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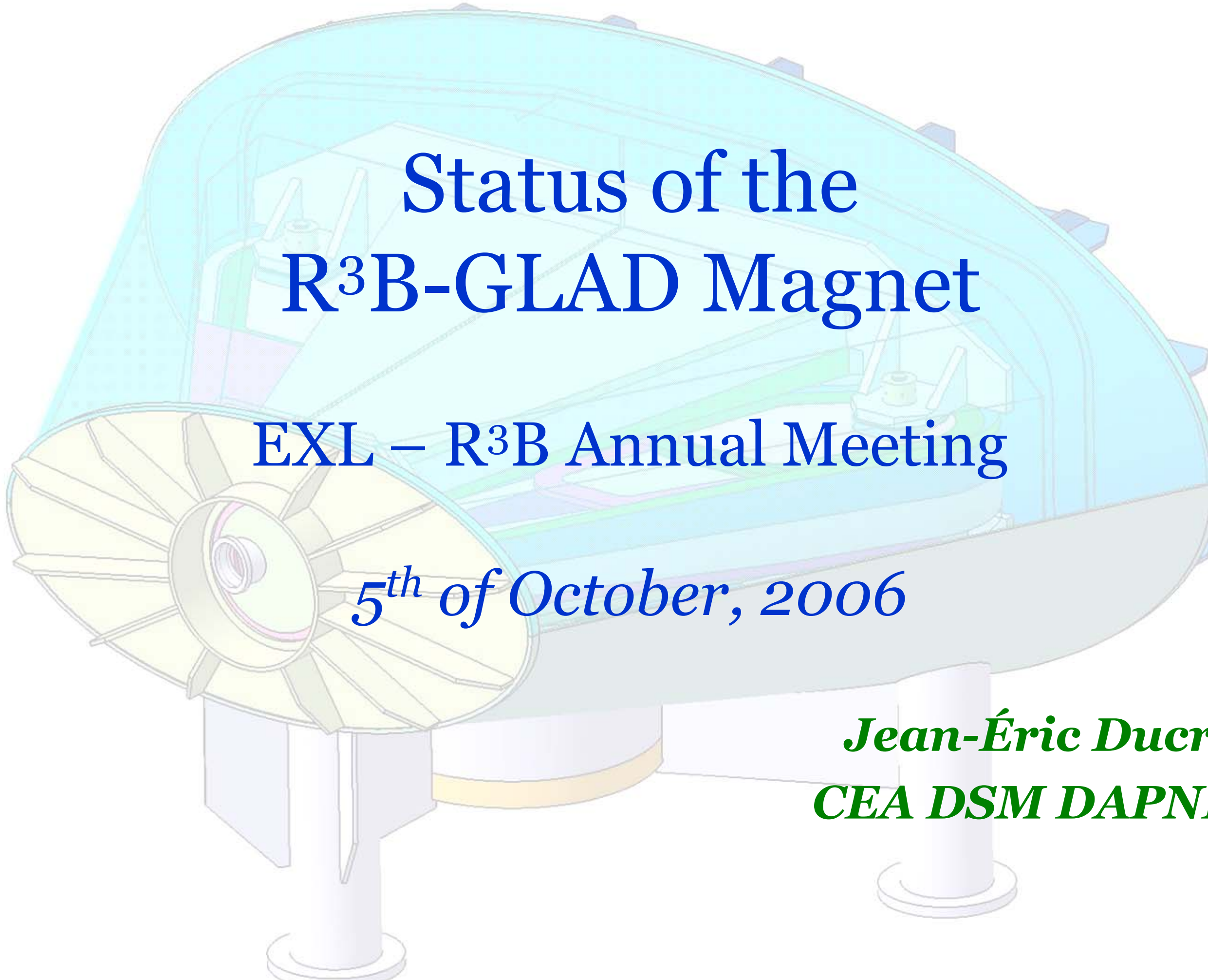

Status of the R^{3}B-GLAD Magnet

EXL – R^{3}B Annual Meeting

5th of October, 2006

Jean-Éric Ducret
CEA DSM DAPNIA

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Status of the R³B-GLAD Magnet

GSI Large Acceptance Dipole

- **Drawings**
- **Technical work fulfilled**
- **Expected delays in the construction**

