HIGH RADIATION TO MATERIALS

PROJECT REPORT

Outline

- The HiRadMat facility – what is it?
- Project overview
- Status
  - WG1 - Beam line
  - WG2 - TNC and T1 dismantling
  - WG3 - New irradiation area
- Schedule
- Operation & user's support
- Summary

On behalf of the project team

S. Evrard – EN/MEF

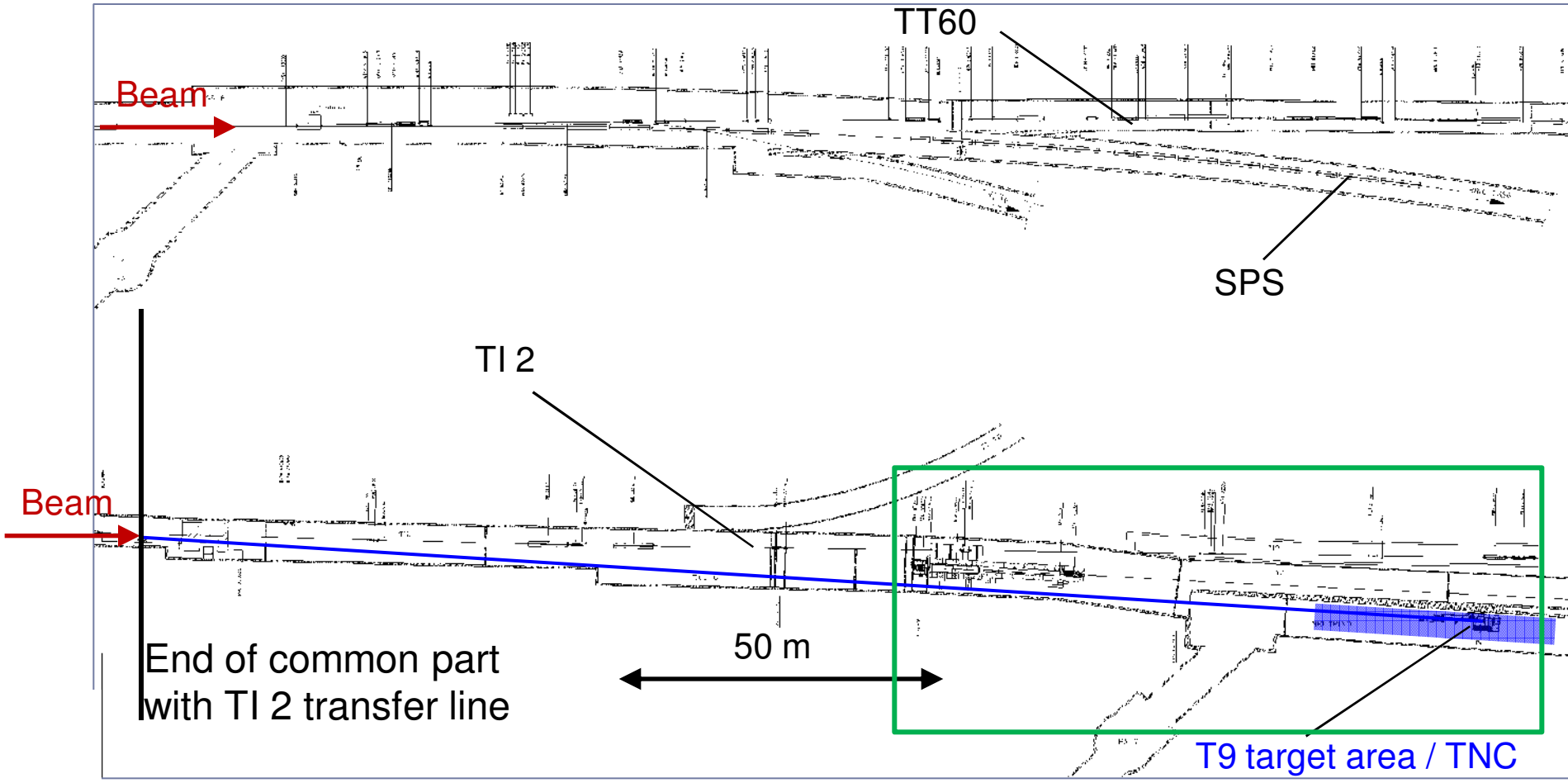
The HiRadMat Facility – What is it ?

Essential purpose

- Study the impact of intense pulsed beams on materials
  - Thermal management (heating)
    - material damage even below melting point
    - material vaporization (extreme conditions)
  - Radiation damage to materials – change of properties
  - Thermal shock - beam induced pressure waves
- Test bed, important for the design validation of LHC near-beam components before installation in the machine
- Requires **LHC-type SPS beam** (450 GeV/c) from **pilot to 288 nominal bunches**
- Foreseen clients : LHC collimators, protection devices, machine components, material studies (bulk, superconductors), high-power targetry, irradiation tests of electronics

The HiRadMat Facility – What is it ?

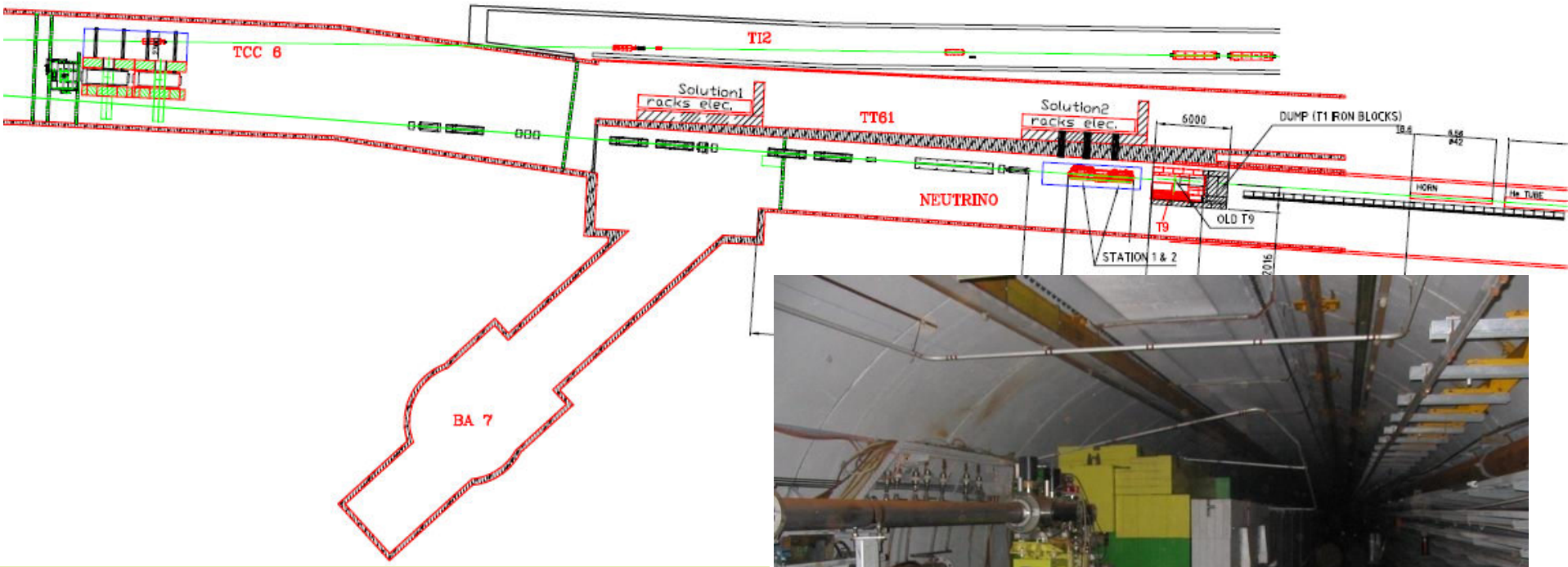
3 Location



C. Hessler, 26/01/09

The HiRadMat Facility– What is it ?

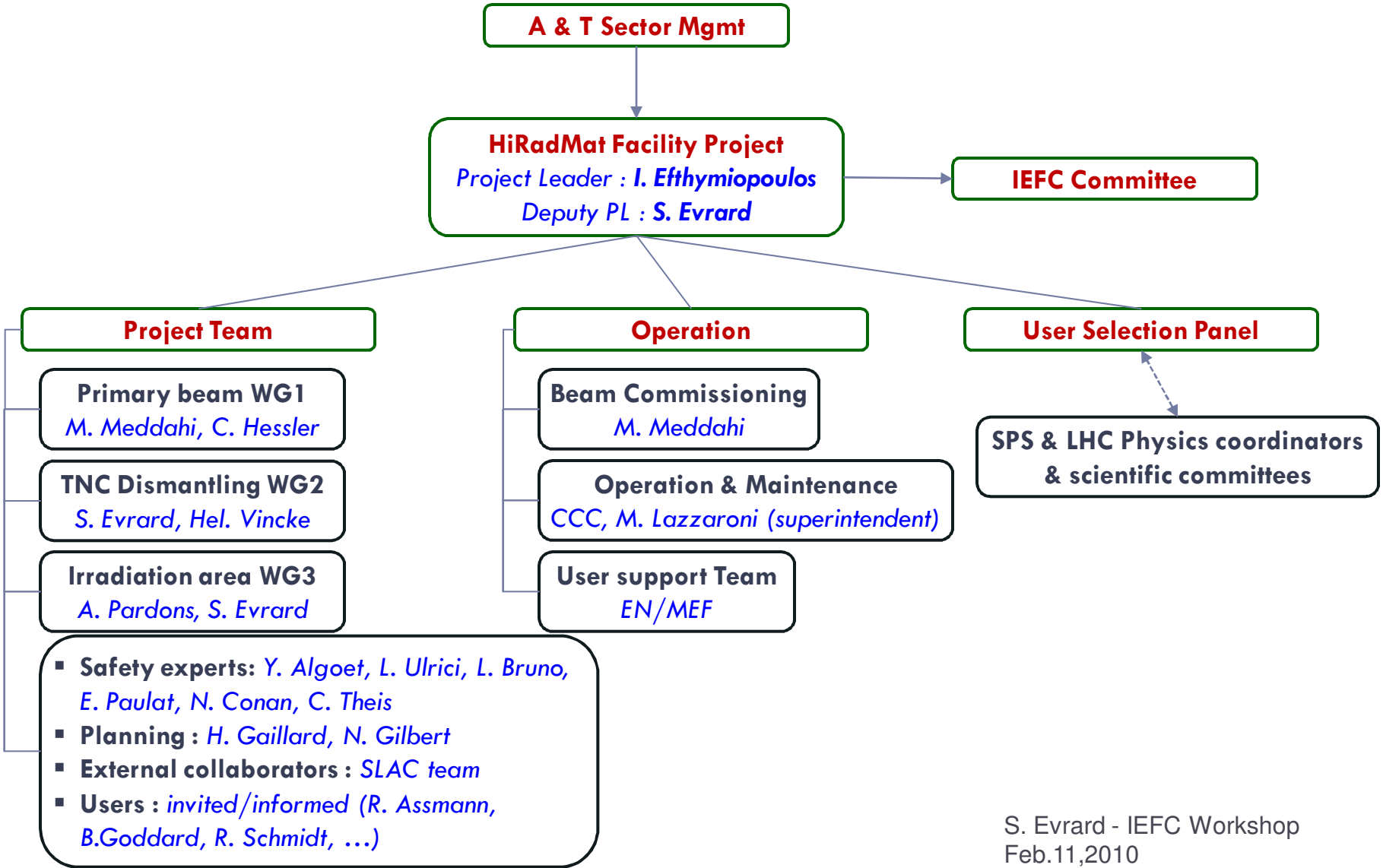
4 Irradiation area layout in the TCC6-TNC tunnels



- Test area upstream the T9 target
- Convert T9 target to a beam dump
- Cleanup the TNC tunnel
- Dismantle/condition WANF equipment
- Maintain escape passage from tunnel end

