ALICE 3 costs, personnel requirements and resources

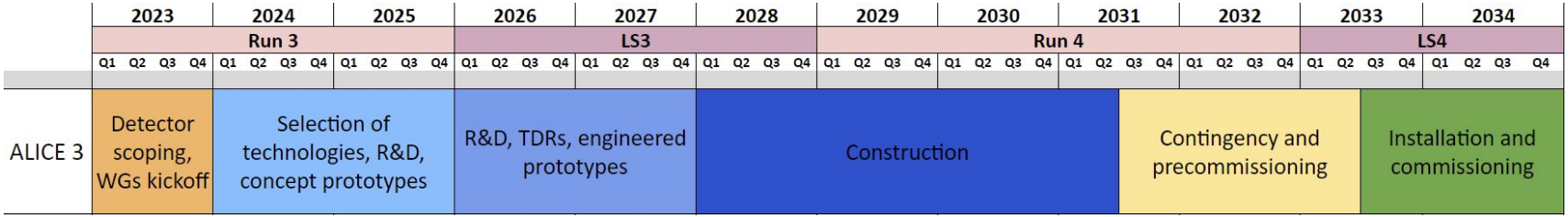
5th ALICE Upgrade Week,
Kraków, 8 October 2024

Andrea Dainese (INFN Padova), Antonello Di Mauro (CERN)

Outline

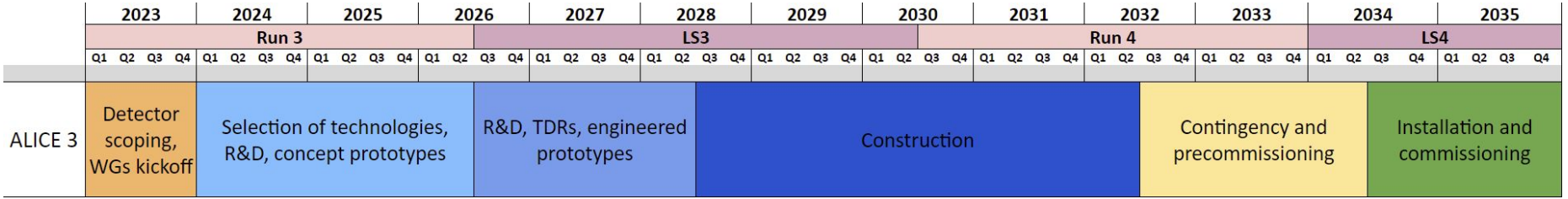
- New schedule proposal after LS3 shift
- Present status of cost and resource estimates
- Status of national groups participation and required/available personnel profiles
- Impact of V4 on resources
- Plans towards TDRs

