Upgrading Babar IFR
to SuperB IFR
Evaluation of the different options

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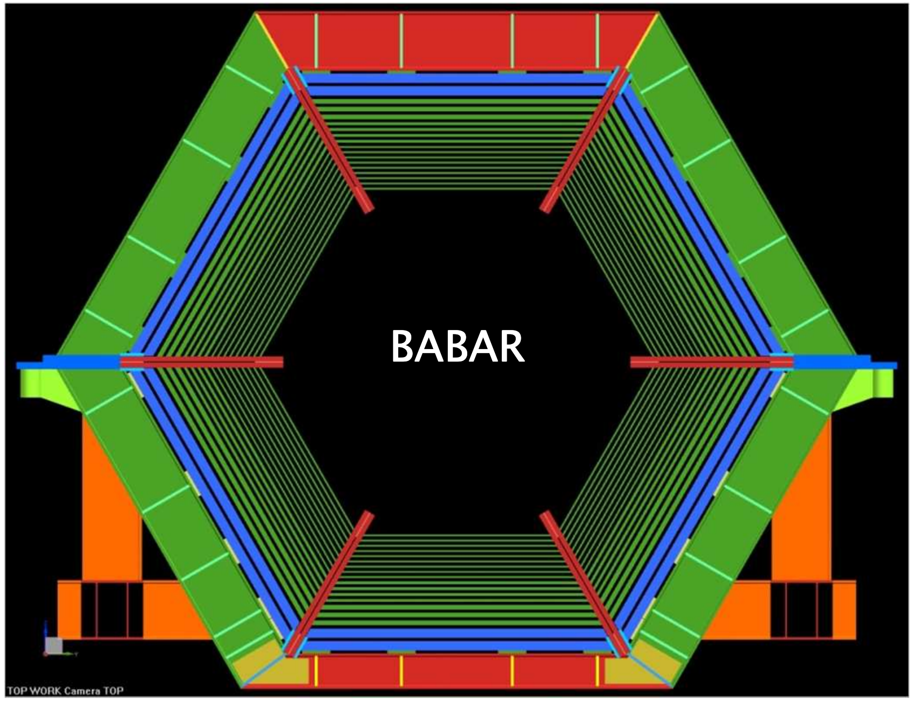
SuperB IFR
Baseline Flux Return detector geometry

Current baseline: Babar IFR recycling + modifications
Main difference: design of SuperB IFR: 920mm; Babar IFR : 650 mm (barrel) 600 mm (doors)

Babar: scarce overall filter thickness (about 50% of nominal thickness)
Many useless slots (e.g. inner wedges: 15 slots)



PROs and CONs in reusing the Babar IFR:

- About 800 t of iron available
- About 95 t of brass plates available for gaps filling
- minimal requirement in terms of design

- Requires modifications
- Requires additional filling or parts replacing
- Shipping management and costs

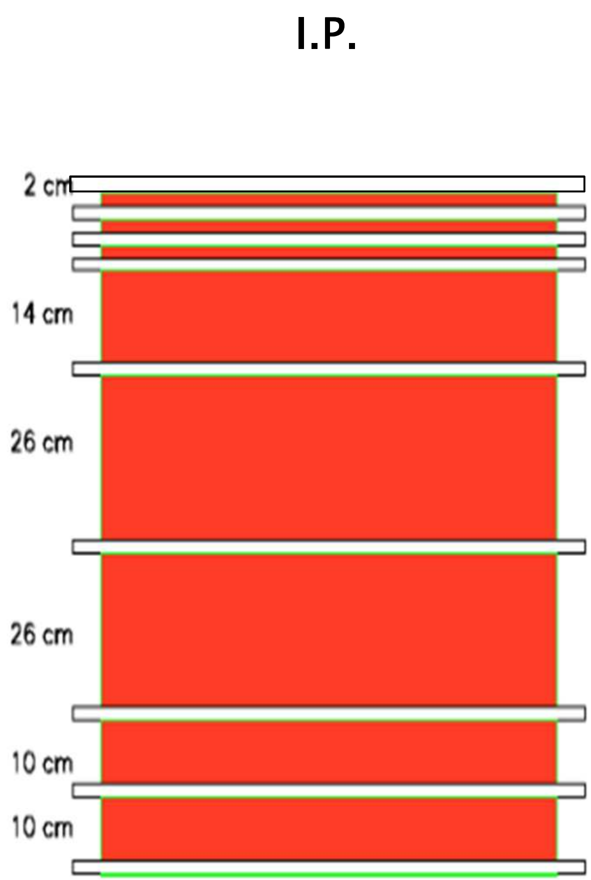
SuperB IFR
Baseline Flux Return detector geometry