Project Overview

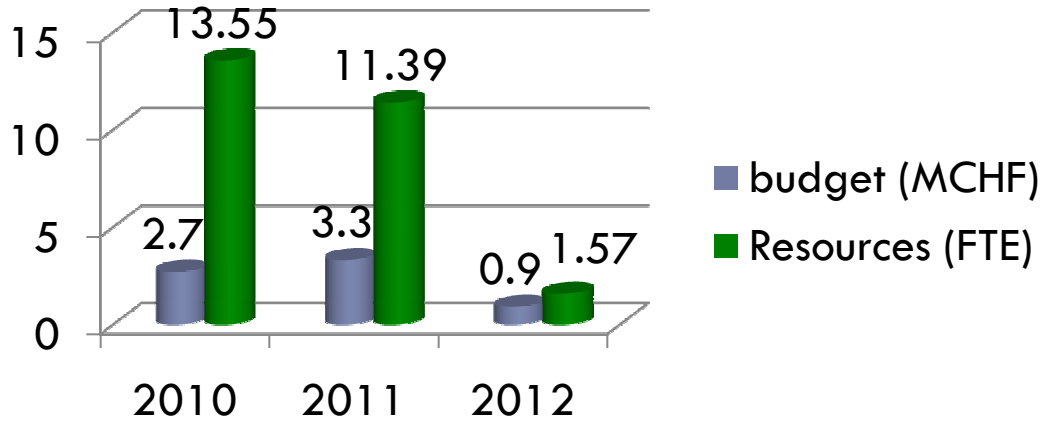
5 Project structure



Project Overview

6 Project budget

- The HiRadMat project is important for LHC.
- A&T sector based project :
  - BE: ABP, ASR, BI, CO, OP
  - EN: CV, EL, HE, MEF, MME, STI
  - TE: ABT, EPC, MPE, MSC, VSC
  - And DG/SCR, DG/SCG, GS/ASE, GS/SEM, IT/CS
- Work packages defined in each WG's in close collaboration with equipment groups.
- Thanks to all groups for providing feedback to update the budget and manpower estimate for the project !
- 6.9 MCHF and 26 FTE's over 2010, 2011 and 2012



WG1 – Beam line: status

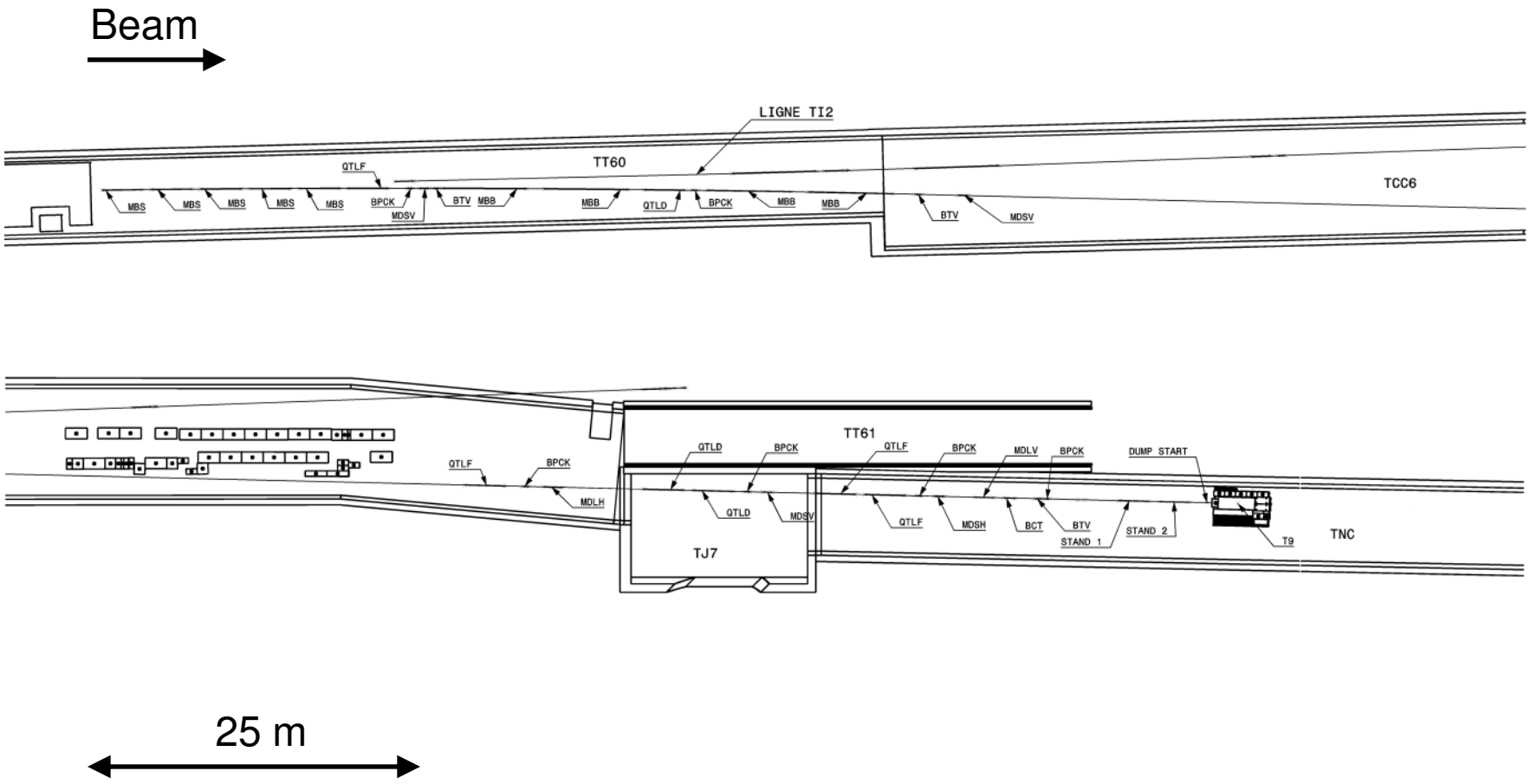
7 Primary proton/ion beam parameters

Parameter	Protons	Ions
Beam energy	**450 [GeV]**	177.4 [AGeV]
Bunch intensity	5×10^{9} to **1.7×10^{11}** [protons]	5×10^{9} to 4.1×10^{10} [ions]
Number of bunches	1 to **288**	52
Bunch spacing	25 [ns]	≥25 [ns]
RMS bunch length	11.24 [cm]	11.24 [cm]
Pulse length	7.2 [μs]	7.2 [μs]
Transverse norm. emittance (1σ)	3.5 [μm rad]	1.4 [μm rad]
RMS beam spot at focal point	1.0 [mm^2] - nominal **0.25 – 4.0 [mm^2] – range**	1.0 [mm^2] - nominal 0.25 – 4.0 [mm^2] – range
RMS beam divergence at focal point	0.2 [mrad]	0.2 [mrad]
RMS shot-to-shot stability	< 0.2 [mm]	< 0.2 [mm]
Transverse beam steering at focal point	+/- 4 [mm]	+/- 4 [mm]
Integrated beam intensity(protons)	**10^{16} protons/year** **10 exp.$\times10^{15}$ protons/exp.** **~30÷100 extractions/exp**	

- Beam in shared mode during SPS operations

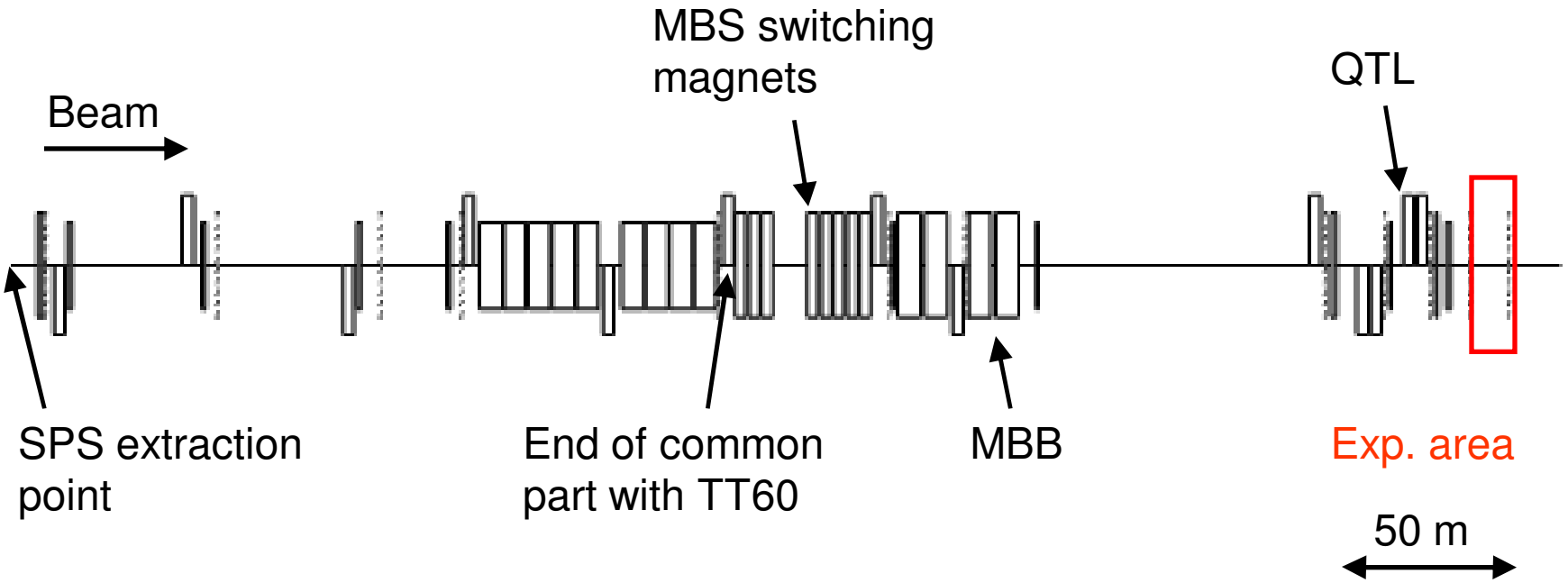
WG1 – Beam line: status

8 Beam line Geometry



WG1 – Beam line: status

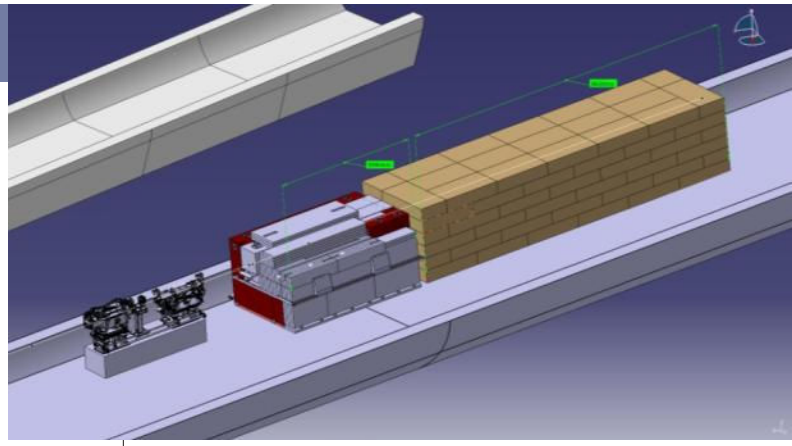
9 Beam line layout

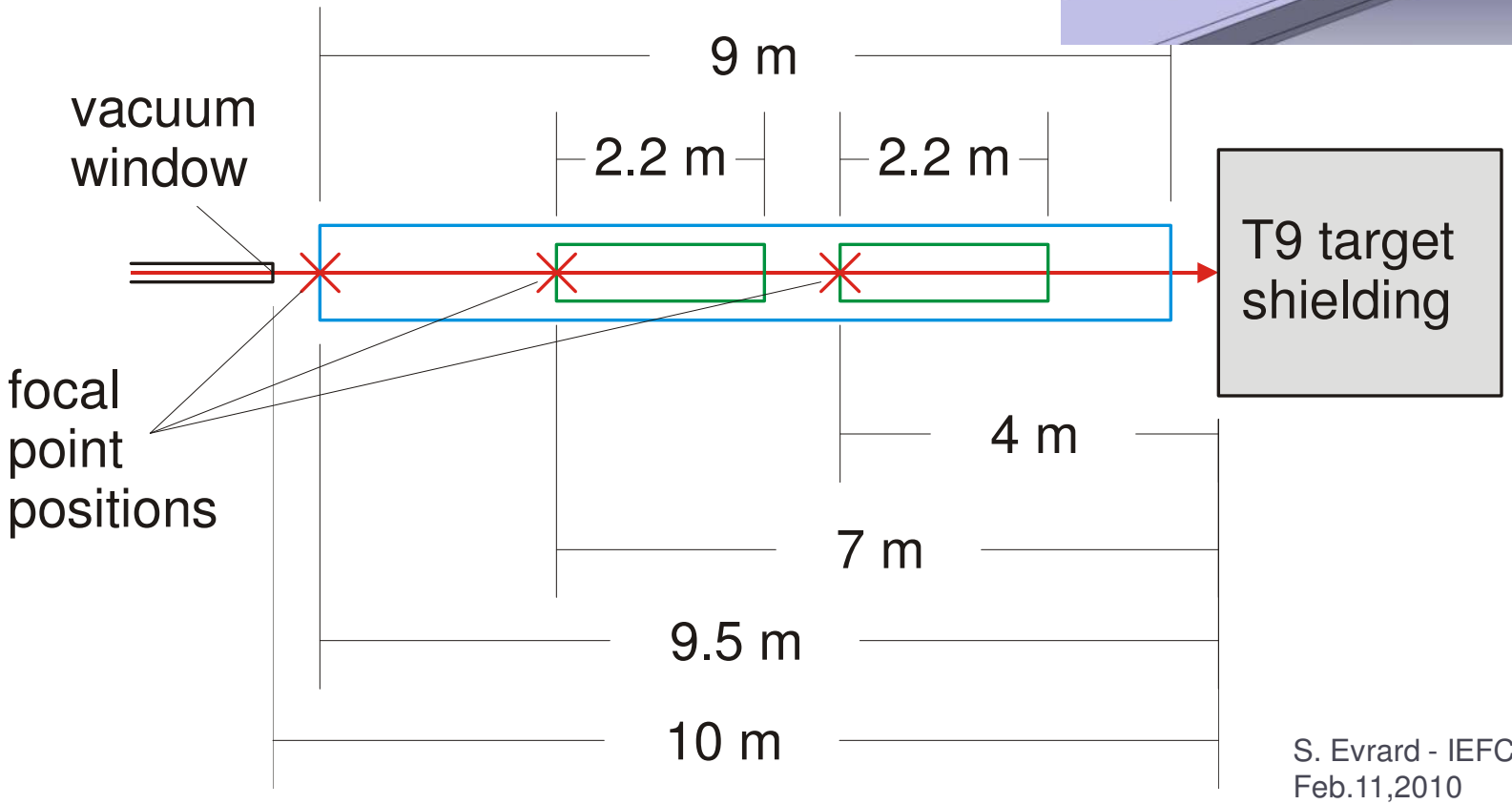


- Flexible optics to provide beam radii of σ = 0.1 to 2.0 mm at the focal point
- Focal point movable to starting points of the three test stands

