, max. gradient: 10 T/m
  - configurations: 1 x QS, 3 x QQS, 1 x QQQ
  - y-steerer still in discussion
  - specifications ready
  - ➢ saving development time & costs, reducing technical risks
- Magnet testing must be discussed, in principle possible at CERN

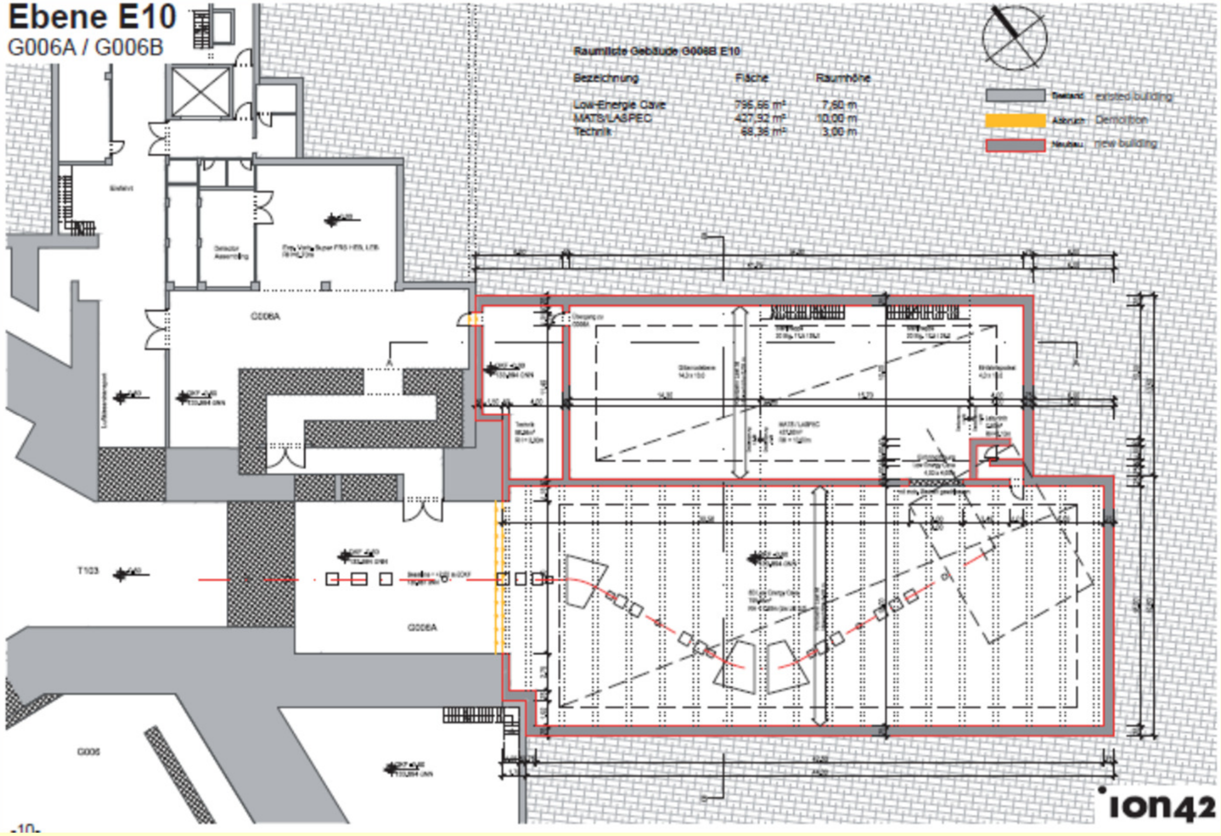
Original VECC dipole design



Cave for LEB/Energy Buncher

LEB task force
(D. Ackermann et. al)

- Architects feasibility study prepared by ION42 (FAIR architects)
- Cost estimate: 8.300k€ (2014)
  - breakdown according German CC cost type (KG xxx) provided
- Low-energy cave:
  - area ≈800 m^2
  - height: 7.6m
  - 5 ton crane
- MATS/LASPEC (annex):
  - area ≈430 m^2
  - height: 10m (2 floors)
  - 5 ton crane
- Annex space (technique):
  - area 2 x 68 m^2
  - height: 3m / 4.5m (2 floors)
- Most important now: clarify funding



- Discussion with funding agenecies/RRB has been initiated
- Additional required pillars can not be provided in an early phase (mid 2014)
- Discussion with FLAIR/SPARC concerning possible impact of FLAIR SPARC building