Main specifications to be frozen for SuperB:
- Overall IFR design thickness
- Number of detectors layers
- Available budget ....

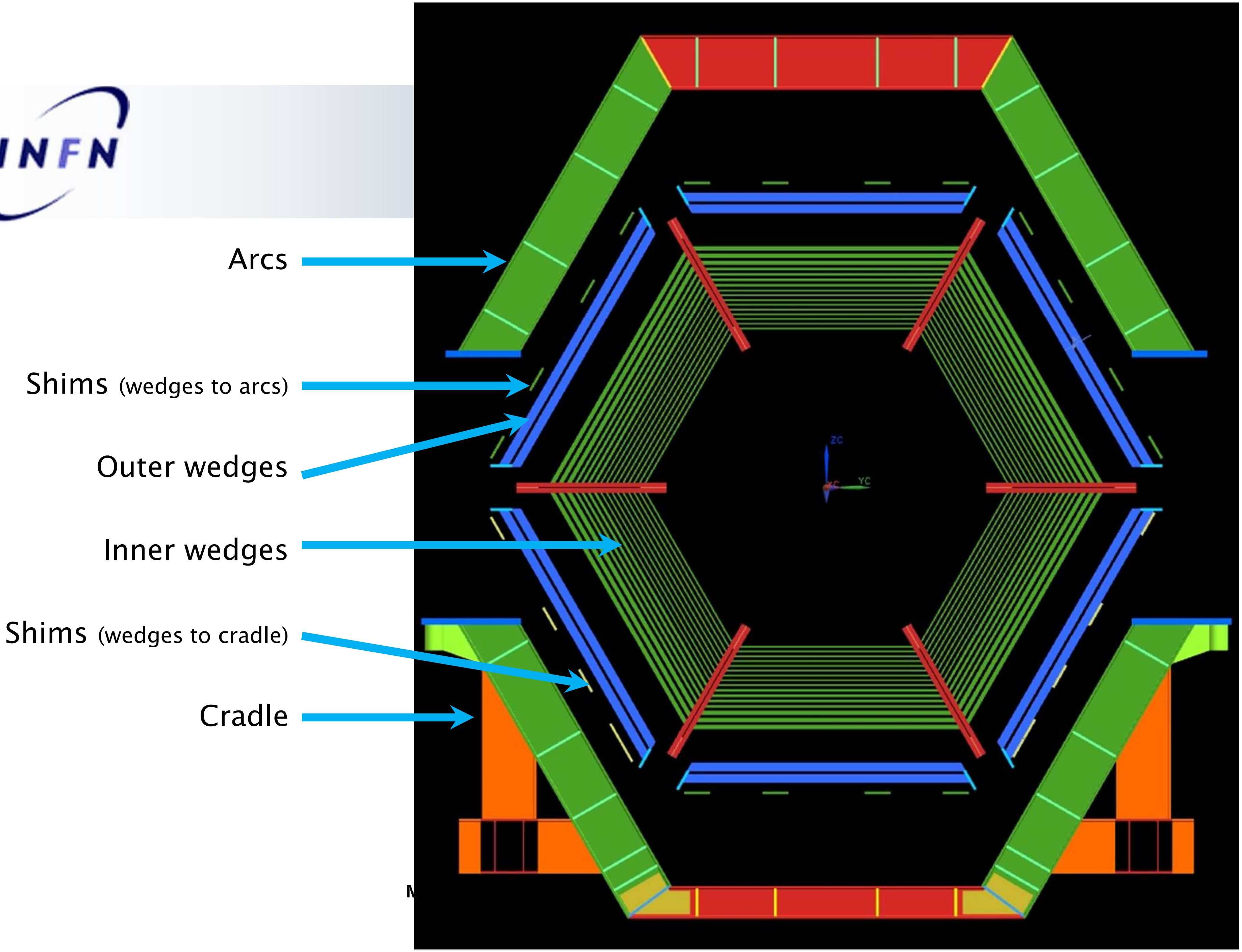
Assumed Baseline:
IFR filter thickness 920mm,
8 scintillator layers
BUDGET?