WG1 – Beam line: status

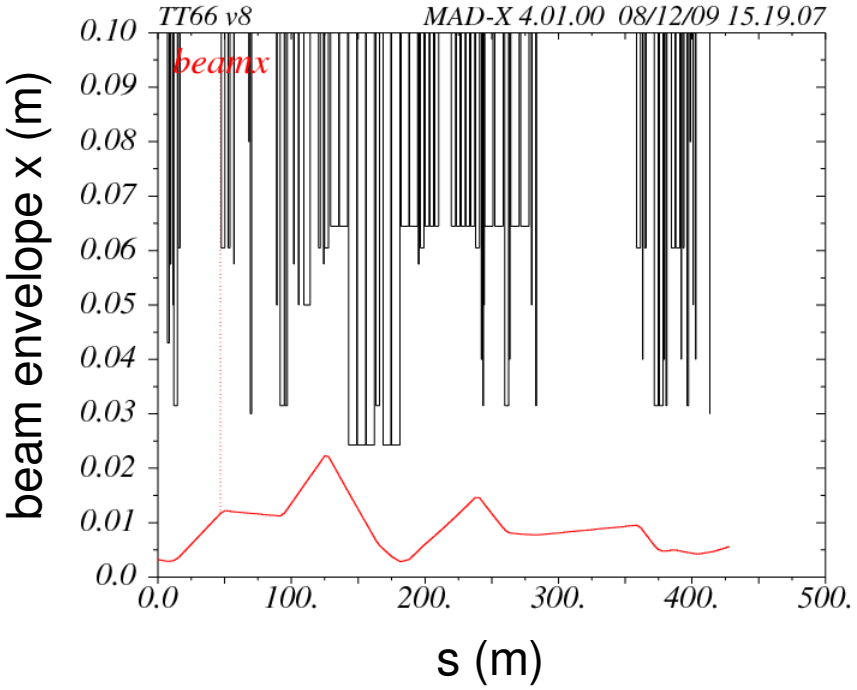
10 Focal point – Layout requirements

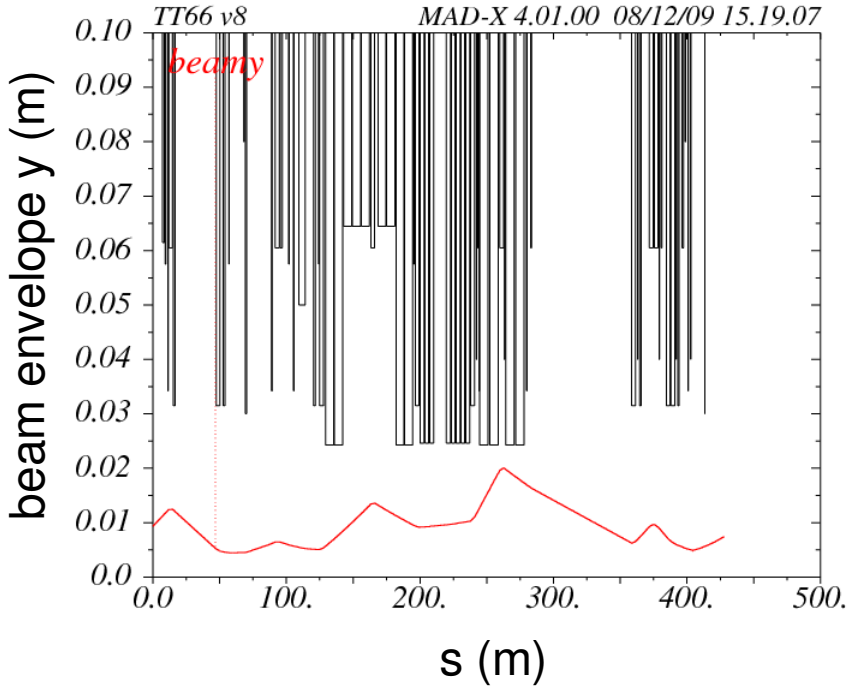




WG1 – Beam line: status

11 Beam Envelope Calculation

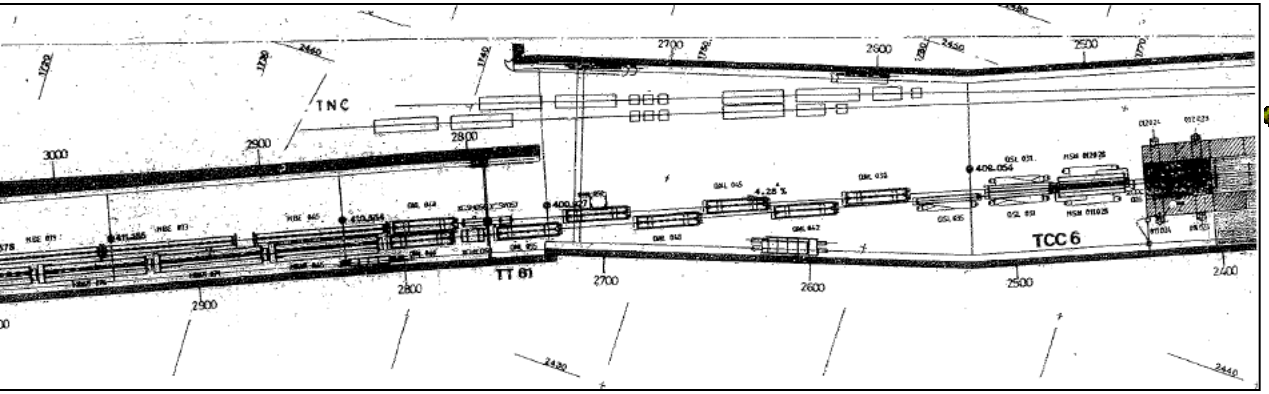


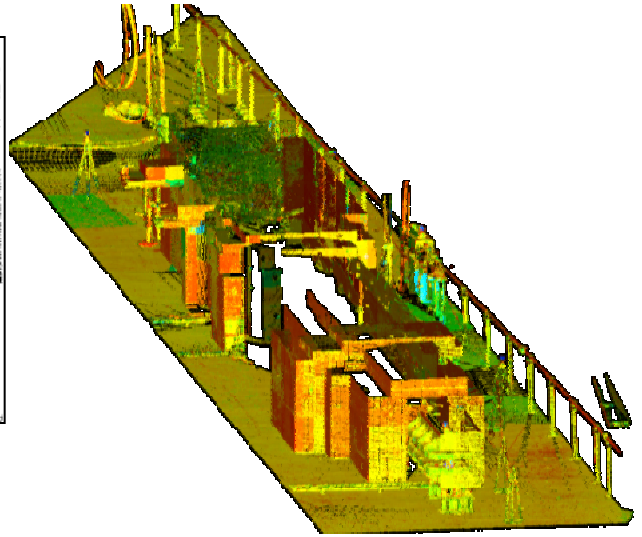


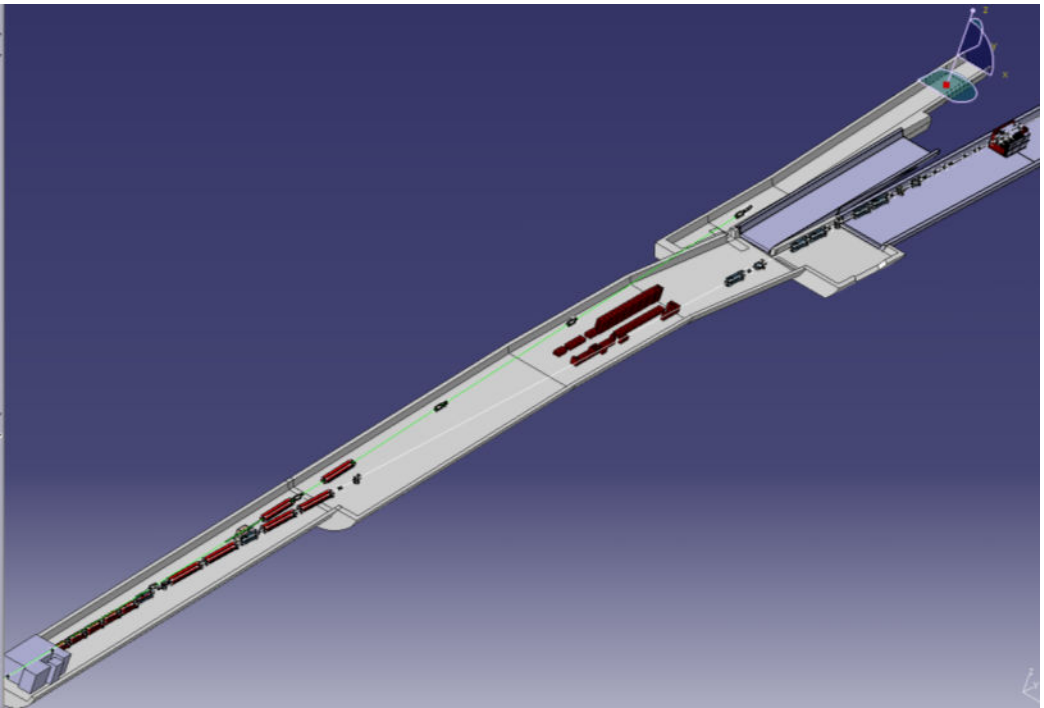
- Focal point position: start of large test stand
- Beam radius at focal point: σ = 0.5 mm
- 6σ beam radius and 5 mm max. trajectory deviation for beam envelope calculation assumed