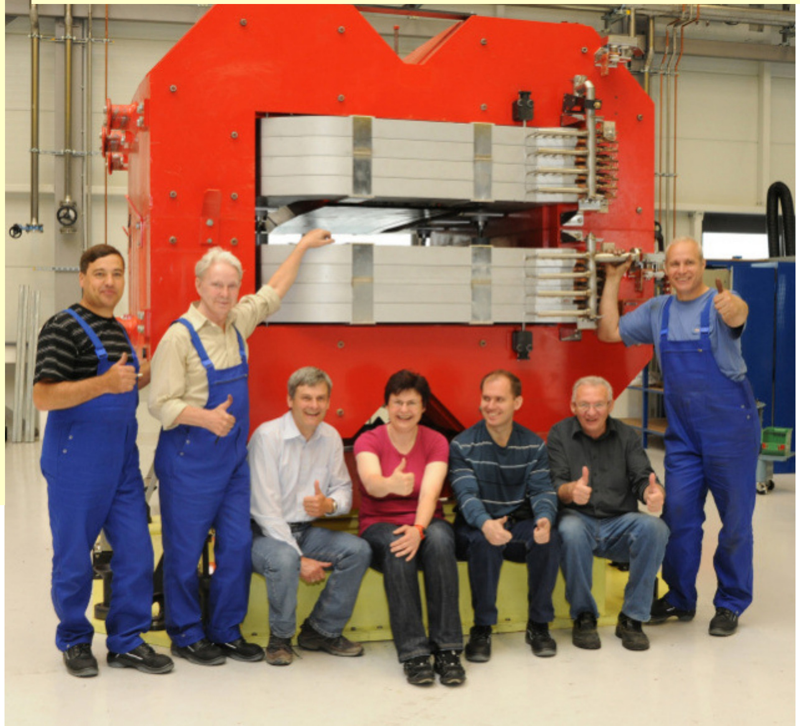
Radiation Resistant Magnets

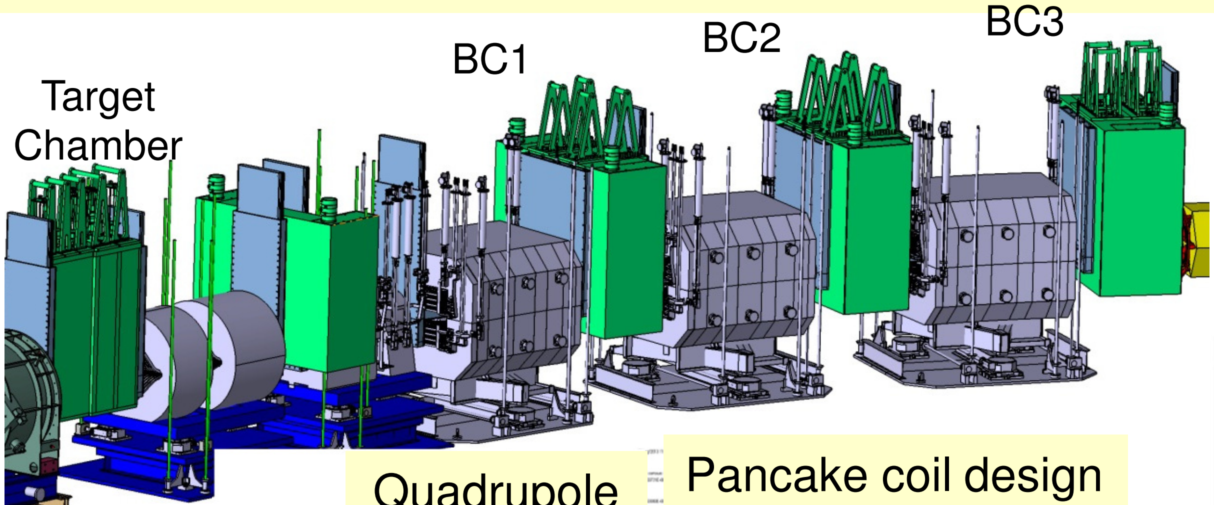
(at the Target Area of Super-FRS)

H. Leibrock
P. Rottländer
T. Blatz et. al

- ✓ Normal conducting magnets using MIC cable
- ✓ Prototype dipole built (95 ton) and tested by BINP
- ✓ Handling tests at GSI under way
- ✓ New design of first two quadrupoles behind target (field gradients were too high)
- Remote connectors and alignment under revision
- Specification in preparation (Q3/2014)
- Tendering by FAIR, Contracts Q1/2015

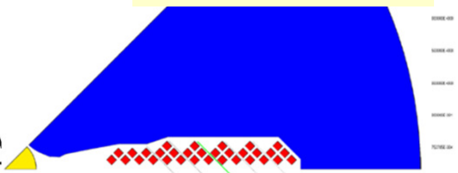
Prototype dipole at GSI testing-hall



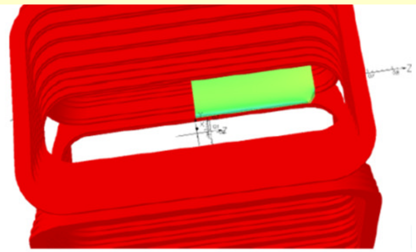


M. Winkler, A

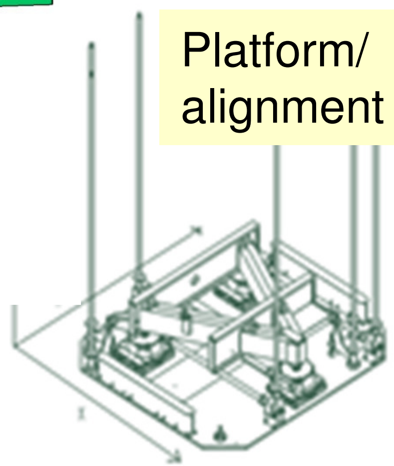
Quadrupole model

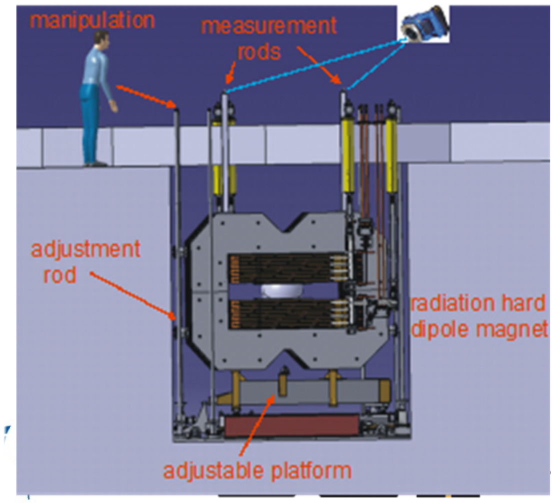


Pancake coil design



Platform/ alignment





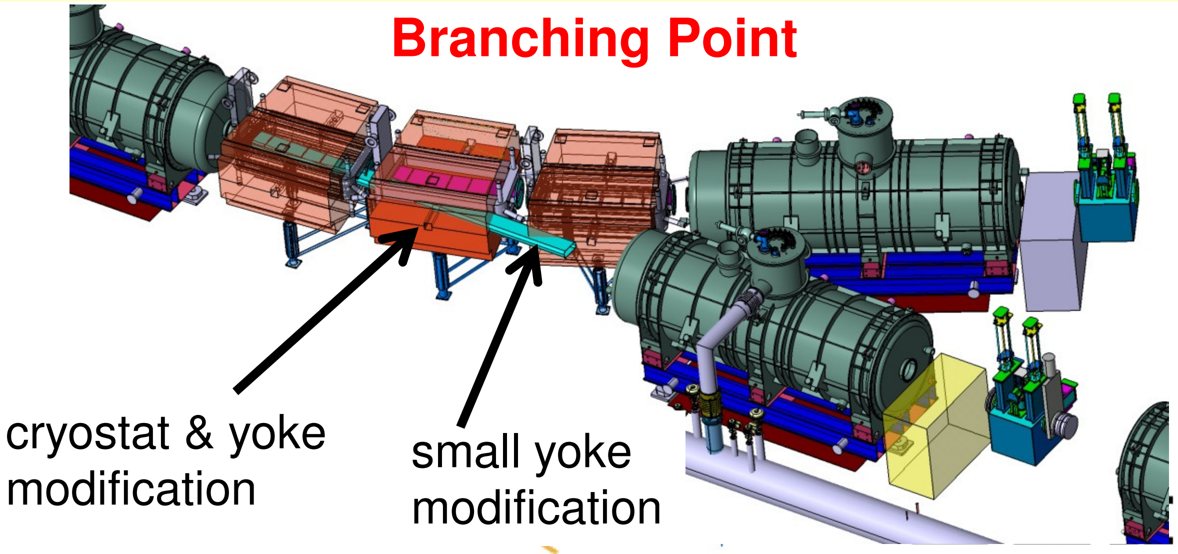
SC Dipole Magnets

M. Müller
H. Leibrock et. al

- 3 dipole units 11°
- 21 dipole units 9.75°
  - 3 times modified cryostat
- Iron dominated
- Warm iron
- SC coil
- Aperture ±190mm x ±70mm
- Weight: 50 to 60 ton
- Prototype built and tested (FAIR China Group)

