Status Report on Super-FRS

M. Winkler

NuSTAR WEEK 2013

Helsinki, October 7 – 11, 2013

Outline

1) Super-FRS Layout (Full Version)
2) Status of Civil Construction
3) Status Low-Energy Branch
4) Status of Components
5) Summary

Layout off the Super-FRS (Full Version)

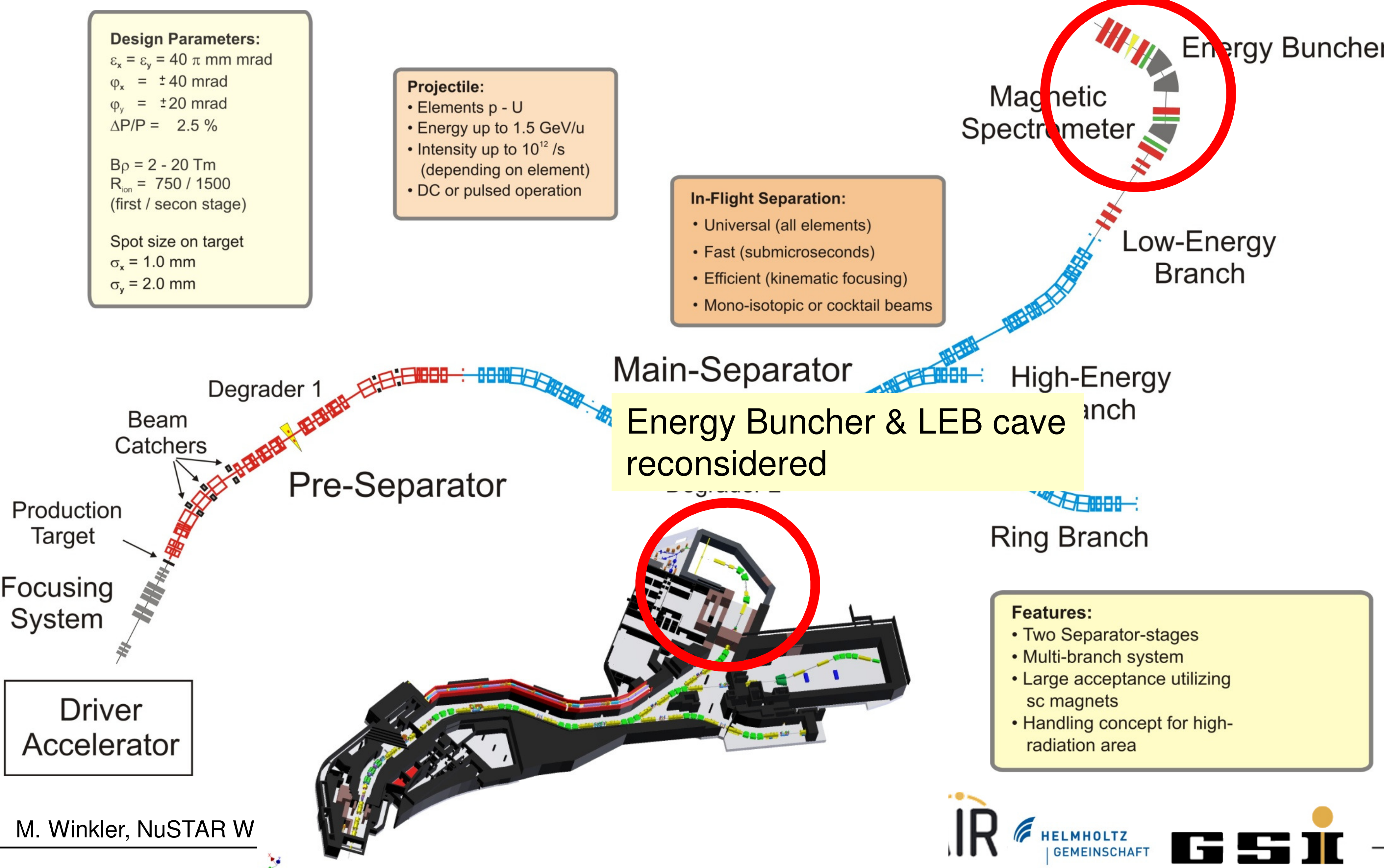
Design Parameters:
$\varepsilon_x = \varepsilon_y = 40\ \pi$ mm mrad
φ_x = ±40 mrad
φ_y = ±20 mrad
$\Delta P/P$ = 2.5 %

$B\rho$ = 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

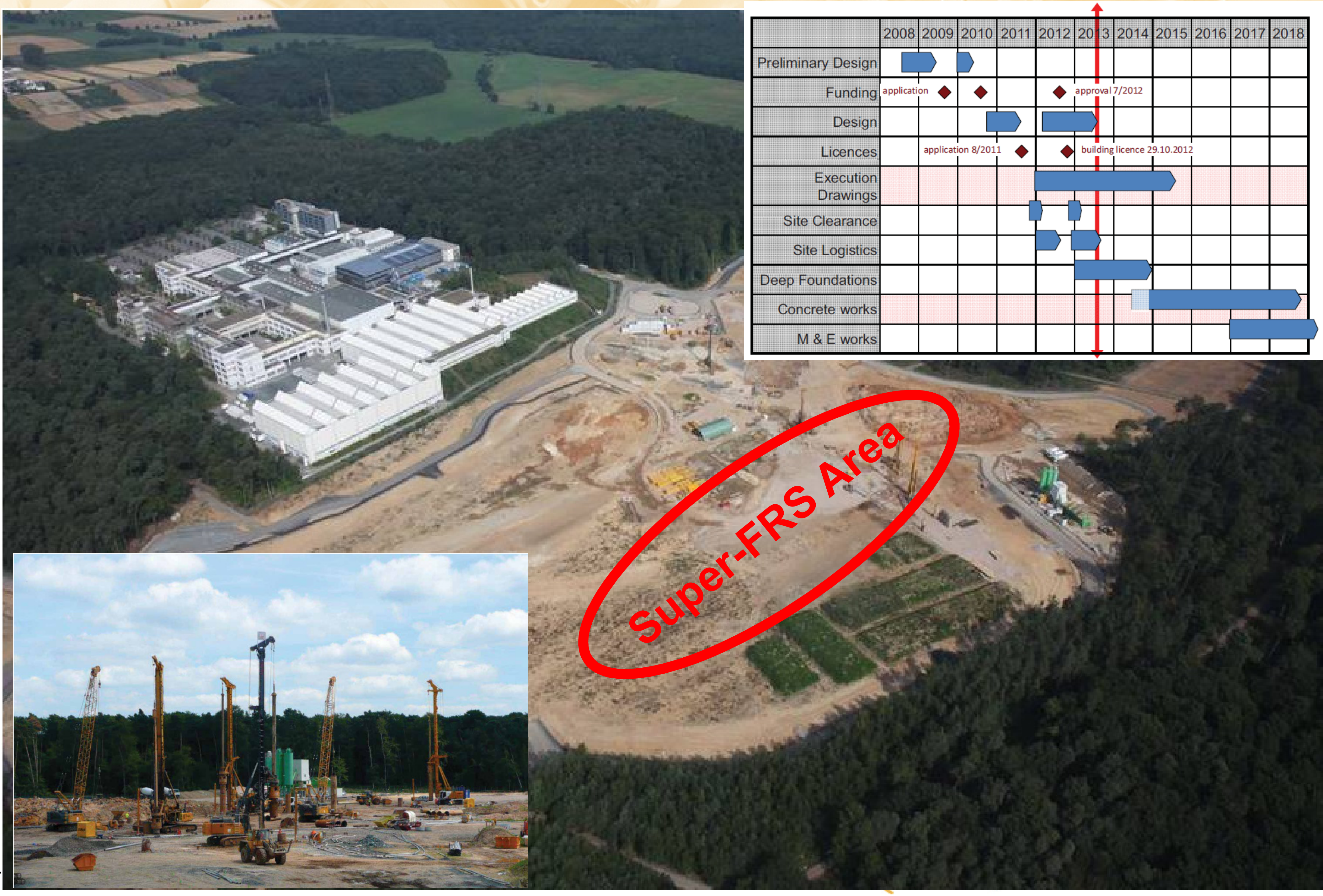
In-Flight Separation:
- Universal (all elements)
- Fast (submicroseconds)
- Efficient (kinematic focusing)
- Mono-isotopic or cocktail beams