WG1 – Beam line: status

12 Integration issues



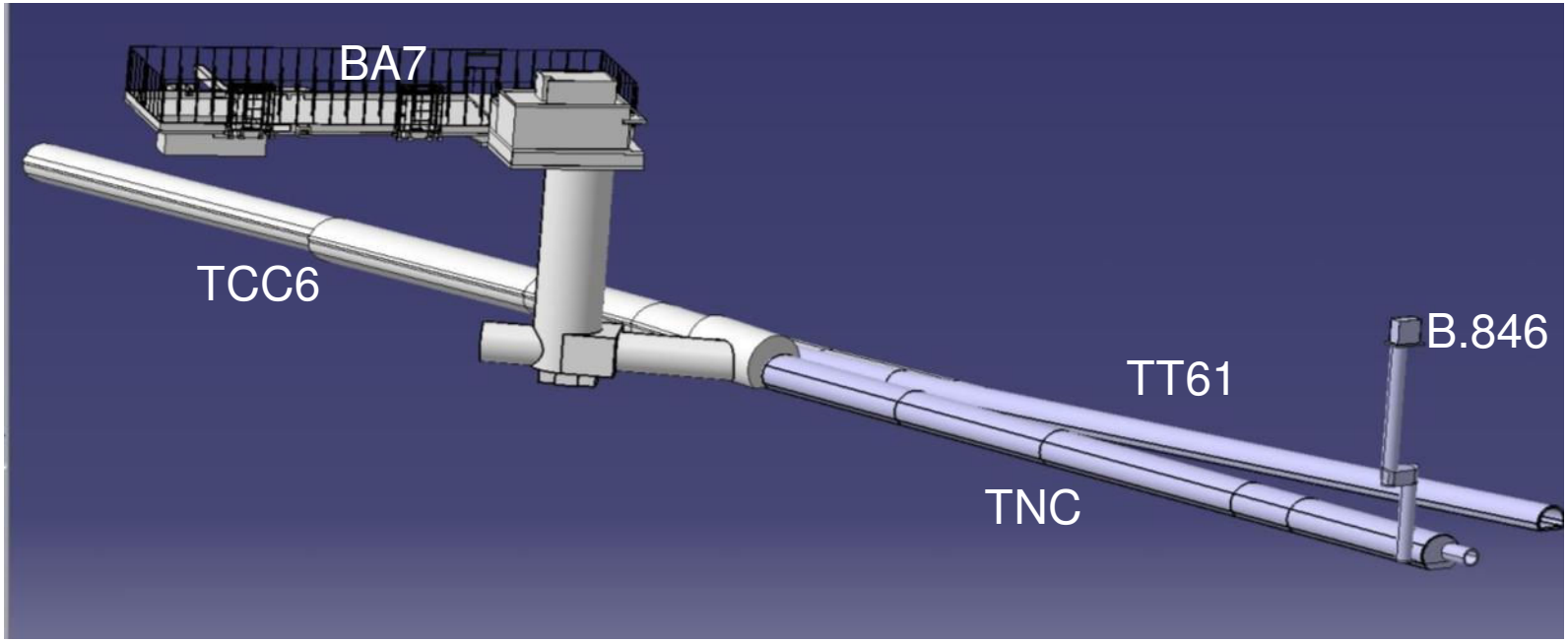




- Paper drawing from early 80's
- Laser scanning of the whole area (TNC + TCC6) achieved just before LHC startup
- Migration to Catia → 3D model now available
- Valuable for future projects
- Weekly integration meetings

WG2 – TNC and T1 dismantling: status

- Radiation survey
  - Dose rate + contamination (→ EDMS 1053964)
- Escape path → B.846
- General safety systems (AUG, red telephones, RIA,…)



WG2 – TNC and T1 dismantling: status

14 Dedicated handling means

- Forklift shielded with lead glass and lead sheet (attenuation factor = 5)
- Automatic hook developed by EN-HE (J-L Grenard and C. Bertone)
- Dose rate attenuation due to operator remoteness
- Already tested successfully in TCX blocks removal

WG2 – TNC and T1 dismantling: status

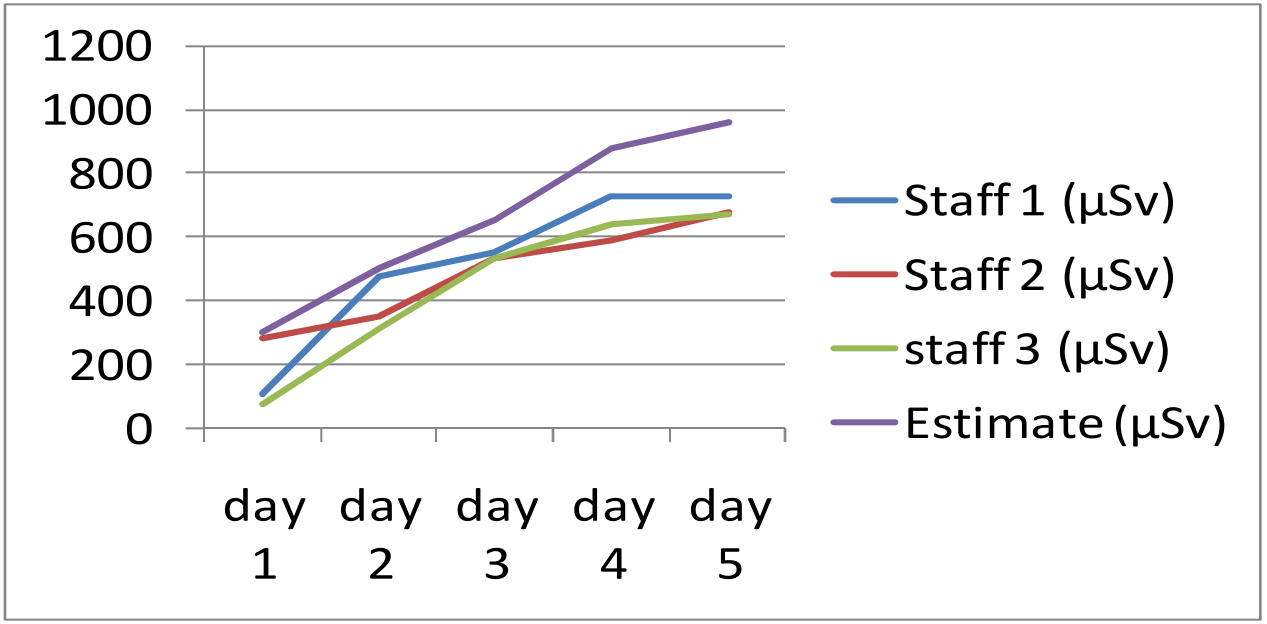
15 First activities carried out

- PR 532 refurbishment
- TNC cleaning
- Beam line removal up to T9 target
- TCX blocks dismantling

WG2 – TNC and T1 dismantling: status

16 Focus on TNC cleaning

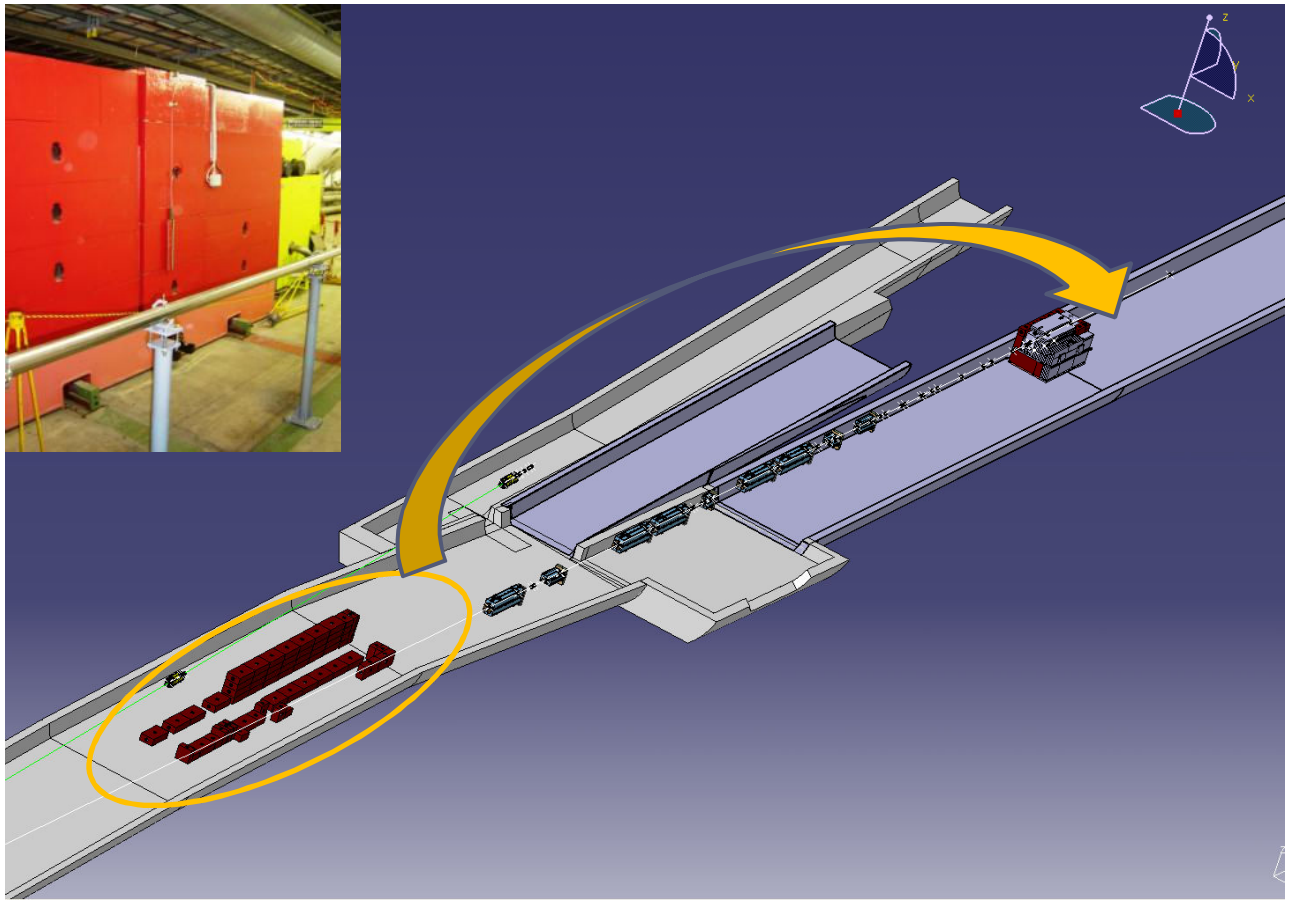
- Specific price enquiry won by ENDEL Nucleaire (F)
- Smear tests taken where contamination was the highest: reduction by a 10 factor (all smear tests < 1Bq/cm^2 = contamination level)
- Dosimetry below estimates (collective dose 2.2 mSv where 2.8 was estimated in DIMR)



WG2 – TNC and T1 dismantling: status

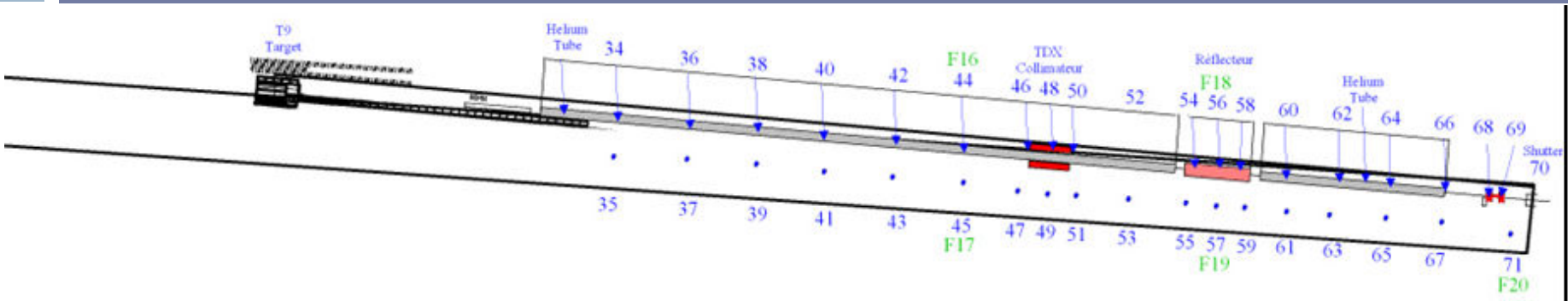
T1 dismantling: our plan

- Complete dismantling of T1 target complex
- Removal step by step during LHC technical shutdown
- MTR magnet removal requires TI2 vacuum dismantling
- Shielding blocks will be re-used for HiRadMat dump.