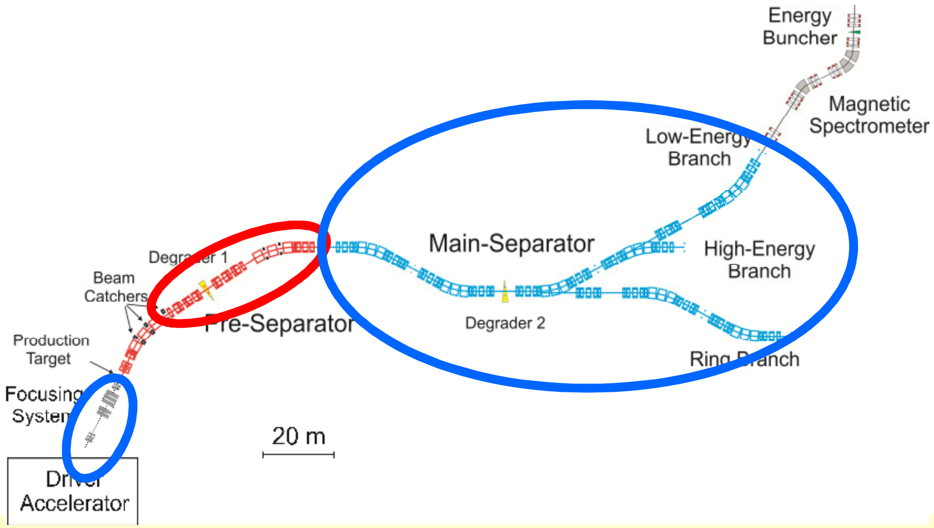
Status:

- ✓ IMoU with CEA/Saclay signed:
  - Engineering design
  - Technical follow-up
  - Participation at CERN testing
- ✓ Technical Kick-off
- Visit IMP CW14/2014 (with CEA, GSI, FAIR?)
- PDR CW20/2014 (includes external advisor)
- FDR Q2/2014 (without special dipoles)
- Tender by FAIR Q3/2014 (option on special dipoles)
- First of Series ready for testing: Q1/2016
- Series production and testing: Q3/16 – Q4/18



SC Multiplets

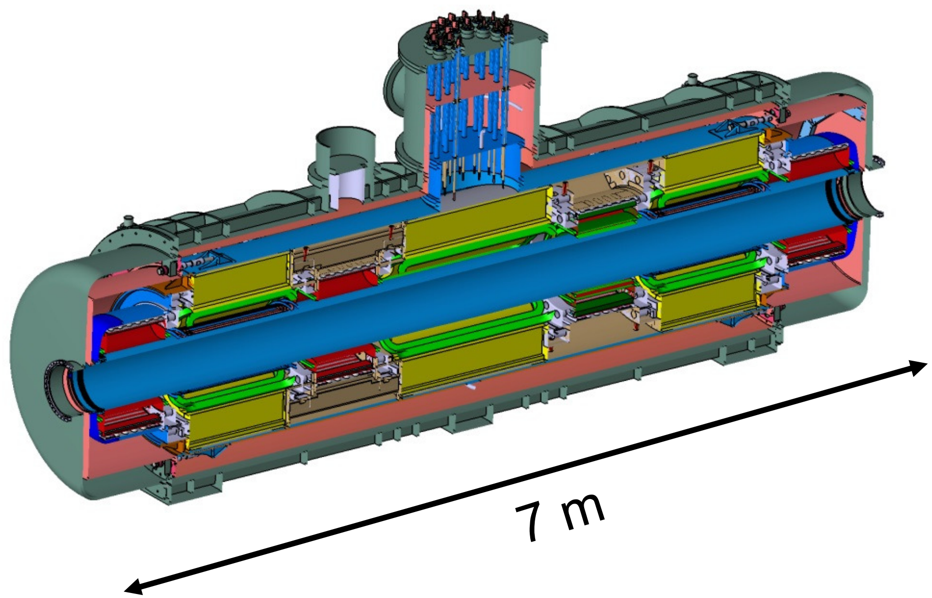
M. Müller
H. Leibrock et. al



- 24 long multiplets (MS)
- 7 short multiplets (PS)
- Quadrupol triplet / QS configuration
- up to 3 sextupoles and 1 steerer
- Octupole coils in short quadrupoles

- iron dominated, cold iron (≈40 tons)
- common helium bath
- warm beam pipe (38 cm inner diameter)
- per magnet 1 pair of current leads
- max. current <300A for all magnets

- **Tender Status:**
- ✓ Bidder submitted quotes Q4/2013
- ✓ 1st round negotiation finished
- 2nd round starting March 2014
- Signing of contract expected Q2/2014
- Testing of First short Multiplet at CERN: Q1/16 – Q2/16
- Testing of first long multiplet at CERN: Q2/16 – Q4/16
- Series testing at CERN: Q1/17 – Q2/19

