EUROPEAN SPALLATION SOURCE

Accelerator systems (ACCSYS)

Mats Lindroos
Head of Accelerators

www.europeanspallationsource.se

November 20, 2013

ESS accelerator

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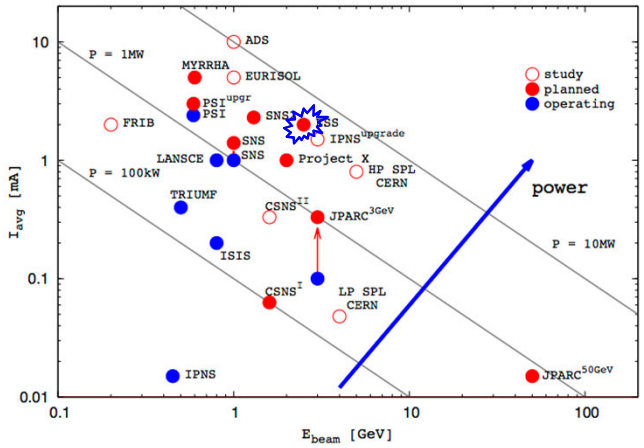
Design Drivers:

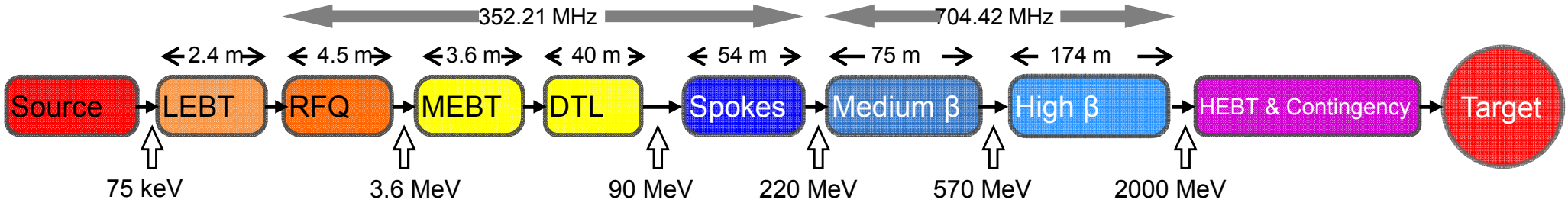
- High Average Beam Power
  - 5 MW
- High Peak Beam Power
  - 125 MW
- High Availability
  - > 95%



Key parameters:

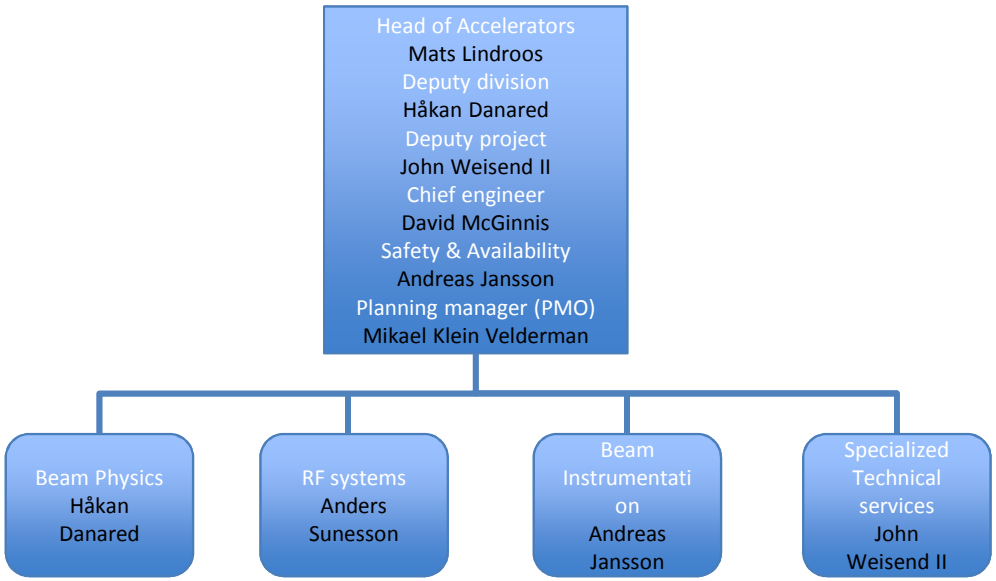
- -2.86 ms pulses
- -2 GeV
- -62.5 mA
- -14 Hz
- -Protons (H+)
- -Low losses
- -Attention is paid to cryoplant turn down capabilities to minimize use of electrical heaters at low temperatures and proper cryogenic design techniques to minimize static heat leaks
- -Flexible design for future upgrades

ESS Linac



	Energy (MeV)	No. of Modules	No. of Cavities	βg	Temp (K)	Cryo Length (m)
Source	0.075	1	0	–	~300	–
LEBT	0.075	–	0	–	~300	–
RFQ	3.6	1	1	–	~300	–
MEBT	3.6	–	3	–	~300	–
DTL	90	5	5	–	~300	–
Spoke	220	13	2 (2S) × 13	0.5 β_{opt}	~2	4.14
Medium β	570	9	4 (6C) × 9	0.67	~2	8.28
High β	2000	21	4 (5C) × 21	0.86	~2	8.28
HEBT	2000	–	0	–	~300	–