ALICE 3 timeline

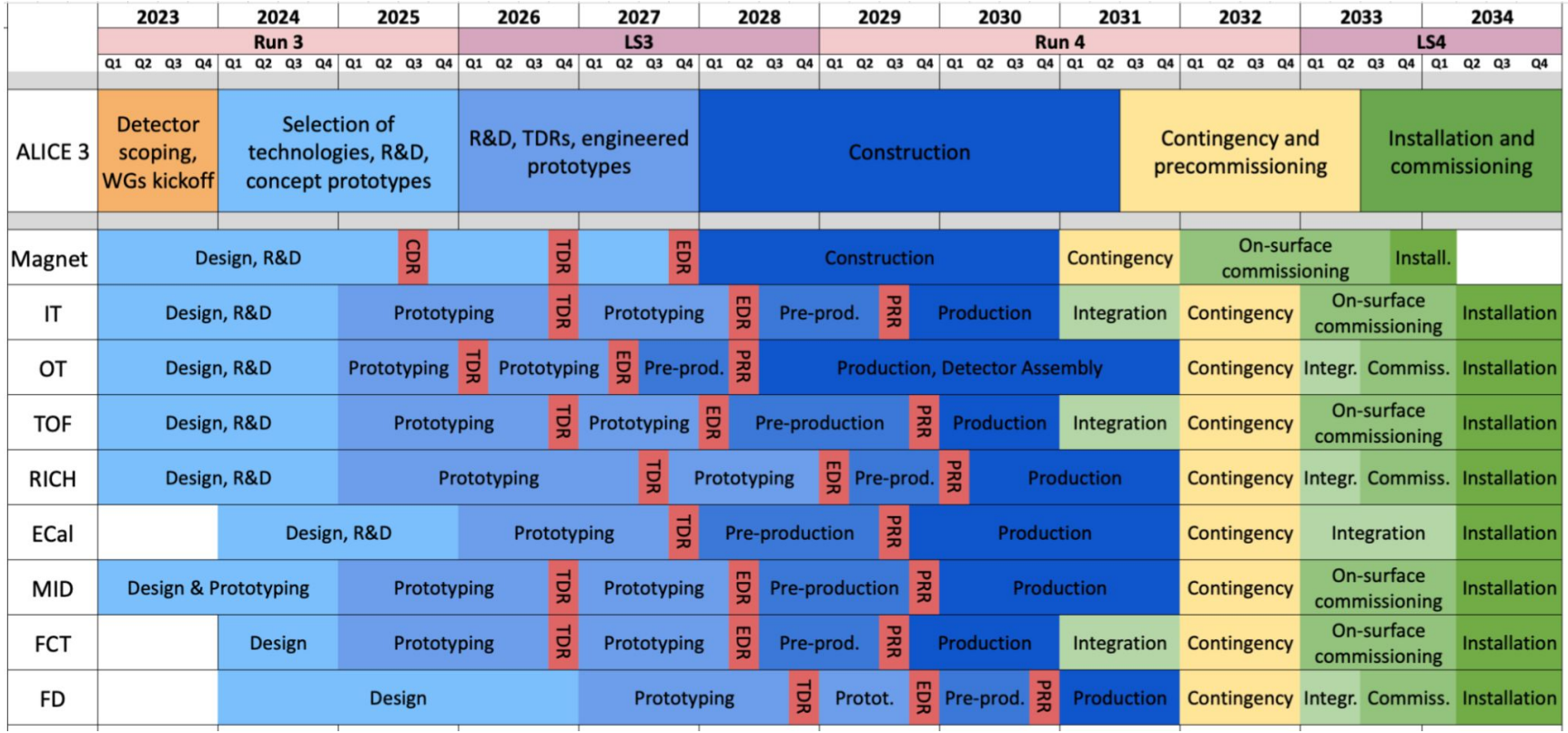


New proposed schedule after LS3 shift:

- depending on sub-system original schedule, distribute the 12 months mainly on the construction phase

