Optical Transition / Diffraction Radiation: status and perspectives

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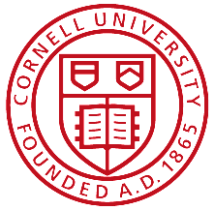
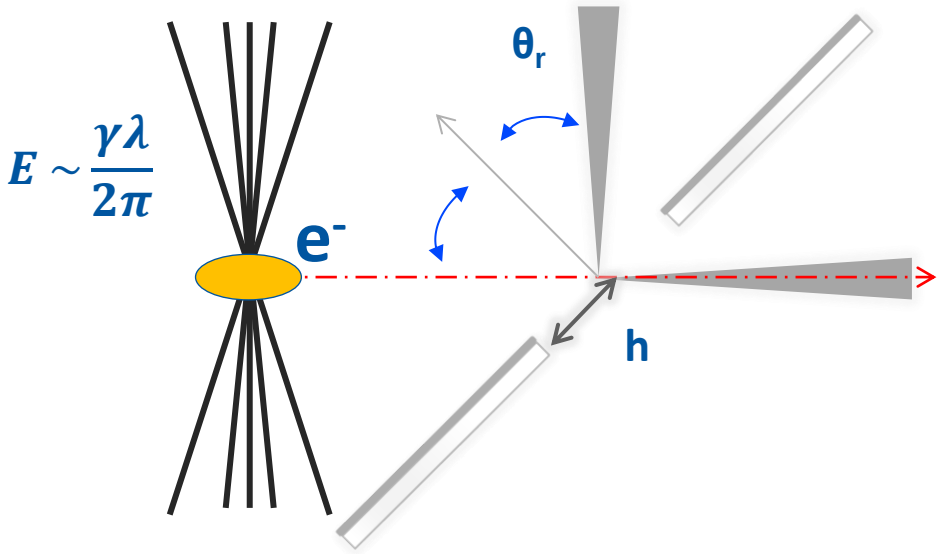


Outline

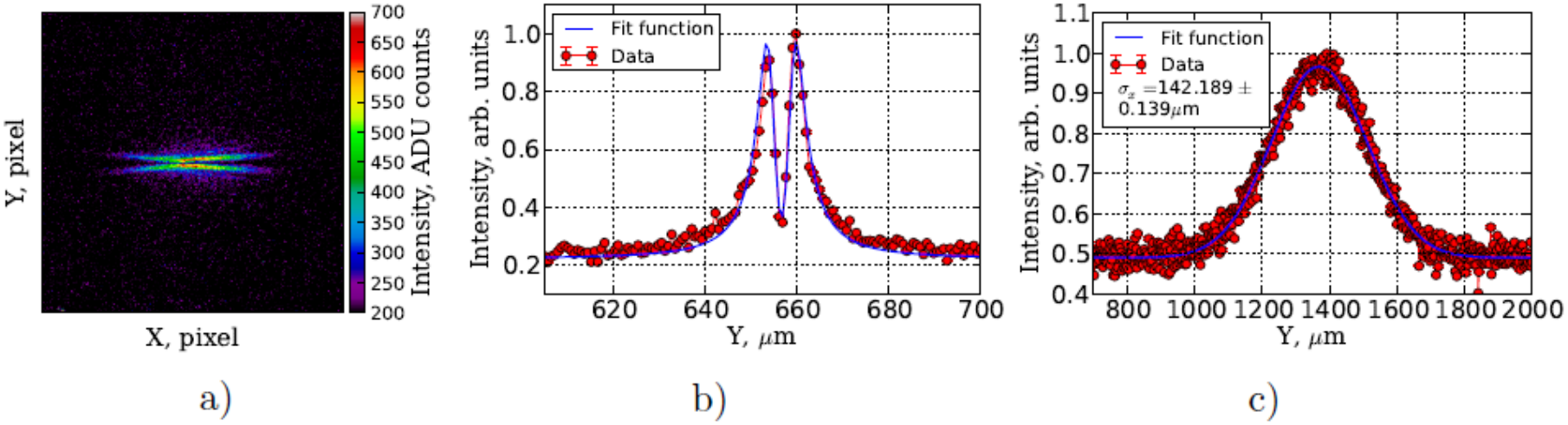
- Introduction
- Overview of recent beam size measurements using ODR (CESRta) and OTR (ATF2)
- Proposed ODR/OTR studies @ ATF2 (2015-2017)
  - Schedule
  - Budget
  - Personnel