WG2 – TNC and T1 dismantling: status

18 TNC dismantling: our plan



Cartographie débit d'équivalent de dose réalisée le 17/11/09

Position	[µSv/h]	Position	[µSv/h]
34	180	53	75
35	85	54	600
36	220	55	90
37	90	56	370
38	300	57	100
39	130	58	580
40	180	59	100
41	90	60	100
42	180	61	75
43	100	62	95
44	300	63	45
45	165	64	80
46	800	65	45
47	200	66	180
48	270	67	55
49	170	68	200
50	230	69	150
51	120	70	65
52	165	71	55

Cartographie contamination labile réalisée le 17/11/09

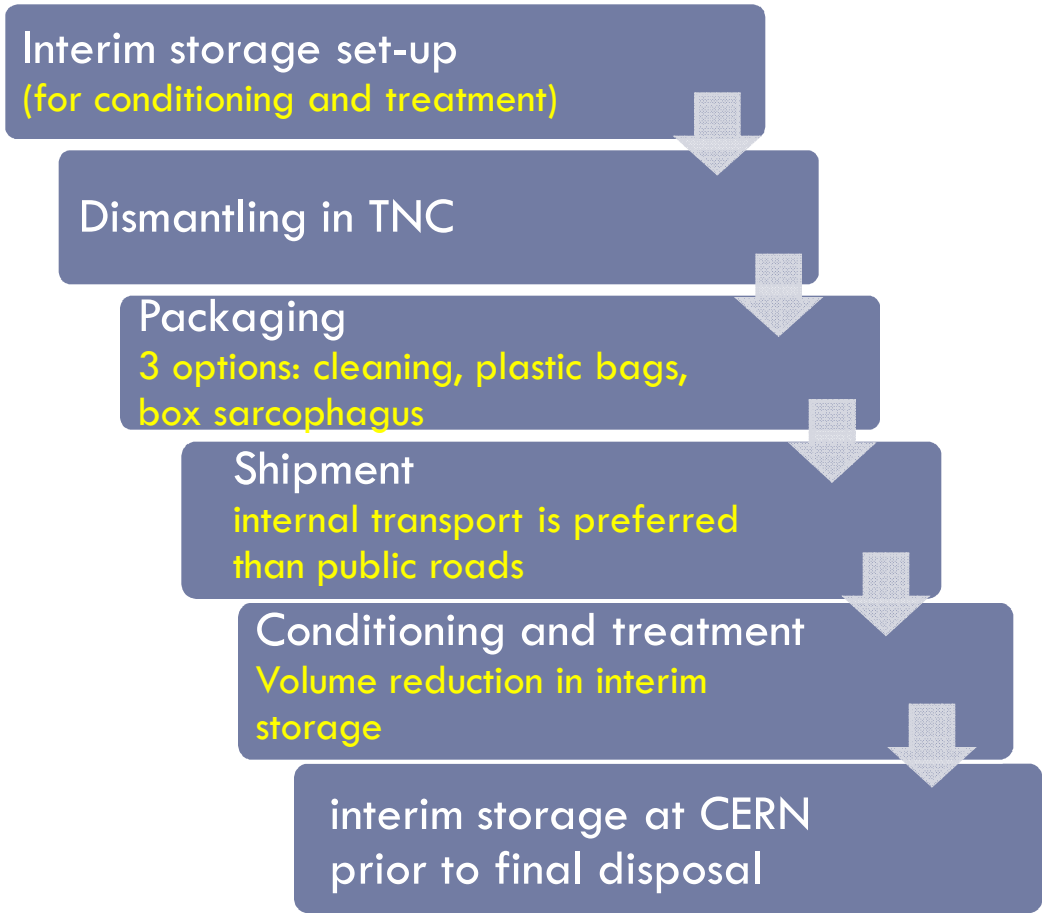
Position	[Bq/cm2]
44 =>F16	5.28
45 =>F17	2.46
56 =>F18	1.23
57 =>F19	0.87
71 =>F20	0.55

EDMS 1053964

WG2 – TNC and T1 dismantling: status

19 TNC dismantling: our plan

- Consultancy study with TUEV Nord (D) in progress regarding the planning of the dismantling
- Optimization of interventions w.r.t. dose, waste conditioning, measurement procedures, storage & disposal possibilities
- Risk management and documentation (DIMR and ALARA committee)



WG3 – New irradiation area: status

20 Design parameters for the experimental area

Specification document

Parameter	Value
Experiments per year	10
Maximum intensity per experiment	1×10^{15} protons <30 full intensity pulses
Waiting time after experiment for de-installation	≥ 2 weeks
Access during experiment (except urgent interventions)	no
Control of experiment and data taking	remote
Maximum intensity per year	1×10^{16} protons

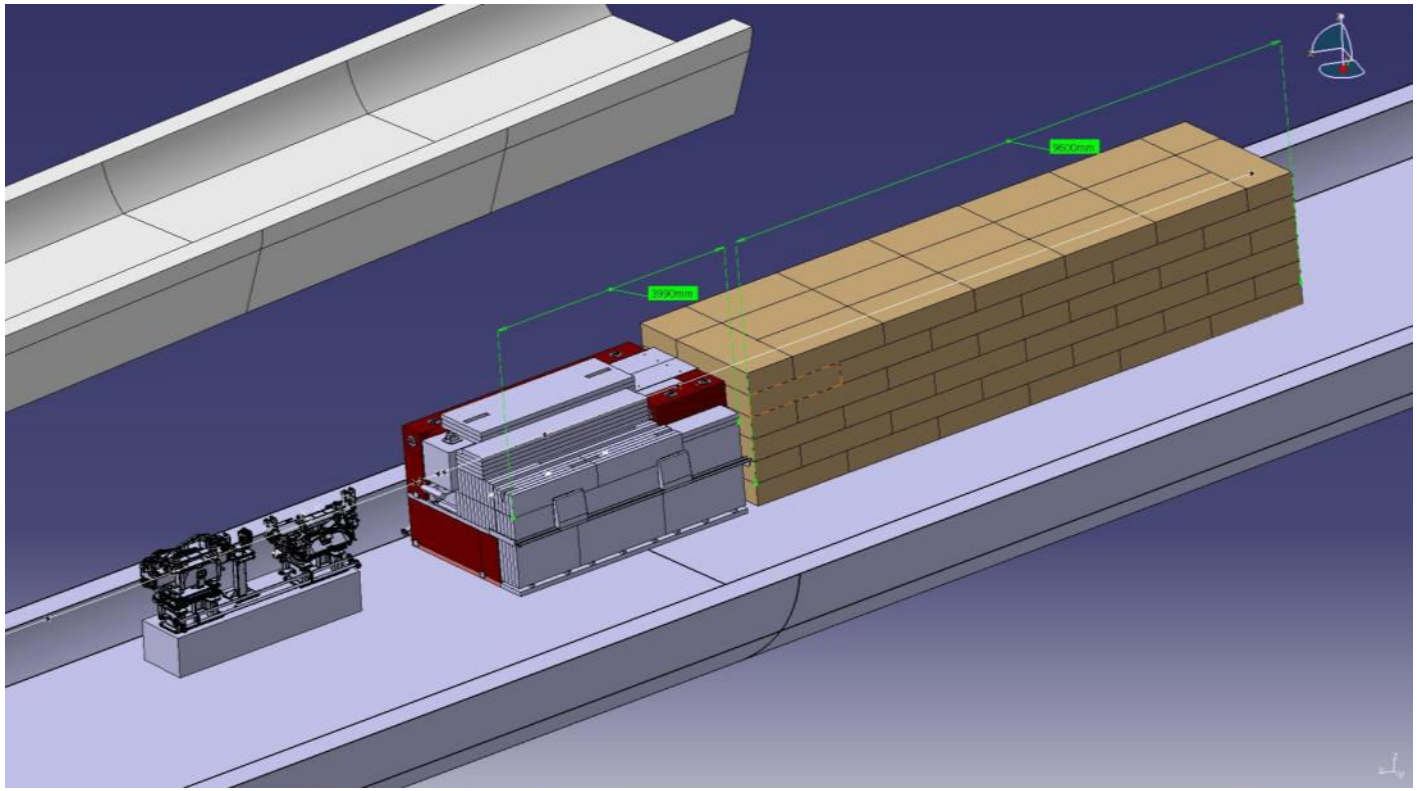
- Additional requirements for the exp. area will depend on the type of equipment and test planned
- Safety and RP constraints should come in addition

Parameter	Value
Installed experiments	1
Material exposed to beam	C, CFC, Cu, W, hBN, Al, Be, …, advanced composite materials
Volume of exposed material	≤ 16,800 cm^3
Equipment size ▪ Length (flange-to-flange) ▪ Width ▪ Height below beam line ▪ Height above beam line	 ▪ ≤ 7.0 m ▪ ≤ 1.0 m ▪ 1.1 m ▪ ≤ 0.8 m
Weight	≤ 4,000 kg
Handling zone (L × W × H)	15 × 2.0 × 2.2 m^3
Equipment support	comes with experiment – quick installation interface required
Cool-down space	see equipment size
Crane support	mobile cranes sufficient
Handling	prepare fast handling and remote installation with crane

