JAGIELLONIAN
UNIVERSITY
IN KRAKÓW

SOLARIS
NATIONAL SYNCHROTRON
RADIATION CENTRE

JAGIELLONIAN UNIVERSITY IN KRAKÓW

SOLARIS NATIONAL SYNCHROTRON RADIATION CENTRE

From green-field project to high resolution photons: case study from the NCPS SOLARIS Synchrotron Project

Bad Zurzach, 5.05.2026

Jarosław Wiechecki

National Synchrotron Radiation Centre SOLARIS

Agenda

1. Overview
2. Case study and major problems
3. Summary

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OVERVIEW

Overview (1)

- First synchrotron in Poland and in Central Europe
- Location: Kraków, Poland
- Part of the Jagiellonian University
- The synchrotron was created thanks to project and cooperation with MAX IV Laboratory

Design phase

- Since 2010
- Building design, machine design, obtaining financing
- Crew: ~15 members (status: January 2012)

Operational phase

- Since May 2015
- Construction completed
- Linac, storage ring and two beamlines after commissioning
- Total cost 50 mln €
- Crew: 50 members

Further expansion of the building

- 2023
- Enlargement of the experimental hall (additional space for new beamlines)
- Total cost 40 mln €
- Crew: 150 members (status: April 2026)

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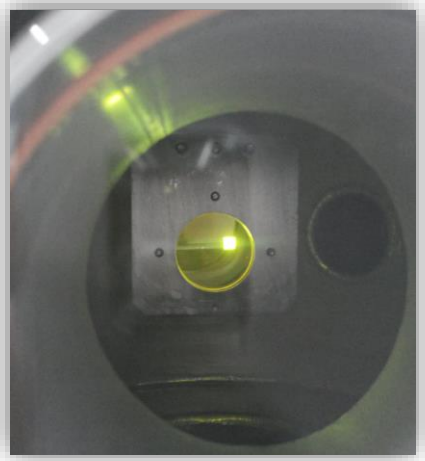
Overview (2)

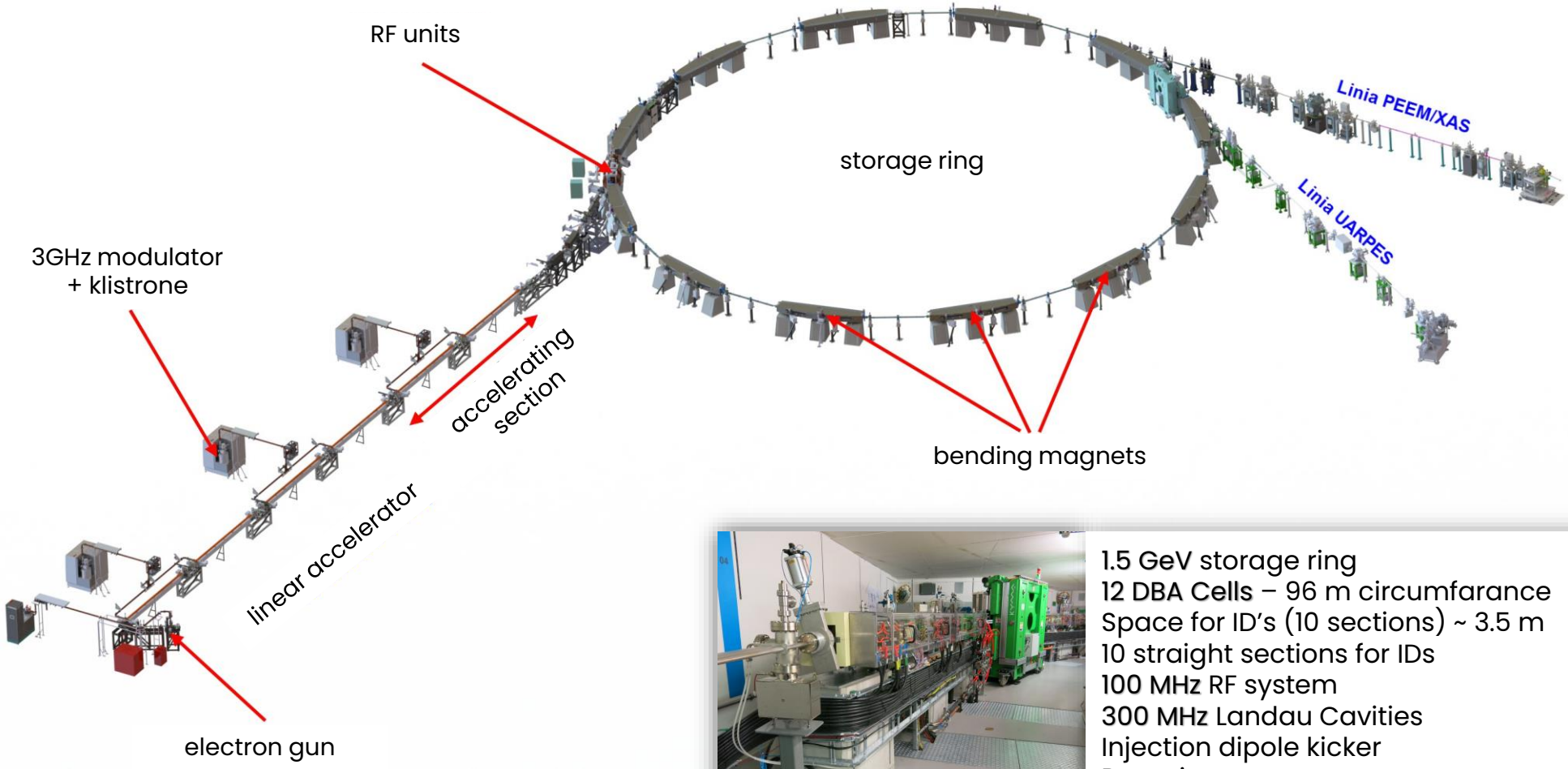
final stage - 2015



„green field" - 01.2012

current status - 2026

Overview (3)



1.5 GeV storage ring
12 DBA Cells – 96 m circumfarance
Space for ID's (10 sections) ~ 3.5 m
10 straight sections for IDs
100 MHz RF system
300 MHz Landau Cavities
Injection dipole kicker
Ramping

600 MeV Linac with RF Thermionic Gun
6 accelerating structures combined in 3 units
Accelerating gradient 20 MeV/m
S-band – 2998.5 MHz
3 RF Units & SLED cavities
In operation since Dec. 2014

Overview (4)