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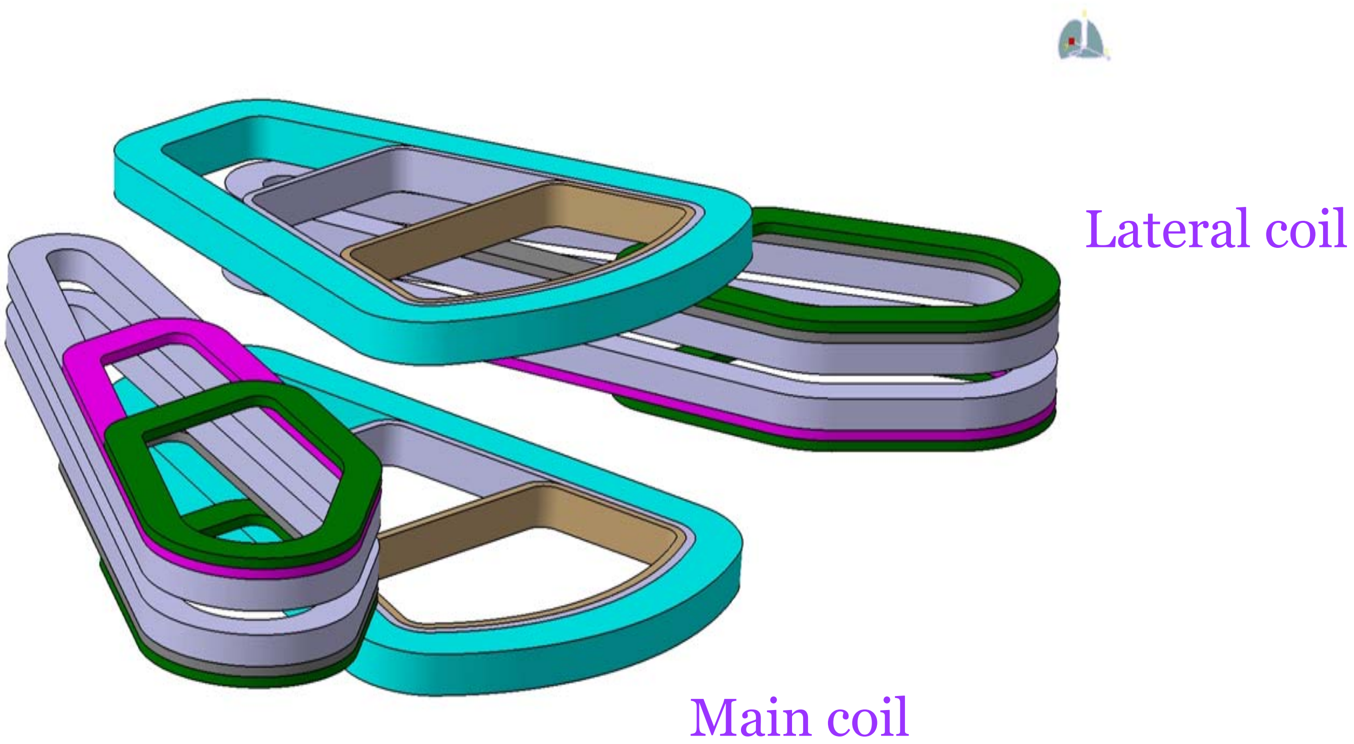
Superconducting coils