Energy Buncher & LEB cave reconsidered

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

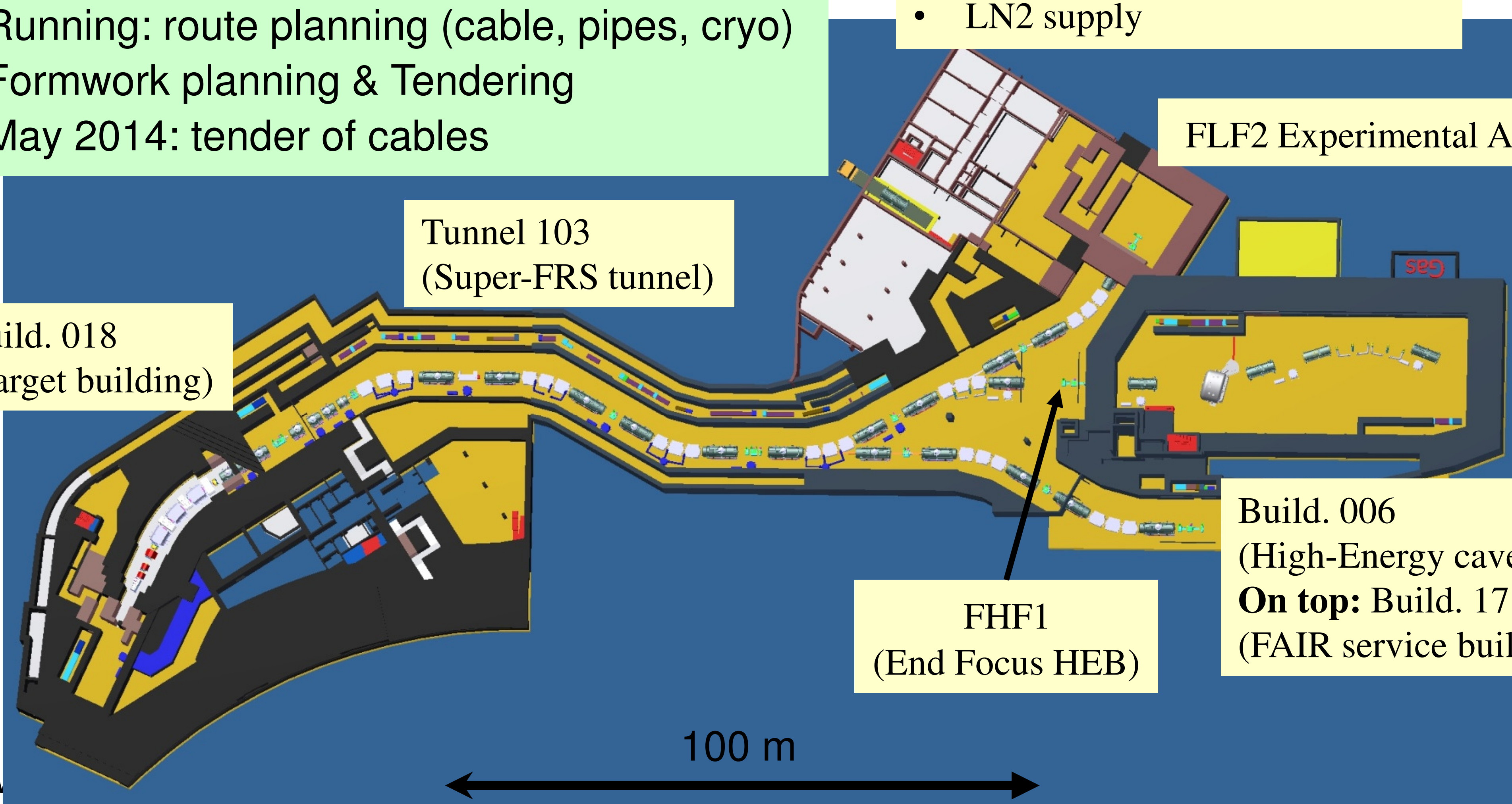
FAIR today


Super-FRS Area
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Preliminary Design
Funding
application
approval 7/2012
Design
Licences
application 8/2011
building licence 29.10.2012
Execution Drawings
Site Clearance
Site Logistics
Deep Foundations
Concrete works
M & E works

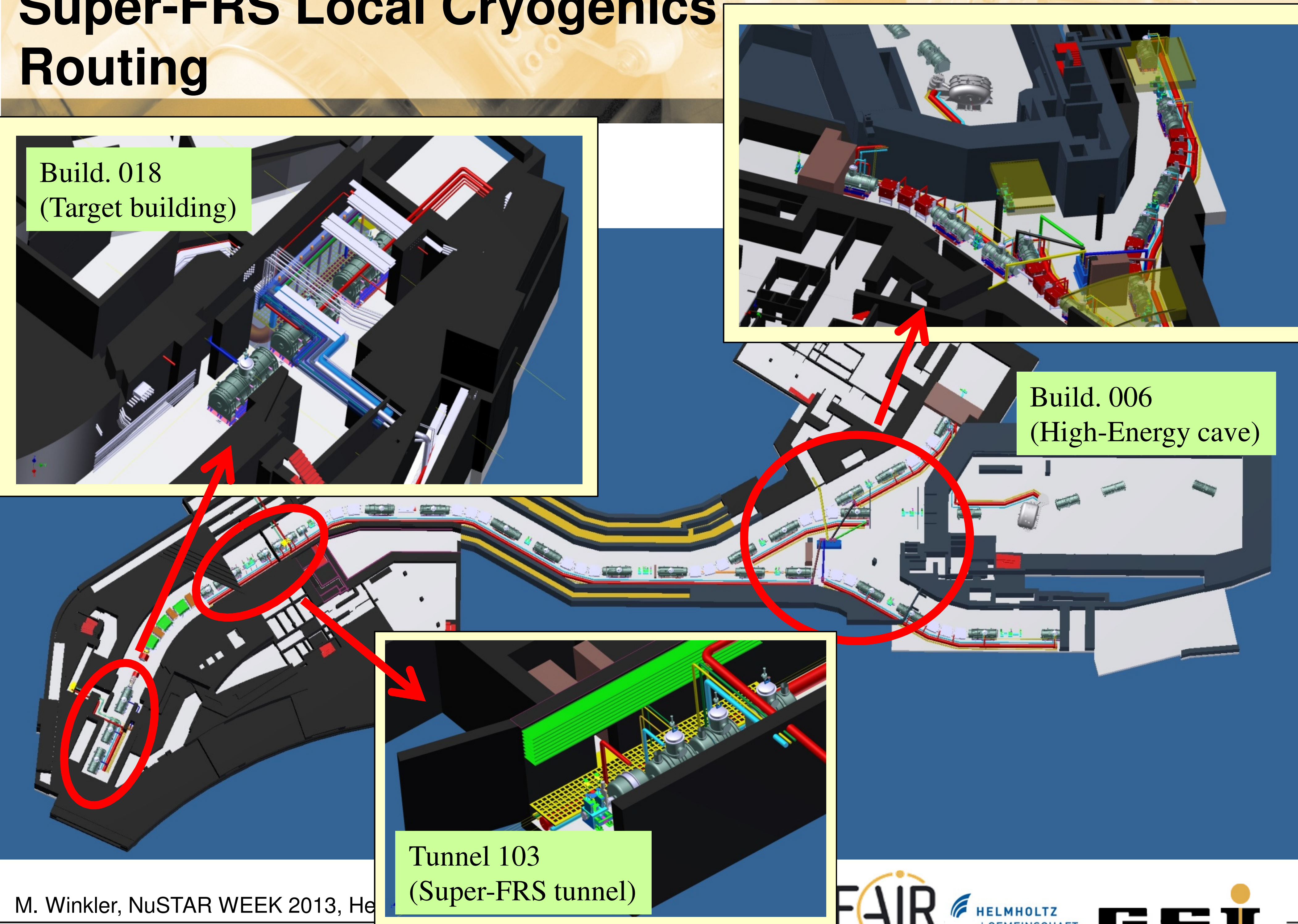
Super-FRS Buildings (MSV)

- Basic evaluation completed
- Preliminary planning completed
- Approval planning completed
- Execution planning under approval
- Running: route planning (cable, pipes, cryo)
- Formwork planning & Tendering
- May 2014: 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
- LN2 supply