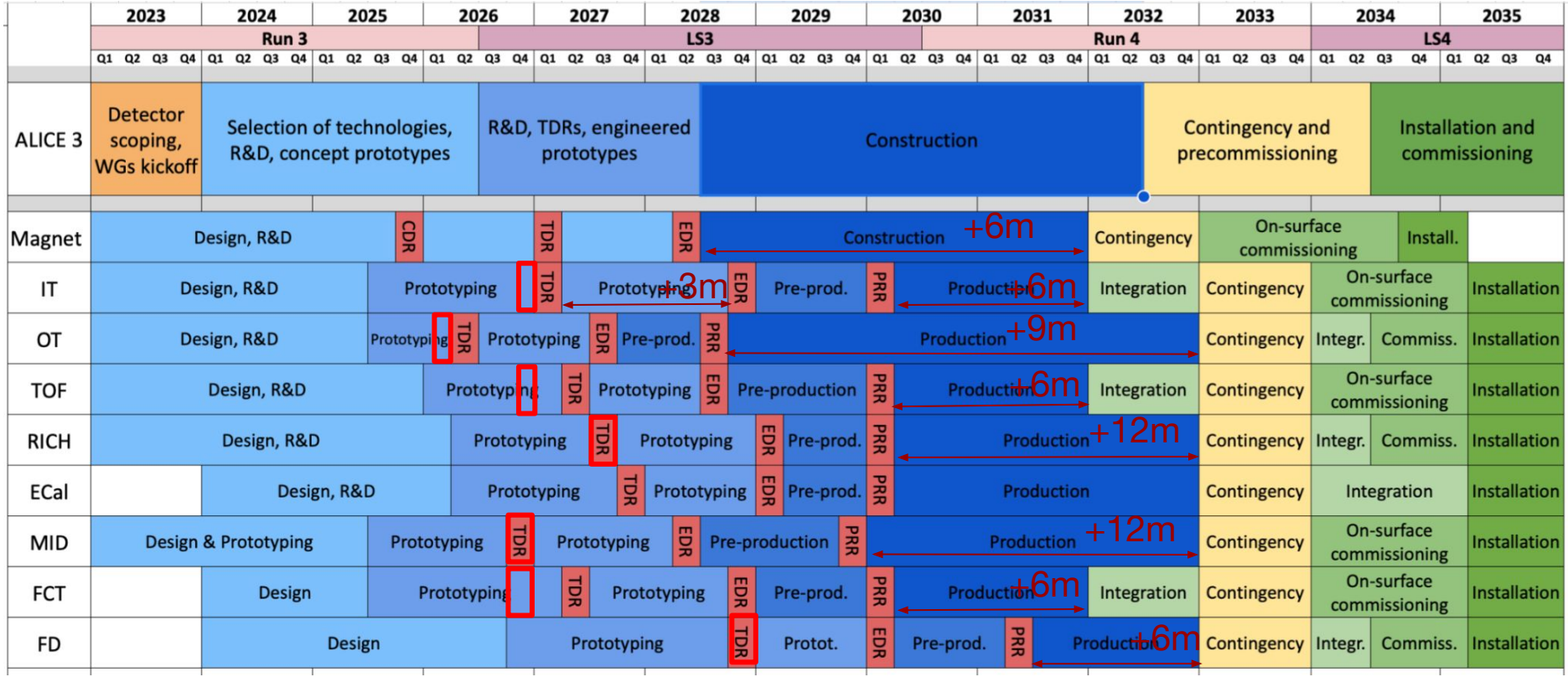


Compact schedules and milestones



Subsystem schedules with main milestones (Technical Design Reports, Engineering Design Reviews, Production Readiness Reviews)

Updated compact schedule (proposal)