Possible variations on specs:
- smaller thickness may be acceptable (vs cost saving) ?
- Upgrade to 9 layer of detectors

All configuration foreseen:
one scintillator layer «before» IFR, one «after» IFR (wrt I.P.),
6 or 7 scintillator layer inside gaps



INFN


Arcs
Shims (wedges to arcs)
Outer wedges
Inner wedges
Shims (wedges to cradle)
Cradle

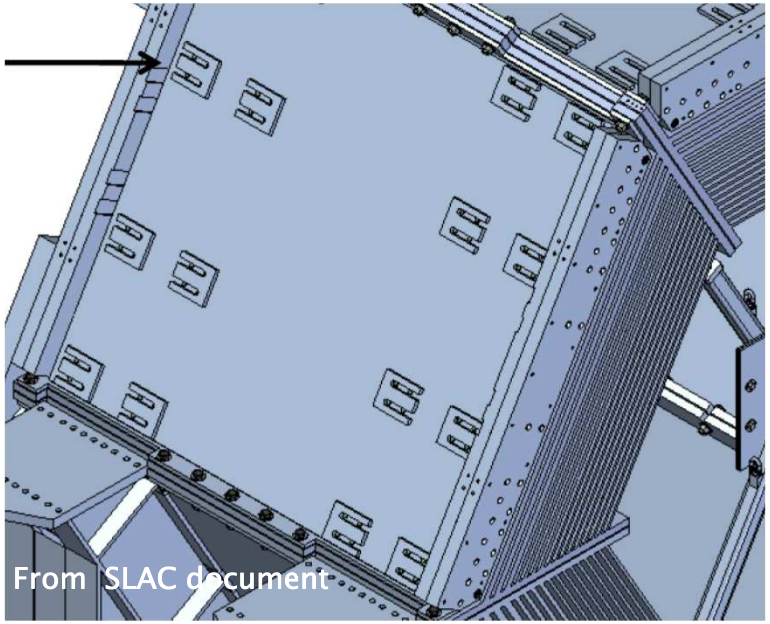
SuperB IFR
Possible options to upgrade Babar IFR

a) Fill unused gaps with «long, cambered» plates 22mm thick (as done in Babar)
b) Fill gaps with thicker plates, likely to be smaller than a)
c) Add steel layer/plates «outside» (at outer distance from IP)
d) Replace parts of Babar IFR

All of them require to make a gap for scintillators outside the barrel, thus to modify/reduce wedges connections to cradle and arcs + modify outer wedges

Possible drawback of combined IFR weight increasing and connections reduction:

- Need to reinforce existing cradle and arcs
- or replace with new ones



SuperB IFR
Gaps filling: plate thickness

Babar barrel already filled with 123 mm (overall thickness) of brass plates (6 layer x 7/8'')
Plates dimensions: Length as gaps span, width 267 mm, thickness 22.2 mm
Plates were cambered to compensate gravity deformation
Other 4 / 5 gaps available for filling
max overall thickness reachable 872/894 mm (with 9 / 8 scintillators layers).