12x Storage ring achromats

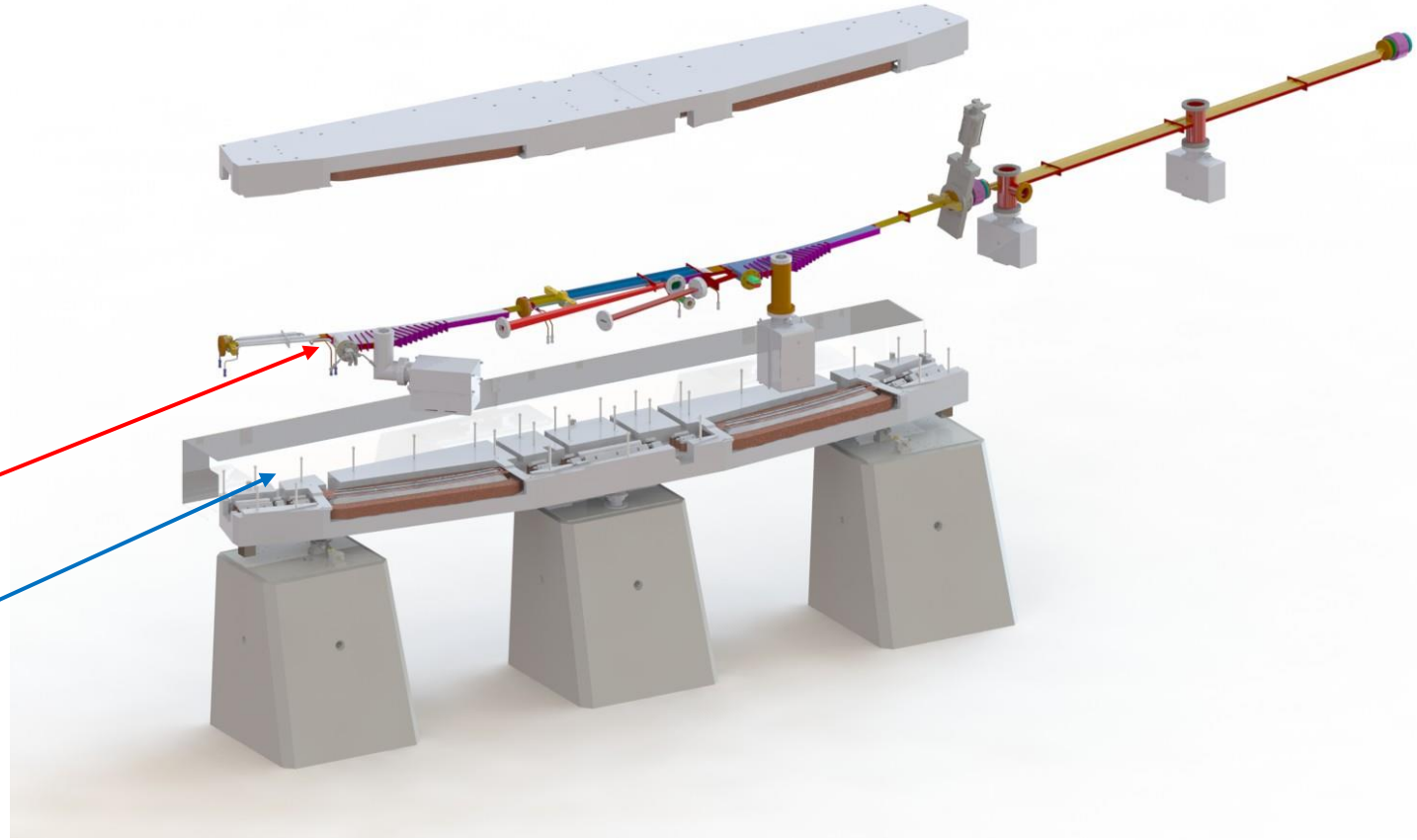
(Double Bend Achromats)

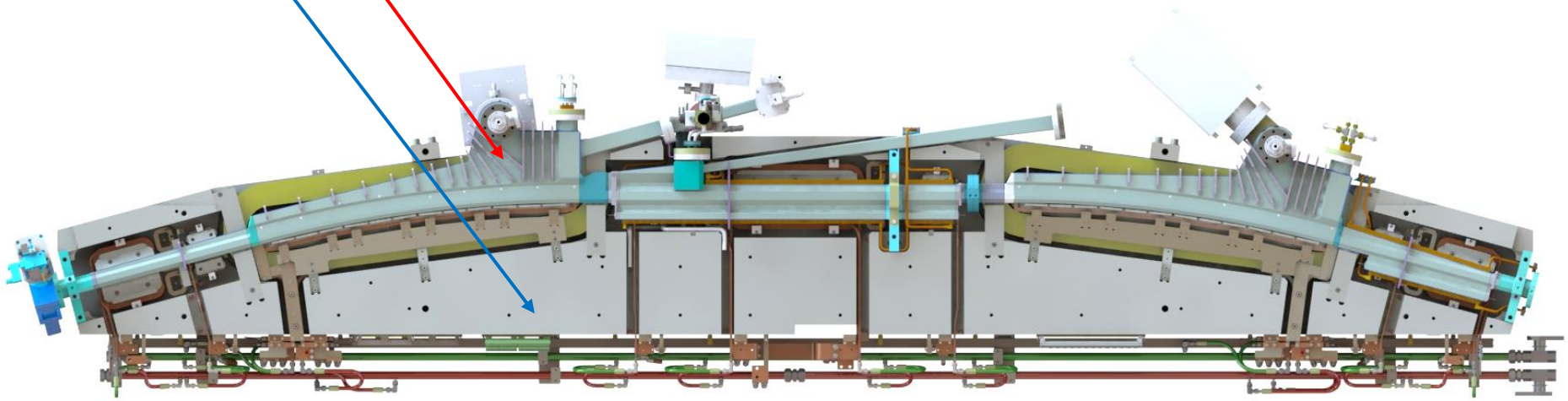
Total weight: 8 tons

Total length: 5 meters

vacuum chamber

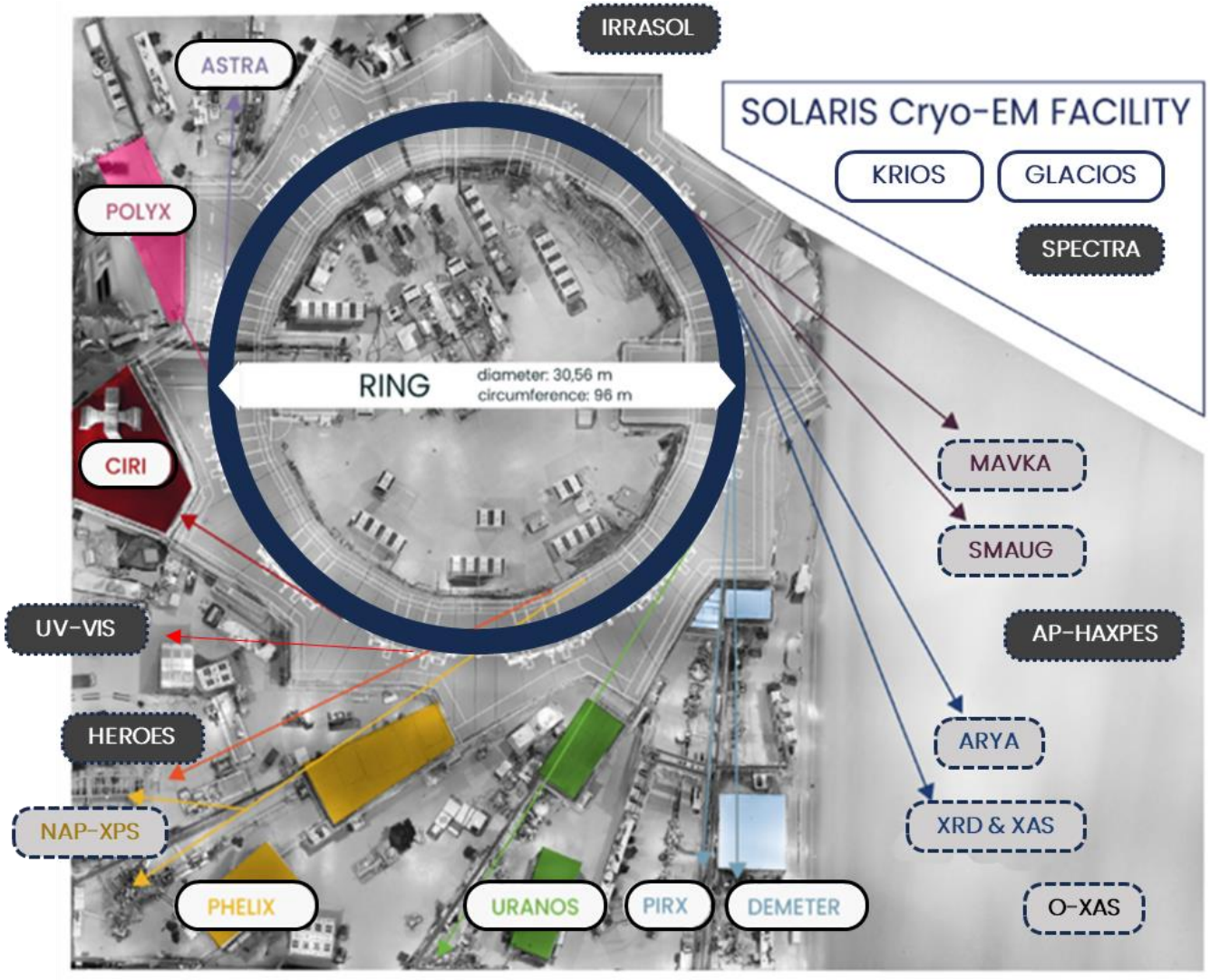
bending magnet





Overview (5)

