CONTINUOUS EB-WELDING OF THE REINFORCEMENTS OF THE CMS SUPER CONDUCTOR

Dr. Peter OVING

OUR EB SOLUTIONS MEET ALL YOUR CHALLENGES

TECHMETA
ELECTRON BEAM EXPERT
Engineering

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COMPANY INFORMATION

I. CMS SUPERCONDUCTING SOLENOID COIL

II. EB-WELDING PRODUCTION LINE SET-UP

1. Component handling
2. Electron beam welding
3. High speed machining
4. Final spooling

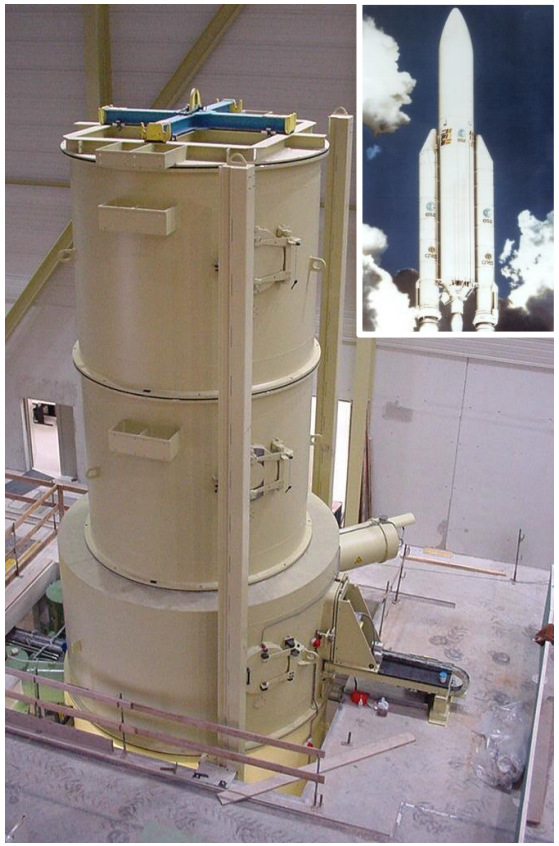
III. PROCESS CONTROL

1. Quality control
2. Ultra-Sonic control
3. Dimension check

IV. EXPERIENCE

CONCLUSION

INTERNATIONAL PROJECT EXPERIENCE



AEROSPACE – ARIANE V
Booster Welding

CERN - CMS
Superconductor Welding

AEROSPACE
Rocket Reservoirs

FRENCH NAVY
Submarine Parts

2021 - DEVELOPMENT – INSIDE CAVITY WELDING

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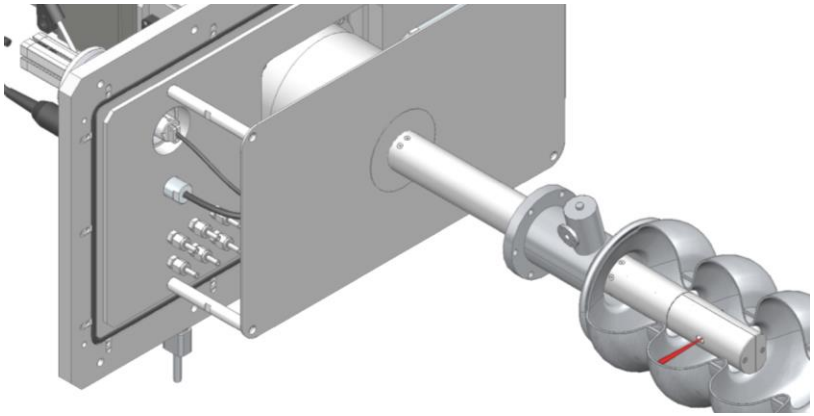
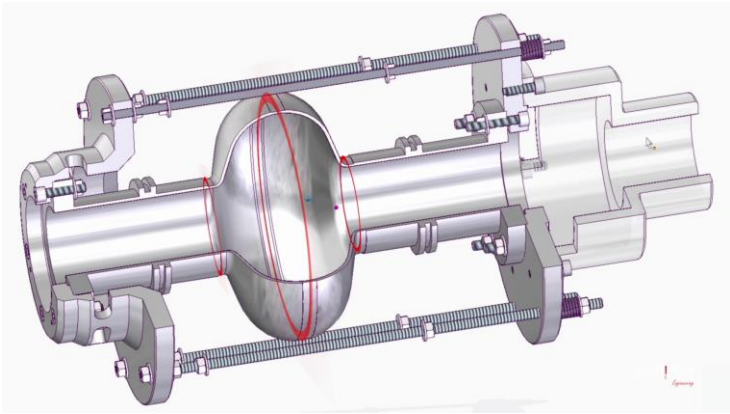
- Equator & Iris Electron Beam welds from the inside

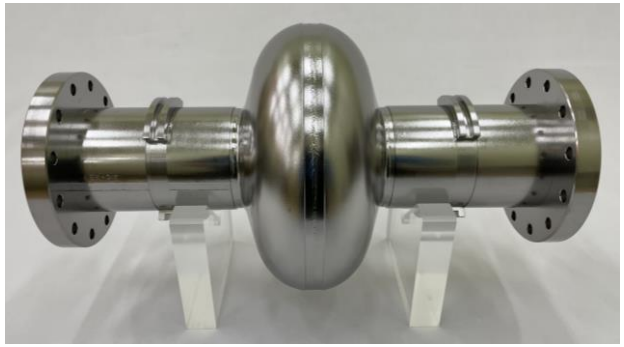




- EB inside welded 1.3GHz Single Cell Tesla Type Cavity
  Cryo temperature tested