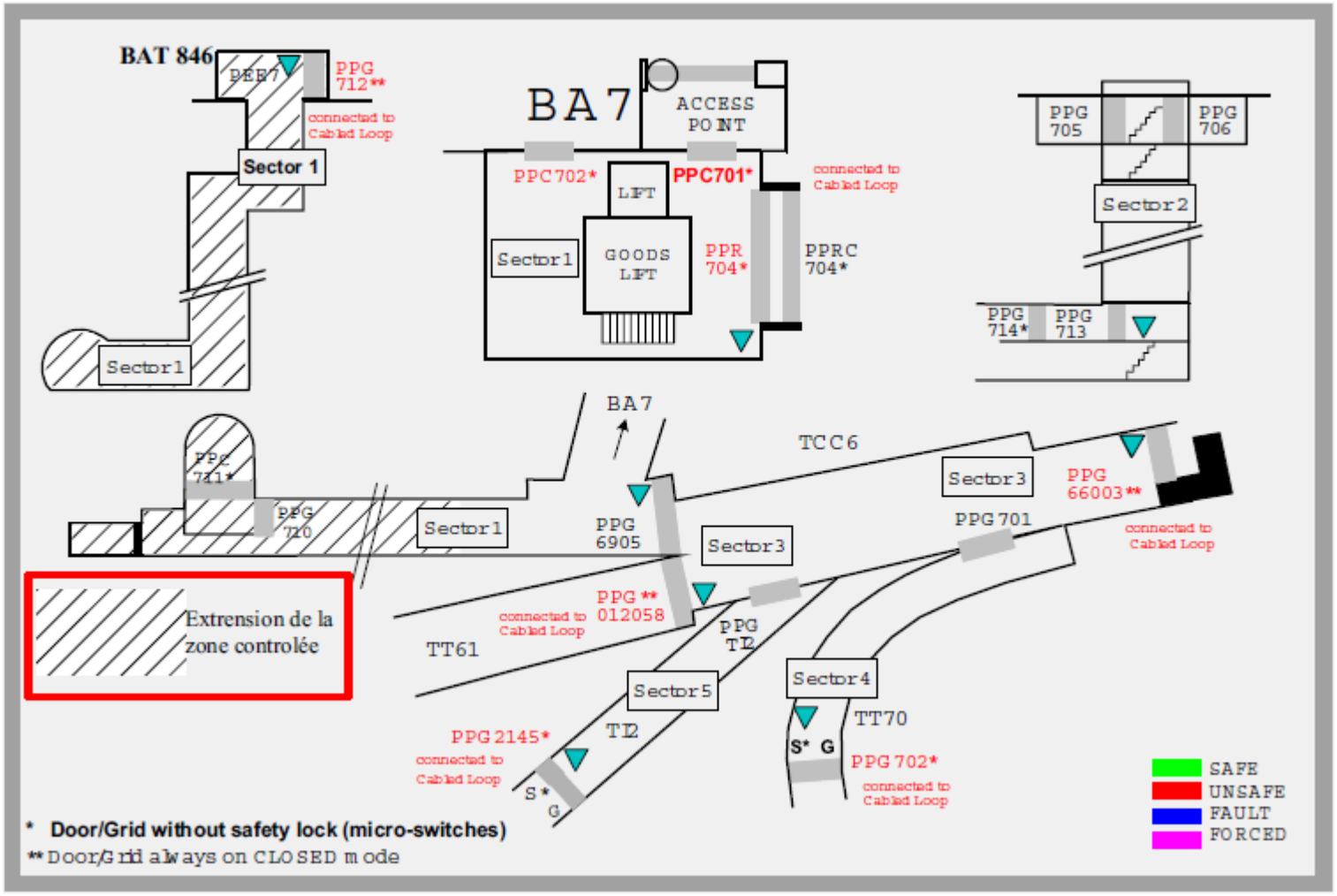
WG3 – New irradiation area: status

21 Test stands and beam dump

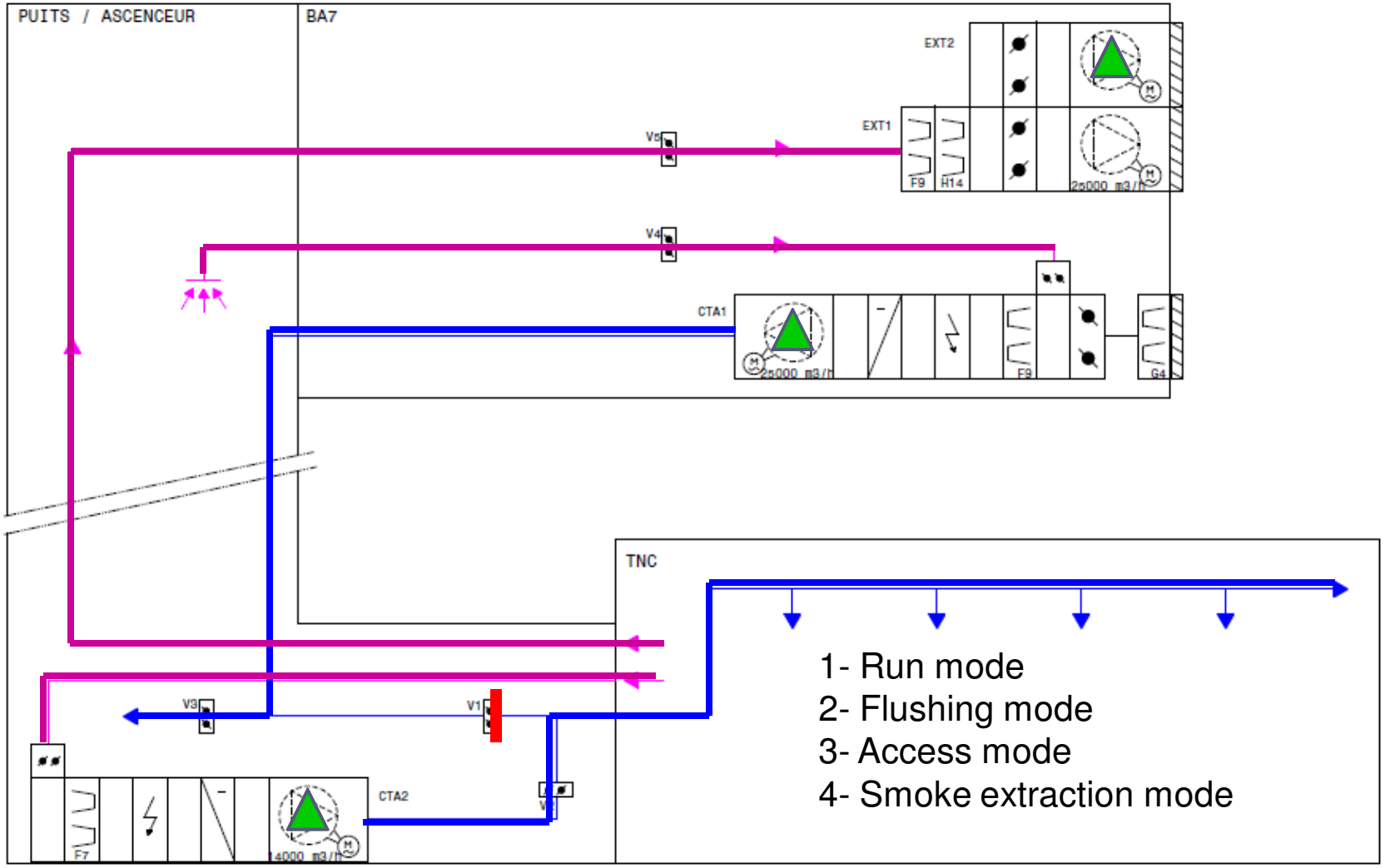
Water-cooled core dump based on TED technology (core graphite bloc)
Secondary dump made of cast iron blocks
2 stands for collimator (or other equipment) to be tested



WG3 – New irradiation area: status



WG3 – New irradiation area: status



TNC

WG3 – New irradiation area: status

24 Radiation monitoring

- 1 x stray rad. Station (includes cabin + infrastructure)
- Ventilation station
- 8 x PMI monitors (for the HIRADMAT area and the neighbouring tunnel, accurate position to be defined)
- 2 x IG5 monitors (hydrogen type), 1 x IG5 monitors (argon type)
- 3 Alarm Units (UA)
- 1 x hand foot monitor
- 1 x material control monitor