Organization and Work package leaders



Lead engineers: Aurelien Ponton, Benjamin Cheymol, Stephen Molloy, Christine Darve, Peter Ladd, Tom Shea

WP#	WP TITLE	WP LEADER	EXTERNAL WP?	LIASON FOR EXTERNAL WP
1	MANAGEMENT	J.G. WEISEND II	NO	
2	ACCELERATOR PHYSICS	M. ESHRAQI	NO	
3	NORMAL CONDUCTING FRONT END	S. GAMMINO	YES	A. PONTON
4	SPOKE CRYOMODULES	S. BOUSSON	YES	S. MOLLOY
5	ELLIPTICAL CRYOMODULES	P. BOSLAND	YES	C. DARVE
6	HEBT & MAGNETS	S. MØLLER	YES	P. LADD
7	BEAM DIAGNOSTICS	A. JANSSON	NO	
8	RF SYSTEMS	A. SUNESSON	NO	
9	ACCEL INFRASTRUCTURE & INSTALLATION	G. LANFRANCO	NO	
10	TEST STANDS	W. HEES	MIXED	W. HEES
11	CRYOGENICS	P. ARNOLD	NO	
12	VACUUM	P. LADD	NO	
13	SAFETY & RELIABILITY	A. JANSSON	NO	
14	REDESIGN EFFORT	D. McGINNIS	NO	
15	COOLING & ELECTRICAL SUPPORT	F. JENSEN	NO	

- Division and project aligned at high level
  - ✓ "WP as a group" would make for too big fragmentation
  - ✓ Four WPs have external leaders
- Weekly or bi-weekly meetings at ESS Accelerator Division
  - ✓ Management board of project and division
  - ✓ WP leaders
  - ✓ Lead engineers
  - ✓ Safety
- Regular meetings for ACCSYS project
  - ✓ Technical board (all WP leaders and reps of labs/uni. with contract) as governance and CCB on project level (6 meetings per year)
  - ✓ Collaboration board with reps of director of of labs/uni. with contracts as oversight committee
  - ✓ Audits yearly of every WP
  - ✓ Reviews (Conceptual, design, ready to build) as required mostly co-organized with audits

Prototyping the ESS accelerator

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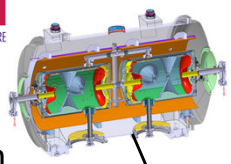
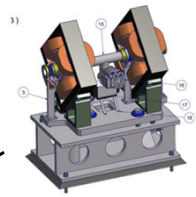
IPN INSTITUT DE PHYSIQUE NUCLÉAIRE ORSAY



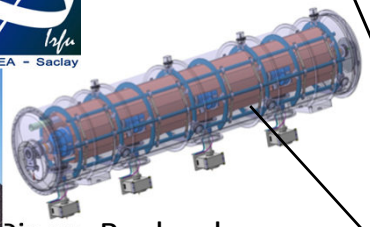
Sebastien Bousson



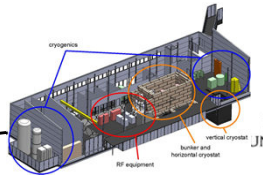
ISA

Søren Pape Møller

cea CEA - Saclay

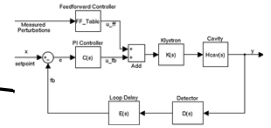


Pierre Bosland



UPPSALA UNIVERSITET

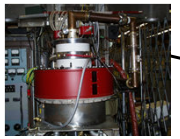
Roger Ruber



LUNDS UNIVERSITET

Anders J Johansson

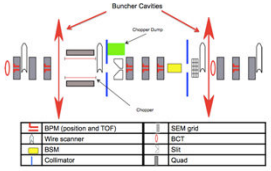
CERN



CERN

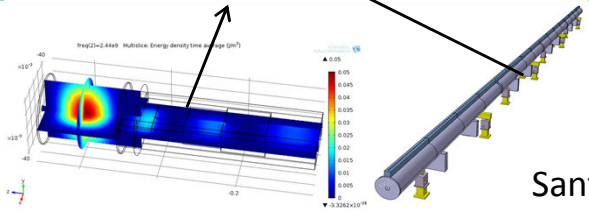
University of HUDDERSFIELD Inspiring tomorrow's professionals