Quality factor **1.7x10^{10}** at **35.0MV/M**

Maximal Field Gradient **37.3 MV/m** at **1.57x10^{10}**



2022 - 2023 – CONTINUOUS STRIP WELDING

- TECHMETA Strips
- **New jobshop** entity on separate production site
- Dedicated to continous strip welding > **2 Production Units**
- Operational > Begin **2023**
- Market > Automobile industry / Electrical cars

I CMS SUPERCONDUCTING SOLENOID COIL

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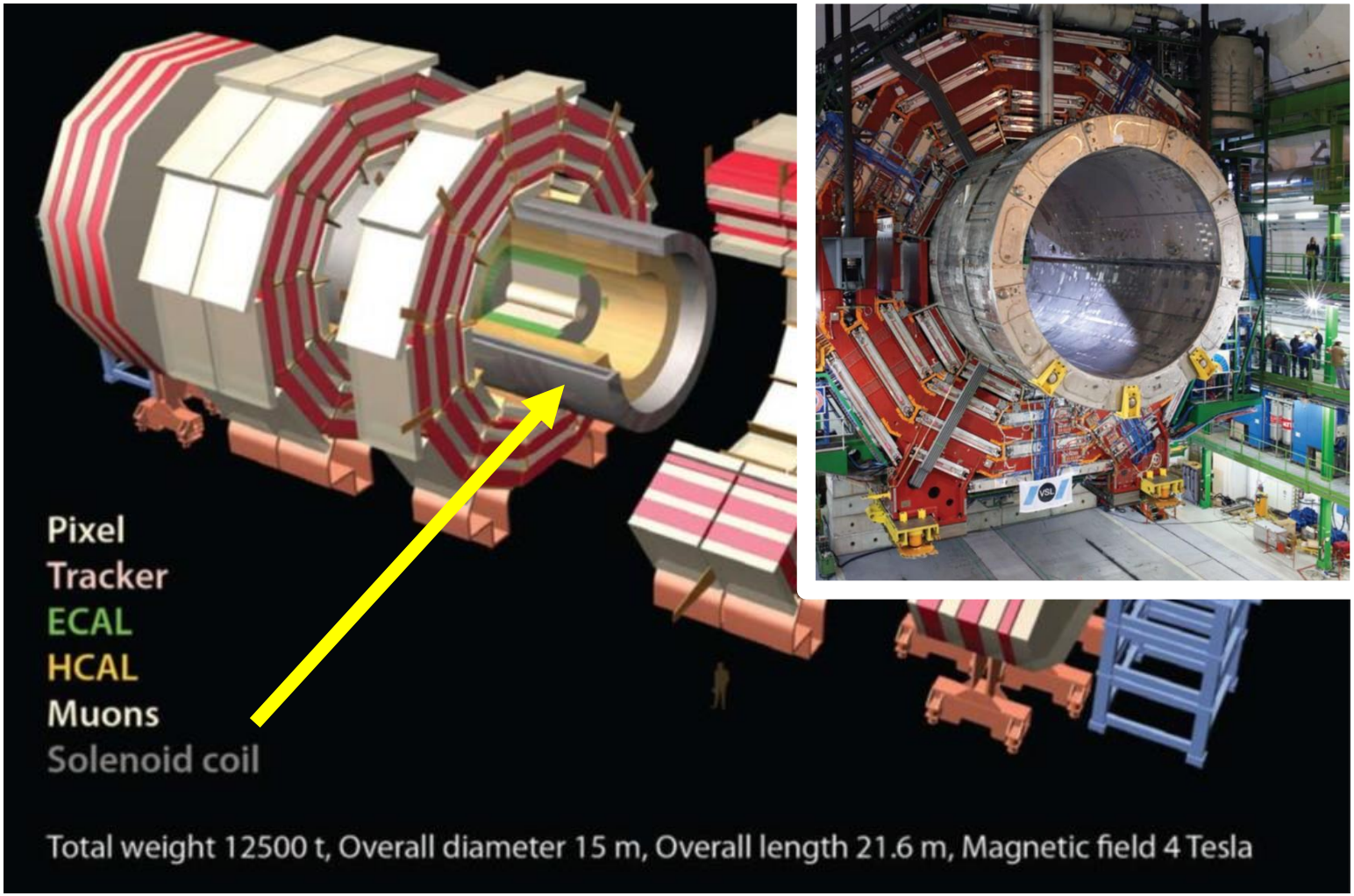
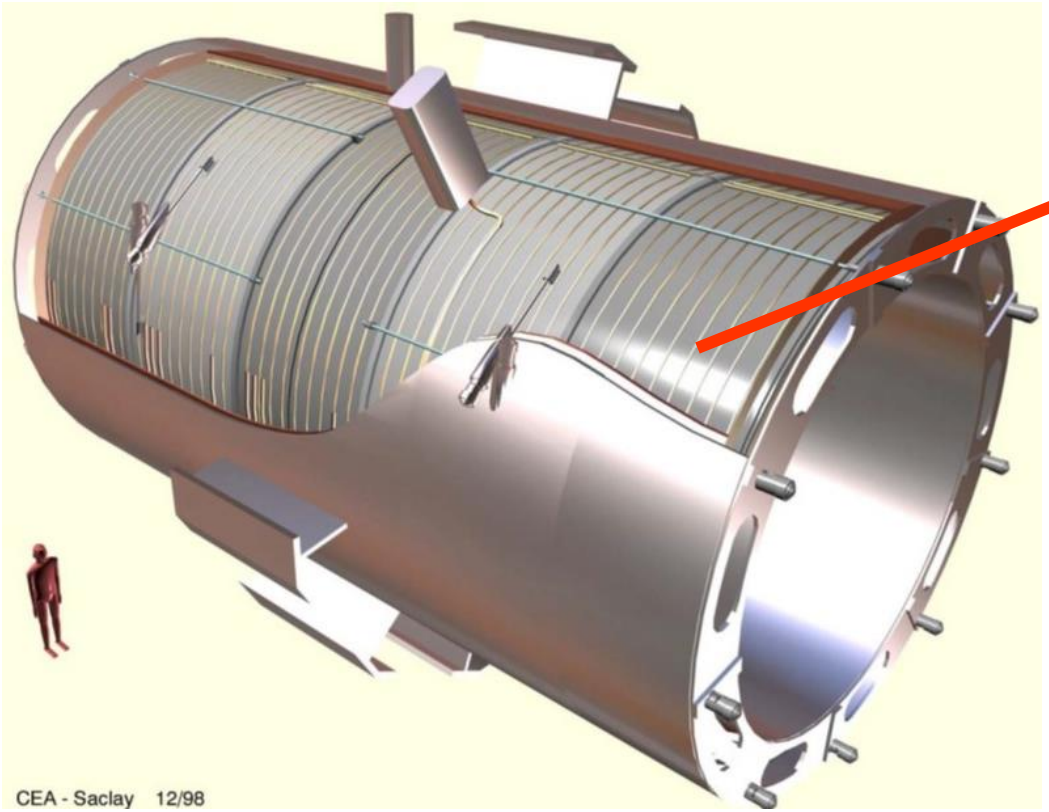
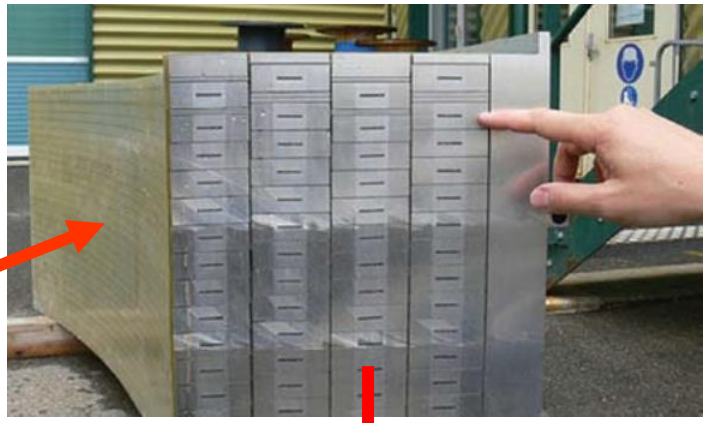
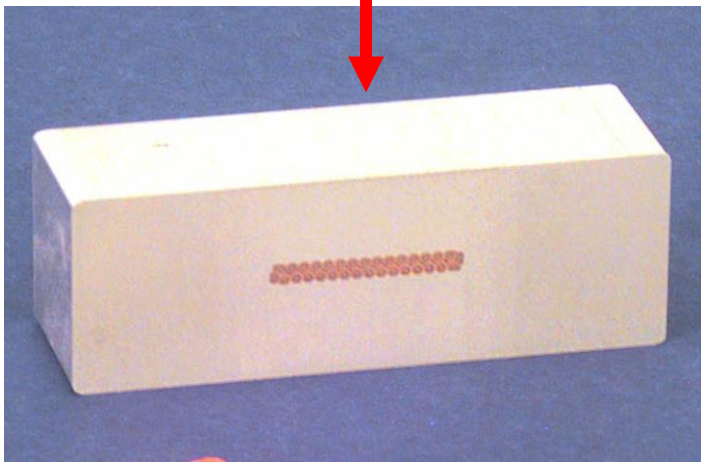