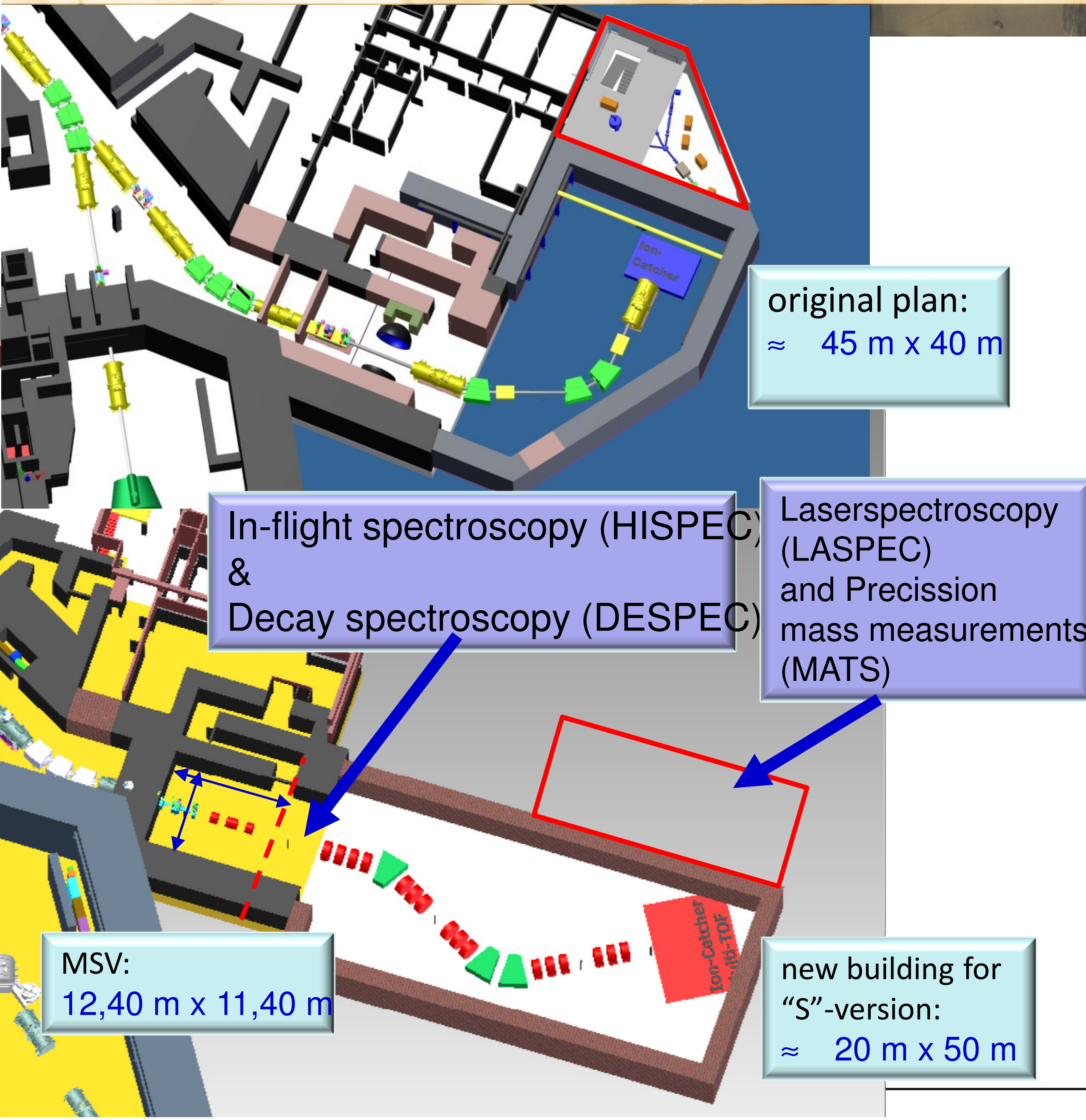


Super-FRS Local Cryogenics Routing



Low Energy Branch
- status and perspectives

LEB tasc force
(D. Ackermann et. al)



Experimental areas required/foreseen

- HISPEC DESPEC: 7x8 m^2
- Focal plane of spectrometer: 2.8 m
- Behind E-buncher: 10x8 m^2
- MATS and LASPEC: 30x13 m^2

Major changes

- 5 more magnets (4 Q-poles, 1 6-pole) additional cost:
  ∅ 600 mm → ≈ M€ 1.5 – M€ 2
  ∅ 380 mm → possible savings
  → transmission reduced by 1.8
  (full magnet illumination)

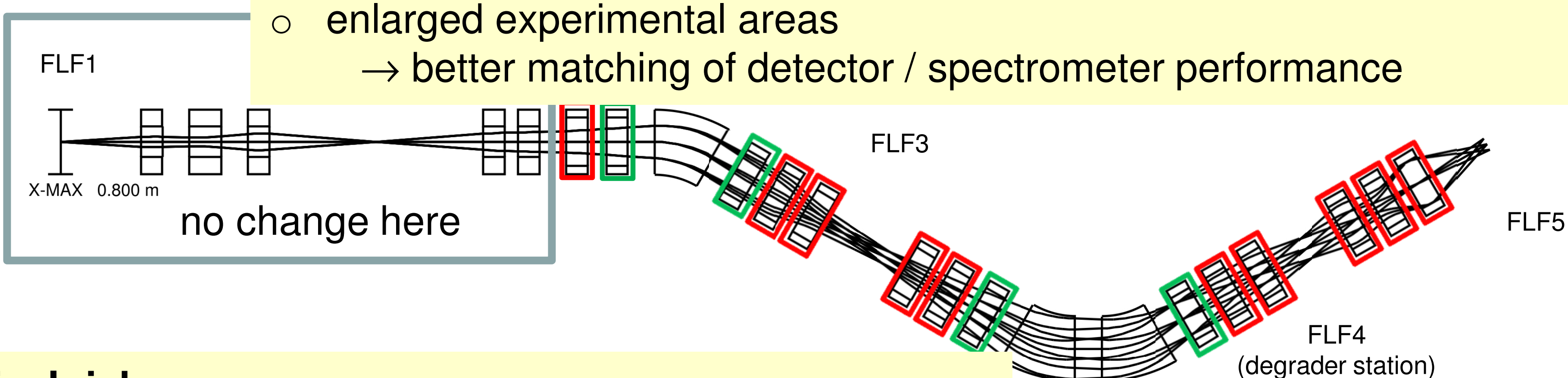
S-shape layout (with standard QP)

LEB tasc force
(H. Geissel et. al)

10 short q
0 standa
4 sextup

Improved operation

- ○ dispersion matching (Main Separator and EB)
- ✓ high-resolution operation mode
- ✓ novel NUSTAR experiments (e.g. HISPEC, Super-FRS Collaboration)
- ○ stigmatic focal plane at FLF4
- ○ intermediate focus at FLF3 for energy bunching
- ✓ reduced dispersion
- ✓ granted overall resolving power of EB
- ○ enlarged experimental areas
  → better matching of detector / spectrometer performance



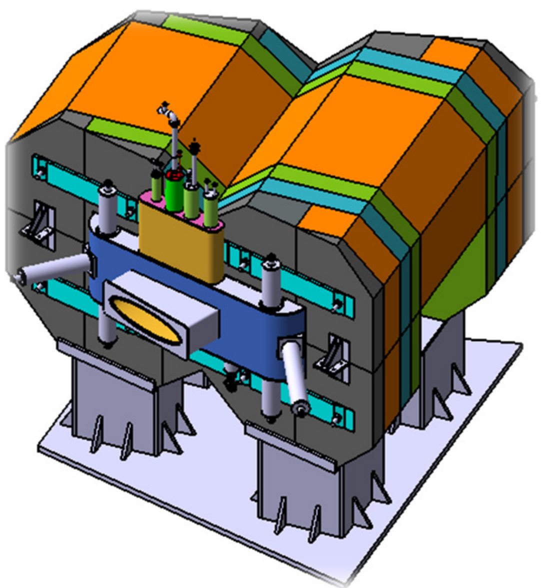
Technical risks

- ○ reduced dispersion (factor of 2 at FLF5)
- ✓ smaller mono-energetic degrader → enhanced feasibility
- ○ standard Super-FRS quadrupole magnets
- ✓ specifications ready
- ✓ magnet test → standard procedure

Progress

LEB tasc force
(D. Ackermann et. al)

- **Thomas Nilsson has positive response from India (Raha) on our ideas for S-shape configuration**
- **documents with details on the LEB status (magnets and building) comparing the original C- and the new S-version(s) prepared and passed to our Indian colleagues**
- discussion with funding agnecies/RBB has been initiated – building cost has to be established for next RRB meeting in 02/2014
- discussion with FLAIR/SPARC to prepare a new study including modification of FALIR SPARC building (16)
- ION42 has been contacted to prepare a new architects feasibility study - an offer has been requested and received