Beam Lines



DZIAŁAJĄCE
7 linii *(10 infrastruktur)*
2 kriomikroskopy

BUDOWANE
4 linie *(6 infr.)*

PLANY
3 linie *(4 inf.)*
1 mikroskop

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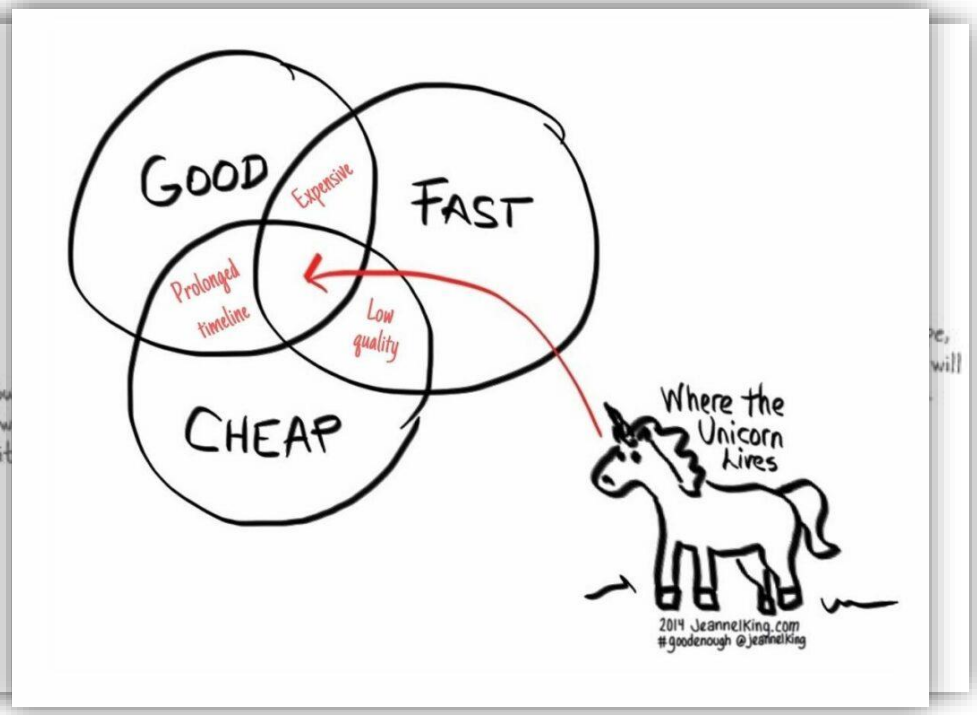
CASE STUDY

Main topics

work schedule
money
manager
people
tender
construction
machine installation
logistics
IT systems

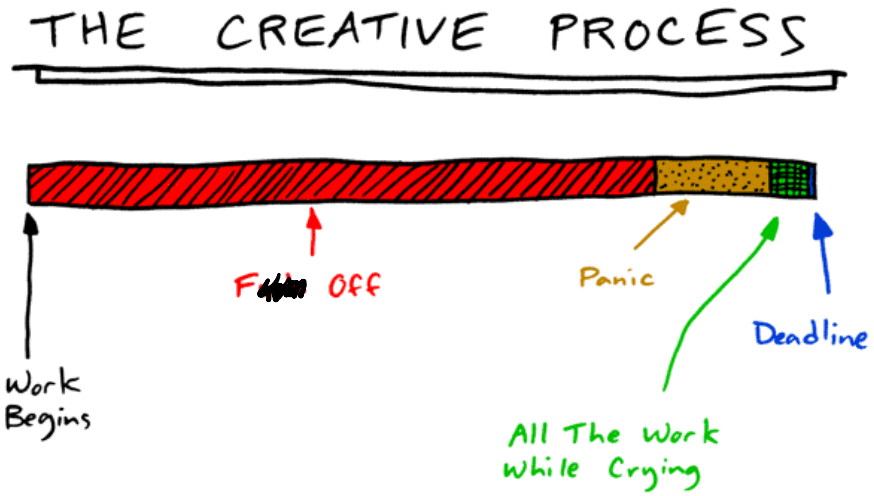

GOOD
FAST
CHEAP
Expensive
Prolonged timeline
Low quality
Where the Unicorn Lives
2014 JeanneIKing.com
#goodenough @jeanneIKing

Work schedule

- SOLARIS was / is using Gantt Diagram for all activities (currently for every shutdown)
- Every activity has been put into work schedule including:
  - manpower,
  - deliveries,
  - overcrossing activities,
  - logistics,
  - available storage space, etc.
- It is important to implement every update….
- …and to discuss every changes and its possible consequences.
- If possible, the schedule must be flexible especially for construction site changes (civil engineering)

The deadline for Solaris was **2015** whereas for MAX IV Laboratory it was **2016**

Lack of information. SOLARIS had to deal with problems on their own and had to search for solutions



Financing / Money

- **There will always be not enough money**

- Stock exchange approach towards payment in foreign currency.
- Fit into currency conversion and its variations

- Unfortunately, there are circumstances beyond our control that affect the financial resources in the project, such as:
  - financial crisis,
  - pandemic,
  - war,
  - disruptions in the supply chain of components and raw materials,
  - currency exchange rate,
  - inflation
  - etc.

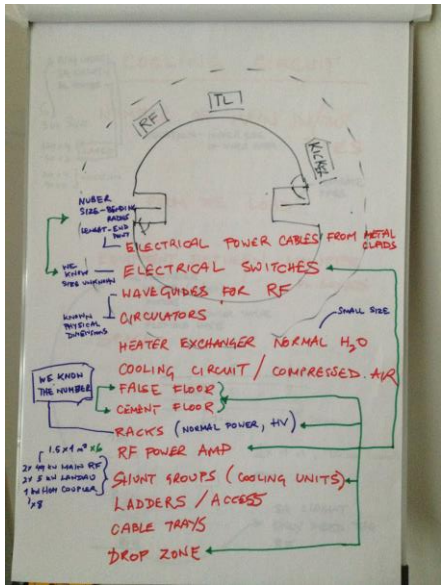
Purchase

- Because Solaris is a public entity, we had to comply with regulations within the range of **public procurement law**.
- However, due to schedule constraints, we had to find alternative routes to shorten and ease this path:
  - Framework agreements enabled the purchase of additional components for Solaris "in conjunction" with the MAX IV orders. This resulted in additional economies of scale and, consequently, reduced costs.
  - Tenders - orders were placed by proven suppliers and established procurement paths. The purchasing specifications were used by both centers: SOLARIS and MAX IV.
  - External companies (sub suppliers) for „dirty" and „clean" installations
- SPLIT & COMBINE method – purchase of problematic equipment, in accordance with the art of public tenders, but in such a way as to avoid complicated procedures, e.g.:
  - Tools for all divisions in synchrotron – combined, single order.
  - Purchasing individual devices and separating them from the main setup to stay below the tender threshold.

Could you tell me the exact amount of steel supports,
that you will need in the project?

Question from Procurement Office 2012

Management



- Project leader from outside the universities structure - Carlo Bocchetta
- A dedicated person hired to complete a specific task within a finite timeframe.
- Rule 80/20
- Change and risk management

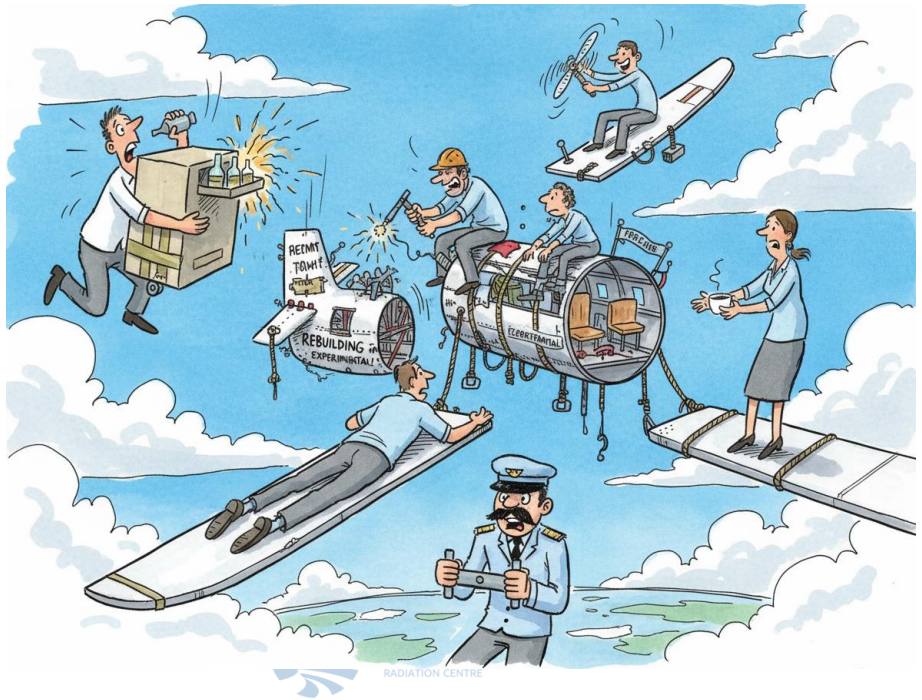
- Additional validation of work progress through periodic meetings of the Machinery Advisory Committee (MAC)

- The beginning of the existing organizational structure - the crystallization of managers of individual sections: MAG, MECH, HVAC, VAC, ELEK, PLC, IT...