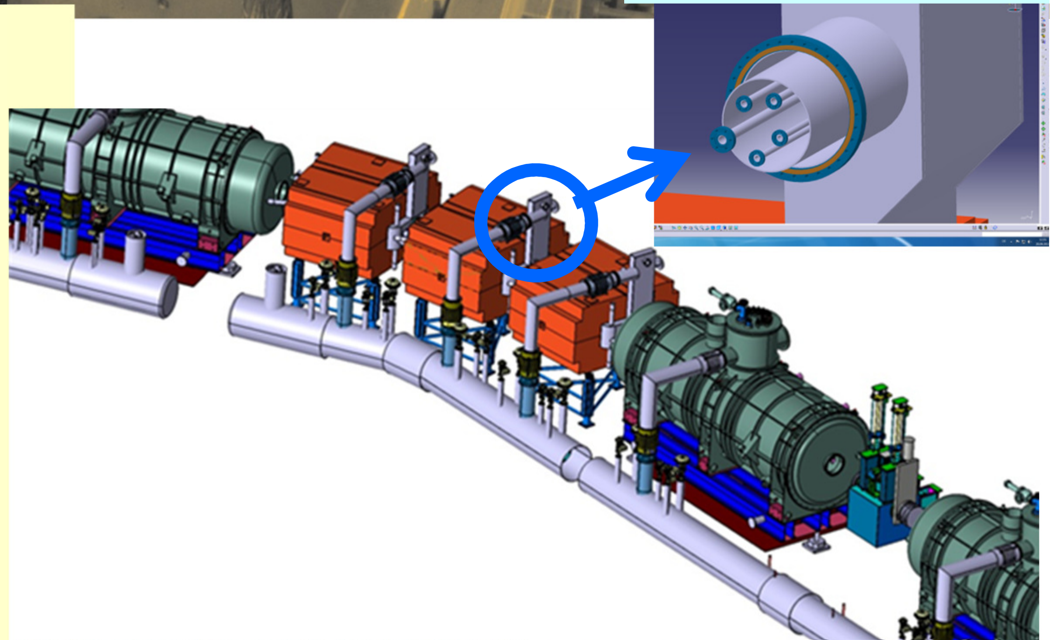


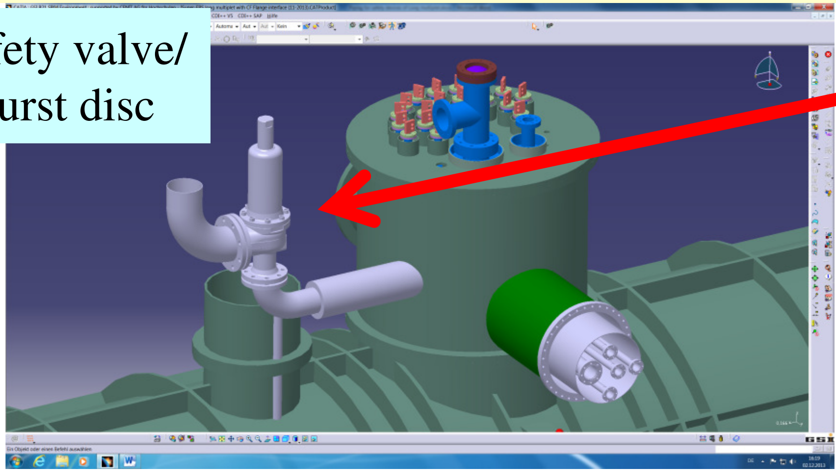
Super-FRS Local Cryogenics

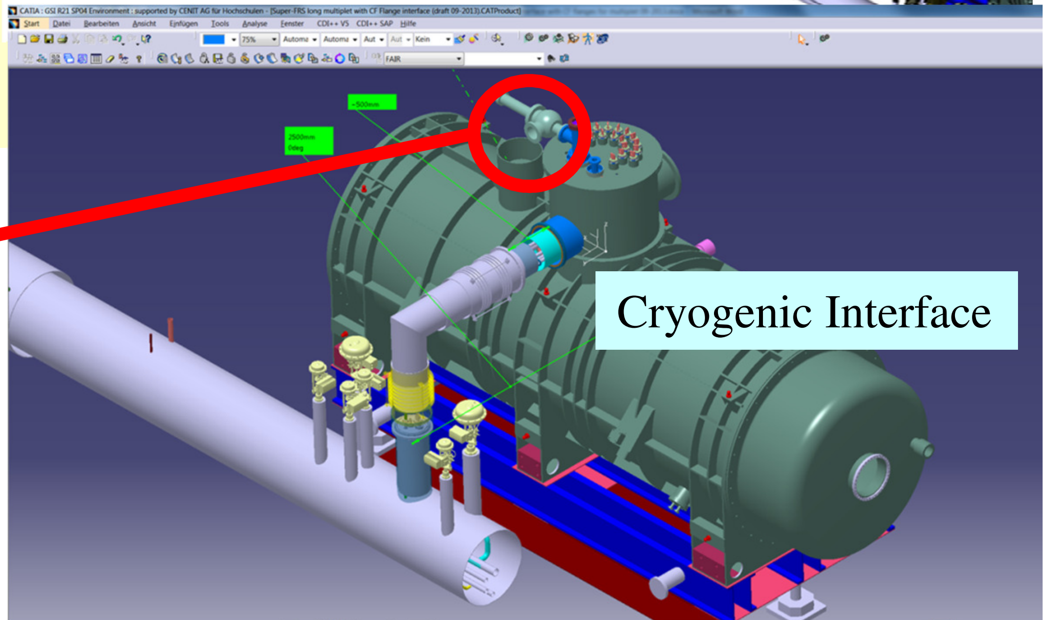
Y. Xiang et. al

(Including Preparation for CERN Testing)

- Flow scheme / Cooldown processes
  - FB controls: 3 dipoles / 2 multiplets
  - Total cold mass (PS + MS): ≈1.100 ton
  - Cryogenic operation modes
- Revision of feedboxes
- Updates of cryogenic interfaces
- Emergency cases
  - Normal quench → 70% of energy deposited in quench protection system
  - Worst case scenario → full energy in He
  - ➢ dimensioning of safety valves/burst disc

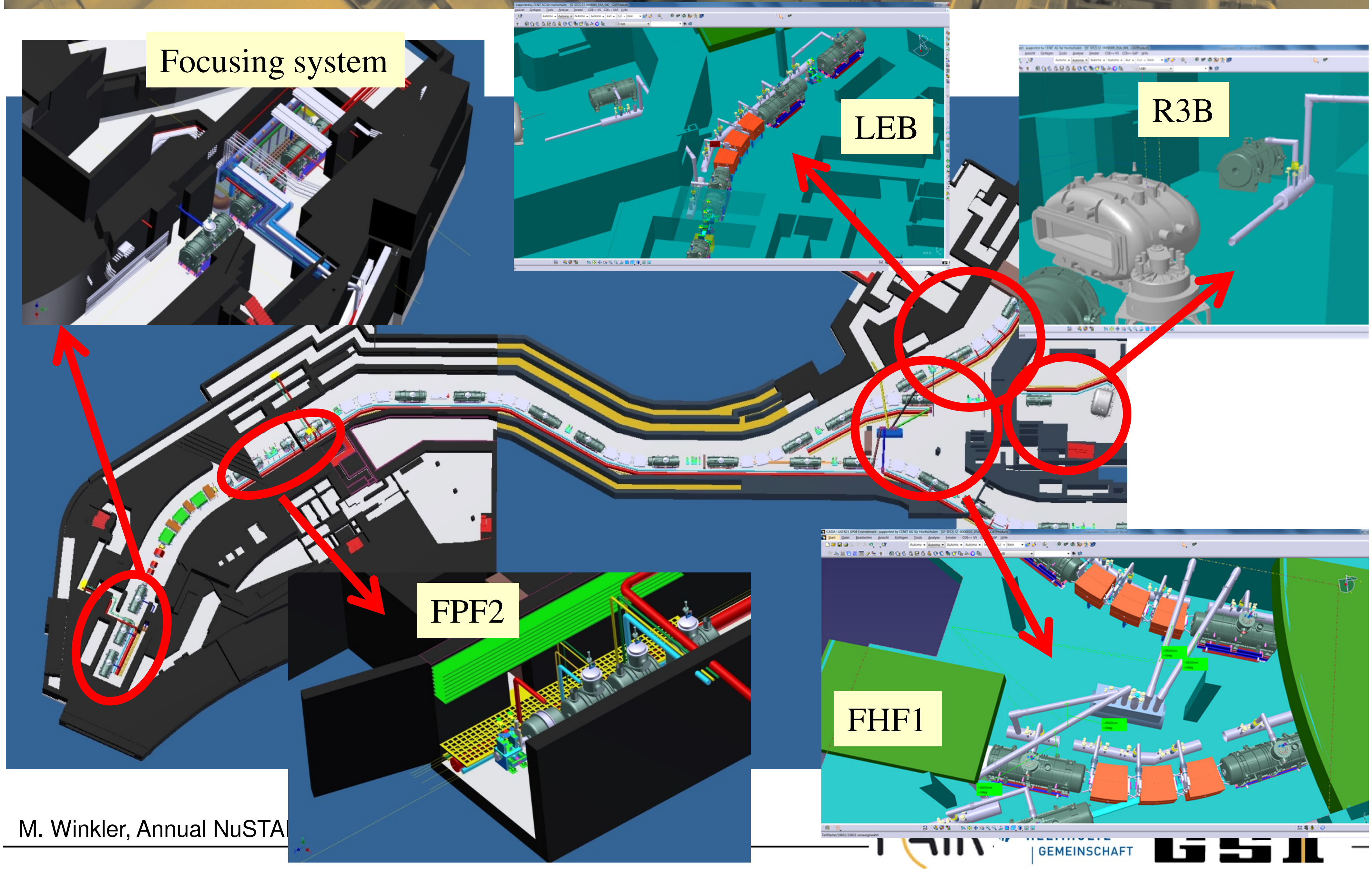






Super-FRS Local Cryogenics Routing
(Driven by CC Planning)