Roger Barlow



Ibon Bustinduy

ESS bilbao

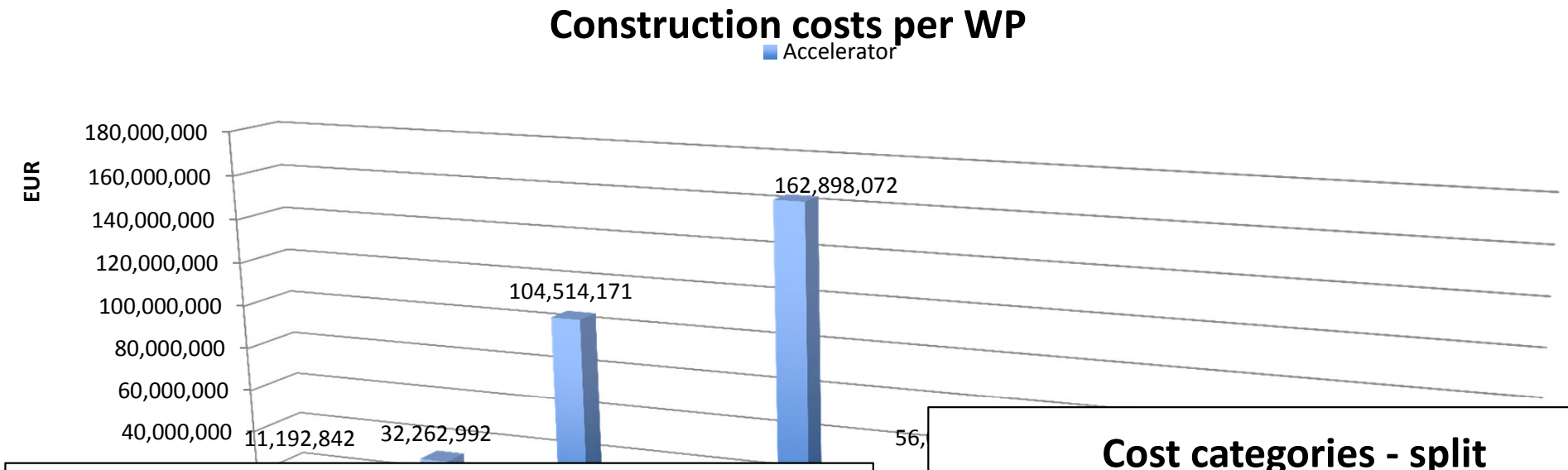


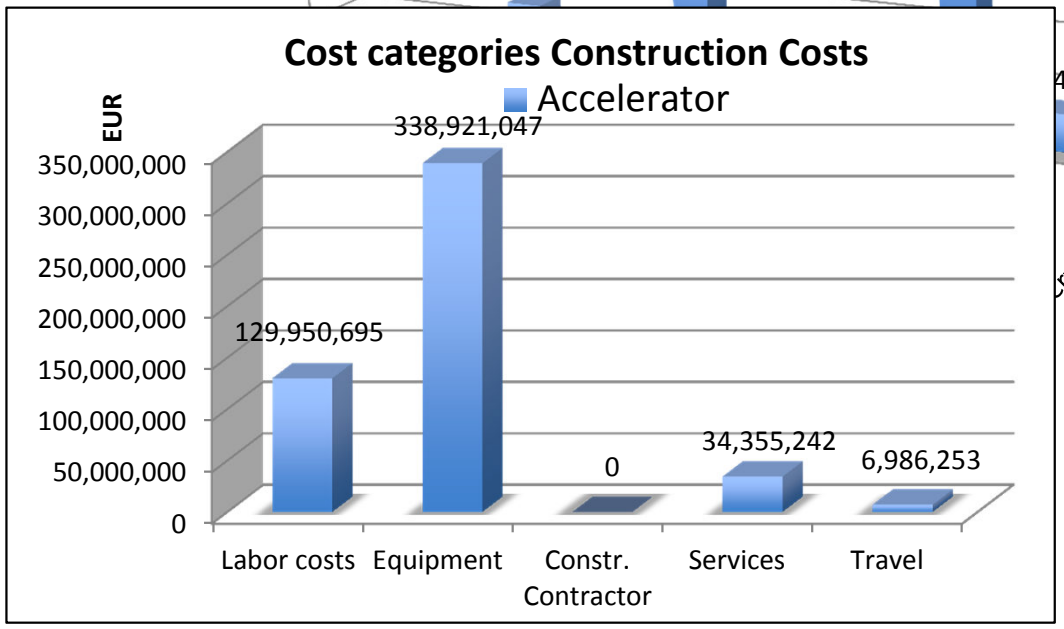
INFN Istituto Nazionale di Fisica Nucleare