- Risk of micromanagement

Human resources (1)

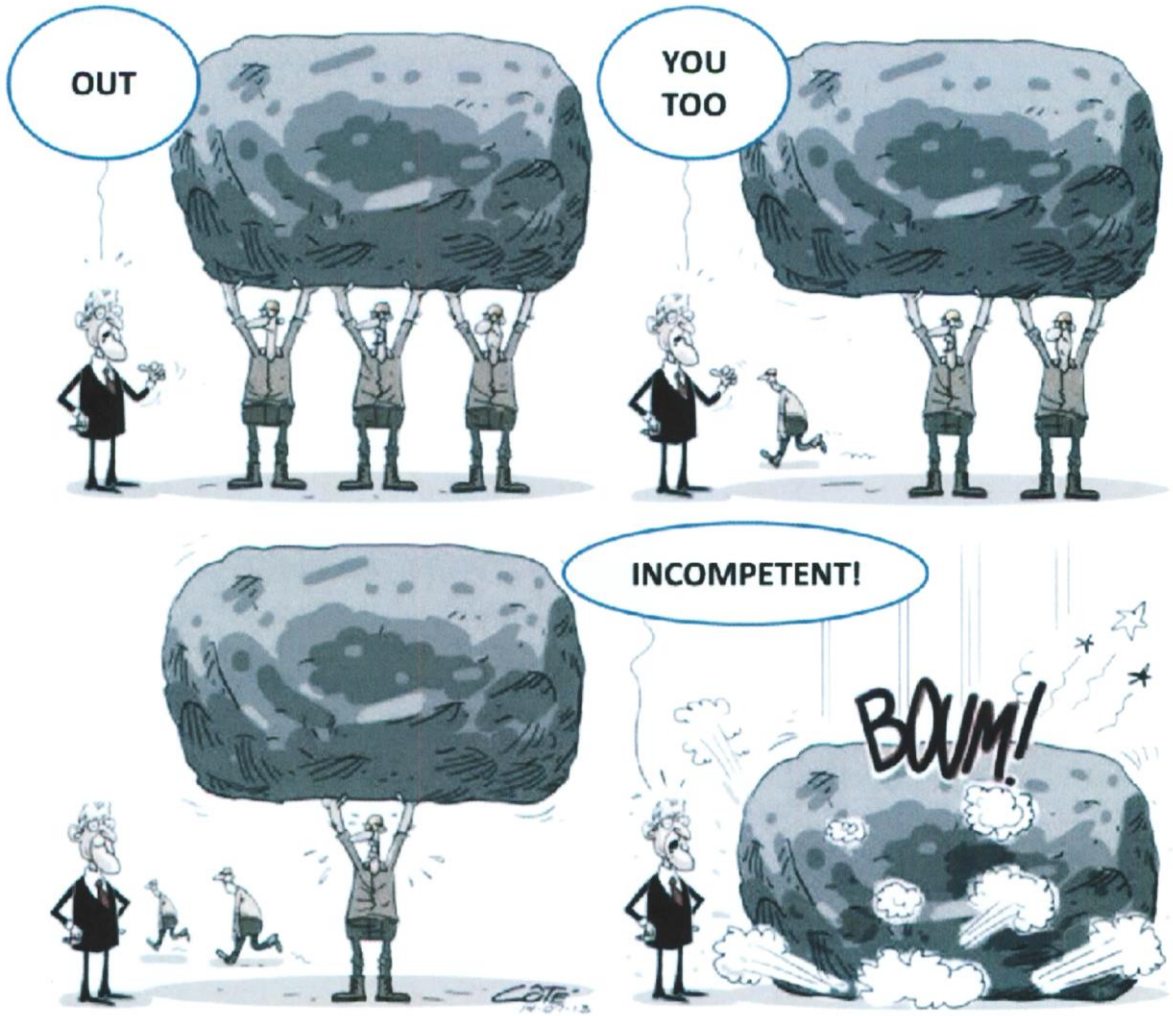
- Building team competencies in accelerator techniques (mid 2012 ~ 15 people)
  - Lack of experience in work being carried out
  - Specialists with expertise in their field, which had to be adapted to Solaris unique infrastructure
  - Lack of understanding of the scale of the investment - people were performing the functions of several specialists simultaneously
  - Five people from Solaris team were permanently supporting the construction of MAX IV
- Cooperation with other synchrotrons
  - Elettra Sincrotrone Trieste
  - MAX IV
  - PSI
- Support of additional subcontractors:
  - Mechanical workshop and „dirty work”
  - Vacuum installation and „clean work”
  - Building installations (cables, pipes etc.)



Human resources (2)

- Risk of team members burnout

- The Solaris Team from time perspective:
  - A highly creative team
  - A pleasant atmosphere
  - Mutual reliance
  - Passion
  - Open-minded
  - A dynamic project manager



Suppliers and sub-suppliers, contractors and subcontractors (1)

- Civil engineering: **construction supervision by Solaris,** not only from the University and the construction company
- **A loophole must be created for possible changes** – up to a certain point in time schedule, some changes can be implemented, after that there is no way back (e.g., barite walls, linac, and ring).
- Our schedule assumed **completion of the project before MAX IV** – at certain point, Solaris was giving the feedback to MAX IV, discovering errors (e.g. short circuits in the achromats and a hole for the TL in the concrete floor).

OUR EXPECTATIONS ≠ WHAT WE GET

Suppliers and sub-suppliers, contractors and subcontractors (2)

- Dealing with a tug-of-war: the investor wants the construction company to complete this project precisely, whereas the contractor wants it to accomplish everything quickly and affordably.
- The contract with the construction company should include all possible aspects and variants of the work. Since this is difficult to enforce on a later stage, e.g. work interruption due to vibrations from heavy equipment and the impact on the beam, or dust in the hall.
- Accuracy issues: for civil engineering it is at the level of a „horse's fingernail", but for us, the requirements are up to several dozen micrometers.
- Flexibility in construction requires good will on both sides: investor and contractor