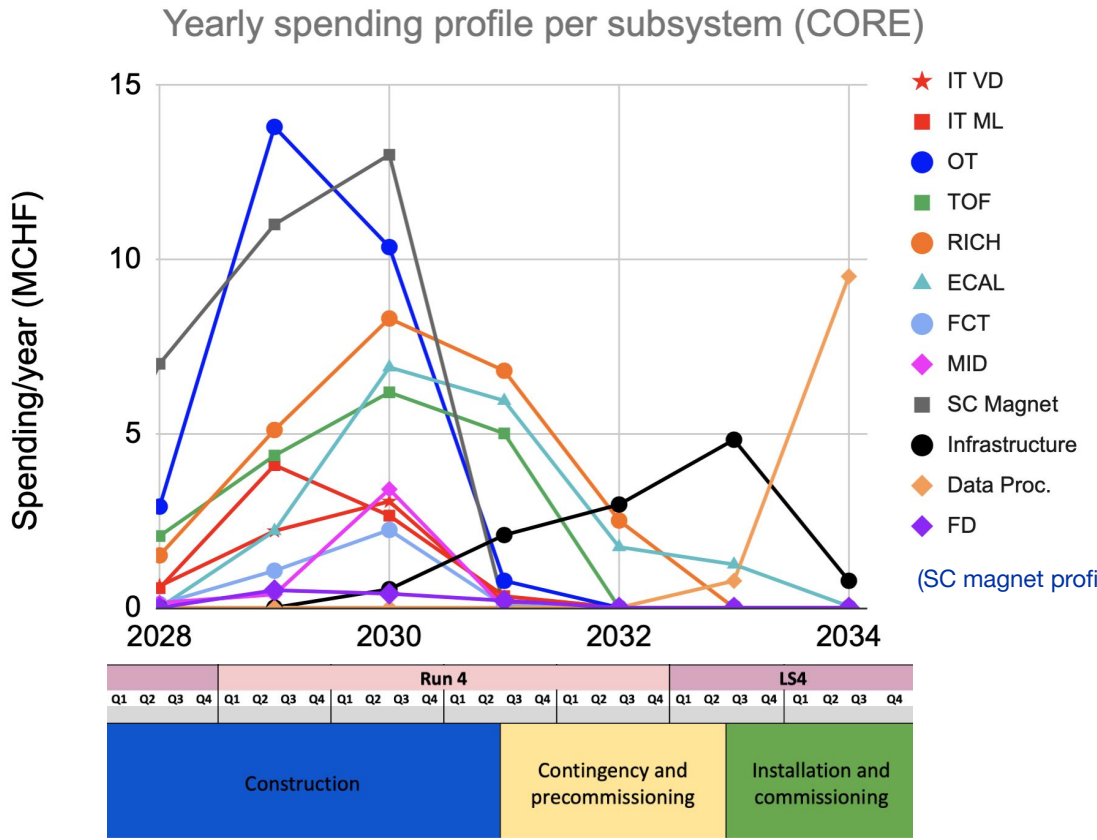


Impact on spending and resource profiles to be assessed to update SD tables

Scoping options detailed cost

System	Technology	V1 Cost (MCHF)	V2-2T no ECal, smaller R SCM and MID Cost (MCHF)	V2-1T SCM B= 1 T Cost (MCHF)	V3a no forward acceptance (|η|< 2) Cost (MCHF)
Inner Tracker	MAPS	13.7	13.7	13.7	11.7
Outer Tracker	MAPS	27.8	27.8	27.8	22.8
TOF	Monolithic LGADs	18.0	18.0	18.0	15.0
TOF	Hybrid LGADs	+13.4	+11.6	+11.6	+10.0
RICH	Aerogel, SiPMs	24.2	24.2	24.2	19.9
ECal	Pb-scintillator + PbWO4	18.1	0	0	0
MID	Iron absorber, scintillators, SiPMs	4.0	3.6	3.6	3.6
FD	scintillators, PMTs	1.1	1.1	1.1	1.1
Magnet system	Superconducting solenoid	31.0	24.7	19.6	16.6
Online computing	CPU and GPU nodes, disk buffer	10.3	10.3	10.3	10.3
TOTAL		**148.2**	**123.4**	**118.3**	**101.0**
Common items	Beampipe, infrastructure, services	+11.1	+11.1	+11.1	+11.1
	TC design and engineering	+10.9	+10.9	+10.9	+10.9
FCT	MAPS, dedicated dipole magnet	+3.45	+3.45	+3.45	+3.45

Spending profiles (old LS3 schedule)



- Construction spending starts in 2028, after TDR approvals
- Peaks in 2029-31 depending on the total construction time
- Needs to be updated according to the new schedule

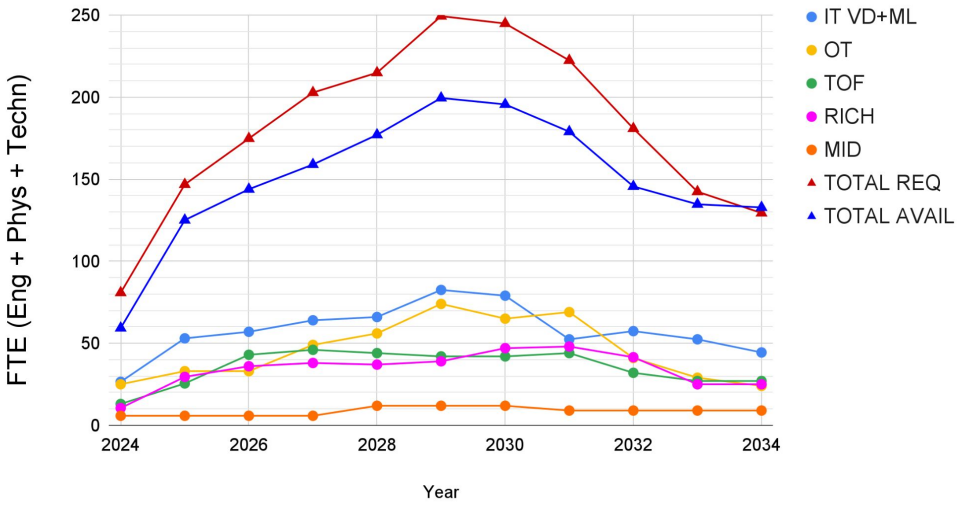
(SC magnet profile still tentative)