I SUPERCONDUCTOR INSERT & REINFORCEMENT

TECHMETA ELECTRON BEAM EXPERT Engineering



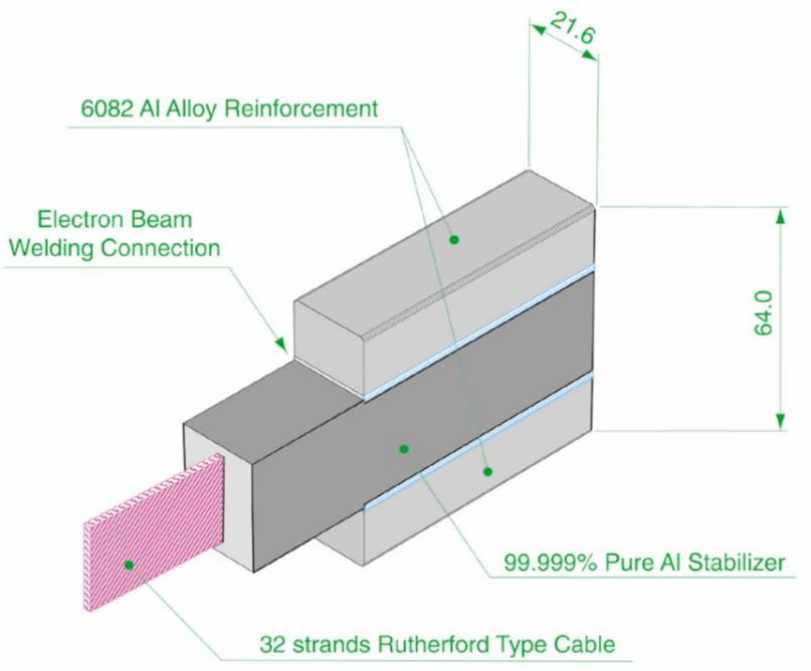


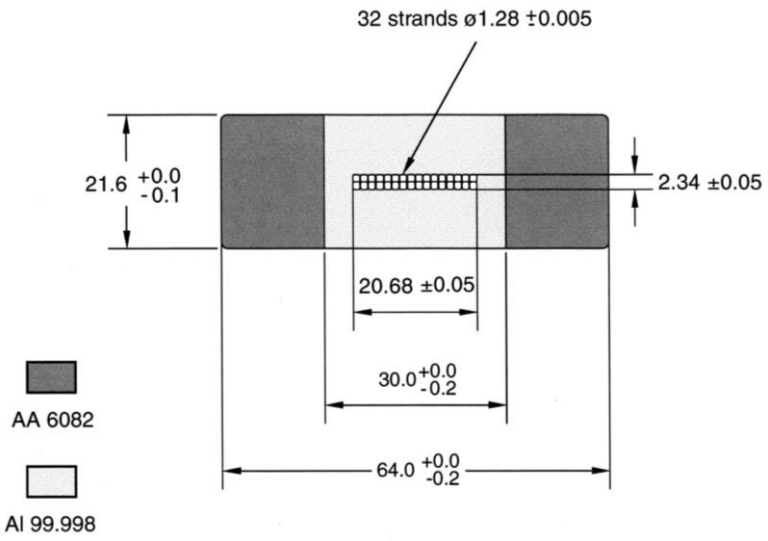


I PURE AL INSERT & AL ALLOY REINFORCEMENT

- **Simultaneous double Electron Beam weld of 2.55km length** > OK
- Soft soldering back-up solution
- Alloy co-extrusion > Temperature Critical for Superconductor > NOK

- **Simultaneous machining** > +/- 50µm thickness tolerance





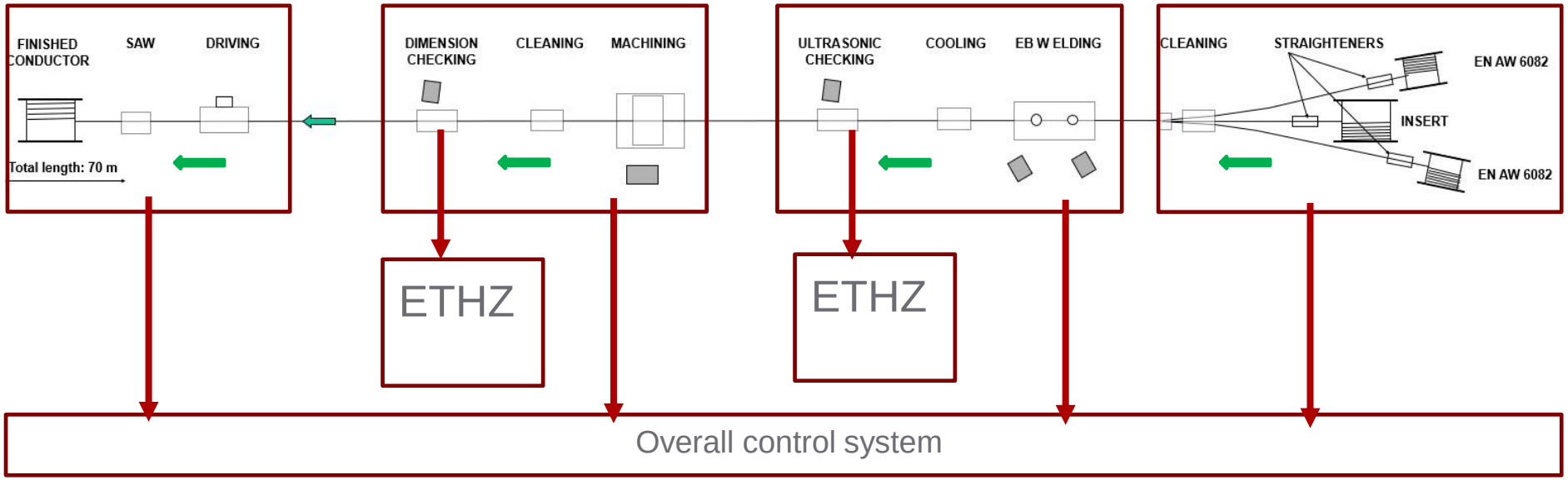
II EB-WELDING PRODUCTION LINE SET-UP

Driving
Cutting Saw
Final coil

Machining
Cleaning
Dimension Checking

EB-Welding
Cooling
US Checking

Initial 3 coils
Straighteners
Cleaners



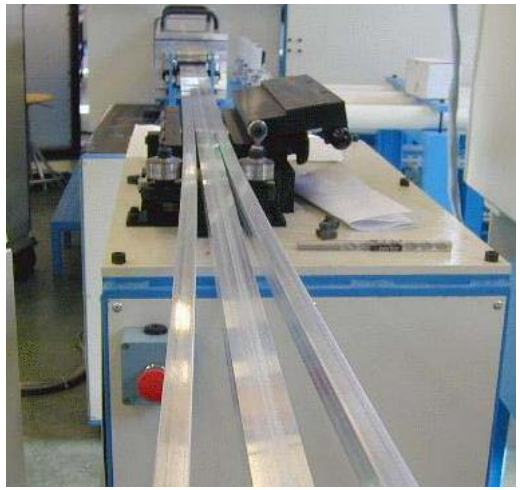
II-1 COMPONENT HANDLING & PREPARATION

II-1 COMPONENT HANDLING & PREPARATION

Pre-straightening
Straightening

Cleaning

Joining one batch to the other



II-2 ELECTRON BEAM WELDING

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Double gun > Different parameter set