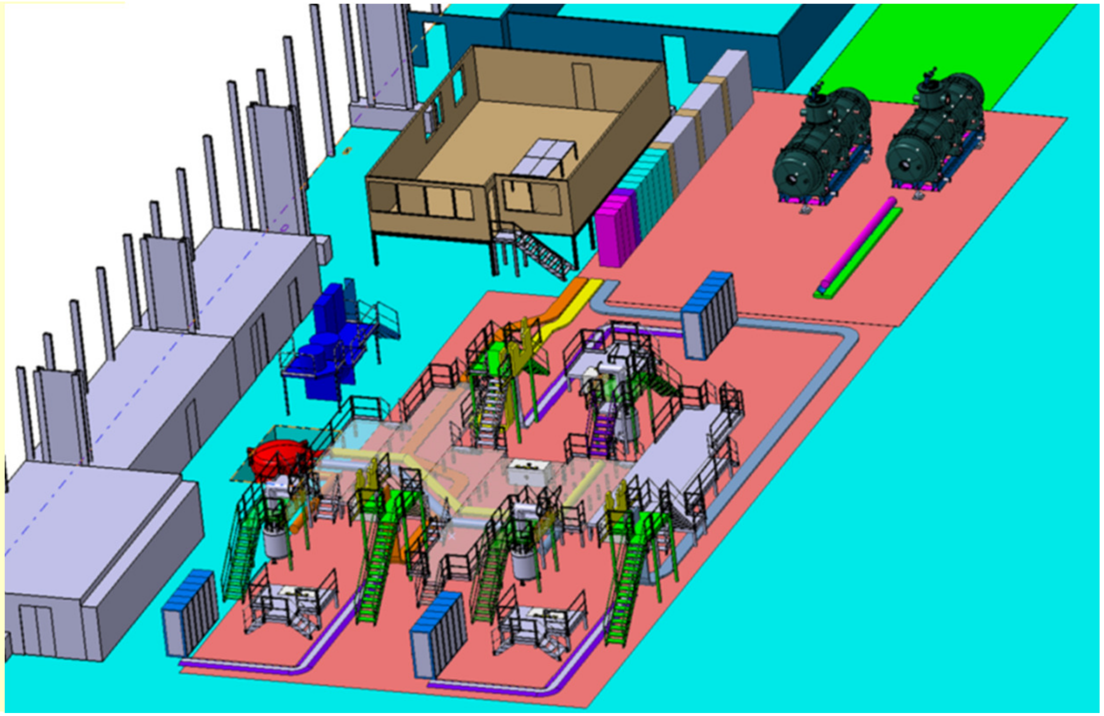
Y. Xiang
S. Purushotaman
A. Kratz et. al



Magnet Testing & Mapping @ CERN

P. Schnizer et. al

- ✓ GSI-CERN Agreement K1727/DG & Addendum #2 (signed)
- Scope (separator magnets):
  - ✓ 24 Dipoles (PS & MS),
  - ✓ 31 Multipletts (+ 2 spare)
- Place: CERN building 180
- 3 universal test benches, basically:
  - 1 setting-up & cool-down
  - 1 measuring
  - 1 warm-up & disassemble

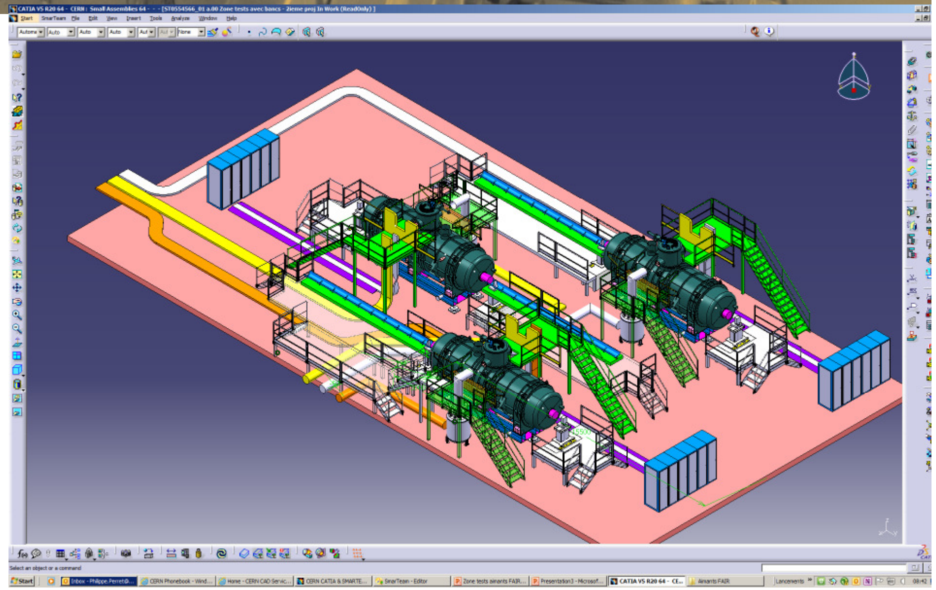


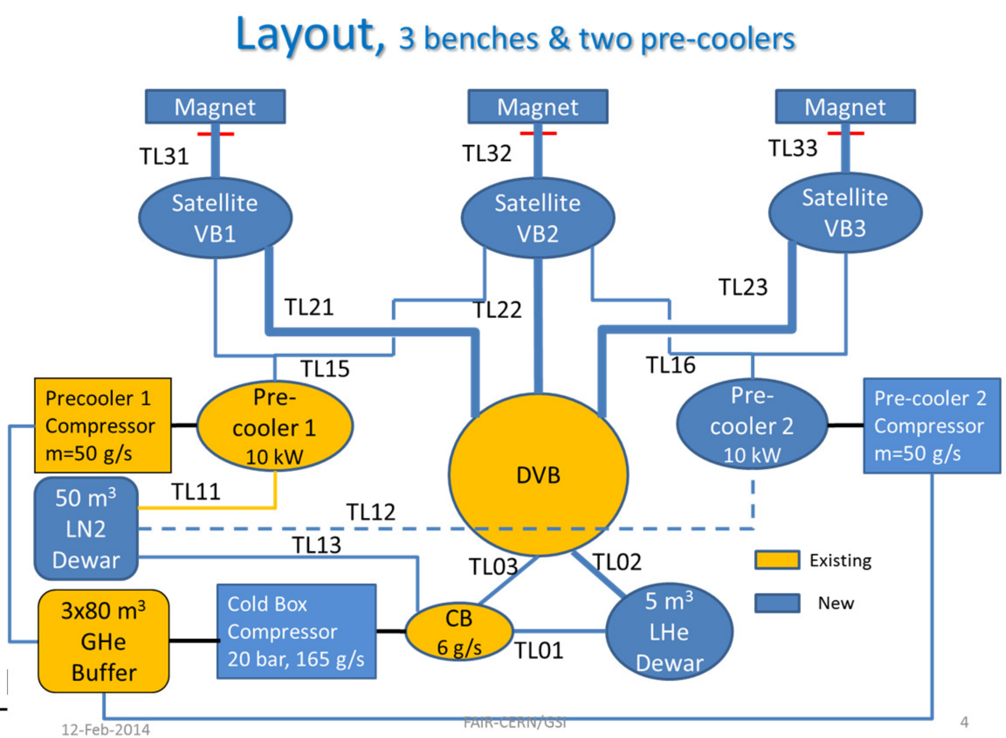
- Ready for testing: Q4/2015
- Time estimate (single multiplet): 44 days
  - Installation, connection, cool-down: 15 days
  - Cold test (powering, magnetic field): 15 days
  - Warm-up, disassembly: 14 days
- overall series measurement time: ≈ 3-3.5 years