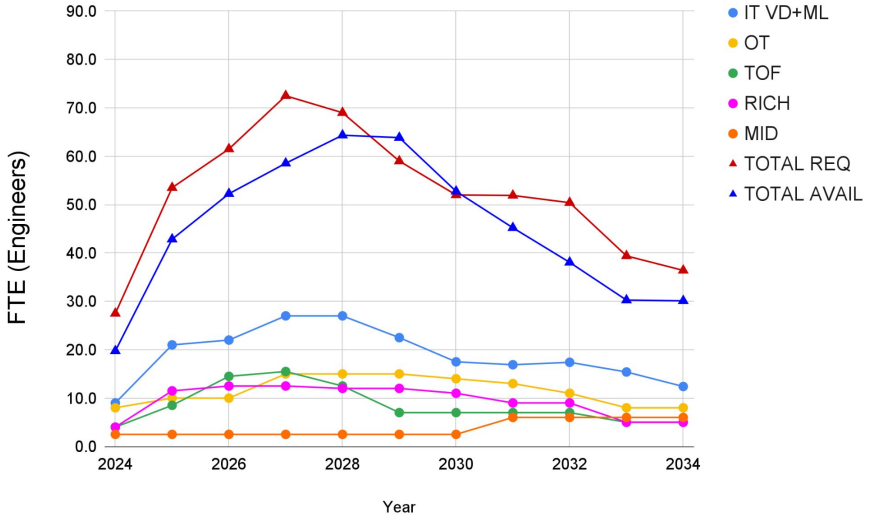
Participation and interests of national groups

Experiment subsystems	National groups
Inner Tracker	CERN, China, Czech Republic, Italy, Netherlands, Norway, Ukraine
Outer Tracker	Finland, France, Germany, Japan, South Korea, Sweden, UK, US
Forward Conversion Tracker	Germany
TOF Detector	Brazil, China, Italy, India, Netherlands, South Africa
RICH Detector	Hungary, India, Italy, Malta, Mexico
Muon Identification Detector	Czech Republic, Hungary, India, Mexico, US
Data flow and online processing	CERN, Germany, Romania
Detector readout, links, clock distribution	CERN, Hungary, Slovakia, UK
Forward Detectors	Denmark, Mexico, Poland
Superconducting magnet design	Brazil, CERN, Italy

- Additional participations under discussion
  - e.g.: Romania in TOF, Poland and US in RICH, …
- Ongoing discussion with FAs to map contributions and finalize money matrix

Personnel resources: summary





- Shortage of projected personnel availability at level of 25%
  - mainly IT, RICH, TOF
- All systems based on silicon technologies, requiring integrated (and parallel) design of sensor, module, readout and control, powering, mechanics, cooling → core engineering expertise needed in R&D and design phase (see right plot)

Personnel resources: considerations

- Significant projected resources and increasing trend in the past months, but as of today some clear gap and specific issues

- Only very few “leading laboratories” for large-scale construction have been identified so far, and still with significant uncertainties (personnel availability, commitments with other projects)

- IT+OT:
  - Sensor design: critical phase next two years in parallel with ITS3 R&D
  - Margin to optimize IT resources: synergy with OT for mechanics, services, construction, DCS, installation

- TOF, RICH:
  - Low overall number of institutes, but growing amount of interested institutes
  - Still critical shortage of mechanical engineers and technicians, especially in R&D phase

Possible impact of v3 on R&D and resources

- **R&D**
  Removes the regions with maximum radiation load and occupancy (except for VD), relaxing the constraints for the ML/OT/TOF sensors and making less severe the challenge for RICH sensors