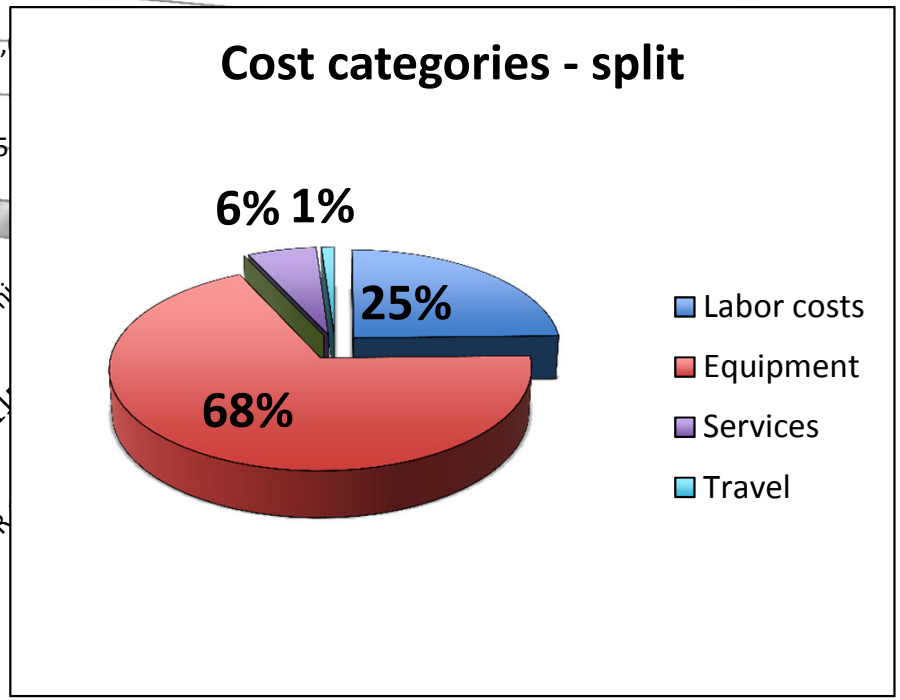
Santo Gammino

The National Center for Nuclear Research, Swierk

Cost ACCSYS: Total 510 M€

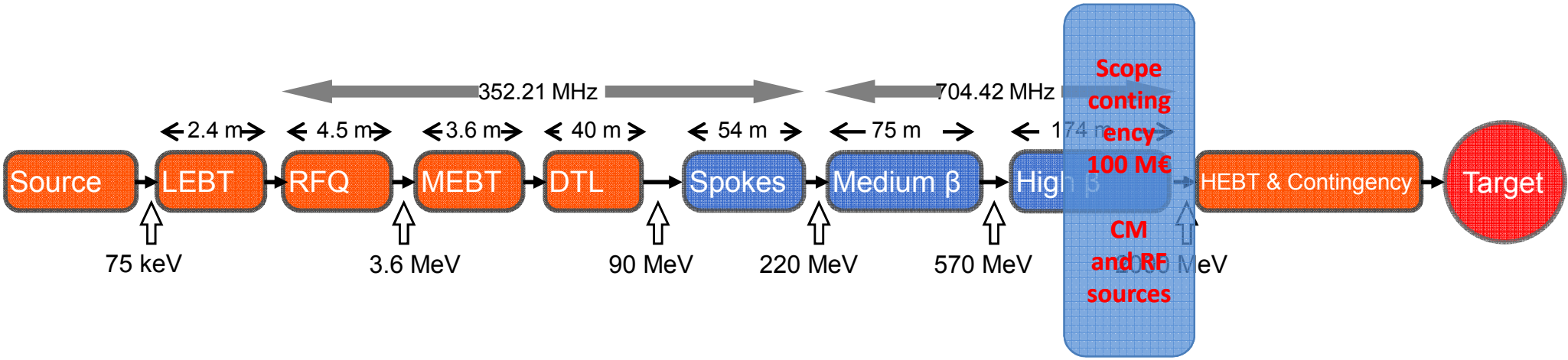




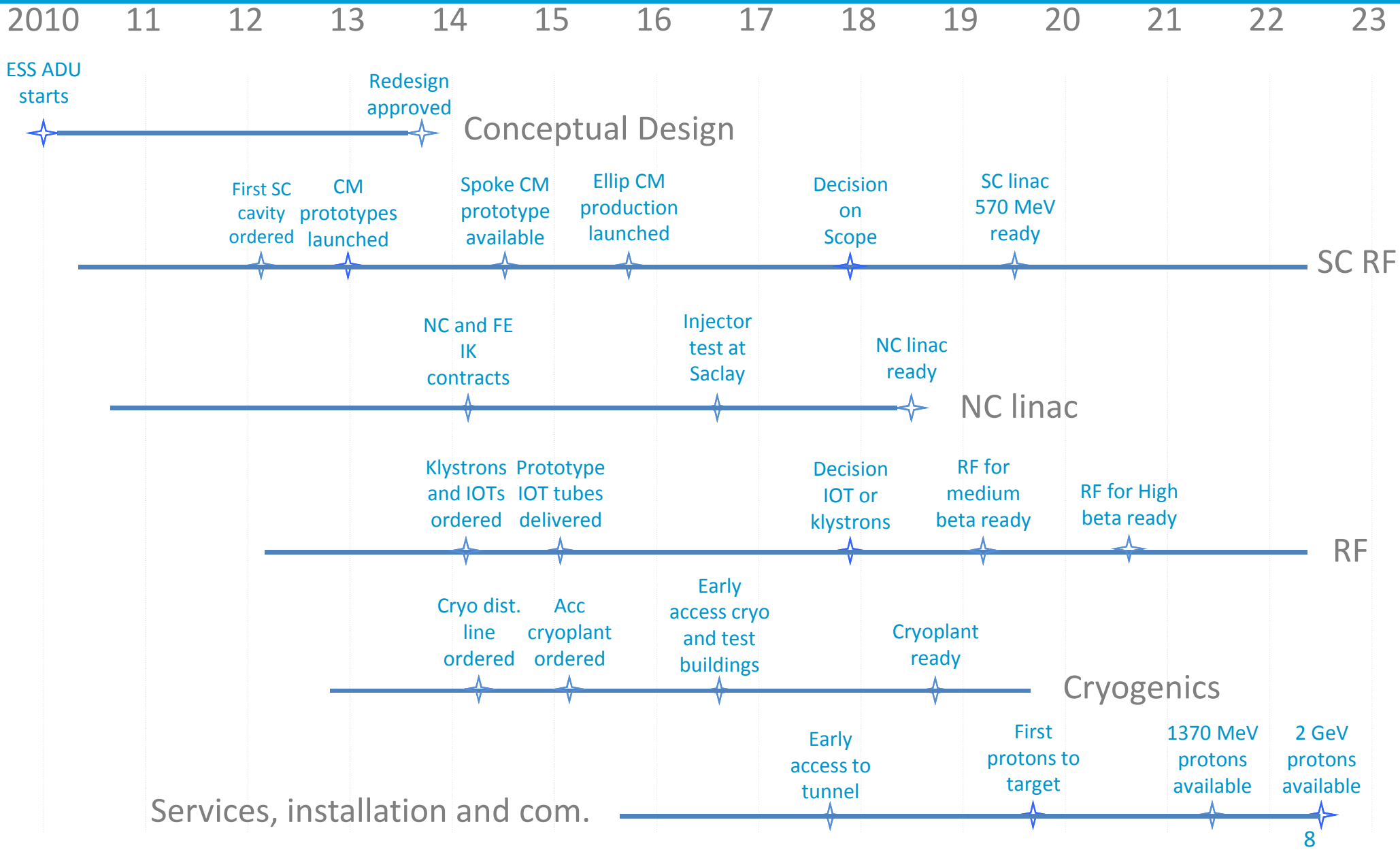


Scope contingency for 5 MW accelerator

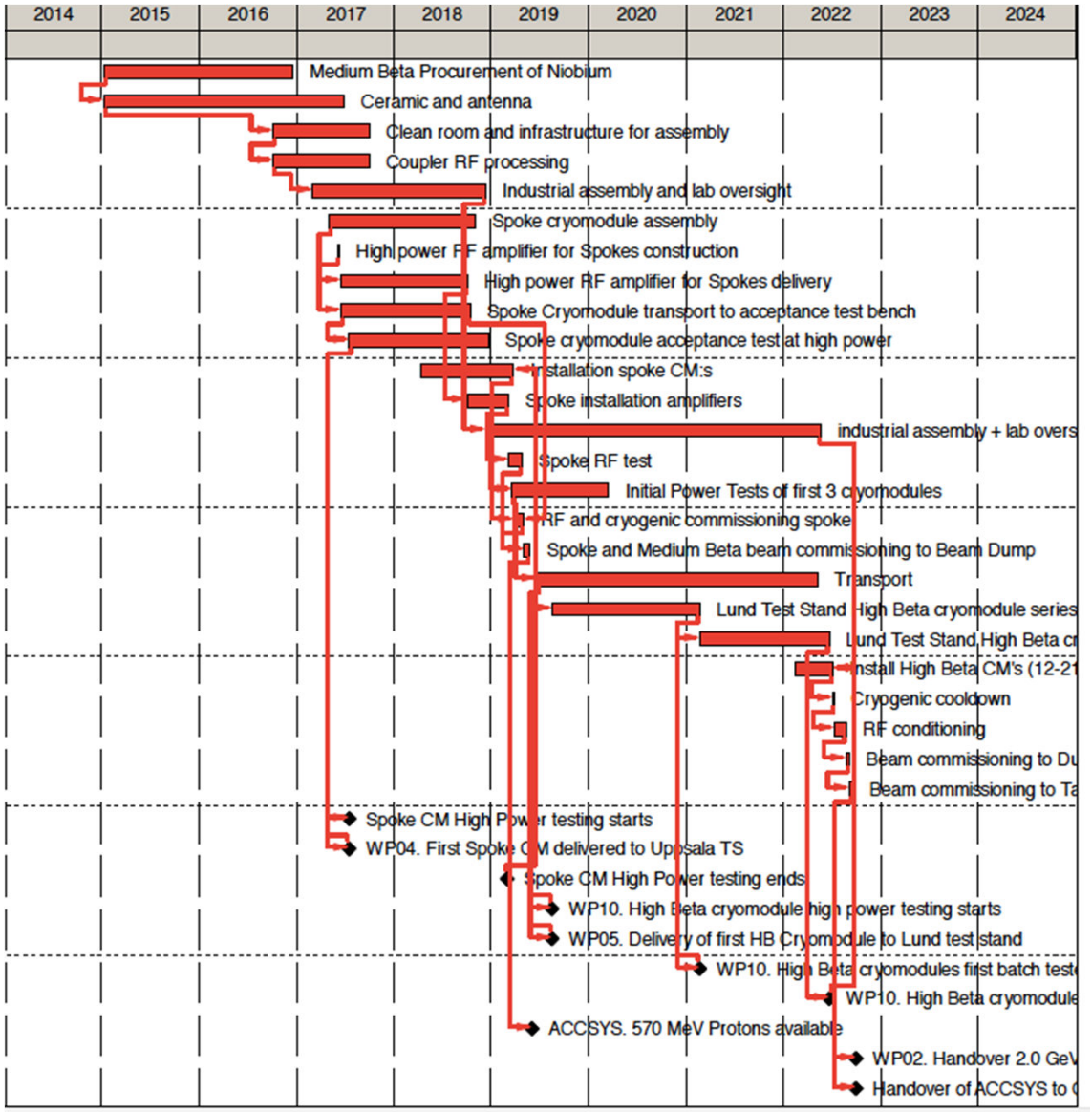
- We plan for delivering a 5 MW accelerator
- The scope contingency for the accelerator is beam power. The purchasing of power supplies and RF sources necessary to go from 2.5 to 5 MW will be scheduled discretely. These purchases will be authorized after the financial requirements for delivering 2.5 MW of beam power are secure.
- Each 7 M€ reduction decrease energy by 70 MeV (=175 kW at 62.5 mA)