May be possible increase plates thickness?
- e.g. 10 gaps filled with 27 mm thick plates
- e.g. 11 gaps filled with 25 mm thick plates
- may require reducing plates dimensions to reduce requirements on flatness

Option b2) Top and bottom wedges with smaller thickness

Filling of the inclined wedges with small plates 25 or 27 mm thick, where deformation of wedge's plates due to additional weight is negligible, while the horizontal wedges - in order to avoid large deformation of wedges plates (meaning thinner gaps for scintillators) could not be filled with so thick plates and thus could not reach the 920mm thickness.
Assess if acceptable top and bottom wedges with smaller overall thickness w.r.t. the other four wedges.
Or if at same thickness the increase of deformation of the plates of the wedges is acceptable.

SuperB IFR
Gaps filling: plates material

Material	Density t/m^3	Interaction Length cm	I.L. x Density g/cm^2	Cost (approx.) €/t	110523 LME quotation Cash b. k$/t
Steel (magnetic)	7.8	16.8 cm	132.1	1.5	0.55
S-steel aisi 304L Low permeability	8	16.8 cm (esteem)	134 (esteem)	4	
Copper	8.9	15.3	137.3		8.8
Zinc	7.1	19.4	138.5		2.1
Lead	11.3	17.6	199.6		2.4
Brass (e.g.30% Zn)	8.4-8.7	16.5 (esteem)	138.5(esteem)	8.3	
Tungsten	19.3	10	192	40 – 50?	

Source (for pure metals): http://pdg.lbl.gov/2010/AtomicNuclearProperties/

Source for quotations: LME. Source for cost: suppliers

Fe and Cu are the most efficient material concerning interaction length (see int.length * density)