- **Resources**

➔ Reduces the FTEs for OT disks, but 6 (or 8) disks remain a large project

Possible impact of v3 on R&D and resources

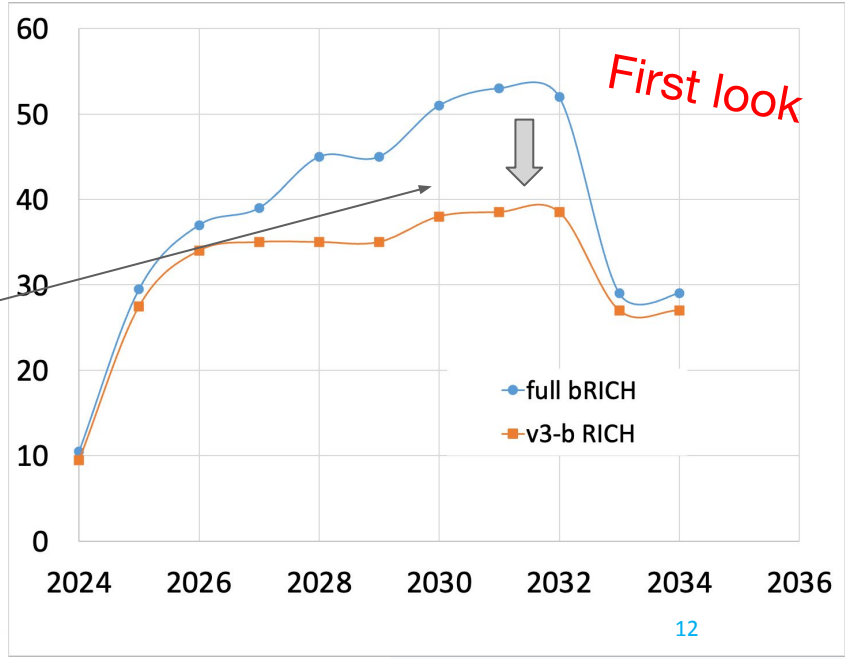
- **R&D**
  Removes the regions with maximum radiation load and occupancy (except for VD), relaxing the constraints for the ML/OT/TOF sensors and making less severe the challenge for RICH sensors

- **Resources**

➔ Reduces the FTEs for OT disks, but 6 (or 8) disks remain a large project

➔ Reduces by ~20% the required resources for TOF and RICH, and reduces the mechanical design complexity (no disks, projective RICH geometry not needed in v3-b)

  - Further reduction can be achieved if the option of oTOF combined with bRICH is technically feasible (already in SD and under R&D)



Possible impact of v3 on R&D and resources

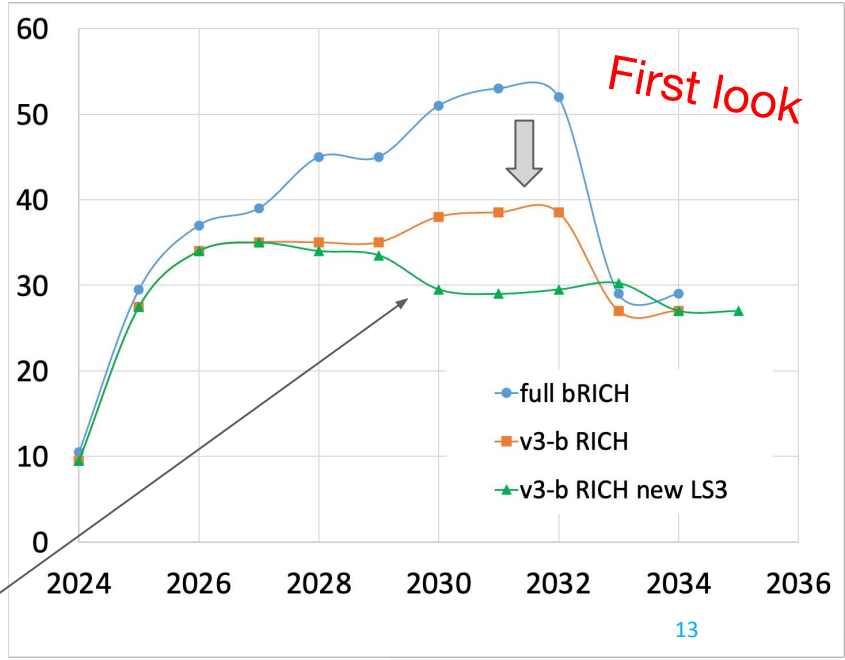
- **R&D**
  Removes the regions with maximum radiation load and occupancy (except for VD), relaxing the constraints for the ML/OT/TOF sensors and making less severe the challenge for RICH sensors

- **Resources**

➔ Reduces the FTEs for OT disks, but 6 (or 8) disks remain a large project

➔ Reduces by ~20% the required resources for TOF and RICH, and reduces the mechanical design complexity (no disks, projective RICH geometry not needed in v3-b)