Transition and diffraction radiation



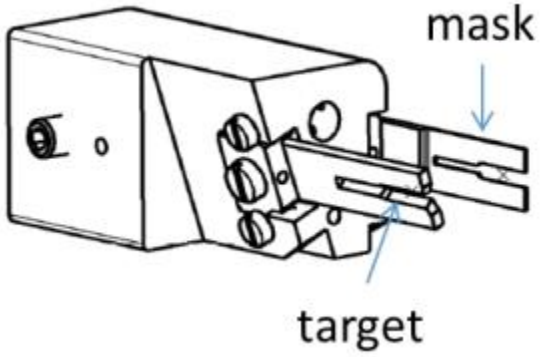
- Electric field of relativistic particle interacts with atoms of a screen (transition radiation) or a slit (diffraction radiation)
- Radiation is emitted along particle trajectory (forward) and in the direction of specular reflection (backward)

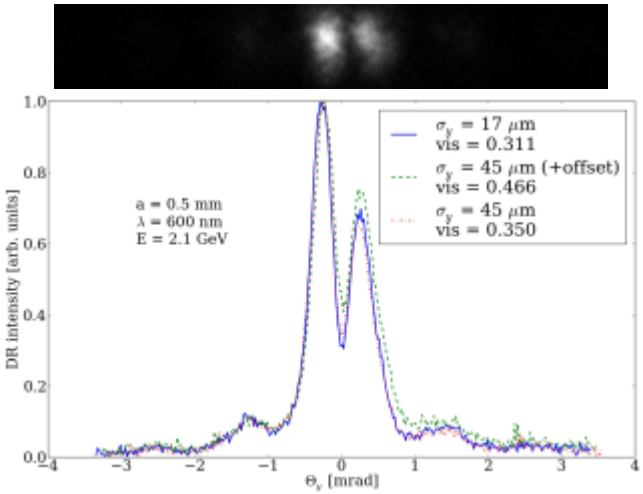
OTR: recent results @ ATF2

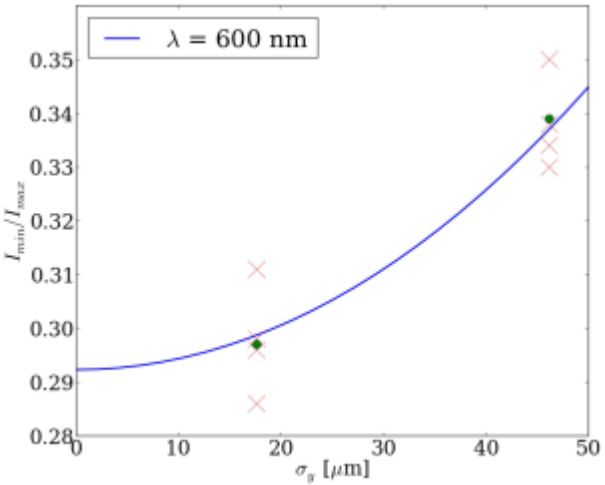


- Sub micron resolution (700 nm) achieved with OTR (Kruchinin et al. 2014)
- Installed in ATF2. 45deg aluminised silicon screen.
- Single lens setup, visible light.

ODR: recent results @ CESRta (I)