II-2 ELECTRON BEAM WELDING

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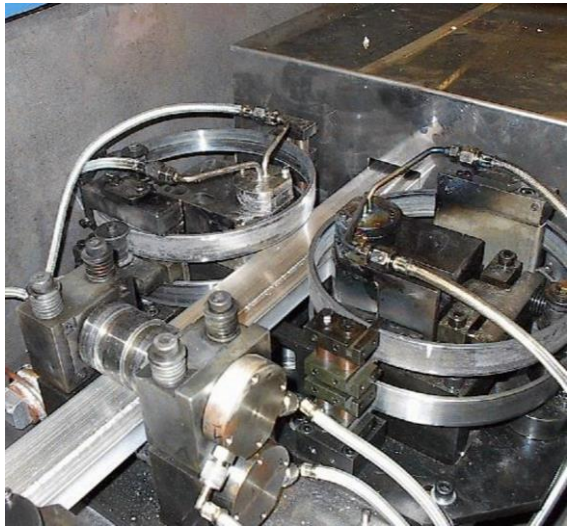
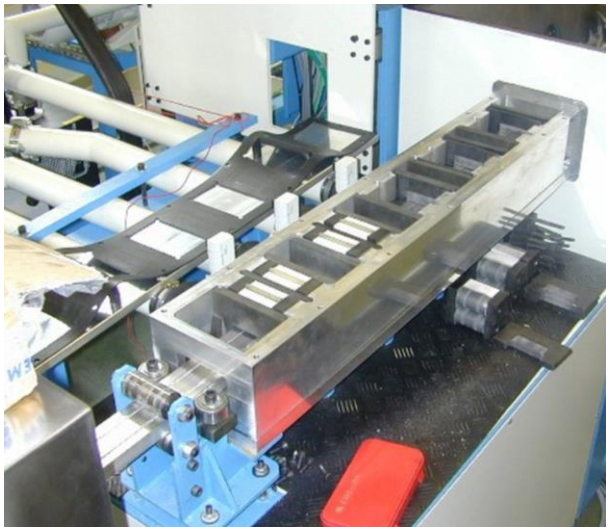
Entrance Air-Vacuum lock



Exit Air-Vacuum lock



Metal projection management

Strip lamination for exit lock

II-3 DIAMOND TOOL HIGH SPEED MACHINING

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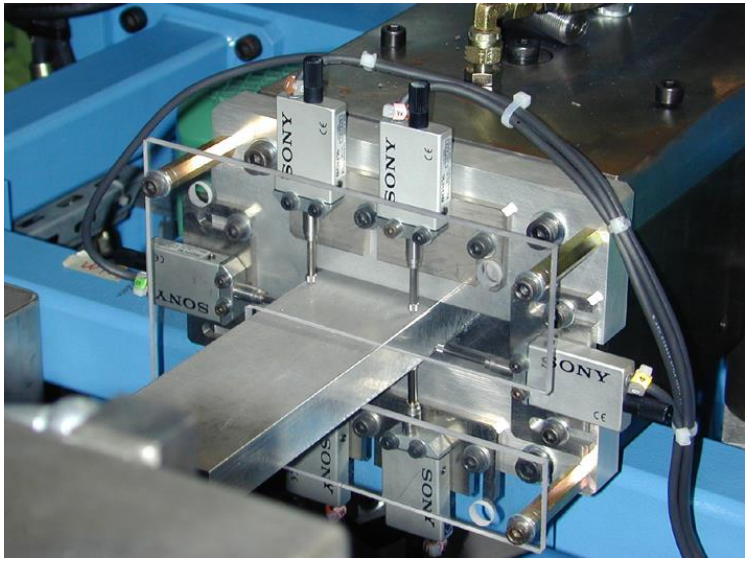
4 side + 4 corner continious maching

II-3 DIAMOND TOOL HIGH SPEED MACHINING

Machining temperature control



Machining dimensional control

II-4 SPOOLING FINAL REINFORCED STRIP

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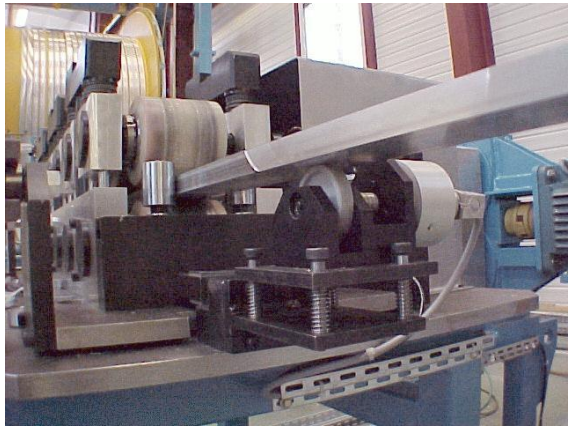
2.55km uninterrupted superconductor reinforced strip

II-4 SPOOLING FINAL REINFORCED STRIP

Caterpillar traction



Speed control

Coiling control

III PROCESS CONTROL & MANAGEMENT

- Control system integrates all synchronised consoles:
  - Commands
  - Signals
  - Alarms

- Man interventions:
  - level 1 Operator attention & Operator OK
  - level 2 Line stop without operator intervention or judgement

- Automatic parameter recording every 500ms

- Samples Begin/End of batch

- Provided by ETH Zurich:
  - EBweld bonding control by US
  - Final dimensional control by laser scanning

III-1 QUALITY CONTROL

- Stepwise process validation
  - 200m
  - 1km
  - Full length

- Acceptance certificate:
  - Provisionnal
  - Final

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CMS SC FS 0001 : Reinforcement by continuous Electron Beam Welding of the conductor of the CMS MAGNET

Order N° B 3137 1239920 May 3rd 1999

PROVISIONAL ACCEPTANCE CERTIFICATE

Data record for conductor N° EBW02 CMS 01 12.12.01

Basic products :

	N° spool number	Expected length	Real length
AA Reinforcement right	N 9	2 690 m	
AA Reinforcement left	N° 10	2 690 m	
Real Insert	CMS 01	2593 m	
Conductor			≈ 2 560 m

□ Welding specification : Left weld : DMOS N° 1573
Right weld : DMOS N° 1574

PRODUCTION PARAMETERS MONITORING :

□ Welding parameters : Copy of CD N° EBW02 CMS 01 Welding parameters

□ Dimensional : Report ETH CD N° EBW02 CMS 01 Dimensional — Valeur moyenne largeur:63,864 ép. :21,584

□ U.S. : report EMPA N° EBW02 CMS 01 US

□ Destructive testing : Report « Labo » Ref. : N° APAVE report 02.0054

Mechanical testing :

Shearing test		Minimum required 30MPA
See APAVE report 02.0054	Start of spool :Ref :1d,1e, 1f	Conforme
See APAVE report 02.0054	End of spool : Ref : 4d, 4e, 4f	Conforme

Tensile test		Breaking in pure Al zone
See APAVE report 02.0054	Start of spool : Ref : 1a, 1b, 1c	Conforme
See APAVE report 02.0054	End of spool :Ref : 4a, 4b, 4c	Conforme

Comments : Scrathes and surface irregularities have been eliminated by manual interventions.