  - Further reduction can be achieved if the option of oTOF combined with bRICH is technically feasible (already in SD and under R&D)
  - New LHC schedule can mitigate requirements



v3 and v4 comparison

	v3-a	v3-b	v4	comments
IT	No iris disks, larger inner radius of disks			• Unchanged: R&D on IRIS, critical path sensor design
OT	6 (or 8) instead of 12 disks		Only 3 layers, total area 10 m2 in barrel, no disks	• Available resources seem compatible with v2 and v3 • Unchanged: R&D on cooling/mechanics, critical path sensor design (but less wrt v3)
TOF	No disks		Only iTOF but R= 20→45 cm	• Still critical path CMOS LGAD design
RICH	No disks	Major change: 60% less surface	Endcaps out of TPC to increase η coverage?	• Possible solution for v4 to be studied • Possibly critical path SiPM technology wrt DCR and radiation hardness
MID	No change	No change	Outside L3?	• Possible solution for v4 to be studied
FARM	Small reduction		Probably ~ x2 increase for pp 5MHz	

Project planning

- Time to TDRs is limited → setup more fine-grained effort
- Start transition of Subsystem-WGs to Projects
  → Substructure with Work Packages and people in charge

- Define schedules with milestones towards the TDRs
  - Put in place progress-tracking
  - Major checkpoint in the second part of next year

Planning towards TDRs

Generic task → approx mapping to TDR chapters	1st Milestone - Q1 2025?	2nd Milestone - Q3 2025?	3rd Milestone - Q1 2026?
Finalisation of specifications ● spatial and time resolutions ● rate capability ● max. occupancy and granularity ● radiation load ● simulations of performance and of readout chain	First version of specifications tables	Final specifications and simulations Assessment of maximum radiation tolerance and input to pp rate target	
Sensor design / selection ● options of technology ● choice of technology or missing steps	Comparison of available options (e.g. for TOF, MID); roadmap for new developments (e.g. for trackers)		
Sensor prototype characterization ● rad. hardness ● noise ● timing,...		Completion of characterization of possible sensor options	Sensor selection (example, depending on subsystem)

Planning towards TDRs

Generic task → approx mapping to TDR chapters	1st Milestone - Q1 2025?	2nd Milestone - Q3 2025?	3rd Milestone - Q1 2026?
Module • interconnection technology • flex/PCB design • assembly procedure • data links integration…	Preliminary conceptual design of module, including interconnection	First mockups for assembly tests with dummy or provisional sensors, including interconnection	Flex/PCB design, depending on sensor status
Module prototype characterization • functional • mechanical/thermal • irradiation		Design of test setups for modules	First results on characterisation
FEE ASIC design (technology, main functionalities, power consumption)	First version of specifications	Final specifications	
FEE ASIC characterization (rad. tol., time resolution)			First characterisation
Readout and off-detector electronics		First version of specifications	Final specifications

Planning towards TDRs

Generic task → approx mapping to TDR chapters	1st Milestone - Q1 2025?	2nd Milestone - Q3 2025?	3rd Milestone - Q1 2026?
Mechanics for module, barrel, disc • staves or supermodules design and assembly procedure • barrel/disc support and assembly procedure • service carriers • integration	Preliminary conceptual design of staves or supermodules Preliminary conceptual design of global mechanics	Characterisation of mockups for staves and support structures First version of detailed design	Service carriers Integration procedure
Powering • power estimates • power units and power distribution		Finalise power estimates	Preliminary design of power system
Cooling • specifications, simulations • cooling plant and distribution • options and prototype tests	First specifications, definition of options, first simulations	First version of detailed design	Prototype tests and selection of option for TDR
Detector safety and detector control systems			Preliminary conceptual design
Resources and planning after TDR (cost estimates and profiles, schedule and milestones, organisation and contributions, risk analysis)			Prepare material

Outlook

- **Excellent work by WG coordinators**
  - general schedules
  - detailed cost estimates and spending profiles
  - required and available personnel profiles

- **Impact of new LHC schedule for LS3, Run 4 and LS4**
  - Need to update project schedules and resource profiles for the Scoping Document

- **Transition to WP structures and milestones towards TDRs**
  - WP definition well advanced in all projects, should start in ~ 4-6 weeks
  - Finalization of milestones on same timescale to plan progress tracking from 2025