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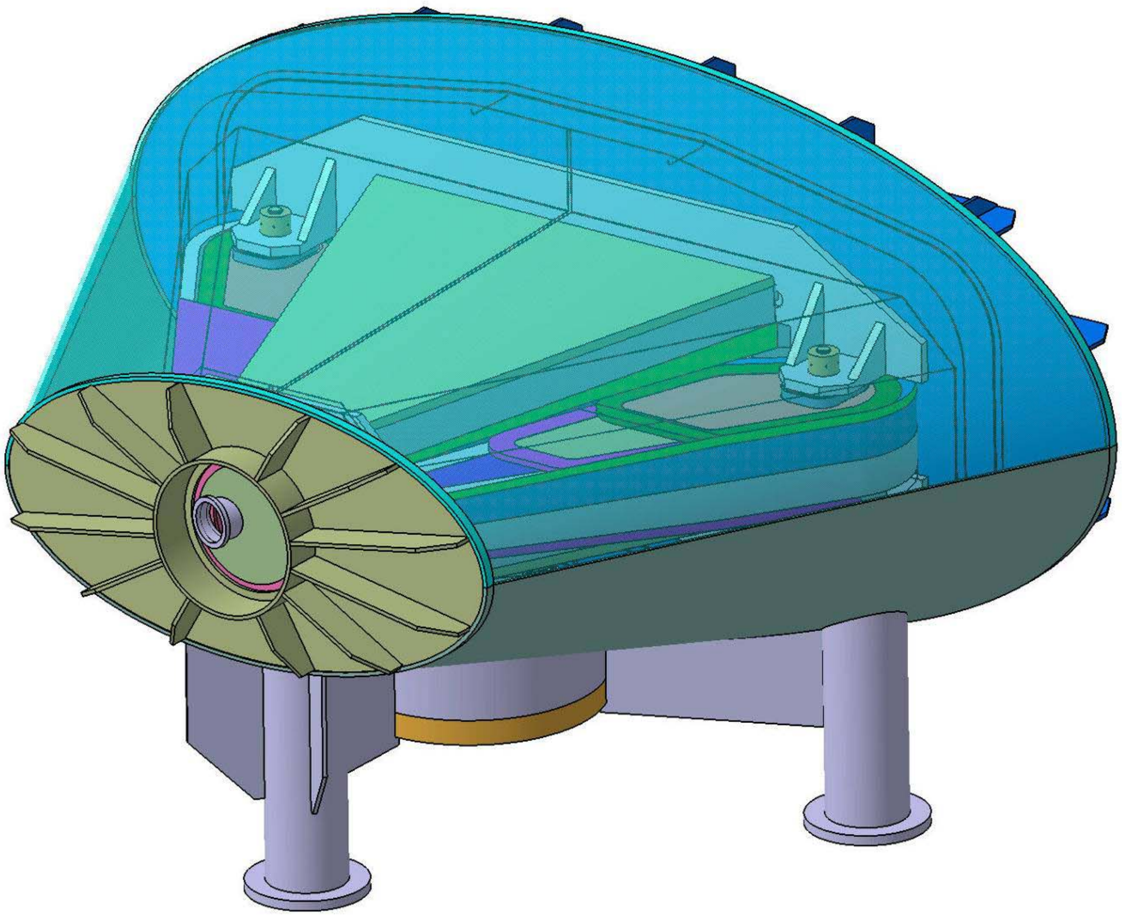
R3B magnet



R3B magnet project-team work fulfilled

What did we do this year for the R3B – magnet ?

- Started the CNI contract 515876 "DIRAC – Phase 1", Oct. 1st, 2005
- Worked to follow the *recommendations of the FP5-PDR*
- Studied :
  - The reduction of the peak field *(which was equal to 7.5 T)* by introducing spacers, reshaping the coils or decreasing the current density (80 A/mm^2);
  - A more classical protection system with an external dump resistor;
- Performed a complete 3D computation to study the very high level of the magnetic forces (300 to 400 t/m) in the coil casing and the cold mass;
- Presented this work at a Technical Design Review on the 4th of July, with emphasis on the general design and the conductor specification;
- Heard the review Committee's recommendations;
- Defined the conductor to order in the industry.

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Magnet acceptance re-definition / optimisation

Parameters of the magnet:

- Angular aperture **+/- 80 mrad** horizontally and vertically
- Transparency to neutrons & to transport of **1 GeV** proton with HI
- Free space of **1 m** around the target, for detectors
- Vacuum connection between the beam pipe and the cryostat
- Thermal screen and thick inner vacuum vessel
- Thick cold casing around the coils to deal with the magnetic forces

New geometry after **optimisation**:

- Distance from the target to the magnet entrance = **1.450 m,**
- A horizontal angle of the beam direction w.r.to the magnet axis = **14°**
- Vertical and horizontal angles of the coils = **5°** & **18.6°**

The fringe field around the target needs to be checked (< 20 mT ?)

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4th of July, 2006 - Technical Design Review

Magnetic design

- Status:

The peak-field decreased from 7.5 T to 6.35 T, the same value in main coils and in lateral coils. This allows in the same time the temperature stability margin to increase from 1 K up to 1.5 K

→ Trying to suppress the spacers for simplicity & cost

→ Trying to reduce the current density by increasing the length of the coils

- Recommendation:

The field sensitivity to coil deformations, movements or misalignments should be quantified to set the requirements for the further mechanical studies.