Results from discussion with Prof. Bhandari during IKRB week

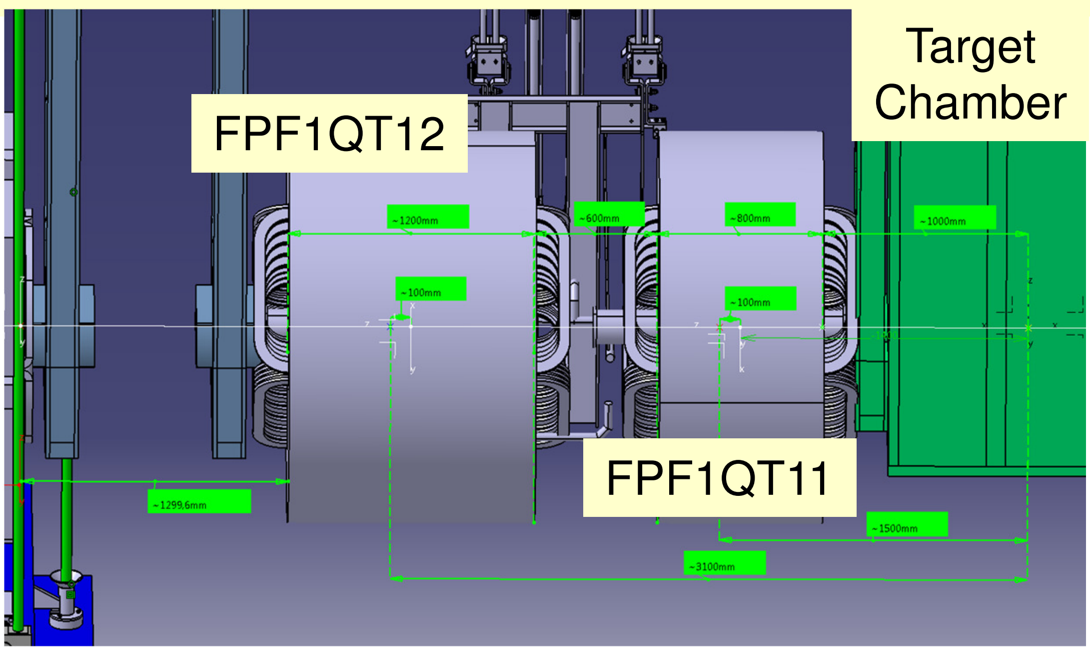
- Engineering design ready (VECC)
  - ✓ 30° deflection angle, superferric
  - ✓ Very large aperture (x = 350mm, y = 100mm)
  - ✓ Weight ≈ 115 ton
- agreement to reduce the aperture
  - ➢ complete fulfilment of magnetic requirements
  - ➢ smaller, easier to handle and to measure
  - ➢ cost reduction
- Review of new dipole design foreseen in beginning of 2014

FAIR HELMHOLTZ GEMEINSCHAFT GSI

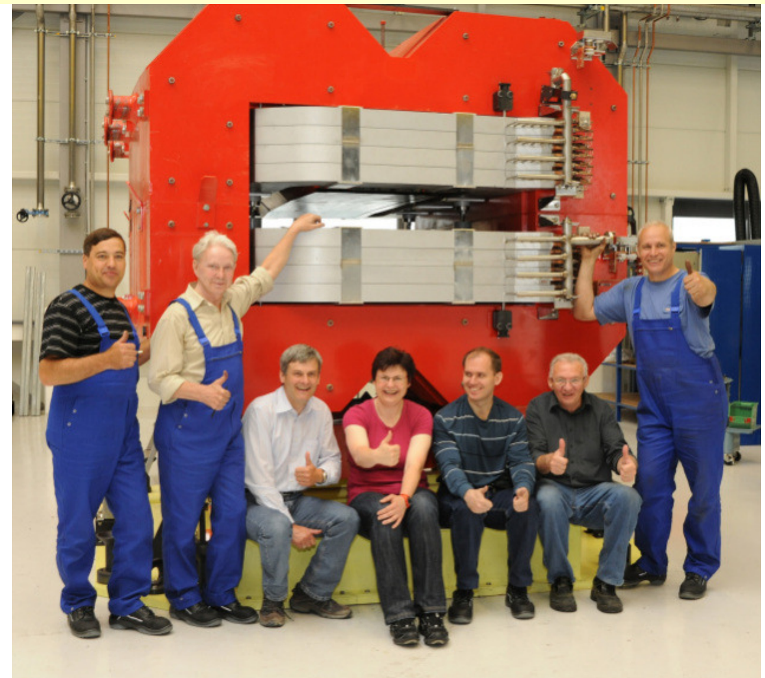
Radiation Resistant Magnets

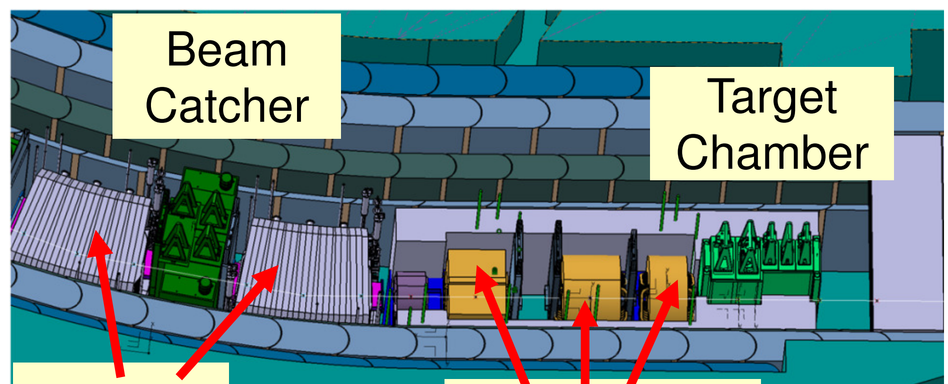
H. Leibrock
C. Mühle et. al

- Normal conducting magnets using MIC cable
- Remote connectors and alignment
- Prototype dipole built (95 ton) and tested by BINP
- Handling tests at GSI under way
- New layout of first two quadrupole magnets
- Specification in preperation (Q1/2014)
- No In-kind proposal so far -> Tendering by FAIR
- Contracts required until Q4/2014



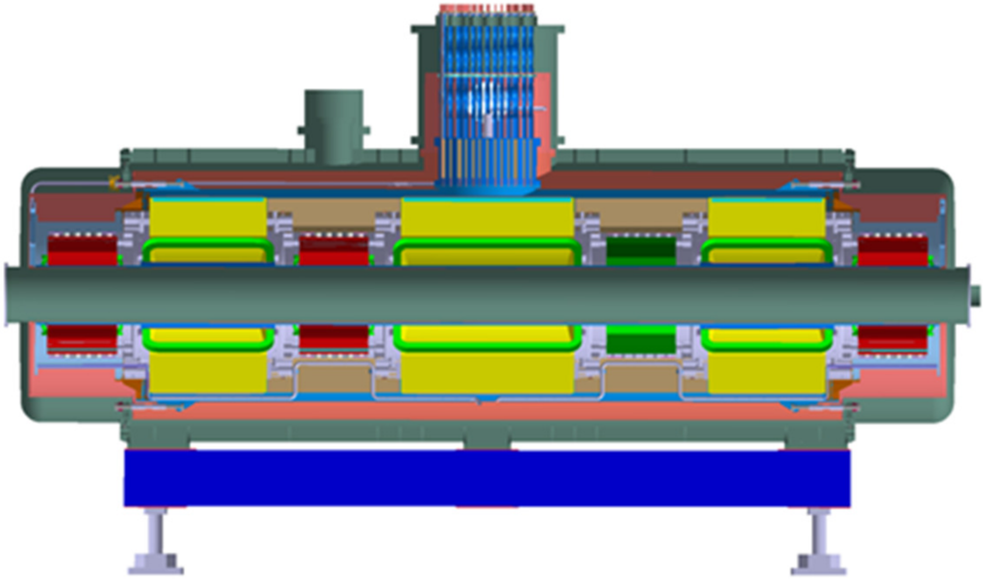
Prototype dipole at GSI testing-hall





SC Magnets

M. Müller
H. Leibrock et. al



- Prototype succesfully tested in 2011
- Collaboration with CEA/SACLAY under preparation:
  - Engineering design
  - Technical follow-up
- Tender by FAIR
- First of Series ready for testing at CERN: 10/15
- Series production and testing: 01/16 – 03/18

- Specifications finished
- Tender in process: Offers expected until for 12/2013
- Signing of contract: 03/2014
- Testing of First short Multiplet at CERN: 09/15 – 03/16
- Testing of first long multiplet at CERN: 12/15 – 09/16
- Series testing at CERN: 09/16 – 02/19

Magnet Testing & Mapping

P. Schnizer et. al

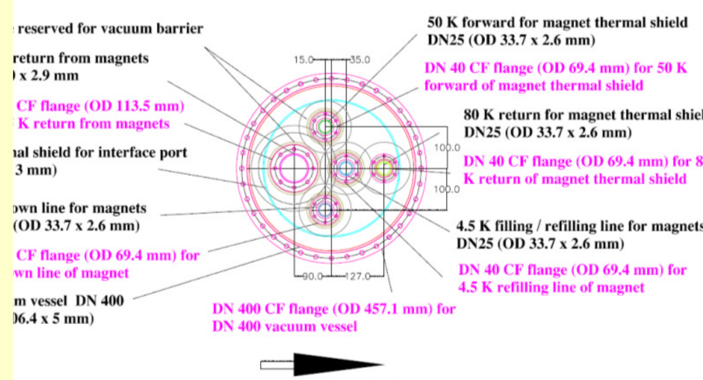
- Regulated by GSI-CERN Agreement K1727/DG & Addendum #2
- Scope: 28 Dipoles, 31 Multipletts, EB magnets are not included
- Collaboration Committee & Technical Coordination established
- Work Package Structure:
  - Magnet Test Bench Organization
  - Magnetic measurements
  - Cryogenics
  - Quench Detection (Super-FRS uses KIT electronics, not available before 2014)
  - Power Converters (CERN, later test of Super-FRS PC discussed)
- Time Schedule (determined by LHC Long-Shutdown periods):
  - LS1: Feb. 2013 – Nov. 2014, Maintenance LHC
  - **Sept. 2015: Magnet Test Bench will be available for Pre-Series Magnets**
  - LS2: from 2018+ , update of LHC interaction zones
  - no further support of Magnet Test Bench guaranteed from CERN personal
- Open Point: Personal (for Testing/Measurement), Responsibility
  - Dipole: will be included in the MoU with CEA
  - Multipletts: was discussed at last IKRB as possible (additional) contribution from India