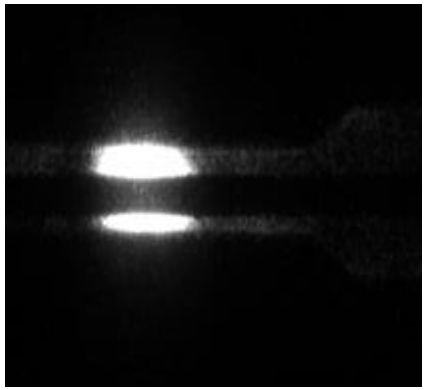


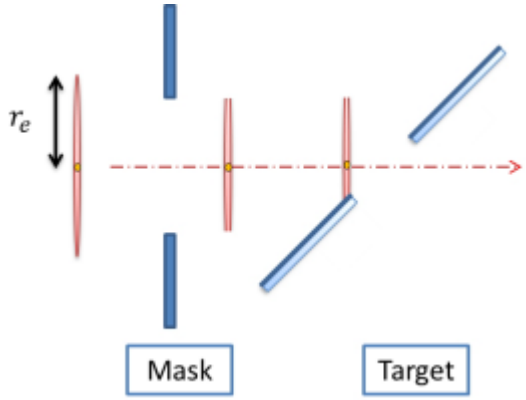


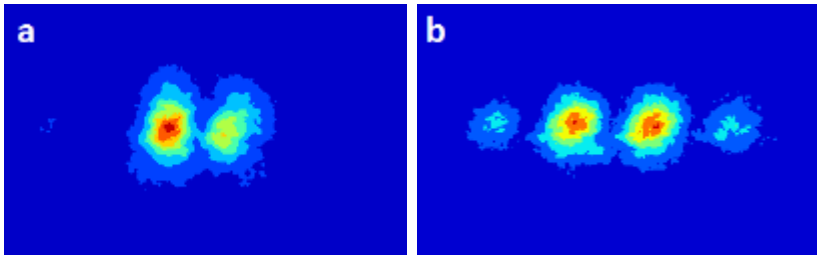


- Beam size measurement through reduction of lobes visibility of angular distribution
- Apertures: slit 0.5 mm, mask 2 mm. Single lens setup, visible light (600 nm , 400 nm)
- Challenges: beam lifetime, SR background, target manipulation

ODR: recent results @ CESRta (II)





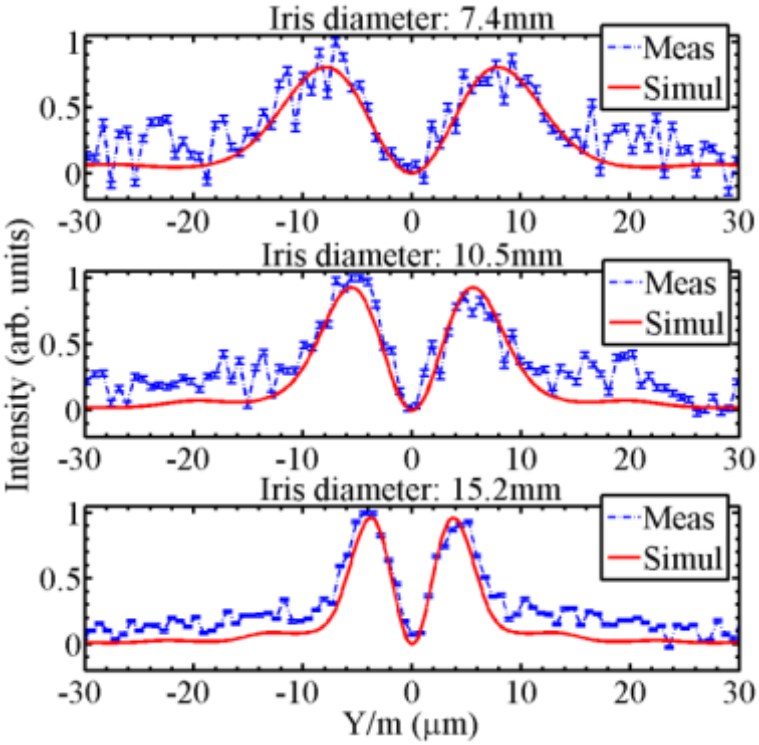


L. Bobb, PhD Thesis

- When mask and target apertures are similar: ODR Interference (ODRI) if distance $< L = \frac{\lambda}{\pi(\gamma^{-2}+\vartheta^2)}$
- EM field from moving particle is “cut” by the mask: shadowing effect.
- In the far field: OTRI signal is the interference between two emitters. Beam size derived from fit.