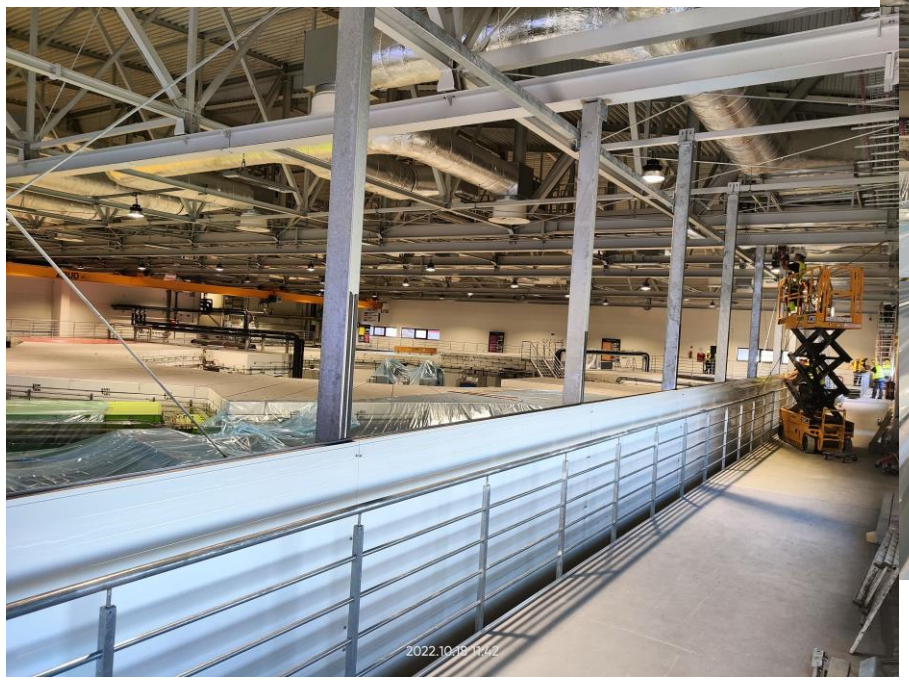
drilling of the additional holes

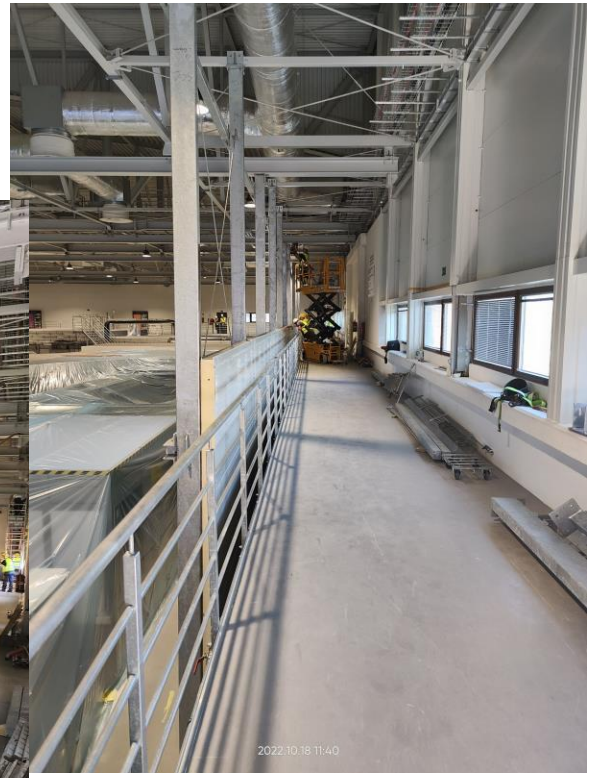
additional shielding wall

new holes for the beamlines squaring the circle

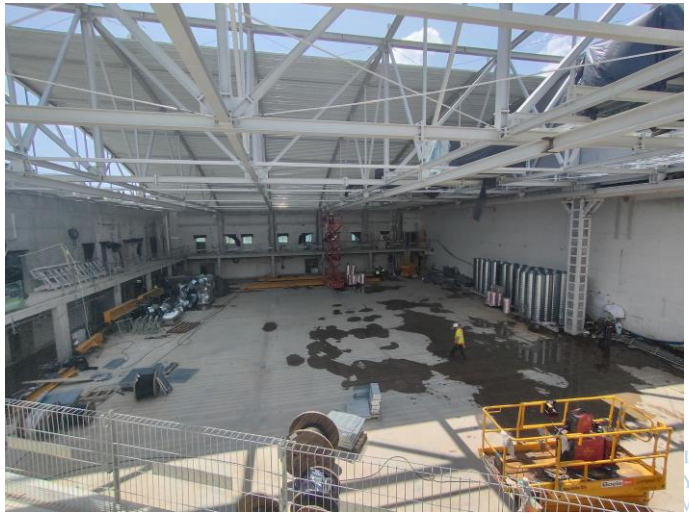
Suppliers and sub-suppliers, contractors and subcontractors (3)

antvibration layer





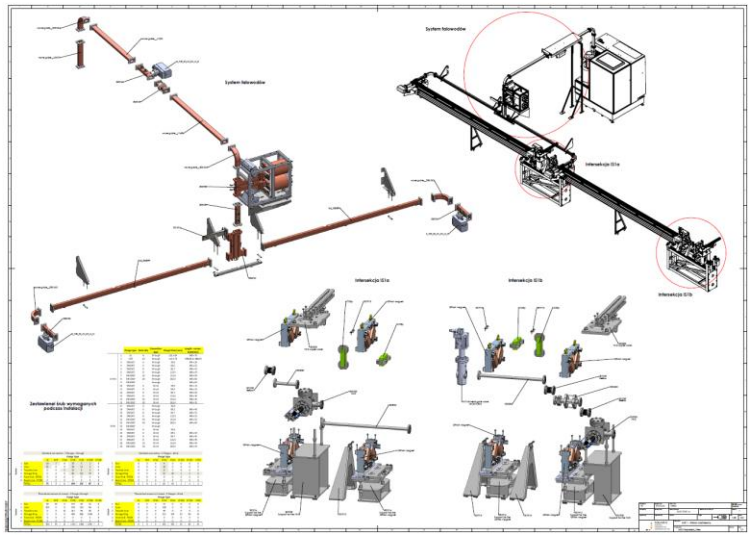
additional shielding wall against dust



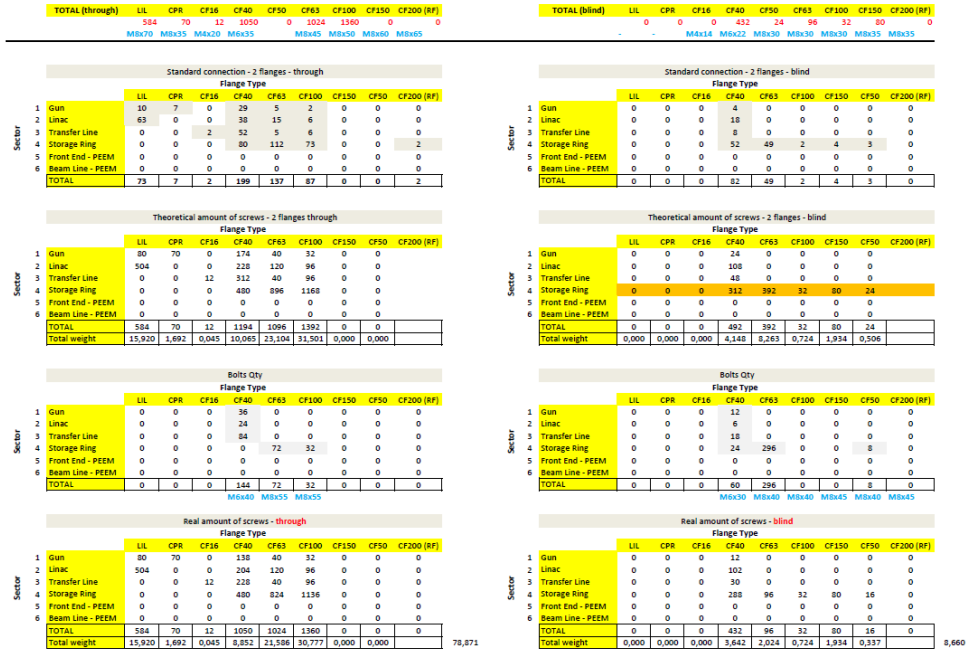
new experimental hall

Machine installation (1)

- GOLDEN RULE: lattice is the center of the universe
- Current installation:
  - Preparation of the installation procedures
  - Preparation of the guidelines for external companies
  - Preparation of the materials and additional equipment
  - Equipping laboratories and workshops
  - Vacuum components installation and their bakeout
  - Alignment
  - Machine conditioning



installation documentation



TOTAL (through)

	LIL	CPR	CF16	CF40	CF50	CF63	CF100	CF150	CF200 (RF)
	584	70	12	1050	0	1024	1360	0	0
	M8x70	M8x35	M4x20	M6x55		M8x45	M8x50	M8x60	M8x65

TOTAL (blind)

	LIL	CPR	CF16	CF40	CF50	CF63	CF100	CF150	CF200 (RF)
	0	0	0	432	24	96	32	80	0
	-	-	M4x14	M6x22	M8x30	M8x30	M8x30	M8x35	M8x35

Standard connection - 2 flanges - through

Flange Type

Sector		LIL	CPR	CF16	CF40	CF63	CF100	CF150	CF50	CF200 (RF)
1	Gun	10	7	0	29	5	2	0	0	0
2	Linac	63	0	0	38	15	6	0	0	0
3	Transfer Line	0	0	2	52	5	6	0	0	0
4	Storage Ring	0	0	0	80	112	73	0	0	2
5	Front End - PEEM	0	0	0	0	0	0	0	0	0
6	Beam Line - PEEM	0	0	0	0	0	0	0	0	0
	TOTAL	73	7	2	199	137	87	0	0	2