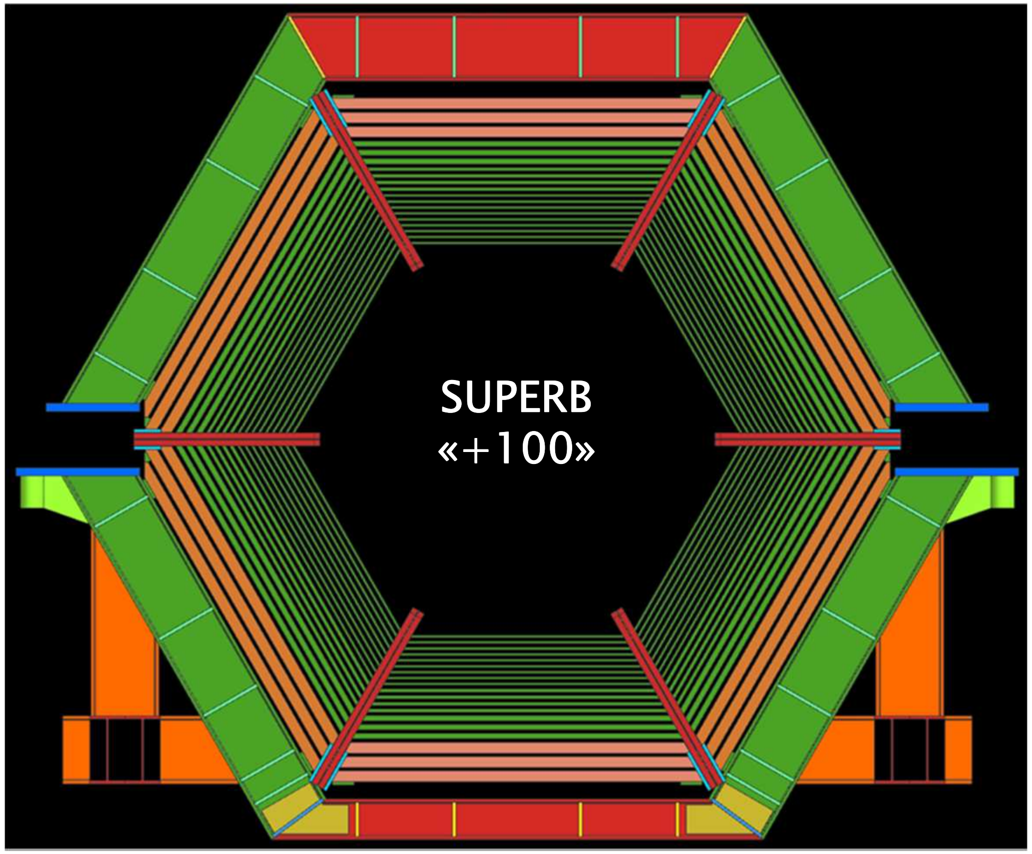
SuperB IFR
Adding steel plates outside

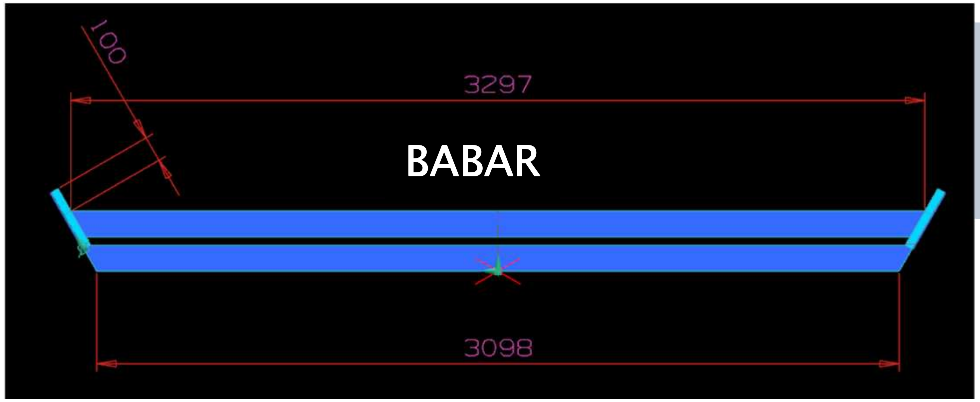
Add 100mm thick plates «on top» the outer wedges, in order to reach required IFR thickness

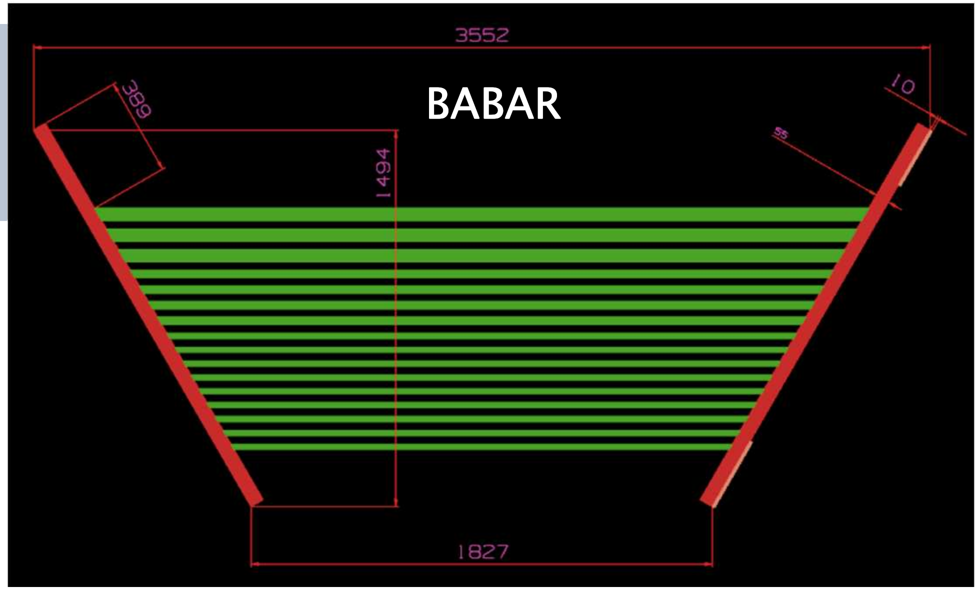
Require to deeply modify all the main parts (inner and outer wedges, cradle, arcs)