4th of July, 2006 - Technical Design Review

Conductor studies

Status: Completed

Recommendation: Our idea is confirmed, the Rutherford cable design provides sufficient stiffness & is preferable, due to a reduced number of joints

Winding & cold mass integration

Status: General concept defined with further studies on the coil precompression and the casing tolerances

Recommendation: Test specimens necessary to confirm the final design, as this point is a critical issue (e.g. to ensure quench-back)

Mechanical studies - Coil casing

Status: Use of arches to reduce the coil deformation to less than 1 mm ; 3D computation of the mechanical behaviour

Recommendation: OK, to be further explored

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4th of July, 2006 - Technical Design Review

Mechanical studies - Cryostat & Integration 2

Status: Conical vessel design accepted *(cost to be considered);* the stiffness of the inner vessel has been studied within the space constraints

Recommendation: The choice between 1 or 3 supports is to be decided in the detailed design

Electrical circuit: Protection study & Power system

Status: Conventional design of external dump resistor studied; Quench-back effect is important to keep peak temperatures down, ensuring the thermal contact between coil and casing is crucial

Recommendation: Quench calculations with less or even no quench-back should be studied

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4^{th} of July, 2006 - Technical Design Review

Cryogenics

Status: The cryogenic system based on thermo-siphon is well advanced and accepted by the committee

Recommendation: The concept is accepted; a more accurate analysis should be performed that include frictional losses & the possibility of vapour pocket formation in near horizontal branches

Instrumentation & Control

Status: Well advanced

Recommendation: Ensure a correct interface with FAIR and R^3B

Assembly, test and Installation

Recommendation: Interfaces with GSI should be further studied (incl. transport and moving requirements)

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2006/2007 – Main Tasks

- Magnetic design optimisation - *Oct. 2006*
  - Mechanical sensitivity study & transport resolution optimisation
- Interface-definition meeting with GSI-FAIR - *Oct.-Nov. 2006*
- Cold Mass mechanical studies
  - Cold Casing: Further coil pre-stress study - *2006 Q4*
  - Detailed winding & Integration study - *2007 Q1-Q2*
- Technical Design Review 2 *(Industrial specification)* - *Jan. 2007*
- Superconducting cable delivery and test - *March - Q4 2007*
- Cold Casing Order - 2007 Q1 & Q2
- Winding & Integration 1 Order - 2007 Q3

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Delays in the work plan

- **Main sources of delay**
  - In Saclay, the real start of the project was delayed (because of the difficulty of constituting a new team; as a lot of people were working on other tasks when the R³B approval decision has been known: + 3 months, *up to + 4 months for mechanics)*

    → *Real start at Saclay : 2006 – Q1*
  - The final assembly time was underestimated and will be increased by 7 months:

    + 5 months before test at Saclay

    + 4 months before test at GSI

    - 2 months (duration of the final test at GSI reduced) (Reason: Initially, the final assembly, mainly of vacuum, cryogenic or electric connections, was regarded as "preparation of the tests". After a detailed task analysis, it appears that it was not possible to put these tasks either in parallel with integration 2, or included in the test duration. But they should be placed between)
- **Total estimated delay:** 3 + 7 months

  → *Planned date for delivery: 2010 – Q2*

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Milestones & Deliverables reached

DIRAC-PHASE-1	Task number : 11	Task title : R3B
Milestones	*Expected*	*Done*
10th month = July 2006	M11-1 Preliminary studies completed	4 July 2006, *at Saclay* Technical Design Review

DIRAC-PHASE-1	Task number : 11	Task title : R3B
Deliverable	*Expected*	*Done*
D11-1	Detailed technical design report	Technical Design Report 1 Validation of the conductor

Rem: In 2007 Q1 : Technical Design Review & Report 2 - Validation of the cold mass specification
The set of these two reports will constitute the Detailed TDR required by E.U. contract

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Milestones & Deliverables reached

R3B	**Technical Proposal**	*December 2005*
Year	***Tasks / Milestones***	
2005	Q4 - Decision on budget	3.5 M€ Dirac-Phase-1 **OK** 2.0 M€ R3B-Collaboration *Preparation*
2006	Q2 - Order of superconductor	Call to candidatures 26/04/06 → 29/05/06 Invitation to tender 21/06/06 → 31/07/06 Technical negotiations → September 06 Order planned for → October 2006