Cryogenic interface of dipole and multiplet cryostats

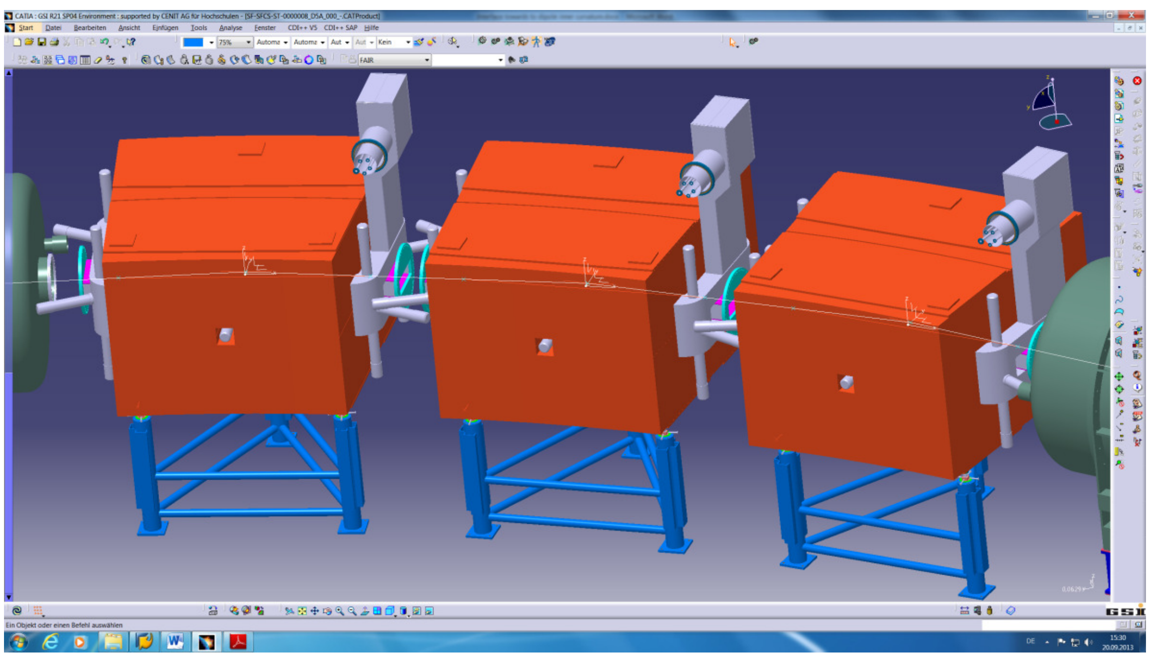
Y. Xiang et. al

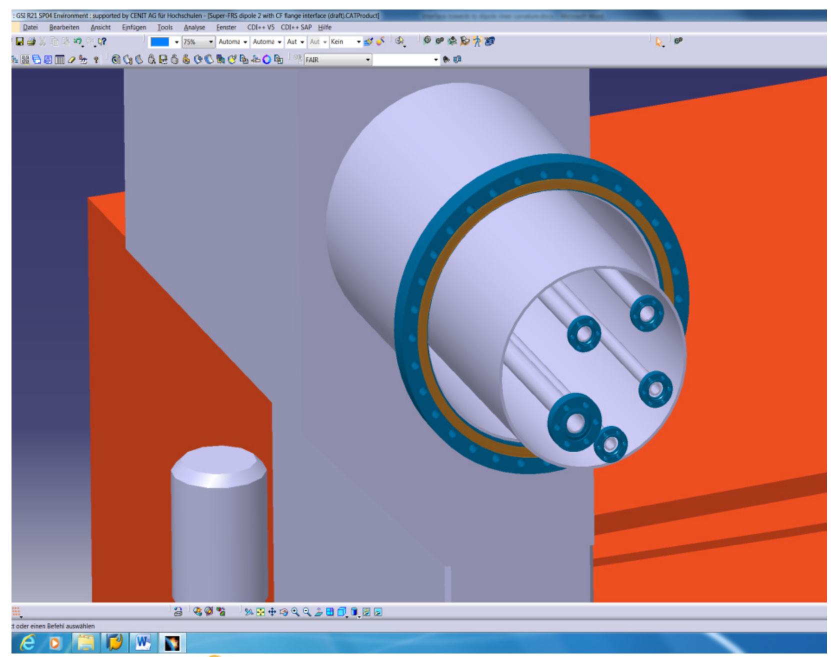
1. Updates of cryogenic interface of dipole and multiplet cryostats for magnet test at CERN;
2. Cooldown calculation for cold mass of 295 tons in the Super-FRS pre-separator
3. Worst case analysis : long multiplet cryostat under sudden loss of insulation vacuum to air
4. Worst case analysis : Total stored energy deposition in helium of long multiplet by simultaneous quenches of all magnets

Cryogenic interface at Multiplets side (5 headers, view from valve box side)



With CF flange connection for magnet test at CERN 03-09-2013 (the space reservation for orbit welding (Orbitec orbital welding, Polysoude, Swagelok) is taken into account with reference of the experience of QRL interface with magnet cryostat)





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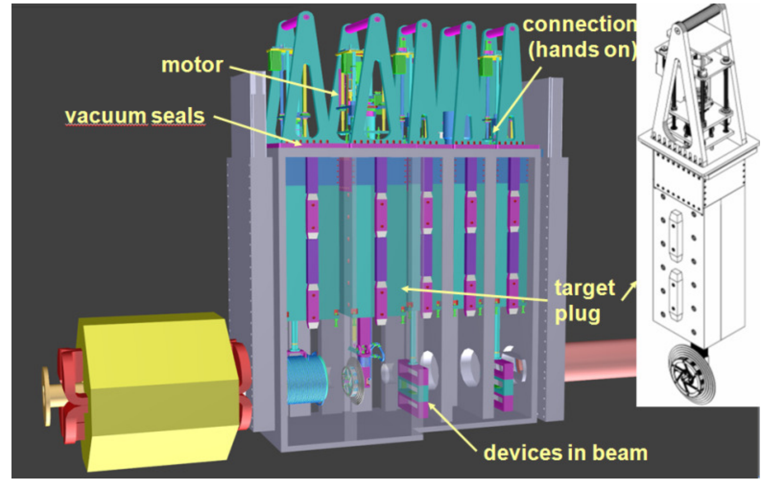
Target Area Installation

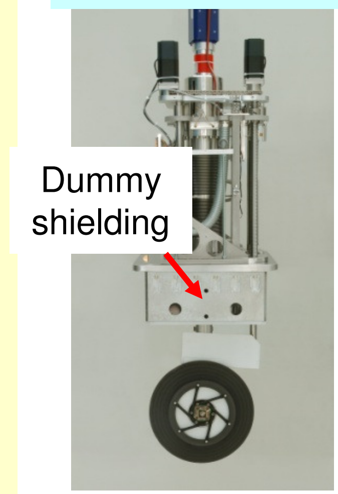
H. Weick
C. Karagiannis et. al

- Target chamber & plug inserts (German in-kind)
  - ➢ Includes vacuum system and diagnostics for target
  - ➢ dimensional design ready
- Target wheel & plug inserts (German in-kind)
  - ➢ prototype target wheel with drive available,
  - ➢ needs update for larger wheel and/or new moving mechanism
  - ➢ Wheel bearing tests in vacuum seem promising now
  - ➢ 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
    ⇨ expected lifetime increase by factor ≈ 3
  - ➢ beam tests at FRS Q1-Q3/2014
    urgently needed = final design input