Standard connection - 2 flanges - blind

Flange Type

Sector		LIL	CPR	CF16	CF40	CF63	CF100	CF150	CF50	CF200 (RF)
1	Gun	0	0	0	4	0	0	0	0	0
2	Linac	0	0	0	18	0	0	0	0	0
3	Transfer Line	0	0	0	8	0	0	0	0	0
4	Storage Ring	0	0	0	52	49	2	4	3	0
5	Front End - PEEM	0	0	0	0	0	0	0	0	0
6	Beam Line - PEEM	0	0	0	0	0	0	0	0	0
	TOTAL	0	0	0	82	49	2	4	3	0

Theoretical amount of screws - 2 flanges through

Flange Type

Sector		LIL	CPR	CF16	CF40	CF63	CF100	CF150	CF50	CF200 (RF)
1	Gun	80	70	0	174	40	32	0	0	
2	Linac	504	0	0	228	120	96	0	0	
3	Transfer Line	0	0	12	312	40	96	0	0	
4	Storage Ring	0	0	0	480	896	1168	0	0	
5	Front End - PEEM	0	0	0	0	0	0	0	0	
6	Beam Line - PEEM	0	0	0	0	0	0	0	0	
	TOTAL	584	70	12	1194	1096	1392	0	0	
	Total weight	15,920	1,692	0,045	10,065	23,104	31,501	0,000	0,000	

Theoretical amount of screws - 2 flanges - blind

Flange Type

Sector		LIL	CPR	CF16	CF40	CF63	CF100	CF150	CF50	CF200 (RF)
1	Gun	0	0	0	24	0	0	0	0	
2	Linac	0	0	0	108	0	0	0	0	
3	Transfer Line	0	0	0	48	0	0	0	0	
4	Storage Ring	0	0	0	312	392	32	80	24	
5	Front End - PEEM	0	0	0	0	0	0	0	0	
6	Beam Line - PEEM	0	0	0	0	0	0	0	0	
	TOTAL	0	0	0	492	392	32	80	24	
	Total weight	0,000	0,000	0,000	4,148	8,263	0,724	1,934	0,506	

Bolts Qty

Flange Type

Sector		LIL	CPR	CF16	CF40	CF63	CF100	CF150	CF50	CF200 (RF)
1	Gun	0	0	0	36	0	0	0	0	0
2	Linac	0	0	0	24	0	0	0	0	0
3	Transfer Line	0	0	0	84	0	0	0	0	0
4	Storage Ring	0	0	0	0	72	32	0	0	0
5	Front End - PEEM	0	0	0	0	0	0	0	0	0
6	Beam Line - PEEM	0	0	0	0	0	0	0	0	0
	TOTAL	0	0	0	144	72	32	0	0	0
					M6x40	M8x55	M8x55			

Bolts Qty

Flange Type

Sector		LIL	CPR	CF16	CF40	CF63	CF100	CF150	CF50	CF200 (RF)
1	Gun	0	0	0	12	0	0	0	0	0
2	Linac	0	0	0	6	0	0	0	0	0
3	Transfer Line	0	0	0	18	0	0	0	0	0
4	Storage Ring	0	0	0	24	296	0	0	8	0
5	Front End - PEEM	0	0	0	0	0	0	0	0	0
6	Beam Line - PEEM	0	0	0	0	0	0	0	0	0
	TOTAL	0	0	0	60	296	0	0	8	0
					M6x30	M8x40	M8x40	M8x45	M8x40	M8x45

Real amount of screws - through

Flange Type

Sector		LIL	CPR	CF16	CF40	CF63	CF100	CF150	CF50	CF200 (RF)
1	Gun	80	70	0	138	40	32	0	0	0
2	Linac	504	0	0	204	120	96	0	0	0
3	Transfer Line	0	0	12	228	40	96	0	0	0
4	Storage Ring	0	0	0	480	824	1136	0	0	0
5	Front End - PEEM	0	0	0	0	0	0	0	0	0
6	Beam Line - PEEM	0	0	0	0	0	0	0	0	0
	TOTAL	584	70	12	1050	1024	1360	0	0	0
	Total weight	15,920	1,692	0,045	8,852	21,586	30,777	0,000	0,000	

78,871

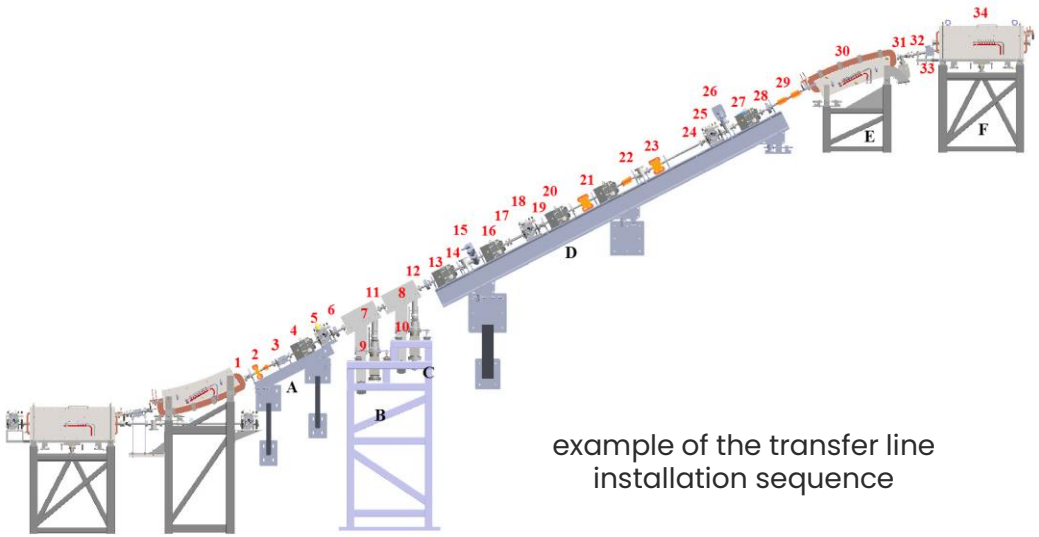
Real amount of screws - blind

Flange Type

Sector		LIL	CPR	CF16	CF40	CF63	CF100	CF150	CF50	CF200 (RF)
1	Gun	0	0	0	12	0	0	0	0	0
2	Linac	0	0	0	102	0	0	0	0	0
3	Transfer Line	0	0	0	30	0	0	0	0	0
4	Storage Ring	0	0	0	288	96	32	80	16	0
5	Front End - PEEM	0	0	0	0	0	0	0	0	0
6	Beam Line - PEEM	0	0	0	0	0	0	0	0	0
	TOTAL	0	0	0	432	96	32	80	16	0
	Total weight	0,000	0,000	0,000	3,642	2,024	0,724	1,934	0,337	