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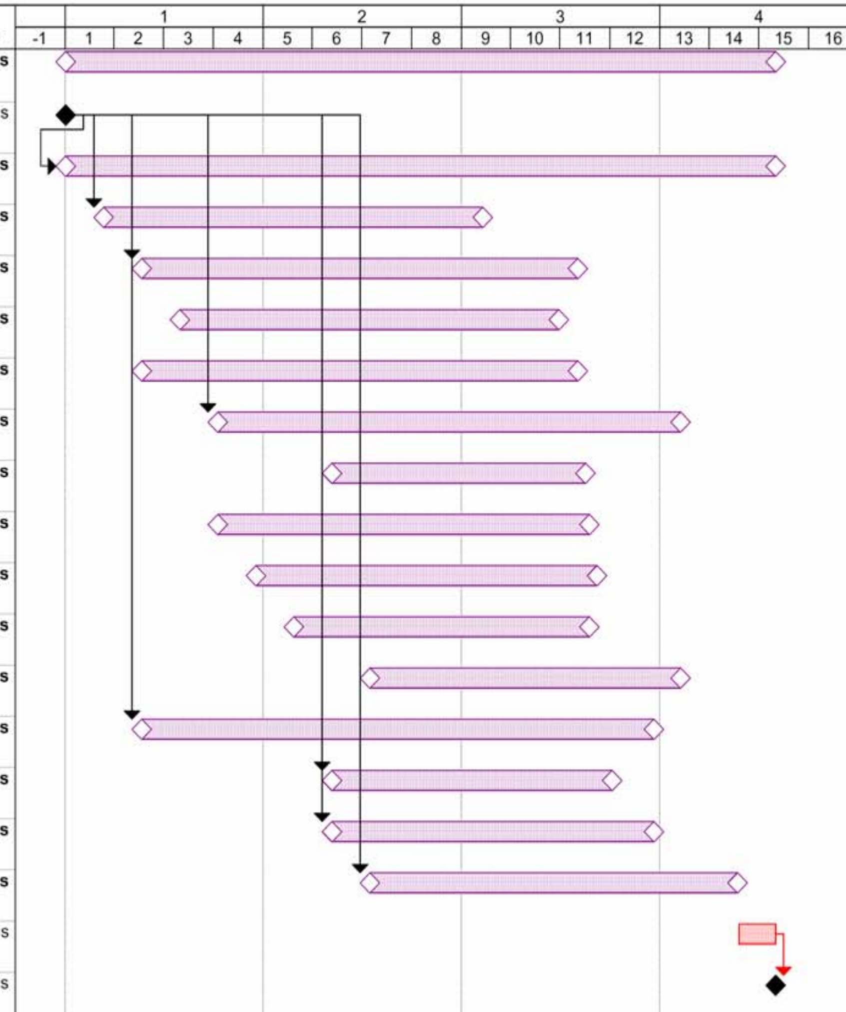
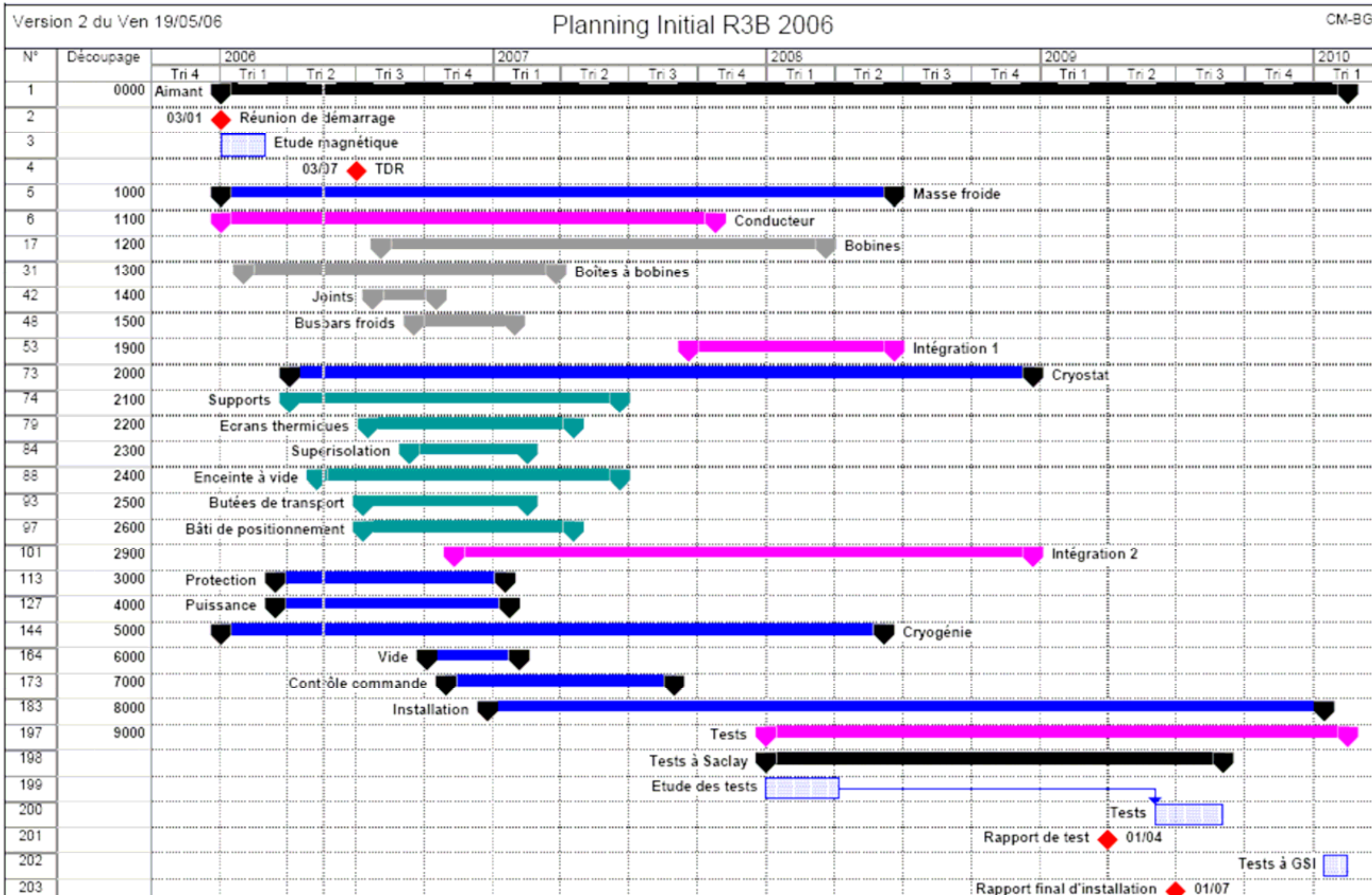
DIRAC Planning : Main tasks for the R3B magnet construction