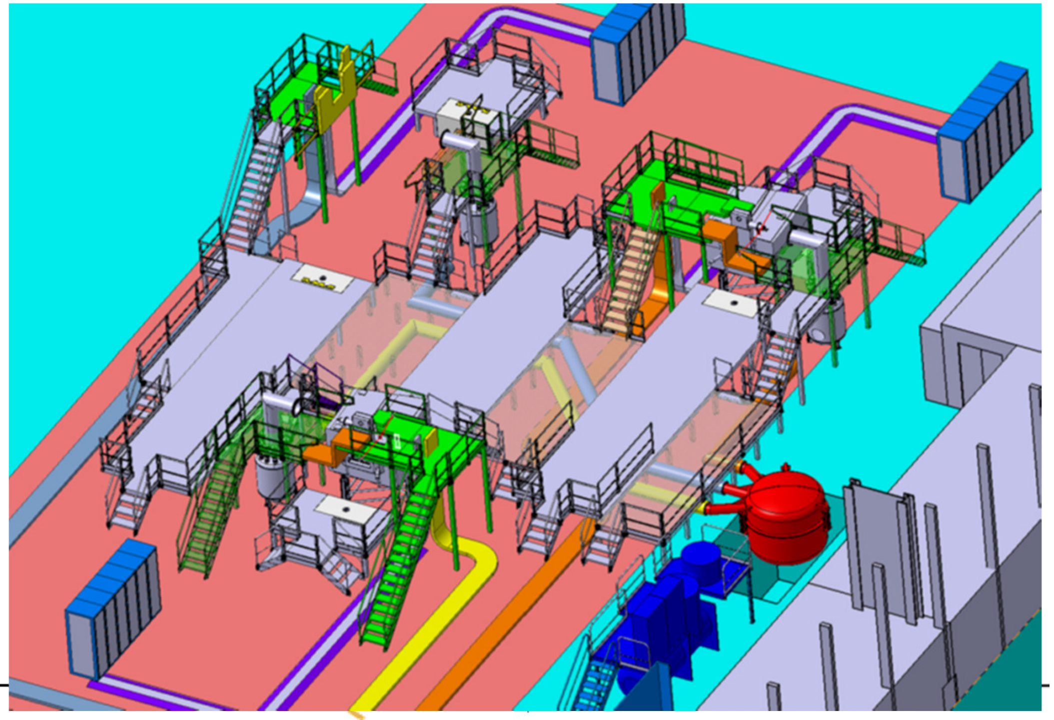
Magnet Testing Area @ CERN

P. Schnizer et. al

- ✓ Existing equipment
  - magnet-measurement station, crane
  - Cryo: Ghe Buffer, distribution box pre-cooler (10kW) + compressor
- ✓ New required equipment (mainly cryo-parts):
  - 2[nd] pre-cooler (10kW) + compressor
  - 3 satellite valve-boxes & cryogenic lines
  - LN2 & LHe tank







Beam Diagnostics & Instrumentation

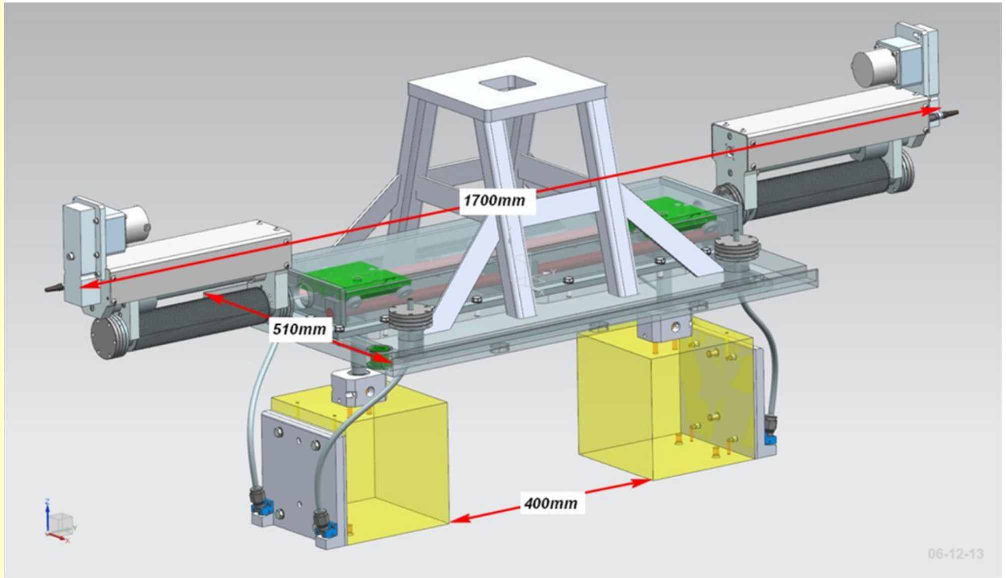
see also presentation by C. Nociforo

brief detector up-date

- GEM-TPC (Finnish in-kind), running WP
  - ✓ prototype ready
  - ➢ low-energy, high-rate beam test: JYU
  - ➢ high-energy beam test: GSI
  - ➢ final specification (Q1/15) → production
- SEM-GRID & ladder system
  - ✓ accepted as Finnish in-kind (Q4/2013)
  - ✓ Project engineer hired (Kari Rytkönen)
  - ➢ integrated together with GEM-TPC
  - ➢ pre-design for SEM-GRID ready (HEBT)
  - ➢ ladder integration to be designed
- various test beam-times in 2014
  - ➢ Dubna (radiation hard ToF)
  - ➢ GSI (MUSIC)
  - ➢ JYV & GSI (GEM-TPC)
  - ➢ Catania (Diamond)

Slit-systems & Secondary Target

- ✓ accepted as German In-kind (Q4/13)
- ✓ Collaboration MoU with KVI-CART
- ✓ project group at KVI established
- ✓ kick-off / regular meetings with KVI
  - ➢ specification, pre-designs
  - ➢ technical aspects (e.g. weight)
  - ➢ cost aspects (material)