Very high level Schedule



Schedule Critical Path

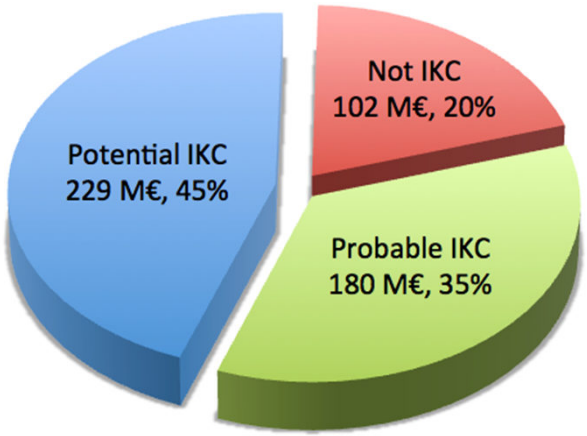


- For first protons to target:
  - ✓ CP is mainly set by cryomodule production
- For final milestone for 2 GeV:
  - ✓ CP is mainly set by elliptical cryomodule production
- Interplay between activities at different labs critical:
  - ✓ Transport
  - ✓ “on the same schedule”

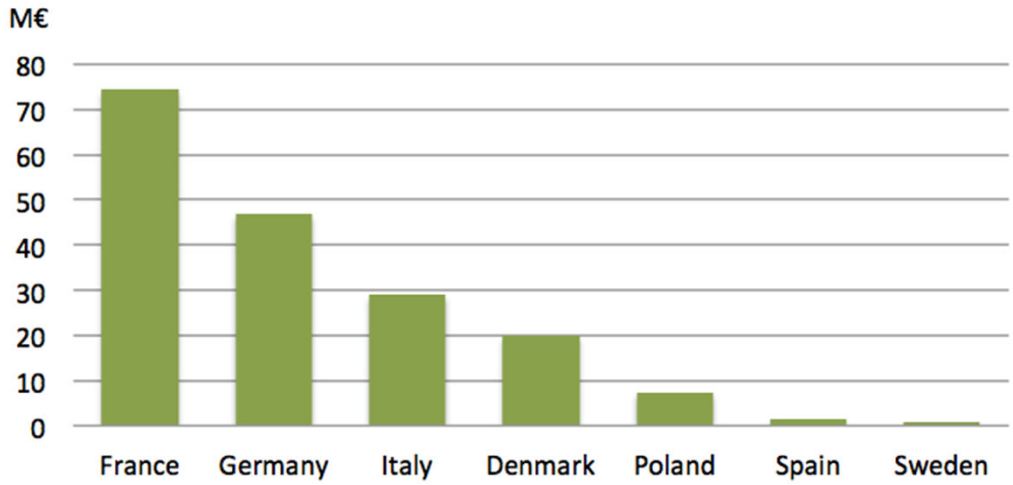
In-Kind Potential and Partners

Probable in-kind contributions where contacts are established with partners amount to 35% of ACCSYS budget.

Another 45% are mainly commercial items which are potential in-kind contributions, but where no partners that could provide funding have been identified.



Seven countries are giving contributions to the ACCSYS pre-construction phase, and all are expected to participate also as in-kind partners for construction.