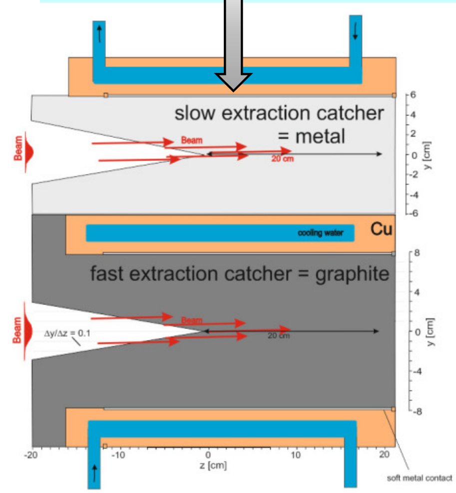
target chamber including plug inserts



prototype target wheel



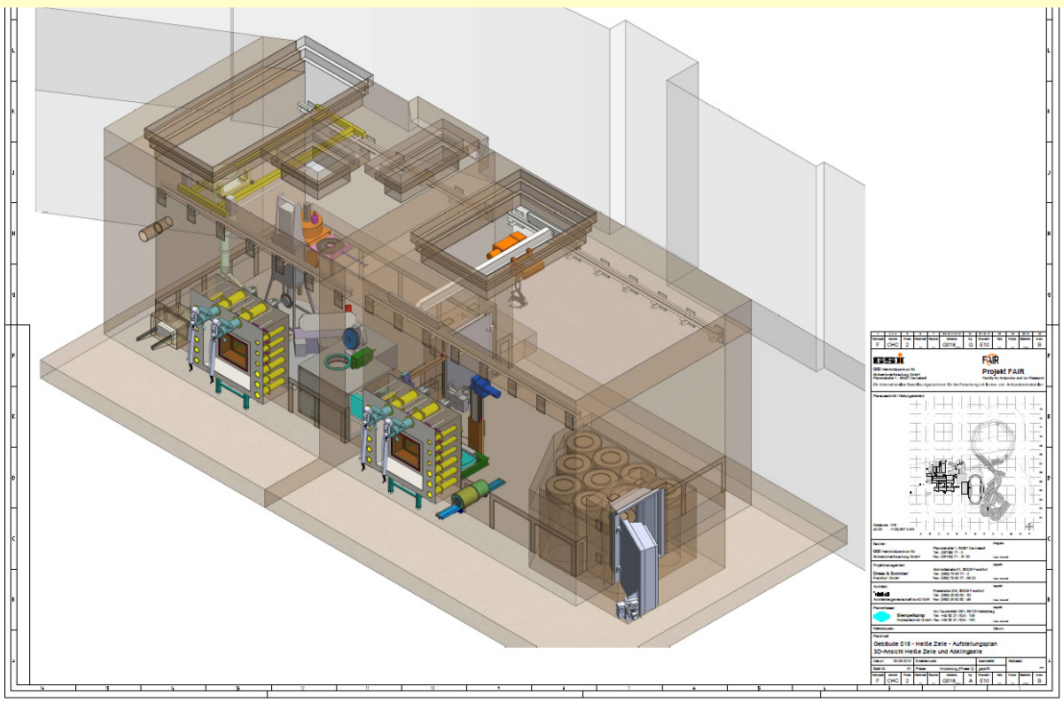
two-halves catcher



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

C. Karagiannis
H. Weick et. al

- Based on study by nuclear engineering company
- Preliminary planning completed
- Execution planning running
  (includes new tooling required for waste handling
- Mock-up installation in preparation (Q4/2013)
- Collaboration with SPIRAL 2 (partially EU CRISP)
- Full realization by contract with company (Q4/2014)

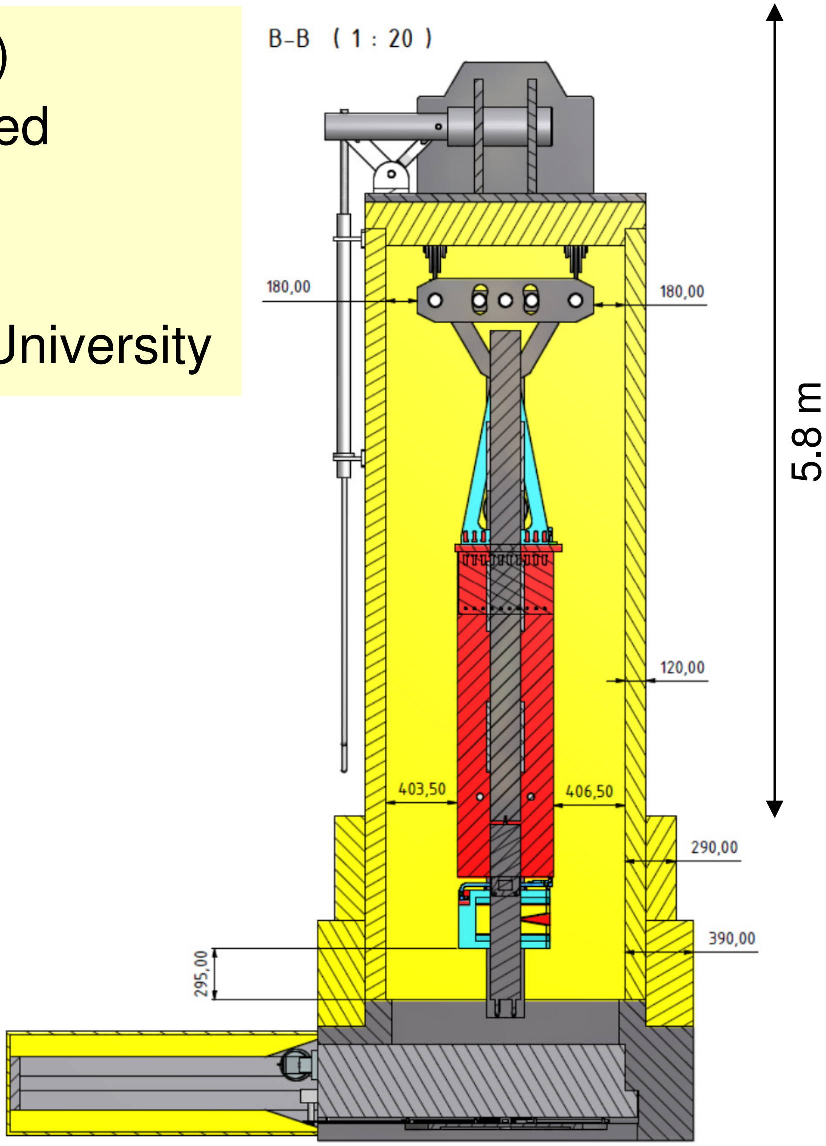


master-slave arms for mock-up
(at manufacturer site)

support frame at GSI

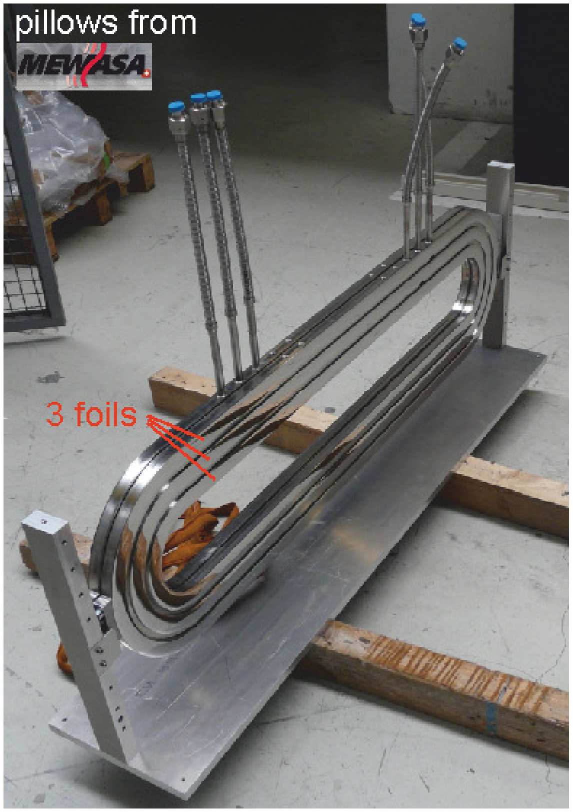
Transport Container

- Presented as Finnish In-kind contribution (last IKRB)
    - ✓ almost all parts of WP ‚Target Area' are covered
- Preplanning to go into approval process, then order production.
- Collaborators: Hollming Works Ltd., ENMAC, Aalto University