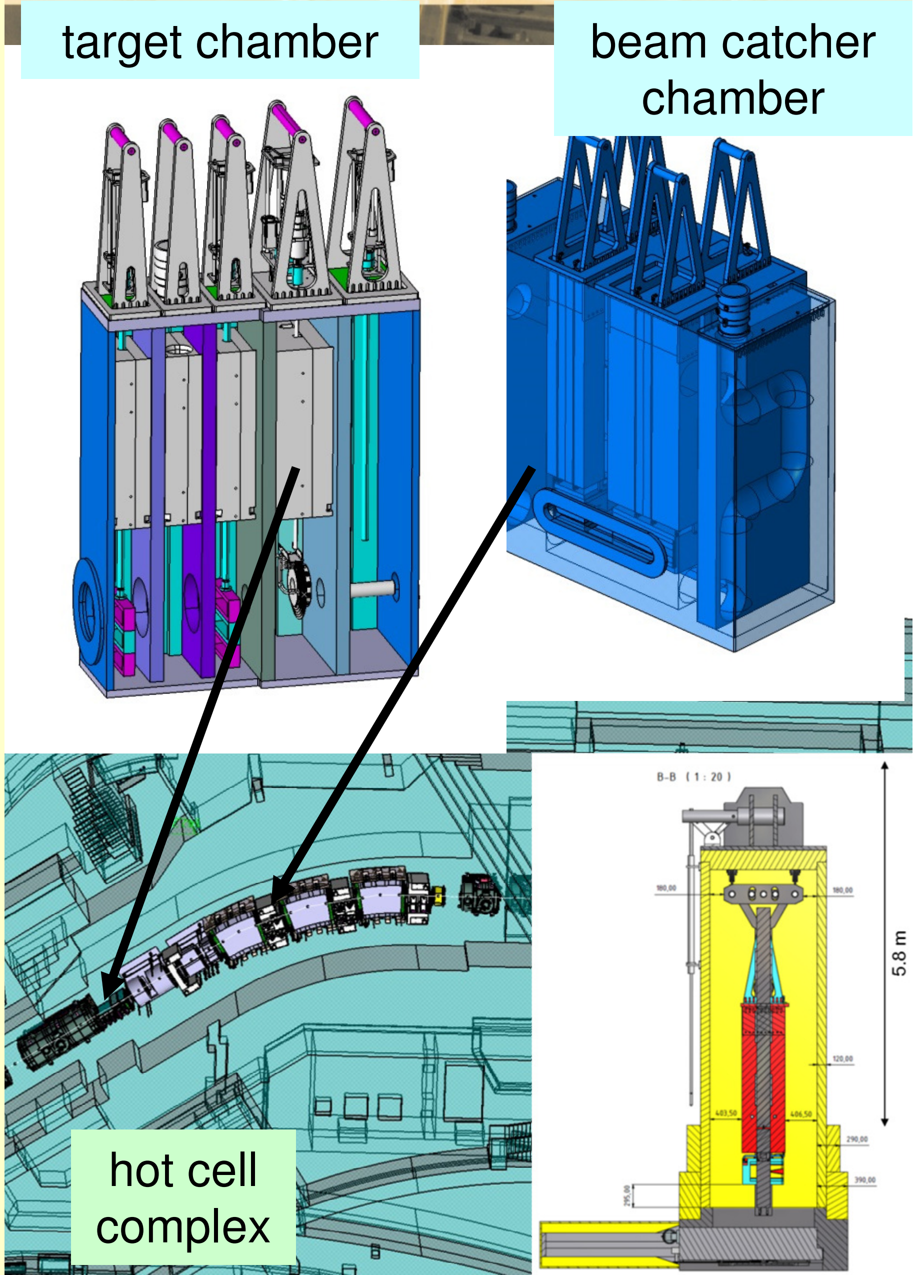


Target Area Installation

H. Weick
C. Karagiannis et. al

- Target chamber & plug inserts (German in-kind)
  - dimensional design ready
  - proposed to be contracted to KVI
- Target wheel & plug inserts (German in-kind)
  - prototype target wheel with drive available,
  - revision ongoing (wheel size, moving mechanism, design for remote handling
- Beam catcher (Indian in-kind)
  - chamber design adjusted (additional pumping channels)
  - two-halves catcher concept design added
    Be/Al for slow extraction
    Graphite for fast extraction

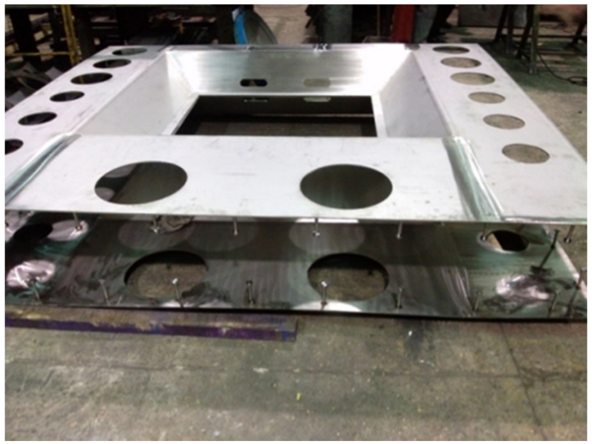
    lifetime increase by factor ≈ 3
  - clarification with India on scope of work
- Shielding flask
  - accepted as Finnish in-kind (Q4/2013)
  - Finnish collaborators: Hollming Works Ltd., ENMAC, Aalto University
  - Preplanning to go into approval process, then order production.

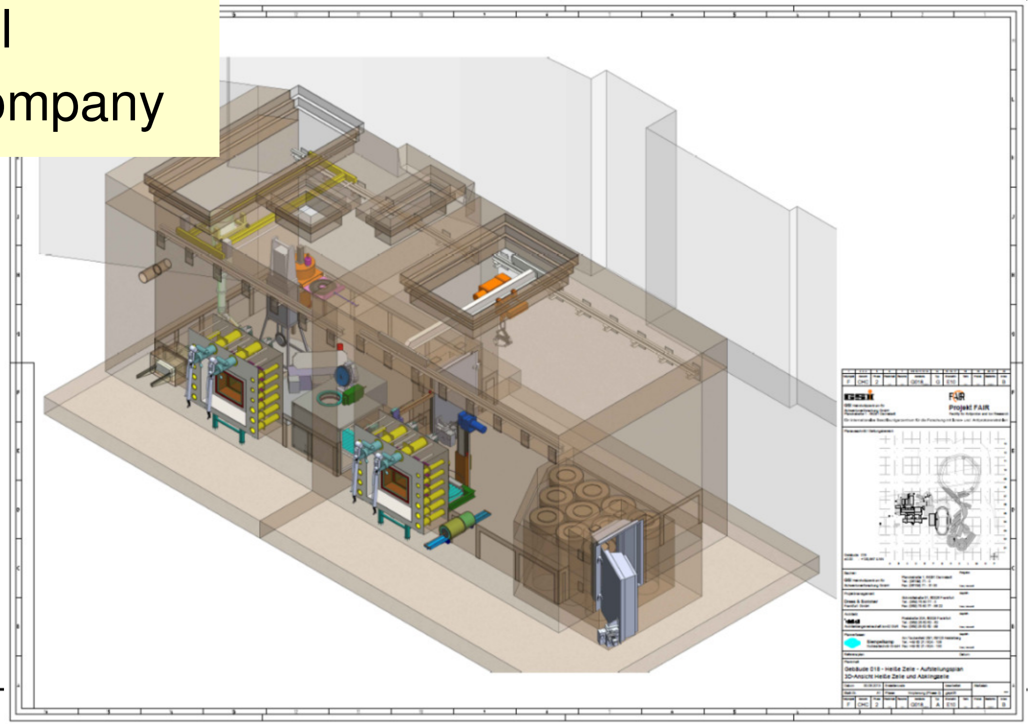


Hot Cell / Mock-up Installation (German in-kind)