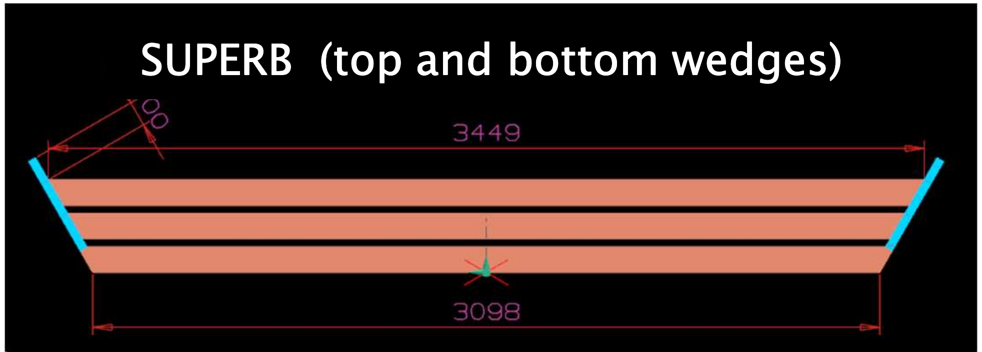
Require additional filling of 2 gaps wrt Babar filling (overall of 8 gaps filled with 22.2 mm each) , or to increase thickness of the additional plates to 140 mm.

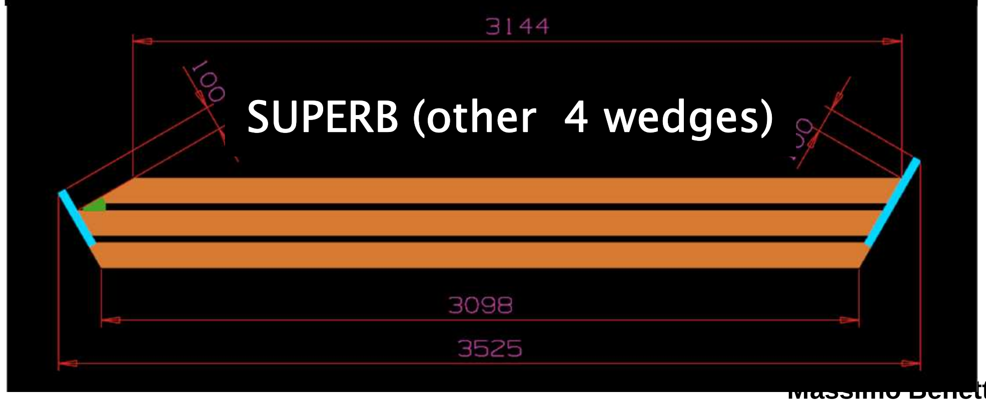
Thicker plates imply bigger integration problems thus can imply the replacing of cradle / arcs and larger dead space of last scint. layers