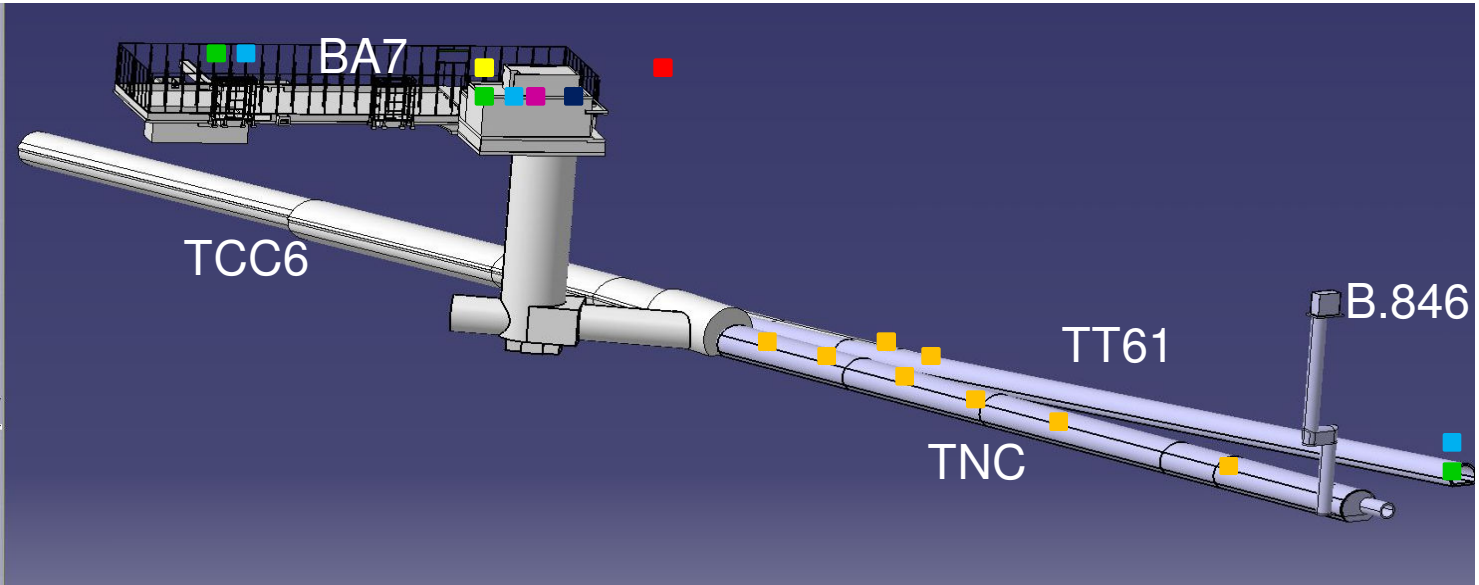

HFM

VGM - VAS

Stray radiation Monitoring


EPIC

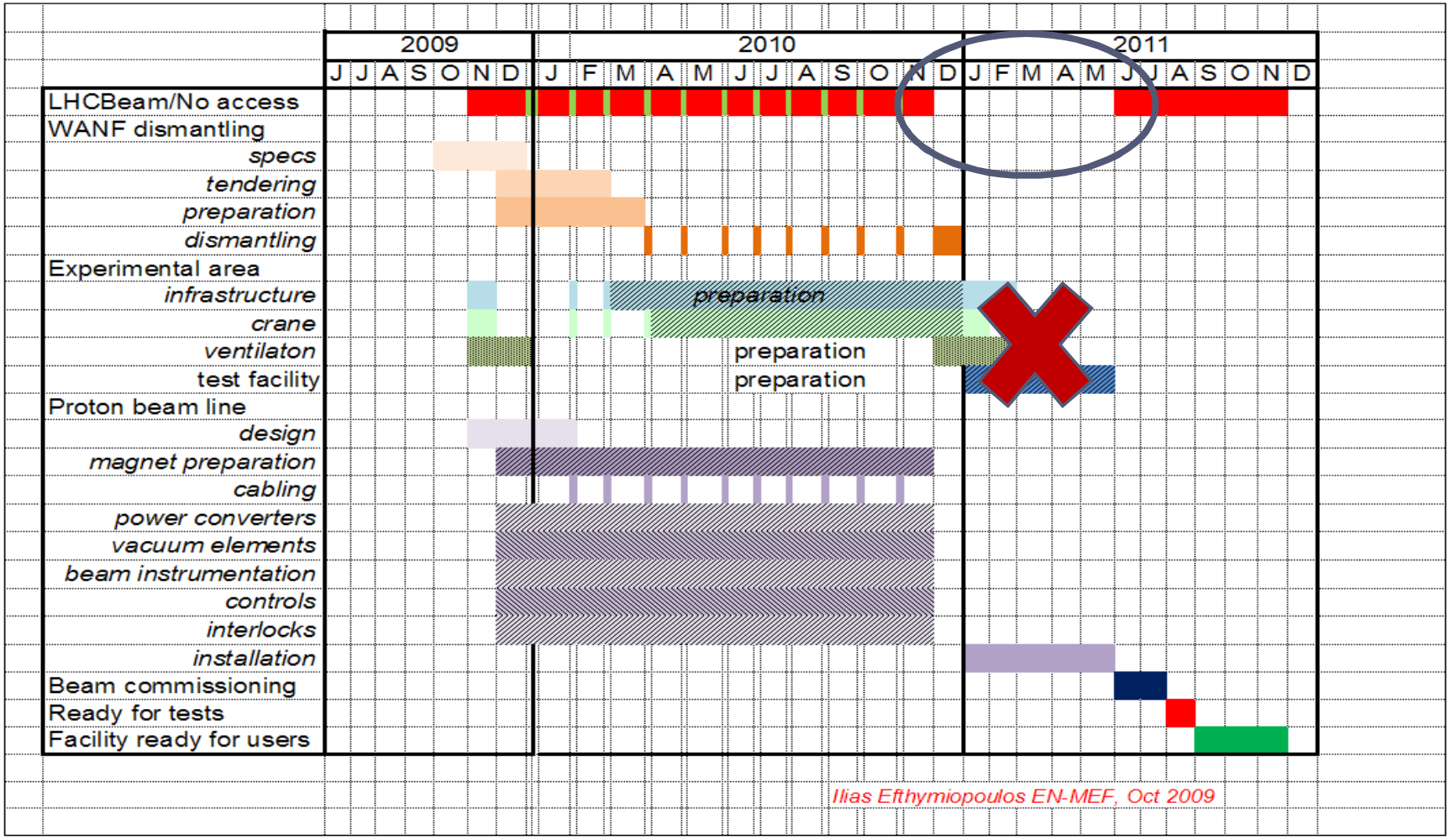

ERC



Schedule: first version

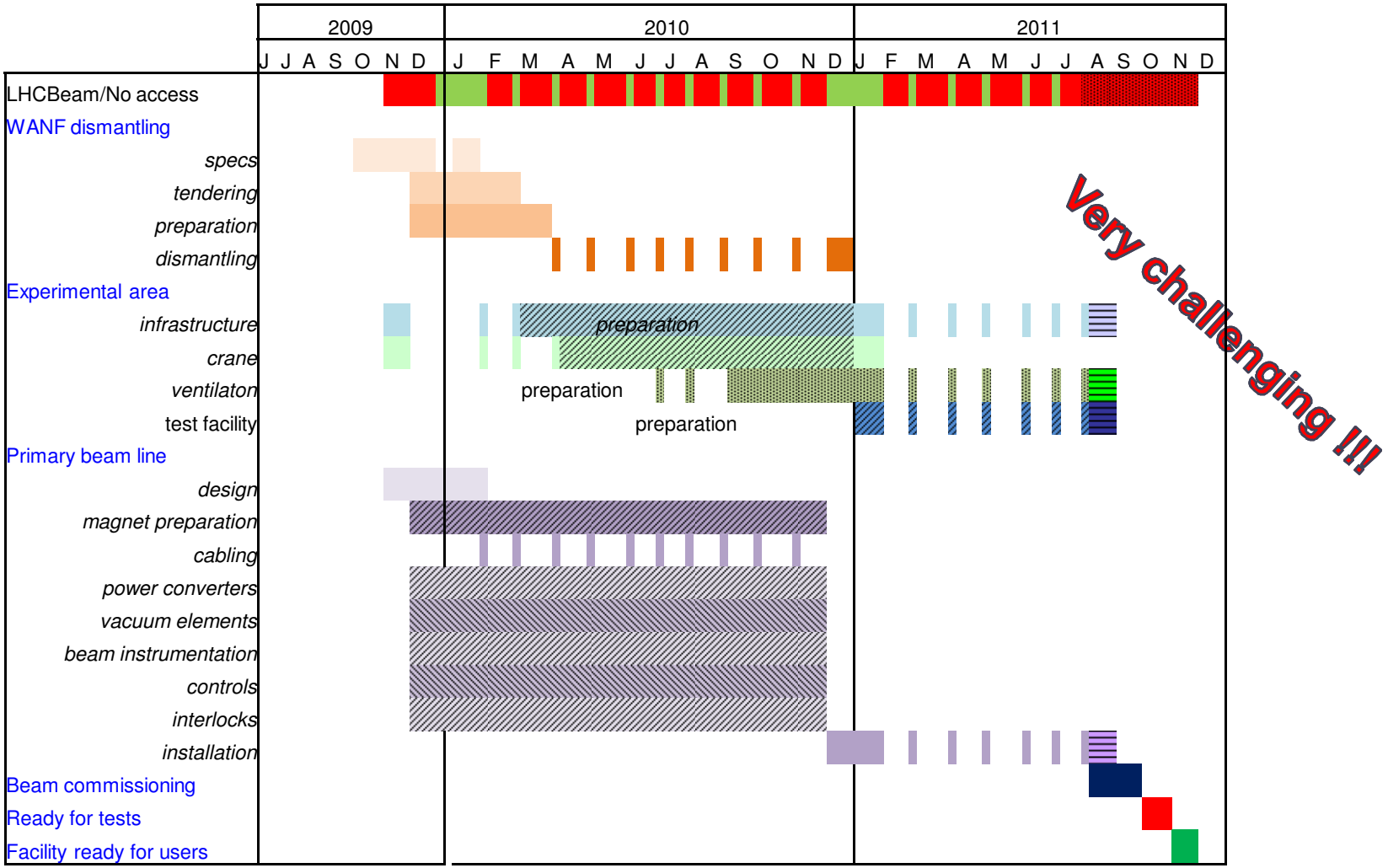
Major deadlines

LHC extended run → even more challenging to meet final deadline



Schedule: revised version

26 Major deadlines



Schedule

27 Most critical items

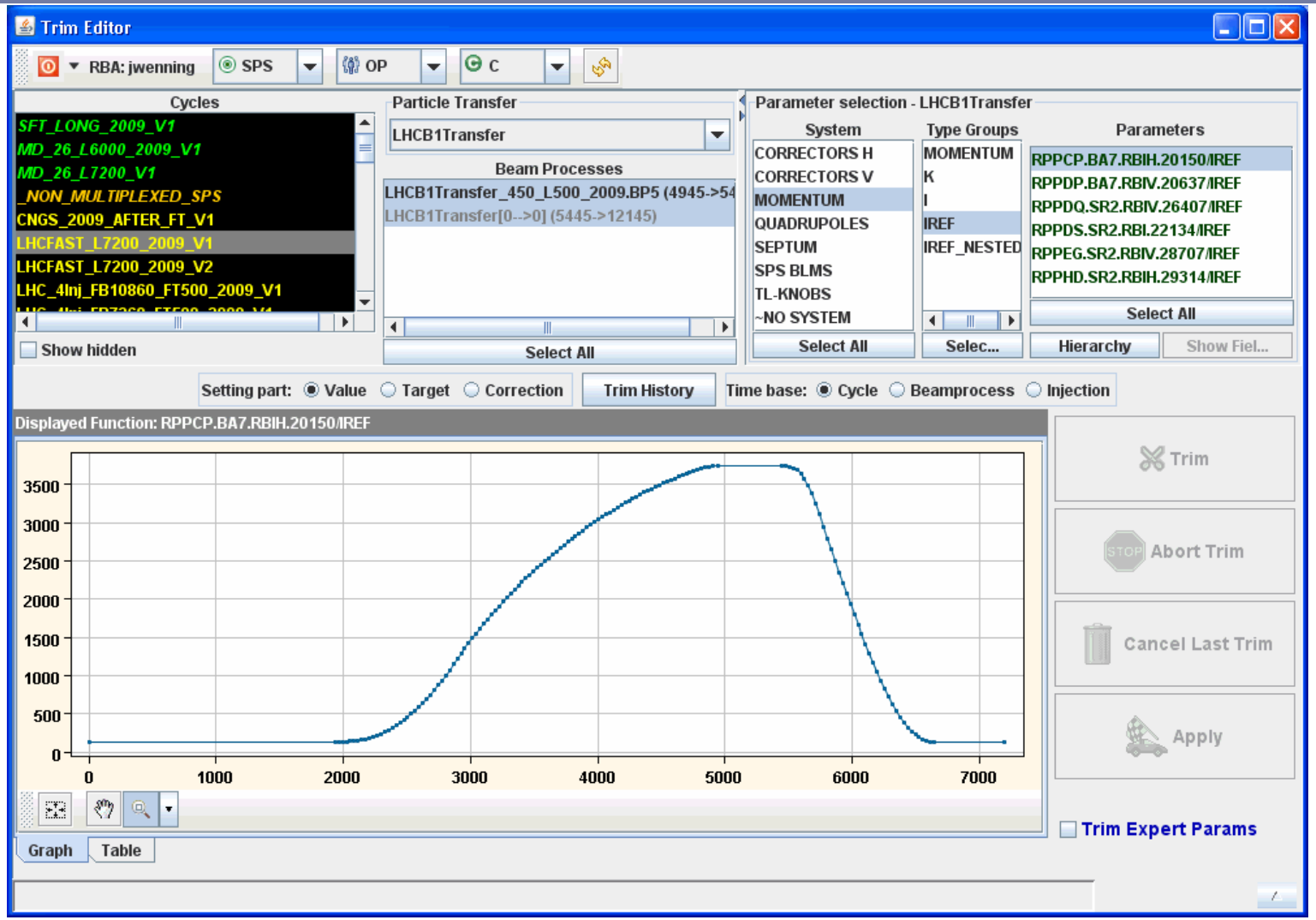
Crit.	Item	Comments
	Water-cooled cables	Could become critical → Inspection planned W12
	DC cables	New cables to be pulled → limit co-activities
	Signal cables	Needs are being collected→ cabling campaigns
	Power converters	Long delivery time
	Ventilation units	Procurement procedure (FC,…)
	Core dump	Re-use of existing one.
	Vacuum equipments	No major concern
	TBSE	Installation time slot to be carefully defined (TI2 line)
	Radiation monitors	Available on the shelf
	Beam instrumentation and control	Monitors of the TI beam line standards
	Magnets	No new magnet to be built, 2 being refurbished
	Survey equipment	Reference points already set-up and surveyed
	Machine Interlocks	Beam Interlock and Magnet Interlock (no major concern on both systems)

Operation

- Guidelines
  - 10 users/year
  - (up to) 10^15 protons/user
  - (up to) 100 high intensity pulses: 100x3.0E11 p/pulse
  - Several pilot pulses/user during setup
- Pilot pulses (setup) can be done in an almost transparent way to present operations
- High-intensity pulses will be done in dedicated HiRadMat cycles – no other physics for SPS
- HiRadMat cycle parameters under study
  - Impact on magnets/power supplies
  - Impact on physics schedule for SPS users

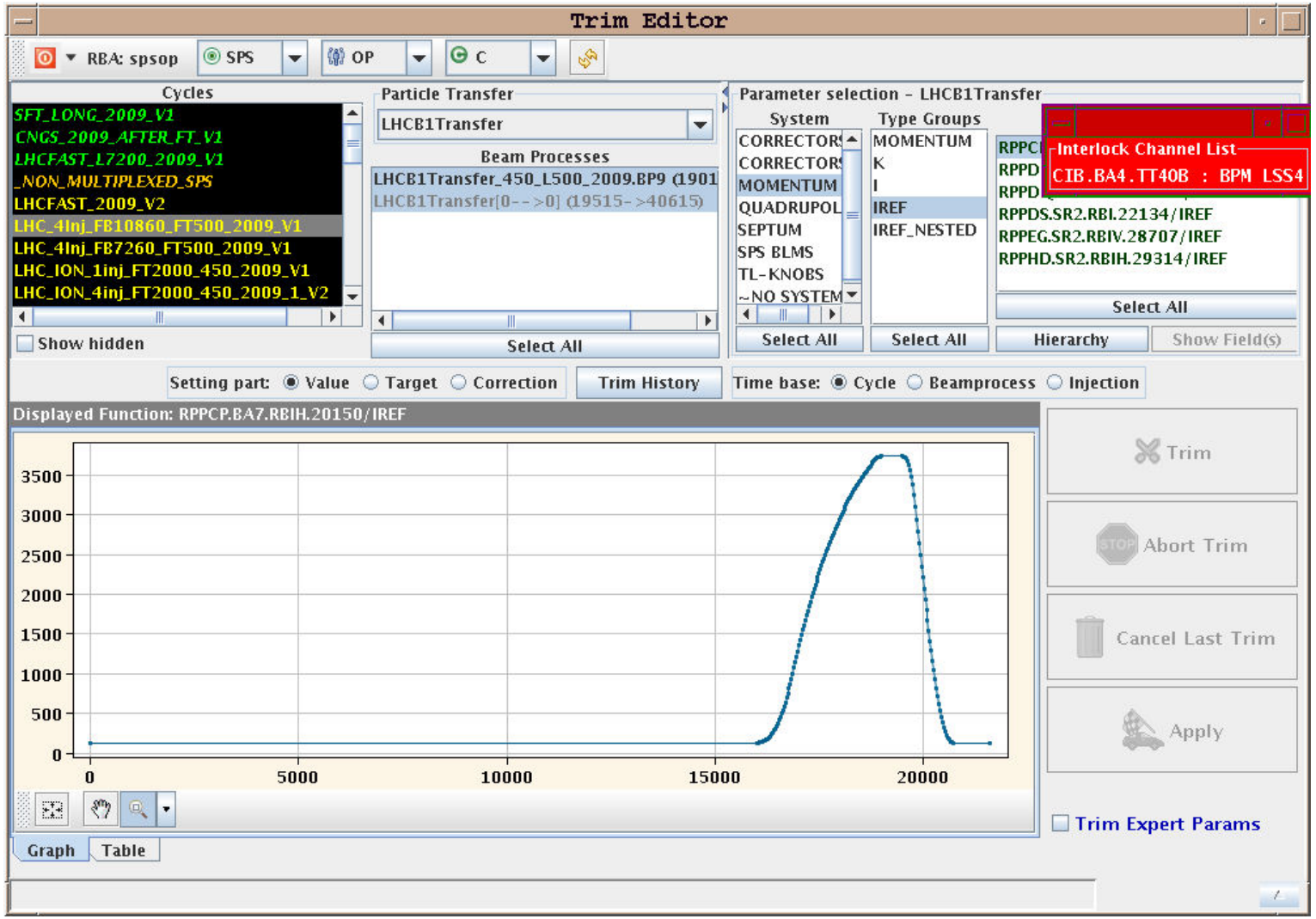
Operation

Power Converter Cycle for Beam Setup



Operation

Power Converter Cycle for HiRadMat Operation



User's support

- Future users already interested in using HiRadMat
  - Collimator phase 2 (prototyping work)
  - LHC beam dump entrance window robustness
  - Studies of protection devices and windows (TE-ABT)
  - Vacuum chamber coatings for electron cloud mitigation
  - R2E teams - irradiation facility – radiation damage
  - BLM developments
  - LARP Rotatable Collimator Robustness Test (SLAC)
  - Radiation tolerance tests (EN-STI)
  - ISOLDE – Target and Ion Source Development
- Infrastructure needed for users
  - Racks/space for electronics and readout in BA7
  - Lab space nearby
  - Office space
  - Training and access procedure

Summary

- Project well on tracks
  - Organization, work packages, budget defined
  - Safety file in progress
  - Design stage almost completed
  - First activities on site achieved
- Schedule very tight
  - LHC driven planning
  - Make full use of monthly technical stops and 2010 Xmas shutdown
- Radiation risk mitigation strategy
- The whole TT60/TCC6/BA6,BA7 areas will be largely renovated.
- Operation issues under study
- Wide range of future users
- Further info at : http://cern.ch/hiradmat

Thanks for your attention

Acknowledgments :

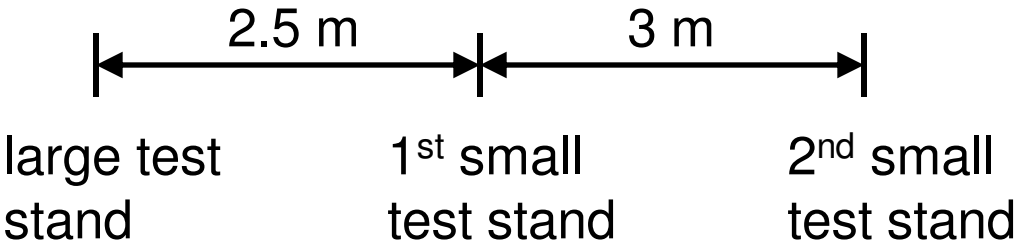
Nadine Conan, Helmut Vincke, Chris Theis, Luisa Ulrici, Yvon Algoet, Daniel Perrin, Malika Meddahi, Christoph Hessler, Brennan Goddard, B. Puccio, Ilias Efthymiopoulos, Catherine Magnier, Serge Pelletier, Caterina Bertone, Dino de Paoli, Hubert Gaillard, Michael Lazzaroni, Thijs Wijnands.