8,660

BOM for fasteners

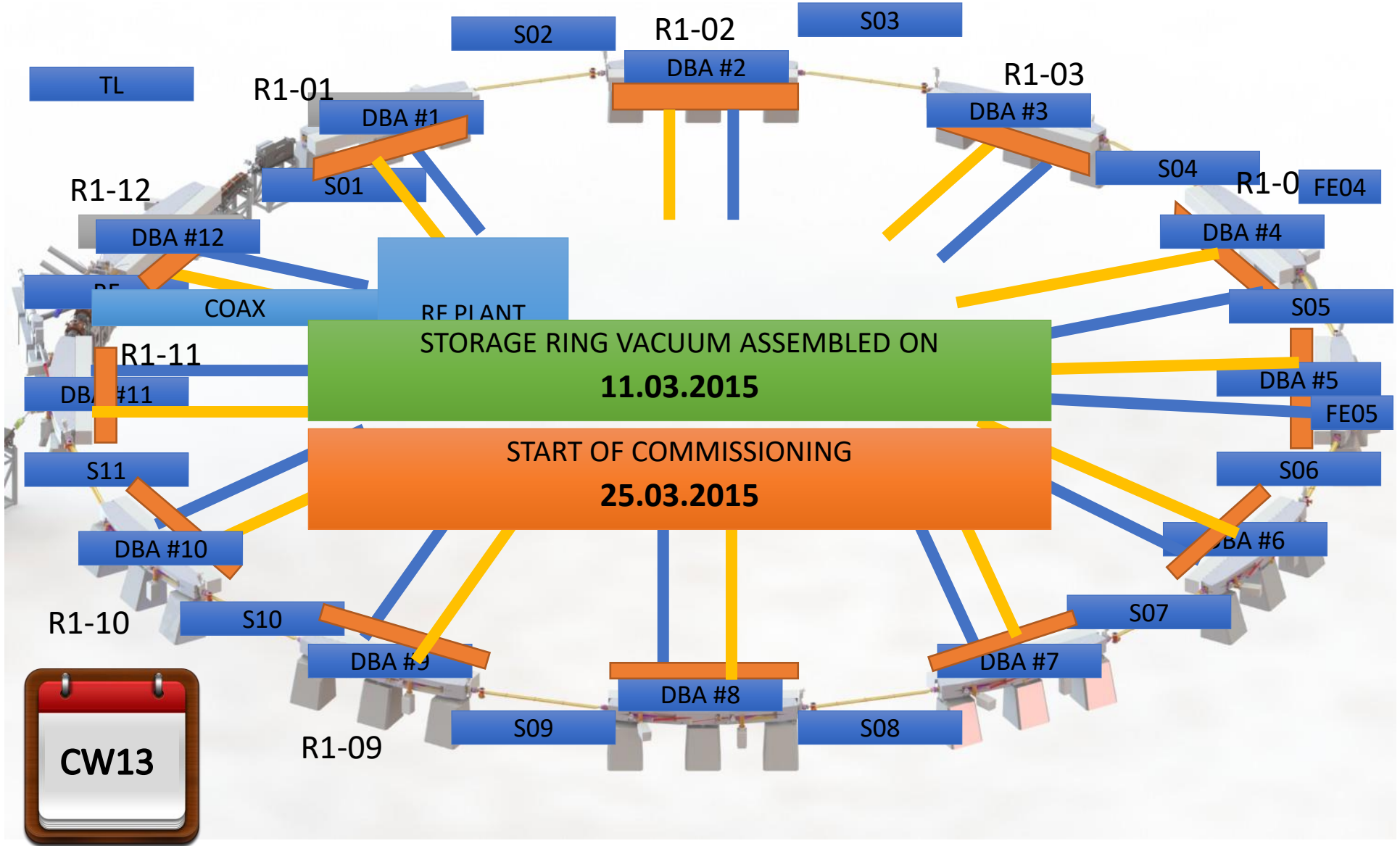


example of the transfer line installation sequence

Machine installation (2)

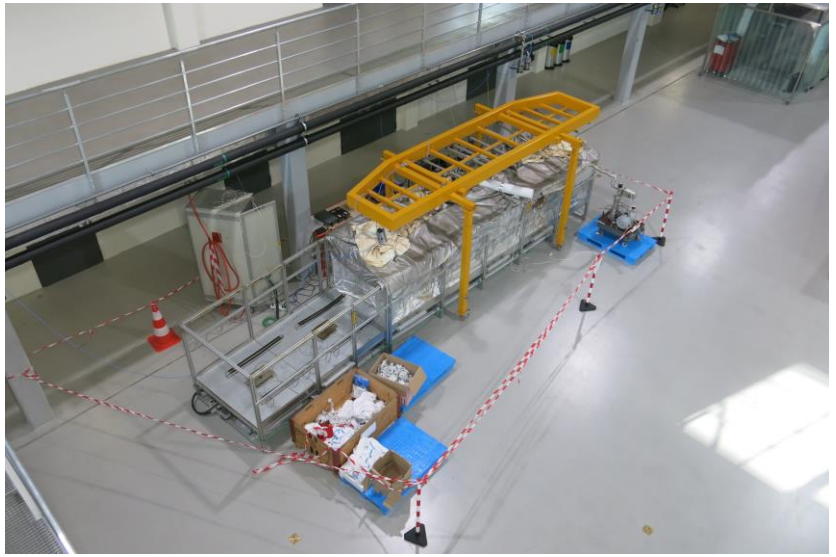
TIME SCHEDULE – STORAGE RING INSTALLATION

Paweł Bulira, 7th Solaris MAC, Kraków 18-19. Nov. 2014

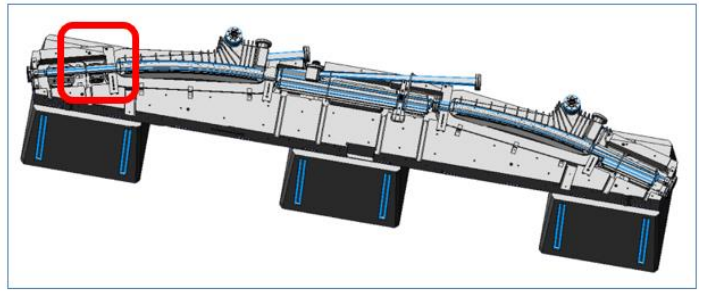


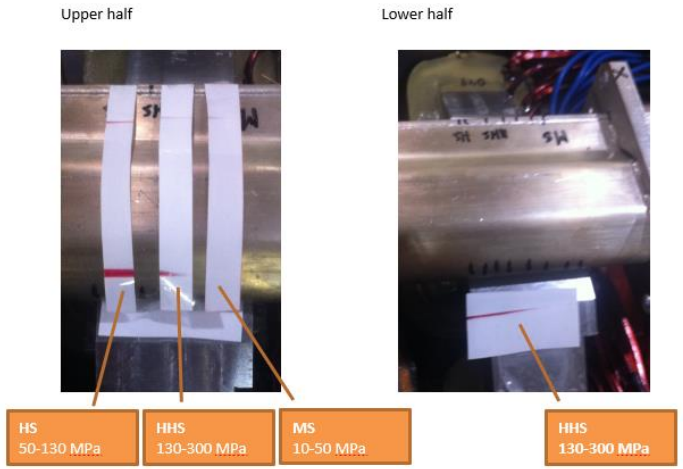
Machine installation (3)

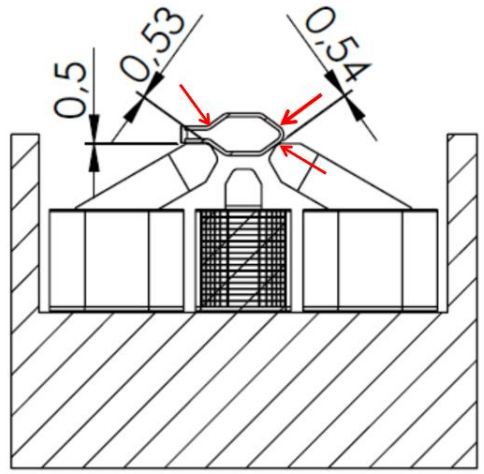
- Solving problems:
  - Overhead crane dusting
  - Faults that occurred during the use of the building
  - Inaccuracies in vacuum chambers and magnets
  - Transportation of the fragile components (thin VC)
  - Dust protection
  - Vibration protection



1. Location #1 – SXCO magnet

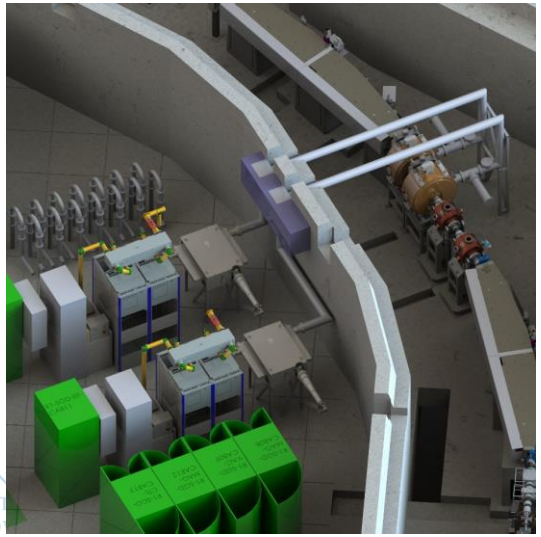






Logistics (1)