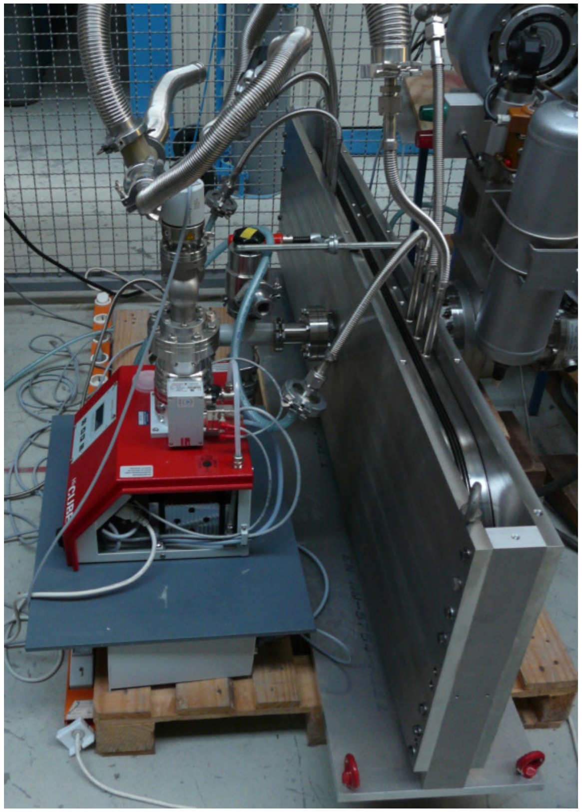


Pillow Seals of Large Size

K.H. Behr
A. Kratz et. al

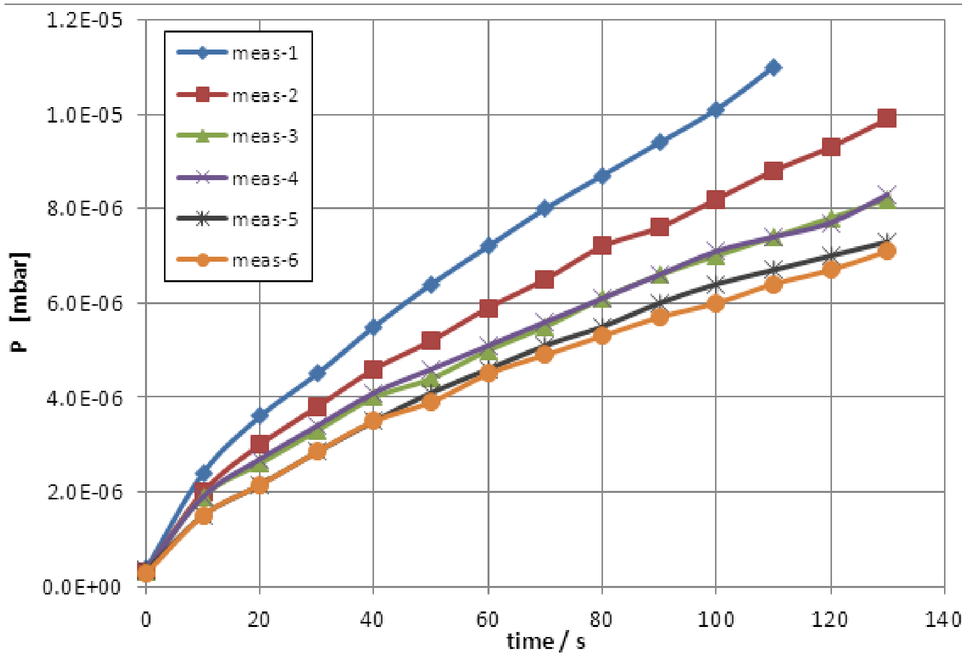


4 large seals at GSI (1200x160 mm²), plus one seal of Ø=500mm



test setup at GSI

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



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

- Requirements reached, also for DN 500 seal.
- Now test of long time stability (temperature, ...)
- Design full plug.

Beam Diagnostics

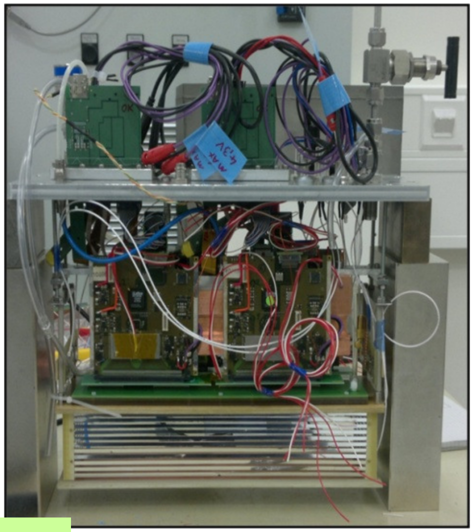
C. Nociforo
A. Prochazka et. al

- GEM-TPC (Finnish in-kind)
  - gas-tracking detectors with detectors $\sigma_x \sim 0.2$ mm
  - single-channel readout electronics (GEMEX)
  - prototype ready
  - low-energy high-rate beam test: Jyväskylä Q2/2014
  - High-energy beam test: GSI Q3/2014
  - final specification (Q1/2015)
- SEM-GRID & ladder system

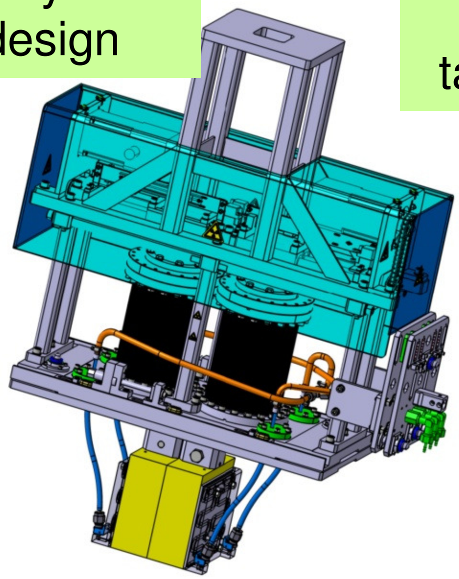
  (proposed as Finnish in-kind)
  - common system together with the GEM-TPC
  - pre-design for SEM-GRID ready (HEBT)
  - ladder integration to be designed
  - specification Q1/2015
- Slit-systems & Secondary Target

  (proposed as German in-kind)
  - pre-designs ready
  - specification in preparation (Q4/2014)

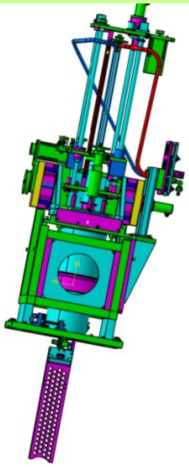
GEM-TPC prototype



Slit-system design



Secondary target design

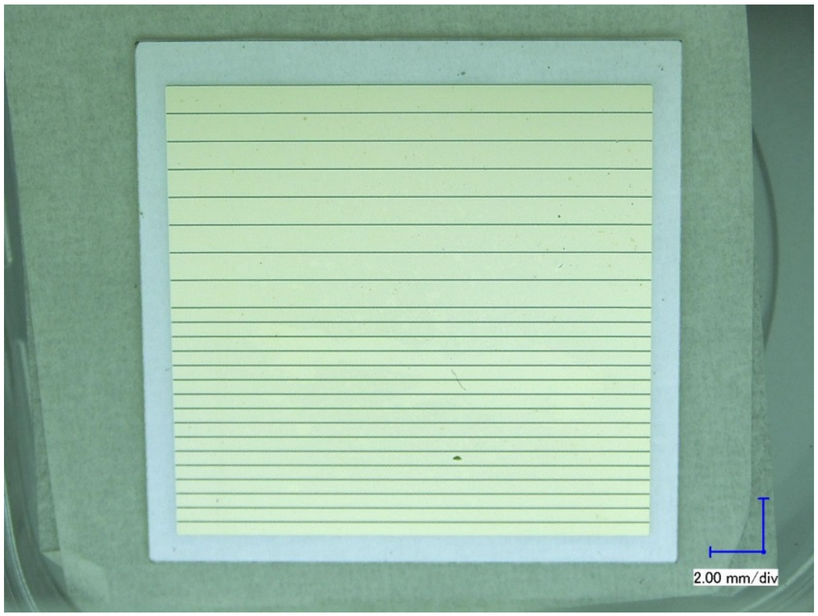


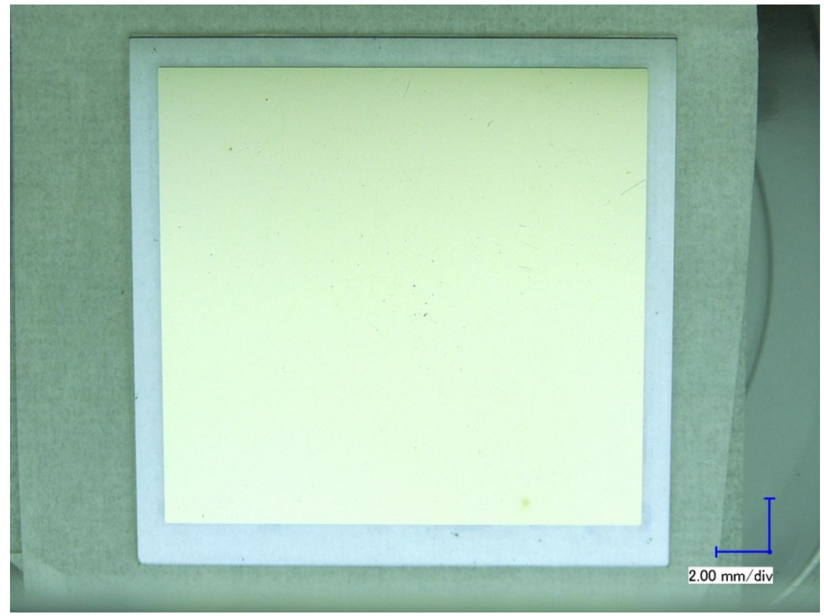
Diamond Prototype Design (ToF)