C. Karagiannis
H. Weick et. al

- Based on study by nuclear engineering company (includes new tooling required for waste handling)
- Mock-up installed on ESR roof
  - metallic frame & two MS manipulators (load capacity 20kg, slave extention 3270 mm)
  - validation of design concepts
  - training of personnel
  - Collaboration with SPIRAL 2 (EU CRISP)
- Manufacturing of window frames for hot cell
- Next step: full realization by contract with company

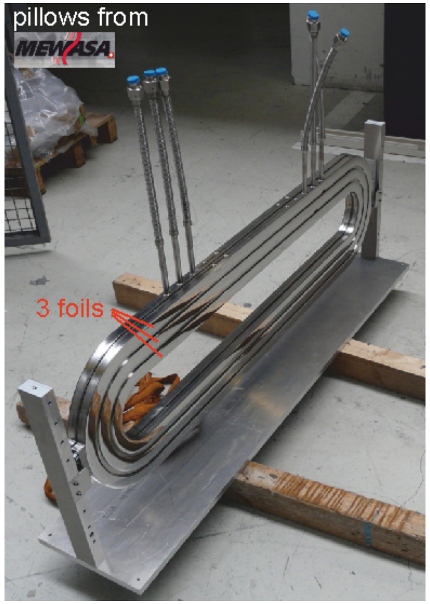


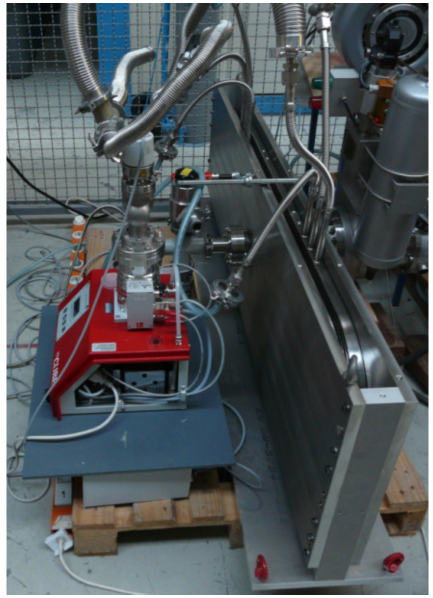


Large Size Pillow Seals

K.H. Behr
A. Kratz et. al

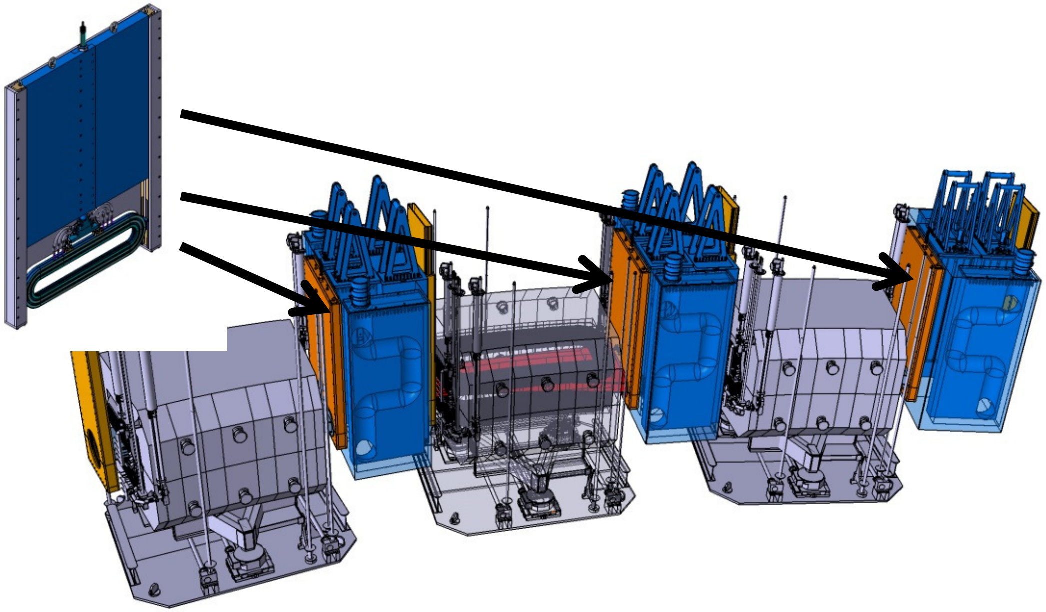
- Pillow seals to be used in the Target Area
- standard will be round Pillow Seal with Ø500mm
- special large size rectangular (1200x160 mm²) seals between dipole and beam catcher
- Developed together with MEWASA
- Test setup at GSI
- Requirements fulfilled
- Long time stability tests running (temperature, ...)
- Next steps: full plug design

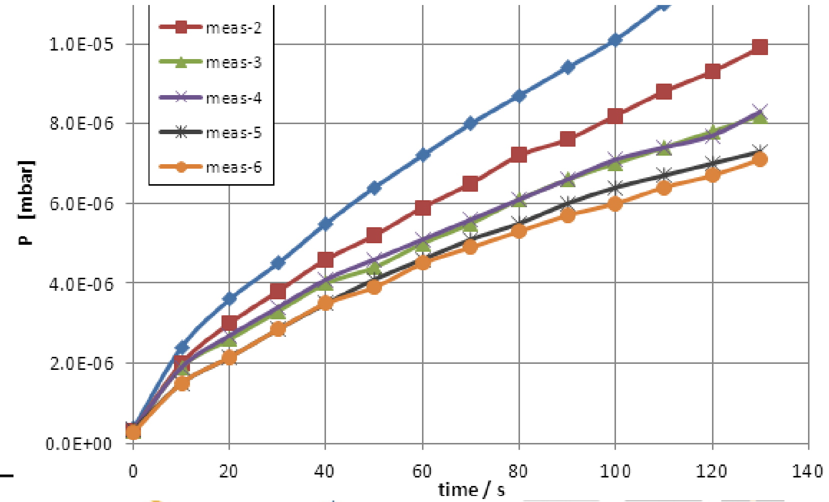




new polishing, seal #4 ~ 1x10^{-6} mbar l/s
seal #3 ~ 1x10^{-6} mbar l/s

Leak rate by measuring pressure increase after stopping pumps on 16.5 l volume.





Summary

- Civil Construction progressing
  - execusion planning under approval
  - route planning running
- Energy Buncher redesigned
  - new LEB cave proposed
  - S-shape solution using standard multiplets
  - dipole magnets to be redesigned by VECC
- Procurement of long-term items (magnets) started
- Magnet test facility at CERN under preparation
- Development of various items (beam instrumentation, target area) in progress