Conclusion :
La bobine du conducteur N° …EBW02 CMS01 –12.12.01 est acceptée.

TECHMETA	ETHZ	CERN
R. CHRISTIN M. VITTET	P.L. RIBONI	R. FOLCH

Memo Reference Number : PV N° RF 436 du 15/01/02 1/4

CT 12022 05/1001

TECHMETA
TESSY
74370 PRINGY

CMS SC FS 0001 : Reinforcement by continuous Electron Beam Welding of the conductor of the CMS MAGNET

Order N° B 3137 1239920 May 3rd 1999

Distance	Evènement EBW02 CMS 01
0	- Date : 12/12/01 - Remise à zéro du compteur (longueur de real insert déjà utilisée à cet instant = 16,7 m c'est-à-dire passage du raboutage au delà de la fraiseuse. - Début de soudage pour prise d'échantillon de début de production (10h 11' 04'').
38,1	- Stop pour accrochage à la bobine après prélèvement des échantillons de début de production. - Go à vitesse établie sur le stop précédent (14h 00' 30'').
55,0	- Mesure de la température (à égale distance des 2 soudures, sur l'insert) en sortie du sas et après le dispositif de refroidissement (méthode de mesure reproduite lors de toutes les mesures effectuées au cours de la production) sas : 205° C refroidi : 39° C
339,8	- Repère longueur soudée (16h 32' 30'').
≈ 356,1	- Début d'une zone de 1,2 m de longueur avec irrégularité en surface du cordon de soudure Tous les paramètres restent constants durant la durée de l'incident, seules les pressions résiduelles enceinte et canon remontent légèrement.
405,6	- Repère longueur soudée (17h 06' 00'').
514,7	- Repère longueur soudée (18h 01' 00'').
≈ 560	- Mesure de la température : sas : 208° C refroidi : 36° C
≈ 711	- Stop opérateur fin de journée. - Nettoyage sommaire de l'outillage de soudage. - Date : 13/12/01 - Go à vitesse établie sur le stop précédent (7h 54' 15'').
757,3	- Stop opérateur suite à apparition de rayures post usinage (8h 17' 30''). - Entretien du système de guidage de la fraiseuse. - Go à vitesse établie sur le stop précédent (8h 58' 00'').
≈ 795	- Mesure de la température : sas : 211° C refroidi : 34° C

Memo Reference Number : PV N° RF 436 du 15/01/02 2/4

CT 12023 05/1001

III-2 ULTRA SONIC CONTROL

Equipment and operator by ETH Zurich

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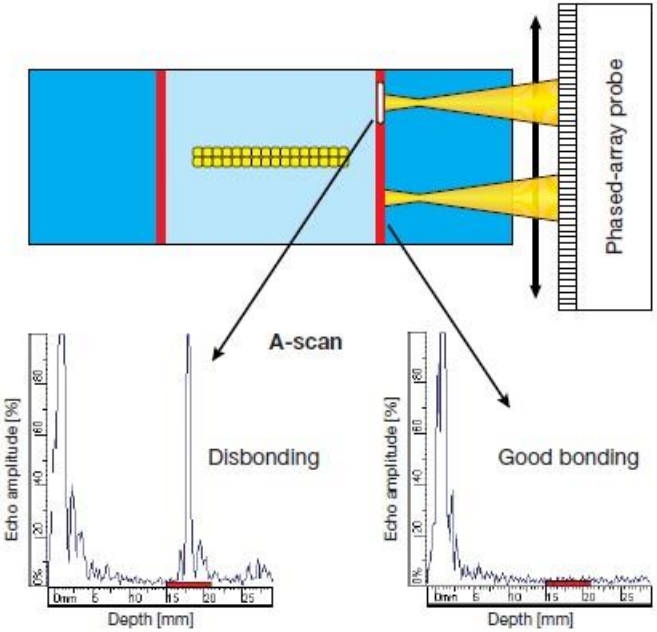
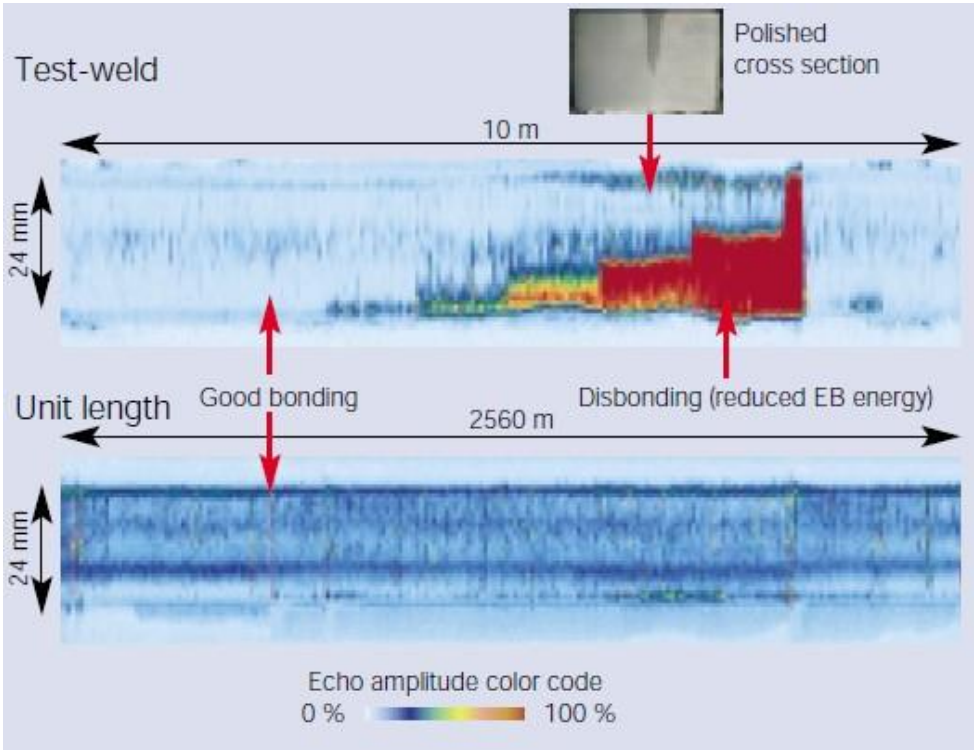
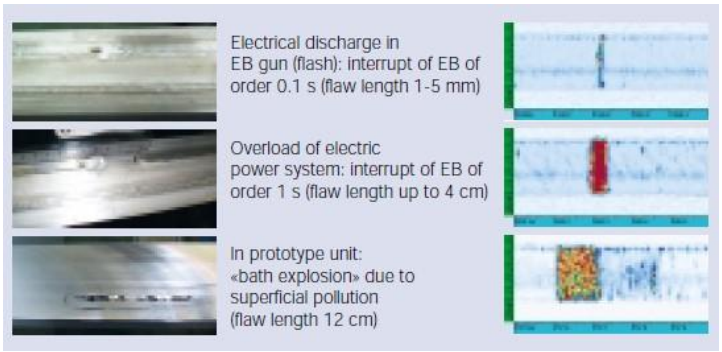
III-2 ULTRA SONIC CONTROL