Nº		TASKS, MILESTONES, DELIVERABLES (Years /Quarters)	Nb of Weeks
1		**R3B full size Magnet**	187 s
2		Kick off meeting	0 s
3		COORDINATION	187 s
6		SUPERCONDUCTOR	100 s
13		COLD MASS	115 s
14		COIL CASING	100 s
19		WINDING & INTEGRATION 1	115 s
26		CRYOSTAT	122 s
27		VACUUM VESSEL	67 s
31		THERMAL SHIELD	98 s
35		SUPERINSULATION	90 s
39		COLD TO WARM SUPPORTS	78 s
43		INTEGRATION 2	82 s
58		ELECTRICAL EQUIPMENT	135 s
62		CRYOGENICS	74 s
66		INSTRUMENTATION	85 s
70		TESTS at SACLAY	97 s
75		TRANSPORT, INSTALLATION & TEST at GSI	10 s
76		DELIVERY to GSI	0 s




Version 2 du Ven 19/05/06
Planning Initial R3B 2006
CM-BG
N°
Découpage
2006
2007
2008
2009
2010
Tri 4
Tri 1
Tri 2
Tri 3
Tri 4
1 0000 Aimant
2 03/01 Réunion de démarrage
3 Etude magnétique
4 03/07 TDR
5 1000 Masse froide
6 1100 Conducteur
17 1200 Bobines
31 1300 Boites à bobines
42 1400 Joints
48 1500 Busbars froids
53 1900 Intégration 1
73 2000 Cryostat
74 2100 Supports
79 2200 Ecrans thermiques
84 2300 Superisolation
88 2400 Enceinte à vide
93 2500 Butées de transport
97 2600 Bâti de positionnement
101 2900 Intégration 2
113 3000 Protection
127 4000 Puissance
144 5000 Cryogénie
164 6000 Vide
173 7000 Contrôle commande
183 8000 Installation
197 9000 Tests
198 Tests à Saclay
199 Etude des tests
200 Tests
201 Rapport de test 01/04
202 Tests à GSI
203 Rapport final d'installation 01/07