F. Schirru
C. Nociforo et. al

pcCVD -DD **20x20x0.3 mm**

active area 380/200 mm x 50 mm
→ 20 units required



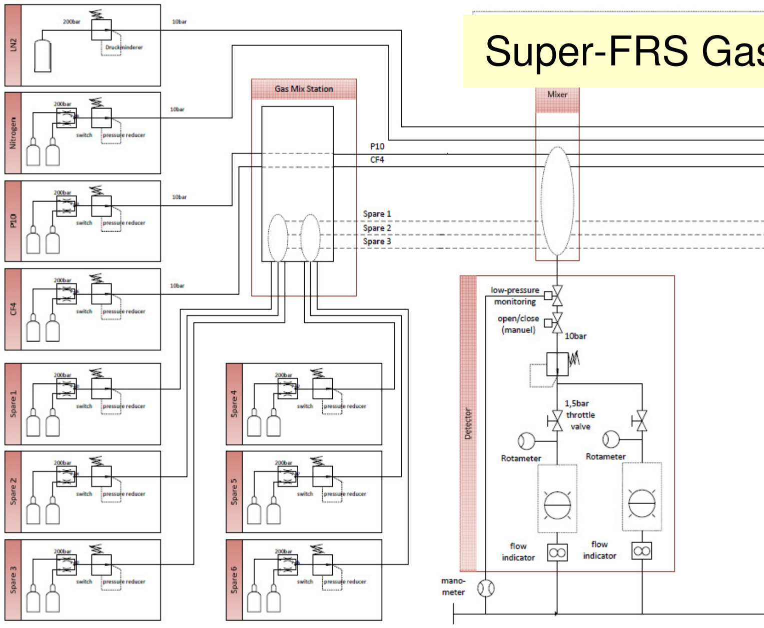


Detector processing:

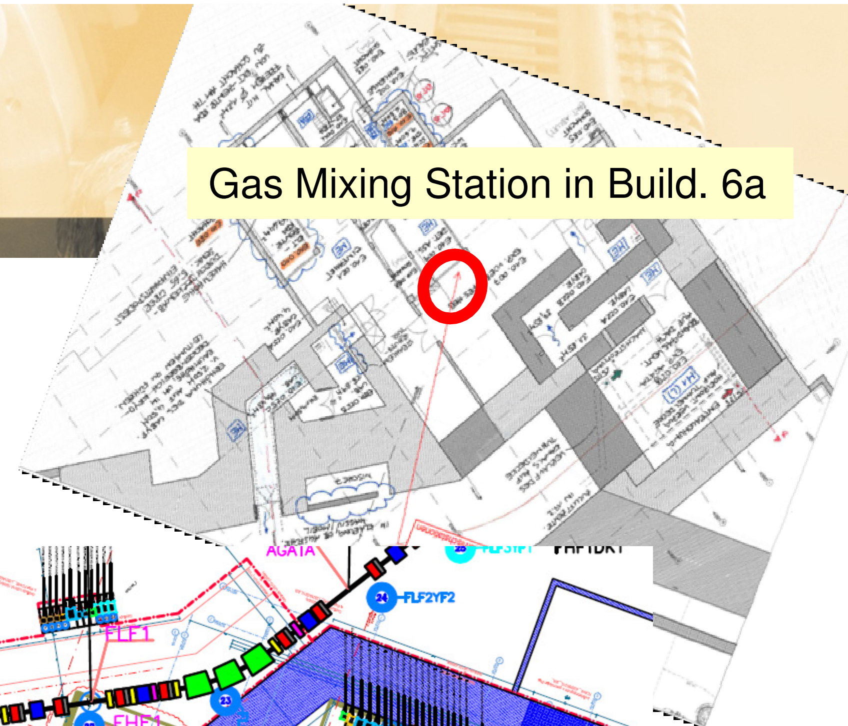
- Electrode metallization with Cr/Au with thickness 50/100 nm
- Photolithography by laser followed by etching
- 8 strips (1 mm) + 16 strips (0.5 mm) – Gap 60 μm
- Annealing of the device at 500º in Ar

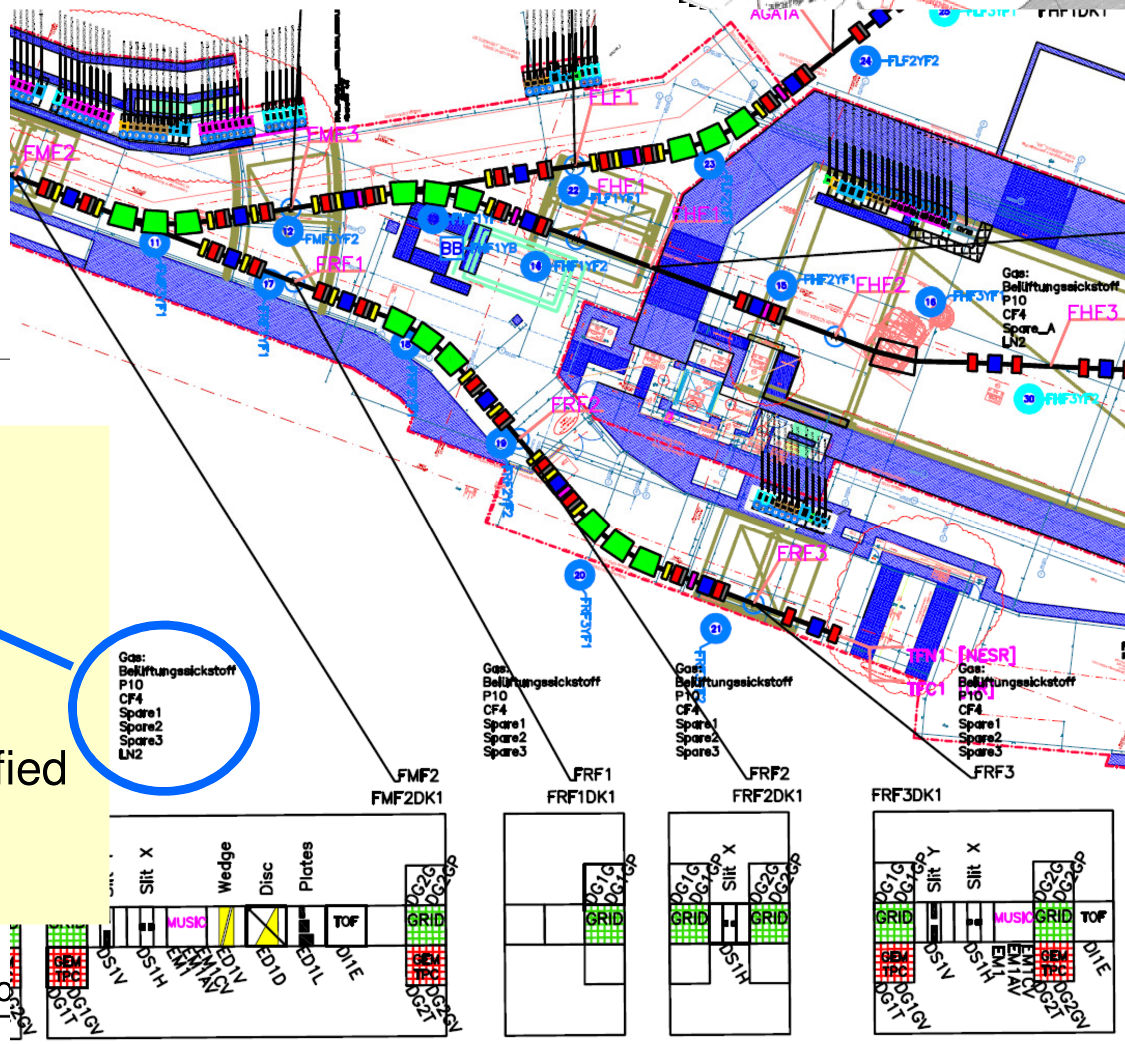
(Detector) Gas Supply

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 probably not provided)

Summary

- Civil Construction progressing
  - execusion planning under approval
  - route planning running
- Energy Buncher redesigned
  - new LEB cave proposed
  - S-shape solution using standard multipletts
  - dipole magnets to be redesigned by VECC
- Tendering for multipletts running
- Collaboration with CEA and tendering of dipole magnets in preparation
- Beam tests in 2014 necessary to finalize specification for various components