Phased array Ultra Sonic system

Same control set-up as Co-extrusion control







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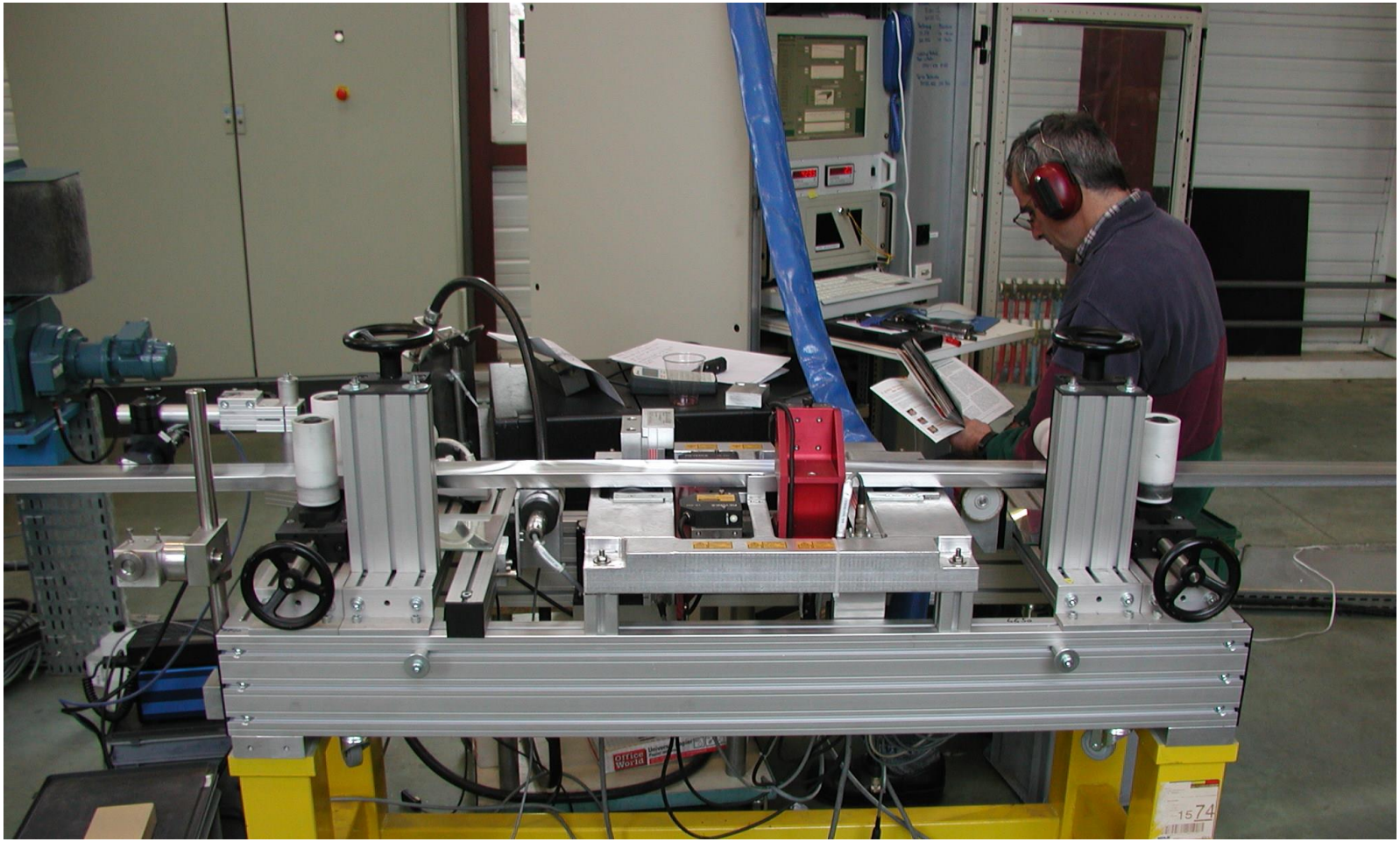
III-3 DIMENSION CHECK