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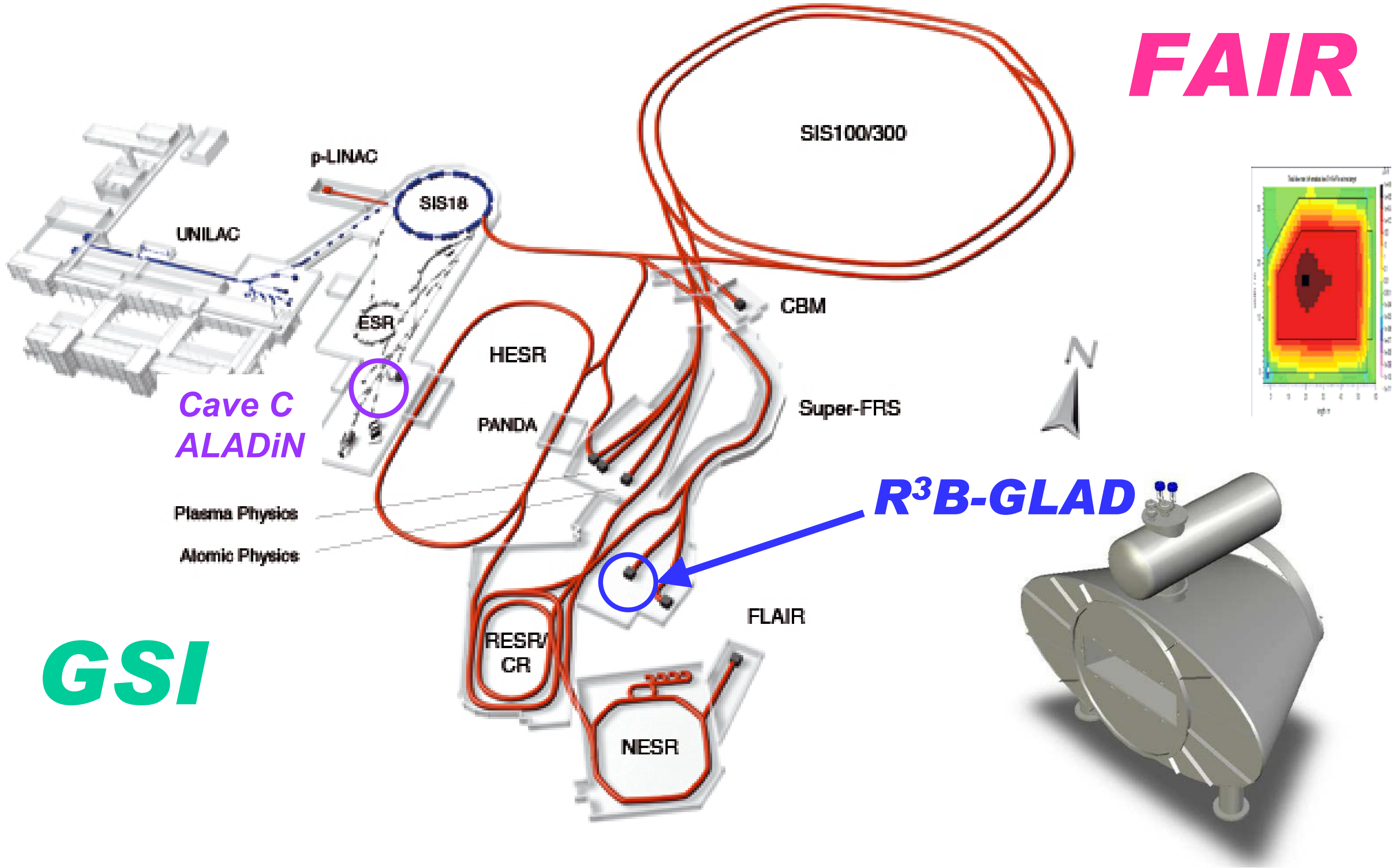
R³B Hall in the FAIR complex