Spares

WG1 – Beam line: status

35 Focal point studies

- Layout:



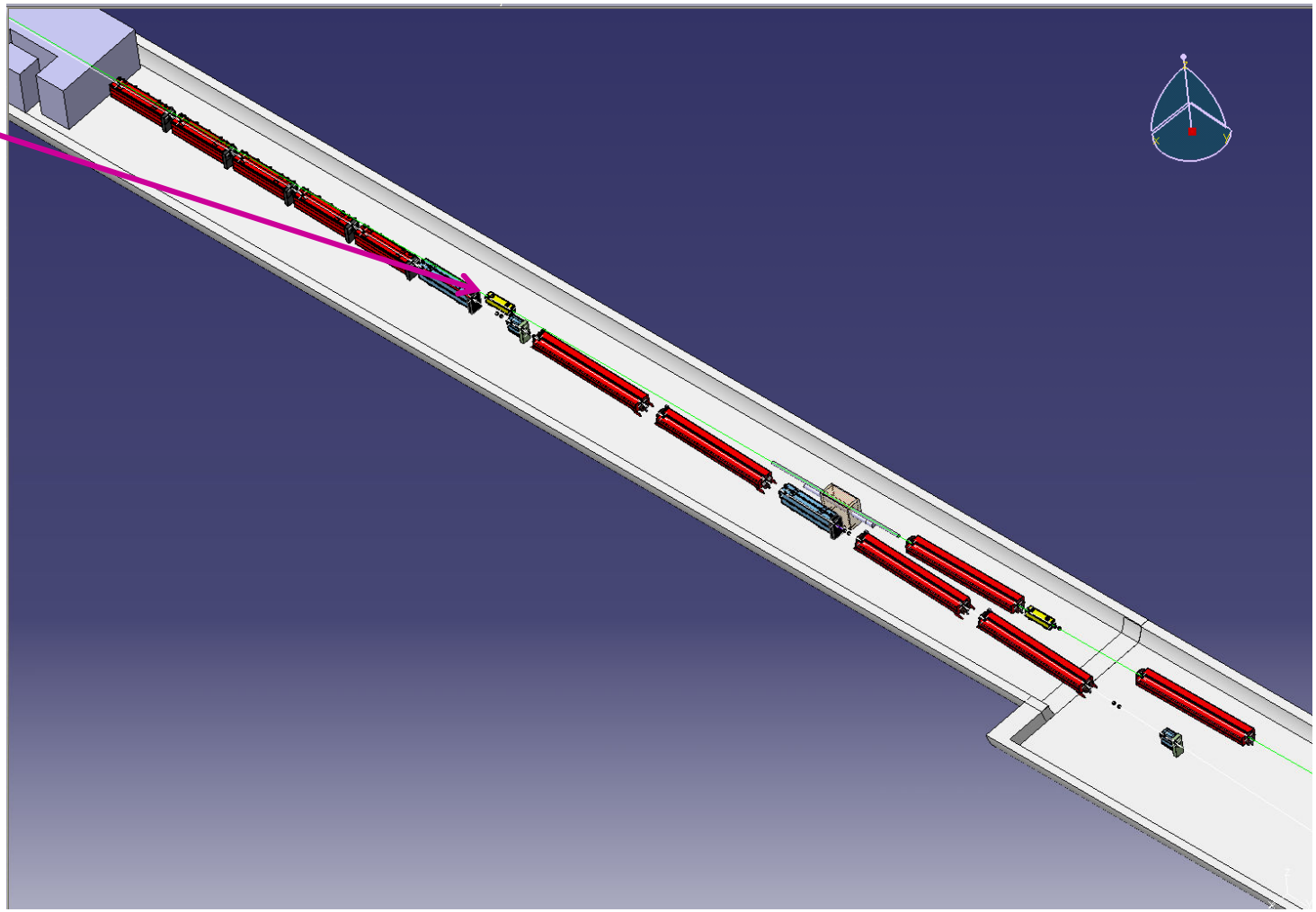
- Focal point achievable at all 3 positions for σ = 0.1 to 2.0 mm
- Focal point @ 1st small test stand:

Beam radius (1 σ) at		
large test stand	1st small test stand	2nd small test stand
~2.00 mm	2.00 mm	~2.00 mm
~0.52 mm	0.50 mm	~0.53 mm
~0.40 mm	0.10 mm	~0.47 mm

WG1 – Beam line: status

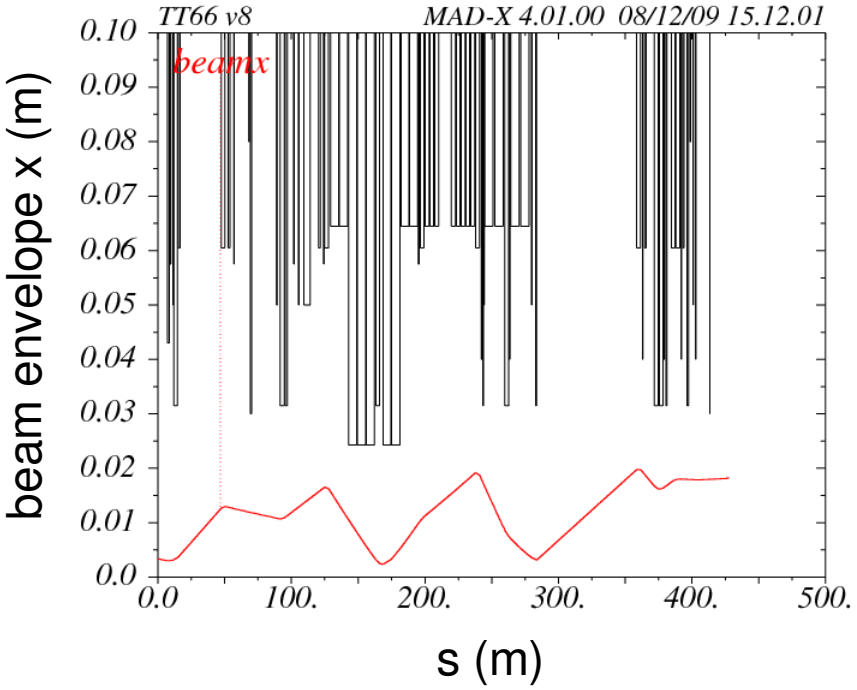
36 TBSE location

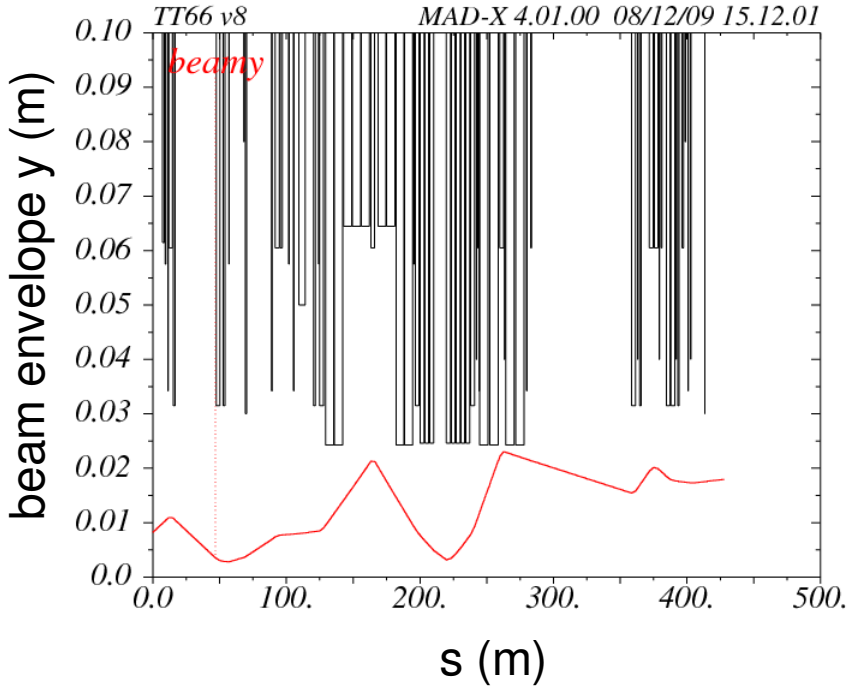
This new TBSE will allow HiRadMat operation while accessing the LHC tunnel



WG1 – Beam line: status

37 Beam Envelope Calculation

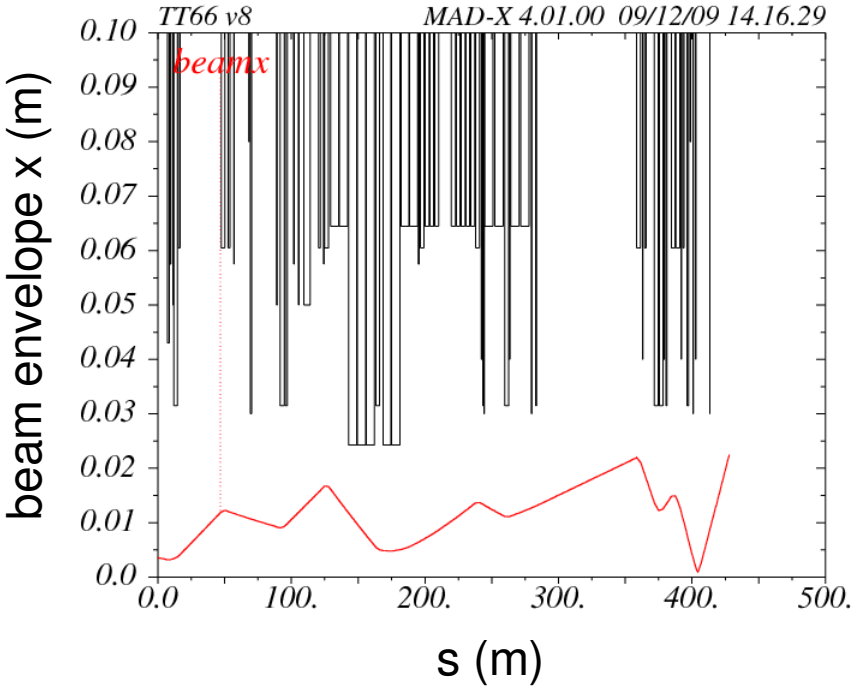


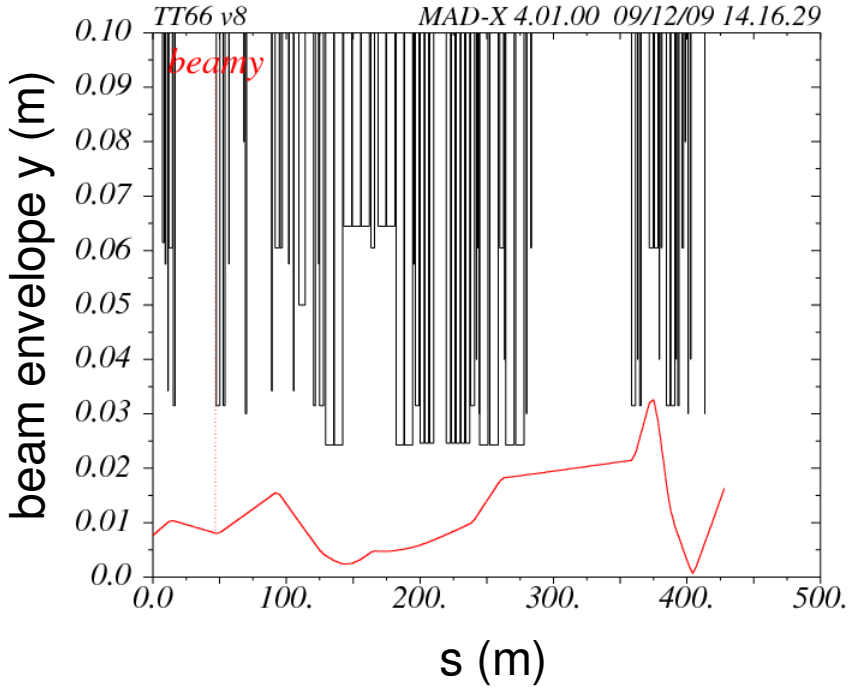


- Focal point position: start of large test stand
- Beam radius at focal point: σ = 2 mm
- 6σ beam radius and 5 mm max. trajectory deviation for beam envelope calculation assumed

WG1 – Beam line: status

38 Beam Envelope Calculation





- Focal point position: start of large test stand
- Beam radius at focal point: σ = 0.1 mm
- 6σ beam radius and 5 mm max. trajectory deviation for beam envelope calculation assumed