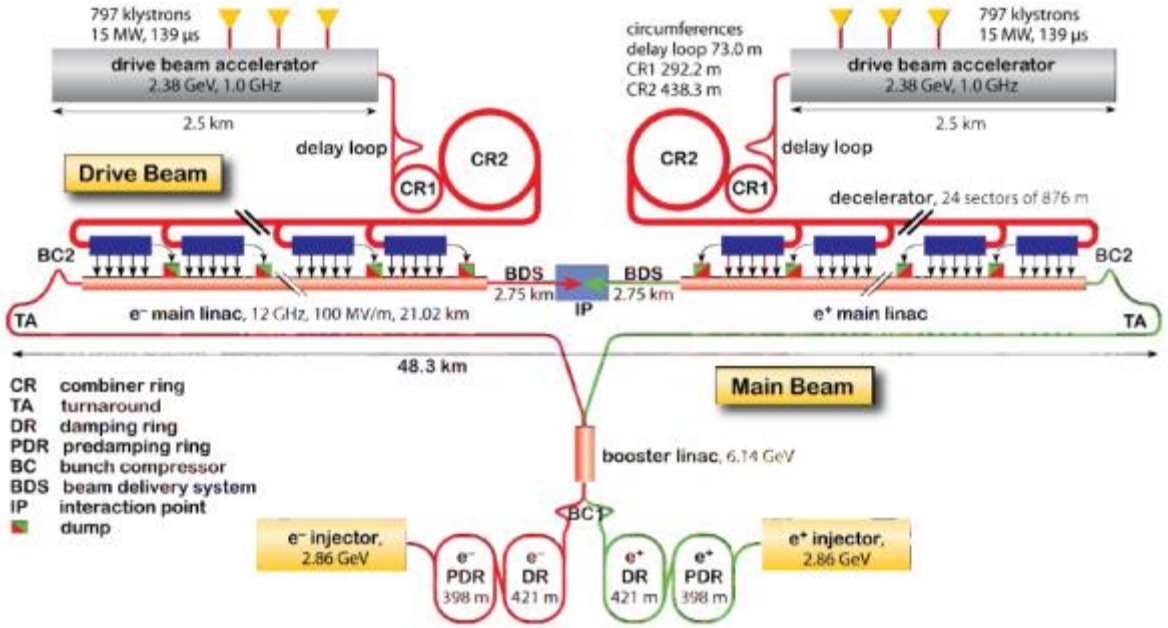
ODR / OTR: simulations.

- Accurate simulations of OT(D)R through a *real* optical instrument.
- Progress over 2012-2014:
  - Simulation of ideal OTR point spread function (PSF)
  - Effect of beam size, target tilt, misalignment, arbitrary apertures for ODR/OTR (T. Aumeyr, PRSTAB, 2014)
  - More recently: interference of two ODR/OTR screens.



Simulation of OTR PSF at various slit diameter (B. Bolzon et al, submitted to PRSTAB, 2014)

Proposed high-res OD(T)R @ ATF2



- Goal: development of a high resolution ODR/OTR station.
- Non-invasive alternative to more complex / expensive beam sizing instruments (eg laser wire).
- CLIC drive beam, ILC/CLIC Main beam in RTML

Proposed high-res OD(T)R @ ATF2

- Improvement of resolution. Three directions:
  - From visible to UV (200 nm - 70 nm)
  - Slit width down to 100-200 μm
  - Better optical performance: two lens system (microscope)
- Separate manipulation for mask and target
  - Mask: movable blades
  - Target: chemically etched, substrate TDB. Control of linear and angular position
  - Chamber has 4D position system (XYZ and angle)

Proposed high-res OD(T)R @ ATF2

- Proposal sent at beginning of 2014.
- ATF2 Technical board comments:

1. “The scenario for using the proposed OTR and ODR in the context of linear collider emittance measurements needs to be better described, including the resolutions which are needed in the various sub-systems”

Sub-systems	Emittance [nm.rad]	Energy [GeV]	Resolution [μm]	Quantity	Charge density [nC/cm^2]
Main Beam					
e^- source & pre-injector complex	10^5	0.2	50	2	$< 5\times10^5$
e^+ source & pre-injector complex	93×10^5	0.2	50	4	$< 5\times10^5$
Injector linac (e^-/e^+)	$1/93\times10^5$	2.86	50	2	$< 5\times10^5$
Pre-Damping Rings (H/V)	63 000/1500	2.86	50/10	4	$< 5\times10^6$
Damping rings (H/V)	< 500/5	2.86	10/1	4	$< 5\times10^8$
RTML	510/5	2.86–9	10/1	70	$< 5\times10^8$
Main Linac	600/10	9–1500	10/1	48	$< 5\times10^8$
Beam Delivery System	660/20	1500	10/1	8	$< 5\times10^8$
MDI & Post-collision line	>660/20	< 1500	1000	6	$< 5\times10^3$
Drive Beam					
Source and linac	100	2.37	50	10	$< 40\times10^6$
Frequency multiplication complex	100	2.37	50	20	$< 40\times10^6$
Transfer to tunnel	100	2.37	50	2	$< 40\times10^6$
Turn around	100	2.37	50	96	$< 1.5\times10^6$
Decelerator	150	< 2.37	50	576	$> 1.5\times10^6$
Dump lines	> 150	< 2.37	100	96	$> 1.5\times10^6$