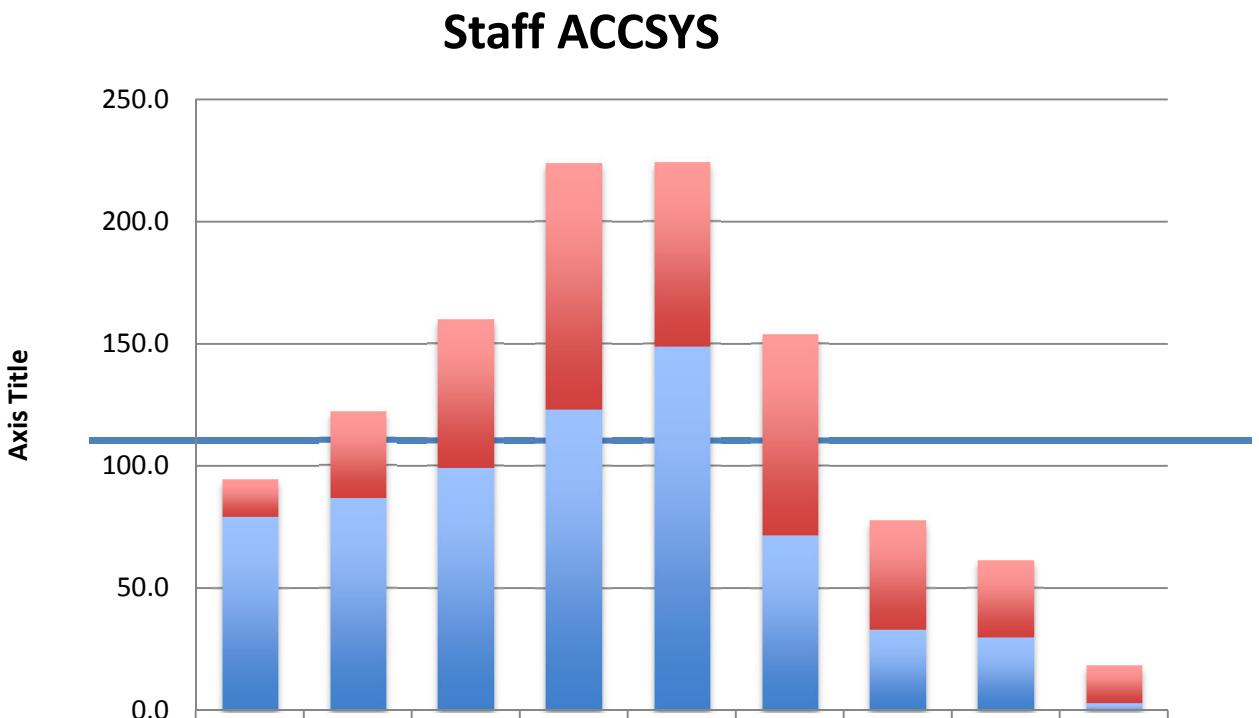


Realistic In-Kind by WP/WU

WP/WU	Title	Institute	Primavera value (k€)	% in kind	In-kind value (k€)	Comment
3.2	Proton source and LEBT	INFN	5 048	100	5 048	In total
3.3	RFQ	CEA	8 298	94	7 838	Except contract
3.4	MEBT	ESS-Bilbao	1 594	100	1 594	In total
3.5	DTL	INFN	16 227	100	16 227	In total
4	Spoke cavities and cryomodules	CNRS	16 582	91	15 119	Except contract
5.2.3	Medium beta cavity fabrication	INFN or DESY	7 702	100	7 702	Except vertical tests
5.2.3	Medium beta vertical tests	DESY	2 377	100	2 377	Vertical tests only
5.2.4	Medium beta cavity follow-up	DESY	1 221	100	1 221	In total
5.2.5	Medium beta power coupler	CEA	5 812	100	5 812	In total
5.2.6	Medium beta cold tuning system	CEA	687	100	687	In total
5.2.7	Medium beta cryomodule	CEA	6 075	100	6 075	In total
5.2.8	Medium beta infrastructure	CEA	5 494	100	5 494	In total
5.3.3	High beta cavity fabrication	DESY or INFN	17 972	100	17 972	Except vertical tests
5.3.3	High beta vertical tests	DESY	5 545	100	5 545	Vertical tests only
5.3.4	High beta cavity follow-up	DESY	2 231	100	2 231	In total
5.3.5	High beta power coupler	CEA	10 854	100	10 854	In total
5.3.6	High beta cold tuning system	CEA	1 604	100	1 604	In total
5.3.7	High beta cryomodule	CEA	10 664	100	10 664	In total
5.3.8	High beta infrastructure	CEA	10 264	100	10 264	In total
6	HEBT, warm magnets, collimators	Aarhus Univ	19 867	100	19 867	In total
7	Beam diagnostics	DESY	22 751	12	2 800	Part of BPMs, BCMs, BLMs
8.2	LLRF	DESY	14 379	96	13 756	Non-labour except prototyping
8.3	Master oscillator	DESY	1 201	60	717	Non-labour except prototyping
9.5	Installation phase 1	IFJ PAN	1 544	48	745	Half of labour cost
9.6	Installation phase 2	IFJ PAN	677	49	329	Half of labour cost
10.4	Uppsala test stand	UU	4 614	16	726	Except contract
11.2	Accelerator cryoplant	DESY	34 987	1	250	3 FTEs
11.5	Cryogenic distribution	WUT	12 608	50	6 304	Estimated capacity
	Sum				**179 821**	

Staff plan and in-kind

- Leveling required: i) move non critical activities, ii) temporary staff movements within division and iii) look for in-kind partners who can contribute with staff on site



	2014	2015	2016	2017	2018	2019	2020	2021	2022
In-kind	15.4	35.3	60.9	100.8	75.5	82.1	44.4	31.5	15.1
ESS	79.2	86.7	99.1	123.2	148.9	71.6	33.2	29.8	3.2

110 in operation

Probable in-kind ->

Risks and Mitigating Actions

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- 60 Project risks (re-)evaluated in the last risk workshop
- Risk management is an on-going task… The ESS successive planning exercise was an eye opener for me!
- 10 top risks:

Risk ID	Risk Owner	Risk description	Created date	L	C	LxC	Risk Response summary
RACS0001	Project Manager M Lindroos	Supplier doesn´t deliver on time with right quality/quantity, e.g. klystrons, modulators, CMs, cavities.	23/Nov/11	4	5	20	Close monitoring of schedule by WP Leader, development of detailed factory acceptance and QA tests
RACS0018	Project Manager M Lindroos	Re-baselining of the accelerator design to meet the top managements cost objective of 497 Meuro will take us 6-8 months to complete. We will only very partially be able to recover some of the delay in the shadow of this work. The	21/Mar/13	5	4	20	Continue work as planned on unaffected work packages. Look for schedule savings and efficiencies in out years to compensate for the delay
RACS0019	Project Manager M Lindroos	There is a schedule risk due to the delay of the procurement of modulator, klystron and RFQ prototypes. This delay results from new requirements (and	21/Mar/13	5	4	20	Investigate impact , if any of this on critical path and look for compensating schedule effeciences as part of the revised strategic plan due by November 2013
RACS0024	Project Manager M Lindroos	Some systems and tools for design, project planning and technical management are not procured, not appropriate, or	25/Sep/13	5	4	20	ACCSYS management continues to work with laboratory management to improve this situation. Develop ACCSYS tools as
RACS0027	Deputy head of accelerator projects J Weisend II	Insufficient resources in the procurement group and evolving procedures may lead to ineffecient procurement process. This may result in delays and/or poor quality.	25/Sep/13	5	4	20	Increasing resources in procurement group and codify and publicise procurement procedures.
RACS0032	Deputy Head of Accelerator Projects J Weisend II	Insufficient workshops and test labs in current plan, potentially causing poor ability to deal with on-site	25/Sep/13	5	4	20	Continue to highlight need of space and develop off-site backup space if needed.
RACS0035	Head of Accelerator Division M Lindroos	Insufficient staffing due to poor staff plans, causing work overload for specific persons or delays in different phases	25/Sep/13	5	4	20	Continoual review staff plans to ensure that optimal staff is being rectuited for both construction and operations phases.
RACS0042	WP9 leader G. Lanfranco	Space for interrim storage during construction and installation not planned for, potentially causing delays due	25/Sep/13	5	4	20	Push for a firm definition of sufficient interim space
RACS0021	WP9 leader G. Lanfranco	Buildings and utilities constructed and provided by CF not ready on time, causing delays of ACCSYS installation and commission activities.	25/Sep/13	4	4	16	Close coordination with CF and addressing of issues as they come up.
RACS0025	Project Manager M Lindroos	Poor or insufficient communication with IKC or partner labs: Tools for data exchange and knowledge transfer are lacking.	25/Sep/13	4	4	16	Work with laboratory management to develop required tools

Risk management – keeps me awake!

- Recruitment of experienced staff and retaining staff
  - Mitigation: Work wit ESS management on competitive salaries, relocation issues, integration issues and enforce sufficient amount of leave
- Compressed schedule for installation in tunnel
  - Mitigation: Pursue detailed planning
- Staff leveling and persons available for installation and testing (including availability in holiday periods)
  - Mitigation: Move non-critical activities, propose staff mobility measures at ESS and Investigate possibility to have installation team as in-kind from partners to increase staff numbers
- Phase 2 for instrumentation, spares and installation costs pushed to pre-ops and early operation
  - Mitigation: Pursue detailed planning of pre-ops and operation
- Complex and slow negotiations with potential in-kind partners
  - Mitigation: Dedicate one person to in-kind negotiations at the project (Håkan Danared) and help establish well working processes at ESS for in-kind

Beam instrumentation

- ESS beam instrumentation work package was planned to be in-house with all development and off-line testing done on site
- Recent decision to open all aspects of the work package for in-kind partners and to phase installation
- Phase 1 installation installed for first protons
- Phase 2 installation installed in shutdowns during early operation for which experience from early operation can be useful
- Full scope for the work package is well documented but details for the phasing and to adapt the work package for in-kind must still be implemented in planning

Next Six Months

- Contracting prototypes for modulators, MB-IOT high power tubes, klystrons and modulators
- Agreement and contracts for (early) in-kind for ion-source, MEBT, RFQ, DTL and cryomodules
- Recruitment at ESS accelerator division according to staff plan
- Finalizing Level 3 and 4 requirements following CCB process at ESS
- Continued project work including audits, reviews and governing meetings of the existing accelerator collaboration

Summary

- The ACCSYS project has a scope, schedule and cost coherent with set objectives
  - ✓ Medium technical risk and high schedule and cost risk
  - ✓ Detailed planning of transfer in 2019 to operation of some staff cost and costs for phase 2 instrumentation and spares in operation
- Success oriented planning
  - ✓ Many near critical paths which all must be monitored
- A new baseline for the Accelerator has been set with requirements to level four.
  - ✓ The requirements have been reviewed by ESS TAC
- Recruitment and keeping experienced staff remains key factors for success
- Timely agreement on in-kind will be crucial for keeping schedule and cost

If budget, agreements and contingencies are in place we can deliver to plan