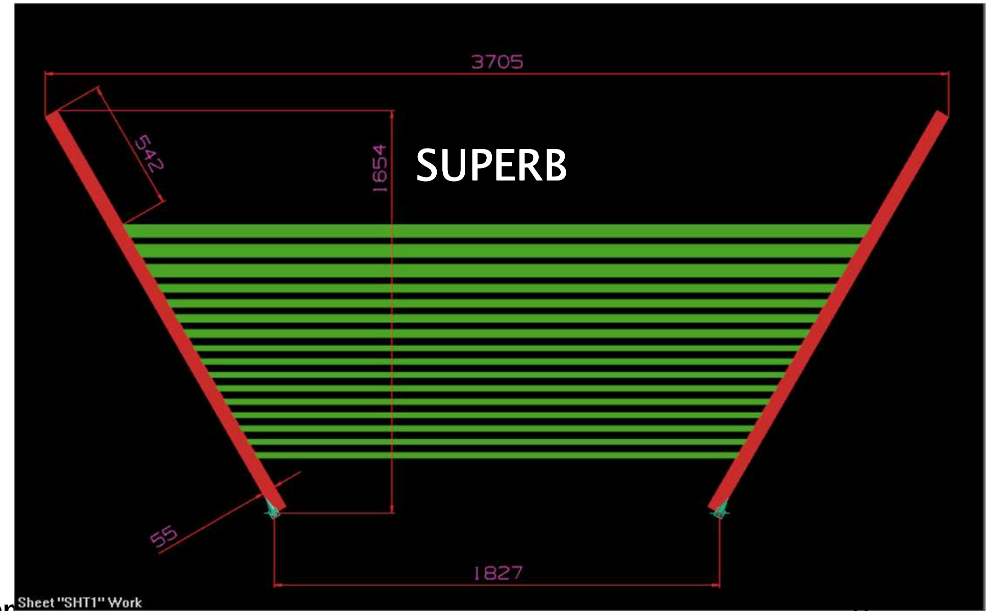



BABAR
100
3297
3098


BABAR
3552
389
10
55
1494
1827


SUPERB (top and bottom wedges)
100
3449
3098


SUPERB (other 4 wedges)
3144
100
3098
3525


SUPERB
3705
542
1654
55
1827
Sheet "SHT1" Work

Options	Max thickness	To do (design and workshop)	PROs	CONs
Babar IFR filled as possible with 22mm thick plates	894 with 8 scintillators layers	Modify carpentry to create a gap between wedges and cradle/arcs	Full recycling, with as less as possible modifications	Low thickness Labour intensive Cost vs thickness if brass is needed Filling with steel/Ssteel to be investigated
Babar IFR filling with thicker (25-27 mm) plates	Maybe 920	Modify carpentry to create a gap between wedges and cradle/arcs	Could reach design thickness, with as less as possible modifications	Maybe not possible, require intensive measurements campaign Could imply large deformation on top and bott. wedges May not reach design thickness on top and bott. Wedges Labour intensive Filling with steel/Ssteel to be investigated
Babar modified adding plates outside	920 mm or more	Modify carpentry to create a gap between wedges and cradle/arcs	Cheaper way to reach 920 mm	Require to modify all barrel parts plus plates filling. Possible loosing of barrel geometric precision. Outer scintillators layer with large dead space.
Replace inner wedges	920 mm or more	Modify carpentry to create a gap between wedges and cradle/arcs	Clean, reliable solution	Cost Big order, burocracy, long timing

IFR
Costs esteem

Cost esteem based on preliminary offers:

- Steel plates for filling 1.5 k€/t
- Stainless steel plates for filling, low permeability: 4 k€/t
- Brass plates for filling 8.3 k€/t
- New carpentries: 3.5 k€/t

- Other possible candidates like Zn, Pb neglected, no evident advantages (apart magnetic properties)

- Shipping SLAC – Italy
  Preliminary esteem: 0.5 k€/t or m^3 (according to density $>$ or $<$ than 1) not updated