Proposed high-res OD(T)R @ ATF2

- ATF2 Technical board comments:

2. What fractions of time will be committed? Are there PhD students involved whose theses will be on this topic and who will depend on the success of the project? Another question concerns technical and financial resources: are they available in the different groups involved in the next two years to pursue this project? A detail plan and schedule with a few milestones should be established for the next two years, including costs and personnel requirements

CERN-ATF2 midterm collaboration Sent June 2014

R. Tomás, M. Barnes, A. Latina, T. Lefevre, M. Modena,
Y. Papaphilippou, J. Pfingster, S. Stapnes and A. Yamamoto

Abstract

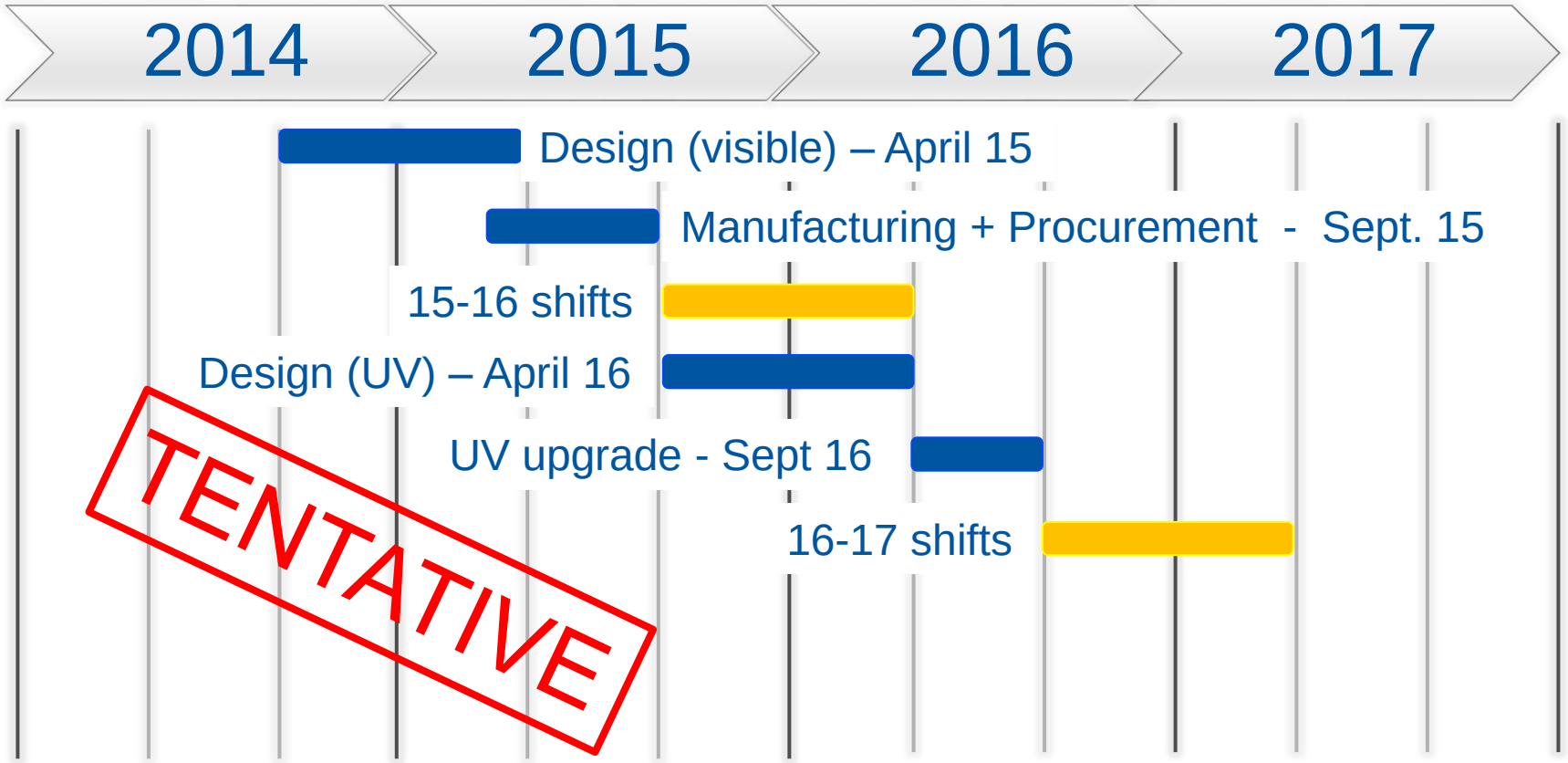
This report describes the CERN R&D midterm projects in ATF and ATF2 in the framework of an increased collaboration between KEK and CERN. Direct contributions from CERN to the operational budget of ATF are considered.