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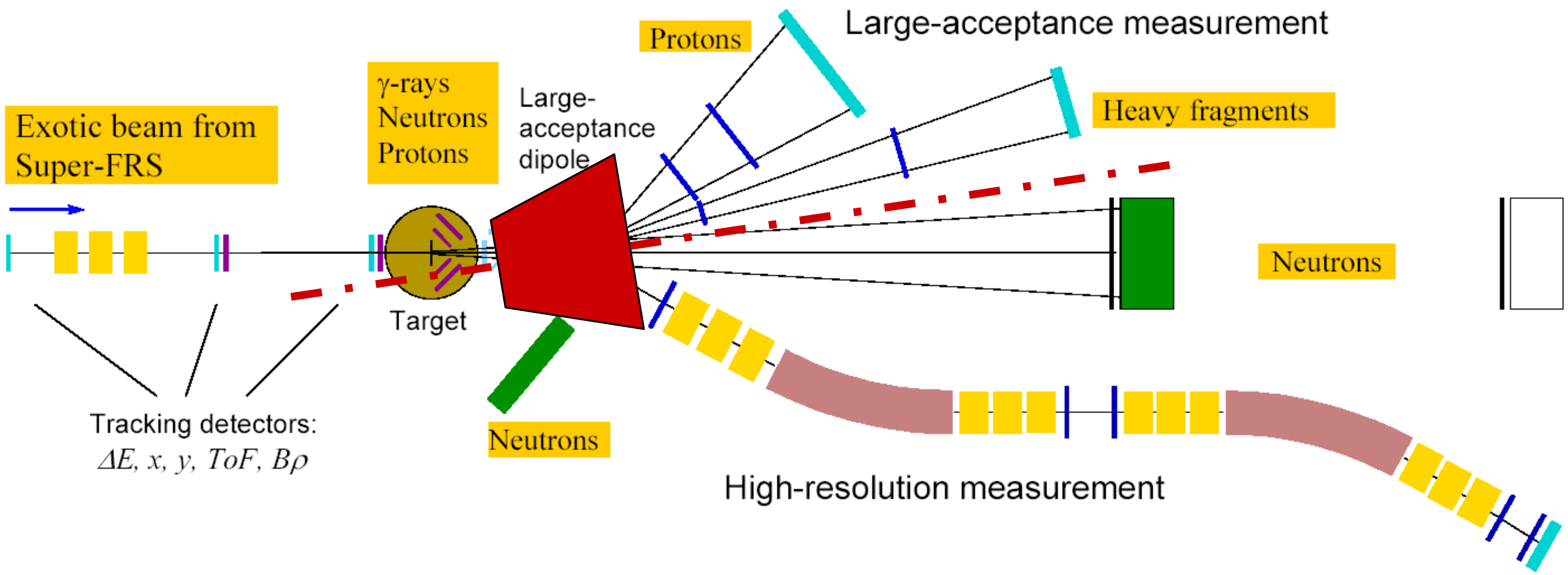
Reaction studies with Radioactive Relativistic Beams (R3B)

Physics requirements for the large-acceptance magnet :

- high heavy ion beam energies *(high magnetic rigidity ~15 T.m)* *typically ~1 GeV/u ^{132}Sn, or 500 MeV/u ^{8}He*
- kinematics forward focusing → acceptance close to 100%
- coincident detection of Neutrons & charged fragments
- detection around the target → low fringe field



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Technical work fulfilled

4 July 2006 - Technical Design Review Presentation :

Magnet Project
Magnetic design
Conductor & stability studies
Winding & cold mass integration
Mechanical studies:
- ***MS1*** **- Coil casing**
- ***MS2*** **- Cryostat & Integration 2**

Electrical circuit: Protection study
Electrical circuit: Power system
Cryogenics
Control & safety systems
Assembly at Saclay & GSI
Final tests

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2006 – First Year main points

- **Preliminary Interface meeting with GSI-FAIR – *27 March***
- Magnet Protection study and Instrumentation – *March & April*
- Preliminary Superconducting cable specification – *April*
- Mechanical studies – *beginning in February*
  - Cold mass – behaviour with magnetic forces
  - Cryostat mechanical studies – behaviour with pressure forces
- Magnetic design optimisation (peakfield)
- Superconducting cable specification – May-June

- **Technical Design Review 1 *(Conductor validation)* – 4 July**
- Check of the Large Acceptance of the present cryostat design – September

- **Superconducting cable Order - (*October)***