IFR
Costs esteem

	max equivalent thickness [mm]	new carpentry to buy [tons]	new layers of plates wrt Babar	new plates to insert [mm of thickness]	Filled layers Overall	Filling Metal	Density	Cost/t	Additional weigth [t] of filling wrt Babar	Overall weigth [t] barrel nut only	Costs [k€]							Missing thickness [mm]
											Transport	plates proc.	plates insert.	New carpent	Carpentr. modifications	Overall	Cost/Dmm (thick-785) [k€/mm]	
a1) Babar with modified cradle/arcs 2 wedges connection, 22 mm plates filled	872	0	4	**89**	**10**	**steel**	**7,8**	**1,5**	**39,0**	399,0	230	58	50	0	120	**458**	**5,3**	**48**
						S-steel	**8,0**	**4,0**	**40,0**	400,0	230	160	50	0	120	**560**	**6,4**	**48**
						Brass	**8,4**	**8,3**	**42,0**	402,0	230	348	50	0	120	**748**	**8,6**	**48**
a2) Babar with modified cradle/arcs 2 wedges connection, 22 mm plates filled	894	0	5	**111**	**11**	**steel**	**7,8**	**1,5**	**48,7**	408,7	230	73	50	0	120	**473**	**4,3**	**26**
						S-steel	**8,0**	**4,0**	**50,0**	410,0	230	200	50	0	120	**600**	**5,5**	**26**
						Brass	**8,4**	**8,3**	**52,4**	412,4	230	435	50	0	120	**835**	**7,6**	**26**
b) thicker(25 mm) plates filling	925	0	all	**275**	**11**	**steel**	**7,8**	**1,5**	**120,7**	480,7	230	181	50	0	120	**581**	**4,1**	-5
						S-steel	**8,0**	**4,0**	**123,8**	483,8	230	495	50	0	120	**895**	**6,4**	-5
c1) Add 100 mm outward	928	60	2	44	8	**S-steel**	7,8	3,5	**19,5**	439,5	230	78	36	210	210	**764**	**5,4**	-8
c2) Add 140 mm outward	923	85	0	0	6		7,8	3,5	**0,0**	445,0	230	0	27	298	210	**765**	**5,5**	-3
d) Replace inner wedges	920,0	360	0	0	0		7,8	3,5	**0,0**	480,0	80	0	0	1260	120	**1460**	**10,8**	0
e) Replace all barrel	920,0	540	0	0	0		7,8	3,5	**0,0**	480,0	0	0	0	1890	0	**1890**	**14,0**	0

Cost esteem vs Metals (LME) quotations

Steel Billet cash buyer

Copper cash buyer

Variation of LME quotation affects about 50% of semifinished cost
(2009-2011: steel semifinished +70%, brass +20%) source: http://www.lme.com/

SuperB IFR
Steps/inputs of decisional process

Freeze the design specifications:
Required overall IFR thickness (or minimum required thickness)
Number of required scintillators layers
Budget

Feasibility of modifications to cradle/arcs to wedges connections to be confirmed having complete information on the full IFR, knowing constraints and overall static model of the full IFR (up to now have been considered only barrel). Up to now anything preventing this feasibility has been found.

Assessment of filling:
Define if magnetic/paramagnetic or other metals can be used for filling (steel, lead, s-steel)
Extensive check of all the gaps ..!.. to assess the max. plate thickness
Assess deformations of gaps on top and bottom wedges vs. load given from filling

Assessment of adding steel plates outside:
Define if dead zone of outer scintillator layers (2 layers) is acceptable (0.5 – 1.5 m)
Assess overall impact of increased geometry on field, doors and front blocks
Cost and reliability of carpentry modifications vs. geometric precision

Assessment of Wedges replacing
«New wedges» reliable cost evaluation must be based on workshop drawings and specifications. (e.g. dimensional and geometric tolerances and material specifications)

IFR
provisionals conclusions

- Modify the connections between cradle/arcs and the wedges and reinforce cradle and arcs seems feasible with no major drawbacks, but requires more accurate FEA models and precise information to input the correct static model .

- Fill with “thicker” plates is cost efficient but feasible thickness unknown
- Proof the feasibility = a lot of work (reliable result?) , cost of which not accounted here.

- If thickness of 894 mm with 8 scintillators can be fine => filling as Babar of 5 additional gaps, overall 11 gaps filled.

- Brass is quite expensive, consider steel (magnetic, fix by welding) or S-steel (as amagnetic)

- Adding plates outside is both cost efficient and matching the design thickness.

- Replacing of Babar wedges with new ones:more expensive but reliable solution.

- The cost of candidate solutions for the upgrade of the barrel should range roughly from .5 to 1.5 M€. (barrel only)