- General thoughts
  - A deep analysis of the installation procedure (answer to the question: How to do it? Can we do it?)
  - Construction of mock-up and validation of the procedure (e.g. installation of the DBA achromats)
- Space
  - Management of the space outside and inside the building
  - Additional storage space for equipment (containers and storage areas)
  - Additional storage space for employees (containers)
  - Establishing safe zones for communication and transportation
  - Management of the concrete slabs covering the storage ring



Logistics (2)

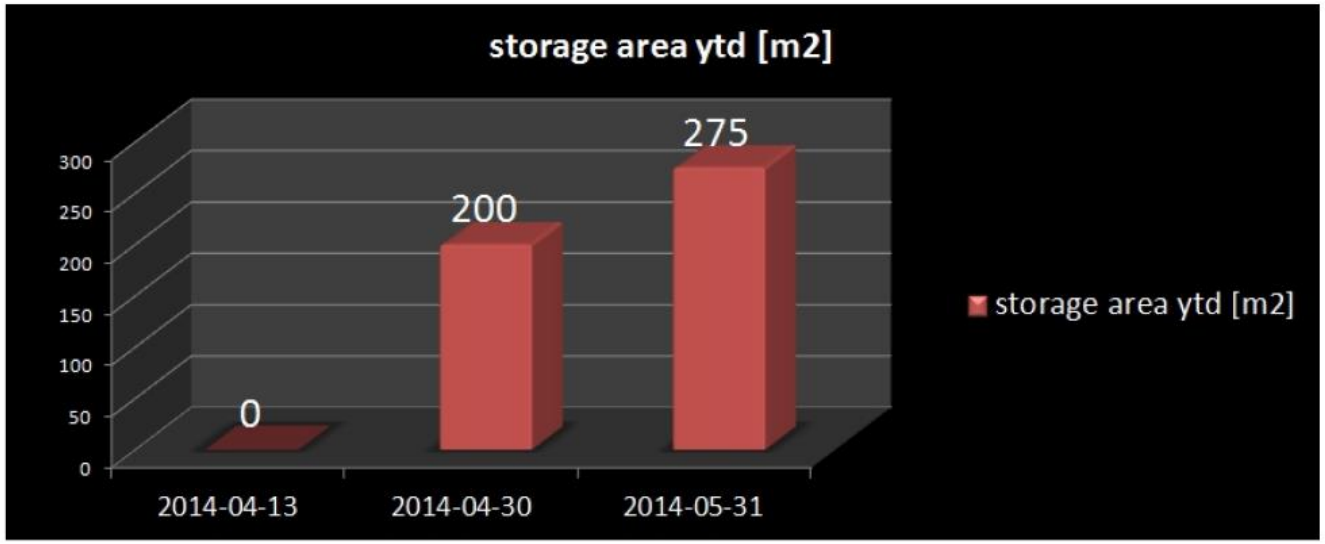
- Deliveries
  - Maximum delay in time (problem occurred when there was no permission to enter the building)
  - Management of space or temporary storage at the supplier

Logistics (3)

Forecast of deliveries till 31.05.2014

Main points:

1. First delivery expected on 18.04.2014 – First DBA magnet !!! (8 tons)
2. Other main components expected: SR vacuum chambers, modulators, bake-out oven, strong-back, racks for linac
3. Rent of temp. storage for linac structures will finish on 30.04.2014 – content has to be evacuated two days before.
4. Till 31.04.2014 we need approx. 200m^2 of storage place – safe, on site



Recommendations:

1. **It's strongly recommended to have the formal & physical access to the building latest from 14.04.2014 even if the building punchlist will be not completed.**
2. **Storage area (over tunnels) should be clean**
3. **If GC will be stiil present on site (punchlist completion) storage area should be fenced**

All the best

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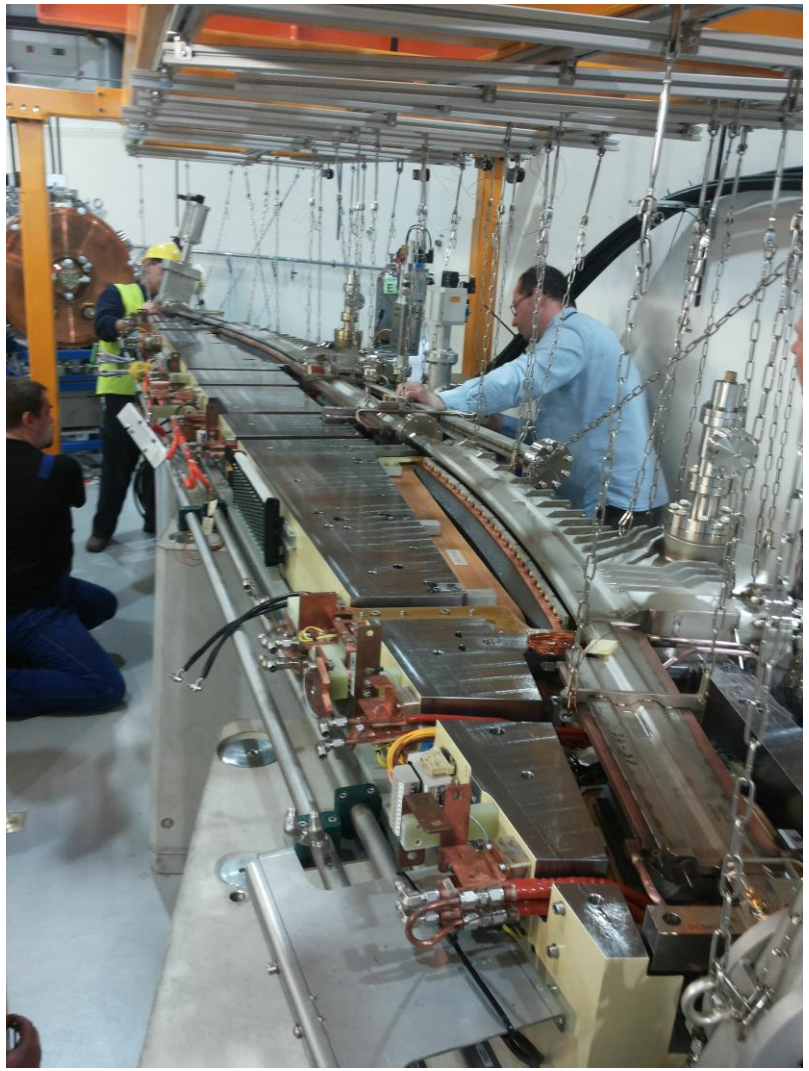
Logistics (4)

- Support of additional subcontractors:
  - Mechanical workshop and „dirty work”
  - Vacuum installation and „clean work”
  - External companies hired to fulfill the transportation topics
- Transportation and installation
  - Handling equipment – dedicated tools, lifting jigs, portable cranes used for transportation (especially in inaccessible places)
  - The ability to respond to the variability and dynamics of events and emerging problems
  - Special purpose equipment e.g. bake-out tent
- Protection
  - Dust protection (beamlines protection against dust)
  - Tents with laminar flux
  - Air curtains and dust mats



IT systems

- Data management – building systems for accessing and exchanging information between sections (Alfresco for all sections), PDM SolidWorks for technical documentation.
- Solaris is using two CAD systems:
  - AutoCAD (2D for all sections: HVAC, PLC, ELEK, IT)
  - SolidWorks (3D for mechanical constructions)
- Hardware – fast workstations for 3D modeling (bigger models – bigger problems with computing resources)

JAGIELLONIAN UNIVERSITY IN KRAKÓW

SOLARIS NATIONAL SYNCHROTRON RADIATION CENTRE

SUMMARY

Remarks for the future

- A dynamic team leader / project manager (decision-making is not delayed)
- Highly qualified team
- Teamwork and care of every person

- Project / risk / changes management

- Cooperation between civil engineers and the investor's team
- Outsourcing

- Developed Logistics
- Additional storage and working space

- Solutions / alternatives to tenders (compilant with the law)

- Use of new technologies:
  - Cloud computing
  - AI for writing tenders, specifications and product descriptions, manuals, safety regulations, market research etc. (in a reasonable sense)
- Observing global trends
- Predicting global market behavior and incorporating it into financial planning

The greatest success is not the technology, but the fact that we managed to build a team that relies on each other.

MAX IV Laboratory

ACKNOWLEDGMENT

TO ALL

PAST, CURRENT AND FUTURE

MEMBERS OF SOLARIS TEAM

THANK YOU FOR YOUR ATTENTION