Equipment and operator by ETH Zurich

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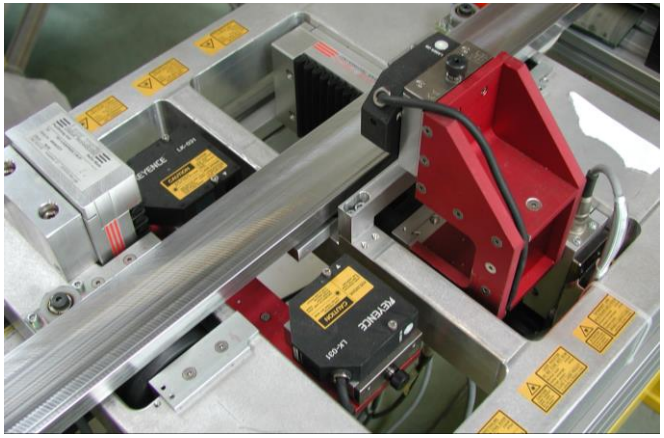
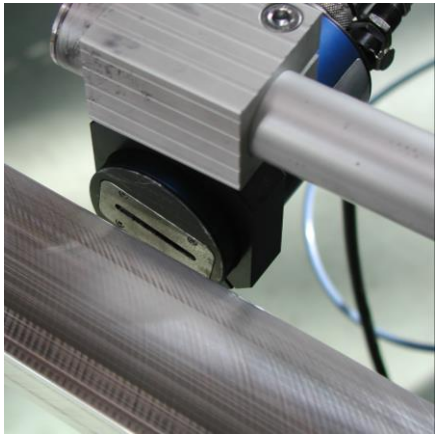
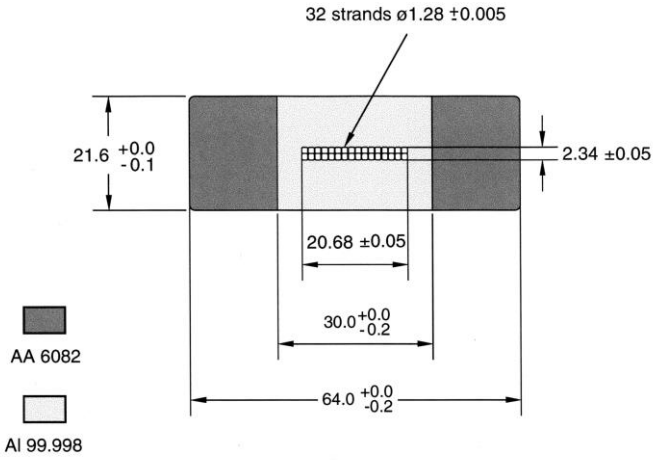
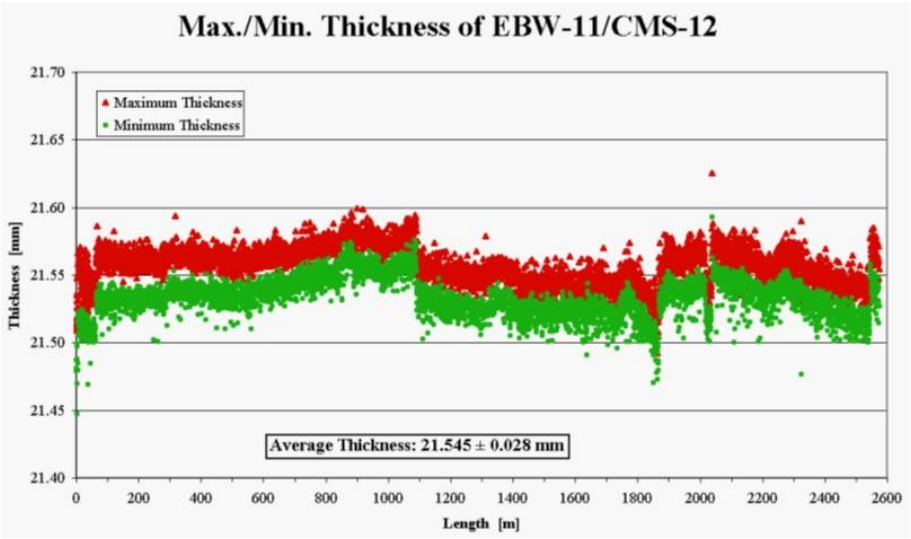
III-3 DIMENSION CHECK

- 4 inclined laser scanners


- Thickness tolerance 100µm





IV EXPERIENCE

- Processing of stiff bars before and after welding
- Micrometer machining of profile in movement
- Managing the risk of overheating of Rutherford cable

- High quality electron beam welding within specifications

- Managing of large number of operations at synchronised work stations

- Production process management & quality assessment

Greatest challenge → Simultaneous control of work stations

Electronbeam welding → No special issues

Specification adjustement: → 30mm non bonded allowed
stop & restart after 12h welding

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TIME LINE

- **1999** > **Order** May 3th
- **1999-2000** > **Realisation** of equipment
- **2001-03** > **Production period – Succesful cooperation** with ETHZ
  20 coils of 2.55km + 1 test coil
  No retreatment of complete coil
  No major incident
- **2003..** > TECHMETA: **Cristal Globe Award** 2003 from CERN/CM
  > CMS **- Succesfull assembly** of High field coil
- **2003.. 2022** > TECHMETA's **developments and skills**:
  Improved Flash management
  Improved Beam generation & guidance
  High speed seam tracking
  Ultra sonic testing
  > CMS **- Succesfull use** of high field coil

Reinforcement EB-welding
=
Proven process
v
2023 and further on…

TE > Ready for new challenges

OUR EB SOLUTIONS MEET ALL YOUR CHALLENGES

‘*Simplicity is complexity resolved*’ – C. Brancusi

TECHMETA
ELECTRON BEAM EXPERT
Engineering

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