Project planning (I)

Manpower		
RHUL	P. Karataev (30%)	Scientific coordination Beam tests
	E. Bergamaschi	PhD student @ CERN. 100% on the project
	T. Aumeyr (40%)	Simulations, Beam tests
CERN	S. Mazzoni (40%)	Overall coordination Beam tests
	T. Lefevre (10%)	
	E. Bravin(10%)	
	R. Kieffer (40%)	Fellow. Simulations, instrumentation (interference)

In addition: CERN design office and workshops

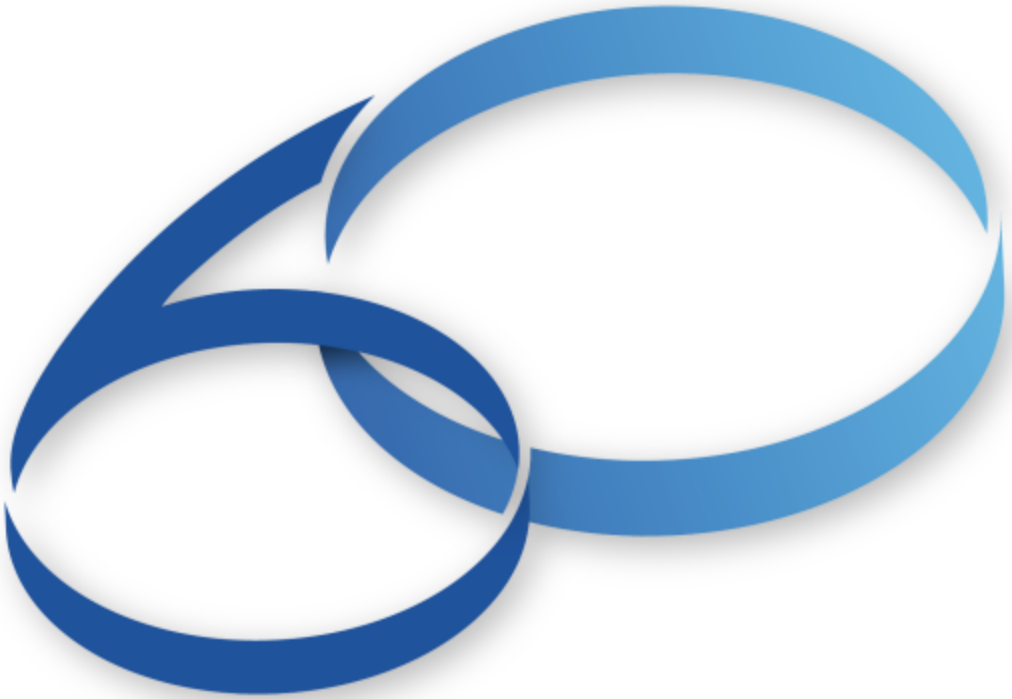
Project planning (II)



Project planning (III)

Cost breakdown (k€)				
	2015	2016	2017	total
Mechanics	153	27	27	207
Optics	120	21.5	17	158.5
Equipment	15	7	7	29
Travel	45	45	45	135
PhD student	45	45	45	135
TOTAL	**378**	**145.5**	**141**	**664.5**

In addition: additional travel budget from EC`s 2020 proposal starting in 2015 (S. Stapnes).



YEARS / ANS CERN